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Climate and surface mass balance of the Greenland ice sheet during 1850-2005 as simulated by the Community Earth System Model: model validation, trends, and physical mechanisms

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The Community Earth System Model (CESM) is the first US climate model with interactive coupling between the AOGCM and the ice sheet components. Here we present results for the climate and surface mass balance of the Greenland ice sheet for the period 1850-2005. The model is run at 1° for the atmospheric and land components, and at 10 km for the ice sheet. The results for the period 1958-2005 are compared to the performance of the state-of-the-art regional climate model RACMO (Ettema et al., GRL, 2009), which has been run at 11 km resolution. The surface mass balance is computed in the land model (CLM), with the same energy balance scheme used for other snow-covered surfaces, in ten elevation classes. The surface mass balance field is linearly interpolated between adjacent elevation classes for downscaling to the ice sheet model.

The simulated 1958-2005 Greenland surface mass balance shows very good agreement with RACMO. The model captures well the two high-precipitation bands along the southeastern and eastern margins, although the magnitude is underestimated in the steep areas with highest precipitation. Precipitation rates are overestimated in the northern interior, possibly due to the smoother topography at 1° resolution. The major ablation zones are well represented. Major biases are shown along the eastern margin, due to the complex local topography. Comparison of the near-surface climate (in particular, annual and summer temperatures, incident shortwave and longwave radiation, and annual albedo) shows good agreement with the regional model. The sensitivity of the surface mass balance to the choice of key parameters (e.g. lapse rate and ice albedo) is evaluated through a set of sensitivity simulations.

Trends in the simulated surface mass balance are explored. The surface climate and ice sheet mass balance are compared for the first and last decades of the data period (1850-2005). The role of the different energy fluxes in changes in the simulated surface mass balance is investigated.