



Development of ORCHIDEE-CROP v1.0: a Nitrogen-Explicit Agro-Land Surface Model and its Evaluation Across European Wheat Sites

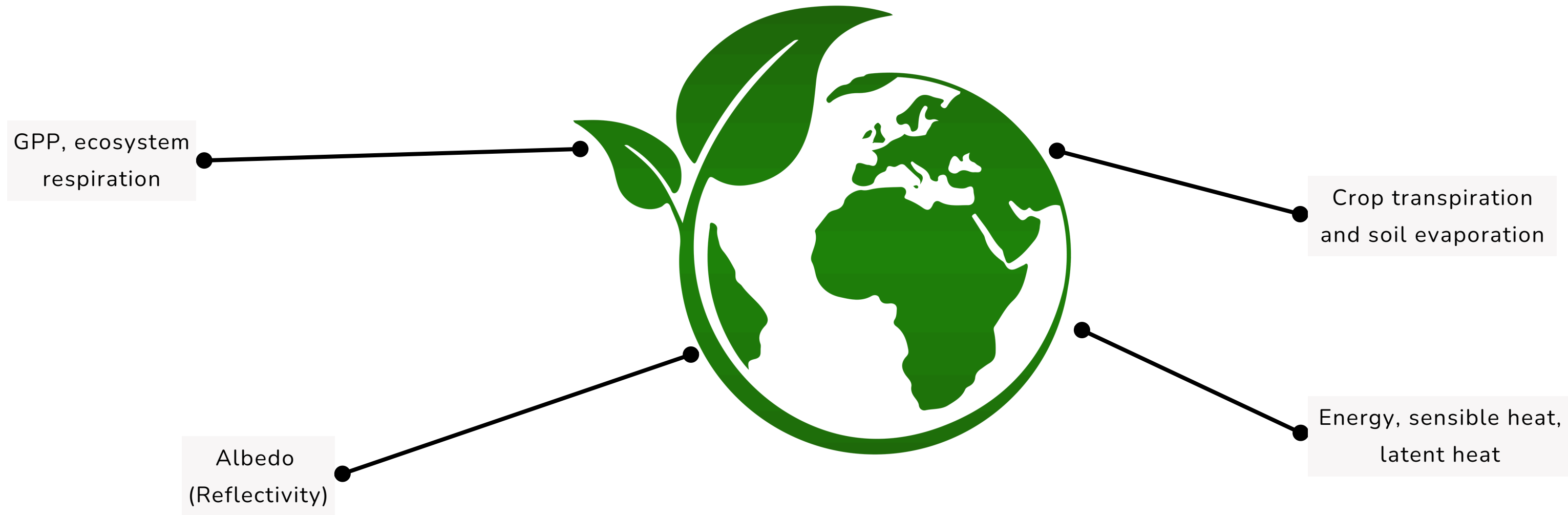
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Importance of Representation of Crops in LSMs



 Croplands cover 12%-15% of terrestrial surfaces

 Crop representation in LSMs critically impacts:

- ➔ CO₂ fluxes
- ➔ Evapotranspiration
- ➔ Surface energy balance



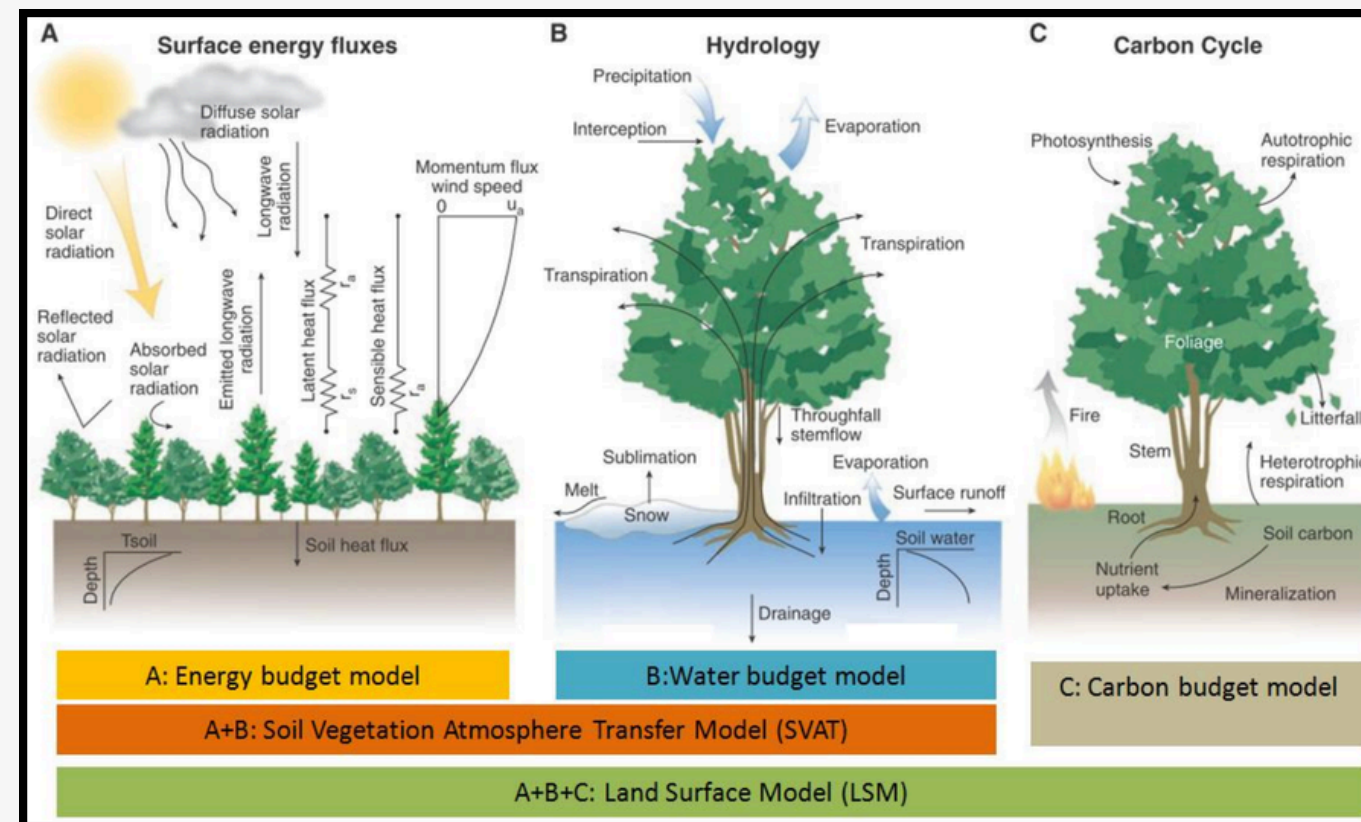
However, in many land surface models, crop processes are still represented in a simplified way

Complementarity Between ORCHIDEE and STICS

ORCHIDEE:

- **Generic crop vegetation:** Represented as simple C3/C4 grass rather than specific crop species.
- **Static Phenology:** Lacks growth stages.

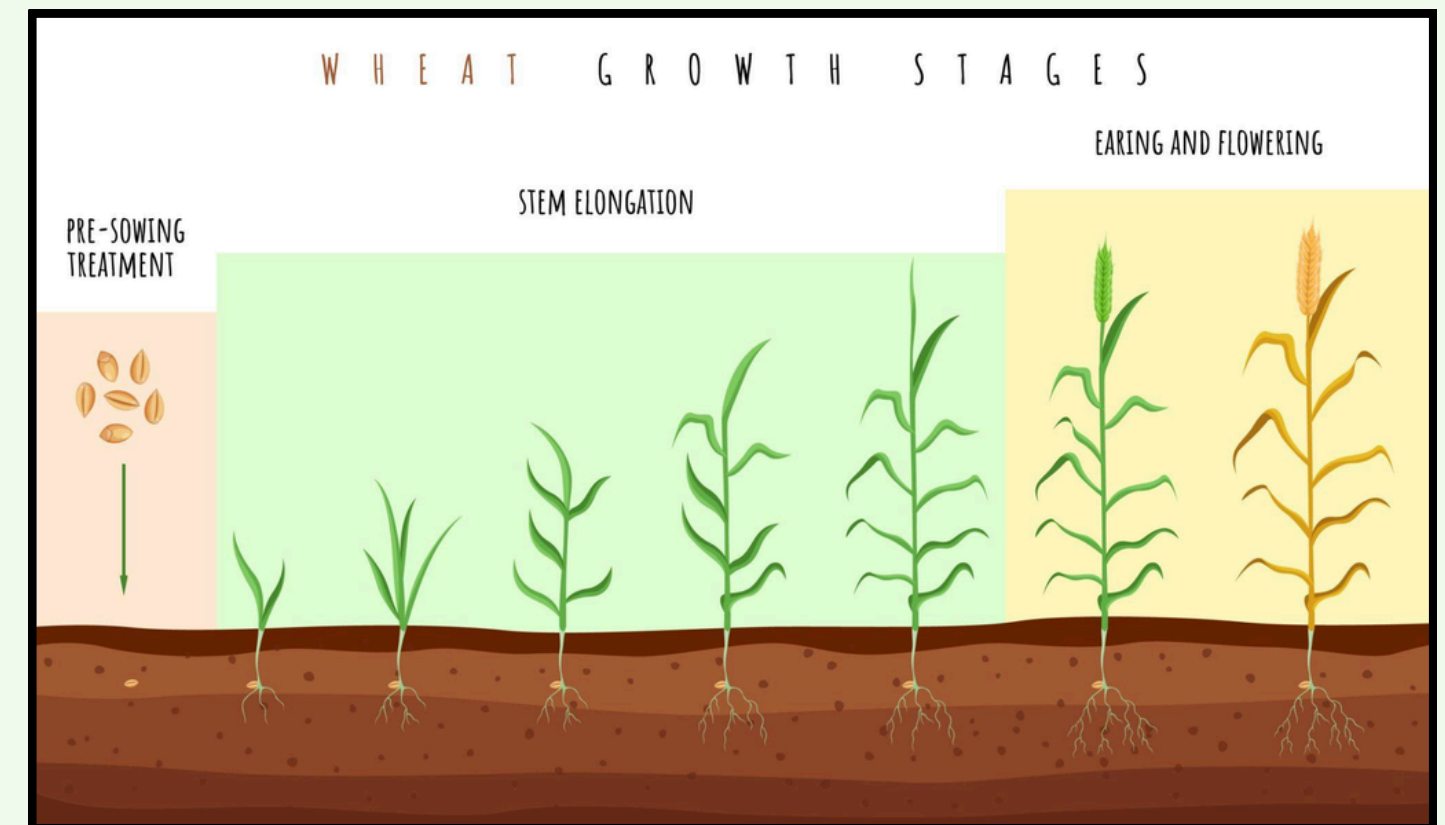
→ **Large spatial scale, simplified crop logic**



STICS:

- **Species-Specific:** Models C3 vs C4 differences.
- **Dynamic Phenology:** Detailed growth stages.
- **Active Management:** Explicitly accounts for irrigation, fertilizer, and harvest.
- **Field-Scale Precision:** Captures local processes.

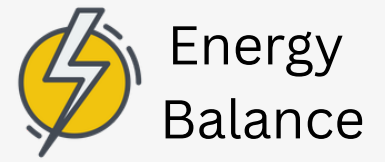
→ **High physiological resolution**



Bridging the gap between physiological resolution and global modeling is key to resolving the terrestrial budget of managed ecosystems.

