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Intercomparison of OLCI's essential vegetation variables retrieved with Gaussian Processes using Google Earth

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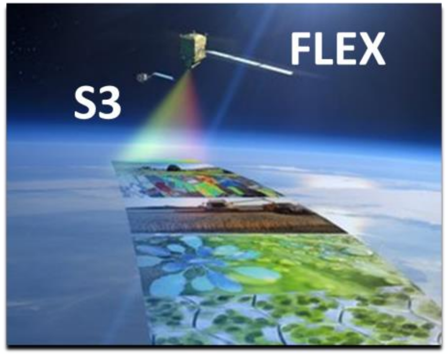
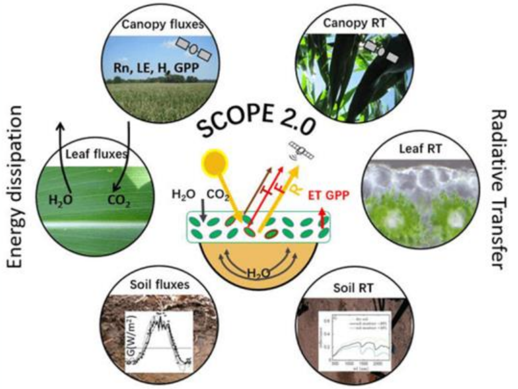
Objectives:

- To retrieve: global biophysical maps of leaf chlorophyll content (**LCC**), leaf area index (**LAI**), fraction of absorbed photosynthetically active radiation (**FAPAR**) and fractional vegetation cover (**FVC**)
- To use: OLCI TOA data and hybrid models trained with **Gaussian Process Regression** (GPR) in Google Earth Engine
- To implement: **Whittaker's** gap filling algorithm
- Intra-annual correlate our LAI/FAPAR GPR products against Copernicus & MODIS products



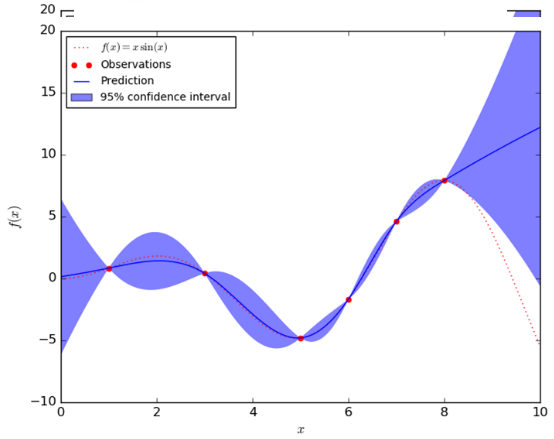
Land Monitoring
COPERNICUS LAND MONITORING SERVICE
State of Play: In situ data requirements



Retrieval method:

1. Started with simulating canopy states: **SCOPE** model
2. SCOPE **TOC** simulations: upscaled to **TOA** using **6SV** RTM[1]
3. Coupling process realized by: Atmospheric Lookup table Generator (**ALG**)[2] and Automated Radiative Transfer Models Operator (**ARTMO**)[3]
4. **GPR** models were trained using TOA radiances

LCC LAI FAPAR FVC **S3-TOA-GPR-1.0** models



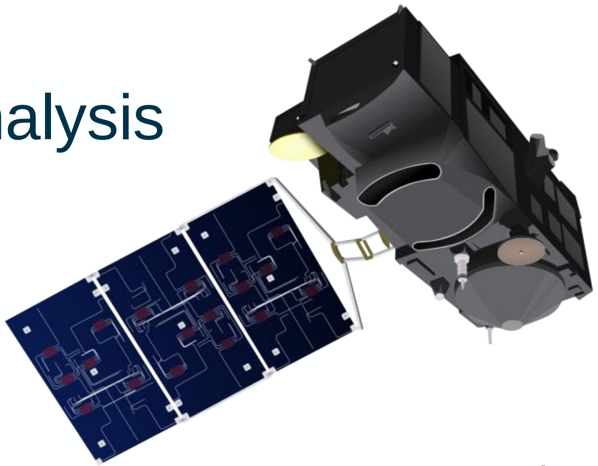
[1]: Vermote et al. (1997)
[2]: Vicent et al. (2020)
[3]: Verrelst et al. (2012)

5. **S3-TOA-GPR-1.0** models were introduced in Google Earth Engine (GEE)

Input data for processing into vegetation traits:

L1B Earth Observation Full Resolution (EFR) product. From all 21 bands of OLCI onboard S3A and S3B

- Prediction and uncertainty algorithms based on matrix operations
- Global maps were generated 10 day intervals in 2019 at 5 km resolution
- 3 European study sites at 500 m resolution for land cover analysis
  - ➢ Iberian peninsula
  - ➢ Western Europe
  - ➢ Scandinavia

