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Experimental evidence of dynamic re-organization of evolving landscapes under changing climatic forcing

Arvind Singh (1), Alejandro Tejedor (2), Ilya Zaliapin (3), Liam Reinhardt (4), and Efi Foufoula-Georgiou (2)

(1) Department of Civil, Environmental, and Construction Engineering University of Central Florida, Orlando, USA, (2) Saint Anthony Falls Laboratory, University of Minnesota, Twin Cities, USA, (3) Department of Mathematics and Statistics, University of Nevada, Reno, USA, (4) University of Exeter Penryn United Kingdom

The aim of this study is to better understand the dynamic re-organization of an evolving landscape under a scenario of changing climatic forcing for improving our knowledge of geomorphic transport laws under transient conditions and developing predictive models of landscape response to external perturbations. Real landscape observations for long-term analysis are limited and to this end a high resolution controlled laboratory experiment was conducted at the St. Anthony Falls laboratory at the University of Minnesota. Elevation data were collected at temporal resolution of 5 mins and spatial resolution of 0.5 mm as the landscape approached steady state (constant uplift and precipitation rate) and in the transient state (under the same uplift and 5x precipitation). The results reveal rapid topographic re-organization under a five-fold precipitation increase with the fluvial regime expanding into the previously debris dominated regime, accelerated erosion happening at hillslope scales, and rivers shifting from an erosion-limited to a transport-limited regime. From a connectivity and clustering analysis of the erosional and depositional events, we demonstrate the strikingly different spatial patterns of landscape evolution under steady-state (SS) and transient-state (TS), even when the time under SS is "stretched" compared to that under TS such as to match the total volume and PDF of erosional and depositional amounts. We quantify the spatial coupling of hillslopes and channels and demonstrate that hillslopes lead and channels follow in re-organizing the whole landscape under such an amplified precipitation regime.