
# Tracking the phenology of Northern hemisphere forests using the Green FAPAR products from MERIS and OLCI.

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23/05/2022

# Talk Outline

- Introduction to phenology
- Overview of FAPAR
- The Copernicus programme and Sentinel-3
- Pre-processing and phenological extractions
- Comparison with in-situ
- Conclusions and next steps

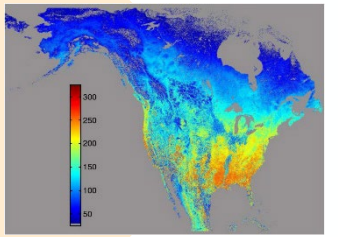
# Importance of LSP


Hawkings (2018)

# Importance of LSP


# LSP design decisions

| Satellite observations | Compositing period | VI or biophysical variable | Model fitting | Phenological metric estimation | Validation / intercomparison |
|---|---|---|---|---|---|
| AVHRR<br>SPOT-VGT<br>MODIS<br>MERIS<br>Landsat<br>Sentinel | Monthly<br>Bi-monthly<br>Dekad<br>Weekly<br>Raw observations | NDVI<br>EVI<br>MTCI<br>LAI<br>FAPAR<br>Backscatter | Fourier<br>Gaussian function<br>HANTS<br>Logistic function<br>Savitzky-Golay<br>No Smoothing | Threshold<br>Derivative<br>Moving average | LSP<br>Flux measurements<br>Phenological cameras<br>Species Observations |



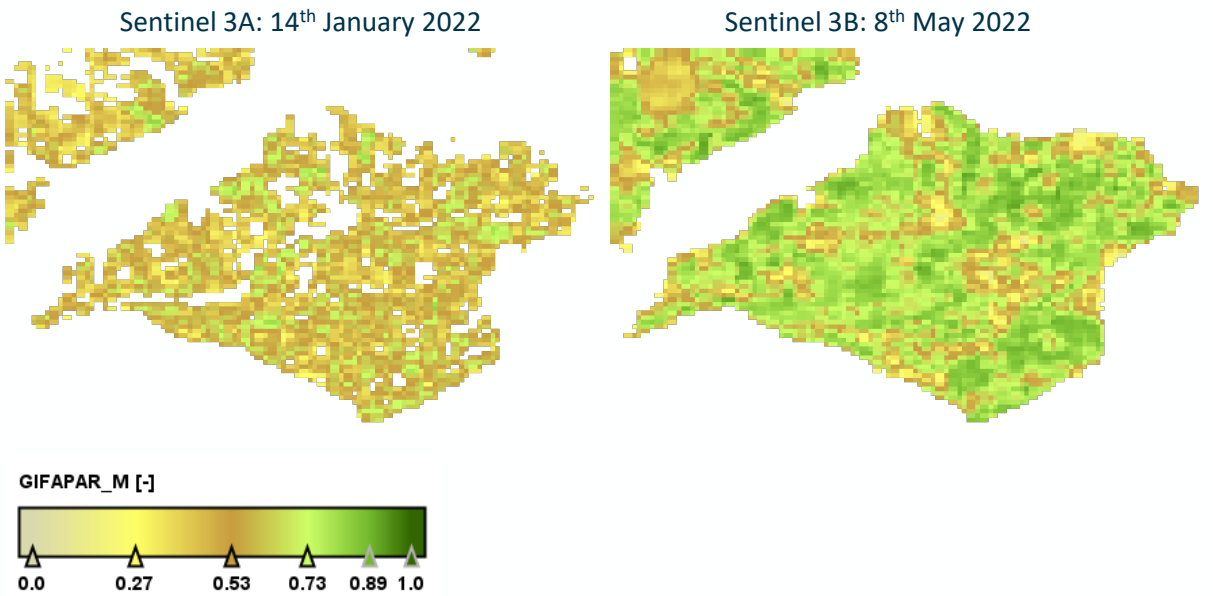
Adapted from Caparros-Santiago et al (2020)

