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Quantifying river incision into low-relief surfaces using local and catchment-wide 10Be denudation rates

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Relief generation in non-glaciated regions is largely controlled by river incision into bedrock but datable fluvial terraces that allow quantifying incision rates are not always present (e.g. Ahnert, 1970; Whipple et al., 1999; Burbank and Anderson, 2012). Here we suggest a new method to determine river incision rates in regions where low-relief surfaces are dissected by streams. The approach consists of three steps and requires the 10Be concentrations of a stream sediment sample and a regolith sample from the low-relief surface. In the first step, the spatial distribution of 10Be surface concentrations in the given catchment is modelled by assuming that denudation rates are controlled by the local hillslope angles. The slope-denudation rate relation for this catchment is then quantified by adjusting the relation between slope angle and denudation rate until the average 10Be concentration in the model is equal to the one measured in the stream sediment sample. In the second step, curved swath profiles are used to measure hillslope angles adjacent to the main river channel. Thirdly, the mean slope angle derived from these swath profiles and the slope-denudation relation are used to quantify the river incision rate (assuming that the incision rate equals the denudation rate on adjacent hillslopes). We apply our approach to two study areas in southern Tibet and central Europe (Black Forest). In both regions, local 10Be denudation rates on flat parts of the incised low-relief surface are lower than catchment-wide denudation rates. As the latter integrate across the entire landscape, river incision rates must exceed these spatially averaged denudation rates. Our approach yields river incision rates between ∼15 and ∼30 m/Ma for the Tibetan study area and incision rates of ∼70 to ∼100 m/Ma in the Black Forest (Wolff et al., 2018). Taking the lowering of the low-relief surfaces into account suggests that relief in the two study areas increases at rates of 10-20 and 40-70 m/Ma, respectively.

References

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