Stable water isotopes in paleoclimate simulations – results from the ECHAM5/MPI-OM and MPI-ESM model

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Scientific Goals & Methods

Summary
- The explicit modelling of stable water isotopes (H, H2O, HD, H2O) in complex climate models (GCMs) is one way to improve our understanding of the mechanisms controlling the water isotopes distribution in link with the variations of climate and to evaluate the GCM model performance.
- Here, we present simulation results using two different GCMs with explicit isotope diagnostics, run under pre-industrial (PI), mid-Holocene (6k), last glacial maximum (LGM, 21k), and last interglacial (LING, 125k) conditions.

Methods
- H2O and HD have been incorporated in all parts of the hydrological cycle of the coupled models ECHAM5/MPI-OM and MPI-ESM.
- Paleoclimate simulations have been performed according to the PMIP3 (for LGM, LIG) and PMIP4-CMIP6 (for 6k) protocols.
- ECHAM5/MPI-OM resolution
  - atmosphere: horizontal grid size 3.8°x3.8°, 19 vertical levels (T31L19)
  - ocean: bipolar grid, 1.5° near the equator, 40 z-levels (GR15L40)
- MPI-ESM resolution
  - atmosphere: horizontal grid size 1.9°x1.9°, 47 vertical levels (T63L47)
  - ocean: bipolar grid, 1.5° near the equator, 40 z-levels (GR15L40)

Results & Conclusions

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- Simulation results of both isotope-enabled GCMs agree well with modern observations of δ18O and ΔT on a global scale.
- Comparison of ice core and speleothem records with simulation results reveals a good model-data agreement in many places for the mid-Holocene (6k), LGM (21k), and last interglacial (LIG, 125k) climate.
- Temporal isotope-temperature relationships are spatially variable for all three investigated periods, and in many locations the temporal gradients are lower than the modern spatial ones.

Conclusions
- For the LGM, δ18O changes in precipitation are dominated by the glacial cooling, but the temporal δ18O-T gradient is substantially lower than the present-day spatial one for most mid- to high-latitude regions.
- For the 6k and LIG climate, simulated temperature changes are small in many regions, and temperature-independent processes dominate past δ18O and ΔT changes in precipitation.