EGU General Assembly 2022

May 24th 2022

Monitoring vegetation traits over Europe using top-of-atmosphere Sentinel-3 data in Google Earth Engine

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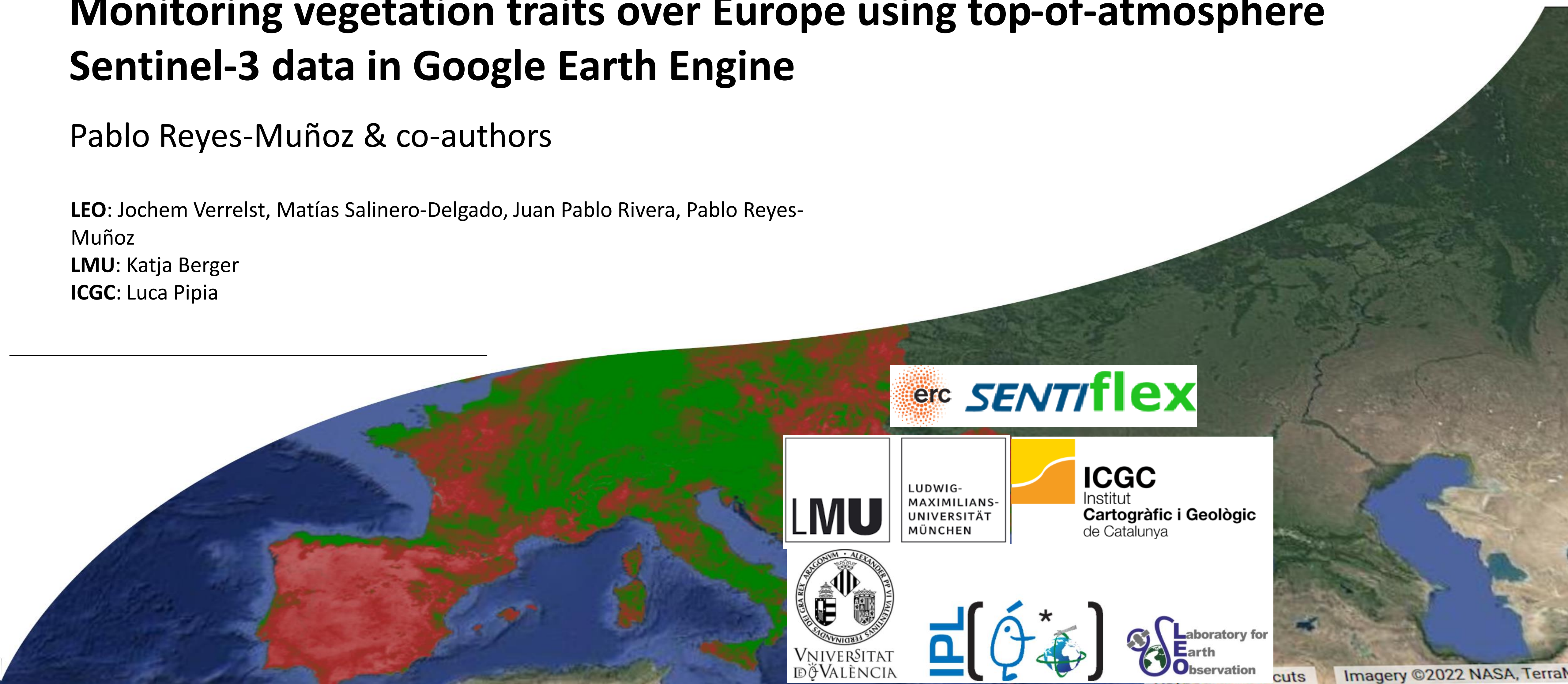
LMU: Katja Berger
ICGC: Luca Pipia



