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Graph theory-based sediment connectivity analysis of a glacierised Alpine basin for different event scenarios

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Sediment connectivity has been receiving increased attention in the last years. Several approaches have been applied to analyse where and to what extent sediment sources are connected to the main fluvial network and/or to depositional areas. Especially in mountain environments, sediment transport is temporally and spatially variable, and thus assessing sediment connectivity is challenging. Within this work, a graph theory-based approach is presented, with the aim to identify changes in space and time within the sediment transport network during the main sediment transport periods of the year.

A network, built up by nodes and directed edges, was manually digitized for the Sulden/Solda river basin (Vinschgau/Venosta valley, Italian Alps). The nodes represent landforms delineated within a previously developed geomorphological map, which features 32 different landform categories and seamlessly covers the entire basin (~130 km²). The directed edges are connecting nodes if sediment transport is (potentially) occurring from one to the subsequent geomorphological unit. This evaluation was made based on visual evidences from orthophotos and geomorphological as well as topographical characteristics of the respective landforms. Furthermore, a sediment transport process type was assigned to each edge.

Snow and glacier melt scenarios are defined by the occurrence of specific sediment transport processes, hence activation or deactivation of the related edges. Scenarios representing potential sediment transport networks during intensive heat periods and intense rain storms are included for both melt seasons, taking into consideration the expected higher frequency of these meteorological conditions in the future decades. For example, rain storm scenarios include edges showing potential debris flow trajectories, whereas these connections are not present in scenarios representing just snow- and ice-melt events. Therefore, functional connectivity changes within the proposed sediment transport network scenarios. For all the events, graph theory measures are calculated, as e.g. the betweenness centrality index to identify “hot-spot” nodes of the sediment cascades. Furthermore, the quantity and the composition of the sediment cascades reaching the

catchment outlet can be identified in order to highlight the most relevant transport processes as well as to derive the most typical sediment cascades for a specific area.

The study basin is characterized by a high sediment availability due to large glacio-fluvial deposits present at the glaciers forefield and to the wide areas covered with talus deposits. However, the connectivity analysis demonstrates that a vast portion of these sediment sources is not connected to the main channel under the modelled melt runoff scenarios. Only in case of intense rainstorms talus deposits might become a coupled sediment source due to the potential occurrence of debris flows. Hence, areas connected only occasionally due to the (re-)activation of specific sediment cascades can be mapped. Additionally, a relative connectivity degree is calculated for every scenario, introducing a better comparability.