Introducing CLM5-FruitTree to model deciduous fruit orchards in CLM5

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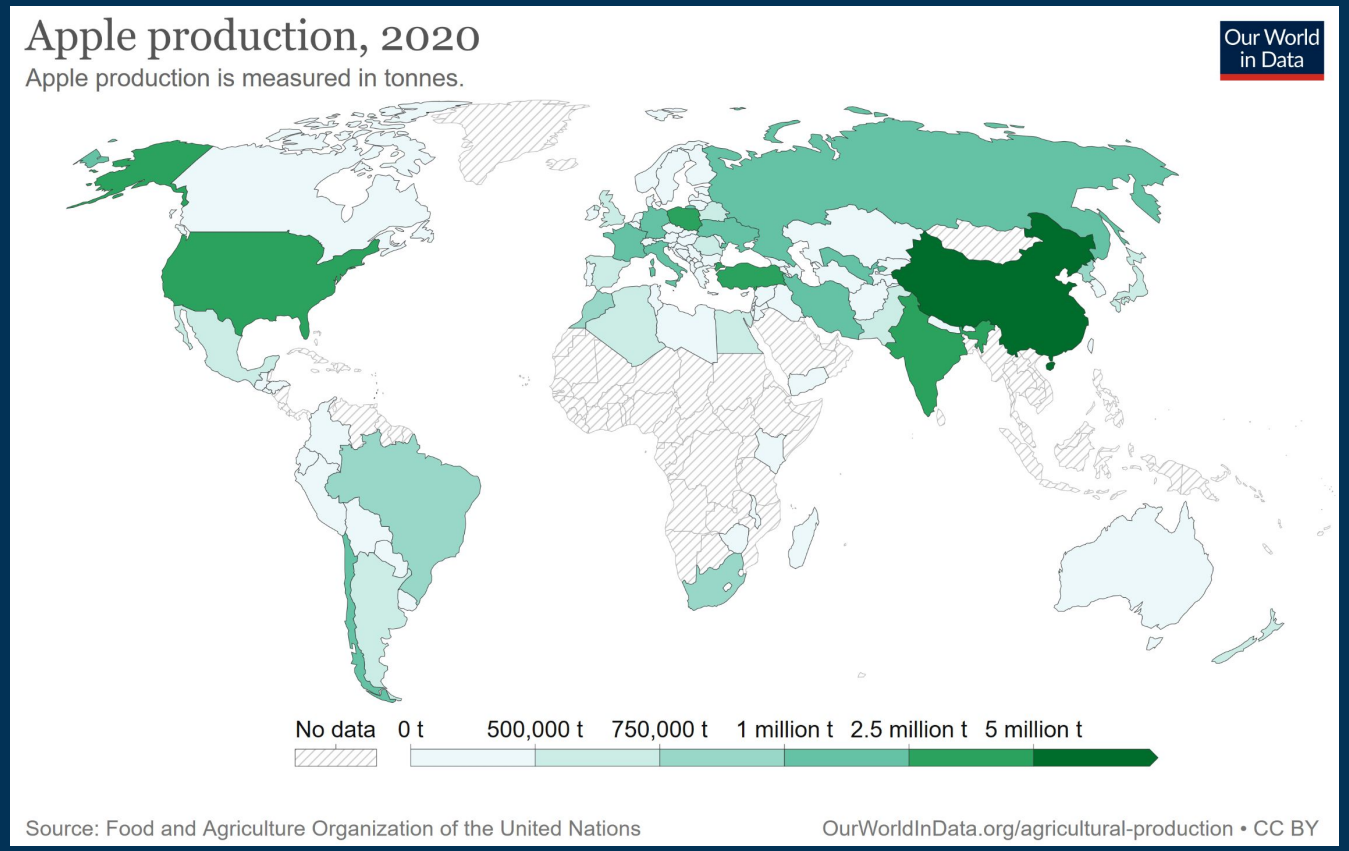
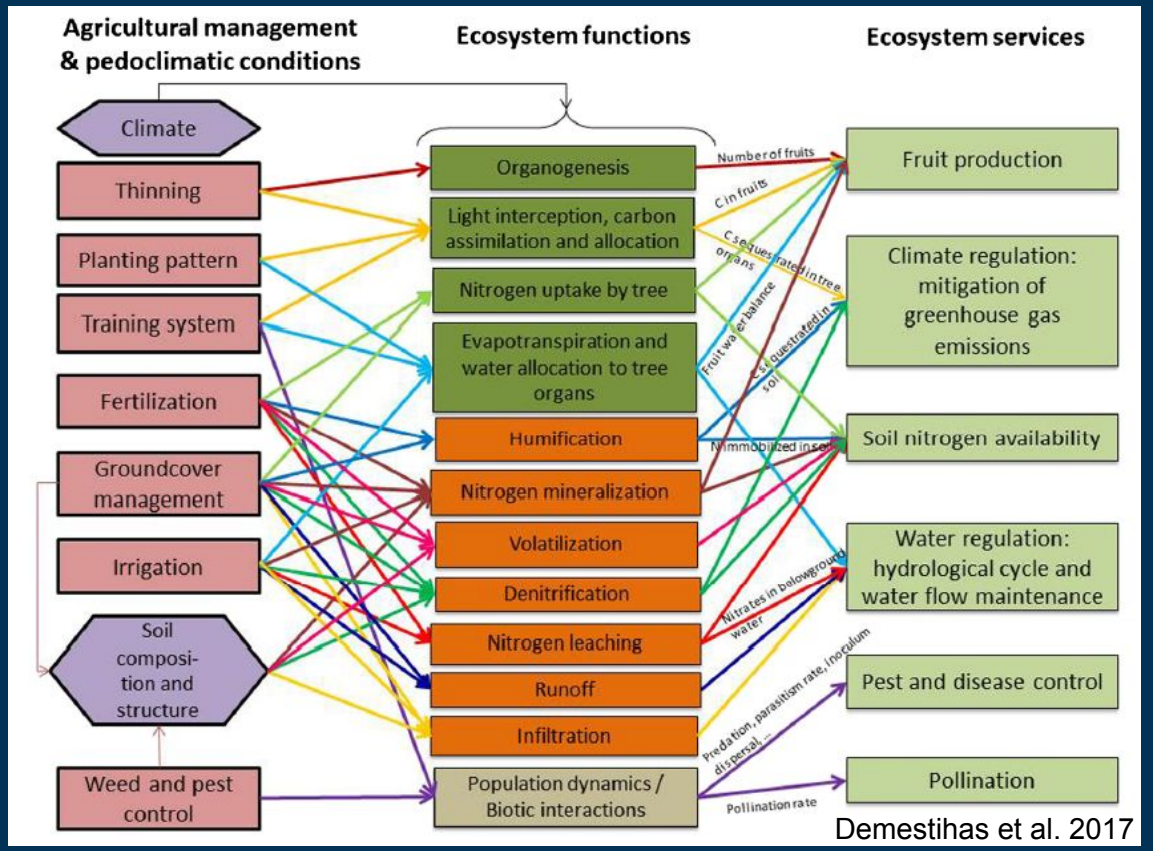
Why consider deciduous fruit trees in land surface modeling?

