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The hydrogen isotope footprint of source water in tree lignin methoxy groups

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The stable hydrogen isotope values of tree lignin methoxy groups (δ^2H_{meth}) show a robust relationship with source water hydrogen isotopes (δ^2H_{SW}), enabling the reconstruction of the source water origin using an average hydrogen isotopic fractionation (ε) of around -200 mUr between δ^2H_{meth} and δ^2H_{SW} values (Greule et al., 2021; Keppler et al., 2007). Reconstructed δ^2H_{SW} is currently mainly used for climatic reconstruction of temperature but could also be used to better understand ecohydrological processes such as root water uptake. As the use of lignin methoxy groups as a source water proxy is relatively new, there are still uncertainties regarding additional influences on δ^2H_{meth} interfering the reconstruction of δ^2H_{SW}. Factors such as temporal changes in the isotopic composition of source water, soil moisture, and changes in root system and biomass may influence lignin methoxy fractionation, and a better understanding of these factors is important to improve the application of this proxy.

Here, we analyzed wood samples collected from a dry pine forest in Switzerland, where an extensive irrigation experiment was conducted. The site was divided into eight plots and since 2003 four of these plots received irrigation during the growing season from a nearby channel fed by the Rhone River, doubling the annual precipitation amount in the irrigated (1200mm) compared to the control stands (600 mm). Irrigation water is about 46 ± 9 mUr more depleted in ^2H than the soil water, resulting in average δ^2H values of -76 vs -68 mUr in irrigated and control soil water (0-10 cm) (Guidi et al., 2023).

We present results of δ^2H_{meth} measurements from four irrigated and four control trees analyzed annually from 1990 to 2023. We observed a significant ^2H depletion in the irrigated trees compared to the control trees, supporting the use of this proxy to reconstruct source water changes. By further comparing δ^2H_{meth} values of irrigated and control trees, including root and leaf samples, we gain additional insight into hydrogen isotope fractionation processes in trees, improving our understanding of the influences of biological processes on δ^2H_{meth}. With our study, we hope to contribute to the further development of a new ecohydrological proxy that potentially allows the reconstruction of past variations in root water uptake of plants.

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