# LSP operational products

| Product Name | Coverage | Spatial Scale | Temporal Range | Vegetation Index |
|---|---|---|---|---|
| MuSLI Land Surface Phenology (MSLSP30NA) | North America | 30 m | 2016 – 2019 | EVI2 |
| VIIRS Land Surface Phenology | Global | 500 m | 2012 – 2021 | EVI2 |
| VIIRS Land Surface Phenology | Global | 0.05 ° | 2012 – 2021 | EVI2 |
| MODIS Land Cover Dynamics | Global | 500 m | 2001 – 2017 | EVI2 |
| eMODIS Remote Sensing Phenology | Conterminous USA | 250 m | 2001 - 2017 | NDVI |
| Plant Phenology Index SOS & GSL | Europe & North America | 500 m | 2000 - 2016 | PPI |
| MODIS Land Surface Phenology | Australia | 0.05 ° | 2000 - 2015 | EVI |
| ForWarn Land Surface Phenology | Conterminous USA | 500 m | 2000 - 2014 | NDVI |
| AVHRR Land Surface Phenology | Conterminous USA | 1000 m | 1989-2014 | NDVI |
| MEASURES VIP Phenology | Global | 0.05 ° | 1981 - 2014 | NDVI / EVI2 |

# Fraction of Absorbed Photosynthetically Active Radiation (FAPAR)

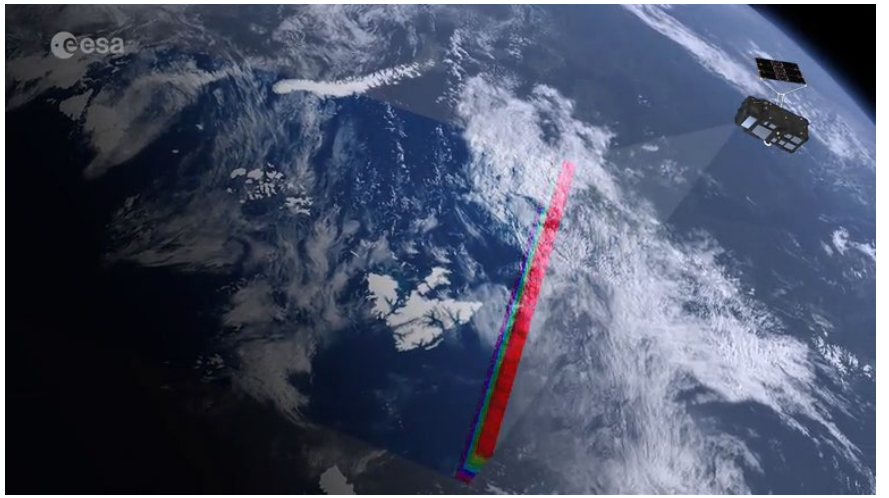
- GCOS ECV
- Solar radiation in the spectral range 400 – 700 nm
- Details the canopies radiation absorption capacity.
- Models:
  - Primary productivity
  - CO2 and energy cycles
  - Health and presence of vegetation




