

Terrestrial Carbon Community Assimilation System and BIOMASS

Thomas Kaminski¹, Wolfgang Knorr¹, Michael Voßbeck¹, Mathew Williams², Timothy Green², Luke Smallman², Marko Scholze³, Tristan Quaife⁴, Tea Thum⁵, Sönke Zaehle⁶, Peter Rayner¹, Susan Steele-Dunne⁷, Mariette Vreugdenhil⁸, Mika Aurela⁵, Alexandre Bouvet⁹, Emanuel Bueechi⁹, Wouter Dorigo⁸, Tarek S. El-Madany⁶, Marika Honkanen⁵, Yann H. Kerr⁹, Anna Kontu⁵, Juha Lemmetyinen⁵, Hannakaisa Lindqvist⁵, Arnaud Mialon⁹, Tuuli Miinalainen⁵, Amanda Ojasalo⁵, Shaun Quégan¹⁰, Pablo Reyes Muñoz¹¹, Nemesio Rodriguez-Fernandez⁹, Mike Schwank¹², Jochem Verrelst¹¹, Matthias Drusch¹³, and Dirk Schüttemeyer¹³

¹The Inversion Lab, Hamburg, Germany

²University of Edinburgh, UK

³University of Lund, Sweden

⁴University of Reading, UK

⁵FMI, Helsinki, Finland

⁶MPI BGC Jena, Germany

⁷TU Delft, The Netherlands

⁸TU Wien, Austria

⁹CESBIO Toulouse, France

¹⁰University of Sheffield, UK

¹¹University of Valencia, Spain

¹²Swiss Federal Institute for Forest, Snow and Landscape Research, Switzerland

¹³ESA, ESTEC, The Netherlands

EObIOMASS Webinar
February 26 2025

ESA UNCLASSIFIED - For ESA Official Use Only

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:

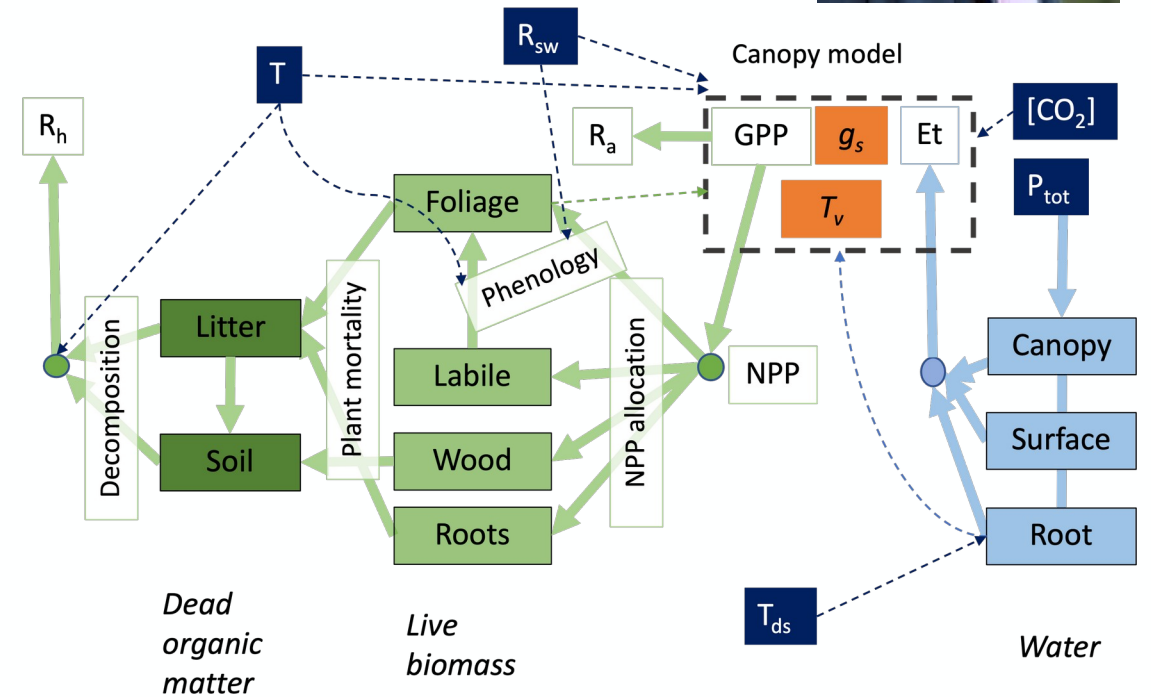


iLab



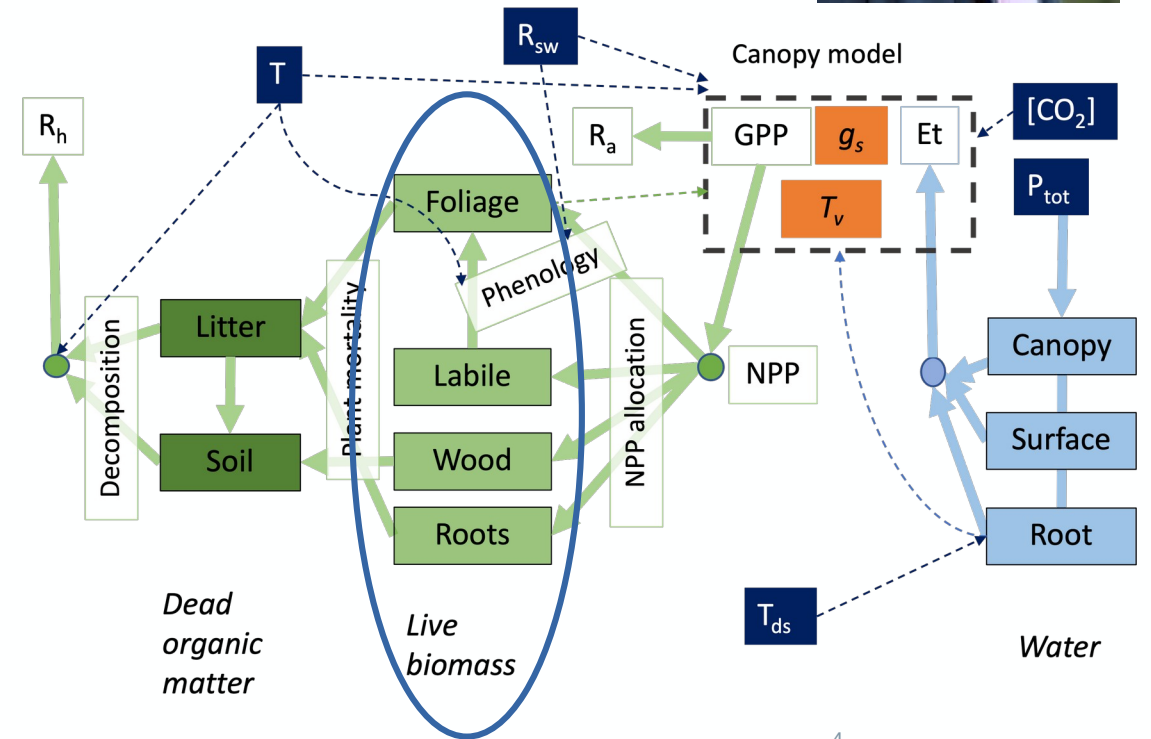
Terrestrial Biosphere Model

- D&B
- Simulation of Carbon, Water, and Energy Cycles



