# Evaluating CLM5.0 response across an environmental gradient in Europe

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**KEYWORDS**

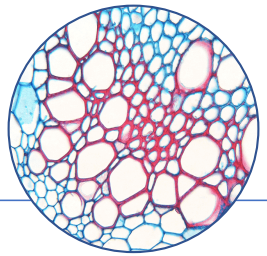
atmospheric climate CLM drought Europe evaluation hydraulic land LSMs LST model moisture observations parameters PFT plant potential predictions regional remote root seasonal sensitivity simulations soil STIC stomatal stress temperature traits transpiration uncertainty vegetation water

**OVERARCHING OBJECTIVE**

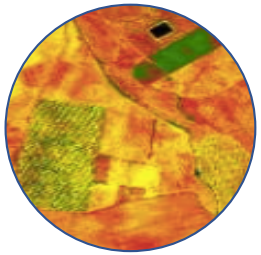
***Investigate the influence of plant hydraulic trait (co-) variability on simulated E and $E_T$ responses across different ecosystems and environmental gradients in Europe***

**METHODS**

**Numerical Simulations**



**Plant Functional Traits**



**Thermal Remote Sensing**

# Selected sites

| SITE | | Time Period | PFT | Species | MAP (mm $yr^{-1}$) | MAT (°C) | $VPD_{max}$ (kPa) |
|---|---|---|---|---|---|---|---|
| FI-Hyy (Finland) |  | 2006-2009 | ENF | *Pinus sylvestris*<br>*Betula pubescens*<br>*Alnus incana*<br>*Populus tremula* | 493 | 4.8 | 2.8 |
| FR-Pue (France) |  | 2001-2014 | EBF | *Quercus ilex* | 914 | 13.8 | 6.0 |
| IT-Pt1 (Italy) |  | 2003 | DBF | *Populus nigra*<br>*Populus tremuloides*<br>*Salix alba*<br>*Alnus glutinosa*<br>*Populus alba* | 533 | 14.3 | 4.6 |
| IT-Ro1 (Italy) |  | 2003-2006 | DBF | *Quercus cerris*<br>*Quercus petraea*<br>*Quercus suber*<br>*Quercus pubescens*<br>*Quercus ilex* | 827 | 14.9 | 5.4 |
| ES-Es1 (Spain) |  | 2003 | ENF | *Pinus halepensis* | 383 | 17.5 | 4.6 |
| NL-Loo (Netherlands) |  | 2002-2014 | ENF | *Pinus sylvestris*<br>*Pinus nigra* | 754 | 10.0 | 4.3 |

## Methods

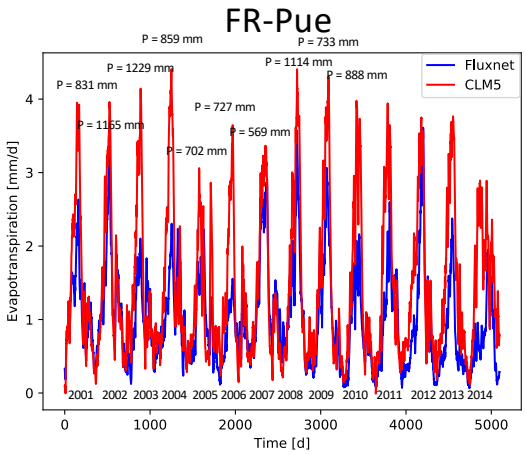
Setup:

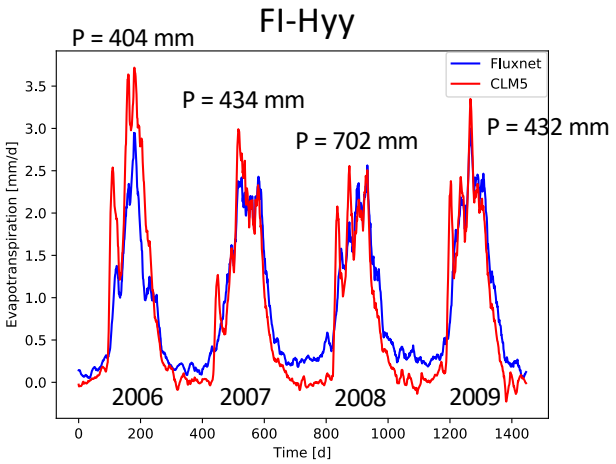
- Point-scale simulations using global-scale land surface characteristics --> CLM5.0 tools
- Meteorological forcing extracted from FLUXNET --> FluxnetLSM tool (Ukkola et al., 2017)
- LAI values updated --> Global Land Surface Satellite (GLASS) at 0.01°

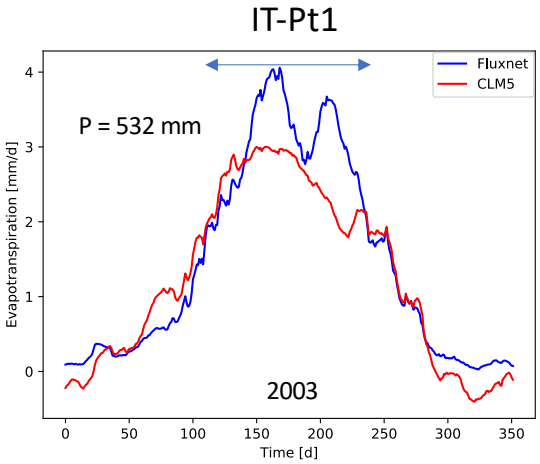
Measurements:

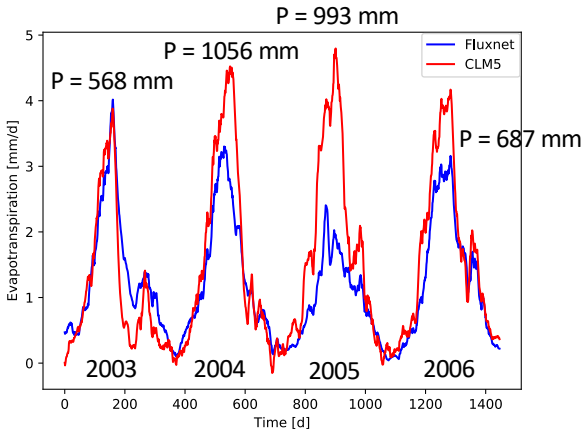
- LH / SH/ GPP --> FLUXNET2015
- T (Puechabon and Hyytiälä) --> SapFLUXNET

