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Spatial and temporal variations of glacial erosion in the Rhône valley (Swiss Alps): insights from numerical modeling

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The present-day topography of the European Alps shows evidence of intense glacial reshaping. However, significant questions regarding Alpine landscape evolution during glaciations still persist. For example, large-scale topographic analyses suggest that glacial erosion is maximized at and above the glaciers' long-term Equilibrium Line Altitude. In contrast, measurements of long-term denudation rates from low temperature thermochronology suggest high erosion towards low altitudes, leading to an increase of local relief in response to glacial erosion. Based on sediment record, low-temperature thermochronology and burial cosmogenic nuclide dating, it has also been proposed that the mid-Pleistocene climatic transition from symmetric, 40kyr to asymmetric, 100kyr glacial/interglacial oscillations sets the onset of intense glacial erosion within the Alps. However, this climate threshold in glacial erosion has not been showed in other orogens, and positive feedbacks between climate periodicity and glacial erosion efficiency still remain to be proven.
We focus on the Rhône valley (Swiss Alps), and use a numerical model to estimate patterns and magnitudes of glacial erosion. Comparing modeling results on an advanced reconstruction of the pre-glacial topography (Sternai et al., 2012) and the present-day landforms, we found that erosion propagates headward as the landscape evolves from a fluvial to a glacial state, leading to an initial increase of local relief in the major valley trunk followed by subsequent erosion at high elevations.
We also test the mid-Pleistocene transition hypothesis by running a 2Myr numerical experiment including a shift from symmetric, 40kyr to asymmetric, 100kyr glacial/interglacial oscillations at 1Myr. Although the change of climate periodicity may have produced an intensification of glacial erosion, our results suggest that other factors such as an increase of rock uplift and/or progressive climate cooling are required to explain enhanced valley carving at approximately 1Myr.