Quantifying above- and belowground interactions by in-situ water isotope monitoring and geophysical techniques

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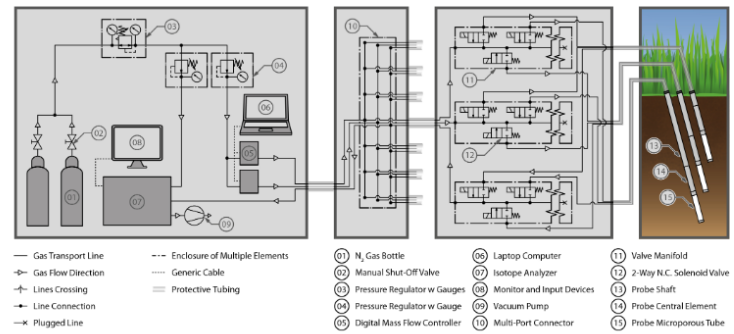
Outline

- Preliminary results of water balance simulations
- In-situ water isotope tracing experiment (Start April 2022)



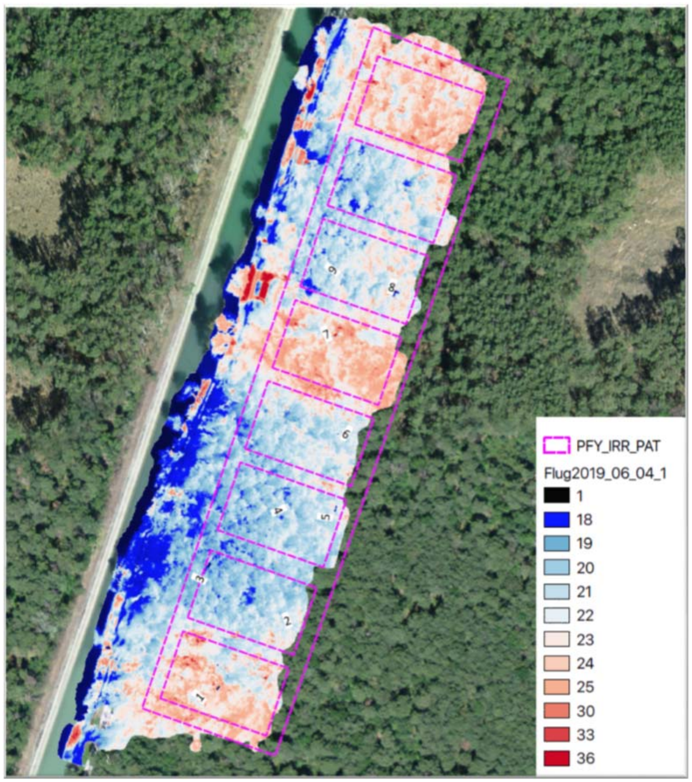
Volkmann & Weiler, 2014

- Msc thesis Roman Hediger: Seismics and electrical resistivity tomography (ERT) of soil profiles
- Msc thesis Isabelle Pfister: Non-destructive geophysical methods to monitor sap flow area

Start: 1.2.2022-31.7.22

Above- and belowground interactions & hotter droughts

Thermal image of a dry pine forest in the Pfynwald, Valais (Rudi Böschl, 2019)