Widespread production and economic importance



Ecologic importance

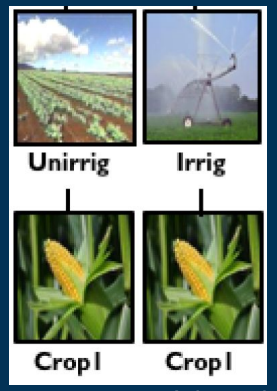


- Fruit orchards influence soil, water, and climate.
- To account for their role and functioning we must include them in our models.

Conceptualization of CLM5-FruitTree

- Crop growth stages
- Harvestable organ
- Crop management

Annual crops



Natural vegetation

- Deciduous trees
- Dormancy period
- Growth and turnover of woody biomass

Adapted from Lawrence et al. (2019)

Deciduous fruit trees

Phenology

- Orchard life cycle: Transplanting of seedlings Orchard rotation
- Seasonal deciduous phenology:
  - Dormancy vs. Growth period
  - Long canopy duration
  - Fruit growth

CN Allocation

- Reserve dynamics and direct growth
- Fates of C and N

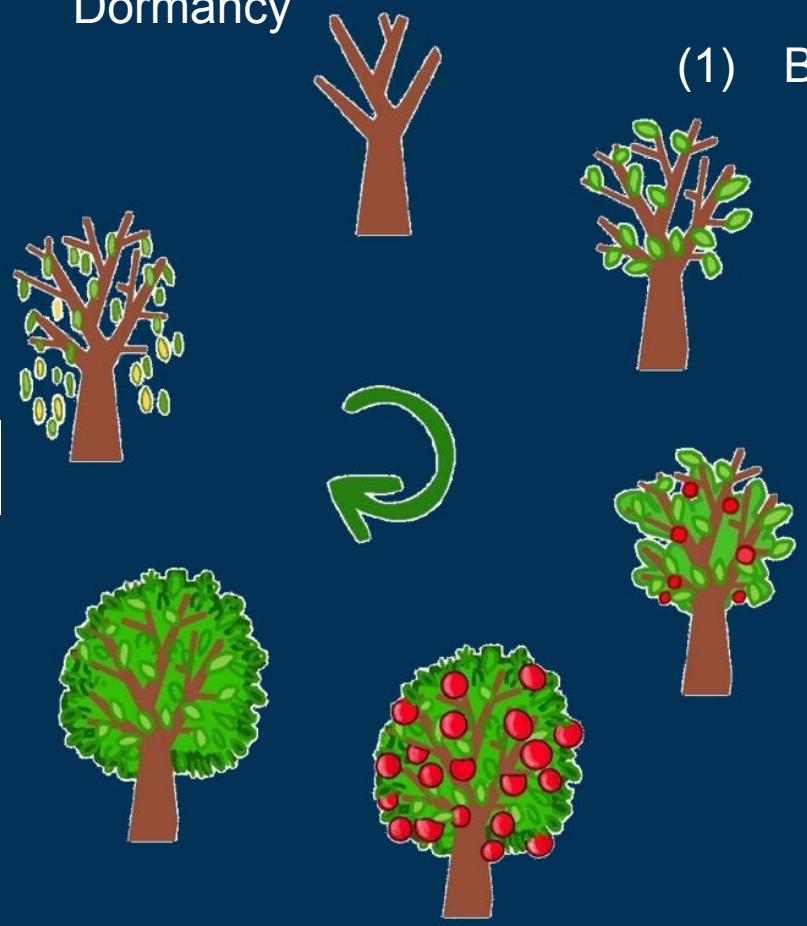
Management practices

- Winter pruning

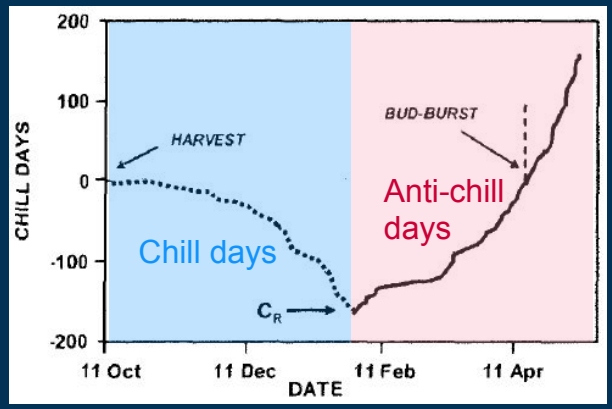
Phenology in CLM5-FruitTree

Dormancy

(1) Bud burst



Sequential model (Cesaraccio et al. 2004)