erc SENTIflex

LMU LUDWIG-MAXIMILIANS-UNIVERSITÄT MÜNCHEN

ICGC Institut Cartogràfic i Geològic de Catalunya

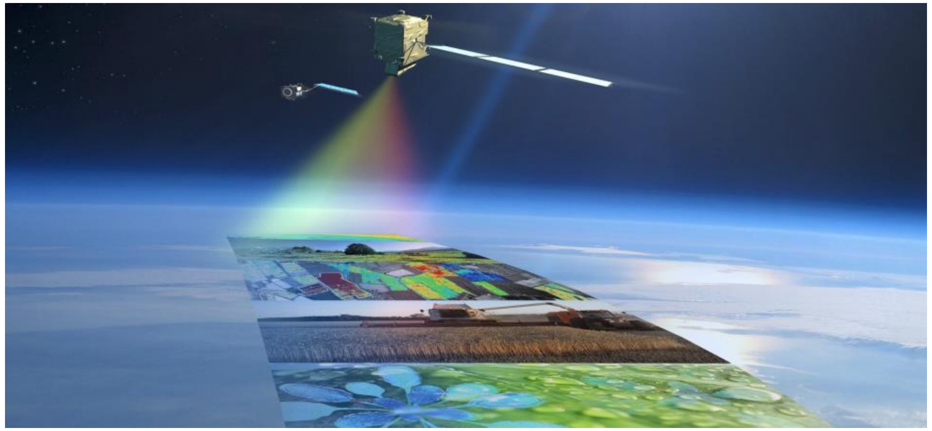
VNIVERSITAT DE VALÈNCIA

IPL

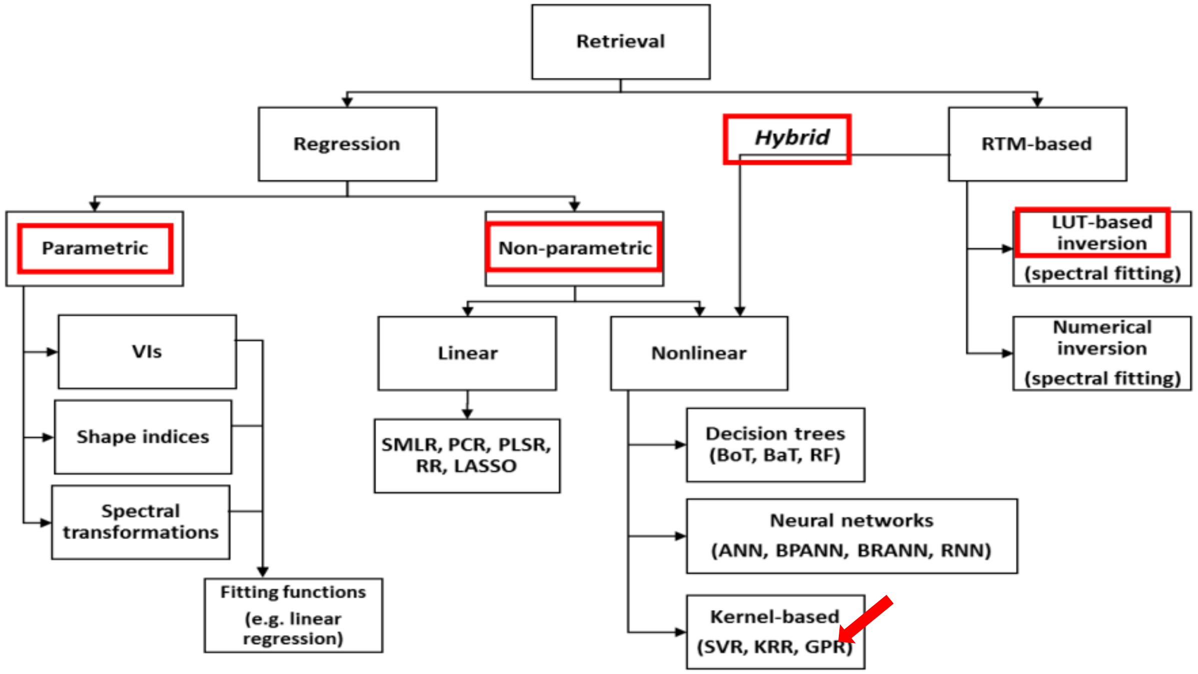
Laboratory for Earth Observation

Mapping of vegetation traits from Sentinel 3-OLCI in the context of the FLEX mission

- Large scale mapping of LAI (Leaf Area Index), FAPAR (Fraction of Absorbed Photosynthetically Active Radiation), FVC (Fractional Vegetation Cover) and Chlorophyll at moderate spatial resolution (300 m)
- Retrievals from TOA S3-OLCI radiance images provided by a cloud computing environment (Google Earth Engine)
- Complementing information acquired by the upcoming FLEX mission monitor photosynthesis activity