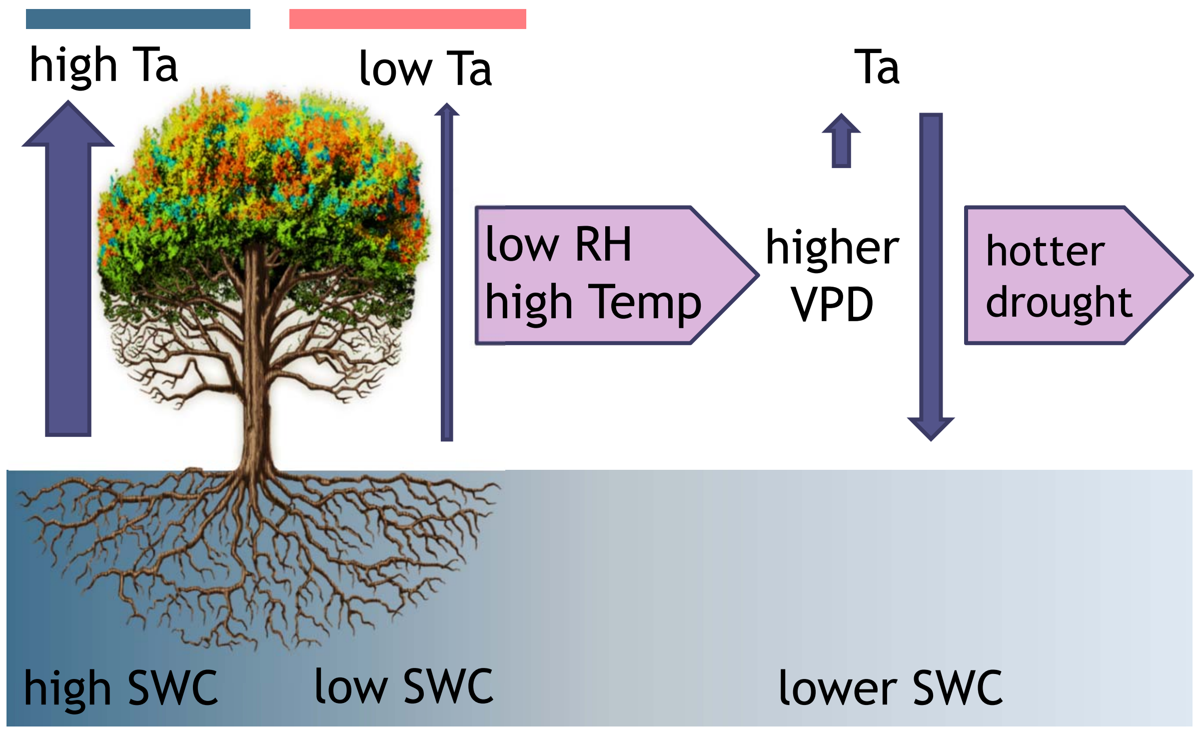


Δtemperatur ~10°C

$\Delta Q_{NetRadiation} = \Delta Q_{Latent} + \Delta Q_{Sensible}$

ΔQ_{Latent} = ET couples the water and energy cycles

(Teuling et al., 2010, 2013)



=>Soil-Vegetation-Atmosphere interactions

Soil-vegetation-atmosphere transport (SVAT) modelling

LWFBrook90R (Schmidt-Walter et al., 2020)

- Meteo forcing data (precipitation, temp, VPD, wind, radiation)
- Stand properties (LAI dynamic, tree height, age)
- Fitting parameters (e.g. Critical leaf water potential at which stomata's close) => calibration data: soil moisture, matric pot.

