# Assimilation of soil moisture observations to constrain carbon fluxes in the Terrestrial Carbon Community Assimilation System (TCCAS)

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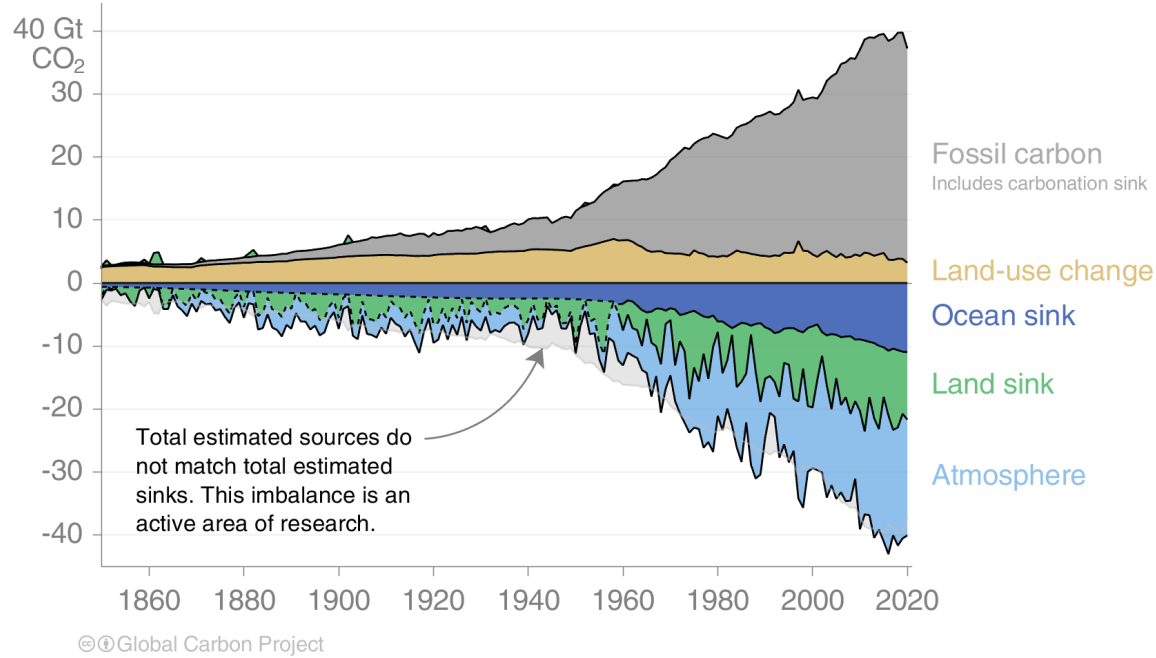
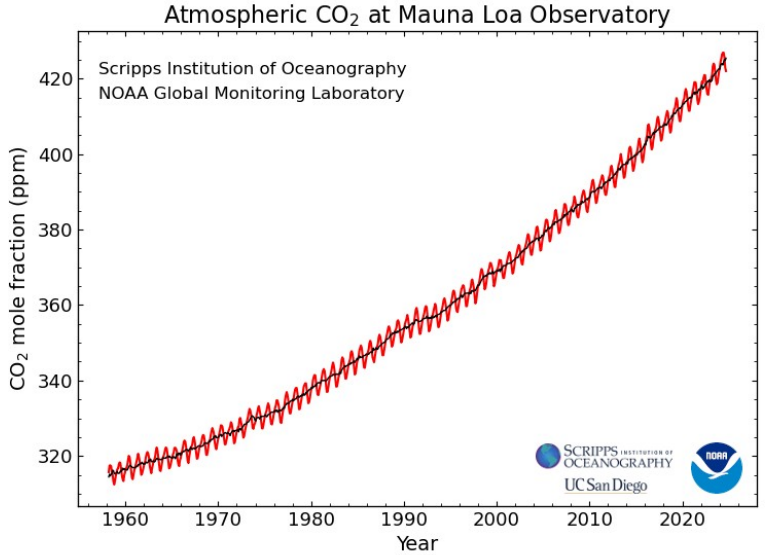
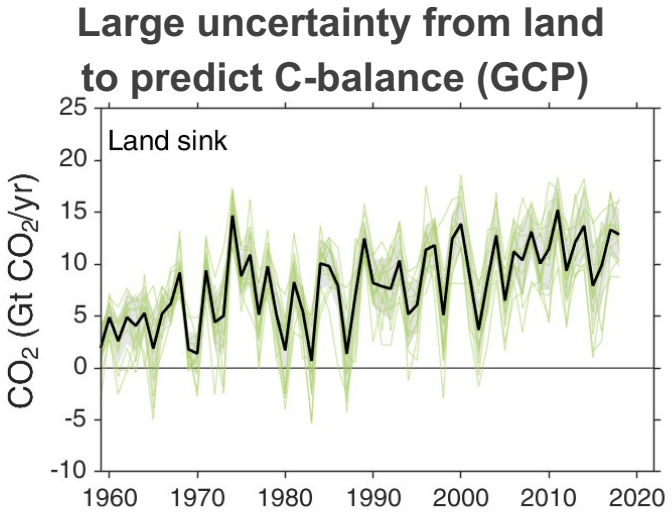
# Background: Atmospheric $CO_2$ growth rate is partly offset by ocean and land sinks

