eLTER

Integrated European
Long-term Ecosystem, critical zone and
socio-ecological Research

Filling a critical gap for top-class science at the continental scale

PhenoApp: A GEE and Geemap based tool to retrieve and validate phenological satellite data

eLTER + \ WP 4.4 \ PhenoApp

eLTER Software workshop - Introducing new tools. Lyon 7-10 february 2023

Ricardo Díaz-Delgado **Diego García Díaz**

eLTER Work Package 4
Estación Biológica de Doñana (CSIC)

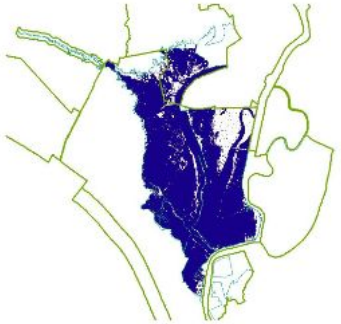
DIEGO GARCÍA DÍAZ

Estación Biológica de Doñana CSIC

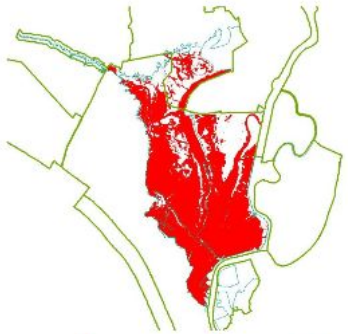
LAST-EBD
LABORATORIO DE SIG Y TELEDETECCIÓN ESTACIÓN BIOLÓGICA DE DOÑANA

DATOS PERSONALES	
Institución	Estación Biológica de Doñana (EBD)
IP	Diego García Díaz
Enlace personal	http://www.ebd.csic.es/laboratorio-sig-y-teledeteccion-last
Web personal	https://github.com/Digdgeo
EXPERIENCIA Y SERVICIOS	
Grupo	Remote Sensing and GIS lab LAST-EBD)
Experiencia del grupo	Satellite time series; remote sensing of wetlands, land-cover classification; upscaling
Experiencia personal	Remot Sensing, GIS, GEE, Python
Servicios ofrecidos	Innundation maps, hydroperiod maps, water turbidity maps, aquatic vegetation cover in wetlands
Enlaces a servicios	https://www.csic.es/es/investigacion/catalogo-de-servicios-cientifico-tecnico/unidades-de-servicio/laboratorio-de-sistemas
Conjunto de datos	Doñana inundation timeseries derived form Landsat sensors1983-2020; Doñana annual hydroperiod, Doñana water turbidity, Temporary ponds cartogaphy in Doñana Aeolian sands
Enlaces a conjuntos de datos	http://venus.ebd.csic.es/imgs/
Aplicaciones	ndvi2gif python Package
Enlaces a aplicaciones	https://pypi.org/project/ndvi2gif/
Otros recursos	Cartografía Digital de Seguimiento del Espacio Natural Doñana
Enlaces a otros recursos	http://venus.ebd.csic.es/seguimiento/

- Geographer linked to LAST-EBD since 2014
- GIS & Remote Sensing Technician
- Python applied to process satellite data
- Flooding, Water Depth, Turbidity, Hydroperiod
- Vegetation Healthy, Phenology
- Coastal Geomorphology



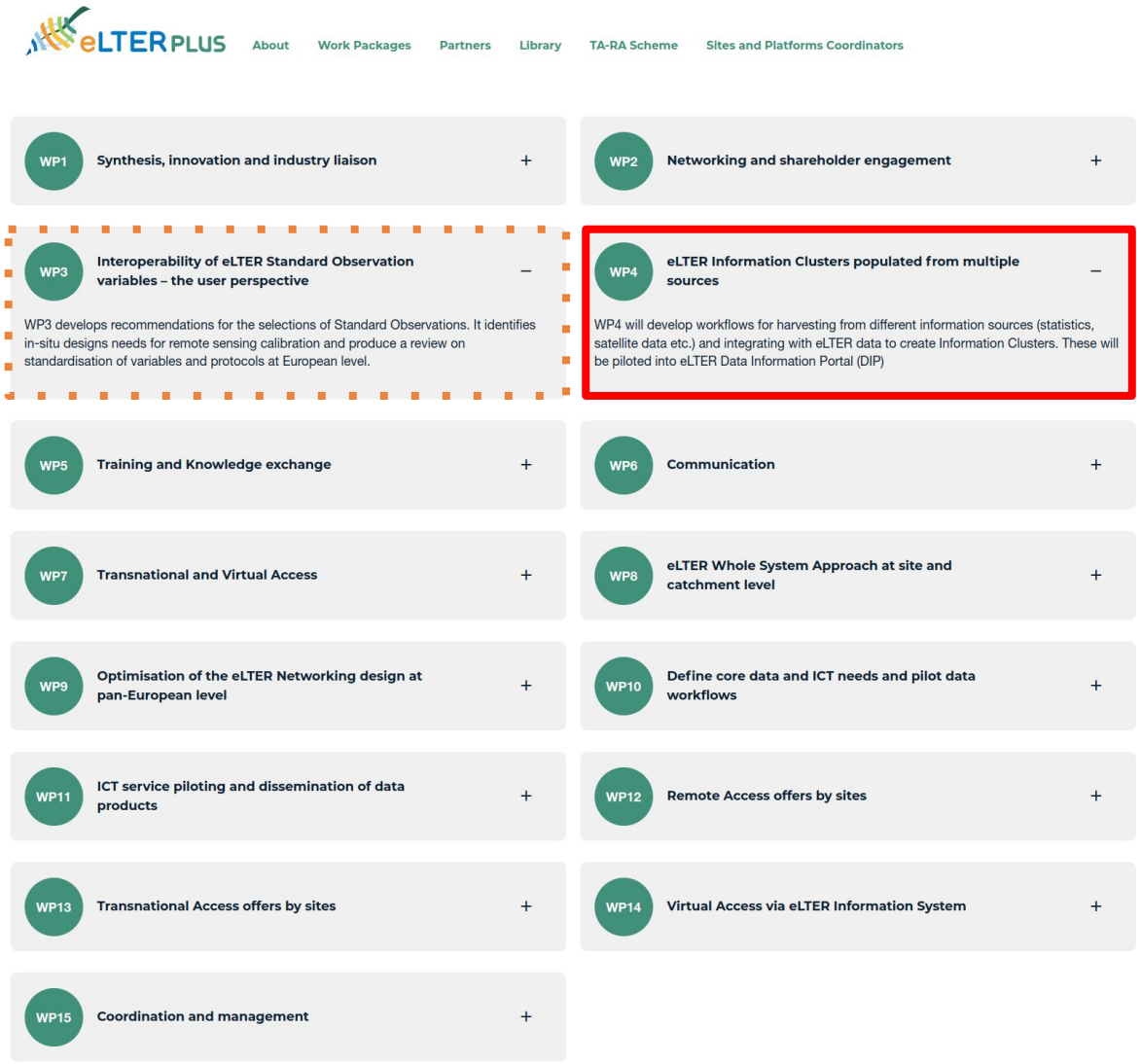
MDT



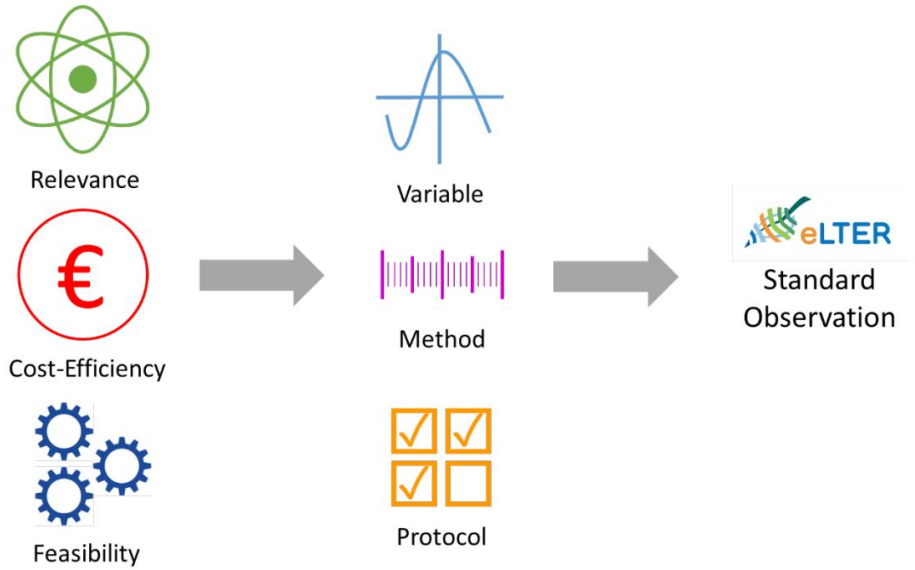
Landsat

eLTER

eLTER Plus Task 4.4. eLTER specific downstream services contributing to eLTER SOV: a pilot study



eLTER Standard Observations (SO) will include the minimum set of variables as well as the associated method protocols that can characterize adequately the state and future trends of the Earth systems



