

Plant Hydraulic Adjustments to Varying VPD & Soil Moisture

– Model Predictions & Measurement Contributions

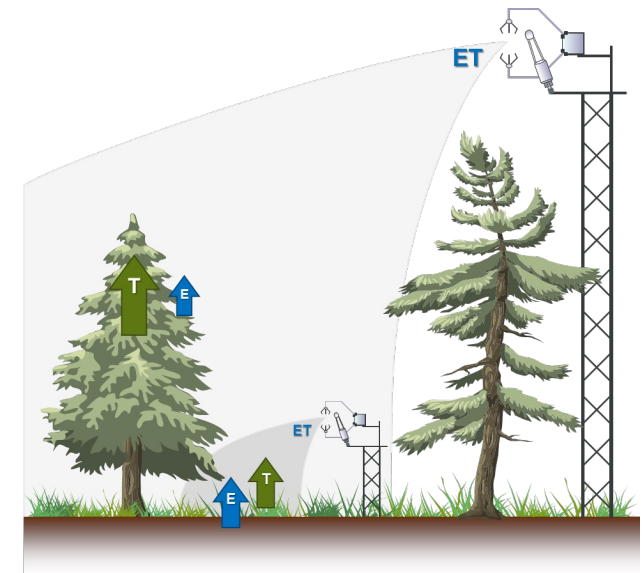
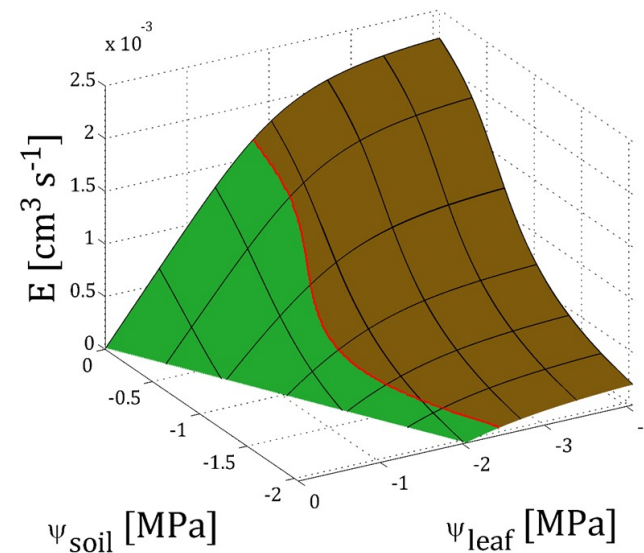
Andrea Carminati, Sebastian Wolf & PoSE Team

ETH Zürich

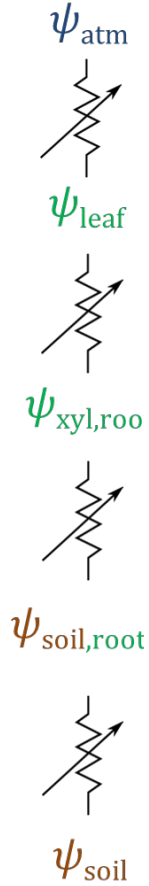
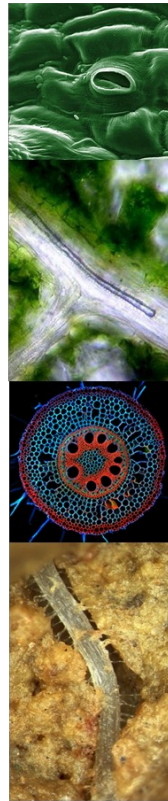
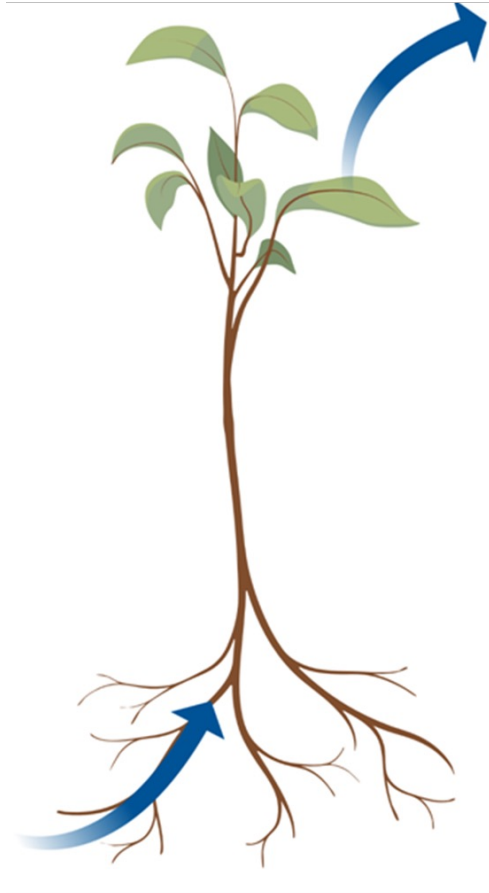
Institute of Terrestrial Ecosystems (ITES)

