Integration of digital elevation models and satellite images to investigate geological processes.

G. Zeilinger[1], M. Mutti[1], M. Strecker[1], K. Rehak[1], B. Bookhagen[2] & M. Schwab[3] ([1]Institut für Geowissenschaften, Universität Potsdam, [2]University of California, [3]Institut für Geologie, Universität Bern)

In order to better understand the geological boundary conditions for ongoing or past surface processes geologists face two important questions: 1) How can we gain additional knowledge about geological processes by analyzing digital elevation models (DEM) and satellite images and 2) Do these efforts present a viable approach for more efficient research. Here, we will present case studies at a variety of scales and levels of resolution to illustrate how we can substantially complement and enhance classical geological approaches with remote sensing techniques.

Commonly, satellite and DEM based studies are being used in a first step of assessing areas of geologic interest. While in the past the analysis of satellite imagery (e.g. Landsat TM) and aerial photographs was carried out to characterize the regional geologic characteristics, particularly structure and lithology, geologists have increasingly ventured into a process-oriented approach. This entails assessing structures and geomorphic features with a concept that includes active tectonics or tectonic activity on time scales relevant to humans. In addition, these efforts involve analyzing and quantifying the processes acting at the surface by integrating different remote sensing and topographic data (e.g. SRTM-DEM, SSM/I, GPS, Landsat 7 ETM, Aster, Ikonos…).

A combined structural and geomorphic study in the hyperarid Atacama desert demonstrates the use of satellite and digital elevation data for assessing geological structures formed by long-term (millions of years) feedback mechanisms between erosion and crustal bending *(Zeilinger et al., 2005)*. The medium-term change of landscapes during hundred thousands to millions years in a more humid setting is shown in an example from southern Chile. Based on an analysis of rivers/watersheds combined with landscapes parameterization by using digital elevation models, the geomorphic evolution and change in drainage pattern in the coastal Cordillera can be quantified and put into the context of seismotectonic segmentation of a tectonically active region. This has far-reaching implications for earthquake rupture scenarios and hazard mitigation *(K. Rehak,* *see poster on IMAF Workshop)*. Two examples illustrate short-term processes on decadal, centennial and millennial time scales: One study uses orogen scale precipitation gradients derived from remotely sensed passive microwave data *(Bookhagen et al., 2005a)*. They demonstrate how debris flows were triggered as a response of slopes to abnormally strong rainfall in the interior parts of the Himalaya during intensified monsoons. The area of the orogen that receives high amounts of precipitation during intensified monsoons also constitutes numerous landslide deposits of up to $1 km^3$ volume that were generated during intensified monsoon phase at about 27 and 9 ka *(Bookhagen et al., 2005b)*. Another project in the Swiss Alps compared sets of aerial photographs recorded in different years. By calculating high resolution surfaces the mass transport in a landslide could be reconstructed *(M. Schwab, Universität Bern)*.

All these examples, although representing only a short and limited selection of projects using remote sense data in geology, have as a common approach the goal to quantify geological processes. With increasing data resolution and new sensors future projects will even enable us to recognize more patterns and / or structures indicative of geological processes in tectonically active areas. This is crucial for the analysis of natural hazards like earthquakes, tsunamis and landslides, as well as those hazards that are related to climatic variability. The integration of remotely sensed data at different spatial and temporal scales with field observations becomes increasingly important. Many of presently highly populated places and increasingly utilized regions are subject to significant environmental pressure and often constitute areas of concentrated economic value. Combined remote sensing and ground-truthing in these regions is particularly important as geologic, seismicity and hydrologic data may be limited here due to the recency of infrastructural development. Monitoring ongoing processes and evaluating the remotely sensed data in terms of recurrence of events will greatly enhance our ability to assess and mitigate natural hazards.

References:

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