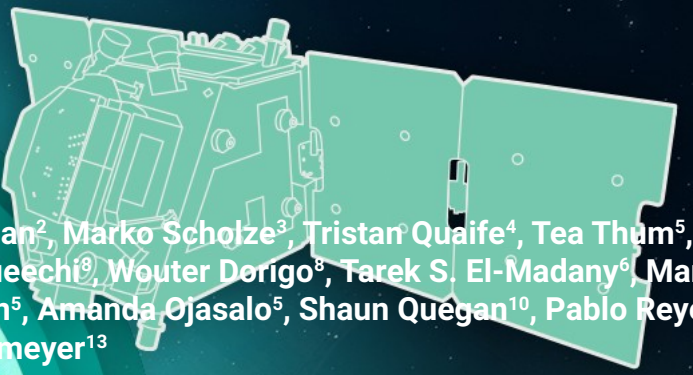
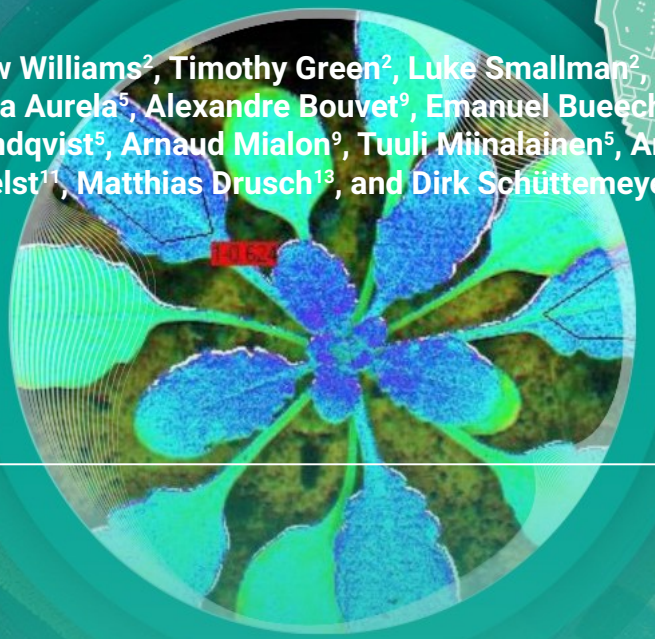
Landsurface Carbon Constellation and Terrestrial Carbon Community Assimilation System





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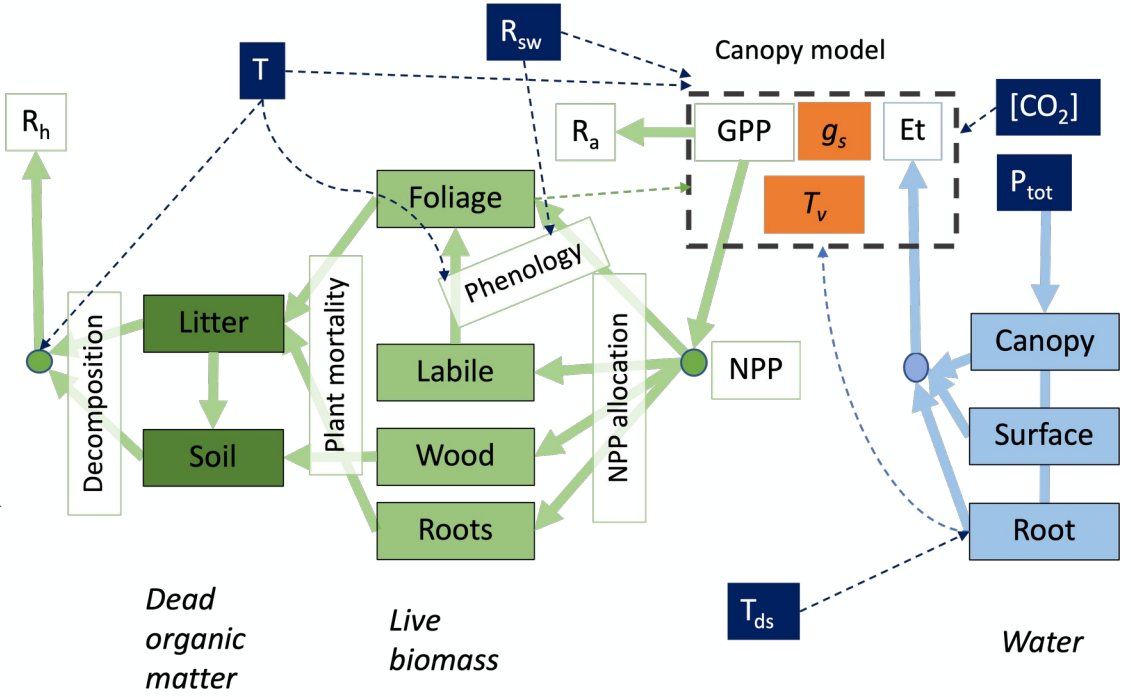
3rd ESA Carbon Science Cluster Meeting,
17. November, 2025

Landsurface Carbon Constellation

- Carbon Cluster
- 13 partners
- 30 months duration
- Synergistic combination of optical and MW observations in a data assimilation framework
- Preparation for BIOMASS and FLEX
- Broad range of activities:
  - EO data
  - Field activities
  - Model and observation operators
  - Data assimilation
- Two main legacies (TCCAS.Inversion-Lab.com):
  - Data Base
    - in situ and EO obs + model output
    - three regions (Lapland, Iberia, NL)
  - Model Development
    - D&B model,
    - observation operators
    - TCCAS

