Satellite data:

What, where & how to use them

Susanna Tora, Carla Ippoliti, Annamaria Conte

Statistics and GIS Unit

Istituto Zooprofilattico Sperimentale dell'Abruzzo e del Molise "G. Caporale"

Overview

- Defining Earth Observation (EO)
- The Copernicus Programme
- The Sentinel missions
- Sentinel-2 data detail
- EO Applications: Sentinel-2
- Example of satellite data application: Ecoregions
- Copernicus Data Space Ecosystem Browser
- How to use them: exercise

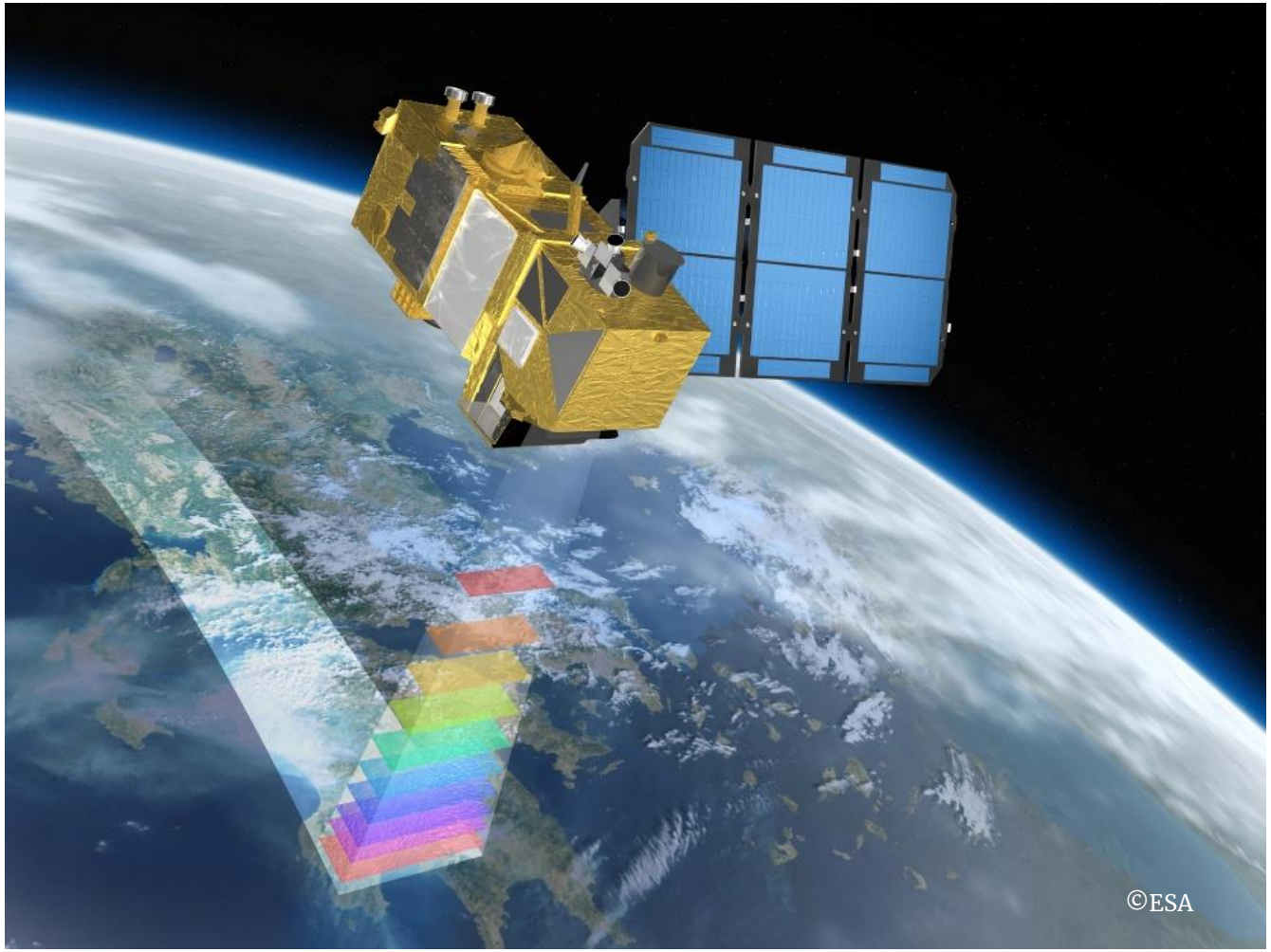
Defining Earth Observation (EO)

Earth Observation (EO) can be defined as the process of acquiring observations of the Earth's surface and atmosphere via remote sensing methods.

Powerful tool for monitoring physical processes and human activities at all scales.

EO satellites

- Capture images on global scale
- Monitor Earth's phenomena **24/7**
- Equipped with **remote sensing sensors** sensitive to specific electromagnetic wavelengths



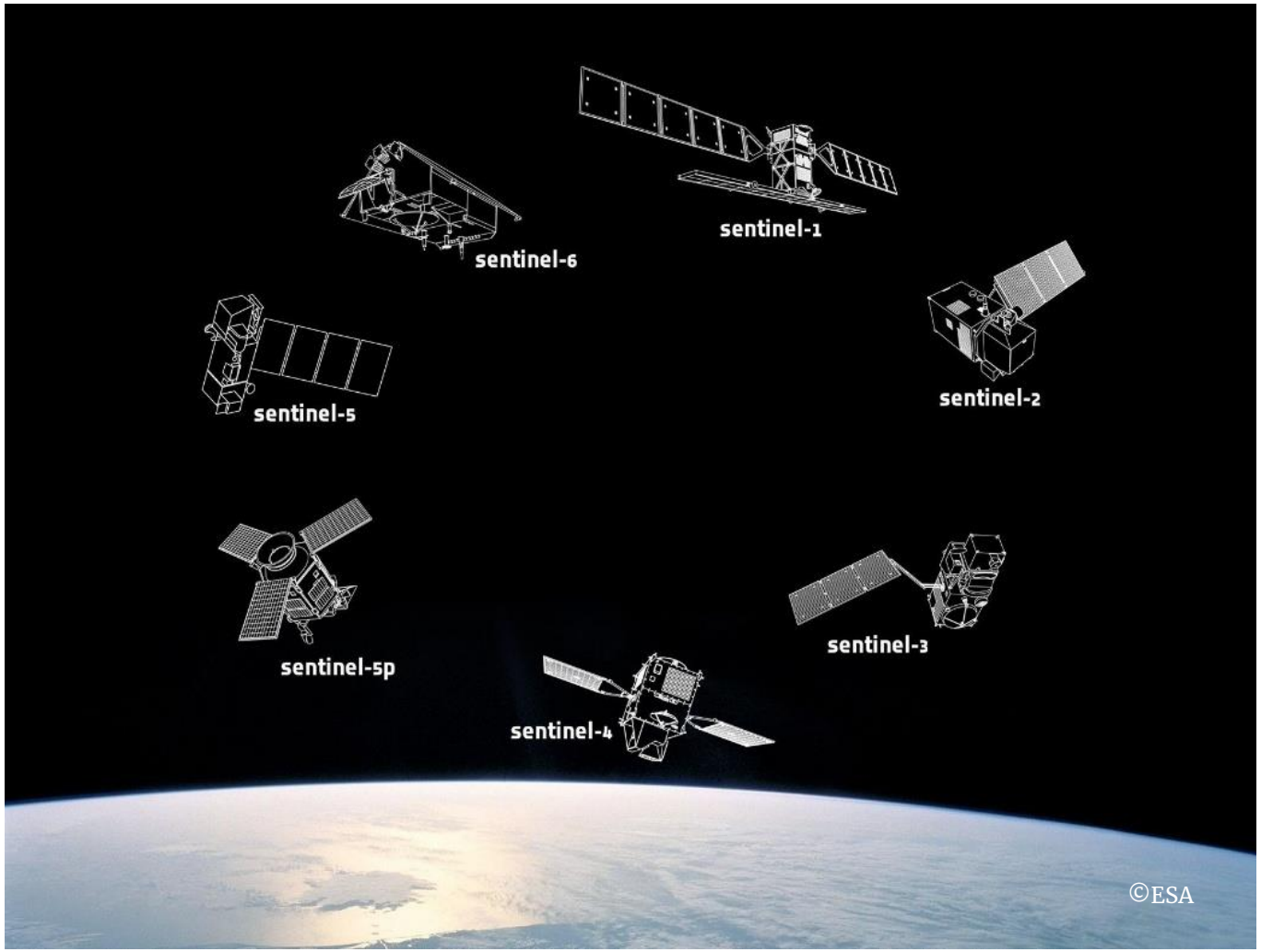
The Copernicus Programme

Copernicus is the Earth observation component of the European Union's Space programme, observing our planet's environment and systems. It offers raw data and derived products that draw from satellite Earth Observation and in-situ (non-space) data.

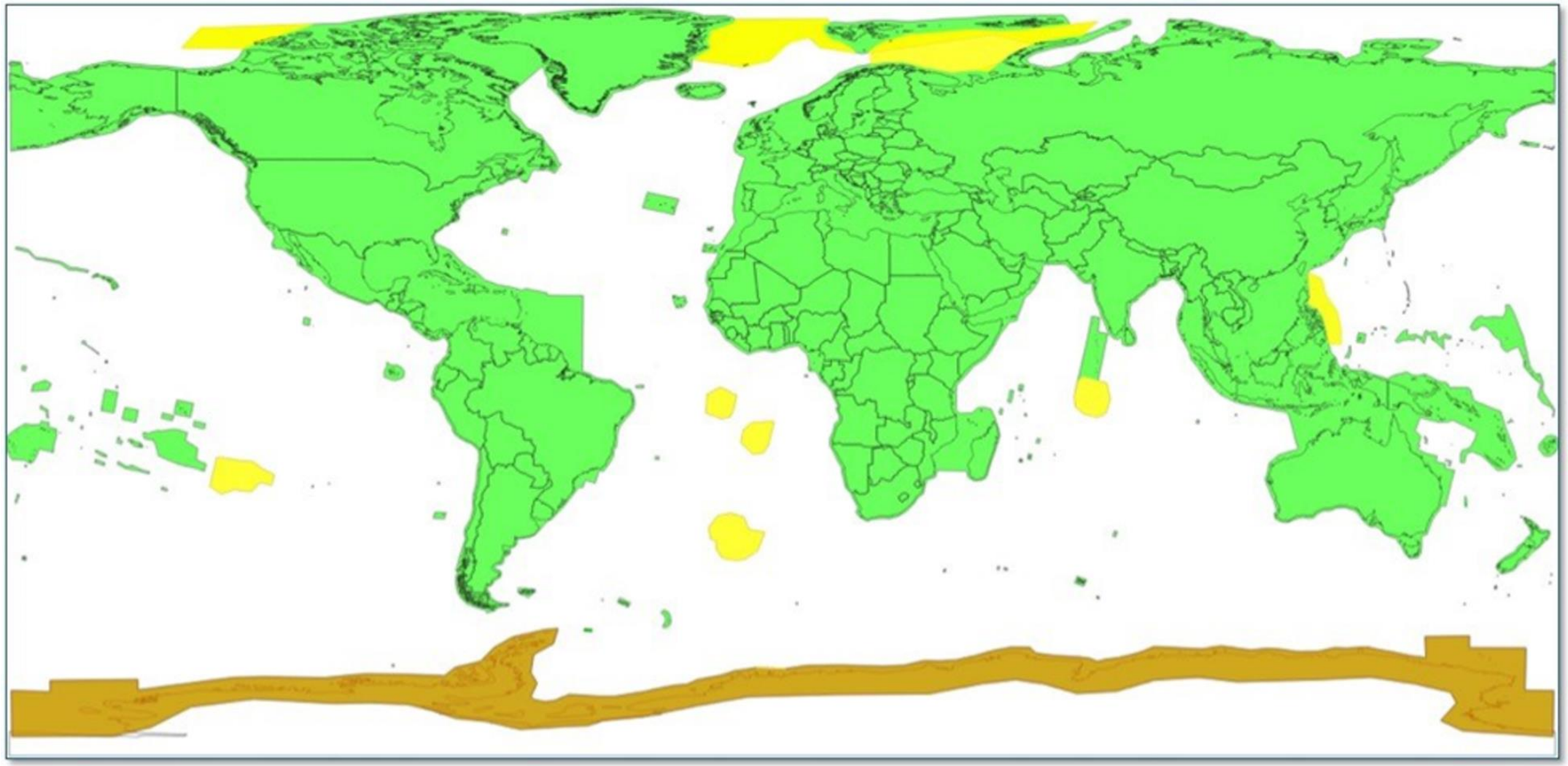
- The world's largest Earth observation programme.
- Open and free data for all.
- 16TB of data collected everyday.
- Huge benefits to business and academia in Europe.
- Key tool to address major societal challenges, such as climate change.