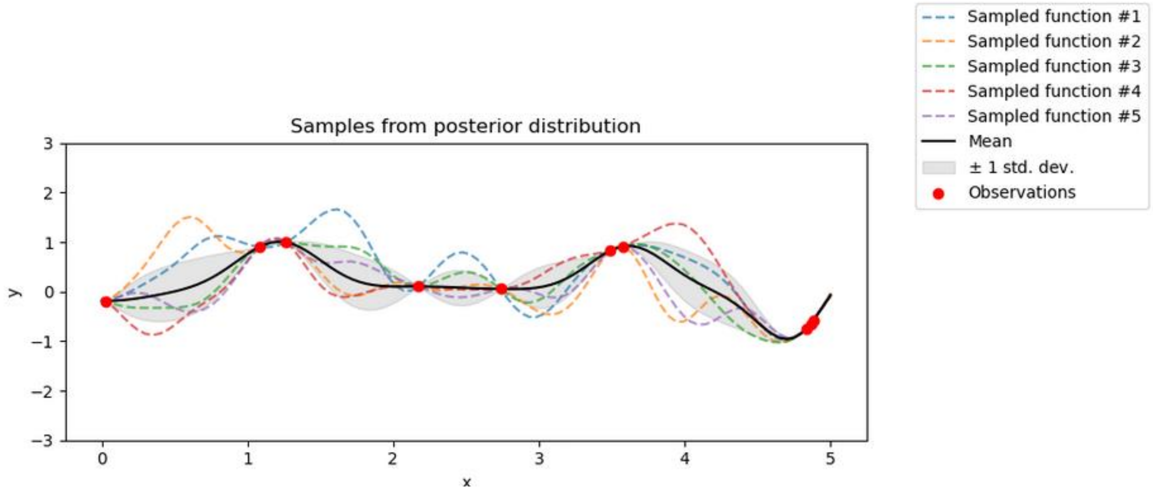
Taxonomy of retrieval methods



towards operational processing

Verrelst, J et al. (2019). Quantifying vegetation biophysical variables from imaging spectroscopy data: a review on retrieval methods. *Surveys in Geophysics*, *40*(3), 589-629.