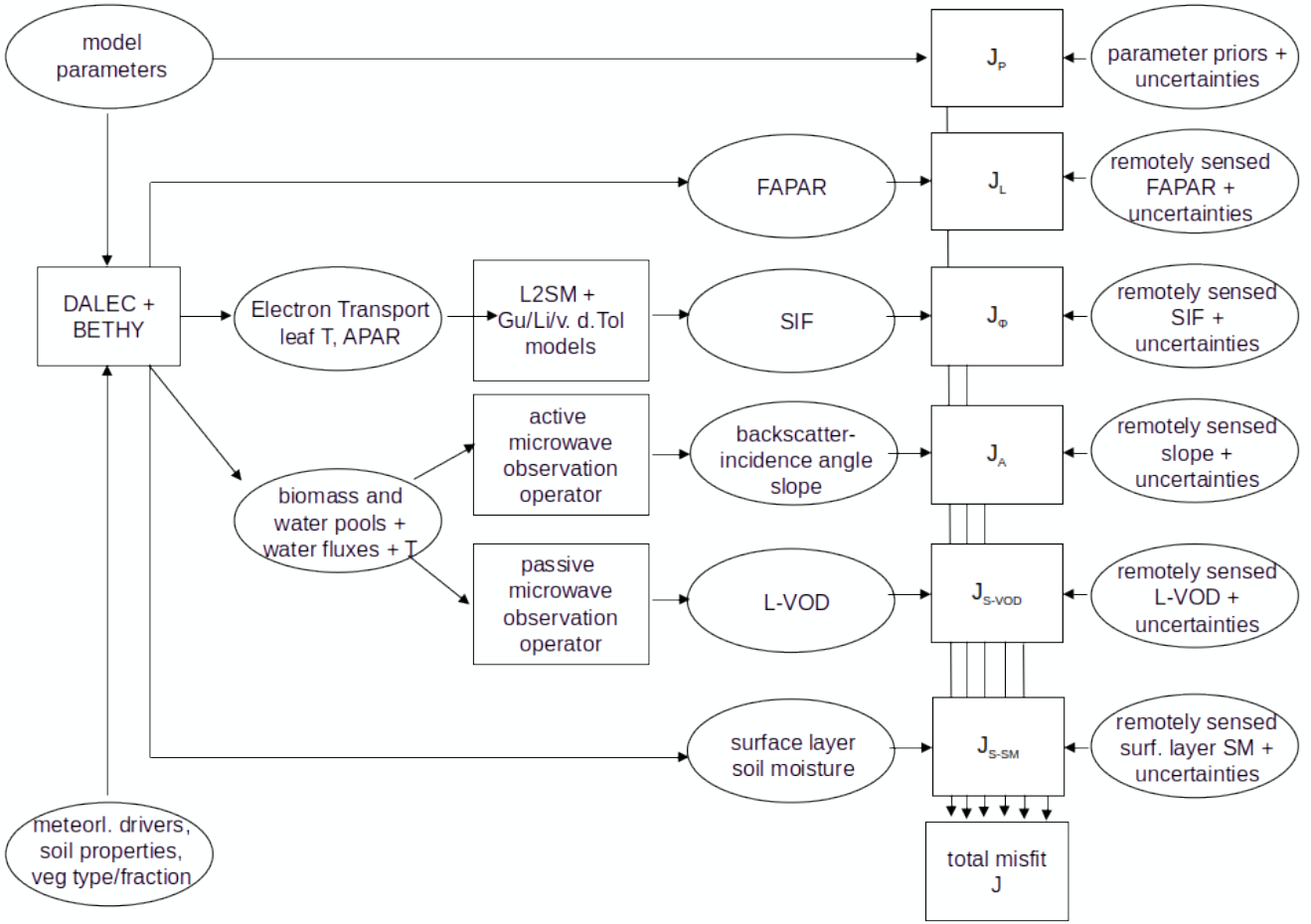


What is TCCAS?

- The **Terrestrial Carbon Community Assimilation System** (TCCAS) is built around the newly developed **D&B terrestrial biosphere** model.
- The focus of TCCAS is the **combination** of a **diverse array of observational data streams** with the **D&B model** to yield a **consistent picture of the terrestrial carbon, water and energy cycles**.
- The development of TCCAS is being **funded** through the **carbon cluster of the European Space Agency** and under Contract No 101082194 by the European Union.
- TCCAS is an open source activity set up by six institution partners:

What does TCCAS offer?

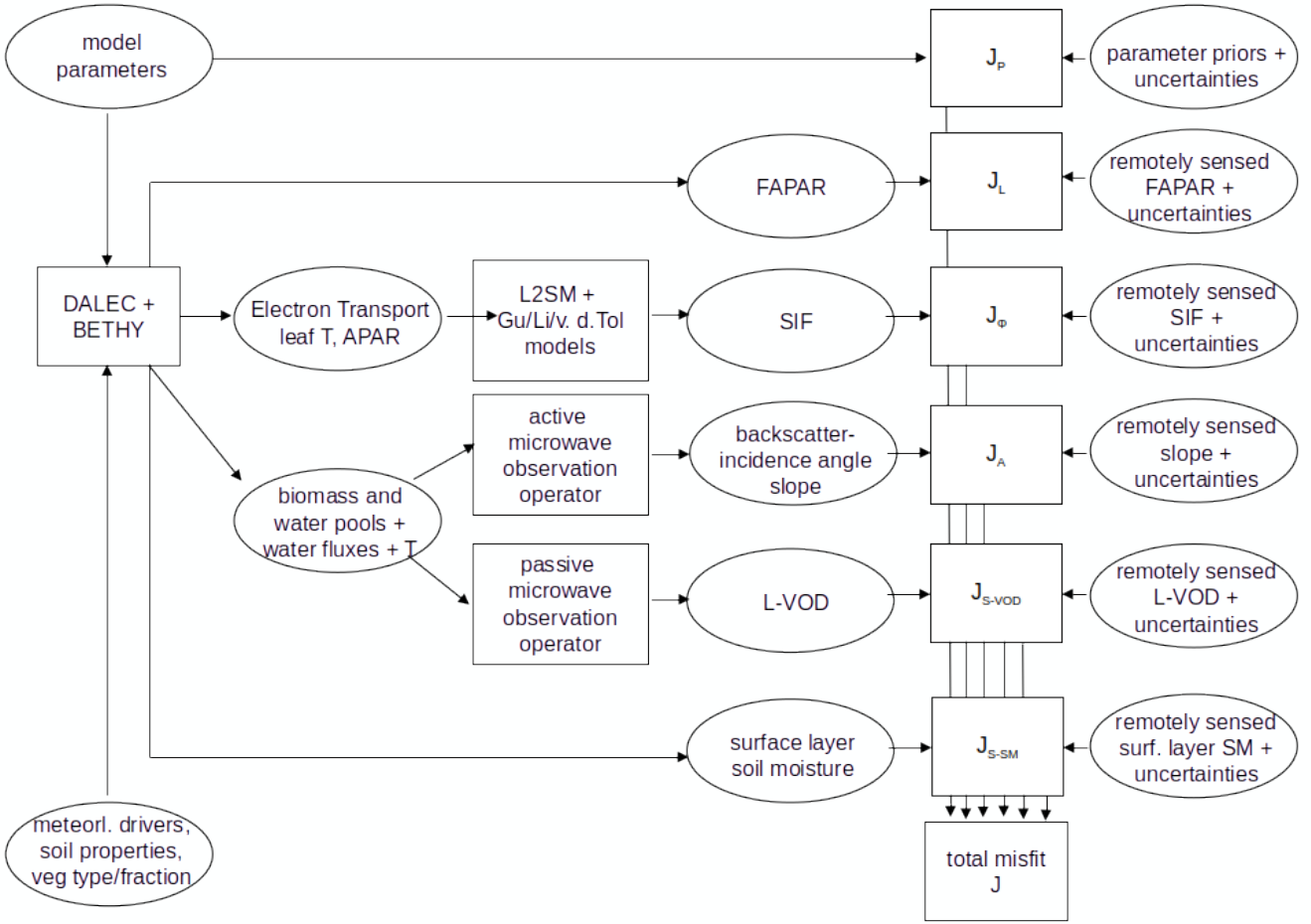
- Open source community system
- Observation operators for optical as well as active and passive microwave observations
- Assimilation on the footprint
- Tangent and adjoint codes
- Modular setup
- Computational efficiency
- Tested on point to regional scales
- Can operate at high resolution
- Experienced developer team
- Documentation
- User support and training



