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Projections of ice sheet and sea level changes over the next millennia with the LOVECLIM Earth System Model

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We present the results of simulations of future ice and sea-level changes obtained with LOVECLIM, a new Earth system model of intermediate complexity. The model includes an interactive Greenland and Antarctic ice sheet model (AGISM) as well as an oceanic carbon cycle model (LOCH). AGISM consists of 3-D thermomechanical ice sheet/ice shelf models which are fully two-way coupled with the atmosphere and the ocean components. The ice sheets are forced by temperature and precipitation changes and provide freshwater fluxes to the ocean. Changes in surface elevation and surface type feed back into the atmosphere model and melting below Antarctic ice shelves is driven by heat input from the surrounding ocean. The response of mountain glaciers and small ice caps is accounted for by a global glacier melt algorithm, consisting of a mass balance model and a geometric glacier model. Model parameters were found for a set of glaciers for 7 regions and generalised over the globe using statistical methods. To complete the sea-level change component of the model, oceanic thermal expansion is diagnosed from the water temperature of the ocean. LOVECLIM was forced by a suite of climate change scenarios over the next 1000 to 3000 years, involving IPCC SRES scenarios, CO2 doubling and quadrupling scenarios, and CO2 stabilisation scenarios at concentrations between 450 and 1000 ppmv. Only for the lowest scenarios with CO2 concentrations below 450 ppmv sea-level rise was found to be limited to

less than 0.5 m and the Antarctic ice sheet found to contribute negatively. For all other scenarios, the eventual response for all components was positive, with predicted sea-level rises of up to 15 m after 3000 years of simulation, half of which from almost total melting of the Greenland ice sheet. In most simulations, mountain glaciers largely disappear after a few centuries. The total volume change of the small ice caps depends more on the applied scenario and was found to shrink to between one third and two thirds of the present volume by the end of this millennium. The contribution of thermal expansion is between 0.5 and 1.5 m after 3000 years, but still rising after that.