# ET variability across the FLUXNET sites

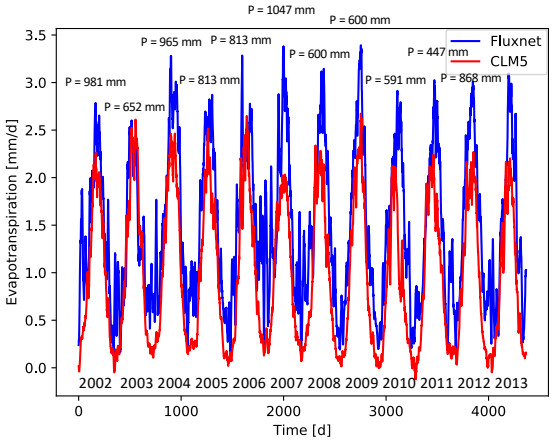


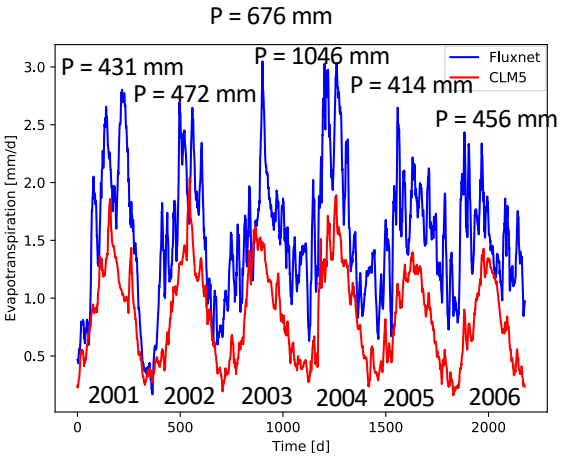




IT-Ro1

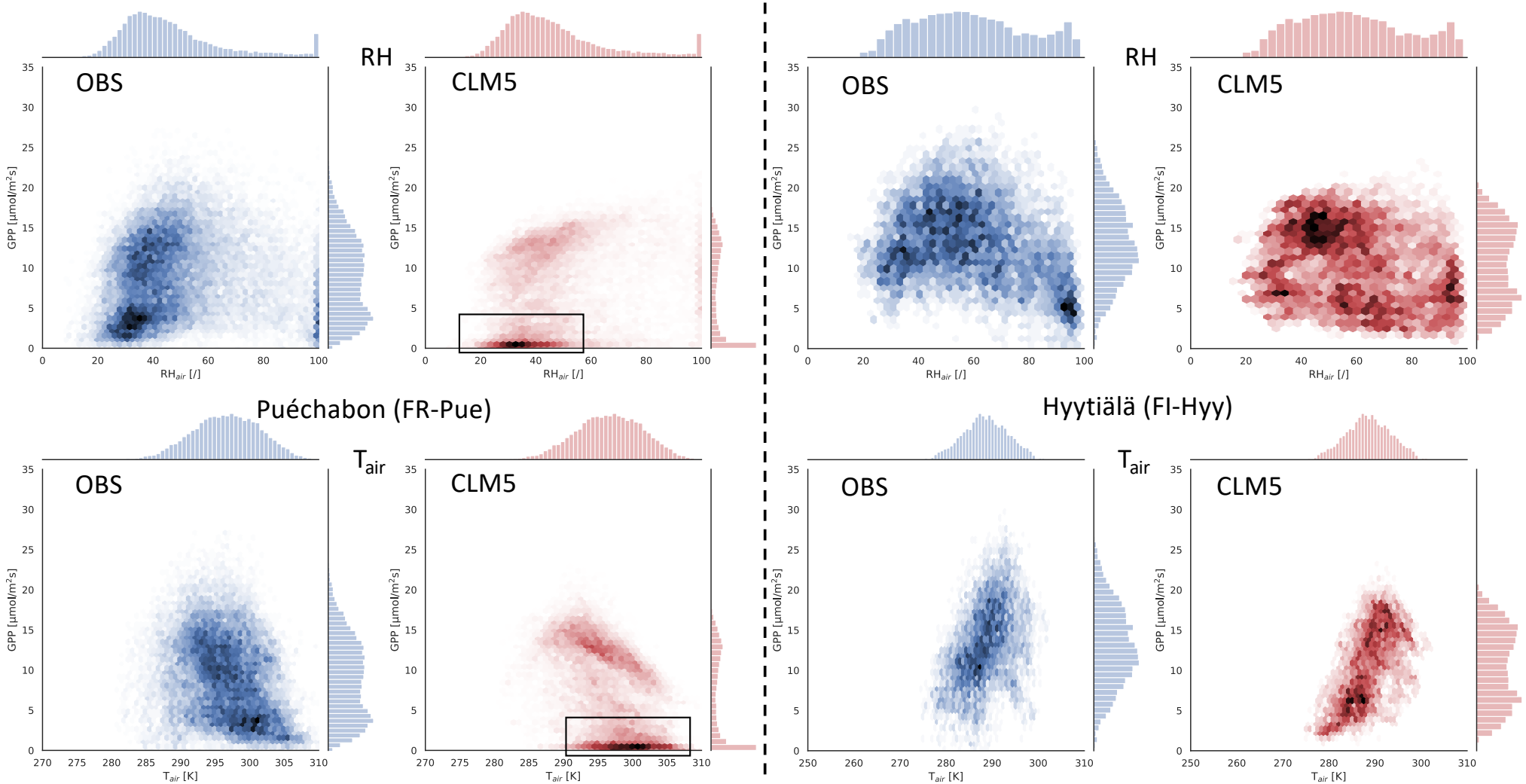



NL-Loo



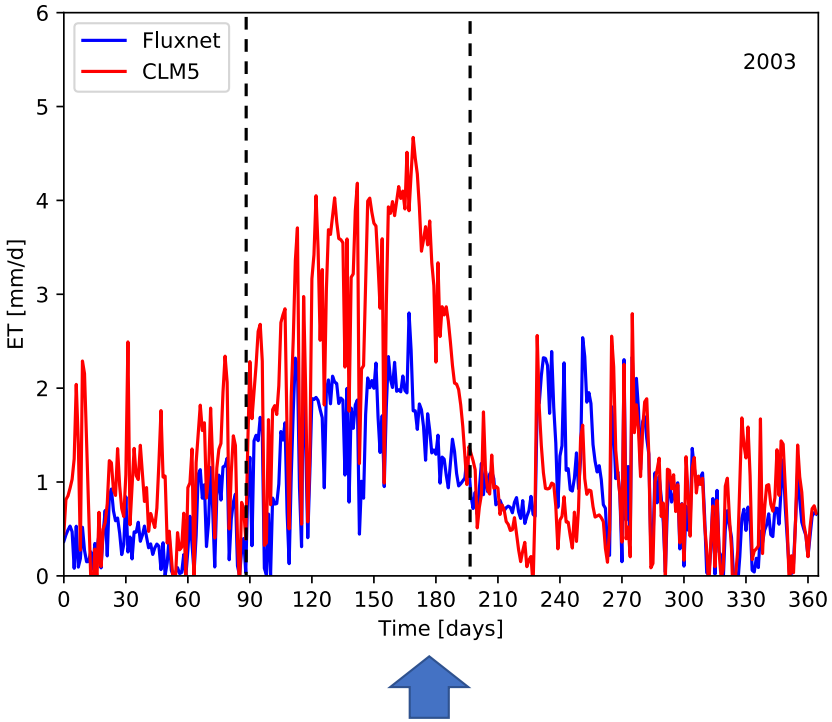

ES-Es1

# Humidity and Temperature Control on Photosynthesis

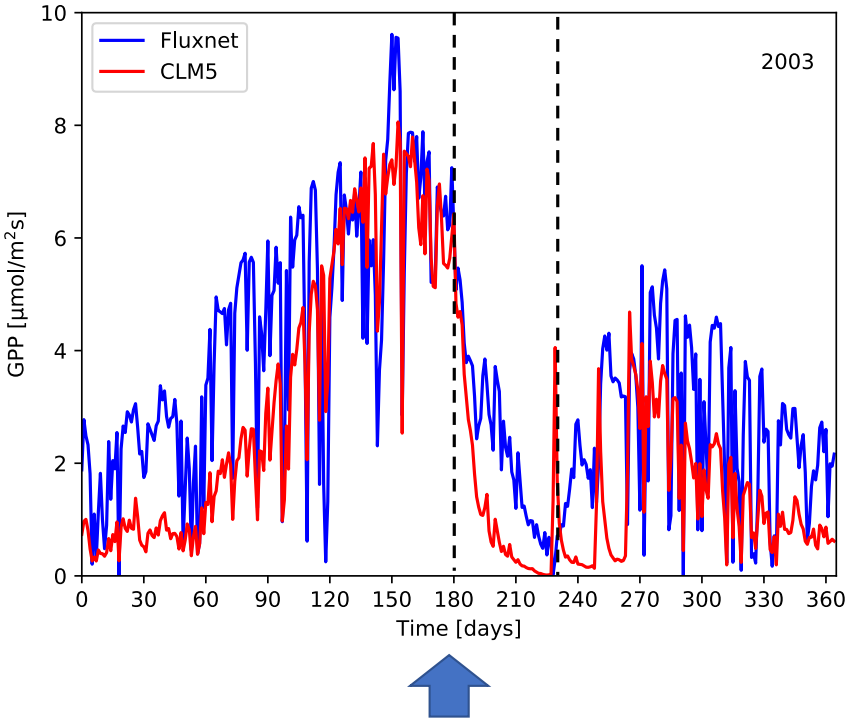


# Annual cycle of ET and GPP

Puéchabon (FR-Pue)



