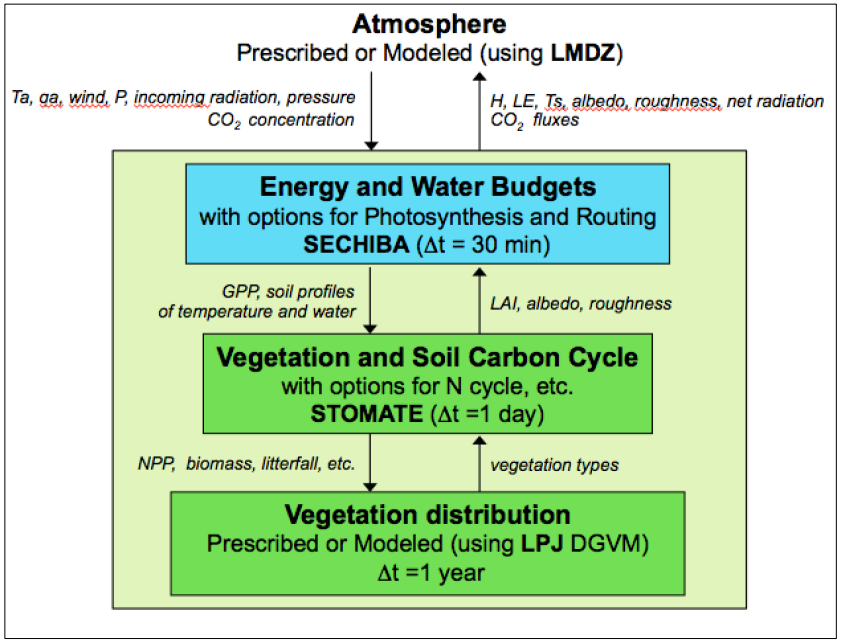
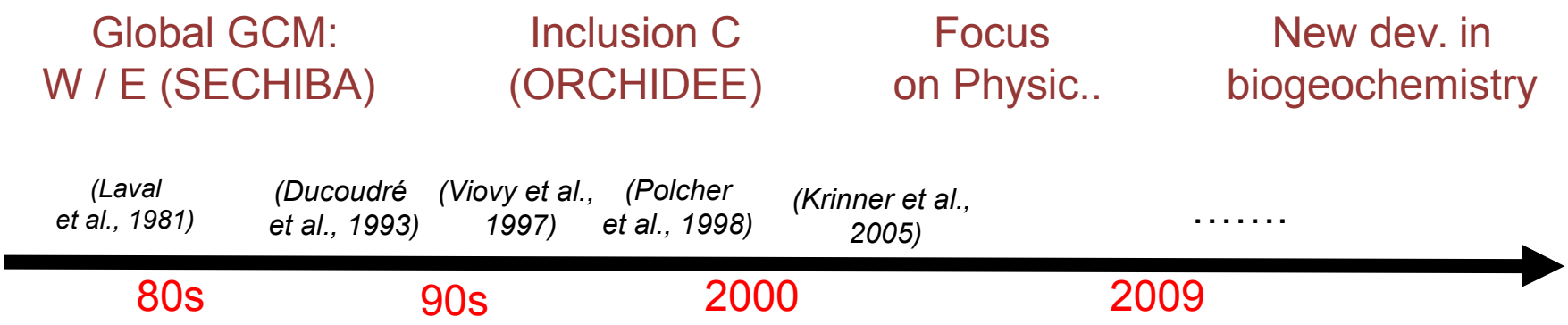
Recent evolutions of ORCHIDEE, progress toward a 3rd generation land surface model.

The ORCHIDEE Team



ORCHIDEE: 20-yr of development

History :



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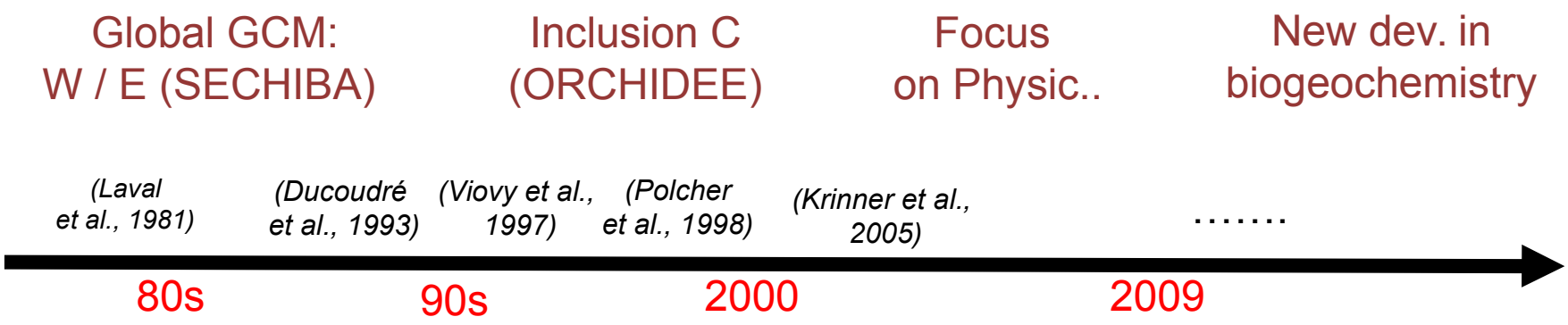
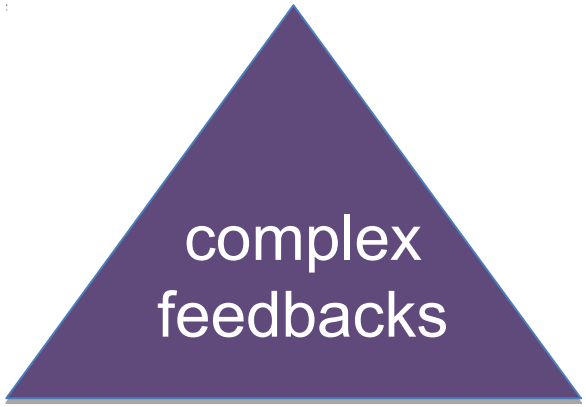


Energie budget



Water budget

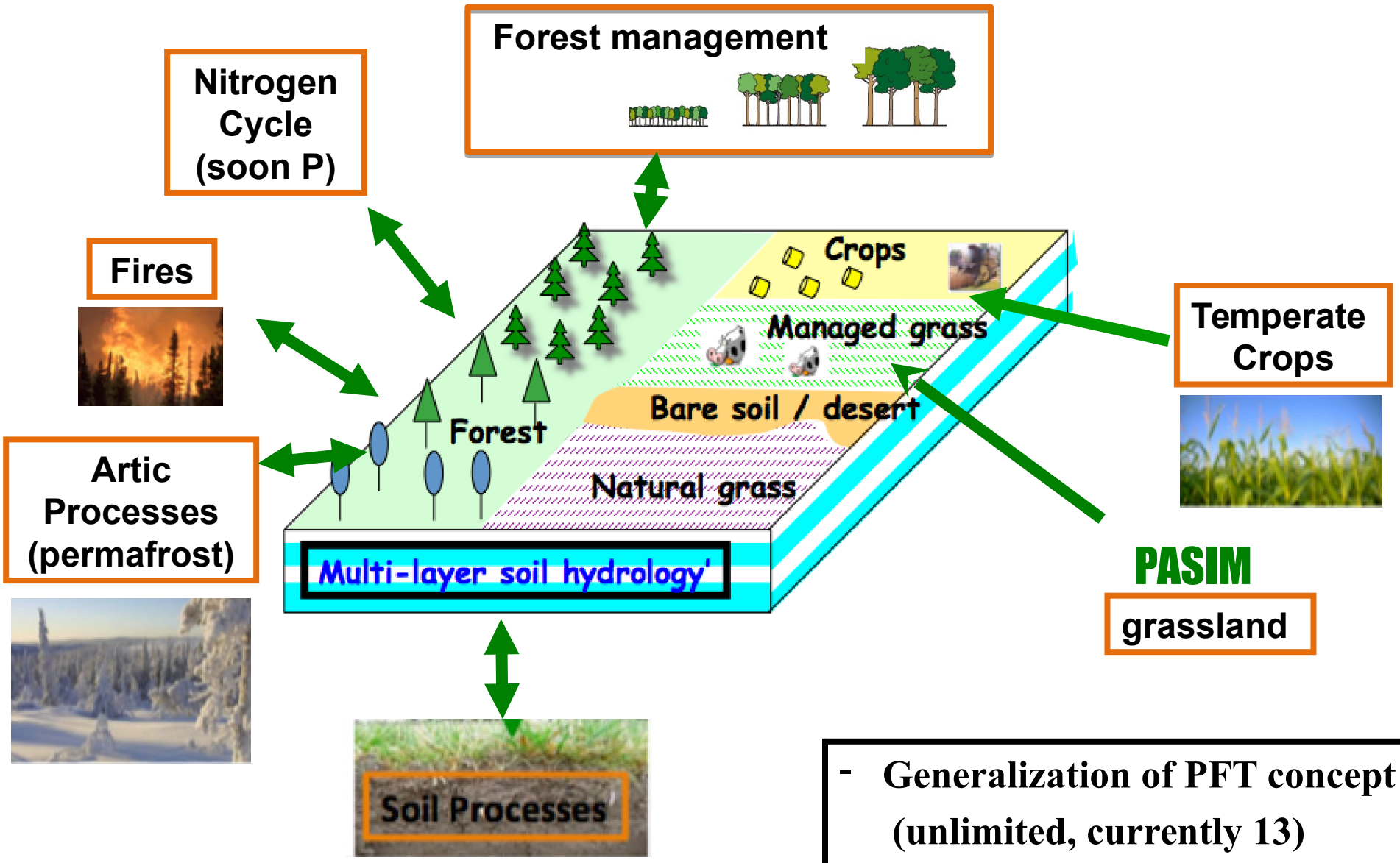
Carbone / Nitrogen budgets

Challenge:
maintain coherence & describe feedback between **Physic** and **Biogeochemistry**