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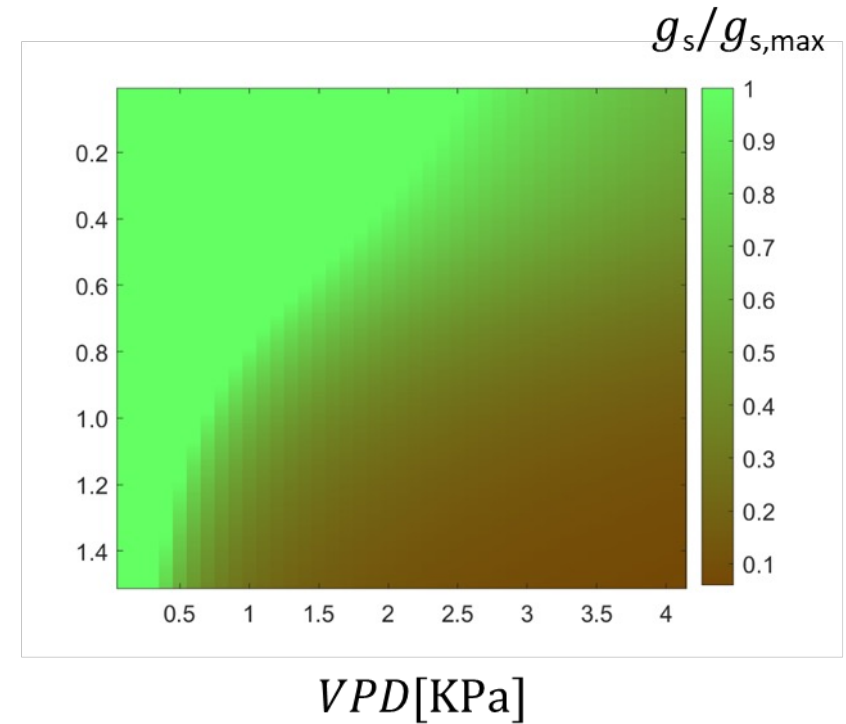
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Plant Hydraulics and VPD



$-\psi_{soil}$ [MPa]



Soil drying and rising VPD

Environmental drivers

The relative importance of high water demand and soil dryness is controversial.

Soil-Plant Hydraulics

It is not clear what are the controlling hydraulic variables

nature
climate change

LETTERS

PUBLISHED ONLINE: 5 SEPTEMBER 2016 | DOI: 10.1038/NCLIMATE3114

The increasing importance of atmospheric demand for ecosystem water and carbon fluxes

Kimberly A. Novick^{1*}, Darren L. Ficklin², Paul C. Stoy³, Christopher A. Williams⁴, Gil Bohrer⁵, A. Christopher Oishi⁶, Shirley A. Papuga⁷, Peter D. Blanken⁸, Asko Noormets⁹, Benjamin N. Sulman¹⁰, Russell L. Scott¹¹, Lixin Wang¹² and Richard P. Phillips¹³

Questions

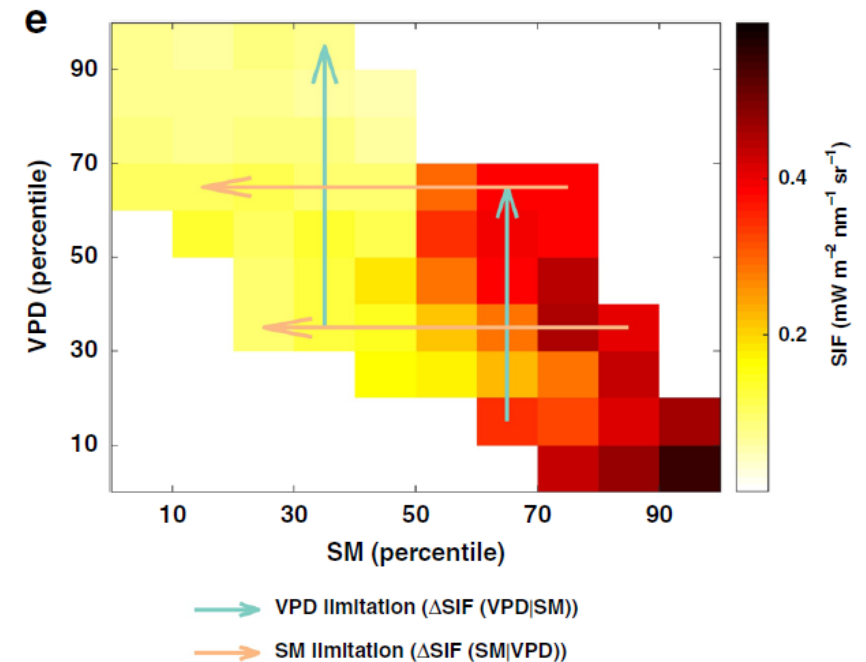
ARTICLE

<https://doi.org/10.1038/s41467-020-18631-1>

OPEN

Soil moisture dominates dryness stress on ecosystem production globally

Laibao Liu^{1,2}, Lukas Gudmundsson¹, Mathias Hauser¹, Dahe Qin², Shuangcheng Li², Sonia I. Seneviratne¹