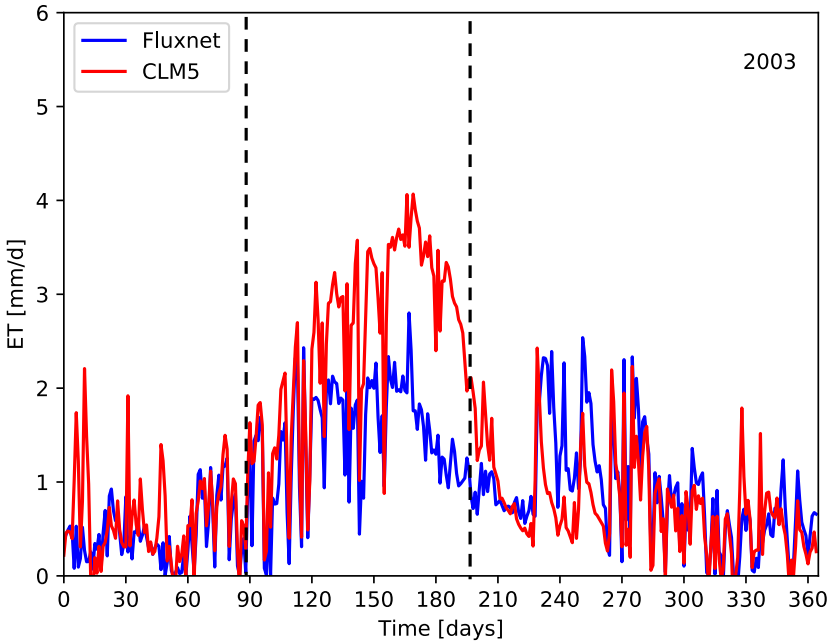

Large ET overestimation during the first part of the year

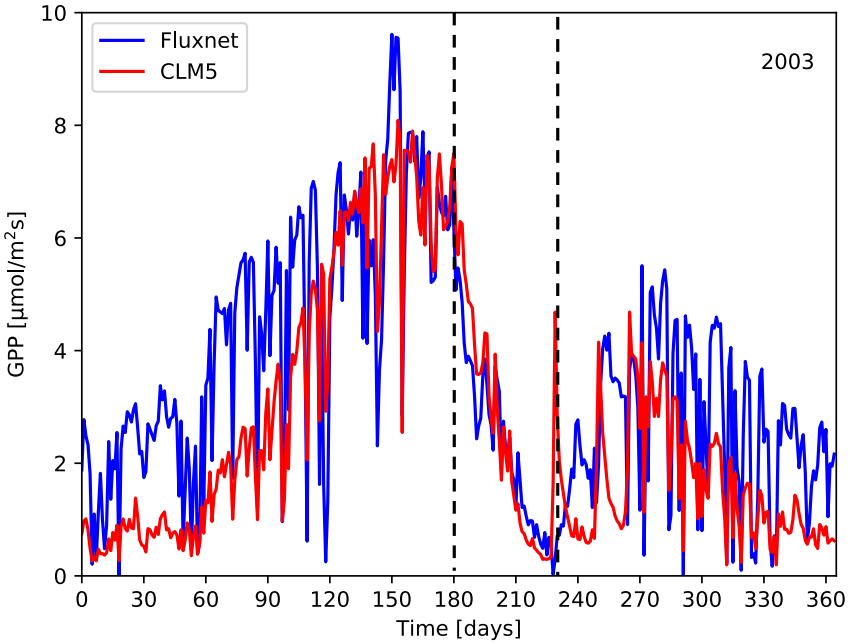



Sharp GPP decline during summer

# Annual cycle of ET and GPP + Soil Resistance

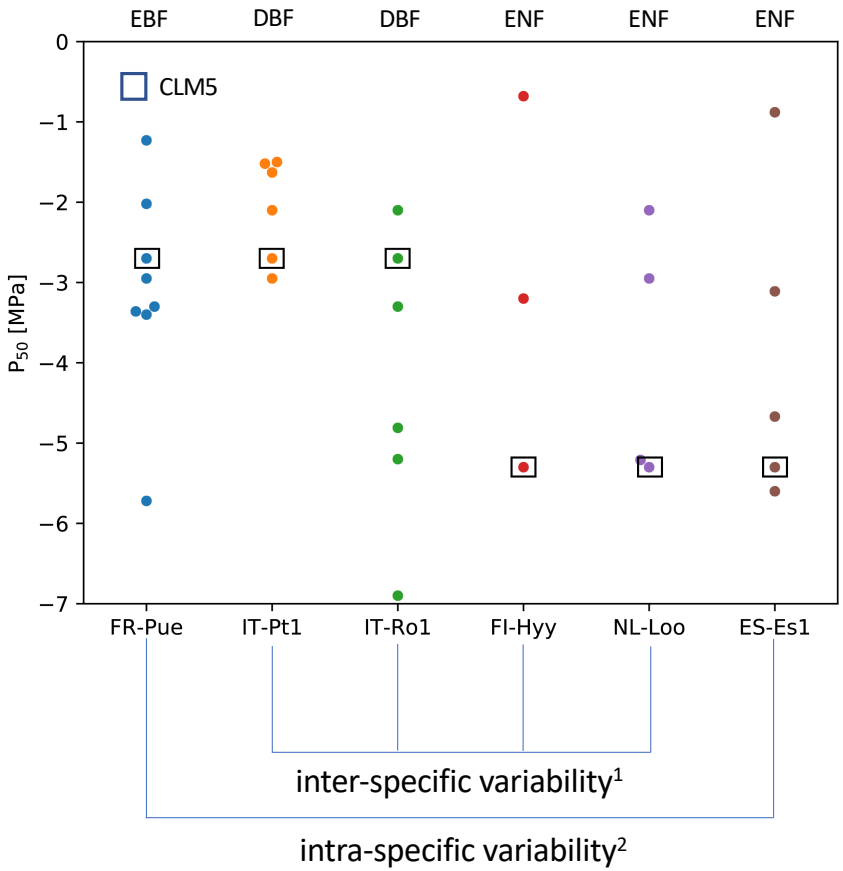
Puéchabon (FR-Pue)

