HETEROFOR: A model to predict climate change impacts on tree growth in heterogeneous stands

Phenology and water cycle

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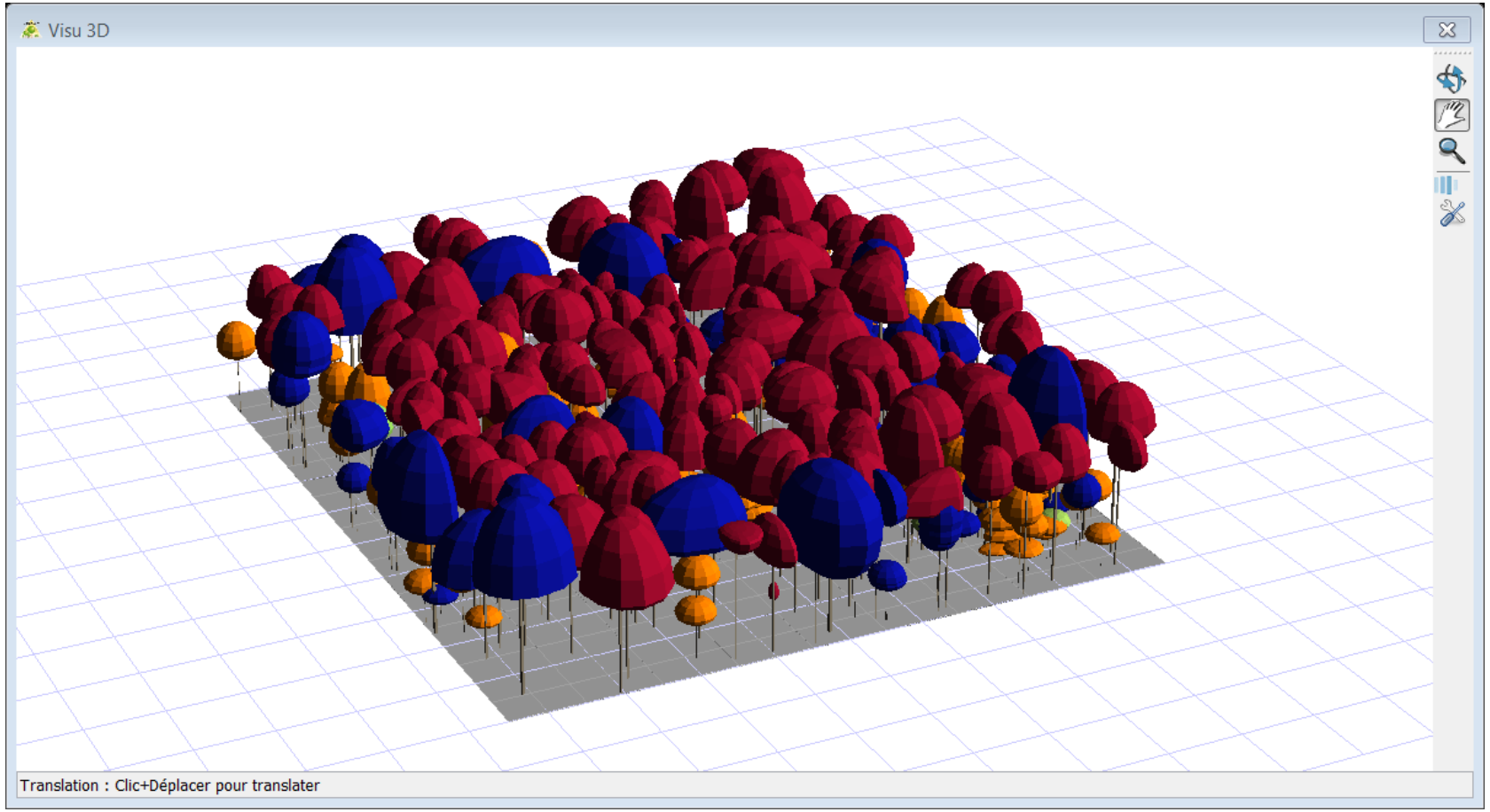
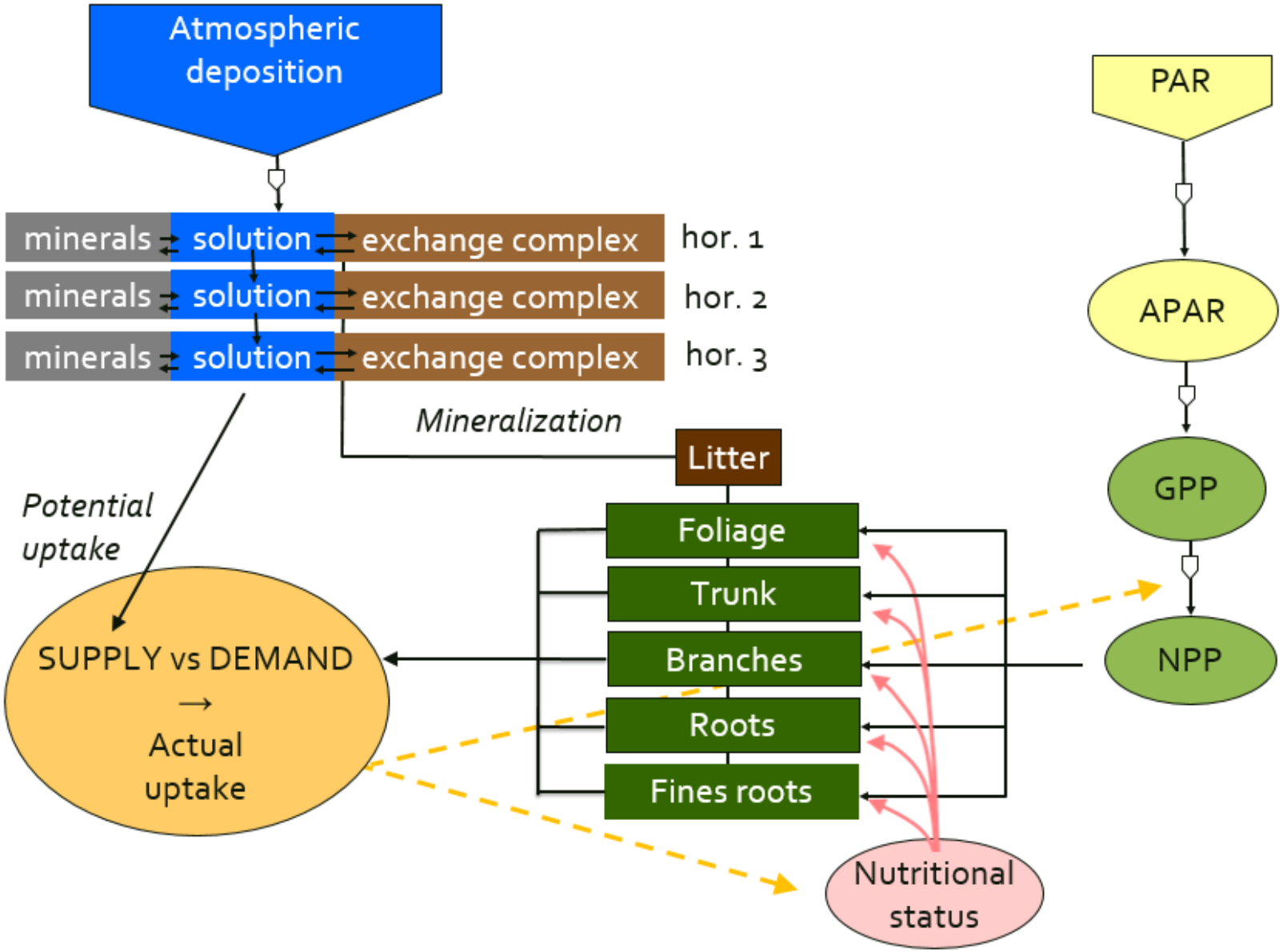
Model features

