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Controls on river long profile development and knickzone retreat in response to tectonic perturbation

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Prominent convexities in channel long profiles – knickzones – are an expected feature of bedrock rivers responding to a change in the rate of base level fall driven by tectonic processes. The morphometry of these convexities provides great potential for placing quantitative constraints on the dominant river erosion process as the rivers respond to the change in external forcing. We present field data regarding the height and retreat rates of knickzones in rivers upstream of active normal faults in the central Apennines, Italy, where excellent constraints exist on the temporal and spatial history of fault movement. The knickzones developed in response to an independently-constrained increase in fault throw rate $\sim$0.75 Ma. The magnitude of the throw acceleration varies spatially along individual fault segments, allowing us to compare rivers that have been perturbed to a different degree. The data show that the height of the knickzone scales approximately linearly with present-day fault throw rate. We also find that the knickzone retreat velocity (calculated from the time since fault acceleration) scales systematically with throw rate, even after accounting for differences in drainage area. This feature of our data is not explained by the classical stream power model for river incision, unless n, the slope exponent in the stream power law, is much greater than 1, a result which lacks a satisfying process-based interpretation.

Channel characteristics and shield stress values suggest that these rivers lie close to the detachment-limited end-member. We use the landscape evolution model CHILD

to investigate the extent to which we may match the long profiles of the studied rivers under the known tectonic forcing, within a detachment-limited erosion framework. In particular, we investigate whether the relationship between knickzone retreat rate and fault throw rate, as revealed by our field data, may be explained by including a physically realistic erosion threshold value, or whether other models ($e.g.$, sediment-flux dependent river incision) provide a better explanation.