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SEEDS - Sentinel EO-based Emission and Deposition Service

Soil moisture and LAI products

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Jean-Christophe Calvet, CNRM/Meteo France

Stakeholder engagement meeting, 30-31 March 2023, Barcelona, Spain

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SEEDS Dry Deposition Concept

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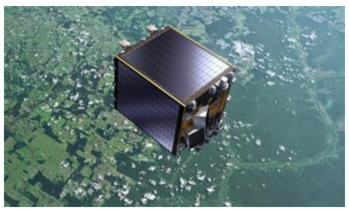
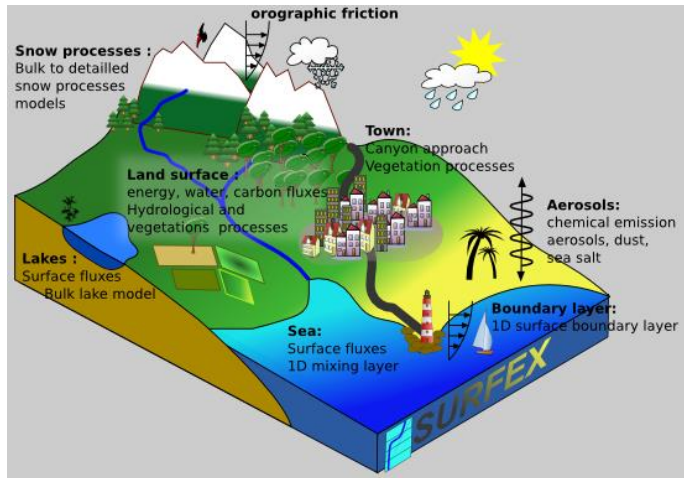
Satellite Observations

PROBA-V
Leaf Area Index



(Copernicus Global Land Service)

SURFEX LDAS-MONDE Data Assimilation



SURFEX dry deposition model

- Links to advanced vegetation model
- Uses assimilated LAI and soil moisture
- Dry deposition calculated for all surface types

- **Deposition velocities**
- **Dry deposition diagnostics**

- Land surface modelling and data assimilation to feed into calculation of dry deposition.
- LAI, soil moisture, and vegetation dynamics play key role in dry deposition modelling.

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ISBA land surface model

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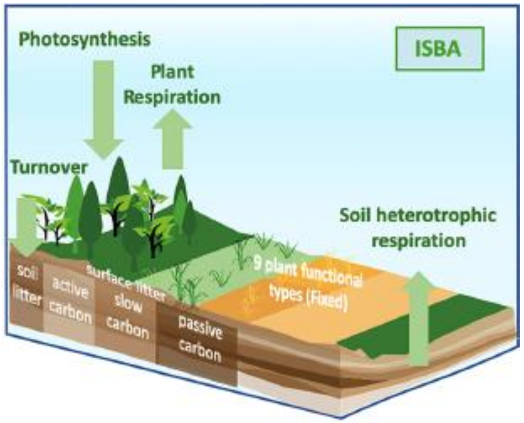
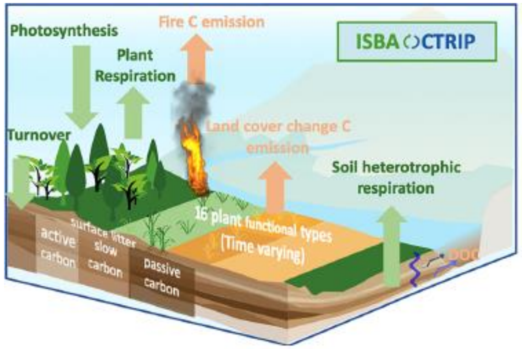
- **Multilayer soil:** 14 layers up to 12m depth for water and energy [Boone *et al.*, 2000; Decharme *et al.*, 2013]
- **Multilayer snow:** explicit scheme with 12 layers [Boone and Etchevers, 2001; Decharme *et al.*, 2016]
- **Coupling with river routing system CTRIP** [Decharme *et al.*, 2019]
- **ISBA-NIT** [Calvet *et al.*, 1998; Gibelin *et al.*, 2008]:
  - Photosynthesis-driven phenology based on Goudriaan approach and prescribed parameters
  - Plant water stress: tolerant vs avoiding
  - 9 Plant Functional Types (PFTs)
- **ISBA-NCB** [Delire *et al.*, 2020]:
  - Updated phenology and 16 PFTs compared to NIT
  - Improved carbon cycle (fire, carbon leaching, …)



ISBA-NIT (top) and **ISBA-NCB** (bottom) adapted from Delire *et al.* (2020)



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Applications involving ISBA

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- ISBA is available through the **SURFEX surface modelling platform: https://www.umr-cnrm.fr/surfex**
- Land Surface part in Numerical Weather Prediction systems at Meteo-France and the ACCORD community (26 Met Services, http://www.umr-cnrm.fr/accord/)
- Land Surface component for operational hydrometeorological monitoring at Meteo-France (Safran-ISBA-Modcou chain at 8km spatial res.)
- Component of CNRM-CM5.1, CNRM-CM6-1 and CNRM-ESM2-1 (**ISBA-NCB**) for climate simulations involved in CMIP5 and CMIP6
- Land Surface model used in LDAS-Monde (**ISBA-NIT**):
  - from global monitoring at 0.25° res. of vegetation and water cycle [Albergel *et al*., 2020]
  - … to monitoring at kilometric scales over France [Bonan *et al*., 2021]

