Contribution of tree uprooting to the evolution of hillslopes and soils - on the examples from the Sudetes Mts., SW Poland

PAWLIK L.(1), MIGON P.(1), KACPRZAK A.(2)
(1) University of Wroclaw, WROCLAW, POLAND ; (2) Jagiellonian University, CRACOW, POLAND

Forest dynamics is an important factor of geomorphic change within the forested hillslope domain. Self-organization of forest community is controlled by various kinds of disturbance (e.g. fire, wind) which occur during the lifespan of trees. These disturbances initiate structural changes in the forest which in turn activate and/or alter the course of surface processes and have direct impact on forest soils. Tree uprooting is a major biotic factor influencing geomorphological and pedological processes in the forest and we aimed to recognize its geomorphic role in the forested environment of the Sudetes (SW Poland).

Our results indicate that tree uprooting is widespread and causes an increase in surface roughness of the forest floor, giving origin to specific associations of microforms called pit-and-mound microtopography. It also results in uneven redistribution of soil material and alters the stratigraphy of inherited Pleistocene slope materials. There are long lasting consequences for sediment transport, water retention, accumulation of organic matter and plant succession. These processes control soil evolution, which in turn makes the investigation of soil profiles a useful tool to infer the origin and age of pits and mounds within slopes.

Even if distinct pit-and-mound forms are no longer observed, we propose that tree uprooting may have been the process initiating further re-shaping of slope morphology, ultimately leading to step-like hillslope profiles (teracettes) and the appearance of stone blankets on slopes, usually attributed to periglacial processes in the Pleistocene.

Our studies show that tree uprooting occurs at two scales. One is catastrophic, connected with single events affecting large sections of hillslopes, while the other one is connected with fall of individual trees. The latter, although less spectacular, may also lead to significant transformations of hillslopes and slope materials, including soils, over the time scale of the entire Holocene.

****

What do organisms do on rocks? A multi-methods approach to evaluating biodeterioration and bioprotection in the critical zone

COOMBES M.(1), NAYLOR L.(2), VILES H.(1), GOWELL M.(1)
(1) University of Oxford, OXFORD, UNITED KINGDOM ; (2) University of Exeter, PENRYN (CORNWALL), UNITED KINGDOM

There is increasing evidence that some organisms have protective functions with respect to rock decay as well as contributing to bioweathering and bioerosion. The challenge, therefore, is evaluating the relative importance of these conflicting roles so that a balanced judgement can be made about their overall geomorphic function. This is particularly true when making management decisions (e.g. whether to remove an organism to minimise decay, or encourage further colonisation to facilitate bioprotection).

We describe an approach in which multiple methods are used in a coordinated way in the assessment of the impact of macroorganisms on rock decay in the coastal zone. Field monitoring, laboratory simulation and microscopy are used to evaluate the influence of seaweeds and barnacles on: weathering conditions (i.e. microclimates); the efficiency of particular deterioration processes (i.e. salt weathering); changes in material properties (i.e. hardness) and; the direct breakdown of colonised materials (e.g. decay artefacts and loss of mass).

We conclude that the relative importance of the studied organisms for bioprotection and biodeterioration is heavily contingent on rock type and local environmental conditions, consequently varying in time and space. This makes generalisations about their bioprotective or biodeteriorative roles especially difficult. However, our observations indicate that marine epibiota can have a significant role in reducing the efficiency of mechanical decay processes. From the perspective of environmental management, if particular decay mechanisms or modes of breakdown are known to be paramount (e.g. loss of material strength for a coastal structure, or ingress and egress of moisture for a historic stone wall), methods of evaluating the role of organisms in decay and protection can be more effectively targeted (e.g. direct measurement of rock strength or stone moisture regimes, respectively).

Landscape self-organization of tidal floodplains by bio-geomorphic feedbacks between vegetation growth, flow hydrodynamics and sedimentation-erosion

TEMMERMAN S.(1), VANDENBRUWAENE W.(1), DIJKSTRA J.(2), VAN DUREN L.(2), DE VRIES M.(2), VAN DE KOPPEL J.(3), HERMAN P.(3), BOUMA T.(3)
(1) University of Antwerp, ANTWERP, BELGIUM ; (2) Deltares, DELFT, NETHERLANDS ; (3) Royal Netherlands Institute for Sea Research, YERSEKE, NETHERLANDS

Fluvial and tidal floodplains form and evolve as a consequence of bio-geomorphological interactions between plant colonization, hydrodynamics and sediment transport. We study to what extent these interactions lead to the spatial self-organization of both geomorphic and vegetation patterns that are observed in a tidal floodplain. Intertidal flats may be colonized by patches of plants with contrasting morphologies, such as flexible sea grass species and stiff salt marsh species, and this is expected to have different outcomes on the landscape self-organization. Firstly, we show results of field and flume experiments, showing so-called scale-dependent interactions: on a small spatial scale within patches of stiff vegetation, flow velocities are reduced, which stimulates local sedimentation and has a positive feedback to plant growth; on a larger scale next to vegetation patches, the flow is accelerated around the patches, which can there initiate channel erosion and have a negative feedback effect on plant growth. The strength of these scale-dependent feedbacks is much weaker for flexible vegetations, since they can bend with the flow and in such a way exert less friction on the flow. Secondly, these effects are up-scaled using a coupled plant growth, hydrodynamic and morphodynamic model, showing that the patch-scale feedbacks lead to landscape-scale self-organization. For stiff salt marsh vegetation, plant colonization of an initially bare flat floodplain results in vegetated elevated platforms dissected by a dense network of non-vegetated channels. For flexible seagrass vegetation, the model shows a more homogeneous development of vegetation while landform changes are minor. The simulated landscape patterns qualitatively agree with observations from salt marsh and seagrass landscapes, demonstrating that plant-flow-landform feedbacks and the morphological properties of plants have a determinant effect on the self-organization of tidal floodplains.

****

How biogeomorphic approaches can be used to identify ecosystem processes and services: using rock weathering studies as an example

NAYLOR L.(1), COOMBES M.(1), VILES H.(1), GOWELL M.(1), THOMPSON R.(2)
(1) University of Oxford, OXFORD, UNITED KINGDOM ; (2) University of Plymouth, PLYMOUTH, UNITED KINGDOM

Biogeomorphic processes serve important mediating functions in most geomorphic systems. Key species or communities have been found to stabilise sediments (e.g. soil crusts, vegetated dunes); alter microclimates (e.g. seaweeds); absorb pollutants (e.g. ivy); sequester carbon (e.g. saltmarshes); or increase sediment mobility in rivers (e.g. crayfish). They are therefore important components of ecosystem processes, which often produce final ecosystem services (FES) and ultimately goods (G) that have a value (V) to society. For example, wave attenuation by saltmarshes regulates tidal waters (= FES) providing flood protection (G) for less money with wider benefits (V) than a hard engineering approach. Our rock weathering research in conservation, urban and coastal built environments is used to critically examine and quantitatively demonstrate how a biogeomorphical approach can improve our understanding of ecosystem processes – and identify previously unrecognised ecosystem services. Thermal and moisture regimes are known to affect mechanical and chemical weathering rates. Field and experimental trials examining seaweed and barnacle bioprotection have determined that extremes and fluctuations in temperature in the critical zone are reduced by up to several degrees. Ivy on limestone walls provides thermal and hydrological buffering and absorbs pollutants. Soft wall capping of ruined buildings also has been proven to provide a thermal blanket and act as a sponge reducing moisture ingress to old, unroofed walls. Biota typically serves to reduce the weathering potential and/or rates of decay; in some cases biota causes weathering. Thus, biogeomorphic approaches can be used to help identify key ecosystem processes at the biotic-abiotic interface, which also provide FES. Field and laboratory experiments testing ecological enhancement of walls demonstrate that these benefits can be encouraged and increased, through biogeomorphologically influenced engineering designs.

Poster presentations:

Landscape morphology and the spatial variation of critical zone processes in the luquillo critical zone observatory of Puerto Rico

SCATENA F.
University of Pennsylvania, PHILADELPHIA, UNITED STATES

It has long been recognized that tropical montane environments exhibit remarkable geologic, hydrologic, and biogeochemical heterogeneity in critical zone (CZ) properties. To explain this heterogeneity, many researchers have embraced the conceptual model that critical zone properties, like soil properties, result from a combination of climate, topography, organisms, parent material, and age. While this general conceptual model has been widely used in diverse environments, most studies have focused on isolating the influence of one state factor on a limited number of CZ characteristics. How the spatial distribution of state factors and their inter-relationships influence multiple critical zone properties across various spatial and temporal scales is poorly constrained. This paper summarizes a series of inter-related studies conducted in the NSF-funded Luquillo Critical Zone Observatory (LCZO) in Northeastern Puerto Rico that address the relative importance of different state factors on a suite of critical zone properties. State factors include 2 distinct bedrocks, 4 forest types, 3 hillslope positions, and a climate that ranges from subtropical moist to wet. CZ properties including vegetation structure and composition, soil bulk density, organic matter and exchangeable cations. In general, hillslope position (ridge, slope, valley) is significantly correlated to stand structure and soil properties in all combinations of lithology, forest types, and climate. Quartzdiorite vs volcaniclastic lithology have distinct weathering regimes, soil textures, and exchangeable cations within and between forest types. While bedrock lithology influence soil organic matter concentrations it has less influence on total soil organic matter content. For most soil properties, combinations of abiotic state factors can explain between 20-30% of the variance between sites. However, when vegetation type and stand age are included the amount of variance that can be explained can double.

****

Drainage network evolution during the initial phase of ecosystem development - observations from an artificially-created catchment

RAAB T.(1), SCHNEIDER A.(2), GERKE H.H.(3), MAURER T.(2), NENOV R.(2)
(1) Brandenburg University of Technology , COTTBUS, GERMANY ; (2) Brandenburg University of Technology, COTTBUS, GERMANY ; (3) Leibniz-Centre for Agricultural Landscape Research (ZALF), MÜNCHEBERG, GERMANY

The initial phase of landform development is characterized by non-equilibrium conditions, high geomorphic process rates, and high variations in geomorphic patterns and can therefore have a lasting influence on patterns of soils, hydrology, and biota in developing ecosystems.

This study attempted to reconstruct and analyze the first five years of hydro-geomorphic evolution in the 6 ha artificial catchment 'Hühnerwasser', which serves as a real world-laboratory to study patterns processes of initial ecosystem development. The first years of surface development in the catchment were characterized by intensive sediment redistribution and the formation of a network of erosion rills.

Our approach was based on the analysis of remotely-sensed data. We analyzed morphometry from a time series of ten Digital Elevation Models (DEMs) and mapped surface structures for four states of development from high-resolution aerial photographs. DEMs and aerial photographs of the initial surface and meteorological monitoring data were used to assess the effect of initial and boundary conditions on surface development. Further network parameters, e.g., energy dissipation in the rill network and connectivity of the surface, were characterized by combined analyses of rill network maps and DEMs.

After a rapid growth of the erosion rill network during the first two years of development, a reduction of the area of actively eroding rills was observed. Differences in precipitation characteristics, the growth of vegetation cover, and locally evolving feedback cycles between flow accumulation and erosion were identified as drivers for this development. Results of the DEM time series analysis show that geomorphic patterns in the catchment were established during the first years of development and remained relatively stable afterwards.

Soil erosion and carbon redistribution in slopes under different lithologies and land uses: the effect of fires.

MENENDEZ-DUARTE R.(1), SANTIN C.(2), FERNANDEZ S.(1), NAVAS A.(3), GASPAR L.(3)
(1) INDUROT-Oviedo University, MIERES (ASTURIAS), SPAIN ; (2) University of Swansea, SWANSEA (WALES), UNITED KINGDOM ; (3) Estación Experimental de Aula Dei(CSIC), ZARAGOZA, SPAIN

Rates of soil erosion and soil carbon redistribution are being studied in slopes under different lithologies and different land uses in an Atlantic mountain area(Cantabrian range, NW Iberian Peninsula). For this purpose, four slopes, two with quarzoarenitic bedrock and two with calcareous bedrock have been sampled. Rates of soil erosion are being quantified by the fallout radionuclide ^{137}Cs. Soil carbon concentrations and characteristics are been determined by elemental analyses and thermogravimetry-differential scanning calorimetry.

For each of the lithologies, a forested hillside (beech forest) and a hillside covered with scrub (heather) and herbaceous vegetation was selected. In each hillside, samples were taken along a transept, from the top to the bottom of the slope (12- 30 sampling pointsper transept). At each sampling pointa bulk sample of thewhole soil profile was taken for^{137}Csanalyses and a surface soil sample (first 5cm) was taken for carbon analyses, adjacent to the bulk sample. In addition to this, ^{137}Cs reference samples (whole soil profile in flat location)were taking for each of the four lithology-land usecombinations.

In this Atlantic region, forests are the 'natural vegetation cover' or ‘undisturbed situation’, whereas the presence of scrub and grass is the result of human alteration of this natural vegetation cover, mainly due to the use of fire as a management tool for pasture maintenance. The results of the present study will allow us to determine 1) rates of soil erosion, 2) distribution of ^{137}Cs in the soil profile, 3) effect of fire on the soil organic carbon pool and, 4) if there isa redistribution of organic carbon in the hillsides associated with the processes of erosion induced by fire as an land management tool.

****

Biogeomorphological interactions in formerly glaciated terrain: the overlooked role of disturbance processes.

BÄTZ N., LANE S.
Institute of Geography and Sustainability - University of Lausanne, LAUSANNE, SWITZERLAND

Research over many decades has demonstrated that the revegetation process in formerly glaciated terrain is exceptionally slow (decades to centuries) not least because of the time it takes for the coupled evolution of the soil-vegetation system. Glacigenic materials, notably morainic materials, commonly have poor moisture retention and relatively slow weathering rates. This reduces fine material availability for pedogenesis, hence hampering the related vegetation succession. However, especially in Alpine glacial systems, such research has tended to overlook the role played by hydro-geomorphological processes, such as linked to alluvial fans, in locally modifying habitat conditions in ways that can substantially speed up the revegetation process. Alluvial fans can introduce substantial amounts of finer material, locally increasing moisture retention capacity and allowing pioneer vegetation colonisation, necessary to add organic matter to the soil system. A positive feedback starts, which improves local habitat conditions and increases local weathering rates. Nevertheless, powerful fan events can locally reset the system. Here we describe what we call a ‘high risk – high reward’ vegetation colonisation strategy in formerly glaciated terrain linked to interactions between disturbance processes and soil development. This strategy rapidly speeds up vegetation successional processes but also appears to feedback into the dynamics of alluvial fans, notably at fan heads. We present: (1) an extensive survey of these phenomenon for Alpine deglaciated terrain; and (2), based upon a case study fan in the Val d’Héréns, Switzerland, a conceptual model for the role of fan related disturbance processes in conditioning vegetation succession and its feedback onto the fan dynamics.

Chemical weathering rate in a steep mountain basin of Northern Japanese Alps: Estimation from in situ cosmogenic nuclides and geochemical mass balance model

HATTANJI T.(1), MATSUSHI Y.(2), KITAMURA Y.(1), OGUCHI C.T.(3), HACHINOHE S.(4), MATSUZAKI H.(5)
(1) University of Tsukuba, TSUKUBA, JAPAN ; (2) DPRI, Kyoto Univsersity, UJI, JAPAN ; (3) GRIS, Saitama University, SAITAMA, JAPAN ; (4) Center for Environmental Science in Saitama, KAZO, JAPAN ; (5) University of Tokyo, TOKYO, JAPAN

Chemical weathering rate in steep alpine environment has not been evaluated by using the recent approach of *in situ* cosmogenic nuclides and geochemical mass balance model. We have estimated chemical weathering rate at nine major sub-catchments of the Ashima River basin, located in Northern Japanese Alps, central Japan. Climate varies from humid temperate with mean annual temperature (MAT) of ~10°C and rainfall of ~1500 mm/y at the bottom of the basin, to cold environment with MAT of ~0°C at the 2300-m high divide. *In situ* ^{26}Al for river sediment in these sub-catchments showed that denudation rate ranges from 200 to 2000 mm/ky, which basically depends on mean slope of each catchment. We have measured chemical compositions of bedrock and sand (grain size of 0.25~2.0 mm) in stream sediment with X-ray fluorescence analysis, and calculated chemical depletion fraction (CDF)', which is defined as the ratio of chemical weathering rate to total denudation rate. Titanium was treated as an immobile element for calculation of CDF. The results showed that CDF ranges from 0.08 to 0.6 and chemical weathering rate ranges from 100 to 400 mm/ky. Some catchments located at the middle of the basin have high denudation rates (~1000 mm/ky) and relatively high chemical weathering rates (~400 mm/ky), which exceeded other reported rates in the previous studies for granitic mountains. In the upstream most catchments with very high denudation rates (~2000 mm/ky), the contribution of chemical weathering declines because physical denudation processes such as landslides predominate.

****

Interactions between floristic diversity and organisation and alluvial fan morphodynamics

BORGEAUD L.(1), LANE S.(2), VITTOZ P.(3)
(1) IGD, Université de Lausanne, LAUSANNE,, SWITZERLAND ; (2) IGD, Universit? de Lausanne, LAUSANNE, SWITZERLAND ; (3) DEE, Université de Lausanne, LAUSANNE, SWITZERLAND

Recent research has recognised that there is a critical co-evolution between geomorphic systems and ecosystems in which vegetation exerts a crucial role as an 'engineer' of geomorphic response, whilst the nature of that geomorphic response has profound impacts upon ecosystem dynamics. Here, we present results that combine a 70 year reconstruction of alluvial fan dynamics for an active fan system in the Vallon de Nant, Canton Vaud, Switzerland. The work is based upon a combination of: dendrogeomorphological records and aerial imagery analysis; and over 100 quadrats in which plants were identified and recorded to species level, and additional environmental parameters (e.g soil characteristics) were measured. Statistical ordination was used to identify the spatial structure of the plant communities. Fractal type approaches were used to identify the spatial scale dependence of emergent alpha- and beta-diversity. These two sets of data were then tied back into the geomorphologic history of fan development. The work showed that distinctive spatial and temporal patterns emerge in fan vegetation communities that can be related to both spatial and temporal properties of fan dynamics, and notably the accommodation space available to fan surface channels. The latter sets the magnitude and frequency characteristics of channel occupancy and causes a down fan shift in community organisation biodiversity from being discrete 'on-off' driven in the more constrained fan head to being more spatially continuous where accommodation space is greater.

Sustainability, vulnerability amd geodynamic hazard in geomorphologic systems of urban territories of the Russian Far East

MIASNIKOV Y.
Pacific Geographical Institute, VLADIVOSTOK, RUSSIAN FEDERATION

The issues of sustainability, vulnerability and geodynamic hazard in geomorphologic systems (GMS) of urban territories (UT) of the Russian Far East (RFE) were approached on morphostructural base. The conclusion was made that the combination of the studied parameters provides quite an efficient assessment system to the environmental and geomorphologic condition of the RFE UT. The GMS parameters of sustainability, vulnerability and geodynamic hazard are based on complex data of endo-dynamics, exo-dynamics and techno-dynamics. The following stages of the study should include research of the detailed composition, development and applied features of the GMS, including monitoring of hazardous endo-dynamic, exo-dynamic and techno-dynamic processes aimed to the efficient management of relevant risks.

****

Periglacial Slope Deposits and the CZ - on their genesis and influence on soil water content by a case study from the Bavarian Forest, Germany

HUBER J., VOELKEL J.
Technische Universitaet Muenchen, MUENCHEN, GERMANY

Periglacial slope deposits (PSD) are widespread in mid latitudes' Pleistocene non-glaciated areas. In the mid-mountainous regions of Germany like the Bavarian Forest these sediments appear as characteristic layered material on any slopes. Typically, the PSDs consist of three different layers: Upper, Middle and Lower Head. Their properties are governed by their genesis at different climates and according to periglacial morphodynamics. Additionally, bedrock lithology and source of strata are influencing factors. The PSDs are crucial part of the critical zone as the uppermost layer between surface and the lowest groundwater level and responsible for layer-characteristic soil water movements. The latter are hydrological processes, like interflow and storage, depending on the PSDs.

In this investigation (DFG funded, VO 585/15-1) selected profiles of the Otterbach catchment are analysed in consideration of the pedological and sedimentological properties. Stratigraphical features and numerical dating techniques (OSL) help to interpret landscape evolution and genesis of its critical zone. In addition, soil water measurements within the single PSDs show the influence of the layers on soil water movement and the importance of the periglacial slope deposits as part of the critical zone.

Estimation of Soil Formation Rate from Vegetation on Tertiary Rock Area in Japan

TODA M.(1), WATANABE T.(2), KOBAYASHI S.(3)
(1) Freelance, HACHIOJI, JAPAN ; (2) Freelance, FUKUSHIMA, JAPAN ; (3) JOHNSON TRADING COMPANY,LIMITED, SAGAMIHARA, JAPAN

In the Boso Peninsula of central Japan there are frequent slope failures in spite of the low relief hilly area. The geology of this area is Tertiary sandstone and mudstone. One of the proposed reasons of the failures is an unstable early formed soil layer. Therefore we were able to estimate the rate of the soil formation from the relation between soil thicknesses on the collapsed slope and the age of the trees on the slope.

The pioneer tree in the collapsed slope of this area is *Cleyera japonica* or *Eurya japonica*. Ages of the trees were measured with an increment borer and the soil thicknesses under the trees were obtained by a dynamic cone penetration test. As a result, the soil was thicker so that the age of tree was older. The relationship between the thickness of soil, D (cm), and age of tree, A (year), was $D=1.6A+47$.

From observation we assumed that there was no soil on collapsed slope just after failure. Then new soil formed through the weathering of the bedrock. The pioneer trees then grew after the formation of the soil layer. Due to the growth of the pioneer trees there was no evidence of the soil movement due to slope failure. Therefore, the above equation shows that the rate of soil formation is 1.6cm a year and the pioneer trees spread on collapsed slopes after soil formed a 47cm layer.

The rate of soil formation provided here is considerably bigger than other studies. This is due to relative high rate of the bedrock weathering. We also performed the weathering tests using rock samples from this area. The wet-dry test was for an index of the physical weathering and dissolution test was for chemical one. As a result, the rock of this area was weak for slaking and was dissolved earlier than limestone. As the geology is weak for both physical and chemical weathering the rate of soil formation of this area is fast.

****

Bedrock weathering and Biogeomorphic processes in the Ouachita National Forest, USA

TURKINGTON A.
University of Kentucky, LEXINGTON, UNITED STATES

The effects of vegetation on soils and geomorphic processes have long been recognized. Studies of these effects have traditionally emphasized biological and chemical effects on pedogenesis, and the relationship between vegetation cover and soil erosion. This study focuses on the direct and active geomorphic roles of biota (rather than indirect and passive). Tree growth, and uprooting, is an important influence on not only pedogenesis, but also bedrock weathering. This research seeks to examine how tree roots can directly weather the bedrock in this area, and how tree throw mines bedrock and delivers it to the surface.

The field site is the Ouachita Mountains in Arkansas, southern USA. The Ouachita's are parallel east-west trending ridges, with intermontane basins. Local relief is 75-530m. The climate is humid subtropical, mean annual precipitation is 1400mm. The sites are dominated by a mixed oak-pine cover, and the geologic setting is typically alternating layers of sandstone and shale, with lesser amounts of quartzite, novaculite and chert. Exposed shales are deeply weathered and highly erodible; sandstones are less altered and more durable.

This study demonstrates that trees directly weather bedrock and subsoil rock fragments, causing biochemical weathering of siliceous sandstone, which was previously understood to be resistant to chemical attack. Processes of root weathering include biochemical and biophysical processes, which dominate at the grain scale and the outcrop scale, respectively. Further, trees can mine large amounts of fresh bedrock to the surface, both sandstone and shale, driven by a number of uprooting mechanisms.

Redox front effect on the adsorption of cesium and strontium on pumice tuff

RAJIB M.
Saitama University, SAITAMA, JAPAN

The part of host rock of a waste repository could always be vulnerable to weathering slowly by contacting the surface/subsurface water and weathered zone or redox front can be formed. This long term weathering processes in the geosphere surrounding the repository might have significant effect on the adsorption of certain nuclides that could be released from the radioactive wastes. Since this phenomenon is quite frequent in subsurface, adsorption characteristics of two strategically very important nuclides from radioactive waste, cesium and strontium were investigated on fresh, unweathered rock and on weathered or oxidized part, collected from redox front zone of pumice tuff, which is already been selected for hosting low and intermediate radioactive wastes in Japan. Batch sorption study was carried out to explore the difference of adsorption mechanism at wide range of pH 4-12, varying nuclide concentration from 10^{-4} to 10^{-7} M and different ionic strength of 1.0, 3.0. Powder of 150-300 µm size and approximately 1 cm^3 blocks of pumice tuff were used as two phases of rock. Pore size distribution and specific surface area of the fresh and weathered pumice tuff were determined as supporting analysis. Mineralogical composition was done by XRD and optical microscopy; and elemental analysis by SEM-EDX. Solution chemistry was determined by ICP-MS and finally data were simulated with IgorPro 6.2. Since a slight weathering of a fresh mineral surface leads to the formation of available exchange sites and an increased sorption, higher distribution coefficient values were found in the weathered part than fresh pumice tuff. The distribution coefficient difference between block and powdered rock is expected to be caused by the effect of diffuse electric double layer, long equilibrium period and the physical property of fracture during experiment.

****

Retracing signals of historical soil erosion in peatbog archives as an indicator for landscape resilience in the context of future landuse changes and weather fluctuations (TUM-CZO, Ammer Mts.)

WINKELBAUER J., VOELKEL J.
Technische Universitaet Muenchen, MUENCHEN, GERMANY

As an example for recent research attempts within the Critical Zone Observatory of the Technical University of Munich (TUM-CZO), located in the Ammer Mountains of the Bavarian Alps, we present a project which deals with the investigation of possible soil loss triggers and dynamics in alpine landscapes. As soils represent the central part of the heterogeneous interaction system of the Critical Zone, they hold an essential relevance for a broad variety of up-to-date questions concerning the long-term sustainability of numerous natural resources and ecosystem services. Soil loss consequently causes serious, irreversible loss of vital soil functions and thus ecosystem services. Hence, determining risks of soil degradation and soil loss is a major task within the Critical Zone research.

The reconstruction and analysis of past erosion incidents is an essential key to understanding the driving factors of soil erosion or landscape resilience as reaction to external triggers (both natural and human). Peat bogs containing interlayered strata of mineral colluvial fillings are ideal archives for such reconstructions. Within the Ammer catchment, we investigate a total of twelve peat bogs distributed across an altitude gradient from alpine to subalpine and lowland landscapes. In addition to the extraction of conventional drilling cores, Ground Penetrating Radar is used as a non-invasive method of highlighting the internal stratification of the peat bogs. Various dating techniques can be applied to both organic and mineral layers (^{14}C, OSL, pollen analysis). Pollen analysis adds additional proxy data on vegetation and climate. The results then allow the correlation with well known, prominent climatical stages (e.g. Little Ice Age) and extreme weather incidents in the past as well as with historical records on land use. By this, valuable insight on characteristic regional landscape dynamics and thresholds is provided.

Simulating vegetation dynamics within Landscape Evolution Models: a simplification too far?

TRUEMAN A., WAINWRIGHT J., DENSMORE A., TURNBULL L.
Durham University, NEWCASTLE UPON TYNE, UNITED KINGDOM

The influence of ecology upon geomorphological processes has long been recognised (see Lyell, 1830; p. 113), however the complex feedbacks between the two have only recently began to be understood. Recent studies have illustrated the importance of riparian vegetation in: the reinforcement of the underlying soil matrix (e.g. Pollen-Bankhead & Simon, 2010); and the mediation of shear stresses related to overland flows (e.g. Liu *et al.,* 2010). Moreover, the influence of geomorphological processes in affecting landscape ecology has been made evident in the role of geomorphological processes in: controlling the spatial distribution of riparian plants through hydrochoric dispersal of seeds/propagules; altering abiotic conditions suitable for seed germination and plant growth; and controlling plant stress through varying the disturbance regime. Indeed, it is now believed that a widespread transition of channel morphologies during the Devonian Era can be attributed to the widespread colonisation by vascular plants (see Gibling & Davies, 2012).

Despite these advances in our understanding of ecogeomorphological feedbacks and their role on landscape evolution, modern Landscape Evolution Models (LEMs) still simulate vegetation change simplistically. Commonly, within LEMs, ecological components experience no spatial/temporal variability in root structure; seasonality; and/or function during simulation. Through these simplifications, an un-quantified level of uncertainty is associated with the conclusions made.

This poster presents an overview of our current understanding of ecogeomorphological interactions and the gulf between this and the current simplified level of sophistication of ecogeomorphological modelling within present-day LEMs. The poster will conclude with an outline of the work currently being undertaken by the presenter concerning the development and coupling of a spatio-temporally dynamic vegetation component within an existing LEM.

****

Four-dimensional reconstruction of gullying processes in a sandy badland of the Spanish Central System

STOFFEL M.(1), STOFFEL M.(2), BALLESTEROS CANOVAS J.A.(3), CORONA C.(1), LUCIA A.(4), MARTÍN-DUQUE J.F.(5), BODOQUE J.M.(6)

(1) University of Berne, Institute of Geological Sciences, BERNE, SWITZERLAND ; (2) University of Geneva, Institute for Environmental Sciences, CAROUGE-GENEVA, SWITZERLAND ; (3) Geological Survey of Spain (IGME), MADRID, SPAIN ; (4) Faculty of Science and Technology, Free University of Bolzano, BOLZANO, ITALY ; (5) Department of Geodynamics and Geosciences Institute (CSIC, UCM), Complutense University of Madrid, MADRID, SPAIN ; (6) Mining and Geological Engineering Department, University of Castilla-La Mancha, TOLEDO, SPAIN

Soil erosion is a key driver of land degradation in various environments worldwide and heavily affects sustainable land management. An appropriate quantification and localization of “hotspots” of soil erosion are therefore critical, as sediment loss has been demonstrated to have drastic consequences both on soil productivity and fertility.The evolution of gully retreat has repeatedly been addressed through short-term field monitoring of headcuts or the interpretation of diachronic aerial photographs, but has rarely been studied with dendrogeomorphology in the gully itself. The only existing study using growth-ring series from anatomical changes in exposed gully roots in southeast Spain estimated medium-term gully-head retreat rates to 6 m^3 yr^{-1} and gully sidewall erosion to 0.1 m^3 yr^{-1} per unit sidewall length.

Floating *Pinus pinaster* roots spanning incised gullies have also been observed in sandy badlands of the Spanish Central System’s piedmont, where averaged retreat rates of merely 0.53 m yr^{-1} have been observed through repeat surveying. The advantage of the roots at the study site in the Spanish Central System lies in the arrangement of roots with respect to the gully, since they not only allow determination of gully-head retreat and sidewall erosion, but also permit documentation and reconstruction of vertical incision and channel widening within the gully over time. The site is also characterized by abundant exposed roots in a ~100-m long gully segments, therefore allowing analysis of changes with time and the identification of extreme erosion events. Based on anatomical changes identified in almost 120 roots and TLS data, we documented, quantified and mapped, for the first time ever, changes within the gully with high spatial resolution, over the past 40 years and in four dimensions.

Biofilm Formation on Sediments is an Adaptive Feature for Vibrio cholerae: A Bio-Geo Interaction Phenomenon

GHOSH C.
Vidyasagar University, MEDINIPUR, INDIA

Vibrio cholerae, the gram negative bacterium is the causative agent of devastating diarrhoeal disorder cholera, considered to be one of the major public health concerns in the developing world. This human pathogen is an aquatic bacteria, can be isolated from freshwater, estuarine and marine environment. Besides its planktonic free living form in aquatic reservoirs, a section of *Vibrio cholerae* organisms remain associated with sediment structures in aquatic bodies. The basic mode of association with abiotic surfaces like sediments, have been established to be by formation of biofilm. Biofim, a three-dimensional surface structure of bacteria, is considered to be an adaptive advantage to the bacteria as it extends protection against several bactericidal effects and thus, enhances their expectancy for long survival in nature. Secretion of exopolysaccharide (EPS), a glucose or galactose-rich polysaccharide structure plays a key role in establishing the abiotic-surface attachment. Besides several environmental factors, a cell-cell communication mechanism known as quorum sensing has been identified to be a major regulator for biofilm formation and subsequent virulence expression. In a recent study parallel but convergent cellular signalling pathways have been identified in a epidemic clone of *Vibrio cholerae* driven by quorum sensing signalling molecules, autoinducers and flagellum (the structure governing motility in bacteria), respectively. Moreover, sodium motive force driven flagellar motor has been found to act as an essential regulator for EPS production. Based on involvement of extracellular signalling system including sodium motive force in EPS expression and suggestion of involvement of flagellum in encountering solid surface for establishing biofilm, we predict an interrelationship of physico-chemical prosperities of sediment structures with EPS biosynthesis. This, in turn, may influence bonding of sediments and influence their entrainment and erodibility.

****

Saline lakes degradation in the Pantanal wetland, central-western Brazil

FURQUIM S.A.C.(1), SAKAMOTO A.(2), BONOMO B.C.M.(1), SOBREIRA M.S.(1)
(1) Universidade Federal de São Paulo - UNIFESP, DIADEMA, BRAZIL ; (2) Universidade Federal de Mato Grosso do Sul - UFMS, TRÊS LAGOAS, BRAZIL

In the Nhecolândia, a sub-region of the Pantanal wetland, shallow saline lakes have been formed by evaporative concentration of subsurface freshwaters. These lakes are in the higher topographic position of the landscape. Consequently, they are not reached by the surface freshwaters that flood the Pantanal and are enclosed by dense savannah vegetation. However, many of these lakes have received flooding waters, mainly due to deforestation and erosion of their surroundings. Our study performed a detailed soil survey under and around a deforested saline lake in order to understand the effects of freshwater introduction in the lake environment. The sequence of horizons of the surveyed soil is: brown, sandy A; pale brown, sandy E; very dark gray, sandy loam and organic-rich B; gray, loamy sand Bkng; and green, sandy loam and impervious Bnxg. This soil morphology is similar to the preserved saline lake soils, as described in previous studies, with the exception of both the presence of the very dark gray B horizon, marked by organic matter illuviation, and the less extension of the Bkng and Bnxg in the deforest lake. Besides, whereas the deforest lake soil is neutral and strongly acid in the A and organic-rich B, respectively, and alkaline below, the preserved lake soils are entirely alkaline, being submitted to solonization processes. These differences suggest the dominance of solodization over solonization in the deforested lake soil, indicating the degradation of the typical soils of the preserved lakes. The acid organic-rich horizon is likely responsible for the destruction of the alkaline Bkng and Bnxg, mainly by clay hydrolysis and oxidation. The green and impervious Bnxg horizon has an important role in the Nhecolândia salinity origin because it allows the seasonal isolation of waters and, consequently, very high rates of evapotranspiration in the lake depression. Thus, the destruction of this horizon may lead to the complete degradation of the saline lakes.

Time and Again: Fire, Tree Root Decay and Slope Stability

MARTIN Y., JOHNSON E., KROEKER S.
University of Calgary, CALGARY, CANADA

Mechanical reinforcement of shear strength in shallow soils by tree root networks has been documented for steep slopes (Schmidt et al., 2001; Roering et al., 2003). Tree death by recurring crown wildfires results in the decline of root reinforcement in shallow soils and may affect occurrence of debris slides and debris flows (e.g., Benda and Dunne, 1997; Martin, 2007; Jackson and Roering, 2009). Despite recognition of tree root decay following wildfire, to our knowledge no annual continuous measurements have been made in a post-wildfire setting to document tree root decay over time. Suggestions have been made that root decay following timber harvesting may provide a reasonable analogue, although this idea remains largely conjecture. Herein, we present our annual field measurements of post-wildfire tree root strength made over the past 9 years at a post-wildfire site in the Canadian Rockies. In these subalpine forests, fire return intervals are shorter than the potential lifespan of trees, making wildfire critical to tree population dynamics. The recurring nature of wildfire leads to a recurring decline in tree root decay in immediate post-fire years and an increased likelihood for mass wasting. Our field measurements of tree root strength were undertaken in the burned subalpine forest of Hawk Creek, British Columbia, Canada. In July 2003, two large crown fires were ignited by lightning in Kootenay National Park and merged to burn 17 000 ha. Annual measurements of post-wildfire tree root strength have been made from 2004 until the present. Each year, tree root measurements, including vertical root depth, root diameter and tensile force at breakage, were made in 15 soil pits located within five slope gradient classes. Results show that that when measured in the same year, tree roots of larger diameter require a greater tensile force for breakage. Most importantly, the gradual decay in tree root strength over time has been meticulously documented and quantified.

****

Volcanic hazard assessment in the bromo volcano aera, East Java (Indonesia)

BACHRI S.(1), STÖTTER J.(1), SARTOHADI J.(2)
(1) Institute of Geography, University of Innsbruck, INNSBRUCK, AUSTRIA ; (2) Department of Geography and Environmental Science, Faculty of Geography, Gadjah Mada University, YOGYAKARTA, INDONESIA

The Bromo eruption in 2010 had modified human environment in the area surrounding. The villages around the crater of Bromo experienced severe impact of erupted materials. Large agriculture areas were covered by ash for a long period, thus decreasing its productivity significantly. Despite suffering from this devastating impact of the volcano, the people in the Bromo region decided to live and adapt to the recurring phenomenon. Identification and assessment of hazard areas due to volcanic eruptions is a necessary pre- requisite to design suitable adaptation strategies in the region.

This paper aims at identifying areas vulnerable to volcanic eruptions in Bromo. The combination of GIS techniques and geomorphological field survey was applied to assess the vulnerability of study area. Factors such as landform, source of hazard and population density were considered for the identification of hazard processes. This objective is addressed in two steps: 1) by deriving a 3D map from contour lines using the implementation of FOSS SAGA-GIS software, and 2) by exploring the considering factors in the field in order to understand the vulnerability patterns.

The results show that the volcanic ravine bottom is the most densely inhabited area. This area is characterized by intensive mass movements of the volcanic deposits, especially during the rainy season. Furthermore, the areas with an elevation over 2000 msl are relatively safe from volcanic ash due to the protection of the caldera wall. The morphology of Bromo Volcano plays important role in controlling some processes of volcanic materials redistribution. About 40% of the study is categorized as volcanic prone area, whereas the rest is vulnerable to other volcanic redistribution processes.

Keywords: Volcanic hazard, landform, Geographic Information System, Bromo Volcano Indonesia

Urmia Lakes, affected with the water level vacillations and critical increase the salt deserts, expectant of aid for again birth

AGHAJANY K.(1), ROOSTAEI S.(2), POURASGHAR F.(3), REZAEI MOGHADAM M.H.(4)
(1) - Ph.D.Student of Physical Geography(Geomorphology), Tabriz Univversity, TABRIZ, IRAN ; (2) Prof, Department of physical Geography,Tabriz Univ., TABRIZ, IRAN ; (3) East Azarbaijan general Bureau and Applied Meterological research center., TABRIZ, IRAN ; (4) Prof,Department of physical Geography,Tabriz Univ., TABRIZ, IRAN

Urmia Lakes lies northwest of Iran and between the estern and the western azarbaijan province and the largest internal lake and to take into account the second salt water lake of world. Urmia Lakes indebted its formation to ancient faults revenue. Tectonic agent cause former formation lakes with gradual revenue in location of lake border mountains. This basin is one of value centers of agriculture and animal activities in Iran. National park of Urmia Lakes is the most value natural enviroment of animales after Anzaly lagoons in Iran.

This province has semi–arid climate and its mean rainfall state is about 250 mm annually. Continuous and lengthy droughts in last years decreased the water level of Urmia Lake and cause saltiness of around agricultural land wells that treated for agricultural activities and natural enviroment of emigrant birds.

In this research have been distinguished by using satellite images(ETM^+), GIS and coastal geomorphology that Urmia lake has retreated in south of lake until 10 km to be extent that remains from 5700 km^2 area of lake only 2700km^2.

The synoptic patterns show that most of the wind direction in the study region is south and south west so wind will carry out salts to the adjacent regions from the dried surface of lake. Urmia Lake drought causes the agricultural, social and health problems in the region.

Keywords: Urmia Lakes; salt deserts;retreated; synoptic patterns

****

Morphological, micromorphological and analytical properties in a toposequence with haplic cambisols in the Nova Lima group - Quadrilatero Ferrifero, minas gerais state, Brazil

COSTA F.(1), BACELLAR L.D.A.P.(1), CASTRO S.S.(2), RESENDE F.R.M.(1), SILVA S.F.(1)
(1) Federal University of Ouro Preto, OURO PRETO, BRAZIL ; (2) Federal University of Goias, GOIANIA, BRAZIL

The Quadrilatero Ferrífero is a region of archaean and proterozoic rocks located in the Minas Gerais State, Southeastern Brazil. There are many geological studies about this region which is rich in mineral resources, such as gold and iron, but the pedological information is still scarce because of its high relief, with steep slopes and poorly developed soils. It is important to understand the distribution and evolution of these soils, with the pedological systems evaluated as a continuum, to identify the effect of geological and geomorphological phenomena related to the regression of erosive scarps and pedogenesis. This work aims to contribute to the understanding of the evolutionary dynamics of a typical pedological system of this region that consists of Haplic Cambisols developed on schists of Nova Lima Group (Rio das Velhas Supergroup). Soil borings were conducted along a 32 % slope for description and sampling along a toposequence, whose results confirmed that this is a system composed of 3 Cambisols in different evolutionary stages, represented by 5 soil profiles Soil (P1, P2, P3, P4, P5) located from medium slope to low slope.Cambisols are deep, 8 and 2.5 meters thick in the medium and lower slope, respectively, and contain a stone line (consisting of quartz and schist fragments and ferricrete from the escarpment top) behind a Bi horizon developed on colluvium. Analytical and micromorphological data showed a vertical transformation system (without lateral matter transfer) for Bi horizons below the stone line and C horizon.A younger Bi horizon developed on the colluvium over the stone line. The first three profiles (P1 to P3) are similar to each other, indicating that they developed simultaneously and are in a more advanced pedogenetic stage when compared to low profile (P4 and P5); P5 profile is the least developed. This typical slope evolved at least in two major morphopedogenetic erosive stages and the upper one is younger.

Relationship between soil, relief and the distribution of gullies in Northwestern Parana - Brazil

CORDEIRO SANTOS L., GONÇALVES MANGUEIRA C., VITOR DO COUTO E.
Universidade Federal do Parana, CURITIBA, FRANCE

The northwestern regionof Paraná, in Southern Brazil, is distinguished by presenting accelerated processes of gullies since the 1950s. The significant presence of areas under the influence of gullies in this region, long since, has aroused the interest and mobilized professionals from different fields and was the main reason for their choice in the study. The aim of this research was to map the gullies found in this area and identify the physical conditions - soils and relief - that influence such gullies. The study area, locatedin sedimentary rocks in the Upper Cretaceous,covers a total length of 22,057 km², which corresponds to approximately 11% of the total territory of Parana. Itrelief is uniform and mild, stepped plateaus, sloping slightly toward the river Paraná valley. For this work, we used 52 images from SPOT and Landsat ETM +7 dated between 2006 and 2008, remote sensing SRTM and soil map. The data were processed in GIS and images from Google Earth ® also were used for helping the identification. To analyze the concentration of gullies, we use the index proposed by SALOMÃO (1994), correlating soils and characteristic relief to the number of features mapped (ICE - Index of Concentration of Total Erosion). Its calculation is given by the ratio between the total number of erosive occurrences and area, multiplied by 100. We have therefore the number of occurrences per 100km ². Have been mapped andclassified 918 gullies, with 63% located on Ultisol and 36% on Oxisol. The spatial features distribution found allowed us to establish a significant differentiation between the soils, noting higher concentrations of gullies on Ultisols (ICE = 3.77), followed by Oxisols (ICE = 1.99). The association betweenrelief and soils, as well as its relation to the conditions of water circulation is fundamental for understanding the dynamics of the modern gullies at the area.

****

Ornithogenic soil toposequence on Rata Island, Fernando de Noronha Archipelago, South Atlantic and quaternary paleoclimatic implications

OLIVEIRA F.(1), SCHAEFER C.(2), ABRAHÃO W.(2), CLEMENTE E.(3), SIMAS F.(2)
(1) Universidade Federal de Minas Gerais, BELO HORIZONTE, BRAZIL ; (2) Universidade Federal de Viçosa, VIÇOSA, BRAZIL ; (3) Embrapa Solos, RIO DE JANEIRO, BRAZIL

The formation of highly phosphatized soils on sites of avian activity is a common feature of oceanic islands. We characterized a toposequence of phosphatic soils on Rata Island, to evaluate the soil genesis based on local topographic variations. For this purpose, four soils ranging from the upper hill down to the lowest landscape position on the island, representing a range of parent materials (basalt and calcareous sands), were analyzed. In the lowest landscape position a shallow Entisol was identified, strongly influenced by birds and marine sprays (Litholic Neosol), developed on " karstified" Pleistocene calcarenites; the three other soils in the upper part of the toposequence are Ornithogenic Inceptsols (Cambisols), ranging from a deep Cambisol profile on Basalt lava to intermediate Cambisols on mixed colluvial sediments of the basalt/calcareous. The lowermost Litholic Neosol is associated with a rugged landscape with strong calcarenite dissolution and karstification, related to a former wetter climate. The soil phosphatization is clearly an inherited process of the Late Quaternary age, when climate conditions were different. Initial weathering took place in the last interglacial period, under wetter conditions during which the Tertiary basalts were strongly weathered, leaving corestones in a saprolitic, oxidized mass. In the late Pleistocene, a gentle surface distributed these weathering products along the pediment slopes as colluvial materials, whereas in the coastal areas aeolian processes formed large sand dunes composed of reworked calcareous sands from marine sources during a time of very low sea level. During this time, widespread bird activity accounted for secondary apatite formation on the surface of calcareous oolites. Finally, the Holocene warming was accompanied by increasing sea level, enhanced tropical weathering, Fe and Al mobility and variscite formation superimposed on degraded Ca-phosphates, forming two phase phosphatic aggregates.

Paraglacial adjustment and vegetation succession in the forefield of an actively retreating glacier - a biogeomorphological perspective

EICHEL J.(1), SCHMIDTLEIN S.(2), DIKAU R.(1)
(1) Institute of Geography, University of Bonn, BONN, GERMANY ; (2) Department of Geography and Geoecology, Karlsruhe Institute of Technology, KARLSRUHE, GERMANY

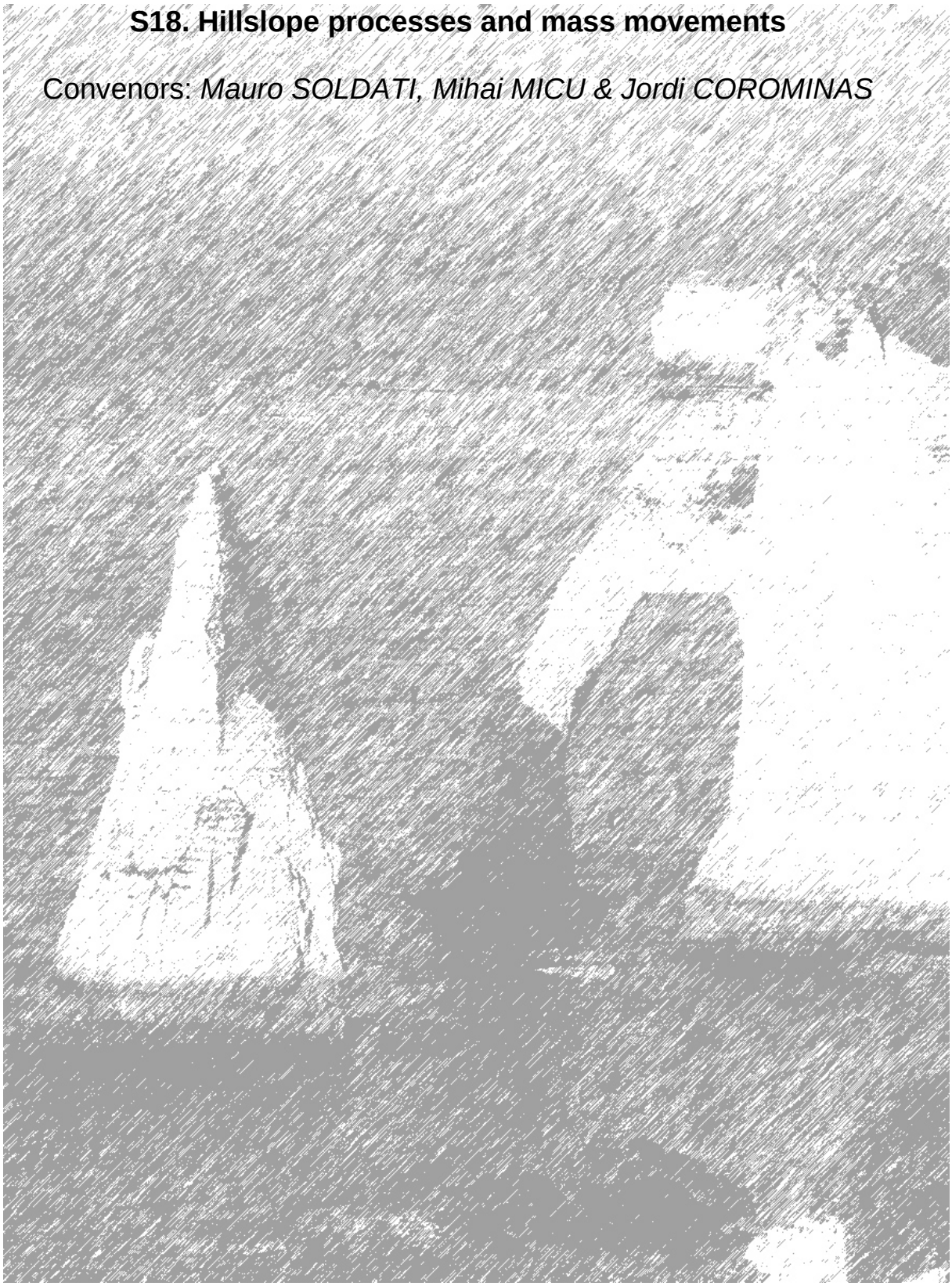
Within the last years, scientific interest in glacier forefields increased in both geomorphology and ecology as these environments are changing at an accelerated pace due to climate change. Geomorphological research focusses on the paraglacial adjustment of the forefield with accelerated geomorphic activity and increasing sediment yields triggered by the retreating glaciers. Ecological research explores vegetation and microbial succession processes in the glacier forefield and their potential future changes. In previous studies, it has been shown that on the one hand, geomorphic processes possess a strong impact on ecological processes while on the other hand, vegetation influences geomorphic processes, e.g. by stabilizing sediment. These feedbacks between the geomorphic changes since the Little Ice Age and the simultaneous vegetation succession are our research interest, which falls into the strongly evolving discipline of biogeomorphology.

The key aims of our study are (a) to assess the paraglacial impact on vegetation succession in our study area, (b) to identify relationships and feedbacks between geomorphic activity and vegetation patterns, and (c) to explain detected relationships and feedbacks using recently developed biogeomorphic concepts. In the forefield of the Turtmann glacier (Turtmann valley, Valais, Switzerland), we used a biogeomorphic approach including methods from vegetation ecology and geomorphology. Our results showed a paraglacial impact on vegetation succession which could be differentiated according to degree of geomorphic activity and attributed to specific species compositions. This sequence of corresponding geomorphic and vegetation change was mostly found on the lateral moraines and interpreted as biogeomorphic succession. We believe it is driven by biogeomorphic interactions at smallest scale. These are mediated by geomorphic-engineer species such as dwarf shurbs and controlled by the ratio between geomorphic disturbance and the relaxation time of the vegetation according to the biogeomorphic transient form ratio. The interactions at small scales result in a co-dependent paraglacial adjustment and vegetation succession at large scale and can thus explain the detected corresponding patterns.

****

S18. Hillslope processes and mass movements

Convenors: *Mauro SOLDATI, Mihai MICU & Jordi COROMINAS*



Oral presentations:

Rainfall control of debris-flow behavior: motion and deposition at Mount Yakedake, Japan

SUWA H.
Center for Spatial Information Science, University of Tokyo, KYOTO, JAPAN

Processes of debris flows have been monitored at a slope of Mount Yakedake, a volcano in Japan since 1970. Number of surge is counted as more than 200 episodes from 91 events. The studies from the data supplied a general concept of debris flows and their geomorphic effects on volcanic slopes as follows. Debris flows are triggered by a large intensity of rainfall in a short duration as long as 10 minute. Threshold of rainfall intensity for debris flows increases with time after the end of volcanic eruption, while it drastically decreases with the eruption. Three types of debris flows were found: Large flows with boulder dam without openwork structure (Type I), small flows with boulder dam with openwork structure (Type II), and small flows with boulder dam without openwork structure (Type III). Rainfall conditions were found to have controlled the difference between these types through water availability to debris flows at the source and the growth reaches of debris flows. Mass and boulder focusing to the flow front are marked, and due to the focusing the flow radiates elastic waves whose energy is from the potential energy of the flow. The energy conversion efficiency from the potential energy to elastic-wave energy is a magnitude of 10^{-3} much smaller than the efficiency for earthquake at 10^{-1} from the strain energy to the elastic-wave energy. Debris flows terminate in the fan leaving two types of debris-flow lobes: swollen lobes and flat lobes. The flat lobes is attributed to the Types I and III, while the swollen lobe to the Type II. It would be important to understand this concept for volcanic debris flows from its initiation to termination for the mitigation of debris-flow hazards.

****

Developing of a standard methodology to characterize and modeling debris flows

BOCCALI C., CALLIGARIS C., LAPASIN R., ZINI L.
Universita' degli Studi di Trieste, TRIESTE, ITALY

Debris flows affect frequently the mountain regions and, because of their speed and destructive force, threaten roads, buildings and human lives. The reconstruction of debris flows paths has long been studied and several simulation models have been implemented, but a believable scenario can be obtained only by resorting to real parameters, suitable to characterize the involved material.

The research presented in the paper is aimed at individuating a standard methodology that from field survey, through different laboratory analysis, comes to the assignment of numerical values to the basic parameters of the debris flow simulations (yield stress and viscosity). After obtaining these values, simulations were performed to validate the methodology. To this purpose a basin sited in the Northeast Italy has been studied and sampled. The chosen test site is located in the Val Canale valley already involved, since 2003, in at least three alluvial events.

The present project started with a sampling phase. In order to ensure the representativeness of the sample, it is important to identify significant collection points, in the source, transport and depositional areas, and to collect a huge quantity of heterogeneous material.

In the laboratory samples were subjected to grain-size, mineralogical and rheological analysis. Suspensions of the fine fractions were prepared at equal solids concentration and studied using a controlled stress rheometer. Different experimental methods were proved to individuate an appropriate methodology suitable to characterize the plastic behavior of the fine particle suspensions derived from the different sampling points.

With the range of values obtained, numerical simulations, using FLO-2D software, were performed in order to verify the consistency of the parameters and their representativeness even if a back analysis is not available.

Debris Flow Process Reconstruction Based on UAV Remote Sensing Imagery of Disastrous Scenario

LIN J.
Institute of Mountain Hazards and Environment, Chinese Academy of Sciences, CHENGDU, CHINA

Debris flow is a moving mass of loose mud, sand, soil, rock, and water that travels down a slope under the influence of gravity. Two main characteristics of debris flow are high velocity and presence of wave front. The Newtonian fluid approach is no more valid as the flowing debris is a non-homogenous and non-Newtonian fluid. The rheological properties and bed friction of the debris are different. Therefore, the debris flow process is significant for researchers to find out its special mechanisms. The process reconstruction of debris flow is generally on the basis of qualitative principles and quantitative data obtained from field observations. It is also the prerequisite for exact numerical modeling and simulation of debris flow and prediction of its occurrence. However, due to the factors of safety, timeliness, and cost, the data acquired from field observations is limited in spatial coverage and accuracy.

With the advantages of low cost, flexible launch and landing, safety, under-cloud-flying, hyperspatial image resolution, Unmanned Aerial Vehicles (UAVs) are more suitable for obtaining remote sensing imagery of debris flow events in the mountainous areas. However, it is a very challenging task to reconstruct the debris flow process with raw imagery of disastrous scenario.

First of all, three-dimensional terrain of disastrous scenario can be reconstructed with UAV imagery.

Secondly, some kinetic parameters and damage information can be directly or indirectly interpreted from UAV imagery.

Thirdly, those values of key parameters acquired from UAV imagery can be integrated into the finite element model to reoccur the process of debris flow, including the stages of launching, transporting, and depositing.

****

The debris slide in the Móafellshyrna Mountain on the 20th of September 2012. Was it triggered by intense precipiation and earthquake activity or simply by melting of the permafrost?

SAEMUNDSSON T.(1), HELGASON J.(2), PETURSSON H.(3)
(1) Natural Research Centre of North-western Iceland, SAUDARKROKUR, ICELAND ; (2) Met Office - Avalanche Center, Sudurgata 12, ISAFJORDUR, ICELAND ; (3) Icelandic Institute of Natural History, Borgum við Nordurslod, AKUREYRI, ICELAND

A large debris slide fell from the Móafellshyrna Mountain in the Fljót area in Central North Iceland on the 20thof September 2012. The slide occurred after a month of intense precipitation followed by an earthquake cycle in N-Iceland. About 440 mm of precipitation fell in the area from the 20thof August to the 20thof September, where the annual precipitation is around 670 mm.

The slide originated in a 200 m wide cirque at 750 m height in the NW slope of the mountain where a frozen solid debris cone slid / crept off a 100 m high rock face into a steep talus slope. Frozen blocks of sediments fell on the water saturated talus slope and triggered another debris slide. It is estimated that around 300.000 to 350.000 m^{3}of debris were removed from the talus slope.

An earthquake cycle started in N-Iceland on the morning of the 19thwith two earthquakes M4 and M4.3 followed by number of smaller ones. Around 9:00 am on the 20thof September another earthquake M4.2 occurred. The debris flow activity started around 12:30 pm in northern part of the cirque, where frozen blocks of sediments begun to fall down the rock face. The debris flow activity continued with increased activity for at least 1^1/$_2$hour, as large blocks of frozen sediments fell onto the talus slope below the southern part of the cirque.

The frozen sediments at 750 m height give clear indication of mountain permafrost in loose sediments at this altitude in the northern part of the Tröllaskagi peninsula. These observations are in good agreement with former calculations.

The cause of this debris flow activity is primary believed to be the intense precipitation followed by the earthquake activity. Melting of the permafrost can also have played a significant role as a triggering factor. The 30 year average temperature (1980-2010) is the highest for almost a century and the summer of 2012 was extremely dry and warm. The summer was also the sunniest in the past 80 years, with the record amount of sunshine hours.

When Debris Flows Run Upslope: Tsunami Induced Debris Flows

WASSMER P.(1), W.M. ISKANDARSYAH T.Y.(2), GOMEZ C.(3), LAVIGNE F.(1), HART D.(3), PRATOMO I.(4), BEL J.(5)

(1) Laboratoire de Géographie Physique, UMR 8591, MEUDON, FRANCE ; (2) Universitas Padjadjaran, Fakulats Teknik Geologi, BANDUNG, INDONESIA ; (3) University of Canterbury, College of Science, Department of Geography, CHRISTCHURCH, NEW ZEALAND ; (4) Museum Geologi, Pusat Survei Geologi, BANDUNG, INDONESIA ; (5) Université de Strasbourg, Faculté de Géographie et d'Aménagement, STRASBOURG, FRANCE

Debris flows are usually considered to be forced by gravity and triggered by the combination of intense rainfall on mountain slopes characterised by readily mobilised clastic materials. Slope steepness increases the energy of the water. Strong erosion ensues, feeding the flow with clastic materials of various sizes, in turn increasing the flow density. Rheology ranges from hyper-concentrated to debris flow. In coastal areas, when a tsunami rushes inland the movement of the flow is not forced by gravity but by energy transferred to the water column when it is suddenly displaced, for example, by an earthquake, submarine eruption or landslide, volcano flank collapse, or meteoritic impact. When a tsunami moves landward, its progression and duration are controlled by several factors including topography, wave velocity, wave height, and position of the wave in the wave-train. The flow behaves in the same way as water flowing downslope. The turbulent front is progressively fed from coastal sediment eroded from beaches, sand dunes, and soils. The fluid takes onboard a huge amount of additional debris (e.g. rocks, concrete, wood, vegetation, vehicles), increasing its density. Depending on the depth of the flood, the importance of the run-up (which is a function of coastal morphology), and on the amount of mobilized material, tsunami waves can start to behave like ‘debris flow’. Observations of tsunami deposits in Indonesia, Morocco and the Canary Islands evidence deposits of large clastic rocks mixed with coarse bioclasts in an unsorted matrix that could be interpreted as a debris flow deposit. Frame analysis of numerous urban video records of tsunami, from helicopters in Japan (Sendai 2011) and from building level in Indonesia (Banda Aceh 2004), support the idea that the global behaviour of the flow front resembles that of a gravity-driven debris flow.

****

Scale Amplification of Natural Debris-Flows Caused by Cascading Landslide Dam Failures

ZHOU G.

Institute of Mountain Hazards and Environment, Chinese Academy of Sciences , CHENGDU, CHINA

Debris-flows are typically caused by natural terrain landslides triggered by intense rainfalls. If an incoming mountain torrent collapses a series of landslide dams, large debris-flows can form in a very short period. Moreover, the torrent can amplify the scale of the debris-flow in the flow direction. The catastrophic debris-flows that occurred in Zhouqu, China on August 8, 2010, were caused by intense rainfall and the upstream cascading failure of landslide dams along the gullies. In the wake of the incident, a field study was conducted to better understand the process of cascading landslide dam failures and the formation of debris-flows. This paper looks at the geomorphic properties of the debris-flow gullies, estimates the peak flow discharges at different locations using three different methods, and analyzes the key cascading landslide dam failure modes and their effect on the scale amplification of debris-flows. The results show that 5 key modes (i.e. different landslide dam types) in Luojiayu Gully and 2 modes in Sanyanyu Gully accounted for the scale amplification of downstream debris-flows in the Zhouqu event. This study illustrates how the hazardous process of natural debris-flows can begin several kilometers upstream, as a complex cascade of geomorphic events (failure of landslide dams and erosion of the sloping bed) can cause to, can scale to become catastrophic discharges. Neglecting recognition of these hazardous geomorphic and hydrodynamic processes may result in high cost.

Study on Surge Triggered by Debris flow Plunging into Reservoir

MIZUNO H.
University of Tsukuba, TSUKUBA, IBARAKI, JAPAN

Typhoon Ma-on brought a large amount of precipitation to Muroto Peninsula in Kochi Prefecture, Japan, on July 19, 2011, and caused a severe deep-seated landslide on the mountain slope on the right bank of Hiranabe-tanigawa, a side stream of the Nahari River. The material of landslide formed a debris flow and plunged into the reservoir of Hiranabe Dam, whose gates were opened in order to discharge. The debris flow generated waves, and the waves traveled not only downstream but also upstream, destroying the machines for opening gates of the Hiranabe Dam in the downstream and a suspension footbridge in the upstream. Records from the rain gauge station at Yanase indicate that the rain series began at 16:00 on July 17 and that 1035 mm of rainfall had accumulated by the time the washout occurred. At that time, the flow rate of the Nahari River was at the maximum, or in other words, had already begun to flood. Although changes in water level rarely propagate upstream, such changes induced by debris flows entering the mainstream can be propagated at the other side of the river, downstream, and upstream. Therefore, in this research, hydrologic conditions at the time the debris flow entered the Nahari River are estimated, and the effect of debris flows momentum influx on the propagation of the increased water level to the upstream area is clarified.

By analyzing the recorded data and hydraulic conditions, the estimated value of Froude number was in the rage of 0.5 to 2.3. It was found that the wave traveled upstream uneasily. Next the process of changing water surface after the plunge of debris flows into the reservoir was analyzed by solving the two dimensional shallow water equations. It was found that the water surface at the suspension footbridge was raised to the bottom of the footbridge. It was found that the wave likely occurred and propagated toward the upstream part of the Nahari River because the momentum of the debris flow was added to the river's normal flow.

****

Development of a geomorphological model for field instrumentation design, Tai O, Hong Kong

NG K.Y., MILLIS S.W.
Ove Arup & Partners (Hong Kong) Limited, HONG KONG, HONG KONG

Geomorphology has been increasingly recognised as an essential component for natural terrain hazard assessment in Hong Kong. Whilst most studies have ultilised geomorphological models to estimate the design volumes of potential landslide hazards for the mitigation measures, there are very few applied geomorphological studies for the design of field instrumentation works to monitor landslide movements. The aim of this study is to develop a geomorphological model to define the scope of instrumentation works for landslide monitoring with due regard to the morphological setting, slope/fluvial processes and geological materials.

The study area is located on a natural hillside overlooking Tai O on Lantau Island. The geomorphological model was developed by a comprehensive review of aerial photos available from Year 1963, geological publications, past instability records and further refined by detailed field mapping and intrusive ground investigation to reveal the depth and thickness of geological strata and processes.

The findings suggest that the hillside comprises areas of intermittent rock outcrops, talluvium, colluvium, as well as volcanic tuff and meta-siltstone/sandstone with various degrees of weathering. The key landslide mechanisms at the site appear to be associated with headward erosion of drainage channels, retrogressive mass movements and historical deep-seated movements associated with lithological control of weathering between the more resistant tuff and the weaker sedimentary strata.

The geomorphological assessment has identified areas of potential surface and sub-surface ground movements within a large landslide complex that facilitated the selection and design of the spatial arrangements of instrumentation systems to further confirm the landslide mechanisms at the site and investigate the rate of ground movements and their relationship with hydrogeological conditions.

Quantification of mass movement and sediment flux at the decadal scale for Alpine mountain basins: the critical role of sediment connectivity

MICHELETTI N., LANE S.N.
University of Lausanne, LAUSANNE, SWITZERLAND

Our understanding of mass movement and sediment flux is well established at both the event scale through direct measurement and over longer timescales through erosion measurement techniques (such as those based upon cosmogenic methods). However, there remains a significant dearth of information at the timescale of decades to centuries, despite this being the timescale over which significant hypotheses are raised over human impacts upon climate change and hence geomorphic systems. Extensive coverage of mountain environments by aerial imagery commonly begins in the 1940s, before the period of most rapid climate warming linked to human activity. Here we show how information contained in such imagery can be unlocked using archival digital photogrammetry to reconstruct quantitative histories of mass movement and sediment flux in high mountain Alpine systems, over the timescales of decades, through the quantitative comparison of successive digital elevation models, including the propagation of error to identify locations and volumes of significant erosion and deposition. We then combine this with classical geomorphological mapping to quantify the distribution of these erosion and deposition rates between different elements of the sediment flux system. We show that whilst particular elements of the sediment flux system prove to have been much more sensitive to climatic warming than others, their net impact is driven by their spatial organization and crucially, through connection between system elements. The presence of warming-driven sediment signals in the short-term dynamics of river basin systems is then highly location specific, as shaped by sediment connectivity.

****

Bayesian modeling of rainfall-triggered landslides using weather forecasting systems

SANDRIC I.(1), CHITU Z.(2)
(1) University of Bucharest, Faculty of Geography; Esri Romania, BUCHAREST, ROMANIA ; (2) National Institute of Hydrology and Water Management; Spiru Haret University, Faculty of Geography, BUCHAREST, ROMANIA

This study is focused on modeling the rainfall-triggered landslides using a rainfall forecast with the WRF model. The main objective is to forecast the daily changes in landslides probability occurrence in Curvature Subcarpathians, Romania. The WRF (http://www.wrf-model.org) model is used to generate daily estimate of rainfall data and the Bayesian modeling is used to predict the landslides probability. The weather forecasting model is downscaled and estimates of soil moisture content are performed on a daily basis. The uncertainties from the weather forecasting model as analyzed in a Bayesian sensitivity model. Because mapping landslides is always associated with uncertainties in spatial delineation of landslides bodies uncertainties analyses are performed on the predisposing factors derived from digital elevation models have also uncertainties, coming either from the interpolation algorithms either from GIS data. All these uncertainties have been modeled using Monte Carlo simulations and for each simulation a new landslides probability map has been created. For all simulations the minimum, maximum, mean, median and standard deviation have been extracted, saved and analyzed. Thus, for each pixel and estimation of uncertainty for landslides susceptibility as assessment is obtained and spatially visualized

Relations between landslide activity and fluvial erosion: slope-channel coupling recorded in tree rings and relief (Western Carpathians and Eastern Sudetes, Czech Republic)

WISTUBA M., MALIK I.
University of Silesia, KATOWICE, POLAND

We have analysed slope-channel interactions in selected 3 stream valleys in Western Carpathians and Eastern Sudetes. With the use of dendrochronological tools we have dated occurrence of fluvial erosion in stream channels – basing on wood anatomy of roots exposed in eroded banks. We have also dated the occurrence of landsliding on slopes directly above studied channels – using eccentricity of tree-rings developed in spruce stems tilted and bent by ground movements. In order to recognize cause-effect relations between landsliding and fluvial erosion we have compared their temporal variability in the last decades with precipitation record (monthly totals and extreme daily totals). Comparison have shown that in analysed valleys these three phenomena appear asynchronously – they alternate. We have determined two types of cause-effect sequences (3-8 years long) of landslide-bank erosion coupling: (1) rainfall-landsliding-erosion – precipitation causes landslide activation, colluvia are delivered into the valley floor, then narrowed valley floor is a subject of intensified erosion (2) rainfall-erosion-landsliding – precipitation causes erosion in the valley floor, then erosion disturbs the equilibrium of a slope, which causes landsliding. Obtained dendrochronological datings also show that these processes can be a subject of a feedback: once the coupling have started it can continue without appearance of heavy rainfalls. We have analysed signs of coupling visible in the relief of studied valleys. Observations indicate that described slope-channel coupling, recorded in tree-rings, in longer periods can lead to gradual widening of valley floors (due to bank erosion and removing delivered landslide colluvia) and can lead to relief evolution from V-shaped into flat-bottomed valleys. Conducted studies prove the presence of landslide-erosion coupling in studied valleys and suggest its importance for general evolution of studied mountain areas.

****

Landslide hydrology: modelling the dynamic interactions between slope deformation, preferential flow and hydrology

BOGAARD T.
Delft University of Technology, faculty of Geosciences and Civil Engineering, Department of water management, DELFT, NETHERLANDS

Hydrology has long been recognized as a crucial factor in the (re-)activation of landslides. It is well-known that fissures as well as other preferential flowpaths are very important for groundwater recharge within a landslide. However, this heterogeneous recharge results in local pore pressure increase whereas many model approaches in landslide hazard analysis assume a more homogeneously distributed recharge and thus pore pressure increase. Moreover, the specific dynamics within a landslide induces changes in fissure distribution due to differential movement. Feedback exists between changes in fissure properties, the hydrological behaviour and differential movement. So far, shifts and hysteresis in landslide activity have not been linked to these feedback mechanisms. This research aims to investigate the dynamic interaction between fissures and the resulting infiltration, storage and preferential flow and spatial and temporal variations in displacement.

Key to this research is the notion that differential displacement can open and close fissures acting as storage capacity, preferential pathways for infiltration and lateral groundwater drains. We studied these interactions both at the single fissure scale using coupled unsaturated-saturated flow models and we also modelled the dynamics at field scale in a distributed model coupling hydrological and stability dynamics developed in the PCRaster environmental modelling software package. Both approaches have been confronted with field data from slow moving landslides. The results show the importance of fissure characteristics in the hydrological behaviour of landslides. This approach results in increased insight in hillslope and landslide hydrology and provided a first step towards the quantification of the complex feedback between changing soil/fissure hydraulic characteristics and differential displacement. Furthermore, this study can help improving hazard assessment and mitigation works for slope stabilisation.

Variations in soil hydraulic conductivity as triggering factors of shallow landslides in the Serra do Mar, Brazil

VILLAÇA GOMES M., VIEIRA B.C.
University of Sao Paulo, SAO PAULO, BRAZIL

Periodically, widespread landslides events occur at the Serra do Mar Mountain Range, a geological and geomorphological compartment located on the Brazilian southeast coast. The slopes, with high angles and shallow soils, are mostly achieved by shallow landslides, and associated with rainfall events of greater magnitude, by debris flows. In the summer of 1966/67, rainfall reached a great extent of the Serra, triggering some of the most catastrophic events recorded in Brazil, among which stands out that occurred in Caraguatatuba City, São Paulo State. Previous works undertaken in the area showed that the 535 mm of rainfall recorded on 17 and 18 March, 1967, have left the soils, which range between 1-10 m depth, with a high degree of saturation and that shallow landslides were preferentially bound to two types of contact where generally are located the perched water table: mature soil (A and B horizons) - partially decomposed rock (C horizon) - bedrock. This fact shows that the mechanic discontinuities between these materials, with different constitutions and degrees of weathering, played a major role in the hillslope hydrology, favoring the occurrence of shallow landslides. Thus, the aim of this work is to identify the role of hydraulic discontinuities in soil mantles that triggers shallow landslides. Therefore, saturated hydraulic conductivity (K_{sat}) tests were performed with the Guelph Permeameter, inside and outside of shallow landslide scars in the following depths: 0.25, 0.50, 1.00, 1.50, 2.00 and 2.50 m. Although the values were relatively homogeneous (between 10^{-5} and 10^{-6} m s^{-1}), some hydraulic discontinuities were observed along the profiles, being more frequent between 1.00 to 2.00 m depth. It is noteworthy that, for the Serra, in these depths are triggered most shallow landslides, i.e. the mechanisms responsible for the instability at this depth reached critical levels, which may be caused by the development of saturation zones in such discontinuities.

****

Mass movements characterization in the disaster occurred in the Morro do Baú Complex, Santa Catarina, Brazil, in November, 2008

BAUZYS F., EGAS H.M.
Universidade Federal de Santa Catarina, FLORIANOPOLIS, BRAZIL

This study aimed to characterize and analyze mass movements occurred in the Complexo Morro do Bau, Vale do Itajai, Santa Catarina state, Brazil, in November 2008, through the geoenvironmental aspects and geological-geomorphological compartments. This mass movements happened so widespread and were triggered by an extreme rainfall event, totaling more than 500 mm in 3 days, preceded by rainfall accumulated over time. This disaster caused a significant change in the landscape, large material losses and tens deaths. This research analyzed the geology and geomorphology of two watersheds located in this area: Ribeirão do Baú e Belchior Alto. The landslide inventory map and the types of landslides characterization, associated with environmental features mapped, provide an overview of the effects of extreme event in this watersheds. It wasidentified three geological areas: (A) Luiz AlvesComplex (Archean and Proterozoic), with rocks like gneiss and hypersthene; (B) Itajai Group (Late Proterozoic), with sandstones, conglomerates and pelites, and (C) Quaternary sediments: deposits with slopes, alluvial terraces and river current. Geomorphologically, the dissection features a strong structural control, marked by faults, lineaments and drainage headwaters, that originate deep valleys and well fitted. The surface coverage develops by a deep chemical weathering, leading quite thick mantles of up to 30 meters deep, especially in Luiz Alves complex. As a main result we carried out the geological and geomorphological mapping of this watersheds and the analysis and reconstruction of the event by mapping processes and mass movementsclassification and debris flows.

The Catastrophic Landslide Event of January 2011 in Rio de Janeiro: Geomorpholocial and Geological Controls

AMARAL C.(1), SILVA A.(2), LIMA I.(2), RAMALHO J.(2), VAREJÃO L.(2), RODRIGUES J.(2), LAGO L.(2), CORREIA R.(2), CORRÊA S.(2), PORTOCARRERO H.(3), MOTTA M.(4), VARGAS JR. E.(4), DE CAMPOS T.(4), DOURADO F.(3), SILVA L.(5), ARAÚJO J.(5), FERNANDES N.F.(5), VIEIRA B.(6)
(1) UERJ & DRM, RIO DE JANEIRO, BRAZIL ; (2) DRM-RIO DE JANEIRO GEOLOGICAL SERVICE, RIO DE JANEIRO, BRAZIL ; (3) RIO DE JANEIRO STATE UNIVERSITY, RIO DE JANEIRO, BRAZIL ; (4) CATHOLIC UNIVERSITY, RIO DE JANEIRO, BRAZIL ; (5) FEDERAL UNIVERSITY OF RIO DE JANEIRO, RIO DE JANEIRO, BRAZIL ; (6) UNIVERSITY OF SÃO PAULO, RIO DE JANEIRO, BRAZIL

In January 2011, intense rainstorms triggered thousands of landslides in the Serra do Mar mountainous region in the state of Rio de Janeiro. Cities like Nova Friburgo, Teresópolis, Petrópolis and Sumidouro, located about 50-100 km north/northeast from Rio de Janeiro city, were severely affected by rainstorms that lasted for about 10 hours, with total volumes of about 350 mm in 24 hours. This catastrophic event, the greatest natural disaster of Brazil, caused about 1300 deaths (350 people still missing) and 20,000 people homeless. During the disaster, the Rio de Janeiro Geological Survey together with three universities (Catholic University, Federal University of Rio de Janeiro and Rio de Janeiro State University) started an intensive research program in order to map landslide scars and define the most important conditioning factors. The results attested a widespread landslide distribution in this event, including hillslopes with different forms and steepness, different lithology types, rural and urban sites as well as transported and “in situ” soils. Mass movements were classified in four major groups: landslides initiated at the soil-rock boundary at the convex hilltop of rock escarpments; torrential flows, hyper-concentrated flows and debris flows (some about 10 km long); shallow translational slides with scars located in the upper portion of the residual soil (affecting the concave portions of gentle hillslopes); and landslides in urban areas (where most of the deaths occurred). However, the consequences of this event could have been much worse because most of the landslides did not take place in the areas of higher risk. Therefore, it is urgent the implementation of effective methodologies that will contribute to landslide disaster mitigation in the state, reducing deaths and economic losses associated with landslides and debris flows.

****

Relation between the precipitation intensity and duration that originated the debris flows in Puebla, México

CARDOSO-LANDA G.
Instituto Tecnologico de Chilpancingo, CHILPANCINGO, MEXICO

The debris flows are particularly dangerous for the life and the properties due to its high speeds and great destructive force, destroying houses, ways, bridges, trees and cultures, currents and ecosystems throughout its trajectory.

The extraordinary precipitation events are one of the predominant physical processes that produce the genesis of the debris flows. The empirical thresholds of precipitation are based on the historical analyses of the occurrence relation precipitation/debris flow, for example statistical analyses. At the present time a limited number of this type of empirical thresholds exists and have been used different diagrams to represent them, depending on the combinations of precipitation parameters more commonly used: antecedent precipitation, duration, accumulated intensity and rain, and the most commons are that obtained by Caine and Aleotti.

An analytical presentation of the concept of threshold of precipitation of a debris flow was recently introduced by Iritanno et al. (1998), who introduced the called function of mobilization Y(t), indirectly describing all the factors that contribute to trigger a process of landslides and that is dependent, in every moment of time t, the amount of water infiltrate on the ground before the time t.

In the full article was applied the Iritanno’s function of mobilization to the records of precipitation that produced the debris flows in the north of Puebla State, in the country of México, obtaining relationships intensity of rain-duration for these debris flows are greater from 3.43 to 2.1 times over empirical thresholds of precipitation generators of debris flows proposed by Caine and Aleotti in other regions of the world.

The combined effect of complex rupture mechanism and topography in regional distribution pattern of the landslides triggered by the 12 January 2010 Haiti earthquake

GORUM T.(1), VAN WESTEN C.(2), KORUP O.(3), VAN DER MEIJDE M.(2), FAN X.(2), VAN DER MEER F.D.(2)

(1) Natural Sciences Research Center, Yildiz Technical University,, ISTANBUL, TURKEY ; (2) Faculty of Geo-Information Science and Earth Observation (ITC), University of Twente, ENSCHEDE, NETHERLANDS ; (3) Institut für Erd- und Umweltwissenschaften, Universität Potsdam, POTSDAM, GERMANY

The 12 January 2010 M_w 7.0 Haiti earthquake occurred in a complex deformation zone at the boundary between the North American and Caribbean plates. Combined geodetic, geological and seismological data posited that surface deformation was driven by rupture on the Léogâne blind thrust fault, while part of the rupture occurred as deep lateral slip on the Enriquillo-Plantain Garden Fault (EPGF). The earthquake triggered >4492 landslides, mainly shallow, disrupted rock falls, debris-soil falls and slides, and few lateral spreads, over an area of ~2150 km^2. The regional distribution of these slope failures defies those of most similar earthquake-triggered landslide episodes reported previously. Most of the coseismic landslides did not proliferate in the hanging wall of the main rupture, but clustered instead at the junction of the buried Léogâne and EPGF ruptures, where topographic relief and hillslope steepness are above average. Also, low-relief areas subjected to high coseismic uplift were prone to lesser hanging-wall slope instability than previous studies would suggest. Here we show that a combined effect of complex rupture dynamics and topography primarily control this previously rarely documented landslide pattern. Compared to recent thrust fault-earthquakes of similar magnitudes elsewhere, we conclude that lower static stress drop, mean coseismic displacement, and blind ruptures of the 2010 Haiti earthquake resulted in fewer, smaller, and more symmetrically distributed landslides within inter-fault blocks (i.e. hanging and foot wall), thus differs from previously documented surface rupture thrust faulting-earthquakes.

****

Relationships between large landslides and late orogenic antiforms in the Northern Apennines (N Italy): geomorphological, structural and thermochronological data

CHELLI A.(1), VESCOVI P.(1), CARLINI M.(1), CLEMENZI L.(1), ARTONI A.(1), TELLINI C.(1), TORELLI L.(1), BALESTRIERI M.L.(2)

(1) University of Parma-Department of Physics and Earth Sciences, PARMA, ITALY ; (2) CNR-Geosciences and Georesources Institute, FLORENCE, ITALY

In active mountain belts, landslides occurrence is also connected with tectonic activity. Besides, denudation processes may be related to the response of the slopes to topographic disequilibria induced by tectonic uplift.

The Northern Apennines is an active fold and thrust belt made by convergence, since Late Cretaceous to present, between European and Africa plates.

Neotectonic activity is testified by seismicity, geologic features and landforms evolution. Northern Apennines experienced uplift since Pliocene with a remarkable increase in Late Pliocene and middle-upper Pleistocene.

This work aims to explore, through several case studies, the relationships between tectonic structures and large landslides (Ossella, Mt. Cervellino and Corniglio-Braia landslides). In the area between Enza Stream and Taro River catchment basins (in the Emilia Romagna region), north of the Apennine watershed, geological, geophysical and thermochronological data allowed to relate the surface uplift to antiforms representing the most recent tectonic structures in the area. Based on AFT thermochronological data, late orogenic uplift was active between 9 and 3 Ma, becoming younger from inner to outer portions of the mountain ranges; geological data constrain the activation of surface erosion processes since around 5 Ma.

The spatial relationship among the antiforms and large landslides and DSGSD has been established through the use of GIS. Detailed structural and geomorphologic analyses allowed to infer that landslide mechanism and type is controlled by the tectonic features. In fact, rock slides and huge complex landslides affect mainly the antiforms' forelimb. Thus, the disequilibria and steepening of the slopes, in response to surface uplift and folding, can be regarded as a main causes for most of the studied landslides which represent one of the latest (at least since 30000 yr BP) surficial process shaping late orogenic antiforms of this portion of the Apennine.

The apply of digital photogrammetric techniques in the generation of landslide inventories of high temporal frequency for villafufre area (Cantabria, Spain)

GONZALEZ-DIEZ A.(1), FERNANDEZ-MAROTO G.(1), DOUGHTY M.W.(1), DIAZ DE TERAN J.R.(1), REMONDO J.(1), CARDENAL J.(2)
(1) DCITIMAC, UNIVERSITY OF CANTABRIA, SANTANDER, SPAIN ; (2) DEPARTMENT OF CARTOGRAPHIC, GEODETIC AND PHOTOGRAMMETRIC ENGINEERING. HIGHER TECHNICAL SCHOOL, UNIVERSITY OF JAEN, SPAIN, JAEN, SPAIN

The landslide inventory of Villafufre area (Cantabrian Range, Spain), is a good example of multitemporal landslide inventory because it has information about the existing landslides dated between 150,000 years to 1989, as well as their triggering factors. Recently, this inventory has been strengthened with data from a new inventory of high temporal frequency, obtained in recent years from aerial images taken from 2003 to 2009, every two or three years, treated through digital photogrammetry, image processing techniques, and with field methods. The images used have high geometrical accuracy (25 cm of pixel size), radiometric amplitude (color and infrared) and are in digital format. Using digital photogrammetric treatments, a reference system for the digital stereoscopic models obtained, by means the different flights used, was done which enables the right measurement between the geomorphic vectors identified. The metric and semantic capacities of images, allows the extraction of geomorphic information about the landscapes depicted. Beside, it is possible to apply this technique with historical aerial images in order to the analyses of landslide modifications. This technique allows to measure thousands of points in a short time, obtaining precise high point density models. With the use of such methods it is possible to reduce many of the errors associated with landslide inventories: to improve the accuracy in the position of the landslides identified; a correct identification of the affected area; a proper assessment of the volume involved; reduce the uncertainties concerning the loss of landslide mass by erosion or rehabilitation of the affected area. Moreover, it is possible to know precisely the role of trigger factor in the genesis of slope processes, obtain relevant data for landslide hazard models, and to know which is the paper of the recent (a few years) small landslides in slope instability and how these processes are contributing to geomorphic mass transfer.

****

Defining digital signatures of landslide types for semi-automated landslide mapping

EISANK C., HÖLBLING D., FRIEDL B., BLASCHKE T.
Department of Geoinformatics - Z_GIS, University of Salzburg, SALZBURG, AUSTRIA

In visual image interpretation experts delineate and categorize landslides manually by analyzing a series of qualitative characteristics that can be recognized in satellite images, aerial photographs or DEMs. Most criteria an interpreter would employ in manual mapping can be modeled with computer-based approaches such as object-based image analysis (OBIA). Due to the lack of standards, the selection of adequate criteria and rules for semi-automated digital mapping of landslides is usually performed in a subjective and time-consuming manner. To speed up the process and to make it reproducible, the implicit knowledge experts employ in manual interpretation has to be conceptualized and made explicit *prior* to semi-automated landslide modeling. The proposed strategy for conceptualizing landslide knowledge is two-fold: firstly, we analyze the available literature with respect to the knowledge and criteria that researchers applied to the mapping of landslides; secondly, we organize an expert workshop where the outcomes of the literature review will be critically discussed and a set of digital signatures of landslide types defined. These signatures should specify (i) the optimal combinations of spectral and morphometric layers for OBIA, and (ii) the optimal set of spectral, spatial, morphometric, textural and contextual features, as well as the feature-dependent thresholds and value ranges for the semi-automated mapping of landslides. We anticipate that the digital landslide signatures will heavily support the development of transparent and standardized landslide analysis workflows that are based on remote sensing data and implemented in OBIA frameworks.

Age-dependent footprint of landslides in airborne laser scanning digital terrain models

BELL R.(1), PETSCHKO H.(1), BRENNING A.(2)
(1) Dept. of Geography and Regional Research, University of Vienna, VIENNA, AUSTRIA ; (2) Department of Geography and Environmental Management, University of Waterloo, WATERLOO, CANADA

To assess the frequency and magnitude of landslides and their role in landscape evolution and sediment budgets as well as to analyze the hazard and risks posed by them, it is crucial to compile substantially complete landslide inventories as a first step. Airborne laser scanning digital terrain models (ALS DTM) provide an excellent source for mapping landslides. However, nothing is known about the age if only an ALS DTM is used as data source. In some cases the relative age can be determined from the freshness of the of landslide features. This is of course not possible for landslides that have disappeared from ALS DTM due to natural erosion or human impact. Thus, field- or ALS DTM-based methods for analyzing the time span taken to modify and blur landslides are needed. In this study, examples from the Swabian Alb in southwest Germany and the Austrian province of Lower Austria are examined regarding possible relationships between landslide age and features detectable in the ALS DTM. Landslides were mapped based on the interpretation of ALS DTM hillshades and combined with landslide age information from other sources (e.g. historical archive analysis, aerial photographs, archive on damaging landslide events of the Geological Survey). The oldest dated landslide occurred approx. in 1690. Landslide age was compared to various roughness parameters derived from the ALS DTM. Furthermore, relationships between human land management and landslide features were analyzed. The resulting correlations suggest that ALS DTM-derived roughness parameters may have promise in assessing the age of landslides that are relatively unaffected by human land management. Many landslides disappeared completely within the analyzed sources due to human impact which may have a strong influence on the correct assessment of frequency and magnitude of landslides for a given study area.

****

Long-term monitoring of slow-moving landslides: examples from the Island of Malta (Central Mediterranean Sea)

DEVOTO S.(1), FORTE E.(2), MANTOVANI M.(3), MOCNIK A.(2), PASUTO A.(3), PIACENTINI D.(1), SOLDATI M.(1)
(1) Dipartimento di Scienze Chimiche e Geologiche, Università di Modena e Reggio Emilia, MODENA, ITALY ; (2) Dipartimento di Matematica e Geoscienze, Università di Trieste, TRIESTE, ITALY ; (3) CNR-IRPI, Consiglio Nazionale delle Ricerche, Istituto di Ricerca per la Protezione Idrogeologica, PADOVA, ITALY

Slow-moving landslides are widespread along the north-western coast of the Island of Malta. They mainly consist of rock spreads and block slides which are strictly linked to the geological setting of the area, namely the overposition of limestones and clayey terrains.

Despite their slow speed rates, these types of landslides may cause damages to infrastructures and favour the onset of faster mass movements, such as falls, slides, topples and flows. Therefore a quantitative analysis of rock spreading and block sliding evolution and their relationships with collateral slope movements are crucial in terms of hazard assessment.

This paper illustrates the results achieved by means of a multidisciplinary and multitechnical approach aiming at defining quantitatively the rates of displacements of the above-mentioned landslides, by combining the outcomes of a traditional geomorphological survey with the outputs of different monitoring techniques and geophysical investigations.

In particular, the state of activity and kinematics of landslides were determined by using GPS observations acquired over a 7-year-time interval, approximately every 6 months, at the end of wettest and driest seasons. The GPS networks, installed at Ghajn Tuffieha Bay and Il-Prajjet, consist of a series of benchmarks distributed on the limestone plateaus affected by rock spreading and on a series of blocks displaced by block sliding.

At Il-Prajjet, research activities have been integrated by GPR and ERT geophysical investigations and by the installation of two automated fissurimeters, which record continuously surface deformations related to two persistent discontinuities caused and enlarged by block sliding movements.

Finally, the multidisciplinary approach implemented enabled a deeper understanding of slow-landslide kinematics to be achieved and provided an essential basis for an improved coastal hazard assessment and management.

Monitoring of large mass movements on El Hierro, Canary Islands, Spain

BLAHUT J.(1), KLIMES J.(1), YEPES J.(2), GALINDO I.(3)
(1) Institute of Rock Structure and Mechanics, ASCR, PRAGUE, CZECH REPUBLIC ; (2) Department of Civil Engineering, University of Las Palmas de Gran Canaria, LAS PALMAS DE GRAN CANARIA, SPAIN ; (3) Department of Geoscientific Research and Forecast, Geological Survey of Spain, LAS PALMAS DE GRAN CANARIA, SPAIN

Coastal and submarine landslides around volcanic islands are the largest known mass movements on Earth. Canary Islands in Spain are one of the places where they regularly occurred during last 300 thousand years, also triggering several tsunamis. In summer 2011 intense seismic activity begun and continues along a volcanic rift on the El Hierro island, the youngest and most tectonically active island of the archipelago.

The presentation aims to show first results from the newly set-up monitoring within a National Geographic Society/Waitt Grants Program project: “Mega-landslides: imminent hazard or sleeping giants? Monitoring the landslide hazard related to ongoing volcanic activity around El Hierro, Canary Islands, Spain”. The monitoring consists of precise TM-71 dilatometers capable of recording three dimensional movements between rock blocks, including rotations, at predefined time intervals and have a precision of better than 0.007 mm. Such precision allows recording micromovements along the faults and fissures that form potentially active landslide shear planes. Relation of the recorded movements to the seismic and aseismic activity on El Hierro will be presented and discussed.

****

Landslide monitoring, temporal analysis and susceptibility assessment at Machu Picchu, Peru

VILIMEK V.(1), KLIMES J.(2)
(1) Charles University in Prague, Faculty of Science, PRAGUE, CZECH REPUBLIC ; (2) Academy of Sciences, Institute of Rock Structure and Mechanics, PRAGUE, CZECH REPUBLIC

Since the alarming news about landslide threat for the Machu Picchu historical site has been revealed, net of dilatometric measurements monitors possible gravitational movements within the Inca city. Landslide occurrence information for its surrounding was acquired by multi-temporal aerial photo interpretation and field mapping. This showed that the coarse time resolution of the historical landslide information may lead to inaccurate interpretations regarding landslide occurrence frequencies in some parts of the study area. Also the assumption that the past landslide frequency can be used to describe the future landslide occurrence was not proved. Thereafter, unique conditional analyses were undertaken to assess landslide susceptibility using a limited number of preparatory factor maps. It showed that large majority of the Inca City is located on least susceptible areas within the region. The results of the susceptibility assessment combined with landslide occurrence frequencies may serve as a basis for the landslide hazard mitigation in the studied area. For these purposes, pixel based susceptibility maps were generalized into expert defined landslide management units. These units provide site managers with easily understandable and applicable hence reliable information about future landslide occurrences. An approach describing usage of the resulting susceptibility maps for on site mitigation purposes was described with respect to the needs of Machu Picchu site managers.

Landslides and erosion times on the Batchingou massive (West Cameroon)

MBATCHOU MBATCHOU S.(1), TCHINDJANG M.(2), WAKPONOU A.(1)
(1) University of Ngaoundéré, NGAOUNDERE, CAMEROON ; (2) University of Yaoundé I, YAOUNDE, CAMEROON

Usually considered as the breadbasket of Cameroon for its rich farmlands, the Western Region Cameroon, densely populated, today faces accelerated erosion and run off linked to the agricultural and pastoral activities that provoke mass movements on exposed slopes. This is what we observed on the flanks of the Batchingou - Bana mountains. Heavy rainfall recorded in recent years due to climate variability (rainfall) also cause times erosion. This situation have resulted in the destruction of crops, obstruction of communications traffic and cut, then the destruction of sociocultural and art works (water tower). Also, these threats are due to increased of human activities.

This paper aims to assess the causes of the occurrence of these risks and vulnerability of exposed populations. Indeed, farming, deforestation (for heating), cattle rearing and digging of pits are growing enough to cause deep lacerations on the slopes. If the purpose of this article is a summary assessment of these phenomena, the methodology used consisted of a direct observation of erosion scars that we measured and spatialized on a map using a GPS (maximum precision 4m) and a double tape measure (50m). We also assessed the erosion rate by collecting eroded material for laboratory analysis.

The results show that the 50 scars observed and measured depended not only on human activities, but also the worsening climate which is a signal of climate variability and climate change that people still fail to adapt. Indeed, for them, the reduction leads to decreased on productivity due to late and misleading rainfall, and a significant crops exposure to dryness. Rainfall becomes scarce as in the past, but rare and violent.

Finally, it appears important to adopt anti erosion measures on this mountain such as seedling local species adapted to improve the cohesion of the soil with a good root system, reducing the effects of heavy and aggressive rainfall and ensuring better slope stabilization.

****

Geomorphological evolution in some clayey small catchments of central and Island Italy during the last 15,000 years

AGNESI V.(1), ARINGOLI D.(2), BUCCOLINI M.(3), COCO L.(3), DEL MONTE M.(4), GENTILI B.(2), MATERAZZI M.(2), PAMBIANCHI G.(2), SCIARRA N.(3)
(1) University of Palermo, PALERMO, ITALY ; (2) University of Camerino, CAMERINO, ITALY ; (3) University of Chieti, CHIETI, ITALY ; (4) University of Rome, ROME, ITALY

In this work the geomorphological evolution in some clayey small catchments of Italy has been recognized. The most important element of space-time correlation is the contemporary starting of the last phase of deepening of the hydrographic network, during the end of Late Pleistocene. More in detail, the four areas considered, representative of the clayey landscape of Italy, are located respectively on the Adriatic (2) and on Tyrrhenian (1) side of central Italy and in the central-western Sicily (1). All these areas are not so large (up to 12 km^2) and are characterized by a similar composition of bedrock, similar relief and, in general, by analogous morphodynamic characteristics. These areas are affected by strong erosional processes of mixed type (landslides and/or runoff effects, like badlands). Basing on geomorphological correlations (locally supported also by radiometric dating), between surfaces considered coevals, it seems realistic to hypothesize an analogous temporal evolution of the hydrographic network among the different areas. These chronological/geomorphological constraints, allowed us to reconstruct, by means of topographic processing and GIS analyses, the geomorphological evolution of the sample areas and to estimate (in some cases) the soil erosion rate for the considered time span (last 15,000 years).

The results obtained are consistent with the data available in literature both for Italy and the Mediterranean Europe and, more in particular, confirmed that very intense erosion processes occurred as a consequence of the Holocene climatic improvement.

Impacts of post glacial rebound on landsliding at a regional scale in Northern Iceland (Skagafjörður): spatial distribution and mechanisms involved

COSSART E.(1), MERCIER D.(2), DECAULNE A.(3), FEUILLET T.(2), JONSSON H.(4), SAEMUNDSSON Þ.(4)
(1) Paris 1 University (Panthéon-Sorbonne) - UMR Prodig CNRS, PARIS, FRANCE ; (2) Nantes University - UMR Geolittomer, NANTES, FRANCE ; (3) UMR Geolab, CLERMONT-FERRAND, FRANCE ; (4) NNV, SAUDARKROKUR, ICELAND

Paraglaciation has often been considered as a main predisposing factor in landslide occurrence; its consequences have been particularly well identified at a fine scale (especially on bedrock jointing). However, the impacts of paraglaciation on hillslope dynamics at a regional scale have never been discussed. We focus here on the Skagafjörður area (Northern Iceland) to compare the role of paraglaciation with that of classic factors (topography, lithology etc.) in landslide occurrence, using a spatial analysis (based upon a chi-square test). The results highlight that landslides are over-represented in areas where post-glacial rebound was at its maximum (i.e. there is a concentration of landslides in the northern part), which fits well with the first chronological benchmark we obtained. Thus, landslides occurred during the first half of the Holocene, when the post-glacial uplift was at its maximum. Finally, the mechanisms that link post-glacial rebound and landsliding are discussed. On the one hand, post-glacial rebound is identified as an efficient process to generate slope instabilities, leading to a concentration of landslides in the northern part of the fjord. On the other hand, the expected role of glacial debuttressing cannot be demonstrated here, although it is often considered one of the most important paraglacial influences on landsliding.

****

Long-term slope instabilities of southern slopes of the Crimean Mountains (Ukraine), the role of karstification and slope-disequilibrium phases of the Late Quaternary

HRADECKI J., PÁNEK T., SMOLKOVÁ V., ŠILHÁN K., LENART J.
University of Ostrava, Faculty of Science, Dept. of Physical Geography and Geoecology, OSTRAVA, CZECH REPUBLIC

A giant system of various types of gravitational slope deformations was recognized in the area of the southern slopes of the Crimean Mountains. In this area we cantest the impact of palaeoenvironmental changes on the acceleration of slope processes and the role of preparatory and triggering factors. Main target of this paper is to determine time constraints ofthe slope deformations within coastal escarpments and adjacent lower parts of the slopes. With the use ofvarious dating approaches we are able to focus on the timing of different slope instabilities. Individual phases of Late Quaternary landslide instabilities have been revealed by means of numericaldating. The dating methods of U/Th series, ^{14}C dating and ^{36}Clexposure dating were used. We are working with a hypothesis that the period of slope instabilities was preceded by avariable-length pre-sliding phase which was connected with the weakening of the masiff as a result of weathering. In the studied region this phase was brought about by deep karstification and genesis ofspleothemes within cave environment. In the case of the resulting landsliding, the caves opened putting anend to the development of speleothems (unroofed caves). New $CaCO_3$ cements that formed in porespaces of block accumulations can be dated using U/Th series. The fact that the Crimean Mountains lie in a seismically active region stands for one of possibletriggering factors of the slope instability (esp. rockfalls, rock avalanches). One of the most important preparatory factors is karstification of the limestone masiff together with its tectonic features. Interrelations between karstified rocks and deep-seated ridge disintegration leading to slope instability propagation are studied on the basis of structuralmeasurements and detailed geomorphological analyses.

The 'El Forn' landslide, Principality of Andorra: a survivor of the late Pleistocene glacier activity

COROMINAS J.(1), PLANAS X.(2)
(1) Universitat Politecnica de Catalunya, BarcelonaTech, BARCELONA, SPAIN ; (2) Ministeri d'Ordenament Territorial, Govern d'Andorra, ANDORRA LA VELLA, ANDORRA

Landslide deposits are typically found blanketing the floor of valleys which were previously occupied by Pleistocene glaciers. Because of this, it is often assumed that such landslides occurred during the Holocene. The El Forn landslide is a complex large slide-earthflow located next to the Canillo village in the upper Valira river valley which age and instability process has been associated to the retreat of the Valira glacier (Soutadé, 1988; Corominas, 1990; Santacana, 1994). In this communication we present a new interpretation of the geomorphic evolution of El Forn landslide from the detailed analysis of a set of drilling cores, laboratory analysis, field reconnaissance and review of previous studies. The main phases of the emplacement of the landslide are discussed considering the sedimentological interpretation of the drill cores and dating of the organic remnants. At least, three main instability phases have been identified and several evidences indicate the existence of an on-going slope deformation in the landslide head. The first one started in the Upper Pleistocene. The relationship of the landslide with the Pleistocene glaciers has been revisited and we conclude that the oldest landslide deposits have been partially reshaped by the advance episodes of Valira glacier although some uncertainties still remain. Finally, present day stability of the landslide is discussed based on the existing geomorphic indicators, borehole inclinometers and DInSAR measurements. The results show the pattern of the present landslide activity is complex and that the different landslide units behave in a non-homogeneous way.The DinSAR results have also shown that the deformation of the rockmass extends beyond the “El Forn” boundary.

****

The morphogenesis of deep-seated landslides in the Romanian Curvature Carpathians as a proxy in regional landslide hazard assessment

MICU M.(1), JURCHESCU M.(1), MICU D.(1), BALTEANU D.(1), ZAREA R.(2), LEAU L.(2)
(1) Institute of Geography, Romanian Academy, BUCHAREST, ROMANIA ; (2) Romanian Waters Company, Buzau-Ialomita Branch, BUZAU, ROMANIA

The deep-seated landslides in the Curvature Carpathians of Romania are showing complex occurrence patterns, favored by the regional structural, lithological, neotectonic, climatic characteristics or land-use changes. The combination of the numerous predisposing, conditioning and triggering factors lead to a large spectrum of landslide types (e.g. shallow translational slides in the outer Subcarpathian hills, deep-seated debris and rock-slides in the Carpathian range), with different morphogenetic features. Landslide complexity is enhanced by the active seismicity of the area alongwith the results of an intense and long-lasting habitation (e.g. deforestation). Rainfalls are commonly a primary factor in landslide triggering in the study region (subsequently followed by freeze-thaw episodes and earthquake events) and depicts three patterns of manifestation: i) spring showers overlapping snowmelt, ii) torrential heavy summer rainfalls and iii) long-lasting autumn showers. The aim of this contribution is to reveal the morphogenetic and morphodynamic complexity of these processes, which may induce important uncertainties in the regional landslide hazard assessment. The paper also outlines the seasonal distribution of rainfalls, imprinting the dynamic character of the movement, which further controls the landslide morphology. The role of temperature in landslide failure is also discussed in this work, focusing on the spatial and temporal variability showed by the frequency and intensity of freeze-thaw cycles. Relationships between the main meteorological variables involved in landslide initiation are investigated herein (based on in situ measurements during several relevant episodes), which are discussed in terms of frequency-magnitude correlations. This study can be considered a step forward to a reliable hazard assessment by including more properly such complex processes in the regional landslide inventories.

Repeated rock avalanches onto the Brenva Glacier (Mont Blanc massif, Italy) during the Holocene

DELINE P.(1), AKÇAR N.(2), IVY-OCHS S.(3), KUBIK P.W.(3)
(1) EDYTEM Lab, Université de Savoie, CNRS, LE BOURGET-DU-LAC, FRANCE ; (2) University of Bern, Institute of Geological Sciences, BERN, SWITZERLAND ; (3) Institute of Particle Physics, ETH Hönggerberg, ZÜRICH, SWITZERLAND

Rock avalanching represents a potential high risk for growing infrastructure and people living in high mountain areas. This hazardous process is due to steep slopes, high relief, intensive rock fracturing, seismicity, paraglacial control, periglacial climatic conditions and the presence and interaction of snow, glaciers, and permafrost. The timing of rock avalanche recurrence intervals is essential.

Numerous rock avalanches (RAs) have affected the south-east side of the Mont Blanc massif (European Alps) in the late Holocene, especially the basin of the Brenva Glacier, where the low-friction substrate offered by the glacier caused excessive run-out distances. As in 1920 and 1997, RAs (volume > 1 million m^3) that travelled onto this glacier mobilized a large amount of ice and snow, and reached the valley floor. Historical (e.g. etchings), geomorphological evidences (e.g. concave slope of the lateral moraine distal flank), and datations (^{14}C, ^{10}Be, lichenometry) suggest their high frequency during the Late Holocene. Besides the two 20th Century RAs, several RAs have been dated to: shortly before 1767 AD; the 14th Century (which will give sense to the legend of the destruction of the village of Saint-Jean de Purthud); the early Middles Ages (after 426–615 AD); and around 3 ka.

As suggested by the several decametre-thick sediment accumulation at the base of the south lateral moraine and the 1-m-thick rock deposit of the ice-RAs of 1920 and 1997, probably more than 10 RAs of this type occurred during the Neoglacial. In some cases, large debris flow were triggered by the catastrophic drainage of the lake resulting from the ice-rock damming of the Val Veny, as suggested by the matrix-supported diamicton of granite boulders exposed downstream in excavations over a 3 km distance and dated to 2.7–2.3 k.yr BP. With the current degradation of rockwall permafrost due to the global warming, Brenva RAs could therefore threaten again the valley floor in the next future.

****

Giant landslides at Late Pleistocene highstands of the Caspian Sea

PANEK T.(1), HRADECKY J.(1), MINAR J.(2)
(1) University of Ostrava, OSTRAVA, CZECH REPUBLIC ; (2) Comenius University, BRATISLAVA, SLOVAKIA

Late Pleistocene transgressions of the Caspian Sea, which culminated during the Early Khvalynian stage (+50 m a.s.l.), caused massive inundation of low-lying landscapes at the northern and north-eastern margin of the basin. Pronounced escarpment (with length ~1500 km and height 100 – 150 m) attributed to Khvalynian transgressions, is contemporarily situated mostly far from the Caspian Sea shoreline, in the semi-desert area of the western Kazakhstan in the Ustyurt plateau and Mangyshlak peninsula. Satellite image and DEM analysis together with field inspection revealed that the escarpment is affected by more than 300 giant landslides, >100 of which are characterized by the volume exceeding $10^8 m^3$. The landslides form distinctive amphitheater-shaped scarps and long-runout lobes accumulated on very gently (<5°) inclined slip surfaces. Deep-seated (>50 m) proximal rotational deformations affecting horizontally-bedded Miocene limestones, marls and claystones contrast with rather shallow (<10 m thick) lobes formed by completely mixed and thrusted material with the signs of flow-type emplacements and liquefactions. A majority of landslide toes are clearly cut by Late Glacial and Holocene shorelines (e.g. +50, +22, 0, -20, -22 m a.s.l), dated by AMS to particular stages occurring between Late Glacial – Middle Holocene. The age of these abrasion levels determines the minimum age of the landslides. Most of them originated most likely during the maximum highstand of the Early Khvalynian transgression (13.6-11.8 ka BP). However, distinct erosion of some landslides indicates their pre-Khvalynian age - probably attributed to earlier Late Khazar transgression (122-91 ka BP, -10 m a.s.l.). Based on our findings, ancient landslides occurring along the cliffs of the Late Pleistocene highstand of the Caspian Sea form the world´s largest cluster of giant landslides situated entirely in the low-topography settings outside the mountain belts.

Long term evolution of 'Les Vaches Noires' cliffs and spatio-temporal occurrence of landslides (Calvados, Basse-Normandie, France)

MAQUAIRE O.(1), AFCHAIN P.(1), COSTA S.(1), DAVIDSON R.(1), FRESSARD M.(1), LETORTU P.(1), LISSAK C.(1), THIRARD G.(1), THIERY Y.(2)
(1) LETG-Caen GEOPHEN, UMR 6554 CNRS, University of Caen Basse-Normandie, CAEN, FRANCE ; (2) EURO-ENGINEERING, PAU, FRANCE

Along 4.5 kilometers between Houlgate and Villers-sur-Mer (Calvados, Lower-Normandy), the '*Vaches Noires*' cliffs evolve under the action of various sub-aerial weathering and marine processes. The main scarp is formed by a thick layer of limestone that recedes by rotational landslides and rockfalls. The downslope part presents a chaotic morphology affected by mudflows flowing between pinnacles.

The aims of the study are (1) on global scale, to analyze the historical and morphological evolution of these slopes, and (2) on local scale, to study a large landslide that occurredin the first part of the XXthcentury.

To analyze the historical and morphological evolution of the slopes, we used a diachronic method to quantify the displacements and the evolution of the coastline position since 1759. The analysis is based on numeroushistorical documents(archives) and spatial data (maps, cadastral surveys, air-photo images from the French national geographic institute (IGN) and GPS)which uncertainties and accuracies were quantified. In function of the nature of the materials, the toe erosion rate ranges from 10 to 15 cm per year which appears relatively low on human scale. However, at numerous places, the sea action is balanced by the materials provided by the active mudflows. The '*toe coast line'* is then temporarily in progression during the necessary time for the sea action to put off the loosed and softy materials.

On local scale, for the '*Ermitage landslide'*, morphodynamic maps were performed in the field using cartographic GPS in order to define the surface morphology and the estimated landslide activity. These field measurements were completed with the analysis of all available air-photo images, in order to identify the occurrence dates and the possible landslides reactivations. The back calculation modelling allow the proposition of an evolution scenario, the position of the slip surface and the relative weight of the different triggering factors.

****

Magnitude-frequency scaling of a long-term inventory of landslides in Great Britain

HURST M.D., ELLIS M.E., ROYSE K.R., LEE K.A., FREEBOROUGH K.
British Geological Survey, NOTTINGHAM, UNITED KINGDOM

The link between the size of landslides and how often they occur is important to constrain both for the assessment of hazards associated with a particular event, and for understanding the long-term mass flux within a landscape. Landslide inventories are usually compiled following a particular triggering event such as an earthquake or storm, and their statistical behaviour is typically characterized by a form of power-law with a small-magnitude rollover. Here we explore the statistical behaviour of a geomorphic landslide inventory for Great Britain, consisting of mapped landslide deposits of unknown age. We use a subset from a high-quality database of over 10,000 landslides which have been verified by geological mapping of Great Britain over the last century. This landslide dataset exhibits magnitude-frequency scaling similar to that observed for event-triggered inventories. In this case, magnitude refers to the area of the deposit (A) and frequency refers to how many have occurred in the geologically recent past (probably post-last glacial maximum). The resulting probability distribution is well approximated by both a double-Pareto distribution and a truncated inverse gamma function. This means that for medium-large landslides ($A > 5000$ m^2) the frequency of landslides decreases as a negative power-law function of the size of the event. Conversely for small landslides ($A < 5000$ m^2), frequency decreases with decreasing landslide size. The position of the peak in frequency ($A \approx 5000$ m^2) is offset towards larger events, compared with inventories where the record can be considered complete, which may suggest that the record is under-sampled with respect to smaller landslides. We split the data into broad lithologic groups to identify which rock/deposit types are most susceptible to landsliding. Finally, we categorise the type of mass movement to explore whether the scaling relationships vary for different failure processes.

Tree-ring analysis in the reconstruction of slope instabilities associated with earthquakes and precipitation (the Crimean Mountains, Ukraine)

ŠILHÁN K., PÁNEK T., HRADECKý J.
University of Ostrava, OSTRAVA, CZECH REPUBLIC

The Crimean Mountains in Ukraine constitute a seismically active region that is abundant in various types of mass movement. The limestone escarpments that rise above the Black Sea coast in the vicinity of the town of Yalta are particularly subject to considerable rockfall, landslide and debris flow processes that often endanger infrastructure and human life. One of these very active slopes is the area of the ancient Taraktash rockslide, characterized by active block-type movement (lateral spreading, toppling, incipient sliding), rockfall, ongoing sliding activity and debris flow. The aims of this study were (i) to employ tree-ring analysis to reconstruct a record of slope instabilities (mainly block-type movement, rockfall, landslide and debris flows) within the Taraktash slope deformation over a period of more than two centuries and (ii) to establish the degree of correlation between periods of enhanced slope activity and both historical earthquakes and climatic data. The temporal frequency of significant slope processes was addressed through a tree-ring analysis that took 738 increment cores from 255 Crimean pine trees*(Pinus nigra* ssp.*pallasiana)*.The tree-ring record reveals periods of increased activity of block-type movements, rockfall and sliding during major earthquakes in 1790, 1875, 1927 and 1986. Although the slope processes studied are predominantly driven by seismic activity, their intensity and duration is also dependent on climatic factors.

****

Analysis of high magnitude mass movements on January 2011 rainstorm - Nova Friburgo, Brazil

LIMA R., MARÇAL M.
UFRJ Federal University of Rio de Janeiro, RIO DE JANEIRO, BRAZIL

On January 11th, 2011, the Mountain Region of Rio de Janeiro State was hit by 240 mm rain in 24 hours. This event caused high magnitude landslides and floodouts, which displaced 2.354 people and damaged seven cities infrastructure. A role of actions from Brazilian authorities was mobilized to assist communities located in the most impacted areas.

The Mountain Region of Rio de Janeiro State is placed within the morphoclimatic context of *"Serra do Mar"*, presenting scarped reliefs and 1.283mm annual precipitation. The rain concentration in the months of summer associated to susceptible soil types makes this region prone to the occurrence of mass movements.

This study aimed to identify the mass movements occurred during 2011 rainstorm, and to evaluate their geographical distribution, connectivity to the drainage system, stream channel morphology adjustments, as well as correlations with physiographic settings such as precipitation, land use and soil types.

The Dantas catchment (53km²) was the most affected area with 197 landslides mapped through Google Earth ™ images. From this total, 44% reached river bed and 66% were disconnected to the channel. However, the sum of connected landslides represented a 4 times larger area than the disconnected ones (2 km² and 0,5km² respectively). The huge soil volume that reached river bed in different locations caused impoundment followed by sequential disruptions of high viscosity debris flow.

The landslide mapped areas were analyzed on a GIS environment, due to assess the relation of these occurrences with the land conver, soil type and precipitation. The results presented that 55% of the landslides occurred in areas with rainforest cover; 64% of events occurred in areas of Latosoil Red Yellow alic; and 70% occurred in areas within 200-240mm precipitation.

Channel rehabilitation programs are being implemented on strategic sites of Dantas catchment due to reestablish geomorphic equilibrium condition.

Spatio-temporal landslide dynamics and their contribution to the channel system from 1946 to 2011, Southern Ruahines, New Zealand

RIEDLER R.A.(1), FULLER I.C.(2), GLADE T.(1), BELL R.(1), MARDEN M.(3)
(1) University of Vienna, VIENNA, AUSTRIA ; (2) Massey University, PALMERSTON NORTH, NEW ZEALAND ; (3) Landcare Research, GISBORNE, NEW ZEALAND

In New Zealand's North Island, where mountains occur in close proximity to densely populated areas, landslides strongly influence human activity and infrastructure. Shallow landslides frequently cause extensive damage to transport routes and contribute to the loss of fertile agricultural land further downstream.

The Southern Ruahine Range, reaching up to a height of 1710 m.s.l, is such an environment. While detailed investigations on landslide activity and sediment flux from this Range were carried out in the 1970's and 1980's there have been no follow-up-investigations since then. Our aim is to better understand the reasons for the spatio-temporal change in landslide distribution patterns, their connectivity to streams and their contribution to the sediment flux from the 221 km² study area over a 65-year period (1946 to 2011). In addition, these relationships were studied in greater detail within a 11.3 km² sub-catchment. Methods used to identify landslide locations and determine their connectivity to the channel system included aerial photograph interpretation and data capture using Geographic Information Systems supported by field measurements using RTK-dGPS and tacheometric surveys to derive landslide area and volumes.

Using six sets of aerial imagery (1946, 1974, 1977, 1999, 2005, 2011) more than 8,500 individual landslides were mapped. Landslide distribution is temporally and spatially variable. Total landslide area ranges from 0.24 km² (1999) to 2.25 km² (1974) and largely reflects the timing and influence of high intensity rainfall events. For the same reason hillslope-channel connectivity is similarly variable ranging from 38% of landslides in 1946 to 78% in 2005.

A better understanding of the drivers of these spatio-temporal changes in the Southern Ruahine Range will benefit policy decisions on remediation strategies required to limit future off-site damage as a consequence of landsliding and excessive sediment flux downstream of this Range.

****

Slope movements shaping the landscape in the Daunia Apennines (Southern Italy), and their effects on the built-up environment

PARISE M., VENNARI C.
CNR-IRPI, BARI, ITALY

The southern Apennines of Italy are characterized for wide sectors by outcropping of clay materials, highly prone to slope movements. This determines a high susceptibility to landslides, which, combined to expansion of the urban areas during the second half of the last century, bring to high vulnerability, too. In Daunia, the hill-to-mountain sector of Apulia, a transition area between the Apulian plain and the Apenninic Chain, slope movements represent the main agent modelling the landscape. They are mostly in a dormant state of activity, which nevertheless can change to active, generally due to rainfall or seismic triggers. A further triggering factor, which is quite often under estimated, is represented by the human action. Lack in the identification of ancient slope movements, and planning of engineering works and construction in landslide-prone areas, has often resulted in partial or total re-activations of ancient slope movements. In the present article, through analysis of an historical database about landslides in Daunia, we intend to investigate the control exerted by gravity-related phenomena on the landscape, the interaction between slope movements and human activities, and the effects produced by landslides on the anthropogenic environment. The issue of rainfall-triggered slope movements is also dealt with, with a first attempt in identifying pluviometric thresholds for the study area.

Constraining relative chronologies of mass movements using soil characteristics

KACPRZAK A.(1), MIGON P.(2)
(1) Jagiellonian University, Institute of Geography and Spatial Management, KRAKOW, POLAND ; (2) University of Wroclaw, Department of Geography and Regional Development, WROCLAW, POLAND

There have not been too many attempts to use soils as indicators of the age of landslides. The Kamienne Mts (SW Poland) are a mountain range which abounds in morphological evidence of past mass movements, often suggesting processes of relatively recent date. However, no historical records of landslide activity are available. On the other hand, it is usually assumed that in this part of Europe most slope materials owe their origin to processes acting in the Pleistocene, while soils are largely products of Holocene pedogenesis altering periglacial slope materials.

We put up a working hypothesis that landslides in the Kamienne Mts, or at least some of them, may have occurred in the Holocene, hence under conditions similar to those of today, but prior to historic times. To verify this hypothesis a study of cover materials and soils on landslide-affected hillslopes was undertaken. It followed an assumption that, if soil material is not removed by erosion, the degree of soil profile development increases with age. If landslides predate the Holocene, soils within and outside landslide-affected slopes should have similar characteristics. Conversely, differences in the degree of soil development on individual slope facets may indicate that they are of different ages, supporting the hypothesis of Holocene age of landslides with poor soil development.

The main investigated soil characteristics included horizonation i.e. the number and thickness of specific soil horizons, the degree of development of soil structure, the content of organic carbon and its distribution in the soil profile, soil texture i.e. particle size distribution, the content and lithology of rock fragments. The results indicate that some slopes have been evidently unstable in the Holocene and different generations of landslides are recognized. Estimation of the absolute age of the landforms is not yet possible. So far we are able to discern Pleistocene forms from the ones originated in the Holocene.

****

Crevice-type rockslide caves and their relation to the slope deformations

LENART J., PÁNEK T.
Department of Physical Geography and Geoecology, Faculty of Science, University of Ostrava, OSTRAVA, CZECH REPUBLIC

Crevice-type rockslide caves are developed in a different types of rocks (sediments, granites, limestones) where some kinds of slope deformations are established. The rockslide caves originate by the process of fissure propagation within the landslide body. The different types of mechanisms are enforced such as toppling, spreading and rotational movement. Each of them is accompanied by the genesis of typical shapes of underground crevices. Some crevice-type cave systems reached the tens of meters depth and thousands of meters length. The caves occur in the different parts of landslide body such as initial crevices above the landslide headscarp, within the slided blocks in the transport zone of the landslide and within the doubled ridges. We investigated some of the typical localities with occurrence of landslides and crevice-type caves: e.g. Crimean mountains (limestones), Outer Western Carpathians (flysh rocks – sandstones, shales; limestones) by several methods: electrical resistivity tomography, microstructural measuring, speleological and surface mapping, digital elevation model and cave maps comparison. By using these techniques we can investigate the internal and external structure of the landslide just in place and discover the genesis, succession and origin of the slope deformation.

Cliffs and screes: the Reverend Fisher, Bakker and Le Heux, Statham and Kirkby and DEM

RICHARDS K., BITHELL M.
University of Cambridge, CAMBRIDGE, UNITED KINGDOM

The evolution of cliff-scree systems is a geomorphological problem with a long pedigree. Fisher (1866) and Bakker and Le Heux (1947) first proposed geometrical solutions to the problem. In these, unit cliff recession generates a volume of particles that define incipient scree at the foot of the cliff, and as successive units of recession occur and the scree grows, the depositional layer becomes progressively thinner. This results in a convex rock core being formed beneath the scree as the cliff retreats. This geometric argument lacks consideration of the detailed process mechanics of scree development. Statham and Kirkby (1975, 1976) therefore focused attention on the rockfall process involved in determining scree geometry and surface sediment sorting; and explain how the scree slope increases as the cliff is buried, the scree tends to have a concave profile rather than being a series of surface-parallel layers, and coarser particles tend to accumulate at the scree foot. In this paper, we present results of Discrete Element Model simulations which reproduce the hypothesised character of the underlying rock core, but suggest that individual rockfall events play a rather limited role in determining bulk scree properties. Scree-head accumulations of rockfall debris instead trigger a sequence of mass failure events of varying scale that redistribute particles, lower the surface gradient temporarily, and generate a quasi-layered internal structure (with layers of sediment at lower gradients than the surface slope). Some of these events may mobilise a substantial proportion of the scree volume. The concavity of scree surface profiles is temporary, and more dependent on scree-head accumulation than on basal run-out; and the effect of mass movement on the scree geometry may only be seen intermittently (and very rarely in stable post-glacial screes). To test the hypothesis that mass movement is critical in scree evolution requires analysis of the internal stratigraphy.

****

Geomorphometric assessment of large mass movements in Afghanistan and Pakistan

SHRODER J.(1), BISHOP M.(2)
(1) University of Nebraska at Omaha, OMAHA, UNITED STATES ; (2) Texas A&M University, COLLEGE STATION, TX, UNITED STATES

The discovery and investigation of large landslides in the Hindu Kush and western Himalaya over the last three decades has demonstrated the significant influence of mass movement phenomena on coupled systems and landscape evolution. In particular, large landslides influence fluvial and glacial systems, as well as regulate catastrophic flood flushing of sediment. Nevertheless, we still lack a systematic quantitative approach for assessing the character and influence of landslides on the geomorphic system. Consequently, the objectives of this research were to investigate the utility of geomorphometry to characterize landside surface topography. Specifically, we used an ASTER GDEM 30 m digital elevation model (DEM) and generated primary and secondary geomorphometric parameters to examine altitudinal variations associated with erosional and depositional landslide zones. Altitude profiles of slope and curvature indicate significant changes in the topography associated with erosion and deposition zones. Planarity and concave profile curvature characterize the upper zones, whereas hummocky topography and highly spatially variable curvature is characteristic in lower depositional zones. Collectively, the hypsometry and altitude profiles may be useful for differentiating landslides and evaluating landscape dynamics. In situations where large mass-movement toes have moved into active glacier or river valleys, the lower altitude mass-movement mass may have been removed by the active glacial or fluvial processes, which can limit analysis. Nonetheless, geomorphometric assessment of mass movement in the Hindu Kush and western Himalaya offers the prospect of quantitative assessments that may more adequately characterize processes than other methods used heretofore.

Geomorphological processes affecting the conservation of the Shahr-e Zohak archaeological site (Central Afghanistan)

MARGOTTINI C.(1), FIDOLINI F.(2)
(1) Department of Geological Survey of Italy, ISPRA, ROMA, ITALY ; (2) Department of Earth Sciences, University of Firenze, FIRENZE, ITALY

The remains of the Shahr-e Zohak fortress are located on a steep hill at the confluence of the Kalu and the Bamiyan rivers, about 15 km east of the city of Bamiyan (Central Afghanistan). The site is thought to have been founded in the Buddhist period (6th-7th century A.D.), even if the fortification is dated to the Islamic period. Its position provided excellent measures of natural defence and control of the valleys as communication routes.

The fortress is protected by ramparts built along the steep cliffs bounding the site and equipped with several watchtowers. The access to the fortress is located on the eastern flank of the hill and the path leads to a triangular plateau enclosed within ramparts and different kind of buildings, at the northern end of the hill. The citadel is located on the topmost part of the hill, on its southern side, separated from the plateau by a NW-SE oriented valley and it is protected by three more orders of walls.

Buildings are mainly made of mud-bricks, obtained by the clayey red mud resulting from the weathering of the local terrain, placed on top of gravelly foundations. Due to the prolonged exposition to weathering, the lack of conservation measures and the misuse during war periods, many buildings have collapsed or are prone to collapse. The main problem endangering the site is the lack of and adequate drainage system ruling the runoff. Ramparts located on the steep flanks of the hill are severely affected by gully erosion and siphoning and building-related material is accumulated in the depressions. The access path is locally eroded or buried by debris cones. The western margin of the plateau is rapidly retreating due to collapses, while the citadel is in danger due to diffuse or gully erosional processes developed on all its sides.

All available information will be used to develop a conservation plan, integrating measures against soil erosion and erosion of mud-bricks walls. Solutions will include mainly the use of traditional techniques to solve deeply investigated geomorphological processes.

Poster presentations:

A 10-year record of erosion on badland sites in the Karoo, South Africa

BOARDMAN J.(1), FAVIS-MORTLOCK D.T.(1), FOSTER I.D.(2)
(1) University of Oxford, OXFORD, UNITED KINGDOM ; (2) University of Northampton, NORTHAMPTON, UNITED KINGDOM

Badlands are developing in the South African Sneeuberg uplands on Holocene colluvia which are up to 6 m deep on footslopes and valley bottoms. The area was overgrazed by sheep from 1850 to1950; stock numbers have been declining for the last 60 years. A farm raingauge within 5 km of the research sites gives annual average precipitation of almost 500 mm for the last 24 years, making this a relatively wet period.

Relatively long datasets of erosion (ten years or more) are rare in geomorphology. Such datasets are necessary to assess the impact of extreme events, and increasingly important as geomorphological studies place greater emphasis on the impacts of future climate change.

Ten sites with 25 erosion pins at each site were monitored annually from 2002 to 2012. Average rates of net erosion (average loss at eroding pins – average gain at accumulating pins) at each site range from 3.3 mm yr^{-1} to 8.7 mm yr^{-1}. These are approximately equivalent to erosion rates of 56 and 148 t ha^{-1} yr^{-1} respectively. At most of the study sites erosion rates are reasonably well correlated with amounts of rainfall within periods of measurement.

Badlands and seriously degraded land occupy less than 15% of the land surface. Most badland sites are well connected to valley-bottom gullies and, hence, small dams. Eroded sediment from a minority of sites is stored on footslopes and in fans and only intermittently moved to valley bottoms. Rates of sedimentation in small farm dam catchments without badlands are of the order of 5 t ha^{-1} yr^{-1} over the last 70 years. These rates rise to ~16 t ha^{-1} yr^{-1} when badlands are better connected to downstream dams. Over the last 50 years rainfall amounts on raindays have increased significantly and this 'climate change signal' is likely to have influenced erosion rates. The increase in rainfall intensity is also likely to influence erosion in the future. However, any climatically-driven increase in future erosion may be offset by falling stock numbers.

****

Le site archéologique El Tajin (Etat de Veracruz, Mexque) serait situé sur un ancien dépôt gravitationnel pouvant être à nouveau affecté par de futurs glissements de terrain

VENCES SANCHEZ D.A.(1), OCHOA TEJEDA V.(2), OROPEZA OROZCO O.(1), PARROT J.F.(1)
(1) UNAM, MEXICO D.F., MEXICO ; (2) Université de Strasbourg, ESTRASBURGO, FRANCE

La région étudiée comprend le site archéologique de l'une des villes les plus importantes de la Mésoamérique de la Période Classique (600 à 1200 de notre ère), El Tajin et son environnement qui correspond à la partie supérieure d'un micro-bassin. El Tajin se situe dans la région septentrionale et centrale de l'Etat de Veracruz, Mexique. On estime en première hypothèse que cette zone archéologique s'est édifiée sur un paléo-talus de débris provenant d'un glissement de terrain qui aurait affecté les formations instables de l'Oligocène de la région (épaisses couches de conglomérats et lits de grès peu consolidés et de schistes argileux). La région présentant de nombreuses traces de glissements de terrain anciens ou actuels, le but de ce travail concerne la recherche des traits structuraux qui permettent de vérifier notre hypothèse. Un Modèle Digital d'Elévation de haute précision sous forme d'image matricielle (2 mètres de résolution au sol, échelle hypsométrique en centimètres) a été engendré à l'aide d'une interpolation multidirectionnelle à partir de données vectorielles couvrant la zone d'étude. Ce Modèle Digital montre indubitablement que la zone archéologique se situe effectivement sur un paléo-talus dont il est possible de reconstituer le mouvement en utilisant une simulation tridimensionnelle spécialement développée à cette fin. Il est ainsi possible de comprendre comment se produisit le glissement de terrain, quelle est l'épaisseur des dépôts et jusqu'où ceux-ci se sont étendus. De plus, la formation en arrière-plan d'une nouvelle zone d'arrachement semi-circulaire laisse présager en l'absence de mesures préventives la répétition dans un avenir plus ou moins proche d'un évènement semblable recouvrant alors les traces de cette zone archéologique de première importance.

Large Landslides in the Nepal Himalayas and their significance: The Phoksundo lake (Dolpo District, Western Nepal)

FORT M.(1), RIMAL L.N.(2), BOURLES D.(3), GUILLOU V.(3), BALESCU S.(4), HUOT S.(5), LAMOTHE M.(5)
(1) Université Paris Diderot, UMR PRODIG, Sorbonne-Paris-Cité, PARIS, FRANCE ; (2) Department of Mines and Geology, Lainchaur, KATHMANDU, NEPAL ; (3) Aix-Marseille Université, CEREGE CNRS UMR 6635, 13545 AIX EN PROVENCE, FRANCE ; (4) Laboratoire Halma Ipel, UMR 8164 (CNRS), Université de Lille 1, 59655 VILLENEUVE D'ASCQ CEDEX, FRANCE ; (5) Laboratoire de Luminescence LUX de Montréal, Département des Sciences de la Terre et de l?Atmosphère, Université du Québec à Montréal, MONTRÉAL, QC H3C3P8, CANADA

Giant landslides are common features in active orogens. They are one of the most powerful processes of mountain slope denudation; they exert a strong control on upper watersheds morphology and sediment cascade. Their occurrence is generally considered as resulting from three main potential triggers: earthquakes, post-glacial debuttressing, permafrost melting. The Phoksundo lake (3600 m a.s.l.; area of 4.5-to-5 km^2) is the second largest lake of Nepal; it owes its origin to the damming of the Suli Gad River by a large (4.5 km^3) collapse of a mountain wall culminating at 5148 m, SE of the lake. The landslide morphology presents a series of mounds (metres to tens of metres high) and depressions of varying size. Its mass is composed of large blocks of massive dolomites found as far as west of Ringmo Village and down to the southern rim of the landslide dam. The coarse debris is widely mantled by a thick (up to 10 m) cover of silts, well prominent downstream above the Suli Gad gorges. Most of the Suli scarp is uphold by limestone's outcrops, but along the central part, where the former Phoksundo gorge is filled in by dark grey, fine sediments (till material), and overlain by orange conglomerates (including dolomites boulders), then by yellowish, unsorted conglomeratic material composed of blocks and calcareous silty matrix. This indicates the damming of the lake was caused by rockslides bodies derived from different parts of the rocky face bounding the lake in its SE part. The presence of glacial till at the very base of the sequence suggests the rockslide event is post-glacial. This assumption is now confirmed by cosmogenic dating: two consistent ^{36}Cl ages of 20,885 ±1675 argue for a single, massive event of paraglacial origin, that fit well with the last chronologies available on the Last Glacial Maximum in the Nepal Himalaya. OSL dating of silts ranges from Late Pleistocene to Holocene, and suggests a progressive trend to dryness of these Northern Himalayan regions.

****

Geomorphological characterization and long-term monitoring of slope movements between Salurn and Neumarkt (Adige Valley, Italy)

BOCCALI C.(1), DEVOTO S.(2), KEIM L.(3), STRADA C.(3), ZINI L.(1)
(1) Universita' degli Studi di Trieste, TRIESTE, ITALY ; (2) Universita' degli Studi di Modena e Reggio Emilia, MODENA, ITALY ; (3) Provincia Autonoma di Bolzano, BOLZANO, ITALY

In collaboration with the Autonomous Province of Bolzano a detailed geomorphological survey was started to identify and describe the slope instabilities of a mountainside along the Adige river, that was indicated by the authorities because it wasn't already study in detail and because of the presence, directly under the slope, of elements at risk.

The study area is located in the Autonomous Province of Bolzano (Northern Italy) and extends 35 km^2, fully on the left bank of the Adige river, from the border province of Bolzano - Trento until the beginning of the town of Neumarkt (BZ) in the North. The zone is dominated by two dolomitic massifs (Monte Madrutta and Monte Prato del Re), which are limited by high vertical walls and debris cones as connection with the valley.

The whole slope is affected by different types of landslide: primarily rock falls, topplings, slidings and, on large scale, lateral spreads. These last phenomena involve huge volumes of rock material. The described instabilities were identified in field by geomorphological and geological evidences: trenches of various sizes, cliff ledges, highly fractured rock masses and presence of ductile layers which underlie hard rocks.

During autumn 2009 a monitoring campaign was started in collaboration with the Autonomous Province of Bolzano. The first phase of monitoring activities has been consisted in a simple technique to measure periodically any movements of the detected fractures, i.e. the installation of fixed points inside the trenches.

In order to survey the surface displacements of the Monte Madrutta, GPS benchmarks have been installed on July 2012. This massif was long discussed by the experts because of a large landslide that generated the great dolomitic wall overlooking the Adige Valley.

This work illustrates the results of long-term monitoring and tries to identify the triggering factors that generate the above mentioned landslides.

Features of gravitational slope deformation in Mizunesawa Basin, west Tokyo, Japan

SAWABE K.(1), KARIYA Y.(2)
(1) Graduate School of Literature, Senshu University, KAWASAKI, JAPAN ; (2) Senshu University, KAWASAKI, JAPAN

We describe the geology and geomorphology of Mizunesawa Basin (MB), in the upper reach of Tama River, from the viewpoint of gravitational slope deformation. MB is surrounded by several mountain peaks at heights in the range ca.1000–1600 m ASL, and the azimuth of the main course of Mizunesawa River is in the NW−SE direction. The bedrock of MB mainly comprises Cretaceous sedimentary rocks of Shimanto Group that strike NW−SE and dip 60° to 80° east. Further, ridge-top linear depressions usually <10 m deep and up to 450 m long and antiscarps parallel to the main ridge are present in the MB. Valley bulging with minor antiscarps and gentle slopes are observed along the valley side slopes immediately below ridge-top depressions and antiscarps; rock deformation caused by toppling can also be observed along these side slopes. The radiocarbon ages of buried soils taken from a ridge-top linear depression indicate that the initial gravitational slope deformation might have occurred before 8000 cal BP and secondary progressive depression commenced after 3400 cal BP. Although MB exhibits well-developed features of gravitational slope deformation, neither accumulation terraces nor natural dams are present here; this fact points to the necessity of further study of long-term geomorphic development in the MB from the perspective of middle to large landslides resulting from rock deformation.

****

Historical rock avalanche in the east side of Mount Jizo, the Southern Japanese Alps, central Japan

KARIYA Y.
Senshu University, KAWASAKI, JAPAN

Bouldery deposits are present along Dondokosawa River in the east slope of Mount Jizo, the Southern Japanese Alps. Without any chronological and lithological evidence, it has been considered that these deposits were attributed to an ice-mass collapse that occurred during the Last Glacial maximum and resulted in considerable river aggradation at the foot of Mount Jizo. However, this study shows that these deposits have features indicative of a rock slide origin. Initial failure occurred on slopes ca. 2300 m ASL; the debris then travelled a distance of 3.6 km and was deposited around the valley floor of Dondokosawa River 1100 m ASL. The volume and H/L ratio of the deposits are estimated to be 1.8×10^7 m^3 and 0.32, respectively. The rock avalanche deposits comprise a thick gravel layer with granitic rock clasts only, though its present-day location is in a region with sedimentary bedrock. The rock clasts have characteristic jigsaw-puzzle structures, which indicate strong deformation by a landslide runout. The rock avalanche deposits immediately overlie a humic soil. Along the Marukawa River parallel to Dondokosawa River which had been blocked by a natural dam formed by the accumulation of rock avalanche deposits, these deposits are covered by fluvial sand layers and drifted wood trunks. Radiocarbon dating of drifted trunks and the wood fossils in a buried soil indicate the ages of the rock avalanche to be cal 778−793 AD. No large earthquakes have been reported in any historical document corresponding to this period. However, *Shoku Nihongi*, a national historical document, describes major losses resulting from floods in September 779 AD in ancient Shizuoka Prefecture just south of the study site; the heavy rains that occurred then may have triggered the rock avalanche. This study stresses on the importance of the chronological and lithological reevaluation of bouldery deposits in mountainous areas on a tectonically active margin.

Optimisation of Landslide monitoring based on geomorphological characterization

MARCATO G.(1), DIXON N.(2), SPRIGGS M.(2), PASUTO A.(1)
(1) IRPI - CNR, PADUA, ITALY ; (2) School of Civil and Building Engineering, 2 Loughborough University, LEICESTERSHIRE, UNITED KINGDOM

The left flank of the Tagliamento River Valley, at Passo della Morte along the National Road 52, is affected by several hill-slope processes, characterized by different typologies and different states of activity. These phenomena were mainly caused by debuttressing due to melting glacier, which occupied the valley until 15000 years ago. The different instability processes involve two road tunnels and can interfere with the Tagliamento River, through a serious risk of valley damming.

The present research is focus on two geological features: blockslides developed in the past as a rock avalanche and a limestone rock mass characterised by a structural setting which presents predisposition to instability.

Geomorphological survey techniques allowed definition of the most critical zones and the points to be monitored for hazard assessment. In particular, the field investigation produced extensive information to enable rigorous decisions in terms of optimum sensor types to be employed taking into account the expecting outputs and a cost and benefit analysis.

After two years of data collection it can be concluded that the choice of sensors has been appropriate to define the geometric characteristics of the unstable masses, and hence to better understand and define the possible evolutionary scenarios of the slope instability. Moreover, it is possible to confirm that the sensor selection and monitoring layout design derived from the geomorphological characterisation could be used in the future as an alert/alarm system for risk mitigation.

****

Contemporary hillslope processes sediment budgets in two glacier-connected drainage basins in western Norway

LAUTE K., BEYLICH A.A.
Geological Survey of Norway (NGU), TRONDHEIM, NORWAY

Hillslopes in defined drainage basin systems function as key elements for sediment production, storage and transfers from sources to sinks. Rates of hillslope processes are exceptionally varied and affected by numerous influences of varying intensity, especially in sensitive cold climate environments. This research has been conducted over four years (since 2009) and focuses on (i) contemporary geomorphic process rates and sedimentary mass transfers within the drainage basins Erdalen (79.5 km^2) and Bødalen (60 km^2) in western Norway, (ii) the absolute and relative importance of the identified relevant denudational processes and (iii) the importance of sediment delivery from slope systems for the drainage basin sediment budgets. Relevant denudational processes are analysed by combining geomorphologic mapping, geophysical subsurface investigations, terrestrial laser scanning and spatial data analysis with process monitoring. For monitoring contemporary surface processes a designed program has been applied at selected hillslope test sites including e.g. installed nets for collecting freshly accumulated rockfall debris, remote cameras for monitoring rapid mass movement events (avalanches, slush- and debris flows), stone tracer lines for measuring surface movements as well as temperature loggers both in rock walls and talus slopes for analysing rock temperatures and mechanical weathering. Slope wash traps for analyzing slope wash denudation have been installed and measurements of solute concentrations at small hillslope drainage creeks for investigating the role of chemical denudation have been conducted. Results show that snow avalanches and rock falls are comparably important processes regarding geomorphic mass transfers. The level of slope-channel coupling is altogether limited. It is higher in Bødalen as compared to Erdalen causing comparably higher rates of sediment delivery from slopes into channels in Bødalen. Both drainage basins represent supply-limited systems.

Analysis of rainfall-induced shallow landslides in Jamne and Jaszcze stream valleys (Polish Carpathians)

BUCALA A.(1), ZYDRON T.(2), DEMCZUK P.(3), GRUCHOT A.(2)
(1) Institute of Geography PAS, KRAKOW, POLAND ; (2) Department of Water Engineering and Geotechnics Agricultural University, KRAKOW, POLAND ; (3) Department of Geomorphology, UMCS, LUBLIN, POLAND

The subject of this paper is the analysis of stability loss of slopes in the Jaszcze and the Jamne stream valleys (the Gorce, the Flish Carpathians), that were caused by heavy rains in July 1997 and 2008, during which maximum daily precipitation was accordingly 70 mm and 76,3 mm. Both streams catchment areas are characterized by V-shaped deeply incised valleys, narrow channels and occurrence of numerous rock steps. More than 61% of slopes have the inclination above 18°. The Jaszcze stream catchment area is a narrow valley with steep slopes exposed mainly to south and north-east, where higher parts of slopes are covered by forests, meadows and pastures. In the lower parts of the catchment area arable lands dominate. The Jamne stream valley is wider, exposed to the south and mostly deforested or agriculturally used. Precipitation from the mentioned period caused activation of a number of landslides that were mostly shallow, translation and rotational slides. Field tests showed that the thickness of weathered clayey gravels was from 1.0 m to 1.6 m in lower part of slope. These formations have medium permeability, which is connected with low content of fine fractions. For determination of slope stability conditions in both catchment areas integrated calculations of infiltration and stability in GIS environment were carried out. For that purpose two calculative models were used, which describe infiltration process of rainfall in soil differently. In the first one – model SINMAP - steady subsurface flow was considered. In the other model – TRIGRS – infiltration of rainfall and changes of stability conditions related to diffusion process of water in soil as well as changes of pore water pressure are considered.The projectis funded by the NationalScience Center (NN 306 659 940).

****

An outline of landslide-triggering rainfall thresholds in the Flysch Carpathian Chain

BIL M.(1), DLUGOSZ M.(2), MICU M.(3)
(1) Transport Research Centre, BRNO, CZECH REPUBLIC ; (2) Institute of Geography and Spatial Organization, Polish Academy of Sciences, KRAKÓW, POLAND ; (3) Institute of Geography, Romanian Academy, BUCHAREST, ROMANIA

The Carpathian Mountains is the most representative mountainous chain of the Central and Easter Europe, extending along some 1,500 km from the Vienna basin (Austria) until the Timok Valley (Serbia). Compared with their highest altitude (2655 m), the flysch belt of the Carpathians, which borders the chain towards exterior, forms low and medium-altitude mountains reaching only 1400-1800 m. The climate, lithology (different strength sandstones, schistose marls and clays alternating with sands or gravels), together with the morpho-structural traits (intensely folded and faulted mountains, sometimes with steep slopes and large valley corridors) and active neotectonic movements, on which overlaps an intense and long lasting habitation, resulted in a wide variety of slope processes.

The landslides represent potential threats to a very large typology of elements at risk, and reliable risk management strategies should be based on proper susceptibility and hazard mapping and assessment. The determination of precipitation quantities leading to soil, regolith or bedrock saturation is difficult, due to diversified conditions of water infiltration and underground circulation and also due to their spatial distribution.

The purpose of this study is to outline, through local case-studies and regional evaluations, certain landslide-triggering rainfall thresholds, which will represent the basis for a proper landslide frequency-magnitude relationship assessment. Intense summer rainfalls, together with long-lasting autumn rains and spring showers (sometimes overlapping snowmelt) reflected by daily-monthly-annually average and maximum values were analyzed in areas like the Vizovice hilly land near the Czech–Slovak border, Beskid Niski Mts., Poland**,** and the Curvature Carpathians of Romania,also outlining the landslide-triggered typology.

The importance of this study is that gives the background of a regional landslide hazard assessment for one of Europe's most landslide-prone areas.

Analysis of spatial distribution of piping forms in Bieszczady Mts., Carpathians

BERNATEK A.
Institute of Geography and Spatial Management, Jagiellonian University, KRAKOW, POLAND

Piping as a process of mechanical flushing of particles by underground streams leads to the formation of surface and subsurface forms. It has an influence on the mountain relief. The knowledge of spatial distribution of piping forms allows to recognize a role of piping in the shaping of mountain relief.

This paper presents first results of research on spatial distribution of piping forms in Bieszczady Mts. (Carpathians). Four areas were selected to the detailed investigation – two in High Bieszczady Mts. (Tyskowa and Wolosatka catchment) and two in Low Bieszczady Mts. (Cisowiec and Bereznica catchment). The detailed geomorphological mapping was carried out. Moreover the detailed geodesic measurements using electronic total station were undertaken.

Piping forms occur in groups of several forms. They develop on the slopes with inclination approximately 10-20 degrees, both on the slopes covered by forest and by grasslands. Moreover, they exist both on the abandoned slopes and slopes used for agriculture (mainly pasture).

According to the morphological relation with landforms, piping forms can be divided into three groups. The first group includes forms which are developed independently of the existing gullies. They are supposed to be an initial stage of formation of the gully. The second group presents forms already connected with gullies. They are in upper part of them, which confirm that they could begin the formation and development of gullies. The last group consists of forms related to the gullies transformed by landslides. They appeared because of the colluvial deposits in channels, where water infiltrates underground to adjust to new condition of runoff.

The analysis of spatial distribution of piping forms enables to recognize the role of piping in shaping of mountain relief. In addition, the geomorphological maps with marked piping forms allow to identify areas where potentially gullies can be developed.

****

Impact of climate change on landslide reactivations in the French Alps

LOPEZ SAEZ J.(1), CORONA C.(2), STOFFEL M.(3), BERGER F.(1)
(1) Irstea, SAINT MARTIN D'HERES, FRANCE ; (2) CNRS UMR6042 Geolab, CLERMONT-FERRAND CEDEX, FRANCE ; (3) Laboratory of Dendrogeomorphology, Institute of Geological Sciences, University of Berne, BERNE, SWITZERLAND

Past process activity on seven landslide bodies of the Riou Bourdoux catchment (southeastern French Alps) was reconstructed with an unusually large number of samples (3036 increment cores) from 759 conifers affected by past landslide reactivations. Based on 1298 growth anomalies identified in the cores, we identified 61 landslide phases since AD 1890. Logistic regressions and threshold analyses using monthly rainfall data and temperature anomalies indicate that landslides used to occur after wet winters with subsequent positive temperature anomalies in spring in the past, and thereby point to the crucial role of snowmelt in landslide triggering at the catchment scale. Since 1990, however, landslide activity in the Riou Bourdoux catchment shows an excessive and unprecedented increase in activity (12.5 events 10 yr–1), which is, in addition, favored by positive temperature anomalies in spring. This evolution suggests a shift from snowmelt induced landslides (controlled by winter precipitation) to events controlled by spring temperatures and add evidence to the hypothesis that climate change (and warmer springs) could further enhance landslide activity in the course of the 21st century.

Hydrometeorological triggers of debris flows in the Tyrol region (Austria) since 1910

CORONA C.(1), STOFFEL M.(2), KAITNA R.(3), HÜBL J.(3)
(1) GEOLAB, CNRS UMR6042 Geolab, CLERMONT-FERRAND, FRANCE ; (2) Laboratory of Dendrogeomorphology, Institute of Geological Sciences, University of Berne, BERNE, SWITZERLAND ; (3) Institute of Mountain Risk Engineering, University of Natural Resources and Life Sciences, VIENNA, AUSTRIA

Through their unpredictable and sudden occurrence, debris flows represent a major hazard in many mountainous regions of the world. The understanding of the triggering factors of such events is crucial for hazard assessment, the forecasting of potential future events and for early warning systems. In the recent past, many studies have been published on debris-flow triggering, rainfall conditions, minimum thresholds, duration-intensity relationships or on antecedent moisture conditions. Yet, these studies often covered a rather limited temporal dimension and remained rather isolated for single torrents.

In the study we present here, the definition of triggering rainfall events is based on an unusually dense database, containing 1047 events and dating back to AD 1008. The assessment is based on a historical database of 181 debris-flow channels located in three different regions, 26 torrents and 36 meteorological stations, all located in the Austrian Alps. We report on the (i) timing and (ii) duration of precipitation events, (iii) the amount of rainfall involved, (iv) changes in the seasonality of events, (v) define minimum precipitation thresholds needed for the triggering of past debris-flow events and (vi) assess the percentage of rainfall events with certain thresholds leading to the triggering of a debris flow.

Results show that the debris-flow season in the Austrian Alps lasts from April to November with July being the month with the highest occurrence of events (30%) whereas events in April and November remain very scarce with 2% and 4%, respectively. The triggers are very sensitive to the selection of the meteorological dataset and to the region. Some 70% of the events were released after persistent advective rainfall of more than 3 days. Total precipitations sums involved in the triggering range from below 20 mm for short-duration events generally occurring in a single torrent to up over 180 mm for the long-lasting events.

****

Landslide development within the Barlad Plateau of Eastern Romania

NIACSU L.(1), IONITA I.(2)
(1) University "Alexandru Ioan Cuza", IASI, ROMANIA ; (2) University, ,

The Barlad Plateau, extending about 8,230 square kilometers is considered as the most typical unit of the Moldavian Plateau of the Eastern Romania. The Miocene-Pliocene clay-sandy layers are inter-bedded with shallow sandstone and limestone seams. These sedimentary layers that have outcropped as a result of erosion are gently dipping toward S-SE in the form of a monocline. Landslides have been recognized as an important environmental threat in the major subunits of the Barlad Plateau, namely: Central Moldavian Plateau, Falciu Hills and Tutova Rolling Hills.

Four main areas of monitoring landslides were explored such as successive aerial photographs of the 1960, 1970, 2005 and 2009 flights, repeated field surveys for a thorough reconnaissance of the study area, classical levelling work and GIS software applications as TNT Mips and Arc GIS. Also, the Caesium-137 technique has been used to get information on documenting sedimentation rates in some small catchments.

Results have indicated that the landslide development is strongly controlled by the northern and western looking steep faces of cuestas, by changes of rock composition and by human impact. Also, it showed great pulses in conjunction with the rainfall distribution. For example, half of the Upper Barlad catchment that drains an area of 22,560 ha is covered by landslides. Furthermore, the active landslides amounted 11% of the total (2,317 ha) after the rainy 1968-1973 period and since 1982 under drier conditions they gradually limited to 444.0 ha (2% of the total).

Landslide Distribution Induced by Large-scale Earthquakes in 2011, in Iwaki City, Japan

SATO G.(1), HAYASHI K.(2), YAGI H.(3), HIGAKI D.(4)
(1) Teikyo Heisei University, TOKYO, JAPAN ; (2) Okuyama Boring Co., TOKYO, JAPAN ; (3) Yamagata University, YAMAGATA, JAPAN ; (4) Hirosaki University, HIROSAKI, JAPAN

Iwaki City in eastern Japan experienced two large-scale earthquakes in 2011: the Great Tohoku earthquake that occurred on March 11 and an active-fault earthquake that occurred on April 11. We developed a landslide distribution map of Iwaki City using aerial and satellite images; this map shows that the number of landslides induced by the April 11 aftershock alone accounted for 70% of all landslides induced by both the March 11 and April 11 earthquakes. In particular, we show that the distribution of landslides caused by the April 11 earthquake was determined by the structure of the fault and the lithological characteristics. The distribution of landslides was relatively concentrated around the hanging wall side of faults that appeared to be normal faults, and the large-scale landslides were concentrated in areas of Paleogene sedimentary rock.

****

The unstable area of Ajanedo, Cantabria (Spain): A proposal for inclusion in Global Landslide Database

FERNANDEZ MAROTO G.(1), GONZALEZ-DIEZ A.(2), DOUGHTY M.(2), MARTINEZ CEDRUN P.(1), DIAZ DE TERAN J.R.(2), REMONDO J.(2), CARDENAL J.(3)
(1) Universidad de Cantabria, TORRELAVEGA, SPAIN ; (2) Universidad de Cantabria, SANTANDER, SPAIN ; (3) Universidad de Jaen, JAEN, SPAIN

Inventories are a tool of special interest in the analysis of landslides hazard because through them you can get information from the spatial and temporal occurrence and the magnitude of landslides involved. Using LiDAR and photogrammetric techniques allows to make high-precision inventories, as it improves the spatial characterization of the event eliminating many of the errors that are attached to the mapping of landslides.

Ajanedo area (Cantabrian Range, Spain) is an area of great interest as it has many types of sliding as rock slides, rock falls and lateral spreads affecting the substrate, with clear signs of recent activity allow proposing to form part of a Global Landslide Database. This area is located at the junction of two tectonic accidents featured within the Cordillera, such as “El Escudo de Cabuérniga” Fault and the “Selaya-Arredondo” Fault, which currently show clear seismic activity, with some energetic episodes recorded during the past 11,000 years and emissionof high doses of Radon^{222} in the waters of the springs associated with these fractures. However, recent weather events (heavy rain, frost, etc..) have revived some of rock avalanches in the area.

Inventory developed has identified a large unstable area of over 212ha where deep landslides are numerous spatially related, among them are a large unstable area covered by forest, a graben area, areas with falling rocks linked the trace of the fault that crosses the zone and a zone of rock avalanches that it has presented numerous events of recent activity. The last event cut in 2006, the road leading to a neighboring locality, leaving her isolated. Besides the inventory has allowed to know the relationships between areas affected by landslides and the volume involved in the same, these data verify models frequency distributions of size-volume proposed in the literature.

Anatomy of a landslide: a study case in the vineyard of Champagne (France)

BOLLOT N.(1), PIERRE G.(1), SAMYN K.(2), FRANCOIS B.(2), MARRE A.(1), GRANDJEAN G.(2), ZORNETTE N.(2), GARCIA O.(3)

(1) GEGENAA - EA 3795, Université de Reims Champagne-Ardenne, REIMS, FRANCE ; (2) BRGM, Risk Division, ORLÉANS, FRANCE ; (3) CIVC, Services techniques, EPERNAY, FRANCE

Mass movement, though unstudied and even unknown until the eighties, is the major process in the development of the hillslopes of the vineyard of Champagne. Thus far, they have been monitored by means of surface analysis, leading to large scale cartography of their relief. Slumps and associated earth flows are mostly concerned. Relative age of these processes is also known: oldest slumps occurred before the last glacial period, some of them (slump and earth flow) are reactivated during the Holocene, and the actual downslope movements, of various sizes, lead to major damages throughout the vineyard. Three of the most important recent slides occurred in Rilly la Montagne (1986), Cuis (1988) and Boursault (2000).

Surface analysis of these mass movements is not sufficient to understand the actual factors of slope instability. Such a study requires considerations of the following criteria: the thickness of the displaced material, its internal structure and its hydrogeological behaviour. Geophysical investigations (seismic surveying and electrical resistivity profiles) made on the rotational slide of Reuil (Marne valley) allow to specify these three points. First of all, and unexpected considering the low energy relief of the vineyard of Champagne, it is a deep-seated slump (60 m thick). Secondly, the knowledge of the internal structure of the displaced material, coupled with piezometric and pluviometric data, leads to a hydro-mechanical slope-model. As planning operations, often consisting in hydraulic managements, are conducted without taking into account slope processes (though most of the vineyard stands on mass movements!), it results in frequent reactivation of the landslides. Thus, a better knowledge of slope instability should permit to assign more means to correction and hazard prevention.

****

Internal structure and triggering conditions of two recent shallow landslides in the Pays d'Auge plateau (Normandy, France)

FRESSARD M.(1), MAQUAIRE O.(1), AMORESE D.(2), FONT M.(3), DAVIDSON R.(1), THIERY Y.(4)

(1) UMR 6554 CNRS, LETG-GEOPHEN, University of Caen Basse-Normandie, CAEN, FRANCE ; (2) Observatoire Volcanologique et Sismologique de Guadeloupe, IPGP, GOURBEYRE, FRANCE ; (3) UMR 6143 CNRS, M2C-Caen, University of Caen Basse-Normandie, CAEN, FRANCE ; (4) EURO-ENGINEERING, PAU, FRANCE

This study concentrates on the identification of the structure and the mechanical properties of two shallow landslides located in the Pays d'Auge plateau (Normandy, France). They are representative of the 180 shallow landslides inventoried on the region. The main objective is to understand the landslides dynamics and behaviour in order to quantify triggering thresholds that could complete the scarce historical data on the region for the hazard analysis.

For the landslide morphology and structure identification, a multi-method approach was selected. Morphodynamic maps were performed in the field using cartographic GPS in order to depict the surface morphology and map the estimated landslide activity. These field measurements were completed with the analysis of all available air-photo images from the French National Geographic Institute (IGN), to identify the occurrence dates and the possible landslides reactivations. For the landslides structure identification, multiple electric tomography profiles combined with augurings and penetration tests were conducted. Despite a globally low electric resistivity of the landslides materials (i.e. ± < 80 ohm.), the electric profiles show good agreement with the interpreted structure using the direct observations (augurings and penetration tests). They have then permitted the identification of the slipping surface, internal morphology and paleotopography of the landslides.

In combining the internal structure and the materials mechanical properties the safety factor was assessed using a finite slope model. The evolution of this safety factor according to the rainfall and the ground water levels show that the landslides are more likely to occur after long episodes of moderate precipitation with an important role of the preliminary conditions. These results are finally well in accordance with the prior general assumptions and the few available well dated landslides.

Morphometric and morphologic parameters and the occurence of debris flow in Serra Do Mar (SP, Brazil)

DIAS V.C., VIEIRA B.C.
Universidade de Sao Paulo - USP, SAO PAULO, BRAZIL

The occurrence of mass movement is related to several controlling factors, such as morphometrics characteristics of the watershed (density and drainage type, number of fluvial channels and hierarchy) and morphology of the slope (lithology, vegetation and soil), wherefore these studies are clearly important for the elucidate the dynamic of the aforementioned factors. In Serra do Mar, a mountain range that extends for about 1,500 km along the southeastern coast of Brazil, the occurrence of landslides and debris flow in some basins is quite common, due to the relief characteristics and the high rainfall indexes. Thereby, the aim of this research is to identify the main morphometric and morphological factors that contribute to the occurrence of debris flow in the city of Caraguatatuba (SP), in the Serra do Mar. Because of intensity of debris flows processes that occurred, the Guaxinduba basin was selected for the study. The morphological and morphometric analysis were made by the elaboration of digital elevation model (DEM), the digitalization of topographic maps and the use of the ArcGis 10's tool (Hidrology). The location of the debris flows deposits was detected by the analysis of aerial photographs dated from 1973 and fieldworks. The major morphological and morphometrics characteristics indicated a strong structural control caused by the presence of geological faults, which influenced the river flow and the distribution of deposits. Besides, due to presence of many concave slopes, there is an accumulation of water in these curvatures, increasing the surface and subsurface flow, as well as sediments into the drainage. This research can contributes for risk potential of debris flow being useful for developing a better land use management, since this is an area with a large number of houses, which are subject to the possible losses arising from the occurrence of debris flow; moreover, the studies about those processes are scarce in Brazil, despite its high frequency.

****

Mass movements, landscape and river morphology evolution around Bujumbura City in Burundi

NKURUNZIZA P.
Universite du Burundi, BUJUMBURA, BURUNDI

The landscape around the Capital city of Burundi, Bujumbura, is subsequent to the forming of East Africa Rift Valley. This is constituted of the Rusizi-plain which is dominated by mountain ranges on both sides. The later are subject to vertical erosion which produces a landscape in V which characterizes a young phase of peneplanation in the spirit of the Davis theory.

Another important phenomenon to observe is the landslides and gullies which affect the landscape on a significant scale. The later are stimulated by river flow on the one hand and intense runoff on the other hand but also by anthropogenic action which is related to a high deforestation and bad agricultural practices.

The objective of this study is to demonstrate that in addition to the natural geomorphic change related to the meteoric action, the anthropogenic influence is a factor which has a negative impact on the geomorphology of the studied area. Thus, due to the bad agricultural practices, we can observe an accelerate erosion of the catchment area which endangers the future generations. Indeed, the mass movements which occur through the reduction of the vegetal coverage and bad agro-technical practices will quickly exposed the rocks at the surface. Moreover, the lack of vegetal coverage combined with the climate change produce dramatically heavy erosion, floods and increases the sediments rate in the Tanganyika Lake.

Another aspect to be the analyze in this study is the impact of a quick and planning loss urbanization of Bujumbura City related not only to rivers morphology but also to the environmental and socio-economic problematic. Indeed, the rivers flow is disturbed because of intensive buildings material exploitation and household waste discharge in the rivers.

Those phenomena which can be considered as "geohazards" will be analyzed with modern methods using combined methods of remote sensing and mapping using the software ArcGis 10, real photos and direct observations on the field.

Environmental fragility of watershed of Serido River (RN/PB - Brazil): subsidies for territorial environmental planning

PEREIRA NETO M.C., FERNANDES E.
Federal University of Rio Grande do Norte, NATAL, BRAZIL

There are many applications coming from geomorphological studies and their different constitutive and inter related elements, to the implementation of public politics of planning and environmental management. This paper presents an analysis of the environmental fragility of the watershed of Seridó River, situated between the states of Paraíba and Rio Grande do Norte (Brazil), including the identification of possible unstable areas. It is based on the methodological approach of Ecodynamics of the French researcher J. Tricart (1977) and on the operalisation proposal advocated by the Brazilian J. Ross (1994), related to the Potential and Emerging Ecodynamic Units, grounded in the index of relief dissection or the topographic roughness, soil, rainfall and land use/vegetal cover. Under a quantitative perspective, the results obtained from the analysis of the watershed can be divided into classes of potential fragility: around 2.613,0 Km² of low intensity, 5.188,4 Km² of medium intensity and 2.585,5 Km² of high intensity. Concerning the emerging fragility, the results are close to 2.212,0 Km² of low intensity, 6.191,23 Km² of medium intensity and 2.062,34 of high intensity. The collected data is relevant for the territorial and environmental planning of the watershed, once we can still verify a close association of the cities on the central area of desertification with the areas of high environmental instability/fragility. This is an important tool to the understanding of the potential susceptibility of the natural and anthropic environments related to the advance and/or intensification of the erosion process, rock falls, mass movements, among other phenomena inside the potential unstable areas. From this perspective, the continuity of this research becomes extremely important to the understanding and arrangement of the process, together with the engendering and sustainability of the system in its totality.

****

Monitoring of sediment movement in an artificial forest, Japanese steep mountain

NISHII R.(1), IMAIZUMI F.(2), UENO K.(3), KUROBE K.(3)
(1) University of Tsukuba, SHIZUOKA, JAPAN ; (2) Shizuoka University, SHIZUOKA, JAPAN ; (3) University of Tsukuba, TSUKUBA, JAPAN

Artificial forests are widely distributed in steep slopes, Japanese mountains. On such steep artificial forests, sediment is easily transported by surface flow as well as gravity acting on the sediment itself. Therefore, sediment movement near ground surface can be sensitive to rainfall and freeze-thaw action. The processes and weight of sediment movement near ground surface were evaluated in an hinoki (Japanese cypress) artificial forest, Ikawa University Forest (about 1400 m a.s.l.), by sediment trap survey from June 2011 to March 2012; Six traps were set up on the slopes of three types which are convex, concave and planer slopes. Sediment accumulated in the traps was collected and weighed 10 times during the period. Concurrently, data loggers monitored meteorological parameters, including precipitation, air and ground surface temperatures and soil moisture. The total weight of sediment indicated large variations from 3 kg to 250 kg depending on the traps. Such a difference in the weight seems, in addition to the slope shapes, to be caused by materials (grain size) composing the ground. During the observation, the sediment movement indicated temporal variation. Timing of active sediment movement corresponded with the intense rainfall events (>50 mm/day). This result suggests that surface flow is important for sediment movement.

Assessing of soil loss caused by active landsliding at the catchment scale: comparison of two different methods in Japan and Italy

OKAMOTO A.(1), UCHIDA T.(1), HAYASHI S.I.(1), CAVALLI M.(2), MARCATO G.(2), PASUTO A.(2)
(1) National Institute for Land and Infrastructure Management, IBARAKI, JAPAN ; (2) IRPI - CNR, PADUA, ITALY

Sediment transport rate in mountainousstreams is strongly controlled by sediment yield due to erosion and landslides, therefore giving a valuable contribution in the definition of the state of activity and potential impact of active landslides. However, a comprehensive monitoring system of sediment dynamics is usually very expensive, time consuming and above all technologically complicated. In this paper we compare two different approaches used in two test sites in Japan and Italy.

The difficulties in directly monitoring of traction processes have been widely recognized and prompted research towards indirect monitoring techniques, including acoustic and seismic methods.Recently, a new method to indirectly measure the volume of bedload transport from sound pressure data, provided by hydrophones, was proposed. The preliminary results of the measurement campaigns in the Japanese test site will be here presented showing that the bedload transport rate evaluated by hydrophone fit very well with the data gathered by direct sampling for both long- and short-term time spans.

Inthe Italian test site, a geomorphometric approach, consisting in computing the difference of DTMs derived from LiDAR data acquired at different times, has been carried out at catchment scale helping assessing the loss of soil caused by erosion processes and in the identification of areas of sediment deposition during a specified time span.This approach is suitable for the study of processes with higher magnitude than sediment transport causing morphological variations higher than the propagated DTMs errors (i.e. debris flow).

The possible integration of these approaches can cover a wide range of sediment transport processes (from suspended sediment to debris flow) that affect mountain basins. Therefore, the resultsso far obtained clearly show that these analyses can be functional in establishing a comprehensive management plan for a sustainable land use, and in designing of mitigation works.

****

Statistic/cartographic approach to the geomorphological analysis of slope instabilities in the periglacial environments of the Aosta valley (Western Alps, NW-Italy)

PALOMBA M.(1), GIARDINO M.(2), RATTO S.(3), POGLIOTTI P.(4)
(1) Dipartimento di Scienze della Terra - Universite di Torino, TORINO, ITALY ; (2) Dipartimento di Scienze della Terra - Universita' di Torino, TORINO, ITALY ; (3) Centro Funzionale Regione Autonoma Valle d'Aosta, AOSTA, ITALY ; (4) Arpa Valle d'Aosta, AOSTA, ITALY

Geomorphological studies have been performed at a regional scale in the Aosta Valley Region (a small alpine region located in NW Italy) to better understand landslide spatial and temporal frequency and to investigate the main controlling factors of instability in high mountain areas of possible permafrost degradation. A comparison between the high mountain areas and the rest of the territory has been also performed. A great amount of data collected and analysed into a GIS system: different landslides inventories (IFFI Project Database, “Catasto Dissesti”), permafrost distribution maps and several geothematic maps produced within the research for the analysis of environmental controlling factors of instability (i.e. slope and aspect maps derived from the Digital Elevation Model for topographic factors and geological maps for litho-structural ones). Then, spatial analysis and statistical studies have been applied to 255 identified landslides within the areas with permafrost: mainly rock falls, corresponding to a landslide density equal to 0.48 events/km^2 and a landslide index of 11%. Data considerably lower than the analogous values calculated for the whole region (respectively 1.18 events/km^2 and 19%). Furthermore, in these areas it has been observed that, in terms of landslides mean areal extent, the obtained values are higher than those of the rest of the region for almost all types of movement (i.e. rock falls increase in the mean areal extent is more than 40%). Only in the case of Deep-seated Gravitational Slope Deformations the values are considerably inferior, because of their lower evolution degree in high mountain areas. The landslide index calculated for all the classes of the controlling factors considered within the research highlighted how, almost in all cases, areas with permafrost show lower values than the rest of the territory.

Topographic controls and mathematical modeling of landslides in Southern Brazil

SILVA L., ARAÚJO J., BRAGA B., FERNANDES N.
Federal University of Rio de Janeiro, RIO DE JANEIRO, BRAZIL

Mass movementsare natural phenomena that occur on the slopes and are important agents working in landscape development. In addition to the mass movements occurring in natural slopes, there is also a large number of accidents induced by human action in the landscape. Thechange of use and land cover for the introduction of agriculture is a good example that have affected the stability of slopes.In Brazil, especially in the southern and southeastern regions, areas of original natural rain forest have been continuously replaced by agriculture during the last decades. In November 2008, a major landslide event took place in a rural area with intensive agriculture in the state of Santa Catarina (Morro do Baú) where many catastrophic landslides were triggered after a long rainy period. In this area, the natural forest has been replaced by huge banana and pine plantations. In this study, based on field mapping and modeling, we characterize the role played by geomorphological and geological factors in controlling the spatial distribution of landslides in the Morro do Baú area. In order to attain such objective, a digital elevation model of the basin was generated with a 10m grid in which the topographic parameters were obtained. The spatial distribution of the scars from this major event was mapped from another image, obtained immediately after the landslide event. Numerical simulations with the SHALSTAB model were carried out in the basin and the results compared to the original location of the scars in the field. The results suggest that the combination of field mapping with the numerical simulation scenarios may contribute to the definition of better land management practices in such environment. Besides this, the replacement of the natural rain forest by huge banana plantations in this environment may have played a major role in defining the spatial distribution of landslides scars and the magnitude of the landslides generated.

****

Landslide Inventory in Ialomita Sub Carpathians, Romania

CHITU Z.(1), ISTRATE A.(2), SANDRIC I.(3)
(1) National Institute of Hydrology and Water Management; Faculty of Geography, Spiru Haret University, BUCHAREST, ROMANIA ; (2) Faculty of Geography, Valahia University, TARGOVISTE, ROMANIA ; (3) Faculty of Geography, University of Bucharest, BUCHAREST, ROMANIA

Landslides are a common geomorphic process in Ialomita Sub Carpathians, producing numerous damages to the infrastructure every few years (1970, 1972, 1975, 1978, 1980, 1986, 1992, 1995, 1996, 1997, 1998, 2005, 2006, 2010 and 2012). This area is located in the western part of Curvature Sub Carpathians, one of the most complex geological units in Romania. In order to reduce landslide consequences, a landslide inventory was carried out for landslide susceptibility and hazard assessment. In Ialomita Sub Carpathians, information about spatial and temporal landslide distribution was recorded (from 1965 to 2000) as point features by Istrate et al. (2006). Beginning with 2007, a landslide inventory, represented by polygon features, was carried out combining geomorphic field mapping and visual interpretation of aerial oblique images. Gemorphic field mapping was done during 2007-2010, using a Total Station SOKKIA, PDA Asus with Garmin Receptor and SIRF III antenna. The oblique images were collected during three flights over the study area between 2008 and 2010 using a small aircraft, model Cessna F172H and a DSLR camera Canon 400D, 10 Megapixels with Tamron lens 18-250mm.Over 1800 landslides were mapped and classified. The landslide inventory was used to generate two landslide susceptibility maps, based on expert knowledge and Weight of Evidence methods. The validation of the two landslide susceptibility maps using ROC method revealed that the ROC curve value (0.76) for the map based on expert knowledge method presents a value close to the ROC curve value (0.82) for the map carried out with Weight of Evidence method. This result leads us to believe that expert knowledge method for landslide susceptibility assessment can be used successfully, saving time and money, when there is a reliable inventory of landslides.

Geomorphic coupling of deep-seated landslides and channels: Paltineni case-study (Buzau Carpathians, Romania)

BELL R.(1), MICU M.(2)
(1) Dept. of Geography and Regional Research, University of Vienna, VIENNA, AUSTRIA ; (2) Institute of Geography, Romanian Academy, BUCHAREST, ROMANIA

The impact of deep-seated landslides on river network has a long history within the Curvature area of the Romanian Carpathians. Several such processes were recorded since 1883, consisting of deep-seated rock and debris-slides and debris-flows, which caused river shifts, blockages and lake occurrences. Developed mostly between 600-900 m a.s.l., they formed permanent lakes (Balatau lake, on Uz river) or temporary lakes (on Basca Rozile, Slanic, Teherau, Hartagu, Zabala, Buzau rivers). Such a landslide occurred at Paltineni, along Buzau river, in a geomorphological setting marked by older and younger similar processes having an obvious impact on the coupled slope-channel system. With just the accumulated landslide tongue covering an area of 29 ha, the landslide affected the entire slope profile and caused a 400 m westwards shift of the river, followed by the build-up of a new alluvial plain. Detailed analysis of this landslide include geomorphological mapping, 2D-resistivity analysis and terrestrial laser scanning. The geomorphological map indicates that 5 ha of the landslide are regularly reactivated due to lateral erosion by the Buzau river and precipitation. The 2D-resistivity results clearly show that below the landslide tongue alluvial sediments can be found. Repeated terrestrial laser scanning display only minor reactivations during the period August 2011 - March 2012 (further such studies will be carried out in March 2013). This contribution is aiming at a better understanding of the behavior of such processes' reactivation, therefore improving the hazard assessment for deep-seated landslides in the study area.

****

A complex landslide: the case of Andoin (Basque Country, Spain)

IBISATE A., ORMAETXEA O., DÍAZ E., SÁENZ DE OLAZAGOITIA A.
Dpt. Geography, Prehistory and Archaeology, University of the Basque Country, UPV/EHU, VITORIA-GASTEIZ, SPAIN

The study case of a long lasting unstable hillslope process activated with rainfall events in Andoin (Basque Country) is presented. Other factors as the alternate lithology, infiltration, slope and rock fractures triggered mass movements, rotational slides and flows with differentiated progressions in a surface of around 5 ha.

Through historical aerial photographs and GPS techniques more than 50 years of the evolution of the process were delimitated. Additionally this evolution has been related to rainfall frequency and annual distribution by the analysisof several meteorological stations located in the surrounding area, as well as the analysis of documents related to the process, available photographs and interviews to local population.

During the last 10 years field measurements have been done in May (after the maximum rainfall period) which has allowed the reconnaissance, characterization and the cartographical representation of many different movement typologies.

Method for estimating the volume of sliding soil mass generated by deep catastrophic landslide: Application to the disaster in the Kii mountain range, 2011

ISOGAI N., MORITA K., ISHIZUKA T.
Public Works Research Institute, TSUKUBA-CITY, IBARAKI-PREFECTURE, JAPAN

In Japan, 72 deep catastrophic landslides were generated because of heavy rain by Typhoon Talas in the Kii mountain range at the beginning of September, 2011. As a result, extensive damage was done of 82 dead, 16 missing person, 379 completely-destroyed houses, and 3,159 partially-destroyed houses.

The estimation of the volumes of sliding soil mass is very important, because it is crucial information or parameters 1) to evaluate the damage which might be caused by deep catastrophic landslide, and 2) to decide assumed external force applying to the design of constructional measures.

The recent laser surveying technique has made possible to estimate the volume of landslide mass briefly and easily, calculating the difference of the digital elevation model (DEM) between before and after deep catastrophic landslide. However, in some cases, the estimation could be inadequate because of the following reason.

In the case of deep catastrophic landslide, collapsed soil mass generally reaches out of original landslide area. Meanwhile, upper part of landslide mass could deposit at the lower part of the original landslide area, especially in the case that deep catastrophic landslide forms natural dam downward of the slope. In this case, the volume of landslide mass can be underestimated because of the overlap of yielded soil mass and deposited one, if the analysisof the difference of the DEM before and after landslide is directly done.

To improve the estimation in the above cases, we applied the following method to the deep catastrophic landslides caused by typhoon Talas in the Kii mountain range. 1) to make the cross section at intervals of 20m(indicating the cross section of before and after mass movement), 2) estimation of the sliding surface shape, 3) to calculate soil mass between each section using average cross section, 4) to accumulate the calculated volumes.

****

Using fallout 210Pbex, 7Be, sediment yield and modeling to assess soil erosion at different temporal and spatial scales in southeastern Brazil

FERNANDES N.(1), SANTOS A.C.F.(1), PINTO C.S.B.(1), BHERING S.(2), GODOY J.M.(3), FONTES R.L.P.(1)
(1) FEDERAL UNIVERSITY OF RIO DE JANEIRO, RIO DE JANEIRO, BRAZIL ; (2) EMBRAPA, RIO DE JANEIRO, BRAZIL ; (3) PUC-RIO, RIO DE JANEIRO, BRAZIL

Soil erosion is a major problem in southeastern Brazil, especially in the highly degraded hillslopes of the northwestern Rio de Janeiro state agriculture fields, where the original rainforest has been continuously replaced by farming activities throughout the last three centuries. This is the case of São José the Ubá region, where the combination of intense farming, steep slopes, erodible soils, sparse vegetation, fires and downhill soil ploughing favored the increase of surface runoff and soil erosion (sheet wash, rilling and gullying), causing a significant decrease in soil productivity, especially in the last few decades. In this study, we assessed the effects of different temporal and spatial scales on soil erosion combining different techniques, including the measurement of fallout 210Pbex and 7Be (a convex-concave 100 m long transect along an agriculture field – from the flat top to the bottom of the hillslope), the continuous monitoring of rainfall, discharge and sediment yield at an experimental drainage basin (during 5 years), and the application of the SWAT model to simulate different future (and past) scenarios of land-use and cover changes. The initial results suggest that at the upper and mid-portions of the hillslope, most of the 210Pbex is concentrated in the first 20 cm of the soil profile, while at the bottom of the hillslope it is concentrated in the first 30 cm of the profile. Besides, at the mid-portions, the inventories of 210Pbex are about 18% smaller than the ones measured at the flat top of the hillslope, suggesting intense soil erosion during the last 100 years. On the other way, sediment deposition is suggested by and increment of the 210Pbex inventories (about 30% greater than the flat top) at the bottom of the hillslope (concave portion). The results obtained from the simulations with the SWAT model attest that land use and cover changes play a major role in controlling soil erosion responses in the different scales.

Mass movements in mountainous region in southeastern Brazil from the disaster of January 2011 as landscape transformers in the Atlantic forest Biome

SOUZA J.M.D.(1), ASEVEDO L.A.(2), BERTOLINO A.V.F.A.(2), FREITAS M.M.D.(1)
(1) Pontifical Catholic University, RIO DE JANEIRO, BRAZIL ; (2) University of State of Rio de Janeiro, SÃO GONÇALO, BRAZIL

In 2011 January, the mountainous region of southeastern Brazil suffered intense mass movements. The research aims to mapping scars of events to make a diagnosis of this and his triggering mechanisms.

The continental collision process makes the predominance be metamorphic rocks in the Atlantic border in the south American continent, generating the track mobile Ribeira and comprise a belt of complex folds and high temperature formed during the collision making magmatism. This afforded granitic rocks with high silica content, resistant to weathering yielding mountaintops (HEILBRON et al, 2004), commons in Serra do Mar. The geomorphologic unit divides in: Mountain cliffs and mountainous domain (DANTAS, 2000) with a relief very rough, shallow soil and topographic amplitudes above 400m.

The rain diary values in the area were obtained through the conventional rain gauges and the automatic station THIES TLX-MET. The data shows a high rain above the average in November and December 2010 and January 2011. On 01/11/2011 was a rain with 209 mm, representing 63% of month precipitation. The rain which done the sliding was between 21:50h (01/ 11) and 7:10h (01/12) reaching 145,2 mm.

Was mapped 33 scars where the mass movements were: 85% landslides, 9% flow, 3% rock fall and 3% rock slide and 43% of scars was in high slope (>47%), its represents areas with greater instability with shallow soils and/or soil/rock contact abrupt, conditions where could make occurs increase positive pressure of soil (MONTGOMERY *et al*, 1997). Of the totalscars, 17 were in the forested area, 6 in the area of traditional agriculture, 5 in the fallow, 1 in pasture area and the other in an urban area.

The data shows which the conditional factors to mass movements in 2011 January in the mountainous region of southeastern Brazil was a combination between antecedent moisture in the soil, high intensity rain of January 11 and slopes with shallow soils with high gradient. This is related with landscape evolution.

****

Resistivity measurements in slope geomorphology: recognition of deep-seated mass movements

TÁBOŘÍK P.(1), PÁNEK T.(2)
(1) Institute of Hydrogeology, Engineering Geology and Applied Geophysics, Faculty of Science, Charles University in Prague, PRAGUE, CZECH REPUBLIC ; (2) Department of Physical Geography and Geoecology, Faculty of Science, University of Ostrava, OSTRAVA, CZECH REPUBLIC

Mass movements belong to the prevailing processes forming mountain landscapes, ranging from slow deep-seated gravitational slope deformations to the fast relocation of shallow colluvial deposits. Genesis of deep-seated gravitational slope deformations (DSGSD) is affected by a combination of many factors, such as hydroclimatic conditions, weathering intensity and particularly morfostructural and structure-geological predisposition. Their recognition is crucial for correct interpretation of earth surface processes. Application of geophysical techniques, as a basic indirect method of subsurface surveying, is very suitable, especially in hardly accessible areas. Resistivity imaging has proved universal utilization in many different tasks and various geological substrates and also offers very valuable subsurface information on DSGSD. Presented study summarizes results from multi-electrode measurements (Electrical Resistivity Tomography, ERT) carried out on the DSGSD phenomena during 2006-2012. The study also evaluates applicability of different types of electrode array and its configuration (electrode spacing, depth range etc.) on specific tasks within DSGSD research. The ERT method was used especially due to sufficient resolution and depth range. Based on the interpretation of the resistivity sections, we were able to distinguish between extremely high/low resistive parts of the landslide bodies which represent different quality (e.g. various lithology, intensity of disruption and weathering, water content or presence of argillaceous minerals). The ERT was mainly used in order i) to confirm tectonic predisposition, iii) detect and track rock discontinuities (fissures and fissure-caves, tension cracks), iii) to detect or confirm shear surfaces and range and thickness of landslide deposits, and iv) to distinguish inner structure of landslide body (e.g., deep-seated blocky rockslide vs. shallower colluvial deposits in the distal part of the complex landslide).

Shallow slope deformations triggered by extreme rainfall: case studies from Czech Republic

SMOLIKOVA J.(1), BLAHUT J.(2), ZIZALA D.(3), VILIMEK V.(1)
(1) Charles University in Prague, Faculty of Science, Department of Physical Geography and Geoecology, PRAGUE, CZECH REPUBLIC ; (2) Institute of Rock Structure and Mechanics AS CR, PRAGUE, CZECH REPUBLIC ; (3) Research Institute for Soil and Water Conservation, PRAGUE, CZECH REPUBLIC

In 2010 considerable precipitation occurred in the Czech Republic and caused floods and slope deformations at several locations. Two distinct areas were chosen for this study, where rapid and shallow mass movements were triggered by extreme rainfall. Torrential debris flows were investigated within the area of the Jizerské hory Mts. as an exceptional phenomenon at the local conditions and earthflow in the Javorníky Mts.

The following methods were used to examine the deformations: a detailed geomorphological mapping; creating a DEM of the body of the deformations using a total station; monitoring of movements by laser scanning and using installed geodetic points; analysing precipitation amount measured by rain gauge; measuring of soil moister; investigation of properties of taken soil samples; obtaining geophysical profile by electrical resistivity tomography; analysing water concentration using runoff lines;reconstruction of debris flows using empirical model, etc.

The mentioned methods are briefly described and their applications are discussed with respect to their contribution to the issues of shallow deformation. The obtained results should be used to identify hazards in the investigated areas.

****

Morphometric analysis of landslides using Gis: the case of d'antas watershed in Serrana region in the state of Rio De Janeiro, Brazil

CARVALHO ARAUJO J.(1), MARIA DA SILVA L.(1), DOURADO F.(2), FERREIRA FERNANDES N.(1)
(1) Federal University of Rio de Janeiro, RIO DE JANEIRO, BRAZIL ; (2) Estadual University of Rio de Janeiro, RIO DE JANEIRO, BRAZIL

Mass movements are recurrent phenomena in the whole Mountain Region of the State of Rio de Janeiro in Brazil. These events actively participate in the relief evolution and are also responsible for many damages and loss of human lives. The triggering of these events depends on the natural environment and the preparatory and immediate action of the physical, biotic and human agents responsible for these processes. This work is based on the hypothesis in which the topographical conditions have a major effect on the spatial distribution of translational landslides caused by decreased of the internal resistance of the material mobilized. Therefore, the purpose of this study is to identify the topographical conditions favorable to landslide triggering based on morphometric analysis in a pilot watershed - D'anta´s watershed - located in the mountainous region of the State of Rio de Janeiro. The indices include the topographic wetness index (TWI), contributing area, slope angleand elevationand were derived from 5-m grid digital terrain model,computed on a Geographic Information System (GIS). The maps produced allowed the analysis of topographic influence on the landslides distribution from the indices of frequency classes (F), concentration of scars (CS) and potential of landslide (PL). The landscape sectors that are more likely to be affected by landslides were the ones where the elevation ranges from 1070m - 1187m, slope anglebetween 40.95° and 47.77°, contributing area between ($\log_{10}$) 1.32 m² - 1.95 m² and topographic wetness indexbetween 7.11 to 9.59. This work provides important information which may help in the decision-making process, using fewer data and indices of easy application. Finally, the results obtained will subsidize of a landslide susceptibility map throughthe implementation of the conditionalprobability methodaimed at predicting and mitigating of the damage caused by landslides.

Influence of the mass movement on the vineyard fragmented. Case study of the Côte de l'Ile de France (Champagne - France)

COMBAUD A.(1), BOLLOT N.(2), CHALUMEAU L.(2), BATAILLER A.(1), CHARBONNIER K.(1), DOURLAT E.(1), EMERIAU G.(1)
(1) Institut Polytechnique LaSalle Beauvais, BEAUVAIS, FRANCE ; (2) Université de Reims Champagne-Ardenne, REIMS, FRANCE

The vineyard of Champagne is typically a north one :for growing vine needs long and strong slopes and porous stones, like on the Côte de l'Ile de France. Mass movement is the major process in the development of these hillslopes. Slumps and associated earth flows are mostly concerned. Relative age of these processes is also known: oldest slumps occurred before the last glacial period, some of them (slump and earth flow) are reactivated during the Holocene. The actual downslope movements, of various sizes, lead to major damages throughout the vineyard stands on mass movements.

The aim of this study is to determinate if landslides influence the fragmented of the vineyard. Plots limits are extracted by remote sensing analysis and merge with the cartography of mass movement for two sectors of the Marne Valley.

****

Study of Landslide hazards and Assessment of Associated Risks in the West-Cameroon Highlands (Central Africa)

TEFOGOUM G.Z.(1), NKOUATHIO G.D.(2), DONGMO A.K.(2), WANDJI P.(3), DEDZO M.G.(2)
(1) Department of Hydraulics and Water Management, High Institute of the Sahel, University of Maroua & Department of Earth Sciences, Faculty of Sciences, University of Dschang, MAROUA & DSCHANG, CAMEROON ; (2) Department of Hydraulics and Water Management, High Institute of the Sahel, University of Maroua, MAROUA, CAMEROON ; (3) Laboratory of Geology, High Teacher Training School, University of Yaoundé, YAOUNDÉ, CAMEROON

The West-Cameroon highlands (WCH) are a part of Cameroon Volcanic Line. WCH are a succession of horsts and graben covering an area of more than 50,000 km2. The region is overlaid by volcanic lava flows and pyroclastic deposits, dated from Actual to 31 Myr (Nkouathio et al., 2008). The best fertility of the soil attracts various active people although the occurrence of mass movement hazards. WCH and neighborhood are tormented by landslide hazards; the most disastrous were recorded in the Limbe and Maga localities respectively in 2001 and 2003 (Zoning et al., 2007). In this work we highlight the most recent landslides that occurred and damaged WCH' localities notably Kékem (2007), Bana (2008), Limbe (2009), and Bamenda (2009), Nteingue (2007, 2011).These landslides occured generally in response to the combination of important factors:

- The climate in the region is subequatorial under the influence of mountainous reliefs;
- steepest slopes (up to 60%);
- the high thickness of the mantle rock;
- the vegetable cover (meadow);
- anthropogenic activities (deforestation, bushfire, buildings, farming and road traffic).

During the landslides, the movement of materials was generally rotational, translational or the combination of the both models depending on the region.

The impact of recent landslide in WCH is relevant; there is loss of human beings, disruption of human activities, destruction of buildings and roads (around several millions USD) and biodiversity (plantations, livestock and wild lives). In view of the perpetuity of landslides in that region, it is suggested to respect a better land use system, lead a suitable geotechnical surveys prior to the road construction, avoid the settlement of population on the risks zones, prohibit bushfires and the deforestation and sensitize the exposed populations through scientific documentations that highlight the effect of landslides in the region.

Recent landslide hazards in the Ba catchment, NW Viti Levu Island, Fiji

STEPHENS M.
School of Geography, Earth Science and Environment, The University of the South Pacific, SUVA, FIJI

This paper reports on a reconnaissance investigation from the Ba River catchment, NW Viti Levu, Fiji, of the processes and causal factors of landslides that were triggered on 25 January 2012 following two days of exceptionally heavy rainfall associated with a nearby low pressure weather system. More than forty individual landslides were recorded, not including several small road-cut slumps, and mass wasting on this scale has reportedly not been witnessed before in the Ba catchment. Rural village settlements occur sparsely in the area and there were casualties in one village where a landslide had directly hit a house. Other impacts were soil erosion and siltation of the nearby streams and the blockage of roads affecting access to some villages and to markets.

The heavy rainfall that occurred on the preceding two days was the major triggering factor and also likely to be in combination with antecedent moisture following heavy rainfall events in recent years (Tropical Cyclones Mick and Tomas, December 2009 and March 2010, respectively). Many of the landslides were shallow debris flows which tend to be common types of failure in mountainous volcanic islands in the South Pacific. The landslides ranged in size from several metres up to dimensions of more than 200 metres long and 100 metres wide. The landslides occurred on a variety of slope angles and in a variety of land uses although many of the larger failures occurred in areas of steep slopes covered by a monoculture of mature pine forest (Caribbean pine, Pinus caribaea).

Many of the landslides started at the upper parts of hillsides as typical of failures caused by the downward percolation of rainwater. The back scarp walls of several of the landslides were found to occur in association with pine logging tracks which create slope instability. Previous studies of landslides in Fiji and the tropical South Pacific are few and this work adds to the body of knowledge on this natural hazard in the region.

****

Storage coupling and sediment connectivity in a high-alpine cascading system (Val Müschauns, Swiss National Park)

MESSENZEHL K., HOFFMANN T.
University of Bonn, Department of Geography, BONN, GERMANY

Sediment transport from hillslopes to streams follows a cascade of different storage compartments. The exchange of sediment between these compartments via different geomorphic processes thereby determines the internal coupling mechanism of the sediment cascade. However, decoupling between adjacent storages may go along with long-term disconnectivity between significant parts of hillslopes and the fluvial system. With regard to sediment budgets and management activities a profound understanding of cascading systems is important even more today.

We studied the alpine sediment cascade of Val Müschauns (6.18 km^2) in the Swiss National Park. The glacial legacy of Val Müschauns is demonstrated by its glacial trough and abundant glacial and paraglacial deposits. By combining traditional geomorphic mapping in field and interpretation of aerial photos and hillshades, we compiled a comprehensive inventory of sediment storages. For a qualitative assessment of the (de-)coupling between compartments of the sediment cascade, we applied the concept of toposequences and examined the functional relationships between neighbouring storage units. To analyse the sediment connectivity on a catchment-wide scale, we used the numerical algorithm by Cavalli et al. (2013), a modification of the approach by Borselli et al. (2008).

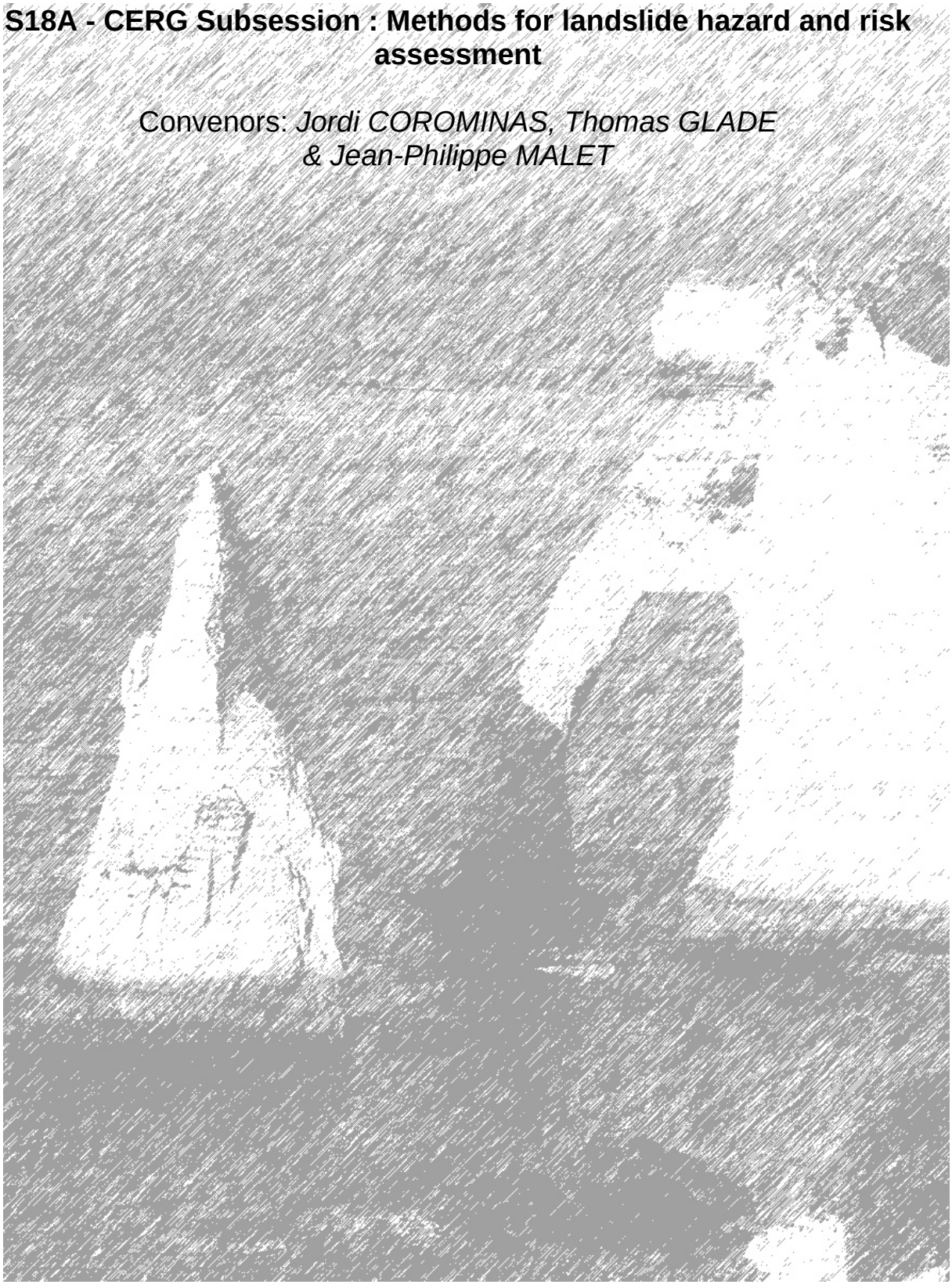
The modelling results indicate that the present-day sediment connectivity is dominantly controlled by the specific valley morphometry being the result of the Pleistocene glaciation. Within the upper hanging valleys, the connectivity to the stream is reduced noticeably. Nevertheless, the numerical algorithm fails to calculate decoupling between neighbouring DTM-pixels and may overestimate the overall connectivity degree. Our qualitative study reveals that most of the toposequences of the upper trough contain a buffering element in-between decoupling around 28 % of the basin surface. Therefore, our findings highlight the great potential of numerical approaches for the study of high-alpine cascading systems, but concurrently emphasize the need of systemic knowledge derived from geomorphic mapping for the model validation.

Borselli, L., Cassi, P. & D. Torri (2008): Prolegomena to sediment and flow connectivity in the landscape: a GIS and field numerical assessment. In: Catena 75: 268-277.

Cavalli, M. Trevisani, S., Comiti, F. & L. Marchi (2013): Geomorphometric assessment of spatial sediment connectivity in small alpine catchments. In: Geomorphology 188: 31-41.

S18A - CERG Subsession : Methods for landslide hazard and risk assessment

Convenors: *Jordi COROMINAS, Thomas GLADE & Jean-Philippe MALET*



Oral presentations:

The use of engineering geomorphology in landslide assessments: a Hong Kong case study

PARRY S.
GeoRisk Solutions Ltd, SHEUNG WAN, HONG KONG

Hong Kong has considerable experience in the assessment and upgrading of man-made slopes, resulting in significant reduction of landslide risk. As a consequence of this Hong Kong has recently embarked on an ambitious programme to systematically evaluate and mitigate “natural terrain” landslide risk.This paper discusses the use of engineering geological/engineering geomorphological mapping for natural terrain landslide hazard assessments. These techniques allow the relative age of the landscape to be evaluated; the identification of both landforms and processes related to different climatic conditions; the development of terrain specific landslide magnitude and frequency data; evaluation of entrainment potential; and, assessment of debris run out. This information allows for a rational derivation of landslide design events for individual terrain components, for analytical modelling and subsequent mitigation design. As such, it assists in reducing uncertainties and allows the evaluation of appropriate and defensible design events.

****

Characterizing the complex morpho-structure of coastal landslides combining airborne and ground-based investigations

LISSAK C.(1), MAQUAIRE O.(1), MALET J.P.(2), BITRI A.(3), BOURDEAU C.(4), DAVIDSON R.(1), GRANDJEAN G.(3), REIFFSTECK P.(5)
(1) LETG-Caen Géophen, CAEN, FRANCE ; (2) Ecole et Observatoire des Sciences de la Terre [EOST], Institut de Physique du Globe de Strasbourg [IPGS], STRASBOURG, FRANCE ; (3) BRGM - Bureau de recherches géologiques et minières, ORLÉANS, FRANCE ; (4) IFSTTAR, PARIS, FRANCE ; (5) TERRASOL, PARIS, FRANCE

In Normandy (North-West France), active landslides occurring along the coasts are large, deep in marly, sandy and chalky formations. All are characterized by a seasonal activity (1-10 cm.y-1) and regularly affected by brutal accelerations inducing pluri-decimetres to pluri-meters horizontal/vertical displacements and the main scarp recession to upstream. The result of this complex dynamic pattern is a composite morphology with a succession of horsts, grabens, counter slopes and several sizes scarps, representative of multiple rotational landslides. The previous studies highlighted the importance of the nested chalk panel composing the landslide and the superficial deposits in the landslide dynamics.

To understand the slope dynamic heterogeneities, this study focused on the landslide current morphology and the internal structure of the slope through the integration of multi approach and multi-source data. The results have been based on data relevant from punctual investigation of the internal structure of the landslide and data interpretation to devise a geometric model of the slope based on a model of distribution chalk blocs. First, a detailed and high resolution morphological maps supported by remote-sensing (airborne LiDAR) and ground-based surveys (differential GPS measurements, field mapping) have been lead. Then, geophysical methods combined with conventional geotechnical methods and geomorphological observations provided a 2D/3D subsurface imaging delineating the landslide in depth. Data allow to propose a complex landslides model composed by several compartments (heterogeneous size and volume) associated to a highly fractured slope and controlling the deformation patterns and the mechanisms of the landslides.

A geomorphologic and probabilistic approach to the number and size of blocks of fragmental rockfalls

MOYA J., COROMINAS J., MAVROULI O.C.
Technical University of Catalonia (UPC), BARCELONA, SPAIN

Rockfalls are frequent phenomena in steep rock slopes. Many rock masses when detached from cliffs undergo fragmentation after the first impacts with the ground. Rockfall fragmentation is a complex process that has received little attention in the literature. It controls the sedimentation rate on talus slopes and the rockfall risk. The incorporation of fragmentation into the rockfall analysis involves the calculation of the number and size of the rock blocks after the breaking of the initial rockfall mass. Due to its complexity, physical modelling of this process appears to be difficult. In this work, we present an approach to assess the number and volume of fragments based on geomorphological observations and on probabilistic simulation. This approach assumes that the volume of blocks resulting from fragmentation follows a defined probability distribution, which is the same with the one observed for the blocks accumulated in the talus slope. Consequently, the volume distribution of blocks accumulated in talus slopes can be used to generate random sets of rock blocks, each one simulating a rockfall event. For each event, the individual block volumes are summed until they reach the specified volume of the detached rock mass. This approach is applied to a talus deposit of the Solà d'Andorra la Vella (Andorra) and the results were compared with the block volume distribution of inventoried rockfall events in the area. The comparison showed that the only difference between the two data sets is the lower proportion of small blocks in the inventoried set, likely due to undersampling of these sizes. For blocks with volume greater than 0.3 m^3, both sets follow the same probability distribution: a power law with an exponent close to 1 and a scale parameter close to 0.3. We conclude that the proposed approach can be applied to sites where no process causing size reduction (e.g. gelifraction) affected the blocks after rockfall deposition.

****

A modelling approach of the large, rapid Yigong rockslide ' debris avalanche, Southeast Tibet

VAN ASCH T.(1), XU Q.(2)
(1) Faculty og Geosciences Utrecht University , UTRECHT , NETHERLANDS ; (2) State Key Laboratory of Geohazards Prevention and Environment Protection, CHENGDU, CHINA

The Yigong rock slide – debris avalanche (YRA), which occurred on 9 April 2000, received worldwide attention as one of the largest non/seismic landslides in recent years, with a volume of $0.3 \times 10^9 m^3$. a run-out track with a total elevation difference of about 3300 m, and a length of nearly 10 km with a mean slope gradient of 31.3%. According to several witnesses, the total duration of the event lasted 3 minutes. Sixty-two days after this landslide event, a catastrophic flood happened because of a landslide dam failure. One of the special features of this debris avalanche is liquefaction, which plays an important role in the entrainment and long run-out distance and high-speed movement of the debris avalanche. Numerous sand boils were found in the deposition zone, providing strong evidence for liquefaction. The YRA provides the first actual evidence for a theoretical model which is proposed here, where the mechanisms of excess pore pressure and liquefaction induced by undrained loading, and entrainment and dissipation control the run out and deposition of the debris avalanche. The position and amount of eroded and deposited material and the run out time are in good agreement with the observations made in the field.
The damage mode to trees and the presence of debris cones or molards with a rounded top is proven to be the result of strong air waves and eddies. These features all imply that the YRA is a solid–liquid–air mixed-debris avalanche.

Physical and geotechnical properties of soils and shallow landslides, Serra Do Mar Moutain Range, Brazil

CARVALHO VIEIRA B., SOUZA FERREIRA F.
University of São Paulo, SÃO PAULO, BRAZIL

The physical and geotechnical properties of soils can be studied by field study and laboratory, measured at different depths to assessing their influence on water flows, especially during periods of intense rainfall. The aim of this study was to determine the influence of some soil properties in the shallow landslides in the Serra do Mar, a mountain range located along the southeastern Brazilian coast, often affected by different types of landslides, especially during the rainy season. In this area there are few studies about relationship between soils and landslides. We selected a basin (24Km²), located in the Caraguatatuba city, with steep slopes and heterogeneous lithology (gneisses, metasediments) and structural features with orientation NE-SW. On 17 and 18 march 1967 the rain gauge registered 535mm and many shallow landslides were triggered and the debris flows reached the gentle areas causing about 400 deaths and many social and environmental damages. We selected three shallow landslides scars of this event and, in each scar, collected sample in three points, one within the scar (material removed by the process), one lateral and another one on the top scar (with preserved material). 37 soil samplesdeformed and 6 undisturbed samples (soil block) were collected to analyzethe following properties: soil grain size distribution, atterberg limits, density porosity and soil cohesion. The results showed high amounts of sand (80%), mainly in the surface horizons (up to 0.60m), and low percentages of clay and these were considered nonplastic or inactive (values below 0.75%). The average values of the density and the void ratio were 2.55 g/cm^3 and 1.151 g/cm^3, respectively. The friction angles were smaller in surface horizons (29.1º and 25.8º), and higher in overlying layers (31.9º and 36.8º) and the cohesion ranged from 0 to 12 kPa. We hope that this study can subsidize understanding of failure mechanisms of shallow landslides in the Serra do Mar mountain range.

****

A reappraisal of field geomorphology in landslide hazard investigation

GHINOI A.
Universita di Modena e Reggio Emilia, MODENA, ITALY

This contribution highlights the relevance of geomorphological expert knowledge in landslide hazard assessments. A recent project, funded by the Emilia-Romagna Region, has led to the revision of the official landslide maps of a large sector of the Romagna Apennines (Northern Italy), which were initially based on pure geological field surveys. Most of the mapped landslides needed significant revision in terms of extent, type of movement and frequency of occurrence. In particular, large-scale landslides, defined as "complex" in the maps, had to be reinterpreted updating the mapping and the landslide database by means of geomorphological investigation. It became clear that landslide accumulations were not normally related to single events, but to the cumulative action, through time, of hillslope processes, also related to different morphoclimatic conditions. The mapped landslide bodies may be currently active not as a whole, but rather just in some smaller sectors and in relation to different causes. Regarding smaller-scale landslides, from the Seventies up to now they show relevant reduction in the extent of the active portions, and new occurrences are few. The outputs of the research showed that the results of many current landslide susceptibility assessments used for wide areas, whose algorithms are based on existing landslide inventories, can be strongly influenced by an improper mapping of existing landslides and by an outdated information on their type of movement and state of activity. Therefore the value of traditional geomorphological survey should be reasserted within landslide susceptibility and hazard assessments, since the proper knowledge of landslide cause-effect relationships through time and under the current changes in climate becomes crucial.

Comparing binary logistic regression and stochastic gradient boosting techniques in debris-flows susceptibility modelling: application in North-Eastern Sicily

LOMBARDO L.(1), CAMA M.(1), CONOSCENTI C.(1), HOCHSCHILD V.(2), MÄRKER M.(2), ROTIGLIANO E.(1)
(1) Dipartimento di Scienze della Terra e del Mare (DISTEM), Università degli Studi di Palermo, PALERMO, ITALY ; (2) Department of Geography, University of Tuebingen, TUEBINGEN, GERMANY

On October 1, 2009 the area around the village of Giampilieri (Sicily), on the Ionian side of the Peloritan belt, suffered thousands of landslides triggered in few hours, causing 36 victims, over 100 injured and more than 0.5M € of damage to structures. This phenomenon was caused by an extreme meteorological event, recorded at the foothills areas with 250mm of rain in just 8 hours.

Due to the peculiar trigger and geomorphologic setting, debris flows and avalanches involved the shallow weathered layer of the outcropping lithologies consisting of medium to high grade metamorphic rocks.

The purpose of this study was to prepare and compare susceptibility models for two catchments (the "Torrente Briga", TB, and the "Torrente Giampilieri", TG, catchments) stretching in the storm centre area, by means of two different methods: binary logistic regression and stochastic gradient boosting.

Besides, the possibility to model susceptibility condition in one of the two hydrographic units, by importing a model trained in the adjacent one, was explored.

The susceptibility models were prepared using a large set of predictors derived from a 2m cell DEM, two thematic maps and the landslide archive built on the basis of direct (on the field) and remote (Google EarthTM) surveys, including 871 landslides in the TB and 1121 landslides within the TG.

We focussed on exporting procedures for susceptibility models because of the importance in optimizing the survey costs as well as or, particularly, when facing phenomena which are locally triggered, such as the ones activated under extreme rainfall events. In this cases, the landslide scenario used to train the statistical model is locally and spatially more limited than the extension of the whole investigated area, so that suitable training areas are to be searched for out of the study area.

The modelling has proved to be highly stable comparing the two different techniques, factor selection and exportation procedures.

****

Landslide susceptibility modelling for extreme rainfall-triggered multiple landslides: a key study from the 2009 event in the Giampilieri Aera (Sicily, Italy)

ROTIGLIANO E., CAMA M.E., CONOSCENTI C., LOMBARDO L.
University of Palermo, Italy, PALERMO, ITALY

On the late afternoon of 1st of October 2009, the area (about 50km^2) centred on the village of Giampilieri (Messina, Sicily), along the Ionian front of the Peloritan belt, was struck by a storm which triggered about three thousands of landslides in the time lapse of few hours, causing 36 victims. A huge number of debris flows and debris avalanches occurred, as a downhill evolution of pure debris slides and debris flows at the head, involving the shallow (0.5-2.5m thick) weathered layer of metamorphic rocks (phyllites and mica schists).

Extreme rainfall events in Mediterranean areas are typically very local phenomena, so that storm-triggered landslide archives, which are mandatories for preparing stochastic susceptibility models, are made of clusters of events, randomly scattered both in time and space. As a consequence, areas that potentially can be involved in multiple landsliding events, frequently do not show past landslide scenarios, simply because recent storms passed some kilometers away. This contribution explores the possibility of modelling susceptibility in these still unstressed areas, by importing models prepared in already struck similar areas, where training landslide inventories are available.

The study focuses on four small adjacent hydrographic units (the Itala, Scaletta, Giampilieri and Briga creek basins), which extend for about 10km^2 each, in the centre of the storm area. By applying forward logistic regression on two landslide archives (before 2009: ALFA; after 2009: BETA) and a set of predictors, which were derived from a 2m cell DEM and a geologic map, different types of susceptibility models were prepared for each unit: model A, trained with ALFA; model B, trained using a random partition of BETA; model C, imported from the other units, using BETA. Validation tests confirm that susceptibility modelling for storm-triggered landslides can be best achieved, by importing models trained in areas, that have been already struck by storms in the past.

Assessment of rockfall susceptibility in different morphostructural frameworks, Abruzzo Region, Central Italy

PIACENTINI T., MICCADEI E., DI MICHELE R.
Dipartimento di Ingegneria e Geologia - Università degli Studi "G. D'Annunzio" Chieti-Pescara, CHIETI, ITALY

Among the types of instability, different for typology, evolution and dimension, rockfalls represent a constant hazard for structures, buildings and inhabitants because of their extreme speed. Rockfalls have been studied all over the world in several geographical and morphostructural settings, from huge mountain escarpments to small cliffs, with different approaches (from standard geomorphological analysis to multidisciplinary analyses including geology, geomorphology, geomechanics, geophysics, modeling/ software simulation, etc.).

This work is focused on the rock fall distribution in central Italy (Abruzzo Region), in a complex morphostructural setting characterized by the junction of chain area to piedmont and piedmont hills to coastal sectors with wide coastal cliff.

The study began from the consideration that rockfalls were 67% of the mass movements triggered by the 2009 L'Aquila earthquake in the mountain area; other episodes were recorded during weather extreme events that caused floods in the piedmont and coastal area.

The analysis of rockfalls in Abruzzo has been conducted through: historical analysis of past events, multitemporal and multiscale analysis of aerial photos, geological and geomorphological field surveys, geomechanical analysis and software modeling.

Analyzing several case-histories, involving different morphostructural contexts and different rocks (calcareous, arenaceous-pelitic, arenaceous-conglomeratic), the role of geomorphological factors in determining propensity to instability has been highlighted. The analysis of these factors has allowed for the evaluation of susceptibility and the outlining of rockfall propensity maps (in terms of detachment areas and fall areas).

These maps provide indications: at regional scale for preventing instability phenomena and reducing rockfall risk; at local scale for a correct land management and as tools for predicting in advance the scene of a disaster and its impact on the anthropized landscape.

****

Assessing for deep-seated catastrophic landslide susceptibility of Japan: Application and verification for Kii mountain range, Japan

MORITA K.(1), ISOGAI N.(1), ISHIZUKA T.(1), UCHIDA T.(2), OCHI H.(3)
(1) Public Works Research Institute, TSUKUBA-CITY, IBARAKI-PREFECTURE, JAPAN ; (2) National Institute for Land and Infrastructure Management, TSUKUBA-CITY, IBARAKI-PREFECTURE, JAPAN ; (3) Ministry of Land, Infrastructure, Transport and Tourism, CHIYODA-KU, TOKYO, JAPAN

In steep mountainous regions, landslides may include both soil and underlying weathered bedrock (hereafter, "deep-seated catastrophic landslides"). The velocities and volumes of deep-seated catastrophic landslides are often very large, so these landslides may cause serious damage such as Shaolin Village, Taiwan, in 2009 and Leyte Island, Philippines, in 2006. Reducing these hazards requires the development of objective methods to assess and map potential sources of deep-seated catastrophic landslide.

We proposed the deep-seated catastrophic landslide frequency map of Japan and the method for estimating spatial patterns of deep-seated catastrophic landslide susceptibility for many small catchments in a study area around Mount Wanitsuka, Japan. This method is based on the concept that deep-seated catastrophic landslide susceptibility are related to the ancient deep-seated catastrophic landslide scars, microtopography and other topography-related factors.

In the Kii mountain range, Japan that have caused serious damage by deep-seated catastrophic landslides in 1889, we have assessed the deep-seated catastrophic landslide susceptibility for catchment-scale (ca., 1 km^2) applying the method above mentioned.

After the assessment, the heaviest rain brought by Typhoon Talas generated 72 deep-seated catastrophic landslides in this area at the beginning of September, 2011. Then we verified the applicability of the method with this data, and found certain correlation of them.

Here we report spatial patterns of deep-seated catastrophic landslides occurred and the verification of the applicability of the method for estimating spatial patterns of deep-seated catastrophic landslides susceptibility using the data of disaster caused by Typhoon Talas in 2011 in the Kii mountain range.

Debris Flows in Rio de Janeiro: Mapping, Modeling and Dating

FERNANDES N.(1), AMARAL C.(2), BIERMAN P.(3), SILVA L.M.(1), ARAÚJO J.P.(1), VARGAS JR. E.(4), DE CAMPOS T.(4), DOURADO F.(5), LOPES M.(1), PEIXOTO M.N.(1), NUNES A.(1)

(1) FEDERAL UNIVERSITY OF RIO DE JANEIRO, RIO DE JANEIRO, BRAZIL ; (2) DRM-RIO DE JANEIRO GEOLOGICAL SERVICE, RIO DE JANEIRO, BRAZIL ; (3) UNIVERSITY OF VERMONT, BURLINGTON, UNITED STATES ; (4) CATHOLIC UNIVERSITY, RIO DE JANEIRO, BRAZIL ; (5) RIO DE JANEIRO STATE UNIVERSITY, RIO DE JANEIRO, BRAZIL

In the last few decades, the state of Rio de Janeiro in Brazil has been affected by many catastrophic landslides leading to equally devastating mud and debris flows. The combination of intense summer rain storms, soil-mantled steep slopes, and largely uncontrolled occupation of slopes and stream-side valley bottoms, generates the conditions not only conducive to landsliding but to disaster as the floodplains of streams and rivers become more densely populated. Despite the many scientific advances in prediction and warning systems the number of deaths and the economic losses in the state continue to grown. For example, in one night in January 2011, more than 1300 people were killed in Rio de Janeiro, both on hillslopes and in adjacent floodplains when an intense summer rainstorm (about 350 mm/24h, after a long rainy period) triggered debris flows that were more than 10km long generating huge debris deposits (some more than 7m thick). Therefore, the main objective here is to improve our ability to predict landslide locations, both in space and in time, thus providing a system by which resulting debris flow hazards can be reduced in the state of Rio de Janeiro. In this study we combine field mapping to delineate the extent of that debris flow deposits in selected catchments of Rio de Janeiro state, soil sampling and field experiments to characterize soil properties, dating of debris flow deposits using measurements of ^{10}Be and ^{14}C to constrain the age and recurrence interval of flows, and modeling of landslides and debris flows initiation and propagation using a combination of different mathematical models. The results, although preliminary, attest the effects of local factors in controlling debris flows initiation and propagation. Besides, they also suggest that the quantitative methodologies used here, based on physically-based procedures, are capable of predicting the location of unstable sites to landslides in dense populated areas of Rio de Janeiro.

****

Accelerated landsliding due to climate warming? Modeling results from western Germany

GRUNERT J.(1), KRAUTER E.(2), KUMCERICS C.(2)

(1) Department of Geography, Mainz University, MAINZ, GERMANY ; (2) FSR (Landslides Research Center), MAINZ, GERMANY

In the 4th edition of the IPCC report the climate change expected until the end of this century is described by different scenarios. For this study, the moderate version A1 B was chosen and, as a tool, the statistical model REMO (Regional Modeling of Present and Future Climate) was taken. The modeled climate evolution of the two periods 2021-2050 and 2071-2100 was compared with the reference period 1961-1990. The model which has been developed by the MPI for climate research in Hamburg is based on pixels of 10x10 km covering central Europe. For each year the following parameters have been calculated: days per months mean temperature lower than 0 °C, and -5°c; daily and monthly precipitation rate and rainy days with P more than 20 mm. As field examples were taken: the vineyards-covered Wissberg in Rheinhessen, built up of tertiary sediments and known as an old landslide area, and a steep slope of the Mosel valley near Puenderich, built up of various devonian rocks. Here, an important railway has been threatened by landslides and rockfalls since 1880. First results are as follows: In both cases frost periods will be eliminated towards the end of this century. Summer rains will be more sparse but more intensive than today. Contrary, winter rains will become more abundant until 2100 with the effect of growing destabilization of the slopes especially by a higher pore water pressure. Roads and railways will therefore become generally more threatened by mass movements than today.

Update of rainfall thresholds for landslide activity in the Lisbon area (Portugal)

OLIVEIRA S.C., ZÊZERE J.L.
Centre for Geographical Studies, University of Lisbon (CEG-UL), LISBOA, PORTUGAL

Landslides have a clear climatic signal in the Lisbon area and rainfall triggered the 25 regional landslide events that occurred since the late 50's of the last century. Traditionally the reference rain gauge of São Julião do Tojal has been used to collect daily rainfall data and to establish the regional empirical relationships between rainfall and landslide activity.

In order to update and to improve the regional rainfall thresholds two pragmatic approaches are used exploring empirical relationships based on the antecedent rainfall records for time periods ranging from 1 to 90 consecutive days prior to landslide events.

The first approach is based on the regression between the critical cumulative rainfall amount and the corresponding rainfall event duration associated to each landslide event occurred during the last 30 years. A regression model is used to automatically derive the minimum daily rainfall necessary to reach a rainfall triggering threshold in 5 meteorological stations located north of Lisbon. A particular attention is ascribed to the critical rainfall duration because short rainfall periods are typically associated with shallow landslide events while deep landslide events are more frequently associated to long lasting rainfall periods.

The second approach is used to assess the maximum, minimum and pre-warning thresholds for the study area. The maximum rainfall threshold is the empirical limit above which no false positive landslide events are expected; the minimum threshold defines the minimum empirical relationship between rainfall amount and rainfall duration below which any landslide event is expected to occur; and the pre-warning threshold is a limit base on a certain percentage rainfall necessary to occur in order to be reached the minimum threshold. For rainfall combinations falling between the minimum and maximum rainfall thresholds the probability of occurrence of a landslide event is calculated based on the ratio true positive/false positive.

****

Quantitative landslide hazard assessment in the hilly valleys of the Pays d'Auge plateau (Normandy, France)

FRESSARD M.(1), THIERY Y.(2), MAQUAIRE O.(1)
(1) UMR 6554 CNRS, LETG-GEOPHEN, University of Caen Basse-Normandie, CAEN, FRANCE ; (2) EURO-ENGINEERING, PAU, FRANCE

A quantitative shallow landslide hazard assessment model is presented for a 24 km² region of the Pays d'Auge plateau. The data required were mostly obtained from field work investigations, completed by scarce historical records. Due to the relative infrequent occurrence of the landslides on the study area, the susceptibility map was obtained using the rare events logistic regression with replication model. This multivariate statistical technique permits the correction of the overestimation of the final probabilities that is often observed in using the ordinary logistic regression. The data introduced in the model: (i) landslide data, (ii) topographic derived data (slope, aspect, curvature etc.), (iii) landuse, (iv) landuse trajectories since 1947 and (v) surficial formations were obtained from the extensive field investigations and air-photo interpretation on a set of five historical images series.

The temporal probability of landslide triggering was estimated using the exceedance probability of rainfall and ground water level threshold. Due to the scarce historical records on landslides in the study area, the triggering thresholds were defined by combination of the available data and detailed analyses of three representative case studies. These analyses are based on the landslide structure identification and safety factor modelling. Since there is no well established classification system of the landslide magnitude prediction, the estimated landslide volume was used as proxy of the magnitude probability assessment. A quantitative landslide hazard evaluation was then obtained from the combination of the landslide initiation, occurrence and magnitude probability. Finally, four landslide hazard maps are proposed considering different return periods of the triggering event (i.e. 5, 10, 20 and 50 years).

The results should allow improving the quality of the operational mapping in Normandy and permit a more robust risk assessment.

Quantitative Risk Analysis for shallow slides: the case of S. Marta de Penaguião (Douro Valley, Portugal)

PEREIRA S.(1), SILVA M.(2), GARCIA R.A.C.(1), ZÊZERE J.L.(1)
(1) IGOT-CEG, University of Lisbon, LISBOA, PORTUGAL ; (2) CEGOT, Dynat, PORTO, PORTUGAL

In this work a quantitative risk analysis is applied for buildings and roads exposed to shallow slides in the Santa Marta de Penaguião municipality, located in the Douro valley (northern Portugal).

767 shallow translational slides dating from 2000 to 2010 were inventoried in the study area using aerial photo interpretation and field work. Seven landslide predisposing factors were weighted and integrated using the Information Value Method supported by the landslide partitioning using temporal and random criteria. The landslide susceptibility models were validated using standard ROC curves and AUC (Area Under the Curve).

The probability of landslide size, which is a proxy for landslide magnitude, was estimated using a probability density function. In addition, a landslide hazard scenario was defined based on a rainfall-triggered landslide event occurred in January 2001 with a 3-years return period.

A detailed inventory of buildings and of the road network was made at the 1:1000 scale. 303 km of roads and 8295 individual buildings were inventoried and classified according to the construction technique, type of material, number of floors and conservation state. Furthermore, the function associated to each building was assessed and classified. A vulnerability curve was constructed for each type of building and road taking into account both the structural properties of exposed elements and the proxy of landslide magnitude (landslide area).

The economic value of the road network was derived from the typical cost of road construction provided by the Portuguese Road Institute. The value of buildings was assessed by considering: (i) the typical construction cost per square meter in Portugal; (ii) the area of the building; (iii) the function of the building; (iv) the location of the building; (v) the quality index of the building; and (vi) the age of the building.

The landslide risk was assessed for each individual building and road path and the final result is expressed in euro.

****

Probabilistic modelling of uncertainties in vulnerability assessment - application to hydro-meteorological hazards in the municipality of Malborghetto-Valbruna, Italy

CIUREAN R.(1), HUSSIN H.(2), FRIGERIO S.(3), GLADE T.(1)
(1) University of Vienna, Dep. of Geography and Regional Research, VIENNA, AUSTRIA ; (2) CNR-IRPI, National Research Institute for Geo-hydrological Protection, PERUGIA, ITALY ; (3) CNR-IRPI, National Research Institute for Geo-hydrological Protection, PADOVA, ITALY

In mountainous European regions hydro-meteorological hazards develop often to disastrous events responsible for considerable losses in the society and the environment. Whilst many risk assessment applications and research has focused on vulnerability to hydro-meteorological hazards in the last years, few studies considered the uncertainties inherent in the vulnerability assessment and their propagation in its successive process stages.

This contribution proposes a methodology for vulnerability assessment of buildings to hydro-meteorological hazards, in particular debris flows, with a focus on the parameter and model uncertainties and their effects on the final vulnerability estimates. Herein, vulnerability is defined as the degree of loss to a given element or set of elements within an area affected by a given hazard. The model uses exceedance probability functions (fragility curves) to describe the damage as probability distributions for each intensity of the hazard using empirical data. In this study, the intensity of the hazard is expressed as flow depth. The fragility functions are then used for the uncertainty analysis in a Monte Carlo (MCS) framework which is structured in two components representing two different sources of uncertainty, aleatory and epistemic uncertainty. Emphasis is placed also towards indicating the sources of uncertainty within the analysis process in relation to data requirements.

The developed methodology is applied in Malborghetto-Valbruna, a municipality in the Province of Udine, Friuli-Venezia Giulia, a region in Italy which experienced extreme precipitation events leading to the occurrence of damaging flash floods, hyper-concentrated flows and debris flows.

The results of the proposed methodology can serve as input in a Probabilistic Risk Assessment (PRA) framework as a more rational support for decision making.

Keywords: quantitative vulnerability assessment, uncertainty, hydro-meteorological hazards, Malborghetto-Valbruna, Italy

Landslide risk models on the basis of recent occurrences

REMONDO J., BONACHEA J., BRUSCHI V.M., GONZÁLEZ-DÍEZ A., DÍAZ DE TERÁN J.R., CENDRERO A.
Universidad de Cantabria, SANTANDER, SPAIN

Mass movements, or landslides, are one of the most common and frequent processes affecting the Earth's surface. This type of process produces important economic losses when affecting vulnerable elements. Therefore, it is necessary to develop methods and/or tools that make possible risk assessment and prediction mapping for these processes. During recent decades significant progresses have been made in this field, developing and applying different methodologies to model landslide susceptibility and hazard. However, procedures for landslide risk modelling are scarce.

The occurrence of landslides in the Bajo Deva area (Guipúzcoa province, Spain) has been studied at length. For this reason a complete inventory of shallow landslides in the zone for the last 60 years has been obtained. In a lesser extent, data on landslide damage could be obtained.

In this work the economic losses caused by two landslides occurred in the study area due to heavy precipitations have been analysed. The study of these slope movements and their effects has been compared with landslide susceptibility, hazard and risk models elaborated in previous works.

****

Landslide risk assessment and management in the archaeological site of Machu Picchu Inca citadel (Peru)

SPIZZICHINO D.(1), MARGOTTINI C.(1), SOLDATI M.(2)
(1) Department of Geological Survey of Italy, ISPRA, ROMA, ITALY ; (2) Dipartimento di Scienze della Terra, Università degli Studi di Modena e Reggio Emilia, MODENA, ITALY

The archaeological site of Machu Picchu, designated by UNESCO as a World Heritage Site since 1983, is affected by frequent landslides which threaten its security and tourism exploitation. Even an alarm about a possible collapse of the entire citadel was lunched in March 2001. Since then, theattention of the international community has been focused on the site investigation and research, to prevent such "catastrophic landslides". The necessity to fully understand the potential and present phenomena in the area of Machu Picchu led international and Peruvian experts to the development of an interdisciplinary research project based on field survey and monitoring activities with low environmental impact (remote sensing techniques). The results of these investigations have not proved the existence of a single catastrophic landslide events, but highlighted the presence of numerous geomorphological processes which may have severe implications for the security of the archaeological remains and its visitors. In order to contribute to a proper site management, further research activities have been developed, on a local scale; these, combined with previous field surveys, monitoring and analysis, have contributed to the definition of a geomorphological model of selected relevant phenomena, in order to assess the related landslide risk. In the present work the following analysis has been implemented on a local scale: geomorphological and geomechanical characterization, passive seismic technique application for stratigraphic purposes and stability analysis implementation. The research outputs allowed the implementation of a more general evolutionary model including the definition of landslide hazard, exposure and vulnerability of the entire archaeological area, in terms of response to geomorphological stress. The main result of the above mentioned activities is the landslide risk assessment for the site and the implementation of a preliminary master plan for the definition of mitigation measures and policy for the archaeological park management.

Retrieving high resolution deformation patterns of slow moving landslides by COSMO-SkyMed SAR data: a sustainable long term monitoring system using artificial reflectors

IASIO C.(1), MULAS M.(1), PETITTA M.(1), CORSINI A.(2)
(1) Institute for Applied Remote Sensing - EURAC, BOLZANO, ITALY ; (2) Earth Science Dept. - University of Modena and Reggio Emilia, MODENA, ITALY

To monitor slow moving landslides affecting broad areas in mountainous regions with high resolution over long time may be very expensive, although this might prevent recurrent and serious losses and damage to infrastructure. The complexity of these phenomena, usually characterised by different sources and interlaced runout areas, adds further difficulty to the understanding of their dynamics and forcing factors. Communities affected by such hazards should be provided with continuous monitoring systems which should be economically sustainable in the long term.

This paper describes a method for monitoring wide complex landslides characterised by slow deformation rates, irrespective of land cover and bedrock lithology. It redefines the approach to monitoring slope displacement based on satellite SAR data, including the validation by sporadic GPS surveys.

The workflow consists of: i. a preliminary study for the selection of relevant points to be instrumented by Artificial Reflectors (AR); ii. data processing by multi-interferometry techniques; and iii. the particular spatio-temporal analysis of the obtained time series for displacement.

This approach has been tested on a well-studied complex earthflow earthslide, 3.5 km long and with an estimated volume of 30 Mm3, threatening the renowned touristic community of Corvara in Badia on the Dolomites (South Tyrol, Italy). The effects of the main forcing factors on deformation have been quantified by the post-processing of time series from 11 measurement points, improving the landslide zoning.

Starting from the lessons learned from this revised remote-sensing application, we show how strengths and weaknesses of a classical persistent scatterers interferometry approach have been addressed by introducing geomorphological criteria in the selection of points to be adequately instrumented with ARs, and how this approach may be further improved.

****

Landslide monitoring: Analysis of displacement data of different landslides in Wanzhou District, Three-Gorges Reservoir, China

GUI L.(1), YIN K.(1), GLADE T.(2)
(1) Faculty of Engineering, China University of Geosciences (Wuhan), WUHAN, CHINA ; (2) Dep. of Geography and Regional Research, University of Vienna, Austria, VIENNA, AUSTRIA

Analysis of displacement monitoring data of landslides plays a significant role in the assessment of landslide stability and deformation stage judgment. Numerous methods have been applied to deal with the monitoring data in order to estimate and predict the movement of landslides, including the fractal theory. It has been proved that the displacement of monitoring points on landslides reflects the fractal characteristics. In this study, the goal is to perform an analysis based on fractal principles to gain characteristics of landslide displacement, and to estimate the deformation stage of different landslides. This study is carried out in Wanzhou District, the Three-Gorges Reservoir, China, where a lot of landslides are being monitored and exhibit different degree of displacement. The data is received from the Three Gorges Geohazard Control Headquarters, based on landslides surface GPS monitoring carried out by the staff of the local environmental monitoring station.

In this study, fractals are applied to analyze the characteristics of different landslides displacement. At first the relationship between landslide displacement and landslide influencing factors, as changes of reservoir water level and precipitation, need to be analyze to get a general idea about reasons of deformation of those landslides. Then the characteristic of landslide displacement is analyzed on fractal theory. The result of each landslide is compared with each other in order to generalize the characteristics of landslide displacement in this area. Finally, the deformation stage of each landslide is estimated. The results from this study will help the involved institutions to get the information of the stability and the deformation stage of these landslides. Additionally, they can transfer this local knowledge to other landslides using this method. It will be meaningful for those who work with early warning system and are in charge of policy making.

Continuous monitoring of a slope affected by shallow landslides in North'Eastern Oltrepo Pavese (Northern Apennines, Italy) for landslide susceptibility assessment: preliminary results

MEISINA C.(1), ZIZIOLI D.(1), BORDONI M.(1), VALENTINO R.(2), BITTELLI M.(3), CHERSICH S.(1)

(1) Earth and Environmental Sciences Department - University of Pavia, Italy, PAVIA, ITALY ; (2) Department of Civil, Environmental, Territorial Engineering and Architecture - University of Parma, PARMA, ITALY ; (3) Department of Agro Environmental Science and Technology - University of Bologna, BOLOGNA, ITALY

Shallow landslides are slope movements, due to extreme rainfall events, affecting superficial deposits of small thickness; their failure surface is, generally, located within the soil-bedrock interface. Although they involve small volumes of soil, due to their close proximity to urbanized areas, they cause significant damage to structures and infrastructures and, sometimes, human losses.

Therefore, identifying at slope scale the soil hydrological and mechanical processes which control the shallow landslide triggering mechanisms is becoming of crucial interest in order to assess the shallow landslide susceptibility using physically based models and to develop early-warning system.

For this purpose an experimental monitoring station was installed in an area of the North–Eastern Oltrepo Pavese where several shallow landslide events occurred in the last years.

The test site slope is representative of other sites in Northern Apennines subjected to shallow landslides: it is characterized by medium-high gradient (more than 15°), the land use is constituted by trees and shrubs developed on abandoned vineyards, the bedrock is made up of gravel, sand and poorly cemented conglomerates.

The experimental station consists in a pluviometer, a thermo-hygrometer, a barometer, a sonic anemometer and a net radiometer. Six TDR probes are placed at 0.2, 0.4, 0.6, 1, 1.2, 1.4 meters from ground level to measure the soil water content. To measure soil matric suction three tensiometers and three heat dissipation sensors are installed at 0.2, 0.6, 1.2 meters from ground level. The data are collected by a datalogger every 10 minutes.

In this work preliminary results obtained from 12 months of monitoring are presented: emphasis is given to the response of the cover materials after dry and wet periods in terms of soil water content and matric potential. These results will be linked to determine the hydro-geotechnical processes that could predispose the triggering of shallow landslides.

****

Poster presentations:

Zoning and analysis of landslide risk in the urban watershed of the stream of independencia, in the city of Juiz De Fora (MG/BR)

ZAIDAN R.(1), FERNANDES N.(2)
(1) Universidade Federal de Juiz de Fora, JUIZ DE FORA - MG, BRAZIL ; (2) Universidade Federal do Rio de Janeiro, RIO DE JANEIRO - RJ, BRAZIL

The landslides are very frequent geomorphological processes in nature. Brazil, by presenting a vast extension with varied relief forms, added to the different climatic regimes, is the stage for a wide variety of these processes. Many are the news about this theme, which are portrayed in the media, mainly in the southeast region of this country, where areas of very mountainous relief are located. When the landslides happen in areas without urban occupation, they do not become target of news, however, when the population growth, followed by the expansion of urban areas, reaches the areas susceptible to the occurrence of these processes, areas of risk can be defined. In this work, an application was presented, demonstrating how to detect and classify the occurrence of slippage in these areas of risks, supported by a deterministic mathematical method called SHALSTAB, in a watershed basin in the process of urban occupation. The results showed that more than half of the areas classified as susceptible to landslide occurrence are not occupied yet, which means that public policies that inhibit their occupation can still be adopted in order that these areas might not be configured as areas of risk to the population. In areas where the risk of landslide was determined, a classification was performed, followed by a geographical analysis.

****

Assessment of landslide susceptibility using landslide map in Japan

DOSHIDA S.
National Research Institute for Earth Science and Disaster Prevention, TSUKUBA, JAPAN

Landslide disasters have been taking our precious lives and assets by occurring in various locations and situation each year. So, it is necessary for us to acknowledge the high-risk landslide locations and situations. National Research Institute for Earth Science and Disaster Prevention (NIED), Japan, have published the landslide distribution map "landslide map" for preventing and mitigating landslide disasters. The landslide map have mapped the 350,000 or more landslide topographies in whole Japan by interpretation of aerial photographs. The objects of this research are to clarify geological and geomorphological features of landslide by analyzing the landslide map and to make the landslide susceptibility map for the assessment of landslide in whole Japan.

I propose the method of the wide area landslide assessment used by the features and distributions according to of geological setting . I calculate the landslide body ratio in each geological unit. The landslide body ratio is that the rate of the landslide body area in each geological unit and the whole area in each geological unit. The landslide body ratio can be considered that landslide susceptibility (occurrence probability of landslides) in each geological unit.

As a result, an average of the landslide body ratio is about 5.6 % in whole Japan. The area consist of the accretionary complex based on volcanic rocks and plutonic rocks have comparatively high-risk landslide susceptibility, and the area of Neogene rocks and Paleogene rocks have the high-risk too. On the other hand, the area of plutonic rocks and Quaternary rocks have low-risk landslide susceptibility. The results show that the landslide susceptibility is greatly different according to geological unit. In the future, I want to assess the landslide susceptibility that accuracy is more high-resolution and better by adding some parameter respectively.

The characteristic features of landslides in the 2011 off the Pacific Coast of Tohoku Earthquake

DOSHIDA S., UCHIYAMA S.
National Research Institute for Earth Science and Disaster Prevention, TSUKUBA, JAPAN

In the 2011 earthquake off the Pacific coast of Tohoku, the loss of human life resulted not only from the direct shaking of the earthquake and resulting tsunami, but also from many landslides that occurred in the region. However, these landslides were few and small, considering the magnitude of the Tohoku earthquake. Furthermore, many of the catastrophic landslides occurred inland instead of in coastal areas near the epicenter. In this research, we consider the underlying cause of this deviation of the landslide distribution by comparing the landslide distribution with various other parameters such as geomorphological features, geological features, the precipitation before the Tohoku earthquake and the peak ground acceleration (PGA) and velocity (PGV) of the seismic waves.

We also compare the landslide distribution produced by the Tohoku earthquake with past landslide distributions (landslide maps published by National Research Institute for Earth Science and Disaster Prevention, Japan). As a result, it is presumed that because of its geomorphological features and geological features, catastrophic landslides do not occur easily in the Tohoku area along Pacific Ocean, the area mainly consist of granite rocks. This is thought to be one of the reasons why there were few reports of catastrophic landslides in spite of the of the Tohoku earthquake. The PGA and PGV of the seismic waves of the Tohoku earthquake had greater values inland than in coastal areas. This is one of the factors that contributed to the large number of catastrophic landslides that occurred inland. An underground structure may have caused these high values in inland regions, although it is necessary to further research this hypothesis in the future.

****

Slope instability at Ischia Island (Gulf of Naples): scenarios for tsunamigenic landslides and coastal vulnerability

DELLA SETA M.(1), ZANIBONI F.(2), TINTI S.(2), PAGNONI G.(2), FREDI P.(1), MAROTTA E.(3), ORSI G.(3)
(1) Dipartimento di Scienze della Terra - Sapienza Universita' di Roma, ROMA, ITALY ; (2) Dipartimento di Fisica e Astronomia (DIFA) - Università di Bologna, BOLOGNA, ITALY ; (3) Istituto Nazionale di Geofisica e Vulcanologia - Osservatorio Vesuviano, NAPOLI, ITALY

This study focuses on tsunami hazard assessment in the Gulf of Naples connected with landslide occurrence at Ischia volcanic island. Ischia is an active caldera affected by an intense resurgence that has generated a maximum uplift of about 900 m over the past 33ka, at the Mt Epomeo block. Such a deformation implies steepening of the relief flanks that, together with seismic shaking, triggers frequent slope failures. A large number of offshore landslide deposits, highlighted by bathymetric surveys, and occurrence of corresponding scars, mainly along the northern and western slopes of Mt Epomeo, testify for numerous past landslides having reached the sea. Previous simulation procedure has shown the tsunamigenic power of some of such landslides.

The potential slide of Mt Nuovo Deep Seated Gravitational Slope Deformation has been assumed as the potential tsunami source. Moreover, given the high population density and tourist value of the island, the coastal vulnerability has also been analysed.

