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Sequence of Heinrich Event 1 to the Bølling-Allerød in transient climate model simulations

Yuchen Sun[1], Xu Zhang[1,2], Martin Werner[1], Gregor Knorr[1], and Gerrit Lohmann[1]
[1]Alfred Wegener Institute Helmholtz Centre for Polar and Marine Research, Paleo-climate Dynamics, Germany (yuchen.sun@awi.de)
[2]College of Earth and Environmental Science, Center for Pan-Third Pole Environment, Lanzhou University, China

During the last deglaciation, the North Atlantic was punctuated by evident millennial-scale climate variability – surface cooling during Heinrich Event 1 (H1), followed by abrupt warming during the Bølling-Allerød (BA). Given its abundance of available proxy records, the last deglaciation is thus a perfect testbed for us to assess the triggering dynamics of these abrupt events. Here, a water-isotope enabled, coupled atmosphere-ocean general circulation model COSMOS-wiso (Werner et al., 2016) is applied to test different mechanisms potentially responsible for a BA abrupt warming. First, two sets of experiments are conducted to test the sensitivity to background boundary conditions: one is based on the Last Glacial Maximum (LGM), and the other was 16ka BP background climate. We also consider the spatial distribution of freshwater flux (FWF) forcing. We find that during the LGM a weak freshwater forcing cannot trigger an Atlantic Meridional Overturning Circulation (AMOC) mode transition. However, the same freshwater forcing can rapidly weaken the AMOC at 16ka BP, including an abrupt AMOC resumption in the subsequent one thousand years. Our experiments support the idea that ice volume plays a dominant role in the stability of AMOC during the termination. Furthermore, we explore the impact of different initial fields on the timing of AMOC recovery. Based on the above 16ka hosing experiment mimicking H1, several phases before the AMOC recovery are selected as initial fields, also with different FWF forcing. Our experiments indicate that the larger the FWF forcing, the longer it would take for the AMOC to recover. In all simulations, we detect an overshoot behavior typically for the BA transition. Finally, we implement a transient experiment from H1 to BA with changing GHGs and orbital forcing to explore the mechanisms of the sequence of rapid climate changes during the last termination.

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