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Sequential assimilation of LAI

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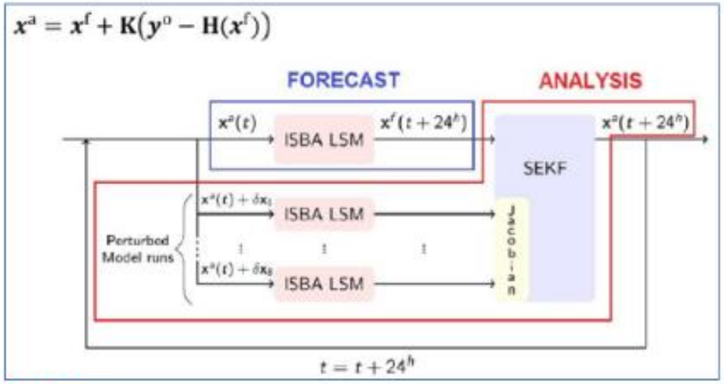
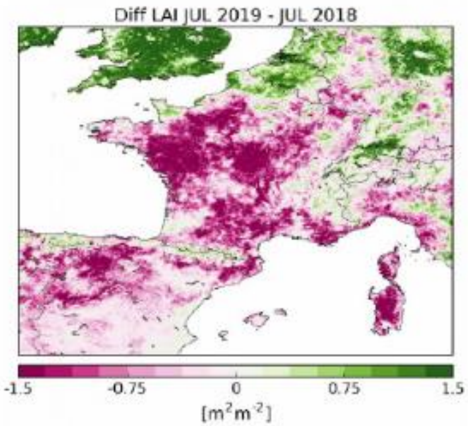
- **Thanks to photosynthesis-driven phenology**
  - based on Goudriaan approach
  - plant water stress: tolerant vs. avoiding
  - flexible LAI : rapid response to rains in semi-arid environments
- **LAI can be assimilated**
  - alone or together with SSM or snow
  - RZSM can be analyzed using LAI observations
- **Towards higher spatial resolution**
  - Global: 25 km x 25 km
    - ERA-5
  - Continents : 9 km x 9 km
    - HRES
  - Western Europe
    - AROME NWP atmospheric variables interpolated on a ~2.5km grid
  - Small regions
    - AROME NWP atmospheric variables on a 1.3km grid





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Validation using GOME-2 SIF data

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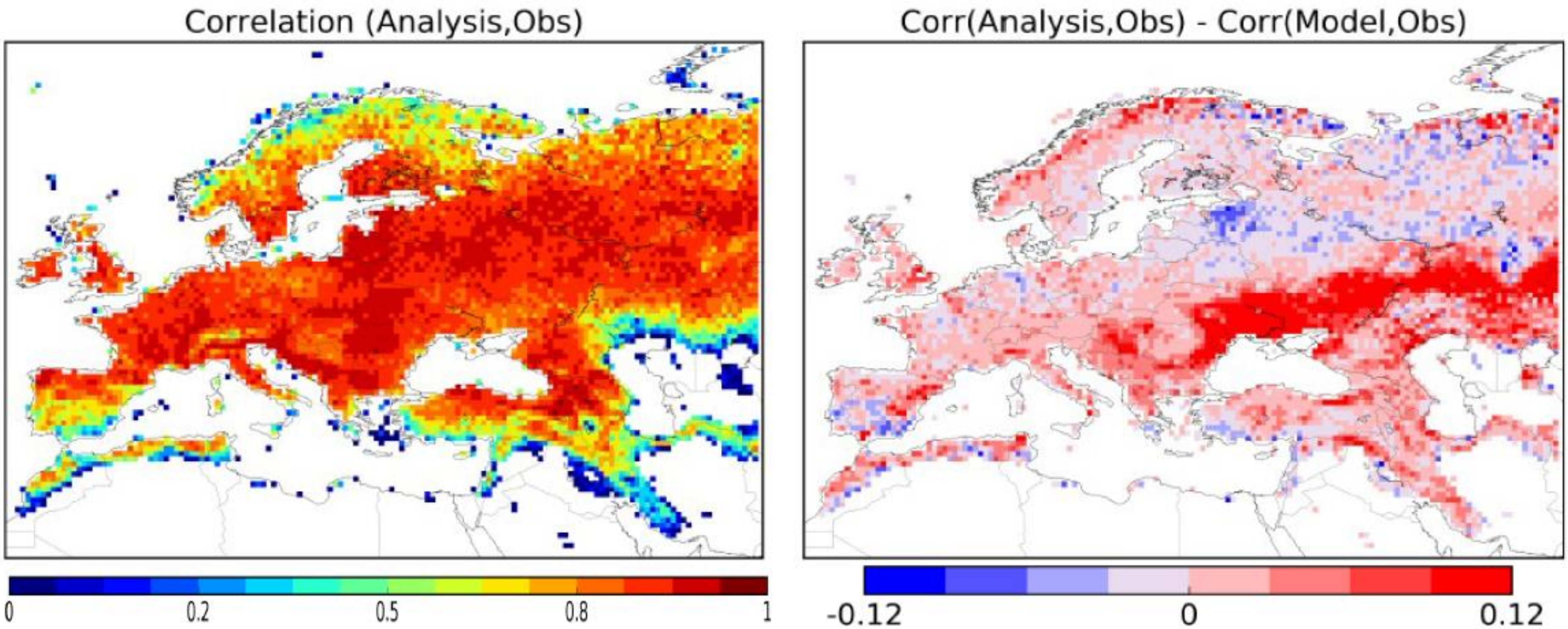
- Solar-induced fluorescence (SIF)
- SIF GOME-2 – Leroux et al. 2018