(2) Start of fruit growth

(3) Fruit ripening

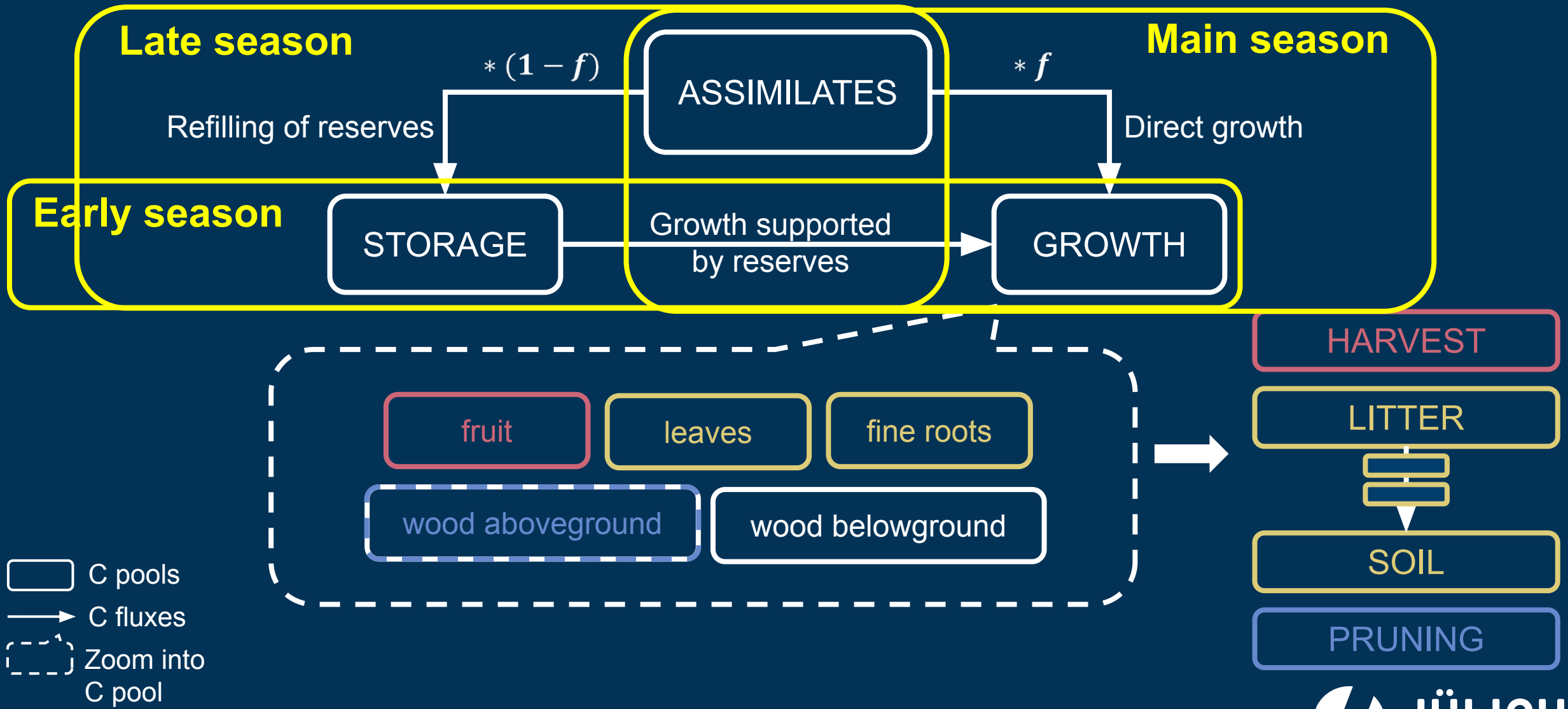
(4) Canopy maturity

(5) Harvest

(6) Senescence

$T_{mean} < T_{crit}$

Carbon allocation in CLM5-FruitTree



Parameterization of CLM5-FruitTree for apple orchards

Apple orchard, Caldaro, Italy

Available Data (Zanotelli et al. 2013, 2015, 2019)

- Orchard management and yield (2010 – 2015)
- Biomass and LAI (2010 – 2012)
- C:N ratios (2010)
- Root distribution (2010)
- Soil respiration (2010)
- Eddy covariance flux data (2013 – 2015)
- Soil heat flux (2013 – 2015)
- Soil water content (2013 – 2015)

