Geophysical Research Abstracts, Vol. 9, 05250, 2007
SRef-ID: 1607-7962/gra/EGU2007-A-05250

Simulating the effect of ice sheet melting on anthropogenic climate change

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Almost all simulations with complex AOGCMs investigating the long-term consequences of anthropogenic greenhouse gas emissions have been made without considering the effect of the ice sheets. Recently some simulations have been published where the potential sensitivity of the Atlantic overturning circulation (AMOC) to a prescribed meltwater input from Greenland has been investigated. Except for studies with models of intermediate complexity, the few long-term simulations where a coupling of AOGCMs and dynamic ice sheet models has been included, have required a flux correction.

Here results are presented from a new earth system model (ESM) containing an dynamic ice sheet model. The entire ESM has been used without artificial fluc correction. The ESM consists of the AGCM ECHAM5 (T31L19), the OGCM MPIOM (40 levels), the ice sheet model SICOPOLIS (80 km) and the dynamical vegetation model LPJ. The mass balance at the surface of the ice sheet is calculated using an energy balance scheme.

With this model CO2 stabilization experiments of 2x and 4x preindustrial level have been performed. The total length of each integration was 600 years. The effect of the ice sheets was determined using one set of experiments with and another without interactive ice sheet model.

The model simulations show a rise of the global mean near-surface air temperature of more than 4K (2x) and 8k (4x). Towards the end of the 2x experiments, most of the Arctic becomes ice-free in summer, whereas the winter sea ice is only slightly reduced. In the 4x experiment the Arctic becomes essentially ice-free even in winter. Around

Antarctica maximal sea ice extent is reduced to 20% of its present value. The boreal forest expands northward reaching in most locations the Arctic Ocean and covers most of the non-glaciated areas on Greenland.

In the CO2 doubling experiment a mass loss of the Greenland ice sheet of more than 1m of global mean sea level equivalent is simulated, in the 4x experiment the ice sheet is reduced to less than 2/3 of its original volume. The Antarctic ice sheet is slightly growing in the 2x experiment, but looses 1.5m of sea level equivalent in the 4x experiment. In the 4x experiment the meltwater release from Greenland reaches almost 0.1 Sv. The results show a neglegible effect of the meltwater input from Greenland during the initial phase of a weakening of the AMOC. During the phase of recovery, however, the effect of the interactive ice sheets is slowing down/preventing the recovery of the AMOC.