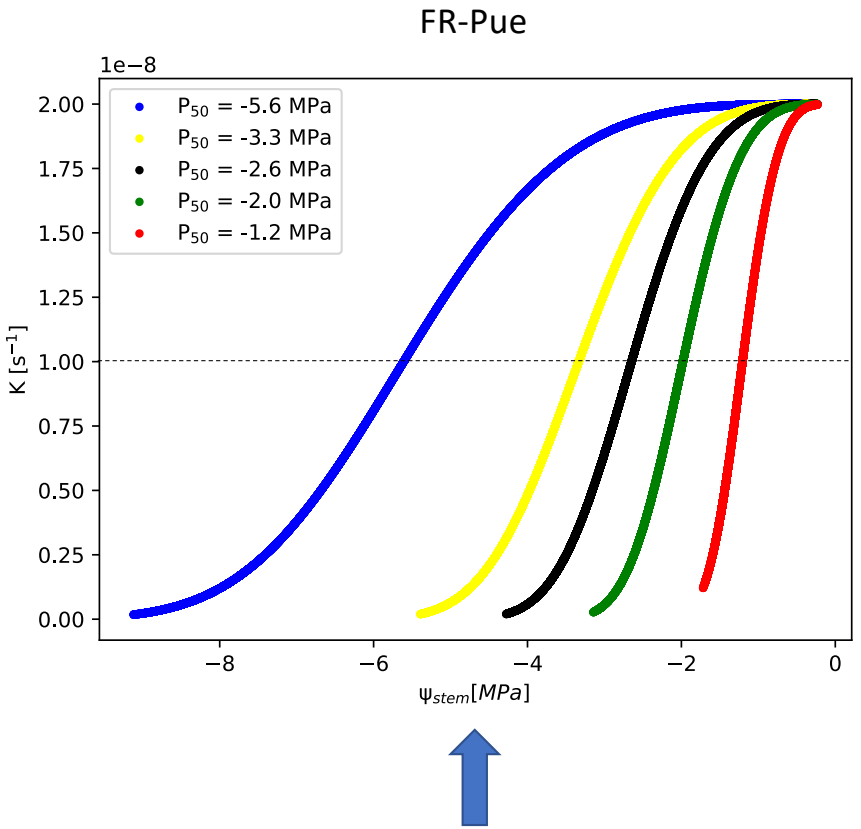



Increase of the dry surface layer (DSL) in the soil resistance formulation

# Uncertainty in Plant Hydraulics

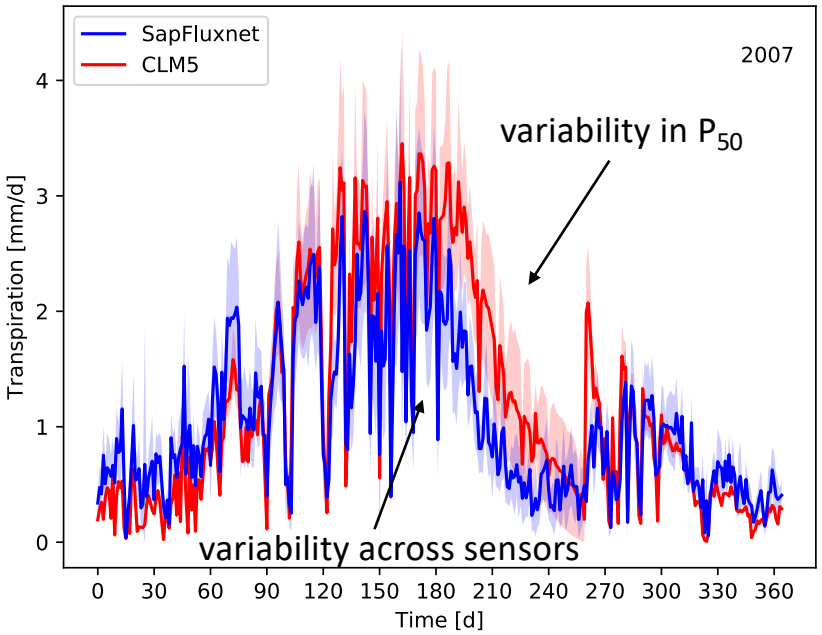


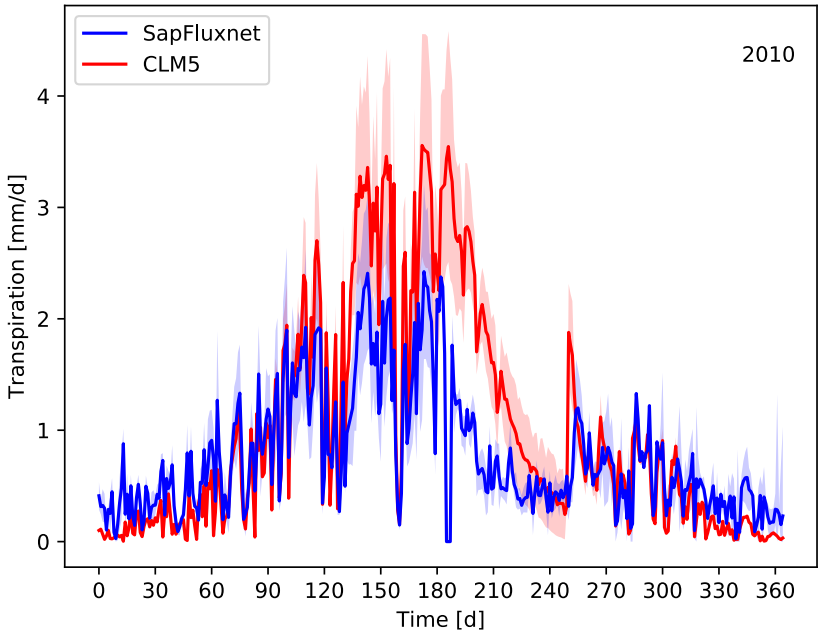




Simulated plant vulnerability curve

[1]Anderegg et al. 2018 ; [2]XFT Database (Hammond et al.)

# Variability in Transpiration Response

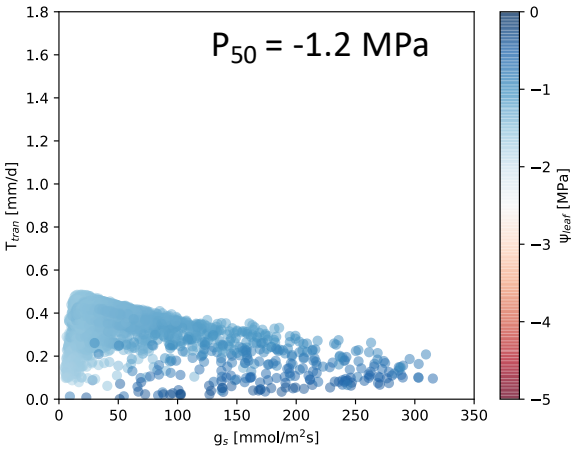


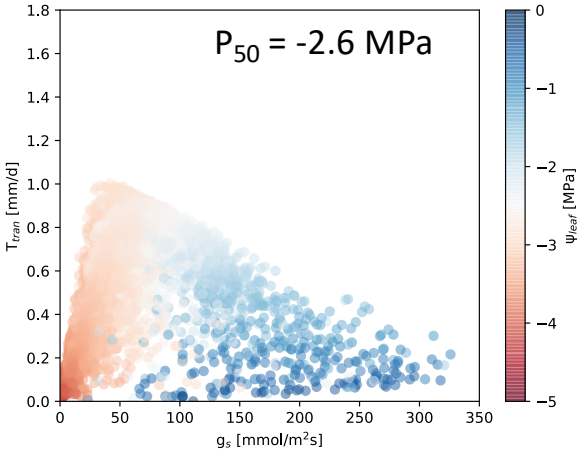



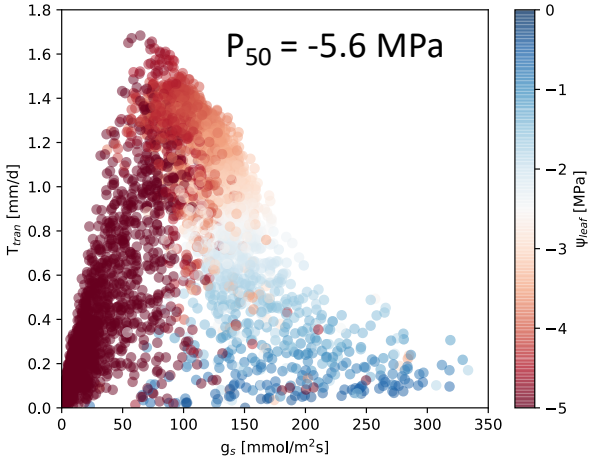

Overestimation of transpiration during spring-summer time

due to a shallow bedrock?

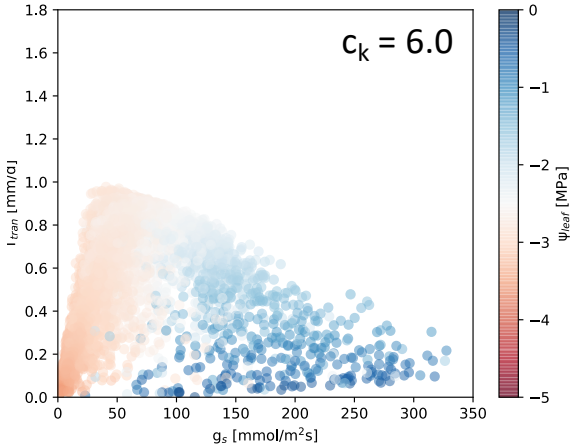
# Stomatal Conductance – Transpiration (Model)