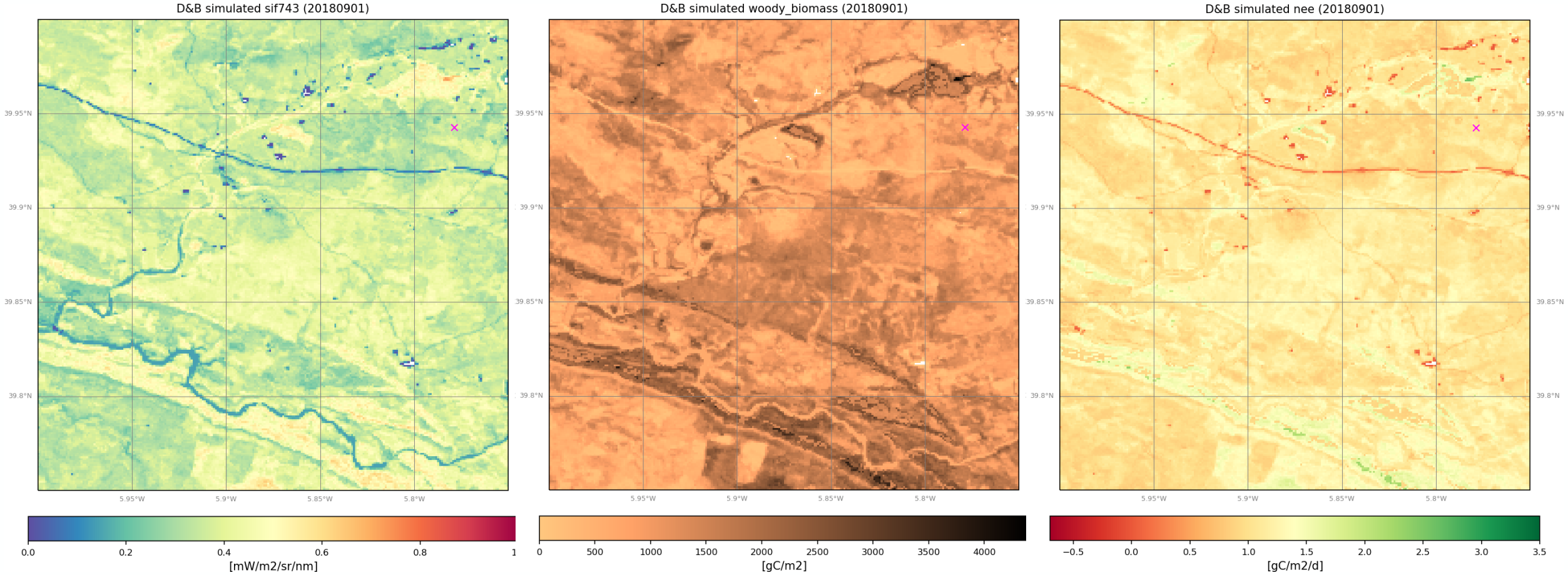
User Training

Training events (>100 users trained in total):

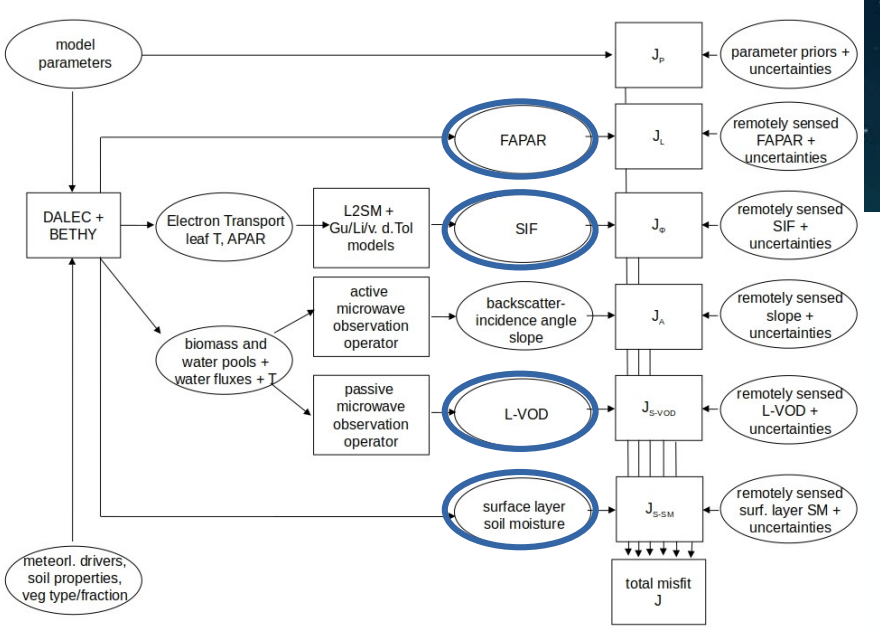
- Edinburgh, May 2024
- On line, June 2024
- ESRIN, October 2024
- Living Planet Symposion, June 2025
- Nanjing, August 2025
- Hamburg, September2025