The Sentinel missions

- **Sentinel-1**: SAR satellite providing all-weather radar imaging for land and oceanic applications.
- **Sentinel-2**: multispectral satellite provides high resolution imagery for land based applications.
- **Sentinel-3**: provides global land and ocean monitoring services.
- **Sentinel-5P**: provides data relating to atmospheric composition monitoring.



Sentinel-2 data detail



Geographic and temporal coverage for data acquisition

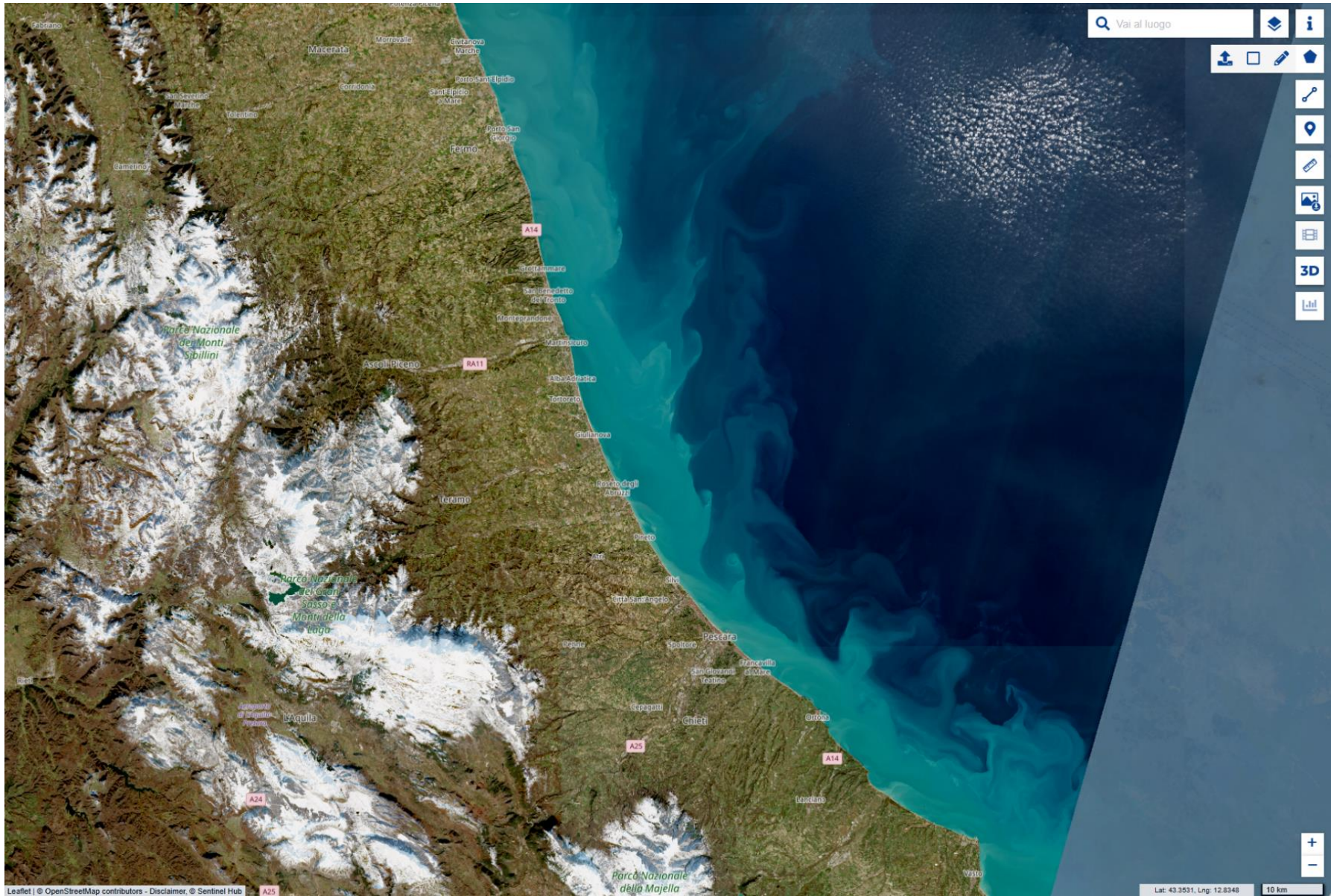
Sentinel-2 data detail

BAND		WAVELENGTH (min-max in micrometers)	SPATIAL RESOLUTION (meters)
Band 1	Costal aerosol	0.421 – 0.457	60
Band 2	Blue	0.439 – 0.535	10
Band 3	Green	0.537 – 0.582	10
Band 4	Red	0.646 – 0.685	10
Band 5	Vegetation red edge	0.694 – 0.714	20
Band 6	Vegetation red edge	0.731 – 0.749	20
Band 7	Vegetation red edge	0.768 – 0.796	20
Band 8	NIR (near infrared)	0.767 – 0.908	10
Band 8a	NIR (near infrared)	0.848 – 0.881	20
Band 9	Narrow NIR	0.931 – 0.958	60
Band 10	Cirrus	1.338 – 1.414	60
Band 11	SWIR (Short wave infrared)	1.539 – 1.681	20
Band 12	SWIR (Short wave infrared)	2.072 – 2.312	20