ORCHIDEE-CROP: Coupling Architecture

ORCHIDEE CORE:



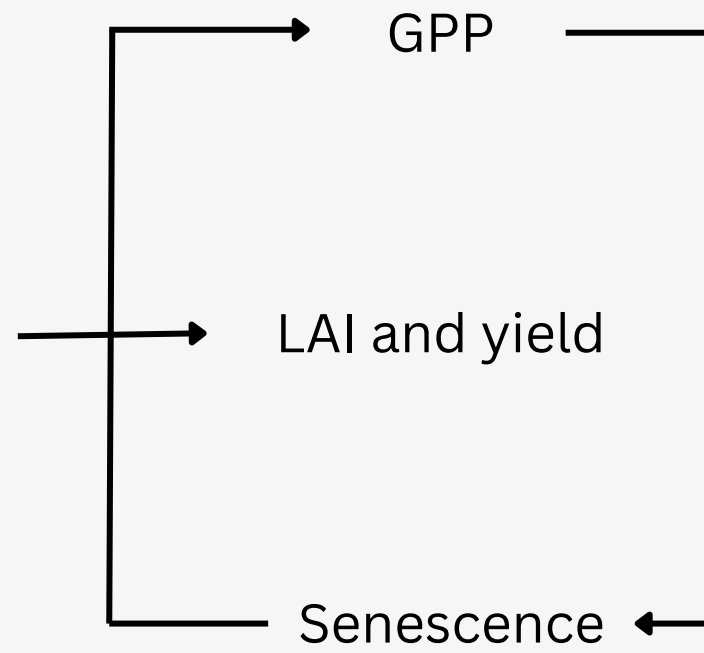
Energy
Balance



Water
Budget

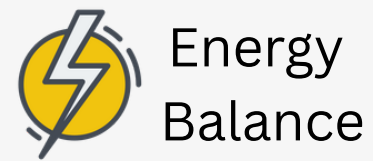


Soil
Carbon
Pools



ORCHIDEE-CROP: Coupling Architecture

ORCHIDEE CORE:



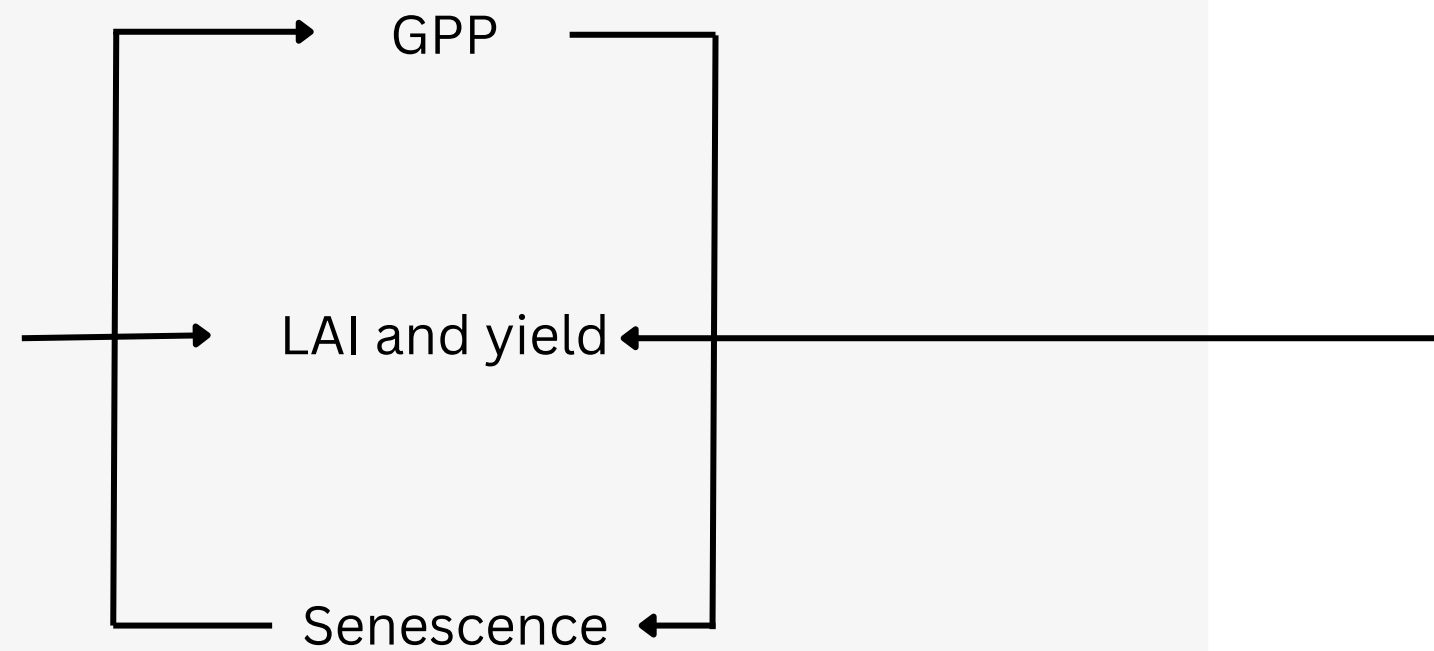
Energy Balance



Water Budget



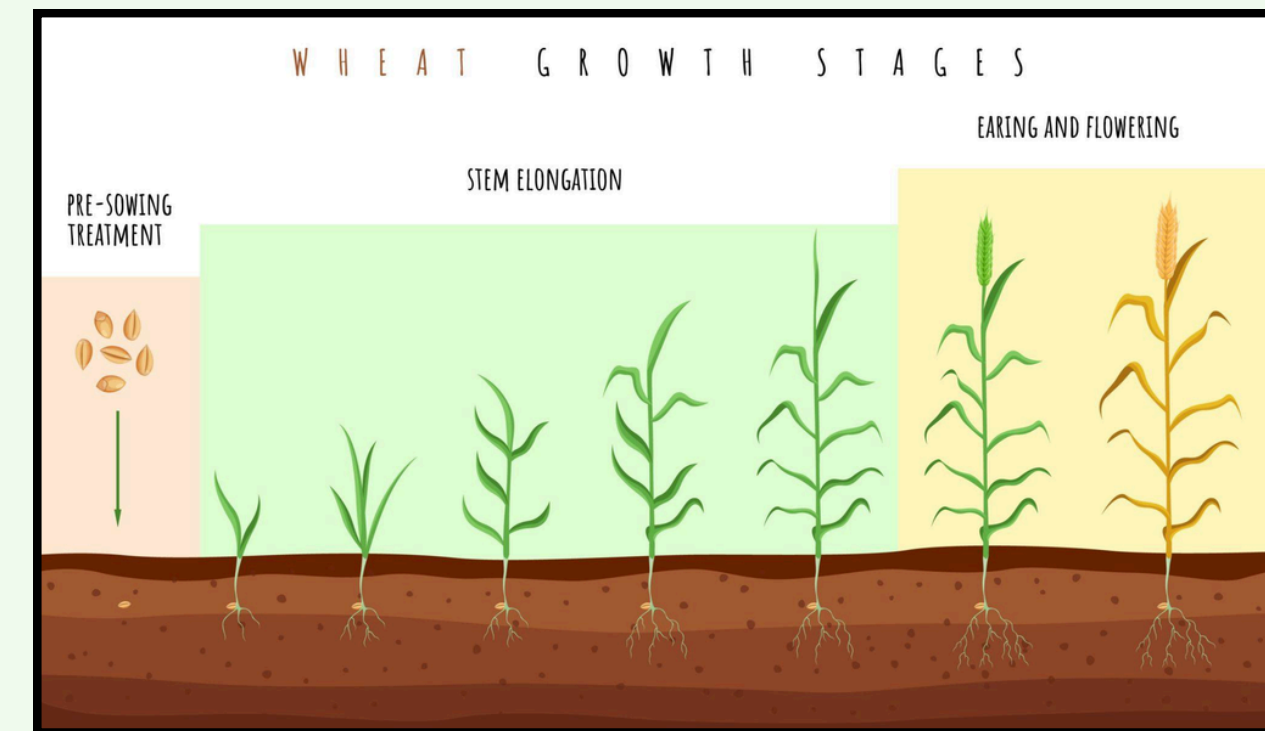
Soil Carbon Pools



STICS:

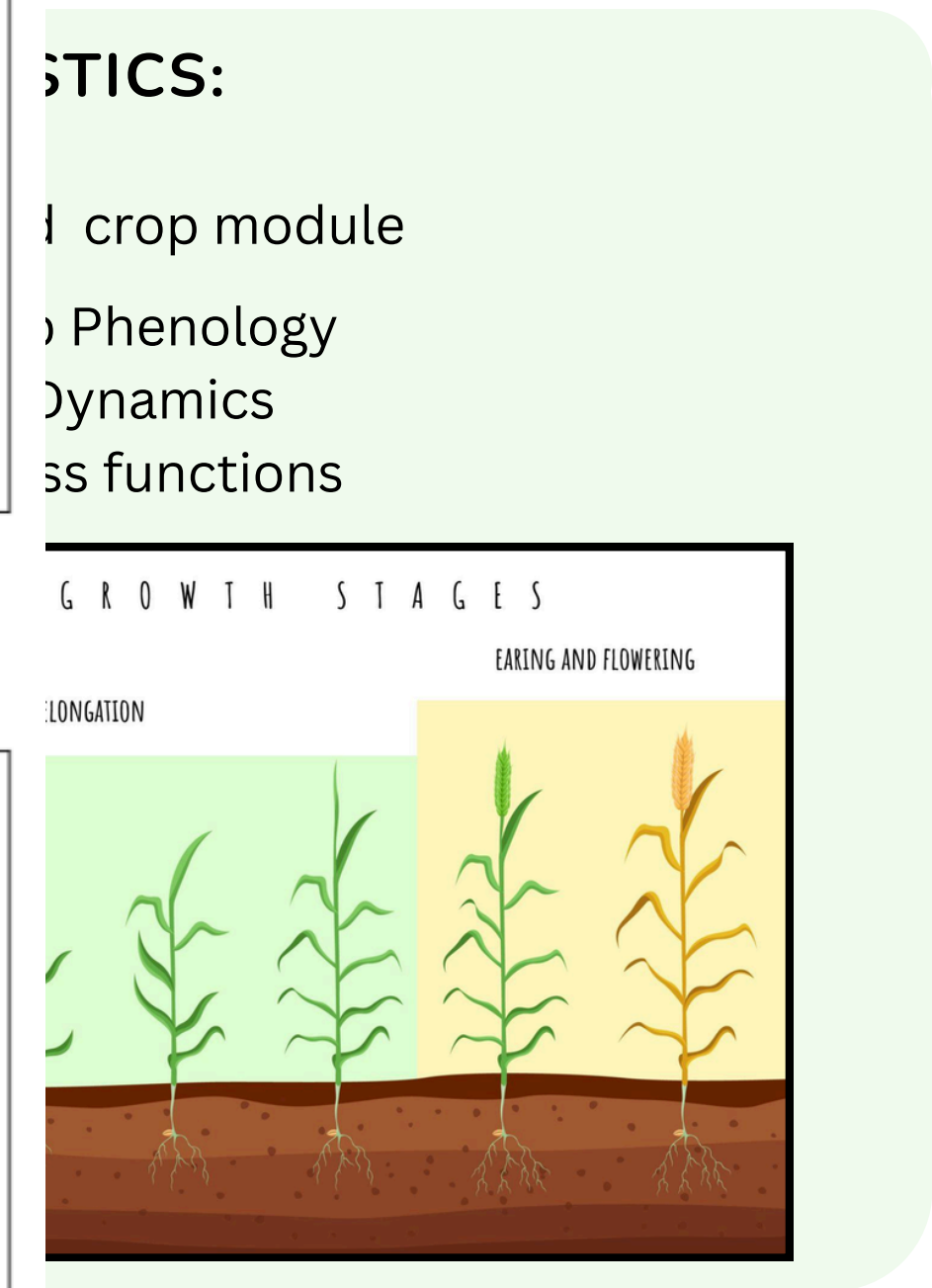
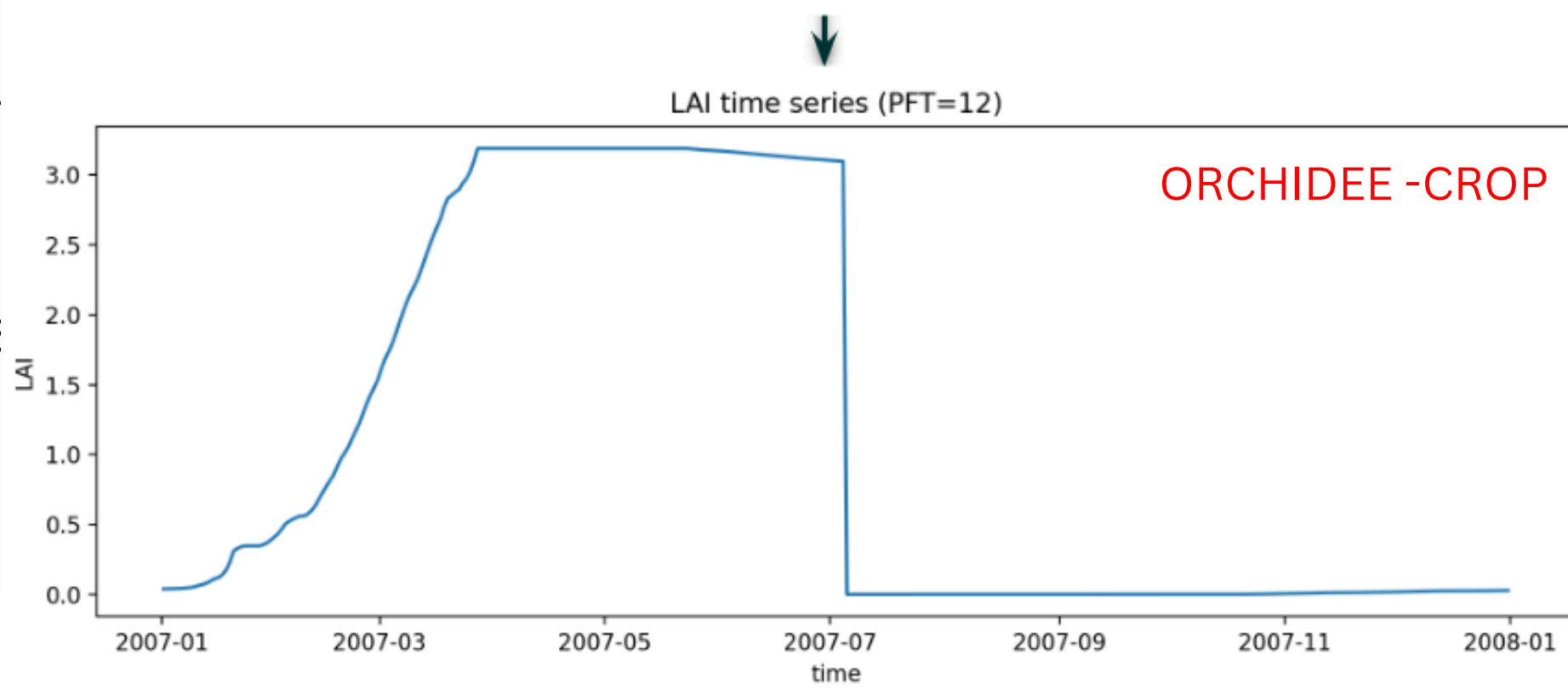
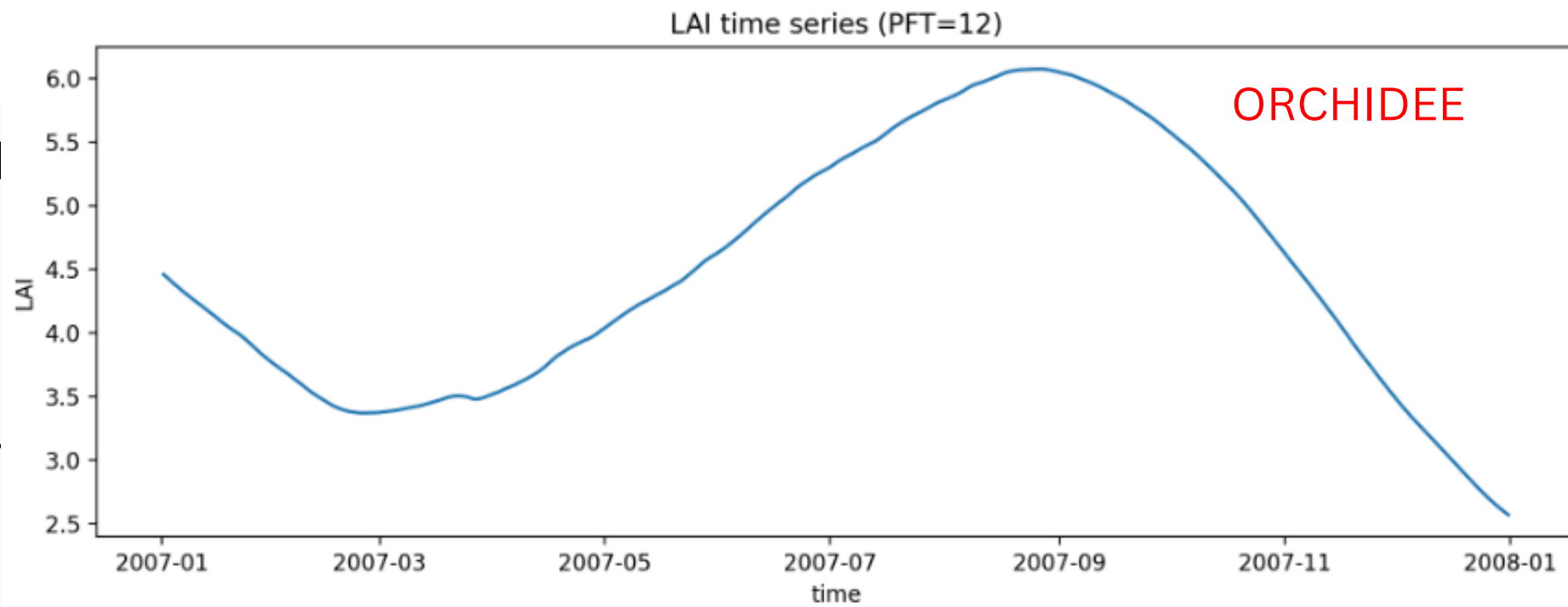
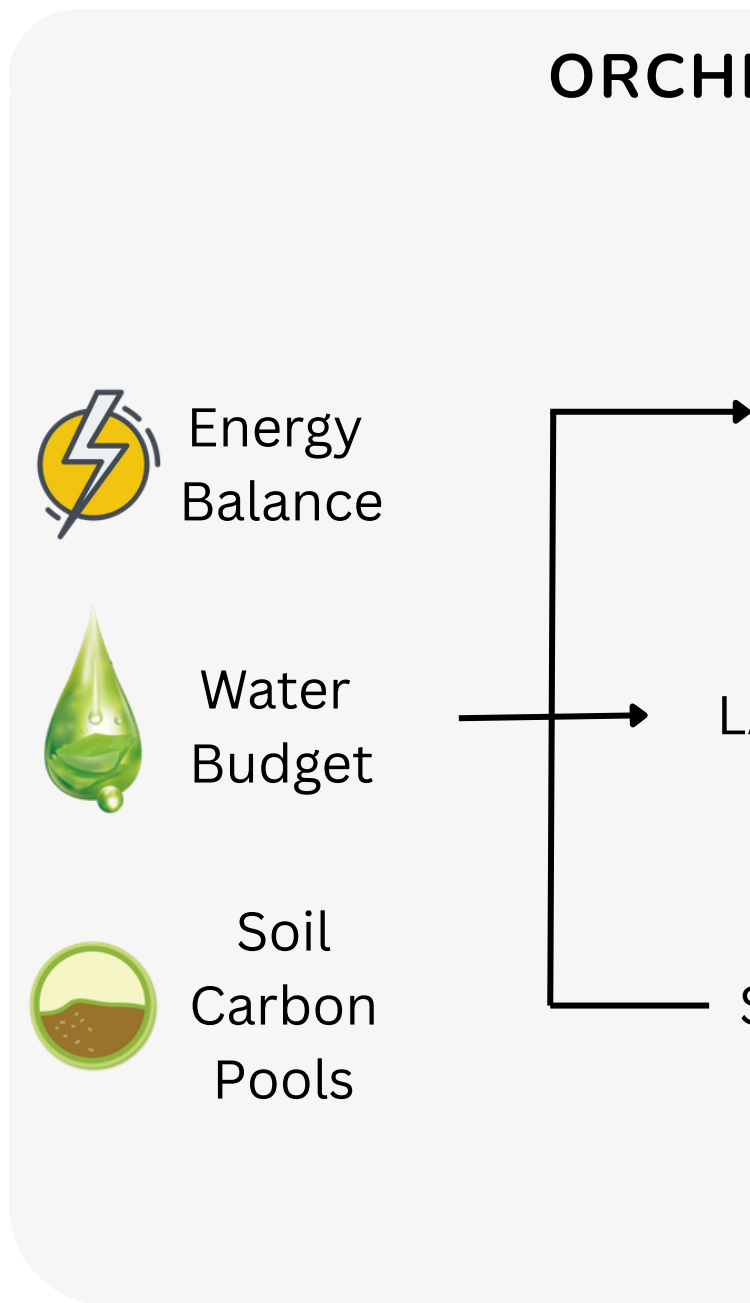
Detailed crop module

- Crop Phenology
- LAI Dynamics
- Stress functions



- STICS improves crop growth representation
- ORCHIDEE simulates ecosystem fluxes at large scale