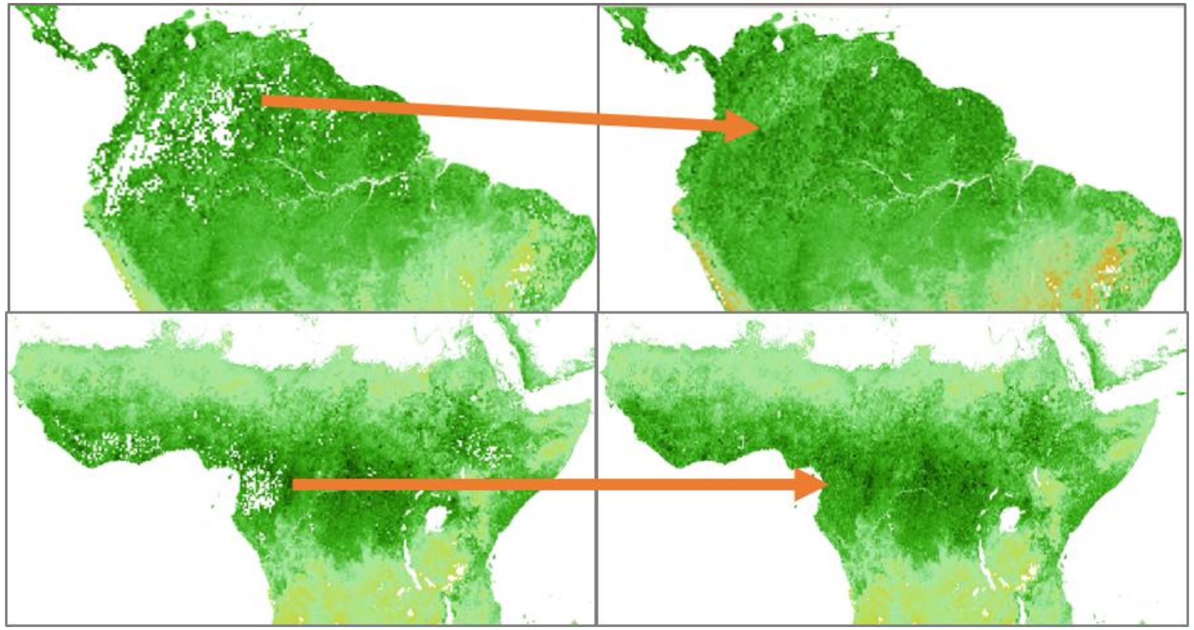


6. Cloud induced gap filling: **Whittaker's** smoother

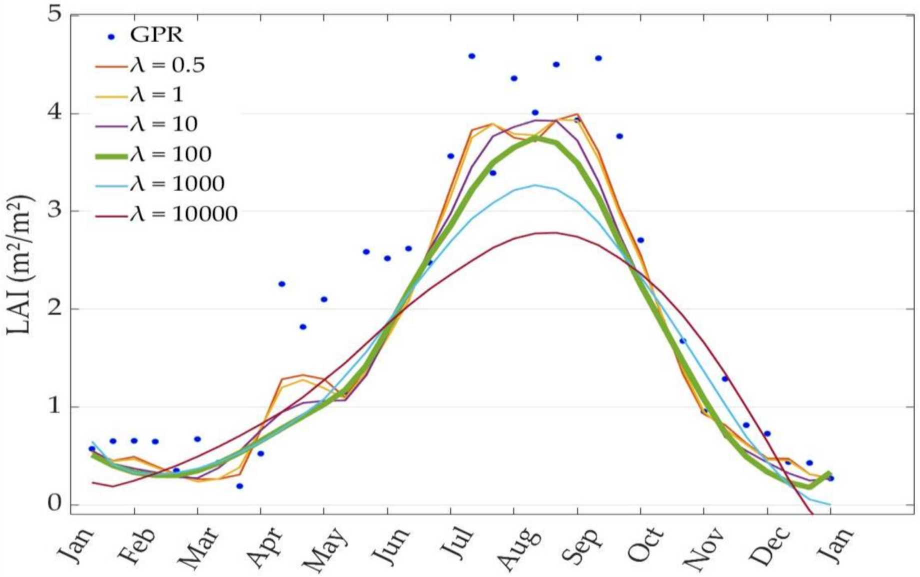
- Optimized penalty weight of function → λ=100
- Gaps around low latitudes and polar regions
- Directly implemented into GEE

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

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



Gaps in evergreen forests in the Amazon and Congo Basin.

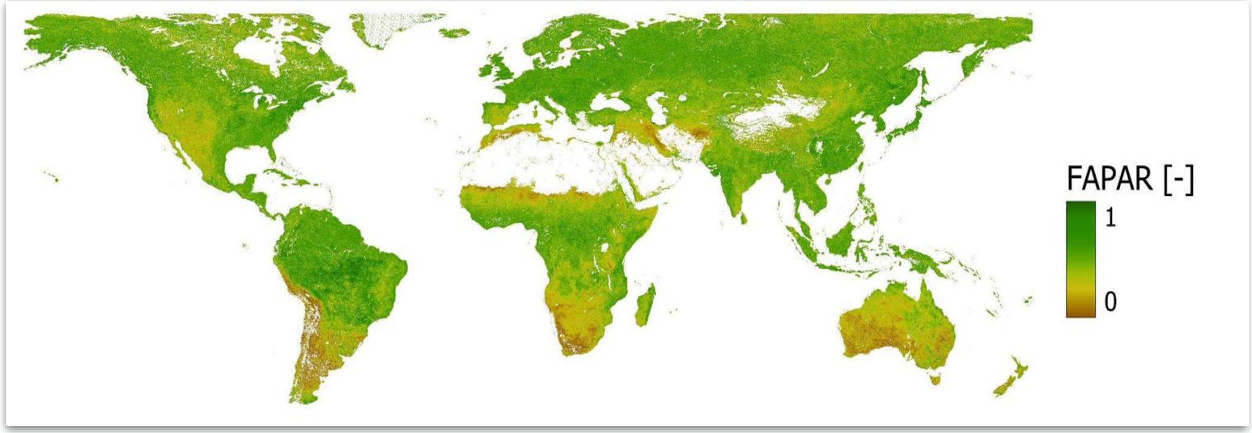


GPR LAI 10 day interval interpolated with Whittaker`s algorithm.

