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Sediment reservoirs and sediment fluxes in high mountain environments: how does sediment move through the system at the decadal scale?

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Faced with rapid climate warming over recent decades, high mountain systems are likely to respond dramatically because of: (1) the vulnerability of permafrost, glacial and nival processes to temperature and precipitation changes; (2) the ample availability of unconsolidated, potentially mobile sediments left after deglaciation; and (3) steep slopes, that potentially aid sediment mobilization. We no surprisingly know little about these processes over the decadal scale because the geomorphic response is often complex, spatially and temporally, and there is little history of decadal scale measurement of these systems. In this paper, we focus upon a number of basins in the Southern Swiss Alps, with a wide range of primary sediment transfer mechanisms and altitude ranges up to 1,800 to 3,600 m asl. We are able to combine a set of unique data on: (1) erosion/deposition processes (derived from combined geomorphological maps and photogrammetrically-derived Digital Elevation Models); (2) sediment flux based upon tracking sediment using image correlation; (3) sediment connection quantified using a new approach to handle DEM noise; (4) changing stream sediment transport capacity derived from hydrodynamic modeling applied to long time series of river flow; and (5) sediment export measured at intakes flushed periodically as part of hydropower management.

Results suggest a distinct landscape response to climatic forcing. A progressive acceleration of surface displacements for different landforms is observed throughout the last five decades. We observed that, with the beginning of a warmer period in the 1980s, glacier retreat and enhanced snowmelt caused water yield to increase considerably for various watersheds. This translates into enhancement of sediment transport capacities, which in combination with the intensification of landscape dynamics (greater erosion rates) explains the increase flushing frequency and hence sediment export registered in the basins. However, whilst sediment export continues to raise under these conditions for some basins, in other cases the export is damped. We attribute this to the constraints imposed by both longer term (centennial scale) erosion/deposition legacy (which creates sediment reservoirs) and the sediment transport mechanisms themselves, some of which can be highly inefficient in moving sediment through the system. Such processes may reduce the extent to which climate forcing of landscape response can be detected in valley-bottom sediment deposits.