River discharge and erosion rates in the Sutlej basin, NW Himalaya

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Several studies have suggested couplings between climate and tectonics in the Himalayas, where high amounts of rainfall often coincide with high exhumation rates (Wobus et al 2003 Thiede et al 2004). In central Nepal, for example, fluvial erosion has been proposed to localize tectonic strain near the Main Central Thrust (Wobus et al., 2003, Hodges et al 2004). However, Burbank et al (2003) found uniform mineral cooling ages across a pronounced precipitation gradient and suggested to decouple rainfall and erosion.

The aim of this study is to explore and quantify the relationship between precipitation, discharge, topography and erosion within the Sutlej basin in the western Himalaya. The Sutlej River originates on the Tibetan Plateau and transects the Great Himalaya in a deep and steep valley before reaching the mountain front. Its catchment spans 52,798 km^2 and is therefore, after the Brahmaputra-Tsangpo and the Indus, the third largest catchment in the Himalayas (Bookhagen and Burbank, in review).

Climate in the Sutlej region is characterized by two main precipitational regimes. The Indian summer monsoon delivers large amounts of moisture form the Bay of Bengal, from mid June to mid September (Bookhagen and Burbank 2006). The rainfall amounts gradually decrease across the Himalayas from 3 m/yr at the front to 0.3 m/yr behind the orographic barrier (Bookhagen et al. 2005). Winter precipitation mainly derives from Western Disturbances, which are upper-tropospheric synoptic-scale waves that can undergo orographic capture as they pass over south central Asia (Lang and Barros 2004). Above 2000 m, Western Disturbances mostly provide snowfall with snow water equivalents (SWE) of up to ~1 m measured at valley weather stations in the Greater Himalaya (Singh and Kumar 1997). These SWE values are likely to increase at mountain peaks and ridges and may be regarded as a lower estimate of the principal moisture source for the high elevations in the Greater Himalayas of the Sutlej region.

To quantify the interactions between precipitation, discharge and erosion on a large spatial scale we used the following approach. We model discharge along the transition of fluvial to nivo-glacial dominated tributary catchments. To capture the different sources of river discharge over a large region we utilized remote sensing data in combination with ground-based measurements. TRMM (Tropical Rainfall Measuring Mission) data provide mean rainfall amounts over the period 1998 to 2006 (Bookhagen and Burbank in review). Interannual variability was derived on the basis of daily precipitation measurements from 15 weather stations within the Sutlej catchment. To take evapotranspiration into account, we used MODIS (Moderate-resolution Imaging Spectroradiometer) derived estimates (Mu et al. 2007). Furthermore, the MODIS snow cover product serves as a proxy for snowfall from which we infer differences in annual snow melt. We plan to model glacier melt based on MODIS-derived daytime temperature, the snow cover products and glacial cover that we mapped using Landsat satellite imagery. Based on discharge measurements form several tributaries along the Sutlej we aim to calibrate our model to estimate discharge on other large (>100 km^2) tributary catchments along the Sutlej River.

Eventually, we gain insights into discharge formation along the Sutlej and across different climatic sectors of the orogen. Additionally, we discuss potential sediment sources based on geological maps, digital terrain analysis and spectral classification, taking into account surface and exposure characteristics, such as soil cover, lithology, vegetation and morphometric characteristics. This approach allows us to subdivide and categorize the tributary catchments into morphological units, which characterizes the catchments susceptibility to erosion (Märker 2001). Finally, we combine the river discharge and suspended sediment concentration (SSC) data, acquired from HPSEB (Himachal Pradesh State Electricity Board) to derive erosion rates for the investigated tributaries and time periods

Our results show that there exists a transitional zone in the Sutlej transect, which receives considerable amounts of monsoonal rainfall (~1 m/yr), and which concurrently benefits form large amounts of snow and glacier melt. This results in increased erosion rates in a high, heavily glacierized tributary catchment (Wanger) in the transitional zone compared to a rather low lying, fluvially shaped tributary catchment (Ganvi) in the rainfall dominated zone. Although the lower basin transports more suspended sediment and receives higher mounts of rainfall, the higher basin gains additional snow- and glacier melt, which sustain high discharge for a longer period than in the lower catchment.

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