EGU24-759, updated on 11 Nov 2024
https://doi.org/10.5194/egusphere-egu24-759
EGU General Assembly 2024

Forest Water Uptake Dynamics in the Long-Term Drought Experimental Site, Pfynwald – Intercomparison of Water Extraction and Isotope Analysis Methods

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The isotopic composition of water in plant xylem in comparison to the soil water isotopic composition is often used to investigate the plant water uptake patterns (e.g., Gessler et al. 2022), drought effects on plants (e.g., Lehmann et al. 2023, in review) and the water exchange through the river, soil, vegetation and atmosphere continuum (e.g., Brooks et al. 2010). Several studies have shown that there is a difference in the isotopic composition between the water source and the xylem water in trees. However, the source of this difference is subject to current scientific debates. Two-water-world hypothesis (Brooks et al. 2010), fractionation during root-water uptake (Vargas et al. 2017), bias due to cryogenic water distillation (Chen et al. 2020; Barbeta et al. 2022), Fractionation during movement of water between different tree tissues (Barbeta et al. 2022) are among the hypotheses proposed in the literature as the origin of the isotopic difference between source water and xylem water.

Here we used several water extraction and isotope analysis methods to shed light on the isotope-based methods in tracking water movement in the soil-vegetation-atmosphere continuum. Our study site is a scots pine forest stand in the long-term drought experimental site, Pfynwald, Switzerland where the forest is exposed to a range of moisture conditions by irrigation.

To extract xylem water, we used the Scholander Pressure Bomb, cryogenic vacuum distillation, and the vapor equilibrium method. For the soil water extraction, the equilibrium vapor extraction and cryogenic vacuum distillation method is used for different depths. Furthermore, we used the isotope ratio laser spectrometer and isotope ratio mass spectrometer to analyse extracted water samples.

With this work, we aim to answer the following questions: a) Is there a difference in the isotopic composition of water extracted with the equilibrium vapor method (in-situ, bulk stem water), Scholander pressure bomb (sap flow water) and the cryogenic vacuum distillation method (bulk stem water)? b) How are the observed isotopic differences between xylem and soil water related to the available moisture conditions?

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