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What controls millennial-scale denudation rates across the Central Andes?

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Sustainable planning of erosion control measures in the Central Andes requires robust knowledge about natural denudation rates. We explore a large dataset combining new and published 10Be (and 26Al) catchment-wide denudation rates from a swath at 17 to 19° S spanning the Western Cordillera that rises from sea level to 5500 m elevation; the Altiplano at ∼4000 m; the Eastern Cordillera with elevations up to 6500 m; the Interandean Zone; the Subandean Zone; and the Chaco Plain at 300 m. The selected catchments span a large spread regarding morphometric and climate properties where mean slope angles range from 1 to 31°, and mean precipitation from 100 to 3900 mm/a. The denudation rates (0.0036 to 1.93 mm/a) are averaged over millennia, and reveal two to three magnitudes difference across the Central Andes. The regional distribution of denudation rates clearly demonstrates a more complex interaction of geomorphological, geological and meteorological parameters with the dominant geomorphological processes.

In order to elucidate the key controls on denudation, we use multivariate statistics such as principal component analysis in order to remove potentially redundant predictors of denudation in the studied catchments. These predictors include catchment elevation, topographic relief, hillslope inclination, mean precipitation, tree cover, specific stream power, channel steepness indices, sinuosity, drainage density and hypsometric index that we derived from the SRTM 90 m Digital Elevation Database, the Tropical Rainfall Measuring Mission (TRMM) data, and the Terra MODIS Vegetation Continuous Fields dataset. Additionally, the rock strength index (PLI) was estimated based on geological units.

Preliminary results allow distinguishing five different longitudinal domains of denudation on the basis of climatic regime, hillslope steepness, and the degree of accumulated crustal deformation. We find that the pattern of 10Be catchment-wide denudation rates in the Central Andes depends largely on the location within the orogen, causing a strong segmentation reflected by metrics of slope (plane versus cordillera) and precipitation (desert versus tropical rain forest). This regional pattern, contained in larger catchments, is superimposed by a local pattern, revealed in mid- to small-sized catchments. Yet a substantial fraction of the overall variance in denudation rates remains unexplained. We discuss possible reasons for this, and reflect on the prospect of predicting denudation rates in ungauged Central Andean catchments.