**Anthr. $CO_2$ emissions and partitioning between ocean, land, and atmosphere** (GCP 2021)

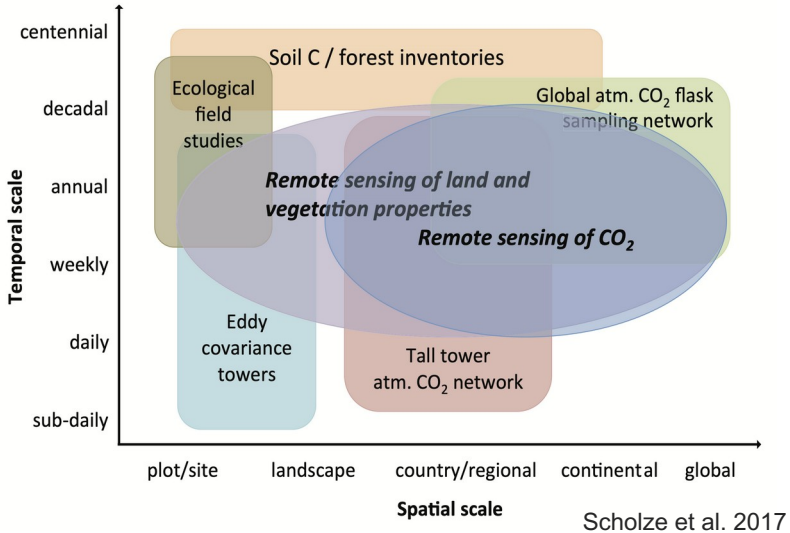


# The case for data assimilation




Friedlingstein et al. 2019




Scholze et al. 2017