Overview

- The multi-layers soil hydrology scheme
- The new snow scheme & High latitude processes
- Swamps and floodplains
- Improved soil carbon decomposition
- A new multi-layers canopy energy scheme
- Conclusions

Recent improvements of ORCHIDEE

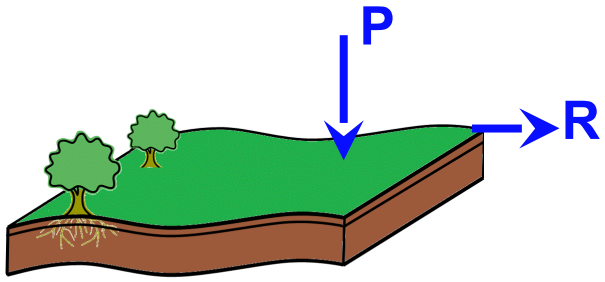


- Generalization of PFT concept (unlimited, currently 13)
- Analytical soil C spin-up

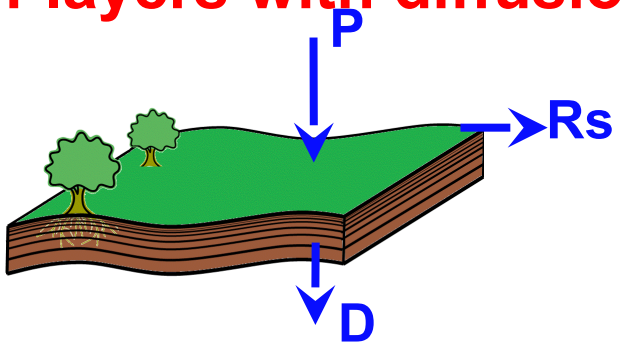
Multi-layer soil hydrology

- Why a “new” physically-based scheme (vs old double-bucket scheme) ?
  - Better represent Infiltration vs Runoff processes
  - Plant water uptake:
    - Different plants have different root profiles
    - Compute hydraulic lift : from soil to leaf water potential
  - SOM decomposition is a function of W, T,..

2 buckets scheme

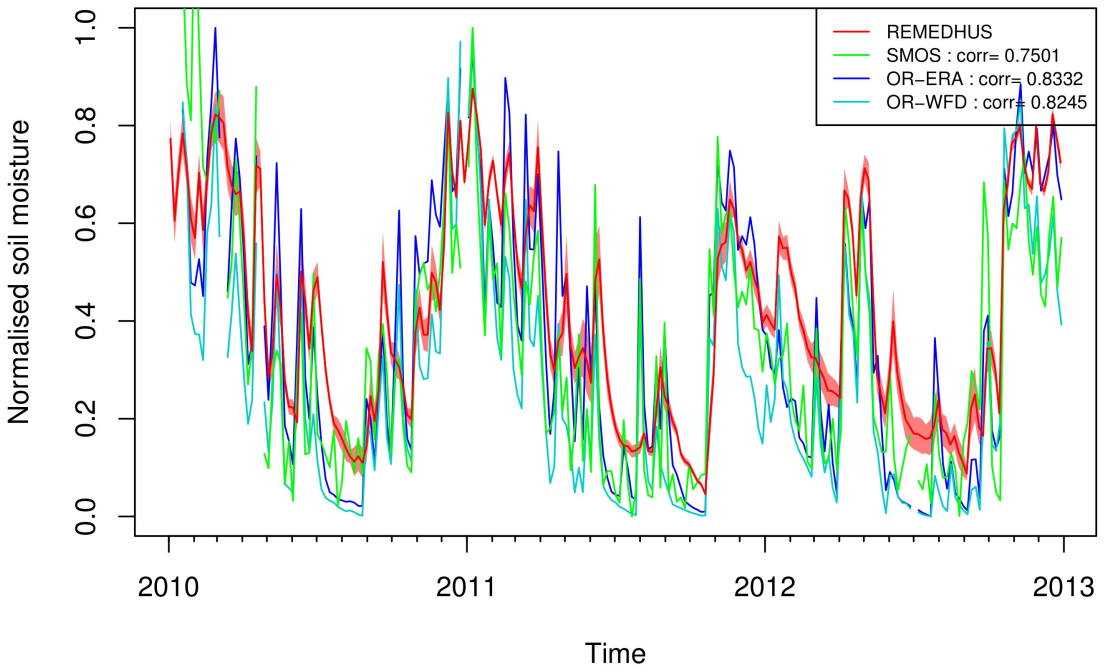


11 layers with diffusion



Soil moisture evolution

Comparison with SMOS data



REMEDHUS site in central Spain:

Lon: -5.3, lat: 41.3.

5 days average to reduce instrument noise

REMEDHUS : spread between 19 stations

SMOS pixel

ORCHIDEE forced by ERA

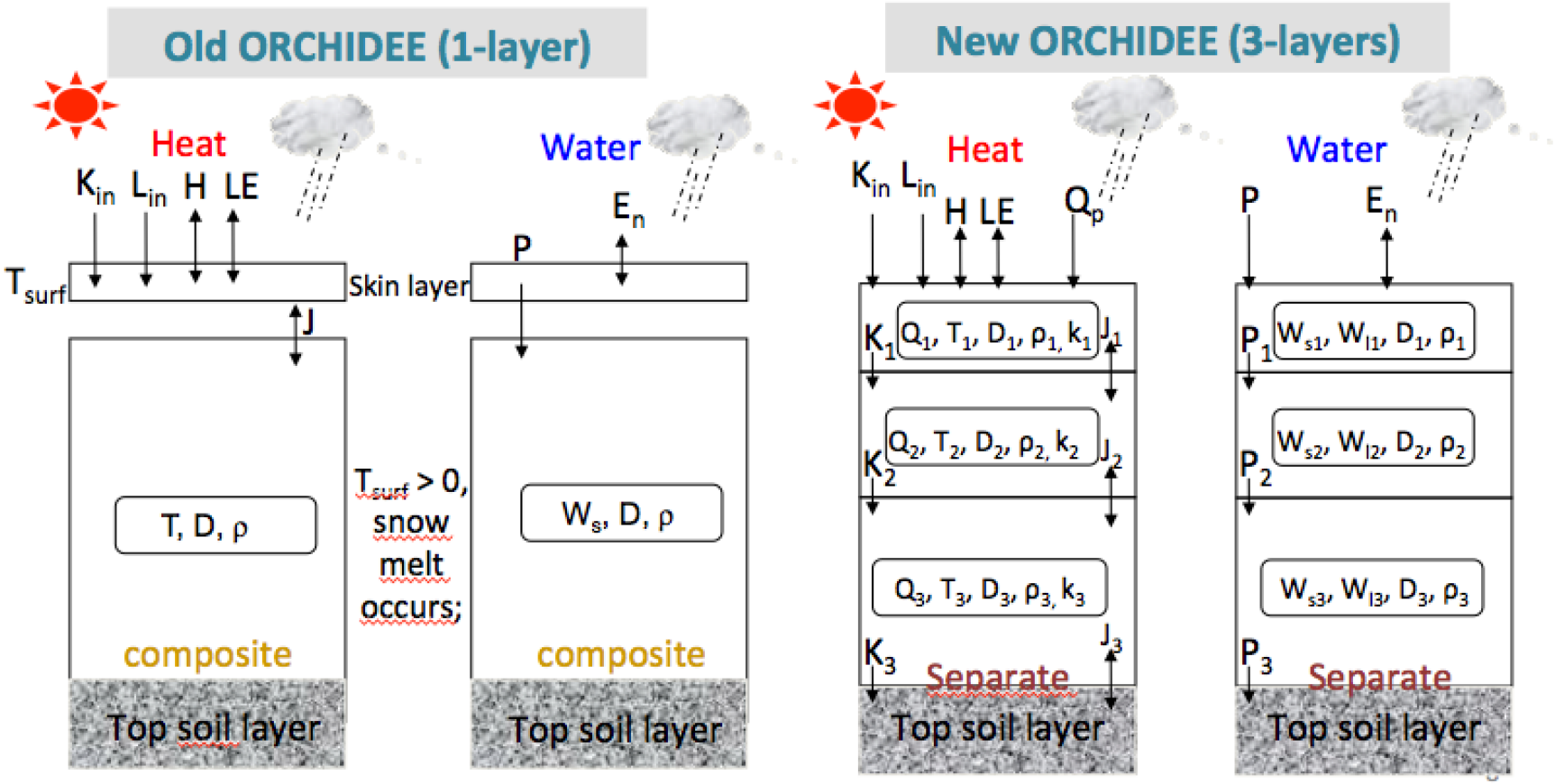
ORCHIDEE by WFDEI

- The general annual cycle is rather well captured.
- The drying is stronger in SMOS and ORCHIDEE.
- SMOS signal is the most spiked observation.

