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Achieving 10m regional crop CO₂ flux mapping in AGRICARBON-EO through a bayesian assimilation of Sentinel2 reflectances in SAFYE-CO₂

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living planet symposium

BONN
23-27 May
2022

Achieving 10m regional crop CO₂ flux mapping in AGRICARBON-EO through a bayesian assimilation of Sentinel2 reflectances in SAFYE-CO2

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session A3.04 Agriculture - Methods and Algorithms, Science, Applications and Policy 24/05/2022 8h45

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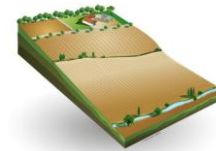
CONTEXT: CARBON FARMING and MRV

Agro-ecosystems and carbon storage:

- 4/1000 (Minasny et al. 2018, Amelung et al. 2020)
- Conservation, tillage, cover crops ... => Carbon farming

National & international Initiatives:

- Label bas carbone (France)
- GREEN deal
- Voluntary carbon market



cover crops
crop rotations
agroforestry

Soil monitoring, reporting and verification framework
adapted from Smith P. et al (2020) *Global Change Biology*

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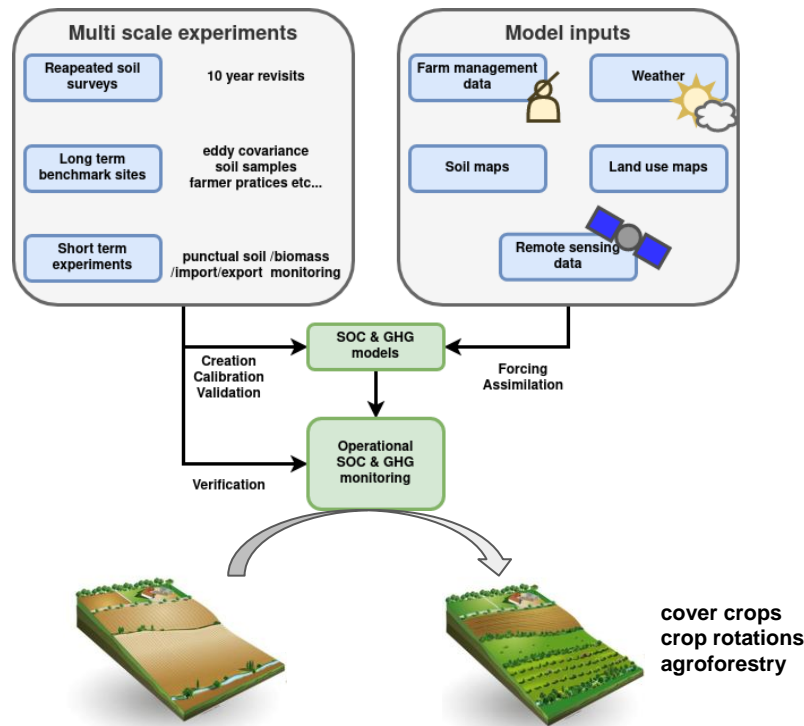
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International scientific cooperation for soil carbon MRV:

- **CIRCASA**(2017-2021)
 - conceptual framework
- **ORCASA** (2022-2024)
 - methodological framework + Prototypes
- **IRC Soil Carbon** (2024-)

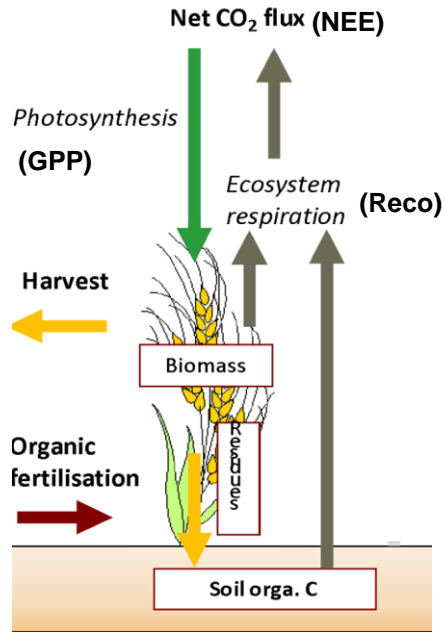
For scaling, the **MRV framework** relies on **satellite products & models**



