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Contrasting histories of the last deglaciation resulting from different reconstructions used in the PMIP-4 protocol

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The PMIP-4 protocol for modeling the last deglaciation (Ivanovic et al., 2016) allows the use of either the ICE-6G_C (Peltier et al., 2015; Argus et al., 2014) or the GLAC-1D (Tarasov et al., 2012; Tarasov and Peltier, 2002) ice sheet reconstruction. To investigate the impact of the underlying reconstructions on the climate, we have performed transient deglacial simulations with the same setup of the Max-Planck-Institute Earth System Model (MPI-ESM) only varying the ice sheet reconstruction. We have taken the ice sheet reconstructions at face value and derived the meltwater fluxes from the changes in ice sheet thickness. Our setup includes dynamic topography, bathymetry, coastlines, river routing directions, and vegetation, thus representing the full set of effects of the changing ice sheets. We show that variations in the meltwater fluxes dominate the millennial scale climate variability. However, these variations differ drastically depending on the underlying reconstructions. We present where to expect differences, and where to expect consistent behavior and point out common features that are not in accordance with proxy evidence. The results show that uncertainties in the reconstructed ice sheets dominate the simulated deglacial millennial scale climate variability. The effects on the climate of the two reconstructions will provide challenges for the comparison of the PMIP-4 transient experiments.

The most dominant common feature, simulated by both ICE-6G_C and GLAC-1D, is a massive Northern Hemisphere (NH) ice sheet decay during the Bølling warming causing a freshwater pulse reaching about 0.5 Sv and thus a shutdown of the Atlantic Meridional Overturning Circulation (AMOC). The resulting AMOC collapse and NH cooling with associated Southern Hemisphere (SH) warming is a standard behavior of climate models when exposed to a strong freshwater forcing, and consistent with expectations from the basic physics.
During the Younger Dryas, ICE-6G_C features ice sheet decay leading to a change in meltwater routing from the Mississippi to the St. Lawrence and Mackenzie rivers, and thus to a strong AMOC decline and NH cooling because of the higher effectiveness of freshwater hosing in this region. In contrast, GLAC-1D shows virtually no melt in this period, and the AMOC stays intact. The effects in the simulation forced with the ICE-6G_C reconstruction show the importance of correctly modeling changes in river routing. While ICE-6G_C shows an Antarctic freshwater pulse during Meltwater pulse 1B (MWP1B), causing NH warming at the end of the Younger Dryas, GLAC-1D features a northern hemisphere meltwater pulse with associated large-scale cooling during MWP1B.
The simulations show that our model is capable of modeling the last deglaciation, and that the occurrence and timing of rapid climate change events is controlled by the ice sheets, making correct reconstructions crucial for modeling the chronology of the last deglacial climate variability.