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Fluvial development of major Alpine valleys since the mid-Pleistocene transition

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The effects of both fluvial and glacial processes are evident in the morphology of bedrock hillslopes and river channels throughout the European Alps. While steep rock slopes in upper, U-shaped reaches of valleys provide clear evidence for a Pleistocene history that includes at least one period of major glacial erosion, river channels near the toe of blocky rock slopes in lower, V-shaped reaches suggest fluvial incision has played an important role in Alpine evolution. In order to differentiate the impact of these two process regimes on the development of the orogen, we use a combination of integral analysis and forward streampower models to identify a series of corresponding steepened channel reaches across a relatively homogeneous tectonic block of the southern Swiss Alps. We consider these steepened channel sections represent up to seven knickpoints that extend 800 m above the elevation of the present-day Rhone Valley. The uppermost (oldest) knickpoint is currently located approximately half-way into each valley, and effectively defines the front of fluvial erosion into a relict glacial landscape preserved in the upper reaches of each catchment.

We expect that these knickpoints form near the outlet of tributary valleys as a result of bedrock uplift during major glacial cycles. The knickpoints are exposed during deglaciation, and propagate upstream as in response to increased streampower during major Pleistocene interglacials. By employing a forward streampower incision model regulated by the timing of global marine isotope stages we are able to reproduce both the form, and location of knickpoints across our study region, and correlate distinct breaks in cross-sectional valley slope to discrete glacial – interglacial transitions. Our results indicate that Alpine landscape evolution has been driven by a combination of tectonic uplift and fluvial incision since an initial period of enhanced glacial erosion prior to 0.7 Ma. We find that rates of tectonic uplift have been relatively consistent since this time, while transitional landscape forms have been largely preserved throughout each glacial cycle.