EO Applications: Sentinel-2

True color

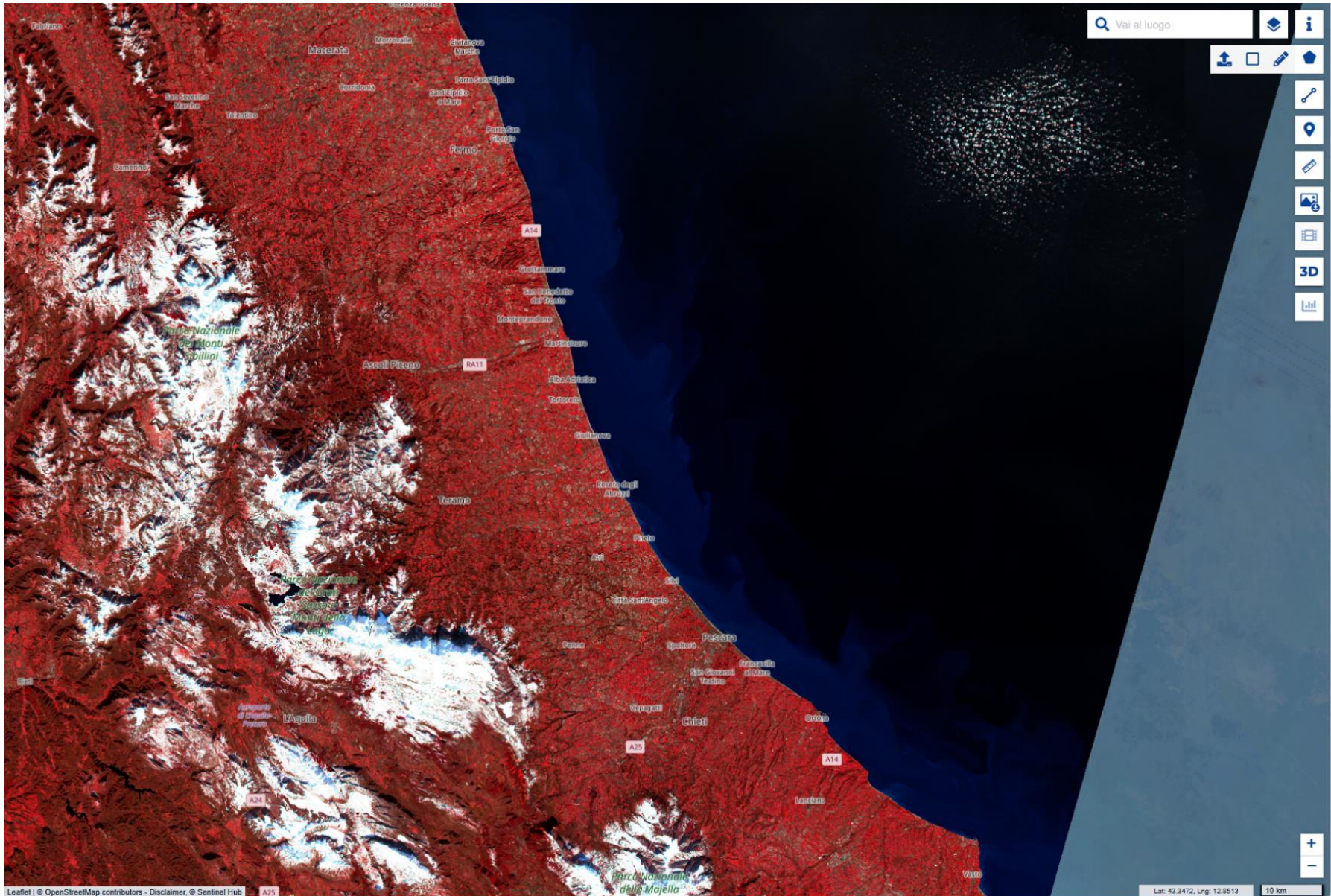
R = B4, **G** = B3, **B** = B2



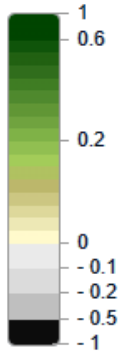
EO Applications: Sentinel-2

False color

R = B8, **G** = B4, **B** = B3

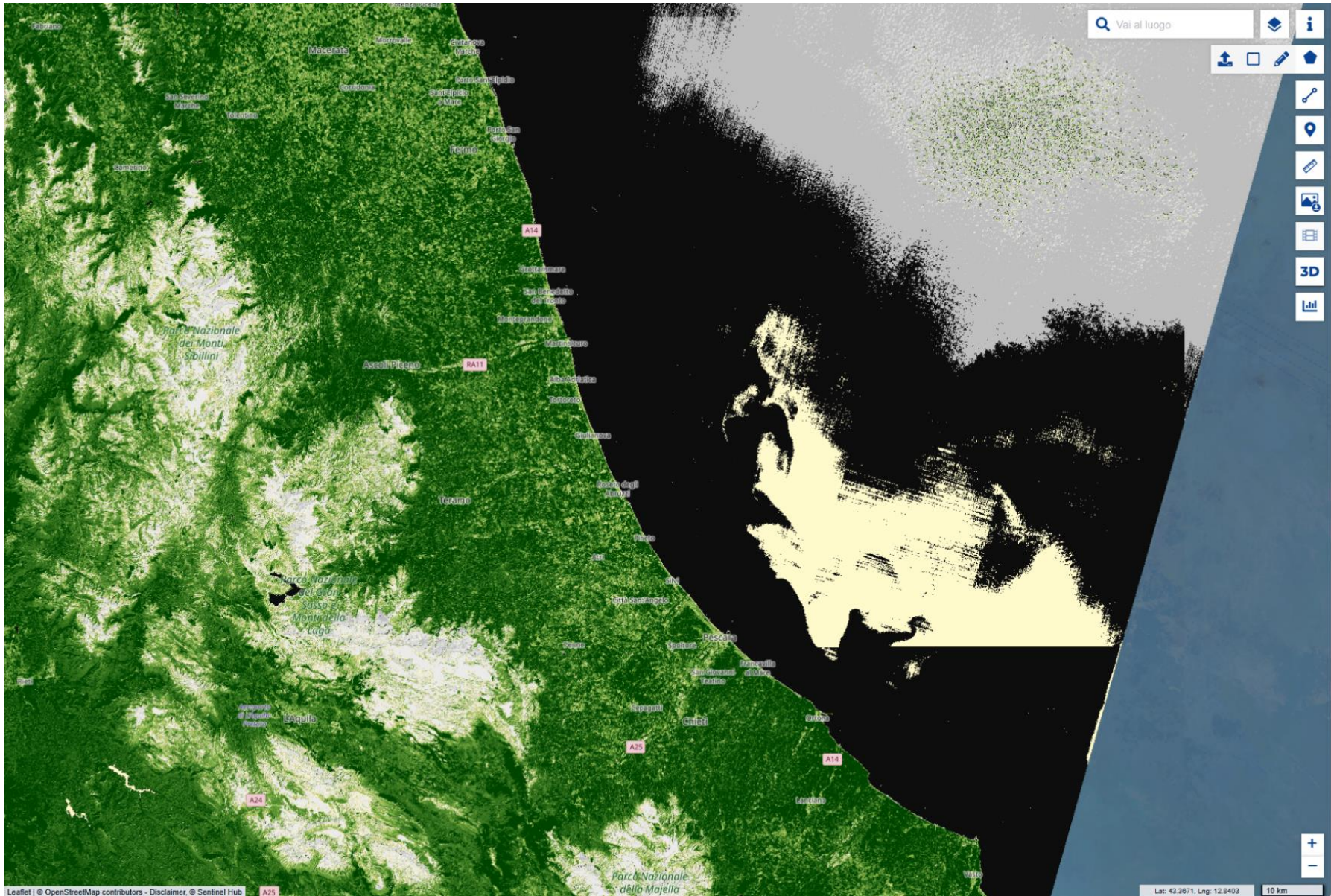


EO Applications: Sentinel-2



NDVI

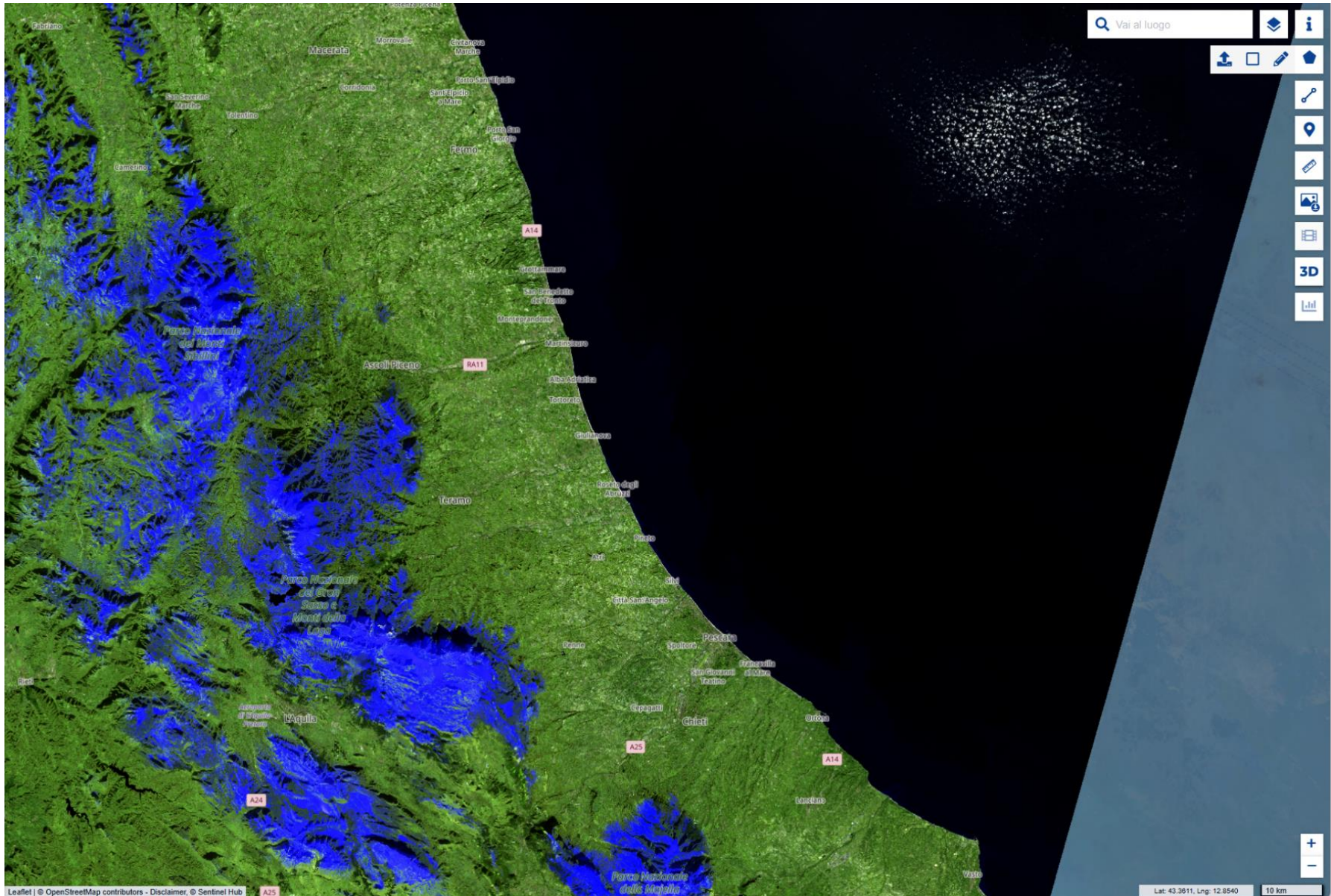
(B8-B4)/(B8+B4)



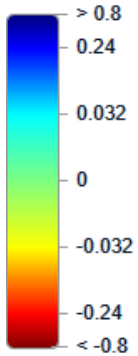
EO Applications: Sentinel-2

False color (urban)

R = B12, **G** = B11, **B** = B4

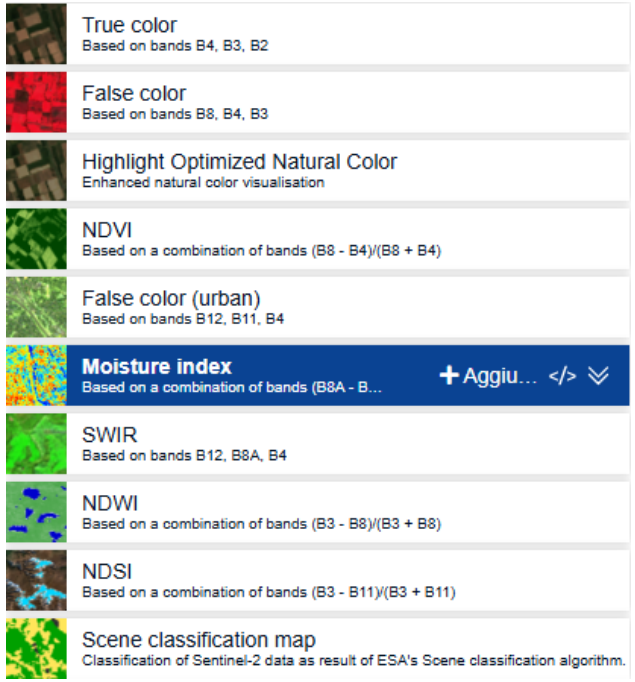


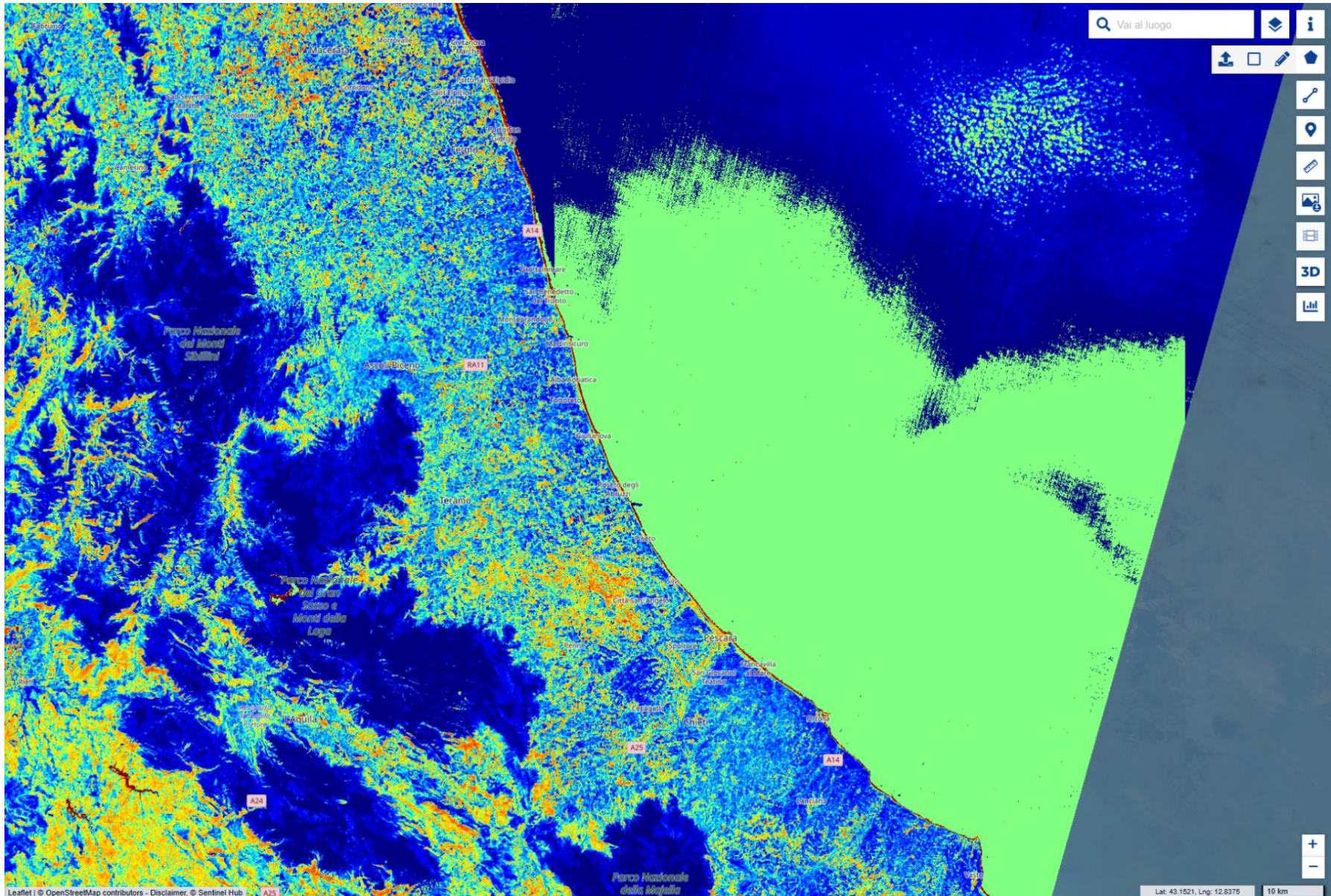
EO Applications: Sentinel-2



NDMI

(B8a-B11)/(B8a+B11)

