Land surface Carbon Constellation project

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Objectives of the project

Investigate the **terrestrial biosphere's net ecosystem exchange** – photosynthetic CO_2 uptake minus respiratory CO_2 release – **response to climatic drivers** by means of combining a process-based model with a **wide range of observations (in-situ and remotely sensed) on local and regional scale** around two (three) sites (Sodankyla, Majadas, Reusel).

For this we will:

- Generate a **community land surface model for its application in a data assimilation framework**
- Acquire and analyse **EO and campaign data sets**

Overview of the LCC project

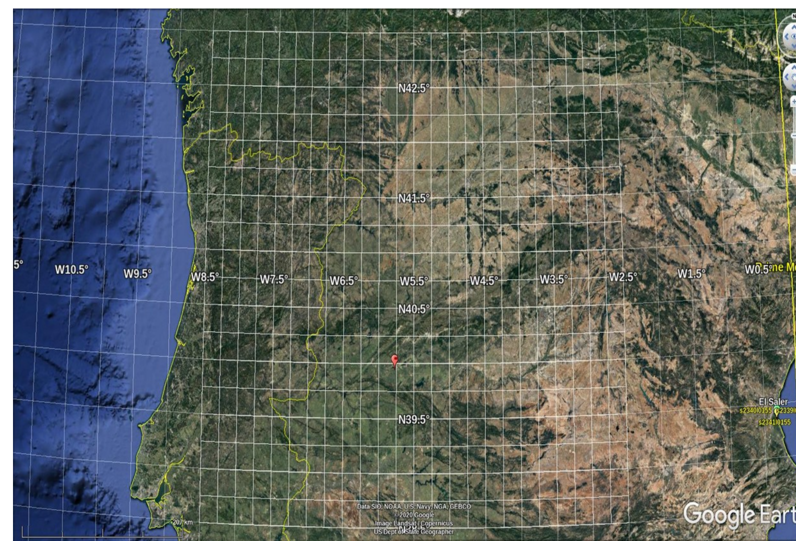
- Kicked off Oct 2020
- 13 partners
- 30 months duration
- https://lcc.inversion-lab.com

Broad range of activities:

1. EO data → Poster N. Rodriguez-Fernandez et al. (65055, Monday)
2. Field activities → Poster J. Lemmetyinen et al. (66971, today)
3. Model and observation operators
4. Data assimilation

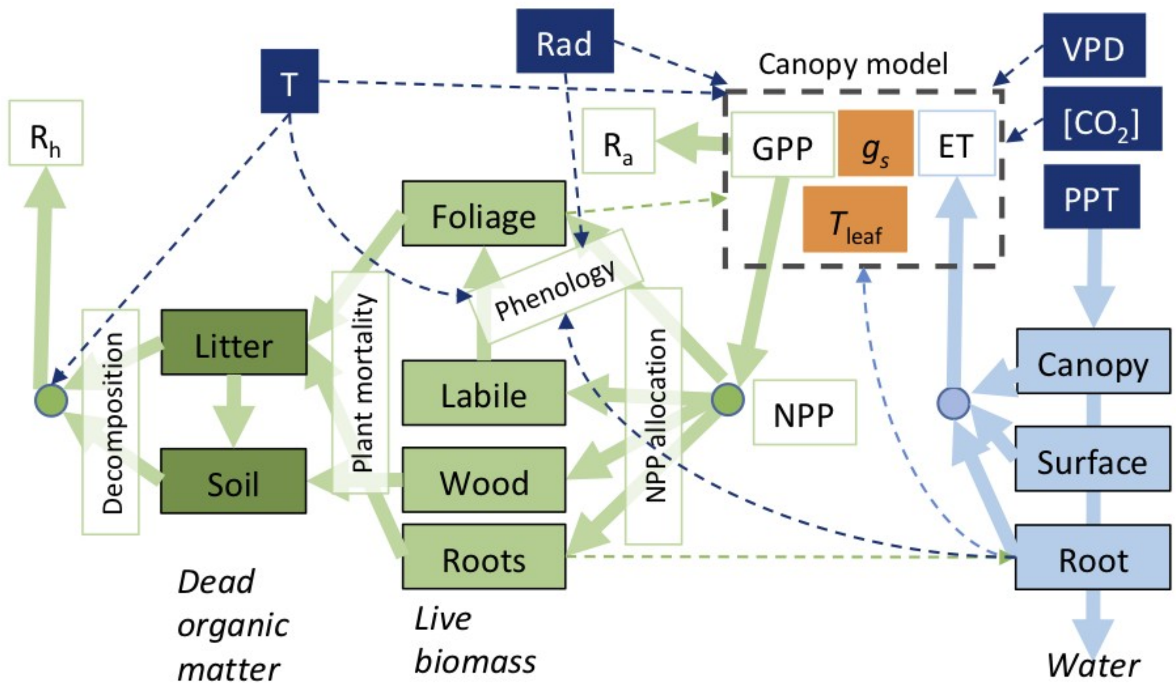
Modelling at local and regional scales

- Demonstration of synergistic use of observations at local and regional scale
- Regional scale: 500 km x 500 km area around the sites at 0.25 deg resolution (Sodankyla & Majadas)

