India Summer Monsoon and Spatial Erosion Variability in the Arun Valley, Eastern Nepal

S. Olen[1], B. Bookhagen[2], M. Strecker[1], D.P. Adhikari[3], B. Hoffmann[1], D. Sachse[1]

[1] *Institute for Earth and Environmental Science, University of Potsdam, Germany*
[2] *Department of Geography, University of California - Santa Barbara, U.S.A.*
[3] *Department of Geology, Tribhuvan University, Kathmandu, Nepal*
olen@geo.uni-potsdam.de

The Arun valley in the eastern-central Himalaya provides an excellent natural laboratory to investigate the relationship between regional tectonics, the Indian Summer Monsoon (ISM) system, and landscape evolution. The Arun is one of the largest trans-Himalayan rivers and intersects all major Himalayan units from Tibet to the Ganges plain. Located in eastern Nepal, the Arun valley is situated near the start of the monsoon moisture conveyor in the Bay of Bengal and thus the valley receives large amounts of highly seasonal rainfall. Using meteorological stations throughout the Arun valley, we calculate approximately 80% of annual rainfall occurs during the JJAS peak summer monsoon months. ISM-sourced rain falls on a steep, two-tiered precipitation gradient caused by the orographic barriers of the Lesser Himalaya in the south and the Higher Himalaya in the north (from a peak >8 m yr^{-1} at the Higher Himalayan front to ~2 m yr^{-1} at the border with Tibet) [1]. A corresponding increase in basin slope and local relief is observed at these orographic fronts.

We combine 51 fluvial river sand samples for basin-wide cosmogenic radionuclide (CRN) analysis [2,3] with topographic metrics and meteorologic data to tease out the competing influences of ISM-fueled rainfall and tectonic forcing on regional erosion and hydrologic discharge patterns. Basin-wide CRN analysis allows us to reconstruct the recent (10^2-10^3 yr) pattern of erosion in the valley. We focus on three sampling targets: the main-stem Arun river, tributary rivers (<10 km^2 to >500,000 km^2), and a fluvial fill terrace near Tumlingtar in the lower Arun. CRN samples were collected over a steep elevation (mean catchment elevation 764 m asl to 4,756 m asl) and rainfall (mean catchment annual rainfall 0.9 km yr^{-1} to 4.2 km yr^{-1}) gradients [1]. Sampled tributary catchments range in average basin slope from 18 ° to 37°, total catchment relief from 378 m to 3,747 m, and mean 1-km local relief from 378 m to 1,257 m. Preliminary results from the CRN samples show a positive correlation between basin-wide erosion rates and basin slope, channel steepness, and local relief.

Temporal changes in tectonics or climate can also be observed in river knickpoints. To further explore the relationship between tectonics, climate, and erosion in the Arun valley, we analyze a 500-m window around the main-stem Arun using a high resolution Digital Elevation Model (DEM) generated from 20-m contour maps and ASTER imaging. This follows the observation in the field of several strath terraces and small hanging valleys above the main-stem of the Arun. We use the high-resolution DEM to identify the spatial pattern of knick-points above the main-stem Arun. These are considered with respect to height above the present-day Arun channel, catchment drainage area, and evidence of modern or recent glaciation in catchments to help determine if climatic or tectonics is the main driver in recent topographic change in the Arun valley.

[1] B. Bookhagen and D.W. Burbank, 2010, Towards a complete Himalayan hydrological budget: Spatiotemporal distribution of snowmelt and rainfall and their impact on river discharge, Journal of Geophysical Research, 115, F03019, doi:10.1029/2009JF001426.

[2] P. Bierman and E.J. Steig, 1996, Estimating rates of denudation using cosmogenic isotope abundances in sediment, Earth Surface Processes and Landforms, 21, 125-139.

[3] D.E. Granger, J.W. Kirchner, R. Finkel, 1996, Spatially averaged long-term erosion rates measured from in situ-produced cosmogenic nuclides in alluvial sediment, Journal of Geology, 104 (3), 249-257.

Key words: monsoon, cosmogenics, topography, knickpoints, erosion