Ref. Ares(2021)1707535 - 09/03/2021

eLTER PLUS

European long-term ecosystem, critical zone and socio-ecological systems research infrastructure PLUS

Discussion paper on eLTER Standard Observations (eLTER SOs)

Deliverable D3.1

8th March 2021

Editorial team:

Steffen Zacharias[1], Saku Anttila[2], Jaana Bäck[3], Kristin Böttcher[2], Ulf Mallast[1], Michael Mirtl[1], Marcus Schaub[4], Volodymyr Trotsiuk[4],

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Task 4.4 is focused on prioritizing the needs eLTER SOV identified in the WP3 Discussion Paper available from EO data products for rapid harvesting and user uptake. **Validation** and **upscaling** using in situ data are the main drivers for T4.4 goals

Compartment	Variable	Relevance	Costs	Feasibility	Priority	Optimal Frequency of Measurement	Field Laboratory Model	Remarks on method	Available protocols (example)	EI Component
Terrestrial	Habitat Structure, vegetation/plant phenology based on satellite remote sensing (European extent)	5	5	3	A	5-year interval	Field model	Remote sensing: Sentinel imagery or equivalent 10-20m for habitat mapping, A combination of sensors and techniques can be suited to each site, with sentinel imagery supporting harmonized coverage across	INT, LUCAS	Biotic heterogneity
Terrestrial	Plant phenology	3	5	4	A	Daily	Field	Automated cameras	INT	Biotic heterogneity
Soil	Soil temperature *(Table 13. Copernicus LST)*	4	5	5	A	30 min	Field	Beyond point scale, wireless sensor networks	INT	Abiotic
Lake	Water level *(Table 13. Copernicus Water bodies)*	5	5	5	A	daily	Field	(Surface and) bottom pressure sensors	ICP Waters	Water balance
Land use and land cover change	Land use & land cover change (historic) *(Table 13 Regional Habitat Landscape heterogeneity and composition)*	5	2	3	A					Socio-ecological

eLTER

- Phenology
- LST
- Water bodies
- Landscape metrics ?

Sites selection according to available in situ datasets.

Pilot will address in situ temporal validation and spatial upscaling of SOV (MODIS, Sentinel 2, Phenocams, **in situ data**).

Workflow in Jupyter Enviroments (eLTER Datalab) enabling:

-Download of site datasets and spatial layers upon request

-Upload of in situ data for validation purposes

Sites PIs will be consulted on this strategy and the services, on their value and future uptake.

The Task will provide an assessment report on eLTER Site Category specific packages of **recommended Earth Observation variables** according to their accuracy for the eLTER Sites with in situ data for validation (WP3).

The integrated and validated products **downstreamed** through the eLTER DIP (WP11) as downstream services for access by end users.

Specific material for **end user training** (WP5) will be produced.

GeeLTERMap

The aim of GeeLTERMap is to provide an easy mapping interface from which people can visualize, analyze, download and check some SOVs retrieved from Earth Observation (Phenology, Land Surface Temperature and Flood).

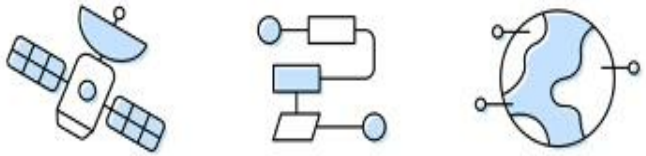
GeeLTERMap (at the moment) consist in 3 buttons:

1. PhenoApp
2. LST
3. Water Detection
4. Landscape Metrics

GeeLTERMap

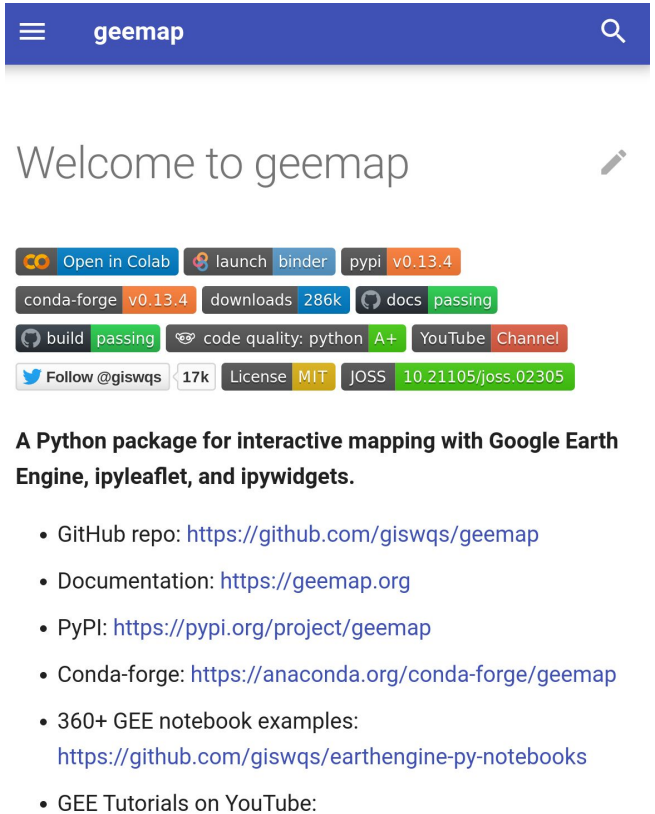
Google Earth Engine

- Cloud computing to visualize and process Geospatial Data
- Petabytes of data (lots of satellite/sensors)
- Raster data (Land cover, climatic data, etc...)
- Vectorial data
- Use your own datasets (space limitation)
- Hundreds of algorithms available
- Javascript and Python APIs
- Huge community very active
- **Design local run global**



Geemap

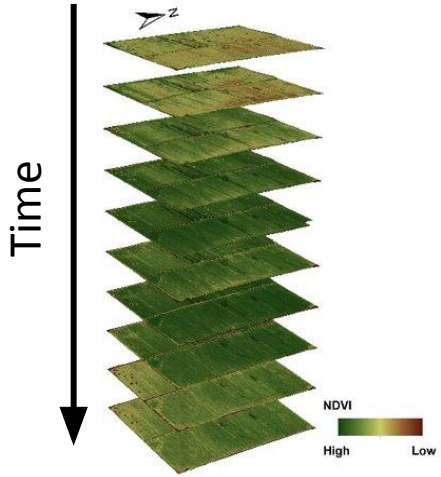
- Python package based in Google Earth Engine python API and Map application Leaflet.
- It allows to apply the power of Python data analysis to Google Earth Engine datasets