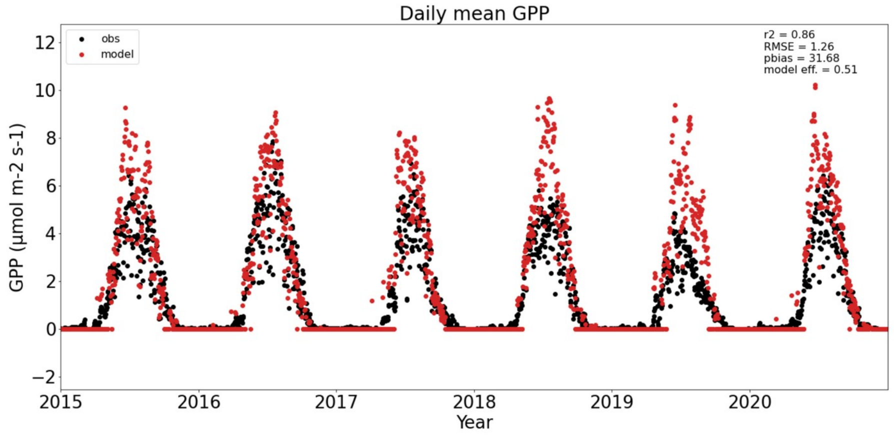


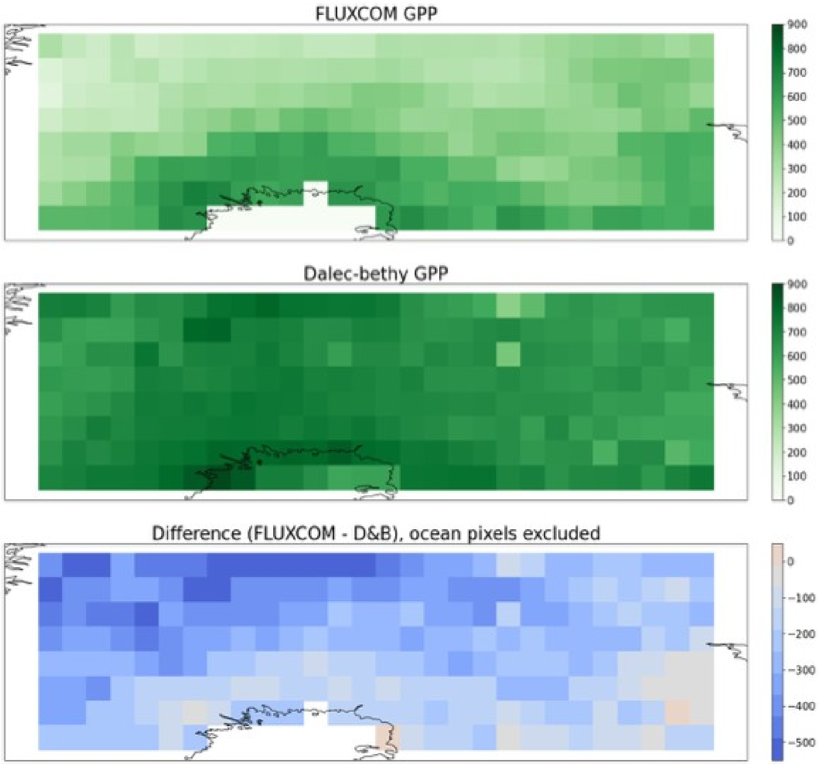
Community land surface model: D&B model

Based on a coupling of DALEC and BETHY

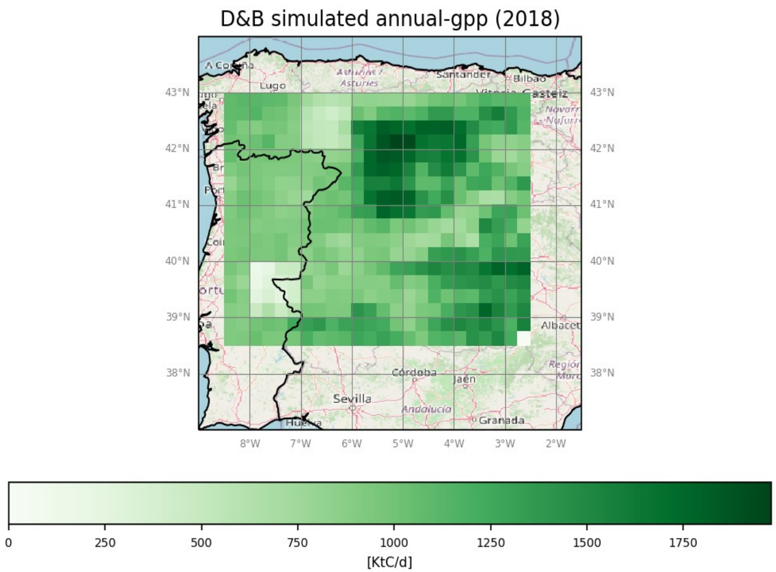


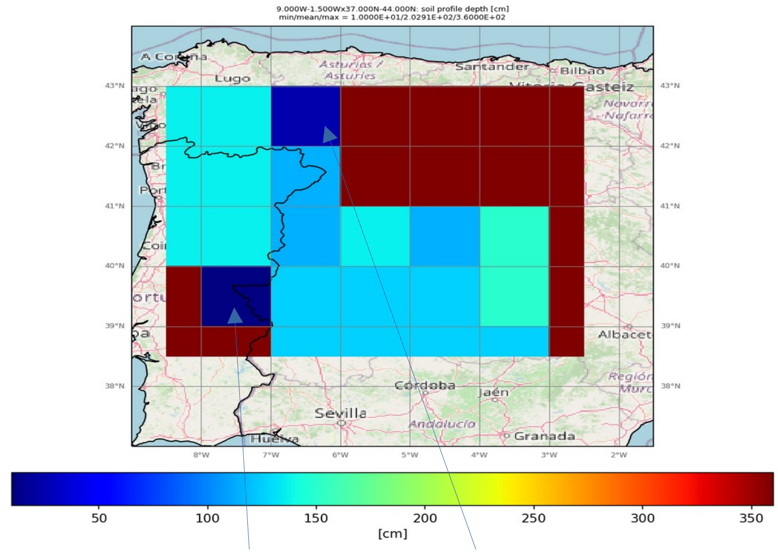
GPP at Sodankylä





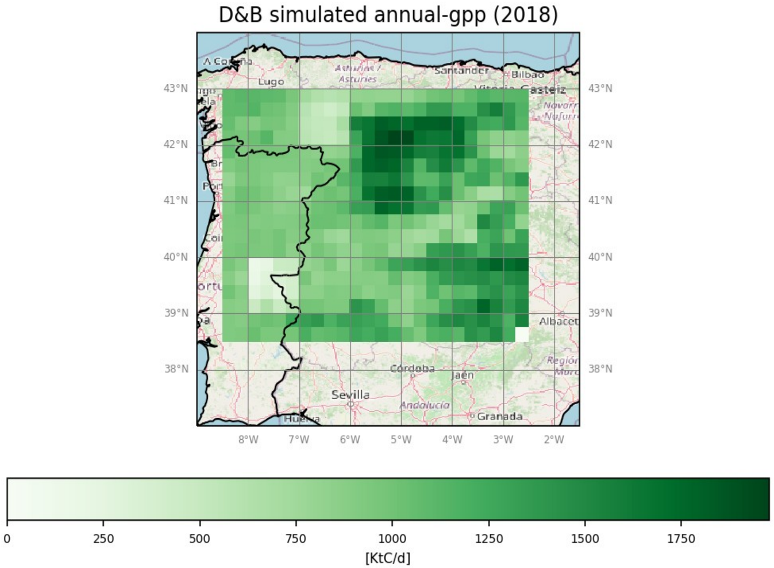
