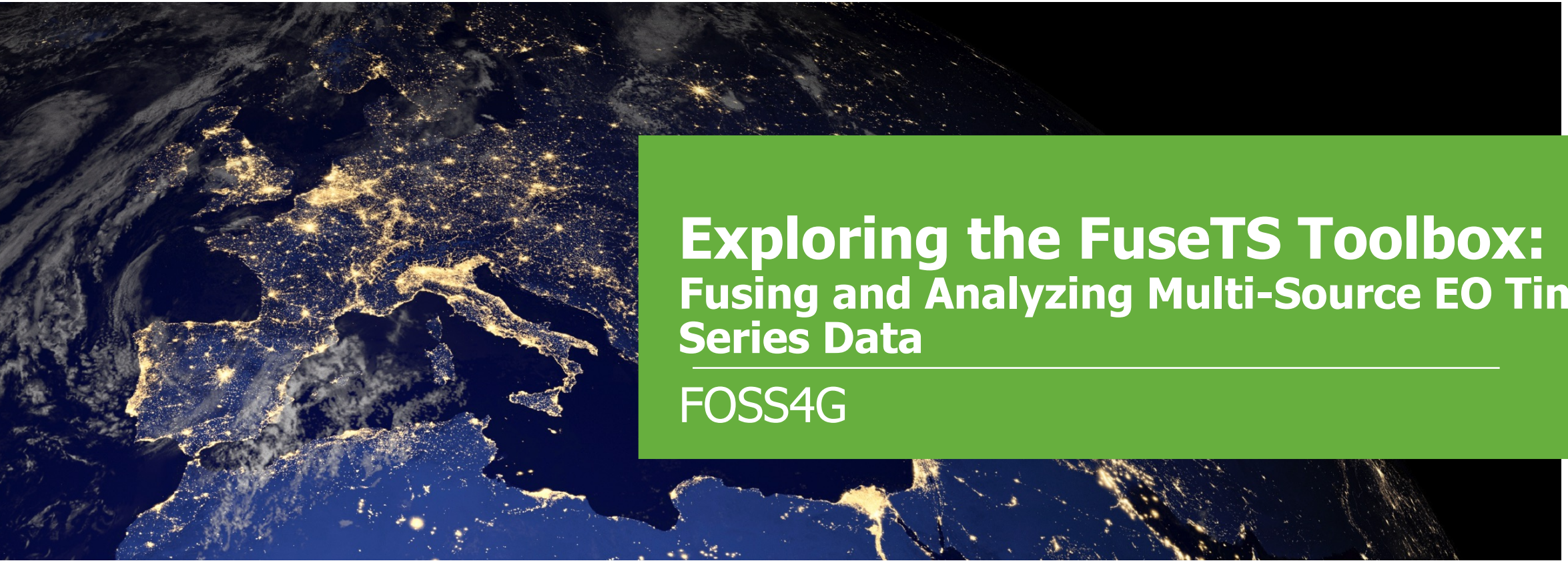


Exploring the FuseTS Toolbox:
Fusing and Analyzing Multi-Source EO Time Series Data

FOSS4G

Content

About FuseTS

- Open-source library
- Pre-Implemented Functions
- Data-Fusion Capabilities
- Focusing on Time-Series data analysis

Aim: To simplify the analysis of multi-dimensional time series data by providing a user-friendly interface open-source framework for detecting and predicting changes in land environments.

About FuseTS

An open-source service in the form of source code that focuses on simplifying and unifying Earth Observation data processing and analysis.

More about openEO in UBT C - N 111: Earth observation data access & processing in openEO

xarray

An open-source Python library for labelled, multi-dimensional array manipulation and analysis.

Why FuseTS?

- Advantages of openEO
  - Simple access to EO dataset, scalable, cross-platform system, reproducibility and independent of underlying technologies.
- Focusing on Time-Series data analysis
  - Designed for processing and analyzing multiple time series data, particularly focusing on Earth observation data.
- Extensive and easy to use
  - Built with a modular and extensible framework, which provides flexibility and customization options.
- Open-source
  - An active community surrounding FuseTS can provide ongoing support, updates, and contributions, making it a valuable resource.