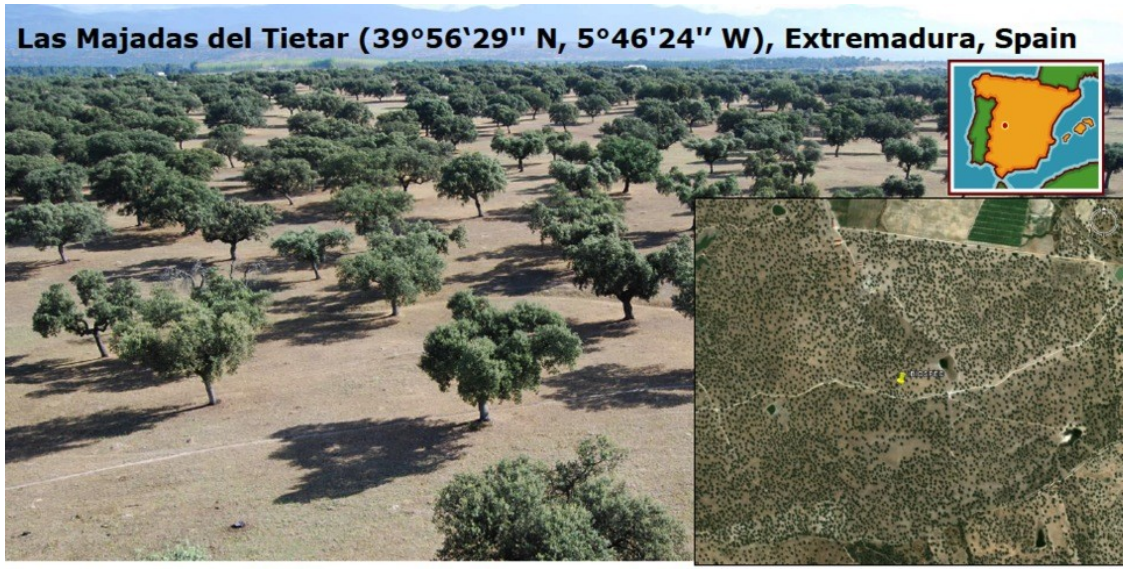
Posterior simulation over a region in Spain at 100 m resolution
SIF (left), Woody biomass (middle), NEE (right)



Example: Majadas de Tietar



- Savannah site in Extremadura, Spain
- C3 grass and temperate evergreen trees
- Spin up 2015+2016
- Assimilation window 2017-2021
- Joint assimilation of:
  - FAPAR: JRC-TIP, twostream RT
  - SIF: TROPOSIF, Gu model
  - L-VOD: SMOS, empirical
  - surface layer soil moisture: SMOS



Ecosystem: ***dehesa*** Mediterranean Holm Oak open woodland (Savanna)

Observation Operator for VOD

biomass multiplier

water status multiplier

$$\tau_\lambda = f(T)(l_{wd}C_{wd} + l_{fol}C_{fol})(l_s f_{soil} + l_f f_E + l_0)$$

C in wood

C in foliage

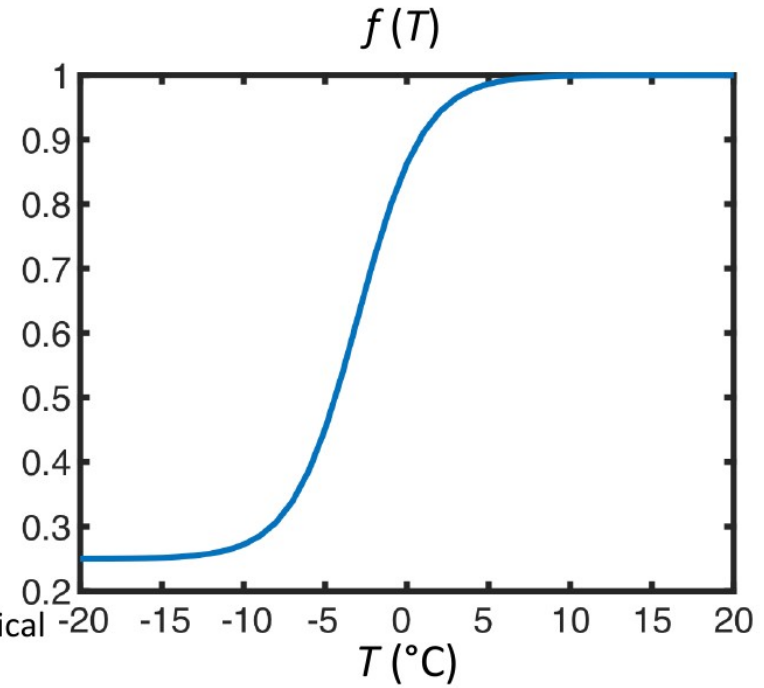
plant-available soil water, fraction of field capacity

actual / potential evapotranspiration

l_x: parameters

temperature function*:

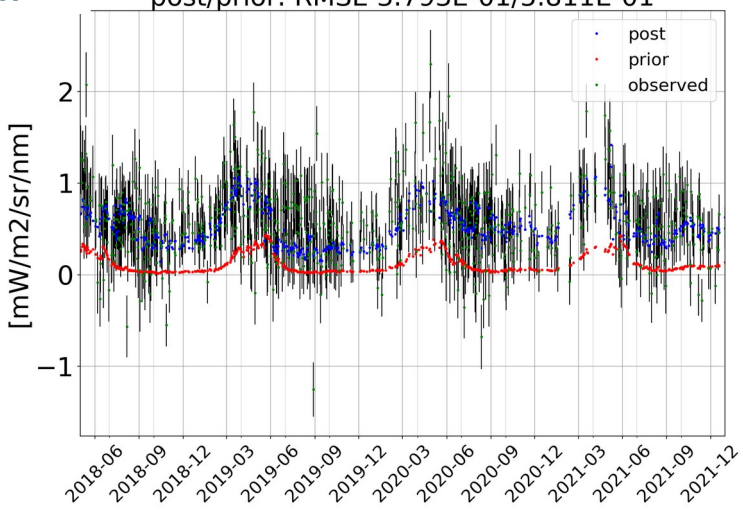
$$f(T) = 0.25 + 0.75/(1 + e^{-0.5(T+3)})$$