Measurements

+

Literature values

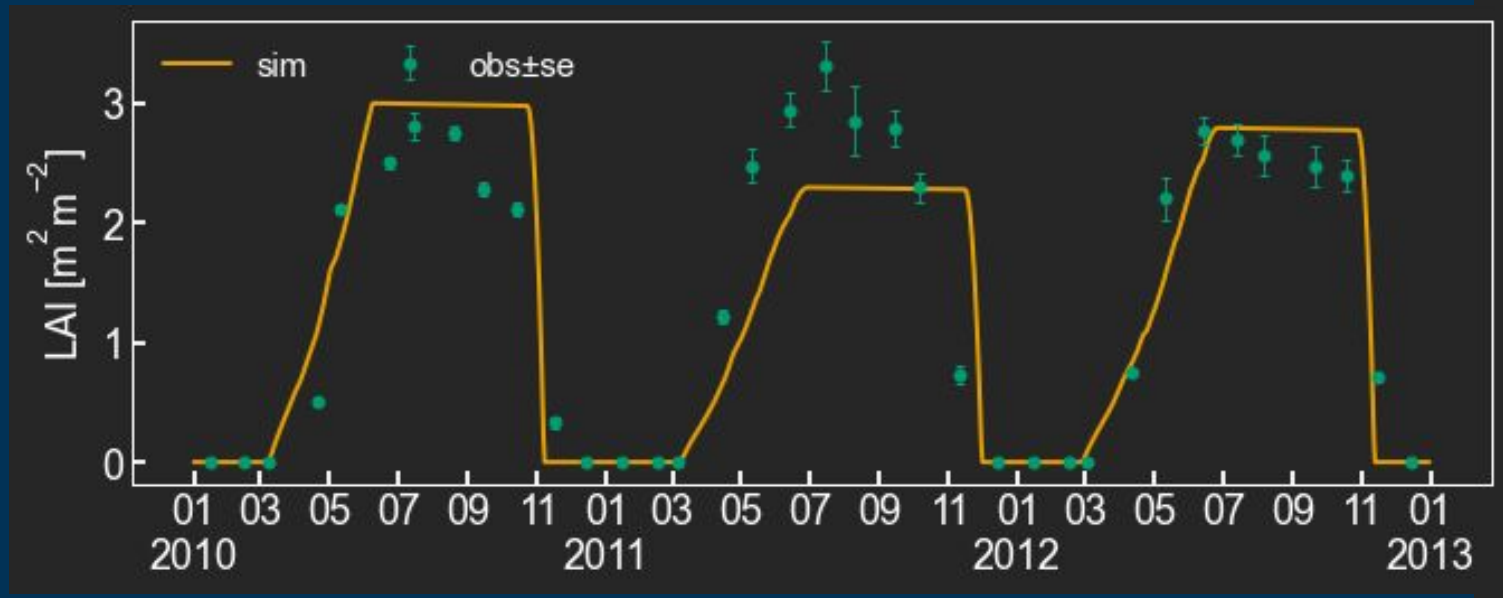
+

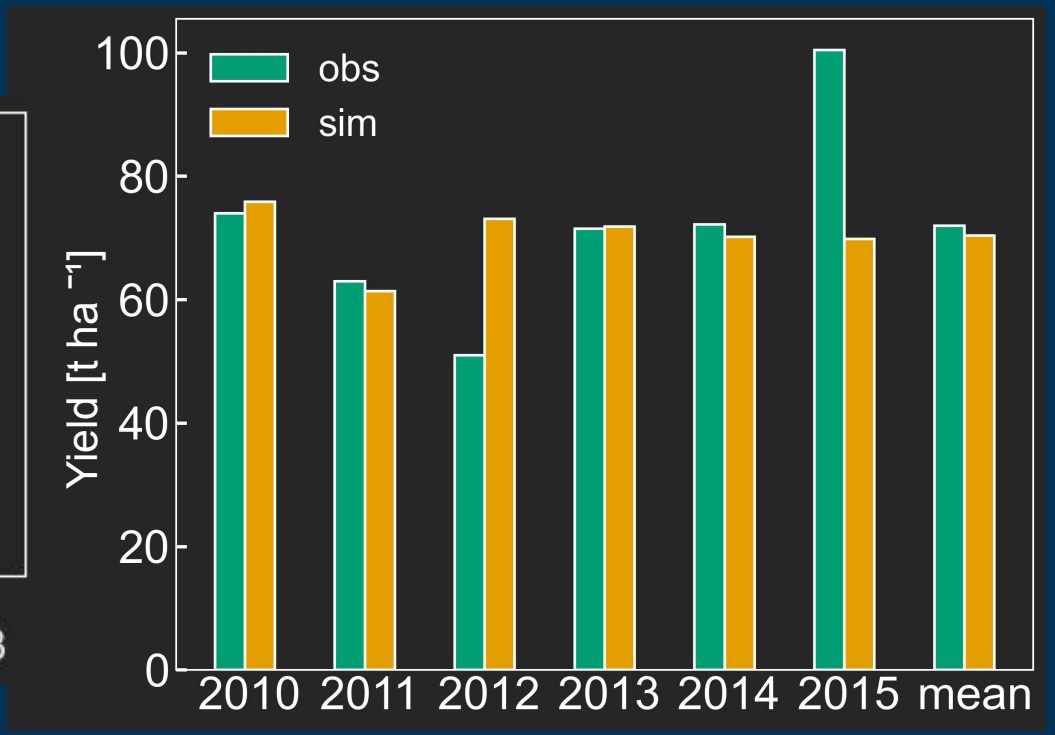
Sensitivity analysis

Apple
PFT 35/36

- Phenology
- CN allocation
- Photosynthesis
- Vegetation structure
- Optical parameters
- Respiration

