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Orbitally forced differences in the variability of the Northern Hemisphere atmospheric flow during two periods of the Holocene

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Abstract

Future projections of climate change imply that our planet moves into a 'super-interglacial' with warmer conditions than present. One testbed are interstadials of the past as some of them are known to have been warmer than present, particularly in polar regions. Although the past interglacials have not experienced any anthropogenic influence they provide information on certain aspects of future climate.

To investigate the atmospheric circulation of such past interglacial periods we generate high-resolution time-slice simulations of various interglacial periods with the NCAR Community Earth System Model (CESM). In the time-slice experiments, the CESM is run without the ocean component. Instead, the lower boundary conditions of the model i.e., the sea surface temperature and sea ice concentration are prescribed. For the present-day time-slice the boundary conditions are based on observational data as used in the Atmospheric Model Intercomparison Project (AMIP) experiment, whereas the boundary conditions for the paleoclimate experiments are derived from a lower-resolution run of the fully-coupled CCSM3, a predecessor of the CESM. Our time-slice experiments are run for 30 years at a 0.9° times 1.25° resolution, what will provide new insights into climate variability on regional scales.

As a prerequisite, the new high-resolution CESM is validated using observational data. In order to do so, we test the AMIP-like simulation against the reanalysis for constraining the major model biases. In general, the model does a very good job in reconstructing the main climate features of the Northern Hemisphere (NH). Comparing with the IPCC/CRU climatology the northern continents show a small positive surface temperature bias. The largest deviations are observed for Greenland where the area of minimum temperature is shifted southwards. In contrast, the 1990-control time-slice forced with CCSM3 lower boundary conditions reveals a clear cold bias for the NH, which originates in too cold sea surface temperatures and a too excessive Arctic sea ice area in the CCSM3 simulation compared with observations. Thus, the largest cold deviation in surface temperature is simulated over the Barent Sea where the CCSM3 largely overestimates the sea ice concentration.

In a first attempt of investigating interglacial periods, we compare the pre-industrial time-slice simulation with an early-Holocene (8000 years before present) simulation which just differ in the orbital forcing. We will present the main features of NH atmospheric circulation i.e., the leading modes of atmosphere variability as well as changes in the synoptic-scale variability. Further assessments include the characterization of the atmospheric flow and moisture transport to the Greenland ice sheet using a Lagrangian back trajectory tool. This will form the basis for later comparisons of the transport routes with proxy data from Greenland ice cores in order to check the model's capability in simulating spatio-temporal changes of the atmospheric flow during different interglacial periods.