ative to the fault tip. Three-dimensional boundary element analyses show that the fracture and fissure patterns are consistent with the along strike propagation of a normal fault as it grows towards the surface.

T21C MCC: Level 1 Tuesday 0830h

Taking the Measure of Deforming Landscapes I Posters *(joint with G, H)*

Presiding: **M A Ellis,** Center for Earthquake Research and Information, University of Memphis**; A L Densmore,** Institute of Geology, ETH Zürich

T21C-0461 0830h POSTER

Convergence history, topography, and early structural evolution of an obliquely convergent oceanic plate boundary: central and southern Macquarie Ridge Complex, Southwest Pacific

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Deformation along the Australian-Pacific transpressional plate boundary south of New Zealand (Macquarie Ridge Complex - MRC) since 5.9 Ma (anomaly 3Ay) has been accommodated by vertically displaced crust and variable amounts of strike slip faulting and/or underthrusting. Variable convergent histories result from the interplay of the close proximity of a drifting pole of rotation and the curvilinear trace of the plate boundary fault. We apply geomorphologic techniques to swath bathymetry data to quantify the amount of interplate deformation along three, distinctly oriented, 300-350-km long segments of the plate boundary since 5.9 Ma. Between 51°S and 61°S we calculate volumes of crust within 70 km of the plate boundary that are vertically displaced from the average seafloor depth occurring beyond the zone of active deformation. These volumes are compared to: (1) variable convergence angles, (2) the cumulative amount of perpendicular convergence predicted by stage pole rotations, and (3) active faulting at the seafloor in order to characterize the geodynamic evolution of the three different regions. Displaced volumes (anomalously shallow and deep bathymetry) adjacent to the plate boundary are proportional to the cumulative amount of plate boundary-normal convergence since 5.9 Ma. We integrate our results with four gravity transects across the central and southern MRC, illustrating the lithospheric-scale morphologic and structural evolution as underthrusting initiates at this obliquely convergent oceanic plate boundary. Along-strike morphologic changes in the MRC can be attributed primarily to the variable angles of convergence since 5.9 Ma. A convergence angle of $\sim$25° marks the transition from strike-slip dominated faulting and large displaced crustal volumes to partitioned underthrusting and strike-slip faulting, and relatively low displaced volumes. Regions where convergence angles have not exceeded 25° correspond to significant bathymetric troughs, representing failed attempts to develop thrust faults. Active thrust faults and deeper bathymetric trenches occur where convergence has been $>$25° since 5.9 Ma. Thus the MRC can be used to help constrain some of the convergence characteristics necessary for establishing underthrusting at obliquely convergent oceanic lithosphere settings.

T21C-0462 0830h POSTER

Rates of Fault Growth and Landscape Development in Central Otago, New Zealand

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Central Otago is a region dominated by NE trending anticlinal ridges which form above buried reverse faults. Slow average velocities (3-5 mm yr^{-1} from GPS), coupled with low erosion rates due to the aridity of the region make this an ideal area to study landscape forming processes over unusually long time periods. DEM and drainage pattern analysis of the Rough Ridge system shows that South Rough Ridge has propagated northwards, pushing the Oliverburn stream to the north as it does so. This stream has cut strath terraces, which record the history of the progressive movement of the stream. After abandonment, these terraces are uplifted and warped by the continuing growth of the ridge. Quartzite boulders on the terrace surfaces were analysed for cosmogenic ^{10}Be and ^{26}Al in order to gain an approximate age for the abandonment of each terrace. Whilst the exact time at which a river cuts down and begins to create a new strath terrace may depend on many variables, such as a change in climatic regime, the relative timing of abandonment of all of the terraces must be a proxy for the growth of the ridge, as it is controlled by the movement of the stream northwards. The progressive warping of higher terrace surfaces and the lack of terrace surfaces of a similar height in the basin to the east of the range indicates that local, rather than regional, base level changes are the controlling factor of terrace formation. The qualitative interpretation of the geomorphology of this region is confirmed by the cosmogenic results. On the tip of South Rough Ridge we obtain an average uplift rate of 0.10-0.15 mm yr^{-1} and a lateral propagation rate of 1.0-2.0 mm yr^{-1} averaged over the last 450,000 years. On neighbouring Rough Ridge, we also obtain minimum ^{10}Be ages of 1 Myr, indicating extremely low erosion rates in this area.

