DKT Abstracts
DKT-10-60, 2015
10. Deutsche Klimatagung

Instability of the Atlantic Meridional Overturning Circulation and interannual climate variability during the last glacial period

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Pronounced millennial-scale climate variability during the last glacial period (specifically, Marine Isotope Stage 3, MIS3) is considered to be linked to changes in the state of the Atlantic meridional overturning circulation (AMOC). The stability of the AMOC to North Atlantic freshwater perturbations is studied from a set of comprehensive coupled climate model (CCSM3) simulations with prescribed glacial boundary conditions for the time around 38,000 years ago. Our series of equilibrium freshwater hosing/extraction simulations with perturbations ranging from -0.2 to +0.2 Sverdrup (Sv) reveal a remarkably unstable glacial baseline state even with respect to minor perturbations. The global climate signal associated with a change in AMOC strength is consistent with a transition from a so-called "interstadial" (strong AMOC) to a "stadial" (weak AMOC) state including an annual mean surface air temperature drop of more than 8 K in central Greenland. Furthermore, we constructed a global spatial fingerprint of the glacial AMOC changes reflected in ocean temperatures and found the strongest response to AMOC changes in northeastern North Atlantic sea surface temperatures, in particular during the boreal summer season. Combining the model results with paleo SST records from the North Atlantic linearly allows us to estimate the magnitude of millennial-scale Dansgaard-Oeschger AMOC variations during MIS3. From this approach, a mean difference in AMOC strength of 9.2 $\pm$ 1.5 Sv (1σ) between interstadial and (non-Heinrich) stadial states is inferred.
AMOC variations have been shown to also impact the climate of other ocean basins. With regard to interannual tropical Pacific variability related to the El Niño/Southern Oscillation (ENSO), paleoclimate reconstructions so far show ambiguous results for the last glacial period. Our analysis of the simulated ENSO amplitude reveals a highly non-linear behaviour with respect to the change in AMOC strength. Accordingly, we suggest that the ENSO response is coupled to changes in the tropical-subtropical mean state and the annual cycle strength which themselves are modulated by the AMOC changes.