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Glacial-interglacial changes of water isotopes as simulated by a fully coupled Earth system model

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During the past two decades, several atmospheric and oceanic general circulation models (GCMs) have been enhanced by the capability to explicitly simulate the hydrological cycle of the two stable water isotopes $H_2^{18}O$ and HDO. They have provided a wealth of understanding regarding changes of the water isotope signals in various archives under different past climate conditions. However, so far the number of fully coupled atmosphere-ocean GCMs with explicit water isotope diagnostics is very limited. Such coupled models are required for a more comprehensive simulation of both past climates as well as related isotope changes in the Earth's hydrological cycle.

Here, we report first results of a newly developed isotope diagnostics within the Earth system model ECHAM5-JSBACH/MPIMOM. Both $H_2^{18}O$ and HDO and their relevant fractionation processes are included in all compartments and branches of the water cycle within this model. First equilibrium simulations have been performed for both pre-industrial (PI) and Last Glacial Maximum (LGM) boundary conditions. Evaluation of the PI simulation reveals a good overall model performance in accordance with available modern isotope data from vapour measurements, precipitation samples as well as marine records. The LGM experiment results in spatially varying isotope depletion in precipitation between -20‰ and 0‰ in agreement with data from various isotope records. The simulated isotopic compoisiton of ccean surface waters shows a strong glacial enrichment in the Arctic. In further model analyses we investigate how the relation between water isotopes and key climate variables, e.g. land and surface temperatures, precipitation amounts, oceanic salinity, might has changed for different regions on a glacial-interglacial time scale. Moreover, the influence of glacial climates changes on second-order isotope signals, e.g. the Deuterium excess, is examined.