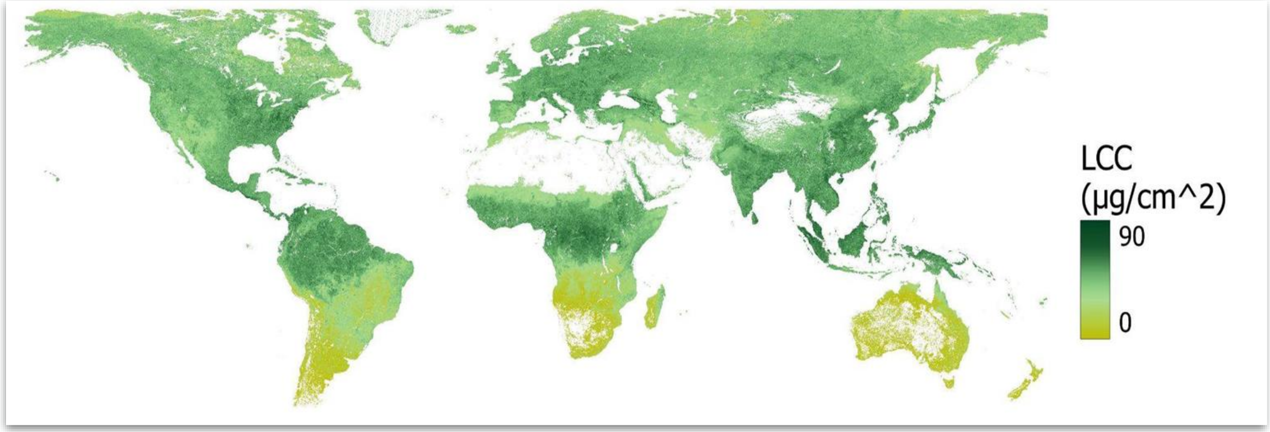
Results:

Gap filled maps. June 2019, monthly averaged (5km resolution).

