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Sediment tracing, mixing and budgets in debris flow catchments: a cosmogenic nuclide perspective

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Mountain catchments are at the start of the source-to-sink cycle in erosional and sedimentary environments. These catchments are sensitive to climate, geomorphic inheritance and human perturbation and are commonly dominated by episodic mass-wasting processes (landslides, debris flows). Quantifying the production and evacuation of sediment from such catchments (i.e. their erosion rates) is difficult and highly dependent on the spatial and temporal scales investigated and the methods/techniques applied. Crucial questions are where and when the sediment is mobilized and discharged, and where and how the quantitative erosion measurement is taken in time and space.

We have investigated such issues in the Haslital Aare of Central Switzerland, from a sediment yield and a cosmogenic nuclide perspective. Localized mobilization of sediment as debris flows due to rockfall, heavy rainfall and permafrost thawing has been quantified volumetrically and in terms of cosmogenic nuclide (10Be) concentrations. Sediment sources and reservoirs (talus slope deposits, glacial debris, hillslopes, debris flow fans) are investigated at the source site, at the tributary - trunk stream junction (debris-flow subcatchment scale, ∼4 km2) and at the outlet of the catchment (∼70 km2). These measurements indicate that the sediment is not as thoroughly mixed at subcatchment and catchment scale as required by the concept of cosmogenic nuclide. However, a balancing effect (potentially back to natural background levels) of localized signals is observed at variable temporal and spatial distances of the episodic event.

Detected sediment volumes mobilized during debris-flow events are larger than those calculated from cosmogenic nuclide derived denudation rates. This is largely due to lateral and vertical sediment entrainment in debris flow channels for which the cosmogenic nuclide method is little sensitive. The incorporation of non-steady produced sediment (residing in shielded fan deposits) can yield apparent denudation that are not representing continuous catchment erosion and sediment discharge processes.

With regard to the dynamics of low-order catchment processes, the question is raised how reliable catchment wide denudation rates are and which temporal and spatial scale of integration is most suitable. It is aimed to quantify the typical nuclide concentration inventories of sediment sources and storage units in order to provide a better understanding of nuclide perturbations, and thus catchment wide denudation rates, in debris flow dominated catchments.