GCOS
GLOBAL CLIMATE OBSERVING SYSTEM

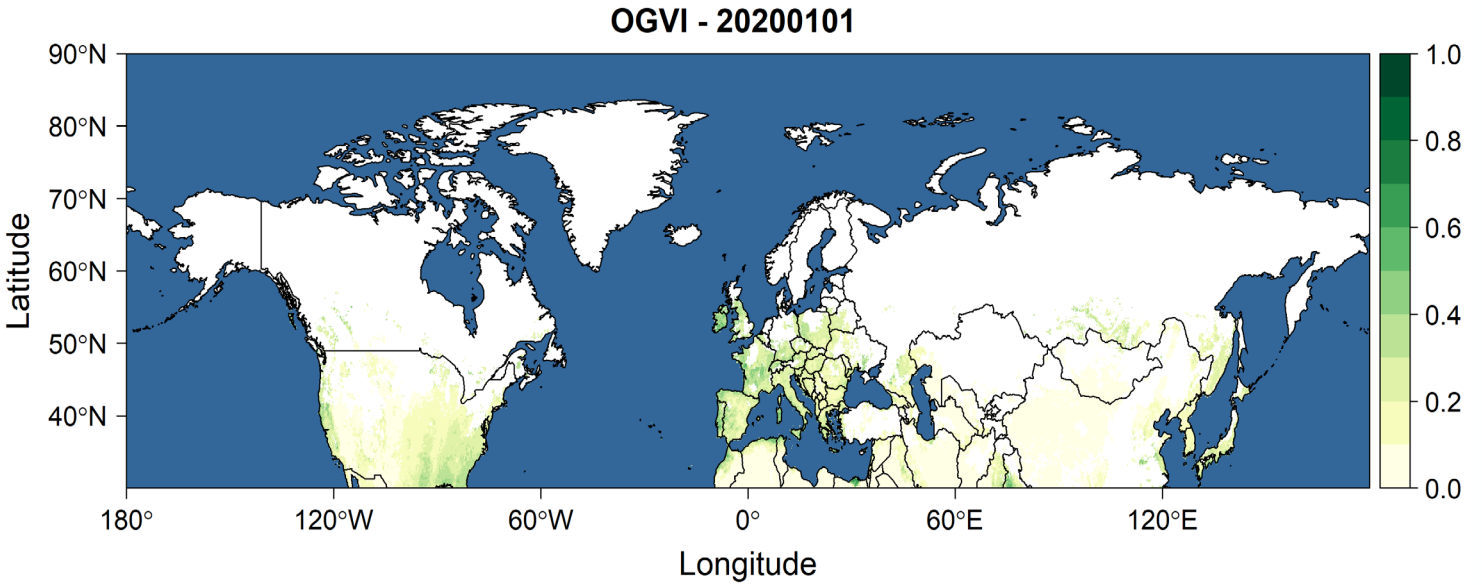
# Sentinel-3 and MERIS overview

- L2 land products
  - OLCI Terrrestrial Chlorophyll Index (OTCI)
  - **OLCI Global Vegetation Index (OGVI)**
- 300 m spatial resolution
- 2 day revisit time
- Pair of satellites
  - S-3A launched February 2016
  - S-3B launched April 2018
- Continuation of MERIS (2003 – 2012)



