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Width control on event scale bedload dynamics in bedrock-confined channels

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In mixed bedrock-alluvial rivers, the response of the system to a flood event can be affected by a number of factors, including coarse sediment availability in the channel, sediment supply from the hillslopes and upstream, flood sequencing, and coarse sediment grain size distribution. However, the impact of along-stream changes in channel width on bedload transport dynamics remains largely unexplored. We combine field data, theory, and numerical modeling to address this gap. Observations from two flood events in the Daan River gorge in western Taiwan suggest that coarse sediment evacuation and re-deposition can cause intra-flood changes of up to several meters in channel bed elevation that are distinct from measured before/after bed changes. We hypothesize that this could be related to the abrupt change in width between the 1 km long bedrock gorge and the river upstream and downstream. An analysis of the theoretical relationships between discharge, channel width, and bedload transport capacity shows that for a given slope, narrow channels transport bedload more efficiently than wide ones at low discharges, while wider channels are more efficient at high discharges. We used the model sedFlow to explore this effect, running a random sequence of floods through a channel with a narrow gorge section bounded upstream and downstream by wider reaches. Channel response to imposed floods is complex, as high and low discharges drive different spatial patterns of erosion and deposition, and the channel may experience both of these regimes during the peak and recession periods of each flood. Our modeling suggests that width differences alone can drive substantial variations in sediment flux and bed response, without the need for variations in sediment supply or mobility. Further, the deposition or erosion that takes place within a flood is often not reflected in the before/after changes to the bed, and this disconnect increases with increasing flood size.