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Fluvial response to environmental perturbations: a perspective from physical experiments

Sara Savi (1), Stefanie Tofelde (1,2), Andrew Wickert (3,4), Taylor Schildgen (1,2), Chris Paola (3,4), and Manfred Strecker (1)

(1) University of Potsdam, Institute of Earth and environmental Science, Potsdam, Germany (sara.savi@geo.uni-potsdam.de), (2) Helmholtz-Zentrum Potsdam, Deutsche GeoForschungsZentrum (GFZ), Potsdam, Germany, (3) University of Minnesota, Department of Earth Sciences, Minneapolis, USA, (4) St. Anthony Falls Laboratory, Minneapolis, USA

Fluvial terraces and alluvial fans that are perched above the modern base level testify to environmental conditions that were different from today. Sedimentological studies combined with chronological constraints can be used to reconstruct the evolution of these landforms in the context of past changes in regional to global forcing. Despite the improvements in the most commonly used dating techniques (e.g. cosmogenic nuclides, ^{14}C, and OSL), field data from fluvial and alluvial archives often represent only a brief glimpse into the evolution of that particular landscape. As such, the challenge of interpreting landscape development and its relationship to external forcing in the remaining time gaps is often unclear.

To gain more insight, we performed physical experiments to test how a fluvial system responds to changes in the boundary conditions. This approach allows us to continuously record the evolution of the fluvial system and to observe, step by step, the response of the fluvial system and the development of the landscape. Additionally, we can directly link the geomorphic modifications to a specific environmental perturbation. Starting with a simple model and a single channel, we changed the amount of discharge (Qw) and sediment supply (Qs) in the system. The most prominent response results from a sudden increase in water discharge. In general, changes in the Qs/Qw ratio control the fluvial morphology (particularly the height/width ratio), the channel's profile, the dynamics of the river, and its ability to modify the surrounding landscape. Responses get more complex with the introduction of a lateral tributary, which changes the dynamics of the main stem and creates feed-back mechanisms between the two systems. For example, a change in the main stem can influence the fluvial morphology and the steepness of the tributary (even with no perturbations in the tributary) and vice-versa, illustrating the potential for non-unique interpretations of fluvial landforms.

Our preliminary results indicate that any modification in sediment supply or water discharge has the ability to leave distinct imprints on the landscape and suggest that these signals, in turn, may be used to infer the direction of the changes that occurred in the past. As such, our experiments provide information for a more robust and reliable interpretation of sedimentary archives, furnishing insights into how geomorphological features could be related to specific environmental perturbations.