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Role of the Winter Westerlies in shaping the western flank of the Tibetan Plateau – new insights from glacier-surface velocities

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Glaciers are ubiquitous in the high-elevation regions (>3.5 km) of the Himalaya and Karakoram and may be responsible for exceptionally high erosion rates that have significantly influenced the morphology of these mountain ranges. Understanding the role of glaciers in orogenic evolution requires knowledge of the erosional potential of glaciers, which is inferred to scale with ice flux. In order to better constrain the relations between mountain glaciation and erosion, we used ASTER satellite imagery combined with the orthorectification and correlation tool COSI-Corr to derive horizontal surface velocities of glaciers in the Himalayan-Karakoram domain. We interpret the velocities to reflect ice flux and thus the degree of glacial erosion potential.

The regional remote-sensing analysis of glaciers in these ranges provides a pattern of surface velocities that suggests a crucial role of the Winter Westerlies in driving glacial erosion. Two key observations can be made: (1) Glaciers in the eastern and central Himalaya are relatively slow, with mean velocities usually below 50-60 m/a. In contrast, glaciers in the western Himalaya and Karakoram are considerably faster, often exceeding 50-60 m/a. This discrepancy occurs irrespective of different glacier size and aspect; (2) a relatively sharp gradient apparently exists in the area of the Sutlej basin in the NW Himalaya of India at approximately 78˚ E. To the east, glaciers have mean velocities of approx. 15-50 m/a, whereas glaciers in the much drier Lahul region to the west attain mean velocities of approx. 30-80 m/a.

Even though latitudinal position and topographic setting influence glacier size and velocity, the observed E-W gradient is best explained in a climatic context: in the central Himalaya precipitation is mainly supplied during summer, while the western Himalaya and Karakoram receive a significant amount of precipitation falling as snow during winter. Our observations show that glaciers in the central Himalaya, dominated by summer accumulation, have generally lower surface velocities, hence ice-flux, and thus only limited potential to erode underlying bedrock. However, their counterparts in the Karakoram, receive moisture during all seasons, have higher ice-flux, are more likely to have expanded during past glacial conditions, and thus play a more important role in sculpting mountainous landscapes. Yet, if an intensified monsoon coincides with an episode of lower temperatures, such as during MIS 3-4, even glaciers in the central Himalaya should have had favorable conditions to advance toward much lower elevations, with higher ice flux. Data from regional glacial chronologies and landscape morphometry support this conclusion, but also underscores the ambiguities inherent in regional moraine correlations in an environment influenced by two major precipitation regimes.