Gaussian Process Regression:
A probabilistic ML algorithm



$$f(x) \sim GP(m(x), k(x, x'))$$

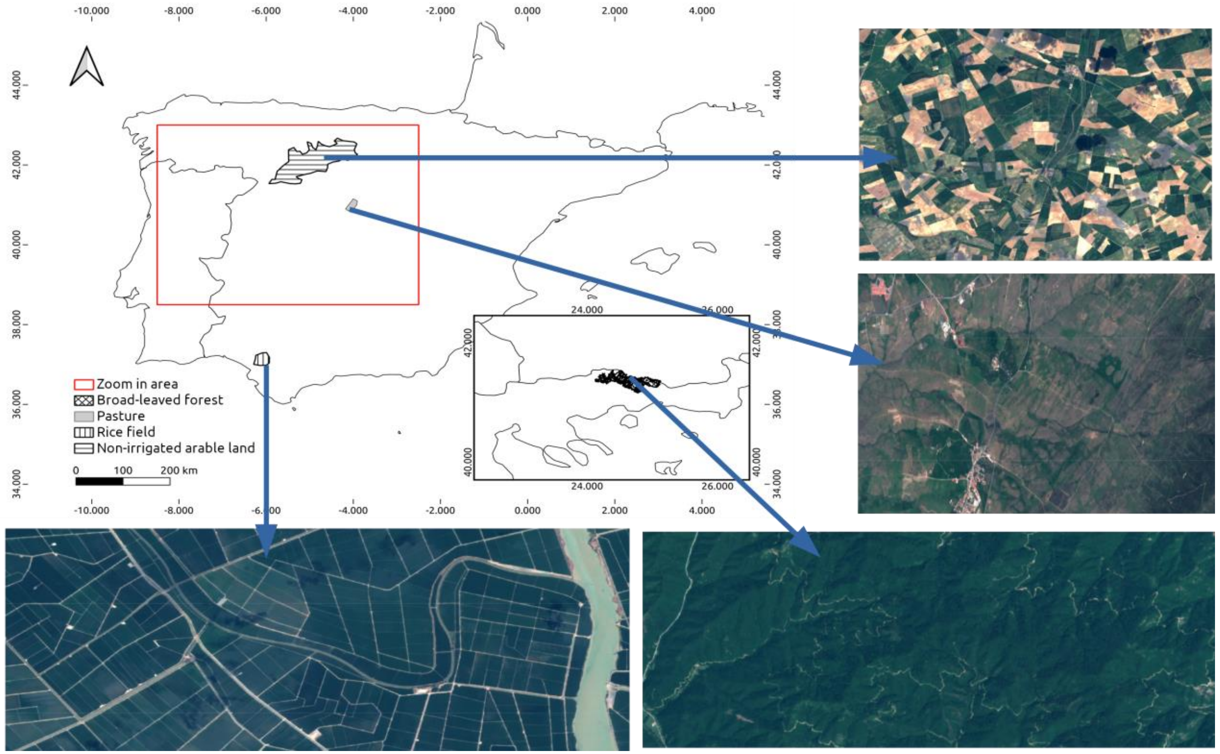
Training and running the models

- Simulations through SCOPE RTM coupled with 6SV

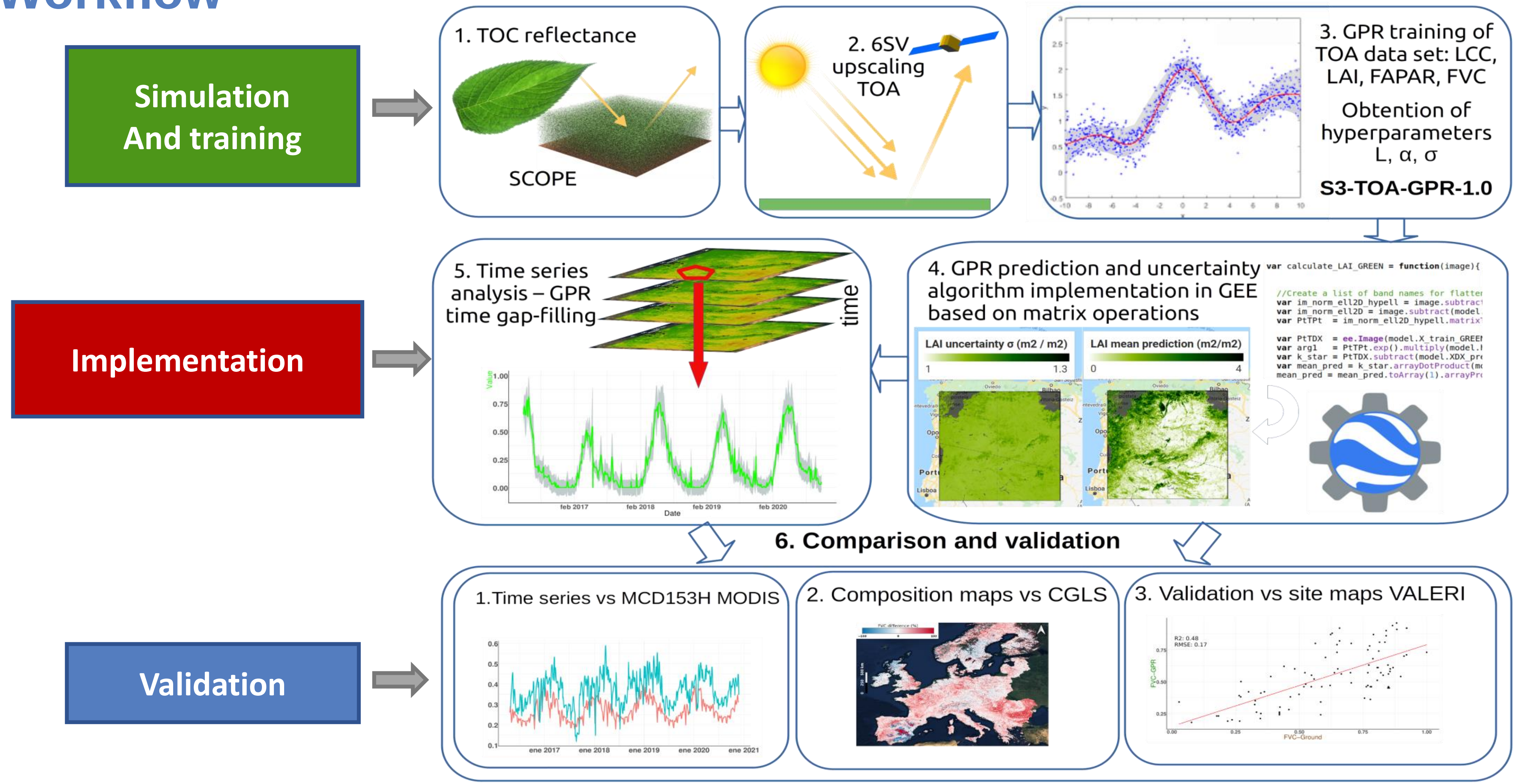
Variable	Distribution	Min	Max	Mean	SD
Leaf structure & biochemistry					
N (Leaf structure parameter [-])	Gaussian	1	2.7	1.5	0.5
LCC (Chlorophyl a,b content, μg/cm^2)	Uniform	0	95.6	-	-
Cxc (Carotenoid content, μg/cm^2)	Gaussian	0	20	10	10
Cdm (Dry matter content, g/cm^2)	Gaussian	0.002	0.02	0.005	0.003
Cw (Leaf water content, cm)	Gaussian	0.005	0.035	0.012	0.006
Canopy structure					
LAI (Leaf Area Index, m^2/m^2)	Uniform	0	7.0	-	-
LIDF (Leaf Inclination, rad)	Uniform	−1	1.0	-	-
Soil					
SMC (Soil Moisture Content, %)	Gaussian	5	55	25	12.5
BSM Brightness	Gaussian	0	0.9	0.5	0.25
BSM Lat (°)	Gaussian	20	40	25	12.5
BSM Long (°)	Gaussian	45	65	50	10
Geometry					
SZA (Sun Zenith Angle, °)	Uniform	20	40	-	-
OZA (Observation Zenith Angle, °)	Uniform	−10	10	-	-
RAA (Relative Azimuth Angle, °)	Constant	180	180	-	-