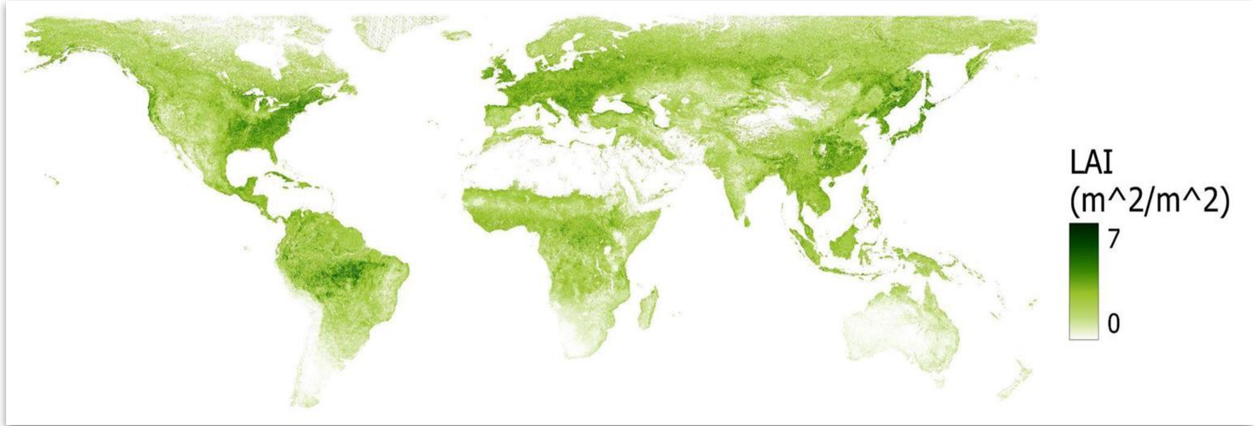
FAPAR



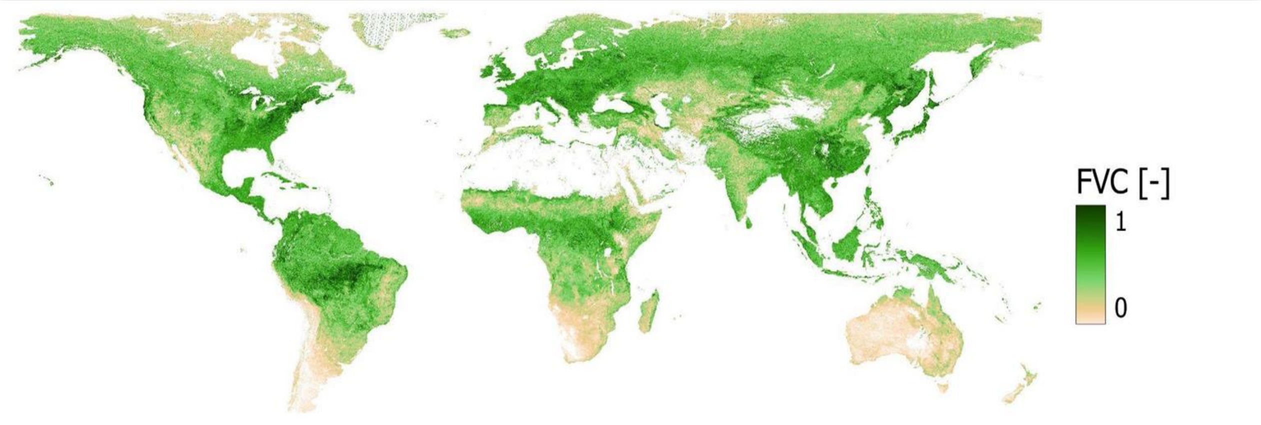
LCC



LAI



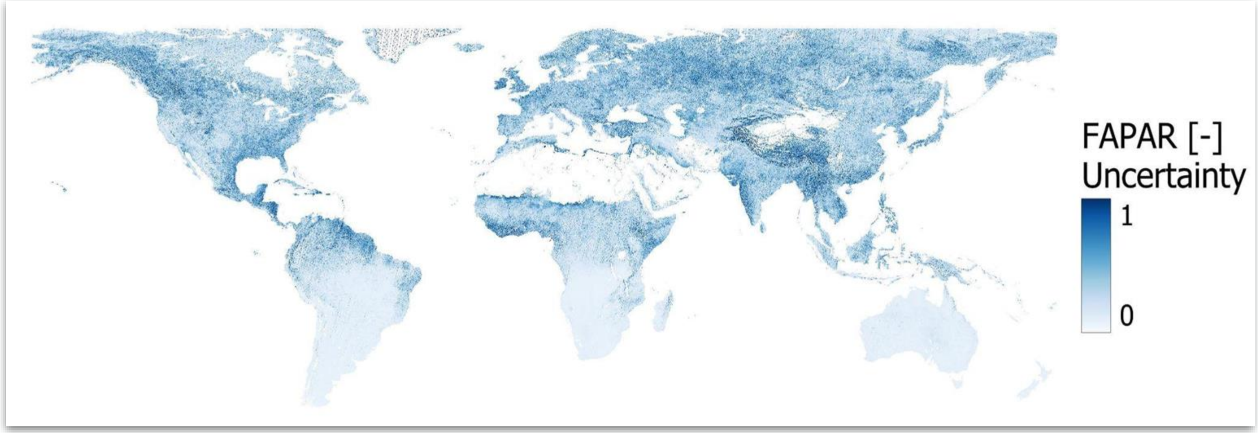
FVC



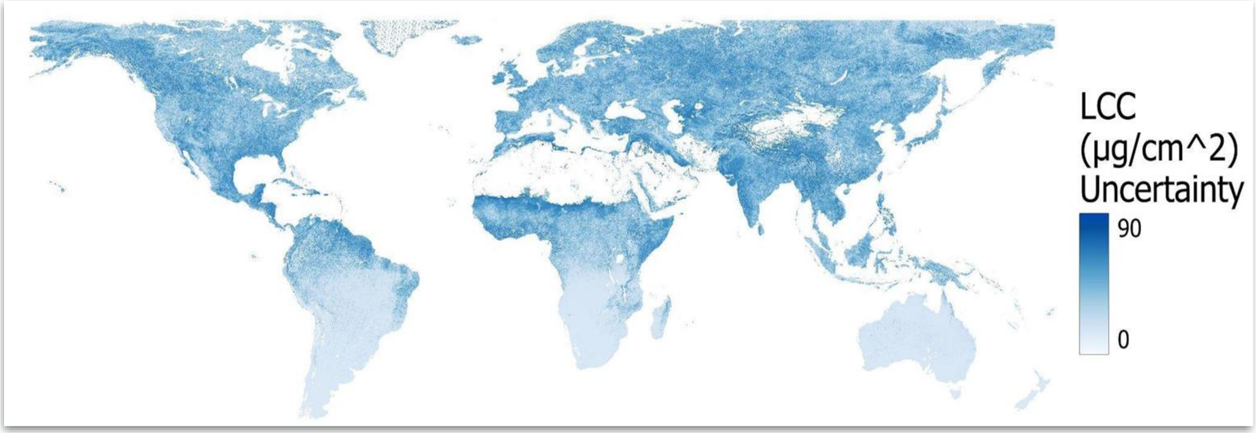
Results:

Gap filled maps. June 2019, monthly averaged (5km resolution).

