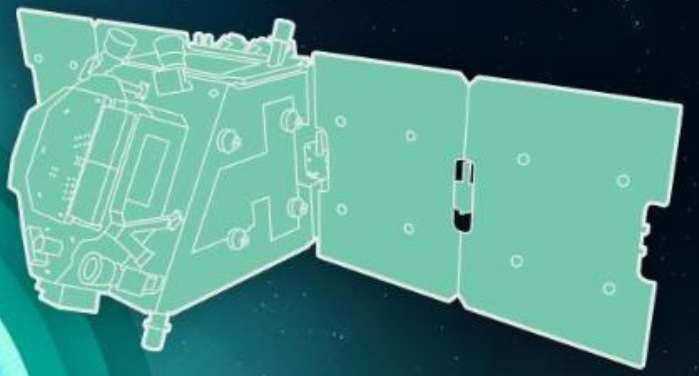

FLEX Fluorescence Workshop 2023

19 – 21 September 2023
ESA – ESRIN | Frascati (Rome), Italy

Global cloud-free production of four essential vegetation traits in support of the FLEX-S3 tandem mission

Dávid D.Kovács[1] , Pablo Reyes Muñoz[1], Matías Salinero Delgado[1,] Mészáros Ixion Viktor[1], Katja Berger[1,2] and Jochem Verrelst[1]

1 Image Processing Laboratory (IPL), University of Valencia, Spain
2 Mantle Labs GmbH, Vienna, Austria

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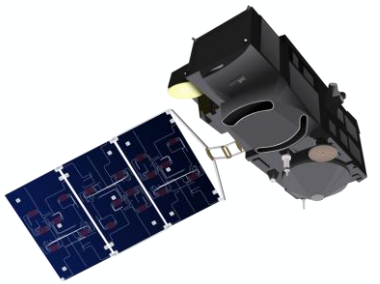
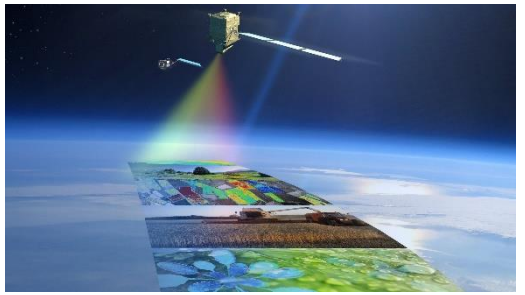
Main objectives: global S3-OLCI EVTs retrieval

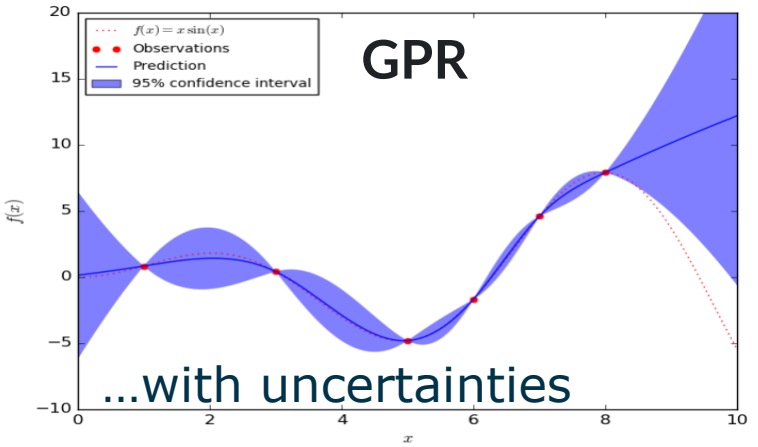
To generate **temporally reconstructed global Essential Vegetation Trait (EVT) products** of:

- **leaf area index (LAI)**
- **leaf chlorophyll content (LCC)**
- **fraction of absorbed photosynthetically active radiation (FAPAR)**
- **fractional vegetation cover (FVC)**





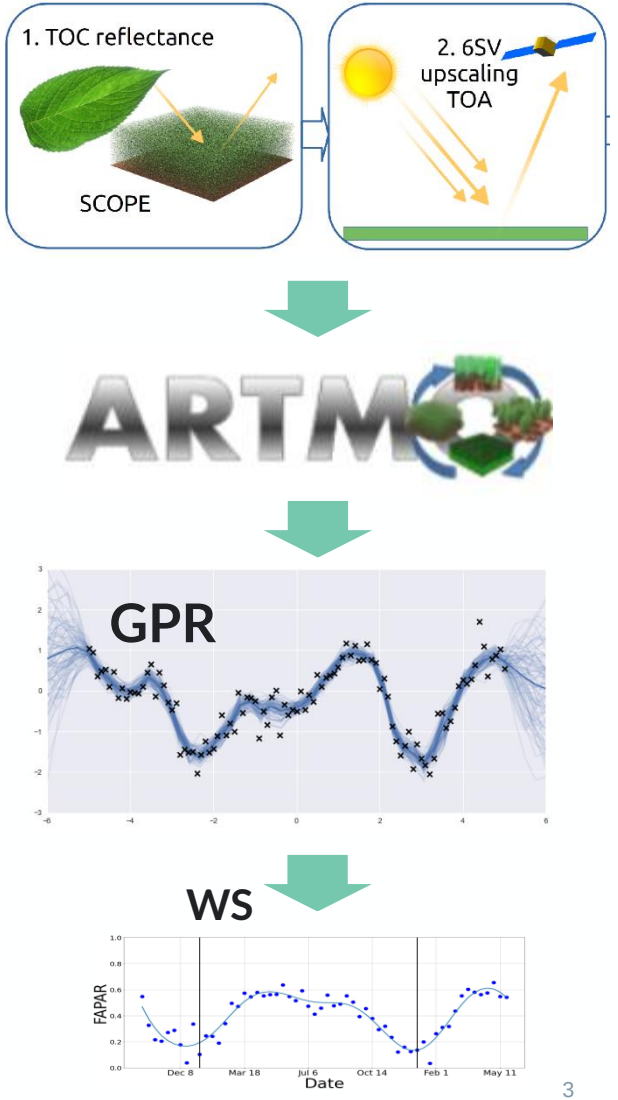
To use **S3 OLCI Top Of Atmosphere (TOA)** data and hybrid models trained with: **Gaussian Process Regression (GPR)**