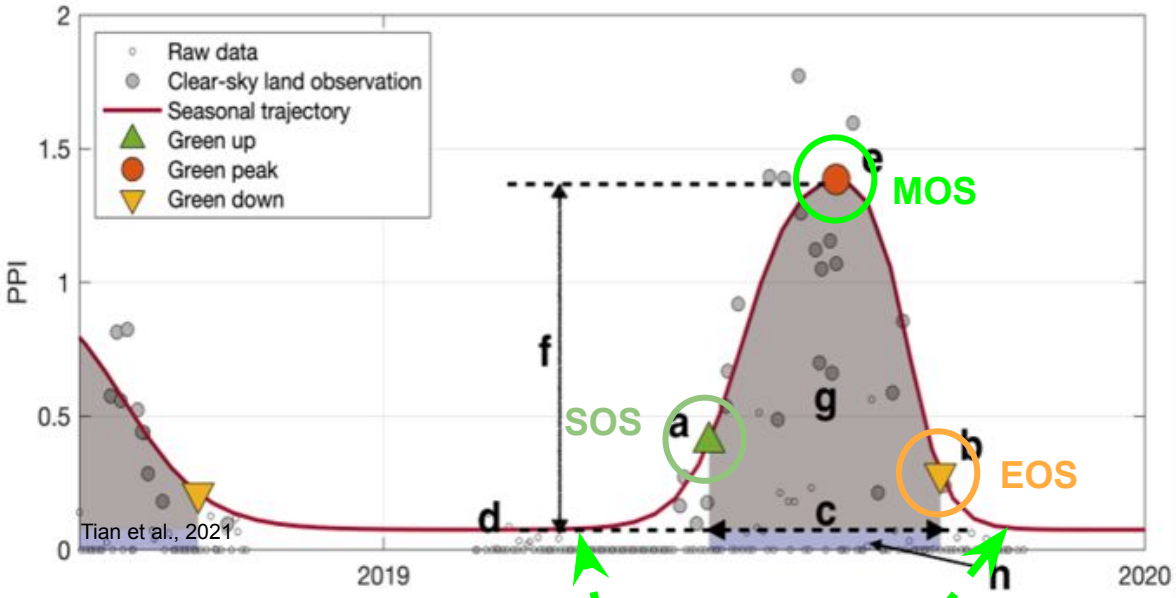


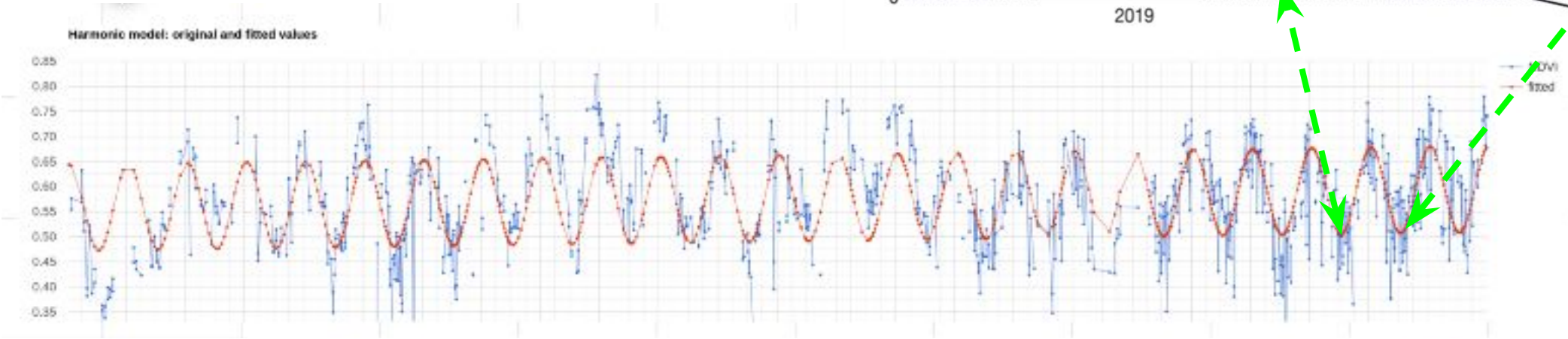
eLTER

GeeLTERMap (PhenoApp. Phenology)

Phenology is the study of periodic events in biological life cycles and how these are influenced by seasonal and interannual variations in climate, as well as habitat factors (Merriam-Webster, 2020.).

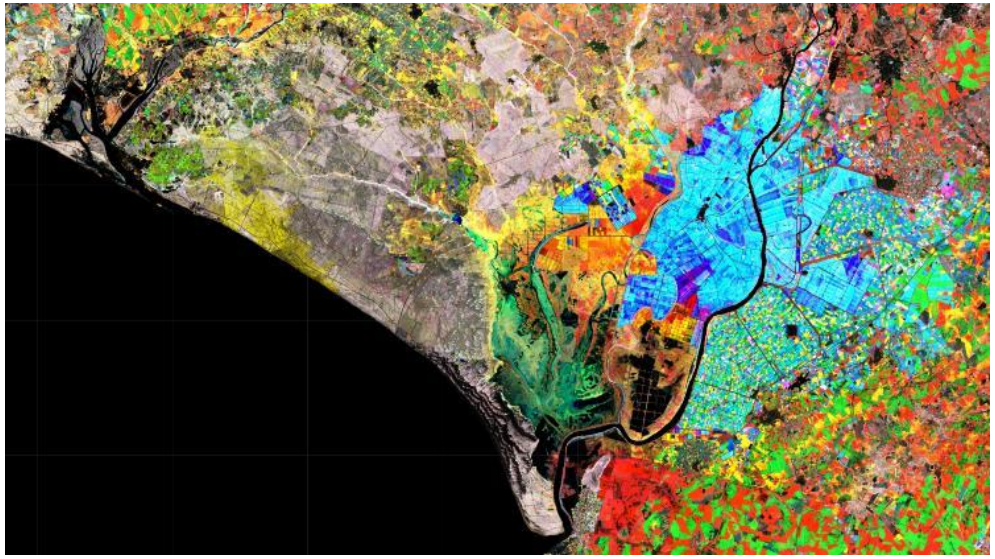


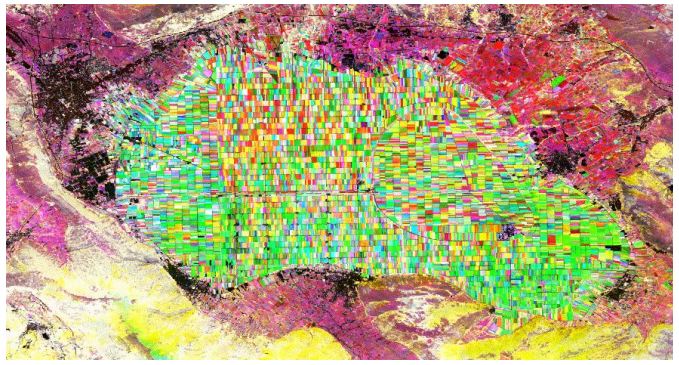


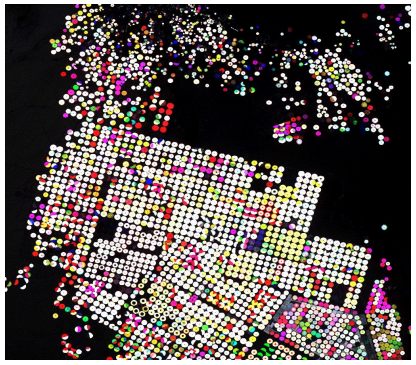


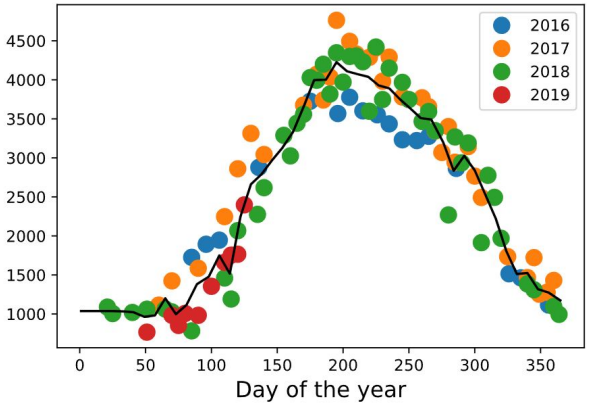
GeeLTERMap (PhenoApp. Datasets)

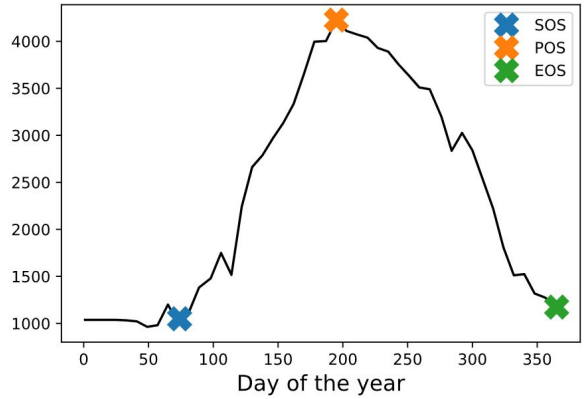
Alongside with Google Earth Engine and Geemap, PhenoApp uses **PhenoPy** and Ndvi2Gif python libraries. Ndvi2Gif allows us to generate seasonal composites using pixel stats for vegetation indexes. We use a 15 days window to get the maximun NDVI value in that period (3 Sentinel-2 images). Then, we use those 15 days composites like input for PhenoPY in order to get the phenometrics.