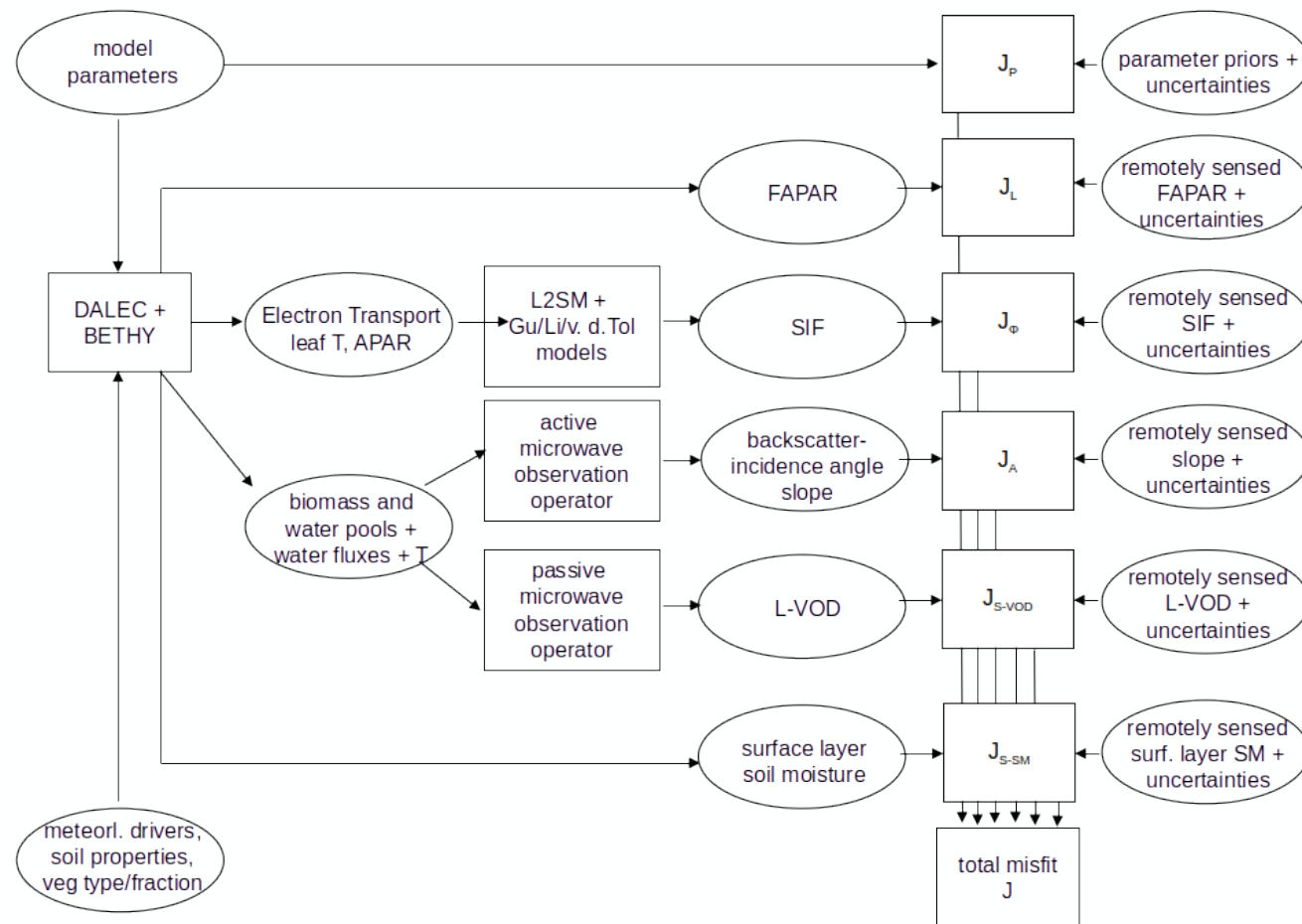
Terrestrial Biosphere Model

- D&B
- Simulation of Carbon, Water, and Energy Cycles



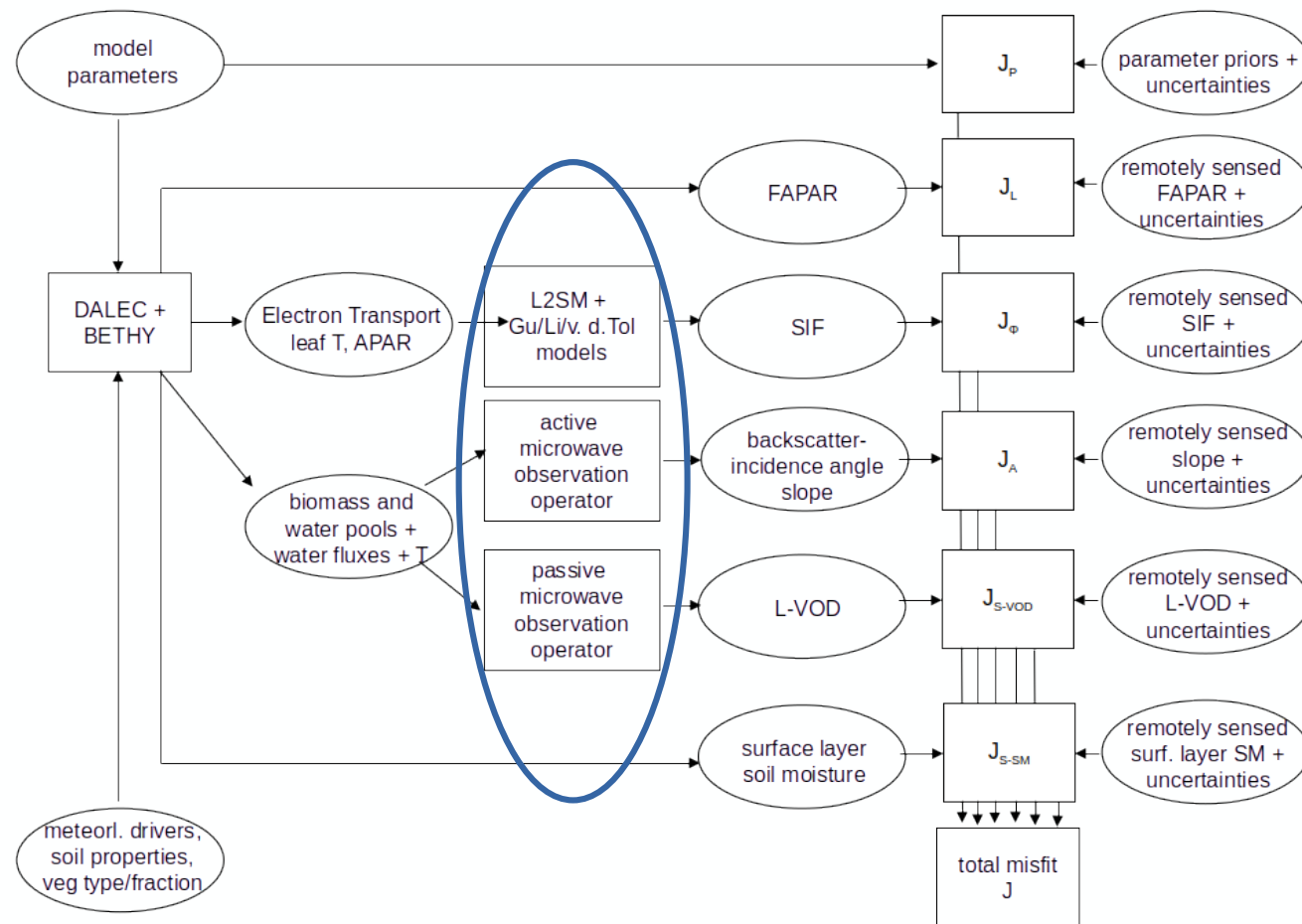
What does TCCAS offer?