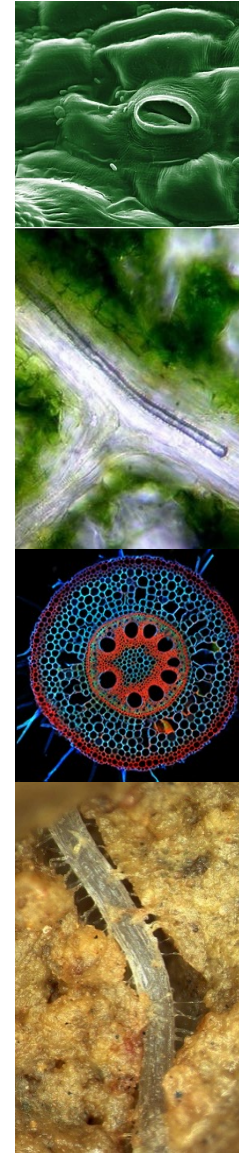
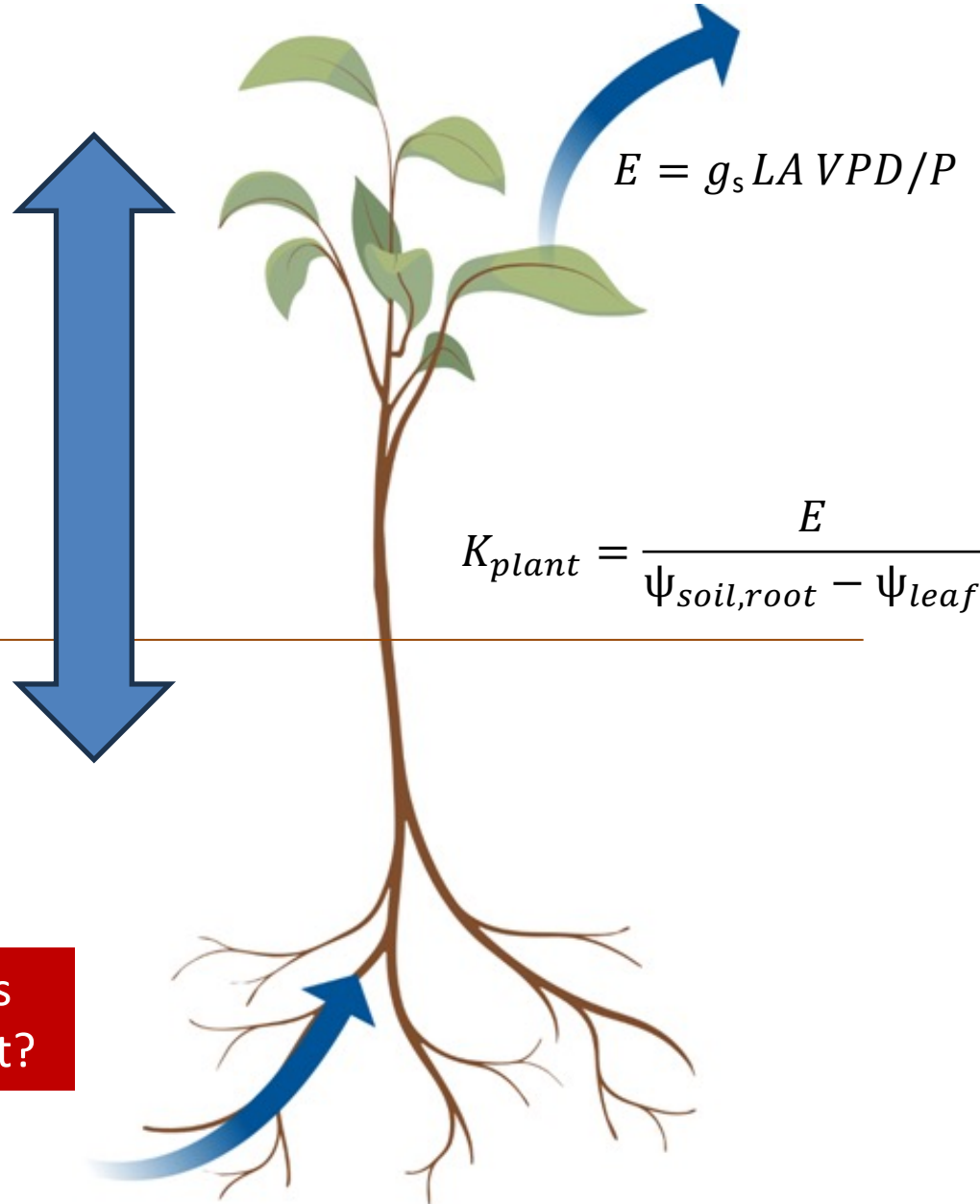


SIF: Daily solar-induced chlorophyll fluorescence

Effect of plant traits on plant water use

Transpiration is limited by VPD when plant hydraulics is limiting (when most of dissipation in water potential occurs in the plant).
 Relevant properties: leaf conductivity, root conductivity, xylem vulnerability.

