Terrestrial Carbon Community Assimilation System

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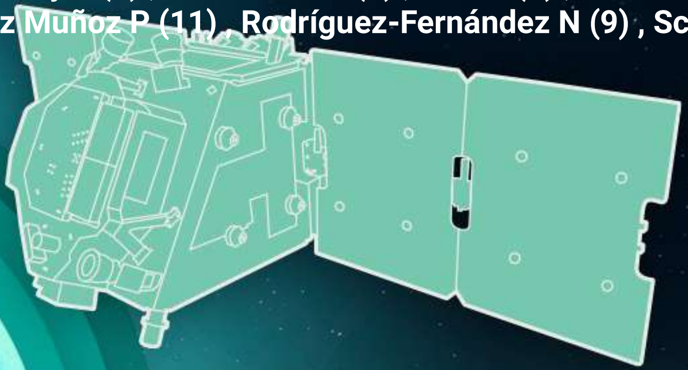

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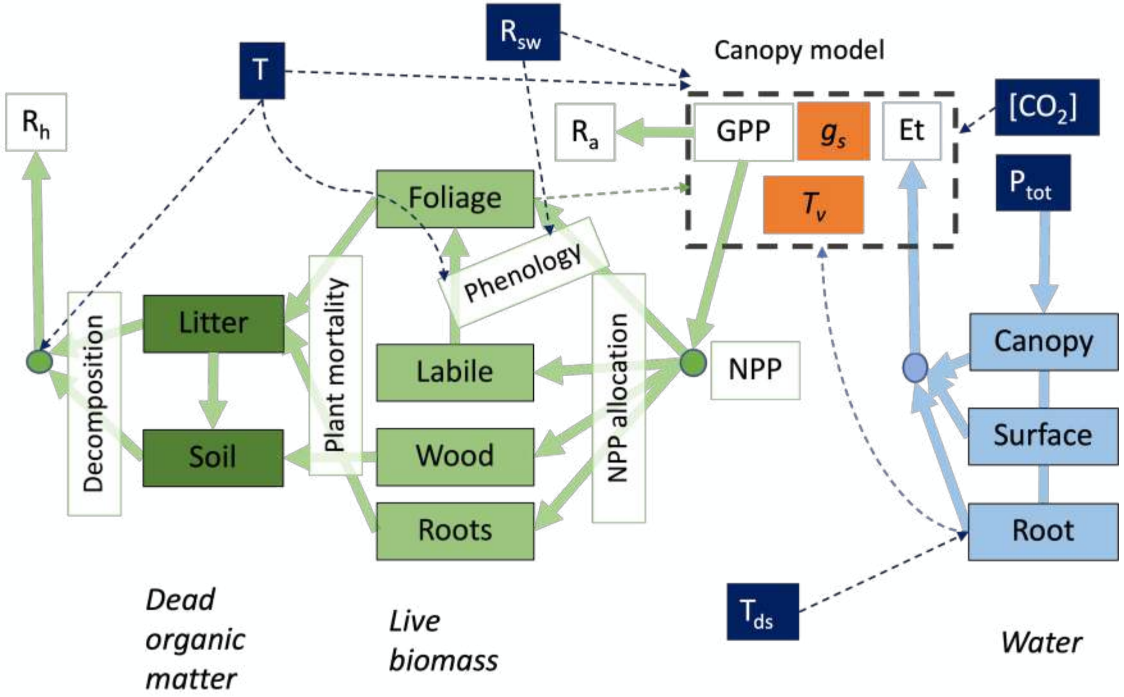
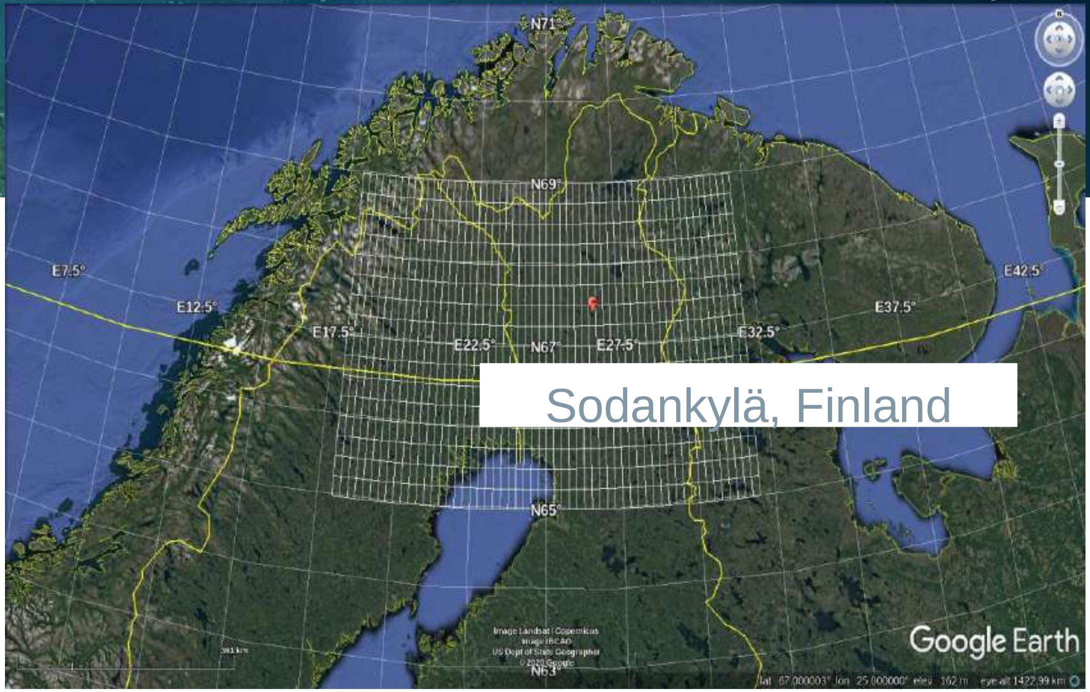
What is TCCAS?

- 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



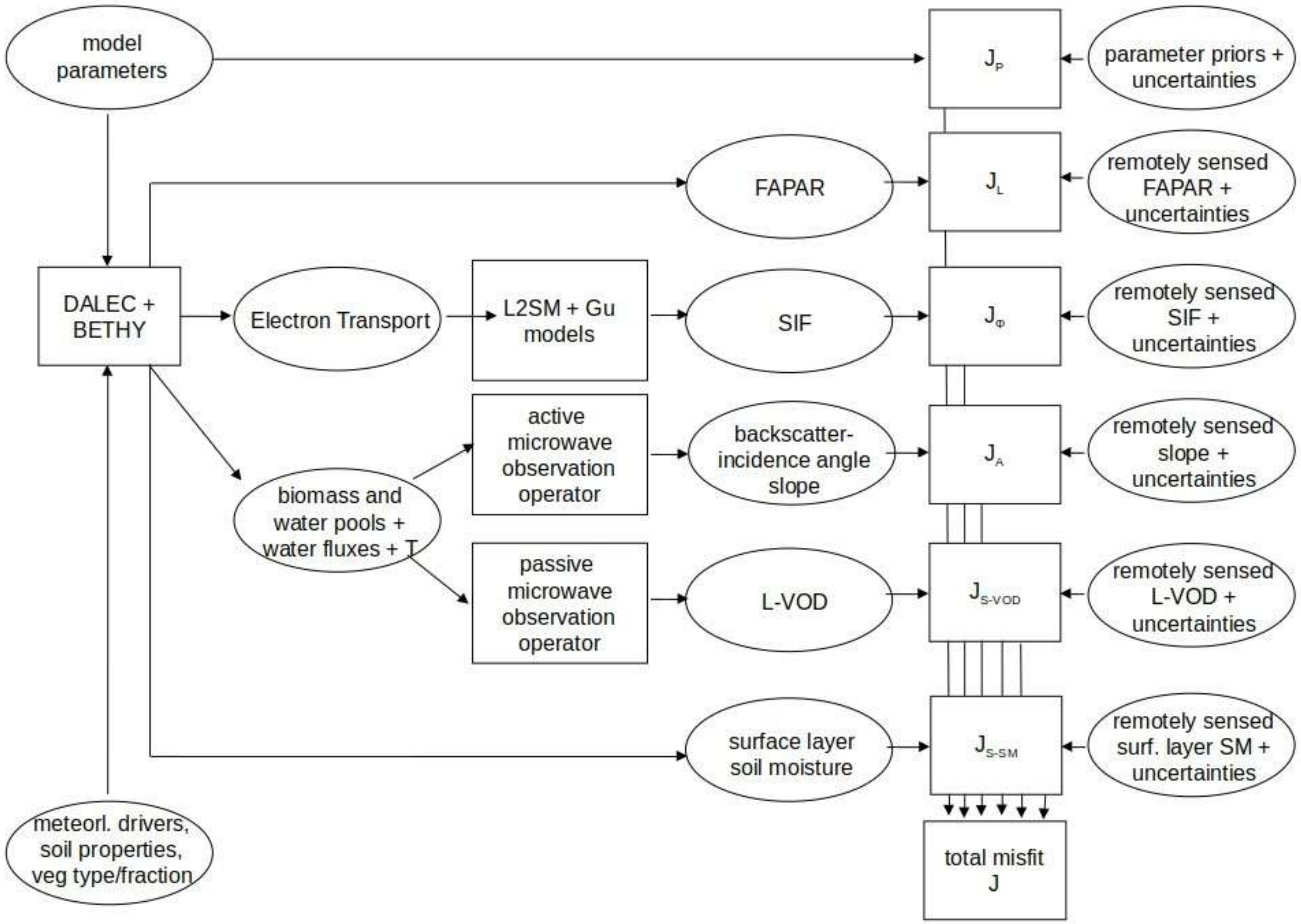
Developed and tested
at site and regional scales