Polcher et al. RSE, 2015

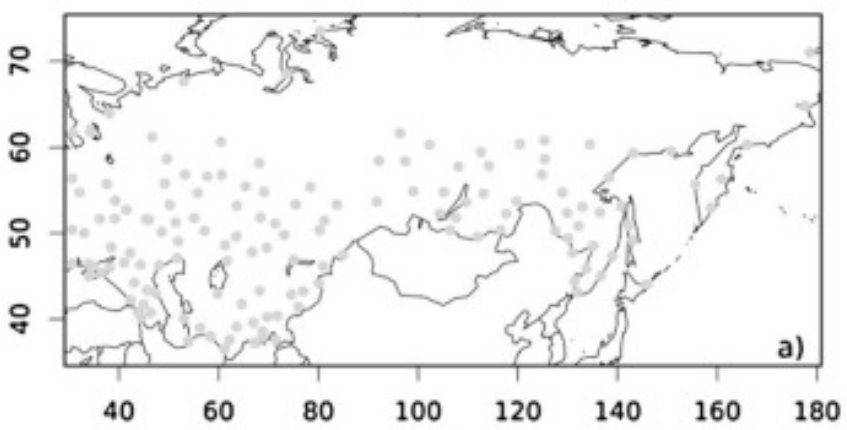
Multi-layer snow scheme

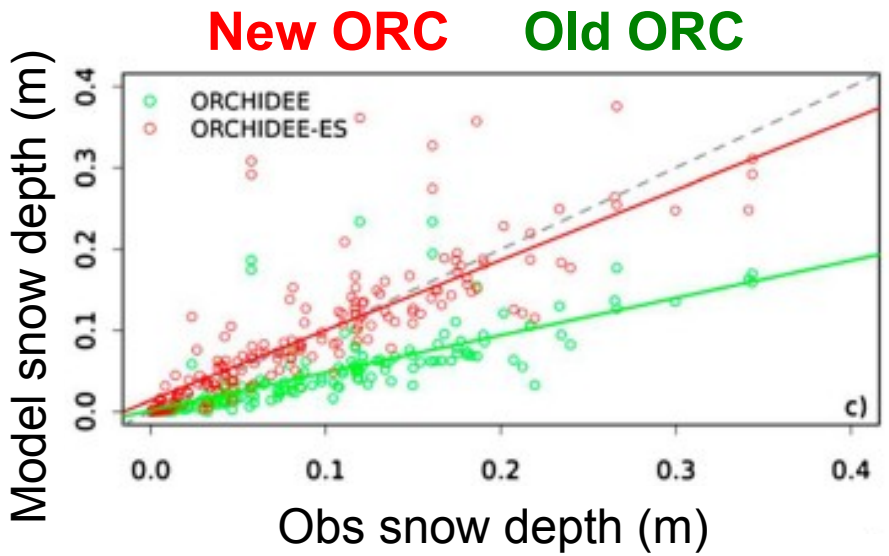
- 3 layers scheme to improve:
  - Snow dynamic (spring)
  - Snow – vegetation interactions (Shrub, grass, ..)



Evaluation on new snow scheme

Daily snow depth (density, SWE) for Northern Eurasia,
165 stations HSDSD (1979-1992)