Soil monitoring, reporting and verification framework
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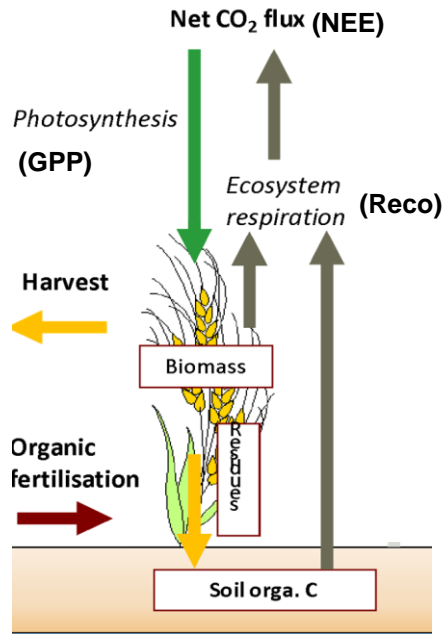
Objective: Quantify the carbon budget components

Process based approach => SAFYE-CO₂ (Pique et al. 2020 A&B)



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Process based approach => SAFYE-CO₂ (Pique et al. 2020 A&B)



At large scale & intra field resolution:

- Regional/National Coverage
- Coherent with biophysical processes & management

Taking in account local growth variability

- Crop rotations ,cover crops, regrowths ...
- Remote sensing data assimilation

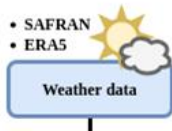
Quality assessments for each component

- Extensive validation using field measurements
- Uncertainty estimations

Argicarbon-EO = SAFYE-CO₂ + bayesian assimilation

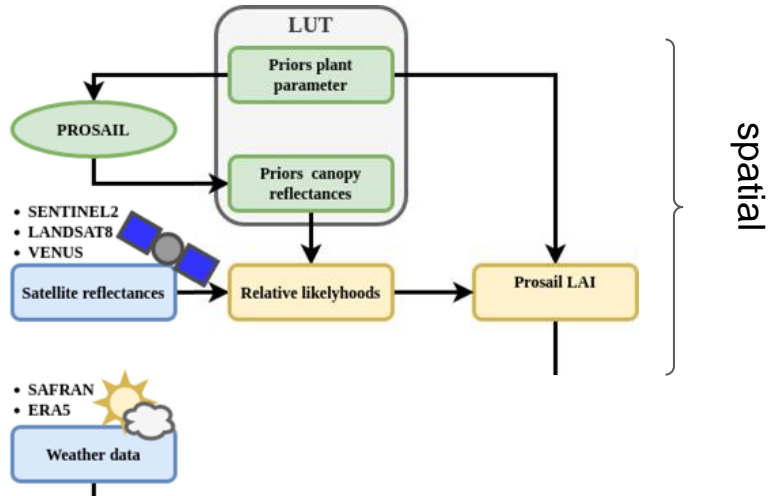


Overview of the Agricarbon-EO processing chain



Downloads, collocates and regrids data: plot contours, weather data (ERA5LAND/SAFRAN) from optical remote sensing data.