- Mechanistic
- Individual based
- Spatially-explicit

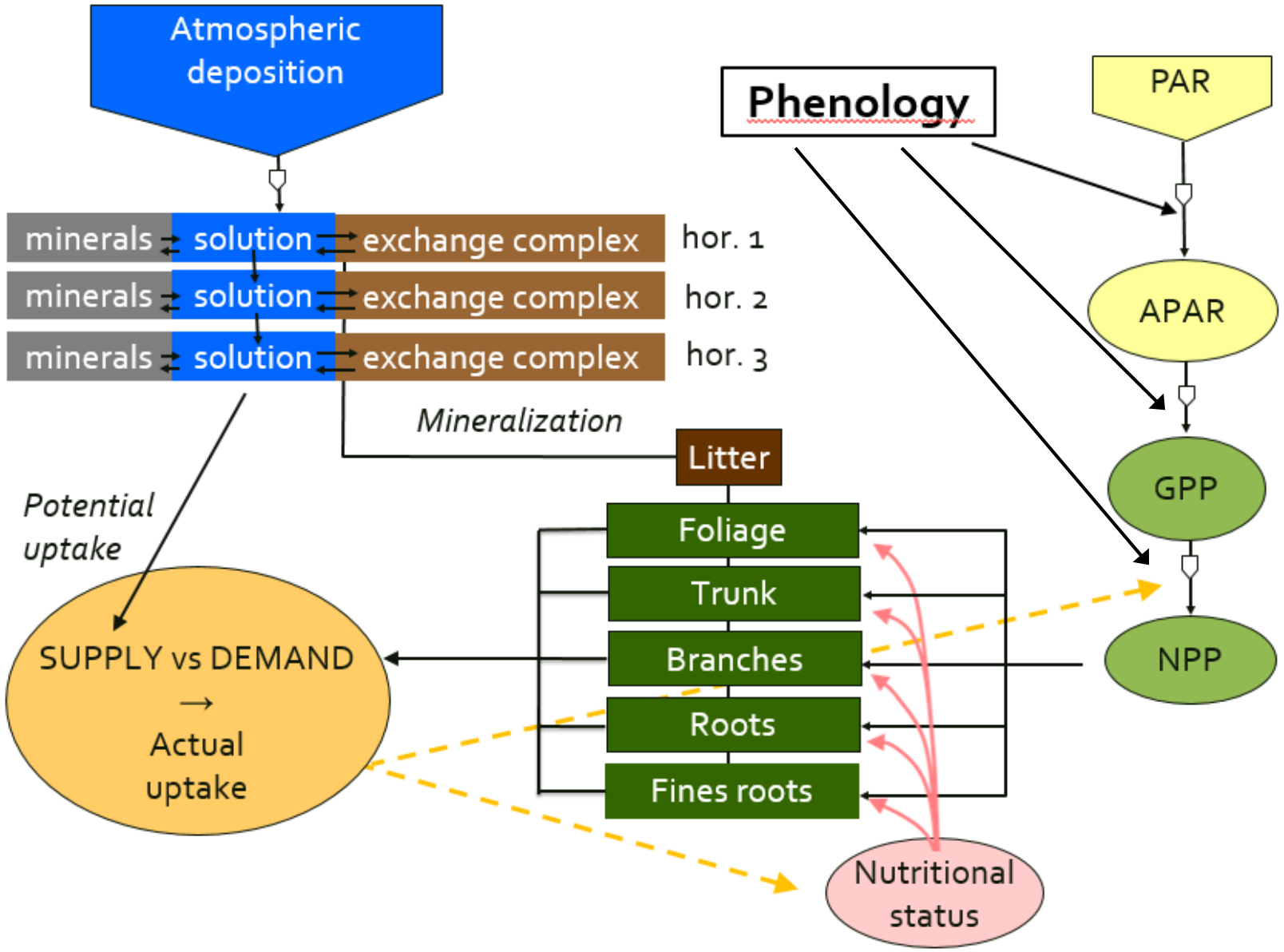


→ Versatile model that can be theoretically used in any environmental conditions and for any stand configuration

