S2/S3 land validation: generating match-up dataset with in-situ measurements over the ICOS ecosystem sites

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IDEAS-QA4EO Cal/Val Workshop #4

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Integrated Carbon Observation System

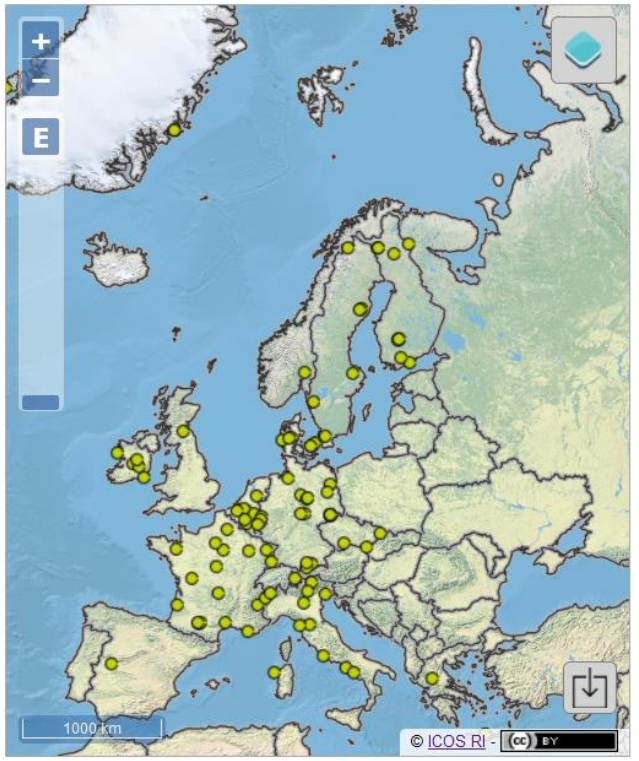
https://www.icos-cp.eu/

The ICOS network is a distributed **pan-European research infrastructure** that provides in situ standardized and open data from more than 140 measurement stations across 14 European countries. The stations observe **greenhouse gas concentrations** in the atmosphere as well as **carbon fluxes** between the atmosphere, the land surface and the oceans. Thus, ICOS is rooted in three domains: **Atmosphere, Ecosystem and Ocean.**

The network of **Ecosystem stations** is an instrumentation setup, usually on a tower, that measures the fluxes of greenhouse gases (GHG) concentrations and **ecosystems-atmosphere interactions**. Ecosystems typically consist of different types of forests, wetlands, croplands, grasslands, agricultural areas, heathlands, lakes or cities. All labelled stations and station types also have the same instrumentation installed in the same way and use the same procedures for submitting the data to the **Carbon Portal** and the **Thematic Centre.**

The ICOS stations observations comply with the monitoring principles of the Global Climate Observation System (GCOS) and have been developed by addressing the **Essential Climate Variables (ECVs).** ICOS provides observations of ECV anthropogenic GHG fluxes mainly related to land use as well as biophysical parameters such as land surface albedo, leaf area index, aboveground biomass, and soil carbon.