LAI and yield in the orchard

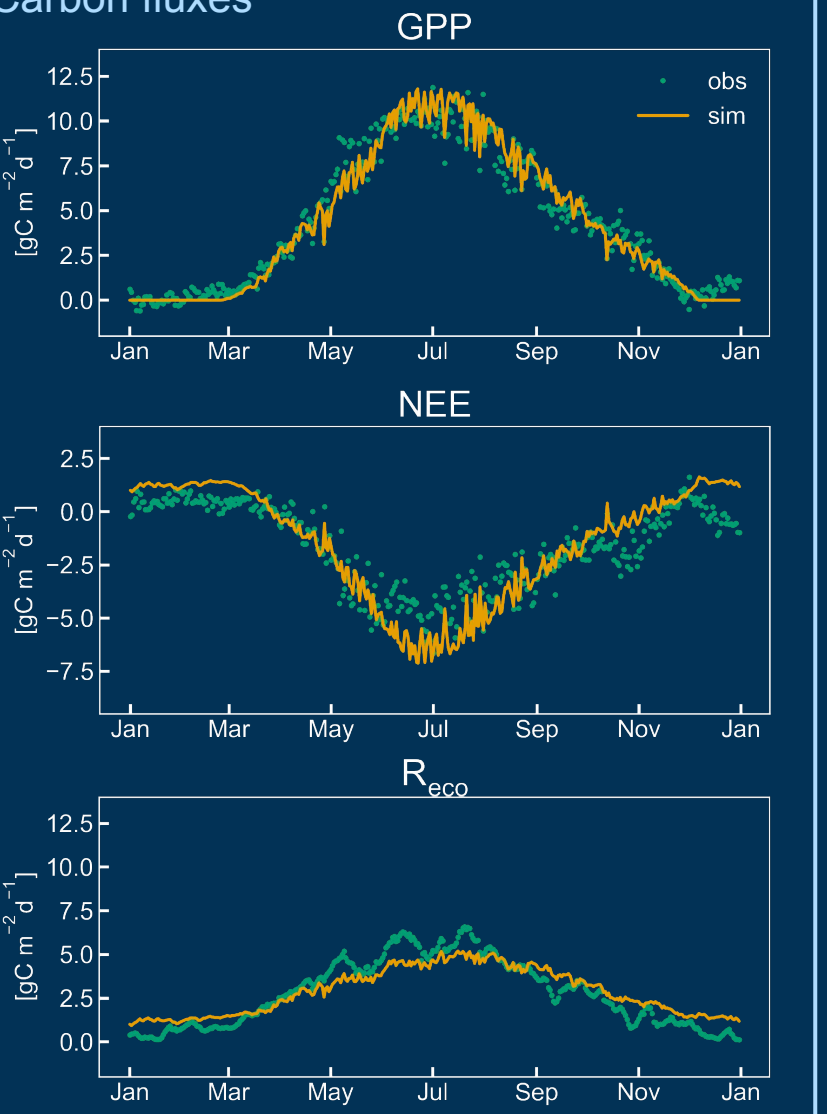




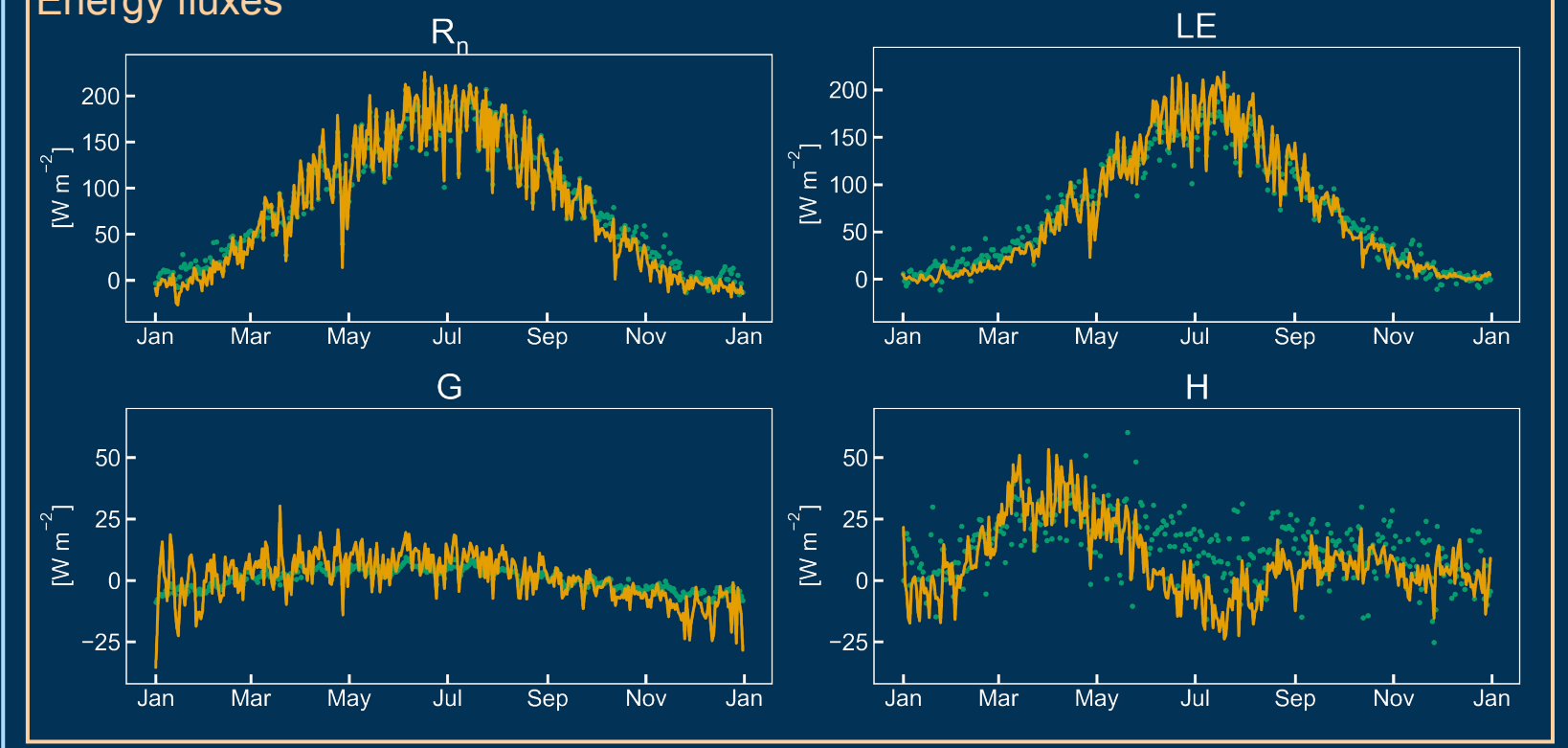
- Canopy duration is well represented.
- CLM simulates low inter-annual yield variability.
- Average yield is well captured.

Seasonal ecosystem fluxes in the orchard (avg. 2013-2015)