Overview of the Agricarbon-EO processing chain

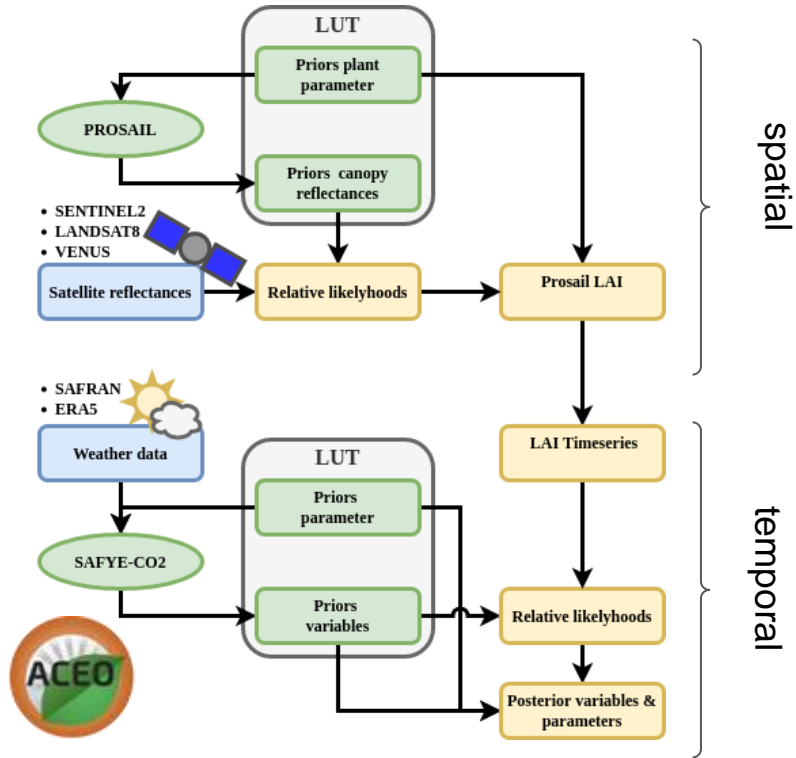


Downloads, colocalizes and regrid data from optical satellites (Theia*), weather reanalysis ERA5LAND (ECMWF**)/SAFRAN & validation data

Bayesian LUT based Inversion of Prosail for each image to obtain LAI +uncertainties



Overview of the Agricarbon-EO processing chain



Downloads, collocates and regrid data from optical satellites (Theia*), weather reanalysis ERA5LAND (ECMWF**)/SAFRAN & validation data

Bayesian LUT based Inversion of Prosail for each image to obtain LAI +uncertainties

Bayesian LUT based assimilation of LAI time series into SAFYE-CO2 to obtain **parameters and variables**

Produces

- Quality indicators & uncertainties
- Maps of variable & parameter as well as their distributions.

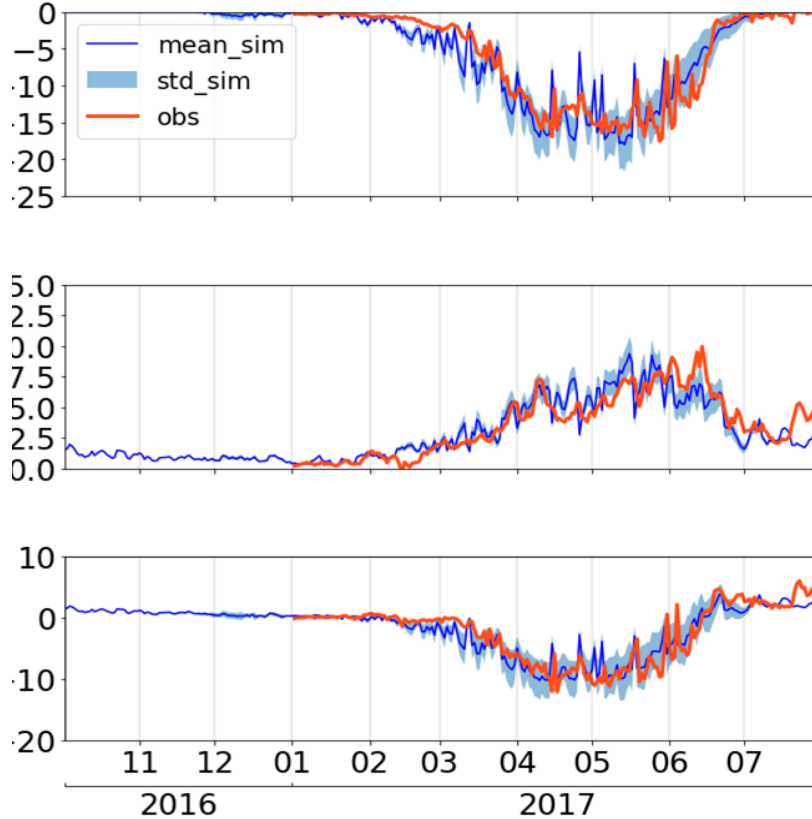
**SAFYE-CO2 simulation
over one Sentinel2 tile 4h**

