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Role of vegetation in modulating denudation and topography across the Himalaya

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Studies of Himalayan denudation, to date, have primarily focused on the effects of lithology, tectonic activity, and climate in shaping landscape and controlling denudation rates. Climate can impact denudation not only through increased precipitation, runoff, or glaciation, but also via its role in controlling vegetation cover. Since the classical study of Langbein and Schumm [1958] emphasizing the role of vegetation cover in determining erosional efficiency, theoretical and plot-scale studies have highlighted the role of vegetation on surface processes [Collins et al., 2004; Istanbulluoglu and Bras, 2005; Collins and Bras, 2010; Carretier et al., 2013; Jeffery et al., 2014].

Vegetation cover and density vary considerably in the Himalaya, both across and along strike. Across strike, vegetation transitions from dense forest and agriculturally-used plots in the Lesser Himalaya to sparse alpine and arid, virtually non-vegetated regions at high elevation and in the rain shadow north of the Higher Himalaya peaks. Along-strike vegetation densities also differ significantly and show a pronounced E-W gradient. To quantify the along-strike vegetation gradient, we use 14 years of MODIS 13C1 enhanced vegetation index (EVI) data to calculate mean annual, summer (MJJASO), and winter (NDJFMA) for the entire Himalaya. Additionally, we calculate a differential EVI that compares summer versus winter vegetation density (MJJASO/NDJFMA). A decrease in vegetation density is observed from east to west, with the greatest difference in winter vegetation cover (225% higher in the eastern than western Himalaya). In contrast, differential EVI is higher in the western Himalaya, increasing 170% from east to west.

To evaluate the effect of vegetation on denudation and landscape evolution, we combine the 14-year EVI data, topographic analysis, and a compilation of >100 published and unpublished 10-Be terrestrial cosmogenic nuclide (TCN) catchment-mean denudation rates from across the Himalaya [Godard et al., 2014; Portenga et al., 2014; Scherler et al., 2014; Olen et al., submitted]. We calculate the relationship between various topographic metrics (e.g. mean basin slope, normalized channel steepness [ksn]) and the TCN catchment-mean denudation of non-glaciated fluvial watersheds from previously published and submitted studies. The variation in vegetation density between study sites correlates with the relationship between topography and denudation in each region. In sparsely vegetated areas, denudation increases in a rapid, non-linear fashion as topographic metrics such as the normalized channel steepness (ksn) or mean basin hillslope increase. Where vegetation cover is denser, the relationship between denudation and topography becomes increasingly linear, such that lower denudation rates are maintained as hillslopes and channels steepen. Additionally, more sparsely vegetated regions appear to reach a maximum steepness lower than that observed in densely vegetated regions. We therefore observe a negative correlation between increasing annual, summer, and winter EVI and the power-law exponent p of the relationship denudation $\approx$ (topographic metric)p; and a positive correlation between p and differential EVI. In contrast to recent studies arguing that Himalayan denudation is primarily forced by tectonics, our study emphasizes how vegetation density, as a climatic agent, modulates erosional style and landscape development along strike across the Himalaya.

Carretier, S., et al. (2013), Slope and climate variability control of erosion in the Andes of central Chile, Geology, 41(2), 195-198.

Collins, D. B. G., and R. L. Bras (2010), Climatic and ecological controls of equilibrium drainage density, relief, and channel concavity in dry lands, Water Resources Research, 46(4), W04508.

Collins, D. B. G., R. L. Bras, and G. E. Tucker (2004), Modeling the effects of vegetation-erosion coupling on landscape evolution, Journal of Geophysical Research: Earth Surface, 109(F3), F03004.

Godard, V., D. L. Bourlés, F. Spinabella, D. W. Burbank, B. Bookhagen, G. B. Fisher, A. Moulin, and L. Léanni (2014), Dominance of tectonics over climate in Himalayan denudation, Geology.

Istanbulluoglu, E., and R. L. Bras (2005), Vegetation-modulated landscape evolution: Effects of vegetation on landscape processes, drainage density, and topography, Journal of Geophysical Research: Earth Surface, 110(F2), F02012.

Jeffery, M. L., B. J. Yanites, C. J. Poulsen, and T. A. Ehlers (2014), Vegetation-precipitation controls on Central Andean topography, Journal of Geophysical Research: Earth Surface, 2013JF002919.

Langbein, W., and S. Schumm (1958), Yield of sediment in relation to mean annual precipitation, American Geophysical Union Transactions, 39, 1076-1084.

Portenga, E. W., P. R. Bierman, C. Duncan, L. B. Corbett, N. M. Kehrwald, and D. H. Rood (2014), Erosion rates of the Bhutanese Himalaya determined using in situ-produced 10Be, Geomorphology(0).

Scherler, D., B. Bookhagen, and M. R. Strecker (2014), Tectonic control on 10Be-derived erosion rates in the Garhwal Himalaya, India, Journal of Geophysical Research: Earth Surface, 2013JF002955.