To implement models into Google Earth Engine (GEE)
Temporally reconstruct with **Whittaker's smoother** (WS) to achieve cloud-free (gap-filled) data
Cross-correlate against **Copernicus (CGLS) & MODIS** products

Workflow

1. Retrieval started with canopy simulations using **SCOPE**[1]
2. SCOPE **Top Of Canopy** (TOC) reflectance were upscaled to →**TOA** radiance simulations using **6SV** RTM[2]
3. Coupling process by: Atmospheric Lookup table Generator (**ALG**)[3] and Automated Radiative Transfer Models Operator (**ARTMO**)[4]
4. GPR models were trained using simulated TOA radiance data and mapped in Google Earth Engine (GEE)
5. Spatiotemporally continuous dataset were obtained by using Whittaker Smoother (**WS): S3-TOA-GPR-1.0-WS** models



[1]: Van Der Tol et al. (2009)
[2]: Vermote et al. (1997)
[3]: Vicent et al. (2020)
[4]: Verrelst et al. (2012): https://artmotoolbox.com/

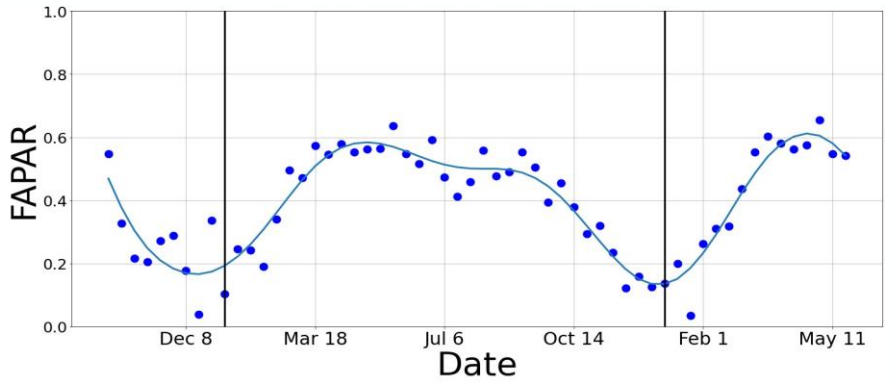
Processing S3-TOA-GPR-1.0-WS models

Whittaker's smoother (WS) for temporal reconstruction

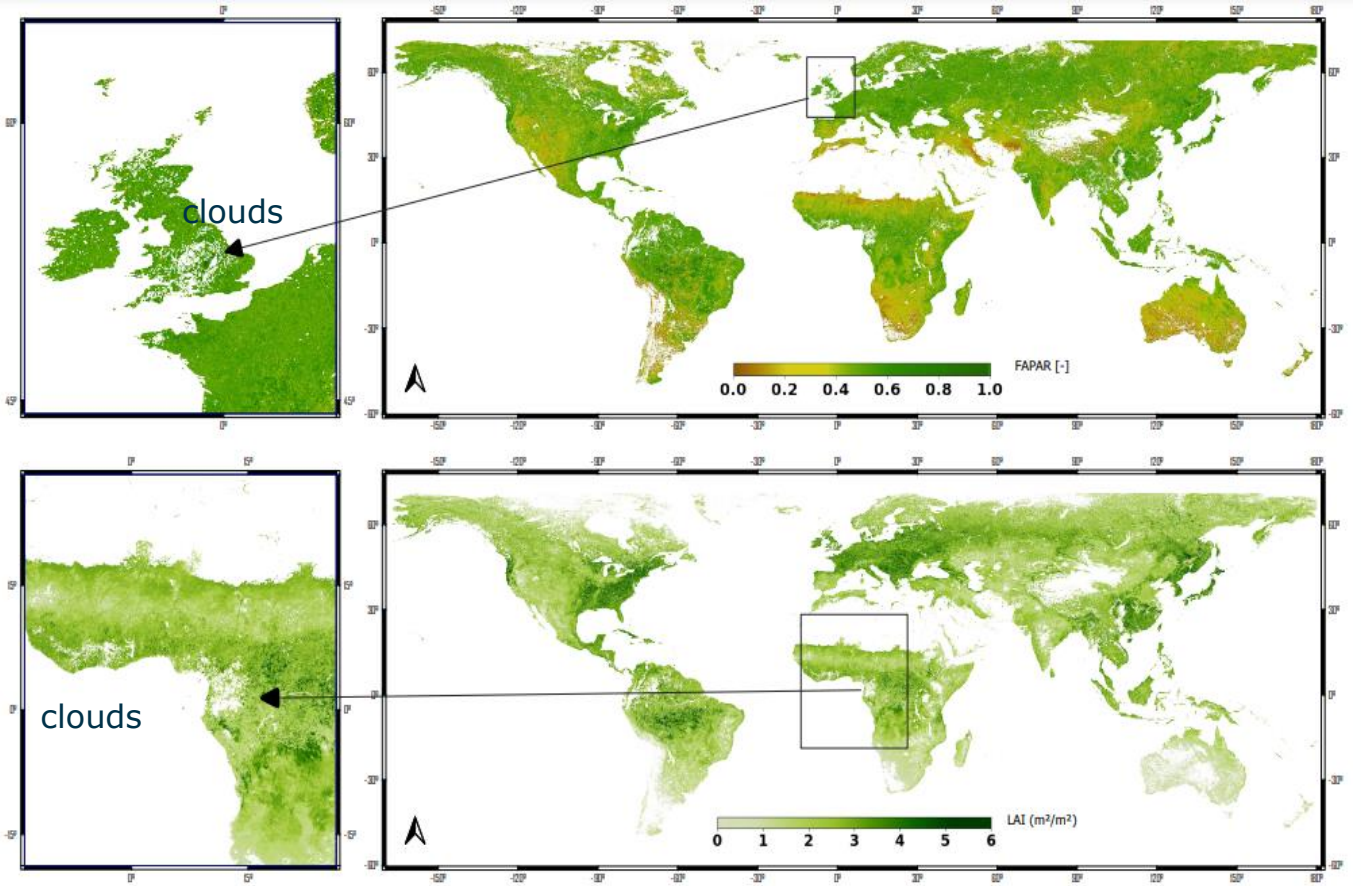
$$(\mathbf{I} + \lambda \mathbf{D}'\mathbf{D})\mathbf{z} = \mathbf{y}$$

