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Relative humidity changes during the Late Glacial-Holocene transition in western Europe: quantitative and mechanistic insights from lipid biomarker D/H ratios and climate model experiments

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Abrupt climatic transitions are often associated with significant hydrological changes on decadal to centennial timescales. It is those hydrological changes that have a profound effect on terrestrial ecosystems as well as human societies. However, climate model simulations of regional hydrological changes during abrupt climatic transitions in the past but also the future are often associated to large uncertainties and few quantitative paleohydrological data exist to assess model performance for past abrupt climate change.
Here we test the accuracy by which a newly developed quantitative dual biomarker (DUB) based paleohydrological proxy recorded changes in relative humidity (rH) during the Late Glacial Period in western Europe and compare our reconstruction to simulated regional annual mean soil moisture from the COMBINED model experiment which describes a combined forcing setup on Late Glacial climate variability, i.e. the Younger Dryas (YD) cold period.
Employing the DUB approach on annually laminated sediments of Lake Meerfelder Maar in western Germany we reconstruct an abrupt decrease in relative humidity of 10% at 12640 years BP (during the onset of the YD) with rH being up to 15% lower during the YD compared to the Allerød. At 11700 years BP, i.e. at the termination of the YD and the onset of the Holocene we find an abrupt increase in relative humidity of 20% within 100 years, i.e. 10% higher than mean Allerød conditions, persisting for about 200 years before a decrease to mean Allerød levels. This proxy based reconstruction is in amplitude and duration excellent in line with the hydroclimate response in western Europe on the COMBIEND simulation experiment (correlation: r=0.75), including the humidity 'overshoot' at the onset of the Holocene. Model results suggest this overshoot was caused by an abrupt increase in the Atlantic Meridional Overturning Circulation (AMOC) strength at the beginning of the Holocene (quadrupling in 100 years) after recovery from reduced/ weak AMOC conditions during the YD. The COMBINED experiment suggests a continuous background influx of melt water during the YD keeping the AMOC in a reduced/ weak mode.
The excellent agreement in the results of both independent studies (proxy vs. simulation based) not only emphasizes the power of the compound specific δ2H-tool for paleohydrological reconstructions. Furthermore, it strongly supports the hypothesis on significant variations in the AMOC strength due to melt water influx as major driver of Late Glacial (i.e. YD) hydroclimate variability in Western Europe.