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Supercritical River Terraces: Processes driving rapid landscape change following climatic variability

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The alternating cycle of strath planation and strath terrace abandonment due to variations in sediment supply relative to river transport capacity is a common feature in many mountainous environments, often driven by climatic variability. However, our understanding of the mechanics of the processes that drive this cycle remains poorly quantified. Here, we used an experimental and numerical study to identify the geomorphic and hydraulic controls driving the response of alluvial rivers to variable sediment supply, discharge and slope. The experimental channels exhibit a newly identified multi-stage response: the narrowing of the channel and stripping of the alluvial cover in a downstream migrating incision wave followed by destabilisation of the bedrock surface and development of self-formed knickpoints when the hydraulic conditions are supercritical. Headward erosion by knickpoints is the most efficient process of strath terrace abandonment, contributing the majority of the total vertical incision, even in the absence of base-level fall or any vertical offset in channel elevation. We also demonstrate the possibility of self-formed knickpoints developing under supercritical flow conditions in driving the rapid response of fluvial systems to external climatic perturbations in natural systems, highlighting a previously unrecognised process leading to strath terrace abandonment. This has implications for the understanding of distributions of strath terrace ages, and how landscapes respond to climatic or tectonic perturbations.