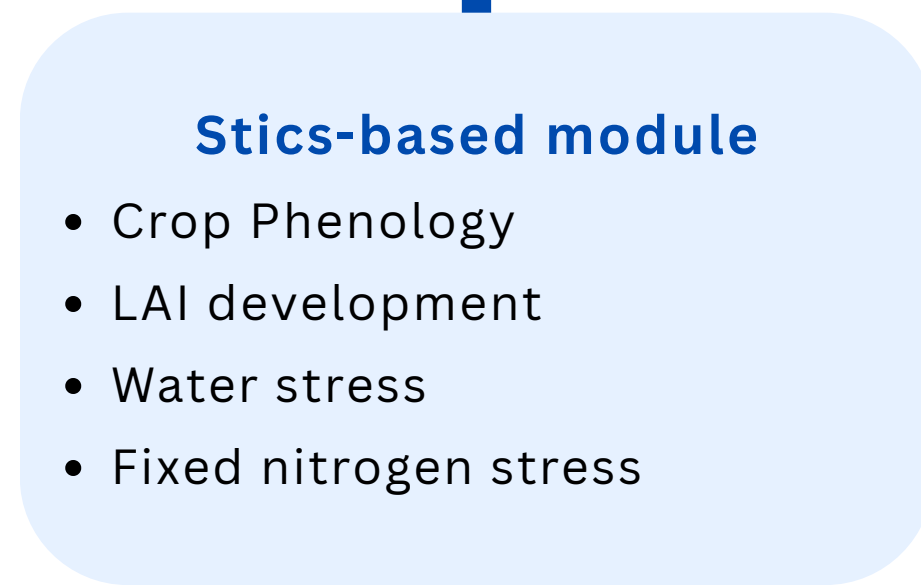
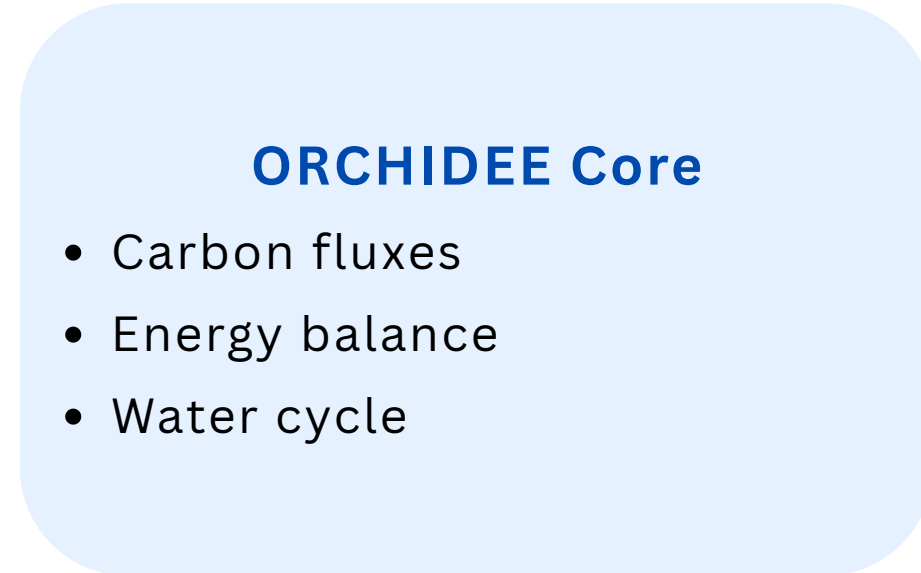
ORCHIDEE-CROP: Coupling Architecture



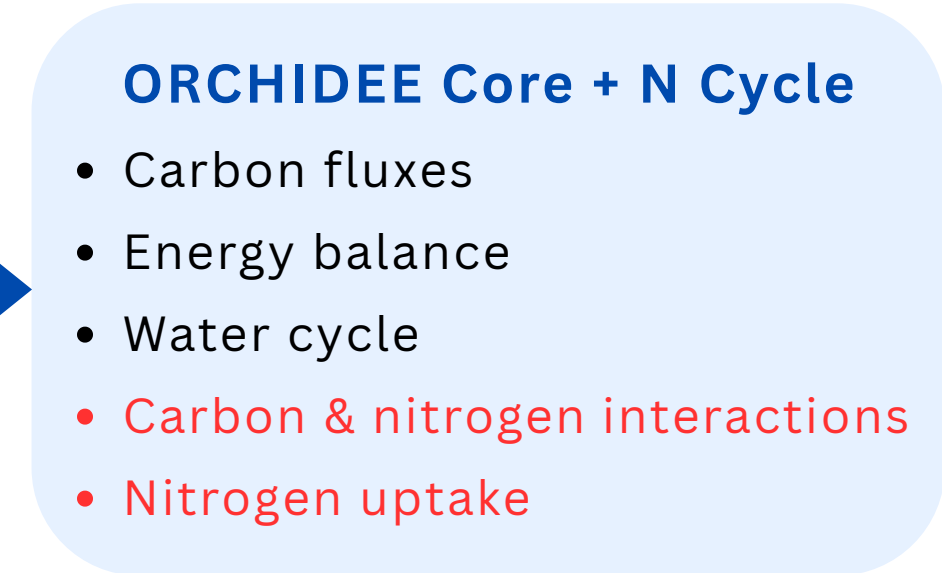
- STICS improves crop growth representation
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ORCHIDEE-CROP Model Evolution: V0.0 vs V1.0

V0.0 (ORIGINAL COUPLING)



V1.0 (NEW DEVELOPMENT)



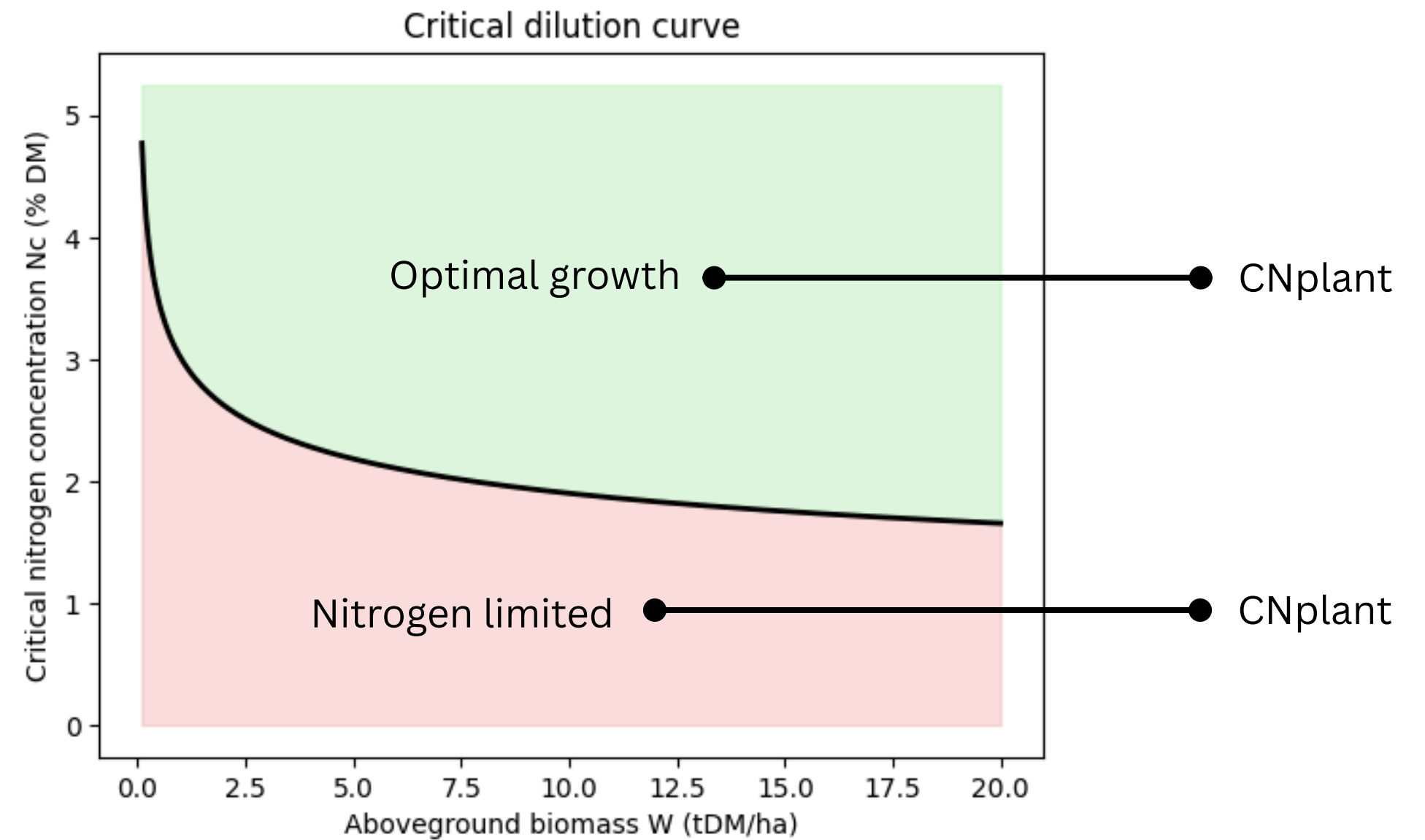
Main improvement in V1.0

- Crop phenology is affected by C/N ratios
- Explicit N limitation affecting leaf growth, senescence, and biomass

ORCHIDEE-CROP: Nitrogen Limitation on Crop Growth

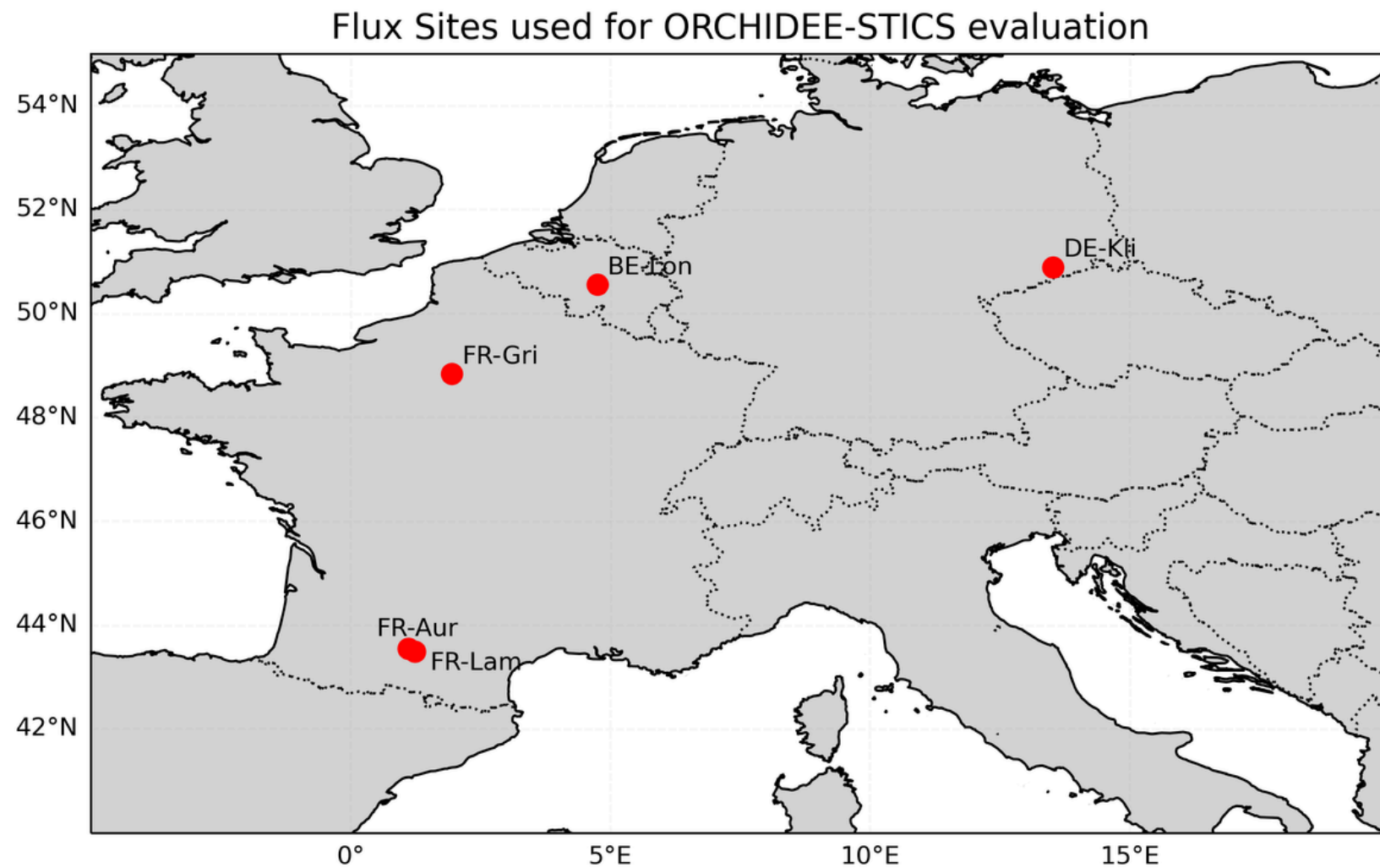
Inputs from Orchidee

- Plant Carbon + Nitrogen
- Above ground biomass



- Crop growth depends on plant N concentration
- Critical dilution curve defines N limitation
- Below threshold \rightarrow nitrogen stress reduces growth

