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Ice-dynamic projections of the Greenland ice sheet to future atmospheric and oceanic warming

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Continuing global warming will have a strong impact on the Greenland ice sheet in the coming centuries. We use a higher-order ice flow model, initialised to the present-day state, to simulate future ice mass changes driven by both atmospheric and oceanic temperature changes. The surface mass balance is calculated with a degree-day runoff/retention model. The projections account for direct effects on ice dynamics from ocean-induced outlet glacier speed-up and from subglacial meltwater drainage that lubricates the base. The regional pattern of ocean warming is linked to modelled outlet glacier speed-up via an observationally calibrated relation.

The mass evolution is projected up to 2300 AD for a suite of ten Atmosphere Ocean General Circulation Models and four Representative Concentration Pathway scenarios. In these projections, surface mass balance and dynamic ice discharge are mutually competitive in removing mass from the ice sheet. Increasing runoff reduces the ice volume that reaches the marine margin and thereby decreases ice calving rates. Discharge is also limited by a gradual loss of the ocean contact and a retreat of the ice sheet margin on land. We find Greenland contributions to global sea-level rise between 1.0 and 15.8 cm by 2100 AD. This mass loss is predominantly caused by changes in surface mass balance. The results suggest that observed rates of change over the last decade cannot simply be extrapolated over the 21st century on account of a different balance of processes causing mass loss over time. They also indicate that the largest source of uncertainty arises from the surface mass balance and the underlying climate change projections, and not from ice dynamics.