Start Date	2017
Spatial Resolution	10 m
Vegetation Index	NDVI (*)
Growth Cycles	1
Source	PhenoPY

(*) Potentially any vegetation index could be applied

Not a GEE tool
Process local and slow

Can be applied to any satellite images
Python process, easy integration

GeeLTERMap (PhenoApp. Datasets)

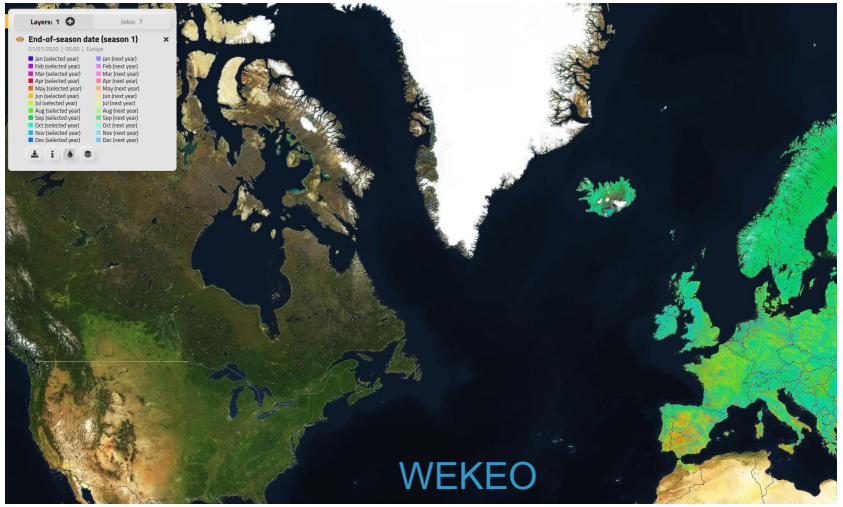
The other 2 datasets that we offer at this point are:

MODIS MCD12Q2.006

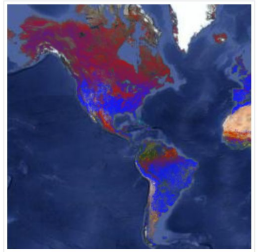
Start Date	2001
Spatial Resolution	500 m
Vegetation Index	EVI
Growth Cycles	2
Source	USGS/GEE

Lots of NoData
Coarse spatial resolution

+20 years of data
GEE collection



MCD12Q2.006 Land Cover Dynamics Yearly Global 500m



Dataset Availability

2001-01-01T00:00:00Z - 2019-01-01T00:00:00

Dataset Provider

NASA LP DAAC at the USGS EROS Center

Earth Engine Snippet

```
ee.ImageCollection("MODIS/006/MCD12Q2")
```

Vegetation Phenology and Productivity

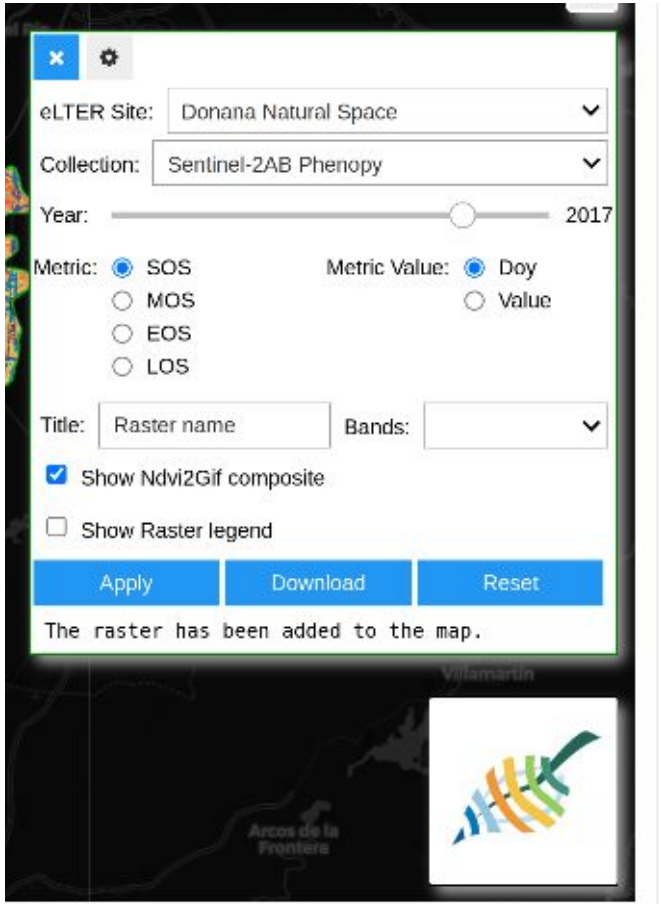
Start Date	2017
Spatial Resolution	10 m
Vegetation Index	PPI
Growth Cycles	2
Source	Copernicus/Wekeo

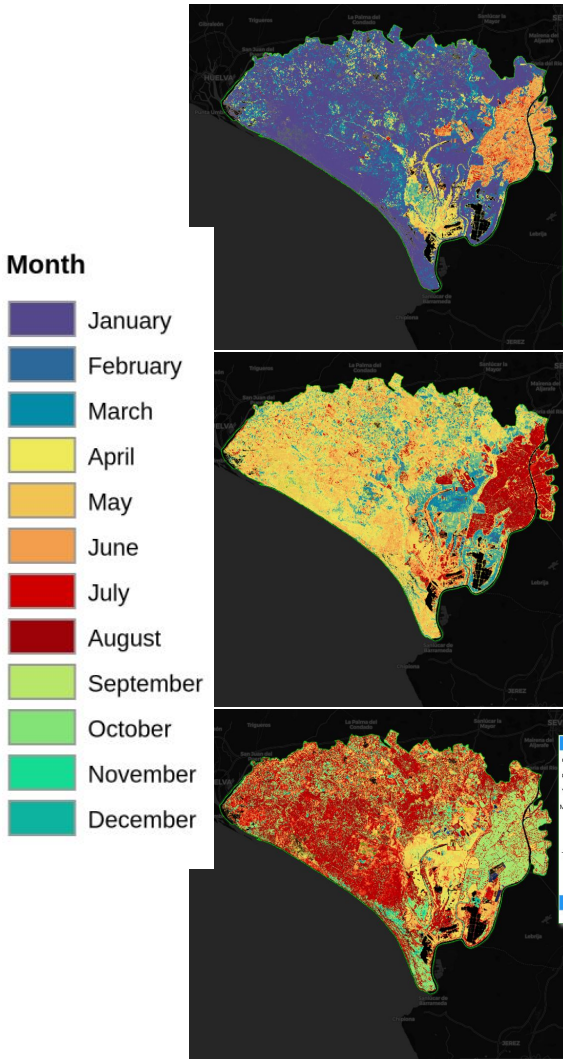
Not a GEE collection
Available since 2017

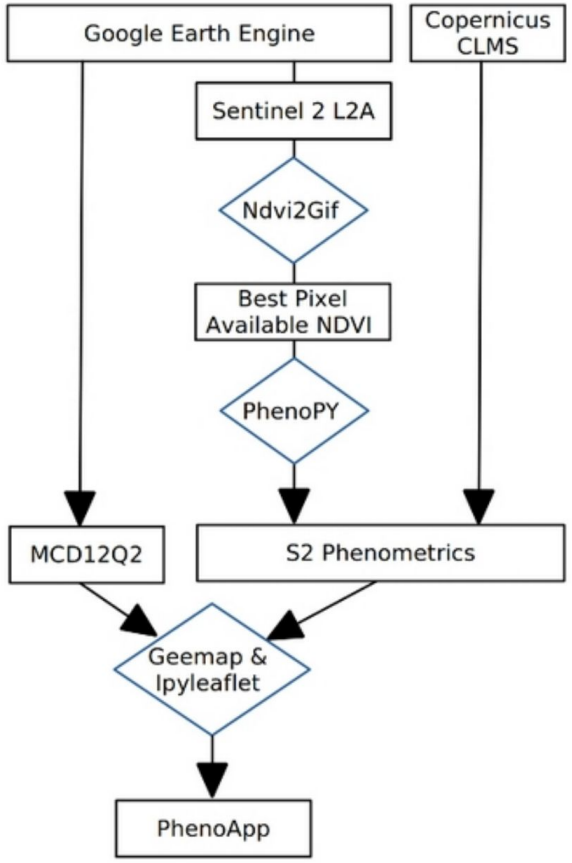
10 m spatial resolution
Python script to download data for eLTER sites