Whittaker's governing linear system of equations. Penalty weight: **λ=100**

- Quickly adjustable Penalty weight (λ)
- Tested between 1-100.
- Gaps around low latitudes and polar regions
- Algorithm directly implemented into **GEE**
- λ can be adjusted quickly

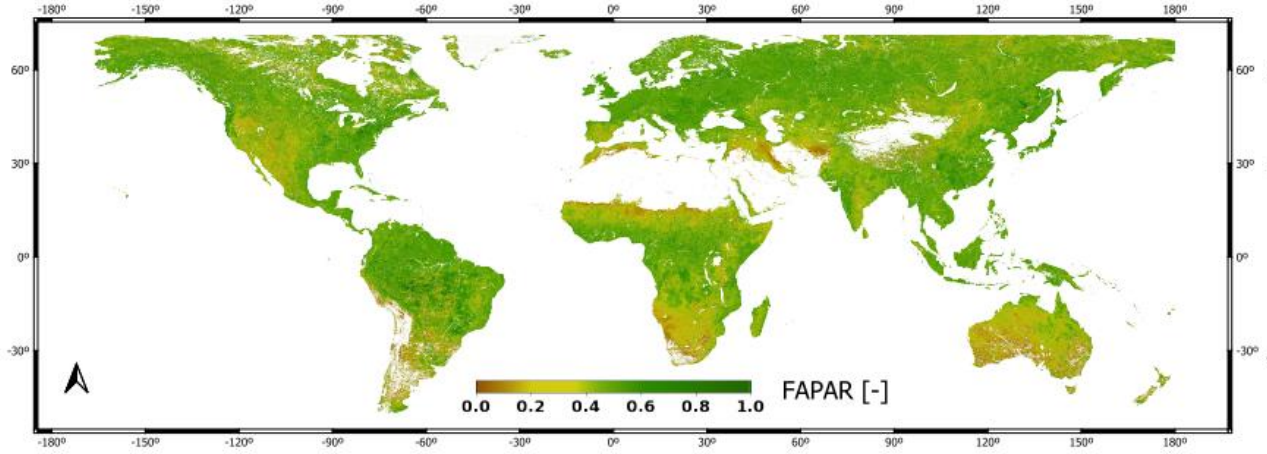


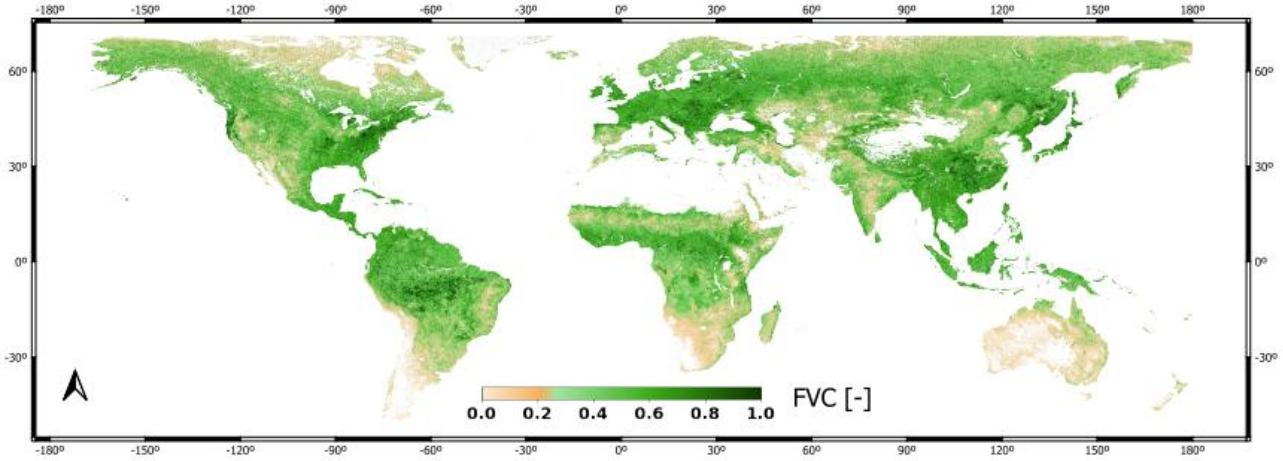
FAPAR interpolated with Whittaker`s algorithm.
6-6 month extended year of 2019

