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Reconstructing the dynamics of the Greenland ice sheet during the last deglaciation

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Today, some outlet glaciers of the Greenland ice sheet (GrIS) are rapidly retreating and may mobilize large volumes of interior ice in the coming centuries. The last period that saw such dramatic, sustained retreat of the GrIS was the last deglaciation, when the ice sheet retreated from its Last Glacial Maximum (LGM) extent. Previous studies have used relative sea level observations to constrain changes in ice thickness and retreat timing during the deglaciation (e.g. Fleming and Lambert 2004, Simpson et al. 2009, Lecavalier et al. 2014). Here we build on these studies by isolating the drivers of ice-sheet retreat, and their spatial and temporal dynamics, during this period. Inclusion of ice-cliff failure and hydrofracturing parameterizations in our model has resulted in a better fit to paleodata for the Antarctic ice sheet, but this modeling approach has not been applied to the GrIS. Here we use a three-dimensional hybrid SSA/SIA ice-sheet model (Pollard et al. 2015) at 10km resolution over Greenland to simulate the last deglaciation. Boundary conditions for the last glacial maximum produce an LGM ice sheet with 3.81 meters sea level equivalent (m s.l.e.) of additional ice. The LGM ice sheet advances to the shelf-break in west, south, and east Greenland with an expansive ice shelf extending across Davis Strait. Applying modern atmospheric and oceanic forcing to the LGM ice sheet yields 1.25 and 1.09 m s.l.e. of melt, respectively, and 1.72 m s.l.e. for both. Ocean warming initially results in a higher rate and magnitude of retreat, but increased surface evaporation over open water results in additional accumulation that offsets losses in 10 kyr simulations. Here, we test the sensitivity of the magnitude of deglacial ice-sheet retreat to uncertainty in bedrock elevation and basal slding coefficients, the applied climate forcing, and the mass balance scheme (positive degree-day or energy balance). We also implement a deglacial climate forcing based on recently published temperature chronologies from Greenland ice cores (Buizert et al., 2014). We compare our retreat rates and deglaciation dates from our model simulations with the latest database of published surface exposure ages for west, south, and east Greenland to identify regions where the forcings are unrealistic and/or the model is not simulating all the relevant retreat processes.