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Effect of Interactive River Routing on North Atlantic Overturning in a Simulation of the last Deglaciation

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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 (AOGCMs) with prescribed ice sheets are able to yield realistic climate changes. Here we present results from our 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 is interactively coupled to the dynamical ice sheet model PISM and the dynamical vegetation model LPJ. The model is integrated from the late Glacial into the Holocene using insolation and greenhouse gas concentrations as transient forcing. To make the long simulations feasible, the atmosphere is accelerated by a factor of 10 relative to the other components using a periodical-synchronous coupling technique. The land sea mask remains fixed at the LGM state. River routing and surface elevation are calculated interactively. A mini-ensemble with different initial conditions is performed. Additionally, one fully synchronously simulation, without acceleration in the atmosphere, is run.

In all simulations the northern hemisphere deglaciation starts between 18 and 17 kyr BP, consistent with the onset of global warming. The model produces Heinrich event like variability. These rapid ice discharge events have a strong impact on the North Atlantic meridional overturning circulation (NAMOC).

The interactive river routing has a strong impact on the simulated NAMOC during the deglaciation. The retreat of the Laurentide Ice Sheet together with the depressed topography due to the former ice load leads to a redirection of the river routes.. In particular, the discharge route for runoff from the melting southwestern Laurentide shifts from the Gulf of Mexico to the Arctic. The consequence is a rapid reduction/suppression of the North Atlantic deep water (NADW) formation. When the Laurentide Ice Sheet retreats from the Hudson Strait, this becomes the new drainage route. Hence, fresh water is released into the Labrador Sea and is less effective in suppressing the deep water formation in the North Atlantic. As a consequence, the NADW formation recovers within a few decades. Our results show the potential importance of interactive river routing for rapid changes in NAMOC strength during the deglaciation.