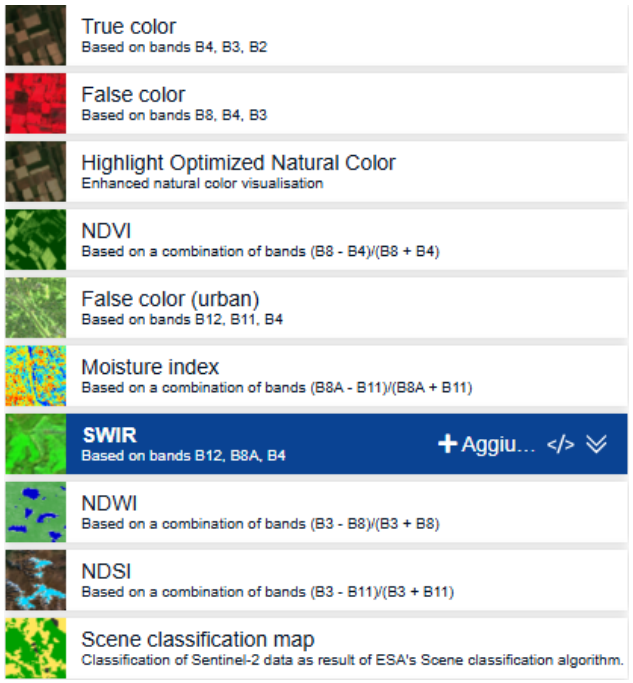


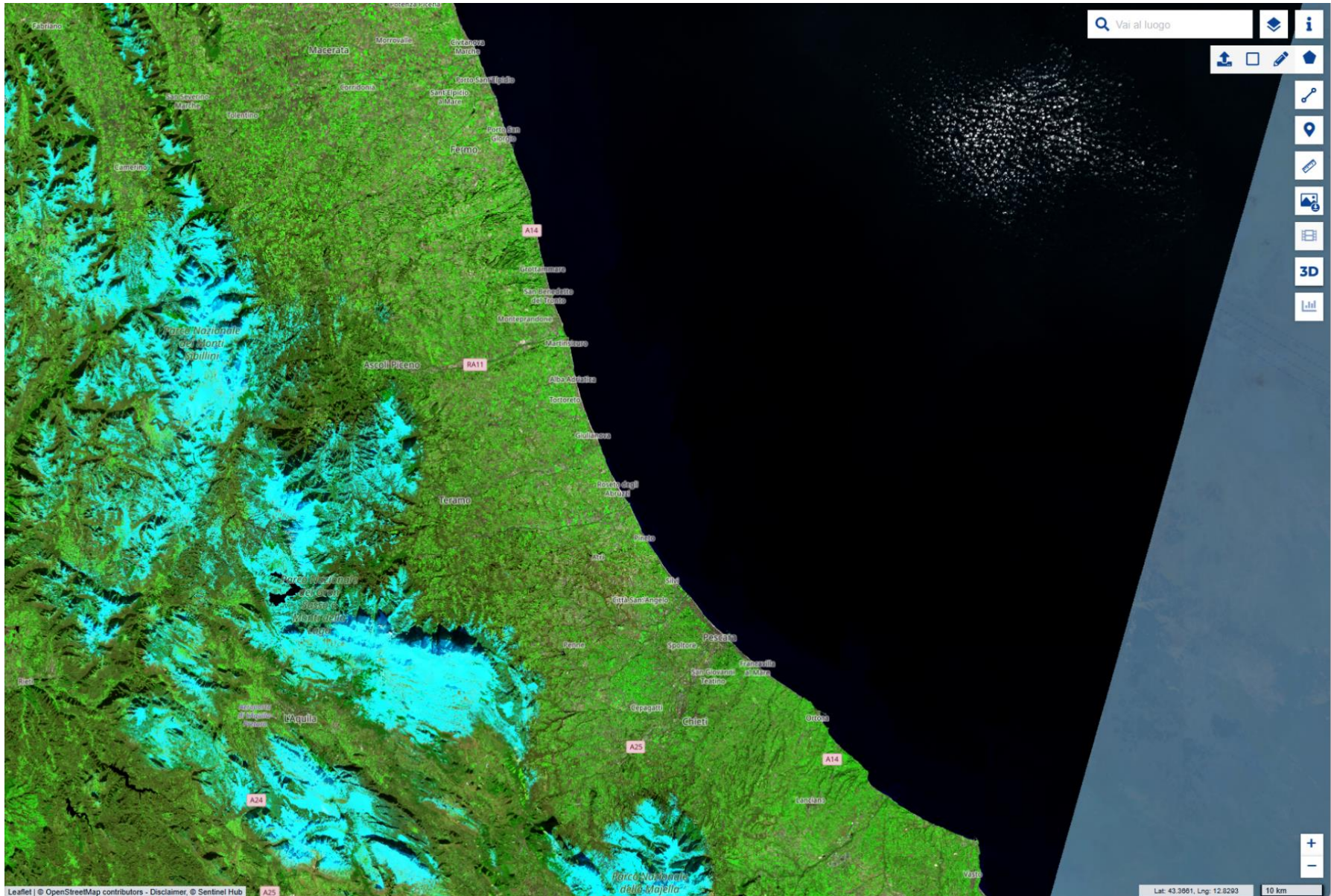


EO Applications: Sentinel-2

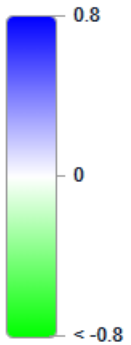
SWIR

R = B12, **G** = B8a, **B** = B4





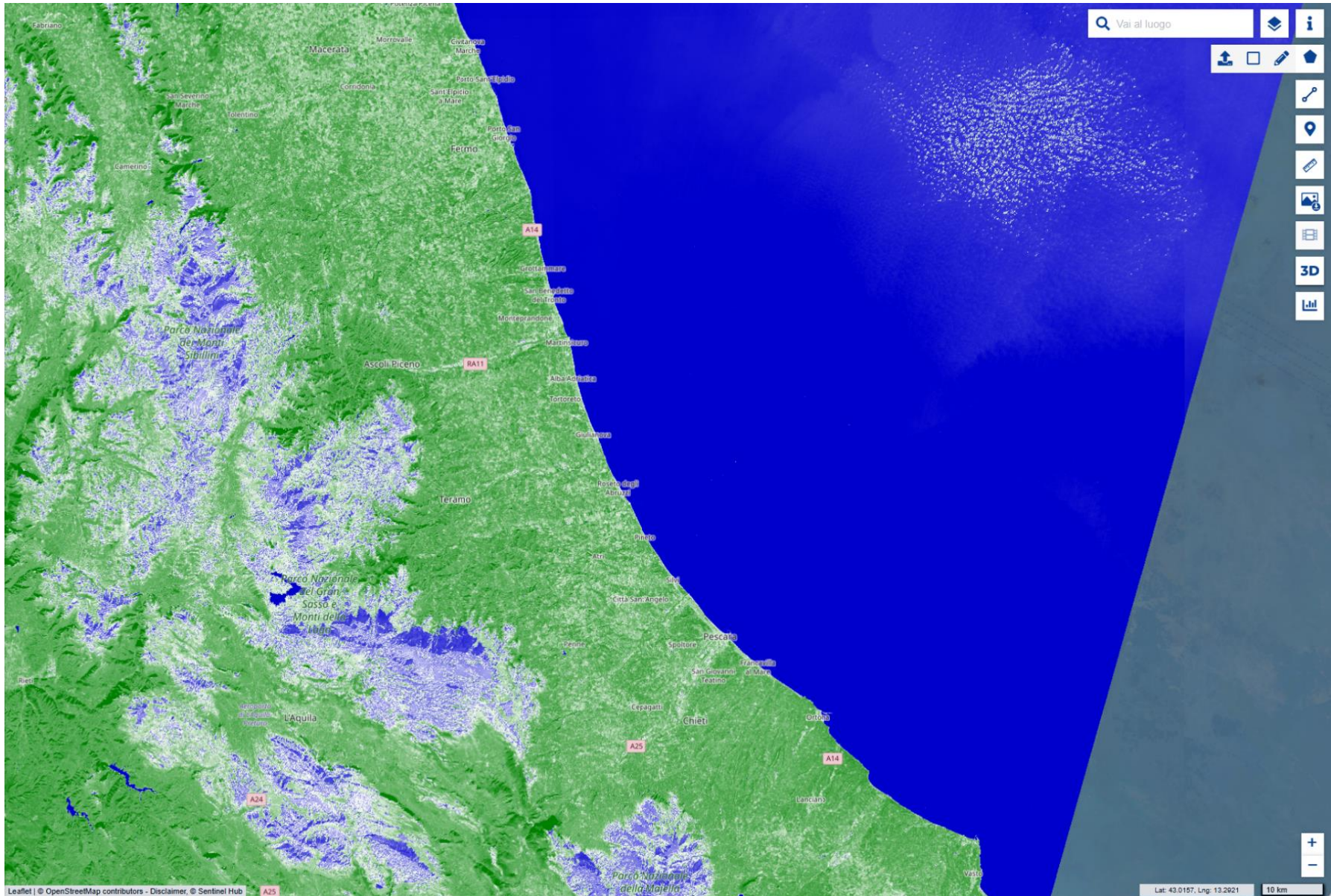
EO Applications: Sentinel-2



NDWI

(B3-B8)/(B3+B8)

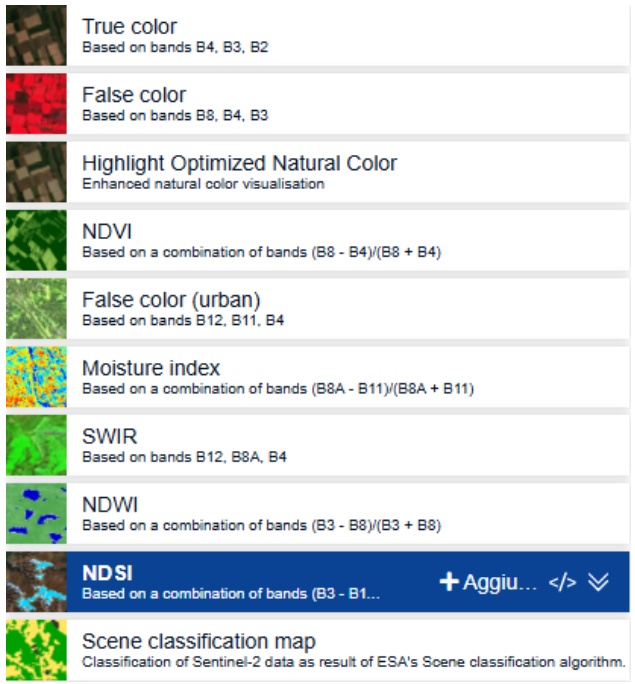
- **True color**
  Based on bands B4, B3, B2
- **False color**
  Based on bands B8, B4, B3
- **Highlight Optimized Natural Color**
  Enhanced natural color visualisation
- **NDVI**
  Based on a combination of bands (B8 - B4)/(B8 + B4)
- **False color (urban)**
  Based on bands B12, B11, B4
- **Moisture index**
  Based on a combination of bands (B8A - B11)/(B8A + B11)
- **SWIR**
  Based on bands B12, B8A, B4
- **NDWI** (selected)
  Based on a combination of bands (B3 - B8... + Aggiu... </>
- **NDSI**
  Based on a combination of bands (B3 - B11)/(B3 + B11)
- **Scene classification map**
  Classification of Sentinel-2 data as result of ESA's Scene classification algorithm.

