Investigating the root plasticity response of *Centaurea jacea* to soil water availability changes from stable isotopic analysis

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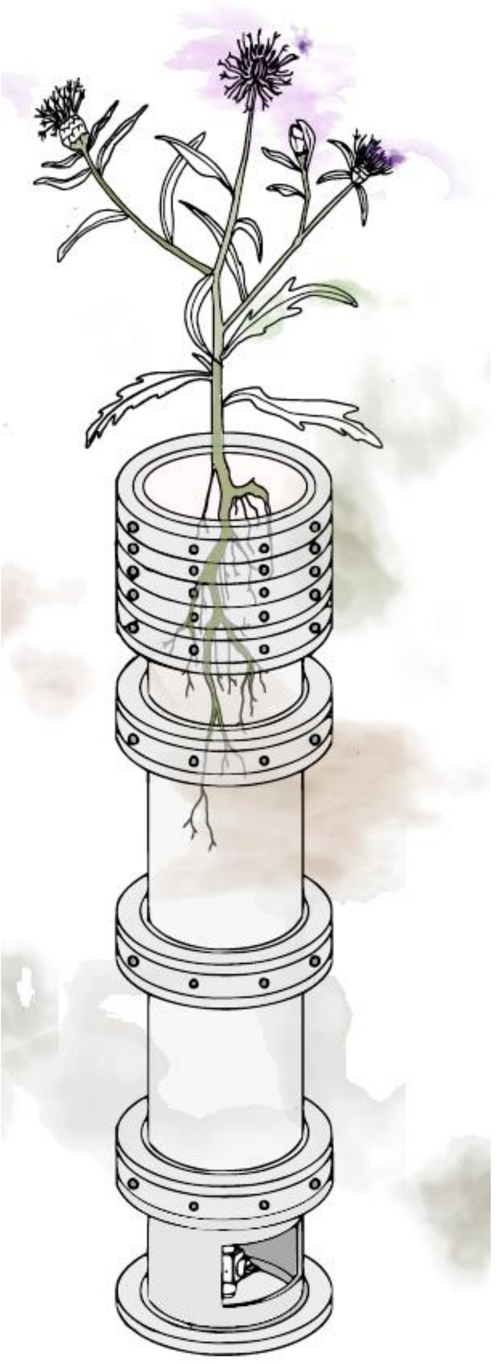
1 Rationale

Root water uptake (RWU) is a key eco-hydrological process for which a physically-based understanding has been developed in the past decades. However, due to methodological constraints, knowledge gaps remain about the plastic response of whole plant root systems to a rapidly changing environment.

- **Novel monitoring methods**[1] **based** on laser spectroscopy and gas-permeable membranes **allow** for a **non-destructive** determination of the **isotopic compositions of soil and plant water**

  → **Water stable isotopes** are on the verge to be used to their **full potential** for addressing **eco-hydrological** research **questions**[2,3]

2 Modus operandi



We designed a laboratory system for monitoring of $\delta^{18}O$ and $\delta^{2}H$ in plant transpiration of an herbaceous species (*Centaurea jacea*) and of soil water across depths. Daily root water uptake profiles were obtained using the Bayesian multi-source mixing model SIAR[2]**.**