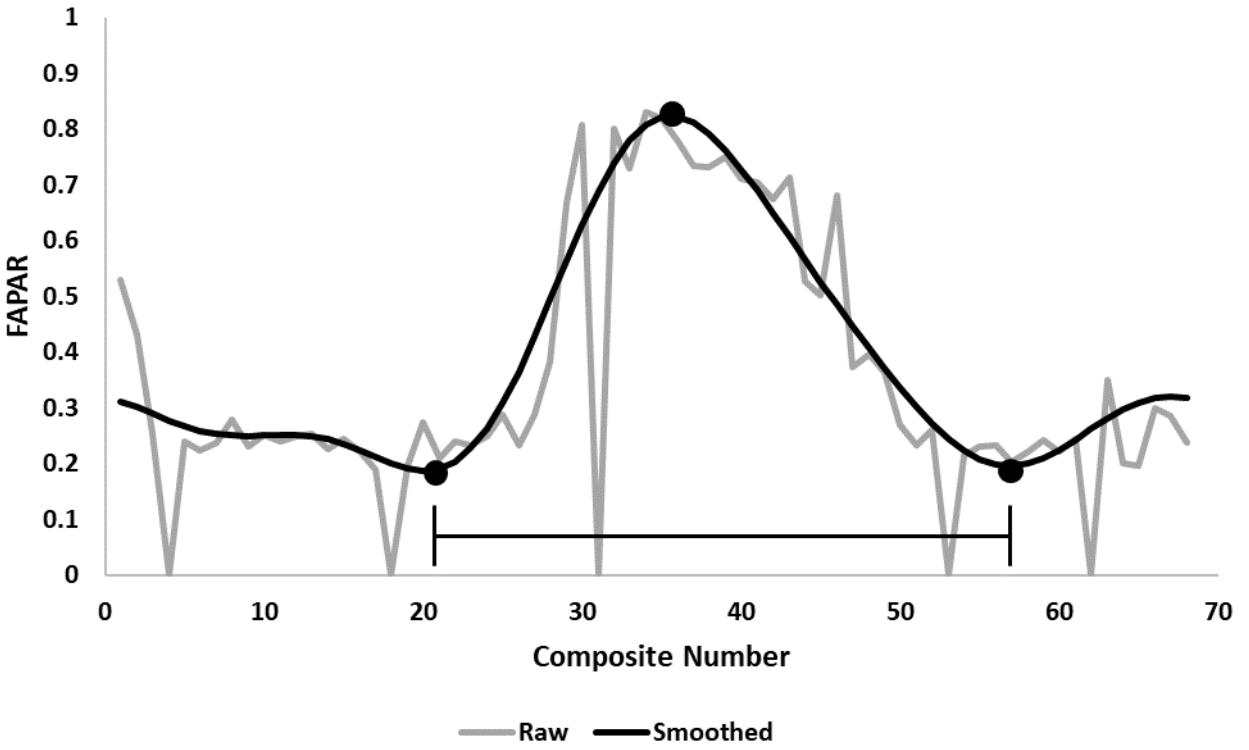
# Composite Production

- Study focused on Northern Hemisphere (30° – 80° N)
- 2003-2011 MERIS
- 2017 – 2020 OLCI
- 8 day mean composites
- 9.6 km spatial resolution
- Average of best quality observations
  - No cloud
  - No snow / ice
  - No out of range data



# Phenological metric extraction

- Time series extraction
  - Drop out removal
  - DFT smoothing
  - Identify Peak (POS)
  - Identify valleys (SOS, EOS)
  - Calculate LOS




OLCI FAPAR time series. HARV forest, 2018

The use of MERIS Terrestrial Chlorophyll Index to study spatio-temporal variation in vegetation phenology over India

J. Dash *, C. Jeganathan, P.M. Atkinson

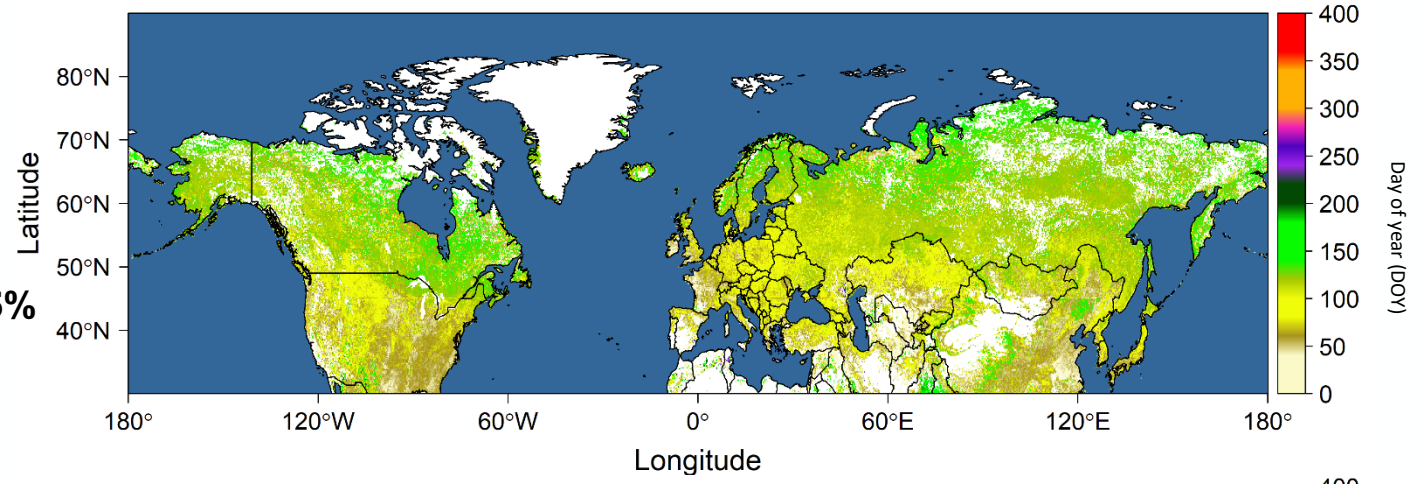
*School of Geography, University of Southampton, Southampton, SO17 1BJ, United Kingdom*