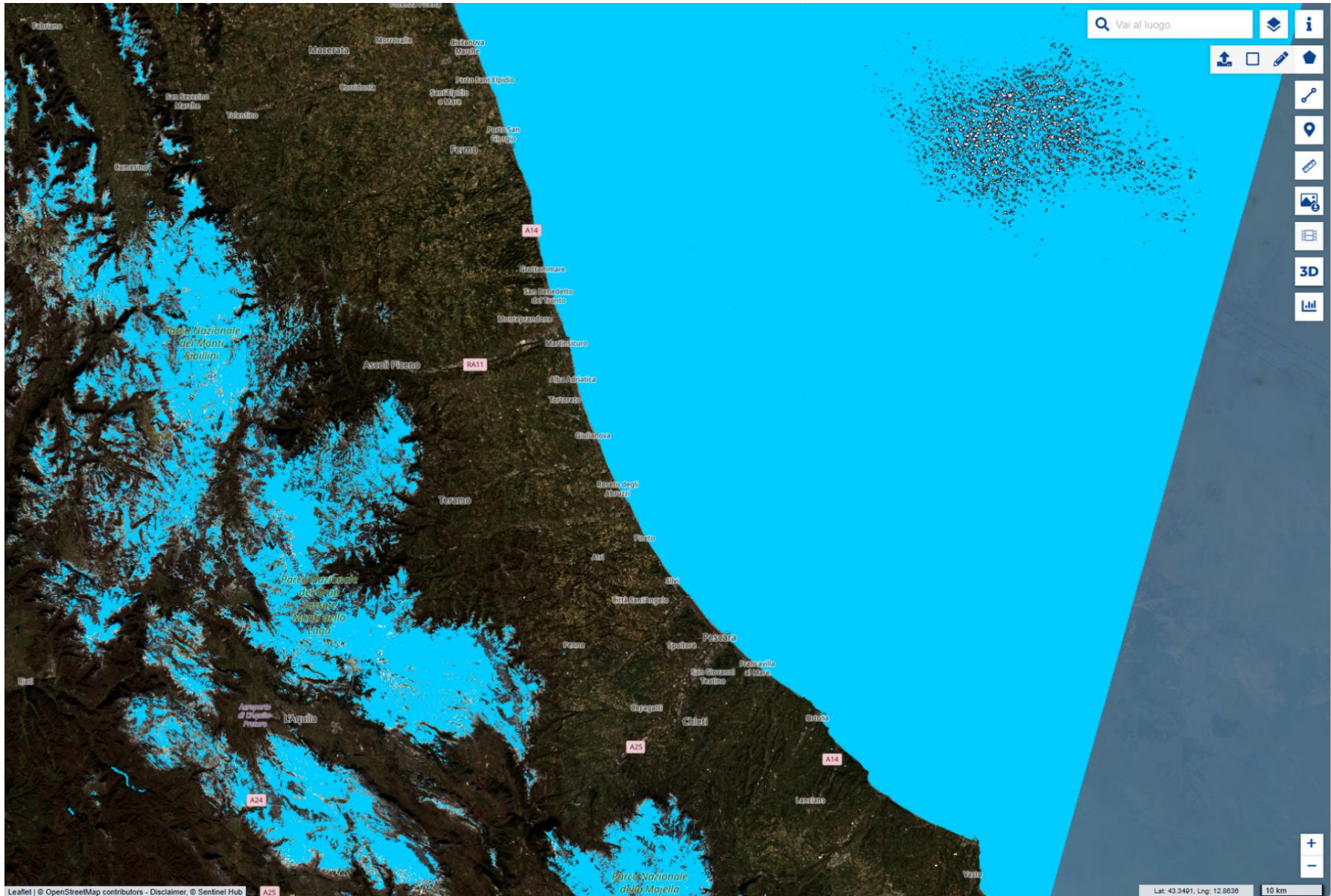


EO Applications: Sentinel-2

NDSI

(B3-B11)/(B3+B11)

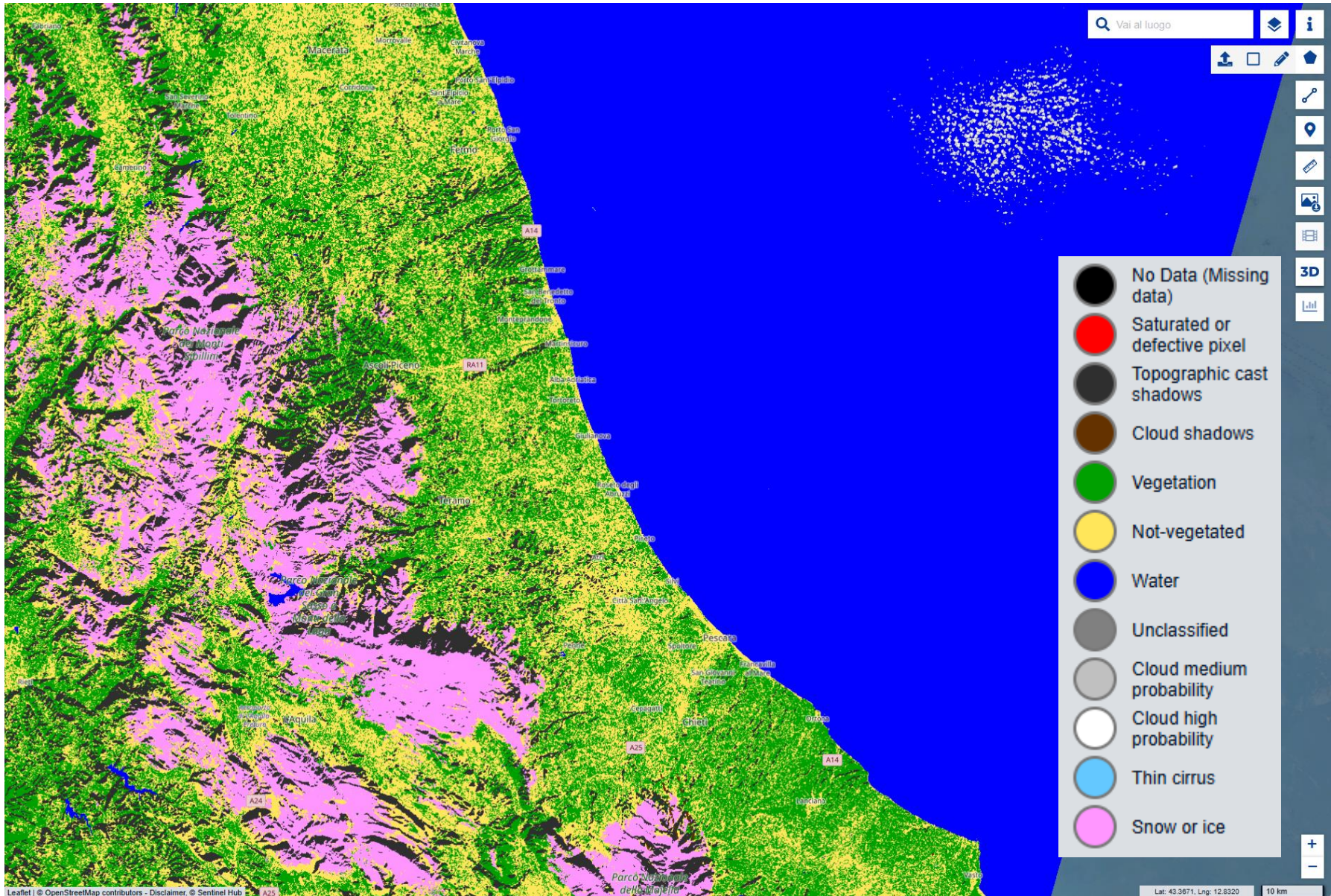




EO Applications: Sentinel-2

Scene classification map

- True color
  Based on bands B4, B3, B2
- False color
  Based on bands B8, B4, B3
- Highlight Optimized Natural Color
  Enhanced natural color visualisation
- NDVI
  Based on a combination of bands (B8 - B4)/(B8 + B4)
- False color (urban)
  Based on bands B12, B11, B4
- Moisture index
  Based on a combination of bands (B8A - B11)/(B8A + B11)
- SWIR
  Based on bands B12, B8A, B4
- NDWI
  Based on a combination of bands (B3 - B8)/(B3 + B8)
- NDSI
  Based on a combination of bands (B3 - B11)/(B3 + B11)
- **Scene classification map**
  Classification of Sentinel-2 data as result o... + Aggiu... </>



Example of satellite data application:

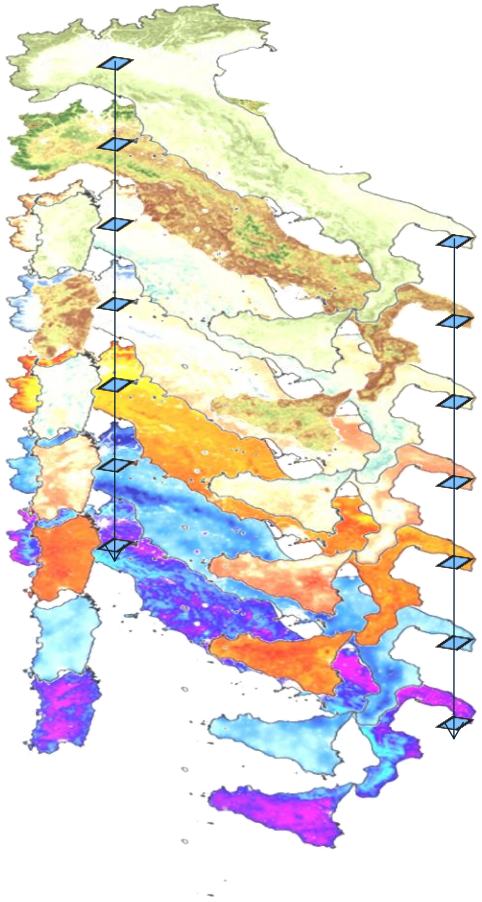
Ecoregions

Ecoregions

Defining ecological regions in Italy based on a multivariate clustering approach: A first step towards a targeted vector borne disease surveillance

Ippoliti et al. 2019 *PLoS ONE 14(7): e0219072*

- ✓ standard deviation of **altitude**
- ✓ mean daytime land surface **temperature** (LST)
- ✓ mean amplitude of LST
- ✓ peak timing of the annual cycle of LST
- ✓ Mean of the annual cycle of **NDVI**
- ✓ Amplitude of the annual cycle of NDVI
- ✓ daily mean amount of **rainfall**



