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The last deglaciation simulated with a coupled atmosphere/ocean/ice sheet/solid earth model

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It is challenging to model the last deglaciation, as it is characterized by abrupt millennial scale climate events, such as ice-sheet surges, that are superimposed on long-term climate changes, such as a global warming and the decay of a substantial part of the glacial ice sheets. Within PMIP, several groups have simulated the last deglaciation with CMIP-type models prescribing ice sheets from reconstructions. Whereas this type of simulations accounts for the effects of ice-sheet changes including meltwater release on climate, the prescribed ice sheet evolution is typically not consistent with the simulated climate evolution. Here we present a set of deglacial simulations that include fully interactive ice sheets that respond to changes in the climate. The setup also allows for feedbacks between ice sheets and climate and , hence, allows for a more realistic representation of the mechanisms of the last deglaciation, as the simulated climate and ice sheet changes are fully consistent..

The model consists of the coarse resolution set-up of MPI-ESM coupled to the ice sheet model mPISM (Northern Hemisphere and Antarctica) and the solid earth model VILMA. The model includes interactive icebergs and an automated calculation of the land-sea mask and river routing directions. A set of synchronously coupled simulations were started from an asynchronously coupled spin-up at 26ky and integrated throughout the deglaciation into the Holocene. The only prescribed external forcing are atmospheric concentrations of greenhouse gases and earth orbital parameters. One goal of this ensemble was to find the optimal combination of model parameters for the simulation of the deglaciation.

The model simulates the decay of the ice sheets, the rise of sea level, the flooding of shelf seas and the opening of passages. A large fraction of the ice sheet retreat is due to dynamical events (e.g. the final decay of the ice sheets on Barents Shelf or the Hudson Bay). Superimposed on the relatively slow glacial/interglacial transition are abrupt climate changes, triggered for example by recurrent ice sheet surges. These surges correspond to Heinrich Events tand result in a weakening of the AMOC. Three source regions for ice sheet surges occur during these simulations: from the Laurentide ice sheet through Hudson Strait, from the Laurentide ice sheet northward directly to the Arctic ocean, and from the Fennoscandian ice sheet into the Norwegian Sea. The characteristic climate response shows a large dependence on the surge location.

The simulated changes in strength of the AMOC are except for millennial-scale reduction events only moderate. However, during glacial periods, brine release is the central process for deep water formation in both hemispheres, in contrast to the Holocene. dDuring the deglaciation the ventilation of the deep ocean is strongly reduced, leading to a strong increase of the simulated deep water ages. This effect lasts longest in the deep North Pacific and extends in some simulations into the Holocene.