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Pre-glacial topography of the European Alps

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We present a reconstruction of the Alpine topography prior to Quaternary glaciation, based on the assumption that the pre-glacial topography of the Alps was a fluvial landscape in equilibrium with tectonic and isostatic rock uplift. Amongst the models that have been proposed, the stream-power law has been profitably used for modeling the dynamics of fluvial bedrock channel incision:

$$\frac{\partial z}{\partial t} = U - KA^m S^n \tag{1}$$

where $\partial z/\partial t$ (m a^{-1}) is the time rate of change of channel elevation, U(m a^{-1}) is rock-uplift rate, A(m) is upstream drainage area, S is local channel gradient, K is a dimensionless coefficient of erosion and m and n are positive constants related to basin hydrology and erosion process. Under steady-state conditions ($\partial z/\partial t = 0$), equation (**??**) can be solved to yield an expression for equilibrium channel gradient:

$$S = \left(\frac{U}{K}\right)^{\frac{1}{n}} A^{-\left(\frac{m}{n}\right)} \tag{2}$$

where the ratios U/K and m/n are generally referred to as the steepness and concavity index, respectively. Particular focus is put on the spatial variability of the steepness index over the Alpine mountain belt. Assuming a constant concavity index, the pre-glacial topography of the Alps is obtained through an inversion technique that resolves local slopes (as described in eq. 2) by minimizing the misfit between the elevations of the actual and modeled channel heads. Comparing the present-day and reconstructed pre-glacial topography, we infer patterns and magnitudes of exhumation and rock uplift produced by Quaternary glaciation in the Alps. We find a correspondence between rock type and pre-glacial channel steepness which may indicate that rock erodibility has a significant importance in determining the pre-glacial fluvial network elevation. Our results also provide insight into patterns of glacial erosion and associated isostatic adjustment, and provide estimates of the increase of valley-scale topographic relief and decrease of mean elevation that glaciation seems to have produced in the Alps.