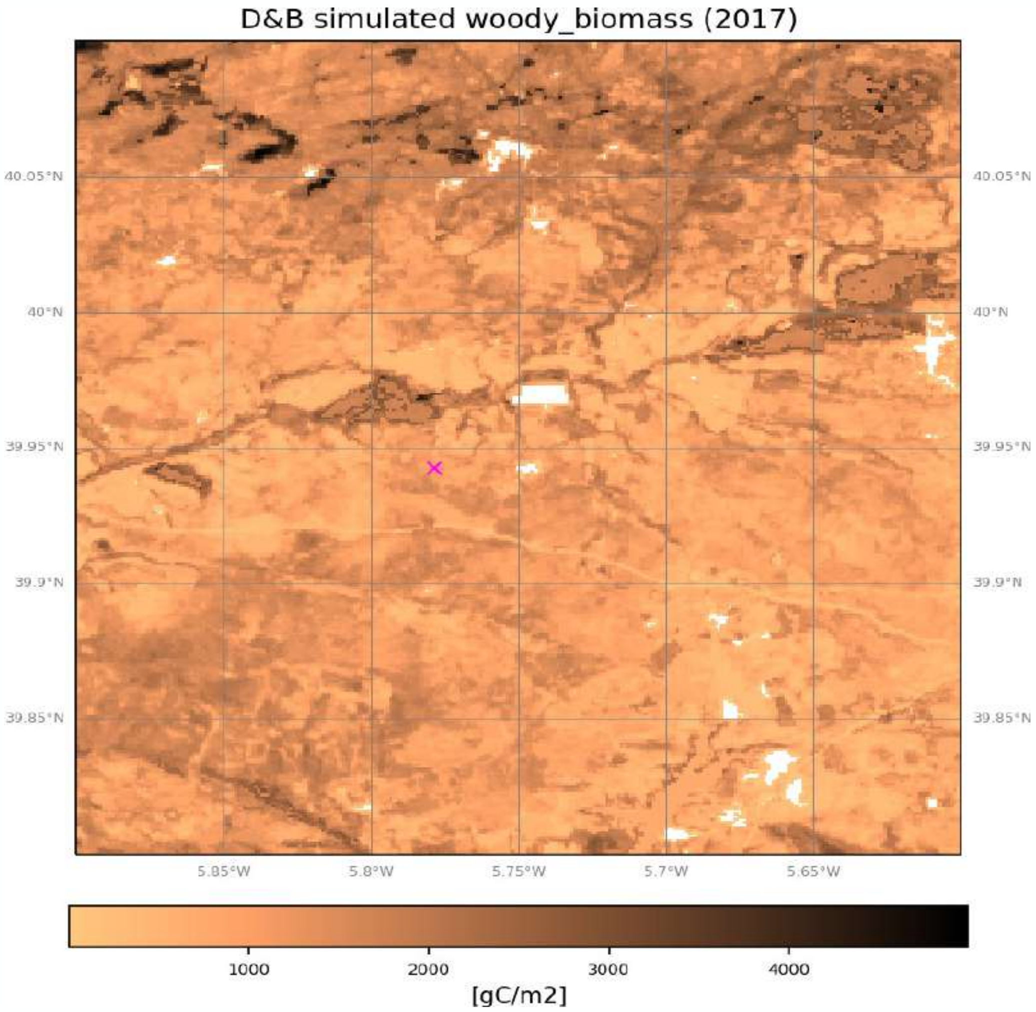
- Within the Landsurface Carbon Constellation Study: https://lcc.inversion-lab.com/
- Relied on comprehensive data base of satellite and Field Data
- Collected over two sites/regions

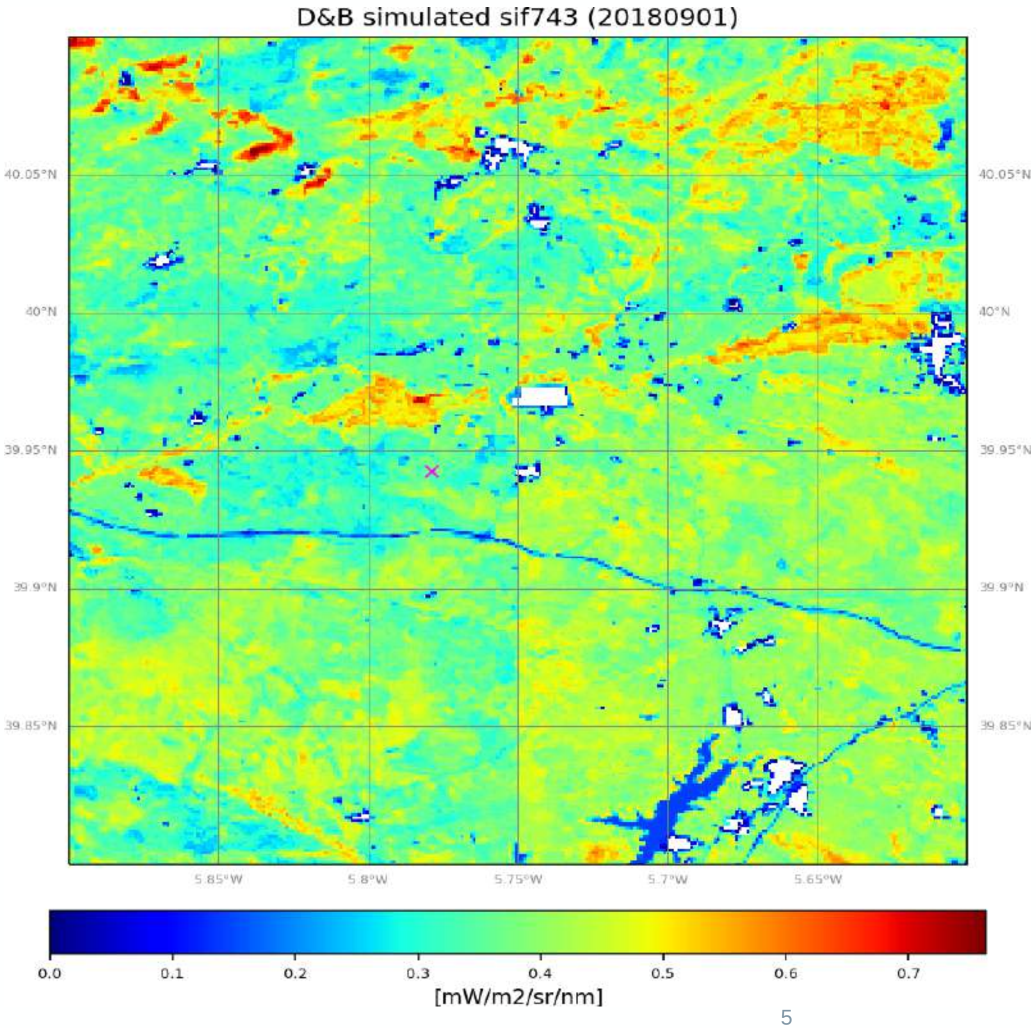
What does TCCAS offer?