**Characterising the Land Surface Phenology of Europe Using Decadal MERIS Data**

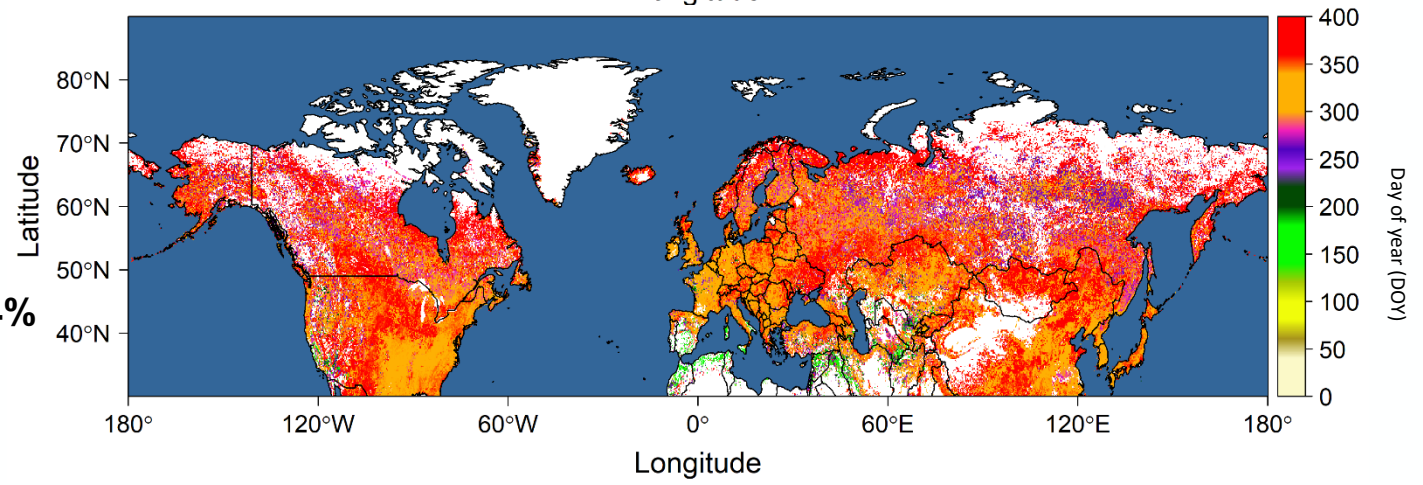
**Victor F. Rodriguez-Galiano [1,2,*], Jadunandan Dash [2] and Peter M. Atkinson [2,3,4,5]**