Included in FuseTS

Time series analytics

```
from fusets import WhittakerTransformer
```

Time series smoothing methods take a single time-series (from a pixel or aggregated over an area) and smooth it over time. This reduces noise and allows the filling of gaps by interpolating along the smoothed curve that is fitted through the observations.

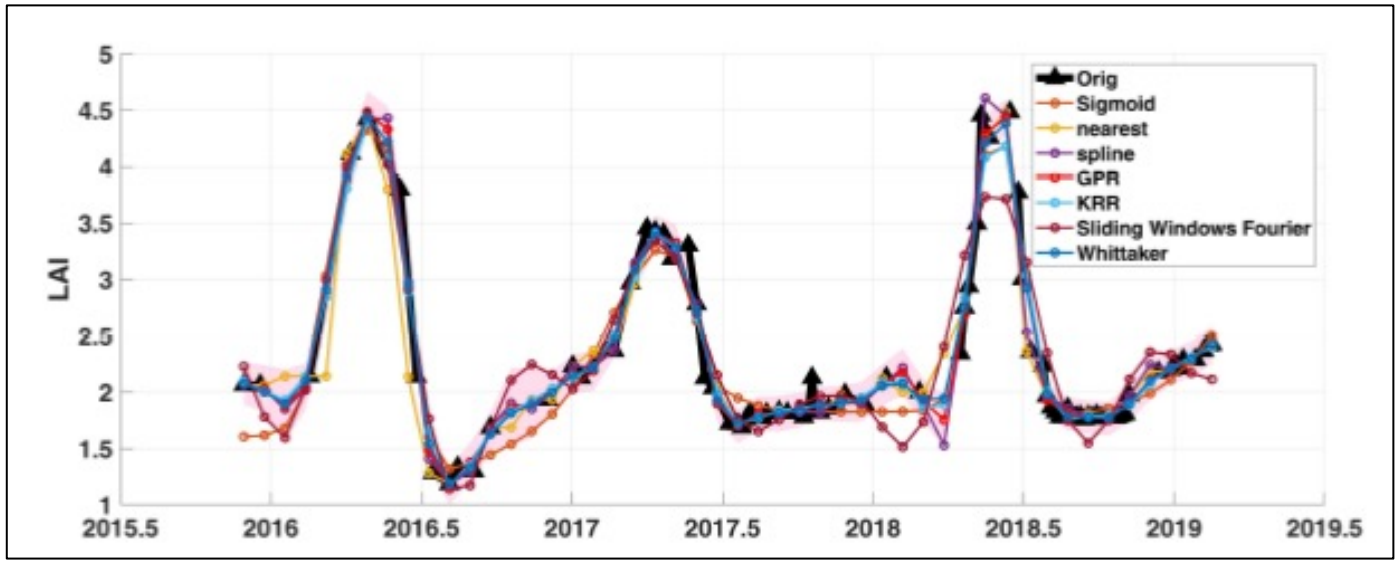
Time Series Fusion & Prediction

```
from fusets import MOGPRTransformer
```

Time series fusion methods take multiple input time series and produce a new, fused product, which tries to capture valuable information from the independent input sources.

More About Smoothing

- Usually single-source gap-filling algorithms
- Useful when time series gaps are rather short (e.g., in the order of weeks)
- The Whittaker gap-filling algorithm proved to be accurate and very fast
- GPR produces uncertainties, but is slower



Original and reconstructed time series of LAI using several gap-filling techniques. Interpolated values of time series at a higher sampling frequency (every 25 days). The GPR uncertainties are shown in red shade areas.