- 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



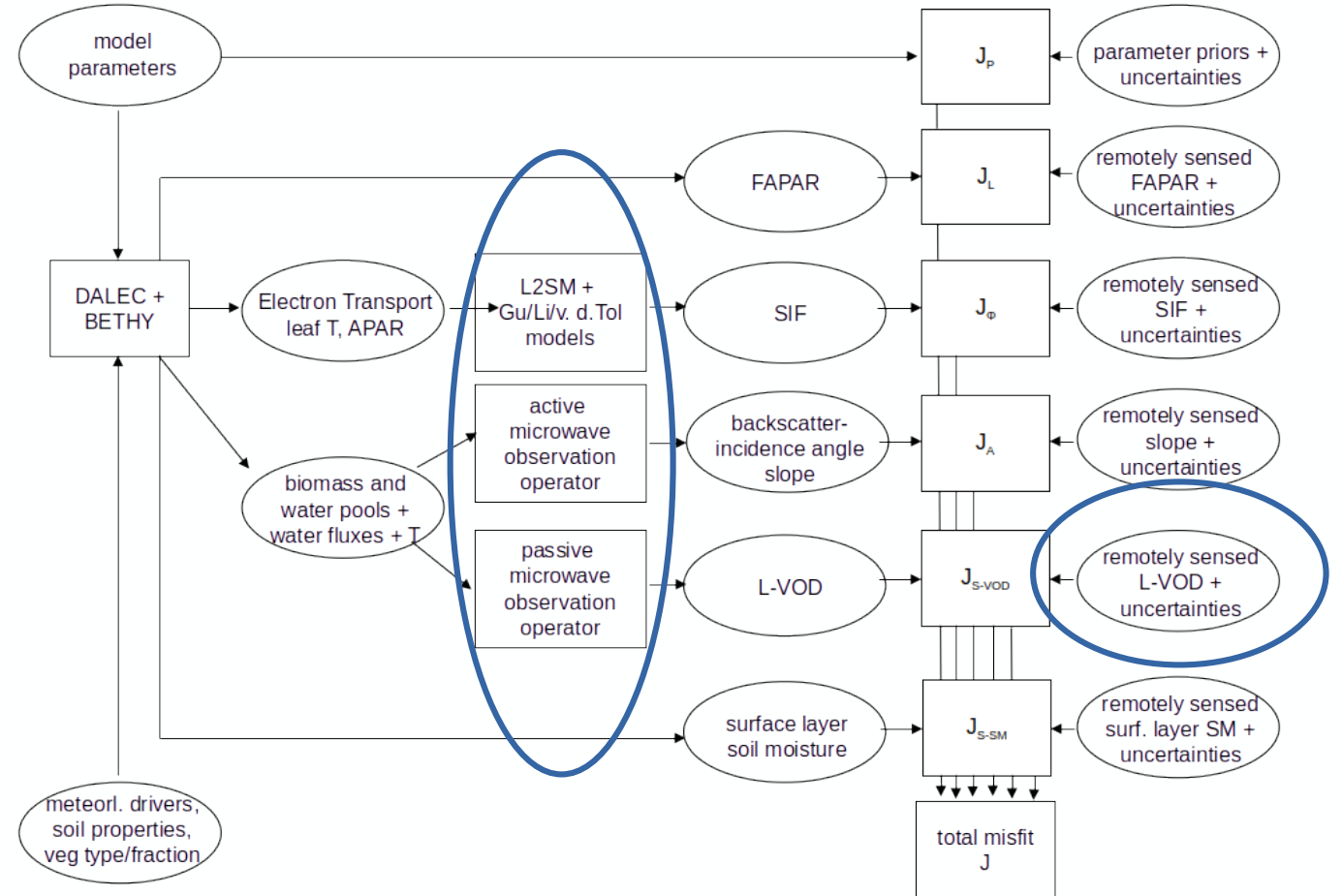
What does TCCAS offer?

- 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



What does TCCAS offer?

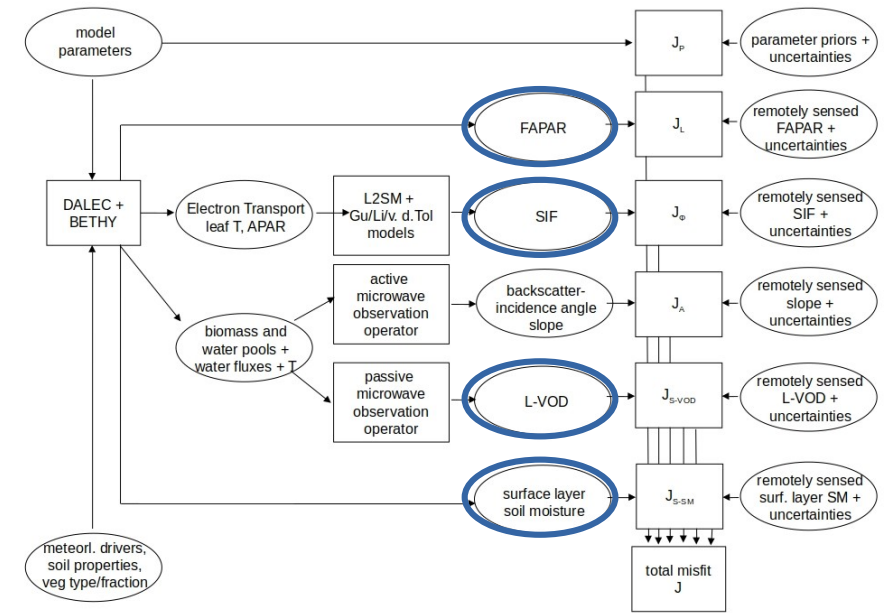
- Open source community system
- **Observation operators** for optical as well as active and passive microwave observations
- **Assimilation on the footprint**
- Tangent and adjoint codes
- Modular setup
- Computational efficiency
- Tested on point to regional scales
- Experienced developer team
- Documentation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



