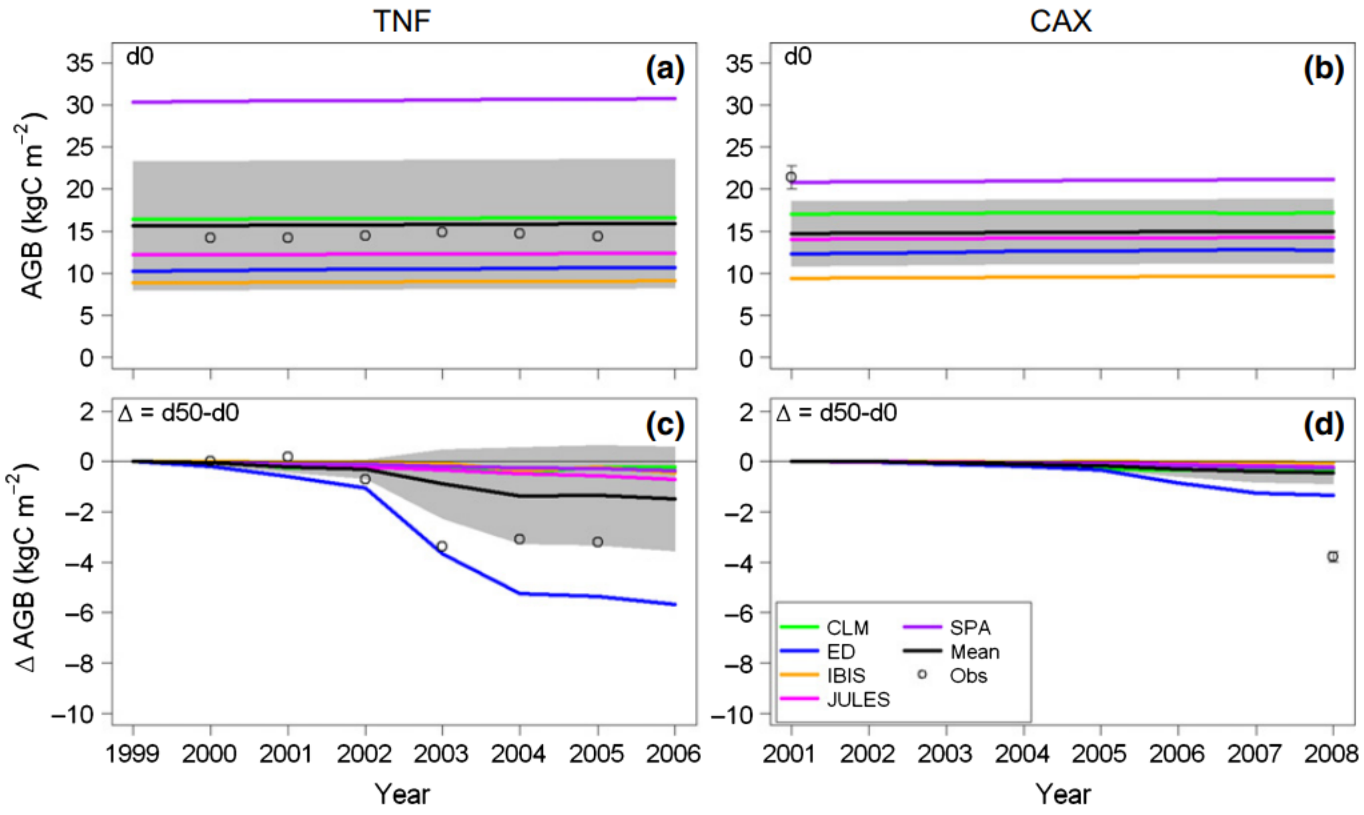
Hydraulic architecture in ORCHIDEE-CAN-NHA