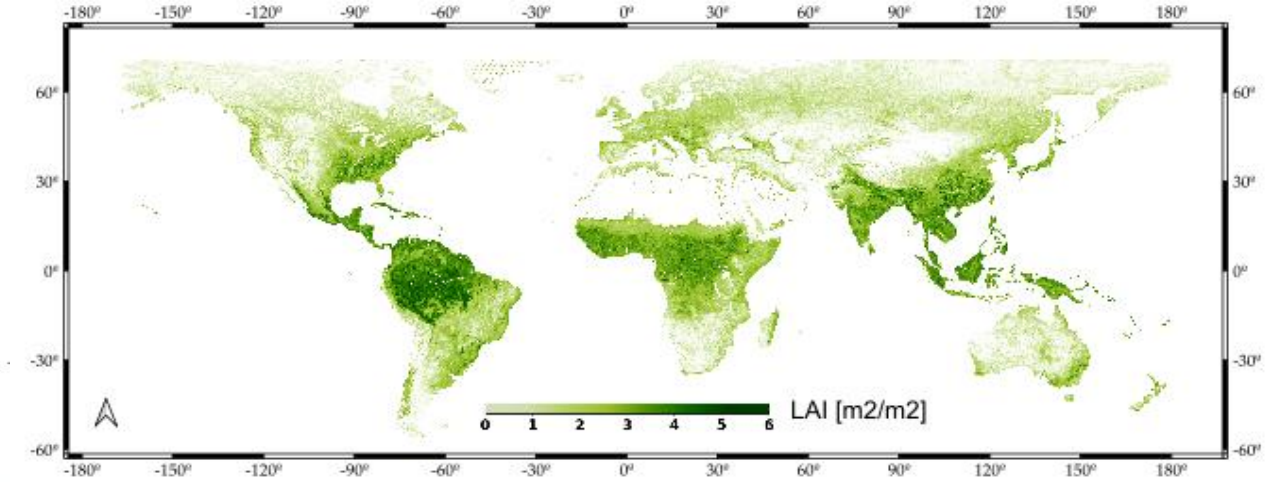


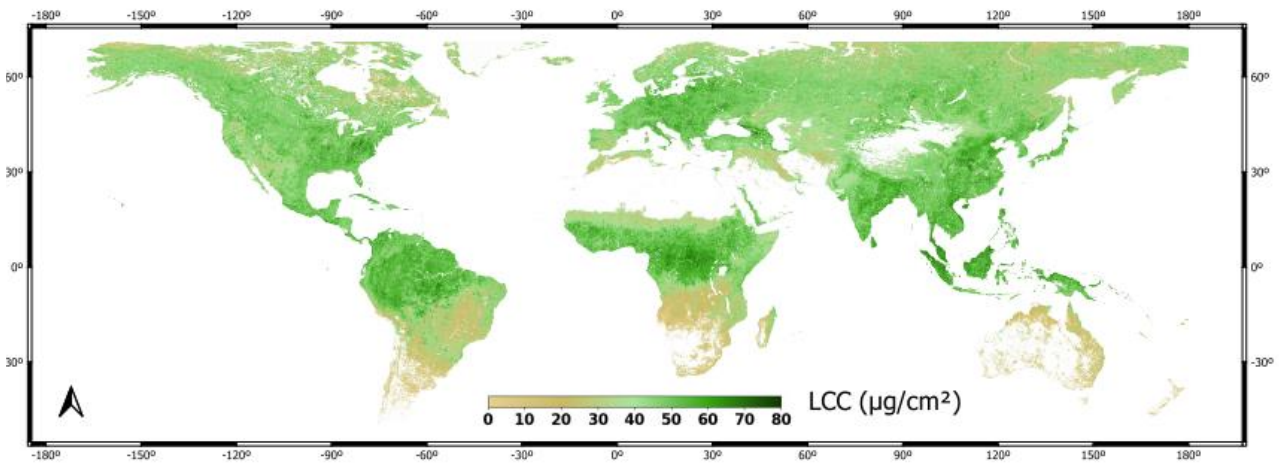
Cloud-Free Global maps

Temporally reconstructed cloud-free maps. 10th July 2019 (5km resolution)



