Tree specific traits vs. stand level characteristics - investigating plant water uptake in a mixed forest stand

Stefan Seeger[1], Nadine Brinkmann[2], Ansgar Kahmen[3] and Markus Weiler[1]

EGU2017 Session HS10.5 - New methods, stable isotope techniques and physical principles in ecohydrology

Motivation

Plant water uptake, a crucial component of the water balance of terrestrial ecosystems, is influenced by species specific traits as well as stand level characteristics. While the latter ones can be measured in the field, the former ones are assumed to be constant and are hardly measurable within the scope of most hydrological studies.

Objectives

Assess the sensitivity of Plant Water Uptake (PWU) to the following **tree specific traits:**

- **Leaf Area Index (LAI)**
- **PWU related plant physiological traits** (parameters for Feddes model)
- **Fine root distribution**

Study site

- Lägeren (Northern Switzerland), WSL research site
- 700 m.a.s.l , permeable calcareous brown soils, yearly precipitation: 810 mm/a
- Mixed forest stand, dominated by *Fagus sylvatica* (beech), other tree species: *Picea abies* (spruce), *Acer pseudoplatanus* (maple) & *Fraxinus excelsior* (ash)

Data

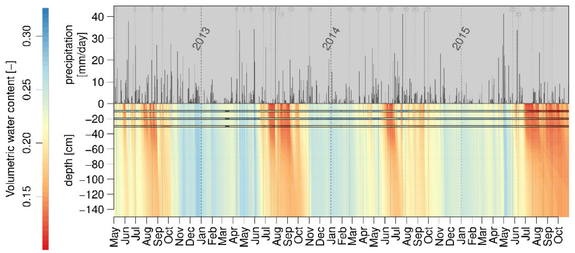
- Stable water isotope samples taken from the xylem of four tree species and depth profiles from 70 cm soil core samples taken at 26 dates from 2012 to 2015
- Stable water isotopes in precipitation (IAEA GNIP)
- Volumetric soil moisture data (10, 20 & 30 cm depth)
- Climatic input data (precipitation, air temperature & humidity, wind speed, solar radiation)

Methods

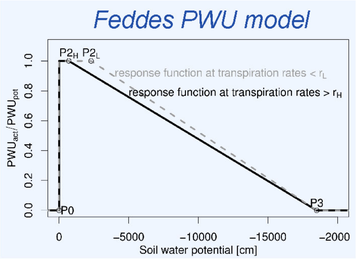
- Estimation of effective parameters for a 1-D Richards-equation based soil water model (Hydrus 1-D) aided by observations of soil water stable isotopes and volumetric soil water content
- Comparison of measured tree xylem stable water isotopes with simulated PWU values based on various scenarios