Soil depth and GPP at Majadas

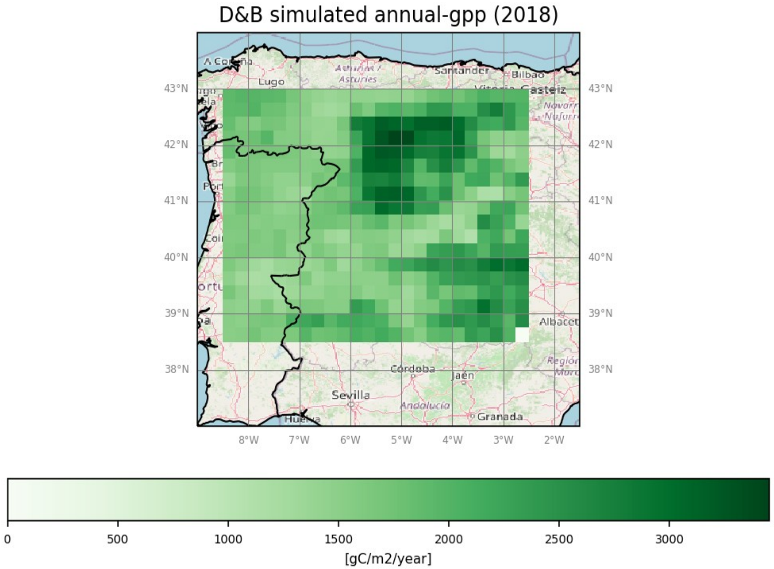




10 cm 25 cm

Soil depth and GPP at Majadas





With soil depth
floor of 115 cm

SOIL GEOGRAPHICAL DATABASE OF EURASIA

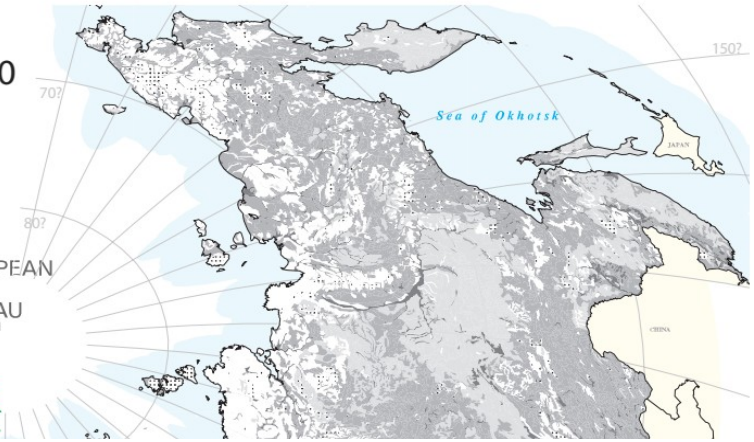
VERSION 4 beta, 25/09/2001 & PEDOTRANSFER RULES 2.0

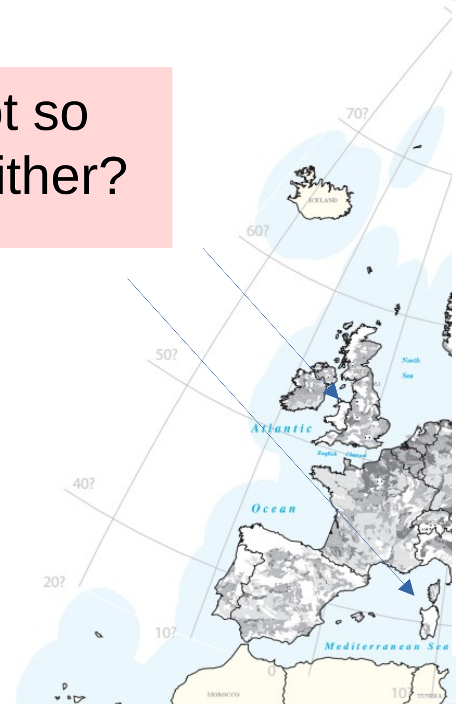