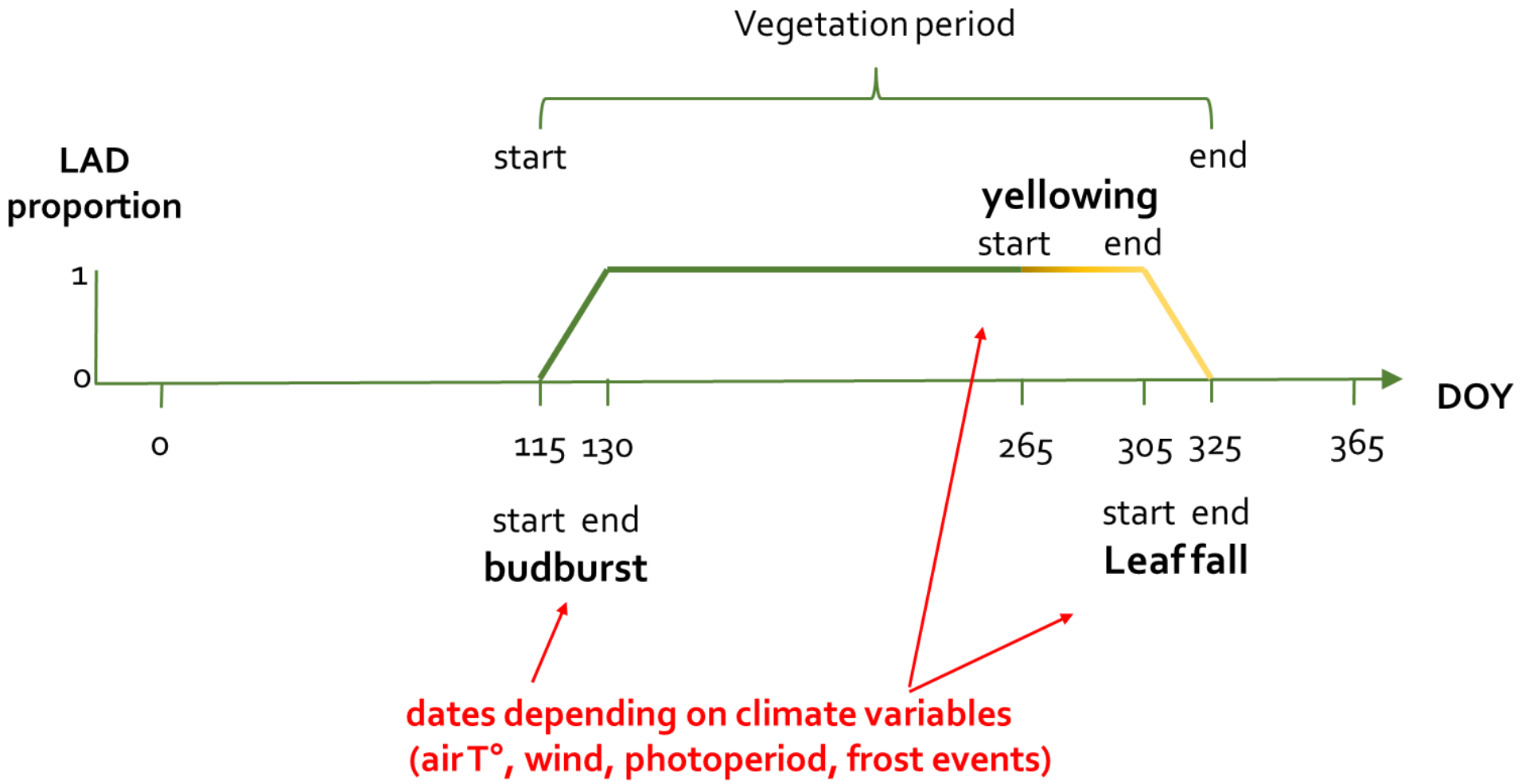
HETEROFOR overview



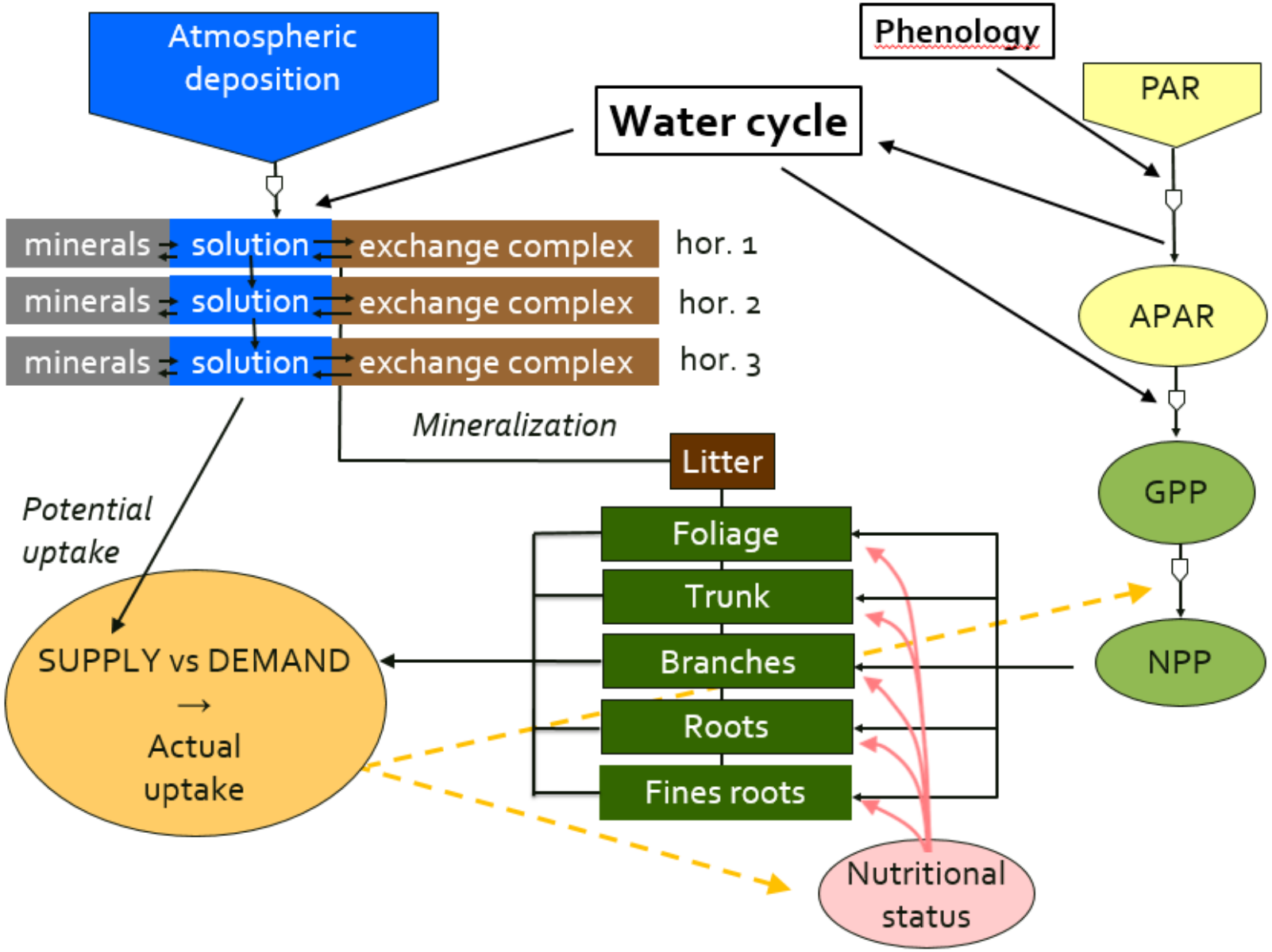
HETEROFOR overview



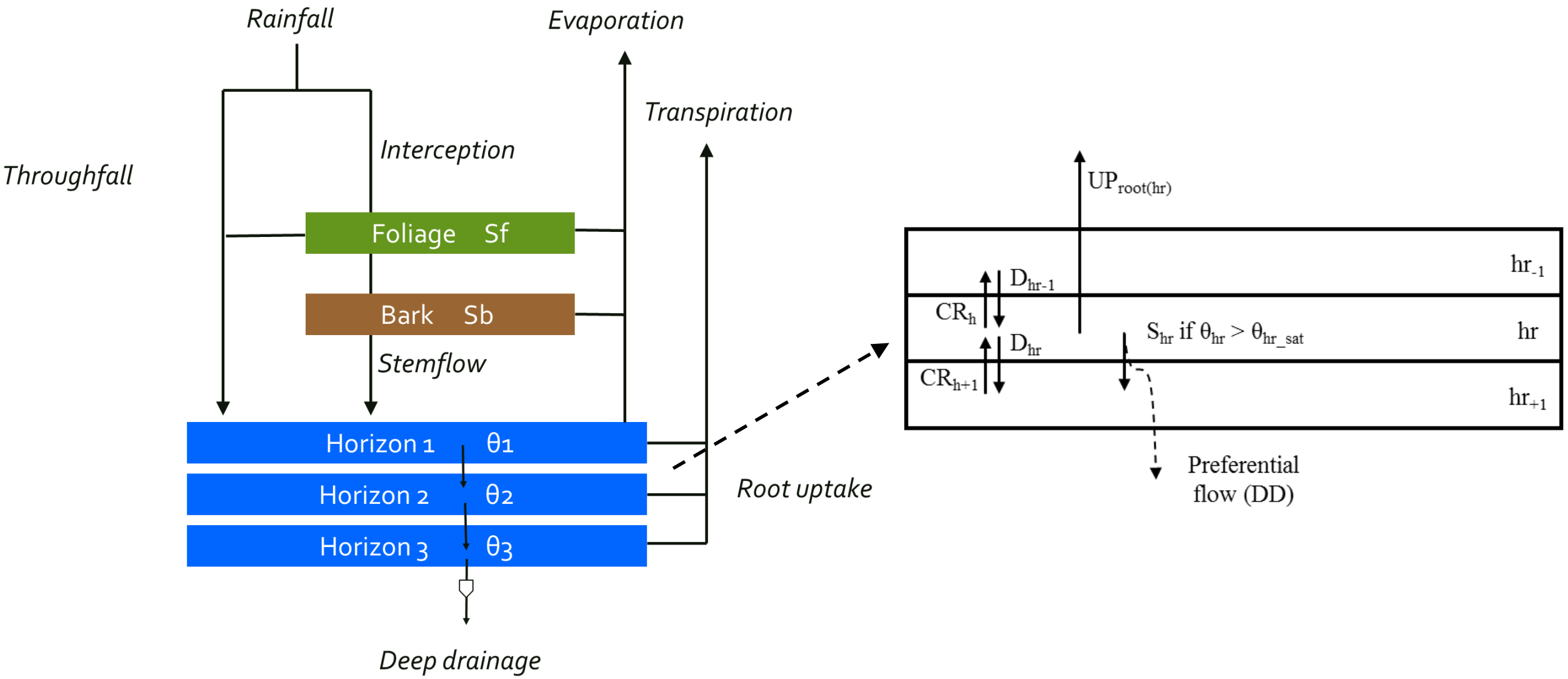
HETEROFOR overview: Phenology



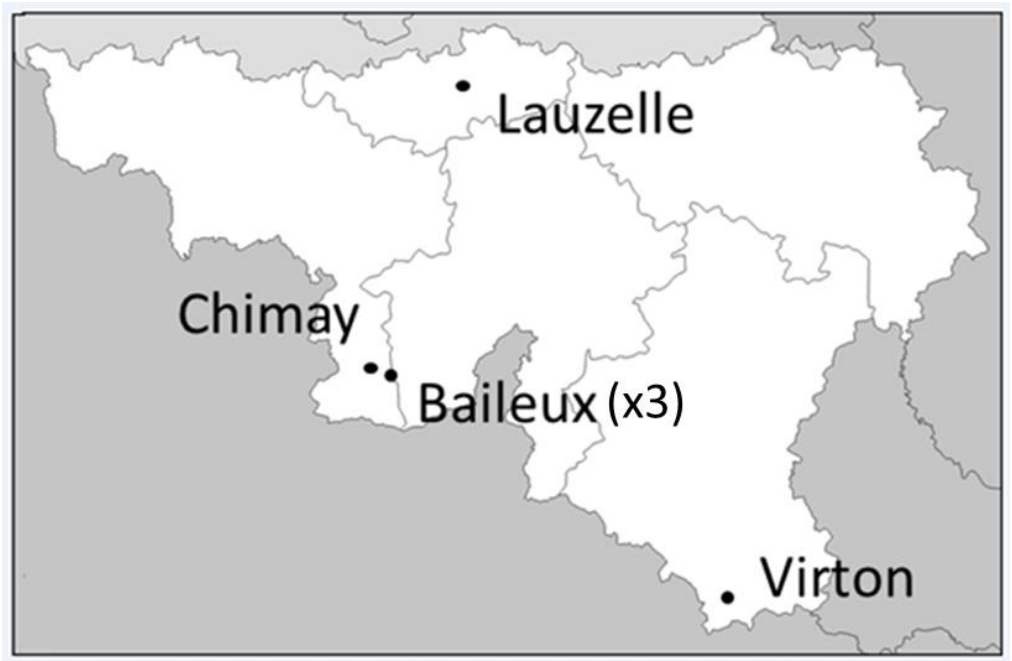
HETEROFOR overview



HETEROFOR overview: Water cycle



Sites of model evaluation



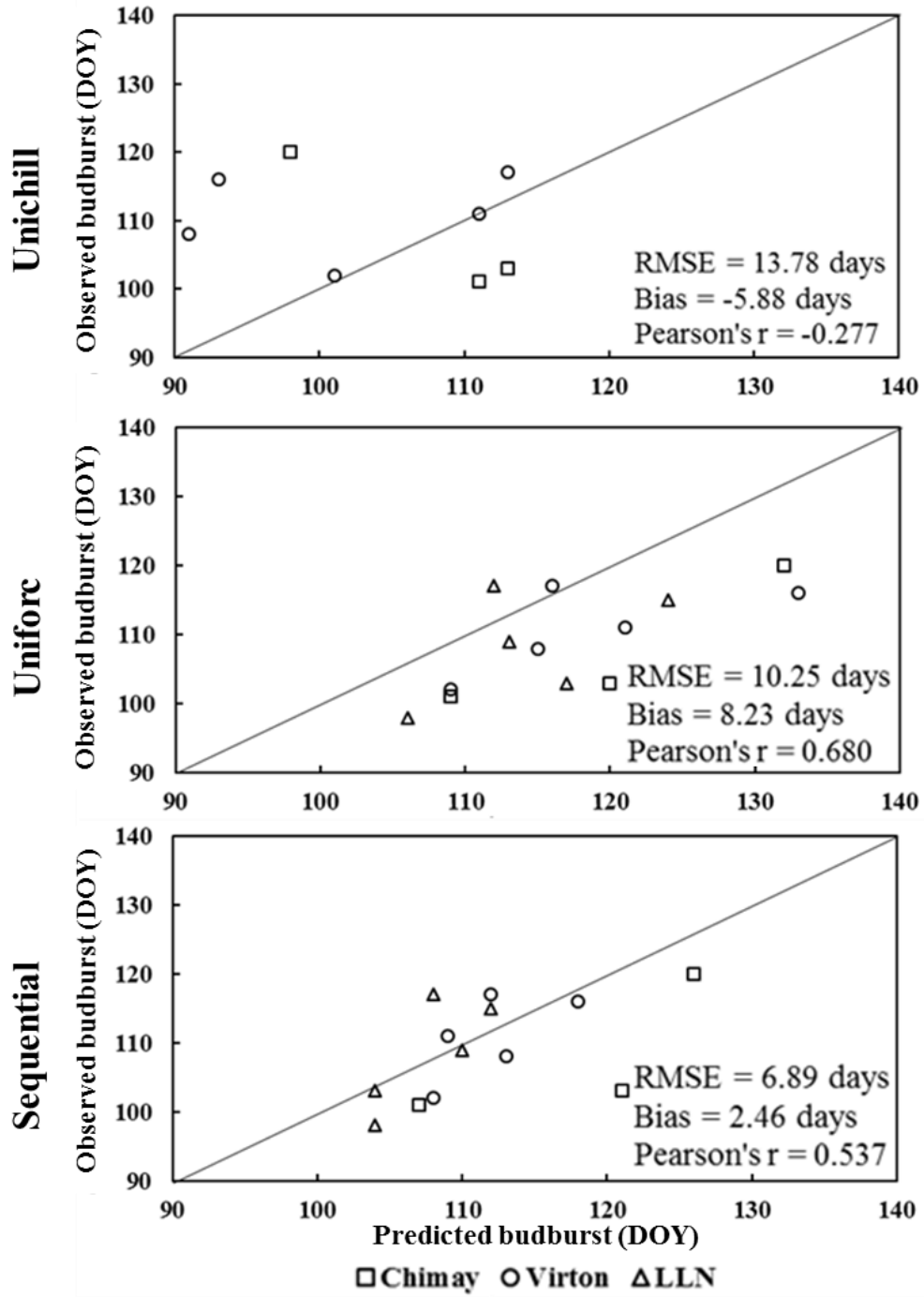
- Lauzelle: Beech stand with a few oaks
