3rd International Conference on Earth System Modelling
Vol. , 3ICESM-164, 2012
3rd International Conference on Earth System Modelling

Glacial variations in atmospheric dynamics from simulations with a comprehensive climate model

U. Merkel (1), M. Prange (2), and M. Schulz (2)

(1) MARUM - Center for Marine Environmental Sciences, University of Bremen, Bremen, Germany (umerkel@marum.de), (2) MARUM – Center for Marine Environmental Sciences and Faculty of Geosciences, University of Bremen, Bremen, Germany

Marine Isotope Stage 3 (MIS3, 59-29 thousand years ago) was a period of pronounced climate variations on centennial-to-millennial timescales and exhibited recurrent successions of cold stadials and warm interstadials, the so-called Dansgaard-Oeschger cycles. The mechanisms involved in the rapid transitions between these stadials and interstadials and the role of the Atlantic meridional overturning circulation (AMOC) therein are only partly understood so far.

In order to further elucidate key aspects of stadial and interstadial climate states, we have performed model simulations using the comprehensive coupled climate model CCSM3 at a rather coarse resolution (T31 resolution in the atmosphere and nominally 3° in the ocean) to allow for long integration times. In our glacial baseline experiments, boundary conditions such as greenhouse gas concentrations, Earth's orbital parameters, sea level and the different extent and elevation of continental ice sheets are taken into account. Furthermore, North Atlantic freshwater hosing is imposed to mimic Heinrich stadial and Dansgaard-Oeschger stadial/interstadial climate states.

Results from these simulations suggest major reorganizations of the atmospheric circulation and a pronounced seasonality of the response, for instance of sea ice, to the different glacial boundary conditions. It is also shown that North Atlantic and North Pacific stormtracks shift meridionally as a result of changes in the SST distribution and the position of the steering jet stream. Significant changes in climate parameters are simulated not only for the extratropics, but also for tropical latitudes. In particular our Heinrich-type simulation suggests significant impacts of an AMOC slowdown on the tropical rainbelt and monsoon systems. MIS3 climates also show considerable reorganizations of the tropical Hadley and Walker circulation cells which will be discussed in relation with rainfall anomalies.
Interannual climate variability associated with the El Niño/Southern Oscillation (ENSO) is found to be strongly affected by the combination of glacial boundary conditions and AMOC variations. We also conclude from our experiments that ENSO teleconnections are largely depending on the respective background climatic state and that the modern "blueprint" of ENSO teleconnections should only be applied with caution in the analysis of past climate.

Furthermore, these findings are also tested in a similar modelling framework using the CCSM3 with prognostic mineral dust included. In addition to the analysis of atmospheric and oceanic circulation characteristics, such a set of experiments allows to assess mineral dust transport patterns, the deposition and radiative impact of mineral dust aerosols under glacial climate conditions.