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Decadal scale climate forcing of mass movement and sediment flux in Alpine mountain setting

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Whilst the inevitability of future climate warming is now recognized, and we also know much more about the nature of climatic variability and its causes, our understanding of the effects of such variability upon landscapes at the time scale of decades is much less well known. This is for two reasons: (1) the complex, non-linear and path-dependent nature of the response of a landscape to climate forcing, and (2) the difficulty of investigating this forcing at the timescale of decades to centuries, despite this being the timescale over which significant hypotheses are raised over human impacts upon climate change and hence geomorphic systems. A unique resource to investigate the linkages between climatic variability and geomorphic response is provided by the extensive coverage of aerial imagery commonly available since the 1940s. The information contained in such imagery can be employed to produce high precision digital elevation models (DEMs) over large spatial scales using archival digital photogrammetry. Here, we reconstruct the quantitative history of mass movement and sediment flux in a high mountain Alpine system, over the timescales of decades, through the quantitative comparison of successive DEMs. Propagation of error methods are used to identify locations of significant geomorphic response and to compute volumes of significant erosion and deposition. These are coupled to extant climate data to show how the landscape responds to climate forcing and to geomorphological maps to understand how this response varies between both landscape elements and their spatial organization. The results show distinct landscape response to both warming and cooling periods but these are found to be asymmetrical because the speed of landscape response to warming is greater than the speed of response to cooling. There is a strong variability between landscape elements in their sensitivity. Whilst some elements of the system are exceptionally sensitive to warming and lead to locally high sediment flux, there is a landscape heritage in the system that can, but not always, lead to disconnection of sensitive zones from the valley bottom. This explains the counter-intuitive observation that whilst the asymmetry of landscape response to warming and cooling implies at net increase in sediment flux towards the valley bottom this is not manifest in the valley bottom itself (e.g. in an increase in alluvial fan dynamics) because this flux is commonly disconnected.