T21C-0463 0830h POSTER

Topographic Development and Exhumation of the Santa Cruz Mountains, From Fission Track Data and Deformation and Erosional Modeling

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Tectonic uplift within and advection of material around restraining bends along strike-slip faults is a controlling factor on the topography in these tectonic environments. We investigate the deformation, exhumation, exposed rock types, and topography within the Santa Cruz Mountains (SCM) along the San Andreas Fault to understand how topography develops in this region due to the presence of an 8^{o} restraining bend. Thermochronologic studies indicate that rock uplift is concentrated within an $\sim$30–40 km long zone to the northeast of the restraining bend. Specifically, reset Apatite Fission Track (AFT) samples in the Sierra Azul portion of the SCM indicate that at least three kilometers of exhumation has taken place in the last 3 Ma, while un-reset AFT samples southwest of the fault indicate that exhumation has been limited. We modeled the total amount of rock uplift through time experienced by crust moving through this restraining bend using the Poly3D boundary element model. We found that even when rock uplift was maximized by fixing the restraining bend to the northeast plate, it was insufficient to reset AFT samples within the Sierra Azul block. Therefore, active contractional structures that strike parallel to the SAF are apparently required to localize uplift in this area and bring rocks from greater than 3 km to the surface. We used Digital Elevation Model and Digital Line Graph analyses of the topography to constrain the amount and distribution of basin relief in areas that have undergone large and small amounts of exhumation along the northeast and southwest sides of the fault, respectively. High basin relief and averaged hillslope angles were correlated most strongly with different geologic units, and to a lesser degree, locusts of uplift defined by the AFT data. Therefore, basin relief appears undiagnostic of high uplift rates within this area without accounting for variations in erosional resistance between lithologic units. To understand the relative role of rock erodibility and uplift in the construction of relief in this area, we have coupled a three-dimensional erosional model that considers bedrock incision to the deformation predicted by the mechanical boundary element model. We are using this model to calibrate the erosional parameters required to produce the topography observed in this area. We will then use this model in a forward sense to assess the conditions under which rock erodibilities and/or rock uplift rates dominate the topographic signature in these types of environments.

T21C-0464 0830h POSTER

Lateral propagation of folding and thrust faulting at Mahan, S.E. Iran

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Folding identified near the town of Mahan in S.E. Iran has no record of historical activity, and yet there are clear geomorphological indications of recent fold growth, presumably driven by movements on underlying thrust faults. The structures at Mahan may still be capable of producing destructive earthquakes, posing a considerable hazard to local population centres. We describe a drainage evolution that shows the effect of lateral propagation of surface folding and the effect of tilting above an underlying thrust fault. River systems cross and incise through the fold segments. Each of these rivers show a distinct deflection parallel to the fold axis. This deflection starts several kilometres into the hanging-wall of the underlying thrust fault. Remnants of several abandoned drainage channels and abandoned alluvial fans are preserved within the folds. The westward lateral propagation of folding is also suggested by an increase in relief and exposure of deeper stratigraphic layers across fold segments in the east of the system, implying a greater cumulative displacement in the east than in the west. The preservation of numerous dry valleys across the fold suggests a continual forcing of drainage around the nose of the growing fold, rather than an along strike variation in slip-rate.