Study Sites and Simulation Strategy

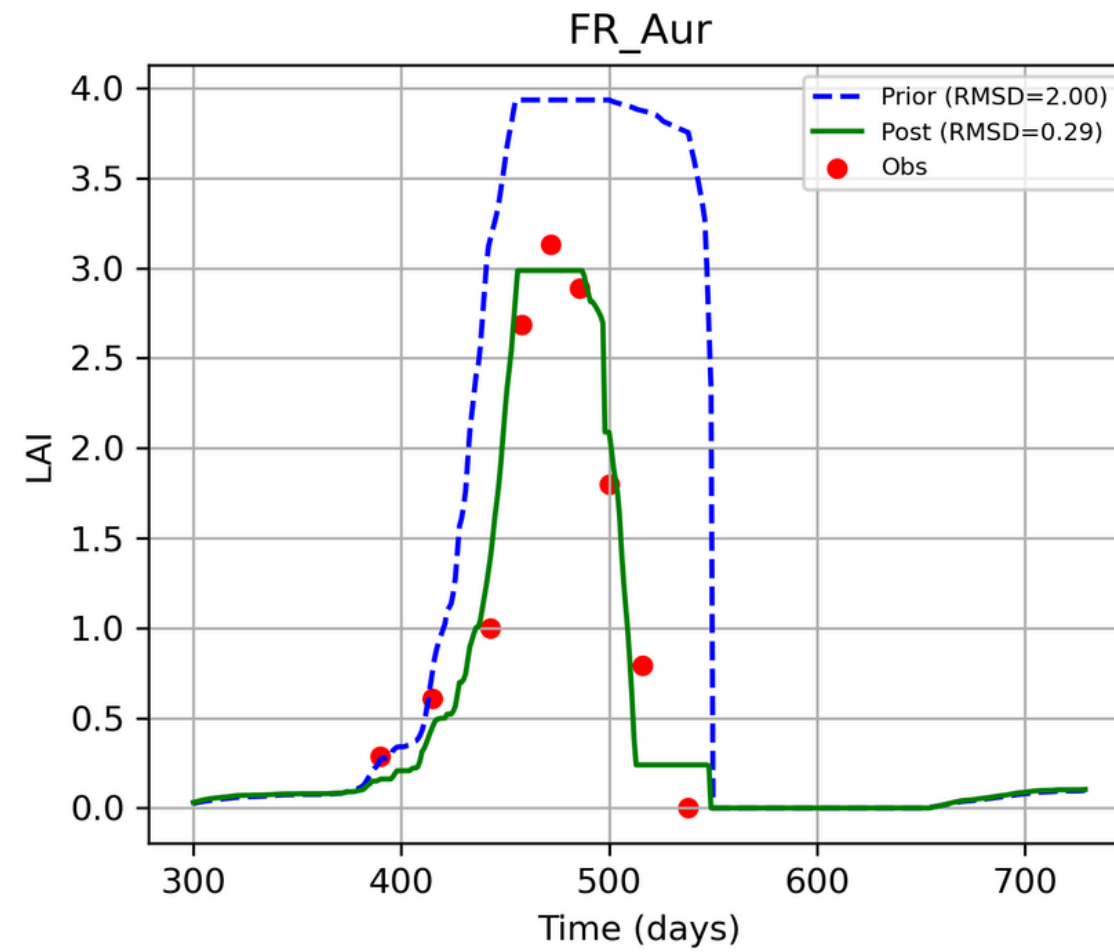
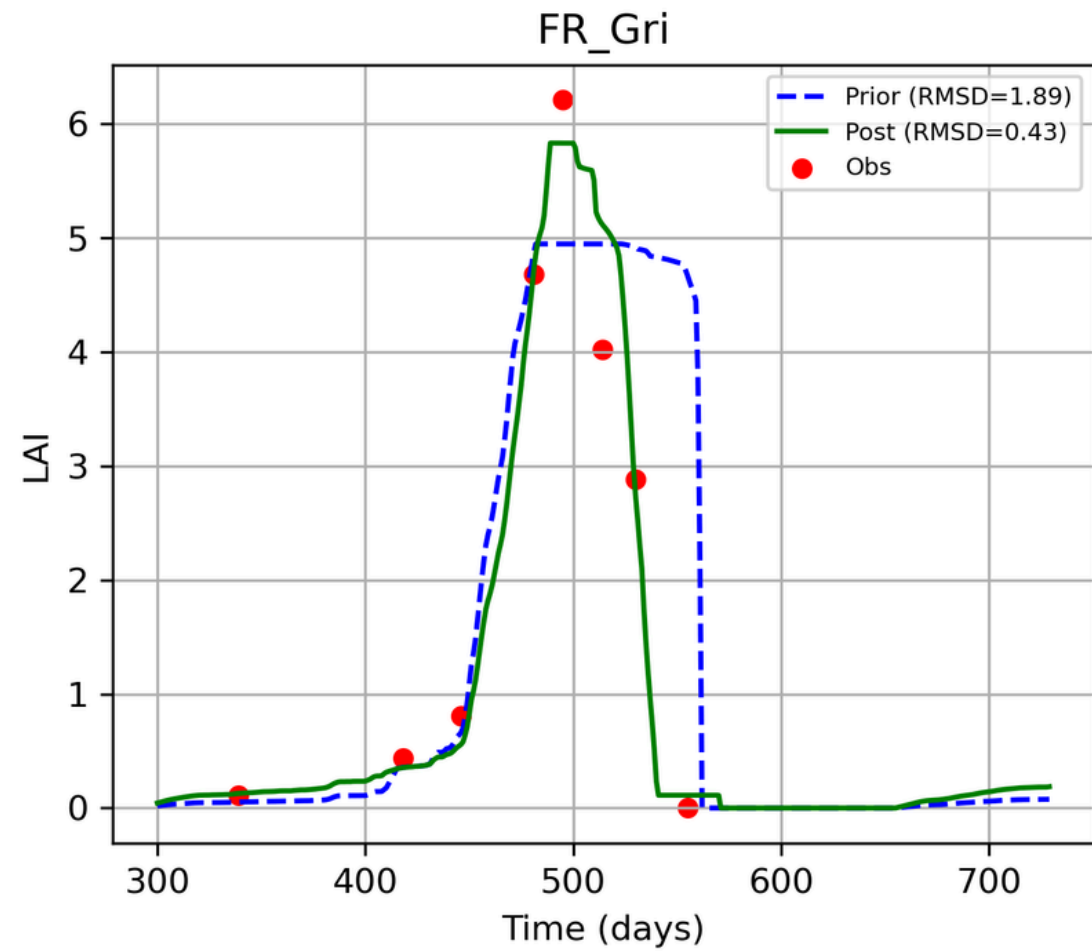
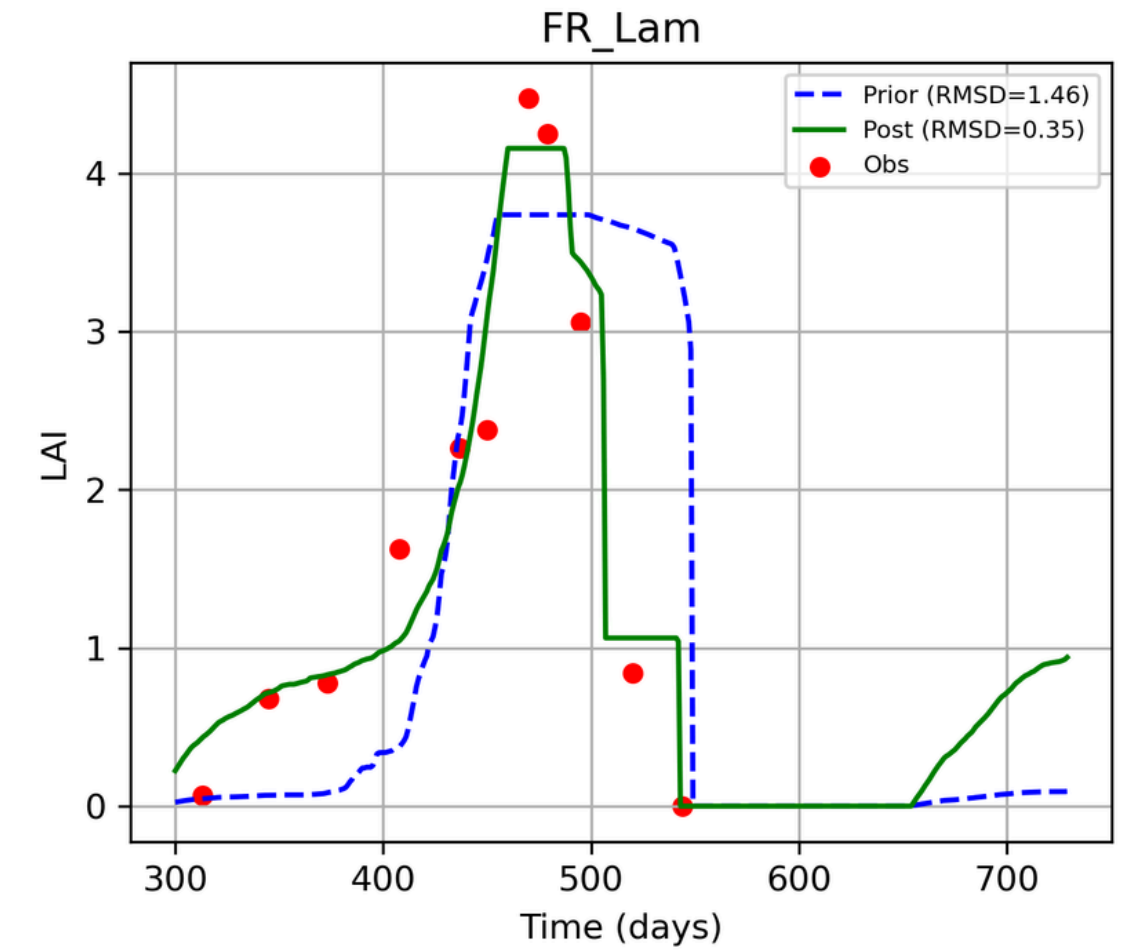
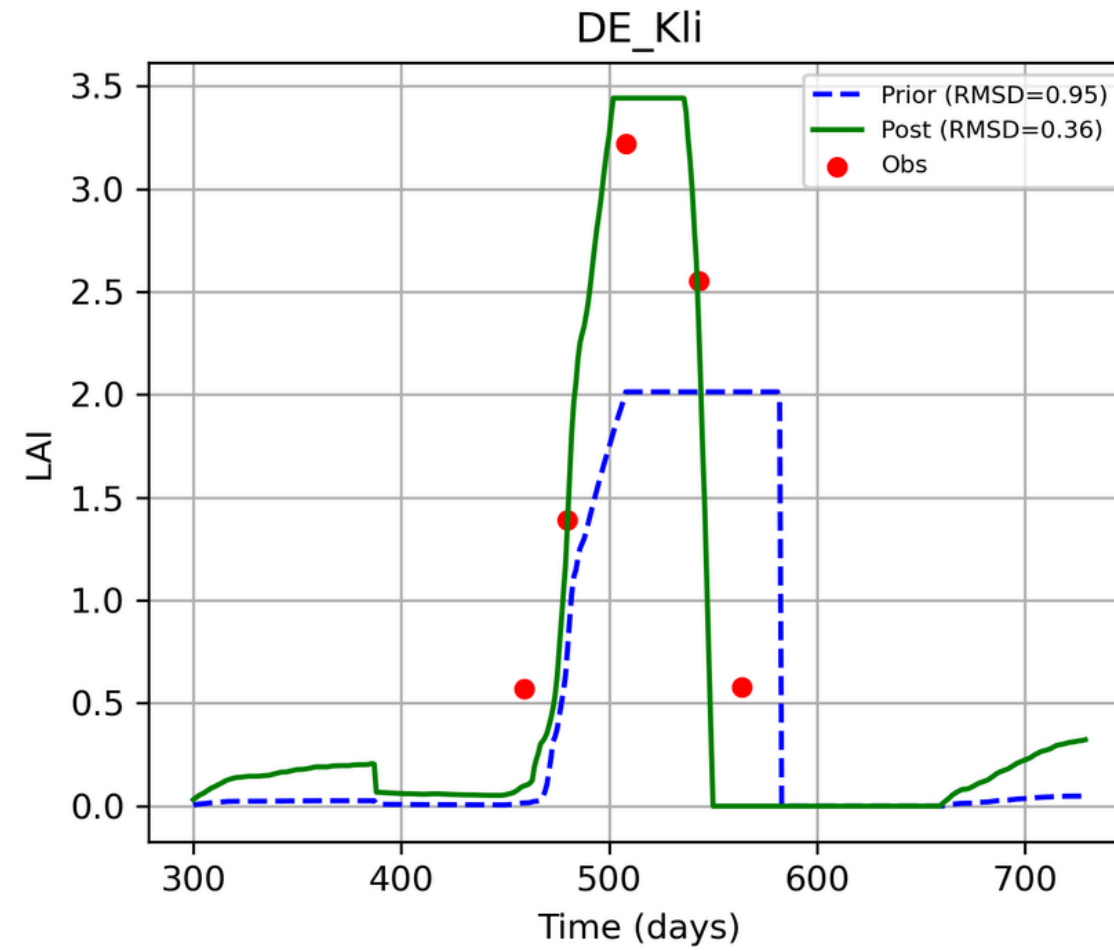
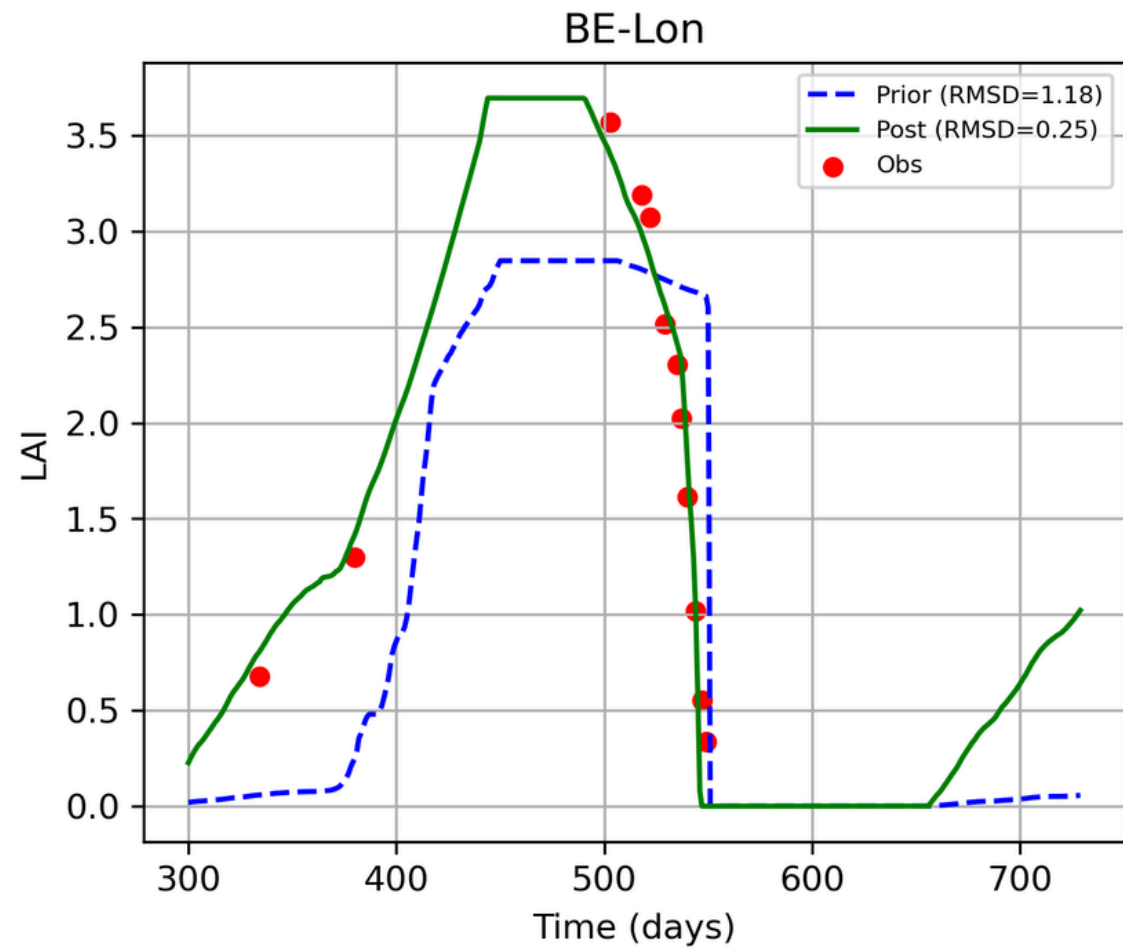