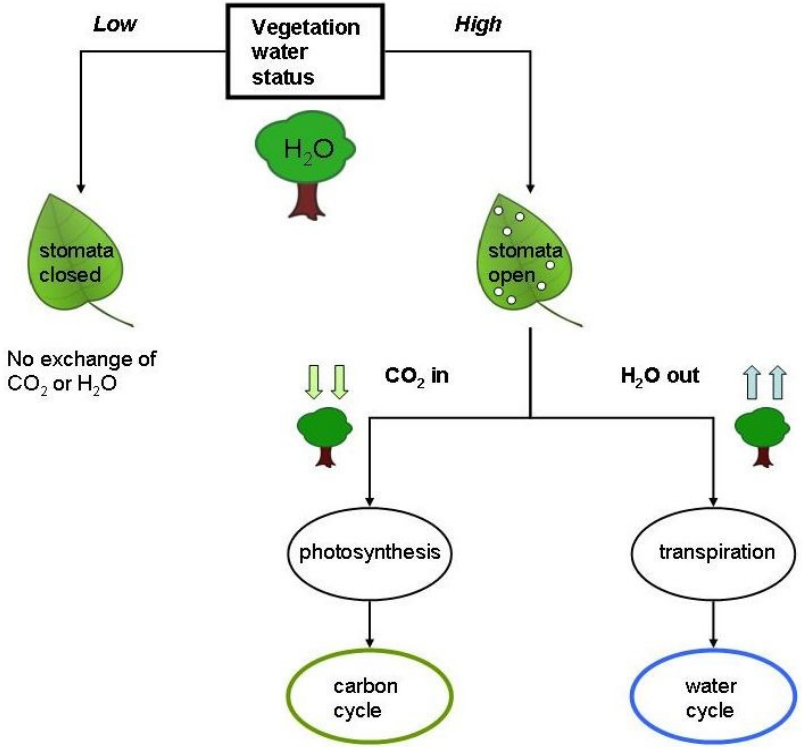
⇒ Carbon Cycle Data Assimilation System

= ecophysiological constraints from forward modelling

+ observational constraints from inverse modelling

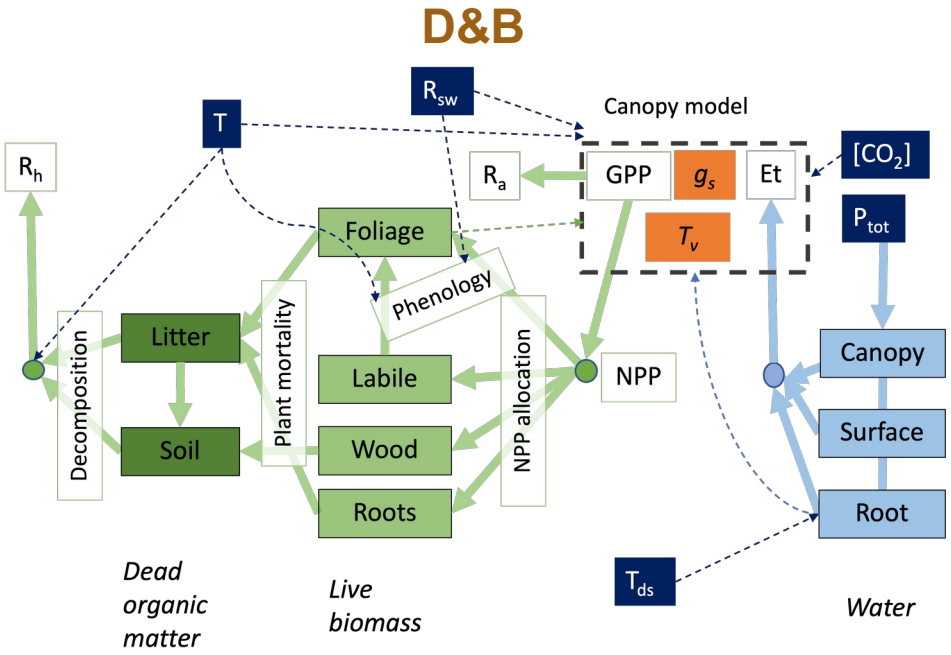
# Why assimilating soil moisture?