Depth to rock.

% OF MAP:	Depth to rock. (Attribute DR):
22 %	Shallow (< 40 cm)
15 %	Moderate (40 80 cm)
49 %	Deep (80 120 cm)
16 %	Very deep (> 120 cm)
	Non soils

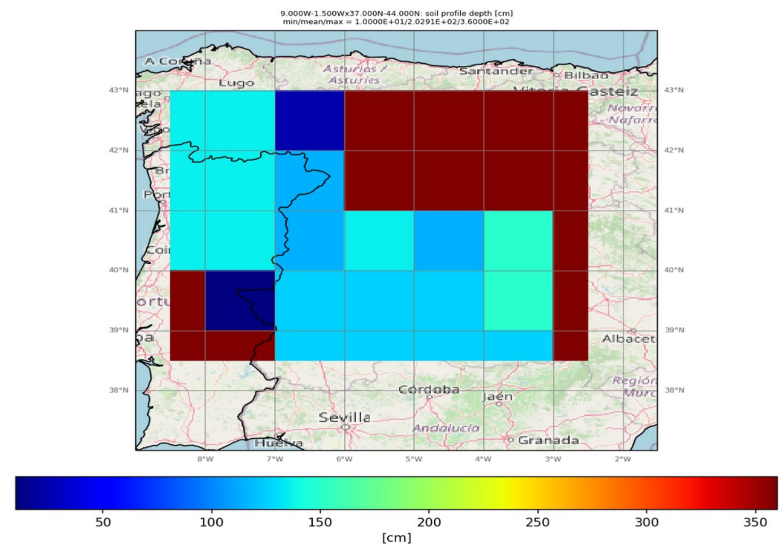
EUROPEAN SOIL BUREAU
EUROPEAN COMMISSION

Edited by INRA





Maybe not so realistic either?