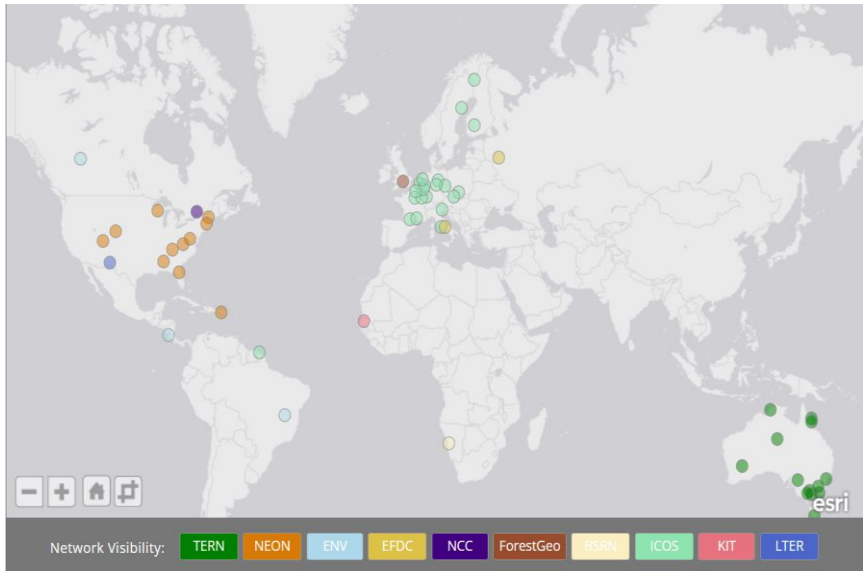
ICOS Ecosystem stations network



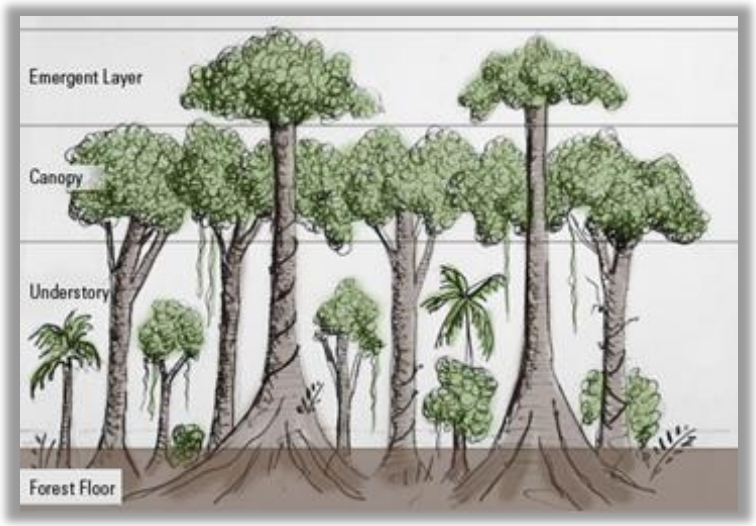
Project Background

Forest **understory reflectance** can **influence** the **radiometric signal** from the upper forest canopy layer to the atmosphere, **introducing potential bias in the estimation** of overstory **biophysical parameters** and contributing to the total energy absorption capacity of a forest. Currently, the understory is often treated as an unknown quantity in carbon models due to the difficulties in measuring it properly and consistently **across larger scales**.

→ the **remote sensing** could be the technology to provide consistent data in this area.



CEOS land validation sites



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https://doi.org/10.5194/bg-18-621-2021

Biogeosciences

Retrieval and validation of forest background reflectivity from daily Moderate Resolution Imaging Spectroradiometer (MODIS) bidirectional reflectance distribution function (BRDF) data across European forests

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→ Tracking of **understory reflectance** and its dynamics **with multi-angle Earth observation data**, **validated** against **in situ measurements** over a set of **ICOS** forest ecosystem sites

Can ICOS forest ecosystem sites serve as a suitable validation data set with respect to their footprint and the pixel resolution of EO products?

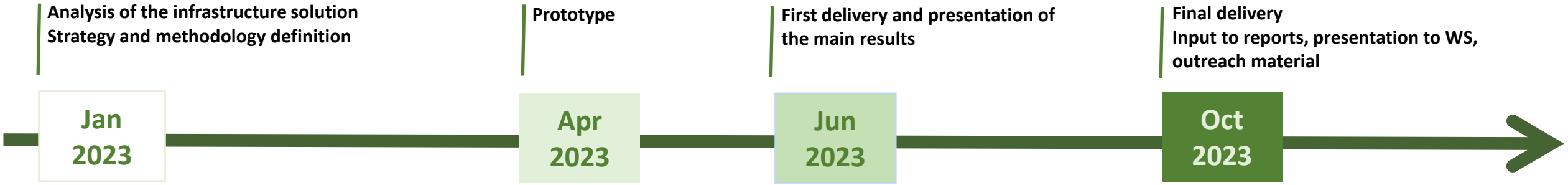
- ✓ Most of **ICOS forest ecosystem sites are representative** and **suitable for validation of EO products** across different scales once having identified how to properly scale and compare the in-situ ground-based measurements with satellite measurements.

- ✓ The ICOS network, included among the **Land Product Validation Supersites** under the Committee on Earth Observation Satellites (CEOS) Working Group on Calibration and Validation (WGCV) Land Product Validation (LPV) subgroup, **can be effectively used for the validation of new satellite-based data products**

WP-2650: Feasibility study on ICOS match-up database for S2/S3 land products validation

Objectives:

- ✓ To enhance our ability to validate satellite data in terms of spatial and temporal coverage by using the ICOS terrestrial ecosystem sites as network for validation of EO products.
- ✓ To generate a match-up dataset of Sentinel-2 and Sentinel-3 products over ICOS ecosystem sites for the validation of bio-geophysical products against the chosen reference measurements



Main tasks (Jan – Feb):

- ✓ Strategy and methodology definition for the reference data generation
- ✓ Assessment of existing cloud-based data services to select the best infrastructure solution
- ✓ Prototype development and first results

