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Estimation of river incision rates in low-relief landscapes by combining local and catchment-wide denudation rates obtained from cosmogenic nuclides

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The topographic evolution of landscapes is substantially controlled by rivers, hence the quantification of river incision rates is crucial to reconstruct the pace and pattern of landscape formation. Most approaches to quantify river incision use geomorphic features like river terraces and their elevation above today's riverbed. This procedure works well, but is not applicable if dateable terraces are absent. Our approach utilizes local and catchment wide erosion rates derived from cosmogenic nuclides in combination with a digital elevation model. The basic concept relies on the general observation of linear correlation between hillslope angles and erosion rates for slopes $<25^{\circ}$. This correlation allows us to assign an erosion rate to every pixel of the DEM within a catchment. Starting with the local erosion rate of a flat surface (into which the river is incising), we compute an average erosion rate for the entire catchment by adapting the linear correlation between slope and erosion rate, so that the modelled erosion rate for each pixel is equal to the one derived from a river sediment sample. This results in a specific linear correlation between local slope and local erosion rate for each catchment. Local hillslope angles adjacent to a river are assumed to reflect the local erosion rate and thus the rate of river incision. Hence, the incision rate can be derived from the hillslopes adjacent to the channel and the linear correlation between slope and erosion for the respective catchment.

We applied our approach to a bedrock peneplain on the southern Tibetan Plateau, where rivers have incised granitic bedrock and generated a local relief of 300-700 m (Hetzel et al., 2011; Strobl et al., 2012). Local erosion rates of 6-9 mm/ka on the peneplain are slightly lower than the catchment-wide erosion rates of 10-16 m/ka (Strobl et al., 2012). The approach outlined above yields river incision rates between $\sim$13 and $\sim$30 mm/ka. These rates are higher by a factor of 2-3 than the difference between local and spatially integrated erosion rates. Our results confirm the notion that the peneplain constitutes a slowly evolving landscape and are consistent with its long-term stability since the India-Asia collision (cf. Hetzel et al., 2011).

Hetzel, R., Dunkl, I., Haider, V., Strobl, M., von Eynatten, H., Ding, L., Frei, D. (2011). Peneplain formation in southern Tibet predates the India-Asia collision and plateau uplift. Geology 39, 983-986, doi: 10.1130/G32069.1.

Strobl, M., Hetzel, R., Niedermann, S., Ding, L., Zhang , L. (2012). Landscape evolution of a bedrock peneplain on the southern Tibetan Plateau revealed by in situ-produced cosmogenic ^{10}Be and ^{21}Ne. *Geomorphology* 153-154, 192-204, doi: 10.1016/j.geomorph.2012.02.024.