T21C-0465 0830h POSTER

Control of Bedload Sediment Supply Upon Bedrock Incision and River Longitudinal Profile in the Eastern Central Range, Taiwan

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Rivers (drainage areas: 130-620 km2) draining the eastern slope of the Central Range, Taiwan, show distinct erosion/sedimentation histories during the Holocene: some develop fill terraces with abandoned alluvial fans at the river mouths while others do not. We conducted area-slope analyses for these rivers by using 1: 25,000 topographic maps (contour interval 10 m). We found that although underlain by similar types of bedrock, the rivers developing fill terraces all exhibit higher values ($>$ 0.4) of profile concavity, and are generally wider and consist of fewer/lower knickpoints in their downstream parts. This feature is difficult to be explained by differential rock uplift. Rather, the stronger concavity of river profiles could reflect greater supply of bedload sediments that enhance incision in the lower parts of the rivers. In this case, the aggradation of the terrace fills appears to be a short-term phenomenon. Maximal incision occurred when the supply of bedload sediments after the aggradation decreased to a degree, at which the dual roles of bedload sediments acting as abrading tools while insulating underlying bedrock were suitably balanced. We also focused on the Liwu River, where the late Holocene bedrock incision rates are estimated over few centimeters per year. Only the river's largest tributary develops fill terraces connecting to those in the trunk stream. This tributary is more concave than the trunk stream, such that much of the river is lower than the corresponding trunk

stream that has the same lengths from the river mouth. Counting lithological types of gravels further indicates that most of the bedload sediments in the trunk stream are currently supplied from this tributary.

T21C-0466 0830h POSTER

Seasonal Surface Deformation In Response To Local Tectonic Activity, Insights From InSAR Observation In The SW Taiwan

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In this study we implement the InSAR (Interferometric Synthetic Aperture Radar) technique and correlate with other geodetic observations for the goal of identifying the seasonal surface deformation in the SW Taiwan. The rate of land subsidence in the SW Taiwan area is very fast, especially the Pingtung Plain. It has even been taken highly for the object of natural hazard mitigation. In the first approximation of topography, most of this area exhibits flat relief and covers urban areas or mixtures of nonvegetation and vegetation zones. Thus it is experimentally suitable for C-band InSAR application. Our preliminary interferometric results show that, the regional land subsidence is faster during the dry season, and whereas the subsidence rate is much slower in the raining season. Because land subsidence on local rather than regional scale is frequently caused by the dewatering of sediments, we compare therefore the well log data of this area with our InSAR observations. The result shows that the seasonal variation of subsidence rate is correspondent with the groundwater level fluctuation. Based on our research results, we infer that the compaction resulting in land-surface subsidence occurs as dewatering removes the buoyant support from the sediments. This successful test shows us that with suitable images, the differential interferometry is a useful high-resolution tool for monitoring the earth surface deformation despite the difficulties in a subtropical area with dense vegetation like Taiwan.

T21C-0467 0830h POSTER

A subdued topography among the high relief, tectonic-active island —registered middle to late Pleistocene climatic changes in Taiwan

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The island of Taiwan is geographically in the frontal zone of the Asian monsoon region, and is geologically located in the collision boundary between the Philippine Sea plate and the Eurasian plate. A Holocene uplifting rate of up to 10mm/yr in the eastern coast has been documented in this high relief mountainous island, and active folds and thrusts are common. When tracing the rivers backward to the mountain, one often encounters a subdued topography, covered by primary lateritic soil, above the higher river terrace and below the rugged mountains, and is referred to as lateritic highland (LH) by a previous author. Studies in paleoclimatology and geomorphology enable us to refine the possible age and origin of this remarkable topography. The penultimate glacial-interglacial cycle and the last interglacial period should be the major interval for the development of lateritic highland. LH may be looked upon as a reference surface for studying the dynamic evolution of the tectonic landscape of Taiwan. It shows that the lower uplifting rate is the most important factor for the preservation of the LH topography in this island. Based on the morphology of LH, different deformation styles are recognized in north and south Chiayi (near tropic of cancer), in western Taiwan. To the north, platforms originating from piedmont LH are well developed, whereas to the south, platforms and piedmont LH are hardly visible. This contrast is probably due to a lithological variance between them.