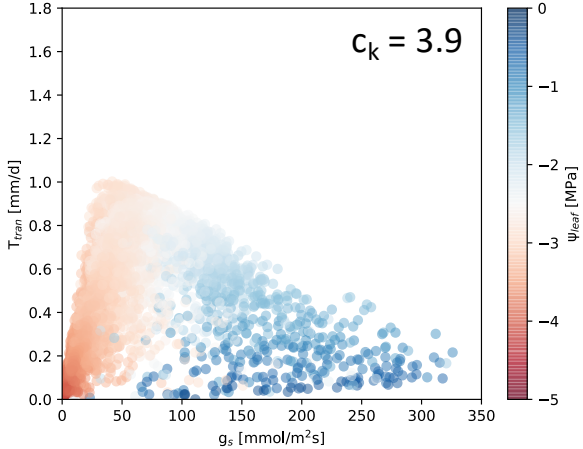


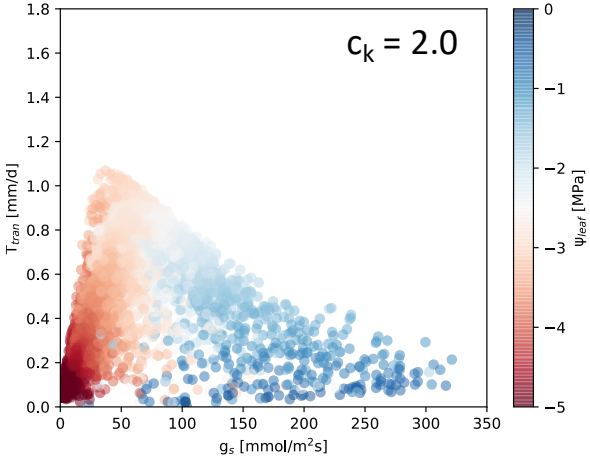



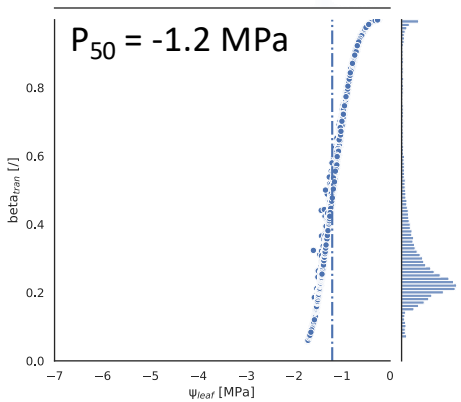

DEFAULT

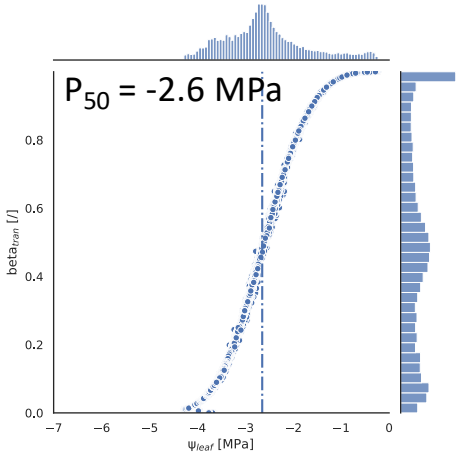


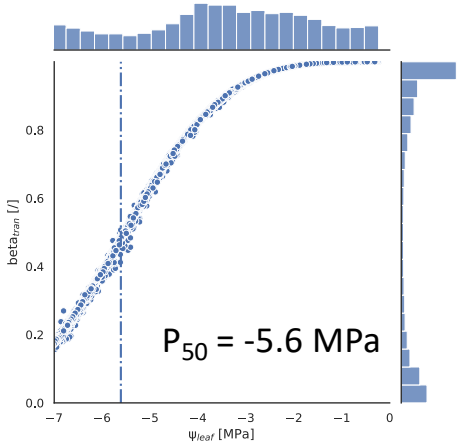



