Geophysical Research Abstracts
Vol. 18, EGU2016-10233, 2016
EGU General Assembly 2016

Landscape response to climate change: quantifying a regime shift in transport processes at the onset of re-organization

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Quantifying the ways in which landscapes are reorganized under changing allogenic forcing, including changes in the patterns, rates, and processes of erosion and deposition, is still an open question. Data at the time scales and resolutions required to undertake such a question are typically not available for real landscapes, making physical experiments attractive and powerful means for studying the dynamics of landscape evolution. To this aim, we capitalize on a series of controlled laboratory experiments conducted at the St. Anthony Falls laboratory at the University of Minnesota. The eXperimental Landscape Evolution (XLE) facility consists of an erosion box (0.5 x 0.5 x 0.3 m3) wherein two main variables can be controlled: uplift rate and rainfall intensity. Topographic data were collected at a temporal resolution of 5 mins and spatial resolution of 0.5 mm as the landscape approached steady state (under constant uplift and precipitation rate), and during the transient state following an increase in the precipitation rate by a factor of 5. In order to quantify the changes observed during the onset of reorganization in the transient state, we perform a connectivity and clustering analysis of the erosional and depositional events, showing strikingly different spatial patterns on landscape evolution under steady-state (SS) and transient-state (TS) conditions, even when the time under SS is renormalized to match the total volume of eroded and deposited sediment in TS. Our results suggest a regime shift in the behavior of transport processes within the fluvial regime of the landscape, from supply-limited to transport-limited, during the onset of the TS. Results on the evolution of the spatial patterns of erosional and depositional events when the time advances within the TS are also discussed.