Geophysical Research Abstracts
Vol. 16, EGU2014-15949-1, 2014
EGU General Assembly 2014

Glacial modifications of short-wavelength topography and potential feedbacks on the denudation of a deglaciated mountain range

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Distinct erosional landforms in the European Alps and other mid- to high-latitude mountain belts highlight the importance of glacial erosion in shaping mountain topography. Here we focus on the glacially induced modifications to the short-wavelength topography of the European Central Alps in an attempt to characterize the impact of glacial erosion on topography and to highlight potential feedback mechanisms on the denudation of the deglaciated mountain range. Glacial induced changes to the short-wavelength topography were analyzed by measuring the variations of drainage density and hillslope relief across the range. Variations of denudation rates were analyzed by compiling catchment-averaged concentrations of cosmogenic 10Be from existing studies covering Alpine and Foreland basins.

Our results underline the importance of the LGM ELA elevation (i.e. the Equilibrium Line Altitude at the Late Glacial Maximum) as an important limit for the destruction of short-wavelength topography: The cumulative impact of glacial erosion above the LGM ELA has progressively decreased (i) drainage density, (ii) channel integration and (iii) commensurately increased hillslopes length (or hillslope relief). Exceptions from this trend are the highest and steepest peaks and ridges, nunataks even during the LGM. Alpine catchments in the orogen parts below this limit (i.e. Alpine foothills) lack strong modifications by glaciers. Here, glacial erosion is largely restricted to glacial troughs.

There is also a statistically significant correlation between drainage density (or hillslope length) and catchment-wide denudation rates. The correlation does not define a single-valued function; rather there are two populations above and below the LGM ELA, one with a positive correlation for low-elevation, fluvially-dominated landscapes and a second for high-elevation, glacially-eroded basins in which this correlation is negative. We speculate that the commensurate lengthening of hillslopes increase slope instability and mass flux, thereby resulting in higher denudation rates. Rock mass strength seems to have a further significant effect on these relationships.

Our results might indicate an important driving mechanism behind surface denudation of glacially conditioned mountain ranges operating over glacial-interglacial time scales.