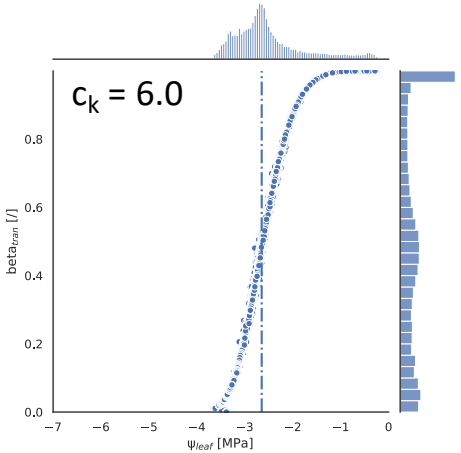



# BTRAN – Leaf Water Potential

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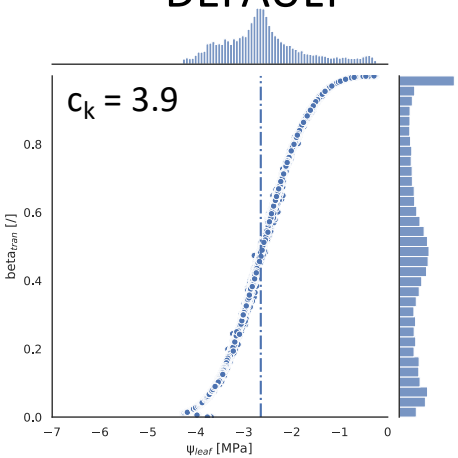
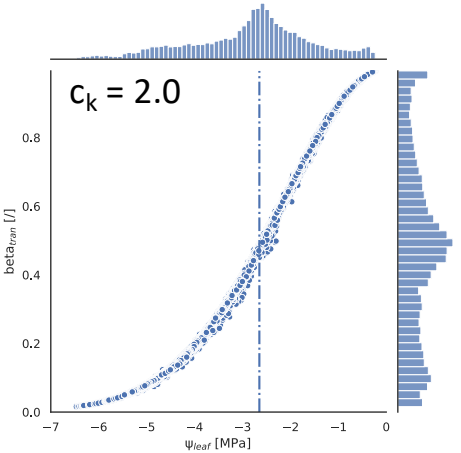
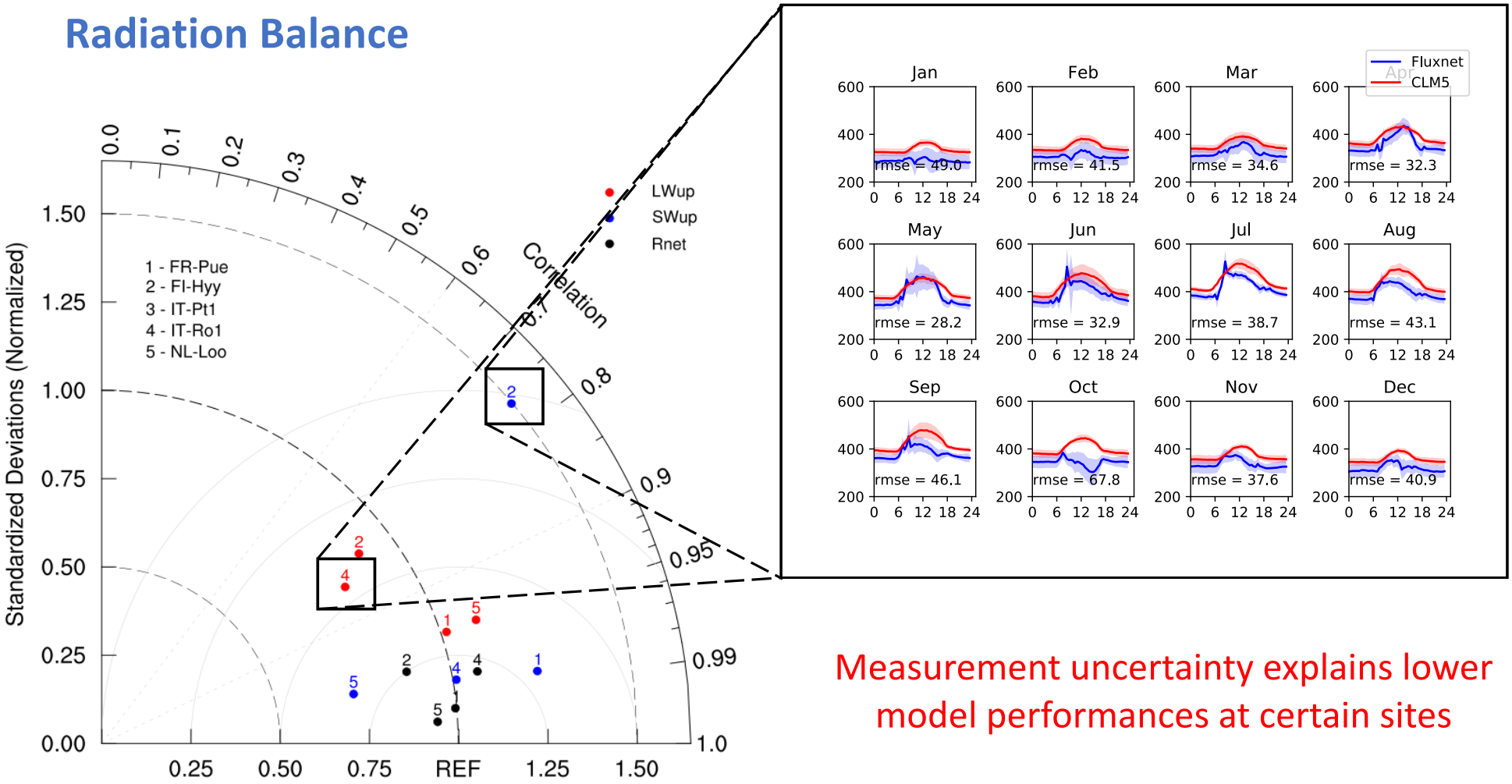