Validations of Agricarbon-EO Wheat: CO₂ fluxes



photosynthesis

net CO₂ flux ecosystem respiration
gCarbon/m gCarbon/m gCarbon/m

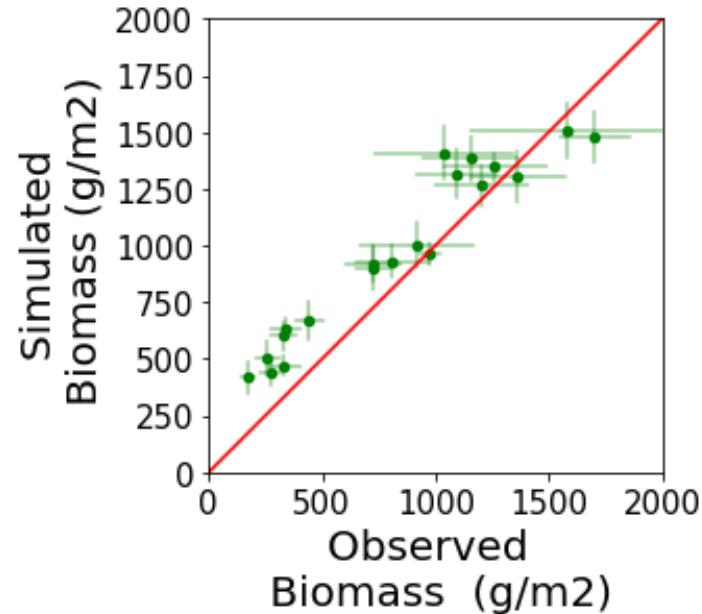


- Slight overestimation of GPP at the beginning of the cycle
- Reco is less accurate
- Overall good performance

	RMSE	MAE	bias	R2
GPP	1.97	1.44	-0.41	0.90
Reco	1.12	0.87	0.08	0.75
NEE	1.55	1.18	-0.33	0.85

**ICOS
FR-Aur
in 2017**

Validations of Agricarbon-EO Wheat: Biomass

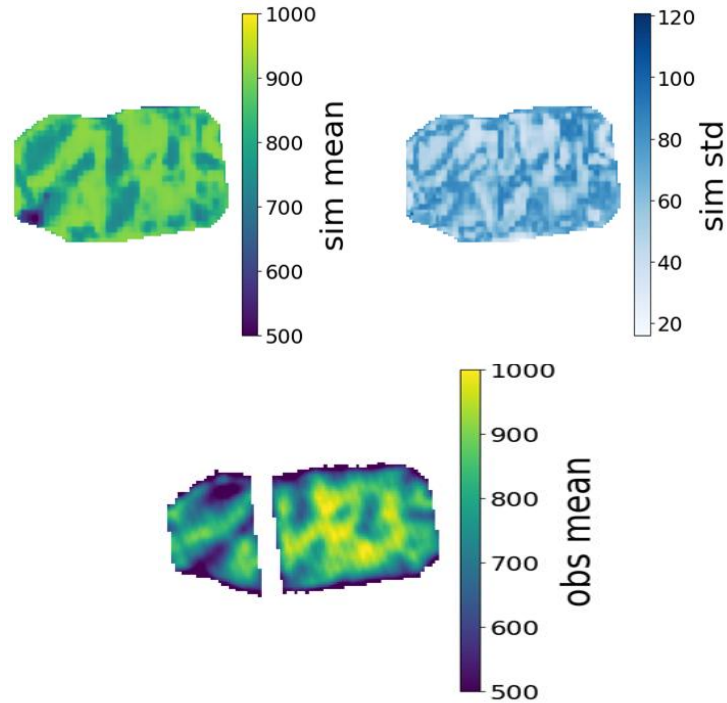


- Slight overestimation of biomass in the begining of the growth
- High correlation and low errors given the measurement and model uncertainties