07/10/2021

The purpose behind the implementation of the hydraulic architecture



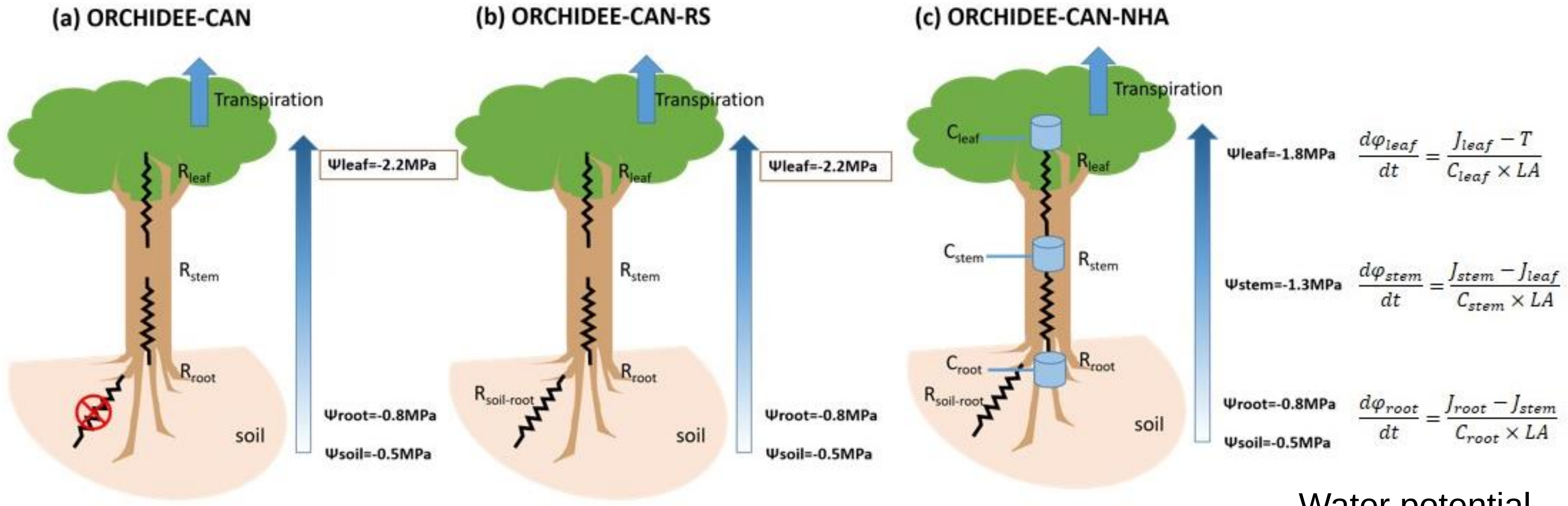
We want to simulate the hydraulic failure!

[Powell et al., 2013]

d0 and d50 are drought levels indicating a 0 and 50% reduction in precipitation

General principal of the model

The water supply at each organ should meet their demand.



Water potential, vertical water flow, and PLC can be simulated.

Focus on different parts of the model

- 1 root absorption part:
  - The soil water potential in root zone is calculated by weighting soil water potential by the amount of water can be absorbed from this layer.
  - The amount of water that can be absorbed is calculated from the soil water potential, the minimum values and soil-root resistance.
  - The soil-root resistance estimates the effective path length for water transport from the soil to root surface (Joetzjer et al., under review)

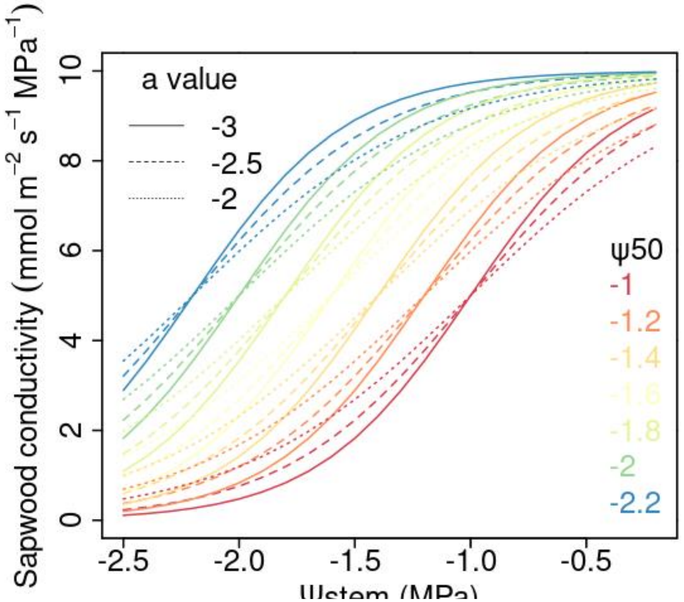
$$R_{sr}(l) = \frac{\ln\left(\frac{r_s(l)}{r_r}\right)}{2\,\pi\, l_r(l)\, G_{soil}(l) \Delta_D(l)} \tag{6}$$