The landslide simulation, based on data collected during a geomorphological field survey, shows that the mobilized rocky mass would attain considerable velocity (30 m/s) being then deposited offshore, close to the coast (up to about 150 m b.s.l.). The generated tsunami would affect the entire northern coast of the island in about 10 minutes with 10-m-high waves. Furthermore, it would approach the continental coast with an almost parallel positive front. Castel Volturno, a coastal town about 30 km north of the island, would be hit after 20 minutes, with inland penetration of more than 1 km.

Preliminary results of tsunami vulnerability study focused on the northern coast, show that almost all the buildings of the Casamicciola and Lacco Ameno towns, located at less than 10 m a.s.l., would be hit by the simulated tsunami, with some light structures completely destroyed. In addition, more than 3,000 buildings would be affected by the slide motion.

The impact of landslides in urban areas. Case study ' the city of Baia Mare

IRIMUS I.A., MAGUT F., ZAHARIA S., POP O.T.
Babes-Bolyay University, Faculty of Geography, CLUJ-NAPOCA, ROMANIA

The city is based on Neogene sedimentary deposits of the Pannonian depression, consisting mostly of alternating marl, grey clay, sandstone, tuff and volcanic pyroclastic materials. The covering Quaternary deposits can be found in the southern terraces and the glacis which borders the volcanic mountains in the north of the built up area. In the northern built up area, mostly due to the high slope values and the geologic characteristics, rainfall and land use changes trigger landslides. Their spatial distribution has been analysed using logistic regression in order to determine the susceptibility of the area to landslide processes. In addition, an analysis has been performed using the heuristic method described in the Romanian legislation (Governmental Decision 447/2003) and the technical regulation GT-019-98. This method uses expert opinions in determining the influence of eight factors on landslide susceptibility.The main impact of landslides in urban areas is the direct damage to buildings which require complex geotechnical measures to be stabilised and repaired. In urban areas these damages are more extensive due to the close vicinity of buildings and the complex infrastructure network which leads to indirect damages related to the disruption of urban functionality. Furthermore, the areas which could have been used for new buildings lose their economic value without stability measures.

The process of predicting landslide prone areas becomes an important factor in reducing the costs of stabilizing active movements and their effects. In this respect the statistical method depends on a very good inventory of landslides and gives better results on small areas, whereas the heuristic method can also be applied to a larger area in order to determine the general landslide susceptibility, but has a certain degree of subjectivity.

****

A comparative study between Weight-rating and Analytical Hierarchical Methods of Landslide Susceptibility Zonation and Geotechnical Investigation of Some Individual Landslides in Dhalai District, Tripura, India

DE S., GHOSH K.
Tripura University, AGARTALA, INDIA

Identification of landslide potential areas by Landslide susceptibility Zonation (LSZ) map is considered as the first step for landslide hazard management. The present study is focused on the spatial analysis of landslide susceptibility zonation using GIS as well as geotechnical investigation of some individual landslides occurred on the slopes of Surma deposits (Lower-middle Miocene) in Dhalai District of Tripura, India ($23^0$25'19"N- $24^0$15'37" and 91d^{0}45'01"E - $92^0$10'26"E).

Two different landslide susceptibility zonation maps have been prepared on the basis of weight-rating and analytical hierarchical methods considering 8 causative factors (layers), such as, lithology, road buffer, slope, relative relief, rainfall, fault buffer, land-use/landcover and drainage density. Geotechnical investigation of some individual landslides has been carried using Total Station and clinometer. Terrain modeling, area and volume of such individual landslide have been estimated through LISCAD software. Soil samples have been tested in the laboratory to determine soil texture and pH values.

The LSZ map produced from weight-rating system shows that only 1.64% and 16.68% of the total study area is falling under very high and high susceptibility zones respectively. LSZ map produced on the basis of the analytical hierarchical method also shows the similar kind of result. Both susceptibility maps show that the high susceptibility zone is restricted within the structural hilly areas and low susceptibility zone is in flood plain areas of the district. Results obtained through geotechnical investigation revealed that unconsolidated sandy materials with occasional intersection of silt or clay layers, high amount of dip of rock strata, continuous seepage through the fractures are considered as the preliminary causes of such menace which is further aggravated by anthropogenic activities and triggered by abundant precipitation during monsoon season.

Landslide susceptibility analysis and mapping: Pahuatlán-Puebla, Mexico

MURILLO GARCÍA F.(1), ROSSI M.(2), REICHENBACH P.(2), MARCHENSINI I.(2), ARDIZZONE F.(2), GUZZETTI F.(2), ALCÁNTARA AYALA I.(3)

(1) A) Posgrado en Geografía, Universidad Nacional Autónoma de México, MÉXICO, MEXICO ; (2) B) Consiglio Nazionale delle Ricerche, Istituto per la Protezione Idrogeologica, PERUGIA, ITALY ; (3) C) Departamento de Geografía Física, Instituto de Geografía, Universidad Nacional Autónoma de México, MEXICO, MEXICO

Analysis of landslide susceptibility is one of the most important issues in landslide hazard studies. We present the results of the application of various statistical multivariate techniques for the estimation, comparison and validation of landslide susceptibility in the municipality of Pahuatlán, Mexico.

We compiled a multi-temporal landslide inventory by analysis of a digital elevation model (DEM) of Pahuatlán area and through field surveys in the period 2011-2012. The DEM (10m×10m spatial resolution) was derived by use of ERDAS IMAGE© and a stereo-pair of Very High Resolution satellite images GeoEye1.

The susceptibility analysis used a partition of the territory into slope units generated with the DEM and a tool developed through GRASS. The tool identified 259 slope units within the study area and calculated for each of those their different morphometric thematic variables such as slope angle, slope aspect and slope profile. Other thematic variables were derived that associated with each slope unit its geological, structural and land use information. The landslide area in each slope unit was used to classify it as stable or unstable (grouping variable).

The derived grouping and thematic (or explanatory) variables were used to estimate landslide susceptibility by use of three statistical multivariate models: (a) linear discriminant analysis, (b) logistic regression, and (c) a neural network. We used a Logistic Regression Combination Model to combine the results of the three models and obtain a final estimate of susceptibility. The models were validated spatially and temporally. The spatial validation used two slope unit datasets randomly selected: the first (larger) to train the models and the second (smaller) to validate them. The temporal validation was performed similarly but used two periods: the first covering the period 1999-2010 was used to train the models and the second covering the period 2011-2012 to validate them.

****

Fluvial sediment transport: the effect of deposition behaviour on vulnerability of elements at risk exposed

FUCHS S.

University of Natural Resources and Life Sciences, WIEN, AUSTRIA

Fluvial sediment transport repeatedly causes damage in mountain environments to elements at risk exposed. Recent empirical studies suggested a dependency of the degree of damage on the hazard impact, and respective damage-loss (vulnerability) functions were deduced for individual torrent fans. However, until now only little information was available on the spatial process characteristics causing the damage. Considerable ranges in the loss ratio only provided the hint that there might be a dependency on the spatial behaviour of the process intensity in the run-out area during individual events. Moreover, frequency-magnitude relationships developed for torrent processes do not deal with such spatial deposition characteristics on a local scale.

Based on data from the Austrian Alps the spatial pattern of depositions was studied with a particular focus on the question whether or not settlement structures have effects on the clustering of high process intensities, and thus high loss ratios for buildings exposed. Using spatial scan statistics, clusters of high and low values of process intensities and loss ratios were analysed. Methodologically, in order to include uncertainties, threshold values concerning the amount and composition of data points necessary for such an approach were studied. It is shown that – within a certain range – the significance and spatial position of clusters of high and low process intensities remains stable over the torrent fans under investigation.

This study contributes to the discussion of the applicability of the frequency-magnitude concept within applied geomorphology, and links fundamental research to applied natural hazard and risk management. It is argued that an approach using spatial statistics may be used to increase our understanding of the spatial dynamics in the run-out areas of torrent processes, and as such to the development of sustainable land-use policies in mountain environments.

Structural Control of landslides movements in the uplifted area of NW Peloponnese (Greece)

GOURNELOS T., TSAGAS D.
University of Athens, ZOGRAFOU,ATHENS, GREECE

In general , rapid uplift is connected to tectonic forces. The geomorphology of such uplifted areas is characterized by steep margins ,high valley incision and slope instabilities.

In this paper we relate the general neotectonic and recent activity to landslide movements. Such movements are numerous in the study area, of different types and affect many villages, regional and local roads and infrastructures. The different stages of this work are

1 - data collection

2 - data analyses

3 - creation of different thematic map in a G.I.S platform

A database has been created including 181 landslides cases of the study area ,the geology, the drainage network, the time and space rainfall distribution, the structural elements such as faults, fractures, fold axes, inclination of bedding planes and the historical and instrumental earthquakes have been considered. The principal mechanisms, for triggering landslides are earthquakes and heavy precipations. A major fault system is situated in the northern margin in this uplifted area (faults of Derveni, Platanos, Rodini,Eliki,Psathopyrgos). The structural induced landslide movements are directly related to reactivation of faulted zones produced by the repeated occurrence of earthquakes.

It is concluded that there is a very good correlation between the spatial distribution, of the structural elements and the locations of landslide areas. Finally human activities such as road construction and land use changes have proved to favour landslide movemnents.

****

Critical rainfall thresholds for triggering debris flows in a human-modified landscape: the case of Carrara Marble Basin (Italy)

GIANNECCHINI R.(1), GALANTI Y.(1), D'AMATO AVANZI G.(1), BARSANTI M.(2)
(1) Department of Earth Sciences, University of Pisa, PISA, ITALY ; (2) Department of Civil and Industrial Engineering, University of Pisa, PISA, ITALY

In the Carrara Marble Basin (CMB, Apuan Alps, Italy) quarrying has accumulated widespread and thick quarry waste, lying on steep slopes and invading or damming valley bottoms. The Apuan Alps area is one of the rainiest in Italy and rainstorms often cause floods, landslides and debris flows: on September 2003 a rainstorm hit the CMB, inducing more than 500 slope failures and causing damage and casualties.

The stability conditions of quarry waste are difficult to assess, owing to its textural, geotechnical and hydrogeological variability. The waste mainly includes boulders and cobbles, together with a matrix formed of a mixture of sand, silt and clay. Therefore, an empirical approach, basing on properties of rainfall able to trigger debris flows, may be effective in assessing landslide hazard and planning warning systems.

Aiming at defining the critical rainfall thresholds in the CMB, a detailed analysis of the main rainstorms was carried out. The hourly rainfall recorded by three rain gauges from 1950 to 2005 was analysed and compared with the occurrence of debris flows. Critical threshold curves were defined in terms of duration, intensity, cumulative rainfall and normalized by the mean annual precipitation. The curves were obtained applying statistical techniques (logistic regression) in order to separate rainfall events which trigger debris flows from events that do not.

The curves obtained for the CMB were compared with the threshold curves proposed for surrounding areas, finding that the rainfall thresholds for quarry waste can often be lower than those obtained for natural slopes. These curves were also compared with global curves proposed by various authors. Finally, the rainfall thresholds obtained for the CMB were validated using rainfall events occurred in 2010 and 2011, obtaining encouraging results.

Coupling terrestrial and marine datasets for coastal hazard assessment and risk reduction in changing environments - A EUR-OPA Major Hazards Agreement Project

SOLDATI M.(1), MAQUAIRE O.(2), MICALLEF A.(3), COSTA S.(2), DELACOURT C.(4), FOGLINI F.(5), JABOYEDOFF M.(6), LETORTU P.(2), LISSAK C.(2), PASUTO A.(7), PRAMPOLINI M.(1), TONELLI C.(1)

(1) Universita di Modena e Reggio Emilia, MODENA, ITALY ; (2) Université de Caen Basse-Normandie, CAEN, FRANCE ; (3) University of Malta, MSIDA, MALTA ; (4) Institut Universitaire Européen de la Mer (IUEM), PLOUZANÉ, FRANCE ; (5) CNR-ISMAR, BOLOGNA, ITALY ; (6) Université de Lausanne, LAUSANNE, SWITZERLAND ; (7) CNR-IRPI, PADOVA, ITALY

The European and Mediterranean Major Hazards Agreement (EUR-OPA) of the Council of Europe is a platform for cooperation between European and Southern Mediterranean countries in relation to na-tech risks. The main objectives are to provide closer cooperation among member states in order to ensure better prevention and protection in case of disasters and to develop new methodologies and tools for risk management.

This contribution outlines the aims and perspectives of a research project funded within this framework. The project, managed by the Euro-Mediterranean Centre on Insular Coastal Dynamics (ICoD) in collaboration with the European Centre on Geomorphological Hazards (CERG), is aiming at linking and integrating terrestrial and marine datasets along the coastlines of Malta and Lower Normandy (France). The investigations carried out so far have contributed to the reconstruction of coastal geomorphological evolution and to a better definition of the kinematics of active landslides that determine risk situations.

The study areas show different morphoclimatic and tectonic setting, but have both been subject to significant changes in sea level since the LGM, when the sea level was some 120-130 metres lower than present. Previous research carried out in the frame of the CERG 2009-11 Project "Coastline at risk: methods for multihazard assessment" has shown that several landslides along the coastlines of Normandy and Malta are likely to extend well below the sea level and therefore coupling subaerial and submarine datasets is likely to provideuseful information for their hazard assessement.

The Project is expected to deliver an original contribution and new directives for risk reduction in coastal areas taking into account historical and possible future climate changes by means of the application of a multidisciplinary approach aiming at the recognition of landforms which are presently under the sea level, but which were emerged in very recent geological periods

****

Evaluation of mitigation measures to reduce shallow-landslide hazard induced by extreme rainfall events: analysis of the road network in the Vernazza catchment (Cinque Terre, Italy)

BRANDOLINI P.(1), GALVE J.P.(2), CEVASCO A.(1), SOLDATI M.(3)

(1) Dipartimento di Scienze della Terra, dell'Ambiente e della Vita, Università degli Studi di Genova, GENOVA, ITALY ; (2) Departamento de Ciencias de la Tierra, Universidad de Zaragoza, ZARAGOZA, SPAIN ; (3) Dipartimento di Scienze Chimiche e Geologiche. Università di Modena e Reggio Emilia, MODENA, ITALY

The severe Mediterranean storm occurred on 25 October 2011 triggered several shallow landslides in the Cinque Terre area (eastern Liguria, Italy) that disrupted transportation routes causing significant direct and indirect economic losses. In the Vernazza catchment the high-intensity rainfall event (472 mm/6h at Brugnato, Vara valley, and 349mm/6h at Monterosso, Cinque Terre) generated more than 500 shallow landslides and all provincial roads connecting the village of Vernazza to the inland were closed due to severe damages. The reparation works on roads has been estimated at more than 10 million Euros. Indirect economic losses related to road closures are unknown but, although difficult to estimate, are likely to be higher than the direct losses, being this area a very famous tourist resort. A quantitative procedure has been applied for estimating shallow-landslide risk along the road network of Vernazza catchment in case a similar event occurs again. Firstly, a landslide hazard model has been produced analyzing statistically the spatial relationship between the landslide-event inventory and several conditioning factors. Secondly, the potential economic losses on roads have been estimated defining damage scenarios. The risk estimation has been calculated by combining landslide occurrence probability and expected losses on every road stretch. Additionally, the following aspects of the risk estimation, assessment and management have been analyzed simulating different solutions for hazard mitigation: (1) Impact of land use changes on landslide hazard and risk; (2) Identification of suitable engineering mitigation measures to reduce possible future economic losses; (3) Cost-effectiveness of proposed solutions. The presented method will be adapted to analyze other elements at risk in the study area to provide decision makers with the basis to select the most adequate mitigation solution considering both economic and societal factors.

Landslide susceptibility validation using multitemporal inventory of landslides in the Moldavian Plateau, Romania

NICULITA M., MARGARINT C.
University Alexandru Ioan Cuza, IASI, ROMANIA

Applying quantitative methods for estimating susceptibility to landslides is based on their spatial distribution. In many cases there is an obvious dynamic areas affected by landslides. On the one hand, given the temporal frequency of triggers, sliding surfaces growths is evident, on the other hand, land use changes often hinders accurate mapping of landslides. This reality translates into a high degree of One of the possibilities to improve these results is to consider several temporal landslide inventories. For an area of approx. 80 km ^{2} decreasing of landslide mapped surfaces. This happens for the inventory of landslides made from photo-interpretation of 2008 aerial images. The 2008 situation susceptibility map was validated using the landslides of 1978, 0.9 AUROC value indicating a good correlation of current delluvial classes susceptibility of the original map.

****

An integrated model to assess rain fall thresholds for critical run-out distances of debris flows in the Wenchuan Eartquake area, SW China

VAN ASCH T.(1), TANG C.(2)
(1) Faculty og Geosciences Utrecht University , UTRECHT , NETHERLANDS ; (2) State Key Laboratory of Geohazards Prevention and Environment Protection, CHENGDU, CHINA

The 2008 Wenchuan Earthquake in the Sichuan Province, SW China generated many co-seismic landslides, which delivered a lot of loose material. It caused a dramatic increase in debris flow occurrences in the subsequent years.

For the development of early warning systems it is necessary to use integrated models which establish a link between rain input, initiation and entrainment processes, propagation and deposition processes. A preliminary model was designed, with entrainment processes driven by run-off water as the main triggering mechanism, to describe the relationship between rain input and debris flow run-out with the intention to assess rainfall thresholds for the start of debris flows and critical run out distances.

The model was calibrated on the depositional volumes of two debris flow events which occurred in two catchments on August 2011 The calibrated model was used to construct a rainfall intensity –duration threshold curve. This curve describes the thresholds for a critical run-out distance, determined by the outlet of the catchment, which was considered as the limit beyond which elements at risk situated in the main river plain are threatened. The calculated thresholds curves were compared with a threshold curve, which could be constructed for the Wenjia catchment on the basis of a number of debris flow rain events with a varying intensity and duration. In this catchment it became evident by field observations that a number of debris flows were triggered by intensive run-off erosion of loose co-seismic rock avalanche material. It appeared that the power functions of the calculated and observed threshold curves for these catchments have the same exponential value, which may indicate that the debris flows are triggered by the same mechanism.

In addition, a method is proposed to estimate the time duration for the depletion of the loose co-seismic source materials for these debris flows.

Assessment of susceptibility for small landslides in the Secchia Basin (Modena Province - Italy) by means of statistical analysis

LIBERATOSCIOLI E.(1), SOLDATI M.(1), VAN WESTEN C.J.(2)
(1) Dipartimento di Scienze Chimiche e Geologiche - Universita' di Modena e Reggio Emilia, MODENA, ITALY ; (2) Faculty of Geo-Information Science and Earth Observation (ITC) - University of Twente, ENSCHEDE, NETHERLANDS

The present work is an attempt to assess susceptibility for small landslides in an area of 492 sq km located in the River Secchia Basin (Northern Apennines - Italy). The Secchia Basin extends for almost 2,300 sq km, but the current analysis focuses only on the hilly and mountain portion of the Modena Province as a prevention tool for local Civil Protection. The altitude of the study area ranges between 125 and 1700 meters a.s.l., and landslide processes represent one of its most important natural hazard. The susceptibility analysis concerns the landslides classified as slide according the Emilia-Romagna Region (RER) Landslide Inventory Map (LIM). The slides are 1081 (76% of which is active) and show the smallest surface among the different landslide types affecting the study area. The Weight of Evidence (WofE) method, a statistical approach, has been selected for performing indirect landslide susceptibility assessment. The choice of the training set, based only on active landslides, takes into account two main possible limitations: 1) the depletion areas are usually not mapped in the RER LIM which reports only the accumulation part of the mass movements; 2) in the RER LIM the term slide includes both earth and rock movements. In order to evaluate the fitting performance of the model, the final training set is randomly divided into two groups: the calibration set (80% of the occurrences) to compute the model itself and the validation set (20% of the occurrences) to estimate its quality. The analysis is based on the following predisposing factors: lithology, slope and other geo-morphometric parameters, aspect, land use and cover, distance from roads. Considering the above mentioned limitations, the resulting model predicts an acceptable number of landslides. However, possible future improvements of the results and their usability for Civil Protection purposes are discussed.

****

Dunes dynamics and potential risks of mass movements in Natal-RN City, Brazil

FERNANDES E., CESTARO L.A., PEREIRA V.H.C.
Universidade Federal do Rio Grande do Norte, NATAL, BRAZIL

Coastal aeolian dune fields in Natal-RN city are inserted in the same dune complex that focuses like a band proximal oceanic eastern coast of the state of Rio Grande do Norte-Brazil, which has been highlighting the scenic-landscape and spatial relationships establishing with the local society and featuring varied uses of these environments. This association between the natural and socioeconomic processes that act on these dunes have promoted changes in the features of the relief from the instability of the steeper slopes, especially those leeward (lee side) that generate induced processes such as mass movements and that endanger these communities.The Environmental Protection Areas of Natal city are as territorial units of the natural environment planning and management regulated by Natal city's master plan. However, these protection zones are distinguished by use conflicts and occupation on these massive dunes. The objective of this study was to understand the dynamics of dune fields in some areas of Environmental Protection in order to identify areas of potential risk to mass movements on slopes of dunes occupied by local population. The modeling of land (slope, elevation) were prepared from contour lines of equidistance 1 meter vectorized using the Spatial Analyst module of ArcGIS 9.3 (ESRI). Sediment analyzes were performed in laboratory in order to determine their morphological characteristics and their maximum angle of friction between the grains. Besides, observations were made in situ indicators of landslides in homes. As a result, the Maps of Potential Risk to Mass Movements presents the following risk classes: NO RISK (slope 0 °); LOW RISK (slope from 1 to 10); RISK MEDIUM (slope from 10 º to 25 º); HIGH RISK (slope from 25 to 31) and IMMINENT RISK (slope> 31 °).

Between spatial autocorrelation and representativity: Seeking the 'optimal' sample size for a statistical spatial prediction model of debris flow initiation

HECKMANN T., GEGG K., BECHT M.
Catholic University of Eichstaett-Ingolstadt, EICHSTAETT, GERMANY

Statistical approaches to predictive modelling on the catchment scale are used very frequently compared to heuristic and physically based methods. In many case studies, we find basic assumptions of statistical models neglected or violated. In case of logistic regression, e.g., problems caused by spatial autocorrelation, multicollinearity and the normally unfavourable ratio of “non-event” to “event” elements have often been ignored. Recent work employing the methodology of “rare event logistic regression” tackles the bias induced by the latter problem, but suggestions concerning the necessary sample sizes (for “non-events”) seem to be based mostly on the literature, without having been thoroughly checked.

We present a case study of a prediction model for slope-type debris flow initiation. Using Monte Carlo analysis with stepwise logistic regression on raster data, the effect of sample size on model results is investigated by estimating 1000 models for a range of sample sizes. The “optimal” sample size is constrained by the requirement of model stability on the one hand (with sample sizes too small, the factors contained in the stepwise analysis and hence the model results are highly dependent on the sample) and sample independence on the other (with sample sizes too high, the raster cells in the sample are too close, on average, and spatial autocorrelation causes the sample to violate the independence assumption). The analysis yields not only the “optimal” sample size, but also the “optimal” geofactor combination (which forms part of most models). The optimal parameters in this respect are used to estimate a logistic regression model for a 15 km² study area in the Austrian Central Alps, which is then validated in a neighbouring area. Moreover, we explore the magnitude and spatial distribution of model uncertainties using an ensemble of 100 models calculated from independent samples.

****

ChangingRISKS: Assessment and communication on possible effects of global changes on landslide risks

MALET J.(1), BÉGUERIA-PORTUGUÈS S.(2), PROMPER C.(3), GLADE T.(3), PUISSANT A.(4), REMAÎTRE A.(1)
(1) Institut de Physique du Globe de Strasbourg, STRASBOURG CEDEX, FRANCE ; (2) Estación Experimental de Aula Dei, EEAD-CSIC, ZARAGOZA, SPAIN ; (3) Department of Geography and Regional Research, University of Vienna, VIENNA, AUSTRIA ; (4) Laboratoire Image, Ville, Environnement, STRASBOURG, FRANCE

Landslides across the Alpine countries are recognised by practitioners, politicians and scientists as having a major socio-economic impact, and may represent a significant risk for the population and the properties in particular locations. The ChangingRISKS project intends to develop an advanced understanding of how global changes (related to both environmental and climate change as well as socio-economical developments) will affect the temporal and spatial patterns of landslide hazards and associated risks in two territories of the Alps, and how these changes can be assessed, modeled and communicated (through mapping procedures) to stakeholders.

The project work is focused on two mountain study areas located in France (*Barcelonnette Basin, South East France*) and in Austria (*district Waidhoffen/Ybbs, Lower Austria*).These research areas, characterized by a variety of environmental, economical and social settings, are severely affected by landslides, and have experienced significant landuse modifications and human interferences over the last century.

Results on the influence of changing landuse conditions and changing climate are presented through the application of a process-based modeling chain able to simulate transient groundwater hydrology and slope instability from observed and simulated climate data sets. Further development of the modeling platform to the calculation of intensity parameters (e.g. runout distances, sediment heights) are described.

Methods for landslide susceptibility assessment, concepts and applications for spatial planning in Lower Austria

PETSCHKO H.(1), BELL R.(1), GLADE T.(1), GRANICA K.(2), HEISS G.(3), LEOPOLD P.(3), BAUER C.(2), PROSKE H.(2), POMAROLI G.(4), SCHWEIGL J.(5)

(1) University of Vienna, VIENNA, AUSTRIA ; (2) Joanneum Research Forschungsgesellschaft mbH, GRAZ, AUSTRIA ; (3) Austrian Institute of Technology, TULLN, AUSTRIA ; (4) Office of the Lower Austrian Provincial Government, Department of Spatial Planning and Regional Policy, ST. PÖLTEN, AUSTRIA ; (5) Office of the Lower Austrian Provincial Government, Geological Survey, ST. PÖLTEN, AUSTRIA

Landslides pose threats not only for specific localities, they are also influencing larger areas and consequently require spatial analysis methods for assessing the susceptibility to landslides. The decision on the most appropriate model is dependent on many factors. These include the size of the study area, the spatial resolution and quality of the input data sets, the usability and flexibility of spatial analysis methods, and the model performance. Geospatial statistics help to estimate the model performance, however, the model should also be assessed based on geomorphic plausibility, checked in the field or within GIS.

This contribution will present a study design for determining the best suited landslide susceptibility map for spatial planning in Lower Austria. As the maps will be implemented in spatial planning practises it was decided that the resulting maps are categorized in three classes. These classes are based on the percentage of slides contained in each class which is defined by the spatial planners and geologists of the provincial government. Considered landslide types in this study include rock falls and shallow or deep-seated slides. Rock fall susceptibility is modelled using the Conefall approach, as the data on rock fall starting zones did not give enough information for statistical modelling. For modelling the susceptibility of shallow and deep-seated slides the generalized additive models (GAM) and the Weights of Evidence method (WofE) are tested. The resulting area under the ROC, which was used as a statistical quality criterion for comparing model performance, does not show significant differences between the GAM and WofE. The final decision of model choice is mainly based on the geomorphic plausibility of the classified map. Therefore, for all landslide processes, the expert is still of major importance not only to obtain detailed spatial input data, but also to provide a final judgement on the quality of the map beyond statistical indicators.

****

Debris flow susceptibility assessment in the avio valley (adamello-presanella massif, Central Alps) through multitemporal and conditional analysis

SALVATORE M.(1), BARONI C.(1), CARLONI I.(1), DELLA SETA M.(2), DEL MONTE M.(2), VERGARI F.(2)

(1) Dipartimento di Scienze della Terra, University of Pisa, PISA, ITALY ; (2) Dipartimento di Scienze della Terra, University of Roma La Sapienza, ROMA, ITALY

Alpine areas, especially those at the highest elevations, are particularly sensitive to climatic changes inducing relevant modifications in the cryosphere extension and occurrence, as well as in frequency and intensity of slope processes.

We present results of a multitemporal analysis of slope processes conducted in a high mountain area by applying a method traditionally used for landslide susceptibility assessment, with the aim of defining the proneness to debris flow occurrence.

The study area is the Avio valley (Adamello-Presanella Massif, Central Alps), among the main tributary valleys of Valcamonica, which has recorded Late Glacial and Holocene glacial fluctuations, and, more recently, the glacial retreat following the Little Ice Age. In the newly forming climatic-environmental condition, the active geomorphic agents are affecting recently deglaciated areas, older glacial and slope deposits, clearly increasing instability processes.

The multitemporal analysis of slope processes, and in particular of debris flows, started from a geomorphologic map surveyed in 1985, and was updated with aerial photographs (1994 and 2006). All data were organized in a geomorphologic database in GIS environment.

The susceptibility evaluation method furnishes an unbiased procedure for causal factor selection based on some intuitive statistical indices, aimed at detecting among different potential factors the most discriminant ones in the study area. Conditional analysis allows to determine the susceptibility index value for a combination of selected causal factors (or vUCU, vector Unique Condition Units).

The multitemporal debris flow database allowed the validation of the obtained susceptibility model, in which many areas estimated as highly susceptible coincide with the area actually affected by debris flows in the period following that considered for the susceptibility evaluation, giving rise to encouraging results.

Deformation and prediction of landslides with step-like deformation in the Three Gorges Reservoir

LI D., YIN K., CHEN L.
China University of Geosciences(wuhan), WUHAN, CHINA

It is very difficult to predict deformation tendency and general failure of landslides with step-like deformation in the Three Gorges Reservoir due to deformation complexity and lack of the failure criterion. The landslide deformation in the reservoir is notably influenced by the coupling effect of rainfall and reservoir water level. The deformation characteristics including local failure, multi-layer sliding and abrupt acceleration are firstly researched in detail based on the monitoring information and geological environment. In order to establish appropriate failurecriterion, the three-dimensional prediction model is established through the multi-dimension body based on the landslide multi-factor. The landslide multi-factor is proposed on the basis of the alert velocity, earth crack of landslide surface and macroscopical evidences. The alert velocity could be obtained from the Voight's model. The three-dimensional failurecriterion is proved by Baishuihe landslide and Xintan landslide.

****

Landslide Susceptibility Mapping Using SINMAP model, Serra do Mar, Brazil

NERY T.(1), VIEIRA B.C.(2)
(1) Cemaden, CACHOEIRA PAULISTA, BRAZIL ; (2) Universidade de São Paulo, SÃO PAULO, BRAZIL

The process-based mathematical model have been used to evaluate the relative susceptibility to shallow landsliding in mountain regions of Brazil. In these regions, especially, the Serra do Mar mountain range (located along the southeastern Brazilian coast), shallow landslides are usual features associated with intense summer storms causing catastrophic damages. On 23 and 24 January 1985, a summer storm (380mm/48 hours) triggered thousands landslides and debris flow in the River valley Moji, in Cubatão, São Paulo state. In this study, we evaluated the shallow landslides susceptibility in the Ultrafértil basin used SINMAP model, that is a probabilistic mathematical model, which defines the relative susceptibility to shallow landsliding. We used high resolution (4m²) Digital Elevation Model (DEM) obtained from a topographic map (1:10.000 scale). The soil parameters (geotechnical and hydrological) and precipitation were extracted from the others works in the Serra do Mar and thegovernmental agencies. Were proposed three scenarios varying the soil thickness (1 m, 1.5 m and 3.5 m).The results suggest high shallow landslide susceptible, with stability indexes exceeding 60%. The landslides occurred mainly on slopes of more than 30° and under conditions of partial saturation. The lower threshold class concentrated the largest number of landsliding (> 100) for the three scenarios. On scenario 2 (1.5 m soil thickness) was concentrated the most part of shallow landslides below the 1 threshold, which corresponds the unstable areas. The ratio (transmissitivy/steady state recharge) was the most sensitive parameter of the model, showing that this ratio and the soil thickness were mainly important for these processes. The process-based model is an important tool to understand the landslides spatial distribution and to predict shallow landslide in steep tropical areas. Therefore, this tool can help the public administrators to reduce the damage in future events.

Multi-scale regional landslide susceptibility assessment in Sicily (Italy): The Sufra Sicilia Project

ROTIGLIANO E.(1), AGNESI V.(1), ANGILERI S.E.(1), ARNONE G.(2), CALÌ M.(2), CALVI F.(2), CAMA M.E.(1), CAPPADONIA C.(1), CONOSCENTI C.(1), COSTANZO D.(2), LOMBARDO L.(1)

(1) University of Palermo, Italy, PALERMO, ITALY ; (2) Assessorato Territorio e Ambiente - Regione Sicilia, PALERMO, ITALY

The SUFRA ("SUscettibilità da FRAna") project, moves from the same multi-level approach of the TIER JRC European protocol. But, in light of the availability for the Sicilian territory of highly detailed geological l.s. and landslide data, SUFRA diverges both in the worked data and in the model building methods, selecting a more detailed three level landslide susceptibility assessment scheme: SUFRA100 (1:100,000), SUFRA50 (1:50,000) and SUFRA25/10 (1:25,000/1:10,000). All the three mapping levels exploit climatic, soil use and seismic informative layers, while differing: in the details of the core data (geology and topography); in the quality and resolution of the landslide inventory; in the modelling approach.

SUFRA_100 is based on the heuristic modelling of a 1:100,000 geologic layer and a 250m cell DEM (IGMI) 250m; the mapping units are 1km side square cells and the models are validated with respect to the available regional landslide inventory (PAI). SUFRA50 is based on the stochastic modelling of 1:50,000 (CARG) geologic maps and 10m DEM; the mapping units are 50m cells and hydro-morphometric units, while the landslide inventory is specifically produced by means of a remote systematic landslide mapping. SUFRA10/25 is based on stochastic modelling of field checked geologic maps and 2m DEM; the mapping units are the slope units (SLUs), which are derived by further partitioning the hydro-morphometric units so to obtain closed morphodynamic units. The landslide inventories are produced by means of field and remote surveys (on focus). SUFRA50 and SUFRA25/10 models are validated by exploiting both random spatial partition and temporal partition methods.

Examples of SUFRA_100, SUFRA_50 and SUFRA_25/10 are presented for some representative key sector of Sicily (northern chain and southern fore-deep sectors). First results attest for the feasibility and goodness of the proposed protocol.

****

Landslide susceptibility map of the Mauritius Island

MICCADEI E.(1), MARSALA V.(2), PIACENTINI T.(1), ROCCA M.(2), SCIARRA M.(1)

(1) Dipartimento di Ingegneria e Geologia - Università degli Studi "G. D'Annunzio" Chieti-Pescara, CHIETI, ITALY ; (2) SGI Studio Galli Ingeneria Spa, PADOVA, ITALY

The landslide susceptibility map of the Mauritius Island is the result of a comprehensive project for the Development of an Inundation, Flooding and Landslide National Risk Profile for the Republic of Mauritius carried out in collaboration with the Ministry of Environment and Sustainable Development that provided the data for this research.

Mauritius is a volcanic islands located in the western part of the Indian Ocean and constructed by three distinct main episodes of volcanic activity from 10 to 0,02 M.y.

The mapping of landslides driving factors was carried out combining digital terrain models, geological, soil map and land use data. An analysis of the orthophoto data was conducted for the main mountainous/hilly areas of the island. The identified landslide prone areas were corroborated through a field geomorphological survey and expert knowledge based analysis. The landslide susceptibility and hazard study of Mauritius was based on a mixed heuristic and statistical analysis with multidisciplinary approach incorporating: 1) definition and GIS mapping of geology and geomorphology factors, directly or indirectly linked to slope instability (slope, aspect, profile curvature, planar curvature, drainage pattern, vegetation, lithology, soil, rainfall), by means of bibliographic data and photogeology analysis; 2) mapping of the existing landslides and superficial deposits by means of photogeology and field mapping; 3) GIS modelling of landslide susceptibility based on the statistical relationships between factors and instability process, calibrated through field surveys.

The adopted methodology defined a different susceptibility for different type of instabilities (rock falls, landslides, rapid earth flows). The ensuing maps were overlayed to obtain the overall instability map, analysed using the cumulative distribution function and reclassified in four main classes. The overlay of these maps produced the comprehensive landslides susceptibility map of the Mauritius Island.

Regional-scale debris-flow modelization for hazard mapping in alpine basins using a high-resolution DTM and events geodatabase

CREMA S.(1), CAVALLI M.(1), MACCONI P.(2), MARCHI L.(1)
(1) CNR-IRPI, PADOVA, ITALY ; (2) Hydrographic Office, Autonomous Province of Bolzano, BOLZANO, ITALY

A very detailed geodatabase of floods, landslides and debris flows is available and kept up to date for the territory of the Autonomous Province of Bolzano, in northeastern Italy (7400 km^2). The database is fed by field surveys carried out after the occurrence of instability phenomena and reports locations and attributes of the events for the last 15 years. The on-site analysis grants the gathering of important information and documentation resulting from field measurements and interviews to witnesses of the events. Particular attention is paid to the recognition of location, magnitude and path of landslides and debris flows.

Data on shallow landslide locations and debris-flow initiation sites have provided the input to a regional-scale debris flow model aimed at the assessment of debris flow paths and inundation areas. A simple mass propagation model based on topographic attributes (Huggel et al., 2003) has been applied to simulate mass movement phenomena for selected basins using initiation sites listed in the regional database. In the model, debris-flow propagation is given in probability-related values representing the hazard potential for the selected locations. All the simulations have been carried out using a high-resolution (2.5m) LiDAR-derived Digital Terrain Model (DTM).

The combination of a georeferenced database of landslides and debris flows and a simple topography-based model constitutes therefore a reliable tool for a fast and preliminary debris-flow hazard estimate, assessment and mapping.

References: Huggel C, Kääb A, Haeberli W, Krummenacher B. 2003. *Regional-scale GIS-models for assessment of hazards from glacier lake outbursts: Evaluation and application in the Swiss Alps*. Natural Hazards and Earth System Sciences 3(6):647–662.

****

Multi temporal LiDAR-DTMs as a tool for modeling a complex landslide: a case study in the Small Dolomites (Rotolon catchment - Italy)

BOSSI G.(1), CAVALLI M.(1), QUAN LUNA B.(2), FRIGERIO S.(1), MANTOVANI M.(1), MARCATO G.(1), SCHENATO L.(1), PASUTO A.(1)
(1) CNR-IRPI, Research Institute for Geo-Hydrological Protection, Italian National Research Council, PADOVA, ITALY ; (2) NGI, Norwegian Geotechnical Institute, ICG, International Centre for Geohazards, OSLO, NORWAY

The geomorphological change detection through the comparison of repeated topographic surveys is a recent approach that greatly benefits from the latest developments in topographical data acquisition techniques. Among them, airborne LiDAR makes the monitoring of geomorphological changes a more reliable and accurate approach for natural hazard and risk management. In this study, the analysis of multi temporal LiDAR-DTMs acquired just before and after a complex landslide event (4th November 2010) in the Rotolon catchment (Small Dolomites, Italy), was used to set up the initial condition for the application of a dynamic model.

The 2010 event detached a mass of 320.000 m^3 from the south slope of Mt. Rotolon partially evolving in a debris flow that stretched for 4.5 km threatening some villages. Pre- and post-event DTMs derived from LiDAR with 2 m resolution were available. The comparison between the DTMs was carried out considering the error propagation. The resulting differential DTM was analyzed in order to identify erosion and depositional areas related to the event and to quantify them in terms of volume.

The knowledge of the dynamics of the phenomenon allowed to back-analyze the event with a dynamic numerical 3D model. DAN3D code was selected because it allows to modify the rheology and the parameters of the moving mass during the run-out. This behaviour was observed along the path of the debris-flow where the mobilized mass encountered rheological modifications due to the hydric contribution of tributary streams and the entrainment of eroded material. Considering these aspects a sound simulation of the 2010 event was computed.

Nowadays some portions of Mt. Rotolon flank are still moving and showing precursor signs of detachment. The same soil parameters used in the back-analysis model were used to simulate the run-out for three possible landslides flows allowing to generate reliable risk scenarios that could be used for creating civil defense emergency plans.

Comprehensive Utilization of SAR and Optical Data for Landslides Investigation in the Bailongjiang Basin, China

CHENG C., BAI S., WANG J., WEI Y.
Nanjing Normal University, NANJING, CHINA

The Zhouqu–Wudu segment of the Bailongjiang Basin in Northwest of China with a total area of 8917 km^2 lies in the transition zone among Tibet plateau, loess plateau and Sicuan Basin. It has already been strongly affected by landslides for a long time, it is one of the most severely landslide affected regions in China. There are more than 2000 large and medium-sized landslides which are greater than $3\times10^4m^3$ before the Wenchuan earthquakein this regions, numerous additional slope failures were triggered by the 2008 Wenchuan earthquake.

This case study has two main objectives: (i) Landslides recognition and mapping using space-borne SAR and Optical imagery; (ii) long term monitoring(from 1995 to 2012) of deformationbased on persistent-scatter (PSI) techniques.The landslides recognition which using supervised classification, change detection and texture analysis method. Interferometric synthetic aperture radar (INSAR) data from ERS and ENVISAT sensors were utilized in the analysis of the deformations. Causing by temporal decorrelation the PS which located inside the landslides is lacking sometimes, the adjacent landslides with sufficient number of PS were analyzed by transformation of the line of sight displacements recorded by the sensors to the slope vector direction.This procedure allowed identification of the precise boundaries of the actively moving landslide parts and the updating of the landslide inventory in this region.

****

Hydroelectric power generation, tropical river flood hazards and mitigation plan for better investment in Uttaranchal, India

CHHABRA N.(1), ROY N.G.(2)
(1) University of Petroleum & Energy Studies, DEHRADUN, INDIA ; (2) Presidency University, KOLKATA, INDIA

The hydraulic performance of the Tons River demonstrates significant flood damage potential in agricultural, industrial and residential areas adjacent the river in this region. Therefore, the design of flood control strategies is one of the main focuses of hydroelectric power projects in this region. This article presents the results of flood analysis in the Tons River catchment at several sites and impact flood control measures of the operational and under-construction dams. We also present the evaluation of structural flood control plans downstream of dams and floodplain areas. In this regard, inundation level and inundated area was calculated by using flood routing model (dynamic) in different situations, without and with different flood mitigation alternatives. Flood damages were determined versus inundation levels by using field survey results and from reports. Then, the expected annual damage for each alternative scheme was calculated by elevation – damage function. Expected annual damage reduction through proper flood control, which is the benefit of investment plan was also determined through all alternatives (scenario analysis). Then, economic indices (NPV in our case) were calculated and justification was evaluated by determining initial investment cost, operation and maintenance cost and also annual benefit of damage reduction using data from existing project.

The results of this study is the integrated flood mitigation plan in the Tons rivers system which includes one operational dam in Mohammadpur, one under-construction dam in Chibro and one development dam in Kalsi. All selected alternatives were economically feasible and environmentally protected.

Keywords: river engineering, flood control, risk analysis, damage analysis, investment.

How can fiber optic technology be used in early warning systems for natural hazards?

BOGAARD T., WENKERS K.
Delft University of Technology, faculty of Geosciences and Civil Engineering, Department of water management, DELFT, NETHERLANDS

In order to reduce the societal risk associated with natural hazards novel technologies could help to advance in early warning systems. In our study we evaluate the use of multi-sensor technologies as possible early-warning systems for landslides and man-made structures, and the integration of the information in a simple Decision Support System (DSS). In this project, particular attention will be paid to some new possibilities available in the field of distributed monitoring systems of relevant parameters for landslide and man-made structures monitoring (such as large dams and bridges), and among them the distributed monitoring of temperature, strain and acoustic signals by FO cables.

Fiber Optic measurements are becoming more and more popular. Fiber optic cables have been developed in the telecommunication business to send large amounts of information over large distances with the speed of light. Because of the commercial application, production costs are relatively low. Using fiber optics for measurements has several advantages. This novel technology is, for instance, immune to electromagnetic interference, appears stable, very accurate, and has the potential to measure several independent physical properties in a distributed manner.

The high resolution spatial and temporal distributed information on e.g. temperature or strain (or both) make fiber optics an interesting measurement technique. Several applications have been developed in both engineering as science and the possibilities seem numerous.

We will present a literature review that was done to assess the applicability and limitations of FO cable technology. This review was focused but not limited to application in landslide research. Furthermore, field and laboratory experiments will be discussed. Several examples of current practices will be shown, also from outside the natural hazard practice and possible application will be discussed.

****

Critical hydro-climatic thresholds for triggering slow-moving landslides along Normandy coasts (France)

LISSAK C.(1), MAQUAIRE O.(1), MALET J.P.(2)
(1) LETG-Caen Géophen, CAEN, FRANCE ; (2) Ecole et Observatoire des Sciences de la Terre [EOST], Institut de Physique du Globe de Strasbourg [IPGS], STRASBOURG, FRANCE

In Normandy (North-West France), landslides occurring along the coasts are large, deep in marly, sandy and chalky formations. All are characterized by a seasonal activity (1-10 cm.y-1) and regularly affected by brutal accelerations inducing several meters slope displacements.

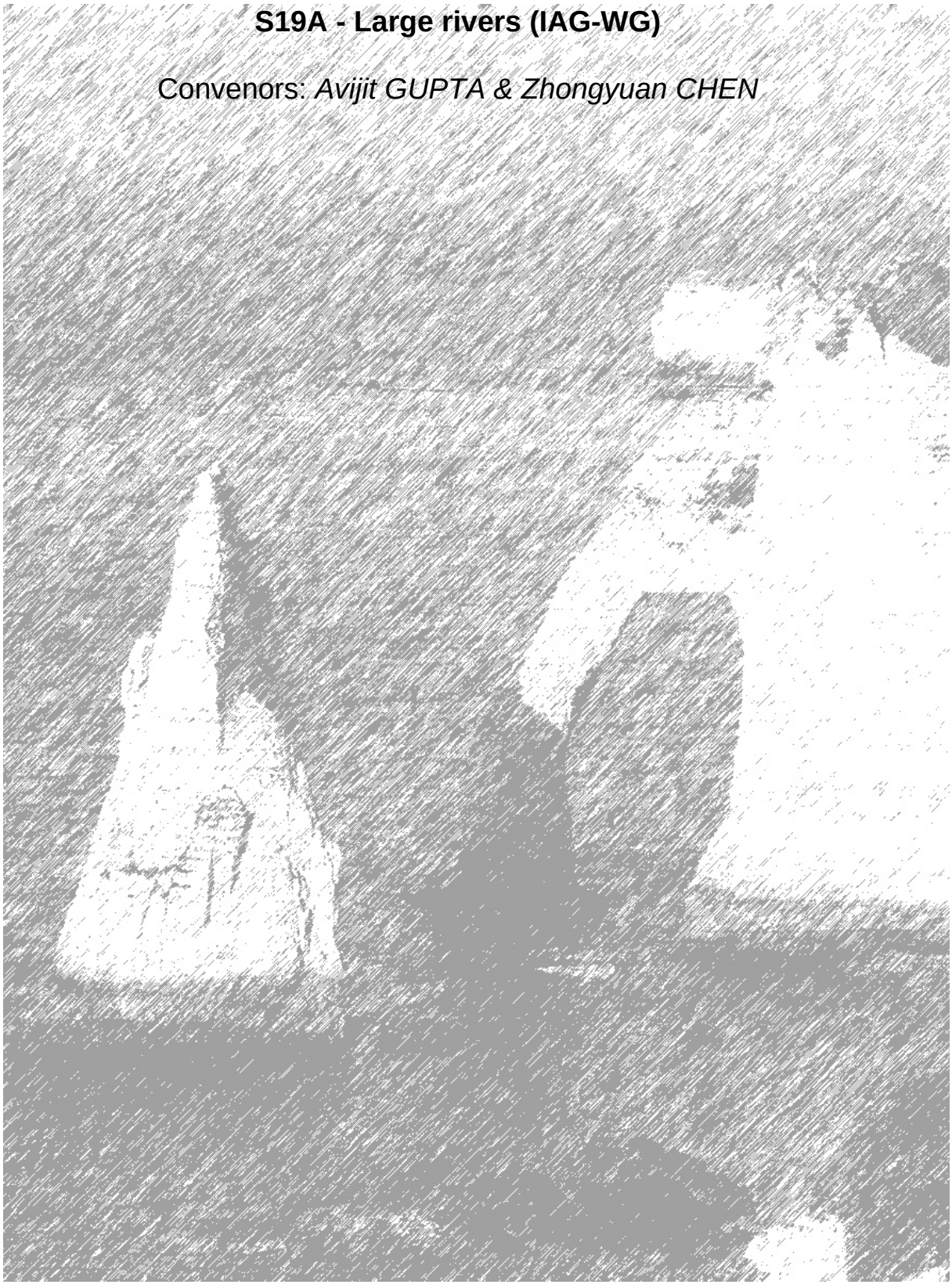
The first investigations after the reactivation of the landslide (January 1982) showed that the several accelerations (January 1982, February 1988, January 1995 and march 2001) were closely related to hydro-climatic conditions.

To improve upon knowledge on slope dynamic associated to rainfall and groundwater level fluctuations, the combination of historical data and punctual or permanent field measurement were necessary. The monitoring system has been implemented to observe the triggering factors (twenty-eight available piezometers whose five with permanent sensors) and very low amplitude displacements through the implantation of three permanent GPS receptors and twenty-three cemented benchmark. These investigations highlight the morphostructural control of the landslide kinematic but also the seasonal variations of the landslide velocity. Finally, groundwater level has been associated to the landslide kinematic to define critical thresholds towards an early warning system to differentiate the permanent activity of the landslide from precursors of major accelerations. Investigations were first conducted on the plateau, a few kilometers from the site, to define early warning piezometric thresholds.

Two main situations were identified: (1) a long-lasting rainfall episodes (several month) with groundwater water elevation of more than 2 meters causing major accelerations (return period of over 5/10 years); and (2) a moderate-intensity rainfall period with a limited groundwater rise responsible for a moderate seasonal kinematic (return period of about every years) with a lag time between groundwater rise and slope acceleration about 1 and 4 days.

S19A - Large rivers (IAG-WG)

Convenors: *Avijit GUPTA & Zhongyuan CHEN*



Oral presentations:

Sedimentary Processes in Large Source-to-Sink Systems Forced by ENSO

AALTO R.
University of Exeter, EXETER, UNITED KINGDOM

Sedimentation patterns and processes are summarized within three large rivers that border the tropical Pacific region responsible for the El Niño/Southern Oscillation (ENSO), a global phenomenon affected by future climate change. The research investigates the supply, transport & deposition of sediment, employing field documentation of accumulation processes, surveys, and inundation mapping.

The rivers are: 1) The Beni-Mamore system in the Bolivia that supplies the majority of sediment and water to the Madeira River, in turn the largest contributor of the ~1 Gt Mt $yr^{-1}$of sediment discharged by the Amazon; 2) The Fly River in Papua New Guinea (PNG) that comprises the largest river basin in Oceania, ranking among the top 25 rivers in the world for water and sediment discharge, at $1.9\times10^{9}m^{3}yr^{-1}$and 85 Mt yr^{-1}, respectively; & 3) The Mekong River, investigated in Cambodia, that also exhibits a runoff-ENSO relationship and supplies sediment to maintain the delta. Because the tectonically active, tropical watersheds of Oceania account for half of the global sediment flux to the ocean, the impact of climate oscillations on sedimentary processes is of particular interest.

In both PNG and Bolivia the majority of the sediment is delivered from mountain headwaters during ENSO oscillations, with sediment accumulation across the lowland floodplains primarily during infrequent, episodic events – not during regular seasonal inundations. These rapid transfers of sediment mass from the active orogeny to the lowland depocenters occur primarily during cold-phase ENSO events immediately following strong warm-phase ENSO conditions that have dried out the floodplains. The impact of ENSO on the accretion of Cambodian floodplains is somewhat less dramatic. Over timescales of centuries to millennia, ENSO may therefore modulate the rates and mechanisms for construction of lowland river floodplains, creation of geological strata, and ultimately the export of material to deltas.

****

Climate change and large tropical rivers

GUPTA A.(1), LIEW S.C.(2)
(1) University of Wollongong, WOLLONGONG, AUSTRALIA ; (2) National University of Singapore, SINGAPORE, SINGAPORE

Large tropical rivers tend to have a common set of properties: a polyzonal basin, longitudinal variations in channel and valley characteristics, a seasonal pattern of discharge, episodic sediment transport, almost the entire sediment derived from the headwaters, large deltas. The Fourth Assessment report of the Intergovernmental Panel on Climate Change lists certain consequences of climate change that should impact these rivers. These include retreat of mountain glaciers, early melting of snow and ice, changes in annual rainfall, enhanced seasonality, regional increase in droughts, increase in the strength of large storms, high rainfall from extreme events, and sea-level rise. It is possible to evaluate the robust changes in stream morphology and behaviour using principles of fluvial geomorphology and past analogues. Although we limit this discussion to the large tropical rivers, generalisations are difficult beyond a point and individual rivers may adjust individually. Anthropogenic activities have modified almost all rivers, and in certain cases, the noise from anthropogenic alterations may override signals of climate change. In spite of these constraints it may be possible to construct a new set of rules for understanding, utilizing and managing rivers. Such attempts are worthwhile as, following climate change, rivers are likely to lose stationarity and also undergo drastic changes, such as avulsion in certain parts of their basins such as mountain-front fans and lower valleys and deltas. As a very large population live in these areas, it is imperative to design a new style of management and adaptive behaviour in order to live near large tropical rivers.

Interactions between global warming, flooding and fluvial form adjustment on the Lena River, Central Siberia

GAUTIER E.(1), FEDOROV A.(2), COSTARD F.(3), KONSTANTINOV P.(2), BRUNSTEIN D.(4)
(1) Paris 8 University - CNRS Lab. Geographie Physique, MEUDON, FRANCE ; (2) Russian Academy of Sciences - Permfrost Institute, YAKUTSK, RUSSIAN FEDERATION ; (3) CNRS UMR 8148 Ides, ORSAY, FRANCE ; (4) CNRS UMR 8591 LGP, MEUDON, FRANCE

The study examines impacts of the current climatic change on a large periglacial hydrosystem, at different spatial and temporal scales. The fluvial dynamics of the Lena River is controlled by a periglacial environment, characterized by a very cold and dry climate and by a deep permafrost. For these reasons, the hydrology of the Lena is characterized by an irregular fluvial regime and a spectacular flood. During the flood, thermal and fluvial erosion jointly cause important retreat of frozen banks, mainly on island heads. In Yakutia, previous studies clearly show significant signs of a climatic change since the end of the 1980's: increase of temperatures, up to 5°C during winter for the air, up to 1°C for the permafrost, and up to 2°C for the stream water during summer.

A first part analyses historical hydrologic data (daily discharge since the 1930's) to detect a possible change of hydrology. We examine flood peaks, flood duration and date of beginning of the outburst. Because of the strong impact of rapid outburst, we also try to detect precisely rapid water elevation to identify exceptional events.

Second, we present the results of field surveys conducted during five years on different sites, in order to determine interactions between flood intensity and duration, water temperature, ice-jam, alluvial vegetation and erosion / deposition processes. The equipped sites were chosen in the upper part of the active floodplain, where there is no direct anthropogenic influence: i) data loggers are installed at different depths in the permafrost; ii) annual topographic surveys associated with sediment trapping system precisely inform on erosion and deposition; iii) captors inform on the height of the water level during flooding. All these data are correlated with water discharge and water temperature at Tabaga gauging site. The study highlights the contrasted effects of a rapid and intense outburst and of a long duration of flooding.

This study is supported by ANR Climaflu.

****

Recent changes in the morphology of river channels in the Mekong delta: natural or anthropogenic?

BRUNIER G.(1), ANTHONY E.J.(2), PROVANSAL M.(1), DUSSOUILLEZ P.(1), GOICHOT M.(3)
(1) Aix-Marseille Univ., CEREGE UMR CNRS 7330, AIX-EN-PROVENCE, FRANCE ; (2) Aix-Marseille Univ., CEREGE UMR CNRS 7330, Institut Universitaire de France, AIX-EN-PROVENCE, FRANCE ; (3) Sustainable Hydropower and River Basin Management, WWF Greater Mekong Programme, VENTIANE, LAOS

The world's river deltas are threatened by hydroelectric dam constructions, embankments, channelling off low, and aggregate extraction. The Mekong delta, in Vietnam, is the world's third largest delta. Changes in the morphology of the Mekong proper and the Bassac, the two main distributaries in the 250 km-long deltaic reach from the Cambodian border to the coast, were analysed using maps and Landsat® and SPOT® satellite images from 1965 to 2008/2009. The results show a significant increase in the mobility of the riverbanks since the early 1990s, with important accretion. The geometry and morphology of the two channels, analysed from bathymetric data for 1998 and 2008, display important irregular bed incision, with expansion and deepening of numerous pools. These changes probably explain the more rapid bank mobility. The mean depth of both channels increased by more than 1.5 m between 1995 and 2008. Mean longitudinal bed incision rates in the Mekong are similar to those in the Bassac even though the former conveys more than 15 times the liquid discharge of the latter.Correlations between bed incision and hydraulic parameters are extremely weak, suggesting that the marked morphological changes are not in equilibrium with flow and sediment entrainment conditions, and are therefore not related to changes in river hydrology. We assume that aggregate extraction, currently practised on a very large scale in the two channels, is the main driver of these recent morphological changes. Future large-scale hydropower dam development on the Lower Mekong mainstream will have cumulative effects, leading to increased morphological changes that should be felt rapidly as the system is already impacted. These changes are already affecting the Mekong delta shoreline, which currently shows significant erosion, following extremely rapid progradation over the last 3000 years, a pattern of recent destabilization not unlike that of other Asian megadeltas.

Regional scale analysis of natural vs. anthropogenic controls on sediment fluxes

BALTHAZAR V., VANACKER V.
Universite catholique de Louvain (UCL), LOUVAIN-LA-NEUVE, BELGIUM

Spatial variability in sediment yield (*SY*) and its controlling factors are often analyzed on the basis of local or global sediment flux data but are rarely based on a regional dataset. As the biophysical and anthropogenic determinants of soil erosion largely depend on the spatial scale under study, extrapolations of plot-scale erosion analyses often lead to inadequate conclusions. A regional assessment of the spatial variability in *SY* allows filling the gap between detailed, process-based understanding of erosion at field scale and empirical sediment flux models at global scale.

In this study, remote sensing data are used as proxies of biophysical and anthropogenic site characteristics. The Blue Nile and Atbara River basins were selected for this analysis, as they are characterised by a large spatial variability in *SY*. First, correlation analyses are used to identify the environmental factors that are controlling spatial variability in *SY* at the regional scale (10^1 to 10^4 km^2). Regression techniques were then used to develop an empirical *SY* model that predicts erosion as a function of site characteristics. Second, the outcome of this empirical, site-specific model is compared to the prediction of the global sediment flux model, *BQART* (Syvitski and Milliman, 2007), and a new modified version of the *BQART* that takes into account the human impact on sediment production. The modified version of the *BQART*model estimates the human influence on *SY* based on a high resolution composite measure of local human impact instead of countrywide estimates of GNP/*capita*. The comparison shows that the global predictive sediment flux model is less suited to capture the spatial variability in area-specific sediment yields (*SSY*), but is very efficient to predict absolute sediment yields (*SY*). Our modified version of the *BQART* is able to explain 80% of observed variation in *SY* for the Blue Nile and Atbara basins and performs only slightly less than locally adapted regression models.

****

Quantification and Modeling of Runoff and Suspended Sediment Transfer Paths in Instrumented Mesoscale Catchments in Spain and Brazil

BRONSTERT A.(1), ARAÚJO J.(2), BATALLA R.(3), GÜNTNER A.(4), FÖRSTER S.(4), FRANCKE T.(1), MÜLLER E.(1), BROSINSKY A.(1), DELGADO J.(1), LÓPEZ-TARAZÓN J.(3), SOMMERER E.(4), VERICAT D.(3), WERB S.(1)
(1) University of Potsdam, POTSDAM-GOLM, GERMANY ; (2) Universidade Federal do Ceará, FORTALEZA, BRAZIL ; (3) University of Lleida, LLEIDA, SPAIN ; (4) GFZ German Research Centre for Geosciences, POTSDAM, GERMANY

This work addresses the relation of transfer, storage and re-entrainment processes that determine the distribution of water and sediments among different landscape components. Selected insights into the ongoing research project "Generation, transport and retention of water and suspended sediments in large dryland catchments: Monitoring and integrated modeling of fluxes and connectivity phenomena" (SESAM) are presented. These encompass the quantification and modeling of runoff and suspended sediment transfer paths in dryland regions and of the connectivity processes in instrumented meso-scale catchments in Spain and Brazil.

The main methods applied in the project are (1) water and sediment tracing based on both spectral fingerprinting and Radio Frequency Identification (RFID) (2) field monitoring of water level, turbidity, precipitation and of changes in hillslope, river bed and nested catchment topography (3) modeling of runoff and suspended sediment transfer paths with WASA-SED (a spatially semi-distributed model for water and sediment transport), including sediment retention in reservoirs and small dams and bed-load transport. To the present day, the comprehensive measurements from plot to meso-scale by field works and remote sensing campaigns has been achieved. The measurements include flight campaigns with hyperspectral and laser sensors onboard, repetitive terrestrial laser volume-scans, as well as several hydrological observations.

The findings of this project are used to extend the WASA-SED model to account for the process understanding of connectivity at the intersections of hillslopes, rivers and reservoirs. Large-scale pilot parameterisations for parts of the Ésera Basin in Spain and the Upper Jaguaribe in Brazil will be conducted. The expected results will improve the knowledge and modelling capability of water and sediment fluxes and their connectivity mechanisms in drylands at spatial scales relevant for water and land management.

Understanding recent change in river-floodplain connectivity in the Baviaans catchment, Eastern Cape: implications for floodplain restoration

JOUBERT R., ROWNTREE K., ELLERY W.
Rhodes University, GRAHAMSTOWN, SOUTH AFRICA

The concept of landscape connectivity broadly refers to the degree of hydrological and sedimentary linkage between different landscape compartments (e.g. hillslope-channel and channel-floodplain linkages); in river catchments, connectivity determines the ease with which sediment is transferred through a catchment and the response (erosion or deposition) of rivers to disturbances (Brierley *et al*., 2006). Recent (last 30 - 40 years) channel incision along a reach of the Baviaans River, in the Eastern Cape of South Africa, has resulted in dis-connectivity between the river and adjacent floodplain through reduced over-bank flooding together with effective channelling of water and sediments away from the main floodplain during flood events. This has resulted in floodplain wetland desiccation and decreased capacity of the river to attenuate flood flows and provide water to local and downstream communities. In this study we investigate the role of human and natural disturbances in driving recent channel incision and floodplain degradation in the Baviaans catchment, and the role of connectivity in determining river response. Preliminary findings suggest that changes in catchment land-use (and associated land cover), human engineering of the main river and tributary streams, and changing rainfall regimes have been important in promoting recent channel incision. We also suggest that the response of the river (through channel incision) to these disturbances has been determined by the nature and degree of connectivity between the main river and large tributary streams along the degraded floodplain reach. These findings have been important for appraising planned floodplain restoration strategies for the Baviaans catchment.

References: Brierley, G., Fryirs, K. & Jain, V. (2006) Landscape connectivity: the geographic basis of geomorphic applications. Area, 38(2): 165-174.

****

The Hydrology of the Yangtze (Changjiang) River, China

FINLAYSON B.(1), CHEN J.(2), WU X.(2), WEI T.(2), LI M.(2), CHEN Z.(2), WEBBER M.(1)
(1) The University of Melbourne, ASCOT VALE, AUSTRALIA ; (2) East China Normal University, SHANGHAI, CHINA

The Yangtzeflows from the Tibetan Plateauto theEast China Sea (6300 km); total drainage area 1.808 $10^6 km^2$. Here we describe the main hydrological characteristics of the Yangtze (precipitation, runoff, variability, seasonality, floods, low flows) both for the whole catchment and the upper, middle and lower sections, since 1955. Briefly, the Yangtze has mean annual precipitation (runoff) of 1037(517) mm, both with a marked summer dominance. Interannual variability of precipitation (runoff), as measured by the coefficient of variation, is low by world standards at 0.066 (0.126). The variability of floods is similarly low: flash flood index 0.18.

The upper catchment has the most marked summer precipitation dominance. It is both the driest and least variable section and with no statistically significant trends in either precipitation or runoff. Both precipitation and runoff increase downstream through the middle and lower basins, variability increases, as does winter precipitation. There is a statistically significant increase in runoff in the middle basin and both runoff and precipitation in the lower basin after 1987. Meanwhile, the runoff ratio shows an obvious increasing trend in the mid-lower basin, possibly caused by changes in the nature of the catchment surface due to rapid urbanization and dam construction. In all cases the magnitude of the trend is small.

The Yangtze has a long (~8,000 yr) history of human occupation and human impacts have increased dramatically since the economic reforms began in China in the late 1970s. The changes since 1980 that would be expected to have a significant hydrological impact include population growth, agricultural intensification, increasing urbanisation, dam construction and industrial development. We find little direct evidence in the hydrology of the Yangtze that reflects these changes. Similarly there is no clear evidence of impacts that could be related to climate change.

Post-dam assessment for change in riverbed and delta-coast morphology following impoundment of Three Gorges Dam of the Yangtze (Changjiang) River

CHEN Z., YUAN W.H.
East China Normal University, SHANGHAI, CHINA

The impacts of a dam on the river downstream in terms of hydrology and morphology is determined by a complex mix of variables that include the patterns of release of water through the dam and the characteristics of the downstream channel. Scour of the downstream channel is a common response since large dams cause a significant interruption to sediment continuity. Here we show that in the case of China's Three Gorges Dam on the Yangtze River the outcome is more complicated than in other cases. The downstream channel and floodplain system is an area of long-term sediment accumulation and unstable channels with seasonally contrasting erosion and deposition patterns related to the migrated seasonal monsoon rainfallzones. It is also the case that in achieving one of the main purposes of this dam, that of flood control in the middle and lower basins, the pattern of flows released from the dam will closely resemble those seasonal flows that are responsible for channel instability in the middle catchment thus effectively making erosive conditions the most common during a year. There is obviously concern about the ultimate impact of sediment storage in the dam on the dynamics of the deltaand adjacent coast and we show that this depends on the trajectory and duration of the erosive responses in the middle Yangtze basin. In this particular case, the outcome is of great significance to the well being of the densely populated riparian to delta-coastal areas of the river catchment.

****

Model of reservoir regulations and their impacts on river fragmentation in the Yangtze River Basin, China

YANG X.K., LU X.X.
National University of Singapore, SINGAPORE, SINGAPORE

The waterregime of the Yangtze River (Changjiang) has been altered by intensified reservoir constructionover the past decadesbecausemore than 42,000 reservoirs have been built in the Yangtze River basin over the past five decades.In recent years, the Yangtze River is being dammed at a dazzling pace; there are even more than 10 cascade dams built on some major tributaries. Under this condition, Modeling to quantify the degree to which the river and landscape are fragmented by dams is crucial to identify environmental risks associated with further impacts on large river systems. In this study ,we used three metrics to assess the impacts caused by dam construction. (1) River free-flowing rate is defined as the ratio of the length of sections that remain "free flowing" to the total length of the river; (2) catchment connectedness provides insights into how different smaller catchment classes are distributed across a large river basin and how they relate to each other in terms of spatial configuration; and (3) stream division, presenting the cumulative segment length distribution, indicates the degree to which the tributary is divided. This study reveals that free-flowing streams are vanishing on the mainstem and major tributaries, such as the Jinshajiang, Wujiang, Dadu, Yuanjiang and Jialingjiang rivers because of dam construction. The most severely impacted tributaries are Wujiang, Yuanjian and mainstem. However, the situation could be worsen as additional large hydropower projects are completed in this basin. Through river fragmentation assessment we can be proactive in reservoir management decisions rather than reactive. This will make it easier to develop the Yangtze basin with a much lower environmental footprint.

Geochemical compositions of the late Cenozoic sediments in the Jianghan Basin: Implications for sediment source and evolution of the Yangtze River

SHAO L.(1), LI C.(2), YUAN S.(3)
(1) Wuhan Center, China Geological Survey; China University of Geosciences, WUHAN, CHINA ; (2) China University of Geosciences, WUHAN, CHINA ; (3) China University of Geosciences; College of urban planning & environment science, Xuchang University, WUHAN, CHINA

The Yangtze River is one of the most important components of the East Asia river system. Understanding the evolution of these large rivers is important to understanding the process of orogeny. The uplift of the mountains and plateaus where these large rivers originate are proposed to profoundly affect the global climate system. Consequently the reconstructions of these rivers are important to understand the global change and its regional response.
Although study of the evolution of the Yangtze River has a long history of more than 100 years, it is still controversial. In this study we applied bulk geochemical analysis to identify the sediment provenance in the Jianghan Basin, middle Yangtze River and tried to reconstruct the evolution of the Yangtze River. The samples were selected from a continuous borehole in the Jianghan Basin and analyzed for geochemical compositions. The $\varepsilon_{Nd}(0)$ values vary between -11.6 and -7.8, with an average of -9.6. Nd isotopic compositions cannot provide compelling evidence to prove whether the Pliocene sediments in the Jianghan Basin were influenced by the source rocks in the Jinshajiang area characterized by extremely high $\varepsilon_{Nd}(0)$ values. While these source rocks made a great contribution to the Jianghan Basin during the Quaternary. Less negative $\varepsilon_{Nd}(0)$ values reflect preferential erosion of source rocks in the Jinshajiang drainage. It reflected changes in erosion patterns during the Quaternary. The trace element compositions also revealed this important provenance change of the Jianghan Basin sediments around the beginning of the Quaternary from more felsic provenances to more basic provenances. Input from the Emeishan LIP should account for this provenance change. Based on these geochemical data, we propose that the Yangtze River appears to develop into a large river similar as the modern Yangtze no later than the beginning of the Quaternary.

****

Declining Sediment Yields in the Upper Yangtze: Dams, Degradation Control or Delivery?

HIGGITT D.(1), ZHANG X.B.(2), HE X.B.(2)
(1) National University of Singapore, SINGAPORE, SINGAPORE ; (2) Institute of Mountain Hazards and Environment, Chinese Academy of Sciences, CHENGDU, CHINA

The global flux of sediment from continents to oceans has declined in recent decades as a result of major dam construction on some of the world's largest rivers. In China, for example, there has been a rapid and continuing expansion of hydro-electric power schemes which have drastically altered the hydrological regime. However, examination of time series of discharge and sediment yield suggest that in some areas the decline in sediment load measured at hydrographic stations is greater than can be attributed to sediment trapping by dams alone. Usually this additional reduction in sediment load has been attributed to the success of soil conservation measures. A case in point is the Jinsha River, the name given to the main branch of the Yangtze upstream of Yibin, Sichuan Province. The catchment area of the Jinsha at the gauging station near Yibin is about 450,000 km2. Following construction of the Ertan Dam on the Yalong River, a major tributary of the Jinsha, in 1998, the sediment load in the Jinsah has reduced dramatically. However, the reduction is far greater than the amount trapped by the Ertan Dam. A geomorphological survey of the river is investigating the likely causes of reduced sediment load. In addition to the impact of the dam and local conservation works, it is probable that a reduction in transport capacity during the monsoon period has influenced sediment delivery dynamics.

Geomorphologic process of the first bend of the Yangtze River

YANG D.
School of Geographic & Oceanographic Sciences, Nanjing University, NANJING, CHINA

The Yangtze River (YR) suddenly changes its flow direction from SE to NE near Shigu at 2136km away from its source, forming a sharp turn with 280 degree named as “the first bending of the world".

Based on many field investigations during recent 18 years, it has been found that the fluvial landforms have a great change in the areas from Benzilan (around 17km long) to Fulong Bridge (45km), and then to Tuoding (15km), to Qizong (60km), and finally to Shigu (73km) reaching to the TLG. From Benzilan to Fulong Bridge, it is the wide valley with four rock-seated and one accumulational terrace. However, from Fulong bridge to Tuoding, the valley becomes sharp V-shape without any terrace and continued valley shoulder distributed, which should be the capturing river part. From Tuoding to Qizong, a distinct gorge presents with three terraces and 10-25m thick fluvial gravel deposits distribute. From Qizong to TLG, it is a strange drowned valley. The relict of the third and second terraces occasionally present along the two banks, and relatively large alluvial fans distribute in the mouth of many small tributaries overlying the floodplain of YR. Furthermore, 70m thick deposits accumulate at the valley bottom, covered by huge rocks sometimes. Several kilometer long river channel near Shigu flows along conjugate fractures with X shape.

According to these morphological characters, it could be concluded that the YR channel between Qizong and Shigu is an ancient tributary, named Shigu River. Its channel is controlled by the conjugate X shape fractures. This River incised deeply headward and captured the ancient YR to become the main channel of the new ancient YR during about 50-60 thousand years ago. The glacial developed and incised deeply in the valley after the formation of the second rock-seated terrace. Subsequently, large scale mass movements (e.g. landslides) happened and blocked the river, resulting of drowned characters in this reach.

****

Characteristics and self-adjusting behavior of anabranching channel patterns along the middle and lower reaches of the Yangtze River

YU G.A.(1), HUANG H.Q.(1), LIU X.F.(1), NANSON G.(2), FAN B.L.(3), LIU T.H.(3)
(1) Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences, BEIJING, CHINA ; (2) Uiversity of Wollongong, NEW SOUTH WALES, AUSTRALIA ; (3) Changjiang River Scientific Research Institute, WUHAN, CHINA

Over a length of 1893 km along the middle and lower reaches of the Yangtze River numerous islands higher than bankfull exhibit in the middle of the river. In the upper part of the reaches there is normally one large island appearing in the river, while in the lower part the number of islands reaches up to 7. The planforms of these islands differ from one to another and the main channel and sub-channels alternate periodically. Previous studies on the behavior of these multi-channel river systems have been dominated with emprical analyses and there has been no consesus of opinions on how these river systems operate by themselves.

Under the encouragement of the success of the variational approach developed by Huang and Nanson (2000, 2002) for understanding the self-adjusting mechanism of straight alluvial channels, this study examines the applicability of the approach in multi-channel river systems. For the purpose a detailed investigation of the morphlogical forms of the islands exhibiting in the Yangtze River is made and several generalized types suitable for performing mathematical analysis are obtained. For a two-channel river system with the island in the middle of the river taking a triangular planform, a detailed mathematical anlysis shows that the width and length of the island are determined by the proportion of water and sediment in two channels when the whole river system achieves equlibrium. Finally a comparison between the theoretical results and field observations is made and the cause for the resulted degree of consistency examined in detail.

Impacts of meander landforms evolution on hydrological fonctionning of a floodplain: the Loire Meander at Guilly (Central France)

RAMOND S.(1), ROBERT V.(2), GAUTIER E.(1), DEPRET T.(3), MARLIN C.(4), DURAND V.(4), MONVOISIN G.(4), NORET A.(4), MASSAULT M.(4)
(1) University of Paris 8 Vincennes - Saint-Denis, CNRS, UMR 8591, Laboratory of physical geography, MEUDON, FRANCE ; (2) CNRS, UMR 8591, Laboratory of physical geography, MEUDON, FRANCE ; (3) University of Paris 1 Pantheon-Sorbonne, CNRS, UMR 8591, Laboratory of physical geography, MEUDON, FRANCE ; (4) University of Paris-Sud 11, CNRS, UMR IDES, ORSAY, FRANCE

The presentation focuses on a protected zone (meander of Guilly, 4.27 km²)) along the Loire River where several actions of wetland preservation have been conducted. Most studies about the Guilly meander have concerned its geomorphologic evolutions. This meander is a part of a particular anthropogenic system which has been impacted by changes of land uses around in the areas close to the Loire River. More precisely, we relate these previous geomorphologic studies with the hydrological functioning of the alluvial plain, in order to demonstrate how and the morphological heritages may influence the present hydrology of the meander.

In the meander and in the alluvial plain, pressure sensors have been installed in several wells in the unconfined aquifers (time interval of ½ hour). The potentiometric data reflect the propagation of the hydrological signal from the Loire River towards the alluvial aquifer. In addition, water has been sampled monthly for both chemical and isotopic (^{18}O, ^{2}H) analyses.

The comparison between the chemical and isotopic compositions of the groundwater from the shallow alluvial aquifer in the meander with that of the regional aquifer (Beauce formation), the rainfall and the Loire River allow to assess the contribution of each end-members. Furthermore, the water exchanges between the different water-bodies in the meander display an important temporal variability and an unequal response time. We observe important variations of water-table elevation according to the discharge of the Loire River; rapid supplies from the river towards the alluvial aquifer exist especially during flood periods.

These supplies show significant spatial variations characterized not only by the distance to the river, but also by morphological and sedimentary heritages. Amongst all the wells, the hydrogeological responseof those located near or into a paleo-channel differsfrom the other ones.

****

Predicting life span of restored secondary channels and backwaters (Rhône river, France)

RIQUIER J., PIÉGAY H.
Université de Lyon, CNRS-UMR5600 Environnement-Ville-Société, LYON, FRANCE

During the last two centuries, human actions have deeply affected the physical and ecological integrity of the Rhône river-floodplain system. A large restoration project aiming to enhance aquatic habitat conditions within the Rhône corridor started in 1998. Twenty-five floodplain channels were dredged, either locally or over their entire lengths with or without upstream and/or downstream alluvial plug removal. The guiding principles were to optimize the ecological functioning and to maximise the diversity of habitat conditions within and between floodplain channels at the reach scale. One of the key questions of such actions was their sustainability. As stated by several researchers, acting on forms rather than on processes may be a short term strategy. From cutoff to final terrestrial stage, floodplain channels experienced various life spans ranging from a few decades to several centuries. The evolution of the water depth in cutoff channels is mainly controlled by overflow sedimentation rates related to suspended sediment concentrations and main channel geometry (i.e. bed degradation/aggradation, channel shifting, entrance geometry linking cutoff and main channel). However this topic has been barely explored in river restoration ecology. Understanding the temporal evolution of sedimentation rates and being able to predict life span of such restored channels are challenging issues in order to propose appropriate and suitable restorations. We used biennial bathymetric and sediment thickness surveys, repeated every two years for a decade, to characterize the temporal evolution of longitudinal sedimentation pattern in eighteen restored floodplain channels (5 secondary channels and 15 backwaters). We established statistical relationships allowing to predict life span of floodplain channels related to a set of geomorphic controls. The restoration procedures are then discussed with regard to the processesaffecting the long term sustainability of these environments.

Severe monsoon floods and floodplain development in the lower reach of the Stung Sen River, Lower Mekong Basin

NAGUMO N.(1), SUGAI T.(1), KUBO S.(2)
(1) Graduate School of Frontier Sciences, The University of Tokyo, CHIBA, JAPAN ; (2) Department of Geography, Waseda University, TOKYO, JAPAN

The Stung Sen River, the biggest influent tributary of the Lake Tonle Sap in Cambodia, is characterized by seasonal changes of water level and discharge under the Asian monsoon climate. Floodplain in the lower reach consists of two major geomorphic elements of back marsh and meander belt displaying a complicated pattern of abandoned channels and meander scrolls. During the decennial-scale severe floods in 2011, along with meander belt, back marsh was considerably submerged by surging in-channel floodwater overflow with heavy rainfall, and dense suspension was widely provided. This is consistent with the constant accumulation rate of back marsh during the Holocene reconstructed by AMS-^{14}C dating of the back marsh sediments. However, during the usual monsoon season, monsoon floodwater rarely widely overflows and the accumulation of back marsh seems not to have been prominent. This suggests that the formation of back marsh is mainly promoted by the decennial-scale severe floods rather than annual floods. The accumulation processes of the Stung Sen River floodplain is probably controlled by the high-magnitude and less-frequent floods in comparison with those of humid temperate climate zone.

****

Morphodynamics and stability of the amur riverbed

KIM V., MAKHINOV A.
Institute of Water and Ecology Problems FEB RUS, KHABAROVSK, RUSSIAN FEDERATION

In the Amur lower reaches its riverbed undergoes extensive transformations. The river divides into numerous large and small sub-channels of different shape and size, thus forming an exceptionally complicated hydrographic system. Large sub-channels compose a time-stable river net carcass of a branching delta type. These sub-channels also divide and merge with dozens of small permanent or temporary streams. Most of them freely meander, but their curves are not sharp.

All along its lower reaches (from the Songhua mouth) the Amur shows the positive balance of discharged suspended solids, which determine most specifics of developing riverbed processes. The intensive accumulation of alluvial deposits in the riverbed and floodplain causes an extremely complicated river branching, a relatively not high floodplain and a very intensive horizontal deformations of main and secondary river channels.

River ice also plays a significant role in the transformation of the Amur banks, as it causes their mechanical destruction and the accumulation of ice-brought sediments in the riverbed and its floodplain.

In the recent 50-60 years human activities in the Amur Basin have noticeably affected the intensity of riverbed transformations and the amount of discharged suspended solids. Most significant Amur riverbed transformations take place in areas of intense anthropogenic impacts, in particular near population centers, hydropower facilities, dredging operations.

River bank erosion, shifting of off-take point: a case study of river Bhagirathi, West Bengal, India

BHATTACHARJEE S.
Jogesh Chandra Chaudhuri College, KOLKATA, INDIA

River Ganges enters Maldah district of West Bengal after touching the outlier of Rajmahal Hills and swings across the deltaic plain. According to Rennell(16th century).Bhagirathi was connected with Ganga near Suti**,** Murshidabad district, West Bengal**.**

During 1801, Bhagirathi was connected in two places- Mohangung near Farakka and Suti (Colebrook, 1801). After that, Mohangung village was destroyed due to bank erosion of Ganges. During 1825 River Ganges captured some portion of Bhagirathi due to shifting of its course and a new off-take point was created in Chokha**,** 12 km away from the previous in south western direction.

In the year 1847 an artificial mouth was made in eastward direction, 3 km away from Suti**.** After a massive flood erosion and westward shifting of Ganges river course, a new off-take point was born in 1852. In 1871 further a new off-take point was found in Chaurashiya**.**

From the map of 1925 (Survey of India), it was found that river Bhagirathi was connected with Ganges in three different places, i.e. Nayansukh, Suti and Giria**.** From the present satellite images, it is found that the off-take of river Bhagirathi is connected with river Ganges near khejurgram of Mithipur, Murshidabad. During 1975-80 Giria was engulfed by Ganges due to severe soil erosion. In between 1974-1985, river Ganga eroded its right bank and shifted in westward direction. Due to severe bank erosion, many villages have been engulfed in the river Ganges. The present paper deals with the spatio- temporal shifting of the off-take point of River Bhagirathi, rate of its bank erosion and related consequences. The entire work is based on the field survey with modern techniques, GIS and RS.

****

Morphological changes of the Lower Siret River from 1891 to 2010: the decisive impact of engineering works and water management strategy

SALIT F.(1), ARNAUD-FASSETTA G.(1), ZAHARIA L.(2), MADELIN M.(1), BELTRANDO G.(1)
(1) Universite Paris Diderot, PARIS, FRANCE ; (2) Faculty of Geography, BUCHAREST, ROMANIA

This study provides an example of a river affected by water management strategy during the twentieth century and how the political-historical context had as much consequences as the hydrological events on spatial and temporal dynamics of the river. The work focuses on the Lower Siret River (100 km length) located east of the Carpathians. The Siret River is one of the last tributaries of the Danube River with a mean annual flow of 210 m^3/s at the Lungoci station, situated 105 km upstream of the Danube confluence. Historic changes (1891-2010) in both channel planform and hydraulic dynamics of the Lower Siret River, especially in relation to river engineering measures (regularisation, channelisation, dams) from the 70's, were quantified. By using a GIS analysis, channel geometry was digitised between 1891 and 2010 and some semi-quantitative variables (active-channel width, sinuosity index and braided index) were calculated. Dykes and groynes network erected in order to protect arable land by regularising the channel and to decrease the harmful effects of the water in the 70's, led to river channelisation, with the narrowing of the channel planform of 46% on average in 60 years, and increased the impact of the floods in the floodplain as it the case during the historic flood event of July 2005. It is necessary to quantify and spatialyse the channel changes imposed by the water management strategy during the Communist period to succeed the implementation of the EU Flood Directive.

Short-term channel adjustments in an anthropized stretch of the Calore River (Southern Italy)

VALENTE A., MAGLIULO P.
University of Sannio, BENEVENTO, ITALY

The results of a study aimed at identifying and quantifying the geomorphological changes experienced by a strongly anthropized stretch of the Calore River (Southern Italy) between 1955 and 1998 are shown. This stretch is characterized by the presence of the town of Benevento and a high frequency of alluvial sediments extraction sites. The study was carried out by processing in GIS environment data derived from interpretation of orthophotos and maps, and from detailed field surveys. In Benevento, a large number of human infrastructures that, according to the existing literature, influence river dynamics, such as bridges and walls, are present. Moreover, in this stretch, all the extraction sites are currently active and sediments are withdrawn directly from the riverbed. The withdrawals started almost everywhere between 1955 and 1977.

The data showed that, in 1955, the morphology of the river was of transitional type. During the examined period, the Calore River underwent a narrowing of ~75%. Field evidence such as exhumation of bridges and walls foundations and terracing of the floodplain that was active in 1955 revealed a lowering of the riverbed, probably still ongoing. The amount of the lowering, not precisely quantifiable, could be of ~3-4 metres. It was also found a drastic reduction in the fluvial bars area, while their number increased significantly, except for point bars. Due to these adjustments, the river morphology changed from transitional to single-tread with alternate bars. This result is in agreement with literature data about most of the Italian rivers. Probably, the causes of the observed adjustments are connected to the drastic reduction of the liquid discharge, due to the Calore River spring exploitation since late 50's, and of the bedload transport induced by sediments extraction and, finally, to the effects of bridges and walls. However, our data do not allow excluding an active role played by climate and/or land use change at the basin scale.

****

Present changing in river system of the upper Po River Plain (Italy)

MARAGA F.(1), BELLARDONE G.(2), TURCONI L.(1)
(1) National Research Council (Cnr), Dept. of Earth and Environment, Insitute for geo-hydrological protection (IRPI), branch of Turin, TURIN, ITALY ; (2) Regione Piemonte, TURIN, ITALY

It refers to the Po river changes in the upper Po plain, north western Italy. The changes implicate the river channel bed deepening and the river channel network contraction. Geomorphologic conditions are related to the active uplift of the landforms in Tertiary sedimentary substrate at the boundary of the fluvial plain having Holocene shallow fluvial deposits. The substrate is emerging in the river beds since few decades due to channel erosion processes.

The present Po river system morphological changes can be summarized as: (1) shortening river axis; (2) narrowing active channel width; (3) sediment erosion at the river channel bottom. The major flood of October 2000 recorded larger bank erosion than previously. Following floods occurred shorter and faster depending on the network changes versus a more steepening system. Bank erosion in the channel exceeded the flooding onto the plain. The Maximum of erosion was noticeable in the channel reaches where the substrate is exposed.

Latest morphological evidences of the river network steepening show meander cuts-off during the previous minor floods from 1949 to 1977. These evidences highlight the faster processes of the shortening changes in the study area by an average shortening of 4 km/year. Longitudinal topographic profiles are 1 m deepened at the channel medium bed level from 1999 to 2004.

The river network contraction involved faster flood propagation, decrease in sediment availability for the sediment transport in the channel bed and fluvial deposition. Instability effect are recognized on the fluvial public works due to damages in walls and bridges. Surface water table deepens in the plain as channel network is deepening and water losing involves water lack in river biomasses maintenance.

Sediment transport measurements providing insights on initiation of motion and high flow bedload transport at the Austrian Danube

LIEDERMANN M., TRITTHART M., GMEINER P., HABERSACK H.
BOKU University, Vienna, VIENNA, AUSTRIA

Within a large restoration project at the Danube River to the East of Vienna an ambitious sediment transport monitoring program using advanced measurement equipment was conducted. Among other methods, a basket sampler was used to quantify initiation of motion, bedload dynamics and annual bedload transport. Due to high flow velocities and water depth, the sampler had to be modified to suit the requirements of the Danube River in order to assure undisturbed sampling.Over four years, a total of 38cross-sectional bed load transport measurements were conductedover the entire discharge spectrum, thereby covering low flows as well as several flood events up to a 15-year event.

Significant bedload transport was observed at low flow conditions, indicating that initiation of motion takes place at much lower discharges than predicted by commonly used uniform bedload transport formulae. Furthermore it was found that the bedload transport increases with discharge, but to a much lower extent around bankfull discharge. Results of a gravel tracer study performed within the same river reach and 3D sediment transport modelling affirmed these findings. Hence commonly used approaches underestimate bedload transport at the reach for low flow conditions and overestimate transport at high flows. Therefore new concepts had to be found for establishing a bedload transport-discharge rating curve. Amongst others, a sigma function was fitted to the data describing better the occurring transport situation.

The analysis of the data led to a substantial progress in describing sediment transport characteristics at a large gravel bed river, thus increasing process understanding and facilitating the evaluation of a restoration project.

****

The evolution of the fluvial process in the lower Yellow River since 1960

TIAN S.M., WANG W.H., LI Y., ZHANG X.H.
Institute of Hydraulic Research, YRCC, ZHENGZHOU CITY, HENAN PROVINCE, CHINA

The Yellow River carries abundant water and excessive sediment and the channel bed and river bank are erodible. Since 1960, many large and middle reservoirs have been built in the Yellow River. The water and sediment conditions of the river have undergone great changes, especially after the operation and the practice of the water and sediment regulation of Xiaolangdi Reservoir. The incoming water and sediment in the lower Yellow River has changed greatly. The cross-sectional shape of the channel has adjusted a little. At the same time, the river training works have been improved since 1960. Under the actions of water-sediment conditions and river training works, the river regime of the lower Yellow River has experienced remarkable variations.

The paper analyzes the characteristics of the river regime and the mainstream lines of the wandering reach in the lower Yellow River since 1960. The results indicate that the bend coefficient shows an increase trend, the mainstream swing and width-depth ration shows a declined trend, which indicate that the wandering features of the river have been inhibited and the river regime has become regular. In addition, the river pattern is also discriminated by the river regime parameters and the fractal dimension method. The values of the discrimination indicators are getting closed to the braided river. In some years, the river pattern has exhibited the features of the braided river.

The changes of the river regime are first due to the water-sediment conditions. With the operation of the reservoirs, the annual water amount, the frequency and the peak of the flood have decreased. Then the flow dynamics and its action on the river channel reduce too. On the other hand, the river training works has limited the swing range of the mainstream. Both of them have affected the fluvial geomorphology of the lower Yellow River and lead to the stabilization of the river. So the river regime have transformed from the scattered to the normalized.

Tracking the middle reach of the Yellow River running eastward across the Ordos Plateau and North China Plain

HU Z., PAN B., GAO H., HU X.
Key Laboratory of Western China's Environmental Systems, Ministry of Education, Lanzhou University, LANZHOU, CHINA

The middle reach of the Yellow River from the Chinese Loess Plateau downward to the North China Plain, runs through the uplifted Jinshan Groge and subsiding Fenwei Basin, offers a favorable setting where the response of the fluvial landscape to the uplift and climatic change can be evaluated individually. In the northern Jinshaan Gorge, a continuous fluviolacustrine strata with a chronological framework of >8.3-3.7 Ma were accumulated in the Baode region, being correlated sediments of the Tangxian Planation Surface. The statistics of gravel fabric and lithology in these fluviolacustrine sediments reveals that a paleo-lake occupying the Baode area was fed by some local streams from surrounding uplifted regions. In the northern Jinshaan Gorge, two fluvial gravel layers covered by aeolian Red Clay were stacked on the Tangxian Planation Surface. Their formation times were dated prior to 4.9 Ma and 3.7 Ma respectively. The statistics of gravel fabric and lithology indicates that these gravel layers represent a northward flowing paleo-river, which is different from the southward flowing Yellow River. It linked the paleo-lake occupying the Baode region and the drainage in the Hetao Basin. A dramatic surface uplift initiating prior to 3.7 Ma not only interrupted the fluviolacustrine sedimentation, but also leaded to lifting of the Planation Surface. Owing to this drastic uplift, hypsographic relief was enlarged, and resulting in fluvial head erosion. In the northern Jinshaan Gorge, the northward flowing river linking the Baode paleo-lake and the drainage in the Hetao Basin was pirated by the river in the southern Loess Plateau, and the Yellow River appeared prior to 1.2 Ma. An episode of drastic uplift initiating at 1.2 Ma forced the Yellow River to continuously downcut along the Jinshaan Gorge, and developing a series of fluvial terraces. The modern spectacular down-cutting valley has been shaped gradually by the Yellow River since this uplift.

****

Geomorphic Changes in the Indian Sundarban between 1917-23 and 2012: Evidences from Maps, Images and Hydrography

BANDYOPADHYAY S.(1), MUKHERJEE D.(2), KAR N.S.(1)
(1) University of Calcutta, KOLKATA, INDIA ; (2) University of Burdwan, BARDHAMAN, INDIA

A high tidal range and tropical climate helped to form the world's largest patch of mangrove wetlands – Sunadarban – at the mouths of the Ganga-Brahmaputra delta (India and Bangladesh). The area started to be reclaimed from early 14th Century. However, an active governmental effort for deforestation commenced from 1790s and by 1950s about 5,366 km^2(56%) of mangroves were converted into farmlands in India. To form a holistic database on long-term changes in the Indian Sundarban, we compared five datasets: Survey of India maps of 1917-23, 1942 & 1968-69 and RS data of L3+Pan (2001) & L4 (2012) from IRS missions. All these materials were georeferenced, mosaiced and digitised.

The results show that all southern sea-facing islands of Indian Sundarban recorded progressive erosion – a trend that continued from 18th century. However, in the interior (often reclaimed) portions of Sundarban, inter-island creeks are being silted up, resulting in net accretion and reduction in number of islands. The progressive and irreversible transformation of intra-island creeks into stagnant water bodies and finally into plugged depressions is one of the most notable post-reclamation changes that largely took place during an approximate span of fifty years.

For maintenance of morphological steady state, length of the resonant macrotidal estuaries of Sundarban need to equal a quarter of the wavelength of the tide entering into them. The tidal wavelength, in turn, depends critically on the mean depth of the estuaries. Reclamation and construction of marginal embankments increase their mean depths and set up time-velocity asymmetry in tidal currents. This condition largely explains bank erosion and in-channel siltation seen in the interiors of Sundarban. The chief reasons for rapid erosion of its seaface include abandonment of sediment-replenishing western distributaries of the Ganga and off-shore interception of westward transportation of sediments by a submarine canyon.

Poster presentations:

Neogene gravels and dammed-lake sediments newly discovered in Nujiang (Salween) River valleys, Yunnan

ZHAO X.(1), WU Z.(2), YE P.(2), TONG Y.(2), HU D.(2)
(1) Institute of Geology and Geophysics, Chinese Academy of Sciences, BEIJING, CHINA ; (2) Institute of Geomechanics, Chinese Academy of Geological Sciences, BEIJING, CHINA

In Our field survey in the Daojie Basin through which the Nujiang （Salween）River passes, lower terraces below 150m above river level were re-identified and re-divided into eight level terraces（T_1～T_8）. At the same time, there are four level higher terraces 180～380mabove river level （T_{10}～T_{13}）and a suit of dammed-lake sediments and their buried alluviums to be newly discovered. Lower terraces were dated by OSL, U-series and ESR methods, whereas the dammed-lake sediments were paleomagnetically analyzed. The results show that six levels of lower terraces are formed since the Middle Pleistocene, and that the upper part of the dammed-lake sediments is dominated by normal polarity but contains two short times of negative polarity, whereas the lower part is of negative polarity. According to correlation with the standard magnetic polarity time scale, the formation age of the dammed-lake sediments should be 4.2～2.6Ma, i. e. the Middle-Late Pliocene. Thus, the burial terrace below the dammed-lake sediments and the higher terracesshould form in the early of Pliocene to the late of Miocene. On the basis of the results in the paper and our preliminary regional stratigraphic correlation, it can be believed that accompanied with intermittent uplift of the Tibetan Plateau since the middle and late of Miocene, the Nujiang River occurred and cut down and by the early of Pliocene cut down into below today's river beds.

****

Hydromorphodynamic of Anavilhanas Fluvial Archipelago - Amazon- Brazil

ALVES N.S.(1), RODRIGUES C.(2)
(1) UNIVERSIDADE DO ESTADO DO AMAZONAS, MANAUS, BRAZIL ; (2) UNIVERSIDADE DE SÃO PAULO, SÃO PAULO, BRAZIL

The Anavilhanas Fluvial Archipelago is situated in Lower Negro River, a tributary of Solimões River in Amazon Region that is characterized by a complex of islands, bars, lakes, "furos" and river channels is inside a region that combines humid tropical forest vegetation cover, mean annual rainfall of 2000 mm and mean annual temperatures about 27ºC.This fluvial island complex, the largest in the world, appears to be a heritage of a sub-Recent anastomosing system whose actual islands are isolated by river channels with narrow margins and internal ocellar lakes. This research has characterized tree main different hydromorphodynamic environments that has identifyed from semi-detailled geomorphologic mapping, morphometric fieldwork and sedimentologic analyses: river channels, channel margins and internal lakes. The distinctive processes of those environments have seasonal variability that follows the dry season, the rise water level period and the wet season, all of them commanded by a bimodal annual variability of the water level of Solimões River, distant about 120 km. The wet season starts in October/November and its first peak of water level occurs in the beginning of the year that is followed by a maximum water level that occurs in June/July. The analysis of water levels data of Manaus (1902 to 2010) has revealed mean annual amplitude of 11 m. The same value and periods have observed in Anavilhanas region over the year of 2011. The major river channels revealed high rates of bedload transport over the wet season, low rates of dissolved and suspended load over the year and exposure of mega-dunes over the dry season. The channel margins appears to be stable in many places but can be eroded over the rise water level period. The lakes have river-lake seasonal dynamics that combines periods of decantation in a lacustrine and low energy environment and periods of rise of water levels that accompanies the growth of flow energy and connection to the river flows.

Fluvial competition exemplified by formation and evolution of the Fen River and Jinshan Yellow River, North China

ZHANG K.
Sun Yat-sen University, GUANGZHOU, CHINA

Competition exits not only in organisms and human society, but in geomorphic open systems evolution of many landforms can be analogized to competition. The Fen and Jinshan Yellow Rivers (eastern-reach of the prominent square-shaped bend of the Yellow River) on E and W sides of the Lüliang Mountains, provide an example of fluvial competition. The Fen River is now a tributary of the Yellow River, the 2nd largest river in China. However, the depositional sequence and chronology (including magneto-loess stratigraphy and OSL dating) along the Jinshan Yellow River, indicates that before connectionof the Hetao Basin (Hetao Great Lake, into which the upper reach of the Yellow River debouched) to the north, the Jinshan Yellow River shared similar features with the Fen River in terms of flow direction and length. Both rivers can be considered as “twins” originating from uplift of the Lüliang Mountains and both flowed from N to S on E and W sides of the mountains, respectively, into the Yuncheng Basin, the local base level. Following two stages of N2 broad valley and early to middle Qp deep gorge development, in late Qp, the Jinshan Yellow River eroded headward and cut into the Hetao Basin. An abrupt increase in the discharge and length of the Yellow River led to rapid down-cutting to “win” the competition with the Fen River, which was degraded to a tributary. A near 100-year debate on the formation age of the Jinshan Yellow River, i.e., N2, early Qp, late Qp, has centered on conglomerate along the broad valley, the highest strath terraces along the lower to middle reaches of the Jinshan Gorge, and the highest strath terraces along the upper reach of the gorge, respectively, representing three evolutionary stages. The various view points are not necessarily conflicting. A large river is not always the oldest one, and vice versa. Fluvial competition can cause one river to develop faster than another resulting in a complicated landform evolution.

****

Permafrost-cored alluvial bedforms and related channel morphology of the Lena River, Central Yakutia

TANANAEV N.
P.I. Melnikov Permafrost Institute, Siberian Branch, Russian Academy of Science, YAKUTSK, RUSSIAN FEDERATION

Major features of formation and development of the large cryogenic alluvial bedforms within the middle reach of the Lena River are reviewed. Under severe climatic conditions of Central Yakutia, permafrost is widely observed within the river channels. Frozen cores in large bedforms limit their mobility, leading to the enhanced bank erosion and channel degradation. It is shown that these bedforms control major river valley morphology features within the studied reach, from the channel topography structure to the formation of the channel pattern and the valley bottom. Development of the pseudomeanders within otherwise braided channel pattern is a distinct effect of these permafrost-cored bedforms. Qualitative model is offered to describe the cyclic development of these bedforms, emphasizing the role of the dominating channel pattern and ice jamming. This cyclic pattern is related to the large–scale water flux variations, which were correlated with Milankovitch–type oscillations via climatic modeling results.

Geomorphological and geoecological mapping of river valleys, floodplains and channels

CHERNOV A.
Faculty of Geogbrahyy, Voscow State University, MOSCOW, RUSSIAN FEDERATION

The paper deals with principles of small-scale mapping of floodplain-channel complexes. Mapping in small scale implies showing river channel and floodplain as a linear object – a multi-component strip over the river line on topographic map. It is a set of stacked over each other bands of successively decreasing width divided with bordering lines. Properties of channels and floodplains are shown by band width, color and hatching, and color of inter-band borders. The following information is shown: width and morphological type of channels and floodplains, channel dynamics (bank erosion rates, meander growth rates), sediment type, morphology and composition of banks, meander curvature, river behavior at confluence reaches, economic activities in channels and valleys influence on channel processes, etc.

Processes and phenomena on valley sides are depicted by symbols alongside river strips. External geographical and geological conditions are shown by colored and hatching background over the whole map.

Such approach was used to compile a set of maps showing river morphology and dynamics in the whole Russia and surrounding states, European part of Russia, selected regions as well as geoecological state of floodplain-channel complexes and risk of channel processes in different Russian rivers. Geoecological maps display environmental conditions governed, first, by dynamics of river channel itself, and, second, by economic activities at river banks. Risk maps show estimations of potential danger that is generated nearby rivers by natural channel migrations and by human impact.

****

A study on phasic changes of sediment erosion and accumulation in the Inner Mongolian reach of the upper Yellow River and contributions of main factors

SHI C., SHAO W., FAN X.
Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences, BEIJING, CHINA

Using data of hydrological records, annual water and sediment diversion, and sediment retention and water regulation by dams, this study investigated the phasic changes in sediment erosion/deposition in the Inner Mongolian reach and in the series of water and sediment inputs to the reach. It is disclosed that there were two abrupt changes in the series of water and sediment inputs to the reach and the reach experienced a period of aggradation, a period of erosion, and then a period of aggradation again with the years 1962 and 1986 as the break points. For determining the causes for the conversions between aggradation and erosion, the contributions of main influencing factors were quantified. The results show that the variation of runoff due to climate change is the important cause for the conversions from aggradation in the first period to erosion in the second period and back to aggradation in the third period. Sediment retention behind the dams on the main stream is found to be the first factor resulting in the transition from aggradation in the first period to erosion in the second period, and reduction of sediment input from tributaries to be another factor making a certain contribution to it. Besides the runoff reduction associated with climate change, the rise of sediment input from tributaries, reduction of sediment retention behind dams, and increase of water diversion are revealed to be favorable to the transition from erosion in the second period to aggradation in the third period. The results also show that water diversion has played an important role in the long-term aggradation of the Inner Mongolian reach and the gradual rise of water diversion has enhanced the aggradation. It is suggested that the control of water use and reduction of sediment input from the tributaries should be an effective way to alleviate the aggradation in the Inner Mongolian reach.

Keywords: Alluvial river; Changes in water and sediment discharge; River channel aggradation.

Evolution of River Systems in the Indian Part of Upper Ganga Delta: Evidences from Maps and Satellite Images

DAS S., BANDYOPADHYAY S.
Department of Geography, University of Calcutta, KOLKATA, INDIA

The western part of the Ganga-Brahmaputra delta, India and Bangladesh, is mostly contributed by the Ganga and its tributaries. The major distributaries and palaeodistributaries of the river that drain the Indian non-tidal part of the delta include the Bhagirathi, Gobra, Bhandardaha, Bhairab, Sialmari, Jalangi, Mathabhanga, Churni, Ichhamati, Jamuna and Anjana among others. Most of these distributaries are characterised by intense meandering and their channels have shifted frequently in the past. The off-takes of the major ones are periodically affected by the shifting of the main channel of the Ganga during the monsoons.

The database for this study consists of maps of James Rennell's *Bengal Atlas* (1:316,800;1767-74) *Atlas of India* (1:253,440;1848-56), Survey of India (1:63,360; 1916–1931) and selected satellite images from Corona (1967), IRS (LISS-3+PAN, LISS-4 Mono: 2001–2007) and Landsat (MSS, TM, ETM+: 1973–2011) missions. Available discharge and gauge height data of selected rivers for different years are collated with the investigation of maps and images. Field surveys are carried out at specific off-takes and confluences using Total Station, Echo-sounder and GPS to analyse the present scenario.

The results indicate marked degeneration of the distributaries especially at their headwaters where siltation is a common phenomenon. This can be linked to abandonment of the western part of the delta. In some instances (e.g., in Ichhamati and Jamuna) the oxbow lakes associated with certain rivers are seen to get smaller in width and depth with decreasing age indicating gradual deterioration of the river channel. This characteristic, however, is not seen in the non-degenerated or artificially resuscitated distributaries (e.g., in Bhagirathi) where the cross-sections of all the ox-bows as well as the active channel are similar. Decay of some of the rivers (e.g., Anjana) can also be related to anthropogenic activity like encroachment and drainage diversion.

****

Spatial organization of Pantanal lagoons in Matogrosso Do Sul, Brazil

FERNANDES E.(1), QUEIROZ NETO J.P.(2)
(1) Universidade Federal do Rio Grande do Norte, NATAL, BRAZIL ; (2) Universidade de São Paulo, SÃO PAULO, BRAZIL

Several studies have highlighted the interesting concentration of lagoons, where the great variability in the quality of their waters, characterized by saline lagoons with sodium and chlorinated, bicarbonate water, would be a peculiarity of the region. These lacustrine groupings occur in southern ledge of Taquari River alluvial macro and are part of the vast alluvial plain of the Pantanal, in the Upper Paraguay River Basin, including Brazil, Bolivia, Paraguay and Argentina. The aim of this study is to show that the lagoons are not randomly distributed in the region; instead, they have an organization or patterns in the spatial distribution, as well as a relationship between their distributions and their sizes that allows us to understand the dynamics and evolution of hydrological landscape. The study was conducted through the use of remote sensing techniques for classification of TM LANDSAT TM 5 (226/73) satellite images and integration of water quality data collected in the field. SPRING (INPE, Brazil) and ArcView GIS 3.2 (ESRI) programs were used for image classification, statistical treatments and correlation of themes. It was classified this universe of lagoons in 3 size classes and, based on these 3 classes, it was carried out the spatial density calculate for each theme. It was used an extension for the Arcview 3.2 program called *"FeatureDensity.avx*" whose algorithm calculated the ratio between the area of lagoons on the total area regional determining concentration of 5 classes of ponds by the method of natural breaks. The spatial organization of ponds has suggested that these have strong genetic influence of two current and past tenses processes, which has been operating in the morphological evolution of Taquari river alluvial fan: 1) morphostructural processes related to regional structural lineaments, 2) hydrodynamic processes of Taquari river alluvial fan.

Similarity analysis of scale effects of specific sediment yield in the Yangtze River basin, China

YAN Y.
Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Science, BEIJING, CHINA

Scale effects of specific sediment yield are very important issues not only for the water and soil conservation, but for the constructions of different levels of dams. The Yangtze River basin is the largest river basin in China. Scale effects of specific sediment yield were studied on different tributaries or on the whole basin. Based on our study of the whole Yangtze River basin, there were three different kinds of relationships between specific sediment yield (*Ys*) and drainage area (*A*), there are, *Ys* increases with *A*, *Ys* decreases with *A,* and *Ys* isindifferent to *A*. In this study, we tried to reveal the reasons to form the different kinds of relationships between *Ys* and *A*. We focused on the study of similarities of scale effects among main channels and tributaries of the Yangtze River basin. All rivers with more than two hydrological stations were selected to. This study were carried out on two levels, firstly, study the similarity of scale effects of main channel of Yangzte River and of the tributaries which flow into the main channel; secondly, study the similarity of scale effects of large tributaries of the Yantze River basin. On the first level, because of the large area which we studied, the influencing factors are very complex, scale effects between main channel and tributaries were much different. On the second level, thought there were several differences in a few large tributaries, in general, the scale effects in each large tributary are similar. While among different tributaries, there were different patterns of scale effects. Scale patterns for the tributaries on the left side of the main channels were much different from that of the right side. Meanwhile for the tributaries on the left side of the main channel, scale patterns were also changed from west to east. Tectonics, landform, geology, climate, as well as land-use and land-cover were used to explain the similarity of the scale effects.

****

Fluvial patterns and its use for the assesment of amazonian geodiversity, discussion and application ont the Xingu River Basin

SILVA J.(1), RODRIGUES C.(1), PEREIRA D.(2)
(1) Department of Geography - University of Sao Paulo, SAO PAULO, BRAZIL ; (2) Geology Centre - University of Minho, BRAGA, PORTUGAL

This research has intended to demonstrate and evaluate the potential use of fluvial geomorphological variables as geodiversity indicators. The aim of this work is the morphological characterization and analysis of fluvial patterns in the Xingu River Basin, in order to demonstrate the relevance of these parameters for the assessment of Amazonian geodiversity. Two different spatial scales were used for this research. On a more detailed scale(1:150,000), maps of fluvial morphology were made for 23 selected areas, which represented the diversity of fluvial patterns in the drainage basin. This characterization proved the great diversity of fluvial patterns in the study area, demonstrating the relevance of this parameter as an indicator of geodiversity. On a less detailed scale, a method to quantify the geodiversity was applied to the entire drainage basin, based on the measurement and integration of abiotic elements spatialized on thematic maps with scales ranging from 1:250,000 to 1:1,000,000. The index of geodiversity ranged from 4 to 32. The hot spot of geodiversity is at the boundary between Complexo do Xingu and the Amazonian Sedimentary Basin, close to “Volta Grande do Xingu”, where there are different types of rocks, soils, reliefs and mineral resources, in addition to the fluvial patterns with the highest scientific and aesthetic value. Although still largely preserved by conservation units and indigenous lands, the Xingu Basin suffers severe anthropogenic pressures, mainly caused by the construction of Belo Monte Dam in the area of highest geodiversity, which presents no legal protection at all. The main contributions of this research are the enrichment of the knowledge basis about large Amazonian rivers, as well as the application of a method for mapping the geodiversity indexes, which can be useful as a tool for environmental planning, particularly in defining priority conservation areas.

Developmental History of the World's Longest Rivers

YANG I.
Ministry of Land and Resources ,China, BEIJING , CHINA

For more than 50 years, the author has surveyed the courses (either entire or most) of the longest rivers of 6 continents and other rivers in the world >5000km. He also discovered key evidence of their geological history , such as the highest terraces (1250m above the current river bottom, in the Three Gorges of the Yangtze River), the largest number of terraces (>32 terraces, in the Longyangxia Gorges, Yellow River), the largest visible thickness of loess deposit (315m, in Lanzhou, Gansu, China), the most complete profile of river evolution for 2.5 Ma. (In Lanzhou), the longest sections of mountains with many terraces (5/7 of the Yangtze and 7/11 of the Yellow R.), the deepest vertical karst sinkholes (622m, in the Three Gorges of the Yangtze). In Mts Andes, on the west slope: the marine terrace is over 1000m a. s. l , on the east slope: the Amazon terrace has 8 more steps, etc. Based on these observations, the author proposed a framework for the developmental history of the world's rivers controlled by new tectonic movement (China, the Andes, the Alps, New Zealand…) and climate change (N. America, Siberia, Europe…) In this framework, we can confirm the detailed history of the world's rivers.

Except the tremendous social impact,this study can also provide a theoretical basis for water management. In China the predictions of this study were confirmed by the Yangtze flood in1998. The study also points out the new channel that will be taken by the Yellow R. after 25 years. According to this study the origional reason of the unprecedented depletion of lower Yangtze since the spring of 2011etc was improper impoundment by the Three Gorges Reservoir. This study is also essential to the research of earthquakes induced by giant reservoirs(such as the Three Gorges and the Longyangxia Gorge reservoir). If these kinds of studies had been carried out prior to the Wenchuan Earthquake, 2008, the number of the deaths couldn't have been reached 87 000.

****

The lower Indus Basin: an anthropogenically modified hydrosystem under the influence of extreme events

ATIF S., ARNAUD-FASSETTA G., FORT M.
Université Paris Diderot, UMR PRODIG, Sorbonne-Paris-Cité, PARIS, FRANCE

The Indus basin is under a constant process of anthropogenic evolution since the earliest human civilizations of Moen-jo-Daro and Harrapa. Irrigation and water management practices have evolved to serve the purpose of its ever-dependent population. Large dams, barrage, link and irrigation canals stretch across the entire river basin. These form a set of anthropogenic controls, to which the river channel adjusts over time. But as large floods such as those in 2003, 2005 and 2010 flow down the lower Indus basin they modify the natural evolutionary behaviour of the stream. In a few places this can be channel migration far and off to highly inhibited land resulting in widespread devastation of property and loss of human lives. Similarly, as a result of anthropogenic controls in the north the river delta, which is an integral component of fluvial landscape and an indicator of the river's health, tends to deteriorate. This situation is further aggravated by coastal cyclones, which have gained momentum during the last decade. This study aims to use a nested reach style approach in an evaluation of the channel's plan form and its possible causes with particular focus on the effects of floods. An additional component is the study of the extent of seawater intrusion into the main river channel.

Simulation of floods in the Rhône valley from Lidar DEM: Assessing impacts of hydraulic structures on the floodplain dynamics faced new regulation of 2014

HENAFF Q., BELTRANDO G., ARNAUD-FASSETTA G.
Universite Paris Diderot - UMR 8586 (PRODIG) du CNRS, PARIS, FRANCE

The recent catastrophic floods (September and November 2002, December 2003) of the Rhône River highlighted the need for knowledge to understand the complexity of the hydrosystem functioning. The Rhône River that is termed as 'hydrologically controlled' by human society and managers, still maintains a paradoxical fluvial risk.

The hydroelectric development of the river changed both its structure and hydrosedimentary functioning. To minimize these environmental impacts, the Environmental Code (Article L.214-18) imposes an enhancement of streamflows for the Rhône River (15 projects required for 2014). The fluvial geomorphological dynamicswill evolve in response to this new regulation, imposing to taking into account for the impacts of flood eventsin the highly urbanized floodplain.

Benefiting of a 1-meter resolution Lidar Digital Elevation Model (BDT Rhône - IGN), which integrates altitudes with a precision of less than 20cm, and with partnerships such ast he French Water Data Center (Eaufrance) and the Compagnie Nationale du Rhône for hydraulic structures data, one-dimensional steady and unsteady flow hydraulic modeling of the Rhône River wasused to simulate floods in orderto define a probabilistic scenarios grid of hydrological hazard. Satellite imagery of the 2002flood event (International Charter on Space and Major Disasters) allowed us to calibrate the hydraulic model and to quantify the impacts of hydraulic structures for simulated floods.

This grid of flood scenarios should represent a useful geodatabase for modeling and mapping hydrological hazard in the Rhône valley considering impacts of hydraulic structures.

****

A quantitative approach of the morphological changes in the Middle Garonne river (South-west France) during the last 300 years

DAVID M.(1), CAROZZA J.M.(2), VALETTE P.(1)
(1) GEODE UMR 5602 CNRS - University of Toulouse, TOULOUSE, FRANCE ; (2) University of Strasbourg, GEODE UMR 5602 CNRS, STRASBOURG, FRANCE

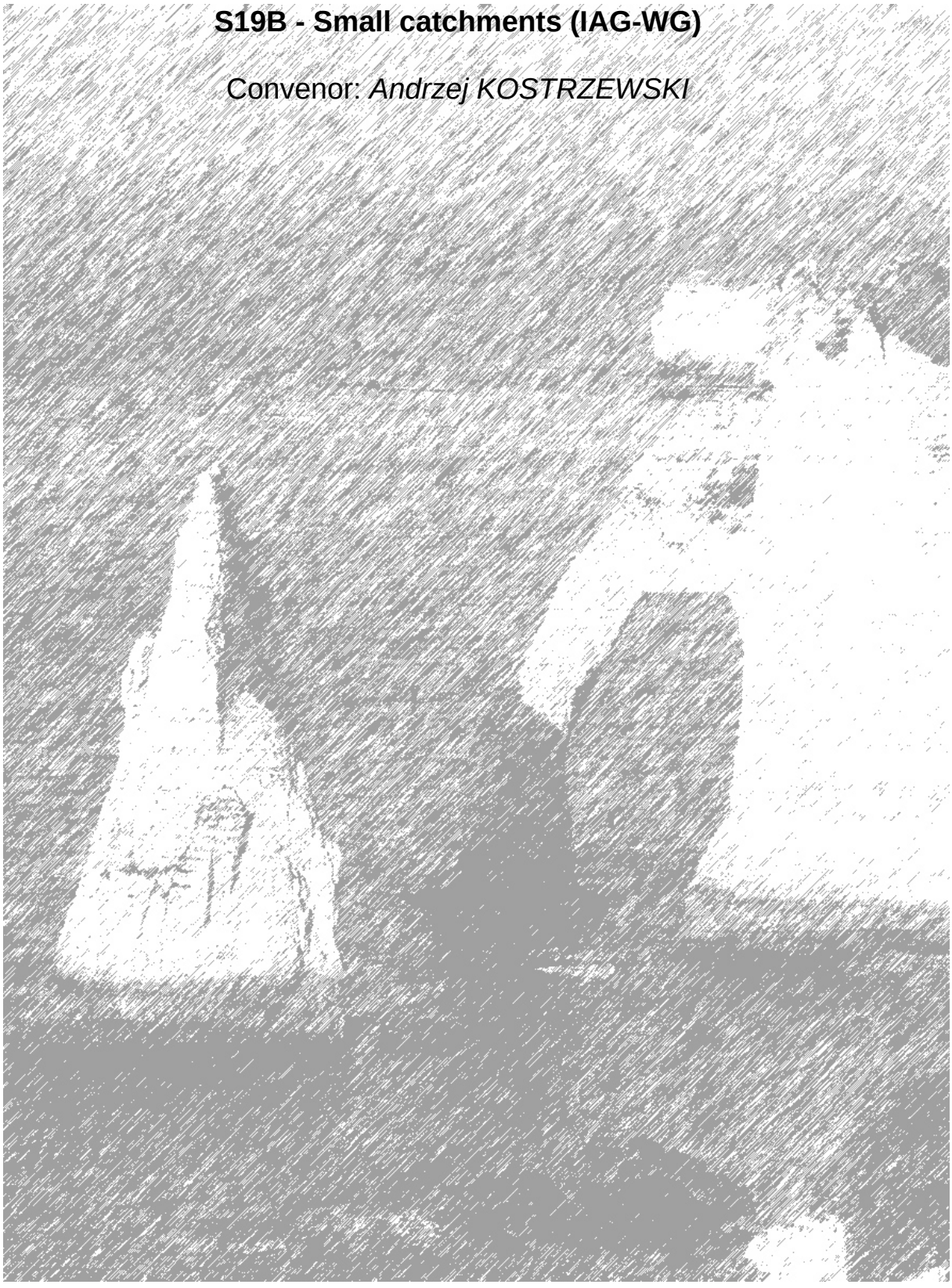
The Garonne river (South-west France) experiments a state of hydrogeomorphological crisis that results in : 1) lose of diversity in riparian environments, 2) decreased of the lateral mobility and 3) a general tendency to channel incision. According to previous studies,these phenomena are the result of human activity intensification in the watershed during the 20th century (reforestation on the slopes of the watershed), in the channel (industrial gravel extraction, sediment retention by hydro-electric dam construction) or on riverbanks (riverbanks stabilization for protection against flooding and for navigation). However, studies on this evolution are parse and generally focus on short time evolution (< 50 yr). The aim of this study is to propose a periodization of morphological evolution of the river Garonne from the 18th century to present, on a reach of nearly 80 km between Toulouse and the Tarn tributary in order to test hypothesis about driven forces (*i.e.* climat vs anthropization).

This work is based on a qualitative and quantitative approach of historical dataset (textual sources, maps, engineering plans, etc.). 1) Fifteen maps covering the all study area allow high temporal resolution analysis of channel/floodplain evolution ; 2) Quantitative analysis of channel planar shape parameters (*i.e.* sinuosity, channel width, active band width, channel island number, braiding index, etc.) for each set maps allows to reconstitute the channel evolution trajectory.

The chronological framework of evolution is compared on the one hand with historical data and anthropic disturbance in the channel, riverbank stabilization, etc. and on the other hand to regional climatic and hydrological data (mainly flood) in order to test hypothesis on anthropic versus climatic driven evolution. These results could highlight management choices and fluvial restoration options in the context of climatic change.

S19B - Small catchments (IAG-WG)

Convenor: *Andrzej KOSTRZEWSKI*



Oral presentations:

The monitoring of small rivers catchments in various climatic zones - assumptions of methodological and methodical studies

KOSTRZEWSKI A.
Adam Mickiewicz University, POZNAN, POLAND

Contemporary shaping and relief changes of the Earth surface are the effects of the denudation system functioning, that zonal specificity is well presented by river catchments.

River and lake catchments are important landscape structures in all morphoclimatic zones. They reveal as research subjects of the specialized as well complex, interdisciplinary character. It can be accepted that river and lake catchments are landscape structures (geoecosystems), very useful to determine past and present changes of Earth surface. Small river and lake catchments are landscape structures especially sensitive in the scope of influences of both natural and man induced processes. External and internal impulses and their results are quickly registered in the memory of the river catchment system.

River catchment is treated as an open system - geoecosystem, where we would like to determine the energy circulation and matter transfer with the use of appropriate methods.

In such a presentation it is essential to standardize field measuring system, the elaboration of appropriate informatics system, the application of geoecological approach and correctly tested models.

Presented methodological and methodical requirements are realized within the Natural Environment Monitoring, treated as a research trend in environmental investigations.

The fundamental assumption of the program "Small catchment" is a realization of interdisciplinary research in river and lake catchments in different morphoclimatic zones, on the base of the organized multi-year stationary studies. The realization of the program intend the use of standardized research methods and gathering the results in thematically oriented data base, allowing comparative studies.

The identification, on the basis comparative studies of response of the fluvial systems to changes in land use, observed climatic changes is very important, in both theoretic and applied points of view.

****

Geomorphological features of small watercourses in a context of river landscape sustainability in the Czech Republic

JAKUBINSKY J.
Global Change Research Centre AS CR, v.v.i., BRNO, CZECH REPUBLIC

The paper presents results of research focused on the study of morphological values of the small watercourses in the Czech Republic and their environmental consequences. Particularly the issues of watercourse countersink, and differences between natural and artificially increase deepening of the river channel conditioned by anthropogenic activities are solved there. Presented are the results of research into the relationship between a number of hydromorphological parameters and intensity of human activities within the river landscape area. The river landscape is traditionally viewed as an ecosystem along watercourses, which functioning is directly conditioned by the presence of a river. Because this is a very attractive place for realization of the human needs, it can be seen a conflict between the activities of human society and effects of the natural processes associated with the presence of a dynamically evolving river networks.

Central question in the study of human impacts on the river landscape is primarily how to distinguish the natural evolution of riverbed morphology from man-conditioned disturbances. Secondary, the prediction of expected changes in watercourses ecosystem taking into account the specific impact of human activities is assess. Research procedures outlined above are implemented using the data acquired by a detailed field survey on several model sites, situated in different regions of the Czech Republic.

The essence of the research comes from the fact that any change in a single variable which affects morphology of the river environment may cause a series of channel pattern changes with the feedback in the form of further secondary channel parameters. A significant part of the solved issues is also a question of establishing the initial (more or less natural) state of the stream channel and inundation area from which it can be derived the procedure for expression the degree of fluvial ecosystem degradation.

Geochemical and physical loss from a small catchment area in the sub-humid 'tropics: contribution of gullies

AUGUSTIN C.(1), CRUZ L.(2), FABRIS J.(1), ROCHA L.(3)
(1) UNIVERSIDADE FEDERAL DE MINAS GERAIS, BELO HORIZONTE, MG, BRAZIL ; (2) Fundação Estadual de Meio Ambiente, BELO HORIZONTE, BRAZIL ; (3) Universidade Federal de São João Del Rey, SÃO JOÃO DEL REY, BRAZIL

Gullies are common features in tropical areas although not restricted to this part of the globe. In tropical areas intense soil loss which constitutes one of the main characteristics of this type of concentrated erosion can sometimes intercept the ground water level resulting in superficial water flow inside the gullies during the entire year and loss of chemical elements that otherwise would remain in the system. In situations in which chemical loss constitutes one of the main processes of landscape denudation, the role of gullies can be significant. The aim of this research is to understand the contribution of chemical and physical losses from gullies and their role in the geomorphic dynamics in an area formed by a 3rdorder drainage basin in a tropical area of southeast Brazil. Results show that the weathering stage has achieved total allitisation at the top and upper portion of the slopes where the gullies occur corresponding to an old erosion surface where an expressive amount of gibbsite and goethite as well as a ratio of SiO_2:Al_2O_3<2 are found. Where intense physical erosion took place, the removal of the old weathered surface (lower slopes, gullies, etc) more likely leads to monosiallitisation resulting in partial removal of $SiO_2$and neoformation of kaolinite (SiO_2:Al_2O_3=2). Data demonstrate also the overwhelming physical loss of sediments in the gullies creates conditions for a more extensive and quicker removal of sediments and chemical elements in solution. This contributes to enhance changes in the thick weathered mantle which tends to be stripped away generating the formation of new soil. This constitutes one of the main processes of landscape development in this relatively stable tectonic area. Gulling also influences chemical balance through the more rapid circulation of underground water leading to the occurrence of less saturated chemical solutions which tends to promote geochemical changes.

****

Extreme land-forming processes development and distribution in the Ukrainian Carpathians under natural and man-made factors

MYKHNOVYCH A.(1), KOVALCHUK I.(2), KRAVCHUK Y.(1), PYLYPOVYCH O.(1), CHIKOVA I.(3)
(1) Ivan Franko National University of Lviv, LVIV, UKRAINE ; (2) National University of Nature Use and Life Sciences of Ukraine, KYIV, UKRAINE ; (3) Ukrainian Academy of Mining Sciences, Mining and chemical raw material department, LVIV, UKRAINE

The Ukrainian Carpathians is the area of wide spectrum exogenous processes development. The paper deals with the analysis of the conditions, factors, regularities of extreme land-forming processes distribution and development intensity. Such analysis is based on the results of the long-term observations and investigations within the special representative areas (study sites) and fields of stationary and semi-stationary observations and measurements. These sites have been chosen due to the specific geological and geomorphologic conditions within the river basin systems of different order. By the combinations of natural conditions and regime of nature use and economical activity the Precarpathian decline with the southern-western margin of the Eastern-European platform, Carpathian mountains and Transcarpathian internal decline are defined.

Natural conditions (tectonic and geological structure, relief, precipitation) define the distribution of zones and periods of extreme activization of land-forming processes in the Ukrainian Carpathians. Most significant and temporary increasing factor of the geomorphologic processes extreme activization is economical activities in the river basins of the region. The third important factor of the activization is seismic activity in the region. Most active in this aspect is the Transcarpathian region where local earthquake epicenters are corresponded to the active tectonic breaks. The largest activization of the geomorphologic processes in the region has been observed in the period of extreme flood events caused by combination of extraordinary meteorological conditions, relief forms and man-made impacts.

Assessment of the relationships among morphometric parameters and hydrologic indices

KARALIS S., KALOGEROPOULOS A., KARYMBALIS E., CHALKIAS C.
HAROKOPIO UNIVERSITY, DEPT. OF GEOGRAPHY, ATHENS, GREECE

This paper seeks to investigate the role of morphometric characteristics of the drainage networks and basins in the physical mechanism of surface runoff. There are two main factors that affect the generation of surface runoff. These are the rainfall characteristics (spatiotemporal context) and the catchments characteristics (static context). Using as a starting point an extreme flash flood event in Xerias torrent which was described as a hundred years flood, an attempt was made to extend this flood throughout 41 small relatively mountainous catchments (ranging in area from 1.5 to 330.5 km) located in North Peloponnese, Greece. A GIS-based spatially distributed unit hydrograph model is used in order to obtain the hydrologic indices (such as rising limb, peak discharge, falling limb, critical time etc). These indices are compared with the basic quantitative geomorphological characteristics of the drainage networks and associated basins (bifurcation ratio, basin circularity, Melton's ruggendness number, basin slope, asymmetry factor) of the study areain order to relate the basin character to the discharge produced. The basic idea is to quantify the relationships among the geomorphology (expressed through quantitative indices) and the hydrological characteristics, which are derivatives of a flood.

****

Quantitative Morph metric Analysis of Machna River basin Management, M.P.(India)

NAMDEO S.
Motilal Vigyan Mahavidyalya, Bhopal, BHOPAL, INDIA

Flowing water (Geomorphological drainage) and associated mass gravity movement have been active over a long time span and are responsible for the development of present surface geometry. Quantitative analysis of geomorphological drainage is systematic description of the watershed and river channel system which measures the linear aspects of drainage network, aerial and relief aspects of channel network. In the present study, the quantitative analysis of drainage basin is based on methods given by Strahler (1953 and 1964), Chorely (1957), Shumm (1956), Miller (1945), Melton (1957), Smith (1950). The Machna river watershed (Lat. $22^0$00' to$22^0$25' N; long. $77^0$45'to $78^0$03' E; Narmada river basin) drains across different landscapes and it is an important source of sustainable water resources of the area. The study reveals the past climatic conditions, impact of present land use along with natural conditions in managing watershed. The bifurcation ratio indicates development of drainage due to underlying homogeneous parent material which is basalt and granitic gneisses. The mean bifurcation ratio indicates well developed surface drainage and permeable strata, a prerequisite for augmenting the ground water level. Parameters of aerial aspects indicate variations in discharge of rain water from different zones of watershed. However, bifurcation ratio suggests a moderate discharge from watershed. The stream frequency and filtration number along with overland flow to enhance understanding of watershed development and relief aspects of the analysis have been found to be useful in designing the various structures of the watershed. The study concludes that quantitative analysis of drainage morphometry is a desirable approach for understanding of the integrated watershed management.

Variability of soil erosion in the last-glacial areas on the example of NE Poland

SMOLSKA E.
University of Warsaw, WARSAW, POLAND

The aim of the study was to recognize soil erosion in the last-glacial area on the example of NE Poland. Monitoring of soil erosion was conducted on selected slopes in the upper Szeszupa catchment in years: 1987-1989, 1998-1999 and 2007-2011, a total during 10 years. In 2007-2009 measurements were also performed within 3 runoff plots on sandy soils under differential land use: black fallow, grain crops and potatoes. Each plot was 22 m long and 2 m wide. During rainfalls of moderate intensity sheet wash caused erosion of the upper and the middle segments of hillslopes and deposition of eroded material in their concave (lower) segments. Rills formed locally due to rainfalls above 20 mm on sandy-loamy, sandy-silty and loamy-sandy slopes longer than 100 m. Only a limited amount of material was transported beyond slopes and accumulated at the footslopes. For the average intensity of rainfalls, annual soil erosion ranged from 0,05 to 7 $t \times ha^{-1}$. Due to heavy rainfalls the effectiveness of both processes: sheet and rill erosion was several times greater, up to 30-50 $t \times ha^{-1}$and locally even 80-90 $t \times ha^{-1}$. Intensive erosion, accompanied by soil loss up to 170 $t \times ha^{-1}$, lead to the formation of frequent rills, and locally, to the development of ephemeral gullies. Strong erosion occurred on hillslopes were several features facilitated the soil loss, most importantly: the type of crop and the early stage of its development, local lithology and morphology of the slope. The study area experiences heavy rainfalls (>30 mm and erosivity > 300 $MJ \times mm \times ha^{-1} \times h^{-1}$) in May or June with frequency once every 7-10 years on average. It is estimated that 15% of the study catchment area is threatened by soil erosion.

****

Weather times and flood generation in the Araguás catchment (Central Spanish Pyrenees)

NADAL ROMERO E., CORTESI N., GONZÁLEZ HIDALGO C.
University of Zaragoza, ZARAGOZA, SPAIN

Flood generation and soil erosion is associated with specific weather conditions that can be described by weather Types (WT) approaches. The WT approach consists on classified atmospheric conditions. Previous climate researches in the Iberian Peninsula (IP) have analyzed the relationship between precipitations and specific WT, being the most prevalent to produce precipitation the Westerly, South-Westerly and Cyclonic WTs. These investigations have also demonstrated that specific WT are the main driven of precipitation accordingly different areas.

In this study, an analysis of WT and flood generation, storm-flow and soil erosion data during 7 hydrological years in the Pyrenees mountain area is presented. The analyses indicates that the Anti-cyclonic (A) type is the most frequent class (17.04%), but contribute with a rather small amount (5%) to total precipitation amount. On the other hand, the three wettest WTs, namely Cyclonic (C), Northwesterly (NW) and westerly (W) types, together representing only 20% of all days, account for 45% of the total precipitation.

Since October 2005, a total of 253 floods were identified in the study area. The most frequent WT generating floods were Cyclonic (19.4%), Northwesterly (NW) (15.4%) and Westerly (14.6%) types. The analysis of monitored storm-flow and sediment yield (SY) in relation to the WTs reveals a clear propensity for the south westerly (SW) weather pattern to dominate the maximum storm-flow generation and the maximum SY.

Typology of torrential systems prone to debris flows occurence in the Hérens valley (Switerland)

MAILLARD B.(1), REYNARD E.(2), THELER D.(1)
(1) ECOTEC Environnement SA, SIERRE, SWITZERLAND ; (2) Institute of geography and sustainability, University of Lausanne, LAUSANNE, SWITZERLAND

Debris flows are one of the most active sediment transport vectors in the mountain regions. The objective of this study on debris flows in the Hérens Valley (Valais, Switzerland) is twofold: (1) to identify geomorphological contexts favourable to trigger debris flows and (2) to estimate the volumes potentially mobilized. The research, conducted by a combination of qualitative and quantitative methods, was divided into two stages. As a first step, we classified small torrential basins based on hydrologeomorphological and morphometric criteria and according to their morphodynamic activity. As a second step, the potentially mobilizable sediment volumes were calculated for several torrential systems particularly active or at risk for infrastructure, using a semi-quantitative geomorphological method. The results show that, because of the variety of factors responsible for the debris flow triggering, it is not possible to predict debris flow activity only from morphometrical analyses.

****

Damming in semiarid, relation between landscape connectivity and effective catchment area on saco creek watershed brazilian semiarid

SOUZA J., CORREA A.
Federal University of Pernambuco, RECIFE, BRAZIL

The water resources management in the semi-arid has a close linkage with the annual and inter-annual variability of precipitation, which induced the creation of a hydro infrastructure network based on construction of dams, in special at warm semiarid zones, to use supply and irrigation to population, being essential the management of these dams and of their contributions areas. This study tried to analyze the physical system of the Saco creek watershed, situated in Brazil semiarid, with emphasis on the fluvial system, and from this evaluate the issue of regional planning aimed at damming the semiarid zone. Having the landscape connectivity as a concernandanalyzing the process of conveyance and sedimentation in semi-arid environment. For this geomorphological and land use, mappings were analyzed, and also classifications of precipitation/runoff events, based on average monthly runoff, that will identify the effective events of the system. The impediments location/characteristic enables the understanding of the effective catchment area on the watershed to three different magnitudes of runoff events. In low magnitude scenario only 33.8%, of the watershed contributed effectively to drainage network, in moderate magnitude this value grew to 61.6%, this augment is a result of the impediments overcoming; reaching to 70.8% in high magnitude events, this little variation is controlled by the existence of dams which storage all sediment, including in high magnitude events, released only with dams disruption. Landscape connectivity analysis can subside the dam management on semiarid zones; with emphasis on capture of the sediments before they arrive in the dams, increasing its useful life.

Debris dams on the far eastern rivers and their impact on the dynamics of riverbed transformations

MAKHINOV A., KIM V.
Institute of Water and Ecological Problems FEB RAS, KHABAROVSK, RUSSIAN FEDERATION

Forest vegetation noticeably effects the formation of the riverbed relief and the intensity of riverbed processes. Big trees in water streams 8-10 meters wide significantly block the water flow and cause the formation of stable broads. Fallen trees often cause changes of riverbed morphology as alluvial material starts accumulating in front of them and broads of specific morphology are formed behind.

Big rivers up to 150 meters wide may also be blocked with debris dams. They may be the result of economic activities in river basins. Wood cutting and forest fires disturb river runoff causing active riverbed transformations and bank erosion. As the result more trees and debris fall into the river and dam the water flow. The last stage of this process is the formation of numerous small river branches, where erosion is significantly lower.

Fallen trees in rivers more than 150-200 meters wide do not noticeably affect the river flow. Such rivers easily carry even big trees, shallows being an exception. Trees in shallow places facilitate the accumulation of alluvial matter or the formation of localized deep pools.

****

Investigating morphodynamics and sediment fluxes in a river reach impacted by a series of dams using landscape evolution modelling with CAESAR-Lisflood

POEPPL R.E.(1), KEILER M.(2), COULTHARD T.(3)
(1) Department of Geography and Regional Research, University of Vienna, Austria, VIENNA, AUSTRIA ; (2) Institute of Geography, University of Bern, Switzerland, BERN, SWITZERLAND ; (3) Department of Geography, Environment and Earth Sciences, University of Hull, United Kingdom, HULL, UNITED KINGDOM

Dams are often considered to have the most significant impact on rivers and concerns about the effects of dam construction have recently increased with the rising number of dams. Dam construction generally reduces downstream sediment fluxes which involves geomorphic changes in the affected river reaches (i.e. upstream/reservoir aggradation, downstream degradation). With dam removal the opposite generally occurrs, i.e. upstream degradation and aggradation in the downstream reaches. However, the situation can become more complex in river systems that are impacted by a series of dams due to emerging feedback processes between the river and the multiple dams. In the presented study we modelled different scenarios of dam construction and dam removal within a river reach impacted by a series of dams using the landscape evolution model CAESAR. The model was run with data from a small catchment located in Lower Austria. Modelled geomorphic changes and sediment fluxes were spatio-temporally analysed and interpreted in the context of dam construction/removal. Geomorphic changes were quantified using zonal statistics in ArcGIS, while calculated water and sediment fluxes were analysed according to their total sediment volume and grain size distribution. In order to validate the modelling results, sedimentological surveys were performed in the field. First analyses of the modelling results revealed the occurrence of negative feedback processes within a series of dams restricting dam-induced downstream erosion as well as upstream erosion after dam removal as a function of distance between dams.

Embedded Dam Technique on River Basins in Rehabilitation Studies: The Case of the Afyonkarahisar Dort River

SELCUK BIRICIK A.(1), EKINCI D.(2)
(1) MARMARA UNIVERSITY, ISTANBUL, TURKEY ; (2) ISTANBUL UNIVERSITY, ISTANBUL, TURKEY

Rivers possess a delicate environmentalism that depends on a regular cycle of disturbance within certain tolerances. The geomorphological processes, plant and animal communities that inhabit the river and river margins have evolved to adapt to their rivers own peculiar pattern of flood and drought, slow and fast current. However floods are the most common and widespread of all natural disastersand there are many disruptive effects of flooding on human settlements and economic activities. Dams are important in this case.There are several types of dams. One of them is embedded dam. They prevent flooding of small areas. The concept of embedded dam is combined with the old principle of stationary set balance to produce an alternative approach for obtaining the steady-state distribution of the level in a dam with general release rule. Embedded dam system shall be indicated and benefits will be determined. These are described in the case of Dort River dam in this study.

****

Coarse sediment study in small mid-mountain catchments: a multidisciplinary attitude

HARTVICH F., LANGHAMMER J., STYCH P.
Charles University in Prague, PRAGUE, CZECH REPUBLIC

Within the project "Impact of disturbances in montane landscape on the dynamics of runoff and fluvial processes", the distribution, analysis and monitoring of the fluvial sediment bodies were among the main objectives, as the dynamics of the fluvial systems is known to be a sensitive indicator of the environmental changes. The study areas are situated in the mid-mountains of the Šumava Mts., a region hit with severe landscape disturbances of both natural and human origin, namely windstorms Kyrill (2007) and Emma (2008), and following bark-beetle infestation and consequent forest management measures including vast logging. Recent development of technologies has enabled using new attitudes also in the fluvial geomorphology. Within this study, we have employed some of these innovative methods. Initially, mapping of the fluvial landforms was performed using a specially adapted form-based mapping methodics, which had two-fold advantage: it enabled even less-experienced field workers to achieve acceptable results, and allowed very easy processing and analysis of the data in GIS. The results were complemented with the analysis of the 1 m LiDAR DEM, thus bringing very accurate relief properties information. Geophysical profiling using the ERT method was applied across the studied valleys to observe the depth of the valley infill. Selected sedimentary accumulations were measured using a ground LiDAR laser scanner, creating extremely detailed surface model, to be used as a reference surface for future repeated measurements, thus calculating the sediment transport volumes. Finally, granulometric analysis using a photography-based software Sedimetrics was performed on suitable accumulations. Although the research has commenced only recently, we have already obtained a valuable data on the current distribution of the sedimentary bodies within the studied catchments as well as a base for future reference aiming to assess the current, disturbance-driven sediment dynamics.

Poster presentations:

The magnitude and frequency of morphogenetic processes in small catchments (Western Tatra Mts., Poland)

PLACZKOWSKA E.
Institute of Geography and Spatial Management, Jagiellonian University, KRAKOW, POLAND

Small catchments 1st-3rd order (according to Horton-Strahler's classification) are very important in the sediments and organic contents fluxes. They are a source of energy and matter for fluvial system. Thus they are transitional segments between slope and channel systems. The aim of the paper is to recognize the magnitude and frequency of morphogenetic processes (especially fluvial processes) in small catchments in Western Tatra Mts.

The study area is the Western Tatra Mountains within the Tatra National Park in Poland. There are three geoecological zones in the study area – forest zone (to 1500 m a.s.l), subalpine zone (1500-1800 m a.s.l) and alpine zone (over 1800 m a.s.l). There is morphogenetic processes differentiation within these zones, especially above and below the timberline. The high-mountain areas are characterized by variable weather conditions. The annual precipitation is up to 2000 mm.

The study was carried out in seven chosen valleys in the Western Tatra Mountains using field experiment with marked debris. Three valleys are located in sub-alpine and alpine zones and four of them are located in forest zone. The study sites were installed in channels of different order, different structure and different hydrodynamics. Simultaneously the water level in streams and discharge were measured. The bedload movement in small channels from 1st to 3rd order is generally rare. It occurs once or twice a year but in the uppermost part of valley it is even less frequently occurring. Distances of bedload movement generally increase downstream and they are from less than one meter in upper stretch of 1st order channel to few meters in 2nd or 3rd order channels. In forest zone the distance of bedload movement can reach up to 60 meters. The occurrence of mineral and woody debris in channels is very important. They build traps for moving debris and reduce its removal from the catchment.

****

The specificity of energy and matter circulation in the coastal, forested lake gardno catchment on Wolin Island (NW Poland)

KOSTRZEWSKI A., TYLKOWSKI J.
Adam Mickiewicz University, POZNAN, POLAND

The operation of the morphogenetic system of lake catchments should be considered in spatial-temporal terms. In the contemporary denudation system of such catchments the physico-chemical transformation of precipitation plays a significant morphogenetic role. Of crucial importance for an insight into the operation of lake geoecosystems is to establish regularities underlying the transformation of the chemical composition of precipitation at the successive stages of the water cycle in a catchment, including throughfall, stemflow, groundwater, and surface water. Seasonal differences in the amount and chemical composition of precipitation determine annual variations of the load of chemical substances introduced into slope covers, and play an important role in net denudation in the catchment.

The full forested Lake Gardno catchment is situated on the Wolin End Moraine. It's neighbourhood of the cliff coast of Wolin Island and it has no surface outlet.

The base of the research was the AMU Environmental Monitoring Station at Biała Góra/Grodno and the period covered was 1997 2012.

The main objectives of the work in the Lake Gardno catchment are following:

- hydrochemical transformation of precipitation
- seasonal variations of water's hydrochemical properties
- marine aerosols influence on the chemical properties of water
- the role of the fog in the water and the elements circulation
- water and denudative balance
- model of the water cycle and the elements in the catchment.

The quantitative assessment of the energy and matter circulation in the Lake Gardno catchment is presented here in a model of the functioning of dissolved matter in a long-term and yearly cycle.

Monitoring programme of sediment flux in small upland catchments, SE Poland

RODZIK J.(1), JANICKI G.(1), CHABUDZINSKI L.(1), FRANCZAK L.(1), SILUCH M.(1), STEPNIEWSKI K.(1), DYER J.(2), KOLODZIEJ G.(1), MACIEJEWSKA E.(1)

(1) Maria Curie-Sk?odowska University, LUBLIN, POLAND ; (2) Mississippi State University, MEMPHIS, UNITED STATES

The purpose of monitoring of small upland catchments, launched in 2011, is to determine differences in sediment and solute yields as well as in sources of material supply to the channels under conditions of land use changes in the eastern part of the Polish Uplands. Seven catchments with an area of 12-68 km^2 and varying land cover were identified, representing different lithological types of upland relief. Five subcatchments were identified within them to determine the impact of the catchment area on the unit size of transport.

Field and laboratory investigations include the following:

- automatic recording of water levels and measurements of flows once per month;
- pH and water temperature measurements once per month;
- quantitative analysis of sediments and solutes in water samples collected once per week;
- qualitative analysis of samples collected once per month;
- quantitative analysis of water samples collected daily during flood events.

The initial research results indicate that the areas built of Cretaceous carbonate-silicate rocks– gaizes and opokas – are characterized by the lowest rate of fluvial transport. The highest rates are found in loess areas incised by gullies. The unit rate of sediment transport clearly decreases with an increase in catchment area, while the rate of solute transport slightly increases.

The presented monitoring scheme is a part of the programme: “Rainstorm prediction and mathematic modelling of its environmental and social-economic effects”, financed from the resources of the Polish National Scientific Centre.

****

The effect of landuse changes on sediment transportation in a small catchment during last 60 years

KIM J.K.(1), NAHM W.H.(1), KIM M.S.(2), YANG D.Y.(1), JEONG G.S.(3)

(1) Korea Institute of Geoscience & Mineral Resources (KIGAM), DAEJEON, SOUTH KOREA ; (2) Korean Association of Soil and Water Conservation, SEOUL, SOUTH KOREA ; (3) Chungnam Natioinal University, DAEJEON, SOUTH KOREA

To investigate the effect of landuse changes on sediment transportation in a small catchment, a short core from reservoir was obtained. Reservoir sedimentation rate changes during last 60 years were reconstructed by radionuclides, exPb-210 and Cs-137, and landuse changes from 1960’s to 2000’s were estimated by analyzing aerial photographs. Reservoir sedimentation rate changes can be recognized in three periods. During first period (1940’s ~ early in 1950’s), reservoir sedimentation rate had increased since the construction of reservoir. During second period (early in 1950’s ~ early in 1990’s), reservoir sedimentation rates were stable relatively around 3 kg m^{-2} a^{-1}, however, two higher sedimentation peaks occurred. During last period (early in 1990’s ~ 2003), reservoir sedimentation rate had increased sharply. Before 1990’s, the sediment transportations from a catchment to reservoir had been changed little although the increase of forest and grassland areas and the readjustment of rice fields had been occurred repeatedly and those landuse changes might not affect considerably the sediment transportation. The increasing of field area and bare area due to the reduction of forest area since early in 1990’s might be a dominant factor for the increasing the supply of sediment from a catchment, and gradually increasing rainfall amount in this study area since 1970’s would also assist the rapid increasing of sedimentation rate. Therefore, these results implied that land use changes and increasing rainfall caused by climate changes could be result in huge sediment transportation in the future.

Changes of size distribution of the raindrops against rainfall intensity in Daejeon, Korea

LIM Y.(1), KIM J.W.(1), KIM J.K.(2)
(1) Seoul National University, SEOUL, SOUTH KOREA ; (2) Korea Institute of Geoscience & Mineral Resources (KIGAM), DAEJEON, SOUTH KOREA

To evaluate the size distribution of the raindrops under various rainfall intensities, the terminal velocity and the size distribution of raindrops for 17 rainfall events were measured from January 2010 to August 2011 using laser-optical disdrometer in Daejeon, Korea. The predominant drop size and median drop size (D_{50}) became larger with rainfall intensity increasing, although the value of D_{50} was stabilized for rainfall intensities over 70 mm/h. Compared to the number of raindrops esitimated by Marshall and Palmer model, the observed number of raindrops less than 2 mm of the diameter overestimated. Gamma distribution was fitted to the number of raindrops with each raindrop size class, however, over 3 mm for the diameter, the estimated line using by gamma distribution enveloped the observed raindrop number. Therefore, we suggest that gamma distribution model and Marshall and Palmer model could be employed as an upper and a lower limit of the number of raindrops for each raindrop size class over 3 mm for raindrop diameter, respectively.

****

The GPR (ground penetrating radar) use to estimate the annual rate of sediment delivery in small catchments from Obcinele Bucovinei (the Romanian Carpathians)

LESENCIUC C.
UNIVERSITY "ALEXANDRU IOAN CUZA" IASI, IASI, ROMANIA

Among the geomorphological processes characteristic to the Romanian territory, landslides are specific to hilly and mountainous areas. These landslides cause serious changes to both the area where they take place and its surroundings, leading to the formation of natural-dam lakes. Lake Iezer from Obcinele Bucovinei falls into this category, being considered, based on present information, the oldest natural-dam lake from Romania.

The lakes formed by landslides represent local pools for the river deposits. They are relevant to geomorphology but especially for hydrotechnics because anthropic lakes are far more younger than natural lakes and longer deposition times can give a better estimation of sediment delivery.

The lake and the upstream catchment area belong to the flysch area of the Romanian Carpathians, with strong folded sediment layers constituted from glauconitic slates, compacted clays, striped clays and clays with globular-siderite, rocks that are prone to trigger the landslides.

The studies focused on this area have begun in 2009 when the lake and its surrounding area were surveyed with a Leica TCR 1201 total station. Based on these surveys, an extremely-accurate digital elevation model (DEM) was created for the present topography and of the clogged valley-sector upstream of the lake. After this, the GPR surveys aimed to create a carbon-copy DEM of the initial valley, before the formation of Lake Iezer. The overlying of the two DEMs enabled us to estimate the sediment volume deposited in the lake. By dividing the total sediment volume by the accumulation period (1100 years old) and the catchment area (3.71 km^2), it resulted an annual upstream catchment sediment delivery rate (21m^3/km^2/year) that was smaller than the estimated rate for other flysch areas of the Romanian Carpathians.

Soil moisture dynamics of a Muhly grass hillslope seep system

SLATTERY M., LLADO L.
Texas Christian University, FORT WORTH, UNITED STATES

Groundwater seeps are characteristic hydrological and ecological features of many landscapes . While they exist in a variety of environments, their extent and hydrologic characteristics are poorly understood. This study examines the hydrology of seeps dominated by Seep Muhly grass (Muhlenbergia reverchonii) in the Grand Prairie Ecoregion of Texas. The objective of the research is to document and quantify the soil moisture dynamics of a hillslope hollow seep system. We monitored soil water content and matric potential for 16 months along a slope transect within a headwater hillslope hollow containing an upslope Muhly seep. We captured seep dynamics across a wide moisture spectrum, including extreme drought, storms, and snowmelt. In all cases, the Muhly seep wetted first and remained at, or above, field capacity for at least three days following a precipitation event. This is the result of local pedologic/geologic controls: these seeps sit atop fractured limestone underlain by a subsurface clay layer, which results in water percolating to the clay, ponding, and then slowly moving downslope on top of what is, in effect, a mid-slope aquitard. The hydrologic functioning of these seeps has both practical and theoretical ramifications. From a practical standpoint, Muhly seep systems are being considered for delineation as possible wetlands; the timing and extent of saturation of these systems suggests they should be. From a theoretical perspective, the Variable Source Area (VSA) may not be adequate in capturing the full hydrologic complexity of seeps, especially if the seeps are geologically controlled and disconnected hydrologically from the rest of the hillslope.

****

Physic Characterization of Watershed of Reibeirão do Feijão, in the counties of São Carlos, Itirapina and Analandia ' Sao Paulo, Brazil ' as Morphopedology Compartmentation subsidy

CERMINARO A., OLIVEIRA D.D.
UNIVERSIDADE DE SAO PAULO, SAO PAULO, BRAZIL

This study has as aim to study the watershed of Ribeirao do Feijão, localized in east-center of Sao Paulo state where ranges the counties of Sao Carlos, Analândia and Itirapina. The main objective is cartographic and theoretical production to characterization of physical, geological, geomorphological and pedological, which structure the landscape of watershed. The products analyses were operationalized in AecGis 9.2 software developed by ESRI, which were used cartographic bases extracted from the letter SF-23-Y-A-I of IBGE, Sao Carlos grid, scale 1:50000. It is aimed with this production such materials to generate of data and information which enable a morphopedological compartmentalization of this area.

Holistic perspective analyses of the surroundings are related to ecodynamics and ecogeopraphy prepositions and morphopedological compartmentalization methods developed by TRICART e KILLIAN (1979), which were propagated by Castro & Salomão (2000). The interdisciplinary understanding of the factors involved in sculpturing the landscape attempts to uncover the relationship of matter and energy exchange between the different factors that contribute to and define the modeled landscape, which are representing through homogeneous units of their compartments. Therefore, the confection and description of the thematic maps are essential to the understanding of systemic watershed, and also based on the whole idea of environment system developed by Chistofoletti (1999).

Studies of pedo-geomorphological interactions, their dynamics and interpretations should be understood as preliminary studies fundamental to planning, because they may allow notes to land uses, supported by information of nature components seamlessly, synthetically processed and represented in areas homogeneous, allowing better definition of guidelines and actions to be implemented in physical space-territorial.

Holocene sediment dynamics for two small river catchments in Normandy (Western France)

VIEL V., LESPEZ L., DELAHAYE D., LE GOUÉE P.
LETG - Caen - GEOPHEN, CAEN, FRANCE

Geomorphological and palaeoenvironmental research on Holocene sedimentation in the valleys of Normandy provides evidence for long term fluvial system changes related to climate and human activities. In order to evaluate erosion rates evolution and subsequent sedimentation on slopes and the valley bottom, an Holocene sediment budget based on field data have been conducted for two small catchment localized on the sedimentary Paris Basin (NW France). An extensive geomorphological survey was carried out for the Thue (80 km²) and the Mue (100 km²) river catchments. Data from 41 cores and 11 hand auger cross-sections, regularly placed among the valley bottom were used to quantify the alluvial storage and identify the stratigraphy. 18 AMS radiocarbon dating on organic samples from core drilling were used to define the chronology of the alluvial filling. Slope erosion was determined using 230 soil profiles description from auger coring transects within a small sub-catchment (9 km²) and extrapolated to the entire river basin according to a soil erosion model. Results underline an important evolution of sedimentation into the valley bottom moving from tufa and organic remains to a widespread silty deposit (overbank and colluvial material). Quantification of alluvial and colluvial deposits indicate that 90% of eroded sediments are stored in the watershed, preferentially on dry valleys and as alluvial deposits. Available radiocarbon dating on the last organic deposit of the valley bottom dates the onset of silty deposits during the end of the Bronze Age and indicates an increase in sedimentation rate during the Gallo Roman period and Middle Age. Results are discussed in relation with the paleoenvironnemental and archaeological data available at the local and regional scale wich suggest an important complexity slope erosion processes and sediment redistribution into the catchment.

****

The results of ravine erosion monitoring in the territory of Udmurt Respublic

RYSIN I.
Udmurt State University, IZHEVSK, RUSSIAN FEDERATION

In order to study the ravine formation mechanism and recieve some quantative characteristics of their seasonal and annual increase some semystationary observations for the growth of more than 160 ravines at 28 key sections located in different landscape conditions are being conducted from 1978 year. The territory of Udmurt Respublic is located in the east of the Russian Plain in the southern part of the Vyatka-Kama interstream area.

By using the method of bench marks, located along the draine line it is possible to determine the rate of ravine growth. At the majority of the stationaries (93 ravines) observations are carried out once a year (usually July) and at 10 key places (46 ravines) measurements are taken twice a year (in spring and autumn). Since 1993 y. 10 ravines located in the environs of Izhevsk are additionally observed in summer after the heavy rainfalls.

The mean velocity of ravine growth ranges greatly. The maximum index is 123 m/year. The mean velocity of secondary ravine growth (1,4 m/year) exceeds that of the primary ravines (1,1 m/year). Bed ravines washing away loamy, sandy, alluvial and gully deposits have the greatest many-years velocity of growth (2,2 m/year).

In the context of many years about 80% of annual ravine increase is produced by spring water draine. However during the years of extremely heavy rainfall 90-94% of annual ravine growth is noticed at some key-places. The growth of certain ravines may exceed annual norm in tens times.

Field stationary studies gave the opportunity to define the limit indexes of the 12 hour precipitation layer, at which various intensity ravine erosion takes place. When this layer is less than 25 mm there is no growth of ravines at all, when it is more than 55 mm the growth is considerable, but at 70 mm it becomes catastrophic. The intensity and time of heavy rainfall has a great importance at this.

Influence of soil and vegetal cover on hydrological behavior of a forested catchment in a mid mountain environment

SERRANO MUELA P.(1), REGÜÉS D.(1), NADAL-ROMERO E.(2)
(1) Instituto Pirenaico de Ecologia, ZARAGOZA, SPAIN ; (2) Universidad de Zaragoza, ZARAGOZA, SPAIN

The study is developed in the San Salvador forested catchment (0.92 km^2). This work presents a summary of the analysis of the hydrological response and the main factors that favors the hydrological dynamics: soils, which favors infiltration processes and vegetal cover, which influences on interception rates and soil processes and the water table fluctuations (Serrano-Muela, 2012).

The hydrological response of the San Salvador catchment has been studied at annual, monthly and event scale. The most detailed study has demonstrated the influence of antecedent conditions, the characteristics of rainfall and the water table dynamics on the flood generation. At annual scale, three hydrological periods can be observed: humid period, in which most of the stormflow of the year is produces and the events are more significant; dry period, frequently without response; and finally, the transition periods showing important variability of responses.

The interception values observed in the basin are generally high. Throughfall values obtained in the three species confirm the influence of this process and its relation to the type of species and their phenological state.

With respect to the dynamics of groundwater levels, they are characterized by a marked seasonality, showing rapid oscillations, a fact very typical of forest areas. This temporal dynamics revealed an effect on the hydrological response.

The study of soils in the San Salvador catchment had revealed the enormous importance of certain soil properties such as structure, texture and organic matter content. These structures, for example, promote the infiltration of water and this circulation within the subsurface and the subsurface water movement.

Serrano-Muela, M.P. 2012. *Influencia de la cubierta vegetal y las propiedades del suelo en la respuesta hidrológica: generación de escorrentía en una cuenca forestal de la montaña media pirenaica.* Tesis Doctoral Inédita. Universidad de Zaragoza. 317 pp. Zaragoza.

****

Groundwater dynamics in a forests submediterranean environment

SERRANO MUELA P.(1), REGÜÉS D.(2), NADAL-ROMERO E.(3), LANA-RENAULT N.(4)
(1) Instituto Pirenaico de Ecolog_a, ZARAGOZA, SPAIN ; (2) Instituto Pirenaico de Ecologia, ZARAGOZA, SPAIN ; (3) Universidad de Zaragoza, ZARAGOZA, SPAIN ; (4) Universidad de La Rioja, LOGROñO, SPAIN

This work studies groundwater dynamics considering this variable as an indicator of the water content status of a catchment, relating this dynamic to the hydrological response, which allowed us to investigate about the identification of dominant hydrological processes in the forested San Salvador catchment.

The groundwater dynamic in this catchment is characterized by three facts:

i) The marked seasonality between the driest and wettest periods, a pattern also observed in other hydrological variables (rainfall, evaporation, storm-flow generation, interception), as a result of the Mediterranean climatic influence.

ii) The absence of moments in which the water table reaches the surface, indicating that during the study period there were no surface saturation situations. The associated stormflow response occurs without saturation, which is indicating the occurrence of subsurface runoff processes.

iii) The rapidly oscillating of water table levels, both rise and declining. This fact is largely influenced by precipitation events, especially by its magnitude. This difference in behavior is related to forest environments, depending on soil characteristics, which are very permeable due to its high porosity and high infiltration capacity, especially in the shady slope.

The water table dynamics is similar in other forest environments, even in different climatic contexts. This study demonstrates that the presence of vegetal cover is a key factor in the soil development and their hydric properties, even more decisive than other factors (climatic or topographic).

Lahar initiation on small upstream catchments of Merapi volcano during 2012-2013 rainy season

WIBOWO S.B.(1), MAJOR J.J.(2), PIERSON T.C.(2), MOUROT P.(3), HADMOKO D.S.(4), LAVIGNE F.(5)
(1) Université Paris 1 Panthéon-Sorbonne, PARIS, FRANCE ; (2) Cascades Volcano Observatory, USGS, VANCOUVER, UNITED STATES ; (3) Myotis S.A.S, ECHIROLLES, FRANCE ; (4) Research Center for Disaster, YOGYAKARTA, INDONESIA ; (5) Laboratoire de Géographie Physique, MEUDON, FRANCE

Unconsolidated tephra resulted from 2010 centennial eruption of Merapi were deposited on the upstream flank of volcano. Although the materials are not very fresh anymore and vegetations (especially *Pennistum purpureum* and *Acacia decurrens*) have grown fast, lahars still can be generated by rainfall events. The objectives of this study are to compare lahar initiation process on small volcanically disturbed and undisturbed basin. We use 4 – 5 rain gauges installed within the catchment areas. Three meters long weirs are installed at the mouth of each catchment to facilitate flow measurement using load cell and laser stage sensor. Soil moisture sensors are also used to measure the infiltration rate of the catchments. We also measure flow depths at the up and middle channel using pore pressure transducer. Until 10 January 2013, daily observation show that one landslide has occurred within the volcanically disturbed basin roughly 15 m before the weir. Flow magnitude and transported materials on disturbed basin channel are greater than on undisturbed basin channel. However, this would change since *Pennistum purpureum* grows extremely fast during rainy season and may reduce surface runoff on disturbed basin.

Keywords: volcanically disturbed basin, lahar initiation, vegetation

****

Land use in floodplains: a study on the Riparian Buffer in Sub-basin river Ipiranga - River tributary guandu / Brazil

TESTA P.M.C., RODRIGUES BARBOSA D., VIEIRA DE MELLO E., GUNDIM SILVA F., MACEDO RODRIGUES N.
UGF, RIO DE JANEIRO, BRAZIL

According to Brazil (2007), generally, the problem of the flood risk areas in Brazil's cities can be summarized in the following items: economic and social crisis with a long-term solution; housing policy for low-income historically inefficient; ineffectiveness of control systems use and occupation of the soil, lack of legislation adequate for areas susceptible to the risks mentioned, lack of technical support for the populations; popular culture living in lowland areas.

For these reasons, the Riparian buffer demarcations (Based on the standards established by the n° 12.651/2012 federal law and by the n° 650/1983 state law) which are strips of land which coincide with the floodplains around the rivers, lakes, and lagoons fundamental to the ecological equilibrium, offering protection for the waters, lakes and dams and preventing the flow of pollutants into the water systems and avoiding losses of material goods, human casualties caused by floods, and others.

The current work seeks to classify the use of land and delimit the riparian buffer in the Ipiranga water basin, which drains a part of the municipality of Nova Iguaçu, located in the Metropolitan area of Rio de Janeiro. The intersection of the two maps will offer as a result, the spatial analysis of the existing conflicts between the practice of environmental laws and other uses of land identified in the floodplains.

The Ipiranga water basin has an area of 2220 Km2 and it was verified that the Riparian Buffer determined by law is 30 meters (for rivers which are less than 10 meters wide) and 50 meters at the source (according to the forestall code). The uses of soil at the water basin were hierarchically organized as follows: pastures (31,63%), riparian vegetation (30,02%), marshes (17.80%), urban occupation (10,24%), agriculture (9,04%) and exposed soil (1,27%).

Determining catchment-scale connectivity using hysteresis analysis of discharge and suspended sediment

MASSELINK R.(1), KEESSTRA S.(1), GIMÉNEZ R.(2), CASALÍ J.(2), SEEGER M.(3)
(1) Wageningen University, WAGENINGEN, NETHERLANDS ; (2) Public University of Navarra, PAMPLONA, SPAIN ; (3) University of Trier, TRIER, GERMANY

Recent developments in hydrology and geomorphology include the connectivity principle, which describes how different elements in a landscape are connected and how water and matter move between these elements. So far, studies on connectivity have been mainly of a conceptual nature, while studies that quantitatively establish relations in connectivity are rare. In this study we have used discharge/sediment concentration hysteresis analysis as a method to assess the connectivity in a catchment. The analyses were done on 17 years of high quality, high resolution discharge and sediment data from two catchments in Navarre, Spain. These catchments are assumed to have high and low connectivity respectively, enabling the test of hysteresis analysis as a methodology for connectivity assessment. The type of hysteresis was determined for all relevant precipitation events (N>150). In addition, the influence of soil moisture patterns and vegetation state on hysteresis types and therefore connectivity was assessed. Results of the analysis will be compared to several indices for connectivity and catchment complexity.
We hypothesise that for catchments with low connectivity a more clockwise hysteresis will be observed, this is, sediment sources distributed around the catchment will not contribute to the sediment loss. Highly connected catchments will display an anti-clockwise hysteresis, or no hysteresis (linear), which means that sediment sources with higher distance to the outflow may contribute also to the sediment losses of the catchment. We also hypothesize that the type of hysteresis is dependent on the time in the growing season and on soil moisture patterns. Variability in soil moisture and vegetation patterns either connect or disconnect water and sediment sources at different stages through time and therefore generate different hysteresis patterns.

****

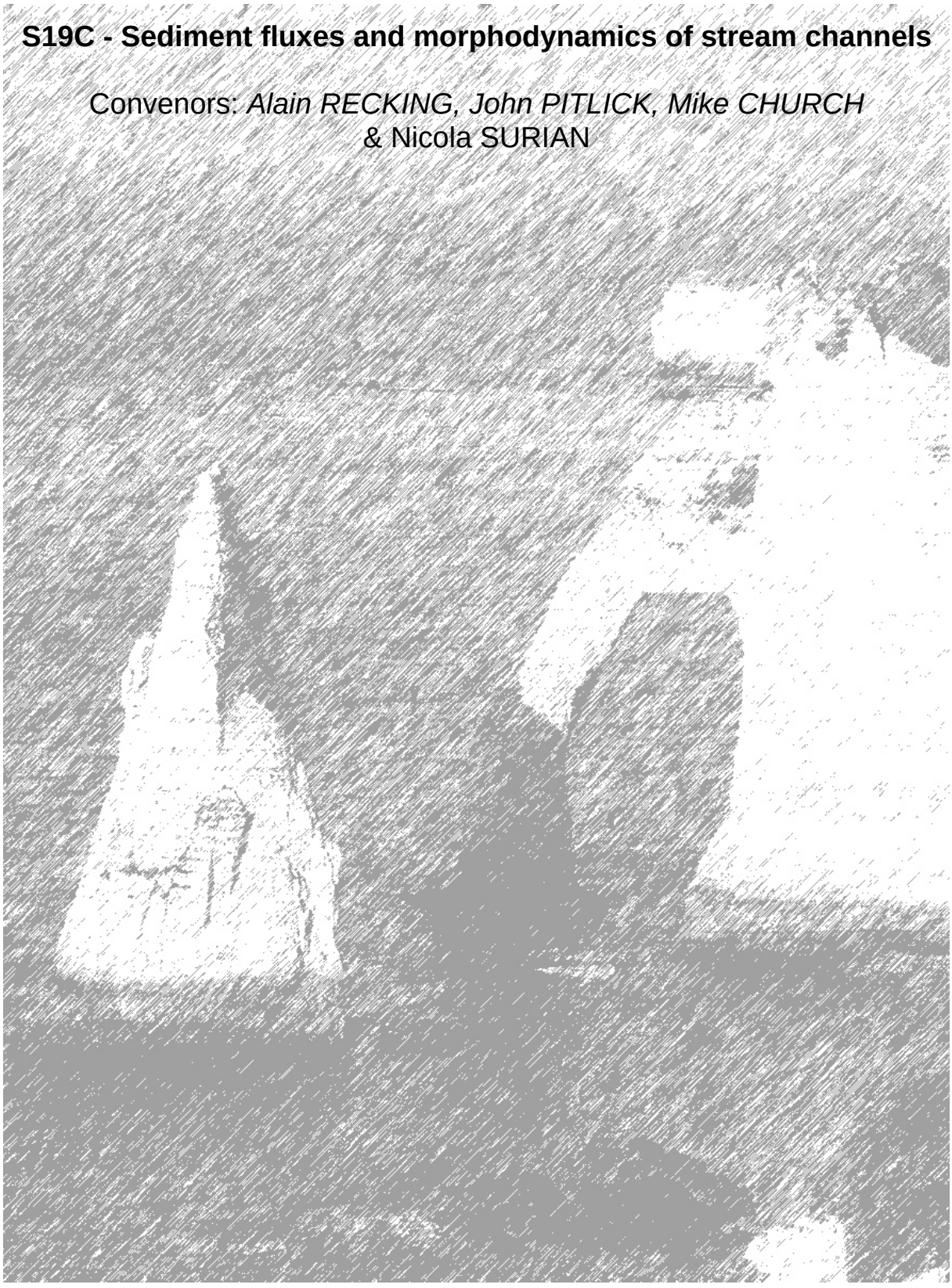
Contemporary functioning of peat catchments on a glaciofluvial fan. Case study: Orawska Basin, Polish Carpathians

LAJCZAK A.
Jan Kochanowski University, Institute of Geography, KIELCE, POLAND

The paper analyzes selected aspects of the functioning of small autochthonous catchments featuring peat bogs found across the Czarny Dunajec glaciofluvial fan in the Orawska Basin, which is located across the northern Tatra Mountain foreland in the Western Carpathians in southern Poland. Consecutive changes in the abiotic environment are discussed relative to increasing human pressure, which has contributed to the gradual transition from meandering channels to braided channels: 1) changes in peat bog extent and volume, 2) changes in the quantity of water permanently stored in peat deposits, 3) changes in groundwater stream recharge, 4) changes in the surface stream network, 5) changes in stream channel morphology. The paper focuses on the last 160 years of catchment evolution. The development of meandering channels common in the study area is determined by the following factors: 1) physical ability to freely meander in an area with clayey parent material covered by peat deposits, 2) significant supply of groundwater to stabilize stream discharge, 3) small channel gradients, 4) large supply of fine sediments. The second factor is the most important of the four factors. The renaturalization of peat bogs started in the 1950s and accelerated in the 1990s and has contributed to an increase in stream sinuosity and a resulting increase in catchment water content. The paper is based on the analysis of maps from the last 230 years as well as aerial photographs, National Hydrological Survey data, extensive field research and laboratory research.

S19C - Sediment fluxes and morphodynamics of stream channels

Convenors: *Alain RECKING, John PITLICK, Mike CHURCH* & Nicola SURIAN



Oral presentations:

Time scale analysis of bedload discharge over steep slopes: from intermittency to white noise

HEYMAN J.(1), METTRA F.(1), MA H.B.(2), ANCEY C.(1)
(1) EPFL - ENAC - LHE, LAUSANNE, SWITZERLAND ; (2) Departement of Hydraulic Engineering, Tsinghua University, BEIJING, CHINA

Bedload transport remains largely unpredictable in steep slope rivers. Comparing experimental data obtained in a steep slope flume and a stochastic model, we show that bedload discharge statistics strongly depend on the measurement time and spatial scale. We base our talk on a flume experiment that resolved 7 orders of magnitude in time (from 10-2s to 105s) of solid discharge. Computing the variance of the mean solid discharge depending on the sampling time, we distinguished three successive time scales: (1) intermittent (2) correlated and (3) white noise limit. The intermittent time scale is the shortest and is characterized by long periods of time without any transport. Then, we observe a correlation time scale that spread over 3 order of magnitude in time. Correlation can result from various phenomena (bedform migration, collective motion...). The largest scale observed corresponds to the white noise limit, and occurred for time scales larger than 103s. To understand better the dynamics involved, we compare these results to a stochastic model that capture the basic dynamics of particles motion. Along a one-dimensional spatial grid, particles can erode, deposit, or be advected by the flow according to a Markov process. In the continuous limit, this process converges to a stochastic partial differential equation (SPDE) of advection-diffusion-reaction for the variable $\rho(x,t)$, the density of moving particles (or particle activity). We theoretically derived the first and second moments of the SPDE, together with the spatio-temporal correlation function. By integration of the later, we show that the three different scaling are well described by our model. We point out that depending on the chosen measurement technique to sample bedload, one can expect different statistical behaviors. Notably, we distinguish between “local” techniques that sample bedload at a given location through time, and “spatial” techniques that sample bedload also in the spatial dimension.

****

From bedform evolution to channel slope fluctuations in steep-slope streams

METTRA F.(1), HEYMAN J.(1), MA H.(2), ANCEY C.(1)
(1) Ecole Polytechnique Fédérale de Lausanne, LAUSANNE, SWITZERLAND ; (2) State Key Laboratory of Hydroscience and Engineering, Tsinghua University, BEIJING, CHINA

In mountain streams, bedload transport rates are prone to strong variability. Indeed an increasing number of laboratory and field studies in steep-slope conditions show fluctuations of bedload transport rate over several temporal and spatial scales. This behavior is even more pronounced for intermediate flow rates (i.e., small but frequent floods). Today, the characteristics and origins of these fluctuations are still poorly understood. One possible explanation of these fluctuations is that the formation and migration of bedforms greatly influence bedload transport.

To accurately investigate bedload transport rates simultaneously with channel bed evolution, we designed an idealized laboratory experiment. A 3-m long, 8-cm wide, transparent flume was used with well-sorted natural gravel (d_{50}=6.5 mm). A technique using accelerometers has been developed to record the arrival time of every particle at the outlet of the flume. An analysis of bedload transport rates on a wide range of time scales is thus possible. In addition, bed elevation is monitored using cameras from the side of the channel.

First, we discuss the presence and the evolution of bedforms (antidunes in this study) for different sediment input rates, flume angles and flow rates. Particularly, in the stationary state, the larger the sediment input rate, the higher the mean migration velocity.

Secondly, keeping steady flow rate and constant sediment input discharge, we observe various migration velocities and fluctuations of global channel slope. This celerity is faster when the channel slope is close to a critical angle. When channel slope is slightly above the angle of no-erosion, the local morphologies evolve slower. This shows that the channel bed behaves like a metastable system and bedform migration seems to be the key mechanism of erosion at the channel scale (like avalanches on a sandpile).

On grain blocking, step formation, sediment transport dynamics and self-organized criticality in steep streams

MOLNAR P., SALETTI M.
ETH Zurich, ZURICH, SWITZERLAND

Steep mountain streams commonly develop a bed morphology which consists of boulders arranged into steps, i.e. channel width-spanning structures which are separated by plunging pools. The step-pool system is a self-organizing and self-sustaining structure. The temporary storage of sediment in steps and the release of that sediment in avalanche-like pulses when steps collapse, leads to a complex nonlinear threshold-driven dynamics in sediment transport. In this paper we explore the notion that the emergent properties of sediment transport and the transient state of the bed morphology in step-pool streams are closely linked, and that the state in which sediment transporting events due to the collapse and rebuilding of steps of all sizes occur is in some aspects analogous to a critical state in self-organized open dissipative dynamical systems. We illustrate these notions with cellular automaton based modeling of grain transport, blocking and release, using spectral analysis, power-law distributions and intermittency statistics of grain counts and sediment transport rates as indicator variables. We compare results of 1 and 2-d models with some data from flume experiments and field observatories. The paper will address the notions of stability and equilibrium, of the attribution of cause and effect, and of the timescales of process and form in step-pool systems.

****

Critical conditions for beginning of coarse sediment transport in headwater channels based in flysch rocks (Moravskoslezské Beskydy Mts., Western Carpathians)

GALIA T., HRADECKý J.
University of Ostrava, Department of Physical geography and geoecology, OSTRAVA, CZECH REPUBLIC

Our contribution summarizes results of incipient of bedload transport research conducted in small headwater streams in region of Moravskoslezské Beskydy Mts. (flysch Western Carpathians). Two methods were applied: flood competence method and marked particle displacement method. The first one presented measuring of diameters of largest boulders (200-400 mm) stored in to fluvial accumulations during Q_{20-25} flood event (5/2010). By contrast, transport of marked cobbles (18-152 mm) was evaluated between 11/2010-7/2011, when some smaller events in local torrents occurred and maximal observed discharge was equal to bankfull stage (Q_1-Q_2). Relationships between grain diameter and critical conditions (unit stream power, unit discharge and bed shear stress) for incipient of motion of bed coarse sediments were developed. Generally, lower critical values for moving of certain grain diameters were derived then they originated from other environments (e.g. Italian Alps or Ands). This may be caused by lower bed armouring or higher sediment supply of relatively smaller particles compared to magnitude of discharges in local evaluated headwater channels. Also there was observed some higher dynamics of sediment transport in pool then in step in step-pool morphology systems during bankfull flows, whereas during lower flows the opposite situation arose.

Evaluating bedload transport in coarse alluvial streams with RFID and motion tracers

LINDSAY O., JOHNSON J.P.L.
The University of Texas at Austin, AUSTIN, UNITED STATES

Bedload monitoring efforts can be challenging because bedload transport only occurs during high flow conditions. We present bedload data that captures both Eulerian and Lagranian transport perspectives based on techniques developed in Reynolds Creek, Idaho, a gauged coarse alluvial stream. To date, we deployed ~1150 Radio Frequency Identification (RFID) tracers and ~170 motion tracers. Our RFID tracers are natural or concrete clasts embedded with RFID tags. Motion tracers are cobbles with RFID tags as well as accelerometers that log ±3 g accelerations along three orthogonal axes (x, y and z) every 10-15 min. Several tracers traveled over 6 km with the majority traveling over 2.5 km. Because a motion tracer provides additional during-flood bedload data, with changes in acceleration indicating movement since its last record, we use these times to constrain total time-in-motion as well as compare tracer movement histories. We gained transport distance information by relocating motion tracers after transport events. With displacement distances and motion timing records, we constrained bedload velocities over several transport events. During floods, we also collected spatial RFID and motion tracer data by installing several stationary RFID antennas that logged times and unique ID numbers as tracers passed. Peaks in tracers passing correspond well with hydrograph peaks and we are evaluating tracer movement relationships to rising and falling limbs of hydrographs. Unique field-based insights acquired from combining RFID and motion tracers with stationary antennas can advance the understanding of bedload transport in coarse alluvial streams environments.

****

Bedload transport monitoring in a small upland catchment

LIEBAULT F.(1), LARONNE J.B.(2), KLOTZ S.(1), JANTZI H.(1), RAVANAT X.(1), FAVARIO J.(1)
(1) Irtsea Grenoble, SAINT-MARTIN-D'HERES, FRANCE ; (2) Ben Gurion University of the Negev, BEER SHEVA, ISRAEL

An automatic Reid-type (or Birkbeck) bedload slot sampler was recently deployed in the Moulin catchment at Draix (ORE Draix-Bléone) to obtain a continuous record of bedload fluxes in extreme conditions of sediment transport. The Draix catchments in the Jurassic black marls of the Southern Prealps of Digne are recognized as very active eroding catchments. Total annual sediment yields measured since the early 1980s reach values of several thousands of t/km²/yr. Suspended sediment concentrations are also very high, reaching values of several hundreds of g/l during spring and summer convective storms. Bedload transport was routinely measured at catchment outlets by topographic surveying of sediment retention basins for almost 30 years. These data only give the total bedload yield integrated over the duration of the event. With the deployment of a bedload slot sampler in the Moulin catchment (drainage area: 9 ha), it is now possible to record bedload flux for a sampling time of 20s. First results obtained with this new equipment gave information about (i) instantaneous bedload fluxes, (ii) bedload responses to hydraulic conditions, (iii) grain size-distribution of bedload, and (iv) the regulation effect of the channel on the bedload response. Maximum recorded instantaneous bedload fluxes are amongst the highest ever reported in the literature. First observations also revealed fluctuating bedload responses to shear stress between seasons, under the effect of changing channel conditions (sediment texture and channel morphology) in the approach reach of the sampler.

Morphodynamic and bedload displacement on a meander loop (Cher River)

DEPRET T.(1), GRANCHER D.(1), GAUTIER E.(2), HOOKE J.(3)
(1) Université Paris 1. LGP CNRS, MEUDON, FRANCE ; (2) Université Paris 8. LGP CNRS, MEUDON, FRANCE ; (3) Liverpool University, LIVERPOOL, UNITED KINGDOM

The aim of the present study is to evaluate precisely bedload displacements in a low-energy meandering river. The migration mechanisms of the Cher River (a Loire River tributary), have been highly constrained for decades because of bank protections.

The morphodynamic functioning of one loop was analysed during 2 years (2010-2011 and 2011-2012) using pit-Tags to measure the bedload displacements. Only the particles larger than D_{50} could be tagged. This method allows us i) to determine the frequency of the bedload mobilization, ii) to estimate the volume carried every year and iii) to reconstitute distances and trajectories of the bedload. Moreover, in order to estimate the efficient discharge during the last 25 years, we used bedload transport formulae (Recking, 2010). This also allowed us to extrapolate the type of transport (partial or total) for discharges higher than bankfull.

Despite of a high frequency of mobilization (between 29 and 87 days each year depending on the location on the loop), the transport is never (or almost never) total. The average and the median distances of transport for both the 2 study years and for the last 25 years can be considered very low because they are systematically lower than the distance between 2 contiguous geomorphological units. Moreover, during the last 25 years, the average and the median distances of transport of the upper half of the particle-size distribution are respectively of 0.35-2.4 km and 0.2-1 km.

Because of the weakness of the current processes, meander loops, and wavelength in particular, largely seem over-sized. The maintaining of these dimensions is interpreted as the direct consequence of bank protections: they have resulted somewhat in a fossilization of the planform pattern.

Bibliography: Recking, A., 2010. 'A comparison between flume and field bedload transport data and consequences for surface based bedload transport prediction', *Water Resources Research 46, 1-16.*

****

Linking process and form using a field data set: issues, challenges and prospects

MARQUIS G.A.(1), ROY A.G.(2)
(1) Université du Québec à Montréal, MONTRÉAL, CANADA ; (2) University of Waterloo, WATERLOO, CANADA

In order to understand landscape evolution and transformation, we need to measure and model the processes that move the material through the forms. However, transport laws that are currently available to predict accurately sediment fluxes are not satisfactory. This is particularly true for bedload sediment transport where multiple factors such as sediment supply or the structure of the particles on the river bed modulate the response. Despite its complexity, bedload transport is continuously investigated as a key process driving changes in river bed morphology. Most of the knowledge on bedload transport was acquired from flume experiments where factors can be controlled and therefore their respective roles determined. However, there are important limitations in the transfer of this knowledge to natural river channels where the interactions of factors may be at play and where unsteady driving forces promote non-linear responses of the system. Bedload sediment transport is difficult to measure *in situ*, especially in gravel-bed rivers where coarse particles interact and move intermittently. Therefore, only a few field studies have collected simultaneous bedload sediment transport and morphological changes over a sequence of several floods. Here, we present such a data set collected for 20 flood events in a small gravel-bed river, Béard Creek (Québec, Canada). The data set is used to explore various issues and challenges on linking process and form measurements obtained in the field: (1) the methods to analyze data collected without experimental control and in a context where contingent conditions may prevail and (2) the scale offset between bedload sediment transport and morphological changes at the scale of a flood event. A detailed analysis of the linkages between bedload fluxes and different aspects of river bed morphology leads us to revisit the conceptual models of gravel-bed river dynamics.

The impact of impoundment on sediment transport and channel bar dynamics on the Brazos River, Texas

SLATTERY M., MELCHIORS M.
Texas Christian University, FORT WORTH, UNITED STATES

Dams typically have significant geomorphic effects downstream, but impacts vary according to size of the river and dam, hydrologic regime, environmental setting, history, and channel morphology, as well as with the purpose and operation of the impoundment. This study examines sediment transport and channel bar response following closure of the De Cordova Bend Dam on the Brazos River near Glen Rose, Texas. We analysed aerial photography spanning two decades preceding and following dam construction, digitizing bar complexes along a reach 53 river kilometers downstream of the dam. We also monitored suspended sediment and bedload transport over a range of flow conditions, and conducted multiple channel bar surveys over one year in order to understand short-term changes within the system. Channel bars remained relatively stable during the two decades preceding impoundment (< 20% variation in bar area) but showed a ~ 40% reduction in area within the first six years following impoundment. Channel bars then recovered to their approximate pre-impoundment extent within 15 years of dam closure. We also observed significant variability over event-time scales, with channel bars losing ~ one-third of their area following large storm events. Mean annual sediment flux totaled 6.48 million tons per annum, with bedload accounting for 24.5% of the overall annual load. We suggest that this reach of the Brazos is in a steady-state with respect to sediment supply and transport capacity, but recognize this as just one of several possible reference states for the system.

****

Morphodynamics of small wadis on the southern slopes of High Atlas Mountains (on the example of upper Dades catchment, Morocco)

ROJAN E.(1), DLUZEWSKI M.(1), KRZEMIEN K.(2), BIEJAT K.(1)
(1) Faculty of Geography and Regional Studies, University of Warsaw, WARSZAWA, POLAND ; (2) Jagiellonian University, Institute of Geography and Spatial Management, Department of Geomorphology, CRACOW, POLAND

The research was carried out in the area of intensive morphodynamic processes caused by high rates of physical weathering and low vegetation density in high mountains of dry climatic zones. The aim of the study was to determine the morphodynamics of main rivers' episodic tributaries within the area of the southern slopes of the High Atlas Mountains. The field research was conducted in three tributary catchments in the lower, middle and upper parts of the upper Dades catchment. The impact of the morphological characteristics of the valleys on the amount of material supplied to the channels was analysed. The shapes of the channels, their erosional and accumulation landforms, the amount of the slope material supplied, were used to identify morphodynamic reaches. In the highest reaches, high amount of material received from the slopes and low river discharge had the biggest impact on morphodynamics, which resulted in low erosion value. Downstream from there, the increased amount of discharge was sufficient to manage with even higher amount of slope material, partly due to considerable channel gradients. These reaches were identified as transitional with erosion dominating over accumulation. The lowest reaches' functioning was typical for multichannel rivers with periodical changes of their shape. These reaches featured a balance of deposition and erosion. Their morphodynamics were driven much less by the supply of slope material than by their morphometry, especially the width and gradient. All three tributary basins included reaches of similar morphodynamic types, but in different proportions. These different compositions were found to have a crucial role in the differentiation of accumulation fans' development. This confirmed a hypothesis that the development of the main river valleys of the High Atlas Mts. was strictly dependent on the denudational and fluvial systems of the tributary catchments.

Revisiting the river bar instability

CHIODI F.(1), ANDREOTTI B.(2), CLAUDIN P.(3)
(1) CNRS - ESPCI - Uni. Paris Diderot, PARIS, FRANCE ; (2) Université Paris Diderot, PARIS, FRANCE ; (3) CNRS, PARIS, FRANCE

The river bar instability is revisited, using a hydrodynamical model based on Reynolds averaged Navier-Stokes equations. The results are contrasted with the standard analysis based on shallow water Saint-Venant equations. We first show that the stability of both transverse modes (ripples) and of small wavelength inclined modes (bars) predicted by the Saint-Venant approach are artefacts of this hydrodynamical approximation. When using a more reliable hydrodynamical model, the dispersion relation does not present any maximum of the growth rate when the sediment transport is assumed to be locally saturated. The analysis therefore reveals the fundamental importance of the relaxation of sediment transport towards equilibrium as it it is responsible for the stabilisation of small wavelength modes. This dynamical mechanism is characterised by the saturation number, defined as the ratio of the saturation length to the water depth L_{sat}/H. This dimensionless number controls the transition from ripples (transverse patterns) at small L_{sat}/H, to bars (inclined patterns) at large L_{sat}/H. At a given value of the saturation number, the instability presents a threshold and a convective-absolute transition, both controlled by the channel aspect ratio β. We have investigated the characteristics of the most unstable mode as a function of the main parameters, L_{sat}/H, β and of a subdominant parameter controlling the relative influence of drag and gravity on sediment transport. As previously found, the transition from alternate bars to multiple bars is mostly controlled by the river aspect ratio. By contrast, in the alternate bar regime (large L_{sat}/H), the selected wavelength does not depend much on β and approximately scales as $H^{2/3}L_{sat}^{1/3}/C$, where C is the Chezy number.

****

Combining Geotechnical and Hydro-Morphological Modelling to Investigate the Dynamics of Meandering Rivers

ROUSSEAU Y.(1), VAN DE WIEL M.(1), BIRON P.(2)
(1) Western University of Canada, LONDON, CANADA ; (2) Concordia University, MONTRÉAL, CANADA

Despite decades of research on the morphological evolution of rivers, the mechanisms by which meandering rivers form and evolve are not well understood. Nonetheless, a common feature of natural and experimental meandering channels is that they develop in vegetated, cohesive soils. Although the effects of cohesion on river bank stability have been assessed over relatively short reaches, it remains uncertain whether the repeated occurrence of smaller bank failures can lead to the formation of a fully-developed meandering planform. Recent improvements in computational power and in the efficiency of bank stability algorithms, combined with expanded knowledge on plant properties and improved access to morphodynamics modelling tools, unlocked the potential to undertake such investigation. This research simulates the development of a meandering river planform through the use of a computational fluid dynamics (CFD) model, namely TELEMAC-2D. The stability of river banks is assessed by a newly developed bank failure module that takes into account translational, rotational and Cantilever slope failure modes. This module is coupled with TELEMAC to simulate lateral channel adjustments along a 9 km reach (~40 channel widths) of a large river (the St. François River, tributary of the St. Lawrence River, Québec) and along a 1.5 km reach (~95 channel widths) of a small semi-alluvial stream (Medway Creek, Ontario). In both cases, detailed bathymetric survey datasets are available to calibrate and validate the model. The modelling results are analyzed in a simple GIS software tool developed for this project to statistically quantify the similarity in predicted flow properties and bathymetries between predicted and measured values. Furthermore, a sensitivity analysis is run to determine the impact of different combinations of river bank and bed properties on the resulting channel bathymetry.

An experimental study of the grain sorting effect on braided pattern

LEDUC P., RECKING A., NAAIM M.
Irstea, SAINT MARTIN D'HERES, FRANCE

Braided rivers are characterized by complex morphologies, with several channels and their dynamics is still poorly understood. A better understanding of braiding depending on the equilibrium state of the river (in equilibrium, erosion or aggradation) is essential for a sustainable river management. We conducted a series of laboratory experiments to study the influence of particle size sorting on braided river morphology.

Two series of experiments were carried out, the first with uniform sediments (0.5 to 1.5 mm with an average diameter of 0.7 mm), and the second with a bimodal distribution consisting of a mixture of coarse and fine sands, ranging from 1.5 mm to 3 mm with a mean diameter of 1.8 mm. Both sands have different color to facilitate visual observations of grain sorting and to measure the spatial distribution of different grain sizes. Hydro-sedimentary conditions were maintained constant in both cases throughout the experiment. Successive bed topographies were measured using the Moiré method. Both sets of experiments showed different mechanisms.

The experience using uniform sediments indicates that bar morphology is controlled by the continuous propagation of sedimentary lobes. The lobe deposit creates various morphological elements including “sedimentary” border and large scour areas. The experience using non-uniform sediments indicate that coarse deposits directly control the direction of flow by locally increasing the bed roughness. Paths taken by the coarse and fine grains are different and depend on the bed roughness. Selective depositions are frequently observed and give to the bed surface a heterogeneous composition. The geometry of the confluence of two active channels depends on the grain size range. Indeed, the depth of the confluence area seems smaller with heterogeneous sediment: coarse sediments are attracted in the pool, limiting thereby erosion. These observations give us keys for understanding fields morphologies and dynamics.

****

Riparian vegetation as a primary control on channel width: results and insights from the laboratory to the field

TAL M.(1), GRAN K.(2)
(1) Aix-Marseille Université, CEREGE UMR 7330, AIX-EN-PROVENCE CEDEX 04, FRANCE ; (2) University of Minnesota Duluth, DULUTH, MINNESOTA, UNITED STATES

Braided rivers are characterized by highly mobile channels that migrate laterally across their braidplain. Riparian vegetation directly opposes this tendency by increasing bank strength and reducing flow velocities. This competition, which can be expressed as a ratio of a biotic timescale to a physical timescale, constitutes a fundamental control on the fraction of the riverbed that will ultimately remain active and the fraction that will become incorporated into the floodplain. From a management perspective, changes in precipitation, vegetation type, and flood control efforts are shifting the balance between lateral mobility and vegetation growth and stabilization on a number of rivers, with implications on a range of issues from sediment transport and flood capacity to the availability and quality of habitat for migratory waterfowl.

Laboratory experiments in which vegetation was added to a braided channel lead to the emergence of a steady-state single-thread channel. The timescale for vegetation to establish versus the timescale for channels to migrate the width of the braidplain was a key control on the bankfull channel width and the extent of vegetation encroachment. The eruption of Mount Pinatubo, Philippines in 1991 filled river valleys with sand and destroyed all vegetation, transforming the once single-thread gravel-bed rivers into braided. As sediment loading from eruptive deposits decreases, vegetation is able to establish in the braidplain and persist through the rainy season. Measurements of physical properties of the reemerging vegetation (root strength, stem diameter and density, etc.) are being combined with measurements of sediment transport, lateral mobility of channels, and aggradation rates in order quantify the competition between channel dynamics and vegetation and predict the future equilibrium form of these rivers.

Effects of bedload input on channel widening in a restored section of the Drau River, Austria

KLOESCH M., TRITTHART M., BLAMAUER B., HABERSACK H.
University of Natural Resources and Life Sciences, Vienna, VIENNA, AUSTRIA

Channel widening became a common measure in Austria for mitigating channel incision, improving ecological integrity and ensuring flood protection. Recent projects aimed to limit the restoration works to removal of bank protection, which enabled self-initiated widening through bank erosion. For now, the restored sections showed the anticipated response to the measures. However, continued construction of hydropower plants may further reduce the bedload input from upstream. This study now aims to test the effects of variations in reach-scale bedload transport on the widening of the restored sections.

In a side-channel of a restored section at the Drau River, widening showed to be associated with the emergence and accretion of bars. During a comprehensive monitoring program a mid-channel bar was observed to accrete during higher discharges and to narrow the branch along the bank, resulting in flow acceleration and subsequent bank erosion. Based on repeated topographic surveys, substrate sampling and measurements of flow velocities and water levels, a two-dimensional sediment transport model was calibrated. Basket sampler measurements conducted 20 km upstream of the restored site delivered a bedload rating curve and defined the bedload input at the upstream boundary of the model. Series of time-lapse images helped determining the onset of fluvial erosion along the bank toe and hydrodynamic-numerical modeling delivered the corresponding flow characteristics leading to bank erosion.

Modelled scenarios with varied bedload input revealed that bank erosion associated with mid-channel bars may be suppressed at reduced bedload input from upstream. Reach-scale bedload transport therefore showed to affect the morphodynamics of restored sections and finally their widening tendencies and overall functionality. Over short time-scale, bank erosion showed to additionally depend on the hydrograph characteristics following the flow events.

****

Experimental sediment reintroduction into the Rhine River downstream the Kembs dam: feedbacks from repeated field measures and high resolution imagery

ARNAUD F.(1), BÉAL D.(1), PIÉGAY H.(1), ROLLET A.J.(2), SCHMITT L.(3)
(1) CNRS UMR 5600 EVS, LYON, FRANCE ; (2) CNRS UMR 6554 GEOPHEN-LETG, CAEN, FRANCE ; (3) CNRS UMR 7362 LIVE, STRASBOURG, FRANCE

The Upper Rhine River has undergone several anthropogenic modifications since the last two centuries for flood protection, navigation and hydropower generation. Channelization, groynes and damming heavily altered the 50 km-long "Old Rhine" by-passed section between Kembs and Breisach inducing channel pattern simplification, bed incision, armouring, ecological alterations. A sediment introduction experiment has been conducted in October 2010 within the framework of the INTERREG project “Redynamization of the Old Rhine”. This project aimed at restoring sediment transport and recreating a variety of ecological habitats to improve the biodiversity of the river reach. For these purposes, 23000 $m^3$of gravel have been injected into the channel forming a 620 m-long and 11 m-wide deposit. A monitoring program investigated the sediment dispersion processes and the improvements in channel morphology and grain size based on three complementary measures: 1) tracking the displacement of 1500 particles equipped with passive integrated transponders to provide knowledge on the mass dispersion and bedload transport rates, 2) surveying bathymetry and topography using DGPS/echosounding and very high spatial resolution imagery to detail changes in bed geometry and sediment wave propagation, 3) sampling the surface grain size of the aquatic channel and emerged gravel bars to characterize the size distribution of the injected sediments excavated from the floodplain and to learn about the sorting effect with the dispersion. Environmental benefits and potential risks for society were evaluated thanks to the four surveys characterized between 2009 and 2013 (initial, post-injection and post-floods approx. Q_2 occurred in December 2010 and June 2012). Feedbacks helped to define large scale and sustainable restoration scenarios in terms of modalities of sediment introduction (quantities, grain size distribution ...) and monitoring program to implement (suitable evaluation indicators).

Relationships between bank protection and forced pool characteristics in a low gradient flood prone river, Central Norway

VATNE G.
Dept. of Geography, Norwegian University of Science and Technology, TRONDHEIM, NORWAY

Forced pools are well-known natural phenomena in mountain streams, and are attributed to constrictions in the stream channel. However, they are not described from many other river environments. A recent detailed survey of the lower reaches (30 km) of the flood prone river Gaula, Central Norway, has revealed a highly variable bed profile, including many pools with residual depth exceeding 5 m. The river ha originally a low gradient (0.001) meandering channel, but the channel is since the 1930's strongly controlled using bank protections schemes. The extensive bank protection is motivated from the many quick clay areas in the adjacent valley, and the many historical quick clay slides that have been triggered by channel migration. Parallel, extensive gravel mining took place from 1950 to 1990s (> 4 mill m^3). This has drastically altered the sediment budget, and has on average lowered the stream bed by 2 m in the investigated reaches, exposing clay along the river bed and banks. Pool characteristics (downstream spacing, volume, exit slope, upstream gradient etc.) have been analysed to test two hypotheses; (1) spacing and location of pools are controlled by the location of bank protections, hence being forced pools, (2) controls of pool characteristics are similar to those found in mountain streams. The analysis shows the majority of the deep pools to be controlled by man-made channel constrictions, but also natural constrictions occur. There is no clear downstream trend in pool characteristics as pool volume is strongly influenced by local channel curvature. Patches of marine clays overlaid by coarse alluvial material is observed in pool beds, suggesting sediment starvation and active pool scouring to continue.

****

Spatial and temporal patterns of channel change and bedload transport of the Wood River, Upper Klamath Basin, USA: implications for assessing river management and restoration

HUGHES M.
Oregon Institute of Technology, KLAMATH FALLS, UNITED STATES

The Wood River in the Upper Klamath Basin of southern Oregon is a spring-fed meandering channel that occupies a north-south sloping graben separating two major volcanic provinces, the Cascade Mountains to the west and the northern Great Basin to the east. Incision and downstream transport of volcaniclastic sediments in the upper watershed has graded the valley floor and emplaced an active meander belt lying approximately 1.0 - 1.5 meters below adjacent surfaces. In the lower valley, the river is channelized, leveed, and perched above lake-fringe wetland systems that were diked, drained, and cleared of native vegetation and converted to cattle pastures in the mid-20^{th} century. River management and restoration projects since the mid-1990's have emphasized naturalization of meander patterns and floodplain reconstruction within the confines of levees that separate the river from the fluviodeltaic wetland systems. Future restoration plans call for reconnecting the river to these wetlands, however several challenges exist, including the relatively large difference in elevation between the channel bed and adjacent wetland floor environments, seasonal backwater effects from Agency Lake near the mouth of the river, and uncertainties regarding sediment transport that would modulate river-wetland reconnection. Early results of an ongoing bedload measurement campaign suggest that in the absence of backwater, the bed is continuously mobile in the lower valley, despite low stream power. Bedload rates range from approximately 0.07 to 0.5 tons per day and generally decrease downstream. Restoration of the lowermost reach appears to have rejuvenated bedload transport, filling a formerly channelized confluence with new bars and vegetated benches. Downstream of this area, diversion of the river into a formerly active deltaic wetland has restored shoal habitats that are now providing substrate for expansion of native vegetation and enhanced wildlife habitat.

Contemporary channel adjustments in a periurban catchment in the frame of a long-term sediment cascade history (Yzeron, City of Lyon, France)

GROSPRETRE L.(1), SCHMITT L.(2), JACOB N.(3), DELILE H.(1), PRIVOLT G.(1), PREUSSER F.(4), COTTET M.(1)
(1) University of Lyon, UMR 5600 CNRS, LYON, FRANCE ; (2) University of Strasbourg, UMR 7362 CNRS, STRASBOURG, FRANCE ; (3) University of Lyon, UMR 5133 CNRS, LYON, FRANCE ; (4) Stockholm University, STOCKHOLM, SWEDEN

The initial goal of the study was to evaluate contemporary geomorphic effects of urbanization in the Yzeron catchment (147 km²). Many incisions were identified in headwater stream channels. Dendrochronological analyses of riparian trees show that most of incisions began between 1970 and 1990,during which urbanization has increased from 15 to 30%. Recentness of incisions is corroborated by stages of channel adjustments, but many of them have beenobserved in the rural as in the periurban part of the catchment. It led us to broaden our approach and seek further explanations in long-term landuse changes. Finally, it appeared that current channels evolutions could not be understood without integrating the long-term sediment cascade history of the catchment.

Extensive croplands have contributed to soil erosion and significant sedimentary fill of the headwatervalley bottomsuntil the end of the 19th century, and likely since the end of the Middle Age. During the 20th century, croplands weremainly replaced by grasslands and forests. It reduced soil erosion, leading to a sediment deficit that disruptschannels stability, so that sediments accumulated during several centuries in headwater valley bottoms are now remobilized and transported downstream. In the periurban belt of Lyon City, grasslands were also replaced by impervious areas and storm sewers after 1950, resulting in greater frequency and intensity of floods. When urbanization extended in a headwater basin after long-term changes in agricultural land use, the latter two disturbances are cumulative and result in severe bed and bank erosion.

Although incisionsextend only over a relatively small part of the hydrographic network (6%), channel enlargement ratios can reach 35 (11,7 on average) and eroded banks are mainly composed of sand (53% on average). Headwater channel incisions are therefore an important source of fine sediment to main channels, in which sand deposits are growing strongly.

****

What Impact Does Urbanisation Have on the Depth of Bedload Sediment in Streams?

ZORRIASATEYN N., STEWARDSON M., VIETZ G., RUTHERFORD I., FLETCHER T.
The University of Melbourne, PARKVILLE, AUSTRALIA

Bedload sediment in streams provides a range of ecosystem services (e.g. instream habitat, nutrient exchange). Urbanisation of a catchment has a significant impact on bedload transport and can upset the balance for retention of bedload sediment. Urbanisation increases the frequency and magnitude of flows that transport coarse-grained bedload sediment, but also affects the sources and amount of sediment reaching streams. The resulting impact on sediment availability is not well understood. This paper examines the impact of urban stormwater flow regimes on the threshold of sediment-carrying capability and the impact this has on the depth of bedload sediment in stream channels. We compare sites across a gradient of urbanisation in the Melbourne region, Australia; a) reference b) peri-urban c) urban and d) urban with stormwater harvesting. For each site a one-dimensional hydraulic model is developed and depth of bedload is modelled as changes to the channel boundary using the deformable bed function and quasi-unsteady flow analysis. Bed level changes are determined for each section based on deformation of the bed boundary. For each flow scenario we demonstrate changes to the stream bed (erosion and deposition) and verify the results against field observations. This study demonstrates that increased urbanisation of a catchment increases sediment transport capacity and decreases bedload sediment depth by 87.4% and 58.6% relatively at the urban sites. Since sediment supply commonly decreases as urbanisation matures, the differences are expected to be even larger than demonstrated. Stormwater harvesting will help mitigate morphologic changes resulting from impervious runoff, however, the feasibility of restoring ecosystems services in urban streams with reduced sediment supply remains open and important question for urban stream management.

Keywords: Urbanisation, Modelling, Bedload depth, Stormwater

Stream incision and sediment wave consecutive to three centuries of timber floating in the Morvan Massif (Central France)

GOB F.(1), JACOB-ROUSSEAU N.(2), LE DREZEN Y.(1), HOUBRECHTS G.(3)
(1) University Paris 1 - Pantheon-Sorbonne, PARIS, FRANCE ; (2) Université Lumière Lyon II, LYON, FRANCE ; (3) University of Liege, LIEGE, BELGIUM

The upper catchment of the Yonne River is nowadays usually considered as having been scarcely impacted by human activity. At the Seine basin scale, the gravel bed streams flowing down the small forested massif of the Morvan are even considered as of high ecological quality. However, this perception of the river changes completely once one looks back to the recent past. Indeed, these streams have been subject to intensive industrial activity for more than 300 years, between the 16th and early 20th centuries, as Paris' need for timber fuel amplified. The Yonne River and all of its tributaries were heavily modified to facilitate the transportation of timber logs towards Paris through floating on the Morvan's dense network of streams and the Yonne's and Seine's main channel. This activity has led to intense modifications of sediment flux still easily observable on the present river morphology, 90 years after the floating activity ended.

Every single stream of the upper Yonne catchment was equipped with small ponds allowing the generation of water releases, flushing the logs downstream. Historical archives allowed the discharges and the frequency of these flushes to be calculated. Artificial floods developing specific stream powers of over 250 W/m² were generated several times per week during wintertime in steep-sided streams that were 4 to 5 m wide. Such energy generated a drastic increase in sediment transport and led to erosion and massive incision of the beds. A few kilometers downstream, when the small tributaries joined the main valley, the Yonne River had a larger bed and gentler slope. Artificial floods were thus less powerful there and sediment transport conformed more to natural conditions. Considering the huge amount of sediment supply from upstream and the slowing down of the sediment flux, the Yonne river bed aggrades. A perched riverbed today lies up to 1.5m higher than the floodplain and may be seen on more than 25 km of the course.

****

Recent morphological evolution of a headwater stream in agricultural context after channelization (Ligoire River, France)

LANDEMAINE V.(1), GAY A.(2), CERDAN O.(2), SALVADOR-BLANES S.(3), RODRIGUES S.(3)
(1) Université de Rouen - BRGM, MONT SAINT AIGNAN, FRANCE ; (2) BRGM, ORLEANS, FRANCE ; (3) Laboratoire GéHCo, TOURS, FRANCE

In France, since the beginning of the 20th century, rural landscapes have been extensively modified by human activities. These practices have resulted in profound sedimentary and morphological alterations (channel bed incision, deposition of fine sediment, bank erosion, etc.), detrimental to the achievement of good status according to the EU Water Framework Directive.

The present study takes place in this context. The main channel (21 km) of the Ligoire small stream was studied. It drains a watershed of 82 km², occupied by nearly 90 % of arable lands.

The objectives of the study were threefold: (1) to quantify the incision and deposition processes since the channelization of the stream (1970), (2) to quantify the deposition rates of fine sediments in the channel, and (3) to explain the spatial distribution of these deposits.

At first, compilation of historical documents allowed the stream original topography reconstruction just after channelization. Then, cross sections and sediment thickness were measured at the same locations.

The results show that over the 1970-2012 period: 60% of the stream was incised on average by -34 cm (- 0.8 cm.yr^{-1}) and the total volume of exported sediment amounts to 16 300 m^3 (390 m^3.yr^{-1}); 40 % of the stream bed rose by +31 cm on average (+0.7 cm.yr^{-1}), the volume of accumulated sediment amounts to 12 400 m^3 (300 m^3.yr^{-1}). These processes of respective incision and sedimentation can be related to the channel topographic evolution over the same period (longitudinal slope, width, etc.).

The volume of rather fine-grained sediments deposited on the bed of the stream channel, measured over the April-May 2012 period, amounted to 12 130 m^3, with an average thickness of 19 cm. The distribution of these sediments is partly influenced by the presence of five water obstacles.

Finally, the methodology developed for this study allows the use of channelization historical documents to quantify stream sediment dynamic over several decades.

The post-glacial evolution of Cordilleran rivers in southwestern British Columbia: timescales, texture and topography

TUNNICLIFFE J.
University of Auckland, School of Environment, AUCKLAND, NEW ZEALAND

The rivers of British Columbia's major Cordilleran valleys have taken thousands of years to re-grade their profiles and adjust their sedimentary character following the close of Pleistocene glaciation. As the rivers incised their considerable glacial valley fills, a heterogeneous mix of material has been recruited to the sediment load, altering the resistance characteristics of the river beds and changing the slope and concavity of their long profiles. We use a 1-d model framework to study the co-evolution of the long profile and longitudinal grain size patterns in a generic river valley model, as well as simulating aspects of the dynamics of some classic paraglacial river valleys of British Columbia. Using reconstructed stratigraphic records of the original glacial valley fills, we employ a surface-based transport model, coupled with a large-scale sediment budget, to examine timescales of (i) bed degradation, (ii) reach storage and turnover, and (iii) development of the post-glacial grain-size fining profile. We further examine factors that influence the final river profile form, such as tributaries, lateral sediment inputs, and storage within sedimentary links. Finally, we evaluate the balance of errors introduced by hydro-climatic reconstructions (e.g. estimates of flood recurrence), channel configuration parameters (sinuosity, cross-section, characteristic planform) and process parameters (abrasion rates, transport formulation, active-layer configuration).

****

Aggradation and incision of the fluvial terraces in response to the change in the river regime and pattern during the Holocene in Gujarat Alluvial Plain, western India

SRIDHAR A.
Department of Geology, The M.S>University of Baroda, VADODARA, INDIA

Aggradation and incision of the fluvial terraces in response to the change in the river regime during Holocene in Gujarat Alluvial Plains, western India

Alpa Sridhar
Department of Geology, Faculty of Science,
M. S. University, Baroda, Vadodara

Fluvial valleys in western India have well-developed terrace systems and exposed sediment records from the upland to the lower reaches in the river basins have been studied in order to understand the process-response relationship of sediment erosion and accumulation to the climate and tectonic pulses. The regime based palaeohydrological and palaeocompetence analyses have been employed to estimate the flow energy and discharge conditions. Gravel terrace from the upland reach provides evidence of braided gravel-bed river that switched to a gravel bed wandering fluvial style during early Holocene; the mid–late Holocene channel form changed from wide, large-amplitude meanders to smaller meanders with decreased width/depth ratio, unit stream power and the bed shear stresses. The discharge estimates indicate similar values to the present day channel, albeit with a higher competence. The results suggest that discharge varied spatially and temporally during Holocene, the incision and aggradation of the sediments was controlled by fluctuations in sediment influx and the river responded to these changes by switching of stream patterns. Whereas the aggradation of the gravel terrace during the early Holocene was controlled by the tectonically induced large sediment influx, the incision that followed was in response to the increased discharge and competence. In the alluvial zone aggradation occurred due to the fluctuating discharge conditions during mid Holocene. The later phase of incision however was possibly independent of the discharge conditions.

Quantifying the influence of landscape connectivity on alluvial sediment flux in the upper Yellow River

NICOLL T., BRIERLEY G.
University of Auckland, AUCKLAND, NEW ZEALAND

Landscape connectivity describes how water and sediment move through and between landscape compartments. The strength of these linkages is a critical determinant of sediment flux at the catchment scale. The upper Yellow River drains an area of approximately 130,000 km^2 within Qinghai province, western China. Within this area, the 235km^2 Garang tributary catchment is a typical example of the major excavation of basin fill sediments triggered by incision along the Yellow River. Landscapes and sediment dynamics vary dramatically within the Garang catchment, from highly disconnected depositional landscapes dominated by broad alluvial plains within the upper catchment (3500-3700m elevation) to the Danxia landscapes of the lower catchment (2200-2400m) that are characterised by high rates of erosion and strong linkages between hillslope sites of sediment generation and the channel network. Sediment volumes within these highly diverse landscapes have been quantified using a combination of field measurement and GIS modelling, creating a generalized field-based sediment budget. This field-based study of sediment dynamics within the Garang catchment is then used to complement and assess a GIS-based examination of landscape connectivity within the entire upper Yellow River basin. This large-scale examination of geomorphometric measures that estimates the degree of landscape connectivity within the upper Yellow River breaks the landscape down into regions by dominant geomorphic process type. The changing importance of various controls on sediment dynamics within these diverse landscapes are examined at the catchment and regional scale.

****

Trends in alluvial channel geometry: an indicator of decadal fluctuations in regional sediment supply and local flood risk

SLATER L.J., SINGER M.B.
University of St Andrews, ST ANDREWS, FIFE, UNITED KINGDOM

Adjustments in alluvial channel geometry over multi-decadal time periods indicate regional changes in sediment supply, but have not yet been investigated systematically over continental scales, for lack of adequate data. Using the recently-available public dataset of USGS stream channel measurements, we applied rigorous filters to evaluate significant trends ($p<0.05$) and variability in stream channel geometry as measured repeatedly in channel cross sections (area, width, and bed elevation), between 1950 and 2012, against land-cover characteristics (e.g., lithology, landcover) and trends ($p<0.05$) in annual streamflow percentiles at the same sites. From these, we identify regional patterns in channel erosion (widening, bed degradation, and area increase) and accretion (narrowing, aggradation and area decrease,) throughout the conterminous United States. We find that while short-term (year-to-year) streamflow sequences drive the magnitude of local changes in channel geometry, long-term trends (channel evolution trajectories) are indicative of regional changes in the sediment balance, which is affected by land use and urbanization. We find that erosional trends are dominant across the continental USA, compared to accretional trends. These decadal trends in channel geometry indicate long-term nonstationarity in basin sediment budgets, with dramatic implications for aquatic habitat and local flood risk, especially under the influence of a changing climate. This work highlights the importance of investigating channel boundaries in combination with trends in flood frequency to clarify the influences of changes in sediment supply and changes in hydrology in increasing/decreasing flood risk.

A simple approach to understand the kinetics of the responses of the river beds to changes in the sediment supply and hydrological regimes at the watershed scale

ALCAYAGA SALDIAS H.(1), BELLEUDY P.(2)
(1) Dept. Civil Engineering, University Diego Portales / UDP, SANTIAGO, CHILE ; (2) Université de Grenoble / Laboratoire d'études d'étude des Transferts en Hydrologie et Environnement, GRENOBLE, FRANCE

Our objective is the assessment of the morphological behaviour of the river network at basin scale in reaction to perturbations of the hydrological regime and of the sediment sources. For such an objective a detailed modelling is not appropriate. On the other hand conceptual models hardly take into account the superposition of effects and the connectivity of the branched system in the watershed.

A simplified model has been built which is based on the use of the flow duration curve and of its integration for the evaluation of the yearly transport capacity of each homogenous river reach. A calculation is made of the yearly transformation of the river characteristics and the consequent sediment volume is conveyed downstream as a consequence of the connectivity of the different reaches.

Under influence of permanent disturbances, the model simulations show that rapid response of the river-bed at the beginning of the relaxation period is followed by a much slower evolution towards a new dynamic equilibrium. This trend in the morphological behavior is coherent with the conceptual ideas and with field observations from the literature. The sensitivity of the dynamic responses to physical parameters included in the hydraulic and sediment transport equations is tested. The model allows also a characterization of the forming discharge for each of the river reaches.

This modelling has been applied for the simulation of the transformations of the Isère river system upstream of the city of Grenoble (drainage area 5700 km²), in response to successive and superposing perturbations of the river during the last 150 years: mainly the channelization of long river reaches, an intense gravel mining which is now stopped, and the development of HP equipment. The model is validated by comparison of its results with actual evolution of the river. It allows some assessment of the relative impacts of the impact of the large HP equipment of the basin compared to the other sources of perturbations.

****

Within-channel levees: a new-recognized fluvial form in the floodplain of a large river (Paraná River, South America)

RAMONELL C.(1), MARCHETTI Z.(2), PEREIRA S.(2)
(1) Facultad de Ing. y Cs. H_dricas - Universidad Nacional del Litoral, SANTA FE, ARGENTINA ; (2) Facultad de Ing. y Cs. H?dricas - Universidad Nacional del Litoral, SANTA FE, ARGENTINA

Bars, islands and benches are the forms classically recognized of intra-channel sedimentation in rivers. We studied intra-channel forms in the Paraná River between the junction with the Paraguay River (27º 17' S) and its mouth (34º 26' S). The floodplain in this reach extends over 32,000 km^2, and is modelled by the Paraná main channel, several major branches (ca. 200 to 500 m-width) and a lot of minor channels. Shifting rates from 1 m/year to 25 m/year were recorded in the branches, and up-to 200 m/year in tracts of the main channel. Bar and island formation, and enlargements and closures of channels are typical processes in the reach.

Inside of paleochannels or in channels with width-reduction tendencies, we found sets of parallel alluvial ridges like to natural levees, but lying below the bankfull levels. We propose the name of "within-channel levees" (WCL) for them, in consideration of their morphology and sedimentology. WCL could attain several km in length, and form ridge and trough reliefs of ca. 1 m, few meters-width. They are straights or curves in planview, sometimes like to scroll bars. Silty sediments are dominant in WCL, which are the prevailing sizes of the wash load in the river.

Inside the active channels the WCL are coupled to hydrophytes; rooted or floating vegetation in the secondary channels could cover significant lengths near the banks. Thus, the origin of the WCL could be related with the trap of suspended sediments by hydrophytes within the channels.

The WCL are conspicuous features in the Paraná River: they were mapped in detail downstream from 32º 04' S, where these forms extend over 3,000 km^2 forming more than 20 % of the fluvial geomorphic units of the area. On the other hand, the WCL are a form by means of river branches adjusts to diminished formative discharges, with siltation of fine sediments not restricted to overbank flows. The WCL recognition expands our interpretations in the analysis of the silty strata of the floodplain.

A comprehensive analysis of bedform evolution on the Rhône River, France

PARROT E.(1), PIÉGAY H.(1), TAL M.(2)
(1) Université de Lyon, CNRS UMR 5600, Environnement Ville et Société (EVS), LYON, FRANCE ; (2) Aix-Marseille Université, CEREGE UMR 7330, AIX-EN-PROVENCE, FRANCE

Over the last 150 years the Rhône River has been heavily altered by human infrastructures along its 512 km length between Lake Geneva and the Mediterranean Sea. The first wave of channel modifications (1860 - 1930) consisted of dikes and groynes designed to narrow the channel and promote incision in order to facilitate navigation. A second period of modifications (1948 - 1986) consisted of construction of canals and dams for hydroelectricity production that bypass large reaches of the original river channel. The sum of these anthropogenic impacts has profoundly disturbed river bedforms and sediment transport conditions along its length.

This study examines the evolution of bedforms in response to these impacts through a comprehensive analysis of recent and historical bathymetric data. Specifically, our focus is on quantifying how mean channel elevation and the shape and frequency of pools and riffles have evolved. We segmented the present-day long profile into 55 homogenous reaches based on qualitative breaks, e.g. dams and tributaries, and quantitative breaks in slope detected statistically using the Hubert test. We then use principal component analysis and cluster analysis to identify groups of reaches with similar bedform properties. Finally, we attempt to explain this spatial organisation through analysis of bed evolution through time in the context of natural and anthropogenic influences. Grainsize and armour index collected along the entire length of the original river channel are used to further shed light on bedform evolution and longitudinal geomorphic pattern.

****

Establishment of a sedimentation monitoring system of irrigation dams in Burkina Faso: The PADI project

HALLOT E.(1), GUYON F.(2), ZANGRE A.(3), DABIRE F.(3), DE THYSEBAERT D.(4), PETIT F.(1)
(1) LHGF - University of Liege, LIEGE, BELGIUM ; (2) APEFE, OUAGADOUGOU, BURKINA FASO ; (3) DGADI - MAH, OUAGADOUGOU, BURKINA FASO ; (4) DCENN - SPW, NAMUR, BELGIUM

Sedimentation in irrigation dams is a natural process which is accelerated by (i) an increase in solid transport as a result of the soil degradation upstream due to poor agricultural practices and deforestation in the basins and (ii) the erosion of the banks aggravated by adverse anthropogenic uses (sand extraction, production of bricks...).

The progressive filling of dams has as effects (i) the decrease in water amounts available for irrigation and other uses of as fishing or livestock, and consequently an increase in conflicts of use, (ii) the degradation of the fragile ecosystems characterizing wetlands. All these effects can produce a negative impact on the living conditions of local populations.

Few studies on sedimentation of dams and streams in Burkina Faso have been conducted so far. However, national-level estimates give a loss of about 2% of their storage capacity each year or a total of at least 100 million cubic meters of water lost per year.

Three pilot small-basins were selected in 3 different areas of the Nakanbe River in order to involve and build up the capacity of a maximum of stakeholders from decentralized structures of the Ministry of Agriculture and Hydraulic.

Research and development activities has been designed to develop knowledge, tools and techniques in order to estimate (i) volumes of sediments deposited in impoundments by cores analysis, (ii) sediment supply from watershed by suspended and bed load sampling and (iii) by spatially distributed soil erosion and sediment delivery model.

Finally, we improve through this project a better planning of land development at local and watershed scale in order to significantly limit sedimentation in the infrastructure.

Evaluation of genetic structure of erosion intensity in river basins according to the analysis of river suspended sediment flux

GUSAROV A.
Kazan Federal University, Institute of Ecology and Geography, KAZAN, RUSSIAN FEDERATION

This paper uses the results of river suspended sediment flux (SSF) analysis to propose a new hydrological method for quantitative estimation of the river bed and drainage basin (sheet erosion, rill and gully erosion) components of total erosion intensity in river basins. The suggested method is based on the establishment of the functional power connection between mean monthly water discharges (WD, *Q(i)*) and suspended sediment fluxes (*r(i)*) calculated for the low-water-discharge phases of a river's hydrological regime in various (on mean annual water discharges) years: $r(i) = a \times [Q(i)^{\mu}]$(where a, μ are some empirical coefficients), and further extrapolation of this connection for other phases of the hydrological regime. Thus, the extrapolation allows us to calculate (in a long-term annual SSF) the proportions of sediments originating in river beds and drainage basins. The proposed method is tested using a long-term (not less than 10 years) series of observations for WD and SSF of 124 chiefly small and midsize rivers of the East-European plain, the Urals, the Eastern Carpathians, the Ciscaucasia and the Caucasus, and Central Asian mountains, containing data on the mean monthly values of WD and SSF. The paper also compares the method with other methods for estimating the components of erosion intensity and SSF.

The preliminary estimation shows that along the whole array of the analyzed basins of plain and mountain rivers the share of river-bed erosion and SSF does not exceed, on average, 8.8±1.6 % with relative minimum of 6.3±2.3 % in the medium-altitude-mountain group of Central Asian basins and with relative maximum of 11.8±3.9 % in the plain river basins.

****

Anomaly suspended sediment loads and channel morphology changes in a Mediterranean catchment: the effects of land cover and land use changes

EGOZI R.
Soil Erosion Research Station, EMEK HEFER, ISRAEL

The relation between suspended sediment concentrations (SSC) and water discharge (Q) is fundamental in sediment transport studies characterizing the natural regime of sediment evacuation from the catchment. It is also known that semi-arid catchment produce relatively higher SSC compare to humid catchments, therefore, it was not surprising to find a good match in SSC-Q relation along Israel rainfall gradient.However, recent measurements of SSC in a Mediterranean catchment at the center of the coastal area of Israel show as high SSC (1,000-10,000 mg/L) as measured in semi-arid catchments with only half the mean annual rainfall amount (550 vs. 240 mm/yr, respectively). A morphological change in the channel network has been observed as well: while some channels have incised and become semi-alluvial channels, other sand-bed channels have been filled to the top with sediments. Land cover and land use changes analysis may provide some explanation to the rapid changes observed in the channel network morphology and sediment transport regime. The results of the study questioning the classic and well accepted channel pattern classifications.

Sediment tracing in the upper Hunter catchment using elemental and mineralogical composition: Implications for catchment-scale suspended sediment (dis)connectivity and management

FRYIRS K., GORE D.
Macquarie University, NORTH RYDE, AUSTRALIA

The (dis)connectivity of longitudinal, lateral and vertical linkages in catchments drives bio-geo-chemical fluxes. Of critical importance is the vertical exchange of water, sediment and nutrients between surface and groundwater systems in the hyporheic zone which is most effective in gravel bed rivers where subsurface flow pathways are created in interstitial space between clasts.

Human activities have impaired the function of this vertical exchange in river channels, but one concern is the influx of fine-grained sediment from upstream sources that clogs the interstices of gravel beds forming a colmation layer. One key aspect of treating this problem is to understand suspended sediment sources and the (dis)connectivity of the catchment sediment cascade. Only then can sources be treated using river rehabilitation techniques that either prevent erosion or promote sediment storage in catchments.

We use a case study from the upper Hunter catchment in Eastern Australia to show how release of alluvial suspended sediment from channel bank erosion sources since European settlement has resulted in the formation of a colmation layer along the upper Hunter River trunk stream at Muswellbrook. We use X-ray fluorescene (XRF) and X-ray diffractometery (XRD) technology to determine the elemental and mineralogical signature of floodplain sediment sources and the colmation layer across this 4200 km^2 catchment. This sediment tracing technique allows us to construct a picture of how suspended sediment flux operates in this system. We place this understanding in context of catchment-scale (dis)connectivity of the sediment cascade by examining the effective catchment area from which these sources are supplied and the effective timescales over which this dynamic is occurring. Understanding the spatial variability in sediment supply is critical for the development of catchment action plans that treat the causes of sediment source and delivery problems rather than just the symptoms.

****

Sediment budget modelling in the northern Great Barrier Reef, Australia; without empirical data ' don't bother!

BROOKS A., SPENCER J., OLLEY J., PIETSCH T., CURWEN G., BOROMBOVITS D., SHELLBERG J.
Griffith University, BRISBANE, AUSTRALIA

The Great Barrier Reef (GBR) World Heritage Area is an international asset under threat from terrestrial runoff, and significant effort has been expended modelling sediment and nutrient export from reef catchments. In this study we test the sediment budget for the Normanby catchment Cape York, Australia; a catchment previous SedNet modelling (based on very few local empirical data) indicated is the 3rd largest contributor of sediment to the GBR. The modelling predicted that 89% of the ~ 1.1Mt annual average suspended sediment output was sourced from hillslope erosion, with 1% from bank erosion and 10% from Gully erosion. Following an extensive data collection program we have established that the upper catchment contributes on average ~1.4Mt/yr of fine sediment to the reef - a similar quantum to previous modelling, but from entirely different sources. The budget is instead dominated by bank erosion in minor alluvial channels (54%); alluvial gully erosion (24%); colluvial gully erosion (13%), primary channel bank erosion (8%) and hillslope erosion (~1%). Sediment storage accounts for ~55% of sediment input (1.27Mt/yr) , of which 424Kt/yr is stored in in-channel benches Sediment tracing using fallout radionuclides confirms the budget is dominated by sub-surface sources (>80%). Geochemical tracing to the receiving bay indicates 46% of benthic sedimentation has a terrestrial source, in contrast to previous estimates of 4%. Of the terrestrial sources, we found that only 18% of the fine sediment is sourced from the upper catchment (i.e. of the ~1.4Mt), with the bulk coming from erosion of the coastal plain/delta (representing an additional ≥ 4Mt/yr not previously considered). The study highlights that without the underpinning of empirical data similar to that used in this study (which we would regard as an absolute minimum), any attempt to model the system is at best, futile, and at worst likely to give completely misleading results and hence management actions.

Poster presentations:

Mechanical and chemical erosion in three basins located in different geomorphologic provinces of Sao Paulo State, Brazil

SARDINHA D.S.(1), CONCEIÇÃO F.T.(2), GODOY L.H.(2)
(1) Alfenas Federal University/UNIFAL ? Science and Technology Institute/ICT, PO?OS DE CALDAS/MG, BRAZIL ; (2) Paulista State University/Unesp ? Geosciences and Exact Sciences Institute/IGCE, RIO CLARO/SP, BRAZIL

The present study compared the mechanical and chemical erosion in the Meio Stream (252.0 km^2), Alto Sorocaba (670.4 km^2) and Jaú River (467.16 km^2) basins located in the Geomorphologic Provinces of: "Depressão Periférica" in the Paraná Basin eastern border; Plateaus and sierras of the East-southeast Atlantic; and Paraná Basin Plateaus, respectively. Total suspended solids (TSS) and total dissolved solids (TDS) concentrations were analyzed by gravimetric method during the dry and rainy seasons over one hydrological year and the outflow calculated in each basin mouth multiplying the water flow velocity by the cross section area of the river channel. The mechanical and chemical annual erosions were calculated using the areas, average weighted concentrations and average outflow for the three basins. The results indicate that mechanical erosion rates were 3.25 t/km^2/year to Meio Stream, 25.40 t/km^2/year for Alto Sorocaba and 14.93 t/km^2/year in Jaú River. The chemical erosion rates were 38.83 t/km^2/year to Meio Stream, 62.55 t/km^2/year for Alto Sorocaba and 21.57 t/km^2/year in Jaú River. The total annual erosion was also calculated, i.e., 11 x 10^3, 59 x 10^3 and 17x 10^3 t/year for the Meio Stream, Alto Sorocaba and Jaú River basins, with approximately 70% of total solids load transported during the rainy summer months. The largest erosion rate was obtained in Alto Sorocaba basin, due to the lithology (phyllites, metabasics and granites) and the greater altimetry variation. In Meio Stream (diabases, sandstones, siltstones and mudstones) and Jaú River (basalts and sedimentary covers), the differences can be explained by the lithology (highest rate of chemical erosion in Meio Stream) and altimetry variation (a higher rate of mechanical erosion in Jaú River). The interaction among rainwater, the atmosphere, rocks and declivity controls the evolution of ground surface and, consequently, the mechanical and chemical denudation velocity on the studied watersheds.

****

Upper Drac River restoration project : restoration of a braided river bed incised in clay substratum through sediment reloading and bed widening

LAVAL F.(1), VENTO O.(1), ESCORIHUELA F.(1), JOUSSE C.(1), KOULINSKI V.(2), BREILH B.(3), MONTANE A.(1)
(1) Bureau d'Etudes BURGEAP, ST MARTIN D HERES, FRANCE ; (2) Bureau d'Etudes ETRM, SEEZ, FRANCE ; (3) Syndicat Mixte de la Communauté Locale de l'Eau du Drac amont (CLEDA), ST BONNET EN CHAMPSAUR, FRANCE

The Drac River restoration project, covering a 3.5 km-long and 1%-sloped stream in the Champsaur valley (French Alps), is based on two geomorphological observations: 1) the whole river bed is subject to a major incision trend (up to 4 m) in clay substratum ; 2) its initial braided fluvial style tends now to a rectilinear one.

This situation is linked to upstream and downstream sediment extractions in the past decades. The last important floods (2006, 2008, 2011) sped up this incision issue: now the river flows directly above clay substratum, leading to a permanent and irreversible incision. The environmental impacts are major: groundwater drop (alluvial forest, wetlands habitat mortality) ; aquatic habitat degradation (coarse armoring, fine sealing, facies homogeneity, lack of spawning areas) ; increasing risks for land uses (treatment plant, diked lake, landslides). Without a remaining ancient upstream weir, the backwards erosion could even propagate upstream.

Beyond ending recent upstream extraction, the project aims at restoring the braided morphology through sediment reloading according to equilibrium profile, bed rewidening and compatible granulometry.

The pre-engineering study successively led to localize substratum altimetry, estimate the reload sediment volume according to objective profiles, analyze available coarse sediment from old terraces and external supply, and finally size the new bed geometry in reference to upper braided streams. The high objective profile, close to the 1913-reference and chosen to avoid substratum contacts, requires to raise a downstream weir, to restore a 80 to 200 m active bed width and to inject a 400 000 m^3 volume. The ecological impacts on forest and river habitats are minimized due to the current degradated situation ; however, ecological measures on protected habitats and species will help fast recovery.

The works are scheduled for the end of 2013 and appear as one of the most ambitious sediment reload projects ever done.

Combining field measurements and flume experiments for analysing fluvial bedload transport and morphodynamics in steep mountain streams

BEYLICH A.A., LAUTE K.
Geological Survey of Norway (NGU), TRONDHEIM, NORWAY

Fluvial bedload transport, temporal storage and channel morphodynamics have high importance for sedimentary budgets of steep catchments and steep mountain streams. In addition, headwater catchments and steep mountain streams can be relevant sediment sources for lowland river systems. Since 2004 extended and interdisciplinary field investigations on fluvial bedload transport and channel morphodynamics using a range of different methods and techniques have been performed in a number of selected stream segments in supply-limited fluvial systems in the inner Nordfjord (Erdalen and Bødalen drainage basins) in western Norway. Field studies in the Erdalen drainage basin (79.5 km^2) and the Bødalen drainage basin (60.1 km^2) have included (i) continuous channel discharge monitoring, (ii) frequently repeated surveys of channel morphometry and granulometric analyses, (iii) different tracer techniques (painted stones, magnetic tracers), (iv) Helley-Smith and other basket measurements, (v) horizontally installed impact sensors, (vi) underwater video filming and (vii) extended biofilm analyses, including also controlled biofilm growing experiments with fixed baskets in selected channels. The field studies have been combined with flume experiments for calibration of field measurements, especially of the measurements that have been carried out with impact sensors. As a key achievement, the entire range of different bedload component grain sizes can be covered by the applied combination of techniques. The flux of bedload material can be quantified and is related to the spatio-temporal variability of sediment supply / availability within the drainage basins and to temporal sediment storage within the channel systems.

****

Islands in a European mountain river: linkages with large wood deposition, flood flows and plant diversity

WYZGA B.(1), MIKUS P.(1), KACZKA R.(2), WALUSIAK E.(1), ZAWIEJSKA J.(3)
(1) Institute of Nature Conservation, Polish Academy of Sciences, KRAKOW, POLAND ; (2) Faculty of Earth Sciences, University of Silesia, SOSNOWIEC, POLAND ; (3) Institute of Geography, Pedagogical University, KRAKOW, POLAND

Long-term observations and recent morphological and botanical surveys conducted in the gravel-bed Czarny Dunajec River, Polish Carpathians, were used to determine the processes and patterns governing initiation and development of vegetated islands and their floristic complexity. Moreover, dendrochronologically estimated years of island inception were compared with the timing and magnitude of flood flows in the period 1970-2011 to infer about controls on the formation and persistence of islands in the river. In the high-energy, braided river, islands originate as a result of deposition of large vegetative particles, mostly large wood, on gravel bars and the associated vegetative regeneration of living wood or the growth of seedlings and saplings in the shelter of wood accumulations. Tree-ring dating of the largest trees growing in particular island zones indicated a predominant upstream island growth in the river. It results from repeated accumulation and subsequent regeneration of living wood on the head of islands and contrasts with progressive downstream island growth in the rivers supplied with large, stable logs of the tree species without the capability to re-sprout. The lack of islands from the years 1982-1996 most likely reflects the removal of relatively young islands by two major floods in the 1990s. After 1997 the occurrence of low to moderate floods facilitated the formation and persistence of islands. The plant inventory demonstrated that species richness increased non-linearly with the increasing age, area and shoreline length of islands. Islands supported more plant species than the riparian forest and attained comparable species richness at an early stage of development. Fast developing, dynamic and supporting rich plant communities, islands contribute highly to the overall floristic complexity of the river corridor and their re-establishment should be viewed as an important factor in the restoration of hydromorphologically degraded mountain rivers.

Geomorphological changes associated with avulsion: a case study of the feshie fan, SCOTLAND

CLARKE L.(1), WERRITTY A.(2)
(1) University of Hull, HULL, UNITED KINGDOM ; (2) University of Dundee, DUNDEE, UNITED KINGDOM

In February 1990 a major flood caused an avulsion on the Feshie fan, resulting in the main channel switching position by 500 metres. The impact and response of fluvial systems to avulsions is a topic of ongoing debate in fluvial geomorphology, and the Feshie fan provides an ideal case study to enhance understanding of fluvial response to an avulsion.

The Feshie catchment drains from the Cairngorms Mountains in the Scottish Highlands yielding, at the confluence of the River Feshie with the River Spey, an active alluvial fan. Investigating contemporary fan processes and the stability of alluvial fans in the northern temperate zone is often hindered by excessively rapid adjustment or large scale engineering. Uniquely the Feshie fan escapes both constraints and, despite some flood control works and land management strategies influencing the vegetation in the area, the fan system is relatively undisturbed and has been designated as a geomorphological Site of Special Scientific Interest (SSSI).

The historical development of the active fan downstream of the current apex is recorded in a series of large-scale maps and aerial photographs, which have been analysed using digital photogrammetry to document the historical evolution of the fan over the last 100 years. These data have been combined with field data, both contemporary and collected immediately following the 1990 avulsion to determine how the morphology and flow conditions on the lower Feshie have responded in the thirty years since the avulsion event.

It was found that the Feshie fan is still active. Preliminary analysis has shown that the position of the main channel has altered continually over the observed period and channel switching and changes in morphology are a characteristic feature of this system. Through reconstruction of the morphology and flow conditions pre- and post-avulsion it is hoped that better understanding can be gained of the processes operating and driving avulsion.

****

River Preservation Project : Evaluating the erosion surface rate of river banks using temporal and spatial analysis on 4 pilot sites of the Lanterne's Basin

LAMBERET T.
BURGEAP, LYON, FRANCE

The analysis of geodynamic activities on the Lanterne river Basin is inscribed in a local will to restore and preserve rivers mobility and biodiversity. For the past five years, a restoration program has been implemented to recover ecological and morphological rivers functionalities, including removal of weirs and riprap (stone embankments) one 4 pilot sites, covering a 15.5 km-long stream in Lanterne Valley (French Vosges Range).

These rivers are characterized by a low slope (0,40 %), a meandering bed and agricultural pressure (pasture, cultivated area), which contributes to the rivers physical alteration (old water mill, stabilization weirs, bank protection). In this specific context, two scenarios of river management have been set: 1) the preservation of weirs and riprap 2) their removal. The aim of the study was to quantify and compare geodynamic, ecologic and hydraulic impacts between the two scenarios at different temporal scales (5, 10 and 20 years from now), and more specifically to estimate erosion rate (m²/year) due to lateral erosion.

The engineering study led to determine annual erosive coefficient of every site by combining different technical methods : diachronic analysis from historical aerial photographs (1949, 1998, 2003, 2008 and 2011), ground investigation (bank erodibility, stream diversity, riparian vegetation, river topography, grain size distribution, riprap deterioration rate), hydraulic modeling, calculation of hydromorphological variable (slope, tractive forces, specific power) and evaluation of mobility potential by construction of geodynamic index (potential sinuosity, meander evolution rate, river amplitude rate).

This exhaustive analysis enables to quantify land surface losses (in m²) and evaluate impacts of every scenario at several temporal scales on water levels and ecologic state.

The results provide an efficient decision support tool notably for land negotiation in order to ensure an effective area for river mobility.