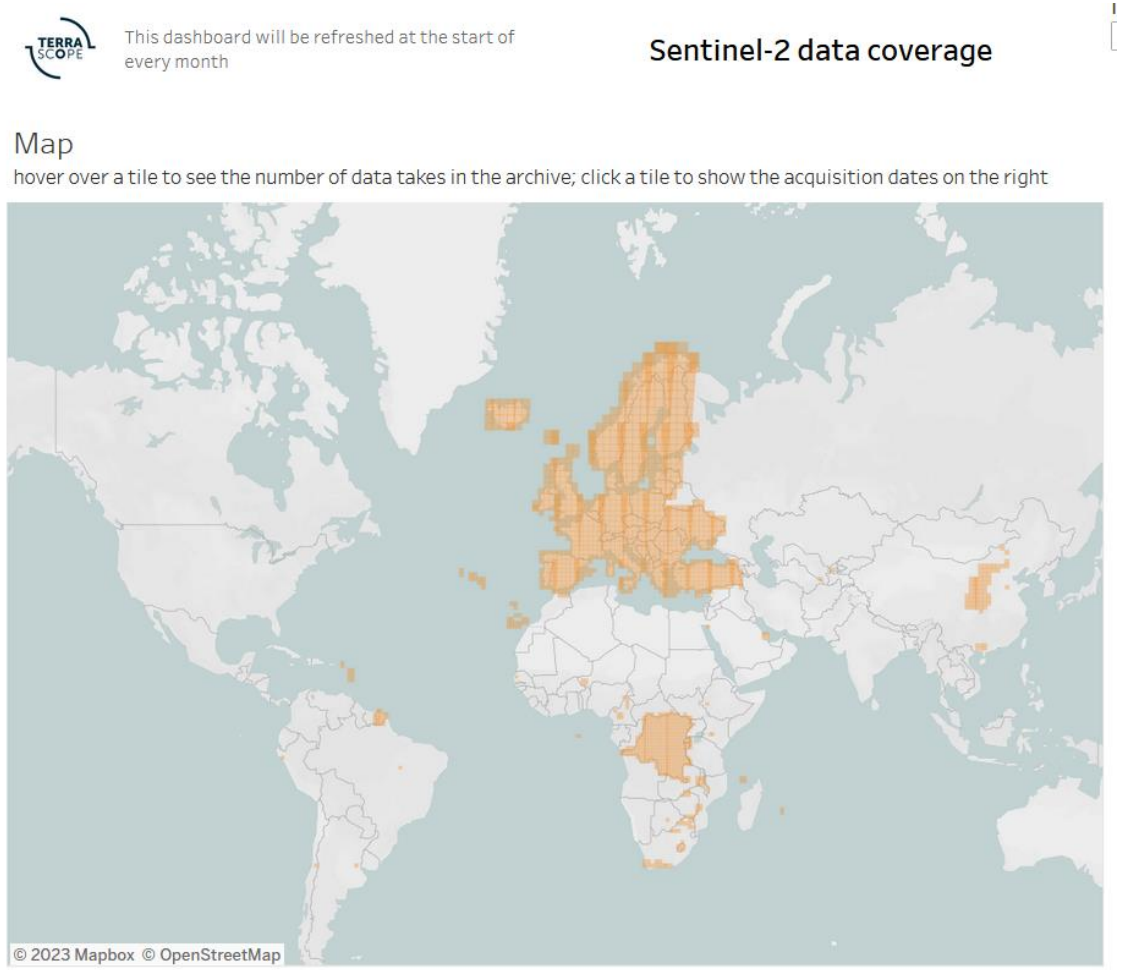
Data and System Requirements

- ICOS dataset constantly updated – matchup dataset to be generated on demand
- High computing performances to manage massive amount of EO data archive – time series
- Direct Access to Sentinel-2 and Sentinel-3 products – high temporal and spatial coverage over Europe
- Outcomes of analysis on Bio-geophysical variables measured at ICOS stations that can be of interest for Cal Val activities

Variable	Protocol applied
Land Surface Albedo	Measured with a radiometer installed between 2 and 10 meters above the canopy on the tower. The sensor is calibrated every 2-3 years. Implemented in all the ICOS sites active. Data collected every 20 seconds.
Phenology	Under implementation using the Star-Dot camera and the same routine applied in the Phenocam network in all the Class1 stations. Under evaluation the possibility to install also below canopy cameras in forest for the understory phenology. Data collected every half hour.
Land Surface Temperature	Currently under discussion for the implementation, ICOS is evaluating Infrared thermometers and also Thermal Cameras to be mounted on the tower. Type of sensor, protocol, calibration plan to be defined
FAPAR	All the sites have PPFD sensors IN and OUT on top of the towers. In a number of forests sites it is under implementation a network of below canopy incident PPFD. Data are collected every 20 seconds.
LAI	LAI is measured in campaigns with methods that are ecosystem specific. The measurements are done 6 times per year while understory LAI is measured once per year.
Volumetric Soil Water Content	Between 2 and 5 vertical profiles of temperature and soil water content sensors are installed, with at least 5 depths and up to 1m depth. Data collected every 60 seconds.
Leaves nutrients	If of interest, chemical elements content of leaves is measured between 1 and 3 times per year through 30 samples collected from the most representative species. Elements include Ca, Cu, Fe, Mg, Mn, C, N, P, K and Zn, in addition to the LMA ration

Cloud-based Data Services: Analysed Solutions

Terrascope (VITO) Belgian platform that provides **free and open data** with an **excellent back-end IT** to manage massive amount of data accessing an **efficient application layer** Belgian Collaborative Ground Segment



Earth Console (Progressive Systems) **cloud-based platform** comprising a set of support services to facilitate Earth Observation data exploitation and directly **access CREODIAS data archive.**

Datasets	Products	Instrument	Locally Held
Sentinel-2A & Sentinel-2B	L1C	MSI	Full archive
	L2A		- Orderable */** - Cached ***
Sentinel-3A & Sentinel-3B	L1 SLSTR	SLSTR	Full archive
	L1 OLCI	OLCI	
	L1 SRAL	SRAL	
	L2 SLSTR (LST/WST)	SLSTR	
	L2 OLCI	OLCI	
	L2 SRAL	SRAL	

Jupyter Notebook prototype:

1. **Satellites data** extraction in a defined spatial and temporal window (match-up with ICOS measurements) – *Rasterio and Proj python libraries*
2. Access to the **ICOS data portal** to extract the dataset – *ICOS Carbon Portal python library*

ICOS4CalVal - Terrascope Prototype (I)

https://www.icos-cp.eu/observations/station-network

- Locations of all ICOS sites retrieved and displayed on an interactive map
- Name, geographical coordinates and site type information

Sentinel-2 time series over ICOS station Network

The goal of this notebook is to extract Sentinel-2 match-ups over the Integrated Carbon Observation System (ICOS) stations (https://www.icos-cp.eu/) with the purpose of implementing a tool that uses the ICOS forest ecosystem sites to validate the main key terrestrial ECVs from remote sensing satellites. The mismatch between the measurements acquired from satellite and ground-based platform due to the spatial and temporal heterogeneity of surfaces and the different spatial and temporal sampling shall be managed in a second step of the analysis by quantifying the agreement of the two datasets in terms of temporal and spatial consistency.