	RMSE	MAE	bias	R2
DAM	197.20	174.81	-138.75	0.92

Validation over punctual biomass field measurements in 2018

Validations of Agricarbon-EO Wheat: Yield

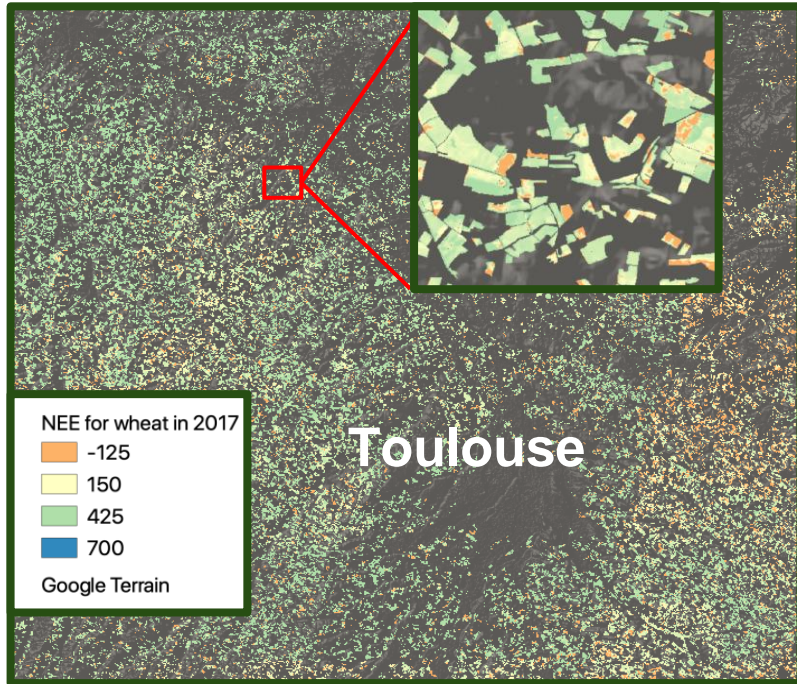


- Representation of spatial variability
- lack of amplitude in the simulations.
- more expertise on harvest maps needed

Validation using harvest maps in 2017

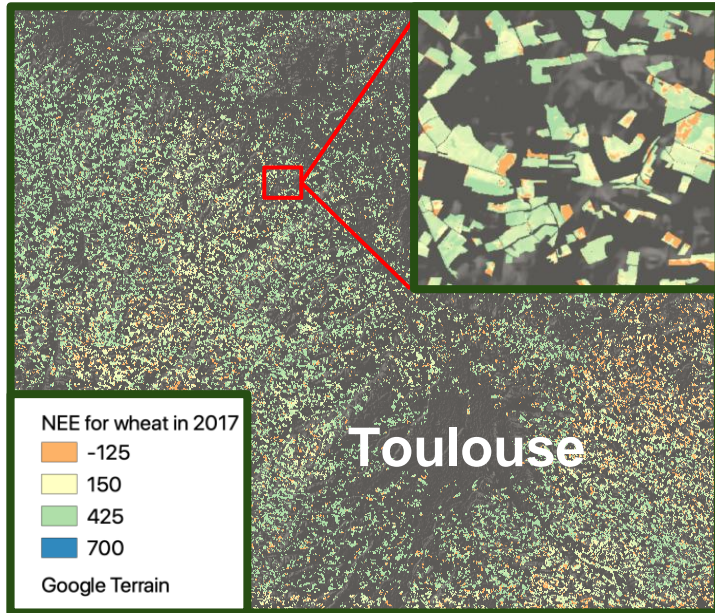
Application: carbon budgets over a sentinel2 tile

10m resolution map of straw cereal Net annual CO₂ fluxes:
T31TCJ Sentinel2 tile (110 x 110 km)

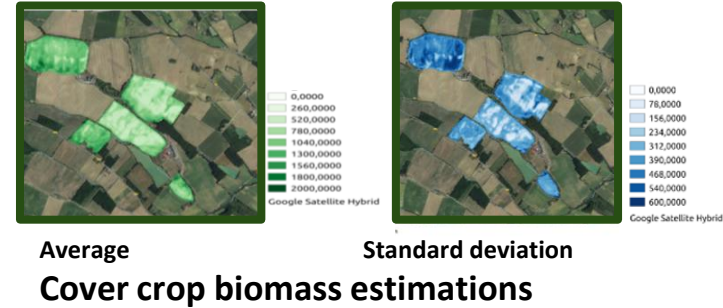


Application: carbon budgets over a sentinel2 tile

Large scale 10m resolution map over the
T31TCJ Sentinel2 tile (110 x 110 km)

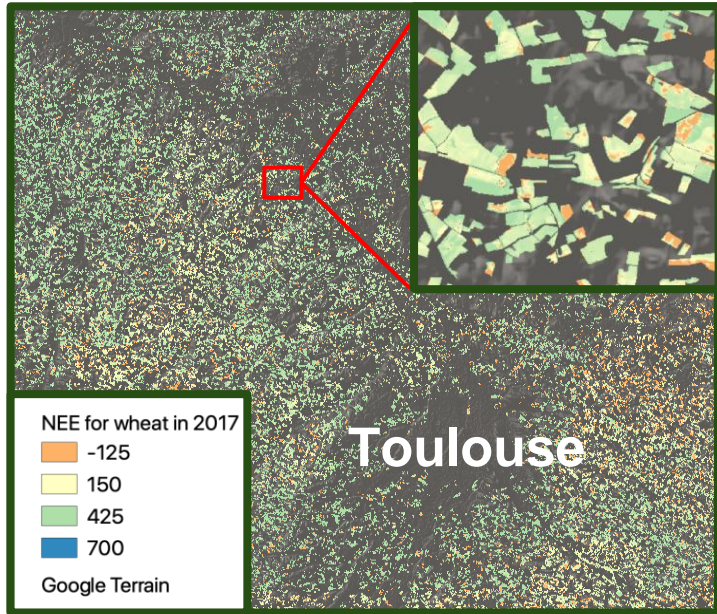


Net annual CO₂ flux (gC-CO₂/m²/yr)



