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Quantification of long-term and time-integrated glaciation patterns in Central Asia

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We use a domain-wide geomorphometric analysis to investigate spatial patterns of glacial landforms. We focus or analysis on glacial depositional landforms (e.g. marginal moraines), as well as larger erosional landforms (e.g. glacial valleys), because our aim is to quantify long-term and time-integrated glaciation patterns. Our area of interest includes two large orogens in Central Asia; the Tian Shan and Altai mountains, both located in the continental interior of Central Asia. Our analysis is crucial as it can reveal the importance of 1) topographic barriers, 2) precipitation gradients and 3) rain-shadow effects on former glaciation patterns. We focus our analysis on six different physiographic regions (n=6), defined by major drainage divides, as well as for formerly glaciated catchments (n=21)—selected because they are intersected by cosmogenic-nuclide glacial-chronological datasets. We mine published datasets on the distribution of glaciers and glacial landforms, and use these datasets, together with freely available digital elevation models, to extract landform-specific hypsometric (area—elevation) distributions. Hypsometric peaks for modern glaciers (i.e. median glacier elevations) show pronounced spatial gradients; increasing elevations from the northern to the southern Tian Shan, and increasing median elevations from the northern to both the southeastern and southwestern Altai Mountains. This is interpreted to reflect topographic barrier effects and decreasing modern precipitation rates (i.e. increasing continentality), as a result of a weakening of the Mid-latitude Westerlies, across the main axes of the two mountain systems. A similar pattern can be observed in the paleorecord; reconstructed long-term and time-integrated glaciation patterns, also show pronounced spatial gradients, equivalent to modern median glacier elevation patterns. This observation indicates that during former periods of glaciation, maximum paleoglacier extents—reconstructed by delineating the extent of glacial depositional and erosional landforms (formed over one-to-several glacial cycles, over >100 thousand years)—were correspondingly controlled by a westerly-sourced moisture supply, and was thus affected by precipitation patterns similar to those of today.