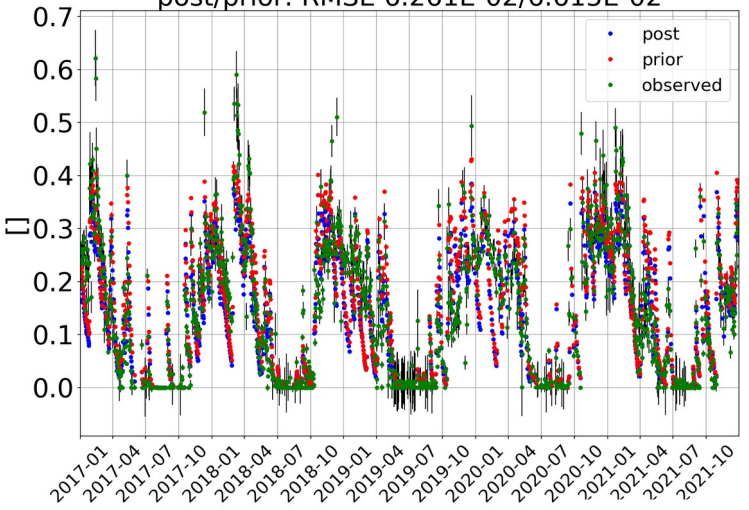
*based on: Schwank et al. Temperature effects on L-band vegetation optical depth of a boreal forest, Remote Sensing of Environment, 2021

Example: Las Majadas de Tietar
Assimilation (left/middle) and validation (right) variables

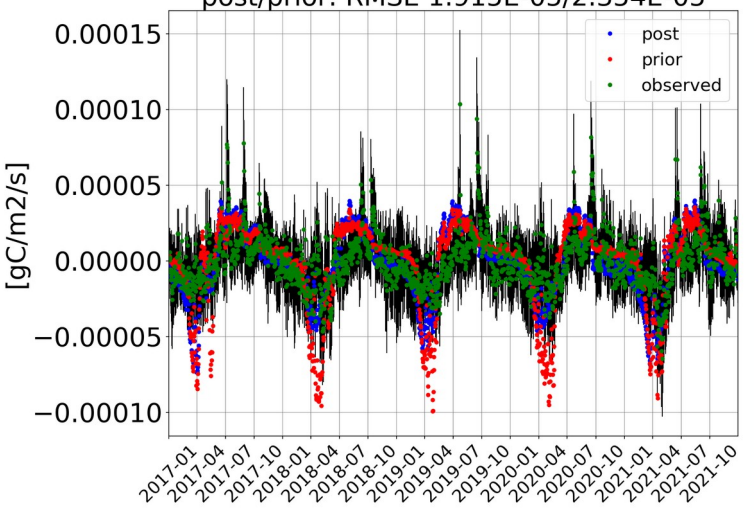
SIF



SM

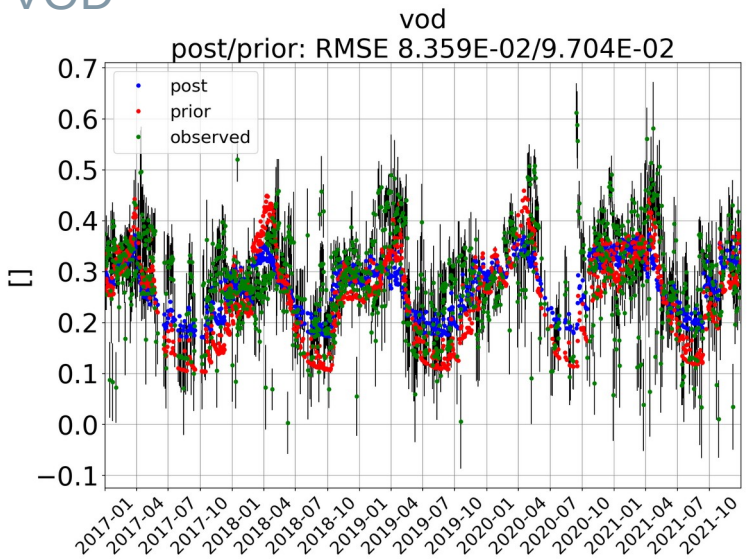


NEP

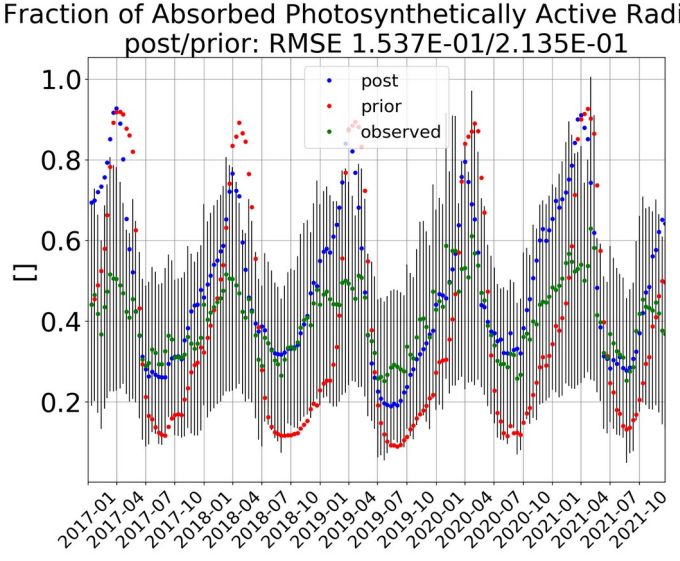


Obs (green), prior (red), posterior (blue)