T21C-0468 0830h POSTER

Numerical Modeling of the Evolution of the Himalayas of Central Nepal due to Active Tectonics and Fluvial Incision

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The recent developments on coupling between tectonics and erosion have emphasized the key role of the fluvial network in active mountainous areas, in particular in leading landscape denudation. However, few of the numerical modeling studies that permitted to investigate this coupling have tried to consider realistic erosion laws, in particular the fluvial erosion processes. We have developed a simplified 2D analytic formalism to introduce landscape denudation by fluvial incision (a detachment limited model) and hillslopes landsliding into a mechanical finite element code (ADELI). We thus investigate the coupling between tectonics and erosion at timescales of 100 ky, and try to evaluate the sensitivity of our model to the chosen erosion formalism and the different responses of the system to external forcing. For this particular study, the model geometry reproduces roughly the structure of the Himalayas of Central Nepal. This area is both one of the most active compressional orogen on Earth, and one of the best documented regarding internal and external processes, in particular for the calibration of a fluvial incision law. First, the introduction of an erosion law derived from dominant fluvial incision leads to much more realistic topographic profiles than a simple diffusion law. The free parameters of the fluvial incision law, like pluviometry or structure of the hydrographic network have a moderate influence on the near-equilibrium topographic profiles, but a significant incidence on uplift, incision and denudation rates across the range. In contrast it appears that variations in bedrock erodability strongly modulate the mean elevation profiles for rivers and topography. Finally, the influence of crustal rheology and its links with the modality of surface denudation are also investigated. We underline the importance of a stratified crustal rheology, i.e. a basic lower crust and a quartz-like upper crust, in association with fluvial incision processes, in order to reproduce Himalayas main features: topographic profiles, denudation rates profiles and subsidence rate in the foreland basin.

T21C-0469 0830h POSTER

Topographic Signatures of Neotectonics in the Central Nepal Himalaya

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The central Nepal Himalaya are characterized by a sharp topographic break, separating the High Himalayan peaks to the north from the more subdued topography of the Lesser Himalaya to the south. River longitudinal profiles derived from a 90-meter digital elevation model of the region consistently reveal a sharp decrease in normalized steepness indices across this transition, while no systematic changes in rock character are observed. These topographic data are consistent with a narrowly distributed decrease in rock uplift rate from north to south. In many of these drainages, $^{40}Ar/^{39}Ar$ thermochronologic data from detrital muscovites also exhibit a profound change in cooling ages across the topographic discontinuity: samples with provenance from the north side of the discontinuity consistently record Miocene and younger cooling ages, while those derived from the southern side record Proterozoic or Paleozoic cooling ages. Field observations, including pervasive small-scale shear zones and hydrothermal activity in tributary valleys along the topographic front, are consistent with motion on a broad shear zone subparallel to the fabric of the Lesser Himalayan lithotectonic sequence. Combined, the geomorphic, thermochronologic, and field data suggest the presence of an extensive and previously unrecognized thrust-sense shear zone in the central Nepal Himalaya, approximately 20-30 km south of the trace of the principal fault of the Main Central Thrust system. Importantly, the results seem inconsistent with traditional models of the tectonic architecture of the Himalaya, which would imply similar deformational and thermal histories for rocks to the north and south of the topographic break. In this setting, river longitudinal profiles provide an important piece of data for narrowing the range of possible tectonic models for the region, and help us inform the sampling strategy for thermochronologic and structural studies.