GeeLTERMap (PhenoApp. Tool)

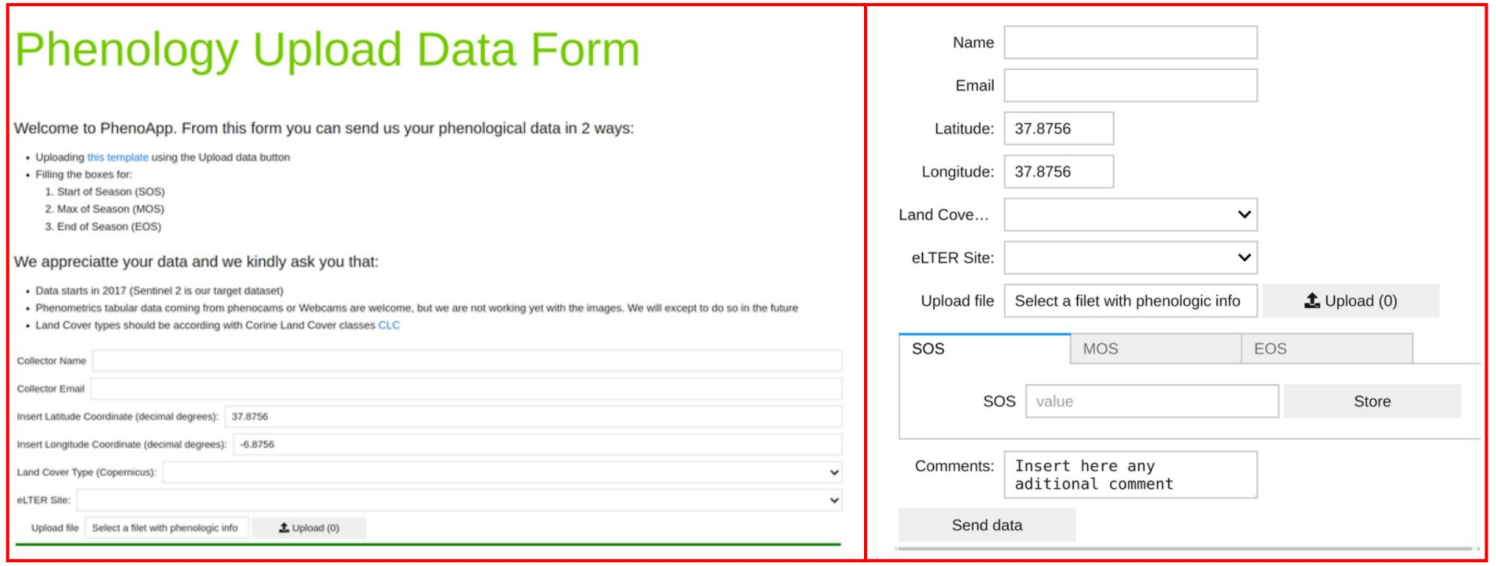
The tool icon opens a box dialog from which we can choose the eLTER site, the satellite collection, year, phenometric (Day of the year and/or value when reached), choose a raster name and band combination to download, show Ndvi2Gif composite, raster legend, Apply, Reset and Download.