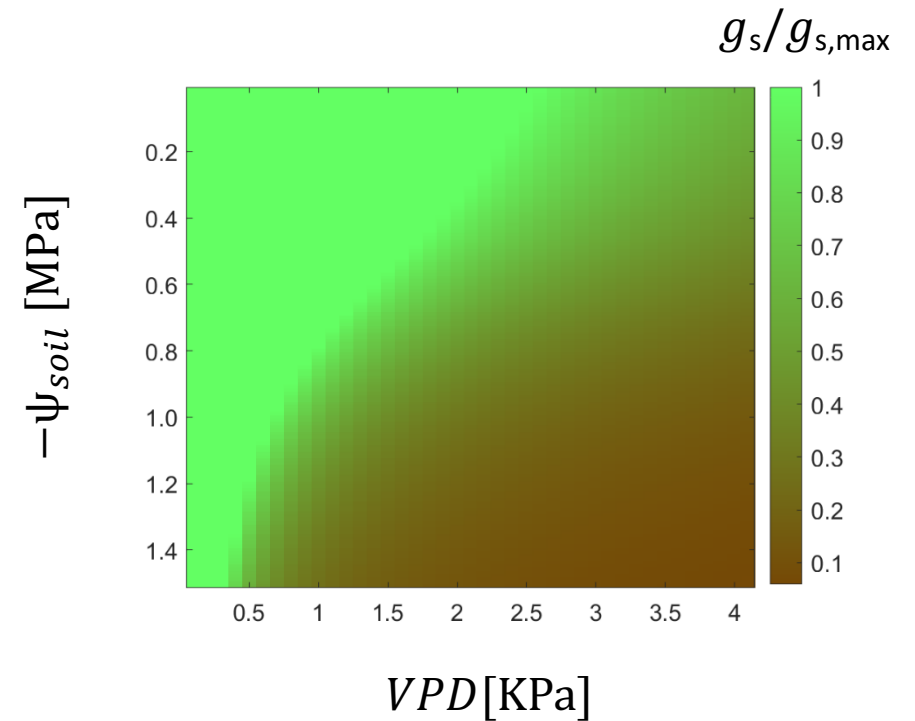
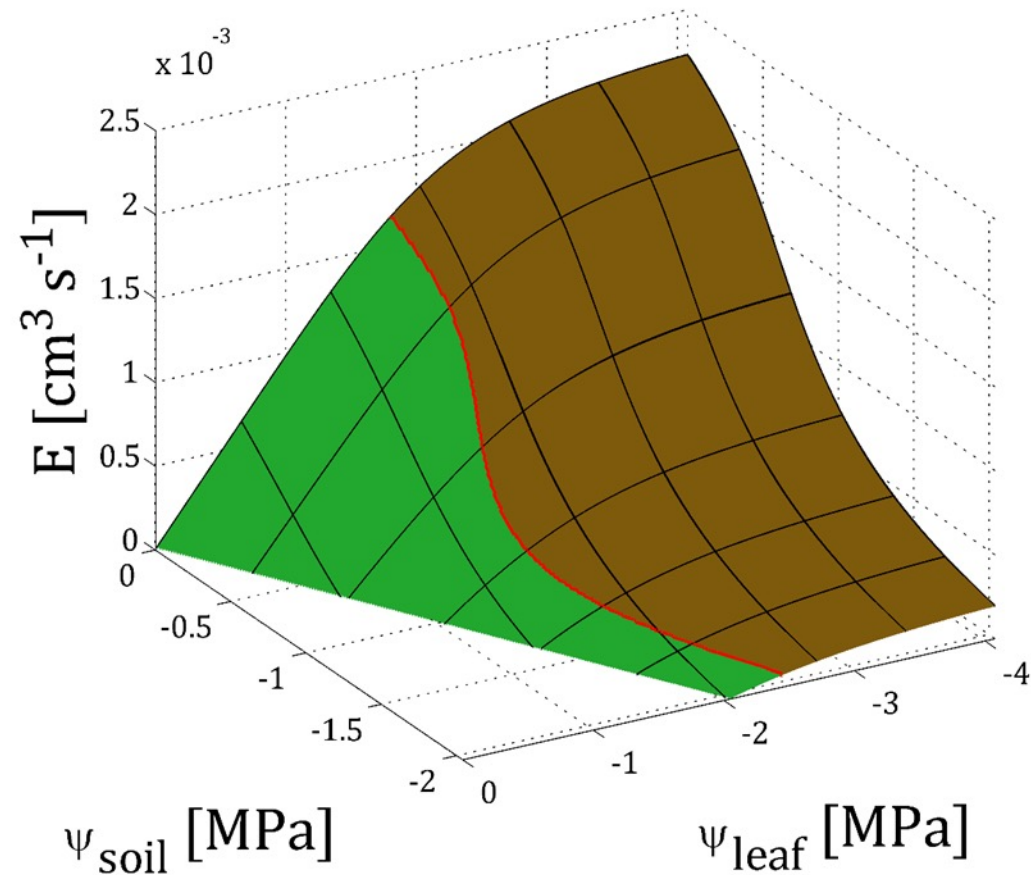
Assuming that the soil is wet. Until when is it wet?