Site	Country	Crop	Period
FR-Gri	France	Winter Wheat	2005–2007
FR-Lam	France	Winter Wheat	2007–2008
DE-Kli	Germany	Winter Wheat	2005–2007
BE-Lon	Belgium	Winter Wheat	2005–2006
FR-Aur	France	Winter Wheat	2006–2008

Simulation strategy:

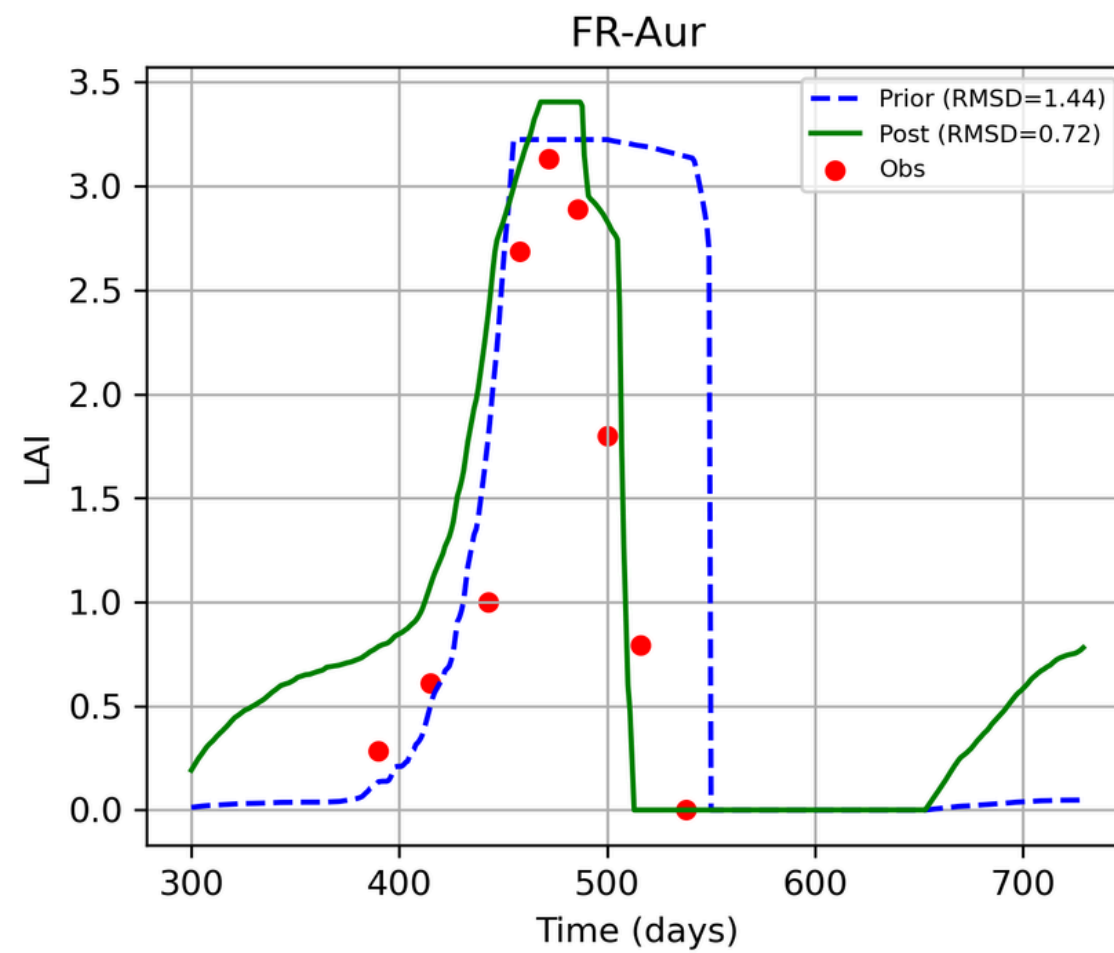
