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Using geomorphological maps to improve digital elevation models in high mountains environments

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Whilst current digital elevation modeling has been substantially aided by ground-based technologies, understanding environmental change impacts in mountain environments over longer timescales requires unlocking of the information held in historical aerial images. These are commonly available from the 1940s for the European Alps and digital photogrammetric approaches have been established for using such data sources to create precise digital elevation models (precise to better than c. $\pm$0.5 m) over large spatial scales (10s and 100s of km^2) that can be used to quantify erosion and deposition in response to recent environmental change. In this paper, we show why geomorphological maps are essential for this development for two reasons. The first is as expected: interpreting catchment scale patterns of erosion and deposition requires reference to the underlying spatial assemblage of landforms present. Digital geomorphological maps can be used to do this, and through classifying erosion and deposition patterns by landform, can be used to identify: those elements of the landscape most sensitive to recent environmental change; and their spatial organization, something that is central to how they interact together to drive sediment flux. The second reason is more surprising. In Alpine environments, the quality of estimation of elevation by digital photogrammetry can be spatially variable and uncertain due to local topography (occlusion caused by sudden elevation changes, areas with large elevation ranges) or varying image texture. Tests on the performance of stereomatching algorithms, including the filtering necessary to guarantee the quality of derived DEM data, show that data quality is highly variable between landform types within a given landscape. Generating high quality DEMs is therefore improved if geomorphological maps are used to define such inherent spatial variability during data processing. Here, we demonstrate these two points using aerial imagery for Val d'Héréns, Switzerland from the 1950s to present, for a landscape ranging in elevation from 1,800 to 3,600 m. This landscape contains an assemblage of glacial, periglacial, hillslope and fluvial landforms. In the paper we will show how digital geomorphological maps have been crucial both to realizing the quality of DEMs defined theoretically by the associated image scale and also for explaining the spatial structure of patterns of erosion and deposition, and hence sensitivity of the landscape to environmental change, over the last 7 decades.