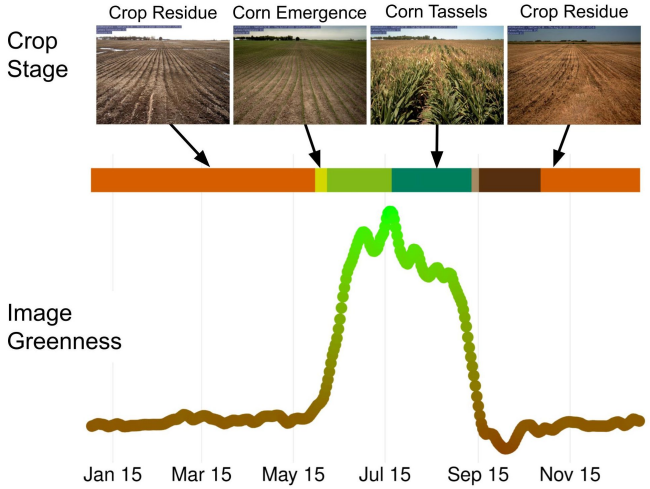


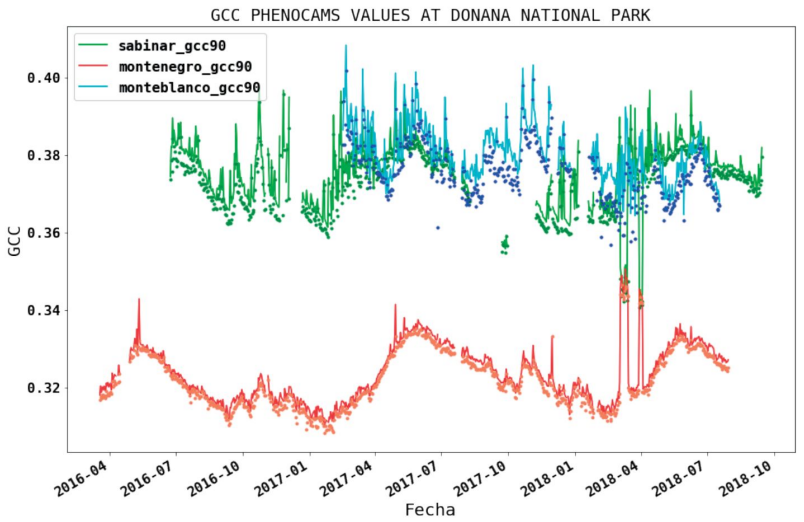


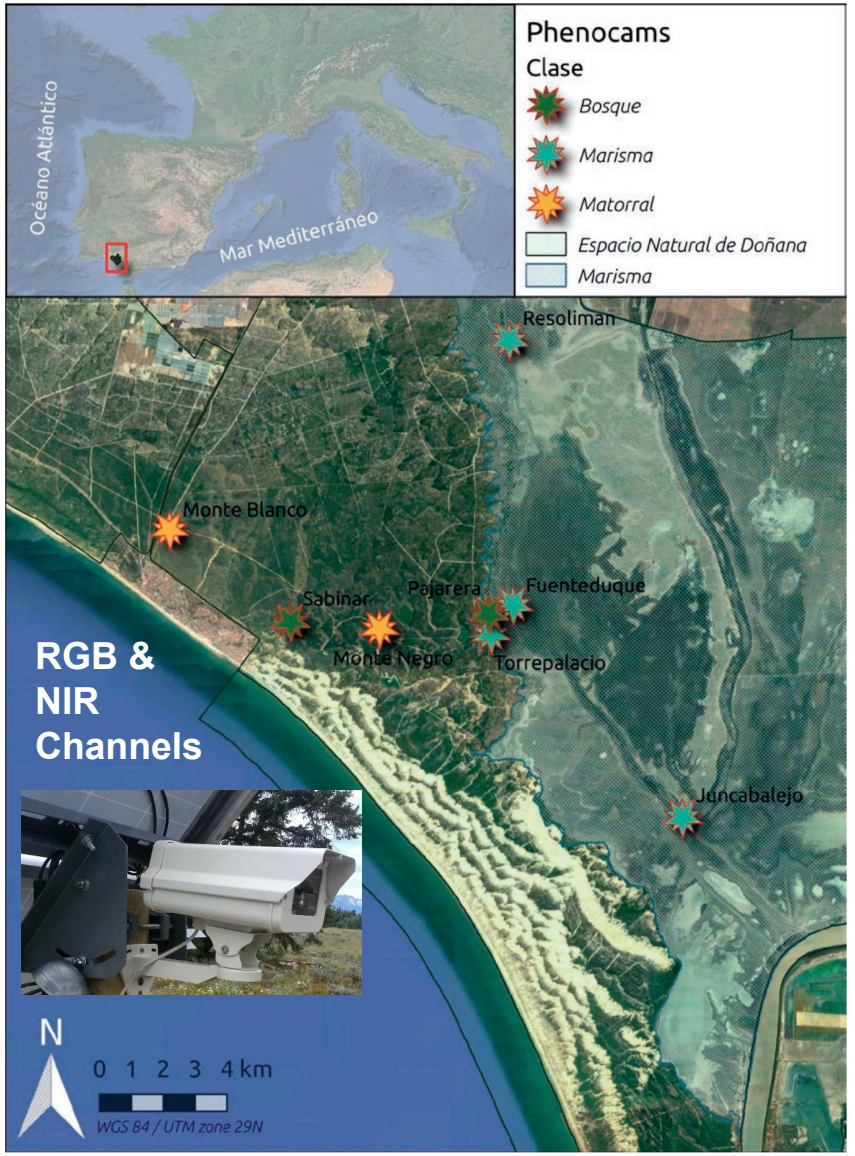


GeeLTERMap (PhenoApp. Validation)









Taylor et al., 2022

eLTER

Recibido: 14/11/2022
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in press

CASO PRÁCTICO

PhenoApp. Una aplicación basada en Google Earth Engine para el monitoreo de la fenología

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Laboratorio de Sistemas de Información Geográfica y Teledetección, Estación Biológica de Doñana (CSIC), Avenida Américo Vespucio 26, Sevilla, España.

Resumen: La aplicación PhenoApp ha sido desarrollada en el marco de los proyectos eLTER Plus y SUMHAL, como una herramienta dirigida a científicos y gestores de los sitios integrados en la red eLTER, con la cual puede realizarse un seguimiento de la fenología a largo plazo de diferentes cubiertas vegetales. La aplicación proporciona un mapa dinámico, que permite la selección de cualquier sitio de la red y consultar las métricas fenológicas de cada píxel o grupo de píxeles generadas con la serie de imágenes Sentinel 2 usando las librerías de Python Ndvi2Gif y PhenoPY. La aplicación integra también los productos de fenología de MODIS (MCD12Q2.006) y de Copernicus Sentinel 2 *High Resolution Vegetation Phenology Product* (HR-VPP). Además, la aplicación incorpora un formulario que permite al usuario proporcionar los datos de fenología obtenidos in situ (mediante observación directa o fenocámaras), que se usarán para realizar una validación de los distintos productos obtenidos vía satélite. A modo de ejemplo, se muestra la validación efectuada en uno de los sitios de la red eLTER ubicado en el Espacio Natural de Doñana (END), usando como datos *in situ* los proporcionados por la red de fenocámaras instaladas en la Reserva Biológica de Doñana a partir de 2016, dentro del marco de la Infraestructura Científica y Técnica Singular de Doñana (ICTS-Doñana). Un análisis de validación preliminar pone de manifiesto la necesidad de considerar las discrepancias entre los distintos productos y métodos de acuerdo con la variabilidad fenológica inherente a cada ecosistema.

Palabras clave: fenología, fenocámaras, Google Earth Engine, Geemap, Python.

PhenoApp. A Google Earth Engine based tool for monitoring phenology

Abstract: PhenoApp application have been developed within the framework of the eLTER Plus and SUMHAL projects, as a tool aimed at scientists and managers of the sites integrated in the eLTER network, for which long-term phenology monitoring can be assessed. The application provides a dynamic map that allows the selection of any site in the network and queries the phenological metrics of each pixel or group of pixels generated with the Sentinel-2 time series of images using the Ndvi2Gif and PhenoPY python libraries. The application also integrates phenology products from MODIS (MCD12Q2.006) and Copernicus Sentinel 2 High Resolution Vegetation Phenology Product (HR VPP). In addition, the application incorporates a web form that allows the user to provide the phenology data obtained in situ (through direct observation or phenocams), which will be used to perform a validation of the different products obtained via satellite. As an example, we carried out a preliminary validation in one of the sites of the eLTER network located in the Doñana Natural Area (END). We used in situ data provided by the network of phenocams in the Doñana Biological Reserve since 2016 installed by the Singular Scientific and Technical Infrastructure of Doñana (ICTS-Doñana). A preliminary validation analysis highlights the need to consider the discrepancies between the different products and methods according to the phenological variability inherent in each ecosystem.

Key words: phenology, phenocams, Google Earth Engine, Geemap, Python.

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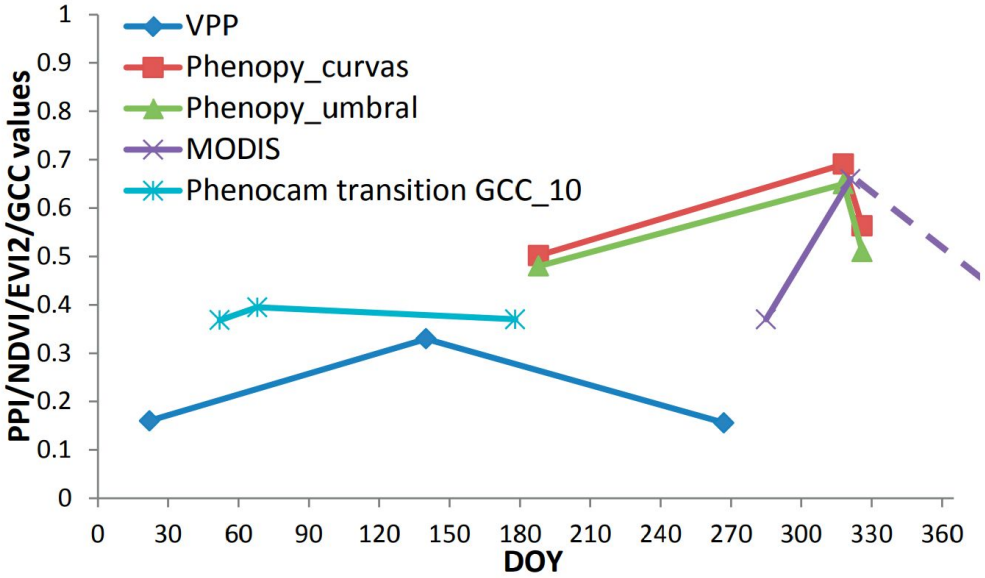
* *Corresponding author: diegogarcia@ebd.csic.es*



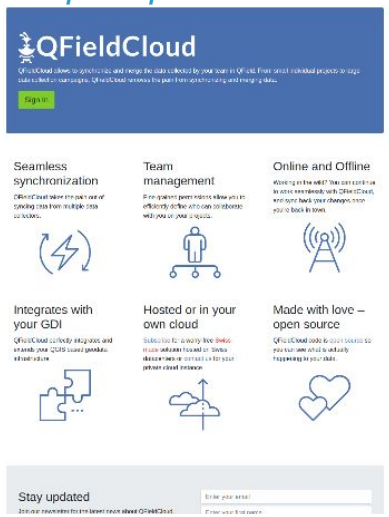
Hands On!

Hands On!