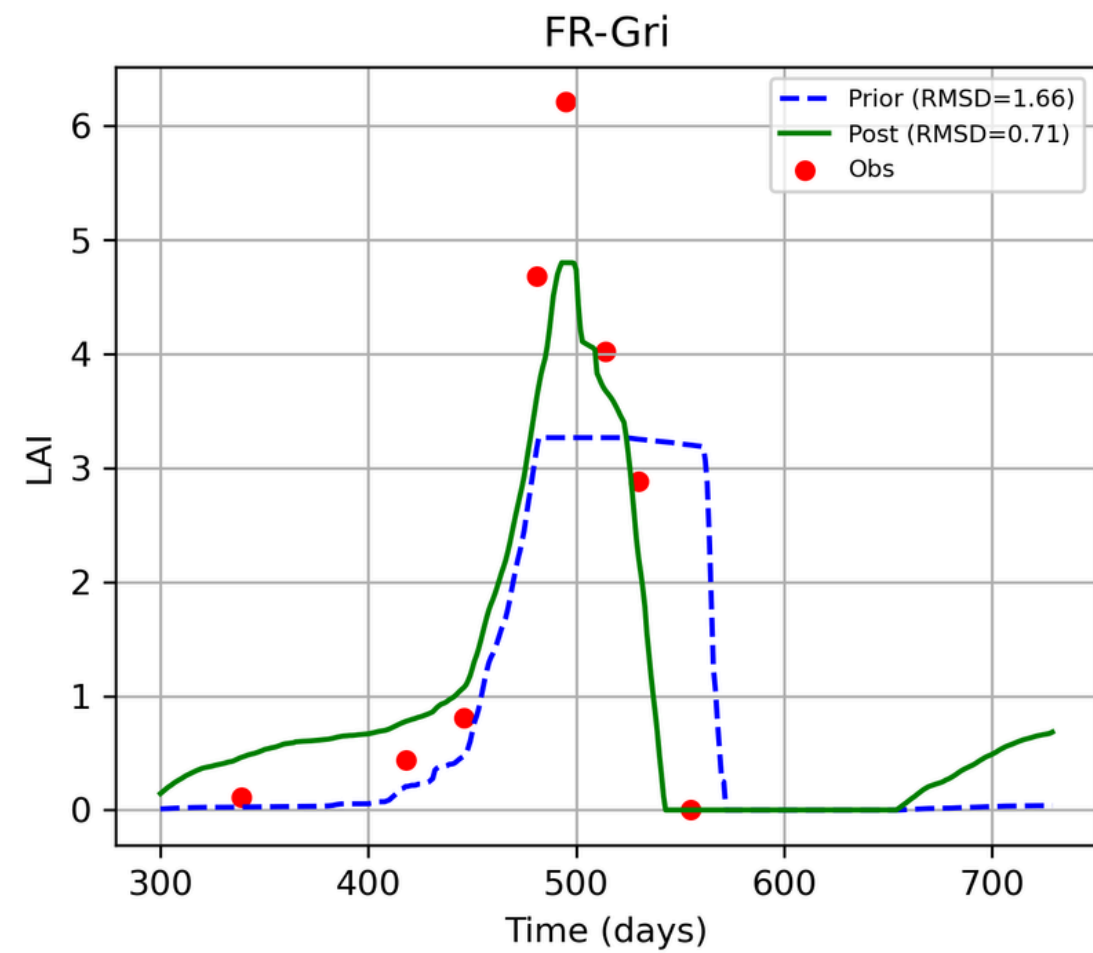
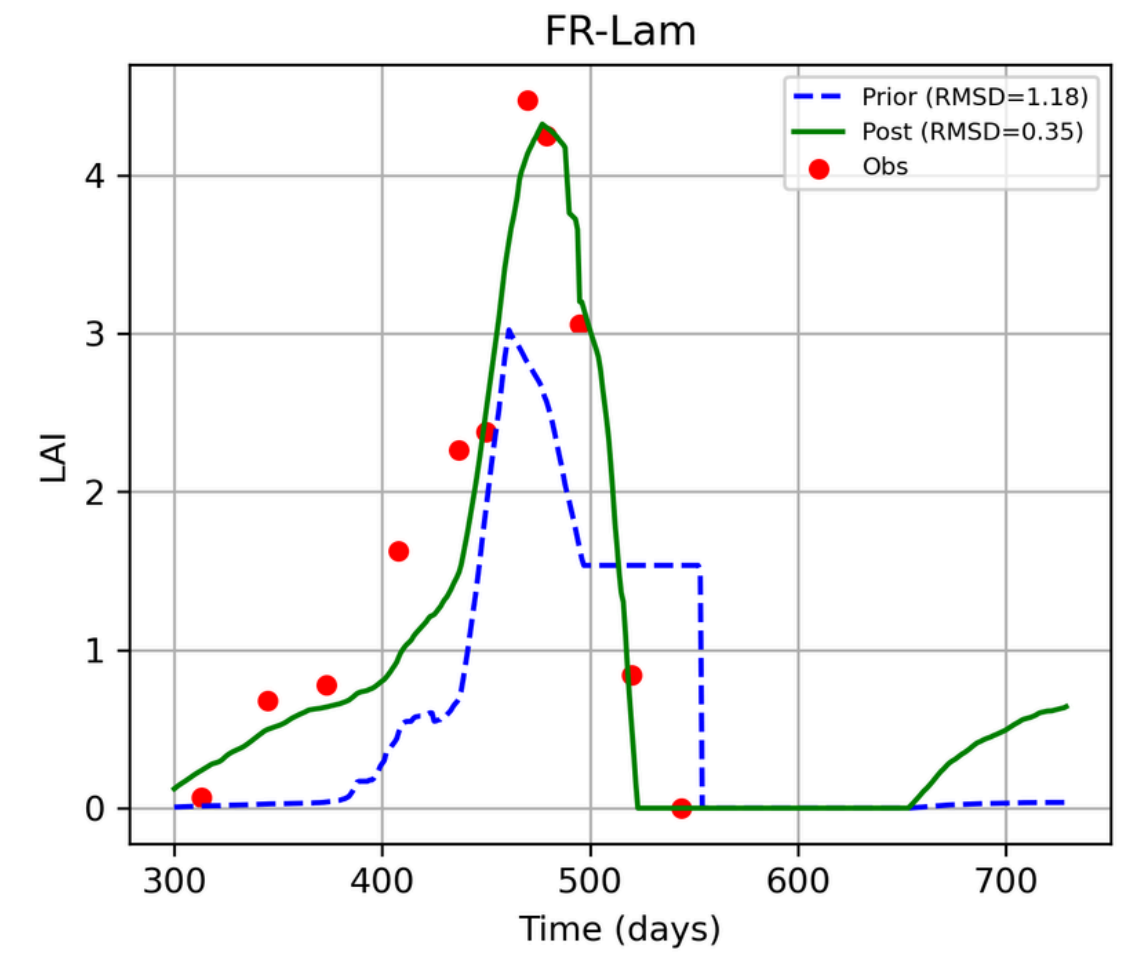
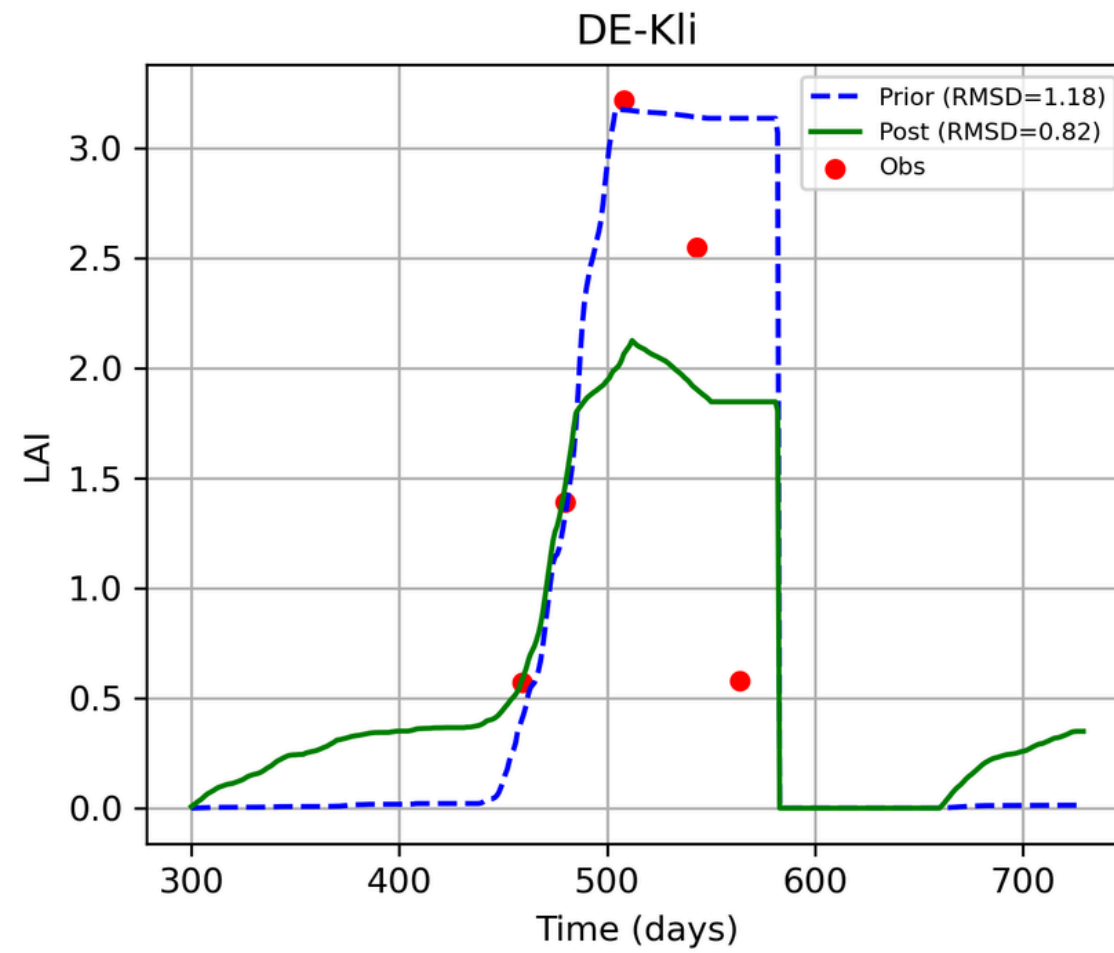
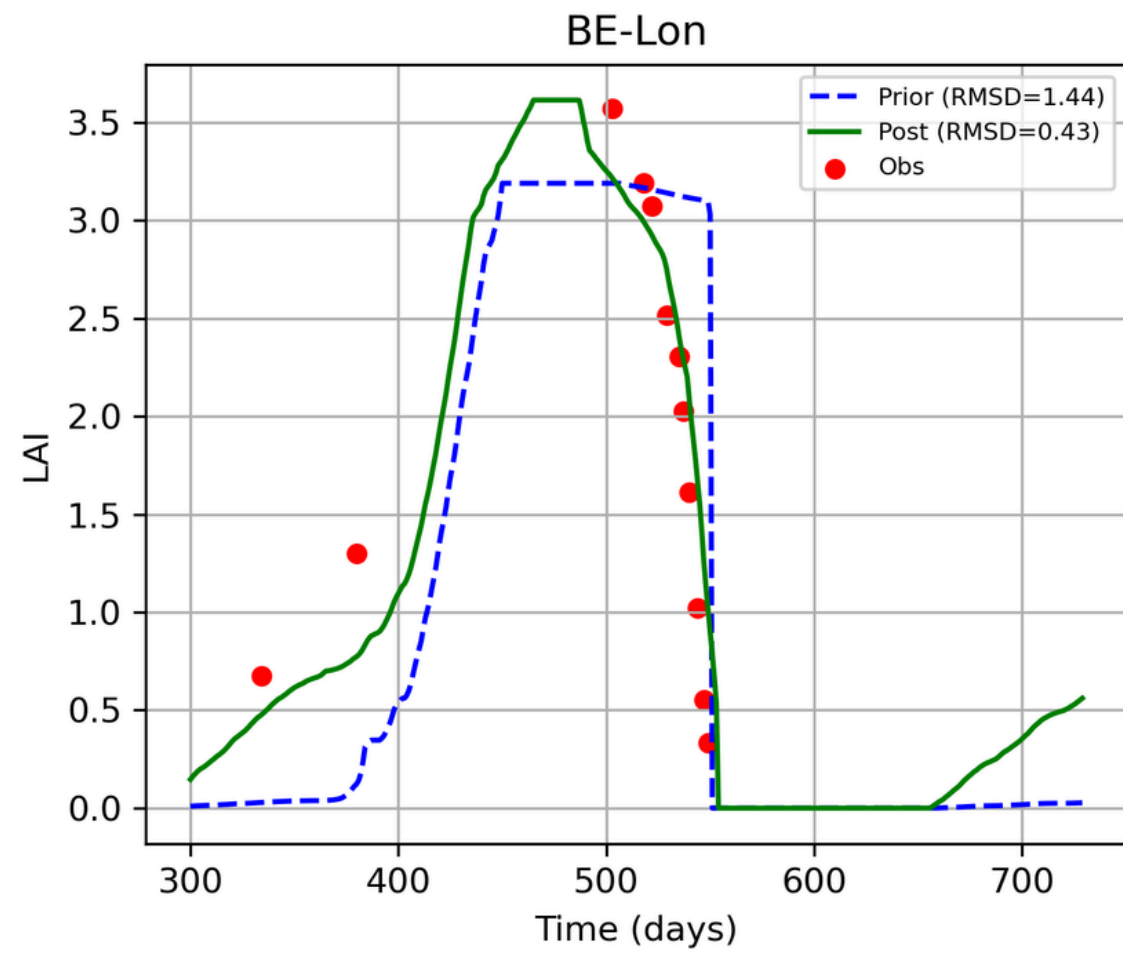
- Parameter optimization using ORCHIDAS (single-site and multi-site optimization)
- The difference ORCHIDEE and ORCHIDEE-CROP