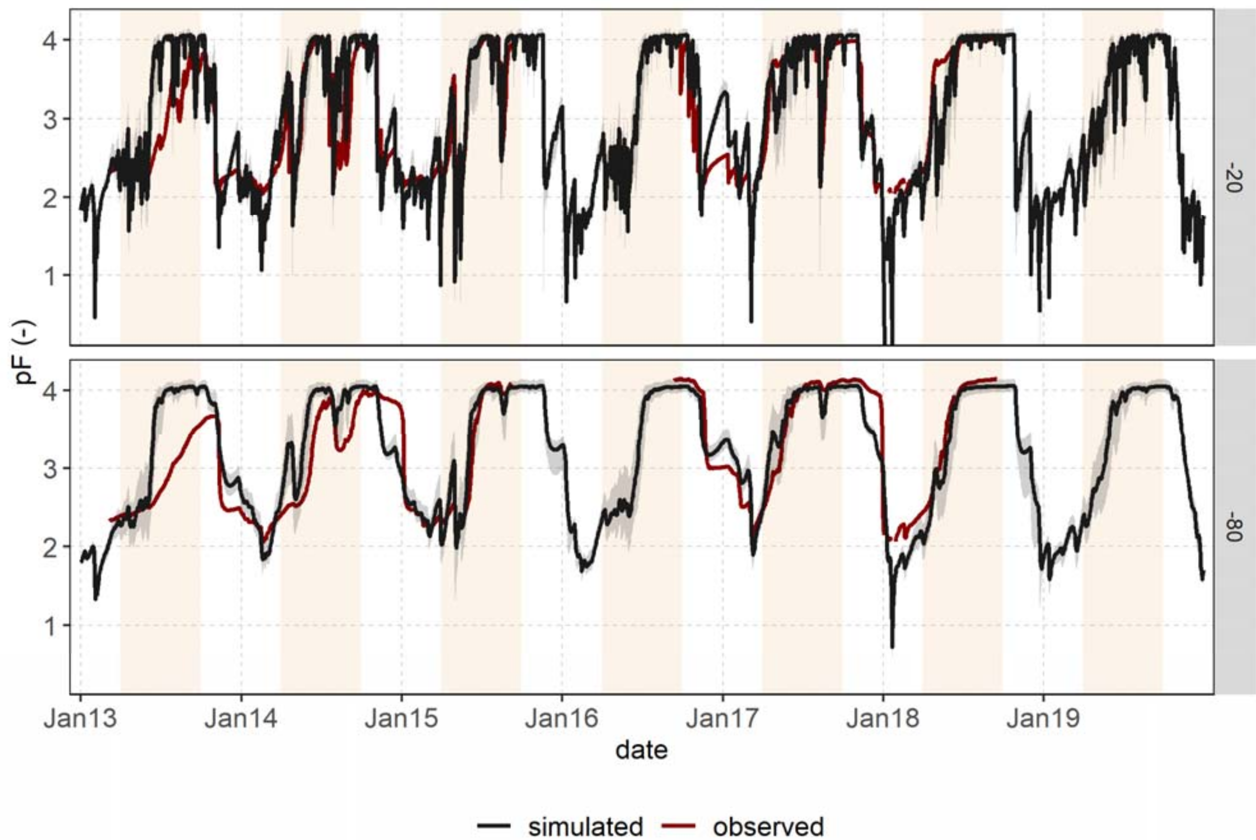
+ stable water isotopes

- Richards equation (soil hydraulic parameters)
- Root distribution (density distribution, depth)