More About Fusion

- Making use of multiple input sources
- Only beneficial in case of long temporal gaps
  (e.g., missing key seasonal events due to persistent cloud cover)
- Able to extract correlations from outputs
- Computational cost is high

MOGPR

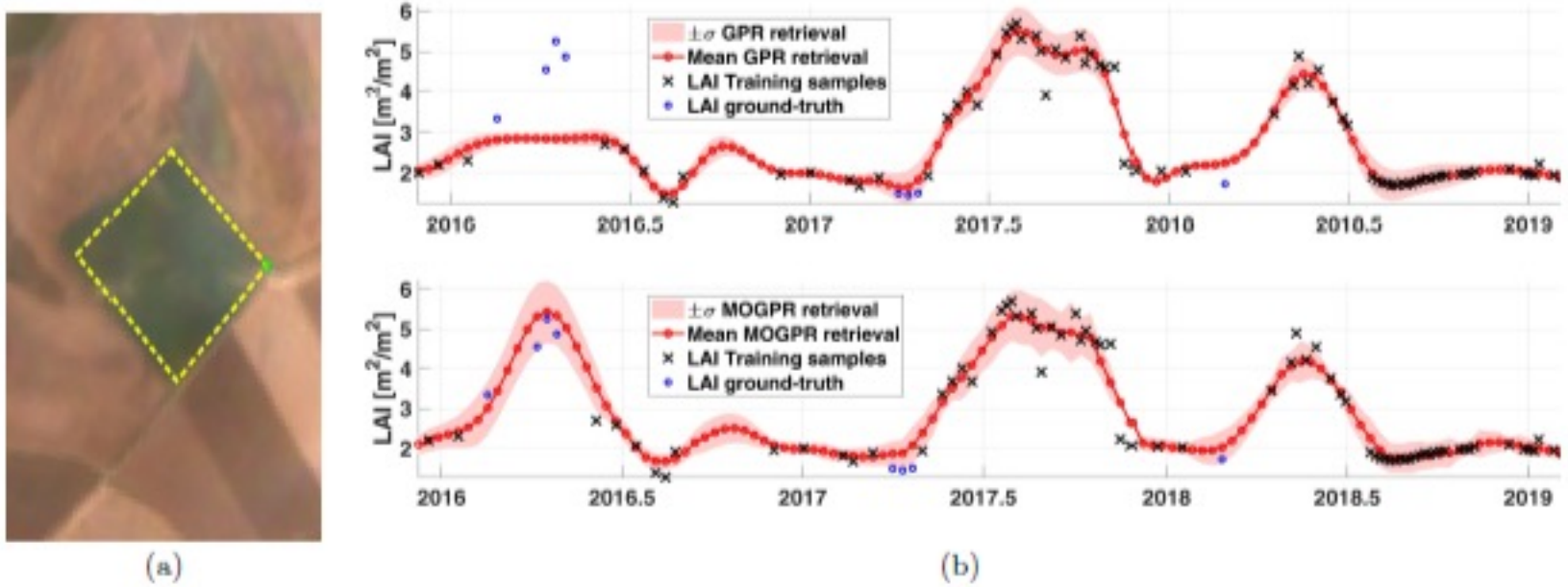
Multi-output Gaussian Process Regression

CropSAR

GAN-based neural network for S1 + S2 fusion

What is MOGPR?

- Multi-output Gaussian Process Regression
- Learns correlations between inputs and produces new outputs
- Comes with uncertainties



