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Sensitivity of isotopes in the hydrological cycle to simulated vs. reconstructed Last Glacial Maximum surface conditions

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The evaluation of a specific component of a comprehensive climate model is often hindered by biases in the coupled system, in simulations of the present as well as of past climate conditions. To assess different implementations of water isotopes as part of the hydrological cycle, we carried out atmosphere-only runs using different atmospheric general circulation models (AGCMs, here: CAM and ECHAM) but the same pre-industrial and Last Glacial Maximum (LGM, ~19,000 to ~23,000 a before present) boundary conditions, especially with respect to the monthly sea-surface temperature (SST) and sea-ice fraction fields. For the LGM, we used a new global climatology of the ocean surface during the Last Glacial Maximum mapped on a regular grid (GLOMAP), which is an extension of the Glacial Atlantic Ocean Mapping (GLAMAP) reconstruction of the Atlantic SST based on the results of the Multiproxy Approach for the Reconstruction of the Glacial Ocean Surface (MARGO) project and several recent estimates of the LGM sea-ice extent. This way, we can, on the one hand, avoid the propagation of the SST bias in coupled climate models. On the other hand, by comparing to fully-coupled simulations, we can isolate the impact of the ocean feedback on the simulated distributions of water isotopes over land, ice and ocean. To analyze the results, we calculated the anomalies between the LGM and pre-industrial climate states and compared them between the different models and to data. It turned out that the model response was affected by the amount of global cooling as well as the structure of the SST anomalies. The patterns in the simulated isotopic composition of precipitation for the LGM tended to follow the patterns in the SST boundary condition; a more zonal structure in the SST led to a more zonal response. Our results show the advantage of using water isotopes as a diagnostic tool for an AGCM through direct model-data comparison.