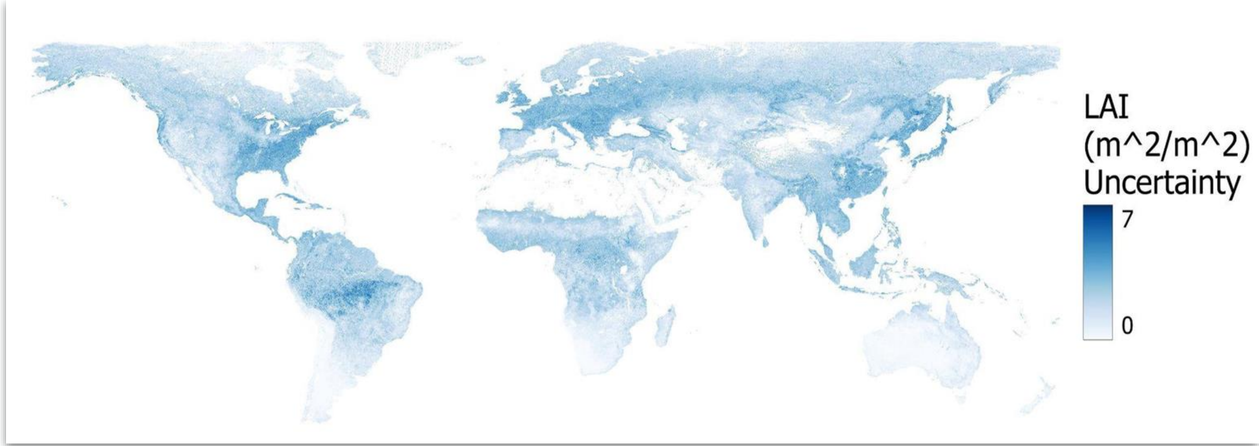
FAPAR



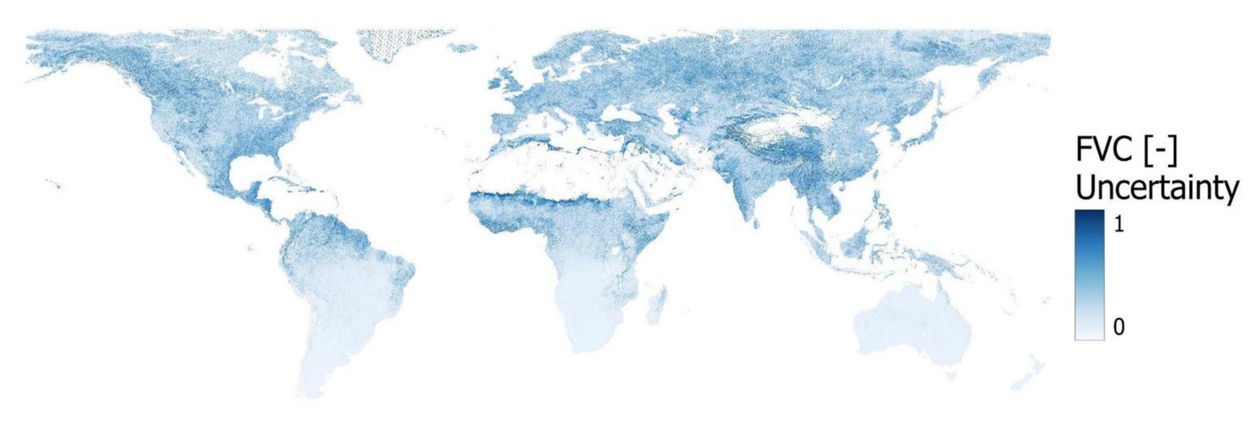
LCC



LAI



FVC



Intra-annual comparison for the year **2019** (34 observations):

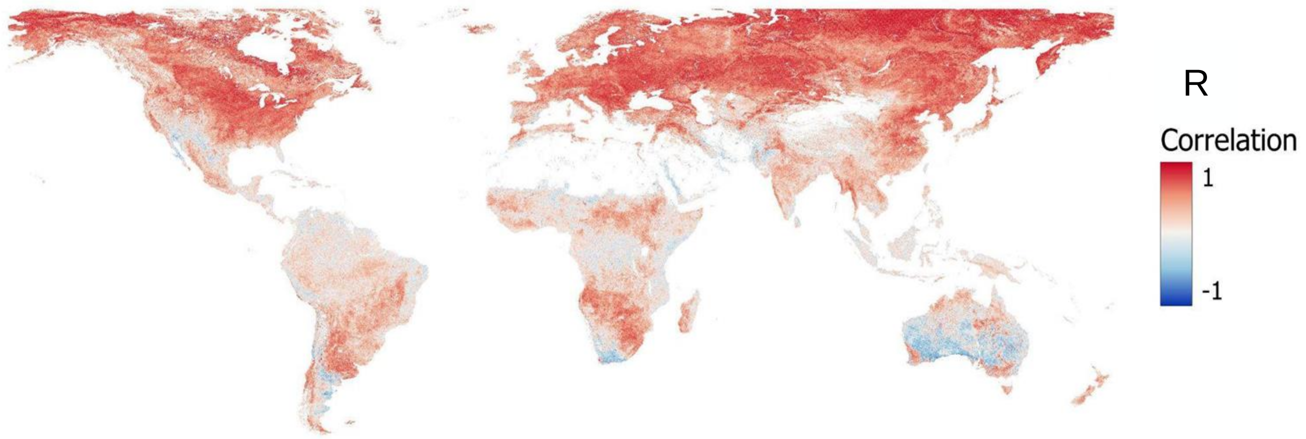
LAI/FAPAR and **Copernicus** products (and additionally MODIS)

European study areas **R^2 >0.7** (LAI/FAPAR)

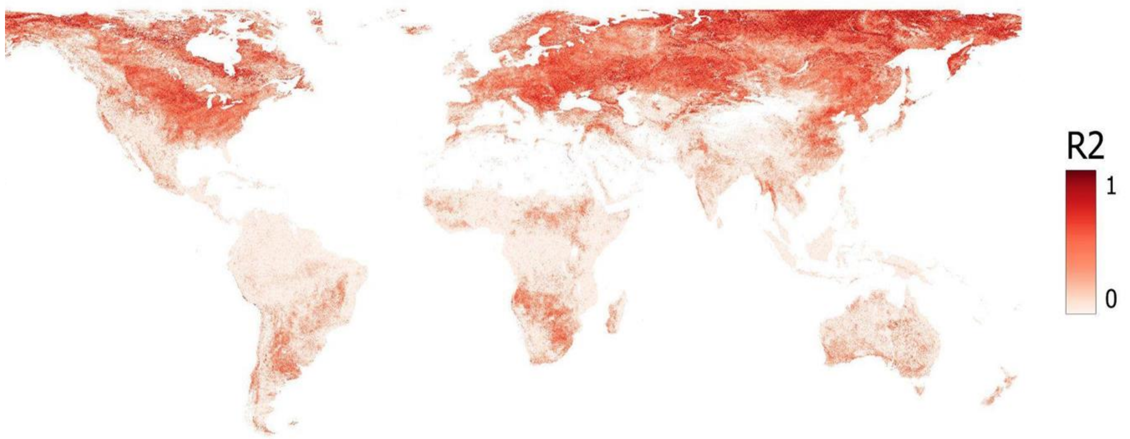
Lower than 20° latitudes **R^2=0.5**. Due to less seasonal dynamics.

