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How does sediment mixing affect 10Be concentrations in alluvial sediments? A case study from a small catchment of the Alps, Zielbach, Alto Adige, Italy

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Basin-wide erosion rates can be determined through the analysis of in situ-produced cosmogenic nuclides based on the idea that samples taken at the outlet of a catchment are representative of the entire upstream basin. However, this is only true when a certain number of assumptions are verified. Among the most important assumptions is that denudation rates are uniform through space and time; i.e. the catchment is in cosmogenic steady-state. If this is the case, then the in-going nuclide flux through production is equal to the out-going flux through decay and erosion, and the system is in isotopic equilibrium. When this condition is not matched, the calculation of basin-wide erosion rates through cosmogenic nuclides is subject to the well-mixing conditions of the alluvial sediment in the rivers. Here, we bring a new contribution towards the understanding of sediment mixing effects on in-situ cosmogenic nuclide concentrations in alluvial sediment. We proceed by following the methodology proposed by Binnie et al. (2006), and present the results from a sediment mixing model for a small ($\sim$42 km2) catchment in the Alps. The model results show the importance of the sampling location and of the catchment's size to have reliable erosion rates. However, the models also highlight the importance of knowing the sediment transfer mechanisms and the processes magnitude. When the transport of sediment mainly occurs through soil creep and shallow landslides, high concentration material is supplied into the fluvial system, increasing the 10Be concentration in the alluvial sediment. Likewise, the high-frequency of mass-wasting processes or the occurrence of sporadic but large-magnitude events, allow the supply of low-concentration sediment that result in a lower cosmogenic nuclide signal in the channels., A strong bias arises for the calculation of basin-wide erosion rates if mass-wasting processes dominate the mechanisms of sediment transfer in the catchment. In this situation the use of cosmogenic nuclides signal results in an over- or underestimation of the erosion rates. Therefore, our results suggest that when using cosmogenic nuclides, the achievement of mixing conditions in alluvial sediment is of primary importance for the correct estimation of the erosion rates and that this latter has to be accurately interpreted when the mixing conditions are unknown or not achieved.