Calibration of δ2Hn-alkane and δ18Osugar for paleoclimate reconstructions in South Africa and its first application to peat sediments from Vankervelsvlei

Paul Strobel1, Roland Zech1, Marcel Bliedtner1, Julian Struck1, Bruno Glaser2, Michael Zech3, Michael E. Meadows4,5, and Torsten Haberzettl6

1Physical Geography, Institute of Geography, Friedrich-Schiller-University Jena, Jena, Germany
2Institute of Agronomy and Nutritional Sciences, Soil Biogeochemistry, Martin Luther University Halle-Wittenberg, Halle (Saale), Germany
3Physical Geography with focus on paleoenvironmental research, Institute of Geography, Dresden University of Technology, Dresden, Germany
4Department of Environmental and Geographical Science, University of Cape Town, Rondebosch, South Africa
5School of Geographic Sciences, East China Normal University, Shanghai, China
6Physical Geography, Institute of Geography and Geology, University of Greifswald, Germany

Hydrogen isotope analyses of leaf wax n-alkanes (δ2Hwax) are widely applied to reconstruct paleoclimate changes. To date, it has proved difficult to disentangle past changes in the isotopic signal of precipitation (δ2Hp) and other fractionation factors, e.g. evapo-transpirative enrichment. Oxygen isotopes from hemicellulose sugars (δ18Osugar) have been proposed to complement δ2Hwax and enable more robust paleohydrological reconstructions by coupling both isotopes. However, up to now, there is a lack of studies analysing both water isotopes in South Africa.

Therefore, we analysed δ2Hwax and δ18Osugar from topsoils from South Africa to evaluate the coupled isotope approach on modern reference material as an initial step towards more robust paleohydrological reconstructions. The results indicate that δ2Hwax significantly correlates with δ2Hp values for growing season precipitation. However, no correlation exists between δ18Osugar and growing season δ18Op. While the apparent fractionation εapp 2H, i.e. the difference between δ2Hwax and δ2Hp, is relatively constant and not affected by climate, εapp 18O correlates significantly with both potential evapotranspiration and the aridity index, indicating a strong influence of evapo-transpirative enrichment on δ18Osugar. Coupling δ18Osugar and δ2Hwax facilitates the reconstruction of δ2Hp and δ18Op in South Africa with a 1σ accuracy of ± ~27‰ and ± ~3.7‰, respectively, and relative humidity (RH) with a 1σ accuracy of ± ~17%.

In a second step, we applied the coupled isotope approach to a 14.6 m long sediment core to complement geochemical and sedimentological analyses. The core is from Vankervelsvlei, a fen near the southern Cape coast located 152 m above mean sea level within the yearround rainfall zone of South Africa. Our results show relatively high values for δ2Hwax between 7,020 ±200/-270 and 4,770 ±280/-230 cal BP. Conventionally, this would be interpreted to indicate more arid conditions (referring to the ‘amount effect’ or enhanced evapo-transpirative enrichment). However,
corresponding reconstructed RH values are high and point to more humid conditions. Thus, we interpret the higher $\delta^2 H_{wax}$ (as well as the isotopically positive reconstructed precipitation) to reflect changing moisture sources, i.e. more summer precipitation related to greater prominence of the Easterlies. Enhanced RH as well as increased wind speed inferred from high wind driven allochthonous input (Al, Sr, Ti), is associated with a maximum in obliquity during that time. Drier and less windy conditions are indicated between 4,770 $^{\pm}_{280/0330}$ and 2,820 $^{350/0330}$ cal BP, as suggested by lower $\delta^2 H_{wax}$ and reconstructed precipitation, low RH and reduced wind driven allochthonous input. Moister conditions persisted between 2,820 $^{350/0330}$ and 1,620 $^{430/0280}$ cal BP and are followed by a ~1 kyr dry period. Moisture levels have been increasing since 640 $^{90/0100}$ Cal BP.