- 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
- Experienced developer team
- Documentation
- User support and training



Spatial Detail
Examples: Woody biomass (left) and SIF (right) around Majadas de Tietar





Simulation on the footprint/target area
Example: SMOS

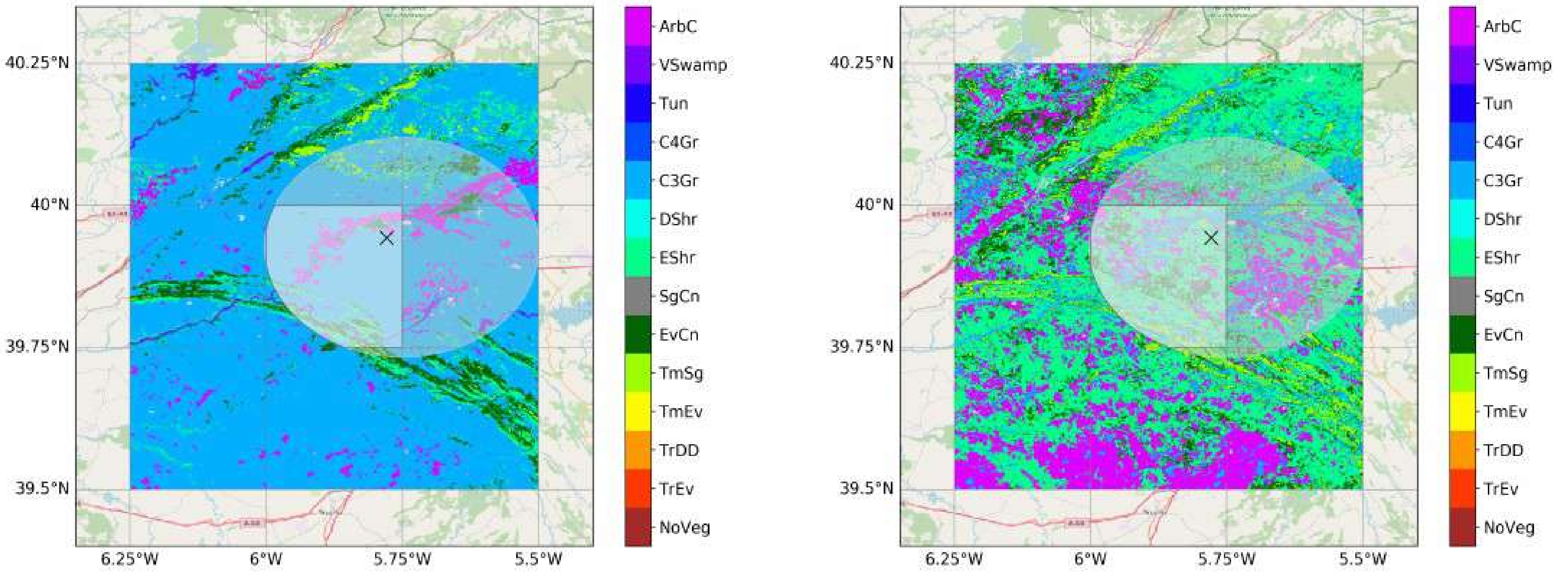
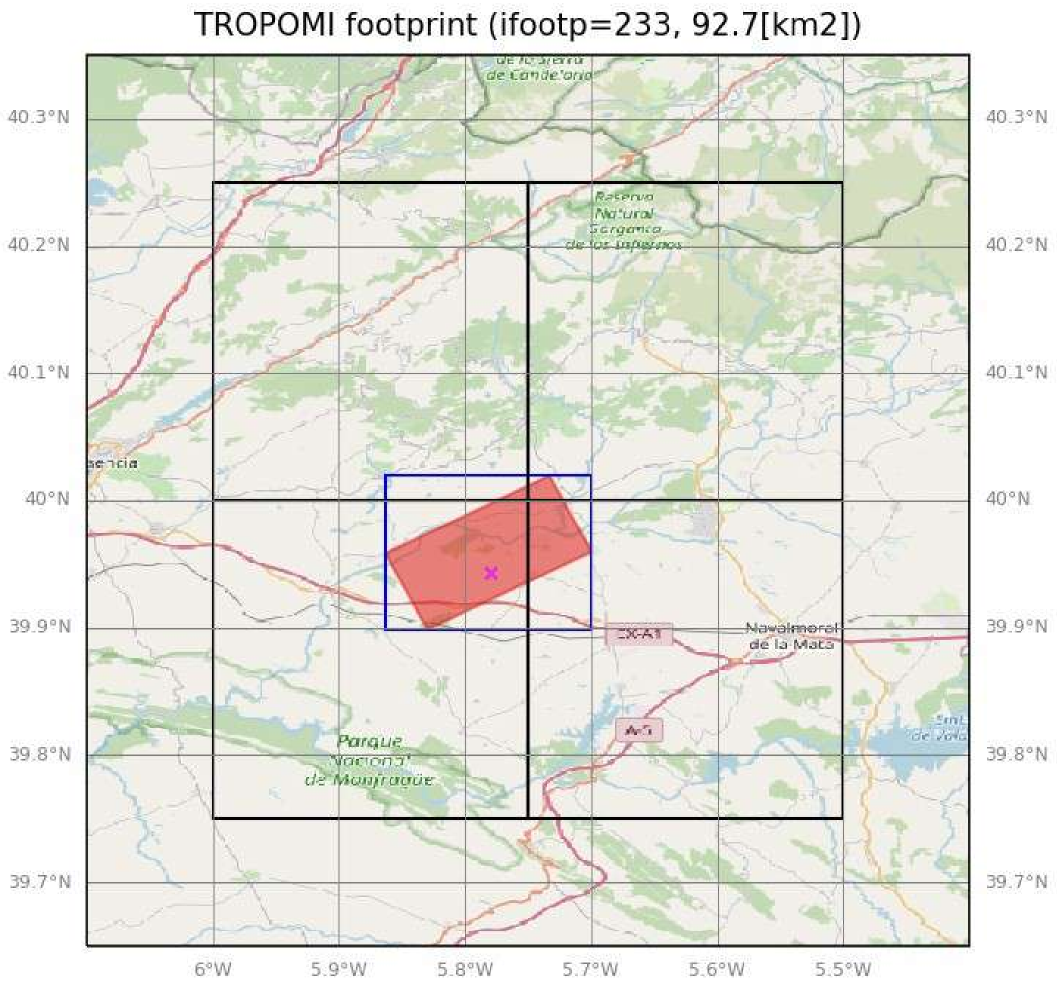
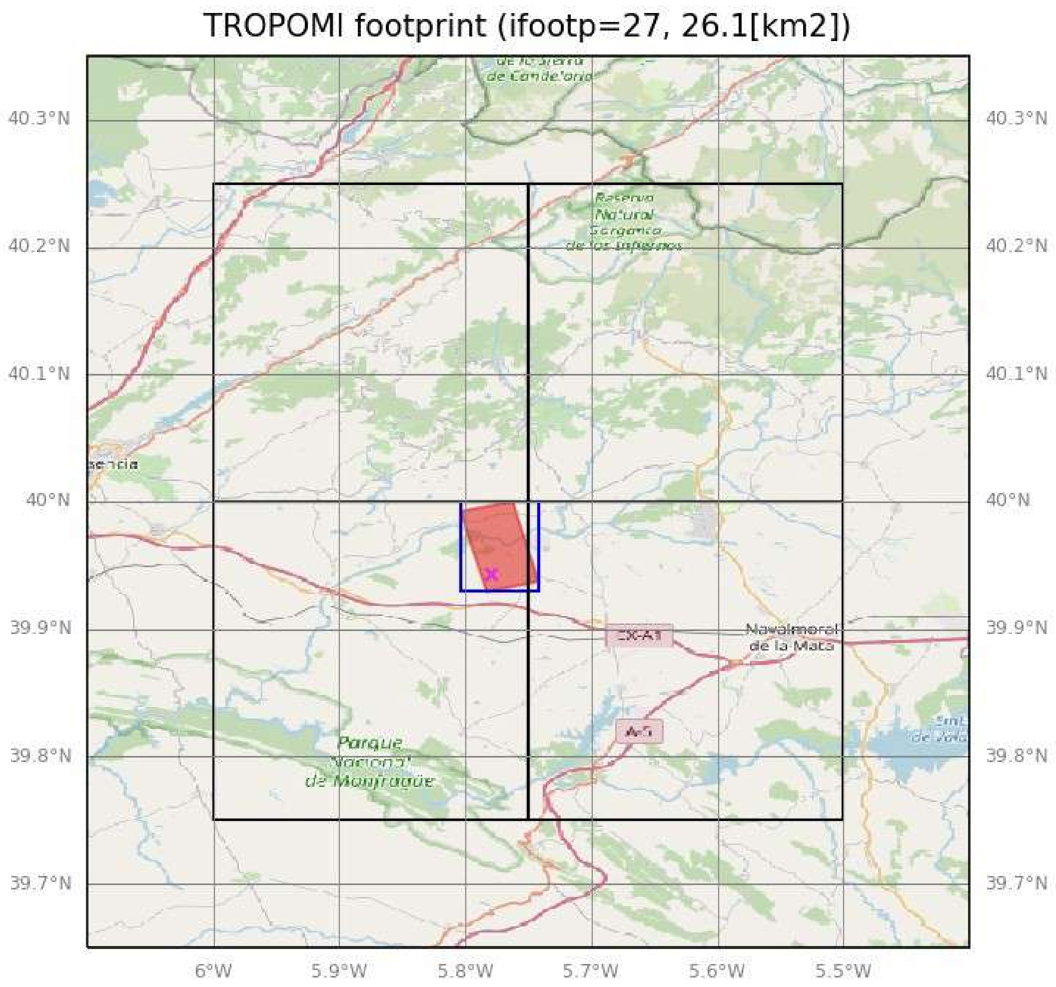