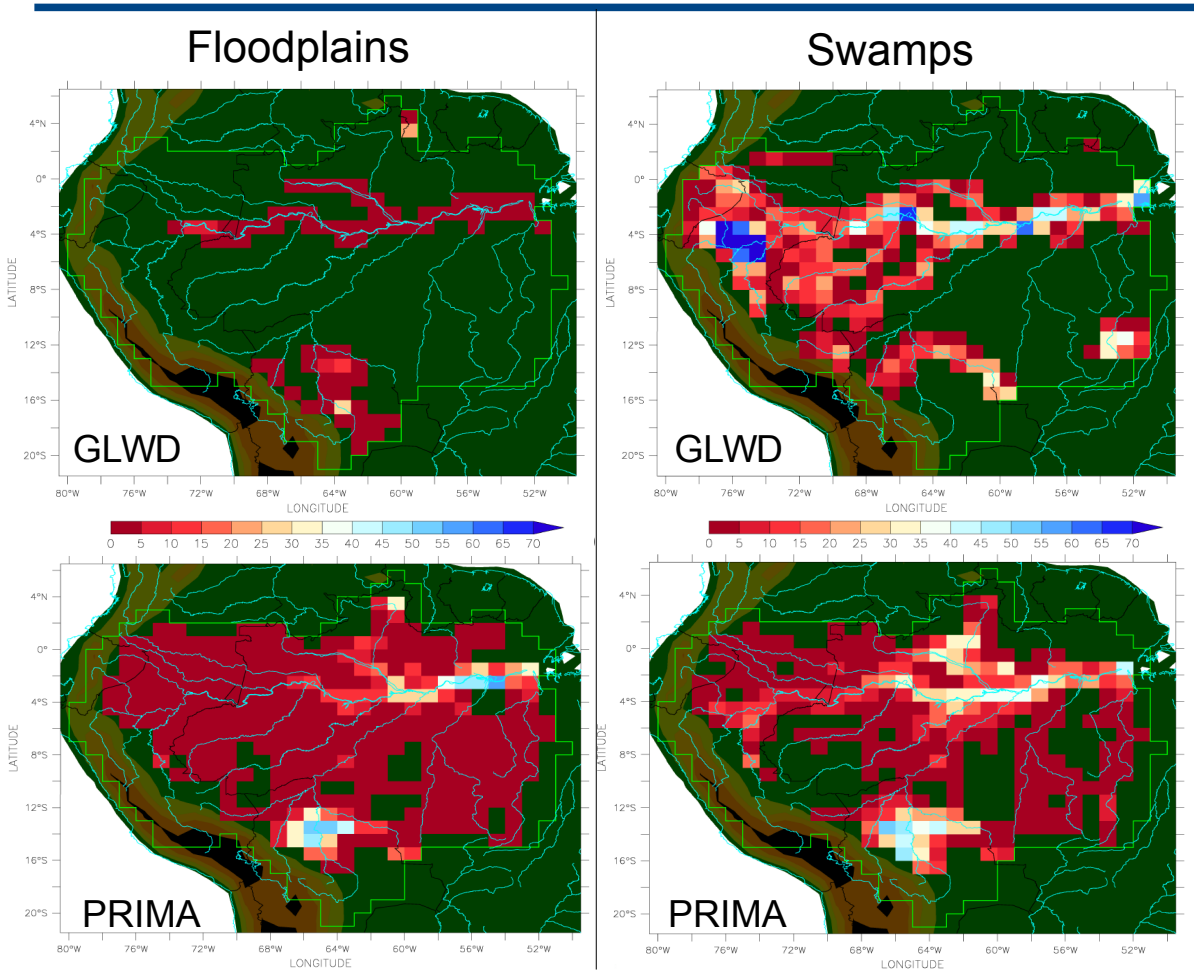




Corr: 0.78 -> 0.83
RMSE: 0.12 -> 0.10 m
MBE: -0.05 -> 0

Wang et al., JGR, 2013

A new satellite-derived map of maximal fraction of floodplains and swamps

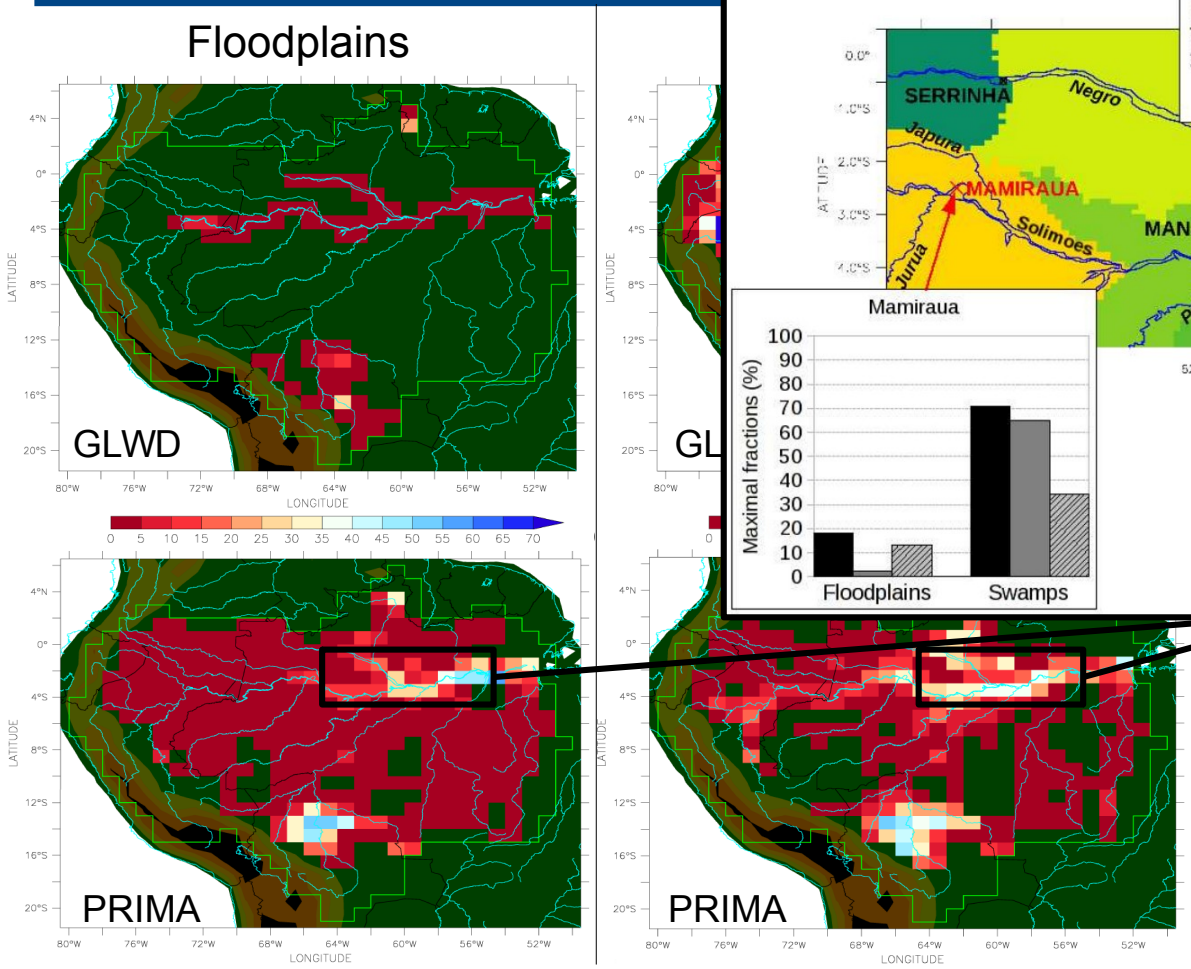


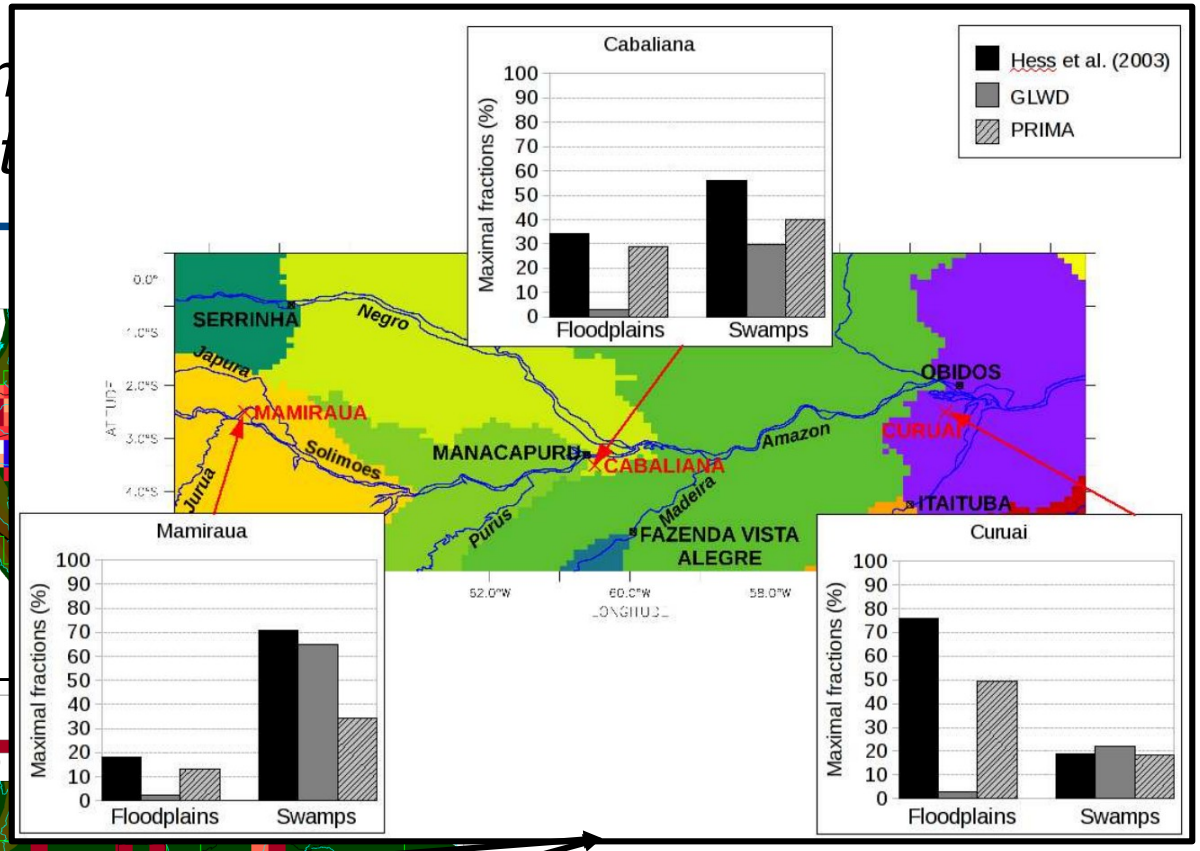
Initially for ORCHIDEE:
GLWD (Lehner & Döll, 2004)
Applications : d'Orgeval & al. (2008)

Combines Prigent et al. Estimates and SAR observations.

Guimberteau et al., HESS, 2012

A new satellite-derived m… maximal fract…





Maximal fraction within the mesh (%)

Guimberteau et al., HESS, 2012

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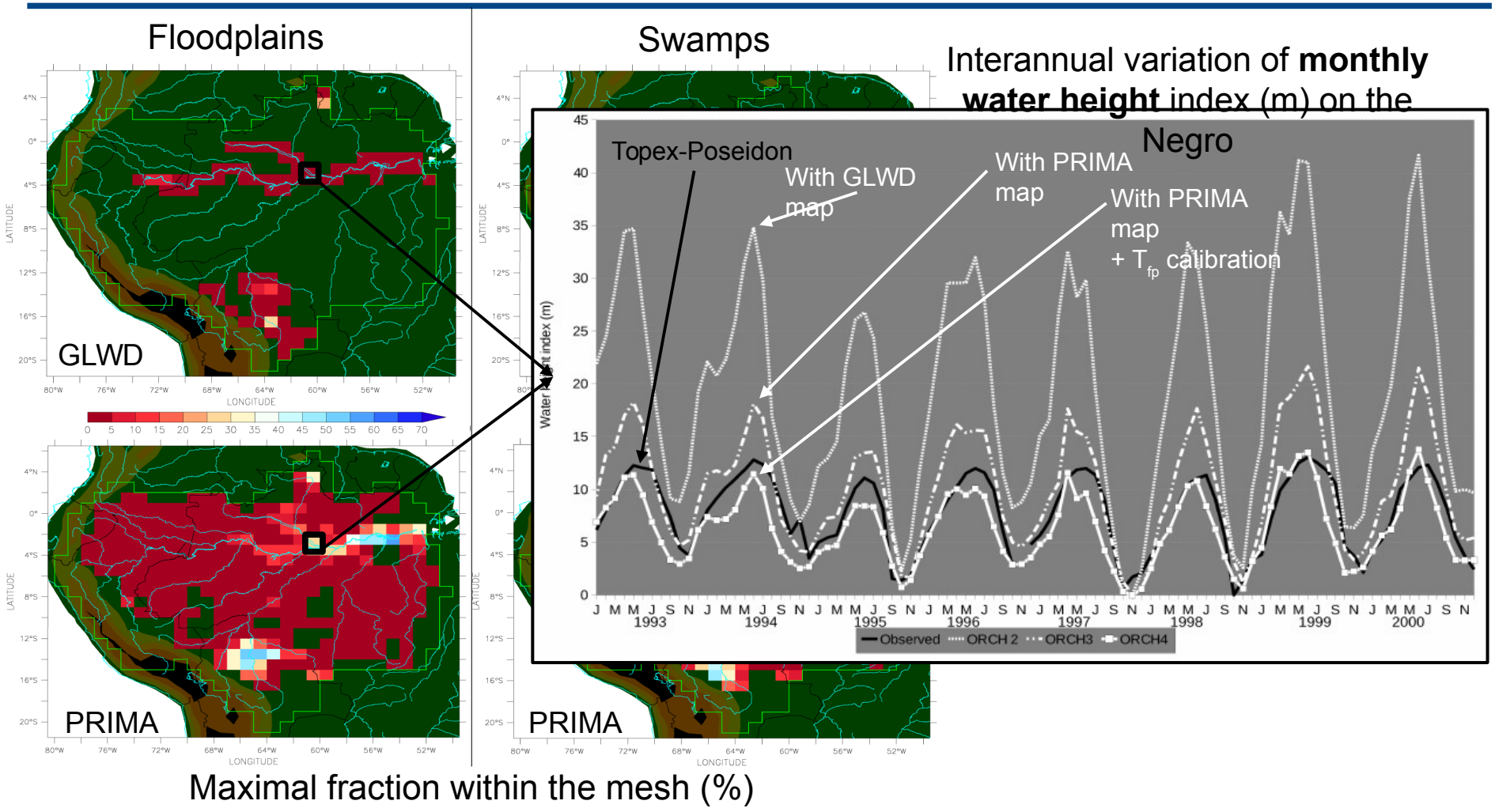
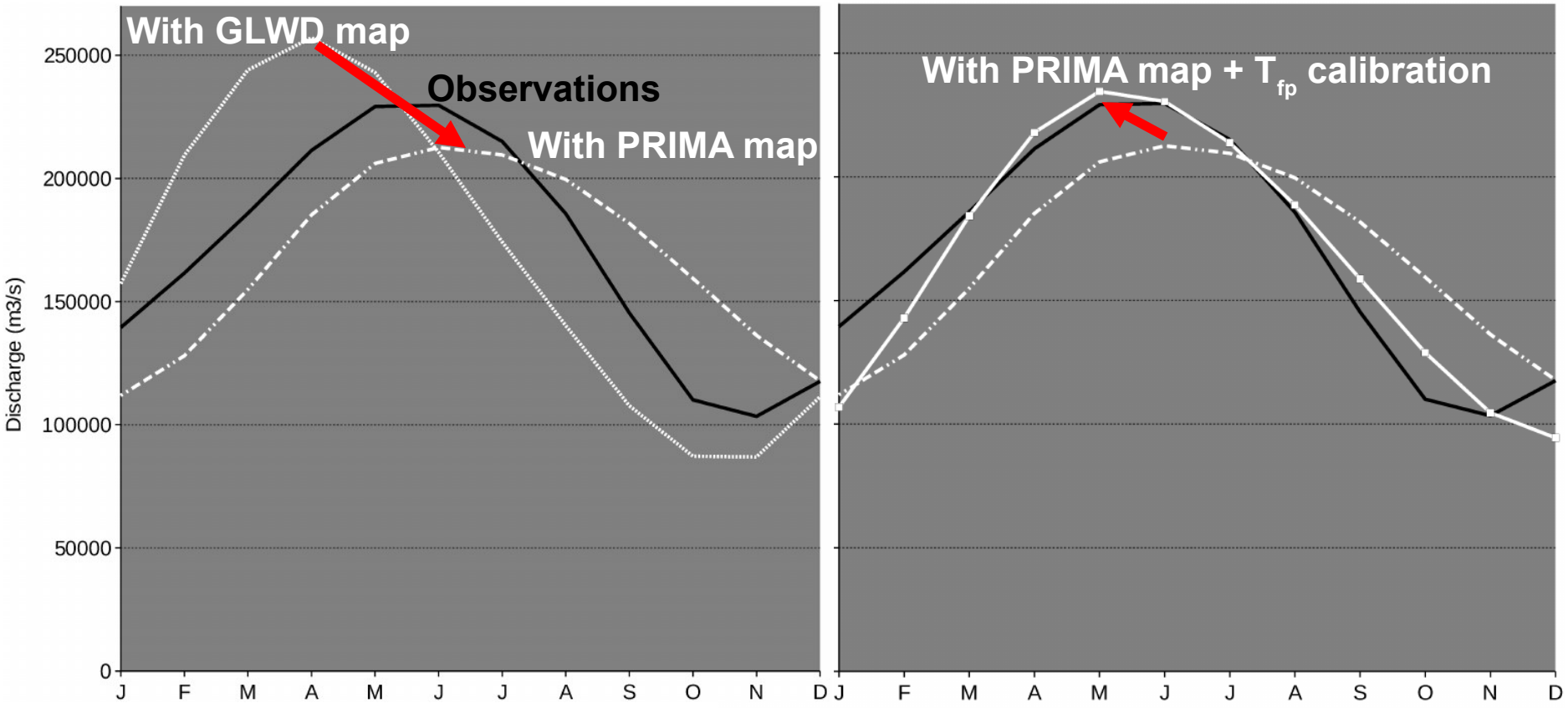


