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Experimental evidence of landscape reorganization under changing external forcing: implications to climate-driven knickpoints

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Understanding and quantifying geomorphic and topologic re-organization of landscape 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. To that goal, a series of controlled laboratory experiments were conducted to study the effect of 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 show an acceleration of erosion in the hillslopes when the rainfall intensity is increased, while the incision in fluvial channels is slowed down exhibiting a sediment-flux dependent behavior. Finally, we document the changes in the longitudinal river profiles with increasing precipitation intensity, revealing the formation of knickpoints at certain confluences where large discontinuities in the ratio Qs/Qw are observed.