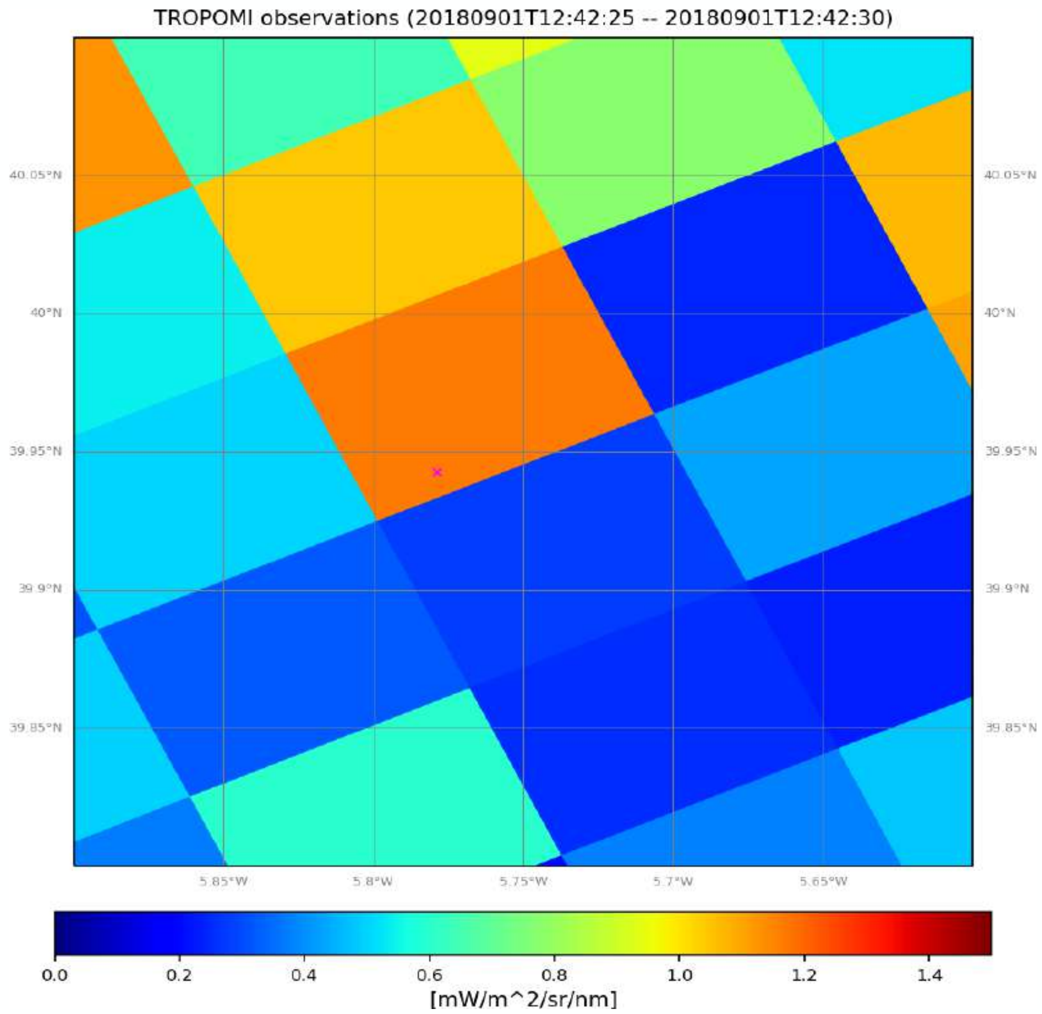
Figure 3: SMOS footprint (ellipse) along with the primary (left) and secondary (right) PFT over the grid defined by the meteorological driving data, with the location of the LM1 site indicated by a cross.

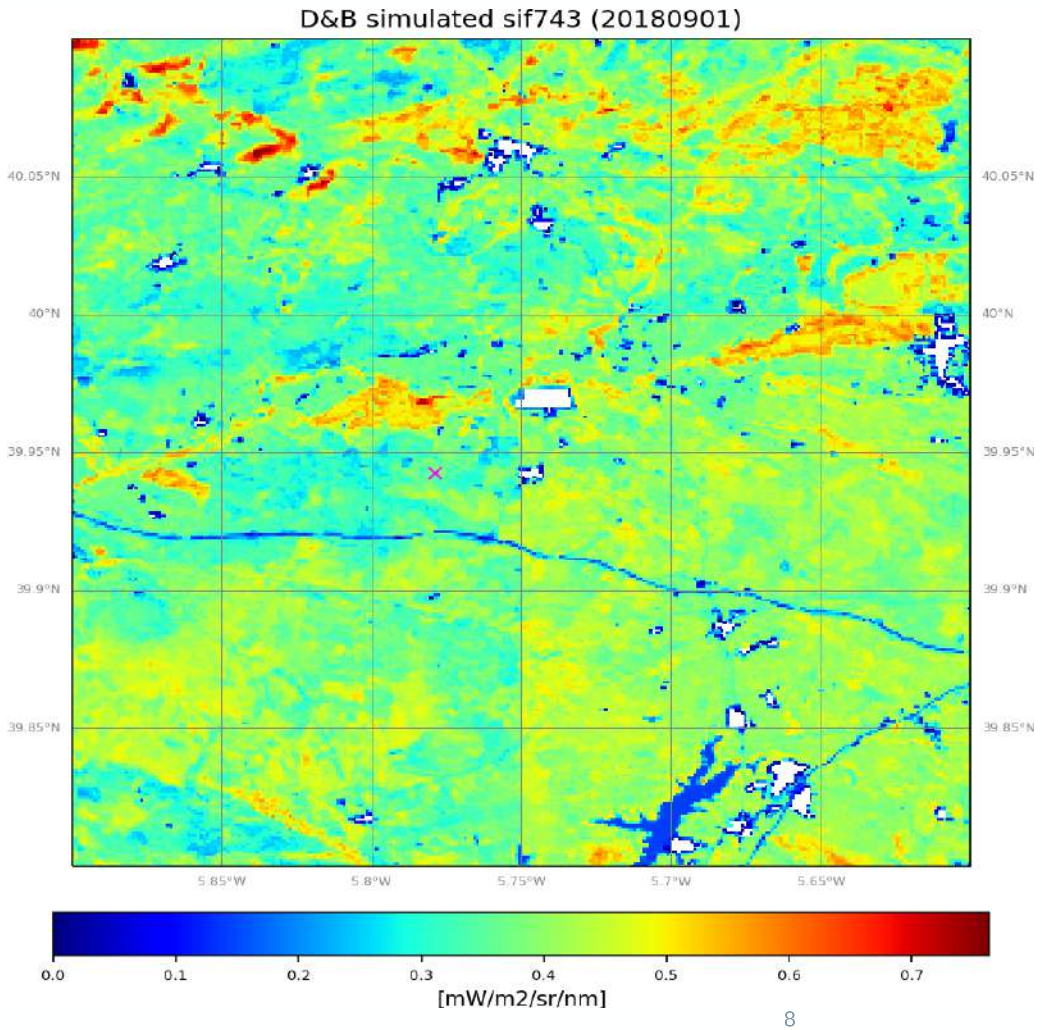
Simulation on the footprint/target area
Example: TROPOMI