- ψ_{atm} **Stomatal conductance:**
 Regulates transpiration, depends on ABA, ψ_{leaf}
- ψ_{leaf} **Xylem conductance:**
 number and radius vessels, cavitation
- $\psi_{xyl,root}$ **Root conductance:**
 root architecture, anatomy, hydropatterning, AQP
- $\psi_{soil,root}$ **Rhizosphere conductance:** soil, root hairs, mucilage, mycorrhiza, root architecture
- ψ_{soil}

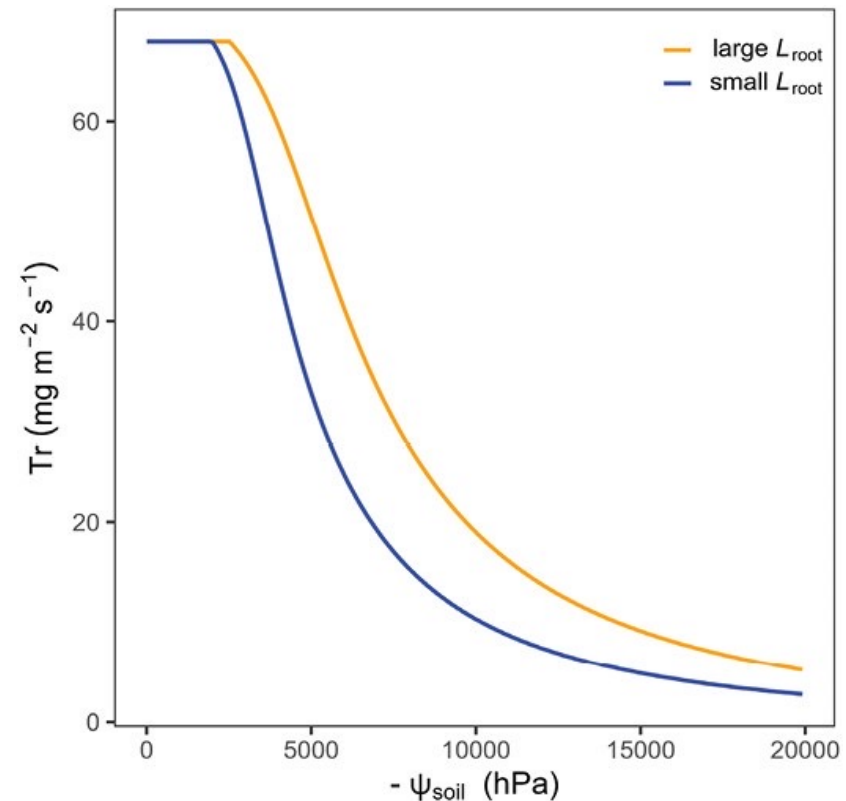
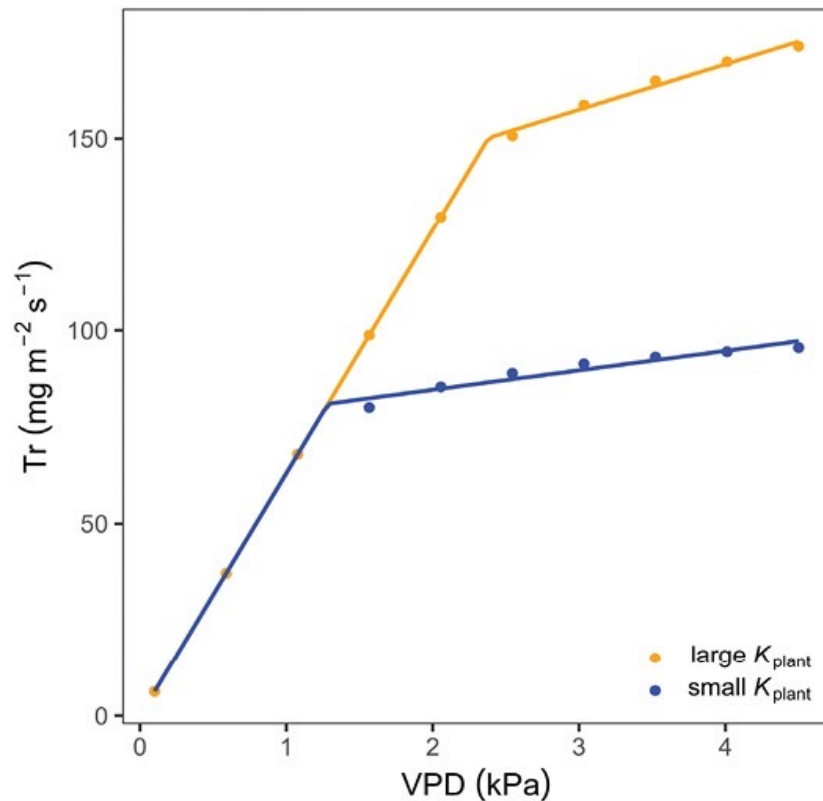
Soil-Plant hydraulics and transpiration regulation

Hypothesis: stomata close when the conductivity of the limiting element starts to decrease (Carminati and Javaux 2020).