Joint Data Assimilation at Sodankyla

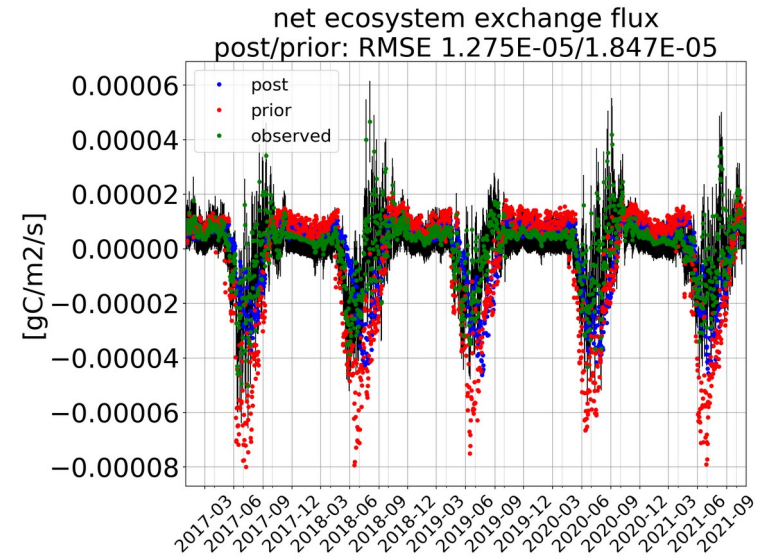
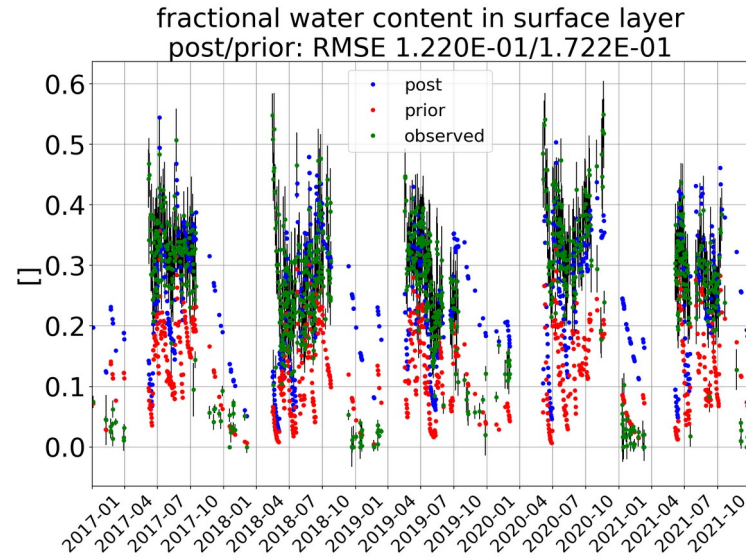
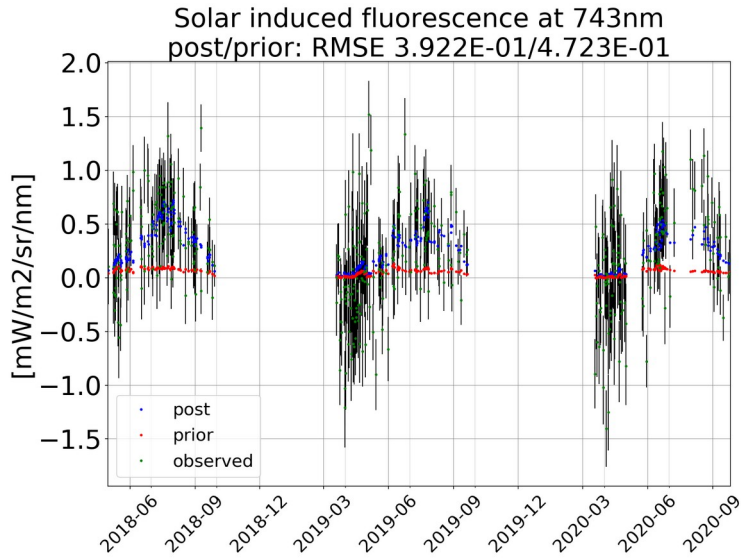


- Boreal site in Lapland
- Evergreen Conifers and understorey
- Spin up 2015+2016
- Assimilation window 2017-2021
- Prior Uncertainty: 20% for all process parameters and 80% for all initial pool sizes
- Joint assimilation of:
 - FAPAR: JRC-TIP, twostream RT
 - SIF: TROPOSIF, Gu model
 - L-VOD: SMOS, empirical
 - surface layer soil moisture: SMOS