Carbon fluxes

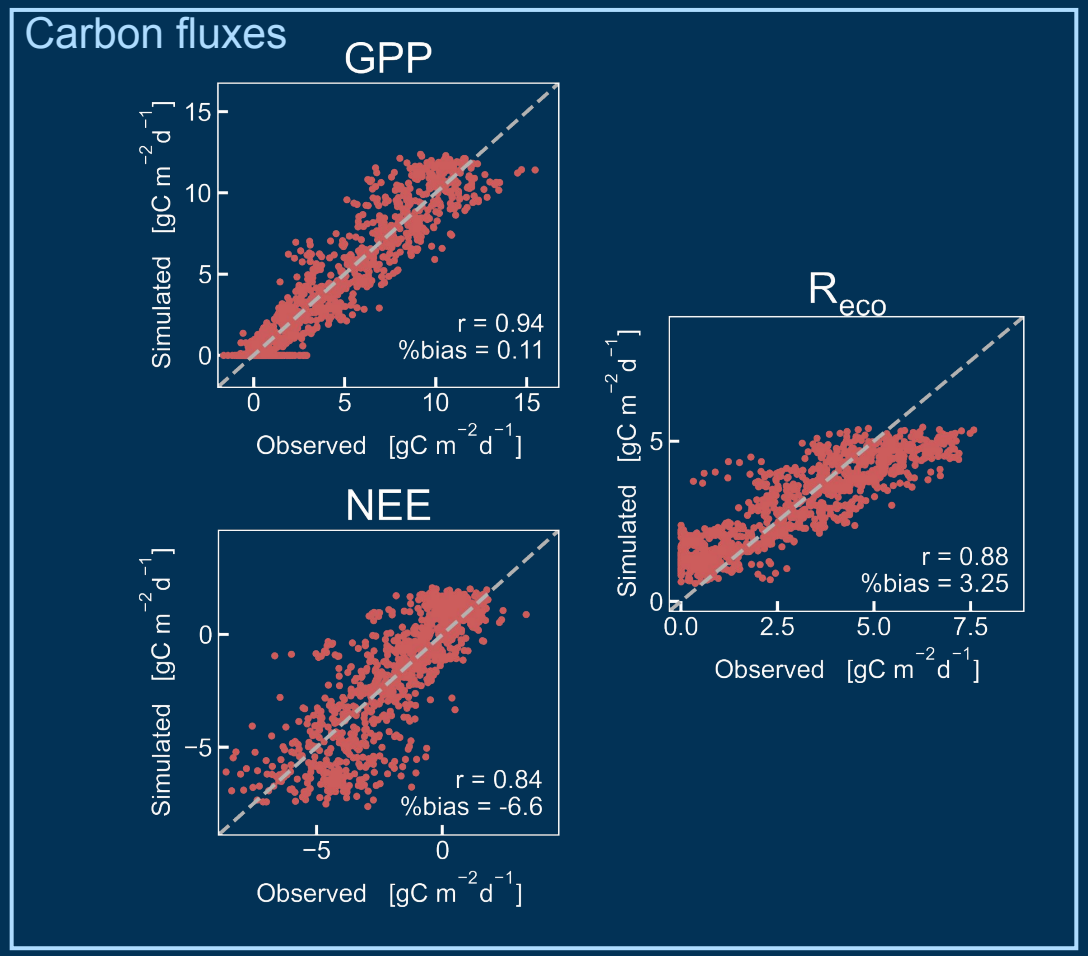


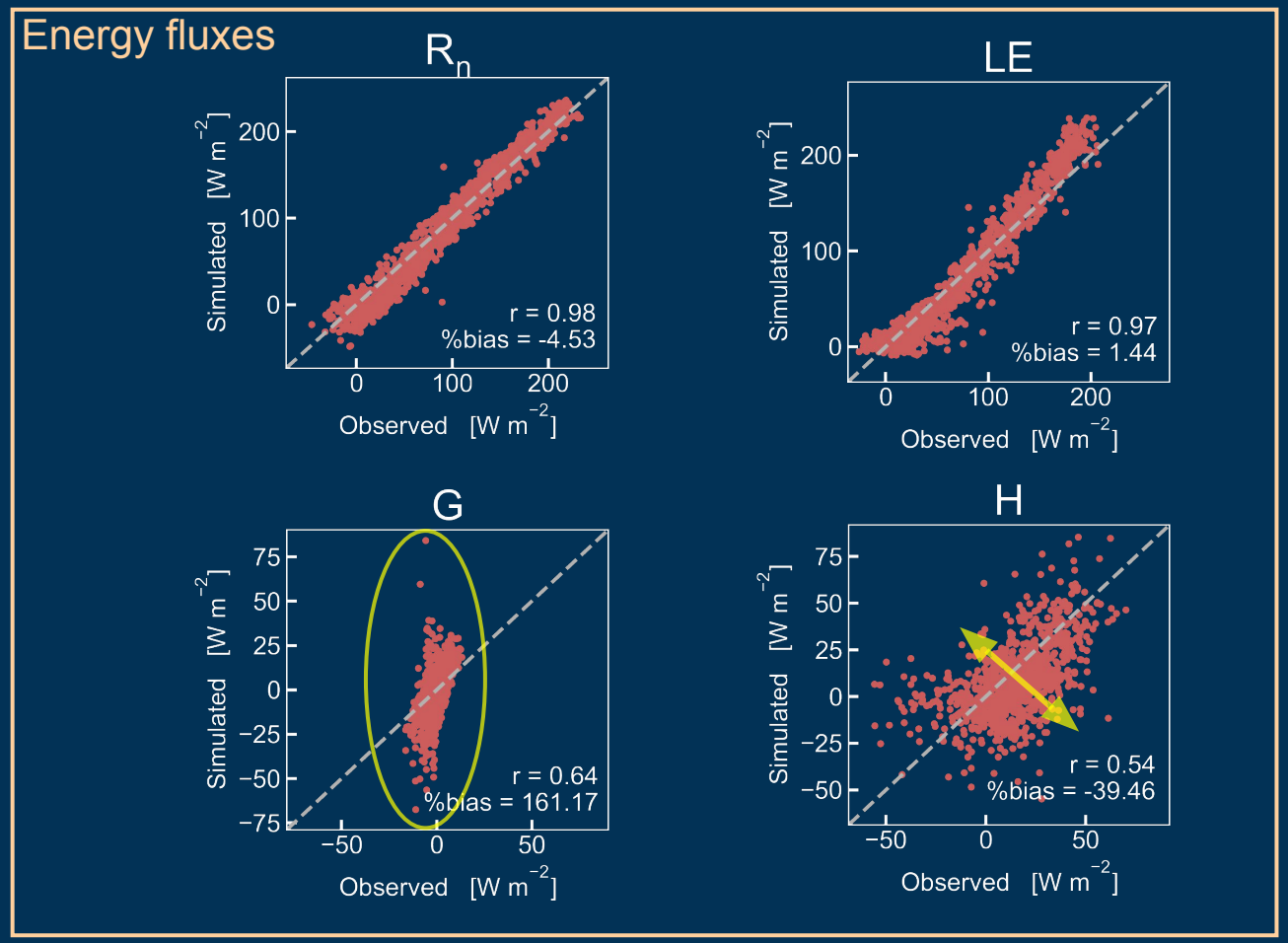
Energy fluxes



- Beginning and end of growing season are well captured.
- Magnitude of fluxes is mostly well captured.
- Lower model variability in Reco□ effects of alley vegetation and additional orchard management? (not simulated)
- Negative bias in sensible heat flux during summer □ irrigation effect?

Scatterplots of ecosystem fluxes in the orchard (2013-2015)





- Ground heat flux → Dampening effect of alley vegetation (not simulated)
- Sensible heat flux → Difficulties in radiation partitioning in complex, discontinuous canopies

Takeaways from developing CLM5-FruitTree

- Biomass and seasonal dynamics of ecosystem fluxes in the deciduous orchard were well represented
- Considering alley vegetation and additional management practices may improve model performance