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Validation using GOME-2 SIF data

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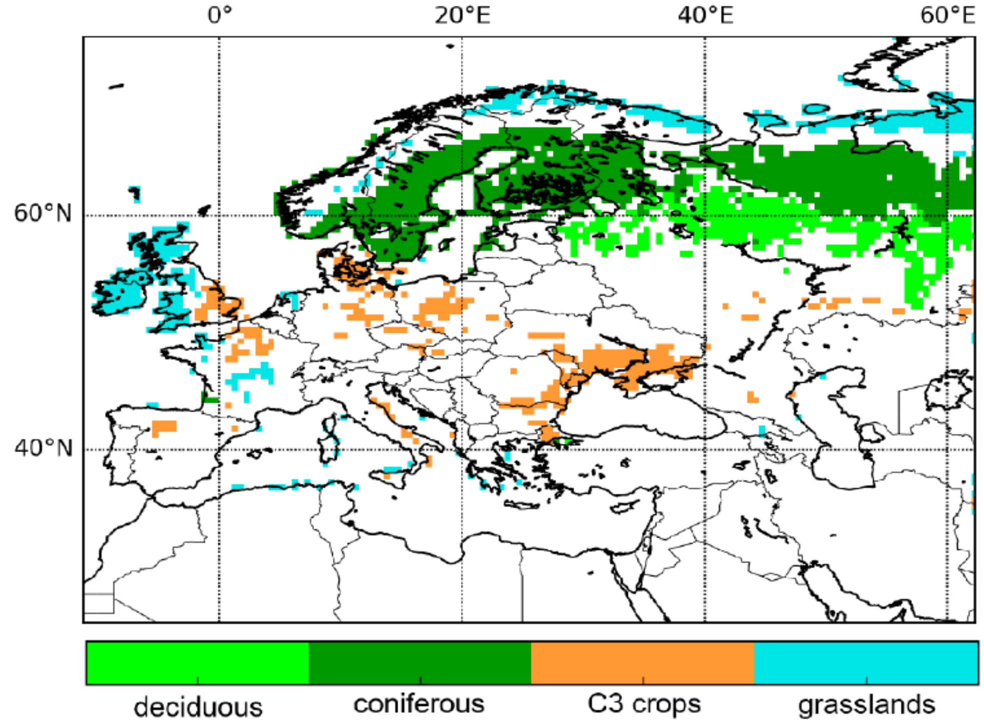
- ➔ Solar-induced fluorescence (SIF)
- ➔ SIF GOME-2 – Leroux et al. 2018

Added value of the assimilation:

larger over croplands



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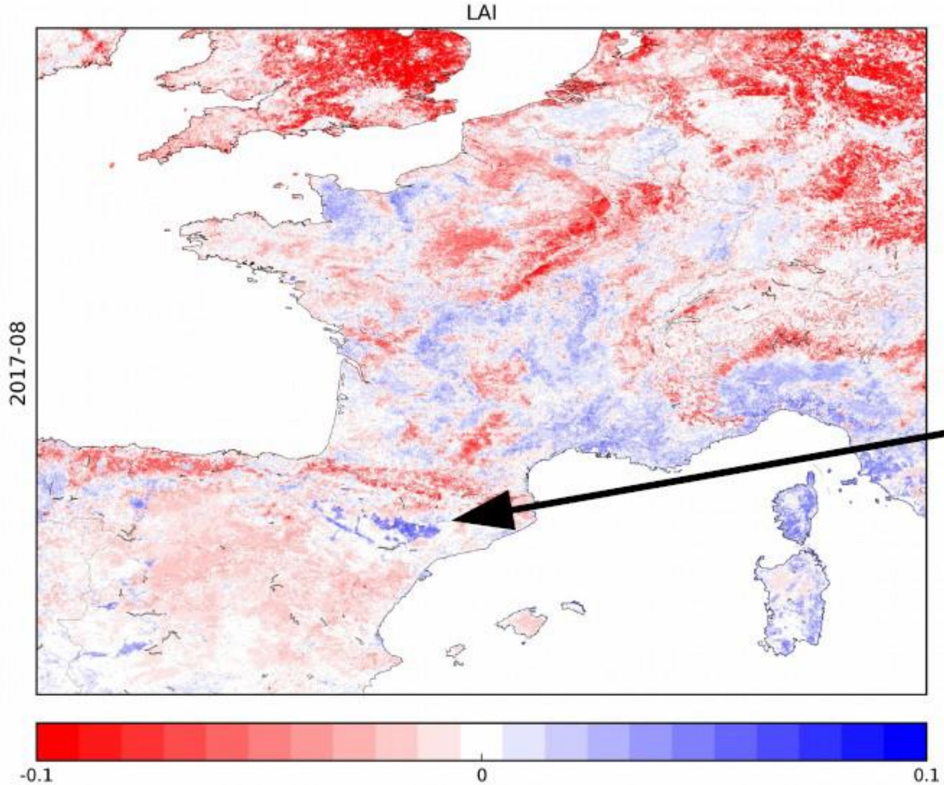
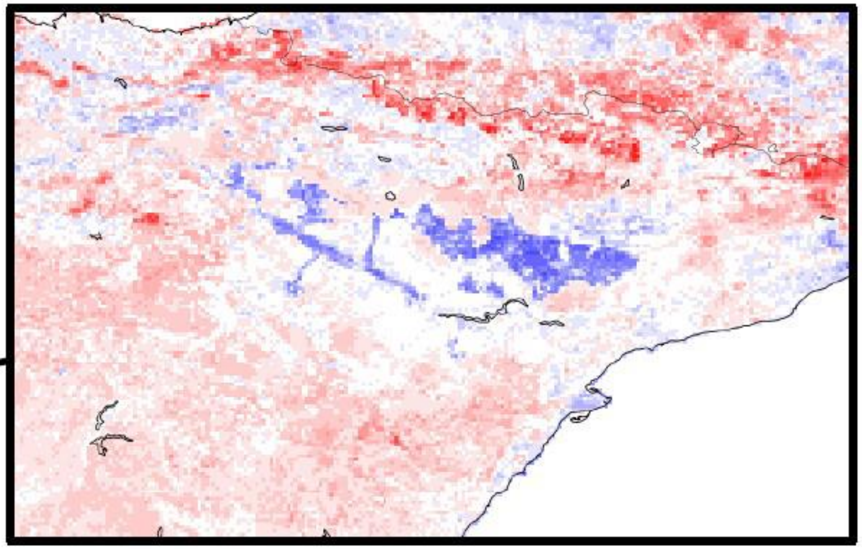
Irrigation can be accounted for

➔ **LAI increments highlighting irrigation over the Ebro basin in August 2017**





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Cereal yields can be captured

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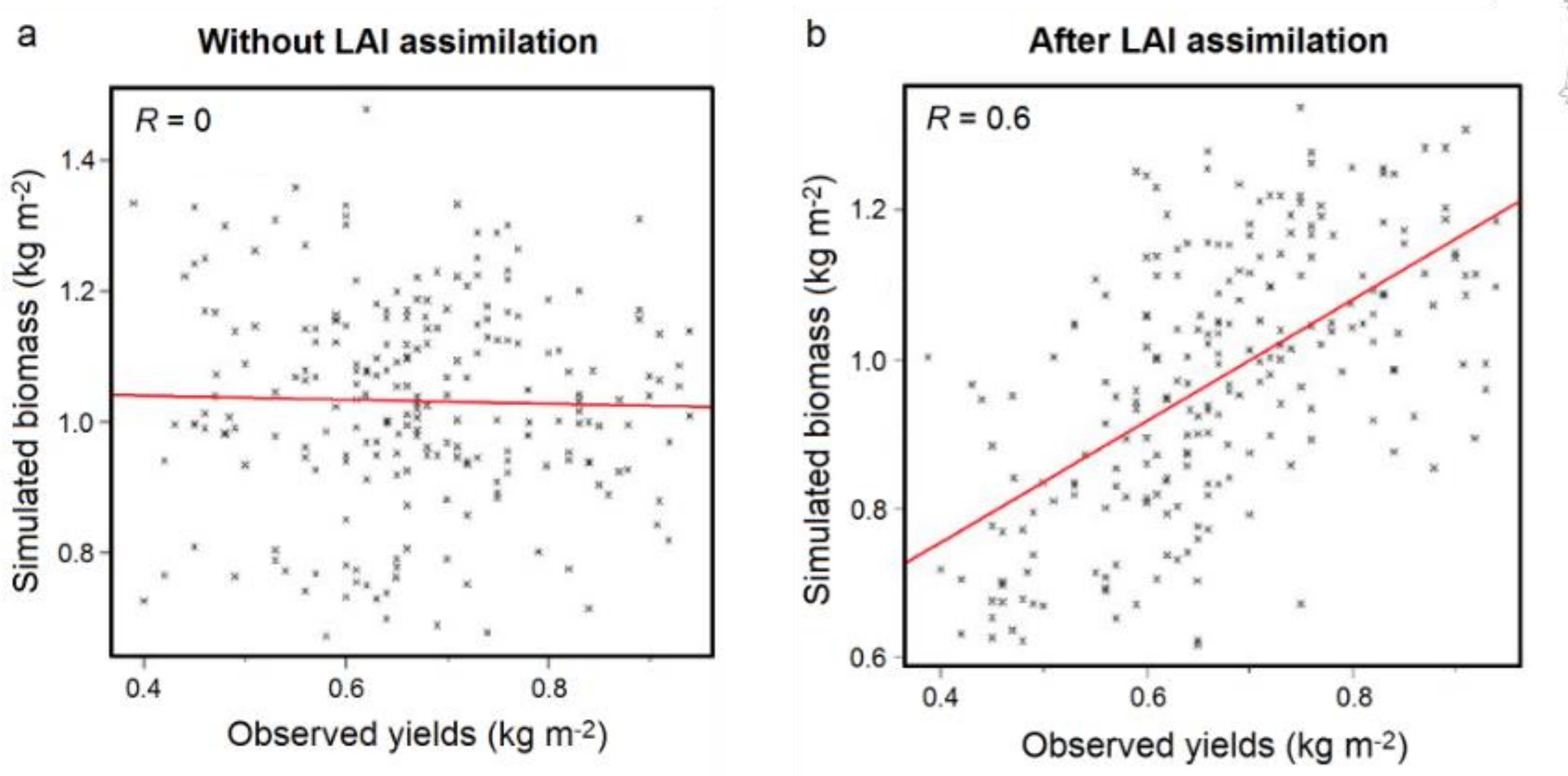

