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Evolution of the Ice Sheets of Greenland and Antarctica under anthropogenic climate change: a study with a new complex Earth System Model

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The mass balance changes of the ice sheets of Greenland and Antarctica due to the global warming associated to the increasing concentration of greenhouse gases could cause significant changes in sea level and ocean circulation during the next centuries; the size of these changes being still unknown. Here we address this question by means of a new comprehensive modelling approach which includes atmosphere, ocean physics, sea ice, land vegetation, and ice sheets, with detailed representation of the main processes in each of these components of the Earth System. The core of this recently developed Earth System Model is the OAGCM ECHAM5-MPIOM, with resolution T31 for the atmosphere. The ice sheets of both hemispheres are simulated with a three-dimensional thermo-mechanical ice sheet model coupled bi-directionally to both the ocean and atmospheric components. The model provides fresh water fluxes, topography and ice mask changes to the system. The calculation of melting does not have the usual problems associated with the use of flux corrections for the interface atmosphere-ice sheets. Instead of the commonly used degree-day method applied on corrected temperature and/or precipitation fields, an energy fluxes scheme (independent of parameters calibrated to current climate, in contrast to the degree-day method) is adopted here.

In the first multi-century experiments performed with this model the effects of a doubled and four-times atmospheric CO_2concentration were calculated. The 4x (2x) experiment shows a decrease in Greenland volume of 1 m (30 cm) sea level equivalent (SLE) after 250 years, with maximum fresh water fluxes delivered to the ocean of 0.1 (0.025) Sv at the end of the simulation. Although the area of the Antarctic ice sheet decreases in both scenarios, the ice sheet gains volume in the 2x simulation and loses

it at increasing rate in the 4x. In the 2x case, increased snowfall is responsible for increased volume; in the 4x case, increased melting at the margins of the ice sheet and Antarctic Peninsula dominates the mass balance.