Guimberteau et al., HESS, 2012

Impact on the discharge at Óbidos

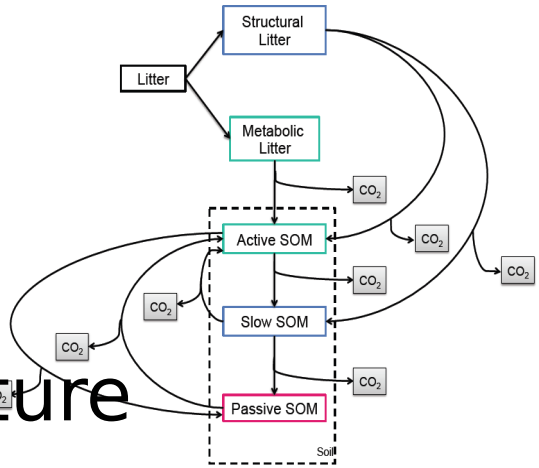


Nash: 0.40 → 0.80

Guimberteau et al., HESS, 2012

New soil carbon decomposition scheme

- Motivations
  - Current model (century) simple missing processes (i.e. priming)
  - Effect of temperature and moisture still relatively simple



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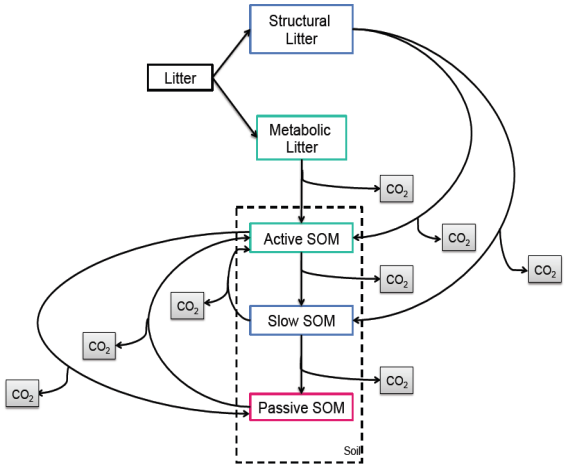
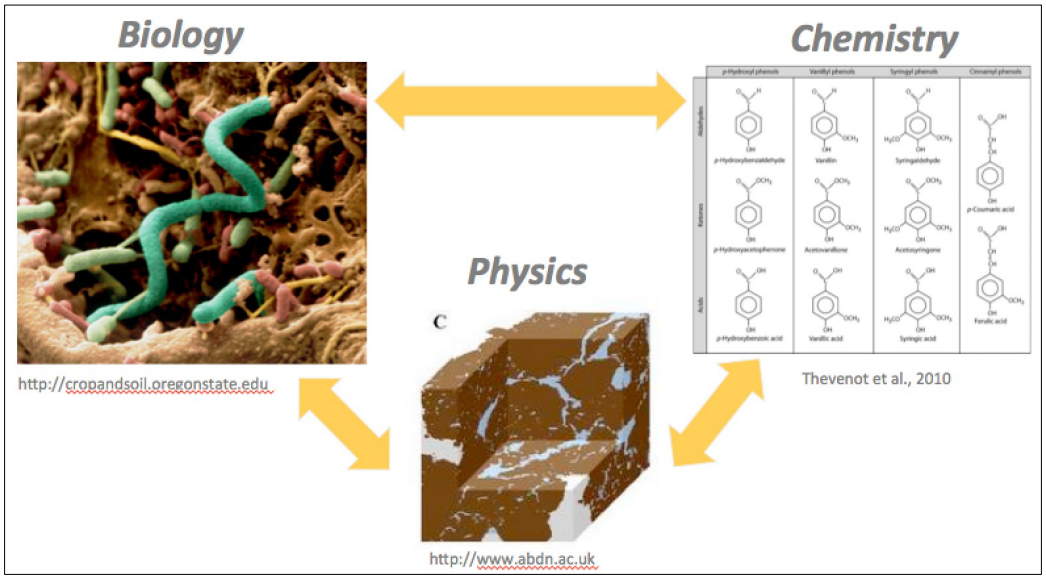


?

