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The Late Miocene to recent erosion pattern of the Alpine foreland basin reflects Eurasian slab-unloading beneath the western Alps rather than global climate change

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It has been proposed that mountainous erosion increased globally around 5 Ma in response to global climate change, mainly because this increase coincides with a cooling trend indicated by global isotopic data (e.g., Herman et al. 2013). The Alps have played a prominent role in this debate. Published sedimentary budgets for the western and eastern Alps for the past 35 Ma show a substantial increase in the erosion of the Alps at c. 5 Ma (e.g., Kuhlemann, 2000). This temporal coincidence was used to call for a climate driver, mainly because this increase was not accompanied by tectonic convergence across the Alps during this time period. However, several authors emphasized the importance of lithospheric-scale processes beneath the Alps, which could also explain the increase in erosion rates through surface uplift.

To provide a new perspective on this debate, we synthesized a spatial gradient map of erosion rates for the Alps and the entire Alpine foreland basin. Our data base consists of published (1) apatite fission-track (AFT) cooling ages for the Alps (e.g., Vernon et al. 2008; Luth and Willingshofer 2008; Wölfler et al. 2012; (2) AFT ages from wells from the Swiss foreland basin (e.g., Cederbom et al. 2011), and (3) stratigraphic data from industry wells in the German and Austrian foreland basin (e.g., Lemcke 1974; Genser et al. 2007). We focus our analysis on the shape and scale of the areas undergoing erosion since 5 Ma.

Our synthesis of published denudation rate data for the past 5 Million years reveals that erosion of the Alpine foreland basin is highest in front of the western Alps (between 2 and 0.6 km), and decreases eastward over a distance of 700 km to the Austrian foreland basin (c. 200 m). For the western Alps, the compilation of apatite-fission-track ages yields erosion rates > 0.6 km/Ma, while erosion rates for the eastern foreland basin and the adjacent eastern Alps are < 0.1 km/Ma, except for a small-scale signal in the Tauern window. The results yield a large ellipsoidal, orogen-crossing pattern of erosion, centered along the western Alps. Most likely, accelerated erosion of the western Alps and their foreland basin occurred in response to regional-scale surface uplift, related to lithospheric unloading of the European slab along the Eurasian-Adriatic plate boundary. This mechanism triggered large drainage-pattern changes that lead to the establishment of the headwaters for the Rhine and Danube rivers, the largest streams in central Europe. Our findings contradict recent views that substantial erosion of the European Alps since 5 Ma was mainly due to global climate change. Instead, regional-scale tectonic processes have driven this asymmetric erosion pattern during this time.