- Chimay: Oak stand with hornbeam understory
- Baileux (three plots): Pure oak, pure beech and mixed stands
- Virton: Beech stand with various deciduous species

Phenology evaluation: budburst

Unichill: Chilling and forcing periods (Chuine, 2000)

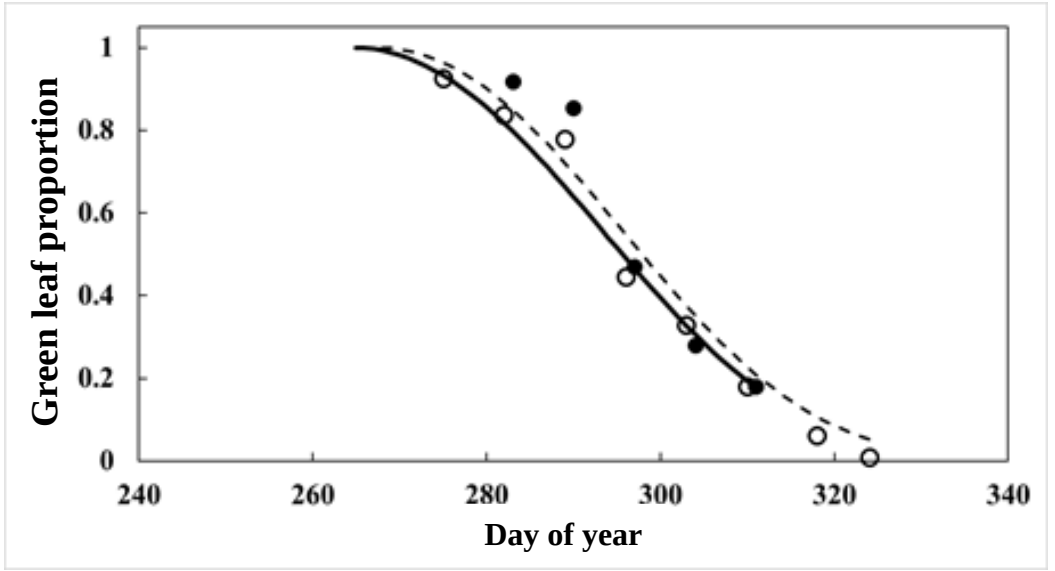
Uniforc: Single-phase forcing period (Chuine, 2000)

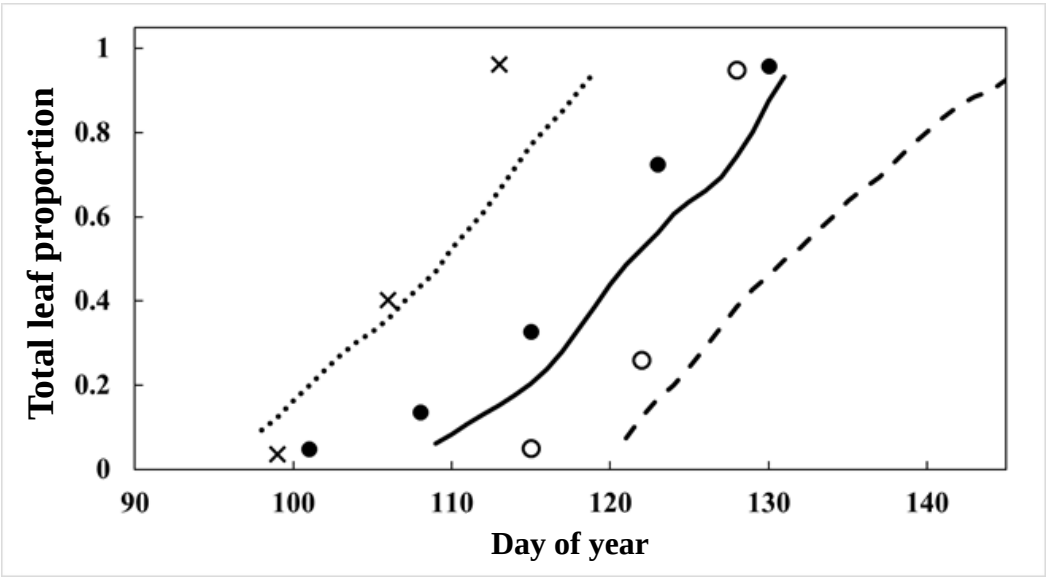
Sequential: Chilling and forcing periods (Kramer, 1994)

