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Glacial conditioning and postglacial erosion of the Central Alps – patterns and magnitude

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The interactions among climate, tectonics and surface processes have received considerable attention in the last years. Most studies, however, have focused on fluvial bedrock erosion or associated hillslope processes. Less is known about the magnitude and geometry of glacial erosion and how this is related to the postglacial erosion pattern. This is surprising given the abundance and distinctiveness of alpine terrain in many mid and high latitude orogens. Mass wasting (e.g. debris flows, landsliding, rock fall) related to unstable hillslopes are the most important features in alpine terrain and are likely to outpace rates of the pre-glacial state. In this study we argue that the reduction of fine–scale topography and the commensurate lengthening of hillslopes reflect the degree of glacial overprinting. We show that the reduction of fine-scale topography, as measured by drainage density, in a catchment is related to increasing catchment denudation rates based on new and published cosmogenic nuclide concentrations in sediment (Wittmann et al., 2007). We interpret this relationship as being a consequence of glacial oversteepening and the increasing number of unstable hillslopes. Postglacial erosion rates are highest around the modern ELA where the obliteration of fine-scale topography is highest as glacial coverage and sliding velocity was cumulatively longest. A secondary but significant effect is rock strength. Our results indicate that at uniform glacial history (glacial thickness) soft rocks (e.g. schists) are associated with a higher degree of obliteration. Steep, isolated ridges and spurs far above the modern ELA show a much lower degree of obliteration as glacial erosion is limited in these regions. Even though no measured erosion rates are available at mountain peaks, this indicates limited erosion.
By measuring the degree of obliteration we also modelled the corresponding postglacial erosion rates on the scale of the Central Swiss Alps. The model highlights high rates in the Aar-Gotthard massif, the Penninic nappes in eastern Switzerland and the Valais (Dent Blanche nappes). Rather low rates prevail within the Lapontine Dome. Our erosion models are consistent with data on precise leveling, confirming the results of previous studies which suggest that the uplift of the modern Central Alps is a consequence of erosional unloading.

References:

Wittmann, H., F. von Blanckenburg, T. Kruesmann, K. P. Norton, and P. W. Kubik (2007), Relation between rock uplift and denudation from cosmogenic nuclides in river sediment in the Central Alps of Switzerland, Journal of Geophysical Research- Earth Surface, 112, F04010, doi:04010.01029/02006JF000729.