LWFBrook90J: F. Bernhard

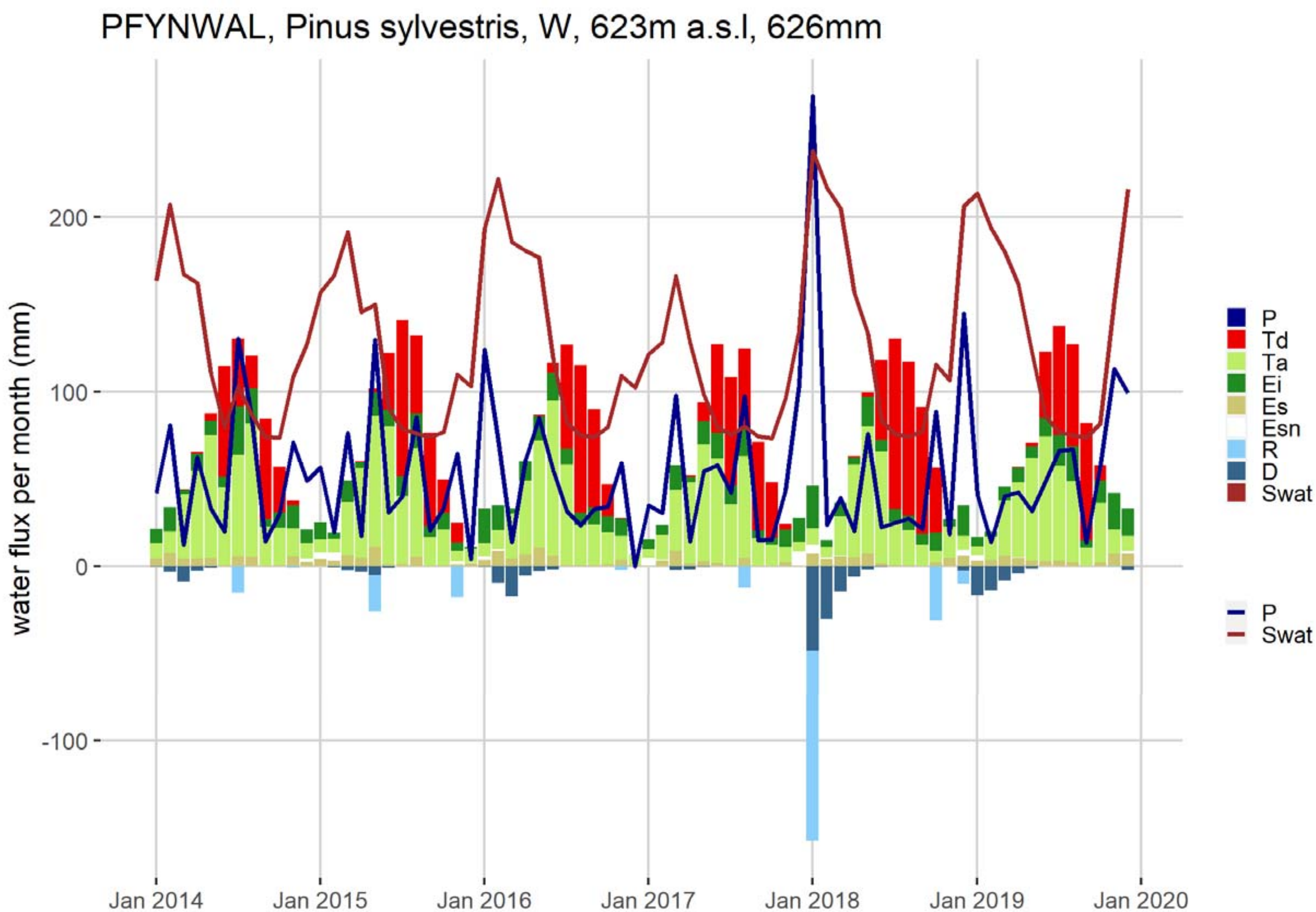
https://github.com/fabern/LWFBrook90.jl

Pfynwald control simulated



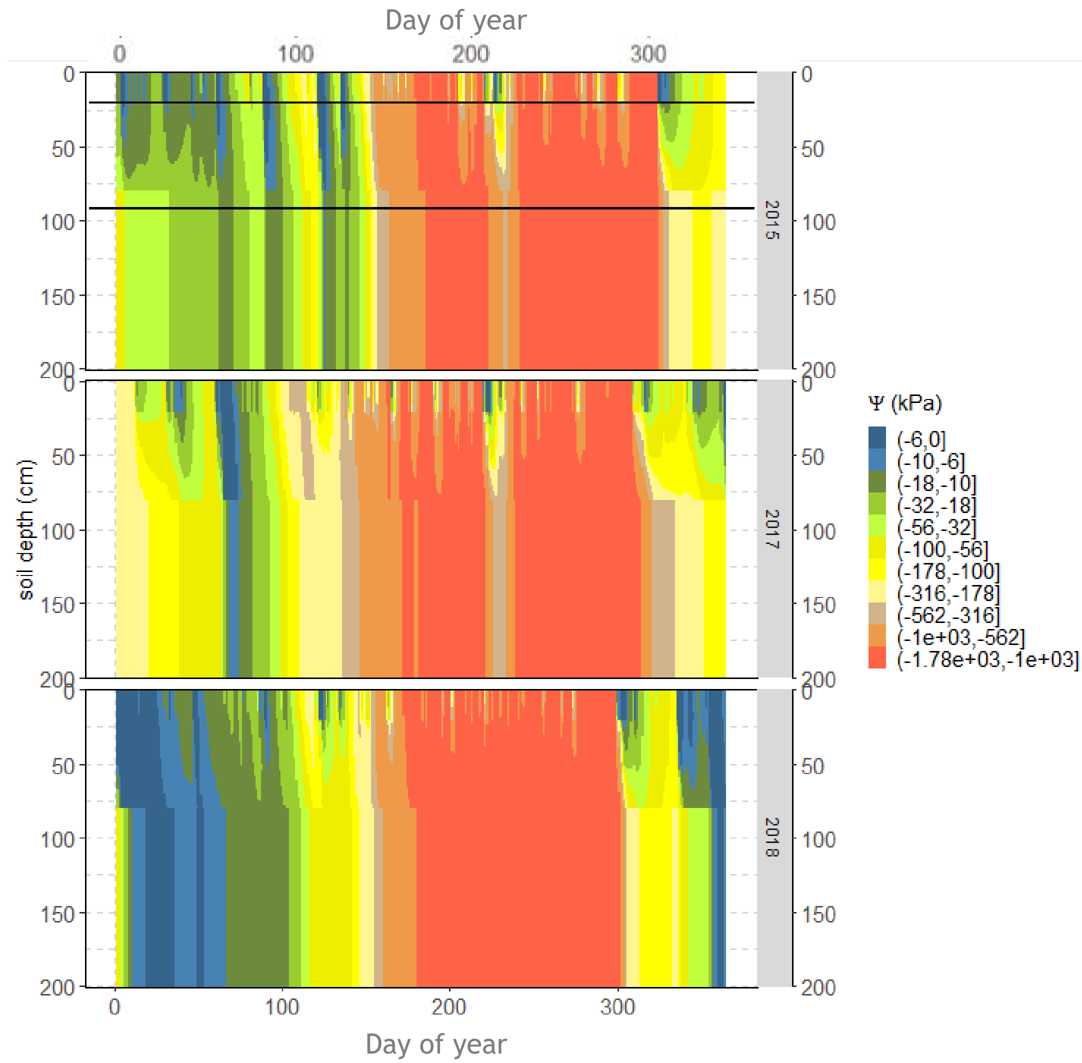
pF = is $-\log_{10} \psi_{soil}$, pF 4.2 corresponds to the permanent wilting point
, pF 1.8 to field capacity
, pF 0.0 to saturation