Site-specific Optimization - LAI



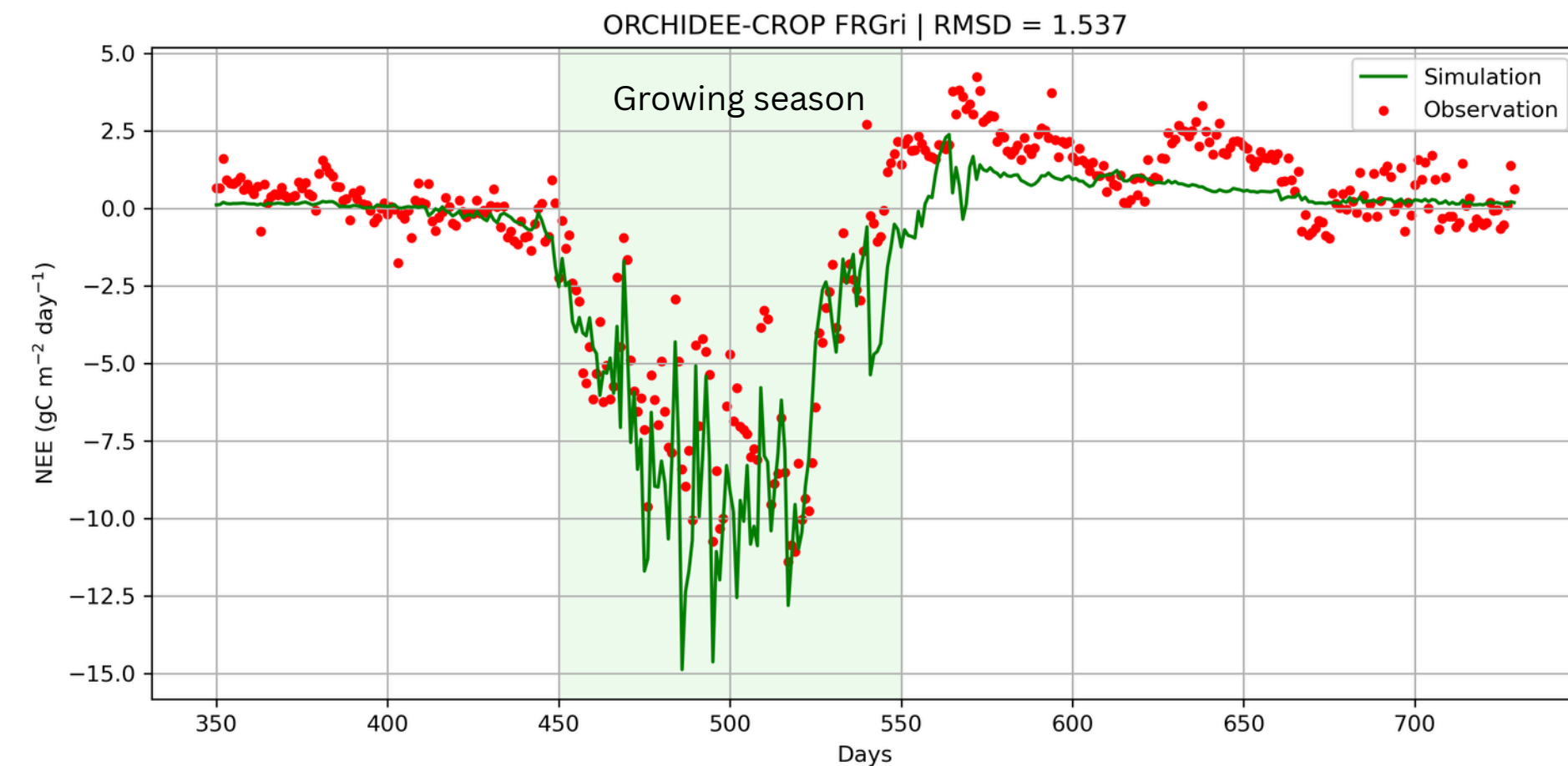
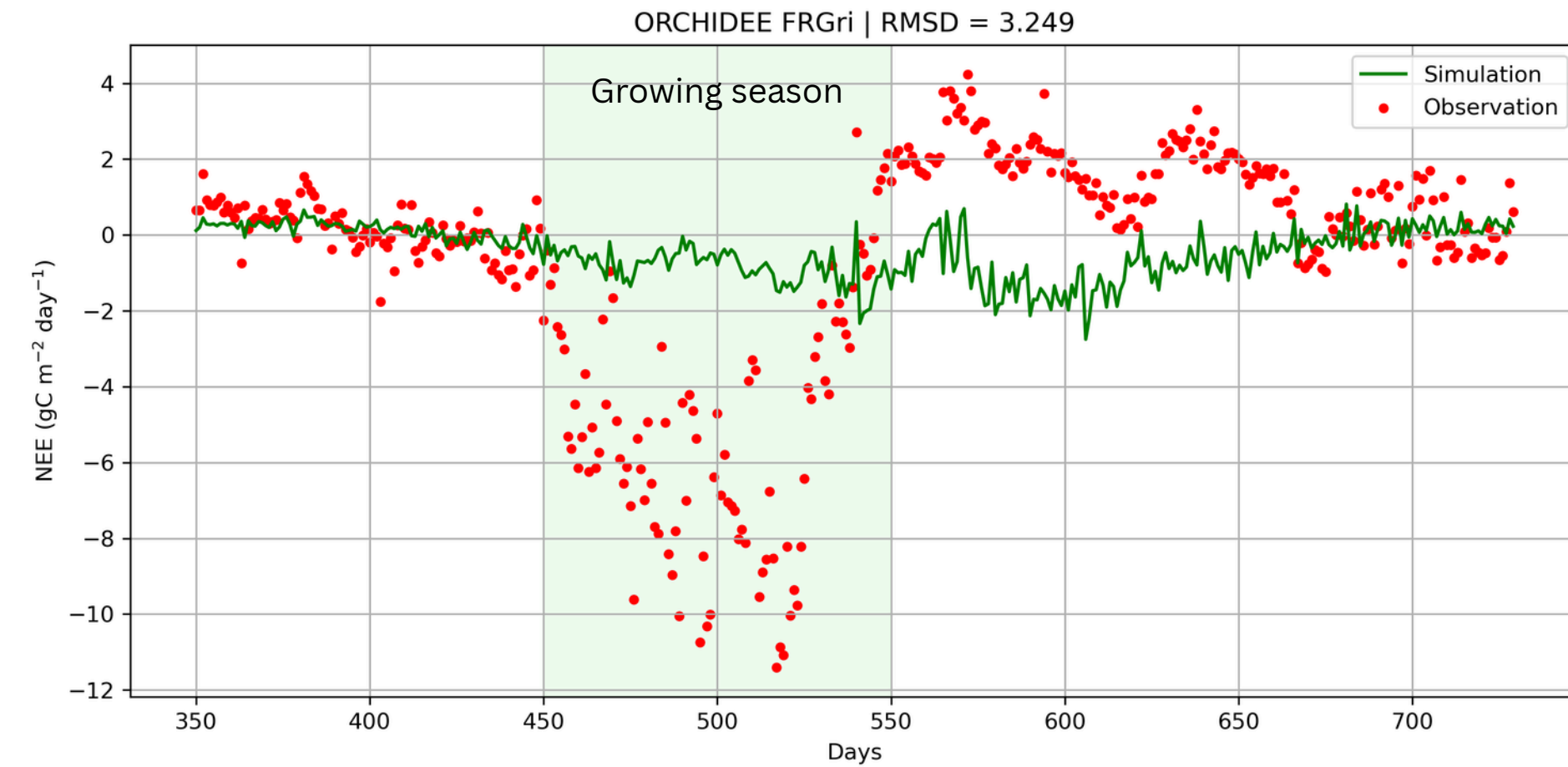
**Average RMSD
reduction: 75.94%**

Multi-site Optimization - LAI



**Average RMSD
reduction: 56.1%**

Example of the Effect of STICS Introduction on ORCHIDEE



- ORCHIDEE underestimates carbon uptake during the crop growing season
- STICS phenology improves crop development timing and magnitude
- Better representation of seasonal NEE dynamics
- ~41% reduction in RMSD across the sites

Perspective and Highlights

- Extension on additional in-situ EU cropland sites
- Regional scale evaluation over Europe using remote-sensed LAI data
- Benefit within the ORCHIDEE community:
 - Management practice modelling
 - Better estimate of the crop residue than standard orchidee (*Ke Yu , Guenet, et al.*)
- First attempt to reactivate ORCHIDEE-CROP with the Nitrogen-enabled ORCHIDEE version;
Need to update the STICS version used in the model
- ORCHIDEE-CROP can be used both agronomic scientists for regional applications and climate/Env. scientists for global applications.

Thank you!