Pronounced yearly phenology yielded **superior** GPR retrievals

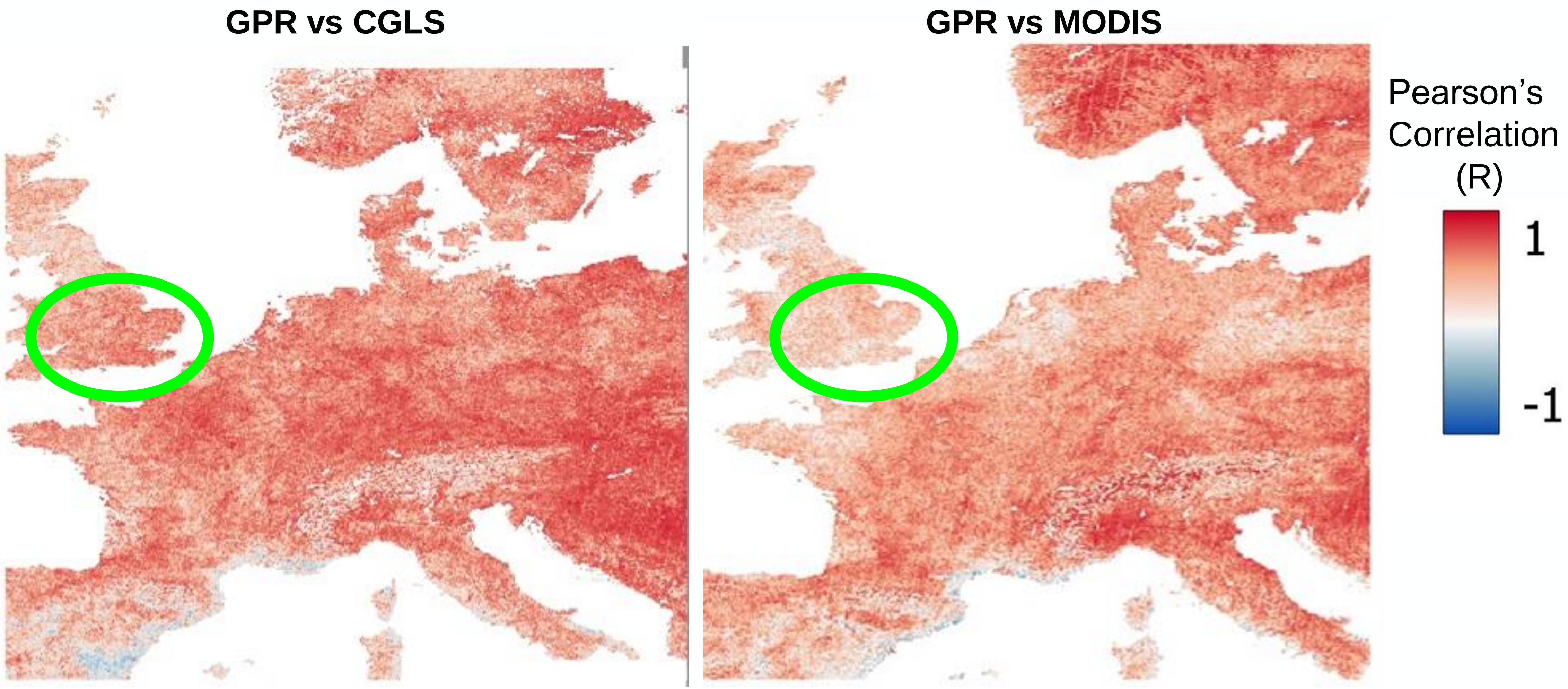
Pearson correlation of 2019 FAPAR: GPR vs CGLS