T21C-0470 0830h POSTER

Stability of Major River Knickpoints Throughout the Himalaya: Evidence for Strong Coupling Between Erosion and Rock Uplift

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For nearly 2000 km, the Himalaya forms a remarkably continuous and smooth arc at the boundary between India and Tibet. We use this arc as reference line to quantify the mobility of knickpoints of the major rivers and the underlying connection between fluvial incision and bedrock uplift throughout the range. The nearly perfect alignment suggests that knickpoints have not migrated more than 50 km during the 40-50 million years since the initial topographic expression of the collision between India and Eurasia was established. This is an order of magnitude less than the migration expected in the absence of localized tectonic uplift in regions of rapid erosion. For this migration to be limited to 50 km, rates of bedrock uplift and incision must be equal, to within 2% of each other, over the life of the orogen. The close erosion-uplift balance is also evident in the syntaxial corners that terminate the Himalayan arc, where the largest, most energetic and, by inference, most erosive rivers in the region slice through the Himalaya. In these syntaxes, the elevated fluvial incision rates are balanced by focused vertical displacement into the corner massifs. This balance constitutes a spectacular and pervasive example of self-organization emerging from diverse feedbacks between erosional and tectonic processes.

T21C-0471 0830h POSTER

Uplift and River Incision Within the Eastern Margin of the Tibetan Plateau from Regional Patterns of Channel Steepness

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Channel profiles extracted from a digital elevation model of the eastern margin of the Tibetan Plateau reveal a zone of steep river channels around the western edge of the Sichuan Basin that continues west into the plateau, linking dynamic geomorphic processes to tectonic deformation within the region. The eastern margin of the Tibetan Plateau is a highly dissected landscape, characterized by steep river gorges cut 2 to 3 km deep into a broadly uplifting margin where mean elevations typically range from 3500 to 4000 m. We created a normalized steepness index for the eastern margin of the Tibetan plateau; the channels we studied are all within major tributaries of the Yangtze River. Moderately high channel steepness values are focused along the topographic front surrounding the Sichuan basin within deep river gorges that dissect the plateau margin. Channels away from the topographic front, which lie higher up on the plateau surface within a low-relief landscape, are characterized by much lower channel steepness values. The highest steepness values within the region are found in two places: within the lower half of the Dadu River basin, on the eastern slopes of the Gonga Mountains, which rise to more than 7500 m, and within the Yalong River Gorge, on tributaries as they enter the main river. Steep channels highlight important aspects of the tectonic and geomorphic evolution of the plateau margin: uplift and river incision. Broad, long-wavelength uplift of the eastern margin of the Tibetan plateau is associated with the India-Asia collision. Recent tectonic and geomorphic investigations suggest that Late Cenozoic, short-wavelength deformation and uplift has been focused in areas adjacent

to the Sichuan Basin. Uplift of the eastern margin has induced dramatic changes in the major river systems that drain this landscape, including the re-organization of drainages and consequent river capture, in combination with major down-cutting and increased channel steepness values as rivers adjust to higher uplift rates.

T21C-0472 0830h POSTER

A Model for Downstream Topography Across a Normal-Fault Footwall

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Detachment-limited fluvial erosion in bedrock channels is often modelled as a power law function of drainage area, A, and stream gradient, S; derived either from a relation between erosion and basal shear stress in the channel, or between erosion and stream power per unit area of channel bed. This function when coupled with a tectonic condition, such as a uniform uplift rate, yields a well known expression for equilibrium downstream channel topography. In this study we present a new derivation for bedrock channel topography across a linearly decaying uplift condition. This is a simple tectonic condition that is a useful first approximation for the decay of uplift rate with distance across a normal fault footwall. Though a reasonably simple solution (of the form of a Beta function) can be derived under the condition of linear decay in uplift rate downstream, the familiar linear relationship between $\log_{10} S$ and $\log_{10} A$, manifest in the analytical solution derived assuming a uniform uplift rate, no longer holds. Hence, the relatively standard form of channel profile analysis, involving linear fitting of downstream topography in $[\log_{10} S]$–$[\log_{10} A]$ space, is not appropriate. Therefore, we apply a technique of direct fitting of this new analytical solution to downstream channel topography for rivers draining across the back of the Paleochori fault, Northern Greece. Of particular interest in this model is that inclusion of an additional variable to the tectonic term, i.e. the gradient of uplift decay downstream, allows the separation of m, the channel drainage exponent, and n, the slope exponent. These terms are inseparable with simpler tectonic models, yielding only a ratio, m/n, which corresponds to the curvature of the channel profile under uniform uplift conditions. Therefore, this model provides a new method for extracting quantitative estimates of parameters that control fluvial erosion.