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Using HRES is better

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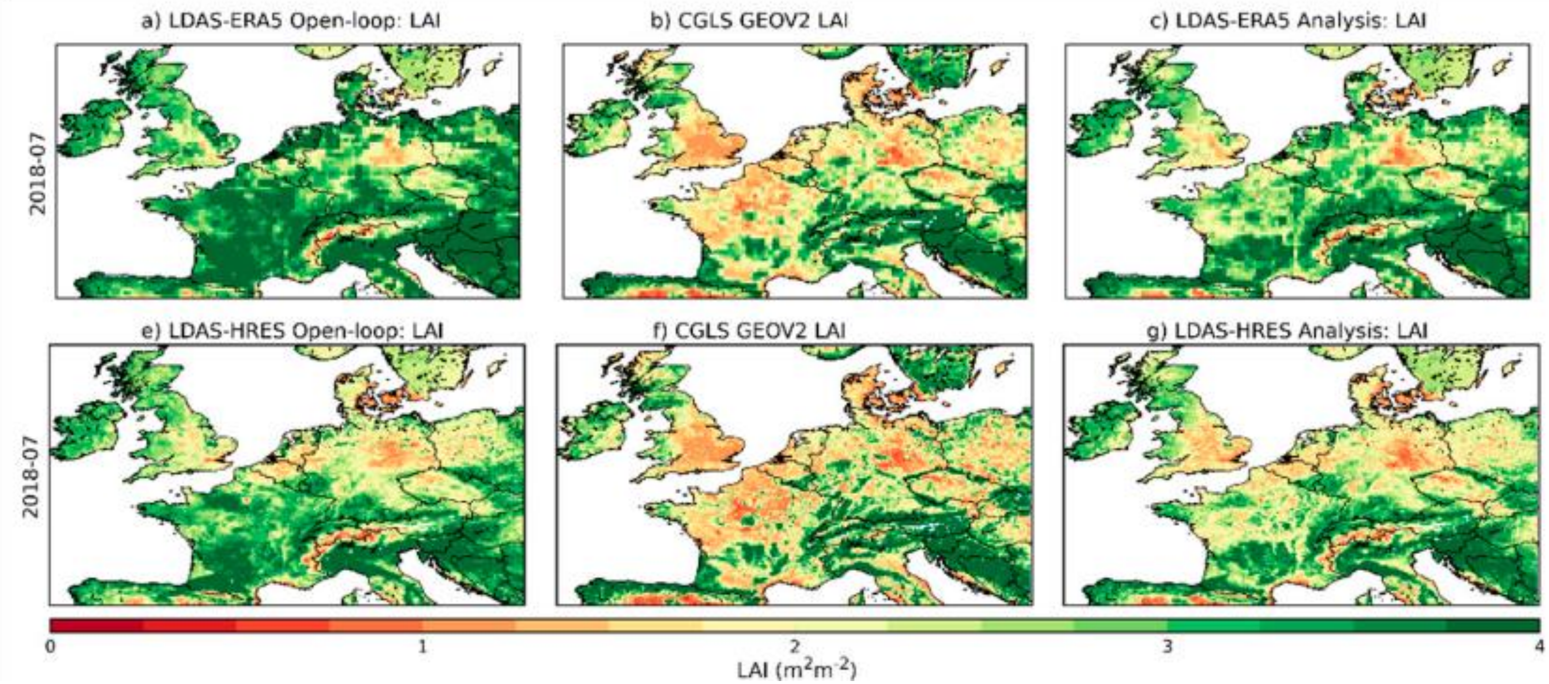
Impact of the 2018 heatwave in Europe (Albergel et al. 2019)

- HRES continuous time series vs. ERA5
  - Impact of heatwave on LAI is better simulated by ISBA
  - Impact of assimilating LAI obs in LDAS-Monde is larger