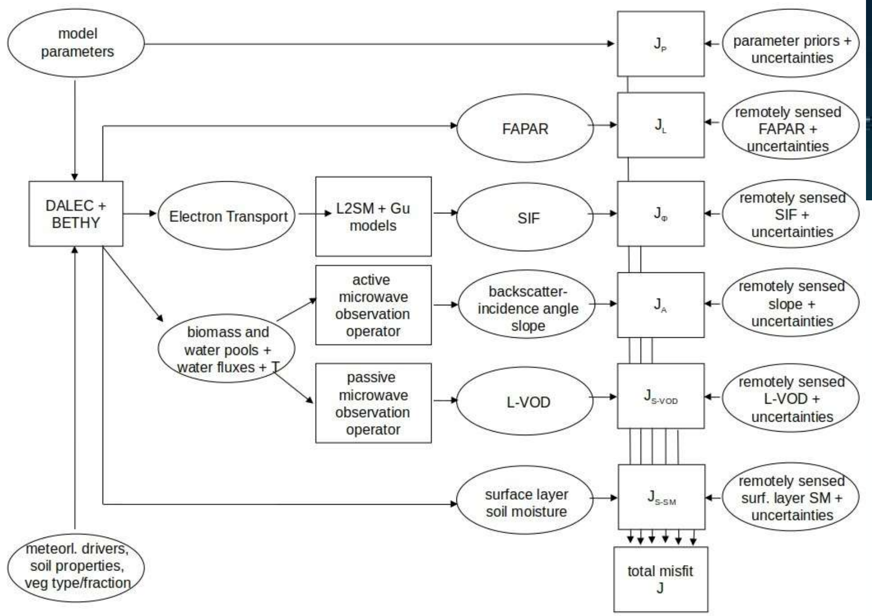


Spatial Detail
Examples: TROPOMI (left) and simulated (right) SIF

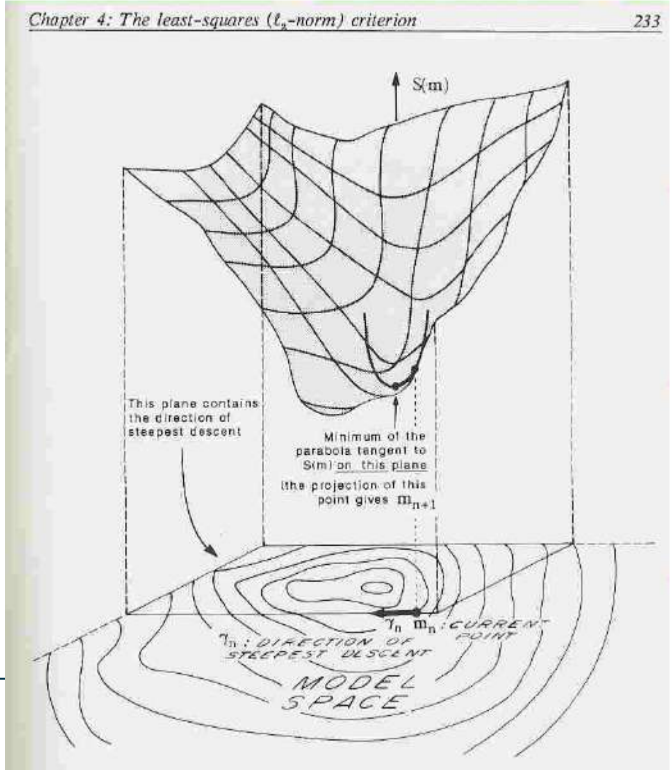




Variational Data Assimilation



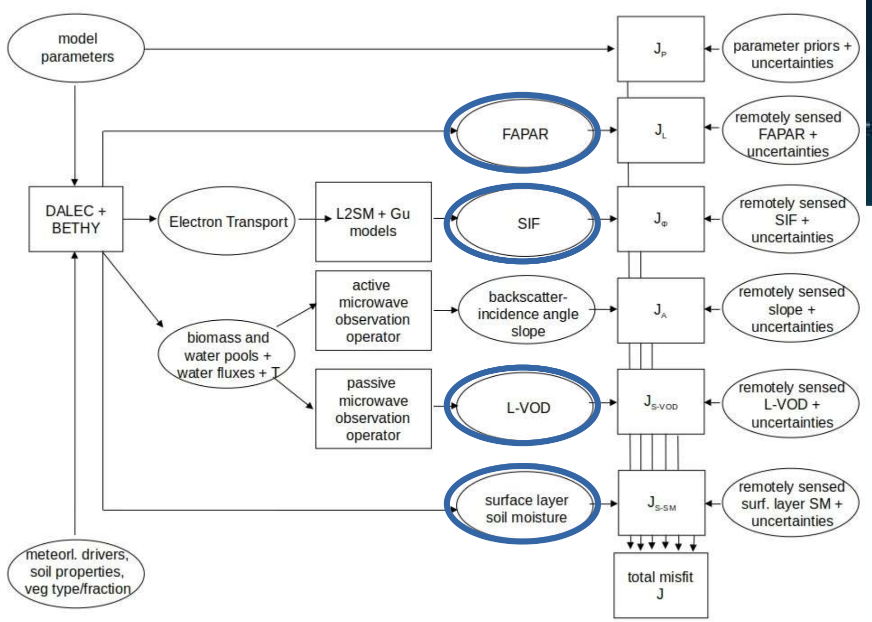
- Assimilating all data in one long assimilation window (need to constrain slow processes)
- Minimisation of a cost function J(x) of a set of process parameters (in core model and observation operators) and initial pool sizes
- Minimisation algorithm uses gradient of J(x) with respect to x
- Gradient efficiently provided by adjoint of D&B

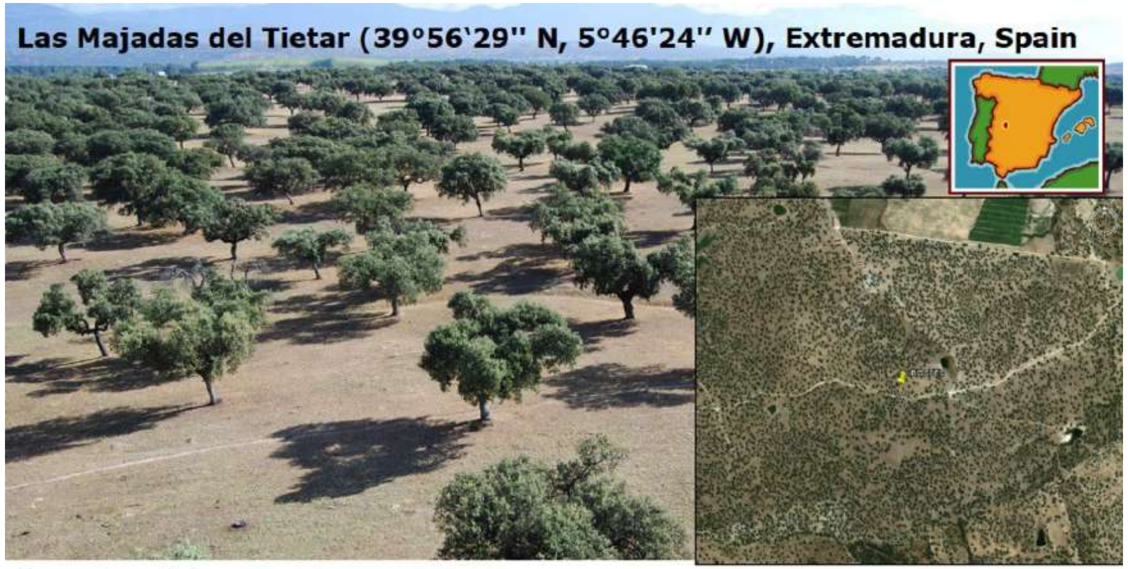


Tarantola 1987

Example: Majadas de Tietarg

- 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 → Tristan's presentation!
  - L-VOD: SMOS, empirical
  - surface layer soil moisture: SMOS