Soil moisture:
Water and carbon cycles tightly coupled



# TCCAS

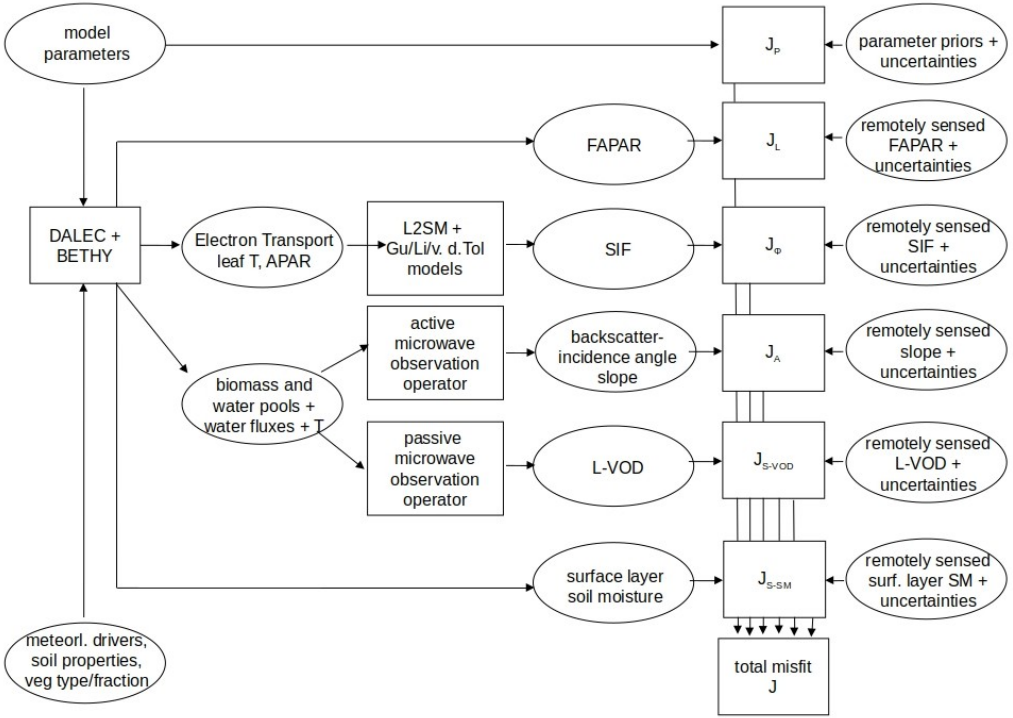
- The Terrestrial Carbon Community Assimilation System (TCCAS) is built around the D&B terrestrial biosphere model.
- TCCAS combines a range of observations with the D&B model to yield a consistent picture of the terrestrial carbon, water and energy cycles.
- TCCAS is being funded through the carbon cluster of the European Space Agency and under Contract No 101082194 (CORSO) by the European Union.