## Conclusions

- CLM5.0 captures the ET variability across six forested sites in Europe
- Soil resistance largely explains model deficiencies in ET partitioning at some (i.e., Puéchabon and El-Saler) sites
- Intra-specific variability of plant hydraulics parameters strongly affects simulated transpiration response during summer time, but the resulting uncertainty bounds do not always extend to the observed ET

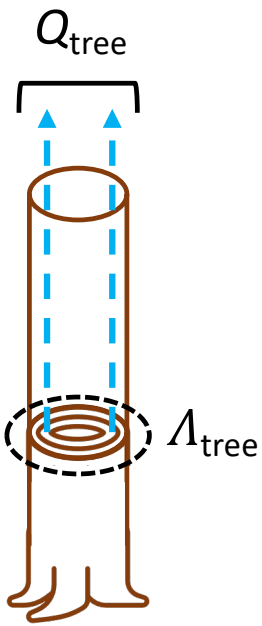
# Radiation Balance

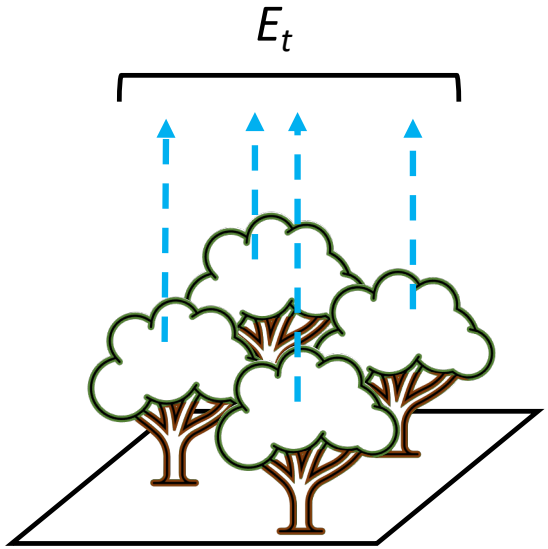



Measurement uncertainty explains lower model performances at certain sites

$$E_{\mathrm{t}} = 10^3 \frac{\Lambda_{stand}}{n} \sum_{tree=1}^{n} \left( \frac{Q_{tree}}{\Lambda_{tree}} \right)$$

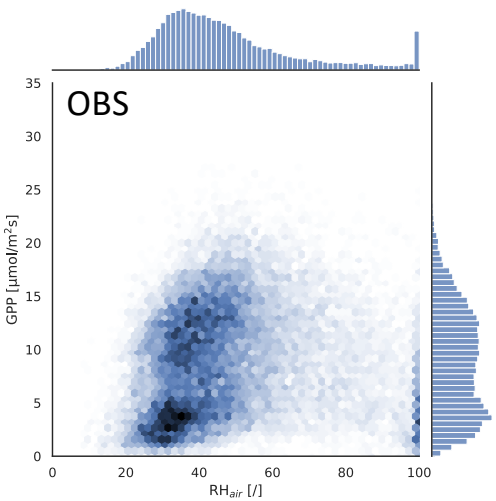
$E_t$: transpiration [mm $d^{-1}$]
$Q_{tree}$: sap flux [$m^3$ $d^{-1}$ $tree^{-1}$]
$\Lambda_{stand}$: stand basal area [$m^2$ $m^{-2}$]
$\Lambda_{tree}$: tree basal area [$m^2$ $tree^{-2}$]
n: number of trees measured