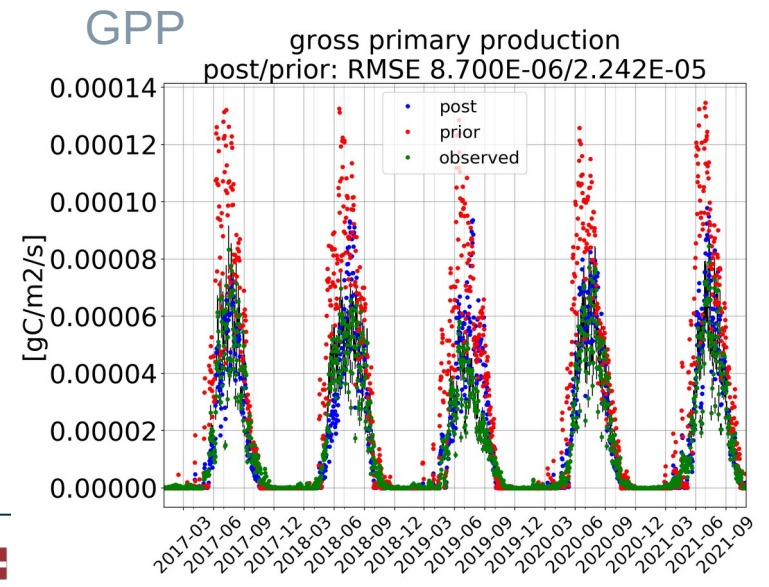
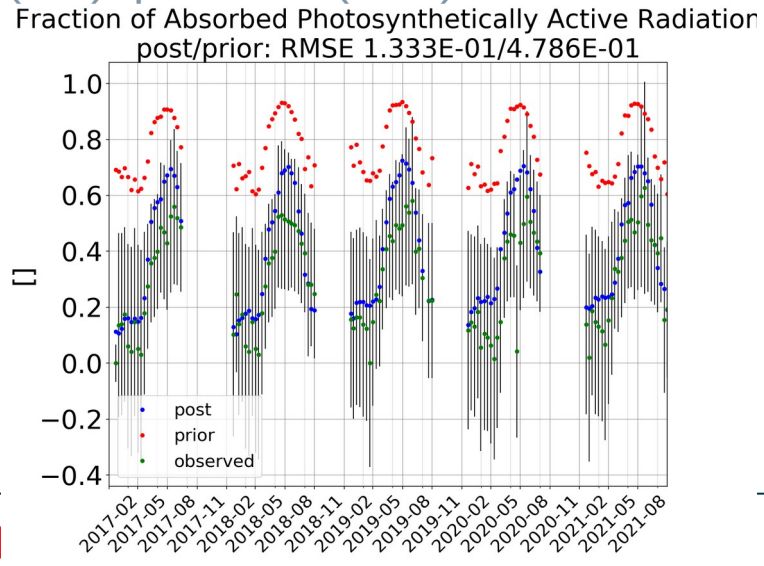
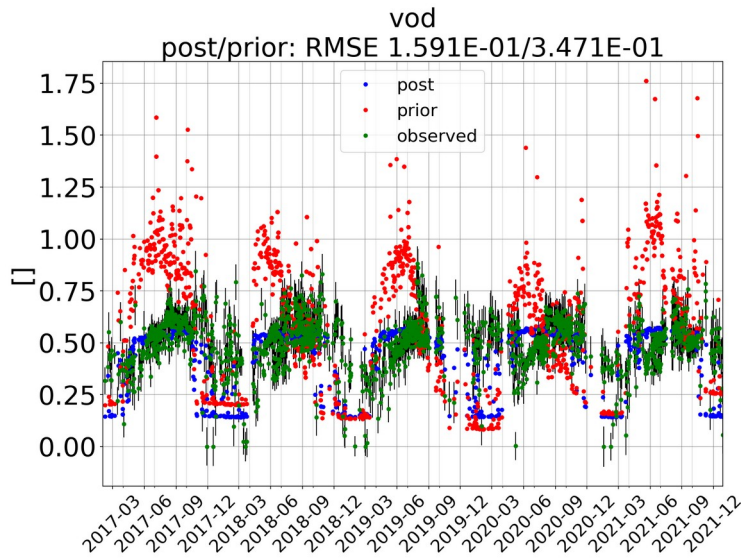




Assimilation (left/middle) and validation (right) variables



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



Analysis of Information Content

A: posterior parameter uncertainty:

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

B: prior parameter uncertainty

R: data uncertainty $R = C_{obs} + C_{mod}$

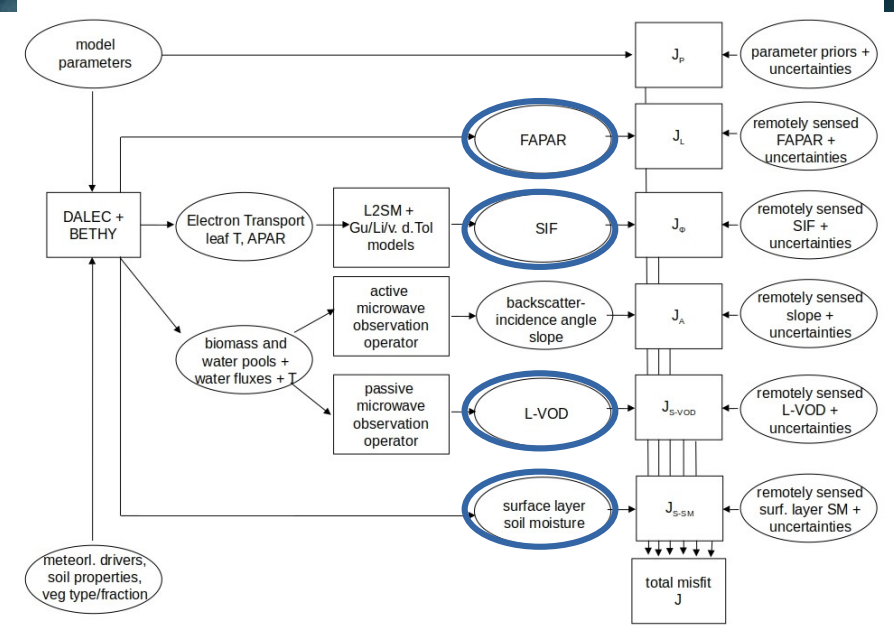
M: linearised model

Plots show unc. reduction:

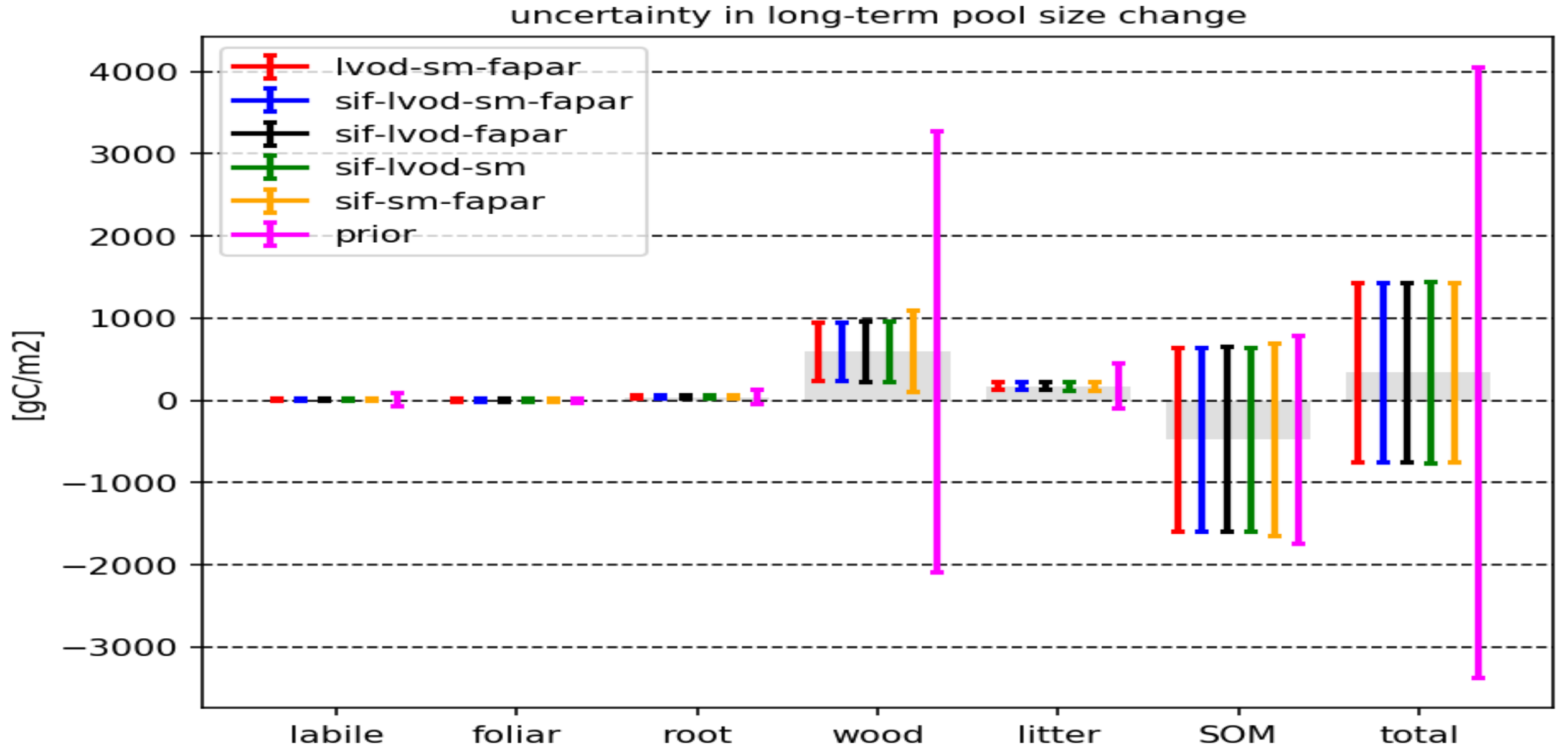
$$(\sigma_{prior} - \sigma_{posterior}) / \sigma_{prior}$$

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

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



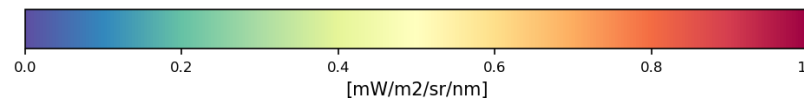
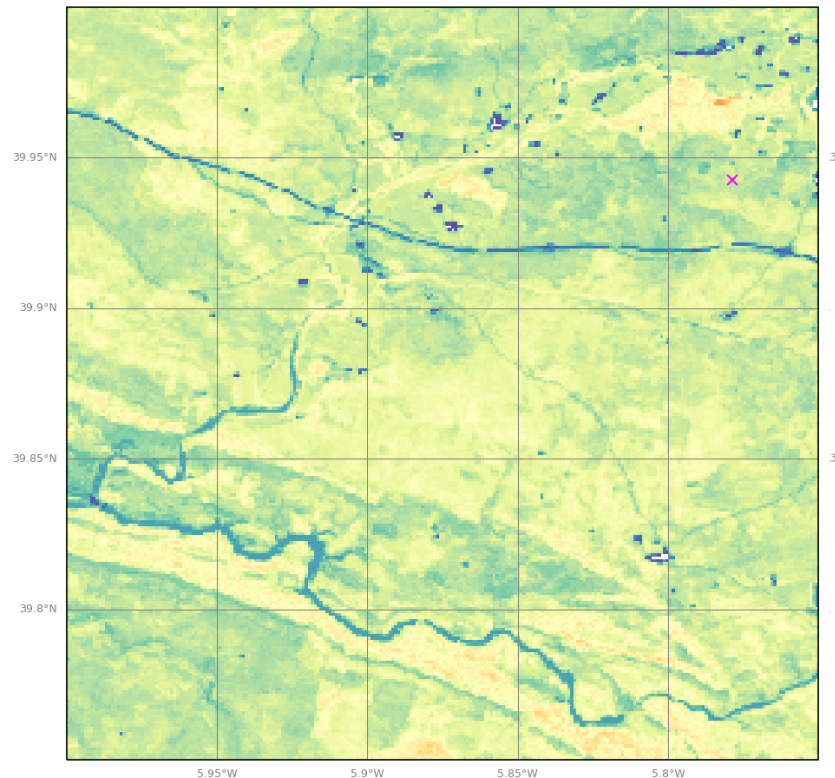
Reduction in uncertainty relative to prior of increase in carbon pools over integration period



