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Water stable isotopes – climate relationships during/between the pre-industrial and mid-Holocene periods using the fully coupled model MPI-ESM-wiso

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The hydrological cycle is a fundamental component of the Earth's climate system. Modeling the time response of this cycle and the implied physical processes challenges the general circulation models (GCM) used to study the climate system and to project future climate. Water stable isotopes ($H_2{}^{16}O$, $H_2{}^{18}O$ and $HD^{16}O$) are integrated tracers of climate processes occurring in various branches of the hydrological cycle. Changes of the isotopic composition, which can be measured in various natural climate archives, have been used, for example, to reconstruct past temperatures changes at high resolution or to study the past dynamics of the monsoon. However, the quantitative translations of isotope signals recorded in the natural archives to climate variables is still challenging. The explicit modeling of these isotopes in GCMs is one way to improve our understanding of the mechanisms controlling the water isotopes distribution link with the variations of climate and to evaluate the model performance.

We present here the results, under pre-industrial (PI) and mid-Holocene (6k) conditions, of the new isotope-enhanced version of the fully coupled Earth system model MPI-ESM, called hereafter MPI-ESM-wiso. For that, the water isotopes have been implemented in all the components of the model (ECHAM6: atmosphere, JSBACH: dynamic vegetation, MPIOM: ocean/sea-ice). The related isotope masses of $H_2{}^{16}O$, $H_2{}^{18}O$ and $HD^{16}O$ are exchanged between the atmosphere and the ocean via the coupler OASIS3. The mid-Holocene, one of the PMIP4-CMIP6 entry cards to evaluate the performance of the coupled GCMs [1], provides the opportunity to evaluate the model response to changes in the seasonal and latitudinal distribution of insolation induced by different orbital forcing conditions. Especially, this period is characterized by enhanced African and Indian monsoons with depleted isotopic contents of precipitation. In addition to classical variables (temperatures, precipitation amount...), we evaluate the isotopic composition of precipitation, water vapor, ocean, etc. simulated by MPI-ESM-wiso against available observations. We also investigate the variability of the isotope-to-climate gradients (spatial and temporal) during and between the PI and 6k periods.

This work will be an important contribution to the Paleoclimate Modelling Intercomparison Project. Indeed, the models with an explicit water stable isotope diagnostics make it possible to perform direct comparisons, at different time periods, with environmental records and to reduce the uncertainties resulting from the interpretation of these records in terms of climate signals in model-data comparisons. The project is part of the PalMod initiative ("Paleo Modelling: A national paleo climate modelling initiative"), funded by the German Federal Ministry of Education and Science (BMBF).

[1] Kageyama et al., *Geosci. Model Dev.*, **11**, 1033-1057, 2018.