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Effect of fjord geometry on tidewater glacier stability

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Many marine-terminating glaciers have thinned, accelerated and retreated during the last two decades, broadly consistent with warmer atmospheric and oceanic conditions. However, these patterns involve considerable spatial and temporal variability, with diverse glacier behavior within the same regions. Similarly, reconstructions of marine-terminating glaciers indicate highly asynchronous retreat histories. While it is well known that retrograde slopes can cause marine ice sheet instabilities, the effect of lateral drag and fjord width has received less attention.

Here, we test the hypothesis that marine outlet glacier stability is largely controlled by fjord width, and to a less extent by regional climate forcing. We employ a dynamic flowline model on idealized glacier geometries (representative of different outlet glaciers) to investigate geometric controls on decadal and longer times scales. The model accounts for driving and resistive stresses of glacier flow as well as along-flow stress transfer. It has a physical treatment of iceberg calving and a time-adaptive grid allowing for continuous tracking of grounding-line migration. We apply changes in atmospheric and oceanic forcing and show how wide and narrow fjord sections foster glacier (in)stabilities. We also evaluate the effect of including a surface mass balance – elevation feedback in such a setting. Finally, the relevance of these results to past and future marine-terminating glacier stability is discussed.