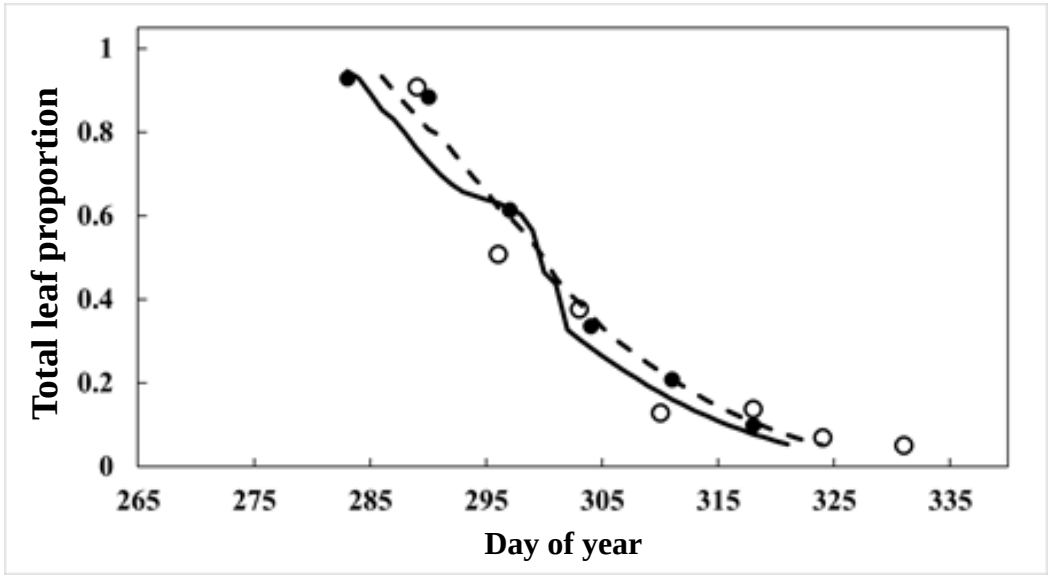


Phenology evaluation: LAD and leaf yellowing

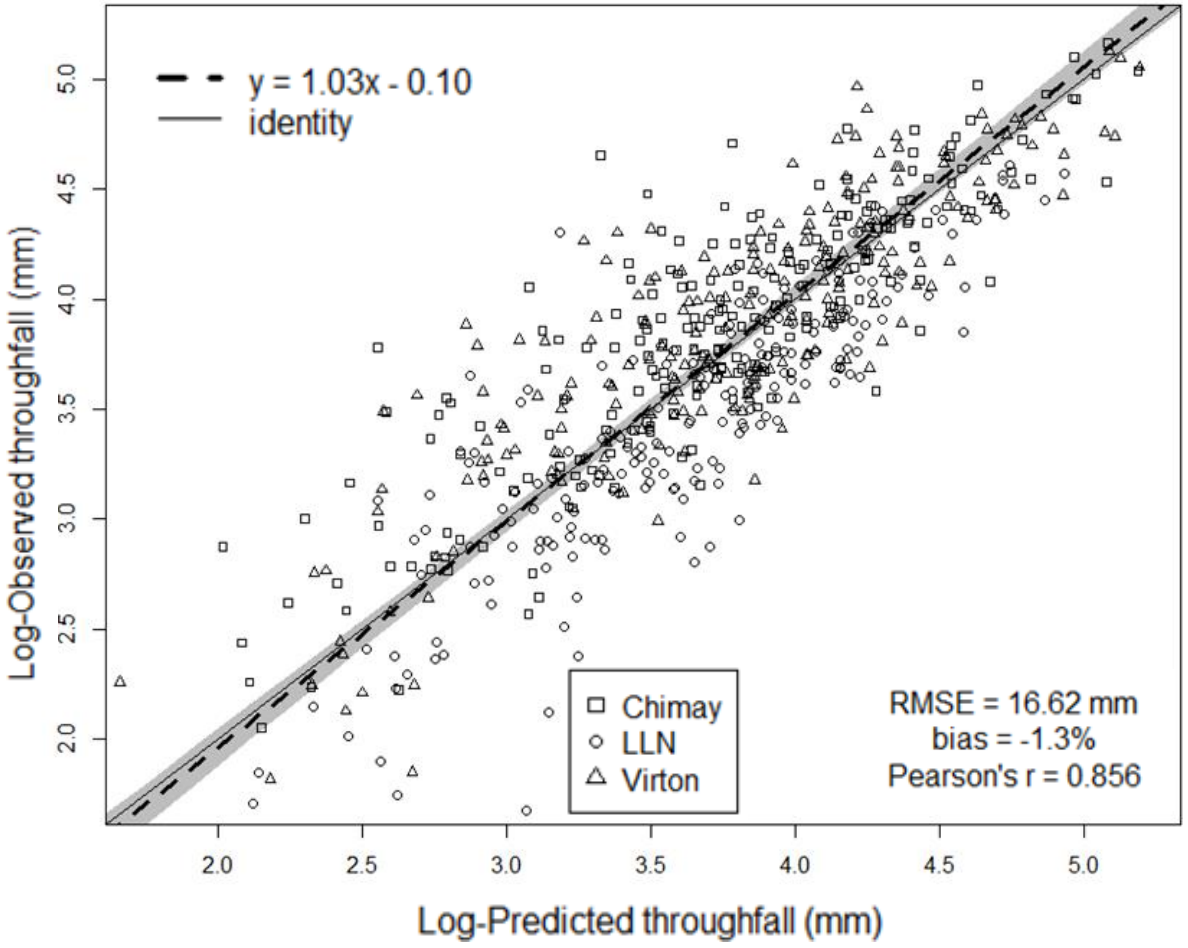
Yearly evaluation of the green and total leaf proportion in an oak stand (Chimay)