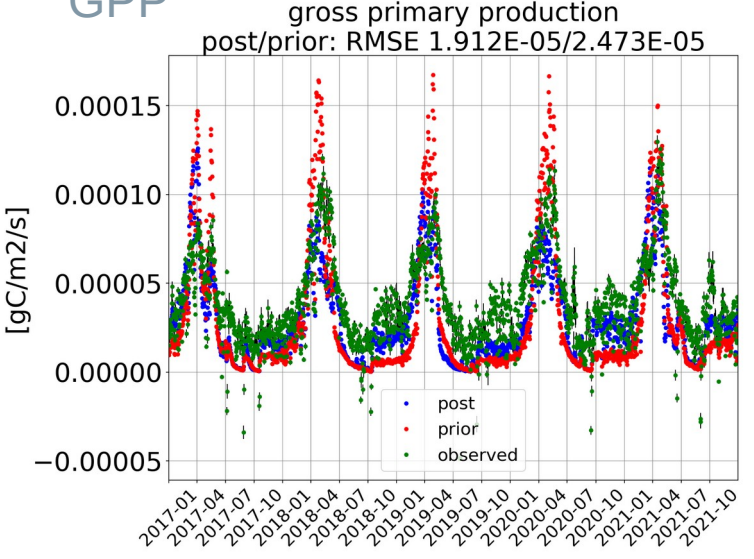
L-VOD



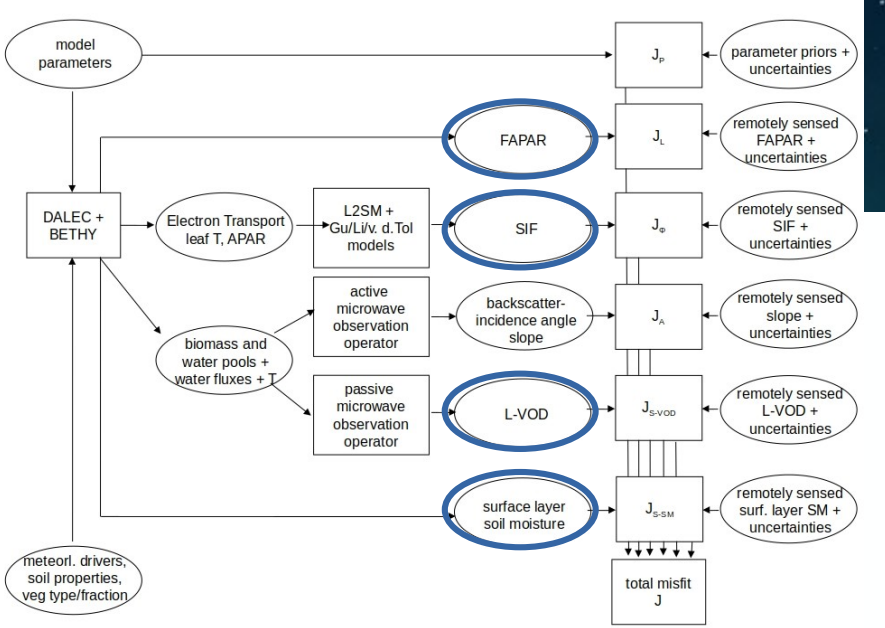
FAPAR



GPP

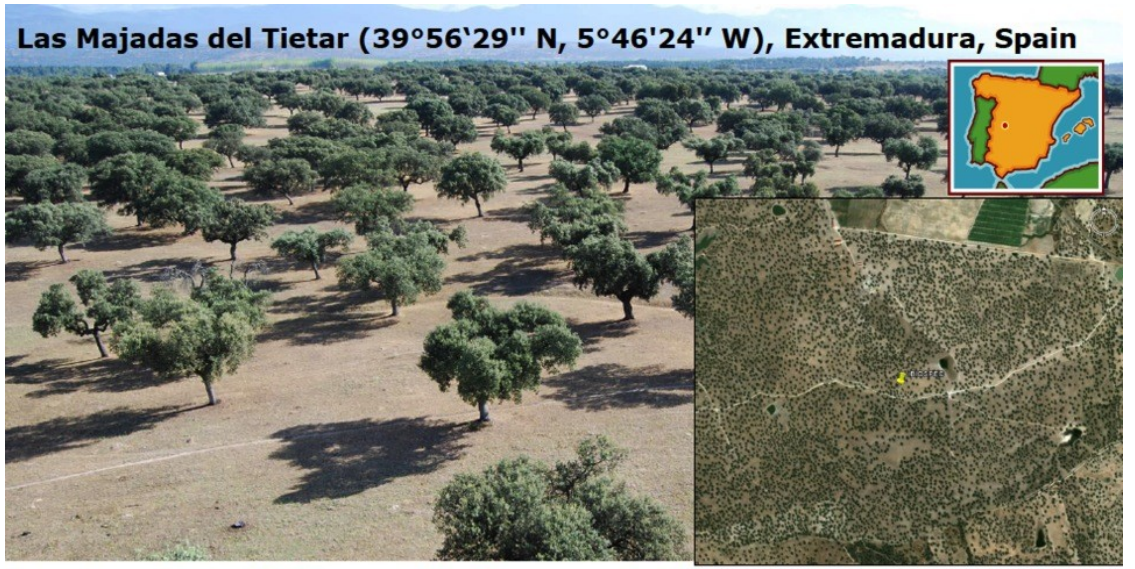


Example: Majadas de Tietar Hypothetical Intervention



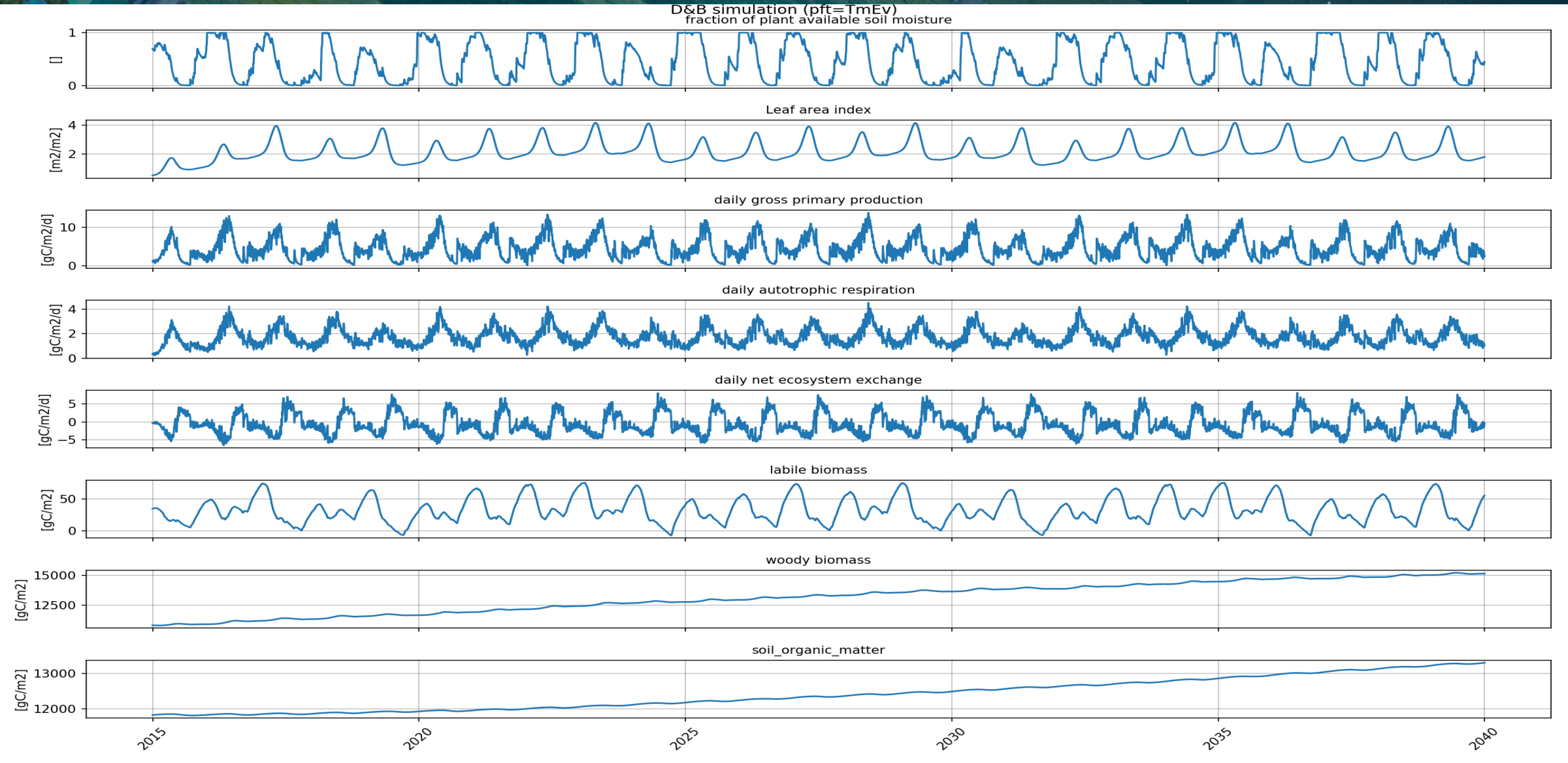
How much **extra carbon** can be **stored** through a (hypothetical) **intervention**?

- We **convert** a fraction of the area **from grass to trees** by replacing the grass with small trees.
