

Quantifying the scale- and process- dependent reorganization of landscape under climatic change: inferences from an experimental landscape

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Knowledge of the dynamics of evolving landscapes in terms of their geomorphic and topologic re-organization in response to changing climatic or tectonic forcing is of scientific and practical interest. Although several studies have addressed the large-scale response (e.g., change in mean relief), studies on the smaller-scale drainage pattern re-organization and quantification of landscape vulnerability to the timing, magnitude, and frequency of changing forcing are lacking. The reason is the absence of data for such an analysis. To that goal, a series of controlled laboratory experiments were conducted at the St. Anthony Falls laboratory of the University of Minnesota to study the effect of space-time variable and changing precipitation patterns on landscape evolution at the short and long-time scales. High resolution digital elevation (DEM) both in space and time were measured for a range of rainfall patterns and uplift rates. Results from our study show a distinct signature of the precipitation increase on the probabilistic and geometrical structure of landscape features, evident in widening and deepening of channels and valleys, change in drainage patterns within sub-basins and change in the space-time structure of erosional and depositional events. A spatially explicit analysis of the locus of these erosional and depositional events suggests a regime shift, during the onset of the transient state, from supply-limited to transport-limited fluvial channels. We document a characteristic scale-dependent signature of erosion at steady state (which we term the “E50-area curve”) and show that during reorganization, its evolving shape reflects process and scales of geomorphic change. We also document changes in the longitudinal river profiles with the formation of abrupt gradient (knickpoints) which advect upstream as time proceeds.