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Spatial gradients in climate, vegetation, and catchment-mean erosion rates in the Arun Valley, Eastern Nepal

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A link between climate, vegetation cover, and regional erosion rates has been widely proposed in the Himalaya, but has proven hard to quantify. We investigate the connection between Indian Summer Monsoon (ISM) rainfall, vegetation cover, and erosion in the Arun valley of eastern Nepal. One of the largest trans-Himalayan rivers, the Arun has cut a natural cross-section through all major Himalayan geological units and structures from the northern Tethyan sequences in Tibet to the alluvial sediments of the southern Ganges plain. Located near the monsoonal moisture source in the Bay of Bengal, the Arun receives significant amounts of ISM rainfall (average 2 m yr^{-1} in the Arun gorge). Rainfall in the valley is focused along the Himalayan mountain front, forced by orographic barriers of the Lesser and Higher Himalayas, resulting in a steep, two-tiered rainfall gradient (from a peak >4 m yr^{-1} at the Higher Himalayan front to $\sim$0.5 m yr^{-1} at the border with Tibet) [1]. Rainfall along this gradient is highly seasonal; based on meteorological stations along the Arun, approximately 80% of annual rainfall occurs during the peak summer monsoon months, corroborating earlier results [1]. Abundant precipitation and relatively warm temperatures in the deeply incised Arun gorge result in dense vegetation cover in much of the valley, ranging from sub-tropical forests to alpine vegetation cover.

In order to quantify erosion variability in the Arun with respect to climate, vegetation, and tectonics, we collected 51 river sand samples over two field seasons for catchment-mean cosmogenic radionuclide (CRN) analysis [2,3]. Samples were collected from the main stem of the Arun and from tributary watersheds ($<$10 km^2 to 18,000 km^2). Basin topography and stream networks are analyzed using the 90-m SRTM DEM [4] and a manually created 15-m ASTER-generated DEM from multiple stereo pairs. Normalized Difference Vegetation Index (NDVI) is used as a proxy for vegetation and soil cover. Sampled tributary catchments range in average basin slope from 18° to 38°, total catchment relief from 378 m to 7,231 m, and 1-km-radius relief from 378 m to 1,257 m. NDVI follows a non-normal distribution within each catchment. In fluvially-dominated catchments, NDVI is skewed towards high values indicating dense forest vegetation; partially or formerly glaciated catchments show a bimodal distribution with sparse vegetation at high altitudes and dense vegetation in the lower reaches of the valley.

Preliminary ^{10}Be CRN erosion rates are relatively low for the Himalaya, despite the high steepness and large discharge of the Arun. We argue that secondary processes may alter and modify erosion rates at cosmogenic nuclide timescales, such as vegetation cover, landsliding, and transiently stored sediments in the valley. For example, the dense vegetation cover associated with a thick soil cover has the potential to increase residence time of quartz grains and thus allow quartz-rich material to accumulate at higher concentrations of ^{10}Be, resulting in lower erosion rates. The influence of such secondary processes suggests an interdependence between climate, vegetation, and landscape development in the Arun valley.

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