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Global analysis of erosional decoupling in fjord-plateau landscapes

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Topographic evolution of glaciated continental margins is a function of evolving feedbacks between ice dynamics and erosion over million-year timescales. Fjord incision strongly influences ice dynamics by promoting ice convergence into troughs and ice-thinning over intertrough areas, while the associated ice streams are the key drainage lines regulating mass balance from ice sheets. In response, isostatic uplift cause feedbacks involving atmospheric temperature, meltwater availability, and subglacial thermal regime —- factors that together govern patterns of subglacial erosion. Ongoing fjord incision leads ultimately to erosional decoupling between the wet-based ice funnelled through deep troughs and the thin, cold-based ice distributed across intertrough plateaus. This decoupling produces a strong spatial gradient in erosion rates across fjord-plateau landscapes that, when fully developed, is exemplified by 'selective linear erosion'. Cosmogenic nuclides measured on bedrock surfaces clearly demonstrate this spatial gradient of erosion.

Here we compute long-term bedrock erosion rates via a Markov-chain Monte Carlo-based inversion model applied to a global compilation of paired cosmogenic 10Be-26Al data (n $\sim$ 1000) derived from high-relief terrain in Antarctica, Greenland, North America, Svalbard, and Eurasia. We find that spatial patterns of erosion show an elevation-dependent trend that is consistent with the hypothesis that the degree of erosional decoupling follows topographic development of fjord-plateau landscapes on continental margins globally. We couple these findings with a set of computational experiments using a landscape evolution model that explores the topographic-subglacial controls on erosional decoupling in plateau-fjord landscapes. Our findings have important implications for 1) the relative timing of erosional decoupling at the different glaciated continental margins globally; and 2) the behaviour and stability of ice sheets draining continental margins. Fjord incision may shift ice sheet mass balance and alter irrevocably the stability of ice sheets.