Here, l_r (m^{-2}) is the root length per unit of soil volume, and is a function of the specific root length (SRL), with SRL set at 10 m g^{-1} (Metcalfe et al., 2008), and of the fine root biomass density per layer ($Biomass_{froots}(l)$, in g m^{-3}): $l_r(l) = Biomass_{froots}(l)\, SRL$; r_s (m) is one-half of the mean distance between roots, computed following (Newman, 1969):

Focus on different parts of the model

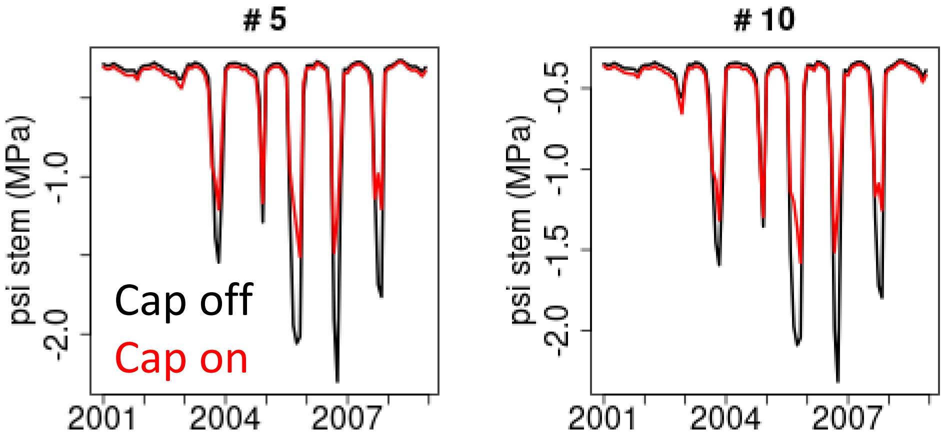
- 2 water transport:
  - Conductance
    - Conductance can vary with water potential in logistic relationship

$$J_{stem,t+1} = (\psi_{root,t} - \psi_{stem,t+1} - \psi_{h/2})k_{trunk,t+1}LA$$



  - Capacitances
    - Water storage pool can vary with the introduction of capacitance values.