Model Variables	Units	Range
Atmospheric variables: 6SV		
O_3 Column concentration	[amt-cm]	0.25–0.35
Columnar Water Vapor	[g·cm^{-2}]	0.4–4.5
Aerosol Optical Thickness	unitless	0.05–0.5
Angstrom coefficient	unitless	0.05–2
Henyey-Greenstein asymmetry factor	unitless	0.6–1

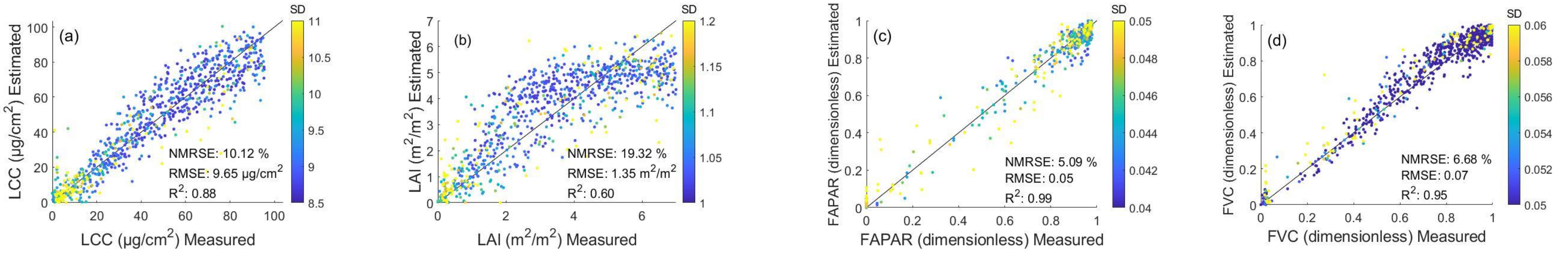
- S3-TOA-GPR models for time-composed large scale mapping and time series over homogeneous land cover types