Pfynwald control simulated

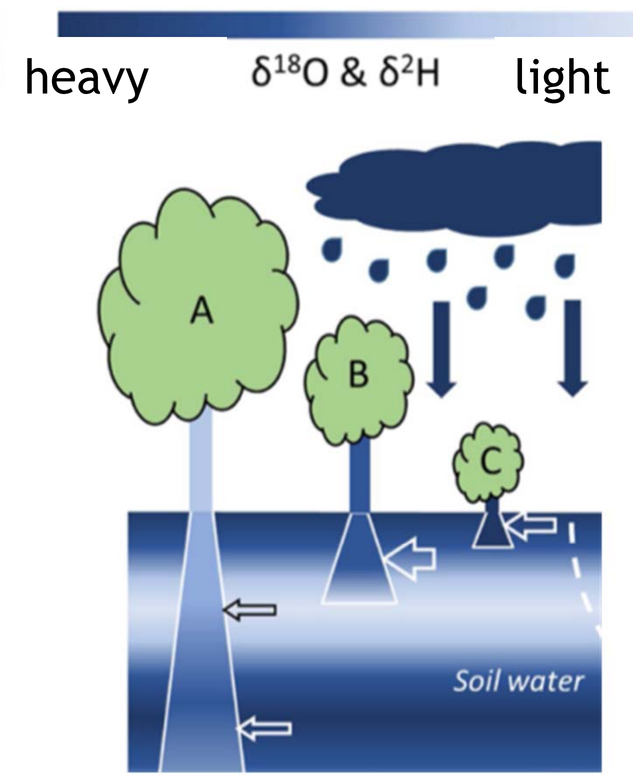


Let’s take a look belowground

- Each year critical soil matric potential occurs
- Up to half of root water uptake originates of deep soil (>80 cm)
- Not each year the wetting front reaches the deeper soil



In-situ water isotope tracing



Penna, Daniele, Josie Geris, Luisa Hopp, and Francesca Scandellari. 'Water Sources for Root Water Uptake: Using Stable Isotopes of Hydrogen and Oxygen as a Research Tool in Agricultural and Agroforestry Systems'. Agriculture, Ecosystems & Environment 291 (1 April 2020): 106790. https://doi.org/10.1016/j.agee.2019.106790.

