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How fast do landscapes respond to active faulting?

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Understanding the rate at which landscapes respond to tectonic perturbation remains a key challenge in the Earth Sciences. Central to solving this problem is the behaviour of transient knickpoints in bedrock rivers draining areas of high relief, because they transmit the signal of boundary condition change to the landscape. Consequently, the rate at which they propagate upstream fundamentally controls geomorphic response times to tectonics. Here we present knickpoint retreat rates upstream of active normal faults for bedrock catchments in Turkey and Italy where we have excellent constraints on both the magnitude and history of fault throw rates, and where climate histories are well documented. We show that the knickpoints have average retreat rates of between 0.2 and 2 mm/yr for catchments with drainage areas between 6 and 65 km^2 and we test whether differences in rock mass strength and catchment size are sufficient to explain this range in retreat rates. Our analysis suggests that even accounting for these two variables, knickpoint propagation velocities differ markedly, and we show that channels crossing faults with higher throw rates have knickpoints that are retreating faster. Importantly, the dependence of knickpoint retreat velocity and throw rate is at least as important as catchment drainage area. The link between the knickpoint propagation velocity and throw rate is best explained by dynamic channel adjustment, because rivers crossing high throw rate faults are both narrower and steeper for the same drainage area than those crossing slower moving faults. These results indicate, counter-intuitively, that landscapes forced by large amplitude tectonic perturbations will have shorter response times than those perturbed by smaller amplitude changes. Our results also highlight that dynamic adjustment of channel widths and slopes, in response to a tectonic perturbation, makes a significant difference to fluvial response times, and we argue that this effect must be incorporated routinely within landscape evolution models.