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SEEDS Land Service Products

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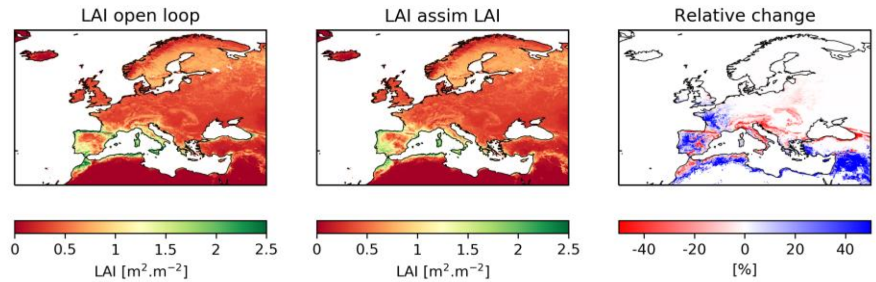
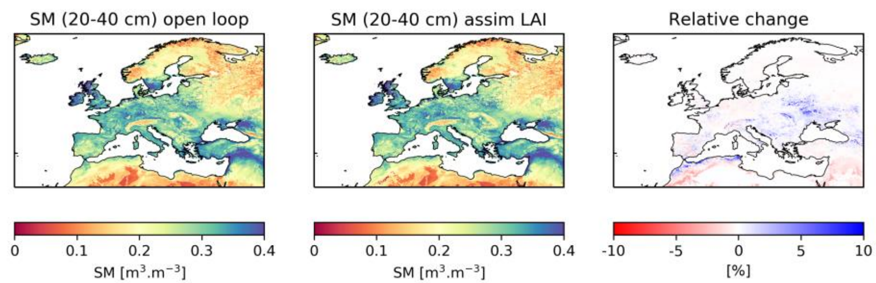
- Land surface variables
  - 0.1° × 0.1° resolution
    - & sub-grid variability
  - Assimilation analysis, open-loop (no assimilation), 96-hr forecast
  - European spatial domain



LAI and soil moisture (-0.3 m) analysis for the first 10 days of 2019

- Leaf area index
  - Daily mean values
- Soil Moisture
  - Hourly values



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How do SEEDS products advance beyond the state-of-the-art?

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- Land surface data assimilation of PROBA-V LAI
- SEEDS uses the state-of-the-art land surface model SURFEX
  - A 14-layer diffusion-based soil scheme
  - An advanced dynamic vegetation model
  - High spatial resolution of $0.1° \times 0.1°$
- SURFEX uses a state-of-the-art land classification map at 1 km × 1 km resolution

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Data delivered so far

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Experiment	Atmospheric inputs	Covered period	Assimilated observations
Open Loop	ECMWF IFS HRES Hourly forecasts (from +1h to +12h) initialized at 00:00 UTC and 12:00 UTC Interpolated on 0.10° x 0.10° grid	2018 – July 2022	None
Run Assimilation LAI		2018 – 2019	LAI GEOV1 from Copernicus Global Land Service
		2020	LAI THEIA with seasonal linear rescaling (1999 – 2019) applied to match LAI GEOV1

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Potential Uses and Users

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- Agricultural management
- Atmospheric chemistry
- Clay shrinking / Land slide risk monitoring
- Forestry management (drought effects, fire risk, …)
- Pastoral farming (forage production)
- Water resource management
- …

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Link to COCO2 and CORSO

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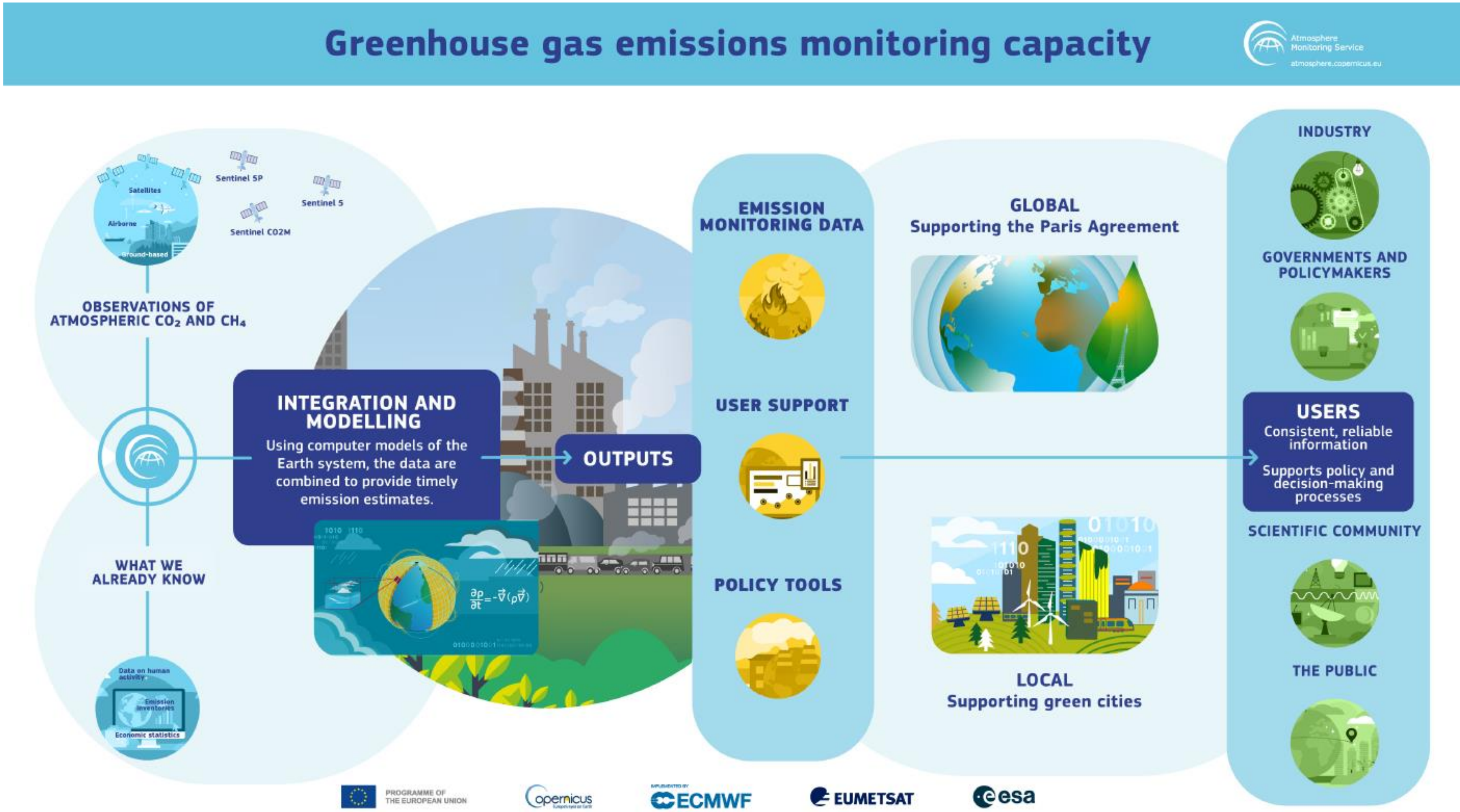