Sediment transport in a small watershed by Agricultural activities in Sao Paulo State, Brazil

SPATTI JR. E.(1), CONCEIÇÃO F.T.(2), PINTO S.D.A.F.(2), PEREIRA L.H.(2)
(1) Paulista State University/Unesp , RIO CLARO, BRAZIL ; (2) Paulista State University/Unesp, RIO CLARO, BRAZIL

The growing demand for geographic space conditioning direct impact on the availability of natural resources, mainly in terms of quantity and quality of water. Thus, it is necessary to consider the processes linked to sediment transport, whose dynamics in a natural system is changed without planning for the occupation of slopes, due to agricultural activities. These anthropogenic influences promote the removal of vegetation and, consequently, increase of erosive processes, which lead to the loss of agricultural lands, reduced soil fertility and productivity, increasing the amount of sediments carried by rivers causing silting of water sources. To evaluate this process, it was performed a monitoring of sediment transport during the period of one year in a small watershed, i.e. Monjolo Grande Stream basin, with 30 km^2 of area and located in São Paulo State, Brazil. Thiswatershed is composed of sandstones, with slopesranging from 20 to 45% and its predominant land use is the sugar cane crops. The sediment transport total in this watershed was obtained through a simplified method of Colby, which is indicated to small watershed covered by sandstones and with small average depth during the dry season. During 2010, with an annual rainfall of about 1480 mm, it was obtained a total of $13{,}735x10^3$ kg of sediment transported from the Monjolo Grande Stream basin. January, with a total rainfall of 520 mm, transported approximately 66% of total sediment carried out of this basin. If the total value obtained for the sediment transport is divided by the areaof the basin, it is possible to estimate a specific sediment transport of $476x10^3$ $kg/km^2/yr$. The results show that the works related to sediment transport in small watershed can be important tools in the study of denudation relief.

****

Experiments and modelling of size segregation in bedload transport

BEL C., RORSMAN K., FREY P.
Irstea, SAINT-MARTIN-D'HERES, FRANCE

Bedload, the larger material that is transported in stream channels, has major consequences, for both environmental sustainability, and flood alleviation. Computing local and even bulk quantities such as the sediment flux in rivers is still challenging. One important reason pertains to the very wide range of grain size leading to size segregation and drastic morphological changes. When the coarser particles of the bed are moving, statistically dynamic void openings permit downward percolation of a large range of grain size, much more than by spontaneous percolation. This process named “kinetic sieving”, has been studied in industrial contexts but rarely in natural sediment transport. We present an experimental study of two-size mixtures of coarse spherical glass beads entrained by a shallow turbulent and supercritical water flow down a steep channel. The particle diameters were 4 and 6mm, the channel width 6.5mm and the slope 10%. The water flow rate and the particle rate were kept constant at the upstream entrance. First only the coarser particle rate was input and adjusted to obtain bed load equilibrium, that is, neither bed degradation nor aggradation over a sufficiently long time. Then a very low rate of smaller particles was introduced to study the evolution of segregating smaller particles. Particle flows were filmed from the side by a high-speed camera. A quasi-continuous region of smaller beads developed under moving and above quasi-immobile coarser beads. The time evolution of segregating smaller beads will be assessed. Normal and streamwise particle velocity and concentration depth profiles will be presented. These experimental results will be compared to existing theoretical models (in particular Gray and Chugunov, 2006).
J.M.N.T. Gray and V.A. Chugunov. Particle-size segregation and diffusive remixing in shallow granular avalanches. *Journal of Fluid Mechanics*, 569:365–398, December 2006.

Development of Basin-Scale Models to Estimate Bed Load Sediment Flux

PITLICK J.(1), RECKING A.(2)
(1) C, C, UNITED STATES ; (2) Irstea, SAINT MARTIN D'HERES, FRANCE

The movement and storage of bed load sediment is of first-order importance in determining the form and function of high-gradient rivers. Unfortunately, measurement programmes designed to sample bed load and quantify fluxes are becoming increasingly rare, thus different approaches are needed to estimate transport rates and annual sediment yields, particularly in areas with high sediment supply. In this talk we will present results from a year-long study to develop basin-scale estimates of bed load sediment fluxes in rivers draining the French western Alps. The study focuses on rivers draining the core of the Ecrins Massif where sediment supply appears to be relatively high. Measurements of channel and bed material properties taken within individual river reaches are being used with a transport relation to model bed load sediment fluxes at channel-forming discharges. An important component of the modeling effort is to evaluate thresholds for incipient motion of bed load in steep channels. Previous research indicates that thresholds for motion are influenced by several factors, including channel slope, relative roughness, and the supply of sand-sized sediment. Our preliminary analysis of data from gravel-bed rivers draining the Ecrins Massif suggests that, at channel-forming discharges, bankfull Shields numbers are much higher than would be predicted using the standard Shields criterion. Corrections for the effects of steep slopes and high relative roughness narrow the difference between bankfull and threshold Shields numbers to some extent, but in many of our study reaches, the shear stress at bankfull discharge is still more than 2 times the threshold for motion. Consequently, we estimate that, in many of our study reaches, width-integrated bed load transport rates at bankfull discharge exceed 100 kg s^{-1}, which is comparable to measured loads in other river systems with very high sediment supply.

****

Lateral channel migration and bank erosion along the Trotus River (Eastern Carpathians)

DUMITRIU D.(1), NICULITA M.(1), OBREJA F.(2)
(1) Alexandru Ioan Cuza University of Iasi, IASI, ROMANIA ; (2) Stefan cel Mare University of Suceava, SUCEAVA, ROMANIA

River bank erosion is a natural geomorphological process specific of river channels. In many countries, including Romania, there was little interest in quantitative measurements of river bank erosion, compared with other processess, although it is a major process responsible for direct feeding the river channels with materials.

This poster presents preliminary results from a larger study focused on river banks as one of the sources of sediments in the Trotus River drainage basin (4,500 km^2). A first step was to identify river reaches subject to bank erosion, which were then classified in two groups depending on prevailing processess that trigger lateral erosion (i.e hydraulic processess and mass movement).

In the second stage, grain size of the river bank materials was analysed as it is known that the effectiveness of erosion depends also on the degree of cohesiveness and particle size of the deposits. With data on the amount of the Trotus River bank erosion and bank material characteristics available, methods and quantification techniques were chosen. Assessment of the bank erosion was made by geomorphological survey, cartographic analysis of different map editions (1896-2010), indirect computing methods and, lately, by using Leica 3D laser scanning techniques for river bank monitoring (laser scanner started in August 2009).

They yielded bank erosion rates varying for different river sectors between 1 and 25 m/yr and bank accretion rates varying between 3 and 12.5 m/yr.

Asynchronicity in floodplain processes. An example from the Dijle catchment, Central Belgium

BROOTHAERTS N., NOTEBAERT B., VERSTRAETEN G.
KU Leuven, LEUVEN, BELGIUM

Major changes in fluvial architectures appear in many Holocene floodplains of Western Europe, under influence of changing catchment properties. Typically, organic and peaty deposits – deposited in a marshy environment during the Early and Middle Holocene – are replaced by minorganic overbank deposits. This domination of minorganic deposits is attributed to an increase in soil erosion due to increasing human impact during the last few millennia. The onset of intense human land use changes is often determined based on a few or one single dating of this transition in fluvial architecture. In this study, the temporal and spatial variability of this transition was studied for two cross sections in the Dijle catchment, located in the Belgian loess belt.

Two study sites were selected: one in a small tributary (13 km² catchment area; floodplain width 90 m) and one in the main trunk valley (760 km²; floodplain width 1020 m), for which the top of the peat layer was dated at several points along a transect perpendicular to the valley axis. Datable material was handpicked for non-aquatous plant remains, and dated using AMS radiocarbon dating. Results for the small tributary show that the end of the peat accumulation is ranging between 376 ±61 and 620 ±40 cal BP (n=6). For the main trunk valley, the top of the peat layer is even more diachronic (ranging from 715 ±24 to 7415 ±56 cal BP; n=15). The results indicate that for the broad lower floodplain, sediment supply starts with low quantities only influencing peat accumulation near the channel, while only later on the distal parts of the floodplain are affected. For the smaller floodplains, the transitions in the floodplain are more abrupt, affecting the entire floodplain width. Overall, the observed asynchronicity in the floodplain transitions shows that the reliability of single-core dating results can be doubted.

****

Sediment transport and morphodynamics of two highly modified rivers: valley management issues and keys for river stakeholders

CHAPUIS M.(1), DUFOUR S.(2), MACVICAR B.(1), ROY A.(1), COUVERT B.(3)
(1) University of Waterloo, WATERLOO, CANADA ; (2) COSTEL, University of Rennes 2, RENNES, FRANCE ; (3) Artelia Group, MARSEILLE, FRANCE

A river system can be highly instable at different spatial and temporal scales. When this instability conflicts with human landscape use, sediment fluxes and morphodynamics issues can be a key factor of river management. We study two highly modified river systems: a large wandering gravel bed river located in the Southern French Alps (Durance River, drainage area 14,000km^2) and a small gravel bed river located in the urbanized area of Toronto, Canada (Wilket Creek, drainage area 15km^2).

Because of a growing human pressure on their valley, both rivers hydrology and morphodynamics has been highly modified in the last 50 years, with increase in flooding risk because of the high lateral and vertical mobility of rivers that conflict with human infrastructures. Despite the difference of scale between these two river systems, we developed a methodology to characterize river mobility in order to give management keys for river stakeholders.

The first step to lead to sustainable river management is to assess the mobility of the fluvial system. To do so, we set up a topographic survey of longitudinal profile and cross-sections. Then we link migration rates with hydrology for the studied periods.

The second step is to lead a diachronic study of migration rates of the river, based on the most relevant orthophotographs of the system. Then we try to link this 'long term' migration rate obtained to the previous 'short term' migration rate.

The third step of our approach is to assess the sediment fluxes that shape the river system. For gravel bed rivers, we monitor the coarse fraction of bed sediments using a RFID tracking of gravels. These surveys give us information concerning distance of transport and travel paths for individual particles for single events. But most of all, we highlight a link between sediment mobility, hydrology and bedforms.

The improved knowledge of river morphodynamics then enables us to give relevant management keys for river stakeholders.

High frequency measurements of suspended sediment particles of the Rhone River, France

ANTONELLI C.(1), ZEBRACKI M.(1), SABATIER D.(2), GAIROARD S.(2), LAUNAY M.(3)
(1) IRSN, SAINT-PAUL-LEZ-DURANCE, FRANCE ; (2) CNRS - CEREGE, AIX-EN-PROVENCE, FRANCE ; (3) IRSTEA, LYON, FRANCE

On the lower Rhone River, suspended sediments are monitored with a high temporal resolution in an observatory largely devoted to contaminant survey. In order to precise contaminants affinities with particles and the role of flood in their transport, grain-size characteristics of the suspended load have to be determined. Recently, a LISST-Streamside has been installed to acquire grain-size distribution with a high temporal resolution. The first step of deployment was devoted to calibrate the apparatus. A LISST-portable and a Beckman Coulter LS 13 320 were used to compare standardized samples and Rhone River samples. During that time, the LISST-Streamside was also used to acquire grain-size analyses in the river.
First results of the inter-comparison tests indicate that:

- Calibration of the LISST-Streamside is coherent with the LISST-portable grain-size analyzer and with the Beckman Coulter used in the lab. Nevertheless, inter-comparison also demonstrate that the finest particles (< 3µm) are overestimated. This overestimation is thought to be due to the limited number of canals of the LISST. Also the optical model of the LISSTs cannot be adapted to the sediment matrix which involves possible bias on the grain size characterization.
- For low level concentrations of suspended sediments, analyses are not well reproducible, that could presume future difficulties to measure particles under low-water conditions,

In the river, we observe that:

- the average median (d_{50}) particle size over the studied period is about 10 µm,
- the correlation between discharge and d_{50} confirm that largest particles are moved for higher discharges. During the only event recorded, sands represented for almost 17% of the total load in suspension,
- the evolution of grain-size distribution is variable at the hourly scale. The effects of flocculation of suspended sediment could explain this variability as demonstrated in the literature but further analyses have to be made to confirm this hypothesis.

****

Interpretation of the fluvial dynamic from Tucum stream/SP, Brazil: sedimentary load balance and transformations of the alluvial forms

VALEZIO É.V., PEREZ FILHO A.
UNICAMP, CAMPINAS, BRAZIL

The fluvial channels express in their typology the integrated dynamic of the physical elements constituents from the system. The relationship between the sedimentary load and its outspread in the fluvial channels configuration is extremely important to understand the processes that there are perpetuated, either for natural order reasons, or anthropogenic order. For analysis and interpretation of the dynamics involved and their answers to changes in relation to the use and occupation of land and in the lithological and pedological costitution of Tucum stream area, located in the city of São Pedro, in the Brazilian state of São Paulo, we used the dynamic equilibrium theory approach proposed by Hack (1960) and the general systems theory, systematized by Bertalanffy around 1930. The results analysis of the sedimentation processes and the increase of the alluvial banks along Tucum stream was performed by collecting water samples at high and low course, as a way of understanding the behavior of the suspended sedimentary load and its outspread in the reconfiguration of the fluvial channel forms. Longitudinal profiles from Tucum stream were also made, based on the topographic letter in scale 1:10.000 (1978) and elaborated *in situ* (2012) via GPS and altimeter. Analysis of the channel changes were performed using not orbital aerial photographs from periods of 1962 and 2000 in approximate scale 1:25.000, providing the interpretation of the processes incidents in it. The results point to increase and insertion of alluvial banks along the medium and low course expressed in the longitudinal profile, also allowing its correlation with the difference between the amount of suspended solids in the sampled areas.

The relationship between wind gaps and histosols in the Atlantic Plateau Paulista, Southeastern Brazil

DE OLIVEIRA D.
Universidade de São Paulo, SÃO PAULO, BRAZIL

The Atlantic Plateau Paulista, in Brazil, is dominated by convex shapes, with deep valleys and high drainage density. The layout of the drainage network depends on several factors, including the geotectonic position of the state, extending over a Precambrian crystalline shield, bathed by the ocean and into the Paleozoic sedimentary basin of the Paraná and the climate factor. The products of erosion were accumulated negative element in the sedimentary basin. Thus, most of the rivers moved inward, to the Paraíba do Sul River or the Parana basin. The Serra da Mantiqueira Hills and Serra do Mar Escarpment led the formation of newer drainage on slopes steeper. Background levels closer and lower arisen due to the post-Cretaceous tectonism in southeastern Atlantic Plateau forced a progressive reversal of parts of the drainages that went into the interior through multiple river captures. In this case, river captures have a relationship with soils, especially Histosols inside the wind gaps. Histosols were found at least in four areas located in Serra do Mar Escarpment and reverse, they are: Paraíba do Sul basin's wind gap, Guaratuba basin's wind gap, Capivari basin's wind gap and Cotia basin's wind gap.
In all these cases, Histosols have an important role in the development of drainage in cases of drainage anomalies and river captures in humid and forested tropical areas.

****

The stream capture process between the rivers Tiete and Paraiba Do Sul in the Atlantic Plateau Paulista: The case of Guararema's Elbow

PASA V., DE OLIVEIRA D.
Universidade de São Paulo, SÃO PAULO, BRAZIL

The Atlantic Ocean formation, as a result of the separation of African and South America continental margins, in the Southeastern region of Brazil, and especially, the Atlantic Plateau Paulista, suffered process of rifting. These formations occur in the margins of the Atlantic Ocean and the result is the intensification of denudational processes, reorganization of the drainage network and greater supply capacity of sediments, giving large sedimentary packages. On the ground, occur abasement and uplift of regional blocks with the formation of elongated and subsidence surfaces, as in the case of the Paraíba valley, between the Serra do Mar Escarpment and Mantiqueira Hills, and more elevated areas, such as the Tietê River. The area understood by these two important rivers is composed of ancient crystalline rocks the Brazilian Cycle, covered by Tertiary sediments, as the São Paulo and Taubaté Sedimentary Basins, of large regional expression, and source material Quaternary. In the region are found predominant faults of direction NE-SW and between the Mesozoic and the Cenozoic, some of these faults were reactivated. In the region of Guararema, the Paraíba do Sul River reversed its direction, as a result of stream capture, getting marked at relief the elbow of capture. Until this period, its drainages flowed its waters at the Tietê River. Are evidences of this connection, as the current structural alignment of drainages, of direction NE-SW, the wind gap and soil type. After the formation of drainage anomaly, one of its branches eroded the watershed and retreated its headwaters to the adjacent drainage, capturing a large part of its tributaries. The soil of the region is the type Histosol, commonly found in environments of paleodrainage, also observed in other anomalies of the Atlantic Plateau Paulista.

Sediment Dynamics and catchment connectivity at the catchment

CROKE J.(1), THOMPSON C.(1), FRYIRS K.(2)
(1) Australian Rivers Institute, BRISBANE, AUSTRALIA ; (2) Macquarie University, SYDNEY, NSW 2109, AUSTRALIA

Although many types of connectivity are defined, overall, there is widespread recognition that the term connectivity in any 'geo-ecological' sense is useful in promoting the interconnection between the morphological components of the landscape and the material fluxes that move across, and through, the drainage basin (Bracken and Croke, 2008). All forms of connectivity are considered relevant to the storage, residency and delivery of sediments and pollutants within a drainage basin. Whilst recent studies have acknowledged the role of connectivity in catchment modelling and landuse management, the lack of field data which actually measures and quantifies it as a process in time and space hinders its widespread adoption as a practical tool in water quality protection and river management. This is especially the case in relation to sediment connectivity.

This paper investigates the dynamics and connectivity of sediment mobilised during an extreme flood event in southeast Queensland during the summer of 2011. The study avails of high-resolution, multi-temporal LiDAR to assess spatial and temporal patterns of sediment movement. Spatial changes in channel capacity exert a major control on downstream patterns of channel to floodplain connectivity. The presence of large macrochannels in particular mid-valley which contain the majority of flood flow for this extreme event limits lateral connectivity with the adjacent floodplain. The delivery of material downstream is not just a function of the spatial arrangement of alluvial landforms such as buffers and barriers, it is also a product of the temporal time frame such landforms are inundated. Some floodplains therefore act as blankets of buffers during frequent flood events whilst others remain redundant and act as barriers except during the most extreme or catastrophic flood events.

****

Intermittent suspension of sand from the bed in the Fraser River

MARQUIS G.A.(1), VENDITTI J.G.(2), CHURCH M.(3), KOSTASCHUK R.A.(2), ATTARD M.E.(2), RENNIE C.D.(4)
(1) Université du Québec à Montréal / Simon Fraser University, MONTRÉAL, CANADA ; (2) Simon Fraser University, BURNABY, CANADA ; (3) University of British Columbia, VANCOUVER, CANADA ; (4) University of Ottawa, OTTAWA, CANADA

In sand-bedded rivers dominated by dune bedforms, bed sediments are entrained into suspension by strong and recurrent vertical turbulent flow structures generated from the interaction between the flow and the dunes. Understanding how these coherent flow structures (CFS) suspend bed material sediment is critical to accurately estimate size-dependent sediment flux, yet most previous work on the link between CFS and suspension dynamics has been qualitative in nature. Here, we examine the linkage between sediment suspension and CFS using high frequency time-series collected in the thalweg of a 12 m deep sand-bedded section of Fraser River at Mission, British Columbia, Canada, during the rising limb of the 2010 freshet. A Laser In-Situ Scattering and Transmissometry (LISST-100) instrument was used to measure the concentration and grain-size distribution of suspended sediment particles 2.5 to 500 microns in diameter at a frequency of 1 Hz. An Acoustic Doppler Velocimeter (ADV) was mounted to the LISST in order to collect simultaneous 3D velocity at a frequency of 32 Hz. The instruments were deployed from an anchored boat to measure at-a-point velocity and sediment concentration over 20 minutes at 5 positions in the water column forming a vertical profile. Analysis reveals that a disproportionate amount of sediment is carried intermittently by CFS and that this effect is grain size dependent. For the smallest grain size, 60 % of the suspended bed material flux occurs during 50 % of the time-series and for the largest grain size, more than 90 % of the flux occurs during 50 % of the time. The increase in flux of the largest sizes is concomitant with slower than average streamwise velocity fluctuations associated with vertical upwelling more than 70 % of the time. These preliminary results quantify the role of CFS play in bed material suspension dynamics and will eventually lead to a more rational understanding of the sand-bedded river morphodynamics.

Effects of human action on the transportation of Tucum Stream Channel in Sao Pedro, Brazil

PEREZ FILHO A.(1), VALEZIO E.V.(2), CARPI JUNIOR S.(2)
(1) Department of Geography, Geosciencies Institute, State University of Campinas (Unicamp), CAMPINAS, BRAZIL ; (2) UNICAMP, CAMPINAS - SP, BRAZIL

River channels are essential part in understanding the dynamics of terrestrial relief sculpting, with its typology resulting directly from the processes present in the hydrographic basin. Such transformations occur along the time of nature through climatic and tectonic changes, and along the time of man by human activities. The dynamism observed by geomorphological processes in areas with hot and humid tropical climate has enhanced characteristics in soils that are susceptible to erosion. As these soils receive a considerable rain load, they present a series of erosive forms, such as ridges, ravines and gullies, especially when inappropriately used and occupied.
In the case of Tucum stream basin in São Pedro, Brazil, the anthropic variable appears as a catalyst of the linear erosion, which, despite having a natural genesis, has been intensified by badly implemented actions by the municipal administration. Taking into account the systemic approach to support discussions, we used aerial photographs, bibliographic and cartographic materials, field work to collect data and observations, as a way to analyze and interpret the changes occurred in the basin over the past 50 years. The significant variations in the longitudinal profile of Tucum stream in recent decades has demonstrated that it is finding a new phase of dynamic balance, mainly influenced by erosion processes located upstream.

****

Event-scale sediment fluxes and morphodynamics of a semi-arid river: the influence of climate drivers and human actions in the Lower Santa Clara River, California, USA

DOWNS P.(1), DUSTERHOFF S.(2)
(1) Plymouth University, PLYMOUTH, UNITED KINGDOM ; (2) Stillwater Sciences, BERKELEY, UNITED STATES

The present-day morphodynamics of the 4,200 km^2 lower Santa Clara River in southern California is influenced by very high rates of sediment supply from the Western Transverse Range mountains, highly episodic rainfall produced by an ENSO-influenced semi-arid climate, and various human activities over historical time. Available sediment gauging records and an unusual frequency of topographic survey over the last 80 years makes it possible to reconstruct channel morphology evolution over recent decades as a response to a number of discrete high flow events. Such reconstruction reinforces the importance in semi-arid environments of large flow events with return periods well in excess of bankfull recurrence interval and statistically in excess of the 3–8 year return frequency associated with ENSO. However, the high flow event-channel morphodynamic relationship is not simple and depends also upon other factors including human activities such as embankment construction, tributary dam building and instream aggregate mining, the relative magnitude of tributary discharges generated during individual storm events, and antecedent conditions wherein the greatest morphological impact generally occurs in response to two large flood events in a single winter, such as occurred in 1969 and 2005. Reach-scale sediment budgets of the observed fluxes and morphodynamic response are used to illustrate these various aspects, focussing attention on the challenges inherent to defining a distinct Anthropocene fluvial response under conditions of changing climate, and of planning sustainable management responses.

The changes in riverbed plant cover in two rivers upstream the dam reservoir. A case study of the Czorsztyn Reservoir in southern Poland

LIRO M.
Jagiellonian Univeristy in Krakow, KRAKOW, POLAND

Riverbed vegetation plays a key role in the erosion and sedimentation processes in a river channel, as it modifies the direction of channel form development. To determine an effect of a dam reservoir backwater on vegetation on the channel form I used the GIS to analyse a set of aerial photographs taken in 2002 and 2009 year after construction of the Czorsztyn Reservoir (CR) in 1997 for two courses of the Dunajec and Białka rivers that flow into the reservoir. Dunajec is a sinuos, single channel river, while Białka has a braided channel. The maximum water stage variations in the CR reach 19.24m. During the highest water levels in the reservoir, the Dunajec and Białka riverbeds are flooded with reservoir water up to 1500m and 400m upstream of the reservoir. In this study the variations in plant cover within these reaches are compared with those of the control reaches remaining beyond the reservoir influences. In the period 2002-2009 the plant cover of the channel forms of Dunajec increased from 46% to 71% within the backwater zone and in both years was above two times larger than that of the control reach were was 20% and 31%, accordingly. In that period the vegetation expansion rate was 1.5 times higher within the backwater zone than that of the control. In that period the plant cover of the channel forms of Białka within the backwater zone remained almost unchanged and reached 14% and 16%, respectively. In the control reach the channel plant cover was also constant but was two times larger in the years under study and reached 30%. The higher rates of vegetation expansion on the Dunajec riverbed within the backwater zone was caused by deposition of fine-grained sediments and channel pattern and dynamics that promote plant development on the channel forms. Vegetation begins from the river mouth zone, where fine-grained sediments deposit most often and runs upstream. On the Białka riverbed such tendency is not observed because of different channel pattern and dynamics.

****

Analysis of the relationship between the dynamics of saturated areas and sediment transport in a basin in Southern Brazil

REDIN VESTENA L.(1), KOBIYAMA M.(2)
(1) Universidade Estadual do Centro_Oeste, GUARAPUAVA, BRAZIL ; (2) Universidade Federal de Santa Catarina, FLORIANÓPOLIS, BRAZIL

The objective of the present work was to analyze the expansion and retraction dynamics of the saturated areas and the fluvial sediment transport in the Caeté River catchment in Alfredo Wagner city, Santa Catarina State, Brazil. The relation between the water discharge and the suspended sediment (SS) concentration were analyzed with the hourly hydrosedimentological data obtained at the automatic stations and by field measurements. By applying the TOPMODEL the sediment delivery ratio of the catchment was estimated and the fluvial solid discharge was related with the saturated areas. The mean values of the total solid discharge and the sediment delivery ratio (SDR), calculated from August 2004 to January of 2008 were 54,257.9 t/year and 4.23%, respectively, with significant annual variations. The months that presented larger SDR were not equal to those presented larger values of soil loss. In the Caeté River catchment, it was verified an intense hydrosedimentological dynamics characterized with a potentially fragile area to the action of the erosive processes, with high mobility of sediments, and with significant deposition amounts on the valleys bottoms and on the slopes ruptures. The TOPMODEL presented satisfactory performance of calibration and validation. The relationship between discharge and SS concentration has the behavior type “eight figure” where the SS concentration peak precedes the discharge peak with the presence of more than one peak for event. The simulated saturated-areas in relation to the total catchment area varied from 3.30% to 13.63%. The correlation of saturated areas with SS discharge and with total solid discharge is stronger than that with SS concentration. It is therefore conclude that the expansion and retraction dynamics of the saturated areas influences on the amount of transported sediment along the river, being constituted in important sediment-source area, because they are directly connected to the river course.

Theoretical and methodical basis of study of granulometry as an indicator of formation conditions of modern and ancient alluvial deposits

GILYAZOV A.
KAZAN (VOLGA REGION) FEDERAL UNIVERSITY, KAZAN, RUSSIAN FEDERATION

Modern geomorphology increasingly uses quantitative tools that allow making objective comparisons and conclusions. One group of such methods is associated with morphometric study of sediments. It includes granulometric, morphometric and textural analysis of the material in order to determination of its origins, the conditions of transport and accumulation, the intensity and direction of the various exogenous processes.

Granulometric analysis for determination of conditions of sediment formation (especially alluvial) is being developed for a relatively long time. But so far, there are only very general ideas that explain the variability in the size of transported and accumulated alluvial particles.

Granulometric features of alluvial deposits and river sediments are influenced by many factors. Importance of these factors varies: in different natural and anthropogenic conditions some of them are the leading factors that determine the appearance of the main features of granulometric of river sediments and alluvial deposits, and others create more subtle variations of these basic features. Investigations on similar subjects were only made at the local level. They considered only the individual factors affecting the granulometric of the alluvial material.

As part of this paper the posed problem is resolved on new level. Extensive quantitative data on granulometric of contemporary river sediments and ancient alluvial deposits in the former USSR have been summarized, mathematical-statistical model of size variability of river sediments and alluvial deposits as a function of landscape-climatic, lithological, orographic, and anthropogenic factors has been proposed.

The solution of this problem has palaeogeographical significance. Knowing the impact of various factors on the formation of granulometry of modern river sediments and floodplains, it is possible to reconstruct formation conditions of ancient alluvium.

****

The fluvial dynamic influences on evolution of the relief in the Pomba River Depression, Southeastern Brazil

OLIVEIRA L., MAGALHÃES JÚNIOR A.
Universidade Federal de Minas Gerais, BELO HORIZONTE, BRAZIL

Located on the east region of Minas Gerais State, Southeastern Brazil, the upper Pomba River basin presents differences regarding the morphology, despite similar climate, lithology, and free of a recognized structural control. This suggests a decisive role of the fluvial processes on the genesis of two distinct morphological compartments: the Pomba River Depression and the Campos das Vertentes Plateau. Aiming to test this hypotheses, it was made the investigation, characterization, interpretation and dating by Optical Stimulated Luminescence (OSL) method of old fluvial sediments on the main valleys which drain both morphological compartments. The datingalso showed that recently (less than 4,000 years), watercourses belonging to the Pomba River basin have captured channels situated at the Campos das Vertentes Plateau and belongingto the Doce River basin. These processes may be responsible for incorporation of Campos das Vertentes Plateau areas to the Pomba River basin, causing the retreat of the hydrographic divider, and contributing to retreat processes of the front escarpment. The recent incision of the upper watercourses suggests a continuing advancement of the Pomba River Depression on the Campos das Vertentes Plateau. Regionally, the fluvial geomorphology is marked by the occurrence of alluvial levels ~25 m above the present rivers on the valleys near the Serra da Mantiqueira scarp. It could be indicative that the depression expansion was refrained by the small rates of the front slope retreat, at least since the deposition of this fluvial level. The depression evolution towards the upper Pomba River basin may occur at bigger rates, what is suggested by the longitudinal profile of the main channel and by the propension of the upper basin to have its tributaries captured by the tributaries of the medium basin.

Geomorphological analysis of longitudinal profiles of the river valleys in the Northern Hemisphere

SATDAROV A.
Kazan (Volga Region) Federal University, KAZAN, RUSSIAN FEDERATION

The formation of the longitudinal profile of the river valley is an important issue of dynamic geomorphology. The longitudinal profile of the river is a very sensitive indicator of changes in the geographical environment. It is important to analyze the shape in various climatic and landscape conditions. Thus, the subject is to construct longitudinal profiles in different areas of the Northern Hemisphere and geomorphological analysis of their shape. Changes in the environment in the best way reflect the plain, zonal rivers of the middle length. Plotting of longitudinal profiles of the rivers is based on topographic maps, and digital elevation models.

Longitudinal profiles of the rivers can be classified according to various criteria. In our research the main criteria is a shape of longitudinal profile. Profiles are divided into 5 types: concave, convex, straight, stepped, complex (combination of different types).

Deformation of longitudinal profiles depends on many factors. These factors include: water flow, sediment flux, the rock composition, relief, tectonic movement, vegetation, and human activities. Best effect of these factors is shown in the lower reaches of the rivers. Statistical calculations make it possible to quantify the impact of given factors. The results of the research show that the greatest influence on the shape of the longitudinal profile and on its slopes have water flow and sediment flux, and the lowest – agricultural human activity.

Curvilinear correlation coefficient between water flow and the weight average of slope of the lower reaches of rivers is 0.73. The relationship between the sediment flux and the weight average of slope of the lower reaches of rivers is expressed quite clearly too. Curvilinear correlation coefficient is 0.60. Longitudinal profile changes slowly, and intensive human activities are not very affected its.

****

Experimental assessment of the effectiveness of sediment transport estimates from morphological changes

BERTOLDI W.(1), GARCIA LUGO G.A.(2)
(1) University of Trento, TRENTO, ITALY ; (2) School of Geography, Queen Mary University of London, LONDON, UNITED KINGDOM

We present preliminary results from a set of experiments conducted in the Hydraulic Laboratory, University of Trento. The experiments were aimed at modelling morphological dynamics and sediment transport processes in gravel-bed rivers characterised by different channel patterns. The investigation was carried out in a flume filled with uniform size sand (d50 equal to 1 mm) scraped at a 1% longitudinal slope, where we changed the width of the channel (ranging from 0.15 to 1.5 m) and the water discharge (1.5 to 2.5 l/s). The set of runs covered different morphologies: narrow, flat bed channels, migrating alternate bars, transitional / wandering systems, and multichannel, braided networks. We monitored the experiments through continuous measurements of the sediment transport rate at the downstream end of the flume and with a high accuracy laser survey of the bed topography (on a point grid of 0.005 by 0.05 m). Two subsequent surveys were conducted for each experiment in order to estimate scour and deposition volume and spatial pattern.

The coupled measurements of bedload flux and morphological change allow the assessment of the effectiveness of sediment transport estimates from morphological budgeting, as well as the effect of different morphologies. In particular, the investigation will highlight the proportion of bed load flux not involved in morphological changes. Furthermore, the analysis will relate the spatial variability of scour/deposition sequences with the temporal fluctuations of the instantaneous transport rate.

Hydrological impacts of floods in SE Spain, September 2012

KIRKBY M.(1), HOOKE J.(2), SMITH M.(1), BARBERA G.(3), GARCIA-PINTADO J.(4), BRACKEN L.(5)
(1) University of Leeds, LEEDS, UNITED KINGDOM ; (2) University of Liverpool, LIVERPOOL, UNITED KINGDOM ; (3) CSIC-CEBAS, MURCIA, SPAIN ; (4) University of Reading, READING, UNITED KINGDOM ; (5) University of Durham, DURHAM, UNITED KINGDOM

The recent floods in SE Spain have been the most severe since the well documented floods of 1973, associated with a daily rainfall in excess of 250mm. Detailed rainfall records in the Nogalte catchment from 1997-2007 showed a maximum daily rain of 120 mm, although this was not sufficient to cause widespread flow within the main river. Using rainfall radar, it has been possible to observe the pattern of storm movement and timing with much greater precision than in the past. Combining these data with detailed fieldwork on infiltration variability within the Nogalte, detailed modelling of overland flow dynamics, and a distributed post-flood survey to reconstruct peak flows across the catchment, it has been possible to identify the areas which produced the greatest runoff and hypothesise the timing of flood generation across the catchment. Results are compared to a analysis of small scale flooding that occurred in 1997. This allows us to evaluate the significance of remedial measures such as check dams, and changes in land use, notably an increasing area planted to almonds, on the generation of the flood, with implications for future practice.

****

Man activity affecting the river (dis)continuum system in the Moravskoslezské Beskydy Mts. and their forefield

SKARPICH V., HRADECKY J., DUSEK R.
Department of Physical Geography and Geoecology, Faculty of Science, University of Ostrava, OSTRAVA, CZECH REPUBLIC

Rivers draining the Czech part of the Flysch Carpathians have been deeply incised over the last 100 years. Regional geological settings predispose to large sediments supply in to the river systems. In case of the sediment deficit, river channels in the weak flysch bedrock are affected by high rates of incision. Focusing on the incision processes and causes affecting the sediment supply and transport through the river system, we studied the contemporary changes in the Morávka, Ostravice and Olše River basins. The highest rate of incision in the study area was recorded in the Morávka River basin – ca. 16 cm per year in the last 40-50 years. Mean value of incision in the Ostravice River basin is ca. 3.2 cm per year and ca. 1.2 cm per year in the Olše River basin. Main causes of the incision were identified as (i) decrease in sediment supply to the channels (related to the land use and land cover changes in the study area and to the man-made channel bank stabilizations, affecting the lateral connectivity in river system) and (ii) high number of barriers (dams or weirs), influencing the sediment transport through the river system in longitudinal direction. Present incision processes are accelerated by the synergy of the local geological conditions and increase in transport capacity of the rivers caused by channel narrowing and channelization.

Channel adjustments in a large gravel-bed river (Tagliamento River, Italy): what's the role of different sediment sources?

SURIAN N., ZILIANI L.
University of Padua, PADOVA, ITALY

The general aim of this study is to explain channel adjustments and controlling factors in a large gravel-bed river. As for controlling factors, the aim is to assess the role of those acting at catchment and reach scales and then, more specifically, the role of upstream sediment sources (i.e. catchment area) versus local sediment sources (i.e. bank erosion). The Tagliamento River is large gravel-bed river in northeastern Italy; in the study reach, 49 km long, the morphology varies from braided to single-thread. Traditional methods for studying historical channel changes (i.e. use of aerial photos, topographic data, field surveys) were coupled with numerical modeling (use of CAESAR cellular model).

River channel underwent three main phases of adjustment over the last 200 years. The first two phases were characterized by narrowing (channel width decreased from 1250 to 540 m) and incision (about 1 m); the third phase, from the 1990s to present day, by widening (from 540 to 600 m) and slight aggradation (about 0.2 m). As for controlling factors, we argue that the long-term channel evolution of the Tagliamento River was driven primarily by human intervention at reach scale (i.e., sediment mining and channelization). Changes in sediment supply in the catchment area had no, or minor, effects in the study reach, though sediment connectivity is very high in this fluvial system. Sediment supply from bank erosion turned out to be a key factor of the most recent channel evolution. This case study shows that over relatively short time periods (i.e. decades) local sediment sources (i.e. bank erosion) can have a major role on channel processes, greater than upstream sediment sources. These conclusions are notable for making prediction on future channel evolution as well as for river management.

****

Influence of bottom vegetation on sediment transport and morphodynamics

LE BOUTEILLER C., VENDITTI J.
Simon Fraser University, VANCOUVER, CANADA

Vegetation growing on the bottom of a stream is a common feature in many rivers. It interacts both with the water flow and with sediment transport. As a result, local morphodynamics are modified.

In order to investigate the effect of bottom vegetation on sediment transport, we perform a series of experiments in a 12-meter long and 1-meter wide flume. Flexible vegetation, made of plastic blades, is attached on the bed over a 6-meter long section. The sediment used for the experiment is fine sand with a D50 of 0.15mm. Water and sediment are recirculated through the system. Low and high plant densities are used. For each flow, the experiment is run until a morphodynamic equilibrium can be defined.

Results show that the plant patch with a low density has little effect on the sediment transport. On the other hand, the sediment transport capacity is reduced in the high-density patch. This results first in deposition at the entrance of the plant patch. An equilibrium configuration allowing a uniform sediment flux in the flume is finally reached by an adjustment of the be, with an increase of the bed slope in the plant patch.

We then partition the bottom shear stress in the vegetated section. The total stress is the sum of a form drag component, due to the bedforms and the vegetation, and of a skin friction component, which is the only component responsible for entraining sediment. As the vegetation density increases, the vegetation-induced form drag increases while the skin friction component decreases. That’s why a higher slope is needed to accommodate a given sediment flux when vegetation is present.

Such findings indicate how morphodynamics react to changes in the vegetation coverage of a channel bottom. They will also be helpful to improve current 2D-morphodynamic models, which do not take into account properly the influence of bottom vegetation on sediment fluxes.

Sediment transfer assessment in Macaé River, Rio de Janeiro, Brazil

AMADEU P., CABRAL J., LUCAS C., MÕNICA M.
Universidade Federal do Rio de Janeiro, RIO DE JANEIRO, BRAZIL

The knowledge of interaction of man within the landscape and the evolution of landscape has made increasingly part of the discussions in the environmental sciences, because of the growing concern over the conditions of natural environments, requiring further studies hydrosedimentological and on connectivity of landscapes. The research was done in the Macaé river, northern state of Rio de Janeiro, characterized by different fluvial environments but is largely rectified in the areas of lowland and in the higher parts there are strong influences of the activities of agriculture, industry and tourism.The aims to assessment transfer of fluvial sediments, in the longitudinal dimension of the channel.The methodology of the study was based on analysis of load and suspended sediments collected in field work between the 5-year (October 2007 to October 2012), with analysis in the laboratory to the load sediments and suspended sediment. The analysis of hydrological data of rainfall and fluvial discharge was sourced from the site HIDROWEB, ANA (National Water Agency). Furthermore, were used images of Google Earth (1:10.000) for the 2003, 2006 and 2010 years to the sectorization of fluvial environments. The Macaé river has four fluvial environments with distinct behaviors of sediments transfer and can be characterized as partially connected. The most sediment retention tends to concentrate in the medium course of the river, with presence of sandy depositional features (lateral, longitudinal, submerged) due geomorphological conditions of the area, as sinuosity, slope, providing small transport coarse sediment, except in extreme events. The understanding of the relationship between environments can be a indicator of possible imbalances in the internal system as well as the consequences of the changes introduced in the environmental system, are needed for studies involving better ways of planning and management for the watershed.

****

Quantifying fluvial sediment transport in a mountain catchment in Upper Styria (Austria) using sediment impact sensors

SASS O.(1), STANGL J.(2), SCHNEIDER J.(3), HARB G.(3)
(1) Institut f_r Geographie und Raumforschung, GRAZ, AUSTRIA ; (2) Institut f?r Geographie und Raumforschung, GRAZ, AUSTRIA ; (3) Institut fuer Wasserbau, GRAZ, AUSTRIA

Sediment transport in river systems is a recurrent problem for geomorphological sediment budget studies, natural hazard assessment and river engineering. However, bedload measurements at alpine torrents are rare; in Styria, they are altogether missing. Due to a catastrophic flooding event in 2011, we chose the catchment of the Schöttlbach in the upper Mur river valley as our study area. In the framework of the ClimCatch project, we aim to develop a conceptual model of coupled and decoupled sediment routing to quantify the most prominent sediment fluxes and sediment sinks, combining geomorphological and river engineering techniques. Diachronous Airborne and Terrestrial Laser Scans provide an overview of mass fluxes on the slopes and in the channels whileground-penetrating radar and 2D-surveys aim at quantifying the volume of temporary sediment stores. The total output of the catchment is quantified by means of repeated surveys of a sediment retention basin at the outlet.
Besides sediment sinks and total sediment output, sediment transport in the torrents is of particular interest. We use sediment impact sensors (SIS) which were installed in several river sections in the main stretch of the Schöttlbach and in its tributaries. The SIS consist of an acceleration sensor installed underneath a steel plate mounted in the riverbed. The number of clast impacts is recorded in a nearby logger-case. Our measurements focus on the representative sub-catchments and deliver values on the in- and output of river sections. Tests and calibration have been carried out in an artificial channel at the Water Engineering laboratory of the TU Graz; the sensors are sensitive enough to record impacts of particles > 5 mm. The SIS were installed in winter 2012/13; further calibrations are currently carried out in the field using mobile basket samplers. First results allow us to derive the start of sediment transport in dependence of precipitation and runoff.

Dynamic of sediments monitoring by terrestrial laserscanner, application to quantify sediment yield of four torrents in French Alps

BERTHET J., ASTRADE L., JAILLET S., PLOYON E.
Edytem, LE BOURGET DU LAC, FRANCE

High resolution topography modeling by terrestrial laserscan (TLS) is becoming a commonly used tool in fluvial geomorphology. The main goal of this method is to make diachronic comparisons, then quantify accurately sediment dynamic or survey changing channel morphology of a delimited river section. The general aims of our research are to get thesediment budgets of four torrents in the French Alps (Creusaz and Arveyron d'Argentière, in Mont-Blanc massif, Glacière in Chartreuse massif and Lampe in Vercors massif), to attempt to extrapolate results to quantify sediment yield in order to have a better understanding of the coupling processes between channels and hillslopes. We have tried to acquire one or two topographic models foreach year. Reaches studied are between 150 and 400 meters long and 5 and 40 meters wide. Sediment transport can be proceeded by debris flows (Lampe and Glacière) or bedload (Creusaz and Arveyron). Torrents may also be held by dikes and checks dams or still be a natural stream. Thus, diversity of environmental requirement is an important parameter which will influence data quality.

Results differ depending on which torrent is studied. Concerning Lampe torrent, where the topographic follow up began in 2004, the diachronic comparison of models shows outstanding movement of debris flows. Sediment yield is relatively easy to understand. Concerning Mont-Blanc massif, the first TLS model is three years old. We have also included in our results other previous data as GPS or aerial LIDAR topographic models. On these latter torrents, channel changing is more complex and the interpretation of theresults has to involve the importance of sediment management. Almost each autumn, between 50cm to 1m of gravels is extracted on the downstream of the Creusaz reach. But as the floor level is the same at the beginning ofeach summer, before flood events, we can estimate and compare the volume of sediment deposits.

****

Suspended Sediment Yield in a Subtropical Watershed

OLIVEIRA F., HAAK L.
Federal University of Parana, CURITIBA, BRAZIL

The study aimed to analyze the variation of suspended sediment yield at different points of the 88 km long Cubatão River and its main tributary, located in Santa Catarina State, southern Brazil. The 490 km^2 watershed is composed mainly by three different environments: the coastal plain, the scarps of the Serra do Mar mountain range and the Atlantic Plateau, with an altitude variation of 1,500 m. The diversity of structural and morphological features has strong influence in the rain distribution pattern, in the vegetation distribution and organization of the drainage network. Those conditions, on its turn, influence river dynamics which reflects on discharge and suspended sediment yield patterns. Discharge, turbidity and suspended sediment concentration were monitored monthly over a period of five years at three different points along the Cubatão River, located in the plateau (point 1), at base of the escarpments (point 2) and at the border of the coastal plain (point 3), as well as at one point in its main tributary located just before their confluence (point 4). Results indicate a clear distinct hydrological and hydrossedimentological behavior within the watershed, with substantially different suspended sediment yield patterns. Suspended sediment concentration may proportionally decrease or increase with discharge variation at the different monitoring points. On the other hand, general suspended sediment yield per unit area decreases from the plateau to the coastal plain despite the increase of drainage area and number of tributaries. Differences in suspended sediment concentrations at the monitoring points can be related not only to relief structure and pluviometric distribution, but also to land use characteristics.

Sediment transport by tidal river management

KEESSTRA S.(1), VAN MINNEN J.(1), DE DIE L.(1), KHAN S.A.(2), WESTER F.(1)
(1) Wageningen University, WAGENINGEN, NETHERLANDS ; (2) Bangladesh University of Engineering and Technology, DAHKA, BANGLADESH

Bangladesh forms part of the largest fluvio-deltaic system in the world, the Ganges-Brahmaputra-Meghna delta. The delta receives sediment from both rivers draining the Himalayas and from the sea with tidal rivers as transporters. In this study we focused on the sediment dynamics by tidal river management in a tidal river in the south west delta between Khulna and Jessore.

In this complex system, the sediment dynamics are dependent on three major factors: (1) tidal range, (2) the area to which the water can flow to, and (3) the sediment load of the water. In addition there are factors changing over longer time spans that influence the sediment dynamics, the height of the low and high tide both at regular days and during spring and neap tide; and the strong seasonality in rainfall due to the monsoonal character of the climate. After the coastal embankment project which separated the river from the flood plains, the river channel silted up due to decreased flow velocity of the water. The river bed became higher than the elevation of the adjacent low-lying lands, locally called *beels*. This caused serious drainage problems in the area due to higher drainage basis of the rivers.

To create a higher flow velocity with the intention to erode the deposited material in the river channels, a group of farmers decided to cut the embankment and open one of the *beels* along the tidal river, thereby creating a so-called *tidal basin*. This paper analyses whether this works in terms of lowering the drainage basis and providing a better livelihood for the people living in the polders or surrounding the *beels*. We have looked at the sediment dynamics both in the tidal basin and the tidal river up and downstream of the tidal basin. In the tidal basin we assessed which parameters influence the sedimentation and how the sediment was distributed in the tidal basin; and how this variable sedimentation might influence the redevelopment of the area when the tidal basin will be silted up.

****

Analysis of the flow of suspended sediments from the behavior of the variation of water stain in the region of the confluence of the Negro and Solimoes-Amazonas Rivers, Amazonia, Brazil

PIMENTEL MARINHO T.(1), FILIZOLA N.(1), SANTOS A.L.(2), NASCIMENTO A.(1), JEAN-MICHEL M.(3), COCHNEAU G.(4)
(1) Universidade Federal do Amazonas, MANAUS-AM, BRAZIL ; (2) SERVIÇO GEOLÓGICO DO BRASIL/CPRM, MANAUS-AM, BRAZIL ; (3) INSTITUT DE RECHERCHE POUR LE DEVELOPPEMENT/IRD, TOULOUSE, FRANCE ; (4) INSTITUT DE RECHERCHE POUR LE DEVELOPPEMENT/IRD, BRASÍLIA-DF, BRAZIL

This work contributes to spatial hydrology studies and is presented here as an alternative to monitor the concentrations of suspended sediments in the Amazon Basin. The analyses focus on the study of the phenomenon of the confluence of the Negro River (black water) and the Solimões-Amazonas River (white water). For the analyses we used images from the Terra and Aqua satellites, MODIS sensor, which presents significant advantages in terms of temporal resolution in relation to other sensors used for studies of Amazonian rivers (NOVO et al, 2007; MARTINEZ et al 2009, ESPINOZA et al 2009). In the region of confluence, we observed the variability of the river´s own section along the length (difference in length between the black and white water portions). This was done in a predetermined area in order to asses both the dimensions of the mixing zone and the variability of suspended sediment concentration. This assessment was conducted by studying an area at the end of the confluence near Itacoatiara town, where one of the clippings of the MODIS Project ORE-HYBAM is (www.ore-hybam.org). This clipping contains a series of spatial data for the period 2000 to 2012. The section was divided into three masks representing black water, white water and the mixing zone. The images were treated and processed using specific software (GETMODIS and MOD3R), developed for the BRO-HYBAM Project. The initial results obtained from the correlation between the data of infrared reflectance of the two rivers and the given quota of the Manaus station show the existent relationships between a strong suspended sediment load from the Solimões-Amazonas River and the very low load of the Negro River. These relationships have very important annual variability that visually mark the hydraulic dam effect existent in this area. (MEADE et al., 1991 and STERNBERG, 1998).

Geomorphic analysis of the ephemeral stream distributary systems of the Kobo basin (northern Ethiopia)

BILLI P.(1), CIAMPALINI R.(2)
(1) Dipartimento di Scienze della Terra, FERRARA, ITALY ; (2) INRA, US InfoSol, ORLEANS, FRANCE

Drylands cover one-third of the Earth's surface Zekai, 2008) and about half of the countries in the world must deal with arid and semi-arid conditions and water supply problems (UNESCO, 1977). Ephemeral streams are a distinctive feature of drylands and are distinguished by high flow variability, as they are dry for most of the year but subjected to sporadic and intense flash floods in response to localized, heavy rainstorms (Knighton and Nanson, 1997). These extreme hydrological conditions provide ephemeral streams with peculiar channel morphology, dynamics and sediment transport processes (Tooth, 2000).

This study deals with the geomorphic features of the ephemeral streams ofthe Kobo basin (Wollo, Ethiopia), that is a typical, recentstructural basin associated with the development of the Danakil branch of the Ethiopian rift. All the ephemeral streams, but one, draining the basin margins end up in the basin floor where they form large distributary systems.Aim of this study is to investigate the control on the geomorphic parameters and geometry of these distributary systems by their catchment characteristics such as area, slope, drainage density, slope gradient and length, hierarchizationand the channel feeder main characteristics such as width, gradient and streambed sediment. The results show that the coupling of the geomorphic features of the upstream portion of the river system and the geometry of the distributary system providesan efficient network for describing the development of ephemeral streams, their distributary systems and their channel dynamics. This study shed some light on poorly known geomorphic agents like ephemeral streams and gets an insight into crucial information for a more efficient land management and flash floods effects mitigation.

Fianally, the geomorphic features of the distributary systems of the Kobo basin ephemeral streams are compared with those observed on Mars to test the hydrologic origin of the latter.

****

Reach-scale morphological changes of a braided river following a 15-year flood with multidate airborne LiDAR

LALLIAS-TACON S.(1), LIEBAULT F.(1), PIEGAY H.(2)
(1) Irstea, SAINT-MARTIN-D'HERES, FRANCE ; (2) University of Lyon, CNRS-UMR 5600, LYON, FRANCE

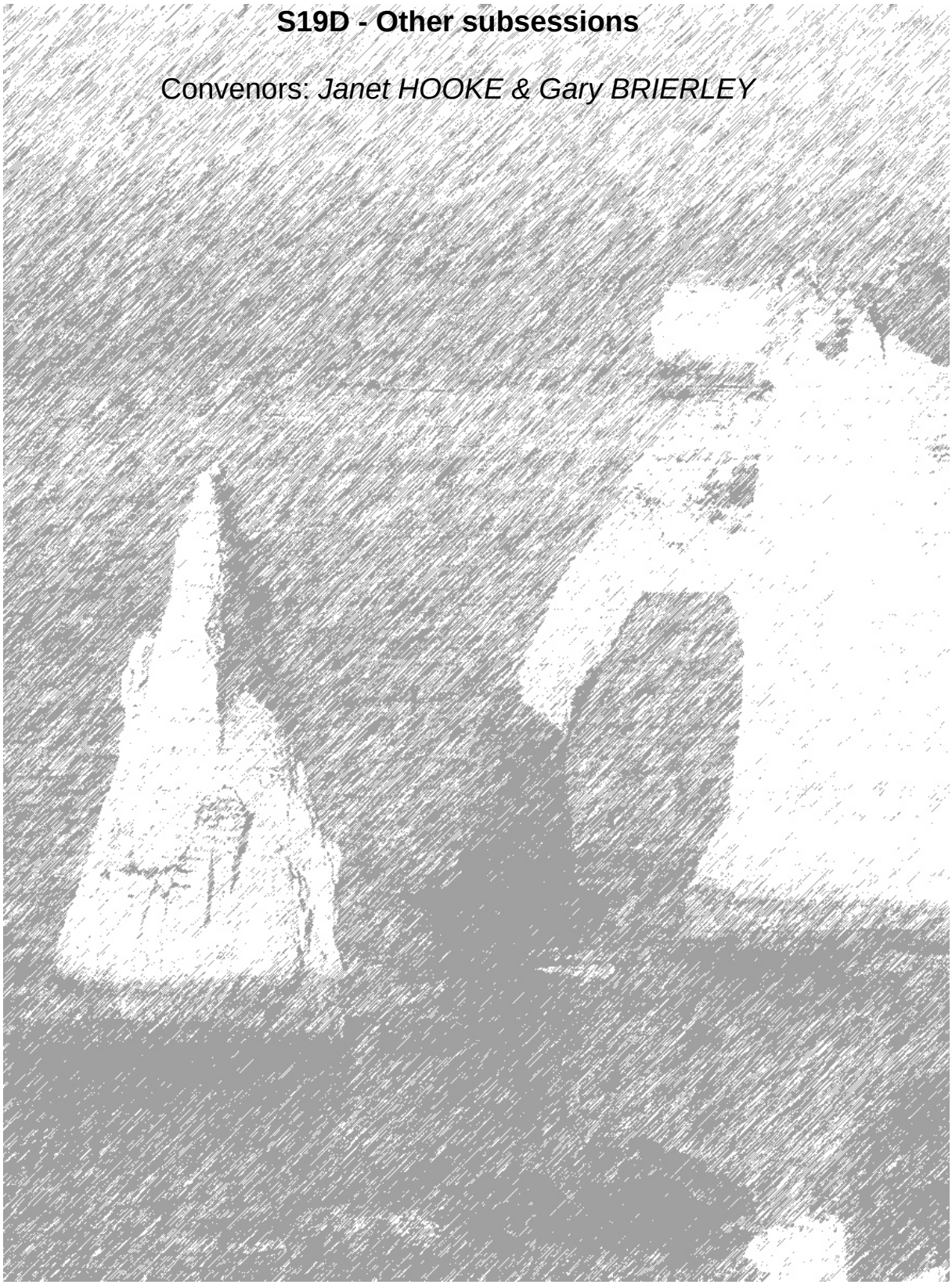
In this study, multidate airborne LiDAR surveys were used to reconstruct reach-scale morphological changes of a gravel-bed braided river following a channel-forming flood event. LiDAR surveys covered a 7-km reach of the Bès River, a very active aggrading braided channel in the Southern French Prealps. The site was surveyed in October 2008 and April 2010. Between these two dates, a 15-year flood occurred in December 2009, with a peakflow discharge of 171 m3 s-1.

LiDAR data processing shows that the two LiDAR surveys were not correctly merged altimetrically and planimetrically. The re-alignment of the two LiDAR surveys was done by selecting stable surfaces. Spatially distributed error in DEM of difference was accounted with dGPS field measurements by sampling different types of terrains, i.e. road, fine and coarse exposed gravel bars, sparse and dense vegetated areas, and alluvial forest. Elevation comparison shows that LiDAR-derived elevations of 2010 overestimate systematically dGPS elevation measures of about 7 cm on the road. This systematic error as well as the standard deviation increase with surfaces complexity, i.e. increase of vegetation density and surface slope. For each combination of terrain, a critical threshold error of morphological change was calculated.

The scour and fill map provided by the calculation of the elevation differences done after correction between the two DEM shows that the Bès River underwent significant morphological changes during the December 2009 flood, e.g bank erosion, channel scour and fill. Fill occurred on surfaces characterized by low relative elevations in 2008. Two types of scour are characterized: bank erosion and bar sculpting. Scour/fill sequences are clearly observable along the streamwise direction, showing a longitudinal periodic signal of sediment budget due to alternating sequences of erosion-deposition. A Fast Fourier Transform gives a period of 665 m, which represents 5 times the mean active channel width.

S19D - Other subsessions

Convenors: *Janet HOOKE & Gary BRIERLEY*



Oral presentations:

A philosophy of rivers

NANSON G.(1), HUANG H.Q.(2)
(1) Univeristy of Wollongong, WOLLONGONG, AUSTRALIA ; (2) Cinese Academy of Sciences, BEIJING, CHINA

Underlying the study of fluvial geomorphology has been the desire to understand the fundamental behaviour of rivers and hence predict their adjustment for purposes of management. Resolving the physical laws governing forces and motions has been prevented by a lack of mathematical closure, hence variational approaches have been adopted whereby assumptions are made regarding possible optimum operating states (extremal hypotheses). However, until recently there has been no logical basis to justify selecting any one of these. By a mathematical 'sleight of hand', the channel form ratio (w/d) has reduced the number of variables and merged Newtonian and variational approaches, showing that rivers are controlled by the *least action principle*. Alluvial rivers evolve teleomatically and iteratively via various forms of *dynamic equilibrium* towards progressively more stable states, *stationary equilibrium* being the most stable and the ultimate attractor. In rivers this is 'survival of the most stable', comparable to biological evolution's 'survival of the fittest'. In clean water this ultimate state occurs at Froude No 1; in rivers transporting bedload it occurs at H No 0.3. Correcting earlier versions of the Meyer-Peter Müller bedload equation with the H number, and using field data from the Yangtze River, we show this large river adjusts its channel morphology to *maximum flow efficiency* (transporting its imposed bedload with the least amount of power). This approach greatly expands an understanding of the dynamics of rivers and shows them to be controlled by least action. This for the first time provides a simple means of quantitatively measuring and defining a river's equilibrium state. It opens the way for predicting channel adjustment and river management in different environmental settings and shows why rivers are rarely straight but adopt various dynamic forms from steep step-pools to gentle anastomosing systems.

****

Bedload dynamics in gravel bed rivers

PETIT F., HALLOT E., PEETERS A., LEVECQ Y., HOUBRECHTS G.
University of Liege, LIEGE, BELGIUM

The aim of this research was threefold: 1) to improve the values of bedload mobilisation discharge in gravel bed rivers, 2) to determine the bedload velocity over the short and long term and 3) to quantify bedload transport and to examine bedload discharge in relation to the stream power and to the excess stream power.

Since 2006, we used the PIT-tag technique in order to mark pebbles from Ardennian rivers. Ten rivers of different geomorphological properties were fitted out with PIT-tags (in 18 different sites) and 67 surveys were carried out after hydrological events.

These data allow a valuable relationship between the stream power during floods and the size of the biggest elements mobilised to be proposed. This relation is obtained for medium sized rivers (50-200 km²) with bed material composed of gravel (D_{50}between 2 and 10 cm).

Furthermore, we also obtained good relationships between the average transport distance and the excess of stream power reached during the hydrological events. In order to estimate the bedload virtual velocity over a longer time scale, we applied these relationships to the hydrological events recorded by gauging stations over more than 30 years. We obtained values of virtual velocity which are between 2 km/century for a low energy river with a sinuous bed and well developed riffle-pool sequences (Rulles River – 33 W/m² at Q_b) and 11 km/century in a more powerful river with a straight channel (Aisne River – 81 W/m² at Q_b) and a sub-flat bed. The propagation velocity of bedload is therefore influenced by the energy available. However, it is also necessary to take into account the river pattern, the characteristics of the armoured layer and the presence of potential trapping sites.

Measuring and modeling of basalt pebble abrasion in the Williams River, Australia

SZABO T.(1), FITYUS S.(2), DOMOKOS G.(1)
(1) Budapest University of Technology and Economics, BUDAPEST, HUNGARY ; (2) The University of Newcastle, NEWCASTLE, AUSTRALIA

The phenomenon of downstream fining in gravel-bed rivers has been attributed to two main processes: size-selective transport and abrasion. In most of the studies, the latter process is considered to be inappropriate to explain the observed strong size reduction, because measurable laboratory abrasion rates are too small. However, a few researchers pointed out that abrasion-in-place processes as an additional abrasion mechanism may be dominant in a real river.

We collected basalt particles along a 100 km reach of the Williams River, New South Wales, Australia and measured the size and shape of them. Firstly, we show that abrasion is clearly important in our case because we found pebble shapes similar to ventifacts (sometimes called aquafacts) at the lower part of the river. These shapes are formed by the “sandblasting” effect of the over-passing suspended load. Secondly, we present statistical results on the downstream variation of grain shape and size along the river. Size variation follows an exponential decrease with a small diminution coefficient which also suggests that abrasion alone is capable to explain the observed size reduction.

Since most of the studies emphasize the role of size-selective transport in gravel-bed rivers, numerical models found in the literature only consider sorting as the fining mechanism. Therefore, based on the field observations, we present a new numerical abrasion model to reconstruct the downstream variation in grain size and shape in the Williams River. The model relies on a recent theoretical result describing the collective evolution of size and shape in large pebble collections as a Markov process, due to mutual abrasion and friction. Model results verify that abrasion is sufficient to produce the desirable exponential downstream fining, at least for small diminution coefficients. The new numerical model is expandable and transparent, so it is easily adaptable to other sedimentary environments as well.

****

In-Channel Fine Sediment Retention and Dynamics: A Review

STEWARDSON M., RUTHERFURD I.
The University of Melbourne, MELBOURNE UNIVERSITY, AUSTRALIA

Fine sediment dynamics in catchments has an important influence on river ecosystem and human health. Contaminants such as pathogens and micropulltants can be attached to fine sediments and their transport, fate and biogeochemical environment in which they might be transformed is dependent on fine sediment dynamics. Further, fine particulate organic matter transported through the river network can support riverine foodwebs through uptake by heterotrophic bacteria. For catchment-scale modeling of sediment budgets, it is commonly assumed that fine sediment delivered to a river network is transported directly to receiving waters or deposited on floodplains during overbank events. In reality, fine sediments can be stored within channels for example in slackwaters, artificial impoundments and the streambed. These fine sediment stores often have physical and chemical properties that support distinct biotic communities. Understanding fine sediment retention and its distribution at the reach and catchment and scales is important for managing riverine landscapes. This paper reviews the literature to establish the current knowledge of magnitude, residence time and longitudinal distribution of these storages within catchments. A conceptual model is presented as a basis for hypothesis development and testing.

The impacts of climatically-driven hydrological change upon sediment flux in Alpine river basins

LANE S.N.(1), BALIN D.(2), LOVIS B.(2), MICHELETTI N.(2)
(1) IGD, Université de Lausanne, LAUSANNE, SWITZERLAND ; (2) IGD, Universit? de Lausanne, LAUSANNE, SWITZERLAND

Both future temperature and precipitation changes could have a dramatic impact upon the geomorphic response of high mountain river basins. The availability of historical climate records and aerial image archives since the 1940s now provides the opportunity to investigate over the recent past the forcing of geomorphic systems by rapid climate change, of importance because very few studies have disentangles the signature of such change in geomorphic records. Here we consider an Alpine river basin (altitude *c.* 1,200 m to 3,005 m), with very little direct human impact, but where there is excellent archival imagery. The imagery reveals three distinct phases of river basin change each period corresponding almost exactly to periods of known climatic warming/cooling in the last 5 decades of the 20th Century. To evaluate this climate forcing, we test a set of plausible hypotheses using mathematical modelling. To assess possible changes in sediment production activity, we apply the 1D heat diffusion equation to the basin scale, driven using historical temperature records. This shows that one plausible explanation remains decreases/increases in the percentage of the sediment supply zone that is frozen during warming/cooling periods. To assess changes in sediment transport capacity, we apply a multi-fraction sediment transport model to the predictions from a reconstruction of basin hydrological response that begins in 1940. This reveals systematic changes in hydrological response which, notably because of non-linearities in the transport equations, translates into dramatic changes in sediment transport capacity that mirror those of possible temperature driven changes in sediment production. Thus, both of these hypotheses remain plausible and it is possible that they act synergistically to cause rapid and dramatic changes in basin sediment state. Thus, understanding climate impacts on geomorphic response requires coupled temperature-precipitation effects to be considered.

****

Quantifying spatial and temporal variations of specific event sediment yields in different climatic zones

GAO P.(1), NEARING M.(2), HICKS M.(3)
(1) Syracuse University, SYRACUSE, NEW YORK, UNITED STATES ; (2) USDA-ARS Southwest Watershed Research Center, TUCSON, AZ, 85719, UNITED STATES ; (3) NIWA, Box 8602, CHRISTCHURCH 8440, NEW ZEALAND

The spatial and temporal variations of suspended sediment (SS) in areas of different climates have been widely studied in term of the relationship between specific sediment yields (SSY) and watershed areas (A). However, such relationship changes as watersheds change from one climatic to another zone, which leads to both uncertainty and difficulty in quantifying the SSY-A relationship. This study introduces an alternative approach to quantifying the distinct characteristics of SS transport among different climatic zones. First, we show that in many arid and semi-arid regions of the world, SS transport in watersheds with various sizes can be generally quantified by a simple proportional relationship between event specific sediment yield (SSY_e, t/km^2) and runoff depth (h, mm). The constant, m (kg/m^3) is physically equivalent to the discharge-weighted event mean sediment concentration. For 15 watersheds from semi-arid American southwest, southern Italy, and Algeria with areas approximately ranging from 0.01 to 500 km^2, values of m range from 11 to 34 with the average of 19 kg/m^3 suggesting that m remains roughly constant across all watersheds and hence reflects the common nature of SS transport in these semi-arid areas. Second, we show that the range of m values in these watersheds is significantly lower than that (around 700 kg/m^3) of watersheds in the loess area of China where SS is transported through hyperconcentrated flows suggesting the powerful role of m in distinguishing different processes of SS transport. Third, we further demonstrate that the proportional relationship also sustains in 9 watersheds of humid regions with variable areas from 1 to 600 km^{2}and the values of m are limited in the lower range between 0.1 and 5. These results clearly reveal that the proportional relationship and the associated constant m can be used to distinguish different patterns of SS transport in different climatic zones.

Modern depositional processes in a confined, flood prone setting: benches of the Shoalhaven River, NSW, Australia

KERMODE S.J.(1), COHEN T.J.(2), REINFELDS I.V.(3), NANSON G.C.(2), JONES B.G.(2)
(1) University of Wollongong, Australian Nuclear Science and Technology Organistaion, WOLLONGONG, AUSTRALIA ; (2) University of Wollongong, WOLLONGONG, AUSTRALIA ; (3) NSW Office of Water, WOLLONGONG, AUSTRALIA

The lower Shoalhaven River provides an opportunity to examine bench processes in a confined setting. Stratigraphic analysis of trenches and augur holes, ground penetrating radar, Hec-RAS modelling and geochronological techniques combine to identify that benches of multiple levels along Bull Reach are composed of coarse material and have been extensively eroded and reworked by modern events. Kermode et al. (2012) established the long-term polycyclical nature of the higher alluvial surfaces (up to 193 ka in age), and this is contrasted with the youth of the lower inset alluvial surfaces, which are shown to be less than 270 years in age.

This study evaluates the relative significance of both flood regime and effects of European settlement on the geomorphic effectiveness of high magnitude events and investigates the characteristics of bench formation in this confined setting. It characterises the nature of depositional events and the relationship between facies at an event scale. Using Hec-RAS modelling, events of different recurrence intervals are compared to explore the relative impact of varying flood magnitudes. The results bring into question the theory that inundation frequencies of these surfaces are constant, or associated with formative processes.

****

Valley floor changes along and adjacent to the Baviaanskloof River, Eastern Cape Province, South Africa: Testing confinement

SMITH-ADAO L.(1), ROWNTREE K.(2), NEL J.(1)
(1) CSIR, NRE, CAPE TOWN, SOUTH AFRICA ; (2) Rhodes University, Geography Department, GRAHAMSTOWN, SOUTH AFRICA

Dryland environments describe the world's hyper-arid, arid, semi-arid and dry-subhumid regions. These regions are seldom seen as priorities for research because of their harsh climates, widespread distribution and limited resources. They are generally poorly understood. Local knowledge of physical processes operating in South African dryland fluvial systems is fragmentary and matches these global trends. River system function and structure are strongly linked to the catchment of which they are a part off. Catchment and channel variables are important in controlling the biophysical characteristics of the valley floor within a spatiotemporal context. The former determine the runoff and sediment regime of the river while the latter control the stability of the channel. The degree of valley confinement in particular devises process-form connections along rivers. A pilot study in the Baviaanskloof revealed the interdependence of river valley morphology, surface-groundwater interactions and vegetation in narrow and wide valley sections. Testing this relationship further on the Baviaanskloof River proved to be suitable as alternating confined, semi-confined and unconfined reaches allow for expression of a wide range of physical forces and biological outcomes. The overall aim of the study was to examine the relationship between fluvial styles, valley floor morphology and vegetation distribution patterns in the semi-arid Baviaanskloof River catchment, South Africa. This study will contribute towards catchment rehabilitation and a long-term monitoring programme. Fieldwork commenced systematically down the valley at 14 study sites during a winter sampling programme, 2009 to 2010. Data collected across the valley floor included cross-sectional surveys, vegetation distribution, sedimentary characteristics (texture and chemistry) and groundwater levels. The methods and procedures that were used to collate the data are briefly discussed, together with detailed interpreted results.

Is braided river index only related to discharge and geomorphic activity? Feedbacks from thermal infrared remote sensing

WAWRZYNIAK V.(1), PIÉGAY H.(1), ALLEMAND P.(2), VAUDOR L.(1), GRANDJEAN P.(2)
(1) Université de Lyon - CNRS UMR 5600 EVS, LYON, FRANCE ; (2) Université de Lyon - CNRS UMR 5276 LGL-TPE, LYON, FRANCE

The study of braided rivers often referred to braided index as an indicator of the intensity of the braided activity. Historical geomorphology often used such index to explore how braided activity increased or decreased through time. More recently, some authors clearly related the braided index to the discharge from experimental approaches.

Nevertheless, neither the discharge nor the braided activity sometimes explain intense braided index at low flow. Some of the rivers can have a very dense braided pattern whereas others are limited to fast flowing channels. Braided patterns can be explained by different connections with groundwater. Herein in order to evaluate groundwater-fed channels, we used thermal infrared images because groundwater exhibits a different thermal signature from surface water. Acquisitions were performed during summer in 9 braided reaches located in the French Alps. We reported two types of thermal patterns. The first type showed very low thermal variability throughout the day. This low variability was linked to the little diversity found in the aquatic habitat, notably due to the proglacial regimes with high summer flows which homogenize water temperature. The second type exhibited a higher thermal variability with changes during the day. The temperature of flowing channels changed during the daytime according to the air temperature. In contrast, the temperature of channels only downstream connected to the main network exhibited smaller changes which created thermal variability over space and time associated with hyporheic or phreatic flows. These findings allow for a prediction of temperature heterogeneity based on time and the aquatic habitat diversity, notably the proportion of ponds, alluvial and groundwater channels. These results should have potential consequences for the implementation of the EU Water Framework Directive for targeting reaches for restoration and conservation.

****

Experimental investigation into the impact of vegetation on fan morphology and flow

CLARKE L., MCLELLAND S., COULTHARD T.
University of Hull, HULL, UNITED KINGDOM

Riparian vegetation can significantly influence the geomorphology of fluvial systems, however, there is still limited understanding of the role vegetation plays in the development of alluvial fans, despite the large number of vegetated fans in temperate and humid climates. An understanding of the feedback loops between water flow, sediment dynamics and vegetation is key to understanding the geomorphological response of alluvial fans. But it is difficult to investigate these relationships in the natural world due to the complexity of the geomorphic and biological processes and timescales involved.

To examine the effects of vegetation on channel form, flow dynamics and morphology during fan evolution a series of experiments were conducted using the Total Environment Simulator at the University of Hull. The experiments followed a ‘similarity of processes’ approach and not scaled to a specific field prototype. Live vegetation (alfalfa) was used to simulate the influence of vegetation on the fan development. Numerous plots were run using the same initial conditions and constant water discharge and sediment feed rates, but the vegetation density and amount of geomorphic time (times of active fan development) between seeding / vegetation growth varied between plots.

The fan morphology was recorded at regular intervals using a laser scanner and overhead photography to gain near-continuous data quantifying fan topography, flow patterns, channel migration and avulsion frequency. The use of these techniques allowed collection of high resolution spatial and temporal data on fan development with minimal disruption to the experiments.

The results of the preliminary experiments showed that vegetation did influence the morphology and flow conditions during fan evolution. Vegetation reduced the number of active channels, and increasing the vegetation density also led to lower lateral migration rates, the formation of narrower and deeper channels and an increase in fan slope.

The Fluvial Critical Zone ' the co-evolution of a geomorphic-vegetation-soil system

BÄTZ N.(1), LANE S.(1), VERRECCHIA E.(2)
(1) Institute of Geography and Sustainability - University of Lausanne, LAUSANNE, SWITZERLAND ; (2) Biogeosciences Laboratory - Institute of Earth Sciences - University of Lausanne, LAUSANNE, SWITZERLAND

Traditionally, braided river research has considered flow and sediment transport processes and their linkages to river morphology. In the last two decades, research has been extended to the vegetation of the fluvial geomorphological system, recognising that vegetation dynamics can be as important as sediment dynamics in controlling braided river forms and processes. However, the role of soil has largely been overlooked. Research in more stable fluvial settings has described and quantified the nature of soils (e.g. terraces), but what is the role of soil in the transformation from an actively braiding river through stabilisation during vegetation development to a terrace system? Is soil simply passive and a consequence of vegetation development on a stabilising braid bar deposit, or is it actively involved in changing the timescales of system transformation? We present and test a conceptual model for the role of river-vegetation-soil interactions over timescales of decades rather than years. We studied the braided Allondon River, a protected nature reserve in the west of Canton Geneva, Switzerland, which comprises a braided river – terrace system, including active braiding processes, rapid vegetation colonisation, stabilisation of braid bar deposits, but also developing soil profiles. Whilst sediment stratification and topography modulate initial habitat properties and initial vegetation colonisation, soil forming processes, notably tied to organic matter accumulation, influence the succession speed and pathways. When combined with disturbance processes, this drives the spatial differentiation of the river-floodplain ecosystem. Overall, we can imagine this system as a 'fluvial critical zone' in which geomorphology, vegetation and soil co-evolve to create a diverse fluvial ecosystem. Given the importance of pedogenesis as a control on the rate of ecosystem change, it is critical to factor soil into questions regarding braided river management.

****

Identifying channel incision and its hydraulic importance: examples from Polish Carpathian rivers

WYZGA B.(1), ZAWIEJSKA J.(2), RADECKI-PAWLIK A.(3)
(1) Institute of Nature Conservation, Polish Academy of Sciences, KRAKOW, POLAND ; (2) Institute of Geography, Pedagogical University, KRAKOW, POLAND ; (3) Department of Hydraulic Engineering and Geotechnique, Agricultural University, KRAKOW, POLAND

Channel deepening may result from either channel incision or river metamorphosis changing a wide and shallow channel to the narrow and deep one. Only that first type of channel change leads to increased flow capacity of the channel. Therefore, a lowering of water stage associated with a given discharge rather than a lowering of river bed should be used to identify channel incision. A lowering of minimum annual stage at gauging stations is normally used to assess the relative importance of channel incision along a river or within a particular region. Rivers of the Polish Carpathians incised by 0.5-3.8 m over the 20th century, with greater incision in their middle and lower courses than in the upper ones. Variability in the hydraulic importance of channel incision with increasing river size was analysed by comparing changes in the frequency of valley floor inundation at gauging stations located along the 7th-order Dunajec River. Despite a lower nominal amount of channel incision in the upper river course, here incision has increased channel conveyance and reduced the frequency of valley floor inundation considerably more than in the lower course. Hydraulic effects of channel incision depend also on lateral stability of an incising river. Low-energy rivers from the eastern part of the Polish Carpathians remained laterally stable during channel incision. As a result, stages for low flood discharges have lowered substantially and less so for high-magnitude floods; and velocity of the flows conveyed over the highly elevated floodplains has become considerably lower. In high-energy rivers of the western part of the Polish Carpathians, incised meander belts were formed due to the alternation of incision and lateral channel migration. This has resulted in substantially lowered stages for all flood discharges and increased velocity of the flows conveyed over the newly-formed, low-lying floodplains.

Anthropogenic intervention into the river pattern as a cause of the Ol'e River floodplain development change (with the use of magnetic susceptibility for the sedimentary record interpretation)

CHUDANICOVA M., HRADECKY J., PANEK T.
Department of Physical Geography and Geoecology, University of Ostrava, OSTRAVA, CZECH REPUBLIC

Sedimentary records of the total six cores and two bank exposures were investigated in the Olše River floodplain. Set of laboratory analyses (magnetic susceptibility measurement, loss on ignition, grain-size analysis) were supported by study of the old maps, historical aerial photos and archive river management and flood records. From the historical records it is obvious that even at the beginning of the 20th century the river in the study area had braiding pattern with 100 to 300 m wide gravel streambed. In 1930s the natural stream was replaced by 28 m wide straightened artificial channel with vegetation enforcements and side channels were enclosed. After these modifications fine sediments were probably deposited on gravel bars of the former wide gravel streambed. Magnetic susceptibility (MS) measurements of upper fines of all investigated cores showed that these are very young because they were completely magnetically enhanced. MS is very sensitive to secondary ferrimagnetic iron oxides or ferromagnetic particles released into the environment especially during high-temperature combustion of fossil fuels, from road traffic or various waste-water outlets. Even several pieces of man made products like plasters and film plastic were found in fine sediments just above gravels. In 1962 flood defences were built at both sides of the channel which probably influenced sedimentation rates of the floodplain. Upper fine sediments of the investigated cores behind flood defences was up to 40 cm thick while the thickness of the inside flood defences fines was around 100 cm.

Further sedimentary record interpretation was based on the assumption that MS peak determines the 1980s, the time of the coal extraction, attached steel production and concentration of fly ashes culmination. This assumption was supported by ^{137}Cs dating of bank exposures. MS values were up to eight times higher than values from other localities in Czech Republic.

****

Changes of channel planform within anastomosing river system transformed by hydro technical works (the Obra River, W Poland)

SLOWIK M.
Adam Mickiewicz University, Department of Geographic and Geologic Sciences, POZNAN, POLAND

The Obra River is one of the largest lowland rivers situated in W Poland. Its river bed was subjected to intensive hydro technical works. Three artificial canals were constructed in the middle course of the valley in the 19thcentury. Before that time, the Obra valley had been an enormous wetland. Historical maps indicate that various river planforms (multi-channel, meandering and “disappearing in wetlands”) had been active here before the anthropogenic intervention.

GPR (ground penetrating radar) surveys ground-truthed by core data and analyses of satellite and aerial images were conducted to retrace the natural course of the river. The field works were carried out in four detailed study sites representing remains of former river patterns. The retraced channels indicate many features of an anastomosing pattern: low valley gradient, remains of floodbasins and high contents of muds and silts in the valley floor. Particular anabranches of the river were characterized by different patterns (meandering and multi-channel) depending on changes of the valley gradient and geology of particular sections of the valley. Moreover, traces of the river bed incision and transformation from meandering to multi-channel planform were found in W part of the valley, close to a canalized bifurcation to the Odra River. The transition and forming the bifurcation might have been caused by an intensive flood event. Its traces, marked by a distinct erosional surface, were discovered in the floodplain architecture.

The research provided a basis for river restoration projects that may be conducted in this area in the future. The results also show that anastomosing rivers had been active in Central Europe before they were transformed by hydro technical works. It is also indicated that relatively small anastomosing systems are easier to study than large rivers characterized by such planforms. They provide a great potential to study processes forming this unique type of river pattern.

Spatial and temporal variability of braided river bio-geomorphic patterns at the regional scale, the case of the French Rhône basin

BELLETTI B.(1), DUFOUR S.(2), PIÉGAY H.(3)
(1) University of Florence, FLORENCE, ITALY ; (2) COSTEL CNRS UMR6554-LETG University of Rennes 2, RENNES, FRANCE ; (3) CNRS UMR5600-EVS University of Lyon, LYON, FRANCE

The French Rhône basin is characterised by several braided reaches, preserved from the widespread disappearing occurred in the XX century. Given the complexity of these river systems, an interdisciplinary project has been conducted to better understand their functioning and to support their management, according to the WFD. In that context, this work focussed on the characterisation of the braided reaches, in terms of aquatic habitat and riverscape patterns. We selected 53 braided reaches located in several geographical contexts and performed a comparison of their contemporary pattern and their evolution since the 1950s. The study is based on aerial photos from the French National Geographical Institute and applies remote-sensing techniques.

We observe that contemporary aquatic habitats and braiding pattern are controlled not only by the water discharge but also by the groundwater position and the connectivity to sediment sources.

From the 1950s to the 2000s, the overall pattern is evolving through a river narrowing but some reaches are still active and widened. The causes seem to be related to: (1) high magnitude and low frequency floods, (2) sediment regime, (3) geographical position in the catchment and (4) colonisation conditions for pioneer species.

We then focussed on 12 reaches, distributed into 4 main hydro-geographical regions, to better understand the role of major floods in the braided river evolution. We analysed the braiding width and the vegetation pattern evolution between five observation dates (1950 to 2000). We found that several evolution patterns exist, depending on (1) the combined effect of the floods (magnitude and duration), (2) the position of a reach in its temporal trajectory, and (3) the river catchment characteristics (i.e. sediment and hydro-climatic regimes).

Finally we make some considerations in terms of braided reach management (i.e. conservation, restoration) in the Rhône catchment, in terms of habitats and braided reach riverscape.

****

Recent channel adjustments of major rivers in southern Apennines (Italy): a contribution to the understanding of fluvial response to human impact and climate change

SCORPIO V.(1), AUCELLI P.(2), GIANO I.(3), PISANO L.(1), ROBUSTELLI G.(4), ROSSKOPF C.(1), SCHIATTARELLA M.(3)
(1) Università degli Studi del Molise, PESCHE, ISERNIA, ITALY ; (2) Università degli Studi di Napoli "Parthenope, NAPOLI, ITALY ; (3) Università degli Studi della Basilicata, POTENZA, ITALY ; (4) Università della Calabria, COSENZA, ITALY

As highlighted by several studies, many Italian rivers have been affected at least since the mid-1950s by relevant channel adjustments, mainly consisting in pattern changes, channel narrowing and lowering, which are largely thought to be controlled by human interventions on the catchments and/or directly on the river systems. This is true also for major rivers of southern Italy, but the case studies are still limited especially when compared to those available for central and northern Italy. Our contribution deals with the analysis of channel adjustments that have affected some of the major Southern Apennines rivers: the rivers Biferno, Trigno and Volturno (Molise), Calore (Campania), Fortore and Ofanto (Puglia), Sinni (Basilicata) and, finally, Crati and Savuto (Calabria) which during the last decades, have all been undergone some type of human intervention such as the construction of dams, in-channel mining, etc. Our reconstruction of channel adjustments is based on a multi-temporal analysis in a GIS environment of topographic maps, aerial photos and orthophotos carried out on selected river reaches, and on the assessment of their actual morphological setting and dynamics by means of field surveys and DGPS topographic measurements. The comparison of obtained results highlight a common evolutive trend consisting in pattern changes from braided to wandering or sinuous, a strong channel narrowing, mostly exceeding 80%, and a moderate to very high channel incision, while, concerning the last 10 years only, some of the investigated rivers, the Savuto and Crati rivers, appear to be affected by an inversion of this trend, consisting in channel enlargement and the increase of fluvial bars. In order to investigate on the possible influence of anthropic and natural factors, the relationships between the reconstructed channel modifications and the main interventions on single river systems at the channel scale and rainfall trends are analysed.

Morphological degradation and restoration of the Ahr river (Italian Alps) and their effect on riparian vegetation

CAMPANA D., COMITI F., GIAMMARCHI F., TONON G.
Free University of Bozen, BOLZANO, ITALY

Over the last two centuries, the vast majority of rivers in the European Alps have undergone significant hydromorphological modifications due to land reclamation, flood mitigation, hydropower production and gravel mining. However, only few investigations have quantified such changes addressing also their impact on riparian vegetation growth.

The Ahr river (Eastern Italian Alps, drainage area 630 km^2, 25 km^2 covered by glaciers) featured an anabranching pattern with the presence of large riparian areas during the 19^{th} century, until the first half of the 20^{th} century. Since the 1960s, the channel underwent intense variations as a result of gravel mining and sediment retention due to a hydropower dam and several check-dams along its tributaries. Bed incision followed by bank stabilization works led to a hydrological and morphological disconnection of the floodplain from the channel. Moreover, cross-section narrowing and deepening of the riverbed brought about bed armouring and reduction of morphological diversity, until several reaches of the river were restored by widening and raising the bed in the period 2003-2011.

Planimetric changes occurred in the Ahr were determined by the interpretation of 10 maps and aerial photos covering the period 1820-2011. Cross-sections derived from topographic surveys and from Lidar-DTM led to estimate the elevation of the different surfaces presents in the river corridor and thus to estimate the extent of vertical changes during the degradation phase. The effect of morphological degradation and restoration on the growth of the adjacent riparian forest is being monitored since spring 2011 through dendrochronological analysis of 3 tree species. Preliminary results indicate a different response to bed incision by the different species in terms of radial growth, whereas no effects are evident after the restoration works. However, these have increased the morphological diversity in terms of morphological units such bars and islands.

****

Historical river channel change and stability in Irish catchments: implications for river management under the EU Water Framework Directive

TURNER J.N., JONES A.F., HARVEY E.
University College Dublin, DUBLIN, IRELAND

An understanding of longer-term processes operating in river channels is necessary for effective river management and to assess potential response to environmental change. Evaluation of types and rates of lateral channel movement over historical timescales using temporal sequences of map and aerial photographic data has been undertaken in catchments worldwide. In Ireland such data are widely available but there have hitherto been few attempts to assess rates and patterns of historical river channel change, particularly at the catchment scale. This is in spite of the acknowledged differences between Irish rivers and those in other nearby regions, such as Britain, and a long history of intensive land use and channel engineering. This study aims to quantify historical lateral channel change in two major Irish river catchments, the Boyne and the Suir, to evaluate downstream variations in channel change in relation to controlling factors and to assess the impact of anthropogenic activity on channel position. Channel margins and islands have been digitized from historical maps and aerial photography to identify areas of erosion, deposition, artificially cut channel reaches and reaches abandoned during engineered realignment. Results are presented for 500 m reaches of the main rivers in each of the two catchments and are compared with channel sinuosity and gradient. Comparisons between individual sub-catchments and between the Boyne and the Suir show variation in the type and rates of channel change recorded, and in the degree and extent of anthropogenic modifications to the river channel. The implications of the history of channel change in Irish rivers are discussed in the context of contemporary typological characterisation and management objectives under the EU Water Framework Directive (2000/60EC).

Detecting the Fluvial Channel Mobility and the Erosion Process Development for a Sustainable Management of the Mayo Tsanaga (North Cameroon)

TEOUGAM N.(1), TCHAWA P.(2), TCHINDJANG M.(2)
(1) University of Maroua, MAROUA, CAMEROON ; (2) University of Yaoundé I, YAOUNDE, CAMEROON

Severe drought episodes, capricious rainfall and vegetation degradation have been identified as the main environmental problems facing the ecologically fragile Far-northern region of Cameroon. But a refined assessment of these problems has brought into light the issue of soil erosion along thirteen rivers and stream flowing from the foothills of the Mandara Mountains to the neighboring plains. The prominent and longest of these rivers is the Mayo Tsanaga, which constitutes an ideal laboratory for understanding how the geomorphic processes of fluvial erosion impacted the sustainable development of the bank land assets buffering in it mid-section 120 km. This major environmental problem compromises the sustainable development of the Maroua and its surrounding cities of Gazawa and Bogo. Field raw measurements performed in this research and analysis of data from different sources (aerial photographs, topographic maps, Google Earth images) show that the width of some channel sections has grown from less than 10 to more than 100 meters over a 50-years period. The result is the increase in the valley width combined to the unpredictable trend of channel migration also providing striking footprints of erosion patterns along the river banks. Also, land uses on the channel buffers and river banks show evident signs of multiple infrastructural degradations, such as soil degradation of farm lands, local disruptions of water pipes and electric cable systems, collapse or severe damaging of many residential properties, and degradation of terrestrial communication infrastructures (roads and bridges) crossing the Mayo Tsanaga river.
Consequently, fluvial dynamics has increased as bank erosion and accumulation profiles have gained length. Overall, the last 50 years meander divagation of the Mayo Tsanaga river indicates an increasing mobility if its channel and the degradation of its banks due to erosion.

****

Catchment-scale versus site-scale controls on flood impact: Flooding in northern Victoria, Australia in 2010 to 2012

MARREN P.(1), ZOLJAN S.(1), SMITH H.(2), TEO E.(1)
(1) University of Melbourne, PARKVILLE, AUSTRALIA ; (2) University of Plymouth, PLYMOUTH, UNITED KINGDOM

After a decade of drought, repeated extreme rainfall events occurred over northern Victoria, Australia in September, October and December 2010, January 2011 and March 2012. These floods caused widespread erosion and channel change, although the impact of the floods was variable, both within and between catchments. This study examines the relative role of catchment-scale processes such as downstream stream power changes, and site-scale controls such as riparian vegetation and channel management history in determining the nature and extent of erosion following these floods. We also examined the roles of event duration and event ordering in controlling flood impact.
A combination of pre-flood survey data, aerial photography and LiDAR data, and post-flood surveys and aerial photography allowed us to map the extent of erosion in the King River and Corryong Creek, tributaries of the Murray River located in northeast Victoria. Erosion was correlated with stream power, vegetation and site-specific factors. We found that there was a general correspondence between stream power and erosion intensity at the catchment scale, but at the reach scale, there was a poor correlation between erosion and stream power. Sites with intermediate unit stream powers (300-600 Wm^{-2}) only had extensive erosion when floods persisted for more than 36 hours. Vegetation played a major role in site-scale variation in erosion. Generally, vegetated sites had less erosion than unvegetated sites, and vegetation became more effective downstream. Reaches with extensive invasive willows often had minimal erosion, but triggered local avulsions as flows bypassed the willowed reach. Where avulsions did not occur flow began to erode behind individual willows in later floods causing rapid local widening of the channel in response to relatively modest flows. Vegetation plays an important role in moderating flood impact, but in high stream power reaches riparian widths one to two trees wide are ineffective.

Geomorphological impact and feedback effects of occurrence and sequences of flood events of differing characteristics

HOOKE J.
University of Liverpool, LIVERPOOL, UNITED KINGDOM

Flood events have morphological and sedimentological effects on channels and floodplains and also associated social, economic and ecological impacts. Prediction of impacts is very important for flood management and for long-term interpretation of the role and frequency of floods. It is often assumed, particularly in sedimentological analyses, that the amount of sedimentation and size of material is proportionate to the magnitude of the peak flow. Here, evidence is examined of erosion and deposition in relation to series of events in two contrasting environments. Geomorphological impacts are found to vary in relation to magnitude, duration, season and sequence of conditions.

On ephemeral channels in SE Spain the effects of differing flows over nearly two decades have been measured, including a major flood in 1997, a series of more minor events and a very large event in October 2012, interspersed with drought periods. Thresholds for impacts are identified and feedback effects of changes in morphology are calculated, together with effects of vegetation. On active meandering channels in NW England the effects of peak flows over a 30 year period are evaluated. Bank erosion rates are closely related to winter peak flow. Evidence is provided that sedimentation varies markedly between winter floods and short duration summer peak flows of comparable magnitude. This has important implications for interpretation of flood magnitude and frequency from the sediment record. In both environments the presence and state of vegetation is found to have a large effect. The evidence from a range of events of varying magnitude enables testing and validation of models of flood impacts and demonstrates the need for a nuanced approach incorporating various characteristics of flood events.

****

Flooding from extreme rainfall: Geomorphological effectiveness as a vehicle for flood risk management and whole river restoration

SEAR D.(1), DEARING J.(1), WHEATON J.(2), BATES P.(3), NEAL J.(3)
(1) University of Southampton, SOUTHAMPTON, UNITED KINGDOM ; (2) Utah State University, LOGAN, UNITED STATES ; (3) Bristol University, BRISTOL, UNITED KINGDOM

Recent attention on the human impacts of extreme rainfall events are understandable and the immediate emphasis on urban flooding justifiable. However, the focus on urban flooding and the decisions taken at a time of crisis may obscure the longer term benefits of extreme events in effecting large scale restoration of hydromorphology, and in some cases, the delivery of flood risk benefits. In this paper, we use the example of a rare (1:1000yr rainfall, 1:600 yr flood), geomorphologically effective flood to explore the case for a re-evaluation of such events. Using a combination of morphological sediment budgeting, flood modeling and long term flood reconstruction we explore the role of a rare events in provisioning longer term ecosystem services such as flood risk reduction, and the restoration of physical habitats. We demonstrate first, that human modification to the floodplain resulted in an increase in flood risk; secondly, that the morphological effects of the flood resulted in a post-event channel that delivered a reduction in the depth and extent of flood risk. Thirdly, we demonstrate that the morphological changes resulting from the flood event delivered a more diverse physical habitat template that might have formed an opportunity to provision other ecosystem services. Finally we highlight the rarity of such events and argue that rather than seeing them only in terms of their immediate human impact, resource managers need to consider their wider, longer term benefits. To achieve this, demands equally rapid inclusion of geomorphological data capture and analysis combined with ecological and hydrological science.

Physical controls of vegetation recruitment patterns on the Drôme River (SE France): An analysis based on a chronosequence of high resolution aerial imagery

RÄPPLE B.(1), PIÉGAY H.(1), MUTZ M.(2), STELLA J.C.(3), TRÉMÉLO M.L.(1), WILCOX A.(4)
(1) CNRS UMR 5600 EVS / Site ENS de Lyon, University of Lyon, LYON, FRANCE ; (2) Department of Freshwater Conservation, Brandenburg University of Technology Cottbus, COTTBUS, GERMANY ; (3) Department of Forest and Natural Resources Management, State University of New York College of Environmental Science and Forestry, SYRACUSE, NEW YORK, UNITED STATES ; (4) Department of Geosciences, University of Montana, MISSOULA, MONTANA, UNITED STATES

Along with the recent recognition of the role of vegetation in influencing channel hydraulics, and thus fluvial morphology, comes the need for scientific research on vegetation recruitment and its control factors. Flood disturbance is known to create a suitable physical template for the establishment of woody pioneers. Sapling recruitment patterns and underlying physical controls were investigated on a 5 km braided reach of the Drôme River in South-eastern France, following the 2003 50-year flood event. The approach was based on the analysis of a chronosequence of high resolution aerial images acquired annually between 2005 and 2011, complemented by airborne LiDAR data and field observations. The study highlights how physical complexity induced by natural variations in hydro-climatic and consequently hydro-geomorphic conditions facilitates variable patterns of recruitment. The initial post-flood vegetative cover, which made up 10% of the total active channel area in 2005, was seen to double within six years. This expansion could be attributed primarily to recruitment, to a lesser extent also to the net growth of older vegetation patches. The variability of hydro-climatic conditions was reflected in the temporal and spatial patterns of recruitment, with a pronounced peak of vegetation expansion in 2007 and a decreasing trend over the following years. Recruitment was further seen to be sustained in a variety of geomorphic units, which showed different probabilities and patterns of recruitment. Active channels were the prominent geomorphic unit in terms of total biomass development, while woody debris units showed the highest probability for recruitment. An understanding of vegetation recruitment is becoming crucial for predicting fluvial system evolution in different hydro-climatic contexts. Applied, these findings should contribute to improve efforts made in the field of flood risk management, as well as restoration planning.

****

Assessment of the annual dynamics of large woods along a 60 km semi-alluvial river section of the Gaspe Peninsula, Quebec, Canada, feedbacks from 3 year field surveys combined with airborne and ground images

BOIVIN M.(1), BUFFIN-BELANGER T.(2), PIEGAY H.(3)
(1) Universite du Quebec a Rimouski/ UMR5600 ENS-Lyon/ Centre d'etude Nordique (CEN), RIMOUSKI/LYON, CANADA ; (2) Universite du Quebec a Rimouski / CEN, RIMOUSKI, CANADA ; (3) UMR5600/ENS-Lyon, LYON, FRANCE

The semi-alluvial rivers of the Gaspé Peninsula, Québec, are prone to introduce and transport large quantities of in-channel wood because of channel shifting due to high energy flows and uncohesive banks. These large quantities of wood influence significantly the river dynamics. The delta of the Saint Jean river encompasses large wood jams (LWJ) building up since 1960, measuring more than 3 km in length and creating frequent avulsions. These jams provide a unique opportunity to quantify a wood budget through time and to better understand the controlling factors. The wood budget includes the evaluation of wood volumes produced by bank erosion (input), still in transit in the river corridor (deposited on bars or channel edges) and accumulated in the delta (output). An annual survey was carried out from 2010 to 2012 to locate and describe more than 300 jams and 600 individual woods along a 60 km long river section. The repeated surveys allowed defining the morphological characteristics as well as the jam configuration that promote wood mobility and deposit. The repeated surveys also allowed examining the transport rates from one year to another for specific river sections. The results indicate that the volumes of woods deposited along the 60 km section are 4 times higher in 2011 and 2012 than in 2010. Increase in wood amount occurs mainly in upper alluvial sections of the rivers whereas decrease is observed in the semi-alluvial middle sections. Airborne and ground photo / video images are used to evaluate the volume introduced yearly by erosion and determine the transport rates. The analytical model developed from the wood budget and the understanding of wood dynamics can assist river managers in their decision making to determine possible solutions that include the production, transport and accumulation of large wood in river.

Necessity of linking paleontological and contemporary approaches for understanding river dynamics

CORENBLIT D.(1), BORNETTE G.(2), STEIGER J.(1), DAVIES N.(3)
(1) Clermont University, CNRS, UMR 6042, GEOLAB - Laboratoire de geographie physique et environnementale, 63057, CLERMONT-FERRAND, FRANCE ; (2) CNRS, UMR 5023, LEHNA - Laboratoire d Ecologie des Hydrosystemes Naturels et Anthropises, 69622, VILLEURBANNE, FRANCE ; (3) Gent University, Department of Geology and soil science, Krijgslaan 281 S8, GENT, BELGIUM

It is well established now that riparian plants within river corridors modulate both the longitudinal and transversal hydrogeomorphic gradients and associated fluvial landforms. By trapping sediment, nutrients and organic matter, plants control the spatio-temporal organisation of ecological processes and related habitats during the fluvial biogeomorphological succession. This control defines the biogeomorphic equilibrium conditions related to the resistance and resilience of the ecosystem structure to flood disturbances. Plants respond to river dynamics at ecological (contemporary) timescales, but have started to respond to river dynamics since they began to colonize terrestrial environments on the continents. These responses are related to physiological, morphological, biomechanical and life-history adaptations to regular submersions and mechanical constraints caused by flood flow. It was recently demonstrated that, at evolutionary timescales, plant adaptations led to the emergence of a variety of contrasted fluvial biogeomorphic types. Each of these types shows characteristic ecogeomorphological structures and dynamics. We suggest that within biogeomorphic type specific kinds of eco-evolutionary dynamics may occur with strong ecological and evolutionary feedbacks between biotic and abiotic components. The future challenge will be to establish a clear link between geomorphic, ecological and evolutionary processes and feedbacks to validate the hypothesis of an eco-evolutionary dynamics within river corridors.

****

Downstream channel changes of a tropical alluvial river due to construction of a dam: The example of the Subansiri in Assam, India

GOSWAMI U., ACHARJEE S.
Dibrugarh University, DIBRUGARH, INDIA

Channel shifting, bankline migration, bank erosion and fill, and varied type of other channel changes are frequently observed in the river channel of the Subansiri since periods of available records. The catastrophic flood event associated with the 1950 Assam earthquake is reported to be one of the main causes behind the gradual change of channel pattern of the river from meandering to braided. The ongoing construction of a mega dam at Gerukamukh since 2006, initiating far reaching changes in channel form and process, has marked the end of the natural fluvial regime of the Subansiri solely responsible for the earlier downstream river channel changes. Notable channel changes as a result of anthropogenic influence are now beginning to appear in the downstream reaches.

A study on the river channel changes of the Subansiri for the period 1990-2010 using remote sensing and GIS reveals noteworthy changes of varied types, during the period 1990-2000, resulting entirely due to its natural fluvial regime. But during the subsequent periods of 2000-2007 and 2007-2010, channel changes bearing signatures of anthropogenic influence are emerging gradually. During the twenty year period from 1999-2010 the river has gained in width, shortened channel length, steepened channel slope and has been actively migrating towards west. The annual rate of erosion has decreased from 7.031 km2 in 1990-2000 to 5.640 km2 in 2000-2007, whereas the annual rate of fill during the same period has increased by 3.80 times from 2.415 km2 to 9.224 km2. As a result there has been an increase in braiding intensity as compared to a decrease in sinuosity index. Thus, while the braided pattern persists during the study period, the river has changed channel pattern from sinuous to straight. Moreover, the characteristic anabranching pattern of the Subansiri, associated with the river since 1920, has now totally disappeared.

Key words: Bankline migration, channel pattern, Subansiri, sinuosity, braiding index.

Geomorphic changes of a dry-temperate meandering river highly disturbed by a large dam, Sauce Grande River, Argentina

CASADO A.(1), PEIRY J.L.(1), CAMPO A.M.(2)
(1) Clermont Université, Université Blaise Pascal, GEOLAB - CNRS, UMR 6042, GEOLAB, CLERMONT-FERRAND, FRANCE ; (2) Departamento de Geografía y Turismo, Universidad Nacional del Sur - CONICET, BAHÍA BLANCA, ARGENTINA

Flow regulation by dams may modify the morphology of the river downstream by altering the equilibrium between the flow transport capacity and the sediment load available to transport. This study focuses on the Sauce Grande River, an ungauged dry temperate basin of about 4000 km² located in central-eastern Argentina. The Paso de las Piedras Dam has impounded the middle river section since 1978 for water supply to Bahía Blanca (400 000 inhab.); despite the large capacity of the impoundment, the effects of the dam on the river environment remain poorly evaluated. This study quantifies the geomorphic response of the river downstream to major decrease in discharge and sediment inputs, and compares the direction of geomorphic changes to qualitative models of channel adjustment.

River channel changes were inspected based on (i) field surveys of the present river channel state, and (ii) historical aerial photographs and imagery of pre-dam (1961) and post-dam (1981; 2004) channel states for two river segments of 40 km-length above and below the dam. Methods used GIS-based measures of channel narrowing (widening), lateral migration and vegetation growth between consecutive time steps, and field-based morphologic descriptions of sample reaches along the river segments.

Results showed that geomorphic changes within the river below the dam were related to human intervention (e.g. bed digging, artificial meander cut-off and levees building) more than to natural adjustments to reduced flow discharge and sediment load (e.g. incision and narrowing). In contrast to the river upstream, which exhibited high lateral mobility, there was no clear evidence of channel activity since dam closure; bank profiles showed high stability and progressive vegetation growth. These findings suggest that the dam has induced stable (moribund) river channel conditions downstream. Results are discussed relative to predictive models of channel metamorphosis below dams available in literature.

****

Geomorphic Impacts of Riparian (Dis)Connectivity: Dams and Dam Removals as 'Natural' Geomorphic Experiments

MAGILLIGAN F.(1), NISLOW K.(2), RENSHAW C.(1), GARTNER J.(1)
(1) Dartmouth College, LEBANON, UNITED STATES ; (2) USDA-Forest Service, NORTHAMPTON, MA, UNITED STATES

Dams, and their subsequent removals, have profound impacts on geomorphic processes and ecologically functioning. Dams can thus be considered natural experiments where the disturbance is fixed in time and space, allowing the ability to test the geomorphic and hydraulic responses to a perturbation (or its removal) and to follow these adjustments spatially and temporally. This presentation covers the type, magnitude, and spatial variability of geomorphic responses to dams and dam removal throughout the Connecticut River watershed. To represent the effects of flow regulation, we analyzed tributary confluences on the regulated West River, VT, where 2 flood control dams exist. We document the time series of post-regulation channel narrowing and associated bar growth due to the influx of tributary sediment and also identify the critical covariate response to simultaneous changes in channel properties and flow competency. To capture the effects of dam removal, we analyzed the recent removal of 2 run-of-river structures. Our detailed pre- and post-removal field and lidar-based results for the Homestead Dam, NH reveal that in contrast to predictions from a widely applied conceptual model, the greatest geomorphic change did not occur adjacent to and immediately after the dam removal. Nor did knickpoint migration, rapid incision, or extensive channel widening in reservoir sediment occur. With thousands of dams likely to be considered for removal/repair in the coming decades, this study helps to advance predictions of the geomorphic response to dam removal and to elucidate the style and timing of fluvial responses to disturbances.

Geomorphological response to weir removal: the River Twymyn, mid Wales, UK

WHITFIELD G.(1), WHITFIELD E.(2)
(1) Environment Agency, WARRINGTON, UNITED KINGDOM ; (2) Liverpool John Moores University, LIVERPOOL, UNITED KINGDOM

Weirs are a common anthropogenic obstruction in British river systems. Historically, these physical barriers were built in an attempt to control river flow for various purposes including navigation, managing flood risk, and abstraction of water to operate industrial machinery. With the move towards catchment-scale restoration of river systems, largely driven by the EU Water Framework Directive, there is a shift in thinking towards considering removal of weirs in an attempt to restore more 'natural' processes to rivers whose hydrological and sedimentological regime are fundamentally influenced by such anthropogenic disturbances. In addition to removing the impounding effects of weirs, weir removal also increases coarse sediment connectivity between the upstream and downstream reaches that may have been largely disconnected following construction. Restoring more natural flow and sediment transfer patterns can lead to significant improvements for the ecological and biological status of rivers, helping to deliver the objectives of the Water Framework Directive. However, the sudden change of base-level that accompanies weir removal can lead to significant morphological adjustment, both laterally and vertically, as the river adjusts to a new longitudinal profile. In this paper we examine the potential geomorphological consequences of weir removal on the River Twymyn, a principal tributary of the River Dyfi in mid-Wales. We demonstrate the value that geomorphologists can bring to the assessment of weir removal projects for identifying risks and opportunities which need to be considered alongside the implications for in-stream ecology and fauna.

****

Geomorphological monitoring after dam removal

IBISATE A.(1), ACÍN V.(2), BALLARIN D.(3), DIAZ E.(1), GRANADO D.(2), MORA D.(3), OLLERO A.(4)
(1) Dpt. Geography, Prehistory and Archaeology, University of the Basque Country, UPV/EHU, VITORIA-GASTEIZ, SPAIN ; (2) ECOTER, S.C. Ecology and Land, ZARAGOZA, SPAIN ; (3) MASTERGEO, ZARAGOZA, SPAIN ; (4) Dpt. of Geography and Land Management, University of Zaragoza, ZARAGOZA, SPAIN

A geomorphological monitoring tool was implemented following several dam removals in different case studies in northern Spain. Hereby the example of Mendaraz dam in Urumea River is presented. Dam removal is one of the most frequent and effective fluvial restoration actions. Nevertheless only in few occasions geomorphological processes have been monitored. This monitoring included channel cross-sections, longitudinal profiles, lateral and vertical dynamics of river banks measurements from fix points and marked trees, sediment grain size, mobility and transport assessment and river bed morphologies. Geomorphological variables and field measurements have to be adapted to the local characteristics of the channel and the channel affected by the adjustment defined in each site. In the case study the river channel has been gradually adjusted after the dam removal and several changes have been identified after an extraordinary flood occurred in November 2011. The monitoring methodology was effective and could be applied to other cases.

Hydromorphological adjustments and re-adjustments of low energy rivers in a sub-urban catchment following historical engineering and recent urbanization

JUGIE M.(1), GOB F.(1), SLAWSON D.(2), LECOEUR C.(1)
(1) LGP UMR 8591, MEUDON, FRANCE ; (2) IRSTEA, ANTONY, FRANCE

According the EU Water Framework Directive (WFD, October 2000), European rivers and streams have to attain "good ecological status" through the preservation and restoration of aquatic environments by 2015. Member States of the European Union will have to ensure environmental continuity through "the adequate distribution of fish species and transport of sediments" that is undermined, longitudinally, by the impacts of transverse structures, such as weirs and dam, or laterally by structures such as levees, dikes and bank protection.

In France, more than 60,000 transverse structures have been identified on rivers as being obstacles to ecological and sedimentary continuity. Because of their historical occupation by societies, rivers flowing in the Paris area have long been anthropized and artificialized. River courses, channel shape, sediment transport and hydrological regime modifications have tremendously transformed the hydrosystems surrounding the city of Paris.

In addition to these ancient pressures a rapid and massive urbanization of the suburban areas around Paris has applied a new type of constraint to the hydrosystems in recent decades. This undermines the balance that was established following ancient engineering and disturbs the current functioning of the majority of valleys. These new types of land occupation have significantly altered the ecological conditions and transformed the hydrological responses of rivers.

In this study, we therefore seek to understand these processes of successive adjustments (ancient and recent) of small rivers from the urban margins of the Orge watershed (to the south of Paris). We use a multi-scalar spatial and temporal approach, and employ multi-disciplinary techniques based on local and global scales, geography, history, ecology and hydrology. Our goal is to provide a set of results to several disciplines through a transversal approach in order to assist decision makers in restoration planning.

****

Long term impacts of flow abstraction upon basin scale sedimentation processes in an Alpine valley system

REGAMEY B., LANE S.N., MICHELETTI N.
IGD, Universite de Lausanne, LAUSANNE, SWITZERLAND

Flow abstraction and diversion to water storage systems is a common element of Alpine hydro-electric power schemes. However, such systems are commonly associated with exceptionally high sediment production rates, necessitating very particular approaches to sediment management. Commonly, whilst water is abstracted, sediment (both coarse and fine fractions) is left behind. In order to avoid infrastructure failure, the latter is commonly designed to allow sediment to pass in short duration high magnitude sedimentary floods. The importance of such schemes aside, there has been relatively little investigation of the geomorphic impacts of such sediment management systems. In this paper, we present results from two spatio-temporal scales of analysis in order to establish these impacts. The first applies image processing to archival aerial photography to document the long-term impacts of flow abstraction and sedimentary floods in the Val d'Héréns, Switzerland. Results show that flow abstraction significantly reduces the time when the river was competent to transport sediment, and hence the total sediment transport capacity. The result has been a temporary disconnection of sediment flux through the system, and reflected in significantly reduced rates of sediment delivery to Lac Léman downstream. However, the image analysis also shows that whilst sedimentation was initially restricted to close to the abstraction sites, this sediment has been progressively reworked through a succession of sedimentary floods, causing deposition sites to move progressively further downstream. These deposition sites are themselves constrained by geomorphic forcing, centred on reaches of lower river bed slope and with sufficient lateral accommodation space. The implication of these observations is that the sediment flux will eventually reconnect with the main valley stems further downstream. The second scale sought to quantify this response in more detail by laser scanning on a 400 m river reach.

On the use of floodplain landforms to generate flood risk maps

DEMERS S.(1), OLSEN T.(1), BUFFIN-BÉLANGER T.(1), BIRON P.(2)
(1) Universite du Quebec a Rimouski, RIMOUSKI, CANADA ; (2) Concordia University, MONTREAL, CANADA

Flood hazard maps are often produced by hydraulic simulations that predict water levels at discharges of given frequencies. The hydraulic approach presents the conditions at one given time in the life of the river and thus marginalizes the effect of time trajectories in both hydrological and morphological conditions. In contrast, hydrogeomorphology (HGM) conceives the floodplain as a physical object resulting from ongoing long-term river processes and represents the extent where flood hazards should be expected. In Quebec (Canada), HGM understanding of river processes and landforms has yet to be considered for flood risk maps and implemented in floodplain regulations. This stems in part from a lack of appropriate HGM mapping guidelines specifically aimed towards risk management. We propose a typology for mapping floodplain forms based on prior HGM practices in order to adapt mapping guidelines to various floodplain styles. This typology is applied to three rivers located in southern Quebec (Canada): the Matane (50 km), Yamaska Sud-Est (3 km) and De La Roche (3 km). These rivers present contrasted floodplain styles of different flow energies and landform arrangements. For the Matane River, increased discharges due to climate change as well as in-channel sedimentation in the most heavily populated zones of the floodplain yields high uncertainty - or low life expectancy - of risk maps produced from hydraulic simulations. A quantification of flood processes using 1D simulation (HEC-RAS) gives a detailed understanding of flood hazards on the three floodplains. Our analysis shows how specific floodplain landforms are related with flood hydrodynamics and how they can be used to infer flood hazards. This leads to general guidelines for the appropriate integration of HGM landforms along with hydraulic simulations in flood risk management which are considered based on Quebec regulations.

****

Inherited rivers. Anthropogenic changes in the low energy rivers in W France from 1500 BC and implications for their current management

LESPEZ L.(1), VIEL V.(1), GERMAIN-VALLÉE C.(2), ROLLET A.J.(1), GERMAINE M.A.(3), CADOR J.M.(1), DELAHAYE D.(1)
(1) Geophen-LETG Caen-UMR 6554 CNRS, UCBN, CAEN, FRANCE ; (2) Service Archéologique du Conseil Général du Calvados, CAEN, FRANCE ; (3) LAVUE-UMR CNRS 7218, UNIVERSITÉ PARIS OUEST-NANTERRE-LA DÉFENSE, FRANCE, FRANCE

European WFD promotes restoration of ecological continuity of aquatic environments and of hydromorphological conditions. In this paper, we propose to put it into perspective by determining the role of heritages in modern systems. In western France, the small rivers constitute mainly inactive rivers of low energy circulating within cohesive alluvial plains. Geomorphological, research conducted in Normandy proposes a model of their long-term evolution. The Time of Nature is characterized by multichannel anabranching rivers in wetland environment. From the 2nd mil. BC, sedimentary archives show increasing overbank silty deposition while the fluvial systems become meandering. This change is the result of the erosion of soils due to increase in cultivated area and connectivity within the catchments. From the Antiquity, the time of hydraulic control is characterized by the creation of drainage ditches, leats, mills that had the consequence of controlling the channel. In the 18th c., a mill could be found every 1.3km along a river. Thus, repercussions of exploitation of the catchments, followed by hydraulic control complete the metamorphosis by creating societal/environmental system of substitution whose equilibrium has been maintained by societies for more than a millennium. So, the temptation of nature that has taken hold of some experts needs to be forgiving because we will never restore the river as they were before. Having assimilated the issues of biodiversity loss, we have to manage inherited channels. From a practical viewpoint, we need investigations integrating sedimentary heritage to assess the equilibrium state of the current rivers. Furthermore, reflexion on the reference model should be open and take into account the relationship with the floodplain while the restoration works conducted are more often focused on the channel. To conclude, we promote the use of a holistic approach of these ordinary waterways including long-term dynamics.

Landscape Connectivity in Hilly Catchments on Middle Paraiba do Sul River Valley, Southeastern Brazilian Plateau

PEIXOTO M., DEL POZO I.F.
Federal University of Rio de Janeiro, RIO DE JANEIRO, BRAZIL

In hilly catchments of Middle Paraiba do Sul River Valley, Southeastern Brazil, different types of erosion processes and mass movements are associated to regional reorganization of drainage systems along the Holocene. This study presents river and connectivity analysis done on 4th order river basins representative of regional quaternary evolution patterns identified by previous stratigraphic and geomorphologic work developed at Southeastern Brazilian Atlantic Plateau, aiming to contribute to river and basin management. Methods adopted comprised: a) mapping quaternary depositional features on valley flats and drainage headwaters concave-plane hollows, accomplished with a semi automatic procedure adapted from Correa (2008), using a 10m resolution DEM generated with 1:5,000 topographic charts of Volta Redonda Municipality; b) land cover and land use mapping using Ikonos satellite images (2009), provided by Geoeye; c) erosion and river geomorphic features mapping, based on Castro et al. (2002) and Peixoto et al. (2010). The maps generated on 1:25,000 scale allowed the recognition of buffers and barriers (according Fryrs et al., 2007) related to different geomorphic features, their spatial distribution and permanence, which are associated to Quaternary landscape evolution, determining the significance of connectivity maps generated. Erosive and mass movement processes connect slopes, valley flats and drowned headwaters to main streams, but also create new features of disconnectivity, like swamps and “empty” valleys, which hydrologic function and potential for river rehabilitation have been investigated.

****

Sediment connectivity in the upper Thina River, Eastern Cape, South Africa

VAN DER WAAL B., ROWNTREE K.
Rhodes University, GRAHAMSTOWN, SOUTH AFRICA

Landscape connectivity has been transformed in catchments worldwide, which has implications for the spatial transfer of sediment. In the Thina River catchment, Eastern Cape, South Africa, an important high rainfall water resource, subsistence farming on communal land led to overgrazing, which increased soil erosion and led to the formation of extensive gulley networks. This increased the slope-channel connectivity and increased the runoff of the system, cutting into valley fills and reducing the chances of channel-floodplain connectivity. Sediment is thus efficiently exported from the system and has effects on the sustainability of downstream water resources. Work is in progress to investigate historical changes to slope-channel and channel-floodplain connectivity in relation to land use and climate changes. The research approach will be outlined and preliminary findings presented. Anticipated results will include mapping of slope-channel connectivity over the last 50 years and dating (OSL and Pb-137) of floodplain sediments, paleochannels and selected terraces.

Characterising Urban Rivers to support their Sustainable Management

GURNELL A.
Queen Mary, University of London, LONDON, UNITED KINGDOM

In order to improve understanding of associations among fluvial processes, vegetation, engineering modification and the form and dynamics of urban rivers, survey and assessment methodologies are needed. Such methodologies need to record information on the detailed physical properties of urban rivers and their margins in a consistent way that is susceptible to statistical analysis. A number of surveys have been developed to characterise rivers and their corridors but few have been developed specifically for application to urban water courses. The Urban River Survey is one such survey.

This paper describes the URS, the indicators that are derived from it and the web tool that handles the data. Results from its application in the UK will be reported. In particular, analysis of URS data reveals the degree to which river engineering constrains the morphological characteristics of urban rivers and their dynamics, and it also provides a way of tracking trajectories of river adjustmant in response to changed engineering or rehabilitation activities. These results provide a framework within which management approaches can be designed and their success documented.

****

Geomorphological assessment of urban river reaches: results and discussion of five case studies (North Italy)

GUSMAROLI G.(1), CEDDIA M.(2), SOGNI D.(2), MANNUCCI G.(3), DOTTI N.(3), PARINI M.(4)
(1) Studio Ecoingegno, VENICE, ITALY ; (2) Progepiter srl, MILANO, ITALY ; (3) ARPA Lombardia, MILANO, ITALY ; (4) Regione Lombardia, MILANO, ITALY

Urban river restoration is worldwide recognized as a current issue both for river basin management and for urban planning strategies. Typically urban waterfronts constitute unnatural borders for river channels and correlated in-stream infrastructures interrupt the longitudinal river continuum, thus making towns to be actual bottlenecks for fluvial eco-dynamics and increasing natural risk conditions (undesired floods and morphological un-stabilities) both locally and up/downstream.

In order to effectively support river management, it is commonly known that a comprehension of fluvial geomorphic processes (past trends and future trajectories) could properly underpin decision making processes. This assumption finds a challenging field of application within urban reaches of watercourses, where giving room to river dynamics (or being subjected to the effects of such a strategy adopted up/downstream) represents a tough socio-economic tangle.

This paper presents the outcomes of the hydro-geomorphologic assessment campaign led on five rivers in the North of Italy (Lambro, Seveso, Olona, Mella, Staffora, with an investigated total length of about 500 kilometres), all of them identified as Po river tributaries flowing within Lombardia administrative territory and characterized by an high degree of urbanization along respective corridors. The study is part of a broader ongoing project ("Progetto Fiumi", promoted and funded by Lombardia Region and implemented by Lombardia Environmental Protection Agency), aimed at assessing ecological conditions of the watercourses above mentioned and supporting catchment scale planning in order to accomplish WFD requirements. The assessment methodology adopted is the one finalized to obtain the Morphological Quality Index (Rinaldi et al., 2012) for each investigated reach. Final discussion concerns the meaningfulness of the information obtained and its possible usefulness for management purposes.

Reach-Scale Index for Sand-Bed Channels

COTTON G.
GK Cotton Consulting, GREENWOOD VILLAGE, UNITED STATES

The development of a reach-scale index for sand-bed channels is presented. The index provides a quantitative means of scaling a prototype reference reach to other reaches within a watershed. The index is shown to be insensitive to a wide range of commonly used sediment transport equations that have been developed independently for sand-bed channels. The index can be applied to the assessment and design of stream restoration projects, where the physical processes of water and sediment transport play a dominant role in the form of the stream channel. The scaling of sand-bed morphology is compared to scaling relationships for cobble and gravel bed streams. Stream data from four independent studies of sediment transport for 91 streams in the western United States was used to compare scaling relationships. These data suggest that channels near threshold conditions (i.e. cobble bed channels) have width and depth that are largely independent of sediment transport, while channels with higher sediment transport (i.e. sand-bed channels) must include sediment transport in the scaling of channel width and depth. A computational method is demonstrated for the application of the index method.

****

Reflections on the application of the 'Freedom space' river management approach to help mitigate climate change impacts on three rivers of southern Québec, Canada

BUFFIN-BELANGER T.(1), BIRON P.(2), LAROCQUE M.(3)
(1) Universite du Quebec a Rimouski, RIMOUSKI, CANADA ; (2) Concordia University, MONTREAL, CANADA ; (3) Universite du Quebec a Montreal, MONTREAL, CANADA

Projected climate change involves modification of the hydrological regime that will in turn affect river dynamics: longer periods of low flow, increased risk of flooding as well changes in bank erosion patterns are likely to occur. In Quebec, the current river management policy does not allow for the consideration of such changes. The development of management tools adapted to climate change is thus needed to ensure sustainable management of rivers. In this paper, we present the results from the application of a “Freedom space” approach on three contrasted rivers of southern Québec: De la Roche, Yamaska Sud-Est and Matane. This approach seeks to strengthen the resilience of river systems by leaving a space of freedom to rivers rather than forcing them to move inside a buffer strip of fixed width. The approach is based on the hydro-geomorphology of rivers and it combines three distinct spaces to maintain natural river dynamics : flooding, mobility and integrity, the latter including wetlands. The methodological tools to determine the minimum space required for ecological integrity that also minimizes the risks associated with bank erosion and flooding in the current and future climate are described for a range of geomorphological contexts. Dynamics and connectivity between wetlands and rivers within the freedom space are also examined for the river De la Roche and Matane. Finally, a cost-benefit analysis compares the current management of rivers based on frequent interventions (eg bank stabilization) with the space of freedom.

Fluvial Geomorphology in Practice: Lessons learnt in the development and application of the River Styles framework

BRIERLEY G.(1), FRYIRS K.(2), TADAKI M.(1)
(1) The University of Auckland, AUCKLAND, NEW ZEALAND ; (2) Macquarie University, NORTH RYDE, SYDNEY, AUSTRALIA

Everything is contextual! The primacy of place-based understandings with which to inform landscape interpretations and management applications is increasingly recognized. Rather than relying unduly on conceptual or theoretical representations of landscapesthat suggest how the world 'should' ideally look and behave, appropriately contextualized, place-based understandings enable us to detect where local differences matter. This provides a critical basis to assess the representativeness of sample or referencesites and the transferability of insights between different locations. Many challenges must be addressed in dealing with inherent complexities of landscape understandings and their applications. The River Styles framework was developed as a generic toolkit to support river management applications. Inevitably, it bears the imprint of its co-developers. In this paper we report on experiences gained in the development of this framework and associated professional short courses, highlighting how they fashioned the (re)framing of this pedagogic toolkit. In this 'learning' approach to river science and management, procedures are open-ended and flexible, enabling them to be adapted to any given situation in an uncertainty-embracing form of science-management interactions. This presents a notable contrast to more prescriptive (cookbook) applications. Significant implications of this work include the development of skill sets with which to apply these principles and steps taken to establish and maintain appropriate information bases. This paper takes up the recent challenges made within physical geography to think more broadly about the work of our science, and steps taken to action it into relevance.

****

A methodological framework for hydromorphological analysis of Italian streams (IDRAIM) aimed to an integrated management of fluvial hazard and river restoration

RINALDI M.(1), SURIAN N.(2), COMITI F.(3), BUSSETTINI M.(4)
(1) Dipartimento di Scienze della Terra, FIRENZE, ITALY ; (2) Dipartimento di Geoscienze, PADOVA, ITALY ; (3) Facoltà di Scienze e Tecnologie, BOLZANO, ITALY ; (4) ISPRA, ROMA, ITALY

Development of integrative approaches for river management is increasingly needed by public agencies across Europe, where recent directives are aimed to conflicting objectives, while scientific frameworks designed for a single objective are in most cases doomed to failure.

In Italy, given the high level of urbanization, flood safety is the main priority in river management, although there is an increasing effort towards river restoration driven by the implementation of the Water Framework Directive. Consequently, the Italian National Institute for Environmental Protection and Research (ISPRA) has promoted a research program with the objective of developing a comprehensive methodological framework (named IDRAIM) to support management of river processes, integrating the objectives of the Water Framework and Flood Directive. The framework stems from existing experiences of geomorphological approaches developed in other countries (e.g. the River Styles Framework), but it accounts for the specific Italian context in terms of channel adjustments and human pressures, and includes the fluvial dynamics component. Some key characteristics are the following: (1) the method builds on a catchment-wide spatially hierarchical framework; (2) the temporal component of the analysis is explicitly accounted; (3) channel dynamics and its implications in terms of fluvial hazards are explicitly accounted for.

The general structure includes the following four stages: (1) catchment-wide characterization of the river system, including an initial setting and segmentation of the river system; (2) analysis of past channel evolution, leading to an assessment of present morphological quality and channel dynamics; (3) evaluation of potential future trajectories of channel morphology; (4) integrated management aimed to improvement of river morphological quality and mitigation of channel dynamics hazards.

Making space for geomorphic processes: the example of buffers for rivers

RUTHERFURD I.
The University of Melbourne, MELBOURNE, AUSTRALIA

The theme of this conference is geomorphology and sustainability. A key to managing geomorphic processes sustainably is to give those processes room to operate. Buffers along streams both protect the river system from human impacts, but also protect humans from bank erosion, deposition, and flooding. The majority of literature on buffers relates to protecting stream water quality. In this talk I will review situations where buffers can be successfully used around rivers – in particular for meander migration, avulsions, and anabranch development – and review approaches to predicting the width of the buffers required. I also demonstrate how the width of the buffers can potentially be reduced by revegetating stream banks with dense native vegetation. Such buffers have been used with success in several areas of the world, but there are also examples where such buffers have been counterproductive. I explore the planning and policy challenges of implementing such buffers in practice.

****

Potential and actual geomorphic complexity of restored streams in headwater streams of northern Sweden

POLVI L.E., NILSSON C.
Umeå University, UMEå, SWEDEN

Ecological theory suggests that habitat heterogeneity and species richness are positively correlated; therefore stream restoration often relies on increasing geomorphic complexity to promote biodiversity. However, to enable sustainability the restored channel complexity should be based on the potential complexity for a given site, as a function of valley and catchment characteristics. Our objectives are to evaluate stream restoration effects after timber floating, by: (1) quantifying post-restoration changes in geomorphic complexity in four geomorphic aspects: longitudinal, cross-sectional, planform, and sediment texture; (2) constructing pre- and post-restoration geomorphic complexity gradients, and (3) determining trajectories of potential complexity. We focus on tributary channels in boreal forests of northern Sweden, where stream modifications associated with log-floating from the 1850s-1960s created highly simplified channels. Driven by concerns for fish, restoration began in the 1970s, with the return of large cobbles and boulders from the channel edge, and evolved into 'demonstration restoration,' placing very large boulders and trees into the channel, reopening side channels, and constructing fish spawning areas. We evaluate 22 reaches along tributaries of the Vindel River in northern Sweden, with four levels of restoration status: channelized, restored, demonstration restoration, and unimpacted. Detailed morphologic, sediment, and instream wood data allow calculation of 5-15 metrics of fluvial complexity for each geomorphic aspect. We compare the complexity metrics by restoration status using ANOVAs and use multivariate ordination to create a complexity gradient. We use these comparisons and characterizations of valley and catchment characteristics to evaluate if trajectories of change in morphology due to reach-scale restoration efforts track with potential reach complexity.

The effects of river restoration on flood risk and flood hydrology

DIXON S.(1), SEAR D.(1), ODONI N.(2)
(1) University of Southampton, SOUTHAMPTON, UNITED KINGDOM ; (2) University of Bristol, BRISTOL, UNITED KINGDOM

The addition of large wood to river channels during river restoration projects is a popular method of attempting to improve physical and biological conditions in degraded river systems. Projects utilising large wood can involve the installation of engineered logjams (ELJs), the planting and enhancement of riparian forests or a combination of both. The success of such restoration projects in improving biotic and geomorphic conditions has been documented; however one aspect which has hitherto received very limited attention in the literature is the effect on catchment flood hydrology.

Altering the wood loading of a channel through installation of ELJs and increasing floodplain surface complexity through encouraging mature woodland could be expected to increase the local hydraulic resistance, increasing the timing and duration of overbank events locally and increasing the travel time of a flood wave through a reach. This reach-scale effect has been documented in models and the field. The impacts of these local changes at a catchment scale remains to be explored. Catchment scale effects are particularly import where headwater stream restoration is upstream of vulnerable urban locations.

We present results of a numerical modelling study based on a 98km^2 catchment using OVERFLOW; a simplified hydrological model. We investigate the effects on catchment scale flood hydrology of implementing three restoration scenarios (using ELJs alone, using riparian forest restoration and a combination of riparian forest and ELJ installation) at scales from reach to sub-catchment.

We demonstrate that changes to catchment flood hydrology are highly location dependant and downstream flood peaks can increase with synchronisation of sub-catchment flood waves. We constrain magnitude estimates for increases and decreases in flood peaks for modelled restoration scenarios and scales. Finally we analyse the potential for using river restoration as part of an integrated flood risk management strategy.

****

The role of geomorphic processes in the sustainability of large wood loads in rivers: A Bayesian approach

STOUT J., RUTHERFURD I., WEBB A.
University of Melbourne, PARKVILLE, AUSTRALIA

A growing worldwide literature is demonstrating the geomorphic and ecologic roles played by wood in streams. After a century of removing wood from streams in many parts of the world, many restoration projects now include extremely expensive reintroduction of wood. Managers are also revegetating cleared stream banks. In large lowland rivers, bank erosion is often the most important mechanism delivering wood to streams. For planning of stream management works, the important question is how long it will take (decades to millennia) for streams to recover an adequate wood load, with and without interventions? We report on a study into rates of wood accession and depletion in Victoria, Australia. The study is based on possibly the world's largest survey of in-channel wood, in which large wood has been mapped by high-resolution aerial photography in over 27,000 km of Victoria's largest streams. This data-set can be combined with LiDAR data, and field-truthed measures of reference sites, providing a cumulative estimate of the effects of the processes driving the mass balance of wood to these systems. Further field work and data mining will be done to populate the parameter spatial distributions of delivery and removal of wood from the river channel.

Over large stream networks, and centuries of time, the gains and losses of wood can be considered in probabilistic terms. A Bayesian statistical approach allows us to model latent (i.e. unknown) parameters as random variables that describe the physical processes driving the addition and loss of wood within reaches across the large network. The model can be used to probabilistically predict future wood loads, addressing the rates of recovery from anthropogenic disturbances, with and without different interventions. An important feedback element of the model is the effect of in-stream wood on bank erosion rates, and bed sediment transport rates. I report on methods used to develop and apply the model to Australian rivers.

Assessing the success of river restoration projects through Geomorphology

PEETERS A.(1), VERNIERS G.(2), DE LE COURT B.(3), HALLOT E.(1), HOUBRECHTS G.(1), PETIT F.(1)
(1) University of Liege, LHGF, LIEGE, BELGIUM ; (2) University of Namur, URBE, NAMUR, BELGIUM ; (3) Service Publique de Wallonie, DECNN, NAMUR, BELGIUM

In the context of the Water Framework Directive's goal of attaining "good ecological status", a LIFE+ project (called Walphy), co-funded by the European Union and the Service Public de Wallonie, was launched in 2009. It aims to undertake experimental river restoration projects and to assess their success on the basis of ecological and geomorphological monitoring.

Geomorphological monitoring differs depending on the type of restoration project: improvement of longitudinal continuity or transversal continuity.

Restoration projects involving longitudinal continuity concern courses where obstacles impede the free movement of fish and sediment. In the Bocq basin, many of these obstacles (old weirs between 1 and 3 m high) have been removed. The release of sediment was studied using traced pebbles (PIT tags), which enable the recovery of bedload transport to be highlighted. Additional monitoring is based on the comparison of topographic surveys and cross-sections carried out pre- and post-removal. This can show a recovery of the natural transport of sediment when stream bed aggradation is observed downstream from the removed dam.

Restoration projects involving transversal continuity concern straightened courses with artificial banks and therefore poor stream-floodplain connectivity. These works consist of enhancing river channels and restoring meanders or banks. Geomorphological monitoring is also based on surveys conducted pre- and post-restoration work. Some reaches have been improved by the reintroduction of spawning gravel. Several methods were used to characterize the clogging of this gravel reintroduction (hydraulic conductivity, wooden stakes). In addition, the mobility of this gravel was monitored using traced pebbles (PIT tags).

Finally, restoration works and their stability and resistance to erosion are considered in relation to flood characteristics (discharge, recurrence, specific stream power and shear stress).

****

Morphological descriptors and typologies of French rivers as tools for managing river restoration

THOMMERET N.(1), BILODEAU C.(2), GOB F.(1), BAUDOIN J.M.(3), ALBERT M.B.(4), BELLIARD J.(4)
(1) Laboratoire de Géographie Physique UMR 8591 CNRS-Université Paris 1 Panthéon-Sorbonne, MEUDON, FRANCE ; (2) LADYSS Université Diderot Paris 7, PARIS, FRANCE ; (3) ONEMA, AIX EN PROVENCE, FRANCE ; (4) Irstea, ANTONY, FRANCE

The European Water Framework Directive (WFD) requires that the hydromorphological conditions of water courses meet good ecological status. In this context, managers of water bodies need morphological descriptors and typology in order to evaluate and quantify the impact of hydromorphological alterations on biocenoces. The application of the WFD thus requires that "reference" characteristics should be determined. The scientific community has agreed, however, that the definition of natural conditions is not meaningful as hydrosystems constantly evolve through time and space.

This study aims to define hydromorphological descriptors from "reference" models and typologies integrating the complexity of the processes at play and the diversity of the various situations. These models are based on well-known theories that link river morphology and basin characteristics (catchment size, geology, land cover, etc.) and build on a large set of reaches considered as relatively poorly impacted by human pressures and statistically coherent on a regional basis.

Our data set results from a collection of about 1000 measurements of French river reaches. They have been collected on the field at station scale following the same protocol, over the last three years and include: topographical descriptions (width, depth, slope, etc.) of the reaches at bankfull stage, discharge measurements, sediment size and riverine vegetation descriptions. They are gathered in the CARHYCE (river hydromorphological characteristization) data set managed by the French National Agency for Water and Aquatic Environments (ONEMA).

Our models allow the quantification of the reaches morphological alteration. They provide tools to manage and better understand key parameters controlling hydromorphological pressure on biocenoces. The objective of these "reference" models is to achieve a more natural functioning of the hydrosystem through performing restoration operations.

Investigating the potential of seed banks as a regeneration niche in riparian systems: Implications for vegetation-based river rehabilitation

O'DONNELL J., FRYIRS K., LEISHMAN M.R.
Macquarie University, SYDNEY, AUSTRALIA

River systems present unique riparian environments for the study of seed banks – accumulations of viable seeds and propagules stored within sediment. Seed banks provide multiple opportunities for plants to establish in a range of environmental conditions and can facilitate the rapid recolonisation of vegetation after disturbance. As such, they are recognised as an important *regeneration niche* and there is a strong drive to increase their utilisation in the rehabilitation of degraded rivers and streams. We present findings of current seed bank research conducted within the Lower Hunter River catchment in New South Wales, Australia. For two sand bed streams we compared the vertical stratification of seed banks between geomorphic units that are characterised by different inundation and reworking frequencies: bars, benches and floodplain. Contrary to our hypothesis that bars would house few seeds as a result of continual disturbance, we found both very high and low seed numbers could be present. Bench and floodplain seed banks were more consistently abundant and species-rich. In terms of seed stratification, benches were highly variable with depth to 30 cm reflecting recurrent reworking and deposition, whereas floodplain seed bank abundance and richness declined with depth, consistent with seed banks formed under low disturbance and sedimentation rates. We are also investigating controlling factors on the formation of seed banks in different geomorphic structures, such as inundation frequencies and unit exposure times, propagule inputs from local vegetation and hydrochory (the transport and deposition of propagules by water). We present implications for the succession of riparian vegetation in relation to both the influence of hydrology and vegetative controls on stream geomorphology. Understanding seedbank dynamics is being incorporated into river rehabilitation activities that focus on riparian re-vegetation.

****

Hydromorphological impacts of hydrosedimentary and ecological continuity's restoration. Example of the Yerres RIV., seine catchment, France

MELUN G.(1), ARNAUD-FASSETTA G.(1), FORT M.(1), CHALAUX E.(2), LUCAS E.(2), FOUREL S.(2), GUESDON L.(2)
(1) Université Paris Diderot, PARIS, FRANCE ; (2) SyAGE (Syndicat mixte pour l'Assainissement et la Gestion des Eaux du bassin versant de l'Yerres), MONTGERON, FRANCE

The European Water Framework Directive (WFD) aims to achieve “a good ecological and chemical status” by 2015. Hydromorphology influences ecological status in three ways: (i) hydrological regime (flow and groundwater), (ii) morphological conditions, and (iii) longitudinal and transverse continuity of rivers. Physical and ecological impacts of those structures upon hydrosystems are known, but removal’s impacts are misunderstood due to lack of scientific feedbacks. According to particular methodology, based on field measurements and modelling, we aim at characterizing and quantifying hydromorphological impacts of dam removals on riverbed and bank structures. This study is applied to the Yerres watershed particularly significant due to its anthropic pressure conditions. We study limnimetric adjustments, stream power variations, transport capacity variations and riverbanks dynamics in no-dam context, at the reach scale. Our results show that there is a clear morphological adjustment of the riverbed and bank structures, even though locally those possibilities are constrained by anthropogenic facilities. Run-of-the-river dam removals result in: (i) systematic lowering of water level, (ii) shrinkage of the cross-section, (iii) increase of stream-power and transport capacity, proportional to uncompartmentalised context (calculated values are locally greater than 35 W/m², hence suggesting that flow would have theoretical capacity to modify the channel geometry notably in sections without protection); (iv) clear recovery of bank erosion processes during flood events. Finally, our study demonstrates that the Yerres River can be hydromorphologically restored; yet higher hydrodynamic conditions in no-dam context involve new issues particularly in relation with the human occupation of the Yerres’s valley (wetlands and channels disconnection, patrimonial buildings destabilization, impacts on recreational uses), that river managers have to consider.

Poster presentations:

Measurement of Hydraulic Head Distribution below River Bed at around Alluvial Fan End: Case Study in the Inukami River, Central Japan

KURASHIGE Y.
The University of Shiga Prefecture, HIKONE, JAPAN

Hydraulic head distribution below river bed was measured at around alluvial fan end of the Inukami River, Central Japan. Ten measurement sites were set at 2 m intervals in a flow direction. At each measurement site, piezometers were set at two different depths. Water level in the piezometer was measured with a digital caliper. A digital caliper was attached with a hand-made connecter, and this connecter can easily set at the top of each piezometer. The caliper was set on each piezometer using this connecter at each measuring time. Accuracy of the water depth measurement in the piezometer was 0.14 mm. The measurement revealed that local water circulation appears in the longitudinal cross section during normal condition and just after a rainfall event. In contrast, several days after a rainfall event, upwelling of groundwater occurs at almost all sites.

****

Restoration of Dynamic Processes - Hydro-geomorphological Research in the Riparian Forest between Neuburg and Ingolstadt

CYFFKA B., FISCHER P., HAAS F.
Catholic University Eichstaett-Ingolstadt, EICHSTAETT, GERMANY

Within the framework of a restoration project eight working groups of different scientific disciplines have been operating since 2009. Major objective of this interdisciplinary project is to foster the dynamic processes on the floodplain. Further object is the identification and analyses of hydro-geomorphological processes and their impact on for vegetation and fauna.

Several measures are being taken to achieve these objectives. First there is a permanent bypass river going round the dam of a hydro power station with a discharge of up to 5 m^3/s. Furthermore, ecological floodings are conducted and a groundwater drawdown is in action. These dynamic features shall create habitats with different ecological conditions. Oscillation of water level is one of the most important preconditions for a sound riparian ecosystem. Therefore the evoked hydro-geomorphological processes are being monitored.

River morphology is controlled by terrestrial laser scanning and large scale mapping by a drone. After analysing the results of this surveillance it will be possible to determine erosion and aggradation rates at selected undercut slopes and point bars. First dislocations of the river course have already been detected and flooding areas were identified. Further methods such as measurement of bed and suspended load, cross profiles and mapping of the river bed are complementary research work.

To understand the effects of the controlled discharge on river morphology is an exciting field experiment with nature-like circumstances. The aim is to detect the interaction of the permanent bypass and the ecological floodings with the biotic nature by applying the mentioned mixture of methods because the interdependencies have not fully been understood so far.

At the end recommendations shall be given in order to control discharge and floodings which will be important for a sustainable development of sensitive riparian ecosystems.

Spatial distribution of cutoffs on the Peixe River, Brazil

MORAIS E.(1), HOOKE J.(2), ROCHA P.(1)
(1) São Paulo State University, PRESIDENTE PRUDENTE, BRAZIL ; (2) University of Liverpool, LIVERPOOL, UNITED KINGDOM

The aim of this study is to investigate the spatial distribution of meander cutoffs on the Peixe River, São Paulo State, Brazil. The river is a tributary of the Parana River and exhibits a meandering pattern with a remarkable alluvial valley which possesses features such as oxbow lakes and paleochannels. Landsat 5/TM images have been analysed between 1985 and 2010 at intervals of five years for a 60 km reach of the Peixe River. Images were geometrically corrected and the fluvial channel was digitized. The results have shown 21 cutoffs along the reach and a trend of cutoffs has propagated upstream. There is a concentration of cutoffs (60%) related to the formation of a secondary channel resulting from an avulsion process (~12 Km). This concentration of cutoffs is intensified upstream after 1995. In 1998 with the construction of a dam at the Parana River, a 4 km segment of the Peixe River confluence was transformed into a reservoir. Cutoff processes have been approached in a multitude of different ways, however an examination of the influence of base level change on the spatial distribution of cutoffs should be considered.

****

Determining soil flux from small riparian areas colonised by the invasive plant, Impatiens glandulifera on a small watercourse in northwest Switzerland

GREENWOOD P., KUHN N.
University of Basel, BASEL, SWITZERLAND

Impatiens glandulifera (common English name: Himalayan Balsam) was introduced into Europe in the mid-19th century. Its invasive tendency has facilitated its expansion throughout mainland Europe due to certain lifecycle traits which have allowed it to become rapidly established and out-compete most native floral species. Its favoured habitat includes damp, nutrient-rich soils which experience frequent natural disturbance, such as riparian zones. Once present, watercourses then inadvertently act as conduits that facilitate the downstream movement of seeds into un-contaminated parts of the catchment. They then form into discrete mono-cultural stands that typically range in area from a few m^{-2} to >150 m^{-2}. *Impatiens glandulifera* is cold-intolerant and experiences rapid 'die-back' in temperate countries during the first frosts. This can increase the susceptibility of riparian areas previously occupied by *I. glandulifera* to soil detachment and erosion by impacting raindrops and surface runoff. This communication reports the preliminary findings from on-going work conducted in a contaminated sub-catchment of the Birs River, northwest Switzerland. The investigation sought to quantify soil flux from a number of discrete riparian areas occupied by *I. glandulifera* before, during and after the die-back period. A technique using erosion pins and an erosion bridge was employed to micro-profile the soil surface, as this caused the least disturbance when measuring through vegetation. Initial soil surface profiles were established at predetermined locations within five contaminated sites before die-back occurred, and at five nearby uncontaminated reference sites. Soil surface profiles at all 10 sites were then re-measured each week. The average change in the soil surface profile (mm $week^{-1}$) was quantified for each site, converted to an equivalent soil flux value (kg m^{-2} $week^{-1}$) and the results were compared for both groups.

River channel recent dynamics in relation to floods in the Curvature Carpathians (Romania)

GRECU F., IOANA-TOROIMAC G., DOBRE R., ZAHARIA L.
University of Bucharest, Faculty of Geography, BUCHAREST, ROMANIA

Our previous studies showed that rivers coming down the Curvature Carpathians' region (including mountainous and subcarpathians areas, and the adjacent plain) cross a channel narrowing stage. This process is due to several factors: on a geological timescale, it is the consequence of neotectonics (Carpathians' uplifting and an active subsidence in the plain) and channel incision; on a historical timescale, it is the consequence of human interventions (dams, dykes…) and sediment load decrease. In this general context, we intend to continue analysing these evolutionary aspects by focusing on the relation between channel's dynamics and floods, especially because since 2005 important floods impacted on these hydrosystems. How these floods modified channel's morphology? Erosion and lateral reactivation, incision or aggradation? Which is the impact on the transport capacity of the channel and, consequently, on future inundations? In order to understand this relation, our study takes into account: aerial photos from 2005 and 2009; cross profiles before and after the floods; water discharges and suspended sediment loads. The comparison between the aerial photos shows the 2D evolution; the comparison between the cross profiles completes the analysis by a 3D image of the channel dynamics; the water discharges and suspended sediment loads allow us to characterise the floods. The preliminary results show that: 1) in the case of Buzau River and Teleajen River, the most affected reaches, near bridges, suffered from an incision process during these floods and, consequently, they were anthropically adjusted in order to diminish water's velocity; 2) in the case of Prahova River, the narrowing process continued despite the floods of 2005 and 2007.

****

Flow variability in large tropical river systems in the Amazon

MANYARI W.
University of Brasilia, BRASILIA, BRAZIL

Growing use of water resources, especially for generating power, has been observed across the globe. Scientific knowledge concerning the dynamics of flow – covering factors such as magnitude, frequency and duration – is scarce in relation to large tropical river systems. The role sediment load plays in preserving the ecological integrity of ecosystems along the banks and in the estuaries of alluvial rivers should not be ignored. Besides examining several features of the extremely complex, dynamic behavior of rivers in the Amazon on the basis of statistical surveys, the present study thus aims to serve as a starting point for formulating management strategies that take due account of the need to preserve the connection between the surrounding plain and the river channel, which is interrupted by a reduction in the frequency and extent of floods and an almost complete suppression of sediment load. Attempts to offset the impacts the installation of dozens of hydroelectric schemes is expected to produce as a result of the new economic cycle under way in the Amazon region should therefore reach beyond the fragmentary approach to flow variability, in which only the minimum flow levels are computed when it comes to defining a so-called ecological flow. The present study analyses the components of the flow regimen for three major rivers in the Amazon Basin (Xingu, Tocantins and Madeira) in stretches immediately downstream from locations where damming is either planned or has already been undertaken for power generation purposes. This introductory analysis seeks to describe the heterogeneous space-time pattern as a key strategy for maintaining ecological integrity with ecotone statistics typical of riverside environments in the Amazon.

Comparison between bedload transport rates estimated with tracer-clasts and results given by theoretical equations in an atlantic mountain stream (Pigüeña rivers, NW Spain)

VÁQUEZ-TARRÍO D., ROSANA M.D.
INDUROT (Universidad de Oviedo), MIERES, SPAIN

High-order reaches placed in mountain basins show an important decrease in slope when compared with the immediate upstream low-order channels and this occur very close to the sediment producing areas. Consequently, coarse sediment deposits develop into these reaches. Then, channel bed sediment typically falls in coarse ranges of grain sizes, being bedload transport sporadic and occurring with flow conditions close to the threshold ones.

Rivers from NW Spain are defined by this situation, dropping by 2,000 m in a short path (50 km). Thus, drainage networks with relatively steep slopes and where channel bed sediment is typically coarse make appearance.

We selected Pigüeña river basin and we used tagged stones (painted and with inserted magnets) to trace bed sediment movement during flood events. By this way, we could estimate bedload transport rates between 1.1 to 4.0 kg/s for three flood episodes. After doing that, we decided to apply nine different transport equations in order to compare the output values given by these formulas with the bedload rates estimated previously with the tracers.

None of the chosen equations performed adequately: all of them tend to overestimate when compared with the tracer results, being the Wilcock-Crowe (2003) equation the only exception to that. For us, the main reason explaining this general overprediction is related with bed structures and textures. These equations assume how the channel will carry the entire load which is able to transport, without taking into account potential limitations in the sediment supply.

But in these rivers, armouring is ubiquitous, and together with structural arrangements could increase the resistance to transport entrainment, inducing a competent-limited situation and reducing the supply of sediment coming from bed surface. Wilcock-Crowe introduces complex corrections into the “hiding fuction” and considers the effect of sand content on entrainment; this could explain why it performs better.

****

A multi-scale framework for assessing processes and forms within European Rivers

GURNELL A.
Queen Mary, University of London, LONDON, UNITED KINGDOM

This poster is presented on behalf of the WP2 team of the REFORM programme.

The REFORM (REstoring rivers FOR effective catchment Management) research programme is an EU FP7 funded collaborative project involving 25 partners drawn from 15 European countries. The team working on work package 2 (WP2) are devising a multi-scale framework for assessing the hydrogeomorphological functioning of European rivers to underpin the hydromorphological and ecological objectives of the Water Framework Directive.

This poster will present the approach being adopted. This includes the definition, delineation, and characterization of a nested hierarchy of spatial units from catchment to geomorphic unit scales. It also includes the indicators that are being considered to support understanding of current river geomorphic functioning and its historical dynamics and to provide a context for assessing sensitivity to future changes in environmental conditions or management prescriptions.

Time-history of the gravel sheet in Ardennian rivers over the last 100,000 years

HOUBRECHTS G., DENIS A.C., JUVIGNÉ E., PETIT F.
University of Liège - Department of Geography, LIEGE, BELGIUM

It is generally held that, in north-western Europe, the main part of the gravel sheets under river beds were deposited during the Weichselian period in a periglacial environment. However, other parameters such as propagation of knickpoints in fluvial networks may also influence incision or aggradation. However, only few studies have dated the periods of formation of the gravel sheets and have described their properties.

The first aim of this research was to determine the thickness of the gravel sheets still remaining under the river beds and to estimate the potential incision of these rivers before reaching the bedrock. Then we tried to answer a number of other questions: When did these thick gravel deposits fill the valley bottom? When were the lowest terraces abandoned? When did the rivers incise the bedrock? What is the morphology of the bedrock under the gravel layer?

Numerous boreholes were made by percussion drilling in different floodplains of the Ardenne Massif and core samples were taken, down to the bedrock. Afterwards, different volcanic tephra from the Late Pleistocene were used as stratigraphic markers to date the relative periods of terrace formation and to reconstruct the past evolution of the gravel sheets. Pollen and metallurgic slag were also used to date the periods of bed level evolution.

In the Ardennian massif, the thickness of the gravel sheet beneath the river beds is very variable (from 10 m in the downstream part of the Ourthe River to less than 1 m in the upper catchments). In some valleys, weathered bedrock has been observed under the gravel sheet to a thickness of several meters.

Different phases of accumulation and incision over the last 100,000 years have been dated. Some evolutions can be clearly linked to climate changes but some modifications of bed levels also occurred during the Weichselian period and could be a response to the propagation of knickpoints in the fluvial networks.

****

Lithotopo units as ecoregions of fluvial systems: methodology and application

HORACIO J.(1), PÉREZ-ALBERTI A.(2), OLLERO A.(3), CANOSA J.F.(4)
(1) Dept. of Geography, University of Santiago de Compostela, SANTIAGO DE COMPOSTELA, SPAIN ; (2) Environmental Technology Laboratory. Technology Research Institute. University of Santiago de Compostela, SANTIAGO DE COMPOSTELA, SPAIN ; (3) Dept. of Geography and Land Management, University of Zaragoza, ZARAGOZA, SPAIN ; (4) Dept. of Geology, University of Oviedo, OVIEDO, SPAIN

A lithotopo unit (LU) is an area with the same lithology and topography, where fluvial-ecological processes respond to similar behaviors. Our research proposes a method for identifying each unit type and analyzes its prevailing morphometric, energetic, sedimentary and hydraulic features. An LU perfectly fits the definition of ecoregion used by the Water Framework Directive (WFD) to classify surface water bodies, hence the importance of designing methodologies that generate distinct and internally homogeneous LUs.

Our method classifies the lithology according to the content of SiO_2 (silica) and by its mechanical behavior against erosion (isotropic and anisotropic rocks). The topographic descriptors that we used were slope, elevation and roughness. All individual variables were assembled into homogeneous groups through multivariate classification techniques. The LU testing took place in Galicia (29.562 km^2, NW of Spain), and yielded a total of eight types. The behavior of the variables was checked at 29 points of the Cabe River basin (732 km2), which includes up to four different LU types. The morphometric variables that we analyzed were the drainage density, the frequency index and the torrentiality coefficient. As for the hydraulic geometry, we studied, at bankfull level, the hydraulic radius, the width / depth ratio and the average depth. The specific stream power and the average size of the sediment were also estimated.

Our results concern three points: i) for each LU, the WFD's System B geomorphological descriptors and those used by us, move in a range of very stable values;ii) the watershed / subwatershed provides a logical scale for resource management, but the LU sets a protocol of action, as river forms and processes are linked toeach LU; iii) LU mapping helps organize the geomorphological and ecological compression of river systems, and facilitates their application and comparison with other areas.

Effects of a major flood on a mountain river on physical habitat conditions for river biota, channel morphology and valley-floor infrastructure

HAJDUKIEWICZ H.(1), WYZGA B.(1), MIKUS P.(1), ZAWIEJSKA J.(2), RADECKI-PAWLIK A.(3)
(1) Institute of Nature Conservation, Polish Academy of Sciences, KRAKOW, POLAND ; (2) Institute of Geography, Pedagogical University, KRAKOW, POLAND ; (3) Department of Hydraulic Engineering and Geotechnique, Agricultural University, KRAKOW, POLAND

To restore the gravel-bed Biała River, Polish Carpathians, establishing erodible corridor was proposed in two reaches located in its mountain and foothill course. In these reaches, longer, unmanaged channel sections alternate with short, channelized sections and that pattern of channel types is associated with a general tendency towards increasing channel narrowing and incision in the downstream direction. In June 2010 a flood with a recurrence interval of at least tens of years occurred on the river and this study aims at determining its effects on physical habitat conditions for river biota, channel morphology and valley-floor infrastructure. Surveys of 10 pairs of closely located unmanaged and channelized cross-sections, performed in 2009 and the late summer of 2010, allowed to assess the flood-induced changes to physical habitat conditions. Before the flood, unmanaged cross-sections were typified by a significantly greater number of low-flow channels, finer bed material and greater lateral variability in depth-averaged and near-bed flow velocity than channelized cross-sections. The flood seems to have equalized habitat conditions in both types of river cross-sections, obliterating differences in particular physical habitat parameters between channelized and unmanaged channel sections. A comparison of channel planform from 2009 and 2012 indicated that greater channel incision typical of more downstream sections was reflected in a lower degree of the river widening by the flood. Bankfull channel width increased by half in the surveyed unmanaged cross-sections and by one third in the channelized cross-sections. However, damage to the valley-floor infrastructure was practically limited to the channelized river sections, indicating incompetent management of riparian areas rather that the degree of river widening as a principal reason for the economic losses during the flood.

****

Sediment yield prediction in river basins by means of geomorphic parameters and regression- ANN relationships

KHANCHOUL K.(1), TOURKI M.(1), LE BISSONNAIS Y.(2)
(1) Badji Mokhtar University-Annaba, ANNABA, ALGERIA ; (2) LISAH, SUPAGRO, MONTPELLIER, FRANCE

Knowledge of sediment yield and the factors controlling it provides useful information for estimating erosion intensities within river basins. Probst and Amiotte-Suchet (1992), in their review of suspended sediment transported by wadis in the Maghreb, have underlined the lack of available data for such river types. Nevertheless, further study of the quantification of sediment transport in these regions and its variability is clearly required. The objective of this study is to build a model from which suspended sediment yield can be estimated from ungauged rivers using computed suspended sediment yield and physical factors. In this work, regression relationships are built between suspended sediment yield that is computed from rating curves established from long-term measurement series at gauging stations in Algerian drainage basins and corresponding basic physiographic parameters (precipitation, runoff, coefficient of torrentiality, basin area, orographic coefficient, lithology index). Moreover, the basic neural network is employed in this study. This used stochastic process possesses a three-layer learning network consisting of the input layer, the hidden layer, and the output layer. The proposed Levenberg–Marquardt algorithm to train the neural networks of the current research study is based on the feedforward backpropagation method. Different combinations of several internal parameters, i.e., data partitioning approach, number of neurons in each hidden layer, transfer function, error goal, are tried. The regression performance (r) and the computation of the efficiency factor (EF) have provided information about the predictive capabilities of the two types of models. Single plot displays of network outputs with respect to targets for training, validation, and test sets have indicated that ANNs are a promising method for predicting suspended sediment yield (r = 0.997 and EF = 0.99), as they have performed better than the conventional multiple regression model.

Longitudinal and temporal variation of bed-material grain size in a mountain river disturbed by gravel extraction and channelization, the Czarny Dunajec, Polish Carpathians

ZAWIEJSKA J.(1), HAJDUKIEWICZ H.(2), WYZGA B.(2), RADECKI-PAWLIK A.(3), MIKUS P.(2)
(1) Institute of Geography, Pedagogical University of Cracow, KRAKOW, POLAND ; (2) Institute of Nature Conservation, Polish Academy of Sciences, KRAKOW, POLAND ; (3) Department of Hydraulics Engineering and Geotechnique, Agricultural University, KRAKOW, POLAND

The impact of human disturbances on the conditions of channel sedimentation in the Czarny Dunajec River, Polish Carpathians, was investigated by reconstructing longitudinal and temporal changes in the grain size of bar sediments. We determined surface bed-material grain size on 47 gravel bars along an 18 km long river reach without tributaries in which some sections were modified by gravel extraction and the resultant channel incision, or channelization over the past few decades. A downstream fining trend of bar sediments was established based on the sites with average river width and a vertically stable channel, and used as reference for the other samples. In the deeply incised, upper part of the reach, bar gravels are markedly coarser than the reference grain size. Here, sieving analysis of channel sediments formed at different periods showed coarsening of the bed material over the second half of the 20th century. With larger particles extracted from the channel in the past decades, fine grains must have been flushed out, whereas the concentration of flood flows in the deeper, narrower channel has increased their competence, enabling a delivery of the coarse particles from the upstream reach. In the narrow, regulated channel section in the middle part of the reach, bar sediments exhibit better-than-average sorting and change from coarser to graded similarly to the reference grain size along the section. In a wide, multi-thread channel in the lower part of the reach, bar gravels are distinctly finer than the reference grain size. The middle section has been channelized to prevent sediment delivery to a downstream-located dam reservoir. However, it actually efficiently transfers the bed material evacuated from the upstream, incising river section. As low unit stream power and high channel-form roughness facilitate sediment deposition in the unmanaged, lower part of the reach, it functions as a sediment sink, reducing bed material delivery to the dam reservoir.

****

The Interannual regime of rivers: a comparison between peixe (western Sao Paulo State, Brazil) and dee river (UK) and the sea index influences

ROCHA P.(1), HOOKE J.M.(2)
(1) UNESP / BRAZIL, PRESIDENTE PRUDENTE-SP, BRAZIL ; (2) University of Liverpool, LIVERPOOL, UNITED KINGDOM

Oceans arethe lower boundary condition most important for climate and have leading a role in interdecadal climate variability. Many researchers have shown the importance of the Ocean Indices in the river regime and hydrology of catchments, by direct or indirect methods. This paper discusses the hydrological behaviour of the Peixe River in Brazil and Dee River in UK, and its relationship with the main climatic Oceans Index. The rivers drain catchments of different global and regional climate zones. The Peixe River basin drains a 2.910 km^2area. The Dee River drains a 1.013,2 km^2 catchments area. Both rivers are in the Cf areas of Climatic Classification of Köppen. The data series of the gauging stations was obtained from official sites in Brazil (National Water Agency) and United Kingdom (National Water Archive). The Tropical South Atlantic Index (TSA) data, the Pacific Decadal Oscillation (PDO) Index; the North Atlantic Oscillation Index(NAO) were made from literatureand complemented by National Oceanic and Atmospheric Administration -Physical Science Division (NOOA-PSD). To compare the hydrological regime of the rivers were used the inter-annual mean deviation of the 1948-2007 series for the Peixe River and 1938-2010 series for the Dee River and its correlations among PDO, TSA and NAO Indices. The results indicate that there was significant variability in the hydrologic regime of Peixe River throughout the evaluated series, with three well-defined periods; the most significant changes happened after the 1970´s, associated with the warm period of the PDO Index. Both PDO and TSA Index had a positive relationship with the Mean Deviation of Peixe River, indicating an influence on the river's flow regime. For the Dee River, three periods were also identified and a positive relationship with the NAO Index. Despite of the positive relationship among rivers and Ocean Indices, they were with low r^2.

Morphological changes along alpine river reaches affected by natural et human impact: examples on river pellice and chisone (NW Italy)

AUDISIO C.(1), TURCONI L.(2)
(1) University of Chieti - Pescara, MURELLO (CN), ITALY ; (2) CNR-IRPI, TORINO, ITALY

The causes of modification along rivers are either natural or human.

If the morphological variations in the past were mainly determined by the severe and extreme floods which periodically affected the rivers, since 1940s, as a lot of works and researches demonstrated, the natural impact cannot be separated by the human impact. The presence of dams, the channelization works, the channel modification and river diversion, the bridge crossing, the sediment removal and mining are part of the anthropic causes which have influenced the river adjustments.

The present work illustrates a summary of the studies and researches done on channel adjustment and evolutionary trend of two rivers flowing in the North Western sector of Italy. The used methodology is based on the reconstruction of spatial *variation*in channel *morphology*and sediment dynamicsusing historical maps and aerial photos in the medium and short-term period. Contemporary, the principal natural and human interventions on the river have been investigated. All data are inserted in a GIS for the uniformity of the coordinate system. Based on the availability of documentary sources, cartographical, photographical and ortho-photographical data, the method allows a reconstruction of the history of the river. Then, the modification of the channel and the active bankfull were related to the natural and human impacts trying to investigate which is the preponderant cause of variation and how floods and human intervention influence each other. The modification of some index over time, as the width, is a useful tool for interpreting the evolutionary trend of the river and tries also to predict its future evolution.

The studied rivers are: River Pellice (35 km – from Luserna San Giovanni to Po confluence), and River Chisone (12 km – from Pinerolo to Pellice confluence).

****

Annual landform changes and their effects on pioneer species in the active braided gravel-bed river in the upper reaches of the Azusa River, central Japan

SHIMAZU H.
Rissho University, KUMAGAYA, JAPAN

The upper reaches of the Azusa River, central Japan, a braided gravel-bed river, is characterized by a pioneer species, Salix *arbutifolia*, occurring as patches of various age classes and old isolated trees in the active riverbed. This is a rare species which has a limited geographic distribution in the Japanese Islands. This is one of the important riverine landscapes in Japan. This study aims to clarify formative process of the landscape from the geomorphological viewpoint. The geomorphological maps of the observation site, which were made in every summer from 1994 to 2012, and which recorded annual landform changes of the riverbed and images of the riverbed taken by interval shooting cameras recorded flood conditions in the summer and autumn season in 2011 and after late spring in 2012 revealed geomorphological processes. Sediment transport and/or landform changes occurred every year in severe heavy rain events more than 100 millimeters per day during the snowmelt flooding season in April and May and/or the rainy season in June and July. There were some stable spots in bars and/or islands in the active riverbed for several years where pioneer plants, especially Salix *arbutifolia*, germinated and grew to young pioneer patches. Generally lateral erosion gives serious disturbance for young pioneer patches. Because most channel migrations were not caused by lateral shifting with lateral erosion but by channel burying and new channel excavation, they could survive after channel migration event. Sometimes slight lateral erosion occurred and it caused destruction and/or size reduction of the patches. If a seedling patch remains not to be destroyed for several years, it becomes a grown patch, finally old isolated trees. Because the germination year was different each patch, the patches are in various age classes. These geomorphic processes provide peculiar riverine landscape in the upper reaches of the Azusa River.

Towards understanding spatial and temporal variations in landscape response to climate change at an upland Karoo site, South Africa.

OLDKNOW C., HOOKE J., LANG A., MAUZ B.
University of Liverpool, LIVERPOOL, UNITED KINGDOM

The semi-arid landscapes of the Karoo, South Africa are highly susceptible to land degradation. Recent studies have shown that erosion has increased tenfold in the past 200 years since the onset of European colonisation expressed through gullying and badlands. Yet these rapidly eroding areas occur in striking juxtaposition with areas of apparent stability, where dolerite dykes intrude into softer Karoo Supergroup mudstones and shales.

Within the Karoo landscape lies the Ganora catchment (31^{o} 51'34.45''S, 24^{o} 37'48.95E), which is a tributary system of the southward flowing Sundays River which drains the Great Escarpment. Patterns of contemporary erosion appear to be superimposed on a longer term record of cut and fill that predates European occupation. Other work nearby suggests that alluvial fills are much older than previously thought (> 100 ka), and could be diachronous due to effects of sediment disconnectivity. Major research questions are herein addressed concerning: i) the timing of past cut and fill episodes and whether these can be explained in terms of autogenic fluvial sedimentation dynamics or climate, ii) Evaluation of intra-catchment scale changes in landscape sensitivity and response through time. The combined results of soil magnetic analyses and OSL dating of alluvial sediments are presented in order to explore spatial variations in landscape response, and whether apparent signals of change are relatable to (non)autogenic factors. Initial magnetic susceptibility determinations provide clear discrimination between different sediment generating zones, and have thus enabled alluvial fill sediments to be fingerprinted.

The preliminary data presented signify a key step towards the creation of a landscape response model that incorporates the influence of buffers and barriers to sediment movement, the dynamics of sediment connectivity through time with associated mechanisms and feedbacks in upland Karoo catchments.

****

Regional scenario of Quaternary climatic oscillations: low river terraces and flood plains in the current context of Depressão Periférica Paulista

STORANI D.L., PEREZ FILHO A.
UNICAMP, CAMPINAS, BRAZIL

The topography of São Paulo State, in the southeast region of Brazil, is divided into geomorphological provinces analyzed from its structure, formation and lithologic basis. Depressão Periférica Paulista (Paulista Peripheral Depression) corresponds to one of these provinces, with a hilly topography, and is a zone of occurence of Paleozoic and Mesozoic sedimentary sequences in São Paulo State, also including discontinuous areas of intrusive bodies. Small areas of Precambrian rocks are also incorporated in this province. Its origin, according with Ab'Saber (1969), is predominantly denudacional.

The proposed study aims to identify and interpret the levels of low Quaternary river terraces and floodplains using the OSL (Optically Stimulated Luminescence) technique in different surface formations located on the terraces and recent alluvium in the selected rivers of the studied geomorphological province. The results obtained will allow to trace the relationship between the genesis of such forms, and possible preterit environmental conditions, in an attempt to identify and explain possible alternations of semi-arid periods and the subsequent carving of the river canal in hot and humid conditions.

The results obtained by the datation method will build a regionalized set for climate oscillations, mainly from the Quaternary (Pleistocene and Holocene). It will also be taken into account the influence of neotectonic activities in the shaping of such forms of topography, allowing the analysis of a regional correspondence between ages and levels of river terraces of the same geomorphological province.

Quaternary Basin of the Pantanal Mato-Grossense, Brazil: fluvial Megafans

FACINCANI E.M., BACANI V.M., SANTOS R.M., PEREIRA W.
Universidade Federal de Mato Grosso do Sul-CPaq, AQUIDAUANA, BRAZIL

The Pantanal is a tectonically active sedimentary basin marked by several fluvial fans, which represent the main feature to determine the characteristics of the Pantanal landscape. This work presents the concepts involved in the formation of the fluvial megafans that, in the Pantanal, involves climatic, hydrological, sedimentological and Neotectonics aspects. The fluvial fans of Pantanal are depositional systems shaped as an open fan or a cone segment, characterized by distributary channels of great lateral mobility, due to unconfined flow from the highlands surrounding the Pantanal Basin. So it is important to understand the formation of mega-fans fluvial systems, because its mechanism is the key to the understanding of the filling of the sedimentary basin of Pantanal. The megafans of Pantanal Basin are positioned mainly at the left margin of Paraguay River,(Corixo-Grande Paraguay, São Lourenço, Taquari, Negro,Taboco, Cuiabá and Aquidauana-Miranda) surrounded by the highlands of Maracaju-Campo Grande, Taquari-Itiquira, Guimarães e Parecis.

****

Negro River: fluvial megafan. Southeastern border of the Pantanal Basin, Brazil

FACINCANI E.M.(1), BACANI V.M.(1), SANTOS R.M.(1), QUIRINO P.B.(1), CORDEIRO B.M.(2), PEREIRA W.(1)
(1) Universidade Federal de Mato Grosso do Sul-CPaq, AQUIDAUANA, BRAZIL ; (2) Universidade de São Paulo, SÃO PAULO, BRAZIL

The Negro fluvial megafan is a depositional system located on the southeastern border of the Pantanal wetland and has been evolving since the Pleistocene. Its surface exhibits modern and relict geomorphological features, such as channels and paleochannels. The NegroRiverflows westward and belongs to the Upper Paraguaydrainage basin. Theater-headed valleys characterize the catchment area on the Maracaju-Campo Grande Plateau, where the NegroRivershows an obsequent behavior in relation to Paleozoic and Mesozoic sedimentary strata of Paranabasin. A conspicuous NNE escarpment is the natural limit between the source area on the plateau and the depositional setting on the Pantanal wetland. The geomorphological zonation allowed to establish an evolution started in the late Pleistocene when unconfined flows given rise to formation of a proximal lobe. During a period dominated by erosion an incised valley has cut older deposits on the upper fan. Sedimentation during Holocene times has been taken place on the modern distal distributary fan lobe and on the meander belt that aggraded the incised valley.

Evaluating a functional hydromorphological restoration of a lateral channel of the Upper Rhine (France): first results and implications of the temporal trajectory to restoration sustainability

LEJEUNE Q., SCHMITT L., ZIMMERMANN A., ESCHBACH D.
University of Strasbourg, ERL 7230, STRASBOURG, FRANCE

The Upper Rhine hydrosystem exhibits a high biodiversity. Since mid-19th century, several engineering projects developed for flood control, agriculture, navigation and hydropower, have drastically impacted aquatic and riparian habitats. In this context, the specific alluvial species of the Rohrschollen natural reserve is declining. Its main watercourse, the Bauerngrundwasser, an anastomosing channel of the Rhine, has now a constant and low discharge (under 0.1m^3/s), inducing a high rate of fine sediment deposition. During periods of high flow, the site is flooded but water has no energy due to a dam's backwater effect.

The LIFE+ project "Restauration de la dynamique des habitats alluviaux rhénans sur l'île du Rohrschollen", managed by the City of Strasbourg, plans to restore the hydromorphological and ecological functionality of the hydrosystem: bedload dynamics, channel mobility, surface water-groundwater exchanges, renewal of pioneer ecosystems. Thus, the Bauerngrundwasser will be reconnected to the Rhine by building a new upstream connection channel. Water input will attain 80m^3/s, leading to dynamic floods and making of this project one of the most ambitious for the French side.

To assess the efficiency of this restoration project, a hydromorphological monitoring (included in an inter-disciplinary project) is carried out and is based on the comparison of pre- and post-restoration dynamics. It includes in particular a topographic (LiDAR, theodolite), a cartographic (aerial photo), a sediment transport (sampling, PIT tag, erosion chain), a hydrological (water level sensors, gauging) and a hydrogeological (piezometer) studies. This paper will give the first results, as well as the implications of the temporal trajectory of the system (historical study based on old maps, aerial photos and sedimentological investigations), which have notably been got in order to give some prospective guidelines concerning the efficiency and sustainability of the restoration.

****

Fluvial geomorphological adjustments to global change in Iberian Rivers

BESN P., IBISATE A.
University of the Basque Country - Department of Geography, Prehistory and Archaeology, VITORIA-GASTEIZ, SPAIN

Global change, not only climatologic conditions but also and especially human impacts have long affected fluvial dynamics, and geomorphic processes and forms in Iberian Rivers due to their particular Mediterranean climatic conditions and the heavy pressure on water resources.

Based on aerial photographs and cartography changes in channel dimensions, planform and vertical adjustments have been analysed in several reaches of 4 river basins representing different environmental conditions: Ebro, Llobregat, Júcar and Guadalquivir. The variations in active channel and riparian surfaces were studied by comparing aerial photographs and ortophoto maps using GIS tools (ArcGis 10). The aerial photographs were firstly georeferenced and geometrically corrected, and the different surfaces digitalized (water surface, unvegetated sediment bars, pioneer vegetation, riparian forest, forest plantations, crops and artificial surfaces). Finally changes of the different surfaces along all the studied years have been measured and quantified. Besides that vertical adjustments were analysed comparing cartography from different dates.

These changes have been related with changes on the river basin and river course (land uses, precipitation, reservoirs, water abstractions, bank protections, etc.) as well as hydrological conditions, mainly floods.

Overall all the reaches present a reduction of their fluvial surface, principally active channel, a channel narrowing and a lost of diversity. Differences have been detected depending on the basin characteristics and climatic conditions of each river reach.

Elucidating the level of influence of key factors on the spatial distribution of overbank deposition

GAMBOA-ROCHA A., STEWARDSON M., RUTHERFURD I., FINLAYSON B.
Melbourne University, MELBOURNE, AUSTRALIA

Floodplains evolve from sediment transport, erosion and deposition processes. As these floodplain-building processes determine floodplain evolution in alluvial systems, it is important to understand the mechanisms and factors that influence the spatial distribution of overbank sediment deposition.

This investigation uses a novel modeling approach combined with Cs^{137} dating techniques to assess the key factors producing spatial patterns of overbank sediment deposition.

Individual floodplain units were strategically selected using LIDAR imagery. These were classified by their hydraulic connectivity and used to locate sites for sediment core collection and radionuclide analysis. A process based conceptual model was developed from an analysis of existing models as reported in the literature. A numerical model was constructed from a refined analysis of the interactions among the key factors that determine overbank sediment transport and deposition. This model therefore incorporates the relationship that exists among the key factors influencing overbank deposition amounts and patterns and also includes an improved relationship between the spatial variability of suspended sediment concentration and sediment travel time. A sensitivity analysis was designed to identify the factors that exerted the greatest influence on the spatial variability of overbank sediment deposition.

Results of the sensitivity analysis suggest that key influencing factors controlling the spatial distribution of overbank sedimentation are variation in (i) the duration of flood inundation and (ii) the flow path and consequent travel times from the channel. The model accuracy was evaluated against field-estimates of overbank sediment deposition. We also found that there is generally good correspondence between model predictions and the measured deposition rates. Our results provide a refined conceptualisation of floodplain sedimentation processes as a basis for further research.

****

Variation trend of the sedimentation rate in the Yinchuan Plain of the upper Yellow River since 0.7 Ma B.P. and its main influencing factors

WANG S., YAN Y., HE L., YAN M.
Institute of Geographic Sciences and Natural Resources Research; Chinese Academy of Sciences, BEIJING, CHINA

As an alluvial plain of the upper Yellow River, the Yinchuan Plain has a Quaternary stratum is closed to 1 km. In order to reveal the historical variation trend of the sedimentation rate in the Yinchuan Plain and analyze its influencing factors, this work mainly based on the dating data of a bore columnar section (thickness 189.6 m) in the plain to estimate the sedimentation rate change since 0.7Ma, and to couple it with the variation of the channel downcutting rate at the Heishanxia gorge (upwards the Yinchuan Plain). The results indicate that an allometric function (R^2=0.977) could be used to fit the historical variation trend of the sedimentation rate with time in the Yinchuan plain. The mean sedimentation rate is 0.115 mm/a in the period from 0.7 Ma B.P. to 112.35 ka B.P. while a distinct increase trend (mean value is 1.962 mm/a) since 112.35 ka B.P. The relationship between time and the channel downcutting rate could also be fitted by a similar allometric function (R^2=0.967). To reveal the potential relation between the sedimentation rate and the channel downcutting rate we calculated the sedimentation rate and the channel downcutting rate in an interval of 10 ka according to the relevant fitted functions, respectively, and a linear relationship (R^2=0.995) between the sedimentation rate and the channel downcutting rate was fitted. It means that the change of the sedimentation rate in the Yinchuan Plain was mainly influenced by the tectonic rise in the upstream basin. The climate of the upper Yellow River basinhas changed to more arid since 120 ka B.P. and has induced decrease of the annual precipitation which could induce the decrease of the vegetation cover and enhanced rainstorm which could induce more strong erosion in the upriver Yellow River basin. The increase of the tectonic rise and the climate change to aridity were the main influencing factor on the increase of sedimentation rate in the Yinchuan plain since 112.35 ka B.P.

Velocity distribution of turbulent open-channel flow over permeable rough bed

CHEN X., LIN M., LIN B.
Fujian Normal University, FUZHOU, CHINA

Fluvial river bed usually consists of sands. When the diameter of the sands is large enough, such as gravel bed, the effects of bed permeability on the main stream flow can not been neglected and the flow characteristics are different from that of impermeable bed, which is still need to be well studied. A laboratory experimental research is reported in the paper which considered such effect on the velocity distribution of turbulent open-channel flow. The experiment was conducted in a glass-sided flume that is 20m long, 0.8m wide and 0.6m deep. The bed of flume was glued a layer of uniform marbles with a diameter of 1 cm. Located at a distance 10m from the upstream end of the flume is a rectangular recess that is 1.65m long and 0.7m wide. The permeable bed is simulated in the recess where is well packed with twelve layers of the same marbles. The velocity measurements were carried out using a laser Doppler velocimeter (LDV, DANTEC) and the probe of the LDV was installed at a high resolution traversing system. The measurements were conducted for three flow conditions. Velocity distribution at 2 locations for impermeable bed and 3 for permeable bed were measured. The results show that the velocity distribution for impermeable bed follows the law of the wall when the reference level is lowered to 0.25-diameter of the marble top. For permeable bed, no-slip condition at bed surface is no longer available and the velocity distribution is the same as that of impermeable bed when a slip velocity was used to modify, and the values of shear velocity are found to increase. How the slip velocity and shear velocity varies are still need to further investigated.

****

Knickpoint initiation and migration rate of bedrock rivers dissecting the Middle to Late Pleistocene marine terraces at North Sanriku coast, NE Japan

OGAMI T.
Chuo University, TOKYO, JAPAN

River knickpoints are detected from longitudinal profiles of rivers at North Sanriku coast, NE Japan. Three bedrock rivers with knickpoints are investigated. Length and catchment areas of the rivers varies 23.5 to 30.1 km and 54.6 to 92.1 km^2, respectively. The rivers are cross cutting the Middle to Late Pleistocene marine terraces. The initiations of the river knickpoints are estimated based on geomorphic features of marine terraces and shoreline angles.

In study area, the Middle to Late Pleistocene marine terraces are developing, which indicate broad tectonic uplifting at North Sanriku coast. Formation ages of the terraces are determined by tephro-chronology. There are at least 8 marine terraces developed during interglacial high-stand periods (MIS 19, 17, 15, 13, 11, 9, 7 and 5e). Altitude of surface of the terraces vary 270 m to 30 m above sea level. Former shorelines dividing the marine terraces are traced approximately parallel each other along present coast.

The river knickpoint of each river is formed at 4.5 km, 5.0 km and 17 km path length from river mouth. They should have been migrating upstream as a result of bedrock erosion since their initiation. Assuming that the knickpoints were formed at the edge of marine terraces, initiating places of the knickpoints are confined within specific area. The place of the initial knickpoints should be located at seaward and higher altitude than present position of knickpoints.

At one of the rivers, the initial knickpoint is estimated to be formed at edge of MIS 13 marine terrace, which formed as sea-cliff during MIS 11 high-stand. At another river, the initial knickpoint is estimated at edge of either MIS 15 or 13 marine terraces, which formed as MIS 13 or 11 sea-cliff. As a result, averaged migration rate of knickpoints are 7.5 m/ka (in 400 ka) and 11−7.2 m/ka (in 400−480 ka). Based on the knickpoint migration rates, incision rate of bedrock rivers are discussed.

Late Quaternary evolution of the lower reaches of Ziliana stream in south Mt. Olympus (Greece)

BATHRELLOS G., SKILODIMOU H., MAROUKIAN H., GAKI-PAPANASTASSIOU K.
National & Kapodistrian University of Athens, Faculty of Geology & Geoenvironment, Department of Geography & Climatology, ZOGRAFOS, ATHENS, GREECE

Active tectonism influences the evolution of hydrographic networks. The uplift and the faults of Mount Olympus directly control the development of its major drainage networks. The study area is located at the southwestern edge of the eastern piedmont of Olympus in east Central Greece. The piedmont is composed of three extensive east looking alluvial fans of Quaternary age and a thickness of 1,100m that are inactive and eroding today. The southern alluvial fan of the Olympus piedmont is located in the study area.

This study examines the paleogeographic evolution of the lower reaches of Lazi Griva, Ziliana and Vathyrema streams having a total drainage area of 141Km^2. For this purpose, detailed field work, large scale geomorphological mapping, sedimentological analysis and geoarcheological investigations were performed. A spatial database was created, and ArcGIS 10 software was used to process the collected data.

The uplift of Mount Olympus has led to active downcutting in the upper reaches of the three streams and enhanced sedimentation rates and occasional heavy floods in the lower reaches. The reactivation of a major normal fault zone running N-S along the eastern front of Mount Olympus has created a temporary local base level (knick-point) at the exit of the three streams from the mountain. At this location, due to the fault zone, the three streams join and reach the sea in a single main channel of Ziliana. At their confluence, on a terrace, there is the Middle Geometric settlement of Livithra (the burial place of mythic musician Orpheus) which is believed to have been destroyed by an earthquake and/or a heavy flood. Consequently, the Quaternary active tectonism is the main geomorphic factor influencing the evolution of the lower reaches of Ziliana stream.

****

Spatial and temporal variability in cut-off sedimentation

HOOKE J.
University of Liverpool, LIVERPOOL, UNITED KINGDOM

Formation of cut-offs in meandering rivers is a major part of floodplain construction and is very important in providing varied habitats as well as the remnants of old channels leaving topographic and compositional signals in the floodplain. Some research has demonstrated the effects of orientation and morphology of cut-off on sedimentation rates but limited data are available on initial patterns and rates of infill. The occurrence of several cut-offs at various dates over the past 30 years on one active meandering river reach with pre-existing morphological data enables the spatial and temporal distributions of sedimentation to be examined. These have all experienced a common hydrological, sediment and land use regime. Data on rates and patterns of sedimentation are presented. The evidence is that rapid, coarse sedimentation occurs initially in the upstream cut-off entrance then finer sedimentation to half bankfull level within a few years. Infill of the downstream exit is much slower and comprises much finer sediment. The amount of infill and presence of water bodies within the old channel is influenced by the pre-existing morphology of pools, riffles and bars. This is closely related to the morphology of the bend and its stage of meander development in the commonly occurring evolutionary sequence. Compound bends at time of cut-off are common and thus a shallowing occurs in the apex, influencing depth of sedimentation and formation of an ox-bow lake. These results have important implications for inferences made from sediment cores in palaeochannels if position of the cores in relation to the meander morphology is not taken into account adequately. The data on variability of habitats created in cut-offs and likely timescales of infill are valuable for geomorphological and ecological management.

The decay and related environment problems of the deltaic rivers in West Bengal, India

BERA B.
Rabindra Bharati University, KOLKATA, INDIA

We live in a land of million rivers. Each of these rivers and their tributaries play an important role in our social, cultural and economic lives. But, at present the rivers of deltaic Bengal are in the state of decay. The river Sialmari, Bhairab, Chota Bhairab, Bhandardaha nala are the main tributaries of river Jalangi**,** and river Jalangi is also the tributary of Bhagirathi-Hugli and distributary of Padma**.** Though river Bhagirathi-Hugli is the most important river, during 16th century River Jalangi was most important river in West Bengal than river Bhagirathi. Another river Mathabhanga is bifurcated into two branches at Majdia as Churni and Ichamati, also the distributaries of river Padma. It is evident from Rennel's Map, several other rivers were also flowing on the vast tract of Murshidabad and Nadia districts of West Bengal during 16th century. Due to shift of river course of Ganga-Padma and gradual siltation at the off-take point of Nadia rivers, many rivers are gradually decayed, somewhere are converted into palaeo channels, otherwise they are entirely disappeared.

Several culverts, bridges and concrete embankments, brick fields have been constructed across the deltaic rivers simultaneously. As a result upland discharge and capability of the rivers are decreasing day by day and various environmental hazards and disasters (flood, river bank erosion, soil erosion) are also occurred in the consecutive years. For unscientific human interference the micro geomorphological features have been modified. Many important rivers are already choked out.

****

Quaternary Paleolandforms at Sanaga-Mbam confluence between geography and historical palaeoenvironmental approach

EKASSI ONDOUA L.(1), TCHINDJANG M.(1), WAKPONOU A.(2)
(1) University of Yaoundé I, YAOUNDE, CAMEROON ; (2) University of Ngaoundéré, NGAOUNDERE, CAMEROON

The Bafia peneplains known as Gulf of Bafia situated at the river Mbam and Sanaga confuence is an area which fairly recorded environmental changes (past and present) recognized by the markers such as the terraces observed on the major rivers. However, apart from a few sources for the period before the Quaternary, information on geomorphological landscapes are mentioned only by regional maps.

This study therefore aims to overcome this lack of information by proceeding to paleoenvironmental studies. In addition to documentary sources that highlight old depletion of Plio-Quaternary climate, this work is based on field studies and observations throughout this Bafia peneplain to reflect the relationships between the different geomorphic units. Superficial deposits samples collected on five pits for this purpose have been submitted to sedimentological analysis in the laboratory.

The results have clarified the various stages of the implementation of paleolandforms (palaeosurfaces, palaeotopographies and terraces), inheritance of Quaternary climatic episodes. Deduction of it paleoclimatic significance and the approximate reconstruction rhythms that marked the geomorphological landscape allow us to understand the current evolution of the environment at the Mbam- Sanaga confluence.

Current development of the bed and major Chari river bank at N'Djamena since Holocene

DOUDJE K.(1), TCHINDJANG M.(2), MOUPENG B.(1)
(1) University of N'Djamena, N'DJAMENA, CHAD ; (2) University of Yaoundé I, YAOUNDE, CAMEROON

River bed provides a lot of information on the evolution of palaeoclimate. But it also help to build an example of models to illustrate some dynamic climatic conditions and geological data. These considerations lead us to study the erosion on the Chari river banks from the Holocene to the present day in N'Djamena. Chari river is an endorheic watercourse who dug his bed in tertiary and quaternary sediments. This river belongs to a tropical system across two types of climate: tropical wet and tropical dry season contrasts. To realize this study, we carried out observations and samples collecting across the Chari banks.

Samplings were made on river sections occupied by banks and quarries; these samples were examined with a microscope and a laboratory tests have been made. The data collection data are supplemented by aerial photographs and satellite images which were used to assess Chari bank erosion. Samples from open cuts by sediments banks showed that it come from fluvio-lacustrine origin deposited during the palaeo-Holocene climatic change. They are mainly sandy clay materials inconsistent silt, therefore less resistant to fluvial erosion. The lateral erosion affects those banks that recede. This phenomenon, its scale, concerned municipal authorities of the city.

Seasonal fluctuations of the Chari regime, seem to be the main factor of sedimentation of fine materials to medium cuts observed on levees which form the floodplain. The heterogeneity in the diversity of materials and layering can be explained by an irregular river dynamic and changing over time.

In addition, during the dry season, Chari river at N'Djamena, seems to suffer from wind influence. The presence of eolised sand as well as the lower level of the Holocene banks dune accumulations occurring in the dry season, now show that throughout the ages, the action of the trade winds has been ongoing on regular basis. This implies that conditions have changed since a few thousand years.

****

Development of the Chari river bank from Mandjaffa to Milezi (1970 - 2008) at N'Djamena (Tchad)

DOUDJE K.(1), TCHINDJANG M.(2), MOUPENG B.(1)
(1) University of N'Djamena, N'DJAMENA, CHAD ; (2) University of Yaoundé I, YAOUNDE, CAMEROON

The Chari River banks at N'Djamena lay on the land sandy - clay of Holocene. It presents from upstream and downstream of Milezi alluvial plain oversized (500 - 1500 m wide) in which the Chari current develops an unsuited system of mobile meandering.

This paper focuses on the geomorphic adjustments of this river banks system belonging to a low energy environment. It is seen as a response of the stream to the spatio - temporal variations of water and sediment discharges and / or a significant change in a component of its internal geometry. The changes in these independent and dependent variables of the riverbed are induced by intrinsic factors (evolutionary process inherent in water) and / or extrinsic (climate change, anthropogenic interventions direct and indirect).

Before understanding the modes and rates of change in these banks, we firstly try to clarify the influence of the geomorphological framework and liquid flow rates on the physical structure and the functioning of this fluvial hydrosystem. Thereafter, one will considered geomorphological changes in three aspects: the shaping of the Chari bed, the morpho - sedimentary dynamics related to seasonal variations in flows, and, finally, the effects of human activities on the evolution of the Chari banks.

The study of Holocene fluvial dynamics shows that the morphological structure of the current floodplain was definitively acquired in the Quaternary with the establishment of a coating sandy clay with an average of 1.5 to 2 m thick. A diachronic analysis of the horizontal alignment reveals a high mobility of the riverbed.

Geomorphological modifications induced by flows characteristics are associated with important solid sediment transportation on the river bed. These results are complementary to the previous work extended to the entire Chad basin.

Linking land use, riparian vegetation and channel changes in two catchments in the Upper Olifants River, Mpumalanga Province, South Africa

PETERSEN C., JOVANOVIC N.
CSIR, CAPE TOWN, SOUTH AFRICA

The Upper Olifants catchment is located in the Mpumalanga Province, South Africa. It is of economic significance with the main activities being mining, agriculture and power generation. Much of these activities are dependent on goods and services derived from aquatic ecosystems and have had a detrimental impact on these ecosystems. The overall research focus is on the fluvial environment and how this understanding can provide insight into the dynamics of pollution such as eutrophication and sedimentation. The aim was determining links between the land use, riparian vegetation and channel form. Geomorphological monitoring in the catchment focussed on two tributaries. The study sites occur in two geomorphological zones and vegetation biomes resulting in different channel impacts and geomorphological processes with agriculture as a common land use. Cross-sections were used for channel form and change. Bank and in-stream sediment and vegetation were sampled and the vegetation composition and distribution was used to assess the effectiveness of the riparian zone in stabilising the banks relative to bank sediments. Discharge data were also related to channel and riparian vegetation changes. In-channel discharge changes have an influence on river morphology, aquatic habitat change and influence the distribution of riparian plant communities. Preliminary results showed that the Wilge River remained relatively stable with little or no change in the channel geometry. The Koffiespruit was dynamic, showing evidence of bed and bank erosion, channel widening and narrowing and in-channel deposition. The riparian zone at the Wilge River adds to the stability of the banks whereas the absence of a riparian zone at the Koffiespruit influences the rivers' dynamic nature. Higher botanical diversities of plant species occurred at the Wilge as compared to the grassland setting of the Koffiespruit.

****

Morphological effects of a large flood: the case study of the Magra River (Italy)

RINALDI M., NARDI L.
Dipartimento di Ingegneria Civile e Ambientale, FIRENZE, ITALY

Understanding patterns and processes of channel response to a large flood and their relations with the evolutionary morphological trajectory is important in order to predict future changes, assess channel dynamics hazards, and identify possible management options.

This study aims to document channel changes occurred during a large flood and analyze them in the context of the longer term (last 150 years) evolutionary trajectory.

The Magra River catchment experienced an extreme flood event (return periods ranging from about 100-200 years along the Magra, and to 500 years along some tributaries) in October 2011 which resulted in morphological changes, flooding, damage and loss of human lives.

Analysis of past channel changes are based on multi-temporal series of aerial photos, cross-sections, longitudinal profiles, and field surveys. Morphological changes consequent to the flood event were investigated by: (1) field survey, including a reconstruction of the peak stage profile; (2) analysis of aerial photos and LiDAR before and after the event; (3) topographic survey of cross-sections.

Results of the evolutionary trends show a recent phase (last 10-15 years) of dominant aggradation and widening, following previous phases (last 100-150 years) of progressive narrowing and incision. The October 2011 produced a complex pattern of changes, but with prevailing aggradation of the channel bed alternated to erosion. Comparison of aerial photos before and after the flood event clearly shows an important channel widening, related to two different processes: (1) bank retreat; (2) overbank sedimentation of bedload. Comparison with the longer term evolutionary trajectory shows that the channel width is still in the range of variations occurred during the last 50-60 years.

Changes in channel width occurred along a series of partly-confined tributaries are more impressive, with frequent avulsions and, in some cases, a complete aggradation of the available alluvial plain.

Abandoned borrow pits from Buzau River's floodplain (Romania) - evolution and management

IOANA-TOROIMAC G., GRECU F.
University of Bucharest, Faculty of Geography, BUCHAREST, ROMANIA

Gravel and sand extraction from dry bars leaves borrow pits – negative landforms. They are an issue of river management, with consequences on river dynamics and ecological functions. Within this general framework, we analysed the example of Buzau River (watershed area: 5264 km^2; mean annual discharge: 29 m^3/s), which is coming down Romanian Curvature Carpathians; our analysis focused on a braided reach of Buzau River, located in a plain region, between Scurtesti and Stancesti villages. We analysed borrow pits of its floodplain to assess their diachronic evolution and to diagnose their management strategy. Therefore, firstly, we investigated their evolution using, both, topographic maps and aerial photos from the last three decades, and particle size measurements. Secondary, we assessed their management by interviewing quarries' owners, local authorities and managers (Romanian Waters National Administration and National Forests Service). Our analysis showed that gravel and sand extraction continues to take place in the abandoned active channel of the river. The resulting borrow pits function independently from the main channel, because Buzau River migrates slowly and it overflows rarely; marshes occur by water table rising. Regarding their management, they are abandoned after exploitation. Furthermore, they are in the middle of a conflict of goals – mining activity vs. habitats' conservation in a Site for Community Importance of Natura 2000 network. We concluded that abandoned borrow pits' management lacks of strategy. Furthermore, because of the uncertain reactivation of Buzau's abandoned active channel, a policy reassessment must be undertaken.

****

Evaluation of morphometric and morphological variables: analyses of topographic, geological and partitioning maps of Guaratuba basin ' Boraceia ' São Paulo ' Brasil

NUNES PATUCCI N., OLIVEIRA D.
UNIVERSIDADE DE SÃO PAULO, SÃO PAULO, BRAZIL

This current research is about the continuation of studies, in Guaratuba basin, started by ROSSI (1999) and OLIVEIRA (2003), however with emphasis on the morphometric and morphological processes. The Guaratuba basin is located in different geomorphological partitioning in Serra do Mar (plateau, sierra and coastal plain), measuring 113, 5 Km ² in area, and located approximately in 45º56´ and 45º52´of west longitude and 23º38´ and 23º42´ of south latitude. Were analyzed spatial and linear parameters to understand the relation between infiltration, runoff and terrain modeling, in order to develop a prognosis for the evolution of the area.

In an attempt to mediate these processes, first it was held the partitioning of topography, characterizing and describing the importance of each compartment, in the second stage it was obtained information regarding the surface structure of the landscape, such as geological and hydrological characterization and in the third moment, the realization of morphometric studies to the understanding of the physical environment of the area.

By the end, it was made the tabulation of the data and preparation of cartographic materials (slope, altimetry, partitioning, geological and drainage maps) using Geographic Information Systems (GIS), in order to provide explanations about the relation draining-sculpturing of the modeled.

To the preparation of the slope map, it was used the EMBRAPA slope classification, where the reliefs range from plan to heavily-mountainous, and to the execution of the altimetry map, it was used a scale that ranged between 80 to 970m.

The following spatial parameters were analyzed: density of rivers, drainage density, area, perimeter of basin, circularity index, maintenance coefficient, and shape index; the linear parameters verified were: the study and quantification of the hierarchy drain, the ratio between the mean lengths of the channels of each order and the extension of the superficial course.

Morphodynamic and morphologic changes analysis in rivers of the Sierra de Comechingones piedemont, Cordoba province, Argentina, during the Late Holocene-present. Environmental implications

DEGIOVANNI S., ANDREAZZINI J.
Universidad Nacional de Rio Cuarto, RIO CUARTO, ARGENTINA

Since Late Holocene, regional drainage networks have started an important incision process, related to tectonic, climatic and anthropogenic causes, that still continues and has generated notorious changes. The Eastern piedmont of Comechingones mountain is part of a Cenozoic bajada (currently inactive) formed by alluvial, colluvial and aeolian sediments, and dissected by fluvial systems. This work discusses the morphological and morphodynamic modifications in piedmont fluvial reaches in the main tributaries of Cuarto River, and their incidence in environmental risks. Geological-geomorphological detail surveys were carried out, and variations in morphological and morphometric indicators for valley and channel were measured, as width, sinuosity index (S) and width/depth ratio (w/d). The oldest fluvial belt, 1000 to 1500 m wide, was developed by meandering rivers, and presents two levels of Holocene accumulation terraces. The channels have a variable width, 80 - 130 m, w/d ratio of 100-150, S in the order of 1,5 - 2,2 and meanders of variable geometry. Although lateral erosion (local rates of up to 100 m/30-40 years) and, subordinately, aggradation processes are important, these channels also respond to the regional incision process. Pleistocene cemented sequences or crystalline rocks were reached in many of the sections as a result of channels downcutting (up to 12 m), generating semi-confined channels, with more straight patterns, narrower fluvial belt (100-200 m), and minor width (lower than 50 m), w/d ratio (30-40) and S (minimum values of 1,03-1,05). The transport and incision process are dominant in these reaches, while the aggradation and banks erosion processes are minimal. In semi-confined channels fluvial erosion hazard, mainly banks erosion, decreased significantly, and flooding hazard was ended, while the speed, height of water in flood events, and the transport capacity were increased, augmenting the downstream threat.

****

The effect of input load on large wood dynamics in braided streams: preliminary results from physical modelling

BERTOLDI W.(1), MAO L.(2), COMITI F.(3), GURNELL A.(4), MCLELLAND S.(5), RAVAZZOLO D.(6), TAL M.(7), WELBER M.(1), ZANELLA S.(1)
(1) University of Trento, TRENTO, ITALY ; (2) Departamento de Ecosistemas y Medio Ambiente, Pontificia Universidad Católica de Chile, SANTIAGO, CHILE ; (3) Faculty of Science and Technology, Free University of Bolzano, BOLZANO, ITALY ; (4) School of Geography, Queen Mary University of London, LONDON, UNITED KINGDOM ; (5) Department of Geography, University of Hull, HULL, UNITED KINGDOM ; (6) Dipartimento Territorio e Sistemi Agro-forestali, University of Padova, PADOVA, ITALY ; (7) Aix-Marseille Université, CEREGE UMR 7330, AIX-EN-PROVENCE, FRANCE

We present preliminary results from a set of experiments conducted in the Total Environment Simulator flume at the University of Hull (funded as an Access Project in Hydralab IV, EC Contract Number 265120). The experiments were designed to reproduce a large gravel-bed braided river, self formed in a well-sorted sand bed (0.725 mm) subject to a constant discharge (1.25 l/s). Three parallel flume experiments were used to investigate the dynamics of large wood - modelled using coloured-coded dowels 80 mm long and 2.6 mm in diameter – at different input rates (ranging from 40 to 180 logs/hour). The three channels were surveyed by a vertical, movable camera with a temporal step of 1 hour. All deposited logs were then manually mapped to describe the position, grouping style, mobility, and persistence of each log.

The results showed that log deposition and re-mobilization was largely controlled by the morphology of the channel network, particularly by the occurrence of sediment bars and flow bifurcations. The rapid morphological changes and bank erosion along the main anabranch were the main cause of wood re-mobilisation. Up to 40% of logs moved after 1 hour, and less than 20% stayed at the same place after 5 hours. As a result of the high mobility of the logs, only about 15% of new logs deposited each hour against an existing jam, resulting in a configuration with small jams and up to 40% of the logs being deposited as single logs. For high log input rates (more than 120 logs/hour), we observed the occurrence of larger jams comprising up to 50 logs. The analysis highlighted that these large log accumulations caused a change in the wood deposition mechanism and decreased the mobility of individual elements within these large log jams.

The results give us an improved understanding of the wood supply / accumulation dynamics in complex river systems which are essential to better understand the interactions among river flow dynamics, sediment transport and large wood.

Fluviomorphological hazards in roads crossing ephemeral channels on the South East coast of Spain

CONESA-GARCÍA C.(1), GARCÍA-LORENZO R.(2)
(1) Departamento de Geografía Física, Universidad de Murcia, MURCIA, SPAIN ; (2) Servicio de Integración e Información Ambiental, Comunidad Autónoma de la Región de Murcia, MURCIA, SPAIN

Most road-stream crossings over ephemeral channels are vulnerable to extreme hydrologic events. Flash flood waters can significantly overflow the channel banks and may change course, defying the ability of drainage work to perform its intended function. Bridges and culverts are usually built when traffic or the road network's importance justifies the cost, while fords are a more common crossing method on local roads. This paper is aimed to analyze the main fluviomorphological hazards (*FH*), affecting road-stream crossings over dry streams in South East Spain. *FH* study provides two different approaches depending on the type of crossing they are applied to: FH_B for *bridge crossings* and FH_{CF} for *road-crossing drainage culverts and fords.* These approaches are focused on estimating the predictable morphological effects for discharges at bankfull and flood-prone stages. The parameters included in FH_B are granular bed susceptibility to incision, associated with the bed armouring rate, critical velocity (*Vc*) and general transitory scouring (*GTS*). In particular, *Vc* and *GTS* directly affect the stability of pier footings and bridge foundations, and can be appropriate indicators for assessing fluviomorphological hazards at these crossings. In contrast, for FH_{CF} factors such as bed instability, bed load transport and channel roughness were considered due to their influence on the obstruction of drains, culverts and fords. The study was carried out on the Mediterranean coast in the Region of Murcia (Spain), where there are numerous examples of road-stream crossings with insufficient drainage over ephemeral channels. These crossings are exposed to high transport rates and erosion during flooding, causing highly dangerous situations for road traffic. In order to test the applied methods, the results were compared with real geomorphological impacts produced by recent floods.

Key words : Fluviomorphological hazards, road-stream crossings, ephemeral channels, South East coast of Spain.

****

Geospatial Mapping Ancient Phad Irrigation System in Mousam Basin, Maharashtra (INDIA): A GIS Approach

THAKRE D.
L.V.H.COLLEGE, NASHIK, INDIA

Traditional water-harvesting systems have existed in India since time immemorial, successfully satisfying the needs of civilizations in their quest for the ‘elixir of life’. Maharashtra has a unique traditional water-harvesting technique, known as the ‘Phad’ system, whose roots can be traced back over 300 years. The Mousam River, located in northwestern part of Nasik District of Maharashtra State is a unique example of Phad irrigation system. The community managed Phad irrigation system is prevalent in northwest. Each system consists of one diversion weir, canals, distributaries, field channels, and the command area. The command area is divided in to four parts. Each part is called as Phad. Size of the Phad is 10 to 200 ha. Te average size is 100-125 ha. The capital costs for construction of weirs were supported by King or Ruler. River Mousam drains the upper part of Western Ghats rain shadow zone of Tapti River system.The natural slope of the basin converging from side slopes, rolling topography, structural terraces in middle part of the basin, and smooth undulating pediment surfaces in the lower reaches are some of the significant geomorphological characteristics, that are supportive to this irrigation system..Present paper attempts to study old Phad irrigation system in GIS environment. By using GIS techniques and tools, Phad canals, distributaries, and command area of each phad zone will be mapped to get the area under each zone. The main trunk Stream of Mousam River and all its major tributaries/distributaries under this system will be mapped to obtain all its geomorphometric data. The results obtained will then tested whether this system can be applicable to the river basin having similar geoenvironmental conditions.

Contribution of geomatic for multiscale characterisation of river systems: application to the Rhone basin

WIEDERKEHR E.(1), DUFOUR S.(2), PIÉGAY H.(3)
(1) CNRS UMR 5600 Environnement, Ville, Soci_t_ - ENS de Lyon, LYON CEDEX 07, FRANCE ; (2) CNRS UMR 6554 - Université Rennes 2, RENNES, FRANCE ; (3) CNRS UMR 5600 Environnement, Ville, Soci?t? - ENS de Lyon, LYON CEDEX 07, FRANCE

To achieve the good ecological status of aquatic environments stated by the WFD, an assessment of the physical condition of the hydrographic network appears as an essential step for targeting actions, yet this issue still requires research of a fundamental nature. Such assessment in the basin of the Rhône generates a number of scientific questions to be answered before considering practical applications. Focusing geomorphic understanding at a regional scale is a new approach which has methodological constraints linked in particular to the great heterogeneity of environments.

We developed a semi-automatic method to provide indicators of physical quality within the Rhone river network. We implemented geomatic tools which have been tested and applied to evaluate their effectiveness and to provide reliable evidence for the characterization of large-scale physical conditions.

We extracted every 100m, the widths of the active channel and the valley bottom. From these data, we created geomorphological homogeneous reaches (GHR). Each GHR have been characterized by a set of metrics such as sinuosity, channel confinement in the floodplain, relative frequency of water channel in the active channel, channel slope, channel active width and inner GHR variability of width. From a statistical analysis performed on this set of metrics, we identified 18 channel pattern types. This database has been then used to perform queries to identify reaches of high natural unheritage value or identify reaches with a high potential in lateral shifting.

This procedure applied systematically at the regional network scale is more powerful than a sampling procedure because it allows identifying longitudinal thresholds and potentially relates them with their drivers. Moreover, the semi-automatically method can be applied on the other basins and the database can be completed by new metrics if no data are available so that the method is reproducible and can be implemented within an adaptive strategy.

****

Hypsometric Analysis for Prioritization and Conservation Planning of Sub Watersheds; a Case study of Arjunsagar Lake Catchment, North Maharashtra, India

NIKAM S.
S.P.H.College, MALEGAON, INDIA

Hypsometric integrals and hypsometric curve are important indicators of stages of watershed development i.e. stabilized, mature and young. In the present study attempt has been made to suggest the prioritization of sub watersheds of study area for water and soil conservation planning based on Hypsometric integrals values. Study area selected for the present investigation is Arjunsagar lake catchment.

Administratively Arjunsagar lake catchment situated in Satana tahsil of Nashik district, Maharashtra state, India and extends between geocordinates of 20°38'08.34"N to 20°43'34.73"N latitude and 73°54'22.50'"E to 73°58'59.02'"E longitude. Total geographical area of study area is 56.36 Km^2 including 02 Km^2 water body. Arjunsagar dam were constructed on *Aram* river flowing from north to south east.

Total 08 sub watersheds from the study area delineated using Survey of India Topographical map 46H/14 on 1:50,000 scale. Elevation of the basin ranges between 703m to 1543m. Area has been calculated for every 20m contour interval of all the sub watersheds. Entire watersheds exhibit high potential of surface runoff and soil loss and no efforts have been taken to properly undertake such kind of assessment. Thematic map of HI values and descriptive statistics of watersheds calculated using GIS techniques. According to generated results hypsometric integral values of watersheds are ranges between 0.21 to 0. 52. Low hypsometric values indicate old and more eroded areas on the other hand high hypsometric integral values indicated less erosion. In the area hypsometric curve observed in S shaped and concave shaped. Convex shaped hypsometric curve characterize watershed in young stage, S shape curves indicate the basins in maturity stage and concave hypsometric curve characterize basins in old stage. Watershed prioritization has been done based on HI values.

Examination of the morphological characteristics of alluvial fans modified by interactions with rivers in broad axial valleys in Yukon Territory, Canada, and Alaska, U.S.A.

GILES P.(1), WHITEHOUSE B.(1), KARYMBALIS E.(2)
(1) Saint Mary's University, HALIFAX, NOVA SCOTIA, CANADA ; (2) Harokopio University, ATHENS, GREECE

Although the predominant planform morphology of an alluvial fan is a roughly symmetrical pattern radiating outwards from the apex, fans in broad axial valleys in Yukon Territory, Canada, and Alaska, U.S.A., commonly exhibit planform asymmetry. Planform asymmetry is defined as inequality in the lengths of longitudinal profiles from the apex to points around the lower boundary. This study investigates interactions between fans and axial rivers that result in the observed asymmetrical morphologies, as well as deflection of axial rivers across their valleys. In narrow valleys, lateral migration of axial rivers is restricted which leads to fan toes being trimmed straight across, or to damming of the valley if fan sedimentation rate overwhelms the river's transport capacity. In broader valleys, episodic erosion caused by lateral migration of axial river channels has been described as an important process that trims fan toes and limits progradation of fans, at least temporarily. In the broad glacial valleys examined in Yukon and Alaska, axial river channels occupy only a portion of the valley width and the rivers tend to be deflected by the fan mass. Therefore, toe erosion and limited progradation cause longitudinal profiles on the axial valley upstream sides of fans to be shorter than the downstream sides which leads to the asymmetry in fan planform morphologies. Scarped faces are frequently observed at the lower ends of shorter profiles, whereas profiles on the longer sides of fans run out gradually. Measurements of fan morphologies were made to describe asymmetry quantitatively and to demonstrate that there is a statistically significant relationship between asymmetrical tendency and direction of axial river flow. However, a related hypothesis stating that unequal longitudinal profile lengths on an asymmetrical fan would cause fan surface gradients to differ, which would consequently influence the spatial distribution of streams on the fan surface, was not supported.

****

Small catchment river styles® in Brazilian dryland, saco creek watershed

SOUZA J., BARROS A.C.M., CORREA A.C.B.
Federal University of Pernambuco, RECIFE, BRAZIL

The growth of the environmental worry has increased the necessity to adopt policies to the hydric resources management. An appropriate management is essential to understand the behavior of fluvial environments, especially in drylands that are primordially instable places. To this, arises the River Styles® Framework that can be used to describe the characteristics and behavior of fluvial environments. Thus, the main concern of this research is to identify and describe the River Styles® of Saco Creek watershed, in semiarid Northeast of Brazil, as well as understand the behavior of each River Style®. To do this, it was used ASTER GDEM data, QUICKBIRD images, air photograph, and field data, in order to identify the elements and characteristics of River Styles®. In the Saco Creek watershed it was identified four different compartments; the headwaters, wetland zone, fault scarp and the pediment zone; that will control the type of River Style®, in addition to the strong anthropogenic influences. It was identified and described seven River Styles; Headwaters and Gullies in the headwaters zone, the gullies will be developed on quaternary colluviums; Floodout, Intact Valley Fill and Discontinuous Sand Bed in wetland zone; Discontinuous Floodplain Bedrock-controlled and Gorges in the fault scarp zone; and Intact Valley Fill, Discontinuous Sand Bed and Discontinuous Floodplain Bedrock-controlled in pediment zone. In the pediment zone the presence of several dams, in special the Saco Dam, which control the evolution of the River Styles® changing the cut-fill channel processes. From the identification and analysis of the River Styles® in each reach, the adoption of policies to hydric management becomes more adequated.

Analysis of relationships among alluvial fans and source basins in Lake Trichonis (Western Greece)

KARYMBALIS E.(1), GILES P.(2), PAPANASTASSIOU D.(3), FERENTINOU M.(1), GAKI-PAPANASTASSIOU K.(4)

(1) Department of Geography, Harokopio University, ATHENS, GREECE ; (2) Department of Geography, Saint Mary?s University ,, HALIFAX, NOVA SCOTIA, CANADA ; (3) Institute of Geodynamics, National Observatory of Athens, ATHENS, GREECE ; (4) Department of Geography-Climatology, Faculty of Geology & Geoenvironment, National Kapodistrian University of Athens, ATHENS, GREECE

In this study 17 morphometric variables describing 23 alluvial fans and their contributing drainage basins in the tectonically active area of Lake Trichonis (Western Greece) are examined. The main objective of this study is to classify the fans according to the primary depositional processes (fluvial and/or debris flow) controlling their formation. Another purpose of this study is to present fan-basin morphometric relationships for the fans, and to investigate the possible relationship between the geographic distribution of the fans and basins with the local tectonic patterns.

The Trichonis graben is a 10km width Quaternary structure that strikes WNW-ESE for a distance of 32km and cuts across the early Tertiary NW-SE fold and thrust structures of the Pindos Mountains. The dipression at north and south flanks is bounded by E-W and NW-SE trending faults. The alluvial fans of the study area are developed on the hanging wall of these neotectonic normal faults.The morphology of the fans is strongly affected by the accommodation space created by subsidence.

Selected morphometric parameters of the basins were measured using topographic maps at 1:50000 scale with 20 m contour lines, while parameters of the fans were derived from topographic diagrams at 1:5000 scale with 2m contour lines. Self Organizing Maps (SOM) were used in order to investigate clustering tendency of alluvial fans according to both qualitative data and morphometric variables.

The coupling of quantitative morphometry and the artificial intelligence method (SOM) led to the classification of the fans into two main types with distinct morphological characteristics. Large, less rugged basins have produced at the eastern side 18 relatively extensive, gently sloping fans dominated by fluvial processes. In contrast, at the western part of the graben 5 of the fans are steeper formed by a combination of fluvial and debris-flow deposition processes supplied by smaller, more rugged basins located.

****

Integrating river geomorphic processes into optimal planning of reservoir operations

DINH Q.(1), BIZZI S.(1), BERNARDI D.(2), PAVAN S.(2), CASTELLETTI A.(1), SCHIPPA L.(2), SONCINI-SESSA R.(1)

(1) Department of Electronics and Information, Politecnico di Milano, MILAN, ITALY ; (2) Department of Engineering, University of Ferrara, FERRARA, ITALY

Water management through dams and reservoirs is worldwide necessary to support key human-related activities ranging from hydropower production to water allocation, and flood risk mitigation Reservoir operations are commonly planned in order to maximize these objectives. However reservoirs strongly influence river geomorphic processes causing sediment deficit downstream, altering the flow regime, leading often to process of river bed incision. Multi-objectives (MO) optimization techniques used to identify optimal regulation policies require elevate computing power and then the modelling of fluvial processes is commonly neglected. This is a significant limitation since the river geomorphic processes deeply affect water management: for instance the variations of river cross sections over few years can notably affect flood mitigation and water supply strategies. Moreover geomorphological and ecological processes are deeply inter-correlated.

We present a case study in Italy on the Po River where alternatives release policies of Isola Serafini dam have been analysed in terms of their effects on hydropower production and river bed incision. A 1-d hydro-dynamic model with mobile boundaries has been used to simulate the river bed evolution on a ten year horizon. The response surface methodology (RSM) has been applied to embed the understanding of the river geomorphic processes into optimal control of water management. The main idea of RSM is to use a sequence of designed experiments to obtain an optimal response surface. The application of such technique allowed us to assess the trade-off between hydropower production and river bed incision of optimal release policies. This is a novel and promising attempt to start integrating the understanding of fluvial geomorphic processes into optimal planning of reservoir operations.

Sedge as an influence on channel form: case study of Carex nudata in gravel-bedded John Day River, Oregon, USA

MCDOWELL P.
University of Oregon, EUGENE, UNITED STATES

New models of interactions between vegetation and hydrogeomorphic processes suggest that vegetation may exert a major influence on channel form. While this principle is well established for woody vegetation, particularly woody debris, there is less understanding of how herbaceous vegetation influences channel form. In the upper John Day River, a montane, cobble- to gravel-bedded river in the intermountain West, a native sedge, *Carex nudata*, forms tussocks on the active channel bed, at and within the low flow water level. These tussocks are highly resistant to erosion due to a dense root network. *C. nudata* was highly suppressed by cattle grazing until it was ended in 2000, and *C. nudata* populations increased dramatically thereafter. This paper uses historical and modern field data to address questions about the expansion, and geomorphic and ecologic impacts of *C. nudata*.

Today the tussocks occur in several distinctive biogeomorphic structures, including bar-fringing tussock rows, tussock rows at the base of banks, and mid-channel clusters and individual tussocks. The tussocks behave as boulder-sized resistance elements. The bar fringing rows stabilize active gravel bars, while the bank-base rows appear to be associated with bank erosion and channel widening. The mid-channel tussocks occur on pool tails and riffle crests. They result in bed scour and, in some cases, channel widening.

From a habitat perspective, *C. nudata* has increased fish cover, as well as the complexity of bed morphology and hydraulic diversity. The flood of record in May 2011 produced only limited erosion of *C. nudata* tussocks. Comparison of pre and post-flood channel cross-sections shows both the stabilizing and erosive effects of *C. nudata*. These changes suggest that *C. nudata* is setting a new trajectory of channel adjustment toward narrower, rougher, more stable, and reduced sediment transport conditions.

****

Diversion of running water discharge from par river to girna river valley

NIKAM C.
M.S.G.COLLEGE, MALEGAON, INDIA

Water is the fundamental need for the Socio-economic development of any region. In recent years, Maharashtra State (India) is facing the problem of regional disparity because of spatial and temporal variability in rainfall and lack of proper utilization of running water slope of Western part of the Sahyadri is very steep, receives excess amount of rainfall and adds wasteful into Arabian Sea. Par River (2000 to 3000 mm Avg. Annual Rainfall) originates from Kame hills of Sahyadri ranges. The river flows further west towards Gujarat State (India) and adds wasteful water into Arabian Sea. Par river basin experience water scarcity in summer in contrast overflow discharge in rainy season. The undulating topography limits the local irrigation.

In contrast, eastern part of the Sahyadri (Girna river valley) is the rainshadow zone receiving very low rainfall (1500-2000 mm Avg. Annual Rainfall). This region therefore always experience water scarcity.

Circulation of water is possible at two levels for sustainable development of any region. In intra-basin circulation of running water, circulation is possible within a basin itself (Punad Project). Whereas, in inter-basin circulation of running water, circulation is possible from one basin to another. Proper utilization of water is possible in the study area by inter-basin circulation of water from Par to Girna basin.

Historical planform adjustments of rivers from the Eastern part of Pannonian Basin, as indicators of neotectonic features

PERŞOIU I., ROBU D.
Ştefan cel Mare University, SUCEAVA, ROMANIA

Someş River, one of the main rivers draining the NW part of Romania, features abrupt changes between meandering, straight and anabranching channel reaches (on both alluvial and mixed channel types). Its longitudinal profile variability, as shown by the planform and vertical morphological and morphometrical characteristics (*i.e.*, sinuosity, channel width, channel slope, river bank heights), reflects both regional geological setting (*e.g.*, different rates of tectonical uplifts and subsidences, structural controls) and, for the last decades, human induced channel straightening.

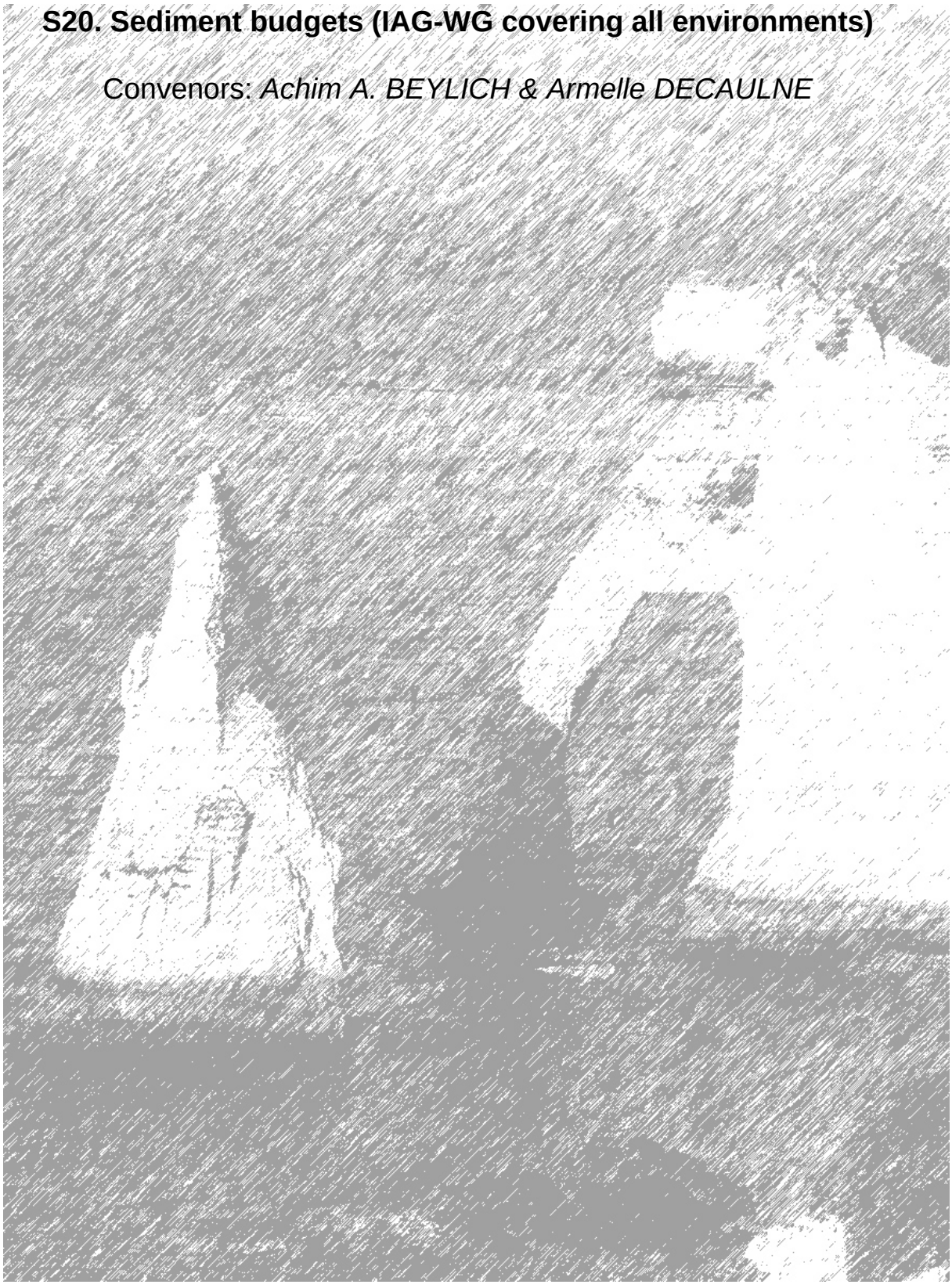
In this study, we analyze, based on successive topographic maps (covering ~150 years), the historical behavior of the lower reach of Someş River, in order to identify local scale neotectonic elements in the subsidence area (-1 mm/yrs) of the eastern Pannonian Basin. The area of investigation has a particular scientific importance, as covering the contact between Romanian Carpathians and the eastern edge of Pannonian Basin, a region with a strong neotectonic activity.

Based on river channel behavior over the past century and half, we have identified a series of local subsidence basins and local active faults, which, superimposed on the geological map of the area allowed us to propose a detailed neotectonic map of the region.

****

S20. Sediment budgets (IAG-WG covering all environments)

Convenors: *Achim A. BEYLICH & Armelle DECAULNE*



Oral presentations:

Development and application of a fingerprinting technique for quantitative source ascription of fine sediment in a large dynamic fluvial environment: Manawatu, New Zealand

VALE S.
Massey University, PALMERSTON NORTH, NEW ZEALAND

Research into the quantification and modelling of sediment movement through a wide range of Earth's surface processes has increased substantially in recent decades. However, catchment scale identification of erosion processes and geomorphically active areas contributing to sediment yield have often been poorly understood and quantified. This lack of understanding is a limitation to identifying critical source areas and appropriate mitigation techniques for governing bodies. Traditional field-based techniques for sediment source identification are typically qualitative, time consuming and difficult to apply to larger catchment scales. Sediment fingerprinting provides an alternative approach to quantifying sediment sources. The Manawatu River catchment provides an appropriate location to test the effectiveness of this technique in a large dynamic catchment subject to significant anthropogenic influences.

In this research 'sediment fingerprinting' techniques were applied to identify the sources of fine sediment throughout the Manawatu catchment, a range of tracer (e.g. elemental, radionuclide, isotopic) analysis's were applied (e.g. XRF, ICP-MS). Initial sampling was undertaken at key confluence sites to explore and test the geochemical techniques as well as guide the concept of design for the full scale study. This focused on what sort of variability was occurring within the study environment, selection of sample locations, and what method of sample preparation and analysis was both resource efficient and provided source discrimination. Source ascription is achieved from the approach of a spatial distribution of sub catchments and the geological source as well as what geomorphic processes are responsible for sediment production. This research demonstrates the use of sediment fingerprinting in a rapid and efficient approach for identifying principal sources of sediment, sediment associated nutrients and contaminants which crucially aid erosion management strategies

****

The sediment budget: a tool to evaluate scale effect on sediment dynamics into a catchment

VIEL V., DELAHAYE D., ROLLET A.J., LESPEZ L., REULIER R., CADOR J.M., DAVIDSON R.
LETG - Caen - GEOPHEN, CAEN, FRANCE

The quantification and characterisation of hydrological and sedimentary transfers are now major challenges to preserving and restoring European soils and water resources (Law on Water; Water Framework Directive, WFD). To provide better watercourse and watershed managements, many studies attempted to evaluate soil and bank erosion at local scale in the hydrosystem. However, sediment dynamics into the catchment remain difficult to analyze from local to global scale because of intermediary traps. Therefore, to improve the knowledge of these systems and to go beyond the "black box" study of the way of the catchment works, it is essential (1) to localise the origin of sediments into the watershed and (2) to identify the role of interlocking scales on the spatial and temporal dynamics of sediment transfers. In order to evaluate sediment dynamics variability at different scales,5 nested sediment budgets quantifying soil and bank contribution, and sediment exports or storages were realized in a same catchment for a three years period. This study specifically focused in the Seulles watershed (430 km²), a typical and poorly documented feature for low-energy water system (<20 W/m²) located in the northern-western part of France, in Europe. To evaluate slope contribution, soil erosion and runoff connectivity were studied for two representative sub-catchments (15 km²). Bank erosion was estimated by field investigation from 5 reference sites. Results were then extrapolated at the catchment scale using a modeling approach. In the same time, 4 high frequency monitoring stations were used to control suspended sediment export at different scales into the catchment. Results underline the role of the initiation of the drainage networks into sub-catchments while bank contribution becomes predominant in the downstream part of the watershed.

Application of the physically based model, power spectral analyses and cross correlation analyses to estimate the sediment budget and the delay time for an impacted stream: case study of Italy

PELACANI S.(1), MAERKER M.(1), SCHMITT F.G.(2)
(1) University of Florence, FLORENCE, ITALY ; (2) Université des Lille, CNRS Laboratory of Oceanology and Geosciences, WIMEREUX, FRANCE

In this study we compare the results of a soil erosion model applied at watershed scale to the suspended sediment measured in the stream network. A sediment delivery model is applied at watershed scale; the evaluation of sediment delivery is related to a connectivity fluxes index that describes the internal linkages between runoff and sediment sources in upper parts of catchments and the receiving sinks. An analysis of the fine suspended sediment transport and storage was conducted for an human impacted catchments draining into a reservoir, Florence, Italy. The time scales of catchment hydrologic response was evaluated using spectral analysis. By comparing the spectral power of the input sediment source and output stations each wavelength determines how strongly the catchment attenuates hydrologic and chemical signals on each timescale. The delay time distribution of the turbidity dataset, and hence of suspended sediment, were calculated using the cross correlation function. Results show that the time of particle transit ranging between 190 days to one year. The turbidity dataset at the output station has consistently lower power spectrum than the inlet station along the range of the studied wavelengths. On the other hand, the output station shows a scaling exponent higher than the inlet station. Implying a higher persistence of the turbidity. The fractal analysis points out that the system is not in equilibrium. The present work has demonstrated that by comparing the spectral power of the input and output stations at each wavelength for the turbidity dataset, it is possible to explain the behavior of a basin subject to anthropogenic disturbances. When the results obtained from field data are compared with those from the RUSLE model, the SDR values indicate that there was sediment storage on the channel bed of the non-impacted stream, more than of the impacted one. This discrepancy may be due to an underestimation of hillslope deposition by the RUSLE model.

****

Modeling of rainfall-runoff and soil erosion processes in various scales and using various DEM - assessment of effects

DEVATY J., DOSTAL T., KRASA J.
Dept. of Irrigation, Drainage and Landscape Engineering, Faculty of Civil Engineering, CTU in Prague, PRAGUE, CZECH REPUBLIC

Rainfall-runoff, erosion and transport processes are of high importance within an area of interest and are often modeled by computer tools of different mathematical approach and precision. Each model requires different set of input data and provides different possibilities to simulate surface runoff pattern complexity. In case of distributed rainfall-runoff models digital elevation model is the essential input . This paper presents results of sensitivity study on DEM's source and resolution for two fully distributed model tools. The simulations were carried out using empirically based continuous model WATEM/SEDEM and physically based event model Erosion 3D. The elevation data used were: (i) 10x10 m resolution DEM GEODIS (professionally treated commercialy available raster DEM), (ii) 5x5 m resolution DEM derived from contour-lines in original scale 1:10000 with equidistance 2 m and (iii) 3x3 m resolution DEM derived from laser-scan elevation LiDAR 5G data. The goal of the modeling was to assess potentials and limits of the DEMs and model tools for description of surface runoff, erosion and sediment transport processes, concerning runoff pattern generation. Set of scenarios was modeled to evaluate variations in soil loss and its spatial distribution in scales of single field plot to small watershed. Different approaches to simulate control measures design and their effects were tested in the small scale using Erosion 3D model and using WATEM/SEDEM or simple USLE/GIS approach in medium to large areas.

This paper was supported by projects:
NAZV č. QI91C008 „TPEO“
NAZVč. QJ1230056 „KLIMA“
BV č. VG 2012 2015 092

Geological and geomorphological controls of suspended sediment fluxes in periglacial environments of Russian Arctic

TANANAEV N.
P.I. Melnikov Permafrost Institute, Siberian Branch, Russian Academy of Science, YAKUTSK, RUSSIAN FEDERATION

It is widely assumed that suspended sediment flux is a product of geomorphic processes, spatially distributed within the river catchment. Periglacial conditions normally restrict the activity of these processes, along with increased volumes of temporary sediment storage. Thus in our study we hypothesize that in the Russian Arctic suspended load tends to originate within the river valleys, due to better source-to-stream connectivity and enhanced sediment availability. Understanding of interconnections between sediment fluxes and its geomorphic controls requires the correct quantification of the former. Contemporary sediment flux calculations were carried out for 22 gauging stations on 13 large rivers of Russian Arctic. Results show that increased sediment yield is observed in geologically 'young' and dynamic areas of Verkhoyansk Range and Arctic Lowlands, in contrast with relatively stable Neogene planation surface of Central Yakutia. Within the Arctic Lowlands, intensively eroded river banks act as a primary sediment source. Bank retreat rates reach 40-50 m at meander heads, bank material is represented by alluvial deposits with high ice content, heavily affected by cryogenic weathering. In alpine environment of Verkhoyansk Range, lacking well-developed Quaternary deposit cover, valley slope failure may supply significant amounts of sediment to the streams. This material generally originates from Sartang (MIS2) moraine complex and glacial till, and is subject to both cryogenic and chemical weathering in river channels, generating suspended load. Periglacial conditions of the studied region thus appear to limit sediment generation and transport on the planation surfaces, while enhancing sediment supply of glacially disrupted material (in Verkhoyansk Mountains) and cryodisturbed alluvial deposits via bank erosion (in Arctic Lowlands).

****

Spatial patterns and timescales of fine sediment redistribution in river basins: application of a sediment budget model with fallout radionuclide tracers

SMITH H., BLAKE W.
University of Plymouth, PLYMOUTH, UNITED KINGDOM

Understanding the redistribution of fine sediment within river basins requires information on the rates and timescale of sediment supply and transfer across various landscape compartments. Sediment budgets provide an effective tool for examining these patterns. Such information is typically available from small intensively monitored research catchments, while examination of larger scale patterns of sediment transfer often requires the use of modelling-based approaches. Furthermore, knowledge of timescales of fine sediment transfer in river basins is limited. Few studies link sediment budgets with explicit information on the residence or travel times of fine sediment. This information is essential for understanding contemporary patterns of river basin sediment redistribution, and has implications for predicting possible recovery times of rivers affected by contaminated sediment from historic or recent pollution. Against this background, we aim to quantify the spatial patterns and timescales of suspended sediment transfer through a river basin (917 km^2) situated in south-west England. We apply a spatially-distributed sediment budget model (SedNet) in conjunction with high-resolution spatial data and long-term rainfall and river flow measurements. Model outputs provide an indication of mean annual patterns of sediment redistribution and yields, which were computed for three land cover surveys (1990, 2000, 2007). This modelling was coupled with methods for estimating fine sediment residence times based on Be-7/excess Pb-210 ratios and a two-compartment radionuclide mass balance model comprising slow and rapid transport components. Findings from this study demonstrate the need for more integrated approaches to better understand spatial patterns and timescales of sediment redistribution in river basins.

Sediment Budgets in data poor environments: Case of the Kambaniru Catchment, Indonesia

HOBGEN S.(1), WASSON R.(2), MYERS B.(1), FISHER R.(1)
(1) Charles Darwin University, DARWIN, AUSTRALIA ; (2) National University of Singapore, SINGAPORE, SINGAPORE

The islands of the East Nusa Tenggara province are some of the driest in Indonesia, with a long dry season, short wet season (3-5 months) and variable low annual rainfall. Food security is an increasing challenge with a growing population and greater variability in rainfall projected under climate change scenarios. Weirs have been constructed to provide reliable agricultural water supplies, however the landscape is highly erodible and weir pools are rapidly filling with sediment. Understanding of sediment sources is needed to design and implement effective measures to reduce sedimentation.

This study of sedimentation in the Kambaniru catchment in eastern Indonesia has developed sediment source mapping and a rudimentary sediment budget. The relative contribution of topsoil and subsoil to sedimentation was determined using radionuclide tracers ^{137}Cs, $^{210}Pb_{(excess)}$ and $^{239+240}Pu$. This analysis highlighted the importance of subsoil sediment sources, previously largely ignored in Indonesian government catchment management policies. Mapping of sediment sources used remote sensing, field measurements and local knowledge. Mapping of 'high risk' areas for topsoil erosion was undertaken based on the RUSLE equation and highlighted breaks in connectivity in the upper catchment due to the presence of dambo like structures acting as sediment sinks. Free software and imagery (SAGA GIS and Landsat, SPOT5, ASTER DEM and imagery on Google Earth) were purposely used to design methods for a low resource context. Gully erosion and channel change (subsoil sources) were found to be locally significant, although topsoil contributions are considerably higher than other reported values for the region. This research provides opportunities for improving the local capacity to understand sedimentation processes as a basis for developing appropriate catchment management.

****

Contributions of on-land sediment sources and transfer to the overall Loire river basin sediment budget

GAY A.(1), CERDAN O.(2), DELMAS M.(3), DESMET M.(4), DEGAN F.(4)
(1) French Geological Survey (BRGM), ORLEANS, FRANCE ; (2) French Geological Survey (BRGM), ORL?ANS, FRANCE ; (3) INRA Infosol, ORLEANS, FRANCE ; (4) GéHCo, TOURS, FRANCE

Sediment fluxes within continental areas play a major role in the global biogeochemical cycles and are often at the source of soil surface degradation as well as water and ecosystems pollution. In a context of significant land use and climate change, it appears important to be able to carry out sediment budgets to assess potential future impacts induced by such changes. The purpose of this study is to examine the source-to-sink dynamic of the sediment cycle for 123 small to medium catchments (10 to 10^4 km²) distributed over the Loire River basin (France). To this aim, three different steps will be carried out. First, estimations of mean annual specific sediment load for the 123 catchments are estimated from suspended sediment concentration and water discharge measurements at basin outlets over the past four decades. Secondly, catchment global parameters (topography, landuse, drainage density…) and simple indices, combining these parameters, will be calculated to study the relationship between hillslope production and sediment load at basins outlet. Finally, we will focus on the development of a distributed modelling approach of on-land sediment transfer processes. Special attention will be given to hillslope runoff and sediment connectivity by taking into account landscape spatial organisation and linear pathways as determinant features for sediment transport. The results from the first step on mean annual specific sediment loads, show that catchments contribute from 30 to 4.10^5 $t.yr^{-1}$ to the overall Loire river sediment exports (which equals 10^{11} $t.yr^{-1}$). Investigations on catchments global characteristics should then allow the identification of dominant processes in sediment redistribution, help to draw local and then regional distributed sediment budgets and bridge the gap between the different spatial scales. Contribution of hillslopes to the overall catchment budget should finally help to assess in-stream contributions and redistribution processes.

Using suspended sediment records and lake deposits to reconstruct current and past sediment dynamics in a small agricultural catchment

FOUCHER A.(1), DESMET M.(1), SALVADOR-BLANES S.(1), CERDAN O.(2), EVRARD O.(3), LEFEVRE I.(3)
(1) Université de Tours, Laboratoire GehCo, TOURS, FRANCE ; (2) BRGM, ORLÉANS, FRANCE ; (3) Laboratoire des Sciences du Climat et de l'Environnement (LSCE/IPSL), GIF-SUR-YVETTE, FRANCE

Sediments budget affords an effective conceptual framework for quantifying sediment mobilization, transport, deposition and storage within, and sediment output from, a drainage basin. Our study aims at assessing the effect of long-term land use changes on suspended sediment fluxes and lake in fillings through the analysis of current and past transfers in a small catchment.

The Experimental Louroux Lake Catchment (24 km²) is a small agricultural basin located in the south-western of the Parisian Basin (France). Since 60 years, this catchment has largely been affected by land use changes. The catchment has been submitted to an intensification of agricultural practices, reflected by land consolidation, and subsurface drainage (more than 220 drain tile outlets, more than 90 % of the catchment drained).

Past transfers are traced through the analysis of four sediment cores taken from the Louroux Lake. The sediment deposits yield valuable informations relating to both the magnitude of sediment yield in the local area and the impact of postwar land use change. Since 1000 AD lake bed sedimentation rates have varied, but a pronounced acceleration since the postwar periods has been recorded. Indeed, since 1945, suspended sediment yields have represented 4 cm/year and seismic data indicate that from 2003 to 2011 sediments in the lake accrued by 55 cm in all lake areas.

Three stream monitoring stations are located at the outlets of the main lake tributaries and two at upstream sub-catchments. Three outlets of subsurface tile drain systems are also continuously monitored in different parts of the catchment. Representative samples of suspended sediment are collected to encompass the variability in suspended sediment sources during the study year.

Finally, the fingerprinting method has been performed over the dated cores, suspended sediments and various supposed sources to explore the relative contribution of those sources on the sediment delivery in the lake.