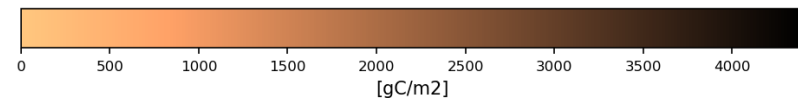
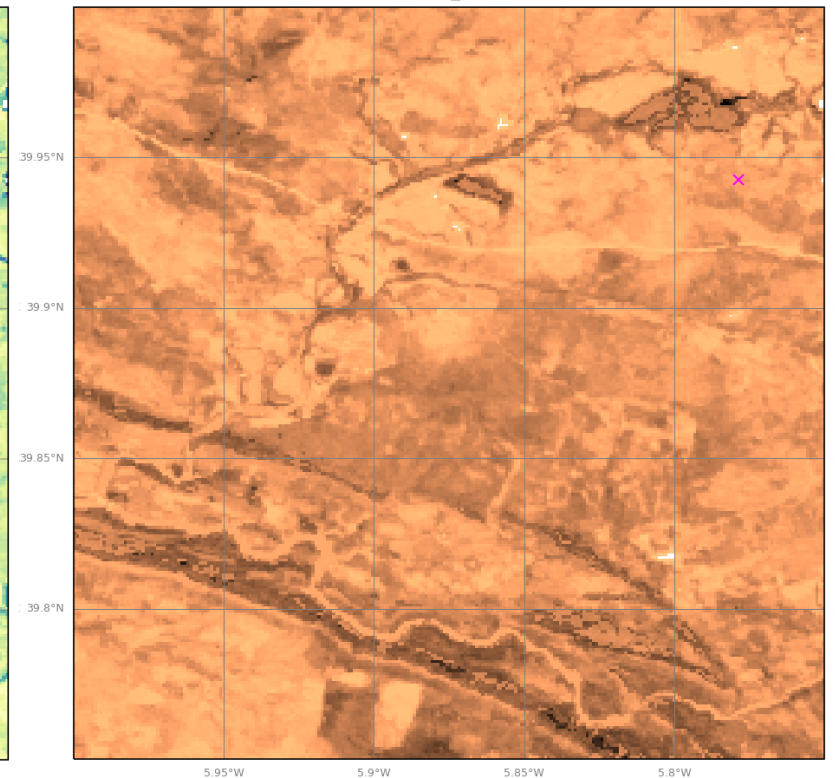
Posterior simulation over a region in Spain SIF (left), Woody biomass (middle), NEE (right)



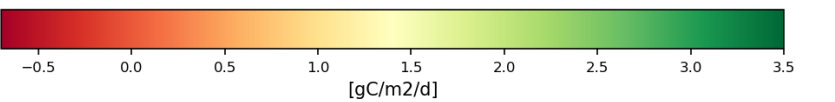
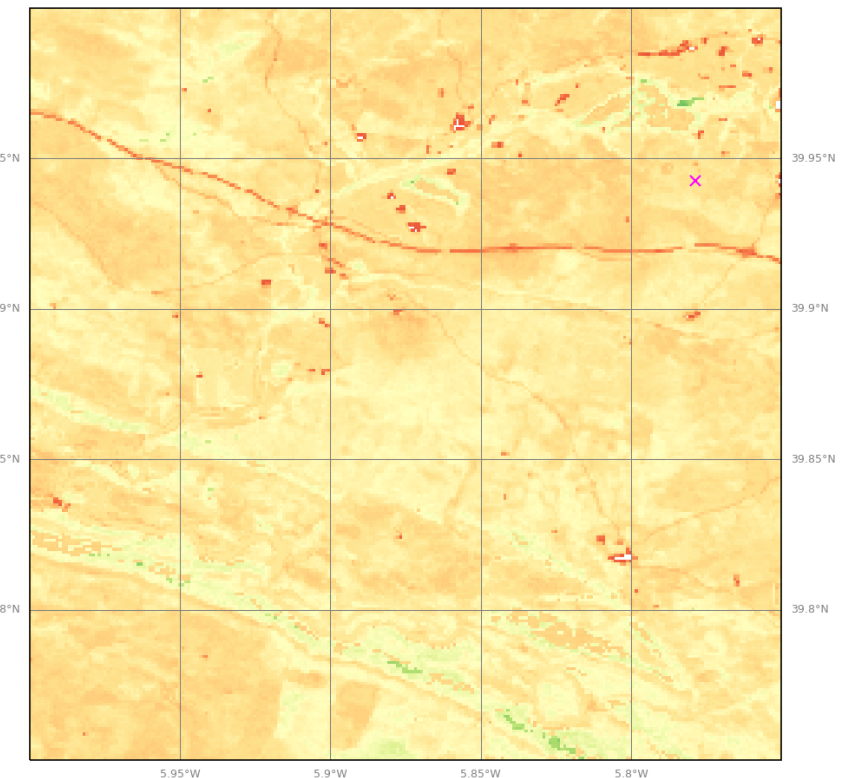
D&B simulated sif743 (20180901)



D&B simulated woody_biomass (20180901)



D&B simulated nee (20180901)



- Data Assimilation
 - Integrated perspective on carbon, water and energy cycles
 - Includes D&B process understanding
 - Information from multiple missions
- Typical applications include
 - Monitoring relevant variables in space and time
 - Assessment of net carbon flux
 - Quantification of the impact of an intervention in the landscape on carbon uptake (Carbon Credits)
- Requirements
 - Need BIOMASS product with uncertainty ranges, ideally also correlation in space and time
 - Need information to construct observation operator

- Contact
 - <https://tccas.inversion-lab.com>
 - TCCAS@Inversion-Lab.com
 - Thomas.Kaminski@Inversion-Lab.com
- Next training events:
 - Living Planet Symposium, Vienna, June 23-27
 - Nanjing, August 24-29