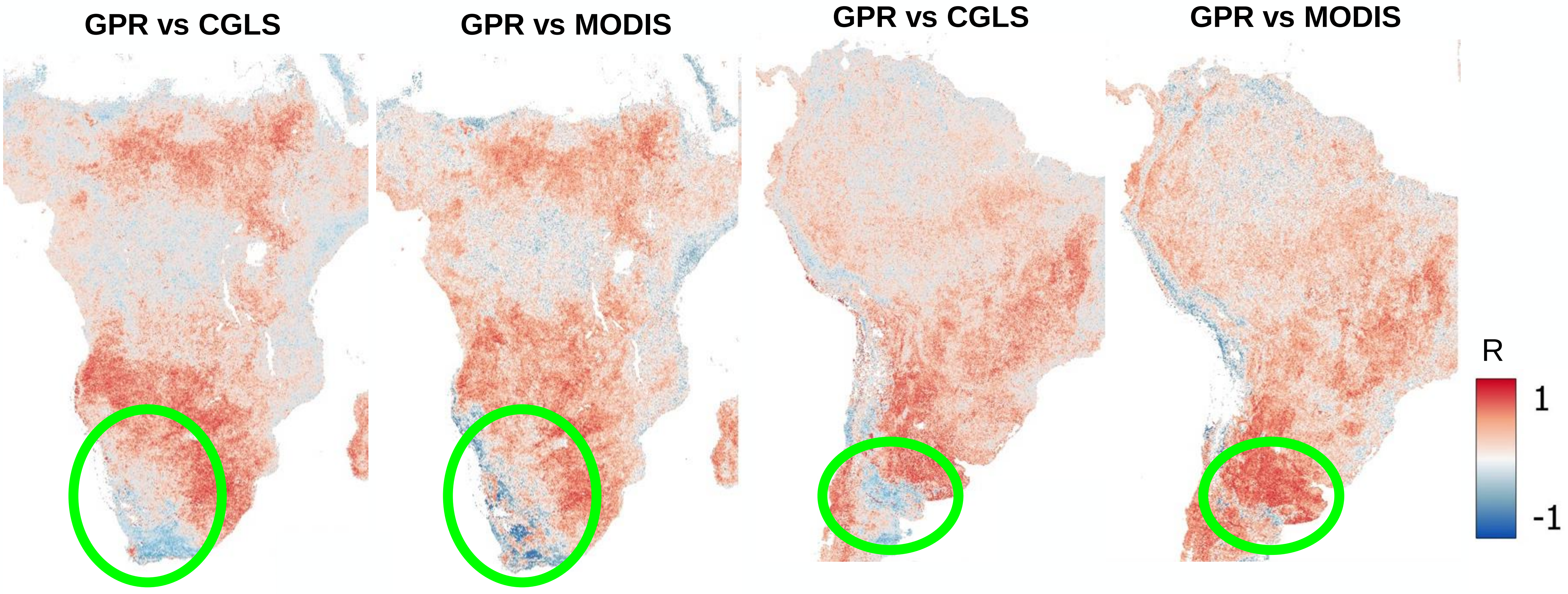
R^2 of 2019 FAPAR GPR vs CGLS



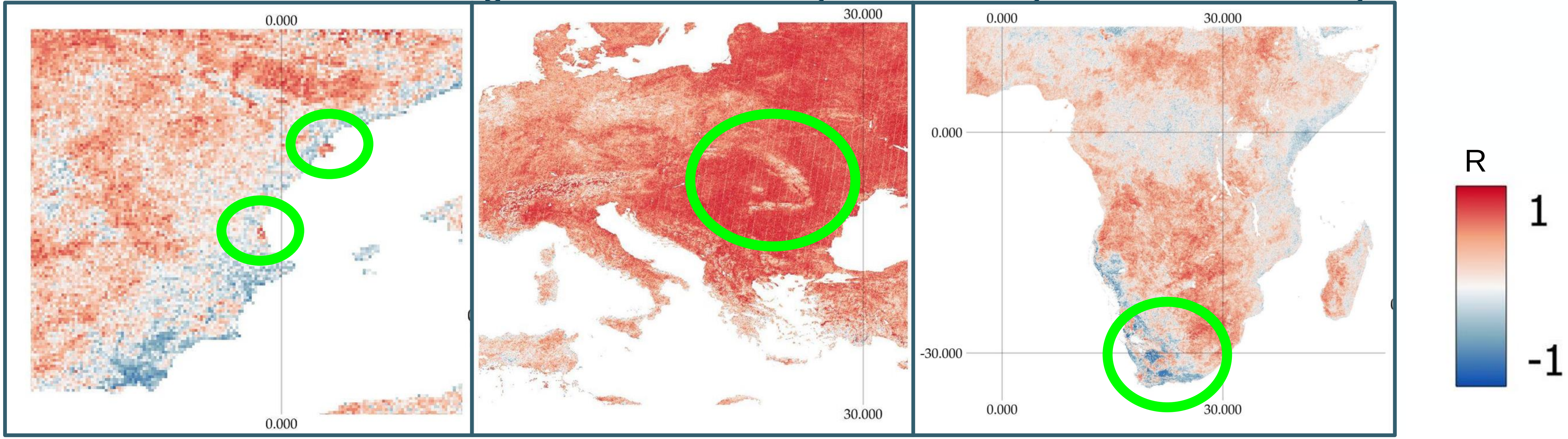
Correlation: FAPAR GPR vs CGLS / MODIS



Correlation: FAPAR GPR vs CGLS / MODIS



GPR vs CGLS: Effect of vegetation seasonality and density on GPR accuracy



High correlation in l'Albufera and the Ebro delta. Both paddy (rice) fields

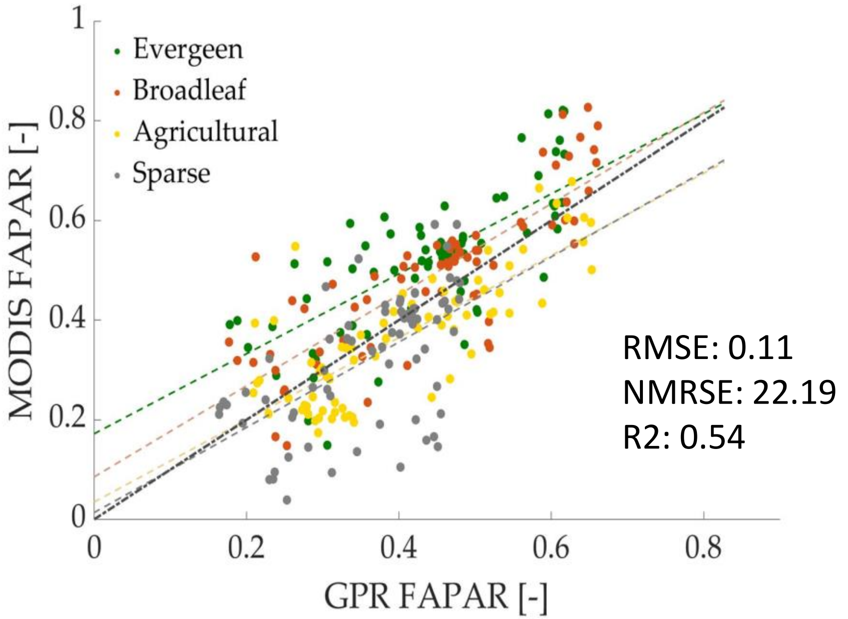
High correlation in deciduous forests along Eastern Europe.
0 correlation on the Carpathian evergreen/sparse/snow covers