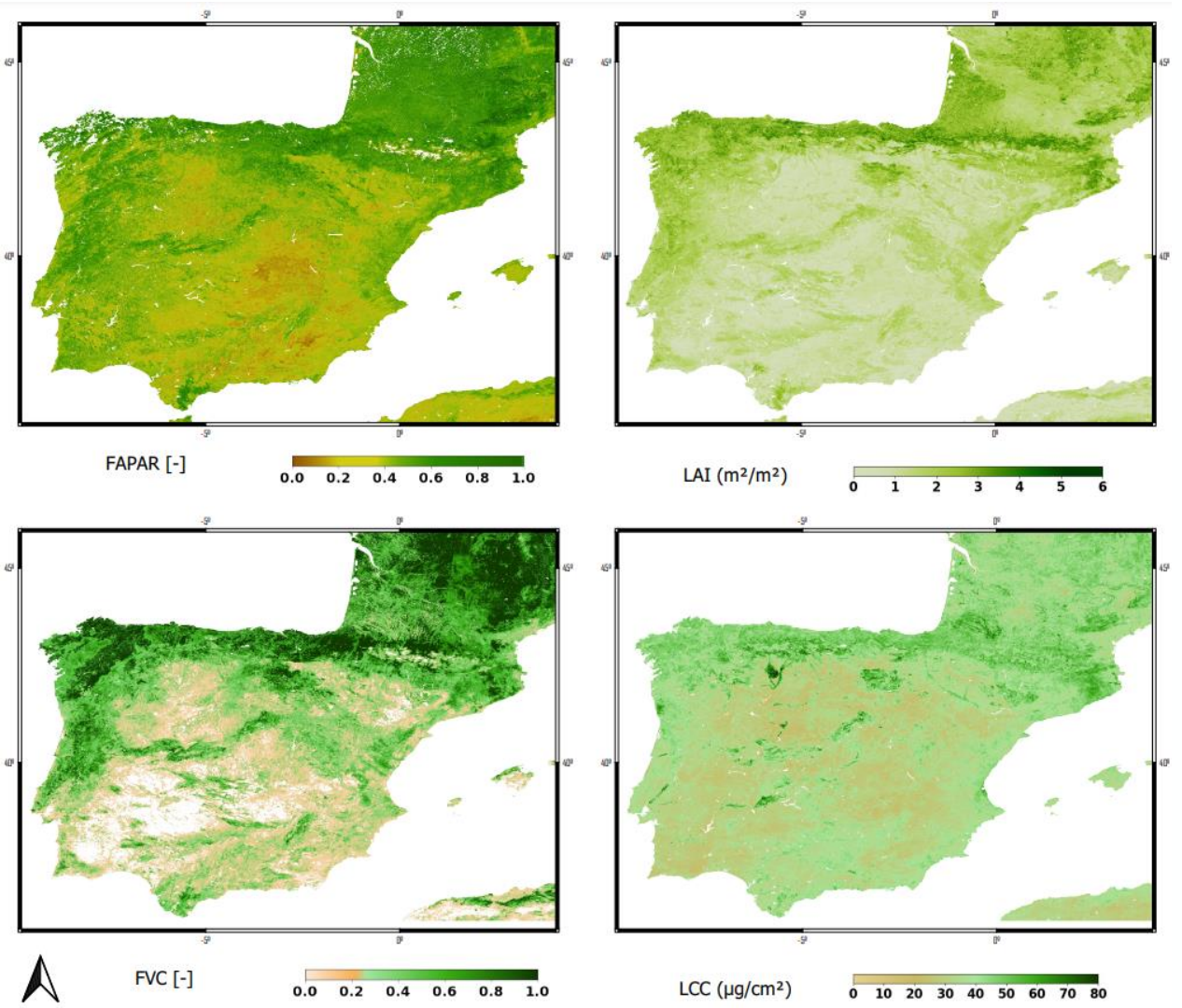






Regional maps at 300m resolution

- **300m** (nominal OLCI) resolution results higher memory usage and longer computation
- Can be used for regional analysis
- 5km optimal trade-off between time and memory, proven consistency on global scale
- Spatial & Temporal resolutions can be customized by customized for specific purposes
- Easy-to-use code, maps can be retrieved by everyone for specific purposes