Within this example we will use the location of the ICOS sites for calculating Sentinel-2 time series. To start, the location of all ICOS sites will be retrieved and displayed on the map together with geographical coordinates. The notebook will calculate the time series of imagery acquired over the selected site with a given radius that defines the region to be analised.

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Collecting ICOS sites

ICOS provides the list of the stations through a web interface (https://www.icos-cp.eu/observations/station-network) where to export all information in a CSV file. By parsing this file we can extract the geographical information for each station. The resulting list of ICOS sites will be displayed on a map for further discovery.

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Overview of ICOS sites

After fetching the location of each ICOS site, we show them on the map. For this we are using the *ipyleaflet* library (https://ipyleaflet.readthedocs.io/en/latest/index.html) to create a map and a clustered view of all sites. A tooltip is added to each marker, showing the main information of the site.

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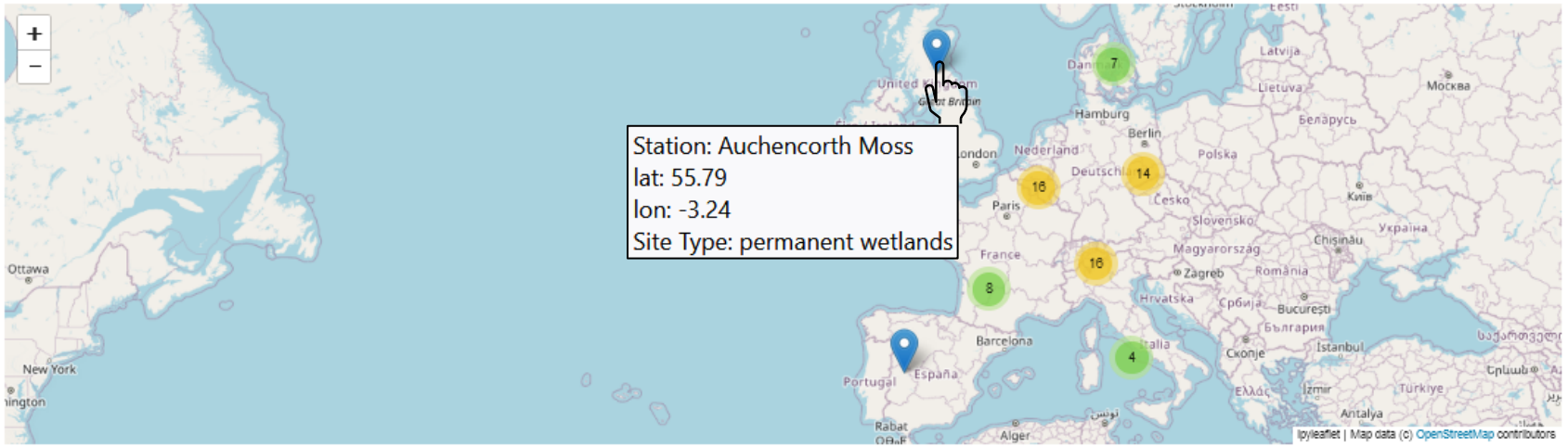
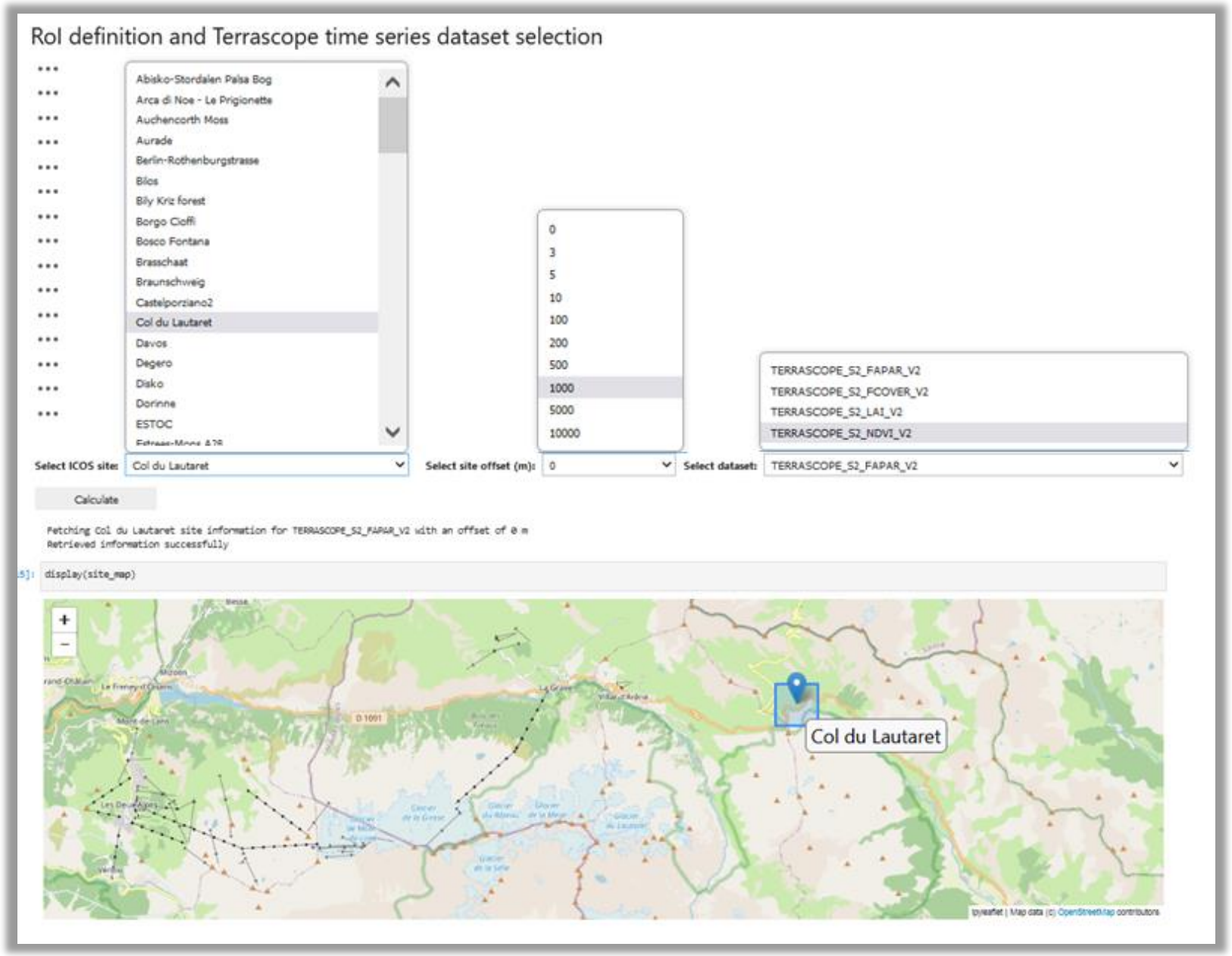