****

A spatially-distributed sediment budget for a regulated catchment in coastal California, USA

DOWNS P.(1), DUSTERHOFF S.(2), LEVERICH G.(2)
(1) Plymouth University, PLYMOUTH, UNITED KINGDOM ; (2) Stillwater Sciences, BERKELEY, UNITED STATES

A distributed sediment budget (1983–2008) is constructed for the non-impounded area of regulated Lagunitas Creek, California (*i.e.*, 64km^2 of 213km^2). The budget uses a combination of extensive field surveys, historical data and topographic surveys, numerical modelling, and a representative-area extrapolation method to generate spatially-explicit sediment delivery estimates for contemporary processes. All major processes are represented and compared to sediment output estimated from gauging station records to avoid issues related to unmeasured residuals. Further independent corroboration is developed using reservoir bathymetric survey and literature-reported sedimentation values from the local area. Error estimates are propagated from measurements associated with field surveys and sediment gauging, while sensitivity analyses provide an indication of uncertainty related to data assumptions and models. An estimated yield of approximately 20,000 t a^{-1} implies an average unit yield of ~300 t km^{-2} a^{-1} from the undammed, sediment-contributing area. This rate is comparable with reported maximum yields of sediment derived during land surface disturbances associated with initial Euro-American settlement in the catchment and occurs because nearly 60% of the effective sediment production is now derived from channel erosion sources (due largely due to flow regulation). Further, catchment sediment yields are maximised because the incising mainstem channel creates a highly efficient routing conduit to the catchment mouth. Together, these attributes illustrate the importance of quantifying channel-derived sediment in estimating contemporary human impacts on fluvial systems, especially those subjected to regulation, urbanisation, channelisation and field drainage as a consequence of population growth in the recent Anthropocene period.

Quantification of the fluvial sediment budget and associated particle-bound pollutant redistribution in an agriculture-dominated river basin of the European Russia: the problem of upscaling

BELYAEV V.(1), EVRARD O.(2), MARKELOV M.(1), SHAMSHURINA E.(1), IVANOVA N.(1), GOLOSOV V.(1), PARAMONOVA T.(3), OTTLE C.(2), LEFEVRE I.(2), BONTE P.(2)

(1) Laboratory of soil erosion and fluvial processes, Faculty of Geography, Lomonosov Moscow State University, MOSCOW, RUSSIAN FEDERATION ; (2) Laboratoire des Sciences du Climat et de l?Environnement (LSCE/IPSL), Unité Mixte de Recherche 8212 (CEA/CNRS/UVSQ), Centre de Recherche du CNRS, GIF-SUR-YVETTE, FRANCE ; (3) Department of Radioecology and Ecotoxicology, Faculty of Soil Science, Lomonosov Moscow State University, MOSCOW, RUSSIAN FEDERATION

Quantitative assessment of a fluvial sediment budget is the key approach in fluvial geomorphology and hydrology, and also an essential tool for investigating the redistribution of particle-bound contaminants. Here we present an application of several independent approaches for quantifying the post-fallout particle-bound redistribution of the Chernobyl-derived ^{137}Cs and the basin-scale sediment budget for the River Plava basin situated in the Central European Russia. First stage of the study included creation of the digital elevation model and land use map for the entire River Plava basin and morphometric analysis of the cultivated slope morphology and fluvial network characteristics. Basing on that, several representative small catchments were selected as key study sites where detailed investigations of local-scale sediment redistribution and delivery have been undertaken at the second stage of the work. Methods used at the key catchments included ^{137}Cs-based sediment tracing, two soil erosion models and the analysis of soil profile morphological structure. At the third stage results obtained for the key catchments have been upscaled in order to reconstruct the entire River Plava sediment budget. The upscaling was based on statistical analysis of cultivated hillslope morphology, sediment delivery ratios for valleys of different Hortonian order and the analyzed spatial patterns of the fluvial network. The results showed that most of the sediment originating from soil erosion on cultivated slopes is redeposited on the uncultivated lower parts of the slopes or in the bottoms of infilled gullies, hollows and 1-3rd order valleys. The River Plava valley itself represents a system dominated by efficient transport, with very limited floodplain sediment storage. Sediment interception by the existing local dams and reservoirs have also been taken into account. It has been estimated that only about 1-2% of the basin-scale sediment volume reaches the River Plava basin outlet.

****

Role of landslides in sedimentary fluxes in tropical mountain regions

GUNS M.(1), VANACKER V.(1), DEMOULIN A.(2)

(1) Université catholique de Louvain, George Lemaître Centre for Earth and Climate Research, Earth and Life Institute, 1348, BELGIUM ; (2) Université de Liège, Dept of Physical Geography and Quaternary, 1348, BELGIUM

Landslides are known to be recurrent phenomena in active mountain belts, but the contribution of landslides to the overall sedimentary fluxes is not yet well known. In this work, we provide new data on landslide-derived sediment production and its contribution to sediment fluxes for a tropical Andean catchment. The Rio Pangor catchment (Ecuadorian Cordillera Occidental, 280km²) is particularly interesting for this study, as it has a wide range of landslide types with varying depths, surface area, and different topographic settings.

Landslide inventories were established based on sequential aerial photographs (1963, 1977 and 1989) and a very high resolution WorldView2 image (2010). Aerial photographs were ortho-rectified, and coregistred with the WorldView2 satellite image. Field campaigns were realised to collect field-based data on landslide types, their depths, widths and lengths. This allowed us to establish an empirical relationship between landslide area and volume, which was then applied to the landslide inventories to estimate landslide-related sediment production rates. The contribution of landslides to the overall sediment flux of the Pangor catchment was then estimated by comparing the landslide-related sediment production to (i) the suspended sediment loads at the outlet of the catchment and to (ii) 10-Be derived denudation rates.

The empirical landslide area-volume relationship established here for the Ecuadorian Andes has a sigma equals to 1.42, which is typical for landslides involving bedrock failure (Larsen et al., 2010), and an exponent alpha equal to 0.18. With our empirical equation, the volume estimation is similar (+10%) to the one obtained using the equation proposed by Larsen et al. (2010) for the Himalayas.

Landslide-derived sediment production is estimated at 250 – 1200 mm/kyr, and is within the range of the 10Be-derived denudation rates. This suggests that landslides are the main source of sediment in this tropical mountainous catchment.

Sediment budget of two glacial rivers in Iceland

JENSEN E.
Icelandic Meteorological Office, REYKJAVIK, ICELAND

Recent analyses on sediment budget in two glacial rivers in Iceland are presented here. These river catchments are very dynamic and hydro power plants have been planned in both of them. Þjórsá river is the largest river in Iceland and hydro power is already being harnessed in the upper reaches. Skaftá river has very complicated hydrology with frequent glacial outbursts (jökulhlaups). Here the total sediment, suspended sediments and bedload budget is summariesed for both rivers. The large river Þjórsá has total budget of 1.64 million tonnes per year whereas the Skaftá river has total sediment budget of 5.5 million tonnes per year. The glacial outbursts occuring in Skaftá were calculated separately and show values between two to over three million tonnes per event. The years 2002 and 2003 had both two jökulhlaup events(glacial outbursts) and as a consequence the annual budget of those two years was almost doubled. This information is very important to future planning of hydro power harvesting. The data includes other interesting information pointing to climate change effects as well as recently confirmed ashfall effects on glacial melt.

****

Geoecological functions of polar river systems

ZWOLINSKI Z.
Institute of Geoecology and Geoinformation, Adam Mickiewicz University in Poznan, POZNAN, POLAND

This paper outlines general functions with which to interpret river evolution, behaviour and character in polar systems. On the basis of different river schemes presented by various authors hierarchical, functional and systematic divisions of river patterns are analysed within drainage basin. Drainage basin or river catchment as holistic system is fundamental assumption of this undertaken analysis. The fluvial system presented by Schumm (1977) is an input to this analysis. Next several river schemes which have various analytical assumptions: geological, geomorphic, morphometric, hydrological, denudational, glaciological, sedimentological, ecological, botanical etc are adjusted. After examination of these different visions useful features of each scheme are adopted to a model of polar river system. Adopted analysis is based on four steps of reading the landscape (Fryirs and Brierley 2012) in this case of fluvial and slope landscapes in glacial, proglacial, periglacial and paraglacial terms. As an effect of analysis geoecological functions for river systems on polar areas are presented. These functions are divided for glaciated and unglaciated catchments. Distinguished functions described successive geoecological zones in polar catchments.

Fryirs K.A. & Brierley G.J., 2012. Geomorphic Analysis of River Systems: An Approach to Reading the Landscape. John Wiley & Sons, Chichester.

Schumm S.A., 1977. The fluvial system. John Wiley & Sons, Chichester and New York.

Response of Landslide Sediment Dynamics to Forest Clearing in Coastal British Columbia, Canada

BRARDINONI F.(1), MAYNARD D.(2), ROLLERSON T.(3)
(1) University of Milano-Bicocca, MILANO, ITALY ; (2) Maynard & Assoc., NORTH VANCOUVER, CANADA ; (3) Golder Associates Ltd., GABRIOLA ISLAND, CANADA

We compile and examine a landslide historical inventory in northeastern Vancouver Island, Canada. The study area is underlain by extrusive (upper Triassic Karmutsen Formation) and intrusive rocks (Jurassic Island Intrusions). The dataset, compiled via interpretation of sequential aerial photosets, helicopter traverses, and extensive fieldwork, comprises a total of 1961 sediment sources, including 798 field-measured events. Field- and photo-based data cover a time window of approximately 70 years. The effects of forest management on landslide activity are assessed in terms of landslide density, sediment production, landslide geometry, landslide magnitude-frequency relations, topographic conditions of landslide initiation and deposition, and sediment redistribution across landscape components.

Results indicate that forest management alters natural landslide dynamics in many respects. Logging-related debris avalanches are typically smaller, consequently the magnitude-frequency relation in logged terrain occupies the small-to-medium magnitude spectrum (< 6000 m^3), with frequencies increasing by over an order of magnitude. Lithologic effects on sediment production appear amplified in that terrain underlain by extrusive rocks become increasingly more unstable than intrusive ones. Analysis of landslide initiation and deposition zones reveals that forest management accelerates sediment aggradation on mid and lower hillslopes and along the gully network. This pattern, which accelerates sediment recharge of gully systems, has the potential of increasing the frequency of channelized debris-flows, hence cause an extended period of disturbance, before sediment dynamics recover to pre-logging conditions. The effects of forest clearing on hillslope-channel coupling are composite: in cutblocks the percentage of sediment delivered to streams is reduced by 20-60% whereas road-related landslides are associated with highest connectivity to streams.

****

Controls of snow avalanche distribution and geomorphic avalanche activity at hillslopes in steep mountain valleys in western Norway

LAUTE K., BEYLICH A.A.
Geological Survey of Norway (NGU), TRONDHEIM, NORWAY

Snow avalanches are common phenomena in Norway. Research on snow avalanches provides insights into possible effects of predicted climate change on avalanche activity and connected sediment transport in mountain areas. This study focuses on (i) controlling factors of avalanche distribution and activity, and on (ii) their relative importance regarding mass transfers in two steep, parabolic-shaped and glacier-connected tributary valleys (Erdalen and Bødalen) in western Norway. Mapping of distribution, extension and run-out distances of avalanches is combined with spatial data analysis of morphometric controls. Based on correlation of climate data with monitored avalanche events the timing and frequency of avalanches is explored and debris mass transfer on hillslopes caused by avalanches is estimated. The denudative effect of snow avalanches occurs in two steps: firstly throughout erosion directly on the surface of the rockwall and secondly due to their transport ability which causes significant remobilization and transport of available debris further downslope. The distribution of snow avalanches depends on the valley orientation, slope aspects and rockwall morphometry. Especially distinct “bowl” shaped leeside upper rockwall areas allow a high accumulation rate of snow during winter which is then released as avalanches during spring. The timing and frequency of avalanches in both valleys depend mainly on snowfall intensity, periods with strong winds combined with a stable wind direction or sudden air temperature changes. As snow avalanches represent one of the dominant denudational processes they have a high relative importance regarding mass transfer within the sedimentary budgets of the entire valleys.

The Temporal and Spatial Quantification of Holocene Sediment Dynamics in a meso-scale catchment in northern Bavaria / Germany

FUCHS M., WILL M.
University of Giessen, GIESSEN, GERMANY

The Aufsess River catchment (97 km^2) in northern Bavaria, Germany, is studied to establish a Holocene sediment budget and to investigate the sediment dynamics since the early times of farming in the 3rd millennium BCE. The temporal characterization of the sediment dynamics is based on an intensive dating program with 73 OSL and 14 ^{14}C ages. To estimate soil erosion and deposition, colluvial and alluvial archives are investigated in the field by piling and trenching, supported by laboratory analyses. The sediment budget shows that 58% of these sediments are stored as colluvium in on- and foot-slope positions, 9% are stored as alluvium in the floodplains and 33% are exported from the Aufsess River catchment. Colluviation starts in the End-Neolithic (ca. 3100 BCE), while first indicators of soil erosion derived alluviation is recorded ca. 2-3 ka later. The pattern of sedimentation rates also displays differences between the colluvial and alluvial system, with a distinct increase in the Middle Ages (ca. 1000 CE) for the alluvial system, while the colluvial system records low sedimentation rates for this period. A contrast is also observed since Modern Times (ca. 1500 CE), with increasing sedimentation rates for the colluvial system, whereas the alluvial system records decreasing rates. The different behavior of the colluvial and alluvial system clearly shows the non-linear behavior of the catchment's fluvial system. The results further suggest that human impact is most probably the dominant factor influencing the sediment dynamics of the catchment since the introduction of farming.

****

Regionalization of geomorphic processes in the proglacial area of Gepatsch and Weißsee glaciers, Oetztal Alps, Austria

HILGER L., HECKMANN T., HAAS F., BECHT M.
Catholic University of Eichstaett-Ingolstadt, EICHSTAETT, GERMANY

Geomorphic processes in proglacial areas show intensities significantly higher than in lowlands. This fact can partially be explained by accelerated geomorphic reworking of comparatively recently exposed sediments and increased rockfall activity, both reflecting a transition to non-glacial conditions. Present day degradation of permafrost in elevation zones above the glacier tongues further contributes to high morphodynamics in such areas. A regionalization of geomorphic process domains and rates is a prerequisite to arrive at process-differentiated and total sediment budgets, not only in high mountain areas.

This paper focuses on the preliminary results of a regionalization of geomorphic processes within the proglacial areas and the sediment contributing slopes of two glaciers in the Ötztal Alps, Austria. The presented work is part of the interdisciplinary joint project PROSA (High-resolution measurements of morphodynamics in rapidly changing **PRO**glacial **S**ystems of the **A**lps) investigating the relative importance of glacial and non-glacial geomorphic processes for a recent process-differentiated sediment budget.

While multi-epoch terrestrial laser scanning data (TLS) of test sites at rockwall-talus systems and heavily gullied lateral moraines made it possible to determine process areas and rates on the local scale, high-density airborne LiDAR (ALS) data was available for all of the ~62 km^2 study area. DEMs of difference (DoDs) were generated from both ALS and TLS data wherein DEM quality adapted limits of change detection (LoDs) were applied. The obtained rates were regionalized by applying both probability based process models and a detailed geomorphic map prepared from high resolution DEMs (and derivatives) and high-resolution orthophotos.

An investigation of process connectivity is under way. A graph-theoretical approach has been proposed for an analysis of the linkages of process domains to the proglacial zone and between different subsystems of the catchment.

Sediment transfer and geomorphic work on a periglacial mountain slope

MUELLER J.(1), GAERTNER-ROER I.(1), KENNER R.(2), MORCHE D.(3)
(1) Department of Geography, University of Zurich, ZURICH, SWITZERLAND ; (2) WSL Institute for Snow and Avalanche Research SLF, DAVOS, SWITZERLAND ; (3) Department of Geoscience and Geography, University of Halle-Wittenberg, HALLE, GERMANY

Mountain geosystems are characterized by an extensive transfer of mass and energy, reflected in its geomorphological processes shaping the landscape. Changes in the temperature regime lead to corresponding changes in geomorphological processes and are manifested in characteristic landforms. Thus, distinct changes are expected in the periglacial belt, which is most sensitive to temperature changes, especially at its boundaries. So far, few attempts have been undertaken to quantify the transfer of sediment or energy in this environment.

A periglacial mountain slope near the lower permafrost boundary was investigated in Eastern Switzerland (Corvatsch). The slope is characterized by a typical coarse debris process chain: rock wall --> rock fall --> talus slope --> permafrost creep --> rockglacier. Rockglaciers are considered to be sediment traps for the coarse debris system, reflecting the erosion history of the corresponding catchment. Headwall recession, creep processes and energy transfer (geomorphic work) of the talus slopes and rockglaciers are quantified using a multi-method-approach combining remote sensing and terrestrial methods. Multitemporal DTMs developed during the last two decades allow the quantification of sediment transfer of the slow moving landforms (frozen talus slopes and rockglaciers). Sediment input from the rock wall is quantified by repeated laser scanning over the last 4 years. The multitemporal high resolution topographic information is used to compute the geomorphic work within this period.

The purpose of the study is to describe sediment and energy transfer on a periglacial mountain slope and to assess the relevance of permafrost occurrence for sediment budgets in a changing climate. The geomorphic work approach allows the characterisation and quantification of the slope's sediment dynamics on the basis of energy transfer and creates process-related and scale independent comparability.

****

Sediment sources, yield and connectivity in a low relief alpine catchment, Snowy Mountains, New South Wales, Australia

STROMSOE N.(1), CALLOW N.(2), MCGOWAN H.(1), MARX S.(3)
(1) University of Queensland, BRISBANE, AUSTRALIA ; (2) University of Western Australia, PERTH, AUSTRALIA ; (3) University of Wollongong, WOLLONGONG, AUSTRALIA

The Snowy Mountains are a unique alpine region from which to investigate the relative significance of fluvial and atmospheric sediment input as well as the yield and transmission of sediment through different components of the landscape. The Snowy Mountains are relatively geologically old, of moderate relief (<2,500m asl) and have a well-developed soil mantle protected by a dense cover of vegetation at even the highest elevations. Some previous research has shown transport rates are generally low for an alpine region (<20t/km^2/yr).

Using uranium isotopes, ^{14}C, ^{210}Pb and ^{137}Cs and ICP-MS analysis of sediment geochemistry, we investigated sediment transport and residence times in the Snowy Mountains over timescales of decades to several thousand years and for multiple depositional landscape features (e.g. tarns, bogs and reservoirs). Results to date suggest highly spatially variable sediment yields between 6 t/km^2/yr (high elevation reservoir) to 230 t/km^2/yr (tarn). Bog environments show almost entirely atmospheric input of sediments, though tarns are dominated by localised fluvial inputs. The modest sized (90 km^2) catchment above the reservoir is moderately disturbed by post-European cattle grazing and recent severe bushfires and has a relatively connected catchment (60% effective catchment area). Yet the low reservoir sediment yield indicates that sediment transmission is reduced by micro-scale patterns of sediment disconnectivity which are observed occur across individual hillslopes. Bog environments proximal to streams are also likely to act as efficient filters, with distal bog environments showing limited or no evidence of sediment transmission and redistribution via fluvial processes. Ongoing work at the hillslope-scale will further quantify erosion rates by investigating soil development and residence times to provide a more complete understanding sedimentation in sediment stores.

Poster presentations:

Estimate of Reservoirs Storage Capacity and Total Sediment Trapped in China

LU X., YANG X., RAN L.
Department of Geography, National University of Singapore, SINGAPORE, SINGAPORE

Chinese rivers have been experiencing a drastic decline in sediment loads in recent decades. This is mainly due to massive reservoirs constructions, although other factors like rainfall reduction, water withdrawals, sand mining, and vegetation recovery also play an important role in the sediment loads decline. By use of remote sensing images in conjunction with Google Earth and field check, the spatial distribution of constructed reservoirs in the large Chinese river basins was delineated and their storage volumes were estimated.The number of the extracted reservoirs (>0.0036 km2) is close to 90,000, almost half of the extracted lakes (over 180,000). The extracted reservoirs have much higher capacity (780 km3) than the extracted lakes (260 km3). The total amount of sediment trapped behind these dams will be estimated. The ultimate goal is to evaluate their cumulative impacts on sediment supply to coastal areas.

****

The I.A.G./A.I.G. SEDIBUD (Sediment Budgets in Cold Environments) Programme: Scientific key issues and future tasks

BEYLICH A.A.(1), LAMOUREUX S.F.(2), DECAULNE A.(3)
(1) Geological Survey of Norway (NGU), TRONDHEIM, NORWAY ; (2) Queen`s University, Department of Geography, KINGSTON, CANADA ; (3) CNRS UMR6042 Laboratory of Physical and Environmental Geography GEOLAB, University of Clermont-Ferrand, CLERMONT-FERRAND, FRANCE

Projected climate change will undoubtedly change surface environments in cold regions and alter the fluxes of sediments, nutrients and solutes, but the absence of quantitative data and coordinated process monitoring and analysis to understand the sensitivity of the Earth surface environment is acute in cold climate environments. The I.A.G. / A.I.G. SEDIBUD (Sediment Budgets in Cold Environments) Programme, building on the ESF SEDFLUX Network (started in 2004), was formed in 2005 to address this existing key knowledge gap. The central research question of this global group of scientists is to "Assess and model the contemporary sedimentary fluxes in cold climates, with emphasis on both particulate and dissolved components". SEDIBUD has developed manuals and protocols (SEDIFLUX Manual) with a key set of primary surface process monitoring and research data requirements to incorporate results from diverse field-based projects and allow coordinated quantitative analysis across the programme. About 50 defined SEDIBUD key test sites worldwide provide data on climate conditions, discharge and particulate and dissolved fluxes as well as information on other relevant surface processes. Defined SEDIBUD key tasks include(i) The ongoing and continued generation and compilation of comparable longer-term datasets on contemporary sedimentary and solute fluxes and yields from SEDIBUD key test sites worldwide, (ii) The continued extension of the SEDIBUD metadata database with these datasets, (iii) The testing of defined SEDIBUD hypotheses by using the datasets compiled in the SEDIBUD metadata database. Detailed information on SEDIBUD is found at the SEDIBUD website http://www.geomorph.org/wg/wgsb.html.

Holocene human impacts on fluvial sedimentary budgets in Malta, Central Mediterranean

SULTANA D.
University of Malta, MSIDA, MALTA

The Maltese Islands occupy a pivotal area in the Central Mediterranean, despite the latter, there have been relatively few studies regarding Holocene sedimentary processes. Research addresses these lacunae and ads to our ability to understand the role the first Maltese inhabitants had in altering sedimentary budgets.

Sedimentological and palynological studies were carried out on core and outcrop data from Marsa with the aim of appraising Maltese middle Holocene (6000 cal. BP) sedimentary depositional environments and processes.

Studies indicate that tectonic and climatic environments within the Islands did not substantially change during the middle Holocene. Despite the uniformity of these parameters, sedimentary studies of fluvial sequences showed exceptionally high rates of accretion during the middle Holocene epoch. Sedimentary accumulation rates as high as 5 meter per 500 years were measured. Palynological studies within the same epoch also indicate a shift in pollen species with a dramatic decrease in woodland pollen and a simultaneous increase in agricultural associated pollen.

High fluvial sedimentation rates during the middle Holocene were not found to coincide with variations in climatic and tectonic environments and were thus not thought to be the cause. The increase in fluvial sediment budget is proposed to be the result of intense soil erosion in upland sediment source catchment areas. The authors propose that high erosion rates were the consequence of deforestation (as early as 7300 cal. BP), brought about by early human agricultural practices. Eroded sediments were transported via fluvial systems and deposited at sea-level forcing rapid delta progradation despite a transgressive marine environment. The study thus gives evidence to the impacts early human activities had on Maltese ecosystems and fluvial sediment budgets.

****

The main snow-avalanche winters of the last 100 years documented by dendrogeomorphology in the Bødalen and Erdalen valleys, inner Nordfjord, western Norway

DECAULNE A.(1), EGGERTSSON Ó.(2), LAUTE K.(3), BEYLICH A.A.(3)
(1) CNRS - Geolab, CLERMONT-FERRAND, FRANCE ; (2) Iceland Forest Service, Research Branch, Mogilsa, REYKJAVIK, ICELAND ; (3) Geological Survey of Norway (NGU), TRONDHEIM, NORWAY

The Bødalen and Erdalen valleys present a high relief and a U-shaped system in the innermost part of the Nordfjord area in western Norway. Elevation varies from 520 to 2082 m a.s.l.

The lower parts of the cones are covered with downy birch (*Betula pubescens* Ehrh.) and grey alder (*Alnus incana* (L.) Moench) shrubs; tress in the runout zone are heavily damaged up to the opposite slope, crossing the sub-horizontal valley floor.

The forest-covered valley floor offers a great opportunity for snow-avalanche reconstruction using tree rings.

The methods used in this study include field survey, tree sampling, sample analyses and construction of a snow-avalanche chronology. Field survey locates the obvious impacts of snow avalanches in the distal runout zone, such as mineral debris deposits and damage on trees. Tree sampling of up to 91 trees, alive and dead, include cores and disks, selected randomly and along transects within the runout zones. The construction of the snow-avalanche chronology is based on the eccentricity signal of the impacted trees, dead of trees and dating of scars; the calculation of the avalanche activity index is derived for each year, according to the number of signals registered by trees related to the number of trees alive at this time.

The age structure of the stands reveals rather young trees, ranging from 20 to over 100 years.

The snow-avalanche chronology reveals numerous winters over the last 100 years with a representation over 10% and more than two trees responding during the same growth season. Four main winters are highlighted, 1940-1950, 1975-1976, 1996-1997 and 2006-2007. All of them have extreme runout distances, reaching 350 to 430 m from the toe of the cone.

Dendrogeomorphology is an efficient tool to unravel snow-avalanche chronology in the valley during the last 100 years. The snow-avalanche calendar is very reliable since the 1950s.

A sediment budget of an intensively cultivated downslope area of the Seine River: The Pays de Caux loess plateaux

LANDEMAINE V.(1), CERDAN O.(2), LAIGNEL B.(3)
(1) Université de Rouen - BRGM, MONT SAINT AIGNAN, FRANCE ; (2) BRGM, ORLEANS, FRANCE ; (3) Université de Rouen, MONT SAINT AIGNAN, FRANCE

In many cultivated areas of the loess belt in Northern Europe, loamy soils are particularly sensitive to runoff and erosion. The different erosion processes may not be continuous within a catchment, and runoff and erosion responses to rainfall events differ in function of the spatial scale of observation. Many of the underlying mechanisms of this scale effect are still unknown and/or not well described. In addition to spatial heterogeneities, erosion processes are also varying depending on the temporal resolution of measurements from the effect of the temporal dynamic of successive rainfall events to more seasonal variations either influenced by climate or anthropogenic land use changes. The objective of this paper is to identify and quantify the scale effects on runoff and erosion, from the field scale to the regional scale. The first part of this study will consider the effect of the spatial organisation of the landscape, both in terms of connectivity and patchiness. The second part will investigate the relative importance of the different processes that emerge as we move from one scale to another. More specifically we will quantify the different form of sediment transfer from local hillslope laminar flow, to concentrated flows to karst areas or to the river systems and, finally, to regional river export to the sea. These different quantifications will be extrapolated at the regional scale, taking into account of the landscape spatial organisation, to establish a regional sediment budget.

****

Relationship between Norway spruce (Picea abies (L.) Karst.) growth anomalies and sedimentation rates in the sulphur mining area of Calimani Massif, Romania

ANGHEL T.(1), STOFFEL M.(2), POP O.(1), BUIMGA-IARINCA S.(1), IRIMUS I.A.(1)
(1) Babes-Bolyai University, Faculty of Geography, CLUJ-NAPOCA, ROMANIA ; (2) University of Bern, Institute for Geological Sciences, Laboratory of Dendrogeomorphology & University of Geneva, Institute for Environmental Sciences, Carouge-Geneva, BERN & GENEVA, SWITZERLAND

Geomorphic processes (e.g., flows, slides) occurring in the poorly consolidated waste dump deposits of the sulphur mines represent a serious threat for the environment and people living downstream of abandoned sites. The Negoiul Românesc volcanic cone (Calimani Massif, Romania, 1895 m a.s.l.) is such a case, and toxic debris flows and landslides have recently started to affect a Norway spruce (Picea abies (L.) Karst.) forest located between 1700 and 1320 m a.s.l. In addition, at the lateral boundaries of the Dumitrelul retention basin, constructed to retain the waste, P. Abies trees are covered with up to 160 cm of toxic, sulphur-rich sediments originating from the waste dump deposits. This study aims at using dendrochronological methods to (i) analyze reactions of trees to sedimentation/burial by toxic debris and (ii) to determine the span time and burial depth tree can support in such an environment. The determination of tree locations was performed by topographical measurements using a Leica 407 total station. The dendrochronological study was performed with 22 buried P. abies trees. To analyze height, extent and intensity of anatomical changes in tree-ring records, a set of samples was extracted every 10 cm on the trunk of each tree, providing 450 increment cores and 57 stem discs. Another 20, non-affected P. abies trees were sampled (40 increment cores) to obtain undisturbed reference tree growth at the site and to compare with growth anomalies (i.e. residuals) in affected trees. The results show that trees severely react producing tangential rows of traumatic resin ducts (TRD) and growth suppression sequences (GS) during or following years with sedimentation events. The samples from affected trees show this type of reaction up to 110 cm under the sediment surface level reached in 2007, but also until 50 cm up on the trunks from this reference level. A high concentration of the TRD and GS is observed between 30 cm underground and 30 cm above to the reference level. These results could improve sampling strategies for the similar future studies in the mountain areas affected by mining activities.

Spatio-temporal variation of snow avalanche activity in Piatra Craiului Mountains (Romanian Carpathians) assessed by dendrogeomorphological methods

POP O.(1), MUNTEANU A.(2), GAVRILA I.(1), ANGHEL T.(1), PETREA D.(1)
(1) Babes-Bolyai University, Faculty of Geography, CLUJ-NAPOCA, ROMANIA ; (2) University of Bucarest, Faculty of Geography, BUCAREST, ROMANIA

Dendrogeomorphological methods were used here to analyze the reaction of trees to snow avalanche impact and to assess the time and spatial distribution of this geomorphic process in four different avalanche paths of Piatra Craiului Mountains. The dendrogeomorphological study was performed with 166 *Picea abies (L.) Karst.)* trees. Another 27, non-affected *P. abies* trees were sampled to obtain undisturbed reference tree growth at the site and to compare it with growth anomalies (i.e. residuals) in affected trees. The tree-rings showing growth anomalies (e.g. tangential rows of traumatic resin ducts, compression wood, callus tissue, growth suppression and growth release) were used to reconstruct a minimum frequency of avalanche activity for each of the four avalanche path site. The results show the affected trees reacted severely during or following years with snow avalanche events. In addition, data shows that the intensity of growth reactions in trees is positively correlated with position of trees on the avalanche couloir.

****

The experimental Louroux lake catchment: continuous records of discharge and suspended sediment flux in a small agricultural catchment

FOUCHER A.(1), SALVADOR-BLANES S.(1), DESMET M.(1), CERDAN O.(2), EVRARD O.(3), LEFEVRE I.(3)
(1) Université François Rabelais de Tours, Laboratoire GeHCo, TOURS, FRANCE ; (2) BRGM, ORLÉANS, FRANCE ; (3) Laboratoire des Sciences du Climat et de l'Environnement (LSCE/IPSL), GIF-SUR-YVETTE, FRANCE

The experimental Louroux lake catchment is a small agricultural headwater catchment (24 km²) of the Indre River which drains into the Loire River (France). This small catchment has been equipped with an experimental setup monitoring suspended sediment fluxes since 2012.

This catchment is characterised by lowland topography with gentle slopes (0.44 %). Most of the catchment (95 %) is cultivated and there are only a few fields occupied by long term pasture. Since the last Second World War, an intensive farming has been established. The catchment has been extensively submitted to subsurface drainage using drain tile. There are at least 220 drain tile outlets in the catchment and it is estimated that 90 % of the catchment is drained, 20 km of stream have been created and the lands reallocated.

A 55 ha lake dating back from the Middle Ages is present at the catchment outlet: this lake intercepts the suspended sediment flow of the catchment. Since 1000 AD, lake bed sedimentation rates have varied, with a pronounced acceleration since the early 1940s with lower quality of lake and rivers waters (N and P pollutions).The increase in suspended sediment yields and water degradation during the postwar periods is attributed to an increase of intensive farming in the catchment.

Eight continuous monitoring stations and one weather station have been positioned over the catchment. Continuous records of discharge and suspended sediment concentration are available from each of monitoring stations using V-notch and turbidity sensors.Three stream monitoring stations are located at the outlets of the main lake tributaries and two at upstream sub-catchments. The outlets of three subsurface drain tile systems draining arable fields are also monitored at different parts of the catchment.

This monitoring should allow a better understanding of the origin and dynamics of sediment transport within small intensively cultivated plain catchments.

Lateglacial to Holocene sediment budget of a small subAlpine river catchment: using 3D palaeotopographic reconstructions for volume quantification

GUITER F.(1), BRISSET E.(2), MIRAMONT C.(1), ANTHONY E.(3), BRUNETON H.(3)
(1) IMBE Aix-Marseille University, AIX EN PROVENCE, FRANCE ; (2) CEREGE/IMBE - Aix Marseille University, AIX EN PROVENCE, FRANCE ; (3) CEREGE - Aix-Marseille University, AIX EN PROVENCE, FRANCE

We present GIS-based quantification of stream catchment sediment budgets in a high-energy subAlpine setting in south-eastern France characterized by markedly different phases of deposition, stream incision, erosion and downstream sediment export. GPS-assisted field investigations were conducted in order to map accurately the geomorphology of the Charanc catchment at 3 key-dates of the morphogenetic evolution corresponding to (1) the abandonment surface of periglacial accumulation glacis at *ca.* 20,000 cal. BP; (2) the state of the catchment before dismantling of the periglacial slopes at *ca.*14,500 cal. BP and; (3) the "Main Postglacial Infilling" (MPI) abandonment surface prior to

Between 20,000 and 14,500 cal. BP, 36 million m^3 of sediments were eroded from the hillslopes. This eroded material was totally exported out of the catchment without intermediate storage. This sediment load did not accumulate in the Drouzet downstream of the Charanc. This entire volume of sediment was exported much further downstream to the trunk valleys of the Petit Buëch and Durance Rivers. Between 14,500 cal. BP and the present, 14 million m^3 of sediment were eroded at the expense of the periglacial glacis remnants and the marly substrate. 73 % (i.e., 10 millions of m^3) of the eroded material was stored in fan-shaped MPI deposits. At the present time, 6 million m^3 of MPI deposits (46 % of the eroded volume) are still stored in the catchment.

We analyse the spatio-temporal variability of these results in the light of the regional palaeo-environmental and climatic framework of the Lateglacial to Holocene periods, and compare specific erosion rates to present-day rates obtained from instrument-based measurements in such highly erodible environments.

****

Sediment Fluxes in Karkevagge, Swedish Lapland: A compilation of Previous Studies

DIXON J.
University of Arkansas, FAYETTEVILLE, UNITED STATES

Kärkevagge is a 5km long glaciated valley located in northern Swedish Lapland at approximately 68^o 26' N latitude and 18^o 18'E longitude. The 30yr Mean annual air temperature from the nearby Katterjåkk climate station is -1.7^oC and mean annual precipitation is 844mm. Mean total sediment output from the catchment is in the vicinity of 0.2-1.2 $tkm^{-2}d^{-1}$ (Rehn et al. 1982). There is however considerable spatial variability in sediment transfer within the valley. In addition, flood and slush events contribute substantially greater amounts of suspended sediment up to as much as 3.4 $tkm^{-2}d^{-1}$. In addition there is considerable variability in suspended sediment transport within the valley channel systems

Considerable variability in solute flux is observed within the valley. Total solute flux is greatest in the vicinity of the valley outlet, but within the valley solute flux is greatest at the base of the dam impounding Lake Rissajaure.

Solifluction movements are on average 4cm per year but display considerable spatial variability depending on available moisture. Mean mass transfer is in the vicinity of 20,000 mt/yr (Ridefelt et al., 2009). Slush avalanches and slush torrents represent significant contributors to sediment transport in the valley. Slush avalanches display considerable temporal variability in their magnitude varying from as little as $0.5m^3$ to $>300m^3$ Rapp (1960). Slush torrents may contribute between 10,000 and 20,000 m^3 of mass flow (Gude et al., 2000). ey.

Sediment fluxes within Kärkevagge are strongly variable both spatially and temporally. There is some suggestion that while some processes appear to have changed little since Rapp's 1960 study other processes have increased measurably in magnitude.

How Far was this Sediment Origin? A Granulometry May Tell

MERCIER J.
Universit_ de Strasbourg, STRASBOURG, FRANCE

On hillslope, using the continuity and flow equations, the altitude of a square meter result's from the local mass balance by unit volume.

This sediment budget obey different geomorphological processes including: production, mobilization, transit, deposition. Some of the processes involved: distance to the source, time travel, residence time, can be inferred from the development of sediment particle analysis. In this text, applying geomorphology, physics and distributions, we use a model that gives a numerical value to characterize sand distribution and a possible explanation of the physical parameters involved.

The samples are originating from the Vosges Mountains were slopes processes, water balance, microclimatic studies have been performed for several decades in the Ringelbach watershed.

****

Morphodynamics of reservoir banks in the Kama River: "accessory" geomorphic processes

NAZAROV N.N., FROLOVA I.V.
Perm State University National Research, PERM, RUSSIAN FEDERATION

At the Kama River reservoir banks (57 N, 55 E) poorly studied are hydration and physical weathering, suffusion, piping (tunnel erosion) and wind erosion.

Hydration weathering together with physical weathering and phytogenic destruction promotes removal of mineral and organic matter independent of any denudation agents. Geomorphic effects of this action are evident from bared roots of trees and stumps.

Frost weathering produces up to 40-cm deep cracks on sandbanks. Later on frost cracks may widen and obtain some intricate configurations under action of wind and surf flows.

Location of suffusion sinkholes is predetermined by rock fissuring. They are mostly abundant at edges of river terraces. Collapses of high banks are being prepared by piping. This process is active inside block slides, scree and landslide bodies that rest against steep banks. Subsurface erosion tunnels reach 1.5 m in diameter and 3-4 m in length.

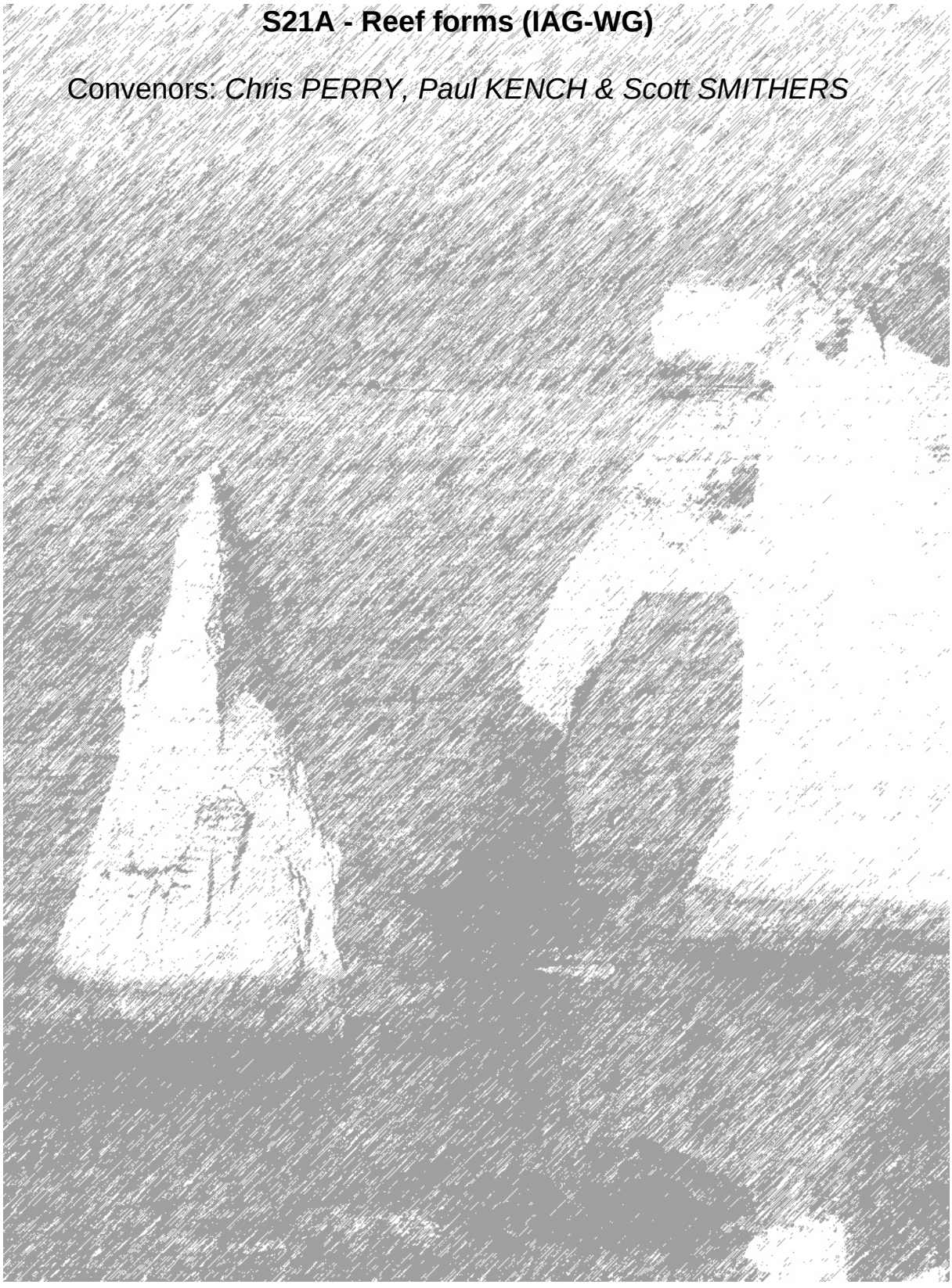
Wind erosion acts on river terraces composed of fine and medium sands. If prevailing wind directions are normal to bank, sand is being thrown from slopes to terrace surfaces and is transported inside by tens of meters from terrace edge. Observations show that under dry windy weather sand layer removed from terrace slope may reach 5-7 cm in a 3 day period.

Aeolian microforms or sand cover formed during the spring-summer season on terrace surfaces at a 30-m distance from the terrace edge are usually 3-5 cm thick (up to 15-25 cm in some years). Traces of redeposited sand are often found as far as 120-150 m from terrace edges.

****

S21A - Reef forms (IAG-WG)

Convenors: *Chris PERRY, Paul KENCH & Scott SMITHERS*



Oral presentations:

Biotic dynamics as a driver of coral reef geomorphology

RIEGL B.(1), PERRY C.(2), SMITHERS S.(3), KENCH P.(4)
(1) Nova Southeastern University, DANIA BEACH, UNITED STATES ; (2) University of Exeter, EXETER, UNITED KINGDOM ; (3) James Cook University, TOWNSVILLE, AUSTRALIA ; (4) University of Auckland, AUCKLAND, NEW ZEALAND

Reef-building is a major geomorphic process accomplished by mostly biological processes. It is therefore not surprising that interference with life-processes of reef-builders should result in visible alterations or even total switch-off of the framework-building processes. Corals have been key geomorphic agents throughout earth history, as can be seen from their contribution to framestones, rubble ridges, and unconsolidated sediments in general. Life-processes of branching corals are generally understood and can be, in combination with findings from taphonomy and geomorphology, be used to hindcast past dynamics on which forecasts to future dynamics can be predicated. We use findings from settings under very different environmental control, from typically reef-building (Great Barrier Reef) to non-reefal (Persian/Arabian Gulf) coral-dominated systems to illustrate how the generation of morphological structure is controlled by life processes such as reproduction, growth, and predation. Present-day climate change is poised to disadvantages corals by increasing disturbance frequency, causing increased rarity of corals or, at the very least, changes in community structure. This has the potential of changing their sedimentological and geomorphological signature. Changes in the constribution of different growthforms will influence the structure of frameworks, depressed coral populations may even result in a transition from frameworks to coral rudstones to floatstones and the morphology of the sedimentary body may in the end no longer be biotically controlled. Models and field-results are used to illustrate trajectories.

****

Holocene growth of King Reef - the largest mainland fringing reef on Great Barrier Reef, Australia

SMITHERS S.(1), PERRY C.(2), ROCHE R.(3)
(1) James Cook University, TOWNSVILLE, AUSTRALIA ; (2) College of Life and Environmental Sciences University of Exeter, EXETER, UNITED KINGDOM ; (3) School of Ocean Sciences, Bangor University, BANGOR, UNITED KINGDOM

The Great Barrier Reef is the world's largest reef system, containing more than 2900 named reefs, approximately one third of which are classified as fringing reefs (incipient and proper). The great majority of these fringing reefs are attached to high islands located in the GBR lagoon, with relatively few adjoining the mainland coast. Sediment and freshwater discharge from coastal catchments have been implicated as factors responsible for this paucity, impeding coral and fringing reef growth along large sections of the coast, including a stretch extending over almost 300 km between the northern Whitsundays and King Reef (17º46'50''S; 146º07'43''E) where fringing reefs are absent. Limited availability of hard rocky headlands to provide appropriate substrate for coral recruitment has also been suggested as a major constraint, with mainland fringing reefs most common on the Whitsunday coast between Cape Conway and Gloucester Island, where strong geological control has produced deep embayments confined by steep headlands. Covering an area of 8 km^2, King Reef is the largest mainland attached reef on the GBR. It is located adjacent to the Wet Tropics where proximal rivers seasonally deliver significant quantities of sediment and water to the coast. Here we report on research aimed at establishing the Holocene evolution of King Reef based on 14 cores from 2 transects and involving 26 AMS radiocarbon dates. Chrono-stratigraphic investigations indicate that King Reef initiated in shallow water over a surprising variety of substrates between 5800 and 5400 cal years BP and was substantially in place by around 400 cal years BP. Although a reasonably healthy reef community exists at the seaward fringe of King Reef today, reef structure has essentially ceased to increase in size over the past few thousand years. In this paper we discuss how the initiation substrates, age and structure of King Reef may challenge common views of reef distribution and growth.

Discovery of submerged karst terrain in modern reef area by broadband multibeam bathymetric survey in the southern Ryukyu Islands, Japan

KAN H.(1), URATA K.(2), NAGAO M.(3), HORI N.(4), OHASHI T.(1), NAKASHIMA Y.(5), GOTO K.(6), YOKOYAMA Y.(7), SUZUKI A.(3)
(1) Okayama University, OKAYAMA, JAPAN ; (2) Osaka University of Economics and Law, OSAKA, JAPAN ; (3) National Institute of Advanced Industrial Science and Technology (AIST), TSUKUBA, JAPAN ; (4) Nara University, NARA, JAPAN ; (5) Ariake National College of Technology, OMUTA, JAPAN ; (6) Tohoku University, SENDAI, JAPAN ; (7) University of Tokyo (AORI), KASHIWA, JAPAN

The extensive development of various types of karst was founded under the modern reef environment in the southern Ryukyu Islands. We conducted a broadband multibeam survey at the central area of Nagura Bay, Ishigaki Island in August 2011. The minimum/maximum depth was 1.6/58.5m in the measured area of 1.85 x 2.7 km. The sounding results were visualized at a lateral grid resolution of 1m.

The observed submarine topography showed the numerous closed contours which is recognized as karst, the topography formed by groundwater flow. The following five karst types were recognized in the surveyed area: 1) doline karst, 2) compound doline (uvala) or mega-doline, 3) cockpit karst, 4) polygonal karst, 5) fluviokarst. These types may reflect the difference of karstification process and stage. SCUBA diving observations suggested the Holocene reef and reef sediments are accumulated on the submerged karst to form “cover karst” in Nagura Bay. The small-scale karst landform such as karren may buried during the reef sedimentation.

By comparing with the sounding results observed from other reef areas around Ishigaki Island, the shape and size of topographic relief was different between submerged karst and coral reef. The reef environment established on the submerged karst was also unique from other fringing reefs and a barrier reef around Ishigaki Island because of the difference in topographic relief, water movement, sedimentary condition and presumably freshwater influence.

****

Calcium carbonate budget of a Maldivian reef platform

MORGAN K., KENCH P.
The University of Auckland, AUCKLAND, NEW ZEALAND

Coral reefs represent the end product of a suite of constructive and destructive ecological processes. Such processes occur at an individual organism scale; however, the collective balance between them dictates the abundance and distribution of reef organisms, net rates of reef accretion and the generation of detrital sediments for entire reef systems. A calcium carbonate budget provides a conceptual framework for quantifying the contribution of different calcareous organisms in the reef-building potential of an individual reef. This study uses a census-based method to estimate rates of gross carbonate production and biological erosion for Vabbinfaru reef platform, North Malè Atoll, Maldives. The study aims to generate new field-based datasets for the central Indian Ocean region and to extend the geographic range of existing budget studies. Gross carbonate production of primary (hermatypic corals) and secondary (encrusting organisms) producers were determined by estimating the benthic cover and abundance of reef organisms, coupled with *in situ* rates of skeletal calcification. Site-specific rates at which organisms (parrotfish, urchins and boring organisms) erode the reef framework were then quantified and subtracted from gross production values to generate an annual rate of net carbonate production (kg m^{-2} y^{-1}). Results from Vabbinfaru are compared to existing budget studies for other reef-building provinces and the implications of the findings are discussed in relation to the ecological state and the geomorphic development of the reef.

Hydrodynamic process controls on reef platform sedimentation and island formation

MANDLIER P., KENCH P.
The University of Auckland, AUCKLAND, NEW ZEALAND

Coral reef islands are accumulations of unconsolidated sand and gravel deposited on reef platform surfaces by ocean waves and currents. The morphological characteristics and stability of islands is controlled by hydrodynamic processes operating on reef surfaces which in turn are largely defined by the interactions of waves with the underlying platform structure. Reef shape and orientation to incident waves are crucial parameters controlling refraction and convergence processes and hence the potential for sediment accumulation and island formation. Platform geometries which promote marked wave refraction and centripetal wave motion are likely to retain sediment on the reef surface and accumulate a sandy cay. In contrast, reef configurations which impede wave convergence exhibit a higher potential for the off-reef evacuation of reef flat sediments and the formation of subtidal leeward sand aprons. This study presents results of wave measurements, bathymetric surveys and analysis of sediments collected from multiple lagoonal patch reefs in the Maldives which corroborate such projections and provide field evidence for a geomorphic model of reef sedimentation and island formation. Analysis of wave and current data demonstrates that platforms exhibit distinctive hydrodynamic process signatures, related to reef configuration, which control the dispersal and characteristics of sediment on the reef flat. Sediment collected from windward interference zones of elliptical reefs exhibit a coarser texture and faster settling properties than surface samples obtained from leeward reef regions and island beaches. Such spatial variations in sediment texture are attributed to across reef wave energy gradients which control the potential to entrain and transfer material of different size and shape. Results validate theoretical projections of hydrodynamic process controls on platform sedimentation and have significant implications for the morphological development of reef flat deposits.

****

Infill of Faro Lagoons: Size Thresholds and Controls on Island Formation in the Maldives

KENCH P.(1), PERRY C.(2), SMITHERS S.(3), YAMANO H.(4), O'LEARY M.(5)
(1) The University of Auckland, AUCKLAND, NEW ZEALAND ; (2) University of Exeter, EXETER, UNITED KINGDOM ; (3) James Cook University, TOWNSVILLE, AUSTRALIA ; (4) National Institute for Enivronmental Studies, TSUKUBA, JAPAN ; (5) Curtin University, PERTH, AUSTRALIA

Faro are annular-shaped reefs that impound lagoons, located within the larger lagoon basin of atolls and are conspicuous yet enigmatic features of Maldivian reef systems. While more than 1,000 faro occur in the Maldives, in varying stages of infill with some remaining largely empty while others are completely filled and capped by islands,the formation and Holocene development of these features remain unresolved. However, faro infill in the late Holocene has been implicated as critical for development of islands within atoll lagoons in the Maldives. Little is known of the rates of infill and timing of infill of faro that may support island formation. Clearly resolution of the timing of faro infill and onset of island building is critical for an improved understanding of the controls on island development and future island building potential. We present a dataset of the latter stages of faro infill and island formation from 7 lagoonal reef platforms in South Maalhosmadulu atoll, Maldives, based on morphostratigraphic analysis of 45 cores. A chronological framework of faro infill and island development is constructed from 90 radiometric dates. Results show a consistent multi-phase sedimentary infill sequence in each faro that terminates in *Halimeda*-rich sediments. Results also identify three apparent size thresholds of morphological development of faro, which have distinct chronological signatures and are related to island building potential. First, platforms <0.5 km^2 are typically filled by 5,500 years BP and have supported island accumulation between 5,000 and 3,500 years BP. Second, platforms 0.5-1.25 km^2 are in the final stages of infill and have ephemeral unvegetated sand cays. These platforms may provide opportunities for further island accumulation under suitable sediment supply regimes. Third, platforms >1.25 km^2 have not filled and given the dimensions of these faro, they are unlikely to fill over the next millennia.

Morphological response of reef island on rocas atoll (South Atlantic Ocean) to Seasonal energetic wave conditions

COSTA M.(1), MACEDO E.(2), SIEGLE E.(1)
(1) Universidade de Sao Paulo, SAO PAULO, BRAZIL ; (2) Instituto Chico Mendes de Conservação da Biodiversidade, FERNANDO DE NORONHA, BRAZIL

Reef islands on Rocas Atoll, the only atoll in the South Atlantic Ocean, are located at its leeward side, being protected from waves most part of the year but subjected to the impact of energetic swells from the north from November to February. With the aim of assessing the morphological evolution related to the incoming waves, in situ measurements were conducted in November 2012, covering a series of energetic wave conditions. Waves were measured by an ADCP (Nortek Aquadopp profiler) deployed at 1.2 km distance from the reef island and 0.9 km from the reef rim during 28 days. Simultaneously, the morphology of the entire reef island was surveyed with the use of a Differential Global Positioning System (DGPS). High energy waves with peak periods of about 13 s and significant wave heights of 2 m presented a weekly recurrence followed by a gradual decay. Morphological surveys show that the northwestern side of the island, which has been historically eroded, undergoes larger morphological changes. However, in contrast, there was an increase in volume on the beach island. The tridimensional terrain elevation models clearly show the removal of submerged banks dispersed on the reef rim and their deposition over the beach. This is thought to be due to the intense wave set-up generated by waves breaking on the leeward reef edge, moving the sediments in the opposite direction to that of the overall gravity-driven outflow. The results suggest that the sediment redistribution by seasonal northern swells contribute to sediment accretion on the reef island, thereby reducing the long-term erosion of this portion of the island.

****

A sediment budget for Lizard Island, northern Great Barrier Reef

JAVIER L.(1), WOODROFFE C.(2), PHINN S.(1), HAMYLTON S.(2)
(1) The University of Queensland, ST. LUCIA, AUSTRALIA ; (2) The University of Wollongong, WOLLONGONG, AUSTRALIA

The gloomy long-term prospect for coral reefs and associated landforms could be attributed to the fact that many of these reef systems, particularly fringing reefs, have experienced little to no growth since the early Holocene and now face multiple and interacting pressures arising from the ‘super wicked problem’ of global climate change. However, current understanding of the feedbacks between ecosystems and landform evolution in a changing climate context is very limited. The study of sediment generation and transport within reef systems is fundamental for understanding processes acting upon reef systems at temporal scales ranging from ecological processes to the evolution of associated landforms. However, there are significant gaps in the scientific understanding of sediment dynamics within coral reef systems. The calculation of a sediment budget by determining volumetric rates of sediment generation, transport and loss is an approach that may enable some reconciliation of the behaviour of a coral reef system at different time scales. In this paper we apply this approach to Lizard Island, a small fringing reef system in the northern Great Barrier Reef (GBR). Lizard Island is unique in the GBR as siliciclastic and carbonate sediments are being co-deposited in close proximity. In addition, the reef system has been isolated from large-scale human activities, providing a great opportunity to investigate sediment dynamics. The aim of this study is to compare the historical and contemporary sediment budgets of the mixed siliciclastic-carbonate coastal system in Lizard Island. The catchment evolution model SIBERIA was used to calculate the rate of sediment production on the island. Carbonate production was upscaled using benthic cover maps and published production rates. The resultant sediment budget was used to better understand the processes driving the geomorphic evolution of this system and provided insights into potential changes under future climate scenarios.

Atoll Island Geomorphology and Stability: Nukulaelae Atoll, Tuvalu, Central Pacific

MCLEAN R.
University of New South Wales-Canberra, CANBERRA ACT, AUSTRALIA

Nukulaelae is an elongate oval shaped atoll aligned NW-SE, 11 km and 3.3 km wide at it narrowest. It is the smallest atoll in Tuvalu. Nukulaelae has a continuous rim with no passages from ocean to lagoon; the reef rim is typically 400 m wide along the eastern and western sides and 600 m at the northern and southern ends. Twenty separate islets occupy a total of 18% of the reef flat rim (1190 ha). On the eastern side are two narrow islets both about 5 km long and 150 m wide. The remaining islets on the north and south are compact, of various shapes, sizes, are oriented orthogonal to the reef and are located on lagoon side of the reef flat. There are no islets on the western side of the atoll.

Twelve cross-islet profiles were surveyed on the five largest islets. Four main landform units were distinguished: (1) ocean-side ridge complex comprising the highest ridge (s) commonly of coral rubble; (2) lagoon-side berm complex is lower, backslope gentler and sediment sand-sized with foraminifera an important component; (3) central depression occupies the low area between ocean ridge(s) and lagoon berm (s); and, (4) pulaka pit-spoil bank complex comprises excavated depressions (pits) and surrounding ridges (spoil banks). These anthropogenic landforms have the highest relative relief on Nukulaelae.

Around the islets shorelines consist of reef derived sand and gravel and consolidated rock platforms. Unconsolidated shores display erosional features and accretional deposits. Minimal changes in islet shorelines have occurred during the last 30 years. All islands present in 1976 exist today. The plan outline and surface topography of the mainislet, Fangaua, in the northwest, is similar to that surveyed in 1897, during the Royal Society's Expedition to Funafuti atoll, 130 km north of Nukulaelae. The location of islands and their plan form and morphology are described and long-term stability discussed.

****

Poster presentations:

Quantifying the impacts of regional scale reef ecosystem decline on the geomorphic performance and growth potential of Caribbean coral reefs

PERRY C.(1), MURPHY G.(1), KENCH P.(2), SMITHERS S.(3), EDINGER E.(4), STENECK R.(5), MUMBY P.(6)
(1) University of Exeter, EXETER, UNITED KINGDOM ; (2) Univeristy of Auckland, AUCKLAND, NEW ZEALAND ; (3) James Cook University, TOWNSVILLE, AUSTRALIA ; (4) Memorial University, ST JOHNS, CANADA ; (5) University of Maine, MAINE, UNITED STATES ; (6) University of Queensland, BRISBANE, AUSTRALIA

Global-scale deteriorations in coral reef health have caused major shifts in species composition and are likely to be exacerbated by climate change. It has been suggested that one effect of these observed and projected ecological changes will be lower carbonate production rates on coral reefs, which will impair reef growth potential, compromise their ecosystem functions, and ultimately lead to states of net reef erosion. However, quantitative data to support such assertions are limited, and linkages between the ecological state of reefs and their past and present geomorphic performance (in other words their growth potential) are unresolved. Here we show that ecological change across the Caribbean has suppressed carbonate production rates and significantly slowed coral reef accretion. Using measures of gross and net carbonate production and erosion from 19 Caribbean reefs, we show that contemporary carbonate production rates are now substantially below those calculated for pre-disturbance and 'healthy' Caribbean reefs. On average, current production rates are less than 50% of pre-disturbance rates, and 37% of surveyed sites were net erosional. Calculated accretion rates (mm yr^{-1}) are also an order of magnitude lower within shallow water habitats compared to Holocene averages. A live coral cover threshold of around 10% is identified that is critical to maintaining positive production states. Below this ecological threshold many carbonate budgets become net negative and reef accretion stalls. Collectively, these data suggest that recent ecological declines are now propagating through the system to impact on the geomorphic performance of Caribbean reefs and will impair their future growth potential. Caribbean reefs thus have vastly reduced capacity to keep up with rising sea levels, and those ecosystem functions most dependent on reef structures are imminently threatened.

Precise timing and elevation of the mid-Holocene highstand at Belitung Island, Indonesia, on the Sunda Shelf, from coral microatolls

SWITZER A.(1), MELTZNER A.J.(1), WU C.C.(2), CHIANG H.W.(1), SHEN C.C.(2), GONG S.Y.(3), SUWARGADI B.W.(4), NATAWIDJAJA D.H.(4), HORTON B.P.(5)

(1) Earth Observatory of Singapore, SINGAPORE, SINGAPORE ; (2) Department of Geosciences, National Taiwan University, TAIPEI, TAIWAN ; (3) Department of Geology, National Museum of Natural Science, TAICHUNG, TAIWAN ; (4) Research Center for Geotechnology, Indonesian Institute of Sciences, BANDUNG, INDONESIA ; (5) Department of Earth and Environmental Science, University of Pennsylvania, PHILADELPHIA, UNITED STATES

The largest relative sea-level (RSL) signal is found in once glaciated (near-field) regions where ice loading produced considerable deformation of the Earth. At increasing distance from the centers of major glaciation, the ice-induced component of the signal diminishes and the eustatic (or meltwater) signal becomes dominant. At tectonically stable far-field locations, such as the Sunda Shelf, the RSL signal is commonly characterized by a mid-Holocene sea-level maximum, or highstand, at the time meltwater production decreased. The fall in RSL from this time to the present is a result of ongoing glacial isostatic adjustment (GIA) processes, including hydroisostatic loading (continental levering). Despite advances in understanding sea-level history in the far field, research near the Sunda Shelf has lagged, and the magnitude and timing of the mid-Holocene highstand in this region remain unresolved.

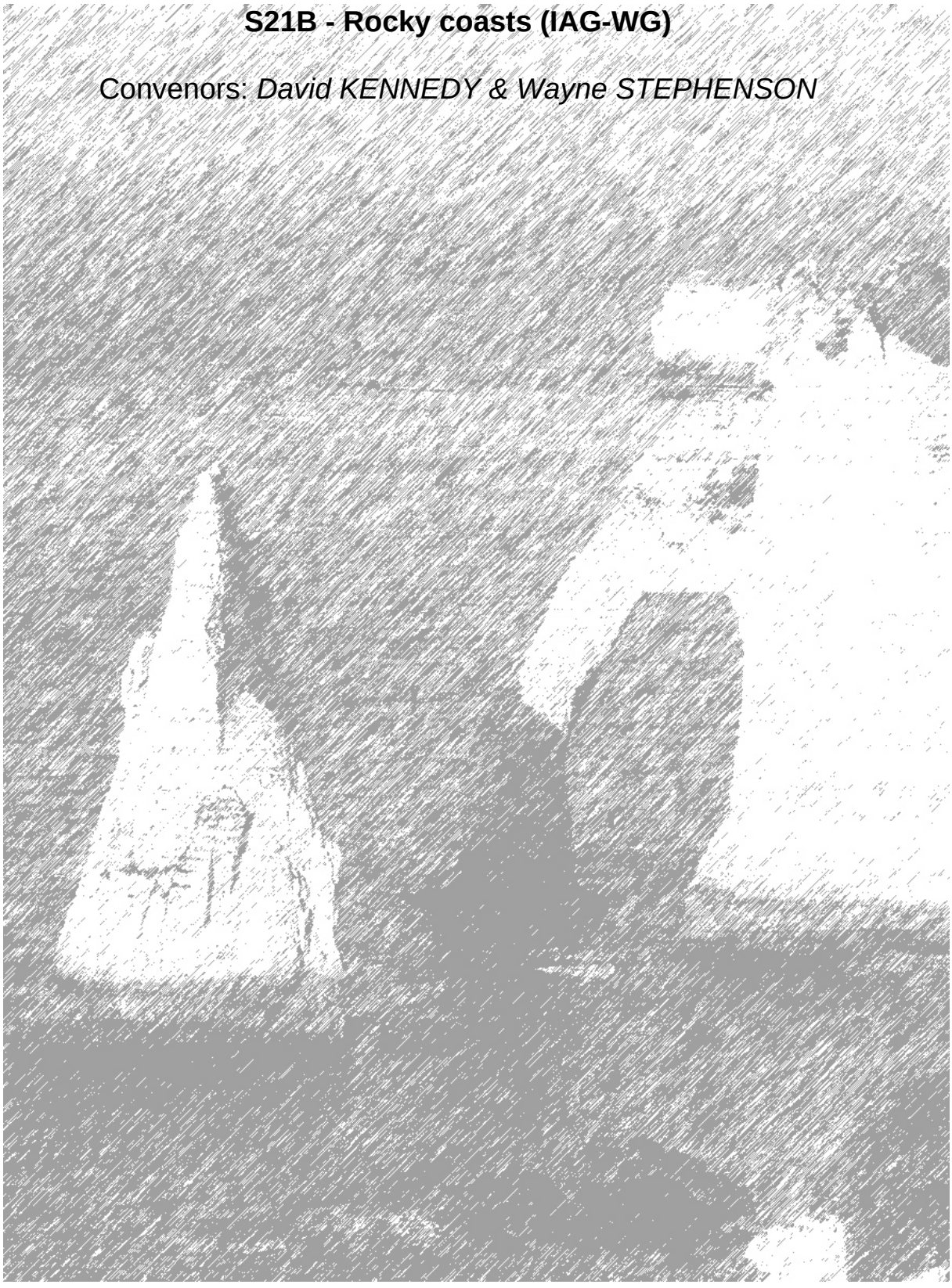
We present a preliminary mid-Holocene sea-level record from Belitung Island, Indonesia, on the Sunda Shelf, based primarily on coral microatolls. Microatolls' upward growth is limited by aerial exposure and hence they track low water to within a few cm, providing a high resolution record of former sea level. We slabbed 16 microatolls (each yielding a series of sea-level index points) and slabbed or cored 14 additional coral heads (each yielding a minimum sea-level marker). Preliminary U-Th and 14C dates suggest sea level rose rapidly to a highstand of +1.8 m at ~6.9 ka and then fell more gradually; we are working to determine appropriate initial 230Th/232Th ratios for the U-Th age calculation and appropriate ΔR corrections for 14C dating.

Although the basic form of our sea-level record is comparable to state-of-the-art GIA models, important differences emerge regarding both the timing and amplitude of the mid-Holocene highstand and the fall in RSL to present. Our data will be critical to calibrating GIA models and will allow for an improved understanding of eustatic history.

****

S21B - Rocky coasts (IAG-WG)

Convenors: *David KENNEDY & Wayne STEPHENSON*



Oral presentations:

The influence of inter-tidal shore platforms on soft cliff recession rates and headland formation on the southwest coast of the Isle of Wight

STUIVER C., NICHOLLS R.J., RICHARDS D., BARTON M.
University of Southampton, SOUTHAMPTON, UNITED KINGDOM

Management of soft cliff recession is one of the major global challenges of the 21st Century. Due to the high cost of coastal defences and the conservation and amenity value placed on natural coastlines, managed retreat is expected to become increasingly common in the future. To accurately predict future rates and patterns of erosion required for managed retreat it is important to understand the factors controlling recession.

On the open coast it is the exposure of the cliff toe combined with its strength that is critical in controlling recession rates. Exposure of the cliff toe is in turn controlled by the presence and character of a beach and/or shore platform. Variations in the exposure of the cliff toe alongshore can result in the formation of subtle headlands. This study on the southwest coast of the Isle of Wight considers the geological and geotechnical properties of the cliff and platform, the beach morphology and sediment budget and the refraction of wave energy along the coast, as controls on headland formation. The shallow dip of the geology and stratigraphic variation means that the lithology of the cliff is not always reflected in the platform. This shows platform lithology is the dominant control over headland formation and evolution. Characterisation of the platform lithology and geotechnical strength is a major focus of this study; to determine the factors which lead to the creation and maintenance of an intertidal platform in one lithology but not another.

This study highlights the importance of considering the detailed variations in geology when investigating cliff recession on sediment starved coastlines. For example one headland within the study area owes its existence to a shore platform created by two beds no more than 1m thick. Furthermore, changes in geological exposure with continued retreat or changes in the lithology outcropping in the intertidal zone with sea level rise can influence the subsequent coastal evolution.

****

Alongshore variations in hard rock coastal cliff erosion

NORMAN E., ROSSER N., BRAIN M., PETLEY D., WAUGH S.
Durham University, DURHAM, UNITED KINGDOM

Characterising the degree to which the planform geometry of hard rock coastlines reflects the distribution and variability of erosive intensity is key for understanding likely future coastline change. However, understanding of the controls and patterns of erosion along rocky coastlines is limited as few studies have focussed on hard rock cliffs. Apparently slow responses to environmental forcing, difficulties in capturing the rate of erosion and the multitude of forcing variables over a variety of spatial and temporal scales have limited the characterisation of cliff change and the dominant controls at the kilometre scale. Terrestrial laser scanning (TLS) has overcome many of these limitations, and is used here to enable continuous monitoring coverage at a high spatial resolution along 3 km of crenulous coastline.

We use TLS to explore the spatial development of cliff face erosion along a 3 km stretch of near vertical rock cliffs along the North York Moors National Park coast, UK. The cliffs are approximately 70 m high, consisting of near-horizontally bedded layers of Jurassic mudstones (at the cliff toe), shales, siltstones and sandstones. Data is presented from one year captured at monthly intervals, from which erosion is compared to the planform geometry of the coast obtained from airborne LiDAR. We explore variability in erosion depths, rockfall magnitudes and frequencies, and the vertical distribution of rockfall up-cliff. We test the effects of varying cliff-line concavity, convexity and aspect with respect to incoming marine and subaerial processes and rock mass structure. In future this data will be used to inform a model of coastline retreat that includes a planform component.

Pluri-decadal evolution of cretaceaous coastal cliffs alonf the eastern English Channel in Upper-Normandy (NW France), as evidenced by aerial photographs and Lidar

ELINEAU S.(1), DUPERRET A.(2), MERRIEN-SOUKATCHOFF V.(3)
(1) UMR 6294 CNRS LOMC, Université du Havre, Laboratoire Ondes et Milieux Complexes, 53 rue de Prony BP540, LE HAVRE, FRANCE ; (2) UMR 6538 CNRS Domaines Océaniques, Institut Universitaire Européen de la Mer, place Nicolas Copernic, PLOUZANE, FRANCE ; (3) UMR Géoressource, Ecole des Mines de Nancy, Université de Lorraine, Parc de Saurupt, CS 14234, NANCY, FRANCE

The Upper-Normandy coastline is made of high (95m) coastal cliffs cut in sedimentary rocks. Successive, transverse-oriented to the coast, topographic cross-sections spaced 500 m apart were extracted from high-resolution LiDAR aerial surveys performed in 2006, 2008 and 2011 north of Le Havre town, between the La Hève and Antifer capes. They show three main slope breaks, that have been mapped, using georeferenced aerial photographs (taken in 1939 and 1985) and orthophotographs (2008 and 2011).

Mapping shows that the cliff toe has a general accretion with a progressive increase to the north. Four spatial sectors can be defined from the La Hève Cape to the north with respective accretions (1) up to 0.50 m/year on a distance of 1 km, (2) a mean of 0.40 m/year on 2 km, (3) 1 m/year on 5 km and (4) 2 m/year on 3.5 km with local peaks at 2.7 m/year.

In parallel, the mid-slope break and the top cliff show deformations associated with a rotational sliding of the entire cliff. Such gravitational deformation has been confirmed by 2D Finite Elements models of the cliff. Nevertheless, the cliff toe evolution is four times more important than the mid-slope break and the cliff top evolutions. This could be related to the Antifer harbor amenities built in 1973 at north of the studied area which favors sedimentary accumulation guided by a littoral drift.

The total volume of the slope wedge is around 38 millions of m^3on 16.5 km of coastline length. Some sedimentary lobes of the slope wedge, reaching the actual sea level (corresponding to 5% of the study coastline length), are eroded by the sea during high spring tides.

We have tested the potential effect of a sea-level rise on the coastal slope instability. A potential surge of 2 m is already observed at Le Havre. If the surge (due to a tempest) is concomitant with a spring high tide, this may amplify the erosion of the wedge toe and extends the contact between the sea and the land from 5% to 65% of the studied coastline.

****

Fall of coastal chalk cliffs in Upper Normandy: Towards the determination of triggering factors

LETORTU P.(1), COSTA S.(1), CADOR J.M.(1), CANTAT O.(1), MAQUAIRE O.(1), BONNET E.(2)
(1) UMR LETG-Caen GEOPHEN, CAEN, FRANCE ; (2) UMR IDEES-Caen, CAEN, FRANCE

Coastal chalk cliffs in Upper Normandy have often been studied in terms of retreat rate. However, few studies have been done on factors and processes leading to fall. It is admitted that coastal cliffs are sensitive to sub-aerial weathering factors (rainfall, temperatures) and to sea action that may be summed up to the evacuation of fallen debris leading to a new instability.

The aim of this work is to attempt to make a distinction between sub-aerial weathering and marine agents in the trigger of fall from these coastal cliffs with shore platform, composed of Upper Cretaceous chalk.

A weekly inventory of 331 falls (from 1 m^3 to 238 000 m^3) that occurred along a 37.5 km long coast (between Veules-les-Roses and Le Tréport) during the 2002-2009 period was analyzed. Statistical analyses were used in order to attempt to relate these fallen debris to meteorological and marine parameters that could be potentially responsible for the trigger of fall.

Our results highlighted:

1) A spatial polarization of scree phenomena or mass movements at Cap d'Ailly (favorable lithostratigraphic context),

2) Falls occurred all year long with a predominance during winter for massive falls (followed by autumn, spring and summer),

3) Most massive falls seemed preferentially triggered by heavy rainfall, and freeze/thaw cycles seemed responsible for scree production phenomena (individual particles),

4) Marine factors were not negligible but their influence is always difficult to quantify as falls of small volumes may quickly be removed during a turbulent period,

5) The fitting of falls samples to power law provided frequencies and return periods of events, useful for predictive purposes. A strong spatial variability due to lithological characteristics of chalk outcrops was noticed.

Despite this important inventory, some difficulties remained in quantifying the proportion of marine and sub-aerial weathering processes (problems of combination or relay of processes and probably hysteresis phenomena).

Analyzing the spatial structure of sea cliff instabilities through repeated high resolution terrestrial laser scanning surveys and point processes statistics

ROHMER J., DEWEZ T.
BRGM, ORLEANS, FRANCE

On rocky coasts, slope failures are spatially discontinuous and temporally intermittent. Many studies have addressed frequency-size statistics by means of collapse scar inventories, but only a few have addressed their spatial distribution. Yet, spatial patterns carry information about the external processes and the predisposing factors underlying sea-cliff retreat.

Over the last decade, terrestrial laser scanning (TLS) has enabled high accuracy surveys of collapse sizes and locations, which opens the way for addressing sea-cliff instabilities within the theoretical statistical background of “spatial point process”.

We use an inventory of >8500 sea cliff failures collated from 6 repeated TLS surveys over 2.5yr along a coastal chalk cliff in Normandy (France). We first show, through the analysis of residuals, that the spatial process underlying the occurrence of instabilities is inhomogeneous, which means that the spatial density (number of events per unit area) spatially varies along the coastline and along the cliff height.

Based on the computation of the inhomogeneous second-order spatial characteristics (e.g., Ripley’s K- function) and Monte-Carlo tests, we highlight several trends:

1. Small instabilities (volume $<10^{-2}$ m^3) cluster in patches over a spatial radius of less than 5-10m, and disperse above this distance;

2. Larger instabilities present a regular spatial pattern whatever the distance between events;

3. Assuming that a unique process both generates small and large instabilities, we show that the probability of occurrence of a given event, whether “small” or “large”, is not influenced by its neighbourhoods;

4. Conversely, assuming that two distinct processes generate small and large events, we show that they are not independent (for a given epoch);

5. The occurrence of small instabilities seems not to be influenced by past events, but a temporal dependence may exist for larger instabilities.

****

A new approach to coastal cliff landslide hazard assessment

DICKSON M.
University of Auckland, AUCKLAND, NEW ZEALAND

Worldwide coastal cliff-top land is highly prized for residential building sites. However, cliff erosion rates are accelerating under sea level rise and arresting erosion is both extremely expensive and temporary. In Auckland, New Zealand, urban development has proceeded at a rate nearly double the national average, and much of this has occurred atop cliffs made of weak sedimentary rock. Hazard planning in New Zealand has historically used heuristic models that yield a setback zone of restricted development. Such models have little predictive power and do not account for spatial variability in erosion rates. However, spatial variability is important: many sedimentary cliffs have slow ‘background’ erosion rates, whereas sudden episodic failure can remove several metres of cliff top in a single event. In this paper we take a different approach to the coastal landsliding problem. The first phase of work involved extensive mapping (field, air photos and LiDAR) along 45 km of coast. Landslide locations were identified and failure characteristics and geological attributes of the cliff were mapped. In tandem, mapping was also conducted on a regular grid at locations without failure, resulting in a large database of failed and unfailed sites, fault locations and other environment characteristics. A machine-learning method was used to identify the key characteristics of sites that had experienced landsliding over the period covered in our database. Three predictors were found to account for more than 80% of the relative influence. A resampling method was used to build probabilistic estimates of landslide likelihood at each sample point, which were then interpolated to produce region-wide maps showing landsliding susceptibility as well as the uncertainty in estimates at each location. The approach was cost-effective compared to previous hazard zone work, and provides a basis for a different type of hazard zonation on cliffed coasts subject to episodic failure.

Application of GNU Octave tools to analyse the shape of a rocky shoreline - an example from Hornsund area (SW Spitsbergen, Svalbard)

SWIRAD Z.(1), REES W.G.(2)
(1) University of Wroclaw, WROCLAW, POLAND ; (2) Scott Polar Research Institute, CAMBRIDGE, UNITED KINGDOM

In order to assess spatial differentiation in the shape of a shoreline objectively, it is crucial to accurately measure geomorphometric parameters of the coastline. GNU Octave free software can be helpful in geometrical calculations of the shoreline.

The shoreline is presented as a set of vectorized points along its course. Vectorization was performed on the orthophotomap. The length of the shoreline is the sum of sections between all the points. Having divided the result by the number of points, the average distance between two points is returned and reasonable distance for interpolation may be chosen. The shoreline is consequently divided into equal sections.

Headlands are defined as the points at which the angle between two consecutive vectors is bigger than at next four points on either side of them. After headlands are defined, orientation, width, depth and mean depth of embayments (areas between each pair of headlands) may be calculated.

The method has been applied to the 17 km long stretch of coastline of Hornsund, south-west Spitsbergen, located on the border of the fiord and open sea. The fragment of the coast is composed by metamorphic rocks: amphibolites, quartzites, schists, marbles and paragneisses.

GNU Octave proposed 16 headlands which were the basis of the analysis focused on intervening embayments. The analysis shows that the deepest embayments face west and south-west (towards open sea), but they also occur in places where structure and lithology are complex. Paragneisses support wide but shallow embayments, whereas most headlands are formed of quartzites. Further within the fiord embayments are carved in the series of schists and marbles and these are deep but narrow.

Since it is reasonable to assume that the shape of an embayment reflects both wave energy and structural control, further analysis will be aimed at identification of controlling factors and their relative influence on the shape of the north Hornsund coastline.

****

A feedback model relates rocky coast erosion to percolation theory, a new perspective on the statistics of erosion events

SAPOVAL B.(1), BALDASSARRI A.(2)
(1) Ecole Polytechnique-CNRS, PALAISEAU, FRANCE ; (2) Institute for Complex Systems-La Sapienza, ROMA, ITALY

Rocky coasts represents around 75% of the world's shorelines (R. A. Davis, Jr, D. M. Fitzgerald, Beaches and Coasts, Blackwell, Oxford 2004) and their dynamics is erratic, featuring numerous small and sometimes dramatic events. We discuss various situations where the coast shape can possibly be attributed to the feedback of the coast morphology on the erosive power. As erosion can spontaneously create irregular seashores, the geometrical irregularity in turn participates to the damping of sea-waves, decreasing the average erosive power. There may then exist a self-stabilization of the coast morphology.

A simple numerical implementation of such stabilization leads, through a complex avalanche dynamics, to the appearance of an irregular sea-shore. The coast shape depends on the coupling between morphology and damping and on spatial correlations in the rocks lithologic properties. When the distributions of the lithologies exhibit long range spatial correlations, a variety of morphologies are obtained mimicking observed coastline complexity. When rock lithologies are uncorrelated and for weak coupling, the process builds fractal sea-coasts with a dimension equal to 4/3, characteristic of percolation interfaces (B. Sapoval, A. Baldassarri, A. Gabrielli, Self-stabilized Fractality of Sea-coasts through Erosion, Phys. Rev. Lett. 93, 098501 (2004)).

On the other hand, the statistics of erosion events display long tail distributions that does not enter the category of Gaussian process, but rather that of critical systems.Our model provides a natural frame to explain these statistics. From a practical point of view, the analogy with percolation interfaces means that the coast constitutes a strong, but simultaneously locally fragile barrier. Accordingly, natural or human degradation of the rocks properties can trigger random and large erosion events, difficult to predict and control. In that sense, natural coasts should be ”preserved” and managed with care.

Set up and evolution of cliff-top storm deposits on the western coast of Banneg island in the Molène archipelago, Brittany, France

FICHAUT B., SUANEZ S.
Université de Bretagne Occidentale, PLOUZANÉ, FRANCE

More than 1000 m^3 of loose blocks quarried from the cliff face and top lie at the rear of the top of the western cliffs of Banneg island. These cliff-top storm deposits can locally form a spread of isolated blocks, however they more often form clusters or ridges at altitudes between 7 and 14 m above sea level and up to 75 m from the edge of the cliff. Locally these ridges are deposited in several parallel lines, up to three in the central part of the island. In the past twenty years these deposits have been drastically re-worked and new blocks have been quarried from the cliffs during two storms in december 1989 and march 2008. Four methods were used to analyze the changes that occured during these events. Analysis of the hydrodynamic conditions and of the extreme water levels, census of the fresh sockets of quarrying in the bedrock, measurement of blocks displacement and time-series analysis of ground photographs were conducted. They enabled to determine that most of the clasts come from the cliff-top and the wave scoured platform immediately on the rear. They also show that where parallel ridges exist, the ones standing right next to the cliff edge have been hardly reworked whereas on the ones lying inland considerable changes occured. Therefore it is possible to propose a spatio-temporal model of clusters formation and to explain the occuring of parallel ridges. The most seaward rigdes are erected first. Concomittant erosion and lowering of the cliff-top enable waves to become airborn and to throw clasts above the front ridge, eventually without reworking it. These blocks form a second ridge inland and eventually a third one possibly linked to the rebound of the mass of water coming from the largest waves.

****

Geomorphic hazard along southern Abruzzo coast (central Italy)

MARINO A., CIUCCI M.
INAIL/DIPIA, ROMA, ITALY

The area object of this research is the coastal are between Ortona and Vasto (southern Abruzzo) where are located several coastal cliffs. The main reason for this choice is constituted by the significant typological variability of existing processes. The most part of the coast is actually affected by landslides not necessarily coincident with active cliffs.

The results obtained from stability analysis and the assessment of retrogradation rates allowed to underline same basic features in morpho-evolutive process of cliffs in the studied area.

In studied cliffs kinematics resulted significant following factors:

Morpho-evolutive stage: in active cliffs erosive processes at the bottom imply steep slopes where instability events mostly develop as toppling or translational slipping along new sub-vertical surfaces; affected volumes are relatively small but the event can be in principle characterised by high frequence.

Waves: further than directly induced erosive processes, results to be significant the wave pressure on cliffs; this tends to modify failure kinematics, causing translational slipping on sub-vertical surfaces, and reducing, at the same time available strength.

Litho-structural features: the kind of kinematics at failure result to be strictly depending both on directly interested by waves lithotype, and on stratigraphic position of different lithotypes related to sea level. Indeed translational plane kinematics appear to be prevailing when stronger lithologies are affected. Whereas rotational kinematics characterise cliffs where clay outcrops at, or just beneath, sea level. In these conditions unstable volumes are larger and the average retrogradation rates are higher; anyway it must be considered that if the frequency of these instabilities does not allow the displacement of landslide mass by marine action the cliff became inactive and the instabilities should be located in stronger materials.

Geomorphological evidence of extreme wave events in the Maltese Islands

MOTTERSHEAD D., BRAY M., FARRES P., SOAR P.
University of Portsmouth, PORTSMOUTH, UNITED KINGDOM

The Maltese islands occupy a pivotal site in the central Mediterranean Sea, around the margins of which are abundant examples of extreme wave deposits, and thus offer a unique location for testing extreme wave effects in an open sea location. Malta is situated in a moderate sea wave environment in an historic tsunamigenic region. Unlike the Caribbean and Pacific, the Mediterranean does not suffer the confounding factors of tropical cyclones nor, unlike the Atlantic Ocean, storm waves of oceanic magnitude.

Maltese coastlines present topographies ranging from high cliffs, through coastal bedrock slopes and platforms to small coastal valleys, offering a range of potential responses to extreme wave attack. We present an extensive range of both erosional and depositional evidence of extreme wave activity and, in particular, a sensitive relationship between relief and the elevation and distribution of the evidence recorded.

The coasts bearing extreme wave evidence face NE, which is not the aspect of maximum fetch or wind velocities. This aspect is also consistent with the orientation of imbricated boulders. Boulder deposits extend up to >22 m asl, with many boulders exceeding the capacity of current storm waves to move them (Nott 2003). Shell encrusted boulders, derived from below sea level are found up to 6 m asl, apparently consistent with tsunamigenic deposits.

Lithological and morphological evidence show that bedrock erosion has occurred at elevations as high as 7-12 m asl, and we report a range of erosional forms which we believe may be previously unreported in Mediterranean contexts.

Some of the evidence may be explained by extreme storms, but a significant proportion appears to require the higher energies of tsunamigenic sources, of which there is other evidence in the region.

The postulation of tsunami waves reaching elevations of up to 22 m has significant implications for public safety and coastal management in Malta.

****

Evidence of storm wave induced shore platform boulder dynamics at Timaru, New Zealand

ABAZOVIC A., STEPHENSON W.J.
Department of Geography, University of Otago, DUNEDIN, NEW ZEALAND

Boulder accumulations on intertidal shore platforms on the east coast of the South Island of New Zealand present an opportunity to examine boulder mobility, transport modes and energy regimes needed for transport. This study is currently monitoring boulder transport through tagging, repeated photographing and surveying. In addition, self-contained accelerometers are being used to investigate the mode of boulder transport during storm events. Initial assessment of boulder sedimentology suggests that storm activity is responsible for boulder movement but transport by tsunami cannot be ruled out at this setting.

Preliminary observations, made in June and October 2012, revealed that the fine boulders located at mid-platform have the highest probability of being moved by storm waves, particularly during south-east swell conditions and minimum wave heights of 4 m. Namely, the smallest two tagged boulders, located in the close proximity of one another, were both tilted over the longest axis between the two observations made. During that period, the most energetic two events had predicted minimum wave heights of 3 m and predicted maximum wave heights of 6 m. These wave heights apparently do not suffice for movement of coarser boulders as no mobility of medium or coarse boulders in close proximity was recorded during the same period. Thus especially the largest boulders, located on the southern end of the platform, very likely require intense storm conditions or possibly a tsunami wave for their movement to occur.

Microseismic observations of coastal ground motion and geomorphic implications

YOUNG A.(1), GUZA R.(2), DICKSON M.(3), FLICK R.(2), WILLIAM O.(2)
(1) Scripps Institution of Oceanography, UCSD, LA JOLLA, CALIFORNIA, UNITED STATES ; (2) Scripps Institution of Oceanography, UCSD, LA JOLLA, CALIFORNIA, UNITED STATES ; (3) University of Auckland, AUCKAND, NEW ZEALAND

Ground motions driven by local swell and infragravity ocean waves were observed at seven unique worldwide coastal settings including rocky, cliffed, and sandy coasts. Coastal grounds motions were generated by low frequency gravitational ocean wave loading and attraction, and high frequency shaking caused by breaking ocean waves and wave-cliff impacts. Ground motions consistently increased with incident wave energy and were tidally modulated at various frequencies. However, tidal modulation differs between sites with dissimilar shore platforms, suggesting that platform elevation and geometry influences ocean-energy delivery to cliffs. High frequency response varied between sites, with elevated response at certain frequencies possibly related to local site geometry, ground material properties, and resonance affects. Similar high frequency ground motion observed at cliff and non-cliff sites suggests difficulties using seismic observations as a proxy for wave-cliff interaction in geomorphic studies. Low frequency cliff ground motion decays rapidly with inland distance from the cliff edge, causing continuous cyclic internal cliff strain. Although the observed strain values are several orders of magnitude lower than typical ultimate strain values for rock, the wave loading applies a large number of cycles and could potentially cause weakening through fatigue processes.

****

Towards an improved understanding of tidal notch development: ten years of micro-erosion meter rates, Phang Nga Bay, Thailand

MOSES C., ROBINSON D., WILLIAMS R.
University of Sussex, BRIGHTON, UNITED KINGDOM

Tidal notches, recesses extending along marine cliffs, develop because of higher weathering and erosion rates in the intertidal zone compared to the supratidal or subtidal zone. They are particularly well developed on Mediterranean and tropical rock coasts but also occur on rock coasts in higher latitudes. They develop in a range of rock types, including basalt and sandstone, but are arguably best developed, and certainly most intensively studied, on limestone. Tidal notches are commonly used as geomorphological indicators of sea level change and tectonic movement, with their horizontal depth often being used to estimate the duration of stillstands. Key models of cliff retreat are predicated on cliff undercutting and notch development.

Despite their importance in geomorphology and quaternary research, understanding of tidal notch erosion dynamics and modelling of their evolution remains limited. There are relatively few studies that directly measure rates of notch development and most have been short-term (2 – 3 years duration) and carried out on relatively soft, young rocks that yield quick results. Models of notch development are predominantly based on morphological studies and therefore give no indication of rates of development.

As part of an on-going, long-term study on Permian limestone at Phang Nga Bay, southern Thailand, we are addressing some of these issues through the collection and analysis of MEM measured rock surface recession data recorded both within notches and on the platforms that sometimes front them. Implications of the results to date, for models of notch development and rock coast erosion under tropical climates will be outlined.

Shore Platform and Cliff Notch Transitions along the La Paz Peninsula, Southern Baja, Mexico

TRENHAILE A., PRESTANSKI K., PORTER N., GAGNON J.
University of Windsor, Windsor, CANADA

Increasing exposure to wave action produces a northerly transition from various types of high tidal notches to narrow shore platforms in the andesitic lahar deposits of the La Paz Peninsula, in southern Baja, Mexico. Notches were surveyed in 18 areas and wear pins were cemented into the apex of each notch. The platforms were also surveyed in three areas and 36 transverse micro-erosion meter (TMEM) stations were installed in them. Laboratory experiments, using fresh and salt water, and geochemical analysis of rock samples taken from the notches and surrounding areas, were used to supplement the field data and to determine rates of notch erosion. Field measurements were made at the beginning and end of a 2.5 year period and the experiments were run for 17 months. There was insufficient erosion in the notches to determine rates of downwearing from the wear pins, but rates in the laboratory experiments were about 1.80 mm yr^{-1} in salt water and 0.39 mm yr^{-1} in fresh water. The shore platforms were narrower (few tens of metres) and steeper (1^{o}) than most platforms in similar microtidal environments, reflecting a weak wave environment and resistant rocks. Mean TMEM downwearing rates on the three platforms ranged from 0.14 to 0.42 mm yr^{-1}. There was a good relationship between notch height and the degree of exposure to wave action, but notch depth is time-dependent and the relationship with exposure was not statistically significant. Notch height was also related to the orientation and wave fetch of the site. The experiments and field evidence suggested that the notches were probably produced by salt weathering resulting from high tidal immersion near the cliff foot and from splash and spray at higher elevations. Contemporary erosion rates compensate for tectonic uplift rates of about 0.12 to 0.15 mm yr^{-1}, and coastal morphology is well adjusted to the present level of the sea.

****

Rocky coast dynamics - comparison between shore platform and adjacent sandy beach

GABRIEL S., OLIVEIRA S., HORTA J., MOURA D.
Algarve University, FARO, PORTUGAL

The balance between erosional and depositional processes depends on nearshore wave propagation as determined by wave climate, bottom slope, relative water depth and the structure connecting cliff and sea floor: shore platform or sandy beach. This work is developed in the aim of the ongoing research project named "*Erosion of Rocky Shores-differences in protection promoted by sandy beaches and shore platforms* (EROS)". Here we compare the wave propagation upon a shore platform and the adjacent sandy beach in a very crenulated rocky coast at Algarve, southern coast of Portugal. For this purpose two study sites differently exposed to the incident waves are considered. Six monitoring campaigns were performed always during spring tides in order to achieve the maximum intertidal exposed area. The nearshore wave characteristics were measured simultaneously in shore platform and sandy beach by four pressure transducers, programmed to acquire at 2 Hz frequency during one tidal cycle. The sensors were placed along transepts perpendicular to shoreline, two at low spring water level and the other two near cliff bottom. The complete wave spectra was post-processed through spectral analysis in order to extract several parameters such as, significant wave height (Hs) and period (Ts), wave energy and power. The offshore wave climate conditions were obtained in the Hydrographic Institute(IH) Faro buoy. Bottom slope was gathered throughout topographic surveys performed both in platform and sandy beach, by using a Differential Global Position System (DGPS). The sandy beach grain size variation was also characterized. The results obtained stressed the dependency of the relationship between the coastline orientation and the offshore wave direction both for wave transformation, beach morphology and sediment granulometry. A more effective dissipation in wave energy was observed for higher Hs measured in seaward sensors, both in shore platform and in sandy beach.

Using beach and sea cliff dynamics to understand rocky coastline morphology, sea stacks, and headland amplitude

LIMBER P.(1), MURRAY A.B.(1), ADAMS P.(2), GOLDSTEIN E.(1)
(1) Duke University, DURHAM, UNITED STATES ; (2) University of Florida, GAINESVILLE, UNITED STATES

On rocky coastlines, interactions between beaches and sea cliffs can explain a wide variety of morphological features and processes, including sea stacks, headland prevalence, cross-shore headland amplitude, and approach to a steady state. The key feedback is that sea cliffs, as they erode and retreat, can produce beach sediment that controls future cliff retreat rates. In small amounts, sediment can accelerate sea cliff retreat by acting as an abrasive tool, and in large amounts it can hinder cliff retreat by dissipating wave energy seaward of the cliff toe. Because wave-driven sediment transport actively distributes beach sediment alongshore, these feedbacks vary spatially. As a result, interesting morphological features can develop, ranging in scale from hundreds of meters to tens of kilometers.

At the largest scale (tens of kilometers), beach and sea cliff dynamics (coupled with alongshore sediment transport) offer a simple understanding of why some rocky coastlines exhibit alternating sequences of rocky headlands and isolated pocket beaches, while others feature wide, continuous beaches backed by stable sea cliffs. An answer can be found using a balance of beach sediment gains and losses, such that alongshore headland prevalence decreases as sediment gains increase, or as sea cliff retreat rates and heights increase. Zooming in and focusing on individual headlands and pocket beaches, the same beach and sea cliff dynamics can explain sea stack formation and prevalence, as well as cross-shore headland amplitude. Numerical and analytical model results suggest that certain combinations of wave climate, sea cliff characteristics, and initial headland shapes can encourage stack formation. When sea stacks do not form, results suggest that equilibrium cross-shore rocky headland amplitude (relative to neighboring embayments) is controlled by alongshore headland spacing, as well as the retreat rates and properties of the headland and embayment sea cliffs.

****

Beach nourishment impact in receding soft rock coastal cliffs using remote sensing techniques (Forte Novo, south Portugal)

NUNES M.(1), FERREIRA Ó.(1), BAILY B.(2), CALVÃO J.(3)
(1) University of Algarve, FARO, PORTUGAL ; (2) University of Portsmouth, PORTSMOUTH, UNITED KINGDOM ; (3) Universidade de Lisboa, LISBOA, PORTUGAL

Beach nourishment is considered to protect rock coastal cliffs from marine erosion, reducing significantly the cliff failures stimulated by wave action. By avoiding a direct marine action beach nourishment enables the analysis of sub-aerial erosion significance in coastal cliffs. The main goal of this study is to compare the role of marine and sub-aerial erosion at a cliff system, before and after beach nourishment.

The coastal cliffs at Forte Novo (Southern Portugal) are composed of Plio-Pleistocene poorly consolidated sandstones, a low resistant cliff material that registered high erosion rates since the construction of hard engineering structures updrift of the study area in the 70's. Beach nourishment in June 2010 added up to 4 m of sediment at the cliff base and 3 m over the berm.

The cliffs were monitored with 11 surveys from November 2009 until May 2012. Data collection initiated with a airborne LIDAR survey. The subsequent surveys were performed using a reflectorless total station or a terrestrial laser scanning to measure the cliff, and a RTK-DGPS to monitor the adjacent fronting beach. Hydrodynamic (wave and tide) and meteorological (rainfall) conditions are combined with cliff loss volume to analyse the forcing factors in cliff retreat before and after nourishment. The different impacts of marine and sub-aerial erosion were evaluated by comparing cliff loss volume during the monitoring period. The retreat of the cliff top line recorded a maximum of circa 7 m previously to the beach nourishment, and a maximum of circa 1 m after beach nourishment. Significant cliff failures occurred before beach nourishment. With a narrow beach the cliff base was frequently reached by waves in high tide and eroded during storms. Marine action was also responsible for the quick (days) erosion or removal of collapsed material. After beach nourishment the cliff became protected from wave attack with a wide beach and only exposed to slower sub-aerial erosion processes.

Boulder mobility and shore platform erosion in southern Galicia, Northwestern Spain

PEREZ-ALBERTI A.
Universidad de Santiago de Compostela, SANTIAGO DE COMPOSTELA, SPAIN

Boulder accumulations, consisting of clasts of up to 2 m in diameter, are common on the granitic rocky coasts of the northwestern Iberian Peninsula. Broken storm waves move these clasts over boulder-strewn shore platforms and within boulder beaches. To determine the mobility of these boulders, and consequently their abrasional or protectional role in the evolution of this rocky coast, a study was undertaken on a boulder beach at Laxe Brava, between the rias of Arosa and Muros and Noia. Several techniques and data sources were used to track boulder movementin this area, including painting the boulders, GPS profiling with centimeter accuracy, airborne LiDAR survey(with an accuracy of 10 cm in 2008 and 30 cm in 2010), and aerial photography with a 4 cm resolution from a remotely controlled helicopter in 2012; these aerial data were used to produce orthophotos for 2008, 2010, and 2012. Boulder mobility, in the vertical and horizontal planes, was recorded and quantified in this area by integrating data layers in a GIS. A second study is being conducted to determine the abrasional affect of loose material, ranging from sand to boulders, in a small bay in southern Galicia. About 40 transverse micro-erosion meter stations were installed in summer 2012, at sites where abrasion is active and, for comparative purposes, in other places where surface downwearing is only by weathering. Photogrammetric techniques, with similar resolution as in the first study, will be used to record boulder movement and the dislodgement of joint blocks and other large rock fragments by wave quarrying.

****

The role of biota in the weathering of microtidal shore platforms: first results from a new approach through case studies along the coast of NW Italy

PAPPALARDO M.(1), CHELLI A.(2), PANNACCIULLI F.G.(3)
(1) Dipartimento di Scienze della Terra, Pisa University, PISA, ITALY ; (2) Dipartimento di Fisica e Scienze della Terra M. Melloni, Parma University, PARMA, ITALY ; (3) ENEA - Centro Ricerche Ambiente Marino - S. Teresa, LA SPEZIA, ITALY

This work was aimed to test if bioerosion and bioprotection can be considered effective morphological processes in the current shaping of small shore platforms in the microtidal environment of the Ligurian Sea (NW Mediterranean). At the study sites the biota colonising the rock surface of the intertidal and lower supralittoral zone displays the following zonation pattern: from sea-level going upwards we can find macroalgae, a fringe with grazing gastropods, echinoids and mussels, a well defined barnacle belt (mostly *Chthamalus* spp.)topped by cyanophytes and lichens (*Verrucaria adriatica*) spreading in the supralittoral zone. Their relative contribution to the overall platform erosion deserves to be tested.

We focussed on the bioerosive/bioprotective role of chtamalid barnacles and lichens on shore platforms surface. We randomly selected 10x10 cm quadrats where we measured organisms percentage cover and rock hardness using a Schmidt hammer test. This analytical method was applied to a number of tracts of the platforms displaying different organisms cover. Results from a number of study sites located in the Gulf of La Spezia on a carbonatic bedrock, demonstrate that only those parts of the rock covered by chtamalid barnacles display a reduction of rock hardness of the order of 10% compared to uncovered rock at the same elevation a.s.l.. Differences in rock hardness between covered and uncovered rock quadrats proved to be statistically significant. If we consider that in the uncovered part of the platforms at intertidal-lower supralittoral rock hardness is reduced by 50% with respect to fresh rock, bioerosion impact proves to be of a much lower magnitude than that of physical weathering. Data from further test sites, shaped in sandstones, and obtained with a different experimental design are presented in order to test our first results against further evidence. Different interpretative hypotheses are discussed to explain the highlighted weathering pattern.

Wave transformations across a macro-tidal shore platform

STEPHENSON W.(1), NAYLOR L.(2), CHEN B.(1)
(1) University of Otago, DUNEDIN, NEW ZEALAND ; (2) University of Exeter, PENRYN, UNITED KINGDOM

How swell and wind waves are transformed across shore platforms has become a central question in rock coast studies with only a limited number of field studies recently reported in the literature. Critical questions include; how much energy relative to deep water is delivered to the platform cliff junction (where platform extension occurs), how much energy is transformed to infragravity frequencies and does energy in the infragravity band have any geomorphic consequence for rock coasts? Previous investigations of wave transformations across shore platforms have mostly occurred in micro-tidal environments where water depth and platform width are limiting factors on wave energy arriving at the cliff platform junction. Only one previous study has occurred in a macro-tidal setting, where the erosive potential of waves was assessed. Here we report on the results of the deployment of three wave recorders across a shore platform in a macro-tidal setting, on the Glamorgan coast of South Wales, United Kingdom. The pressure transducers were deployed across a platform for four days recording 2048 samples at 4 Hz, in burst at 10 minute intervals over eight high tides (489 burts). At the outer edge of the platform water depths at high tide were 8 m meaning that waves crossed the platform without breaking. Maximum wave height at the top of the platform was 2.4 m and Hsig never exceeded 1.34 m. Water depth at the cliff platform junction at high tide were 1.4 m and limited wave heights by forcing breaking. Only a small amount of energy were observed at infragravity frequencies at the top of the platform. Analysis shows that less than 8% of the total energy is contained within infragravity frequencies; swell, wind and capillary waves dominate containing 92% of the total energy. On this platform it is unlikely that infragravity energy has any geomorphic function other than to remove a small amount of energy from the gravity wave frequencies.

****

Comparative rates of surface erosion of coastal engineering materials and of chalk and sandstone platforms, East Sussex, southeast England

ROBINSON D., MOSES C.
University of Sussex, BRIGHTON, UNITED KINGDOM

Understanding shore platform erosion dynamics is important in the context of coastal management, because platform erosion is considered to be linked to cliff retreat and, because coastal defence structures are often built directly into the platform at the cliff toe. The effective life span of defence structures is affected both by downwearing of the platforms on which they are built and by the resistance of the engineering materials to weathering and erosion.

The Cretaceous Chalk coasts of northwest Europe, and particularly those of southeast England, are among the most dynamic and most intensively studied rock coasts in the world. Perceptible changes to platforms, measured on monthly, seasonal, annual and decadal time scales provide a discontinuous database of erosion rates of Sussex platforms spanning over twenty years. The cliffs and platforms composed of Cretaceous sandstone, that occur also in southeast England, have been much less intensively studied. Much of the coast is urbanised and long stretches have been protected by various combinations of groynes and sea walls, some built of concrete, incorporating local flint, others comprised entirely of imported rock-blocks. The erosion rates and therefore potential life span of these engineering structures are essentially unknown.

Complementing and extending the existing dataset on the Chalk platforms, we provide some additional data on erosion rates, collected using Micro-Erosion Metres, of chalk and sandstone platforms, concrete walls and groynes, and imported rock-blocks, all collected over the same time period, for a range of sites along the southeast coast of England.

The implications of the results for coastal erosion rates and the lifespan and effectiveness of the coastal defence structures will be discussed.

Rocky shore platform's evolution in the North-West Coast of Egypt

SALEEM A.(1), MAHMOUD A.M.(2)
(1) Ain Shams University , CAIRO, EGYPT ; (2) Ain Shams University, CAIRO, EGYPT

Both recent and old shore platforms are the most common element of the Egyptian Mediterranean rocky coast. Topographic and geological characteristics of the shore platforms have been identified in the field: platforms are situated at different altitudes in relation to mean sea level and they are formed in different carbonate formations from Miocene to Pleistocene ages. We measured many aspects of platform's rock discontinuities such as joints, bedding and minor faulting.

Absolute dating of the old platforms is not possible due to the lack of datable and precise biological sea level indicators. This study seeks to examine relative ages of shore platforms.

Many features testify to inheritance of the platforms such as:

- The occurrence of well developed benches and tidal notches above current MSL.
- Residual pools isolated by platforms down wearing.

We examined the long term evolution of shore platforms applying two field methods:

- Schmidt hammer test was used to quantitatively measure what degree, the platforms are weathered. Field measurements denote that subaerial weathering weakens rock strength by 50% and 40% for Miocene and Pleistocene limestone respectively
- Studying platform derived boulders: angular clasts of different size '' pebbles to very coarse boulders'' were moved by wave quarrying process. Firstly we defined platform derived boulders based on field measurements and notes and laboratory petrographic test then mathematical modeling, data of extreme waves ''instrumental and or historical '' were used to asses wave quarrying process on the platforms. It was found that regular winter storms are reshaping platforms every season however paleo extremity ''storms and or tsunamis'' had played a fundamental role in removing the largest blocks over long time scale.

****

260 km of snorkel-geomorphological surveying along the Istrian rocky coast (Croatia, Slovenia, Italy): results from the 'Geoswim project'

FURLANI S., CUCCHI F.
Dept. of Mathematics and Geosciences, University of Trieste, TRIESTE, ITALY

The northeastern Adriatic coast is dominated by limestone plunging cliffs or near-vertical slopes. Although the present-day notch is completely lacking, the occurrence of a well-carved submerged notch have been observed by several Authors. It has been used, together with archaeological markers, to evaluate the tectonic subsidence of the area. In order to map in detail the submerged notch and to evaluate the factors driving its development, an ongoing snorkel geomorphological and hydrological survey has been carried out along the Istrian coast.

The survey was carried out during July 2012 through a 260 km snorkel-surveying, from Luka Budava to Trieste by S. Furlani. Moreover, two limited coastal sectors were selected to test the method. The route was covered by swimming in 28 days. A small boat with surveying instruments (two underwater 3D cameras, a CTD diver, GPS, invar rods, a roughness meter, an ultrasonic depth meter, etc) was pushed during the survey.

Data collected show that the submerged notch occurs only in the northern part of the Gulf of Trieste and the central part of the Istrian peninsula, along plunging cliffs, are even if the studied coast is carved on the same Mesozoic limestone. The coastal sectors where the submarine notch occur are bordered by high vertical limestone plunging cliffs. Moreover, the sites are interested by the occurrence of submarine springs which provide large amount of freshwaters, even during periods marked by very low rainfalls.

Although data collected are not sufficient to distinguish between bioweathering rates and chemical solution related to freshwaters, a strong positive correlation between coastal morphology, the occurrence of submarine springs and the submerged notch can be observed.

Data collected suggest (1) the effectiveness of the snorkel surveying on long sectors of rocky coasts in geomorphological studies and (2) to reconsider the role of submarine freshwater in the notch genesis and evolution.

Poster presentations:

Photogrammetric evaluation of rocky coasts using UAV mapping system

PEREZ-ALBERTI A.(1), PIRES A.(2), LÓPEZ-SÁNCHEZ M.(3)
(1) Universidad de Santiago de Compostela, SANTIAGO DE COMPOSTELA, SPAIN ; (2) Universidade do Porto, PORTO, PORTUGAL ; (3) Cartogalicia, AMES, TEO (A CORUñA), SPAIN

In small scale areas (limited extent) unmanned aerial vehicles (UAVs) are an effective alternative to integrate with GIS mapping and applied cartography. UAVs are becoming the basis for photogrammetric projects and GIS platforms. These systems can be cost effective and have reasonable prices consequently they are applied in research projects with low budgets. UAVs reached a level of accuracy and expertise which allow the use of these systems as GIS mapping platforms. Over recent years UAV-platforms turn out to be very relevant for applications in precision farming, infrastructure maintenance, like road maintenance and dam surveillance. Likewise, UAVs can be applied to cadastral laws, generation of elevation models in small-scale areas such as gravel pits or even to other measurement technologies. Apart from all these applications this research gives an overview about the workflow of UAVs systems and their application for photogrammetric assessment of Galician rocky coasts (NW Spain).

The research presents the suitability of UAVs for GIS mapping applications; two examples for coastal cartography will be given in this work. Based on the general overview of UAV mapping and the two examples presented here, in future coastal projects it can be predicted using UAVs for most purposes which involve high resolution and accuracy. The boulders/clasts movements, coastline changes and shore monitoring are important data which depend on a quick and low cost system development to collect near real time spatial information. Such a prompt information collection skill has become a developing trend in the technology of remote sensing and GIS mapping. In this study, a UAV based spatial platform is proposed coupling GIS methodologies. Shoreline monitoring and boulder mobility analysis are important for integrated coastal zone management/planning. The current investigation is still in development to provide more detailed information.

****

Cliff erosion in a monochromatic wave flume: analysis of cliff recession and collapse events

CAPLAIN B.(1), REGARD V.(2), ASTRUC D.(1)
(1) Institut de Mécanique des Fluides de Toulouse, TOULOUSE, FRANCE ; (2) Géosciences Environnement Toulouse, TOULOUSE, FRANCE

Rocky coast erosion could be divided into cycles, each one corresponding to three successive phases: (i) the notch creation at the cliff toe by mechanical action of waves, (ii) the cliff fracturation leading to a collapse event (Young and Ashford, 2008) and (iii) the fallen cliff debris progressively evacuated by waves and currents modifying the bottom morphology. This study is devoted to the experimental analysis of the cliff recession rate, as a function of the wave climate, the grain size of sediment and the cliff height.

We performed the experiments in a wave flume of about 5 m long. A wetted sandy cliff is build with a height from water free surface of 8 cm. Three types of sand were used (D_{50} = 0.28-0.41-0.48 mm). In order to detect the free surface and the sand surface, we set up two cameras, one on the side of the flume and the other above the flume. The wave climate is estimated by capacitive probes and is characterized by the surf similarity parameter ξ and the incident wave energy flux F.

At the beginning of the experiments, cliff retreat is very important and collapsed sediment quickly creates a sandy platform on the 10% slope, then the recession rate tends to 0. We showed that the cliff recession rate are proportional with F and are not monotonic with ξ which controls the bottom morphology. We deduced the volume of each collapse event and so we estimated the material cohesion. We observed that the cliff recession is more important for finer sand while the cliff is more cohesive. The volume of cliff collapse events increases with the cliff height h_C and the cliff recession decreases with h_C, actually the total volume of eroded sediment is independent with the cliff height.

Young, A. and Ashford, S. (2008). Instability investigation of cantilevered seacliffs. Earth Surface Processes and Landforms, 33:1661–1677.

Late Holocene sea-cliff retreat recorded by 10Be profiles across a coastal platform: Theory and examples from the English Channel and Korea

REGARD V.(1), DEWEZ T.J.(2), BOURLÈS D.L.(3), ANDERSON R.S.(4), DUPERRET A.(5), COSTA S.(6), LEANNI L.(3), KEVIN P.(7), MAILLET G.M.(8)

(1) GET, Université de Toulouse/UPS/CNRS/IRD, TOULOUSE, FRANCE ; (2) BRGM; Risques Naturels, ORLÉANS, FRANCE ; (3) Aix-Marseille University, CEREGE, CNRS/IRD UM 34, AIX-EN-PROVENCE, FRANCE ; (4) University of Colorado, Dep. of Geological Sciences / INSTAAR, BOULDER, UNITED STATES ; (5) UMR CNRS 6538 Domaines océaniques, IUEM, PLOUZANÉ, FRANCE ; (6) Geophen, Université Caen Basse Normandie, CAEN, FRANCE ; (7) M2C, Université de Caen/CNRS, CAEN, FRANCE ; (8) LUNAM Université, CNRS UMR 6112 LPGN-BIAF, ANGERS, FRANCE

A new method for documenting the long term retreat rate of sea cliffs based on measurements and modeling of ^{10}Be concentration transects across present-day shore platforms is presented. The proposed numerical model relies on a scenario in which sea level rises since the last deglaciation, and predicts the shape of ^{10}Be concentration transects as a function of prescribed cliff recession and vertical coastal platform downwearing rates. Two independent transect features allow fitting the long-term recession rate model to field observations: a sharp ^{10}Be concentration drop predicted at the former stationary location of the cliff during the last glacial period ~100 ka ago, and a characteristic dome shape whose magnitude is directly related to the recession rate of the cliff.

A retreating chalk cliff site from the English Channel coast of France, at Mesnil Val, where the 7 m tidal range broadly exposes the shore platform, was selected to test the proposed method. Although retreat rates were too high to pinpoint the predicted ^{10}Be concentration drop at the last glacial cliff position, the ^{10}Be concentration of the flints sampled across the shore platform are consistent with the expected dome shape. When modeled using the proper tidal range and proposed Holocene sea level rise history, the ^{10}Be data yield a cliff retreat rate since the mid-Holocene of 11-13 cm/yr. This is consistent with a 30-year-long measurement record, strongly supporting the validity of the ^{10}Be method.

Using the data recently published by Choi et al. 2012, a second site, in Anmyeon island, western Korea, was tested,. A significantly lower retreat rate,,less than 1cm/yr, was then deduced.

Reference: Choi, K.H., Seong, Y.B., Jung, P.M., and Lee, S.Y., 2012, Using Cosmogenic ^{10}Be Dating to Unravel the Antiquity of a Rocky Shore Platform on the West Coast of Korea: Journal of Coastal Research, v. 282, p. 641–657, doi: 10.2112/JCOASTRES-D-11-00087.1.

****

Identification and quantification of rates of surface erosion on shore platforms in Malta and their relationship to environmental change

GAUCI R.(1), INKPEN R.(2), SCHEMBRI J.A.(3), FURLANI S.(4)

(1) University of Malta, PEMBROKE , MALTA ; (2) University of Portsmouth, PORTSMOUTH, UNITED KINGDOM ; (3) University of Malta, PEMBROKE, MALTA ; (4) University of Trieste, TRIESTE, ITALY

This study examines the erosion processes operating on horizontal and sloping limestone shore platforms in five sites of the Maltese Islands. Nineteen transverse micro-erosion meter (TMEM) stations have been set along the north-eastern, north-western and south-eastern coastline of Malta. All the TMEM stations were placed in belt transect positions across the width of the shore platforms. Schmidt Hammer tests were undertaken to determine variations in the rock hardness along the established transects. This study forms part of a five-year research project aimed to establish a network of erosion monitoring sites that will provide a baseline of shore platform erosion rates and against which to assess future rates of change. The methodology and results obtained during the first year of the project will be presented and discussed in this presentation. Understanding the erosion patterns of Maltese shore platforms has important implications on the functioning of the wider coastal system. The selected shore platforms all form part of a headland system and are situated either at the tip of a headland or flank the side of a headland. On a larger scale these platforms are planar but at a finer scale they are mostly rough and rugged, with frequent discontinuities. The sites chosen are all backed by soft limestone sea cliffs. Thus, these platforms also act as regulators of wave energy impinging on cliff toes and govern the rates of sea cliff recession over time. The initial data collected suggests that surface erosion rates on the selected Maltese shore platforms integrate primarily processes of wave erosion and subaerial weathering (such as wetting and drying cycles); and these, in turn, are influenced mainly by the geology, coastal exposure and elevation-efficacy characteristics.

Key words: shore platform, transverse micro-erosion meter, surface erosion rates, Malta.

Rock resistance variability across High Arctic rocky coastal zones - case studies from sheltered fjords of Svalbard and tsunami-affected coasts of Western Greenland

STRZELECKI M.

1. Department of Geography, Durham University, UK; 2. Department of Geology, UNIS, Norway; 3. Department of Cryospheric Research, AMU Poznan, Poland, DURHAM, UNITED KINGDOM

Recent decade has seen the major advance in cold region coastal geomorphology due to research progress along ice-rich permafrost coastlines of Siberia and Alaska.

On the contrary little attention was paid to Arctic rocky coastlines and their response to the reduction of sea ice cover and increased number of storms reaching Arctic region.

A significant limit to current understanding of cold coast evolution is the paucity of field observations regarding rock resistance of different polar coastlines and, in particular, the controls of different environmental variables on spatial patterns of shoreline morphology.

Results are presented from a pilot survey of rock resistance using N-type Schmidt Hammer Rock Tests across rocky cliffs and and shore platforms developed in:

- sheltered bays of Billefjorden, Svalbard characterized by prolonged sea-ice conditions and very limited operation of wave and tidal action

- Vaigat Strait and Isfjorden in W Greenland influenced by landslide-triggered tsunamis and waves induced by ice-berg roll events.

The aim of a pilot study was to test the hypothesized coastal impact on the rate of rock weathering in high latitude regions. To do so I characterize the changes in rock resistance on the following coastal landforms:

- modern and uplifted wave-washed abrasion platforms– looking for relation between degree of rock surface weathering and distance from the shoreline as well as thickness of sediment cover on platform surface

- modern and uplifted rocky cliffs - looking for relation between degree of rock surface weathering and distance from the shoreline as well as difference in height above the sea level and relation to rock lithology

The results present another line of argument supporting intensification of weathering processes in cold region coastal settings.

****

Geo-engineering mapping of Aguiño groyne (Galicia, NW Spain): a rocky platform as a foundation?

PIRES A.(1), PÉREZ-ALBERTI A.(2), CHAMINÉ H.(1)

(1) Laboratory of Cartography and Applied Geology, School of Engineering (ISEP), Polytechnic of Porto; and Centre GeoBioTec|UA, PORTO, PORTUGAL ; (2) Laboratory of Environmental Technology (Geomorphology Area), Institute of Technological Research, University of Santiago de Compostela, GALICIA, SPAIN

It is well known that the wave climate of the Galician coast (NW Spain, Iberian Peninsula) is very energetic. The coastline is strongly diversified and characterised by mixed marine environments. The Aguiño site is located in Ribeira coastal area (NW Galicia) and comprises a very particular geomorphological setting. The studied site presents a rocky platform which is used mainly as a foundation for the maritime work and narrow sandy areas along the shore. The mixture of environments and the hydraulic conditions severity in Aguiño area made an unique research site. Several interdisciplinary studies were carried out to assess the coastal system considering the geomorphology, geotectonics, morphodynamic processes, forcing conditions, geomechanics of materials, geo-engineering methodologies and GIS mapping. The Aguiño maritime structure uses the rocky platform as a foundation so, this type of coastal protection solution offers numerous features that matters to be analysed and characterised.There is an intrinsic relationship between the artificial maritime design/construction and the natural rocky coast. The detailed cartography allowed reaching interesting results and encompasses geomorphologic, geo-engineering and coastal dynamic data. In addtion, were performed in-situ strength tests to determine the hardness/rebound and durability of the rock material, not only on the rocky platform and boulders, but as well as on the armourstone placed along the groyne's armour layer. That holistic approach allowed the study of coastal geomorphology and geo-engineering along Aguiño site. The thematic maps will be very useful in the future to determine vulnerability zones to coastal erosion, hydraulic structure silting up, 3D modelling, geo-hazards and regional/local assessment for coastal management. The study presents also recommendations related to coastal zone management and planning in Aguiño area.

Highly-resolution quantitative reconstruction of detritic quaternary cliffs retreat based on anatomical changes in exposed roots (Porquerolles island, France)

ROVERA G.(1), LOPEZ SAEZ J.(2), CORONA C.(3), STOFFEL M.(4)
(1) University J. Fourier, laboratory PACTE UMR5194 CNRS, GRENOBLE, FRANCE ; (2) IRSTEA UR EMGR, laboratory PACTE UMR5194 CNRS, GRENOBLE SAINT MARTIN D'HERES, FRANCE ; (3) Laboratory GEOLAB UMR6042 CNRS, CLERMONT-FERRAND, FRANCE ; (4) Laboratory of Dendrogeomorphology, University of Berne, BERNE, SWITZERLAND

The coasts of the western Mediterranean basin are interesting to quantify global warming effects as marine level rising or storms actions. Three types of coasts can be distinguished: cliffs, sandy beaches and rocky coasts with alternatively capes and pocket beaches. These pocket beaches are often associated with small detritic cliffs (<10 m) shaped by sea in quaternary slope sediments. The study concerns these small cliffs in Porquerolles (France), a forested island weakly impacted by coastal development and sedimentary inputs. In this context, the recent retreat of these cliffs, revealed by the increasing of numerous exposed roots and border pines falls for two decades, could be related to more frequent strong storms and sea level rising.

The first aim of this study is to quantify the contribution of the cliffs in the sedimentary balance of pocket beaches, which are isolated geomorphic units. The second is methodological: we use a dendrogeomorphic approach based on exposed roots of *Pinus halepensis* to quantify cliff retreat. A total of 58 exposed root sections were sampled and anatomical variations in annual growth rings resulting from denudation have been analyzed.

On average, the roots were 25 years old and have been exposed since 15 years. At the plot scale, average medium-term erosion rates range between 4.5 and 34.5 mm yr^{-1} (average: 20 mm yr^{-1}). The dropped debris volumes vary between 10 and 50 m^3 yr^{-1}. These values are significantly lower than those obtained for the Mediterranean beaches (60 cm yr^{-1} , 200 m^3 yr^{-1}), but higher than cliff erosion rates. This contribution demonstrates that dendrogeomorphic analyses of roots have a significant potential for the quantification of cliff retreat and beach reloading in areas where past measurements are lacking. Detritic cliffs closed to pocket beaches seem sensitive spots to record strong storms effects and marine level rising, if the increase of these phenomena continues.

****

S. Paio (Labruge, Vila do Conde, Northern Portugal). A protected area and its geomorphologic value

ARAÚJO M., GOMES A.
FLUP-CEGOT-Universidade do Porto, PORTO, PORTUGAL

Northern Portuguese coast has a general trend of NNW-SSE from Bayonne till Espinho. This is a generally low coastline. Sandy beaches and dunes often cover Precambrian/Paleozoic bedrock. However, in some rare points, we have rocky cliffs. S. Paio is one of the highest points in this coastline.

An Iron Age settlement was discovered in the top of a 14 m amsl platform. Archaeologist calls it a “castro”. At Galicia (northern Spain), this “castros” appear by the sea. But in Portugal this is the only one upon the coastline, and it was jugged as quite unique by archaeologists. In the eighties this place had a difficult road access. The road improvement brought many visitors seduced by the scenic beauty of the place and also the danger of destructing archeological remains. Fortunately the city council decided to excavate the site and to protect it. It was important to make the city council archaeology cabinet understand that the scenic interest of the area was a consequence of geological and geomorphologic singularities and that all this valences together should be an important asset to local people economic sustainability and welfare:

1 – Imposing, rectilinear cliffs, all in NNE-SSW direction.

2 – Preserved rocky benches bearing marine deposits at several altitudes.

3 – A spectacular notch carved in fresh granite hanging over a vertical cliff, 9m amsl.

4 – A sequence of deposits (marine, probably Eemien, solifluidal, aeolian – TL dated 84k years).

The singularity of this staircase like topography, with hanging benches, deposits and notches suggests a recent uplift. A thrust fault affecting a quaternary deposit is found at a small distance (5km). This suggests that neotectonics are a possibility, improving the scientific value of the site.

The centre is now ready for visitors and it shows geologic, geomorphologic, archaeological, ethnographic and biologic information in a simple and interactive way.

Investigating the interrelationship between boulder beach dynamics and storm events

BRAYNE R.(1), NAYLOR L.(2), REINHARDT L.(1), LORANG M.(3)
(1) University of Exeter, PENRYN, UNITED KINGDOM ; (2) University of Glasgow, GLASGOW, UNITED KINGDOM ; (3) University of Montana, FLAT HEAD LAKE, UNITED STATES

Clastic assemblages composed of pebble to boulder-sized material (Blair & McPherson, 1999) are a common feature of rocky coastlines globally. Such features effectively defend coasts against wave action and potential erosion. However, the limited number of field studies that address the dynamics of pebble-boulder beaches are rather qualitative or incomprehensive in their experimental approach. Consequently, our quantitative understanding of the dynamics of pebble/boulder beaches lags that of their sandy counterparts. We have developed a quantitative relationship between the rate of longshore transport and the local wave conditions by surveying the daily position of ~200 traced clasts whilst obtaining concurrent, detailed wave measurements from the adjacent shore platform over a number of field visits. The surveys were conducted within a ~300m stretch of Abbotsham beach, Bideford Bay, North Devon, which is a pathway of coarse clastic material to the ridge which protects Westward Ho! from inundation and erosion. The dynamics of clasts at Abbotsham therefore has a direct effect on the quantity of clastic material nourishing the valuable ridge. Field surveys, conducted during calm, moderate and stormy sea conditions, have enabled conclusions to be drawn about the relationship between the rate of longshore transport and the local wave characteristics. Our results show net longshore transport of clastic material towards the NNE during all observed wave conditions. The rate of longshore transport appears to be strongly related to the local wave conditions with individual clasts migrating up to 70m in one day during a storm. The forecasted change in the storminess of the north-east Atlantic and accelerated sea level rise is likely to have an impact the dynamics of coastal sedimentary systems. It is therefore important to develop a quantitative understanding of systems such as that in Bideford Bay to help predict their response to the forecasted change in wave climate.

****

Lithological control on coastal rock cliffs erosion of Safi, Morocco

RAGARU E.(1), MERCIER D.(1), CHAIBI M.(2), MAANAN M.(1)
(1) LETG-Nantes, Géolittomer, UMR 6554, Université de Nantes, NANTES, FRANCE ; (2) ELMar, équipe GEGEL, Faculté Polydisciplinaire de Safi, Université Cadi Ayyad de Marrakech, SAFI, MOROCCO

The coastline of the Safi region, between the Beddouza Cape (32°54'N - 09°28'W) and Jorf Lihoudi (32°18'N - 09°26'W), is characterised by different forms of coastal cliffs ranging from 5m to 153m high. Three different lithological units have been defined from the bottom to the top: 1*)* Plio-Quaternary aeolianites and coquina, 2) Cretaceous clays and sandstones, "Clay of Safi" 3) "Limestone of Dridrat" and 4) Jurassic limestones with clay, gypsum and sandstone.

The aim of this study is to identify 1/ the spatial and temporal distribution of coastal instabilities with a catalog events developed from aerial photographs using the GIS (1954-2011) and 2/ the lithological controlling factor, with a special focus on Clay of Safi, using a ratio : clay layer thickness/ cliff height × 100.

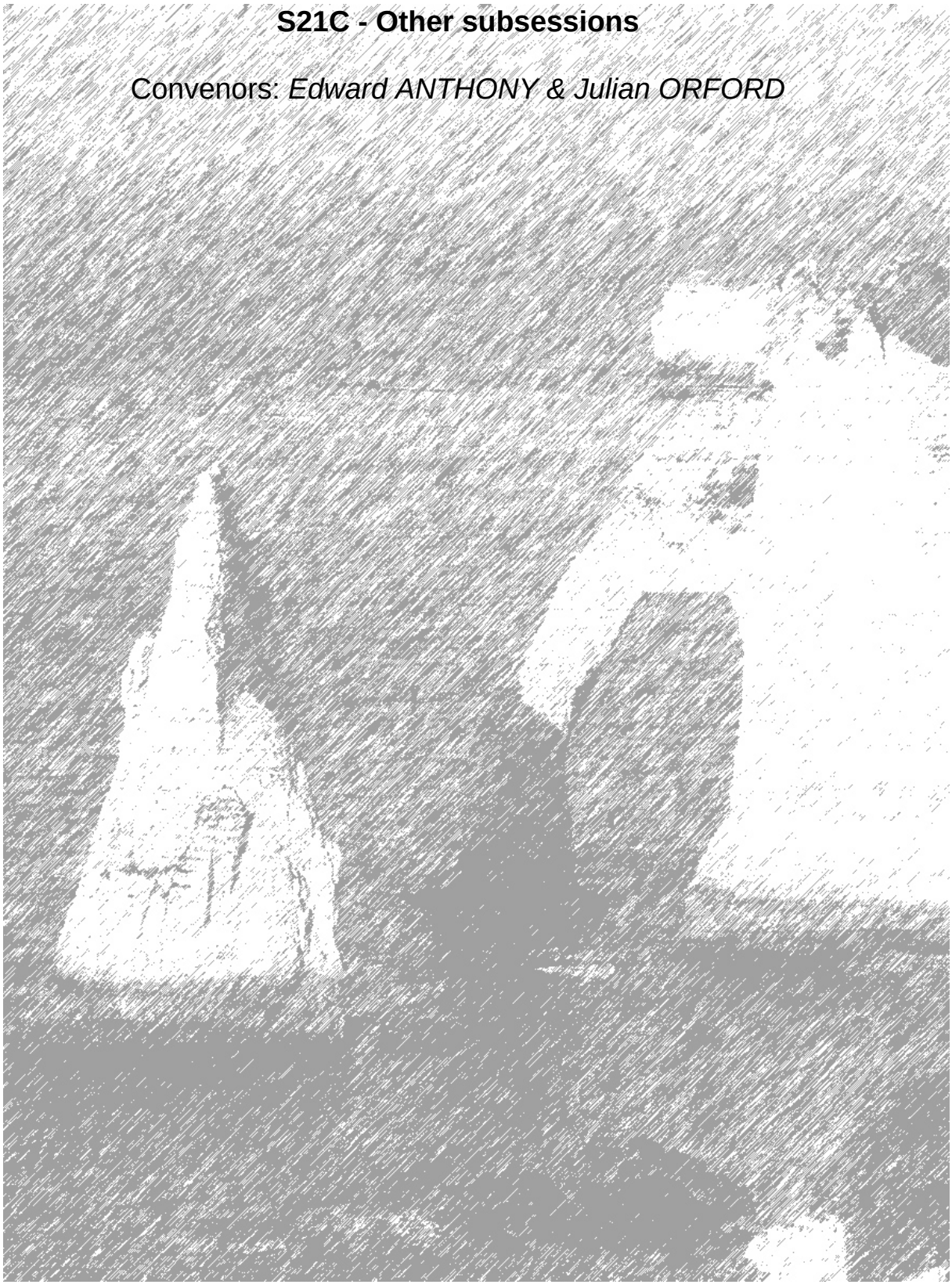
A conceptual model is used to define the processes acting on Safi coastal cliffs. Lithological, geomorphic, climate and anthropic parameters of 15 representative cliff sites are listed in a database.

The results of aerial photographs analysis revealed a low number (10 significant erosion hotspots) of events (collapse, rock fall and landslide) that have affected cliffs during the last 60 years. Historical erosion rates range from 7 to 13 cm/yr, where they are subject to erosion.

In Safi, the cliff retreat may be controlled by the proportion of clays whereby lower cliff angles are more clay-dominated. Cliffs, with a clay ratio upper than 60%, are more prone to mass movement than the others. This reflects the efficiency of continental processes. However, cliffs with less than 30% of clays ratio have no mass movement and are more subject to marine erosion. Laboratory analysis will be performed to confirm this hypothesis.

S21C - Other subsessions

Convenors: *Edward ANTHONY & Julian ORFORD*



Oral presentations:

What is the contribution of abrasion to the sediment budget of a mixed sand and gravel beach?

CHEN B.(1), STEPHENSON W.(1), HEMMINGSEN M.(2)
(1) University of Otago, DUNEDIN, NEW ZEALAND ; (2) University of Canterbury, CHRISTCHURCH, NEW ZEALAND

This project focuses on the identification and quantification of the abrasion of gravels on mixed sand and gravel beach using both the laboratory and field based experiments. Abrasionis the reduction in weightof gravels as they collide with each otherin the swash zone following the impact of waves. The resultingfine sedimentabraded from stones, is thought to cause significant sediment loss from mixed sand and gravel beaches.However, it is unclear just how much fine sediment produced by abrasion is lost from mixed beaches.There are a very few reported rates of abrasion based on field experiments. Using RFID technology and a VHF tracking system, abrasionof single gravel and groups of gravels were measured in the field. Field experiments not only measurein-situabrasion rates, but also allow the abrasion rates to be linked to wave conditions during a range of energy levels including stormsand calm conditions. Initial abrasion rates from early two experiments, when significant wave heights were 1.6m and 2.1m respectively, are reported as 0.043% and 0.120%, based on the average rate of abrasion of thirty tagged gravels during two days on the study beach. In additionfive abrasion bins were deployed across the surf zone at 6m intervals from the top of the high tide to almost the low tide zone. The abrasion rates from top to bottom were 0.014%, 0.017%, 0.413%, 0.326%, and 0.178%,for those bins that remained stable in the swash zone over two days.

****

Microtidal sandy beachs erosion: Diagnosis by DGPS measurements. Case study of the algiers west coast region- Algeria

BOUAKLINE S., BOUTBA M., GUETTOUCHE M.S.
University of Sciences and Technology Houari Boumediene (USTHB), Faculty of Earth Sciences, Geography and Spatial Planning, Laboratory of Geography and Spatial Planning, BEB EZZOUAR - ALGIERS, ALGERIA

The coastal erosion is a reality that has been almost everywhere; it is the main problemthat affects a majority of coasts all around the world. This natural scourge, driven bynatural and human factors, as among them: (1) rising sea level, (2) large storms attacks, (3) decreasing sediments quantities feeding the beaches and (4) humananarchicactions… that may induce beaches desperation and unpredictable disasters.

As everywhere in the world, the algerian coast suffers from this phenomenon too. Erosion's abundance and absence of scientific detailed mapping approach suggest proposing, in this study, a spatial model. We have considered Algiers's west coast, located between the peninsula of Sidi Fredj and the mouth of the Wadi El Agar (Zeralda), as the test site. The model was performed by a diagnosis based on field observations and erosion assessment through rigorous and repeated DGPS measurements of beach profiles and frequent shoreline monitoring.

Multi-date GPS shoreline data (2008, 2010 and 2011) have been superimposed and compared with other shorelines extracted from aerial photographs (1959, 1972 and 1980). The present study indicates that erosion during the period from **1959** to **2011**was predominant. A net rate of evolution has been estimated and is of the order of **-0.12 m / year**. This study indicates also that the sediment budget obtained from topographic measurements along beach profiles for the time period from **2008** to **2011** presents clearly a deficit estimated to**-13622m^3.**

The twoapproaches used in this study show many similaritiesin spatial organization of the erosion processes but also a similar sediment transport direction along the test site area. Erosion will become increasingly important from southwest to northeast while thesedimentary transit is reversely organized. At the same time however, there is an important cross-shore movement of the sediment going offshore.

Key Words:coastal erosion, beach profiles, shoreline, sediment budget, DGPS**.**

Coastal monitoring and medium-term shoreline dynamics in Brittany (France)

SUANEZ S.(1), STÉPHAN P.(2), FICHAUT B.(1), CUQ V.(1), BLAISE E.(1), CARIOLET J.M.(3), CANCOUËT R.(1), DELACOURT C.(1)

(1) Université de Bretagne Occidentale, PLOUZANE, FRANCE ; (2) LGP UMR 8591 CNRS, MEUDON, FRANCE ; (3) University of Leicester, LEICESTER, UNITED KINGDOM

This study is based on morphosedimentary monitoring of several sandy dune-beach systems and/or gravel beaches and barriers, located all around the Brittany coast (departements of Finistère and Côtes d'Armor). This monitoring was started in the early 2000s as part of the “Observatoire du Domaine Côtier (ODC) de l'Institut Universitaire Européen de la Mer”. Depending on the site, the survey consists of (i) shoreline change measurements, and/or (ii) beach profile measurements including dune and tertidal beach, and/or (iii) 3D surface topography survey including aerial dune/beach system and offshore beach. From all these data, we propose a morphosedimentary budget of shoreline dynamics of Brittany beaches for the last decade. Between winter 2002-2003 and winter 2005-2006, sandy beaches were mainly suppied and gravel spits experienced lack of rollover and crestal overtopping. When beaches were in erosion, shoreline retreat was very low during this period where shoreline was less eroded. This first phase contrasted with the previous period, especially between 1999 and 2002 where erosion was predominant due to the impact of several storm events. During the winters 2006-2007 and 2007-2008, erosion was acting inducing sediment loss of all beaches (sandy beaches and gravel barriers). When beaches where already eroding, shoreline retreat was higher (e.g. storm event of 10 March 2008). Since the spring of 2008 (2008-2012), new phase of beaches recovery was observed due to the low morphogenetic activity (no impact Klauss in 2009, Xynthia in 2010 and Joachim in 2011, storm events). Analysis of hydrodynamic meteomarine consditions can offer a global schema of the morphodynamic fonctionning. The conjunction of storms, including SW direction, with high spring tides seems to play a much more important role in shoreline dynamics.

****

Long-, mid- and short-term morphological behaviours of gravel barriers: illustrations from the coast of Brittany (France)

STEPHAN P.(1), SUANEZ S.(2), FICHAUT B.(2)

(1) Laboratoire de Geographie Physique (UMR8591 CNRS), MEUDON, FRANCE ; (2) Laboratoire Géomer LETG (UMR 6554 CNRS), PLOUZANÉ, FRANCE

This study is asynthesis of 10 years of research on long-, mid- and short-term morphological behaviours of gravel barriers located on Brittany coastlines in the western part of France. At the long time-scale (10^3 yr), the lithostratigraphy and biostratigraphy (foraminifera) of several back-barrier sediment sequences are examined to determine thephases of construction and breakdown of gravel barriers. These phasesare correlatedwith rates of sea-level rise, variations of sediment supply and wave-climate changes. Three major phases of barrier breakdown are identified around 800BC, 0-200 AD and 1070-1170 AD. This phases could be related to periods of major climatic changes and storminess, known as the Bond Cold events. At the mid time-scale (10^2 yr),the recent mobility of 30 gravel barriers has been studied.The quantification of the recent mobility of the spits was performed using more than 200 aerial photographs taken between 1930 and 2011. Results show a sediment budget deficit at regional scale revealed by cannibalization, landward retreat by rollover and, in places, complete destruction of the gravel-dominated spits. Anthropogenic forcing partially explains the erosion of a minority of gravel spits studied. Analysis of climatic forcing, based on the reconstruction of high water levels, show that the rate of landward retreat by rollover is controlled by the frequency and the intensity of overwash events, the barrier alignment, the sediment budget and the accomodation space. On an annual timescale, morphological evolution of five gravel barriers affected by erosion was studied by a DGPS survey undertaken between 2002 to 2012. The role played by overwash dynamic was also studied by analysing oceanographic data set. Results show different pluri-annual phases of morphogenic activity on the gravel barriers and hightlight the high variable degree ofresilience of the barriers to extreme storm events.

Potential and limitations of Bayesian networks for understanding shoreline mobility: an example in La Réunion island

BULTEAU T.(1), BAILLS A.(1), PETITJEAN L.(2), GARCIN M.(1), DE LA TORRE Y.(3), PALANISAMY H.(4), LE COZANNET G.(1)
(1) BRGM, ORLÉANS, FRANCE ; (2) Laboratoire de météorologie dynamique - Université Pierre et Marie Curie, PARIS, FRANCE ; (3) BRGM, MONTPELLIER, FRANCE ; (4) LEGOS - Observatoire Midi-Pyrénées, TOULOUSE, FRANCE

Coastal erosion is a global growing threat as more and more human activities and settlements concentrate on the coastal fringe. Today's climate change and induced sea level rise also contribute to change the risk of erosion. Understanding the current shoreline evolution is a necessary step to predict future changes and better manage this risk.
The shoreline mobility results from numerous factors and complex mechanisms acting at different spatial and temporal scales. Here, a data mining approach based on a Bayesian network (BN) is tested enabling one to use readily available data to analyse some causes of decadal-scale shoreline evolution in La Réunion (a volcanic tropical island in the Indian Ocean) and to reproduce the observed evolution trends. The BN is built to define causal relationships between 5 variables describing the state of a given coastal segment: geomorphic settings, exposure to energetic waves, presence of an estuary (importance of continental sediment loads), presence of human works in the vicinity of the segment and current shoreline mobility (accretion, stability or erosion, representative of about 30 years).
The retrospective predictions are correct in 79% of the cases. Evaluation of the model performance using log likelihood ratio scores indicates that the BN provides shoreline mobility predictions that are better than the prior probability. By evaluating the model behaviour using from one to four variables, the geomorphic settings are identified as the most important model parameter determining coastal evolution trends. Incorrect predictions of the BN are analysed in details and experts' know-how is used to assess the local causes of the observed mobility and to point out limits of the BN. Among the multiple causes of mis-prediction, the lack of sediment budget information (alongshore transport and interactions between adjacent coastal segments) is the most common.

****

High resolution coastal evolution: dynamic profiles and geomorphological resilience beach index (GRBI)

MORISSETTE A.(1), JOYAL G.(2)
(1) Universite du Quebec, RIMOUSKI, CANADA ; (2) Université Laval, QUÉBEC, CANADA

The morphological evolution of a spit, the Pointe a Emile, on the North Shore of the St.Lawrence estuary, Quebec, was investigated by photointerpretation from 1931 to 2011. The results suggest that the displacement of the neutral point of the spit is associated with an increase of erosion profiles at the expense of accumulation profiles. Photointerpretation, however, does not allow quantifying the monthly evolution models. To examine the micro fluctuations (horizontal and vertical) of the coastal morphology, 27 beach profiles at very high spatial (<2 cm) and temporal (monthly) resolution were collected using a DGPS from May 2011 to December 2011. The monthly profiles allow also evaluating the resilience processes and the level of coast resilience. The analysis of monthly evolution models reveal the existence of five dynamic profiles with morphological response directly related to hydrodynamic conditions. The geomorphological resilience beach index (GRBI) developed in this study is a way of clustering semi-quantitative data in order to express the level of resilience of beach profiles. The fluctuations of the GRBI represent monthly the level of beach profiles resilience and the rate of monthly morphological adaptation. The data show that the resilience of profiles without coastal protection is significantly different to that of profiles where rock armor has been used. The rate of monthly morphological adaptation of natural profiles (A, B, C and D) suggests that they can adapt morphologically to coastal hazards, while the sensitivity of the profiles with coastal protection tends to reduce the geomorphological resilience of the spit. This contributing to the emergence of a distal profile of submersion (D) and decreasing bluffs resilience in adjacent profiles (B). This represent another effect of coastal protection on reducing beach resilience.

Longshore variation of overwash occurrence in a barrier island (Portugal)

MATIAS A.(1), CARRASCO A.R.(1), PACHECO A.(1), LOUREIRO C.(1), NUNES M.(1), FERREIRA Ó.(1), ARMAROLI C.(2), MASSELINK G.(3)

(1) CIMA - Universidade do Algarve, FARO, PORTUGAL ; (2) Università di Ferrara, FERRARA, ITALY ; (3) University of Plymouth, PLYMOUTH, UNITED KINGDOM

The occurrence and intensity of overwash depends on a number of factors that include hydrodynamic conditions, nearshore and foreshore topography, dune morphology, engineering structures, location and orientation of footpaths and roads, and buildings on the shorefront.

To study longshore variations in overwash, 24 cross-shore topo-bathymetric profiles were set on Barreta Island (Ria Formosa barrier island system, Portugal), from the nearshore (depth =12 m, below mean sea level, MSL) until the lagoon level on the island backbarrier. Pre- and post-overwash surveys were made between August 31, 2012 and December 28, 2012. During this period, overwash occurred both under storm conditions (maximum significant wave height of 3.5 m, in November) and non-storm conditions (maximum significant wave height of 1.5 m, in October). Barrier crest elevation was 3.6-4.6 m, and after November overwash the crest lowered up to 0.2 m. Overwash water intrusion distance across the barrier varied significantly alongshore between 0 m (at West) and 70 m (reaching the lagoon water). Differences in overwash intensity along the barrier are probably associated to nearshore and offshore bathymetric features. At West no overwash occurred because the swash bars that form part of the ebb delta of Ancão Inlet provide protection to the barrier dunes, as wave energy is dissipated further offshore. Towards East, overwash intrusion, barrier crest elevation and orientation are variable and so is the nearshore, with alongshore sand bars particularly until the depth of 6 m, where the beach profile is more active. Sand bars are probably related to sediments transported by littoral drift from Ancão Inlet delta or are remnants of ebb delta sediments from previous Ancão Inlet positions. Moreover, in 1996 the entire study area was westwards of Ancão Inlet and its migration changed the nearshore morphology, which currently influences the wave propagation and thus overwash occurrence on Barreta Island.

****

Longshore cell development in a boulder beach, Mission Rocks, South Africa

GREEN A.N., COOPER J.A.G., SMITH A.M., SALZMANN L.

Geological Sciences, School of Agriculture, Earth and Environmental Sciences, University of KwaZulu-Natal, DURBAN, SOUTH AFRICA

Mission Rocks is a rocky coastline with a well-developed shore-platform fronting a coastal dune cordon. The shore-platform slopes seaward and is overlain to landwards by a storm beach comprising slab-like boulders. Distinct imbrication patterns and boulder groupings are present within this beach. Boulders are separated into cells by coast-normal imbrication chains or by shallow, boulder-free “channels”. The boulders, piled against the dune and between the channels show a coast-parallel, northerly-directed imbrication with a spread in orientation of the long axes. Each cell forms crude bedforms with a lee face sloping in the direction of longshore transport. These boulder-rich bedforms and the orientation of the boulders themselves are a product of storm-wave induced superimposition of swash to the shore platform and the development of longshore cells in the storm surge littoral zone.

Geomorphological development and sedimentary architecture and of two barrier islands (Sylt and Amrum/ German North Sea): Insights from ground-penetrating radar surveys and sedimentological data

TILLMANN T.(1), WUNDERLICH J.(2)
(1) Goethe-University Frankfurt a. M., Department of Physical Geography, FRANKFURT A. M. , GERMANY ; (2) Goethe-University Frankfurt a. M., Department of Physical Geography, FRANKFURT A. M., GERMANY

Barriers comprise approximately 15 % of the world's coastlines and are formed due to the combined action of wind, waves, and longshore currents. Barrier islands and barrier spits are geological young, highly dynamic and represent a complex coastal system that includes a number of different but closely related sedimentary depositional environments and geomorphologic elements of varying origin, genesis and evolution.

In this study ground-penetrating radar data of different antenna frequencies and sedimentological data were combined to reveal the sedimentary structure and architecture of two adjacent barrier island spits. Radiocarbon datings and amino acid racemisation datings (AAR) of shells help to define a chronological order and allow setting up a barrier island stratigraphy.

Based on these data, different geomorphological models of barrier spit development have been generated which describes the inter-action between extreme events, coastal processes and sedimentary development and contains the major episodes of island evolution.

The first model is concerned with thespit add-on zone where the southern barrier spit of Sylt is attached to thecentral island moraine core and shows alandward migration through barrier rollover affected byan interplay of barrier retreat and washover flooding associated with accumulation of sediment in a backbarrier environment as a result of several storm surges. The second model demonstrates a barrier spit accretion through southerly directed progradation. Eroded sediment was transported along the west coast of Sylt by longshore drift and was added to the southern spit-end. Progradation and barrier spit accretion were interrupted by severe storm surges. Storm surge generated erosion unconformities in a foreshore to shoreface environment redraw old spit-end positions that represent stages of barrier spit progradation. The third model describes the spit enlargement of Northern Amrum that was strongly influenced by overwash processes.

****

Ecomorphodynamic Feedbacks Determine Barrier Island Response to Climate Change

MOORE L.(1), DURAN O.(1), WALTERS D.(1), YOUNG D.(2), FAGHERAZZI S.(3), MARIOTTI G.(3)
(1) University of North Carolina Chapel Hill, CHAPEL HILL, UNITED STATES ; (2) Virginia Commonwealth University, RICHMOND, VA, UNITED STATES ; (3) Boston University, BOSTON, UNITED STATES

As low-lying coastal landforms, barrier islands are especially sensitive to changing environmental conditions. Ecomorphodynamic (i.e., combined biological and physical) interactions and feedbacks play a critical role in determining how these landscapes will evolve in the future as sea level rises, storm intensity increases and plant species composition changes. Barrier islands tend to exist in one of two primary states: Low and High. Low islands have little relief above sea level and are dominated by external processes, responding quickly on short time scales to changes in forcing (e.g., storms, sea level rise, etc.), migrating rapidly, and being low in ecological diversity. In contrast, High islands are less vulnerable to storms, tend to be dominated by internal processes (e.g., sand trapping by vegetation), require long time periods to respond to changes in forcing, migrate slowly (if at all) and host a range of plant species and morphological environments. The continued existence of barrier islands will depend on the degree to which islands can maintain elevation above sea level while responding to changes in forcing by migrating landward.

A long-term morphological-behavior model representing coupled barrier-marsh evolution (for the first time) and a new ecomorphodynamic model exploring the formation/recovery of dunes as a function of storms, shed light on the role of ecomorphodynamic interactions in determining barrier island response to climate change. Results suggest that connections between the marsh and barrier realms, which are mediated by biological processes in the marsh environment, are highly sensitive to factors such as sea level rise rate, antecedent morphology and marsh composition. Results also indicate that ecomorphodynamic feedbacks, such as those involved in dune-building processes, may cause gradual changes in biological and physical forcing to result in abrupt, non-linear transitions from the High to Low island state in the future.

Projected Changes in Barrier-Island Wetland Distribution Caused by Sea-Level Rise

GIBEAUT J.
Harte Research Institute, Texas A&M University - Corpus Christi, CORPUS CHRISTI, TEXAS, UNITED STATES

Projecting future trends in wetland distribution is important for developing adaptation strategies for sea-level rise. The style of transition of estuarine wetlands during rising sea level depends largely on the slope of the upland and sediment supply. Fringing wetlands on Texas' barrier islands exist within an elevation range of 30 to 50 cm. On the bay sides of these islands, this amount of topographic change occurs in complicated patterns across relict geomorphic features, such as storm-surge channels, washover and flood-tidal delta deposits, and beach ridges and swales.

Using lidar digital elevation models and detailed wetlands mapping, we developed an inundation model that projects future wetland distribution caused by sea-level rise. Vertical accretion, edge erosion, and land-subsidence components are also included in the model. The model was applied to the barrier islands of the Galveston Bay System in Texas using the annual record of ocean level recorded for 90+ years by a nearby tide gauge. Results show the interplay of decadal-scale water-level variation and topography in determining wetland distribution.

The wetlands model was run 90 years into the future and shows wetlands migrating up the back barriers in a pattern dictated by geomorphology but disappearing on the bayward side owing to inundation and shoreline retreat. At the end of 90 years, upward migration allows for no net change in the total area of wetland environments. However, the ecologically important low marsh environment decreases by 15% while high marsh increases by 35%. The geomorphic stage of evolution of the barrier islands, transgressive versus regressive, also causes along-the-coast differences in how wetlands are expected to be impacted by sea-level rise.

****

Morphodynamics of barrier island evolution off SW Taiwan: An example from Wan-tzu-liao barrier, Tainan

LIN T.Y.(1), LOU J.Y.(2), LIOU J.Y.(3), HWUNG H.H.(4)
(1) Department of Geography, National Taiwan Normal University, TAIPEI, TAIWAN ; (2) Department of Marine Science, Naval Academy, KAOHSIUNG, TAIWAN ; (3) Tainan Hydraulics Laboratory, National Cheng Kung University, TAINAN, TAIWAN ; (4) Department of Hydraulics and Ocean Engineering, National Cheng Kung University, TAINAN, TAIWAN

A series of barrier islands are situated along the Tainan coast, in southwestern Taiwan, to form a barrier-lagoon system that plays an important role in coastal protection. Most of the sand barriers have become attached to the coastline during the last century due to human reclamation of the lagoon area, which has become used as breeding and fishing ponds. The Wan-tzu-liao barrier is the only island left that has retained its more natural state and could adjust itself to the changes created by coastal processes. In this paper, an extensive collection of vibration cores from different sedimentary environments of the Wan-tzu-liao barrier island is used to identify the sedimentary characteristics for each depositional unit. At the same time, the facies changes in the vertical stratigraphic sequences are used to speculate the possible environmental changes and explain the morphological evolution of the barrier island.

Based on preliminary analyses of the sedimentary sequences, the major processes that control the morphological changes of the barrier island may include : 1) the onshore-offshore sand movement facilitated by waves; 2) the prevailing longshore drift southward; 3) the strong wind transport southward during the winter; and 4) the overwash process that moves sand landward during a storm or typhoon. A transgressive model may be suitable for this barrier system. With the island migrating landward in response to the global trend of rising sea levels, this morphodynamic model predicts that the Wan-tsu-liao barrier's landward movement may accelerate and finally become attached to the continent coastline that is currently fixed at its position by a sea wall. Once the sand barrier is attached to the sea wall, it will become a sand beach at the toe of the sea wall, and, with rising sea levels, this sand beach would ultimately become submerged into the sea.

Linking nearshore and coastal changes in the southwestern North Sea and Dover Strait: the role of tidal sand banks on coastline evolution

HEQUETTE A.(1), RUZ M.H.(1), ANTHONY E.J.(2), MARIN D.(1)
(1) Université du Littoral Côte d'Opale, DUNKERQUE, FRANCE ; (2) Université Aix-Marseille, AIX-EN-PROVENCE, FRANCE

Tidal sand banks occur extensively near the coast of the eastern English Channel and southern North Sea where they form linear shore-parallel, or slightly oblique, shallow sand bodies that affect the propagation of incident waves. Because they can play an important role in the dissipation and distribution of wave energy along the coast, they may have important effects on coastal morphodynamics and shoreline evolution. The coast of northern France largely consists of wide macrotidal sand beaches and coastal dunes that experienced contrasting evolutions during the last decades as revealed by aerial photographs. Hydrographic field sheets and historical bathymetry maps were used for mapping nearshore bathymetry changes since the 19th century. The spectral wave model SWAN was used for simulating wave propagation over different bathymetries in order to evaluate the effects of changing seabed morphology on wave refraction and on the pattern of wave energy distribution at the coast. Our results show variable nearshore sand bank evolutions that are associated with different shoreline changes along the coast. Sand banks commonly migrate alongshore at rates of several tens of m/yr due to strong alongshore-directed tidal currents that can be reinforced by wind forcing. Nearshore banks may also move onshore, but at slower rates, this landward movement being attributed to the action of storm waves. Onshore-migrating sand banks may eventually weld to the shore, supplying sand to the adjacent beaches, which can result in significant shoreline progradation. When sand banks are not attached to the shore, they are separated from the coast by a relatively deep channel that limits onshore sediment transport, favoring sediment deficit that may lead to shoreline retreat. Our results point to a strong relationship between changes in nearshore bathymetry and shoreline evolution, sand banks having different effects, however, depending on their depth, orientation and distance to the coast.

****

Study of strandplain evolution along the Iranian coast of Makran (north western Indian Ocean) with application of ground penetrating radar

SHAH-HOSSEINI M.(1), MORHANGE C.(1), NADERI BENI A.(2), ANTHONY E.(1)
(1) CEREGE, AIX EN PROVENCE, FRANCE ; (2) (Iranian National institute for Oceanography, TEHRAN, IRAN

Omega shaped bays protected by rocky headlands are prominent morphological features in tectonically uplifting coast of Makran. In these bays the coastline is prograding and stranded coastal deposits are present to about 6 km from the modern coastline. Geomorphic landforms on these strandplains comprises of beach ridges, inter-ridge swales, sand dunes and fluvial deposits. The beach ridges are made of marine sand and shells trend parallel or nearly parallel to the modern shore. Strandplains of Chabahar bay studied along three shore-normal transects. Detailed mapping of geomorphic features took place based on SPOT5 satellite and radar imageries. Internal structure of the beach ridges imaged to a depth of 10 m at a resolution of 0.2 m using ground penetrating radar (GPR) with unshielded 100 MHz transmitter. Subsurface imaging complimented by direct observation of sedimentary sequences in vibratory cores and trenches. The chronology of the strandplain relies on the radiocarbon dating of fourteen minimum reworked marine shells collected from the beach ridges. Beach ridges are found to distance of more than 5 km from the coast and elevation of 12 m above the present sea level. GPR images reveal seaward dipping reflectors representing shoreface deposits which are capped by parallel or wavy foredune deposits. The contact between aeolian sand and underlying shoreface facies used as past sea level indicator. Dating on the marine shells from the swash zone deposits yields ages from 4800 to 270 years BP at the respective distances of 5 km to 500 m from the modern shore. Resulted profiles demonstrate up to 10m fall in local sea level during the last ~4800 years. The rates of changes in sea level vary in shore-normal and shore-parallel directions; this implies the controlling role of geological structures related to tectonic uplift in the formation of strandplains.

Anegada Island, British Virgin Islands: a case study of beach ridges

CESCON A.L., COOPER J.A.G., JACKSON D.W.T.
University of Ulster, COLERAINE, UNITED KINGDOM

Beach ridges occur worldwide in a variety of environmental settings. Their definition and formative processes, however, are still under debate. Of particular interest is their relationship to periods of storminess since in many cases they have been used as palaeostorm archives.

Anegada Island, located in the British Virgin Islands (Caribbean Sea), contains a 6 km^2 beach ridge plain with north and south-facing components. The northern (Atlantic-facing) plain has around 25 ridges while the southern plain has about 15 ridges. The origin of the beach sediments is the fringing coral reef that surrounds the island. The isolated site position is an opportunity to study the beach ridge formation without influence from other sediment sources.

Basing ourselves on six sets of historical aerial photos between 1953 and 2002 we have examined the beach ridge plain geometry and the temporal evolution of the shoreline. The southern beach ridge plain is more complex than the northern one and historical analysis shows that the south shore was reworked many times between 1953 and 2002. Accretion of around 80 metres has occurred at some locations along the north coast of Anegada Island within the same period.

On Anegada island west side we also examined a number of wave scenarios using a shallow water wave modeling (SWAN) to investigate the degree of forcing required to emplace the beach ridges.

Aerial imagery and wave modeling observations cast some light on the origin of beach ridges. Since 1953 several high magnitude storms were recorded in this area. For example Hurricane Donna in 1960 was at Category 4 when it passed over Anegada. This relationship between storm frequency and beach ridge genesis will be also discussed.

****

Geomorphology and Internal Sedimentary Structure of Holocene Coastal Sandy Barriers along Rio de Janeiro Coast, Brazil

FERNANDEZ G.(1), BAPTISTA DA ROCHA T.(2), RODRIGUES A.(3)
(1) Laboratory of Physical Geography (LAGEF). Univ. Federal Fluminense., NITER_I, BRAZIL ; (2) NEQUAT. UNIVE. FERDERAL FLUMINENSE, RIO DE JANEIRO, BRAZIL ; (3) LAGEMAR. UNIVERS. FEDERAL FLUMINENSE, NITEROI, BRAZIL

The coastline of Rio de Janeiro is a mosaic of environments, where we observed dunes, estuaries, rocky coasts, lagoons, deltas and mainly coastal sandy barriers (CSB). The morphology of CSB included different environments that extend from the backshore to the beach and shoreface. Several works development in USA, Europe, Australia and more recently in Brazil provides a well documented examples of morphological types that these features assume, specially related to the main process that controlled the Holocene evolution of CSB. These processes include sea level behavior, wave and tides regime, substrate morphology and gradient and sediment supply. The recent advances in high accurate morphological data by using Differential Global Positioning Systems (DGPS), airborne and terrestrial laser scanning create new possibilities for the study of CSB. If these studies include, for example, ground-penetrating radar (GPR) profiles, to show the internal sedimentary structure provides even better results. In this case the main objective of this work is describe the with high resolution data the different types of the geomorphology of the CSB observed along Rio de Janeiro coast. Associated with high resolution morphology, several GPR profiles were made to identify the subsurface structure. The results showed a coexistence of different morphological types of CSB, i.e. we identify regressive, transgressive and agradational barriers, distributed along the Rio de Janeiro coast. The regressive barriers were associated with the major rivers, suggesting the direct contribution of fluvial sediments. The internal structure observed by radar units shows a beach ridge pattern. The agradational barriers, marked by incorporation of aeolian sediments from the beach, by onshore winds, forming foredunes/blowouts, observed by high resolution data. Transgressive barriers forming by barrier-lagoon morphology, presents in the sedimentary structure facies derived from overwash above lagoon spits.

Post-Little Ice Age evolution of High Arctic paraglacial coasts in Svalbard

ZAGÓRSKI P.(1), STRZELECKI M.(2), SUPERSON J.(1)
(1) Maria Curie-Sklodowska University, Faculty of Earth Sciences and Spatial Management, LUBLIN, POLAND ; (2) University Centre in Svalbard, Department of Arctic Geology, LONGYEARBYEN, NORWAY

Since the end of the Little Ice Age (LIA) Svalbard landscape has been undergoing rapid environmental change and experiencing paraglacial readjustment transforming formerly glacial environments into non-glacial systems. In recent years the geomorphological research on Svalbard has focused on the paraglacial processes operating in proglacial zones and valley slopes of freshly deglaciated areas. On the contrary, relatively little is known regarding the potential impacts of paraglacial landscape transformation on the evolution of High Arctic coasts.

Here we analyse the mechanisms of adjustment of Svalbard coastal zone to paraglacial conditions associated with abrupt climate warming following the end of the LIA at the beginning of the 20th century. The results of the post-LIA observations document dramatic changes in sediment flux and coastal response under an intervals characterised by a warming climate, retreating local ice masses, a shortened winter sea-ice season and melting permafrost.

The attention is paid on the similarities and differences in the cascade of geomorphological processes which operate along the coastal zones in two following regions:

1) Recherchefjorden located in NW Spitsbergen – with coastal zone development influenced by storms developing in Greenland Sea

2) Northern Billefjorden located in central Spitsbergen – with coastal zone development constrained sheltered location, limited wave and prolonged sea-ice conditions.

The attention is paid on the similarities and differences in the cascade of geomorphological processes which operate along the coasts in two selected regions that differ in the intensity and frequency of storm events, climatic conditions and bedrock topography.

This study highlight the need for greater understanding of present-day geomorphological processes operating on High Arctic coasts, in the context global warming and accelerated rate of glacier retreat, future High Arctic landscape evolution is to be predicted.

****

Morphogenesis of Phra Thong's beach-ridge plain (Thailand) ' the contribution of gradual processes and episodic events

BRILL D.(1), BRUECKNER H.(1), JANKAEW K.(2), KELLETAT D.(1), SCHEFFERS A.(3)
(1) University of Cologne, COLOGNE, GERMANY ; (2) Chulalongkorn University Bangkok, BANGKOK, THAILAND ; (3) Southern Cross University, LISMORE, AUSTRALIA

Koh Phra Thong is located on the Andaman Sea coast of southwest Thailand, separated from the mainland only by tidal channels. The topography of the island is dominated by series of approximately shore-parallel beach ridges and swales, which reach heights of 2-5 m above mean sea level. While these morphologic features are predominantly covered by dense vegetation in the east of Phra Thong, they build up to an open beach-ridge plain in the 3 km wide western part of the island. Dating with optically stimulated luminescence (OSL) revealed an age of more than 100 ka for the eastern part of Phra Thong, thus suggesting a formation during the last interglacial period, while the western section accumulated during the last 6000 years. In general, the evolution of this beach-ridge plain was controlled by the littoral process responsible for the formation of single ridges and ridge sequences. While the ridges are formed by the longshore current together with the swash of waves in the stormy season, the periodic process of ridge-sequence formation was probably controlled by a combination of sediment supply and small-scale variations of the relative sea level due to tectonic uplift and subsidence at the Sunda Arc subduction zone. Variations in granulometry between different sections of the island, erosive discordances within the beach-ridge plain, and temporal changes of progradation rates between 30 and 250 m per century, point to repeated changes of these processes during the formation of the island. Another aspect is the episodic impact of tsunamis that inundated the island every 500-600 years, which may have contributed to the shape of the beach-ridge plain as well.

Middle to late holocene storminess record in western britany

VAN VLIET-LANOE B.(1), HENAFF A.(2), DELACOURT C.(3), FERNANE A.(3), GOSLIN J.(2), HALLEGOUËT B.(2), PENAUD A.(3)

(1) UMR 6538 Domaines Océaniques, PLOUZANI, FRANCE ; (2) UMR 6554 CNRS LETG-Geomer, PLOUZANÉ, FRANCE ; (3) UMR 6538 Domaines Oc?aniques, PLOUZAN?, FRANCE

In order to have a better insight into the recurrence conditions for large storm event to assess coastal flooding risk, the record of storminess has been analysed on the southern coast of Audierne's Bay and in other sites of western Brittany. This work belongs to the COCORISCO project. Drilling transects, stratigraphic works and dating have been performed to constrain the chronology, the strength and if possible the wind direction of the main events. New dating, with recalibration of older one in a specific stratigraphic context, at Audierne and along the coasts of Brittany allow to define the conditions of occurrence of at least centennial events. A renewed relative eustatic curve has been constructed for the region on SLIP methodology (see Goslin et al.). Most events seem linked with cooling episodes, a negative winter NAO and a relative sea level close to the present one. A series of millennial storms occurred immediately prior to the Middle Age thermal Optimum. Other storms are clearly responsible for breaching, sand drift and dune building or remobilization. A direct consequence of it is the building of the recent coastal dunes from 1100 AD. Even storms exist at least since the Subboreal cooling, the storm frequency and intensity rose by steps during the Late Holocene. The maximum efficiency is reached during the Little Ice Age, during and after the Maunder solar minimum, with clustered events and duration of several days. This increase in storminess during the late Holocene is in agreement with the orbital forcing and the Holocene glacial history.

****

Geomorphology, sedimentology and geochronology of cyclone-generated landforms and washover deposits along the coasts of NW Australia

MAY S.M.(1), ENGEL M.(1), BRÜCKNER H.(1), PINT A.(1), KELLETAT D.(1), SCHEFFERS A.(2), SQUIRE P.(2)

(1) Institute of Geography, University of Cologne, COLOGNE, GERMANY ; (2) Southern Cross GeoScience, Southern Cross University, LISMORE, NSW, AUSTRALIA

Palaeotempestological research uses sedimentary evidence to enlarge the temporal frame of storm occurrence patterns given by historical records. Different sedimentary archives storing traces of tropical cyclone impact (washover fans, back-barrier mud flats, beach ridge systems) were investigated along the coasts of the Exmouth Gulf (W Australia) in order to evaluate their use for palaeotempestological research. (1) Washover sediments W of Onslow indicate several depositional units of mainly well-stratified sand with distinct heavy mineral laminae of varying concentrations, similar to modern storm and tsunami deposits documented in comparable settings. Different depositional events (cyclone and/or tsunami) can be inferred according to bioturbation horizons. (2) Along the W coast of the Exmouth Gulf, distinct lobate washover fans exhibit washover terraces, channel systems and delta-type sedimentation patterns. Their stratigraphy consists of shell debris layers, sand, coarse coral fragments and entire shells. Multiple reactivation of the washover fans is inferred from their complex pattern of accumulation and incision and a minimum of three palaeosols, each of them indicating one depositional event and a subsequent period of geomorphologic stability. (3) In Giralia Bay, S Exmouth Gulf, sandy chenier-like beach ridges characterize the landward boundary of extensive mud flats. Their geomorphology and stratigraphical architecture reflect the influence of intermittent/sporadic phases of morphodynamic activity due to littoral-type processes and are assumed to record recurring cyclone impact. Our preliminary findings suggest that the investigated sedimentary archives have a high potential for improving extreme wave histories (tsunamis, cyclone landfalls) of W Australia. Main challenges include dating (^{14}C, OSL, U/Th, ^{210}Pb) and distinguishing (a) between event and non-event processes, and (b) between event types, based on sedimentology, microfauna, and shell taphonomy.

Storm Regime and Morphological Changes at Different Time Scales on the Romanian Black Sea Coast

VESPREMEANU-STROE A., TATUI F., CONSTANTINESCU S., PREOTEASA L., ZAINESCU F.
University of Bucharest, BUCHAREST, ROMANIA

An expected consequence of global climate change that will potentially impact the coastal landscape in the 21st century include an increase in storminess, which could result in an intensification of coastal erosion and more frequent flooding of low-lying coasts. Storminess can vary as a function of the local climatic variability, ultimately controlling the intensity of the coastal dynamics.

Hourly wind speed and direction data registered between 1960 and 2012 at five meteorological stations placed on the Romanian Black Sea coast were used to analyse the coastal storm ($v \geq 10$ m/s, $T \geq 24$ h) regime: mean wind speed, total duration, resultant wind direction, storm severity index – SSI and storm impact factor - SIF.

The coastal storms temporal variability shows three active intervals (1961-1973, 1975-1978, 1995-1998), with high intensities of both the erosional and accretional coastal processes, and two calm periods (1989-1994, 2005-2012), with a decrease of 50-70% of the shoreline migration rates. The last interval (2005-2012) is an exceptional negative anomaly, the storm frequency being half of the multi-decadal average. All intervals are strongly negatively correlated with the North Atlantic Oscillation ($r = - 0.76$), which demonstrates the control of climate variability systems on the frequency and intensity of winter storms on the Romanian Black Sea coast.

This coast is subject to intense geomorphological processes with a net domination of erosion (70% of total shoreline length). The strongest coastal processes are recorded during winter, due to high storms frequency and magnitude. The storm activity is responsible for 62% of the total longshore sediment transport (LST); moreover, the high prevalence of northern storms (89% from all storms) imposes an unidirectional development for many coastal processes at different time scales: LST, aeolian sediment transport, sand wave migration and deltaic lobes lop-sided development.

****

Coastal Foredune Evolution Under Extreme Events: Superstorm Sandy

PSUTY N.(1), SCHMELZ W.(1), SPAHN A.(1), CHRISTIANO M.(2)
(1) Rutgers University, HIGHLANDS, NEW JERSEY, UNITED STATES ; (2) National Park Service, NEW YORK, UNITED STATES

The impacts of superstorm Sandy produced major changes to the geomorphological features of the Fire Island (USA) barrier island, a coastal barrier consisting of a National Seashore, a State Park, a County Park, and seventeen private communities. The changes may represent a step-wise displacement in the evolution of the barrier island and an episodic response to the effects of sea-level rise and negative sediment budget. The changes produced in this latest major hurricane have resulted in numerous instances of barrier washover, foredune erosion, inlet creation, and shoreline migration. Long-term monitoring (since 1976) of the foredune system on portions of the barrier island helps to provide perspective to these latest changes. They can be indicative of the nature and dimension of foredune erosion, recovery, and spatial displacement. The present dimensional analysis combines the products of previous monitoring results with extensive LiDAR data sets to provide a unique insight to the barrier's morphological response and evolution associated with extreme events. Further, responses are analyzed across the several types of land ownership and land use that incorporate differing coastal beach and foredune management strategies in the public and private sectors of the barrier island.

New understanding and prediction of storm impacts on gravel beaches (NUPSIG project): roles of geomorphological investigation and numerical modelling

MASSELINK G.
Plymouth University, PLYMOUTH, UNITED KINGDOM

Gravel beaches protect low-lying back-barrier regions from flooding during storm events Gand their importance to society is widely acknowledged. Unfortunately, breaching and extensive storm damage has occurred at many gravel sites and this is likely to increase as a result of sea-level rise and enhanced storminess due to climate change. Limited scientific guidance is currently available to provide beach managers with operational management tools to predict the response of gravel beaches to storms. The New Understanding and Prediction of Storm Impacts on Gravel beaches (NUPSIG) project aims to improve our understanding of storm impacts on gravel coastal environments and to develop a predictive capability by modelling these impacts.

The NUPSIG project uses a 5-pronged approach to address its aim: (1) analyse hydrodynamic data collected during a proto-type laboratory experiment on a gravel beach; (2) collect hydrodynamic field data on a gravel beach under a range of conditions, including storm waves with wave heights up to 3 m; (3) measure swash dynamics and beach response on c. 6 gravel beaches during extreme wave conditions with wave heights in excess of 3 m; (4) use the data collected under 1-3 to develop and validate a numerical model to model hydrodynamics and morphological response of gravel beaches under storm conditions; and (5) develop a tool for end-users, based on the model formulated under (4), for predicting storm response of gravel beaches and barriers.

Results of the NUPSIG project will be presented and it will be argued that both geomorphological investigation and numerical modelling are required to significantly enhance understanding of gravel beach response under extreme conditions. It will also be argued that for the new understanding to have a significant impact on sustainable coastal management, end users need to be involved from the outset of the project, during the design of research approach and deliverables, and not added as an afterthought.

****

The impact of extreme and above average processes on morphodynamics of cliff slumps (Wolin Island - NW Poland)

WINOWSKI M.
Adam Mickiewicz University, POZNAN, POLAND

Extremeprocesses undoubtedly have a major impact on the functioning of the Polish coast. These processes are the most common factor initiating the development of the coast. Increased activity of the sea and weather factors often results in the intensification of slope processes on sea cliffs. The result is the forming of new slumps and activate existing ones.

Based on thecorrelation of hydro-meteorological conditions prevailing over the last four decades, the date of initiation of slumps and field observations was recognized the origin of slumps and partial course of slumps development. To recognize slumps age, the dendrological method was used and the analysis of documentary material collected in the Department of Geoecology of the Adam Mickiewicz University in Poznan since 1981.

In total,over the last four decades (1973-2009) six episodes that have had a significant impact on the development of landslides within the cliffs of the island of Wolin were documented. Analysis of these episodes has allowed to determine the thresholds of slumps creation. On the base of the proposed thresholds, a catalog of extreme hydro-meteorological events (1973-2009) was presented. The analysis of presented events showed that in past 37 years extreme hydrometeorolgical phenomena occur on average every 2 years and 4 months and the frequency at this time grew three times.

New insights on morphological and sedimentary evidences of high energy marine flooding along the Moroccan Atlantic coast

EL TALIBI H.(1), ZAGHLOUL M.N.(1), ABOUMARIA K.(1), WASSMER P.(2), MERCIER J.L.(3)
(1) Department of Earth Sciences, University Abdelmalek Essaadi, Faculty of Science and Technology, TANGIER, MOROCCO ; (2) Laboratoire de Géographie Physique, UMR 8591, Université Paris 1 Panthéon-Sorbonne, MEUDON, FRANCE ; (3) Faculté de Géographie et d'Aménagement, Université de Strasbourg, STRASBOURG, FRANCE

Despite a position along the passive margin of Africa, the Moroccan Atlantic coast is under the influence of the earthquake generation zone related to the collision between African and European plates along a W-E fault line crossing Gibraltar strait. The 1755 Lisbon quake, with an epicenter located 200 km WSW Cape St. Vincent, triggered a tsunami that struck the shores of Portugal 20 minutes after the earth tremor. Southward, the Moroccan coastline was affected by tsunami waves reaching 2 to 15 m in depth asdocumented in western historic archives for the cities of Tangier, Asilah, Sale and Mazagao. Investigations along the Moroccan coastline based on sedimentary proxies, in the framework of the MAREMOTTI project, led to propose a lowering of these values. Recently, we re-investigated the Moroccan Atlantic coast and found out morphologies and sedimentary deposits evidencing a strong energy flooding event. This event we attribute to the 1755 tsunami leaves noticeable traces on a hilly dissected topography. In the proximal domain, no deposits were emplaced. The strong turbulence of the flow allows a complete erosion of the soil. Landward, the decreasing of the energy induced a strong depositional process. The thick brownish sandy layer deposited contains at the base large angular rip-up clasts of dark soil. Marine origin of the depositsd is attested by the presence of benthic and planctonic foraminiferas (*Ammonia tepida, Globigerinoides sphaeroidinellopsis*; *Bulimina sp.*...). In the distal domain, the sudden loss of energy due to a reverse slope results of an accumulation of a huge amount of unsorted marine bioclasts, remains of microlithic industry, rounded pebbles, sub-angular beach rock clasts and fragments of pottery displaying blunt breaks. Beyond an undulating line, the energy was insufficient to erode the soil which remained unaffected. These new insights plead for a high energy flooding that might be consistent with the waves depth provided by the 1755 archives.

****

Coastal multi-hazard cascades: how 12 seconds can reset baselines & trigger decades of coastal system adjustment

HART D.E.
University of Canterbury - Geography, CHRISTCHURCH, NEW ZEALAND

Coastal environments are characterised by complex processes which interact with each other and respond to antecedent conditions. Such geomorphic dynamism, combined with the current global population 'rush to the sea', makes coastal hazard management a challenging problem. This presentation uses the example of earthquakes in an urban coastal setting to show how one type of geomorphic trigger can induce a cascade of changes that alter numerous coastal hazards risks.

From 2010 to 2011 Christchurch, New Zealand, experienced a shallow earthquake sequence, including a devastating 5 km deep, 6.2 M_M quake with peak ground accelerations of 2.2 g. The seismic shocks radiated through the Holocene progradational plain occupied by the city, triggering extreme liquefaction; flooding; subaerial and submarine ground deformation; riverbank rafting and channel shrinkage; fine sediment pulses in tributaries, streams, estuaries and beaches; pollutant leakage into waterways; and widespread failures of coastal and riverside lifelines networks.

Instantaneous coastal consequences included relative sea level and horizontal shoreline changes of up to 1 m; marine cliff collapses; loss of tidal prism capacity and estuary surface area; isolation of harbour and bay suburbs; and prolonged closure or total loss of many coastal and river recreation amenities. Ongoing responses include unprecedented fining of beach deposits; low recruitment of marine and estuary biota; shoreline shifts; and changes to sediment budgets, mudflat profiles, and storm, tsunami and sea level rise risks.

Most of the earthquake effects can be explained by seismic interactions with coastal and river environments, past, present and future. As such, the Christchurch experience graphically illustrates why local awareness of the potential for coastal hazard cascades is essential for planning responses to coastal events that avoid exacerbating existing and future coastal hazards.

Extreme sea-level rise and adaptation options for coastal resort cities

LEMCKERT C.(1), COOPER A.(2)
(1) Griffith School of Engineering, SOUTHPORT, AUSTRALIA ; (2) University of Ulster, COLERAINE, UNITED KINGDOM

The Gold Coast, Queenslan, Australia, like many other localities around the world, is a coastal resort city whose urban environment has evolved through a series of human interventions on the natural shoreline and backshore zone. Such cities rely on a perceived high quality environment to attract tourists, which in turn results in them being reliant on continued maintenance operations. Any sea-level rise, for whatever reason, is likely to result in increased inundation frequency and shoreline erosion episodes. In this presentation we consider adaptation options and possible strategies for the city under various future high-end sea-level rise (SLR) scenarios of 1 m, 2 m and 5 m. We assume the beach and waterways must be preserved to enable the city to continue to exist as a resort environment. It is concluded that pre-planned adaptation would probably enable the city to survive SLR of 1 m. For a 2 m SLR we postulate that even with an adaptation plan in place, the scale of measures required would severely stretch the city's resources. Under a 5 m SLR we do not believe that any amount of planning would enable the city to survive as a coastal resort due to excessive cost. Such outcomes are expected to have international applicability.

****

Holocene sedimentary processes in the West Bengal Sundarbans: facies dynamics in a peri-marine environment

FLOOD R.(1), ORFORD J.(1), TURNER J.(2)
(1) Queen's University Belfast, BELFAST, UNITED KINGDOM ; (2) University College Dublin, DUBLIN, IRELAND

The Bengal Sundarbans is one of the largest tidal halophytic mangrove forests in the world stretching across the India-Bangladesh border. Situated between the river Hoogli in the west and the Ganges-Brahmaputra delta to the east, the Sundarbans was declared a UNESCO World Heritage Site in 1987 and serves as the primary habitat for endangered flora/faunal species. The relevance of this research is to identify the sources and fate of sediments in the Indian (West Bengal) Sundarbans tidal islands on the contemporary inactive deltaic system to the west of the present day Ganges-Brahmaputra, dominated by river estuary and cyclone activity. Through the application of geochemical and sedimentological facies analysis, an enhanced understanding of the Sundarbans sedimentary dynamics can be discerned. Geochemical and textural analyses have been completed on three cores from uninhabited intertidal islands (c 9m max depth) with high resolution geochemical (X-ray fluorescence (XRF)) and x-radiography carried out using ITRAX™ core scanning. Speculation regarding the sedimentary provenance in the Sundarbans has been viewed as being primarily marine-derived from the currently active delta front of the Ganges-Brahmaputra to the east of the Bengal Basin (Battacharrya et al., in press). The results obtained in this project, question such claims of provenance and processes with sedimentary pathways being more complex. Sediments appear to be the outcome of reworking within the deltaic-estuarine system with siliclastic and possible terrigenous loads dominating the sedimentary facies. Tidal geomorphological processes represent the dominant controls over sediment re-distribution within the Sundarbans, with possible high-energy depositional events characterising stochastic variation. The Sundabans inter-tidal sedimentary environment is not completely understood, yet is central to the future of ca. 4 million inhabitants in a changing peri-marine environment.

The Influence of Tide for Suspended Sediment Transport in Barito River Delta, Southern Kalimantan, Indonesia

ARISANTY d., SARTOHADI J., MARFAI M., SRI HADMOKO D.
Gadjah Mada University, YOGYAKARTA, INDONESIA

Delta is an accumulation of sediment that influences of river and marine. Marine agent has a function to redistribute sediment in delta, such as tide. Intensively, tide influenced Barito Delta development. Barito River Delta was one of delta in Kalimantan, Indonesia. This delta was flat topography which southern part and central part of Barito Delta elevation were about 0-2 m above mean sea level, then rising to 3-4 m to the northern of Barito Delta.

Survey method was used in this research.Tidal measurement location consisted of 4 location, i.e. Tamban channel, Trisakti harbor, and Kapuas (lower part of delta) and Belawang (upper part of delta). Tide was measured in dry season and wet season for one day with 1 hour interval. Suspended sediment was taken on the highest and lowest tide level during 24 hour.

The research showed that tide in wet season was higher than in dry season due to rain water. Both in wet season and dry season were no significant differences of the height of tide between spring tide and neap tide. In wet season and dry season, low tide transported suspended sediment more intensively than high tide in spring tide and in neap tide. The velocity of tide current was higher in the low tide than high tide hence the sediment was transported was higher in low tide than high tide. The influence of tide to sediment transport decreased in upper part of delta (Belawang).

Keywords: Barito River Delta, Tide, Suspended sediment

****

Altération of delta morphology by channel abandonment processes at Mahakam delta, east Kalimantan, Indonesia

HUSEIN S.
Department of Geological Engineering, UGM, YOGYAKARTA, INDONESIA

The modern Mahakam Delta, East Kalimantan, Indonesia, has been acknowledged as a typical example of a tropical mixed fluvial and tide-dominated delta (e.g. Galloway, 1975). Its subaerial delta plain has a fan-shaped morphology and is dissected by numerous distributary and estuary channels. As distributaries branch seaward out from the delta apex, they can be grouped into the northern and southern areas, while the central area is only occupied by estuaries.

This study investigates the distributary abandonment processes in the northern area which has 3 distributaries and 3 estuaries, by using echo-sounding profiles, grab sediment samples and hydrodynamics measurement. Distributaries exhibit relatively straight channels with flaring mouths while estuaries are more sinuous and have deeper and smaller mouths. Sand is more distributed in the bottom of the active distributaries than in the abandoned distributaries and gradually fines seaward but does not extend to the channel mouths while mud dominates the estuaries and the distal reaches of the distributaries. Hydrodynamic data indicates that the interaction of fluvial and tidal processes is dynamically active along the entire length of the distributaries. Fluvial processes dominate the sandy reaches of the distributaries, while tides are the most important process in the lower reaches of active distributaries, the inactive distributaries and estuaries.

This study suggests that the channel abandonment processes in the Mahakam Delta is sequential. As the tidal processes become more dominant, fluvially-supplied sand is being stored onshore in the distributaries and tidal processes are modifying distributary morphology and dominating sedimentary facies progressively further landward. As a whole, the present-day deltaic lobate morphology reflects a relic geometry of a former fluvial-dominated delta.

Formation and evolution of the abandoned Yellow River delta

ZHANG Y.
School of Geographic & Oceanographic Sciences, Nanjing University, NANJING, CHINA

A large scale delta, called the Abandoned Yellow River delta (AYRD), was built at the middle of Jiangsu coast while the Yellow River entered into the Yellow Sea during 1128-1855AD. It formed a promontory in the Jiangsu coast, and the Jiangsu coast changed into the tide dominated tidal flat coast from the wave dominated sandy barrier bar – lagoon coast.

Since 1855AD when the Yellow River returned back to enter into the Bohai Sea, lost the huge sediment supply suddenly, the coastline of AYRD began to retreat rapidly suffering from the coastal erosion. In the early stage, the coastline retreated 400m/a at the cape part, and more than 23km withdrew so far. Furthermore, the erosion coast extended southwards. -5 m and -10 m isobaths regressed landwards. The offshore slope changed from convex shape into concave shape, and then retreated paralleled. The abandoned river mouth became a small estuary, formed chenier in the middle of 20th. After the high dikes and groins were constructed later of 20th, the regressive progress of the coastline was stopped. The abandoned river mouth turned into a small artificial bay, and the silty sand beach formed inside with remnant silty deposits. Obviously, wave dynamics is becoming active again along the coast. Meanwhile, the offshore slope is increasing, and -15m isobaths is moving landwards rapidly while part of the erosional materials are deposited in certain offshore area. Consequently, -10m~-15m deep tidal channels have been formed in the offshore area along the both sides of the AYRD. The surface sediment of the sea bottom is getting coarser, fine sand distribution area is extending landwards. The underwater part of the AYRD is still adjusting controlled by the wave and tide dynamics.

****

Longshore drift and sand sequestering in river deltas

ANTHONY E.
Aix Marseille Universite, Institut Universitaire de France, CEREGE UMR CNRS 7330, AIX-EN-PROVENCE, FRANCE

The retention of river-borne sediments essential to delta growth under a stable sea level depends on the receiving basin characteristics and on the relative influence of river, waves and tides, the three cornerstones of delta morphological classification. The wave factor primarily concerns longshore transport of river-supplied bedload. Strong unidirectional longshore drift can prevent delta development, or lead to strongly longshore-skewed deltas that eventually cease to prograde, with sand totally evacuated downdrift, giving a simple equilibrium drift-aligned delta shoreline, as in the textbook example of the Senegal delta. Even where wave influence is strong, large-scale delta morphodynamic adjustments can command the longshore drift cell structure, preventing sand leakage from the system. Wave-angle control has been advocated as a cause of drift reversal downdrift of wave-influenced delta mouths[1]. Similar drift reversal also occurs well downdrift of delta mouths where shoreline orientation changes rapidly due to more pronounced progradation in the mouth(s) sector where the 'hydraulic groyne' effect of river (+ tidal) discharge refracts waves, resulting in conservation of a large share of the bedload for progradation. The downdrift delta termini are commonly prominent sand spits. Examples occur on many deltas, including the Rhône and Ebro. Where several distributary mouths occur, multiplying the hydraulic groyne effect, pronounced longshore variability in wave-induced sand transport ensues, resulting in multiple drift cells that assure sand retention, as in the Mekong and Niger deltas. By affecting the way waves redistribute delta sediments, these controls express fluvial (+ tidal) determinants on delta development even when the ambient wave influence is strong, as shown by the wave-formed beach-ridge sets common in these deltas.

[1]Ashton, A. D., L. Giosan (2011), Wave-angle control of delta evolution, Geophys. Res. Lett., 38, L13405, doi:10.1029/2011GL047630.

Temporal and spatial variability of coastal change on deltaic coast of Tabasco, Mexico

MAGDIEL LYDIA B.R., ORTIZ PEREZ M.A.
UNAM, Instituto de Geografia, MEXICO, MEXICO

The coastal plain more extensive and one of the most important in the southern Gulf of Mexico, is the coastal plain in the state of Tabasco in Mexico, associated with recent geological sedimentation processes of the central basin of the hydrological system the rivers Usumacinta-Mezcalapa. Even though predominant a plain fluvio-deltaic.

The coast of Tabasco presents remarkable changes in the advance and retreat of the relative position of the shoreline, which is attributed to the nature of the system changes in fluvial-deltaic and morphological adjustment to the front beach hydrodynamic conditions, which is uneven from one sector of the coast to another sector.

The dynamics of coastal environments exposed to the sea, like inlets and barrier islands, the dispersion control removal and deposition of sediments transported streams or channels adjacent to the margins of the inlets and barriers, which cause deposition or erosion on shoreface.

The morphodynamic coastal is the result of the interaction of variables that play a role in changing the relative position of the coastline, such as:

a) Changes in the hydrodynamic conditions of the coast, mainly the relative rise in sea level by the inverse barometer effect, which is the response of the ocean surface to changes in atmospheric pressure.

b) The variations in the circulation of winds and ocean currents, which are translated into a greater intensity of tropical cyclones, hurricanes, storm surges and tickets, "North" significantly affecting the coast of Tabasco.

c) Changes in sediment dynamics, affected mainly by longshore transport of littoral drift along the coast.

d) The redistribution of sedimentary deposits, generated mainly by diffraction and refraction of waves and local currents, near the margins of the barrier islands and their mouths.

****

Geomorphology and evolution of the Save River Delta plain, South-Centre Mozambique

MASSUANGANHE E.(1), WESTERBERG L.O.(1), ACHIMO M.(2)
(1) Department of Physical Geography and Quaternary Geology, Stockholm University, STOCKHOLM, SWEDEN ; (2) Department of Geology - Eduardo Mondlane University, MAPUTO, MOZAMBIQUE

Located in South-central Mozambique, the Save River delta is one of the larger deltas in Southern Africa and records its evolution by the geomorphologic features and sediments. In this study we used satellite images (Spot 5) and aerial photos to interpret and map the geomorphologic units of the delta aiming to assess the evolution of the delta plain. The map was integrated with field observations and sedimentary logs from exposed sections along the main river channel and cores. Additional analysis for grain size and radiocarbon dating was also performed. The results of this study show that the delta plain is composed by mangrove wetlands lying in intertidal flats characterized by a sequence of 1 to 2 meters of clay with organic matter intercalated with fine sand layers and overlapping medium to coarser beach sand. The mangrove wetland is crossed by beach ridges and dunes lying parallel to the present coastline, and coastal dunes forming a barrier to the open sea overlapping the wetland. Alluvial terraces, located topographically higher, stand morphologically elongated seawards at the center of the delta plain. Stratigraphically this unit is characterized by cyclic sequences of alluvial sand intercalated with bioturbated clay (at the bottom), peat layers (in the middle) and paleo-topsoil (in the top) for at least 4.5 meters of thickness. Incisive paleo-channels in the upper layers filled by very fine sand record the late distributary pattern of the river during the depositional process of the terrace. In overall, the geomorphologic and sedimentologic features of the Save River delta have evolved strongly controlled by the river in a progradation system covering the intertidal deposits.Ongoing dating will provide time sequence for these processes.

A renewed Holocene relative sea-level envelope for Western Brittany (France): Global signal and local artefacts

GOSLIN J.(1), VAN-VLIET LANOË B.(2), HENAFF A.(1), DELACOURT C.(2), FERNANE A.(2), HALLEGOUET B.(1), PENAUD A.(2), SUANEZ S.(1)
(1) GEOMER, CNRS UMR 6554, IUEM, UBO, PLOUZANÉ, FRANCE ; (2) Domaines Oceaniques CNRS UMR 6538, IUEM, UBO, PLOUZANÉ, FRANCE

Along the last fifty years, researches made on Holocene sea-level reconstruction led to demonstrate that no real consensus exists on the Holocene eustatic curve at a worldwide scale (Fairbridge, 1961, Jelgersma, 1979, Gehrels, 1999, Vella & Provansal, 2000, Laprida, 2007). Then, many studies put in light that even sea-level reconstructions constructed from regions of a same oceanic facade could led to different results (e.g. for the French Atlantic coast, Morzadec-Kerfourn 1974, Ters, 1986, Lambeck, 1997, Stephan, 2011, Goslin et al., submitted). In particular, it has been continuously discussed whether sea-level rose under a continuous trend until present-day level or followed an oscillating pattern with negative variations superimposed on this global rise-tendency.

In Brittany region, a need for a renewed sea-level curve was felt in the framework of the COCORISCO research project on coastal risk assessment. New data were obtained all around the Finistère peninsula by performing a total of 25 new percussion cores and drillings. Particular attention was paid to the diversity of the studied sites, in terms of morphological site configurations, size, and storm swells exposition, in order to have the best insight of possibly recorded relative sea-level variations.

Thanks to more than 60 new C14 datings, this work represents a major advance in the knowledge of Brittany Holocene relative sea-level history. Results we obtained put in light the complex connections that exist between global sea-level signal and local sites sedimentary records. If correlations with global Holocene climatic cycles could be observed, it appears that negative sea-level signals observed in some sites could not be supported when confronted to other records. New information obtained on two sites by bathymetric and seismic campaigns will help to form hypothesis on specific local morphological evolutions and on the possible behavior of Brittany sedimentary stocks to Holocene sea-level rise.

****

Incipient foredune development along macrotidal beaches, Northern France

RUZ M.H.
Université du Littoral Côte d'Opale, DUNKERQUE, FRANCE

Incipient foredunes are new or developing foredunes forming by aeolian sand deposition within pioneer plant communities on the backshore of beaches. They represent the initial stage of foredune formation and are usually found along stable to prograding coastlines. Most studies on incipient foredune formation and evolution were carried out along micro to mesotidal coastlines while incipient foredune development on macrotidal coasts received little attention. The aim of this study is to describe incipient foredune development along macrotidal sandy beaches of northern France. In this area, where mean tidal range varies from 8 to 4 m, the beaches are 400 to 700 m wide at low tide and are characterized by a bar-though topography. Along stable to slowly prograding beaches, characterised by a narrow (< 30 m wide) upper beach, “classical” incipient foredunes are found. They develop from pioneer plant seedling in the wrack line seaward of the foredune stoss slope. In areas of sufficient sediment supply they rapidly coalesce, eventually forming a continuous dune ridge that develops into a new foredune. Along rapidly advancing shoreline sectors, specific incipient foredunes develop. Near Calais, onshore bank welding in the recent past has created a large sand flat up to 1000 m wide at low tide, offering a very important fetch and serving as a substrate for significant embryo dune development. At the landward margin of this sand flat, discrete hemispheric low elevated convex mounds (coppice dunes), surrounded by water during spring tides developed. They evolved *in situ*, growing in height over time, forming “mega” nebkha, more than 3 m high. They are aligned parallel to the shoreline and still separated from the established foredune by a swale reached by uppermost water levels. Ultimately they could form a new foredune ridge. Along this macrotidal coast, the width of the upper beaches appears as a major factor controlling incipient foredune development.

Morphological types of foredunes in Poland as an indicator of coast trend changes

LABUZ T.
University of Szczecin, Faculty of Geosciences, SZCZECIN, POLAND

The Polish coastal zone localized on south Baltic coast is 500 km long and mainly exposited on N direction. It is aligned and build by loose material (sand, till or peat, mainly). Almost 85% is built by sandy aeolian deposits creating different dune types. Among them typical coastal dune ridges are covering sand spits, barriers or lowlands on which they are developed. Only 15% of coastal dunes are in accretion phase. Foredunes - called incipient dunes - are an indicators of accumulative character of the coast. This work is a part of project called FoMoBi (www.fomobi.pl) – that is aimed to recognition of morphology and biodiversity of accumulative dune sections of Polish coast. Project is financed by Polish National Centre for Research and Development (NCBiR).

Work presents issues of foredunes morphodynnamics classification that is created due to conducted field works and laboratory analyses. Methods of the field research are: i) field leveling as profiles across coastal forms, ii) surface measurements in plots 5x5 m of the embryo dunes on the upper beach and on larger areas 200 m along foredune ridge as 3D leveling using GPS RTK base and in future iii) ground laser scanning as a innovative tool.

There are used some indicators of relief changes as: foredune base and ridge or edge movements, foredune height and dune base width, beach width and height, height and dynamics of embryo dunes on the beach.

Foredunes are very variable in time and space where their surface changes is effect of several factors irregularly affecting through year. On the Polish coast there are few dynamics types of foredunes: A - coast of fast progradation with several small sandy dykes, B - one high still grooving dyke on stable coast, C - more or less stable dune occasionally eroded and restored, D – accumulative coast with withdrawing ridge due several erosion phenomena.

****

Decrease of the supply of wind-blown sands in front of artificial pine forest in coastal dunes

CHOI K.H., KIM Y.M., JUNG P.M.
National Institute of Environmental Research, INCHEON, SOUTH KOREA

Forestation on the coastal dunes has been thought to stabilize the dune landscapes and protect the residential area from strong winds, blown sands, and salt spray.Planting pines for dune stabilization was very common in the pastand has still been performed by local governments in South Korea. However, it could cause coastal landscape less dynamic and deprive of its natural ability to recover, which in turn, results ina retreat of coastline. In this study, we compared topographic changes in the front side of artificial pine forest and the grass-covered area,for the purpose of the effectiveness of planting trees on dunes. We constructed two monitoring plots featured by AWS (automatic weather stations), erosion-deposition pins, and vegetation quadrats at each site, and have collected wind data and vegetation change as well as the information on the pattern and rate of wind-blown deposition of sandy materials since February 2011. Sand dunes on both sites grew from late winter to spring, when the strong northwesterly wind is dominant. From March to April, thick depositionwas observed on the front side of the grass-covered dune: thesand dune piled up to ca. 30 cm vertically and advancedca. 25 m landward from the high tide line. On the other hand, it affected only ca. 10 m landward in front of the forested area, with newly deposited materials less than ca. 12 cm. This small accretion might be related with the frequency of the effective wind.Compared with the grass-covered area, the meanwind velocity in artificial pine forest area decreased by up to50%. Especially, the velocity of the strong winds faster than 4.5 m/s diminished to 25% of the control sites, resulting in decreased blown sand supply. Planting pines seems to be ineffective in protecting pines, but rather it lead negative impact on coastal dunes. It may result in a retreat of coastline, loss of land, and devastation of dune ecosystems.

Dune fences efficiency assessment on northern beaches of Portugal

PINHO J.(1), GRANJA H.(2), ALMEIDA E.(3), HENRIQUE A.(4), TEIXEIRA A.(3), VIEIRA S.(3)
(1) C-TAC/ Department of Civil Engineering, University of Minho, BRAGA, PORTUGAL ; (2) CIIMAR/ Department of Earth Sciences, University of Minho, BRAGA, PORTUGAL ; (3) University of Minho, BRAGA, PORTUGAL ; (4) Biological Park of Gaia, VILA NOVA DE GAIA, PORTUGAL

The coastal zone of the northern region of Portugal has experienced a continued erosion process whose mitigation has passed, at an early stage, by the construction of coastal defense structures (mainly groins and revetments) that, given the acquired experience and current economic context, has revealed to be a solution whose efficiency and effectiveness are questionable.

Finding low cost alternatives to increase the resilience of coastal systems based on natural processes dynamics is an important area of applied research, allowing alternative sound responses in a context of progressive erosion of coastal systems beaches and dunes.

In this work we present results obtained for coastal segments of Vila Nova de Gaia municipality, Portugal, where a considerable investment on dune fences installation was done in an attempt to increase and recover the back dunes and their ecosystems through the trap and effective accumulation of sand moved by local winds.

Observation methodology is based on two different approaches: (**i**) coastal digital elevation models where derived recurring to aerial photogrammetric techniques (November 2008, April 2009, November 2009, May 2010); (**ii**) local measurements where conducted during the year 2012 in a set of dune fences. Obtained field data was processed through geographic information systems (GIS) tools.

During the observation period, the sediment budget was predominantly stable, although for some locations a positive trend was clearly observed. In some cases, the dune fences infilling was completed in a year. Obtained aeolian fluxes are presented as well as correlation results for wind and precipitation patterns.

****

The role of the inter-bar depressions in hydrodynamic and sediment transport processes of sandy macrotidal beaches

CARTIER A.(1), HÉQUETTE A.(1), LARROUDE P.(2)
(1) Laboratoire d'Oceanologie et de Geosciences UMR CNRS 8187, Universite du Littoral Côte d'Opale, DUNKERQUE, FRANCE ; (2) LEGI-UMR 5519 UJF, Université de Grenoble, GRENOBLE, FRANCE

Macrotidal beaches are generally characterized by a bar-trough topography consisting in an alternation of intertidal sand bars and depressions, intersected by shore-normal channels. Several studies have pointed out that sediment transport rates in these depressions can be important, notably during runnel drainage. Often described as a significant recycling mechanism of sediment in intertidal bar systems, currents and rates of sediment transport in inter-bar depressions have never been precisely studied or measured on macrotidal beaches however. The exact role of trough and channel topography on beach hydrodynamics and sediment transport processes are therefore not well known. Hydrodynamics measurements have been undertaken at Wissant Bay on the shore of the Dover Strait, Northern France, where 4 hydrographical instruments were deployed. An Acoustic Doppler Current Profiler (ADCP) coupled with an Acoustic Doppler Velocimeter measured the current and wave parameters in a well-defined trough while an electro-magnetic current meter and another ADCP have been deployed on the stoss side of the bars encompassing the trough. Sediment transport rates were calculated using the Van Rijn's (1993) formula which is integrated in a 2DH-model. Results show that during the falling or the rising tide, the trough experiences a strong increase of the current speed from the moment when the bar located seaward of the trough begin to emerge or be submerged, leading to a channelization of the flow. Current direction during such event is not controlled by wave or tidal conditions but by the topography itself. This increase of the mean flow results in an upper flow regime which is responsible of bedforms destruction associated with high sediment transports rates. This mechanism contributes to the stability of the barred morphology of these macrotidal beaches by inducing a residual circulation of wave-driven onshore transport sands from the upper to the lower beach during the falling tide.

Dune Vulnerability and Management Strategy: A Case Study of West Bengal and Orissa Coasts, Bay of Bengal, India

DAS MAJUMDAR D.(1), PURKAIT B.(2), PAUL A.K.(3)
(1) Department of Remote Sensing & GIS, Vidyasagar University, MIDNAPORE, INDIA ; (2) Department of Geology, University of Calcutta, KOLKATA, INDIA ; (3) Department of Geography & Environment Management, Vidyasagar University, MIDNAPORE, INDIA

Vulnerability assessment of coastal sand dunes is necessary to evaluate the conservation status as well as to find out the most relevant disturbance events along the coastline. A critical study on the coastal dune vulnerability & management has been undertaken along the coastal tract of West Bengal and Orissa, Bay of Bengal, India. A total of 37 coastal dune sites have been surveyed and analyzed on the basis of structured rating scheme to assess the in situ geo-environmental condition and range of protection measures. Parameters likegeomorphological condition (GC), marine influence (MI), aeolian influence (AI), vegetation condition (VC) and anthropogenic effects (AE) have been considered for vulnerability analysis. The percentages of the maximum possible rating for each category of information have been calculated and summation of the above information provides a Vulnerability Index (VI) which ranges from 42% to 65.9%. The Protection Measure (PM) as defined by the defence strategies has been undertaken for managing the dune vulnerability. The PM value ranges from 18.2% to 86.4% for the entire coastal stretch. Finally, based on VI/PM ratio a descriptive categorization of the vulnerability and protection measures of coastal dune at each site has been derived. The Euclidean distance in cluster analysis is used as the measure of association which enables to group the dune sites into five major classes according to their vulnerability levels. Wilks' Lamda test signifies the dimensionality of group discrimination at the 0.05 level of significance. Mapping of all the calculated parameters regarding dune vulnerability and protection provides spatial interpretation about the sensitivity of the dune system along the study area. The data-base thus generated on different aspects of dune system might be helpful for delineating the dune vulnerability and suggesting proper strategic measures.

****

Interactions between waves, sediments and pioneer plants in tidal marshes: Results from a full scale flume experiment

SILINSKI A.(1), HEUNER M.(2), DAUWE S.(1), PUIJALON S.(3), TROCH P.(4), BOUMA T.J.(5), VAN BELZEN J.(5), SCHÖDER U.(2), FUCHS E.(2), MEIRE P.(1), TEMMERMAN S.(1)
(1) Universiteit Antwerpen, WILRIJK (ANTWERPEN), BELGIUM ; (2) Federal Institute of Hydrology, KOBLENZ, GERMANY ; (3) Université Lyon 1, VILLEURBANNE CEDEX, FRANCE ; (4) Ghent University, ZWIJNAARDE, BELGIUM ; (5) Netherlands Institute for Sea Research, YERSEKE, NETHERLANDS

In theory, seaward expansion of tidal marsh shorelines can take place through establishment of pioneer plants on intertidal flats through *i)* clonal expansion, *ii)* rhizomes, or *iii)* seeds. In the Scheldt estuary (SW Netherlands), seedlings only occur occasionally, and the survival of transplanted plants on the mudflat has proved to be very limited. This arouses the question which factors limit plant establishment and survival. We studied in a wave flume the impact of short and long waves at several water levels on the tiredness of plants, drag forces on plants, and sediment scouring around adult shoots and seedlings of *Scirpus maritimus*.

The Wave Flume of the Department of Civil Engineering at the University Ghent has a length of 30 m, width of 1 m and height of 1.2 m. A natural sand slope was imitated on a length of 7 m. Waves with a height of 17 cm at the wave paddle and with 2 s and 10 s wave period were generated at three different water levels (5 cm, 20 cm and 35 cm). Individual seedlings and adult shoots of *Scirpus maritimus* were transplanted into the sediment bed with 10 replicates. Each test consisted of 200 waves sent onto the plants.

Under equal hydrodynamic conditions, adult plants and seedlings showed different responses. There was no clear tendency regarding the tiredness of seedlings. The adult shoots, however, showed a gradient of increasing tiredness with rising water level and higher wave period. Drag force was equally low on the seedlings for all conditions (< 0.25 N), whereas adult plants experienced higher drag forces (up to 3 N) from higher water levels and longer periods. The volume of the sediment scouring depended mainly on the hydrodynamic conditions and on the stem diameter. Analysis on shoot tensile strength and stiffness showed a clear difference in behaviour between adult plants and seedlings, potentially explaining the differences in drag force and in tiredness.

Biogeomorphic succession of mangroves: Basic knowledge to improve restoration and management of tropical mangrove coasts

BALKE T.(1), JEUKEN M.C.J.L.(1), HERMAN P.M.J.(2), BOUMA T.J.(2)
(1) Deltares, DELFT, NETHERLANDS ; (2) Royal Netherlands Institute for Sea Research, YERSEKE, NETHERLANDS

Mangroves are closely linked to their physical environment e.g. with the colonization of mudflats by seedlings or the trapping of sediments and elevation change to keep up with sea-level rise. Recent advances in biogeomorphology of tidal wetlands have improved our understanding of how these threatened and valuable ecosystems are interlinked with coastal sediment dynamics. Mangroves follow a biogeomorphic succession from a physical phase where physical disturbance forms a bottleneck to seedling establishment, through a biogeomorphic phase where feedbacks due to the vegetation cover alter sediment dynamics towards a partial disconnection from external forcing. We show with a series of flume and mesocosm experiments how colonization of mudflats is limited by coastal hydrodynamics and sediment dynamics. Moreover we analyzed spatial pattern of accretion/erosion processes in mangrove forests. Finally we present a conceptual framework for the biogeomorphic succession of mangroves. On the basis of this fundamental knowledge of mangrove dynamics we suggest measures to improve sustainable mangrove restoration and management. The close linkage of physical processes with mangrove functioning has long been marginalized and has only recently started to be considered when planning restoration projects. Present study quantifies a series of processes along the biogeomorphic succession by experimental work and field surveys with direct implication for applications.

****

Mangrove evolution and morphodynamic processes in Mayotte Island (Indian Ocean)

JEANSON M.(1), DOLIQUE F.(2), ANTHONY E.(3)
(1) EPHE - Laboratoire de Geomorphologie et Environnement Littoral, DINARD, FRANCE ; (2) Université des Antilles et de la Guyane, UMR 228 ESPACE-DEV, SCHOELCHER, MARTINIQUE ; (3) Aix Marseille Université, Institut Universitaire de France CEREGE, UMR CNRS 6635, AIX EN PROVENCE, FRANCE

Mayotte Island, located in the Mozambique Channel, western Indian Ocean, is characterised by a vast, highly diversified reef-lagoon complex comprising significant mangrove development. The mangroves were mapped from 1949 to 2008 using digitised aerial photographs and a GIS was used to determine the evolution and rates of mangrove growth and loss. The results highlight a remarkably variable mangrove system subject to progression or stability on the north and east shores of the island, but exhibiting a clearly regressive pattern along the southern and western shores. On these latter coasts, hydrodynamic measurements and topographic surveys were conducted in several mangrove forests in order to gain a better understanding of this evolution. Results show that the decline of mangrove systems leads to a reorganisation of the sediment stocks previously fixed by the tree roots and the emergence of new shoreline morphodynamic patternsresulting from modifications in the hydrodynamic processes. Field observations also show longshore intertidal bar-trough systems fringing the southern and western mangrove forests. The surveys reveal that these bar-trough systems can affect the dynamics of mangrove forests by enhancing either erosion or accretion.

A risky retreat: Fine-tuning projections of salt marsh development in managed realignment projects

WHITE A., HANLEY M.E., MASSELINK G., BLAKE W.H., HOGGART S.P.G.
Plymouth University, PLYMOUTH, UNITED KINGDOM

In many coastal regions the restoration of salt marshes following managed realignment is recognised as a cost-effective and sustainable alternative to the construction of traditional 'hard' coastal defences. However, successful transition to salt marsh on actively managed sites is unpredictable and dependent on a host of local chemical, geomorphological and biological factors.

We monitored the response of low-lying grazing marsh to flooding at a site in Devon, UK after a self-regulating tidal gate (SRT) was installed in June 2011, applying an integrated, biogeomorphological approach (involving monitoring vegetation alongside changes in marsh morphology, inundation regime and sedimentation) in order to assess development of the site into a fully functioning salt marsh.

Four months following realignment, vegetation die-back was extensive in areas subjected to tidal inundation and freshwater marsh species remained as dominant. However, limited halophytic vegetation had emerged in the restored area within 12 months. A pressure transducer on the restored side of the SRT revealed that water levels were below 1.0 ODN for 90% of the time. Given the elevation of the marsh (0.9-1.0m ODN), the frequency, depth and spatial extent of inundation were less than projected. As a consequence, sediment deposition was negligible and suspended sediment concentrations measured at the SRT were similarly low. Predictions of potential sedimentation rates show that even if water levels on the restored marsh were increased to 1.2m ODN, a vertical accretion rate of only 0.9mm yr^{-1} could be expected.

These results indicate that increasing water levels on managed sites still may not encourage salt marsh development if sedimentation rates are inhibited by the breach design. This highlights the necessity of monitoring and facilitating a variety of factors simultaneously in order to assess the development and future success of managed realignment schemes.

****

Geomorphological responses of tidal islands and estuary channels to embankments: a paradox of sustainability and protection in the West Bengal Sundarbans

ORFORD J.D.(1), PETHICK J.(2), KUMAR S.(1)
(1) Queen's University, BELFAST, UNITED KINGDOM ; (2) Independent Consultant, BEVERLY, UNITED KINGDOM

The Indian (West Bengal) Sundarbans is composed of tidal islands superimposed on the palaeo-delta facies at the western edge of the contemporary Ganges delta (Bay of Bengal). The tidal islands define a series of blind rivers, which originally were part of the anastomosing proto-Ganges. They are now tidally dominated estuaries with channel-side morphological changes that are adjusting to varying time-scales of environmental change related to tidal prism, sea level change and sediment supply. For several centuries there has been in-migration to the Sundarbans by landless poor, who have now developed a sophisticated, but subsistence, monsoon-dominated rice economy. In West Bengal there are c. 4million inhabitants over 3500 km^2 protected from estuary water-sediment activity, cyclone surges and the threat of rising sea level, by hand-built embankments (dating back to the 19th century). The impact on the geomorphological system of the tidal islands (both inhabited and uninhabited) by the mode of embankment building (eg use of channel muds), the placement and presence of embankments (eg controls on island sedimentation; channel dynamics) is considered in terms of the implications for 21st century living under scenarios of change related to island subsidence; rising rates of extreme sea-level; sedimentation scarcity and positive feedback of tidal regime changes. The problem of how these communities can survive sustainably with local geomorphological condition, when the embankments are themselves contributing to the context of change is considered. The paradox is that upgrading embankment protection is an evidently popular (if not demanded option), but offers only short-term protection gain, compared to the rising embankments further distortion (positive feedback) of the estuary forcing conditions that will overcome the embankment protection in the longer-term. Consideration is made of potential island upwarping as a potential survival strategy for some of the population.

Evolution of the coastline of anthropised islands off Galicia and Brittany: Ons and Ushant

REGNAULD H.(1), DAIRE M.Y.(2), LOPEZ ROMERO E.(3)
(1) Rennes 2, RENNES, FRANCE ; (2) Rennes 1Archeosciences, RENNES, FRANCE ; (3) Cesic, SANTIAGO, SPAIN

Remote islands have been anthropised from the late neolithic but to a lesser extend than the neibouringh continental areas. For this reason the impact of anthropisation on the “natural” behaviour of the coast is supposed to be far less important than on the main land. Studies on island of Ons, off Galicia and of Ushant off Brittany (within the frame work of the GALA project –Géographie et Archéologie du Littoral Atlantique) have shown that this statement may be strongly criticised. Even if the population is less abundant and if the occupation is discontinuous in time the local sensitivity of the coast makes it far more vulnerable than the main land coastline. The study of coastal exposures (with 14C datations) together with the study of archaeological remains allows to reconstruct the interfingering between coastal accumulation/erosion and human activities. Surprisingly enough human impact was more efficient at times, and on some precise sites, during the middle ages than today. At that time, small coves and pocket beaches were intensively used for fishing and boating. Today these sites are too shallow for present boats and are not used any more for fish trapping. Most often they are included into protected zones. They presently behave as natural places even if they still bear the traces of their former state of semi artificialised coastlines.

****

Shoreline evolution of Capo Peloro, the northernmost point of Sicily(Italy) : causes and temporary management

RANDAZZO G., LANZA S.
University of Messina - Department of Phisics and Earth Sciences, MESSINA, ITALY

Sicily, the largest island in the Mediterranean Sea, is separated from the Italian Peninsula by the 3.6-km-long Strait of Messina, extending along the homonymous town. The northernmost point of the Island and the one closest to the continent is Capo Peloro, a characteristic round beach which gives rise to the saddle separating the Tyrrhenian from the Ionian Sea. Along the beach, in the summertime, there are several lidos attracting daily thousand people from the town of Messina and its cosmopolitan area. In the recent past the shoreline of the Capo Peloro beach has undergone continuous evolution, monitored since Smith’s survey in1883 to the most recent aerial photographs and the field surveys. During autumn 2011 – winter 2012 the beach completely disappeared and the waves washed the local Coastguard Station. In this case, it is difficult to cite anthropogenic impact as being responsible for the abrupt shoreline change because coastal structures have not been built in the lat years. In the area, dominant and regnant prevailing winds are general affecting the coastline from W – NW winds which are strongly screened because of the presence of the Eolian Archipelago. During the period of October 2011 – April 2012 several violent storms approached from the N – NNW sector from which the coastline has not any natural protection. Sedimentological and topographic surveys of the beach, performed in early spring, showed a surface-area loss of about 12,000 m^2along about 1 km of coastline. In this situation, because of the particular context of the area, it was unadvisable to propose any hard structures for protecting the shoreline.

For that reason, an auto–transplantation of compatible (granulometrically and compositionally) coarse sand sediment was proposed. The whole amount of sediment (dredged material) was available, at a distance of about 500 m, accumulated along a short artificial channel. Unluckily bureaucracy has stopped this possible soft solution.

Anthropic interference versus littoral dynamics: Aguda (Northern Portugal) breakwater, Holocene evolution and recent coastal erosion

ARAÚJO M.(1), MONGE SOARES A.(2), CUNHA P.P.(3), GOMES A.(1), VIEIRA M.(4)
(1) CEGOT-FLUP, Universidade do Porto, PORTO, PORTUGAL ; (2) IST/ITN, Instituto Superior Técnico, Universidade de Lisboa, SACAVÉM, PORTUGAL ; (3) Faculdade de Ciências e Tecnologia-Dep. Ciências da Terra, COIMBRA, PORTUGAL ; (4) Ichron, MANCHESTER, UNITED KINGDOM

Northern Portuguese coast has a general trend of NNW-SSE from Silleiro Cape, in Galicia, till Espinho (ca 124km). This coastline has a Precambrian/Paleozoic bedrock, generally covered by modern sandy beaches and aeolian dunes. In some places, beach erosion allows us to see ancient marine and lagoon deposits (from last interglacial untill the Holocene) upon the bedrock.

Aguda beach is located near Porto, 11km south of Douro river mouth, close to Espinho (southern part of the Iberian Massif littoral outcrop).

The construction of a detached breakwater, accomplished in Spring 2002 in order to help the artisanal fishing activity had several consequences:

1 – Accumulation of sand in the North of the beakwater and severe erosion to the South affecting "aristocratic" Granja beach.

2 – This erosion revealed interesting sedimentary sequences and archaeological remains.

3 - Authorities began to transport sand accumulated by the breakwater to feed the Granja beach. This transport was made over the beach sands and underling sediments by 50 tones trucks, destroying the sedimentary and archaeological evidences.

Fortunately some statigraphic/sedimentologic work had already been done. However, the scarcity and discontinuity of the deposits, together with man made disturbance made sediment correlation more difficult.

We had an initial TL dating 8.7 ka BP in a black lagoon sediment, ca 3-4 m above mean sea level. However a more recent C14 data indicates a younger age for the sediment: 2950-3460 cal BP. A piece of *Salix* collected from that sediment was dated 2960-3214 cal BP and pollen analysis suggests a fresh-water environment.

These data indicates the existence of a lagoon with no-direct influence from the sea until a very recent time and may be a key to understand relative sea level during Holocene.

As a general conclusion we would like to underline the consequences of man interventions in the coastline: revealing old deposits, and, in the other hand, destroying them.

****

The relief cartography in coastal areas: a contribution to the environmental planning of Bertioga, Sao Paulo State, Southeastern Brazil

TRAVALINI V.(1), CUNHA C.M.L.D.(2)
(1) UNESP Rio Claro, S_O PAULO, BRAZIL ; (2) UNESP Rio Claro, S?O PAULO, BRAZIL

The coastal environmental systems are areas of high complexity, due to material and energy exchanges existing in the interaction processes between the sea and the continent. These areas play an important role in territorial dynamics of a considerable group of countries, which shows intense human activities in coastal environments. The city of Bertioga, located in the coast of São Paulo estate, southeastern of Brazil, it is in this context and shows a recent urban expansion, mainly related to the touristic activities. This phenomenon brought changes to the coastal environmental systems of Bertioga, pointing out the importance of an appropriated environmental planning of the area. In this context, this research aimed to analyze the relief morphometry of Bertioga, quantifying the attributes of the relief to understand the morphological structure and the fragilities of the area. The analysis was made elaborating three morphometric maps: Slope, Vertical and Horizontal Dissection and Geomorphology. Bertioga is comprised by three geomorphological compartments: Atlantic Plateau, Serra do Mar and Coastal Plain. In the Altantic Plateau region the relief forms have a large variation, requiring a complex management of the land use. The Serra do Mar region is a mountain range with an abrupt relief with high slope values. This area is protected by a state park and the urban activities are not allowed. The Coastal Plain is a flat surface formed by sea and continent sediments. In this area the flat relief contributes to the urban occupation, but the environmental characteristics are not appropriated to the intense activity, because the soil sediments are not consolidated and there are mangroves and sandbanks remaining. Finally, this research contributed to increase the understanding of the land use dynamics and the fragilities of environmental system in Bertioga, and can be combined with other environmental studies to contribute to the environmental planning of the coastal regions.

Coastline vulnerability in the Kerkennah archipelago between 1963 and 2010

ETIENNE L.(1), BOUAZIZ R.(2), DAHECH S.(3), DAOUD A.(4), BELTRANDO G.(1)

(1) Université Diderot Sorbonne Paris Cité, UMR PRODIG, PARIS, FRANCE ; (2) Faculté des sciences humaines et sociales de Tunis, Laboratoire CGMEG, SFAX, TUNISIA ; (3) Faculté des lettres et sciences humaines, département de géographie, Université de Sfax, Laboratoire SYFACTE, SFAX, TUNISIA ; (4) Faculté des lettres et sciences humaines, département de géographie, Université de Sfax, Laboratoire EEE, SFAX, TUNISIA

Sea level rise is a well-known factor of vulnerability in coastal areas. Indeed, it can lead to a retreat of the coastline that will itself cause a degradation of coastal habitats and economic activities. The Kerkennah archipelago, located in the Gabes Gulf in Tunisia, displays several archeological, geomorphological and botanical signs that suggest a retreat of the coastline; and dykes, walls and other structures have been recently built to protect the population on the seaboard. In this context, we attempt to understand and quantify the evolution of the coastline and to evaluate its vulnerability using the Coastal Vulnerability Index (CVI).

For that purpose, we analysed a Spot 5 image from 2010 and aerial photographs from 1963 which have been georeferenced and compared in a GIS. Using the Digital Shoreline Analysis System from Arc Gis, we evaluate the coastal evolution between these dates and show that the Kerkennah coastlines are mostly retreating (with a maximum of 100m). Additionally, data gathered during a field study indicate that those retreats depend on the orientation of the coast and to a greater extent, on the type of coast and on recent anthropic developments. The calculation of the CVI, adapted for this study, shows that coastal vulnerability is variable in the archipelago.

Finally we discuss the temporal and spatial scales chosen for this study. Indeed, most of the anthropic activities of the coast were installed after the 80's and therefore their impact must be recent. Also, the direction of the strongest winds, that generate the larger and most damaging waves have changed since the 70's. Our understanding of the cinematic of coastal evolution could therefore be significantly improved by the comparison with high resolution images from these two periods. Additionally, larger spatial scales should also be taken into account, since regional scale elements such as climatic change and subsidence might explain some of the local changes we observed.

****

Toward a prevention of coastal erosion in the Magdalen Islands, Quebec, Canada

DREJZA S., BERNATCHEZ P., DUGAS S.

Universite du Quebec a Rimouski, RIMOUSKI, CANADA

The Magdalen Islands are situated in the Gulf of St. Lawrence (eastern Canada) and are composed of six rocky islands (28 % of the coastline) that are linked together by double sandy barrier systems (40 %). Coastal erosion is a serious concern in the archipelago because 68 % of the coastline undergoes erosion and since the 1950's the relative sea level rose by 3.5 mm/year. For these reasons, the Government of Quebec designated the archipelago for a priority study to better understand the entire coastal system and help manage erosion.

Regarding the coastal type, the processes, the hydrosedimentary cells and the strength of historical and recent erosion rates, we defined 251 homogeneous units over the entire coastal system (235 km). For each of them, we determined the most likely scenario of coastal evolution for the next 50 years, by taking into account the coastal processes, the past climate and the projections of future climate. This region is subsiding and will be particularly sensitive to the sea level rise. The reduction of more than 50 % of the ice cover will also lead to an increase in the number of storm events affecting the coast. The results show that the coastal system will undergo a sedimentary deficit, with projections of 81 % of coastline under erosion (35 % with a rate of more than 1 m/year) and only 14 % of the coastline under accumulation. Furthermore, the historical migration mean rate of -0.24 m/year is likely to triple to up to -0.66 m/year.

Afterward, we developed coastal erosion security setbacks for each of the homogeneous units of the archipelago, based on the following formula: setback distance = {yearly erosion rate following the most likely scenario X management horizon} + {maximum erosion retreat measured during one single event}. For the areas lacking data, based on a precautionary principle, a minimum setback was established for each type of coast. These setbacks will easily be applicable by managers to feed local land use policies.

Geomorphic Changes at a Bay of Fundy Salt Marsh Restoration in New Brunswick, Canada

OLLERHEAD J.
Mount Allison University, SACKVILLE, NEW BRUNSWICK, CANADA

The purpose of this presentation is to report on geomorphic changes at a salt marsh restoration at a site near Aulac, NB in the Cumberland Basin of the Bay of Fundy. The Basin is a 118 km^2 turbid estuary with a semi-diurnal tidal range of 10 to 13 m. The fetch ranges from 5 to 20 km and the water has a high suspended sediment concentration (mean > 300 mg/L).

The project was designed and implemented in 2010. Three openings were cut in an existing dyke at the site in October 2010. As a result of this action, two different agricultural fields are now being regularly flooded with salt water from the Bay of Fundy. Field data were collected prior to construction for a number of environmental variables (e.g., topography, vegetation) and marker horizons installed.

Since the openings were constructed, they have been mapped three times using ground-based (2010, 2011) and aerial LiDAR (2010, 2012). Flows through one of the openings have been measured using an acoustic Doppler current profiler (ADCP) and water levels both inside and outside of the restoration cells have been measured for several months. Surface elevation change has been measured using cryogenic coring, DGPS, and aerial LiDAR.

Water flows through the openings remain mostly as modeled/expected. Erosion of the openings has been largely as expected (mostly of the channel banks). In the first year, up to 50 cm of sediment deposition per m^2 was measured, with mean deposition ranging from 9 cm per m^2 at the west end of the site to 22 cm per m^2 at the east end of the site. Sediment deposition now exceeds 70 cm per m^2 in some locations. The presentation concludes with an assessment of the initial success of the project.

****

Science in Support of Coastal Management: Developing Louisiana's 2012 Coastal Master Plan

REED D.
The Water Institute of the Gulf, BATON ROUGE, UNITED STATES

The purpose of the 2012 Louisiana Coastal Master Plan is to identify projects that will make a difference for the coast and communities of south Louisiana. Models were developed to estimate the effects of hundreds of projects that have the potential to make a difference to the coastal landscape and/or its c communities and industries. While the most obvious symptoms of coastal degradation are land loss and increased damage from coastal storms, it was necessary to consider an array of consequences associated with actions geared towards either building land or protecting communities from flooding.

Results from eco-hydrology, wetland morphology and barrier morphology models were used to identify the effects of projects on the extent of coastal land, while vegetation, upper trophic level and ecosystem service models provided additional insight on how the resulting changes in estuarine gradient and landscape would affect a number of ecosystem metrics. Predicting change over time for a 50 year period allowed the consideration of tradeoffs among restoration approaches which either build land quickly that is then subject to decay and those which build land gradually over time. Storm surge/wave models were run across the 50 year future without action landscape and its expected vegetative cover. The resultant damages to coastal assets were calculated and both ‘structural’ and ‘non-structural’ risk reduction projects were selected on the basis of their cost, ability to meet desired levels of risk reduction, and overall reduction in expected annual damages.

A list of restoration and protection projects was thus identified with an expected cost of $50 billion. Further modeling is being conducted to explore interactions among projects and the effect of different implementation sequences. The results of these analyses allow the State of Louisiana to move forward with implementation of the Master Plan knowing not only what it wants to do but what it expects to achieve.

Influence of sediment recycling-recharging on mixed beach behaviour: a case study at Cayeux-sur-Mer, north France

CUROY J., MOSES C., ROBINSON D.
University of Sussex, FALMER, UNITED KINGDOM

Gravel and mixed sediment beaches are widely distributed around the world and are increasingly important as a coastal defence.

Cayeux-sur-Mer has a mixed sediment beach located at the downdrift end of a 146 km long sedimentary cell that stretches from the Seine to the Somme estuary in N. France. The updrift stretch of the beach is managed by groynes together with sediment recycling and recharging combined. Immediately downdrift of the last of these groynes, the ungroyned beach is managed solely by recycling-recharging events. The recycle-recharge sediment, comprising 80% gravel and 20% sand, is deposited at the top of the beach along a 450 m stretch and modelled into a steep-walled compact ridge, ~4 m high and ~15 m wide. The impact of this ridge of sediment on the profile shape and surface grain size distribution of the beach face has been monitored along two cross-shore profiles, one directly in front of the ridge and the other 1 km downdrift from it. Measurements were made on each tide of a semi-lunar cycle between 28/10 and 11/11/2005, immediately following a recycling-recharging event.

Recycling-recharging had a significant impact on the beach profile in front of the ridge. First, the beach gradient steepened due to the incorporation of some of the recycled-recharged material. Second, the proportion of fines in the surface material across the beach increased compared to that recorded on the downdrift profile. Steepening will render the beach more reflective whilst the addition of sand will reduce the hydraulic conductivity of the beach face. Consequently wave energy will not be dissipated as efficiently as on a pure gravel beach and such coastal management could in fact result in more sediment transport than anticipated, hence eventually having a less beneficial effect than expected for the site.

****

Coastal squeeze: its assessment and integration within regional- and municipal-level planning tools

JOLICOEUR S.(1), BÉRUBÉ D.(2), DESROSIERS M.(2), O'CARROLL S.(1)
(1) Université de Moncton, MONCTON, CANADA ; (2) Ministère des ressources naturelles, BATHURST, CANADA

In the context of climate change, long-term planning is a requirement for sustainable development of the coastal zone. With sea-level rise (SLR) driving an accelerated mobility of the coastline and a migration of coastal habitats, and socio-economic factors driving a densification of development at the coast, documenting and predicting the response of coastal systems to SLR is paramount to the achievement of conservation and urban planning goals. Natural Resources Canada and the provincial departments of Natural Resources and of the Environment have carried out an assessment of past coastal squeeze (CS) on the coast of New Brunswick. Quantitative estimates of past (1940s-) and future (2100) losses due to CS were obtained for selected habitats (based on sensitivity to CS, role in resilience of communities and presence of species of special status). Two scenarios of SLR, climate change-induced sediment budget modification, and socio-economic development in the coastal zone were applied. These results will help decision makers prioritize actions at the provincial level. However, municipal authorities also have an urgent need for specific tools in order to develop regulations to warrant the continuing integrity of coastal habitats in the future, to move away from short-term management of the coastal zone, and to prevent degradation or destruction of ecologically, culturally and economically valuable habitats. Such decision-aid tools have been prepared for a small rural community of Southeastern New Brunswick. GIS-derived erosion rates and a DTM have been used to estimate the position of the coastline and inner limits of coastal habitats in 2025 and 2055. These limits have been superimposed on cadastral information and (a) sectors sensitive to CS and (b) accommodation space necessary to allow migration of coastal habitats have been assessed. Methods and deliverables from both approaches will be presented.

Embayed configuration and geological control on beach morphodynamics and management: an overview of contrasting responses in embayed beaches of southwestern Portugal

LOUREIRO C.(1), FERREIRA Ó.(1), COOPER A.(2)
(1) CIMA - Universidade do Algarve, FARO, PORTUGAL ; (2) CCMR - University of Ulster, COLERAINE, UNITED KINGDOM

Morphological change in embayed beaches is generally assumed to be influenced by embayment configuration and is consequently dependent on the planform, indentation and exposure to incident waves. In addition, in such bedrock-framed beach systems, geological control has been found to exert a substantial influence on beach morphodynamics, by modulating beach shape and segmentation, influencing sediment size and availability, causing alongshore variations in the wave field and inducing topographically-controlled nearshore circulation. Aiming to evaluate drivers of morphological variability and characterize morphodynamic behaviour of embayed beaches exposed to contrasting environmental conditions, a monitoring program was established in six embayments along the coastline of southwestern Portugal. Embayed beach morphological and sedimentary change was surveyed regularly over two years. Datasets were explored using statistical (e.g. empirical orthogonal functions) and probabilistic (e.g. Bayesian networks) analysis and related to forcing parameters obtained from time-series of observed and modelled hydrodynamic parameters.

While the dominant pattern of variability in all embayments was related to wave energy, as indicated by highly significant statistical correlations with the normalized wave power, secondary patterns of embayment morphological change were related to embayment specific responses, particularly beach rotation and rip circulation. The results of this study also confirmed earlier suggestions that geologically constrained beaches represent a distinct type of beach environment with particular modes of behaviour during and after storms. This new understanding has the potential to benefit management approaches within the constrained sedimentary setting of embayed beaches. Improved understanding of embayment morphodynamics will not only enable natural changes to be understood but will also contribute to maintenance of, or improvements in, beach use and safety.

****

Development of an Integrated Geomorphic Model of Soft Cliff Retreat: Investigating the effects of varying lithology in the vertical

CARPENTER N.(1), NICHOLLS R.J.(1), DICKSON M.E.(2)
(1) University of Southampton, SOUTHAMPTON, UNITED KINGDOM ; (2) University of Auckland, AUCKLAND, NEW ZEALAND

Geomorphic modelling of soft rock cliffs is an important method to understand future rates of retreat as it enables the consideration of a range of process interactions and can simulate changing environmental and climatic conditions. However, owing to the complexity of the cliff system and the need to understand mesoscale (10-100year) responses, modelling inherently involves simplification of the system under question. Therefore, one key issue concerns the treatment of variable lithology on geomorphic processes and shore retreat both in the alongshore and vertical.

A number of previous models have considered the impacts of alongshore variations but such studies have emphasised the role of a significant fronting beach. Considering sediment poor environments and the impact of coastal engineering structures on reducing downdrift beach volumes it is important that the impacts of variable lithology and interactions with sea-level rise are further understood. Moreover, it is important to understand the possible effects of vertical heterogeneity, as most cliffs are composed of interbedded stratigraphy of varying strength and composition.

This paper presents modifications to the reduced complexity, 2D SCAPE (Soft Cliff and Platform Erosion) model to consider the influence of horizontal layers of variable material strength in the vertical. Using the revised model we address some key geomorphic questions considering its impact on shore profile morphology, rates of cliff toe retreat and interactions with sea-level rise. We then apply the model to a study frontage of complex varied geology (demonstrated by the presence of a series of discrete headlands and bays) on the south west coast of the Isle of Wight (UK). Using the study frontage the model has been validated and used to consider the future implications of climate change on long term rates of retreat along the frontage.

Cliff-top large boulders emplacement along the Southern coast of Menorca (Balearic Islands, Western Mediterranean): addressing the role of storm or tsunami wave processes in rock coast deposits

GOMEZ-PUJOL L.(1), ROIG-MUNAR F.X.(2)
(1) SOCIB, Balearic Islands Coastal Observing and Forecasting System, PALMA, SPAIN ; (2) Departament Ciències de la Terra, Universitat de les Illes Balears, PALMA, SPAIN

The presence of large boulders along the cliff-top line of rocky coasts induces a debate on the occurrence and nature of past storms and/or tsunamis. Boulders of probable tsunami or storm wave origin have been reported throughout the world. Nevertheless there exists a controversial discussion about the origin of such deposits because sedimentary differences between those deposits have been poorly understood. In the Mediterranean different authors have interpreted the presence of boulders weighing over 20 t as moved by tsunamis whereas others recognise the role of storm. In southern and southeastern Menorca, the rock coast is characterized by anomalous deposits of calcareous boulders along terraces or platform surfaces 2–10 m above present sea level. This study investigates the size, shape, position and long-axis orientation of 73 boulders resting on two different locations, Punta des Pinar and ets Enderrossalls. Most of these boulders are rectangular, with sharp, broken edges. They are calcarenite fragments from 0.25 to 27 t in mass without evidences to have been submerged. Based on geomorphological evidence, we infer that the majority of boulders encountered were from a joint-bound pre-transport setting. The assessment of such cliff-top accumulations allow the depositing wave/s to be characterized in terms of necessary breaking wave height through the use of linear hydrodynamic equations. Additionally the use the significant wave height and period of maximum observed storms during the last 44 years, we have estimated the conditions that would have lead to their deposition, discerning between stormy deposition or tsunami evidences. Results show that 10 years return period storm waves could be enough to detach and explain the placement of many of the boulders, but there are some of them that do not fit with this pattern. Also, the placement of the boulders suggests the control of fractures and joints orientation as a control on boulder location.

****

Beach development on microtidal shore platforms

KENNEDY D.
The University of Melbourne, PARKVILLE, AUSTRALIA

The rocky shore is often considered to be an inhospitable environment for beach development; however, sandy beaches are found at the rear of shore platforms around the globe from mid oceanic islands such as Niue, the continental microtidal margins of southern Australia, the macrotidal Bay of Fundy as well as the storm-dominated shores of England. Mathematical modelling of macro and mesotidal shorelines suggests beach accumulation is primarily controlled by the relationship between the gradient of the platform and the beach and the amount of available sediment. This research investigates the morphological parameters that influence beach accumulation on microtidal subhorizontal shore platforms. The sandstone-dominated parts of Victoria, Australia, are used as a field site where beaches over 1 m thick are found on the platform rear. These beaches are composed of well-sorted medium grained sand which slope seaward at between 3 – 5°. All the beaches are fronted by subhorizontal platforms at least 30 m wide and sit on top of abrasion ramps which, on average, have a slope 1° less than the overlying beach. The evolution of ramps and beaches appear related; ramps do not occur in locations where sediment cannot accumulate. At all the sites ample sediment occurs on the seabed which is available for transport onto the platforms. Little relation appears to occur between platform width and beach accumulation. The elevation of the platform immediately in front of the beach toe appears to be a critical factor in controlling whether sediment can accumulate with beaches only being present when the platform occurs below mean high water spring elevations.

Erosion, progradation and sediment transport between beach-dune systems and adjacent beaches on shore platforms

BLANCO-CHAO R., FEAL-PEREZ A., DUARTE-CAMPOS A.
Universidad de Santiago de Compostela, SANTIAGO DE COMPOSTELA, SPAIN

We studied a process of erosion in beaches on shore platforms related with dune progradation and stabilization in NW Spain. The coast is composed of two beach-dune systems of 0.8 and 2 km in length, enclosed at the north and south ends by rocky sectors with sand beaches. Two proxies were used to study the erosion-accretion trends: the seaward limit of vegetated dunes in the beach-dune systems and the seaward edge of sand in the beaches on shore platforms. The proxies were digitized from digital aerial photographs from 1956 to 2010 and the changes in both proxies were calculated using the DSAS software (Thieler et al, 2005). Results confirm a process of dune progradation and stabilization in the beach-dune systems that occurs at the same time that the erosion of the beaches on the shore platforms. To investigate changes in wave and meteorological regime we analyzed the main wave parameters (from current and hindcast models), rain and wind parameters from meteorological stations and sea-level changes from tide gauges. No significative tendencies were found in any of the parameters but a trend to decrease in wave energy can be detected in the periods 1958-1971 and 2000-2010.

Results suggest that sediment is transported from the beach-dune systems to the beaches on the rocky sectors. As the beach-dune systems became progressively stabilized, the sand transport was reduced resulting in the erosion of the beaches on the shore platforms. The rates of change calculated for each period show a high correlation (r=0.96) between the dune progradation and the erosion of the beaches on shore platforms. The highest rates of progradation and erosion were recorded in the north dunes and in the north rocky sector, due to the prevailing northward drift.

Thieler, E.R., Himmelstoss, E.A., Zichichi, J.L., Miller, T.L., 2005. *Digital Shoreline Analysis System (DSAS) version 3.0: An ArcGIS extension for calculating shoreline change*. U.S. Geological Survey Open-File Report 2005-1304.

