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Himalayan Denudation: Noise vs. Time

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Comparing estimates of denudation rates is notoriously difficult given the broad choice of geological archives, dating techniques, and the measurement intervals that these rates are averaged over. Even for a given method such as measuring detrital cosmogenic Be-10 concentrations in river sands in order to infer catchment-averaged denudation rates, estimates may vary by orders of magnitude in comparable settings. This variance has confounded the search for straightforward tectonic, climatic, or morphometric predictors of denudation rates, let alone field-based verification of theoretical models that predict relationships between landscape metrics and denudation rates.

Both regional and global studies using Be-10 derived denudation rates have aimed at constraining such trends using linear regression, though with mixed and partly inconsistent success. Yet part of the simple linear regression approach largely overlooks that Be-10 derived denudation rate estimates inherently depend on the apparent exposure age of the samples. Therefore, samples that reflect rapidly denuding basins integrate over only a few centuries of apparent exposure time, and thus must also contain less landscape memory; contamination by recent erosional events may further distort longer-term denudation rate estimates.

We hypothesize that any correlation between denudation rate and a meaningful tectonic, climatic, or topographic predictor should be largely invariant with respect to the timescale of observation in order remain a robust indication of a potentially underlying causal relationship. We test this hypothesis by analysing an inventory of nearly 300 cosmogenic Be-10 derived catchment-averaged denudation rates from the Himalaya-Tibet orogen. These rates span nearly three orders of magnitude and reveal significant noise that largely prohibits meaningful models based on linear regression.

However, we demonstrate that quantile regression can be used to (a) decipher and correct for a timescale-dependent signal in basin-wide denudation rate estimates; (b) determine which tectonic, climatic, and topographic predictors appear to be most promising; and (c) predict denudation rates at the basin scale from those metrics. We conclude that quantile regression not only lends support to some postulated relationships between denudation rates and topographic and climatic metrics in the Himalaya-Tibet orogen, but also points to timescales at which those relationships break down.