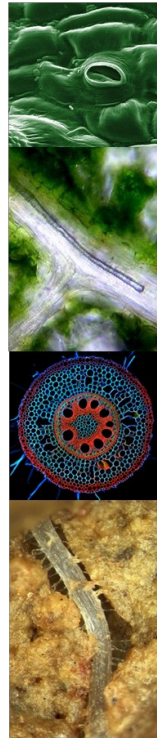
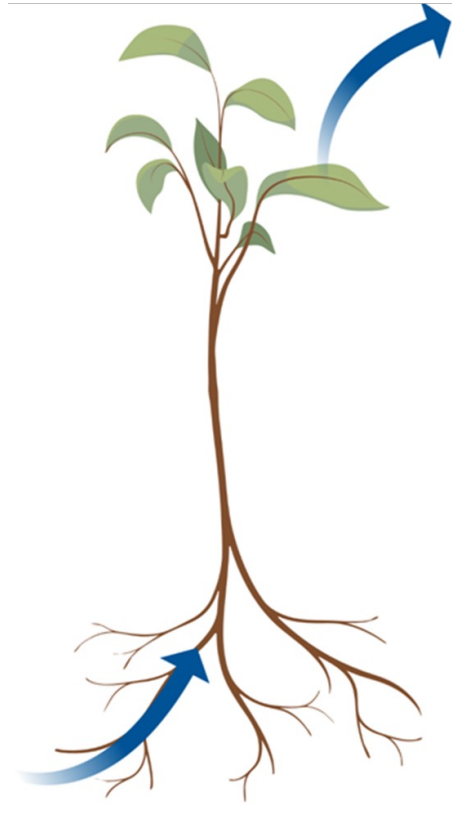
Soil-Plant hydraulics and transpiration regulation

$$K_{plant} \propto L_{root} ???$$



Transpiration response to soil drying versus increasing vapor pressure deficit in crops: physical and physiological mechanisms and key plant traits

What controls K_{plant} ?



ψ_{atm}



Stomatal conductance:
Regulates transpiration, depends on ABA, ψ_{leaf}

ψ_{leaf}



Xylem conductance:
number and radius vessels, cavitation

$\psi_{\text{xyl,root}}$



Root conductance:
root architecture, anatomy, hydropatterning, AQP

$\psi_{\text{soil,root}}$



Rhizosphere conductance: soil, root hairs, mucilage, mycorrhiza, root architecture