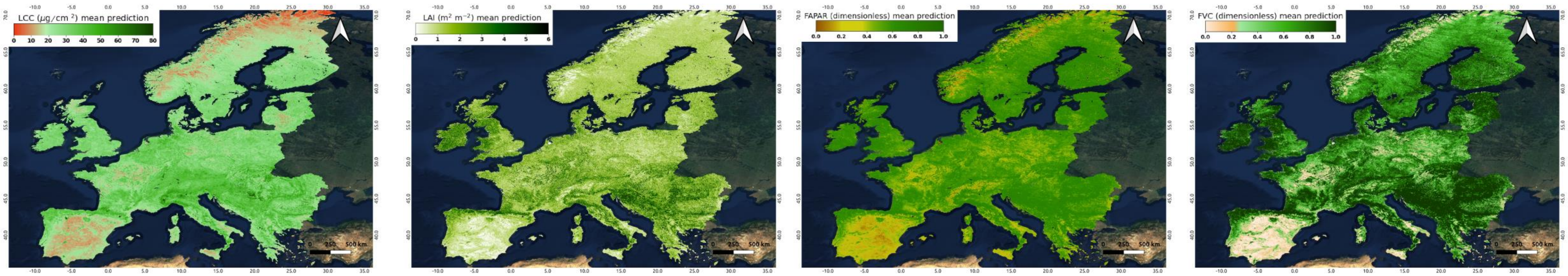


Workflow


Simulation
And training
1. TOC reflectance
SCOPE
2. 6SV
upscaling
TOA
3. GPR training of
TOA data set: LCC,
LAI, FAPAR, FVC
Obtention of
hyperparameters
L, α, σ
S3-TOA-GPR-1.0
Implementation
5. Time series
analysis – GPR
time gap-filling
time
Value
Date
feb 2017
feb 2018
feb 2019
feb 2020
4. GPR prediction and uncertainty
algorithm implementation in GEE
based on matrix operations
LAI uncertainty σ (m2 / m2)
LAI mean prediction (m2/m2)
var calculate_LAI_GREEN = function(image){
6. Comparison and validation
Validation
1.Time series vs MCD153H MODIS
ene 2017
ene 2018
ene 2019
ene 2020
ene 2021
2. Composition maps vs CGLS
3. Validation vs site maps VALERI
R2: 0.48
RMSE: 0.17
FVC-GPR
FVC-Ground

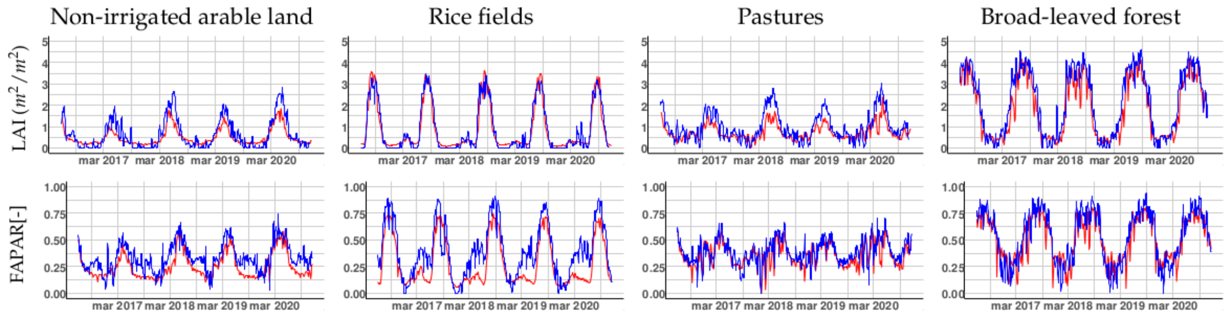
Theoretical performance and graphical results