Application: carbon budgets over a sentinel2 tile

Large scale 10m resolution map over the
T31TCJ Sentinel2 tile (110 x 110 km)



Net annual CO₂ flux (gC-CO₂/m²/yr)



Farmer data
(C imports/exports)



Average



Standard deviation

Cover crop biomass estimations



High resolution carbon budgets map.

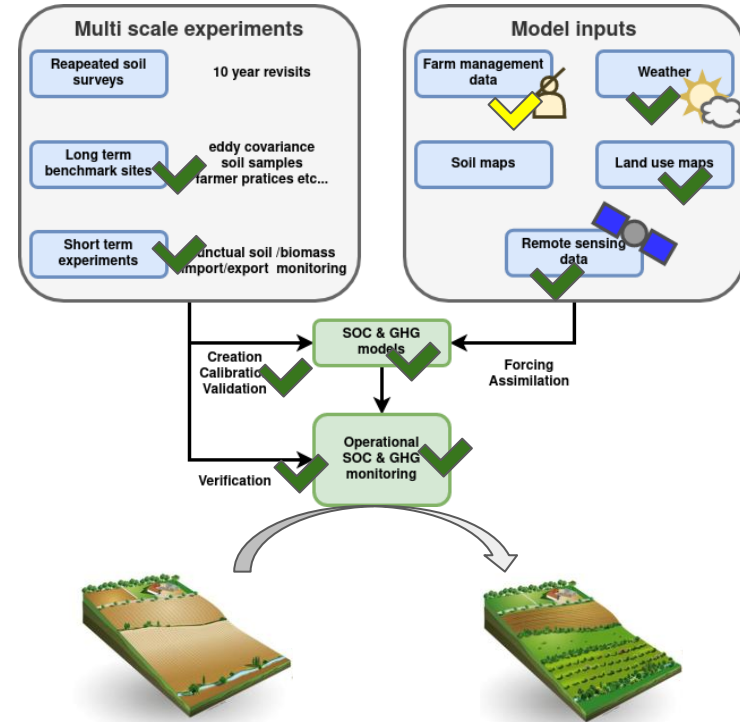
Conclusions:

Agricarbon EO:

- Monitor Carbon budget components
- Large scale & intra field resolution
- Local growth variability
- Quality assessments

MRV compatible demonstrator

- Streamline the access to farmer data (Agdatahub)
- Introduce SOC model
- Assimilate other remote sensing products.