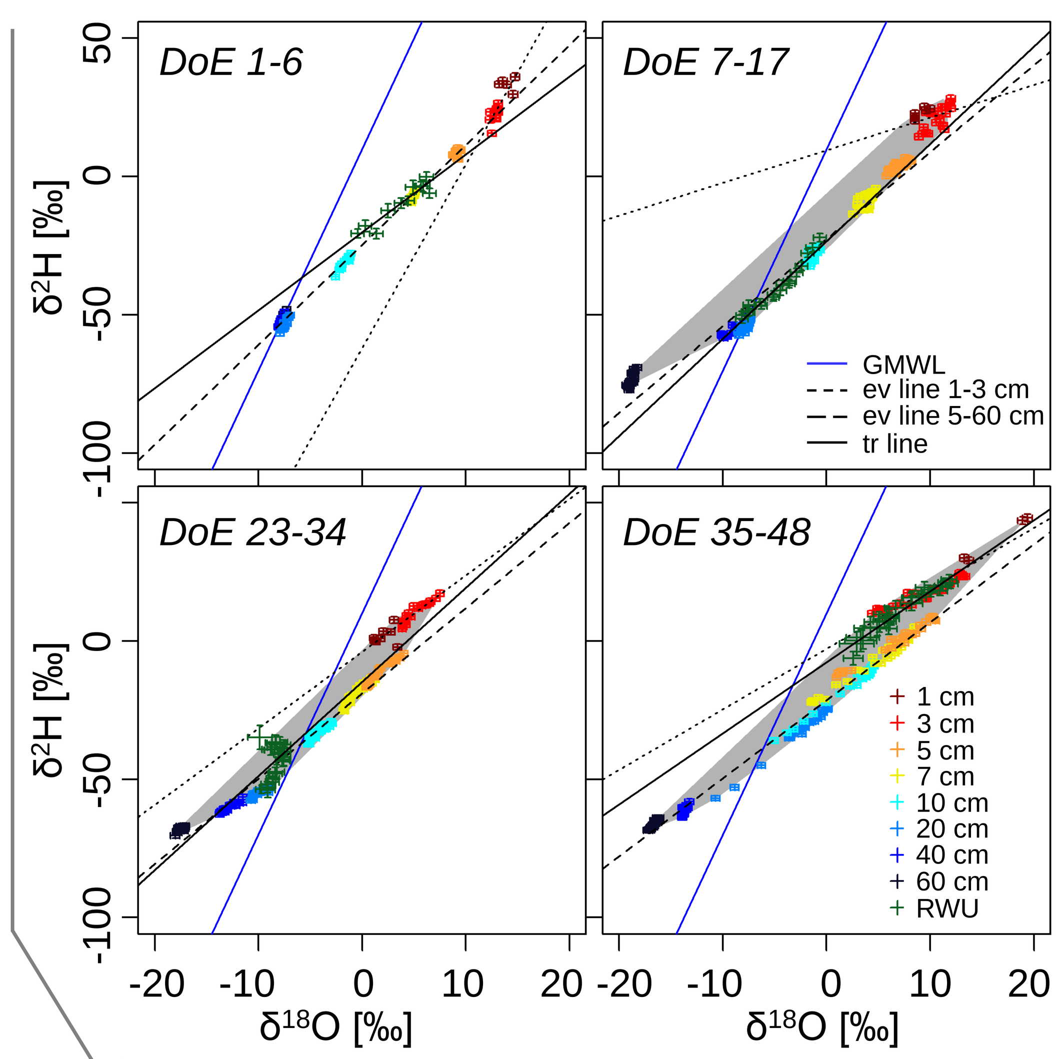
- **Soil water** content (θ), **$\delta^{18}O$ and $\delta^{2}H$ monitored** at **8 depths** from 1-60 cm
- **Steady state transpiration flux, $\delta^{18}O$, and $\delta^{2}H$** monitored with a plant chamber
- **Column** filled with dry sieved **silt loam** and **saturated** from the **bottom**
- Following transplantation (DoE 1), isotopic **labeling** at the **top** (DoE 1-3 and 35-38) and at the **bottom** (DoE 7-10) to simulate an ***enriched* rain** event and the capillary rise of ***depleted* groundwater**
- **Root length density** (RLD) profile determined destructively at the end of the experiment

[1]Rothfuss, Y. et al., *Water Resour. Res.*, 49, 1-9, doi:10.1002/wrcr.20311, 2013.
[2]Rothfuss, Y., and Javaux, M., *Biogeosciences*, 14, 2199-2224, doi:10.5194/bg-14-2199-2017, 2017
[3]Dubbert, M., and Werner, C., *New Phytol.*, 221, 1754–1763, doi:10.1111/nph.15547, 2019.