- QField Project
- PyHDA Wekeo Download Script
- PhenoApp Form
- PhenoApp Map
- Some Geemap coding applied to PhenoApp

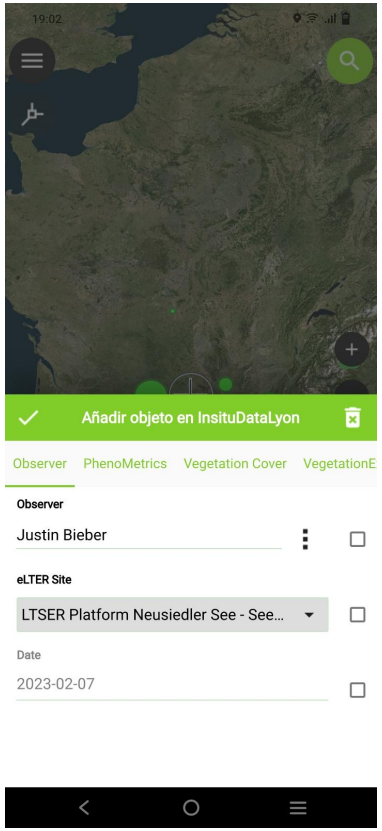
Hands On! QField Cloud

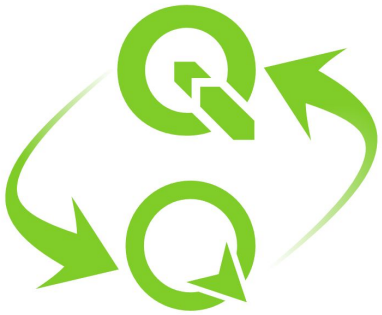
https://qfield.cloud/



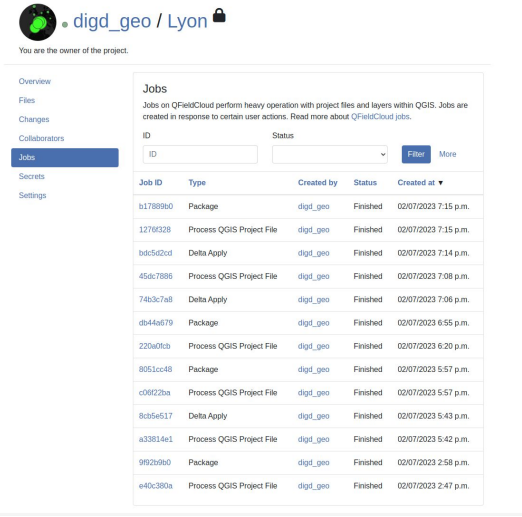
Create an Account

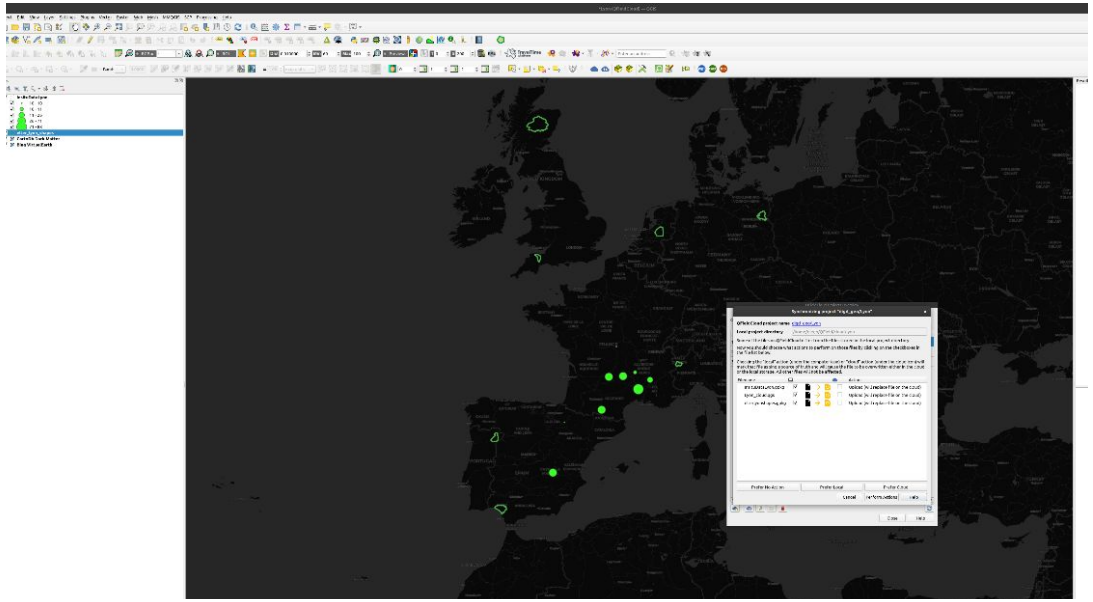
Be aggregated to project





Take & Send your data





Hands On! PyHDA & Wekeo Download

Wekeo is a platform to access Copernicus satellite data. It allow to check and to download data but download process could be difficult. Luckily they have developed a python package (HDA) to accelerate the downloading.

"./wekeo_downloadL.ipynb"

https://notebooks.apps.mercator.dpi.wekeo.eu/

By using HDA and our script is possible to use a shapefile as input and get all the images that intersect the shapefile, adding the possibilite to mosaic the tiles and crop with the shapefile.

HDA PYTHON LIBRARY

In this page

Note :

As an alternative to using the HDA API directly (see this guide) or the sample Jupyter notebooks, you can use the Python client library **hda**, that abstracts away the details of the API.

The following example explains how to download files into a virtual machine (https://www.wekeo.eu/docs/virtual-machines) instance, or a Jupyter Notebook (https://www.wekeo.eu/docs/using-jupyter) environment.

- First of all, this library needs to be installed in the environment. Open a terminal and type: `pip install hda`
- Afterwards, a configuration file needs to be created, in order to store the data-broker url, and the WEkEO credentials.
- Create a file in the root location of the current user
- Click File -> new -> Text File

  fill it with the following

```
url: https://wekeo-broker.apps.mercator.dpi.wekeo.eu/databroker
user: your_wekeo_username
password: your_wekeo_password
```

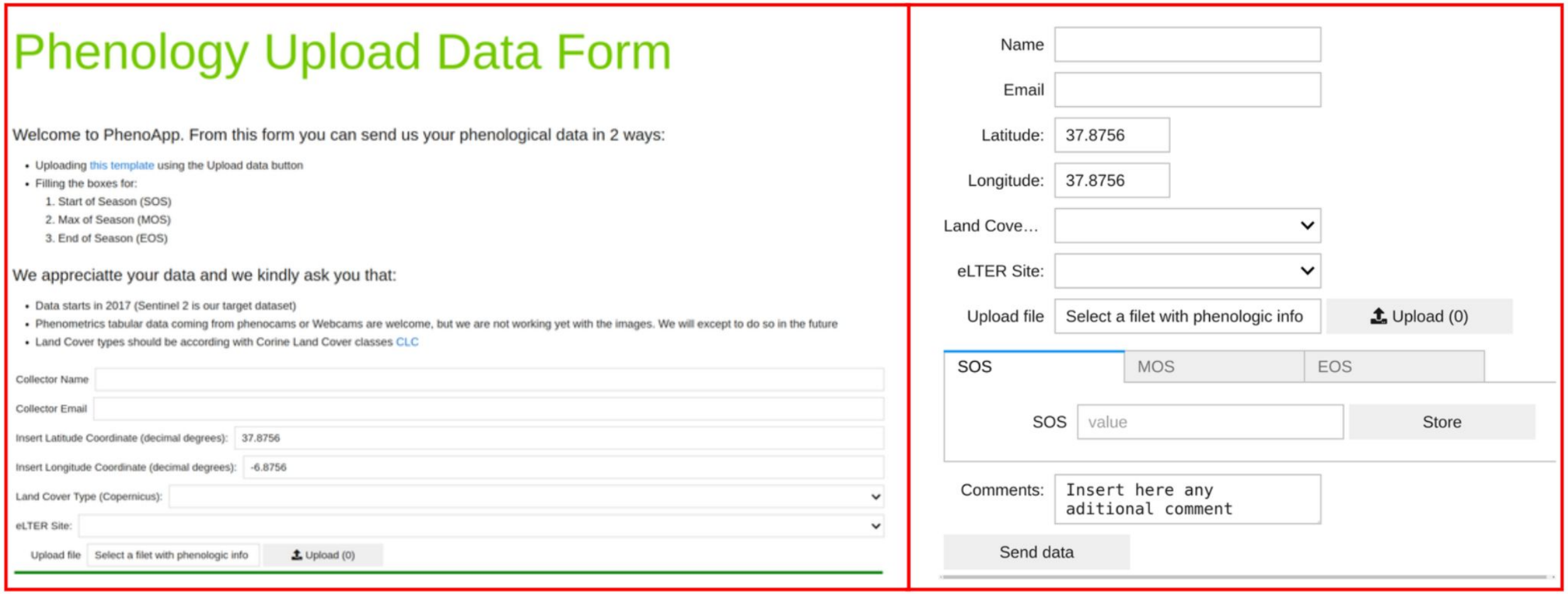
- Click File ->Save As -> enter *.hdarc* as the name
- Move your file *.hdarc* to */home/jovyan*

