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Long-term evolution of hillslopes and drainage networks under repeated impact of glacial erosion

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The morphology of hillslopes is an important indicator of landscape change and erosion. In nonglacial catchments, its characteristics depend to a large extent on channel processes and are a function of climate, tectonic and underlying bedrock. These factors may however become secondary when affected by glacial erosion as it is the case in many mid- to high-latitude mountain belts. The perturbation of the initial steady state hillslope morphology (where uplift is balanced by surface lowering rates) will tend to become successively larger if the repeated action of glacial processes exceeds the potential of fluvial readjustment during deglaciated periods. In the limiting case that fluvial or colluvial readjustments to the topography are smaller than modifications by glacial action, the history of glacial erosion rate may be faithfully archived in the form of hillslopes and the channel network (Salcher et al., 2014). This relation is furthermore important as significant mass is generally mobilized and eroded in the hillslope domain delivering material to the channel system. Here we analyzed the glacially modified topography of the European Central Alps, a region which has been multiply glaciated during the Quaternary and were tectonic processes have largely ceased. The higher elevated catchments suffered a more intense impact of glacial erosion than lower elevated catchments whereas fluvial (steady state) processes dominate the alpine foothills or regions outside the former ice sheets. To investigate variations to the hillslope domain we utilized digital elevation models to define hillslope parameters (area, length relief) as function of channel head locations. Channel heads are then calculated as a function of minimum channel plan curvature. Our results show that hillslope area, relief and length increases with the cumulative impact of glacial action. This relation is however only valid were individual tributary glaciers and associated headward erosion could evolve during any time of the Quaternary. We also found that the Strahler orders of the according basins decrease. Potential long-lasting effects of these glacially modified hillslopes on the erosion of the contemporary landscape were analyzed by utilizing catchment-averaged concentrations of cosmogenic 10Be from existing studies of Central Alpine basins. We finally observed variations in hillslope's land cover distribution, its potential dependence on hillslope shape and an influence on catchment erosion rates.

Salcher, B.C., Kober, F., Kissling, E., Willett, S.D. (2014): Glacial impact on short-wavelength topography and long-lasting effects on the denudation of a deglaciated mountain range. Global and Planetary Change 115, 59–70.