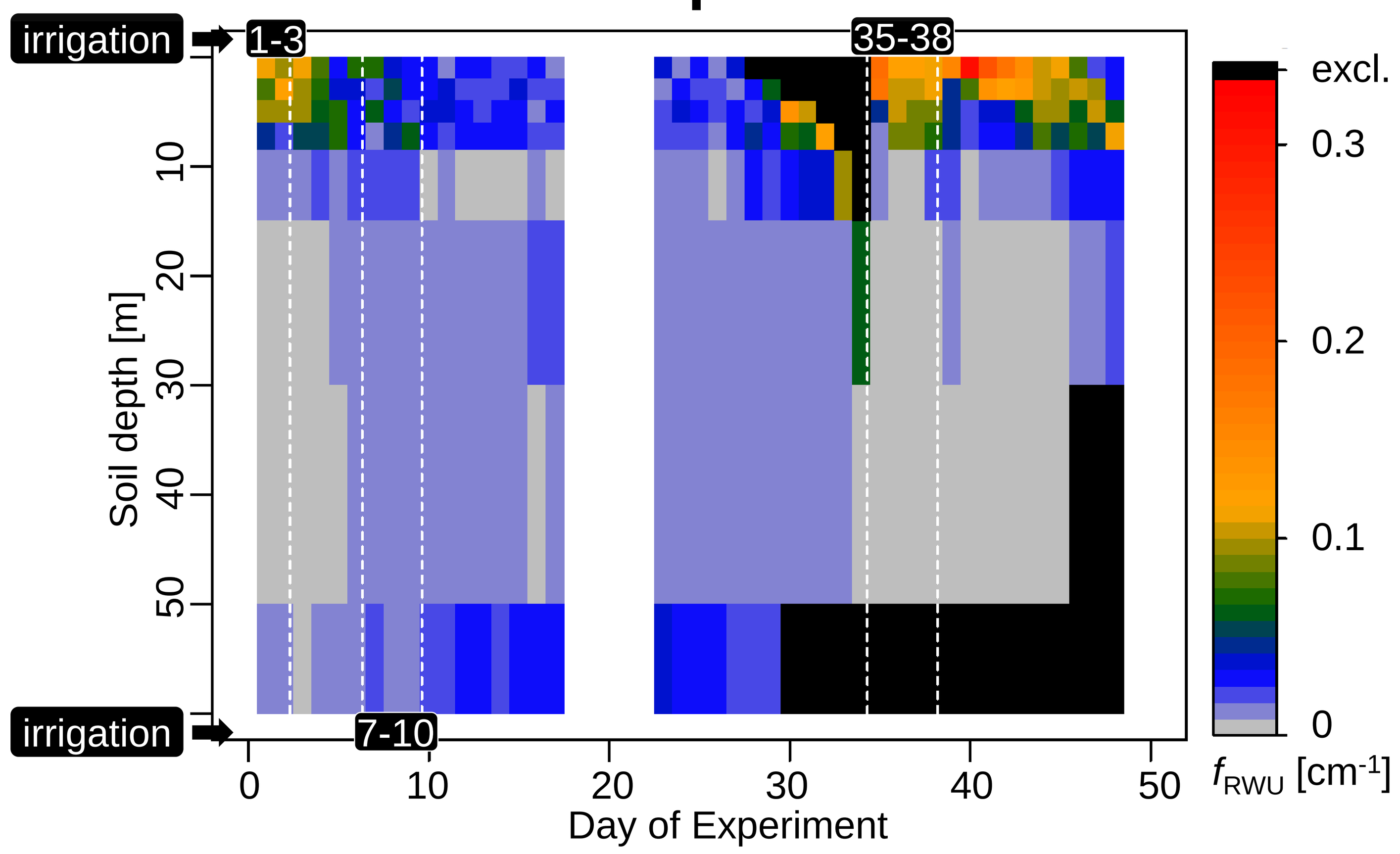
3 Experimental results

Shifts in soil water and transpiration $\delta^{18}O$ and $\delta^{2}H$ could be observed and translated into RWU profile temporal dynamics.

