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Simulating the last glacial-interglacial transition with a coupled atmosphere-ocean-ice sheet model

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One of the major challenges in climate modeling is the simulation of glacial-interglacial transitions. A few models of intermediate complexity have been successful in simulating the last termination. Complex atmosphere-ocean general circulation models have been shown to be able to yield realistic climate changes with prescribed ice sheets. Here we presents results from a first attempt to simulate a substantial part of the last glacial cycle with an AOGCM coupled interactively with a state-of-the-art ice sheet model.

The ECHAM5/MPIOM AOGCM has been interactively coupled to the dynamical ice sheet model PISM. The latter is run for most of the northern hemisphere with a horizontal resolution of 20 km. An earlier version of this model (Ziemen et al. 2014) has been applied to a steady state simulation of the last glacial maximum (LGM).

The model was integrated from the late Glacial into the Holocene using insolation and greenhouse gas concentrations as transient forcing. Land sea mask and ocean topography are fixed at LGM conditions, river routing and surface elevation for the atmospheric model component are calculated interactively depending on the simulated ice sheets. To make these long simulations feasible, the atmosphere is accelerated by a factor of 10 relative to the other model components using a periodically-synchronous coupling technique. A mini-ensemble with different initial conditions has been run.

In all simulation the northern hemispheric deglaciation starts between 18 and 17 kyr BP, consistent with the onset of global warming. The model produces Heinrich event like variability as part of its internal variability. These rapid ice discharge events have a strong impact on the North Atlantic meridional overturning circulation (NAMOC). During the peak deglaciation the NAMOC is collapsed (with a few short interruptions) for several thousand years, which is longer than the estimates from reconstructions. This seems to be an artifact due to keeping ocean topography and land sea mask at LGM state. An experiment with an interactive ocean topography shows an improved behavior. The effect of the acceleration of the atmosphere will be evaluated by comparison with an ongoing completely synchronously coupled simulation.

Ziemen, F. A. et al. (2014), Climate of the Past, 10, 1817-1836. doi:10.5194/cp-10-1817-2014.