GPR (top) and MOGPR (bottom) predictions (red) of S2 LAI

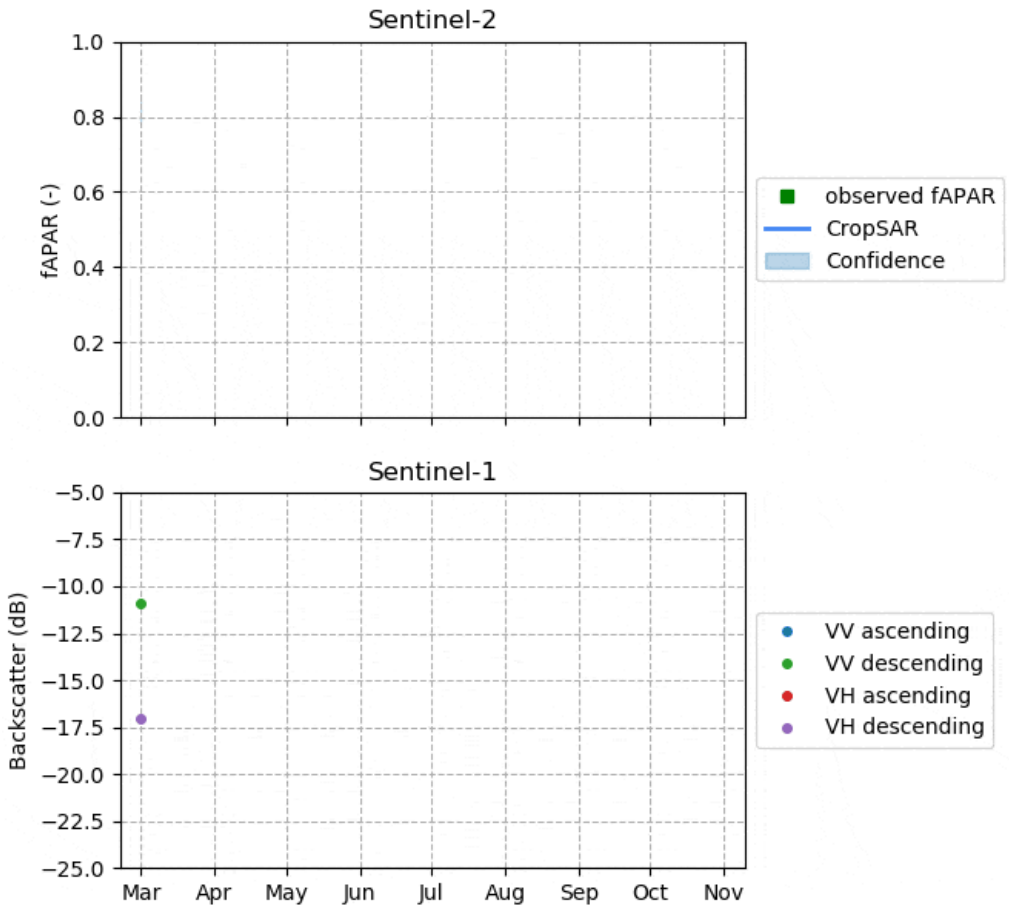
Black crosses represent data during training, while blue points are ground-truth data eliminated from the training step

MOGPR captures these eliminated points from correlations with S1 data

The ± σ prediction uncertainty is represented by the boundary shade (pink)

What is CropSAR?

- An AI-based tool to extract cloud-free time series of biophysical indices (NDVI, fAPAR, fCOVER)
- Based on joint radar Sentinel-1 and optical Sentinel-2 observations
- Works best over agricultural fields



Animation of CropSAR performing over a potato field. It builds upon any available cloud-free Sentinel-2 observations (green squares).

The long absence of valid Sentinel-2 data during crop emergence is here successfully bridged by CropSAR, thanks to the information contained in the Sentinel-1 signal.

Use Cases

- Gap filling and smoothing
  - Short gaps with single-source methods
  - Long gaps with fusion methods
- Phenology
  - Extraction of subsequent phenology metrics such as start-of-season, peak-of-season, end-of-season, …
- Prediction
  - Predict seasonal trends ahead of time