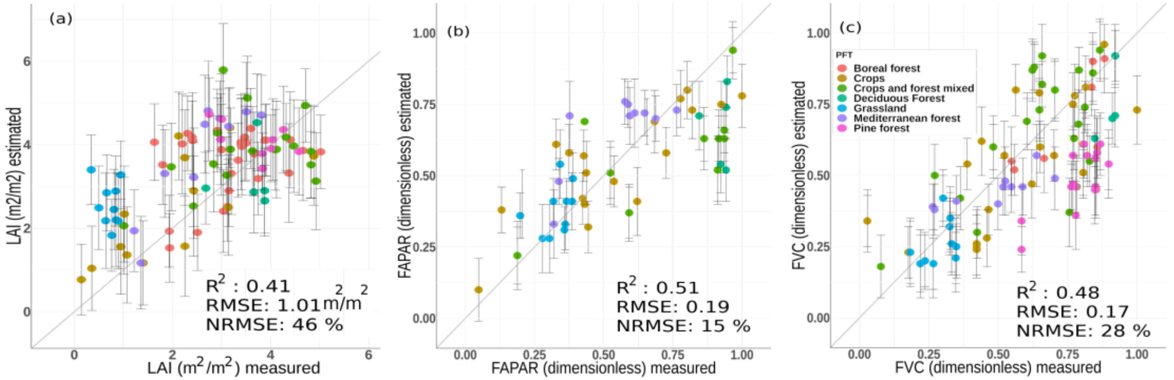


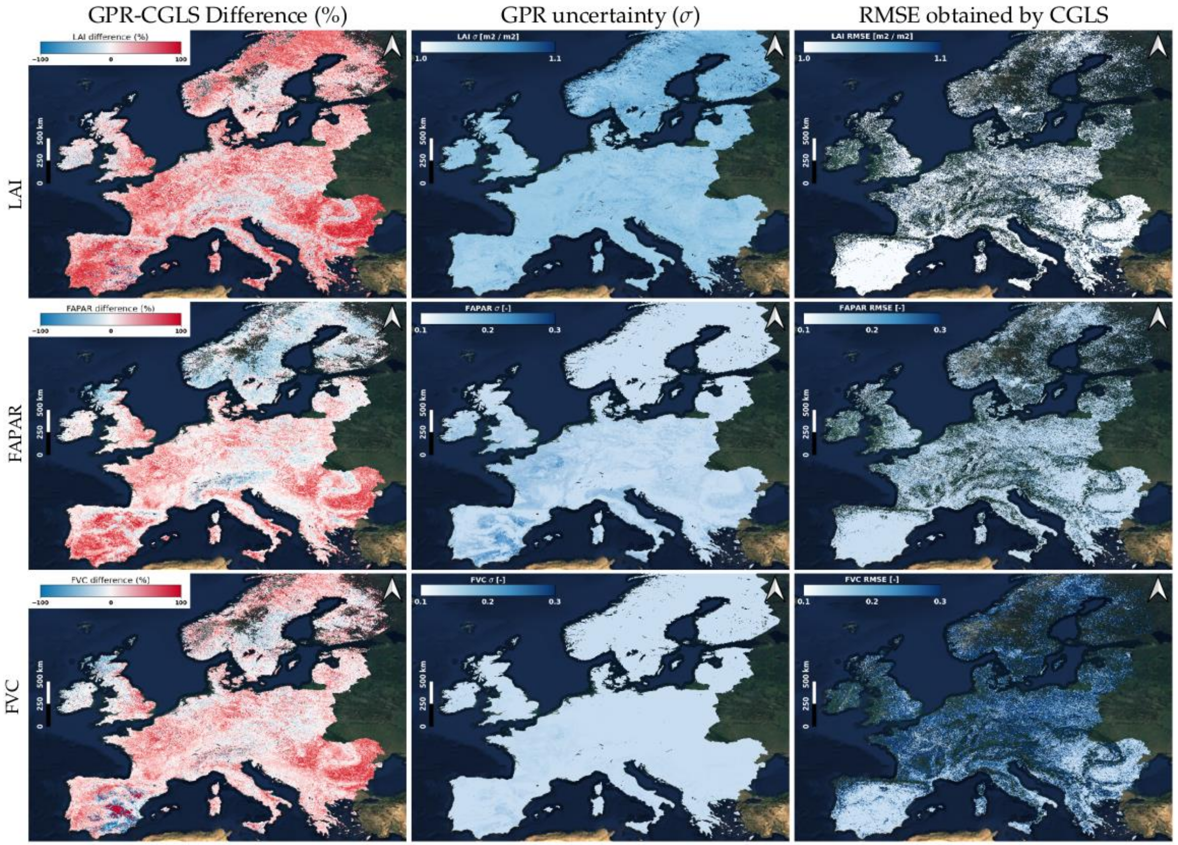


- Vegetation traits maps at european scale
- Good theoretical performance in all cases
- Spatial distribution meets expected ranges

Validation against reference products: MCD15A3H, COPERNICUS-Vegetation and VALERI network