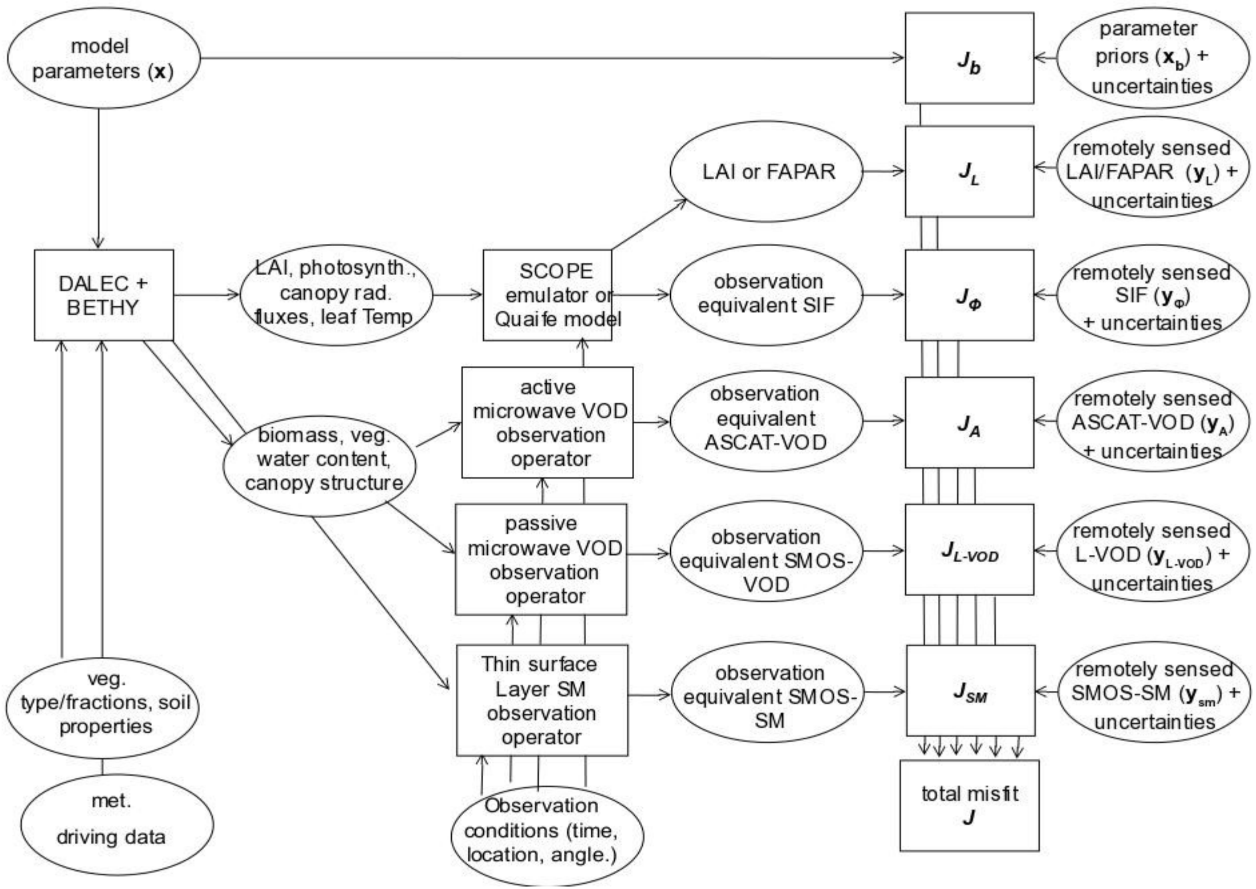


Scale 1 : 30 000 000

0 1000 2000 km

Rule number: 411 (attribute DR).
Last rule update: 01/08/1996
Last rule inference: 31/07/2002
Plot date: 16/01/2004

Observation operators and data assimilation (on the swath)

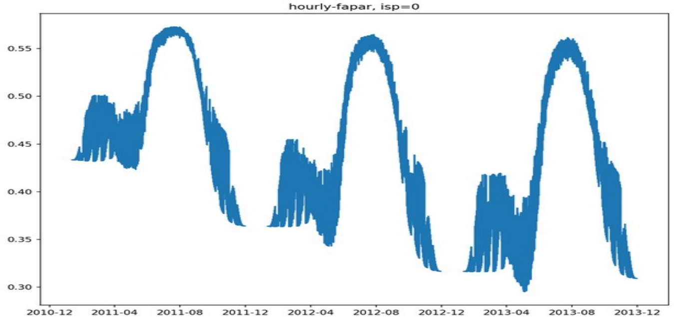


Observation Operators

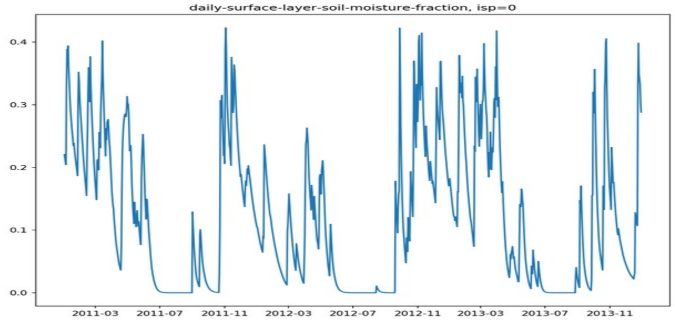
Inclusion of observation operators in the data assimilation framework for:

- FAPAR (Sellers 2-stream model)
- Surface layer soil moisture (1L-VIC)
- SIF (L2SM: embeds Gu et al. (2019) source into Sellers 2-stream model)
- Active/passive microwave VOD (empirical approach + physical approach of Schwank et al. (2021))

FAPAR at Sodankyla



SM at Majadas



VOD – empirical approach

Starting point: $VOD_{\lambda, PFT}(t) = g_\lambda(T) * f_\lambda(B_w, h_s, B_l, h_f)$
where

- f_λ is a function specific to the respective sensor (wavelength λ) and (group of) PFT
- $g_\lambda(T)$ specifies temperature dependence (motivated by Schwank et al., 2021)