****

Poster presentations:

Analysis of the relief of the city of Ilha Comprida, south coast of São Paulo, Brazil

SOUZA T.A., OLIVEIRA R.C.
Universidade Estadual de Campinas, CAMPINAS, BRAZIL

The city of Ilha Comprida is located in the South Coast of the State of São Paulo (Brazil). It is characterized as a barrier-island, isolated from the continent by esturian channels of the “Mar Pequeno” (or “Mar de Iguape”) and the “Mar de Cananéia” (or “Mar de Fora”); and is part of the coastal plains of Cananéia-Iguape, the best developed coastal plain in the Paulista coastline. Ilha Comprida is considered the last episode responsible for the configuration of the coastline of the State of São Paulo. Its differential is been a product of sea level modifications throughout the Quaternary, which enables the affirmation that its geological evolution is quite recent, with its formation beginning around 5100 years B.P. (Before the Present), with the exception for the Morrete, a Pre-Cambrian alkaline intrusion with a 42-meter elevation, where Ilha Comprida’s formation probably began, working as a “lashing points” for sediment deposits. The island presents well reserved relief formations due to the low population density, which enabled the geomorphological mapping with great precision. Facing these considerations, the objective of this study is to analyze the relief cartography of the city of Ilha Comprida made in the scale 1:10.000, contemplating the geomorphological compartmentalization and the relief formations present in each of these compartments, from stereoscopic pairs of aerial photographs from the year 1962.

The White Sea Coasts' response to the extreme storm of 15-16 November 2011. Coastal Development Forecast

REPKINA T.
Faculty of Geography at Lomonosov Moscow State University, MOSCOW, RUSSIAN FEDERATION

During a storm the sea levels rose to levels above observed 50-year maximum (1.5-2m above the mean water level at high tide). Evaluation of the coastal response of varous morphogenetic types of coast to the extreme storm serves to validate our forecast for the coast development using field data.

About 300 km of the coastline Dvina and Onega bays were explored. To evaluate the coastal dynamics repeat instrumentation measurements, geomorphological and landscape features and survey data obtained from local residents were used.

The abrasion coasts undergone a widespread intensification of erosion. Major mechanisms and magnitude of destruction were defined by lithology of kliffs and orientation of the coast relative to prevailing directions of extreme storm waves. Large quantities of coastal retreat (1-3m, and up to 7m), were observed at the erosion coasts developed in sandy sediments.

The most dramatic changes occurred at accumulative beaches composed of sands. The coastline retreated by 1-7m here. Front-dunes were damaged or completely washed away. Beaches were flattened. The beach sand moved to the tidal flats. Sand bars and shafts of the tidal flats were completely transformed. Residual value of deformation of the tidal flats reached up to 0.5 - 0.7m. This type of coasts are among the most densely populated, and most commonly used for recreational purposes. The private construction here occurs without consideration given to extreme natural phenomena. Therefore, the damage caused by the storm was the greates here.

Accumulative littoral shores were flooded during the storm (by 0.2-1 km). Traces of erosion were not found.

Field data confirms the tendency of the coastline of the Dvina and Onega bays to retreat. This was revealed by examination of aerial photographs and topographical maps of various periods of time.

The research has been conducted as part of the Project "Natural Disaster Risk Evaluation in Coastal Areas".

The Project Leader is K.P. Koltermann.

****

Evidences of sea-level oscillations on the coasts of Vistula and Curonian Spits (SE of Baltic Sea)

BADYUKOVA E., ZHINDAREV L., LUKYANOVA S., SOLOVIEVA G.
Moscow State University, MOSCOW, RUSSIAN FEDERATION

The geomorphologic structure of the accumulative barrier forms bordering significant parts of sea coasts does not leave doubts in close connection of the reasons and stages of their formation with changes of a sea level. Such dependence is traced and in the structure of sandy barriers of southeast Baltic - Curonian and Vistula Spits. The most part of their surface is consist of the aeolian sand, marine genesis has a modern sea beach, and marine-lagoon genesis have a beach and low terraces in the Curonian and Vistula gulfs. Terraces fragmentary frames the lagoon coasts of both the spitsand have height not more than 1.5 m.

On sea coast of the Vistula spit there are the layers of pebbles in the bottoms of some blow-outs. These layers can serve as age analogue of lagoon terrace. The present pebble layers position exceeds a modern sea level on 1.5 - 2 m. The pebble is also found out by a borehole on seaside of the Curonian spit, behind the foredune at absolute height of 1.5 m. Thus, along Vistula and Curonian Spits sea coast the ancient coastline corresponding to one of the last sea-level rise is traced. This rise not exceed, apparently, 0.5 mabove its contemporary position. On the erosion sites the coastal bar fixing high position of a sea-level, exposes in the cliff bottom. On the accumulative coasts accompanying with the development modern and ancient aeolian forms of a relief, marine deposits substantially burred under aeolian sand. On the basis of radiocarbon dating ^{14}C of the mollusk shells from marine sediments absolute age 1270+60 cal BP (LU-6129) has been received. According to opinion of a lot of researchers, by this time one of last peaks of Limnea transgression exceeded. Sea level was on 0.5 m higher than contemporary one.

Detecting rapid changes in the hardness of engineering materials in the coastal built environment using the Equotip durometer

COOMBES M.(1), FEAL-PÉREZ A.(2), NAYLOR L.(3)
(1) University of Oxford, OXFORD, UNITED KINGDOM ; (2) Universidade de Santiago de Compostela, SANTIAGO DE COMPOSTELA, SPAIN ; (3) University of Exeter, PENRYN (CORNWALL), UNITED KINGDOM

Engineering materials used in the coastal built environment (e.g. rock and concrete) are exposed to the same agents of weathering and erosion as natural rocky outcrops (e.g. waves, water, wind, salts, insolation, ice, abrasives and biota). These agents act to modify hard substrata in ways that are relevant to engineering durability and performance, and the conservation and aesthetics of structures of heritage and social value. Non-destructive tools able to provide comparable and easily obtainable information of material properties, and that can detect changes through time, are therefore of considerable value for material selection and monitoring during service life.

The equotip (Proceq) hardness tester was applied to rock and concrete exposed in the intertidal zone for three different time periods (0, 8 and 20 months). Limestone showed significant and progressive loss of hardness, while concrete increased in hardness. Granite showed no significant change. The observations are related to micro-scale (< mm) changes occurring at the material surface primarily via chemical and biological means. The equotip device is sensitive enough to detect changes in the hardness of engineering materials over relatively short periods of time.

****

River channels as conduits for high energy coastal events

KAIN C.(1), GOMEZ C.(1), HART D.(1), WASSMER P.(2), STARHEIM C.(1)
(1) University of Canterbury, CHRISTCHURCH, NEW ZEALAND ; (2) Université de Strasbourg, STRASBOURG, FRANCE

Coastal overwash events such as tsunami and storms transport large amounts of sediment and leave important signatures in the landscape. The configuration of the coastline and topography has a significant impact on the depositional process and form of preserved features, and inundation distances and patterns are affected by surface roughness and elevation. Consequently, inundation may occur from directions other than shore-normal, significantly affecting deposition patterns. This research investigates the role of river channels as conduits for sediment transport during washover events, by virtue of their comparatively lower elevation and low friction of the water surface. A suite of sandy deposits on an embayed coastal plain in Canterbury, New Zealand was examined with the aim of determining their mechanism and direction of deposition. Analyses were undertaken on seven transects across an area of 2 km^2, following the boundary of the river and beginning 1 km inland from the coast. Methods include stratigraphic logging, grain size analysis and Anisotropy of Magnetic Susceptibility (AMS) to determine spatial trends in deposit character and direction of deposition. AMS results confirm a deposition direction that is sub-parallel to the coast, i.e. from the river. This is confirmed by sedimentology results, which show deposits thin and fine inland. Mineralogy and microfossil content confirmed a marine origin for the sediment, suggestive of a high-energy coastal event. This has important implications for the reconstruction of high energy paleo-events from their deposits, and the use of the AMS technique to constrain flow direction improves the accuracy of modelling for such events.

Current and wind-wave interactions with a low shoot-density Zostera noltii meadow in a fetch-limited micro-tidal setting, Berre Lagoon, Mediterranean France

PAQUIER A., MEULÉ S., ANTHONY E.
Aix-Marseille Université, CEREGE, AIX EN PROVENCE, FRANCE

Berre Lagoon is a fetch-limited, micro-tidal brackish lagoon on the Mediterranean coast of France occupied by Zostera noltii meadows that significantly regressed in the early 20th century. It is inferred that sediment transport processes act as limiting factors through enhanced turbidity and meadow burial or erosion. The meadow shoot density is likely to create variations in sediment transport potential as shown in previous studies. The aim of this study is to elucidate the interactions between the Berre Lagoon low shoot-density meadow and currents and wind waves.

Winds, currents and waves were surveyed within a meadow thriving in very shallow water. Different wind orientations were monitored, notably during the Mistral, a strong and frequent NNW wind affecting French mediterranean sea, and which has the largest fetch over Berre Lagoon. Our initial hypothesis was, therefore, that the Mistral generated the highest waves, the strongest currents and thus induced efficient resuspension events within the meadow. However, the Mistral generated relatively weak currents, a feature we attribute to the morphology of the lagoon. In contrast, equivalent wave heights were observed with lighter winds having lower directional occurrences than the Mistral. These winds also induced stronger lagoon currents, and are thus likely to have a greater impact on the meadow by controlling sediment transport. A typical velocity profile that did not depend on wind direction was observed with flow reduction in the lower denser part of the canopy, and high turbulence and a stronger velocity gradient at the top of the canopy, in agreement with the literature. Despite meadow growth during spring, the boundary layer thickness did not increase significantly. We assume that this is due to flexibility of the Z. noltii canopy under the current flow effect.

****

Beach morphodynamics under rock-armour breakwater protection in a microtidal, storm-dominated Mediterranean setting

GIAIME M.(1), ANTHONY E.(2), DUSSOUILLEZ P.(2)
(1) Aix Marseille Université, AIX-EN-PROVENCE, FRANCE ; (2) Aix Marseille Universit?, AIX-EN-PROVENCE, FRANCE

Four rock-armoured breakwaters were installed in 1989 on the eroding southern extremity of the embayed and highly touristic microtidal beach of St. Raphaël Bay on the Mediterranean coast of France, forming one of the rare breakwater fields in France. A nourishment of 200,000 m^3 of sand accompanied the project, resulting in an expanded beach area of nearly 36,000 m^2. Between 1989, following this nourishment, and 2011, the breakwater-protected beach has remained quite stable, characterized by salients that developed in the lee of each breakwater. Six digital elevation models of the beach behind one of the breakwaters obtained between December 2011 and October 2012 show the construction of prominent low-energy berms that are partially destroyed by storms within this relatively stable budget context. Wave height measurements from pressure sensors deployed in various sectors of the pocket beach behind the breakwater display clear gradients in attenuation. The success of the breakwaters is related to the initial complementary nourishment that significantly enlarged the beach and its buffer capacity, and the optimal breakwater dimensions in terms of breakwater distance to the beach (X), breakwater length (B), and gap between breakwaters (G), which, for the study area, yield an index of X/(2B + G) =0.08, well below the critical breakwater efficiency threshold of ~1 proposed in the literature. A third factor of stability, suggested by the wave height gradients, may reside in breakwater-induced sand exchange between the open stable beach to the north, which has not required protection, and the hitherto eroding but now breakwater-stabilized beach sector.

Consequences of the coastal geomorphologic system to the tsunami deposits generated by 1883 Krakatau eruption in Ujung Kulon Peninsula, Indonesia

ISKANDARSYAH T.(1), WASSMER P.(2), SCHWARTZ D.(2)
(1) Universitas Padjadjaran, JATINANGOR, INDONESIA ; (2) Université de Strasbourg, STRASBOURG, FRANCE

Ujung Kulon is a peninsula at the west end of Java Island, close to the Krakatau volcanic complex. In 1883 Mount Krakatau erupted and generated a mega-tsunami, which had destroyed the neighboring coastal areas. The effects of Krakatau mega-tsunami reached Ujung Kulon up to the coastal of Indian Ocean. The tsunami deposits in the coastal plain of Ujung Kulon are assessed using textural and compositional analysis based on drilling and trenching data. In general, the tsunami deposits consist of a sandy layer with abundant reworked shell and other carbonate fragments, these coarse materials could be derived from the seabed until 40 meters depth. An important diagnostic criterion for these Krakatau tsunami deposits are the presence of pyroclastic materials of the 1883 Krakatau eruption. The pyroclastic materials associated with the tsunami deposits are volcanic ash and pummice, as product of pyroclastic flow which entering the sea. In the western part of Ujung Kulon National Park, the tsunami deposits have a thickness between 30 – 50 cm and locally more than 50 cm. On the contrary, along the coastal plain of the eastern part of Ujung Kulon National Park (Gunung Honje), the tsunami deposits are relatively thin but well-preserved (less than 15 cm). The thickest tsunami deposit was found in the middle part of Ujung Kulon (could be more than 1 meter), and it was presumably caused by its coastal geomorphological condition which was a narrow peneplain between Sunda Strait and Indian Ocean and situated on a V-shaped bay. When the great tsunami wave coming from the northern part, this area might be a wave trapped and the tsunami longer inundated with low accumulation rates. It could be the reason also for the presence of bioturbation in the pyroclastic layer at the upper part of tsunami deposit package. Moreover, the various tsunami deposits formed under the influence of different types of flow both from the Sunda Strait and the Indian Ocean.

****

DGPS and high resolution SAR satellite data integration for coastline extraction and monitoring coastal assessment

BALDASSARRE M., BELLOTTI P., DAVOLI L.
Sapienza - University of Rome, ROME, ITALY

The application of high resolution methods for shoreline mapping and shoreline map detection is expanding its importance for safe navigation, coastal resource management, coastal environmental protection, and sustainable coastal development and planning.

Remote sensing is providing useful tools for coastal monitoring and mapping not only based on optical sensors but also on SAR, because these last ones are increasing their performance both spatial and in time resolution.

The Italian COSMO-SkyMed mission offers a great opportunity to obtain radar images, useful for mapping, being characterized by high revisit time, thanks to its four-satellites constellation, and high spatial resolution (1x1 meter in SpotLight mode). Moreover SAR being spaceborne active sensor has the uncontestable advantage to extracting information during the night and to penetrate atmosphere virtually in every weather conditions. From COSMO-SkyMed data, different typologies of information can be obtained, characterizing a coastal system and providing a reliable monitoring device.

Aimed at investigate the capability of shoreline extract from high resolution SAR images, the results have been compared to manually digitized shorelines data and to high precision Differential Global Positioning Systems (DGPS) data. Three different images, captured between October 2008 and December 2009, have been analyzed for the present work. They recorded marked seasonal coastline variations.

The study has been carried out along the northern coastal stretch of Sant'Eufemia Gulf (Tyrrhenian coast of Calabria, Southern Italy). This area is affected by high dynamism, with abundant transport of material. Moreover the area has high potential touristic attraction such a great environmental importance and, since 1995 it has been included in the European Conservation Program (LIFE Nature Project).

Restoration of the coastal geo-environment along Tottori Sand Dunes

KODAMA Y.(1), WATAKABE T.(2)
(1) Fac. Regional Sciences, Tottori-Univ., TOTTORI, JAPAN ; (2) Grad. School Regional Sciences, Tottori-Univ., TOTTORI, JAPAN

Along the coast of Tottori Sand Dunes, western Japan, dimensions of offshore bars were illustrated from air photos taken in 1968-2008 at 5 year intervals and grain size distributions at berm crests on the beach have been investigated over a half century since 1955. The results show that beach environments have been restoring naturally after damages induced by human activities, such as sand and gravel harvesting in the Sendai River during 1960-1975, which had caused diminishing of offshore bars, coastal erosions and beach sediment coarsening (>1.0 mm) at1980's and finally vegetation covering of the Tottori Sand Dunes . After stopping sand and gravel harvesting, large floods occurred in 1998 and 2004. These floods transported lots of sediment from upper parts of the drainage area to the main Sendai River. Around 2000, offshore bars along the coast became larger and grain sizes on the beach changes finer (<0.4mm) after 2011. These grain size values are similar to those in 1955. We are expecting that weeds on the Tottori Sand Dunes will relief naturally by activating blown sand. These phenomena become a good story to get visitors notice well-coordinated natural systems as a geo-park site in the San'in-kaigan Global Geo Park.

****

Coastal Dynamics in western Sicily

LIGUORI V.(1), MANNO G.(1), AGATE F.(2)
(1) DICAM - Universite degli Studi di Palermo, PALERMO, ITALY ; (2) Enviromental Engineering, PALERMO, ITALY

The study of the evolution of the beaches plays a fundamental role in every territorial politics regarding the coastal band. More than half the world population lives in coastal regions which support a florid touristic activity in many countries. The beach constitutes, in terms of economic value, the most important element of the coastal system, but also the more fragile and morphologically variable. Thus, studying its evolutions is fundamental in order to adopt the best management of this complex, densely populated and economically interesting zone. In this regard, the western coast of Sicily (Italy) is an effective example. It took its origin from variation of the sea middle level (Quaternary), with the consequent formation of marine terraces**.** Morphologically, the shore is made up by low and rock coast alternating beaches. The historical evolution of the coast has been performed through the use of aerial images identifying, despite several uncertainties, the position of the shoreline. Indeed the shoreline position extracted from an aerial image is a wet/dry line that describes the instantaneous land-water boundary at the time of imaging rather than a “normal” or “average” condition. Each wave instantaneously influences the shoreline position and hence, to take into account shoreline oscillations due to wave motion. Even if from a conceptual point of view the shore line is defined as a border between the emerged earth and the sea, its perennial variability makes it difficult to determine.

In order to start a correct management, a cognitive geomorphological study has been carried on, as well as a study of high strategic value and environmental sustainability. It was based on a continuous decisional process based on objectives defined by the UE, in order to classify the beaches and to define the characteristic which are necessary for a correct coastal management.

Spatial Variation of Grain-Size Composition of Artificial Beach at the Novosibirsk Reservoir

FEDOROVA E.
Institute for Water and Environmental Problems of SB of RAS, BARNAUL, RUSSIAN FEDERATION

The largest artificial beach of the Novosibirsk reservoir is located in its northern part. In 1959-1962, to protect the railway, the beach was nourished, and in 1987 it was replenished. Currently, the research on the necessity of second replenishment is needed.

Grain-size is one of the determinants of sediment migration and accumulation. Grain-size composition is a stable parameter which keeps the information about previous and modern processes forming morphodynamics of coastal accretive forms.

The study of the beach's grain-size composition was made by IWEP SB RAS in 2010 and 2012. Based on the results of field studies on spatial and temporal variability of sediment grain size in the area under study, the authors analyzed current lithodynamic and hydrological processes. Ground samples were taken from the most characteristic morphological parts of the coast, namely in the berm, foreshore and underwater beach profiles. The samples were dried, weighed and sieved. Fractions >10; 10-5; 5-2; 2-1; 1-0.5; 0.5-0.25; 0.25-0.1; 0.1-0.05 mm were selected.

The constructed graphs of the mean grain size distribution within the profile clearly demonstrate the level regime change in the reservoir. The largest material(d50 = 0.42 mm) is observed at normal water level of 113.5 m, then, down the profile, mean particle size decreases up to 0.26 mm. At low water level (111.2 m) mean size of the material increases to 0.31 mm, while down the profile it decreases again. The amount of fractions (less than 0.25 mm) increases in number in the sea direction. For beach nourishment sand size smaller than 0.25 mm is not suitable, because during storms and strong winds such particles are carried away from the land into the water and never come back to the land again. The sediments larger than 2 mm in size are absent in the underwater beach profile. The largest particles (5-10 mm) are concentrated in the center of the beach, out of reach of strong autumn storms when the reservoir level becomes low.

****

Study of annual equilibrium beach evolution at coastal of man-made lake

KHOMCHANOVSKII A., KHABIDOV A.
Institute for Water and Environmental Problems of SB of RAS, BARNAUL, RUSSIAN FEDERATION

The goal of the study was to investigate the influence of seasonal variation of wave action and water level on the beach profile changes.

The investigation has been done by numerical simulation and by field observations. An artificial sand beach located at Novosibirsk reservoir was chosen as an object of the study. This beach was constructed in 1959-1962, and it was replenished 25 years later. The long-term observations have demonstrated that the beach profile is in equilibrium.

The reservoir's water level varies seasonally. It rises up to the normal value in May – June, stays at this mark in July – August and slowly drops down to the minimal value in fall and winter.

Time series of wind data of from the nearest weather station were used to reproduce typical wave action during the ice-free period.

The numerical simulation of the beach profile changes has been done by SBEACH software.

The following main conclusions can be drawn from the results of numerical simulation and field observations conducted:

1). The most significant changes of the beach profile occur in autumn as a result of just a few south-west storms;

2). The reservoir's water level variations have a substantial influence on the annual beach profile evolution. For example, in September 2010 the bar that had been formed by the strong storm was moved towards the shore line due to lowering the water level.

Analyses of coastal geomorphology change in a macrotidal setting, west coast of Korea

PARK S., LEE G.E.
Chungnam National University, DAEJEON, SOUTH KOREA

The Asan Bay in the western coast of Korea (eastern Yellow Sea) is a well-known macrotidal embayment with tidal ranges of up to 8 m. Strong tidal action caused by high tidal ranges in this area significantly increases the potential for erosional/depositional processes within the embayment. Furthermore, there has been active development such as the construction of seawalls, industrial complex, and harbor in the Asan Bay since the 1970's. This development changed the physical characteristics of the seawater including tidal current velocity and sediment flux, which caused changes in the coastal morphology. In this study, we studied the morphology change of the bay over the past 30 years both qualitatively and quantitatively, using a GIS's overlay analysis with data collected in 1976, 1985, 1996, and 2006.

We found that the Asan Bay became shallower for over the last 30 years; a shallowing tendency is distinctively observed around the large sand bank (Jungangcheontoe) and in tidal channels. The sand bank moved toward the northeast until 1996 and toward the south since 1996. The size of the sand bank was enlarged toward the southwest by profile section. We also observed that in profile of tidal channels, the southern channel became shallower than the northern channel. The sedimentation rate of the southern channel has been approximately five times higher than that of the northern channel. We conclude that the construction of artificial structures in the Asan Bay changed the tidal current velocity which changed the sedimentation and erosion rates, and caused changes in the coastal morphology.

****

Field observations of morphological change on contrasting beaches: An investigation at two sites on the North Atlantic coast of Morocco

TAAOUATI M.(1), ANTHONY E.J.(2), EL MRINI A.(3), NACHITE D.(1)
(1) Department of Geology, Faculty of Sciences, TETOUAN, MOROCCO ; (2) Aix-Marseille University, Institut Universitaire de France, CEREGE, UMR CNRS 7330, Europôle Méditerranéen de l'Arbois, AIX-EN-PROVENCE, FRANCE ; (3) Géolittomer, LETG UMR 6554 CNRS, Faculté Lettres et Sciences Humaines, NANTES, FRANCE

This work presents research, conducted for the first time, on beaches on the Tangiers Peninsula, North Atlantic coast of Morocco. The main aim was to investigate seasonal beach change under variations in wave climate. The field observations consisted of high-resolution topographic surveys of two selected beaches, Charf el Akab in the North and Asilah in the South, from 2005 to 2007 using a total station. The study area is a mesotidal environment subject to strong Atlantic swells, and the beaches are primarily composed of fine to medium sand and exhibit a gentle slope with a mean intertidal gradient of 0.02 and 0.04 at Charf el Akab and Asilah, respectively. The beaches show seasonal morphodynamic behavior, the rhythmic nature of which is governed by the swell and wind regime. Accretion episodes generally observed during the relatively low-energy summer season, are characterized by classic swash bar formation, whereas bars are flattened by winter storms. These changes, driven by wave energy, are typical of switches between the dissipative (winter) and intermediate (summer) domains. The volume changes further show the dominance of cross-shore variability at Charf el Akab beach, thus highlighting a strong relationship between morpho-sedimentary adjustments and wave energy flux; whereas longitudinal changes are more important at Asilah beach, where longshore drift prevails. The study shows thus the co-existence of a swash- and drift-aligned beach on a straight exposed coastline. Normalized beach volumes of –0.01 and +0.04 m^3/m^2 for Charf el Akab and Asilah, respectively, are within the volume error margin (± 0.05 m) and thus reflect sediment budget stability over the two-year survey period. The short-term sediment budgets and longer-term remote-sensing evidence suggest that the beaches are attuned to these two different sand transport contexts. The local environmental conditions, including longshore drift continuity for Asilah beach, explain this difference.

Monitoring of the sandy shoreline changes on the Pays de Monts coast from the 1920s to 2010

JUIGNER M.(1), ROBIN M.(1), FATTAL P.(1), MAANAN M.(1), DEBAINE F.(1), BAUDOIN V.(2), LE GUERN C.(2), GOUGUET L.(3)
(1) IGARUN / UMR 6554 LETG - Geolittomer, NANTES, FRANCE ; (2) BRGM, NANTES, FRANCE ; (3) ONF, NANTES, FRANCE

This presentation points out the multi-temporal shoreline change over a 90 year period (1920-2010) along the sandy coast of Pays de Monts (W France).

The aims of this study are to improve the shoreline change trends detection and the processes at the origin of these movements. Moreover, this is also to develop a repeatable method to quantify the coastline mobility on the sandy coast. Both GPS cross-shore and foredune topographic surveys (conducted at April 2010, 2011, 2012) and eight aerial photograph coverage are used to describe the coastline.

The coastline is based upon identification of morphological and botanical features characterizing beach-dune contact. The coastlines were digitized on each aerial photograph. The Digital Shoreline Analysis System (DSAS) enables calculation of rate of change statistics from multiple shoreline positions was used in combination with ArcGIS to calculate coastline change between consecutive aerial photographs. The change rates are computed with two statistic methods offered by the DSAS -WLR and EPR.

The long-term results indicates that the coastline in accretion is predominant with 37,4 % whereas erosion affects 26,4 % of the coastline with a maximum rate of -0,63 m/an. The periodic results show that intensity of erosion seems to be increasing since few years. It may be correlated with the marine and climatic setting (conjunction of tide, wind, swell, atmospheric pressure, leading to surges). Moreover, this study highlights the morphological impacts of the Xynthia storm and the foredune resilience over a short term. Finally, this study points out a smoothing method which allows digitizing accurate shorelines. This allows too segmenting the shoreline in order to analyse and classify the periodic results.

****

Multi-temporal scale development of embryo dunes on an accreting macrotidal beach: North Linconshire, UK

MONTREUIL A., BULLARD J., CHANDLER J.
Loughborough university, LOUGHBOROUGH, UNITED KINGDOM

Embryo dunes are important precursors to the development of established dunes in coastal and desert dunefields butare rarely the focus of research efforts.Topographic surveys of the embryo dunes located on the upper (>MHWS) section of an accreting macrotidal beach on the north Lincolnshire coast (UK) were carried out seasonally over a period of 16 months (July 2009-October 2010) using high resolution terrestrial laser scanning. This made it possible to quantify morphological changes and sand budget variability, as well as patterns and potential processes involved in sand input and output to the embryo dune field. The relationships among wind regime, storm surges and dune geomorphology were also explored. The volume of sand within the embryo dune field ranged from a minimum of 12,622.54 m^3 in January 2010 to a maximum of 13,263.17 m^3 in June 2010. The majority of volume gain was a result of seaward accretion in response to onshore aeolian sediment supply as opposed to either a gain in height or an expansion of the dune field in an alongshore direction. Sediment volume was reduced in the embryo dune field as a result of two severe storm surge events that occurred during the winter months. The storm surges caused erosion of corridors between dunes. Between October 2009 and January 2010 the embryo dunes lost c.315.49 m^3 of sandcorresponding to a volumetric ratio of sand thickness of -0.026 m $month^{-1}$. However, subsequent surveys show that the dunes then progressively recovered. In addition, the annual morphological develoment of the embryo dunes was explored between 2001 and 2011. After ten years, the patch of embryo dunes is still expanding but the influence of oblique onshore and alongshore winds has caused it to become elongated and also possibly prevented the dunes from merging with more established foredunes to landward.

Predicting storm erosion impacts on exposed beaches

TRINDADE J., RAMOS-PEREIRA A.
Centre of Geographical Studies of the University of Lisbon, LISBOA, PORTUGAL

High energetic events and their impact on coastal zones are of fundamental importance when extreme system responses, maximum system resilience or susceptibility mapping are considered and studied. In beach systems, the magnitude of this dynamic behavior is highly dependent on wave height, period and direction, tide amplitude, sediment size and pre-existent morphology. The main objective is to present the results of predicted high magnitude storm impacts on beach profile erosion. These results are based on beach profile systematic monitoring data and correspondent empirical morphodynamic modeling, using SBEACH model, applied to three beach systems in the exposed and rocky coast near Lisbon (Portugal).

Measured profiles show considerable differences in the morphodynamic behavior of the three beach systems, considering their proximity and similar exposure to NW dominant wave direction. Planimetric behavior and sediment budgets differentiation are shown and measured storm impacts are analyzed and considered for profile extreme erosion prediction.

Predicted behavior of the beach profiles in the three beach systems is based on a 100year wave height return period using SBEACH morphodynamic model. The empirical nature of this beach profile behavior model allows the calibration using local hydrodynamic, sedimentological and mophodynamic parametrization. Results of the model calibration and validation processes are discussed.

Maximum profile recession due to extreme storm impact is finally mapped in the three systems and major systems predicted modifications are discussed in the management framework.

****

Influence of coastal geomorphology on boulder transport by ice in the St. Lawrence estuary (Quebec, Canada)

MARIE G.(1), NEUMEIER U.(2), LE ROUX A.(3)
(1) Universite du Quebec a Rimouski, RIMOUSKI, CANADA ; (2) ISMER - Universite du Quebec a Rimouski, RIMOUSKI, CANADA ; (3) Universite de Bretagne Occidentale, BREST, FRANCE

Sea ice, which is present 3-4 months each winter in the St. Lawrence estuary, is a significant sediment transport agent. It erodes, pushes and carries sediments of all sizes in the intertidal and nearshore areas.

We studied the movements of large boulders (1-5 m) at two macrotidal locations on the south shore of the lower St. Lawrence Estuary: (1) Pointe-aux-Épinettes in the Bic Provincial Parc, a sand flat and salt marsh that is partially sheltered in a large embayment, and (2) East of Sainte-Luce-sur-Mer, a straight exposed coast with an irregular rocky platform. At the two locations, 200 and 100 boulders, respectively, were tagged with an electronic chip (PIT tag) to identify them unambiguously. Their position was surveyed using a differential GPS with a 15 mm accuracy during the ice-free season. Long-term movements were also estimated between Rimouski and Saint-Ulric from georeferenced historical aerial photographs (1963 and 2009).

Boulders are either pushed or rafted by ice-floes. Boulder transport appears relatively unpredictable with an interannual variability and a great spatial variability that depend on the coastal morphology (exposure to wave and tidal current, profile, roughness and lithology of the intertidal zone, position and burial of the boulder) and the conditions during ice break-up (ice abundance, wind, waves and currents).

Displacements are important on flat muddy and rocky costal zones. They appear random in protected areas, with higher boulder mobility near the mean water line. On the cobble pavement covering the lower part of many rocky platforms, boulder movements are limited except at its margin.

Blocks pushed on short distance by ice-floes are quite frequent when the boulder is not too buried in mud or blocked by cobbles. Long distance movements of blocks by ice-rafting are less frequent, but they are probably responsible for a large amount of small-size sediment transport.

Changing Water Resources of West Bengal, India: A Micro level Study

BISWAS B.
The University of Burdwan, WEST BENGAL, BURDWAN, INDIA

There may be no definite change in temporal pattern of water cycle of India but some parts including West Bengal is showing declining precipitation. So, the availability of water is decreasing. The situation is aggravated with the polluted surface water and contamination of the ground water by arsenic, fluoride etc. The increasing agricultural activities and urbanization also requires more water and land. The impact is felt on the decreasing surface water bodies, declining ground water resources.

India receives highly uneven 3816 TMC of precipitation. With the available management practices, presently West Bengal is having 13.02 Mham water requirement (82% of the total available water), while in 2025 the demand for water may be about 105%! This is observed even in the smaller villages also.

The ground water table has gone down at least 10 meter in several places in West Bengal in last 10 years and using Markov Random Field/Chain it has also been calculated the surface water bodies are also reducing its number and size at an alarming rate.

In West Bengal, 85% of water is withdrawn from ground water while 92% of it is used for irrigation. The meandering streams and rivers and other water bodies cover at least 5% of its area. Calculation has been done, using RS-GIS that they can hold excess rain water throughout the year and may also be used for domestic and other uses with proper care and management.

****

Complex rotation of an embayed beach, Essaouira, Morocco

ELMIMOUNI A.(1), ANTHONY E.(2), DAOUDI L.(2)
(1) University Cadi Ayyad, MARRAKECH, MOROCCO ; (2) Institut Universitaire de France, Aix-Marseille Université, AIX-MARSEILLE, FRANCE

This study concerns a relatively complex beach sediment circulation system in an embayment exposed to Atlantic waves, high-energy flash floods from a nearby wadi and intense aeolian activity. Essaouira bay beach, a famous resort on the Atlantic coast of Morocco, is enclosed to the north by a rock headland comprising a sheltered harbour and to the south by the mouth of a wadi, the River Ksob, which drains a steep catchment of 1480 km2. The mouth of the wadi is characterized by a large spit platform recurved to the north, and is connected to a 7 km-wide dune barrier. The beach is separated from this barrier by the city of Essaouira. The sand mobility on this beach implies a ‘rotation’ process between the two ends of the embayment the rock headland to the north and the broad wadi-mouth sandy spit platform to the south - that is not just under the command of waves, as is commonly reported for beach rotation in the literature. The rotation process also involves active aeolian mobility of sand towards the wadi mouth under the influence of constant winds from the north. The gradual accretion and build-up of the wadi mouth, notably via spit platform growth from both aeolian inputs and fresh sand supply by the Ksob, is periodically interrupted by high-energy flash floods that redistribute sand offshore. Sand is further abstracted from the spit platform and transported by wind and longshore drift towards the open beach south of Essaouira bay. The recovery of Essaouira beach occurs via wave-induced onshore transport, with redistribution towards the lower-energy northern sector of the beach through longshore drift induced by wave refraction and wave energy gradients in the bay. This beach rotation mode is original inasmuch as winds and flash floods are actors in the process. A planned resort in the Ksob estuary as well as the projected new Zerrar dam 30 km upstream of the bay could result in serious disequilibrium of the fragile sedimentary system of Essaouira beach.

Holocene evolution of coastal formations in the estuaries of the Guadalquivir and Tinto-Odiel (Gulf of Cadiz, SW Spain)

CLEMENTE SALAS L.(1), MENANTEAU L.(2), RODRÍGUEZ-RAMIREZ A.(3)
(1) Instituto de Recursos Naturales y Agrobiologia de Sevilla (IRNAS, CSIC), SEVILLA, SPAIN ; (2) LETG-Nantes GEOLITTOMER UMR 6554 CNRS and University of Nantes, NANTES, FRANCE ; (3) Departamento de Geodinámica y Paleontología, Universidad de Huelva, HUELVA, SPAIN

The paper summarises the dynamics of the Atlantic coast between the mouths of the rivers Tinto and Odiel and the Guadalquivir in the Holocene. The changes begin at Flandrian Transgression maxima (circa 6500 BP) with the stabilisation of sea level. This marks the beginning of coastal progradation, as seen in the formation of peat deposits in coastal lagoons dating from 4500 BP due to the development of sandy spits which tend to close the mouths of minor rivers. Successive spits have been dated at the mouth of the main rivers. In the Tinto and Odiel, we note the Punta Umbría spit (West), the Punta Arenilla reverse spit (East) and the hook complex of Isla Saltés. The evolutionary sequence has been established through study and dating. The current position of, for example, the watch towers built under Philip II is proof that progradation continues to this day.

In the Guadalquivir estuary, the progression of the Doñana and Algaida spits encouraged the development of the wetlands or Marismas. In these spits we distinguish active dune successions as well as a series of ridges built over several progradation phases: the first between 4200 and 2300 years BP, the second between 2000 and 1300 BP, and a third between 1000 BP and the present. These phases also underwent erosion between 4.500-4.000 years BP, 2.500-2.000 BP and 1300-1000 BP, as seen in the Carrizosa and Vetalengua ridges. They correspond to periods of greater marine influence in the estuary, giving rise to a series of ridges which constitute the chenier plain of Marilópez-Las Nuevas. The ridges of La Marismilla are formed in the final progradation stages of the Doñana spit. In all, there are 21 crests, each of which was formed over a period of 50-60 years, and they have been dated from 1800 BP to the present.

****

Morondava, town in danger

RAZAFIMBELO M.R.(1), RATIARISON A.(2)
(1) University of Antananarivo - Department of Sciences of Earth, ANTANANARIVO, MADAGASCAR ; (2) University of Antananarivo - Department of Physic, ANTANANARIVO, MADAGASCAR

Built on the delta of the River Morondava, between the two major distributary of the River, the city of Morondava which took the name of the River is, since 1914, prey to intense coastal erosion. The period from 1974 to 1997 is characterized by cyclic periods of erosion and sedimentation. A decrease of 100 metres was found in 1979.

The fight began in the years 1950-1960, with the construction of groynes along the waterfront of the city, the most affected part of the coastline. Areas (port, Hellot channel, dam of Dabara) during the colonial period, have caused significant destabilization almost irreversible, represented by spectacular erosion. The construction of the Spurs slowed the process of erosion for a few years but had not arrested him. It is from 1924 that is found the first effects of erosion at the end of the Hellot channel (Betania bay): when the flow of the North arm is low, the channel is subject to infilling and silt, the sea then tackles the marine shoreline from the mouth of the Hellot channel. When the flow is important, there is an important burial and sea fattens then this part of the shore. Then, there is the need to build a maritime boulevard to protect the city against tidal wave whose frequency is estimated at five to eight years. In 2010, work has been made to protect the coastline and rehabilitation of port access road. This work involved a linear 170 m on the side of Morondava. Despite this, the city continues to see its coastline gradually eaten away by the sea.

The use of satellite photos has highlighted the decline in shoreline and littoral drift evolution. Currently, the city is faced with the choice of an appropriate method in the design of coastal areas.

Keywords: Erosion, Littoral, layout, Morondava, Madagascar.

Morphological changes and dynamics of comet-tails in the Molène archipelago (Brittany, France)

SUANEZ S.(1), FICHAUT B.(1), COSTA S.(2), DAVIDSON R.(2), ARDHUIN F.(3)
(1) Université de Bretagne Occidentale, PLOUZANE, FRANCE ; (2) Université de Caen - Basse Normandie, CAEN, FRANCE ; (3) LOS - IFREMER, PLOUZANÉ, FRANCE

From 2002 to 2012, a morphosedimentary survey of trailing accumulations that form comet tails was conducted on Trielen and Lez ar Chrizienn Islands in the Molène archipelago (Brittany, France). In addition, the local hydrodynamics, based on tidal measurement, and wave data obtained from modelling and field measurements, and local tide current meausrements, was analysed. These comet tails are no longer supplied with active sediments from the nearshore platform. Therefore, the morphosedimentary evolution of these depositional forms involved reworking the current [*in situ*] stock and primarily depends on hydrodynamic conditions. When storm waves are coupled with high spring tides, sediment are transported from east to west. This orientation results from offshore waves that reffract when passing Ouessant Island and thereby take on a northerly direction and attack the north-eastern tip of the comet tails. Sediment transport in the direction of western incident waves only occurred during periods of low morphogenetic conditions. From 2002 to 2012, for both studied comet tails, the net longshore sediment transport occurred in a direction opposite of the transport direction that prevailed during the construction of these accumulations. These morphosedimentary dynamics involve a process of “cannibalization” that is shared by all trailing accumulations that are no longer supplied with sediments. It is due to the depletion of Pleistocene stocks sedimentary stored on continental shelf platform. The analysis of hydrodynamic conditions shows no apparent relationship between the morphosedimentary changes and the North Atlantic Oscillation. The conjunction of storms with high spring tides seems to play a much more important role in the evolution of comet-tails.

****

Quantifying disturbances of lake terraces at two lakes on the NE Tibetan Plateau

LOCKOT G.(1), HARTMANN K.(1), WUENNEMANN B.(2)
(1) Freie Universitaet Berlin, BERLIN, GERMANY ; (2) Nanjing University, NANJING, CHINA

Investigation of palaeoshorelines is a common used method to illustrate lake level changes and palaeoclimatic conditions since almost 150 years. Abandoned beach ridges and terraces reshape the form of ancient lakes conserving information about extend of former water bodies. But many preserved palaeoshorelines do not mirror the original height of the past lake levels. They can be altered e.g. by deposition, erosion, tectonics or permafrost. Most studies omit these modifications in feature height. With help of two exemplary lakes from the NE Tibetan Plateau we present first ideas how to quantify uncertainties. Both lakes are located in the monsoonal area of the Tibetan Plateau thus receiving varying amounts of precipitation over the Holocene causing lake levels in different heights.

Lake Donggi Cona (35°18’N, 98°32’E) is situated in an active pull apart basin of the Kunlun Fault, one of the main fault systems in China. Hence it must be assumed that the development of lake terraces was influenced by tectonic, too. Broad dGPS surveying yield to the identification of four terrace generations, averaging at 3.5m, 6.1m, 10.1m and 16.7m above the recent lake level (4090m a.s.l.). Each generation varied within a certain range, suggesting a stronger (tectonic-driven) disturbance the more heterogeneous the generation appears. One-Way ANOVA enables grouping of every level into several subgenerations. Comparing these subgenerations with the known fault pattern the amount of tectonic alteration could be evaluated.

In contrast the terraces of Lake Heihai (36°N, 93°15’E) are disturbed by massive permafrost uplift. Here ancient lake sediments interfinger with segregation ice, building up a terrace complex 8m above the actual lake level (4500m a.s.l.). These uplifted sediments blocked one of the main inflows and changed the whole hydrology of the catchment. Hotspot analysis of a DEM revealed the spatial influence of the permafrost and made it extractable from the modern terraces.

Morphological evolution of the Sillon de Talbert gravel barrier spit (Brittany, France) since the 17e century: a challenge for coastal managment?

STEPHAN P.(1), FICHAUT B.(2), SUANEZ S.(2)
(1) Laboratoire de Geographie Physique (UMR8591 CNRS), MEUDON, FRANCE ; (2) Laboratoire Géomer LETG (UMR 6554 CNRS), PLOUZANÉ, FRANCE

The Sillon de Talbert is one of the most larger gravel barrier spit of the English Channel and forms a swash-aligned formation. It partially protects the islands of the Bréhat Archipelago against coastal erosion and marine flooding of low-lying land. The main morphological changes to the Sillon de Talbert have been studied since the 17th century, and were accurately quantified between 1930 and 2012, based on early marine maps, aerial photographs and topographic surveys recently conducted by DGPS. The examination of early maps shows that this barrier was attached to the Olone Islands until the end of the 17th century. Towards the mid-18th century, a breach that had formed in the north of the barrier resulted in its transformation into a trailing spit. A slow cannibalisation processes began, dividing the spit into a source area at the proximal section, a transit zone in the median section and an accumulation zone at the distal section of the spit. Long-term analysis of shoreline changes over the past decades highlights the mobility of the Sillon de Talbert, which is characterized by rapid landward retreat by rollover. The results obtained show that for the entire period, the mean migration rate was 1.1 m/yr. This trend has led, over time, to the idea that action must be taken to stabilise and/or protect it by hard structures of coastal defense, especially from the 1960s as the lowland areas behind the spit were beginning to be urbanised. Since the 2000s, the national organization in charge of the acquisition of coastal land for its preservation has been implementing an acquisition policy geared towards urbanized areas sensitive to coastal erosion and marine flooding in the back-barrier area of the Sillon de Talbert. This policy enables the organization of strategic withdrawal and leaves natural processes to gradually take their course. DGPS survey show the resilience of the barrier to extreme strom events is better since the hard structures were destroyed.

****

Nearshore Sandbars Behavior on Danube Delta Coast

TATUI F., VESPREMEANU-STROE A.
University of Bucharest, BUCHAREST, ROMANIA

Two-dimensional alongshore sandbars are uniform, straight bars oriented parallel to the shoreline and are typical features on non- to meso-tidal, wave-dominated coasts.

Their dynamics is analyzed along the Romanian Danube Delta (Black Sea coast) virtually tideless beaches. We used statistical methods (complex empirical orthogonal functions and cluster analysis) applied on 10 years of seasonal bathymetric surveys (2003-2013), carried on cross-shore profiles, in order to investigate the differences and similarities in spatial and temporal sandbar characteristics with a series of geometric, morphometric and morphodynamic parameters.

The seasonal behavior of nearshore sandbars clearly indicates a pronounced offshore movement during winter (due to intense storm activity) and a slow onshore movement in the summer. At the multiannual scale, they migrate net offshore in a cyclic manner, in close relationship with the overall shoreline mobility patterns.

The analysis points to significant inter-site differences in spatial and temporal sandbar behavior along the different coastal sectors as a result of the medium and long-term evolution of the coast, via the nearshore slope, wave climate and sediment availability for each sector. There are substantially different sandbars number, morphology and behavior on the sediment-rich accretional sectors than on the erosional ones.

Besides inter-site variations, nearshore sandbars exhibit considerable intra-site variability in their long-term behavior. This variability is related to a grouping of bar migration patterns linked with the differences in geometric and morphometric bar parameters (bar zone width, bar volume) between different sub-sectors of the same coastal area. This is the result of the specific coastal processes and environmental characteristics: nearshore slope; submersed morphology, expressed by the presence of arm mouths; alongshore distribution of wave patterns, longshore and cross-shore currents and sediment budgets.

Prototype of the information system for coastal zone monitoring

LYGIN A., MARUSIN K., LYGIN A., KHABIDOV A.
Institute for Water and Environmental Problems, SB RAS (IWEP SB RAS), BARNAUL, RUSSIAN FEDERATION

Prototype of the Information System for Coastal Zone Monitoring (IS) was designed to store and process data on coastal zone dynamics obtained from various sources such as “Mobile System for Coastal Zone Monitoring”, developed in the framework of the federal program, or State Observation network stations.

Data Access Layer (DAL) uses a relational model (connected and disconnected levels) and Entity Data Model (EDM). DAL is packaged in dynamic link libraries for using with web-services and local desktop applications.

Providing information services are launched on the Microsoft® Internet Information Services (IIS) version 7.0. Communication via TCP and HTTP is feasible.

The IS includes seven software components for solving some engineering problems based on the data obtained:

- program for calculating wind wave parameters outside the coastal zone;
- program for calculating wave shoaling and refraction;
- program for calculating equilibrium beach profile and nourishment volume;
- program for calculating net annual alongshore transport;
- program for modeling storm-induced sand beach profile changes;
- program for modeling erosion of the clay coastal profile;
- program for modeling shoreline changes.

The components have options for export data to XML and flat text files. The work was supported by RFBR (project 11-05-10046-κ) and federal target program “Research and development on priority directions of scientific-technological complex of Russia in 2007-2013” (project 16.515.11.5075).

****

Water level modeling on micro-tidal beach, application of several wave breaking approaches

NICOLAE LERMA A.(1), THOMAS Y.F.(2), ANDRADE C.A.(3)
(1) BRGM, Risques Côtiers et Changement Climatique, 3 AVENUE CLAUDE-GUILLEMIN - BP 36009 - 45060 ORLÉANS, FRANCE ; (2) Laboratoire de Geographie Physique, 1 PLACE ARISTIDE BRIAND, 92195 MEUDON, FRANCE ; (3) Escuela Naval ?Almirante Padilla?, CARTAGENA DE INDIAS, COLOMBIA

Beaches of Bocagrande peninsula, in the South-West of the Colombian old bastioned town of Cartagena de Indias are of great interest for coastal floods studies. The urban and touristic activities of the district suffer regularly substantial floods, due to the very low-lying topography of the whole sandy bar. In today’s sea level rise context, concerns about flood’s extents and frequencies are locally growing. The site benefits from high precision topographic data (LIDAR), a ΔGPS topo-bathymetric evolution monitoring and a video observation system (HORUS) used to detect high water level during storms and strong swell events.

Those assets make Bocagrande an appropriate site to realize a crossed study of several wave breaking models and compare the different simulated water levels with observations. From nested-scale simulations of wave propagation with WW3 and SWAN models, several methods aiming at reproducing the wave breaking phenomenon are tested. Parametric formula (Stockdon/ Holman), boussinesq model (pCOULWAVE), Non-Linear Shallow Water model (SWASH) and Smooth Particule Hydrodynamics approach (SPhysics) are applied on Bocagrande’s beaches’ characteristics to derive water levels at the coast.

The comparison between observations and simulations shows variable results. While the most accurate simulations have a vertical precision of 0,10 to 0,20 m, others shows a link between beach steepness and the increase in error values. Moreover the water levels calculations underline the importance of beach profile morphology on the highest reached levels and on floods’ extents.

Geomorphological Evolution of the coastline in Baie d'Audierne (Western Brittany, France) and relation with changes in the land use

RUAULT R.(1), REGNAULD H.(2), TIERCELIN J.J.(3), PROUST J.N.(3), MOTTE E.(2)
(1) Université Rennes II, RENNES, FRANCE ; (2) Université Rennes II, UMR 6554, RENNES, FRANCE ; (3) Université Rennes 1, OSUR Géosciences, RENNES, FRANCE

This study deals with the evolution of one part of the coast line (Baie d'Audierne, western coast of Brittany) since WW2. At this moment, the Baie d'Audierne was exploited for military protection work (extraction of one million tons of pebbles). As a consequence the gravel ridge was unable to cope with storms and the fresh water lagoons (Trunvel and Kergalan) were very often flooded by marine waters. The ecological behavior of the entire sites was deeply changed. The local communities decided to take control of these lagoons: close the outlet in order to raise the level of fresh water within the lagoon or contrarily artificially open the gap to empty the lagoon and use the new dry land for agriculture. There is a changing and complicated relation between political decisions and the ecological state of the study sites. With the help of air photographs, local archives and field work in sedimentology, land use changes map were drawn and dune building was reconstructed since gravel extraction has ceased. We try to see if there is a present reconstitution of new natural environment that could work without artificialisation (or human control) of the gaps and outlet.

****

Geological Exploration in the Coastal Zone of Bangladesh

ALAM A.K.M., TALUKDAR A., AHSAN A.
Geological Survey of Bangladesh, DHAKA, BANGLADESH

Systematic geological and geomorphological mapping covering the entire coastal zone of Bangladesh has been done under a project funded by the government. Main objectives of the work were to determine the geomphological and geological characteristics, to delineate spatial distribution of each unit, and to understand the coastal dynamic processes. Moreover, identification of the natural hazard prone areas along the coastal zone has been made.

Different multitemporal and multispectral remote sensing data (SPOT Panchromatic, IRS LISS, Landsat and aerial photographs), topographic maps have been used for mapping and change detection. Extensive fieldwork has been carried out for checking the interpretation, and collecting samples and other relevant data. Besides the surfacial mapping subsurface samples have been collected from bore holes with depth ranging from 20m to 260m. Geophysical logging in the bore holes and survey using seismic refraction method have also been carried. The collected samples have been analyzed for mineralogy, chemistry, palynology, micropaleontology and age dating.

Geomorphologically, the coastal zone of Bangladesh has been divided into 3 each having different geological characteristics. Bank erosion, flash flood, cyclone, landslide, water logging, salinity increase and arsenic contamination in groundwater are the major natural hazards identified in the coastal area. A geoscientific database has been created which can be used for hazard mitigation or loss reduction, landuse planning, urban planning, formulating strategy for combating and /or adaptation to climate change effects etc. i.e. for sustainable development planning

Evolution of quaternary coastal landscape in the Giglio Island (Tuscany, Italy)

CIAMPALINI A.(1), FIDOLINI F.(1), ANDREETTA A.(2), CONSOLONI I.(3), MORETTI S.(1)
(1) Earth Sciences Department, University of Firenze, FIRENZE, ITALY ; (2) Dipartimento di Scienze delle Produzioni Vegetali, del Suolo e dell'Ambiente Agro Forestale, Università di Firenze, FIRENZE, ITALY ; (3) Earth Sciences Department, University of Pisa, PISA, ITALY

Eolianite deposits represent important relict coastal landforms on many mid-latitude continents and islands. These kind of sediments are very useful in paleoclimatic reconstruction because their deposition occurred usually during the interglacial and some interstadial sea-level highstand especially in the Quaternary.
On the other hand, several studies suggest that other eolianite deposits can be formed during glacial periods, during a low sea-level stand. These deposits are eolian-reworked relict shelf or coastal sediments, or remnants of former highly mobile coastal dunes. The study of the sedimentary characteristics, the isotopic composition and the use of an suitable dating method can help to understand when and under which climatic conditions, a considered eolianite deposit was formed.
Along the northern coast of the Giglio island (Tuscany, Italy) a small outcrop of eolianite deposits has been recognized. These deposits are placed at the top of a sedimentary sequence formed by continental deposits. The investigated sequence is placed along the coast about 1 m a.s.l. Facies analysis suggests that the sequence evolved from fluvial to eolian environment.
Fluvial sediments consist of sandy channel deposits cutting alluvial plain deposits, showing a well developed paleosol lying on a granitic bedrock.
A sample from the upper, strictly aeolian part of the sequence and one from the channel deposits were subjected to OSL (Optically Stimulated Luminescence) dating.
The succession has been sampled for oxygen isotopic analysis, collecting pedogenic carbonate concretions (ryzoliths) and continental mollusks.
This work contributes to the increase of the number of Quaternary eolianite deposits accounted for in literature and it helps to outline climatic and environmental boundary conditions for the formation of this type of deposit.

****

Survey and analysis of coastal geomorphology using Terrestrial LIDAR in Kosrae, Federated States of Micronesia

PARK H.S.(1), KWON M.S.(1), JEON C.K.(2)
(1) KIOST, ANSAN, SOUTH KOREA ; (2) KESTI, SEOUL, SOUTH KOREA

Coastal areas in the equatorial Pacific island nations are being threatened by coastal erosion and flooding caused by the global climate change and sea level rise. Actually, 80% Coastal regions of Kosrae, Federated States of Micronesia have high exposure to the effect of coastal erosion. Survey on coastal geomorphology is important because it can serve as a direct indicator for sea level rise and be used in the basic data for coastal vulnerability analysis. In this study, the precise 3D topography using terrestrial LIDAR and total station was surveyed in Kosrae, Federated States of Micronesia, and vulnerable areas to floods were also analyzed by 3D terrain analysis. As a result, an average elevation of the intertidal zones, dykes, roads and residential areas were -0.2m, 2.4m, 2.6m and 1.9~2.4m above sea level, respectively. The elevation of the north and south coastal road was about 2.7m, while coastal road in central area located at estuary of the river was about 2.2m, and represented in the lowest elevation. An average elevation of central area in dyke was also 2.1m, and represented the lowest. The central area was analyzed as being high vulnerability to floods, given that the tide range of this area was 1.8m. Especially, flooding comes first in inland area located at estuary when assumed a simple sea level rise. It is due to low elevation, 1.4m. The elevation of the intertidal zone raised toward the south (average 0.5m) from the north (average -0.4m) high, while the width of the south intertidal zone was more narrow than north. In other words, the waves break near the dyke due to the narrow width of the south intertidal zone area. There is a high possibility that the wave energy may is a risk factor causing the dyke erosion as a result. In actual fieldwork and data provided from the local government of Kosrae, it can verify that active erosion had been found around the south coastal road.

Morphological Evolution along the North Part of Paraíba do Sul River Delta, Rio de Janeiro Brazil

FERNANDEZ G.
Laboratory of Physical Geography (LAGEF). Univ. Federal Fluminense., NITER_I, BRAZIL

The morphological evolution of Deltas is determined by fluvial input and the hydraulic process (waves, tides and currents), reworking the sediments, forming a complex of different environments. The Paraíba do Sul Delta represents a example of wave dominated delta, where sequences of beach/foredunes ridges can be observed and describes different phases of deltaic sedimentation along the late Quaternary. In early studies, most of the authors focus in the Holocene evolution, which describes that the main process for the coastal evolution was linking by regressive trend of sea level, during mid-late Holocene, after maximum occurred in 5.300 B.P. Instead this previous works suggest that the inappropriate use of term Delta, because the role of fluvial input was not detected, in recent investigations proved that the sediment supply is the main source for the deltaic sedimentation. In this case the main objective of this work is understanding the mechanism for the formation and evolution of the beach/foredunes ridges, in the north part of Paraíba do Sul Delta, and the internal sedimentary structure. To reach these objectives we survey the submarine morphology along the delta front and the prodelta, using 10 bathymetric profiles across the coastline. We choose 3 bathymetric profiles and prolonged to the beach, to describe the topographic evolution connecting the beach and the shoreface. The internal structure was made by Ground Penetrating Radar profiles. The bathymetric profiles showed that, along of the delta front and the prodelta, sequences of submarine bars were gradually organized as one, by incident waves. The emergence bar migrates towards to the beach, identified by topographical surveys, by overwash process. Finally the emergence bar is connecting to the coast, and promotes the shoreline progadation by incorporation sequences of the ridges. The internal sedimentary structure, determined by GPR profiles, showed radarfacies associated of beach and shoreface patterns.

****

Geomorphic evolution of the Pinios River delta, in Central Greece, in the Late Holocene

KARYMBALIS E.(1), KOUGEMITROU E.(1), GAKI-PAPANASTASSIOU K.(2), TSANAKAS K.(2), DRINIA H.(3), ANTONARAKOU A.(3), STATHOPOULOS V.(4)
(1) Department of Geography, Harokopio University, ATHENS, GREECE ; (2) Department of Geography-Climatology, Faculty of Geology & Geoenvironment, National Kapodistrian University of Athens, ATHENS, GREECE ; (3) Department of Historical Geology and palaeontology, Faculty of Geology & Geoenvironment, National Kapodistrian University of Athens, ATHENS, GREECE ; (4) Technological Educational Institution of Halkida, PSACHNA, EVIA ISLAND, GREECE

This study deals with the geomorphic evolution of the Pinios river delta, which is a late Holocene arcuate type delta, located in the southern Thermaikos Gulf (Central Greece).

This work has combined field geomorphological mapping with the study of the stratigraphy of Late Holocene deltaic sediments. A detailed geomorphic map at the scale of 1:5,000 has been prepared showing both the deltaic plain and the coastal zone features using GIS techniques. Comparative interpretation of aerial photographs taken in different dates and reliable maps of the last two centuries along with field observations depict recent changes of the delta morphology. Three boreholes reaching the depth of 4.5m were drilled with a portable drilling set. The stratigraphy of the late Holocene sediments was studied in detail and 40 sediment samples, collected from selected sedimentary layers, were analyzed using micropaleontological and granulometric methods while molusc samples were dated using AMS radiocarbon method. The study of the stratigraphy of the Holocene deltaic sediments showed that during this period the sea invaded the area of the southern delta and created a shallow open marine environment which at times was disturbed by multiple terrestrial inputs induced by fluvial discharge and longshore drift.

Geomorphological mapping showed that among the most important factors for the recent development of the delta are fluvial sedimentation, wave activity and longshore currents. The dominant landforms in the deltaic plain is the numerous abandoned meandering channelsand four generations of beach ridges through which the coastline has advanced during the late Holocene. Today the delta shoreline is generally retreating due to marine processes especially where former river mouths occur where retreat rates reach up to 4m/yr for the last 60 years.

Conceptual Models for Natural Mechanisms of Sediment Bypassing at the Tidal Inlets along the Konkan Coast of Maharashtra, India

DHORDE A.(1), DHORDE A.(2)
(1) Department of Geography, Nowrosjee Wadia College, Pune, PUNE, INDIA ; (2) Department of Geography, University of Pune,, PUNE, INDIA

Inlet sediment bypassing is the process by which sediment moves from the up drift to the down drift side of the inlet, involving the inlet channel and ebb tidal delta (FitzGerald et al, 2000). Sediment movement onshore typically takes place in the form of large landward migrating swash bars which may vary in size. Part of the sediment moving along the down drift beach may be recirculated back towards the inlet or even get transferred further down the bar. In either case sediment movement will be totally determined by the morphology of ebb tidal delta and the wave approach. These general patterns of sand transport result in sediment bypassing at the inlet. This paper attempts at demonstrating mechanisms by which sand is transferred to the down ward shoreline at the tidal inlet along the *Konkan* coast.

Four conceptual models are presented based on the pioneering work of Brunn and Gerritsen (1959), Brunn (1966) and FitzGerald (1982). In all the models only natural, unstructured inlets are considered. The first model proposes the mechanism of spit elongation, ebb channel extension & elongation and natural reclamation of the bay area. The attributing factors being sea level regression and excessive sedimentation based on past processes. The second model tries to stress mechanism behind the spit extension and inlet migration in the near past. The third model is related to the ongoing processes and proposes the mechanism of ebb tidal delta breaching and ebb channel shifts. The last model relates to flood delta formation and bay filling.

Bruun, P. (1966). Tidal inlets and littoral drift: Vol. 2, Universitelsforlaget, Oslo.

Bruun, P.,and Gerritsen,F.(1959) Natural bypassing of sand at coastal inlets,J*our. Waterways and Harbors Div.,* 85, 401-412

FitzGerald,D.M.(1982). Sediment bypassing at mixed energy tidal inlets,P*roc. 18th Coastal Engg. Conf.,* ASCE, 1094-1118.

FitzGerald,D.M.,Kraus,N.C,Hands,E.B.(2000):Natural Mechanisms of Sediment Bypassing at Tidal Inlets, CHETN-IV-30,US

****

A quantitative comparison of seasonal, annual, and decadal changes in coastal geomorphology in the southern Outer Hebrides, Scotland

YOUNG E.(1), DAWSON S.(1), MCKENZIE B.(2)
(1) University of Dundee, DUNDEE, UNITED KINGDOM ; (2) The James Hutton Institute, INVERGOWRIE, UNITED KINGDOM

In January 2005 a severe storm caused extensive coastal erosion along the western coast of South Uist. A combination of extremely low atmospheric pressure (953 mb[1]) and high wind speeds coincided with high tide, leading to widespread wave undercutting of the dune toe and machair front, with up to 10 m of coastal retreat reported[2] along particularly exposed areas. Large areas of the coastal machair grasslands were flooded, or covered with storm debris, and roads and buildings were damaged. The physical effects of the storm were perceived to be so severe that coastal defence works were erected in five locations to protect infrastructure and agricultural land.

However, it has been suggested that the coastal retreat associated with the January 2005 storm may not be significantly greater than that which would be expected to occur over a typical winter storm season[2]. It is the aim of this research to provide a better context for interpreting the effects of extreme events such as the January 2005 storm by quantifying the cyclical changes that occur on the western coast of South Uist over tidal, seasonal, and annual timescales. Repeat RTK-dGPS surveys and a 2005 LiDAR dataset (© SNH) covering the coastal zone at three sites are used to assess planimetric and volumetric changes. Additionally, historic aerial photography and maps are used to establish the rate and nature of longer term coastal trends in this area. Initial results and interpretations indicate a long term trend of coastal retreat, with highest rates of retreat occurring at exposed sandy headlands, and significant seasonal variability in the beach profile.

[1]Dawson, A., Dawson, S., Ritchie, W. 2007. Scott. Geogr. J. 123(2): 135-149.

[2]Angus, S., Rennie, A., 2008. SNH Commissioned Report, Inverness.

Reconstruction of coastal evolution and Holocene sea-level history from surface morphology and lagoon sediments of a regressive, micro-tidal environment

SANDER L.(1), MORIGI C.(2), FRUERGAARD M.(1), JOHANNESSEN P.N.(2), NIELSEN L.H.(2), PEJRUP M.(1)
(1) University of Copenhagen, Department of Geosciences and Natural Resource Management, COPENHAGEN, DENMARK ; (2) Geological Survey of Denmark and Greenland, COPENHAGEN, DENMARK

The island of Samsø is located in the southern Kattegat Sea, Denmark. The area experienced a period of rapid transgression during the early Atlantic, reaching its maximum approx. 7,600 yr BP. Since then, isostatic uplift gradually caused relative sea-level to drop. Ephemeral shallow-water lagoons and associated barrier systems evolved in topographic depressions along the shores of Samsø. Most of these filled in and became inactive until today.

In the scope of this project we study the evolution of the coastal landscape from the mid-Holocene to present day. Methodologically, we combine the interpretation of the surface morphology with the investigation of stratigraphical variations in the sedimentary deposits, based on core samples.

We use a high-resolution digital elevation model (DEM) and GPS-supported field survey data to “read out” the geomorphological record as well as to deduce a first estimate on timing and accretion rates of beach ridge and spit development. The sedimentological analysis of core samples taken along transects in the fine-grained lagoonal deposits allows us to single out varying energy levels and sediment influx from surrounding sources and thus gives us valuable insight into the evolution and the forming processes of these lagoons and their associated landforms. Age control is established by optically stimulated luminescence dating on sandy samples as well as by radiocarbon dating where applicable.

We further explore the use of benthic (intertidal) foraminifera as an interpretative tool for paleoelevation and correlation of core samples as well as to assess palaeoenvironmental changes (e.g. tides, salinity) in the lagoon.

The aim of this study is to facilitate a three-dimensional description and interpretation of Holocene deposits, landforms and their relation to sea-level.

****

Landslide hazard zoning at large scale along Lower Normandy coast affected by slow-moving landslides (France)

MAQUAIRE O.(1), LISSAK C.(2), COSTA S.(2), THIERY Y.(3), FRESSARD M.(2), DAVIDSON R.(2)
(1) LETG-Caen GEOPHEN, UMR 6554 CNRS Universit_ de Caen Basse-Normandie, CAEN, FRANCE ; (2) LETG-Caen GEOPHEN, UMR 6554 CNRS Universit? de Caen Basse-Normandie, CAEN, FRANCE ; (3) EURO-ENGINEERING, PAU, FRANCE

In Normandy (North-West France), landslides occurring along the coasts are large, deep in marly, sandy and chalky formations. All arecharacterized by a seasonal activity (1-10 $cm.y^{-1}$) and regularly affected by brutal accelerations inducing pluri-decimetres to pluri-meters horizontal/vertical displacements and the main scarp recession to upstream. These landslides are located along a very touristic coastal area where an increasing land pressure is observed. The landslides have induced direct damages to infrastructures (roads, buildings) and indirect damages to the economical activity.

In a context of land use planning help, this study focused on the landslide hazard zoning at the local scale and on the potential landslide extension based on the integration of multi approach and multi-source data.

First, a geomorphological diagnostic based on several complementary methods to provide direct, indirect and spatially-distributed information of the slope morphology and the internal structure. The results have highlighted the landslides composition into several compartments related to the existence of nested chalk panels and blocks.

Secondly, the historical landslide dynamic reconstruction has been lead to define the potential evolution of the major scarp position based on the interpretation and comparison of historical data (aerial photographs, topographic maps…).

In a prospective way, and mainly based on morphological criteria, three degrees of hazard have been determinate (high, moderate, low) according to two scenarios based on knowledge of the morphostructure.

Development of a Coastal Sensitivity Index for Elafonissos Island, Peloponnese

MAGKLARA M., KARYMBALIS E.
HAROKOPIO UNIVERSITY OF ATHENS, DEPARTMENT OF GEOGRAPHY, ATHENS, GREECE

Many of the world's coasts appear sensitive to the impacts of climate change and particularly sea-level rise. Approximately half the EU population lives 50 km or less from the coast; with 19% of the EU population living within a 10 km coastal strip. In this study, the effects of an anticipated sea-level rise by the year 2100 for the small island of Elafonissos located in southern Peloponnese are estimated. For this purpose a Coastal Sensitivity Index (CSI) similar to the formula proposed for the US and Canada coasts is applied, modified for the Mediterranean environment. CSI calculation involves the relation of the following physical variables, to be related in a quantifiable manner that expresses the relative sensitivity of the coast to physical changes due to future sea-level rise: geomorphology, coastal slope, relative sea-level rise rate, shoreline erosion or accretion rate, mean tidal range and mean wave height. Every section of the coastline is assigned a risk ranking based on each variable, and the CSI is calculated as the square root of the product of the ranked parameters divided by the total number of variables. Rocky and cliffed sections as well as beaches backed by dunes are less sensitive whereas sandy beaches backed by low plains record the highest sensitivity. The results of this study provide a framework for coastal managers and planners to prioritize efforts to enhance the resilience or consider adaptation measures in the coastal zone within the study region.

****

Verification of dean's equilibrium beach profile formula for large man-made lakes

LYGIN A., LYGIN A., KHABIDOV A.
Institute for Water and Environmental Problems, SB RAS (IWEP SB RAS), BARNAUL, RUSSIAN FEDERATION

The Dean's equilibrium beach profile formula describes the shape of dynamic equilibrium sandy profile:
$h(x)=Ax^{2/3}$, (1)
where h - a water depth ranging from 0 to Dc.
Dc - a closure depth, the maximum depth up to which the movement of sediment and, consequently, the current fluctuations in the profile form occur.
A - a steepness parameter profile that depends on the grain size of the material (d).
Ease of Dean's function use is in its simple analytical expression that allows to avoid time-consuming numerical simulations under the equilibrium profile construction. It is known that the Dean's equilibrium model holds for the seashore. But we can prove empirically that it is also valid for large man-made lakes.
In fact, the formula of Dean (1) is a special case of a power regression of the form
$h(x)=A_1x^n$, (2)
except for the Dean's coefficient n fixed at 2/3, and the parameter A , independent of the actual configuration of the profile for which an equilibrium is built, but depended equilibrium just of the average median grain size of the material d, which has developed this profile.
Suppose that the shape of the dynamic equilibrium profile has a form of a power function, then for each coastal profile a unique profile of equilibrium expressed by (2), with their unique coefficients A and n depending solely on the actual profile configuration exists. Coefficients A and n can be calculated by the least- squares method (LSM) widely used in regression analysis.
If Dean's coefficients A=A(d) and n=2/3 are close to coefficients A1 and n obtained by LSM, and the mean relative error of approximation is within the tolerance range, the Dean's model is adequate for this profile.
Successful validation of Dean's formula was done for sandy profiles of the Novosibirsk reservoir, which are in equilibrium in the last tens years.

Rip channel patterns on the beach near the mouth of Sele River (southern Italy)

VALENTE A.(1), PENNETTA M.(2), SICA M.(3)
(1) University of Sannio, BENEVENTO, ITALY ; (2) University of Napoli "Federico II, NAPOLI, ITALY ; (3) Autorità di Bacino Interregionale del F.Sele, NAPOLI, ITALY

The analysis oflong-term measurements carried out on the coast of Sele River, located on the western margin of southern Italy, showed a rather articulated morphology of the submerged beach. Along it several channels perpendicular to the shoreline were found, which affecting the original bars parallel to the shore, thus they have shrunk dramatically. These channels are developed mainly between 0 and 5 meters deep and, according tothe sedimentological characters, play a significant role in the seaward transport of sediments removed from the bottom. More specifically, the bars are constituted by fine and relatively unsorted sands, while the channels are characterized by the presence of sandy and sorted sediments. The increased size of the sediment in the channels as well as its better selection correlates well to the high hydrodynamic energy of flowing water in the channels probably modeled by rip currents. The presence of these currents has been confirmed by some bathymetric surveys.
Therip currents are also responsible for the morphological changes of the emerged beach and of the typical rhythmic shoreline, with alternating embayments separated by cusps. The embayments are located in correspondence of the head of rip channels, while the cusps laid out at the bars edges, on which the incident waves break. The rip currents erosion on the seabed extended over the inner portion of the emerged beach, causing erosion processes on the dune and discontinuity in the dune system. Such discontinuitiespromote the genesis of blowouts and parabolic dunes on the beach, that can be the first sign of severe erosion of the coastal system, which is already quite evident in the investigated coastline.

****

Vulnerability assessment of Al Hoceima bay (Moroccan Mediterranean coast): a coastal management tool to reduce potential impacts of sea-level rise and storm surges

KHOUAKHI A.(1), SNOUSSI M.(2)
(1) University Mohammed V, Faculty of science -Agdal , RABAT, MOROCCO ; (2) University Mohammed V, Faculty of science -Agdal, RABAT, MOROCCO

Projected increases in sea level rise (SLR) and in the magnitude and frequency of extreme weather events pose a major challenge for the management of low-lying coastal ecosystems and human settlements in the context of climate change. The bay of Al Hoceima is one of the least studied and largest low-lying coastal areas of the Moroccan Mediterranean coast, and is highly exposed to the effects of SLR and storms. The coast is also a touristic area and one of the most important economic assets in the region of Al Hoceima. Physical coastal vulnerability assessments are one of the principal tools for developing coastal management plans. Here we assess the vulnerability of the coastline to sea level rise and extreme weather events through a standard index methodology based on physical and geomorphological indices a) litho-morphology, b) Beach width c) Coastal slope d) Width of forest behind the beach e) Exposure of the coast, based on the orientation of the coast relative to wave direction and finally f) the Width of vegetation behind the beach. Subsequently a socio-economic valuation of potential impacts in the area was warred out. Using a combination of high resolution maps and remotely-sensed data, we selected the five most relevant physical parameters for local-scale vulnerability analysis, based on 50m/50m cells along the coastline. A total of 822 cells were identified and evaluated, with individual parameter scores ranging from 1 to 4 and calculated total scores from 10 to 20. We found that 28% of the studied coastline is highly vulnerable to the effects of SLR and extreme weather events. These findings will have direct repercussions for coastal development programs over both the short and long terms.

Definition of geomorphologic coastal systems at the Sao Paulo's coast - a taxonomic proposal

MATOS FIERZ M.
UNIVERSITY OF SAO PAULO, SAO PAULO, BRAZIL

The geomorphological researches of the coastal area are generally focused on understanding which preterit processes that resulted current forms. Thus, propose a taxonomic order to the coastal geomorphology which consists of an adequate systematization of representations of relief in the evolution context of these processes and forms that borders and contributes to the dynamic and maintenance of the coastal plains. The taxonomy can be directed to the geomorphological characteristics represented by the molded recesses shapes and sustained on materials of Crystalline Basement and filled by the Quaternary sediments sourced from the continent or the continental shelf. Therefore, the contribution occurs in the sense of defining a subdivision in taxonomic levels for the researches in coastal geomorphology. To define the different geomorphological systems in the fieldwork, we used the following instruments: the penetrometer to measure the strength of materials and GPR (Ground Penetrating Radar) to differentiate the materials which forms the layers of Quaternary deposits with different levels of resistance in coastal plain. The proposed taxonomy of coastal relief presents the main morfostructures and morfesculptures (Mecerjakov, 1968) and its characteristics depending on the bedrock and soil, resulting in the genesis of active coastal processes. The macrocompartiments or geomorphological systems and subsystems are represented on the geomorphological mapping. Thus, it was defined the genetic characteristics of morfostructures of the Crystalline Basement (first taxon), Quaternary deposits (second taxon) and Coastal Plain (third taxon), which is part of the morfoesculptures of fourth taxon or geomorphological subsystems, namely: beach, plain fluvial, fluvial terrace, plain intertidal, marine terrace, plain fluvial-marine, marine terrace covered with dunes and sandy ridges, hills and coastal hills of the southern coast of the state of São Paulo.

****

The Ubatuba Beachrock (State of São Paulo, Brazil): A New Evidence of a Mid-Holocene Negative Sea-Level

DE GOUVEIA SOUZA C.
Geological Institute, SAO PAULO, BRAZIL

There has been recent debate on whether there has been a negative oscillating of the Holocene sea-level in Brazil. This paper presents a new evidence of a negative sea-level in the mid-Holocene, based on a beachrock found on the Tenório Beach, at Ubatuba County (State of São Paulo, Brazil). Beachrocks refer to the calcium carbonate-cemented sediments that result from lithification in the intertidal zones of tropical coasts, and are considered incontestable evidence of sea-level oscillations. In Brazil, they are common features outcropping along the whole Northeast and East coasts, but they are rare at the Southeast (Rio de Janeiro and São Paulo states), where the most southward remains are referred for the Cabo Frio region (Rio de Janeiro). The Ubatuba beachrock became exposed in 2010 after several storm surges. Its surface lies *ca.* 0,4m below the current mean sea-level, and exhibits *ca.* 600 m^2 in area and 0,4m of maximum height. Although internal sedimentary structures are difficult to be identified, its surface shows morphology from upper foreshore and backshore zones relief. The beachrock is composed by very coarse sands rich in shell fragments, what suggest different morphodynamic conditions from the present beach (fine sands). The cement is mainly formed by calcite. Some penetrative fractures crossing the main body are also filled by calcite cement. Both cements have been dated by the AMS method and showed ages from 4820-4400 yr cal BP (4400 ± 30 yr BP) to 3950-3630 yr cal BP (3830 ± 30 yr BP), respectively. The whole surface of the beachrock is marked by dozens of palaeo-urchin burrows, indicating that it has been submerged after the cementation. Considering that some authors have found evidences indicating that the Holocene transgression maximum began about 5000 yr BP for the study area, then the Ubatuba beachrock seems to prove that after this maximum there was a rapid negative sea-level oscillating down to *ca.* -0,4 m, followed by a new sea-level rising.

Geoindicators and beach classification for coastal management in Arraial do Cabo, Rio de Janeiro, Brazil

PEDROSA F., NASCIMENTO F.
Federal University of Fluminense, RIO DE JANEIRO, BRAZIL

The research of geomorphology can be useful for many different studies. On the coastal management, it also has an important role. The evaluation of different geomorphologic components of a beach and shoreline can help classify the current state of a beach; and therefore determine the best kind of management for the area. The study of the geoindicators on the shoreline was the method chosen to classify the urban beaches in Arraial do Cabo, RJ, Brazil. To study and classify the urban beaches, was made a visual observation of some geoindicators that could show the state of the beach: erosive, stable or accreting. This method isvery simple to observe, and it can diminish the time spent in field researchers with the same purposes, just as it reduces the cost of the same researches. It was observed the following geoindicators: the length of the beach; the presence or absence of vegetation, frontal dunes and cliffs; the energy of the waves; if the beach is protected or exposed to open sea; the presence or absence of deteriorated beach vegetation; the granulometry of the sand; the presence or absence of heavy minerals; the presence or absence of engineering intervention; and the presence or absence of urbanization (residential, commercial or touristic purposes) and its position related to the beach. With all these geoindicators observed, it can be determined if the beach researched is more or less exposed to coastal erosion. The principal results are: Praia Grande was classificed as a beach with stabilizing tendency. Prainha has erosive tendencies. Praia do Forno indicates a prior state of stableness, but a erosive tendency. And Praia dos Anjos, the same as Praia do Forno. Thus, is possible to say that three of the four beaches has an urgent need of coastal management, with suggestions of ways to prevent the total erosion. The geoindicators can also be used as an instrument by the Brazilian coastal legislation, to cover the necessity of coastal monitoring and management.

****

Chronology of coastal progradation rates along the Santa Catarina litoral, Brazil

GONZALEZ-VILA F.
IRNAS-CSIC, SEVILLE, SPAIN

The study was done along a 3 km trench profile, perpendicular to the shore line in Volta Velha and at the front of prograding Holocene barriers. Inorganic, and organic elemental analyses, extractable lipid fraction (GC-MS), analytical pyrolysis (Py-GC/MS) and ^{13}C nuclear magnetic resonance (NMR) were used for the characterisation of organic matter, which was dated by ^{14}C AMS. In the samples, quartz grains are weekly cemented by a mixture of sesquioxides (2-4%) and humic material with elemental C content between 1 and 3%.

Most of the intensity in the solid-state ^{13}C NMR spectrum of both VV1 and VV2 samples, differing in age by *ca* 4 kyr, is in the alkyl C region (45 - 0 ppm) assigned to methylene groups i.e. in fatty or amino acids but also in paraffinic structures. Comparable high intensity is seen in the Carboxyl/carbonyl C region, which is also assignable to amide C.

The signal at 75 ppm in the region of O-alkyl C (110 to 60 ppm) originates most likely from carbohydrates. The low relative contribution of this signal indicates a high humification degree in the older sample VV1. Comparing samples VV1 and VV2, clear time dependent decrease in the carbohydrates is observed, probably reflecting the time of exposure of organic matter to weathering.

In terms of chronology of the accretionary process, the results of 6 AMS ^{14}C dating performed on samples from the soil B horizon (80 cm depth), plotted against the distance from the active shore, fitted almost perfectly the polynomial, uniformly accelerating trend line.

The starting point of the sequence corresponds to the period antecedent to the mid-Holococene highstand (5800-5000 Cal BP). The first period of costal accretion (7-3 kyr cal BP) corresponds to a slower (0.2 m/yr) progradation. After 3000 cal BP the accretion is faster (0.61 m/yr); the lowering of the RSL permitted the formation of broad prograding barriers. These data further corroborate the model of Angulo et al. (2006) for the regional costal barriers.

Environmental Problems in coastal margins of Nile delta

SAYED M.(1), SHAABAN A.B.(1), REGNAULD H.(2), ABDEL HAMID A.(1)
(1) Cairo university, CAIRO, EGYPT ; (2) Rennes 2 University, RENNES, FRANCE

During the last five decades the coastal strips of the Nile delta had been changed dramatically and affected by various land use changes. The environmental system consists principally of lagoons, sand bars, spits, vegetated dunes, river estuaries and wetlands. With the overpopulation change of Nile delta, human-induced changes have covered many aspects like land-reclamation, fish-farming, urban expansion, and international & regional highways. The current study detects extends and limits of these changes since the oldest map available (1818) till 2010 satellite images. Sequence of field surveys through 2008-2012 have assured the results and sustain the data check techniques. This paper will focus on three examples of the land-cover changes: (1) the Rosetta promontory retreatment; (2) coastal dunes destruction in north-western parts of the delta; and (3) the Urban geomorphology of salt weathering in south-eastern margins where the delta conjunct with Suez Canal region.

****

Quaternary environmental evolution recorded by littoral deposits in China's southeast coast

ZHIZHONG L., JIANHUI J., XIULING C., FANGEN H., XIANLI W., JIN X.
College of Geographical Sciences, Fujian Normal University, Fuzhou Fujian Province, FUZHOU FUJIAN, CHINA

Two littoral sediment profiles, Liushui and Keren, on the southeast coast of China provide clear environmental evolution history since 1.80Ma. Two transformation events of neotectonics- climate changes, their boundaries between Calabrian Stage and Ionian Stage (C/I, or Q1/Q2) and between Ionian Stage and Upper (I/U, or Q2/Q3), had caused two obvious depositional hiatuses in Liushui Profile . The age of C/I hiatus (115.2-75.2 Ma, ESR ages) agrees well with the boundary age between Brunhes Epoch and Matuyama Epoch (B/M) of palaomagnetism. The depositional hiatus of I/U characterized by a suddenly changing grain-size parameters of “old red sand”. These hiatuses reflects the influence of coupled the neotectonics-climate (global sea level) changes on the region depositional environment. According to these hiatuses, environmental change history of the area can be divided into two stages. The stratum of lower stage consists of two marine facies layers and a littoral “old red sand” layer. The grain size and magnetic susceptibility of lower stage sediments characterized by the influence of high frequency and small amplitude global sea-level oscillation. The upper stage sediments is made dominantly of littoral “old red sand” depositing since Ionian Stage(or Q2, about 0.78Ma,ESR ages), including coarse reticulate “old red sand” developed in Ionian Stage(Q2), and fine reticulate “old red sand” in early Upper（Q13）. There is an obvious OSL age gap and a suddenly changing sedimentary facies from 100-80Ka at the depth of 12-11m in Keren Profile. They are evidence that reflect the transitional change of last interglacial period (MIS5e) to last glacial period (MIS4). Due to fine reticulate “old red sand” of early Upper (Q13) widely distributed in northeast coast of China’ south subtropics, the warm-wet climate similar to that of north margin of tropical climate today would appeared in northeast China’s south subtropics areas in early Upper(or last interglacial period, MIS5e).
Key Words: littoral deposits; neotectonics; climate change; sea-level change; ESR and OSL dating; southeast coast of China.

Ecological and Geomorphic Controls on Spatial Variation of Crab Burrows: A Case Study in Bakkhali Beach Area, West Bengal, India

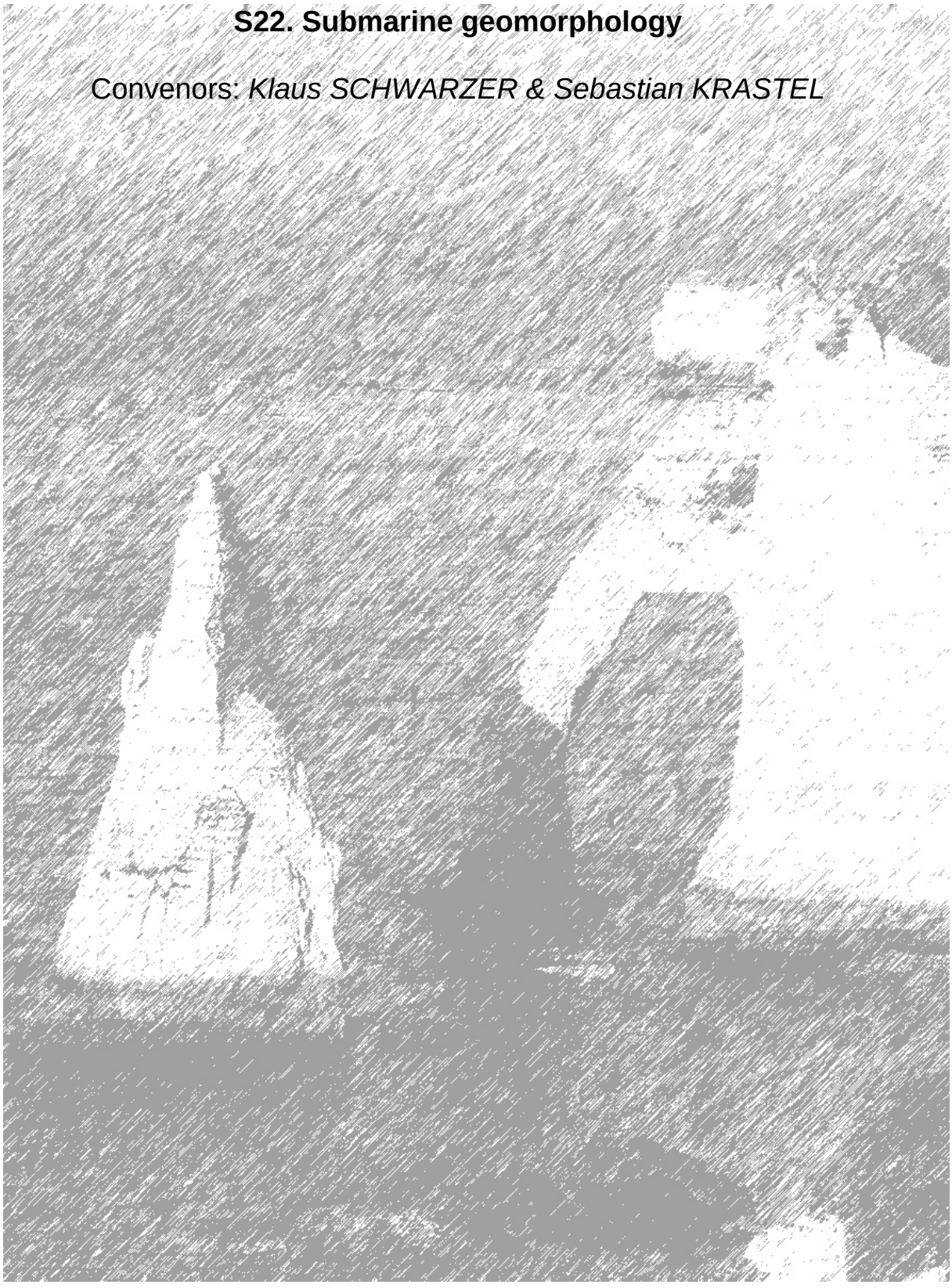
CHAUDHURI S.
West Bengal State Univeristy, KOLKATA, INDIA

Observations on crab burrows in the beach environment of Bakkhali helps to decipher the spatial differentiation of crab behavioural responses with the changing ecological and geomorphic parameters. The present paper deals with crab dwelling structures and this exhibit maximum variation in their characteristics near the spring high tide line and also between the mean and spring high tide line. Near the low tide line the crab burrows are less diversified with other associated species. Random and zone-wise data on bioturbation parameters (viz. average burrow diameter, burrow orientations and burrow density) indicate dominant control of elevation or inundation on crab ichnofabric. Larger burrows show a landward increasing burrow density and dispersions in their burrow orientations suggesting that these were constrained with elevation/inundation. Apparent correlation of bioturbation parameters with sedimentation parameters was also noted, for these post-event burrows. Indirect control of energy fluctuations appears to be more relevant in this context that determines the direct control of varied nutrient supply in the beach area. Plaster casts of crab burrows indicate that the deepest and widest burrows are present near the high tide line, which are often attached with a terminal chamber at the end of the burrow. The shape of the burrows vary from the typical 'J' shape to more complex 'Y' and 'U' shapes. Detailed investigation of the burrow shapes and dimensions show some correlation with beach elevation and tidal inundation zones, which may throw some light on the ecological behaviour of the crab species.

****

S22. Submarine geomorphology

Convenors: *Klaus SCHWARZER & Sebastian KRASTEL*



Oral presentations:

Deriving long-term (multi-century) quantitative measures of marine geomorphological change using qualitative records

BURNINGHAM H., FRENCH J.
UCL, LONDON, UNITED KINGDOM

Hydrographic charts are widely used for the assessment of submarine geomorphology and short- to medium-term (years - decades, possibly centuries) seabed morphodynamics. Advances in GIS have facilitated a revival of these cartographic archives through enhanced methods of georeferencing, digitisation and spatial analysis, to produce detailed insights into seabed evolution. The time frame associated with geospatially-accurate hydrographic charts is primarily the 1900s to the present, and in some locations, charts from the mid to late 1800s might also be available. The temporal perspective is often compromised in favour of spatial precision, which usually limits the historical scope to 100-150 years. The period of exploration and discovery (late 1500s to early 1800s), however, delivered a number of resources that, although unsuitable for geospatial analyses, can still be used to reconstruct a multi-century scale history of submarine geomorphological change. In this paper, we use a landform unit scale (feature-focused) approach to describe and analyse an extended history of change in inner shelf geomorphology, using examples from southeast England and the southern North Sea. Banks, shoals and cross-bank channels are assessed in terms of their minimum depths and between-bank channels in terms of their maximum depths. Using more than 200 atlases, navigation pilots and seabed maps and charts, a 300-400 year history of change is achievable. The measures enable the identification of accretion (vertical growth of banks), breakdown (vertical denudation of banks), shoaling (of channels), entrenching (vertical accretion of banks and deepening of between-bank channels) and evolution of feature shape (change in major and minor axis lengths). Examples presented include evidence of: a) the demise or appearance of seabed forms, b) features that exhibit contrasting pre- to post-19th century behaviour and c) significant reshaping of seabed forms.

****

Submarine geomorphology and the geomorphometric approach - Recent developments

MICALLEF A.
University of Malta, MSIDA, MALTA

Whereas geomorphometric techniques have become a standard tool in the investigation of terrestrial and planetary landscapes, their application in the study of submarine environments has been more infrequent. Advances in seafloor data acquisition systems made in the last two decades, however, have generated a renewed interest in employing geomorphometric techniques and geomorphologic concepts to investigate submarine landscapes.

In this presentation I will provide an overview of techniques that I developed for the geomorphometric analyses of multibeam echosounder data, and demonstrate how their application has enhanced our understanding of three aspects of shallow and deep marine geological phenomena:

(i) **Mass movements** - by improving the mapping of slope failures across the Norwegian continental slope, identifying their triggering mechanisms and modes of failure, and demonstrating scale invariance in terms of statistics and morphology.

(ii) **Canyons** - by comparing the morphology of submarine canyons in four continental margins (Catalan, Hikurangi, Argentinian, Maltese) and characterising the differences in canyon processes and evolution between active and passive margins.

(iii) **Submerged landscapes** - by reconstructing the evolution of the submerged terrestrial paleolandscape of the Maltese Islands during the last glacial cycle and relating this to key stages in Quaternary environmental change.

Geomorphological expression of shallow water carbonate buildings in the Mediterranean Sea

BRACCHI V., SAVINI A., MARCHESE F., CORSELLI C.
Dept. of Earth and Environmental Sciences, Milano-Bicocca University, MILANO, ITALY

Coralligenous habitat consists of autochthonous carbonate build-ups, which produce frameworks with three-dimensional structure that serve as shelter and provide storm protection by buffering wave action along coastlines. So it plays a primary role in the geomorphological development of continental shelf. It is further on considered a high spot of biodiversity and recognized as a protected habitat in the EC Regulation No. 1967/2006 concerning management measures for the sustainable exploitation of fishery resources in the Mediterranean Sea. Different actions were indeed promoted to collect new more detailed data on its range of distribution and extent in the Mediterranean and European seas.

In the framework of BIOMAP project (P.O FESR 2007/2013), promoted by Puglia Region, Italy, two oceanographic cruises were carried out along the Apulian continental shelf (central Mediterranean sea) to collect acoustic data (through MultiBeam Echosounder Systems (MBES) and high-frequency Side Scan Sonar (SSS)) and video inspections, to identify and locate coralligenous habitats, between 10 and 100 m of water depth. The whole data set was processed and analysed through proper GIS-based tools, to investigate the variety of morphologies that coralligenous habitat developed at the explored locations. Detailed Digital Terrain Models (DTMs) have been provided trough MBES data-processing and merged with SSS backscattering. The obtained *morpho-acoustic facies* were quantitatively characterized (through morphometric and textural analysis of their acoustic proprieties) and associated to the collected ground-truthing information (i.e. video inspections).

Different geomorphological expressions of coralligenous habitat have been thus identified. The role of some main environmental parameters (i.e. water depth and current exposure) in determining such different morphologies of coralligenous habitat was investigated.

****

Characterization of current sediment dynamics, obtained from the distribution and movement of underwater dunes: the example of the English Channel

GARLAN T.
SHOM, BREST, FRANCE

During the bathymetric surveys achieved by the French Hydrographic Office (SHOM), submarine dunes were detected in the shallow water zone, at the end of the nineteenth century. He nevertheless had to wait until the late twentieth century, with the arrival of multibeam echo sounder and GPS, to have an accurate characterization of the morphology and location of these dunes. It has thus become possible over the past fifteen years to precisely quantify the speed of dunes and follow their morphological evolution over time. According sediments and hydrodynamics involved, these rates vary from a few meters to tens of meters per year. The synthesis of Wever (2004), gives all the values of dunes displacements reported in the scientific literature. These studies are unfortunately limited to depths less than 40m. SHOM has done campaigns for several years devoted to the study of the dynamics of dunes of the North Sea, the English Channel and the Celtic Sea, ie the border of Belgium to the continental slope of the Atlantic. The most recent hydrographic surveys conducted in the north and west of Britain, at depths of 70 to 200m, delineated two very large dune fields, that until now had been described only by a few old profiles. More than two thousanddunes were identified during surveys of 2011 and 2012. These one have been added to the GIS dedicated to banks and dunes of the French continental shelf. These surveys have highlighted the boundaries of these two dune fields, and have highlighted the existence of fields of barchan, giant dunes and very large variations in the orientation of the dunes, characterizing the complexity of these environments. After describing the dune fields, we establish a classification of dunes based on their shape, their dynamics and their environment in order to achieve a synthesis of the sedimentary dynamics of the Channel and the Celtic Sea.

Submarine geomorphology of a tropical shelf: examples from the Rio Grande Do Norte Shelf, NE Brazil

VITAL H., GOMES M., NOGUEIRA M., PIERRI G., LIRA H., SILVA J.P., ALMEIDA N.
Universidade Federal do Rio Grande do Norte, NATAL, BRAZIL

This study focuses on the submarine geomorphology of the Brazilian continental shelfa djacent to the Rio Grande do Norte State, NE Brazil. This tropical shelf represents a modern, highly dynamic mixed carbonate-siliciclastic systemcharacterized by reduced width and shallow depths as compared with other parts of the Brazilianshelf. It has an average width of 40 km, the shelf-break lying at a depth of ~ 60 m.and comprises two different sectors separated by the Touros structural high: an eastern and a northern. The study area was investigated by single and multibeam bathymetry, associated with high resolution seismic, remote sensing, sample collection, and scuba dive. The analysis of this data-set revealed an expressive submarine geomorphology represented by very large dune-fields (dune heights reach up to 6 m, and dune widths vary from 400 m to more than 900 m),both longitudinal and transverse to the coast, and small wave- and current generated dunes. Corals knolls and patch reefs are present in the middle to outer shelf in the northern sector, while the most visible are on the inner shelf along the eastern sector, especially around the Touros High. The most important traces of continental terraces are the Natal plateau and marginal Rio Grande do Norte plateau. Channel structures originating at the mouths of the main rivers and extending to the shelf edge can be regarded as incised valleys which cut into the shelf deposits during sea level lowstands. Submerged sand banks are common along this shelf. They are observed at different depths (of 10, 20, 40 and 60 m), the most continuous and prominent structure being found on the 20-25 m isobaths and extending from eastern to northern sector. Samples taken by diving, revealed laminated sandstone cemented by carbonates, similar to the beachrocks commonly exposed along the coast and could be related to ancient coastlines.

****

Geomorphological response to North Atlantic Deep Water circulation: Examples from high-energy current environments at the Faroe and Greenland margins and abyssal southwestern North Atlantic

NIELSEN T., KUIJPERS A.
Geological Survey of Denmark and Greenland, COPENHAGEN, DENMARK

North Atlantic deep convection in the Greenland Sea region and Labrador - Irminger Sea basins leads to strong bottom current activity associated with Greenland-Scotland Ridge (GSR) overflow and deep western boundary current circulation. We will present examples of seismic records and other evidence (e.g. side scan sonar) documenting strong bottom current action on the seabed along the Nordic Seas overflow pathway from the Faroe-Shetland gateway via the Southeast Greenland margin and thereafter northward along the Southwest Greenland margin towards Davis Strait. In addition, seabed evidence from the Greater Antilles Outer Ridge north of Puerto Rico demonstrates persistent strong boundary current activity also at western North Atlantic lower latitudes. Geomorphological response to this high-energy bottom current regime is expressed in a variety of dynamical bedforms ranging from mega-scale contourites via well-defined sediment waves, sand ribbons and erosional furrows to small-scale ripple marks. Boundary current activity may interact with other seabed shaping processes. For instance, on the Southeast Greenland slope and rise complex interaction between downslope (turbidity flow) sediment transport processes and strong bottom current activity has resulted in the formation of large, well-developed transverse ridges separated by turbidity flow channels. Using known relationships between various bedform types and bottom water dynamics, an estimate of maximum (near)bottom flow speed can be made. Applying this information to actual results from bottom water current measurements, indications for fluctuating maximum bottom water speed have been found, demonstrating important variations in the NADW flow pattern through time.

Sea floor morphology of north-western Gulf of Corinth (Greece): combined impacts of Late Quaternary eustatism and active tectonics

BECKERS A.(1), BECK C.(2), HUBERT-FERRARI A.(1), TRIPSANAS E.(3), SAKELLARIOU D.(3), DE BATIST M.(4), DE RYCKER K.(4), BASCOU P.(2)
(1) University of Liège, LIÈGE, BELGIUM ; (2) University of Savoie, LE BOURGET DU LAC, FRANCE ; (3) Hellenic Center of Marine Research, ANAVYSSOS, GREECE ; (4) University of Gent, GENT, BELGIUM

Two high-resolution seismic reflection surveys (single channel sparker) were performed in the western part of the Gulf of Corinth. aboard HCMR's R/V ALKYON, within the frame of SISCOR ANR Project. This intra-continental marine basin is related to Late Cenozoic to Present extension separating "continental" Greece from Peloponnese. The connection of this active rift with the Ionian Sea (Mediterranean) is nowadays a 62 m deep sill, a situation which implies possible separations during low stands of global sea level, especially the last ones (MIS 2 and MIS 6). The western part of the Gulf, which is the most seismo-tectonically active part, appears as a transfer zone with both normal and strike slip faulting, identified through a dense grid of seismic lines.

As a consequence, the offshore northern edge between the Mornos River delta and the Trizonia island shows a complex morphology due to the interaction between these structures, huge terrigenous feeding, deltaic development and sediment failures. Pre-Quaternary basement (Hellenids) was partly submitted to aerial erosion and paleodeltas are superimposed on the induced relief, visible at a depth of 110 m below Present sea level. The paleovalleys are filled with onlapping layered sediments, affected by several WSW-ENE and W-E oriented faults, part of them still active.

An attempt to decipher both sources of relief genesis and evolution is presented. Beside, location and slip rate of active faults are discussed.

****

Geomorphological mapping of complex submarine slides (Apulian ridge, eastern Mediterranean Sea): implication for geohazard assessments

SAVINI A.(1), VERDICCHIO G.(2), MARCHESE F.(1)
(1) Milano-Bicocca University, MILANO, ITALY ; (2) Impresub, TRENTO, ITALY

Over the past 10 years a large dataset of bathymetric, seismic and sedimentological data, that covers more than 2000 km^2, was acquired along the Apulian ridge (northern Ionian sea), between 80 and 1400 m of water depth. The ridge is, a NW-SE elongated structural high, crosscut by a NNW–SSE penetrative normal fault-system; this tectonic setting controls the large scale morphology of the margin, shaped by prominent scarps and ridges. The sedimentary setting of the area is indeed characterized by complex mass-wasting deposits, most likely related to the local high seismicity of the margin, which is considered the result of the activity of the normal fault network. Clear morphological evidence of mass-wasting is given by the presence of a number of arcuate head-scarps, indenting the shelf break, and a variety of superficial deformation (i.e. compressional and extensional ridges, low scarps, lineations and a noteworthy blocky pattern that extends over more than 600 km^2). Large areas of mass-movement deposits appear exposed on the seafloor. Sub-bottom profiles and sediment core data suggest this deposits took place before 13ky, although the presence of younger deposits can be hypothesized in some areas.

The occurrence of recent widespread mass-wasting deposits, along with possible evidences of incipient failures on the upper slope and the present-day activity of the normal faults suggest that future slope failure events can eventually affect the area.

This work provides high-resolution geomorphological dataset of the topographically complex seabed of the Apulian upper slope, for evaluating geo-hazards associated to possible slope failures.

Holocene evolution of the Northern Adriatic Platform: morphologic and stratigraphic evidence

FONTANA A.(1), CORREGGIARI A.M.(2), SLAVEC P.(3), REMIA A.(2), MASELLI V.(2), ZERJAL A.(3), POGLAJEN S.(3), CELARC B.(4), BAVEC M.(4), ROSSATO S.(1)

(1) University of Padova - Department of Geoscience, PADOVA, ITALY ; (2) CNR-ISMAR, BOLOGNA, ITALY ; (3) Harpha Sea d.o.o, KOPER, SLOVENIA ; (4) Geological Survey of Slovenia, LJUBLJANA, SLOVENIA

The northernmost part of Adriatic Sea lies between Istria, Karst and the Friulian Plain and it is divided between Italian, Slovenian and Croatian waters. A robust chrono-stratigraphic framework of the Northern Adriatic shelf was supported by the geophysical, bathymetric and stratigraphic data collected during cruises VE2004, VE2005 and RISA2009, that led to the production of the geological map of the Italian seabed. Moreover, in the last years Harpha Sea Inc. carried out a multibeam bathymetric survey of the Slovenian waters, leading to the production of a very high-resolution DEM. This was a key tool for understanding the sea-floor morphologies. During cruise NAD2012 the oceanographic vessel “Urania” surveyed the Italian and Slovenian shelf, acquiring 750 km of CHIRP-sonar seismo-acoustic profiles and 10 gravity cores. These new data allowed for the first time to observe in continuity the transition from the rocky coast of Istria to the Friuli plain.

The area between Monfalcone and Piran Bay is characterized by a mud-dominated body, consisting of Holocene marine deposits, with a maximum thickness of about 25 m in Piran Bay and that thins toward the Friulian coast, where the delta system of Isonzo River (Soca in Slovenian) is present. The marine sediments seal the alluvial plain that characterized the area until ca. 7.5 ka BC, when sea-level rise led the Adriatic to re-occupy the Gulf of Trieste. The ancient alluvial plain is characterized by a complex network of fluvial ridges fed by the valleys draining Karst and Istria; moreover, DEM highlight an incised meandering paleochannel, recognizable from the Italian shelf to Koper Bay.

The evolution of the Trieste Gulf was constrained by a main morphologic threshold corresponding to the deep morpho-structural depression existing in front of Savudrija Promontory. Some very large submarine dunes are connected to this incision.

****

Aeolian to shallow-marine shelf palaeo-landscapes off a major desert since the Late Pleistocene (Northern Mauritania)

HANEBUTH T.(1), MERSMEYER H.(1), KUDRASS H.(1), WESTPHAL H.(2)

(1) MARUM, BREMEN, GERMANY ; (2) ZMT, BREMEN, GERMANY

Continental shelves off desert regions are not expected to host substantial amounts of sediments due to long-lasting, unfocused material supply and a high re-mobilization potential of aeolian material. This study demonstrates significant volumes of sediments have accumulated on the hyperarid northern Mauritanian shelf during the past climatic cycle.

Using high-resolution seismo-acoustic data and sediment cores, eight late Pleistocene/Holocene depositional units are identified, each reflecting an individual depositional history. Based on (1) an older Pleistocene palaeo-landscape, (2) a continental dune complex (MIS-4), (3) a thick regressive shallow-water clinoform (late MIS-3), (4) a regressive to lowstand shore deposit (latest MIS-3), and (5) a local transgressive cover (LGM to deglacial) have developed. During the Holocene sea-level highstand, (6) an open-shelf highstand cover, (7) an outer-shelf highstand wedge and (8) mid-shelf mud depocenters have formed.

The common formation of locally confined depositional units, and in particular the MIS-3 progradational unit, is related to an interplay of a) partly pronounced arid climatic conditions resulting in enhanced aeolian and coastal sediment input, b) shelf current patterns focusing sediment deposition at certain locations, and c) early post-depositional sediment stabilization providing protection against erosion. Prominent internal surfaces at 63 and 115 m modern water depths indicate widespread and intense erosional activity during late MIS-3 regression and MIS-2 lowstand to transgression, hosting coarse shell sands and gravels from beach and shoreface palaeo-environments. Reasons for the surprisingly high preservation potential of confined stratigraphic units are a) carbonaceous cementation, b) sediment composition (massive widespread shore-related gravel and shell beds; subtle minor admixture of cohesive material), and c) morphological protection (inside seafloor depressions; behind sheltering relief).

Axial and off-axial morphology of Arctic and Polar Atlantic spreading ridges (analogous modeling)

KOKHAN A.
Moscow State University, Earth Sciences museum, MOSCOW, RUSSIAN FEDERATION

Spreading ridges of the region are presented with Reykjanes, Kolbeynsey, Mohns, Knipovich, Gakkel ridges. Crust in their rift zones extends with ultra-slow velocities less than 20 mm per year. Each of these ridges develops in specific geodynamic and kinematic conditions. They results in formation of specific axial and off-axial morphology. In order to distinguish basic structure-forming factors for each of the ridges we collected information covering their morphology, geological and geophysical structure, used morphostructural mapping and morphometrical analyses based on detailed bathymetry and unique analogous experimental method. Reykjanes and Kolbeynsey ridges develop under the influence of Iceland plume. This influence is asymmetric, concentrated mainly on Reykjanes ridge. Their morphology changes with increase of distance from Iceland. Axial volcanic ridges become higher and shorter, amplitude of offsets increases. Axial rise transfers to axial valley. Changes are defined by changes of width of heating zone and thickness of brittle crustal layer with increasing distance from Iceland plume. Mohns ridge is developing in conditions of narrow heating zone and strongly oblique spreading. Knipovich ridge forms in the transition zone between Mohns and Gakkel ridges along the Spitsbergen continental margin. It is subdivided into several segments each with its own obliquity. Morphology is defined by orientation of each segment relative to direction of regional extension. Gakkel ridge is the slowest portion of world system of spreading ridges (spreading velocity is less than 13 mm per year) and the longest of examined ridges. Its morphology is defined by changes of velocity, obliquety and, presumably, mantle temperatures along the ridge. Mohns, Gakkel and Knipovich ridges have amagmatic and magmatic segments. Length of amagmatic segments increases with decrease of spreading velocity and increase of obliquity.

****

Poster presentations:

River-Sea interaction and paleo-Yangtze giant delta system studies

WANG Y., ZOU X., YIN Y., ZHANG Y., LIU S.
Dept. of Coastal Ocean Science, Nanjing University, Nanjing,Jiangsu, CHINA

Recent researches indicated that the Paleo-Yangtze giant delta system distributed in South Yellow Sea and East China Sea was formed during mid-late Pleistocene, originating from the huge river sediments, discharged from ancient Changjiang and Yellow River, and being shaped by monsoon waves and tidal currents. Upon the huge delta base, there are four delta unions superimposed on the top, and developed in different geological time: Paleo Changjiang-Yellow river delta, radiative sand ridge field, Holocene-modern Changjiang river delta and abandoned Yellow River delta. The Paleo-Yangtze giant delta system geographically covers most areas of East China Sea and South Yellow Sea, which also presents the characteristics of local continental shelf sediments. A pioneering multi-dimensional survey to this region is proposed in the paper, which includes RS analysis, water depth and hydro-dynamic survey, seismic profile survey on bottom stratigraphic structure, sea-bottom surface and sedimentary core sampling, followed by multi-disciplinary scientific studies of marine geology, marine sedimentology, marine dynamics, land-sea interaction, sea-level change and marine GIS etc. Through the comprehensive study, it is expected that the geographical range of Paleo-yangtze giant delta system be identified, the sedimentary structure and geomorphologic features of the delta system be revealed. Furthermore, the study will re-build the land-sea interaction process and dynamic mechanisms during mid-late Pleistocene in the region, and supply case study on the development of accumulative continental shelf, which will also provide theoretical input to marine geology. Further study of this giant delta system will help to understand the developing trend of eroding-depositing dynamics of modern tidal flat, to legitimately plan potential land resources in the region, and to contribute important scientific evidences to guard the National territorial sea-rights.

Geodynamical analyses of relief of rift zones of ultra-slow spreading ridges

KOKHAN A., DUBININ E., GROKHOLSKY A.
Moscow State University, Earth Sciences museum, MOSCOW, RUSSIAN FEDERATION

The ultra-slow spreading ridges with extension velocities less than 20 mm/year are presented with Reykjanes, Kolbeynsey, Mohns, Knipovich and Gakkel ridges situated in North Atlantic and Arctic, and South West Indian (SWIR) and American-Antarctic ridges (AAR) situated in south Atlantic and southern part of Indian ocean. All of them develop in specific geodynamical conditions, which result in influence of certain geodynamical factors (kinematics, underlying mantle temperature, crustal structure). We see different patterns of structure-forming factors leading to formation of different relief of rift zones. Analyses of morphostructure and morphometry on a basis of detailed bathymetry, published data and results of experimental modeling let to distinguish morphotectonic types of ultra-slow spreading ridges and key structure forming factors leading to formation of their relief and tectonic patterns. Reykjanes and Kolbeynsey ridges, central part of SWIR form under influence of hotspots. Relief changes from fast-spreading-like to slow-spreading like with increase of distance form hotspots. Knipovich ridge and AAR formed as a results of regional changes of plate kinematic patterns and have significant strike-slip components in their kinematics. Relief is formed by long strike-slip segments with absence of magmatic activity and short magmatic segments. Central part of Gakkel ridge and eastern part of SWIR form in conditions of «cold» spreading and are largely amagmatic. Basalts are almost absent and replaced by serpentinised peridotites. Large portions of the ridge have no volcanic features. Western part of SWIR and Gakkel ridges, presumably, form in conditions of increased mantle temperatures. They have relief same with slow spreading Mid-Atlantic ridge. Thus, relief is formed under different combinations of tectonic, magmatic and metamorphic (serpentinisation) geomorphodynamical processes. Geodynamical conditions of ultraslow spreading are considered also.

****

Underwater geomorphological survey revealing past temporary standstills of the relative sea level in carbonate rock areas

EVELPIDOU N.(1), PIRAZZOLI P.(2)
(1) University of Athens, ATHENS, GREECE ; (2) CNRS-Laboratoire de Géographie Physique, MEUDON, FRANCE

Tidal notches can form on carbonate coasts during periods of relative stable sea-level, or when sea-level changes occur at a rate lower than the rate of bioerosion. Tidal notches have often been used for Quaternary sea-level reconstructions and for estimating tectonic movements, especially in uplifting areas.

Underwater geomorphological survey may reveal evidence of submerged tidal notches. Detailed, accurate and systematic survey along the coastal zone by boat is necessary, to access all sites and establish lateral continuity of observation. During the survey, the local lithology is taken into account. For each site, the time and the GPS coordinates are collected. Underwater, the observed features are measured in relation to sea level and photographed. Notch geometries (height, vertex and inward depth) are measured and interpreted. The accuracy can be improved by multiple measurements and by corrections based on air pressure and tidal records.

submerged tidal notches cannot be dated directly, but their age can be inferred from coastal cores or archaeological data. Information on the duration of the various sea-level positions can be deduced from assumptions on the minimum and maximum values of intertidal bioerosion in carbonate rocks.

Through this methodology new evidence concerning the rates of subsidence in the investigated area may be provided. The profiles of submerged notches, resulting from different combinations of RSL in sheltered areas, allow to qualitatively distinguish the way of subsidence e.g. co-seismic event, gradual relative sea-level rise, etc.

Some examples of tidal notch development and tectonic movements are provided from fossil submerged notches in Greece. Although tidal notches are not forming anymore in the present-day mid-littoral zone, underwater marks on carbonate cliffs may still provide evidence of submerged tidal notches corresponding to former sea-level positions, or to recent vertical shoreline displacements of seismic origin.

Late Holocene shorelines deduced from tidal notches on both sides of the Ionian Thrust: Fiscardo Peninsula (Cephalonia) and Ithaca Island

EVELPIDOU N.(1), KARKANI A.(1), PIRAZZOLI P.(2)
(1) University of Athens, ATHENS, GREECE ; (2) CNRS-Laboratoire de Géographie Physique, Meudon, PARIS, FRANCE

A submarine survey along the coasts of Ithaca and Fiscardo has permitted the identification of fossil shorelines produced by recent co-seismic movements.

In both areas a tidal notch slightly submerged below present MSL was observed at various sites. This “modern” notch is known to have been submerged by the global sea-level rise during the 19th and 20th centuries. The depth after tide and air-pressure correction of the vertex of the “modern” notch (= MSL before the recent sea-level rise) was measured between -19±6 and -25±6 cm at Fiscardo and between -34±6 and -43±6 cm at Ithaca. The presence of this “modern” notch at the same depth on both sides of the Ionian Thrust would give evidence that both areas were not affected by the co-seismic vertical movements that occurred in 1953 in the wider area, while a greater depth in Ithaca could be an effect of co-seismic subsidence. Both cases are discussed and analysed in this paper. Assuming that the development of the “modern” notch was produced by bioerosion, it is possible to deduce a period of relative sea-level stability before the 19th century during 2.4 to 4 centuries at Ithaca and 1.5 to 4 centuries at Fiscardo.

Over the longer term, the tectonic behavior of Ithaca differs from Fiscardo. At Ithaca no evidence of emergence has been found and Holocene vertical movements have been only of subsidence: fossil submerged tidal notches can be distinguished below MSL at depths (±6 cm) of about -40 (modern), -60, -75, -90, -100, -120, -130, -140, -150 and -220 cm. A southward tilting of the island is suggested from the -110 cm notch, but this is not the case for the -70 cm shoreline.

On the east coast of Fiscardo Peninsula impacts of ancient earthquakes have left some marks (±6 cm) of emergence at about +15 and +40 cm, and of submergence at about -20 (modern) -35, -50, -60, -70, -80, -90, -100 and -230 cm, with even some evidence of past uplift and subsidence at the same sites.

****

Raft Tectonics in SE Brazil as an example of large-scale gravitational collapse on continental margins

PIEDADE A.(1), ALVES T.(1), ZÊZERE J.L.(2)
(1) Cardiff University, CARDIFF, UNITED KINGDOM ; (2) RISKam.University of Lisbon, LISBON, PORTUGAL

The SE Brazil continental margin is dominated by continental-slope embankment, incision of submarine channel system and significant mass-gravitational processes, with salt tectonics playing a significant role in upper-crust deformation.It is known to comprise a margin rich in oil and gas, in which raft tectonics plays an important role in their migration and accumulation.

The interpreted high-resolution 3D seismic-reflection volume covers an area of 2400 km^2 offshore Espírito Santo, SE Brazil. This seismic volume was used in this study to evaluate the processes previously invoked to explain the gliding and deformation of rafts. Interpreted horizons include the base and top of Albian rafts, Late Santonian and seafloor.

To critically understand the relationship between rafts deformation and sediments was the key theme of this study, with the aim of ultimately answering the following questions: 1) how the post-raft overburden influences the gliding and deformation of Albian rafts?; 2) what other factors that overburden loading and slope gradient control the gravitational gliding of the raft tectonics?

Statisticalanalyses, surface images and thickness maps helped to describe and understand relationship between (i) thickness of rats and slope gradient; (ii) overburden thickness and thickness of rafts and (iii) spacing between rafts and sediment overburden. The acquired statistical data showa positive correlation between the degree of deformation observed in rafts and the thickness of overburden strata. The distance between adjacent rafts was also show to be influenced by the weight of the sediments overburden. We interpret these data as a proof that underlying salt was a primary control on raft tectonics in the study area, overriding the effect of overburden thickness and variable slope gradients on the rafts’ internal compartmentalisation. This study will show different styles of compartmentalization observed in Albian rafts from SE Brazil.

Morphological alterations of the seabed related to relict sand dredging for beach nourishment

NONNIS O., PAGANELLI D., PROIETTI R., PAZZINI A., NICOLETTI L., GABELLINI M.
ISPRA, ROME, ITALY

Beach nourishment with relict sands has been carried out for several years as a way to counter coastal erosion problems. It has proven to be a successful beach protection method and it is considered to be one of the main tools for coastal management. These deposits, located along the continental shelf, at variable depths, generally contain a large amount of sediments that have sedimentological characteristics similar to the actual beach sediments. It is however known that relict sand dredging may have significant physical and biological effects on the marine environment (seabed, water column and benthic and fish assemblages), especially in highly biodiverse environments and sensitive habitats, such as the Mediterranean marine-coastal system.

Within this framework, ISPRA has performed specific environmental studies related to relict sand dredging aimed at beach nourishment of a deposit situated offshore Montalto di Castro (Central Tyrrhenian sea) in order to assess the effects of relict sand mining on the marine environment.

The relict sand-dredging activities in this area took place in three different periods, July 2004, June and September 2005. For the first dredging, an anchor dredge was used, whereas for the second and third dredging a trailer dredge was used. The monitoring environmental surveys were carried out from May 2004 to October 2006, before, during and after the dredging activities.

The present study focuses on the morphological impact of relict sand extraction, and aims to examine the results of acoustic investigations performed before and after the dredging activities in Montalto di Castro deposit. These techniques represent an essential tool for an effective management of the marine environment and are particularly useful to accurately study the impact of human activities on the seabed.

****

Geomorphology of the Cyclades plateau (Aegean Sea, Greece)

SKENTOS A.(1), PAVLOPOULOS K.(1), KAPSIMALIS V.(2)
(1) Harokopio Univeristy, ATHENS, GREECE ; (2) Hellenic Center for Marine Research, ATHENS, GREECE

The Cyclades plateau is located in the central Aegean Sea and represents a shallow platform with an average depth of about 200 m. The sea floor is characterized by a complex morphology as a result of the recent geodynamic activity of the Aegean Sea. The purposes of this study are the identification and mapping of the submarine landforms, and the interpretation of the geomorphological particularities of the Cyclades shelf. High resolution seismic profiles and existing bathymetric data were used for mapping the seabed relief by using semi-automated cartographic tools. Further analysis and interpretation of the seismic profiles led to the identification of the sedimentary processes, stratigraphy, internal structure occurred in the study area sicne the Middle-Upper Quaternary. All data were imported into a Geographical Information System (G.I.S.) and were properly managed with main object the creation of a medium scale geomorphological map of the Cyclades plateau.

Geomorphology of submarine canyons and channels in the St. Lawrence Estuary (Eastern Canada)

NORMANDEAU A.(1), LAJEUNESSE P.(1), ST-ONGE G.(2)
(1) Centre d'études nordiques & Département de géographie, Université Laval, QUÉBEC, CANADA ; (2) Institut des sciences de la mer de Rimouski, Université du Québec à Rimouski, RIMOUSKI, CANADA

The morphology of the seafloor of the St. Lawrence Estuary is characterized by a deep submerged valley along its axis, the Laurentian Channel. In many sectors between the mouth of the Saguenay River to the west and Pointe-des-Monts to the east, the northern slopes of the Laurentian Channel are highly incised by many submarine canyons and channels. Despite that the stratigraphy and sedimentology of this region has been relatively well studied, the geomorphology, origin and evolution of these submarine landforms still remain poorly documented. These canyons and channels can provide important information on past environmental changes such as deglaciation history and relative sea-level fluctuations as well as past and present land-to-sea sediment transfer. In order to investigate these canyons and channels, multibeam echosounder, high-resolution subbottom profiler and sedimentary data were collected between Tadoussac and Pointe-des-Monts and allow their detailed examination. The newly acquired data reveal a wide variety of types of canyons with different sediment sources. Some canyons and channels are located at the mouth of rivers while others are found at the end of a littoral cell. Other canyons and channels are presently inactive and appear to have been activated during past higher relative sea-levels or during deglaciation.

****

Seafloor undulations in the Policastro gulf (South-eastern Tyrrhenian Sea): description and possible genetic mechanism

PALAMARA S., SAVINI A.
URL - CoNISMa, Milano-Bicocca, MILANO, ITALY

Sea-floor undulations have been observed in different contexts, from continental shelves to abyssal plains; such bedforms range from few meters to hundreds of meters in length and from centimetres to meters in height. Several genetic mechanisms have been suggested: some authors support the hypothesis that sea-floor undulation are depositional structures induced by bottom currents and/or hyperpycnal flows, others relate sea-floor undulations to slope instability, while some other authors attribute such structures to the combination of currents and gravity processes.

Our study focus on sub-bottom profiles and multibeam swath-bathymetry data collected in the Policastro Gulf (South-eastern Tyrrhenian Sea), by the Italian R/V Universitatis in 2004.The whole data set revealed the presence of a sea-floor undulations field, off Policastro, along the Bussento River prodelta, in water depth ranging between 50 and 70m.

To evaluate a possible genetic mechanism, in relation to the local hydrodynamic and morphologic condition, the sea-floor undulation off the Bussento River were mapped, described and measured; in summary they range from 20 to 130 m in wavelength and from 1.40 to 1.60 m in height. The crests orientation is WSW-ENE, following the trend of the shelf isobaths. Based on measured morphological parameters and a comparing with other undulation fields described in literature, we assume that these bedforms are produced by hyperpicnal flows generated by the Bussento river.

Detached blocks from submarine slides investigated using quantitative geomorphological techniques

MARCHESE F., SAVINI A.
Milano-Bicocca University, MILANO, ITALY

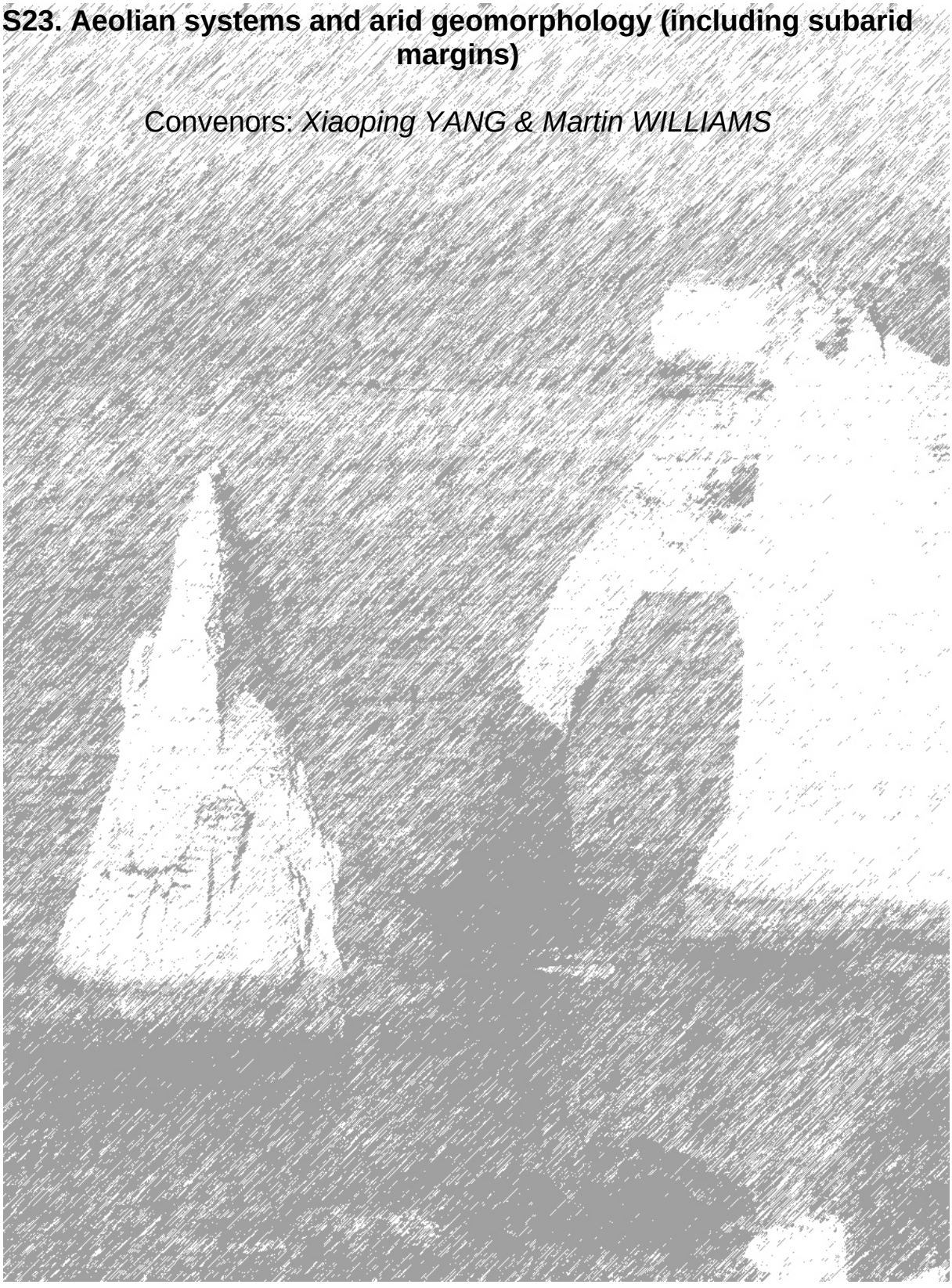
Quantitative analysis on Digital Elevation Models (DEMs) are rarely conducted on submarine landscapes. Only recently the application of quantitative geomorphometric techniques to the bathymetry data set has been effectively tested and the authors demonstrated their utility in improving the geological interpretation of submarine environments.

In this paper geomorphometric analytical techniques were applied to a high-resolution bathymetry data set acquired along 2000km^2 survey area located on the upper part of the southern Apulian slope (Northern Ionian sea), between 80 and 1400 m of water depth. The DEM provided by multibeam data processing and the computed terrain parameters, well show a broad area affected by mass-transport deposition, which results in a very complex hummocky seafloor, shaped by detached block-like features. We focus our analysis on the automatic extraction of the most significant morphometric features of the surveyed area. The objective identification of morphologic features represents indeed a significant step in defining spatial units that are related to geomorphological processes. Our computation was in particular applied to observe the seafloor distribution of the complex pattern of the identified detached-blocks like-features. The quantitative analysis of these features showed that he blocky pattern is more pronounced where it regionally faces NE and SW on the more elevated sectors of the margin, where tectonic deformations generated a suite of vertical offsets; whereas fewer blocky features are evident within the more depressed areas. Since these blocky features are colonised by carbonate framework building organisms (i.e.: cold water corals), our quantitative results strongly support the hypothesis that in this area cold water coral growth has tended to enhance the complex morphologies of the seabed, originally formed by a variety of mass-transport processes.

****

S23. Aeolian systems and arid geomorphology (including subarid margins)

Convenors: *Xiaoping YANG & Martin WILLIAMS*



Oral presentations:

Mean residence time in barchan dunes from numerical modelling

ZHANG D.(1), YANG X.(1), NARTEAU C.(2), ROZIER O.(2)
(1) Institute of Geology and Geophysics,Chinese Academy of Sciences, BEIJING, CHINA ; (2) Institut de Physique du Globe de Paris, PARIS, FRANCE

How the bedforms affect the motion and the storage of sedimentary particles is still an open issue. Then, there is still no satisfactory residence time distribution and transport laws to describe the evolution of individual grains in sedimentary layers sheared by a fluid flow. We analyze sediment particles motions in steady-state barchan dunes by tracking individual cells of a 3-D cellular automaton dune model. The overall sedimentary flux may be decomposed into various physical processes to show how advective and dispersive fluxes contribute to the barchan dune shape. The net lateral sediment transport from the center to the horns indicates that dispersion on the lee slope is more efficient than avalanches on the stoss slope. However, the combined effect of these two antagonistic dispersive processes enhances the lateral mixing of sediment particles in barchan dunes. We find that the mean residence time of sediment particles in barchan dunes is equal to the surface of the central longitudinal dune slices divided by the input sand flux. We infer that this central slice contains most of the relevant information about the barchan dune morphology. Finally, we use the relationship between the mean residence time and the characteristic migration time of barchan dunes to discuss sediment transport and memory and transport in presence of bedforms.

****

Complex Geo-Ecological responses to climate change in dry-land areas: Northern Negev desert, Israel

YAIR A.
Hebrew University of Jerusalem, Department of Geography, JERUSALEM, ISRAEL

Semi-arid and arid areas are often regarded as highly sensitive to climatic changes. A positive relationship between average annual rainfall and related environmental variables is usually assumed for such areas. This approach disregards the fact that a climate change in dry-land areas is often accompanied by by a parallel change in surface properties, such as sand deposition during adry climatic phase and loess during a wet phase. The new surface properties can be expected to exercise a strong influence on infiltration, runoff, soil moisture regime and water availability for plants. The sandy area, along the Egyptian-Israeli border offers a good opportunity to study the complex relationships between climate and various environmental variables along the present day rainfall gradient (86-170 mm average annual rainfall). Along a transect, 35 km long, several different gradients have been identified (geomorphological, micro-biological, botanical, hydrological, organic matter content etc..). Some of the variables are positively related to average annual rain amounts, while others show an opposite relationship. On the whole, data collected show a differential development of the biological crusts along the rainfall gradient. The crust, in the wetter area, is better developed, richer in fine grained particles and organic matter content than the crust in the drier area. However, the better developed crust is able to absorb, and retain, all rainwater at most rainstorms, limiting thus the depth of water infiltration and water availability for higher plants. At the same time, the crust in the drier area absorbs less water and generates surface runoff. The overall result is deeper water penetration and water availability for the perennial vegetaion, very well expressed by the extent of the vegetation cover and species diversity.

Dynamic stone pavements - insights from experiments and numeric modelling

DIETZE M., KLEBER A.
TU Dresden, DRESDEN, GERMANY

Stone pavements are prominent surface phenomena of arid environments. Although most stone-pavement properties may be explained by vertical processes, there remain several features (buried clast stratae, recovering surface disturbances, preferred bimodal, slope-aspect-symmetrical clast orientations) that argue for lateral processes to restore and maintain stone pavements. Field experiments identified two mechanisms that may contribute to lateral clast transport: unconcentrated overland flow and creep. Both processes are described in terms of i) conceptual models, ii) physical equations used for numerical modelling and iii) laboratory experiments to test the models.

The vesicular horizon plays a decisive role for both processes. It is a prominent surficial formation in the fine-grained aeolian sediments typically deposited below stone pavements. Unconcentrated overland flow of a few centimetres depth is able to drag clasts and rotate them upon collision with obstacles (e.g. other clasts). This angle-dependent force equilibrium is able to exactly reproduce the natural bimodal clast orientation pattern and is confirmed by flume experiments. The creep process is exceptional, as it affects only clasts whereas finer sediments remain essentially in place. Upon rain-water infiltration into the vesicular horizon, an advancing wetting front replaces soil air, which preferentially escapes from the soil under the dry clast undersides thereby lifting them. This lifting results in an average downslope displacement of 100 µm per wetting event (or up to a few metres per thousand years). Colliding clasts become rotated, similar to water-dragged objects. Thus, both lateral processes contribute to stone pavement recovery from disturbance. Including lateral dynamics to existing stone pavement formation models allows to more fully explain the observed properties.

****

What makes Australian desert dunes so stable? Vegetation and sand transport response to variable rainfall

HESSE P.
Macquarie University, MACQUARIE UNIVERSITY, AUSTRALIA

The vegetated sand dunes of Australia's dunefields have shown lateral stability over tens of thousands of years and episodic vertical accumulation. How much of their present stability is dependent on the vegetation cover, and how sensitive is that cover to climate variability?

Sand dunes in the Simpson and Strzelecki Deserts were monitored through the 2000-2010 drought and during the subsequent wet La Nina period. Vegetation and sand transport indicators were measured on the dune crests. Sites included vegetated longitudinal dune crests and bare patches with small slip-faces.

There is a negative relationship between the amount of mobile sand and the areal cover of vascular plants but an even stronger relationship with the areal cover of binding cyanobacterial crusts. However, there is no relationship between the frontal area of the vegetation and sand transport indicators. In summary, vegetation stabilises the dune crests by sheltering the surface and binding the sand, but not by increasing surface drag.

This may be due to the complex vegetation structure. Several components of the vegetation were observed to vary greatly over the ten year period of measurement, more or less independently. There is a weak dependency of cyanobacterial crust on short-term (3 month) rainfall. Tall vegetation (> 50 cm) shows a relationship to longer term rainfall (up to 3 years) for perennial vegetation and previous summer rainfall for some ephemeral mega-forbs.

The stability of the protection offered by vegetation stems from the relatively high frequency of large rainfall events, even during drought, and the lagged response of vegetation, even continuing after death.

To destabilize these dunes would require many consecutive months without large (>20 mm) rainstorms and extended periods of many years with annual rainfall less than 100 mm. This is more severe than the current driest average climate of the Simpson Desert but occurred for several years during the the early 20th Century.

The relative efficacy of wind and fluvial erosion of bedrock in northern Chile

PERKINS J.(1), FINNEGAN N.J.(1), DE SILVA S.L.(2)
(1) University of California Santa Cruz, SANTA CRUZ, CA, UNITED STATES ; (2) Oregon State University, CORVALLIS, OR, UNITED STATES

Yardang fields testify to the dominance of wind erosion of bedrock in many arid settings. However, landscapes that apparently arise from the interaction of wind and fluvial bedrock erosion processes are also common on Earth and Mars, suggesting that fluvial and aeolian bedrock incision processes can occur at similar rates. Such a finding would have important consequences for interpreting arid bedrock landscapes, however to our knowledge rates of fluvial and wind erosion processes have not been quantified in the same setting. Here we exploit a natural experiment within the 4.09 Ma Puripicar ignimbrite along the western slope of the Andes in the Atacama desert. The Puripicar is incised by a series of bedrock river gorges with large knickpoints that likely reflect a transient response to the emplacement of the ignimbrite. These knickpoints are nested behind a broad north--south escarpment that is retreating headwardly from wind erosion via undercutting and block toppling of the bedrock, resulting in an array of megayardangs between the gorges. Strong geologic evidence indicating the original extent of the Puripicar allows us to map the initial escarpment location and thus directly measure windward escarpment retreat since its emplacement. To quantify bedrock incision rates, we use well-established approaches that relate vertical bedrock incision rate to knickpoint retreat rate. These calculations yield a median vertical incision rate of 0.1 mm/yr from analysis of 17 channels. Measurements of windward escarpment retreat, however, yield a median value of 0.8 mm/yr from analysis of 18 megayardangs. Thus wind erosion is by far the dominant driver of landscape evolution along the western slope of the Andes in northern Chile. As far as we know, this study is one of the first direct comparisons of aeolian and fluvial incision rates within a bedrock landscape, and highlights the significant geomorphic impact of wind even where bedrock river gorges are present.

****

Form-flow interaction of star dune arms

BIEJAT K., DLUZEWSKI M.
Faculty of Geography and Regional Studies, University of Warsaw, WARSAW, POLAND

The focus of the study was to analyze different types of star dunes' arm shape, which depend on the locally induced wind flow. The study was made on compound star dunes differentiated in size, in the area of bimodal wind regime. In this area the direction of main arms is related to two dominant wind directions. The vertical arms development depends on locally induced wind direction, which inclination must be more than 30° to the arm direction.

We distinguished 3 main types of arm shape. The first one has sharp crestline and high slope inclination on both sides. Its development relates on high acceleration of streamline on the stoss side and formation of strong reverse flow on lee side. It causes the vertical grow of arm, with low impact on lateral migration. The second type has also sharp crestline but a different slope inclination. On the slope of lower inclination the streamline acceleration is lower than in first type of arms, but the avalanche on the lee slope does occur. On another side the reverse flow is weak and doesn't give the opportunity to transport the material up the lee side slope. The arm migrates laterally but doesn't grow vertically. On the third type, the upper part of arms has convex shape, with no sharp crestline. On both sides the slope inclination is low to moderate. The development of this type of arms depends on streamline acceleration on stoss side, which is related to the slope inclination. On this type the convex streamline curvature is also very important: it encourages flow stabilization and a decrease in shear stress.

We found that the types of star dune arms don't depend on its size. The analyses of the shape of main and subsidiary arms show that on main arms mostly occur first and second type of arms shape and on subsidiary arms mostly the third one. The occurrence of the first type of arms shape on subsidiary arms is very rare. Our study shows that especially on development of star dune arms flow-form interaction is very important.

Sand bulk density as an indicator of form-flow interaction on barchan dunes

DLUZEWSKI M., BIEJAT K.
Faculty of Geography and Regional Studies, University of Warsaw, WARSAW, POLAND

The aim of the study was to analyze the sand bulk density of the surface layer of barchan dunes. The bulk density measurements were made in the natural conditions with the use of densimeter prepared specially for the field study. Before the measurements were made, the densimeter was tested and calibrated with height level ofgoodness of fit. To check the universality of our results, we ran the measurements in 2 periods and in two areas differentiated on wind regime, sand texture and mineralogical composition. In each of 42 dunes we made 300 sand bulk density measurements on average. The position of each point on the dunes surface was done with the use of GPS RTK.

We distinguished 3 main zones of different sand bulk density. Obviously, the lowest bulk density is on the avalanche slope where flow separation takes place. The highest bulk density is on the barchan arms where the flow is decompressed and decelerated. The most interesting is the zone on the stoss slope, which is the area of wind flow acceleration. The density depends there on slope topography and on wind direction changes. If the wind comes from dominant direction, the main factor influencing the density distribution is only the dune morphology. In the direction of the symmetry axis, the size of low density zone depends mainly on the length of the slope with highest inclination and the streamline curvature. In the areas of higher wind directional variability, the dune is wider and becomes a bigger barrier which causes the extending of low density zone in the direction perpendicular to the symmetry axis. If the wind direction changes, the zone of low density will move to the front of incoming wind. Our results show that bulk density distribution can be a good indicator of form-flow interaction and short time variability of wind direction. The comparison of the results from 2 investigated areas shows that the position of the analyzed zone doesn't depend on textural or mineralogical composition of dunes sand.

****

Vegetation change and geomorphological response of dryland hillsopes

CAMMERAAT E.(1), KAKEMBO V.(2)
(1) IBED-Earth Surface Science, AMSTERDAM, NETHERLANDS ; (2) Geosciences Department, Nelson Mandela Metropolitan University, PORT ELIZABETH, SOUTH AFRICA

The geomorpghological response of ecosystems often changes as a result of vegetation cover alterations. These changes can either be due to human or climatological factors. We compare in this study two rangeland ecosystems with respect to their geomorphological and hydrological response, one in SE Spain and one in SE South Africa respectively.

In southeastern Spain degradation occurs through extension of rill and gully systems in semiarid semi-natural tussock grass dominated rangelands. In southeastern South Africa sub-humid grasslands on abandoned soils are spontaneously being invaded by the exotic shrub Pteronia incana (Blue bush) originating from the semi-arid and arid Karoo region. This results eventually in the occurrence of bare patches and the development of bare patches.

In both cases the connectivity between bare areas is increased leading to increased soil loss and rill and gully erosion and consequently loss of soil quality. This in consequence is changing the eco-hydrological response of the hill-slopes leading to a dramatic increase of runoff and erosion.

We analyzed high resolution low altitude images of vegetation patterns in combination with terrain model analysis. We applied this procedure for different patterns reflecting a time series covering the observed changing patterns. By doing so we may be able to unravel critical processes as indicated by changes in vegetation patterns that might enable us to mitigate degradation of dryland ecosystems.

Fog-induced slumping in a hyper-arid dunefield, Namibia

BOURKE M.(1), VILES H.(2), CONWAY S.(3), GOUDIE A.(2)
(1) Trinity College, DUBLIN, IRELAND ; (2) University of Oxford, OXFORD, UNITED KINGDOM ; (3) Open University, MILTON KEYNES, UNITED KINGDOM

Fog is the principal mode of moisture precipitation in the hyper-arid Namib Desert. It is an important resource for humans, plants and animals. The influence of the fog regime in aeolian systems is not well understood, despite the significant volume of moisture (and salts) that can precipitate. This paper presents data from a field campaign in Namibia that measured the diurnal-scale cycling of fog precipitation on dunes. Data were collected on moisture, and temperature at the surface, in the shallow sub surface (<5cm) and to 50 cm depth over 5 consecutive diurnal cycles under conditions of fog precipitation. Soil samples were analysed for salt composition and amount and grain size.

Fog collectors deployed at the dune surface show daily variation in total moisture receipts between 28% and 58% weight. Our data show that while there is some limited effect of dune aspect on the receipt of moisture, the fog moisture penetration front is shallow, detected only in the upper 2 cm of mobile sand. Natural drying of moisture from the dune surface occurred rapidly each day during the sample period.

Dune surface sands had between 7 and 33 ppm cations and 7 and 52 ppm anions. Pilot samples indicate a decrease in concentration with distance from the coast. There is significant variation in the concentrations of salts in the dune and interdune sediments. This reflects an enrichment of interdune sediments by a high local watertable.

Extensive shallow slumping of dune slopes indicate a geomorphic threshold was crossed on the dunes when >55% and <58% (weight) fog moisture was precipitation on the dunes. Meso and micro fissuring of the moist surface sand was extensive on the steep dune slopes with the development of large slump areas (1-4 m wide) with concomitant sand blocks, overthrusts and tangential fracture systems. The failure plane developed between the moistened surface and dry underlying sand. Sediment transport during wind gusts may have played a role in destabilising slopes.

****

The Kufrah paleodrainage system in Libya: Mapping the past from space

PAILLOU P.
Univ. Bordeaux - OASU, FLOIRAC, FRANCE

Using sub-surface mapping capacities of spaceborne radar, we mapped a major paleodrainage system in eastern Libya, the Kufrah River, that could have linked the Kufrah Basin to the Mediterranean coast through the Sirt Basin, possibly as far back as the middle Miocene. Radar images acquired by the Japanese PALSAR sensor revealed a 900 km-long river system, which connects the Kufrah Basin to a large alluvial fan in the Sarir Dalmah region. Despite the sand dunes of the Calanscio Sand Sea prevent orbital radar penetration, a 300 km-long link to the Gulf of Sirt through the already known Wadi Sahabi paleochannel is likely. New results, obtained by combining radar images and topography from the SRTM mission, confirm the hypothesis of an uninterrupted sediment pathway between the Kufrah Basin and the Mediterranean coast. The Kufrah River paleowatershed, at its maximum extent, would have then covered more than 400000 km2, representing close to a quarter of the surface area of Libya. It represents a likely corridor for fauna and human dispersal in the eastern Sahara, and thus indicates locations where further paleontological, paleo-anthropological and archeological field exploration should be conducted.

The Southern Westerlies in Central Chile during the last glacial cycle as documented in coastal dunes and paleosols

VEIT H.(1), PREUSSER F.(2)
(1) Geographical Institute, Univ. of Bern, BERN, SWITZERLAND ; (2) Stockholm University, STOCKHOLM, SWEDEN

The long term dynamics and changes in the position of the Southern Hemisphere Westerly Winds (SWW) during glacial-interglacial cycles have been discussed since decades. In South America related paleoclimatic information is mainly based on marine and limnological/pollen records. Here, we discuss for the first time results obtained from the investigation of dunes and paleosols along the semiarid central Chilean coast ("Norte Chico", 33-30°S). Rainfall in that area originates exclusively from the SWW during their northernmost position in wintertime which itself, is controlled by the position and intensity of the South Pacific Anticyclone (SPA). This geographical position makes the Norte Chico to a very sensitive region for changes in the position and intensity of the SWW/SPA.

Coastal dunes and their interbedded paleosols were studied at three locations, applying geochemical analysis and OSL-dating. Altogether, four dune generations during the last glacial-interglacial cycle could be identified. The older three paleosols are characterized by Bt-horizons with well developed clay cutans. The Holocene soils, in contrast, are weakly developed Cambisols. Dune formation and soil evolution seem to follow a periodic pattern during the last 100.000 years, showing a strong match with the precession cycle and the insolation at 30°S. Accumulation of sands predominantly occurred during periods with low summer and high winter insolation. This mode could have led to a relatively southern position of the SPA during winter, blocking the westerly storm tracks and leaving the Norte Chico dry. Probably, wind speed also increased during that mode, distributing the Aeolian sand relatively far inland. Vice versa, during periods with high summer and low winter insolation, the SPA remained in a relatively northern position during winter and rain from the SWW could penetrate further north. This allowed soil formation with deep clay illuviation at the coast.

****

Causal links between Eastern Mediterranean sapropel formation, Nile floods and White Nile source-bordering dunes confirmed by OSL and radiocarbon dating.

WILLIAMS M.(1), DULLER G.(2), WILLIAMS F.(1), MACKLIN M.(2), WOODWARD J.(3), EL TOM O.(4), MUNRO N.(5)
(1) UNIVERSITY OF ADELAIDE, ADELAIDE, AUSTRALIA ; (2) Aberystwyth University, ABERYSTWYTH, UNITED KINGDOM ; (3) The University of Manchester, MANCHESTER, UNITED KINGDOM ; (4) Agricultural Research & Technology Corporation, WAD MEDANI, SUDAN ; (5) Old Abbey Associates, DIRLETON, UNITED KINGDOM

It has long been hypothesised that beds of highly organic mud or sapropels seen in marine cores from the floor of the Eastern Mediterranean accumulated during times of high fluvial discharge and sediment input. Our recent fieldwork in the valleys of the Blue Nile and main Nile has for the first time revealed a sequence of extreme flood episodes synchronous with sapropel units S9 (240 ka), S8 (217 ka), S7 (195 ka), S6 (172 ka), S5 (124 ka), S4 (102 ka), S3 (81 ka), S2 (55 ka) and S1 (13.5-9 ka). During times of extreme floods, wide distributary channels of the Blue Nile flowed across the Gezira alluvial fan in central Sudan and transported a bed load of sand and gravel into the White Nile valley. The sands were reworked by wind to form source-bordering dunes, all of which contain heavy minerals of Ethiopian provenance. Three conditions are necessary for source-bordering dunes to form. The first prerequisite is a regular supply of bed load sands brought in by rivers that dry out seasonally, leaving their sandy point-bars exposed to deflation. The second requirement is an absence of riparian vegetation so that sand movement out of the channel through deflation is not impeded. The third condition is a regime of strong unidirectional winds, in this case from the north. For the dunes to develop and continue to extend downwind, the alluvial sand supply needs to be regularly replenished. These dunes were active at 115-105 ka, 60 ka and 12-7 ka, all times of extreme Blue Nile floods. The flood and dune sediments were dated using a combination of OSL and radiocarbon analyses. The Nile floods discussed here show a precessional signal and reflect episodes of stronger summer monsoon and more northerly seasonal movement of the ITCZ, linked to times of higher insolation in northern tropical latitudes. Progressive aggradation of Holocene Nile channels in northern Sudan had a profound influence upon human settlement in the last 8000 years.

From dune accumulation to soil formation - Is climate change required?

FAUST D.(1), WILLKOMMEN T.(2), YANES Y.(3), ZOELLER L.(4), RICHTER D.(1)
(1) TU Dresden, DRESDEN, GERMANY ; (2) TU-Dresden, DRESDEN, GERMANY ; (3) CSIC, GRANADA, SPAIN ; (4) Uni Bayreuth, BAYREUTH, GERMANY

The northern part of Fuerteventura is characterized by large dune fields. We investigated dune palaeosol sequences in four pits to establish a robust stratigraphy supported by some OSL-datings. According to our results we propose a standard section for the eastern Canary islands. An interaction of processes like dune formation, soil formation and redeposition of soils and sand are most important to understand the principles of landscape development in the study area. To our mind a process cycle seems to be important: First climbing dunes are formed by sand of shelf origin. Then soil formation took place (or not). Soil and/or sand were then eroded and deposited at toe slope position. This material in turn is the source of new sand supply and dune formation. The described cycle may be repeated several times and this ping pong process holds on.

We ask if palaeoenvironmental conditions may change without disturbing dominant process combinations. Our geochemical data and mollusc assemblages point to changing environments in space and even climate oscillation in time. One fundamental question still remains unanswered. Do we in deed need climate change to change process combinations (e.g. from dune formation to soil formation)?

Assuming that different processes may happen under one climate, increasing soil forming intensity could be mainly a function of decreasing sand supply. This in turn could be caused by reduced sand availability. These ideas may stimulate a new discussion in geomorphology about geomorphic changes (soil formation vs dune accumulation) regardless of the climate.

****

Climate change and sandy aeolian depositition during the Last Glacial Maximum and Late Glacial in northwest Europe with special reference to the Lutterzand type locality, eastern Netherlands

KASSE C.
Faculty of earth and life sciences, Vrije Universiteit, AMSTERDAM, NETHERLANDS

Periglacial aeolian sand sheets and dunes of the last glacial cover extensive areas of northwest and central Europe. Four sedimentary facies have been identified that are related to fluvio-aeolian and cryogenic processes, moisture content of the depositional surface and surface morphology. Three phases of aeolian sand deposition have been distinguished. High-resolution dating using optically stimulated luminescence of the type locality Lutterzand in the eastern Netherlands has recently improved the age control. Phase I (c. 28-19 ka) with predominant fluvio-aeolian deposition was related to continuous permafrost conditions of the Last Glacial Maximum. The first climate warming and permafrost degradation occurred at circa 19-16 ka during the formation of the Beuningen Gravel Bed, an erosional unconformity and desert pavement. Phase II (c. 16-14 ka) represents a short period of coversand formation at the waning stage of the last glacial. The rapid climatic improvement at the start of the Lateglacial (c. 14.7 ka) resulted locally in a decreased aeolian accumulation rate and formation of the Lower Loamy Bed. Aeolian deposition came to a hold during the Allerød interstadial when the Usselo Soil developed. Phase III (c. 13-11 ka) with more localized deposition occurred in the Younger Dryas stadial probably related to opening of the vegetation cover. In contrast to the Pleniglacial-Lateglacial climatic warming, the Younger Dryas to Holocene transition is reflected by an immediate system response and cessation of aeolian deposition. It is shown that the aeolian phases not strictly coincide with glacial or stadial conditions. Climatic aridity, limited vegetation cover and delayed responses of the aeolian environment to climate and vegetation changes determine the duration of the aeolian phases.

Pleistocene cold-climate wind system in the foreland of the Pannonian Basin

SEBE K.(1), ROETZEL R.(2), FIEBIG M.(3), LÜTHGENS C.(3)
(1) University of Pecs, Dept. of Geology, PECS, HUNGARY ; (2) Geological Survey of Austria, WIEN, AUSTRIA ; (3) Institute of Applied Geology, BOKU, WIEN, AUSTRIA

During cold periods in the Quaternary, the intracontinental Pannonian Basin was part of the European periglacial zone, and aeolian erosion had a profound effect in shaping the landscape. Geomorphologically most effective winds were channelled between the Alps and Carpathians and entered the Pannonian Basin from the NW. To assess the nature of meteorological conditions producing these winds, field studies were carried out in the foreland of the basin entrance, in Eastern Austria.

As a result, we report on the first bedrock ventifacts from Austria and aeolian sand occurrence in the Bohemian Massif. Through a compilation of published data and field work, the distribution of ventifacts was mapped and appears to be controlled primarily by available lithologies. Paleo-wind directions were identified using ventifact mesoforms, especially flutes. The acquired air flow directions are accordant with the orientation of erosional landforms on soft sediments and form a coherent system, with westerly winds in the west, which turn toward the entrance of the Pannonian Basin in the east. There are no directions referring to the direct influence of katabatic winds, instead, the wind system must have been driven by synoptic-scale patterns, e.g. polar fronts. The narrow distribution of wind directions suggests that the low-altitude air flow system was relatively stable even without a funneling topography as in the Pannonian Basin, though the Alps could have acted to deflect the winds. The results provide data for aeolian transport studies, among them for loess provenance analyses.

****

Timing and spatial distribution of loess-like sediments and late Quaternary alluvial fans in Mongolia and adjacent areas

LEHMKUHL F.
Department of Geography, RWTH Aachen University, AACHEN, GERMANY

Geomorphological and sedimentological investigations in the mountain areas of northern Mongolia (lower and middle reaches of the Orkhon River) and investigations of aeolian sediments in southern Mongolia (Khangai and Gobi Altai) provide evidence for late Pleistocene terraces and huge alluvial fan development. Pleistocene and lateglacial luminescence data were obtained for basal sand deposits overlying slope bedrock and the Pleistocene terraces and alluvial fans of the Orkhon River. During the Holocene soil development occur in mainly silt-size aeolian deposits in the mountain areas and in northern Mongolia. OSL and radiocarbon data from aeolian sediments and paleosols indicated soil formation at around 11-10 ka, 7-6 ka and 3 ka. In the deserts of southern Mongolia a more humid early and mid Holocene can be divided from a more arid late Holocene.

Landforms of the hyper-arid Northern Emirates, United Arab Emirates

PAIN C.
University of Seville, OLVERA (CADIZ), SPAIN

The first important event in the evolution of landforms in the Northern Emirates was the Miocene uplift of the Hajar Mountains, which form much of the eastern half of the Northern Emirates. This initiated erosion of deep valleys in the mountains, transport of the resulting sediment out into the surrounding areas, and development of alluvial plains. These plains extended at least as far as the present coast and are now covered by relatively thin sand dunes.

Quaternary sea level and climate changes have played an important role. Low sea levels exposed large areas from which sand was blown from the west to the east, leading to dune building. High sea levels cut off the sand supply and allowed alluvial erosion and deposition from the mountains to dominate in the east. Wetter climates led to erosion on the mountains and alluvial deposition on the plains, while drier climates meant more eolian activity and dune building.

During glacial periods the Arabian Gulf was almost dry and the sea retreated to the Strait of Hormuz. The Tigris and Euphrates rivers extended the entire length of the Gulf, and carried large loads of sediments that were reworked by the dominant north-westerly Shamal winds. The Shamal is primarily responsible for the formation and continued evolution of the dunefields seen in the Northern Emirates today. These winds created extensive dune fields and also deflated areas, leaving small plains of alluvial material exposed between dune systems, where groundwater levels approach the surface. Dust storms continue to add dust and calcium carbonate to the dunes.

The current marine incursion into the Arabian Gulf limits the source of new material to continue feeding the dune fields of the Northern Emirates. This shortage has led to minor deflation of existing coastal flats to a level that reflects the extent of the capillary fringe from the underlying saline water tables. The formation of coastal landforms was dominated by the effects of the current high sea level.

****

Morphoclimatic significance of eolian plugs on the northern margins of Sahara desert

BENAZZOUZ M., BOUREBOUNE L.
Faculty of Earth Sciences, University Mentouri Constantine, Algeria, CONSTANTINE, ALGERIA

The actions of the aeolian morphogenesis through the Northern margins of the Sahara desert result to triggering a partial disorganization of the hydrographic network in Saharan atlas mountains during the upper Pleistocene. This disorganization of runoff puts in evidence the major role of the aeolian plugs filling bottoms of valleys and plains. The interaction of the wind actions and fluvial actions is at the origin of the setting up of the aeolian plugs with blackish paludal formations and travertinous beds as indicators of temporary paralysis of the runoff and could be good indicators of the palaeohydrological variations.

These aeolian plugs are located on the borders of the eastern Saharan Atlas mountains and develops a length and a width of a few hundreds of meters to some kilometers and a thickness of 10 to more than 30 meters.

These accumulations are composed of two superposed forms:

- The sandy dam with convex forehead constitutes the sedimentary body obstructing,
- The sandy aeolian plug in progress uphill and linking down to a terrace or glacis level. The study concludes to identify arid climatic fluctuations of this period confirming the influence of the desert outside the northern limits of the Algerian Sahara.

Mapping China's deserts and desert margins: A database approach to understanding form, process and causality

SCUDERI L.(1), WEISSMANN G.(1), YANG X.(2), KINDILIEN P.(3)
(1) Dept of Earth & Planetary Sciences, University of New Mexico, ALBUQUERQUE, UNITED STATES ; (2) Institute of Geology and Geophysics, Chinese Academy of Sciences, BEIJING, CHINA ; (3) Center for Rapid Environmental Assessment and Terrain Evaluation, U. New Mexico, ALBUQUERQUE, UNITED STATES

Despite decades of research on China's desert and desert margin systems, fundamental questions remain about how they function and interact with other environmental systems both regionally and globally. The predominant focus of past desert research in China, and globally, has been location specific with case studies within distinct subdisciplines. This narrow view makes development of a comprehensive understanding of desert system dynamics difficult. In part, a great deal of the current research weakness is due to the lack of a unifying conceptual approach and the failure to appreciate the value of synoptic overviews provided by highly structured and synthesized compilations of data, organized in user-friendly formats. Recent developments in platforms and sensors, as well as the ability to access these rich new data sources in real time present scientists with both opportunities and problems. We now record data about the physical world at unprecedented rates with extremely high spatial/spectral resolution. Yet the ability to extract scientifically useful knowledge from such immense data lags considerably. The fields of database creation, data mining and modern statistics all focus on such interdisciplinary data analysis problems and in recent years these fields have made great advances in analyzing complex real-world data. However these methods have enjoyed relatively modest penetration into the sciences. We report on the application of these new technologies to the desert environments of China as well as to other global scale systems and illustrate the value of well-constructed databases and tool-rich analysis environments for understanding form, process and causality in these systems. We also show that our approach provides a "living" archive that allows us to capture change currently occurring in all of China's deserts as well as to assess human efforts to modify desert and desert margin environments.

****

Aeolian sand landforms in the Mainling Wide Valley of the Yarlung Zangbo River

ZHOU N., ZHANG C.
State Key Laboratory of Earth Surface Processes and Resource Ecology, Beijing Normal University, BEIJING, CHINA

Aeolian sand landforms are a distinctive geomorphic feature of China's Mainling Wide Valley. We measured topographic parameters in the field and via remote sensing to characterize their distribution, aeolian sand activity, and evolutionary sequence. The landforms displayed a banded, discontinuous pattern along the river valley. Belts of aeolian sand on river terraces play a key role in transporting sand uphill from the river. Three sand belts were identified: in the embryonic belts (EB), an erosive air stream combined with relatively high vegetation cover (10%) produced sparsely (degree of closeness, B = 0.32) and irregularly (degree of fluctuation, E = 0.40) distributed parabolic dunes; in the adolescent belts (AB), an erosive air stream followed by a slightly depositional air stream, combined with low vegetation cover (3%), formed denser (B = 0.35) but more regular (E = 0.35) barchans and barchan chains; and in the mature belts (MB), an erosive air stream followed by a strongly depositional air stream, combined with low vegetation cover (2%), produced the densest (B = 0.73) and most regular (E = 0.32) complex dunes. Dune size and patterning increased from EB to MB, and increased within the MB from erosion to deposition areas. Unidirectional winds, lateral linking and merger of dunes, and time explain the evolution of these aeolian landforms. Aeolian sand belts appear to evolve from disordered embryonic parabolic dunes to isolated adolescent barchans and regularly distributed barchan chains, and then to well-organized, large-scale mature complex dunes. Sand accumulation on valley slopes also produces large climbing dunes.

Aeolian sediments on the north-eastern Tibetan Plateau

STAUCH G.(1), LEHMKUHL F.(1), HILGERS A.(2), ZHAO H.(3)
(1) Department of Geography, RWTH Aachen University, AACHEN, GERMANY ; (2) Institute of Geography, University of Cologne, COLOGNE, GERMANY ; (3) Cold and Arid Regions Environmental and Engineering Research Institute, Chinese Academy of Sciences, LANZHOU, CHINA

Aeolian sediments in high mountain environments often show a complex spatial pattern. Different types of aeolian deposits have been studied in the catchment of the Donggi Cona on the north-eastern Tibetan Plateau in elevations between 4,100 and 5,000 m asl. Four distinct groups were classified according to the related process and the grain-size composition: loess, sandy loess, reworked loess and sand dunes. The spatial distribution of these different groups is related to the local topography and the activity of the sediment source areas. Beside the spatial differences, the timing of deposition varies. 51 OSL datings have been obtained to develop a numerical timescale ranging from the Lateglacial nearly to the present. The deposition of aeolian sands started around 14 ka. However, a phase of intensive deposition of sands occurred between 10.5 to 7.5 ka. The accumulation of the loess occurred during the same period (10.5 to 7 ka). The formation of these deposits is related to the strengthening of the Asian summer monsoons. Wetter climatic conditions lead to an enhanced trapping of the aeolian sediments. This pattern is different from the accumulation processes in the Chinese Loess Plateau. In the high mountain environment formation of aeolian deposits in the early Holocene is mainly related to the conditions in the depositional area and only to a lesser degree to the sediment availability. Fluvial erosion of the deposits under full monsoonal conditions was strongest between 9 to 6 ka. From 3 ka onwards reactivation of sands took place. This is coherent with drier and cooler climatic conditions, and probably an enhanced human influence in the area. Additionally new sediment sources from exposed lake bed influenced the grain-size composition of the archives.

****

North Sinai Sand Sea, Egypt: Dune Types and Forms, Sediments, and Hazards

EMBABI N.
Department of Geography, Faculty of Arts, Ain Shams University, CAIRO, EGYPT

This study represents a part of a research project on the Egyptian sand seas, aiming at a better understanding of sand accumulations dynamics and their relationship to present/future economic projects in Egyptian deserts. The North Sinai Sand Sea extends from the Mediterranean coast to the northern slopes of Gabal Maghara and Halal in the south, and from the eastern borders of Egypt to the Suez Canal in the west, covering an area of 13 000 km^2. The aim of this paper is to analyze local variations in dune types & forms, and to pin point areas where sand dunes represent a hazard for economic projects. To achieve these goals, topographic maps, aerial photographs, Landsat & Geogle Earth images, and climatic data of North Sinai were analyzed, and assisted by field work to check some of the aspects extraced from maps and photos and to collect some sand samples.

This study revealed that this sand sea has the most complex dune system anong Egyptian sand seas and is composed of at least two superimposed generations of dunes. Nearly all forms of dunes and patterns can be recognized. Drowned dunes are spotted in Bardawil Lagoon on the Mediterranean coast. Of these dune forms, small linear ones are the most widespread. Dune orientation varies greatly from one locality to another, but it can be said that nearly all directions are present. Sand dune movement represent a major hazard to development projects in the region of Sinai.

The analysis of dune sediments revealed that they were originated from Nile sediments, ancient local fluvial deposits, beach sand and the product of digging and deepening the Suez Canal. Also, it was found that wind regime, the presence of a chain of mountains in the south, climatic and sea level changes are the main factors affecting this sand sea.

Geomorphology of western desert Iraqi

HAMED W.
Plymouth University, PLYMOUTH, UNITED KINGDOM

The study area geomorphological effected including several factors such as the River activities, gully erosion, the land masses movement and dissolving phenomena, geomorphological units classified by Google Earth images and filed work. The Majority of the geomorphological features were formed under the arid conditions however well-developed drainage pattern and the relics of older ones bear the evidence of the influence of some more humid periods. Recent climate corresponds, according to the observation in the Rutba station Dennis, 1953 during the year 1937-1952 to the arid and semiarid one yearly mean precipitation in that period was 100mm/min 50 max 150mm/, yearly means temperature was 20^{o}C. Rainfall occurs during the winter months in the form of heavy local showers influencing the whole surveyed area only exceptionally. For the compilation of the geomorphological map the geomorphological analysis was used exploiting detail data on the land forms, their relationships, genesis and lithology of the bedrock gained by the field geologists. Besides that many special geomorphological traverses were completed and some important sections and localities were studied in detail, for example the whole area was sampled for the pebble analyses to solve the problem of the arid environments sediments. The Majority of the geomorphological features were formed under the arid conditions; however, well developed drainage pattern and the relic of older ones bear the evidence of the influence of some more humid periods. Recent climate correspond, according to the observation in the Rutba station. During the past (50) years ago the arid to semi-arid yearly mean precipitation of Rutba station has been 100 mm and the mean temperature was 20^{o}C in day. Rainfall occurs during the winter months in the forms of heavy local showers, influencing the whole surveyed area only exceptionally for the compilation of the geomorphological map.

****

Complex dune patterns of the northern Rub' Al-Khali, UAE ' age and origins

LANCASTER N.(1), SINGHVI A.(2), GLENNIE K.(3), TELLER J.(4), PANDEY V.(2)
(1) Desert Research Institute, RENO, UNITED STATES ; (2) Physical Research Laboratory, AHMEDABAD, INDIA ; (3) University of Aberdeen, ABERDEEN, UNITED KINGDOM ; (4) University of Manitoba, WINNEPEG, CANADA

The northern Rub' Al-Khali sand sea in the area of the United Arab Emirate exhibits a complex pattern of dunes, comprising large compound crescentic dunes in the south and W-E trending linear dunes in the north and east, in addition to marginal crescentic dunes and sand sheets. The linear dunes are modified in many places by superimposed crescentic dunes. Understanding this complex pattern requires integration of multiple data sets on duen morphology, chronology, and sediment characteristics

The complex pattern of dune generations reflects a long history of sand accumulation involving both quartz-rich and carbonate-rich sands., as well as modification of pre-existing dunes in response to climatic and sea level changes that affected sediment supply, availability, and mobility. Sediment sources include quartz rich sediments derived from the Zagros Mountains and the highlands along the Red Sea Rift, as well as carbonate rich sand derived from the floor of the Arabian Gulf during periods of low sea levels. In conjunction with analysis of dune patterns and geomorphic relationships between dune generations, a synthesis of currently available chronometric information enables identification of multiple periods of aeolian accumulation over the past 200ka. Prior to 80 ka, the preserved record is dominated by crescentic dune accumulation, and now-buried carbonate-rich sediments (aeolianites). From 30 to 9 ka, the preserved record is characterized by quartz-rich linear dune formation. The period 8-2 ka was one of very rapid reworking and accumulation of quartz-rich sand in both crescentic and linear dune environments, as well as formation of coastal crescentic dunes.

Particle-size fractionation of eolian sand along the Sinai - Negev erg

ROSKIN J., KATRA I., BLUMBERG D.G.
BEN-GURION UNIVERSITY OF THE NEGEV, BEER-SHEVA, ISRAEL

This study examines changes in the eolian sand fractions along the west - east transport path of the northern Sinai Peninsula – northwestern (NW) Negev erg of Egypt and Israel. This erg is composed of active linear (seif) dunes in northern Sinai (its western part), and stabilized vegetated linear dunes (VLDs) in the NW Negev dunefield (its eastern part). Sand samples were analyzed for sand grain morphology, particle-size distribution (PSD) and optically stimulated luminescence ages.

Linear seif dunes differ from VLDs in their vegetation cover, linearity, and dynamics. Although both are continuous landforms with similar orientations and sand-grain roundness values, the linear dunes of Sinai are coarser-grained than the Negev VLDs. The VLDs have a significantly higher proportion of very fine sand (125-50 μm) content and a varying but lower *sand fining ratio* defined as the ratio of fine sand percentage to very fine sand percentage. From these observations we infer that fractionation of sand occurred along the studied eolian transport path. Very fine sands are suggested to have been winnowed by saltation and low suspension from source deposits and sand sheets.

We suggest that the very fine sand fraction of Nile Delta and Sinai sands has been transported downwind since the late middle Pleistocene. In the late Pleistocene, linear dunes reached the Negev due to last-glacial period windiness of intensities unprecedented today and probably larger sediment supply. Generally decreasing wind velocities and increasing precipitation along the west - east dune transport path enhanced vegetative cover in the NW Negev and enabled deposition of the very fine sand component that was also transported by low suspension. We hypothesize that these very find sands also probably compose a partial fraction of the Negev loess deposits, still farther downwind. Our results suggest that PSD can elucidate much about erg and dunefield history over timescales of a glacial-interglacial cycle.

****

Windy silt deposits (or loess) in Southeast Tunisia (Northern borders of the Great Sahara): chronostratigraphy and paleoenvironments of their deposition

BEN FRAJ T.
Faculty of Letters and Humanities of Soussa, Geography department, KSIBET MEDIOUNI, TUNISIA

Geomorphological researches conducted in the northern Jeffara plain and north-eastern part of Matmata-Dahar plateau (S-E Tunisia) have allowed us to determine the place of windy silt deposits (or Loess) in the chronostratigraphy of the Quaternary and redraw the outlines of the paleoenvironmental and geomorphological evolution in this nowadays arid domain.

The thickness of the windy silt deposits, rich of calrcareous concretions, ranges from 1 to 8 m. Two red levels of variable decimeters thickness or two calcareous crusts separate two or three generations of these silts. The first calcareous crust is zonary and about 10 cm average thick. The second is about 2 to 3 cm thick and it has spongy appearance.

Windy silt deposits overcome always a conglomeratic deposit sealed by a pudding or a clayey-silty-gypseous deposit sealed by a gypsum crust. All of these deposits can be formed into terraces, alluvial fan or erosion surfaces.

Geomorphological data, Prehistory data and those provided by radiometric dating (14C), allowed identifying two major phases of accumulation of windy silts. The first took place during the second half of the upper Pleistocene. The second is attributed to the lower/middle Holocene.

Stratigraphic and lithologic data indicate the occurrence of two major phases of climatic fluctuations during these two periods. There were passages from semi-arid to arid shades but they remained wetter than the current.

The analysis of heavy minerals and the transposition of the current wind regime in southern Tunisia can be linked to the hypothesis of an origin of silts from the “Grand Erg Oriental”. But, possible deposits from the Great Chotts or from the coastal domain and its sebkhas are not, however, excluded. These deposits are most likely related to seasonal variations in wind directions.

The role of active sand seas in forming desert loess sequences with implications to the Chinese Loess Plateau.

AMIT R.(1), ENZEL Y.(2), ONN C.(3), MUSHKIN A.(3), JIGJIDSUREN B.(4), GILLESPIE A.(4)
(1) Geological Survey of Isreal, JERUSALEM, ISRAEL ; (2) Institute of Earth Science, Hebrew University of Jerusalem,, JERUSALEM, ISRAEL ; (3) Geological Survey of Israel, JERUSALEM, ISRAEL ; (4) Department of Earth and space Sciences, University of Washington, SEATTLE, UNITED STATES

In earlier work we demonstrated that coarse silt quartz grains that comprise most of desert margin loess, must have been formed through aeolian abrasion within upwind active sand seas. In the Sinai-Negev desert, the coarse mode of silts is composed mostly of abraded quartz grains and increases in percentage and in grain-size with time, and therefore indicating a time-transgressive advancing proximal dust source. In the carbonate bedrock terrain of that region, the only proximal dust source for high amount of coarse quartz grains are the sands of northern Sinai derived from the Nile that were transported coevally with the loess accretion during the late Pleistocene. Examined available data for loess in the margins of the deserts of Sahara, Arabia, South America, and the Thar revealed that all these desert loess sequences are located downwind of adjacent sand seas at present and during the Pleistocene. These observations suggest that sand dunes must have been an important source for desert loess and silt grains are generated through active aeolian abrasion of sand grains during episodes of intense windy conditions, primarily in glacial times. A detailed study of potential dust sources in south and central Mongolia, one of the suggested major dust and loess source for the Chinese Loess Plateau (CLP), revealed that this desert cannot be a major source for the coarse silt fraction of CLP. However, a compilation of all available data regarding particle size distribution of the CLP indicates that processes, similar to those outlined above for the warm desert margins, can be associated with sandy areas in the Mongolian Gobi and with several of the largest sand seas in the world surrounding the CLP . Our results stress the primary role of long-lasting active ergs and aeolian abrasion associated with frequent strong winds in the formation of Quaternary desert loess sequences.

****

Dust emission dynamics and source area variability: field measurements for climate modelling

WIGGS G.(1), KING J.(1), THOMAS D.(1), WASHINGTON R.(1), ECKARDT F.(2), BRYANT R.(3), NIELD J.(4), VICKERY K.(2)
(1) University of Oxford, OXFORD, UNITED KINGDOM ; (2) University of Cape Town, CAPE TOWN, SOUTH AFRICA ; (3) University of Sheffield, SHEFFIELD, UNITED KINGDOM ; (4) University of Southampton, SOUTHAMPTON, UNITED KINGDOM

Climate models must account for aeolian dust in order to avoid large radiative and dynamical errors. The simulation of the dust cycle depends on a wide range of earth system components but begins with the realistic representation of source areas. However, there are very few measured data from dust source regions and none of emission processes operating at model grid-box resolution. This paper presents field results from the Do4 Models (Dust Observations for Models) project that aims to understand the variability in dust emission processes at relevant scales for climate modelling. Specifically, the project aims to evaluate the value added to predictions of aeolian dust emission with the measurement of erosivity and erodibility parameters at differing scales within source areas.

Data are presented from a field campaign across a 12 km x 12 km grid cell in Sua Pan, Botswana. 11 meteorological stations were deployed consisting of anemometer arrays, sediment transport detectors, high-frequency dust monitors, soil moisture meters, and shallow well networks. Further data were gathered across the grid on the dynamics of surface characteristics and erodibility parameters that impact upon erosion thresholds. Our data show for the first time the substantial variability in erodibility of an apparently homogenous surface in both time and space as a result of changing moisture and crustal characteristics, coupled with irregularity in erosivity due to variations in surface roughness. Such variability results in the identification of dust emission 'hot-spots' even within the area of a single regional climate model grid cell. This dataset provides a starting point from which to construct and test new dust emission schemes at scales relevant for climate modelling that incorporate the sensitivity of erosion thresholds to small changes in surface and atmospheric conditions.

Soil organic carbon enrichment of dust emissions: magnitude, mechanisms and its implications for the carbon cycle

STRONG C.(1), WEBB N.(2), CHAPPELL A.(3), MARX S.(4), MCTAINSH G.(1)
(1) Griffith University, BRISBANE, AUSTRALIA ; (2) USDA-ARS Jornada Experimental Range, MSC 3 JER, NMSU, Box 30003, , NM 88003-8003, USA, LAS CRUCES, UNITED STATES ; (3) CSIRO Land and Water, CANBERRA, ACT, AUSTRALIA ; (4) GeoQuEST Research Centre, School of Earth and Environmental Science, University of Wollongong, WOLLONGONG, AUSTRALIA

Soil erosion is an important component of the global carbon cycle. However, little attention has been given to the role of aeolian processes in influencing soil organic carbon (SOC) flux and the release of greenhouse gasses, such as carbon-dioxide (CO_2), to the atmosphere. Understanding the magnitude and mechanisms of SOC enrichment in dust emissions is a necessary step in evaluating the impact of the wind erosion part of the dust cycle on the carbon cycle. This research examines the SOC content and enrichment of dust emissions measured using Big Spring Number Eight (BSNE) wind-vane samplers across five land types in the rangelands of western Queensland, Australia. Our results show that sandy soils and finer particulate quartz-rich soils are moreefficient at SOC emission and have higher SOC dust enrichment than clay-rich aggregated soils. We also show from two months data, that size selective sorting of SOC during transport can lead to further enrichment of SOC dust emissions. These preliminary results provide impetus for additional research into dust SOC enrichment processes to elucidate the impact of wind erosion on SOC flux and reduce uncertainty about the role of soil erosion in the global carbon cycle.

****

Dust Sources of Southern African

ECKARDT F.
University of Cape Town, CAPE TOWN, SOUTH AFRICA

Southern African dust sources have been identified using a variety of remotely sensed products including Photography, TOMS, SeaWifs, MODIS and MSG. While each sensor introduces its own observational bias it is the true colour rendition of MODIS which appears to provide the most versatile and consistent product, capturing both low level coastal plumes as well as those originating from larger inland sources. Southern African sources include ephemeral recharge playas of the interior as well as coastal discharge sabkhas from Namibia in addition to dry river valleys with headwaters in the western escarpment and beyond. The Kalahari and Namib consistently produce plumes while dust in the Karoo region has remained undetected from space. The temporal plume detection record from remote sensing combined with reanalyses data suggests distinct synoptic drivers at play, which include west coast troughs intensified by continental high pressure systems at a regional scale and berg winds in coastal slope settings. Ground based observations have added important dimensions to our understanding of the processes. Applying the Gobabeb weather observations to the Kuiseb River plumes suggest persistent winds and topographic channelling of air flow may be an additional factor for many of the Namibian River valleys. Saltation as an agitator appears a lesser driver but cannot be discounted in the proximity of active dune fields. Intensive ground based observations as part of DO4 (Dust Observation For Models) have been underway since 2011. In general southern African sources are supply limited in nature and availability of material is controlled by flooding history for both river and lake systems, while playas feature the additional limitation of crust formation and fluff retention. Southern Africa may not be the dustiest place on earth but numerous discrete sources including Sua Pan and Namibian West Coast have enhanced our understanding of surface process geomorphology.

Poster presentations:

Eolian terrain of the lower course of the river Vilyui (Central Yakutia)

PAVLOVA M.
Tomsk State University, TOMSK, RUSSIAN FEDERATION

Erenow in the XIXcentury researches knew about the wide spread occurrence of the unique eolian land forms called tukulans (massive deflate hilly sands) in a lower course of the river Vilyui. The first information about them is cited in the writings of R. Maak (1886). In subsequent years tukulans were researched by various scientists: E. Katasonova (1963), S. Skryabin, P. Pavlov (1977).

Tukulans of the lower course of the river Vilyui are situated between the rivers Umulun (Vilyui's left tributary) and Lungh (Lena's left tributary), on the surfaces of the terraces above the flood-plain and on the territory of the dividing stretches with the altitudes up to 270 metres above the sea level. Blown sands massives area is 2056 km^2 (total area of the region is 21540 km^2).

The largest tukulans of the lower course of the river Vilyui are Hotugu-Ulahan-Tukulan (square 302 km^2), Kyundul-Tukulan (51 km^2), Berende-Tukulan (49 km^2), Chiertike (29 km^2), Balagannah (16 km^2).

Tukulans surface is covered with young and old parabolic dunes, deflation basins and other eolian formations. Dunes form is different crescent-shaped, javelin-shaped or annular-shaped. Their high amounts to 10–30 metres, width amounts to 50–60 metres. The windward slope is usually gentle (5–15º), the downwind slope is steeper (to 30º). Deflation basins width amounts 200–300 metres. Generally the sources of the sand accumulation are the local underlying rocks.

Today, the insufficience of data about eolian terrain of the lower course of the river Vilyui complicates the decision of the practical questions (for example, how to protect forest areas and farmlands from tukulans invasion). The detailed research of the peculiarities and regularities of the eolian terrain of the lower course of the river Vilyui enables to get more accurate trend concerning the problem of origin and formation of these land forms and to get the data about tukulans quantitative characteristics substantiation.

****

Study on Arid Geomorphologic Features in the Queletag Mountain in Southern Piedmont of the Tianshan Mountains, Xinjiang, China

ZHAO X.
Xinjiang Institute of Ecology and Geography, Chinese Academy of Sciences, URUMQI,XINJIANG, CHINA

In this paper, the geomorphologic features and forms in the Queletag Mountain in southern piedmont of the Tianshan Mountains, Xinjiang, China, were studied using the GIS spatial analysis and the methods of geologic structure, formation lithology, altitude, relief amplitude and geologic profile. The results show that the Queletag is a folded mountain consisted of the Cainozoic lacustrine and fluvial amaranthine sandstone, siltstone and conglomerate, and it is precipitous and runs from east to west. These reveal that the earth surface was strongly folded by a south-north compression under neotectonics, with the fold some thrust faults of parallel anticline axes, shear faults of chamfer anticline axes and steep or gentle anticlines and synclines were developed, and the strata were crushed seriously. All these reveal that the tectonics in the southern piedmont of the Tianshan Mountains is currently at an active stage, and the development of landforms is at the metaphase of postadolescence. The features of altitude contour lines show that the surface weathering has been dominated by mechanical disintegration since the mid-Pleistocene under the effects of extreme arid climate, violent drying denudation and wind erosion, rainstorm wash, topography dissected by seasonal flood, lithologic difference weathering, gravity landslip, etc. Thus, the various particular arid landforms were developed in geomorphologic process in this arid area, which include the large peaks with clear stratification, deep valleys, steep cliffs, marvelous Yadan landforms, salty dunes, etc.

Keywords: GIS spatial analysis, geologic structure, altitude, arid landform, Queletag Mountain, southern piedmont of the Tianshan Mountains

Intensified, gusty latest Pleistocene winds forced abrasion of Sinai/Negev sand into a continuum of finer grains downwind

ENZEL Y.(1), AMIT R.(2), CROUVI O.(2), PORAT N.(2)
(1) The Hebrew University of Jerusalem, JERUSALEM, ISRAEL ; (2) Geological Survey of Israe, JERUSALEM, ISRAEL

Data from the edge of the Sinai-Negev sand field indicate that ergs are mega-grinders of sand into very fine sand and silt under gusty, windy late Quaternary climates and in ancient aeolian deserts environments. In the carbonate terrain of the northern Sinai-Negev desert, only sand abrasion in an active erg could have produced the large quantities of quartzo-feldspathic silts constituting the late Quaternary northwestern Negev loess. In this poster presentation we focus on the continuum of downwind fining of grain size distributions from this identified source (with its medium sand-size grains of the dunes and without silts or very fine sand), to the silts of the accreted loess. We point that the very fine sands, unaccounted for in enough quantities in the record are deposited at the dune field margins. In the current research we focus on and demonstrate that as predicted by experiments, abrasion by the last and relatively fast advancing dunes at 13-11 ka, generated large quantities of very fine sand (60-110 μm) deposited within the dune field and in close proximity downwind. This very fine sand is absent from the particle size distribution of the dunes and must have been generated 13-11 ka, possibly under gusty winds and sand/dust storms during the Younger Dryas in the SE Mediterranean. These very fine sands filled small basins formed by the blocking advancing dunes under these same winds; elsewhere, outside these sampling basins it is difficult to identify these sands as a distinct product that point to extremely windy episodes. Past proposals for common gaps in the formations of eolian grain sizes should be reconsidered by tighter spatial sampling.

****

Tukulan Phenomena - Specific Cryoarid Landforms of Central Yakutia

GALANIN A., URBAN A., PARFYONOV M., TANANAEV N.
Melnikov Permafrost Institute SB RAS, YAKUTSK, RUSSIAN FEDERATION

Tukulans are unique natural phenomena of Central Yakutia, representing aeolian cryoarid landscapes in permafrost surroundings, well-developed in the central part of the Lena River Basin and its major tributaries – Viluy, Linde. They are polychromic complexes of frozen parabolic or crest-shaped dunes of different sizes. Typical tukulan section was studied on the 4-km long exposure site on the right bank of the Viluy River. Marker layer of swamp-lacustrine deposits with buried peats, disrupted by ice wedges, was established within the cross-section. Radiocarbon dates of 4470±95, 4450±90 and 4060±95 cal. BP, obtained from buried wood within the marker layer, evidence colder and wetter environment. Thus the studied deposits can be attributed to the late Atlantic period of Blytt-Sernander sequence, marking transition to early Subboreal. This marker layer separates underlying alluvial deposits from typically aeolian deposits of Late Holocene. The latter include a number of buried soil horizons and vertically buried tree trunks, related to the periods of relative dune stability under soil and vegetation cover. These can potentially be attributed to the periods of weaker wind activity, reflecting the increased stability and intensity of the Siberian Maximum, defining the Central Yakutia climate during Holocene Little Ice Age. Six radiocarbon dates, obtained from stratigraphically distinct soil horizons, are unexpectedly young, not exceeding 150-200 y. BP. They reflect changes in wind activity and evidence intensive tukulan area increase after that time. This studies were supported by Russian Fund of Basic Research, Projects # 11-05-00318-a 12-05-98507-vostok_a.

Application of SRTM and ETM in identification of unknown geomorphologic forms,Case Study: Lut Plain in south east of Iran

NAEIMINEZAMABAD A.
.Islamic Azad UniversitySaveh Branch, SAVEH, IRAN

According to the World Meteorological Organization (WMO), the highest temperature measured on Earth in September 13, 1922, were in El Azizia, Libya, reached 58.0°C (136.4°F). study landsat Data Obtained in July 6, 1999 by Landsat 7 obvioused that in seven years of global land surface temperatures , the Lut Desert in Iran ranked as hottest in five of the years. In five of the seven years -2004, 2005, 2006, 2007 and 2009 - the highest surface temperature on earth was found in the LUT desert. the single highest LST recorded in any year in any region,occured there in 2005,when MODIS recorded a temperature of 70.7°C(159.3°F)—more than 12°C (22°F) warmer than the official air temperature record from Libya. For determine geomorphologic structure in this wild and unknown area we at the first used from new technologies and new data's. Based analyzed of SRTM data that achieved in 2003 we found a hole in center of LUT Desert. 3D analyses of SRTM data obvious that depth of hole is about 100 meters from the marginal lands. Areas and this hole was about 900 hectare. Analyses of Satellite images, especially ETM obvious that we are faced with an expanse of mud and wet. Based these results, Geology Maps of Iran and other Data Reviewed that no detailed information was obtained from this area. For identify of geomorphologic character of this hole an expedition was organized. after 5 day Hard drive in the center of Lut desert we achieve to the this hole and found that this hole created based Collision of a meteorite because we found many meteorites that separated in that place and morphology of this hole were different with other place of that area. Geomorphologic forms of this hole were similar study SRTM data and ETM satellite image analyses, we found a hole with depth about 100 meter and that were muddy and wet.In result application of new data's and technologies specially GIS and RS pioneering for discover unknown places in the world.

****

Hydrochemical characteristics of natural water and origins of dissolved salts in the eastern Hunshandake Sandy Land, Eastern Inner Mongolia, China

REN X., YANG X., ZHANG D., LI H.
Institute of Geology and Geophysics, Chinese Academy of Sciences, BEIJING, CHINA

In order to understand the hydrochemical characteristics of natural water and the origins of the dissolved salts in the water in the eastern Hunshandake Sandy Land, eastern Inner Mongolia of China, we collected water samples in 2011 and 2012 from the rivers, lakes, springs and wells of the region. Temperature, pH, electrical potential (EP), electrical conductivity (EC), total dissolved solids (TDS) and salinity were examined immediately on site by a portable multi-parameter analyzer. Major cations and anions were measured using a ion-chromatograph and titration with HCl in laboratory. The alkalinity was measured using Gran Titration Method. The TDS-EC and EP-pH ratios confirm that our measurements were precise. The value of TDS shows that the river, lake, spring and ground waters are mostly of fresh water quality in this desert environment. The pH value indicates that the spring and ground waters are neutral or even slightly acidic, the river and lake waters are neutral to slightly alkaline. The alkalinity in all natural waters is low, but the ground water's alkalinity is higher than other natural waters', and its TDS also the highest in all samples. HCO_3^-, CO_3^{2-} and OH^- content indicates that the alkalinity is mainly caused by the HCO_3^-. In all samples the main anions are HCO_3^-, SO_4^{2-}, Cl^- and HCO_3^- is the predominantly one in all river and lake samples, and in the majority of the spring and ground water samples. However, SO_4^{2-} is the predominant anion in the rest of spring and ground water samples. The main cations are Ca^{2+}, Mg^{2+} and Na^+, and Ca^{2+} is the predominant one in all water samples. The appearance of NH_4^+ and NO_3^- in some samples may suggest evident anthropogenic impact on the water bodies in this region. We conclude that the ions in natural waters of the region are sourced mainly from carbonate rocks, rather than the desert evaporites, as having occurred in the deserts of western China.

Desertification and human impact in the arid region of Northwestern Argentina

SAYAGO J.M.
Consejo Nacional de Investigaciones Cientificas y Tocnicas, SAN MIGUEL DE TUCUMON, ARGENTINA

Since the beginning of the Spanish colonization and up to our days the region was affected by deforestation, overgrazing or cultivation un restricted explaining the severe box desertification affecting this vast region. In parallel, the climate changes of the last millennium influenced the settlement of the pre-Hispanic cultures and during the Hispanic period to the present day. In a preandean valley, taken as pilot area, analyzed the genesis and evolution of desertification which starts on downhill pediments with the disappearance of the primitive herbaceous vegetation being replaced by a xerophytic shrub layer in response to the loss of surface horizons whose soil sediments carried to the plains of major rivers modify the fluvial geometry and drainage pattern. During arid periods the floodplain area are the source of input for the development of a dune landscape developed to the sides of the river valleys. Today the region is characterized by soils in the foothills totally degraded, where prevailing wind and water erosion. In the summit areas and transverse valleys natural vegetation has not been completely changed, while the presence of high terrace with dune pattern provides a marked fragility and low terrace, with saline and alkaline soils, has only a moderate fitness pastoral rustic species, especially during the wet season. An inventory of desertification at semi detailed scale from geoecological and socioeconomic perspective is suggested as a necessary condition to define sustainable management, especially facing the prospect of future environmental changes.

****

Geochemical properties of loess-paleosol sequence in the Haemi area, West Coast of South Korea

YOON S.O.(1), HWANG S.(2), PARK C.S.(1)
(1) Dept. of Geography and Research Institute for Basic Sciences, Kyung Hee University, SEOUL, SOUTH KOREA ; (2) Dept. of Geography, Kyungpook National University, , DAEGU, SOUTH KOREA

The Haemi section found in the Haemi area, Seosan-si consists of loess-paleosol sequence (LPS), transitional layer I (TL I), transitional layer II (TL II) and marine terrace deposits from top to bottom. This study tries to estimate the physical properties using the MS measurement and grains size analysis and consider the formative processes, provenance and weathering properties using geochemical analysis. The LPS in the section indicates very similar geochemical compositions to each other and the Chinese Loess Plateau (CLP), and different from the bedrocks around the section. However, the elements sensitive to weathering processes indicates large differences to the CLP. These means that the LPS has originated from the CLP and/or its source areas and experienced intensive weathering process under the climatic environments in the Korea after the depositions. These weathering properties can be found in the Korean loess reported as well as the sequence and slight spatial differences in weathering intensities within the Korea are also found. The differences of elemental compositions among the samples in the TL I and TL II are larger than those in the LPS and their elemental compositions are different from the LPS and the degree of differences are greater in the TL II than in the TL I. The TL II has the similar compositions to the bedrocks around the section. Therefore it can be suggested that the TL II consists of mainly the weathering products of bedrocks with small inputs from the materials of sequence. On the other hands, the TL I indicates the similarities to the sequence rather than the TL II and thus it contains a great deal of the materials of sequence with small inputs from the weathering products of the bedrocks.

Eolian denudation in the baikal region under conditions of climate aridity

TIUMENTCEVA E.
East-Siberian State Academy of Education, IRKUTSK, RUSSIAN FEDERATION

Eolation is shown on considerable spaces of the Baikal region. Their development is promoted by dryness of climate, high speeds of wind, an insignificant snow cover, a repasture, considerable recreational loading, etc. The process study was carried out using modern methodic on the expedition stations. The main peculiarities of the modern relief and the role of eolation were found out. At the western coast of Baikal processes are most intensive in the mouth parts of valleys of the rivers of Sarma, Goloustnaya, etc. The physiognomical shape of landscape testifies the leading part of deflation in formation of modern relief. The maximum size of deflation reaches 2-4 cm on a surface of abrupt slopes and on tops of manes on flood plains. At east coast it is observed twisting sandy thicknesses and formation moving eolian forms mainly in a coastal strip.

Environmental conditions against high seismic activity of region define intensity and features of development modern exogenous processes.

During the dry periods the arid condition of geosystems is observed. In system exogenous formation of relief the component dominates eolian environment. The higher levels of superficial sediments are exposed to deep eolian processing, the rock debris increases, on a surface of slopes a pavement of detrital material is formed, ventifacts are marked. The slopes are polished by winds. All circles of a relief become an arena of eolian substance migrations. The eolian material is redistributed between winded and leeward slopes of Baikal regions ridges.

Eolation manifested itself in high sensitivity and fast response on climate change. The strengthening tendency of eolian processes in Prebaikalia in the last years resulted from increase of dry climate and rising of the role of meridional circulation. The area of eolian formation is expanded on the background of natural forest-steppe where mountain-steppe soils communities with a spare vegetative cover are formed.

****

Provenance analysis of aeolian sediments in the wide valleys of Middle Reaches of Yarlung Zangbo River in Tibet, China

ZHENG Y.(1), WU Y.(2), LI S.(3)
(1) College of real estate, Beijing Normal University, Zhuhai, 519087 P. R. China., ZHUHAI CITY, GUANGDONG PROVINCE, CHINA ; (2) MOE Engineering Center of Desertification and Blown-sand Control at Beijing Normal University, Beijing 100875, P. R. China, BEIJING, CHINA ; (3) College of Geography and Environment Science, Northwest Normal University, Lanzhou 730070, P. R. China, LANZHOU, CHINA

The Cha'er Section is located in the northern bank terrace (about 30m average height above the river level) of Yarlung Zangbo River at a 3856m altitude, 5km west away from the township government of Cha'er, Namling, Shigatse, Tibet, China. This section is 3.68m thick, and sediments of interbedded aeolian sands and paleosols. The characteristics of grain diameters and heavy minerals of aeolian sands in the Cha'er Section and surface deposits around the section are contrastively analyzed. The results suggest that, the aeolian sediments of the Cha'er Section is mainly composed by medium sand and fine sand, whose mean grain diameter and grain composition are very similar with those of mobile dunes around the section, the mountain front diluvium, and the river alluvium at the marginal bank and second terrace of the Yarlung Zangbo River wide valleys. The heavy mineral contents of aeolian sediments in the section are between 2% and 2.5%, mainly composed by unstable minerals, such as augite, hornblende and epidote. The contents andmajor constituentof heavy minerals are similar with those of local river alluvium, diluvium and bedrock weathering substance, but the characteristics of relative content of heavy minerals and composition of minerals in the aeolian sediments in this section mainly inherit the heavy mineral characteristics of river alluvium at the marginal bank and terrace. Therefore, most of the aeolian sediments in the wide valleys of Middle Reaches of Yarlung Zangbo River are proximal deposition, whose sources are probably local surface deposits, consisting mainly of river alluvium of Yarlung Zangbo River.

Keywords: provenance analysis; aeolian sediment; Yarlung Zangbo River; Tibet;

Acknowledgements: This work was supported by the National Natural Science Foundation of China (41071129) and National Basic Research Program of China (2013CB956001).

Using a 3D laser scanner to monitor the wind erosion in wind tunnel test

YAN P., ZHENG S., GUO J., LI X.
State Key Laboratory of Earth Surface Processes and Resource Ecology, Beijing Normal University, BEIJING, CHINA

Wind erosion is one of most serious environmental problems in the arid, semi-arid and dry sub-humid areas around the world. Accurate measurement of wind erosion rates is essential and urgent. The complexity, randomness, and boundlessness of the wind erosion process make it difficult to measure wind erosion rates precisely. Current methods including field observation, wind tunnel tests, and wind erosion models have numerous limitations in their practicability, cost, and accuracy. Hence the 3D laser scanning technique was used to measure the wind erosion in the wind tunnel. Three incased soil samples (soil box) with original structure were collected in the steppe of Inner Mongolia, and blown by six wind velocities (10、15、17、20、25、30 m/s) to simulate wind erosion in the wind tunnel. The soil surfaces after each test were scanned by a Trimble 3D Laser Scanner to create DEM by ARCGIS. Then the wind erosion rate, micro-morphology and surface roughness of soil samples can be quantified.

Comparing with weight method for wind erosion measurement, which is strenuous for transit in the lab and impractical in the field, the scanning test of three samples can reach an overall error value of wind erosion rate between -1.59－10.23%, averaging 6.28%. That means the wind erosion rate may overestimate about 6% by scanning, likely to be attributed to the scanner's precision, shelter from the laser and image treatment. Image analysis indicates that as the wind erosion strengthens, the micro-morphology of soil surface has changed from smooth plain, to smallstripes, grooves and finally to blowouts. And the roughness has varied mildly as wind velocity less than 20 m/s, and increased sharply by 4 times of the origin after the velocity exceeds 20 m/s. The preliminary results of this test show that the 3D laser scanning technique is valuable for its convenience, high efficiency and accuracy to measure the wind erosion rate directly and non-contacted, especially in the field's observation.

****

Exceptional preservation of Pleistocene aeolian forms in an outwash plain. Central Ebro Basin (NE Spain)

LUZÓN A.(1), RODRÍGUEZ-LÓPEZ J.P.(2), PÉREZ A.(1), SORIANO M.A.(1), GIL H.(1), POCOVÍ A.(1)
(1) Universidad de Zaragoza, ZARAGOZA, SPAIN ; (2) Universidad Complutense de Madrid, MADRID, SPAIN

Although proglacial Pleistocene aeolian sands in Europe are mostly located between 50º-54ºN and their southern boundaries roughly coincide with the Pleistocene maximum ice sheet, during this epoch an aeolian dunefield developed and exceptionally preserved in the central Ebro Basin (41.50ºN) in Spain. It was located in the distal part of the outwash system constructed by water flows coming from ice caps in surrounding areas, mainly the Pyrenees. Periods of ice fusion favoured high-energy meltwater flows organized in a braided fluvial pattern and dominated by tractive processes. Among fluvial deposits longitudinal gravel-bars and channels prevailed that evidence high volumes of both water and sediment discharges. During more intense glaciation of highlands, river discharges reduced and wide extensions in the outwash plain became exposed. These areas were subjected to aeolian processes with subsequent development of landforms and different sedimentary structures. Windblown deposits are integrated by fine-grained very well-sorted sands with a dominant saltation population. The main features of the aeolian deposits indicate the presence of sandsheets, transverse dunes, complex dunes and loess. During periods of sub-saturated winds deflation lags with ventifacts generated. Meltwater flows led to aeolian forms destruction with generation of hyperconcentrated flow deposits. The distal outwash plain spread over a thick Tertiary evaporite series and synsedimentary karstification prevented aeolian deposits from erosion favouring their exceptional preservation under such high-energy water flows dominated environment.

The Effect of Wind Barriers on the Airflow Field in A Wind Tunnel

ZOU X., WU X., ZHANG C., WANG R., ZHAO J.
State Key Laboratory of Earth Surface Processes and Resource Ecology, Beijing Normal University, BEIJING, CHINA

Porous wind barriers are widely used and proven more efficient than solid barriers. In this study, the shelter quality of wind barriers of different porosity, row space and row number was compared based on wind-tunnel measurements. The 14 cm-high scaled models of wind barriers were placed perpendicularly to the wind direction in the wind tunnel, and rough elements were placed upwind of the models to obtain a reasonable self-simulation zone and Reynolds number. The results show that the airflow field changes little in the area above one-row wind barriers. In the area below the models, the airflow field is rearranged into four energy regions. The best shelter effect achieved downwind is always obtained using a 0.35-porosity wind barrier, so we suggest the optimal porosity of 0.3-0.4 for wind barriers in sand-control engineering. The shelter effect comparison of two-row 0.35-porosity wind barriers indicates that 6 H is the optimum row space. Two-row and three-row wind barriers obviously provide better shelter than one-row barriers. Therefore, we suggest 5-7 H as the optimal row spacing for multi-row wind barriers. Our results indicated good agreement with previous studies regarding porosity, row number and row space, with some exceptions about wind barrier design regarding porosity.

****

Active sand seas are a major source of desert loess

CROUVI O.(1), AMIT R.(1), ENZEL Y.(2), GILLESPIE A.(3)
(1) Geological Survey of Israel, JERUSALEM, ISRAEL ; (2) The Hebrew University of Jerusalem, JERUSALEM, ISRAEL ; (3) University of Washington, SEATTLE, UNITED STATES

Loess is a widespread eolian deposit dominated by coarse silt-sized quartz particles, which serves as an important archive of information on Quaternary climate change. Despite the intensive research during the past century on desert loess formation, its origin remains poorly understood and is still a fundamental problem in sedimentology and in Quaternary paleoclimatology. The ongoing debates are focused on the sources of the loess and on the production of coarse silt quartz grains. Although laboratory experiments indicate the potential of dunes with their abundant quartz sand grains as a primary source for generating coarse silt grains, this concept has been generally rejected as field-based evidence for abrading from sand grains (eolian abrasion) is rare. Here we adopted a global view to examine desert loess sources and to suggest possible processes for the formation of coarse silt grains in loess. We examined in detail several well-known late Pleistocene loess regions in different subtropical deserts (North Africa, The Sahel, Middle East and Arabia) and found that all these loess regions are located downwind of adjacent sand seas. Together with evidence of mineralogical similarity between the loess and the sand dunes and their contemporaneous activities, these observations suggest that sand seas are an important source for desert loess. Since there is only limited silt grains storage in sand dunes, we postulate that the silt grains comprising most of the loess are not reworked from the dunes but are generated probably through active eolian abrasion of the medium sand grains under past climates characterized by intensified winds. As a result, the role of sand dunes and eolian abrasion in formation of desert loess can be more important than previously thought.

Field evidence for the upwind velocity shift at the crest of low dunes

CLAUDIN P.(1), WIGGS G.(2), ANDREOTTI B.(3)
(1) CNRS - ESPCI, PARIS, FRANCE ; (2) School of Geography and the Environment - Oxford Univ., OXFORD, UNITED KINGDOM ; (3) Univ. Paris Diderot, ESPCI, PARIS, FRANCE

Wind topographically forced by hills and sand dunes accelerates on the upwind (stoss) slopes and reduces on the downwind (lee) sides. This secondary wind regime, however, possesses a subtle effect, reported here for the first time from field measurements of near-surface wind velocity over a low dune: the wind velocity close to the surface reaches its maximum upwind of the crest. Our field-measured data show that this upwind phase shift of velocity with respect to topography is found to be in quantitative agreement with the prediction of hydrodynamical linear analysis for turbulent flows with first order closures. This effect, together with sand transport spatial relaxation, is at the origin of the dune instability mechanism.

****

Understanding the causes of increased sand influx at the Begrawiya (Meroe) pyramids archaeological site, Sudan: initial findings to support the implementation of a mitigation programme

MUNRO R.
Dept Earth & Environmental Sciences, Leuven University, Belgium, NORTH BERWICK, UNITED KINGDOM

In Pharaonic and Mediaeval North Sudan / Nubia infrastructure burial, mostly by aeolian sand deflated from the Nile, was a severe problem and often uncontrollable. Today, drifting sand sources at the same sites are largely from the Sahara and Nubian deserts; deflation of sands from wadis and bedrock augment this supply. Since the 1970s adrastic increase in accumulation of aeolian sand has been observed at the Royal Pyramids of Meroe at Begrawiya, Sudan [Hinkel, 2004: *Sudan & Nubia*, **4**]. Today, dunes now partly cover the site, resulting in inability of access to the monuments, while sand blasting damages stonework. Our regional reconnaissance [Munro et al, 2012: *Sudan & Nubia*, **16**] has drawn on Hussien Abuzeid's work: over 885 days (2005-07) he measured sand drift in N Sudan to provide an accurate view of drift rates. Most sands drift from the north, but during the *khareef* SW monsoon winds reverse and sand is from south: irrigation planners use these data to design canals alignments and establishment of structured windbreaks.At Begrawiya, working with the NCAM we are utilising this knowledge too in a feasibility study that is assessing the sand drift problem and preparing a mitigation plan that will aim to reduce future sand influx and also clear the site of existing sands by deflation, or manual methods. Work includes an assessment of the dynamics of winds and sand deposition in the area; examination of historical ground and aerial photography to gauge change; assessment of land use and climate change scenarios as a cause of the sand movement into the site; processing of satellite imagery to observe regional and local trends in sand movement; preparing specifications and costs for the design and implementation of an irrigated shelterbelt that could entrap sand upwind of the site; establishing criteria for monitoring and evaluation indicators; and disseminating the experience gained for application at other sites in Sudan affected by sand incursions.

The Study of Relationship between Moving of the Farming-pastoral Boundary and Preaching of Catholic Church in Kalgan, Northern China

ZHANG X., SUN T., XU J.
Institute of Chinese Historical Geography, Fudan University, SHANGHAI, CHINA

The area along the Great Wall is the transition belt between subhumid region and arid / semiarid region, and was the boundary between agriculture area and nomadic area in northern China since Qin Dynasty（221-206 BC）. Although the political forces in the central area and nomadic area might have influence on the location of the farming-pastoral boundary, this boundary basically was fixed on the Great Wall belt for over 2000 years. However, as soon as the farming land crossed the Great Wall since late Qing Dynasty(1840), the boundary between farming and animal husbandry was pushed northward and westward about 3-6 miles a year in Mongolia Plateau substantially.

Based on the data from local archives, Christian materials and investigation, the research aims to study the mission and social works of Catholic Church, from Lazarist to Congregation Immaculate Cordis Mariae(CICM), in Kalgan Area, beyond the Great Wall since 1840, especially on the influence of the land reclamation in the region. In the case study, the authors found that Catholic Church had became an important force in the pushing of the farming-pastoral boundary northward and westward in late Qing Dynasty after they took the strategy of preaching the Han Chinese rather than the Mongols in Kalgan region. In the process, Catholic Church achieved success in their missionary work in Inner Mongolia by immigrating the Catholics and establishing Catholic villages there. As more and more Han Chinese Catholics entered Inner Mongolia, the former grassland began to change to farm land. At the same time, the organizational form and social policy of CICM was suitable for the natural and social condition of Inner Mongolia. In view of this, the study has a significant scientific value as to discover the law of environmental evolution in arid/semi-arid region. Meanwhile, it could analyze how the natural ecological pattern and environmental evolution influence the local political form, economic structure, and cultural pattern.

****

Aeolian activity in DingJie area(southern Tibet, China)during Holocene

PAN M.(1), WU Y.(2), ZHENG Y.(3)
(1) Northwest Normal University, LANZHOU, CHINA ; (2) Beijing Normal University, BEIJNG, CHINA ; (3) Institute of Geographic Sciences and Natural Resources Research, BEIJNG, CHINA

In Dingjie area（southern Tibet）where the aeolian deposition is concentrated, the author selected XL, JJ and TG profile of paleo-aeolian deposition in Holocene and established chronological sequence of each section by the means of OSL, AMS ^{14}C and ^{14}C dating. With the main method of grain size, referring to the methods of magnetic susceptibility, organic matter contents and chroma characteristics, the paper rebuilt the process of aeolian activities in Holocene in Dingjie. The results of deposition record of paleo-aeolian show the development of aeolian geomorphy experiences multiple strong to weak and to strong shifts of aeolian activities and soil fixing with the alternations of cool-dry and warm-humid climate in Dingjie since Holocene. 12.8 kaB.P. to present, the climate has fluctuated frequently and experienced following 5 processes: being warm-humid with weak wind and less sandy paleosol developing during 12.8～11.6 ka B.P. and 6.6～4.9 ka B.P.;in the period of 11.6～9.3 ka B.P. and 2.4～0.2 ka B.P., the sandlot expanded with cool-dry climate and strong wind and aeolian activities, and the moving dunes were developing; Being cool-dry relative to warm-humid back ground with strong aeolian activities and fixed and semi-fixed dunes during 9.3～6.6 ka B.P. and 4.9～2.4ka B.P.. Compared with the records of ice-core, lacustrine deposits and tree rings, the time of origin of Holocene events recorded by paleo-aeolian deposition is corresponded with that is recorded by other methods as a whole but with little discrepancies.

Keywords: Holocene; aeolian activity; aeolian geomorphy; climate change; Dingjie area

*This work was supported by the National Natural Science Foundation of China (41071129) and National Basic Research Program of China (2013CB956001).

Recent development of coastal sand dunes, Parangtritis, Yogyakarta, Indonesia

SRIJONO S., HENDRATNO A., HUSEIN S., FRESKY Y.
Department of Geological Engineering, UGM, YOGYAKARTA, INDONESIA

ParangtritisBeach is located 30 km south of Yogyakarta, Central Java, Indonesia. Facing to the Indian Ocean, this beach is considered to be unique due to the presence of coastal sand dunes, a rare geomorphic phenomenon in the equatorial Southeast Asia, hence became the main reason to develop the area into a major tourist destination. This study attempts to investigate the recent development of Parangtritis sand dunes under the influence of tourism.

This research involves multi-temporal aerial photos analysis. Field mapping was conducted to identify the existing landuse and to collect surface sand samples, whilst auger hand-drilling was completed to collect sub-surface sand samples and to identify soil horizons. Laboratorium analysis was performed to study sedimentological aspect of sand samples, i.e. mineralogical composition and granulometry.

The sand dune complex of Parangtritis is composed of longitudinal, barchans, and transversal. Sand mostly composed of andesitic transported from the active Merapi Volcano, 55 km to north from the beach. Dune-forming wind is the southeast trades from Indian Ocean. Granulometric analysis suggests that those dunes were built by fine sands (23.3 – 68.4 %) and medium sands (22.6 – 72.9 %) with good sortation.

Area coverage of the sand dunes complex at 1960 was approximately of 4.5 km^2, but it shrinks to just about 1 km^2 at present-day, suggesting a 80% decreasing rate for 50 years. For the last 5 years, barchan dunes was poorly developed, due to growth of tourism area and extension of agricultural area. Sand supply from Merapi Volcano also significantly reduced due to lahar-controlling dams in upstream of Opak River that effectively cut the sediment transport to the lowland. A serious method need to be implemented to preserve the sand dune complex of Parangtritis, considering the consequences of volcanic sediment supply reduction and expansion of tourism and agricultural areas.

****

Modeling aeolian coastal dunes mobility in Aquitaine, South Western France

GABARROU S.(1), LE COZANNET G.(2), PARTELI E.(3), PEDREROS R.(1), OLIVEROS C.(1), BRIVOIS O.(1), MULLER H.(1), GUEBER E.(1), MALLET C.(1)
(1) BRGM, ORLEANS, FRANCE ; (2) BRGM / Univ Paris 1 / LGP, ORLEANS, FRANCE ; (3) Universidade Federal do Ceará, Departamento de Física, FORTALEZA, BRAZIL

The aquitaine coast (South western France) comprises a 230 km coastline of sandy beaches and dunes. Since 1979, most of the coastal dunes of Aquitaine are softly managed by maintaining their vegetation. When wind erosion landforms appear, they are stabilized by bringing vegetation debris and wind obstacles. One question is to understand if dunes management could become softer without strong consequences for assets located behind the dunes. In absence of vegetation, such as in the Pyla dune, ongoing dune mobility is expected to affect a road and a tourism facility in the future. Finally, changing wind patterns potentially due to climate change or variability may affect Aeolian sand transport. These questions motivated a modelling study of coastal dunes mobility based on examples in Aquitaine.

In this study we used an aeolian dunes model previously validated in deserts, in order to evaluate its potential for representing dunes movements. The results show poor capabilities to represent the competition between vegetation growth and winds in the case of vegetated dunes. In the case of Dune du Pyla, while the profile of the dune is not modelled satisfactorily, the modelled dune velocity (3m/year) are in good agreements with an analysis of maps (between 2 and 4 m/year from 1964 to 1994). We used a statistical model that generates longer wind time series in order to estimate uncertainties and longer term dunes mobility due to changing wind patterns. Model uncertainties are lower than the variability due to observations, highlighting the fact that strong winds transport is underestimated in the model. According to the model, an intensification of winds by 15% would lead to increase dune velocity of 9%. More frequent storms would lead to averaged mobility rates of up to 4m/year. Although these modelling results must be considered carefully, the approach of combining a stochastic model for winds with a physical dune model provides some insight to their future evolution.

Dust Observations for Models (DO4Models): Project Overview

WIGGS G.(1), WASHINGTON R.(1), KING J.(1), THOMAS D.(1), WOODWARD S.(1), ECKARDT F.(2), HAUSTEIN K.(1), BRYANT R.(3), NIELD J.(4), VICKERY K.(2), MURRAY J.(5), BRINDLEY H.(5), JONES R.(6)
(1) University of Oxford, OXFORD, UNITED KINGDOM ; (2) University of Cape Town, CAPE TOWN, SOUTH AFRICA ; (3) University of Sheffield, SHEFFIELD, UNITED KINGDOM ; (4) University of Southampton, SOUTHAMPTON, UNITED KINGDOM ; (5) Imperial College, LONDON, UNITED KINGDOM ; (6) UK Meterological Office, EXETER, UNITED KINGDOM

Climate and weather prediction hinge on numerical models. Most of the climate models included in the Coupled Model Intercomparison Project 5 (CMIP5) and which will underpin the Intergovernmental Panel for Climate Change 5th Assessment Report (IPCC AR5) include a dust module because dust is known to play an important role in the Earth system. However dust emission schemes in climate models are relatively simple and are tuned to represent observed background aerosol concentrations most of which are many thousands of kilometres from source regions. The physics of dust emission in the models was developed from idealised experiments such as those conducted in wind tunnels decades ago. Improvement of current model dust emission schemes has been difficult to achieve because of the paucity of observations from key dust sources. Dust Observations for Models (DO4Models) is a project designed to gather data from source regions at a scale appropriate to climate model grid box resolution. The UK NERC funded project, led by the University of Oxford, aims to: 1) Generate a data set at an appropriate scale for climate models which characterises surface erodibility and erosivity in dust source areas from remote sensing and fieldwork 2) Quantify how observed erodibility and erosivity influence observed emissions at the climate model scale 3) Test, develop and optimise the dust emission scheme for the Met Office regional model (HadGEM3-RA) using this unique dust source area data set 4) Quantify which component(s) of observed erodibility and erosivity, and at what spatial scale, make the largest improvement to physically-based, observationally optimised dust emission simulations in climate models. This paper provides a project overview and some early observational and modelling results from the 2011/2012 field seasons.

****

More than 5000 years of interaction between aeolian, fluvial and anthropogenic systems in the central Egyptian Nile valley

VERSTRAETEN G., MOHAMED I., NOTEBAERT B.
KU Leuven, LEUVEN, BELGIUM

Interactions between aeolian processes and the Nile fluvial system have been illustrated for the late Pleistocene at many sites along the River Nile, but for the Holocene period almost no data is available on this interaction. In this study we reconstruct the interaction between the South-Rayan Dune Field (SRDF) and the Nile valley in central Egypt for the last 5000 years by applying a field-based geomorphic approach, combining geophysics, sediment coring, quarry stratigraphy, geochemistry and radiocarbon dating. Three main units/periods could be distinguished: the Pleistocene Nile braidplain, the aggrading Holocene Nile silts, and the Late Holocene desertification, with dune expansion from the Western Desert into the Nile floodplain. The latter is indicated by an intercalation of flood deposits and dune sediments, with increasing thickness of Nile silt layers at greater depths. The transition from the second to the third unit most probably corresponds to the drying period characteristic for the Nile River Basin and the Sahara since the Mid-Holocene. Several cultivation layers, the oldest dating from the onset of the Old Kingdom, could be detected illustrating the presence of humans in a fluvial landscape that becomes influenced by aeolian processes. Through time the Nile floods were more and more blocked by invading dunes, although the sand flux into the Nile valley was insufficient to block the Nile itself. It is, however, suggested that invading sand dunes shifted the Bahr-Youssef channel further east. At present, the major process shaping the interaction area is of anthropogenic origin. Field observations and satellite images from 1963, 1984 and 2003 showed that dunes are being removed at high rates by quarrying activities, leveling, irrigation and the establishment of agriculture. As such, these sediment archives providing valuable information on the Holocene fluvial-aeolian interactions are being obliterated.

Process and causes of neo-exoreism in Sahel: 'Koris' study case in the area of Niamey (Niger)

MAMADOU I.(1), GAUTIER E.(2), BOUZOU-MOUSSA I.(3), DESCROIX L.(4)
(1) Dept of Geography University of Zinder, ZINDER, NIGER ; (2) Dept Geography University Paris 8 - Laboratoire de Géographie Physique (LGP) / CNRS UMR 8591, Meudon, PARIS, FRANCE ; (3) Dept of Geography University of Niamey, NIAMEY, NIGER ; (4) IRD - LTHE, GRENOBLE, FRANCE

This paper focuses on rapid endoreism bursting in the area of Niamey within the context of changing environmental conditions in order to evaluate the impact of anthropogenic factors and West Africa drought. Since the late 1980's numerous new "koris" (wadi) have developed in the area of Niamey; some of them were created during a single event of summer storm. Rapid runoff caused by intense rainfall has connected together former seasonal or perennial pounds and the new created channels have evolved downstream and upstream during the following humid seasons. The main origin of the neo-exoreism process is the rapid land-use change that causes a pronounced increase in runoff and soil degradation. The long drought acting since 1968 in West Africa (in spite of a recent rainfall increase) also participates to the desertification process. The paper first presents the evolution of land-use for the last 40 years in two basins that are representative of the significant increase in crops and disappearance of natural bushes in the whole Sahel. The two study cases clearly show the strong correlation between extension of bare surfaces, soil crusting and runoff coefficients. Secondly, the study analyses in details the koris functioning: hydrological processes, sediment transfers and morphological changes. It emphases the part played by the koris (mainly by bank retreat) on the sediment supplied in the Niger River. Huge alluvial fans deposited by the koris at the Niger River junction trigger fluvial dynamics and human activities (water resources, navigation…). Finally, the study proposes a typology based on pattern evolution and dynamics of the koris.

****

The structure and development of a star dune, Lala Lallia, Erg Chebbi, Morocco

BRISTOW C.(1), DULLER G.(2)
(1) Birkbeck University of London, LONDON, UNITED KINGDOM ; (2) Aberystwyth University, ABERYSTWYTH, UNITED KINGDOM

Star dunes have a pyramidal form with radiating arms, and are the largest and most complex type of desert sand dunes (Lancaster 1989). They are reputed to be the largest sand dunes on Earth (Wasson & Hyde 1983) and are certainly the tallest type of sand dune, reaching 300m in the Badain Jaran Desert (Chen et al. 2004). Star dunes are relatively widespread amongst the world's major deserts with examples in the Northern Sahara, Namib Sand Sea, Gran Desierto, Gobi Desert & Rub al Khali; they have also been identified on Mars (Edgett & Blumberg 1994, Fenton et al 2003, Hayward et al. 2007). On Earth, star dunes are believed to comprise around 11% of all desert dunes (Pye & Tsoar 1990) and contain a greater volume of sand than any other dune type (Wasson & Hyde 1983). However, in spite of, or possibly because of, their large size there has been very little research into star dune morphodynamics, or their deposits.

Given the widespread distribution of star dunes today, often at the heart of the world's largest sand seas, their large volume, and association with sediment accumulation it is reasonable to expect that star dunes should be preserved within the rock record. However, ancient examples are exceptionally rare and we know of only two documented examples (Clemmensen 1987, George & Berry 1993) – it is not clear whether this paucity of ancient star dunes is real, or a reflection of the lack of sedimentary studies of star dunes, although the latter appears to be a strong possibility.

The visualisation of star dune stratigraphy using GPR in this paper provides the information required to develop a sedimentary model to address this conundrum. In addition, we provide the first chronology for star dunes by optical dating showing the rate at which they can form. We challenge the paradigm that star dunes are old and relatively static by demonstrating that a star dune has accumulated 65m in under 1000 years in a low wind energy environment.

Size distribution of barchan dunes with a cellular model

KATSUKI A.
Nihon University, FUNABASHI, JAPAN

Sand dunes are found in many places such as deserts, the sea bottom and the surface of Mars. They are formed through interplay between sand and air flow or water flow. When a strong flow blows, sand grains are dislodged from the sand surface. The entrained sand grains collide with the ground and are sometimes deposited. This process takes place repeatedly, resulting in the formation of a dune. The profile of the wind flow is modified by dune topography. Most fascinated dune is barchan, which is crescent dune. We reproduced many barchans in numerical simulations and investigate the dynamics.

The motion of sand grains is realized by two processes: saltation and avalanche. Saltation is the transportation process of sand grains by flow. The saltation length L and the amount of transported sand q are modeled by the following rules,$L = a+bh(x,y,t)-ch^2(x,y,t)$, where h(x,y,t) is local height. In the avalanche process the sand grains slide down along the locally steepest slope until the slope relaxes to be (or be lower than) the angle of repose which is set to be 34°.

We reproduced a few hundred of barchans in numerical field by above model. Barchan releases sand from tips of two horns. The downwind barchan can capture the sand stream. Also, barchans sometimes collide each other. These direct and indirect interaction forms complex barchan fields. The size distribution of a few thousand of barchans is fitted by lognormal distribution well. The average size of barchans increase as the amount of supplied sand do. Next, when two barchan corridors collide, the size of barchan in the boundary between corridors has three type. Type (I) is not decoupling distribution, which shows superposition of each distribution. Type (II) is a distribution of uniform size. Through collision and inter-dune sand stream, the size of each barchan become uniform. Type (III) shows a enhanced distribution of the barchan's size.

****

Non-linear differentiation in fluid thresholds for wind-induced sediment mobilisation in low-pressure, high-altitude mountain environments

DE VET S., CAMMERAAT E.
IBED-Earth Surface Science, Unviversity of Amsterdam, AMSTERDAM, NETHERLANDS

In planetary research, atmospheric pressure has been a parameter in experimental simulation for decades. In spite of the well-developed cadre, only little attention has been given to the pressure gradients that exist in high-alpine region on Earth. Global climatic change causes upward migration of climate zones that will heighten hydrological stress and therefore the effects of aeolian erosion might increase. We therefore carried out experiments using a hypobaric (low-pressure) wind tunnel to measure sediment transport by rolling at the fluid threshold. In addition to a systematic variation in particle diameters we also varied the atmospheric pressure in a gradient from 1024-240 mbar to quantify the altitudinal variation in these aeolian thresholds. The used pressures correspond to altitudes of 0-10 km above sea level and make the observed thresholds applicable for ecosystems at sea level, the European Alps, Andes and Himalayas, up to the summit of Mt. Everest. We found that the upper range for rolling of dry sediments at the fluid threshold can be up to 56-125% higher in many of the world's high-alpine areas. However, these thresholds increased nonlinearly for different textures with decreasing pressure. Mobilisation is thus more selective by winnowing of e.g. sandy textures. Compared to a given state, dehydration of a high-altitude ecosystem can shift the force balance in sediment in favour of rolling and this will increase sand fluxes. As these thresholds differ with altitude, rates of aeolian erosion can be much higher in high-altitude environments than suggested by studies under ambient sea level conditions.

A Global Digital Database and Atlas of Quaternary Dune Fields and Sand Seas

LANCASTER N.(1), HALFEN A.(2)
(1) Desert Research Institute, RENO, UNITED STATES ; (2) University of Kansas, LAWRENCE, UNITED STATES

Sand seas and dune fields are globally significant sedimentary deposits, which archive the effects of climate and sea level change on a variety of temporal and spatial scales. Dune systems provide a valuable source of information on past climate conditions, including evidence for periods of aridity and unique data on past wind regimes. Researchers have compiled vast quantities of geomorphic and chronological data from these dune systems for nearly half a century, however, these data remain disconnected, making comparisons of dune systems challenging at global and regional scales. The primary goal of this project is to develop a global digital database of chronologic information for periods of desert sand dune accumulation and stabilization, as well as, pertinent stratigraphic and geomorphic information. This database can then be used by scientists to 1) document the history of aeolian processes in arid regions with emphasis on dune systems in low and mid latitude deserts, 2) correlate periods of sand accumulation and stability with other terrestrial and marine paleoclimatic proxies and records, and 3) develop an improved understanding of the response of dune systems to climate change. The database currently resides in Microsoft Access format, which allows searching and filtering of data. The database includes 4 linked tables containing information on the site, chronological control (radiocarbon or luminescence), and the pertinent literature citations. Thus far the database contains information for 990 sites world wide, comprising 2780 luminescence and radiocarbon ages, though these numbers increase regularly as new data is added. The database is only available on request at this time, however, an online, GIS database is being developed and will be available in the near future.

****

Initial investigations of the age and provenance of the dunes of Rooisand in the Great Escarpment region of western Namibia

STONE A.(1), GARZANTI E.(2)
(1) School of Geography and the Environment, University of Oxford , OXFORD , UNITED KINGDOM ; (2) Laboratorio di Petrografia del Sedimentario, Dipartimento di Scienze Geologiche e Geotecnologie, Università Milano-Bicocca, MILANO, ITALY

In a topographic low point between the Hakos Mountains and the Gamsberg, where the Great Escarpment separates the Khomas Highland from the Namib Desert plain, there is a distinctive patch of red sand, covering about 10 km^2. This appears to be of aeolian origin, however to the best of our knowledge almost nothing is currently known about the potential origin and depositional age of these sediments. This poster presents the results of a reconnaissance investigation using bulk-petrology and heavy mineral analysis and optically stimulated luminescence dating. Our hypotheses is that the sediment is derived from the Namib Sand Sea, and has been transported north-west during some point of the Quaternary. However, it is also possible that the material has been derived from the Kalahari to the east of the Escarpment, meaning the material has blown from the east of the site, or that the sediments represent the product of local-weathering. Whilst the petrology is likely to yield definitive results about sediment provenance (e.g. Garzanti et al., 2012) the challenge to establishing the timing of the initial deposition of these sediments is that luminescence ages record only the last phase of sedimentary deposition. It is arguably not only possible but also likely that these sediments have gone through a number of cycles of deposition, erosion and re-deposition by the wind and possible fluvial transport by the small tributaries of the Kuiseb River in this region. Establishing the source region will allow palaeoenvironmental inferences to be made about dominant wind directions and if these sediments prove to be from the Namib Sand Sea, perhaps the northernmost travelled preservation of Orange River delta material.

Garzanti, E., Andò, S., Giovanni, V., Lustrino, M., Boni, M., Vermeesch, P. (2012) Petrology of the Namib Sand Sea: Long-distance transport and compositional variability in the wind-displaced Orange Delta. *Earth Science Reviews* 112 (3-4), 173-189.

Modelling the interaction between sand dunes and rivers, and the impact on geomorphology

BAOLI L., COULTHARD T., MCLELLAND S.
University of Hull, HULL, UNITED KINGDOM

Aeolian and fluvial systems are usually studied independently which leaves many questions unresolved in terms of how they interact. When sand dunes and rivers coincide with each other, the interaction of sediment transport fluxes between the two systems may lead to change in either or both systems therefore can significantly change surface morphology. An inventory is presented from 187 globally distributed study sites from locations where fluvial and aeolian systems interact with each other.

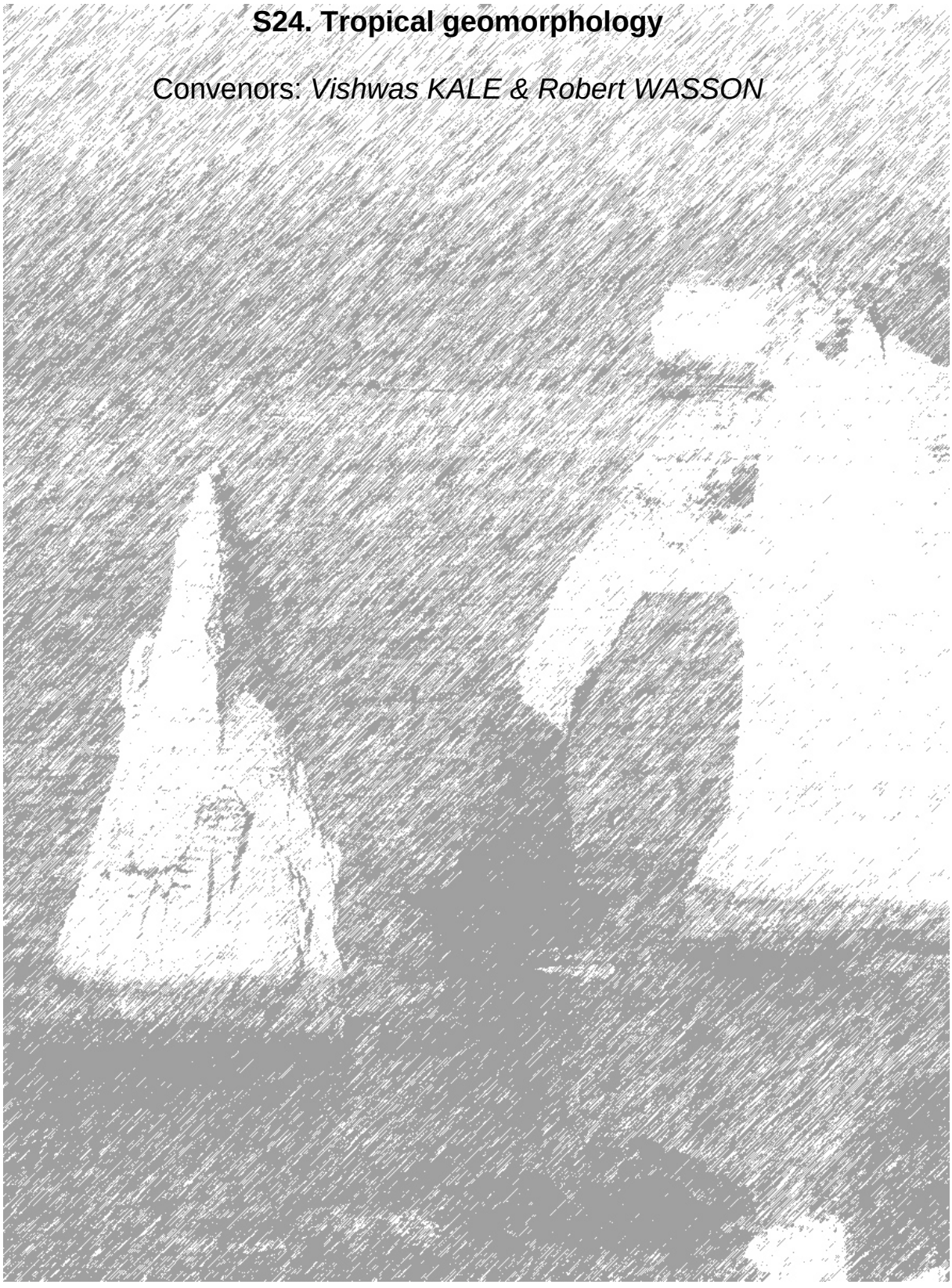
From this field survey, 6 different types of interaction are classified and the results have been analyzed to understand the most frequent modes of interaction. There are about 47% of all examples in which the rivers flow parallel to the wind direction and braided rivers are the dominant channel pattern (42%). Longitudinal dunes rather than transverse dunes are most frequently associated with these braided channel patterns, possibly due to transverse dunes being associated with low sediment availability and therefore the aeolian sediment flux is insufficient to change the river channel type. In contrast meandering rivers occur more frequently when sand sheets dominate the aeolian system. Overall, cresentic dunes are the most common dune type (55%) where fluvial and aeolian systems interact.

Based on this analyzes, a cellular aeolian/dune model and fluvial model are used to simulate interacting processes which presents different interacting behaviours. Different factors (wind/water speed, sediment supply) are examined to investigate the triggers that may switch the dominance between processes and the consequent changes in morphology that may occur.

****

S24. Tropical geomorphology

Convenors: *Vishwas KALE & Robert WASSON*



Oral presentations:

Anabranching patterns in large rivers: state of the art and clues from the tropics

LATRUBESSE E.
The University of Texas at Austin, AUSTIN, UNITED STATES

I proposed a new category or large rivers, including the nine largest rivers on Earth: mega-rivers, which are those with a Q_{mean} of more than ~17,000m^3/s. They are the Amazon, Congo, Orinoco, Yangtze, Madeira, Negro, Brahmaputra, Japura and Parana. As noted, six of the largest rivers of the world are located in South America (four of them in the Amazon basin). The understanding of why the largest rivers differ from smaller rivers and how this response is observed in the planform channel geometry is a critical topic in fluvial geomorphology. The decoupling of knowledge between large and smaller fluvial systems represents a central current scientific concern. Such big rivers are few in number but spectacular in size. Considering the importance of large rivers and river floodplains to a range of global-scale ecological issues, such as sediment flux, carbon sequestration, and water resources, this represents a significant problem for river management. Indeed, most of the runoff on Earth is transported by a few very large rivers, with ~16 to 20% of the runoff discharge by the Amazon.

Over the past two decades, there has been a growing appreciation of the distinctiveness and importance of anabranching rivers and slowly the interest on large tropical rivers also have been increasing. When applying the concept of a channel pattern continuum I obtained a surprisingly result: the universal end member pattern for large alluvial rivers is anabranching. All the rivers in the world with mean annual discharge larger than 17000 m^3/s are not capable in maintaining a relatively pure “braided” or meandering pattern.

On the other hand the floodplain characteristics of large anabranching rivers are different than other smaller systems.

I discuss in this presentation the state of the art on anabranching channel characteristics and classifications as well as the morphological-morphodynamics processes that generate anabranching patterns in large rivers.

****

Monsoonal rivers of Australia's "Top End" in the late Quaternary

MAY J.H., NANSON G.C.
School of Earth and Environmental Sciences, Uni Wollongong, WOLLONGONG, AUSTRALIA

Due to their strategic position between significant atmospheric phenomena, subtropical and tropical river systemsare considered unique and sensitive archives for the detection of past changes in global circulation patterns. In Australia, most data on the Mid- to Late Quaternary evolution of fluvial systems comes from the southeast of the continent as well as its dry interior. Even though here peaks in discharge and effective moisture do not appear to have occurred everywhere synchronously, much of the hydrological variations in Central Australia have generally been attributed to variations in monsoon strength and position. Given these issues, unravelling the impacts of past changes in monsoonal intensity on fluvial systems in Australia's tropical north - the 'Top End' - will substantially contribute to our understanding of causes and mechanisms of climate changes in Australia.

Our study will present first results from the major river systems draining the 'Top End' (Adelaide, Mary, and South Alligator Rivers). Upstream of bedrock constrictions and the effects of sea-level change, extensive but currently inactive floodplains have accreted along the middle reaches of the catchments. Virtually no data is so far available from these floodplains although their stratigraphic and sedimentary record should contain valuable information on the late Quaternary evolution of the fluvial system in northern Australia. Here, we (i) present first stratigraphical data for these floodplains, (ii) document their geomorphologic setting based on the analysis of elevation models and remote sensing data, and (iii) discuss the significance of these results in terms of the larger-scale paleoclimatic evolution in the seasonal tropics.

The Quaternary Mekong River terraces: sediments, climate and former river courses

MESHKOVA L., CARLING P.
University of Southampton, SOUTHAMPTON, UNITED KINGDOM

Due to the environmental and economic significance of the Mekong River in South East Asia there is an increased attention to understand the modern fluvial processes. However the present river dynamics together with the future dynamics, in part, are conditioned by the longer-term climatic and tectonic contexts of the river. The knowledge of the Quaternary fluvial landforms of the Mekong in Cambodia are currently basic but have been advanced by investigations of the river terraces into which modern channel has incised. Three terrace levels can be recognised, separated in the vertical, lateral and temporal dimensions with distinctive sedimentary signatures. The terraces are composed of sand and gravel beds, lying above weathered bedrock or clay deposits with frequently observed laterites developed in the uppermost parts of the terrace sections. The highest (notionally at 100+ masl) is deeply dissected into bedrock with a veneer of sand and gravel dated as ~700Ka. The river then incised to form a strath terrace before aggrading to produce a distinctive level between 60 and 40masl (40+masl terrace). A further terrace is locally developed at 20+masl and floods during exceptional flood events. Petrified wood is locally abundant in the terrace gravels and has been used as a tracer to examine prior hypotheses concerning palaeo-courses of the river. Satellite images and DEMs have been used in a GIS framework to map the terraces and delineate main course palaeochannels. Mapping the various outcrops of Quaternary river alluvium within the Lower Mekong Basin, notably in Thailand, have extended our knowledge of Mekong terrace development through the basin and together with the tectonic history allow suggestions as to the development of the Mekong in the region during the Quaternary. Altogether these observations comprise a picture of regional pattern of fluvial development in the region due to the combination of climate cycles and neotectonic movements.

****

Quaternary Evolution of the Pearl River Delta, China, Inferred from Terraces and Boreholes

YU Z., ZHANG K.
Sun Yat-sen University, GUANGZHOU, CHINA

The Pearl River Delta, one of the largest deltas in China, is located at north margin of the South China Sea. The evolution of the delta is subject to both sea level changes and local neotectonic movement. Previous research indicates that the delta has 6 formations representing 2 marine transgression cycles. Although there has been consensus on the age of the 2nd cycle, which resulted from a postglacial sea level rise, the age of the 1st cycle is greatly debated. Based on 14C and TL dating (40-50 ka BP), the 1st cycle was regarded as deposits during MIS3. But the sea level of MIS3 was about 50m lower than present, and the altitudes of the marine deposits of the 1st cycle, i.e. -25m~-10m, in the delta do not match with the sea level of MIS3. The radiocarbon range is limited to 40-50 ka and the samples may also be contaminated. Comparison of the terraces in the delta area and boreholes provides a new perspective to solve these problems. Based on detailed field investigation, environmental proxies, and dating of OSL and 14C, the relationship between the sediment on the terraces and in the cores can be revealed: (1) The sedimentary sequences on the terraces are uplifting parts of the 1st cycle; (2) the 1st cycle deposits covered the period of MIS6(150ka OSL dating) and MIS5 without deposits of the time interval of MIS4-MIS2; (3) the layers on the terraces connected with 1st cycle indicate uplifting and tilting after MIS5. Furthermore, the comparison of the delta sedimentary sequence with that in continental shelf of Northern South China Sea illustrates besides 2 cycles in Pearl River Delta, there are more older cycles on the continental shelf. So the subsidence in the delta area is the result of northwestward extension of subsidence in the continental shelf, and only records the last 2 transgression cycles.

Sedimentary Records of Monsoon Variability from Historical Tanks in the rainshadow zone of the Western Ghat, Deccan Trap Region, India

KALE V.S.(1), MAGAR A.(1), BASAVAIAH N.(2), RAJSHEKHAR C.(3)
(1) Department of Geography, University of Pune, PUNE 411 007, INDIA ; (2) Indian Institute of Geomagnetism, New Panvel, NAVI MUMBAI 410 021, INDIA ; (3) Geology and Palaeontology Group, Agharkar Research Institute, PUNE 411 004, INDIA

The Deccan Trap Region covers an area of about half-a-million square km. In this youngest morphotectonic region of India, the reconstruction of the palaeo-monsoon history on different time scales is hampered by limited potential of traditional climate-proxy archives such as natural lakes, tree rings and speleothems. The fluvial records are limited in extent and, thus, not very helpful in the reconstruction of climate over the last few centuries. Lakes are generally considered as one of the most reliable natural archives of basin-wide precipitation and the catchment response. However, there are no natural lakes in the climate-sensitive rainshadow zone of the Western Ghat to perform a multi-proxy climate reconstruction. Developing a baseline of late-Holocene monsoon precipitation variability using a multi-proxy methodology is key to understanding monsoon variability of the present and the future. Therefore, about half-a-dozen historical tanks were identified and investigated. These tanks were constructed between the 16th and 20th century. The historical tanks under investigation receive runoff and sediments only from the local catchment. Consequently, any change in physical, chemical and mineral magnetic properties of the tank sediments directly reflects variations in the input from the catchment. Sediment samples were collected for textural, geochemical and magnetic susceptibility analyses as well as for chara studies. By and large, the sediments do not reveal significant vertical variations in sediment characteristics in terms of texture, magnetic susceptibility and Chemical Index of Alteration (CIA). The remarkable similarity denotes only subtle variations in the water budget and environmental conditions. The main conclusion of the study is that the rainshadow zone of the Western Ghat has not witnessed dramatic changes in the monsoon rainfall strength and intensity during the last two to four centuries.