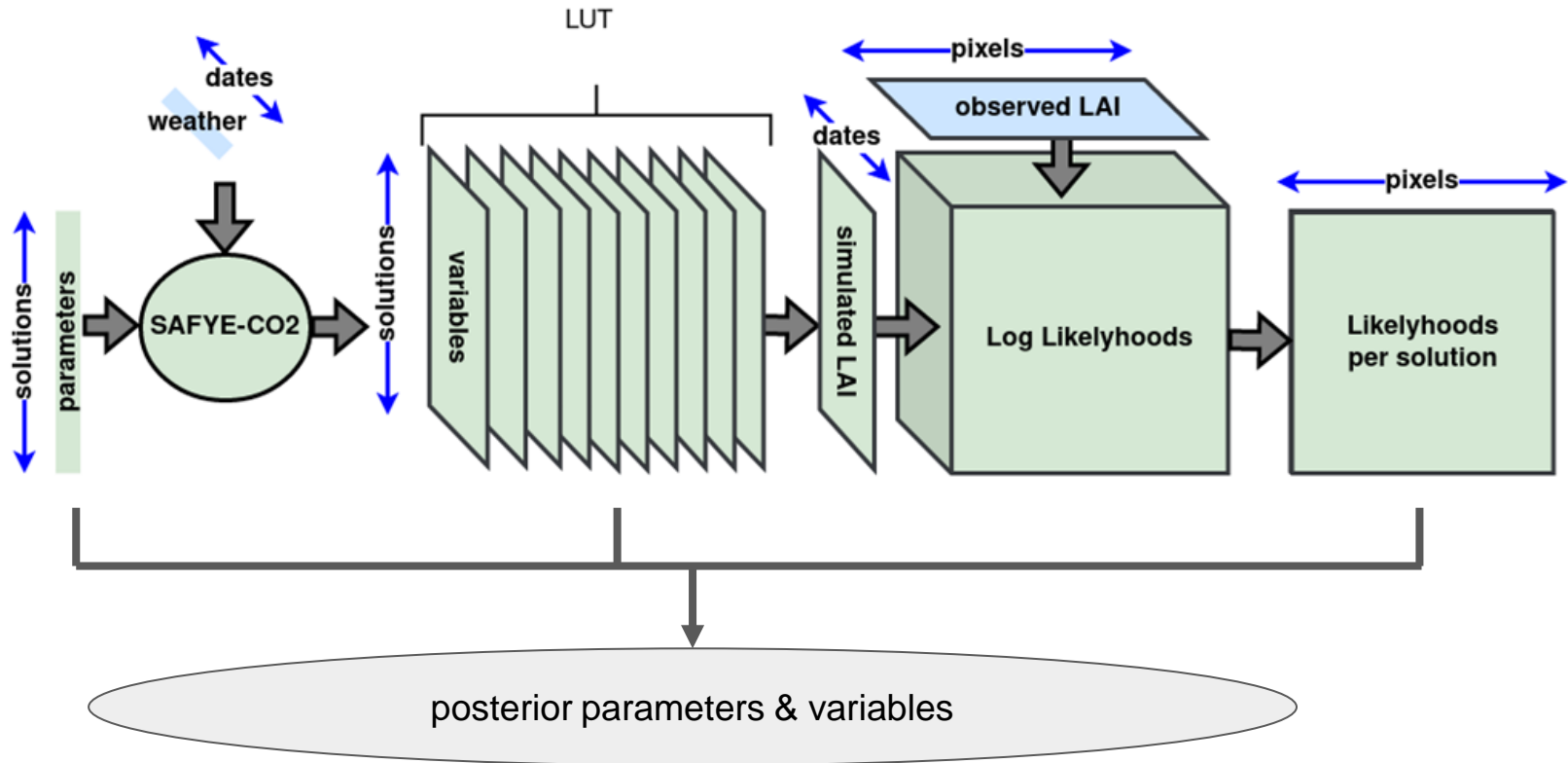
Soil monitoring, reporting and verification framework adapted from Smith P. et al (2020) *Global Change Biology*

références & contacts

to finish

**Thank you
for your
attention**

Assimilation & bayesian Inversion



Models: PROSAIL & SAFYE-CO2

Prosail

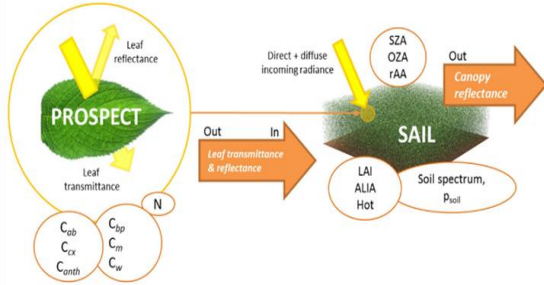
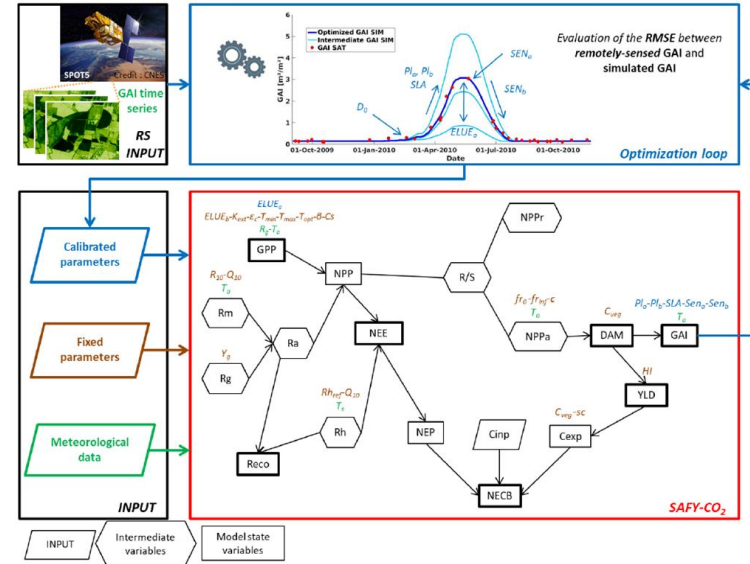