# Spatial Distribution

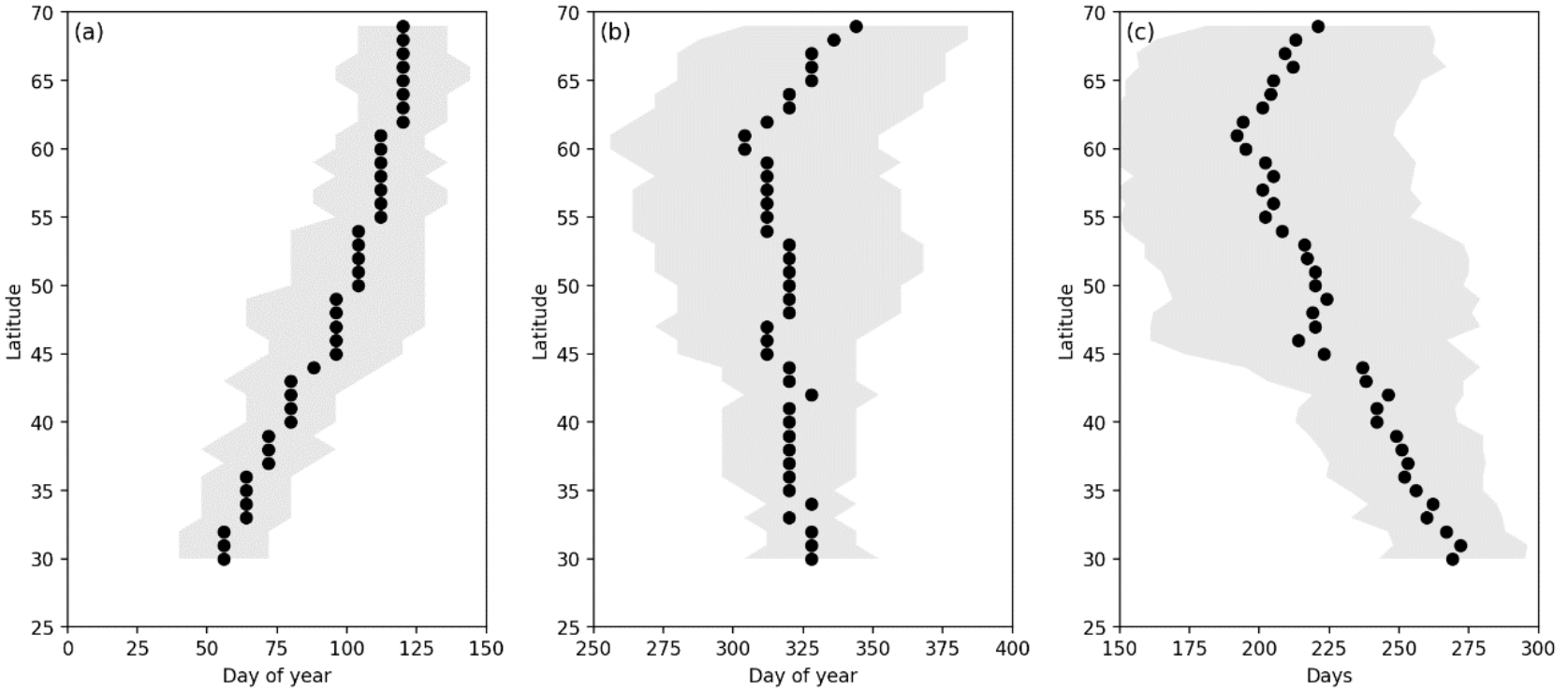
**SOS mean**
**(2003 – 2020)**
**valid retrievals: 62%±5%**




**EOS mean**
**(2003 – 2020)**
**valid retrievals: 57%±4%**



# Latitudinal gradient




| Forest type | $r^2$ SOS | LOS | EOS |
|---|---|---|---|
| ENF | 0.92 | 0.90 | 0.09 |
| EBF | 0.07 | 0.28 | 0.00 |
| DNF | 0.69 | 0.01 | 0.09 |
| DBF | 0.96 | 0.95 | 0.38 |
| Mixed | 0.02 | 0.00 | 0.01 |
| All forest | 0.95 | 0.81 | 0.00 |

Latitudinal variation in (a) SOS, (b) EOS and (c) LOS for all forest pixels per latitude band (1°).