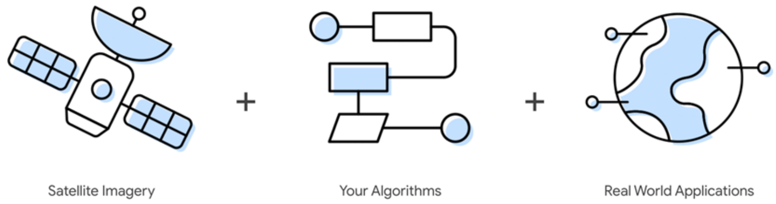


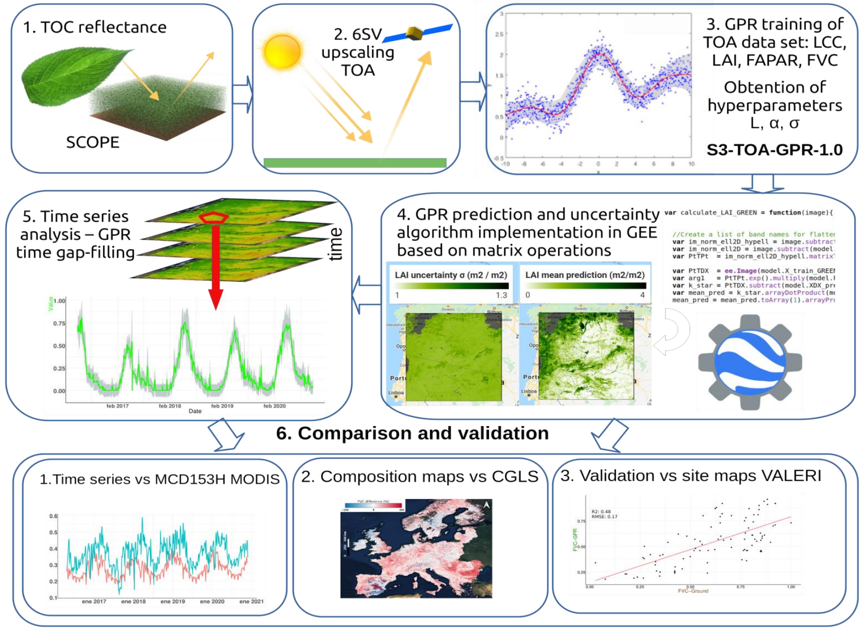


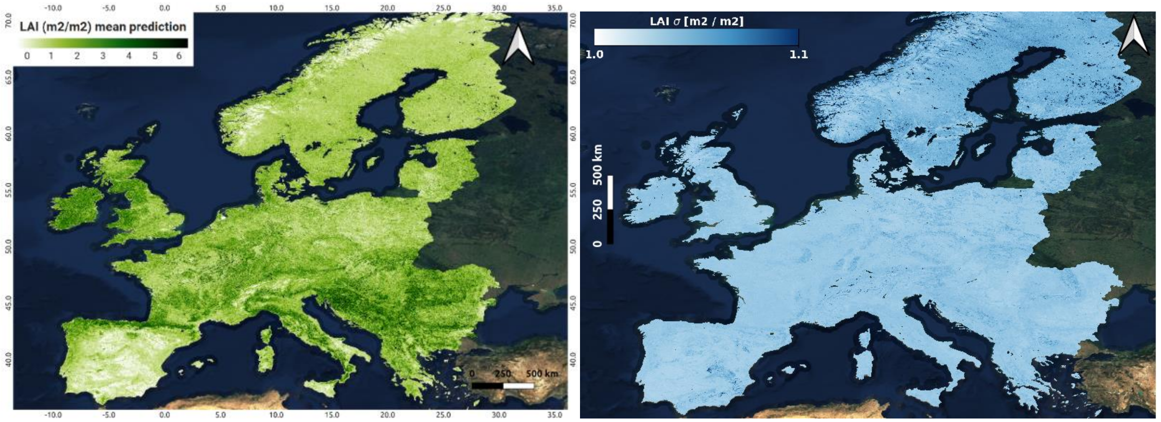
- Similar temporal patterns as MCD153H – MODIS
- Good fitting with Vegetation products offered by Copernicus

Conclusions

- Workflow for mapping vegetation traits at **continental scale**.
- **Uncertainties** as an indicator of quality of the models when predicting from real data.
- Spatiotemporal analysis showed good correlation with reference products (MCD153H MODIS, Copernicus-Vegetation L3 and VALERI)
- Potential uses: ecological studies, carbon cycle, support for FLEX mission







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Thank you!

Questions ?

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Acknwoledgment

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