ICOS4CalVal - Terrascope Prototype (II)



- Selection of ICOS site
- Definition of AoI around the ICOS site
- Selection of satellite dataset of imagery acquired over the AoI

ICOS4CalVal - Terrascope Pr

RoI definition and Terrascope time series dataset selection

Abisko-Stordalen Palsa Bog
Arca di Noe - Le Prigionette
Auchencorth Moss
Aurade
Berlin-Rothenburgstrasse
Bilos
Bily Kriz forest
Borgo Cioffi
Bosco Fontana
Brasschaat
Braunschweig
Castelporziano2
Col du Lautaret
Davos
Degero
Disko
Dorinne
ESTOC

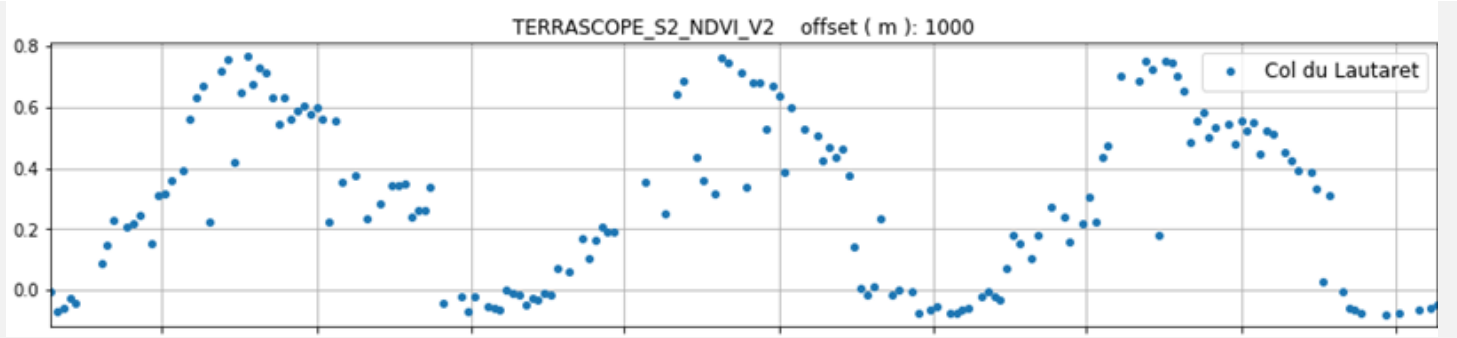
0
3
5
10
100
200
500
1000
5000
10000

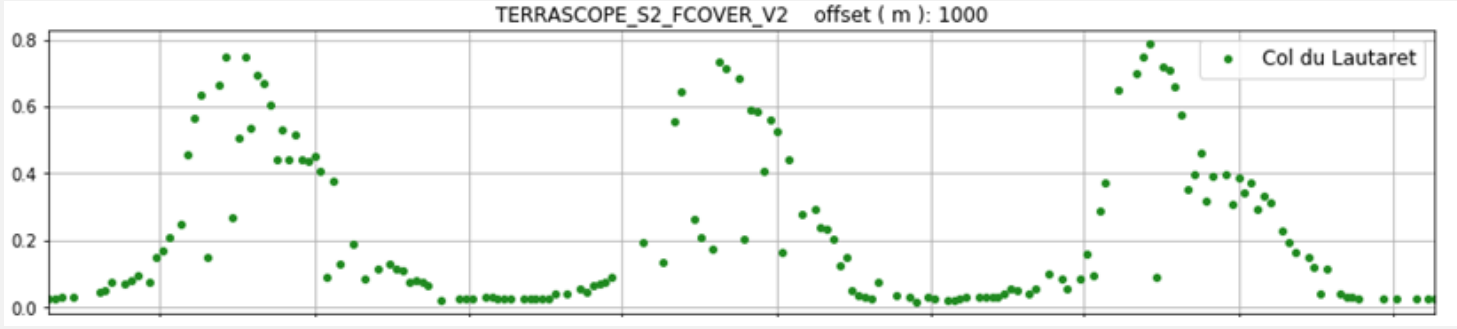
Select ICOS site: Col du Lautaret
Select site offset (m): 0
Select data