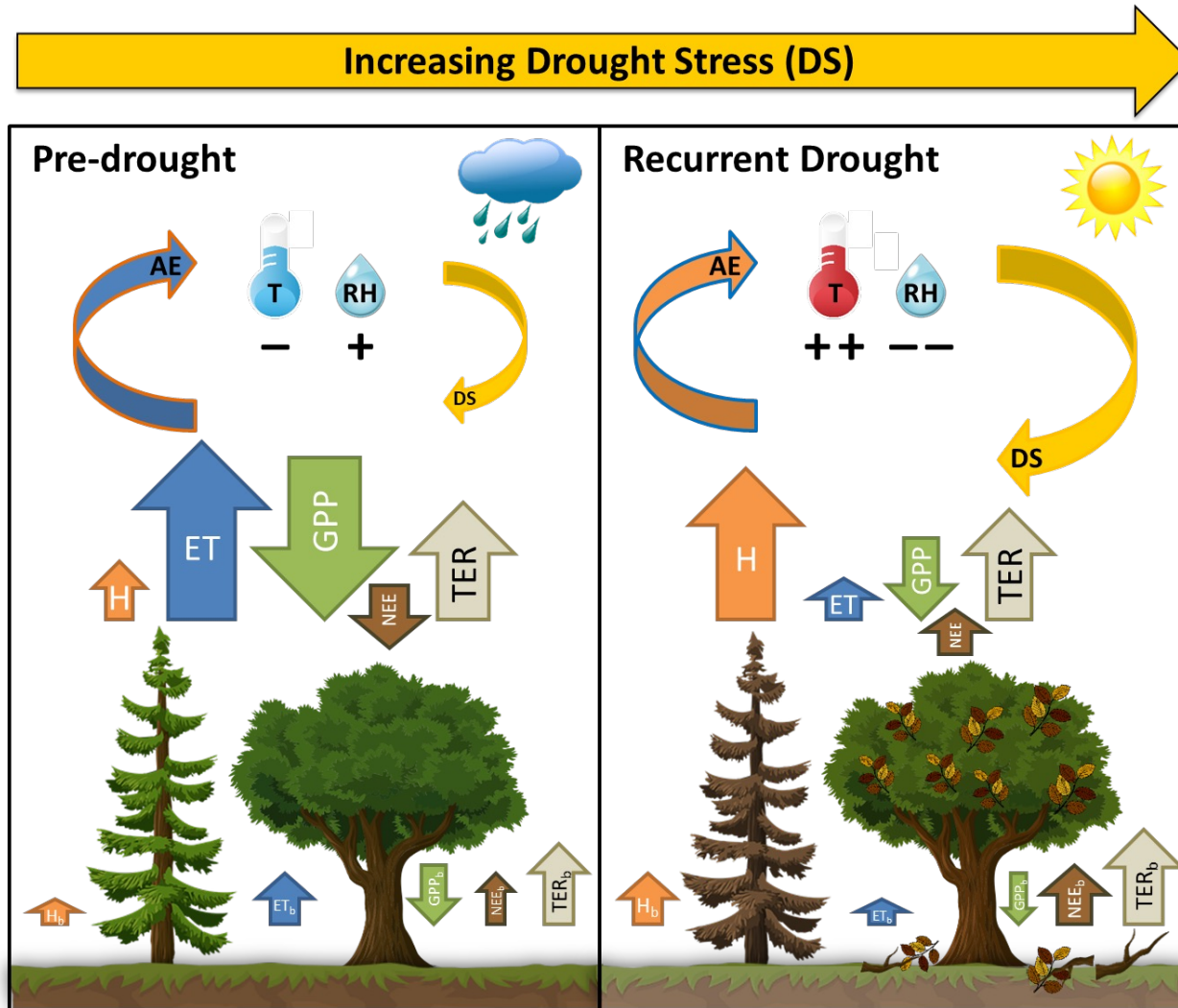
ψ_{soil}

VPD response can be predicted based on plant hydraulics. Stomata close when the water demand is not matched by the water supply (which depends on K_{plant})

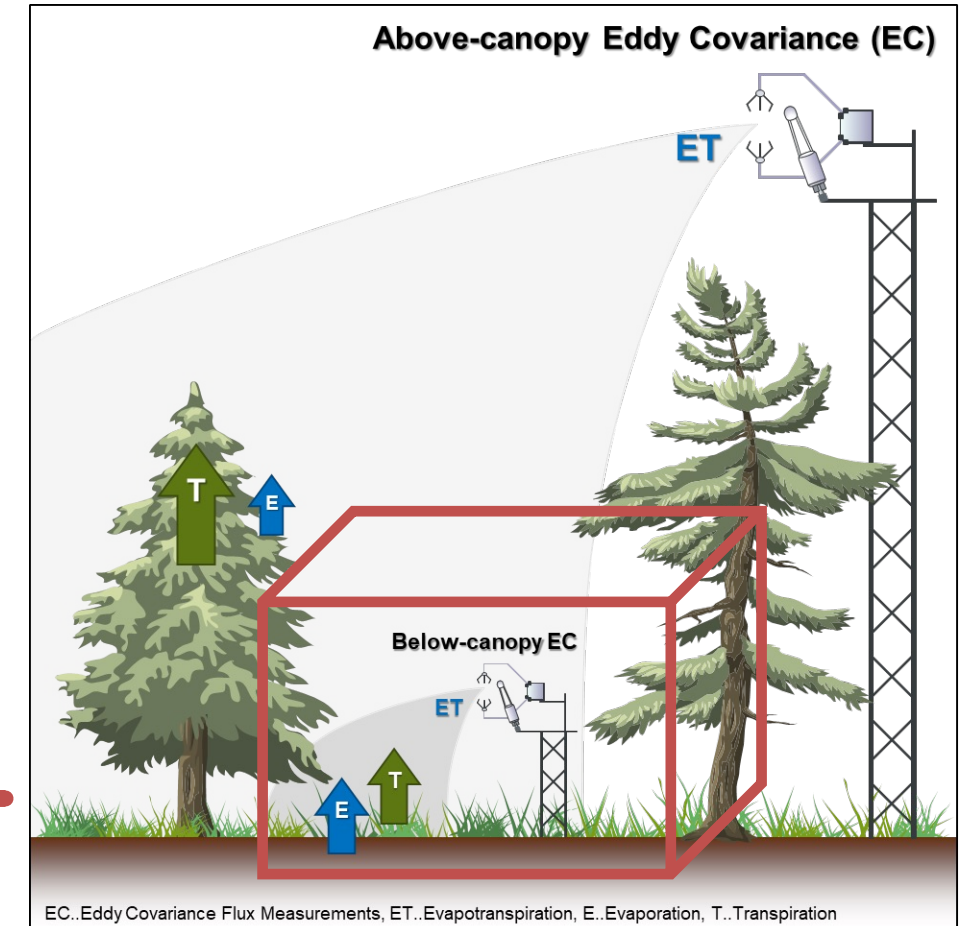
If the main resistance is in the root system, this can be very plastic and respond to soil water conditions.