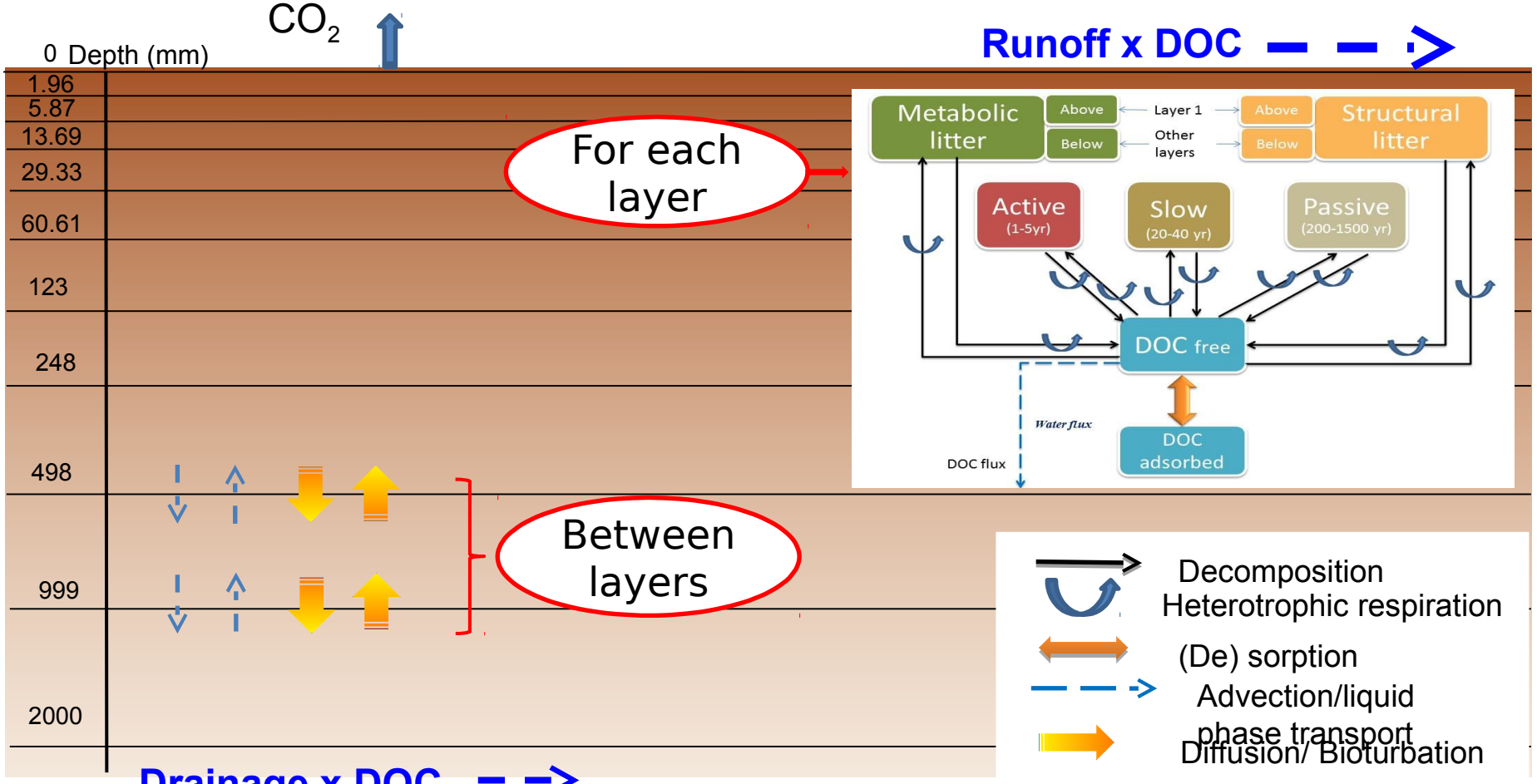


A NEW SOIL CARBON MODULE

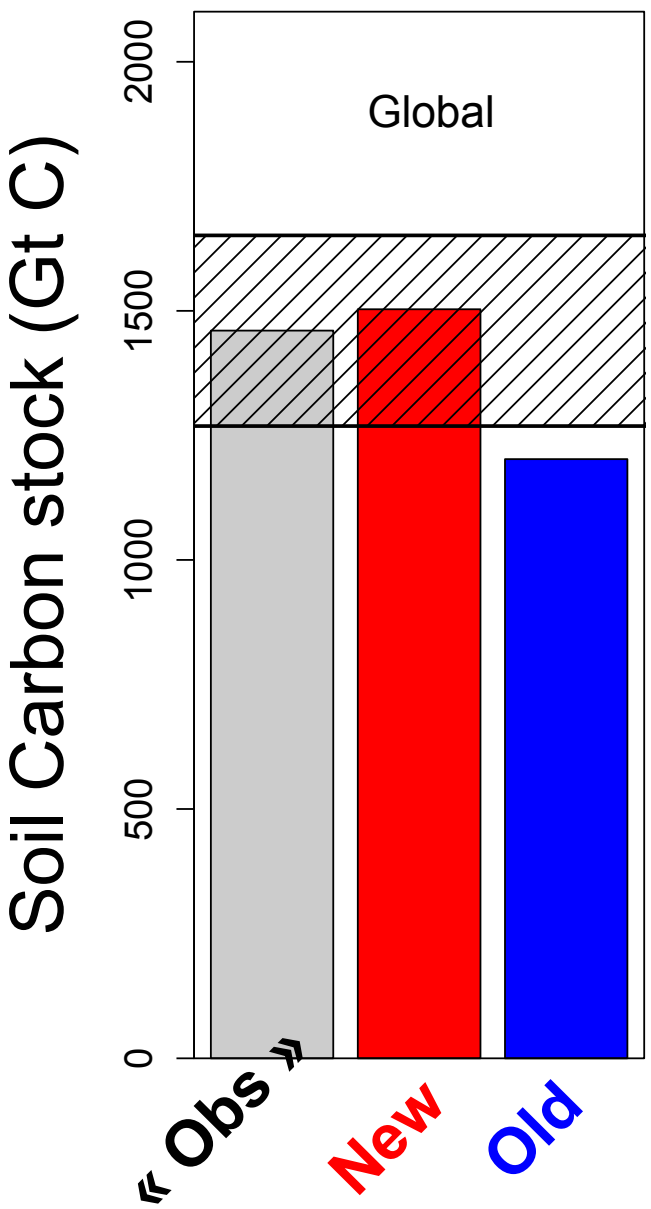
- Discretized soil carbon (11 layers) + new pools introduced (DOC)

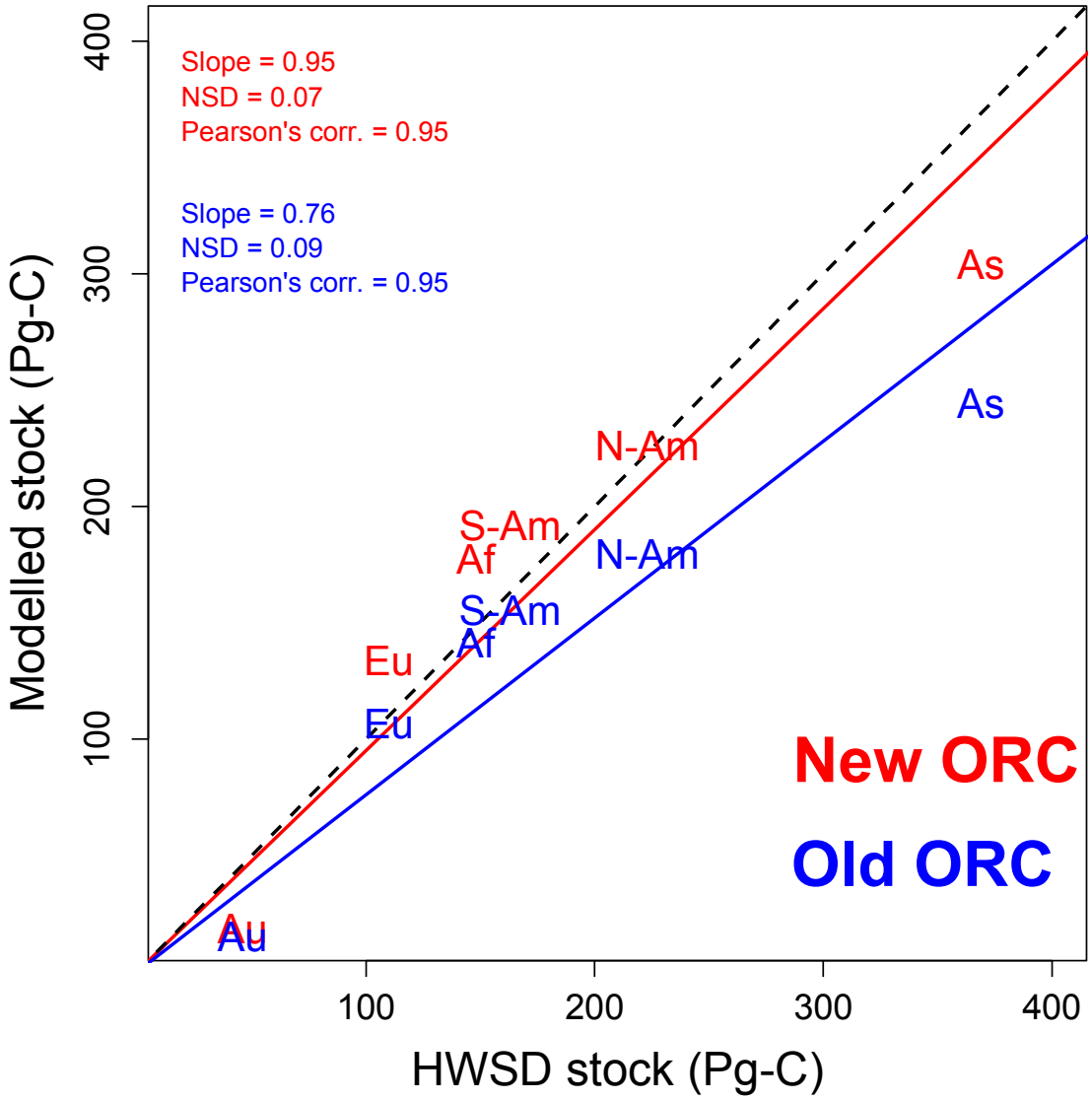
$$\frac{\partial SOC}{\partial t} = I - k_{SOC} \times SOC \times (1 - e^{-c \times FOC}) \times \theta \times \tau$$

- New decomposition scheme (priming):



Impact of new scheme on total SOM





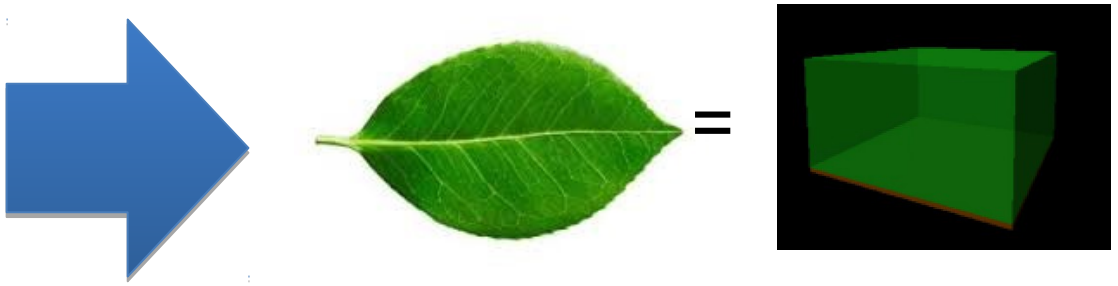
A new multi-layer energy balance scheme

- Why a multi-layer energy canopy scheme ?