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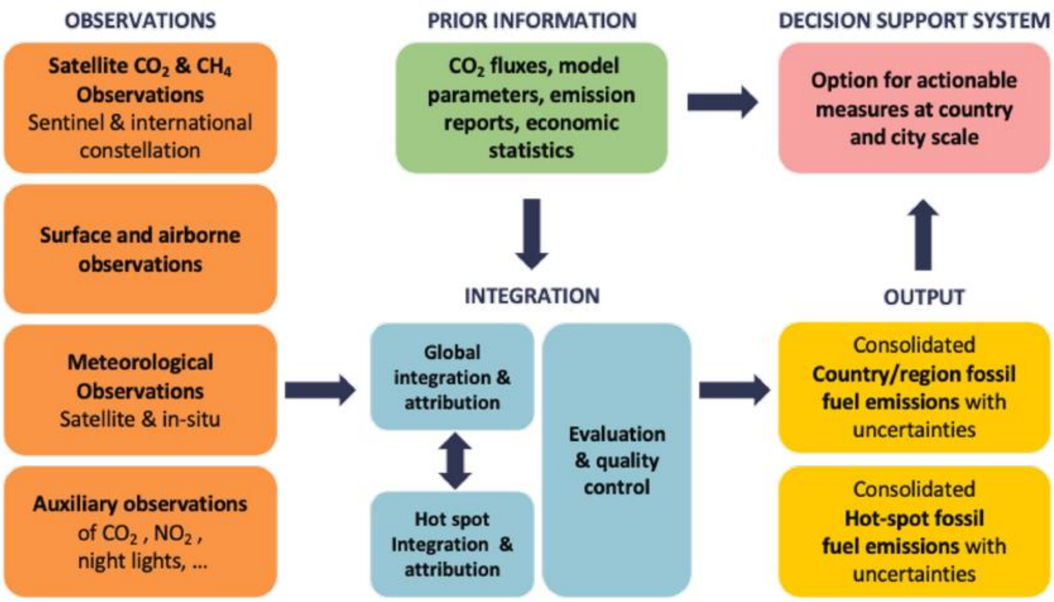
High-level blueprint



Atmosphere Monitoring Service

atmosphere.copernicus.eu

An integrated system approach based on experience in NWP and air quality monitoring & forecasting.

Same system (in potentially different configurations) for greenhouse gases and atmospheric pollutants.

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CORSO project aims

1. Deliver improved estimates of emission factors/ratios and their uncertainties.

2. Deliver the capabilities at global and local scale to optimally use observations of co-emitted species to better estimate anthropogenic CO_2 emissions.

3. Provide clear recommendations to CAMS, ICOS, and WMO about the potential added-value of high-temporal resolution $^{14}CO_2$ and APO observations as tracers for anthropogenic emissions in both global and regional scale inversions.

4. Develop coupled land-atmosphere data assimilation in the global CO2MVS system constraining carbon cycle variables with satellite observations of soil moisture, LAI, SIF, and Biomass.

5. Provide specific recommendations for the topics above for the operational implementation of the CO2MVS within the Copernicus programme.

