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Validation of a $\delta^2H_{n-alkane}$-$\delta^{18}O_{hemicellulose}$ based paleohygrometer: Implications from a climate chamber experiment

Johannes Hepp (1,2), Imke Kathrin Schäfer (3), Mario Tuthorn (2), Lorenz Wüthrich (3), Jana Zech (3), Bruno Glaser (2), Dieter Juchelka (4), Kazimierz Rozanski (5), Roland Zech (3), Christoph Mayr (6), Michael Zech (2,7)

(1) Chair of Geomorphology and BayCEER, University of Bayreuth, Germany (johannes-hepp@gmx.de), (2) Institute of Agronomy and Nutritional Sciences, Soil Biogeochemistry, Martin-Luther University Halle-Wittenberg, Germany, (3) Institute of Geography, Group of Biogeochemistry and Paleoclimate, University of Bern, Switzerland, (4) Thermo-Fisher Scientific, Bremen, Germany, (5) Faculty of Physics and Applied Computer Science, AGH University of Science and Technology, Poland, (6) Institute of Geography, Friedrich-Alexander-University Erlangen-Nürnberg, Germany, (7) Institute of Geography, Chair of Landscape- and Geoecology, Technical University of Dresden, Germany

Leaf wax-derived biomarkers, e.g. long chain n-alkanes and fatty acids, and their hydrogen isotopic composition are proved to be of a value in paleoclimatology/-hydrology research. However, the alteration of the isotopic signal as a result of the often unknown amount of leaf water enrichment challenges a direct reconstruction of the isotopic composition of paleoprecipitation. The coupling of $^2H/^1H$ results of leaf wax-derived biomarkers with $^{18}O/^{16}O$ results of hemicellulose-derived sugars has the potential to overcome this limitation and additionally allows reconstructing relative air humidity (RH) (Zech et al., 2013). This approach was recently validated by Tuthorn et al. (2015) by applying it to topsoil samples along a climate transect in Argentina. Accordingly, the biomarker-derived RH values correlate significantly with modern actual RH values from the respective study sites, showing the potential of the established 'paleohygrometer' approach. However, a climate chamber validation study to answer open questions regarding this approach, e.g. how robust biosynthetic fractionation factors are, is still missing.

Here we present coupled $\delta^2H_{n-alkane}$-$\delta^{18}O_{hemicellulose}$ results obtained for leaf material from a climate chamber experiment, in which Eucalyptus globulus, Vicia faba and Brassica oleracea were grown under controlled conditions (Mayr, 2003). First, the ^2H and ^{18}O enrichment of leaf water strongly reflects actual RH values of the climate chambers. Second, the biomarker-based reconstructed RH values correlate well with the actual RH values of the respective climate chamber, validating the proposed 'paleohygrometer' approach. And third, the calculated fractionation factors between the investigated leaf biomarkers (n-C_{29} and n-C_{31} for alkanes; arabinose and xylose for hemicellulose) and leaf water are close to the expected once reviewed from the literature (+27‰ for hemicellulose; -155‰ for n-alkanes). Nevertheless, minor dependencies of these biomarker fractionation factors from temperature and relative humidity of the climate chamber, as well as from the measured transpiration rate of the plants are evident from the data. As an outlook, the proposed coupled $\delta^2H_{n-alkane}$-$\delta^{18}O_{hemicellulose}$ approach allows (i) more robust $\delta^2H/\delta^{18}O_{precipitation}$ reconstructions and (ii) paleohygrometry studies in future paleoclimate research.

References

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