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What can we learn from fluvial incision in high mountains?

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High and actively deforming mountain ranges attract the attention of geoscientists as they provide natural laboratories of fast evolving process-response systems.
Tectonic compressional settings, often linked to perpendicular extension, control the topographic growth and hence, erosion, transport pathways and sedimentation. High altitude differences within short horizontal distances promote material re-organisation and high rates of surface processes. Furthermore, high mountains constitute orographic barriers that affect atmospheric circulations as well as host different climate regimes similar to those of widely separated latitudinal belts. Both cause a high sensitivity of surface processes to changes in climatic conditions. However, feedbacks between climatic and tectonic forcing are complex. Additionally, the dominance of one or the other varies in space and also over time, inheriting various traces of the paleo-morphodynamic conditions to the subsequent process regimes.
To unravel the forces driving the evolution of relief in active mountains, numerous studies employ the drainage network of the corresponding mountains as a proxy of landscape evolution. Especially the rates of river incision provide a powerful tool to characterize the surface response and infer causes behind it. Several parameters of river incision are available to describe the fluvial incision at individual sites (e.g. terrace incision rates), along the river course (e.g. longitudinal river profiles, Hack index) and in its perpendicular dimension (e.g. valley cross sections, valley shape ratios). But they require careful interpretation. They are sensitive to both, climatic and tectonic forcing. Therefore, the synopsis of such indices for fluvial incision is essential to evaluate the role of climatic versus tectonic forcing.
Here, we use the Panj river system, the major river draining the Pamir mountains of Central Asia, as an example. The Panj experiences high altitude changes of more than 4000 m and deflects several times from the main river orientation, where it cuts through major deformation zones and dome structures of the Pamir. Our contribution discusses the potentials and limitations of river incision analysis. We infer climatic versus tectonic forcing based on terraces along the Panj river together with the indication from its longitudinal profile, Hack index and valley shape ratios.