Then, VPD response might depend also on soil conditions

Measurements we could contribute to Pfywald

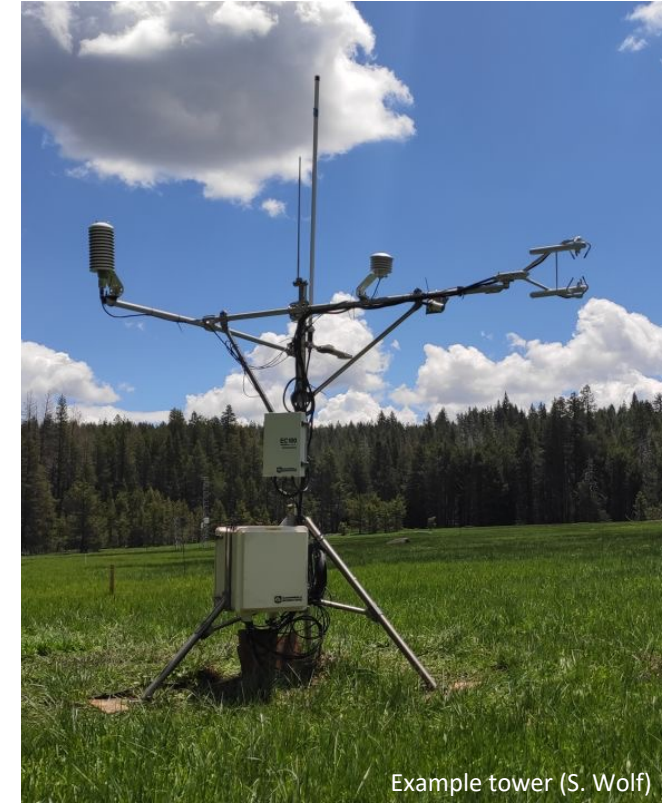
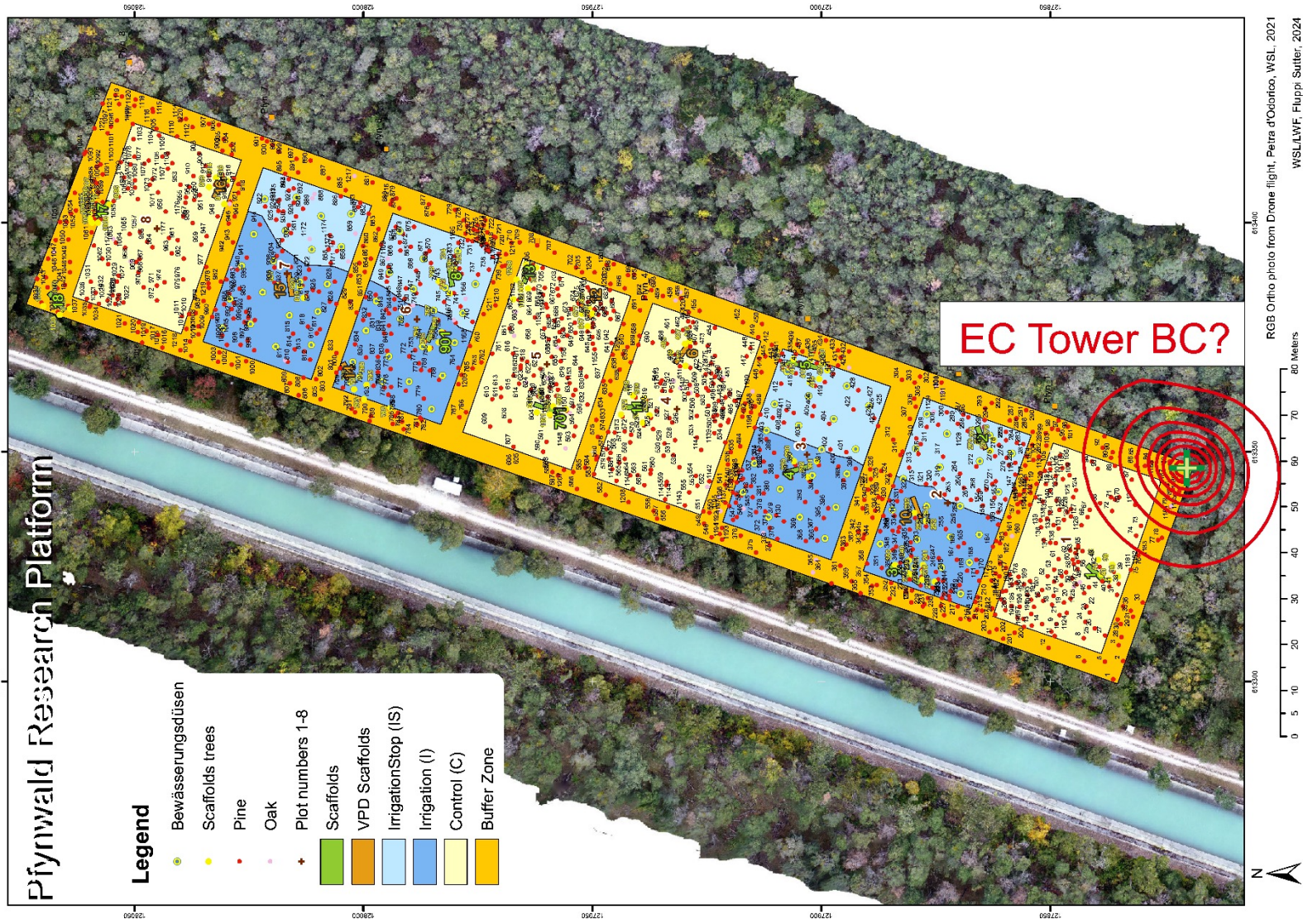


AE..Available Energy, T..Temperature, RH..Relative Humidity, DS..Drought Stress, H..Sensible Heat Flux, ET..Evapotranspiration (Latent Heat Flux), GPP..Gross Primary Production, TER..Total Ecosystem Respiration, NEE..Net Ecosystem Exchange, b..below canopy (understory)



EC..Eddy Covariance Flux Measurements, ET..Evapotranspiration, E..Evaporation, T..Transpiration

Below-canopy EC Flux measurements @Pfywald?



Questions & Discussion

Acknowledgement: PoSE Team (www.pose.ethz.ch)