****

Holocene alluvial records of the northeast monsoon dominated rivers of south India

ACHYUTHAN H.
DEPARTMENT OF GEOLOGY, ANNA UNIVERSITY CHENNAI, CHENNAI, INDIA

The sub-tropical area around the coastal Chennai, Tamil Nadu, is drained by three parallel to sub-parallel meandering rivers (Koratallaiyar, Cooum and the Palar) that debouch their sediments into the Bay of Bengal. These rivers bear signatures of past phases of aggradation and incisions. Detailed mapping and logging of the fluvial litho section stratigraphy supported by sediment texture and structure, ^{14}C and OSL dates have been used to infer the periods of aggradation and incision. The dated alluvial sequences show that a major periods of aggradation occurred in the early Holocene 9000 to 8400, mid Holocene period 6000-5000 yrs BP and late Holocene to recent periods (2000 and 1300 yrs BP, 800-600 yrs BP) and around 200 yrs back. The period in between these clusters implies fluvial erosion and channel incision events cutting down to the present river-bed in the recent years. The gap of radiocarbon and OSL dates (5000 to 2000 ka cal BP) approximately begins with the 4200 cal BP short-term event (onset of aridity) and ends with 2000 cal BP enhanced monsoon event due to the dominant NE rains. Older terraces north and north west of the Koratallaiyar are preserved due to tectonic uplift; protected by the Late Neogene- Early Pleistocene ferricrete profiles of the Upper Gondwana sandstone and shale and Early Holocene sea level rise. The younger ages of the southern flowing streams indicate that they have not preserved older terraces, eroding them due to subsidence and late Holocene meandering. These rivers have been alluvial plains under the strong driving force of the north-east monsoon and the alluvial surfaces show a good correlation with patterns of precipitation and discharge. Presently it is difficult to decouple the control of climate and tectonics.

Hydro-climatic trends of the Upper Ganga Plains how significant in water resources management

ROY N.(1), SINHA R.(2)
(1) Presidency University, KOLKATA, INDIA ; (2) IIT Kanpur, KANPUR, INDIA

Hydro-climatic trends at basin scale are required for developing strategies related to planning, development and management of water resources in a river basin. In order to identify hydro-climatic trends of the Upper Ganga Plains (UGP) discharge and rainfall data along the major and minor rivers and from their associated catchment area were collected from Indian Government agencies. Trends at individual station were evaluated based on the Mann-Kendall non-parametric statistical test. For obtaining the basin wide trends of the parameters Belle and Hughes (1984) chi-square test method was adopted.

The analysis of rainfall and discharge time series from 1960 to 1997 shows decreasing trends (sometimes significant) of discharge along the major rivers, particularly during monsoon season (June - September), while minor rivers do not have any basin wide consistent trends. However, the minor rivers show significantly increasing trends during non-monsoon season (October - May). The decreasing trends of rainfall are significant and basin wide consistent throughout the year. The statistical homogeneity test showed that the climatic trends are regional whereas the hydrologic trends are more localized in nature lacking a distinct basin-wide significance.

The assessment of anthropogenic inputs showed that the population of Uttar Pradesh State (UGP) grew at a compound rate of about two percent per annum during the past four decades. The comparison of discharge diversion through side canal from the major river Ganga for irrigation and the comparison of the land-use changes in the Uttar Pradesh State (UGP) between 1930 and 1990 reveal noticeable trends which are found to be in favour of localized decrease of the discharge of the major rivers in UGP.

Key words: hydrological trends, climatic trends, trends homogeneity, anthropogenic impact

****

An appraisal of geomorphic complexity of a large tropical river, Ganga River system, India

JAIN V.(1), TANDON S.(2), SINHA R.(3)
(1) Department of Geology, Centre of Advanced Studies, University of Delhi, DELHI, INDIA ; (2) Shiv Nadar University, Greater Noida, GAUTAM BUDH NAGAR - 203207, INDIA ; (3) Indian institute of Technology Kanpur, KANPUR - 208016, INDIA

Understanding the complex geomorphic response of a large river dispersal system to external disturbances is a major geomorphic challenge, because multiple compartments (landforms) in a large river system are characterized by threshold driven differential sensitivity and equilibrium stages. Geomorphic records of the Ganga River system, a large tropical river that also supports dense population in its basin has been analysed to understand its response to external forcing. The landform scale geomorphic records have been integrated to analyse spatio-temporal variability of the large dispersal system. Different tributaries of the Ganga River basin are characterized by diverse geomorphic sensitivity due to which similar climatic events have generated contrasting landforms related with erosional or depositional processes. Further, different reaches in the large Ganga river system may not be connected at millennial time scale, as available data on sediment residence time in different landforms varies from 100 ka to 1000 ka. The disconnected nature will be responsible for dissimilar response by various compartments (landforms) of the dispersal system, as each component will respond independently to any climate change event. Further, the magnitude of sediment contribution from any particular hinterland area has also temporally changed in the Ganga River system, which adds extra complexity and unpredictive behaviour of river response. In terms of magnitude-frequency analysis, high magnitude floods are more significant for effective sediment transportation, which suggests dominant role of extreme events on the geomorphic system of this region. This analysis highlights significance of the threshold and the connectivity in controlling the nonlinear and complex behaviour of river response to any external disturbances. Quantification of threshold condition and connectivity index is a major challenge for better geomorphic understanding of the Ganga River system.

Long term geomorphic landscape evolution and gold deposits in the Central African Republic (CAR, Bandas Greenstone Belt)

RUNGE J., EISENBERG J.
Goethe-Universitaet, FB 11: Institut fuer Physische Geographie, FRANKFURT, GERMANY

A new project funded by DFG (German research Foundation) is introduced. Focus is on long term landscape evolution in the *Bandas Greenstone Belt* north of Bambari in CAR. The site is a geologically old and resource-rich area. Main objective is to glean new findings and knowledge on the geomorphic landscape evolution of the planated multilevel relief complex. The denudational zone, originally located in a landlocked geographical position, was characterized by arid climate. Triggered by the Jurassic/Cretaceous break apart of Gondwana, weathering and denudational processes changed fundamentally. Nowadays the landscape is characterized by extended strongly mineralized, auriferous lateritic crusts. The composition of *in situ* formed crusts reflects the underlying rocks. Zoogenic sediments accumulated over the crusts give evidence of the composition of the saprolite. Geomorphological and pedological mapping and field trips are applied. Remotely sensed data and GIS support the interpretation and documentation. Exposure dating of iron crust levels is conducted by cosmogenic nuclides. Results will complement the relative dating approach of the geomorphological interpretation of landscape evolution by means of the surface schemata by absolute dating (minimum age) of different surface levels. Deduction of a “geological fingerprint” by lateritic crusts as well as by the characteristics of soil and saprolite leads to the development of a landscape "palaeo-environmental scheme”. An applied result of this study on Gondwanian and Post-Gondwanian surfaces is an estimation of distribution and concentration of gold in the parent rock on the basis of lateritic crusts. A Canadian mining company has conducted extensive drillings for exploration during the last five years. Until 2015 six open pit mines shall be go up for gold exploitation. If the methodological approach and hypothesis are confirmed high gold exploration costs can be minimized in future.

****

Hydro-geomorphologic comparison of two Amazonian rivers: Napo river and Beni river

GARCIA-GOVEA C.(1), GAUTIER E.(2), BRUNSTEIN D.(3), LARAQUE A.(4), GUYOT J.L.(5), ROSALES-SIERRA V.(1)
(1) INSTITUTO MEXICANO DEL PETROLEO, MEXICO, D.F., MEXICO ; (2) Université paris 8/CNRS LGP, MEUDON, FRANCE ; (3) CNR LGP, MEUDON, FRANCE ; (4) IRD, TOULOUSE, FRANCE ; (5) IRD, PEROU, PERU

Nowadays, fluvial systems in tropical environment are still little known. This work proposes a hydro-geomorphologic analysis of two important tributaries of the Amazon river: Beni river and Napo river which are in different hydro-climatic and morpho-tectonic contexts. The objective is to compare the evolution of these two rivers by the distinction of morphological styles: Beni river is characterized by a style of meanders of fast migration while Napo river is characterized by an anabranching pattern with individual islands covered by vegetation and sand banks. We have traced the evolution of the two rivers in space and time (diachronic) from satellite images and in situ measurements using a Geographical Information System (GIS). With this diachronic analysis (annual and multi-annual) we have characterized the dynamics of the two rivers and we have established a link between water discharge and solid discharge. The results show the construction mechanism of alluvial plains and place Beni river and Napo river in the Amazonian context improving the understanding of it.

Were tropical glacier fluctuations synchronous with mid-latitudes during the Holocene?

JOMELLI V.(1), FAVIER V.(2), KHODRI M.(3), BRAUCHER R.(4), BLARD P.H.(5), RINTERKNECHT V.(6), LEANNI L.(4), BOURLES D.(4), BRUNSTEIN D.(1), GRANCHER D.(1), FRANCOU B.(7)

(1) Université Paris 1 Pantheon-Sorbonne CNRS UMR 8591, MEUDON, FRANCE ; (2) OSUG UJF LGGE, GRENOBLE, FRANCE ; (3) IRD LOCEAN, PARIS, FRANCE ; (4) Université Aix-Marseille Cerege CNRS-IRD, AIX EN PROVENCE, FRANCE ; (5) Centre de Recherches Pétrographiques et Géochimiques (CRPG) UPR2300, NANCY, FRANCE ; (6) Université St Andrews, ST ANDREWS, UNITED KINGDOM ; (7) IRD, LA PAZ, BOLIVIA

Updated worldwide studies based on a large moraine record from glaciers selected in mid-latitude regions revealeddifferent deglaciation patterns in the two hemispheres during the Holocene. In the Southern Hemisphere extra-tropical glaciers reached their maximum extent at the beginning of the Holocene and since then, have experienced a continuous retreat interrupted by minor advances. Northern Hemisphere extra-tropical glaciers underwent several large advances during the late Holocene in contrast with the overall trend in the Southern Hemisphere. As tropical regions reflect the interplay between the two hemispheres, it is not clear whether tropical glaciers fluctuated like those at extra-tropical latitudes and if so, which extra tropical pattern they followed. We explored the issue of tropical deglaciation chronology during the Holocene using the most complete preserved moraine sequences from different Andean tropicalglaciers providing the missing link needed to compare interhemispheric history throughout the Americas. To allow a precise reconstruction of the palaeoglacier extents, weused ^{10}Be published chronologies of moraines landscapes. To better constrain glacier evolution during period without moraines we simulated glacial extents using a glaciological model forced by GCMs outputs for selected glaciers. Comparisons of the moraine dating with the ice core records, and the current knowledge about processes driving tropical glacier melting and climate made us possible to underline the hemispheric influences and the major climate controls on glacier evolution.

****

Poster presentations:

Neo-tectonics in Central African river catchments evidenced by lineament analysis - Examples from Southern Cameroon

EISENBERG J., RUNGE J.
Goethe University, FRANKFURT AM MAIN, GERMANY

Remote sensing and field work was carried out on south Cameroonian fluvial systems to reconstruct their evolution since the opening of the South Atlantic 95 Ma ago (Eisenberg, 2012). In the framework of DFG (Deutsche Forschungsgemeinschaft – German Research Foundation) founded research geological lineaments were recorded at different scales by using DLM, SAR and Landsat data. Regional focus was set on the north-western swell of the Congo Craton. The main strike directions are representing the thrust fold of the pan-African Yaoundé series (Neoproterozoic) as well as the Archean Ntem faults (E-W) and the Palaeoproterozoic thrust fold of the Nyong series (NE-SW).

A repeated remobilisation of the faults is assumed which was triggered by the Cretaceous opening of the South Atlantic. Uplift which has increased since the Miocene due to the collision of Africa with Eurasia is also the reason for geomorphological modifications as incision or denudation on the one hand and extensional fractures at the rise of the Congo Craton on the other hand. Earth quakes along the pan-African South Cameroon Shear Zone (Kribi earth quake in 2002) and the Sanaga Shear Zone (Yaoundé, 2005) give evidence for a sub-recent to ongoing remobilisation. As a result of lineament analysis and field work mainly linear features striking in N-S, E-W and NE-SW directions were neo-tectonically remobilised.

Examples from the upper catchment areas of Nyong and Ntem Rivers are introducing the geomorphological forms of the region and its interpretation by means of neo-tectonic activity as well as climate modifications.

Eisenberg, J. (2012): Geomorphic evolution of the Nyong and Ntem River basins in Southern Cameroon considering neo-tectonic influences. – In: Runge, J. (ed.): Landscape Evolution, Neotectonics and Quaternary Environmental Change in Southern Cameroon. *Palaeoecology of Africa* 31: 31-136.

Soil transformation system and lake Mandacarú formation in the Três Cantos compartment area, at Maracaí, São Paulo, Brazil

ALVES G., QUEIROZ NETO J.P.
USP - Universidade de Sao Paulo, SAO PAULO, BRAZIL

The Três Cantos compartment, defined by Alves (2010), located at Paranapanema River's medium haul shore, presents a series of closed depressions. These are situated at the extension of a basaltic plateau with sandy coating, which presents Oxysol of medium texture. The plateau is supported by a lateritic cover which overlays the basalts; outcrops of this cover appear on the inside and on the edges of Três Cantos compartment. At the edge of the lake a 26.6 m of length and 9% steepness trench was observed. Upstream, Oxysol with microaggregates and ferruginous concretions, which increase in depth until the laterite, occurs. It presents yellowish spots due to degradation, and some clay and manganese skins in the cracks. The yellowish spots increase downstream in soil and laterite, without modifying the structure, and the laterite becomes more friable. Hereafter, gray spots appear both on the ground and on the laterite, already severely degraded. Downstream the concentration of sand increases, especially in the upper horizons. Clay skins become common at the end of this yellower sector. Hereafter, a gray sector, where the laterite is completely degraded, shows bigger increase of clay as it deepens and upwelling groundwater at the base of the trench. Silty and olive yellow materials, with tonsils filled with quartz and fragments of olive brown color, were observed below the degraded laterite, indicating the presence of much altered basalt.

Observation of this pedological cover shows that in passing from Oxisol microagregate to Ultisol clay elimination occurs in the surface horizons, residual sand accumulation is a consequence of this process, as well as gradual laterite disappearance as it deepens. This loss of material causes soil deformation originating the depression.

****

Geomorphic processes in tropical environment: a study in piloes-pb city

HENRIQUE F.M., FERNANDES E.
Universidade Federal do Rio Grande do Norte, NATAL, BRAZIL

In tropical landscapes, geomorphic processes acting on model originating different materials and shapes from other climates on Earth. Understanding the relationship between morphogenetic and pedogenic processes has provided the understanding of relief modeling in largely of wet tropics and sub-wet areas. Tied to erosion occurring on the surface, these processes cause a deeper weathering mantle causing deep soils and slopes with convex shapes.This research analyzes the relationship between pedogenic-morphogenetic processes and anthropic activities present in Pilões-PB city, Brejo region in Brazilian northeast through the morphopedological approach (TRICART; KILLIAN, 1982, CASTRO; SALOMÃO, 2000) by proposal-based toposequences (BOULET, 1993). Collected samples were subjected to treatments and mineralogical and physical-chemical analyses which enabled the understanding of the relief sculpturing processes of area of research. Pilões city has a relief marked by convex shapes and amphitheater-like headwaters, in addition to mantles of deep change, a result of the decomposition of Precambrian gneiss, yielding clay type kaolinite. Four morphopedological compartments in the city were identified, called the MP-I, MP-II, MP and MP-III-IV. These compartments are products of the interrelation between the geological substratum, relief and soils, constituting homogeneous and intrinsic temporal-spatial units in physical environment. It was found that the erosions have been concentrated in MP-I and-II compartments, because they showed more favorable characteristics to the erosive processes, such as steep slopes, morphologies favoring the concentration of superficial flow, and soils with textural discontinuities.

Keywords: Tropical Geomorphology. Morphopedology. Erosion, Pilões.

Ethnogeomorphology as a methodological resource, applied to land use planning, semiarid ceara state, Brazil

MARCAL M.(1), RIBEIRO S.(2)
(1) Universidade Federal do Rio de Janeiro - UFRJ, RIO DE JANEIRO, BRAZIL ; (2) Universidade do Cariri - URCA, CRATO - CEARÁ, BRAZIL

The planning of natural resources has been discussed by various sectors of society responsible for building methodologies that lead to environmental sustainability. The enormous diversity of landscapes in Brazil shows that planning natural resources must necessarily pass through the regional understanding of the relationships between its physical environment, social and cultural.

This paper aims to point the knowledge of Ethnogeomorphology as a methodological resource applied to the planning of land use in the sub-basin of the Salgado River, in the southern state of Ceará, Brazil.

We accomplishedthe systematization of theoretical and methodological knowledge of the physical and empirical experimentation by the same traditional cultures. We visited rural communities, where scripted interviews provided data for this analysis ethnogeomorphological understanding.

The Ethnogeomorphology corresponds to the study of landforms and their formative processes to better organization and the use of landscape management by human societies. The prefix ethno refers to aspects and skills of people or ethnic groups that is the knowledge of groups of individuals who share a culture. Ethnogeomorphological studies are those who seek to understand the geomorphology of the area linking it to the attention of communities with their own culture. Such knowledge comes from generations of experimentation between these societies and their environment seeking better ways to use and manage natural resources through time.

In the sub-basin of the Salgado River we realized there is an ethnogeomorphological knowledge from the rural farmer of semiarid northeast that has been handed down through the generations, since the settlement of the region, so vernacular. This knowledge is intrinsically related to the agropastoral practices and it produces a classification / designation of the facts and geomorphic processes very peculiar.

****

The Erosional features of Espraiado basin, São Paulo, Brazil

DANIEL E., VIEIRA B.C.
Universidade de São Paulo - USP, SÃO PAULO, BRAZIL

The occurrence of the erosional features in Brazil is notorious, especially in cities hinterland the state of São Paulo, as in the case of São Pedro, where there are many of these features that cause social and economic damages.The aim of this research was evaluate the origin and distribution of the erosional features in the Espraiado basin, where there is a high concentration of erosion. We evaluated the morphometric parameters (curvature and slope) and the land use (1962 and 2006) by using the integrated and quantitative analysis. In this analysis we used the Erosion Potential (EP), which is the ratio between the number of cells with gullies, in each class, and the total number of cells of that same class. The results showed a reduction of the total area of features, but an important concentration in the channel head. Regarding the land use we observed the increase of the percentage of forest, urban area consolidated and forestry. The reduction of the exposed soil and pasture classes was important to the erosion decrease, although the urban area consolidated also have influenced the arise of new features and the evolution of others.The concave curvature, the slope between 20 and 40% and the exposed soil and pastures show highest susceptibility, and the convex and rectilinear curvatures and slopes between 0 and 15%, with low levels of EP, when significantly modified by land use, were recorded several erosional features. On the other hand, the use classes with low EP when associated with morphometric parameters of high provided an increased formation of erosional features.Therefore, the analysis from the combination of maps (erosional features, land use and morphometric) contributed to the assessment of the role play of these parameters on the origin and distribution of the erosional features.

Geomorphological and Geological Control on the Chemistry of Groundwater: A Case Study from the Meghna Basin, Bangladesh

HOSSAIN S.(1), HASAN M.A.(2), AHMED K.M.(3)
(1) Dept. of Civil and Env. Engineering,Saitama University, SAITAMA CITY, SAITAMA, JAPAN ; (2) Dept. of Geology,University of Dhaka, DHAKA, BANGLADESH ; (3) Dept. of Geology, University of Dhaka, DHAKA, BANGLADESH

The eastern part of the Meghna basin, Bangladesh comprises of three different geomorphic units of distinct geologic ages. As groundwater arsenic contamination is severe in the eastern Meghna basin of Bangladesh, it is crucial to identify the controlling factors on changing groundwater chemistry. This study was aimed to investigate the geomorphological and geological controls on groundwater chemistry along a transect down the flow line. Fifty-eight groundwater samples were collected along the transect from shallow (<100 m) and deep (140-275 m) aquifers. Integrated interpretation of hydrochemical data along with the geomorphological and geological characteristics revealed considerable spatial and vertical hydrogeochemical variations along an east-west transect passing through a number of geomorphic unitsof the Meghna basin. Hydrogeochemical profile of major ions along the transect shows that the shallow aquifers in the Flood Plain and Delta Plain are relatively high in HCO_3^- , Na^+ and Cl^- whereas the deeper aquifers are low in HCO_3^- but relatively high in Na^+ and Cl^- with maximum concentrations in the eastern side i.e. the delta plain. High chloride concentrations in middle part of the Meghna basin in deep aquifer is indicative of the presence of inlet of the bay or tidal stream in the geological past. Concentrations of dissolved arsenic are found mostly low (<10 ppb) in shallow aquifers of Plio-Pleistocene age in the Terrace part, whereas arsenic concentrations are high (<10 to1000 ppb) in the shallow aquifers of Delta Plain and Flood Plain of Holocene age. The deep aquifers are generally low (<10 ppb) in arsenic along the transect.

****

The role of gallery forest in semi-arid fluvial system dynamics: case study from the Yamé River (Mali, West Africa) during the Holocene

GARNIER A.(1), LESPEZ L.(1), CAILLAULT S.(2), DUFOUR S.(3), EICHHORN B.(4), NEUMANN K.(4)
(1) LETG Caen -Géophen. Université de Caen Basse-Normandie, CAEN, FRANCE ; (2) Institut National d'Horticulture et de Paysage, AGROCAMPUS OUEST, ANGERS, FRANCE ; (3) LETG Rennes-Costel. Université Rennes 2, RENNES, FRANCE ; (4) Goethe University, Institute of Archaeological Sciences, FRANKFURT AM MAIN, GERMANY

In tropical areas, especially in the Sahelian zone where water is irregularly distributed in space and time, riparian vegetation is an important component of landscapes and fluvial system. Floodplain forests have greater diversity and ligneous density than the surrounding savannas and are subject of a high human pressure. The extent of theses vegetated areas is extremely variable in space and time. Until recently, studies on fluvial system have demonstrated the fundamental and complex controls that hydrological processes impose on riparian vegetation. However, gallery forest may significantly control hydrological and geomorphic processes and have strong impacts on landforms dynamics.

This presentation aims to discuss the role of riparian vegetation on fluvial system dynamics during the last 6000 years in the Yamé valley (Mali, West Africa). First, a reconstruction of the gallery forest has been conducted by satellite images for the recent time (1967-2007) and by phytolith analysis recorded in sediment deposits for the Holocene period. Phytolith analysis coupled with geomorphological studies is a good tool to delimit the spatial scale of vegetation reconstruction in particular floodplain vegetation from savanna grasslands. Then, changes in riparian composition and density were compared with the fluvial system variations during the last 6000 years.

The results show an openness of the gallery forest during the last 2 millennium in response to climatic changes and a general increasing impact of societies. It results to an increase in sediment supply and colluvial inwash to valley bottom. More recently, the Sahelian drought crises in the 70-80's associated with an intensification of the shepherd pressure on gallery forest have contributed to a change in a fluvial style of the Yamé River. Indeed, in response to an augmentation in sediment supply the channel became wider and straighter shifting from meandering to braided river pattern.

Typology of tropical elementary landforms based on 30 m SRTM data: Example from the French Guyana shield

CAROZZA J.(1), CORNU J.F.(2), GUITET S.(3), BRUNEAU O.(4)
(1) University of Strasbourg - GEODE UMR 5602, STRASBOURG, FRANCE ; (2) UMR BOREA, IRD 207, National Museum of Natural History, PARIS, FRANCE ; (3) UMR AMAP and National Forest Office, MONTPELLIER, FRANCE ; (4) National Forest Office, CAYENNE, FRENCH GUIANA

In shield area, large scale peneplain and plateau relief are composed of repetitive and monotonous landforms *i.e.* multiconvex shape landforms. Despite their apparent homogeneity, multiconvex landforms show a strong diversity that has been correlated in previous works with lithology, climatic factors and/or geodynamic context.

In this work, we explore the geomorphodiversity of elementary landforms of the French Guyana shield by geomorphometric analysis. The first challenge to reach is the individualization of elementary landforms and landscape segmentation. In regions of high drainage density, repetitive elementary landforms unit can be defined as areas of relative high (terra-ferma) relief surrounded by lowlands/waterlogged talwegs. The recognition of such topographic structure was done using a three dimensional fractal index, Box Counting Algorithm type. About 230000 elementary landscape units were delimited by this way. This automatic method allows an objective extraction of elementary landforms and give results close to manual extraction.

For each of these landforms, eighteen specific geomorphometric criteria were computed in order to characterize they planar and vertical shape geometry and outline complexity. These criteria were then used to perform a CPA analysis and K-mean clustering. Twelve basic landforms type are identified and composed the landscape diversity. Spatial repartition of landforms type is highly auto-correlated and landforms type seems sensitive to both lithological and climatic factors. This new analysis improves previous large scale geomorphologic maps proposed by Boyé (1979) and reworked by Paget (1999) based on photo-interpretation. Landforms type seems sensitive to both lithological and climatic factors.

****

Multiconvex landform object-based segmentations: Regions vs. edge based approaches with different DEM

CORNU J.F.(1), GUITET S.(2), BRUNEAU O.(3), CAROZZA J.M.(4)
(1) UMR BOREA, IRD 207, National Museum of Natural History, PARIS, FRANCE ; (2) UMR AMAP and National Forest Office, MONTPELLIER, FRANCE ; (3) National Forest Office, CAYENNE, FRENCH GUIANA ; (4) University of Strasbourg - GEODE UMR 5602, STRASBOURG, FRANCE

Landforms represent the central cartographic units for many geomorphological works aiming to represent terrain configuration. The recent multiplication of studies focusing on the definitions and methods associated with this cornerstone concept encourage automatic landforms and terrain cartography which is presently a fruitful and active research field of applied geomorphology. Landforms identification and terrain segmentation are the objects of many published works. Nevertheless, the methodological choices (pixel vs. object, region-based vs. edge-based) are not neutral and are strongly associated with the geomorphometrical theoretical framework retained (continuous vs. specific vs. discrete geomorphometry) and the area under study (main geomorphological processes shaping the terrain).

In this context, only few studies have focused on wet tropical areas where multiconvex landforms represent one principal types of landform. Therefore applicability and efficiency of published landform segmentations were not sufficiently assessed and compared in these areas.

In this study we propose to test some continuous pixel-oriented (unsupervised classification), region-based (local variance) and edge-based (mean-curvature watershed) object-oriented segmentations published in the literature with a new one based on the use of a local fractal operator. Three areas localised in French Guiana representative of (1) littoral and low relief landscapes, (2) moderately incised topographies and (3) mountainous reliefs will serve as test areas. Finally, we will assess the ability of these approaches to mimic human work with a reference segmentation done manually by an expert based on the interpretation of topographic maps.

Sediment distribution and flux patterns of active boulder bars in a montane tropical river ' Rio Pacuare, Costa Rica

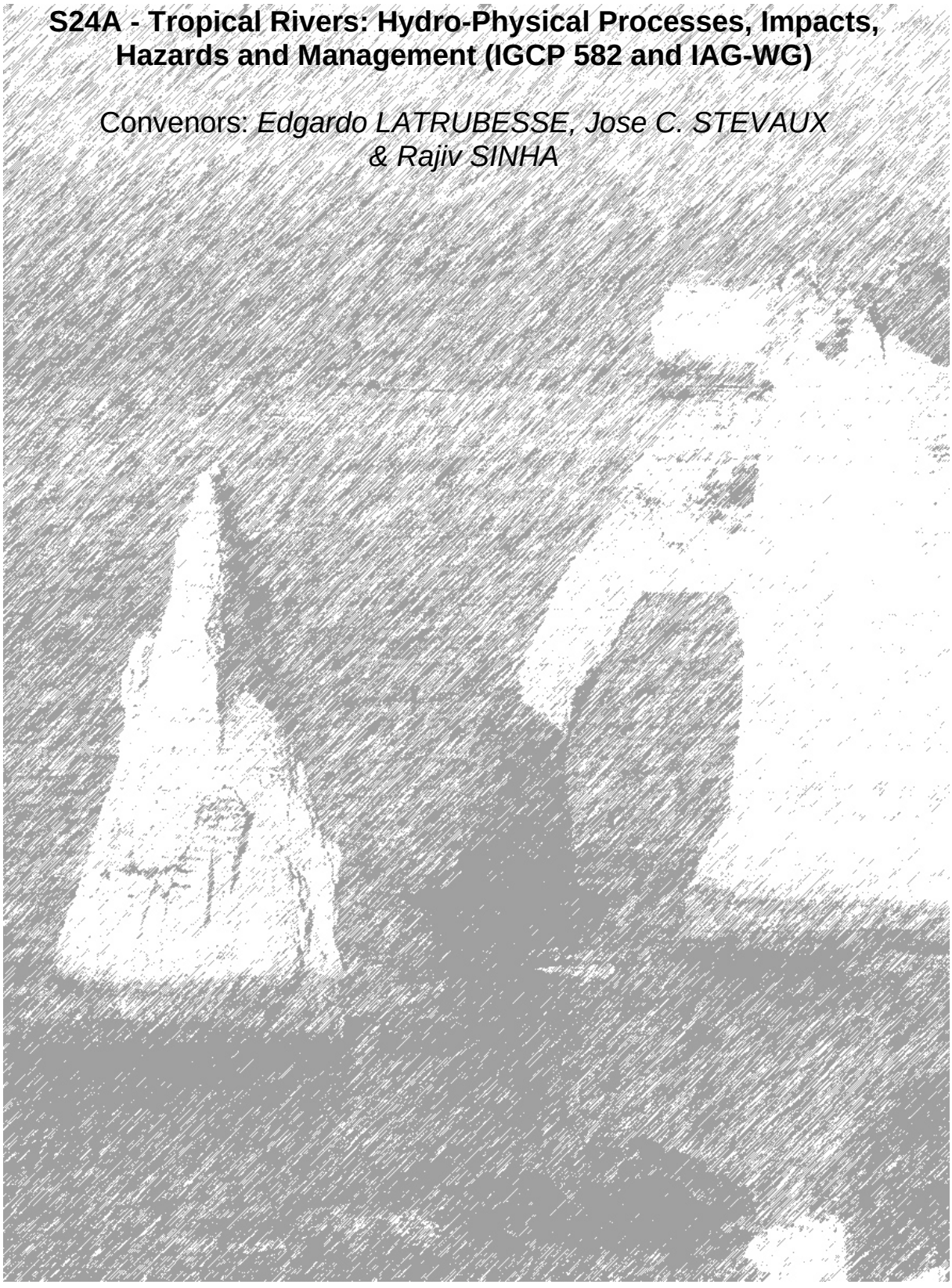
LIND P., MCDOWELL P.
University of Oregon, EUGENE, UNITED STATES

Humid tropical montane rivers convey large magnitude floods that have the potential to mobilize boulder-sized bed material multiple times during a year. On the Rio Pacuare active boulder deposits with surface areas of up to 300 x 75 meters influence channel form in this otherwise hillslope confined river. The rate of sediment flux occurring within and between reaches provides insight into the geomorphic sensitivity of the system. This research project has produced digital maps and volumetric estimates of the Rio Pacuare's sediment sources including active-channel deposits, tributary inputs, hillslope coupling, and small inset terraces. Data collected on site (Nov 2012-April 2013) combined with GIS analysis and hydraulic modeling have generated preliminary sediment transport rates for the D_{84} and D_{50} at seven sites within the four montane reaches. Results indicate that grain-size distribution at a site can vary slightly throughout the year depending on seasonal discharge patterns and upstream sediment inputs. Boulder bar shape may also vary slightly but surface area is generally maintained when there is no significant change to upstream sediment inputs. These preliminary results suggest that the Rio Pacuare and similar tropical montane rivers are geomorphically sensitive to changes in discharge regimes (climate change) or channel impoundment (dam construction).

****

S24A - Tropical Rivers: Hydro-Physical Processes, Impacts, Hazards and Management (IGCP 582 and IAG-WG)

Convenors: *Edgardo LATRUBESSE, Jose C. STEVAUX & Rajiv SINHA*



Oral presentations:

Physiogeographic features and hydrological characteristics of the Congo and the Oubangui drainage basins, Central Africa

RUNGE J.
Goethe-Universitaet, FB 11: Institut fuer Physische Geographie, FRANKFURT, GERMANY

The Congo River occupies a total of 3.747.320 km^2 between 9°15' North to 13°18' South and 15°18' to 34°02' East. The Congo-Lualaba River is in total 4374 km long and describes an initially south to north, from Kisangani down-stream, a westerly oriented, bow to curve like river pattern that crosses the equator twice. The Oubangui River is the largest right bank tributary of the Congo that drains at the Bangui gauge station an area of 488.500 km^2. It is this river that reflects by its discharge environmental dynamics on the North-Equator swell. The poster focuses on the present and past physiogeographic properties of the Congo basin and shows recent environmental trends evidenced by discharge and floods, mainly for the Oubangui River. Frequency analysis of floods resulted in return periods between 7 and 35 years. Regional extensions of urban floods – severely affecting the town of Bangui – were reconstructed for events in 1916, 1962 and 1999. The economic importance of the two rivers for transport infrastructure (river steamers), fishing and hydropower is also taken into consideration.

****

Catchment-scale hydrology of and sediment transport by the Ayeyarwady (Irrawaddy) River and landforms of its catchment

FURUICHI T.(1), WIN Z.(2), LIN S.(2), OGASAWARA M.(3), YAMAMOTO M.(4), OCHIAI S.(4)
(1) Department of Science, IT, Innovation and Arts, BRISBANE, AUSTRALIA ; (2) Myanmar Hydrological Study Group, YANGON, MYANMAR ; (3) Geological Survey of Japan, AIST, TSUKUBA, JAPAN ; (4) Low Level Radioactivity Laboratory, Kanazawa University, KANAZAWA, JAPAN

The Ayeyarwady (Irrawaddy) River, whose ca. 414,000 km^2 catchment is almost entirely in the country of Myanmar, is one of the least known tropical large rivers in the world. We present results of analyses on recent hydrological data, recent and previous sediment transport data and sediment geochemistry of the river.

The Ayeyarwady rises at 5,900 m above sea level to the east of the eastern Himalayan syntaxis. It flows through the Central Burma Basin which formed as fore-arc and backarc basins associated with subduction of the Indian Plate beneath the Eurasian (or Indochina) Plate. The river then forms extensive delta whose coastline is thought to be in equilibrium, that is sediment deposition currently balances subsidence and sea level rise.

The catchment-scale monthly water budgets indicate that discharge (inputs) from the middle reach area (Central Dry Zone) to the main channel is small or negative in most months. The small or negative values of inputs (increase) in the water budgets are not attributed to the evaporation from river surface but are supposedly consequence of small precipitation and large evapotranspiration in the Central Dry Zone and of considerable intake of water within this reach of the Ayeyarwady.

Comparison of annual sediment load data in the past (late 19th century and late 20th century) and in the present (year 2010) shows apparent decrease of the annual sediment load in the Ayeyarwady. Geochemical compositions of river sediments from two major upstream sub-catchments (the Upper Ayeyarwady and the Chindwin) are clearly different, and the geochemical characteristics suggest sediments from the Chindwin contribute more than those from the Upper Ayeyarwady.

Analysis of the state of the flow and morphology interaction in the hydropower dominated Middle Zambezi subcatchment

MWELWA E.(1), CROSATO A.(1), WRIGHT N.(2), BEEVERS L.(3)
(1) UNESCO-IHE Institute for Water Education, DELFT, NETHERLANDS ; (2) University of Leeds, Department of Civil Engineering, LEEDS, UNITED KINGDOM ; (3) Heriot-Watt University, School of Built Environment, ADINBURGH, UNITED KINGDOM

The research work in the Middle Zambezi sub-catchment has the key objective to investigate the state of the river and its flood plains in terms of flow and morphological variation for both the pre and post damming situations. From the rich biodiversity that this area supports, both Zambia and Zimbabwe have established national parks, with Mana Pools National Park, Sapi and Chewore safari areas being designated as UNESCO World Heritage Sites in 1984. The sustenance of these wild areas depends on the river channels and associated morphological features together with the river flow regime whose modification can lead to negative environmental consequences.

The research results highlight: the dominance of hydropower regulation in the water balance of the Middle Zambezi river reach, river channel morphology changes associated to dam operation and important consequences for the floodplain habitat. Based on one- and two-dimensional modelling, the future state of the Middle Zambezi River has been analysed taking into account the following scenarios: absence of damming; continuation of current water regulation and operations; modification of water regulation to induce favorable changes and; climate-related variation of droughts. The implications for maintaining the current dam operation practices are outlined in relation to the sustainability of the hydro-morphology of the river corridor which supports a rich wildlife habitat.

The study output will provide information that will be useful for broadening the understanding of the complex floodplain (sub-surface and surface) flow and morphological interactions at a range of spatial and temporal scales. This understanding can feed into decision making frameworks for the water resources managers in charge of hydropower generation management in order to consider modifications to the current dam operating rules and water allocation for environmental flows.

****

Stream power based threshold identification for explaining channel morphological variability, Yamuna River system, India

BAWA N., JAIN V., SHEKHAR S.
Department of Geology,Centre for Advanced Studies,University of Delhi, DELHI, INDIA

Channel morphology is one of the fundamental parameter to define river health. Morphological variation not only depicts dynamic nature of the river but also it defines the riverine habitat. Morphological characteristics at a given state are governed by the balance of driving and resisting forces. Hence, stream power distribution pattern, which is a measure of driving force in fluvial system has been analysed to identify the threshold for geomorphic change at different scales. The analysis was carried out on the Yamuna River system, the largest tributary of the Ganga River, India.

Channel morphological mapping was carried out using LANDSAT data of 30m resolution. Morphological attributes at different scales were used to classify the basin area into different landscapes and further used to define various River Styles reaches in different landscapes. Stream power variability was analysed using 90 m SRTM and 30 m ASTER data. Stream power is characterized by significant variability, which is mostly controlled by channel slope variation except at confluence points.

The Yamuna river basin is characterized by three landscapes namely Himalayan mountainous area in north, badland topography in south and alluvial plain in the midstream area. These landscapes are characterized by distinct range of stream power values, which decreases from 12,000 W/m at mountain reaches to 4,000 W/m at plains reaches, and further increases significantly upto 35,000 W/m in the Badland topography. At reach scale, the confined and partially confined River Styles reaches are characterized by high stream power (13,000 W/m to 40,000 W/m). Further, percentage of bar area in channel reaches increases with decrease in stream power. Mostly, the midchannel bars and alluvial islands types of bars are associated with lower values of stream power. The identification of threshold condition will assist in analysing the river sensitivity for geomorphic changes in response to external control(s).

Rivers in Northern Thai History: Implications for Management

NG S.(1), WOOD S.H.(2), ZIEGLER A.D.(1)
(1) National University of Singapore, SINGAPORE, SINGAPORE ; (2) Boise State University, BOISE, UNITED STATES

This study investigates the historical interactions between the Ping River and the population of Wiang Kum Kam. Wiang Kum Kam was the former Lannathai capital located on the Ping River near Chiang Mai Thailand; it was buried under flood sediments several centuries ago. We challenge two previous paleoflood studies suggesting that an elongated mound on the floodplain in Wiang Kum Kam was an old levee system of the paleo-Ping River channel. Instead, we show the mound was a man-made dyke, constructed after 1411 AD to alleviate effects of persisting floods. One distinct layer in the floodplain stratigraphy consisted of a 30 cm of coarse sand overlain by 10-15 cm of fine-silty sand. Radiocarbon dating of charcoal found in this layer suggests that the sediments were deposited by a large flood ca 1477 AD to 1512 AD. Comparisons with deposits of 2005 and 2011 Ping River floods revealed that this flood event was a high-energy, destructive event that likely caused the migration of the Ping River and the abandonment of Wiang Kum Kam. Our work demonstrates that the historical importance of rivers in northern Thailand was anchored upon society's dependence on them for sustenance and defense. Rivers also have religious and cultural meaning. The proximity of settlements to rivers enhanced the susceptibility of the population to flood hazards. This vulnerability exists today despite advancements in flood prediction and mitigation technologies.

****

Geomorphic considerations for environmental flow and habitat suitability in the Ganga river system, India

SINHA R.(1), MOZUMDER C.(2), JAIN V.(3)
(1) Indian Institute of Technology Kanpur , KANPUR, INDIA ; (2) Indian Institute of Technology Kanpur, KANPUR, INDIA ; (3) University of Delhi, DELHI, INDIA

Environmental flows (e-flows) in rivers are defined as the flows required for the maintenance of ecological integrity of rivers, their associated ecosystems and the goods and services provided by them.Major geomorphic considerations for determination of e-flows include geomorphic connectivity (longitudinal, vertical and lateral), sediment supply and dynamics, bank characteristics and riparian vegetation and bed characteristics. Satellite remote sensing data coupled with field measurements of river channel form were used to characterize selected stretches of the Ganga River for habitat suitability and to derive input parameters for e-flow assessment. These parameters were integrated in GIS environment using Analytical Hierarchical Process (AHP). Finally, a Habitat Suitability Index (HSI) was derived to classify the river system into four classes viz. excellent, good, degraded and poor. Separate weightage schemes were developed for the reaches in mountainous and plains areas. Our results suggest that the mountainous reaches in the selected window are generally in 'good' condition but the reaches in the plains are significantly 'degraded' geomorphologically either due to engineering interventions or due to planform dynamics and flow reduction due to poor longitudinal connectivity. The only exceptions are the reaches upstream of the Narora barrage that are classified as 'excellent' due to ponding of water for the nuclear power plant and sustained efforts by the WWF for maintaining a dolphin sanctuary. Geomorphic data wasintegrated with the hydraulic models to computeflow volumesnecessary for channel maintenance from geomorphic perspective and these were integrated with similar inputs from the ecological data to arrive at a common value of e-flow.

Fluvial Forms, Processes and Sediment Characteristics of River Teesta in India

GUPTA S.(1), GHATAK S.(1), SHARMA S.(1), KATURI A.(2)
(1) Geological Survey of India, NEW DELHI, INDIA ; (2) CEPT University, AHMEDABAD, INDIA

The present day landscape and Quaternary fluvial records of Teesta River draining the Himalayan upland, pediment and the foredeep in India represent an outcome of complex interplay of Himalayan tectonics, geology, climate, hydrogeomorphology and various anthoropogenic practices. The landform characteristics and geomorphic evolution of River Teesta has been evaluated by synthesis of time series data of Teesta and its tributaries (between 1969 & 2012) using multi dated maps/imagery,digital terrain model data (SRTM 90m, Aster GDEM 30m) and field studies. The present study reveals that Teesta forms a rectangular drainage in hilly terrain and braided pattern after it debouches onto the plain. Significant spatio-temporal geomorphic variation along this alluvial tract during Holocene times had been brought in by variable tectono-climatic influences and is manifested in terms of development of sheet flood to stream flow dominated alluvial fan, unpaired terraces, river piracy (along NW-SE trending Teesta Lineament), avulsion of Teesta, development of terraced landscape further downstream, frequent channel abandonment and formation of paleochannels in the flood plain (<1^{o} slope and ~100m elevation). Quaternary deposits from fan apex up to the flood plain of Teesta are dominantly sandy. The time series analysis indicates that Teesta River is highly avulsive and dynamic in nature. In recent past (between 1993 & 2005) a general increase in braiding intensity along Teesta has been observed from the changing planform character of mid channel bars and this has been attributed to anthropogenic intervention and local climatic behavior. The present study provides a framework for hydrogeomorphic evolution of the Teesta basin with special reference to river dynamics and flood hydrogeomorphology in the Jalpaiguri Town and adjacent areas, which are under the threat of floods due to massive siltation in the river bed.

****

Homogeneous Sections of Suspended Matter in a heterogeneous large tropical river: the Orinoco river (Venezuela)

CASTELLANOS B.(1), LARAQUE A.(2), LOPEZ J.(1), PEREZ J.(3), RODRIGUEZ M.(3), ROSALES J.(3), STEIGER J.(4)
(1) IMF UCV, CARACAS, VENEZUELA ; (2) IRD GET, TOULOUSE, FRANCE ; (3) CIEG UNEG, CD GUAYANA, VENEZUELA ; (4) GEOLAB, CLERMONT FERRAND, FRANCE

For the Orinoco the well-known lateral asymmetry within its main stem, from the source to the river mouth, is maintained by the continuous supply on its left-bank by white waters tributaries rich in TSS (Total Suspended Solid) concentrations flowing from the Andes, while right-bank tributaries are characterized by black waters, which deliver only very small quantities of TSS from the Guiana Shield. However, this lateral heterogeneity may be interrupted locally, as for example at the Ciudad Bolivar cross-section on the Orinoco River. In this section, using a point sampling protocol for eleven suspended flow measurements operated at different water stages, it was shown that one sample taken close to the water surface is representative of the mean of TSS concentrations sampled at various points over the whole channel cross-section.

For this one large river, the unusual spatial homogeneity of TSS concentrations in this section is also favored by the conjunction of various geomorphological factors, which, begin several kilometers upstream, with a structural control point marqued by:

(i) a succession of closed meanders with opposing curves which send the water from one bank to the other, (ii) the presence of a place of intense rapids named “boca del infierno”, (iii) the existence of crossing stream lines, downstream of the river islands, (iv) the alternation of contractions and expansions of the river cross section as the variable relief riverbed, (v) and at the place of the bridge of “Angostura” (old name of Ciudad Bolivar city, which illustrates the narrowness of this section), the presence of a funnel form, where, after a wide section of 8 km, the Orinoco flows crossing a narrow canyon (1 km), where several bedrock outcrops of the Guiana Shield, provokes flow vortices and turbulence which cause a certain homogenisation of the TSS.

It seems appropriate to preferentially look for this kind of section pattern to study the TSS fluxes in large rivers.

Amazon River suspended sediment behavior on water surface - observations at the Manacapuru hydrometric station, Amazonas, Brazil

FILIZOLA N.(1), MARTINEZ J.M.(2), FRAIZY P.(3), ARMIJOS E.(4), SOARES C.(5), SAMPAIO F.P.(1), MARINHO T.(1), MARTINELLI A.(6), ZUMAK A.(1), SONDAG F.(7), GUYOT J.L.(8)

(1) Universidade Federal do Amazonas, MANAUS, BRAZIL ; (2) IRD, TOULOUSE, FRANCE ; (3) IRD, MANAUS, BRAZIL ; (4) INPA/UEA, MANAUS, BRAZIL ; (5) SIPAM, MANAUS, BRAZIL ; (6) CPRM, MANAUS, BRAZIL ; (7) IRD, BRASÍLIA, BRAZIL ; (8) IRD, LIMA, PERU

The results show a heterogeneity behavior in the field which is very coincident when viewed under satellite image. Average and maximum concentrations are higher in low water period (October) and early in the period of high water (February-March). The variance and standard deviation are also higher than the same periods the average and maximum. The minimum values are a little more homogenous. However, they trend to be lowest in the high-water period (June), with other values despite coming heterogeneous pattern for the low water period and the beginning of rising waters. The variance and standard deviation are much greater in the dry season (October). The variance and standard deviation are much greater in the dry season (October). The figure of a plume seen in the satellite image is more visible, so the low water period. However if the classes of concentrations of suspended solids are adjusted to the extent identified in each period, it is possible to identify a picture image in all results of sampling in the mesh. Thus it is notable heterogeneity, even on at all time periods. The heterogeneity in surface is to be expected, most likely, a heterogeneity in depth. More data, collected at the same times, but depth in vertical profiles are being analyzed to obtain planning this. This site investigation indicated heterogeneity in terms of suspended solids determined in surface correlated with plume figure visualized by satellite images. This figure can be related to a strong relationship with a local geological structure that seems to be the responsible for a special mixed trend in terms of suspended sediment load distribution at the river section (Filizola et al, 2009). Also, hydrological data marked that this trend varies seasonally. These results put in evidence another view about the Amazon Basin internal suspended sediment behavior.

****

The Mekong River, a reappraisal of sediment transfer based on geomorphology and grain size

BRAVARD J.
University Lyon2, VILLEURBANNE, FRANCE

The Mekong River is commonly considered as a river carrying mostly silt and clay to the ocean, the yearly sediment discharge averaging 140-160 millions tons (suspended load only). Most of sediment transport is related to the monsoonal high discharge period which occurs from August to October.

Several recent papers underlined upstream-downstream discontinuities in suspended sediment concentration and in suspended load, tentatively explained by conveyance losses, dilution effect by tributaries, and different sampling procedures. The impacts of Chinese dams since 15 years increase the complexity of the question.

For documenting the present study, field surveys were performed at low flow in March 2011 and 2012. They allowed a detailed description of sand deposits on riverbanks from Lao PDR mountains to the delta. In each site, sampling was performed at different elevations on the banks. Samples were processed by sieving and the CM image technique was used for understanding transport processes during floods. The results show that deposits originate mostly from graded suspension, and in rare cases from uniform suspension (including some amount of fine sand). Wash load is not deposited upstream of Cambodia. We may demonstrate that, according to energy (unit stream power) available along discrete river reaches, sand can be transported both as bed load, or as suspended load. These results suggest a reappraisal of the yearly bed load transit at Kratie, the lowest station in the Cambodian reach, since most of the sand is transported as bed load in the downstream reaches.

However natural processes have been already altered by reservoir trapping in China and on tributaries (irreversible impact), and by aggregate harvesting (reversible impact), notably in the downstream reaches. It is now to late to monitor precisely natural transport processes.

Processes of Sediment and Carbon Sequestration within Large Tropical Rivers

AALTO R.(1), AUFDENKAMPE A.(2)
(1) University of Exeter, EXETER, UNITED KINGDOM ; (2) Stroud Water Research Center, AVONDALE, UNITED STATES

Dating (high-resolution ^{210}Pb & ^{14}C), imaging (sub-bottom sonar & ERGI) and biogeochemical analysis have facilitated the characterization and inter-comparison of floodplain sedimentation rates, timing & carbon loading across several large tropical river basins. We present examples from the 72,000 km^2 Beni River basin in Northern Bolivia and the 36,000 km^2 Strickland River in Papua New Guinea – fluvial systems that are located on either side of the Equatorial Pacific warm pool that drives the ENSO phenomenon.

Our research suggests that rapid-rise, cold-phase ENSO floods account for the preponderance of sediment transport & accumulation within these two tropical systems. New results better delineate the full distal extent of modern (~100 yrs) deposits within both systems & provide a deeper perspective into how these extensive floodplains developed over the Holocene, both in response to external forcing (climate and sea level) and internal system dynamics. The vast scale of these temporally discrete deposits (typically 10s of millions of tonnes emplaced over relatively short time periods) equate to high burial rates, which in turn support the high carbon loadings that are sequestered within the resulting sedimentary deposits. We have identified the principal source of this carbon and sedimentary material to be extensive landslides throughout the high-relief headwaters - failures that deliver huge charges of pulverized rock, soil, and plant material directly into canyons (in both the Bolivian Andes and the PNG Highlands), where raging floodwaters provide efficient transport to lowland depocentres. We present recent research results from these basins, providing insight into the timing, distribution, and geochemistry of such enormous relocations of mass that result in significant carbons sink within the floodplains. Processes, timing, and rates are compared between the two tropical dispersal systems, illuminating the nature of geomorphic hillslope-channel coupling.

****

Tropical multichannel rivers: processes, forms and evolution

STEVAUX J.(1), LELI I.(2), GON P.(2), ASSINI M.(2)
(1) Universidade Estadual de Maringa, MARINGA, PR, BRAZIL ; (2) UNESP/Rio Claro, RIO CLARO, SP, BRAZIL

Nine of the ten largest megarivers in the world present multichannel pattern. In spite of it, models for this type of rivers were developed, in its majority, for relatively small river systems under semi-arid climate. The present study is related to the upper Paraná River, the second large fluvial basin in South America and the 10th largest river in the world concerning water discharge (Qm = 13,000m^3.s^{-1} at the study reach and 18,000m3.s-1 at the mouth). The present alluvial plain has a complex history initiated with the increasing in humidity at the Pleistocene-Holocene limit. The increasing in discharge promoted, during the “Holocene Climatic *Optimum*” (*ca*. 8-7ka BP), channel incision that generated a multichannel river of 8 km in width, with large islands up to 90km long and 15km width. At this time channel occupied totally the present alluvial plain (channel plus floodplain). This scenario maintained up to 3-2ka when, by a combination of light climatic change and small tectonic movements, the channel shifted to left bank abandoned islands and channels that became the substratum of the present floodplain in the right side. Under the new hydrological condition, the specific stream power increased and a different channel pattern is settled. The channel eroded partially the ancient morphology and generated a new anabranching pattern constituted of long, narrow and relatively stable islands formed by annexation bar processes that keeps active at the present. Riparian vegetation rapidly adapted to new dynamics and system seems to be in equilibrium. The impacts introduced by dam construction (closed in 1999) have begun to modify change this condition and many alterations can be seen in the reach.

The Perils of Human Activity on Andean Rivers: Lessons from Colombia's Experience with Soil Erosion

RESTREPO J.
EAFIT University, MEDELLIN, COLOMBIA

Many anthropogenic influences, including deforestation, an agriculture and pastureincrease by 75%, poor soil conservation and mining practices, and increasing rates of urbanization, may have accounted for the overallincreasing trends of sediment transport in Colombian rivers. The percentage of forest cover in the Andes of Colombia was estimated to have declined from 66% in 1970 to 22% in 1990, with an annual deforestation rate of 1.9%, or 274,000 ha yr^{-1}. For the whole country, a recent assessment of deforestation between 2000 and 2008 indicates a national rate of forest loss of 336,000 ha yr^{-1}. This rate is considered to be among the highest in the world.

All the previous facts indicate that human induced activities have dramatically altered the fluvial fluxes from Colombian rivers. According to our recent study of human activities in terms of deforestation, 32% of the observed variance in sediment transport from the Magdalena River is explained by deforestation! Thus, the amount of sediment transported by the Magdalena to its delta plain, approximately 50 Mt annually, is due to deforestation. Also, the Patía River in the Pacific coast has witnessed an increase in sediment transport by 45% during the last decade, an increase mainly accounted by deforestation.

In the last decade, scientific studies on sediment transport and its controlling variables by Universidad EAFIT allow us to suggest that there is an increase in the rate and magnitude of natural disasters along lowlands and delta plains associated with soils (floods, landslides) that could be due mainly to growing land-surface modification caused by human activity, and to a lesser extent, by climate change. If this hypothesis is proved for the Colombian rivers, it could have a major impact on mitigation strategies, since funds could be directed towards soil conservation within river catchments rather than climate change mitigation.

****

The igapó of the Negro River in central Amazonia: Linking late-successional inundation forest with fluvial geomorphology

MONTERO J.(1), LATRUBESE E.(2)
(1) Institute of Silviculture, University of Freiburg, FREIBURG, GERMANY ; (2) Department of Geography and the Environment, University of Texas, AUSTIN, TEXAS, UNITED STATES

Despite important progress on Amazonian floodplain research, the flooded forest of the Negro River “igapó” has been little investigated. In particular, no study has previously focused the linkage between fluvial geomorphology and the floristic variation across the course of the river. In this paper we describe and interpret relations between igapó forest, fluvial geomorphology and the spatial evolution of the igapó forest through the Holocene. Therefore, we investigate the effect of geomorphological units of the floodplain and channel patterns on tree diversity, composition and structural parameters of the late-successional igapó forest. Our results show that sites sharing almost identical flooding regime, exhibit variable tree assemblages, species richness and structural parameters such as basal area, tree density and tree heights, indicating a trend in which the geomorphologic styles seem to partially control the organization of igapó´s tree communities. This can be also explained by the high variability of well-developed geomorphologic units in short distances and concentrated in small areas. In this dynamic the inputs from the species pool of tributary rivers play a crucial role, but also the depositional and erosional processes associated with the evolution of the floodplain during the Holocene may control floristic and structural components of the igapó forests. These results suggest that a comprehensive approach integrating floristic and geomorphologic methods is needed to understand the distribution of the complex vegetation patterns in complex floodplains such as the igapó of the Negro River. Thus, by integrating the past into macroecological analyses will sharpen our understanding of the underlying forces for contemporary floristic patterns along the inundation forests of the Negro River.

Channel morphodynamics in semiarids aeras: Jaguaribe River, Ceara, Brazil

ALMEIDA CAVALCANTE A.
UNIVERSIDADE ESTADUAL DO CEARE, FORTALEZA, BRAZIL

This paper discusses channel morphodynamic in northeast of Brazil and observes the effects of the Castanhão Dam in the Ceará State during the last decade. The Jaguaribe River extends 610 km and its catchment area is 74,000 km². It is a typical semiarid basin, where precipitation concentrates 700mm yr-¹ between February and May. The Pre Cambrian predominates in the entire catchment and slopes are 1 m km-¹ in high course and 0.30 m km-¹ in low course. Channel profile and erosion bank (pins of erosion) measurements in 11 stations distributed downstream of the Castanhão dam were collected during field work (2009-2010). Comparative analysis of aerial photographs and images from different years allowed for the observation of channel morphological changes and potential bank erosion areas, as well as the evolution of the human use and occupation of the floodplains. The morphological analysis has shown erosion sites with bank retraction of around 1-7m yr-¹ during the period analyzed (1958-2010). Nevertheless, 23km at the base of the Castanhão dam demonstrated accelerated bank retreat two times faster between 2003-2010 (15m yr-¹) when compared with the period before (1958-2002). Findings from this research indicate that the Jaguaribe River tends to go through a slow but progressive change in its level base as the reduction of the river's capacity and competence resulted from the controlled discharge flows by dam. Thus the construction of Castanhão dam in 2002 appears as a milestone that altered the hydrological, morphological and sedimentological dynamic of the Jaguaribe, which now seeks other forms of equilibrium.

****

Moving forward, locking backwards: preparing for the next large Asian floods

ZIEGLER A.(1), LIM H.S.(1), WOOD S.H.(2)
(1) National University of Singapore, SINGAPORE, SINGAPORE ; (2) Boise State University, BOISE, UNITED STATES

The abundance of large floods in Asia over the last decade is not necessarily an indicator of anthropogenic climate change, nor an obvious result of land-cover change, especially deforestation, which has been occurring for several decades. Analysis of a 90-year streamflow record on the Ping River in Thailand shows that high peak flows occur typically in response to large late-season tropical storms, sometimes in conjunction with monsoon anomalies. At this spatial scale (> 10,000 km^2) the effects of land-cover change are not discernable. At this temporal scale (< 100 years), the influence of regional-to-global climate phenomena, particularly ENSO, is not apparent. The record shows no significant increase in peak flows since 1920; but an observed decrease in low flows is related water management. Elsewhere, major floods have occurred on the Chao Phraya river in each of the last few decades. The current attitude of fighting flooding via engineering works is potentially flawed because it fails to address the underlying issue of vulnerability. Furthermore, paleo-flood evidence on the Ping and Mekong rivers suggests much larger floods than those witnessed in the recent past have occurred in the last 5000 years. Given the current situation of lucrative business ventures and millions of people encroaching the flood plains of major rivers, future floods could be devastating.

River response to European-style agriculture in a large, subtropical catchment: Brisbane River, Australia

KEMP J., OLLEY J., MCMAHON J., ELLISON T.
Griffith University, BRISBANE, AUSTRALIA

The sensitivity of rivers to land use change can be difficult to define. In southeastern Australia, rivers in temperate areas experienced substantial alterations to sediment and channel characteristics, or complete floodplain metamorphosis, following the introduction of European-style agriculture after 1788. By contrast, tropical and subtropical catchments are comparatively little studied, and less is known about the post-European transition. Here we describe c.190 years of channel change in the Brisbane River, a large, subtropical river characterised by regular extreme flooding, most recently in 2011 when suburban areas were inundated up to 15 m depth and one million tonnes of fine sediment was deposited in its estuarine reaches. Channel characteristics at the time of European settlement were reconstructed from documentary and historical records, including maps and surveys, aerial photographs, early photographs and historical accounts, and 103 years of instrumental streamflow record. These suggest that increased hillslope erosion was responsible for higher bedload transport rates within 15 years of forest clearance. Localised bank erosion was recorded around 40 years after settlement in lower reaches of the river, probably owing to removal or thinning of riparian vegetation. Widespread, discontinuous bank erosion was triggered by large floods in 1893, 1974 and 2011. The compound channel form and flood-dominated floodplain of the Brisbane River has remained essentially unchanged. Channel position since at least 1885, and bed level since at least 1894 has remained stable, despite the completion of large water supply and flood control reservoirs in 1958 and 1984. This suggests that hydrologically variable, subtropical rivers are less sensitive to changes in sediment supply and runoff than more temperate systems. This has important implications for the management of large river systems in the wet-and-dry tropics.

****

High-Resolution Characterization of a Tropical Montane Stream: Using Terrestrial Laser Scanning to Relate Channel Morphology to the Distribution of Stream Power and Shear Stress

LISENBY P.(1), WASKLEWICZ T.(2), SLATTERY M.(1)
(1) School of Geology, Energy, and the Environment, Texas Christian University, FORT WORTH, TX, UNITED STATES ; (2) Department of Geography, East Carolina University, GREENVILLE, NC, UNITED STATES

Mountain streams provide great opportunities to study dynamic channel morphologies despite the challenging topographic and climatic conditions of their basins. In this study, we show that a detailed understanding of the reach-scale channel morphology/flow hydraulics relationship can be gained using an innovative terrestrial laser scanning (TLS) technique in a tropical mountain stream in north-central Costa Rica. An orthographic channel-reach surface is derived by suspending a Leica HDS 7000 terrestrial laser scanner upside-down from a frame placed in the streambed. The technique accommodates the tropical canopy, steep stream gradient and boulder-bed material to produce a high-resolution point cloud. After data filtering and cleaning using Leica Cyclone software V. 7.4, the points are interpolated into a 2cm planimetric resolution digital elevation model (DEM) using ArcGIS software. Using the River Bathymetry Toolkit (RBT) we measure a cross-section for every meter of channel length on the DEM surface. We calculate the streamwise distribution of mean stream power and boundary shear stress by defining bankfull elevations, measuring hydraulic geometry and calculating velocity, using the standard deviation of bed elevations (σ_z), at each cross-section. We show the partitioning of shear stress for a cross-section by assuming that the bed contributes the majority of resistance to the flow. Finally, we symbolize each cross-section to display mean stream power and boundary shear stress values and overlay them on the DEM. By effectively utilizing the high resolution of the DEM surface through the dense sampling of hydraulic geometry, we are able to accent the linkages between channel morphology, flow hydraulics, and large woody debris (LWD) distribution in a high-energy channel reach under variable flow conditions.

Geomorphology and interaction river-sea changes after construction of large dams in Sao Francisco river, Brazil

DA SILVEIRA FONTES L.(1), LATRUBESSE E.M.(2), STEVAUX J.C.(3)
(1) Universidade Federal de Sergipe, ARACAJU-SERGIPE, BRAZIL ; (2) University Texas, AUSTIN, UNITED STATES ; (3) UNESP Universidade Estadual de São Paulo, RIO CLARO, BRAZIL

The lower course of the river São Francisco, has undergone marked changes since the late 90s, with the proliferation of marginal erosion and formation of new sandy bars in the channel. The region of the mouth, in the Atlantic Ocean, has been subjected to an episode of severe coastal erosion, promoting the complete destruction of the Cabeço village. Moreover, since the '70s has been promoted to regularization of river flows by building a cascade of large dams upstream. An investigation was conducted to verify the role played by anthropogenic interventions in hydro-sedimentological fluvial regime and the outbreak of changes in river and coastal dynamics. The initial step was to understand the natural dynamics of the river system, with the identification of geomorphological controls, geological, climatic, hydrological and fluvial geomorphologic compartments. Then, we performed a comparative analysis between the multitemporal periods pre-and post-dam, with identification of changes in the morphological features in the river channel, floodplain, shoreline and bar mouth. Geomorphological changes observed were compared with changes in hydro-sedimentological regime promoted by the construction and operation of large dams. The natural river regime was characterized by large annual floods and high sediment transport and river in the new situation regularized occurred a drastic reduction in peak flows, elimination of annual floods and 94% reduction in sediment delivery to the ocean. After construction of the dam Xingó in 1994, outbreaks occurred proliferation of marginal erosion and, in the region of the mouth, there is a continual retreat of the shoreline and the mouth bar migrated south, accompanied by the inflection of the underwater extension of the river channel. The episodes identified in the coastal zone were confronted with changes in regime hydro-allowing fluvial sedimentological evidence of the role played by large dams on the changes underway.

****

Poster presentations:

Oscillation of River Ganges through time and its predicting tendency for vulnerability analysis with Remote Sensing and GIS

LAHA C., BANDYOPADHYAY S.
Department of Geography, University of Calcutta, KOLKATA, INDIA

Ganga river bank erosion has been a long lasting chronic problem since remote past in West Bengal, India. She changes her path so frequently, that bank erosion, land loss generating a huge mass of refugees as well as administrative boundary problem come up as a devastating natural hazard. From the imprints of ancient river channel e.g. meander scars, buried channels, meander scrolls, it can be seen that, since historical times, the river continued to swing within its playfield in between Rajmahal Hard rocky terrain and Farakka Barrage, two obstructions to river flexibility. Before 1900, Ganga was flowing through GOUR, a historical site, 17 km away from present bank. Evidences say that, Up to 1929-30, river had a westward shift. But, afterword, a huge left bank shift happened every year till 2005. Around 2001, total discharge was bifurcated into three channels: Right, Central and Left channel. Among them left channel carried the maximum discharge resulting left bank failure. **B**ut after 2005, a tendency of huge sedimentation in left channel has been observed which gives an indication to the returning tendency of 1977 river course. The river has been swinging within its playfield from ancient time and by analyzing changing mid channel characteristics, we can predict a upcoming river course associated with vulnerable zone identification to help the management to take preventive measures. So, this study enlightens the mitigation to the geomorphic hazard with the help of space technology to step forward towards the solution of human problems.

Key-words: River course change, bank erosion, land lost, mid-channel, sedimentation, mitigation.

Geomorphology and Ecosystem Based Management of Tropical Montane Streams in Puerto Rico

SCATENA F.
University of Pennsylvania, PHILADELPHIA, UNITED STATES

This paper synthesizes recent geomorphic and ecological studies conducted on streams in NE Puerto Rico. These stream drain land uses that range from old growth tropical forests to high density urban areas and are characterized by frequent high magnitude flows, boulder and bedrock lined substrates, and diadromous aquatic life. Geomorphic studies indicate the streams are supply limited with respect to sediment, and that hydrogeomorphic riparian features can be used to identify active channel boundaries that occur at constant flow frequencies. After decades of urban development, the morphologic changes that occur in response to urban runoff are less in these channels that are already subject to frequent large magnitude storms. Studies of species distributions also indicate that aquatic communities are resistant to urbanization as aquatic diversity in urban areas can be comparable or higher than streams in adjacent mature forests. Geomorphic migratory barriers do influence species distribution and maintaining baseflow and migratory pathways is critical in developing ecological flow requirements for these streams. Although their morphology, hydrology, and ecology have distinctive characteristics, the streams do not appear to have diagnostic landforms that can be solely attributed to their low-latitude locations. An emerging view is that their morphology and dynamics results from a combination of high rates of weathering and a high frequency of significant geomorphic events rather than the absolute magnitudes of individual floods. Their bedrock reaches and immobile boulders combined with their ability to transport finer-grained sediment suggest that they are relatively resistant to environmental change. However the restorative processes in these systems may be less responsive than in other fluvial systems.

****

Petrified wood as a tracer of the Mekong River palaeo-course

MESHKOVA L., CARLING P.
University of Southampton, SOUTHAMPTON, UNITED KINGDOM

Investigations of Quaternary terraces of the Mekong River in north-east Cambodia have clarified the nature of the sedimentary profile of the river development during the last 700000 years. However, doubt remains as to former courses of the river during the Quaternary. For example, it has been suggested thatthe Mekong in Laos diverted to the east and flowed around the Bolvens Plateau via the “Saravan loop” in contrast to the present day north-south river course which demarcates the international boundary between Laos and Thailand before the Mekong enters Cambodia. The river is believed to have abandoned the southern direct route when it was blocked by Neogene-Quaternary basalt flows emanating from the Bolovens Plateau, only to reoccupy the former course when the basalts were finally dissected by the river.To verify this hypothesis petrified word has been used for the first time as a fluvial tracer. Petrified wood occurs commonly in the Mekong terraces. It also occurs as a weathering product on the surface of outcrops at numerous locations across Thailand and Laoswhere it can also be found in situ. Previous studies of the petrified wood demonstrate that there are two genera which are unique for each country and absent in another. This geographical differentiation in genera at outcrops allows determining the geographic origin of petrified wood found in the terraces. Computer tomography (3D) and thin sections (2D) were used to identify wood genera and show their distribution at outcrops and in ancient gravel. Preliminary results demonstrate that the method has promise both for use as a tracer in South East Asia but also elsewhere, as petrified wood is widely distributed across the continents and has been neglected as a potential indicator of river development.

Channel Pattern variability along the Pastaza River (Ecuador and Northern Peru)

BERNAL I.(1), CHRISTOPHOUL F.(2), DARROZES J.(2), LARAQUE A.(2)
(1) Escuela Polit_cnica Nacional, QUITO, ECUADOR ; (2) GET, TOULOUSE, FRANCE

The aim of this study is to analyse the channel pattern variability and its causes within the Pastaza River. This river is born in the Ecuadorian Western Cordillera (from de confluence of the Patate and Chambo rivers) and flows down into the Marañón River in the Peruvian Amazonia. Along the Pastaza River (in a reach431 Km long)the geologic, geomorphologic and hydro climatic conditions change dramatically. These particular conditions mean that phenomenon like channel pattern could have different causes depending on the setup of every area. Changes in channel pattern appear to be controlled by 1) upstream, due to its passage around active tectonic structures, and 2) downstream, where tectonic influence diminishes and factors controlling channel pattern are more correlated with the lithology, low slope and aggradation processes. More over the configuration of the Pastaza River floodplains show an anastomosed system that was formed by full avulsion. These processes occurred in the anastomosed system area since the Plio-Quaternary and their trace reinforces the idea of the main western shift of the Pastaza River.

****

Floods of the Mekong at Chiang Sean, northern Thailand: Archaeological and OSL dating of large floods

WOOD S.H.(1), ZIEGLER A.D.(2), RITTENOUR T.M.(3)
(1) Geosciences, Boise State University, BOISE, IDAHO, UNITED STATES ; (2) Geography, National University of Singapore, SINGAPORE, SINGAPORE ; (3) Geology, Utah State University, LOGAN, UTAH, UNITED STATES

Floodplain sediment,1.5-m thick, buries AD 14-15th C brick temple ruins and cultural layers on the Laos floodplain of the Mekong, across from Chiang Saen Noi. Dark soil layers separating three flood-sediment layers suggest the soils developed on sediment layers deposited by large floods. The upper flood layer was probably deposited by the September, 1966 flood that inundated Chiang Saen city to a depth of three meters, with maximum gage height reaching 13.82 m, and peak flow of 23,500 m^3/s. In comparison, the depth of the August 2008 flood in the flood plain at the sample site was about 1.3-m: maximum gage height was 10.57 m and peak flow ~15,000 m^3/s. Although stage was at least 10 m for three days, the event did not deposit a recognizable sediment layer at the sampling site.

In June 2012, during the annual low water period (stage = +2.45m at Chiang Saen), we sampled flood layers from the 11-m high Laos riverbank for single-grain quartz OSL dating. The top of the riverbank is equivalent to a river stage of 13.45 m. The floodplain, extending about 1 km to either side of the channel, presumably accumulates 0.35-0.6m thick sediment layers during infrequent large overbank floods that inundate the plain 3-4m deep.

On the Thai side are the ruins of Chiang Saen Noi, founded in AD 1329 on similar banks about 10-m above low water (described by Wood et al., 2008, Geomorphology, 101, 510-523). Subsequently we obtained small-aliquot quartz SAR OSL ages on floodplain silt 4-7-m deep of 4,750 ± 260, and 5,600 ± 310 years. Thus, this site began accumulating floodplain silt over bedload gravel of the former channel about 5,000 years ago. No clear flood layers occur in the surficial 0.5-m thick AD 14-15th C cultural layer. The new Laos site is the best paleoflood record discovered to date for the upper Mekong River. Once dated, the stratigraphy will provide a better understanding of the frequency of large floods on the Mekong.

Morphodynamics of the Brahmaputra River in upper Assam, India using a GIS based approach

SINHA R.(1), LAHIRI S.(2)
(1) Indian Institute of Technology Kanpur , KANPUR, INDIA ; (2) Indian Institute of Technology Kanpur, KANPUR, INDIA

Among the large tropical rivers of the world, the Brahmaputra has undergone significant spatio-temporal changes in its planform and interchannel geometry over a time span as short as ninety plus years. Three major rivers of the eastern Himalayas namely, the Lohit, the Dibang, and the Siang meet in the extreme NE part of India to form the Brahmaputra River. A 240 km long stretch of the Brahmaputra River extending from its 1915 confluence point at Kobo to the end of the old Majuli Island was divided into three units on the basis of the presence of exceptionally large river islands termed locally as the 'Majuli' (means land locked between two rivers). Majuli Islands differ from other sandbars in the sense that the latter develops directly as the consequence of the sediment load redistribution whereas the former represents older floodplains now incorporated within channel belt due to anabranching or avulsion. Formation of Majuli-like landforms is thus a part of river dynamics that might be related either purely to the variability in the sediment dispersal pattern or neotectonic influences and or interplay of both. This paper focuses on understanding the nature and causal factors of bankline shift and channel belt width variation and their interrelationships. It was observed that during 1915-2005, the Brahmaputra River banks made overall positive excursions causing thereby continuous widening of the river. Both units 1 and 3 represent major sites of aggradation. However, the site of aggradation seems to be switching lately from unit 1 to 3. The variability in the widths of the channel belt seems to be controlled by bankline shift on either side. We have also done a trend analysis of thebankline shift (cycles/unit length), which provided us a scheme of classifying the nature of *forcings* operational in shaping the bankline.

****

Continental-Scale Morphometric Analysis of Andean Basins

BEAN R., LATRUBESSE E.
The University of Texas at Austin, AUSTIN, TX, UNITED STATES

Presently there are no regional-scale morphometric analyses of Andean fluvial basins. Therefore, we created a continental-scale database of these basins. Morphometric parameters such as the circularity ratio, hypsometric integral, slope, relief index, longitudinal profiles and measures of basin concavity were calculated based on a SRTM terrain model (90 m resolution). Thus we gain insight into differences among basins based on present-day conditions, which gives a better understanding of the tectonic evolution of the Andean basins. Further, we demonstrate how the database provides a platform that can integrate other data such as lithology, soils, vegetation, and climate for studies that link geomorphic structure to hydrologic and ecologic function.

The Ucamara depression, Peruvian Amazonia: Quaternary fluvial record and present day hydro-sedimentological dynamics

BEAN R.(1), LATRUBESSE E.(1), STEVAUX J.(2), ABAD J.(3)
(1) The University of Texas at Austin, AUSTIN, TX, UNITED STATES ; (2) UNESP, Department of Geosciences, RIO CLARO, BRAZIL ; (3) The University of Pittsburgh, Department of civil and Environmental Engineering, PITTSBURGH, PA, UNITED STATES

The Ucamara Depression is the largest wetland system in the Peruvian Amazon. Located in-between the Ucayali and Marañón Rivers, which are part of the Andean foreland basin , the study area is over 100,000 km^2in size. We investigate the Quaternary fluvial record using remote sensing and fieldwork including coring and dating of sediment to ground reference. A Quaternary geomorphologic map of the basin, was generated.

The area has acted as a sink during part of the Pleistocene and perhaps, during part of the Holocene. Remote sensing analysis allowed us to assess the present day fluxes of sediment from the major rivers draining into the Ucamara depression.

****

Fluvial morphometric analisys of the Pardo River basin (SP-MG, Brazil) and morphotectonic inferences

CELARINO A.(1), LATRUBESSE E.(2), LADEIRA F.(3)
(1) Unicamp/University of Texas, CAMPINAS, BRAZIL ; (2) University of Texas, AUSTIN, UNITED STATES ; (3) Unicamp, CAMPINAS, BRAZIL

The Pardo river basin in Brazil, has a drainage area of 17752km^2, flowing from the Mantiqueira ridge in Minas Gerais state to its mouth at the Grande river. The Pardo River flows on both ancient bedrocks and on younger sedimentary bedrocks. The river basin was studied using morphometric parameters from forty five topographic sheets and Arcmap software. The aim was to identify drainage anomalies and connect them with neotectonic movements in the entire river basin, as the most of the previous work in this area is concentrated in specific compartments, mainly the upper Pardo. A longitudinal profile and tens more on its larger tributaries, drainage density analysis and stream gradient index were carried out. For drainage density analysis, seventy sub-basins were selected in order to make an interpolated map using the Kriging method. For stream gradient index, the fifty larger streams including the main river were selected. Indices were measured per drainage segment in order to interpolate by kriging. The results suggest that both that the identified anomalies on stream profile analyses and on stream gradient index come from right side of the main river, towards Brazilian crystalline bedrocks, as well as the main geological lineaments. Some of these anomalous features were: channel migration, structural control of drainage and rapids. These features are linked with recent reactivation of ancient shear structures of Ouro Fino and Campo do Meio, Cabo Frio tectonic seismic and passive lineaments at the border of Paraná Basin sedimentary rocks and crystalline bedrocks. Meanwhile, the drainage density analysis results are better correlated with soil types founded in different sectors, as a result of the influence of the rock types on soils.

Historical Evaluation of the distribution of PAHs in samples from lakes in Southern Brazil

VIEIRA L.(1), FROEHNER S.J.(2), COUTO E.V.(2)
(1) Federal of Parana Technical Federal University, CURITIBA, BRAZIL ; (2) Federal of Paraná Federal University, CURITIBA, BRAZIL

The development and growth of humanity also brought about growth in the alterations of the quality of water and aquatic ecosystems. Some effects are visible, such as silting, hydric pollution, presence of toxic chemical compounds, euthrophization, loss of biodiversity, biomagnification of contaminants, as well as the loss of the potential of the body of water for multiple uses in a basin. In order to control the pollution of such hydric resources it is necessary to know the pollution process which caused current conditions. Within this context, it is necessary to obtain information about the past of the hydrographic basin related to the disturbances to which the environment was subjected in the past, for such information make it possible to understand the current pollution scenario within a historical context; it also assists in establishing a standard in a temporal scale. The sediments contain substances of low solubility. Among the compounds investigated which are associated with pollution processes, are the aromatic and aliphatic hydrocarbons. PAHs are compounds which are usually produced by anthropogenic activities; their formation takes place by three chemical processes: pyrolytic, petrogenic or biogenic. Due to their physical and chemical properties, PAHs hardly ever decompose within a short period of time, thus they are often found in sediment. Thus, we evaluated the distribution of PAHs in two samples taken from Igapó Lakes I and II in Londrina, State of Paraná. Greater amounts of PAHs are clearly found in the first centimeters of the sediment, while the smaller amounts are found in the deeper layers. Such behavior is typical of PAHs. Anoxic environments make biodegradation more difficult, thus it is possible to associate their distribution with past events, such as the removal or organic matter or debris by burning, which was very common at the beginning of the occupation of this region.
Keywords: PAHs, Igapó Lakes, biomarks, sediments.

****

Tropical erosion: the story of Panama

SOSA-GONZALEZ V.(1), BIERMAN P.R.(1), NICHOLS .K.K.(2), ROOD D.H.(3)
(1) University of Vermont, BURLINGTON, UNITED STATES ; (2) Skidmore College, SARATOGA SPRINGS, UNITED STATES ; (3) University of Glasgow, EAST KILBRIDE, UNITED KINGDOM

Background erosion rates place human-induced erosion in context and are necessary for evaluating, regulating and remediating human impacts on erosion. This study presents the first broad quantification of background erosion rates in Panama and relates these to landscape variables including climate, seismicity, landuse, rock-type, and topography.

Using measurements of *in situ* ^{10}Be in river sand, we calculated erosion rates for 40 watersheds (14 to 2410 km^2). 44 variables were quantified for each watershed to assess their relationship to erosion rates using bivariate linear regression, multiple regression, and ANOVA. We used grain size analysis as well as sampling up and downstream of a landslide to assess the impact of landslides on calculated erosion rates.

^{10}Be–inferred erosion rates ranged from 26 to 600 m/Myr. The strongest and most significant relationship is between erosion rate and silicate weathering rate, the mass of material leaving the basin in solution. None of the physiographic variables showed a significant relationship with erosion rate at the 95% level. The relationship between erosion rates and seismicity varied with quake distance from the watershed and average quake depth. ^{10}Be concentration and grain size were inversely related in landslide samples. Landslide material has lower ^{10}Be concentration than stream sediments.

Erosion rates in Panama are higher than other published ^{10}Be-derived erosion rates in tropical climates – including those from Puerto Rico, Madagascar and Sri Lanka – likely the result of Panama's active tectonic setting. Although many cosmogenic studies have concluded that physiography controls erosion, Panamanian data are unique because they show little if any relationship between erosion rates and landscape-scale variables. We speculate that controls on erosion in humid, tropical climates are more complex than those elsewhere in the world – perhaps the result of widespread landsliding.

Channel morphology and morphodynamics of the Madeira River in Brazil

BONTHIUS C.(1), LATRUBESSE E.(1), ABAD J.(2), STEVAUX J.(3), FILIZOLA N.(4), AQUINO S.(1)
(1) Department of Geography and the Environment, The University of Texas at Austin, AUSTIN, UNITED STATES ; (2) Department of Civil and Environmental Engineering, The University of Pittsburgh, PITTSBURGH, UNITED STATES ; (3) Geosciences, UNESP-Rio Claro and Maringa State University, MARINGA, BRAZIL ; (4) Department of Geography, Universidade Federal do Amazonas, MANAUS, BRAZIL

Severely understudied and poorly understood, the Madeira River offers the opportunity to investigate the roles of geomorphologic controls and hydraulic mechanisms in large anabranching fluvial systems. The Madeira River is a mega-river and demonstrates an unusual anabranching channel pattern. The channel alternates between a single straight channel and multiple-channel structure, indicating that the river is on a geomorphic and hydraulic threshold. Three distinct channel patterns are present in the selected study reach: a single-channel meandering stretch, a box-shape meandering stretch, and an anabranching stretch with sinuous second order channels. Analyses of multi-temporal satellite and radar imagery show that the channel morphology demonstrates overall stability. The lateral movement of the channel is geologically constrained by a variety of floodplain morpho-stratigraphic Quaternary units. Large islands are persistent features in the river channel. Measurements of suspended sediment, water velocity, and bathymetry collected with an Acoustic Doppler Current Profiler (ADCP) indicate that bed and channel morphology affect hydraulic characteristics of the Madeira River and its observed channel patterns. Several cross sections present unusual deep pools in the outer bank, which might indicate geological constraints in the exaggerated depths or that water flow is preferentially downwards due to depositional patterns. Measurements of channel width in the study reach reveal a wave-like tendency to increase and decrease with the widest range of widths seen in the meandering stretch. The greatest differences in water velocity are also seen in this part. The interaction between channel width, depth, and water velocity suggest that channel pattern reflect losses and gains in water momentum through the study reach. The analyses presented here represent a synthesis of baseline conditions of the Madeira River.

****

Flood flows and their Implications in Humid Tropical and Urbanised Catchments: A Case-study of the Mfoundi River (Yaounde-Cameroon)

DZANA J.G., KUATE S.
University of Yaounde 1, YAOUNDE, CAMEROON

Hydro-geomorphic effects that are induced by flood flows through the channel/floodplain complex of the Mfoundi River –considered as an archetype of humid tropical urban hydrosystems– have been examined.

Channel movement initiated by sub– to bankfull discharges have been documented by comparing three sets of cross-sectional survey data collected at the reach scale and by computing volumes of sediment eroded and deposited. Although the overall cross-sectional adjustments may appear minor for the studied river, they are more significant for sites that are located downstream from major tributaries. A detailed analysis along studied reaches has permitted to realise that there is a juxtaposition of flow sections alternatively marked by channel dilatation, stability and contraction.

Field investigations on floodplain inundation, overbank deposition and its associated sediment transporting mechanisms, have provided evidence permitting to analyse and interpret the movement and action of floodwaters beyond the channel compartment. The inundation maps reveal that the processes, extent and patterns of flooding are determined by the morphology of the alluvial plain. The floodplain accretion reflects this topographical variability, with the highest rates (0.27-0.62 kg m^{-2}) recorded within proximal depressions. The CM image of the overbank deposits shows that the Mfoundi River is competent enough to transport and deposit sandy material onto the floodplain surface as graded and uniform suspensions. This reflects conditions where the supply in fine-grained material is strictly limited.

Late Quaternary shifts in drainage morphology in the Demini River area, northern Amazonia: paleoenvironmental implications

CREMON E.(1), ROSSETTI D.(2), ZANI H.(2)
(1) Brazilian National Institute for Space Research, SAO JOSE DOS CAMPOS, BRAZIL ; (2) Brazilian National Institute for Space Research, S?O JOS? DOS CAMPOS, BRAZIL

The morphological characterization of megafans is an issue still under development. Due to the wide extent (> 1000 km²), this depositional system has been described mostly with basis on remote sensing data. A set of megafans has been recently recognized in association with late Quaternary deposits of a tropical humid area of northern Amazonia. In the present work, we provide a geomorphological characterization of one of these megafans, known as the Demini megafan, which is the largest one in that region. Our morphological study was based on topographic characterization derived from the digital elevation model (DEM) provided by the Shuttle Radar Topography Mission-SRTM. Color composite TM/Landsat-5 images recording different hydrological periods were used additionally with the SRTM data. The topographic characterization was performed using trend surface analysis considering only areas of the megafan morphology that display open vegetation and bare soil to avoid the influence of tree height. The results showed that the study area displays concentric contour lines that are distributed radially from upstream to downstream, with a slope of 0.008°. The Demini River, which is the main river currently present in the area, flows through a confined meander belt ~5m below the average surface. This modern drainage is dissectional, being constituted by a series of tributaries, with the main river flowing southeastward into the Negro River. In contrast, the paleodrainage is composed of elongated and sinuous belts that define an older branched network with a distributary pattern. This type of paleodrainage morphology is typical of braided megafans. This suggests a significant change in the landscape of this region during the late Quaternary. A detailed morphological analysis might provide the basis to discuss the main factor that led to this drastic shift from distributary to tributary drainage in this area.

****

Characteristics of the Solimões-Amazon River bed: implication of neotectonics

FRANZINELLI E., IGREJA H.
Federal University of Amazonas - UFAM, MANAUS, BRAZIL

The more frequent depth of the Solimões-Amazonas River bed is around 30 meters, but an analysis of the bathymetrical data related in the Brazilian Navy nautical charts from Iquitos (Peru) to Macapá, on the Amazon mouth, shows the occurrence of holes irregularly scattered along the channel of the river. These holes are more frequent in the central part of the Amazon Basin .They have variable depths (up to 100 meters), lengths (up to 30 km) and common trends NW/SE or NE/SW, rarely N/S or E/W. In general they are parallel to the “Barreiras Vermelhas”, outcrops of the Alter do Chão, Solimões-Pebas and Barreiras Formations, cretaceous and tertiary geological unities that form the floor of the quaternary alluvial plain and sometimes the bed and the banks of the Amazon. The origin of these holes is attributed to the actions of neotectonics since the channel of the Amazon is located in a belt submitted to expressive neotectonic movements. In this paper we show some configurations originated by neotectonics in the Amazon plain coinciding with the holes in the bed of the river to justify their origin.
Keywords: Solimões-Amazon River, Channel bed, Neotectonics

Processes, forms and rates of floodplain building in a large South American river: the Middle Paraná River, Argentina

RAMONELL C.(1), LATRUBESSE E.M.(2)
(1) Facultad de Ing. y Cs. H_dricas - Universidad Nacional del Litoral, SANTA FE, ARGENTINA ; (2) Dept. of Geography and the Environment, University of Texas at Austin, AUSTIN, UNITED STATES

The Middle Paraná River (mean discharge: 17,100 m^3/s) flows with an anabranching pattern along ca. 800 km downstream the junction with the Paraguay River (27º17'S). Its floodplain extends over 20,000 km^2, with large areas without sediments occupied by minor and large lakes. The main channel (effective width: 1500 m), major secondary branches (ca. 200 to 500 m-width), and deltaic splays accounts for the most of the present morphodynamics in the river.

The main channel has a sinuous to meandering thalweg. By means of thalweg shifts and cut-offs, and bar and island formation, the main channel swept a belt similar to its width in the last century, with mean shift rates of dozens m/year or higher. Submerged sandy bars have linguoid shapes, evolving to more diverse and complex forms when emerge. Emerged bars are transformed in entirely vegetated (and higher) islands in few years.

Secondary branches are straights or meanderings, with shift rates ranging between 1m/year and 25 m/year. Exceptionally, some of they formed alluvial belts of few kilometres-width in the last 100 years, by avulsions. Typical forms in these branches are scrolls bars and "within-channel levees" (a new-recognized fluvial form likes to natural levees, but formed inside channels below the bankfull levels).

Deltaic splays progradate in the floodplain lakes or in abandoned tracts of the main channel. These forms become very active during the last 30 years following the occurrence of large floods; expansion rates up to several hundreds of m/year were measured in some of them. Singular geomorphic processes, such as formation of deep scour holes (up to 20 m depth) and sedimentation downstream were detected in the deltaic splay channels.

The vertical accretion of fine sediments in the floodplain is small, although reach local rates in the order of cm/year or dm/year near of the major channels. It is noticeable the high variability of these siltation, even in short distances of a same geomorphic unit.

****

Renaturalization of streams and rivers - Institutional arrangements in Urban Planning and Flood Mitigation

LINDOSO T., QUINTELA M.F., MIGUEZ M.
Universidade Federal do Rio de Janeiro, RIO DE JANEIRO, BRAZIL

The Brazilian legislation of the 60's and 70's decades of the past century, encouraged the occupation of wetlands and riparian areas. In urban areas, the public administration encouraged the canalization of rivers. Nowadays, the disastrous results of these works are visible and have their damages multiplied, due to the demographic explosion in urban centers in the last decades.

The overall objective of thiswork is to present the relationship between the Teresópolis Mayor's Department of Environment (SMMA), as the executing agency, the State Public Ministry (as the intervener) and the property owners of an watershed ofapproximately 1.4 ha, involved in the issue of inappropriate land use and occupation, in order to implement corrective and preventive actions, aiming to minimize the problems resulting from the numerous interferences in natural water flows, such as landfills of lowlands and canalization of the river.

This area has been chosen to implement a pioneer project for Teresópolis in order to reverse the environmental degradation. This project is based on the diagnosis of the watershed and the identification of past interferences in the natural drainage system and their negative impacts. The diagnosis of the flood situation was supported by a mathematical model, called MODCEL, developed in order to allow simulations of many hydraulic processes that interfere mainly with the quantity of water in the watershed. The design of this model assumes that a watershed can be divided into a set of homogeneous interconnected compartments which cover the watershed plan in an arrangement capable of reproducing the flow patterns.

The following solutions were proposed by SMMA: the construction of a detention basin with controlled output flow, the renaturalization of the the river, the partial recovery of the marsh that once existed and the increase of permeable area. Each owner takes part in proposed activities, based on the damage arising from his property.

Geomorphological-ecological-sedimentological evolution of Chuksar Island, hugly estuary, India: a neoichnological approach

CHAKRABORTY A.
Jogamaya Devi College, KOLKATA, INDIA

Dynamic control of geomorphological, ecological and sedimentation processes on coastline evolution has been studied in Chuksar Island (N21.5676°-21.5784/ EN88.0128°-88.0272°), outer Hugly Estuary, India, since 2008 based on sediment-animal interactions *in space and time.* Neoichnological record preserved in soft sediments reflects impacts of net loss in substrate relief and concomitant occurrences of repeated storm events with occasional reversals in sedimentation. A gradual replacement of *Psilonichnus* ichnofacies by *Skolithos-Cruziana* transitional ichnofacies in this intertidal part of north-ward advancing macrotidal sand ridge is consistent with the inferred high stand system tract, at least on a localized scale, as inferred from sedimentological and geomorphological observations. Anthropogenic interferences through sediment dredging-dumping in the adjacent Haldia Port area is predicted to have a substantial contribution influencing the natural sediment dispersal system in the vicinity of this dynamic regime of sedimentation.

****

Impacts of rainforest disturbance and conversion to oil palm on large river catchments in Borneo: evidence from sediment fingerprinting and long-term monitoring

WALSH R.(1), ANNAMMALA K.V.(2), NAINAR A.(2), BLAKE W.H.(3), BIDIN K.(2), DOUGLAS I.(4)
(1) Department of Geography, Swansea University, SWANSEA, UNITED KINGDOM ; (2) School of Science and Technology, Universiti Malaysia Sabah, KOTA KINABALU, MALAYSIA ; (3) School of Geography, Earth and Environmental Science, Plymouth University, PLYMOUTH, UNITED KINGDOM ; (4) Manhester University, MANCHESTER, UNITED KINGDOM

This poster presents results of studies into the downstream consequences of upstream rainforest logging and land-use change (chiefly conversion to oil palm plantations) in some large river catchments (notably the Segama, Brantian and Kalabakan basins) in Sabah (Malaysian Borneo). These downstream consequences include enhanced suspended sediment transport, sedimentation, channel change, river pollution and flooding. This paper uses a multi-proxy sediment fingerprinting approach to reconstruct changes over the past 50 years in sedimentation rate and the relative contributions of different sub-catchments to the downstream sediment budget of the large Segama catchment in eastern Sabah. The catchment has been subject since the 1970s to rotational selective logging and conversion of part of the lower catchment to oil palm plantations. Downstream evidence is derived from a 1.6 m deep sediment core on a high lateral bench protected by a bankside tree on the Lower Segama. Bed-sediment samples were taken from channel-margin sites at low flow for the major upstream tributary catchments (the hypothesized sediment sources) of the Segama. All sediment samples, both from the Lower Segama pit and the upstream sub-catchments, were dried and sieved to obtain the fine (<63_m), inferred suspended sediment fraction and analysed using a portable Niton XRF elemental analyser to obtain the elemental composition. Distinct down-profile changes in individual elements are evident and some of these are relatable to distinctive geochemical signatures of upstream tributaries, allowing changes in their relative contributions to the downstream sediment budget through time to be inferred. Finally monitoring evidence of the impact of logging and conversion to oil palm on suspended sediment transport and river pollution is also presented for the Brantian and Kalabakan catchments.

The influence of standards morphometric on changes in the levels of water in Madeira Basin - Brazil: an assessment of damages under extreme conditions hydrological

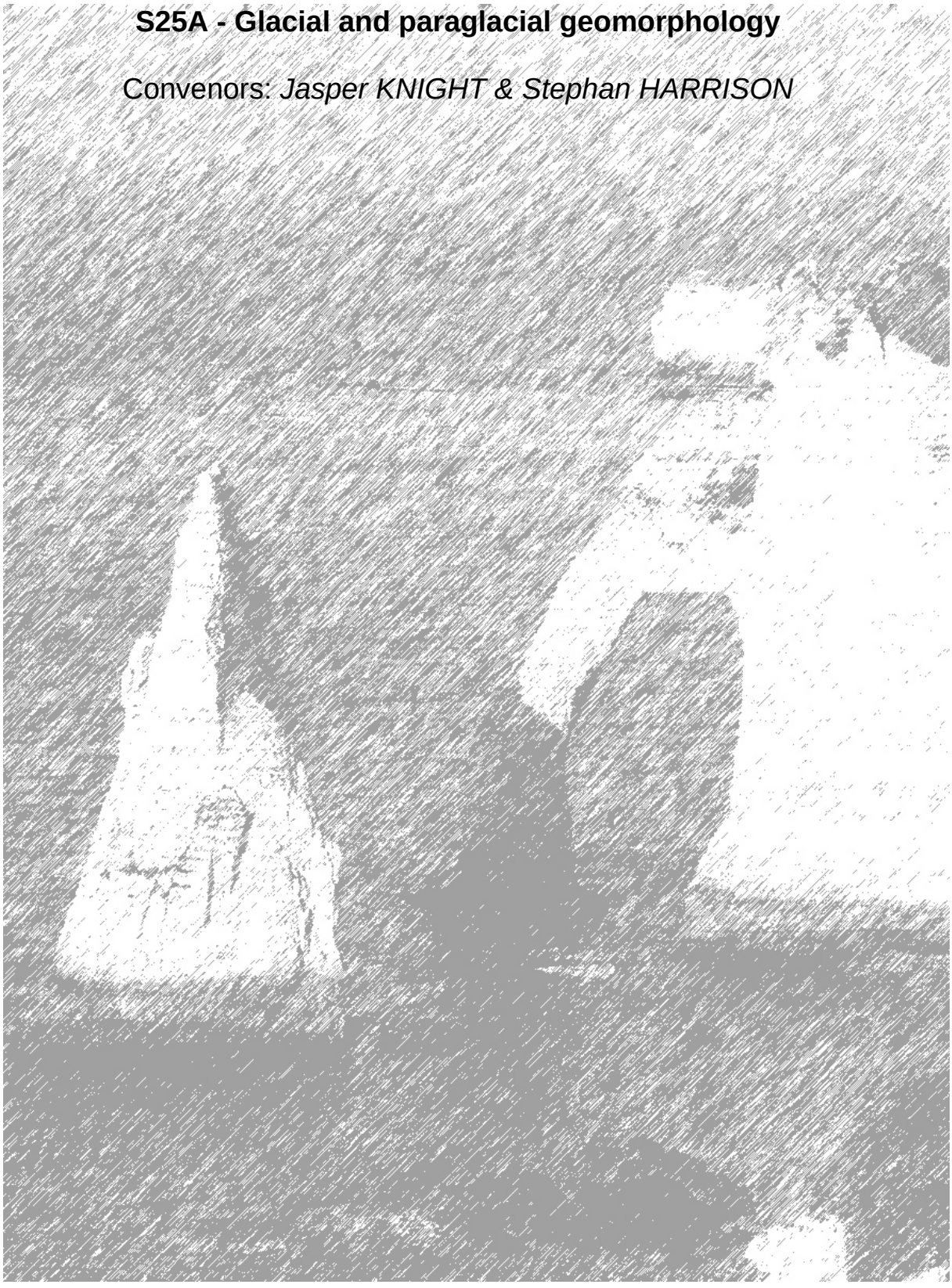
MUNIZ L.(1), FILIZOLA N.(1), FRAIZY P.(2), MELO E.(3)
(1) Universidade Federal do Amazonas, MANAUS - AM, BRAZIL ; (2) Institut de Recherche pour le D´eveloppement, MANAUS, BRAZIL ; (3) Pós-graduação em Clima e Ambiente - INPA/EUA, MANAUS, BRAZIL

This study presents an analysis of the spread and variation of water level in extreme hydrological events (droughts and floods) through a comparison between the morphometric parameters of sub-basins and patterns of variability fluviometric. The study area is the Madeira River Basin (in the Brazilian portion), whose main river is the largest tributary of the Amazon River on its right. This basin covers an area of almost 1.4 million km^2, which represents 23% of the entire area of the Amazon basin, involving portions of three South American countries: Bolivia, Brazil and Peru, is a huge drainage network only in Brazil occupies 671,841.648 km ². The authors use data from hydrological stations of the National Water Agency - ANA (www.ana.gov.br) and the Center for Environmental Hydrology and Geochemistry of the Amazon Basin Geodynamics - ORE / HYBAM (www.ore hybam.org) the historical period analysis is 30 years, and especially under extreme hydro-year events. The SRTM images available on the home page of the Brazilian Agricultural Research Corporation - EMBRAPA (www.relevobr.cnpm.embrapa.br) were the basis of the mosaic to obtain morphometric parameters extracted using GIS' tools. The results of hydrological variability on the basis described above were also compared with reports of assessing damage from Civil National Defense Database (www.defesacivil.gov.br). This type of analysis is being conducted to understand the dynamics of extreme events. This result is part of baseline studies for future comparisons with new patterns of taxes Madeira River Basin due to construction of two reservoirs for hydroelectric plants under construction on the Madeira River in Brazil.

****

S25A - Glacial and paraglacial geomorphology

Convenors: *Jasper KNIGHT & Stephan HARRISON*



Oral presentations:

Glaciers, rock avalanches and 'the buzzsaw' in cirque development

EVANS I.
Durham University, DURHAM CITY, UNITED KINGDOM

The close relation between cirques and climate is convincing evidence of the dominance of glacial erosion, rather than rock avalanching, in mountain cirque development and distribution. Cirque floor altitudes have a lower limit that varies with snowfall by 1000 m or more between windward and leeward sides of mountain systems. Glaciation Levels and Equilibrium Line Altitudes implied by cirques vary in parallel with those for modern glaciers. Cirques are often found mainly on the poleward or leeward slopes of individual mountain ranges, as are modern small glaciers (because of solar radiation and wind effects on ablation and accumulation).

The 'overdeepening' (rock basins with reversed slopes) found in a large minority of cirques cannot be due to rock avalanching, fluvial or periglacial erosion. Degree of cirque development can be related to duration of exposure to glaciation. Scars from rock avalanches may resemble poor or moderately developed cirques, but tend to be more scattered and closely related to geology, whereas glacial cirques develop on all rock types. Often rock slope failures are found adjacent to cirques, or in glacial transfluences; only a proportion are well situated to develop into glacial cirques.

The proposal that most cirques are "source-area depressions of large, deep-seated rock slope failures" should therefore be rejected, in favour of the traditional glacial explanation. Rock slope failure is an ancillary process of cirque extension or widening through collapse of glacially-oversteepened slopes.

Headward extension of adjacent cirques on a ridge leads to displacement of the divide, sometimes by 1 or 2 km. When a relatively lower snowline has led to cirque erosion on all sides of a mountain, cirque intersection lowers ridge altitudes; the so-called 'buzzsaw' effect. The buzz-saw hypothesis is not applicable, however, where remnants of a preglacial summit surface survive.

****

Glacial and paraglacial dynamics inside glacial cirques. A 3D morphometric analysis

VALCARCEL M., OTERO-OTERO M., MARTÍNEZ-CORTIZAS A., BLANCO-CHAO R.
Universidade de Santiago de Compostela, SANTIAGO DE COMPOSTELA, SPAIN

We studied the geomorphology and morphometry of 93 glacial cirques in Ancares mountains, in the NW of the Iberian Peninsula. We propose a paraglacial morphodynamic evolution that explains the geomorphology during and after the glacial stages.

The cirques were classified in those cirques with no evidences of periglacial activity (type I) and those cirques with two sections; one covered by periglacial deposits or rock glaciers, and one with evidences of glacial overdeepening (type II).The perimeter of the cirques was digitized from topography, ortophotos and field data for reference. Slope and aspect were calculated from a Digital Elevation Model with a pixel size of 5 m. The mean, maximum and minimum values of elevation and slope were extracted for each cirque. The aspect directions were classified in classes of 22.5 degrees. The total area for each aspect class was calculated and the frequency expressed as percentage of the total area of the cirque. The mean orientation of each cirque was calculated in a spreadsheet taking each direction as a vector with a module equal to the corresponding percentage of the area of the cirque. The results gave a mean orientation of 103º for cirques type I and of 33º for the type II. Those sections of cirques of type II that were subjected to glacial overdeepening has a mean orientation of 54.36º, meanwhile the areas covered by slope deposits of periglacial origin and/or rock glaciers the mean orientation is of 340º.

The analysis reveals that those cirques with a complex evolution show a glacial dynamic in the sides of the cirque with a NE orientation and paraglacial in the sides with a NW orientation. The sides oriented to the NW are characterized by steep rock slopes that under cold, but not glacial, conditions favoured the development of rock glaciers or thick slope deposits at elevations close to the ELA. Those conditions existed inside the studied cirques and support the paraglacial control of the landform evolution.

Geomatics techniques applied to the rock glaciers, glaciers and ice-patches in Spain (1991-2012)

BERENGUER F.(1), JOSÉ JUAN DE SANJOSÉ BLASCO J.J.(2), ATKINSON GORDO A.(2), DE MATIAS J.(2), SERRANO E.(3), RICO I.(4)

(1) UNEX, CACERES, SPAIN ; (2) UNEX, C?CERES, SPAIN ; (3) UVA, VALLADOLID, SPAIN ; (4) UPV, VITORIA, SPAIN

Nowadays there are several types of geomatic techniques, terrestrial (total station, GPS, close-range photogrammetry, scanning laser) or aerial (remote sensing, aerial photogrammetry, LIDAR, radar interferometer,…), for study of rock glacier dynamic. From 1991 a little research group have used some of mentioned techniques to study rock glaciers in Spain.

During these years appear new different types of geomatic instruments and several of them were used in glacier measurement: total station, terrestrial scanning laser, convergent photogrammetry and GPS. Not on all glaciers can be used all geomatic techniques, changing depending of characteristics of emplacement (cirque, valley, slope) and the ice body. In this work, it is analyzed how each instrument has limitations in some situation and why all the tools are not useful in all places.

Studied ice bodies have been Corral del Veleta rock glacier (Sierra Nevada), Argualas, Posets and Maladeta rock glaciers (Pyrenees), La Paul glacier (Pyrenees) and the ice-patches of Jou Negro and Llambrión (Picos de Europa). From 1991 to 2012 they have been surveys at different periods. The dynamic of each glacier, rock glacier and ice-patch are different depending on ice characters and geographical influences, but in each individualised geographical area the ice bodies have a homogeneous comportment.

Besides horizontal and vertical displacement surveys, detailed topographic maps, cross sections, volume and contour of glaciers are obtained. Works permits us measurements with ± 3cm accuracy, useful precision to know the evolution and dynamic or studied ice bodies in short times.

Key words: Cartography, Geomatics, Climatic change, ice bodies dynamics.

****

The role of glacial/permafrost interactions in patchy alpine landscape development

BERTHLING I.(1), ETZELMÜLLER B.(2)

(1) Norwegian University of Science and Technology, Department of Geography, TRONDHEIM, NORWAY ; (2) Department of Geosciences, University of Oslo, OSLO, NORWAY

Alpine landforms shaped by cirque and valley glaciers are prominent features in southern Norway. In many areas, landforms from these glaciers are well developed, while they are lacking in others. In southern Norway, we observe a gradient of the degree of such alpine glacier imprint, with only a slight imprint in the eastern parts towards a fully alpine landscape further west. In some areas, the alpine landscape coexists with pre-glacial surfaces that remained untouched by glacial erosion, mainly in areas close to or above the present mountain permafrost limit in the central parts of southern Norway. In these areas blockfields consisting of weathering material of pre-glacial or periglacial origin has been left more or less intact even if southern Norway was repeatedly covered by Quaternary inland ice sheets. This pattern has been attributed to cold based ice, preserving subglacial ground cover. One paradox remains in this explanation: if cold-based ice sheets protected pre-glacial surfaces and sediments, why did they not protect the sedimentary landforms formed by these cirque and valley glacier systems? No lateral and terminal moraines in cirques and alpine valleys in these areas have been found to be of pre-Holocene age. A likely scenario is that as the inland ice sheets grew, the moraine systems and sediments in front of former cirque and valley glaciers where incorporated into the basal ice of the ice sheet and exported, while neighbouring areas were left untouched. Permafrost/glacier interactions may be a key factor for an explanation of such a scenario. Ground ice within the glacial forefield, especially within ice-cored moraines, will respond to the stress of a growing glacier above it by deformation, which may cause large-scale sediment deformation and also sediment export; while the coarse-grained neighbouring blockfields may contain ground ice amounts too small to render this surface liable to subglacial deformation.

Glacial and periglacial erosion rate inferred from five years of detrital flux monitoring (Bossons stream, Mont-Blanc massif, France)

GUILLON H.(1), GODON C.(1), GOUPY B.(2), POHL A.(2), BUONCRISTIANI J.F.(2), MUGNIER J.L.(1)
(1) ISTerre, LE BOURGET-DU-LAC, FRANCE ; (2) Biogéosciences, UMR/CNRS 5561, DIJON, FRANCE

A better knowledge about present-day erosion is needed to understand the long-term relief evolution in glacial and periglacial context. The rapidly retreating glacier des Bossons was chosen to estimate the sediment budget in its partially glaciated watershed and thus determine the part of glacial erosion versus periglacial denudation.

Sediment budget was determined using: i) three calibrations curves – suspended load/water discharge, suspended load/turbidity and bed-load/water discharge – built through high frequency sampling of water discharge and turbidity since 2009; ii) annual DGPS measurements of elevation evolution; iii) transit time for coarse particles given by radio-frequency monitoring of 185 pebbles.

Sediments come from two reservoirs : the glacier and the lateral moraines. Both interact with a third reservoir: the alluvial area through which the subglacial Bossons stream flows and where hillslope processes provide material. Telling the difference between each sedimentary flux is allowed by determining: i) the hydrologic behaviour of the partly glaciated catchment by using the degree-day GSM-Socont model; ii) relationships between the sedimentary flux that enters in the alluvial area, the released one and the stored one; iii) granulometric and lithologic characteristics of each sedimentary source and how they mix in the river and its exported load.

Results show that i) 75% of the 4000 t/y of exported material are fine particles (silts/sands), mainly coming from lateral moraines during extreme rainy events; ii) the stored sediment volume corresponds to about 25% of the exported sediments (1000 t/y); iii) the subglacial erosion is smaller than 0.8 mm/y beneath the glacial tongue.

This combined methodology applied to the Bossons glacial and periglacial watershed demonstrates that erosion mainly concerns the recent exposed periglacial surfaces (i.e. moraines), and that subglacial erosion contributing weakly to the total exported sediment flux.

****

Rock slope failure in the mountains of Europe: paraglacial-parafluvial transitions

JARMAN D.(1), HARRISON S.(2)
(1) mountain landform research, GLASGOW, UNITED KINGDOM ; (2) University of Exeter, CORNWALL CAMPUS, UNITED KINGDOM

Rock slope failure (RSF) occurs in most mountain ranges, on hectometric to kilometric scale, and in more catastrophic to more deformational modes. Its spatial incidence is often clustered, and may indicate "concentrated erosion of bedrock" with consequent excess slope stresses inducing rebound ruptures. In the mountain ranges of Europe, RSF has been assumed to be a 'paraglacial' response to glacial erosion. Such erosion may for example be concentrated at and below breaches of recent origin or enlargement - possibly indicating later Pleistocene shifts in icesheds, ice piracy, and icestream dispersal routes.

However recent work identifies similar RSF forms in weakly or non-glaciated contexts. This is proposed as 'parafluvial' RSF. Local and regional transitions from paraglacial to parafluvial predominance suggest that the bulk of the concentrated erosion may often be fluvial. A recurring pattern associates such parafluvial RSF clusters with fluvial invasions of asymmetric divides; glacial occupation of their headwaters may only be a minor factor, influencing the cyclical occurrence of RSF rather than driving the process. Fluvial incision may also be maximised at times of climatic stress, including deglaciation. Even where significant directly parafluvial major RSF is absent, paraglacial RSF incidence can be greater on the steep side of divides, or where long-term uplift has driven fluvial reincision, preventing glacial troughs from stabilising.

This paraglacial-parafluvial spectrum is explored in the Scottish Highlands, northern England, central Alps, eastern Pyrenees, Tatra, and Carpathians. The utility of GoogleEarth imagery in systematically identifying such RSFs is examined. Although valuable in regional scoping, detection rates are variable. Groundtruthing, aided where available by high-detail conventional mapping, is usually essential.

The Vatn landslide, Skagafjördur, northern Iceland: early Holocene dating and Holocene palaeoenvironmental reconstitution potentialities

DECAULNE A.(1), MERCIER D.(2), COSSART E.(3), FEUILLET T.(2), JÓNSSON H.P.(4), SÆMUNDSSON Þ.(5)

(1) CNRS - Geolab, CLERMONT-FERRAND, FRANCE ; (2) Université de Nantes, CNRS Laboratoire Géolittomer-UMR 6554 LETG, NANTES, FRANCE ; (3) Université Paris 1, Laboratoire PRODIG, France, PARIS, FRANCE ; (4) Northwest Iceland Comprehensive College, SAUÐÁRKRÓKUR, ICELAND ; (5) Natural Research Centre of NW Iceland, SAUÐÁRKRÓKUR, ICELAND

The Vatn landslide is located in the Skagafjördur fjord, in northern Iceland (65°57,337'N, 19°23,900'W). Of modest size (estimated to 830,000 m^3), the slide deposit exhibits a poor spatial dispersion and longitudinal runout. The morphology of the northernmost lower part of the slide shows a flat area trapped between the slide deposit and an elongated raised beach; the contact between the slide and the beach is open by a deep anthropogenic ditch.

By examining stratigraphic sections along the ditch, and opening log sections on the flat area at the slide contact and onto the slide deposit, numerous dating elements were obtained. The lower pits are rich in organic material and tephra layers (the oldest one, H4, is dated to 3,826±12 cal. yr BP), while the upper pit revealed little accumulation over the slide deposit surface, exhibiting only tephra layers separated by poor organic units.

The combination of radiometric method and geochemical analysis of the tephra layers results in a good time constrain for the landslide occurrence, before 9070±86 cal. BP and 8677±181 cal. BP (oldest tree remnants).

Such a result reinforces the hypothesis of a major paraglacial geomorphologic activity at the early Holocene time, leading to numerous slope failures following the last glacial maximum retreat. The presence of the raised beach at the lower contact with the landslide seems to indicate an occurrence later than 11,000-11,400 cal BP (intrapolated age of the raised beaches located at 22-31 m asl).

The lower pit section encompasses the full Holocene period, exhibiting a succession of organic layers and a poor accumulation in minerogenic material. Those 2 m (i) document the palaeoenvironmental settings throughout the Holocene with potentialities for palynology and diatoms analyses; (ii) shows the decoupling of slope processes triggered in the rockwall upper part from the lower slope, as during the last ca. 10000 years, no minerogenic material was archived in the lower pit sections.

****

Geomorphological data for the recognition of mountain areas prone to glacial-related hazards, French Alps

GARDENT M.(1), DELINE P.(1), SCHOENEICH P.(2)

(1) EDYTEM - University of Savoie, LE BOURGET DU LAC, FRANCE ; (2) PACTE, University og Grenoble, GRENOBLE, FRANCE

Since the end of the Little Ice Age, one of the most obvious impacts of the climate change in the Alps is the glacial retreat. In this context, more hazards linked to glacial shrinkage are expected. A geomorphological approach mainly based on mapping is proposed to recognize areas that could potentially be affected by glacial hazards in the French Alps.

Geomorphological maps of proglacial margins were realized by means of field work and analysis of recent orthophotographies and old documents. Three types of geomorphic data are collected: (i) the present glacier extension, as a part of an inventory of the today French glaciers; (ii) landforms and formations (till, moraines, roches moutonnées) that record past glacier extensions, especially the Little Ice Age ones; and (iii) markers of active processes (e.g. debris-flow, glacial lake outburst flood, landslide in moraine) that inform about potential instabilities. All these data are integrated in a GIS.

Combining these geomorphic data with DEM and geological data, or with maps of the permafrost distribution, we localize areas that could be affected by glacial hazards. Automatic methods of recognition are developed through the GIS software, but additional manual work is still required.

For instance, we map areas of debris flow potential occurrence (DFPO) in proglacial margins by using simplified existing methods where slope angle and till volume are the main predisposing factors. These two factors are classified from lowest (1) to highest (3) susceptibility to debris flows, and combined to generate an index from which 3 DFPO classes (low, moderate, and high) are derived.

Another approach deals with rockfall potential occurrence. Steep rockwalls towering above a glacier can be destabilized by its shrinkage. The overlapping of glacierized bedrock and glacial extension during the LIA in the GIS defines areas that could potentially be affected by rockfall.

Mechanisms controlling the post-Little Ice Age evolution of paraglacial coasts in Svalbard Archipelago

STRZELECKI M.(1), LONG A.(2), LLOYD J.(2)
(1) 1. Department of Geography, Durham University, UK; 2. Department of Geology, UNIS, Norway; 3. Department of Cryospheric Research, AMU Poznan, Poland , DURHAM, UNITED KINGDOM ; (2) Department of Geogrpahy, DURHAM, UNITED KINGDOM

In contrast to mid and low latitude coasts, relatively little is known regarding the potential impacts of climate and sea-level change on high latitude coastal margins. Indeed, many of the existing intellectual paradigms regarding the functioning of polar coasts are now out-dated, based on descriptive geomorphology and a limited process-based understanding.

This paper aims to address this deficiency by improving our understanding of the mechanisms of recent adjustment of the High Arctic coastal zone to non-glacial conditions associated with the paraglacial period following the end of Little Ice Age.

The pristine coasts of Svalbard provide a superb opportunity to quantify how High Arctic coasts are responding to rapid climate warming. These (largely) terrestrial processes are interacting with glacio-isostatic land emergence and on-going global sea-level rise. Existing sediment budget approaches in Svalbard have focused attention on quantifying the volumes of sediment transported by glacial rivers and derived from glacier erosion and reworking of fluvial sediments. Little attention has been paid to the functioning of sediment storage and reworking systems within coastal zone

In this paper, we summarize results of several case studies carried out along paraglacial coast of Svalbard during the last decade. Research was based on the combination of methods including aerial photogrammetric and GIS analyses, sedimentological tests of coastal deposits and field-based geomorphological mapping.

The presented results document dramatic changes in sediment flux and coastal response under intervals characterized by a warming climate, retreating local ice masses, a shortened winter sea-ice season and melting permafrost.

Our work highlights the need for a greater understanding of the controls on paraglacial coastal sediment budgets in High Arctic settings, especially given the potential for accelerated warming and sea-level rise in the coming decades and centuries.

****

Geomorphological sensitivity: implications for landscape responses to climate change in glacial environments

HARRISON S.
Exeter University, PENRYN, UNITED KINGDOM

Climate sensitivity is defined as the equilibrium temperature response of the climate system to a doubling of atmospheric CO_2 levels from pre-industrial levels. Despite three decades of debate in the climatological literature on the estimation and significance of climate sensitivity, very little appears in the geomorphological literature on the implications of this for geomorphological systems. This paper examines the concept of climate sensitivity and applies its findings to an assessment of future landscape change in cold regions. It is concluded that paraglacial processes will become the dominant mechanism of sediment transfer in currently glaciated catchments and that this period of sediment mobilization will be the last episode of major sediment movement for geological time periods.

Toward a comprehensive paraglacial model: case studies from Iceland

MERCIER D.(1), COSSART E.(2), DECAULNE A.(3), FEUILLET T.(1), COQUIN J.(1), BOURGEOIS O.(4), POCHAT S.(4), JÓNSSON H.P.(5), SæMUNDSSON Þ.(6)

(1) Université de Nantes - Laboratoire LETG-Géolittomer (UMR 6554), NANTES, FRANCE ; (2) Université Paris 1, Laboratoire PRODIG, PARIS, FRANCE ; (3) CNRS Laboratoire Geolab-UMR6042, CLERMONT-FERRAND, FRANCE ; (4) Université de Nantes - Laboratoire de Planétologie et Géodynamique de Nantes, UMR 6112, NANTES, FRANCE ; (5) Northwest Iceland Comprehensive College, SAUðÁRKRÓKUR, ICELAND ; (6) Natural Research Centre of NW Iceland, SAUðÁRKRÓKUR, ICELAND

From the end of the Weichselian period and during the early Holocene, the landscape in Iceland underwent major changes. During this short-time interval, while glaciers were retreating from the lowlands, an exacerbation of geomorphic activity is noticed, due to lowering of the relative sea level, large glacial rivers flooding from the retreating ice margins and hillslope debutressing. As a consequence, many of the major paraglacial landforms that carved the Icelandic landscape are still visible nowadays.

Two kinds of early Holocene paraglacial landforms can be identified in Iceland: (i) paraglacial denudation landforms (some slope failure deposits such as sackungs, rock avalanches and various other landslide types…), and (ii) paraglacial deposition landforms (alluvial fans, terraces, valley-train deposits, outwash plains or “sandurs” with outburst floods or “jökulhlaups”, coastal deposits…). By using the sediment cascade framework, several paraglacial sources and sinks are also identified. This classical geomorphological approach privileges forms, processes to typify their temporal evolution through the Holocene. Some post-little ice age analogues in Iceland are also clear examples of such paraglacial evolution.

To those external paraglacial dynamics we also propose to couple the consequences of the deglaciation to the internal earth dynamics (such as seismicity and volcanism, i.e. internal paraglacial effects). All around Iceland, glacio-isostatic rebound can explain the formation of numerous raised beaches, deltas, and strandflats. Also, an intense volcanic activity phase occurred within the early Holocene in Iceland, highlighting a link with the ice pressure release on the magma transfer.

Based on our own researches and on literature review, we develop a spatial analysis at different time and space scales and propose a comprehensive paraglacial model, including external and internal earth dynamic implications.

****

Spatial and temporal patterns of paleoglaciation across Central Asia

HARBOR J.(1), STROEVEN A.(2), BLOMDIN R.(1), CAFFEE M.(1), CHEN Y.(3), CODILEAN T.(4), FU P.(2), GRIBENSKI N.(2), HÄTTESTRAND C.(2), HEYMAN J.(1), IVANOV M.(5), LI Y.(6), LI Y.(6), LIFTON N.(1), LIU G.(3), PETRAKOV D.(5), ROGOZHINA I.(4), USUBALIEV R.(7)

(1) Purdue University, WEST LAFAYETTE, IN, UNITED STATES ; (2) Stockholm University, STOCKHOLM, SWEDEN ; (3) Peking University, BEIJING, CHINA ; (4) GeoForschungsZentrum, POTSDAM, GERMANY ; (5) Lomonosov Moscow State University, MOSCOW, RUSSIAN FEDERATION ; (6) University of Tennessee, KNOXVILLE, UNITED STATES ; (7) Central Asian Institute for Applied Geosciences, BISHKEK, KYRGYZSTAN

Understanding the evolution of mountain landscapes and testing global climate models require well-constrained information on past spatial and temporal patterns of glacier change. Particularly important are transitional regions that provide a sensitive record of past climate change and that may have high spatial and temporal variation in glacier activity. Central Asia is an extreme continental location with glaciers that respond sensitively to temporal variations in the dominance of several major climate systems.

As an international team project, we are reconstructing glacial histories along the Tian Shan, Altai and Kunlun Mountains, as well as several areas of the Tibetan Plateau. Remote-sensing-based geomorphological mapping, building on previous maps produced by local and international scholars, is being augmented with field observations of glacial geomorphology and the maximum distribution of erratics. We are using cosmogenic nuclide, optically stimulated luminescence and electron spin resonance dating of moraines and other landforms that constrain the former maximum extents of glaciers. Comparing consistently dated glacial histories across central Asia will allow us to examine potential shifts in the dominance patterns of climate systems over time in the region. Results to date show significant variations in the timing and extent of glaciation, including areas in the southeast Tibetan Plateau and Tian Shan with extensive valley and small polythermal ice cap glaciation during the global last glacial maximum in contrast to areas in the central Tibetan plateau that had very limited valley glacier expansion during the global last glacial maximum.

Topographic controls upon moraine distribution

BARR I.D.
Queen's University Belfast, BELFAST, UNITED KINGDOM

Ice-marginal moraines are the most direct and ubiquitous indicators of former glacier dimensions, and are frequently used as a foundation for palaeoglacier reconstructions, which are, in turn, used as proxies for palaeoclimate. Despite being widely applied, this procedure is based upon the following assumptions, which are rarely explicitly discussed in palaeoglaciological literature: (i) the distribution of moraines reflects the former dimensions of glaciers, and (ii) glacier dimensions may be linked to palaeoclimate. Here, these assumptions are discussed by considering a population of more than 8,000 moraines in Eastern Siberia. Ultimately, it is argued that the distribution of these moraines reflects a complex signal of palaeoclimatic and topographic controls upon glacier dimensions, dynamics, and moraine preservation; and that extracting a palaeoclimatic signal from this landform record is a difficult task.

****

Landform development at the High-Arctic valley glacier landsystem, Ragnarbreen, Svalbard

EWERTOWSKI M.
Department of Geography, Durham University, DURHAM, UNITED KINGDOM

Evolution of a small High-Arctic valley glacier landsystem was analyzed based on Ragnarbreen, Svalbard. Study area is located near Petuniabukta in the northern part of Billefjorden in the central part of the Spitsbergen Island. Landforms transformations were quantified using time-series digital elevation models (DEM) constructed from aerial photographs from 1960, 1990 and 2009. Small scale transformations were also quantified by field surveys in 2007, 2011 and 2012. Furthermore, the time-series geomorphological maps were also created. The elements of the landsystem of the Ragnar glacier have undergone several transformations since the LIA maximum:

1) Increasing amount of water flowing from the glacier was blocked by end moraine complex and the ice marginal lake was created.

2) As a consequence of lowering of the glacier surface non covered by debris and formation of the distinct lateral moraines, the debris delivery from the valley sides has been limited only to very narrow zone of the glacier.

3) Accelerated recession of the ice mouth and limitation in delivery of debris from sides of the valley caused that amount of deposits released at the contemporary ice margin is small.

4) The debris cover on the lateral moraines is relatively thin. Moreover, as a consequence of lowering of the clean ice surface, slopes of the lateral moraines are very steep. It causes that mass movement processes (especially debris flows) are ubiquitous.

The spatial and temporal transformations of the landforms on the glacier foreland indicate that the dominant geomorphological processes influencing high-Arctic landscape are very varied and include among other mass movements, fluvioglacial, laccustrine and glacial deposition. The model of Ragnarbreen landsystem development can serve as a very good analogue for reconstructions of gemorphological processes in similar settings.

Project was founded by Polish National Science Centre (decision number DEC-2011/01/D/ST10/06494)

Character and rates of glacial sedimentary processes in the terrestrial part of Billefjorden basin (Svalbard)

RACHLEWICZ G.
Adam Mickiewicz University in Poznan, Institute of Geoecology and Geoinformation, POZNAN, POLAND

In the Atlantic sector of the Arctic, where Svalbard is located, due to intensive glacier covers decay of last decades, large amounts of glacially derived sediments are discharged within the valley systems, building up marginal zones, being transferred by proglacial rivers, partly stored on land and finally supplying coastal environment.

Based on detailed mapping and quantitative analysis of processes in three partly glacier covered catchments in the head fragment of Billefjorden basin (central Spitsbergen, inner fjord area, about 78.7oN and 16.6oE), the structure of present-day behavior of the remaining basin part, composed of five drainage basins, glaciers covered in between 12 and 80%, was determined. GIS enhanced geological and geomorphological investigations allowed to estimate the sediment yield, based on its stored amount, in the range between 1.2 and 2.8 mm per year, from which 62% were delivered by meltwater. Depending on the basin structure the rates of denudation are between 0.1 and 1.0 mm per year, within which chemical denudation constitutes even up to 70%, depending in quantity and character on their source of supply.

In spite of general similarities of glacier systems functioning in the frame of regional features, a wide range of individual patterns as ice body size, geology, initial relief, ice covers dynamics, arrangement of glacially generated landforms etc., influence the rates of glacial sedimentary processes observed on land, before a part of deposits find their place at the bottom of the fjord building up a geological archive.

****

Glacial geomorphology of the High Atlas, Morocco

HUGHES P.
University of Manchester, MANCHESTER, UNITED KINGDOM

This paper presents the evidence for glaciation in the Toubkal area of the High Atlas in Morocco. Valley glaciers emanated from a central ice field during the largest glaciation and moraines are present at altitudes as low as 1900 m a.s.l. There is also evidence for ice cap glaciation in some areas. The lowest moraines have yielded ^{10}Be and ^{36}Cl exposure ages of 30-80 ka and indicate that the oldest recorded glaciation occurred well before the last global last glacial maximum (LGM). Higher moraines yielding ^{10}Be exposure ages of 19-24 ka correlate with the global LGM. A third, higher, suite of moraines are present in all valleys have yielded a tight scatter of ^{10}Be exposure ages of 11-13 ka and these moraines correlate with the Younger Dryas. The lowest Pleistocene glaciers formed on the northern flanks of the High Atlas. Here, equilibrium line altitudes (ELAs) were < 3000 m a.s.l. during the most extensive glaciation. Permanent snow fields still survive today in some places on north-facing slopes. Several glaciated valleys contain large rock avalanche deposits. However, these landforms yield Holocene cosmogenic exposure ages and appear unrelated to Pleistocene glaciation, although rock wall over-steepening may make glaciated valleys prone to rock slope failure long after deglaciation. The glacial record of the High Atlas has important implications for understanding moisture supply to the Sahara region during Pleistocene cold stages.

Cirque development and the glaciation of the Romanian Mountains

MINDRESCU M.(1), EVANS I.(2)
(1) UNIVERSITY OF SUCEAVA, SUCEAVA, ROMANIA ; (2) UNIVERSITY OF DURHAM, DURHAM, UNITED KINGDOM

The moderate altitudes of the Carpathian Mountains limited glaciation to cirque and short valley glaciers, but these were widespread in the Romanian Mountains, and many well-developed cirques were eroded. The 'marginal' nature of glaciation means that glaciers formed first on the most favourable (shadiest and leeward) mountain slopes, giving valuable indications of former wind directions (from west-northwest). Some cirques are completely isolated from others, but several mountain ranges rose sufficiently high above snowline that glaciers and cirques developed on all slopes, as in the Retezat, and Făgăraş Mountains.

Cirque development is measured both subjectively (5 grades) and objectively: the relation between these measures is shown by an R^2 of 62% when grade is predicted from maximum gradient, minimum gradient, and plan closure. Cirques larger in horizontal dimensions have better grades. Cirque enlargement in plan is faster than vertical enlargement, as shape changes with size (allometry).

Despite being in an active orogenic belt, Romanian cirques are more similar to those in Britain than to those in British Columbia, where relief and thus vertical dimensions are greater. 'Cirque-in-cirque' forms are common in the higher ranges of Romania: Retezat, Godeanu and Făgăraş. Isolated cirques are relatively simple. Lakes are most frequent on granite, as in the Retezat. Geology affects especially vertical dimensions and gradients. Cirque form relates firstly to glaciological (climatic) factors and secondly to geologic (lithological and structural) factors.

Uplift of the Carpathians is recent and ongoing, so that traces are found only of recent glaciations, and glacial transformation is immature or incomplete. Mountain ranges can be ranked in terms of glacial modification, from the Retezat to the Suhard, Ciucaş and Bihor Mountains. This correlates with the degree of local asymmetry (of cirque aspect).

****

10Be exposure dating of onset and timing of Neoglacial glacier advances in the Ecrins massif, French Alps

LE ROY M.(1), DELINE P.(1), CARCAILLET J.(2)
(1) EDYTEM, UNIV SAVOIE, LE BOURGET DU LAC, FRANCE ; (2) ISTERRE, GRENOBLE, FRANCE

Alpine glaciers are known to be highly sensitive to change in temperature and precipitation on decadal to centennial time scales. For two decades, numerous studies on Holocene climate revealed a period marked by abrupt cold reversals (*e.g.* 8.2 ka event) with increasing frequency and magnitude after the Holocene Climatic Optimum, during the so-called Neoglacial period (roughly the last 4 ka). State-of-the-art studies indicate that largest alpine glaciers failed to exceed their Little Ice Age (LIA) extent during these LIA Type-Events, unlike certain smaller glaciers.

In the French Alps, very few investigations were conducted to date on Holocene glacier variability. Almost all studies focused on the most glacierized area: the Mont Blanc massif, where suitable organic remains to apply radiocarbon dating and dendrochronology are available. Other glacierized massifs are poorly studied, without any Holocene/Neoglacial glacier chronology up to now.

Here, we present the results of a study focusing on six glacier forefields distributed in the Ecrins massif. Detailed geomorphological mapping and *in-situ* produced ^{10}Be dating were carried on multi-crested so-called "LIA composite moraines". The targeted ridges are located in distal position with respect to late LIA drift in order to identify Holocene cold pulses that have led to (or slightly exceeded) LIA-like glacier extent.

The 35 ^{10}Be ages obtained revealed that the onset of Neoglacial occurred at ~4.2 ka, and that at least two other advances were recorded at ~3.3 ka and ~0.85 ka. One site has yielded a nearly complete Neoglacial record as four discrete events have been dated. These results highlight the potential of lateral moraine ridge stratigraphy which could yield accurate record when sufficiently preserved, but also the different preservation of landforms along the glacier margin which could censor the record.

Measurements of glacial and subglacial mass exchange of Gepatschferner (Ötztal Alps, Austria)

STOCKER-WALDHUBER M.(1), SCHMIDT K.H.(2), KUHN M.(1), MORCHE D.(2), LAMBRECHT A.(3)
(1) Institute for Meteorology and Geophysics, University of Innsbruck, INNSBRUCK, AUSTRIA ; (2) Institute for Geosciences and Geography, Physical Geography, Martin-Luther-University of Halle-Wittenberg, HALLE (SAALE), GERMANY ; (3) Alfred Wegener Institute for Polar and Marine Research, BREMERHAVEN, GERMANY

Within the subproject “Glaciology and Geomorphology” which is part of the DFG/FWF joint project PROSA (Proglacial Systems of the Alps), all of the changes of the tongue of Gepatschferner (2150 – 2850 m.a.s.l., Ötztal Alps, Austria) and the production of sediments due to the glacier are being investigated.

The mass balance at the surface is determined by using the direct glaciological method and the whole glacier mass balance by using the geodetic method including multiple high resolution airborne laser scans. Surface velocity is ascertained by DGPS and feature tracking with two digital cameras. In order to obtain the resolution and the periodic change of the sediment layer between rock and ice, which seems to play an important role as a sediment source to the forefield, the new method of vibroseismic comes into operation. Additionally the ice thickness is measured with ground penetrating radar and a comparison of the two methods shall be aspired.

A first analysis of the vibroseismic data shows that the spatial resolution exceeds the thickness of the subglacial sediments. At the upper part of the tongue were the ice is about 100 meters thick a sediment layer of more than ten meters of depth was detected. Due to the high surface velocity of the glacier of more than 50 meters per year at the root zone of the tongue, the erosion of the subglacial sediments is expected to be very high. With the effort to get these changes in thickness the vibroseismic measurements will be repeated.

****

Transition from glacial to periglacial processes in the Dolomites: the case of Cima Uomo area (Eastern Italian Alps)

ZANONER T.(1), SEPPI R.(2), CARTON A.(1), NINFO A.(1), BONDESAN A.(1), FRANCESE R.(3)
(1) Department of Geosciences - University of Padova, PADOVA, ITALY ; (2) Department of Earth and Environmental Sciences - University of Pavia, PAVIA, ITALY ; (3) National Institute of Oceanography and Experimental Geophysics (OGS), TRIESTE, ITALY

Several glaciers of the Dolomites were progressively covered by debris during the retreating phase occurred after the LIA, allowing their preservation at relatively low altitudes. In some cases, these ice-debris systems are currently developing under permafrost conditions, leading to examples of transition from glacial to periglacial processes. In this study, we analyze the relationships between ground temperature and climatic parameters (air temperature, snow cover and topographic solar radiation) in order to understand which are the main factors controlling the morphodynamic processes of these environments.

The study area is located in upper Val San Nicolò (Dolomites) between 2200 and 3000 m of altitude. Here, a cirque glacier fed by avalanches was present as a clean glacier until the ‘50s. This glacier was depicted in historical maps, where its evolution from clean to debris-covered glacier can be observed. Now it is completely covered by a thick layer of debris andthe surface morphology suggests that is developing in a rock glacier-like landform.

In order to detect if Cima Uomo ice-debris mass is under permafrost conditions, BTS and GST measurements were carried out. The observed low ground temperatures suggest that permafrost conditions are largely present in the debris body. In particular, BTS measurements performed in 2010 showed temperatures consistent with permafrost existence (from -3 to -4°C). The GST data of 2009 and 2010 showed winter equilibrium temperature (WEqT) lower than -2°C. The topographic solar radiation was calculate (on a Lidar-DEM) to correlate its influences to the measured ground thermal condition. The geophysical surveys confirmed the existence of an ice body under the debris layer and the topographic measurements have detected small movements of the ice-debris mass.

The study of this transitional processes on Cima Uomo can be consider representative of many other ice-debris masses of the Dolomites.

Poster presentations:

Paraglacial - a comparative study of German and Anglo-Canadian usage

EMBLETON-HAMANN C.(1), SLAYMAKER O.(2)
(1) University of Vienna, Department of Geography, WIEN, AUSTRIA ; (2) University of British Columbia, Department of Geography, VANCOUVER, CANADA

The meaning of the term paraglacial has been defined in the Anglo-Canadian literature between 1972 and the present (e.g. Church and Ryder, 1972 and Ballantyne, 2002). Many of the ideas discussed in the Anglo-Canadian literature were implicit in the early 20thcentury German literature. However, the German literature does not seem to have imbedded the paraglacial idea into an overarching framework for the study of postglacial glaciated landscapes. It was not until the end of the 20thcentury that the Anglo-Canadian paraglacial model was directly applied to the interpretation of the European Alps (Müller, 1999).

This poster reviews the two favoured definitions of paraglacial from the Anglo-Canadian literature and then provides examples of implicit uses of the model and explicit uses of the term “paraglazial” in the German literature. Implicit uses are illustrated from the work of Ampferer, 1931, and Patzelt, 1987. Explicit uses of the term “paraglazial” in the sense of "ice-marginal" are found in Klebelsberg, 1950, and several other references. Most recently Kuhle, 1991 and Iturrizaga, 2007 state that the proper meaning of the term “paraglazial” is "ice-marginal". Examples of the explicit use of the Anglo-Canadian paraglacial model in the German literature can be found in Hinderer, 2001 and Schrott et al., 2003.

The Anglo-Canadian paraglacial model views the postglacial glaciated landscape as a landscape of transition between the full glacial of the LGM and the present almost entirely deglaciated landscape. This conceptual framework provokes the question “what is the degree of transition” of a specific landscape as indicated by the paraglacial elements in that landscape.

****

The survival of preglacial landforms in basement complex areas

HUGUET F.
Université Paris-Nord, PRES Sorbonne Paris Cité, VILLETANEUSE, FRANCE

European basement complex areas which have been widely glaciated during the cold phases of the Quaternary, for instance the Black Forest, the Welsh mountains and the south-western Kerry (Ireland), show remarkable glacial features, such as glacial troughs and cirques. However, those glacial features did not totally obliterate the preglacial topography and it is possible to evidence, close to the glacial cirques, remnants of the preglacial topography, namely remnants of stepped landforms and piedmont staircases. Glacial cirques in basement complex areas frequently about to the break of slope separating two successive benches or to the slope separating a culminating hill from its pedestal. That frequent location, statistically significant, can be easily accounted for, because those breaks of slope and steps facilitated the piling of snow and reduced the volume of rock to excavate.

Contemporary sub-glacial landscapes: case studies from three Antarctic ice streams

KING E.
British Antarctic Survey, CAMBRIDGE, UNITED KINGDOM

The formation mechanism of subglacial landforms such as drumlins and mega-scale glacial lineations remains controversial. Factors include the type and properties of subglacial sediments; the availability and pressurization of water; and the thickness and flow speed of the overlying ice. While new survey techniques have allowed increasingly sophisticated quantification of the morphology of palaeo-bedforms, observation of contemporary examples has remained difficult, thus inhibiting the development of viable models of formation. I have undertaken ground-radar surveys of three currently-active Antarctic ice streams (Rutford Ice Stream, Talutis Inlet and Pine Island Glacier) to map the type and distribution of subglacial landforms to provide primary observations to inform this debate.

The observed bedforms cover a wide range of elongation ratios and degrees of streamlining and the locations of the surveys cover a range of flow speeds from 70 m/yr to >1000 m/yr. While there is some correlation between flow speed and bedform elongation, the juxtaposition of bedforms of different types within the same flow regime demonstrate that flow speed is not the only controlling factor. It is clear that the physical properties of the basal sediment and the availability of water are also key to the spatial distribution of drumlins, hummocks and mega-scale glacial lineations.

****

Subglacial processes and drumlin formation in west Connemara, Ireland

KNIGHT J.
University of the Witwatersrand, JOHANNESBURG, SOUTH AFRICA

In western Ireland, Late Weichselian ice flow dynamics and resultant patterns of landforms and sediments reflect the interplay between intrinsic (glaciological) and extrinsic (climate and geologic) forcing on the eastern Atlantic fringe. Landform and sediment patterns in the flat lowland region (>100 km^2 below 30 m asl) to the south of the Twelve Bens mountains reflect the interplay of these intrinsic and extrinsic controlsacross an igneous and metamorphic substrate. Sculpted bedrock forms (whalebacks, rock drumlins, roches mountonnées, striae) are present across the region and reflect areal subglacial abrasion. Subglacial sediments that are shaped into drumlins are found only in isolated bedrock valleys and around the western margins of the area and ahead of incised valleys (Nye channels). Drumlin sediments are exposed at Ardmore and Ballyconneely. Here, leeside stratification sequences dominated by cyclic debris flows overlie an overconsolidated basement comprised of lodgement till. Growth of the drumlin form in these specific locations in west Connemara reflects positive feedback (emergence) and self-organisation of subglacial sedimentary processes in a sediment-limited subglacial environment.

Last Glacial Maximum to Holocene glacial and paraglacial landscape reconstruction in the Cachapoal valley (Southern Central Andes, 34°22'S/70°05'W)

ITURRIZAGA L.
Institute of Geography / University of Goettingen, GOETTINGEN, GERMANY

The research project focusses on a glacial geomorphological reconstruction from the Last Glacial Maximum to the Holocene glacier extent in the Cachapoal valley with their specific characteristic glacial landform assemblages. The E-W trending Cachapoal valley, a tributary of the Rapel River, drains one of the most southern located mountain massifs exceeding altitudes of 5000 m (Picos Barroso 5180 m). In climatic respect the valley is situated in the transition zone from the Dry Central Andes towards the Wet Andes with increasing annual precipitation amounts. Thus, the upper catchment area inhibits one of the largest debris-covered glaciers of the region, the 13 km long Cachapoal glacier. The research work has been carried out on a multi-proxy-approach based on geomorphological mapping, 10^{Be}dating, the analysis of satellite images and historical data. The preliminary analysis of the field investigations suggests a dentritic LGM-Cachapoal-glacier-ice stream with the affluents of Cachapoal, Las Leñas, Cortaderal and Cipreses reaching a length of at least 60 km and flowing down to about 800 m a.s.l.. A special emphasis has been put on the genetic interfingering of moraines and landslides. In the last decades a lot of classical moraines in various regions of the world have been reinterpreted as landslides. Recently the question has been even raised in how far end moraines can be used as climatic indicators when the influence of landslides dominates. The Upper Cachapoal valley is located in a seismic active and therefore landslide-prone region crossed by the El Diablo-El Fierro-thrust fold. The present study aims to highlight the interplay of glaciation and landslides. Moreover the historical glacier surging dynamics of the Cachapoal glacier have been considered in the study. Research work has been financed by the Alexander von Humboldt-Foundation and the Universidad Andrés Bello (Santiago de Chile).

****

The age of the Last Glacial Maximum in the Asian North-East

GALANIN A.
Melnikov Permafrost Institute SB RAS, YAKUTSK, RUSSIAN FEDERATION

The analysis of geomorphic and biostratigraphic data on four key Late Glacial complexes located in the mountains of Chersky Range and Kolyma Upland has demonstrated that the Last Glaciation had reached its maximum in the second part of Karginsky Termochrone (MIS 3) and it had formed in the conditions of moderate humid and cool (subarctic) climate. The Glaciation had considerably reduced to the end of Karginsky Termochrone (MIS 3). During Sartan Cryochrone (MIS 2) the degradation of the Glaciation had continued and the Periglacial Area was widespread and accompanied with eolian and permafrost processes. On the boundary of Pleistocene and Holocene the small cirque-type glaciation had occurred due to the marine transgression. The Last Holocene glacial activity is related to Neoglacial Epoch and it appeared with the rock glaciers formation development. This study was supported by Russian Fund of Basic Research, Projects # 11-05-00318-a; 12-05-98507-vostok_a.

Differentiation of the younger saalian ice-sheet dynamics in the interfluve of the Krzna and Bug Rivers (E Poland))

GODLEWSKA A.
Maria Curie-Sklodowska University in Lublin, Department of Geoecology and Palaeogeography, LUBLIN, POLAND

According to the commonly accepted model, during the younger Saalian glaciation the area of eastern Poland was subjected to areal deglaciation conditioned by continental climate. My recent studies reveal a differentiation of the younger Saalian ice-sheet dynamics in the interfluve of the Krzna and Bug rivers. The research conducted in the marginal zones of the ice lobes -Liwiec, Toczna and Klukowka -suggests as follows: 1) recession of the Liwiec Lobe was frontal, disturbed by local re-advance (along the pra-Liwiec valley filled with fine deposits); 2) recession of the Toczna Lobe was frontal on flat substratum; 3) recession of the Klukowka Lobe was areal over substratum high.

Spatial differentiation of dynamics of the ice masses in the marginal zone of the ice sheet was conditioned by relief and lithology of ice substratum. It is best reflected in extremely contrary mechanisms of dynamics of the Liwiec and Klukowka lobes: the valley filled with fine deposits conditioned re-advance of the Liwiec ice masses, and the substratum high determined the Klukowka lobe disintegration into dead-ice blocks. These conclusions question the hitherto accepted model of only areal deglaciation and also bring down the belief about an influence of continental climate on dynamics of the younger Saalian ice sheet in eastern Poland.

****

The overlapping problem of paleoglacial and periglacial landforms under an evident scenario of global warming but a tectonic uplifting in the central Andes (Northwestern Argentina)

BUSNELLI J.
National University of Tucuman, TUCUMAN, ARGENTINA

The upper basins above more than 5000 m.asl in the mountain regions of Northwestern Argentina have a continuous history of glaciation and tectonic movements. During the whole Quaternary, there were many glaciations resulting from temperature decrease and snow fall increase due to high values of humidity. Nonetheless, the mountain glaciers have just developed due to the presence of the orographic front that promoted the air masses raised, chilled and condensed in snow precipitation. But, in the other hand, during interglacial dry period, the original glacial landforms, such as moraines and cirques, turned into complexes forms under hydric, fluvial and mass movement processes that followed the cold period. All these processes masked the original glacial forms, so their recognition becomes difficult. The second and more important problem is the neotectonic that began with the Andean Orogeny and continues nowadays. This diastrophic effect affects the current geomorphological processes that yields active rock glacier. In the current research the aim was, first, to distinguish between relict or fossil and inactive rock glaciers from active rock glaciers, and then between glaciogenic (derived from quaternary glaciations) and geocriogenic (derived from typical periglacial processes). The rock glacier mapping was carried out through photointerpretation and satellite image analysis using Geographic Information Systems (GIS's) and field control documenting the active morphodynamic periglacial processes. Concluding, it was determined that the mountain tectonic uplifted has had a differential movement in the analyzed basin. The western upper basin have low slope U shape valley with remnant cirques and fossil rock glaciers, while the south exposition basins have a higher rate of uplifting having high slope valleys and dominant active rock glaciers. In this way, the current research proposes a method of neotectonic analysis using paleoglacial and periglacial geoindicators.

Fluvial adjustments in response to glacier retreat: Skaftafellsjökull, Iceland

MARREN P., TOOMATH S.
University of Melbourne, PARKVILLE, AUSTRALIA

Glacier retreat has accelerated globally since the mid-1990s. Changes in discharge and proglacial topography will lead to changes in the morphology and functioning of proglacial rivers. At present, most of our knowledge of river response to glacier retreat is based on studies of Quaternary landscapes. Few studies have examined annual changes in glacier extent and related them to changes in proglacial drainage patterns.

The proglacial drainage network of Skaftafellsjökull, Iceland was monitored from 1998 to 2011. Skaftafellsjökull has retreated at an average rate of 53 m per year since 1999. From 1999 to 2003, the river incised and formed a sequence of now abandoned channels and fluvial terraces extending ~1 km downstream from the glacier. Retreat of the glacier from an ice-contact slope meant that there was a positive correlation between distance of glacier retreat and amount of fluvial incision. Incision was episodic, occurring in response to annual drainage reactivation and reorganization. The annual rate of retreat is moderately negatively correlated with the rate of incision. This is because the ice-contact slope decreases away from the position of maximum glacier extent, and also because faster retreat releases more sediment, counteracting the effect of retreat down an ice-contact slope. In 2003, proximal terrace formation ceased, as a proglacial lake was established. Downstream of the lake outlet further incision deepened the channel, with most change occurring during a flood in 2006, where incision in the upstream confined reach was accompanied by downstream aggradation and terrace formation.

Proglacial changes in response to glacier retreat are a result of the interactions of river channel incision, terrace formation, aggradation, lake development, and flooding, which together control river channel changes, sediment redistribution and sandur stratigraphy. Further work will extend this model away from lowland outlet glaciers into other proglacial settings.

****

Micromorphology and macrofabrics of Late Quaternary sediments in the Aragonese Pyrenees, Spain

HIRSCH F., RAAB T.
BTU Cottbus, Chair of Geopedology and Landscape Development, COTTBUS, GERMANY

Within the scope of the research project *Post-LGM pedogenesis and geomorphodynamics in the Aragonese Pyrenees* we used a combination of field and laboratory methods to differentiate and classify Late Quaternary sediments. Our analyses indicate no post sedimentary erosion of the LGM lateral moraines in the Aragon and Gallego valley. Precipitation of calcium carbonate led to the fixation of the diamictons and thus stabilized the glacial landforms. Clasts in the glacial sediments are orientated parallel to the Pleistocene glacial flow direction and therefore underpin the stability of the glacial deposits during paraglacial times. Grain size analyses and OSL ages indicate the covering of glacial sediments by an eolian deposit before the onset of the Holocene.

The Glacier des Bossons protects Europe's summit from erosion

GODON C.(1), MUGNIER J.L.(2), FALLOURD R.(1), PAQUETTE J.L.(3), POHL A.(4), BUONCRISTIANI J.F.(4)
(1) Université de Savoie, LE BOURGET DU LAC, FRANCE ; (2) CNRS University of Savoy, LE BOURGET DU LAC, FRANCE ; (3) CNRS, Université Blaise Pascal, CLERMONT FERRAND, FRANCE ; (4) Université de Bourgogne, DIJON, FRANCE

The relative efficiency of erosion beneath cold glacier, beneath temperate glacier, and on ice-free mountain slopes is one of the key parameter in the development of relief during glacial periods. Detrital geochronology methods have been applied to the sub-glacial streams of the north face of the Mont Blanc massif in order to estimate the efficiency of erosional processes. The lithology of this area is composed of a ~303 Ma old granite intruded within older polymetamorphics. In this study, we use macroscopic criteria (on ~10 000 clasts) and U-Pb dating of zircon (of ~500 grains) to determine the provenance of the sediment transported by the glacier and by the sub-glacial streams. The lithology of sediment collected above or below the glacier is compared with the distribution of bedrock sources. The analysis of this distribution takes into account glacier characteristics (areas above or below the ELA, beneath temperate or cold ice), its surface flow lines and the extent of the watershed of the three sub-glacial outlets, located at altitudes of 2300 m, 1760 m and 1450 m, respectively.

A comparison between the proportion of granite and polymetamorphics in these samples indicates that: 1) glacial transport does not mix the clasts derived from sub-glacial erosion with the clasts derived from supra-glacial deposition, except in the lower tongue where supra-glacial streams and moulins move the supra-glacial load to the base of the glacier; 2) the glacial erosion rate beneath the tongue is smaller than the erosion rate of adjacent non-glaciated areas; 3) glacial erosion beneath cold ice is at least sixteen times less efficient than erosion beneath temperate ice. Our results indicate that the low rates of subglacial erosion on the north face of the Mont Blanc massif means that the glaciers are protecting Europe's summit from erosion. A long-term implication would be a growing of the maximum altitude of the Alps.

****

Determination of La Bana Lake (NW Iberian Peninsula) Origin using clast macro-fabric analysis

SANTOS-GONZALEZ J., REDONDO-VEGA J.M., GONZÁLEZ-GUTIÉRREZ R.B., GOMEZ-VILLAR A.
UNIVERSITY OF LEON, LEÓN, SPAIN

La Baña Lake is located in the northwestern Iberian Peninsula, SW of León province. The lake and its surroundings were declared Natural Monument in 1992 and were included in Castilla y León Natural Protected Areas Network due to its natural interest and glacial geomorphology landforms. Since then, and because the clear glacial features in the valley, a glacial origin was accepted for both, the lake and the small pond located a bit further north.

However, the field study and the analysis of the deposit's structure and morphology which dams the lake and the pool undoubtedly show a postglacial origin, probably within paraglacial dynamics, from a great rockslide of the substrate slates. In order to characterize and demonstrate its postglacial origin, we carried out six fabrics (25 clasts each) in different areas of the deposit that dammed the lake. In addition, the same analysis was carried out for other deposits, one of them on a scree slope and, the other one located in the bottom valley downstream of the lake (interpreted as till due to its characteristics).

The comparative analysis of all data shows clear differences between the three deposits concerning their composition, lithological diversity, matrix, and the A-axes inclination and direction. Furthermore, this analysis demonstrates that the lake was dammed by a great accumulation of materials from a rockslide developed in the side of the glacial valley, not by a glacial moraine as previously researches indicated.

Till fabric and grain size analysis of glacial sequences in a complex paleoglacial system, the case study of the upper sil valley, cantabrian moutains, NW Spain

SANTOS-GONZALEZ J.(1), SANTOS J.(2), REDONDO-VEGA J.M.(1), GONZÁLEZ-GUTIÉRREZ R.B.(1), GÓMEZ-VILLAR A.(1)
(1) UNIVERSITY OF LEON, LEÓN, SPAIN ; (2) UNIVERSITY OF COIMBRA, COIMBRA, PORTUGAL

During the Last Glacial Maximum**(**LGM**)** a complex glacial system developed in the Upper Sil basin of NW Spain. An extensive area with twelve main transection glaciers generated an ice tongue, which received fourteen other valley glaciers with lengths between 3 and 20 kilometers long. In summary, the glacial ice extent in the basin was approximately 450 km^2, the largest in the Iberian Peninsula outside the Pyrenees. Close to Páramo del Sil four main glaciers, Sil (46 km), Valseco (19 km), Salentinos (14 km) and Valdeprado (11 km) merged in an area with low relief and generated several ice-dammed lakes in small lateral valleys.

Scarce glacial landforms are present today due to a weak lithology (slates, sandstones and quartzites) and rapid postglacial erosion, but many glacial deposits are still preserved mainly on flat surfaces at relatively low altitudes (750-900 m). Stratigraphic sequences with till, glacio-lacustrine and fluvio-glacial deposits are visible in some exposures up to 20 meters tall, indicating a progressive glacier front recession.

Till fabric and grain size analysis of diamictons from eight exposures allowed the reconstruction of the palaeo**-**glacier dynamicsof the Sil glacial system. A-axis fabrics of 100 clasts in each deposit and grain size analysis (four samples per deposit) were conducted in order to infer glacial dynamics. Subglacial tills display a moderate to strong clastfabric (S_1 eigenvalues of > 0,70) and a fine-grained matrixwhen compared with supraglacial melt-out tills.

In conclusion, the results confirm the magnitude of the Upper Sil Valley glaciation and explain glacial dynamics in a very complex area. Fabric analysis combined with grain size analysis are relevant not only to discriminate supraglacial and subglacial tills, but also to reconstruct paleo-glacial dynamics in an area where glacial landforms aren't preserved due to a weak lithology and rapid postglacial erosion.

****

Reconstruction of Late Holocene fluctuations of La Mare Glacier (Eastern Italian Alps): a combined approach

CARTURAN L.(1), BARONI C.(2), CARTON A.(3), CAZORZI F.(4), DALLA FONTANA G.(1), DELPERO C.(3), SALVATORE M.C.(2), SEPPI R.(5), ZANONER T.(3)
(1) Department of Land, Environment, Agriculture and Forestry - University of Padova, LEGNARO, PADOVA, ITALY ; (2) Department of Earth Sciences - University of Pisa, PISA, ITALY ; (3) Department of Geosciences - University of Padova, PADOVA, ITALY ; (4) Department of Agriculture and Environmental Sciences - University of Udine, UDINE, ITALY ; (5) Department of Earth and Environmental Sciences - University of Pavia, PAVIA, ITALY

High-resolution glacier length curves provide valuable insights on glacier fluctuations as response of past climate. Since the end of the XIX and the beginning of the XX century, the Italian Glaciological Committee (CGI) coordinates the systematic monitoring of frontal variations of the Italian glaciers, which however can locally display interruptions or inhomogeneities, supplying anyway one of the longest series of observations of frontal variations in the world.

Here we present a combined approach, which uses different sources of data and modern technologies of terrain analysis, for reconstructing the Late Holocene fluctuations of La Mare Glacier, a 4 km^2 wide valley glacier located in the Ortles-Cevedale massif (Eastern European Alps). This glacier built one of the most impressive and well-studied Holocene morainic complex of the Italian Alps, and displayed significant fluctuations during the 19^{th} and 20^{th} Centuries, experiencing a frontal withdrawn of about 2.4 km since the maximum Holocene position reached during the Little Ice Age.

Frontal variations occurred before the direct monitoring were reconstructed by detailed geomorphologic surveys of the proglacial area, integrated with high-resolution Digital Elevation Models analyses. The chronologic constrain of moraines was assessed by the reconstruction of soils chronosequence on different moraine ridges, comparing historical documents (e.g. maps, paintings, photographs), by lichenometry, radiocarbon dates and surface exposure dating of glacial deposits and relict landforms. The retreat curve deriving from systematic field observations was checked with multitemporal photographs and maps, which enabled the identification of landmarks used by the observers and the reconstruction of fluctuations in periods lacking measurements.

The largest Italian valley glacier with little ice during the Sub-Boreal: evidences from a buried log in the Forni Glacier forefield

LEONELLI G., BOLLATI I., DIOLAIUTI G., MERLINI A., TROMBINO L., SMIRAGLIA C., ZERBONI A., PELFINI M.
Università di Milano, MILANO, ITALY

The assessment of past climate variability is a crucial issue in palaeoclimatic studies for the understanding of the ongoing global warming compared to past natural conditions. Precise information on past climate conditions can be derived from geomorphologic features as well as from several natural proxies that can be found in glacial and temperature-limited environments, both at high altitudes and latitudes. The combination of morphological interpretation of glacier deposits, radiocarbon dating, dendrochronological techniques and sedimentological analyses has allowed to reconstruct Holocene fluctuations of the Forni Glacier. Based on the retrieval of a buried subfossil log found along the right side of the Forni valley and an integrated multidisciplinar approach, we could develop new hypotheses about the position of the Forni Glacier tongue. The anatomical analysis revealed that the retrieved log belongs to a specimen of *Pinus cembra*, the most widespread species in the Forni Valley and the dendrochronological analyses revealed that the minimum age of the tree was 273 years. The radiocarbon dating gave as result 3920±25 yr BP, i.e. 4426-4256 cal. yr BP. Since about 50 yr around the pith were not measured because of bad wood conditions, the oldest tree ring in the log can be dated at 4526-4356 cal. yr BP. Grain size analyses substantiate the presence of two distinct pedostratigraphic units. At present the area where the trunk was found is colonized only by very young trees, especially of *Picea abies*, suggesting a higher tree line and a different widespread of tree species in the proglacial area.

Field data are evidence of warmer temperature conditions in the analysed time period thus suggesting an upper glacier terminus position respect to the present one (at c. 2600 m asl) and also the possibility that in the sub Boreal the largest Italian valley glacier could be fragmented into three smaller ice bodies (which are presently the three glacier accumulation basins).

****

The spatial distribution of cirques during Quaternary glaciations in Greece

BATHRELLOS G., SKILODIMOU H., MAROUKIAN H.
National & Kapodistrian University of Athens, Faculty of Geology & Geoenvironment, Department of Geography & Climatology, ZOGRAFOS, ATHENS, GREECE

Large parts of northern Europe and North America were covered by ice sheets during the Quaternary glacial periods. There were, however, numerous locations outside these areas which were affected by mountain glaciations. Naturally, as one moves towards the Equator these become more localized and occur at higher altitudes.

In Greece, mountain glaciations appear to have been quite extensive, along the mountain range of Pindus, on Mt. Olympos and in the highlands of Peloponnese, during the Last Glacial Maximum (LGM).

This study focuses on the extent of the Quaternary glaciations in Greece based on the examination of cirque formations. An initial spatial database of these glacial forms was created for the first time in Greek Territory. Some of the glaciated sites have been taken from previous literature, but most of them were recorded from topographic maps (scale 1:50,000) and air photos. ArcGIS 10 software was used to process the glaciated sites. A map depicting the glaciated areas of Greece was compiled with about 140 cirques. Detailed geomorphological maps of each location and morphometric analysis of the glacial and glaciated features were performed. The stages in dissection and lithological conditions of each cirque were examined.

The vast majority of cirques occur at altitudes varying from 2,700 to 1,500 m.a.s.l. The preservation of ice for longer periods of time is more likely at altitudes higher than 1,500 m.a.s.l. The few cirques observed at altitudes lower than 1,500 m.a.s.l., may be due to karstification.

Cirques have developed on north, northwest and northeast facing slopes. During the last glacial period, a high barometric system over central Europe carried cold air masses to the south resulting in increased snowfall on the northern slopes of Pindus range and the other mountains of Greece. As a result, most cirques in Greece are open towards the northern quadrant.

The Greenland Ice Sheet erodes its bed some places but not in others

BIERMAN P.(1), CORBETT L.(2), GRALY J.(3), NEUMANN T.(4), ROOD D.(5), SHAKUN J.(6), NELSON A.(1)
(1) University of Vermont, BURLINGTON, UNITED STATES ; (2) Dartmouth College, HANOVER, UNITED STATES ; (3) University of Wyoming, LARAMIE, UNITED STATES ; (4) NASA Goddard Space Flight Center, GREENBELT, UNITED STATES ; (5) Scottish Universities Environmental Research Centre, EAST KILBRIDE, UNITED KINGDOM ; (6) Harvard University, CAMBRIDGE, UNITED STATES

The rate and spatial distribution of erosion done by ice sheets is poorly known. We are using the cosmogenic isotope ^{10}Be as a proxy to understand where and how much the Greenland Ice Sheet (GIS) erodes its bed through isotopic analysis of exposed boulder and bedrock surfaces and sediment transported by the ice sheet. To study subglacial erosion, we measured meteoric ^{10}Be in samples from the basal, dirty-ice zone of the GISP2 ice core and both in situ and meteoric ^{10}Be in >200 samples collected from the ice sheet margin.
Silt in 17 samples from the basal 6.5 meters of the GISP2 ice core (summit of GIS) has high concentrations (0.6 to 3.8 x 10^8 atoms g^{-1}) of meteoric ^{10}Be, far more ^{10}Be than could be accounted for by short, interglacial exposures. The silt contains 0.3 to 1.7% organic carbon and has an average C/N ratio of ~10, consistent with incorporation of a long-lived, cold-region soil. The existence of this ancient soil for several million years after formation of the GIS indicates extremely low rates of subglacial erosion at Summit, Greenland, consistent with the ice being frozen to the bed for most, if not all, of the Quaternary.
Analysis of in situ cosmogenic ^{10}Be in boulders and bedrock around the margin of the GIS indicates that areas near outlet glaciers, where ice is warm-based, are effectively eroded whereas other areas, especially highlands, retain evidence for multiple periods of exposure and burial, indicating that there ice was cold-based and did not erode its bed. Sediment in and leaving the ice today tells a similar story. 86 clasts, collected directly from the ice margin, have measurable but very low levels of *in situ* ^{10}Be indicating they were sourced from areas where both preglacial regolith and rock exposed during interglacial times were effectively eroded by ice. Sand-sized sediment collected from outwash streams exiting the ice margin has more ^{10}Be, suggesting that different grain sizes are sourced from different subglacial locations.

****

Early Warning of Glacial Lake Outburst Floods and Climate Change Monitoring in the Karakoram Mountains, P.R. China

HAEMMIG C.(1), KEUSEN H.(1), HESS J.(2), TOBLER D.(1)
(1) GEOTEST SA, BERNE, SWITZERLAND ; (2) Federal Office for Environment, LAINAT, BERNE, SWITZERLAND

Yarkant River is located in the southwest of Xinjiang Uygur Autonomous Region, at the western margin of the Tarim Basin. In the last decade, 5 glacial lake outburst floods (GLOF) damaged infrastructure and claimed human lives along Yarkant River. The spontaneous floods are a threat for over 1 Mio inhabitants in the floodplains and are causing an annual monetary loss of 10 Mio €. There are 33 recorded flood disasters during the last 50 years. The floods are provoked by melt-water, rainstorms and glacial lake outbursts (peak discharges > 6'000 m^3/s). The largest and most frequent GLOF occur in the area of Keleqin River. Keleqin is one of several tributaries of Yarkant River.
In 2011 a project was launched with the goal to implement an early warning system, allowing authorities and population to take the necessary measures in order to avoid victims, to raise the safety of settlements and livestock and to minimize damages to infrastructure and agricultural land. A further goal is to assess the long-term development of the flood hazard situation in the catchment area of Yarkant River by analyzing past and real-time information on the glacier lake situation. In addition, scenario based forecasts of the future glacial lake developments are elaborated, considering Climate Change.
As a first step, a GLOF early warning system (EWS) was implemented combining satellite remote sensing, an automatic terrestrial observation and warning station. Two automatic gauge and warning stations are operational since autumn 2012. Both water level fluctuations and EWS functionality are continuously monitored. Because the volume of Kyagar Glacier Lake is directly linked to its blocking ice-dam, mass-balance calculations are crucial. Such calculations and climate change monitoring are needed to define future hazard scenarios and to plan protection measures. Flood modelling, the elaboration of a hazard index map and an emergency risk management plan are other key issues of the project.

The Glaciation of southwest England

HARRISON S.
Exeter University, PENRYN, UNITED KINGDOM

Until recently, the geological consensus was that southwest England escaped glaciation during the Quaternary. However, the recent evidence for the widespread glaciation of Dartmoor and valley glaciation on Exmoor has demonstrated that the moors of southwest England were capable of developing glacial ice at relatively low altitudes. Missing from this debate has been any discussion of the development of small glacionival features in the southwest landscape. Here we assess the evidence for widespread glaciation of the region's uplands and also show the evidence for smaller glacionival landscapes with reference to nivation hollows from Exmoor and extreme west Cornwall. We argue that these features were likely more numerous during the LGM than previously thought, and this has implications for reconstruction of LGM ice extent and climate in areas previously considered to be extra-glacial.

****

Glacial erosion in northern Ostrobothnia, Finlan

ESKOLA T., PEURANIEMI V.
University of Oulu, Department of Geosciences, OULU, FINLAND

The study area in northern Ostrobothnia, Finland, is located in the central part of the Pleistocene Fennoscandian ice sheet. Inferences of glacial erosion is based on observations of striae, glacial grooves, crescentic gouges, crescentic fractures and lunate fractures on roche moutonnèes and whaleback forms of bedrock outcrops. Erosional forms were studied in 44 different sites and approximately 500 measurements were registered. The length, breadth and depth of erosional forms were measured and the rock type of every observation site was registered. Multiple striae orientations were discovered with the evidences of cross-cutting striae. Prevailing and dominant orientation is from WNW. Orientations from NW were commonly registered on the lee sides of roche moutonnèes. Some faint but clear striae from WSW and from NNW were also observed. Some of these erosional forms probably date back to the pre-ice lobe phase of the Weichselian glaciations whereas some might be related to the late Weichselian Oulu ice lobe phase.

****

Glaciomorphic depositional formations in northern Ostrobothnia, Finland

ESKOLA T., PEURANIEMI V.
University of Oulu, Department of Geosciences, OULU, FINLAND

The morphology and inner structure of different glaciogene moraine formations and glaciofluvial formations were studied in northern Ostrobothnia, Finland, by using aerial photographs, field observations and LiDAR (light detection and ranging) data. The study area is situated in the central part of the former Fennoscandian ice sheet. The Quaternary sediments consist of different glacial and glaciofluvial deposits. Typical moraine formations in the area are cover moraine, drumlins and hummocky moraines. The formations are composed of different depositional facies as lodgement, melt-out, flow and deformation tills and sorted material such as sand and gravel lenses and beds occur in places. Drumlin swarms occur on higher ground and hummocky moraine trains on lower ground. Some cross-cutting drumlin ridges have been observed in one specific part of the study area. These drumlins represent older and younger ice flow directions and can be termed as palimpsest glacial landforms. Glaciofluvial formations are composed of esker chains where both deltaic parts and ridges occur in the esker chains. Some observations have been made on till covered eskers.

From minor to major: understanding the LGM Adige-Brenta-Astico glacial system in the eastern Southern Alps through the analysis of transfluence tongues

ROSSATO S.(1), MOZZI P.(1), MONEGATO G.(2)
(1) University of Padova - Department of Geosciences, PADOVA, ITALY ; (2) National Research Council, Institute for Geoscience and Earth Resources, TORINO, ITALY

The Adige River valley is one of the major Alpine valleys. It is located in the eastern Southern Alps, North of the Garda Lake. The Brenta Valley is located few km eastwards of the Adige Valley, to which it is connected via some saddles and narrow gorges (average altitude: 500 m a.s.l.). The Astico valley is located South of the Brenta Valley; the connection between the two valleys is provided by the Carbonare saddle (1075 m a.s.l.). During the LGM these valleys hosted an interconnected glacial system.

According to the reconstructed glacial mass and the sand petrography of glaciofluvial deposits, the Astico glacier during major Alpine glaciations was fed by glacial transfluences from the Adige and Brenta valleys, and could not be sustained only by local ice accumulation. Hence, the glacial collapse derives from the ceasing of the transfluence and provides an accurate estimation of the onset of glacial downwaste in the whole system. Such event is well recorded in the minor Prealpine Astico Valley, whilst it is more difficult to be detected in the main Adige and Brenta valleys.

Three distinct glacial pulses are well recorded in the Astico Valley, in good agreement with other nearby Alpine glaciers (i.e., Piave and Tagliamento glaciers) which show several oscillations during LGM after 27.5 cal ka BP. Radiocarbon datings of glaciofluvial deposits indicate that the collapse of the Astico glacier may have occurred between 20.5 and 16.5 cal ka, while the withdrawal of the Brenta glacier started at around 17.5 cal ka. The last glacial pulse in the Adige glacier took place after 25.0 – 20.0 cal ka, while the onset of deglaciation is not well constrained by radiometric dating.

****

Thickness constraints of the Patagonian Ice Sheet over the last glacial cycle using surface exposure dating

GEIGER A.(1), FABEL D.(1), GLASSER N.(2)
(1) University of Glasgow, GLASGOW, UNITED KINGDOM ; (2) Aberystwyth University, ABERYSTWYTH, UNITED KINGDOM

The Patagonian Ice Sheet (PIS) was the largest ice body in the southern hemisphere outwith Antarctica stretching a unique span of latitudes (36-54° S). Over the past ten years glaciological and glacial geomorphological investigations have provided some insights into the paleo-glaciology of Patagonia and its function within the climate system. For example, numerical modeling experiments have been used to estimate ice thickness, the timing of glacier disintegration, volumetric configurations and consequent sea level contibutions since the global last glacial maximum. However critical empirical field based constraints on vertical ice extent are lacking. In-situ produced cosmogenic ^{10}Be and ^{26}Al in quartz are utilized to date the surface exposure of erratic boulders and/or bedrock of present-day and palaeo-Nunataks which are used as dipsticks recording vertical ice downwaisting. The surface exposure ages presented here are the first to constrain ice thickness and rates of ice surface lowering at the former centre of the PIS (49°S, 72°W) over the last glacial cycle up to the mid-holocene.Based on the geomorphology and the exposure ages discussion of the complex climate interactions within Patagonia, southern South America, will be provided.

Modelling depth of river incision caused by meltwater discharge from the retreating Cordilleran Ice Sheet, Alberta, Canada

MALOWANY K., OSBORN G., MARTIN Y., MARSHALL S.
University of Calgary, CALGARY, CANADA

Rivers flowing eastward from the Canadian Rockies across the Alberta plains are situated in narrow, flat-bottomed valleys located 15 to 120 m below the plains surface. It is assumed that rivers were established in their present courses following deglaciation because valleys cut local till-bedrock contacts. We hypothesize that large amounts of meltwater from the Cordilleran Ice Sheet caused rivers to incise rapidly for a period of about 2 000 years following the retreat of the ice sheets (14-12ka.) In this study, a combined ice sheet-climate model is used to estimate the amount of water derived from the melting Cordilleran Ice Sheet between 14 and 12ka. Resulting annual discharges allocated to each basin indicate that major rivers were approximately 3 times greater in discharge than their modern counterparts. Two approaches are taken to estimate the ability of these discharges to cause incision through till and local bedrock. First, a bedrock-incision equation is applied to a situation of very erodible material to estimate incision through shale and weak sandstone. This approach yields incision rates greater than those observed for these rivers. Second, the Bagnold sediment transport equation is used to estimate the amount of soft material removed from the system during periods of high discharge. Together these two approaches provide estimates of incision depths that could result due to increased discharge from meltwaters of the Cordilleran Ice Sheet. Uncertainty concerning the duration and magnitude of large floods operating during deglaciation creates large variations in results; however, even the most conservatively estimated discharges are shown to be capable of causing incision of rivers to depths greater than indicated by field observations.

****

Cosmogenic nuclide constraints on Late Quaternary glacial chronology on the Dalijia Shan, northeastern Tibetan Plateau

WANG J.(1), KASSAB C.(2), HARBOR J.M.(2), CAFFEE M.W.(3), CUI H.(1), ZHANG G.(1)
(1) Key Laboratory of Western China's Environmental Systems (Ministry of Education), Lanzhou University, LANZHOU, CHINA ; (2) Department of Earth, Atmospheric, and Planetary Sciences, Purdue University, WEST LAFAYETTE, UNITED STATES ; (3) Department of Physics, Purdue Rare Isotope Measurement Laboratory, Purdue University, WEST LAFAYETTE, UNITED STATES

Cosmogenic nuclide apparent exposure dating has become a widely used method for determining the age of glacial landforms on the Tibetan Plateau with >1200 published ages. We present the first Be-10 exposure ages from the Dalijia Shan (4636 m a.s.l), the most northeastern formerly-glaciated mountain range on the Tibetan Plateau. The moraine groups identified from field and remote sensing imagery mapping record four glacial events at 37.07±3.70–52.96±4.70 ka (MIS3), 20.17±1.79–26.99±2.47 ka (MIS2), 16.92±1.49–18.76±1.88ka (MIS2), and 11.56±1.03–11.89±1.06ka (Younger Dryas). These ages indicate that glaciation in the northeastern Tibetan Plateau is much younger than previously thought.

Ice completely filled the valley at ~39 ka and probably spilled into the neighboring valley to the east. As the glacier retreated, boulders were deposited in Dalijia Pass (~23.5 ka) that is equivalent to the age of the next youngest lateral moraine (~21.8 ka). A terminal moraine from this older glaciation is not preserved. We assume it reached far down valley and has since been destroyed or covered by fluvial processes. A ~17.3 ka terminal moraine is preserved just below the junction of the Deheisui Valley and Qitai Valley, recording the limited extent (<10 km) of the MIS2 advance. The youngest event, ~11.7 ka, records either a small advance or a period of time when the glacier reached a stillstand during retreat, possibly recording a Younger Dryas event. Even though we are confident that only two boulders provide reliable estimates of depositional age due to their close agreement, future work should include increasing the sampling size to better determine if this moraine is truly a Younger Dryas event, which has not been noted in many parts of the Tibetan Plateau.

In addition, this record is consistent with many other regions on the Tibetan Plateau, with a local last glacial maximum during MIS3 asynchronous with Northern Hemisphere last glacial maximum during MIS2.

Glacier recession from 1955 to 2007 on Sat (Ikiyaka) Mountains, Southestern Anatolia, Turkey

YESILYURT S.(1), DOGAN U.(2), SENKUL C.(3)
(1) Cankiri Karatekin University, CANKIRI, TURKEY ; (2) Ankara University, ANKARA, TURKEY ; (3) Afyon Kocatepe University, AFYON, TURKEY

In the present study, present glaciers of Sat (İkiyaka) Mountains (3794m) located in Southeast Anatolia, one of the most important recent glacier areas of Turkey, is dealt with within the context of the impacts of climatic changes on glaciers. Alpine type present glaciers of these mountains, which quickly respond to climate changes, provide significant data for Turkey and Middle East that limited number of study is available. In this study, based on aerial photographs taken in 1955, 1968 and 1988 together with Quickbird satellite images taken in 2007, four main stages were examined using remote sensing and GIS technologies. The results of *performed analysis demonstrate that* the paleo-glacier cover of the Last Glacial Age (most likely the Last Glacial Maximum) on the Sat Range was about 80 km² in area as compared to the actual glaciers found an area of only 1.5 km². 730 meter recession has been detected in glaciers located around the Satsivrisi peak for the 52 years period from 1955 to 2007. These glaciers have retreated between 2 and 14 meter per year depends on their thickness-mass characteristics and the geomorphologic characteristics of the cirques that they located in. Some of the glaciers have significantly lost their mass in 52 years (for example, Geverok glacier has lost 47% of its mass) due to this retreat rate. According to the temperature records of meteorological stations located near environment of the mountainous area, both long-term average (1961-2003) summer and annual temperatures indicates a warming trend. Also, new moraines around the glaciers clearly show the area that glaciers covered during the last progression phase. According to the retreat speed of these glaciers which created the moraines for the last half century, it is understood that they have been rapidly retreating since the end of the Little Ice Age to the present. Therefore, new moraines are evidences of Little Ice Age glaciation.

****

The Quaternary glacial maximum in the center of the Cantabrian Mountains (northern Iberian Peninsula): Aller-Nalón-Porma catchments

RODRIGUEZ RODRIGUEZ L., JIMÉNEZ-SÁNCHEZ M., DOMÍNGUEZ-CUESTA M.J.
Departamento de Geologia, Universidad de Oviedo, OVIEDO, SPAIN

The Cantabrian Mountains is a coastal range up to 2648 m altitude that is considered the westward projection of the Pyrenees in north Iberia (~43^{o}N 5^{o}W). Like in Pyrenees, the occurrence of well-preserved glacial landforms and deposits in this mountain range has proved the occurrence of former glaciers during the Quaternary. Previous research here supports a regional glacial maximum prior to ca 38 cal ka BP and an advanced state of deglaciation by the time of the global Last Glacial Maximum (Jiménez-Sánchez et al., in press).

A geomorphologic database has been produced in ArcGIS at 1:25,000 scale details for an area about 220 km^2 that partially covers the Redes Natural Reservation and Picos de Europa Regional Park. A reconstruction of the ice extent and flow pattern of the former glaciers is presented for this area as a previous step to plan further chronological studies. Our reconstruction shows that an icefield covered ca 156 km^2 of the study area (72.3 %) during the maximum extent. The altitude difference between the glacier fronts of both mountain slopes was ca 100 m. The ice tongues that drained the icefield also showed a remarkably asymmetric length between both slopes, being 1 to 6 km-long and up to 19 km-long in the north and south faces respectively. This asymmetric character of the ice tongues can be related to geologic and topo-climatic factors.

Jiménez-Sánchez, M., Rodríguez-Rodríguez, L., García-Ruiz, J.M., Domínguez-Cuesta, M.J., Farias, P., Valero-Garcés, B., Moreno, A., Rico, M., Valcárcel, M., in press. A review of glacial geomorphology and chronology in northern Spain: timing and regional variability during the last glacial cycle. Geomorphology, doi: 10.1016/j.geomorph.2012.06.009.

Research funded by the project CANDELA (CGL2012-31938) of the Spanish national research program in Earth Sciences and Hydric Resources (MINECO). L. Rodríguez-Rodríguez has developed her research under a grant of the Severo Ochoa Programme (FICYT- Asturias).

The Norwegian strandflat - glacial or periglacial erosion?

BERTHLING I.(1), LANDSNES E.(2), FREDIN O.(3)
(1) Norwegian University of Science and Technology, Department of Geography, TRONDHEIM, NORWAY ; (2) Norconsult AS, SANDVIKA, NORWAY ; (3) Geological Survey of Norway, TRONDHEIM, NORWAY

The strandflat is a prominent feature along many coasts that experienced Quaternary glaciations. The strandflat is developed along a major part of the Norwegian coastline, including Svalbard. In some areas it is several tens of kilometers wide from the outermost islands to its typical abrupt termination in steep cliffs towards backing mountains. Periglacial weathering and sea ice action has been regarded the main processes responsible for its development. The main object of this study was to test this hypothesis by calculating denudation rates based on volumetric estimates of Quaternary strandflat erosion in some test areas. An automatic classification of the Norwegian strandflat between Karmøy and Trondheimsfjorden based on topographic parameters was performed. The classification was based on primary topographic parameters, generated from a 100 meter digital elevation model. Secondly the preglacial paleic landscape was reconstructed at two locations (Bømlo and Smøla). At both locations a minimum and maximum preglacial surface was created. The present topography (at Smøla also bathymetry) was subtracted from the preglacial landscape envelopes. Based on a maximum age of 2.8 Myears, denudation rates ranged from 0.15 – 0.27 mm/year, while average Quaternary glacial conditions (600 Kyears) yielded rates between 0.7 and 1.25 mm/year. The obtained denudation rates seem more consistent with glacial processes than periglacial weathering. This does, however, not preclude repeated reworking of the strandflat by subaerial processes in periods without large ice sheets. We conclude that glacial processes are the main agent behind strandflat erosion, but that the characteristic features of the strandflat may have been shaped by a combination of weathering and mass wasting in a periglacial environment.

****

Ice shelf structural and (geo-)statistical mapping: a case study using satellite imagery

SAMYN D.(1), GLASSER N.(2)
(1) Nagaoka University of Technology, NAGAOKA, JAPAN ; (2) University of Aberystwyth, ABERYSTWYTH, UNITED KINGDOM

Antarctic ice shelves have attracted much scientific and media attention recently. Knowledge on their dynamics and stability has become of primary importance for predicting Antarctica future behaviour, as it contributes to a better understanding of the physical mechanisms behind ice shelf collapsing and coastal glacier shrinking in Polar Regions. We present herein an application of new mapping methods using GIS tools to reconstruct the formation history of glaciological and marine ice features in ice shelves and to determine their influence on ice shelf dynamics and stability. The method was applied to Nansen Ice Shelf, a small ice shelf in Terra Nova Bay, Antarctica, of which three ASTER images (Jan. 2001, Oct. 2001 and Dec. 2004) were extensively analysed and compared. A total of more than 7,250 recognizable points were surveyed across the ice shelf to produce velocity fields, and more than 20,000 features (including longitudinal flow structures, crevasses, rifts, ice blocks and debris lineations) were mapped to define local zones of specific flow. Combined with (geo-)statistical analysis, we used this information to localize the grounding line, often considered as the best indicator for ice shelf activity, and followed its behaviour through the studied period. It is suggested that topographical confinement might play an as important role as grounding line activity on the ice shelf dynamics. The degrees of anisotropy of velocity fields and of other characteristics of mapped features were also obtained by autocorrelation analysis. Finally, probability distributions of mapped features were intercompared to determine the degree of filiation between these features.

****

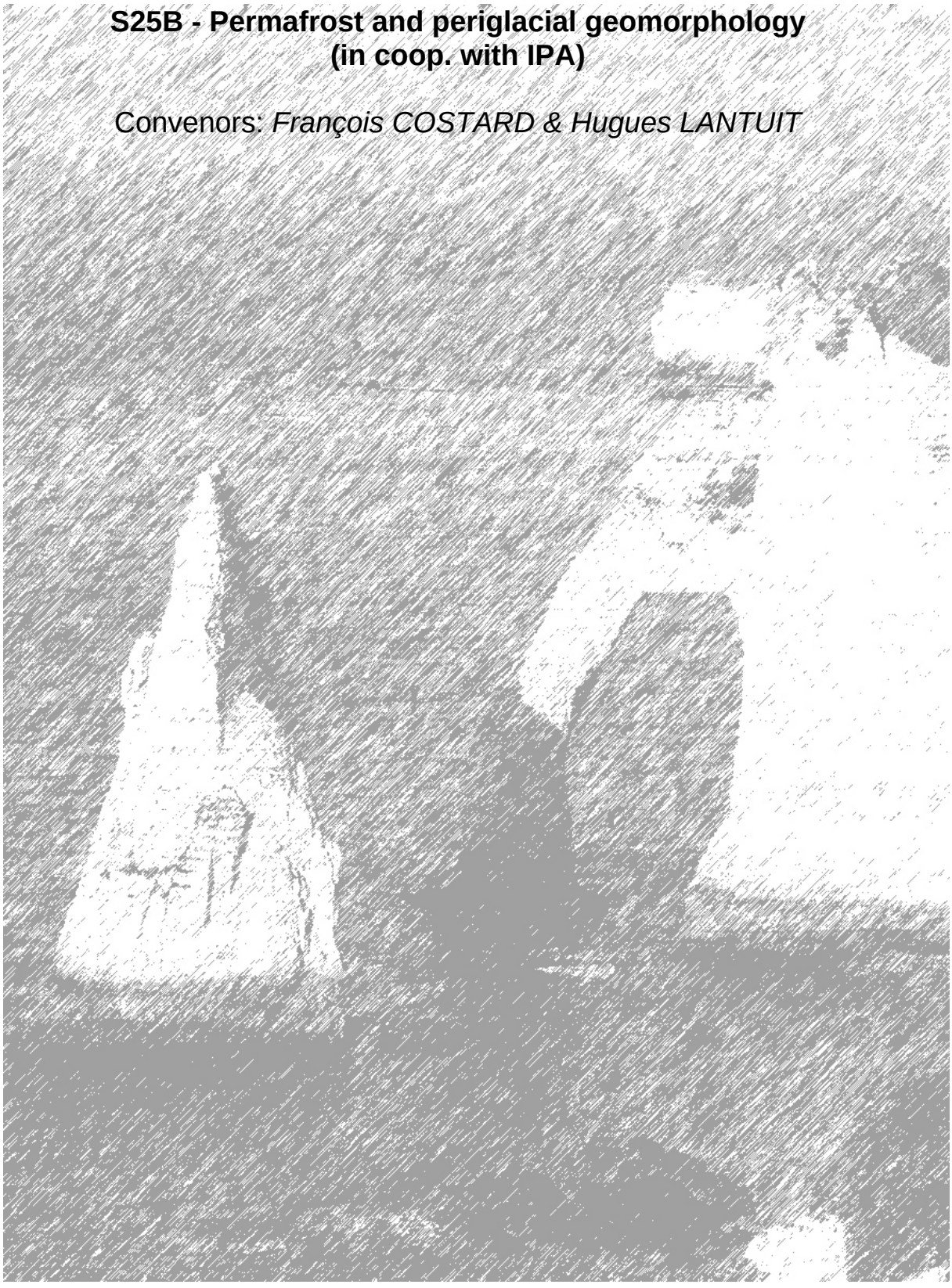
Surface exposure dating of rock slope failures in Northern Romania

GHEORGHIU D.M.
SUERC, University of Glasgow, GLASGOW, UNITED KINGDOM

The Romanian Carpathians are prone to rock slope failures (RSFs). Several RSFs have been investigated in the northern part of the country, especially in the Maramureş and the Rodna Mountains, where the RSFs are up to 1.6 km2. These failures reflect the combination of high relief, lithological and structural controls. As the temporal pattern of paraglacial adjustments is unknown in these areas, the surface exposure dating method was employed in 3 locations. Preliminary data suggest that the RSFs are associated with areas subject to the over-steepening by glacial erosion during the Last Glacial Maximum (LGM) and the subsequent loss of support after deglaciation.

S25B - Permafrost and periglacial geomorphology (in coop. with IPA)

Convenors: *François COSTARD & Hugues LANTUIT*



Oral presentations:

Assessing the factors that affect growth and propagation of 'mega-slumps' in Canada's Northwest Territories

KOKELJ S.(1), TUNNICLIFFE J.(2), LACELLE D.(3), LANTZ T.(4)
(1) Northwest Territories Geoscience Office, YELLOWKNIFE, CANADA ; (2) School of Environment, University of Auckland, AUCKLAND, NEW ZEALAND ; (3) Department of Geography, University of Ottawa, OTTAWA, CANADA ; (4) School of Environmental Studies, University of Victoria, VICTORIA, CANADA

In this study, we examine processes associated with major retrogressive thaw slumps (>40 ha) that have developed in formerly glaciated foothills of the Richardson and Mackenzie Mountains (Peel Plateau) of NW Canada. The upslope growth potential and perpetuation of a thaw slump is related to the evacuation of materials from the scar zone. Analysis of climatic timeseries and timelapse photography show strong relationships amongst temperature, precipitation, net radiation and resultant sediment flux from these mega-slumps. Warm, wet periods drive considerable slug flow from the scar zones: in one case, a slump has filled its master valley, forming a lake upstream. A single mega-slump may displace more than 10^{-6} m^3 of material, severely impacting downstream river and riparian ecosystems; the slumps may entirely reconfigure local slopes and channel networks in drainages of less than 1 km^2. Monitoring of suspended sediment clearly indicates impacts at a catchment scale of 1 000 km^2. The relatively high relief of the incised Peel Plateau provides sufficient transport gradient to evacuate slump detritus and thus propagate into much larger features, distinguishing these features from smaller slumps in low-relief terrain. There are notable feedbacks amongst sedimentary cover, vegetation and ice-melt; slump propagation may accelerate if ground ice is exposed, or be arrested when it is covered. Mega-slump features persist for decades, although the magnitude of such slumps, and number of such features found within the study area, is increasing. The intensification of thaw slump activity has been associated with climate warming, however, our data point suggest that warm and wet conditions are likely most conducive to the initiation and perpetuation of thaw slump activity.

****

Retrogressive thaw slumps: structure, evolution and relevance to carbon cycle of the Arctic Ocean

LANTUIT H.(1), FRITZ M.(1), KRAUTBLATTER M.(2), ANGELOPOULOS M.(3), POLLARD W.(4)
(1) Alfred Wegener Institute for Polar and Marine Research, POTSDAM, GERMANY ; (2) Technical University Munich, MUNICH, GERMANY ; (3) Golder Associates, MONTRÉAL, CANADA ; (4) McGill University, MONTRÉAL, CANADA

Retrogressive thaw slumps (RTS) are spectacular lateral thermokarst features occurring in ice-rich permafrost regions. They develop along streams or coastlines and expand inland to form landslide-like U-shaped scars exceeding a kilometer size in selected locations. These slumps are a major source of sediment, organic carbon and nutrients that have a large effect on the aquatic environment. The consequences of the occurrence of RTS, which have been shown to occur at increased frequencies in the Arctic are not well understood, mostly because they have only been studied over the past ten years. The impact of RTS sediment delivery on coastal ecosystems is even less known, even though RTS contribute quantities of sediment sometimes greater than coastal erosion itself.

In this study, we present the results of a systemic multidisciplinary study attempting to understand the structure, the evolution and the fate of RTS on Herschel Island, Yukon Territory, in the southern Canadian Beaufort Sea. Herschel Island for the exceptionally ice-rich nature of the permafrost and the occurrence of multiple RTS. We use information stemming from cryostratigraphic sampling in the ice headwall of the RTS, from cores collected above the headwall and in the slump floor, from sediment and water samples collected in the slump outflow, from timelapse photography, from outflow channel discharge measurements and from geophysics (mostly Direct Current and Capacitive Coupled Resistivity) to describe the structure of the slump. We emphasize the role of ground ice distribution, sea water vicinity and sensible and radiative heat input in dictating the pace at which slump initiate, stabilize and re-activate. We compare this information to past knowledge on slumps to emphasize the transient nature of slump occurrence in the arctic coastal zone and the existence of “pulses” of slump activity with potentially important impacts on the nearshore ecosystem.

Important melting of ice-wedges and formation of thermocirques on slopes of thermokarst lakes in Central Yakutia (Siberia)

SEJOURNE A.(1), FEDOROV A.(2), COSTARD F.(3), GARGANI J.(3), SKORVE J.(4)
(1) WROONA Group, Institute of Geological Sciences PAS, WROCLAW, POLAND ; (2) Permafrost Institute, Russian Academy of Sciences, YAKUTSK, RUSSIAN FEDERATION ; (3) Univ. Paris-Sud XI, CNRS, Laboratoire IDES, ORSAY, FRANCE ; (4) Norwegian Space Agency, OSLO, NORWAY

On Earth, permafrost containing a high ice volume (referred as ice-rich) are sensible to climate change and have been regionally degraded (thermokarst) during the early Holocene climatic optimum forming numerous thermokarst lakes in Central Yakutia (eastern Siberia). Nowadays, recent temperature increases in the Arctic and Subarctic have been significantly greater than global averages. The frequency and magnitude of terrain disturbances associated with thawing permafrost is increasing in these regions and is thought to intensify in the future. Therefore, understand how is the current development of thermokarst is a critical question.

Here, we describe the significant melting of ice-wedges on the hill-slopes of thermokarst lakes in Central Yakutia that leads to formation of amphitheatrical hollows of tens of meters. The evolution of thermocirques in Central Yakutia has been little studied and analyzing their formationcould help to understand the recent thermokarst in relation to climate change in Central Yakutia. We studied the thermocirques at two scales: (i) field surveys of different thermocirques to examine the processes and origin of melting of ice-wedges and; (ii) photo-interpretation of time series of satellite images to study the temporal evolution of thermocirques (KH-9 Hexagon images of 6-9 m/pixel and GeoEye images of 50 cm/pixel).

****

Thermo-erosional landforms in Siberian ice-rich permafrost

MORGENSTERN A.(1), GROSSE G.(2), ARCOS D.R.(1), GÜNTHER F.(1), OVERDUIN P.P.(1), SCHIRRMEISTER L.(1)
(1) Alfred Wegener Institute for Polar and Marine Research, POTSDAM, GERMANY ; (2) Geophysical Institute, University of Alaska Fairbanks, FAIRBANKS, UNITED STATES

Of major concern in periglacial research is the question of how arctic permafrost landscapes react to climate change. Warming and thawing of ice-rich permafrost may result in substantial hydrological, geomorphological, ecological, and biogeochemical feedbacks which may have local to global impacts. While numerous studies have investigated thermokarst as one main process of permafrost degradation, data is sparse on thermal erosion, another widespread process of permafrost degradation. Siberian coastal lowlands underlain by ice-rich permafrost often feature streams, valleys, and valley networks that have formed under the influence of thermal erosion, but systematic regional studies have been lacking. We present an inventory of streams and valleys in three ice-rich lowland areas adjacent to the Laptev Sea using GIS-based analysis of remote sensing data, elevation models, and field investigations. The calculated total stream length is 4,153 km in the Cape Mamontov Klyk area, 1,541 km in the Lena River Delta area, and 2,047 km in the Buor Khaya Peninsula area; valley densities are 1.8, 0.9, and 1.0 km/km², respectively. Strong variations in the morphology and spatial distribution of streams and valleys are observed and can be attributed to differences in the size and relief characteristics of the study areas as well as to their predominant cryolithological properties, which are also influenced by previous degradation of the study areas by thermokarst. Based on the results, the evolution of different valley types in continuous ice-rich permafrost landscapes is discussed. The current valley pattern is largely the result of the late Holocene evolution of the hydrological system that is strongly connected to the degradation of ice-rich permafrost by thermal erosion.

A reassessment of the erosional potential of fluvial thermal process during ice breakups of the Lena river (Siberia)

COSTARD F.(1), GAUTIER E.(2), FEDOROV A.(3), KONSTANTINOV P.(3), DUPEYRAT L.(1)
(1) UMR 8148 IDES, ORSAY CEDEX, FRANCE ; (2) UMR 8591, MEUDON, FRANCE ; (3) Permafrost Institut, YAKUTSK, RUSSIAN FEDERATION

We analyze the impact of the breakup on the erosional process on the head of several fluvial islands from one of the largest Arctic fluvial systems – the Lena River (Yakutia). The purpose of this work was to reevaluate the role of the thermal erosion during ice breakup of the Lena River. In 2008-2011, a 4-years observation program was initiated to quantify the relative influence of fluvial thermal erosion during the ice breakup of the Lena River. During the initial stage of the ice breakup, ice pushes into river banks and produces huge accumulations of sediment that protect the island head against the mechanical and thermal effects of the river flow. That initial stage is relatively short, and occurs within a few days period. In a second phase after the fluvial ice thawing, the island heads are ice-free. In the case of high water levels, the flood, in permanent contact with the frozen river bank, undergoes efficient thermal and mechanical erosion, sometime through the fall season during a secondary discharge peak. The careful analysis of the annual data shows a high variability of the erosion rate, mostly due to the variability of the duration and timing of the flood season.

****

Features of suffosional processes in permafrost (Central Yakutia, Russia)

GAGARIN L.
Melnikov Permafrost Institute, YAKUTSK, RUSSIAN FEDERATION

In Central Yakutia, suffosional processes are best developed on the Bestyakh terrace of the Lena River. The terrace is composed of fine- to medium-grained sands of Middle Pleistocene age varying in thickness from 5 to 80 m and underlain by Lower Jurassic sandstones and Middle Cambrian limestones. The development of suffosional processes is related to the site-specific permafrost and groundwater conditions. Permafrost is 200 m in thickness and its temperature is on average -0.2 to -0.5˚C, lowering to -2.5˚Cin the river and creek valleys. The frozen sediments contain open and closed taliks maintained by the thermal effects of solar heat, surface water and confined subpermafrost water, referred to in the Russian literature as radiation-thermal, hydrogenic and hydrogeogenic taliks. Recharge of aquifers occurs predominantly through the radiation-thermal and hydrogenic taliks, while the hydrogeogenic taliks provide a path for groundwater movement to discharge areas.

The complex permafrost structure and the specific hydrodynamic groundwater regime promote the development of suffosional processes in the groundwater discharge areas. Suffosional processes are defined here as mechanical erosion and removal of soil particles or lumps by groundwater flow. In permafrost areas, suffosion development has some specific features related to the heat exchange between water flow and permafrost; thus suffosional processes are closely related with thermal erosion. Under the combined action of these processes, cavities form in the Bestyakh terrace sands within the groundwater discharge areas. The cavities gradually grow in size, and their roofs eventually collapse to create sinkholes on the surface. Over time, the depressions can grow significantly, from initial 0.5 - 2 m in diameter and 0.5 -1 m in depth 30 m in plan and 15 m in depth. All suffosional depressions form along the groundwater flow line and string for 350 m or more. Gradually expanding, sinkholes may merge to form gullies.

Thermal and Moisture Regimes in the Active Layer of Western Dronning Maud Land, Antarctica

DWIGHT R.(1), SCOTT D.(1), MEIKLEJOHN I.(1), MATCHER G.(1), LEE J.(2)
(1) Rhodes University, GRAHAMSTOWN, SOUTH AFRICA ; (2) Stellenbosch University, STELLENBOSCH, SOUTH AFRICA

Ground temperatures have been measured in shallow boreholes in Western Dronning Maud Land for between four and six years, while soil moisture readings have been logged for three years. The active layer was found to vary in depth from less than ten centimetres in the interior (altitudes greater than 1 200masl) to over 20cm near the coast and at altitudes below 400masl. The mean annual ground temperature in the region ranges from -8.7°C at the coast to -17.9°C at over 1 200masl in the interior. Two distinctive thermal regimes were identified, namely longer-term (seasonal) and shorter-term (diurnal) frost cycles. The number of cycles across the 0°C isotherm was location dependant and ranged from just over 30 to nearly 70. However, at only one site was soil moisture detected and, therefore, in reality there were effectively only an average of 25 frost cycles per summer season. At this and other locations where moisture and fine substrates were present, diurnal frost activity has produced sorted patterned ground, while at locations where no effective frost cycles were identified, only thermal cracking was evident. This study represents exploratory research that is being used to understand landscape controls on the distribution and abundance of biota. In Antarctic ecosystems abiotic factors are thought to take primacy in determining patterns of biological distribution. It is argued that abiotic processes provide the habitat in which the biotic components of the environments survive. However, the precise form of the interactions between abiotic variables and community structure is poorly understood, much less how it will change in the future. Given the rapidly changing climates in the region, improving knowledge of what drives patterns of biodiversity at a local and regional scale is vital to assess consequences of environmental changes.

****

Cold region geomorphology and Permafrost Evolution in the North-Atlantic region

ETZELMULLER B., LILLEOREN K.S.
University of Oslo, OSLO, NORWAY

Since 2003 numerous shallow boreholes have been equipped to monitor ground temperatures in Norway, Svalbard and Iceland. The monitoring stations are setup to characterize the ground thermal regime in different periglacial landforms and environmental settings, and to validate spatially distributed, equilibrium and transient permafrost models. We evaluate variations in the ground thermal regime during the period of meteorological observations since the end of the Little Ice Age c. 1870 (Svalbard since 1912) until today on monthly and daily basis. Furthermore, selected sites have been forced by Holocene climate parameters to address the relative age of permafrost. These analyses display clear regional differences, providing important insights to the climatic response of mountain permafrost in the north-Atlantic region, and allow us to relate this information to geomorphological processes within the framework of the cryo-conditioning of landform and landscape evolution. In this presentation we will discuss the development of ground thermal regime in the study areas, and subsequently relate this to geomorphological processes and longer-term cryo-conditioned landscape development.

Modelling alpine permafrost distribution in the Hohe Tauern region, Austria

SCHROTT L.(1), OTTO J.C.(1), KELLER F.(2)
(1) Department of Geography and Geology, University of Salzburg, SALZBURG, AUSTRIA ; (2) Academia Egiadina, SAMEDAN, SWITZERLAND

Knowledge concerning permafrost distribution in the Alps is an important prerequisite to estimate potential developments caused by climate change. An assessment of natural hazards or the creation of risk maps in high alpine catchments very often requires the consideration of potential permafrost occurrence. This study for the first time shows a high resolution and index based permafrost distribution for the region Hohe Tauern (approx. 4400 km^2), which is based on the empirical model PERMAKART 3.0. The approach integrates three different relief classes (rock walls, steep slopes, foot slope position) in a topoclimatic key. The used thresholds were calibrated with field observations (geophysical soundings, mapping) from six different test sites. The modelling results were validated with more than 600 BTS (bottom temperature of snow cover) measurements. At present an area of 550 km^2 is affected by permafrost to a lesser or greater extent. Low altitude sporadic permafrost occurrence is possible in shady northerly exposed slopes at 2000 m a.s.l., whereas southerly exposed rock walls remain permafrost free even above 3000 m a.s.l. In the national park “Hohe Tauern” (1856 km^2) 25% of the area is underlain by permafrost. A major challenge remains the estimation of the future development of permafrost in the Alps. Thawing permafrost is one consequence of warming trends in the European Alps which causes a continuous change in permafrost distribution and influences a number of earth surface processes such as rock falls or debris flows. A simple scenario taking into account a possible temperature increase of 1 K would lead to widespread permafrost degradation. The produced permafrost map assists planers and decision-makers and contributes to better understanding of our mountain ecosystem.

****

Permafrost investigation in the Mont Blanc massif steep rock walls: a coupled measurement, modelling and geophysical approach

MAGNIN F.(1), DELINE P.(1), RAVANEL L.(1), GRUBER S.(2), KRAUTBLATTER M.(3)
(1) Université de Savoie - EDYTEM Laboratory, LE BOURGET DU LAC, FRANCE ; (2) Glaciology, Geomorphology and Geochronology, Department of Geography, University of Zurich, ZURICH, SWITZERLAND ; (3) Monitoring, Analysis and Early Warning of Landslides, Technische Universität München, MÜNCHEN, GERMANY

The intense rockfall activity affecting high-elevation steep rock walls in the Mont Blanc massif is presumably linked to permafrost degradation in response to climate change. We investigate this link at various temporal and spatial scales within the massif.

Mean Annual Rock Surface Temperature (MARST) is derived from Mean Annual Air Temperature (MAAT) and direct solar radiation calculations in a GIS-based statistical model based on a 4 m resolution DEM of the massif. While the quality of this model can be assessed with MARST measurements at individual points, the relationship between MARST and permafrost occurrence in the rock wall at depth is unknown. Here, we address this issue by comparing simulated MARST rock temperature monitoring and Electrical Resistivity Tomography (ERT) measurements.

The Aiguille du Midi site, a set of granite peaks (3842 m a.s.l), has been steadily instrumented since 2005 with rock temperature sensors inserted in near surface and three 11-m-deep boreholes. Records show that at a single point measurement, MARST differs of about 7-8°C between North and South, warm (>2°C) and cold permafrost are coexisting within a few tens of meters, and active layer thickness varies from 2 m to 6 m depending on aspect and inter-annual variations. MARST can deviate by about 1 to 3°C from permafrost temperature under various surface conditions (snow cover, rock discontinuities).

Five ERT transects have been realised on steep rock walls for evaluating the MARST model. They are focused on simulated temperatures between -1°C and 3°C, aiming to detect zones with and without permafrost in each profile. Survey lines are 160 m long and the median depth of investigation reaches up to 30 m.

Currently, ERT data are processed and we expect a clear distinction of frozen and unfrozen bedrock. This will help to evaluate the relationship between simulated MARST and permafrost occurrence at depth. An overview of these investigations and their first results will be presented.

Identification of geomorphic and climatic controls on degradation of Alpine rockglaciers

GAERTNER-ROER I., MUELLER J.
Dept. of Geography, University of Zurich, ZURICH, SWITZERLAND

Rockglaciers are known as typical landforms of the high mountain cryosphere and serve as indicators for the occurrence of permafrost. It is assumed that changes in the temperature regime lead to respective changes in geomorphological processes. Thus, for the future, distinct changes in structures and processes are expected in the periglacial belt, which is most sensitive to temperature changes.

Spatio-temporal characteristics of rockglacier kinematics are quantified for several landforms in a small catchment in the Swiss Alps. Measurements are taken between 1975 and 2012 by combining in-situ and remote sensing techniques. Some landforms exhibit significant changes in the last decade. The changing geometry (thickness change, horizontal velocities) gives insight into ongoing processes, such as “normal” creep behavior, ice aggradation/degradation or destabilizations such as collapsing tongues or the development of deep crevasses. The differentiation between normal creep behavior versus degrading landforms helps to identify and describe geomorphic and climatic controls on rockglacier kinematics.

The purpose of this study is to describe different types of rockglacier movements and derive a better understanding of the ongoing processes. The findings allow for a first description of rockglaciers sensitivity towards geomorphic and climatic controls.

****

Permafrost existence in rock glaciers of the Southern Carpathians (Romania)

URDEA P.
WEST UNIVERSITY OF TIMISOARA, TIMISOARA, ROMANIA

Knowledge of permafrost distribution in Romania is still very limited since only a few investigations were attempted as for the permafrost environment in the Southern Carpathians. This study gives an overview of the investigations performed for mapping mountain permafrost in Romania in the last 5 years. Spatial distribution of mountain permafrost was assessed using geophysical methods (DC resistivity tomography and GPR measurements) as well as measurements of Bottom Temperature of Snow Cover (BTS) and Ground Surface Temperature (GST). In order to determine the spatial extension and the characteristics of permafrost 9 rock glacier from three sites - Retezat, Parâng and Făgăra Mountains- , were studied using geophysical surveys. Thermal investigations were carried out on 20 rock glaciers from: arcu, Godeanu, Retezat, Parâng, Făgăra and Iezer Moutains to detect the existence of permafrost. The results revealed that isolated patches of permafrost could exist in very favorable sites for permafrost conservation (e.g. north-facing bouldery rock glaciers) in Southern Carpathians above 1950 m. According to the geophysical measurements the moderate resistivity values of the materials suggest that the ice content within the investigated rock glaciers is low to medium (sediments cemented by interstitial ice and ice lenses). Considering the mean annual air temperature (between 1 and -2,5°C), the depth of the active layer (3-10 m) and the limited thickness of permafrost layer (below 10 m) it is possible to conclude that permafrost from Southern Carpathians exists in marginal conditions and the permafrost occured during a cold phase of the Early Holocene. That is why the preservation of permafrost is dependent on site-specific conditions and is strongly controlled by solar radiation, snow cover depth and duration and surface characteristics like debris cover.

Authors: *P. Urdea, A. Onaca, A. Ardelean, R. Șerban, F. Sîrbu*

Rock glaciers debris accumulation for assessment of rockwall retreat

LE COEUR C.
University of Paris 1, PARIS, FRANCE

Rock glaciers can be considered as down slope debris accumulation. In some case, rock tongue results from periglacial reactivation of former debris covered glaciers located in upper valleys. In other cases, rock glacier extending below talus were mainly nourished by rockwall block detachment. These rock glaciers are material sinks within the debris transport system of mountain areas. Consequently, the amount of rock material stored within rock glaciers can be used to estimate geomorphic process rates (Barsch, 1977; Humlum, 2000; Brenning, 2005) in relation to rockwall surface.

In Western Vanoise (French Alps) a set of rock glaciers located in different morphostructural arrangements and into various lithology allow an assessment of Holocene debris production. Research sites are located in the Gebroulaz glacier area and in the Cerces massif.

An assessment of debris volume implies to discriminate possible inherited stocks (from a former till stock) and to evaluate internal ice content. The second point is to set a chronology and possibly some datations in order to establish rockwall retreat rates. This approach offer evidence of different accumulation rhythms resulting from uneven processes from scree production to large rockwall collapse. From these exemples we could assume contrasting rates matching different conditions and durations in cold debris production.

****

Dendrogeomorphology in the Arctic regions - methods and case studies

OWCZAREK P.(1), MIGALA K.(1), NAWROT A.(2), MALIK I.(3)
(1) University of Wroclaw, Institute of Geography and Regional Development, WROCLAW, POLAND ; (2) Polish Academy of Sciences, Institute of Geophysics, WARSZAWA, POLAND ; (3) University of Silesia, Faculty of Earth Sciences, SOSNOWIEC, POLAND

The activity of geomorphic processes in the High Arctic area was changed during last few decades. Fast increase of temperature and retreat of glaciers influences the course of these processes. This study demonstrates the possibility of analyzing environmental changes using growth-ring series of the Arctic dwarf shrubs. The research was carried out in the Svalbard Archipelago. Two plant species were chosen to dendrochronological analysis - *Salix polaris* and *Salix reticulata*. These low, creeping plants have well-defined growth-rings which ranged from 0.2 mm to less than 0.01 mm in width. The wooden samples, including the root and branch systems, were collected from different geomorphic sites: debris flow tracks, talus cones, fluvioglacial terraces and abandoned river channels. The samples were sectioned with GSL 1 sledge microtome, taking 15-20µm cross-sections from 4 to 6 different locations along the length of the individuals. Serial sectioning, which reduces dating errors, was necessary for construction of the ring-width chronologies. The chronologies cover a period of max. 120 years. Dendrochronological methods were used to determine minimum age of the geomorphic landforms. Field observations show that debris flow processes attains the highest intensity in the first and last phase of the short Arctic summer and are connected with increase water input to the active layer. The dendrochronology approach confirms this statement. Detailed research indicates several periods, when the debris flows and talus cones activity was increased during last 100 years (1950-1960, 1968-1975, 1992-1997, 2004-2008). The fast retreat of the glaciers affects the changes of sediment mass balance in the contemporary river channels. The transition from glacial to fluvial dominance is observed in the research area. The wooden dwarf shrubs allow dating the age of fluvial landforms (terraces, paleochannels) and identify tendency of the river runoff and geomorphic activity in the future.

Late pleistocene sand wedges along the Patagonian Coast (Argentina): chronological constrains and implication for coastal permafrost distribution

RIBOLINI A.(1), BINI M.(1), CONSOLONI I.(1), ISOLA I.(2), PAPPALARDO M.(1), ZANCHETTA G.(1), FUCKS E.(3), PANZERI L.(4), MARTINI M.(4), TERRASI F.(5)

(1) Dipartimento di Scienze della Terra University of Pisa, PISA, ITALY ; (2) Istituito Nazionale di Geofisica e Vulcanologia, PISA, ITALY ; (3) Facultad de Ciencias Naturales y Museo, Universidad Nacional de La Plata, LA PLATA, ARGENTINA ; (4) Dipartimento di Scienza dei Materiali, University of Milano Bicocca, MILANO, ITALY ; (5) Dipartimento di Scienze Ambientali, University of Naples 2, NAPOLI, ITALY

Several wedge features have been detected in the continental deposits covering the marine sediments of MIS 5 along the St Jorge Gulf coast and in the Puerto Deseado area, in the Patagonian coast of Argentina. The lab analyses of the infilling sediments report for fine sand, moderately sorted, with a symmetrical skewness and a mesokurtic kurtosis, consistent with a depositional environment dominated by aeolian transport. Also the microtextures of quartz grains observed at SEM point to an aeolian environment, favoring mechanical collisions during the transport by saltation process. The existence of fragments of Andean volcanic rocks (glass shards) in the wedge infillings indicates a long-distance transport with a west component of wind direction. These data, together with the evidences of polygonal networks on the surface, enable us to interpret the wedge features as primary sand wedges formed in a permafrost environment.

The OSL age (14,670 ± 750 yr BP) obtained in the sediment affected by sand wedges and the ^{14}C ages (25-27 kyr BP) of pedogenetic crust cross cut by the sand wedge indicate that these sedimentary features have formed during the Lateglacial.

These results imply that the reduction/reversal in the trend of temperature rise (Antarctic Cold Reversal, 14,500 to 12,900 cal. yr BP) during the post LGM deglaciation has been registered in the coastal continental deposits with the formation of primary sand wedges, indicative of permafrost condition.

Beside a general condition of aridity, the coastal environment was affected by westerlies, capable to transport volcanic material of Andean origin, coherently with an unvaried position of the South Western Wind atmospheric currentduring the ACR.

****

New periglacial features on the ancient terraces of the lower Rhône valley (Costières, Gard, France): mapping, datings and implications for the taphonomy of the palaeolithic lithic remains

BRUXELLES L.(1), JORDA C.(2), MOURRE V.(3), RAUX A.(3)

(1) Inrap, SAINT-HIPPOLYTE-DU-FORT, FRANCE ; (2) INRAP, VILLENEUVE-LÈS-BEZIERS, FRANCE ; (3) INRAP, NÎMES, FRANCE

The Costières formation corresponds partly to old alluvial terraces deposited by the Rhône River during the end of the Pliocene and the first part of the Pleistocene. Between the lower and the middle Pleistocene, this valley was abandoned and the Rhône took a more direct way toward the sea, through the Camargue plain. There remain several levels of terraces affected by a strong fersialitic soil.

For two years, several teams of Inrap have led a huge archaeological diagnosis prior to the building of a high speed railroad between Nimes and Montpellier. Thousands of soundings permit us to reappraise the stratigraphy of all the superficial formations.

Some periglacial features were already known. Polygonal soils, ice wedges, vertical pebbles and loess deposits were described in previous works. They become more prominent in the vicinity of the Rhône valley due to the cold brought in this southern area by the Mistral wind.

Our work permits us to precise but also to complete these observations. We studied several sections through all the area and we can clearly see the periglacial features becoming more and more important toward the Rhône valley, confirming the role of the Mistral. In addition with the features already described in this area, new ones such as lamella structures or reworked loess deposits were identified and studied. But the most important is the discovery of thermokarst features which confirm the existence of permafrost. Numerous closed depressions are now identified and mapped in the eastern part of the Costières. These depressions vary from one to hundred meters in diameter and can reach several meters of depth .They were formed by the partial molten of the permafrost during the Tardiglacial period, which is confirmed by the OSL datings. These depressions subtracted the pleistocene colluviums and part of the loess cover from the erosion. The lower palaeolithic remains were also trapped in the same time and sites appear as a secondary concentration.

Poster presentations:

The Spatial Distribution of Rock Glaciers and Protalus Ramparts in the Central Italian Alps

BRARDINONI F., SCOTTI R., CROSTA G.B.
University of Milano-Bicocca, MILANO, ITALY

We present a regional inventory of rock glaciers (1514) and protalus ramparts (228) from the central Italian Alps. To identify and classify the landforms we inspect air-orthophoto mosaics and a 2m-DSM, and conduct field work. The inventory forms an empirical basis to analyze: (i) the significance of hillslope and glacial processes to rock glacier sediment supply; (ii) linkages between periglacial landforms and topographic attributes; (iii) the spatial variability of periglacial activity in relation to a parsimonious set of environmental variates (i.e., elevation, precipitation, and lithology); and (iv) the effects of the Pleistocene-Holocene climatic transition on the distribution of intact and relict landforms. This analysis reveals that the elevation of rock glacier termini can vary over 200 m as a function of slope aspect. In turn, the distribution of periglacial landforms among aspect categories is controlled by the structure of the valley network that promotes NW and SE exposures. Talus rock glaciers prevail numerically over the glacier-derived typology, even though the latter population appears to have increased during the Holocene. Relict and intact rock glaciers have distinct spatial patterns in that the former display, on average, a 400-m elevation drop and a less clustered distribution towards northern aspects, suggesting that they have developed in more "permafrost-prone" climatic conditions. Analyzing the study region through a 27.5 km-grid has been instrumental for showing that rock glacier specific area and terminus elevation are: (i) positively correlated with terrain elevation; and (ii) negatively correlated with mean annual precipitation. As a consequence, in relation to Holocene generalized climate amelioration, intact rock glaciers have progressively disappeared from the wetter and milder portions of the area. Analysis of rock glacier occurrence across litho-tectonic sectors does not provide conclusive dependences and requires further analysis.

****

Age and structure of perennial frost mounds in Yakutia region

URBAN A.
Melnikov permafrost Institute SB RAS, YAKUTSK, RUSSIAN FEDERATION

Frost mounds (canadian “pingo”, yakutian “bulgunnyakh”) were forming during Late Pleistocene and Holocene. Analyze of frost mound’s age shows its active formation started more then 8500 years ago. Frost mounds age is established from 150 to more then 8500 years.

Holocene period is characterized significant climatic and geographical conditions changes, which is approached to modern climate. During 2500–8000 years period cyclic warming and cooling of climate happened. It due to ideal for frost heaving processes conditions was formed sufficient ground moisture, good conditions for peat accumulation, subsequent cooling and ground ice forming processes. Modern trend of frost mound development is determined mostly by climatic and permafrost conditions of territory. Now we talk a lot about it degradation, however we have enough examples of stable state and its active formation.

Territory of Yakutia differ variety climatic and geocryological conditions. Mutual influence of these factors in different part of Yakutia cause different mechanism of frost mound’s formation.

This paper presents materials of field researching conducted by author. As a result we got subsurface profiles, temperature data and age of perennial frost mounds.

Characteristics and Development of an Autochtonous Blockfield, Western Dronning Maud Land, Antarctica

MEIKLEJOHN I.(1), HANSEN C.(1), DWIGHT R.(1), LEE J.(2), SCOTT D.(1)
(1) Rhodes University, GRAHAMSTOWN, SOUTH AFRICA ; (2) Stellenbosch University, STELLENBOSCH, SOUTH AFRICA

An autochthonous blockfield on the Northern Buttress of the Vesleskarvet nunatak in Western Droning Maud Land, Antarctica was studied to document its characteristics and to investigate its origin. The blockfield is located on a dolerite sill in a permafrost environment with an active layer that is currently 16cm deep. Initial fracturing by dilatation, following glacial retreat, has produced the blocks that comprise the blockfield and which have been subsequently displaced from their original positions. In places, the individual blocks are separated from adjacent and underlying material by an ice matrix. Well-developed case hardening and patination are indicative of a substantial period weathering subsequent to initial bedrock fracturing.

The dimensions and orientations of more than 300 individual blocks were measured along predefined transects, while the characteristics of each face of the rocks sampled were noted. In addition, an Equotip and Schmidt Hammer were used to investigate rock hardness and, hence, relative weathering. Rebound values were mapped and interpolated over the extent of the study area. While no statistically significant relationship was found to occur between different aspects of individual rocks sampled, differences over the entire nunatak reflect the variability in aerial exposure and moisture conditions brought about by the spatial distribution of snow cover.

The development of the blockfield is suggested to have resulted from the freezing of moisture derived from snowmelt that has flowed into bedrock cracks through the active layer to the upper surface of the permafrost. During the cooler winter, freezing of the liquid water heaved and displaced the pre-existing blocks to produce the observed blockfield. These findings are the first known field observations that support this model of blockfield formation.

****

Ground temperature regime and periglacial dynamics in three different sites from the summit area in Sierra Nevada (southern Spain) from 2006 to 2012

SALVADOR-FRANCH F.(1), OLIVA M.(2), SALVÀ-CATARINEU M.(1), GÓMEZ-ORTIZ A.(1)
(1) Universitat de Barcelona, BARCELONA, SPAIN ; (2) Universidade de Lisboa, LISBOA, PORTUGAL

Ground temperatures and its control on snow cover are crucial factors conditioning the activity of current periglacial processes in the highest lands of Sierra Nevada (Betique Range, Iberian Peninsula).

We present summary results of the monitoring period from September 2006 to August 2012 in three sites with contrasting topography, aspect and snow cover. Temperatures loggers have recorded data at 2 hours time lapse at: a) Veleta glacial cirque, an environment with marginal permafrost and a small active rock glacier in it (3107 m asl), b) the *flat summit*plateau of Collado de los Machos (3297 m) characterized by the existence of inactive sorted circles with scarce snow cover, and c) the southern cirque of Rio Seco, an area with moderate snow cover and widespread solifluction lobes (3105 m).

We discuss the periglacial activity in the three study sites in relation with ground temperatures. Results show evidence of the decisive control played by snow cover (duration and thickness) in the thermal regime of the ground (rhythm, depth and intensity of freezing). Only the site in the Veleta cirque has revealed the existence of permafrost, which is inexistent at the summit plateaus and southern cirques. The freezing and thawing of the ground depends substantially on the geographical characteristics of the sites, although a common pattern is detected: the thawing occurs more rapidly than the freezing and the number of freeze-thaw cycles in air temperatures is substantially higher than in ground temperatures.

Mapping the consequences of global change on permafrost extent: a case study from the Clarée valley, southern French Alps

PERRIER R.(1), COSSART E.(2), FORT M.(1)
(1) Université Paris-Diderot, UMR 8586 PRODIG CNRS, PARIS, FRANCE ; (2) Université Paris 1 Panthéon-Sorbonne, UMR 8586 PRODIG CNRS, PARIS, FRANCE

Global warming could affect the evolution of permafrost and lead to its degradation. In this context, mountain areas may be affected by an increase of natural hazards such as rockfalls, debris flows or slope instabilities. As mountain areas may provide locations for urban water sources, construction borrow sources, drill sites, transport infrastructures, ski lifts, and dams, it becomes essential to determine spatially relevant sectors that may be affected by permafrost degradation.

Here, we present a first approach of a permafrost degradation distribution model through the use of field data and GIS (Geographical Information System). Two statistical models are developed, one for permafrost distribution and one for degraded permafrost spatial extent. For both models, a logistic regression model was used and respectively based on presence/absence of permafrost occurrence and presence/absence of permafrost degradation symptoms.

Both distribution models are based on a combination of permafrost/permafrost degradation evidence and statistical analysis. For permafrost distribution model, empirical data was obtained using spring water temperature collection method (60 points collected between summer 2007 and 2011 in the Clarée valley, southern French Alps). For permafrost degradation model, permafrost degradation symptoms (thermokarst, melt furrow, mass movements) were collected during field campaigns between 2008 and 2011. For both models, topographic variables (altitude, slope, curvature) and climatic variables (latitude, longitude and incoming solar radiation) are used as predictor variables and derived from a 25 m DEM (Digital Elevation Model) (BdAlti-IGN) in a GIS. Finally, both spatial distribution models are represented at different scales by interpolation with the help of a GIS.

Results show that potential permafrost degradation areas are heterogeneously distributed as they depend on local glacial/permafrost history as well as local topographical conditions.

****

The distribution and climatic implications of granite tors on the Great Dividing Range, Australia

SLEE A.
University of Queensland, BRISBANE, AUSTRALIA

Tors in mountain environments have long been considered to be indicative of periglacial environmental conditions. In Australia many of the highest regions of the Great Dividing Range are composed of extensive granitic plutons that form flat topped plateaus that rise above the surrounding landscape. While periglacial landforms in the form of block streams and solifluction deposits are prominent in the southern parts of the Great Dividing Range they are related to basalt and metamorphic lithologies and are poorly developed or absent within granitic terrain. While block streams are absent from granite terrain; tors are common throughout the Great Dividing Range as far north as Warwick in south-eastern Queensland at a latitude of 28°15'S. Mapping and classification of granite terrain along the length of the Great Dividing Range has revealed patterns of granite tor distribution. These are related to cold climate processes controlled by altitude and continentality or coastal weathering regimes.

Geophysical signatures of permafrost in SW Spitsbergen

KASPRZAK M.(1), KONDRACKA M.(2)
(1) University of Wroclaw, WROCLAW, POLAND ; (2) University of Silesia, SOSNOWIEC, POLAND

In the periglacial zone there exist various landforms, which contain an ice-core or are formed in the presence of ground ice. We examined internal structures of such forms in the test area on the west coast of Wedel Jarlsberg Land, SW Spitsbergen. The main aim of this work was to investigate structures of depositional landforms in different but typical terrain situations.

In this work geophysical methods were applied. We used the 2D electrical resistivity tomography (ERT) with chosen method of electrodes arrays: Wenner-Alfa, Schlumberger and Dipole-Dipole. We surveyed more than 20 profiles (78–235 m long, 2–5 m unit electrode spacing) – across ice-cored end moraine of the Werenskiold Glacier, debris and debris-flow taluses, rock glaciers and Holocene marine terraces.

Results allow us to detect strong freezing of bedrock under ice-cored moraine. ERT profiles demonstrate very significant differences instructure and ice content inside individual lobes of rock glaciers. Obtained resistivity models confirm strong correlation between the presence of ice inside talus and its thickness, shape, slope and slope water runoff. However, most interesting are results concerning thickness of permafrost across marine terraces. Here, the influence of sea water causes elimination of permafrost bed and its discontinuous character near ground surface.

Electrical resistivity methods determined non-invasively and in a dynamic manner what is the impact of the ice in the structure of examined terrain forms. Finally, results make possible to verify earlier views on internal structure of medium- and small-size landforms in the periglacial zone and formation of permafrost on Greenland Sea coast. The method is particularly useful in protected area of Svalbard where excavations are not allowed.

****

3D geophysical imaging to study the evolution of a debris covered glacier in the Dolomites (South-Eastern Italian Alps)

ZANONER T.(1), FRANCESE R.(2), BONDESAN A.(1), GIORGI M.(2), CARTON A.(1), SEPPI R.(3), NINFO A.(1)
(1) University of Padova - Department of Geosciences, PADOVA, ITALY ; (2) National Institute of Oceanography and Experimental Geophysics (OGS), TRIESTE, ITALY ; (3) University of Pavia - Department of Earth and Environmental Sciences, PAVIA, ITALY

The Cima Uomo glacier is located in the upper San Nicolò Valley (Dolomites, Italy) between 2200 m and 3000 m a.s.l. It was a cirque glacier fed by avalanches and, during the 50s, it was initially classified as a clean glacier. Later it evolved into a debris-covered glacier and it is currently developing in a rock glacier-like landform.

The internal structure of the ice-debris mass and the morphology of the bedrock were investigated using a 3D resistivity imaging and 2D radar profiling.

Field data were collected with 48-electrode Syscal R1 Georesistivimeter and with a GSSI SIR-2000 radar system equipped with an unshielded 75 MHz antenna. The resistivity spread was 48-electrode, 3 m electrode spacing longitudinal profile recorded both in pole-dipole, using 6 remote poles, and Wenner mode. The radar scan was also a longitudinal profile of about 350 m of length. The stations were georeferenced conducting a DGPS and total station survey.

Data processing was not straightforward as the electrical field was severely distorted due to the surface morphology and the difficulties in coupling the radar antenna with the ground.. After a comprehensive processing with the removal of about 10% of noisy values and a careful selection of the modelling parameters, electrical data turned out to be good quality. To improve radar data quality some specific processing routines were coded.

Subsurface geophysical images show a close correspondence, indicating the existence of a thick ice layer ranging from few tens of decimetres below the surface to a depth larger than 10 m. The ice body has a complex shape with two distinct frontal lobes and a clear physical continuity from its front to the back part located at higher altitude. The radar signature in the higher portion of the ice-debris mass seems to be quite different with a sudden increase in the amplitude decay function, probably due to a major percentage of the silty matrix in the uppermost layers.

Biodiversity and thermal regimes on cold scree slopes

STROHMEYER V.(1), HUC S.(2), DESPLANQUE C.(3), SCHOENEICH P.(1), CECILLON L.(4), HUSTACHE E.(5), ROBERT Y.(3)

(1) Institut de Géographie Alpine, GRENOBLE, FRANCE ; (2) Conservatoire Botanique National Alpin, GAP, FRANCE ; (3) Office National des Forêts, GRENOBLE, FRANCE ; (4) IRSTEA, GRENOBLE, FRANCE ; (5) Natura 2000 Dévoluy, ASPRES-SUR-BÜECH, FRANCE

Cold scree slopes are particular geosystems in mountain areas, due to internal, alternating seasonal ventilation of the scree deposit. They can contain an ice lens and a permafrost patch in the distal part, far below the lower limit of discontinuous alpine permafrost. These cold screes often bear boreo-alpine plant species constituting “abyssal” ecosystems at low altitudes where they normally do not grow.

A “cold scree slope” network was created as part of the PermaFRANCE observing system and Alpine Flora Conservation group. Its objective is to better understand the relations between temperature regimes and the development of specific vegetation on these scree slopes. The first step was an inventory of the sites in the French Alps, and a typology of related ecosystems. A total of 38 cold scree slopes were identified, and some sites have been equipped for ground temperature measurements.

Field surveys show that cold scree ecosystems are located mainly on north-east to north-west exposed slopes, with mean elevations ranging from 900 to 2000m. These shady and cold situations maintain strong ventilation (winter/summer) and allow the development of a typical boreo-alpine vegetation even at low altitude.

First botanical surveys reveal a great variety of ecosystems. The main characteristics are dwarf trees (*Pinus uncinata*, *Picea abies*) growing on a very thick raw humus layer, and forming patches of upper subalpine character within the lower subalpine or the upper montane belts. They are accompanied by shrub (*Rhododendron ferrugineum*) herbaceous (*Dryas octopetala*), moss and lichen species normally found in alpine meadows or even tundra environments.

The inventory and the measurements allow investigating the relations between lithology, temperature and ecosystems. The botanical survey will serve as a reference for further surveys, in order to monitor the sensitivity of abyssal ecosystems to climate change or to modifications of the ground thermal regime.

****

Past and present dynamics of a potentially hazardous rock glacier (Dérochoir, Mont Blanc Massif, France)

BODIN X.(1), KRYSIECKI J.M.(2), SCHOENEICH P.(2)

(1) Laboratoire EDYTEM, UMR 5204 CNRS / Universite de Savoie, LE BOURGET-DU-LAC, FRANCE ; (2) Laboratoire PACTE, UMR 5194, CNRS / Universite Joseph Fourier, GRENOBLE, FRANCE

In the late 19th century, the Arandellys steep catchment has been subjected to several torrential floods that damaged the city of Les Houches, in the Mont Blanc Massif. At that time, the investigation pointed out the potential role of a debris accumulation with locally high ice content, now identified as the Dérochoir rock glacier. This morphological crisis finally ended up after 1897, but the rock glacier has nevertheless been recently identified as one of the few sites in this highly touristic area where the degradation of permafrost might generate hazardous situations.

We present here the main findings of a collaborative study that aimed at i) reconstructing the past dynamics of the rock glacier and the geomorphological and climatological context that led to the crisis, ii) estimating the evolution of the rock glacier during the XXth century, iii) quantify the present dynamics in terms of surface displacement and ground thermal regime and iv) precising the present geomorphological context and the internal structure of the rock glacier.

We observed that the surface velocity experienced by the rock glacier during the last years (until 2008), estimated by air photo comparison, is twice higher (0.51 m/yr) than between 1974 and 2004, whereas the velocity over the 1895-1974 period, more roughly estimated by comparing the distance between the rock glacier edge and the path, seems to have been even lower (0.19 m/yr). Spatially, the highest velocities have moved from the West lobe, as testified by the strongest deformations of the path, to the East lobe where surface displacements measured by differential GPS reach 0.69 m/yr in 2009-2010. In terms of internal structure, the geoelectrical soundings performed in summer 2012 revealed that the probable highest amount of ground ice is presently found in the slowly moving West lobe, whereas on the fast-moving one the ice is probably present in lower quantity and/or at higher temperature and/or with a higher water content.

Ice sheet - permafrost interactions inferred from landform and sedimentary structures, Weichselian Ice Sheet, Poland

EWERTOWSKI M.(1), KASPRZAK L.(2), SZUMAN I.(2), TOMCZYK A.(2)
(1) Department of Geography, Durham University, DURHAM, UNITED KINGDOM ; (2) Faculty of Geogrpahical and Geological Sciences, Adam Mickiewicz University, POZNAN, POLAND

Past cryogenic structures and landforms related to them were used for interpretation of the past permafrost and its relationship with Weichselian ice sheet. Study area is located in the central Wielkopolska (west-central Poland) and characterized by moraines, fans, till plains, mega scale glacial lineations, tunnel valleys and outwash plains formed during the recession of the Weichselian Ice Sheet from maximum extent (Leszno Phase) to Poznan Phase and further to the north. Varied types of sedimentary structures and landforms were used to infer about environmental conditions in the foreland as well as beneath the ice sheet. The most important ones were ice-wedge ice-wedge pseudomorphs located beneath the subglacial till and with till infilling, which suggest that the ground was permanently frozen during ice advance. Other common features like frost cracks, sandy intraclasts and glaciteconic moraines also indicate the frozen ground conditions. Spatial distribution of these features as well as their vertical variations (below and above the subglacial till layer) suggests that thermal conditions greatly varied with time and space.

Results of the research suggest that in west-central Poland: (1) permafrost exist on the forefield of the Weichselian ice sheet during Last Glacial Maximum (LGM); (2) permafrost developed on freshly deglaciated areas and had an important impact on shaping post-glacial landforms; (3) degradation of permafrost were slow and the thermokarst processes played an important role; (4) there were no abrupt changes of climatic condition after the LGM – rather gradually change from glacial to periglacial conditions.

This works was supported by Polish National Science Centre (project number N N306 599640)

****

The influence of altitude, exposure and declivity on freeze-thaw processes in non-permafrost mountain areas: the Southern Carpathians, Romania

VASILE M., VESPREMEANU-STROE A.
Faculty of Geography, University of Bucharest, BUCHAREST, ROMANIA

The distribution of freeze-thaw cycles on free rockwalls could be used as an indicator of frost processes control on mountain slopes evolution. This study presents the conditions of freeze-thaw cycles regime in the Southern Carpathians, a mountain range that mainly lacks permafrost or it preserves it in sporadic patches. In terms of intensity and frequency, frost behaviour is defined by a sum of controlling factors of which, the present work evaluates the weighting of the altitude, exposure and declivity. Thermal regime was monitored at more than 40 sites in order to find the rockwall facets that are probably the most affected by thermal weathering. The measurements were extended between 1600 and 2450 m a.s.l., on northern, southern, eastern and western rockwalls, on slopes varying from 0 to 90 degrees. Both seasonal and diurnal freeze-thaw cycles were taken into account. Thermal amplitude, duration and freezing index were calculated for each cycle and used in the estimation of freeze-thaw cycles efficiency and frost depth.

Southern rockwalls are twice to three times more affected by efficient diurnal freeze-thaw cycles than the northern ones, while seasonal frost propagates to estimated depths of about 5.5 m on South and up to 8 m on North for elevation higher than 2000 m. No obvious correlation was set between the total number of freeze-thaw cycles and elevation levels. Nevertheless, the magnitude (expressed by the frost depths) increases with altitude and the maximum of freeze-thaw efficiency is encountered within 2000 - 2300 m level. Mean and high slopes (30 to 90 degrees) are the most responsive to thermal weathering, except for the northern rockwalls where declivity is less significant.

Distribution and characteristics of mountain permafrost under the Tropics: insights from an inventory of rock glaciers on the Altiplano, Chile and Bolivia (20-22°S)

ANETAS G.(1), BODIN X.(1), SORUCO A.(2)
(1) Laboratoire EDYTEM, CNRS / Universite de Savoie, LA BOURGET-DU-LAC, FRANCE ; (2) Instituto de Investigaciones Geologícas y del Medio Ambiente, Universidad Mayor San Andres, LA PAZ, BOLIVIA

Located in the dry area of the tropical Andes in Chile and Bolivia, the Altiplano is a high elevation plateau surrounded by numerous volcanics edifices that reach more than 6000 m asl. and host a few glaciers and many rock glaciers. When they are active, rock glaciers are typical indicators of the creeping of ice-rich mountain permafrost in debris accumulations. These landforms can play a significant role in shaping the geomorphological landscape and also contribute to the hydrological regime in a still poorly understood way. In several mountain ranges of the world, it has been observed that rock glaciers, as a cryospheric feature, react to climate change in substantially modifying their dynamics, and recent observations suggest that the warming of ice in permafrost may lead to increasing deformation rates and even to terrain destabilization. Nevertheless, under the Tropics little is known regarding permafrost and rock glaciers, although it is proved that tropical glaciers has been severely retreating since several decades as a consequence of a warming trend and modifications in the ENSO regime. Therefore, the aim of this study is to compile an exhaustive database of rock glaciers in order to improve our understanding of the factors that control the permafrost distribution and its state in this region.

Around 150 active and inactive rock glaciers have been inventoried and mapped using Google Earth images, between 20 and 22°S (South of Bolivia and North of Chile). According to existing GIS-based methodologies, the morphometric, topoclimatic and geomorphological characteristics were extracted in a geodatabase using available DEM and satellite imagery. The distribution of rock glaciers was compared to geological settings, including volcano activity, and to regional climatological datasets, such as meteorological stations records and reanalysis gridded datasets.

****

Age and dynamics of blockstreams in the easthern velay highlands, Massif Central, France: preliminary findings

DEFIVE E.(1), LE COEUR C.(2), VIRMOUX C.(3), PEIGNELIN C.(1), POIRAUD A.(4), GUNNELL Y.(5)
(1) Université Blaise Pascal, GEOLAB, UMR 6042-CNRS, Maison des Sciences de l'Homme, 4 rue Ledru, F-63057 Clermont-Ferrand, France, CLERMONT-FERRAND, FRANCE ; (2) Université Paris 1 Panthéon-Sorbonne, Laboratoire de Géographie Physique, UMR 8591 CNRS, 1 place A. Briand, 92195 Meudon principal Cedex, PARIS, FRANCE ; (3) Laboratoire de Géographie Physique, UMR 8591 CNRS, 1 place A. Briand, 92195 Meudon principal Cedex, MEUDON, FRANCE ; (4) GEOLAB, UMR 6042-CNRS, Maison des Sciences de l'Homme, 4 rue Ledru, F-63057 Clermont-Ferrand, France / Bureau d'étude "Inselberg", 261 allée des Bauges, 73000 Chambéry, France, CLERMONT-FERRAND, FRANCE ; (5) Université Lumière-Lyon 2, UMR 5600 CNRS Environnement, Ville, Société, 69635 Lyon Cedex 07, France, LYON, FRANCE

Many blockstreams occur in the Miocene volcanic area of Mont Mézenc, eastern Velay, SE Massif Central, France. They were supplied by frost-shattered exposures of lava-flow boundaries, phonolitic domes and other intrusions. These ‘rivers of rock’ are ribbons of chaotically upheaved blocks presenting an openwork structure, are 400 to 1100 m long and 20 to 200 m wide, and are today disconnected from the rock exposures that supplied the debris. Some occur on very low gradient slopes. The largest blockstreams offer evidence of compression ridges and post-depositional block subsidence. Their dynamics and age are not precisely known in the study area and they have been interpreted by default as Late Pleniglacial rock glaciers. Field observations (stratigraphic relations with other surficial deposits, topographic position, distance from bedrock source areas and from talwegs, structural context), however, indicate that the situation is more complex, with new implications for their age, origin and past dynamics. This reconnaissance study proposes a typology of blockstreams for the area. The base of the blockstreams remains inaccessible to direct observation but several ground-penetrating radar transects were carried out in order to map the topography at depth. Results show that the blocks fill gullies 5 to 15 m in depth. At the surface, a sharp textural transition with other slope deposits is clearly detected but the latter grade topographically to the surface of the blockstreams, not to the gullies beneath them. These cross-cutting relations provide a relative chronology not previously established in the case of blockstream deposits.