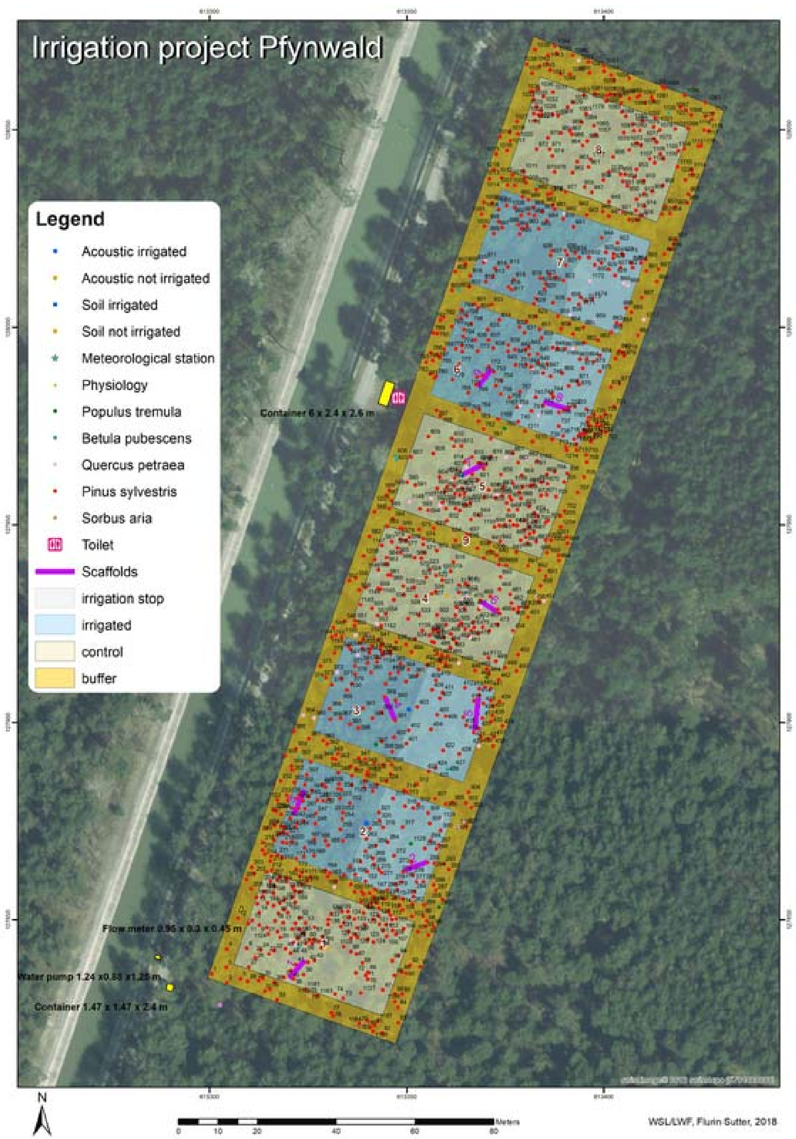
- How important is water uptake from deeper layers for control trees?
- Irrigation increased the rhizosphere area by 60% (Gao et al., 2021) Do irrigated trees still take up water from below?
- What about the irrigation stop trees?

=>Xylem water isotopes provide a fingerprint of the source soil water

Problem: no unique solution, relative contribution

AIM: Combination of isotope data with sap-flow and matric potential measurements ideally integrated to LWFBrook90J will offer best constrains on the quantification of water fluxes.

Setup: In-situ water isotope tracing



Focus on two plots: 5, 6

<u>Isotope probes</u>

- 5 trees per treatment
- 4 depth per treatment
- 3 atmospheric measurements per treatment
- 4 standards

<u>Sap flow</u>

- 5 trees per treatment
- 1 temperature sensor per treatment

<u>Matric potential</u>

- 4 depth per treatment (each with 2 types of sensors)

Destructive sampling (xylem, soil, phloemsugar)

+ gs, transpiration?

Dr Zhaoyong Hu

ETH zürich

Investigating soil water distribution during an irrigation experiment in Pfynwald: Implications on drought stress

Roman Hediger

ETH zürich

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Project Overview

Objectives:

- Detect ground or channel water
- Area and depth of root water uptake
- Heterogeneities in water availability

→ Find linkages to plant stress (PRI imagery collaboration with P. D'Odorico)

Experiments:

- Subsurface water content imaged with geophysical techniques: Seismic and ERT.
- Time-lapse method

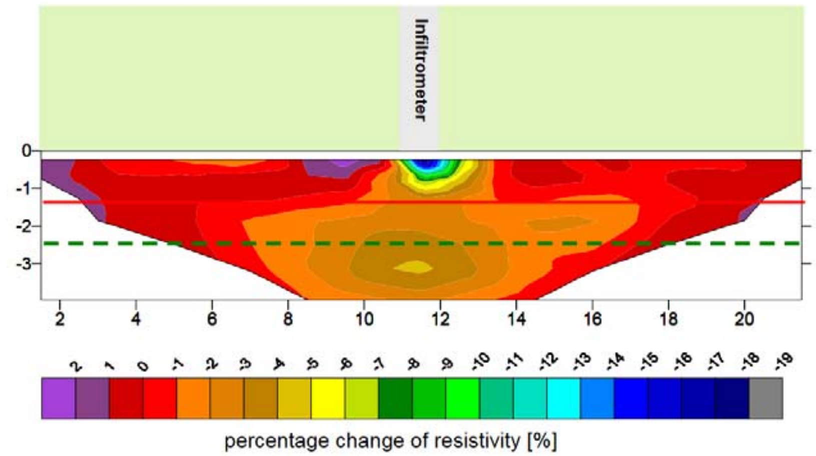

Figure 5-15: ERT Transect D (Time-lapse model of perceptual resistivity change calculated with the simultaneous inversion method).