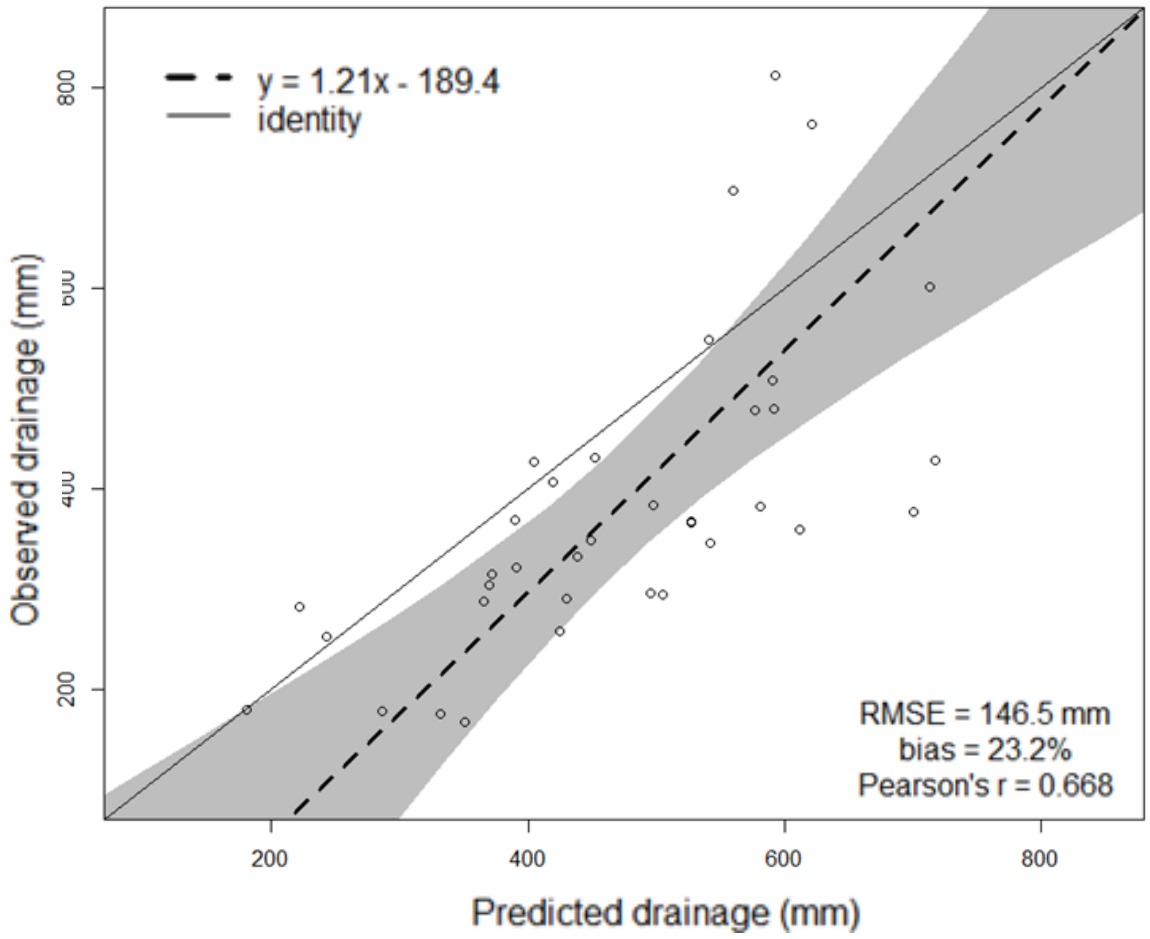






Water cycle evaluation: Throughfall and deep drainage



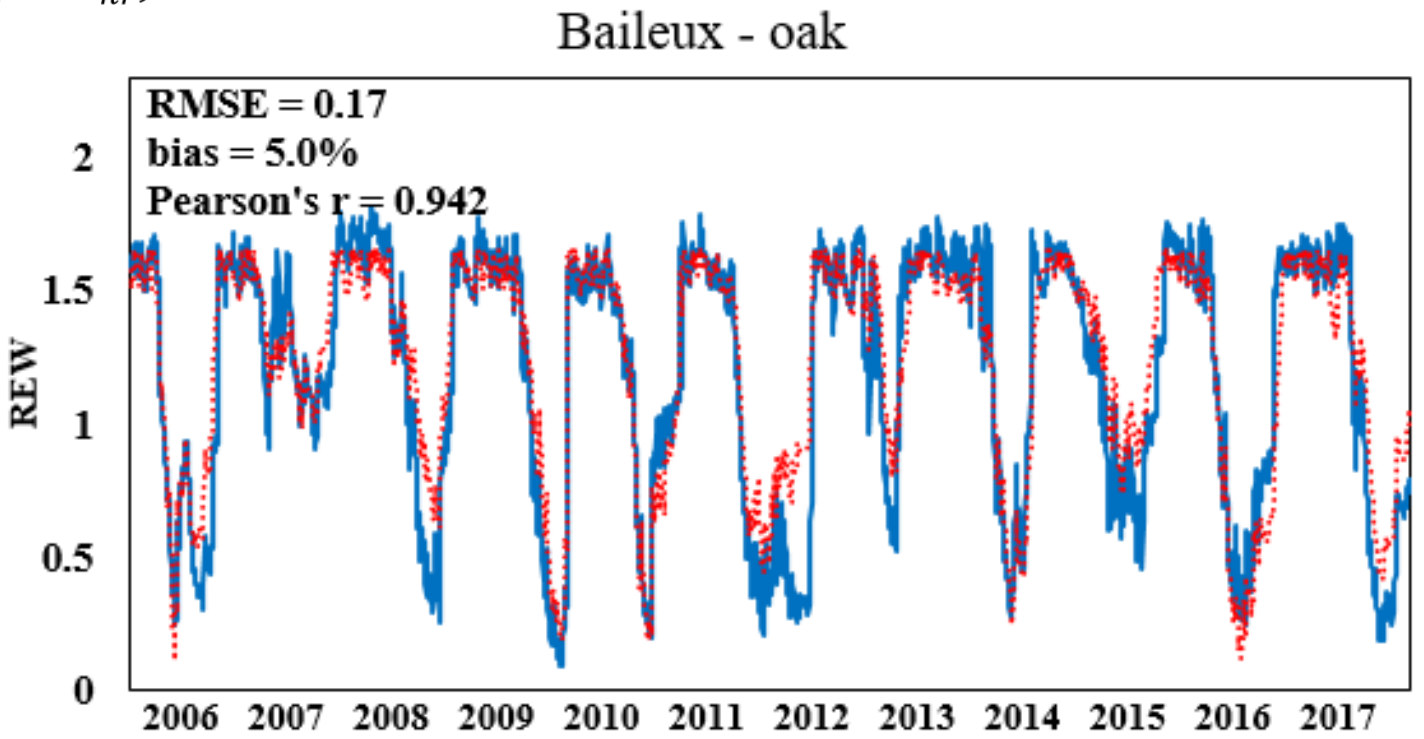


Water cycle evaluation: Relative extractable water

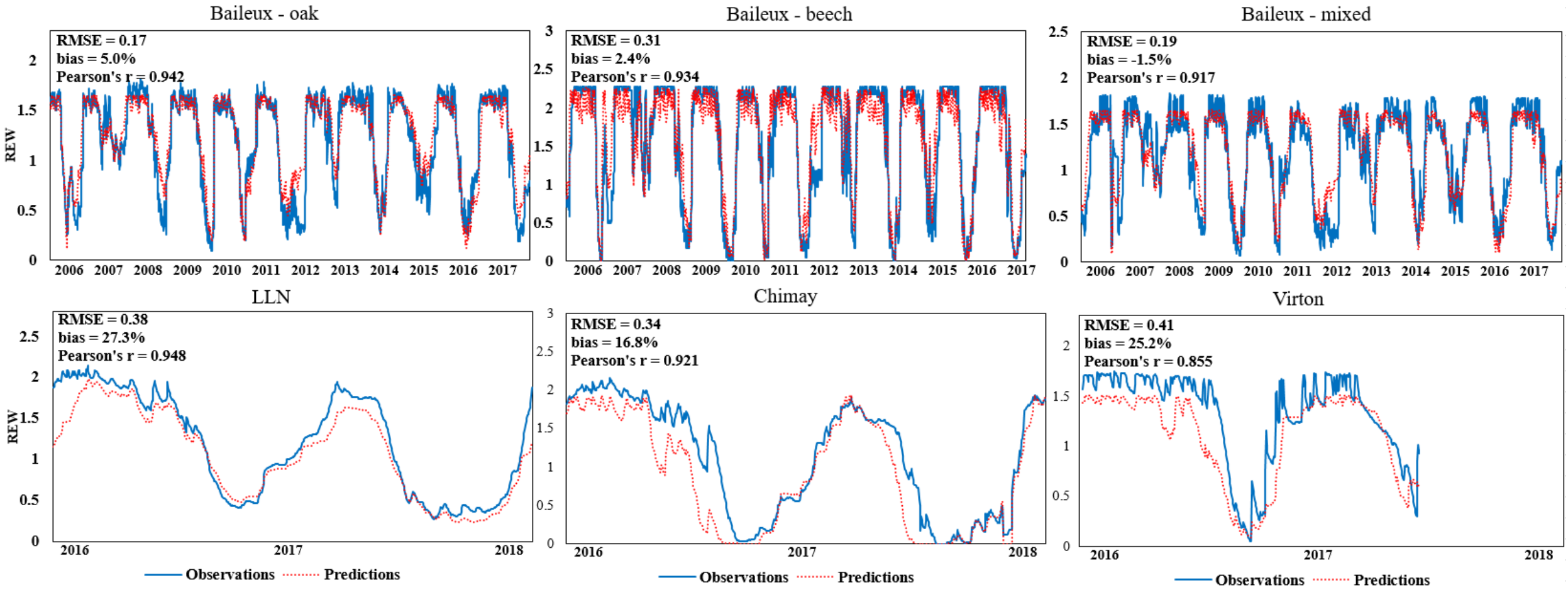
$$REW = \frac{EW}{EW_{ref}}$$

with $$EW = \sum_{hr=1}^{n} (\theta_{hr} - \theta_{\text{wp }\_hr}) \cdot th_{hr} \cdot (1 - \nu_{hr})$$

$$EW_{ref} = \sum_{hr=1}^{n} (\theta_{\text{fc }\_hr} - \theta_{\text{wp }\_hr}) \cdot th_{hr} \cdot (1 - \nu_{hr})$$