Phytomass and soil organic carbon inventories related to land cover classification and periglacial landscape features at Ari-Mas and Logata, Taimyr Peninsula

RAMAGE J.(1), HUGELIUS G.(1), PALMTAG J.(1), LASHCHINSKIY N.(2)

(1) Department of Physical Geography and Quaternary Geology, Stockholm University, STOCKHOLM, SWEDEN ; (2) Central Siberian Botanical Garden, Russian Academy of Sciences, NOVOSIBIRSK, RUSSIAN FEDERATION

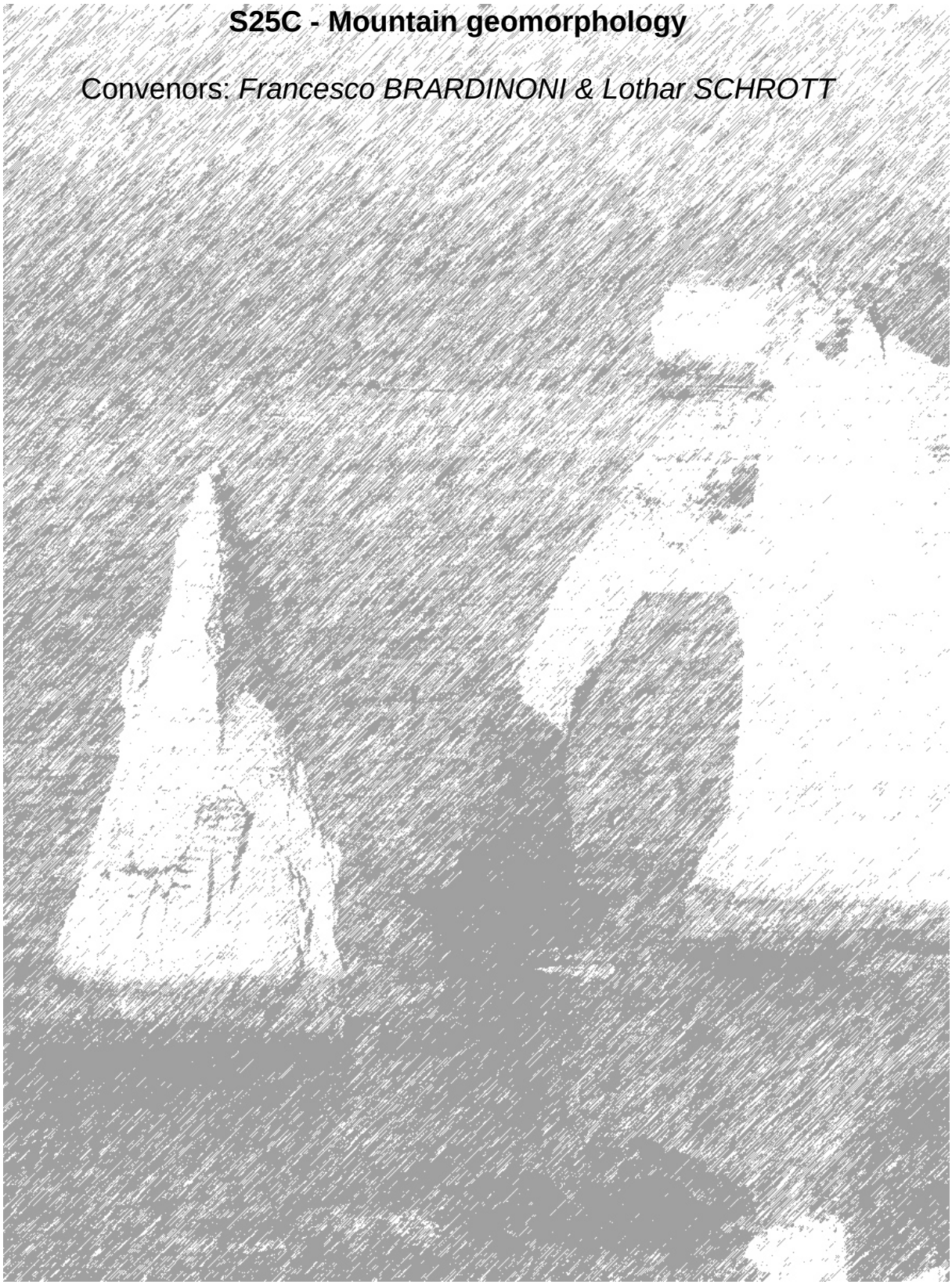
Permafrost presents a sensitive response to temperature changes. Changes in the ground thermal regime, due to an increase in atmospheric temperatures in the Arctic, are expected to alter the turnover of soil organic carbon (SOC) through changes in the ground properties.This study assesses the landscape diversity in two sites within the typical tundra in the Taimyr Peninsula (Russian Arctic) and associates it with the differing patterns of SOC storage and partitioning in the first top meter of soil. The results were obtained from soil and vegetation inventories in combination with remote sensing analysis. Upscaling methods were used to estimate the amounts of carbon at a landscape scale, based on a land cover classification.

On average, 29.5 kg C m2 were stored, mainly in mineral horizons found in the active layer. However, the carbon distribution shows a tremendous variability across the tundra at a large scale. High amounts of SOC are found in upland areas and within the patterned ground features found in peatlands. The vegetation stores a small percentage of the total carbon, a mean C phytomass storage of only 1.38 % of the total SOC storage, but is assumed as an important parameter for controlling the ground thermal regime. Highest amounts of aboveground phytomass carbon are found in deciduous shrubs and moss layers. The large variability in SOC due to complex land cover emphasizes the necessity of conducting detailed field investigations and challenges the use of land cover classification in SOC storage assessment.

****

S25C - Mountain geomorphology

Convenors: *Francesco BRARDINONI & Lothar SCHROTT*



Oral presentations:

Lightning strikes and their influence on mountain geomorphology and sediment supply

KNIGHT J., GRAB S., MAYET N.
University of the Witwatersrand, JOHANNESBURG, SOUTH AFRICA

Lightning strikes are common along the Drakensburg escarpment of east-central Southern Africa in particular where they are driven by rapidly-rising and moist air masses. Although lightning climatology is not fully known and is subject to high spatial and temporal variability, the geomorphological impacts of cloud-to-ground lightning strikes have been described from many bedrock mountain surfaces worldwide. This evidence includes angular and shattered bedrock fragments, conjugate fractures that penetrate into bedrock, and heat-fused quartz grains (fulgarite). Despite this wide-ranging evidence, no examples have yet been described from Southern Africa nor has the role of lightning strikes on mountain geomorphology and sediment supply over long time periods been previously considered. This is important, however, since lightning strikes can contribute to mountain weathering and denudation and produce materials that may appear morphologically similar to those produced by other mountain weathering processes. As such, understanding the role of lightning strikes in mountain sediment supply is not geomorphically insignificant for reconstructing past mountain-shaping processes and products. In this paper we discuss for the first time, geomorphological evidence for lightning strikes on hilltops in eastern Lesotho (c. 3200 m asl), including their number, locations, size and relative age based on rock surface hardness and lichenometric methods. From these observations, we then present a geomorphological model that outlines the relative role of lightning-produced debris with respect to other mountain weathering processes, and their interrelationships.

****

Debris talus and cones dynamic in a calcareous Atlantic high mountain (Picos de Europa, Northern Spain)

SERRANO E.(1), SANJOSÉ J.J.(2), GONZÁLEZ-TRUEBA J.J.(3)
(1) University of Valladolid, VALLADOLID, SPAIN ; (2) University of Extremadura, CÁCERES, SPAIN ; (3) CIESE-Comillas, COMILLAS, SPAIN

The high mountain of the Picos de Europa is characterised by a nivoperiglacial environment and the most important geomorphic processes are the nivation, linked to the depth, changes of snow cover and snow avalanches, karstification, solifluction and gelifraction. Talus and debris cones are the most extended active landform in the Central Massif of Picos de Europa (Cantabrian Range). Located in the north of Iberian Peninsula, it is a glaciokarstic relief featured by Pleistocene glaciations.

The aim of this work is to know the mechanisms working in the debris transfer from walls and high cirques to the valleys in calcareous Atlantic High Mountain (nival processes, snow avalanches, debris flow, rockfall, frost creep) and estimate the movement and deformation of debris cones. Techniques applied in this work have been a detailed geomorphological map (1:10.000), a surface morphological and sedimentological analysis, soil thermal regime control by dataloggers around Peña Vieja Group and in the La Vueltona area have been analysed the winter snowcover changes by images and the movements and deformations of talus and cones by Terrestrial Laser Scanner (TLS). The TLS is a useful tool for monitoring changes, movements and deformations on surface of landforms. The surface of three debris cones have been scanned in summers of 2008, 2009, 2010, 2011 and 2012 and permits to know surface changes and deformations in the debris body.

Processes involved in the dynamic of debris talus are rock fall by gelifraction, debris flow, related to the spring melt and stormy episodes, creep, small movements not related to frost, and nival processes. The debris and talus cones are complex, and three debris cones types can be differentiated: gravitational debris cones with debris flow, snow avalanches debris cones and mixed debris cones. The TLS show small displacement and deformations affecting at all body. The most important changes take place in the debris flow channel by infill of sediments.

Holocene rockwall retreat in an inner-alpine headwater catchment (Gradenmoos Basin, Schober Mountains, Austrian Alps)

GÖTZ J., SCHROTT L.
University of Salzburg, Dept. of Geography and Geology, SALZBURG, GERMANY

Alpine denudation and rockwall retreat has been investigated on various spatio-temporal scales resulting in a wide range of rates (~10–4000 mm/ka). This study quantifies postglacial sediment storage in the glacially overdeepened Gradenmoos Basin – an alpine lake mire with adjacent floodplain deposits and surrounding hillslope storage landforms (subcatchment size: 4.5 km^2) – in the central Gradenbach catchment (32 km^2, Schober Range, Austria). Using the sediment budget approach, postglacial rockwall retreat is accurately reconstructed from these volumes due to several reasons:

- Holocene sediment output of the basin is negligible due to lake existence after deglaciation for ~7500 years as observed by core-drillings.
- Sediment volumes are accurately assessed as a consequence of the multi-method approach (geomorphologic mapping, terrestrial laserscanning, geophysical methods (refraction seismic, ground-penetrating radar, DC resistivity), core-drillings, GIS and 3D modelling).
- Postglacial sediment storage is corrected by pre-Holocene basal till derived from drilling data.
- Landform based sediment volumes can be associated to clearly delimitable source areas.
- A time period available for postglacial sedimentation and rockwall retreat is established by radiocarbon dating, palynologic and stratigraphic analyses of the sediment cores.

Postglacial sedimentation commenced ~11 ka BP and the (latest) Egesen glacier oscillation effectively scoured the basin leaving a shallow layer of basal till (~1.4 x 10^6 m^3; 8 % of entire basin storage). Total (postglacial) sediment storage amounts to ~19.7 (18.3) x 10^6 m^3. Single landform volumes range from ~0.03 (0.01) - 6.26 (5.97) x 10^6 m^3, whereas hillslope storage overbalance basin fill deposits by a factor of five. As will be discussed, three scenarios of rockwall retreat provide relatively low rates of up to 520 mm/ka considering the highly weathered mica-schist lithology and the glacial imprint in the study area.

****

Geomorphological and climate context of debris flow regional occurrence in the Northern French Alps

PAVLOVA I.(1), ECKERT N.(2), GRANCHER D.(1), JOMELLI V.(1), BRUNSTEIN D.(1)
(1) Laboratoire de Geographie Physique, CNRS, MEUDON, FRANCE ; (2) Erosion torrentielle, neige et avalanches, Cemagref, GRENOBLE, FRANCE

The general objective of this study is to determine with high accuracy triggering factors of debris flows occurrence in the Northern French Alps over the last thirty five years. Among all factors resulting in debris flow initiation meteorological conditions and geomorphologic context are considered as the most relevant. Both factors are quite well explored separately but we have a poor knowledge about the combined analysis of both geomorphic and climatic initiation factors at regional scale.

Our multivariate statistical approach aimed to determine climate and geomorphologic parameters responsible for debris flow activity changes on the base of one probabilistic model. A hierarchical Bayesian annual logistic regression probability model of debris flow triggering was fitted between the climate characteristics and geomorphic catchment characteristics over the last 35 years. Individual catchment characteristics of nearly 300 debris flow events consisted of morphometric (altitude of the area, exposure, mean slope and others) and qualitative (dominant lithological type, dominant land use type) data. Regional annual meteorological parameters (such as mean annual temperature and precipitation) were computed from mean values of reanalyzed Safran data.

Globally, hierarchical probabilistic analysis demonstrates a dominant influence of geomorphological parameters (55%) compared with climate parameters (29%) in the explained regression. Such global approach gives better estimates of triggering probabilities and highlights new significant variables compared with climatic and geomorphic variables analyses separately. Most significant geomorphological factors explaining debris flow spatial variance were surface area and presence of specific land use type, whereas mean slope or lithological type parameters are less important. Temporal regional changes are explained by annual number of rainy days and maximum temperature.

Geomorphic change detection using LiDAR DTMs in two small basins of the Italian Alps

GOLDIN B.(1), CAVALLI M.(1), BRARDINONI F.(2), COMITI F.(3), MARCHI L.(1)

(1) CNR - IRPI, PADOVA, ITALY ; (2) Department of Earth and Environmental Sciences, University of Milano-Bicocca, MILANO, ITALY ; (3) Faculty of Science and Technology, Free University of Bozen-Bolzano, BOLZANO, ITALY

The description and quantification of landscape changes as modulated by geomorphic processes, at different spatial and temporal scales, constitute the core of modern geomorphic research. The high resolution and accuracy of currently available airborne digital terrain models (DTMs) allow the development of new methods for the quantitative monitoring of geomorphic changes. In this context, DTM of difference (DoD), which can be created by subtracting one elevation model from another, represents a convenient way to estimate volumetric changes across landscape components between successive topographic surveys.

In this contribution we quantify the topographic variations associated with the activity of rapid geomorphic processes (e.g., debris slides and debris flows) in Gadria and Strimm catchments, two adjacent basins, covering a total area of 14.7 km^2, in the Eastern Italian Alps. To this purpose we perform DoD on two LiDAR-derived DTMs (2 m resolution), acquired respectively in the summer of 2006 and 2011, applying a fuzzy logic-based method (Wheaton et al., 2010) which considers the uncertainty in the surface representation of the topographic data.

Results indicate that shallow rapid failures and channelized processes such as debris flows and debris floods have been by far the dominant processes in both basins over the study period. In particular, we are able to track the effects of a debris-flow event (July 12^{th} 2010) originating on the western slopes of Strimm basin and that has been estimated to transport 15,000 m^3 of sediment down to the confluence with Gadria Creek. Not surprisingly, upland terrain characterized by subdued topography and dominated by slow periglacial processes does not exhibit any appreciable change.

Reference: Wheaton J.M., Brasington J., Darby S. E., Shear D. A., 2010. Accounting for uncertainty in DTMs from repeat topographic surveys: improved sediment budges. Earth Surface Processes and Landforms, 35, 136-156.

****

Temporal variations of bedload transport in a glacierized mountain basin

COMITI F.(1), DELL'AGNESE A.(1), MAO L.(2), ENGEL M.(1), LUCÍA A.(1), PENNA D.(1), BERTOLDI G.(3)

(1) Free University of Bozen-Bolzano, BOLZANO, ITALY ; (2) Pontificia Universidad Católica de Chile, SANTIAGO, CHILE ; (3) European Academy EURAC, BOLZANO, ITALY

Glaciers in the European Alps have retreated substantially over the last century, but the role of their remaining portions on downstream channel dynamics is presumably still relevant. However, only few studies have analyzed the influence of the hydrological regime on sediment transport processes in glacier-fed streams.

This contribution will present sediment transport measurements associated to a water runoff analysis in the Saldur basin, a high-elevation glacierized watershed (19 km^2 drainage area, 3 km^2 covered by a glacier) lying in the Eastern Italian Alps. Bedload transport is monitored continuously at 2100 m a.s.l. by means of a hydrophone and by fixed antennas for tracing clasts equipped with PITs. Bedload samples are collected at the same location and at a cross-section further upstream (drainage area 11 km^2) by using “Bunte” bedload traps. Turbidity is measured continuously by a fixed turbidimeter installed at the lower section and by a portable one at the upper section during bedload sampling times. Water samples are collected at different sources and sections in order to assess the spatial and temporal variability of tracers (i.e. electrical conductivity and stable water isotopes) in the channel network.

In the period 2011-2013, bedload was sampled from June to August during daily discharge fluctuations associated to snow- and glacier-melt, up to near-bankfull conditions. These daily cycles showed variations of electrical conductivity and isotopic content of stream water which permitted to assess the relative contribution of snow and ice to the total runoff. Parallel cycles in suspended and bedload transport were detected, and most importantly bedload transport rates turned out significantly higher - for the same discharge range - during August glacier-melt flows. Season-dependent hysteresis effects in bedload transport were also observed, likely due to the activation of different sediment sources.

Root-exposure: a new tool to quantify medium term erosion rates in gypsum areas (Massif de la Vanoise, France)

ROVERA G.(1), CORONA C.(2), LOPEZ SAEZ J.(3), STOFFEL M.(4)
(1) University J. Fourier, laboratory PACTE UMR5194 CNRS, GRENOBLE, FRANCE ; (2) Laboratory GEOLAB UMR6042 CNRS, CLERMONT-FERRAND, FRANCE ; (3) IRSTEA UR EMGR, laboratory PACTE UMR5194 CNRS, GRENOBLE SAINT MARTIN D'HERES, FRANCE ; (4) Laboratory of Dendrogeomorphology, University of Berne, BERNE, FRANCE

In the Northern Alps, gypsum slopes are subject to intense erosion (karstic forms and gullies). Many studies have been carried out on the meteorological degradation of carbonate outcrops, but only a few exist to date on gypsum. In the Vanoise Massif (French Alps) erosion rates were obtained with surface elevation change-based methods and the monitoring of weight and volume losses of calibrated gypsum tablets. Measurements indicate denudation rates between 3 and 6 mm yr^{-1} in the subalpine zone (1800–2100 m a.s.l.).

On forested slopes, such continuous denudation processes are sufficient to expose roots while allowing them to keep their tips in the ground. In the past, the assessment of erosion rates based on root exposure has been applied successfully on a large variety of lithologies (marls, quaternary deposits), in climatic contexts where tree growth is restricted but where annual increment rings are therefore being formed. In this study, data from continuous field monitoring based on micrometric method and gypsum tablets covering the past 10 years, have, for the first time, been compared with an alternative method based on dendrogeomorphology. A total of 45 exposed roots of *Pinus montana* were sampled in the gypsum bad lands and the anatomical variations in annual growth rings due to exposure caused by denudation were analysed. The first year of exposure was determined via the peculiar size reduction of earlywood tracheids.

The medium-term erosion rates (4–5 $mm.yr^{-1}$) as observed in the root-ring series match with erosion rates derived from monitored iron stakes. The detailed knowledge of anatomical changes in roots is though demonstrated a powerful tool for geoscientists to quantify minimal rates of soil erosion in areas where measurements of past processes are not readily available.

****

Glacial chronology in the Mérida Andes, Venezuela, deduced from cosmogenic 10Be radionuclide dating

ANGEL I.(1), CARCAILLET J.(2), CARRILLO E.(1), AUDEMARD F.(3), BECK C.(4)
(1) Universidad Central de Venezuela, CARACAS, VENEZUELA ; (2) ISTerre, Université de Grenoble 1, GRENOBLE, FRANCE ; (3) Fundación Venezolana de Investigaciones Sismológicas, CARACAS, VENEZUELA ; (4) ISTerre Université de Savoie, CHAMBERY, FRANCE

The Merida Andes are located in the west of Venezuela, in northern South America. This cordillera extends over 400 km and reaches a maximum elevation of ~5000 m. Despite numerous descriptions of glacial landforms, lack of available data prevents detailed reconstruction of the last deglaciation. This study documents the post-Last Glacial Maximum (LGM) glacier history using *in-situ* produced cosmogenic ^{10}Be nuclides. Samples were collected in the Mucubají and Gavidia valleys. In the Mucubají valley, the LGM has been identified as the most important phase for moraine development. The oldest evidence of glacier advance has been dated at ~18 ka, while the end of the LGM *s.s.* has been dated at ~16.5 ka. The youngest evidence of glacier activity was observed at 4000-4200 m elevation and dated at ~9.2 ka. The dataset evidences intensification of the vertical ice retreat rate from ~25 m/ka during upper Pleistocene to ~310 m/ka during early Holocene. In the Gavidia valley, results suggest that main of the glacier retreat occurred during the Holocene with ages ranging between ~4.7 ka to ~9.6 ka with a vertical retreat rate of ~270 m/ka. The dataset provides the first complete chronology of ice retreat in the tropical Venezuelan Andes. Moreover, our data have been compared with local and global paleoclimatic records. All the significant ice retreat phases are associated with global warming periods.

Terrestrial cosmogenic nuclides dating of a sackung on a cirque in the Japanese Alps

NISHII R.(1), MATSUSHI Y.(2), MATSUZAKI H.(3)
(1) University of Tsukuba, SHIZUOKA, JAPAN ; (2) Kyoto University, UJI, JAPAN ; (3) The University of Tokyo, BUNKYO, JAPAN

Sackung features (scarps) have widely developed around Mt. Noguchigoro (2924 m a.s.l.), Northern Japanese Alps, as a result of gravitational deformation. These scarps are distributed in the upper slopes which consist of Cretaceous granite. In particular, a large scarp (400 m long and 8 m high) lies on a cirque wall which experienced deglaciation after the Last Glacial Maximum. To evaluate gravitational deformation in the cirque after deglaciation, the concentration of cosmogenic nuclides (^{10}Be and ^{26}Al) was measured in the scarp face (slip plane); Two samples were taken at ca. 70 cm and 270 cm vertical distance from the top of the scarp. In addition, the timing of glacier retreat and the activity of debris production were also evaluated from dating of roche moutonnee and gravels rolled down from the cirque wall, respectively. The results indicated that the concentration of cosmogenic nuclides at the upper part of the scarp was four times higher than that at the lower part. Such a concentration difference in the same scarp suggests that the scarp had grown slowly or step-by-step. The minimum exposure age showed that the glacier retreated during 8–11 ka. Then, the scarp started to grow at 6 ka at least. The growth of the scarp seems to have accelerated at or after 1.5 ka. Such a change in the rate may reflect climate change (increase of precipitation) and/or earthquake activity.

****

Geomorphic landscape evolution along the river valleys in Ladakh region of NW Trans Himalayan range during Late Quaternary: implications to climate and tectonics

PHARTIYAL B.(1), SINGH R.(1), NAG D.(1), KOTHARI G.C.(2)
(1) Birbal Sahni Institute of Palaeobotany, LUCKNOW, INDIA ; (2) Institute of Seismological Research, GANDHINAGAR, INDIA

The Himalayan system is a complex and youngest fold mountain chain, which stretches across six countries-Afghanistan, Pakistan, India, Nepal, Bhutan and China. The Trans Himalayan sector exhibits a cold desert environment and is a part of the rain shadow area for the ISM and comes under the Westerly influence. The area receives an annual rainfall of around 30 mm and is dry and barren. Indus river and its tributaries Shyok, Nubra and Tangtse are major drainage patterns and all have played a major role in shaping the geomorphology of this region. These rivers follow courses along major tectonic fault/thrust lines; Indus Suture Zone, Shyok Suture Zone and Karakorum fault. The river valleys have enormous Quaternary deposits of glacial, lacustrine, palaeo-lacustrine, fluvial and aeolian origin. The major geomorphic landforms are U-shaped glacial valleys, gorges, glacial moraines, fill terraces, strath terrace, alluvial fans, debris cone, lacustrine deposits, varves, deflected stream courses, scree and talus cone, fossil valleys, abandoned channels, etc. The sedimentary records represent the changes in melt water and rainfall related hydrology of the river. The geomorphological landscape of young fold mountain belt can change drastically even within short time scales of few thousand of years. The existence of a 185 km valley lake during the Late Quaternary occupying the present day Tangtse and Shyok river valleys is one such example. Our Studies suggest that several lakes occupied parts of these river valleys at 40-30, 20-3 ka BP in Tangtse-Shyok sector and 17-14 ka BP and 12-3 ka BP along the Indus river valley. We have attempted to build geomorphic evolution history from ~50 ka to present in this region. Lying in the vicinity of the major fault lines tectonic disturbances is also evident in deformed lacustrine sediments and moreover these lakes are formed due to the damming of the rivers by different landslides (either due to tectonic activity or abrupt monsoon event).

Consequences of a subglacial lake outburst flood for a proglacial fluvial system (Fagge River, Kaunertal, Austria)

MORCHE D., BAEWERT H.
Martin-Luther-University Halle-Wittenberg, HALLE, GERMANY

Recently deglaciated glacier forefields in high mountain geosystems are mainly covered by unconsolidated glacial and glacio-fluvial deposits such as (ice-cored) moraines and braid-plains. These sediment stores are vulnerable to surface changes.After deglaciation melt water channels are “imprinted” in the proglacial landscape either in the bed rock or as braided channels on outwash plains. The proglacial area of the glacier Gepatschferner (Ötztal Alps, Austria) is drained by the Fagge River. The river originates from two glacial meltwater channels which were separated by ice-cored moraines proximal to the glacier and further downstream by rouche mountonees. This landform configuration was valid for the last decade after deglaciation as analyses of aerial photographs show. The right channel is 10 m wide and has incised several meters in bed rock. The left channel had a width of about 2 m and run in a moraine-covered small valley. The relief between the higher right channel and lower left channel is 20 m. Concurrent discharge measurements in both rivers have shown that 90 % of the total melt water was discharged in the right channel.

During the 26th August 2012 a sudden partial collapse of the glacier tongue occurred and a subglacial lake outburst flood breached the moraine ridge which divided the two meltwater channels. This event has caused severe geomorphologic changes in the downstream course of the Fagge River. These consequences are comparable to outburst floods from landslide- or moraine-dammed lakes. Since the flood the drainage pattern has completely changed and >99% of the melt water is discharged through the left channel. In order to quantify surface changes of different sediment stores in the forefield of the Gepatschferner terrestrial and airborne laser scanning surveys are carried out. Starting our laser scanning survey a few weeks before the flood event we present a sediment balance of the glacier forefield based on pre-and post-event data .

****

Ground ice distribution in a high mountain sedimentary environment and its influence on sediment fluxes and local hazards: results of geoelectrical tomography in the Rognes sector (Mont-Blanc, France)

BOSSON J.B.(1), BODIN X.(2), DELINE P.(2), SCHOENEICH P.(3), BARON L.(4), GARDENT M.(2), KRISIECKI J.M.(3), LAMBIEL C.(1)
(1) Université de Lausanne - IGD, LAUSANNE, SWITZERLAND ; (2) Laboratoire EDYTEM, Université de Savoie, CNRS, LE BOURGET-DU.LAC, FRANCE ; (3) Institut de Géographie Alpine, PACTE/Territoire, Université Joseph Fourier, GRENOBLE, FRANCE ; (4) Université de Lausanne - CRET, LAUSANNE, SWITZERLAND

The major crisis experienced by the mountain cryosphere in response to climate change arises critical issues, especially because of the high energy potentially involved in the mobilization of large amount of rock/debris and ice/water. Such cold geomorphic systems respond in a complex way to the global warming, in particular through para- and periglacial processes of unusual intensity and rate that can be a source of hazards.

In high alpine areas, the dynamics of large sediment volumes are closely related to ground ice occurrence: a sound knowledge and understanding of the ground ice distribution and dynamics is therefore required.

Constituted from several sediment accumulations (glacier forefields, push moraines and rock glaciers), the Rognes ridge area (2450 – 3050m a.s.l) is one of the largest sector that contains ground ice in the Mont-Blanc Massif. We present here the main results of an electrical resistivity tomography (ERT) campaign held in August 2012 in order to characterize the internal structure of the landforms. The 10 48-electrode and the 5 24-electrode ERT profiles yeld the following findings:

- Rognes area: a continuum between the upslope debris-covered glacier, the ice-free glacier forefield and frozen marginal push moraines. Because of the topography, the ice cementation of the distal part and the absence of efficient connection with hydrosystem, this continuum is a transport-limited system.
- Pierre Ronde area: an ice-free glacier forefield and a marginal rock glacier. Local till of this sector was the main solid supply of the water-pocket outburst of the Tête Rousse glacier in 1892. Our surveys show that, in case of a repeated water-pocket outburst, more than 10m thick of unfrozen till could be mobilized in the main channel flow.
- Dérochoir area: a talus-derived hanging rock glacier feeding torrential stream paths. The torrential crisis experienced by the torrent during the 19th century may be directly linked to rock glacier activity.

Influences of Snow Cover on Permafrost in unstable Rock Walls

DRAEBING D.(1), KRAUTBLATTER M.(2)
(1) Department of Geography, University of Bonn, BONN, GERMANY ; (2) Monitoring, analysis and early warning of landslides, Technische Universität München, MÜNCHEN, GERMANY

Degrading permafrost in rock walls can cause instabilities due to changes in rock- and ice-mechanical as well as hydraulic properties. Snow cover can alter thermal and mechanical processes. We used seismic refraction tomography (SRT) to evaluate the degradation of permafrost in steep rock walls. Five parallel NE-SW transects were installed across a crestline in the Steintaelli, Matter Valley, Switzerland, at 3070-3150 m a.s.l.. Time-lapse p-wave velocity measurements were performed in the summers 2006, 2007 and 2012. August 2012 was the second warmest month ever measured after the heat summer of 2003.

(i) Snow depth was evaluated qualitatively 2006 and 2007 by digging snow pits as well as quantitatively with snow poles in 2012. Snow accumulates as a snow cornice on the crestline, as patches on rock ledges and on footslopes.

(ii) In the laboratory, p-wave velocities of Steintaelli rock samples were measured (Draebing & Krautblatter, 2012, doi:10.5194/tc-6-1163-2012) to use the results as a priori information for field measurements and to develop permafrost scenarios for the resulting SRTs.

(iii) Time-Lapse SRT was used to monitor monthly, annual and 6-year alterations of the thawing front. In 2006, the tomographies display ice-filled fractures and permafrost in depths of 4-8 m. Due to lateral onfreezing of glacierets and a persistent snow cornice, permafrost was obtained close to the surface in 2007 (Krautblatter & Draebing, in review). In 2012, the second warmest august since 2003 in combination with a little expanded snow cornice permafrost was degraded to depths of 5-15 m.

Here we show, that (1) snow cover significantly influences permafrost in steep unstable high-alpine rock walls and (2) p-wave refraction seismics is capable of measuring and monitoring permanently and seasonally frozen rocks.

****

Mapping and modelling the discontinuity of mountain permafrost: a challenging task

LAMBIEL C.(1), DELALOYE R.(2), DELUIGI N.(1), SCAPOZZA C.(3), BOSSON J.B.(1)
(1) Institute of geography and sustainability, University of Lausanne, LAUSANNE, SWITZERLAND ; (2) Department of Geosciences, Geography unit, University of Fribourg, FRIBOURG, SWITZERLAND ; (3) University of Applied Sciences and Arts of Southern Switzerland (SUPSI), LUGANO, SWITZERLAND

In the mountain periglacial belt, the geomorphology, the topography and the surface characteristics may vary strongly on very short distances. This leads to strong variations of the ground (surface) thermal characteristics from one location to another one, which has a strong impact on the permafrost occurrence. To get a precise knowledge of how permafrost is distributed at the local scale, large efforts of field data acquisition must be realized.

At the Universities of Lausanne and Fribourg, many field campaigns were carried out during the last 15 years in the Western Swiss Alps. They permitted to create adatabase composed by around 150 electrical resistivity tomography profiles, more than 200 vertical electrical soundings, a hundred of apparent resistivity mapping lines, about ten seismic refraction tomography profiles, 16 boreholes equipped with temperature sensors and more than 500 ground surface temperature locations. This database reveals an extremely large discontinuity in the permafrost distribution.

Modelling such a complexity is a challenging task. In order to reproduce the spatial heterogeneity of the phenomenon at the local scale, we tried recently to use Machine Learning algorithms to propose a new approach for mountain permafrost modelling (Deluigi & Lambiel 2012). The basic concept of Machine Learning is that the machine learns from the data. The first results show that, if the dataset is large enough, the high spatial discontinuity of mountain permafrost can be successfully represented. For instance, rock glaciers can be automatically recognized and, in some cases, permafrost is designed only in the lower part of talus slopes, which corresponds to several field data.

Deluigi N., Lambiel C. (in press). PERMAL: a machine learning approach for alpine permafrost distribution modeling.*Actes du colloque de la Société Suisse de Géomorphologie, 29 juin – 1er juillet 2011, St-Niklaus*

Permafrost landforms in the Tröllaskagi peninsula, northern Iceland - implications for the deglaciation pattern

LILLEØREN K.(1), GÄRTNER-ROER I.(2), ETZELMÜLLER B.(1)
(1) Department of geosciences, University of Oslo, OSLO, NORWAY ; (2) Department of geography, University of Zürich, ZÜRICH, SWITZERLAND

In northern Iceland, relict rock glaciers are observed close to the present sea level. This observation has implications for how to interpret the deglaciation of this region, as the large relict rock glaciers must have required millennia of ice-free conditions in order to form. The formation of rock glaciers and long-lasting stable ice-cored moraines is constrained to areas subjected to permafrost, and the presence of such landforms is used as a direct indicator of present or former permafrost conditions. In the present study we used recently published air photos (2002-07), ALOS PALSAR data (2007), MODIS land surface temperature data (2003-2010) and field mapping, to systematically re-examine the Tröllaskagi peninsula for permafrost landforms. In this re-examination, intact and relict rock glaciers were separated by strict geomorphological criteria, i.e. surface structure, front slopes and vegetation cover. We also consider ice-cored moraines to be indicators of permafrost, if they appear stable and 'oversized' compared to the upslope glaciers. Ice-cored moraines are considered active features when they appear stable, but do not necessarily possess indications of creep.

This study will discuss present and relict permafrost distribution based on the mapped rock glacier and ice-cored moraines in Tröllaskagi. In addition, various characteristics of the landforms such as the state of activity are given. This study supports a previous permafrost landform inventory which indicated evidence of typical rock glacier formation at low elevations, indicating long ice-free and cold periods prior to the onset of the Holocene Thermal Maximum.

****

Possible climatic controls on the recent (2004-2013) variations of surface displacements of cryospheric landforms in an Andean environment (Chile, 33°S)

SCHIAVONE S.(1), BODIN X.(1), BRENNING A.(2), AZOCAR G.(2), QUENSE J.(3)
(1) Laboratoire EDYTEM, CNRS / Universite de Savoie, LE BOURGET DU LAC, FRANCE ; (2) Department of Geography and Environmental Management, University of Waterloo, WATERLOO, CANADA ; (3) Instituto de Geografia, Pontificia Universidad Catolica de Chile, SANTIAGO, CHILE

In semi-arid Andes, the dynamics of debris-covered glaciers and rock glaciers, in which large volumes of ice are stored, is of great significance for the hydro- and geosystems as it can influence water resource and natural hazard management strategies in inhabited areas. The effects of climate change on those cryospheric landforms are poorly known yet, but they might strongly depend on properties of the surficial debris layer and on the seasonal variations of the snow cover.

In this work, we monitored displacements of a hundred marked blocks with annual and pluri-annual differential GPS campaigns on a complex of one debris-covered glacier and two rock glaciers in a watershed that provides up to two-thirds of the drinking water supplies to Santiago, Chile. In parallel, a thermal monitoring has been ongoing since 2009 thanks to 45 stations spread over the debris-covered glacier and the rock glaciers. It records hourly the temperature and the presence/absence of snow at the ground surface and 50 cm above.

Over the whole studied period, the 3D velocity ranges from a few cm/yr up to 6 m/yr. A clear distinction can be made between debris-covered glacier patterns and rock glaciers ones. The former is characterized by a vertical change that can exceed the horizontal component due to high ice-melting rates. The latter have a horizontal component comparatively higher because of a movement mostly dominated by creeping, ice being protected from fusion by a thick debris layer. The seasonal velocity decomposition shows that 67-84 % of the rock glacier displacements are experienced during austral summer (dec. to apr.), moreover a significant speed up was measured in 2010-2011.

Using data from local weather stations, it is then discussed how nivo-meteorological conditions may influence the thermal regime of the monitored landforms, and consecutively, how it may control both ice-downwasting and creeping processes.

The climatic significance of relict periglacial landforms in the New England Tablelands, Australia

SLEE A.(1), HAWORTH R.(2), GONTZ A.(3), SHULMEISTER J.(1)
(1) School of Geography, Planning and Environmental Management, University of Queensland, BRISBANE, AUSTRALIA ; (2) School of Behavioural, Cognitive and Social Sciences, University of New England, ARMIDALE, AUSTRALIA ; (3) Department of Environmental, Earth and Ocean Sciences, University of Massachusetts-Boston, BOSTON, UNITED STATES

While no permafrost landforms have been discovered In Australia, relict cold climate landforms that have formed by diurnal freeze-thaw processes are widespread in the Australian Alps and Tasmania (Barrows et al. 2004). However the altitude distribution and northern extent of periglacial landforms in Australia has been poorly documented. An important paper by Galloway (1965) suggests that during the Last Glacial Maximum periglacial climatic conditions may have been active as far north as the Northern New England Tablelands (New South Wales) at approximately 30°S. However to date no definitive periglacial landforms have been documented north of the Australian Alps at 35°S.

Here we report results from work aimed at testing the existence of late Quaternary periglacial landforms on the New England Tablelands. We have identified several locations near Guyra (30°13'08 S : 151°40'18 E, 1330m asl) where block slopes and solifluction lobes of apparent periglacial origin are present. The sites are extensive (tens of hectares in extent) but are all confined to south and south-west facing slopes. They occur at moderate elevations between 1200 and 1350 m, well below the highest peaks at c. 1500m. Cumulatively, the geomorphology is diagnostic of severe freeze-thaw environments and is the dominant landscape element on these southerly slopes.

Temperature logging of the best developed site over the last year indicates that freeze thaw processes are still very active at the site at the present day but cannot be responsible for the key periglacial features we have identified. At this site a probable nivation hollow bounded by a protalus rampart suggests that there was significant seasonal snow accumulation in the past. We conclude that freeze-thaw processes are significant at the present day but that the main landscape modification happened under colder conditions.

****

Poster presentations:

Hypsometry of glaciated basins upon the Kamchatka Peninsula

BARR I.D.
Queen's University Belfast, BELFAST, UNITED KINGDOM

Hypsometry (distribution of land surface area with altitude) has been variously used to classify landscapes according to their geomorphic development. Here, the hypsometry of glaciated basins is used to assess the relative importance of glacial erosion and tectonic uplift in shaping the mountains of the Kamchatka Peninsula (Eastern Russia). This is achieved through consideration of hypsometric curves, hypsometric integrals, altitude frequency-distributions, Last Glacial Maximum equilibrium-line altitudes (LGM ELAs), cirque floor altitudes, and geomorphological indicators of former ice velocity. These attributes are analysed at a basin (catchment) scale, and it is argued that: (i) inter-basin variations in land-surface hypsometry are partly governed by variations in the intensity of former glacial erosion; (ii) in northern and southern sectors of the peninsula, an efficient glacial buzzsaw has limited mountain topography; and (iii) elsewhere, a number of high peaks appear impervious to topographic restrictions imposed by the glacial buzzsaw. Thus, the topography of the region is a function of neotectonics and Late Quaternary glaciations.

Debris flow hazards in high mountain area, Moxi basin, Southwestern of China

TIE Y.
Chengdu Center of China Geological Survey, CHENGDU, CHINA

Moxi basin in southwestern of China is a unique high mountain region with high geo-dynamics activity, strong glacier erosion, strong freezing process and vulnerable geo-environment, this condition favors the form of debris flow. During the past 20 years, tourism resource exploitation in this region has experienced rapid economic growth. However, there are near 4000 local residents and more than 170 millions dollars wealth are vulnerable to 49 debris flow gullies. The potential risk from debris flow hazards in Moxi basin is a prominentproblem.

Most of the debris flows initiate at high elevation, ranging from 2000 to 4500 m. These loose sources are mainly from moraine which distributed in Moxi basin widely. Based on the field survey and statistic, the potential volume of unstable moraine which in Moxi Basin is $3012\times10^4 m^3$, and the volume of loose moraine which can becoming the resource of debris flow directly is $1247\times10^4 m^3$.The starting zones of debris flows correspond to the uppermost occurrence of loose moraine, often located at the front of glacier, upstream or middle stream of stream, time range from early Gongga Ice Age to Little Ice Age. These moraines consist of thick 50-300m, wide distribution and instability. Under the erosion process, there moraine has been incised strongly, the erosion depths range from meters to decameters, with steep gully slope 40～80° , volumes range from several thousand cubic meters to ten billion cubic meters.

Topographic features of debris flow gullies have been calculated using GIS software. The analysis shows that 73.5% of the debris flow gullies are not randomly distributed but concentrated directly adjacent to the western side of Moxi gully, and only 26.5% are located to the eastern side. The numbers, frequency, catchments area, gully length, gully slope ratio of these debris flow gullies in Moxi basin were controlled by the glaciations and Moxi fault.

****

Hydrospatial assessment of streamflow yields and effects of climate change in the Australian alps

REINFELDS I.(1), SWANSON E.(2), COHEN T.(2), NOLAN A.(3), WILLIAMS S.(1)
(1) NSW Office of Water, WOLLONGONG, AUSTRALIA ; (2) University of Wollongong, WOLLONGONG, AUSTRALIA ; (3) Snowy Hydro, COOMA, AUSTRALIA

Australia's limited alpine areas form a critically important watershed, providing a reliable water source for the world renowned Snowy Mountains hydro-electric Scheme (SMS) and 40% of Australia's irrigated agriculture. During the development of the SMS, the Snowy Mountains were subject to the most intense hydrometric effort ever undertaken in Australia, averaging one gauging station per 75 km^2. GIS-based hydrospatial analysis of annual streamflow yields, catchment area-average annual precipitation and catchment topographic indices for 112 gauging stations demonstrates that elevation is the primary control on precipitation and yields. Catchments with mean elevations greater than 1850 m show a steep increase in yield over lower elevation catchments and have runoff coefficients greater than unity, a situation that is partly attributable to deep accumulations of drifting snow across the highest peaks of the Australian alps. Annual precipitation across the highest elevation catchments shows strongly significant declines of up to 11.0 mm yr^{-1} from 1944-2009, with the magnitude of precipitation declines increasing with elevation. Despite the magnitude of precipitation decreases, only the rivers that have the longest ongoing records dating to the mid-1950s show significant decreasing trends in annual runoff. Annual runoff coefficients for Australia's highest elevation river (the Snowy River), however, show a significant increasing trend since the 1950s due to drying of hydrophobic alpine humus soils, providing a buffering effect for streamflow yields against precipitation declines. Climate change effects on the timing of peak snowmelt discharges for the highest elevation rivers are pronounced. Regression analyses for the Snowy and Geehi Rivers show strongly significant shifts toward earlier peak discharges of 6.2 and 4.0 days per decade, respectively, in the ordinal (Julian) day of peak snowmelt discharges since the 1950-60s.

An inventory of the glaciers in the French Alps at the end of the Little Ice Age

GARDENT M.(1), DELINE P.(1), SCHOENEICH P.(2)
(1) EDYTEM - University of Savoie, LE BOURGET DU LAC, FRANCE ; (2) PACTE, University of Grenoble, GRENOBLE, FRANCE

In spite of short advances, glaciers in the Alps are shrinking since the termination of the Little Ice Age (LIA). Before our study, there was no exhaustive data about glacial retreat between the end of the LIA and the 2000s for the whole French Alps. In order to fill this gap, an inventory of past (LIA) and present (2006-09) glaciers was realized and integrated in a GIS. Glaciers outlines of the present glaciers were manually delineated using 50-cm-pixel orthophotographies from 2006 to 2009. The LIA glacier inventory is based on reconstruction of the glacial extension through photo-interpretation, geomorphological field work, and analysis of old documents.

Two kind of geomorphic data were collected: (i) landforms and formations (till, moraines, roches moutonnées) that record the Little Ice Age glacier extension; (ii) markers of active processes (e.g. debris-flow, glacial lake outburst flood, landslide in moraine) that inform about potential instabilities, as these markers are the base for the recognition of areas prone to glacial-related hazards (EU-funded project *GlaRiskAlp*, Alcotra France-Italy). All these geomorphological data were integrated in a GIS.

Results for the whole French Alps will be presented. In the Vanoise massif for instance, the present glacier area is 92.5 km², ~ 60 % less than at the end of the LIA when the glacial extension was about 236 km². Some variations in the retreat rate are observed across the massif, from the strong post-LIA glacial retreat in the Péclet-Polset area (-60%) to the slightly lower one for the Glaciers de la Vanoise (-50%). Results of our study about parameters that control this glacial retreat since the LIA will be exposed.

****

Using soils to reconstruct geomorphological history of a puzzling cirque in the Colorado Front Range

TEMME A.(1), DECHIER D.(2), BIRKELAND P.(3), SCHWERING M.(1), DIEK S.(1)
(1) Wageningen University, WAGENINGEN, NETHERLANDS ; (2) Williams College, WILLIAMSTOWN, MA, UNITED STATES ; (3) University of Colorado, BOULDER, CO, UNITED STATES

4thof July cirque in the Colorado Front Range of the Rocky Mountains presents a number of puzzling questions related to the relative and absolute timing of minor early Holocene glaciations and other landscape features. Answering these questions is not easy, as evidenced by a number of conflicting interpretations in literature. Yet it is important, because it allows us to find out how the relatively arid Front Range has reacted to post-glacial climatic fluctuations.

We use soil chronology techniques that were pioneered in this mountain range, radiocarbon and luminescence dating to shed additional light on the area's history. Soil chronology results, based on the total amounts of iron and clay in the soil, suggest that existing relations between soil properties and age do not hold for this, highest part of the range. We suggest an extension to these relations, and use it to assign relative ages to the soils in the cirque and by extension the landforms that they cover. We discuss the strength of the soil-landform relation, illustrated by repeat soil observations on the same landforms. Radiocarbon and OSL dating support our main argument that soils and landforms in the cirque date from after the last glacial maximum, in contrast with some of the literature about the area. The extended relation between soil property and age is considered to be useful in wider areas of the Colorado Front Range.

Can we make rockfall maps using climber's books? A semi-quantitative analysis

TEMME A.(1), EGLI M.(2)
(1) Wageningen University, WAGENINGEN, NETHERLANDS ; (2) University of Zürich, ZÜRICH, SWITZERLAND

Rockfall rates in mountain ranges are expensive to measure over large spatial scales, mainly due to the inaccessibility of mountainous terrain. Existing methods to measure rockfall include acoustic, spectral and volumetric methods. These methods, especially in combination, have allowed researchers to quantitatively derive rates (and changes of rates over time) of rockfall for several well studied locations.

However, the small spatial support of these methods means that results are only valid for small well-studied locations. This is a problem when we need information on rockfall rates over entire mountain chains and ranges – which is important to study their temporal distribution and their relation with climate change. This contribution explores the potential of information contained in climber's guidebooks to derive qualitative rockfall rates with large spatial and temporal coverage.

Climber's guidebooks have been published since the early 1900's, giving prospective mountaineers strongly codified information about routes and conditions expected along the way. The information about the looseness of rocks, which is clearly important for climbers from a safety perspective, may be linked to rockfall rates. I have used a series of guidebooks published at irregular intervals for the Bernese Oberland in Switzerland to study the change in descriptions of looseness of rocks for a number of famous climbing routes. These routes were selected because of the opportunity to complement information in guidebooks with other (visual and written) sources of information.

Results indicate that descriptions of looseness of rock can be used to derive a qualitative pattern of rockfall, especially over larger spatial scales. The value of the information is also valuable as a link to temporal changes in rockfall rates, but this use is hampered by the fact that text is sometimes copied between successive guidebooks without a stringent reassessment of actual conditions on the route.

****

Debris flows and relief evolution in the Tatra Mountains

KOTARBA A., RACZKOWSKA Z.
Institute of Geography and Spatial Organisation, PAS, Department of Geoenvironmental Research, KRAKOW, POLAND

Role of debris flows in the recent evolution of the high-mountain landforms in the Tatras is evaluated based on results of 20-years long field studies and interpretation of satellite images.

Geology, climate and vegetation are there differentiated both vertically and horizontally. The varied influence of glacial and periglacial morphogeneses in the Pleistocene made the Tatric slopes sets up different conditions for debris flows. In the High Tatra narrow crests and rockwalls dissected by rocky chutes (density 8-17 km/km²) with talus slope below predominate. In the Western Tatra ridge culminations, gradually change from gently inclined near-ridge slope segments into rocky slopes dissected by chutes (density 6 km/km²) with alluvial-avalanche fans below. The Belianske Tatry have a shape of asymmetric ridge of *crete* type.

Debris flows are dominant process which model the present-day relief of the Tatric slopes. They may develop in all geoecologic zones, although their relief-forming role is most apparent in the cryonival morphogenetic domain above the upper timberline. Over 3.5 thousand modern tracks occur in that small massif. The most of them (2300) and the largest forms (up to 1000 m long) are in the High Tatra. Sizes, number and distribution of the debris flows depend mainly on local topography and substrate properties.

Extreme rainfalls during summer seasons are the main trigger of debris flows. The latter are generated most often during short-lasting storms and very intensive convection precipitation confined to small areas. Therefore there is no clear relation between periods with high daily precipitation and debris flows. The minimum amount of rainfall, which can trigger a debris flow is 20 mm per hour. The zone of the highest precipitation on the northern side of the Tatra massif (1400-2000 m a.s.l.) co-occurs with the zone where the debris flows start (1290-2390 m a.s.l.), which emphasizes the role of precipitation in present-day relief evolution of the Tatras.

Megafans and outsize fans in the Tirol Alps - incremental, episodic, or catastrophic ?

JARMAN D.
mountain landform research, GLASGOW, UNITED KINGDOM

A sequence of anomalously large debris fans emanating from tiny catchments occupies much of Vinschgau, South Tirol. The most extensive, the 11 km-long Malser Haide, has been published (2011) as a 1650 Mm^3 deposit with a reconstructable lost mountain of comparable volume above the side valleyhead. An even greater deposit of 2200 Mm^3 has been calculated (INQUA 2011) for the Allitz-Laas cone, again with a reconstructable lost mountain (Gadriaspitz) suggesting a catastrophic event or possibly a few large episodes.

Conventional interpretations for such fans assume incremental build-up by alluvial or debris-flow processes during numerous rainstorm events over the Holocene. However limited historical and archeological evidence suggests such processes often only rework or veneer pre-existing large landforms. The source catchments for incremental fans should be characterised by intense gullying and/or abundant small scars, rather than one or a few large cavities. Examples include Illgraben, upper Rhône, and Mieming, Inn valley. In Vinschgau, such distributed sources are less common.

Groundtruthing now confirms reasonably reconstructable lost mountain spurs, crests, or summits for episodic/catastrophic fans in Vinschgau, Munstertal, Antholzertal, Gailtal, and around Lienz. Similar anomalous fan-cavity assemblages are scattered across the Alps, eg. in Valtellina, at Chur (Rhine), and east of Trento, but are puzzlingly hard to identify in other comparable ranges.

Until such fans can be dated, evidence for oneshot/fewshot emplacement is geomorphological, statistical, and contextual. Their concentration on the steep south side of the main Alpine divide implies a response to sustained deep incision and bulk erosion in troughs. These fan-cavity assemblages should be assessed alongside the numerous rockslides and slope deformations in the same areas as part of the large-scale mass-movement component of the glacial-paraglacial landscape evolution cycle.

****

Recent dendrogeomorphic approaches in Romanian Carpathians. Spatio-temporal reconstruction and patterns of snow avalanche activity in Făgăraș massif and Bucegi Mountains (Southern Carpathians) - Romanian Carpathians.

VOICULESCU M., ONACA A., CHIROIU P.
West University of Timisoara, Department of Geography, TIMISOARA, ROMANIA

Usage ofdendro geomorphologic method is new in Romanian geographical research.

We have doneour research in two representative mountainous areas, where avalanche activity is high and where there were recorded over time the most cases of fatalities and casualties: there are the Făgăra massif and Bucegi Mountains, located in the eastern half of the Southern Carpathians (Romanian Carpathians). In the semountainous areas, snow avalanches endanger human lives and settlements (mountain huts and shelters in our case) and cause damage to forests, infrastructure or transportation routes.

They are characterized by the highest altitudes, above 2400-2500 m and by the most important glacial relief and very dynamic periglacial processes. The climate of Făgăra massif and Bucegi Mountains is harsh, characterized by a long cold season: between 0.2 and -2.5^{o}C average annual temperature, between 1,200-1,300 mm average annual precipitations, 140-180-220 days with snow cover, between 90 and 140 days with snowfall and 8-9-11 months/year with snow cover.

Also, both mountain areas are characterized by important winter tourism practices, in many situations climbers, skiers and tourists triggering snow avalanches.

In these mountains we chose a few representative sites where avalanches have a high incidence. The purpose of our study is: (i) to continue all studies on snow avalanche occurrence and to complement existing archival records, (ii) to establish an avalanche chronology, based on frequency and return period and (iii) to validate our results of snow avalanches reconstruction with historical archives from Mountain Rescuers and with nivometeorological database from Bâlea Lake Work Laboratory- 2070 m (Făgăra massif) and Vf. Omu (2505 m) and Sinaia (1500 m) Work Laboratories (Bucegi Mountains).

Since in theRomanian Carpathians the cadastral maps of snow avalanches or risk maps are missing, we believe that our work will bring valuable insights on the phenomenon.

Two Different Example for Glacio-Karstic Evolution in Western Taurus (SW Turkey): Akdag Mountain and Dedegol Mountain

BAYRAKDAR C.(1), ÇILGIN Z.(2)
(1) ISTANBUL UNIVERSITY DEPARTMENT OF GEOGRAPHY, ISTANBUL, TURKEY ; (2) Technical and Vocational High School, ISTANBUL, TURKEY

The study areas concerned are Akdağ (3014m) and Dedegöl Mountain (2992m) which were undergone glaciations in Pleistocene. Both mountains have lots of peaks higher than 2500m and seems high massives surrounded by faults. While Akdağ is located in Teke Peninsula western Taurus, Dedegöl is located the west of Beyşehir Lake and 200km the northeast of Akdağ. Both mountains mostly consist of carbonate rocks and the karstic evolution started in Oligocene when Anatolia surfaced beneath the sea an even though it was affected by tectonic activities and climatic changes the karstic evolution has continued so far. Due to the complex structure induced by the Lycian nappes Akdağ lithological units soluble and permeable rocks from the bottom or sides surrounded by the ophiolite is dominated by shallow surface karstification, Mountain Dedegöl due to the depth of a thousand meters, continuous thick carbonate sequence is dominated by karst. This structure affected the development and spread of the Pleistocene glaciations. Accordingly, these two factors both in the mountains, and the process product were found to be polygenic. In this study the Pleistocene paleo-karst features two different mountain glaciations driven out how to explain. Pleistocene glaciations; Akdag equilibrium line altitude Wurm glaciers on the plateau-shaped depressions growth of Paleo-karst. Cave systems were destroyed by the glaciers in the mountains of Dedegöl deep glacial valleys with steep walls and created a circus. As a result, litho-stratigraphic framework of Pleistocene glaciations in the mountains the course of the two locations with the Western Taurus Mountains close to each other seriously affected areas and the distribution of polygenic has created its own. GIS, morphometric analysis, geophysical methods, sedimentological analysis and OSL dating method were used in evaluation of glasio-karst evolution.
Keywords: Akdag, Dedegöl Mountain, Glasio-karst, litho-stratigraphy, Pleistocene glaciations.

****

Relative age and Holocene distribution of permafrost in Norway

LILLEØREN K., ETZELMÜLLER B., GISNÅS K., SCHULER T.V., HUMLUM O.
Department of geosciences, University of Oslo, OSLO, NORWAY

For Scandinavia in general and Norway in particular the present regional distribution of mountain permafrost is reasonably well known, both through ground temperature measurements in boreholes, geophysical soundings and spatial modelling exercises. An important question in this context is the dynamics of permafrost during the Holocene, as a major factor for landscape development and geomorphological processes in high mountain areas of Scandinavia.

In the present study we addressed the temporal and spatial Holocene permafrost distribution in Norway by 1D heat flow modelling in well-calibrated boreholes and 2D equilibrium modelling (CryoGrid 1.0) of selected time periods. The result of this study indicates an altitudinal zonation of permafrost age in Norway; (1) permafrost has existed continuously since the deglaciation in the highest areas, (2) permafrost degradation during the Holocene Thermal Maximum (HTM), and reappearance post-HTM, and (3) permafrost only during the Little Ice Age (LIA).

These findings also have implications for the subglacial temperature regime of the late-Pleistocene glaciations. Cold-based ice is often interpreted as a deglaciation phenomenon in Norway when considering landforms such as lateral meltwater channels and the lack of for example eskers within certain regions, but an ice-sheet transgression into permafrost areas is just as likely. One can expect most of the build-up areas of the ice sheets to have been underlain by permafrost at the time, and only areas where we positively find evidence of large-scale erosional landforms (hence U-shaped valleys and fjord systems) to have been permafrost free during the glaciations. Aggrading permafrost during interstadials must also have been important for the subglacial thermal regime while new ice-sheet transgressions took place.

Postglacial rockfalls controls on environmental partitioning of the Haute-Romanche valley (Massif des Écrins, french Alps)

ROUSSEL E.(1), CHENET M.(2)
(1) Université Clermont 2, MSH, USR-3550 CNRS, CLERMONT-FERRAND, FRANCE ; (2) Université Paris 1, LGP, UMR-8591 CNRS, PARIS, FRANCE

The Haute-Romanche valley, located in the Massif des Écrins, was widely glaciated during the LGM. Nowadays, the Romanche river is an effluent of two separated glaciers: the Clot des Cavales and the Plate des Agneaux. From the current glaciers fronts to the downstream neoglacial moraines, five successive rockfalls were identified. Their locations are probably linked to preferential areas of postglacial debutressing expression. These large rockfalls produce a semi-permanent environmental partitioning of the valley by controlling sediment flux and fluvial patterns. The objectives of the study are to quantitatively assess the partitioning functions of rockfalls of various volume on the streams long profiles, the downstream fluvial pattern succession and the spatial distribution of archaeological evidences. The topographic surveys of the Haute-Romanche valley floor and rockfalls were done using terrestrial multi-image photogrammetry coupled to a set of DGPS ground control points. The long profiles of the rivers were achieved with DGPS survey. Volumes of rockfalls were estimated by topographic modeling and volumetric computation using GIS software resources. Fluvial pattern analysis and archaeological mapping were completed based on photo-interpretation and field observations. Results show that river channel morphology is highly dependent of rockfall location and volume. Consequently, the downstream river patterns succession is deeply disturbed inducing a long-term segmentation of the fluvial continuum. This longitudinal partitioning of hydro-sedimentary dynamics has potentially major ecological, geoarchaeological and management implications.

****

The topographical factors in the formation of gully type debris flows in the upper reaches of Minjiang River

YU B.(1), ZHU Y.(2), QI X.(2)
(1) State Key Laboratory of Geohazard Prevention and Geoenvironment Protection , CHENGDU, CHINA ; (2) State Key Laboratory of Geohazard Prevention and Geoenvironment Protection, CHENGDU, CHINA

There are three groups of factors related to topography, geology and hydrology which have influence on the formation of gully type debris flows. In this study a single representative factor (G-factor) for the topography is proposed, which can be used to give threshold values for debris flow formation. The study was carried out in the upper reaches of Minjiang River, which is located in the Wenchuan Earthquake area. During some rainfall events after the earthquake, some gully type debris flows were triggered in some catchments. In some catchments no debris flows were triggered even though these catchments were in the vicinity of gullies with triggered debris flows. We were able to isolate and analyze the influence of the topography on the formation of debris flows because during these rainfall events the hydrological conditions were almost the same in the investigated gullies. We could also neutralize the influence of the geological factors by selecting groups of neighboring catchments located in areas with the same geological characteristics. A new G-factor is proposed in this study as a topographical indicator: $G=FJ(A/A_0)^{0.2}$, in which F is the form factor of formation area, J is the average slope of formation area, A is the area of formation area, and A_0 is the unit area ($=1km^2$). Higher G-factor values are generally related to higher probabilities of debris flow formation. The roles of G-factor are analyzed in other areas with the same geological characteristics and almost same hydrological conditions. They show that the higher G-factor values, the higher probabilities of debris flow formation are in generally.

Glacial lake outburst flood hazard assessment, example of the Palcacocha Lake, Cordillera Blanca, Peru

KLIMES J.(1), VILIMEK V.(2), EMMER A.(2), COCHACHIN A.(3)
(1) Institute of Rock Structure and Mechanics CAS, PRAGUE, CZECH REPUBLIC ; (2) Charles University, Dep. of Physical Geography and Geoecology, PRAGUE, CZECH REPUBLIC ; (3) National Water Authority, Glaciology Unit, HUARAZ, PERU

Glacial lake outburst floods (GLOFs) are one of the major natural hazards in high mountains worldwide including the Cordillera Blanca Mountains, Peru. In this country, GLOFs have claimed more than 30000 lives over the last century. GLOFs usually originate when ice and rock avalanches or landslides fall into the lake and cause displacement waves, which over top the lake dams. Slope movements are responsible for 80% of GLOFs with known origin in the Cordillera Blanca. Landslide as a trigger of GLOF has been reported from several sites within the Cordillera Blanca, e.g. Artizón Baja, Safuna Alta and Palcacocha Lakes.

Moraine-dammed lake Palcacocha was selected for detailed study since it was responsible for catastrophic outburst flood in 1941 which devastated large part of the regional capital city of Huaraz. Evaluation of moraine dam stability and its development was done by using set of historical aerial pictures, field mapping and geophysical investigation by the electric resistivity tomography. Slope stability model was calculated to specify conditions under which the moraine could fail by landsliding. At the same time the probability of sudden water release was assessed using qualitative, semi-quantitative and quantitative methods. Variety of lake basin and dam characteristics of the Palcacocha Lake were collected and compared with other lakes in the region. Detailed evaluation of the advantages and disadvantages of each method was performed, while most of them pointed out the Palcacocha Lake to be the most hazardous lake out of the investigated lakes.

****

Current evolution of high mountain glacier systems: the case of the Rognes and Pierre Ronde systems (St-Gervais, Mont-Blanc, France)

BOSSON J., UTZ S., LAMBIEL C.
University of Lausanne - IGD, LAUSANNE, SWITZERLAND

The negative mass balance of many glaciers can lead to their burial under debris which isolates partially the ice from atmosphere and leads to reduced melts rates. Moreover, due to climate history and without an efficient connection between the glacier systems and hydrosystems, important sediment accumulations are common in high alpines areas (above the isogeotherm of -2°C), where glacier/permafrost interactions are frequent. Thus, landforms with massive ice bodies, ice-cemented debris and unfrozen debris are present in high mountain. With their top-down position and the large amount of rock/debris and ice/water involved, deep knowledge and understanding of their internal structure and of their complex responses to global change need detailed studies.

This poster exposes the results from 2011-2013 measurement campaigns on the glacier systems of Les Rognes and Pierre Ronde (Mont-Blanc Massif, France). Located between 2600 and 3050m a.s.l., these small glacier systems (0.3 and 0.25 km^2) present different landforms such as snowfields, debris covered ice, glacier forefields, push moraines and rock glaciers. Electrical resistivity tomography, DGPS survey and ground surface temperature measurements have been carried out. The results show:

- Les Rognes: a continuum between the upslope debris-covered glacier, the ice-free glacier forefield and frozen marginal push moraines. Decimeters to meters movements have been measured in surface. Because of the topography, the ice cementation of the distal part and the absence of efficient connection with hydrosystem, this system can be considered as transport-limited.
- Pierre Ronde: an ice-free glacier forefield with a marginal rock glacier. Local till was the main solid supply of the water-pocket outburst of the Tête Rousse glacier in 1892. Our surveys show that more than 10m thick of unfrozen till fill the central depression. Current response to global change is characterized by slow gravity rebalancing (decimeter movements).

Changes in hardness of rock surface as a result of weathering through the Holocene in an alpine area in Switzerland

IKEDA A., ADACHI K., HATTANJI T.
Life & Environmental Sci. Univ. Tsukuba, TSUKUBA, JAPAN

Systematic comparison of rock-surface hardness is one of field techniques to date relative ages of landforms, because weathering duration controls the hardness. In this study, we apply three methods to characterize weathering properties of bedrocks after deglaciation in the Swiss Alps where the former distribution of glaciers is well reconstructed. A number of rebound values of a Schmidt hammer and an Equotip hardness tester were measured on roches moutonnees and rockwalls. P-wave velocities of the bedrocks were also measured on several sites. Two timings of release from glacier beds, the end of Younger Dryas (YD) and the end of Little Ice Age (LIA), were clearly identified for the studied roches moutonnees and rockwalls from moraines mapped by glaciologists. In addition, bedrocks exposed previous to YD and after the Last Glacial Maximum were also compared. Four types of geology were chosen for the targets: granodiorite, diorite, gneiss and limestone/dolostone. The difference in hardness of the bedrock surfaces between the LIA age and YD age is obvious except for limestone, although the surfaces older than YD show no significant difference from those of the YD age. Ten thousand years are a duration enough that the surface hardness reaches stable in the study area. The P-wave velocities and uniaxial strengths of samples having the LIA and YD ages indicate that the weathering does not reach the subsurface. Contrary to the other rock types, limestone has the rebound values similar through the time, which indicates that chemical denudation keeps the surface fresh.

****

Evidence of paraglacial and periparaglacial crisis in the evolution of sediment transfer in the Southern Swiss Alps since the Last Glacial Maximum

SCAPOZZA C.
Institute of Earth Sciences, University of Applied Sciences and Arts of Southern Switzerland (SUPSI), CANOBBIO, SWITZERLAND

Continental hillslope deposits – in particular talus slopes and alluvial fans – and valley floor deposits, can be read as important palaeoenvironmental archives for the reconstruction of the morphogenesis and the evolution of alpine valleys since the last deglaciation. The study of these deposits it is of particular importance because, especially in the actual context of a warmer climate, a «geosystemical» approach focusing on the sediment transfer in a whole alpine hillslope – from the rockwall to the valley floor – is of great importance to understand and evaluate the past processes and to try to assess how they might evolvein the future.

In this framework, the state of the art concerning the knowledge about sediment transfer in the Southern Swiss Alps is presented, allowing defining the major morphoclimatic crisis that has occurred during the Lateglacial and the Holocene. The quantification of the sediment transfer from rockwalls to talus slopes in the periglacial belt allow to show the existence of “paraperiglacial rockfall phases” related to the permafrost degradation in rockwalls which coincides with rapid climate warming periods, as at the beginning of the Bølling and during the Preboreal. A similar behaviour was found by the analysis of the infilling chronology of the Ticino valley floor and of the Ticino river delta progradation rates, with the erosion/sedimentation dynamic during the Lateglacial and the Holocene that was putted in relation with the paraglacial sedimentation model.

In future, these results will be improved by investigation at the local scale, including for example the assessment of sediment transfer from glaciers and rockglaciers to the valley floors, the study of the relationship between mass movements and alluvial fan development and the detailed study of the stratigraphy of some talus and alluvial cones thanks to the presence of outcrops dues to sand and gravel quarries or archaeological excavations.

Joint analysis of rock glacier kinematics and complementary permafrost monitoring elements observed in the Swiss Alps

STAUB B.(1), DELALOYE R.(1), LAMBIEL C.(2)
(1) University of Fribourg, Department of Geosciences, Geography Unit, FRIBOURG, SWITZERLAND ; (2) University of Lausanne, Institute of Geography, LAUSANNE, SWITZERLAND

As characteristic landforms of the Alpine environment, active rock glaciers express both past and present periglacial processes through their morphology and morphodynamic behaviour. Former research has shown a close relation between ground surface temperature anomalies and inter-annual changes in rock glacier creep velocities, indicating a high and fast response of rock glacier activity patterns on external factors governing the ground thermal regime. Regarding also shorter time scales, strong fluctuations and a distinct seasonal rhythm of the creep velocities have been observed. For a better understanding of the processes involved and to assess the sensitivity of rock glacier kinematics to external driving forces, an integrative data analysis approach is being applied over a large data set of permafrost monitoring elements measured in the Swiss Alps (Swiss Permafrost Monitoring Network PERMOS).

The current research within the SNF Sinergia project “The Evolution of Mountain Permafrost in Switzerland” (TEMPS, 2011-2014) aims at a process-oriented understanding of the sensitivity of mountain permafrost to external effects (e.g. air temperature during the snow-free phase) by the use of a landform-specific approach. To get an overview about the recent evolution of different mountain permafrost properties, explorative data analysis methods will be performed relating kinematics to complementary permafrost observation data (e.g. ground and ground surface temperatures, geophysical data), indices and derivatives. Of particular interest are similarities and differences on a regional scale as well as the topographical context (e.g. exposure to wind and solar radiation) and subsurface characteristics (e.g. ice and water content, boulder size) on a local scale. The poster presents preliminary results of this study focussing on rock glaciers.

****

Avalanches in relation to relief of the Tatra Mountains

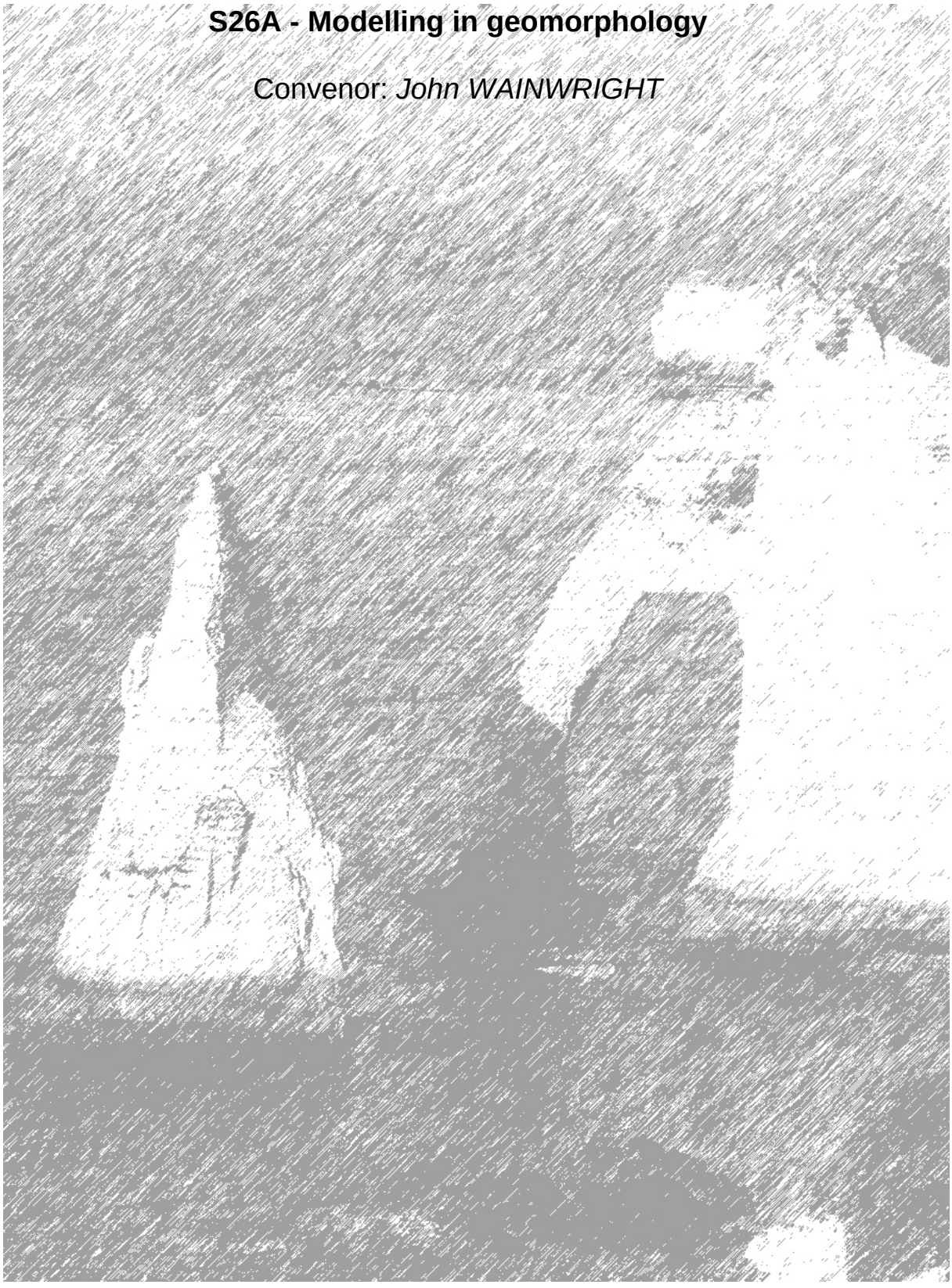
ROJAN E.(1), RACZKOWSKA Z.(2), KALAFARSKI M.(3), DLUGOSZ M.(2), KACZKA R.(3), GADEK B.(3)
(1) Faculty of Geography and Regional Studies, University of Warsaw, WARSZAWA, POLAND ; (2) Institute of Geography and Spatial Organization, PAS, Department of Geoenvironmental Research, CRACOW, POLAND ; (3) University of Silesia, Faculty of Earth Science, SOSNOWIEC, POLAND

Snow avalanches are among main factors influencing the high-mountain environment of the Tatras. Avalanche tracks are common and occur regardless of slope exposure, and their frequency and size vary significantly. In Polish part of the Tatras 457 avalanches tracks was identified. More avalanche tracks occur in the High Tatras, where its density is one third higher then in the Western Tatras. Similar pattern of avalanches tracks is also in the Slovak Tatras. The reason is difference in relief, conditioning avalanche formation. Slopes in the High Tatras are stepper and have relatively dense net of chutes, while in Western Tatras chutes net is less dense, but gentle and wide upper part of valley slopes favour greater activity of avalanches. There is also great spatial variability of avalanches tracks, in some fragments of the Western Tatras its density is like in the High Tatras. Based on relief analysis 8 chosen avalanche tracks, located on slopes of different aspect, was chosen for detailed measurements of geomorphological effects and modelling the dynamics of avalanches, started in 2012 year.

Geomorphological work is done only by full-depth avalanches. The most of avalanches did not left permanent landmark in the landscape. Changes in the upper timberline are one of the most spectacular effects of avalanche activity. Analysis on air-photos from 1938, 1955, 2004 evidences temporal and spatial variability of avalanches. Regression in size and extent of great number of large avalanche tracks was found. The result of this analysis are important for evaluation of the role of avalanches in the transformation of landform not only at present but in the recent past. The extent of avalanches in the High Tatras in particular time span not change too much, opposite to the Western Tatras. The difference in relief between those two group could be also one of the reason.

S26A - Modelling in geomorphology

Convenor: *John WAINWRIGHT*



Oral presentations:

Coupling 3D hydraulic numerical modeling and field survey to assess morphodynamics of a wandering gravel bed river (Durance River, Southern French Alps)

CHAPUIS M.(1), DUFOUR S.(2), PROVANSAL M.(3), COUVERT B.(4), DE LINARES M.(5)
(1) University of Waterloo, WATERLOO, CANADA ; (2) COSTEL, University of Rennes 2, RENNES, FRANCE ; (3) CEREGE, Aix-Marseille University, AIX-EN-PROVENCE, FRANCE ; (4) Artelia Group, MARSEILLE, FRANCE ; (5) Artelia Group, GRENOBLE, FRANCE

The Durance River is a wandering gravel bed river located in the Southern French Alps. This large (mean width: 240m) and steep (mean slope: 0.28%) river is deeply impacted by flow diversion and gravel mining in its entire catchment area (14,000km^2). The Durance River is characterized by a sediment deficit that led to a reduction of active channel width and river bed degradation (from 50 to 80% for the 1960-2000 period). These lateral and vertical modification of the bed lead to important issues in terms of landscape management, because of (i) maintaining the bed hydraulic capacity to evacuate flood discharges and (ii) planform evolution of the river that conflicts with landscape use.

In order to better understand the link between sediment fluxes and river bed morphodynamics for a flood event (Q=1,200m^3.s^{-1}, recurrence interval: 4 years), we developed a hydraulic 3D model of the study reach to describe spatial distribution of shear stresses and flow directions at flow peak. We used the finite element Telemac 3D code to obtain steady-flow velocities and water height at each node (15,600 2D nodes, integrated on 10 planes).

For this flood event, we also set up a sediment particle survey in the channel, using RFID tracking. Coupling hydraulic numerical modeling and particle displacement field data enabled us to link peak flow direction and particle displacement. We consequently validated the use of such a hydraulic model for studying the link between shear stresses and particle displacement at reach scale. As the Telemac 3D model is now functional and calibrated, we also validated the use of hydraulic 3D modeling for wandering river management purposes. However, the calibration with field data highlighted some limits of the numerical model: in such a dynamic reach of a wandering river, the steady-flow modeling cannot take into account the intra-event bedform mobility (bank erosion), and thus can explain only part of the particle displacement.

****

Numerical simulation of turbulent sediment transport

CLAUDIN P.(1), DURAN O.(2), ANDREOTTI B.(3)
(1) CNRS - ESPCI, PARIS, FRANCE ; (2) Department of Geological Sciences, Univ. North Carolina, CHAPEL HILL, UNITED STATES ; (3) Univ. Paris Diderot, ESPCI, PARIS, FRANCE

Sediment transport is studied as a function of the grain to fluid density ratio using two phase numerical simulations based on a discrete element method (DEM) for particles coupled to a continuum Reynolds averaged description of hydrodynamics. At a density ratio close to unity (typically under water), vertical velocities are so small that sediment transport occurs in a thin layer at the surface of the static bed, and is called bed load. Steady, or `saturated' transport is reached when the fluid borne shear stress at the interface between the mobile grains and the static grains is reduced to its threshold value. The number of grains transported per unit surface is therefore limited by the flux of horizontal momentum towards the surface. However, the fluid velocity in the transport layer remains almost undisturbed so that the mean grain velocity scales with the shear velocity. At large density ratio (typically in air), the vertical velocities are large enough to make the transport layer wide and dilute. Sediment transport is then called saltation. In this case, particles are able to eject others when they collide with the granular bed, a process called splash. The number of grains transported per unit surface is selected by the balance between erosion and deposition and saturation is reached when one grain is statistically replaced by exactly one grain after a collision, which has the consequence that the mean grain velocity remains independent of the shear velocity. The influence of the density ratio is systematically studied to reveal the transition between these two transport regimes. Based on the mechanisms identified in the steady case, we discuss the transient of saturation of sediment transport and in particular the saturation time and length. Finally, we investigate the exchange of particles between the mobile and static phases and we determine the exchange time of particles.

Morphogenetic modelling of coastal foredunes

ZHANG W., SCHNEIDER R., KOLB J.
Institute of Physics, University of Greifswald, GREIFSWALD, GERMANY

Coastal foredunes are developed as a result of interplay of multi-scale land-sea processes. The orientation, size and interval of well established foredunes and foredune sequences are directly linked to the prevailing wind direction, extreme wind-wave event frequency and sources of sediment supply. Basic driving mechanisms of the formation of coastal foredunes as well as natural processes and factors involved in shaping the foredune geometry are studied in the present work by a robust Cellular Automata model. The model, which consists of a set of rules to describe the aeolian sediment transport, the hydrodynamic effects on the beach and the growth of vegetation, is applied to simulate the coastal dune patterns developed by varied combinations of wind-wave climates, sediment supply and characteristic growth rates of vegetations. Simulations indicate that the formation of an established coastal foredune results from a subtle balance between the wind-wave impacts and the vegetation growth. Driven by a prevailing onshore wind and a boundary sediment supply, small embryo dunes start to develop on the beach and migrate landward. They are then trapped by vegetation. The first established foredune forms just behind the landward limit of a transitional zone (i.e., storm impact zone or scarp zone) due to the trapping of sediment by vegetation. According to the simulation results, the formation of an established foredune on an initially flat vegetation-free surface has to meet three preconditions: 1. a prevailing onshore component in the wind spectrum; 2. an onshore or lateral sediment supply; and 3. a favorable environment for vegetation growth (e.g., an appropriate moisture and nutrient level). The spatial interval between a new foredune and the present one is determined by a combination of the seaward progradation rate of the beach, the extreme wind-wave event frequency and the rate of vegetation growth in front of the present foredune.

****

Numerical simulation of current driven sediment transport processes

BURKOW M.
Institute for Numerical Simulation, University of Bonn, BONN, GERMANY

Current driven sediment transport causes the evolution of bedforms like dunes, ripples or scour marks. These bedforms are formed by the interaction of entrainment and deposition of sediment particles. In this study we use a numerical simulation of the three dimensional fluid flow and the simultaneous transport processes to reproduce these processes. To solve the incompressible Navier-Stokes equations we use NaSt3D as fluid solver for incompressible flow problems in three dimensions. High order discretization schemes provide a reliable algorithm for calculating fluid and sediment properties. The main variants of sediment transport are modelled by applying a advection-diffusion equation for Suspension load and Exner equation to bed load transport. The rearrangement of sediment leads to a new sediment surface height which results in new bedforms. To test our model we simulate the erosion of sediment from a dune crest and the evolution of a scour mark around an obstacle.

2D-Hydrodynamic modelling of large wood transport in rivers

RUIZ-VILLANUEVA V.(1), DÍEZ-HERRERO A.(1), BODOQUE J.M.(2), BLADÉ E.(3), SÁNCHEZ-JUNI M.(3)
(1) Geological Survey of Spain, MADRID, SPAIN ; (2) University of Castilla-La Mancha, TOLEDO, SPAIN ; (3) Technical University of Catalonia (UPC), BARCELONA, SPAIN

Large woody material (LW) transported in the flow may be entrapped at critical stream geometry configurations (e.g. at bridges), and therefore may dramatically increase the destructive power of floods. This was the case in a mountain catchment where a flood event with LW loading took place in 1997, and relevant data was available. The aim of this study was to numerically simulate a bridge clogging process, modelling individual pieces of wood moving with the water flow and interacting with the bridge. First, the boundary conditions (inlet discharge and wood) were established, and then a 2D model was developed to simulate the transport of LW together with the hydrodynamics. A combination of weir and gate internal conditions was used to represent the bridge geometry, and the model simulated the way in which the wood's interactions with it affect the hydrodynamics. Different scenarios for the wood budget allowed us to study the influence of inlet boundary conditions in bridge clogging. For the studied event, the scenario which best reproduced the bridge clogging effect and the flood characteristics was the one in which 60% of total wood entered before the peak discharge. This dropped to 30% at the peak itself, and finally fell to 10% during the recession curve.In addition, the accumulation patterns of LW along the reach were compared with photographs, showing that the model succeeded in predicting the deposition patterns of wood.

****

Modelling soil erosion on medium-term: the application of a landscape evolution model in a Mediterranean catchment

CIAMPALINI R.(1), FOLLAIN S.(2), LE BISSONNAIS Y.(3), DAVID M.(4), COUTURIER A.(5), WALTER C.(6)
(1) INRA, InfoSol, ORLEANS, FRANCE ; (2) SupAgro, MONTPELLIER, FRANCE ; (3) INRA, UMR LISAH, MONTPELLIER, FRANCE ; (4) GEODE, UMR 5602, TOULOUSE, FRANCE ; (5) INRA, UR Science du Sol, ORLEANS, FRANCE ; (6) AGROCAMPUS OUEST, RENNES, FRANCE

Soil resources are being irreversibly lost and degraded (EEA, 2000). Pressure has been generated by the concentration of population and activities in restricted spaces as well as changes in climate and land use. Relevant human-induced changes include those implemented by farmers as well as those imposed by policy in a range of spatial scales. Climate-induced changes are those related to changes in the seasonal distribution of climate factors and in the frequency of extreme events predicted by projections of future climate change (IPCC, 2007).

The aim of this research is to evaluate the influence of land use on medium-term soil erosion delivery in a Mediterranean context, focusing on a small catchment (91 ha) located in the south of France and characterized by extensive vineyard land use. We used LandSoil (Ciampalini et al., 2012) – a landscape evolution model operating at the field/small catchment scale – to analyse different land use for the 21st century. Land use changes have been designed considering the actual scenario as stationary reference and introducing variations of soil use and landscape structure from the most conservative to the most degraded condition according to realistic hypothesis.

Results indicate that land use and landscape structure play a main role in sediment delivery: *i*) soil loss variations in favourable and unfavourable land-use scenarii range from -3.7% to more than ten times compared to the stationary scenario, ii) landscape structure variation represents a minor factor in soil loss variations ranging from -54% to +110%. Future strategies should consider adaptation to climate change and land use – landscape structure reorganisation.

Flash floods susceptibility assessment through cellular automata modelling: a case study in northern France

DOUVINET J.(1), ESCUDIER A.(2), DELAHAYE D.(3), LANGLOIS P.(4)
(1) University of Avignon - UMR ESPACE 7300 CNRS, AVIGNON, FRANCE ; (2) SCHAPI, TOULOUSE, FRANCE ; (3) University of Caen, UMR LETG-6554 Caen, CAEN, FRANCE ; (4) University of Rouen, UMR 6566 MTG CNRS, ROUEN, FRANCE

In northern France (Upper-Normandy), flash floods are generated shortly following high rainfall ranged from 50 to up to 100 mm in less than 6 hours. Such phenomena present single features, as a sudden onset, a rapid rising time and a surge rushes down the main dry valley just a few minutes after rainfall has peaked in less than 1h. But assessing occurrence and dynamic of flash floods remain unknown at regional scale as real previous events never occurred on the same areas. In this study, we propose to better define the flash flood susceptibility by applying RUICELLS, a triangular Cellular Automata model developed for simulating the spatial evolution of water flow pathways in dry valleys. Our objectives are to further understanding of the effects of spatial interactions between basin morphology and land use on hydrological responses, and to enable identification of higher peak of discharges and shorter time-responses on 156 basins of less than 20 km•. The simulation results confirm the susceptibility changes following rainfall inputs. On one hand 73 basins present discharges up to 4m3/s following 40mm in 1h (against 10 basins for 40mm in 2h); among them, 26 have a specific discharges exceeding 1m3/s/km•, and 11 have a short time-response (in less than 2h). On the other hand the discharges are bigger than 4m3/s for 112 points of measurement (more than 10 m3/s on 25 basins) following 50mm in 1h; among them, 64 present a specific discharge up to 1m3/s/km•, and 25 have short response (in less than 2h). Finally this study enables detection of functioning thresholds on the 156 studied basins, and questions the “basin size” as a sufficient parameter to anticipate discharges or responses face to flash floods.

****

The dynamic cellular automata landscape evolution modelling platform CDP

BARKWITH A., WANG L., JACKSON C.R., HURST M., ELLIS M.
BGS, NOTTINGHAM, UNITED KINGDOM

The CAESAR-DESC Platform (CDP) acts as a base for high-resolution modelling of environmental sensitivity over daily to centennial timescales. The Dynamic Environmental Sensitivity to Change (DESC) project couples cellular automata modelling from various backgrounds to generate the CDP; a geomorphological simulator that allows a variety of Earth system interactions can be explored. A derived version of the well established CAESAR model, CAESAR-Lisflood, is used as the platform kernel. The two dimensional modular design allows great versatility in the range of simulated spatio-temporal scales to which it can be applied. CAESAR has been used to investigate a variety of sediment transport, erosional and depositional processes under differing climatic and land-use scenarios in river reaches and catchments around the world. The recent addition of Lisflood to the code has improved river flow representation within the model by incorporating momentum. Non-Lisflood controlled surface hydrology is replaced with a new distributed model (SLiM), and an unconfined cellular automaton groundwater model. Surface-subsurface water exchanges within the CDP are coupled by recharge to groundwater and groundwater discharge to rivers. To deal with the complex energy and sediment fluxes that occur during a debris flow a modified version of the SCIDDICA model, originally developed to simulate flow-like landslides, has been incorporated into the CDP. As the surface hydrology drives the processes within the platform, CDP facilitates the analysis of climate change influences on a range of environmental processes. The dynamic application of climate factors also opens up the possibility of including a decadal-scale evolving vegetation within the model, which could be used to improve both the partitioning of water between the surface processes and the adhesion properties of vegetation-covered sediment with time.

Physically based modelling of soil erosion from the plot scale to the catchment scale

CERDAN O.(1), LE M.(1), ROUSSEAU M.(1), CORDIER S.(2), LUCAS C.(2)
(1) BRGM, ORLEANS CEDEX 02, FRANCE ; (2) MAPMO, Univ. Orléans, ORLÉANS, FRANCE

In areas modified by human activities, accelerated erosion can lead to serious environmental issues such as the flooding of urban areas or the pollution of water bodies. In order to prevent or to mitigate such events, it is therefore necessary to be able to predict the dynamic as well as the spatial extent of runoff production and particle transfer. To meet this demand and to reflect the complexity of the processes involved as well as the spatial heterogeneity of the landscape, several modelling approaches of various complexities have been developed. Many research efforts are devoted to the development of physically-based models able to improve our understanding and modelling of these fluxes. One of the main obstacles to the application of such models is the difficulty to describe the spatial and temporal variability of the input parameters. In this context, the objective of this study is to develop a robust physically based modelling approach and to adapt its parameterisation to be able to incorporate coarse scale input parameter. A dynamic erosion model coupling the Shallow Water equations with the Hairsine-Rose model was developed. It uses a well-balanced numerical scheme with a hydrostatic reconstruction to preserve the equilibrium and the positivity of water height and to be able to capture spatial heterogeneities. A first application is realised at the plot scale to test the model predictive ability. In a second step, to integrate inner grid variability when modeling at the catchment scale, for each cell, we use the proportion of wetted area as a microtopography indicator. For the case of erosion, the system is coupled to the sediment transport equations. In such context, an additional equation describing the micro-topography evolution caused by erosion is introduced and the numerical scheme of Godunov-type for this model is implemented. The results of a second application at the catchment scale are presented.

****

Space time substitution in geomorphology (modelling by rainfall)

A. ALMODARESI S.A.
civil engineerin dep. yazd branch, islamic azad university, YAZD, IRAN

Between different categories In geomorphology, the course of Ergodicity has been one of the most important subjects. This filed, adopted both in physical thermodynamic science and in geomorphology, has interested many researchers. However, because of its complexity, a significant dearth of theoretical studies exists in this regard. Put it simply, the growing importance of this subject is attributed to historical modeling, since one of the most important phenomena in biological geology and in geomorphology is time and its relationship with changes and successions. Phenomena which not only astronomical time is not able to describe the matter studying in their field but also there is not suitable time's substitution in their relation**.** Ergodicity theorem was born in physics. Ergodic hypothesis, in which observing a member of an ensemble is the same as the average of the ensemble at a definite time evolved in 1960 as an analogy in experimental sciences. However, this issue has not been widely studies in Iran, and hence, this project tries to explain the various dimensions of Ergodicity and its analog face in geomorphology and provides a background to start quantitative researches in Iran. The relationship between evolution, repetition, palimpsest, waves, the origin of phenomena and fractal geometry with Ergodicity are subjects that have been considered in this study. After explaining the physical dimensions and the Ergodic mathematical equations, Ergodic evolution of gullies at Koor-Biabanak district was case studied and its accuracy was evaluated. Further, a miniature model was created for a succession procedure through time and for defining Ergodicity of a small Basin in Yazd-Ardakan region where a lot of rifts appeared. The results provided important allometric rates for the stability of the basin through time. itis our hope that the work reported here will inspire others to further explore issues and enrichthe Ergodic literature in geomorphology.

Non-Linear Equilibrium Points in geomorphology

SEPEHR A.
Ferdowsi University of Mashhad (FUM), MASHHAD, IRAN

The concept of "*equilibrium*" is quite basic to system theory and is considered here to imply a complete adjustment of the internal variables to external conditions. The external conditions usually change in two statuses: catastrophic and gradual changes. The response of a geomorphic system to these statues is different, although in the two statuses, change towards equilibrium points is main goal of geomorphic system. The geomorphic systems are complexity systems with properties of open system. In these open systems the threshold is a bifurcation point. The path followed by the thermodynamic branch beyond the threshold may involve further thresholds and hence bifurcations. In passing through a bifurcation point, the system loses its structural stability and undergoes a sudden or catastrophic change to a new form. The new equilibrium point has new energy status. The energy flow creates patterns in the geomorphic system which can be an early warning signal to find thresholds and resilience limitation of geomorphic system to response geo hazards. In this article has been analyzed these equilibrium points in the geomorphic systems. If the constraints are strong then the system may change smoothly along a thermodynamic branch into non-equilibrium states in which the theorem of minimum entropy production still applies. At a certain distance from equilibrium, called the thermodynamic threshold, non-linear relationships emerge and the steady states along the branch are not of necessity stable. Beyond the threshold, the solutions of the equations governing the dynamics of the system may no longer be unique: the system may enter one of several new regimes. The results and discussion of this article can be a new conceptual paradigm in the geo-hazards risk management.
Keywords: non-linear equilibrium, early warning signals, Thresholds, thermodynamics

****

Development of experimental landforms with rainfall-erosion and uplift of various rates

OUCHI S.
Chuo University, TOKYO, JAPAN

A series of experiments with rainfall-erosion and uplift of various rates suggests the existence of threshold uplift rates, across which experimental landforms show different aspects of development. A mixture of fine sand and kaolinite compacted in a square-prism-shaped container (60x60x40cm) is pushed out at a constant rate from a flat ground surface under the artificial mist-type rainfall. In the experiment with a low uplift rate below the lower threshold, a certain low characteristic relief determined by the mound erodibility and rainfall intensity develops with exclusively fluvial erosion under the detachment-limited condition. In this case erosion may slightly exceed uplift to slowly lower the surface. When the uplift rate becomes higher than this lower threshold, uplift exceeds erosion in the upstream area where fluvial erosion works less. Hills grow and slope processes start working. While slope failures inside the uplifted area do not lower the average height unless the sediments are carried away by fluvial processes, the increased sediment supply from slopes helps streams become steeper with uplift and enhances their transport ability. Uplift and erosion then become balanced under the transport-limited condition to keep average height roughly constant and landscapes similar. The uplift of higher rate makes hills grow higher and increase the sediment supply from slopes more, and this works to keep average height higher corresponding to the uplift rate. The experimental landform seems to attain a certain steady state with the equilibrium between uplift and erosion. If the uplift rate becomes even higher and crosses the possible upper threshold, uplift overwhelms erosion and hills grow into high mountains until the relief hits the limit probably determined by the threshold slope. Whenever the uplift ends, the experimental landform starts decreasing its height and relief exponentially, and a peneplain-like surface develops in a long period of erosion.

Modelling stratigraphic and surface dynamics processes on a coupled thermo-mechanical lithospheric model: an example in oblique continental rifting

MONDY L.(1), DUCLAUX G.(2), SALLES T.(2), THOMAS C.(1), REY P.(1)
(1) The University of Sydney, SYDNEY, AUSTRALIA ; (2) CSIRO Earth Science & Resource Engineering, SYDNEY, AUSTRALIA

Interlinks between deformation and sedimentation have long been recognised as an important factor in the evolution of continental rifts and basins development. However, determining the relative impact of tectonic and climatic forcing on the dynamics of these systems remains a major challenge. This problem in part derives from a lack of modelling tools capable of simulated high detailed surface processes within a large scale (spatially and temporally) tectonic setting.

To overcome this issue an innovative framework has been designed using two existing numerical forward modelling codes: *Underworld*, capable of simulating 3D self-consistent tectonic and thermal lithospheric processes, and *LECODE*, a forward stratigraphic and geomorphic modelling framework dedicated to simulating highly detailed surface dynamics. When coupled together, the resulting models can provide high-resolution data on the mechanical feedback between surface and tectonic processes. These include changes in deviatoric stress, strain, strain-rates, thermal evolution, as well as a stratigraphic record, grain-size variations, sediment provenance, porosity changes, fluvial hydrometric, and geomorphic evolution.

Here we illustrate via this coupling the feedback loop between surface and tectonic processes on an example of 3D oblique rifting. Our fully coupled model enables us to visualise the distribution of sediment sources and sinks, and how these evolve through time. From this we can extract and analyse at each simulation timestep the stratigraphic record anywhere within the model domain. Further to this, we can compare finite and instantaneous sedimentation and erosion. We compare a tectonic model with and without surface processes to assess the significance and magnitude of their interaction.

This work is supported by the CSIRO, and the John Stocker Scholarship.

****

How stream piracies are initiated in landscape evolution models? Predictive study in the Meuse basin

BENAICHOUCHE A.(1), STAB O.(1), COJAN I.(1), BRULHET J.(2), TIJANI M.(1), TESSIER B.(1)
(1) Mines ParisTech, Centre de Géosciences, 35 rue Saint-honoré 77305, FONTAINEBLEAU, FRANCE ; (2) Agence nationale pour la de gestion des déchets radioactifs, 1-7 rue Jean Monnet 92298, CHÂTENAY-MALABRY, FRANCE

Topography and hydrographic networks are in continual evolution. Drainage structures change over time and modify the landscape. Several piracies (in the upper and middle Quaternary) are recorded in the North-East of France at the expense of the Meuse River. The specific morphology of the Meuse Basin let us suppose that other piracies may occur in the future. But where and when? What impact can be expected on the topography at local and regional scale?

Mechanisms provoking piracies are numerous and complex. In this paper, we focus on stream piracy by headward erosion and investigate geometric, analytic and physical based models. The later integrates the classical landscape evolution equations: diffusion in hillslope and advection in river (stream power). Finally, simulations are realized with GOLEM software (developed by Tucker & Slingerland).

Estimating piracies ages with physical models requires accurate parameters fitting and classical approaches do not seem to be suitable (slope-drainage area relationship…). So, we opted for a sensitivity analysis in order to explore the solutions space. The results show that the location of piracies is mainly controlled by the local topography and is not model-dependent. On the other hand, their chronology relies on the flux water exponent (of the stream power model) but is not sensitive to lithological characteristics. All solutions (of the 4500 simulations) can be regrouped according to three scenarios with various consequences on the topography. Finally, in order to estimate the piracies ages, the Meuse and the Moselle terraces data were used for the calibration of the stream power model. But simulation gives piracies durations that seem too long comparing with those recorded in the past. Integrating more complex processes (karst process, climate forcing…) and taking into account the Meuse river deposition tendency may accelerate the piracies occurrences in our modelling.

Relating landscape morphological complexity to catchment connectivity

BAARTMAN J., MASSELINK R., KEESSTRA S.
Wageningen University, WAGENINGEN, NETHERLANDS

Connectivity relates to the coupling of landforms (e.g. hillslopes and channels) and the transfer of water and sediment between them. The degree to which parts of a catchment are connected depends largely on the morphological complexity of the catchment's landscape. Landscapes can have very different and distinct morphologies, such as terraces, V-shaped valleys or broad floodplains. The objective of this study is to better understand and quantify the relation between landscape complexity and catchment connectivity. We hypothesize that connectivity decreases with increasing landscape morphological complexity. To quantify this relationship we use artificially created DEMs with distinct morphologies in the landscape evolution model LAPSUS to simulate the connectivity of each landscape for different types of rainfall events. Secondly, the effects in terms of sediment redistribution and related connectivity were evaluated over time for different rainfall event time series. Thirdly, we tested the hypothesized landscape complexity – connectivity relation for some typical morphologies of real-world catchments. To quantify connectivity and landscape complexity several indices were selected. Landscape complexity was quantified by the mean slope, catchment dissection and the Topographic Convergence Index (TCI). The degree of catchment connectivity was assessed with the Borselli's index of connectivity (IC; Borselli et al., 2008). Preliminary results confirm the hypothesis and show that total erosion increases with connectivity and decreases with increasing landscape complexity. However, total deposition seems not to be related to connectivity, while it is related to slope variability and thus landscape complexity.

Reference:

Borselli L, Cassi P, Torri D. 2008. Prolegomena to sediment and flow connectivity in the landscape: A GIS and field numerical assessment. *Catena* **75**: 268-277.

****

Modelling response to local base level change using LAPSUS

VAN GORP W.(1), SCHOORL J.(1), TEMME A.(1), VELDKAMP A.(2)
(1) Soil Geography and Landscape Group, Wageningen University, WAGENINGEN, NETHERLANDS ; (2) Faculty ITC, University of Twente, ENSCHEDE, NETHERLANDS

Multi-process modelling of long-term landscape evolution using reduced-complexity models has become increasingly popular in the last decades. Landscape Evolution Model (LEM) LAPSUS is such a LEM that has recently been enhanced to incorporate 3D geology and to identify newly deposited sediments. The aim of this study was to model landscape evolution with LAPSUS in a catchment that experienced base level change due to lava-damming. After modelling several scenarios with lava dams of different erodibilities using a test Digital Elevation Model (DEM), the LEM was applied in an actual catchment which is part of the Upper Gediz basin near Kula, Turkey. Here, lava flows have blocked the trunk river and tributaries several times since the Early Pleistocene until the Holocene. Model inputs are a DEM, results of geomorphological and geological fieldwork and a climate reconstruction using regional climate data. Age control is derived from Ar-Ar dated lava flows and Post-IR IRSL (Post-Infrared Infrared Stimulated Luminescence) dated sediments. Modelling results are evaluated using river profile evolution, cross-sections, sediment yield and spatial redistribution of sediments. Results are expected to show the influence of lava damming and breaching on catchment evolution and answer the question whether catchment response to these past events is still on-going. This is of importance to find out whether the trunk river is in dynamic equilibrium with large-scale tectonic uplift of the area. The technique that we use has potential for answering these and related questions in other dam-affected fluvial systems.

Validating predictions of braided river morphodynamics: static and dynamical metrics

WILLIAMS R.D.(1), HICKS M.(2), MEASURES R.(2), BRASINGTON J.(3)
(1) Aberystwyth University, ABERYSTWYTH, UNITED KINGDOM ; (2) NIWA, CHRISTCHURCH, NEW ZEALAND ; (3) Queen Mary, University of London, LONDON, UNITED KINGDOM

Numerical morphological modelling of braided, gravel-bed rivers is gaining momentum as a technique to inform environmental management. In particular, “full process” models, such as Delft3d, are being used to simulate the morphodynamics of braided rivers using high resolution topography to provide initial boundary conditions. Whilst considerable attention has been paid to developing the hydraulic and sediment transport algorithms associated with such models, comparatively less attention has been paid to developing appropriate approaches to validate model predictions. This paper assesses a range of metrics that can be used to evaluate morphological predictions at the timescale of single flood events. First, DEMs are constructed using multi-temporal, high-resolution topographic data that were acquired during an eight-month monitoring campaign on a 2.5 km long reach of the braided, gravel-bed Rees River, New Zealand. This campaign acquired topographic data using a fusion of Terrestrial Laser Scanning and optical-empirical bathymetric mapping. Next, the pre-storm DEMs are used as boundary conditions for Delft3d morphological simulations of the same storm events. Two approaches to model validation are then presented. First, “static” metrics of the observed and modelled post-event DEMs are evaluated. These metrics include measures of braidplain planform, such as anabranch width and depth, inundation area at low flow, and braiding indices. They also include statistical comparisons of DEM similarity. Second, “dynamical” metrics are evaluated. These metrics include those that quantify sediment transport volumes and evaluate the dimensions of erosion and deposition patterns.Such techniques also provide an approach to validate results from sensitivity, or Monte-Carlo, runs of multi-parameter models.

****

A machine learning approach to estimate river bank erosion through multi-temporal LIDAR and spectral imagery

IWASHITA F., BROOKS A., CURWEN G., SPENCER J.
Australian Rivers Institute - Griffith University, BRISBANE, AUSTRALIA

This work presents an alternative approach to estimate river bank erosion at regional scale through the Self-Organizing Maps (SOM) technique. LIDAR data was used to calculate erosion values at local scale, while satellite imagery combined with digital elevation model (DEM) were used as predictive variables for regional scale. The LIDAR data was collected in the Normamby River Basin, Australia in 2009 and 2011, from which elevation, canopy height and percent canopy coverage were calculated. The differences in elevation between 2009 and 2011 produced values of erosion along the rivers that were used as training points in the modeling process. Landsat TM5 (Thematic Mapper) sensor images were corrected for atmospheric attenuation and converted into reflectance values to calculate band ratios to enhance spectral features. A subset of fifteen hundred points was randomly selected in areas where erosion was detected and associated to band ratios values and DEM derived measures (elevation, slope, aspect and hydrological flow accumulation). These points were used to train the SOM and construct the predicting model. The SOM are well-suited to analyze noisy, sparse, nonlinear, multidimensional, and scale dependent data enhancing nonlinear relationships while preserving the topology of the original dataset, one of the key advantages of this data mining method, since most of multivariate methods assume that relationships between predicted and predicting variables are linear. Results show an increasing trend of erosion from the headwaters to the lower reaches associated with bank retreat due to mass failures. Anomalous high values of erosion in the upper basin are likely related to alluvial gully erosion as observed during our fieldwork. Stochastic cross-validation indicates that the SOM is unbiased and provides a way to measure the magnitude of prediction uncertainty.

Massively parallel particle-based methods in landscape evolution modelling: geomorphic validity and performance

MARTEL T., VAN DE WIEL M.
The University of Western Ontario, LONDON, CANADA

Landscape evolution modellers suffer from the dilemma of either having to take on considerable computational overhead with a reductionist physics-based approach, or using a highly simplified reduced-complexity approach. Particle-based methods for solving flow, such as smoothed particle hydrodynamics (SPH), are ideally suited to parallelization, inherently adaptive, and can interact with complex boundaries. As such, particle-based methods might bridge the spatio-temporal gap from sub-reach to catchment scales, and take the next step toward modelling full landscape evolution. However, particle-based approaches have not yet been adapted to perform sediment transport in a way proven to yield quantitatively accurate landscape morphologies. This paper presents preliminary results from a particle-based flow model which has been extended to simulate catchment- and reach-scale sediment transport. The model is evaluated with respect to geomorphic validity of the results, and with respect to performance gains relative to both reductionist and reduced-complexity models.

****

PARALLEM: A new parallel-coded Landscape Evolution Model

MADDY D.(1), MCGOUGH S.(1), WAINWRIGHT J.(2), TRUEMAN A.(2)
(1) Newcastle University, NEWCASTLE UPON TYNE, UNITED KINGDOM ; (2) Durham University, DURHAM, UNITED KINGDOM

PARALLEM is a new landscape evolution model designed to leverage the immense processing power of massively parallel GPGPUs in order to facilitate high spatial resolution modelling of large river catchments . Modelling catchments in excess of 10,000 km2 from source to sink, even at modest spatial resolution e.g. 45m cells, requires computations based upon massive grids comprising millions of cells. Conventional CPU-based sequential models cannot perform this task within tractable execution time i.e. a few weeks. Such a task requires utilisation of high performance computing (HPC), where computation is spread across multiple processors in parallel.

PARALLEM has been coded to exploit the massively parallel CUDA architecture deployed in NVIDIA GPGPUs. Comparatively small grid models can be deployed utilising a single node with up to 4 attached GPGPUs but the model will scale for HPC deployment using associated MPI-based inter-node communication.

After a brief introduction to the process model underlying PARALLEM, this paper will present results from the initial testing of this model across a range of spatial and temporal scales; discuss how model sensitivity analysis is being undertaken using high throughput computing resources; outline the planned future extensions to the model; and discuss our initial target for full deployment.

Parallel processing in WPS services for geological and geomorphological mapping

ALVIOLI M., MARCHESINI I., ROSSI M., SANTANGELO M., CARDINALI M., REICHENBACH P., ARDIZZONE F., FIORUCCI F., BALDUCCI V., MONDINI A.C., GUZZETTI F.
CNR-IRPI, PERUGIA, ITALY

Exploiting to the maximum possible extent the information contained in spatial data, along with specialized and optimized computing intensive analysis processes, is mandatory in order to cope with the challenges posed by the huge amount of existing and upcoming data. Dealing with spatial data and related computing processes can be a hard task for many subjects, preventing proper dissemination of information and modeling advances. One possibility for sharing data content, specialized model implementation and distributed computing power is represented by Web Processing Services, an Open Geospatial Consortium standard specifically designed to facilitate the inter-operability of geospatial data by client-server interfaces.
The client side of the interface presents the user with a choice of services exposed by the server, and the possibility of specifying parameter values and uploading own maps. The main advantages of such an approach are the possibility of publishing specialized and optimized processes, corresponding to sound and well-established models; the complexity of the implemented processes is hidden by the server side, where a number of chained procedures can be summarized in a single service, optionally using different programming languages and, most importantly, exploiting distributed and parallel computing. We have implemented tools for (i) statistical models of the distribution of landslide areas (ii) estimation of the attitude of bedding planes from the corresponding bedding traces (iii) production of maps showing the geometrical relationship between bedding planes and terrain slopes (iv) automatic delineation of hydrological slope units. These few prototype services for landslide modeling, representative of a vast class of processes from the algorithmic implementation point of view and the parallelization schemes we have used, represent a starting point for a systematic publication of models through similar web services.

****

Multivariate Global Sensitivity Analysis of a Landscape Evolution Model: Multiple Model-Ensemble Deployment on a High Throughput Computing Grid

TRUEMAN A.(1), MADDY D.(2), MCGOUGH S.(2), WAINWRIGHT J.(1)
(1) Durham University, DURHAM, UNITED KINGDOM ; (2) Newcastle University, NEWCASTLE UPON TYNE, UNITED KINGDOM

Landscape Evolution Models (LEMs) are now prevalent tools within geomorphology due to facilitating the investigation of research questions over spatial/temporal scales unviable within field/laboratory studies alone. In recognition of their value to geomorphological research, on-going development of LEMs has improved their sophistication and range of process representation. However, as with all models of natural systems, a degree of uncertainty is associated with the internal parameterisations/assumptions of these LEMs. Estimation of model sensitivity to their internal parameterisations is commonly studied with simple local sensitivity analysis (SA) techniques - which are not suitable for non-linear models such as LEMs. Global SA techniques overcome the limitations of local SA, but are rarely applied to LEMs due to the nature of the time-series outputs of LEMs often producing thousands of sensitivity indices.
Recently, a more parsimonious principal component analysis (PCA) based approach to global SA on time-series outputs has been developed. Yet, its widespread adoption has been deterred by computational limitations related to the need to execute a large number of model runs. However, High Throughput Computing (HTC) grids allow multiple model runs to be executed concurrently; greatly reducing the time required for the execution of all runs required for the analysis.
This paper presents the results obtained from the PCA-based global SA of an existing LEM, alongside the methodology undertaken for concurrent model execution on a HTC grid. Through concurrent execution on the HTC grid, a reduction of over two orders of magnitude in time required for the execution of all model runs has been achieved (when compared to serial execution). The results obtained from the PCA-based global SA have allowed an informed evaluation of the LEM's parameterisations, whilst also illustrating a current limitation associated with the model's vegetation component.

Are 'Physically-based' soil erosion models physically-based? Some elements from a sensitivity analysis of the Hairsine and Rose model

ROUSSEAU M.(1), CERDAN O.(1), ERN A.(2), LE MAÎTRE O.(3), SOCHALA P.(1)
(1) BRGM, ORLÉANS, FRANCE ; (2) Université Paris-Est, Cermics, Ecole des Ponts ParisTech, MARNE LA VALLÉE, FRANCE ; (3) LIMSI-CNRS, ORSAY, FRANCE

We study parametric uncertainty propagation and quantification for the simulation of erosion processes in the presence of rainfall and/or runoff. Uncertain input parameters of the Harisine & Rose model are treated in a probabilistic framework, considering them as independent random variables defined by prescribed probability density functions. This probabilistic modeling is based on a literature review to identify the range of variation of the main input parameters. The output statistical analysis is realized by Monte Carlo sampling and by Polynomial Chaos expansions. Our analysis aims at quantifying uncertainties in selected model outputs and establishing a hierarchy within input parameters according to their respective influence on output variability by means of global sensitivity analysis (Sobol indices). The sensitivity of the output variability to the different parameters is discussed. Furthermore, our analysis of the Harsine & Rose erosion model permits to conclude that, for the quantities of interest considered, the parametric interactions are not significant in the rainfall detachment model, but they prove to be important in the runoff detachment model.

Poster presentations:

Effect Meander Development at change land cover in Mond River with Spatial Data Modeler

NAEIMINEZAMABAD A.
Islamic Azad University,Saveh Branch, SAVEH, IRAN

A meander is a bend in a sinuous water course or river. Meanders formed when the moving water in a stream erodes the outer banks and widens its valley. The first impact of create a meander is changed in geometry of river and also change land use and land cover in bank of rivers. In this study we calculate structure of Mond river habitation in section of the plains where river flows until to Persian gulf. Based study of ETM, IRS and in some area's Quick Bird satellite image that receive from 2000 until 2008 and also aerial photo (Scale 20000) that photographed in 2005 and also use from Topographic Data, river Bathymetry we create Landover and river Geometry in four section. The all digital data's that create'd base satellite images and other data's were inputs for run a simulation model based SDSS in ArcGIS software. Based structure of river and land cover change we create a prediction model in Spatial Data Modeler. Prediction model in SDM were based Unsupervised Neural Network. To achieve the desired result in this part ,we developed this extension in VBA environment. all of data's joint with together in unsupervised neural network and in result we create a good simulation model with maximum 5% error. Based result of this simulation obvious that 38% of land cover in river banks will change until 6 years and in this change approximately 48% of existing land covers that will change are inside of meandering around erodable corner and 52% of land cover that will change are in deposition corner. Landcover digital layer refer to year 2008 werean indicator for compare result of model with existing condition. In result, based use for spatial simulation, be able identified behavior survey of river change and also knowledge of the nature change, especially aware of the changes in river geomorphology can help for better planning based sustainable development in areas affected by river flows.

****

The use of ground models for the integration of geomorphological, geoenvironmental and engineering geological data

GILES D.
University of Portsmouth, PORTSMOUTH, UNITED KINGDOM

The use of conceptual ground models (CGM) together with conceptual site models (CSM) is becoming an increasingly important tool for the characterisation and interpretation of engineering sites and in particular as part of the investigation and redevelopment of potentially contaminated Brownfield sites. The key data sets of geomorphology, solid and superficial geology, hydrogeology and site history which are necessary for the investigation, interpretation and risk management of a particular site can be complex to present together. The use of a visualised ground model allows for a clear interpretation of these data to be made in a format that is readily accessible by an end user.

A visualised ground model provides the geomorphologist and engineering geologist with a simple and easily understood vehicle to aid in the understanding of the three and often four dimensional variability of a given site. Complex interactions and potential geohazards, whether geomorphological or geological, can be identified and emphasised by the use of such models.

This paper will review the current approaches to ground model design and will highlight the need for geomorphological data to be integrated within them. Various examples will be presented of the different approaches that are available, particularly with regard to contaminated former Brownfield sites.

Regional characterization based on a new drainage network parameter. The case of the Coatzacoalcos fluvial system.

RAMIREZ NU_EZ C., PARROT J.F.
UNAM, MEXICO D.F., MEXICO

Fractal measurements are generally used to characterize different drainage network patterns. The fractal dimension would be closely related to the flux configuration. As the fractal dimension is not only related to the configuration but also to the way in which the pattern fills the space, this measurement is not sensible enough to really distinguish different drainage network features. This is the reason why it was necessary to develop the algorithm presented here in order to study the complex fluvial Coatzacoalcos river system (State of Veracruz, Mexico) characterized by the development of numerous meanders, anastomosed and dendritic structures.

The method consists on using a moving window of size $m \times m$ centered on a pixel i,j (i for the line, j for the columns); in a first step the program labels the different segments of the drainage network encountered and only takes into account the segment passing through the window center. The total number (Np) of pixels describing the chosen segment as well as the total number of confluents *(Nc)* are calculated. The proposed new parameter (R_{cj}) is calculate as follows: $R_{cj} = (R_2/R_1) \times 100$ where $R_1 = 100 - (Nc \times 10/Np \times 100)$ and $R_2 = [Np/(m \times m)] \times 100$. The parameter R_{cj} is able to distinguish the dendritic drainage network from the meandric drainage network and its value is reported on the resulting image at the position i,j. For instance, in the studied region the meandric configuration has a R_{cj}around 3.6 meanwhile the R_{cj} value for a dendritic drainage network is greater than 5.

As the R_{cj}values are only reported at the position occupied by the pixels belonging to the drainage network, the regionalization of these values in a second step requires using another moving window (of size $m \times m$ or $n \times n$) in order to calculate the mean value of *Rcj* of the pixels that do not correspond to the drainage network.

****

Morphology and dynamics of star dunes from numerical modelling

ZHANG D.(1), NARTEAU C.(2), ROZIER O.(2), COURRECH DU PONT S.(3)
(1) Institute of Geology and Geophysics,Chinese Academy of Sciences, BEIJING, CHINA ; (2) Institut de Physique du Globe de Paris, PARIS, FRANCE ; (3) Laboratoire Matière et Systèmes Complexes, Univ Paris Diderot, PARIS, FRANCE

Star dunes are giant, pyramid-shaped dunes composed of interlaced arms. These arms are marked by sinuous crests and slip faces of various directions. Their radial symmetry and scale suggest that the star dunes form as a result of complex interactions between a multidirectional wind regime and topography. However, despite their ubiquity in modern sand seas, comparatively little is known about their formation and evolution. Here we present a discrete numerical model of star-dune behaviour based on the feedback mechanisms between wind flow and bedform dynamics. Our simulations indicate that the morphology of star dunes results from the combination of individual longitudinal dunes. We find that the arms of the star dunes propagate only under favourable wind regimes. In contrast to dunes that form from an erodible bed, the crests of the propagating arms are oriented such that sand flux is maximized in the direction of arm growth. Our analysis of the simulated three-dimensional structures suggests that the morphodynamics of the arms are controlled by the frequency of wind reorientation, with a high frequency of reorientation leading to smaller arm dimension and high rates of growth. We suggest that arm propagation is an important process of mass exchange in dune fields.

Predicting river morphology after restoration. Application to a Brazilian case of the methodology VALURI

NARDINI A.(1), GOMEZ MIGUEZ M.(2), PITZER JACOB A.C.(3)
(1) Italian Centre for River Restoration -CIRF (www.cirf.org; mail: a.nardini@cirf.org), MESTRE, ITALY ; (2) Universidade Federal do Rio de Janeiro, Polytechnic School and Civil Engineering Program PEC-COPPE (mail: marcelomiguez@poli.ufrj.br), RIO DO JANEIRO, BRAZIL ; (3) Universidade Federal do Rio de Janeiro, Polytechnic School and Civil Engineering Program PEC-COPPE (mail: carolinepitzer@coc.ufrj.br), RIO DO JANEIRO, BRAZIL

River Restoration (see for instance www.ecrr.org) is increasingly recognized as a core discipline not only to improve the ecological status of rivers (a requirement of the European Water Framework Directive), but also to combat flood and hydro-morphological risk. After the application of a River Restoration project which foresees significant changes in the system of defence and exploitation works as well as man-made morphological adjustments (e.g. reconnection of an incised main channel with the surrounding ex-floodplain), river morphology will change and its hydraulic and geomorphic dynamic as well. It is hence key to predict in advance the future morphology and geometry that the river will assume after the project, in order to evaluate whether the effects of the foreseen project are indeed desirable or not.

Nardini and Pavan (2012, *J. of River Basin Management*, 10/1) proposed a semi qualitative, articulated methodology to carry out such a prediction and applied it to the Italian case study of the Chiese river. In this paper, a twofold exercise is conducted, by adopting the same methodology, for a Brazilian case study: the Dona Eugenia river. On the one side, a prediction is carried out for few RR alternatives proposed within a more general project of RR of the area, exactly as it had been done for the Italian case study, but with all the modifications due to the different nature of the river and its context. On the other hand, a partial attempt to validate the methodology itself is carried out through an ex-post prediction exercise; i.e., we try to predict current morphological status , starting from a point in the past before great land use modifications and hydraulic works had occurred.

Although several weaknesses can still be identified in the methodology adopted, the need for it is evident and additional validation exercises and successive improvements can pave the way for an important and effective tool complementing traditional mathematical modelling.

****

Analysis of methods of potential environmental fragility in a small sized watershed

CORREA E.A., PINTO S.D.A.F., MORAES I.C.
Sao Paulo State University, RIO CLARO, BRAZIL

The aim was to analyze the methods of Universal Soil Loss Equation-USLE (WISCHMEIER e SMITH, 1974) and the Empirical Analysis of Fragility of natural environments anthropogenic, with support in the slope classes (ROSS, 1994), referring to potential environmental fragility in the small sized watershed, considering that the same is located in an area with sub-tropical climate, predominantly wavy/strong wavy relief and predominantly sandy soil. The variable that constitutes both methods was obtained by cartography, statistics and geoprocessing techniques, being raised slope-steepness, type of soil, erosivity, erodibility and slope-length variables, all scale 1:10.000. The variables erosivity, erodibility, slope-length and slope-steepness were crossed in GIS, as formulation of Wischmeier e Smith (1974) and reclassified as Bertoni e Lombardi Neto (1999), obtaining the map of potential environmental fragility of USLE. Also in GIS, the map of potential environmental fragility obtained through of Empirical Analysis of Fragility of natural environments anthropogenic, was prepared by superimposing the information sheets of slope-steepness, erosivity and type of soil as methodology proposed by Ross (1994). In both products, the areas of higher fragility localized in sectors of greater slope and the presence of vulnerable soils were classified as strong/very strong fragility. Also, the areas localized in sectors of lower slope and soils with low erodibility were classified as low/very low fragility. However, it was verified that the products derived from method Ross (1994) showed 40% of area classified as strong/very strong fragility because of greater importance given to factors geomorphology and slope. The conclusion is that areas of high slope, the method of Ross (1994) can present excessive results compared to reality. GIS demonstrated effective in the analysis of environmental fragility, being possible the applying of methodology in studies of environmental planning.

Comparative study of overland flow modeling with different numerical resolutions

ROUSSEAU M.(1), CERDAN O.(2), DELESTRE O.(3), DUPROS F.(2), CORDIER S.(4), JAMES F.(4)
(1) BRGM, ORL_ANS, FRANCE ; (2) BRGM, ORL?ANS, FRANCE ; (3) Laboratoire de Mathématiques J.A. Dieudonné & EPU Nice-Sophia Antipolis, Université 11 de Nice-Sophia Antipolis, NICE, FRANCE ; (4) MAPMO, Université d?Orléans, ORLÉANS, FRANCE

In the last decades, more or less complex physically-based hydrological models have been developed to solve the shallow water equations or their approximations using various numerical methods. Model users may not necessarily know the different hypothesis lying behind those developments and simplifications. Therefore it might be difficult to judge if a code is well adapted to their objectives and test case configurations. Our study aims at comparing the predictive abilities of different codes and evaluating potential gain by using advanced numerical scheme for modeling runoff. We present four different codes; each one based on either shallow water or kinematic waves equations and using either finite volume or finite difference methods. We compare these four numerical codes on different test cases which allow emphasizing their main strengths and weaknesses. Results show that, for relatively simple configurations, kinematic waves equations solved with finite volume method represent an interesting option. Nevertheless, as it appears to be limited in case of discontinuous topography or strong spatial heterogeneities, for these cases we advise the use of shallow water equations solved with the finite volume method.

****

Assessment of annual streamflow responses to different land use and land cover in a mountainous area of Rio de Janeiro, Brazil

SILVA A., FERNANDES N.
Federal University of Rio de Janeiro, RIO DE JANEIRO, BRAZIL

Risk assessment of future land use changes with respect to their ecological impact is still a problem. The application of hydrological models to quantify the effects of different land use and land cover on the streamflow response of the catchment can clarify the processes involved and support management decisions. This study investigates the contribution of different types of land use and land cover on the streamflow of Bonfim river basin through analysis of the hydrological response by sub-basins using the distributed hydrological model Soil and Water Assessment Tool (SWAT). Located in the mountainous region of Rio de Janeiro, the basin is covered predominantly by forests with different stages of succession, rocky outcrops, agriculture and small portion of urbanized area. Based on the sensitivity analysis, calibration and verification, the hydrologic response was simulated. The results indicated that the levels of flow varied according to the use and coverage. Subbasins with forest presented reduced levels of flow than subbasins with predominance of agriculture. The subbasins with urbanized area, even associated with forest, were those that produced higher levels of flow. We can conclude that in mountainous areas, with slopes ranging from 20 to 75° degrees, associated with urbanized areas hold a higher concentration of water flow. Results of this study improve our understanding of how the production of water is spatially distributed, the role of forests to contain the flow of the watershed even with different stages of succession and the contribution of rocky outcrops and slope to flow levels. The expansion of agricultural or urban areas could represent a significant increase in the levels of flow in Bonfim's catchment. SWAT has the potential to simulate the streamflow of the watershed presenting reasonable results and given support to expand research aimed scenarios with replacement coverage for different uses.

Concept of sustainable management involves landscape geodiversity of hydrogeomorphological units: the Dębnica River, Poland

BORYSIAK J.(1), MAZUREK M.(2), ZWOLINSKI Z.(2)
(1) Institute of Physical Geography and Environmental Planning, Adam Mickiewicz University, POZNAN, POLAND ; (2) Institute of Geoecology and Geoinformation, Adam Mickiewicz University, POZNAN, POLAND

The concept of sustainable management of landscape geodiversity for the Dębnica drainage basin, representing the lakelandareas formed by the Vistulian ice-sheet, is presented. A geoecosystem model is used for solving planning dilemma. The model treats natural environment as a system of abiogenic, biogenic and anthropogenic components (and their state) described as hydrogeomorphological units. Within the research procedure GIS framework the following main tasks are conducted: 1 – designing and delimitation of a geoecosystem map, based on catchment divisions (HRU), potential natural vegetation, present-day vegetation and types of land cover/use, showing a spatio-functional structure of landscape subsystems, 2 – analysis of geoecosystem linkages, 3 – classification of the distinguished geoecosystems in terms of landscape geodiversity. Geoecosystem model of the DębincaRiverdrainage basin allows to assessment of classified units from the ecosystem services point of view. The sustainable management of classified units enables identification and elimination of risks for existing and potential ecosystem services. Therefore geoecosystem model of any drainage basin determines optimal functions for hydrogeomorphological units.

****

The Importance of the USLE L Factor in Erosive Modeling: a Brazilian perspective

PINHEIRO L.(1), CUNHA C.(2)
(1) Universidade do Estado de Minas Gerais, FRUTAL, BRAZIL ; (2) Universidade Estadual Paulista, RIO CLARO, BRAZIL

The sheet erosion, due to its peculiar characteristic, is hardly detected by most of the population, especially in the early stages, so there is a need for the establishment of correct practices for soil conservation. Universal Soil Loss Equation (USLE) seeks to estimate soil loss by sheet erosion, considering the factors that influence in the erosion, it is a model of erosion widely applied in national and international research. However, there are limiting factors, the USLE does not consider the geometry of the sides and partially addresses the question of extending the slopes. Thus, the main objective of this research was to analyze how the systematic collection of data length strands affect the results obtained with USLE, and from this analysis, propose an efficient way to produce data extension slopes. As the study area was selected Watershed of Stream Ibitinga, inserted in municipality of Rio Claro, with headwaters in rural production area and its middle and lower course in the area of the Sustainable Use and Conservation of Environment Unit, of the Environment Secretarit of State of the São Paulo, the Edmundo Navarro de Andrade Forest (FEENA). This paper was applied on soil loss, considering the erosive modeling (USLE) and the implementation of erosion plots, with emphasis on Factor L (extension slopes), analyzing systematically obtaining such data. Activities were carried out in the field, laboratory and office to survey and analysis of soil loss and erosive modeling. It was noted that the L factor significantly influenced the generation of the Letters of Potential Natural Erosion and Soil Loss Estimates. The quantification of the slopes extents by three methodologies pointed to satisfactory results on the research proposal. The slopes segmentation technique was more appropriate, differentiated values presented LS Factor along the lower slope and small generalization of data, was presented the highest values coincidence with the experimental plots.

A GRASS GIS model for high-mountain multihazard assessment at the regional scale

MERGILI M., GRUBER F.E., SCHNEIDER J.F.
Institute of Applied Geology, BOKU University, VIENNA, AUSTRIA

High-mountain areas are commonly experiencing pronounced environmental changes, caused by atmospheric temperature increase. Such changes include both permafrost melting and the retreat of glaciers. Together with earthquakes, they disturb the dynamic equilibrium of the fragile high-mountain geomorphic systems, leading to an increased occurrence of rapid mass movements, sometimes with long travel distances. Here we demonstrate a scheme for a regional-scale high-mountain multihazard assessment, including (1) Lake outburst floods; (2) Rock-ice-avalanches; and (3) Rock slides.

The scheme is developed in the Open Source Geographic Information System GRASS GIS and applied to a 100,000 km² study area in the Pamir (Central Asia). First, the susceptibility of each type of event is determined and a score is assigned to each object (lakes, hanging glaciers) or pixel (rock slides). This score is increased for areas with melting permafrost, which are particularly susceptible to mass relocation processes: a solar irradiation model is used to determine permafrost areas under the current conditions and under projected conditions in the future.

Second, the possible travel distances and impact areas of all types of processes are computed using empirical relationships. Inaccuracies of the relationships are accounted for by applying multiple random walks with the key parameters varied within the confidence interval. The results for all processes are overlaid, so that a multihazard impact susceptibility score is assigned to each pixel.

The impact susceptibility score is then superimposed with a layer of settlements, farmland and infrastructures, in order to derive a pixel-based risk indication map. The risk indication scores are summarized by village. The results shall represent an objective base for (1) the prioritization of areas requiring mitigation measures and (2) the identification of safe places.

****

Modelling river evolution: conceptual and numerical model on the river pellice (North-Western Italy)

PASCULLI A., AUDISIO C., SCIARRA N.
Department of Engineering and Geology, University Chieti-Pescara, CHIETI, ITALY

Models are a simplifying abstraction of reality. Furthermore, they provide one of the crucial links between the study of processes and the study of the world around us, the two traditional activities of geomorphology.

Particularly, the fluvial geomorphologic models have been developed to address problems both on pure scientific research and river engineering. In general, in the first step of modelling processes for identifying the river reaches for more detailed investigation, the conceptual models are most often used. However, together with the computational hardware, the use of numerical simulation models in fluvial geomorphology has rapidly increased in the last twenty years.

Starting from these considerations, the present research illustrates the reconstruction of spatial variation in channel morphology and sediment dynamics in the long, medium and short-term period using the traditional methods of investigation through historical maps (1880-1945), aero-photographs (1945-1999) and ortho-photographs (2007). This reconstruction allows a preliminary comparison with a conceptual model but it leaves several doubts on river evolution in the short-term periods. As a consequence, a numerical model (cellular automaton) has been introduced in order to trying to estimate and evaluate a set of evolutionary scenarios of the river.

In our research activity, we have applied the Conceptual Evolution Model (CEM) proposed by Surian and Rinaldi in 2003 and its following adjustments and CAESAR modeling at the case-study of the River Pellice, left tributary of the River Po. It drains a 905 km^2 wide catchment in the Central Cotian Alps in Piedmont and for about 40 km it runs in the plain sector of North-Western Italy.

Estimates of river flows, floodplain inundation and land-atmosphere feedbacks in tropical African wetlands

DADSON S.
School of Geography and the Environment, University of Oxford, OXFORD, UNITED KINGDOM

The response of African rivers and floodplains to climate variability and change is of interest to hydrologists, meteorologists and water managers. Over wet surfaces, high daytime evaporation rates and suppressed sensible heat fluxes induce a shallower, moister planetary boundary layer, which affects atmospheric instability and favours the initiation of new storms. Yet because models of the Earth system do not usually represent fluvial floodplain processes, little is known about the ability of regional models to reproduce regional patterns of hydrological response to climate variability and change, and few studies have directly addressed the impact of fluvial inundation on water, energy and carbon fluxes between the atmosphere and the land surface.

Here the JULES land surface modelis used to produce estimates of river flows over Africa.This model uses a probability distributed model of soil moisture and runoff production coupled with a discrete approximation to the 1D kinematic wave equation to route river water downslope. Subgrid resolution topographic data are used to derive a two parameter frequency distribution of inundated areas for each grid box which we then employ to represent overbank inundation in the model. The model was configured at 0.5 degree resolution and driven using the WATCH Forcing Data. The model reproduces the salient features of observed river flow and inundation patterns including substantial evaporative losses from inundated regions accounting for increased land atmosphere water fluxes during periods of greatest flooding. Results are evaluated against observed estimates of inundation extent obtained using satellite infrared and microwave remote sensing and the implications of these findings is considered in relation to future changes in climate, wetland extent and carbon fluxes.

****

A GRASS GIS-based deterministic model for the analysis of deep-seated slope stability in complex geology

MARCHESINI I.(1), MERGILI M.(2), SANTANGELO M.(1), BUCCI F.(1), CARDINALI M.(1), ROSSI M.(1), FELLIN W.(3), GUZZETTI F.(1)
(1) CNR IRPI, PERUGIA, ITALY ; (2) Institute of Applied Geology, BOKU University of Natural Resources and Life Sciences, VIENNA, AUSTRIA ; (3) Unit of Geotechnical and Tunnel Engineering, University of Innsbruck, INNSBRUCK, AUSTRIA

We present a GIS-based, three-dimensional slope stability model capable of dealing with deep-seated slope failures in complex geology. The model is developed in GRASS GIS as the raster module r.rotstab and builds on a slight modification of the three-dimensional sliding surface model proposed by Hovland and revised and extended by Xie et al. (2003). Given a Digital Elevation Model (DEM) and a set of thematic layers, the model evaluates the slope stability over a large number of randomly determined potential ellipsoidal slip surfaces. In addition, truncated ellipsoids can be used to simulate the presence of weak layers, most commonly delimited by regolith discontinuities or the interfaces between geological layers. Any raster cell may be intersected by various sliding surfaces, each associated with a computed safety factor. The lowest value of the safety factor is stored for each raster cell together with the depth of the associated slip surface. This results in an overview of potentially unstable regions without showing the individual sliding areas.

We apply the model in the Collazzone area, Umbria, Central Italy. Initially, we assume homogeneous regolith. Even though the model successfully predicts much of the observed deep-seated landslides, it fails in a significant number of cases. According to field observations in the Collazzone area, morpho-structural settings – and therefore the bedding attitude of the geological layers – play a crucial role for deep-seated landslide distribution. Therefore, we prepare a 3D model of the geological substrate, based on the superficial strike and dip directions of each layer, and use this model as input for the r.rotstab model. The results for selected subsections of the Collazzone area are shown and evaluated in comparison with the results yielded with the assumption of a homogeneous substrate.

Using field data to evaluate modeling input parameters and attempt to include spatial distribution of flow bulking of lahars in three valleys at Cotopaxi volcano, Ecuador

ETTINGER S.
Clermont Université, Université Blaise Pascal, GEOLAB & CNRS, UMR 6042, GEOLAB, CLERMONT-FERRAND, FRANCE

LaharZ is a computer model that estimates areas of potential inundation from volcanic debris flows often termed lahars. The software, that runs within a geographic information system (GIS), requires estimates of flow volume and a digital elevation model (DEM) as input data. Rapid and reproducible results make the software amenable to use during volcanic crises to assess hazard and aid mitigation measures in potentially affected floodplains. LaharZ algorithms and input parameters affect the output. Both the estimates of volume and quality of the topographic data influence the results. This study analyzed geomorphological parameters of potentially inundated areas at Cotopaxi volcano, Ecuador, using aerial and oblique photographs and morphometric measurements to assess whether input data would improve output by changing various local hazard scenarii. DEMs of different generic type (remote sensing derived DEMs compared to derived from contours) and spatial resolution had observable differences in lateral and longitudinal extent of potentially inundated areas. In addition, a new LaharZ-macro attempted to incorporate field data to simulate flow bulking of lahars along their downstream path, changing the volume and output areal extent. In this example, using simple cross-section measurements and deposit volume calculations, the algorithm attempts to emulate progressive total erosion of existing lahar deposits along the valleys. Estimated sediment bulk volume is $< 0.79 \times 10^6$ m^3 and thus too small to result in change inundated cross-sectional and planimetric areas in well-confined drainage segments. However, these changes increase lateral spreading in less confined segments and runout distance. Such field observations may improve model outputs as well as interpretation of those outputs.

****

Innovative Modelling Techniques to Upscale Novel Field and Laboratory Estimates of Soil Erosion

WAINWRIGHT J.(1), PARSONS A.J.(2), COOPER J.R.(3), LONG E.J.(4), HARGRAVE G.(4), KITCHENER B.(2), HEWETT C.(1), ONDA Y.(5), FURUKAWA T.(5), OBANA E.(5), HAYASHI H.(5), NOGUCHI T.(5), PATIN J.(5)
(1) Durham University, DURHAM, UNITED KINGDOM ; (2) University of Sheffield, SHEFFIELD, UNITED KINGDOM ; (3) University of Liverpool, LIVERPOOL, UNITED KINGDOM ; (4) Loughborough University, LOUGHBOROUGH, UNITED KINGDOM ; (5) University of Tsukuba, TSUKUBA, JAPAN

Erosion is a particle-based phenomenon, yet most current understanding and modelling of this process is based on bulk measurements rather than the movement of individual particles. Difficulties with measuring particle motions in dynamically changing conditions are being overcome with the application of two new technologies – particle imaging velocimetry (PIV) and radio frequency identification (RFID). It is thus possible to evaluate the entrainment, transport and deposition of individual particles

Both PIV and RFID tagging have been used in laboratory experiments to evaluate the detachment process by raindrops on bare surfaces and in shallow flows using rainfall simulation. The results suggest that the processes are more complex than hitherto thought with multiple detachment and transfer mechanisms. Because both mechanisms affect travel distance, they affect the ways in which estimates of soil erosion can be scaled from plot to hillslope and catchment scales. To evaluate movements at larger scales, we have also used RFID-tagged particles in field settings to look at sediment transfers following the Fukushima accident in Japan, 2011.

A marker-in-cell model (MAHLERAN-MiC) has been developed to enable the laboratory results to be upscaled and tested in a field setting. Markers (representing sediment particles), are initially distributed on a cellular grid. A cellular model is used to set up the boundary conditions and determine the hydrology and hydraulics on the hillslope. The markers are then moved through the grid according to these properties. This technique combines the advantages of Eulerian and Lagrangian methods while avoiding the shortcomings of each (computational efficiency vs. accuracy). We demonstrate how distributions of travel distances change as spatial and temporal scales of application change, and thereby how the laboratory and field experiments can be best used to develop more robust approaches to the upscaling of estimates of erosion rates.

Robust interpolation techniques for estimating suspended sediment yields in logged catchments, south-central Chile

MOHR C., ZIMMERMANN A., FRANCKE T., KORUP O., BRONSTERT A.
University of Potsdam, POTSDAM, GERMANY

Most estimates of suspended sediment yields rely on time series of both streamflow discharge and sediment concentrations (SSC). The step from discrete measurements to continuous time series, though, remains tricky and often complicates quantitative estimates of sediment transport. To this end either physics-based modelling or statistical interpolation comes into play. Both approaches, however, may be limited under disturbances such as land-use changes or environmental boundary conditions that otherwise change during the observation period: Recent research has amplified on effects of timber harvest or rare events such as rainstorms, wildfires, and earthquakes that may temporarily boost sediment dynamics. This implies that a robust quantification of soil erosion is critical in order to assess the impact of clear-cutting unbiased from such disturbances which in turn permits a firm basis for management recommendations.

Here we estimate sediment yields of catchments of similar size (~10 ha) under different forestry use in the Chilean Coastal Range using Quantile Regression Forests (QRF). QRF is a non-parametric regression technique that combines bootstrap aggregating with random variable selection. We calculated (annual) sediment yields and their uncertainties of a control catchment and two adjacent catchments of which one was clear cut during the rainy season while the other was harvested during the dry period. We then compared the results obtained with previous results based on physics-based modelling (WASA-Sed) and simple discharge-SSC-relationships.

Our findings show that QRF models may be a promising tool to estimate sediment yields under disturbed conditions such as clear-cuttings. Ultimately, our study suggests that conventional approaches employing physics-based modelling or simple regression approaches, i.e. sediment rating curves, may be prone to bias in disturbed environments dominated by hysteresis effects between streamflow and suspended sediment discharge.

****

A Conceptual Understanding of Sedimentation in South African Catchments by a Sediment Flow Model

BRYSON L., HUGHES D.A., ROWNTREE K.M.
Rhodes University, GRAHAMSTOWN, SOUTH AFRICA

Increased sediment concentrations in rivers and sedimentation in reservoirs have been creating significant implications on land and water resources in South Africa. An understanding of the physical processes that determine sediment dynamics in semi-arid catchments is needed if erosion management is to succeed. Reliable sediment yield predictions are a useful tool for understanding and can be obtained by using a sediment model. There are a variety of models available, but issues such as scale, limited understanding of sediment dynamics and increased complexity limit application. What is needed in South Africa is a simple sediment model that can work in data poor environments and be representative of the landscape.

Probability distribution theory allows for a simple semi-distributed model which can be incorporated into a geographic information system (GIS). An erosion hazard probability distribution function (PDF) would be developed by incorporating PDFs of the erosion factors soil, vegetation and topography. This can be considered the sediment availability, whilst sediment production relies on rainfall. A modification of the Pitman rainfall-runoff model would provide daily and monthly runoff outputs to be incorporated with the erosion hazard distribution to determine sediment production. The addition of a storage component is also necessary as not all sediment produced reaches the catchment outlet. The end result of this model would be a conceptualisation of sediment dynamics that can be easily understood and be representative of a semi-arid catchment.

The timing and pattern of sediment movement in response to rainfall events are important in semi-arid regions such as South Africa where erosive events usually occur as the result of high-intensity, short-duration storms. This new sediment model provides a simple conceptualisation of sediment dynamics that has become increasingly necessary in a changing environment.

Evaluating landscape evolution models with object-based landform classifications

ANDERS N.(1), SEIJMONSBERGEN H.(2), BOUTEN W.(2)
(1) Wageningen University, WAGENINGEN, NETHERLANDS ; (2) Institute for Biodiversity and Ecosystem Dynamics, University of Amsterdam, AMSTERDAM, NETHERLANDS

Dynamic landscape evolution models are recognized means for increasing the understanding of geomorphological processes and their impact on the environment over time. Evaluating model results remains, however, a challenge. We suggest integrating landform classifications with dynamic landscape evolution models to visualize and evaluate model dynamics. We introduce a modular erosion/sedimentation model to simulate post-glacial landscape development in a small alpine catchment. This model comprises three different modules, in which each module different geomorphological processes are described, namely the 1) mechanical weathering of bedrock and production, transportation and deposition of debris through rock fall, 2) fluvial erosion of converging water streams by incision into bedrock, and 3) redistribution of unconsolidated materials through superficial flow/slide processes. Model results are visualized with object-based landform classifications to interpret the dynamics of the model. The segmentation and classification procedure is applied at several time steps of simulated landscape evolution and clearly shows the development of fluvial erosion channels which accelerates mechanical weathering and rock fall. The classifications allow the analysis of simulated topographic change per landform type and reveal a transition from a glacial towards a fluvial landscape in a quantitative fashion. We concluded that categorizing landscape objects into functional landforms enables a quick but detailed overview of simulation results and model behavior. Using landform classifications we partly automated the interpretation which allows the investigation of the change of the functioning of a landscape during a simulation. Integrating landform classifications in landscape evolution modeling opens up new opportunities for e.g. evaluating complex dynamics in landscape evolution models, or analyzing scenario-based landscape development and specific landform evolution.

****

Gully Development Assessment with Google Earth, GIS and Statistics

QUENEHERVE G.(1), MÄRKER M.(1), ZAKERINEJAD R.(2)
(1) Heidelberg Academy of Sciences and Humanities, TUEBINGEN, GERMANY ; (2) Tübingen University, TUEBINGEN, GERMANY

In this study, we estimated the usefulness of Google Earth in order to map the different kinds of gully systems appearing in the study area of Northern Tanzania (linear, dendritic, anastomosing, and ephemeral gullies) and to distinguish with the help of Geographic Information Systems (GIS) old (inactive systems) from young (active systems) ones. Old gully systems are characterised as well developed and prolonged within their according watershed.

As previous studies stated (McInnes *et al.,* 2011), the use of Google Earth for the estimation of gully systems are in particularly useful where old, well developed gully systems are prevalent. As the Makuyuni River catchment is located in an area that suggests no or only very minor faulting prior to ~1 Ma (Ring *et al.* 2005), there are good reasons to estimate the age of a high number of existing gullies as old. Google Earth provides images at no costs for the detection of gully systems. For the whole of the Makuyuni River catchment (~3000 km²) gullies have been identified via Google Earth.

The delineations of the gullies have been supported and validated by auxiliary field studiesfor a part of the catchment. Additionally, we processed a WorldView-2 scene (~170 km²) with 2m panchromatic resolution as well as aerial photographs from the 1980s, both datasets covering the field work area, to countercheck the accuracy.

To distinguish between gully and streambank erosion, we defined streams as drainage lines of third or greater Strahler order (Strahler, 1952). To assess the gully evolution, we used the gully development concept proposed by Kosov *et al.* in 1978. As basis for the Digital Elevation Model (DEM), we used SRTM 30m data. A Maximum Entropy analysis (Phillips *et al.* 2006) validated our results with a training dataset for the whole of the catchment.

Methodological comparative assessment of the landslide susceptibility - case study: The Niraj River Basin (Transylvania depression, Romania)

ROSCA S.M., PETREA D., IRIMUS I.A., SURDEANU V.
Babes Bolyai University, Faculty of Geography, CLUJ NAPOCA, ROMANIA

The importance of hazard and risk mapping is unanimous recognized in the last decades due to the fact they provide extremely useful information within the frame of hazardous events prevention and the related planning decisions adoption. Unfortunately, depending on the quantity and especially on the quality of the data used in the analysis, as well as by the large variety of the quantitative and qualitative applied methods, the evaluation proceedings became heterogeneous, difficult and implicitly ambiguous. The main objective of the present study is to evaluate the landslide susceptibility for an area of 658 km2 according to Romanian Governmental Decision No. 447/2003, by estimating the importance of each class of the eight factors involved: lithology, geomorphology, structure, hydro-climatic factors, hydrogeology, seismicity, forestry and anthropogenic factor. Each thematic map was built up and analyzed and after that for each factor influencing slope instability a specific coefficient was given according to the methodology and thus the average coefficient hazard was calculated. The case-study discussed here concerns the Niraj basin area that can be considered representative for the NE of Transylvanian Depression from different points of view: similar slope, aspect, average curvature, land-use, vegetation and lithology. Specifically, statistical model based on the bivariate probability analysis was applied to predict the spatial distribution by estimating the probability of landslide occurrence. In order to validate the model, the resulting maps were compared with the existing landslide identified by field research trips, topographic maps scale 1:25000 and SPOT 5 satellite images and calculate the percentage of landslide within each hazard map. The validations shows that 98,7% of the landslide mapped are included in the high susceptibility (obtained by statistical approach), versus 89,7% (obtained by semi-quantitative approach).

****

Modeling debris flow erosion in Alpine Holocene debris fans: application to the Spreitgraben catchment, Switzerland

FRANK F.(1), MCARDELL B.(1), DEUBELBEISS Y.(1), HUGGEL C.(2), KULL I.(3)
(1) Swiss Federal Research Institute WSL, BIRMENSDORF, SWITZERLAND ; (2) Department of Geography, University of Zurich UZH, ZÜRICH, SWITZERLAND ; (3) Geotest AG, ZOLLIKOFEN, SWITZERLAND

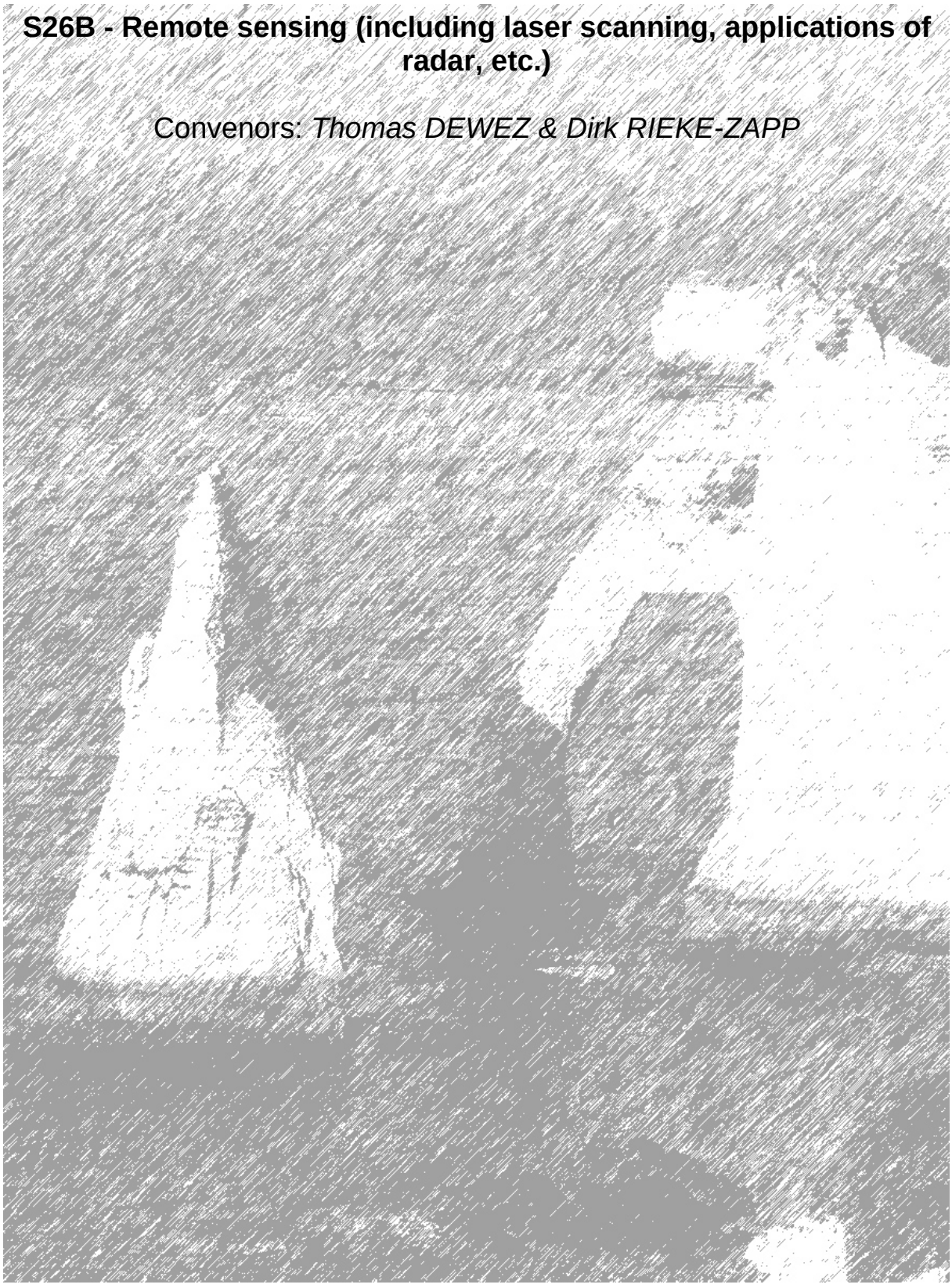
Debris fans are characteristic Alpine landforms constructed by some combination of modern, historical, or Holocene mass movements including rockfall, rock avalanches and debris flows. The geometry of debris-flow-dominated fans and their sediment deposits depend on the magnitude and frequency of the debris flows: relatively small and frequent debris flows (1000's of m^3 per event) are expected to produce generally steeper landforms than larger but much less frequent debris flows (on the order of 10^4 to a few 10^5 m^3 per event). The sudden onset of large and erosive debris flows has been observed recently in different catchments in Switzerland.

In the Spreitgraben catchment (Canton Bern, Switzerland; catchment area 4 km^2) e.g. there has been a massive increase of the frequency of large debris flows. The cumulative magnitude of channel erosion since 2009 is on the order of several 10's of meters for certain channel sections. Consequently the banks have become over-steepened and there is significant channel widening, too.

Here we describe our attempts to interpret the erosion produced by debris flows using a debris flow runout model. The RAMMS debris flow model solves the 2D shallow water equations of motion for granular flows, and it includes either the Voellmy friction relation (VF) or a modified version of the Voellmy relation (MVF) where the friction coefficients are adjusted as a function of the internal random kinetic energy due to particle collisions within the flowing mass. A corresponding erosion model is based on generalization of field data (maximum shear stress, with the VF relation) or proportional to the granular temperature of the flow (MVF relation). While the granular temperature-based erosion model contains a more physically realistic description of the erosion process, the VF relation, after calibration, also produces plausible results and may be more useful for practical applications until we gain more experience with the MVF-based erosion algorithm.

S26B - Remote sensing (including laser scanning, applications of radar, etc.)

Convenors: *Thomas DEWEZ & Dirk RIEKE-ZAPP*



Oral presentations:

Differential SAR Interferometry in alpine geomorphology: Potential of this high precision technology for detecting and surveying landforms in mountain environment

BARBOUX C.(1), DELALOYE R.(1), LAMBIEL C.(2), STROZZI T.(3), COLLET C.(1), RAETZO H.(4)
(1) Dept. of Geosciences, Geography, University of Fribourg, FRIBOURG, SWITZERLAND ; (2) Institute of geography, University of Lausanne, LAUSANNE, SWITZERLAND ; (3) Gamma Remote Sensing, GÜMLIGEN, SWITZERLAND ; (4) Federal Office for the Environment FOEN, BERN, SWITZERLAND

A large spectrum of mass wasting processes (e.g. deep-seated and shallow landslides, rock glaciers, debris-covered glaciers) are actively changing the surface topography of alpine mountain slopes over time. The rate of motion is typically ranging from millimeter to several meters per year. In the general context of investigating the cascading of sediment along mountain slopes, the use of Differential SAR Interferometry (DInSAR) has proven to be a valuable tool for detecting (recognition, identification) and surveying (monitoring) various types of slope motion phenomena at both local and regional scales.

This presentation will review DInSAR for detecting and surveying movement on mountain slope in an Alpine environment. After a brief presentation of basics, the use of the DInSAR technique for the detection and surveying of landforms surface deformation will be described. Through different examples, the presentation aims to suggest to geomorphologists different means of understanding and interpreting DInSAR signals in the specific environment. Actually, the capability of DInSAR for detecting both the location of moving zones and the magnitude of their displacement rate has been successfully tested in various regions of the Swiss Alps. Research challenges are now mainly focusing on the possibilities of using DInSAR for monitoring tasks to evaluate to which level DInSAR data could be used independently of field measurement. Thus, the presentation will overview some DInSAR projects dealing with the detection and the survey of moving zones in the Swiss Alpine periglacial belt allowing to show potential applications of this modern technique in mountain environment. Finally, requirements of the DInSAR technology will be discussed in order to show how this technique is really valuable for alpine geomorphology investigations, and perspectives for further applications will be suggested.

****

Sea cliff erosion monitoring by boat-borne Laser-scanning

GIULIANO J.(1), DEWEZ T.(2), GODARD V.(3), LEBOURG T.(4), MARCOT N.(5)
(1) BRGM / GEOAZUR / CEREGE, AIX EN PROVENCE, FRANCE ; (2) BRGM, ORLEANS LA SOURCE, FRANCE ; (3) CEREGE - Université Aix Marseille, AIX EN PROVENCE, FRANCE ; (4) GEOAZUR - Université Nice Sophia Antipolis, SOPHIA ANTIPOLIS, FRANCE ; (5) BRGM, MARSEILLE, FRANCE

Laser scanning is an efficient method for cliff erosion monitoring, but available terrestrial or airborne systems are limited by particular constraints associated with the configuration of the coastline, as tidal range or cliffs slope. We need to qualify rock fall hazard in Carry Le Rouet (West of Marseille, Southeastern France) which is motivated by the high level of risk due to dense settlement. But, as along the 3.5-km-long coastline there is no suitable platform to set up a terrestrial scanner, we study cliff evolution by repeated boat-borne scanner surveys from the sea.

We discuss the performance of three subcontracted boat-borne scanner surveys of the cliff in February 2011, November 2011 and July 2012. The typical point spacing in the clouds is 5-10 cm. Initial results suggests that (i) delivered device position and altitude still contains location inaccuracies around 4.3 cm, (ii) the repeatability of measurements are within 5 cm, (iii) comparison between clouds needs careful co-registration at post-processing stage.

First comparison of results between February and November 2011 indicates that the total eroded cliff volume amounts to 20-30 cubic meters, for a total cliff surface of 36,000 square meters, which is equivalent to an erosion rate of 1 mm/yr. The erosion involves various processes ranging from gravitational collapse to gully erosion. Thus, boat laser survey appears to be a suitable tool for the study of coastal morphology and topographic change in previously inaccessible settings.

Keywords: laser scanning; boat borne scanner; cliff; erosion; coastal morphology; topographic change

Airborne laser scanning of forested rock extraction: Airborne parameterizations, quality assessment, and rockfall modeling

RAZAK K.(1), QUAN LUNA B.(2)
(1) University Teknologi Malaysia, KUALA LUMPUR, MALAYSIA ; (2) NGI, Norwegian Geotechnical Institute, ICG, International Centre for Geohazards, OSLO, NORWAY

Modern remote sensing based approach has revolutionized the rockfall hazard and risk assessment. It enables the parameterization of topography, and natural barriers (e.g. vegetation) in a forested environment. The extraction of rock blocks under forests and their characteristics still remains difficult because of deficiency of high resolution geospatial data, e.g. insufficient number of airborne laser scanning (ALS) points and lack of reliable field data. The performance of ALS data for measuring and assessing the geomorphology, geological settings, structural discontinuities and mechanical characteristics of slopes and rock blocks is poorly investigated.

This research demonstrates the capabilities of high density ALS (HDALS) data: i) to map rock blocks beneath forest and characterize rockfall parameters, ii) to determine the rockfall trajectory and simulate the physical process of rockfall based on HDALS-derived rockfall parameters. A very high density ALS data was utilized, with a point density of 170 points m^{-2} in the Barcelonnette region, the Southern French Alps, and supported by field evidences and historical forest reports.

We revealed airborne parameterization based on the hierarchical robust interpolation algorithm for extracting rock blocks under forest and quantified them. Very high resolution digital terrain and surface models from HDALS data were generated. HDALS data were used to extract forest attributes and 12 surface roughness values computed at different lithology units and landcover classes.

The rockfall trajectory was determined and its physical process was simulated solely based on HDALS product using Rockyfor3D. Spatial modeling was performed using Rockfall Analyst to compute the travel distance, velocity and energy of rockfalls. The results were compared with the output generated from a coarse data. We also critically addressed the numbers of limitations of the methods and highlighted research challenges.

****

Predicting Rock-Movements by Interferometric Radar Measurements

TOBLER D.(1), MEIER L.(1), GRAF K.(2)
(1) Geopraevent SA, ZUERICH, SWITZERLAND ; (2) GEOTEST SA, ZOLLIKOFEN, SWITZERLAND

During the last decade, advances in science and technology have improved the potential of early warning systems (EWS) to reduce human loss from natural hazards. Effective EWSs are widely recognized as good practice if evidence-based and people-centred, thereby empowering individuals and communities to take timely and appropriate preventive measures to reduce the possibility of injury, loss of life and damage to property and environment. EWS shall be reliable, redundant, low-maintenance and provide a high probability of detection. As climate change is likely to produce more extreme climate events, EWSs will become more important elements of public safety.

In May 2012 a large rockfall (volume of 300'000 m^3) occurred, close to the village of Preonzo in southern Switzerland. The outcrop area, located 1000 m above the industrial park of the village, has been known as instable for long time. Since many years, the local authorities have monitored the instable rock mass using crackmeters and laser-based geodetic measurements. Prior to the event, an interferometric, synthetic aperture radar system has been installed to monitor the moving rockwall before, during and after the collapse.

The main advantage of a ground-based radar monitoring systems is the possibility to perform a permanent quasi real-time monitoring, independent of weather conditions. Furthermore, it allows the acquisition of information on the displacement over the entire observed area, without needing in-situ instrumentation on potentially instable and fast-moving elements. The detailed deformation history retrieved from interferometric radar observations is important when setting alerting procedures and alarm thresholds for EWS.

The presentation emphasises on measurements as well as advantages and disadvantages of radar-based monitoring of instable rock slopes. Furthermore, different strategies and methods for EWSs of rapid mass movements for an efficient emergency management will be presented and discussed.

The application of UAV's for high-precision glacial, periglacial and hydrological monitoring

MOORMAN B.(1), WHITEHEAD K.(1), HUGENHOLTZ C.(2)
(1) University of Calgary, CALGARY, CANADA ; (2) University of Lethbridge, LETHBRIDGE, CANADA

With the recent advances in Unmanned Aerial Vehicles (UAV's), there are new opportunities to make geomorphological measurements at both temporal and spatial scales much greater than has been available to date.

Through the use of UAV airplanes and helicopters we have been able to collect remotely sensed imagery with sub-centimeter resolution, covering in the order of 10 square kilometers in less than 1 hour with great ease and at low cost. This has enabled rapid photogrammetric mapping of glacier and periglacial terrain and resulting in digital elevation models comparable to those generated by LIDAR at less than a tenth of the cost. As well, because the systems are very portable and simple to use, repeat surveys can be conducted up to several times a day to quantify rapid processes (such as hydrologic fluctuations).

These new opportunities are been made possible by a convergence of a number of advances in, UAV lift capacity, battery life, GPS technology, autopilot flight control systems and mission planning software. While airplanes offer rapid data acquisition, we have now developed helicopter based system as it offers the ability to fly lower and slower for extremely high resolution imagery. Through the use of a real-time point of view camera, the helicopter also offers the ability to interrupt a preprogrammed flight path to investigate areas of interest in greater detail.

The flexibility of these platforms offer the opportunity to rapidly interchange different sensors such as, visible, NDVI and thermal cameras or more advanced sensors such as LIDARs and radars.

****

Rockglacier movement detection by D-InSAR in French Alps using ERS archive data and TerraSAR-X data

ECHELARD T.(1), KRYSIECKI J.M.(1), SCHOENEICH P.(1), GAY M.(2)
(1) Grenoble University, Institute of Alpine Geography, GRENOBLE, FRANCE ; (2) GIPSA-Lab, GRENOBLE, FRANCE

Interferometric Synthetic Aperture Radar (InSAR) is a method of measurement based on the phase difference between two radar images, which represent the same area but at different time intervals. The technique generates interferograms, maps of surface deformation in two-dimensions allowing for the detection and quantification (in centimeters) of variations in distance between the target and the radar between two different data acquisitions. Recent research has shown that the InSAR technique can be used to quantify rockglacier deformation (under the assumption that certain conditions are respected with regard to generating and interpreting the interferograms).

ERS radar images (dating from 1991 to 1995) were obtained in courtesy of ESA with the aim of generating interferograms. In this study, we are interested by the detection of rockglacier movements in all the French Alps. We selected all ERS archive data and chose the more relevant of them. Finally more than 20 interferograms were generated. To analyse thisamount of data two methods were employed : i) a GIS analysis of interferograms (helped by orthophotography and topographic data) by geomorphologists, ii) a comparison between interferograms and existing rockglaciers shape inventory to evaluate the quality of the radar detections.At the end of the analysis a map of the French Alps with all detected rockglacier movements was produced.

Another part of the present study uses TerraSAR-X data (in courtesy of DLR) on a local scale and tries to compare different kind of methods to detect and quantify rockglacier movements. Analyses focused on the Vanoise massif in the French Alps. We used and compared three different methods with brand new data from summer 2012 : i) differential SAR interferometry, ii) texture tracking and iii) permanentscatterers. Three continuous GPS were installed on rockglaciers during summer 2012 to compare radar data and GPS field data.

Time-lapse stereo-photogrammetric monitoring of volcanic slopes

DEWEZ T.(1), MOSER S.(2)
(1) BRGM - French Geological Survey, ORLEANS LA SOURCE, FRANCE ; (2) ., STRABOURG, FRANCE

Piton de la Fournaise volcano (La Reunion Island) due to its crater collapse of April 2007 which created 200m to 300-m-high sub-vertical cliffs in a matter of minutes offers a rare opportunity to observe the morphological fingerprint of numerous rock avalanches. In the framework of ANR-Undervolc, a research project funded by the French Research Council to investigate geophysical determinants of volcano construction and destruction, a pair of time lapse photogrammetric packages was deployed along the active crater edge in October 2009. In this talk, we will discuss the qualitative and quantitative benefits and short-comings of time lapse stereo monitoring based on an hourly photo sequences captured between 28 December 2009 and 15 April 2010. In short, time synchronization between cameras must be guaranteed in order to capture the space and time location of detected objects, failure to do so results in erroneous instantaneous 3D locations. Synchronization requirement depends on the velocity of the monitored object. Visual change detection, by compiling movies from still shots, is hampered by the changing illumination of the scene throughout the day. To lessen its impact, we recommend making movies at constant time of day when the sun angle changes only on a slower seasonal time scale. For quantitative change detection, the stereoscopic capabilities of the camera setup enabled automated extraction of hundreds of Digital Surface Models (DSM). This was achieved by generating Photomodeler Scanner instruction from Matlab, though the so-called Dynamic Data Exchange (DDE) protocol. Three cases were investigated: DSM sequences of rock avalanche corridors, rockfall scar detection and eruption volume quantification. The volume of January 2010 volcanic eruption came out to 1 597 200 ± 95 660 m^3, i.e. a relative precision of 6%. Time-lapse stereo photogrammetry holds promises for in-situ geomorphological monitoring despite a few creases still needing ironing out.

****

Continuous tracking of objects for characterizing landslide displacements from terrestrial images

GANCE J.(1), MALET J.P.(1), DEWEZ T.(2), TRAVELLETTI J.(3)
(1) Institut de Physique du Globe de Strasbourg, STRASBOURG CEDEX, FRANCE ; (2) BRGM, ORLÉANS, FRANCE ; (3) BEG - Bureau d'Etudes Géologiques, APROZ, SWITZERLAND

Very high resolution terrestrial images can provide highly detailed observations over long periods. Such type of device is well adapted to monitor landslides characterized by large displacements (a few meters per year) because the cameras are installed out of the moving areas (contrary to total station, dGPS or extensometer surveys) and allows to infer spatially distributed information.

This work aims to present a methodology to characterize landslide displacements from very high resolution terrestrial images. The method is based on object detection-tracking and is applied on two images datasets acquired at the Super-Sauze landslide (French Alps).

The analysis of the first serie of images consists in the tracking of white Styrofoam spheres (e.g. benchmarks) regularly positioned on a profile in the most active part of the landslide. Pairs of images with a baseline of ca. 75 m and a B/h ratio ranging between 1.6 and 2.1 are used. The displacements observed over the period June-July 2011 range from 0.5 to 0.7m.

The analysis of the second serie of images consists in the monitoring of natural objects observed at the surface of the landslide, such as large blocks. Images taken from one single camera located at the toe of the landslide are used. The displacements observed in the image plane are projected in the ground coordinate system using a pinhole model. The results obtained for both applications are validated with dGPS observations (campaigns and continuous monitoring) and image correlation techniques.

A sensibility analysis is performed in order to characterize the robustness of the method and define the different sources of error. The displacement time series are further analyzed in terms of kinematics (velocity vs. acceleration) using “time to failure” approaches.

High-resolution quantification of mountain permafrost displacements: insights from Terrestrial Laser Scanning and image correlation techniques

BODIN X.(1), DEROUX B.(1), VACHER P.(2), THIBERT E.(3)
(1) Laboratoire EDYTEM, UMR 5204 CNRS / Universite de Savoie, LE BOURGET-DU-LAC, FRANCE ; (2) Laboratoire SYMME, EA 4144, Polytech Annecy-Chambery, Universite de Savoie, ANNECY-LE-VIEUX, FRANCE ; (3) Unite de recherche ETNA, IRSTEA, SAINT MARTIN D'HÈRES, FRANCE

In the context of climate change, mountain permafrost is affected by a pluri-decadal warming that has strong implications in terms of slope stability and dynamics. Permafrost degradation is well exemplified by recent acceleration and destabilization of rock glaciers, suggesting that potentially catastrophic phenomena may threaten societies. Therefore, it is necessary to better understand the deformation mechanisms of ice-rich permafrost along mountain slopes.
In this sense, this study aims at using Terrestrial Laser Scanning (TLS) to accurately quantify surface deformation of rock glaciers at an interannual and pluri-annual scale. We focused on the Laurichard rock glacier (Hautes Alpes, France, 2500 m asl) which is already subjected to an annual geodetic survey since more than twenty years. The surface of the rock glacier was scanned three times with an average density of 7 points/m² and referenced using DGPS-measured fixed points.
The main challenges arose from the topographic variability: microtopographic features like plurimetric ridges and furrows shield some areas from the laser, whereas surface roughness of the pluri-decimetric coarse blocky cover is difficult to cope with when comparing point-clouds between each others.
We employed 3D point-cloud processing and image correlation tools to i) adjust separately annual scenes, ii) georeference them, iii) compare 3D-datasets together with a sub-decimetric precision and iv) extract various spatially-distributed measurements.
High resolution maps of surface kinematics quantities were validated from comparison to in situ high precision geodetic measurements: at the various considered time scales, the differences between TLS-derived measurements and geodetics measurements are lower than 5 cm/a. The spatially-distributed information provides rich insights into the deformation mechanisms of rock glaciers and open new challenging opportunities to move further into rheological laws and physical models.

****

Change detection of river channel utilising laser scanning, sonar survey and UAV-photogrammetry based bathymetric model

ALHO P.(1), KASVI E.(1), VAAJA M.(2), FLENER C.(1), LOTSARI E.(1), KUKKO A.(3), KAARTINEN H.(3), HYYPPÄ J.(3), HYYPPÄ H.(4)
(1) University of Turku, TURKU, FINLAND ; (2) Aalto University, ESPOO, FINLAND ; (3) Finnish Geodetic Institute, KIRKKONUMMI, FINLAND ; (4) Metropolia, Univ. of Applied Science, ESPOO, FINLAND

Field measurements for the acquisition of digital terrain models (DTMs) based on traditional approaches (e.g. tachymeter, GPS) are limited in riverine environment because steep riverbanks, curved point bars and dense vegetation create occluded areas on the sight of survey. Airborne laser scanning (ALS) has been applied for more detailed modeling of the riverine environment. Terrestrial laser scanning (TLS) is a more accurate approach than ALS for gathering topographical data, e.g. TLS-based DTMs have been employed in measuring landslide bodies, defining the influences of earthquakes, as well as in riverine change detection. Although TLS allows the collection of data at a higher resolution and accuracy than ALS at a lower cost, its areal coverage is considerably more restricted. This limitation can be improved using laser scanning from a mobile platform (MLS). In this paper, we demonstrate multi-temporal TLS and MLS approaches in change detection of the point bars and riverbanks. We gathered high-resolution aerial photography using a camera embarked on a low-flying unmanned aerial vehicle (UAV).We utilised spectrally based bathymetric modelling techniques based on the UAV images for riverbed. Based on this bathymetry and laser scanned point clouds, we created a high-resolution seamless DTM of a a sandy-bed river. We also analysed how the flow characteristics of different stages affect to the morphological changes on river channel and point bars. Therefore, we measured the three-dimensional flow field of the channel using an Acoustic Doppler Current Profiler (ADCP) at different flow stages. Subsequently, we analysed fluvio-morphological changes on point bars and riverbanks based on multi-temporal DTMs of MLS and TLS. The associated ADCP measurements of the 3-D flow structure over the flow regime makes it possible to link the morphological changes to the flow field of the river channel.

Identification of factors disrupting remote bathymetry: experimental approach from ground imagery on the lower ain river (France)

BENACCHIO V.(1), PIEGAY H.(2), MICHEL K.(3), VAUDOR L.(3)
(1) Université de Lyon, UMR 5600 - EVS, Université Lumière Lyon 2, LYON, FRANCE ; (2) CNRS UMR 5600 - EVS, LYON, FRANCE ; (3) Université de Lyon, UMR 5600 - EVS, ENS de Lyon, LYON, FRANCE

Airborne imagery was used to calculate bathymetry of the lower Ain River, France, but such approach is not always efficient because image radiometry is not only related to water depth but to other factors such as the cover of biofilm, which is not always homogenously distributed in space. The purpose of this work is to survey the various factors, including biofilm, which limit bathymetry mapping from remote sensing, to optimize time schedule for image acquisition. A Reconyx Hyperfire PC800 camera was used to take every quarter photos perpendicular to the water surface. A pressure sensor was set so as to link each picture to water level. The work area is about 12 m². Effects of various factors on the channel bottom visibility, then the images radiometry were studied.

The maximum water depth for which we can distinguish the channel bottom is 1.74 m. Probability of seeing the bottom of the river – and so to be able to determine the bathymetry - is 80% for water depths lower than 1.50 m, which occurs here 35% of the time during the spring-summer period. Then it decreases quickly and becomes null for all depths greater than 1.80 m (41% of time). To demonstrate the impact of biofilm on the image radiometry and water depth detection, the studied area was brushed in part. Radiometric spectrum recorded greater local heterogeneity when the biofilm was removed. However, the radiometric mean is not changed, probably because the biofilm seems pretty chlorophyllous. The wind produces ripples on the water surface which is another factor of disruption. Time was also studied, as an incident angle of sunlight on the surface of water. For given sunlight angles, water depth cannot be detected because of reflections. The best conditions to take pictures correspond to early morning hours: before 9:00 am, it was 50% more likely to see the bottom of the river, while the probability decreases gradually until the end of the day. However, all hours of the day are potentially workable.

****

Kite aerial photogrammety system for monitoring coastal change in the Netherlands

SMITH M.(1), PARON P.(2)
(1) Kingston University, KINGSTON UPON THAMES, UNITED KINGDOM ; (2) UNESCO-IHE, DELFT, NETHERLANDS

Coastal protection is one of the main challenges for the Netherlands, where a large proportion of anthropogenic activity is located below sea level (both residential and economic). The Dutch government is implementing an innovative method of costal replenishment using natural waves and winds to relocate sand from the side to the other of the country. This requires close monitoring of the spatio-temporal evolution of beaches in order to correctly model the future direction and amount of sand movement. To do so -on the onshore beach- we tested a Kite-Aerial Photography System for monitoring the beach dynamics at Zandmotor (http://www.dezandmotor.nl/en-GB/).

The methodology follows that of Smith et al., (2009), applied to a highly dynamic environment with low texture and small relief conditions. The method used here consists of: 1) setting up the Kite Aerial Photography System (KAPS); 2) locating the ground targets (ground control points); 3) surveying the targets for their XYZ position; 4) flying the kite over the area acquiring stereopairs for the whole area; 5) post-processing of the photos and GPS points.

In this case study we used a commercial DSLR camera (Nikon D7000 with a 20mm lens), a gyro-levelled rig, Sutton flow form kite and Leica GNSS Viva GS10, with GSM connection to the Dutch geodetic network. We flew using a 115 m line with an average inclination of 40 to 45 degrees, giving a vertical distance of the camera of about 80 metres and pixel resolution of 36 mm. We present here the results of the system set-up and data post-processing, including both an image mosaic and a digital elevation model.

Future repeat flights using the same system are planned over a period of six months in order to capture the spatio-temporal variability of beach morphology due to natural and anthropogenic interference. The research has been funded by Deltares R&D and supported by the UNESCO-IHE.

Integration of LiDAR and optical remote sensing for the study of fluvial and anthropogenic landforms in the Brenta-Bacchiglione alluvial plain (NE Italy)

NINFO A., MOZZI P.
Department of Geosciences University of Padua, PADOVA, ITALY

The geomorphological study of alluvial plains takes great advantage from the integration of detailed altimetry with high resolution images, especially in the lower relief sectors, like those in the distal plain of the Brenta and Bacchiglione rivers near the city of Padua (mean slope 0.4‰).The LiDAR data which were specifically acquired for this research (Riegl LMS-Q560; mean density 7 points/m^2, over 123 km^2), were classified and interpolated in order to map fluvial and anthropogenic landforms. The DEM (z accuracy <5-10 cm) was processed and analyzed in integration with high resolution oblique and vertical (VIS+IR) aerial images, acquired in specific seasonal time windows, to maximize the vegetation response (cropmarks) to soils, deposits, and palaeohydrographic features. A detailed field survey (hand augerings, soil profile description, deep borehole stratigraphy) was conducted to validate the remote sensing interpretations.

The detailed topography allows to individuate low rise interfluves and scarps (<1-2 m), paleochannels, scroll bars and crevasse splays. The reconstruction of the precise “ground” surface has allowed a better definition of the geometry of the multi-stratified archeological mound in the historical center of Padua.

Cropmarks result the most appropriate to complete the mapping of the numerous fluvial forms, that have no topographic relevance being smaller (i.e. minor crevasse channels and splays) and/or flatted by anthropic activity (mainly ploughing). LiDAR intensity permits a precise individuation of LGM deposits that have shown peculiar reflectivity related to specific soil characteristics (i.e., presence of calcic and argillic horizons).

At this scale (cell size <0.5-1 m) the real complexity of this highly anthropized low plain environment fully emerges. The results bring advances in the comprehension of the Holocene evolution of the Brenta-Bacchiglione plain, also in close relation to ancient settlements.

****

The application of radar and optical remote sensing to analyse dune dynamics at the dune-field scale

DELGADO BLASCO J.(1), MOHAMED I.L.(2), VERSTRAETEN G.(2), HANSSEN R.F.(3)
(1) Division of Geography, KU Leuven, Belgium & Geosciences and Remote Sensing, Delft University of Technology, The Netherlands, LEUVEN, BELGIUM ; (2) Division of Geography, KU Leuven, LEUVEN, BELGIUM ; (3) Department of Geoscience and Remote Sensing, Delft University of Technology, DELFT, NETHERLANDS

The increasing availability of remote sensing data for larger regions have made it possible to study (less) inaccessible regions such as large desert dune fields. Contrary to the detailed study on individual dunes, this has also made it possible to study the dynamics of entire dune fields. Multi-temporal analysis of remote sensing data offers to the potential to quantify dune migrations rates and sand fluxes. However, dunes usually appear bright in optical images due to the high reflectivity of the sunlight towards the sensor that is produced on sand dunes. Hence, the delimitation of the shape of the dunes is often a major problem in applying optical data. Active remote sensing data, such as SAR, may provide a solution as sand bodies used to appear with a huge contrast within their environment, being able to differentiate much better than the optical images. In this study, barchan dunes in the South-Rayan dunefield (SRFD) in central Egypt were examined through multi-temporal Lansat imagery as well as Envisat ASAR SLC images. Both images were used to detect and delineate dune shape, and to calculate dune migration rates using the centroid algorithm. Pros and cons of both methods are discussed. The method used for extracting dunes’ shape from radar imagery is easier, faster and requires minimum human interaction than their extraction from optical data. Average dune migration rates in the SRDF are in the order of 4 m per year and rates are consistent between optical and radar images.

Geophysics and Remote Sensing Data for the Detection of Soil Texture Distribution

QU_N_HERV_G.(1), MÄRKER M.(1), BACHOFER F.(2)
(1) Heidelberg Academy of Sciences and Humanities, TUEBINGEN, GERMANY ; (2) Tübingen University, TUEBINGEN, GERMANY

Our main objective was to automatically map soil texture distribution within the semi-arid environment of the Makuyuni River catchment. The study area is located in the eastern branch of the East African Rift System and the environment is distinguished by a variety of degradation as well as erosion processes due to the long dry periods and short but intensive rainfall events.

Since field work is time assuming and expensive we propose a methodology which is integrating geophysics together with terrain analysis based on Digital Elevation Model (DEM) as well as multi-spectral remotely sensed data.

Geophysical methods such as electromagnetic induction (EMI), to measure the soil's apparent electric conductivity (EC_a), provide a quantitative assessment of soil properties. In non-saline soils conductivity variations are primarily a function of soil texture. Such a methodology is able to distinguish between predominant sand, silt and clay fractions.

The DEM is based on a SRTM 30m satellite image and 16 primary and secondary topographic attributes have been calculated according to Hengl & Reuter (2009) and Wilson & Gallant (2000). Multi-spectral data derivatives have been gained of an ASTER L1B scene with 15m to 90m ground resolution according to their spectral channel. 34 different band combinations have been computed according to the standard ASTER enhancements products (after Kalinowski & Oliver, 2004).

A TreeNet™ [Salford Systems, USA] analysis has been carried out, to validate the gained information. The classified conductivities are the target variables and the 50 satellite-based attributes are the predictor variables. This approach, a stochastic gradient boosting method (developed by Friedman, 2002), is able to rank the predictors for each target variable according to their relative importance. This information is now used, to compute the according conductivity class for the whole of the available SRTM/ASTER scenes extent.

****

Estimation of Surface Runoff for an Urbanized Watershed Using Satellite Data: A Case Study of Ramnadi Basin, Maharashtra, India

DHORDE A.(1), DHORDE A.(2), KUMAR K.(2)
(1) Department of Geography, University of Pune, PUNE, INDIA ; (2) Department of Geography, Nowrosjee Wadia College,, PUNE, INDIA

The present work deals with the estimation of surface runoff in an urbanized watershed of Ramnadi, a tributary of river Mula in Maharashtra, using Landsat TM data of 1989 and 2011. Population calibrated impervious surfaces (IS) were extracted for the watershed by employing a regression analysis wherein IS was thought to be the function of band values, NDVI, TC band II, slope, elevation and population density. Runoff, seen as a function of imperviousness in the area, has been calculated using the SCS-CN method. Curve numbers (CN) were obtained from the standard tables provided in the National Engineering Handbook-4 (NEH-4) published by the USDA, USA. These were derived basically by analyzing the land use land cover pattern, hydrological soil group and condition for the entire Ramnadi basin. In order to compute the surface runoff these CN were incorporated in the standard equations given in the SCS-CN method.

The study indicated a major change in the land use land cover pattern in the last 22 years, as indicated by the net growth in built up area from 21.13 % (1989) to 45.43 % (2011). Growth in the built up area has led to the increase in IS in the basin. IS have gone well above 25 % especially, in the suburbs of Pune city & nearby villages and the transportation routes. The impact of increase in built up area and IS has intensified the surface runoff in the basin. Taking in to consideration a constant basin area of 52.48 sq. km and an average rainfall of 60.2 mm, the average antecedent moisture condition (AMCII) yielded an estimated runoff of 525 million cubic meters in 2011 as against 406 million cubic meters in 1989. Thus it is quite evident that the growth in built up area and impervious surfaces have enhanced the capacity of the Ramnadi basin to generate more runoff even with lower order storm events.

Poster presentations:

Ortophoto and satellite imagery to monitoring charcoal in mountain soils (NW of Cantabrian Range, Spain)

FERNANDEZ S.(1), ROCES P.(2), RECONDO C.(2)
(1) University of Oviedo, MIERES, SPAIN ; (2) INDUROT, MIERES, SPAIN

In the Northwest of the Cantabrian Mountain Range the climate is oceanic and the vegetation cover should be mainly wood forests and heathlands. However, frequent wildfires have led to a progressive degradation of the vegetation cover by enhancing the development of extensive moorlands and pyrophytes species of high combustibility. Previous studies have proved that this intense fire history promoted structural degradation, soil erosion (the average values of soil losses, measured with ^{137}Cs on burned slopes, is around 6,5 t/ha-1year^{-1}) and degradation of the structure and hydraulic properties (infiltration rate increased from 0.0107 to 0.1070 cm/s) of burned soils.Also the fires altered the rates of carbon (C) transfer from vegetation to soil. In this way, C stocks of 32 Mg/ha and 90 Mg/ha were measured in unburned and burned forest soils, respectively. Satellite imagery and ortophotography could be useful in order to monitor the C sequestration in soils. We want to test the use of satellite imageries and orthophotos to monitoring the*charcoal* poolin soils of mountain areas with high rates of C transfer from vegetation to soil, promoted by forest fires. 55 georeferenced soil samples, taken in an area 100 km^2 located in the Northwest sector of the Cantabrian Range were crossed with ortophotos and satellite images taken in the winter season. Several spectrometric indexes related to soil properties (NDSI, NDBaI,), color indexes from the visible part of spectrum (SWIR) and values from visible and thermal infrared were calculated for each soil sample. Results from multivariate linear regression analysis showed good adjust (R^2 0, 69) from soil organic carbon estimation using indexes and color variables calculated with Landsat images. Also models calculated using transformed color variables over ortophoto shows adjustment nearly to R^2 0,54.The models were regionalized to large scales and validate with new soil samples RMSE was 6,4 and 16 % respectively.

****

Digital elevation modelling from a Smartphone

LANE S.N.(1), CHANDLER J.H.(2), MICHELETTI N.(3)
(1) IGD, Université de Lausanne, LAUSANNE, SWITZERLAND ; (2) Loughborough University, LOUGHBOROUGH, UNITED KINGDOM ; (3) IGD, Universit? de Lausanne, LAUSANNE, SWITZERLAND

Digital photogrammetric measurement as a means of creating digital elevation models has developed dramatically over the last decade, notably with the advent of Structure from Motion (SfM) technologies. The critical SfM development has been the ability to undertake automatic image matching using large numbers of oblique imagery, in which image registration, image correction for sensor distortion effects and image matching to extract data points are handled simultaneously. This opens up the use of a much wider range of sensors, in theory any kind of sensor that measures with sufficient pixel resolution. SfM is increasingly available via web based platforms, where images are sent via the internet for processing. In theory, this opens up the intriguing possibility: low cost, real time digital elevation modelling using images acquired by and sent from a Smartphone. In this paper, we test this approach for the construction of digital elevation models of three different scales: (1) high resolution models of pebble clusters; (2) medium resolution models of river banks; and (3) low resolution models of alluvial fans. We use comparison with high resolution laser scanned images to evaluate each scale of application. The results confirm the potential of this technology. There is some degradation of resolution and precision in comparison with scanning technologies, but the costs of the method are almost negligible and there is some additional flexibility gained from the ability to rapidly survey features from multiple angles, so reducing dead ground effects.

Testing a Terrestrial Laser Scanner and photogrammetric techniques for studying badland dynamics

NADAL ROMERO E.(1), REVUELTO J.(2), LÓPEZ-MORENO J.I.(2), VICENTE-SERRANO S.(2), GARCÍA RUIZ J.M.(2)
(1) University of Zaragoza, ZARAGOZA, SPAIN ; (2) Instituto Pirenaico de Ecología, ZARAGOZA, SPAIN

Geomatic techniques have been routinely applied in recent years in Geomorphology studies. The aim of this study is to assess the *in situ* operational functioning of the TLS (Terrestrial Laser Scanning) and Photogrammetric techniques to evaluate badland dynamics and erosion rates in a humid badland area in the Araguás catchment (Central Spanish Pyrenees). By comparing different DEMS of the same area, obtained at different moments, variations in the terrain and temporal dynamics can be analyzed.

Data analysis has been carried out using the Riprofile Software. A density of about 1000 points/ m^2 (maximum about 2500 points/m^2 and minimum values of 500 points/m^2) was reached with the TLS analysis.

The preliminary results show that TLS data sets and photogrammetric data provide new opportunities in the study of geomorphology dynamics in badland areas (highly erodible landscapes), given the rapidity of the hillslope evolution. These methodologies are potentially useful for erosion studies as they operates without contact with the ground surface, the acquisition time is relatively short and the precision is sufficient for detailed erosion studies and geomorphological dynamics in very active areas.

****

Reconstruction of past hillslopes morphology using aerial photographs: data quality and applications for the investigation of landscape changes at the decadal scale

MICHELETTI N.(1), LANE S.N.(1), CHANDLER J.H.(2)
(1) University of Lausanne, LAUSANNE, SWITZERLAND ; (2) Loughborough University, LOUGHBOROUGH, UNITED KINGDOM

The potential of archival digital photogrammetry to measure landforms surfaces and landscapes has been proved by its increasing use for the extraction of quantitative elevation information in geomorphology. With technological advances, digital photogrammetry has become increasingly automated and cost-effective. However, the increased use of terrain data generation remains complicated by the user needing to define critical parameter and choose appropriate algorithms. The choices affect data quality and hence surface description, which can be critical for measuring complex surfaces. Here, we present and test a workflow for reconstructing high mountain topography and topographic change using archival digital imagery. Aerial photographs from 1950s to present are used to generate DEMs at different dates, combining fieldwork data and manual stereo-matching with automatic tools. An investigation of the choice of parameters and the quality and uncertainty of related results is proposed. The latter is based on (1) the quality of the stereo-matching solution (2) the accuracy of spot heights based upon independent check data, and (3) quantification of the effects of data collection strategies upon surface features derived from the DEMs. Finally, and using the appropriate error propagation methods, we test the application of the generated models for change detection in deglaciated valley hillslopes in the Swiss Alps. Results demonstrate that archival photogrammetric methods can, with the appropriate care, be employed to reconstruct surface changes over hillslopes and mountainous regions in general, over decadal scale. However, it is not a 'plug-and-play' technology: that is, extracting reliable information is dependent upon optimization of data collection strategies and field campaigns, especially from imagery with sub-optimal scales.

Surveying Channel Morphology Using Ground-Based Photogrammetry

ROUSSEAU Y.(1), ASHMORE P.(1), BIRON P.(2), VAN DE WIEL M.(1)
(1) Western University of Canada, LONDON, CANADA ; (2) Concordia University, MONTRÉAL, CANADA

Research projects in geomorphology often require the detection of morphological changes at a fine resolution. This is notably the case in river-related studies where changes in bank morphology are often subtle and difficult to detect. Accurate elevation models can be generated from devices such as terrestrial LIDAR and differential GPS units, but their acquisition costs remain high, limiting the number of detailed bank topographic surveys available for research experiments. Photogrammetry has recently been proposed as a method to produce continuous terrain models in a range of landscapes including small river channels. There, alternative technologies would be either too expensive to use or complicated by the presence of obstacles such as vegetation or by poor satellite reception. This research aims at testing the feasibility of surveying the topography of both the bed and banks of a river channel using a consumer-grade DSLR camera mounted on a portable, 7m tall pole. The experiment was conducted in a narrow, 16-meter wide, shallow semi-alluvial stream channel (Medway Creek, Ontario), along a 1.5-kilometer reach with riparian vegetation. The generated terrain model is compared with topographic surveys conducted in the same reach using a total station and a high-resolution DGPS. The resulting terrain models are statistically compared between the three surveying techniques used. Other aspects, such as acquisition, pre- and post-processing efforts, are also taken into account to produce an overall assessment of this low-cost surveying method which can provide very useful datasets for numerical modelling studies on bank erosion.

****

Hyperspectral proximal and remote sensing applied to clay minerals identification and mapping

DUFRECHOU G., HOHMANN A., GRANDJEAN G., BOURGUIGNON A.
BRGM, ORLEANS, FRANCE

Swelling soils contain clay minerals that change volume with water content and cause extensive and expensive damage on infrastructures. Based on spatial distribution of infrastructure damages and existing geological maps, the Bureau de Recherches Géologiques et Minières (BRGM, the French Geological Survey) published in 2010 a 1:50 000 swelling hazard map of France, indexing the territory to low, intermediate, or high swell susceptibility. At local scale, characterization of soil properties and identification of clay minerals using conventional soil analysis (DRX, chemical, and geotechnical analysis) are slow, expensive, and does not permit integrated measurements. VNIR (400-1100 nm) and SWIR (1100-2500 nm) spectral domains are characterized by significant spectral absorption bands that provide a largely unexploited tool for recognize swelling minerals. Hyperspectral proximal (*i.e.* field measurement) sensing, using an ASD Fieldspec Pro spectrometer, provides thus a rapid and less expensive field surface sensing that permits to measure soil spectral properties. The BRGM aims to combine proximal and remote (*i.e.* airborne measurement) sensing to apply and optimize hyperspectral reflectance imaging for mapping clay minerals and soil properties, so that local mapping of swelling clays susceptibility could be assessable from an economical point of view.

Gullies detection on satellite imagery in an intra urban catchment of tropical region. Methodological development in river Bumbu catchment (Kinshasa, RD Congo)

MAYAMBA AIME M., TSETA FELICIEN M., KOMANDA JULES A.
Université de Kinshasa, KINSHASA, CONGO (THE DEMOCRATIC REPUBLIC OF THE)

In contrast to the effort during the last decades to investigate sheet (interrill), rill and gully soil erosion processes in agricultural environment, relatively few studies have been focused on quantifying and/or predicting gully erosion in urban sites. The extension of the use of modern spatial information technologies, such as geographical information systems (GIS), differential global positioning system (DGPS) and remote sensing, have created new possibilities for research in this field. A key issue to be addressed, as the basis for predicting the effects of global changes such as land use and climate changes, is the mapping and quantification of gully erosion rates, including rate of retreat of gully walls and rate of sediment production. This research work presents a method to detect and map gully in tropical urban environment using a visual interpretation key.

The proposed method uses high resolution satellites images and DGPS data, both of which have been processed using GIS techniques. The research was applied to a sample catchment of 23 km2 located in Kinshasa, DR Congo. Satellite image at 0.76 meter from 2006 and field data from 2009-2010 were used to map gully and validate interpretation keys used to detect gully.

51 gullies with different length and state were detected in the catchment from satellite image and 51 founded in the field in different states of activity. Too criteria dominate to determine gullies: shape and color. Some accelerated causes of gully erosion were also detected.

In comparison with the traditional visual interpretation of satellite image, the proposed method integrates local realities.

****

Terrestrial laser scanning methods as instrument of landslide and erosion processes study

YERMOLAEV O., USMANOV B.
Kazan Federal University, KAZAN, RUSSIAN FEDERATION

Methods for estimating the intensity of hazardous exogenous geological processes are being developed. For this purpose laser scanning system used high precision instrument "Trimble GX".

Study of landslides held in the observation point Kamskoe Ust'e (Volga River, East Russian Plane, Russia), where under the action of the Kuibyshev reservoir, landslide processes actively destroys slopes, threatening buildings and destroying the old cemetery. The length of the landslide circus front is 180 meters. From remote sensing data and the results of field observations, the average retreat rate of the slope edge is 3 m per year, annually removed area ranges from 500 to 1,500 square meters, that allows to relate study area to dangerous category. Annual and intraseasonal rescan allowed us to estimate the intensity of the landslide processes more accurately over traditional methods, and get the exact volumes of slope destruction to the entire front of the landslide circus.

Erosion processes (rill and sheet erosion) studied in Kazan city (Russia) during April - June 2012 period on the experimental plot with the loamy slope without greensward, 40 sq m area, 30 degrees angle, measurements were taken after snowmelt and heavy rains. Maps of deviations between all stages of surveying and TIN-models build directly on point clouds. Obtained results may provide insight into the processes of erosion and accumulation on a slope and consider in detail the formation of erosion forms as a result of rainfall and snowmelt , also to calculate such quantitative characteristics as volume and layer of accumulation and erosion of the soil. For experimental plot erosion layer is 1.3 mm.

Use Of Remote Sensing to Locate Subsurface Shallow Waters in Al Madinah Al Munawwarah, Western Saudi Arabia

AL-DOAAN M., DAOUDI M.
King Abdulaziz University, JEDDAH, SAUDI ARABIA

Al Medina Al Munawwarah, a city in the western part of the Kingdom of Saudi Arabia, is located in a dry area, with average annual precipitation of less than 70 mm. Due to the limited amount of water resources available to the city from traditional rain water or wells, the government has resorted to alternative sources, such as desalinated sea water to meet the city's growing water needs for the population. The aim of this study is to search for wadis, or riverbeds that might be abundantin subsurface waters in Medina. Such waterways were the main source providing the city with its water needs until 1970, before the availability of desalinated sea water.To locate rich underground water reservoirs and to provide maps of the area, satellite-borne data has been obtained using (TM+ Landsat 7, Ikonos, XI Spot 5) and the software program (ENVI) was used to digitally process the remotely-sensed data.Preliminary results show that new sources of rich underground water beneath the earth's surface are available, which can be accurately located and the water can be maximally extracted from these reservoirs that date back to the Pleistocene period , and lie under layers of volcanic lava.
Keywords **:** digital imaging, mapping technique, arid region, shallow water, Saudi Arabia.

****

InSAR as a complementary tool for identifying alluvial morphological units: Vega Media of the Segura River (SE Spain) case study

CONESA-GARCÍA C.(1), TOMÁS R.(2), HERRERA G.(3), LÓPEZ BERMÚDEZ F.(1), CANO M.(2), NAVARRO-HERVÁS F.(1), PÉREZ-CUTILLAS P.(4)
(1) Departamento de Geografía Física, Universidad de Murcia, MURCIA, SPAIN ; (2) Departamento de Ingeniería de la Construcción, Obras Públicas e Infraestructura Urbana, Escuela Politécnica Superior, Universidad de Alicante. Unidad Asociada de investigación IGME-UA de movimientos del terreno mediante interferometría radar (UNIRAD), ALICANTE, SPAIN ; (3) Geohazards Remote Sensing Laboratory, Grupo de Riesgos Geológicos, Instituto Geológico y Minero de España. Unidad Asociada de investigación IGME-UA de movimientos del terreno mediante interferometría radar (UNIRAD), MADRID, SPAIN ; (4) Centro de Edafología y Biología Aplicada del Segura (CEBAS), Consejo Superior de Investigaciones Científicas (CSIC), MURCIA, SPAIN

It is widely known that differential subsidence in a valley significantly controls its fluvial dynamics. Nevertheless, major uncertainty exists about the way in which alluvial forms respond to this process. Alluvial sediments constitute loose and unconsolidated deposits characterized by their low strength and bearing capacity. These sedimentary units have a moderate to very high compressibility (i.e. capacity for reducing a material volume by decreasing voids either filled with air or water) mainly depending on the grain size and the depositional conditions of the particles. The *Vega Media* of the Segura River is an alluvial area, affected by subsidence processes, mainly since the Pleistocene, whose current anthropization makes it difficult to delineate the limits of its morphological units. In this work, Differential SAR interferometry data from 1995 to 2008 were used, as a complementary tool to available geomorphological information, for identifying and delineating different alluvial units in the *Vega Media* of the Segura River, based on their different deformability rates. For this purpose, SLC SAR images from ERS-1 and ERS-2 satellites have been used for generating a total of 79 interferograms. The selected study area (100 km^2) extends from the village of Alcantarilla to the city of Murcia and represents the typical morphological evolution of the whole *Vega Media*. The results obtained are shown and commented on in relation to the main issues involved in this topic. From the analysis of data, four deformational behaviours related with different alluvial units have been identified: a) Non-deformational units (consolidated alluvial fans and upper fluvial terrace); b) Slightly deformable units (lower terraces and abandoned meanders); c) Moderately deformable units (e.g. SW sector, old area of the Lower Guadalentín River flowing to the Segura River); d) and highly deformable areas (non-active flood plain and valley bottom).

Application of remote sensing for geomorphological mapping and reconstruction of geomorphological evolution

PETROVIC D., PAVLOVIC R.
University of Belgrade, Faculty of Mining and Geology, BELGRADE, SERBIA

Geomorphological mapping in Serbia was conducted using instructions for reviewed (Gams etc., 1981) and detailed geomorphological map (Gams etc., 1985) which define content and technique of geomorphological maps in accordance with international standards (IGU, 1968). Mapping method is being changed during years. Basic instruction has been adjusted to specific requests, conditions as well as the development of new methods of geomorphological mapping.

Remote sensing is important part of geomorphological mapping and analyzes of geomorphological evolution of an area. In this paper, remote sensing include qualitative visual analysis of satellite and areal images. With these procedures, two different type of data can be pointed out. First data are morphostructural elements which present conditions for the development of some exogenetic processes and geomorphological evolution. Tectonic fabric, especially neotectonic active ruptures and blocks defined by them, seismological activity, epirogenetic-orogenic movements and volcanism present the basic endogenic factor in control of exogenetic processes. Analysis of satellite and areal images can be used for determination of important data about distribution and relationships between ruptures and morphological entities created by tectonic and igneous activity. Second data include morphosculpture elements, presented as single landforms and phenomena from different geomorphological processes. High resolution satellite images and aero images are excellent base for morphological analysis of landforms, determination of relationships between them and monitoring of their evolution. In this way, information about evolution and interaction of geomorphological processes in time has been acquired.

In this paper remote sensing was used for reconstruction of Oligocene-Miocene igneousactivity, glaciation and landslides in Serbia and Montenegro. There are numerous examples for every of these processes.

****

Vada Volaterrana (Italy). High-resolution Ground Penetrating Radar in Geoarchaeology: the application of STREAM X multichannel system

PAPPALARDO M.(1), RIBOLINI A.(1), PASQUINUCCI M.(2), BARONI C.(1), BINI M.(1), MENCHELLI S.(2), MORELLI G.(3), SALVATORE M.C.(1), SANGRISO P.(2)
(1) Dipartimento di Scienze della Terra, Pisa University, PISA, ITALY ; (2) Dipartimento Civiltà e Forme del Sapere, Pisa University, PISA, ITALY ; (3) Geostudi Astier, LIVORNO, ITALY

*Vada Volaterrana*was the main harbour of *Volaterrae*in Etruscan and Roman times as documented by Latin sources. Based on geomorphologic and archaeological data, the harbour was located at the sheet of water in front of modern Vada settlement, protected by a large shoal system. Immediately northeast of this area stratigraphic excavations are in progress and a Roman quarter related to the harbour has been brought to light.

We started an integrated geoarchaeological project to reconstruct the landscapes. Because of its high-resolution data and 3D visualization capabilities, Ground Penetrating Radar (GPR) is one of the most frequently used geophysical techniques for geoarchaeological prospection. Routine data acquisition is based on single or double channel GPR systems moved on the surface following generally 30-50cm spaced cross profiles. The resulting lateral spatial resolution of acquired data might not be fully adequate to resolve the subsurface structures because of aliasing effects. The new generations of multi-channel GPR instruments avoid the spatial sampling biases reducing the antenna channel separation on the surface, allowing a significant increase in resolution up to few centimetres.

In *Vada Volaterrana* site, we employed the STREAM X system by IDS S.p.A, equipped with 15 antennas of 200 MHz central frequency, 12 cm spaced. The system was easily moved on the surface by means of a 4-wheel vehicle, while the positioning of the acquired data was provided by a RTK-GPS station interfaced with the acquisition software.

We obtained a 3D ultra-dense data volume, processed with a specific software according to a standard procedure. We interpreted the continuous and spatially coherent radar reflections, visible in the data volume section, which were cut parallel to the surface at different depths (depth slice). Selected areas of the investigated surface were explored by means of shallow coring, allowing a more liable interpretation.

Estimation of medium-term soil erosion rates by means of terrestrial laser scanner and exposed roots

GOMEZ-GUTIERREZ A., SCHNABEL S., RUBIO-DELGADO J., BERENGUER-SEMPERE F., LAVADO-CONTADOR F.
Universidad de Extremadura, CACERES, SPAIN

The estimation of medium-term sheet erosion rates represents a challenge in areas with long land use history. In the present paper, a new methodology for estimating medium-term sheet erosion rates is presented. The methodology is based on the analysis of the morphology of tree stems, exposed roots and surface micro-topography using data obtained with a Terrestrial Laser Scanner. Specifically, botanical evidences were used to estimate the antecedent level of the surface. Later, previous and current surfaces were confronted in order to obtain a volume of soil loss. On the other hand, the age of the trees in the study area was estimated by means of an existing tree growth model. Finally, soil erosion rates were calculated using the volume of soil loss and the estimated age of every tree. The sampling was carried out in the farm *Buitrera de Villavieja* in Cáceres (Spain). The landscape and the management system is known as dehesa land use which is based on livestock grazing besides forest, and in some cases, agricultural exploitation (not in Buitrera). Climate is Mediterranean with mean annual temperatures about 17^0C and an annual rainfall of 620 mm. Soils are very shallow, developed on schists, with low amounts of organic matter and classified as distric leptosols. A representative hillslope (260 m long and 190 m wide) within the catchment was selected for the sampling, obtaining a point cloud of 112 063 056 points in an area of 50 000 m^2. A total of 134 trees were processed, with ages ranging from 40 to 250 years. High soil erosion rates were estimated for young trees while lower rates resulted for the older ones. A negative exponential relationship was obtained for soil erosion rates and tree ages, pointing out to a land-use intensification during the last century. Estimated soil erosion rates were also compared with the existing ones in the literature. The role of micro-topography was also explored; however no strong or significant relationships were obtained.

****

Using UAV as a source of DSM data in geomorphological 3D modelling

PANEK J., MACHACEK J.
Palacky University in Olomouc, OLOMOUC, CZECH REPUBLIC

A digital surface model (DSM) is a digital representation of ground surface topography, including all objects (houses, bridges, trees, etc). DSMs are often used in geographic information systems (GIS) and Computer Aided Design (CAD) environments, and are the most common basis for digitally-produced relief maps and true orthophotos. Industries such as mining, dredging, heavy engineering construction, etc. often rely on topographic ground surveyors for ground measurements and for accurate DSMs.

The unmanned aerial vehicles (UAV) allow users to create very dense point clouds - similar in density to a typical aerial LIDAR scanner - but with the advantage of requiring less demanding and costly equipment. This paper presents the results of a case study which introduces the use of unmanned aerial vehicles as a source of DSM data in geomorphological 3D modelling. As GIS and DSMs have become indispensable for geomorphological mapping and quantitative topographic research in the last decade, UAV mapping and data sourced from such devices will become a valuable source of spatial information, especially in relation to point clouds, in the next decade. This approach enables users to collect data in a short time and even in very complicated environments. The paper will outline the methodologies followed and the sources used in the process of UAV mapping and the visualisation of data. Secondly, the paper will share the results from the first Czech commercial use of UAV in quarry mapping and volume calculation. Thirdly, it will demonstrate how modern GIS and Remote Sensing methods can boost effectiveness within the Czech mining industry.

Integrated geomatic techniques for surveying glacial and recently deglaciated areas

DAMIANO E.(1), BACENETTI M.(2), BERTOTTO S.(2), GIARDINO M.(2), GODONE F.(1), PEROTTI L.(2), CHIARLE M.(1)

(1) Istituto per la Protezione Idrogeologica CNR-IRPI, TORINO, ITALY ; (2) Università degli Studi di Torino, Dipartimento di Scienze della Terra, GeoSITLab, TORINO, ITALY

Climate changes are more and more attracting the attention of the scientific community because of their direct impacts on geomorphic systems and human activities.

A number of studies are currently under way to investigate the evolution of high elevation environments, which proved to be particularly sensitive to climate changes and point to increased in instability in areas of cryosphere occurrence.

The here presented research has been developed in the framework of the Alcotra project n.56 “GlaRiskAlp”, by CNR-IRPI Torino in collaboration with the DST Torino - GeoSitLab laboratory and is aimed to the validation of an integrated geomatic approach for the evaluation of geomorphologic changes, and related hazards, in glacial and periglacial areas, in the contest of present climatic trends.

The proposed approach is based on the coupling of remote sensing techniques and field surveys, in particular digital aerial photogrammetry and satellite imagery, terrestrial scanning LiDAR, and GNSS survey.

High-resolution terrestrial LiDAR acquisition, processing and interpretation are used to map periglacial areas in the three dimensions. Laser-generated models offer a visualization tool that, through the comparison of DEMs of different years, allow to detect and to interpret even small geomorphologic changes in time. GNSS-networks are suitable tools for detecting changes over larger surfaces, or horizontal ones. Digital aerial photogrammetry and satellite images can be used to create ortophotos and DTMs of different years, allowing the reconstruction of main geomorphologic changes over the last 50 years.

The proposed approach has been applied to case studies of the Piemonte region (Western Italian Alps).

****

Monitoring geomorphological change with unmanned aerial vehicles

ANDERS N.(1), KEESSTRA S.(1), SEEGER M.(2), SUOMALAINEN J.(3), BARTHOLOMEUS H.(3), KOOISTRA L.(3)

(1) Soil Physics and Land Management, Wageningen University, WAGENINGEN, NETHERLANDS ; (2) Department of Physical Geography, University of Trier, TRIER, GERMANY ; (3) Laboratory of Geo-Information Science and Remote Sensing, Wageningen University, WAGENINGEN, NETHERLANDS

Remote sensing of the Earth’s surface is a valuable tool for analyzing the environmental setting of a landscape. Despite technological advances to increase the spatial resolution of satellite imagery, spaceborne data is not ideal for monitoring purposes due to cloud interference and low temporal resolution. Manned airborne imagery may be too expensive to use for frequent monitoring studies. In the context of the SMARTINSPECTORS project, we demonstrate the potential of using Unmanned Aerial Vehicles (UAVs) for analyzing and monitoring geomorphological processes in a changing landscape. We demonstrate the work flow and first results of a study in a small agricultural catchment (~2km^2) near Pamplona, northern Spain. We used a small airplane (MAVinci, wing span of ~1.6m) with an integrated consumer 16MP digital camera (Panasonic GX1, 20mm lens). The airplane operated based on a predefined flight schedule and autopilot. From the raw photographs we created detailed orthorectified air photos and high-resolution digital elevation models (DEMs) at different moments in time. With automated mapping procedures we are able to rapidly register the geomorphological setting and landforms, and follow their development over the measured time. By subtracting different DEMs we were able to locate source and sink areas, and transport channels. Future applications may include analyzing hydrological connectivity, calculating local erosion rates and identifying areas vulnerable to land degradation. Other sensors can be integrated which are e.g. sensitive to near-infrared light, that provide information related to specific soil physical properties and soil moisture. Based on the first results, we claim that UAVs are valuable tools for a rapid geomorphological assessment and the monitoring of small-scale processes.

Vegetation and landslides in the Serra do Mar (SP), Brazil: evaluation by satellite images processing

DIAS ALVES PORTELA V., CARVALHO VIEIRA B.
University of Sao Paulo, SAO PAULO, BRAZIL

Landslides have been the subject of studies mainly in the tropical, notably the role of vegetation in the distribution of these processes. By means of remote sensing is possible to argue the role of vegetation as indicator of landslides considering that this tool can analyze spectral properties of physiognomic types of species and canopies. This study aimed to relate the different vegetation cover and distribution of shallow landslides in the Serra do Mar, mountain range located along the SE Brazilian coast, in Caraguatatuba city (São Paulo state, Brazil). The Serra do Mar is characterized by steep slopes and elevation ranging between 20-1000m, with dominance of gneisses, migmatites, granites and micaschists. It acts as a barrier prevents the advance of moisture coming from the coastal zone to the mainland with the concentration of cold fronts and convection currents. The precipitation in the Serra do Mar is high with an annual average of 3000 mm that cause orographic rainfall. Because of your characteristics, shallow landslides are the major geomorphological processes in the evolution of this relief. In this research was conducted vegetation mapping by the processing of THEOS satellite images (year 2012) with the multispectral bands of the resolution of 15m and 2m in panchromatic band in the software Envi 4.5. We mapped the slope and aspect, 1:10,000 scale, the geomorphological units map (1:50,000 scale) and was also we prepared the landslide scars map. The interrelationship between vegetation data and geomorphological parameters was obtained using software ArcGIS 10.1. These results allowed to associate the types of vegetation and landslide scars and these were concentrated on the granites and gneisses and SW. The interrelationship of the data allowed to identify the importance of landforms and geomorphological processes in the vegetation structure and relate them to landslides scars in the study area.

****

An insight into the mud volcanoes morphodynamics. A Romanian case-study

GAL A.(1), BELL R.(2), MICU M.(3)
(1) Faculty of Geography, Babe?-Bolyai University, CLUJ-NAPOCA, ROMANIA ; (2) Faculty of Earth Sciences, Geography and Astronomy, University of Vienna, VIENNA, AUSTRIA ; (3) Institute of Geography, Romanian Academy, BUCHAREST, ROMANIA

Mud volcanoes are distinguished from igneous volcanoes by genesis, eruption products and magnitude-reduced derived forms and processes. Generally, they are triggered by natural gas and oil seepage, hydrothermal or seismic activity. In Romania mud volcanoes are widespread in various morphotectonic settings and are very often related to hydrocarbon reservoirs. The lithological structure of the discharged material reflects the structure of the geological formations through which the mud migrated towards the surface. The purpose of this paper is to outline the main morphodynamic characteristics of the mud volcanoes in two key-areas in Romania: the Transylvanian Basin and the Curvature Carpathians. Once the mud emerged and piled, the bulging volcano may form sometimes extended plateaus, (like those at Paclele Mari, covering approx. 30 ha) marked by scattered or grouped gryphons. The flows of mud, after drying, are affected by erosion forming impressive gullies. Using terrestrial laser scan measurements at two locations (Paclele Mari and Paclele Mici) we have started a time-series to quantify the outflow and accumulation of mud from the more active Paclele Mici mud volcanoes and erosion of the less active Paclele Mari plateau. With the next measurements in March 2013 the results will cover 3 measurements within a 2 years period, which so far shows significant accumulation and erosion. The results will be discussed in the general framework of morphodynamics of mud volcanoes in Romania.

Imaging spectrometry for the geomorphological and spectral characterization of the lower Odiel river course (Huelva, Spain)

GARCIA-MELENDEZ E.(1), BUZZI J.(2), RIAZA A.(2), CANTANO M.(3), MINGUEZ A.(4), RODRIGUEZ GARCIA A.(1)
(1) Universidad de Leon, LEON, SPAIN ; (2) Instituto Geologico y Minero de España, MADRID, SPAIN ; (3) Universidad de Huelva, HUELVA, SPAIN ; (4) Instituto Geologico y Minero de España, LEON, SPAIN

In this work, based on the interpretation of airborne hyperspectral HyMap images, the main geomorphological features of the Odiel river (southwest Spain) along its lower reach are mapped and their spectral responses are analyzed in compositional and textural terms. Hyperspectral imagery provides wide possibilities for mapping complex features of the surface of the Earth, by offering a high dimensionality of data. The procedure for feature extraction for thematic purposes used in this study is an interpreter oriented sequential spectral separability method using standard algorithms, leading to a spatial pattern and spectral identification for pixels within the scene. The standard sequence of algorithms begins with Minimum Noise Fraction Transforms, followed by Pixel Purity Index and n-dimensional Analysis to extract significant statistical populations, and finally a classification through the Spectral Angle Mapper algorithm. The obtained results show a good differentiation between gravel/sand bars occurring on alternating sides of the channel as point or lateral bars with a lower overall reflectance, and channel-fill deposits with predominant silty and muddy sediments located in abandoned secondary channels, with a higher overall reflectance. The spectra in both bars and abandoned channels are dominated by absorption features related to the precipitation of iron-oxides minerals associated with the presence of acid mine drainage. On the other hand, in the lower terraces and floodplain these absorption features are not present.

Keywords: fluvial sedimentation, HyMap, spectroscopy.
Aknowledgements: *work supported by the Spanish PNI project CGL2007-6004/CLI*

****

The use of Structure for Motion for repeat topographic surveys of active boulder bars on a hydrologically dynamic tropical river

DIETRICH J., LIND P.
University of Oregon, EUGEN, UNITED STATES

Grain-scale alterations of boulder bar surfaces are not captured with traditional point-survey techniques due to the inherent uneven topography created by boulder grain size and shape. This study applies the close-range photogrammetry approach of Surface from Motion (SfM) to quantify changes in area, elevation, and grain mobilization of the surfaces of active boulder bars in the Rio Pacuare, Costa Rica during the 2012-2013 rainy season. High-resolution 3D landscape models of boulder bar surfaces were produced through photogrammetric surveys atop six boulder bar surfaces before and after flood events. Survey photos were taken with a pole-mounted camera in an overlapping grid pattern to maximize exposed surface area of each grain. This paper presents some of the challenges and the applicability of close-range repeat photogrammetric surveys on active coarse-grained surfaces.

SRTM employment images in physiographic subdivision: a case study in the region of São José dos Campos - SP - Brazil

SANTOS CORREA C.(1), TAVARES DE MATTOS J.(2), DIAS BRITO H.(1)
(1) UNESP, RIO CLARO, BRAZIL ; (2) UNESP GUARATINGUETA, GUARATINGUETA, BRAZIL

An important factor topromote the inclusion of relief in the identification and analysis of terrestrial systems comes from recent topographic data collection by remote sensing techniques. The project SRTM (Shuttle Radar Topographic Mission) comes from cooperation between NASA and NIMA (National Imagery and Mapping Agency), DOD (Department of Defense) of U.S. and space agencies of Germany and Italy. Of the total data collected by the SRTM data were processed for C-band coverage in 80% of the Earth's land area, between latitudes 60 ^{0} N and 56 ^{0} S (JPL, 2003). Thus, this article aims to demonstrate the results obtained from the use of SRTM images to the physiographic subdivision in the region of São José dos Campos (SP), Brazil. The study area is part of the Taubate Sedimentary Basin and is limited to the south and north by the Crystalline Basement, featuring morphologies linked to these rock types. The methodology consisted by the use of images and SRTM topographic maps at 1: 50,000 scale, which went through the process of Photoreading, Photoanalysis and Photointerpretation (SOARES & FIORI, 1976). The results showed the presence of the Subdivisions Basics Units, which are subject to environmental studies and geotechnical character geoenvironmental. Thus, images SRTM stand out as relevant tools in die geomorphological studies, since it allows the identification of landscape elements, such as slope and drainage.

****

Application of principal components analysis (pca) to detect geomorphological faces, case study: meyghan lake

GHAHROUDI TALI M.
Shahid Beheshti University, TEHRAN, IRAN

Meaghan Lake, one of the places that have been preserved evidence of climate change as evaporating surfaces and destructive deposits. At present the lake collects water in its catchment area of approximately 5528 square kilometre which already has a dry climate, with evaporation over precipitation. This study was conducted to identify faces Geomorphologic Meaghan playa.

1:25000 topographic maps, Aster data, ETM + and IRSP6, images, 1:100000 geological maps and field research were used. Principal Component Analysis (PCA) has been used to identify Microgeomorphologis lands. The results were evaluated using field observations. The results showed, area of the lake has been 129 square kilometres during the last cold period. Due to landform are made of evaporate minerals including calcite, gypsum and halite. It can be found reduced precipitation and increased evaporation may lead to smaller the lake. And changes in lake levels caused to deposit evaporative minerals according to their solubility. Finally the levels of various forms have been left.

Acquisition, Resolution and Precision of Dieppe Costal Cliffs Point Clouds from Mobile Laser Scanning

MICHOUD C.(1), CARREA D.(1), AUGEREAU E.(2), CANCOUËT R.(2), COSTA S.(3), DAVIDSON R.(3), DELACOURT C.(2), DERRON M.H.(1), JABOYEDOFF M.(1), LETORTU P.(3), MAQUAIRE O.(3)

(1) Centre de Recherches en Environnements Terrestres - Université de Lausanne, LAUSANNE, SWITZERLAND ; (2) IUEM University of Brest, BREST, FRANCE ; (3) LETG-CAEN GEOPHEN University of Caen, CAEN, FRANCE

Mainly formed by sub-horizontal deposits of soft chalk and flinstone, the Dieppe coastal cliffs, in Normandy, France, are destabilized by an intense weathering and the Channel sea erosion; moreover, small and large rockfalls are regularly observed and contribute to retrogressive cliff processes. Cliffs and intertidal topographies have been acquired during Autumn 2012 with a Terrestrial Laser Scanner (TLS) and a Mobile Laser Scanner (MLS), coupled with seafloor bathymetries realized with a multibeam echosounder (MBES).

MLS is a recent development of laser scanning based on the same theoretical principles of aerial LiDAR, but using smaller, cheaper and portable devices. The MLS system, which is composed by an accurate dynamic positioning and orientation (INS) devices and a long range LiDAR, is mounted on a marine vessel; it is then possible to quickly acquire in motion georeferenced LiDAR point clouds with a mean resolution of about 15 cm. For example, it takes about 1 h to scan of shoreline of 2 km long. MLS is becoming a promising technique supporting erosion and rockfall assessments along the shores of lakes, fjords or seas.

In this study, the MLS system used to acquire cliffs and intertidal areas of the Cap d'Ailly was composed by the INS Applanix POS-MV 320 V4 and the LiDAR Optech Ilirs LR. On the same day with a calm sea at 2.5 Beaufort (small wavelets), three MLS scans with large overlaps (J1, J21 and J3) have been performed at ranges from 600 m at 4 knots (low tide) up to 200 m at 2.2 knots (up tide). Mean scan resolutions go from 25 cm for far scans to about 8 cm for the closest scan. Moreover, one TLS point cloud on this test site has been acquired with a mean resolution of about 2 cm, using a Riegl LMS Z390i. In order to quantify the precision of the methodology, comparisons between scans have been realized with the software CloudCompare, calculating shortest distances between points of one cloud and the interpolated mesh of the reference point cloud. A MatLab™ routine was also written to extract interesting statistics.

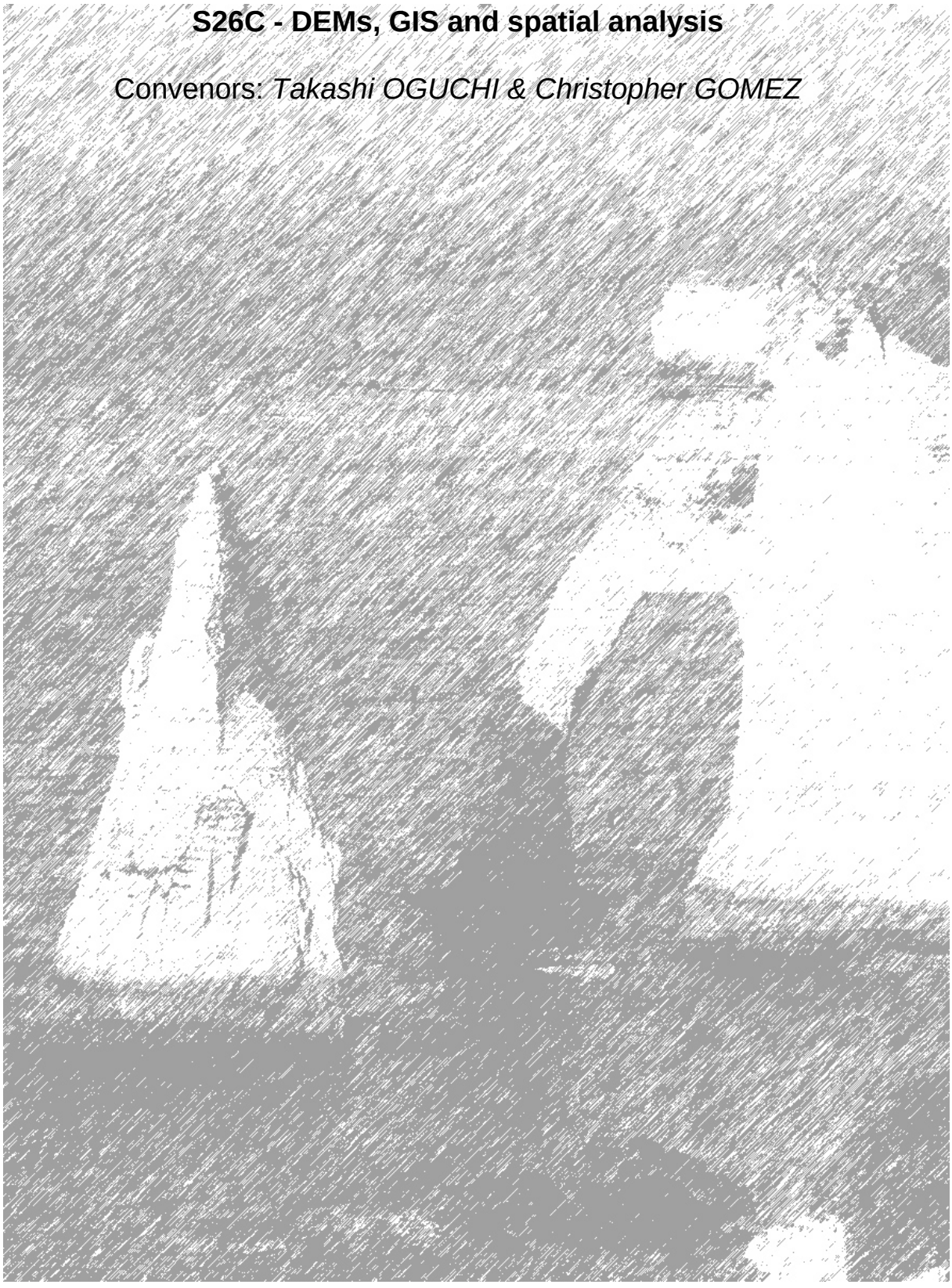
First, mean distances between points of the reference point clouds (J21) and its interpolated surface are about 0.35 cm with a standard deviation of 15 cm; errors introduced during the surface interpolation step, especially in vegetated areas, may explain those differences. Then, mean distances between J1's points (resp. J3) and the J21's reference surface are about 4 cm (resp. -17 cm) with a standard deviation of 53 cm (resp. 55 cm). After a best fit alignment of J1 and J3 on J21, mean distances between J1 (resp. J3) and the J21's reference surface decrease to about 0.15 cm (resp. 1.6 cm) with a standard deviation of 41 cm (resp. 21 cm). Finally, mean distances between the TLS point clouds and the J21's reference surface are about 3.2 cm with a standard deviation of 26 cm.

In conclusion, MLS devices are able to quickly scan long shoreline with a resolution up to about 10 cm. The precision of the acquired data is relatively small enough to investigate on geomorphological features of coastal cliffs. The ability of the MLS technique to monitor small and large rockfalls will be investigated thanks to new acquisitions of the Dieppe cliffs in a close future and enhanced adapted post-processing.

****

S26C - DEMs, GIS and spatial analysis

Convenors: *Takashi OGUCHI & Christopher GOMEZ*



Oral presentations:

Generating high spatiotemporal resolution digital terrain models for debris flow deposits from 3D structure-from-motion imagery and an unmanned aerial vehicle

STARHEIM C.(1), GOMEZ C.(1), DAVIES T.(1), OWENS I.(1), HADMOKO D.S.(2)
(1) University of Canterbury, CHRISTCHURCH, NEW ZEALAND ; (2) Universitas Gadjah Mada, YOGYAKARTA, INDONESIA

Monitoring the evolution of landform morphology at high spatial and temporal resolutions can generate valuable insight on the erosion, remobilization, and emplacement of sediments in geomorphologically active environments. While conventional remotely sensed data (e.g. commercial aerial photography, satellite imagery, and airborne LiDAR data) are frequently used for this type of research, the availability and expense of datasets often limits the resolution of the findings and thus, the usability of the technique for small and/or highly active features. By contrast, the present study applies innovative structure-from-motion (SfM) technology to generate a time-series of high-resolution digital terrain models (DTMs) for an active debris flow fan deposit. Repeat photo-surveys of the deposit were completed with consumer-grade digital cameras from ground positions and from an unmanned aerial vehicle. Agisoft PhotoScan Professional software was then used to process the images with an automated multi-view SfM algorithm, which identified common points and features in the photos, calculated camera positions and orientations, and amalgamated the images into a 3D model of the deposit. Ground control points were established in each survey using a differential global navigation satellite system and were used to geo-reference each DTM. Analysis of successive DTMs revealed significant evolution in the debris flow deposit morphology associated with sediment erosion and remobilization. Further analysis of these DTMs, coupled with detailed field observations and subsurface deposit imagery is expected to improve debris flow deposit interpretation. Although the present study primarily focuses on alpine debris flow deposits, the methods and techniques discussed are applicable to a wide range of high-energy environments including fluvial, coastal, glacial, and volcanic.

****

Impact of tsunami erosion on coastal valley formation in northeastern Japan: an airborne and terrestrial laser scanning approach

HAYAKAWA Y.S.(1), OGUCHI T.(1), SAITO H.(1), KOBAYASHI A.(2), KOMATSU G.(3), GOTO K.(4), BAKER V.R.(5), PELLETIER J.D.(5), MCGUIRE L.(5)
(1) The University of Tokyo, KASHIWA, JAPAN ; (2) The University of Tokyo, TOKYO, JAPAN ; (3) Università d?Annunzio, PESCARA, ITALY ; (4) Tohoku University, SENDAI, JAPAN ; (5) University of Arizona, TUCSON, UNITED STATES

Devastating tsunami waves induced by the Tohoku-Oki megaearthquake caused severe erosion of side-slopes in valleys along the ria-type coast of the Sanriku region, Japan. Removal of vegetation, soil, regolith and even erosion of bedrock induced by the tsunami wave is observed at inland areas of valleys facing the coast. One of the most typical cases is the valley of Aneyoshi, where a very high runup of tsunami wave (38.9 m) was recorded. We investigated detailed morphology of the eroded valley-side slopes using high-resolution topographic data obtained by airborne and terrestrial laser scanning (ALS/TLS). The ALS data were provided by the Geospatial Survey Institute of Japan, whereas we used a Topcon GLS-1500 scanner to obtain the TLS data. Morphological analyses revealed several characteristic features in the valley: 1) small cliffs and steps were found on the valley-side slopes, and their locations correspond to the tsunami-inundated heights; 2) the valley side slope is gentler at the outside of the incised meander bend and steeper at the inside, and this asymmetry is unusual and inverse to that of an incised meander formed by fluvial erosion; 3) the valley is extraordinary wide at its downstream reach compared to the discharge of the river, and suddenly narrows at just upstream of a major meander bend; and 4) a knickpoint is located near the maximum tsunami-runup point in the narrowed reach, c. 100-m upstream of the bend. These topographic features likely reflect tsunami wave erosion which could have occurred multiple times during the late Holocene. In other words, if such characteristic forms in coastal valleys are found in other areas, they suggest repeated attacks of tsunami, and future tsunami magnitudes there may be estimated from topographic characteristics.

Accuracy assessment of DEMs derived from low-cost UAV-based remote sensing for geomorphic landform representation

CLAPUYT F.(1), VANACKER V.(1), VAN OOST K.(2)
(1) Earth and Life Institute, Georges Lemaître Centre for Earth and Climate Research, Université Catholique de Louvain, Belgium., LOUVAIN-LA-NEUVE, BELGIUM ; (2) Earth and Life Institute, Georges Lemaître Centre for Earth and Climate Research, Université Catholique de Louvain, Belgium. Fund for Scientific Research FNRS, Rue d Egmont 5, 1000 Bruxelles, Belgium., LOUVAIN-LA-NEUVE, BELGIUM

This study investigates the construction of a digital elevation model (DEM) using aerial photographs taken from a drone in the perspective of geomorphic applications. In this context, a representation of the earth surface at very-high resolution is crucial to accurately quantify small geomorphic landforms with high precision. These very high resolution digital elevation models can then theoretically be used to quantify changes in earth surface topography over time, based on differencing of DEMs taken at various time periods. However, high accuracy topographic representation is compulsory in this case as DEM differencing automatically leads to error propagation.

As a low-cost alternative, we equipped an eight-propeller drone with a standard reflex camera. This equipment can easily be deployed in the field, as it is a lightweight, low-cost system in comparison with classic aerial photo surveys and terrestrial or airborne LiDAR scanning.

Here, we tested to methods to extract a high-resolution DEM on the basis of the aerial photos. (1) Aerial photos are individually georeferenced and then processed into professional DEM extraction software. (2) Aerial photos are first processed into free software which generates 3D point clouds from arbitrary image configuration. The entire generated point cloud is then georeferenced. The accuracy and precision of both earth surface representations is then assessed by comparing them with very high resolution topographic data from airborne LiDAR and very high-resolution GPS measurements.

****

SfM vs. RTK: FIGHT! (Structure from Motion versus Global Navigation Satellite System Real Time Kinetic)

GOMEZ C., STARHEIM C.
University of Canterbury, CHRISTCHURCH, NEW ZEALAND

Recent technological advances enabling the construction of high-resolution digital elevation models (DEMs) have opened the long-closed Pandora-box of research in geomorphology. As new technologies, including terrestrial laser scanning (TSL) and structure-from-motion (SfM) are introduced it becomes increasingly essential to properly evaluate the benefits and limitations of each technique. Differences often extend past the basic methods for data acquisition and processing to the types of data potentially recorded. In this contribution the authors offer a direct comparison between two point-cloud datasets for DEM generation collected using: first, real time kinetic (RTK) data acquired from a Trimble differential global navigation satellite system (dGNSS), and second, SfM data acquired from a 'low-cost' commercial digital SLR camera (Canon EOS 1100) equipped with the standard 35 mm lens.

The study focuses on an area measuring approximately 100 m x 20 m on an active debris-flow fan in the Cass region of the New Zealand Southern Alps. Detailed one-hour RTK-dGNSS and SfM surveys were completed with the intention of generating DEMs of the study site. While results indicate that the SfM technique is superior to RTK based on the number of data points collected, the ability to record supplementary data including the RGB-colour of features, and the resolution of reconstructions, it is argued that a combined SfM-RTK approach is best suited to monitoring changes in active micro-landforms, especially because SfM does not record any 'real-life' spatial benchmark and it is only developed in a relative space. Potential geomorphological applications of SfM datasets are further discussed with particular emphasis on the benefits of obtaining information on featured spectral values.

Three dimensional reconstruction of paleotopography to assess the role of antecedent morphology before and after rapid deposition events

KAIN C., GOMEZ C., HART D.
University of Canterbury, CHRISTCHURCH, NEW ZEALAND

Three dimensional reconstruction of paleosurfaces using GIS aids analysis of rapid-deposition event deposits. Depositional patterns of a flow event are constrained by topography and thus deposits may vary significantly across a small area. Without pre-event surveys for comparison, deposit configuration with respect to original topography is difficult to quantify in three dimensions. Thus, the topography underlying paleodeposits is often not known at a high resolution spatial scale and this information gap can cause inaccuracies when reconstructing an event from its deposit.

This research develops a GIS-based method of assessing deposits with respect to paleotopography and considers the influence of their form on morphological evolution post-event. A suite of overwash deposits in an infilled coastal embayment on Banks Peninsula, New Zealand is used as an example. Components include constructing a surface DEM from differential GNSS surveying, subsurface structure investigation using Ground Penetrating Radar (GPR), and sediment fabric analyses to assess flow direction. ArcGIS was used to reconstruct topography and paleosurfaces and explore the spatial and temporal relationships between layers. Anisotropy of Magnetic Susceptibility (AMS) data determined the direction of flow during the deposition of the overwash deposits, which served two purposes. Firstly, where underlying topography was visually apparent, the influence of topography on deposition was confirmed. Where boundaries were unclear, AMS was able to distinguish between depositional directions in the absence of topographical evidence, enhancing process reconstruction. By combining separate DEMs of surface and paleotopography in three dimensions, then comparing these with flow directions and thickness of the intervening sand layers, the degree to which topography affects interpretation of paleodeposits and the influence of rapid landscape-change events on further morphologic development can be better understood.

****

3D Mapping of liquefaction phenomena induced by May 2012 Emilia earthquakes (Po Plain, Northern Italy)

ZIZIOLI D.(1), NINFO A.(2), MEISINA C.(1), ZUCCA F.(1), PELLEGRINI L.(1)
(1) Earth and Environmental Sciences Department - University of Pavia, PAVIA, ITALY ; (2) Department of Geosciences - University of Padova, PADOVA, ITALY

Coseismic effects may have a very short life; most of the sand boils and cracks triggered by the main shocks of the May 20th and 29th Emilia earthquakes have disappeared just a few days after, both because of the atmospheric agents, and due to human intervention. In order to create an accurate database of these small micro-morphologies, several photogrammetric surveys were carried out using digital reflex cameras. Fixing in three dimensions the impact that shocks have made on the landscape allows to extract many morphometric parameters with high precision and, in a relatively simple way. Structure From Motion (SFM) algorithms are well known computer vision technique for the ability of reconstruct sparse point cloud from overlapping photographs; when they are combined with fixed calibrated optical and complemented with robust stereo-matching algorithms, detailed three dimensional models can be built with great resolution and accuracy. In order to obtain high resolution DEMs several convergent images were taken trying to cover all the angles and the whole area of the object. The first step called alignment, the reconstruction of the photograph shooting position is done by SFM that detect some images key points and subsequently correlates the movement of these along the image sequence. Once the basically geometry of the scene is known, dense stereo matching algorithm processes the scene trying to correlate every pixel for each photo in order to reconstruct a dense point cloud. Finally the obtained point cloud is triangulated and a detailed mesh is constructed. In order to build a local reference system suitable for use in GIS different targets of known size were distributed around every scene and ground control points were collected. More zenithal pictures were used to orthophotos production. Using this methodology we were able to develop DEMs with resolutions ranging from one millimeter for the small forms to some centimeter for the big ones.

Digital Bathymetric Models (DBM) : multiple sources, multiple uses ... and multiple models. A comparison of known DBM for the Bay of Biscay

SCHMITT T.(1), BISCARA L.(1), LOUBRIEU B.(2)
(1) SHOM, BREST, FRANCE ; (2) IFREMER, BREST, FRANCE

Bathymetry is vitally and economically important for our societies. Its primary use is to secure the transportation of goods and persons (navigation). Bathymetry also plays a key role in a variety of fields of marine geosciences (geology, oceanography, environmental, engineering …) where it provides a driving physical variable for the description and monitoring of the environment. For example marine ecosystems, offshore resources, coastal risks are known to be correlated with the morphology of the seafloor. A detailed and representative morphological analysis is therefore dependant on the quality of the underlying digital bathymetric model.

Bathymetric data are nowadays commonly acquired using multibeam echo-sounders (swath mapping). But in reason of the vastness of the oceans and the cost for multibeam mapping, only 10% of the ocean is mapped with high resolution and accurate precision technology (Hall, 2006). Therefore, less accurate sources of data sets with lower density and accuracy (in both positioning and depth accuracy), such as historic (lead line or singlebeam surveys) or remotely sensed (satellite altimetry) data cannot be ignored.

In order to compute a representative bathymetric model, a number of different approaches are considered for both the selection of valuable datasets (resolution, sampling, processing of biaises and/or noise, horizontal and vertical reference,...) and the interpolation models (Inverse distance weight, spline, ordinary krigging, …). The main goal of this work is to propose a thorough description of existing bathymetric models, highlighting the advantages and disadvantages of the different approaches. The test area considered for this analysis is located in the Bay of Biscay, where a variety of morphological features exist and where multiple data types can be considered.

****

Graph theory - recent developments of its application in geomorphology

HECKMANN T.(1), SCHWANGHART W.(2), PHILLIPS J.(3)
(1) Catholic University of Eichstaett-Ingolstadt, EICHSTAETT, GERMANY ; (2) University of Potsdam, POTSDAM, GERMANY ; (3) University of Kentucky, LEXINGTON, UNITED STATES

Graph theory has been widely applied across a range of disciplines as different as population and landscape ecology, sociology, economic and transportation geography, informatics and climatology – yet these disciplines have in common that they deal with systems consisting of multiple subsystems or compartments that are coupled by relations. Although geomorphic systems lend themselves to network representations (see e.g. Chorley and Kennedy's systems approach to physical geography, 1971), the application of the conceptional and methodological toolbox of graph theory has been quite rare and restricted. In the 1960ies, graph theory was used to study the topology of river networks; since the 1970ies, studies in geomorphometry have employed it to model the topological structure of topographic surfaces.

