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Long-term topographic feedbacks along glaciated continental margins

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Deep troughs carved by glaciers during Quaternary cold intervals dominate high-latitude mountain ranges in Greenland, Norway, Canada, New Zealand, Chile and Antarctica (Sugden & John, 1976). In addition, areas of relatively low relief are typically found at high elevations between the troughs. These high areas are often draped by block-fields, indicating that slow weathering processes dominated their evolution, at least throughout the most recent series of interglacial periods (Ballantyne, 2010).
Ice sheets must have repeatedly covered the high areas during glacial maxima, but the ice did not erode the underlying bedrock; most likely because the ice was predominantly frozen to its bed (Kleman & Stroeven, 1997). The geomorphic contrast between the troughs and the high-elevation, low-relief areas shows that factors controlling glacial erosion can fluctuate dramatically across short distances, and that landscapes in cold regions concurrently support some of the fastest and slowest surface-erosion processes on Earth (Sugden & John, 1976).

However, the strong contrast in efficiency of subglacial erosion has likely evolved in response to landscape evolution. The gradual emergence of glacial troughs over time establishes a feedback between ice flux and subglacial erosion, leading to focused ice drainage and accelerating erosion in the troughs and stalling erosion in the high-elevation areas between the troughs (Kessler et al. 2008). This distinct pattern of selective erosion along cold-region continental margins during the Late Quaternary may therefore reflect the product of topographical feedbacks that focus glacial erosion over time.
We used computational landscape evolution models to study these topographic feedbacks, with the objective to evaluate landscape evolution in the high areas prior to the development of deep glacial troughs. Our experiments suggest that early overriding ice-sheets most likely eroded the highs and smoothed the regional topography before isostatic uplift and localization of the ice flow caused regions of cold-based ice to spread along the margins.

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