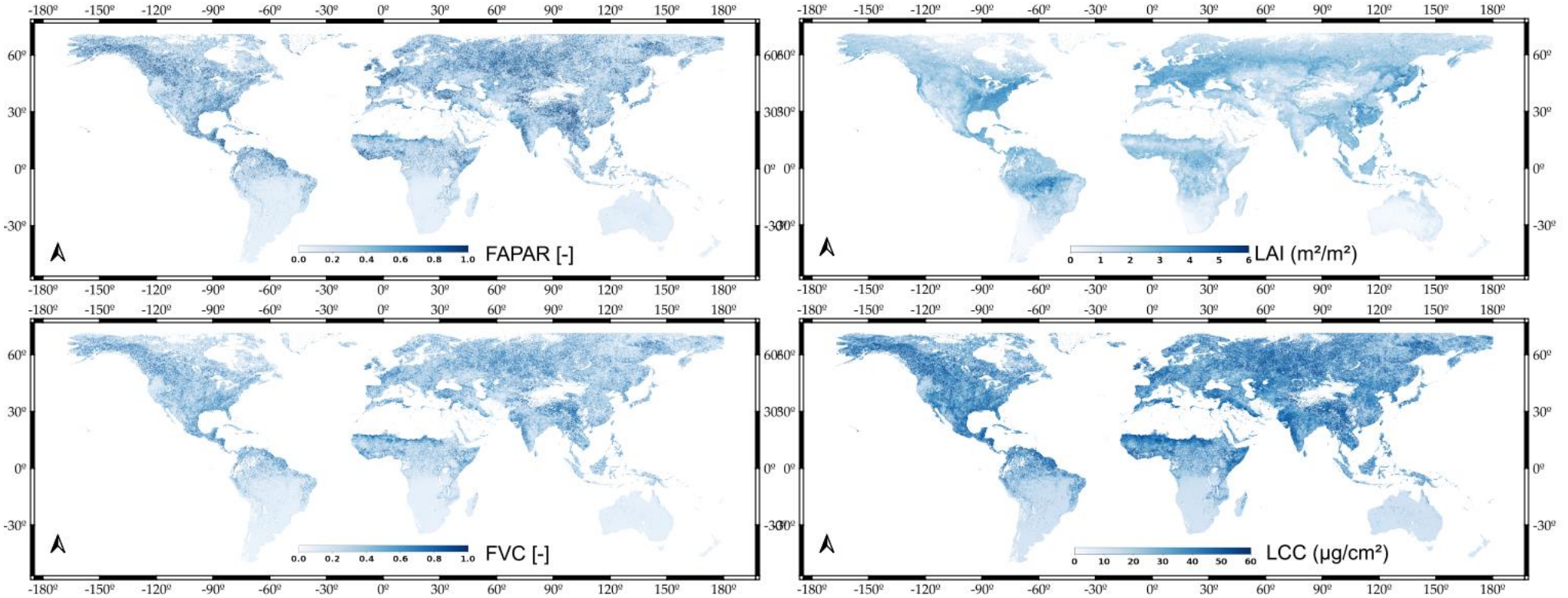
10th July 2019 (300 m resolution)

Uncertainty maps

The Bayesian GPR algorithm also provides associated uncertainties (σ)

Each σ relates to the absolute value of the estimate

Uncertainty maps 2019, monthly averaged (5km resolution)



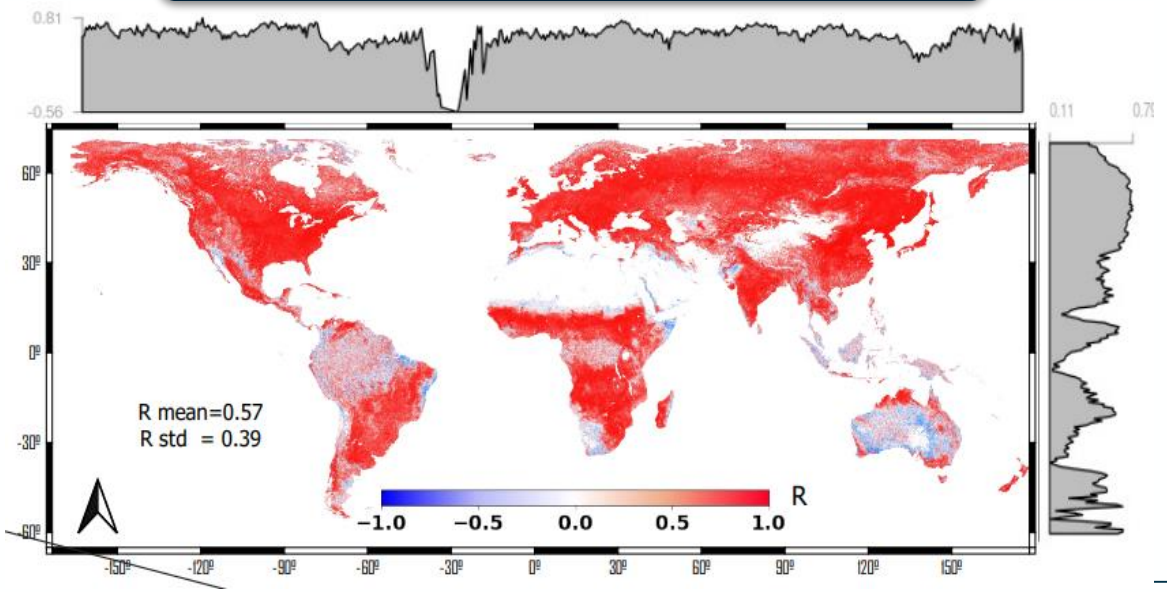
Intra-annual cross-comparison vs reference

Per-pixel intra-annual cross-comparison for 2019 of the 4 EVTs:

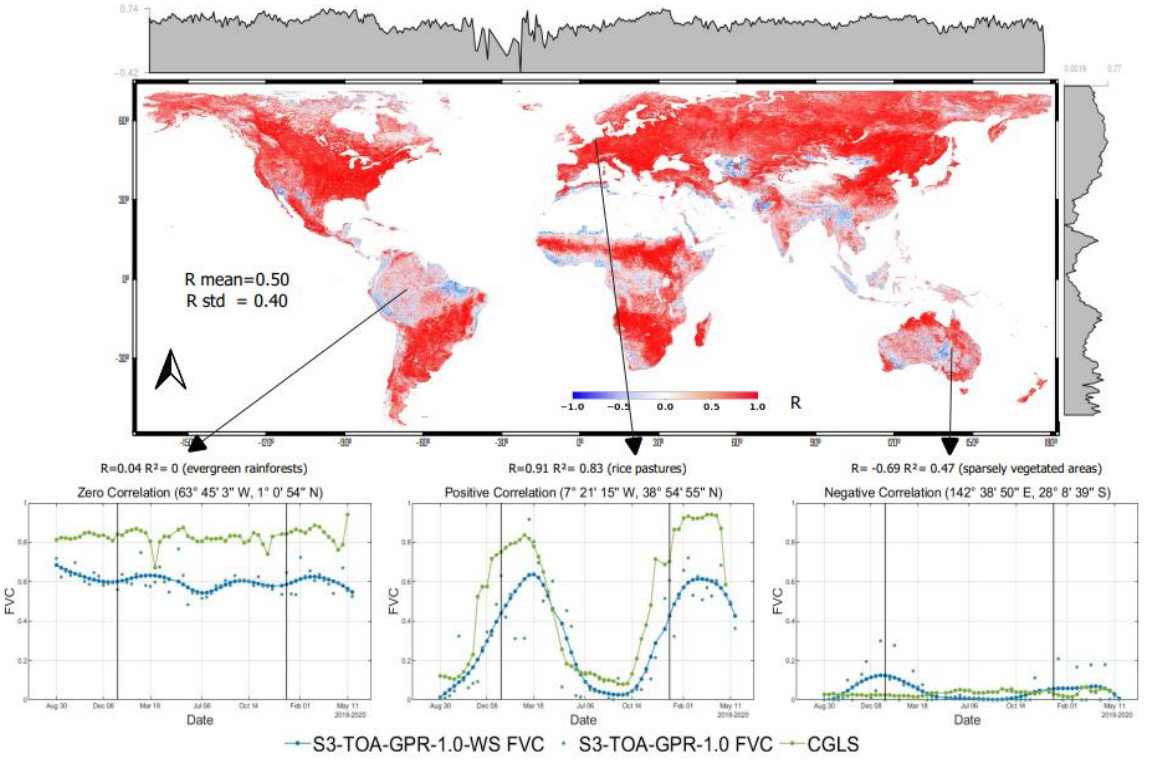
- Copernicus (CGLS) and MODIS reference products
- High consistency over 30-60° latitudes

- Lower consistency over latitudes lower than 20°
- Pronounced yearly phenology yielded **superior** GPR retrievals

LAI R correlation against CGLS



FVC R correlation against CGLS



Land cover specific analysis vs reference

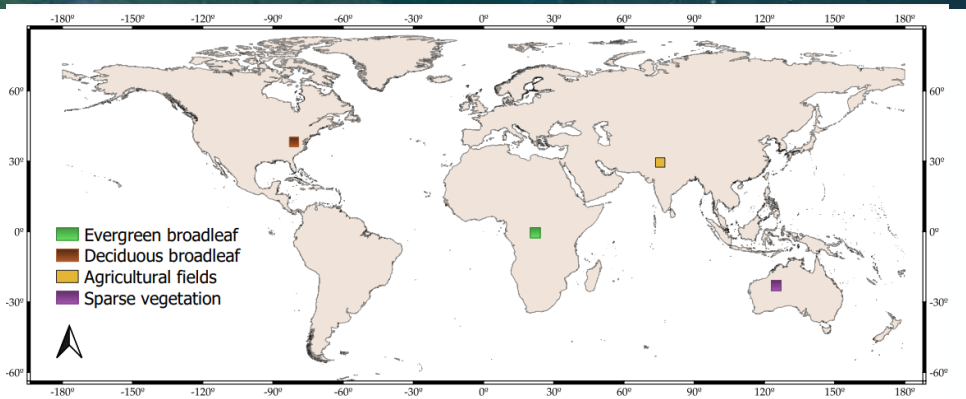
Variables cross-correlated over:

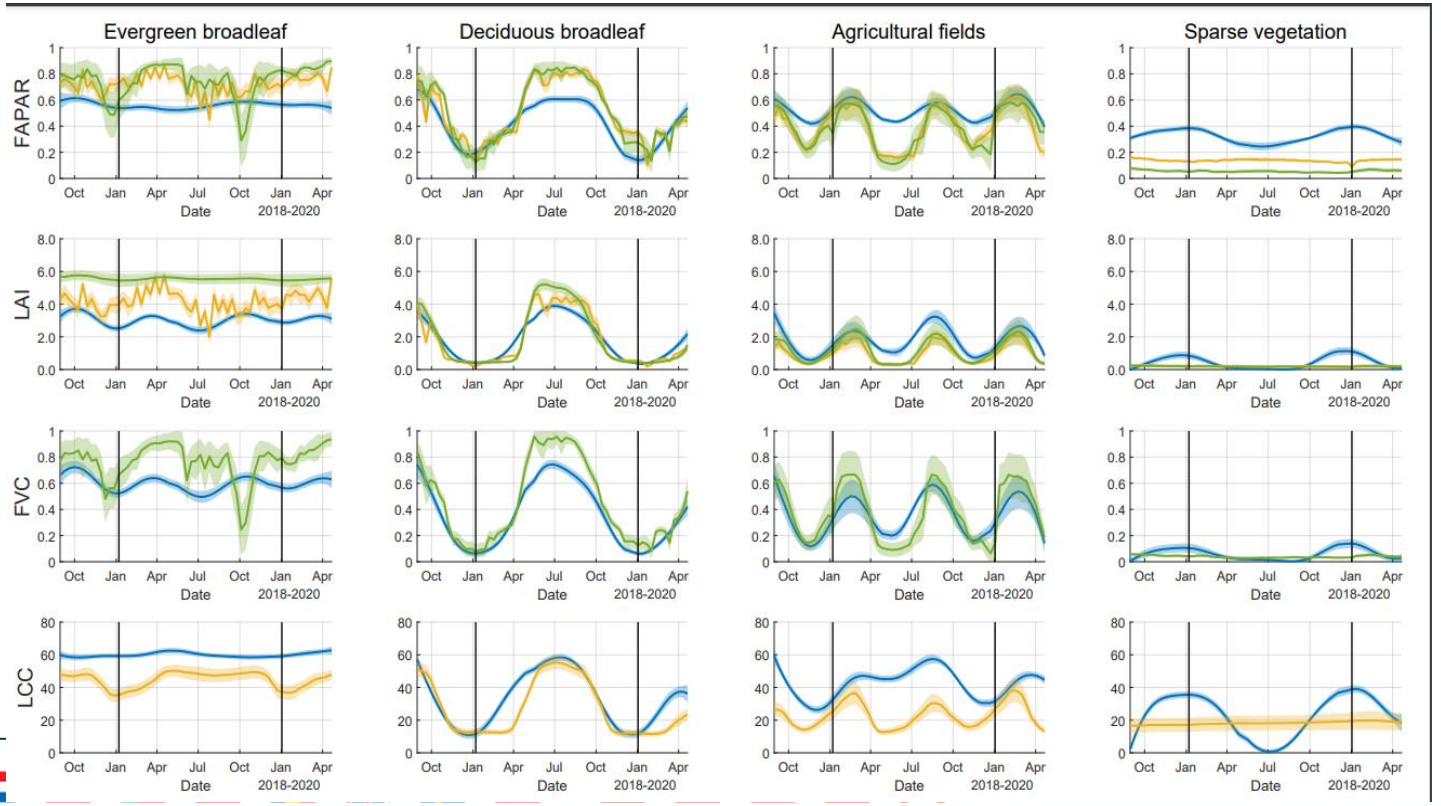
- Evergreen broadleaf (EB)
- Deciduous broadleaf (DB)
- Agricultural (rice and wheat) (AG)
- and Sparse land covers (SP)

Highest correlations, all over DB:

1. FVC **R=0.98** vs. CGLS
2. LAI **R=0.95** vs. CGLS
3. LAI **R=0.95** vs. MODIS

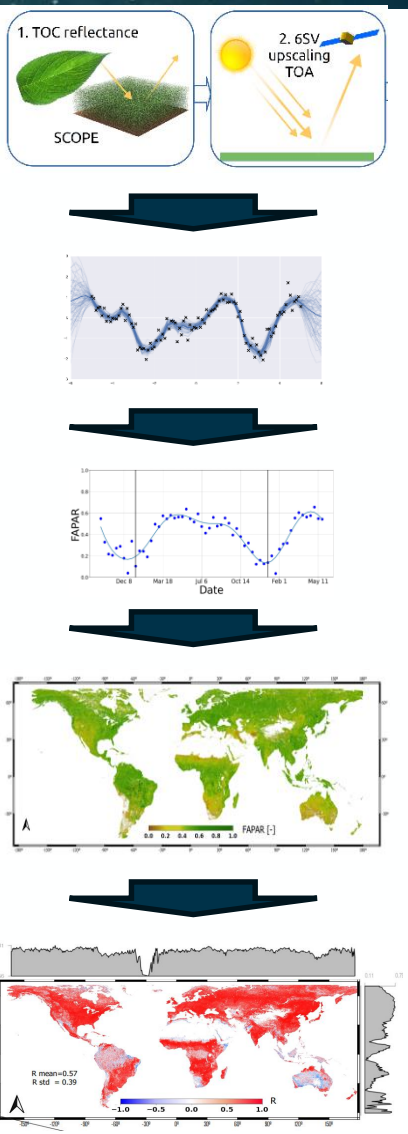
Sites for Land cover specific analysis





Conclusions

- **Cloud-based GPR models**: can be easily implemented in **GEE for global mapping**
- **GEE mapping spatially and temporally scalable**
- **General inra-annual consistency with corresponding MODIS and CGLS products**
- Intra-annual consistency strongly correlated to **vegetation seasonality**
- Validation against in-situ data is promising, and will be continued
- Easily shareable and applicable: https://github.com/SentiFLEXinel



GitHub repo:
daviddkovacs/Global-EVT-maps

VNIVERSITAT DE VALÈNCIA

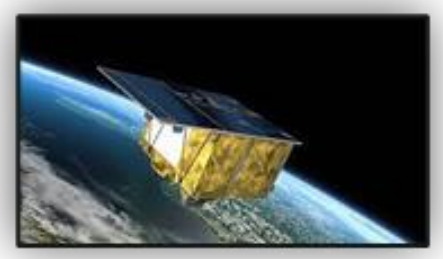
Questions? david.kovacs@uv.es

IPL IMAGE PROCESSING LABORATORY

EARSeL Imaging Spectroscopy Workshop 2024 in València!

Abstract submission deadline: 30 October 2023

Notification of acceptance: **15 Dec 2023**

Early registration deadline: **15 February 2024**

Tutorial day: **19 April**, workshop: **16-18 April 2024**