- We perform simulations for the intervention case based on the **posterior parameter set and initial pools** sizes. For the converted fraction, the initial size of dead pools is taken from the grass and for the living pools have 1% of the sizes of the adult trees.
- We compute the **effect of intervention on carbon uptake** for **25 year time horizon** by subtracting the counterfactual case from the intervention case.

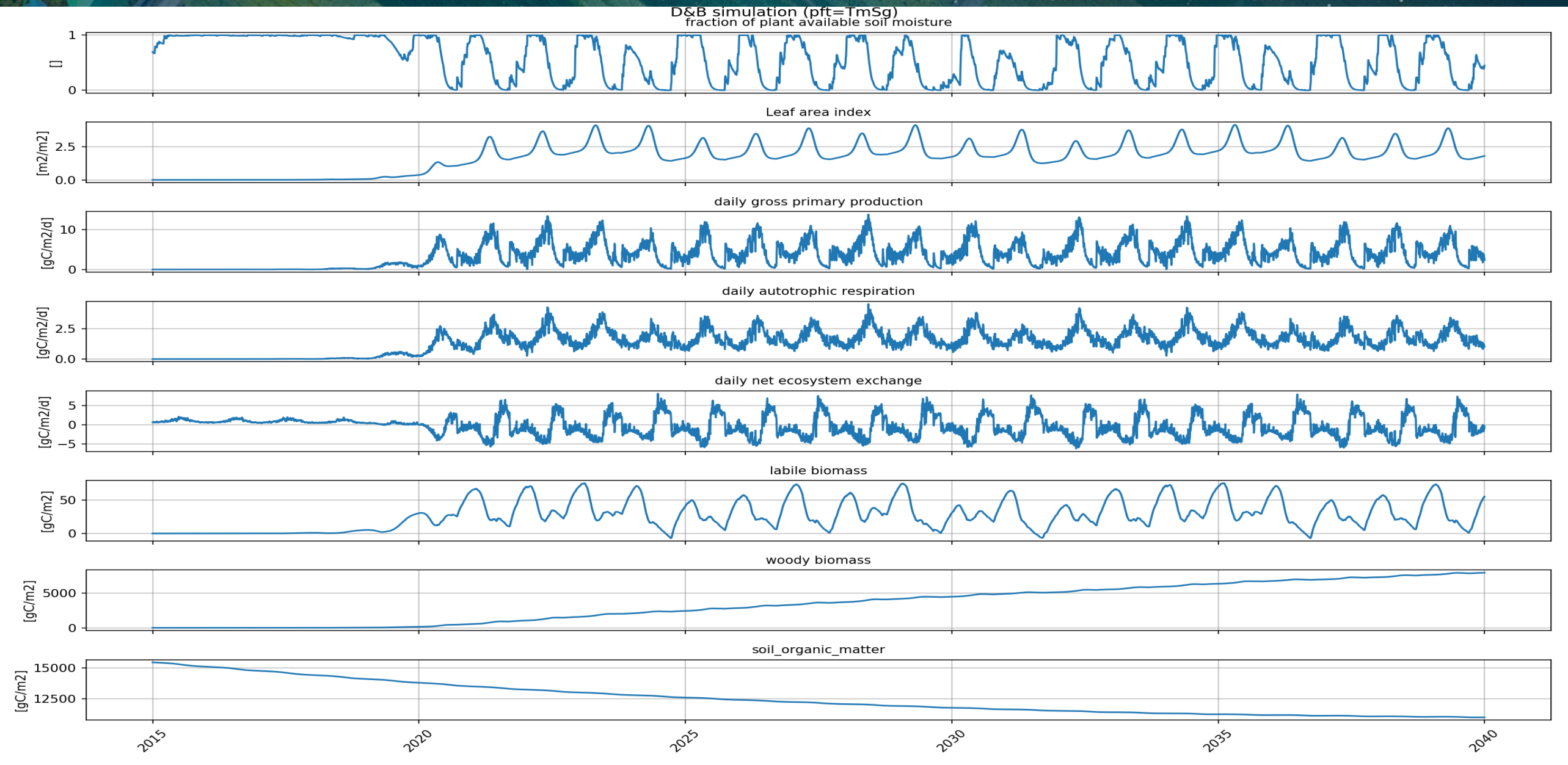


Ecosystem: ***dehesa*** Mediterranean Holm Oak open woodland (Savanna)