- Model weaknesses in energy partitioning in complex, discontinuous canopies exist
- Datasets at other sites needed for further model testing and validation!

Dombrowski et al. 2022

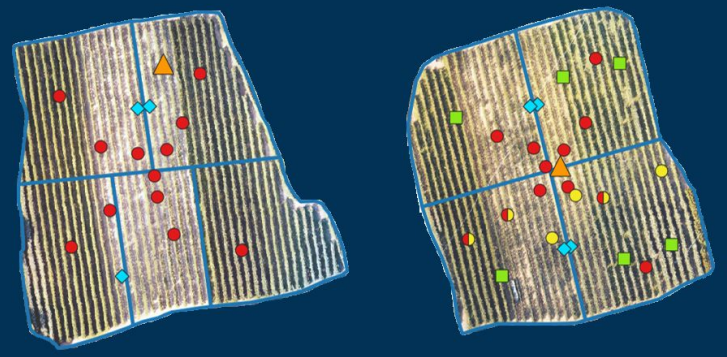
Geoscientific Model Development

CLM5-FruitTree: a new sub-model for deciduous fruit trees in the Community Land Model (CLM5)

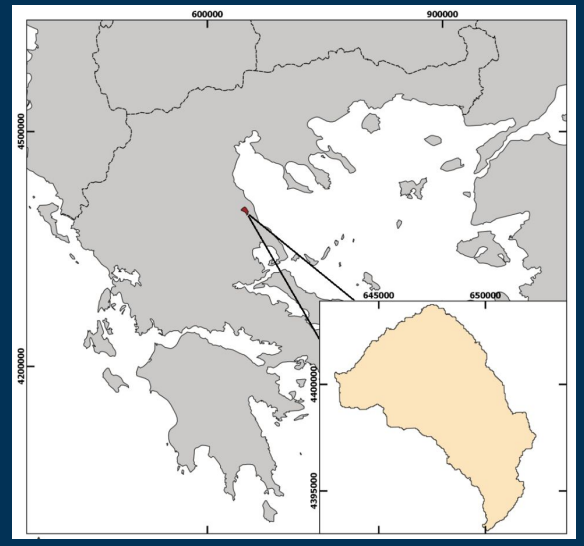
Ongoing work with CLM5-FruitTree in a Greek catchment

CLM5-FruitTree

Single point simulations
Apple orchards (1ha each)



Regional simulation
Pinios Hydrologic Observatory (82 km²)



Field scale irrigation
- Model application and validation
- Assessment and adaptation of irrigation routine

Regional water resources
- Crop water consumption
- Sustainability of irrigation practices
- Adaptation measures

Thanks for your attention!

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