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An analysis of the daily precipitation variability in the Himalayan orogen using a statistical parameterisation and its potential in driving landscape evolution models with stochastic climatic forcing

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A current challenge in landscape evolution modelling is to integrate realistic precipitation patterns and behaviour into longterm fluvial erosion models. The effect of precipitation on fluvial erosion can be subtle as well as nonlinear, implying that changes in climate (e.g. precipitation magnitude or storminess) may have unexpected outcomes in terms of erosion rates. For example Tucker and Bras (2000) show theoretically that changes in the variability of precipitation (storminess) alone can influence erosion rate across a landscape. To complicate the situation further, topography, ultimately driven by tectonic uplift but shaped by erosion, has a major influence on the distribution and style of precipitation. Therefore, in order to untangle the coupling between climate, erosion and tectonics in an actively uplifting orogen where fluvial erosion is dominant it is important to understand how the 'rain dial' used in a landscape evolution model (LEM) corresponds to real precipitation patterns.

One issue with the parameterisation of rainfall for use in an LEM is the difference between the timescales for precipitation ($\leq$1 year) and landscape evolution ($>10^3$ years). As a result, precipitation patterns must be upscaled before being integrated into a model. The relevant question then becomes: What is the most appropriate measure of precipitation on a millennial timescale? Previous work (*Tucker and Bras*, 2000; *Lague*, 2005) has shown that precipitation can be properly upscaled by taking into account its variable nature, along with its average magnitude. This captures the relative size and frequency of extreme events, ensuring a more accurate characterisation of the integrated effects of precipitation on erosion over long periods of time. In light of this work, we present a statistical parameterisation that accurately models the mean and daily variability of ground based (APHRODITE) and remotely sensed (TRMM) precipitation data in the Himalayan orogen with only a few parameters. We also demonstrate over what spatial and temporal scales this parameterisation applies and is stable. Applying the parameterisation over the Himalayan orogen reveals large-scale strike-perpendicular gradients in precipitation variability in addition to the long observed strike-perpendicular gradient in precipitation magnitude. This observation, combined with the theoretical work mentioned above, suggests that variability is an integral part of the interaction between climate and erosion.

References

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