Knorr et al., GMD, 2025

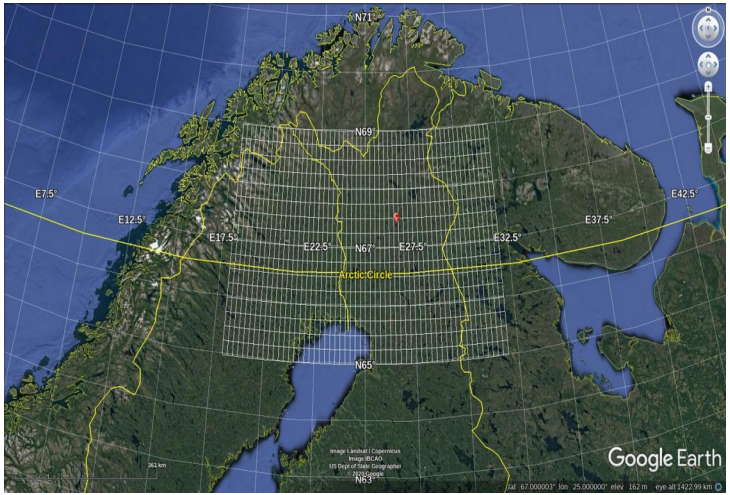
# Variational data assimilation

- 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



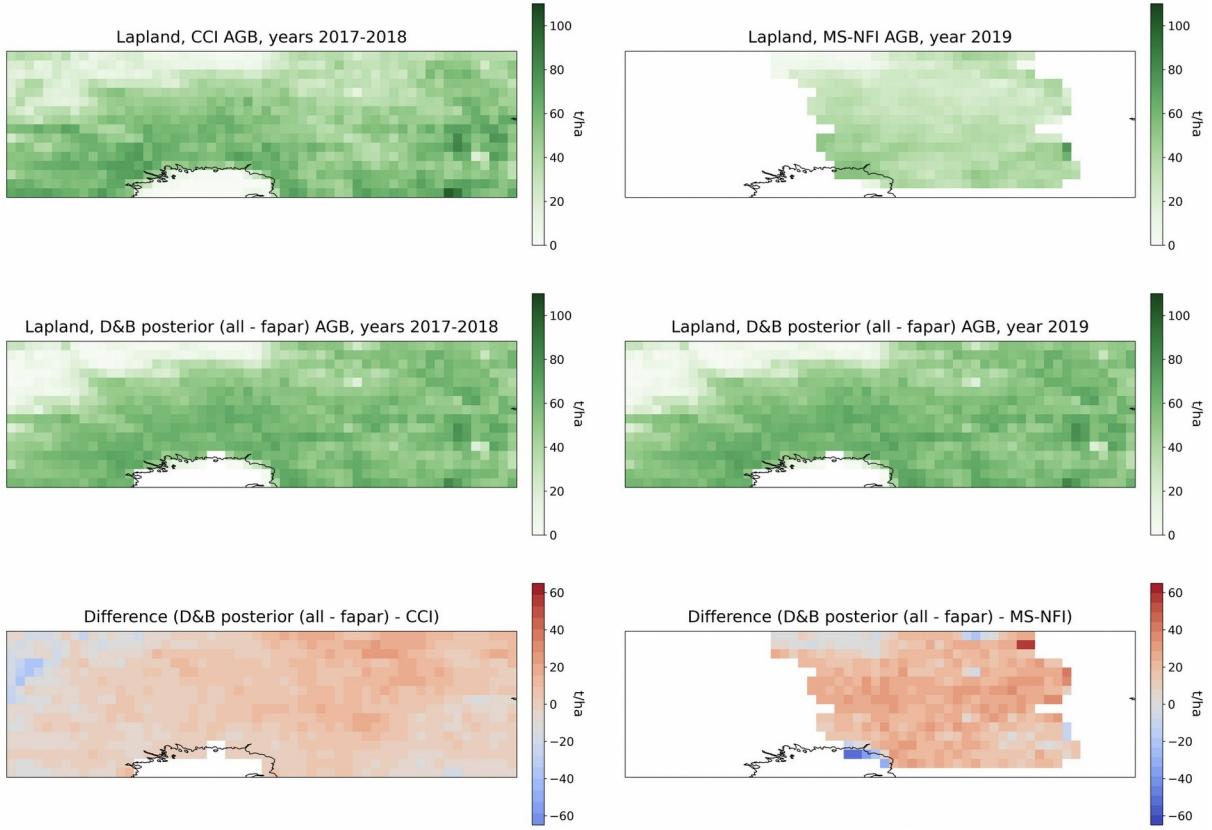
# Modelling at local and regional scales, Lappland

- Demonstration of synergistic use of observations at local and regional scale
- Regional scale: 500 km x 500 km area around the site (Sodankylä) at 0.25 deg resolution
- Spin up 2015/16, assimilation window 2017-21
- Prior Uncertainty: 20% for all process parameters and 80% for all initial pool sizes
- Joint assimilation of:
  - surface layer soil moisture (SMOS)
  - L-VOD (SMOS)
  - FAPAR (JRC-TIP)
  - SIF (TROPOMI)



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

# Example of posterior validation
# 2 AGB products over Lapland

# Take home messages

- **The combination of soil moisture observations together with a range of additional EO data (FAPAR, SIF, VOD), a terrestrial biosphere model and suitable observation operators in a data assimilation system provides a powerful tool for assessment of terrestrial carbon fluxes and pools**
- **Particularly suited to assess additionality**
- **TCCAS openly available: hps://tccas.inversion-lab.com**

# Thank you!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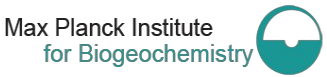
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