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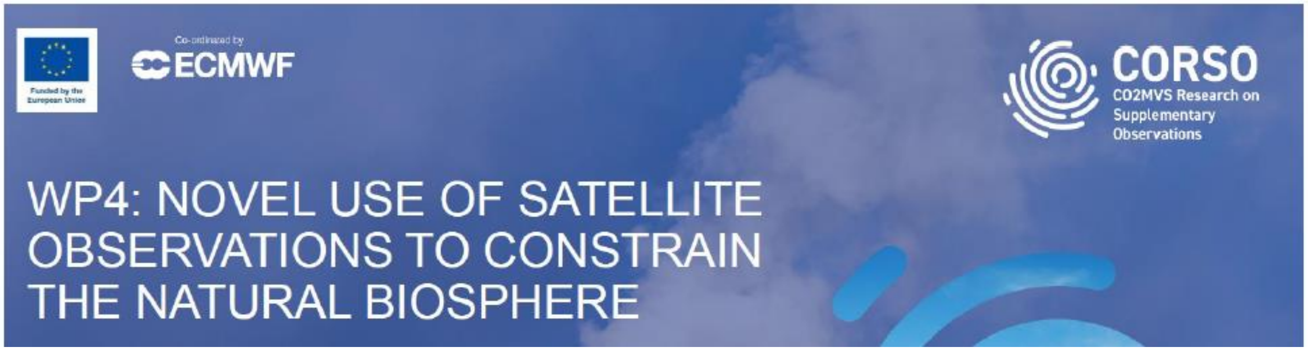
CORSO H-Europe project (2023-2025)



Enhance the exploitation of satellite observations in coupled land-atmosphere assimilation to constrain vegetation water and carbon cycle variables:

- Extend the assimilation of observations that we already use for NWP but not yet for CO2MVS, such as SMOS and ASCAT, to analyse vegetation variables,
- Develop assimilation of existing observations that are not yet used such as SIF observations,
- Pave the way for future observations assimilation such as Metop-SG/SCA, Copernicus Expansion CO2 and CIMR missions, which are all relevant to consistently constrain vegetation and carbon fluxes in CO2MVS

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Task 4.3: Use SIF level-1 observation assimilation to analyse water and carbon cycle variables in ECLand (**ECMWF**, CEA, MF, ULUND)

When: Month-1 to Month-36

Deliverables: D4.3 and D4.4 (public reports)

What:

- Use the NN-based SIF observation operators from Task 4.1 in offline experiments in LDAS-Monde and ECLand to assess the impact of coupled soil-vegetation assimilation.
  - Assess filtering and length of the data assimilation window configurations.
- Implement and test the best performing operators from these offline tests in the IFS, the prototype system for the future global CO2MVS,
- Assess the impact of SIF L1 data assimilation in the coupled data assimilation system.

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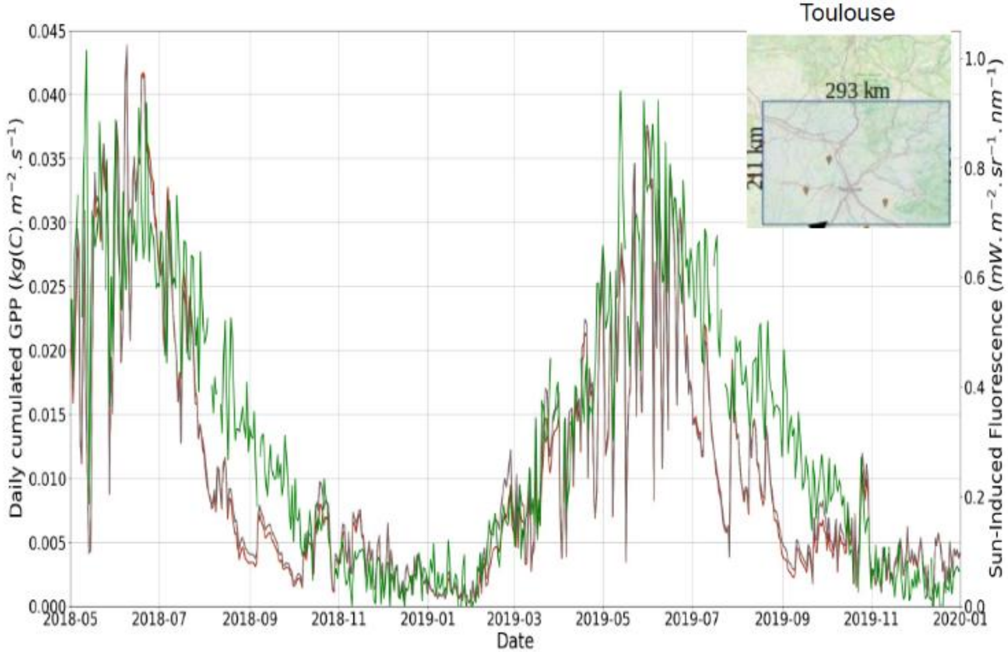
- USE OF TROPOMI SIF DATA
  - From verification purposes to data assimilation

SIF is not GPP

- Linear relationship may disappear in very dry condition
- Disentangle instrumental noise from geophysical signal

Assimilating SIF in ISBA?

- Comparison between daily TROPOSIF and daily GPP from ISBA
- Use machine learning to build an observation operator



SIF (in the 743-758 nm window) daily data available from 01/05/2018 to 31/12/2019, with 91% daily data for this period

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Thank you for your attention ☺

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jean-christophe.calvet@meteo.fr

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