Rhizosphere soil moisture dynamics and sap flow – determining root water uptake in a case study in the Attert catchment in Luxembourg

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3. Data Description

The dataset consists of measured soil moisture, sap velocity, precipitation and solar radiation time series, additionally calculated time series of root water uptake (RWU) and sap flow, including a python script for calculating RWU. The measurements were collected at two sites in mixed beech stands (*Fagus sylvatica* L.) in contrasting geological settings (sandstone and slate). Both sites are situated within the Attert catchment in western Luxembourg and were part of the monitoring network of the CAOS project (DFG research unit "From Catchments as Organised Systems to Models Based on Functional Units"; *Zehe et al.* 2014). In the vegetation period of 2017, we measured soil moisture across two profiles in the trees' rhizosphere. These time series are compared to sap flow measurements in nearby trees. Moreover, we include precipitation and solar radiation data for the study period. For conversion of soil moisture to soil matric potential, we provide van Genuchten parameters (*van Genuchten*, 1980) for soil water retention at both sites, based on a previous study (*Jackisch, 2015*). The recent study was published by Jackisch et al. (2020).

3.1. Spatial and temporal domain

Projection →	Gauss Krüger EPSG: 2169 Luxembourg 1930		Decimal Degree EPSG: 4326 WGS 84	
Site	**Easting**	**Northing**	**Latitude**	**Longitude**
Sandstone	60316.96	85922.91	49.7075172	5.8952425
Slate	53803.10	97094.41	49.8077084	5.8041883

Temporal dimensions of the datasets are from 5th of April 2017 to the 30th of November 2017. The time zone is Central European Time (GMT-1).

3.2. Soil moisture data

Soil moisture was monitored using TDR tube probes (Pico Profile T3PN, Imko GmbH), which allow for installation with minimal disturbance using an acrylic glass access liner (diameter 48 mm). The liner tube was installed in the rhizosphere of the trees without any excavation using a percussion drill. For optimal contact of the liner with the surrounding soil, the drill diameter was 40 mm and the tube was installed more than one year prior to the recorded data set.

Each TDR probe segment integrates the soil moisture measurement over its length of 0.2 m. The signal penetrates the soil about 0.05 m which results in an integral volume of approx. 0,001 m^{-3}. The probes can be stacked directly on top of each other, permitting spatially continuous monitoring over the soil moisture profile. At the sandstone site, we were able to install a sequence of 12 probes reaching a depth of 2.4 m. At the slate site, percussion drilling was inhibited by the weathered bedrock. There, we installed a sequence of 9 probes reaching a depth of 1.8 m. Soil moisture is recorded in 15 min intervals and aggregated to 30 min means.

3.3. Sap flow data

Sap velocities were monitored in four beech trees in the direct vicinity of the soil moisture profile (as part of the CAOS research unit). At the sandy site, the reference sap velocity time series could be obtained from the exact tree where the TDR sensors were installed. It had a diameter at breast height (DBH) of 64 cm. At the slate site, the sap velocity sensor of the intended tree failed 3 weeks after leaf out. There, we refer to a neighbouring beech tree with a DBH of 48 cm about 9 m from the TDR measurements

The sap flow sensors (East30 Sensors) are based on the heat ratio method and measure simultaneously at 5, 18 and 30 mm depth within the sapwood. Installation and calculation of sap velocities followed the description in *Hassler et al.* (2018). The sensors were installed before leaf out of the vegetation period in 2017. The data is recorded in 30 min intervals.

We provide both the measured sap velocities and the upscaled sap flows. We assume the two outer measurement points in the sapwood to be representative for the radial area between 0–11 mm and 11–24 mm. Both are the mid points between the sensor positions. The inner sensor is representing a flow field, which has been shown to follow a Weibull distribution (*Gebauer et al.*, 2008) in the active sapwood. To estimate the sap velocity distribution at each time step, we fit the Weibull function with the beech-parameters of (*Gebauer et al*., 2008) to the observed measurements at the mid and inner point via a scaling factor. For a correct position reference, the bark thickness is removed after *Rössler* (2008). As an inner limit, the 95% percentile is used to mark the transition to the inactive sapwood (*Gebauer et al*., 2008) (“zero” sap velocity limit). The resulting time series is now reporting sap flow in L h^{-1} and is aggregated to daily values.

3.4. Meteorological data

As further reference for the drivers of temporal dynamics in soil moisture and sap velocity we use 10 min solar radiation records (Apogee Pyranometer SP110) subsampled to the time stamps of the precipitation data. Corrected hourly radar stand precipitation at canopy level is obtained from combined data from DWD (Deutscher Wetterdienst, Germany), ASTA (Administration des Services techniques de l'agriculture, Luxembourg) and KNMI (Koninklijk Nederlands Meteorologisch Instituut, Netherlands) after *Neuper and Ehret* (2019).

