



Seasonality controls on glacial erosion in the Himalaya and Karakoram

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The waxing and waning of mountain glaciers during the Quaternary left a clear imprint of glacial erosion in form of deeply incised, U-shaped valleys in many mountain ranges around the world. Temperature changes and the availability of moisture are generally thought of as the limiting factors for the geomorphic work that glaciers accomplish. Here, we present evidence that the seasonality of moisture supply strongly affects glacial flow velocities, and thus the erosional efficiency of glaciers.

We used ASTER satellite imagery to measure flow velocities of glaciers in the Himalaya and Karakoram during the last decade. Being situated in the transition between moisture sources rooted in the Indian Summer Monsoon and the Northern Hemisphere Westerlies, this region provides a natural laboratory to study the influence of seasonally different moisture sources on glacier dynamics. We interpret the measured surface velocities to reflect ice flux, and use them as a proxy for glacial erosion. We tie our observations to east-west gradients in climate and how they affect the mass balance of glaciers. In the central Himalaya, glaciers characterized by summer accumulation, flow at generally lower velocities compared to glaciers in the Karakoram in a winter accumulation regime. The data also show that most ice flux occurs near the equilibrium line altitude (ELA), and thereby provide empirical support for focused glacial erosion at distinct, climate controlled altitudinal sectors. These zones are presently located at approx. 4.8-5 +/- 0.5 km in the Karakoram and western Himalaya, and at approx. 5.5 +/- 0.5 km in the central and eastern Himalaya. A mean position of the Quaternary ELA, depressed by approx. 500 m, delineates a zone of focused glacial erosion that corresponds well with areas of <0.5 m annual rainfall, but high local relief. These areas dominate the western end of the Asian highlands, including the western Himalaya, the Karakoram, eastern Hindukush, and the Pamir. Here, aridity constrains the efficiency of fluvial erosion and we suggest that relief production in these areas is dominantly due to Quaternary glacial erosion.