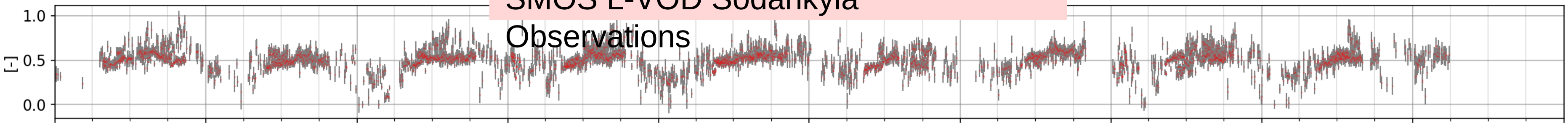
VOD for PFT mix, with fc denoting PFT fractional cover in satellite footprint:

$e^{-VOD} = fc(PFT1)\, e^{-VOD(PFT1)} + fc(PFT2) e^{-VOD(PFT2)} + \ldots$

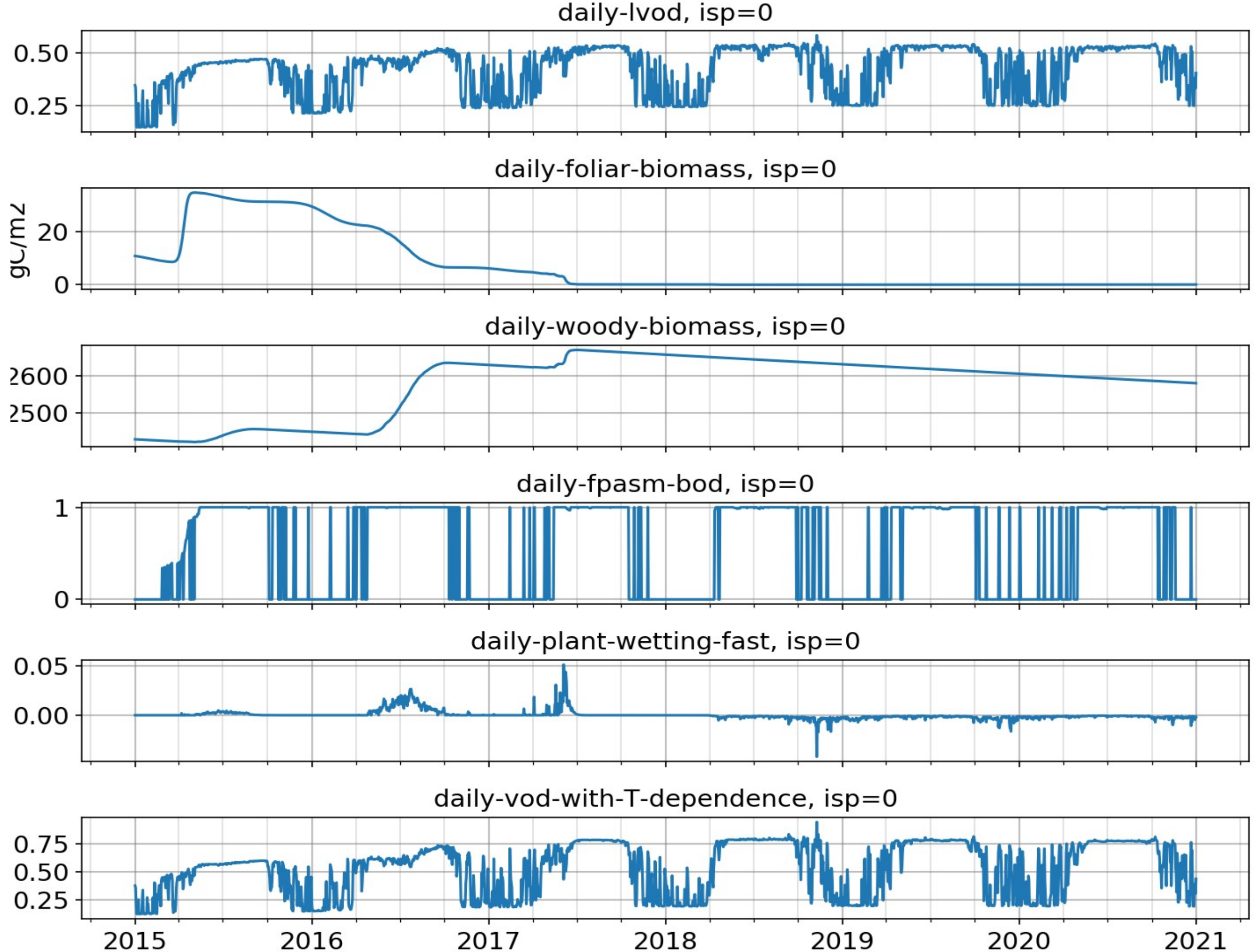
$h_{f/s}$ are measures of the plants' hydrological status, for fast and slow changes approximated by actual over potential canopy evapotranspiration and plant available soil moisture in the root zone, respectively.

$B_{w,l}$ are the plants' wood and leaf biomass pools , respectively.