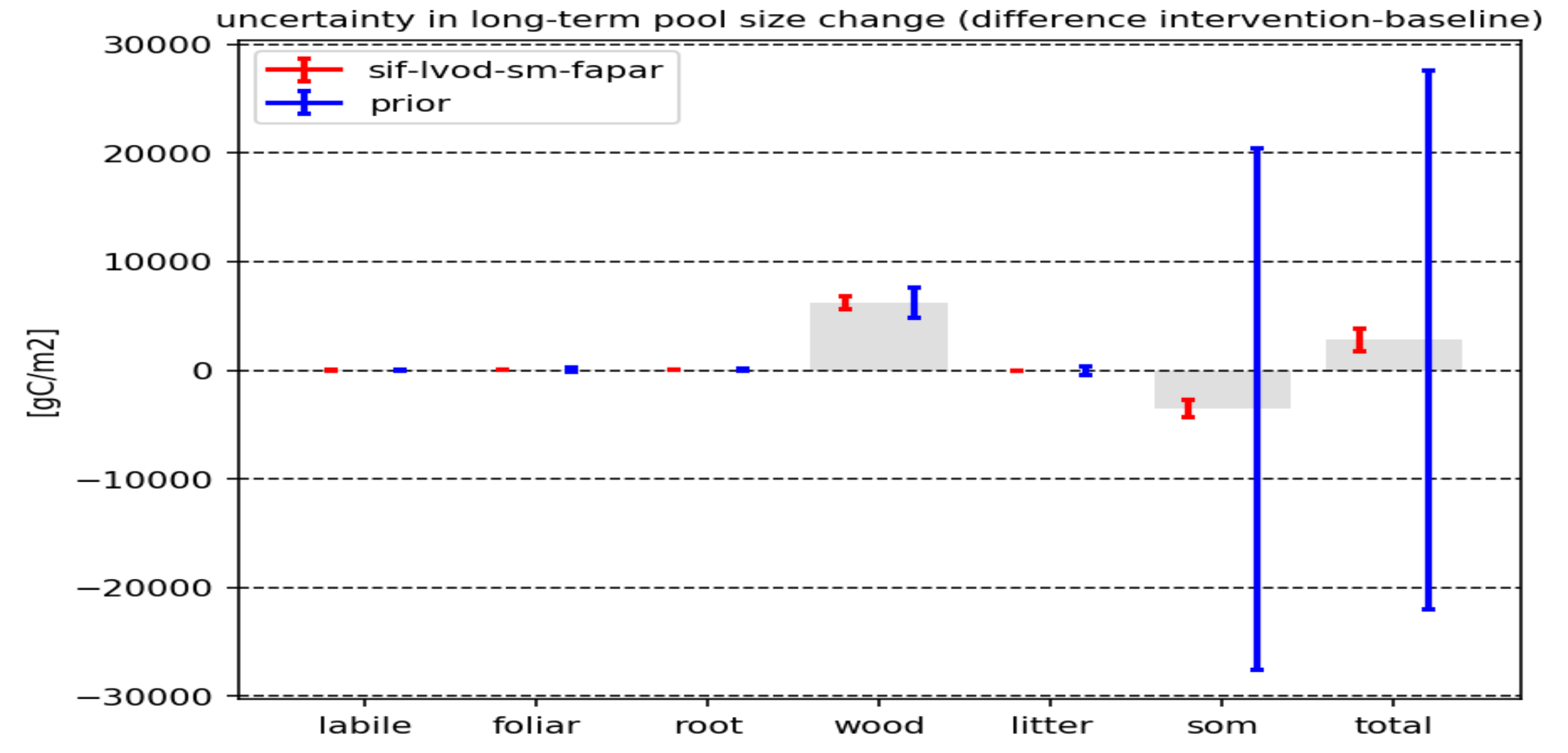
Adult trees


D&B simulation (pft=TmEv)
fraction of plant available soil moisture
[]
1
0
Leaf area index
[m2/m2]
4
2
daily gross primary production
[gC/m2/d]
10
0
daily autotrophic respiration
[gC/m2/d]
4
2
0
daily net ecosystem exchange
[gC/m2/d]
5
0
−5
labile biomass
[gC/m2]
50
0
woody biomass
[gC/m2]
15000
12500
soil_organic_matter
[gC/m2]
13000
12000
2015
2020
2025
2030
2035
2040

Baby trees


D&B simulation (pft=TmSg)
fraction of plant available soil moisture
[]
1
0
Leaf area index
[m2/m2]
2.5
0.0
daily gross primary production
[gC/m2/d]
10
0
daily autotrophic respiration
[gC/m2/d]
2.5
0.0
daily net ecosystem exchange
[gC/m2/d]
5
0
−5
labile biomass
[gC/m2]
50
0
woody biomass
[gC/m2]
5000
0
soil_organic_matter
[gC/m2]
15000
12500
2015
2020
2025
2030
2035
2040

Reduction in uncertainty relative to prior of increase in carbon pools over integration period relative to baseline



Summary

- TCCAS provides an integrated perspective on carbon, water and energy cycles
- Combines information from multiple missions (synergy) with D&B process understanding
- Can monitor relevant variables – including net carbon flux - in space and time
- Can quantify of the impact of an intervention in the landscape on carbon uptake (Carbon Credits)
- BIOMASS mission products are expected to provide a strong additional contraint

Further Information

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