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Correlation between elevation and denudation from in-situ produced ^{10}Be in stream sediments (French Western Alps): effect of frost-shattering?

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The morphology of the Pelvoux–Ecrins massif (French Western Alps) has been strongly influenced by Quaternary glaciations. Combining in-situ produced cosmogenic nuclide measurements and morphologic analyses provides a powerful tool to study interactions between tectonic forces, climate and surface processes. The aim of this study is to determine and quantify erosion processes in this massif on post-glacial timescales. Here, we report spatially averaged denudation rates from twelve catchments within the massif with mean elevations ranging from 1700 to 2800m. Spatially averaged denudation rates were calculated using in-situ produced ^{10}Be concentrations from the quartz fraction of alluvial sediments. Mean denudation rates vary from 0.32 $\pm$ 0.03 mm/a to 1.73 $\pm$ 0.15 mm/a with integration times of 3.2 and 0.75 ka respectively. No correlations with catchment area, mean slope gradient or mean geophysical relief has been observed. However, mean denudation rates are strongly correlated with the mean elevation of the catchments (R^2 = 0.76). As glacier-covered sediments have low ^{10}Be concentrations, their contribution can bias the calculation of integrated catchment-scale denudation rates. We have corrected for this effect by fixing to zero the ^{10}Be production rates of areas covered by the Little Ice Age glacial extension. Mean denudation rates after this correction vary from 0.3 $\pm$ 0.03 mm/a to 1.1 $\pm$ 0.09 mm/a with integration times of 3.4 and 1 ka respectively. These results are in good agreement with published studies of post-Last Glacial Maximum denudation rates in the Alps and retain their correlation with mean elevation of the catchments (R^2 = 0.55). Moreover, we can exclude the link of this relation with a glacial erosion-effect.

In the relatively restricted Pelvoux-Ecrins massif, where rock-uplift rates can be considered uniform, we interpret this relation between spatially averaged denudation rates and mean elevations of catchments as the effect of temperature reduction with altitude. High-elevation catchments are more sensible to frost-shattering processes which increase the denudation rates at the catchment scale. Our study thus strongly suggests that present-day denudation of this mountain belt is controlled by a climatic driven factor and has important implications for the interpretation of variation of denudation rates on larger spatial scales.