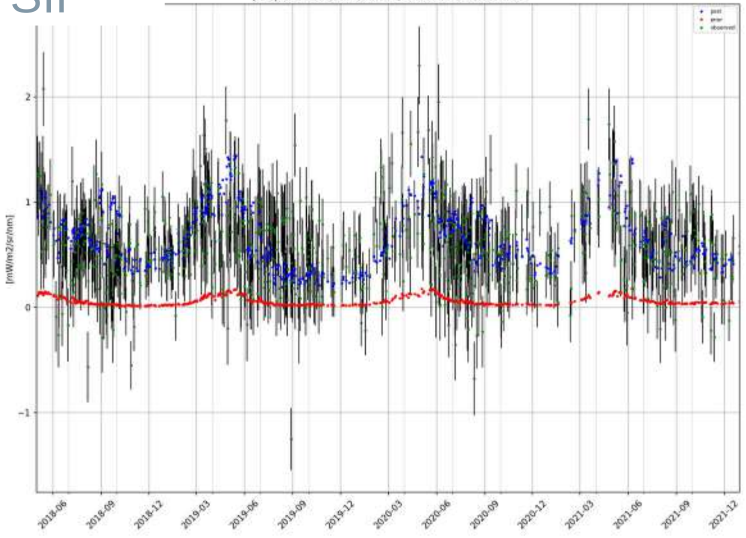




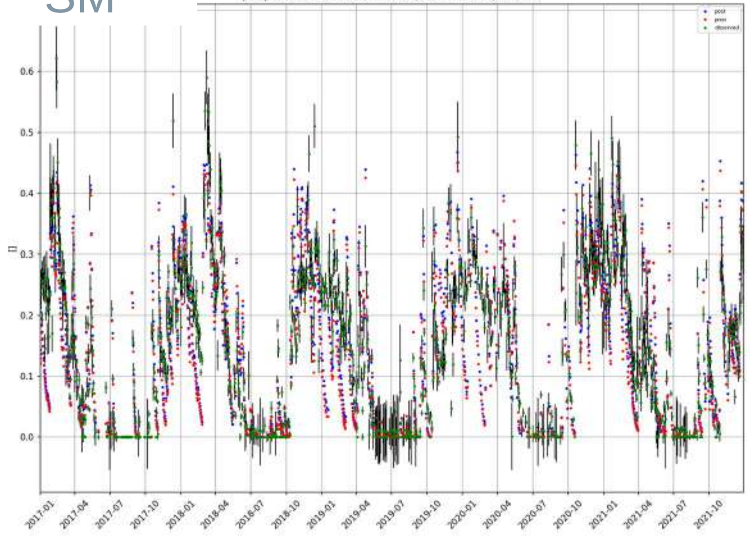
Ecosystem: ***dehesa*** Mediterranean Holm Oak open woodland (Savanna)

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

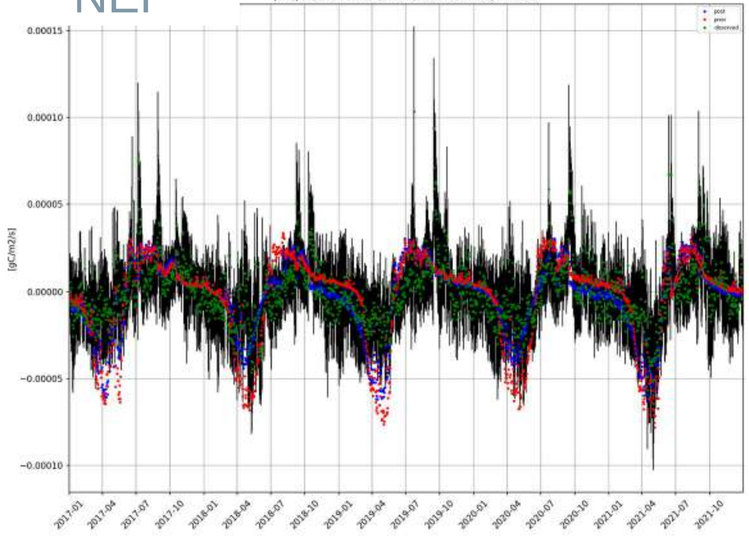
SIF



SM

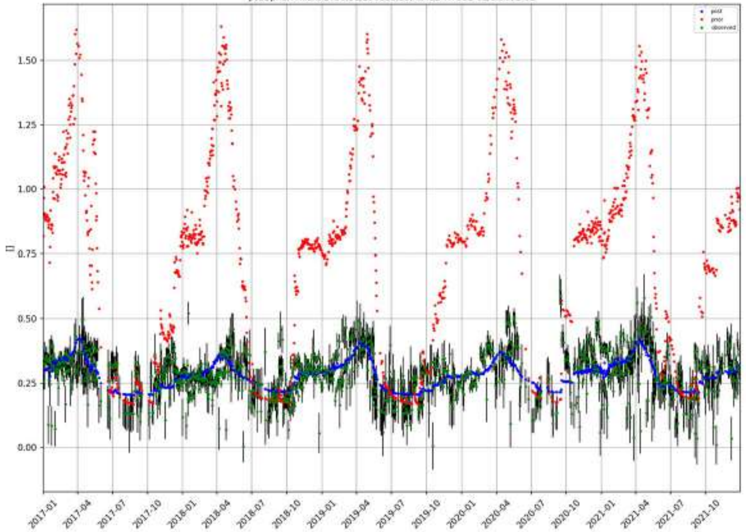


NEP

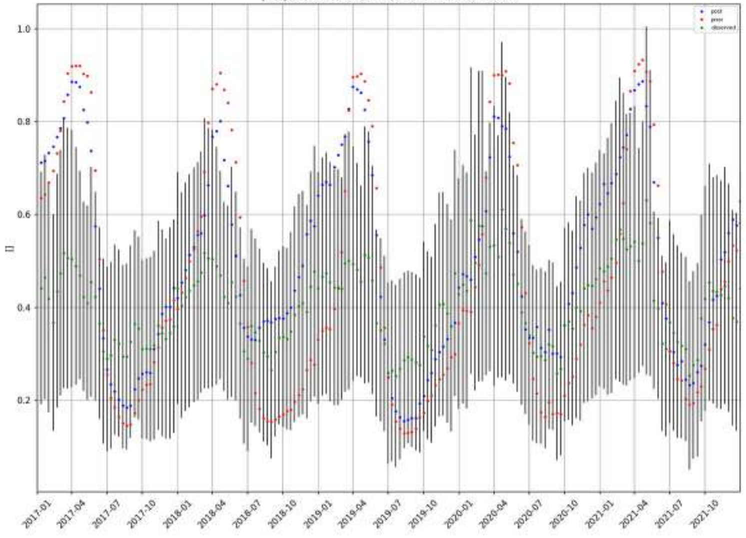


Obs (green), prior (red), posterior (blue)