2007-2016

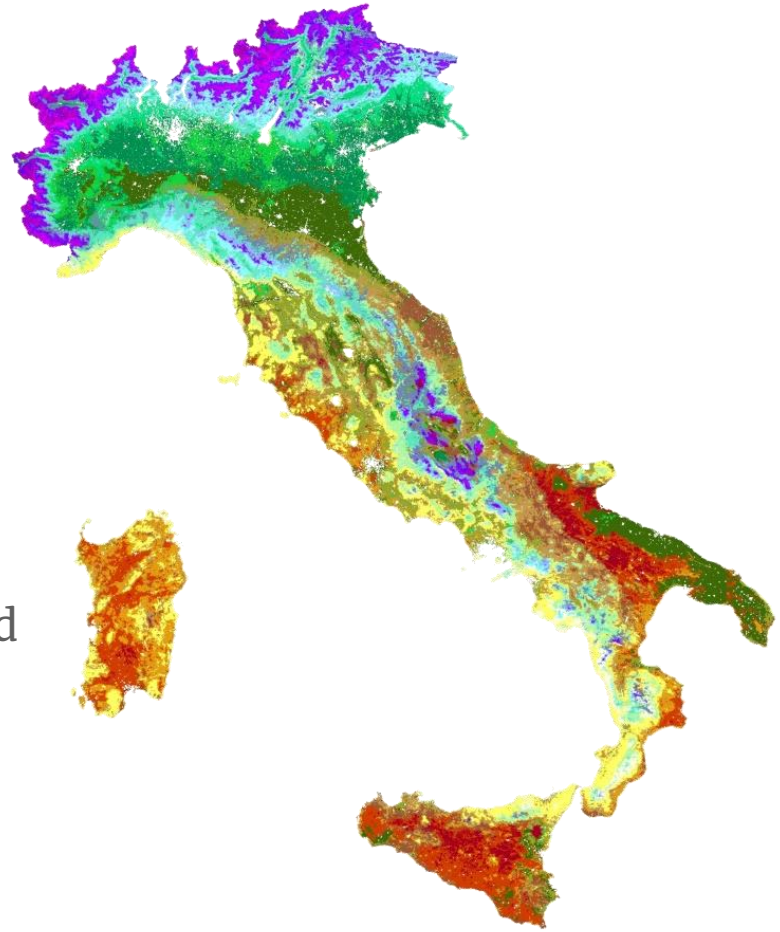
Fourier transformation

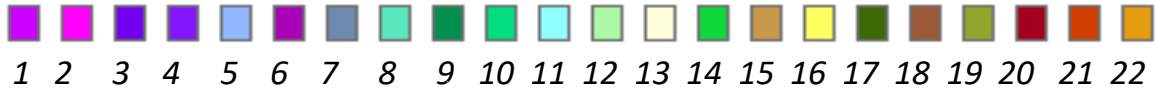
PCA

Unsupervised k-medoid

Clustering

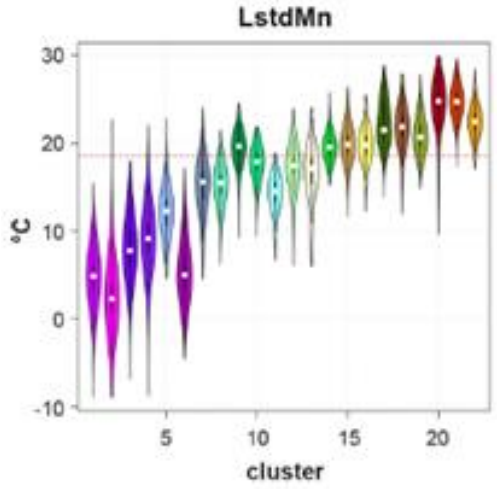
RGB channels





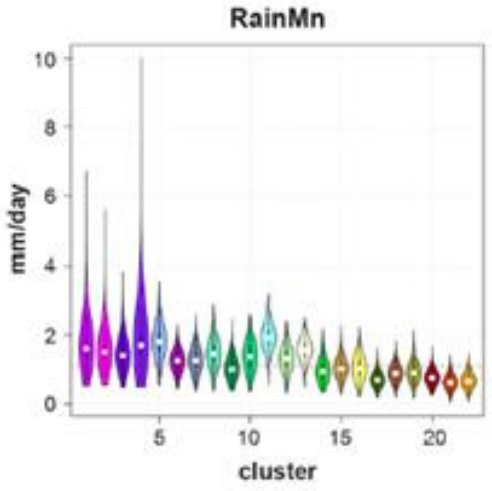
Ippoliti et al. 2019 *PLoS ONE 14(7): e0219072*

Ecoregions

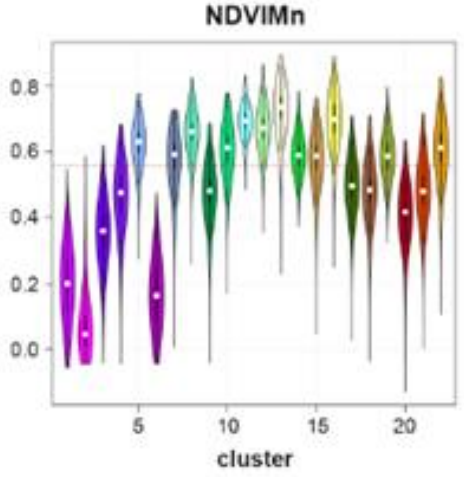


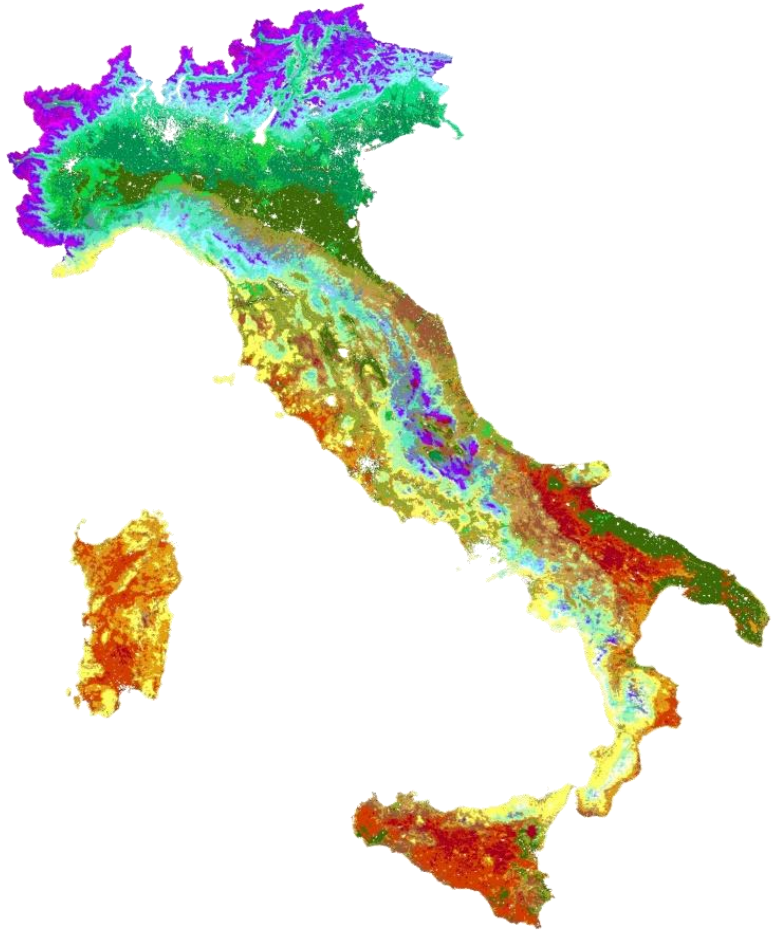
temperature

rainfall



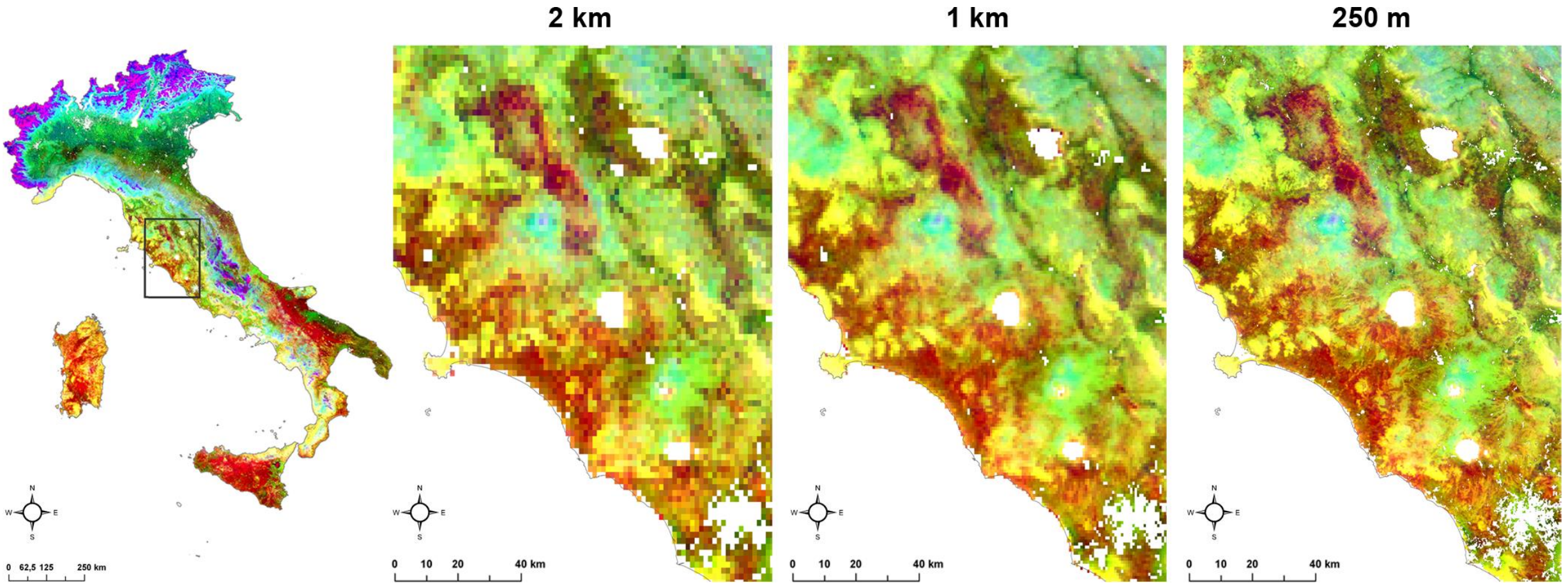
NDVI





1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22

Spatial resolutions



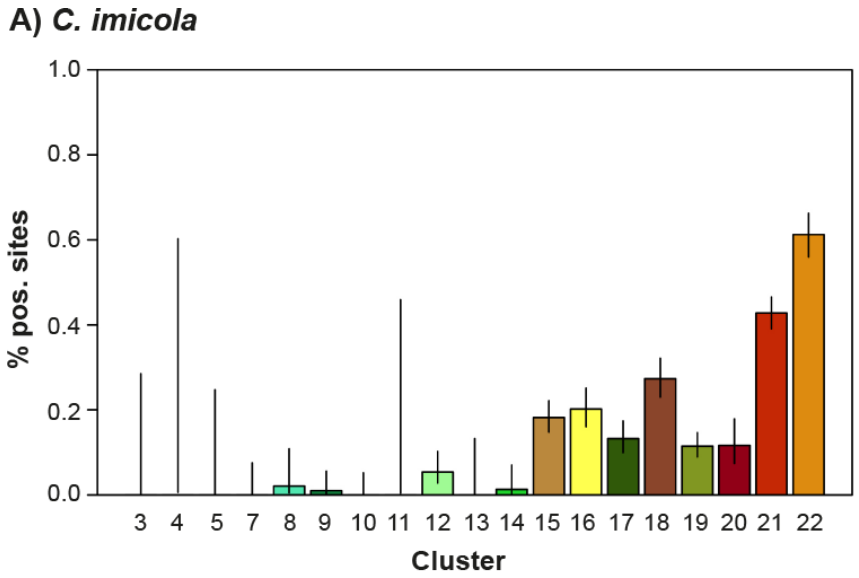
Number of pixels per resolution (Italy)

