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Geometric Controls of Fjord Glacier Dynamics

Thomas Frank[1], Henning Åkesson[2,3], Basile de Fleurian[4,5], and Kerim H Nisancioglu[4,5]
[1]Department of Physical Geography, Stockholm University, Stockholm, Sweden
[2]Department of Geological Sciences, Stockholm University, Stockholm, Sweden
[3]Bolin Center for Climate Research, Stockholm, Sweden
[4]Department of Earth Science, University of Bergen, Bergen, Norway
[5]Bjerknes Center for Climate Research, Bergen, Norway

Retreat of marine outlet glaciers and ice shelves may initiate depletion of inland ice and lead to ice loss that by far exceeds what would be expected from ocean and atmospheric warming alone. Many marine outlet glaciers draining large parts of past and present ice masses have shown non-linear and variable retreat rates, with adjacent glaciers sometimes showing a highly different response to the same large-scale climate forcing. This suggests that individual glacier characteristics play a dominant role in governing retreat.

There is widespread evidence that the dynamic glacier adjustment to an external forcing is highly influenced by fjord topography. However, whether this stabilizes the glacier, or promotes enhanced retreat, depends on the shape of the fjord. So far, no rigorous, systematic assessment of the exact influence of certain geometric features such as overdeepenings or embayments has been undertaken in a model framework that incorporates all relevant processes in a 3D layout.

Here, we analyze a multitude of topographic settings and scenarios using the Ice Sheet System Model (ISSM), which accounts for all relevant physics in a 3D framework. Using artificial fjord geometries, we investigate glacier-topography interaction and quantify the modeled glacier response directly in relation to topographic features.

In light of our modeled topographic influence on glacier retreat, we consider whether we reliably can extrapolate observations from a few well-monitored glaciers to those less studied. Furthermore, we discuss implications for past and future ice sheet mass loss and associated sea-level rise. Finally, a deeper understanding of processes at the glacier front improves confidence in the climate signal derived from the deglacial landscape, as glacier-proximal landforms can more confidently be linked to climate.