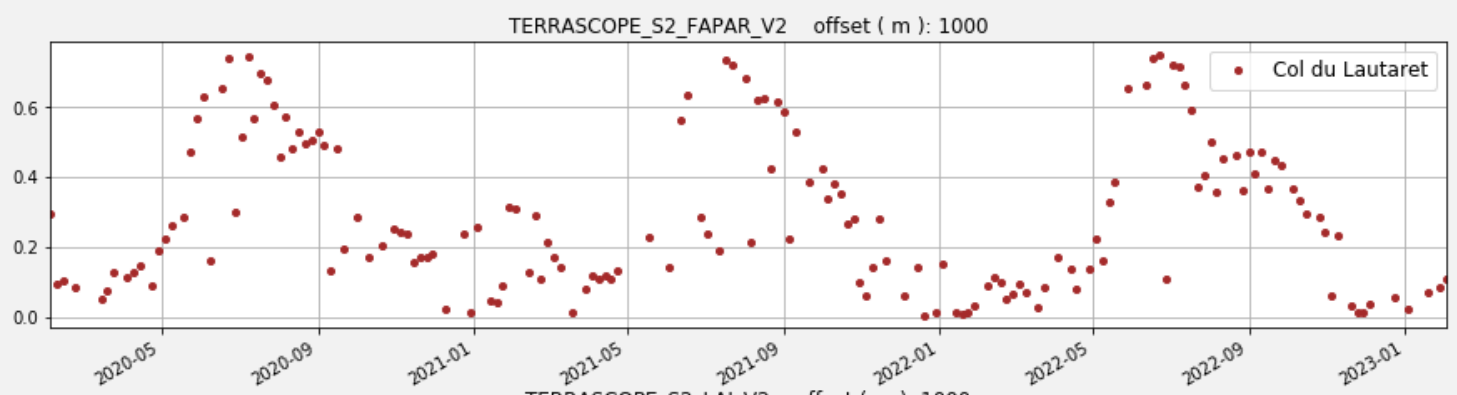
Calculate

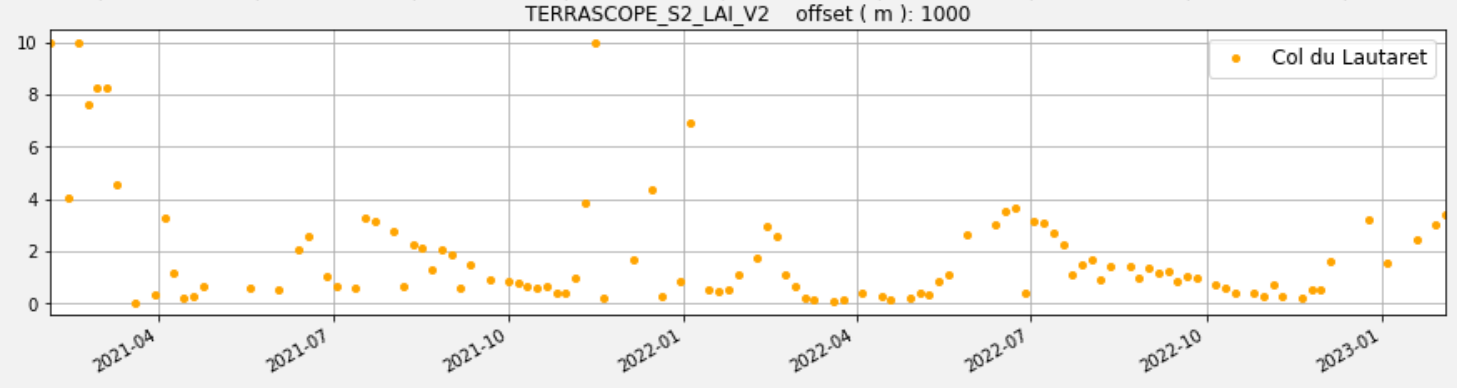
Fetching Col du Lautaret site information for TERRASCOPE_S2_FAPAR_V2 with an offset of 0 m
Retrieved information successfully

[5]: display(site_map)