$$W_{stem,t+1} = c_{stem}(\psi_{stem,t+1} - \psi_{stem,t})v_{stem}$$



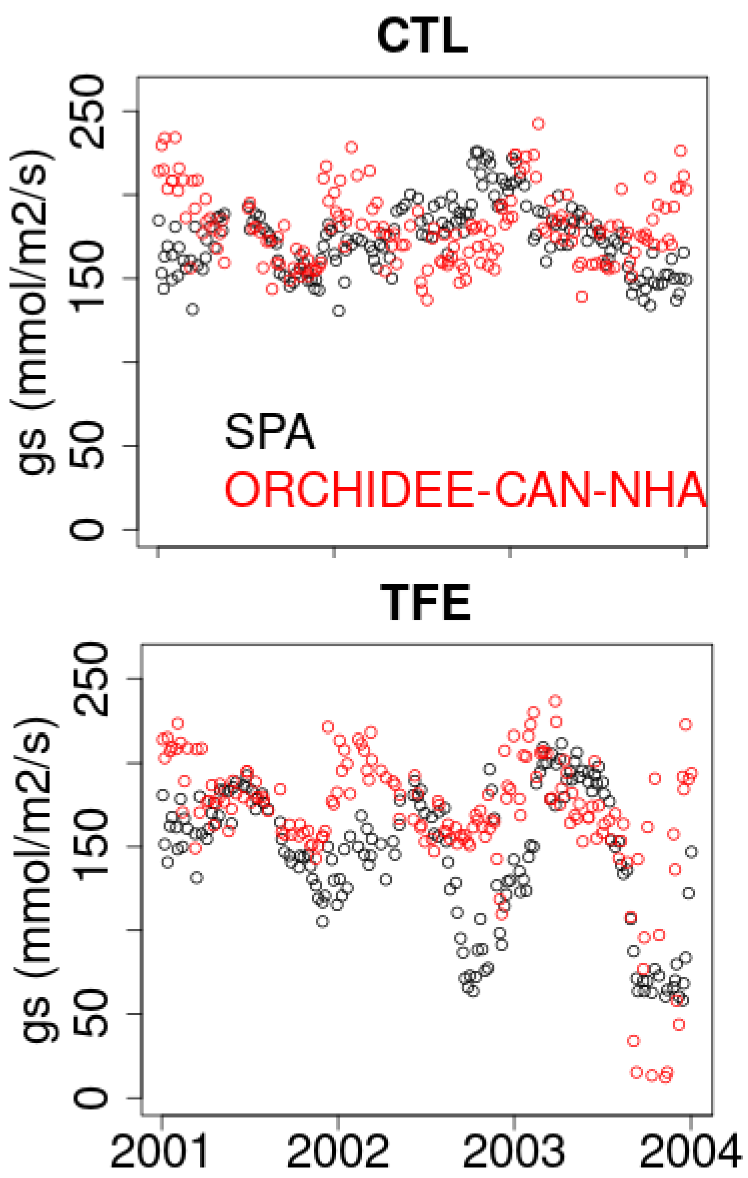
Focus on different parts of the model

- 3 stomatal conductance:

$$g_s = \frac{g_{max} f(rad)}{1+e^{a_{gs}(\psi_{leaf,t}-\psi_{50,gs})}} + g_{min}$$

$$f(rad)=\frac{L\times Rad}{L\times Rad+L_k}$$

The function of short-wave radiation, is used to ensure the gs in night to be close to 0

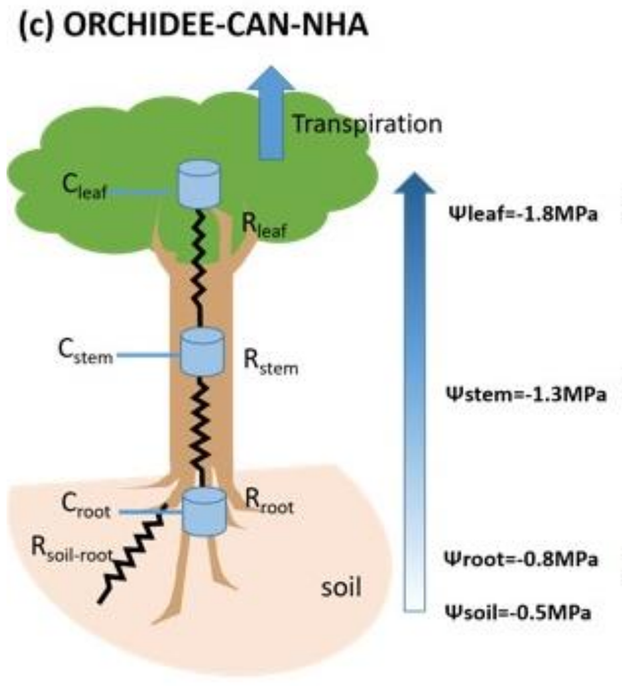


Mathematical choices

- Iterations/predictions
  - If transpiration < transpiration supply, transpiration is recalculated (vbeta3).
  - When we calculate the water potential at leaf/stem/root, we use minpack library to solve nonlinear equations.

Technical implementation

We assume that the water supply should meet its demand in each organ.



