Detecting geomorphic and sedimentary effects of modern climate change: how much do we know?

*Amy E East[1], Joel B Sankey[2]

1. U.S. Geological Survey, Santa Cruz, California, U.S.A., 2. U.S. Geological Survey, Flagstaff, Arizona, U.S.A.

Hydroclimatic changes associated with global warming have been documented widely over the past 50 years, but associated physical landscape responses are poorly understood thus far. Detecting sedimentary and geomorphic signals of modern climate change presents challenges owing to short record lengths, difficulty resolving signals in stochastic natural systems, influences of land use and tectonic activity, long-lasting effects of individual extreme events, and variable connectivity in sediment-routing systems. However, being able to resolve and constrain geomorphic and sedimentary response to rapidly progressing climate change has widespread implications for ecosystem resilience, human health and safety, infrastructure, water security, and economics. We have reviewed and synthesized existing literature to investigate the nature and extent of sedimentary and geomorphic responses to modern climate change, focusing on the western United States, a region with generally steep relief and high sediment yield likely to be sensitive to climate variability. We test four hypotheses: that recent climate-driven changes will have caused (1) greater watershed sediment yields, (2) changes in slope stability, (3) more dynamic fluvial morphology, and (4) more aeolian sediment mobilization. We examine the extent to which these hypotheses are currently testable given the state of the science, and identify knowledge gaps that limit robust testing. Each hypothesis is supported to some degree, by small numbers of studies with limited geographic scope; none can be refuted with the currently available literature. To detect ongoing and future responses to climate change will require better understanding how landscape response scales with disturbance, how lag times and hysteresis operate within sedimentary systems, and how to distinguish relative influence of superimposed disturbances, including some that are unrelated to climate. We are in need of abundant data from many more places globally, at greater spatial and temporal resolution, to determine the nature and extent of landscape response to ongoing climate change. Where applicable, this should include thorough reporting of negative results; well constrained tests for a lack of sedimentary and geomorphic responses—and studies capable of rejecting hypotheses such as ours—are just as necessary as data that indicate support for the hypotheses we have posed.

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