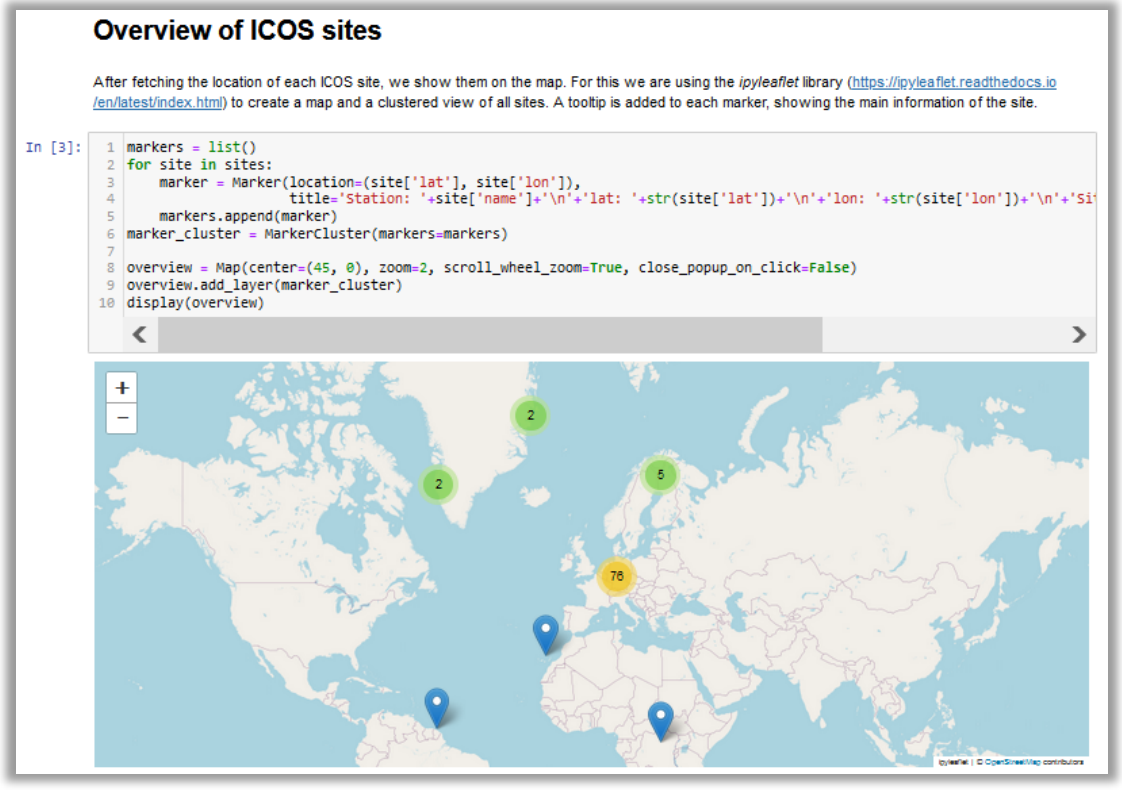


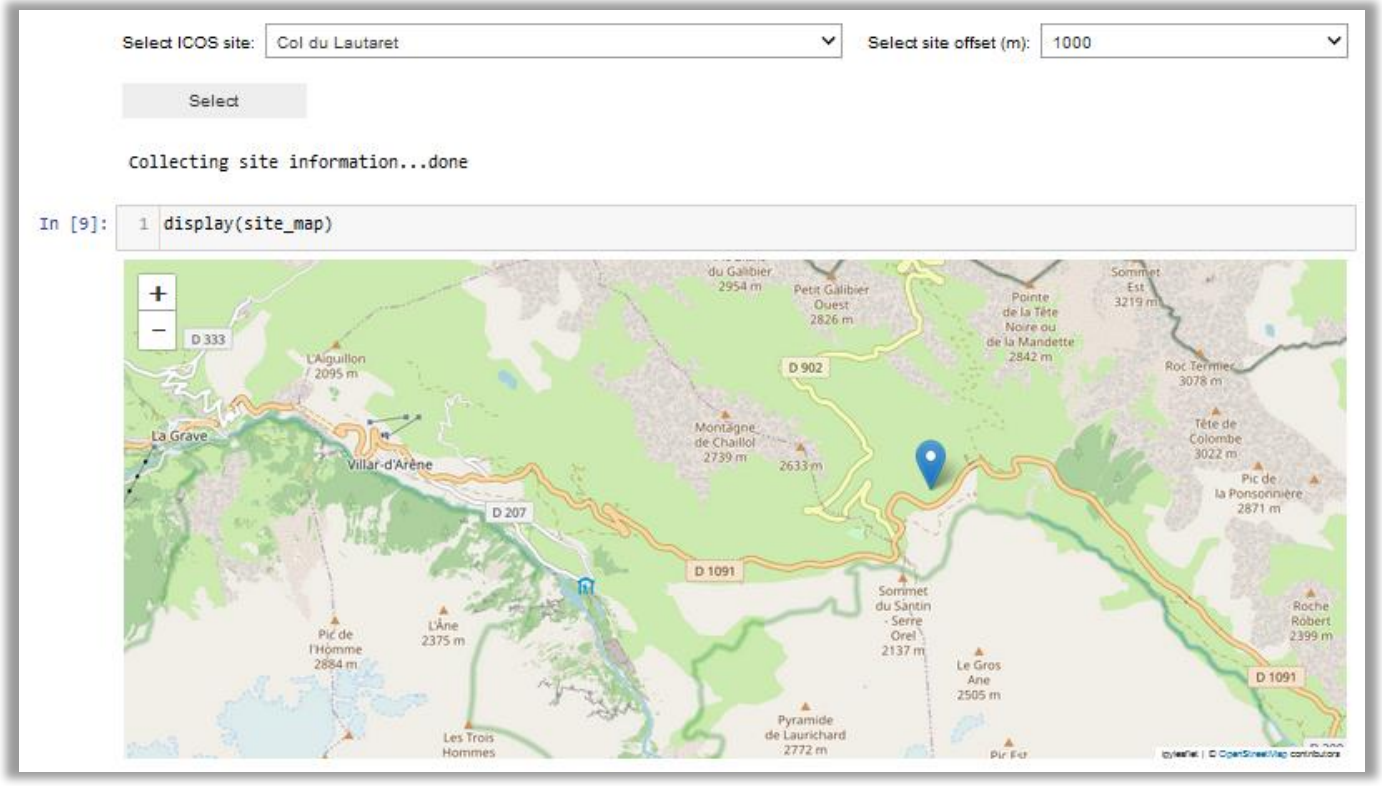






ICOS4CalVal – Earth Console/CREODIAS Prototype (I)





