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Modeling the Greenland ice sheet within the Community Earth System Model

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Ice sheets are a major component of the Earth System, however they are not yet interactively coupled to most global climate models. Here we present past achievements in this front with the CESM1.0 version as well as first results and challenges with the upcoming CESM2.0, where the Community Ice Sheet Model 2.1 is bi-directionally coupled to the atmospheric and ocean components, as opposed to only one-way coupling in CESM1.0. In both CESM versions, the surface mass balance (SMB) is calculated in the land component (CLM) with explicit albedo and refreezing calculations, and downscaled to the ice sheet model resolution via elevation classes and bi-linear (horizontal) and linear (vertical) interpolations. A major highlight of CESM is that the most important coupling process between ice sheet and atmosphere, the albedo feedback, is explicitly modeled, as opposed to state-of-the-art parameterizations of albedo and/or surface melt.
Regarding future Greenland ice sheet projections with CESM1, we summarize our results on: 1) doubled end-of-the-century melt rates under RCP8.5 from increased incoming thermal radiation and turbulent fluxes despite decreased incoming solar radiation over Greenland from more clouds, 2) increase in SMB variability due to reduced accumulation to ablation area ration, 3) bimodal emergence of an anthropogenic signal on the SMB due to both increasing melt and snow accumulation, 4) reduction in ice discharge from marginal thinning.
We also outline work in progress in preparation for our contribution to the Ice Sheet Model Intercomparison Project 6 (ISMIP6) and paleo-research on the last deglaciation, e.g., on model initialization, improved SMB calculation, evaluation of CESM2.0 climate over Greenland, and parameter optimization of the higher-order CISM2.1.

Keywords: Greenland ice sheet, coupled modeling, surface mass balance, sea level projections.