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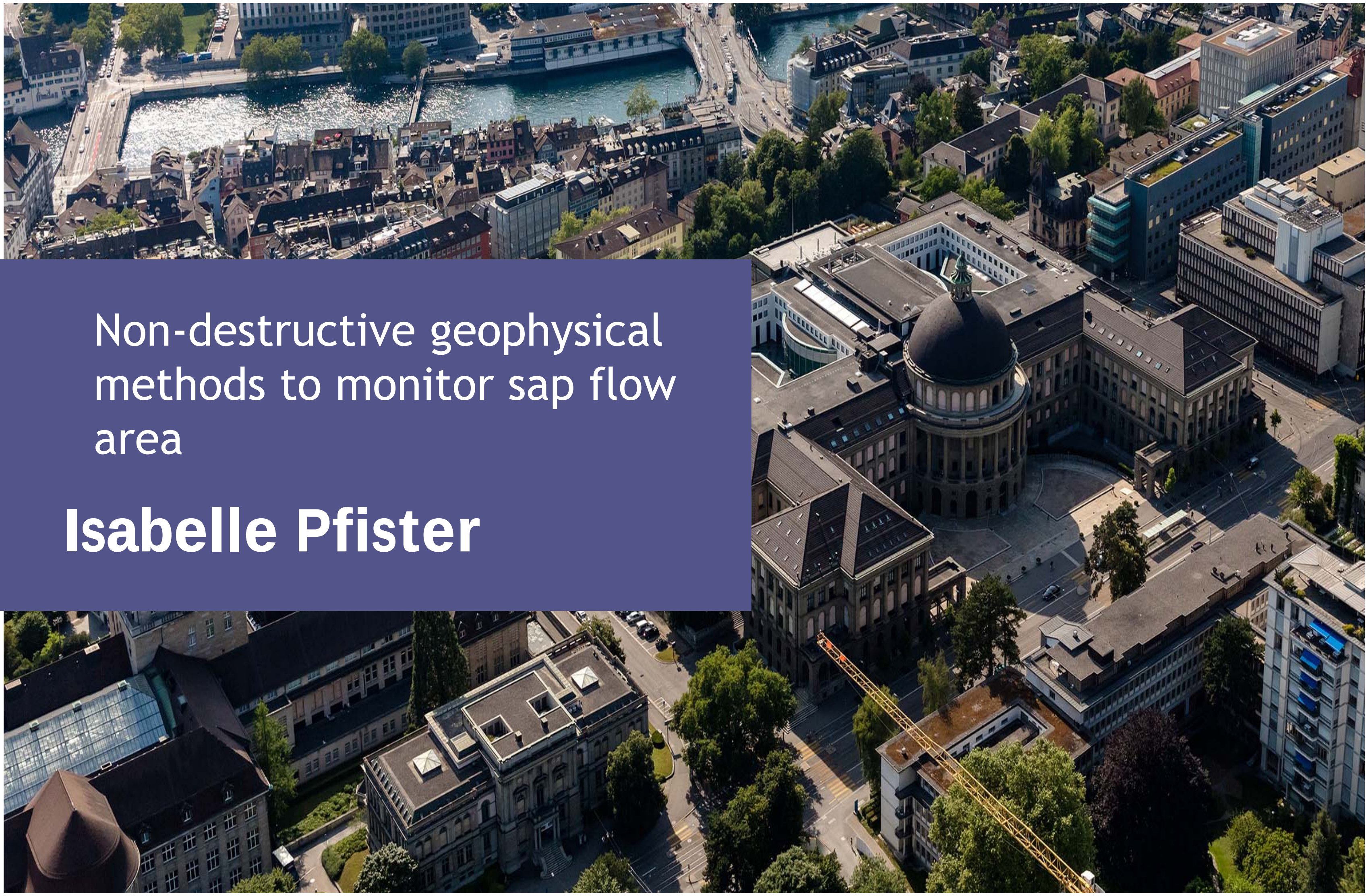


Non-destructive geophysical methods to monitor sap flow area

Isabelle Pfister

Objective

- Background: “transpiring area needs to be supported by a proportional amount of sapwood” (Zweifel et al., 2020)
- Aim: Investigation of **sapwood resistivity** by the application of **Ground Penetrating Radar (GPR)** and **electrical resistivity (ER)**