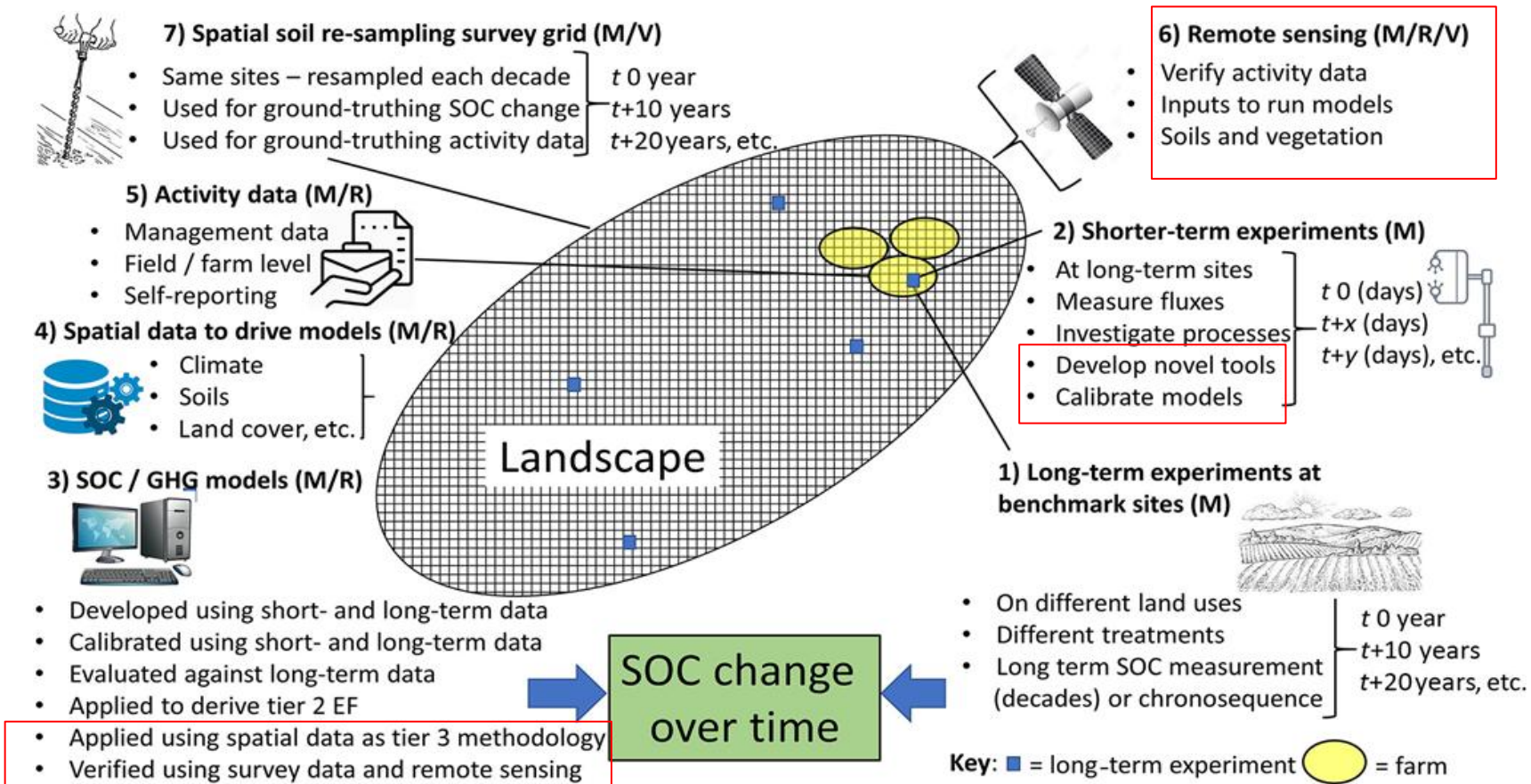
Figure 1. Calculation of canopy reflectance using the coupled PROSPECT + SAIL models. Variable symbols are explained in Table 1 and in the text.

Katja Berger et al. (2018)

1D radiative transfer model
Widely used in the community



Simple agronomic model



Soil monitoring, reporting and verification framework

from Smith P. et al (2020) *Global Change Biology*