Measurements & model simulations

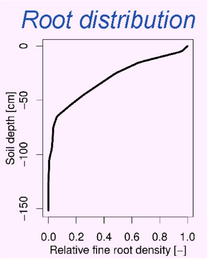
Simulated and observed soil moisture



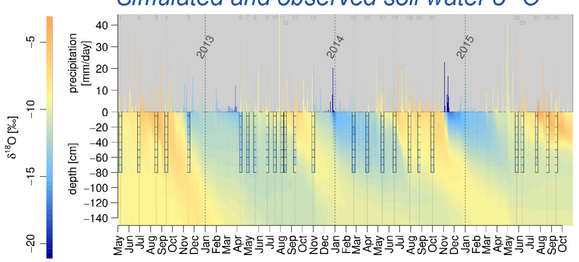
Feddes PWU model



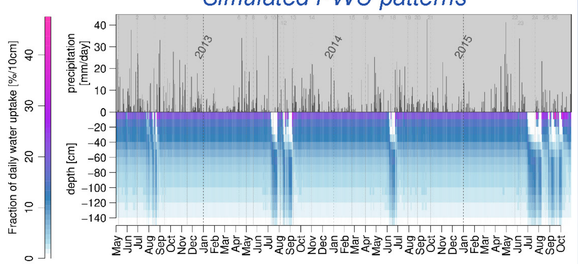
Root distribution



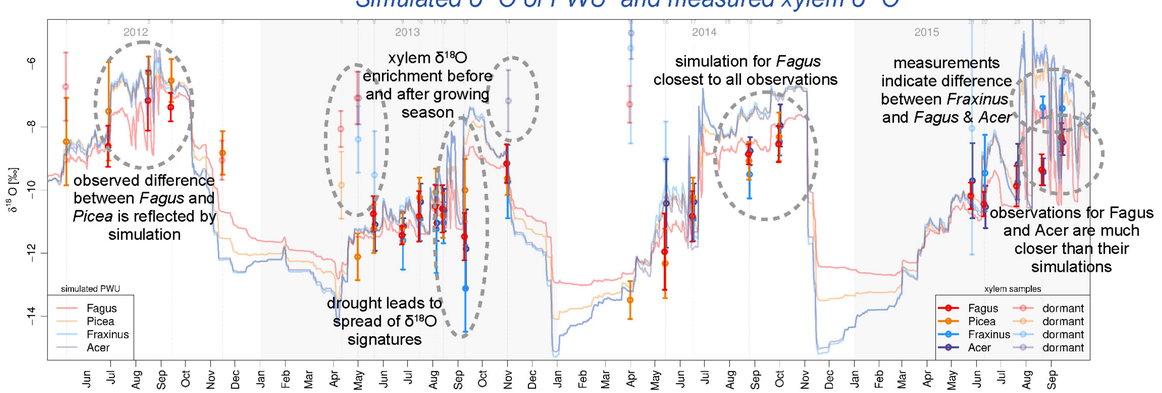
Simulated and observed soil water $\delta^{18}O$



Simulated PWU patterns

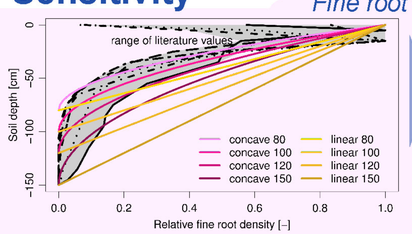


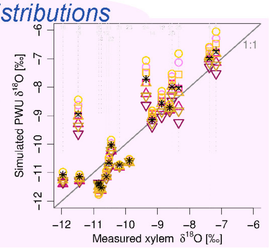
Simulated $\delta^{18}O$ of PWU and measured xylem $\delta^{18}O$



Sensitivity

Fine root distributions

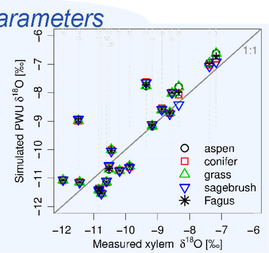




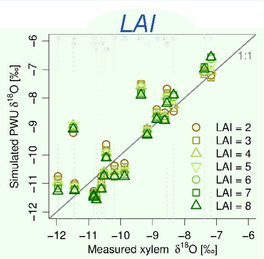
Feddes parameters

species	P0 [cm]	$P2_H$ [cm]	$P2_L$ [cm]	P3 [cm]	r_H [cm/d]	r_L [cm/d]
aspen[1]	0	330	2000	15000	0.5	0.1
conifer[1]	0	5100	12800	21500	0.5	0.1
forbs[1]	0	300	1000	15000	0.5	0.1
sagebrush[1]	0	400	5100	33000	0.95	0.1
Fagus[2]	0	700	2300	18500	0.5	0.1

1) Lv, Ling, "Linking Montane Soil Moisture Measurements to Evapotranspiration Using Inverse Numerical Modeling"(2014) All Graduate Theses and Dissertations. 3323. http://digitalcommons.usu.edu/etd/3323
2) obtained by model optimization towards observed soil moistures and soil water isotopes



LAI



- PWU isotopic signature most sensitive to fine root distributions
- Deeper roots → lighter PWU signature
- Feddes parameters only sensitive during drought conditions
- LAI differences of ± 2 have little effect on PWU isotopic signature

Conclusions

Stand level characteristics (climatic forcing and soil properties) **are the main influence on** simulated **PWU** isotopic signatures. The **most sensitive tree specific trait is the fine root distribution**. Under humid conditions, **tree specific LAIs and Feddes parameters** are **less important for modeling PWU** isotopic signatures.

With approximately known fine root ditributions, at least for humid sites, **continuous modeling of PWU isotopic signatures** is **possible without** necessarily **knowing** the **exact LAI and plant specific Feddes parameters***.

* Groundwater influence and hydraulic lift aside...

1) Hydrology, Faculty of Enivronment and Natural Ressources, University of Freiburg
stefan.seeger@hydrology.uni-freiburg.de www.hydro.uni-freiburg.de
2) Physiological Plant Ecology, Environmental Systems Science, ETH Swiss Federal Institute of Technology Zurich
3) Sustainable Landuse, Environmental Sciences, University of Basel

Acknowledgments:
The main author of this poster is funded by a scholarship of the LGFG (Landesgraduiertenförderung) Baden-Württemberg.