Hypotheses:

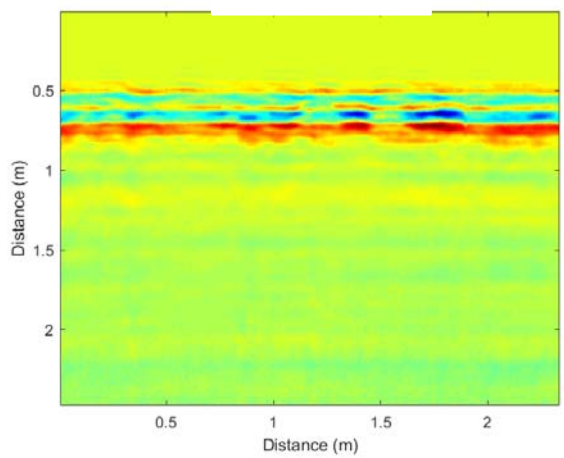
- Irrigated and stop irrigated trees show a larger sapwood area as compared to the control plots.
- Sapwood resistivity increases with decreasing water content, increasing soil resistivity for all treatments.
- Hardwood resistivity does not change with climatic nor treatment conditions.
- The application of the GPR constraint on the resistivity inversion at the hardwood-sapwood boundary increases the sensitivity of the modeling approach.

- First field campaign: 17.03 – 19.03.22

GPR on Scots pines

- 1000 MHZ antenna on 4 irrigated and 4 control plot Scots pines
- Data processing by Matlab:
    - High- and lowpass filters
    - Time gain
    - Conversion to polar coordinates

→



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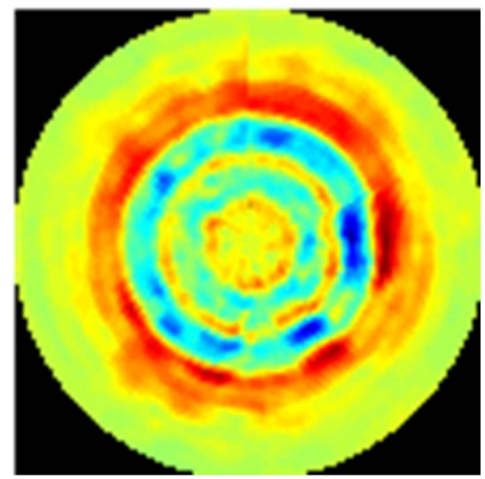
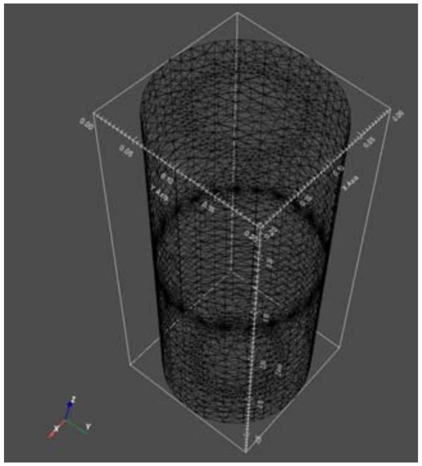
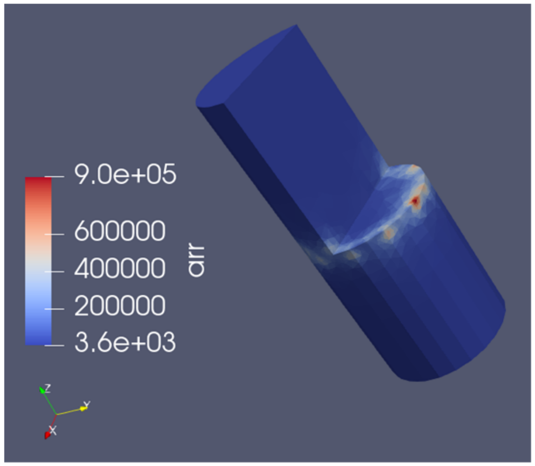


ER on Scots pines

- 12-24 electrodes on 4 irrigated and 4 control plot Scots pines
- Data processing by pyGIMLi:
  - Application of constraints (e.g. sharp hardwood-sapwood boundary)
  - Inverting the data



In progress:



Thanks for your attention!

Questions, ideas, suggestions…