3.5. Soil water retention properties

Soil water retention properties of the sites are given for two layers. The data was assessed in a previous study using the free evaporation method of the HYPROP apparatus and the chilled mirror method in the WP4C (both Meter AG) with 250 mL undisturbed soil samples from the sites (*Jackisch*, 2015). Following this method, the matric potential is divided into bins (0.05 pF). All retention data of the reference soil samples is bin-wise averaged to form the basis for the fitting of a van Genuchten retention curve. We have aggregated the results of 44 and 41 soil samples in the subbasins of the sand and slate site.

4. File description

4.1. File inventory

- 1_soilmoisture.csv: measured TDR soil moisture profiles
- 2_rwu.csv: calculated root water uptake
- 3_sapvelocity.csv: measured sap velocities
- 4_sapflow.csv: calculated sap flow values
- 5_precip_radiation.csv: meteorological variables precipitation and radiation
- 6_vG_RWU.csv: calculated van Genuchten parameters
- rootwater.py: python script for root water calculation algorithm

4.2. Description of data tables

1_soilmoisture.csv

Column header	unit	Description
TIMESTAMP	yyyy-mm-ddThh:mm:ss+01:00	date and time of measurement (ISO 8601)
Sand_SM_*depth* (12 columns)	Vol. %	Measured volumetric water content at the sandstone site. "*depth*" refers to the middle of each 20 cm depth increment.
Slate_SM_*depth* (9 columns)	Vol. %	Measured volumetric water content at the slate site. "*depth*" refers to the middle of each 20 cm depth increment.

2_rwu.csv

Column header	unit	Description
Date	yyyy-mm-dd	date
Sand_RWU_*depth* (12 columns)	mm d^{-1}	calculated root water uptake at the sandstone site. "*depth*" refers to the midpoint of each 20 cm depth increment
Slate_RWU_*depth* (9 columns)	mm d^{-1}	calculated root water uptake at the slate site. "*depth*" refers to the midpoint of each 20 cm depth increment

3_sapvelocity.csv

Column header	unit	Description
TIMESTAMP	yyyy-mm-ddThh:mm:ss+01:00	date and time of measurement (ISO 8601)
Sand_SV_outer	cm h^{-1}	sap velocity at the sensor in 5 mm xylem depth in the tree at the sandstone site
Sand_SV_mid	cm h^{-1}	sap velocity at the sensor in 18 mm xylem depth in the tree at the sandstone site
Sand_SV_inner	cm h^{-1}	sap velocity at the sensor in 30 mm xylem depth in the tree at the sandstone site
Slate_SV_outer	cm h^{-1}	sap velocity at the sensor in 5 mm xylem depth in the tree at the slate site
Slate_SV_mid	cm h^{-1}	sap velocity at the sensor in 18 mm xylem depth in the tree at the slate site
Slate_SV_inner	cm h^{-1}	sap velocity at the sensor in 30 mm xylem depth in the tree at the slate site

4_sapflow.csv

Column header	unit	Description
Date	yyyy-mm-dd	date
Sand_SF_outer	L day^{-1}	daily sap flow for the outermost xylem increment (0–11 mm xylem depth) in the tree at the sandstone site
Sand_SF_mid	L day^{-1}	daily sap flow for the middle xylem increment (11–24 mm xylem depth) in the tree at the sandstone site
Sand_SF_inner	L day^{-1}	daily sap flow for the inner xylem increment (24 mm xylem depth – "zero" sap velocity limit) in the tree at the sandstone site

Slate_SF_outer	L day^{-1}	daily sap flow for the outermost xylem increment (0–11 mm xylem depth) in the tree at the slate site
Slate_SF_mid	L day^{-1}	daily sap flow for the middle xylem increment (11–24 mm xylem depth) in the tree at the slate site
Slate_SF_inner	L day^{-1}	daily sap flow for the inner xylem increment (24 mm xylem depth – “zero” sap velocity limit) in the tree at the slate site

5_precip_radiation.csv

Column header	unit	Description
TIMESTAMP	yyyy-mm-ddThh:mm:ss+01:00	date and time of measurement (ISO 8601)
Sand_precip	mm h^{-1}	hourly precipitation sum at the sandstone site in mm h^{-1}
Slate_precip	mm h^{-1}	hourly precipitation sum at the slate site in mm h^{-1}
Rad	W m^{-2}	global radiation for the site W m^{-2}

6_vG_RWU.csv

Column header	unit	Description
Samples		samples that form the basis of the individual van Genuchten curves, with respect to site (sandstone/slate) and depth increments.
ths	Vol.%	van Genuchten parameter: saturated water content
thr	Vol.%	van Genuchten parameter: residual water content
alpha	m^{-1}	van Genuchten scaling parameter
n		dimensionless shape parameter of the van Genuchten curve
m		dimensionless shape parameter of the van Genuchten curve
ks	m s^{-1}	saturated hydraulic conductivity

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