- **Steady state transpiration** (i.e., **RWU**) samples are distributed on the **surface area** delimited by the soil samples in a **($\delta^{18}O$, $\delta^{2}H$) dual space**
- **Plant physiological** and **soil physical information** were **incorporated** into SIAR



***Soil** water and **RWU** (i.e., isotopic steady transpiration) samples in a ($\delta^{18}O$, $\delta^{2}H$) plot*

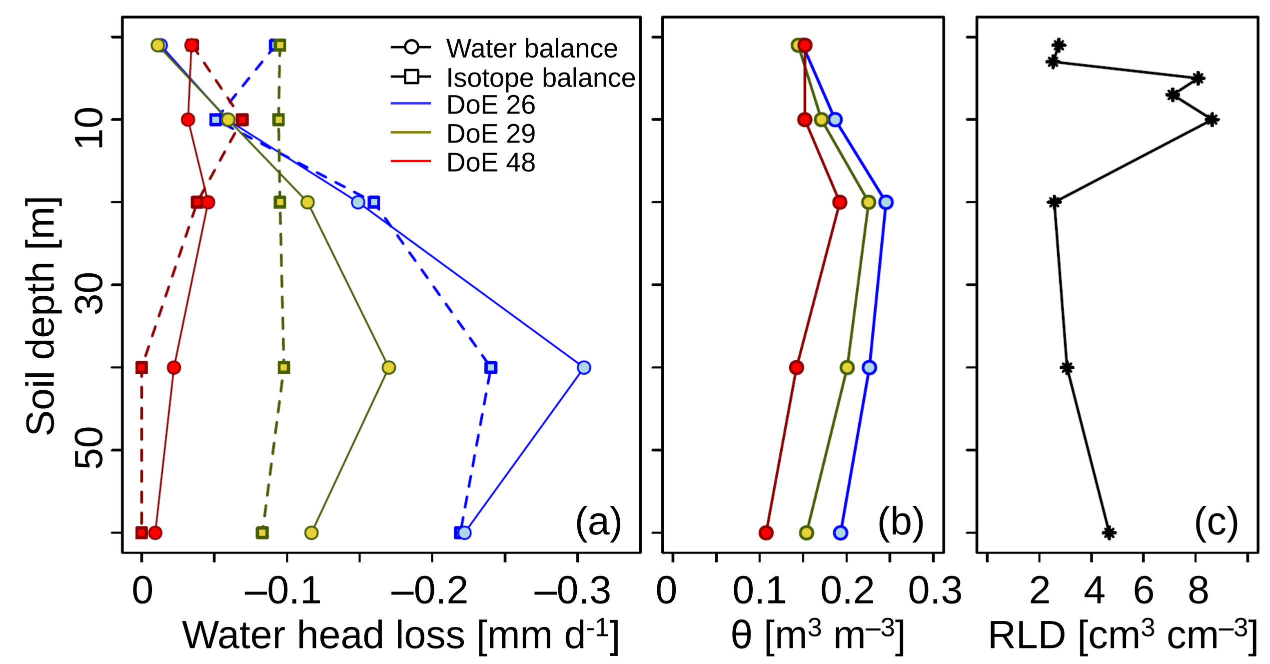


RWU fraction (f_{RWU}) profile simulated by SIAR. Values are normalized by the soil layer thickness and expressed in cm^{-1}. Soil layers colored in black indicate $f_{RWU}=0$ where soil water potential ≤ –4 MPa. Periods of irrigation from the top/bottom of the soil column are indicated

4 Closing the water balance

A simple exercise of water balance closure underlined the non-unique relationship between RWU profile on the one hand, and θ and RLD profiles on the other.

- **Soil water head loss** was computed from the temporal **changes** of θ and **compared** to estimates based on **transpiration flux** and relative **RWU** profiles from SIAR



Water head loss (a) across soil layers determined exemplarily on DoE 26, 29, and 48 from the changes of θ (b) and from the SIAR output. (c) RLD profile

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