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Sediment characterization, stocks and erodible relief quantification in alpine context using sloping local base level, from single watersheds to large-scale source-to-sink systems

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Erosion rates in alpine context since the last glacial maximum are classically calculated from accumulated sediments in glacial overdeepenings. Such erosion rates omit stored sediments in lateral valleys and secondary glacial troughs that have yet to get transported to the final sink. Their potential availability to the dominant mass wasting processes, such as landslides and debris-flows, is also important to assess, since sediment production and availability is a major driver of those hazardous phenomenon.

In this study, a methodology to characterize sediment stocks and estimate their volume is applied to several watersheds, ranging from single torrential systems up to whole lateral valleys, and finally the complete source-to-sink system of the alpine Rhône river.

First, areas occupied by colluvium, Holocene processes deposits and slope instabilities are mapped, using geological maps and HR-DEM hillshade. Each area is identified by its dominant formation process, and its situation in regard to glacially shaped valley geometry. For instance, glacial troughs are treated differently from valley walls and glacial cirques. The volume of sediments is given by subtracting a bedrock surface estimated with the SLBL methodology, with rock outcrops as fixed points, from the current topography. Where available, coring and geophysical data are used to constrain the geometry of the bedrock surface.
Secondly, erodible relief is identified by considering the upper reaches of hydrologic networks as base levels. The volumes are constrained at the base with a slope angle derived from rock mechanics literature, thus changing with lithology, to emulate future potential slope movements towards the river network.

The estimated stocks are then analyzed by process, age, and situation in the sediment cascade. The erodible relief allows localisation of future mass wasting potential, including the remobilization of existing stocks and future input from the still intact rock mass. The proposed method is applicable quickly and permits a rapid geomorphodynamic assessment of local and regional areas.