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Latitudinal Variations in the Influence of Vegetation on Catchment Denudation (Ralf Alger Bagnold Medal Lecture)

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Earth surface processes are modulated by fascinating interactions between climate, tectonics, and biota. These interactions are manifested over diverse temporal and spatial scales ranging from seconds to millions of years, and microns to thousands of kilometers, respectively. Investigations into Earth surface shaping by biota have gained growing attention over the last decades and are a research frontier. Examples of the scales of biotic interactions with surface processes range from microbial and fungal consumption of mineral surfaces over short temporal and small spatial scales, to vegetation interactions with climate, sedimentation and erosion over temporal scales of hours (individual storms) to millennia (global climate change), and spatial scales of centi- to kilometers (encompassing individual plants to catchment scale biomes). Finally, mountain building and Milankovitch cycle-driven climate change produce ecologic, climate, and erosional gradients across temporal scales of millennia to millions of years and large spatial scales.
In this lecture, I present an integration of new observational and numerical modeling research on the influence of vegetation cover on catchment denudation. I do this through an investigation of millennial timescale catchment denudation rates measured along the extreme climate and ecologic gradient of the western margin of South America from Peru to central Chile (6 to 36 Degrees S latitude). Results identify different zones of behavior between vegetation and catchment denudation that are separated by two distinct thresholds, where the effects of vegetation cover on denudation exhibit either an increasing or decreasing correlation with denudation rates. Additional insights into the observed latitudinal variations, and non-linear behavior in vegetation and denudation rates are provided with coupled dynamic vegetation and paleoclimate models, and a landscape evolution model that accounts for vegetation cover effects on hillslope and fluvial erosion. The modeling approach provides insights into a physical explanation for precipitation and vegetation controls on denudation along the western South American margin.