  Note : *No brackets, commas ,or quotation marks are to be used around the username and password.*

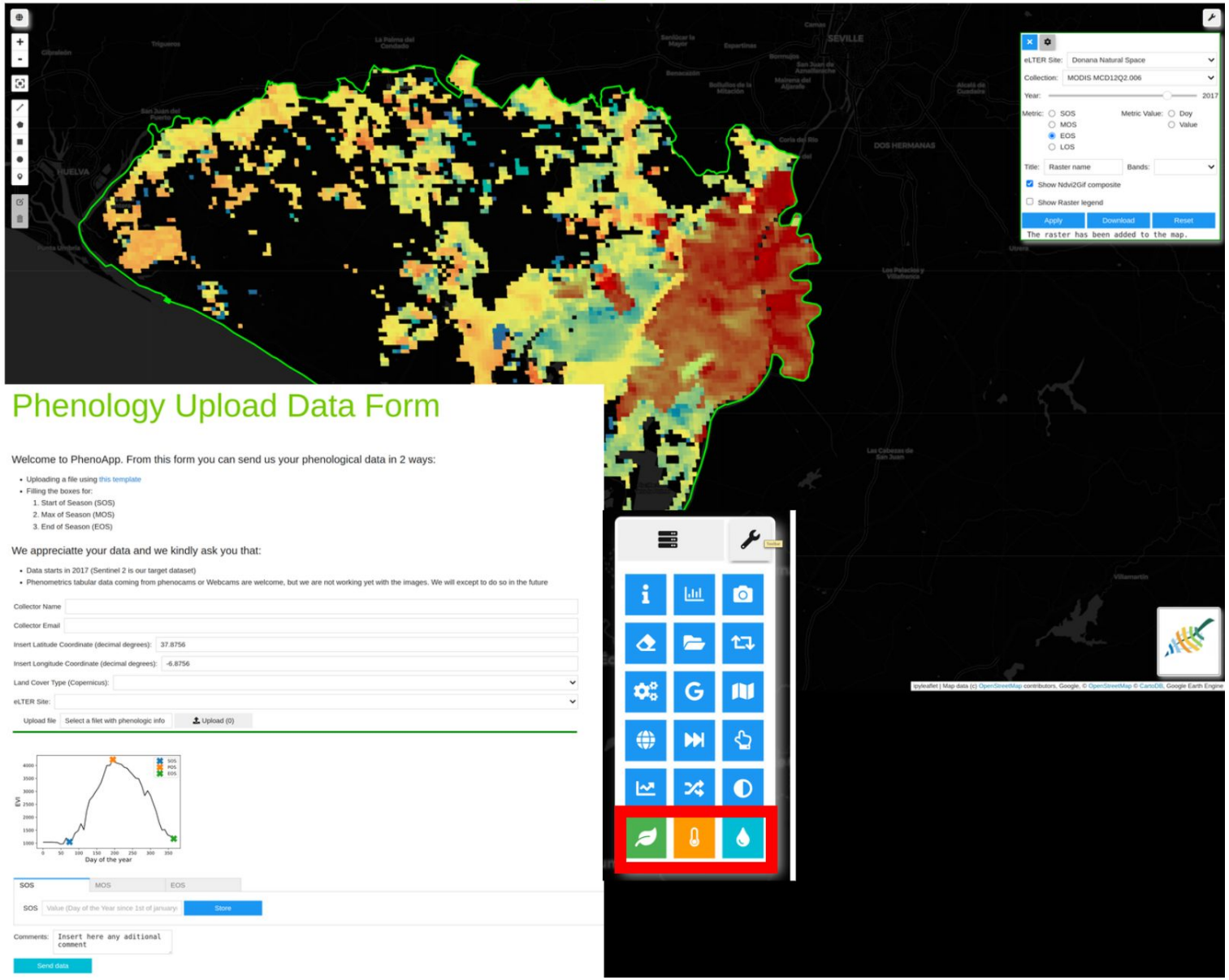
- Here is an example of a Python script to query and download data. It is advised to store it in a Python file, and run it using Python3. The variable **query** contains the data descriptor. It can be generated by selecting the product and the region of interest in the HDA API. In this example, the Dataset used is "OLCI Land Colour Full Resolution - Sentinel-3" .

Hands On! PhenoApp form

"./phenoappL.ipynb"



Hands On! PhenoApp form



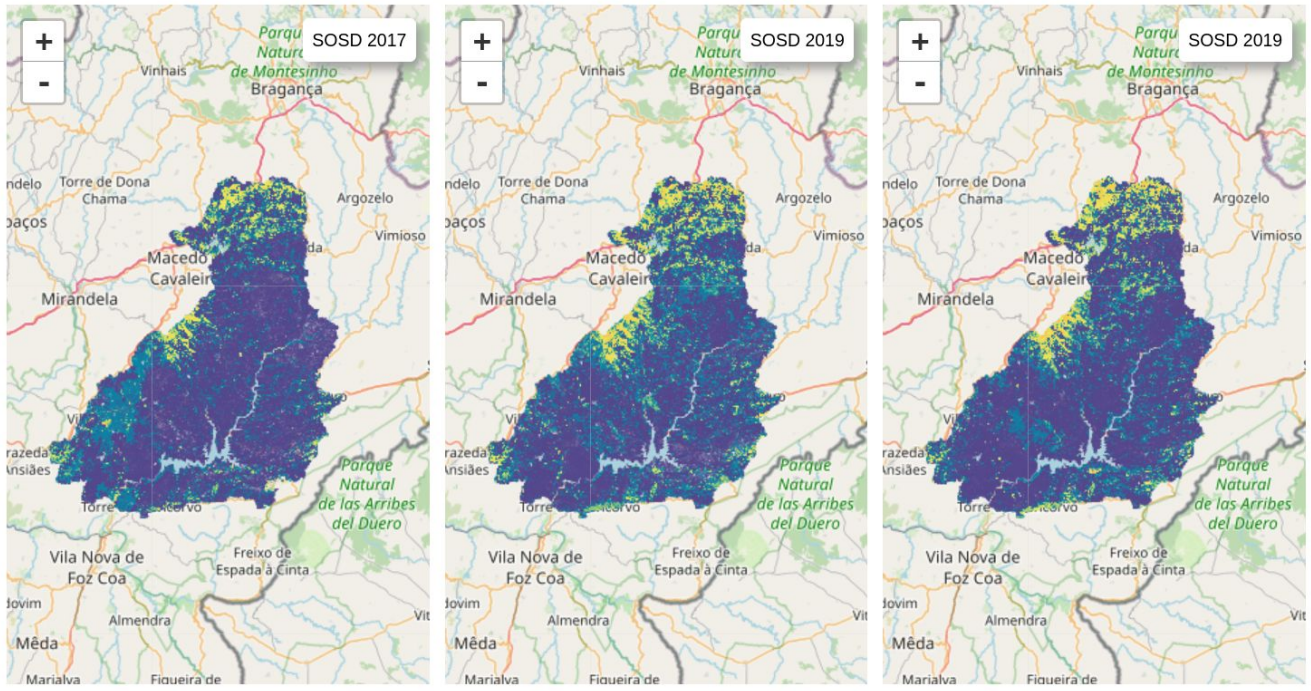
"./phenoappL.ipynb"

Hands On! PhenoApp form

In [15]:
```
vis_params = [sos_vis_17, sos_vis_19, sos_vis_21]
#{'bands': ['summer', 'autumn', 'spring'], 'min': 0.1, 'max': 0.7, 'gamma': 1.3}]

labels = [
    'SOSD 2017',
    'SOSD 2019',
    'SOSD 2019',
]

geemap.linked_maps(
    rows=1,
    cols=3,
    height="500px",
    center=[38.4151, 21.2712],
    zoom=12,
    ee_objects=[SOS_2017, SOS_2019, SOS_2021],
    vis_params=vis_params,
    labels=labels,
    label_position="topright",
)
```



"./geemapfeaturesL.ipynb"