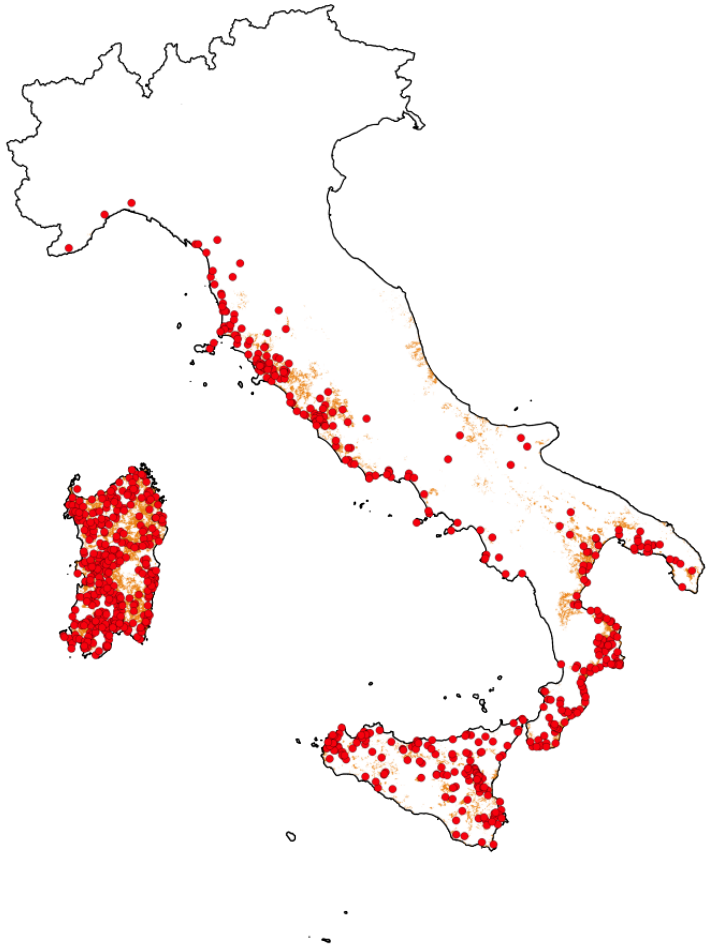
2 km	1 km	250 m
79,619	312,673	4,869,825

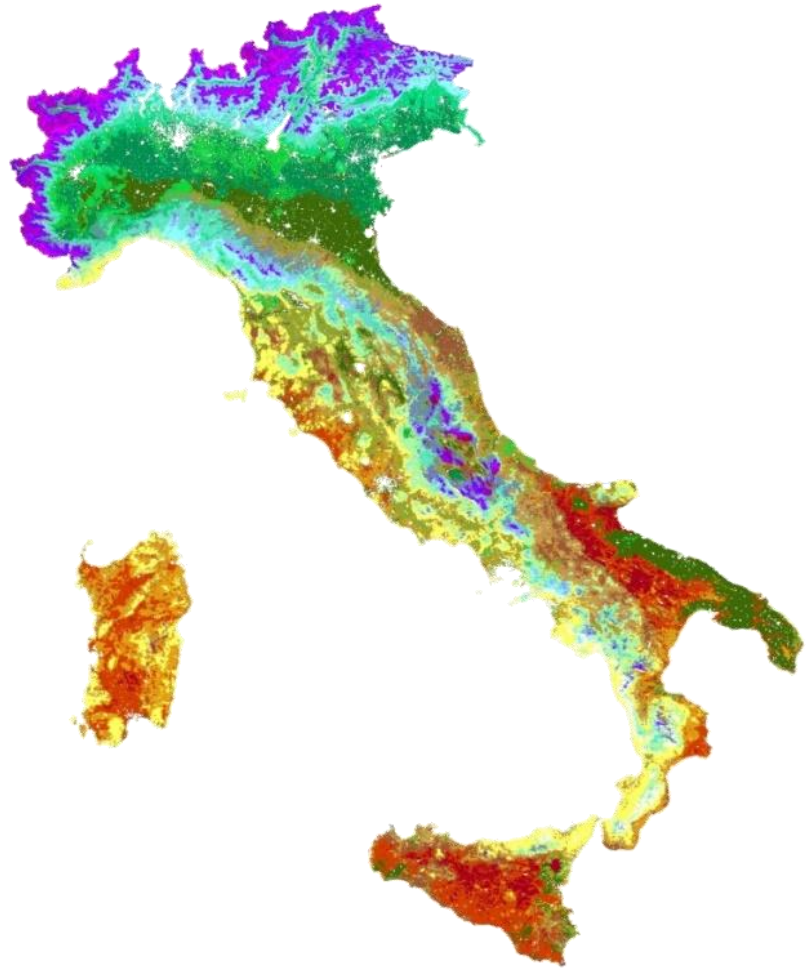
Ippoliti et al. 2019 *PLoS ONE 14(7): e0219072*