T21C-0473 0830h POSTER

Neotectonic uplift of the central Dead Sea fault (Lebanon and Syria) revealed by InSAR and DEM analysis

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A 200 km long restraining bend along central Dead Sea fault (DSF), the transform boundary between the Arabian and African plates, has resulted in the uplift of the Mount Lebanon and Anti Lebanon ranges. The length scale of this restraining bend compares with other large bends observed along continental transforms, including the Big Bend along the Sand Andreas fault system. Our study of active and late Cenozoic tectonism along the central DSF includes the application of Synthetic Aperture Radar Interferometry (InSAR) for the construction of a high resolution (20 meter pixel) digital elevation model (DEM) and to assess present-day vertical motions. The DEM provides a base to assess neotectonic uplift through mapping of macro-scale geomorphic features and morphometric analyses. The regional pattern of late Cenozoic uplift is revealed by a late Neogene paleo-surface that demonstrates greater uplift and erosion in the Mount Lebanon range compared with the Anti Lebanon range. The present-day geometry of this paleo-surface also suggests structural segmentation. Morphometric analyses, including relief and stream length-gradient indices, further illuminate the spatial distribution of uplift and/or tilting. Preliminary results of InSAR point target analysis yield insight into present-day vertical movements. Uplift and subsidence measured by InSAR may represent elastic loading of dip-slip faults beneath the Lebanese ranges. Asymmetric uplift patterns correspond with differences in the overall structures of the Mount Lebanon (a monocline) and the Anti Lebanon (broad anticlinorium). These structural differences may reflect competing influences of adjacent tectonic features including the Lebanese passive margin and the intracontinental Palmyride fold belt (in southern Syria). The obliquity of the Arabian-African plate motions relative to the restraining bend suggests that NW-SE crustal shortening locally accommodates a significant amount of the total 5 - 10 mm/yr. plate motion. It is plausible that some of the historically documented earthquakes during the past 2,000+ years may have occurred along dip-slip faults, instead of strike-slip faults. Hence, dip-slip faulting and related folding present an important, but little studied, element of the regional earthquake hazard.

T21C-0474 0830h POSTER

A Topographic Analysis of the Colorado River Drainage: Insights into Interaction Between Topography and Incision History

