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Simulating the climatic response of Hardangerjøkulen ice cap since the Little Ice Age with ISSM

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Glaciers and small ice caps respond considerably faster to climate change than the large ice sheets Greenland and Antarctica. We use the Ice Sheet System Model (ISSM) to model the dynamics and evolution of the maritime-continental Hardangerjøkulen ice cap (73 km^2, $60.55°$N, $7.43°$E) from the Little Ice Age (LIA) until today.

ISSM is a finite element model with anisotropic mesh capabilities (resolution can be refined in regions of interest) and includes different approximations for the dynamics of ice flow, including the Shallow Ice Approximation (SIA) and Full-Stokes. The SIA neglects important stresses when topography is complex; however it has proved accurate in representing glacier volume fluctuations on decadal and longer timescales. As Hardangerjøkulen has relatively gentle slopes and lacks areas of very fast flow, we choose to use the SIA to study this ice cap on climatic time scales.

As initial forcing for the ice flow model, we use a dynamically calibrated mass balance history corresponding to moraine evidence from the Little Ice Age maximum in 1750 AD, as well as later outlet glacier front positions from moraines, direct measurements and aerial photographs.

For the 1900s, we use surface mass balance from a spatially distributed energy-balance model using data from meteorological stations as forcing. Glaciological mass balance records and front positions for the two main outlet glaciers, along with surface DEMs, are used for calibration.

We investigate total ice volume and outlet glacier responses since the LIA. The sensitivity to surface mass balance as well as the applicability of the SIA to small ice caps is also discussed. Finally, our findings are compared and contrasted with previous model results for Hardangerjøkulen.