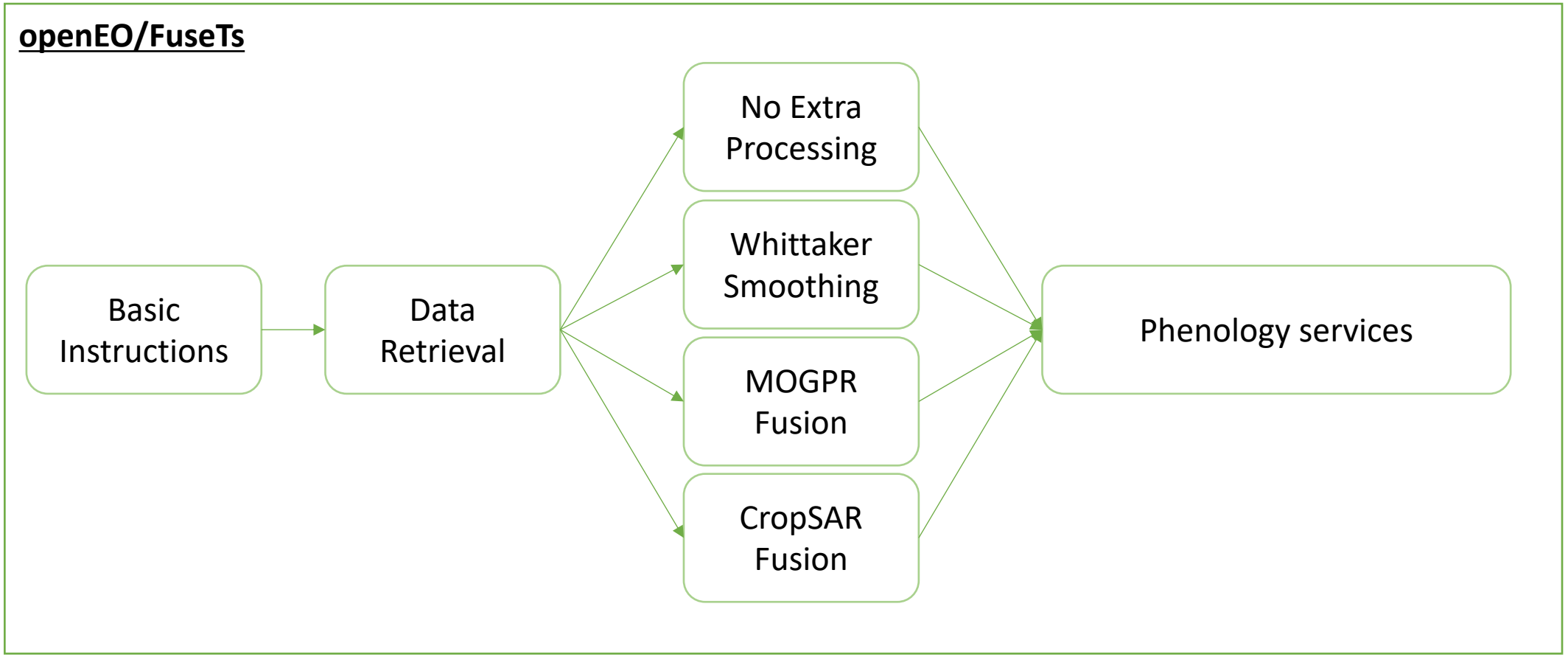
Challenges We Faced

- Understanding the shortcomings of the library
- Evaluating and improving performance of implemented tools
- Understanding complex fusion and analytics methods to recognize areas of useful applications

Implemented Solutions

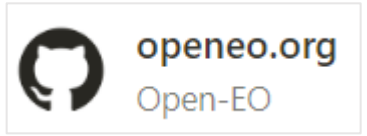
- Optimization of the included processes
- Versatility, so it can be used in different use cases
- Usability: both local and cloud versions

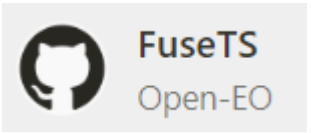
Hands-on


openEO/FuseTs
Basic Instructions
Data Retrieval
No Extra Processing
Whittaker Smoothing
MOGPR Fusion
CropSAR Fusion
Phenology services

How to contribute?

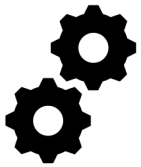
1. Familiarize yourself with the library

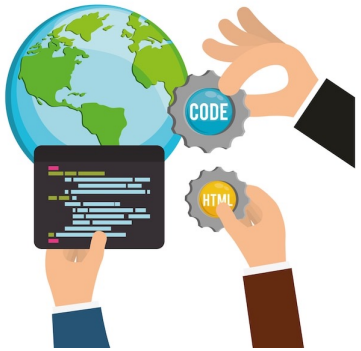




2. Fork the repository and submit a Pull Request

3. Collaborate and share your suggestions/feedbacks





THANK YOU

remotesensing.vito.be

Sentinel-2 image Copernicus Sentinel data (2016)