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A 220 ka terrestrial δ18O and deuterium excess biomarker record from an eolian permafrost paleosol sequence, NE-Siberia

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The natural abundances of stable oxygen (18O/16O) and hydrogen isotopes (D/H) are valuable proxies of climate changes in the past. Yet, to date no continuous δ18O and only few δD records are available from loess-paleosol sequences. Taking advantage of a recently developed method based on compound-specific δ18O analyzes of hemicellulose sugar biomarkers in soils (Zech and Glaser, 2009), we here present a first terrestrial δ18O biomarker record from an eolian permafrost paleosol sequence in NE-Siberia that covers the last $\sim$220 ka.
The δ18O values of the hemicellulose biomarkers arabinose and xylose range from 22.5 to 32.8‰ and from 21.3 to 31.9‰ respectively, and reveal systematic glacial – interglacial shifts. The modern topsoil and the interglacial paleosols exhibit more positive δ18O values, whereas the glacial paleosols are characterized by more negative δ18O values. This is in agreement with the δD record obtained for sedimentary n-alkane leaf wax biomarkers. We present a conceptual model for interpreting the combined δ18O and δD biomarker record. Based on this model, we suggest that both our δ18O and the δD record primarily reflect the temperature-controlled isotopic composition of paleoprecipitation modified by evaporative isotope enrichment of leaf water during transpiration.
Considering fractionation factors during sugar and n-alkane biomarker biosynthesis allows reconstructing the leaf water isotopic composition and the deuterium excess of the leaf water. The deuterium excess may serve as proxy for evaporative enrichment and allows calculating relative humidity using a Craig-Gordon model. Accordingly, relative humidity in NE-Siberia was higher during marine isotope stage (MIS) 6 compared to MIS 2, 4 and 5d and thus could help explaining the much larger extent of the Late Saalian glaciation compared to the Weichselian glaciations.
Using the Craig-Gordon model, we also calculated δ18O of the plant source water (δ18Osource water), which can be assumed to primarily reflect δ18O of paleoprecipitation. Our 220 ka δ18Osource water record is well in agreement with the δ18Odiatom record from Crater Lake El'gygytgyn in NE-Siberia and enables a regional paleoclimate reconstruction and interpretation. Accordingly, summer temperature was periodically warmer than at present during the Weichselian glacial period and there is a strong July insolation forcing of the summer temperature in the extremely continental study area. Overall, our study highlights the great potential of the novel hemicellulose biomarker δ18O method for paleoclimate reconstructions, especially when combined with δD analyzes of n-alkane lipid biomarkers.