Simulation of Long-Term Response of the Greenland Ice Sheet to Global Warming With an Ice Sheet Model Coupled to a Regional Energy-Moisture Balance Climate Model

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Using the 3D, thermo-mechanical ice sheet model SICOPOLIS coupled to a simple, regional energy-moisture balance climate model, we simulated the response of the Greenland ice sheet under various global warming scenarios. Until now, the usual approach to specify surface boundary conditions for ice sheet models has been to use present day temperature and precipitation distributions in combination with anomalies to scale the values to the past or future. This method is only justified, however, when the ice sheet area and elevation remain similar to present day, because it assumes that the patterns of temperature and precipitation remain similar to present ones. However, it is likely that the distributions of temperature and, especially, precipitation would be much different for a partially or completely ice-free Greenland. In our approach, the climatology used to force the ice sheet model explicitly accounts for albedo feedback and elevation changes. This is important for long-term (multi-centennial to multi-millennial) climate change scenarios, in which the Greenland ice sheet could melt completely, since the albedo feedback would produce higher temperatures in the interior of Greenland, altering the temperature pattern from the current distribution, and the precipitation pattern, particularly in Southern Greenland, would be strongly affected by elevation changes. We present results of simulations for several long-term global warming scenarios and compare them with those found using the traditional (anomalous) approach. We also performed a stability analysis of the Greenland Ice sheet in CO_2 phase space by performing a set of equilibrium experiments for different CO_2 concentrations and initial conditions.