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Modelling grounding line retreat during deglaciation of the Western Fennoscandian Ice Sheet using ISSM

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Recent marine-based ice mass loss in Greenland and Antarctica has been broadly attributed to increased air temperatures and warmer ocean conditions. However, these changes display considerable spatial and temporal heterogeneity, suggesting that topographic factors are modulating the response. To elucidate factors important for decadal and longer time scales, the relatively short observational record needs to be complemented by studies of past marine-based mass changes. Large-scale ice sheet models are however too coarse to accurately resolve grounding line migration, marine-terminating glacier acceleration and ice shelf collapse on paleo-time scales.
Here we study regional marine ice sheet changes during deglaciation of the Fennoscandian Ice Sheet in SW Norway, with similar topography to Greenland. With coastal mountains deeply incised by fjords extending far inland, this area provides clues to responsible processes and rates of future mass loss from the Greenland Ice Sheet, and associated contribution to sea level.
We use the state-of-the-art ice sheet model ISSM to transiently simulate the entire deglaciation from 18 to 11 ka, including the readvance during Younger Dryas. Grounding line migration is tracked highly accurately within the adaptive finite-element model mesh. We use proxies, geomorphological data, and exposure dating of ice thickness and marginal changes to provide three-dimensional constraints on ice sheet thinning and retreat. We find that the modelled outermost ice sheet margin is largely insensitive to ocean warming, and that ice shelf collapse has a minor effect on upstream flow. Instead, considerable surface mass balance changes are required to trigger retreat. Once initiated, grounding line retreat is rapid, paced by fjord topography and submarine melt rate.
We discuss the implications of our findings in context of deglaciation of the Laurentide and Eurasian Ice Sheets, as well as recent mass loss and potential future marine ice sheet instability in Greenland and Antarctica. Finally we highlight the potential to apply similar methods to other deglaciated regions.