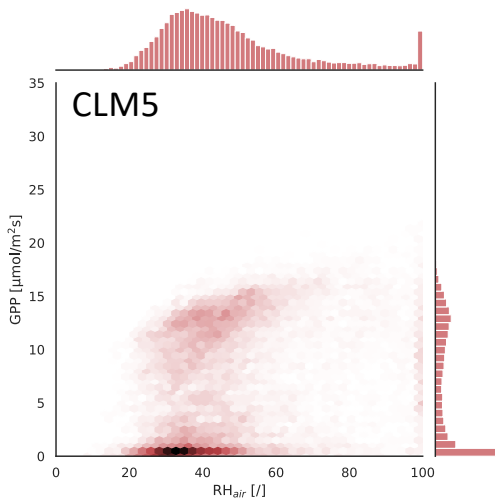


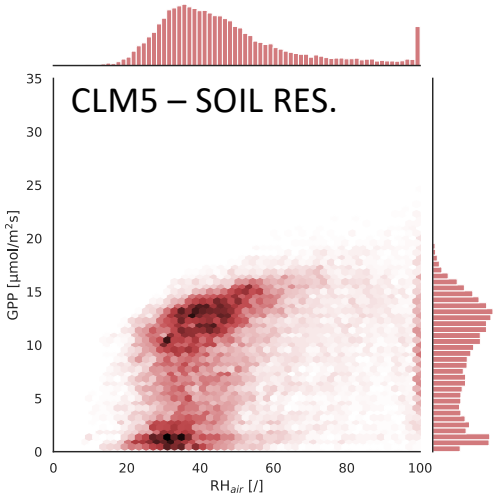



# Humidity and Temperature Control on Photosynthesis (FR-Pue)

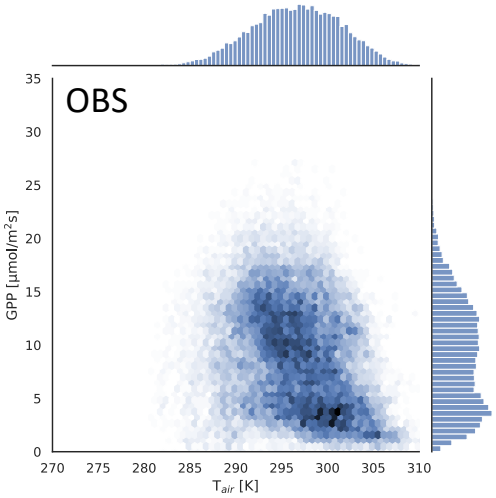
RH

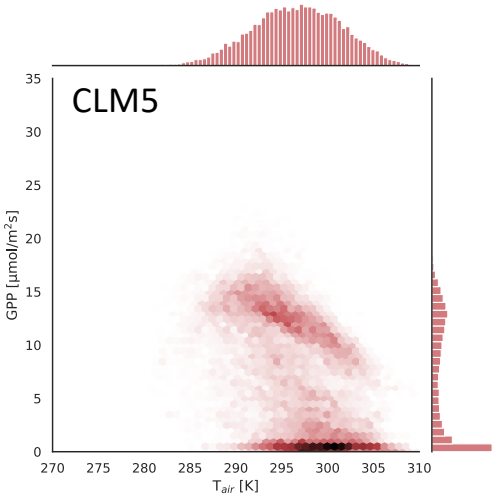


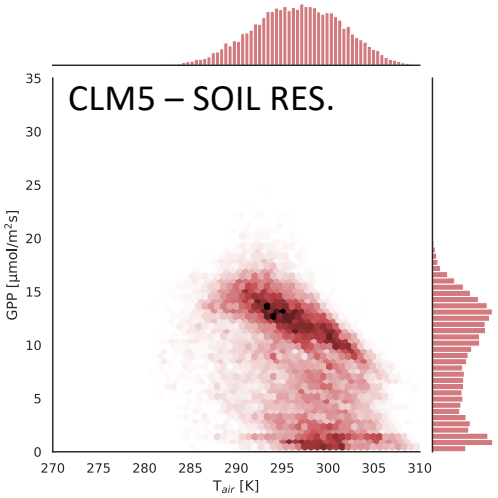



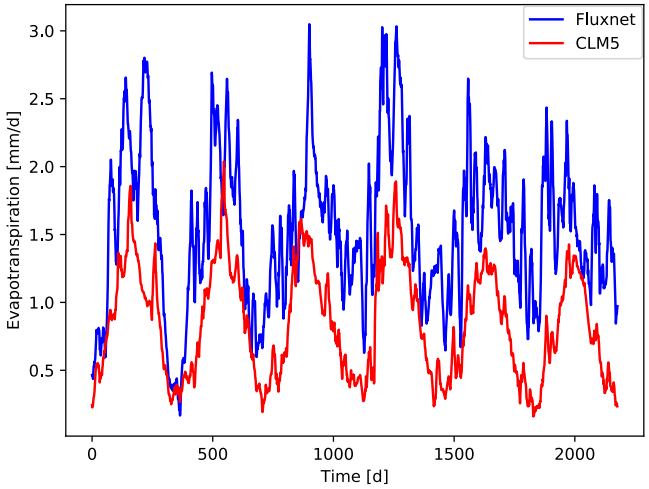



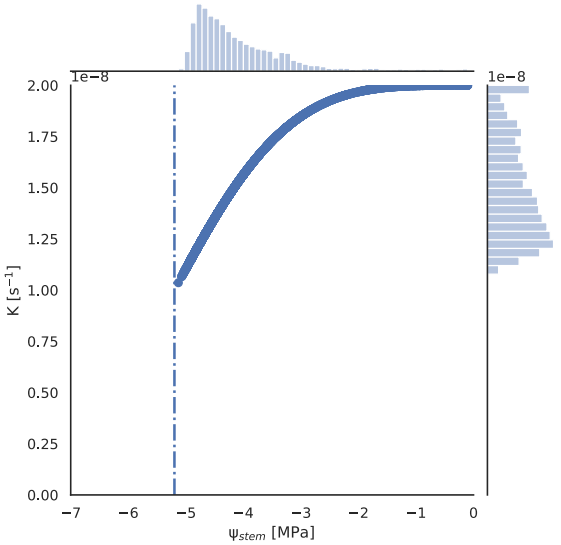

$T_{air}$



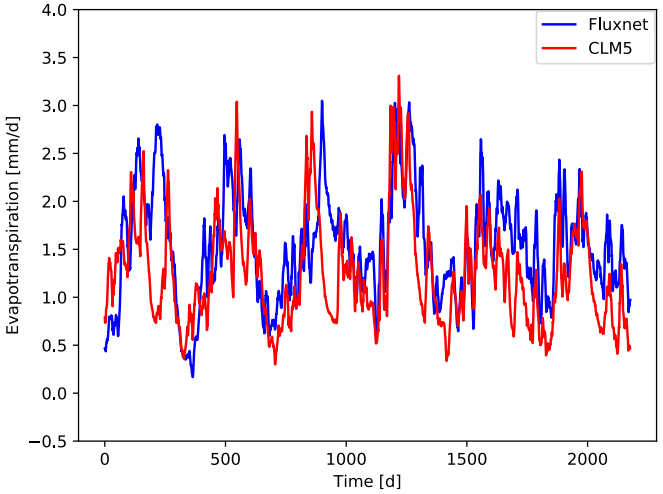



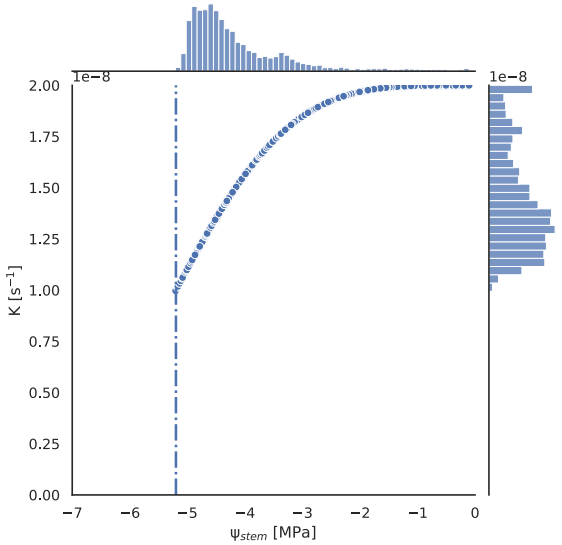

Fluxnet
CLM5
Evapotranspiration [mm/d]
Time [d]
3.0
2.5
2.0
1.5
1.0
0.5
0
500
1000
1500
2000


1e−8
1e−8
K [s$^{-1}$]
$\psi_{stem}$ [MPa]
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
−7
−6
−5
−4
−3
−2
−1
0

El-Saler

# DECREASED SOIL RESISTANCE




El-Saler