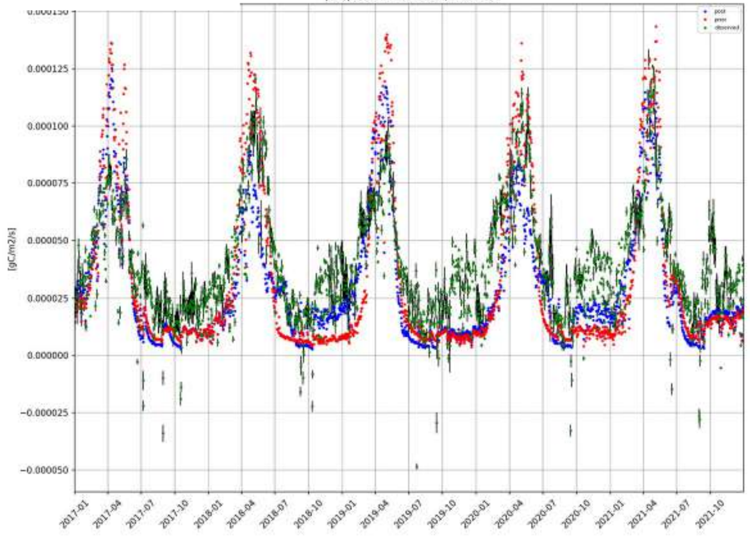
L-VOD



FAPAR



GPP



Analysis of Information Content

A: posterior parameter uncertainty:

$$A = (M^T R^{-1} M + B^{-1})^{-1}$$

B: prior parameter uncertainty

R: data uncertainty

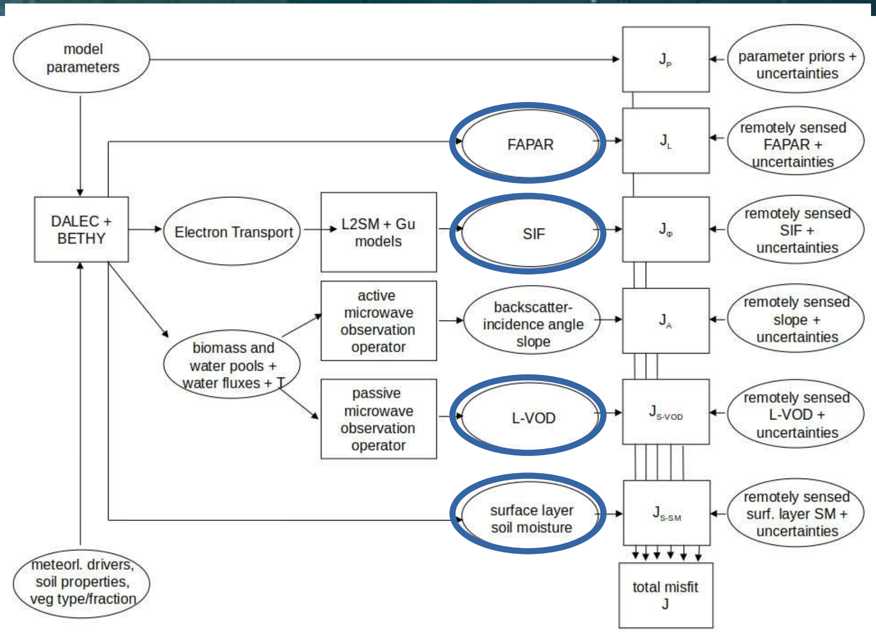
M: linearised model

Plots show unc. reduction:

$$(\sigma_{prior} - \sigma_{posterior}) \,/\, \sigma_{prior}$$

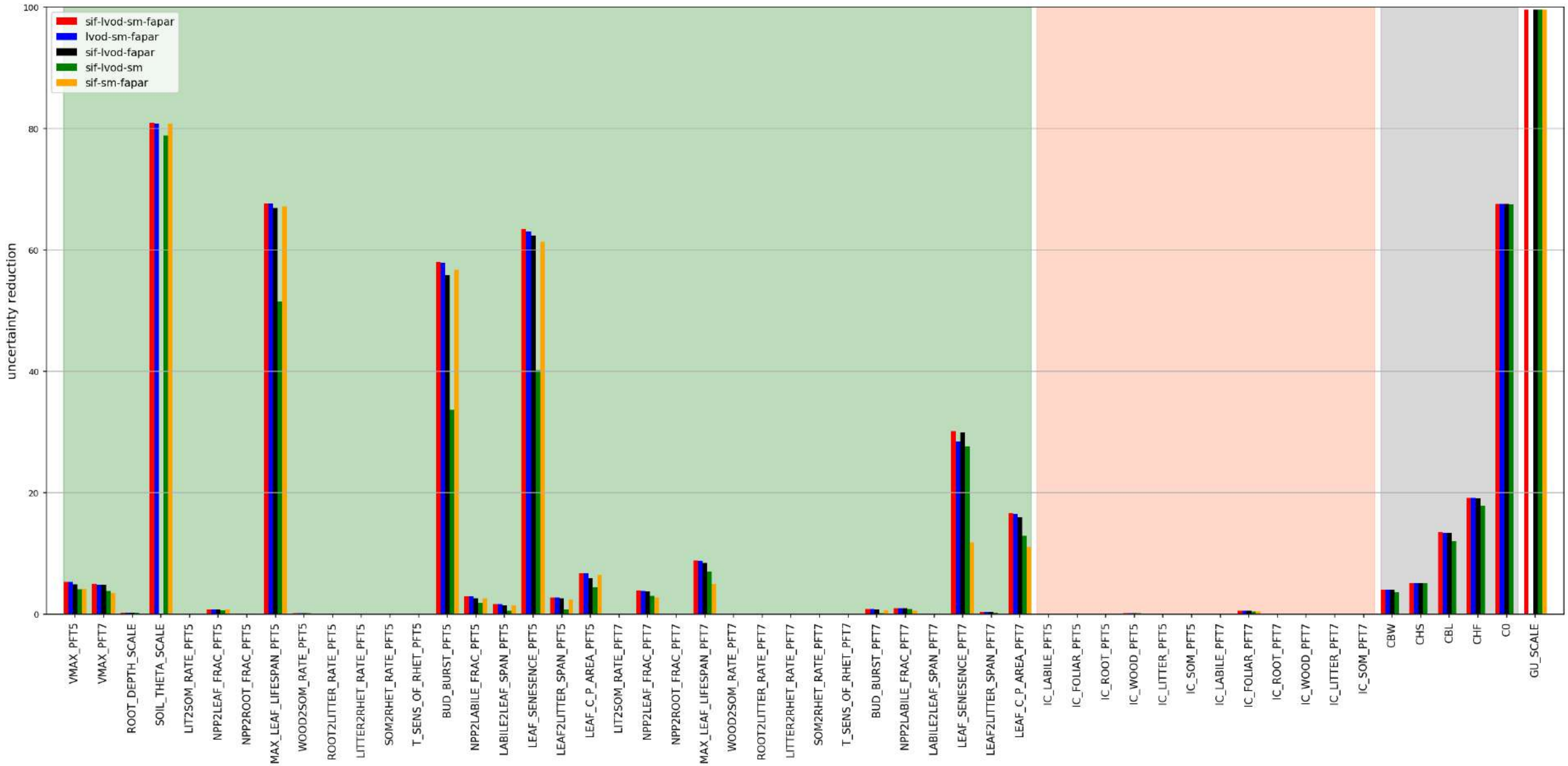
5 Experiments at Sodankylä (Everg. Conifer and understorey):

- First, joint assimilation of all 4 data streams
- Then, leaving one data stream out (in turn)