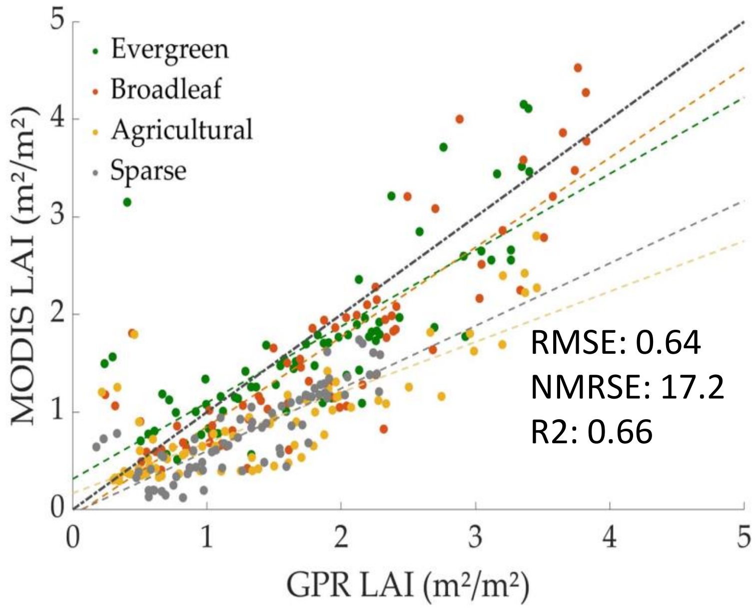
Low correlation: low seasonality in rainforests along the Equator. Also negative correlation in the Namibian desert and shrublands

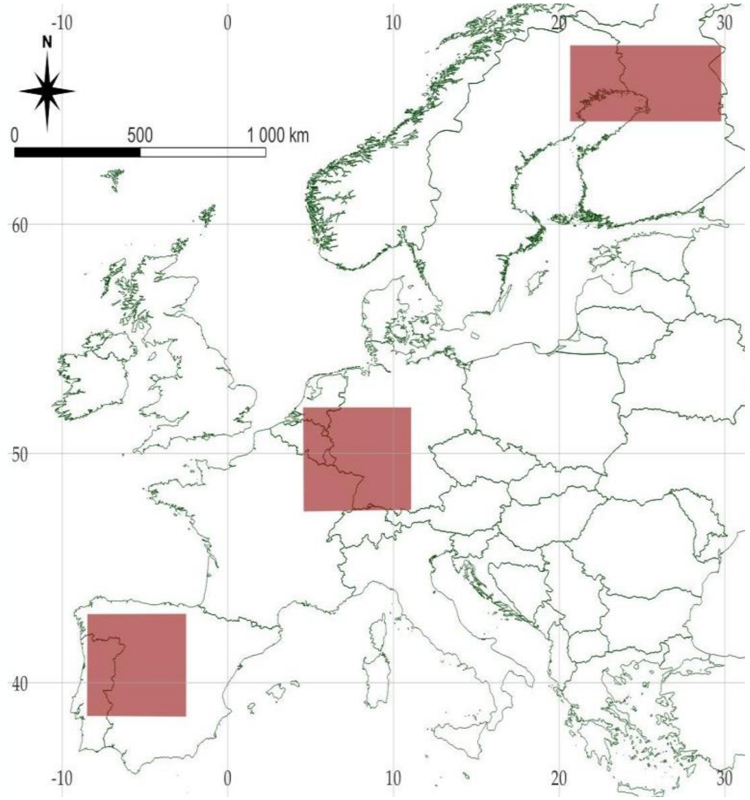
- Land cover analysis (GPR vs. MODIS):
  - Different CORINE land cover types were correlated

    Evergreen & **Broadleaf** forests

    Agricultural and **Sparse**ly vegetated areas



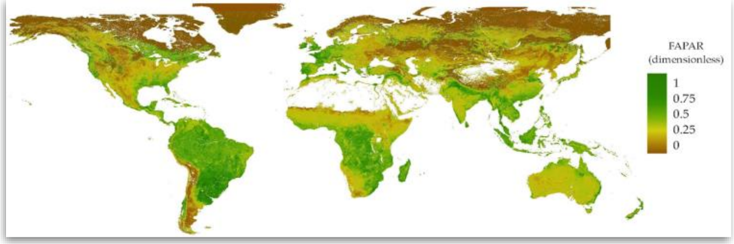


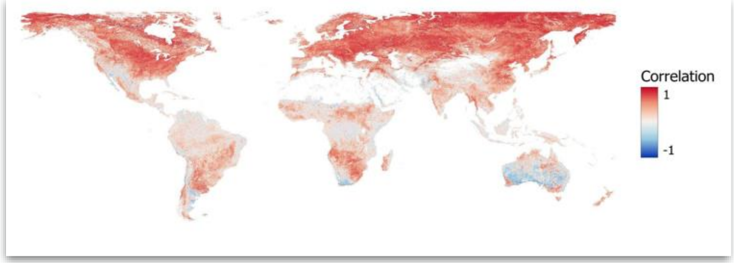


Study areas in Europe. Maps retrieved at 500m resolution. Correlated different land covers in each region of interest.

Conclusions:

- GPR models in GEE: efficient way to produce global maps with uncertainties
- Uncertainties with inter-tropical convergence zone clouds
- Further improvements with Gap-filling will solve this issue
- General consistency with CGLS and MODIS products
- Validity is related to vegetation seasonality





Thank you for your attention!

Any questions?

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