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Responses of climate modes to different ice sheet configurations during the Last Glacial Maximum

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Over the Last Glacial Maximum (LGM, ∼21ka BP) and subsequent deglaciation, the presence of vast Northern Hemisphere ice sheets caused abrupt changes in surface topography and background climatic state. While the ice-sheet extent is well known, several conflicting ice-sheet topography reconstructions suggest that there is an existence of uncertainty in this boundary condition. Simulations with a water isotope-enabled fully coupled Earth system model (COSMOS) and five different Laurentide Ice Sheet (LIS) reconstructions of different elevation are used to assess the range of sensitivity of climate modes in response to the uncertainty in this LIS topography. This study reveals that a change in ice sheet height can alter the coupled oceanic and atmospheric climate system during the LGM. A warming anomaly can be found over the region of lower ice sheet height, i.e. North America and lead to a slightly enhanced P-E over the North Atlantic, which also contributes to a weaker ocean circulation in the northern North Atlantic. The continental and sea surface temperature (SST) of the LGM as simulated by climate models have been compared with the subfossil pollen and plant macrofossil based reconstruction and reconstructed from marine temperature proxies. The continental reconstruction shows a similar pattern and in a good agreement with model data. The SST proxy dataset comprises a global compilation of planktonic foraminifera, diatom, radiolarian, dinocyst, alkenones and planktonic foraminifera Mg/Ca-derived SST estimates. Significant mismatches between modeled and reconstructed SST have been observed. Among the five LIS reconstructions, Tarasov LIS reconstructions show the highest correlation with reconstructed SAT and SST. In the case of Radiolarian, Mg/Ca, diatoms and foraminifera show a positive correlation where dinocyst and alkenones show very low and negative correlation with the model. Dinocyst-based SST records are much warmer than reconstructed by other proxies as well than PI temperature. However, large deviations with respect to model temperatures recorded by different proxies remain. Therefore, it has been speculated that considering different habitats depth and growing seasons of the planktonic organisms used for SST reconstruction could provide a better agreement of proxy data with model results on a regional scale and can reduce model–data misfits is determined. It is found that shifting in the habitat depth and living season can remove parts of the observed model–data mismatches in SST anomalies. The findings of this study give a clear reference for PMIP communities to use an appropriate ice sheet reconstructions with a more reliable ocean state as well as indicate that modelled and reconstructed temperature anomalies are to a large degree only qualitatively comparable, thus providing a challenge for the interpretation of proxy data as well as the model sensitivity to orbital forcing.