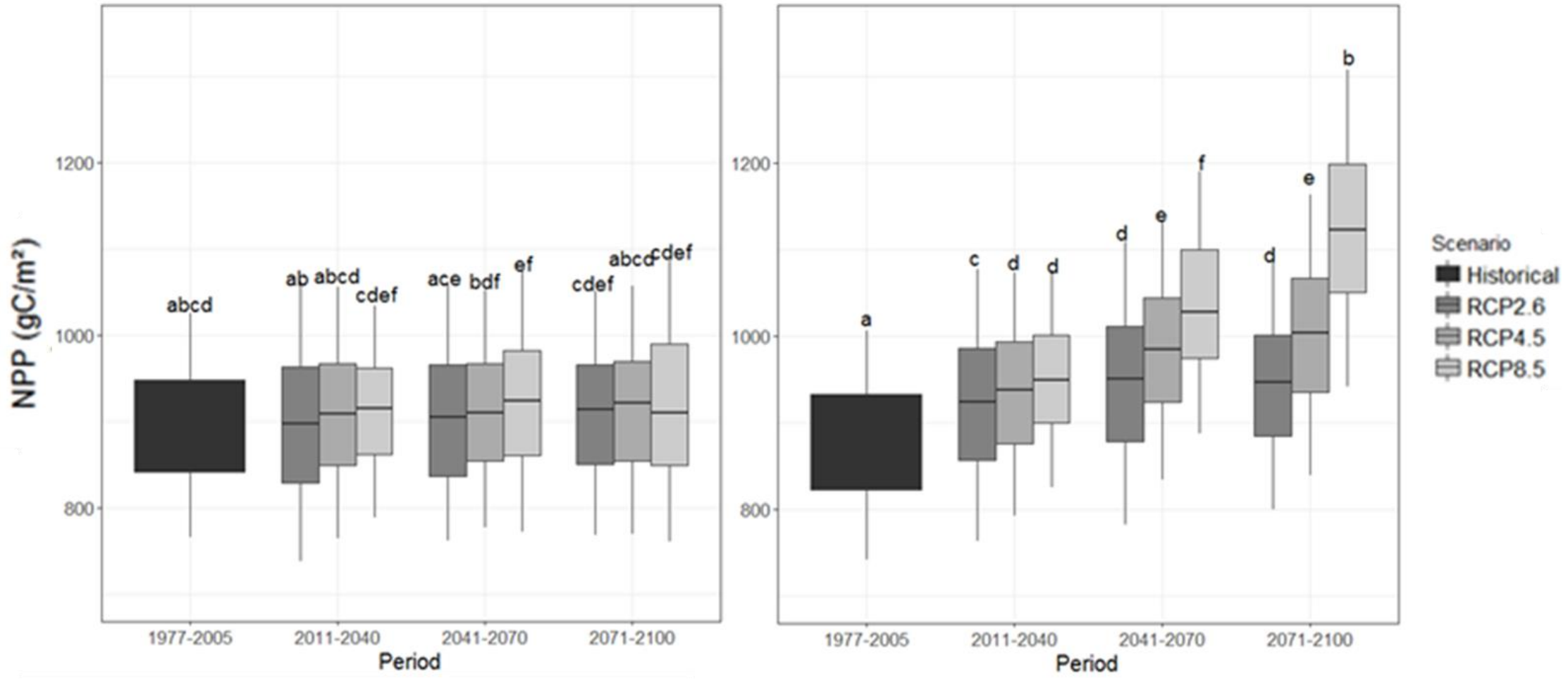
Water cycle evaluation: Relative extractable water



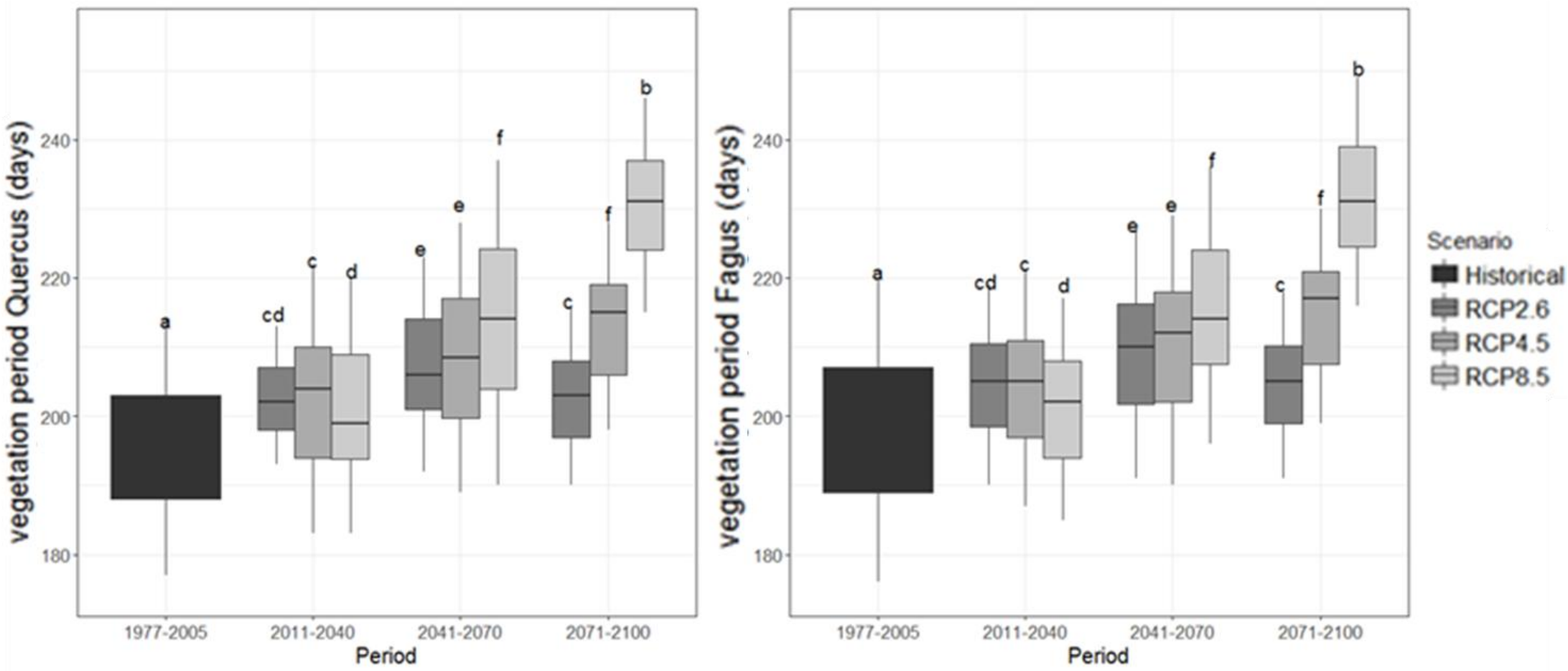
Simulation description

- 6 sites in Wallonia (Southern Belgium)
- 3 downscaled climate scenarios (RCP2.6-4.5-8.5) for the 2011-2100 period
- 1 downscaled reference climate period between 1976-2005
- Succession of 1-year model run with same initial conditions
- Repetition of simulations with constant and variable CO_2 concentrations

