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Quantification of coarse sediment connectivity in alpine geosystems

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In alpine catchments several subsystems (rock face, slope, and valley floor) are sedimentologically connected by geomorphic processes like rock fall, debris flows, avalanches, etc. If these processes work together by propagating sediment from source (rock face) to sink (outlet) they constitute sediment cascades.

Sediment connectivity is a system property which describes the integrated state of coupling of these processes to sediment cascades in a given catchment. It accounts for the nonlinearity of the sediment delivery ratio at different scales and is mainly a function of the topologic configuration of the geomorphic system.

In the presented study numerical GIS-based models are applied to digital elevation models (DEM) to investigate the coupling of geomorphic process units by delineating the process domains of important geomorphic processes in high-mountain environments (rock fall, slope-type debris flows, slope aquatic and fluvial processes). Graph theory is used as an overarching framework to analyze the individual process domains and to connect them to a sediment cascade. For a given outlet the coupled area and the sediment transfer potential can be obtained. The models also generate so-called edge lists that can be converted to adjacency matrices and graphs which can be used to calculate connectivity indices.

The results are validated by field mapping and show that only small parts of a catchment are actually coupled to its outlet with respect to coarse (bed load) sediment. Such quantification complements the mainly qualitative appraisal of coupling and connectivity; the effect of connectivity on other catchment properties such as specific sediment yield and catchment sensitivity can then be studied on the basis of these quantitative measures.