Ecosystem structure

Model representation

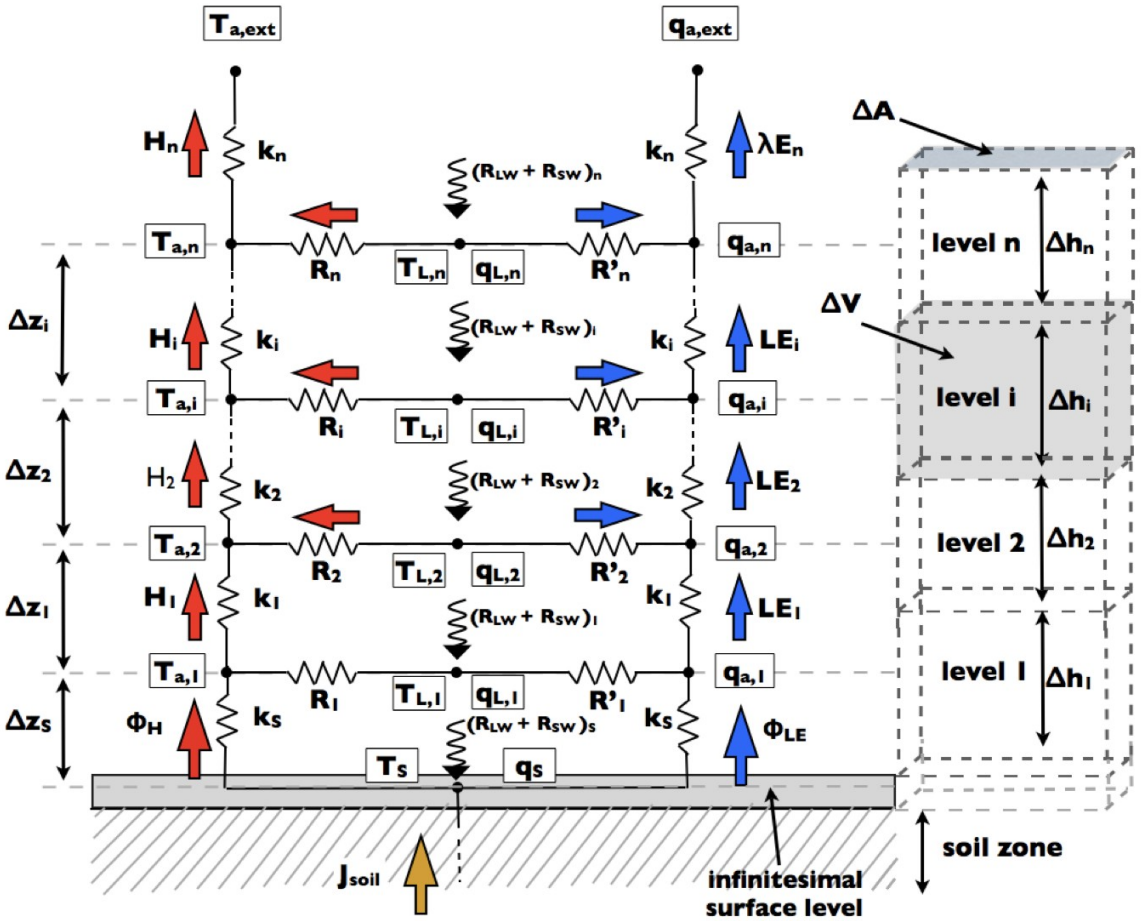
Big leaf model



- Poorly represent site-level heat fluxes
- Canopy space and Trunk crown have different behaviours
- Under-storey vs over-storey representation ?
- Link to atmospheric turbulence

Multi-layer scheme implementation

- Free number of layers
- E / W / C exchange at each level
- Turbulence mixing within air canopy
- Light penetration following Pgap model



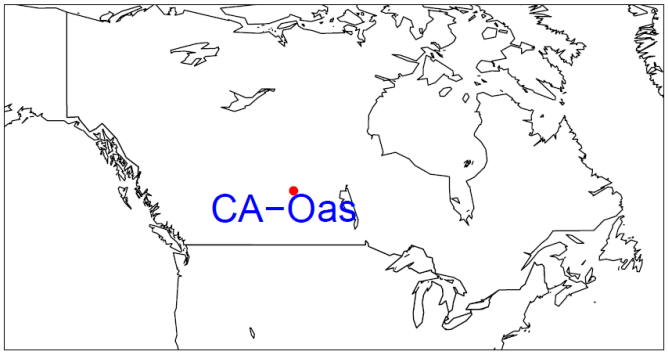
Implementation constraints :

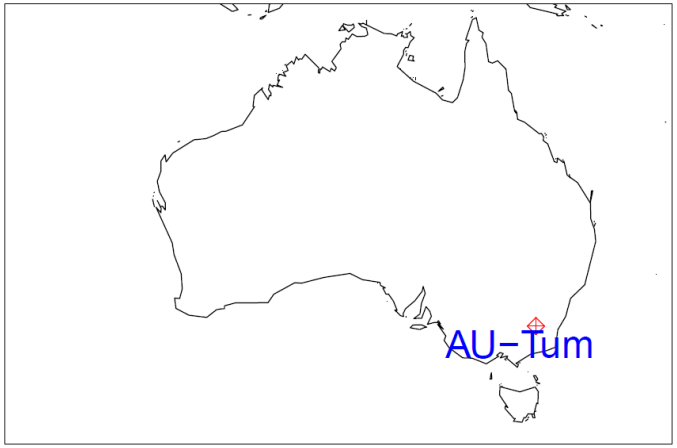
- Coupling with plant growth / harvesting module (variable plant height)
- Implicit coupling with Atmospheric model (30' step)
- Parametrisation of intra-canopy turbulence

