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Workshop on High-mid latitude northern atmospheric circulation

Atmospheric dynamics and teleconnections during glacial climates

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Unterstanding glacial changes in atmospheric circulation on centennial to millennial timescales is of ultimate importance for an improved understanding of glacial aerosol transport and for a fundamental interpretation of mineral dust archived in polar ice sheets.
In order to study atmospheric circulation at various glacial climatic states, we employ the comprehensive NCAR Community Climate System Model (version 3). The focus is on the Last Glacial Maximum (LGM, centered on 21 ka BP), and Marine Isotope Stage 3 (centered on 35 ka BP). Glacial boundary conditions including changes in ice-sheet distribution, greenhouse-gas concentrations and orbital parameters are taken into account. On top of the glacial boundary conditions, freshwater perturbations at high latitudes of the North Atlantic are imposed to mimic Heinrich Stadial 1 and Dansgaard-Oeschger stadials and interstadials.
Our simulations suggest that glacial boundary conditions induce major modifications of the mean atmospheric circulation, such as a pronounced split and southward shift of the mid-latitudinal jetstream and a more pronounced zonal asymmetry in response to the presence of the glacial continental ice sheets. The upper-tropospheric wind field is modified on a hemispheric-to-global scale. Over central Europe, for instance, easterly wind anomalies throughout the troposphere are simulated for the LGM. Over eastern Asia, however, no significant signature is found in the surface wind response compared to pre-industrial control climate. Compared to LGM, the MIS3 stadial climate simulation exhibits an almost circum-global band of pronounced westerly wind anomalies at mid-to-high northern latitudes. We hypothesize that this can be mainly attributed to the reduced 35 ka continental ice sheet heights.
Our simulations also suggest that different glacial boundary conditions induce major reorganizations of the North Atlantic Oscillation (NAO). For instance, the modern NAO meridional dipole-like pattern of sea level pressure (SLP) variability disappears in our LGM simulation, which has a significant impact on the mean flow over Europe. In the Heinrich Stadial 1 simulation, the dominant pattern of SLP variability is more similar to the modern NAO structure but with a much stronger eastward extension into Eurasia. Possible implications for atmospheric aerosol transports will be discussed.