SMOS L-VOD Sodankylä Observations



Sodankylä PFT Mix Posterior

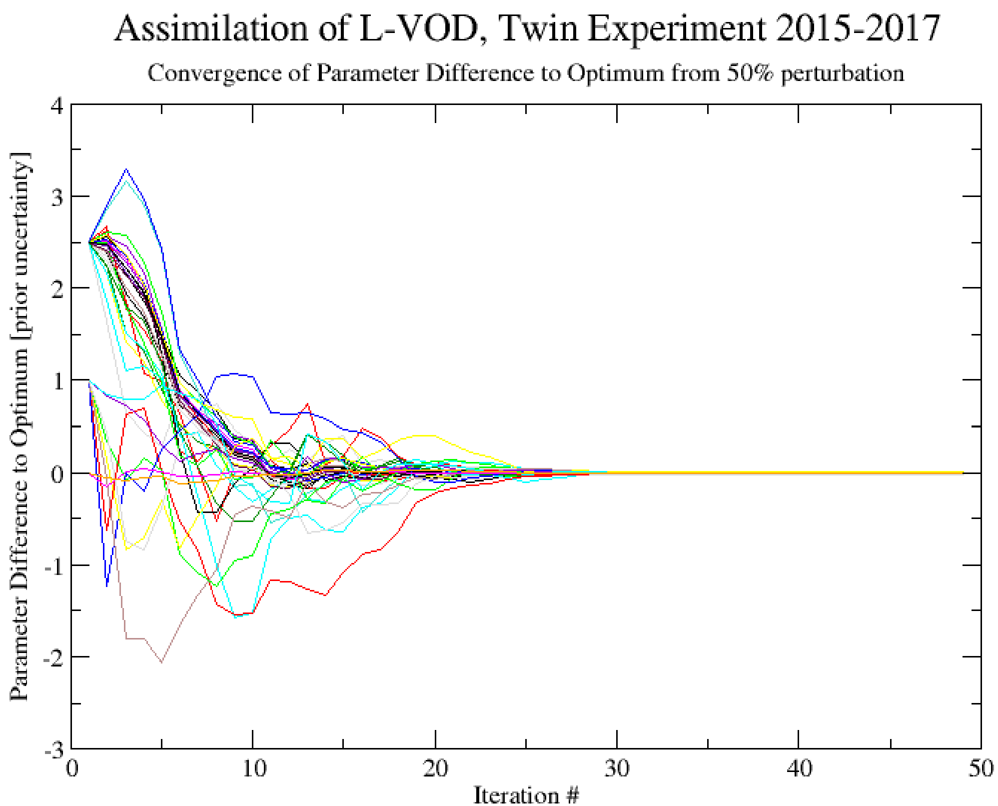


<u>First assimilation experiments:</u>

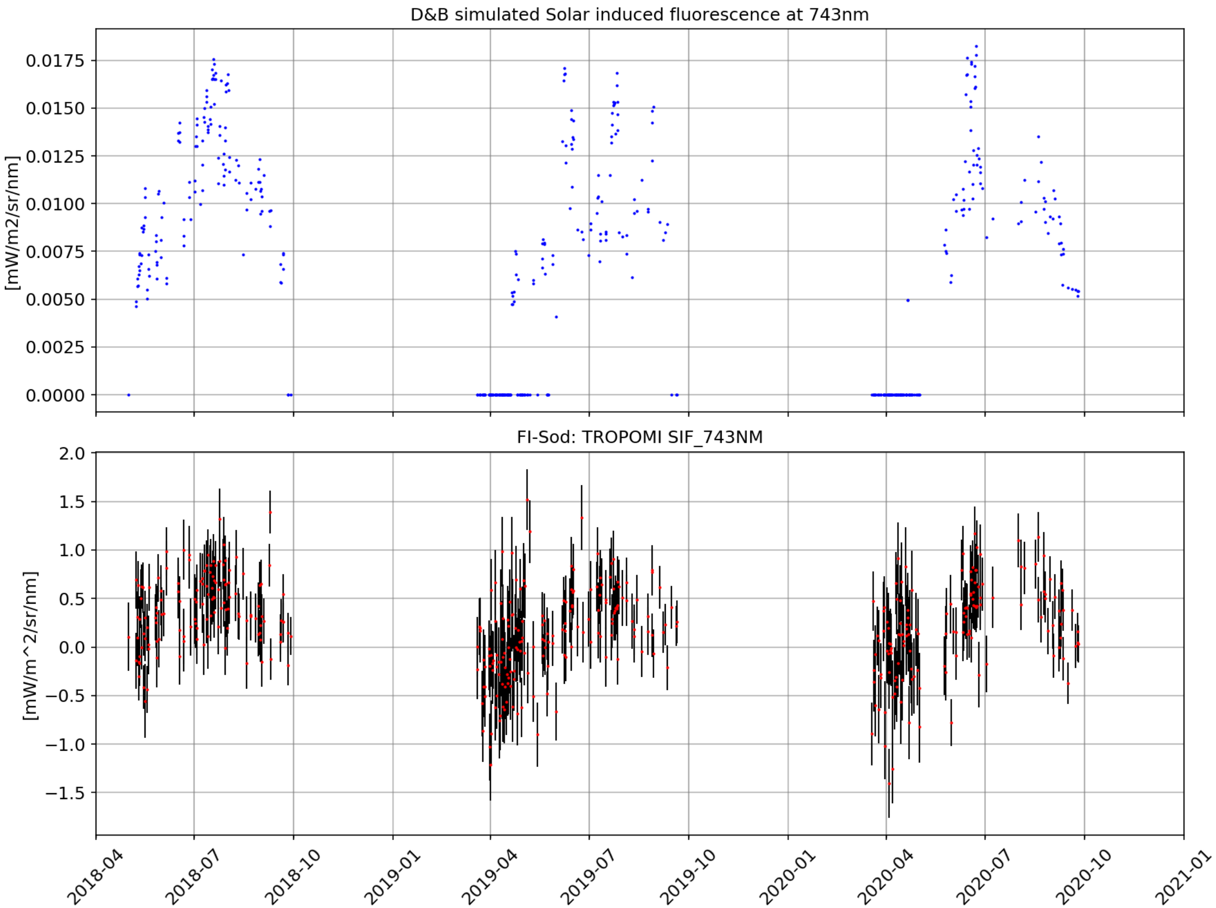
- 48 Parameters for model, 10 for L-VOD observation operator
- L-VOD constrains carbon pools
- This solution to the inverse problem is not realistic
- Further constraints (complementary data streams) will be helpful
- Longer spin-up will be helpful
- And the spatial variability …
- To check that it works at the technical level we go one step back and look at identical twin experiments

