A dual-biomarker approach to Quantitative Paleohydrology

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Recent progress in the mechanistic understanding of the leaf wax lipid δD proxy, namely the identification of evapotranspiration as an important driver, now paves the way for quantititative paleohydrological reconstructions from sedimentary records of lipid biomarker δD values from closed catchment lakes. In particular, recent experimental studies have suggested, that leaf wax n-alkane δD values of dicotyledonous plants record the δD values of plant leaf water. The isotope enrichment of plant leaf water above plant source water (i.e. precipitation) is mainly driven by relative humidity (rH) and temperature (T), as such these factors are expected to excert major influence on leaf wax n-alkane δD values – in addition to the isotopic composition of plant source water. Therfore, it should be possible to extract quantitative information about any of these variables, if the other variables can be constrained.

Here we present a conceptual framework based on a combination of plant physiological modeling and δD values of aquatic and terrestrial lipid biomarkers to extract quantitative information about past changes in rH from lacustrine sedimentary sequences.

In our approach we use the isotopic difference between aquatic and terrestrial lipid biomarkers ($\varepsilon_{aq\text{-}terr}$) as a measure of mean ecosystem leaf water isotope enrichment and employ a Craig-Gordon leaf water isotope model where we constrain input variables from available vegetation cover information (based on palynological records) and climate proxy data (T). This model is then solved for rH.

We apply our dual-biomarker approach to a previously published record of lipid biomarker δD values from sediments of Lake Meerfelder Maar and estimate rH changes during the Younger Dryas (YD) cold period in western Europe. Our results imply a rapid and substantial increase in relative humidity during the YD on the order of 15%, consistent with the increased abundance of plant taxa adapted to dry conditions at that time as well as previous suggestions of substantially dryer conditions during the YD in western Europe.

Our new dual-biomarker approach provides a framework for the reconstruction of quantitative hydrological data, which can be directly compared to the output from climate models.