$$\frac{d\varphi_{leaf}}{dt} = \frac{J_{leaf} - T}{C_{leaf} \times LA}$$

$$\frac{d\varphi_{stem}}{dt} = \frac{J_{stem} - J_{leaf}}{C_{stem} \times LA}$$

$$\frac{d\varphi_{root}}{dt} = \frac{J_{root} - J_{stem}}{C_{root} \times LA}$$

Supply

$$J_{leaf,t+1} = (\psi_{stem,t} - \psi_{leaf,t+1} - \psi_{h/2})k_{upper,t+1}LA$$

$$W_{leaf,t+1} = c_{leaf}(\psi_{leaf,t+1} - \psi_{leaf,t})LA$$

Demand

$$T_{demand} = g_s \frac{VPD}{atm} LA$$

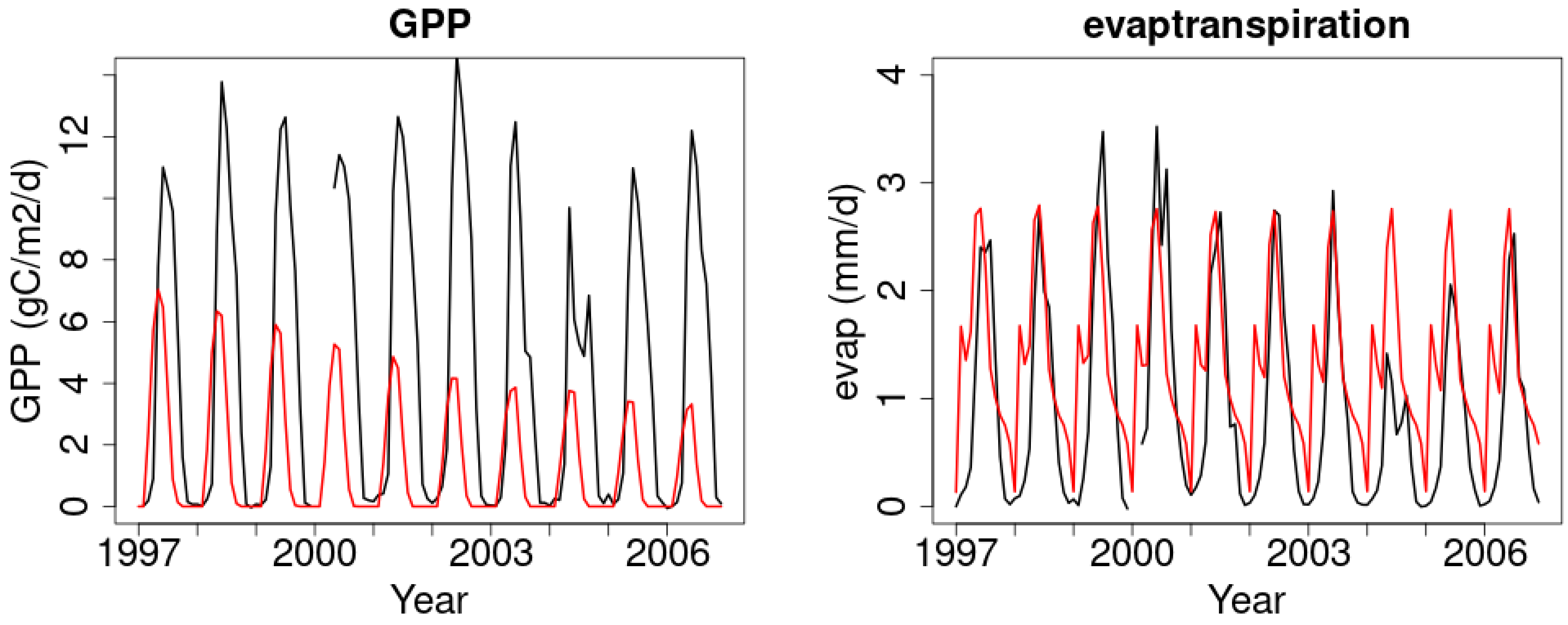
$$k_{leaf,t} = \frac{k_{leaf,max}}{1 + exp\left(a_{leaf} \times (\varphi_{leaf,t} - \varphi_{50,leaf})\right)}$$

$$k_{stem,t} = \frac{k_{stem,max}}{1 + exp\left(a_{stem} \times (\varphi_{stem,t} - \varphi_{50,stem})\right)}$$

$$k_{root,t} = \frac{k_{root,max}}{1 + exp\left(a_{root} \times (\varphi_{root,t} - \varphi_{50,root})\right)}$$

Results: simulation at FR-Hess site

Flux observation
Model



(the biomass can be very unreasonably high during spinup)
GPP underestimation -> parameters tuning?