Sodankylä Tree Posterior

VOD – identical twin experiment



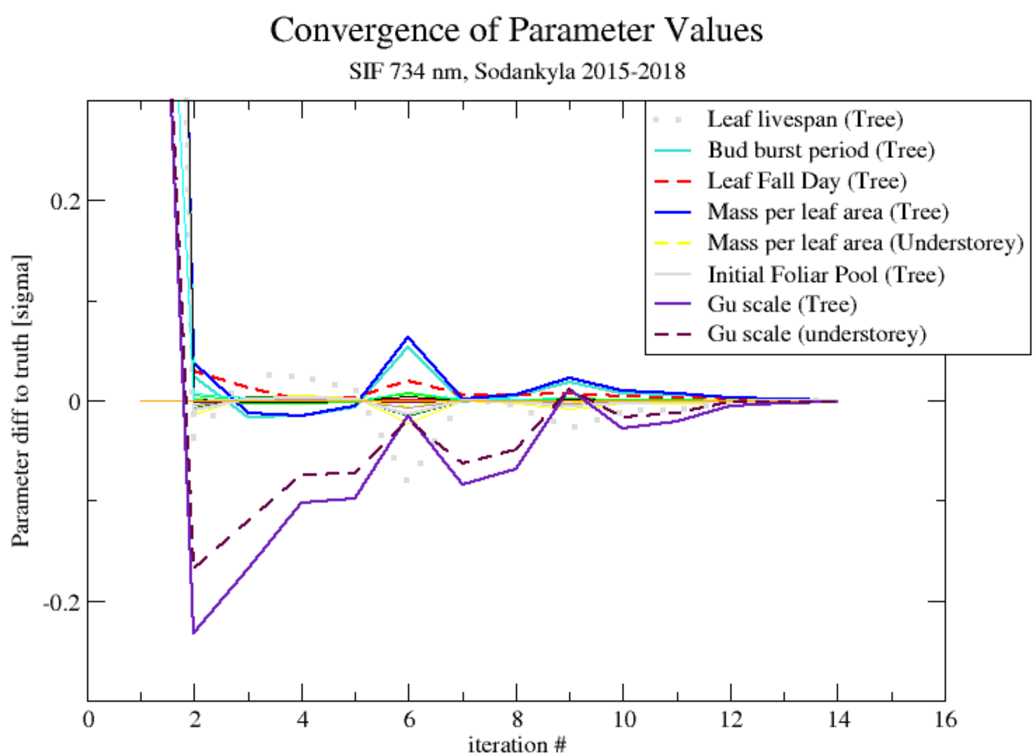
SIF – comparison of simulations against observations at Sodankylä



Modelled SIF for TROPOMI footprint

TROPOMI

SIF – identical twin experiment



Summary D&B Model

DALEC & BETHY model:

- developed for simulation and assimilation of EO and field data
- to provide an integrated perspective on terrestrial carbon and water cycles
- includes observation operators “on the swath” for a diverse array of observations
- includes tangent and adjoint codes for efficient data assimilation (system needs to be applicable at high spatial resolution)
- to be released to public domain as community model for use by larger group beyond the LCC team

Working in the LCC team, which combines experts in field work, remote sensing, modelling, and data assimilation is **CHALLENGING, FRUITFUL**, and **FUN,** much more than working isolated within the respective communities

Thank you!
More to come soon…