# In-situ FAPAR measurements

- The in-situ dataset: 10 sites, selected on the basis of in-situ data availability, all part of the US National Ecological Observatory Network (NEON).

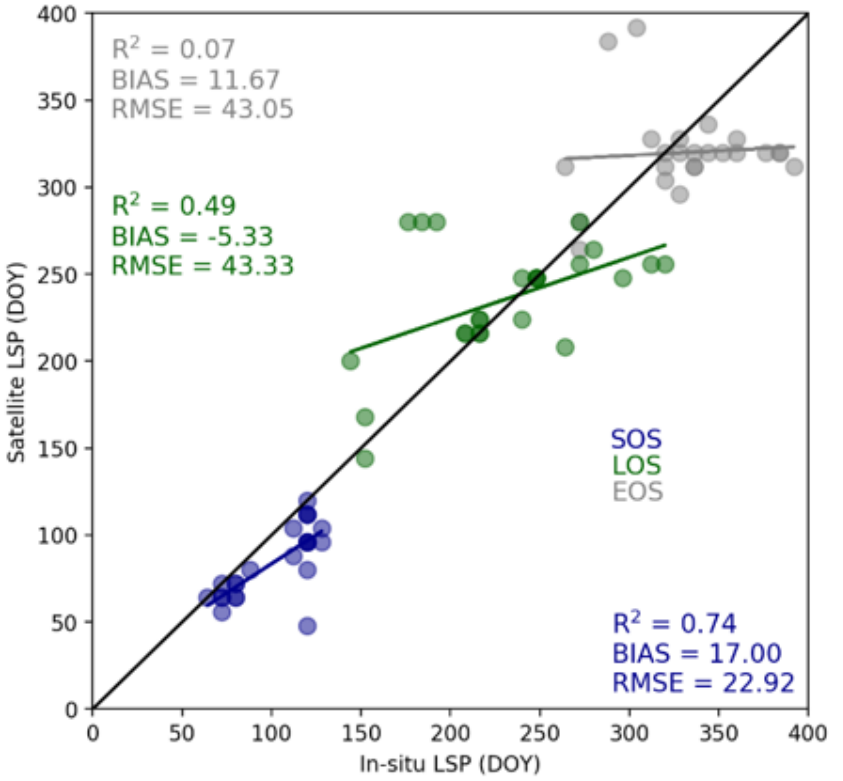
$$FAPAR = 1 - \frac{I}{I_0}$$

- Measurement closest to 10:00 solar time selected as daily value.


NEON (National Ecological Observatory Network). Photosynthetically active radiation (PAR) (DP1.00024.001). https://data.neonscience.org (accessed May 12, 2022)

# Comparison with in-situ

- SOS results (mean± standard deviation):
  - In-situ DOY (102 ± 22)
  - Satellite DOY (85 ± 20)
- LOS results:
  - In-situ DOY (230 ± 48)
  - Satellite DOY (235 ± 34)
- EOS results:
  - In-situ DOY (332 ± 35)
  - Satellite DOY (320 ± 26)



# Discussion

- In situ validation:
  - Inclusion of ICOS sites
  - Spatial mismatch
  - FAPAR definition
- Combine S3A and S3B observations
- Next steps:
  - Analysis could be performed at higher spatial resolution
  - Inter-comparison with other LSP products to be performed
  - Investigate trends in phenological metrics in relation to temperature

# Conclusions

- 13 years of FAPAR phenological metrics derived over Northern Hemisphere.
- In-situ validation:
  - Good relationships for SOS ($r^2 = 0.74$) and LOS ($r^2 = 0.49$).
  - Weak relationship for EOS ($r^2 = 0.07$).
- Copernicus programme offers unique opportunity to develop a long-term phenological product based on an ECV.

- Thank you to all of my collaborators on the project!

# Q&A

Any Questions?

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