Interactive map to select spatial and temporal parameters to be given as input to the CREODIAS finder

StartDate='2020-02-04’
EndDate='2023-02-03’

169 products

```
In [109]:
input_prod=query_maker.productIdentifiers
input_prod

Out[109]: ['/eodata/Sentinel-2/MSI/L2A/2020/02/04/S2A_MSIL2A_20200204T103221_N0214_R108_T31TGK_20200204T121112.SAFE',
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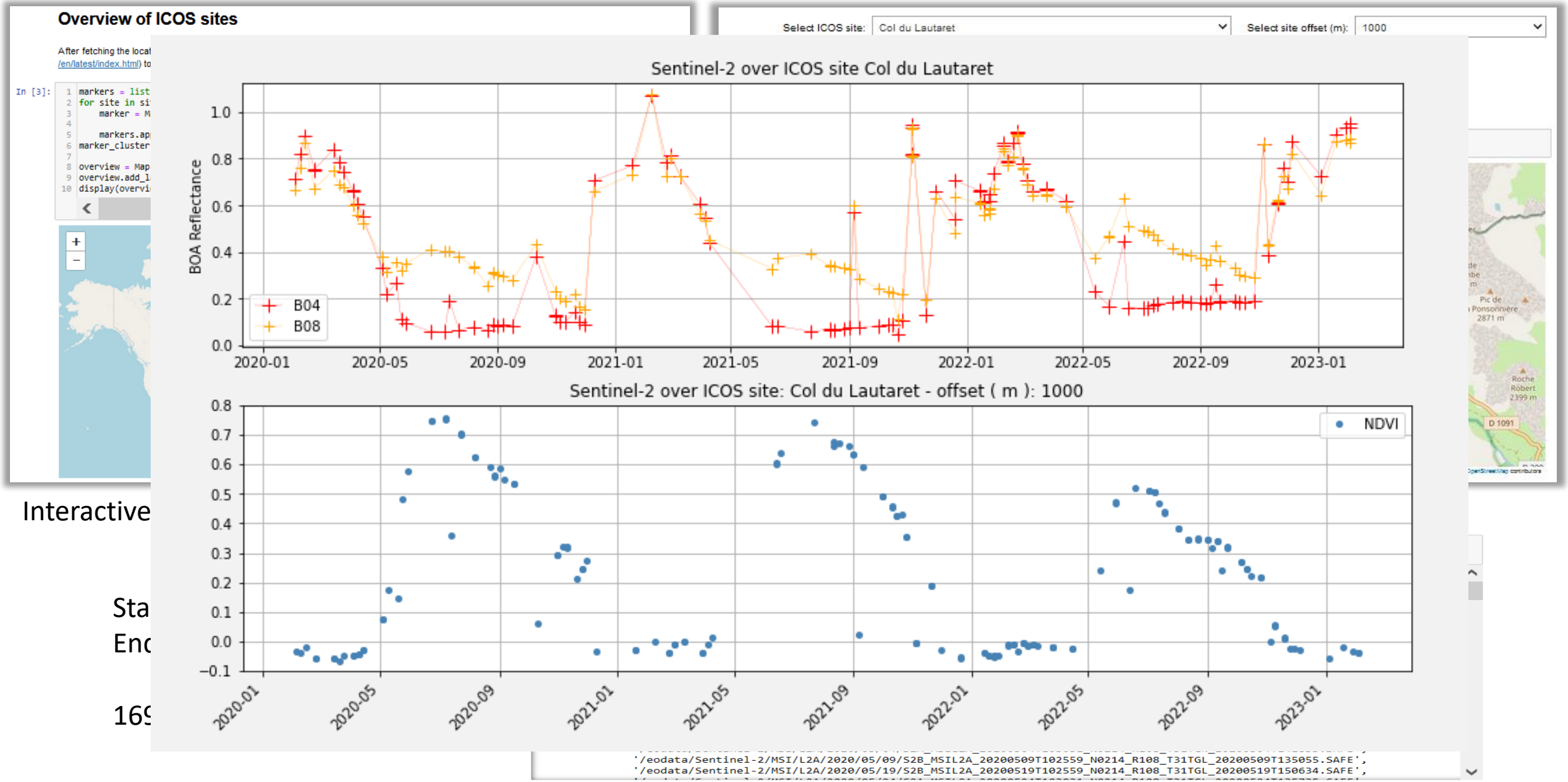
ICOS4CalVal – Earth Console/CREODIAS Prototype (I)



Interactive

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Conclusions and Way Forward

- Efficient tool to easily access satellites data by means of a user-friendly tool interfacing a performing cloud platform with direct access to the data archive

→ Similar solution to be implemented for Sentinel-3 products
→ Finalize the analysis of infrastructure solution in terms of performances, cost associated and spatial/temporal data coverage

- Definition of a good strategy to access the ICOS data

→ Finalization of a set of Bio-geophysical variables measured at ICOS stations that can be of interest for Cal Val activities - close cooperation with ICOS thematic center
→ Interactive tool instead of a fixed dataset will give the possibility to easily update the required dataset according to any possible new requirement coming from the community

→ Statistical metrics to quantify the agreement of the two datasets in terms of temporal and spatial consistency

→ Delivery of tutorial material associated to the Notebooks and outreach activities

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