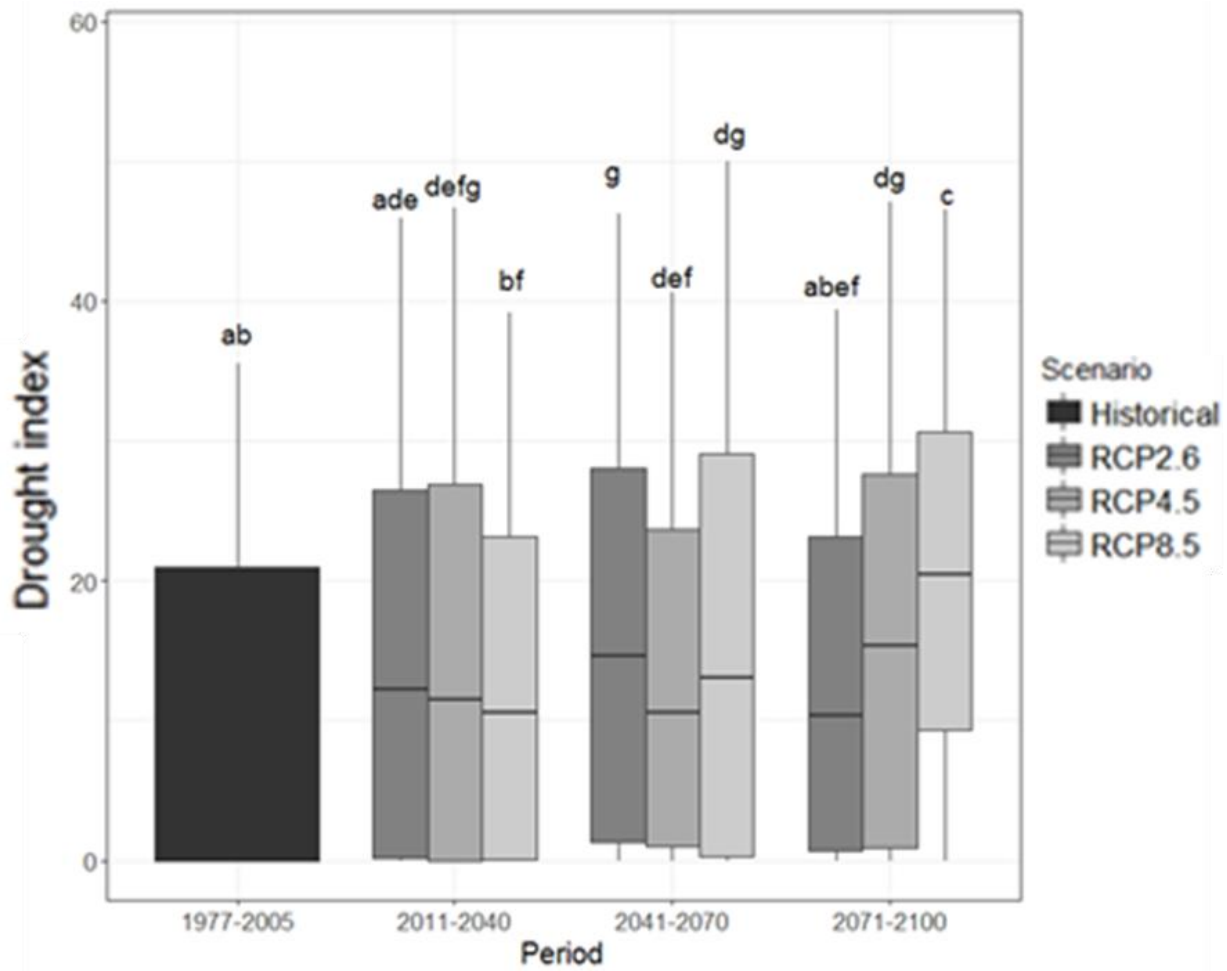
Simulation results: NPP evolution

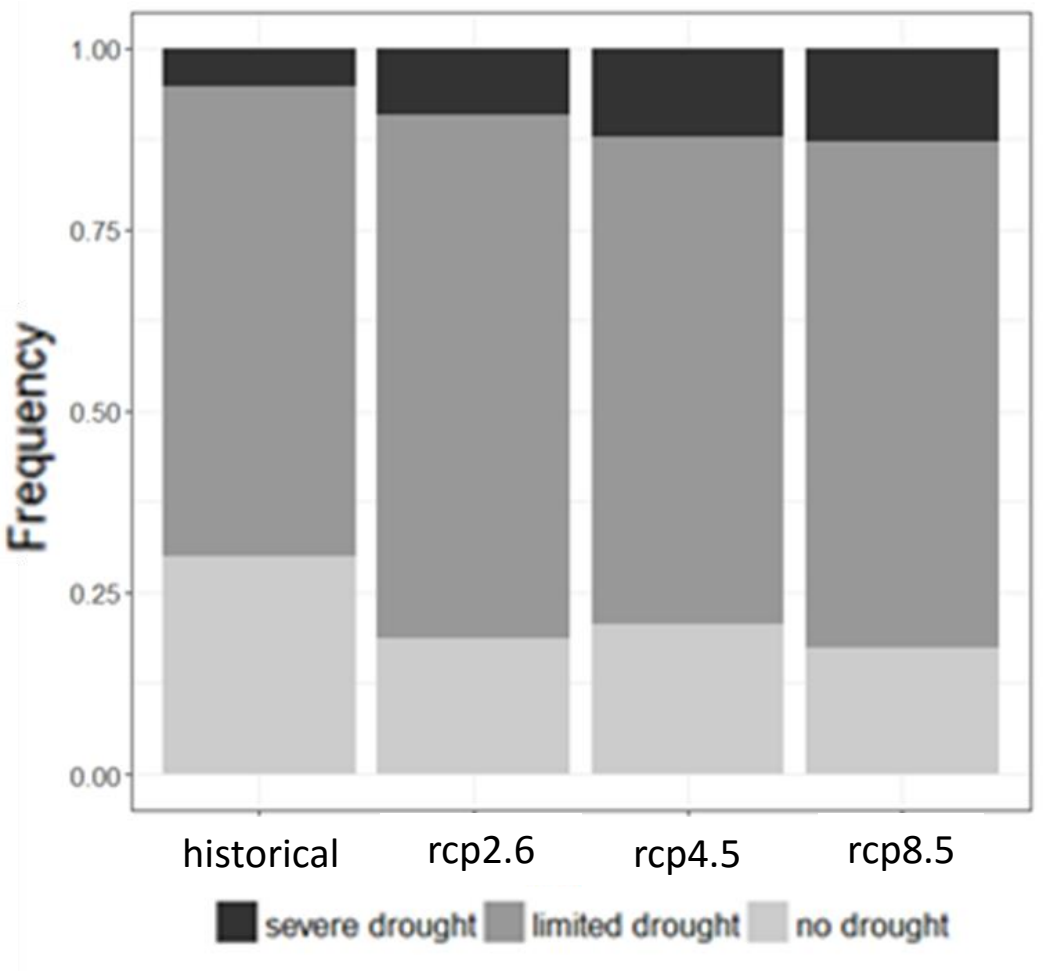


Simulation results: Increase of vegetation period



Simulation results: Increase of drought stress





Simulation results: Factors of NPP variability

Drought index explains 32% of NPP variability

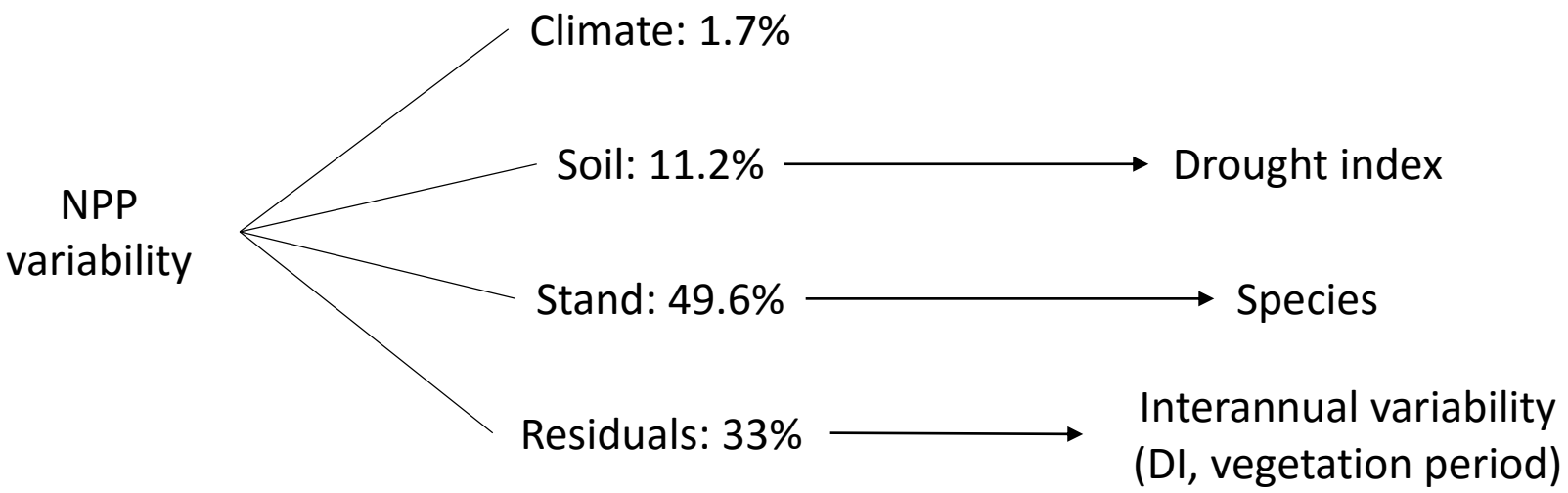
The influence of the vegetation period length is significant but often hidden because of its lower variability

A major part of NPP variability (38%) depends on the site (stand, soil and climate)

	Estimate	R^2
Fixed effects		
Intercept	545.42	/
Drought index	-5.48	0.322
Vegetation period	2.07	0.066
Random effects		
Site	0	0.384
Residuals	0	0.230
Total	/	0.770

Disentangling the stand, soil and climate influence

Simulations with 6 stands x 6 soils x 4 climate (reference period) = 144 combinations



Perspectives: Improvement of the model ability to predict climate change impacts

- Adaptation of HETEROFOR to coniferous species (Norway spruce, Scots pine, Douglas fir, Silver fir)
- Model evaluation and simulations at the European scale using level II plots of ICP forests (RENECOFOR)
- Estimation of prediction uncertainty originating from climate projections and model parameters
    - Improvement and comparison of climate downscaling methods
    - Characterization of model parameter distribution with a Bayesian calibration procedure