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Topography is a fundamental geophysical observable that reflects the geodynamic, geologic, and climatic history of a region. A number of recent studies have explored ways to extract tectonic information from topography and several provocative interpretations have been made about the topographic fabric in the Western U.S., including: 1) The topographic spectral power decreases systematically as the tectonic age of the underlying crust increases; 2) Local relief, mean elevation, and thermochronologically-determined exhumation history vary systematically across the major Paleozoic accretionary boundaries; 3) Neogene and ongoing rock- and possibly surface-uplift is driven by the creation of mantle buoyancy; and 4) there is a strong correlation between topography and lithospheric features such as mantle velocity structure, crustal thickness, and Precambrian crustal provinces. The Colorado River drainage provides a unique natural laboratory to evaluate to relationship between crustal-scale tectonic processes and the observed physiography. The drainage, extending more than 1400 km from the Gulf of California to the heart of the Rocky Mountains in Colorado, traverses the Southern Basin and Range, Colorado Plateau and Rocky Mountain provinces. A priori, we expect changes in the topographic character of the drainage to correspond to differences in bedrock geology, tectonic genesis, ongoing faulting, and the nature and position of province boundaries. Here we test this hypothesis through the use of a quantitative topographic analysis that extracts information about the topographic roughness organization, grain orientation, spectral power and fractal dimension. The analysis was applied to a 3-arc-second topographic DEM of the drainage. A particular topographic feature of interest is the change in river gradient at Lee's Ferry, just north of the Grand Canyon at the boundary between the Marble and Glen Canyons. This river knickpoint correlates with a change in topographic roughness and in standard deviation of the fractal dimension, both of which correspond with a peak in the spectral power at topographic wavelengths less than 10km. Strong peaks in the spectral power at very long wavelengths (40 to 100km) are spatially associated with structural features (East Kaibab monocline, Toroweap-Hurricane faults system, Grand Wash trough, Uncompahgre uplift) suggesting that these structural features influence topography. We note only a weak signal in the topographic roughness and organization values across the Basin and Range - Colorado Plateau boundary Preliminary conclusions include: 1) an observed spectral bulge in Rockies appears to correspond to the Aspen anomaly and is indicative of active doming due to mantle magmatism and resulting buoyancy; 2) spectral bulges in Grand canyon correspond to structures of different ages; 3) Changes in topography character (e.g., roughness) at river profile knickpoints is striking and offers a way to test whether these topographic features of Colorado River drainage are due to young tectonism or to more passive incision of a previously elevated plateau. In the latter case, topographic features are simply responses to bedrock changes and style of early structures; in the former case the river system is a sensitive gauge to differential tectonism in the western US.

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A Method for Improving SRTM DEMs in High-Relief Terrain

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The Shuttle Radar Topography Mission (SRTM) had the objective of mapping the Earth's surface between 56° S and 60° N to produce the first near-global high resolution digital elevation model (DEM). The dataset, with a horizontal resolution of 1 arc second (~ 30 m), has now been released for the conterminous U.S. Recent investigations aimed at assessing the vertical accuracy of the dataset have revealed that elevation accuracy is well within dataset specifications in areas of low- to modest-relief but that errors generally increase in high-relief terrains. Statistical analyses performed with the objective of characterizing the error structure in two study sites within the U.S. have highlighted the existence of correlations between elevation residuals and slope gradient, slope bearing and elevation. In particular, the analyses show that the largest errors occur on steep slopes and that slope bearing has a marked influence on the sign of the elevation residuals. Based on these findings we are currently investigating a method for correcting relevant vertical errors in SRTM-derived DEMs according to their topographic location. We propose to use a combination of indices derived from the statistical analyses to predict the occurrence, magnitude and sign of the vertical errors.

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Application of Permanent Scatterers on Mining Induced Subsidence

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Our study area is an active brown coal mining area in the Lower Rhine Embayment, Germany. It is a rural area with moderate topography, and divided in two big clods (the Erft-clod and the Cologne-clod) by NW-SE striking faults. Groundwater withdrawal around the open cast pits has led to wide spread subsidence, with a maximum subsidence rate of approximately 10 cm per year. Conventional Differential SAR Interferometry can hardly be applied to study this area due to temporal decorellation. Therefore, we use the Permanent Scatterer technique (PS), invented at POLIMI by Ferretti et al., to analyze this area. The PS technique overcomes the problem of temporal decorellation by only considering time-stable points in a stack of many radar images. This technique has proven to be very well suited for the analysis of urbanized area, and we have successfully applied it to a more rural area. Our first results are obtained using 40 ERS-1/2 images. An elliptic subsidence bowl of approximately 18 x 12 km can be observed, which agrees very well with available ground-based leveling data. Differences in the deformation rate are in the order of a few percent. Research is ongoing to improve the estimation, and to investigate the correlation between the structure of the subsidence bowl and the regional tectonics by analyzing systematic changes of the displacement rates on both sides of the faults.

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