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Sensitivity of Greenland ice sheet projections to model formulations

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Physically-based projections of the Greenland ice sheet contribution to future sea-level change are subject to uncertainties of the atmospheric and oceanic climatic forcing and on the formulations within the ice flow model itself. Here, a higher-order, three-dimensional thermomechanical ice flow model is used with forcing from a high-resolution regional climate model and from flow-line models for individual marine-terminated glaciers. The model is initialised with the present-day geometry using ice temperature derived from a palaeo-spin-up over several glacial-interglacial cycles. The experiments span the next 200 years and consider climate scenario SRES A1B. Thinning and retreat rates from explicitly modelled outlet glaciers are generalized by region to all marine-terminated glaciers grounded below sea level. To evaluate the sensitivity of the projections to a range of forcing strategies, the surface mass balance scheme is taken either from a regional climate model or from a positive-degree-day model using temperature and precipitation anomalies from the underlying climate models. Different model resolutions and an alternative initialisation technique are also compared.

Our results confirm earlier findings on the contribution of the Greenland ice sheet to future sea-level change that stress the dominant effect of surface mass balance changes. Outlet glacier dynamics only account for between 7 % and 17 % of the sea-level contribution. Furthermore, interaction between surface mass balance and ice discharge is limiting the importance of outlet glacier dynamics with increasing atmospheric forcing. Forcing from the regional climate model produces a 14-33% higher sea-level contribution compared to a positive-degree-day model run with the same parameters than for IPCC AR4. A lower ice-sheet model resolution and initialisation with a freely evolving geometry are both shown to result in larger sea-level projections compared to the reference model. However, the combined uncertainties of the modelling decisions described here are small compared to the uncertainties in climate scenario and the spread of climate sensitivity of AOGCMs.