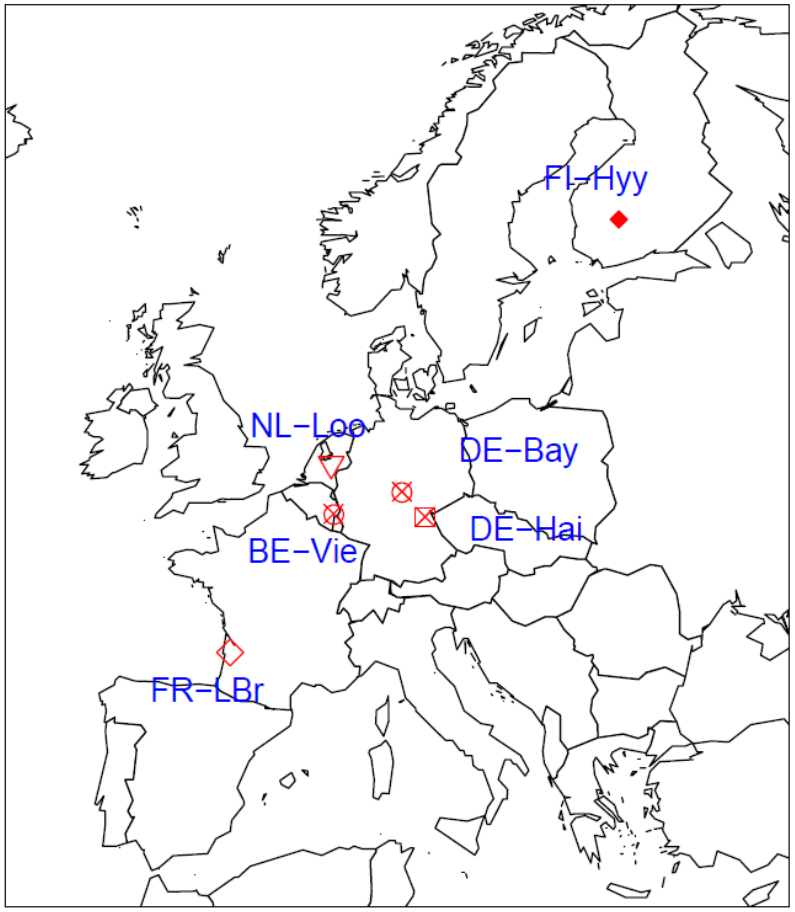
Ryder at al, GMD, 215

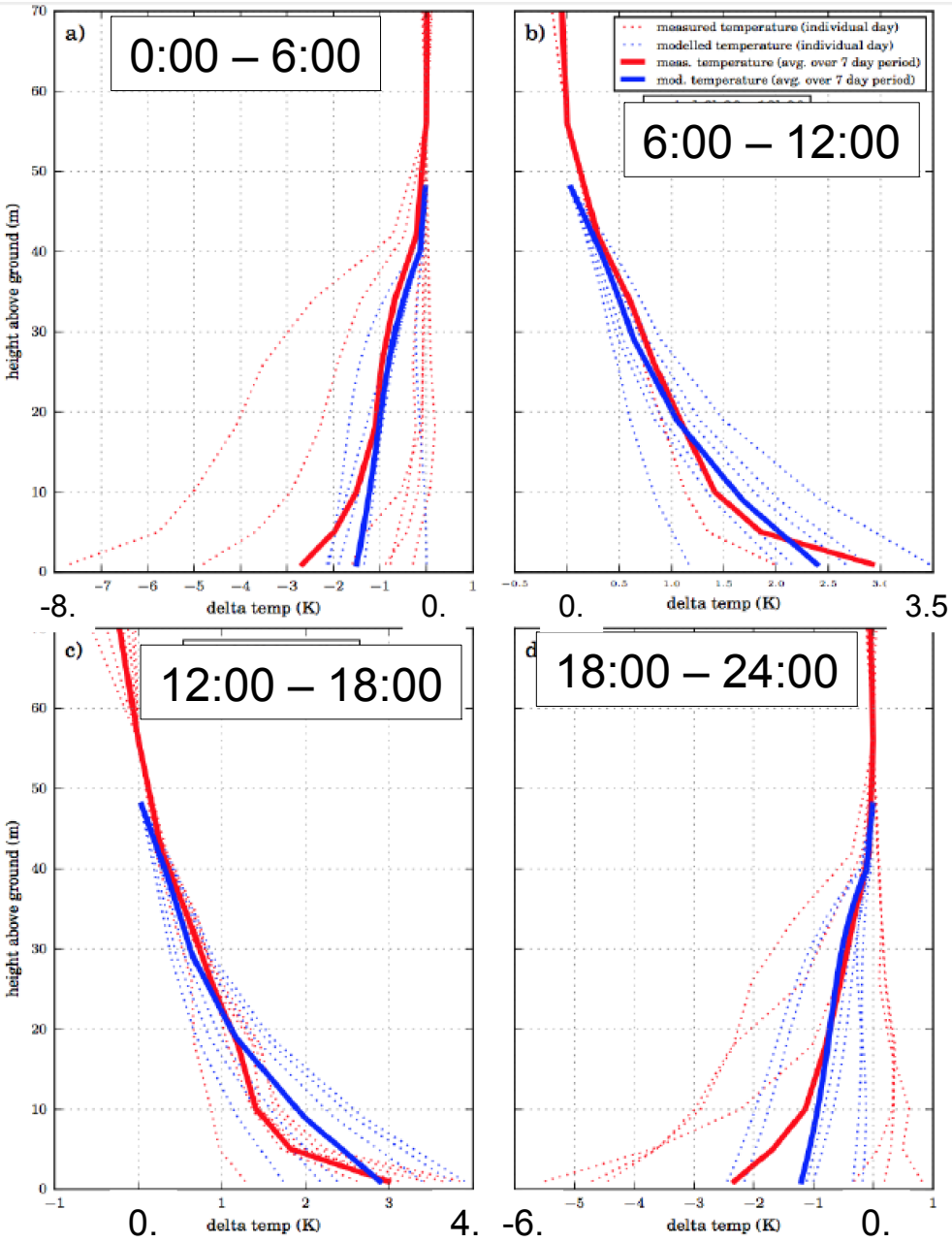
Site evaluation of the model

→ Availability of vertical profiles for Temp, Wind, Rh is crucial









Daily temperature

Temperature profile at Tumbarumba site

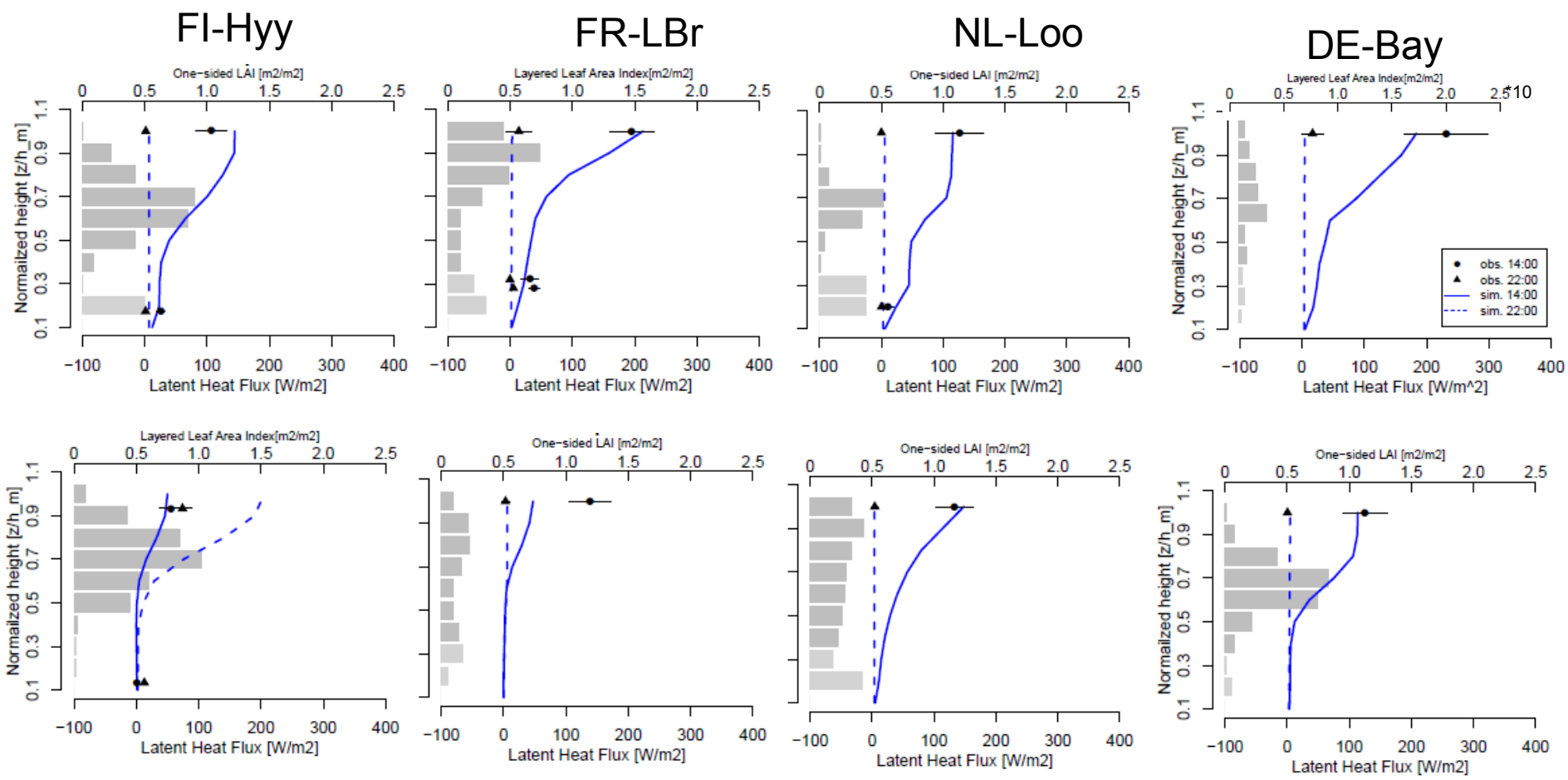
Observations

Model

Ryder at al, GMD, 215

Multi-Layer Latent Heat Flux

▲ ● Obs — — 22:00 ——— 14:00



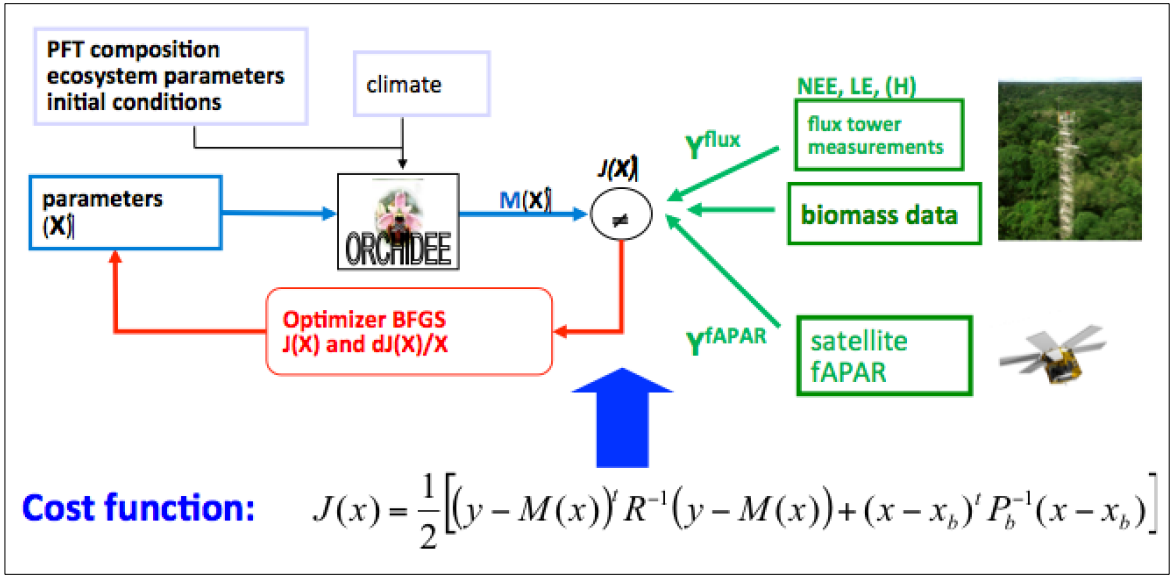
Monthly average flux (months change from one site to the other)

Chen et al. In preparation

What can we learn from Data Assimilation ?

Optimization of ORC parameters

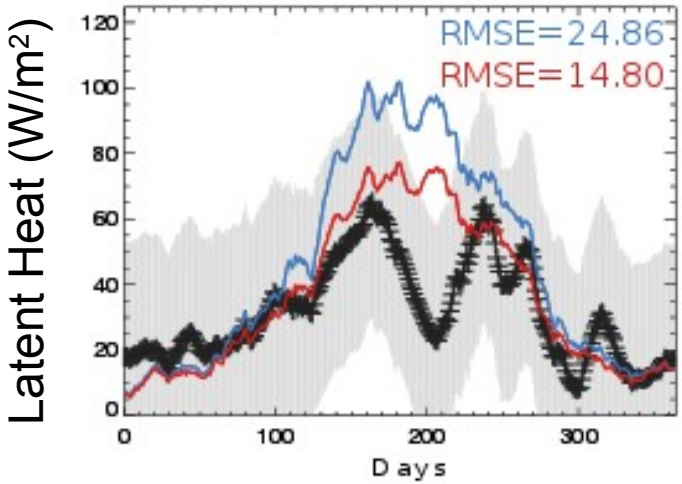
- ✓ FluxNet data (70 sites)
- ✓ ≈ 25 optimized parameters / PFT



➔Parameter errors can be nearly as large as Structural errors

➔Large param. error correlations

➔Highlight model deficiencies



Puechabon Fluxnet site (2004)
Bacour et al. sub

Conclusion

- Soil physic (W, C, E), snow are critical..
- Escaping from the “big leaf” concept will be part of 3rd gen. LSMs.
- Parametrization are critical and may depend on scale considered.
- We need to better use data on plant traits and other ecological characteristics.
- Biogeochemistry & Biophysics should be developed together.
- Difficult to maintain coherence between various component !

Thanks for your attention..

ORCHIDEE

yesterday

(many branches)

.?.

ORCHIDEE

tomorrow

All developments into main Trunk