The recent re-discovery and development of graph theory applications in geomorphology run on two lines. (a) The spatially explicit analysis of sediment cascades in geomorphic systems where nodes represent their compartments (depending on the spatial scale of the study the latter can be single landforms or larger terrain subunits up to whole catchments), and edges represent the linkage of system components through water or sediment flux. This approach is closely related to the analysis of hydrological and/or sediment connectivity. (b) The analysis of geomorphic systems whose properties are represented by graph nodes, and the relations between them by graph edges. Graph theoretical measures, derived e.g. by eigenvalue analysis of the adjacency matrix, have been shown to reflect system properties such as synchronization and scale relations.

Our contribution reports on these recent developments. We present case studies and discuss future applications in geomorphology that could benefit from graph theory.

Spatial distribution of the sinkhole and sinkhole affecting factors in the vicinity of Karapınar (Konya, Central Turkey)

OZDEMIR A.
Selcuk University, KONYA, TURKEY

There are several hundreds of sinkholes in the vicinity of Karapınar. Agricultural irrigation has accelerated the formation of sinkholes.About 20 big sinkholes occurred within the territory of the Obruk Plateaubetween 1970 and 2012.Formation of sinkholes is the most serious geological hazards in the study area, because they can damage engineering structures, settlement and agricultural areas. There is no study conducted on distribution of sinkholes in this region. In this study, spatial distribution of the sinkholes existing in the region and the factors affecting sinkhole formation were studied through the geographical information systems. In the study, first of all, 182 sinkholes, which had been formed in the region, were determined through a topographical map by examining the digital elevation model produced by using this map. Then, they were mapped after they had been checked through the field studies. On the other hand, topographic, geomorphologic, geologic and hydrogeological 30 factor maps, which were considered effective in sinkhole formation, were produced to investigate their relation with sinkholes. According to this investigation, it was determined that sinkhole formation around Karapınar has become more concentrated in the areas in which topographic elevation is low (972-1081 m). The sinkholes across the region have generally been formed as a result of dissolution of Neogene aged lacustrine Insuyu formation made of limestone and clayey limestone. Furthermore, sinkhole formation increases as drainage lines and faults become closer (<1000 m) and cover thickness decreases (<30 m). As a result, factors affecting sinkhole formation were identified. Injuries and property losses caused by sinkhole formation may be prevented or reduced by using sinkhole susceptibility and risk maps, which may be produced according to these factors.

****

River basins of Russian Plane: geomorphometrical analysis and geomorphological zoning

MALTSEV K., MALTSEV K., YERMOLAEV O.
Kazan Federal University, KAZAN, RUSSIAN FEDERATION

The article describe computer-aided delineation method for little river basin watersheds of Russian Plane. First, algorithm and vector planar map of basin's watersheds was created for this territory. The digital elevation model "GTOPO30" was used for creating 27630 river basins of 3-4 order. The average catchment area of these basins is 107 km^2; minimum area - 1.4 km^2; maximum area – 430 km^2. Estimating of model accuracy was accomplished. The geomorfometrical analysis was realized for every river basin. Elevation, slope, magnitude of average catchment area, plan and profile curvature was calculated.

Second, algorithm of computed-aided geomorphological zoning was developed for Russian Plane. The self-organizing map(kind of artificial neural network) was used for this task. The basins was used for zoning as operational-territorial units. The morphometric parameters of river basins was involved in this process as classification features. The main classification features was elevation and slope. The 225 initial classes were used for zoning. This count was reduced till 13 thematic classes at the last stage of classification.

The verification of computer-aided zoning map shows rather good coincidence with map, which was made earlier by traditional method.

The lows of "Horton-Rzhanitsin" was validated for rivers from different natural zones and morpho-genetic types of relief. The regularities between count of different orders water flows, average length and bifurcation coefficient was confirmed during of spatial analysis.

Active hydrological stream network extraction: a GIS approach based on DEM and climate data

CORNU J.F.(1), CAROZZA J.M.(2), OBERDORFF T.(1)
(1) UMR BOREA, IRD 207, National Museum of Natural History, PARIS, FRANCE ; (2) University of Strasbourg - GEODE UMR 5602, STRASBOURG, FRANCE

Rivers are major features of the Earth surface system. They are fundamental in shaping processes of continental landscape, life and ecosystems. Therefore, hydrological stream networks are among most common datasets used in GIS for hydrology, fluvial geomorphology or freshwater ecology applications. The large success of HydroSheds as other global (*e.g.* TRIP, STN-30, Hydro1k,) or regional packages (*e.g.* CCM2, etc) shows the expectation of the scientific and expert communities for such data.

Commonly, hydrological stream networks are mostly extracted from DEM based on geomorphological (*e.g.* concavity characters, etc.) and/or hydrological approaches (*e.g*. upstream area derived from flow direction models). Nevertheless, such approaches design the potential stream network (talweg) that reflect past fluvial erosion activity or a sufficient theoretical upstream precipitation catching area. Different landscape upstream area thresholds or geometrical (i.e. fractal dimension) and geomorphological characteristics (i.e. slope/area relationship) of the hydrological stream network are used to force the potential stream network to mimic the active one. Unfortunately, such approaches are spatially and temporally climate dependent and can not be used in the context of climate change.

To overcome these limits, we propose to include a climate component in the study of the slope/area relationship. Climate component will firstly be taken into account indirectly by climate segmentation of watersheds and in a second step directly by a climatic weighting of the area component in the slope/area relationship. We will apply and assess performance over the African continent with a reference hydrologic network previously digitalized on paper sheet maps. Finally, we will use 2090 IPCC climate projections to assess the future contraction/dilatation of stream networks.

****

Assessing drainage network extractions in a low-relief area from Lidar-derived DEM and DEM-derived from other data sources: a case study from the Cuvelai Basin, Namibia

PERSENDT F., GOMEZ C.
University of Canterbury, CHRISTCHURCH, NEW ZEALAND

Accurate delineation of drainage networks is crucial for modelling hydrological, hydraulic, and floodplain processes. Low resolution gridded DEMs are however not well-suited for drainage network extraction in areas of low topographical variations, especially when gridded DEMs are of low resolution. One solution of this problem is the usage of Airborne light detection and ranging (LiDAR) that provides high resolution DTM (digital terrain model).

In the area of the Cuvelai Basin, in Namibia, sinuosity and longitudinal root-mean-square-error (LRMSE) analysis methods will be use to compare the extraction of drainage networks with the traditional grid-based delineation using TauDEM and a spectral imagery method. Moreover, this comparison has also been extended to the capacity of the different techniques to extract characteristics of the drainage networks and related parameters such as the numbers of streams, the stream orders, and the stream lengths.

The results show that the LiDAR derived DEM present notably additional detail, in particular useful to identify low order stream (headwater) segments. The study also proved that, with the significantly increased resolution of LiDAR data, smaller grid sizes yielded superior stream network delineations, based for example on LRMSE and sinuosity. The study concludes that drainage networks of low-land area with limited topographic variations should be preferentially derived from LiDAR-derived DEM and when possible combined with multi-, hyper-, and spectral imagery analysis to reach best delineation of drainage networks.

Semi-automated identification of landforms intensity by geomorphometric signature

VASCONCELOS V.(1), CARVALHO JUNIOR O.A.(1), MARTINS E.D.S.(2), COUTO JUNIOR A.F.(1), GUIMARÃES R.F.(1), GOMES R.A.T.(1)
(1) University of Brasilia, BRASILIA, BRAZIL; (2) Embrapa Cerrados, BRASILIA, BRAZIL

Landforms extraction and classification from Digital Elevation Model (DEM) are main issue in geomorphometric studies. Several geomorphometric parameters have been described in an attempt to characterize the landscape, highlighting the altimetry and its first and second-order derivative. These attributes show different levels of generalization and applicability that should be used for specific conditions in the landscape stratification. One way to represent the terrain attributes in a landform is based on the establishment of a standard curve that describes it. In this paper, it is proposed the concept of geomorphometric signature, which is described as representative spectral curves of landforms attributes derived from DEM. The method considered a specific combination of pairs of curvatures: Longitudinal/Cross-section and Minimum/Maximum. There is composed a spectrum with the following curvatures: (i) longitudinal, (ii) cross-section, (iii) minimum, (iv) maximum. Thus, each grid cell unit (ground) is described by a curve of the attributes of the ground (spectrum) which can be compared with specific curves of landforms (signatures). This approach leads to the use of pattern recognition techniques from multivariate statistical methods commonly employed in digital processing of remote sensing images. The proposed method consisted in a classification system based on sequential architecture using *Shuttle Radar Topography Mission (SRTM)*.The procedures are based on hyperspectral image processing with the following steps: (a) reduction of the spectrum size, (b) reduction of the spatial size, and (c) identification of geomorphometric signatures using n-dimensional viewer. The results evidenced different landform classes and their intensities which represent distinct homogenous units in the studying area. The SAM classification using geomorphometric signature enabled a detection of hillside variations described by its spectral inflections.

****

Do highly resolved DEMs improve the quality of rockfall model output? - A case study from Central Spain

TANARRO L.M.(1), CORONA C.(2), STOFFEL M.(2), LUCIA A.(3), BALLESTEROS J.A.(4), TRAPPMANN D.(2)
(1) Dpto. Analisis Geografico Regional Y Geografia Fisica. Complutense University of Madrid, MADRID, SPAIN ; (2) Laboratory for Dendrogeomorphology. Institut of Geological Sciences. University of Berne, BERN, SWITZERLAND ; (3) Faculty of Science and Technology. Free University of Bolzano, BOLZANO, ITALY ; (4) A.I. en Peligrosidad y Riesgos Geológicos. Instituto Geológico y Minero de España, MADRID, SPAIN

Recent studies on rockfall focused on the development and application of GIS-based 3D simulation models. In general, these models use high resolution digital elevation models (DEMs) as main input.

In this study, two DEMs obtained from Terrestrial Laser Scanning (TLS; resolution 0.2m) and stereo-photogrammetric restitution (resolution 2m) were successively used as input for the Rockyfor3D model. Simulations were conducted in a small calcareous canyon, located in the northern piedmont of the Guadarrama Mountains, close to the city of Segovia (central Spain). The release area consists of a main vertical calcareous scarp of 15-20 m height and 65º slope linked to a talus of about 70 m length with a slope ranging from 15-35º. Soil has a low roughness although it is covered by boulders of past rockfalls.

Past rockfall activity is revealed by the presence of boulders on the talus. Additionnally, a recent rockfall occurred during the night of 26-27 December 2011 and was accurately documented. The event was characterized by a mobilization of approximately 148 m^3 of rocks. The average size of the blocks, defined through their length, width and thickness, was 0.96 × 0.65 × 0.5 m. Most of the blocks were stopped at the foot of the scarp, but a large boulder (33 m^3) travelled a distance of 64 m, leaving impact craters on its way downslope. The tracks of this boulder and the deposits of past events were used to validate the simulation runs.

In the simulation, the average and large-sized boulders of the recent rockfall reveal that both the TLS-derived DEM and the terrain model obtained with stereo photographs reproduce the trajectories and the reach of boulders in a similar way. Yet, for simulations with the largest boulder sizes, the TLS-derived DEM yields more realistic results in terms of travel pathways and extreme run out zones, whereas the DEM gathered with the stereo photographs tends to overestimate runout distances.

Geomorphological assessment of alpine watersheds using SLBL and steady-state profiles

RUDAZ B., GAVILLET L., JABOYEDOFF M.
University of Lausanne - Center of Research on Terrestrial Environment, LAUSANNE, SWITZERLAND

The alpine topography is in a strongly transient state, with epigenetic gorges joining lateral valley to the main valley, and local cirques to the lateral valleys, creating strong, and thus unstable relief. Slope instabilities above torrential thalweg influence the torrent's sediment supply. Localisation of geomorphologically active areas inside a torrential watershed is thus crucial.

This method evaluates the geomorphodynamic state of a watershed using the DEM as input to determine the steady-state profile of the torrential streams, of their overlooking slopes, and of the long-term trend of such gemomorphic system, using the slope local base level method (SLBL) and the theoretical steady-state exponential longitudinal profile. This method gives respectively the steady-state profile of the streams, the total rock mass available above the actuel thalwegs, and the rock mass available over a steady-state profile. In addition, the quaternary deposits volume stored inside the valley is estimated, based on the geomorphological map, again with the SLBL method.

The method is applied to five alpine torrential streams set in different geological settings and of different watershed area and to a complete mountain ridge. The legacy of the last glaciation is shown to be still dominating over torrential and gravitational processes, with little to no steady-state landforms being observed.

****

Geomorphologic analysis method using ASTER GDEM v2 digital elevation model over the tropical rainforest: implementation to lakes problematic in Sangha National Park (Central African Republic)

LEROUGE G., ROUSSELIN T., NAVARO B.
Géo212, PARIS, FRANCE

In the Sangha National Park tropical rainforest (SW of Central African Republic), photointerpretation detected a set of circular lakes in the middle of clearings. Old regional studies, through analogy with other landscapes of the country, associate those lakes with sinkhole ponds, traces of a deep karst under continental sands. This karstification, probably developed in a Proterozoic calcareous schist suite with unknown structural organization, has never been confirmed through field work, due to the difficult access to the area. With a SPOT 5 scene (2.5 m resolution) and a 30 m resolution digital elevation model ASTER GDEM v2, we conducted a geomorphological interpretation. Rainforest that covers the whole region, intact and only cut by the Sangha River and its tributaries, is an obstacle to classical photointerpretation. SPOT interpretation can accurately extract the river system through foliage, but reliefs remain imperceptible. On the other hand, GDEM resolution highlights the canopy irregularities related to topography. Shelf breaks inherited from selective erosion of the lithology are accessible. Their morpho-structural analysis and the analysis of the river system geometry show that the lakes spatial distribution is mainly controlled by complex and asymmetrical eroded anticline lines, with overall N-S axis, related to the side of a large dome located further east. This structure is intersected by two major directions of fracturing, NW-SE and NE-SW, the second corresponding to strike-slip fault. Lakes appear arranged in the axial and uniclinal coomb valleys of fold. Anticlinal ridge and crests guide flows and communication possibilities between these different man-made lakes. Based on a DEM available worldwide, our method allows to better understand and lead reconnaissance field work of those complex and poorly accessible areas.

Remote sensing and GIS for environmental fragility assessment in the upper Coxim River Basin, Brazil

BACANI V.(1), SAKAMOTO A.(2), QUÉNOL H.(3), LUCHIARI A.(4)
(1) UNIVERSIDADE FEDERAL DE MATO GROSSO DO SUL, AQUIDAUANA, BRAZIL ; (2) UNIVERSIDADE FEDERAL DE MATO GROSSO DO SUL, TRÊS LAGOAS, BRAZIL ; (3) UNIVERSITÉ DE RENNES 2, RENNES, FRANCE ; (4) UNIVERSIDADE DE SÃO PAULO, SÃO PAULO, BRAZIL

The watershed of the Upper River Coxim (UCB) has an area of approximately 1375 km² located in the municipalities of São Gabriel do Oeste and Camapuã in the state of Mato Grosso do Sul, Brazil. It is pertinent to emphasise that the headwaters of watershed of the UCB occur on the Planalto of Mato Grosso do Sul state in the flow direction of Coxim-MS to the Pantanal plain. The aim of this work was to evaluate the environmental fragility of the UCB using fuzzy logic implemented at a Geographic Information System to propose a model of physical-territorial management through the preparation of an environmental zoning. The theoretical and methodological basis consisted of environmental integrated analyses starting from the systemic perspective of the concept ecodynamics unities. Spatial data used were arranged in a database implemented in a Geographic Information System (GIS). It consists in topographic maps at 1:100.000 scale, satellite image Resourcesat-1 LISS III (23.5 m), SRTM interferometric radar image (30m interpolated), thematic maps existing and field data. The generation of the physical-territorial management model was carried out considering preparation of UCB relief mapping, potential natural erosion, land-use and land-cover, environmental fragility and, environmental legislation. Results indicated a significant relationship between landforms and their uses: mechanized agriculture in the Chapada of the São Gabriel and livestock development on the Plateau Taquari hills. The major areas of environmental degradation were identified in the lower course associated with livestock activity mapped as the highest potential erosion and high fragility area. The guidelines set out by the type of land use proposals were: Priority areas for permanent preservation, priority area for rehabilitation and preservation and areas for sustainable use.

****

GIS-based methods to evaluate morphometric characteristics of small catchments within a debris-flow susceptibility assessment approach at a regional scale

BERTRAND M.(1), LIÉBAULT F.(1), PIÉGAY H.(2)
(1) Irstea, SAINT-MARTIN-D'HERES, FRANCE ; (2) CNRS UMR 5600 Plateforme ISIG, LYON, FRANCE

Debris-flows are recognized as one of the most damaging phenomenon in mountainous environments. Within a debris-flow susceptibility assessment approach, we propose GIS and statistical methods to identify catchments prone to trigger and propagate debris-flows. As a first step of debris-flow susceptibility assessment, we develop methods that allow the characterization of the torrents and catchments morphometry, and the extraction of control indicators of debris-flow susceptibility, i.e. the Melton ruggedness index and the channel slope. The Melton indicator is a normalized index of the gravitational energy of the catchment. Those two indicators combined within a logistic regression model give a probability of debris-flow response of the catchment.

The morphometric indicators are extracted from a spatial analysis of the 25m DEM along the hydrographic network in our study area (Southern French Alps). We proceed into three steps: (1) we identify the network we wanted to characterize (drainage area greater than 0.1km²), (2) we form geomorphic fluvial units, which are homogeneous reaches in term of slope (HSR), (3) we extract both Melton index and slope for each HSR and the probability of debris-flow response of the catchment.

As a second step, we cumulate erosion patches areas that are connected to the hydrographic network. Erosion patches are first automatically mapped with an object-oriented supervised classification of infrared orthophotos. The connectivity is addressed using a topographic indicator (convergence) whose scalar level is chosen through a proxy. It is based on the study of the relationship between connected erosion area cumulated from sources to the HSR and the geomorphic response materialized by the active channel width.

The most sensitive HSR are identified with the analysis of the DEM. GIS allows an automatic application of debris-flow susceptibility assessment through the characterization of morphometric indicators and sediment supply for each HSR.

A multi-scale GIS and hydrodynamic modelling approach to fish passage assessment: Clarence River gorge, NSW Australia

REINFELDS I.(1), BONETTI R.(2), BUTLER G.(3), BRODERICK T.(4), CHISHOLM L.(2)
(1) NSW Office of Water, WOLLONGONG, AUSTRALIA ; (2) University of Wollongong, WOLLONGONG, AUSTRALIA ; (3) Department of Primary Industries, GRAFTON, AUSTRALIA ; (4) Northern Rivers Catchment Management Authority, GRAFTON, AUSTRALIA

Natural barriers such as waterfalls, cascades and rapids limit the dispersal and in-stream range of migratory fish, yet little is known of the interplay between these gradient dependent landforms, their hydraulic characteristics and flow rates that facilitate fish passage. The resurgence in dam construction in numerous river basins world-wide provides impetus to the development of robust techniques for assessment of the effects of downstream flow regime changes on natural fish passage barriers and associated consequences as to the length of rivers available to migratory species. This paper outlines a multi-scale technique for quantifying the magnitude of natural fish passage barriers in river systems and flow rates that facilitate their passage. First, a GIS based approach quantifies channel gradients for the length-of-river from a high resolution DEM, setting the magnitude of potential passage barriers in a length-of-river context. Second, LiDAR and bathymetric survey based hydrodynamic modelling is used to assess flow rates facilitating passage across barriers identified by the length-of-river gradient analysis. This multi-scale approach to fish passage assessment is applied to the Clarence River gorge, NSW Australia, where a series of 2-8 m high waterfalls situated only 35 m above sea level form one of the most severe natural barriers to fish movement at such a low elevation for a major river system on the eastern Australian seaboard. The fish passage analysis, confirmed by independent data on actual fish migration from an acoustic fish tagging and tracking program, highlights the importance of small floods with an average recurrence interval of 1.25 years in facilitating upstream passage across this natural barrier. Flow rates facilitating passage for Australian bass are exceeded, on average, for less than 2% of days per year highlighting the sensitivity of such barriers to flow regimes changes.

****

GIS analysis of asymmetric valleys dissecting Pleistocene uplands in and around Tokyo, Japan

MORIOKA T.(1), OGUCHI T.(2), LIN Z.(3), YOSHIDA H.(4)
(1) Graduate School of Science, Univ. Tokyo, TOKYO, JAPAN ; (2) Center for Spatial Information Science, Univ. Tokyo, KASHIWA, JAPAN ; (3) Department of Earth Sciences, Zhejiang Univ., HANGZHOU, CHINA ; (4) School of Arts and Letters, Meiji Univ., TOKYO, JAPAN

Previous studies pointed out that in valleys dissecting the Musashino upland in and around Tokyo, north- or northeast-facing valley-side slopes are gentler than south- or southwest-facing slopes. This asymmetry has been attributed to different effects of freezing and thawing due to microclimatic differences and tectonic ground tilting in northern direction. However, the previous studies did not quantitatively analyze the shape of valley-side slopes. Using a high-resolution DEM and GIS, we quantitatively examined valley asymmetry for six river valleys in the Musashino upland and the nearby Omiya upland. Lines perpendicular to each valley were set at an equal interval to derive many cross sections. Analysis of section form indicates that two of the six valleys have distinct asymmetry with gentler valley-side slopes facing N or NE, confirming the result of the previous studies. Two other valleys show relatively weak asymmetry, and the rest two valleys are almost symmetric. This result disagrees with the previous studies which attributed valley asymmetry to a factor affecting a wide area in a similar manner.
Investigation of landforms around the valleys revealed that large-scale tributaries from the south or southwest tend to flow into the valley where asymmetrical cross-sections are observed. This means that abundant water and sediments supplied from one side pushed the main stream toward the opposite side to induce lateral erosion, resulting in the steepening of valley-side slopes on the northern or northeastern side of the river. By contrast, when gradients of only uppermost parts of valley-side slopes are measured, north- or northeast-facing slopes tend to be gentler in all valleys. At the uppermost slopes, running water is weak, and creep and small collapses of sediment containing volcanic ash are the main geomorphic processes. Therefore, freezing and thawing seem to account for the consistent asymmetry at the uppermost valley-side slopes.

Response of channel offsets to active strike-slip faulting of the Red River fault

LIN Z.(1), CHEN J.(2)
(1) Department of Earth Sciences, Zhejiang University , HANGZHOU, CHINA ; (2) Department of Earth Sciences, Zhejiang University, HANGZHOU, CHINA

The right-lateral Red River fault is one of the largest strike-slip faults on the southeast margin of the Tibetan Plateau. To understand the response of channels to the active strike-slip faulting during the Pliocene–present, strike-slip offsets of stream channels along the Red River fault are extracted and investigated from Quickbird images, ASTER GDEMs and field observation. Firstly, we focus on the small scale offsets of gullies. The small deflected gullies mainly distribute along the northern part of the fault and decrease to the southeast, to zero southeast of a major bend in the fault, reflecting the tendency of the strike-slip motion from the late stage of Late Pleistocene. The smallest offset we find is 5 m, and the stream offsets appear at various groups of 5–10 m, 20–30 m, 50–70 m resulted from repeated large seismic events. We further examine the channels without river capture. The relation between the progressive offset D and the upstream length L from the deflected point is analyzed, and a linear relation, $D = a L$, is identified. Based on it, the correlations among a values and strike-slip rate s sand erosion rate E of drainage are inferred, and the average-slip rates along the fault are constrained, which range from 0.8 mm/y - 6.9 mm/y. Since the largest channel offset without river capture along the fault is around 400 m, the average-slip rates are for the late Pleistocene-Holocene period. Finally, for the large rivers that river capture repeated, we reconstruct the stream nets. It reveals an largest displacement of 27 km near the middle part of the fault zone, and the displacement decreases both to the northwest and southeast along the fault. Combined with the ages of rivers in these regions, the long term average-slip rates along the fault from Pliocene are assessed. The study helps to understand the Pliocene to present activity along the Red River fault.

****

Relationship between geomorphology and dry forest in Parana Valley, Goias, Brazil, using sensor modis images and morphometric data

HERMUCHE P., GUIMARÃES R., CARVALHO JUNIOR O., GOMES R.
University of Brasilia - UnB, BRASILIA, DISTRITO FEDERAL, BRAZIL

The Paranã River basin, located in central Brazil, has one of the largest Dry Forests fragments in the country. This Cerrado vegetations type is currently rather fragmented, mainly due to selective logging and pastures expansion. Several investigations have been made in order to maintaining its endemic biodiversity and understanding forest landscape dynamics. This study aims to identify regional Dry Forests in Paranã River basin to assess the relationship with the geomorphological aspects. The Dry Forests identification was based on analysis of multitemporal images of vegetation index NDVI derived from MODIS sensor (period of 10 years), since this vegetation type has typical spectral behavior due to seasonal variations (with higher values during the rainy season and low values during the dry season). The geomorphological units map was defined based on morphometric parameters derived from digital elevation model (Hydroshed). The methodology can be divided in to the following steps: (a) multitemporal NDVI data acquisition for Dry Forests location , (b) elaboration of geomorphological map based on morphometric parameters derived from DEM, (c) validation of geomophological map by field investigation and previous map, (d) comparison between the classified image from time series of NDVI and geomorphological map generated. The results showed that the methodology used was able to determine the Dry Forests location in Paranã River basin, and also allowed to determine regional geomorphological units using MODIS sensor data and morphometric parameters. Thus, the results attest that the Dry Forests have a strong relation to Karstic relief found in the study area.

Landslide susceptibility zonation by exploiting GIS tools and two statistical methods: binary logistic regression and multivariate adaptive regression splines. A test in western Sicily (Italy)

CONOSCENTI C.(1), CIACCIO M.(2), GÓMEZ GUTIÉRREZ Á.(3), ROTIGLIANO E.(1), AGNESI V.(1)
(1) Dipartimento di Scienze della Terra e del Mare, Università degli Studi di Palermo, PALERMO, ITALY ; (2) Dipartimento di Scienze Agrarie e Forestali, Università degli Studi di Palermo, PALERMO, ITALY ; (3) Geoenvironmental Research Group, University of Extremadura, CÁCERES, SPAIN

In the recent years advanced statistical methods and GIS tools have been frequently used to assess landslide susceptibility. The latter is estimated by establishing statistical relationships between landscape characteristics and spatial distribution of past slope-failures. These are mapped mainly by recognizing changes on slope morphology produced by gravity. Despite of this, most of the researches on landslide susceptibility do not consider that slope-failures modify topography and associate high probability of landsliding with topographic characteristics that differ from those that led slope-failures.

In this research we analyzed landslide susceptibility in the basin of the Malvello river with two statistical methods: binary logistic regression and multivariate adaptive regression splines. The study area, which extends for 51 km^2 in western Sicily (Italy), is characterized by large outcroppings of clays and marls and is severely affected by shallow landslides. Bedrock lithology and land use were included as predictive variables, in addition to a set of primary and secondary topographic attributes. The latter were derived from a digital elevation model where altitude of areas hosting landslides was interpolated from adjacent undisturbed portions of the slopes. We assume that these artificial surfaces represent the old topography more efficiently respect to the morphology of depletion and accumulation zones of landslides. Ten random samples, with the same number of positive and negative cases, were used to train and test the susceptibility models. Accuracy, as well as overfitting and robustness of the models, were evaluated by drawing receiver operating characteristic (ROC) curves and calculating the area under the ROC curve. In addition of comparing the performance of the statistical methods, the validation results allowed us to highlight advantages/drawbacks of reconstructing original topography of slope-failures when mapping landslide susceptibility.

****

Evolution of volcanic landforms by construction and destruction events constrained from DEM-based numerical reconstructions

LAHITTE P.(1), LAVIGNE F.(2), GERMA CHARBONNIER A.(3)
(1) Univ. Paris-Sud, Laboratoire IDES, ORSAY, FRANCE ; (2) Univ. Paris 1 Sorbonne, Campus Bellevue, MEUDON, FRANCE ; (3) Univ. Of South Florida, Department of Geology, TAMPA, FLORIDA, UNITED STATES

Quaternary volcanic landforms result from a complex evolution, involving volcanic constructional events and destructive ones by collapses and long-term erosion. Applied here to Rinjani (Indonesia) and Conil-Pelée (Martinique Island) volcanic complexes, our GIS-based geomorphologic approach quantifies erupted or dismantled volumes by numerically modeling the successive volcanic topographies resulting from each main evolution stages. We extract from the current DEM points these the altitude of which are analyzed as still representative to the resultant remnant surfaces. A primary elevation surface is firstly adjusted to these points by modeling a first-order pseudo-radial surface defined by: i) a generatrix curve fitting the average concave-upwards volcano profile; ii) the location and elevation of volcano summit around which the generatrix is rotated to form the surface; iii) eccentricity and azimuth parameters that allow to stretch and contract the generatrix as it rotates around the summit to obtain an elliptically-shaped surface in planar section. Residuals between the input point's elevations and those obtained by the first-order modeled surface are interpolated by kriging. The resulting residual surface is next summed to the first-order surface to obtain the definitive primary surface elevation of the considered event adjusted to its second order variations due to local heterogeneity. Independently, evolution of previous modeled landforms by either erosion or flank or caldera collapse is computed. Each modeled surface is then compared to the evolved previous ones to define the actual geometry of the volcano after the newly modeled event and to generate a new unit map. Finally volumes, provided with measures of uncertainty, of each constructive or destructive event are computed by integration of the height differences between the pre- and post- event elevation surfaces. Such method allowed us to define up to 10 paleo-landforms on the favorable studied volcanoes.

Poster presentations:

Use of aerial photograph interpretation and Geographic Information Systems to study tidal channel changes: an example from the Venice Lagoon (Italy)

RIZZETTO F.
Istituto di Scienze Marine - Consiglio Nazionale delle Ricerche, VENICE, ITALY

The geomorphological transformations of modern tidal channels were examined to identify the effects of sea-level fluctuations (i.e. relative sea-level rise and tides) on wetlands (Rizzetto and Tosi, 2011; 2012). The study was carried out in a salt marsh area not particularly modified by human interventions and located in the northern Venice Lagoon (Italy). The two-dimensional planform changes in channel morphology were analyzed through the interpretation of a chronological sequence of ultra-high resolution aerial photographs and satellite images, spanning the past 73 years, using Geographic Information Systems. Only high quality photographs were examined to reduce errors deriving from their rectification during the georeferencing process and to guarantee both the exact geographic position of the channels and the accurate identification of their morphological modifications. The tidal networks were manually digitized and the obtained maps, each showing the planimetric features in a different year, were overlaid and compared to identify exactly the channel planform changes. These modifications were quantified and compared to the yearly data of both sea-level rise and tides to highlight the control of water-level oscillations on channel evolution. In particular, the effects of long- and short-term sea-level variations were distinguished. These results were made possible by the availability of a high number of images, which gave a real detailed evidence of tidal network development, not based on theoretical models.

References

Rizzetto F., Tosi L., 2011. Aptitude of modern salt marshes to counteract relative sea-level rise, Venice Lagoon (Italy). Geology 39 (8), 755-758. doi: 10.1130/G31736.1.

Rizzetto F., Tosi L., 2012. Rapid response of tidal channel networks to sea-level variations (Venice Lagoon, Italy). Glob. Planet. Change, 92-93, 191-197, doi: 10.1016/j.gloplacha.2012.05.022.

****

River flux modeling

PARROT J.(1), RAMIREZ NUñEZ C.(2)
(1) LAGE, Instituto de Geografia, UNAM, MEXICO D.F., MEXICO ; (2) Posgrado en Ciencias de la Tierra, UNAM, Mèxico, MÉXICO, MEXICO

The present resolution of digital data allows doing detailed observations of the Earth surface, in such a way that river networks do not strictly correspond to a thin line drawing the thalweg, but to the real river surface the slope of which as to be researched. Then, by using Digital Elevation Models, the river slope must be integrated as an essential element of the land, especially for following flooding events. In many digital data, the limit of the water bodies is supported by a unique code. For this reason, it was necessary to develop the method presented here. Before obtaining the final DEM interpolation, the “soul” of the river bed surface is researched and obtained using a skeletonization such as the k × k thinning treatment. The different altitude points of the river soul are obtained when this soul crosses the contour lines. Then it is possible to (a) define river segments, (b) calculate the length of the segments (number of pixels in a first approximation), (c) measure the slope rate of each segment, and finally (d) calculate the altitude step attributing the altitude value to each pixel and describing the river soul. Hexagonal dilation using two different structural elements of the mathematical morphology treatments is applied to each pixel component until reaching the river banks in order to define the altitude value of the river surface. The resulting values are reported to the curve line image before the final interpolation. The document obtained (32 bits raster DEM)represents an important contribution to the study of flooding areas, because it is possible tofollow the general water movement as the slope can be considered as an analogical representation of the current.

The logarithmic slope as a critical geomorphological parameter.

PARROT J.(1), HERNÁNDEZ M.(1), RAMIREZ NUñEZ C.(2)
(1) LAGE, Instituto de Geografia, UNAM, MEXICO D.F., MEXICO ; (2) Posgrado en Ciencias de la Tierra, UNAM, México, MÉXICO, D.F., MEXICO

Generally,angular values of the slope do not reflect the morphology of the areas that are relatively flat or that are characterized by a low slope. Morphological features are more obvious only when the angular value of the slope increases. This is the reason why we tried to enhance the morphological features of the more or less flat zones in order to obtain information about their roughness. In fact this roughness enhancement is peculiarly needed when studying, for example, flooding events or oil spills. The proposed method consists on calculating the logarithm of decimal slope values incremented by the value 1 as it is not possible to obtain the logarithm of zero. Then the logarithmic scale is normalized between 0 and 255 (8 bits) and the correspondences between gray tones thus obtained and the decimal slope values are reported in a table. This method has been applied recently to the study in the Coatzacoalcos region (State of Veracruz, Mexico) where accidental petroleum spills are frequent due to pipeline ruptures as well as regular flooding events.

****

GIS analysis as a tool for identification of preglacial large-scale landform assemblages and quantification of glacial erosional impact on northern shields

EBERT K.
Stockholm university, STOCKHOLM, SWEDEN

The use of quantitative assessment methods in large-scale bedrock geomorphology remains scarce. Yet analysis and integration of DEMs with other digital data in GISs now allows us to rapidly analyze landform assemblages and patterns across huge areas.

I analyze areas within the glaciated Fennoscandian shield to investigate preglacial landform patterns as well as to assess the effects of glacial erosion on the preglacial shield surface. Analyses of all data available from land surveys and geological surveys in Fennoscandia are the input parameters in the database. In the DEMs of 50m and 25m resolution, hypsography, relative relief and slope angles show preglacial landform patterns like stepped erosion surfaces and inselberg clusters that are not visible on first sight and that are difficult to detect and show only by field work or other forms of remote sensing. Integration of these patterns with rock type and structure helps us to assess the influence of geology on the surface morphology. Slope angles and bedrock types are statistically coupled to drill core databases with bedrock depth information. This 3D terrain analysis enables a picture of surficial glacial streamlining and the removal of the preglacial weathering mantles, and thereby assessment and comparison of different degrees of glacial modification of the shield bedrock surface.

In combination with field validation, DEMs and GIS analyses have brought us much further in identifying patterns of glacial erosion as well as quantifying glacial erosion depth on the shield surface. We find clear defined areas with negligible erosion in proximity to areas with clear glacial streamlining. However, even in areas of strongest glacial erosion, the preglacial large-scale bedrock landscape prevails. Comparison of these areas infers that maximal glacial erosion of shield bedrock was in the 0-50 m range, with extensive areas showing <10 m of erosion.

Effect of clear-cutting on landslide occurrences: Rainfall thresholds and topographic analysis at Mt. Ichifusa, Japan

SAITO H.(1), MURAKAMI W.(2), DAIMARU H.(2), OGUCHI T.(1)
(1) Center for Spatial Information Science, The University of Tokyo, KASHIWA, JAPAN ; (2) Forestry and Forest Products Research Institute, TSUKUBA, JAPAN

Vegetation cover is an important factor influencing the occurrence of rainfall-induced landslides. We analyzed the effect of clear-cutting on initiation of landslides in terms of empirical rainfall thresholds at Mt. Ichifusa, Japan, which is characterized by granite rocks. Rainfall-induced landslides had occurred frequently in the northern part of Mt. Ichifusa since clear-cutting began around 1967. We interpreted orthorectified aerial photographs using GIS, and mapped clear-cutting areas and landslides in 1969, 1976, 1980, 1985, 1990, 1995, 1999, and 2005. We then analyzed all rainfall events in the warm season during 1952–2011 using raingauge data obtained around Mt. Ichifusa. This study used basic rainfall parameters, such as the mean rainfall intensity (mm/h), the peak rainfall intensity (mm/h), the duration (h), the cumulative event rainfall (mm), and the soil water index (SWI). Finally, we examined empirical rainfall thresholds for landslide occurrences in each period of aerial photographs, and the relation between landslide occurrences and topographic characteristics from DEMs.

Results showthat landslides seldom occurred at the beginning of clear-cutting, but frequently occurred after clear-cutting, such as during 1976–1980, 1980–1985, and 1990–1995. In these periods, many landslides occurred at concave-steep slopes in the clear-cutting area, although few landslides occurred in the non-clear-cutting area. The rainfall analysis indicatedthat rainfall thresholds after clear-cutting declined to the one-third of those at the beginning of clear-cutting and in the non-clear-cutting area. This result is important for future forest management and landslide hazard assessments,and should be verified in other clear-cutting areas in Japan and other countries.

****

Cluster analysis in watersheds using morphometric parameters in the state of Goiás, Brazil

GOMES R., MENKE A., GUIMARÃES R., CARVALHO JÚNIOR O.
Universidade de Brasilia, BRASILIA, BRAZIL

Basin is the fundamental unit in environmental studies, which are related to land form and its changing process. Watershed is used in environmental studies, mainly in morphometric studies, based on geographic information systems. The geomorphometry is defined as a science of quantitative analysis of the surface. In geomorphometry, the Digital Elevation Models (DEMs) are the main source of information. In this work, we use the model HydroSHEDS. From this model, it was possible to derive maps as slope, curvature, aspect, contribution area and flow direction. This work aims to obtain a classification of basins, from cluster analysis method, using morphometric attributes of drainage basins in the state of Goiás, Brazil. The methodology can be divided into the following steps: (1) HydroSHEDS SRTM processing, (2) automated basin delineation, (3) calculation of morphometric attributes, (4) Classification of drainage basins from K-means method. The K-means method allow to obtain groups with similar morphometric characteristics based on Euclidean distance. The maps show good results for basins classification. The classes have high correlation with the morphometric attributes and allowed to define units based on these attributes. The method can be extended to other morphometric studies, either regional or local. We obtained a geomorphometric units map with four classes: class 1; class 2; class 3; and class 4.

GIS application in morphometric-statistical analysis of relief in the upper Dniester River catchment (East Carpathian Foreland, Ukraine)

HOŁUB B.
Maria Curie-Sklodowska University in Lublin, Department of Geoecology and Palaeogeography, LUBLIN, POLAND

Region of the East Carpathian Foreland (Carpathian Foredeep zone) in its north-western part is crossed by the European watershed between the basins of northern and southern seas. In this section it is the watershed between the San River (Baltic Sea) and Dniester River (Black Sea). The studies of relief evolution in this area indicate the common functioning of both rivers in the older part of Pleistocene when the San River was a tributary of the Dniester River, and again, temporarily, during the Central-European maximum extent of the San (= Elsterian, Oka) ice sheet, which reached the Carpathians margin and covered the valley of the upper Dniester River.

Within the Carpathian Foreland the area of the Dniester River catchment is composed of three partial catchments: Bolozivka, Stryvigor, and upper Dniester. In order to obtain a quantitative description of these catchments, there was used the classification of rivers according to Strahler, which was also the basic layer in all spatial analyses and the key to their interpretation. The selected physiographic indices of the partial catchments were supplemented with the morphometric-statistical parameters, which were calculated and presented graphically (among other things as base-level maps, maps of isolongs, goniobases) in detail and in various combinations of mutual connections using the GIS methods. Based on these data, many conclusions about relief of the upper Dniester basin were drawn, as well as about neotectonic activity of the area under study.

****

Coastal Quakes: using global datasets to expose an underrated hazard

HART D.E., GOMEZ C., BEALING P.
University of Canterbury - Geography, CHRISTCHURCH, NEW ZEALAND

Since the late twentieth century, coastal populations have been growing at twice the global average. In this context, there exists an opportunity to mitigate future development-disaster cycles by understanding how coastal regions interact with a range of natural hazards. For example, in 2007, Woodroffe identified cities built on Holocene progradational plains as susceptible to non-linear threshold responses to accelerated sea level rise. Recent advances in earth system monitoring and measurement mean that we now have key global datasets to aid in such analyses. This paper describes novel research into coastal city vulnerability to earthquake disasters. Analysis of global DEMs along with seismic, geomorphic, population and infrastructure data shows that coastal cities are disproportionately susceptible to earthquake effects and earthquake-induced hazards.

On the surface, proximity to sea level means that even minor levels of uplift or subsidence across coastal plains can dramatically alter shoreline features and states while the vertical faces of relict marine cliffs are vulnerable to collapse. And where development occupies narrow coastal plains or complex shores, lifelines vulnerabilities are exacerbated by a lack of inbuilt network redundancy. More deeply, patterns of land damage including liquefaction, lateral spreading, slumping, and subsidence result from seismic interactions with coastal and fluvial deposits and elevated water tables. Evidence from a number of recent and historical coastal earthquakes is used, along with global dataset analyses, to forecast likely patterns of earthquake effects along coastal margins worldwide. These include initial responses to seismic events as well as the cascade of ‘other’ adjustments that can amplify pre-existing coastal hazards not traditionally linked to seismic events.

Landform prediction and environmental constraints ' examples and geomorphological implications

ETZELMULLER B.(1), HJORT J.(2), LILLEOREN K.S.(1)
(1) University of Oslo, OSLO, NORWAY ; (2) University of Oulu, OULU, FINLAND

The combination of digital elevation models, digital terrain analysis and geomorphological maps or landform inventories allows for statistical prediction of distribution for landforms. In these analyses different types of predictor variables (topography, climate, geology) were used to evaluate the probability of certain landform existence within an environmental setting. Transferability of different types of statistical models between different regions in northern Europe has been tested earlier, along with scale problems and the relative importance of input variables. Overall, these models perform very well within certain limitations, resulting in AUC-values above 0.8. The exploration of response curves now allows for the evaluation of environmental constraints of particular landforms, leading to a better understanding of land-forming processes and ultimately landscape development. In our study we have evaluated the distribution of gravitational landforms in the periglacial realm, mainly solifluction and rock glaciers in southern and northern Norway, Svalbard and Iceland. The presentation discusses distributional pattern**s**, which clearly are relatable to geomorphological processes and climatic development during the Holocene.

****

The ecological-geomorphological assessment of urban areas using GIS (a case study Yerevan)

ASMARYAN S.
Center for Ecological-Noosphere Studies NAS RA, YEREVAN, ARMENIA

Yerevan is the capital and social, economical center of Armenia. The most part of the industrial life with the population is concentrated here. So it increases the environmental load. The city of Yerevan grows spatially and the future spatial development requires data about the stability of the surface, which supposes special investigations. The main goal of this study was to assess the real state of the urban surface and to reveal the suitable and stable places for Yerevan future development. The tasks to achieve the goal were the analyzing the qualitative and quantitative characteristics of the relief of Yerevan city, analyzing and revealing the man made forms urban relief, revealing the characteristics of the distribution of man-made deposits, assessment of urban relief stability of Yerevan city. In this study the ArcGIS software were used. The Weighted overlay process in Model Builder has been used to do the analysis. To combine input themes with different kinds of data, we assigned the values in the input themes to values on a common evaluation scale. We weighted the themes of relief morphogenetical types exogenous relief forming processes, man made relief forms and deposits, seismic characteristics, hypsometry, slope inclination, slope exposition, depth and density of erosion dissection as to their influence. We have chosen three-point scale. Running the model we get the map of the relief stability of Yerevan city. As a result of the comparison of remote sensing data and the topographical maps of early data the principals of land-use the dynamic of the growth, the transformation of the territory of Yerevan city are found out. The geomorphological and environmental data base is formed, which we plan to update with the geochemical and geophysical data in order to perform the geomorphological and geochemical risk assessment.

Mass-Conservative Depression Removal from DEMs

VAN DE WIEL M.(1), TEMME A.(2)
(1) University of Western Ontario, LONDON, ONTARIO, CANADA ; (2) Wageningen University and Research Centre, WAGENINGEN, NETHERLANDS

Many DEMs contain depressions, *i.e.* enclosed areas of lower elevation than the surrounding area. Regardless of whether these are real features of the landscape or whether they are spurious features arising from measurement error, they are usually considered undesirable elements in a DEM for many hydrological or geomorphological applications, because they hinder continuous surface flows. Consequently, many algorithms have been developed for eliminating DEM depressions, either by filling the low-lying area or by removing terrain that is obstructing the natural flow path. These techniques have the drawback of either artificially creating new elevation or artificially eliminating elevation from the DEM, *i.e.* the algorithms are not mass-conserving. Some combined algorithms have been developed that try to minimize these volume differences, but currently no algorithm achieves full mass-conservation.

This paper presents a new algorithm of removing depressions. The algorithm is, by design, fully mass-conservative and essentially relies on a redistribution of the DEM elevations in the depressed area and its downstream outflow zone. The algorithm is intuitive and straightforward to implement. For the current research it has been coded as a stand-alone program, but it can easily be implemented in existing terrain analysis software or GIS packages. Tests on a range of DEMs (artificial, LiDAR, SRTM, Aster GDEM2) show that the algorithm works well and does exactly what it is intended to do: remove pits and depressions from a DEM, whilst maintaining the total mass of the terrain. The corrected DEMs also avoid the spurious parallel drainage that often occurs with other depression removal algorithms. Computationally, however, the mass-conserving algorithm is slower than some of the existing non-mass-conserving routines.

****

DTM models of coastal dune relief and dynamics as a tool for coast erosion and flooding prediction

LABUZ T., OSOCH P.
University of Szczecin, Faculty of Geosciences, SZCZECIN, POLAND

Research on the influence of the sea on the coastal zone is an important element of the forecast of coastline changes and flooding threats. FoMoBi (www.fomobi.pl) project pays attention to the dune relief changes that occur on accumulative part of Polish coast. These changes are mainly periodic or continuous coastal erosion: reducing beaches and dune undercutting land structures.

Research are carried out using modern surveying equipment based on satellite location of surveyed sites. Application of GPS RTK technology allows high accuracy to obtain morphometric data forms found in marine coastal zone. Surface measurements for DTM creation is a key to understand potential threats for weak coastal structures. It also can be used for measurement of material volume changes due storm surge affection or designate potential areas that may be flooded. On the Polish Baltic coast each year storm surges are flooging area up to 3.5 m amsl. Runnels or previously developed storm gates, foot paths and other concave forms in coastal dune belt is a potential threat.

Dynamic effects of catchment morphology in the Alcabrichel estuary, Portuguese Estremadura

ALEIXO C., RAMOS-PEREIRA A., TRINDADE J.
Centre of Geographical Studies, Institute of Geography and Spatial Planning, Univ. Lisbon, LISBON, PORTUGAL

This research has been accomplished under the project PCDT/CTE-GIX/104035/2008. Its objective is to identify the sediment supply of the alluvial plain estuary of River Alcabrichel, and mainly to explain the dominance of finer grain size sediments in the floodplain of Maceira despite the abundance of coarse sediments in the drainage basin.

The geomorphology of the basin is conditioned be the presence of consolidated and unconsolidated Mesozoic sedimentary materials, with different lithological competence that prints sharp differences into the relief, with presence of compact limestone gorges that confer a selective and differential action to agents of erosion and modellers landscape.

The sediments of a borehole in the floodplain of Maceira were studiedfor textural analysis.To access the apparent paradox mentioned above,several indices has been use, including sediment transport index (STI), stream power index (SPI) and wetness index (WI), and the results discusses with those obtained with the core sediment samples.

The effect of topography on erosion (STI) is more pronounced in limestone, but the chemical weathering formed clay minerals. SPI shows similar results to STI. WI indicates that the areas of highest sediment supply stay upstream the first limestone gorge.

The hydrological modelling (with Ilwis software) through these indices indicates that the coarser sediments are deposited upstream the geomorphological barriers and only the finest grain size of sediments reach the downstream floodplain of Maceira. The importance of the morphology will be pointed out.

Acknowledgements: This research was funded by research project, PCDT/CTE-GIX/104035/2008–FMI 5000-Environmental changes: Fluvio-marine interactions over the last 5000yrs, from Portuguese Science and Technology Foundation (FCT-MCTES). Aleixo acknowledgesthe FCT scholarshipof FMI 5000 Project.

****

Graph theory: the Ford and Fuklerson, and the Edmonds-Karp Algorithms to Model Dynamic Sedimentary Systems

GOMEZ C.(1), WASSMER P.(2), STARHEIM C.(1), HADMOKO D.S.(3), LAVIGNE F.(4)
(1) University of Canterbury, CHRISTCHURCH, NEW ZEALAND ; (2) Laboratoire de Geographie Physique, UMR8591, MEUDON, FRANCE ; (3) Universitas Gadjah Mada, Department of Geography, YOGYAKARTA, INDONESIA ; (4) Universite Paris 1 Pantheon-Sorbonne, LGP UMR8591, PARIS, FRANCE

Graph theory is the study of graphs, which are mathematical structures used to model pairwise relations between interconnected objects in a system. In Geo-sciences, it has been mostly applied to transportation modeling, as it offers a precise and effective evaluation of flows organized in systems. It also enables researchers to evaluate the effects of different network modifications on overall system flows and assess subsequent reorganization of the network.

Despite the potential advantages in other fields of research, graph-theory has been largely ignored in environmental science and geomorphology.

The present contribution therefore resolves to test two graph-theory algorithms (the Ford and Fuklerson algorithm and the Edmonds-Karp algorithm) and how they can be successfully used with GIS (Geographical Information System) to assess change in an environmental network.

Early results have demonstrated that graph-theory may prove to be a valuable geomorphological tool in at least four applications including: (1) detecting the tipping points in a system; (2) identifying regions particularly vulnerable to changes in sediment supply, erosion rates, and formational processes, (3) identifying the maximum tolerance of a network before the flow modifies it (e.g. diversion) and; (4) finding preferential pathways depending on system energy. These algorithms and findings have been incorporated into GIS using the Matrix representation of networks. The successes, limitations and future directions of incorporating graph-theory into a GIS using Matlab and ArcGIS are discussed.

Morphometric models of lake's bottom as necessary tool for limnological investigations

NAUMENKO M.
Institute of Limnology of Russian Academy of Scienses, ST.-PETERSBURG, RUSSIAN FEDERATION

Detailed digital maps of lake bottom are used for many purposes included comprehensive resources management plans, environmental impact assessments, limnological and geomorphological investigation.

The creation of digital bathymetric models of lakes allows not only collecting the data on depths and coasting line in a standard format, but also to estimation major morphometric characteristics of the reservoirs.

To calculate the water, thermal and chemical budgets of large lakes, it is important to know the distribution of their surface areas and volumes with depth. The built bathymetric models of largest European lakes - Ladoga and Onega have allowed updating the morphometric characteristicsand can be used for ecological modeling of their lakes. Theirs models have used during a two decades for thermal and hydrophysical investigations. We calculated two dimensional spatial autocorrelation functions for determination of relationship temperature and depth distribution/

In the presentations we discuss a variety of lake bottom digital models of the world and their usage for limnological investigations.

****

Morphometric analysis of alluvial fans and source basins for regions with different climates

OCHIAI S.(1), OGUCHI T.(2), HAYAKAWA Y.S.(2)
(1) Graduate School of Science, Univ. Tokyo, TOKYO, JAPAN ; (2) Center for Spatial Information Science, Univ. Tokyo, KASHIWA, JAPAN

Previous studies examined telationships between morphometric properties of alluvial fans and source basins. Although the increased availability of global DEMs allows us to explore details of the relationships in various regions of the world, such studies are still limited. Therefore, this paper discusses the effect of source basin characteristics on fan morphology in several areas of the world with different climatic conditions: Japan, the American Southwest, the southern Philippines, southwestern Turkey and the eastern coastal area of the Gulf of Alaska. Three geomorphological components are examined: the whole of a source basin as the area of sediment supply; the trunk stream of a source basin as the course of sediment transport; and an alluvial fan as the area of deposition. GIS is used to analyze DEMs and digital geological maps. Data of fan area, mean fan slope, basin area, mean basin slope, mainstream length, mean mainstream slope, and dominant geology in the source basin are obtained, and their characteristics and mutual relationships are analyzed.

In each study area, the fan area and fan slope depend on the basin area, and the fan slope depends on the basin slope. These reflect not only the amount of sediment supply but also differences in sediment production processes and the ratio of sediment to water runoff. In addition, with increasing regional precipitation, the fan area increases and the fan slope decreases for the same basin area. More precipitation leads to broader and more diffused sediment deposition. The mean fan slope tends to be smaller than the mean mainstream slope if basin area is larger than a certain value, and the value differs among the study areas. The value decreases with increasing precipitation, which may also reflect the effect of sediment dispersal. In contrast, dominant geology of source basins plays only a minor role in determining fan morphology, indicating the dominance of topographic and climatic controls.

Multiscale Wavelet Analysis of ASTER DEM to detect geomorphologic and tectonic processes in the Gaxun Nur Basin, China

HAEDKE H.
Freie Universitaet Berlin, BERLIN, GERMANY

This study is focusing on the tectonic impact on the morphology of one of the world's greatest inland deltas, the Gaxun Nur Basin in Inner Mongolia, China. The main objective is, to extract geomophological features from ASTER-DEM, which are linked to tectonic impacts or the interfingering of geomorphological processes on the basin margin. With Wavelet Transform (WT), the DEM of the basin can be split into several layers, according to the size, shape and orientation of the inherent surface structures. The DEM can be regarded as a 2D signal and structures can be considered as signal events. By using a respectively defined wavelet function which is dilated, translated and hence compared to the signal (the DEM), the resulting coefficient matrix works as a blueprint of the filtered structures. Choosing an eligible wavelet function and using the coefficient matrix holds the potential to not only detect, but enhance the signal of unseen surface structures. Each wavelet function responses to a distinct surface structure shape. Diverse structures on different scales, pointing to ongoing tectonic events or geomorphological processes, could be defined:

In the East and South basin margins two perpendicular lineaments, which are underlying the great Badain Jaran dunefield, could be detected. The North and West basin margins show a change of fluvial and lacustrine features (ancient beach bars, fluvial channel) which sustain the marks of successively proceeding tectonic events. In the central basin old river channels could be distinguished, which show perpendicular changes in the stream course and indicate tectonic impacts.

WT is sparsely used in geomorphology, nevertheless it can be presented here as a promising approach to find evidence of tectonic processes in sediment surfaces, which are not obvious to the naked eye. Further, we point out, that wavelet analysis of surface features provide intelligence about the chronology of sedimentary and tectonic processes.

****

Visibility and optimal routes from the Roman Camp Site of Via Carisa, Cantabrian Mountains (Asturias, NW Spain)

DOMINGUEZ-CUESTA M.J., JIMENEZ-SANCHEZ M., RODRIGUEZ-RODRIGUEZ L.
University of Oviedo, OVIEDO, SPAIN

A multidisciplinary research (funded by PC10-14 Project, FICYT-Rioglass S. A.) was carried out in the Roman Camp Site of Via Carisa, in the axis of the Cantabrian Mountain Range (NW Spain). This site has a great historical relevance, since it is interpreted as a military camp (*castra aestiva*), built under the legate of Publio Carisio (26-22 a BC). This research highlights the strategic position of the site of the Roman Camp, located near the Via Carisa, a historical path between the Cantabrian Coast and the interior of the Iberian Peninsula. Both, visibility and accessibility to the surroundings from the Roman Camp have been analysed with Geographical Information Systems (ArcGIS 9.3). A Digital Elevation Model (5 m pixel) has been used to extract the viewshed from the Pico Boya (1728 m asl), the highest elevation of the environment. A total area of about 450 km^2 could be seen from the camp, even coming to see Cabo Peñas, in the Cantabrian Coast, 60 km away to the North. This resulting visual basin has been superimposed to different influence areas of radius 1, 5 and more than 10 km from the Camp, respectively. Thus allows to take into account the immediate environment of the site and calculate the visibility around short, half and long distance. Moreover, accessibility analysis and costs displacement between the Roman Camp and different areas of availability resources (fluvial courses, outcrops of conglomerates providing rolling stones used as projectiles, etc.) have been calculated. The results of the work enhance the potential of the site as a strategic position of domain under the times of Roman occupation in the Mountains of NW Iberian Peninsula.

Digital mapping of geomorphological features in a tropical semiarid climate of Ceará State, Brazil

SOUZA VALLADARES G.(1), AQUINO R.P.(2), CUNHA COELHO M.F.(1)
(1) Universidade Federal do Piaui, TERESINA, BRAZIL ; (2) Universidade estadual do Piaui, TERESINA, BRAZIL

The geomorphology interpretation improves integrated view of the physical aspects of a particular area of interest. The geomorphological map of watersheds has fundamental importance in classifying the vulnerability of land. This study aimed to identify the different geomorphological features of the lands in the Banabuiú River basin, located in the central part of Ceará State, Brazil. The study area corresponds to 1500km^2. Using the altitude and slope gradient derived from SRTM digital elevation model, was possible to separate seven geomorphological features using GIS and Boolean logic. The altitude of the study area varies from 173 to 852 m above sea level, comprises generally the domain of dissected pediplain, and dries sierras. The geology comprehends metamorphic rocks of Precambrian and climate is tropical semi-arid. The altitude was subdivided into eight classes: <200m, 200-300m, 300-400m, 400-500m, 500-600m, 600-700m, 700-800m and> 800m. The slope gradient was divided in 0-3%, 3-8%, 8-13%, 13-20%, 20-45% and> 45%. The river valley of Banabuiú occupies the lowlands, identified by alluvial terraces, and lower portions of the slopes. The dissected pediplains correspond to lands with elevations up to 300m and a maximum gradient of 13%, characterized by hills. With altitudes varying from 300 to 400m and gradients between 3 and 13%, were separated slopes and hills in the transition between sierras and pediplains. Areas with elevations ranging from 200 to 500m with high gradients above 13%, were identified very dissected slopes in the sierras and residual inselbergs. The valleys in the interior of sierras correspond to altitudes between 400 and 600 m and a maximum gradient of 13%, characterized by hills and lowlands. Lands with elevations above 500 m with elevated gradient or higher than 600 m were considered dissected slopes of sierras or isolated interfluves.

****

Unexpected geomorphic features of a sandstone tableland revealed by LiDAR-derived DEM

MIGON P., KASPRZAK M.
Department of Geography and Regional Development, University of Wroclaw, WROCLAW, POLAND

We studied geomorphology of the multi-storey Cretaceous sandstone tableland of the Stołowe Mountains (SW Poland) using DEM derived from airborne laser scanning. The area has a long history of research but coarseness of topographic maps, insufficient resolution of previously available DEMs, and dense forest cover were severe constraints in geomorphic mapping and analysis.

A new LiDAR-derived DEM at the resolution of 0.6 x 0.6 m reveals a wide range of previously undetected landforms and helps to recognize their actual spatial patterns. In particular it shows, in detail unparalleled before, the morphology of sandstone-capped escarpments and their foot zones.

In the presentation we show a few selected examples, illustrating features of different origin. [1] The mesa of Mt Szczeliniec Wielki is shown to be deformed by large-scale sagging at its eastern end. Vertical drop is c. 20 m and the subsided area is a chaos of huge sandstone blocks. Sagging induced bulging in the mid-slope which in turn caused rotational slides extending to the foot zone. [2] Tongue- and fan-like concentrations of big sandstone boulders in the foot zone of the mesa suggests catastrophic releases of large rock masses rather than steady supply from caprock through fall. [3] Extensive lower slope sections of the northern marginal escarpment, cut across weak Permian sedimentary rocks, show wavy surface topography indicative of the existence of shallow slides and earth flows. Thus, the occurrence of large sandstone boulders far away from caprock is reinterpreted in terms of passive transport on landslide bodies. [4] Hoodoo rocks in the NE part of the plateau are not randomly distributed but are subordinate to the grid-like pattern of troughs surrounding bedrock elevations. Regular distribution indicates strong joint control.

Our study confirms the great potential of high resolution DEMs in geomorphology, able to reveal unexpected features even in areas considered to be well known and understood.

Generation of morphometric semantics for automated mapping of geomorphological process domains

PRASICEK G.(1), KRAUS A.(2), OTTO J.C.(2), SCHROTT L.(2)
(1) University of Salzburg, Department of Geoinformatics, SALZBURG, AUSTRIA ; (2) University of Salzburg, Department of Geography and Geology, SALZBURG, AUSTRIA

Geomorphometry is the quantitative analysis of terrain characteristics based on digital terrain models (DTMs) and its derivatives land surface parameters (LSPs). The transition from general to specific geomorphometry and the extraction of discrete entities from a continuous digital image has been a main research field for decades. Recently, object based image analysis (OBIA) has been used to decompose DTMs into homogenous units which offer a multitude of features for classification. This technique has been applied to delineate landform elements and landforms but, as opposed to investigations in the pixel-based realm, little attention has been paid to geomorphological process domains.

This investigation seeks to identify morphometric characteristics of geomorphological process domains based on DTMs and its derivatives to allow for automated delineation and classification of these units. The following research questions are addressed: How can morphometric characteristics of process domains be extracted from digital terrain data, and which LSPs or combinations of LSPs are most suitable to describe these characteristics. The methodology is based on the general relation between the shape of the land surface and drainage area. The study site, an alpine catchment revealing strong imprint of former glaciation, is located in the Austrian Alps. Process domains have been manually mapped as polygons based on field and aerial image mapping supported by DTM-analysis. From the DTM, drainage area and basic LSPs like elevation, slope and curvature are calculated and extracted for each mapped polygon. The derived data are visually analyzed by plotting LSP values against drainage area. The observed characteristics are reduced to indices and serve as main semantic input for automated extraction of process domains. Results indicate that the chosen LSPs provide a suitable basis. However, for some processes the input of thematic data would considerably enhance the outcome.

****

A new method for estimating ocean reference depth

WLOSINSKA M., NIEDZIELSKI T., MIGON P.
University of Wroclaw, WROCLAW, POLAND

We present a new method for computing the present-day value of the reference ocean depth (*dr*). Variations in *dr* have implications for inferences on sea level changes in geological time scale, and our main objective is to verify the existing estimates of *dr* in the light of the most recent bathymetric data.

The Global Bathymetric Chart of the Oceans (GEBCO) dataset provides a global framework for the computation. The GEBCO consists of a sea floor topography raster, revealing global coverage with spatial resolution of 30 arc-seconds.

Oceanic lithosphere cools and subsides as it moves away from the ridge crest. Subsidence decreases asymptotically towards the ultimate oceanic lithosphere thickness *a*, where the ocean depth is *dr*. In the plate model of Parsons the *dr* value is equal to 6400 metres. Another approach (GDH1 model) relates ocean depths to the ridge axis (5651 m).

The analysis of individual cases in the vicinity of the subduction zones shows a number of situations where the depth of oceanic crust stabilises at a certain level (equilibrium point) before reaching the subduction zone at a depth which is much lower than 6400 meters. Therefore, in order to properly analyse the sea level variations, it seems important to verify the reference depth value using new methods that integrate powerful tools provided by the Geographic Information System (GIS) and statistical inference. We have developed a Python geoprocessing script that automatically generates numerous cross sections of the submarine terrain, along the lines that are perpendicular to the subduction zones. Such an approach produces *B* samples that show how sea floor topography varies in the vicinity of the subduction zone. Subsequently, we have applied our iterative procedure to quantitatively and statistically evaluate the asymptotic behaviour of *dr* and to re-visit its previous estimates. The methods has been tested for lithosphere of various ages.

Supervised testing of segmentation for automated delimitation of landforms in DEMs

EISANK C.(1), SMITH M.(2), HILLIER J.(3)
(1) Department of Geoinformatics - Z_GIS, University of Salzburg, SALZBURG, AUSTRIA ; (2) School of Geography, Geology and Environment, Kingston University, LONDON, UNITED KINGDOM ; (3) Department of Geography, Loughborough University, LOUGHBOROUGH, UNITED KINGDOM

Object-based image analysis (OBIA) offers a range of techniques promoting that the process of manual landform delineation on DEMs can be automated. Among those techniques, multiresolution segmentation (MRS), a region-growing algorithm, has recently been used to segment DEMs into homogeneous terrain patches. Usually, those patches have to be aggregated to model actual landforms. A more efficient way is to omit the aggregation step by optimizing MRS so that terrain patches approximate the size and shape of the targeted landforms. To achieve this, we proposed a supervised testing scheme for calibrating the algorithm for automated delimitation of landforms. Calibration of MRS mainly concerns the definition of optimal algorithmic settings and of optimal land-surface parameters (LSP) on which MRS is performed. The scheme was implemented in OBIA software and therefore is operational. It comprises three steps: firstly, iterative segmentation of the input LSP is performed with various settings to produce differently sized homogeneous terrain patches. Secondly, the spatial overlap between reference landforms and individual terrain patches is evaluated. Terrain patches that overlap reference landforms by 50% or more are automatically extracted. Once the set of best fitting terrain patches is identified, in the third step global measures of spatial accuracies are calculated to quantify how well the segmented landforms spatially match the reference landforms. Different settings and LSPs were tested, specifically for the delimitation of drumlins in synthetic DEMs. Highest accuracies pointed to the optimal MRS solutions.

****

Multi-agent modeling as a tool of spatial analysis for monitoring sediment fluxes

REULIER R., CAILLAULT S., DELAHAYE D., VIEL V.
Universit? de Caen Basse-Normandie, CAEN, FRANCE

Hydro-sedimentary transfers on agricultural watershed, acting from plots to streams, affect all levels of the hydrosystem (e.g., soils degradation, floods, pollution…). A good understanding of the role of the anthropogenic networks (e.g., hedges, roads, ditches) is essential to improve the knowledge of these hydro-sedimentary transfers. To this end, we developed a flow processes simulation including anthropogenic networks. This simulation is developed on a multi-agent programming language (NetLogo). As a complement to the GIS, the use of a tool of modeling on the basis of multi-agent allows to identification of the role of each linear network (local interaction) on the global response of watershed. The simulation is tested and applied to a 15 km² catchment area (Lingevres, Calvados, France) represented by patches referred to as pixels (10*10m). Flow pathways are defined from the digital model elevation (DEM) in function of the slope unless there is presence of linear. If present, linear networks modify the flow directions. Many spatial analysis indices could be bringing thereby: area impacted, input points in the network, location of effective networks, and impact on the distance to the outlet…This simulation was completed and confronted to the reality by anexpert approach with a rigorous field monitoring during different rainfalls events. These complementary approaches allowed testing the assumptions provided by the model and check the good reproducibility of the processes observed on the basin.

Measuring coral reef terrain roughness from a very-high resolution Digital Elevation Model (DEM) derived from Structure from Motion (SfM) Point Clouds

JAVIER L.(1), PHINN S.(2)
(1) The University of Queensland , ST. LUCIA, AUSTRALIA ; (2) The University of Queensland, ST. LUCIA, AUSTRALIA

Coral reef hydrodynamics operate at several and overlapping spatio/temporal scales. Waves have the most important forcing function on reefs as they drive most ecological and biogeochemical processes by exerting direct physical stress, indirectly mixing water (temperature and nutrients) and transporting sediments, nutrients and plankton. The effectiveness of reefs to dissipate wave energy is related to the extreme hydraulic roughness of the coral reef benthic composition which provides an important ecosystem service protecting highly valued shorelines. Hydraulic roughness is usually obtained empirically from frictional dissipation calculations, as measurements of bottom roughness is a very labour and time-consuming task, particularly on reef environments. However, considerable improvements on modelling wave transformation over heterogeneous reefs have been observed when incorporating spatially-explicit bottom friction coefficients representing the variability of the reef structure. Traditional methods to measure bottom roughness (e.g. chain-method or profile gauges) are labour intensive and fixed in resolution and spatial scale. This study aims to investigate the hydraulic roughness across a reef flat derived from a very high resolution digital elevation model (DEM). The DEM is derived from overlapping photos using feature matching and Structure from Motion (SfM) photogrammetric techniques to create three dimensional point clouds that are subsequently interpolated into a continuous grid (cm-scale). Terrain roughness is estimated across different benthic substrate types and implications on wave modelling results discussed.

****

Cluster Analysis of Watersheds as a Guideline for the Study and Sampling of Regoliths

LAVARINI C., MAGALHÃES JR A.P., OLIVEIRA F.S.
Universidade Federal de Minas Gerais, BELO HORIZONTE, BRAZIL

Knowing a priori the variables, or factors, which influence the genesis of regoliths and their spatial distribution it is possible to deduce relevant information via statistical and geoprocessing analysis for the next research steps in a fieldwork. In doing so, this paper aims to demonstrate the possibility of watersheds clustering from the factors of soil formation as well as its subsequent relevance in an exploratory fieldwork. For these purpose, we extracted in *ArcGIS 10* some morphometric variables such as (i) relief, (ii) horizontal curvature, (iii) vertical curvature, (iv) slope and (v) hypsometric integral from the headwaters of Upper-Middle Course of Ribeirão Mata-Porcos in Quadrilátero Ferrífero, Minas Gerais state, Brazil. These variables were joined by clustering techniques broadly known as Hierarchical and Non-Hierarchical Cluster Analysis. The results showed that the Hierarchical Cluster was mainly significant for the possibility of exploratory analyzes of groups, elements and variables. According to the dendrogram, we observed eight groups which best fitted the dataset nevertheless these groups were reduced based on numerous non-hierarchical analysis tests to just seven statistically consistent groups. In the field, we found morphological evidences and/or pedostratigraphical records reflecting the regional complexity. Furthermore, since the results of the cluster analysis described above are naturally grouped data, with less intentionality and human subjectivity, they tend to represent the existing complexity much more reliably than the simple analysis of cartographic products.

Determining the optimal pixel size of topographical parameters for the prediction of hazardous geomorphological phenomenons of different magnitude: gullies and landslides

GOMEZ-GUTIERREZ A.(1), CONOSCENTI C.(2), ANGILERI S.E.(2), CARRASCO R.M.(3)
(1) Universidad de Extremadura, CACERES, SPAIN ; (2) Università degli studi di Palermo, PALERMO, ITALY ; (3) Universidad de Castilla la Mancha, TOLEDO, SPAIN

Nowadays, powerful tools are available to produce high-resolution DEMs and DTMs such as LIDAR, TLS or ground-photogrammetry. On the other hand, DTMs are one of the most common inputs of predictive models in geomorphology. However, pixel size effect is still a source of uncertainty. In this work, we explore the role of pixel size in the accuracy of statistical predictive models generated in order to obtain susceptibility maps for two very different geomorphological phenomenon; gullies and landslides. Two study areas were selected to represent every process; 1) Mula Basin in Murcia (Spain) and San Giorgio Basin in Sicily (Italy) for gullies and 2) Trabiata in Sicily (Italy) and Jerte Valley in Extremadura (Spain) for landslides. Only topographical variables with resolutions ranging from 2 to 50 m were used as input in order to isolate the effect of pixel size. The relationship between the optimal pixel size and landform magnitude was also analyzed using datasets with a variety of landform sizes. The obtained models were able to reproduce the spatial distribution of gullies and landslides in the study areas only using the DEMs and derived topographical attributes with values for the Area Under the ROC Curve ranging from 0.67 to 0.90. Even, the accuracy of the models could be improved including variables related to lithology, land use, vegetation cover, climate, infrastructures, etc. A clear relationship between pixel size, landform magnitude and model performance was observed. In fact, the smallest pixel size did not produce the best results in all the cases. The importance of the different attributes was estimated for every study area-process, finding important differences. Finally, the complexity of the resulting models was not related with landform magnitude. The results obtained here could be used in the future to guide through the optimal selection of the pixel size for modeling purposes.

****

DSGSDs diagnostic landforms: a morphometric LiDAR based approach

NINFO A., ZANONER T., GRUBER N., MASSIRONI M., CARTON A.
Department of Geosciences University of Padua, PADOVA, ITALY

Deep Seated Gravitational Slope Deformations affect many Alpine slopes, but depending on the local environment, geological setting and stage of their evolution, they can be more or less seriously degraded up to the complete dismantle of the bulging at the lower part of the slope.This research aims to a more objective identification of DSGSDs focusing on the morphostructures (i.e. double ridges, scarps, counterscarps, trenches), considered by many authors the most “diagnostic” DSGSDs landforms. We propose a methodology based on the visual interpretation and statistics analysis of morphometric indices (i.e. slope, curvatures, openness, ruggedness, WI, etc.) derived from a LiDAR-DEM with a multi-scalar approach. Counterscarps results the most abundant on all the studied DSGSDs. These forms are generally mapped like linear features, butfrom a DEM based perspective an areal definition is needed and in this work was conducted through a value threshold on profile curvature and slope. About 300 counterscarps were mapped and statistically analyzed, resulting long 30 – 700 m and wide 10 to 150 m, with an average direction perpendicular to the maximum slope; despite the appreciable dimensions their morphological relevance is low (<1-2 m). Counterscarps morphometry results scale independent and characterized by well define changes in curvature (-+) and mean values (>|0.4|), with an half concave part that changes to convex through an intermediate low gradient area (< 10°) the only DSGSDs “flat“ zones. A detailed field survey was conducted to validate the derived indices and the interpretation. The statistical analysis allowed us to identify a common “morphometric signature” of the counterscarps. In addition different typologies of DSGSDs seem to be more discernable on the basis of counterscarp spatial-frequency distribution than on other shape factors; width is the only one showing some correlation with the local structural setting.

Study of the reference levels of erosional surfaces in the western Cantabrian Mountains and Montes de León (northwest Spain) through Digital Elevation Models

MINGUEZ-MENENDEZ A.(1), GARCIA-MELENDEZ E.(2), MARTIN-SERRANO A.(3), SUAREZ-RODRIGUEZ A.(1), RODRIGUEZ-GARCIA A.(2), RODRIGUEZ-FERNANDEZ R.(3)
(1) Instituto Geologico y Minero de España, LEON, SPAIN ; (2) Universidad de León, LEON, SPAIN ; (3) Instituto Geologico y Minero de España, MADRID, SPAIN

The main objective of this research is to identify the remnants of old erosional surfaces developed over the Variscan basement bordering the tectonic Cenozoic depression of El Bierzo, in the Northwest of Spain. For this identification, a methodological approach using topographical profiles extracted from a Digital Elevation Model (DEM) was used. The study area was divided into 10 mountain areas belonging to different mountain ranges (sierras) in order to extract the topographical profiles of the main summit levels and interfluves. A total number of 213 profiles along more than 1600 Km were obtained for the analysis. The comparison of the adjacent profiles in each of the 10 sierras allowed the reconstruction of old surfaces through the global polynomial interpolation Trend of height values. Afterwards, the trend of these old theoretical surfaces was analyzed, calculating the slope and aspect of each of them, highlighting the relationships between adjacent surfaces. As a result, 21 surfaces were mapped and grouped into 8 categories ranging in height between 1000 and 2100 m. These categories probably belong to a lower number of original surfaces that have been dislocated into several fragments by the Cenozoic tectonic activity and highly dissected by fluvial processes.

Acknowledgements: work supported by the Spanish projects: “Junta de Castilla y León” LE311A12-2 and Consolider Ingenio 2006 CSD-2006, TopoIberia Geociencias en Iberia.

****

New Algorithm to Extract Longitudinal Stream Profiles (LSPs) based on unfilled DEMs

BYUN J., SEONG Y.B.
Dept. of Geography Education, Korea University, SEOUL, SOUTH KOREA

Stream Profile Analysis (SPA) has played a major role in understanding the interaction between tectonics and surface processes. With widely accessible DEMs and tools for automatically extracting LSPs from them, SPA can be performed easily and it has led to increasing research into inaccessible areas. However LSPs based on DEMs have a serious problem due to the pretreatment of DEM to remove depressions. Nowadays many DEMs are made from the dense cloud point measurements of elevation, so DEMs with depressions could represent real topography. In that case, pretreatment of DEM could distort topography and it could lower the accuracy of analysis.

In this research, we invented a new algorithm to extract LSPs based on unmodified DEMs and tested its potential. This algorithm comprises the following procedures. First, it identifies not only all depressions in a DEM, but also their outlets through which water from around a depression overspills if water exceeds the volume of the depression. Second, it modifies flow direction of some cells within each depression for the water in that depression to reach to its outlet. Third, if a depression comprises more than one sub depression (composite depression), it finds the lowest ridge cell between the already modified sub depression and an adjacent sub depression, and then modifies flow direction of some cells within the adjacent depression connected to the lowest ridge cell again. This procedure continues until all sub depressions are visited. Fourth, it records stream path inversely beginning from the main outlet of the DEM to every channel head. Therefore, when it meets an outlet of a composite depression, it goes down until meeting the sink of a sub depression and moves up to a lowest ridge, then goes down until meeting the sink of an adjacent sub depression and then goes up again. The results show that LSPs based on this algorithm can trace the relatively deepest part along valley bottoms and they improve the accuracy of SPA.

Morphometric and morphotectonic indexes for quantitative geomorphology analysis of the Cannobino drainage basin (Piemonte, NW Italy)

GHIRALDI L.(1), BACENETTI M.(2), MILLEMACI P.(3), PEROTTI L.(2), GIARDINO M.(2)
(1) Natural Sciences Museum of Torino, TORINO, ITALY ; (2) University of Torino - Earth Sciences Department, TORINO, ITALY ; (3) Freelance, CANNOBIO, ITALY

Preliminary studies have been conducted in the mountain area of Northern Piemonte (NW Italy) for characterization of the Cannobino drainage basin through morphometrics and morphotectonics indexes. From the geological point of view the valley belongs to the Southern Alps and his Hercynian basement is divided in two units: Ivrea-Verbano Zone (IVZ) and Serie dei Laghi (SDL). These units are separated by two discontinuities: the Cossato-Mergozzo-Brissago and Pogallo lines. The IVZ outcrops in the northern sector of the basin; main rocks types are: migmatized metapelitic schists (Kinzigite), amphibolites and mafic stratified complex (granulite, metagabbros and peridotite). SDL outcrops In the southern and central sector. It is divided in two complex: Scisti dei Laghi (metasedimentary schists, orthogneisses) and Strona-Ceneri (paragneiss, schists).

A DEM (5x5 meters, Piemonte Region) of the Cannobino drainage basin has been imported into the GIS environment in order to evaluate the basin and river network's geomorphometry. The workflow included several steps: a) lineament features digitalisation and interpretation; b) drainage network extraction and hierarchization; c) azimuthal distribution of drainage pattern; d) evaluation of linear and areal indexes: drainage density, bifurcation ratio, stream frequency, texture ratio, hierarchicalanomaly index, elongation ratio, hypsometry integral and curves, transverse topographic symmetry factor, amplitude of relief, normalized stream length index. The valuesofthese parametershave been interpolatedby meansofgeostatisticalalgorithms for the creation of different thematic maps. Furthermore, majors morphometric parameters have been identified: the significance of their geomorphic role have been evaluated by means of principal component analysis (PCA), and the statistical relationships with different type of rocks has been investigated.

****

Geomorphological units and the risk of erosion in the central hinterland of Ceara, Brazil

AQUINO R.P.(1), VALLADARES G.S.(2), COELHO CUNHA M.F.(2)
(1) UNIVERSIDADE ESTADUAL DO PIAUÍ, TERESINA, BRAZIL ; (2) UNIVERSIDADE FEDERAL DO PIAUÍ, TERESINA, BRAZIL

The establishment of environmental units from geomorphological approach constitutes an important instrument for planning and sustainable use of natural resources, in view of its importance for understanding the dynamics of how the environments work. This way, we performed a geomorphological subdivision of part of the river basin Banabuiú, located in the backlands of Central Ceará, Brazil, located in the field of cratonic areas and semi-arid tropical climate. The demarcation of the geomorphological compartments based on the demarcation on the image morphometry derived from SRTM, formed by a composition containing false color altimetry, slope, and curvature of field, taking into account the tone and greater or lesser closeness of the curves for level, which were overlaid on raster morphometry. We identified seven units of relief. Generally the higher altitudes (above 300 m) and the levels of dissection of the relief are in interfluves structural crests in residual and structural slope dissected by looking up the domain of slope greater than 8%, characterizing undulated tightly curled. In the valley of Banabuiú and on the pediplano dissected it were identified the lower altitudes (below 300m) and the smaller slope (below 13%). Overlaying relief units maps and slope, allowed the establishment of different classes of erosion risk, and areas with slopes of up to 3% were considered very low risk, the 3-8% low risk, those of 8 to 13% of moderately high risk; those of 13 to 20% high risk, those of 20 to 45% of very high risk, and large areas with a slope exceeding 45% very high risk of erosion. It is observed throughout the study area, deforestation and land degradation, which are further impacted when used in agriculture, especially in hilly areas.

Fragility environmental analysis of River Basin Caulim - Sao Paulo/SP/Brazil

DA SILVA SOUSA A., SOUSA A.
University of Sao Paulo, SAO PAULO, BRAZIL

From the present study we sought to develop an empirical analysis of environmental fragilities shown in the basin of the River Caulim, using for that the concept proposed by Tricart Ecodinâmicas Units (1977) and developed by Ross (1990, 1994). The study is based on the partitioning of relief until the 5th level taxon (Ross, 1992) and finally to its association with land use in the area, allowing to establish a framework of potential environmental weaknesses.

****

Application of a geographical information system to debris flows

CARDOSO-LANDA G.
Instituto Tecnologico de Chilpancingo, CHILPANCINGO, MEXICO

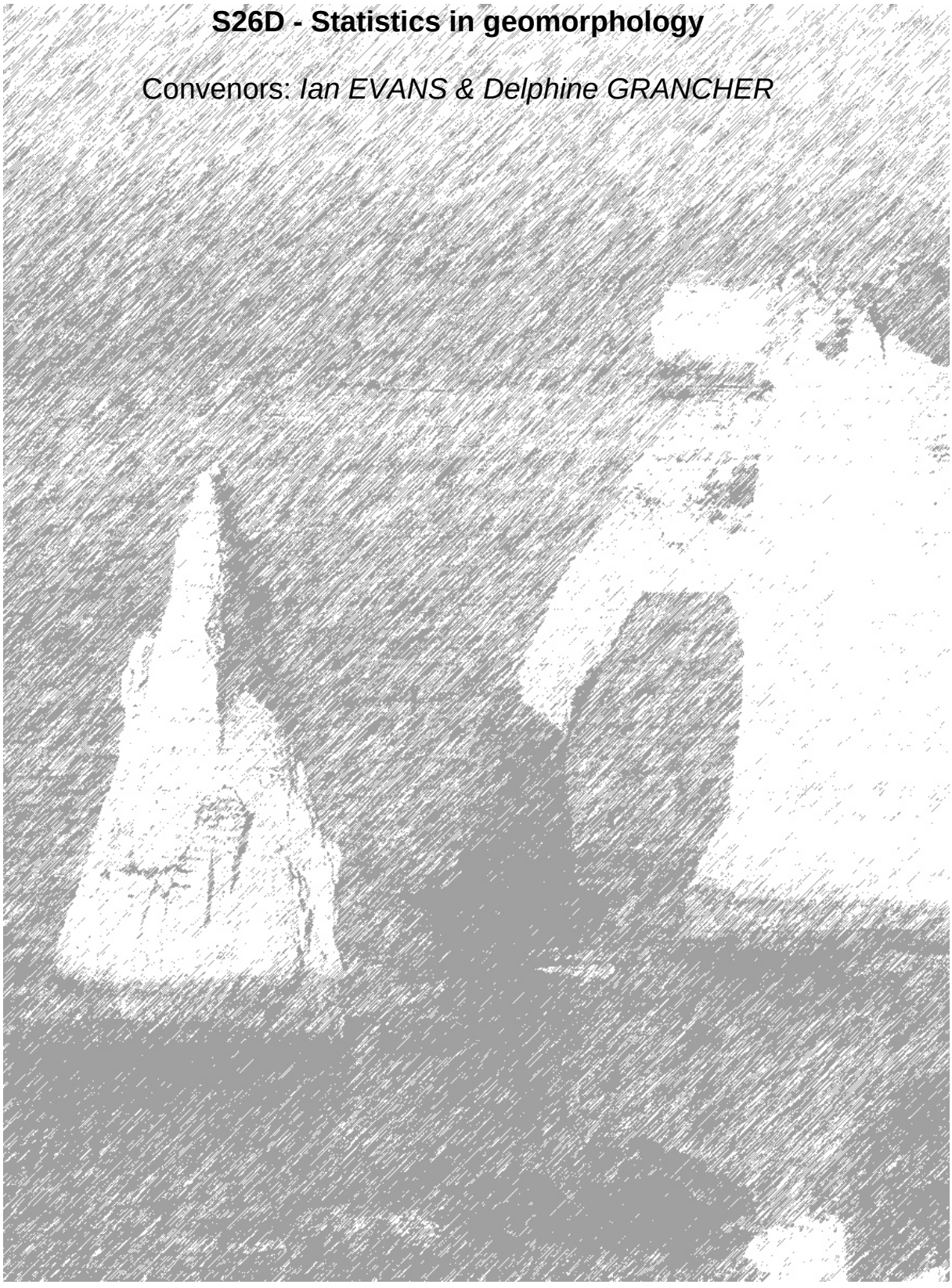
The last days of September and October of 1999 appeared extraordinary rains on the mountains of the north and the northeast of the state of Puebla and in the neighboring states of Veracruz and Hidalgo in the country of Mexico, generated by the tropical depressions 11 to 14, which, combined to other factors of genesis, triggered around 3000 mass processes in the zone, fundamentally debris flows, and falls, and slides, and combination of the previous ones. These events produced deterioration of the infrastructure of the zone, losses of human lives and disappear, mainly in the populations of Chachahuantla, Teziutlán and Totomoxtla, affecting 96 municipalities, 16511 houses in different degree, 199 schools, 59 federal public buildings, 50 buildings of the cultural patrimony, 8 health centers, in addition to 256 dead people and 55 missing ones. October 5 of 1999 very intense precipitations appeared on the city of Teziutlán, Puebla, generating around 30 debris flows and superficial ground slides of different magnitude and type, which produced 150 dead people.

It was developed a geographic information system of the study area and using Takahashi scheme were obtained the types of debris flows, and the angles of fault, and the average speeds of debris flows applying Takahashi equations. Finally were compared these results with the natural angles of the slope in the zone of Teziutlán México, showing the results in the full paper.

****

S26D - Statistics in geomorphology

Convenors: *Ian EVANS & Delphine GRANCHER*



Oral presentations:

Susceptibility analysis of landslide in the Bacia Do Marumbi (Morretes/PR) using bivariate and multivariate statistical methods

UBER J.A.(1), ZÊZERE J.L.(1), SANTOS L.J.C.(2)
(1) Universidade de Lisboa, LISBOA, PORTUGAL ; (2) Universidade Federal do Paraná, CURITIBA, BRAZIL

This work aims to apply bivariate and multivariate statistical methods (the information value method and the logistic regression, respectively) to perform the landslide susceptibility assessment in the Bacia do Marumbi (Morretes/PR). The study area is a catchment with 102 km² located in the Serra do Mar, where landslides are very important processes within present geomorphic evolution. For the confection of the landslide susceptibility maps, the following procedures were made: (i) multi-temporal inventorying of landslides of slide type using aerial photo interpretation and field work validation; (ii) division of the landslide inventory in two subsets using a temporal criterion modeling group (landslides older than 2006, 39 cases), validation group (landslides occurred after 2006, 37 cases); (iii) identification and classification of landslide predisposing factors (elevation, slope, plan curvature, wetness index (inverse), lithology, soil type and land use); (iv) weighting of landslide predisposing variables; (v) integration of variable weights and production of landslide susceptibility map; (vi) evaluation of the predictive model performance (success rate and prediction rate; calculation of the Area Under Curve - AUC).

The predisposing factors that have the higher influence on the occurrence of landslides are elevation, slope and soil type. The smallest contribution was presented by the slope plan curvature.

According to the criterion of Guzzetti et al. (2005), the obtained results are considered very satisfactory, once the AUC of the success rate curve is 0.84, and the AUC of the prediction rate curve is 0.81 in both methods. However, although the rates are equal, the information value method shows a higher efficiency if we considered the 20% of the area classified as more susceptible by both methods. For this area, the predictive capacity is of 77.75% for the model built with the Information Value method and only 60% for the Logistic Regression model.

****

Automated geomorphological classification for the creation of rigorous shaded relief maps

VERONESI F., HURNI L.
ETH Zurich, ZUERICH, SWITZERLAND

Advances in remote sensing have increased the availability of high resolution digital elevation models. These data can be extremely useful for environmental studies, but they need processing in order to provide geomorphological insights. This can be done with two approaches: shaded relief maps and numerical identification of landforms.

In the first case, the landscape is classified by the cartographer, who is able to generalize different landforms and accentuate them in shaded relief maps. These are highly informative but also exposed to a certain degree of subjectivity. On the other hand, numerical landforms classification is mostly concerned with the identification of landforms elements, thus decreasing the informative power of the final output.

In this research we are trying to find a better way to classify major landforms, in order to provide a better framework for shaded relief mapping. For doing so we used Random Forest, trained on a set of interactively selected points, to classify a test area for rock outcrops, screes, alluvial fans and plains.

Random Forest is trained using DEM derivatives and imagery, and used for classifying the area of interest. The algorithm not only produces a classification value, but can also give a probability value, which can be used to show uncertainties.

With this approach the user select the training points were he is certain to find a particular landform, the boundary between landforms are set by the classification algorithm, thus creating a more objective result, keeping the user interaction to a minimum. On the other hand, the uncertainty map may shows areas where the prediction accuracy is low. The user can then easily go back to step one in order to optimize the training set and increase the overall accuracy.

Another advantage is that the map can be updated as soon as new data are available. This way even in highly dynamic environments the thematic map can be easily, automatically and almost effortlessly kept updated.

Interpreting wavelet-based decompositions of geomorphological features: the example of the Rhone river bathymetry

VAUDOR L., PARROT E.
CNRS (UMR 5600 Environnement Ville Societe), LYON, FRANCE

Wavelet-based decomposition of signals is increasingly used in geosciences as a tool for describing time series or spatial series at multiple scales. Still, although it seems to be the obvious method to provide a multi-scale study of the river continuum's features, its use in hydrogeomorphology is rare. The main reason to this it that this method is both difficult to understand from a mathematical perspective, and purely descriptive, making the interpretation of the decomposition difficult to non-specialists.

In this study, we provided guidelines as to how to interpret wavelet-based decompositions, both in a descriptive and inferential way. In particular, we associated wavelet-based decomposition with statistical methods such as segmentation (on individual scales) and clustering (on several scales). First, we quantified its power to detect scale-specific changes according to various parameters (rate of change, series length, changes at close scales, etc.). Then, we tested its ability to classify river sections into groups according to their features on multiple scales.

Besides, we provided one practical example of wavelet-based decomposition of a signal: that of the bathymetry of the Rhone river (Southern France). We use this example, in particular, to illustrate the intricate nature of this kind of geomorphological signal in terms of scales interlocking and show to which extent wavelet-based decomposition might help analyze it.

****

Accounting for uncertainty in fluvial geomorphology using Bayesian statistics

SCHMELTER M.
Freeport-McMoRan Copper & Gold, MESA, UNITED STATES

The movement of eroded sediments from mountain highlands to the oceans is a complex process that involves several components of variability and uncertainty at a number of scales. Over the last 100 years advances have been made in the field of fluvial sediment transport including the development of numerous sediment transport models and theories. Despite these advances, however, uncertainty in predictions, models, and model parameters is a fundamental challenge for applied fluvial geomorphologists. In recent years, Bayesian statistics have been increasingly used in numerous disciplines including, among others, environmental and climate science as a framework for accounting for and estimating uncertainty in model predictions and parameters. These methods, however, have not yet received wide attention in the field of fluvial sediment transport.

Recent work by the author demonstrates the applicability of Bayesian methods in fluvial sediment transport—specifically, bed load transport in rivers. Bayesian statistical models marry deterministic sediment transport relationships with probability distributions making it possible to generally specify how sediment transport behaves while accounting for the reality that model parameters, such as critical shear, and model predictions are probability distributions and not fixed values. These can be applied to subsequent analyses such as sediment budgets and help inform river management strategies and quantify risk. Several models are illustrated ranging from simple uni-size excess shear equations to contemporary multi-fraction sediment transport equations. The model results use synthetic, laboratory flume, and field data collected on a gravel bed river to test the models. The results show that the Bayesian approach to sediment transport has many advantages over purely deterministic approaches and has practical implications for the practice of the art.

Hierarchical Bayesian modelling for hydrological spatiotemporal mountain climate proxies

ECKERT N.(1), LAVIGNE A.(2), PAVLOVA I.(3), THIBERT E.(1), BEL L.(2), GRANCHER D.(3), PARENT E.(2), JOMELLI V.(3), NAVEAU P.(4), BOREUX J.J.(5)

(1) Irstea, GRENOBLE, FRANCE ; (2) AgroParisTech, PARIS, FRANCE ; (3) LGP, MEUDON, FRANCE ; (4) LSCE, SACCLAY, FRANCE ; (5) Université de Liège, LIÈGE, BELGIUM

High altitude mountain zones have been shown to be very sensitive to climate change. Climate proxies, i.e. indirect climate indicators such as tree rings, are useful to supplement direct measurements for reconstructing past climate. Among them, hydrological proxies such as glacier mass balance are particularly interesting since their changes result from a mixed temperature and precipitation signal. Furthermore, studying their past temporal fluctuations is help to anticipate the future evolution of related natural hazards (glacier outbursts, major avalanches, etc.).

Recently, Hierarchical Bayesian modelling has seen growing interest for processing gridded climate data. This framework is also particularly well suited for inferring a climatic signal from a set of partially correlated hydrological climate proxy series. The non-linear nature of their response to climate covariates can be acknowledged at the latent variable level. Furthermore, significant spatio-temporal patterns such as change points can be separated from “random” annual fluctuations, with the different sources of uncertainty treated rigorously.

The objective of this talk is to illustrate these statements using three complementary examples. The first is an analysis of seasonal glacier mass balance point measurements at Sarennes. The second is an analysis of debris flow activity in the Northern French Alps taking into account geomorphological and climatological covariates in a multivariate hierarchical logistic regression model. The third is an analysis of avalanche counts all over the French Alps where non-separable spatio-temporal effects are inferred in a hierarchical probit regression model. We will discuss the main common points and differences of these case-studies, including the covariates and model structure used, and point out the major statistical and applied challenges remaining.

****

Poster presentations:

Landslide morphometric signature

ROSSI M.(1), MONDINI A.C.(1), MARCHESINI I.(2), SANTANGELO M.(1), BUCCI F.(2), GUZZETTI F.(2)

(1) Istituto per la Protezione Idrogeologica, Consiglio Nazionale delle Ricerche - Dip. Scienze della Terra, Università degli Studi di Perugia, PERUGIA, ITALY ; (2) Istituto di Ricerca per la Protezione Idrogeologica, Consiglio Nazionale delle Ricerche, PERUGIA, ITALY

Morphometric parameters are widely used in landslides mapping and modeling. Morphological information is used by geomorphologists to map landslides in the field or during aerial photo-interpretation and using remote sensing techniques. Landslide models can explicitly consider this information (e.g. slope in physically-based infinite slope modeling), or assess its importance through a statistical inference (e.g. morphometric variables used in statistical multivariate landslide susceptibility models). Investigators have attempted to quantify morphological changes produced by landslides locally or in small areas, but at present no common criteria, or set of variables or analysis tools exist to compare globally these changes. Here we present a framework to analyze the morphological fingerprints of landslides in a territory. We also define a method to group them in categories based on different triggers and environmental settings. For this purpose we identify a set of morphometric variables and a procedure to distinguish different morphological landslide signatures. Further we provide a web processing service to allow external user to apply the proposed procedure in specific areas. Our intent is to create a library of the landslide morphological signatures as much as possible complete. Results will be helpful to improve: (a) the ability to detect landslide on the surface, (b) the modeling capabilities, and (c) the knowledge of landslide processes.

Statistical approach to analyze evolutions of statistical long-term hydrological data sets on the loire river (France)

RAMOND S.(1), GRANCHER D.(2), GAUTIER E.(1)
(1) University of Paris 8 Vincennes - Saint-Denis, CNRS, UMR 8591, Laboratory of Physical Geography, MEUDON, FRANCE ; (2) CNRS, UMR 8591, Laboratory of Physical Geography, MEUDON, FRANCE

The fluvial bed of the Loire River, the longest French river, tends to stabilize, and this is often explained by the disappearance of large floods since the mid-19th century. A lot of studies focus on fluvial landform adjustments of the Loire River without interest for other possible hydrological causes. The aim of this study is identification and characterization of hydrological evolutions in the middle part of the Loire River to better understand its geomorphologic behavior and to help river management.

The hydrology of the Loire River was altered by human society and river management. The construction of large dams, climate change and evolutions in land-use induce past and future hydrological changes at catchment scale.

This study is based on daily streamflow data provided by the DREAL Centre, and monthly meteorological data from Météo France. Fourteen streamflow-gauging stations and thirty weather stations, distributed across the upstream and middle sections of the river catchment, were selected. Data sets essentially begin in the mid-20th century, however a few temperature, precipitation and streamflow data sets start in the mid-19th century. In addition, three data sets of restored natural streamflow enable us to study in detail large dams influence on the Loire River hydrology.

After testing these data sets for anomaly, we extracted therefrom a total of 35 relevant indices, such as the monthly median streamflow, the minimum streamflow during ten consecutive days or the length of high water periods. We then applied statistical tools, such as continuity tests, to these indices, in order to either detect potential disruptions, or to show that the pattern of the data series does not suffer any discontinuity.

We could identify several changes : summer floods disappeared after the 1920's, and low water was completely transformed by the low water support policy.

****

The discontinuous spatial distribution of Alpine Permafrost: an application of exploratory spatial data analysis

DELUIGI N.(1), LAMBIEL C.(1), KANEVSKI M.(2)
(1) University of Lausanne - Institut de géographie et durabilité (IGD), LAUSANNE, SWITZERLAND ; (2) University of Lausanne - Centre de recherche en environnement terrestre (CRET), LAUSANNE, SWITZERLAND

A deep knowledge of the permafrost distribution at different scales, including the scale of the micro-topography, has both fundamental and applied importance. Up to now, none of the existing robust models have been able to simulate the high spatial discontinuity of mountain permafrost, especially in blocky loose sediments where the ground thermal regime may be strongly affected by air advection processes. An intelligent spatial data analysis and modeling by using a Machine Learning (ML) approach meets the requirements in order to integrate this complexity into spatial models. The key feature of the ML models is that they learn from data and can be used in cases where the modeled phenomenon is complex, not very well described or subject to multidimensionality, namely dependent on multiple factors which can vary if the distribution itself is characterized by a multi-scale component.

In this poster, preliminary results on *exploratory data analysis* (EDA) and *exploratory spatial data analysis* (ESDA) are presented. These techniques reveal underlying structures in data, detect the presence of anomalies, determine relationships among explanatory features and allow to preliminary select the appropriate modeling approaches and the related optimal calibration. They open the way to the *adaptation of the most efficient ML classification algorithms for environmental data modeling*. Field investigations of mountain permafrost in the Swiss Alps provide detailed empirical knowledge of the distribution and characteristics of permafrost in sedimentary terrains. Without any a priori user assumption concerning the relationship between permafrost and its explaining variables, ML algorithms are able *to detect spatial patterns in data and to understand their spatial proprieties.*

The results of this study should improve the understanding of spatial data in the alpine permafrost scientific field and would provide a new methodology for mapping the discontinuous distribution of this phenomenon.

Robustness of fractal dimension estimators for vector talweg network characterization

THOMMERET N.(1), BAILLY J.S.(2), BARDET J.M.(3), KAISER B.(1), PUECH C.(4)
(1) Laboratoire de Géographie Physique UMR 8591 CNRS-Université Paris 1 Panthéon-Sorbonne, MEUDON, FRANCE ; (2) UMR LISAH, AgroParisTech, MONTPELLIER, FRANCE ; (3) Equipe SAMM, Université Paris 1 Panthéon-Sorbonne, PARIS, FRANCE ; (4) UMR TETIS,Irstea, MONTPELLIER, FRANCE

The fractal approach is often used to characterize natural objects. Numerous studies have focused on fractal analysis of river networks in particular. However, only few papers discuss the estimation methods and the uncertainty of the main fractal indicator, the fractal dimension. Firstly, the distinction between infinite mathematical fractal and nature fractal should be taken into account to estimate fractal dimension. Moreover, the networks are most of the time integrated in GIS database and represented by vector object. This type of representation possesses its own properties and we think that the impact on fractal measure should be evaluated.

In this context, the work we propose aims at testing the robustness of different fractal dimension estimators for the characterization of vector talweg networks. We focus on the two most popular estimators: a classical estimator for river networks, based on a topological approach with the Horton-Strahler ratios, and the box-counting dimension, based on a geometric approach. A third estimator, the less known correlation dimension, also based on a geometric approach, offers interesting possibility for calculating a stable fractal indicator, in particular in the case of a reduced number of stream-segments. These methods are applied on both virtual (such as Scheidegger network), and actual vector networks. The actual case is a network extracted from a high resolution DTM of the Draix badlands in the French Alps.

Three main methodological results can be highlighted: 1- the study of virtual network contributes to the assessment of the estimators relevance, according to the network branching structure; 2- an empirical fractal domain must be determined on the Log-Log curve with an objective method to estimate fractal dimensions that can be compared; 3- the observation of uncertainty of the fractal dimension is necessary for any valid comparison.

****

A flexible open-source toolbox for robust end-member modelling analysis - The R-package EMMAgeo

DIETZE M.(1), DIETZE E.(2)
(1) TU Dresden, DRESDEN, GERMANY ; (2) GFZ German Research Centre for Geosciences, Section 5.2 Climate Dynamics and Landscape Evolution, POTSDAM, GERMANY

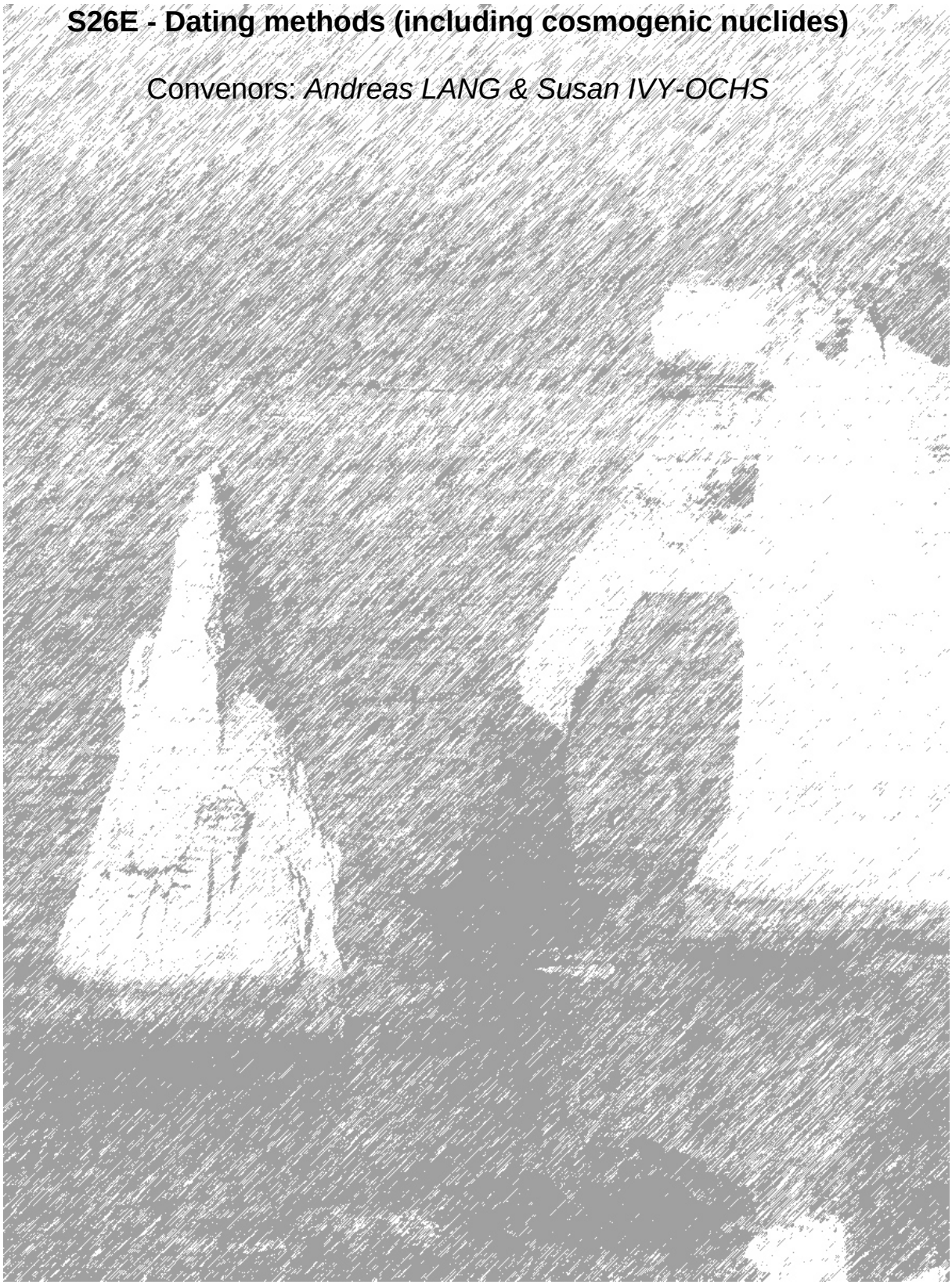
Interpreting geomorphological and sedimentological processes from grain-size data in terrestrial archives runs into problems when source- and process-related grain-size distributions become mixed during deposition. A powerful approach to overcome this ambiguity is to statistically “unmix” the samples. Typical algorithms use eigenspace decomposition and techniques of dimension reduction.

This contribution presents a package for the free statistical software R. It bases on a Matlab-based end-member modelling algorithm and contains several extensions and added functionality. Some of the great advantages of R are the open code structure, flexibility and low programming effort. The package contains several flexible functions for data test, preparation, modelling and visualisation tasks. The package supports simple modelling of grain-size end-member loadings and scores (eigenspace extraction, factor rotation, data scaling, non-negative least squares solving) along with several measures of model quality. It also provides pre-processing tools (grain-size scale conversions, tests of data structure, weight factor limit inference, determination of minimum, optimum and maximum number of meaningful end-members) and allows to model data sets with user-defined end-member loadings. EMMAgeo also supports uncertainty estimation from a series of plausible model runs and determination of robust end-members.

The contribution presents important package functions, thereby illustrating how large data sets of artificial and natural grain-size samples from different depositional environments can be analysed to infer quantified process-related proxies.

S26E - Dating methods (including cosmogenic nuclides)

Convenors: *Andreas LANG & Susan IVY-OCHS*



Oral presentations:

Surface exposure dating of rock avalanche deposits in the Ferret Valley (Mont Blanc massif, Italy)

AKCAR N.(1), DELINE P.(2), IVY-OCHS S.(3), KUBIK P.W.(3), SCHLÜCHTER C.(1)
(1) Institute of Geological Sciences, University of Bern, BERN, SWITZERLAND ; (2) EDYTEM Lab, Université de Savoie, LE BOURGET-DU-LAC, FRANCE ; (3) Laboratory of Ion Beam Physics, ETH Zurich, ZURICH, SWITZERLAND

One of the largest rock avalanches of the Alps occurred in the night of September 12th, AD 1717. A huge volume of rock and ice from Triolet Glacier was mobilized and more than 7 km travelled down valley in the upper Ferret Valley, Mont Blanc Massif (Italy). This mass destroyed two small settlements, causing seven casualties and loss of livestock. Although this rock avalanche was historically recorded, no detailed maps were made at the time. Later investigators attributed the accumulation of granitic boulders and irregular ridges covering the upper valley floor to either deposition by a Lateglacial glacier, or the AD 1717 rock avalanche, or a complex mixture of glacial deposition, earlier rock avalanche and AD 1717 rock avalanche origin. Can cosmogenic ^{10}Be be used to end this dilemma?

With the aim of answering this question, we sampled 16 boulders of this deposit and three from boulders outside of this deposit for surface exposure dating with cosmogenic ^{10}Be. Two boulders from distal Holocene glacier-free areas yielded ^{10}Be exposure ages of 10.9 and 9.7 ka, respectively. The third outside boulder, embedded into the Little Ice Age terminal moraine (*sensu lato*), yielded exposure age of around 240 years. ^{10}Be exposure ages of the granitic boulders within the upper valley deposit vary between 300 and 500 years within the limits of error. These results show that at least 14 of these boulders were deposited by the AD 1717 rock avalanche, and its deposits do cover the whole upper Ferret valley floor. With this study, we directly contribute to distinguish between rock avalanche deposits and older moraine sets in valleys of formerly glaciated mountains, two assemblages of landforms which often look alike, and to the assessment of the natural risks in the Mont Blanc Massif area.

****

Age modelling of Mid-Holocene sedimentary sequences using a Bayesian approach

MONGE SOARES A., CESÁRIO PORTELA P.J., MATOS MARTINS J.M., RAMOS PEREIRA A.
IST/ITN, UTL, SACAVEM, PORTUGAL

Accurate dating is essential for the construction of reliable paleoenvironmental and paleoclimatic models based in multi-proxy analysis of sedimentary records. Radiocarbon dating is one of the most common dating methods used to develop chronological frameworks.

In estuarine environments, where fluvial-marine interaction is more intense, the reworking of organic materials often affects the ^{14}C dates which induces difficulties in the establishment of a robust chronological framework. Bayesian analysis provides the necessary tool to evaluate the data set and to identify possible outliers and age-depth reversals.

To assess the evolution of interface environments along the Portuguese coast, a mesotidal estuary (Alcabrichel estuary) with an alluvial plain and a medium drainage basin and with different geological and geomorphological frameworks was selected. Two mid-Holocene sedimentary cores were collected in this estuary and radiocarbon dated, providing the necessary chronological dataset to establish a reliable paleoenvironmental and paleoclimatic reconstruction from these sequences.

In an attempt to overcome some difficulties related with the chronological data a bayesian approach was applied using the OxCal calibration software that allows the incorporation of the stratigraphic sequence and an outlier analysis of the dataset.

This analysis allowed the identification of outliers in our results and the assessment of deposition models for each sedimentary sequence, establishing a robust chronological framework for the sedimentary sequence in the Alcabrichel estuary, during the last 5000 years.

Acknowledgements: This research was funded by the research project, PTDC/CTE-GIX/104035/2008 - FMI 5000: Environmental changes: Fluvio-marine interactions over the last 5000 yrs, from Portuguese Science and Technology Foundation (FCT-MCTES). J.Martins acknowledges the PhDgrant SFRH/BD/45528/2008from the same institution. P. Portela acknowledgesthe FCT fellowshipof FMI 5000 Project.

The utility of portable optically stimulated luminescence (OSL) readers in providing temporal contexts in clastic depositional systems: opportunities in geomorphology

MUNYIKWA K.(1), BROWN S.(2), PLUMB E.(2)
(1) Athabasca University, ATHABASCA, CANADA ; (2) University of Alberta, EDMONTON, CANADA

The recent development of functional portable optically stimulated luminescence (POSL) readers has ushered in new opportunities in geomorphology. Although POSL readers do not necessarily provide absolute ages as in regular OSL dating, they can be used to readily acquire luminescence signals from clastic sediments. Such signals can be used to construct luminescence profiles which depict the variation of the luminescence signal with depth within a depositional sequence. Luminescence signals depend on dose rate, sensitivity of the mineral grains, mineralogy, degree of bleaching and burial age of the sediments. When all these parameters apart from burial age are held constant, the luminescence profile can serve as a proxy for the chronostratigraphy.
A number of studies we have carried out on the Canadian prairies with a POSL reader developed by the Scottish Universities Environmental Research Centre serves to illustrate the utility of the readers. Their portability means that the device can be carried to the field and analysis can be performed on bulk samples, negating the need for time-intensive mineralogical separations, as is required in regular OSL dating. In one study we used the POSL reader to profile Holocene eolian dune sequences to determine the relative ages of the depositional units as well as ascertain whether any lengthy depositional hiatuses exist within the sequences. In another study we profiled postglacial dunes that overlie glaciofluvial sands in an effort to delineate the interface between the two depositional facies. In a third study we used luminescence profiling to identify eolian dune sands that were still intact from those that had experienced post-depositional mixing. In all three cases, luminescence profiling afforded an enhanced temporal context of the stratigraphy, permitting better sample targeting for regular OSL dating. Overall the studies underscore the breadth of geomorphological settings in which the POSL readers can be used.

****

Last Glacial Maximum glaciers on Akdağ, southwest Turkey, inferred from cosmogenic Cl-36 dating of moraines

SARIKAYA M.(1), HIMMET H.(1), ATTILA Ç.(2)
(1) Fatih University, ISTANBUL, TURKEY ; (2) Hacettepe University, ANKARA, TURKEY

Past glaciations in the Eastern Mediterranean region provide useful information about the paleoclimate of the region. Determination of extent and timing of past glacial activities can be done by field surveys and measuring in-situ produced cosmogenic nuclides. For this purpose, we conducted a study on Akdağ, a small mountain located in the southwestern Turkey (36.54^{o}N, 29.57^{o}E, 3016 m above sea level). We mapped the past glacial extent in three glacial valleys and dated 40 limestone boulders on well-preserved terminal and lateral moraines by using cosmogenic Cl-36 nuclide. Results showed that, during the Last Glacial Maximum (LGM) (about 21 ka ago; 1ka=1000 calendar years) glaciers in the mountain reached their maximum extents (about 6 km from their cirques). LGM moraines (dated in between 23.8 ±1.8 ka and 19.5 ±1.4 ka ago) were found at 2000-2300 m above sea level. They retreated until 16.3 ±1.1 ka ago. Today, there is no glacier in the mountain. These preliminary results are the first numerical data in this mountain and the obtained ages are consistent with the nearby mountains. This set of glacial activity during the Late Quaternary provides a basis for paleoclimatic proxy data, which can be used to reconstruct the history of climate change in the region since LGM.

A tragic flood but an invaluable opportunity to build a better model on catchment wide denudation rate (CWDR) using a pair of 10Be and 14C

SEONG Y.B.(1), LEE S.Y.(1), KIM D.E.(1), CHOI K.H.(2), YU B.Y.(3)
(1) Korea University, SEOUL, SOUTH KOREA ; (2) National Institute of Environmental Research, SEOUL, SOUTH KOREA ; (3) Korea Institute of Science and Technology, SEOUL, SOUTH KOREA

A tragic flash flooding occurred in the Seti River of Western Nepal on Saturday 5 May 2012, and caused the death of more than 70 people. Despite various arguments on the exact location of the source and the mode of the flash flood, this tragic event can provide us with a unique natural lab to check on the present model of CWDR using cosmogenic nuclides through comparing any variation in the concentration of cosmogenic nuclides such as ^{10}Be, ^{26}Al and ^{14}C of the active channel sediments deposited before and after the High-magnitude Low-frequency event, respectively. Total of 26 samples were collected for estimating the concentrations of cosmogenic ^{10}Be and ^{14}C in the fluvial sediments. This research has double-folds: to quantify the role High-magnitude Low-frequency event plays on the process of sediment evacuation and to estimate the storage effect of the fill deposits such as terraces, alluvial fans, etc. which hold sediments for substantial time but has been poorly constrained in CWDRs using single ^{10}Be or a pair of ^{10}Be and ^{26}Al. Most of the present model on catchment-wide denudation rate using single cosmogenic nuclide of ^{10}Be or a pair of ^{10}Be-^{26}Al tends to underestimate the effective denudation rate of the catchment, because single ^{10}Be or even a pair of ^{10}Be-^{26}Al with long half-life is difficult to estimate any stored duration of sediments shorter than ~10^5 yrs. However, the use of short half-life, in- situ ^{14}C coupled with ^{10}Be makes us better quantify the storage duration of sediments in depositional settings which in turn, are reincorporated into the active fluvial system. In the study area, there are two tributaries of the Seti River showing the widely different settings of sediment storage: the Seti Khola is extensively covered by thick (up to a couple of meters) terrace deposits and wide valley form whereas the adjacent, Mardi Khola shows typical, V-shaped valley form with little fill terrace but a few of narrow, rock-cut strath terraces.

****

Timing of ice decay after the LGM in the high Alps

WIRSIG C.(1), IVY-OCHS S.(1), ZASADNI J.(2), AKCAR N.(3), DELINE P.(4), KOBER F.(1), SCHLUCHTER C.(3)
(1) ETH Zurich, ZURICH, SWITZERLAND ; (2) AGH University of Science and Technology, KRAKOW, POLAND ; (3) University of Bern, BERN, SWITZERLAND ; (4) Université de Savoie, LE BOURGET DU LAC CEDEX, FRANCE

Extensive investigations over the previous century have produced a robust model of the extent of ice in the Alps during the last glacial maximum (LGM). In Switzerland, glaciers advanced far into the foreland fed by ice domes that formed in the high Alps. Constraining the timing of events proves to be a more challenging task. ^{10}Be surface exposure ages and radiocarbon ages imply that thepiedmont glacier in the Swiss Alpine foreland had retreated before 19 ka BP. This result is in excellent agreement with the end of the last glacial period spanning from 30 – 19 ka BP, as inferred from stable isotopes in marine and polar ice cores. Did the ice surface in the high Alps decay simultaneously? Here we will present ^{10}Be surface exposure ages from several sites in the Swiss and Austrian Alps. Conclusions of previous attempts to date this event were fairly ambiguous. Their very nature does not allow studies using radiocarbon, OSL or other dating techniques to date the decay of the ice surface directly. Analyses of cosmogenic nuclides, in contrast, directly yield the duration that a surface has been exposed, i.e. since the retreat of ice formerly covering it. So far, the small number of studies using the same methodology report ages that are no older than 17.3 ka. The influence of temporary sediment or ice cover on the samples is generally taken to explain the age discrepancy compared to the ice retreat from the foreland and to the results from marine and polar ice cores. At the exposed locations of our study sites in supposedly ice-free conditions since the LGM we believe we can exclude these circumstances. Here we will present results from cosmogenic nuclide dating of these sites using ^{10}Be and construct a comprehensive chronology of the decay of the Alpine LGM ice surface by comparing them to published ages.

A continuous high-resolution 700-yr snow-avalanche chronology from the Queyras massif recorded from tree-ring and historical archives

CORONA C.(1), LOPEZ SAEZ J.(2), STOFFEL M.(3), BERGER F.(2)
(1) GEOLAB, CNRS UMR6042 Geolab, CLERMONT-FERRAND, FRANCE ; (2) IRSTEA, UR EMGR, SAINT MARTIN D'HÈRES, FRANCE ; (3) Laboratory of Dendrogeomorphology, Institute of Geological Sciences, University of Berne, BERNE, SWITZERLAND

Snow avalanches are mainly ruled by temperature fluctuations, heavy precipitations and wind regimes, so that climate change is likely to modify their frequency and magnitude both in terms of ordinary and extreme events. Papers dealing with this question generally analyze the evolution of the snow cover rather than the changes in avalanche activity and analyses of real avalanche data generally focuses on the past few decades. Some chronicles dating back to the 16th century have been realised by using historical documents reporting damage to buildings and fatalities. However, this kind of analysis cannot be used to assess the evolution of natural events because only catastrophic avalanches are generally reported in such data bases. Along forested avalanche paths, dendrogeomorphology has been demonstrated to greatly help documentation of past events.

In that respect, the purpose of this study was to reconstruct spatio-temporal patterns of avalanche events in forested avalanche paths of the Queyras massif (Echalp and Souliers avalanche paths, southeast French Alps).

Analyses of past events were based on tree-ring series from 315 heavily affected, multi-centennial larch trees (*Larix decidua* Mill.).Growth disturbances were identified in the samples permitting the reconstruction of destructive snow avalanches between 1338 and 2010.

At the Echalp avalanche path, the comparison of dendrogeomorphic data with historical records demonstrate that at least 18 events – six of which were undocumented – reached the hamlet of Echalp during the past seven centuries, but no significant temporal trend was detected concerning the temporal frequency of these extreme events. At Souliers, no event was documented in the archives. On a temporal plan, the study focused on the maxima in snow avalanche frequency reconstructed at the beginning of the 16th and 19th centuries and around 1850. These maxima were then correlated with fluctuations in meterorological data and in other proxies.

****

Poster presentations:

Amino acid racemization analysis (AAR) as a successful tool for dating Holocene barrier island spit accretion: Examples of Southern Sylt (North Sea/ German Bight)

TILLMANN T.(1), ZIEHE D.(2), WUNDERLICH J.(3)
(1) Goethe-University Frankfurt a. M., Department of Physical Geography, FRANKFURT A. M. , GERMANY ; (2) Johann Heinrich von Thünen-Institut, BRAUNSCHWEIG, GERMANY ; (3) Goethe-University Frankfurt a. M., Department of Physical Geography, FRANKFURT A. M., GERMANY

Dating of Holocene sediments in shallow coastal areas of the German North Sea by conventional techniques often turns out to be difficult. Due to the marine reservoir effect radiocarbon dating cannot be applied to sediments younger than about 400 years. Amino acid racemization dating (AAR) is a viable alternative for dating young sediments. The method is based on the determination of ratios of D and L amino acid enantiomers in organic matrices of biogenic carbonates.

In this study we use AAR as a tool for dating Holocene barrier islands sediments. Based on these dating a model of barrier spit accretion has been generated, which describes the interaction between extreme events, coastal processes and sedimentary development. The stratigraphy has been figured out by using ground-penetrating radar (GPR)surveys and sedimentological coring data. AAR helps to define a chronological order and allow setting up a barrier island stratigraphy of Southern Sylt.

AAR provided high temporal resolution and has been used for dating stages of barrier spit accretion. These time lines are marked as storm surge generated erosion unconformities in the stratigraphic profile. Individual shells and shell fragments of *Cerastoderma edule*, *Mya arenaria*, *Mytilus edulis and Scrobicularia plana* have been accumulated by short-term storm events as shell layers at the erosion unconformities and have been dated by AAR.

Time lines reveal that the barrier spit accretion occurred episodically, depending on the provided rate of sand delivery and are going to be younger by approaching to the south.The time lines have been verified and correlated by historic maps and sea charts. As a result, spit enlargement increased significant during the Middle

Ages (1593 – 1794) and was coupled with several intensive storm surges in this period. The findings indicate that AAR provides useful results of high accuracy for dating stages of barrier spit progradation.

Investigations on anthropogenic shell accumulations in the Longotoma dune complex (central Chile) ' geochronological data and palaeoenvironmental context

MAY S.M.(1), BRÜCKNER H.(1), HILGERS A.(1), KELLETAT D.(1), PÖTSCH S.(2), RIXHON G.(1), ZANDER A.(1)
(1) Institute of Geography, University of Cologne, COLOGNE, GERMANY ; (2) Institute for Geography and Geology, Ernst Moritz Arndt University of Greifswald, GREIFSWALD, GERMANY

Shell midden archaeology plays a significant role in the research on the colonisation of South America. However, geoarchaeological investigations on the palaeoenvironmental context of these cultures are rare though potentially providing important data for their interpretation. The Longotoma dune system is situated in the northern part of central Chile, framed by the estuaries of the rivers La Ligua and Petorca. Numerous cultural layers occur together with accumulations of mollusk shells, often related to stone fragments. While associated ceramics indicate a post-archaic age for some places, hunter-gatherer sites of pre-ceramic, mid-archaic age are described as well. A succession of fluvial terraces and two main dune generations are inferred from satellite images and preliminary field work, the younger characterized by migrating barchanoid dunes. Undercut slopes, formed by the La Ligua river, provide insight into the stratigraphy of the older dune generation at its eastern margin. Here we present first results from an international research project, dealing with the palaeoenvironmental context of these archaeological remains. A former alluvial terrace was found below the present dune field. A sequence of palaeosol sediments and an *in-situ* palaeosol were detected in the older dune generation, associated with a shell deposit. Bone fragments of small rodents, charcoal, leaves and abundant mollusk shells (*Mesodesma donacium*, *Concholepas concholepas*) confirm its anthropogenic origin. ^{14}C-AMS datings of shells and charcoal yielded similar ages of c. 5200 cal BP, giving further evidence for the presence of archaic coastal populations at Longotoma. IRSL datings provide a first chronological framework for the palaeoenvironmental context by (i) estimating the age of the fluvial terrace below the present dune field to ~4500-3500 BP, by indicating (ii) different phases of dune activity and (iii) a period of relative geomorphodynamic stability of several hundred years.

****

The land use interference on geomorphological aspects and sedimentation rates in the low course of the Piracicaba River basin, São Paulo State, Brazil

CUNHA C.(1), CONCEIÇÃO F.T.D.(1), SIMON A.L.H.(2), PEREZ FILHO A.(3)
(1) UNESP, RIO CLARO, BRAZIL ; (2) Universidade Federal de Pelotas, PELOTAS, BRAZIL ; (3) UNICAMP, CAMPINAS, BRAZIL

Currently, the São Paulo State, Brazil, possesses more than 55 reservoirs. The geomorphological classical literature affirms that there is a tendency for the occurrence of silting in the area intercepted by artificial dams. The use of isotopes to obtain the sediment ages has important applications in studies of sedimentation rates in reservoirs, which may be changed after their constructions. Thus, the land use interference on geomorphological aspects and sedimentation rates in the low course of the Piracicaba River basin, São Paulo State, Brazil, was evaluated. The land use dynamics and geomorphological aspects in this area were made by mapping of scenarios of 1962 and 2006. Furthermore, the sedimentation rate from upstream Barra Bonita Reservoir was obtained using the Pb-210 method. The results indicate that changes in geomorphological features in the studied area have direct relationship with the Barra Bonita Reservoir construction, which transformed the landscape of the area, flooding the alluvial plain. About the land use dynamics, there was an increase in sugar cane crops areas in relation to pasture, the main land use in 1962. The sedimentation rates were 12.1 mm/yr and 15.4 mm/yr for the periods from 1974 to 1985 and 1985 to 2010, respectively. The sedimentation rates obtained in this work is higher than the other studies along the Piracicaba River basin (~5 mm/yr), indicating the influence of Barra Bonita Reservoir in the sediment processes in the low course of the Piracicaba River basin after its construction in 1965. Additionally, it is attributed to the expansion of areas with sugar cane crops in the early 1980s, due to Pro-alcohol Program developed by the Brazilian Federal Government, the increase in the sedimentation rate in the studied area. the increase in the sedimentation rate in the studied area.

Surface exposure dating of the Chironico landslide (Leventina valley, southern Swiss Alps)

CLAUDE A.(1), IVY-OCHS S.(2), KOBER F.(3), ANTOGNINI M.(4), SALCHER B.(5), KUBIK P.W.(2)
(1) Institute of Geological Sciences, University of Bern, BERN, SWITZERLAND ; (2) Laboratory of Ion Beam Physics, ETH Zürich, ZÜRICH, SWITZERLAND ; (3) Geological Institute, ETH Zürich, ZÜRICH, SWITZERLAND ; (4) Museo cantonale di storia naturale, LUGANO, SWITZERLAND ; (5) Departement of Geography and Geology, Salzburg University, SALZBURG, SWITZERLAND

During the Lateglacial and Holocene, an increased activity in mass movements in the European Alps seemed to have occurred perhaps due to postglacial landscape response. In this study, we investigated the Chironico landslide in the Leventina valley in the southern Swiss Alps. About 530 million m^3 of crystalline granitic gneiss belonging to the Lower Pennic nappes detached from the eastern valley wall and slid along valleyward dipping exfoliation joints and fractures. The slide mass was deposited into the Ticinetto stream mouth and dammed the Ticino river. Wood fragments originated from lacustrine sediments in an upstream-dammed lake, yielded a minimum age for the landslide of around 13'500 cal yr BP.

In order to directly date the landslide, 14 boulders were sampled for surface exposure dating with the cosmogenic nuclides ^{10}Be and ^{36}Cl. Exposure ages indicate that the failure occurred around 13.3 ka, revealing that it was one event during the Bølling-Allerød interstadial and implying that the Chironico landslide is the oldest dated landslide in the Alps in crystalline rock. Runout modeling has reproduced the character and extent of motion of the landslide and the potential failure scenario could be identified. Geologic and geomorphologic investigations helped to reconstruct the temporal landscape evolution history of the Leventina valley around Chironico. It could be concluded that the landslide was triggered around 3000 years after deglaciation, suggesting that glacial unloading did not directly trigger the landslide. It however prepared the failure by decreasing the rock strength and oversteepening the steep SSW-dipping eastern flank.

****

Cosmogenic nuclide dating of Swiss Deckenschotter

CLAUDE A.(1), AKÇAR N.(1), IVY-OCHS S.(2), GRAF H.R.(3), KUBIK P.(2), VOCKENHUBER C.(2), DEHNERT A.(4), MEINERT R.(4), SCHLÜCHTER C.(1)
(1) Institute of Geological Sciences, University of Bern, BERN, SWITZERLAND ; (2) Laboratory of Ion Beam Physics (LIP), ETH Zürich, ZÜRICH, SWITZERLAND ; (3) Dorfstrasse 40, GÄCHLINGEN, SWITZERLAND ; (4) Swiss Federal Nuclear Safety Inspectorate ENSI, BRUGG, SWITZERLAND

Deckenschotter (cover gravel) are proximal glaciofluvial gravels of the Northern Alpine Foreland, showing locally interbedding with till and overbank deposits. These Quaternary sediments cover Tertiary Molasse or Mesozoic bedrock and occur beyond the limit of the Last Glacial Maximum. Based on their distinct topographic positions, these deposits can be divided into two main geomorphic units: Höhere (Higher) and Tiefere (Lower) Deckenschotter. Despite its topographically higher position, the Höhere Deckenschotter is older than the Tiefere Deckenschotter. A phase of incision separates the two units from each other. Both Höhere and Tiefere Deckenschotter bear evidence of at least four glacial advances that reached the Alpine foreland and are, therefore, complex lithostratigraphic sequences.

The age of the Deckenschotter complexes is poorly constrained. The only existing quantitative age is between 2.5 and 1.8 Ma, which is based on mammalian faunal assemblages (MN17) found in the Höhere Deckenschotter at the Irchel site. They are therefore the oldest Quaternary units in the northern Swiss Alpine foreland known so far. In this study, we apply burial dating, isochron dating and depth-profile dating with the cosmogenic nuclides ^{10}Be, ^{26}Al and ^{36}Cl in order to establish the timing of Early and Middle Pleistocene glaciations in the Alps. Reconstruction of the chronology of these glaciofluvial units will provide fundamental information about the onset of Quaternary glaciation in the Alps as well as about major incision history of the area.

Late Pleistocene Glacier advances in North Anatolia deduced from cosmogenic 10Be and 26Al

REBER R.(1), TIKHOMIROV D.(1), AKÇAR N.(1), YESILYURT S.(2), YAVUZ V.(3), KUBIK P.W.(4), SCHLÜCHTER C.(1)

(1) Institute of Geological Sciences, University of Bern, BERN, SWITZERLAND ; (2) Department of Geography, Çankırı Karatekin University, ÇANKıRı, TURKEY ; (3) Faculty of Mines, Istanbul Technical University, MASLAK, ISTANBUL, TURKEY ; (4) Laboratory of Ion Beam Physics, ETH Zürich, ZÜRICH, SWITZERLAND

Moraines are the morphological evidence for glacier oscillations in the past. Surface exposure ages from the erratic boulders and bedrock are used in the reconstruction of the chronology of these oscillations, which are directly correlated to extreme climate conditions. In this study, we focused on the Basyayla Valley in the northern part of eastern Back Sea Mountains (Turkey) in order to extend the existing knowledge about the late Pleistocene glaciations in Anatolia. In the Basyayla Valley, terminal and lateral moraines constrain at least three well-defined glacier advances. We collected 40 samples from erratic boulders for surface exposure dating with in-situ cosmogenic ^{10}Be and ^{26}Al. In addition, a bedrock outcrop on the crest line of the northwestern valley flank was sampled. ^{10}Be exposure ages show at least one advance at around 35 ka, which extended down to an altitude of ca. 2350 m a.s.l. The subsequent advance occurred at around 21 ka and remained at ca. 2480 m a.s.l. The Lateglacial advance at around 16 ka was limited to a cirque glacier at an altitude of ca. 3050 m a.s.l. Since then, the valley was free of ice. ^{10}Be and ^{26}Al concentrations from the bedrock sample indicate a simple exposure history and that there was no ice contact to the adjacent valley at least during the last 37 ka. Our results correlate with the existing chronology from the neighborly Çoruh, Kavron and Verçenik valleys and from Uludağ, as well as with the existing chronologies from the other Anatolian Mountains. Our study provides a better understanding of glaciations in Anatolia prior to the global Last Glacial Maximum at 21 ± 2 ka.

****

Geochronology of Danube terraces in Hungary, using cosmogenic 10Be and luminescence dating

CSILLAG G.(1), RUSZKICZAY-RÜDIGER Z.(2), NOVOTHNY Á.(2), THAMÓ-BOZSÓ E.(1), FODOR L.I.(3), BRAUCHER R.(4)

(1) Geological and Geophysical Institute of Hungary, BUDAPEST, HUNGARY ; (2) Department of Physical Geography, Eötvös University, BUDAPEST, HUNGARY ; (3) Geological, Geophysical and Space Sciences Research Group of Hungarian Academy of Sciences at Eötvös University, BUDAPEST, HUNGARY ; (4) Centre Européen de Recherche et d'Enseignement des Géosciences de l Environnement, AIX EN PROVENCE, FRANCE

The existing terrace chronology in the Hungarian Danube valley was based on geomorphological, sedimentological and palaeolontological data. This old system has been questioned due to some new Th/U and luminescence dating results, obtained from travertine and loess, respectively, overlying the terraces and due to in situ cosmogenic ^{3}He dating of andesite strath terraces. Major part of these data showed that Danubeterraces, and connected uplift of the surrounding hills are significantly younger then it was suggested before. On the other hand, some of them suggested older than expected ages. Accordingly, a novel terrace chronology is necessary, which we try to approach by using two different dating methods on the alluvial terraces: luminescence dating, which provides the burial ages and cosmogenic ^{10}Be dating, which yields the exposure ages of the sediments. Cosmogenic ^{10}Be and luminescence samples were collected from several locations from terraces IV and IIb (at Győr, Bana, Mocsa, Dunaalmás and Tata). Cosmogenic ^{10}Be sampling occurred along depth profiles, because this method allows determining both the exposure time and the denudation rate at each locality by using all particles involved in the cosmogenic nuclide production. Post-Infrared Infrared Stimulated Luminescence (post-IR IRSL) measurements were carried out on K-feldspar samples, comparing the post-IR IRSL 290 and post-IR IRSL 225 signals. Besides, younger quartz samples were also measured using optically stimulated luminescence (OSL).

Although preliminary results are promising and the luminescence ages are partly in good agreement with preliminary cosmogenic ^{10}Be ages, it has to be taken into consideration, that the processes, which are dated with these methods are different. In case of disagreement the effect of surface erosion also has to be taken into account. The possible effect of post-depositional sediment mixing could be excluded by the observation of the original bedding of the alluvial material.

Quantification of optically stimulated luminescence dating uncertainties based on the analysis of samples collected from a paleoseismological trench of an active fault in Central Greece

TSODOULOS I.(1), STAMOULIS K.(1), PAPACHRISTODOULOU C.(1), IOANNIDES K.(1), PAVLIDES S.(2), CHATZIPETROS A.(2), KOUKOUVELAS I.(3)

(1) Department of Physics, University of Ioannina, IOANNINA, GREECE ; (2) Department of Geology, Aristotle University of Thessaloniki, THESSALONIKI, GREECE ; (3) Department of Geology, University of Patras, PATRAS, GREECE

Documenting the displacement in past faulting events, observed in excavated paleoseismological trenches across faults, stratigraphic and structural information contained within the walls should be interpreted. Since often it is difficult to correlate the lithologic units on the foot and hanging walls of the fault, the reconstruction of past displacements is a demanding task, requiring the application of various methods, such as radiometric dating or compositional and mineralogical analysis methods.

In this work, samples from a recently excavated paleoseismological trench were collected and analyzed with the method of the Optically Stimulated Luminescence (OSL) dating, in order to establish a reliable chronological framework. The trench was excavated in a typical active fault namely Gyrtoni, Larissa, Thessaly plain in Central Greece. The initial preliminary interpretation of the trench wall structure provided indications of recent reactivations of the fault. Seven samples, one for each lithologic unit, were collected from the upthrown fault block and 9 samples were collected from the downthrown fault block. The samples were dated following the OSL dating method, using the Riso TL/OSL DA-20 reader. The single-aliquot regenerative-dose (SAR) protocol was followed for the equivalent dose (De) determination. Also, the natural radioactivity of soil from the surroundings of the original sample location was assessed, using gamma spectrometry. The dose rates were calculated using the appropriate dose conversion factors and corrected for the humidity content of the surrounding soils.

Since the application of the OSL dating method involves a number of intermediary factors and processes, all being the sources of uncertainties propagating to the total uncertainty, an exhaustive analysis of the involved uncertainties is presented and the implications to the derivation of conclusions used for paleoseismology are discussed.

****

GIS-based geomorphological mapping, dating of selected landforms and landscape evolution during the Lateglacial and Holocene, in the region of Val Tuoi, Grisons, Switzerland

MESSERLI M.(1), IVY-OCHS S.(2), MAISCH M.(1)

(1) University of Zurich, ZURICH, SWITZERLAND ; (2) ETH, ZURICH, SWITZERLAND

The study of glacial and periglacial landforms provide important information about the climate history of the region. Since the Last Glacial Maximum (LGM) glaciers in the Alps have advanced and retreated many times leaving traces of their activities in the field. The Val Tuoi, Grisons, Switzerland offers a wide range of glacial and periglacial landforms. This valley forms a tectonic boundary, on the left orographic side is the lower Austroalpine from the geological window of the Lower Engadine (Unterengadiner Fenster) and the right side is predominated by amphibolites and orthogneisses of the Silvretta units. The bedrock differences are reflected in the abundance of slope instabilities on the left side (east). In contrast, the right side displays steep walls with a series of debris cones. Well developed lateral moraines indicate Lateglacial ice extents.

A detailed understanding of the geomorphological settings and the corresponding dating method are compulsory to reconstruct the regions climate history during the Lateglacial and the Holocene. To obtain absolute rock surface dates, 12 samples on moraines and three on rock-glaciers have been collected. Surface ages are calculated by ^{10}Be exposure dating method. To determine the relative age relation between selected landforms, Schmidt-Hammer technique was applied on 17 debris cones, 12 moraines, two active and one relictic rock glacier. Furthermore a GIS-based map will be produced and analyzed to show the spatial distribution and dynamics of the geomorphological shaping processes.

Assessing processes and timescales of sandstone landscape formation in Zhangjiajie Geopark of China

HUANG H.(1), MAY J.H.(2), FINK D.(2), WRAY R.(2), GU J.(1)
(1) Institute of Geographi Sciences and Natural Resources Reserach, Chinese Academy of Sciences, BEIJING, CHINA ; (2) University of Wollongong, NSW 2522, AUSTRALIA

Sandstone landscapes around the globe exhibit a surprising variety in terms of their landforms and formative processes. Ultimately, this reflects the wide range of geomorphic controls that dominate on regional scales, such as lithology, physical and chemical weathering, tectonics, and climate. In Zhangjiajie Geopark ofthe Hunan Province, China, a unique landscape has developed in Devonian sandstone over an area of ~400 km^2,which is characterized by more than 3000 sheer vertical sandstone pillars, peaks and walls of up to 350 m height. Due to these spectacular features, the area has become a major tourist attraction, and has recently been declared an UNESCO Global Geopark.

Uplift, a densely spaced joint pattern, and the uniformity of sandstone beds have been suggested as major prerequisites for the formation and preservation of the landscape. We aim to investigatethe underlying processes and controls responsible for the development of this landscapeby determining a chronological framework for its age, and assessing ratesof formation and surface erosion. The initiation of uplift ~1 Ma ago and subsequent stepwise evolution of the landscapehas been inferred from cave sediments and surrounding alluvial terraces. No direct information, however, is available on the shorter-term evolution of the vertical sandstone walls, peaks and pillars.

In this study, we (i) consider sampling strategies for applying surface exposure dating (SED) in this challenging morphological setting, (ii) present some first results, and (iii) discuss their significance in providing estimates on rates of catchment-wide denudation, weathering, retreat of the vertical sandstone walls, and bedrock incision. In combination with a GIS-based assessment of sediment volumes stored in and eroded from the catchment, these data will help to elucidate the relative roles of fluvial, mass-wasting, and weathering processes in the longer-term, late Quaternary formation of this distinct landscape.

****

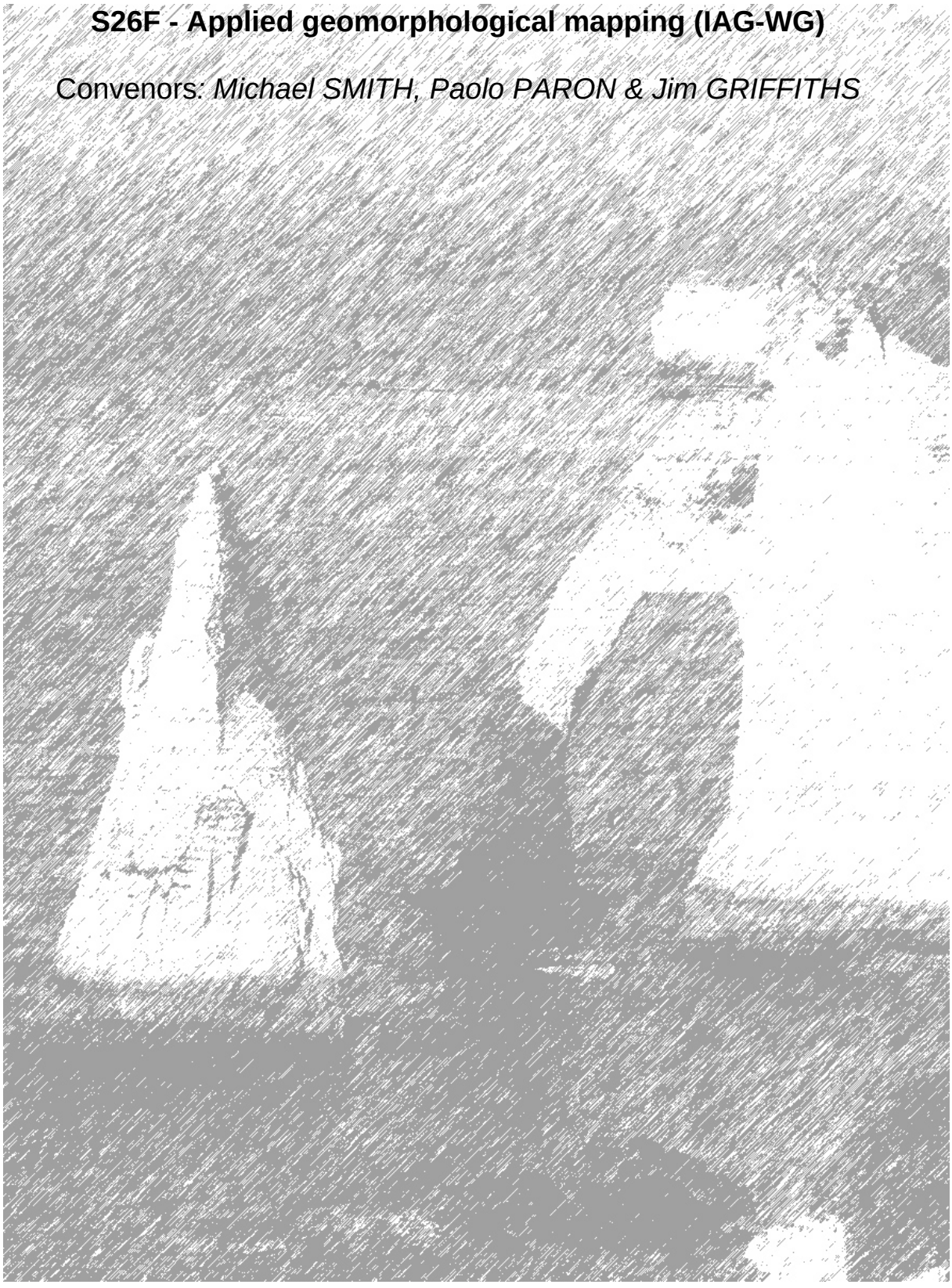
Application of fallout radionuclides for investigating recent overbank sedimentation rates on river floodplains: potential and limitations

GOLOSOV V.(1), WALLING D.(2), BELYAEV V.(3)
(1) Faculty of Geography, Lomonosov Moscow State University & Institute of Ecology and Geography, Kazan Federal University, MOSCOW & KAZAN, RUSSIAN FEDERATION ; (2) Geography, College of Life and Environmental Sciences, University of Exeter, EXETER, UNITED KINGDOM ; (3) Faculty of Geography, Lomonosov Moscow State University, MOSCOW, RUSSIAN FEDERATION

Overbank sedimentation rates on river floodplains provide a key indicator of the intensity of sediment and sediment-associated pollutant redistribution in river basins and the efficiency of sediment delivery. Combined application of the fallout radionuclides ^{137}Cs (bomb-derived and/or Chernobyl-derived) and excess ^{210}Pb provides an effective means of documenting recent medium-term overbank sedimentation ratesThis approach is particular useful in areas of Europe affected by Chernobyl fallout, because it is frequently possible to determine sedimentation rates for three or more time intervals. In addition, it is possible to use the information on sediment chronology provided to reconstruct the history of industrial and agricultural pollution in the upstream river basin. However, despite the important advantages of fallout radionuclides for establishing overbank sedimentation rates and dating sediment deposits, it is necessary to recognize the possible limitations of the technique, as well as the sampling and sample analysis requirements which need to be considered when documenting and interpreting radionuclide depth distributions. Recently published studies indicate that the requirements for the successful application of fallout radionuclide tracer techniques are unfortunately sometimes ignored, leading to unreliable results or incorrect interpretations. The potential and limitations of fallout radionuclides for investigating overbank sedimentation rates on river floodplains will be reviewed, based on the authors' own studies as well as other recently published work.

S26F - Applied geomorphological mapping (IAG-WG)

Convenors: *Michael SMITH, Paolo PARON & Jim GRIFFITHS*



Oral presentations:

Spectral properties of Southern Baltic bottom roughness

SZEFLER K., TEGOWSKI J., NOWAK J.
Maritime Institute in Gdansk, GDANSK, POLAND

Multibeam swath acoustic technique is very attractive for construction of the high resolution digital elevation model of the ocean bottom as the base for the geomorphological characterisation of measured area. In the years 2007-2010 the Maritime Institute in Gdansk conducted exhaustive research of the bottom in the Polish Exclusive Economic Zone (the Baltic Sea) collecting a large set of swath and subbotom acoustic data. A particular attention was given to six different areas of size up to 10 by 20 km, which demonstrate typical geomorphological seafloor features for the southern Baltic Sea. The acoustical measurements were accompanied by geological sampling and video inspection. This work is focused on development of consistent geomorphological classification system based on spectral properties of seafloor roughness. Two dimensional spectra (2D FFT) of the surface and the spectral parameters as maximal value of spectral density function, spectral exponent and strength, spectral moments, mean frequency, spectral width and skewness were computed for each analysed area divided by overlapped 200 by 200 m squares. Moreover, other features characterised the corrugated surface as fractal dimension, radius of autocorrelation, elevation slope and statistical parameters were estimated. The spectral parameters were the input to Principal Component Analysis and next to the unsupervised neural network algorithm, which produced maps containing morphologically classified seabed areas. Proposed method provides fast and efficient tool for seafloor classification taking into account scales and shapes of geomorphological forms.

****

Geomorphological mapping of an active landslide on the south-east coast of the Isle of Wight, U.K.

GRIFFITHS J.
University of Plymouth, PLYMOUTH, UNITED KINGDOM

The Undercliff on the south-east coast of the Isle of Wight is one of the largest urban landslides complexes in Europe being over one kilometre wide and some ten kilometres long. Studies of this landslide complex have identified areas in varying states of stability that move intermittently primarily in response to changes in ground water conditions. In late 2000 to early 2001 at Binnel Bay, towards the western end of the Undercliff, a 300 metre long and 100 metre wide section of the landslide started to move damaging the coastal road and destroying a number of mobile homes. Geomorphological mapping of the landslide at a scale of 1:2,500 was undertaken whilst the landslide was actively moving at a rate of a few centimetres/day. The mapping identified the failure as a relatively shallow multiple translational landslide that was retrogressing rather than a deep-seated movement involving the main landslide complex. The shear surface was less than 10 metres deep and lay within a more plastic horizon in the Cretaceous Gault Clay. The failure, therefore, was found to be part of a general degradation process and not a reactivation on a larger scale of the whole Undercliff's pre-existing landslide complex. The mapping was used to provide recommendations for the safe evaluation of the site using standard ground investigation techniques as a prelude to the design of remedial measures.

Geomorphological mapping of himalayan terrain using multi-sensor data: a case study of himachal pradesh, India

PANI P.
Jawaharlal Nehru University, NEW DELHI, INDIA

In the present [paper an attempt has been made to map geomorphological units of a middle inner Himalayan terrain using multi sensor data. The aim of the research work is to identify the geomorphic units and their attributes as geomorphology plays an important role in land use planning of the Himalayan terrain. Parvati valley of Himachal Pradesh is selected for such study using Remote Sensing and GIS techniques. Physiographically rugged topography, steep sided hills, escarpments, narrow valleys and interlocking spurs are the characteristics features of the area with a variation of altitudinal heights between 1300 – 3000 metres. Indian Remote Sensing satellite senor LISS III, LISS IV data along with LANDSAT data of different years were used to map the geomorphological units of the mountainous terrain. In order to have an idea of the valley profiles DEM has been prepared and analysed from the Cartosat 1 data.The major geomorphic units are various dissected hills, river terraces, alluvial fans, levees, channel bars and glacial features. The geomorphic features are the product of fluvial as well as glacial action. Field verification of many geomorphic units of this Himalayan tract have been conducted with hand held GPS. The study of temporal changes of the geomorphological units for about forty years has been done to understand the type of phases under which the area is presently going on. The land use practice in the area is mostly confined to the alluvial terraces. It is concluded that geomorphology plays an important role in the land use practices of mountainous region of Himalaya.

****

The influence of slope morphometry on erosion processes: the application of MSI (Morphometric Slope Index)

BUCCOLINI M.(1), COCO L.(1), ARINGOLI D.(2), MATERAZZI M.(2)
(1) Università "G.D'Annunzio" Chieti, CHIETI, ITALY ; (2) Università di Camerino, CAMERINO (MC), ITALY

The morphodynamic processes and the development of drainage systems are strongly influenced by the topography of the slopes. Several authors investigated slope parameters individually, resulting in partial relations with morphogenetic processes, for instance between drainage density and slope inclination of some river basins, obtaining different results.

Slope geometry may be analyzed using the Morphometric Slope Index (*MSI*) and simplified through the tributary basin that influences the landform. *MSI* combines the slope main morphometric features, both linear and areal. Its formula is $MSI = A_{3D}/A_{2D} \times L \times R_c$, where A_{3D} is the three-dimensional area of the slope, A_{2D} is its plan area, L is the slope length and R_c is the circularity ratio. The statistical analyses demonstrated its effectiveness, giving the significant correlations between *MSI* and the parameters that constitute its formula, but also with the slope inclination, that is not explicitly contained in the formula.

*MSI*can be useful for many purposes, both for development studies and for predictive studies.

*MSI*can be calculated considering the initial slope topography, prior to the development of a landform, reconstructed tracing the straight contour lines that connect the points with the same height on the opposite sides of the slope, and measuringA_{3D} on the initial topography. In the study of calanchi processes, drainage densityresulted inversely proportional to*MSI*, considering both the single hydrographical units in parallel *calanchi* and a set of dendritic *calanchi*. Moreover, the eroded volume in *calanchi* basins was directly proportional to *MSI*.

In a river basin, considering the landslides that occur in second-order sub-basins, the areal frequency of landslide resulted inversely proportional to *MSI*. Moreover, *MSI* influenced the amount of total eroded volume in the sub-basin.

Further use of *MSI* could be in a predictive way, using the three-dimensional actual surface of the slope.

Landslide susceptibility zonation using bivariate statistical analysis and GIS in Constantine city (North East of Algeria)

BOURENANE H.(1), BOUHADAD Y.(2)
(1) National Center of Applied Research in Earthquake Engineering (CGS), ALGER, ALGERIA ; (2) National Earthquake Engineering Center (CGS), ALGER, ALGERIA

The town of Constantine, which is the third largest town in the northeast of Algeria suffers from frequent and severe progressive landslide phenomena during the last decade because of its geological, geomorphological and climatic settings alternated by the human activities. Its unstable urban perimeter covering total areas of approximately 706 hectares (7.124 km2) that represent about 11,84 % of its urban space. In order to reduce the risk emanating from potential landslide, there is a need to generate a comprehensive Landslide Susceptibility Zonation (LSZ) map of the area for an effective and efficient disaster management. In the present study, an attempt has been made to generate LSZ map of the town Constantine situated in north east Algeria using bivariate statistical modified Information Value (InfoVal) method in a GIS environment. The various causal factors responsible for landslide occurrence associated with landslide activity, have been considered and the corresponding thematic layers have been generated using remote sensing and GIS techniques. The relative importance of these layers for causing landslides has been evaluated using modified InfoVal method and a landslide susceptibility zonation (LSZ) map has been generated. The landslide susceptibility index was segmented into five zones, viz. very low, low, moderate, high and very high susceptibility. The accuracy of the LSZ map has been evaluated using frequency ratio and success rate methods and indicates more than 85 % of landslide prediction accuracy.

Keywords: Landslide susceptibility zonation (LSZ), InfoVal, GIS, Bivariate statistics, Constantine

****

Subsurface geomorphology of the North Kelantan Plain, as revealed by geoelectrical resistivity surveys

ISLAMI N.
University of Malaya, KUALA LUMPUR, MALAYSIA

The North Kelantan Plain is located in the northeastern part of Peninsular Malaysia adjacent to the South China Sea coastline, and is drained by the Kelantan and Pengkalan Datu rivers. It is covered by fluvial sediments of Quaternary age deposited on granite bedrock. The aquifer system of the area is confined within these sediments, and is largely controlled by subsurface geomorphology. Seventy-four geoelectrical resistivity surveys were conducted along the Kelantan River to reveal the subsurface structure and layering within the sediment. Important parameters that need to be determined for geomorphological studies are the location and extent subsurface geomorphology and its characteristics, and the spatial variability of the formation. All these parameters control the aquifer system in the study area.Four major geomorphological features were discovered. First, in the area within 2 km of the coast, profiles parallel to the shore are dominated by parallel discontinuities, while those perpendicular to the shore are dominated by discontinuities that are wavy, with an average wavelength of 15-20 m and amplitude of 3-6 m, indicating the influence of prevailing winds on the geomorphology at the time of deposition. Commonly, the pattern is similar to modern today. Second, in the delta of the Kelantan River, the shallow and deep aquifers are connected, indicating that the ancient Kelantan River has sifting and moving to the other traverse. Third, in the area between 10 and 25km landward from the shore, subsurface geomorphology controls the distribution of naturally polluted groundwater, and lastly, in areas where the elevation is greater than 30 meters above mean sea level, the granite bedrock is shallow, restricting the presence of fresh groundwater aquifers.

Methodological procedures of digital geomorphological cartography in brazilian Central Plateau

BARBOSA SOARES NETO G.(1), SOUZA MARTINS É.(2), VASCONCELOS V.(2), LLACER ROIG H.(1), B. J. MENEZES P.H.(1)
(1) University of Brasília, BRASÍLIA, BRAZIL ; (2) EMBRAPA, BRASÍLIA, BRAZIL

The objective of this paper is to present a standard procedure of geomorphological cartography. The proposed methodology involves geomorphometric elements as amplitude and slope of terrain. The integration of geomorphometric elements and geomorphological classification is performed by geoprocessing techniques. The process of classification of terrain units is dynamic and automated. The principle of the proposed methodology is the evaluation of terrain metrics without involving the genetic aspects. The absence of standardization in geomorphological representation associated with peculiarities of the process of obtaining data which characterize the surface could be mentioned as factors that hinder the elaboration of geomorphological charts. The area chosen for the application of the methodology was the Brazilian Central Plateau, embedded in a terrain mostly flat to gently undulating, interspersed with areas to the north with high level of dissection. The proposed methodology was implemented with a variety of ranges for morphological and morphometric classes. Using topologically consistent data it was possible to model, in GIS environment, structures that allow a better interpretation of morphological data and morphometric data description. The geomorphological units represented are associated with diversity of forms found in upland structures. The method applied obtained consistent and reproducible results, whereas previous methods that did the standardization of morphology primarily by visual analysis ended up not maintaining a standard of identified terrain classes, thus leading to inconsistency of the data analyzed. The methodology herein developed, besides standardizes the process of interpretation of classes, especially regarding to morphology, retains control of small nuances that determine the differences of terrain classes.

****

Open Geomorphological Map. Romanian case study

NICULITA M.
University Alexandru Ioan Cuza, IASI, ROMANIA

Geomorphological mapping is a finality of geomorphologic research. Geomorphological maps are very usefull in natural resource and environmental management, in planning, and other areas. Classic geomorphologic map are sometimes hard to disseminate, while very few countries have national wide geomorphologic maps are high scales. GIS and digital cartography started a revolution in geomorphological mapping, because digital geomorphologic maps are easy to maintain and disseminate.

The rise of open data and open philosophy could also sustain this revolution in geomorphological mapping. Web mapping technology is one of the best option to use when digital maps need to be disseminated. Web maps are distributed in web browsers as raster or vector data using various web servers and applications. While tiled raster data is the easiest method for serving spatial web data, the vector data permit a high level of interactivity.

Web geospatial data have almost the same advantages as GIS data. The generalization is a strong component of web mapping, because the interactive zooming must be performed efficiently. The use of layers, integration with aerial and satellite images and the interactivity of the web maps gave the possibility to deliver a surplus of data.

We present an example of open digital geomorphometric maps obtained based on SRTM data and geomorphometric methods, for the Romanian territory. We believe that this type of approach will help the reviving of the geomorphological mapping.

The vector data is stored in a PostGreSQL PostGIS enabled database, and the conversion to tiled raster maps is made by Mapnik, while the web rendering is made by OpenLayers, being the cheapest and easiest option for delivering online geomorphologic maps.

Poster presentations:

Geomorphological map of Northern Jeffara plain and North-eastern part of Matmata-Dahar plateau (Southeast Tunisia) 1/100 000

BEN FRAJ T.
Faculty of Letters and Humanities of Soussa, Geography department, KSIBET MEDIOUNI, TUNISIA

Following geomorphological researches conducted within the framework of a doctoral thesis at the Faculty of Humanities and Social Science of Tunis, a geomorphological map summarizing the results obtained was developed. The realization of this map is based on topographical and geological coverage of the northern Jeffara at 1/100 000, on various dates of aerial photographs and using maps of the exercise carried out in the field. The figures used are those of the “Legend for the geomorphological map of France at 1/50 000, R. C. P. 77, C. N. R. S. 1970”.

The design was made clean using CorelDRAW 11. The result is a map of 120 by 80 cm in size.

The map hepls recognize some topographic and hydrographic data of northern Jeffara, and the various structures and structural forms. It also shows the age, nature and spatial extension of different continental, coastal and marine Quaternary deposits and forms.

****

Geomorphological mapping applied to regional planning and geoheritage: study on Figueira da Foz Nazaré area (western central Portugal)

RAMOS A.(1), CUNHA L.(2), CUNHA P.(3)
(1) CEGOT - University of Coimbra, COIMBRA, PORTUGAL ; (2) Department of Geography, CEGOT, University of Coimbra, COIMBRA, PORTUGAL ; (3) Department of Earth Sciences, IMAR-CMA, University of Coimbra, COIMBRA, PORTUGAL

A geomorphological characterization of the Figueira da Foz – Nazaré area (Portugal), is here presented. The region shows a diversity of landforms that resulted from the action of marine, fluvial, aeolian and mass-wasting processes, but also of lithologic and tectonic controls that occurred mainly during Pliocene and Pleistocene times.

The study leading to the identification of geomorphological features was undertaken in three stages: (1) field mapping on topographical (1/25,000) and geological (1/50,000) base maps; (2) analysis of 1/26,000 black/white aerial photographs and of a digital elevation model (DEM) based upon a 1/25,000 topographic database, in order to improve the mapping and (3) ground-truthing in the field to refine the geomorphological map produced. The final representation of geomorphological features in a geomorphological map was built using GIS and includes information on morphometry, morphography, hydrography, lithology, structure, age, and process/genesis.

A main geomorphological unit is located at east, represented by the limestone reliefs of the Massif of Sicó and Massif Calcário Estremenho. It is in this unit that are recorded the higher elevations and slopes, presenting very high susceptibility to slope movements (collapse, landslide or flows), and forest fires. Another main unit, the Coastal Platform, is located at west, presents siliciclastic lithologies, lower elevations and slopes and the shore line. It is possible to identify the higher susceptibility to a larger number of dangerous natural processes: landslides (on rocky on sandy relieves), forest fires, earthquakes (along faults), flooding (on flood plain and river mouths) and coastal erosion.

The structural and lithological characteristics of the area are responsible for a diversified geomorphological framework that, for their uniqueness, representativeness, aesthetic importance and cultural, educational and scientific values deserve to be inventoried and conserved as geoheritage.

Remote sensing and gis applied to geomorphological mapping of the watershed stream Indaia, MS, Brazil

CUNHA E.(1), BACANI V.(1), FACINCANI E.(1), SAKAMOTO A.(2), LUCHIARI A.(3)
(1) UNIVERSIDADE FEDERAL DE MATO GROSSO DO SUL, AQUIDAUANA, BRAZIL ; (2) UNIVERSIDADE FEDERAL DE MATO GROSSO DO SUL, TRÊS LAGOAS, BRAZIL ; (3) UNIVERSIDADE DE SÃO PAULO, SÃO PAULO, BRAZIL

The remote sensing data implemented in a Geographic Information System (GIS) allows the establishment of an advance in taxonomic mapping of relief, giving in this way, the bases for planning and land management. The watershed stream Indaiá located in the State of Mato Grosso do Sul, Brazil, in the southwest of the city of Aquidauana, whose area is approximately 94.97 km². The Indaiá stream is a tributary of the Taboco river, which consequently enters the Pantanal wetlands. Technical scientific procedures employed consisted in the application of proposed methodology relief taxonomy developed by Ross (1992), Florenzano (2008) and image processing routines described in Novo (2008). The geomorphological compartmentation was developed from intermediate cartographic products derived from physiographic analysis (satellite image of LANDSAT 5 TM and GeoEye) and supported by morphometric of from radar interferometric SRTM (Shuttle Radar Topographic Mission). The mapping geomorphological was characterized by the 5th taxon, where it was possible identify the following units of relief: fluvial plain, hills convex slopes up to 6%, hills convex slope between 6% and 12%, hills convex slope between 12% and 20%, hill top convex, hill top convex. Among the mapped drives predominate convex tops of hills in approximately 90% of the basin area associated with slopes that do not exceed 20%, sustained over the Aquidauana Formation in essence consists of granulating medium reddish sandstones. The infiltration processes are favored by the constitution lithological unit favoring a low drainage density and consequently the development of medium and large hills, morphological this domain is one of the factors that influenced the current process for use and occupation through the installation of complex settlements Indaiá, since this action emphasized removal of the canopy causing imbalances morphological (silting, gully) in the basin.

****

Geomorphological map of Croatia 1:100.000

BUZJAK N.(1), PAHERNIK M.(2), FAIVRE S.(1), BOCIC N.(1)
(1) University of Zagreb, Faculty of Science, Dept. of Geography, ZAGREB, CROATIA ; (2) Croatian Military Academy Petar Zrinski, ZAGREB, CROATIA

Within the task of geomorphological mapping and making of Geomorphological map of Croatia 1:100.000 in GIS environment, model of the geomorphological database and mapping data model were created. Spatial framework of geomorphological map series is related to the projection reference system HTRS96/TM based on ellipsoid GRS80. Division of map sheets is identical to that of topographic maps at the scale of 1:100.000 (56 sheets, sheet area 40×60 km). Within conceptual modeling of geomorphological database, methods of an object-oriented analysis were used, wherein the objects (landforms) with basic characteristics were defined. This included the identification of problem areas (units), classes, objects and their attributes. Landforms are grouped according morphogenetic characteristics in 10 data groups: slope, fluvial-denudational, fluvial, karst, fluviokarst, glacial, periglacial, aeolian, suffosional and anthropogenic landforms. Based on object-oriented design the logic of software objects was established. It is the basis for the implementation of the logical model into a physical model of geomorphological database. Using UML in object-oriented design, a scheme of geomorphological database was created and then implemented in the geodatabase logical model. Cartographic model of the geomorphological map is defined by 5 groups: geological structure, morphogenetic, morphographic, morphometric and morpho-chronological data. The advantages of such system are numerous. Using a modern GIS based geomorphological map system the process of determination of relief quantitative parameters was accelerated. Unifying of the geomorphological data in spatial databases improved synthetic display of geomorphological features using digital geomorphological map and updating of map content. Clearly defined objects within geomorphologic database also enabled easier correlation and connectivity with other geoscientific databases.

The geomorphological map of the Hérens valley (Switzerland)

MAILLARD B.(1), REYNARD E.(2), KUMMERT M.(2), LAMBIEL C.(2), THELER D.(1)
(1) ECOTEC Environnement SA, SIERRE, SWITZERLAND ; (2) Institute of geography and sustainability, University of Lausanne, LAUSANNE, SWITZERLAND

Within a project dealing with debris flow hazards in the Hérens valley (Valais, Switzerland) a geomorphological map of the whole valley has been produced. The map is based on a legend developed in the 1980s at the Institute of geography of the University of Lausanne. The morphogenetic legend classifies the landforms according to the process(es) responsible of their formation (green for fluvial processes, pink for periglacial processes, etc.) and according to erosional (graphics on white background) or depositional (graphics on coloured background) character. The map has been produced within a GIS environment.

The poster will present: (1) the principles of the legend; (2) the mapping methodology; (3) how the map is used as the basis for the reconstruction of the valley morphogenesis.

****

Geomorphological map of the Diablerets massif - Swiss Alps

SCHOENEICH P.(1), LAMBIEL C.(2), BOSSON J.B.(2)
(1) Institut de Géographie Alpine - PACTE/Territoires, Université Joseph Fourier, GRENOBLE, FRANCE ; (2) Institut de Géographie et Durabilité, Université de Lausanne, LAUSANNE, SWITZERLAND

The Diablerets massif is part of the frontal limestone ranges of the Western Swiss Alps, and culminates at 3200 masl. Geomorphological processes range from glacial and periglacial in its upper part to gravitational, torrential and fluvial processes in the lower parts, and it is concerned by huge powder avalanches. The area includes a very well preserved lateglacial moraine complex, a fluvial terrace system, as well as limestone and gypsum karst.

A detailed geomorphological map at 1:10'000 of its northern slope has been established, using the legend of the University of Lausanne. The field surveys were digitized using orthophotos and a 1 m resolution laser DTM. The map has been edited with GIS and CAD softwares.

The geomorphological survey has been used for lateglacial paleoglaciological reconstructions, for reconstruction of historical and recent glacier fluctuations, and for the assessment of hazards related to permafrost and of torrential hazard. The map covers several registered geomorphosites and will serve for public education as well.

The poster will present the geomorphological map, as well as maps of lateglacial and recent glacier fluctuations.

Adaptation of the geomorphological mapping system of the University of Lausanne for ArcGIS

LAMBIEL C.(1), MAILLARD B.(1), MARTIN S.(1), PELLITERO ONDICOL R.(2), SCHOENEICH P.(3), REYNARD E.(1)

(1) Institute of geography and sustainability, University of Lausanne, LAUSANNE, SWITZERLAND ; (2) Department of Geography, University of Valladolid, VALLADOLID, SPAIN ; (3) Institut de Géographie Alpine, PACTE/Territoires, Université Joseph Fourier, GRENOBLE, FRANCE

The geomorphological mapping legend of the University of Lausanne has been used for more than 20 years for detailed mapping especially in high and middle mountain regions. It is a morphogenetic mapping system built on the following principles:

- The colours represent process categories;
- The signatures have a genetic significance and are drawn in the colour of the related process;
- The morphodynamic differentiation of erosion and accumulation areas is achieved by white and coloured surfaces respectively.
- The morphography, the slope gradient and the lithology are not represented.

The legend was developed first for mapping by hand with colour pencils in the field. In the 1990s, several attempts were made for developing computer-assisted maps, especially by using Adobe Illustrator software. The improvement of the graphical performance of GIS in the last years permitted the adaptation of the legend for GIS to be considered. Through various geomorphological mapping projects, a new version could be developed in ArcGIS 10.0. It consists in a geodatabase containing three Feature Datasets containing respectively the Features Classes “points”, “lines” and “surfaces”. Specific symbols were developed using the Representation tool in ArcGIS 10.0. For some landforms (e.g. alluvial fans, rockglaciers, deltas), it was necessary to combine two or three point, line or surface symbols. Thanks to the ArcGIS version of the legend, it is now possible to map the geomorphology in a GIS environment from the combination of orthophotos, topographical maps and high resolution DEM, that is with reduced field survey.

This poster will present the concept of the legend, the geodatabase and some illustrative examples.

****

Survey the relationship between geomorphology and forest types (Case study: Kheirod forest, North of Iran)

MOEINI A.(1), ALIZADE A.(1), AHMADI H.(1), ETEMAD V.(2)

(1) Science and Research Branch, Islamic Azad University (IAU), TEHRAN, IRAN ; (2) University of Tehran, TEHRAN, IRAN

In Iran, the literature about the relationship between geomorphology units and vegetation in rangeland has been studied, but, due to lake of multidisciplinary information to our knowledge in forest areas such researches have not been regarded. The goal of this study is to survey the relationship between geomorphologic factors and forest types. We studied the relationship in Kheiroud forest in the North of Iran, with the longitude and latitude of 36°27′ _ 36°40′ and 51°32′ _ 51°43′ , respectively. Firstly, in this study we prepare a geomorphology map originating from slope, hypsometry, geology, and aspect maps with the aid of Arc GIS software. The final map was then reclassified.

We also develop a map of the forest types map. Then tow maps (geomorphology and forest types maps) were overlaid. Finally we investigated of both. Using SPSS software, we investigate the relationship between geomorphology factors and evidence of forest types. We relied on ANOVA and found that the geographical aspect had the highest variance and standard error, showing the weakest relationship of the aspect mentioned with the forest types. Also hypsometry and slope represented the greatest correlation with forest types, respectively. The strongest correlations were between geomorphology units and forest types including, Acer Velutinum, Acer Mixed, Querceto–Alnetum, Alnus mixed, Querceto–Carpinetum, Carpineto – Quercetum, Alneto–Acertum, Alnetu–Carpinetum and Fraxinetu. The survey was showed that forest types including Fagus Orientalium, Carpinus Orientalium, Carpineto–Fagetum, Fageto – Carpinetum, Parotio – Carpinetum have the weakest correlation with geomorphology units. We found that these types have the highest adaptability with environment, and that such conditions help them grow in extensive areas of the North of Iran with same weather.

The main geotouristic objects in the Lodz region (Central Poland)

DZIEDUSZYNSKA D., WACHECKA-KOTKOWSKA L.
University of Lodz, Faculty of Geographical Sciences, Department of Geomorphology and Palaeogeography, LODZ, POLAND

The Łódź Region is located in central Poland on the border of the Polish highlands and lowlands. The geological history of the area and variety of processes created landforms which nowadays may attract the tourists.

The oldest geotouristic objects of the Łódź Region are grouped in the south and are connected with the Mesozoic (e.g. limestones with dinosaur traces the Żarnów vicinity is called “Polish Solnhofen” acc. to Kin & Błażejewski 2012). The most numerous geotouristic objects go back to the last glacial episode of the Łódź Region – Wartanian Stage (MIS 6, Late Saalian, Middle Polish Complex). A peculiar group of attractive landforms of the region was formed under periglacial conditions in the Weischelian such as dunes, dry valleys, sections of river valleys, fluvial terraces and structures originating within the frozen ground.

The Holocene objects are connected both with natural and anthropogenetic processes. Human activity in the Łódź Region left the deepest outcrop in Europe at the Bełchatów vicinity (340 m deep) and other excavations, dumpling grounds and geological profiles exposed on the banks of artificial reservoirs.

Work in inventorying of geotouristic sites was carried out in order to compile the Geotourism in the Łódź Region map at a scale of 1:270 000. In the area of 18 218,95 km^2, apart from the above mentioned object, additionally distinguished were objects protected by nature preservation regulations: 23 nature reserves, 11 nature monuments, 43 ecological areas, 32 geosites, geological exhibitions (3 museums, 5 lapidaries, 4 exhibitions).

In the Łódź Region there are 7 landscape parks. Potentially Łódź’s Hills Landscape Park may be chosen as a geopark. It would represent combination of geoheritage - unique polygenetic relief of glacial, periglacial and recent stages in landscape evolution of the region and human heritage.

Investigation founded by Department of Touristic of the Marshal’s Office of the Lodz Region.

****

Hydrogeomorphological mapping in hard-rock groundwater systems

TEIXEIRA J.(1), FREITAS L.(2), AFONSO M.J.(1), ROCHA F.(3), PEREIRA A.J.S.C.(4), MARQUES J.M.(5), CHAMINE H.I.(1)
(1) Laboratory of Cartography and Applied Geology, School of Engineering (ISEP), Polytechnic of Porto and Centre GeoBioTec, University of Aveiro, PORTO AND AVEIRO, PORTUGAL ; (2) Laboratory of Cartography and Applied Geology, School of Engineering (ISEP), Polytechnic of Porto, PORTO, PORTUGAL ; (3) Centre GeoBioTec, University of Aveiro, AVEIRO, PORTUGAL ; (4) Laboratory of Natural Radioactivity / IMAR, Faculty of Sciences and Technology, University of Coimbra, COIMBRA, PORTUGAL ; (5) Centre for Petrology and Geochemistry (CEPGIST), Instituto Superior Técnico, Technical University of Lisbon, LISBON, PORTUGAL

Hydrogeomorphology is an evolving interdisciplinary scientific domain including geomorphology and hydrology. Groundwater is a dynamic and renewable georesource, but in hard-rock terrains its availability is rather limited. Such type of groundwater systems require a comprehensive understanding of geology and morphotectonics, which are controlled by the ground characteristics like weathering grade, fracturing degree, permeability, slope, drainage pattern and density, land cover, and climate. Although hard-rock watersheds are essentially confined to fractured and weathered horizons, they are a source of valuable water resources at a regional level, namely for domestic, industrial and agricultural purposes, and public supply. Hydromineral and geothermal resources have a relevant economic value in the bottled water / thermal spas industry and energy supply, respectively. Hydrogeomorphological mapping was performed in two distinctive groundwater frameworks: an urban area and a hydromineral system. GIS based cartography provided an accurate way to improve knowledge on water circulation models and global functioning of aquifer systems. Thematic maps were organised from a geodatabase comprising several layers namely lithology, tectonic lineaments density, slope, drainage density, rainfall, net groundwater recharge and water quality. Hydrogeochemistry, natural radioactivity and hydrotoponymy issues were also cross-checked. Normalized weights were assigned to all these categories according to their relative importance to groundwater potential, based on their effectiveness factors. These maps were prepared and combined using a GIS platform with the purpose to elaborate an integrated hydrogeomorphological map that might outline the recharge potential areas and infiltration rates. This approach highlights the importance of hydrogeomorphological mapping as a useful tool to support hydrological conceptualization, contributing to water resources sustainability.

Geomorphological analysis on the geological formations in downstream valley of the Da River, the Western Hanoi City, Vietnam

NGUYEN XUAN N.
Vietnam institute of geoscience and mineral resource, HANOI, VIET NAM

Da River is the large river originates from China's Yunnan flows through northwest of Vietnam with a length of 527 km in the direction of the mainstream is Northwest-Southeast, but its downstream segment with 60 km in distance from Hoa Binh town change to the Northward into the Red River in Viet Tri town. This paper presents research results for Da River valley from HoaBinh to VietTri with the semi-automated geomorphological mapping, analysis of 11 surfaces of geomorphological unit and their interaction with the geological formations, the results can be show that the topographical surface is dependent on the geological formations and based on that to determine more accurate surface topography as denudation, erosion, tectonic surface. The article also interprets the time that formed downstream valley of the Da river, through which shows the downstream valley of Da river has just appeared in the middle Pleistocene.

****

Use the of engineering geomorphological mapping for landslide hazard assessments in Hong Kong

PARRY S.
GeoRisk Solutions Ltd, SHEUNG WAN, HONG KONG

As part of the review and updating of the current Hong Kong Government guidelines with respect to the assessment of landslide hazards from “natural terrain”, an evaluation of the level of engineering geomorphological input, in particular mapping techniques, was undertaken. The first stage comprised a review of published literature and completedassessment reports. The geomorphological mapping typically undertaken canbe classified as being direct geomorphological mapping commonlyon a catchment basis at a scale larger than 1:2,000. The implications of the review of completed projects were that a significant number of completed studies are considered to have limited engineering geomorphologicalinput. Consequently, “good practice” illustrated with case studies has been documented.This paper discusses the review and suggested “good practice”.

Mapping flood vulnerability. Case study: Tecuci Town (Romania)

COMANESCU L., NEDELEA A., ZAHARIA L., SAFTOIU L.
University of Bucharest, BUCHAREST, ROMANIA

The aim of this paper is to assess and map the vulnerability to flooding of an area (Tecuci Town) where such phenomena have been present since 2007. In order to produce the flood vulnerability map the following variables will be taken into account: terrain features, assessed with GIS techniques; Hydrological characteristics of the Bârlad andTecucel rivers, based on the data provided by the National Institute of Hydrology and Water Management; Meteorological conditions, relying on the data collected from the National Meteorological Administration.

All numerical data were analyzed and interpreted thoroughly, so that to avoid the occurrence of potential errors. The results were processed by using statistical techniques as well, which allowed the computation of a number of indices that emphasize the general evolution trend. Under the circumstances, we were able to use for our GIS analyses the most accurate datasets. In order to develop the flood vulnerability map we used the following software and digital outcomes: The digital terrain model provided by the National Agency for Cadstre and Land Registration, having an altimetric accuracy of 0.5 m along the main rivers and 0.5 – 2.5 m for the rest of the area; The watershed outline in ESRI format; The land use map of scale 1:50000 in ESRI ArcInfoshapefile format; The geological map of scale 1:200000 in ESRI ArcInfoshapefile format; Orthophotoplans of 0.5 m resolution of the entire watershed in ECW format;

The resulting vulnerability map suggests that Tecuci Town, thorough its geographical position and geomorphological features, lies in an area where floodings are a common phenomenon. Consequently, one can identify the following types of areas: areas never affected by floods, with low flooding vulnerability; areas affected by exceptional floods, with medium vulnerability, and areas affected by floods every year, where vulnerability is high. Every type of vulnerability was mapped differently, by using specific indices

****

Multi-scale and multi-purpose Geomorphological Mapping for landscape evolution, geotourism, slope instabilities, and medical geology

PIACENTINI T., MICCADEI E., DI MICHELE R., RANALLI O., SCIARRA M., URBANO T.
Dipartimento di Ingegneria e Geologia - Università degli Studi "G. D'Annunzio" Chieti-Pescara, CHIETI, ITALY

Geomorphological maps are primary tools for landscape study and management. Mapping at different scales and mapping different features can be focused on different purposes: from basic research to land management, from geomedicine to geotourism.

This work is a contribution of data and examples to enhance modern geomorphological and geothematic maps; examples of Morphotectonic maps, Slope instabilities maps, Geomedical maps and Geotourist maps are presented, at different scales ranging form 1:10.000 to 1:50.000, realized in the main morphostructural sectors of the Abruzzo Region.

The creation of morphotectonic maps in the southern Abruzzo chain-piedmont area is based on drainage basin scale geomorphological analysis within GIS environment and provides a contribution to define the main phases of post orogenic landscape evolution of the piedmont area of the Apennines chain.

In the same area (Aventino - middle Sangro area), a geotourist map is presented. The map is reinterpreted from the geomorphological maps, distinguishing outcropping rocks as concern their surface expression into distinct geological landscapes.

Slope instabilities maps presented in this work outline geomorphological instabilities, triggered by heavy rainfall events that affected the Coastal area Abruzzo Region in the last six years, by means of aerial photo interpretation and field geomorphological mapping. These kind of maps are the base for flooding and slope instabilities hazard analysis and for the estimation of sediment volumes eroded during the events. This is particularly important for minor drainage basins of coastal slopes and coastal hills where erosion and hazard are frequently underestimated.

Finally, geomedical maps are recently developed in many countries incorporating multiple land features: bedrock lithology, surface deposits, pedology, geochemistry, disease distribution and incidence etc. In this work, the first geomedical maps realized in the Abruzzo region is presented.

Ecological-geomorphological features of transboundary interaction in the Irtysh river basin

PLATONOVA S.
Institute for Water and Environmental Problems, Russian Academy of Sciences, Siberian Branch, BARNAUL, RUSSIAN FEDERATION

The paper presents the results of the analysis of environmental and geomorphological features of transboundary interaction in the Irtysh River basin on the border of Russia and Kazakhstan. The study was aimed at identifying the contribution of the border regions of different countries to the transboundary transport of pollutants depending on topographic features. The methodology was based on the evaluation of ecological and geomorphological characteristics of different ecological and geomorphological areas (V.I. Kruzhalin et al., 2004). The areas were defined with the schematic map of natural hazards and risks of geodynamic processes in the transboundary Irtysh basin, comparing the basin boundaries, hypsometric levels, morphological and climate conditions and the boundaries of morphostructural elements. The type of the region state was defined by the direction and nature of air, water and groundwater movement, i.e. divergent, transit, convergent, divergent transit and transit-convergent. Regionally, the divergence zones are presented by slopes of regional watersheds with prevailing denudation. The transit zones involve the channels of large rivers, where the material transport takes place. The convergent type is determined by accumulation of transported material which is found in the end pools. Transit-divergent type is prevalent within the areas with flat surface. Transit-convergent type characterizes the conditions of transport and accumulation of material from fluviolacustrine valleys.As a result of integrated assessment of areas by the type of state (the nature of water and sediment movement) and the total anthropogenic load all the border regions of transboundary Irtysh basin are considered by their ecological wellbeing in terms of transboundary pollutant transport as the "unfavorable", "relatively favorable", and "favorable". The results obtained can be used in the development of a program of international cooperation.

****

Geomorphology explains the regional beta-diversity of French Guiana rainforest and furnishes consistent maps to optimize forest management, regional planning and biodiversity conservation

GUITET S.(1), RICHARD-HANSEN C.(2), BRUNAUX O.(3), CORNU J.F.(4), CAROZZA J.M.(5)
(1) INRA - ONF, MONTPELLIER, FRANCE ; (2) ONCFS, KOUROU, FRENCH GUIANA ; (3) ONF, CAYENNE, FRENCH GUIANA ; (4) IRD, PARIS, FRANCE ; (5) Univ de Strasbourg, TOULOUSE, FRANCE

The aim of this study was to describe the floristic and structural diversity of terra-firme rainforest across the all French Guiana to identify and map different natural habitats in order to better take into account the biodiversity preservation issues in forest management and regional planning.

Twenty six sites distributed over the entire territory had been sampled using a rapid assessment method based on the repetition of 3km-long transects. 92 transects had been implanted and divided into 2750 contiguous 100mx20m plots. All trees larger than 17.5 cm diameter at breast heigh had been measured and identified using a vernacular nomenclature with a good reliability with taxonomic taxa. We used constrained and unconstrained ordination (Correspondence Analysis and Non-Symmetric Correspondence Analysis with or without Instrumental Variable) to analyze the variation in abundance of the 210 taxa and 50 families. The influence of several environnemental factors, including geomorphologic ones, had been tested with partionning methods and compared with multiscale spatial analysis to detect the most important patterns and the most efficient scales to explain beta-diversity.

This nested multi-scale approach allowed us to detect strong broad scale patterns showing a good correspondence with the geomorphologic landscape factor. Geology and rainfall shown less potential to explain beta-diversity and spatial variation. No more structure had been detected on intermediate and local scale but topography appeared to have a strong local but non-structured effect on forest composition. A simplified additive model including geomorphologic landscape and topography effects predict the abundance of 83 taxa out of 210 representing 77% of the trees.

In the context of very old and eroded terrain, as Guiana shield, geomorphologic landscape is the best predictor of trees diversity because of its integrative value summarizing both actual environnemental filters and ancient ecological dynamics.

Multi-temporal mapping of a large, slow-moving earth flow for kinematic interpretation

REVELLINO P.(1), GUERRIERO L.(1), COE J.A.(2), GRELLE G.(1), GUADAGNO F.M.(1)
(1) University of Sannio, BENEVENTO, ITALY ; (2) U.S. Geological Survey, DENVER, UNITED STATES

Periodic movement of large landslides produces modifications of the topographic surface, creates faults and folds, and influences the locations of springs, ponds, and streams. The geometry of the basal-slip surface and the variation in the rate displacement are responsible for differential deformation of the landslide body which can control the position of structures. Thus, large landslides are often composed of several distinct morphologic elements, which often represent kinematic domains within the main landslide. They are broadly characterized by stretching of the upper part and shortening near the toe. On this basis, we mapped structures on the surface of the periodically active Montaguto earth flow in southern Italy between 1954 and 2010. We recognized several kinematic elements and associated structures. Within each kinematic element, the flow velocity was highest in the middle parts, and lowest in the upper and lower parts. As the velocity increased, stretching of the earth flow body induced the formation of normal faults. Conversely, decreasing velocity and shortening of the earth flow induced the formation of thrust faults. A zone with relatively few structures, bounded by strike-slip faults, was located between stretching and shortening areas. The spatial variation in movement velocity associated with each domain, mimicked the pattern of movement for the overall earth flow. That is, the earth flow displayed a self-similar pattern at different scales. Furthermore, the presence of other structures such as back-tilted surfaces, flank-ridges, and hydrological elements provide specific information about the shape of the basal surface. The study offer a preliminary interpretation of the long term-kinematic evolution of the earth flow and the influence of the basal-slip surface on its movement. Main faults remained stationary through time, despite extensive mobilization of material. We therefore assumed the slip-surface has remained relatively similar since 1954.

****

A new interdisciplinary approach to build a geomorpho-archaeological map: the case study of the Versilia plain (NW Italy)

BINI M.(1), BARONI C.(1), RIBOLINI A.(1), ANICHINI F.(1), GATTIGLIA G.(1), PARIBENI E.(2)
(1) Pisa University, PISA, ITALY ; (2) Soprintendenza per i Beni Archeologici della Toscana, PISA, ITALY

The geomorpho-archaeological map is an essential starting point for integrated studies that would like to depict the history of a territories with a holistic approach, considering both natural and human-induced changes. This aspect becomes more and more important taking in account both the open debate regarding the critical transition from natural to anthropogenic-dominated environments, and the time-period characterized by anthropogenic disturbance, almost globally recognized and informally called “Anthropocene”. This study is focused on to identify a new methodological approach based on geomorphological, sedimentological, geophysical and archaeological data, finalized to build a geomorpho-archaeological map. The test area is the Apuo Versilian coastal plain which suffered a lengthy and intense human land-use history, documented by numerous archaeological sites and historical sources. At least since ca. 2700 BP, evidences of human settlement in the area exist, but these become more relevant during roman time as attested by several roman sites. Geologically the area is well studied because it hosts the type site of the so-called “Versilian”, i.e. the Holocene transgression which followed the LGM. The progradation of this coastal plain has been starting since 3000 yrs BP when the coastline was located about 2,5 km landward in respect to its present-day position. The identification of four high-frequency small-scale transgressive-regressive cycles within the succession recording the Late Holocene phase of progradation points out that the progradation rate of the coastline was subjected to cyclic fluctuations. The managing of geomorphological, stratigraphic, geophysical and archaeological data via GIS techniques enables us to explore procedures to integrate natural and anthropogenic occurrences. The reliability of the reconstructed history of the Versilian coastal plain represents a good validation of our methodology.

Geomorphological Map of Piumhi Topographical Sheet (1:50.000) - Minas Gerais - Brazil

RODRIGUES S.C., MARTINS T.I.S.
Universidade Federal de Uberlandia, UBERLANDIA, BRAZIL

This study presents a geomorphological map and research about Piumhi Sheet (1:50.000) located in the upper part of São Francisco River basin, in highlands of central Brazil. The study area presents a complex geological organization with three different structural domains, with sandstones, mudstones, conglomerates, intrusive rocks and Pleistocenic-Holocenic alluvial deposits. The methodology of studies uses GIS technology to generate basic morphometric information as topography, slopes angles, aspect and curvatures and delimitation of drainage basin. The morphogenetic approach was used to make a manual interpretation of satellite pictures and after field works a huge number of particular features were delimited. In the karstic area a complex landscapes with limestone massifs with lapiez fields, sinkholes, uvalas, poljes, blind valleys and caves was identified. The sedimentary region presents a homogeneous fluvial-dissected landscape, and the main rivers presents meandering pattern with large alluvial plains in which features as oxbow lakes and rounded lagoons are mapped. A ridge elaborated in the intrude rocks is located in the south part of the mapped area. The legend of the map was organized to present morphometric and morphogenetic information. The challenge of this study was to map a complex landscape in tropical area and uses a mix of traditional and modern technics of interpretation and presentation of geomorphological data about an area with little detailed information. The interpretation of the evolution of landscape in basis of past climatic changes and the occurrence of neotectonics in the area still a doubt and reinforces the necessity of complementary studies. This geomorphological map is a start that will be used a basis to new researches to be made in a near future.

****

Database development for mapping fluvial channel variations: case study Cecina River (Central Italy)

TERUGGI L.B.(1), CHIAVERINI I.(1), OSTUNI D.(1), FARENGA M.(2)
(1) Dipartimento di Ingegneria Civile e Ambientale, FLORENCE, ITALY ; (2) Instituto de Geologia de Costas y del Cuaternario, MAR DEL PLATA, ARGENTINA

Nowadays, in environmental studies the use of Geographical Information System(GIS) has become an indispensable tool. Advances in GIS technology has increased the contribute that historical maps and aerial photographs can give to the analysis of morphological variations. We report on a study achieved on fluvial morphological changes. Lateral channel migrationwere monitored and mapped and integrated with historical data of some representative reaches.

This study is carried out in the Cecina river watershed. It is located in southern Tuscany, central Italy, and flows into the Tyrrhenian Sea. The Cecina is a gravel bed river, is 79 km long and has a drainage area of 900 km².

To analyze lateral changes a database has been developed using historical maps and aerial photographs of different scales.

Historical analysis of maps and aerial photography data has allowed to measure temporal and spatial changes in the river channel. Channel width and sinuosity index have been measured.

Two representative alluvial reach were selected for monitoring channel tendenciesusing light aircraft and commercial digital calibrated cameras for large scale analysis.

The surveys were repeated after two years. Photogrammetric procedures to generate Digital Elevation Models (DEM) were applied. The net accuracy was 50 x 50 cm. These surveys provided information about channel sediments behavior before and after flow events. The resulting 3D-data were processed with specific software. Comparison between the surveys enabled precise calculation of the volumetric differences between them and the total volume of material eroded and accumulated.

A map of channel surface was constructed in order to identify the distribution and intensity of erosion and sedimentation along channel reaches.

A map of lateral channel variation was developed. In some representative reaches, changes in land-use and forest cover floodplain were mapping and quantified by comparing aerial photographs using GIS data processing.

Using geospatial mobile applications and devices for geomorphological field data collection in mountain areas: a camparison test

BACENETTI M., PEROTTI L., GIARDINO M.
University of Torino - Department of Earth Sciences, TORINO, ITALY

Classical methods for field data collection on geological and geomorphological features are based on the use of relatively simple tools, such as paper notebooks, coloured pencils, base maps… together with the personal skills of researchers. So far, data collected on the field had to be interpreted, summarised and redrawn in order to create base geological and geomorphological maps and/or more elaborated geothematic ones.

In the last 15 years, the use of computers and other electronic devices for collection, analysis and distribution of field data had a notable development also in the Geomorphology and their applications to environmental analysis. This originated effective improvements not only in the field activities, but also in the laboratory ones, in terms of enhancement in both rapidity and precision of data processing, interpretation, and representation. Still, many not-yet-resolved problems concern either the conceptual framework or the practical solutions for field data collection and their transposition into maps.

Technological developments in the geographical application of mobile geoinformation technologies make easier mapping of difficult terrains of rough morphologies and allow quantification of temporal and spatial dynamics of various geomorphological processes. While many developments in GPS and mobile GIS have been considered from the viewpoint of geodesy, their versatility in geomorphological situations has had limited attention.

The paper presents and discusses the results of laboratory and field researches conducted in mountain areas of Europe and Canada, including some considerations on essentials in mapping activities, attributes of geological/geomorphological features and characteristics of Geomatics tools, device and methodologies.

****

Les inondations urbaines dans la ville de Khénifra (pied du Moyen Atlas occidental, Maroc) : caractérisation et cartographie

EL GHACHI M., EL KHALKI YAHIA
Université Sultan Moulay Slimane, FLSH, Av. Ibn Khaldoun, B.P: 524, Beni Mellal, BENI MELLAL, MOROCCO

Le Maroc, comme les autres pays du pourtour méditerranéen, n'est pas à l'abri des inondations même s'il appartient à une zone climatique semi aride. Les inondations ont constitué durant ces 10 dernières années un risque majeur pour le territoire national, surtout pour les villes situées au pied de la montagne.

La ville de khénifra est un exemple de ces villes qui connaissent en permanence des inondations avec une fréquence d'une année sur cinq (1/5). Cette situation de risque peut s'expliquer par divers facteurs liés à son site particulier :

i) position de cuvette au pied du Moyen Atlas,

ii) entre quatre grandes montagnes,

iii) oued Oum Er Rbia qui la partage en deux du Nord au Sud,

iv) présence des 9 châabates (vallée temporaire) qui débouchent sur la ville.

En l'absence des stations hydrométriques, nous avons fait appel à l'approche naturaliste géomorphologique, pour déterminer les zones à risque d'inondation au niveau de la ville de Khénifra. Cette approche se base essentiellement sur le travail de terrain.

En termes de résultats, cette approche cartographique a permis de déterminer les zones à risque d'inondation le long de l'oued Oum Er Rbia et le long des différentes châabates. Elle a permis aussi de caractériser la vulnérabilité et d'identifier les différents enjeux territoriaux.

L'objectif final de ce travail est d'aider la commune de Khénifra via les cartes d'aléa, de vulnérabilité et des zones à risque de prévoir le phénomène d'inondation et de prendre en considération ces zones dans les projets d'aménagement et de protection.

Mots clés : Risque d'inondation – Cartographie –Approche géomorphologique- Chaabates – Ville de Khénifra – Maroc

Geomorphological units of Mainland Portugal: definition and mapping

PEREIRA D.(1), SANTOS L.(2), PEREIRA P.(1), SILVA J.(2), HENRIQUES R.(1)
(1) Geology Centre of University of Porto / University of Minho, BRAGA, PORTUGAL ; (2) Geography Department, Federal University of Paraná, CURITIBA, BRAZIL

A cartography of Mainland Portugal (89,015 km^2) geomorphological units at 1:500,000 scale was produced, constituting the first map of this kind for this country. It follows the traditional definition of physiographic provinces started in the United States of America at the beginning of the XX century though automating the numerical and cartographic analysis of topography and increasing the detail and accuracy of the mapping using GIS procedures. Morphostructure and morphosculpture concepts developed recently in similar works in the states of São Paulo and Paraná (Brazil) were adopted. The 1:500,000 scale allowed the use of a three level classification of Morphostructural Units (level 1), Morphosculptural Units (level 2) and Morphosculptural Sub-Units (level 3). All mapping was performed using digital elevation models (DEMs) obtained from the Shuttle Radar Topography Mission data (SRTM; http://srtm.usgs.gov), supplemented with geological and topograhic maps. The texture of the DEM reflects geomorphological elements that are visually distinguishable in the image (summit surfaces, slopes, valleys and drainage patterns). Variations in relief and drainage patterns were identified through image analysis and used to define different units. The unit boundaries were then checked in the field with their description, photography and coordinates registration. In laboratory all data was assembled into the computer and correlated with the mapping database. From the notes and photos it was possible to resolve conflicts, and to correlate polygons with field observations. The resulting geomorphic map allowed the identification of 3 morphostructural units at level 1, 9 morphosculptural units at level 2 and 56 morphosculptural sub-units at level 3. Quantification was made of parameters like the area of the mapped units, the length of all hydrographic channels, drainage density (horizontal and vertical), altitudinal and slope classes (in area and proportion) for each unit.

****

A GIS based interdisciplinary analysis of Río Quequén Grande watershed in Argentina

TERUGGI L.B.(1), MARIN E.(2), CAPORALI E.(1), VACCARO C.(2), SALA S.(3), KRISTENSEN M.J.(3)
(1) Dipartimento di Ingegneria Civile e Ambientale, FLORENCE, ITALY ; (2) Dipartimento di Scienze della Terra, FERRARA, ITALY ; (3) Facultad de Ciencias Naturales y Museo, LA PLATA, ARGENTINA

The Río Quequén Grande watershed covers an area of about 9.940 km^2 in southeast of Buenos Aires province, Argentina. The region is characterized by intense agricultural activities and it is part of one of the most productive plain in the world. Due to the intensive farming practices a diffuse pollution on the aquatic systems can be identified. Three main vectors that impact the ecological status of water bodies need to be investigated: variation in water quantity, variation in water quality and geomorphology alteration. In this frame, the integration of all the available data, coupled with specific data from appropriate monitoring campaigns is proposed. Particularly, a GIS is developed and an interdisciplinary approach is implemented for mapping water bodies geochemical features and the interactions with the geomorphological context. The watershed is characterized trough a DEM, geomorphological, sedimentological, hydrological and hydraulic data, integrated with biological monitoring data for water quality assessment. The aim of the research is to integrate abiotic and biotic data together with all the available information, to identify natural and anthropogenic spatial heterogeneity and ecological status of the watershed. From source to mouth, textural, chemical and petrographical river bed sediments data and water chemical parameters of the main hydrographic network are monitored and analyzed. Geochemical analyses are obtained by an X-ray fluorescence spectrometer, ARL Advant'X series. The integrated GIS-based modeling cascade from catchment and reaches to aquatic habitat is the broad result of the research. The spatial analyses carried out on the available distributed data integrated with the monitoring on site data lead specific results that are recorded in the integrated informative system. The GIS based system can be used for the watershed assessment and to develop spatially distributed mitigation strategies for a sustainable growth environment respectful.

Geomorphological mapping in Poland

ZWOLINSKI Z.
Institute of Geoecology and Geoinformation, Adam Mickiewicz University in Poznan, POZNAN, POLAND

At the beginning of the 21st century, thanks to the growing of geotechnology, it was possible to proceed with the works which started over half a century earlier. Firstly, there were individual works, then, after a few years, long-term works on resuming geomorphological mapping could be taken up within Association of Polish Geomorphologists. This initiative coincided with the implementation of the INSPIRE directive and the actions of Head Office of Geodesy and Cartography resulting from the directive mentioned. These were the favorable conditions for highly professional preparation for modern geomorphological mapping and support from various institutions. The preparation for geomorphological mapping is divided into three stages:

1. a formulation of content assumptions;
2. a formulation of technical standards;
3. a formulation of editorial and technical assumptions.

When all preliminary goals mentioned above are achieved, it will be possible to initiate a systematic nationwide geomorphological mapping and, subsequently, to edit digital geomorphological maps. For Poland's area there should be 1085 such maps (1:50 000 scale). This project is supported by the regulation of the Council of Ministers of the Republic of Poland(2011).

****

Rainfall intensity, aggregate stability, shear stress resistance as parameters to evaluate soil erosion by water: an experimental study

KEESSTRA S.(1), MARRUEDO ARRICIBITA A.(1), LASSU T.(1), SEEGER M.(2)
(1) Wageningen University, WAGENINGEN, NETHERLANDS ; (2) University of Trier, TRIER, GERMANY

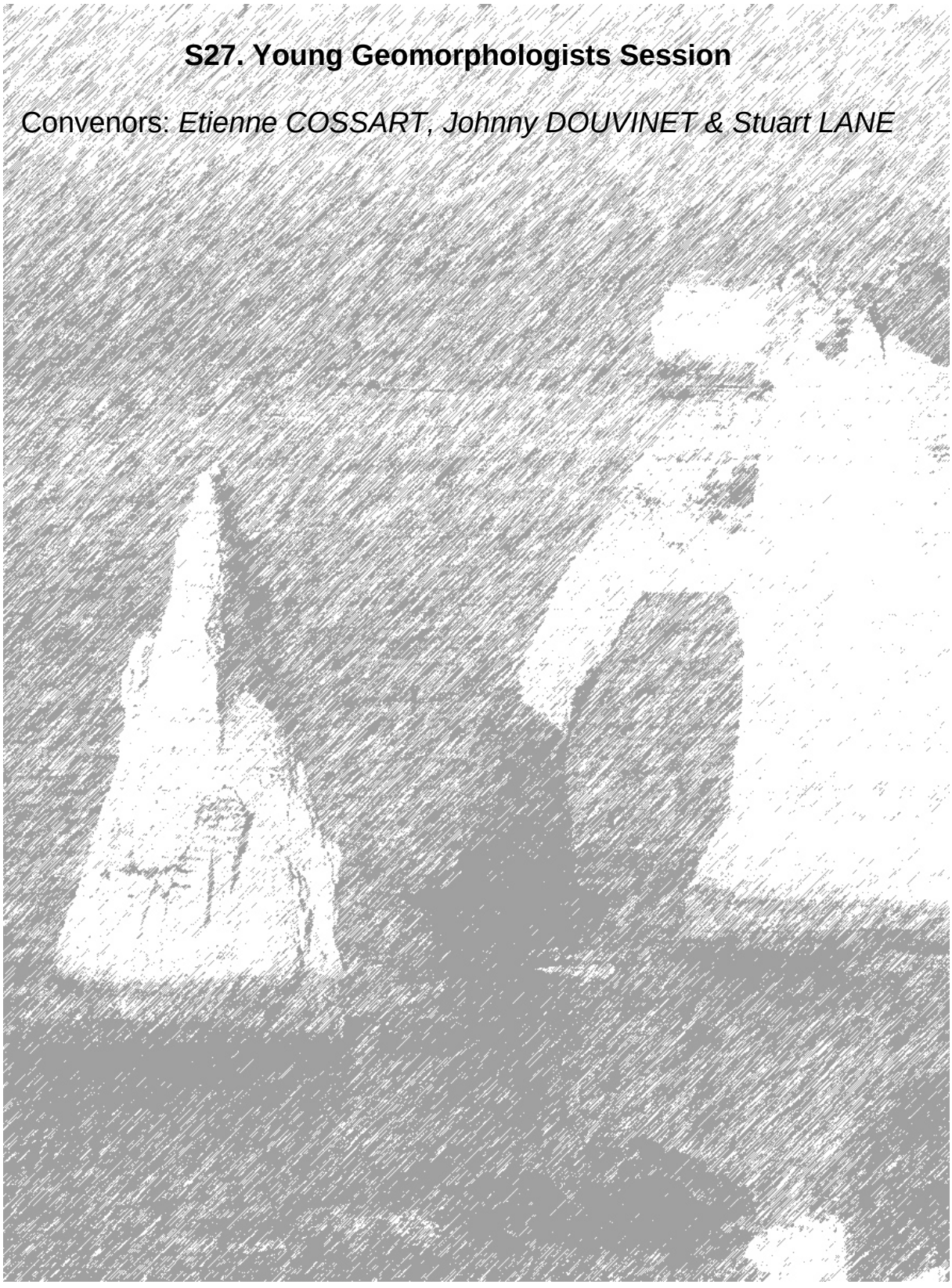
It is generally assumed there is a relation between raindrop impact on soil surface and aggregate disruption. Depending on the rainfall characteristics, this induces changes in the soil's surface and thus, it is assumed that it leads to changes in aggregate size distribution, aggregate stability and shear strength at the soil's surface. In most studies aggregate stability is seen as a constant parameter over time, however, raindrop impact can have a significant effect on aggregate stability. This study explores the influence of different rainfall intensities on changes in aggregate stability and shear strength of a loamy texture soil from arable land in laboratory rainfall experiments. Furthermore it assesses the hydrology and erosion dynamics on the micro scale as well as the micromorphological changes on the plots surface (rill and crust development) to understand initiation of flow paths.

The experimental set up consisted of two experiments in a laboratory rainfall simulator. Each experiment comprised 4 boxes (100cm x 49.5cm) filled with loamy material. Two slope angles, 2.5 and 10-12 degrees were analysed. Rainfall intensity ranging from 30 to 60 mm/h, were used for a period of 5 times 15 minutes (5 repetitions).

The results show that to be able to quantify the complex relationship between the different rainfall intensities and moisture content, Ca cohesive component and aggregate stability, as well as the soil surface roughness changes in time, better suitable methodology is needed. Nevertheless, the results show a clear complex interaction between the analysed components. Thus further research on the influence of different rainfall intensities, slope, soil textural type and crusting processes on the studied variables: Ca cohesive component, moisture content and aggregate stability is recommended. Furthermore, this study showed that the chain method used is not sufficient to assess small scale erosion and deposition processes like observed in this study.

S27. Young Geomorphologists Session

Convenors: *Etienne COSSART, Johnny DOUVINET & Stuart LANE*



Oral presentations:

Morphometry of talus slopes in the high mountains methodological problems

LELEN M.
Pedagogical University of Cracow, CRACOW, POLAND

Talus slopes are significant elements of the high-mountains landscape as a results of denudation process, especially rocky slope and rockwall erosion. They occurs in different geoecological belts. Size, type of longitudinal-profil and development of talus slope are dependent on intensity of geomorphological processes modelling them. Rockwall character is an important factor influencing the formation of the talus slopes. Transfer of weathering debris material from rockwall is due mainly gravity (sometimes with the participation of water, snow and wind). The line of falling of weathering material is various and depends on the rockwall and rocky slope topography. Determination of the exact size of the supply area for talus slopes formation is problematic. It is especially difficult when the remote sensing methods and DTM are used for the studies. So-called „difficult rockwall" with complicated topography and unclear exposure system, require a thorough cartographic analysis and detailed verification in the field. Establishing the direction of transfer of falling debris material requires correlation several factors (exposure, inclination, height, surrounding topography of the rockwall). The problem of determining area from which originates falling debris material do not concern the rockwalls and rocky slopes of the simple topography. Another problems appears when talus slopes extent and and its basic morphometric parameters are measured. So-called „easy rockwall" with not complicated topography not impaired additional difficulties determine them. Compact forest (middle sections of the valley) and alpine vegetation (upper sections of the valley), inaccessible terrain or small size surface are main complicating factors. They cause increasing limit of error in morphometric measurements based on remote sensing methods and DTM. The crucial is using proper compilation methods in the studies to minimize measurement error.

****

Thermal regime of ground surface in the French Southern Alps: a case study from the Clarée and Ubaye valleys

PERRIER R.(1), COSSART E.(2), FORT M.(1)
(1) Université Paris-Diderot, UMR 8586 PRODIG CNRS, PARIS, FRANCE ; (2) Université Paris 1 Panthéon-Sorbonne, UMR 8586 PRODIG CNRS, PARIS, FRANCE

Permafrost is an important part of the cryosphere and a key indicator of climate change in mountain areas. Actual global warming may induce ground warming and lead to permafrost degradation, which in turn may enhance natural hazards such as rockfall, debris flow or slope instability. Understanding and monitoring permafrost thermal regime becomes a fundamental issue to predict its long term evolution.

Physical processes that control ground temperatures, and thereby permafrost in mountain areas, are highly affected by extreme variability in topoclimatic parameters (altitude, solar radiation), ground material and snow specificities. Therefore multiplication of measurements in various topoclimatic conditions should provide a better understanding of the effect of these factors on ground thermal regime. Studies undertaken on this issue in France for the last decades are rare and restricted to very specific areas. We contribute to expand this research to wider sectors of the French Alps.

We present the results of a two years (August 2010-August 2012) monitoring of thermal regime of ground surfaces by applying continuous measurements of Ground Surface Temperature (GST) using Miniature Temperature dataloggers (MTD). In this contribution, data and analyses from GST are presented for two alpine valleys of the southern French Alps (Clarée, Ubaye). Seven sites have been selected depending on their topoclimatic and geomorphological specificities (rockglaciers, rockfall deposits, talus screes) and have been implemented with 19 MTD (Ibuttons®) measuring temperatures with a 3-hour interval.

Results show that thermal regime is highly dependent on local parameters. In summer, ground surface temperature is influenced by air temperature which itself depends on altitude and solar exposure. In winter, snow duration and height are the major parameters influencing ground temperature as it may isolate ground surface from cold winter air temperature.

Recent contributions of dendrogeomorphology for the study of mass movements in an Alpine context

LOPEZ SAEZ J.
Irstea, SAINT MARTIN D'HERES, FRANCE

Dendrogeomorphology relies on the capacity of ligneous vegetation to react to external stresses induced by changes in the environment and to register these impacts in the form of either characteristic annual rings or morphological anomalies. By analyzing the radial growth of trees (in the form of one or several abnormally narrow or wide tree rings), their morphology (scars, resumption of apical growth, change of growth axis, tilting, adventitious roots) and their associated anomalies (formation of reaction wood, tangential rows of traumatic resin ducts, modification of the cell structure), past mass movements such as debris flows, landslides, rockfalls, snow avalanches and erosion can be reconstructed with yearly or even monthly precision. In turn, dating these events allows for the assessment of environmental changes and geomorphic processes on a spatial scale. This presentation will focus on the main dendrogeomorphic methods, starting with the Event /Impact/Response concept, and examines the model's evolution, especially in the Alps. Based of recent progresses in the field of dendrogeomorphology, It will also discuss the model's relevance for the study of geomorphic processes with respect to the knowledge and management of natural hazards and risks.

****

New constraints on landscape sensitivity to glacial-interglacial climate change: A detailed and quantitative record from debris flow deposits in Owens Valley, California

D'ARCY M., WHITTAKER A., RODA BOLUDA D., ALLEN P.
Imperial College London, LONDON, UNITED KINGDOM

The geomorphological evolution of a landscape is controlled by a number of fundamental controls which should be quantifiable, including tectonics, erosion and climate. Fluvial landscapes are known to be sensitive to tectonic boundary conditions; these are recorded geomorphologically and stratigraphically with a response timescale on the order of $10^{5\text{-}6}$ years. Much less is known about how climate controls landscape evolution. Theoretical insights suggest that sediment supply from mountain catchments should be sensitive to climate change, but a lack of observational data means we do not yet know the nature, magnitude or timescale of possible responses. This is very limiting: if we could quantify the independent controls on sediment generation, transport and deposition we may be able to invert observational records (like alluvial fan stratigraphy) to build time-integrated, terrestrial archives of climatic and tectonic history. We provide new insights on landscape sensitivity to climate change from debris flow deposits along the Sierra Nevada front in Owens Valley, California. These deposits have been dated in detail and span the period ~140 ka to present, enabling us to extract a high resolution record of sediment supply and deposition throughout a full glacial-interglacial cycle. By comparison with detailed local palaeoclimate records, we find that alluvial fan stratigraphy is a highly sensitive record of climate change which can also be quantified. We describe new stratigraphic and sedimentological data which reveals the impact of climate change on the catchments, and our data sheds further light on how useful interpretations can be made from (often neglected) debris flow deposits. Furthermore, we document a 10^4 year response timescale following climate perturbations, which challenges popular theoretical ideas about the preservation of climatic signals in alluvial fan deposits.

Study of the spatial interactions in the hydrosedimentary transfers on agricultural watershed

REULIER R., DELAHAYE D., VIEL V., CAILLAULT S., ABDELKRIM B., DAVIDSON R.
Université de Caen Basse-Normandie, CAEN, FRANCE

Erosive runoff is a major cause of land degradation and affects more than one hundred million hectares in Europe.If these processes are well established at the agricultural plot scale, research is shifting towards on the dynamics of hydrosedimentary transfers from fields to streams. In hedgerow context, the dynamics are complex because they are constrained by the landscape mosaic induced especially by anthropogenic developments (e.g., hedges, ditches, roads …). Nevertheless, the analysis of the hydrological role of these linear elements is critical to the good understanding of the watershed functioning. To grasp the role of the man-made networks, knowledge of their localization, their organization, and their induced dynamics is necessary. To this end, two complementary approaches are presented here. First, the revealing of hydrosedimentary transfer with an estimation of sedimentary transfers during different rainfall events will be presented. This expert approach is made possible by field monitoring on a 15 km² catchment area (Lingèvres, Calvados). Secondly, this investigation is complete with the use of a simulation by multi-agent programming (NetLogo). NetLogo is particularly well suited for modeling complex systems evolving over time and enables identification of the role of local interactions (played at the hedge, ditch or plot scale) on the evolution of spatial structures at a higher level (group of plots, basin heads ...).This approach, called bottom-up, allows - a better understanding of the behavior of the studied watershed (global) - to obtain of the hydrologic effectiveness indices at the linear scale (local) –to follow dynamics connections (continuity of the hydrological basin from upstream to the stream). The simulations confirm the field observations and provide new spatial analysis indications (linear impacts on hydrological flow, visualization of input points in the network, location of places of behavioral changes flow…).

****

Morphometric analysis of two calanchi areas in Sicily (Italy) by exploiting high resolution Digital Elevation Models

CARABALLO ARIAS N.(1), CONOSCENTI C.(2), DI STEFANO C.(1), FERRO V.(1)
(1) Dipartimento di Scienze Agrarie e Forestali, University of Palermo, PALERMO, ITALY ; (2) Dipartimento di Scienze della Terra e del Mare, University of Palermo, PALERMO, ITALY

In the Mediterranean areas, specifically in Sicily (Italy), irregular rainfalls, strong seasonal changes, scarce vegetation cover and, frequently, outcropping of clayey deposits favor water erosion phenomena. Badland landscapes are the result of severe erosion processes, characterized by steep slopes, sparse vegetation, high drainage density, rapid erosion rates and a shallow or non existing regolith profile. In this investigation we focused on the *calanchi* badland type, consisting of heavily dissected terrain with steep, unvegetated slopes and channels that rapidly incise and extend headwards. This research was carried out in two *calanchi* sites located in Sicily. The geometry of 25 badland channels was characterized in order to verify if relationships, already tested for minor linear erosion landforms (i.e. rills, ephemeral and permanent gullies), could also be verified for these bigger erosion channels. To this aim, two Digital Elevation Models (DEM) were processed in a Geographic Information System (GIS) environment: the first DEM obtained by a LIDAR survey, with 2 m and 0.1-0.2 m of horizontal and vertical resolution; the second DEM obtained by photogrammetry of 840 images captured by a drone, with 0.3 m and 0.05 m of horizontal and vertical resolution. Each channel was divided into segments delimited by transverse sections. Cumulative length and volume of all channels segments were plotted on scatter diagrams showing highly significant power relationships. Additionally, some morphometric attributes of channels segments (length, volume) and sections (depth, width), were combined into two dimensionless groups, already tested for minor erosion landforms, providing measured pairs also highly correlated by power relationships. The results of this experiment confirm that length of erosion channels is sufficient to predict volume of eroded material and evidence a morphological similarity between rill, ephemeral and permanent gullies and *calanchi* landforms.

Spatial Correlation between Geomorphological and Subsurface Characteristics: A Case Study of Bantul, Yogyakarta, Indonesia

NURWIHASTUTI D.(1), NURWIHASTUTI D.W.(1), SARTOHADI J.(2), MARDIATNO D.(2), NEHREN U.(3)
(1) PhD student at Faculty of Geography, Gadjah Mada University; Department of Geography, State University of Medan, North Sumatra, Indonesia, YOGYAKARTA, INDONESIA ; (2) Faculty of Geography, Gadjah Mada University, YOGYAKARTA, INDONESIA ; (3) Institute for Technology and Resources Management in the Tropics and Subtropics, Cologne University of Applied Sciences, COLOGNE, GERMANY

Bantul has been experienced by several earthquakes creating severe damages. The last major earthquake caused severe damage occurred on May 27th, 2006. The damages in the flat fluvial landform of Bantul had a certain pattern. The damages pattern controlled the subsurface characteristic below the fluvial landform. Understanding the geomorphological and subsurface characteristics of the area is important for earthquake hazard analysis.

Remote sensing and Geographical Information Systems techniques were applied to analyze geomorphological characteristics. Gravity analysis was applied to identify the subsurface structure and the basement depth. While geoelectric analysis was applied to identify groundwater characteristic and sediment depth. Moreover, spatial correlation analysis was used to identify the relationship between the geomorphological and subsurface characteristics.

The results show that fluvial, marine and aeolian landforms have low rock density value based on gravity analysis. These indicate that they were composed by thick unconsolidated material of Quaternary alluvium. While denudational, structural and solutional landforms composed by material of Tertiary rocks have high rock density value. Moreover, the subsurface structure is a asymmetric graben. The sediment depth is varied 3 – 150 m based on the analysis of geoelectric data and drilling data. The thick sediment occupied in the fluvial landform close to the escarpment of Baturagung Range in the eastern part of Bantul. In vice versa, the shallow sediment occupied in the fluvial landform close to the isolated hill and denudational hill in the western part of Bantul. In addition, the water level of groundwater varied 0.30 – 24.5 m. The shallow water table is located in the fluvial, marine and aeolian landforms. While the deep water table is located in the denudational, structural and solutional landforms.

Keywords: spatial correlation, geomorphology, subsurface characteristic

****

Geomorphic mapping for environmental management in urban areas (case study of Moscow parks)

SAMSONOVA S.
Moscow State University, MOSCOW, RUSSIAN FEDERATION

Moscow city is one of the biggest megalopolises in Europe, with a population of more than 10 million occupying over 1,000 sq. km of territory. Environmental management is the newest type of land use in Moscow which is represented by the system of protected areas (19 existing and 20 planning). All protected areas in Moscow have administrative borders which do not match with natural landscape borders. All parks are isolated; include pieces of private property and infrastructure. To ensure sustainable development of green areas in Moscow it is necessary to monitor natural landscapes within the boundaries of parks, but also adjacent urban landscapes which are represented by residential areas, roads, industrial zones etc. In order to improve the management at the local level, a specific methodological approach was applied.

The approach is based on geomorphic mapping of urban areas and includes series of maps:

1) land use;

2) morphomerty (elevation, slopes, aspects, plan and profile curvature);

3) streams and watersheds;

4) urban landforms (buildings, roads) and it's relation to natural landforms;

5) geomorphological zones.

It is strongly recommended to take into consideration geomorphologic features of the territory, its historical and cultural specifics, the land use structure and the influence of neighbouring areas, including technogenic landforms. The method, implemented by the author, combines all these parameters and, thus, provides a complex geomorphic monitoring on protected areas. This research aims to develop recommendatory schemes for city administration in order to improve environmental management and ensure sustainable development of urban protected areas.

Exploring geomorphic and vegetational features of low energy rivers using GoogleTM Earth

SEKARSARI P.(1), GURNEL A.M.(1), HENSHAW A.J.(1), ZOLEZZI G.(2)
(1) Queen Mary University of London, LONDON, UNITED KINGDOM ; (2) University of Trento, TRENTO, ITALY

Google™ Earth provides an enormous potential source of information on the character of rivers worldwide over the last decade. This paper describes research that is investigating properties of low energy, single thread river channels and their floodplains in order to assess the variety of characteristics shown by such rivers across Europe as environmental conditions change. There have been many attempts to differentiate characteristic geomorphic features and categorise such river systems (e.g. Schumm, 1985, Nanson and Croke, 1992), and recent work has illustrated that riparian vegetation may also be influential, in addition to the physical properties of sediment and flow regime (e.g. Eaton et al, 2010). By using Google™ earth as a data source, this research has assembled a data set describing both channel dimensions (planform, width, gradient), floodplain and channel geomorphic features, and vegetation structure and extent of approximately 100 European rivers. This data set underpins empirical exploration of interrelationships between river and floodplain properties and riparian vegetation and supports the identification of different low energy river types. Early analyses have already revealed associations between longitudinal channel width variability, planform sinuosity, sediment bar and vegetation structure and reach-averaged hydraulic properties computed with a simple 1-D mathematical model.

References

Eaton, (2010). Channel patterns: braided, anabranching, and single-thread. *Geomorphology* 120, pp 353-364.

Nanson, G. C. & Croke, J.C. 1992. A genetic classification of floodplains. *Geomorphology*. Volume 4, pp. 459-486.

Schumm, S., 1985. Patterns of alluvial rivers. Annual Review, *Earth and Planetary Sci.*, 13, pp. 5-22

****

Typology of eolian landforms of South Kharga oasis (Western Desert of Egypt): original evolution models and local specificities of Saharan loess deposits

CREPY M., CALLOT Y.
Laboratoire ArcheOrient (UMR 5133 CNRS - Universite Lumiere Lyon 2, Maison de l'Orient et de la Mediterranee, LYON, FRANCE

The Western Desert of Egypt is the largest area of high aridity in the world. In this kind of environment, wind and eolian dynamics have a great influence on morphogenic processes. The study of eolian dynamics and associated landforms is very important in arid areas where there is human occupation or archaeological sites: eolian landforms can be both a resource (arable land, moisture-retaining places and soil formation) and a constraint (ablation, wind abrasion and sanding up).

In Kharga Oasis, which receives less than one millimeter of mean annual rainfall, there are many contemporary cultivated fields and villages, thanks to deep wells in the Nubian Sandstone Aquifer System. During Antiquity (from the beginning of Persian domination to late Roman times), this area was already affected by hyper-aridity and wind effects: archaeologists from the IFAO (Institut Français d'Archéologie Orientale) have revealed that the water resource was artesian and that some remains of buildings in the south of Kharga oasis present architectural features related to defence against wind abrasion or sanding up. Moreover, many remains of ancient fields or buildings are located on top of yardangs composed of eolian sediment.

This work in Kharga oasis attempts to identify specific aspects of eolian dynamics and their Holocene evolution, especially from 2500BP to the 21th century. The first results show that:

Some thick fine-grained deposits, previously thought to be playa-deposits are Saharan loess deposits which had been used as arable land during Antiquity. The relation between this kind of deposit and artesian springs or cultivated fields is highlighted.

Some eolian forms, barchans for example, do not follow a classic evolution model.

Several deposition and ablation phases occurred during the Holocene. Ablation and deposition were very rapid.

Eolian sediment is very important for agriculture, and fields function as sediment traps.

Poster presentations:

Tectonic sway on alluvial fan trilogy at Himalayan foothills

MANDAL S.(1), SARKAR S.(2), BOSE P.K.(2)
(1) ASUTOSH COLLEGE, KOLKATA, INDIA ; (2) JADAVPUR UNIVERSITY, KOLKATA, INDIA

Similar evolutionary history of 3 Quaternary alluvial fan systems spread over a linear distance of ~100 km at immediate south of the Mountain Front Thrust of Eastern Himalayas manifests neotectonics at the aftermath of the orogeny.DEMs delineate fans of 5 different generations within each of the 3 fan systems,belonging to the Rivers Tista,Chel and Neora-Murti.The 3 fan systems shrank over time and apices of their constituent fans tended to shift upslope,although the active river channels incise deeply through the systems.Diversion of axes and overall increase in slope,tilt,as well as convexity of the fans through time evinces influence of tectonism rather than climatic shift to aridity on evolution of the fan systems.Progressive increase in maximum clast size and enhanced contribution from successively older formations in the massflow fan facies are in good agreement with sediment source uplift.Preferred concentration of SSD structures along the fan contacts traced over a distance in excess of 100kms further elicits the tectonic effect.

On the other hand,either upheaval of the piedmont or significant enhancement of water discharge caused deep incision of the presentday channels through the fan systems and formation of unpaired terraces on their banks.Topographic profile and the basement configuration reconstructed from known gravity anomaly data documents a basement depression along the axial lineament of which runs the Tista on the piedmont.On both flanks of the depression other rivers show overwhelming tendency to incise deeper as well as to migrate closer towards the Tista.Rapid downward migration of the Tista presumably dragged the water table down towards the valley axis and compelled the rivers on the valley flanks to swerve sharply towards the Tista digging deeper simultaneously to reach the inclined water table.This tectonically induced incision and migration,however,stopped effectively sometime before 1962 in case of two rivers,viz.,the Mahananda and Chel.

****

Identifying complex internal architecture in debris flow and lahar deposits using ground penetrating radar

STARHEIM C.(1), GOMEZ C.(1), DAVIES T.(1), OWENS I.(1), HADMOKO D.S.(2), WASSMER P.(3), LAVIGNE F.(4)
(1) University of Canterbury, CHRISTCHURCH, NEW ZEALAND ; (2) Universitas Gadjah Mada, YOGYAKARTA, INDONESIA ; (3) Université de Strasbourg, STRASBOURG, FRANCE ; (4) Université Paris 1 Panthéon-Sorbonne, PARIS, FRANCE

Debris flows and lahars help shape many mountain and volcanic landscapes around the world, yet current understanding of their flow and deposition processes has been largely restricted by the nature and unpredictability of events. One approach used to circumnavigate these inherent limitations has been to focus research on the interpretation of post-event deposits using conventional stratigraphy, sedimentology, and geomorphology. As channel bank exposures, erosional outcrops, and depositional surfaces are most easily accessed during forensic survey of deposits, findings typically over-represent the longitudinal profile of deposits, with comparatively few studies comprehensively examining the internal architecture of deposits parallel and perpendicular to the flow path. Recognizing this, the present study integrates ground penetrating radar (GPR) surveys, geospatial data, and forensic field observations to investigate debris flow and lahar deposits at high spatial resolutions along their longitudinal and transverse axes. Although corroborative evidence from GPR surveys and field observations frequently verified the presence of primary stratigraphic deposit features (e.g. inversely graded beds), GPR imagery exposed additional sub-surface architecture that was not readily discernible using only field-based visual observations. Distinctive deposit sub-units identified with GPR imagery were thought to reflect individual flow surges and/or discrete flow events. Findings from ancillary analyses of lahar video-imagery and modelled debris flow deposition patterns are discussed in an effort to further explain the internal architectural features identified in this study. As well as demonstrating the need for continued investigation of deposit architecture using non-traditional techniques, these findings are expected to generate improvements to post-event deposit interpretations.

The use of a rain simulator as an infiltrometer at Kinshasa (D.R. Congo)

MAKANZU IMWANGANA F.(1), MOEYERSONS J.(2), NTOMBI M.(3)
(1) Laboratoire de Géomorphologie et Télédétection, Centre de Recherches Géologiques et Minières (LAGEOT/CRGM), KINSHASA, CONGO (THE DEMOCRATIC REPUBLIC OF THE) ; (2) Division of Geomorphology and Remote Sensing, Royal Museum of Central Africa, TERVUREN, BELGIUM ; (3) Département des Sciences de la Terre (Géographie-Géologie), Faculté des Sciences, Université de Kinshasa, KINSHASA, CONGO (THE DEMOCRATIC REPUBLIC OF THE)

The partial contribution of different soil uses to the alimentation of mega-gullies has been studied in Kinshasa. The water infiltration envelope for several soil uses on slopes varying between 5 and 10° has been defined. A rainfall simulator of the sprinkler type (KULeuven)has been used as an infiltrometer. The circular impluvium of this apparatus has a diameter of ±3 m.

The envelope is established by measuring the time between the start of the constant artificial rain intensity and the moment that a runoff runnel goes 10 cm beyond the impluvium border. This procedure is followed on the same site in three impluvia with the same soil use. The rainfall intensity varies for every impluvium. The envelope is the power trend line through the three points in a graph with logarithmic scale where the Y-axis indicates the applied rainfall intensity (mm h^{-1}) and the X-axis the time to runoff (seconds). On every impluvium a ring infiltrometer has been used to measure the hydraulic conductivity of the soil at his initial state of water content.

The tested soils are sands (mean D_{10} of 100µm) and show a mean recalculated hydraulic conductivity of 354 mm h^{-1} and a mean bulk density of 12.7 kN m^{-3}. Runoff generation varies considerably from one soil use to another. Earthen roads and other hard bare surfaces quickly produce runoff. The other soil uses with vegetation generate retarded runoff. Generally speaking, time to runoff is proportional to the degree of vegetation soil cover and inversely proportional to the bulk density of the soil. There are two particularities: loose bare sands colonized by a thin layer of lichen and grass-plots with a root mat (Paspalum notatum *sp*.). Both quickly produce runoff and join the group of the bare and compacted surfaces. The other soil uses are rather weak runoff generators and can only significantly contribute to the alimentation of gullies in the case of exceptional rains.

Keywords: gully, infiltrometer, rainfall simulator, runoff, soil use

****

Spatial distribution of beach ridges in the Intra-Americas Seas islands: a supervised manual investigation using Google Earth

CESCON A.L., COOPER J.A.G., JACKSON D.W.T.
University of Ulster, COLERAINE, UNITED KINGDOM

Beach ridges landforms are still under debate about their formative process. If along the tropical coasts we can observe occasionally one or two beach ridge landforms, when they occur in wide plains they are easily identifiable.

This work considers the beach ridges of the islands in the Intra-Americas Seas. Using Google Earth it aims to identifying and describing almost all the beach ridge plain sites.

We used a human-supervised approach to identify and characterize beach ridges landforms and plains on Google Earth available images in 2012. This kind of work can be done because the shape of beach ridges can be well defined on remote sensing imagery material by a human observer.

Not only were the position of all beach ridge sites and their number recorded, but also other qualitative and quantitative elements that can be observed on the imagery, like the distance from the reef, the vegetation cover or the approximate percent of building cover over the plains.

The number of beach ridge plains in this area is significantly greater than what was expected. More than 100 beach ridge sites were identified and almost 200 other possible sites. In the Bahamas where more than 100 possible sites were identified there is no literature about modern beach ridges to our knowledge.

This work represents a first attempt to identify and characterize the beach ridges in these areas at a very high spatial resolution. The quantitative and qualitative observations were discussed in each context to isolate some beach ridges categories for the Intra-Americas Seas geographical area.

A methodological framework for the spatial decision support of the management of coastal wetlands

ZOUVA C.(1), GAKI-PAPANASTASSIOU K.(2)
(1) Department of Geography and Regional Planning, Faculty of Rural and Surveying Engineering, National Technical University of Athens, ATHENS, GREECE ; (2) Department of Geography - Climatology, Faculty of Geology and Geoenvironment, National & Kapodistrian University of Athens, ATHENS, GREECE

Coastal wetlands, such as lagoons and deltas, considering their geomorphology and ecological status, are complex and sensitive environments, directly threatened by climate change. It is important to develop methodologies and models with modern technological tools for their effective vulnerability assessment and management against the rise of the sea level. Therefore, understanding and interpreting this problem is important and necessary today, not only for practical reasons but also for the challenge to the theoretical framework. The aim of this paper is to summarize the theoretical background of this issue, stressing the gaps and then, propose a new methodology by using G.I.S. and Fuzzy Logic. This will help decision-makers in the effective management of coastal wetlands that are at risk from the future sea-level rise. The proposed methodology examines the variables which are related to the problem by forming a geodatabase and making an initial classification of the coastline. These variables will be transformed into fuzzy sets, expressing the uncertainty input in the system. The appropriate membership functions will be proposed and the parameters will be ranked according to weights, so that the decision makers will be able to compare different vulnerable regions in coastal wetlands in a flexible and non data-driven manner. The discussed approach will be applied in a typical coastal wetland of continental Greece, in order to validate its efficiency.

****

Interaction of tectonic, karstic and sedimentary processes in Early Pleistocene deposits (central Ebro Basin, NE Spain)

GIL H., SORIANO M.A., LUZÓN A., PÉREZ A., POCOVÍ A.
Universidad de Zaragoza, ZARAGOZA, SPAIN

Sediments and deformation structures of the oldest alluvial Quaternary deposits located in the central Ebro Basin are analysed. Miocene continental detrital deposits, evaporites and carbonates filled this zone. Quaternary detrital materials, mainly alluvial, covered partially the former. In this context, the Early Pleistocene deposits correspond to gravel bars of braided fluvial system with high availability of water. Interbedded aeolian sands and, less frequently, lutites deposited in small lakes, are present. Vertical and lateral relations show a clear interaction between these environments. These materials were deposited during the Matuyama chron, with reverse polarity, as paleomagnetic data obtained from samples indicate.

These deposits show deformation structures with varied genesis and scale. Faults and fractures are frequent and affect to gravel and sand. Their main trends are NNE-SSW and NW-SE being consistent with the regional stress field and with the fracturation of the Miocene substratum. This mayindicate a structural control of the deformation in Quaternary materials. Moreover, structures with rounded, tubular and synform morphologies disrupting the Pleistocene sediments are observed. The sediments can be either structured or unstructured and the deformation can be syn- and post-sedimentary. Collapse, subsidence and suffosion are the main processes involved in their generation. These structures are interpreted as related to karstification of evaporites at depth. In addition, karstification caused the existence of subsiding areas where an increase of sediment rates, development of diverse sub-environments and modification of environments location took place. At the same time, karstification generated sedimentary accommodation space and facilitated the preservation of fine deposits (as for instance aeolian dunes) that, in other circumstances, will be easily eroded by the activity of the gravel braided river.

Lake Allos: a 12,000 year reference record of past climate-Human-environment interactions in the Mediterranean French Alps

BRISSET E.(1), MIRAMONT C.(2), GUITER F.(2), TROUSSIER T.(2), ANTHONY E.(3), ARNAUD F.(4)
(1) CEREGE/IMBE Aix-Marseille University, AIX EN PROVENCE, FRANCE ; (2) IMBE - Aix-Marseille University, AIX EN PROVENCE, FRANCE ; (3) CEREGE - Aix-Marseille University, AIX EN PROVENCE, FRANCE ; (4) EDYTEM, CHAMBÉRY, FRANCE

Lake Allos lies in a cirque in the southern French Alps at an altitude of 2200 m. A 15 m-long core down to the lake substratum was obtained in 2011 and multiproxy analyses conducted on core sedimentology, geochemistry, and palynology, supported by a relevant age-depth model (22 ^{14}C AMS ages). Preliminary sedimentological observations of thin sections under the scanning electron microscope show: (1)millimetre to centimetre-thick detrital graded-bed layers that may be attributed to detrital inputs by rivers flowing into the lake; (2) clayey laminae containing poorly sorted detrital particles deposited during spring ice-melting of the lake; (3) homogeneous matrix-supported layers indicating recurrent intra-lake sediment destabilization between *ca.* 8000 and 3000 cal. BP.

These facies suggest four main palaeoenvironmental phases. From 12,000 to 10,500 cal. BP, organic-poor sediment indicates seasonal detrital inputs probably associated with glacier retreat in the Allos catchment. Organic matter content increases after 10,500 cal. BP with mainly biogenic laminations of algae and terrestrial micro-remains, whereas detrital layers are less frequent up to 9000 cal. BP. These conditions indicate a phase of forest colonization and stable soils probably due to efficient sediment retention on slopes. Detrital layers become more and more frequent after 6300 cal. BP, and their thickness has increased since 2500 cal. BP, signaling a phase of slope instability and forest retreat due probably to climate deterioration and/or increasing human pressure through deforestation and pastoralism.

These multi-proxy analyses and the reconstructed sediment dynamics will subsequently be discussed in the light of the pollen record that is currently being established, thus enabling elucidation of anthropogenic and/or climatic controls on Lateglacial/Holocene sedimentation.

****

Geomorphology of Sylhet City, Bangladesh - for Sustainable Urban Planning

HAQUE N., SHAMSUZZAMAN .., RAHMAN M.A., EKRAM A.R., UDDIN N., HASAN F.
Geological Survey of Bangladesh, DHAKA, BANGLADESH

Sylhet is one of the oldest cities in the north-eastern part of Bangladesh. People are living here from ancient period but now experiencing rapid growth and unplanned expansion of the city. The city has been expanding rapidly without taking consideration of geomorphological parameters. Rapid urbanization without planning compelled to face the area with various geo-hazard problems. The present study has been carried out to provide geomorphological map and related information of the city area and probable use of the map units which may help to future city planning.

Geomorphologically, the area has been classified into two broad units - Fluvial and Hilly units. Fluvial unit is sub-divided into twelve units. Hilly unit is sub-divided into four units. Total mapped area is about 160 sq. km. Among the area, flood plain and natural levee comprises about 40%, backswamp about 15%, Piedmont about 13%, alluvial fan about 10%, level hill about 9% and other 13%. Average height of the area is about 18.856 AMSL. Northern part of the area is characterized by low bounded hillocks which are 30 to 70 meters high. Slope of the area is toward the south direction. Minimum slope is 0.5 degree in floodplain and maximum is 25 degree in hill slope region. The Surma river produces the main drainage system of the area but average drainage density is low.

Each geomorphic unit has some potential uses. Some units are suitable for residential and some may be used for recreation and industrial purposes. Analyses of some data show that different unit faces different geo-hazard problem such as flood, bank erosion, flash flood, land slide, rill and gully erosion etc. The outcome of the study may play key tools for planners and decision makers for sustainable development of the city area and also as a model for other urban area of Bangladesh. Maps may also be used as base map of hazard vulnerability assessment of the area.

Assessing the impact of the pipeline on the swamp geosystems

ADAM A.
INSTITUTE FOR WATER AND ENVIRONMENTAL PROBLEMS SIBERIAN BRANCH OF THE RUSSIAN ACADEMY OF SCIENCES, BARNAUL, RUSSIAN FEDERATION

The interaction ofa gas pipeline with a range of environments have different repercussions both for a gas pipeline and for the surrounding environment. In this paper, the problem of the interaction betweenthe gas pipeline and wetlands in the south of Western Siberia is considered. The swamp under study is an oxbow swamp located on the terrace above the floodplain of Chumysh River, a large right tributary of the Ob. The swamp area is about 40 km^2, it stretches for 5 km from north to south and up to 6.5 km from east to west. Based on a study, the peculiarities of the interaction of engineering construction and swamp geosystems were revealed, the dynamics was assessed, and theforecast of geomorphic processes development was made. The forecast of the swamp impact on the gas pipeline was done.

****

Modelling sediment transport: Evaluating the effects of spatially refined input data

WERB S., DELGADO J.M., BRONSTERT A.
University of Potsdam, POTSDAM, GERMANY

Hydrological models working at the meso-scale are often based on a lower degree of spatial information. Giving consideration to computation times, the larger the modelling domain, the less information of individual hillslope components can be accounted for. However, the spatial representation of soil and vegetation patterns can have considerable effects on partially connected sediment delivery towards the channel system.

The spatially semi-distributed model WASA-SED (**W**ater **A**vailability in **S**emi-**A**rid Environments – **SED**iments) uses a bottom-up aggregation scheme. In this study it is applied to simulate sediment transport at the Isábena catchment (445 km²) in the Central Spanish Pyrenees. This catchment includes a large system of badlands these being one of the major sediment sources, driving the severe siltation of the downstream Barasona reservoir.

Improved data availability of climate and hydrological data as well as the spatial information of land-use patterns provided by high resolution satellite data such as Rapid Eye images may improve simulation efficiency. Different parameterisations of the model are used for independent simulations in order to understand the effect of spatially refined input data. As a result improved calibration techniques can be applied. It is to be evaluated how a refined spatial resolution of input data affects the efficiency of water and sediment transport.