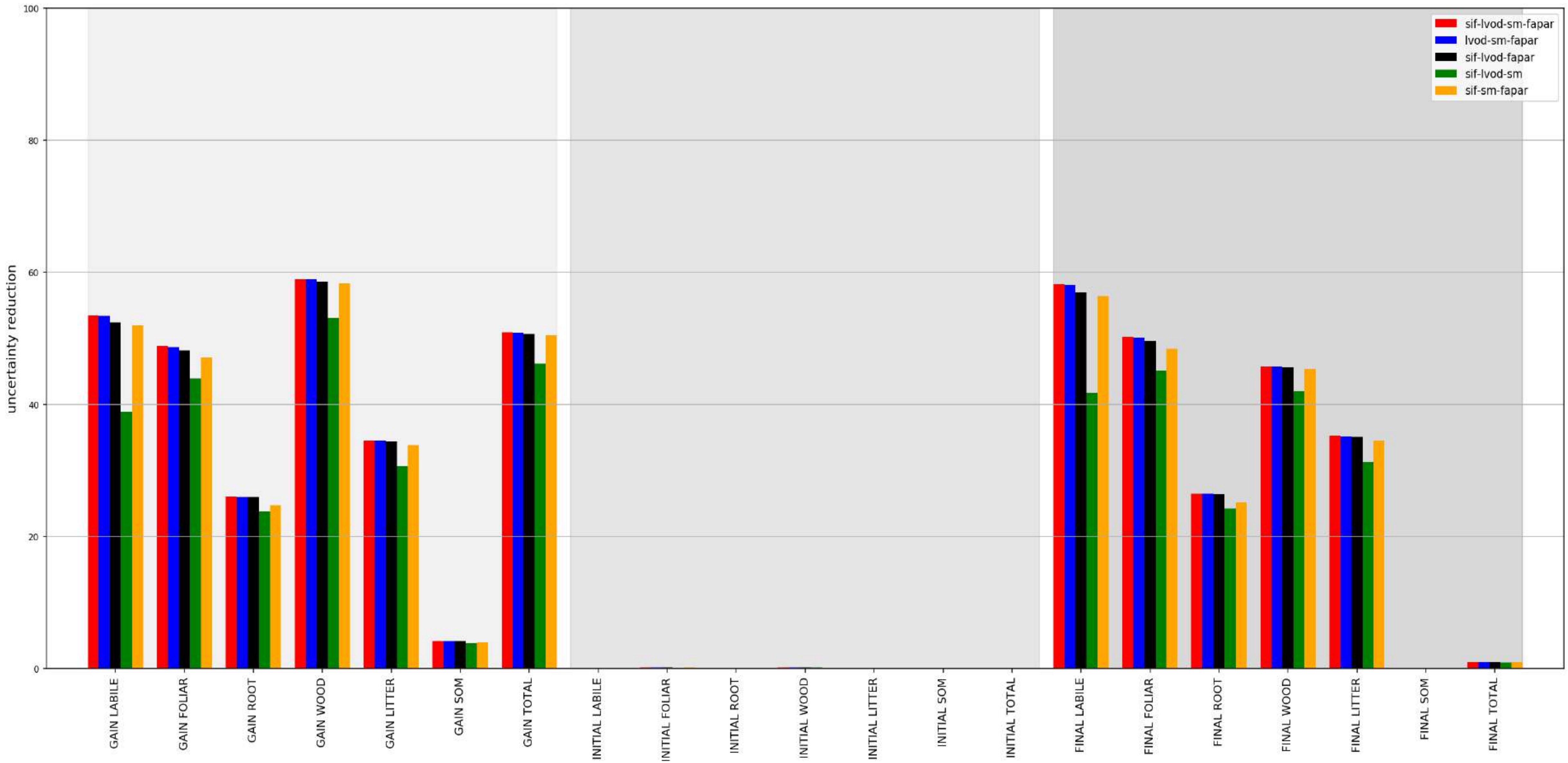


Analysis of Information Content

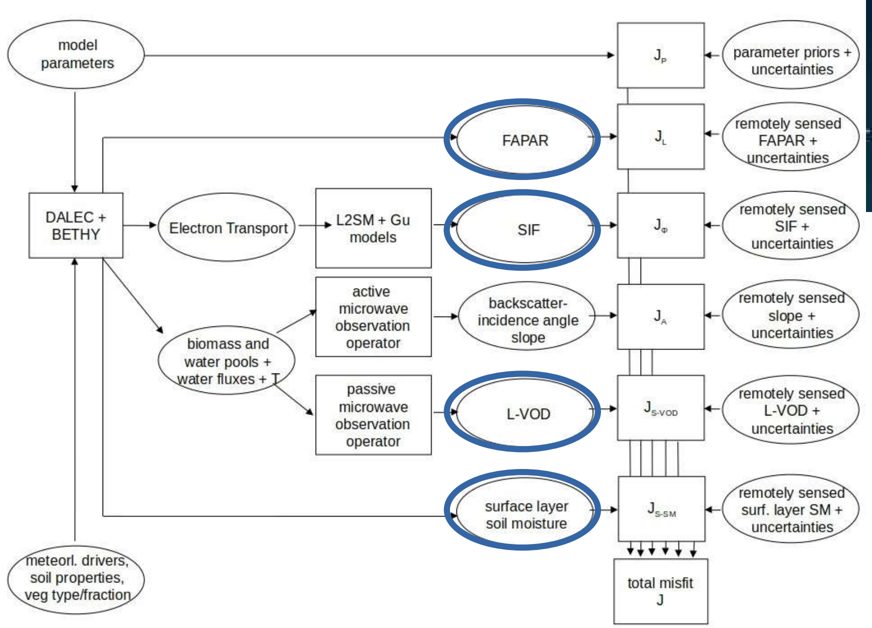
Example: Sodankylä; Uncertainty Reduction Parameters (left), Initial Pool sizes (middle) and Parameters of Observation operators (right)



Analysis of Information Content
Example: Sodankylä; Uncertainty Reduction Fluxes (left), initial (middle) and final (right) Carbon Pools



Example: Lapland



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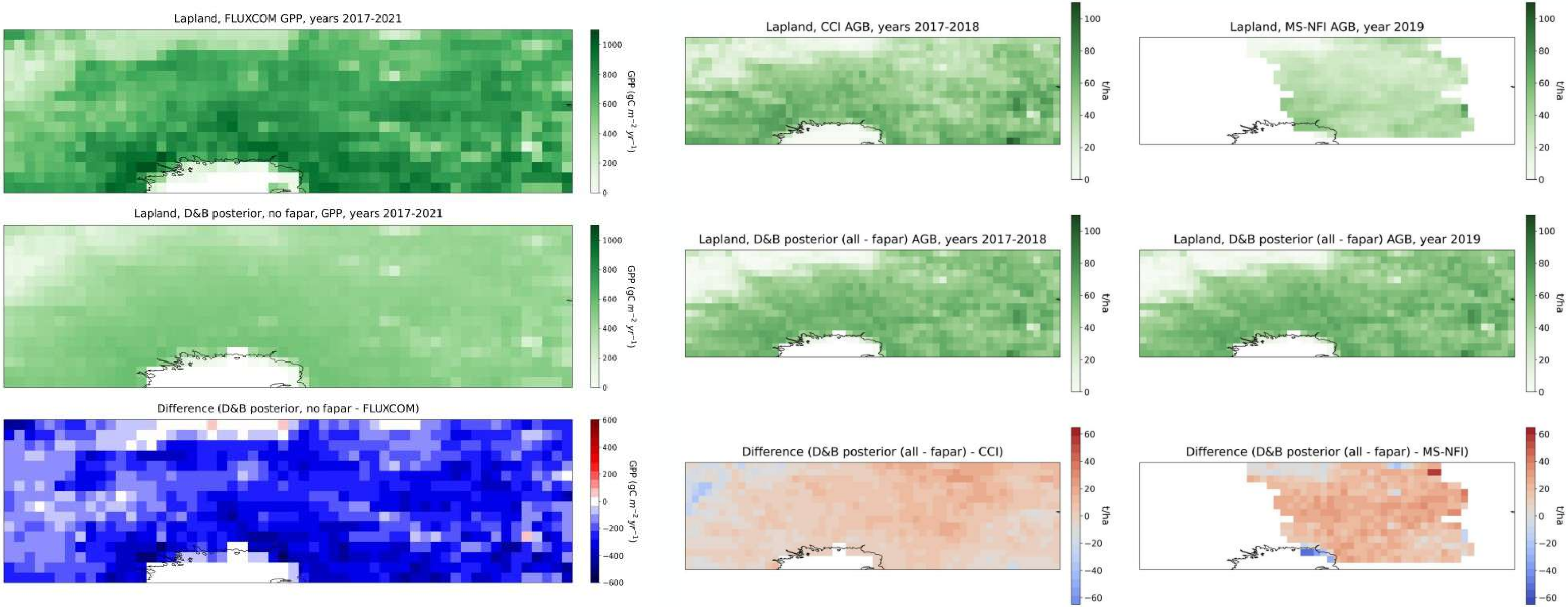
  - L-VOD: SMOS, empirical
  - surface layer soil moisture: SMOS

Example: Lapland
Validation of posterior fluxes (left) and biomass (middle/right)



Outlook

- Implement one alternative observation operator for SIF:
  - functionality from Li et al. (2022)
  - Explicit thermal dissipation term
  - 2 x NPQ formulations
  - Based on the van der Tol (2014) formulation
- Documentation
- Work with test users from early 2024
- User Training event around autumn 2024
- https://tccas.inversion-lab.com/