Ecoregions

C. imicola



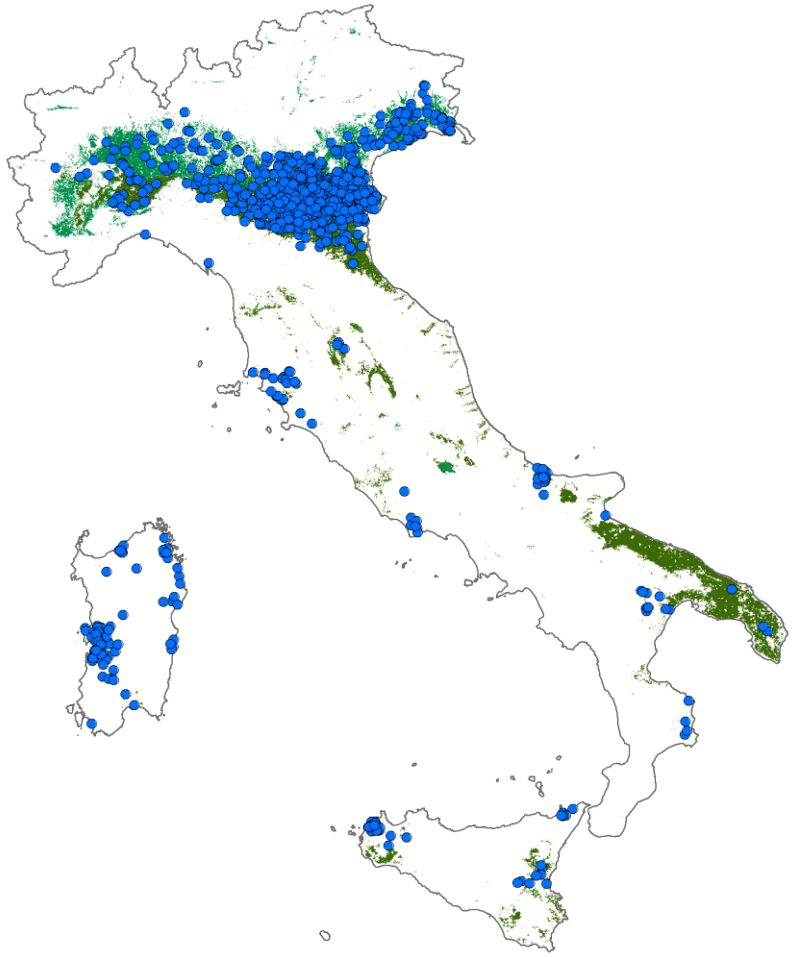


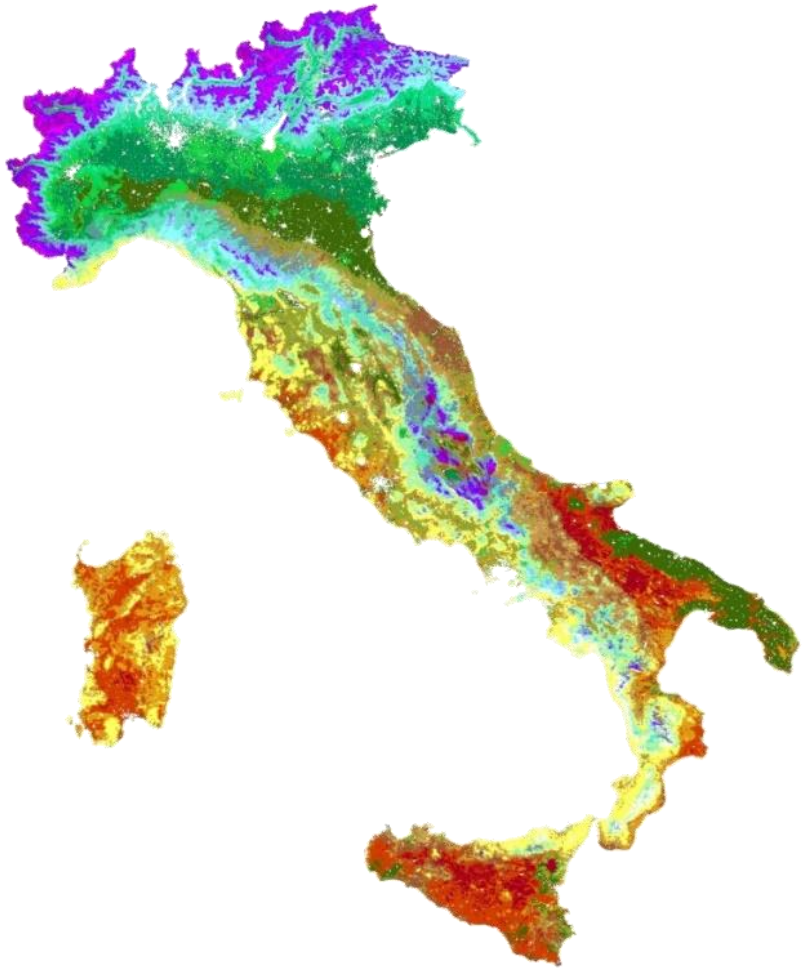


Ippoliti et al. 2019 *PLoS ONE 14(7): e0219072*

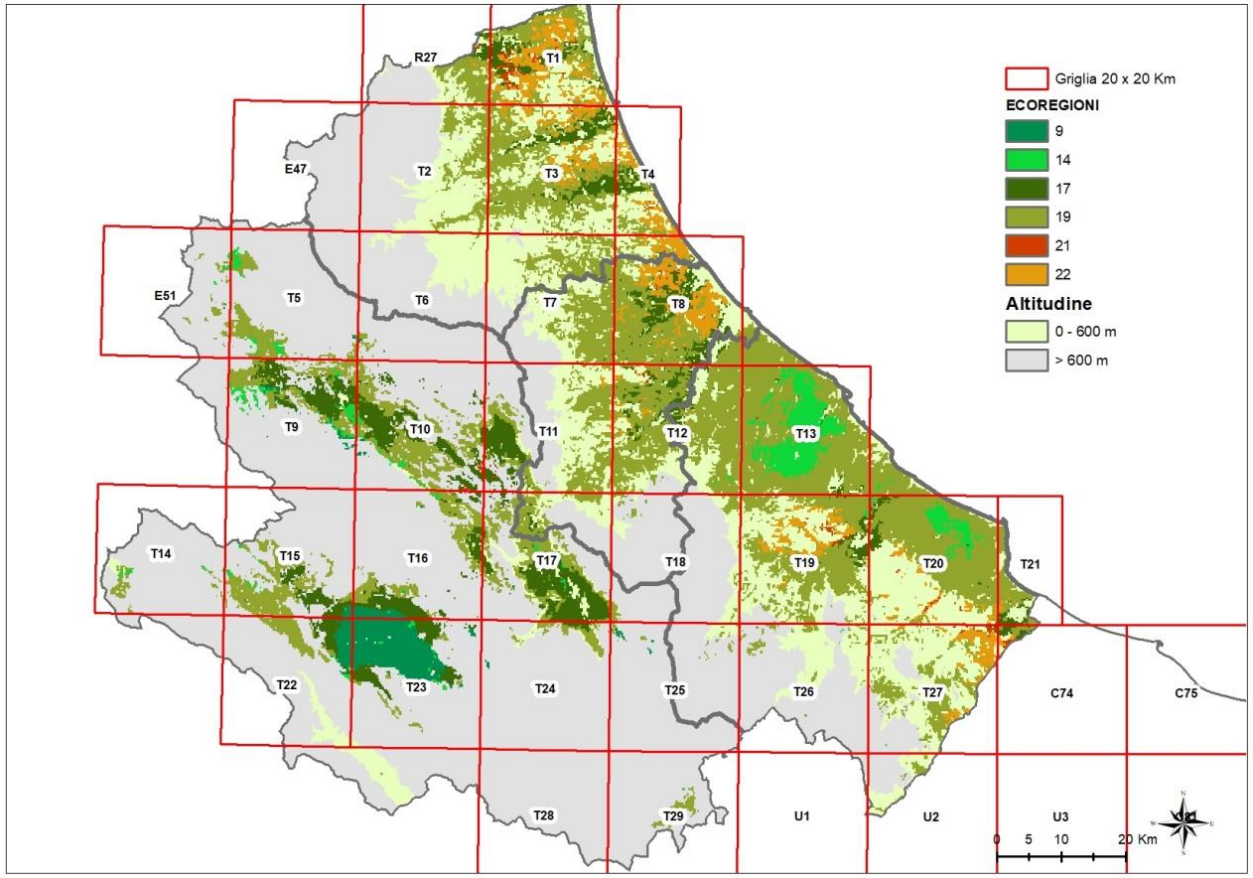
Ecoregions

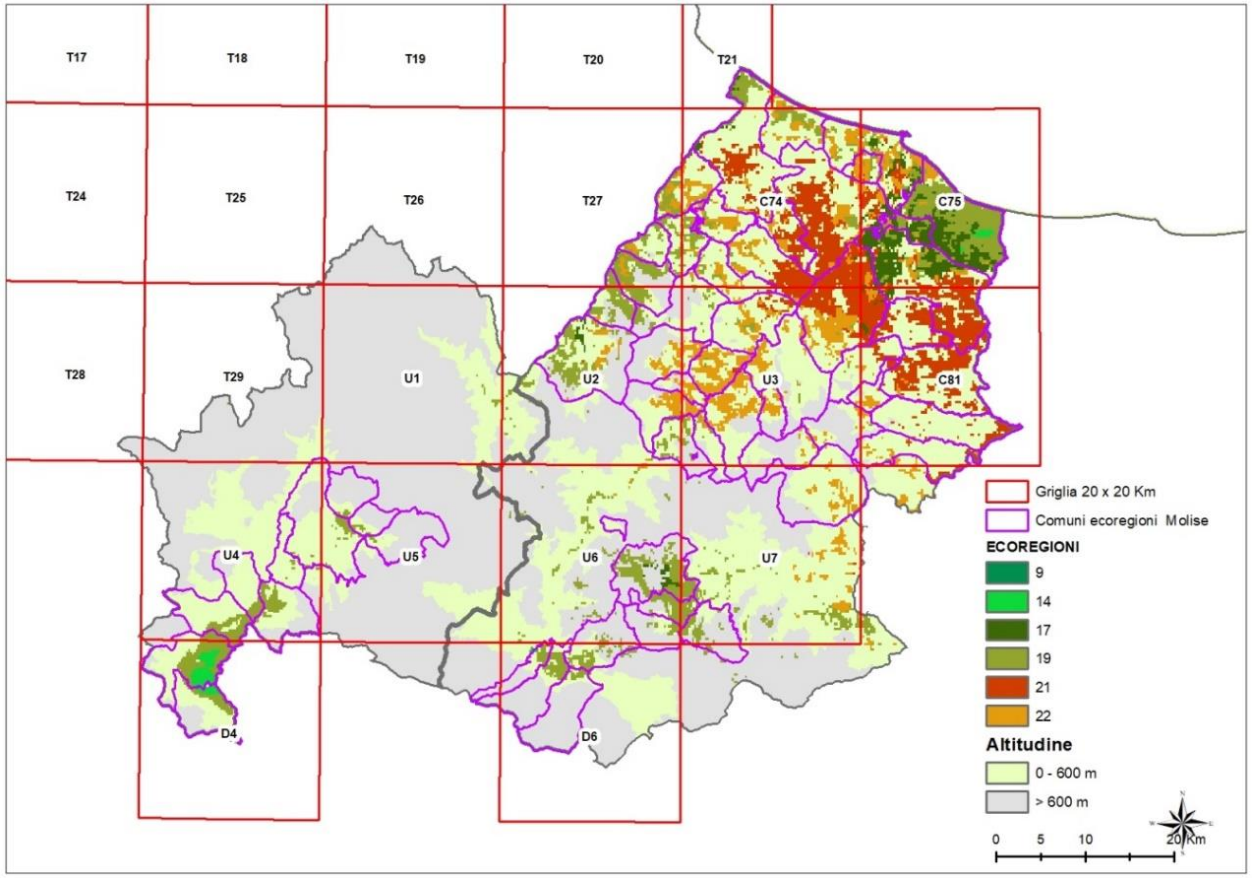
WN cases 08-16





Ecoregions for entomological surveillance in the national arbovirosis plan





Ippoliti et al. 2019 *PLoS ONE 14(7): e0219072*

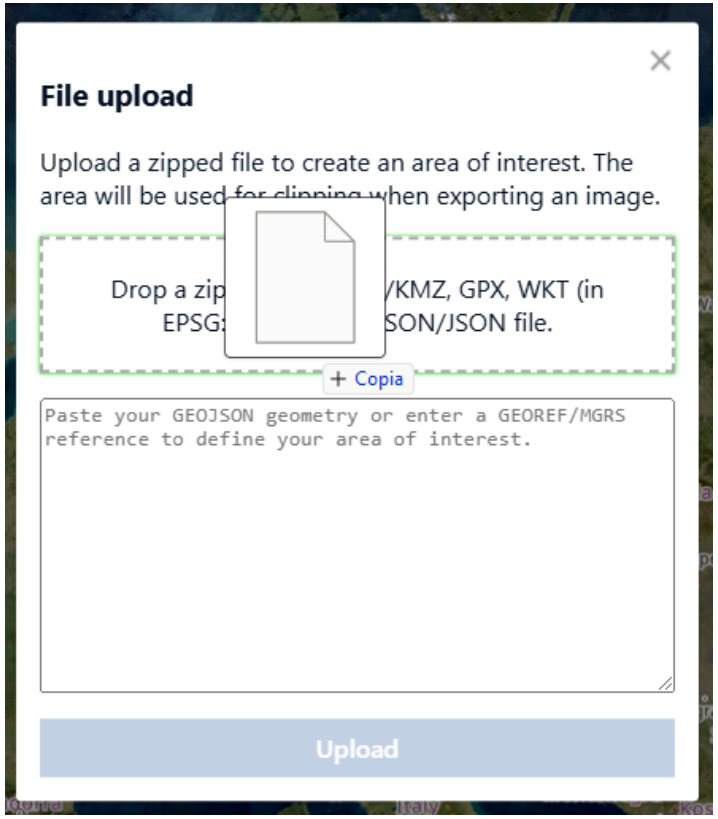
IZS TERAMO

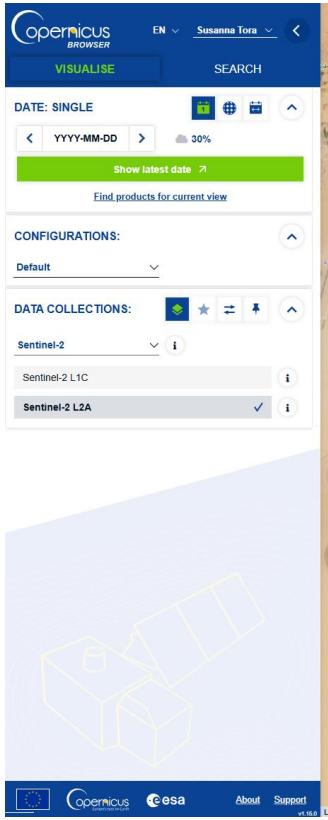
Copernicus Data Space Ecosystem Browser


Copernicus BROWSER
EN
Login
VISUALISE
SEARCH
DATE: SINGLE
YYYY-MM-DD
30%
Show latest date
Find products for current view
CONFIGURATIONS:
Default
DATA COLLECTIONS:
Sentinel-2
Sentinel-2 L1C
Sentinel-2 L2A
Please zoom in or search for a location of interest
Go to Place
3D
Login
Copernicus Data Space Ecosystem Browser
https://browser.dataspace.copernicus.eu/
The data distribution service is open and free.
About
Support
Leaflet | © OpenStreetMap contributors - Disclaimer, © Sentinel Hub
300 km

How to use them: exercise

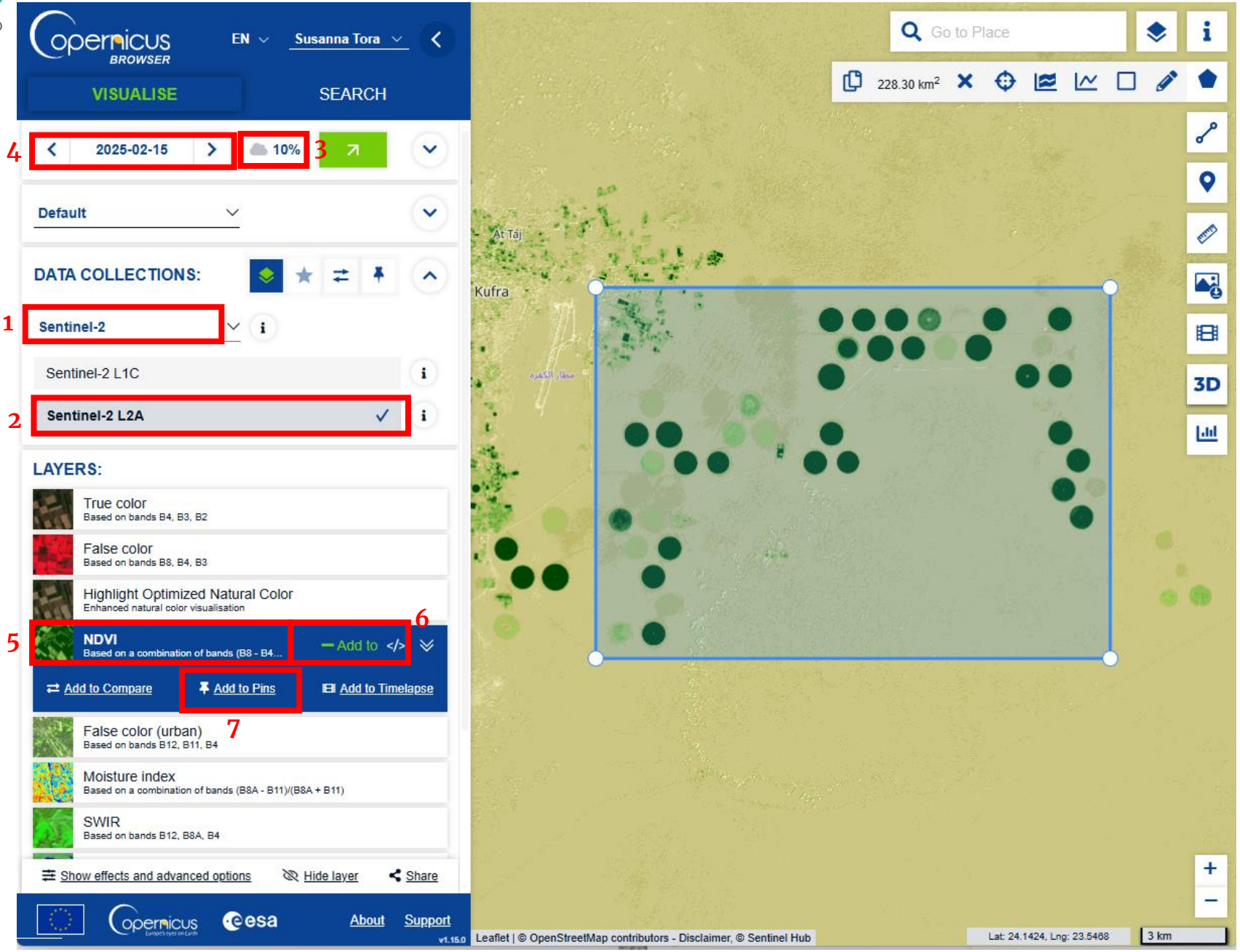
Upload a file to create an AOI





What area is this?

Select layer



Data collections: Sentinel-2

Product: Sentinel-2 L2A

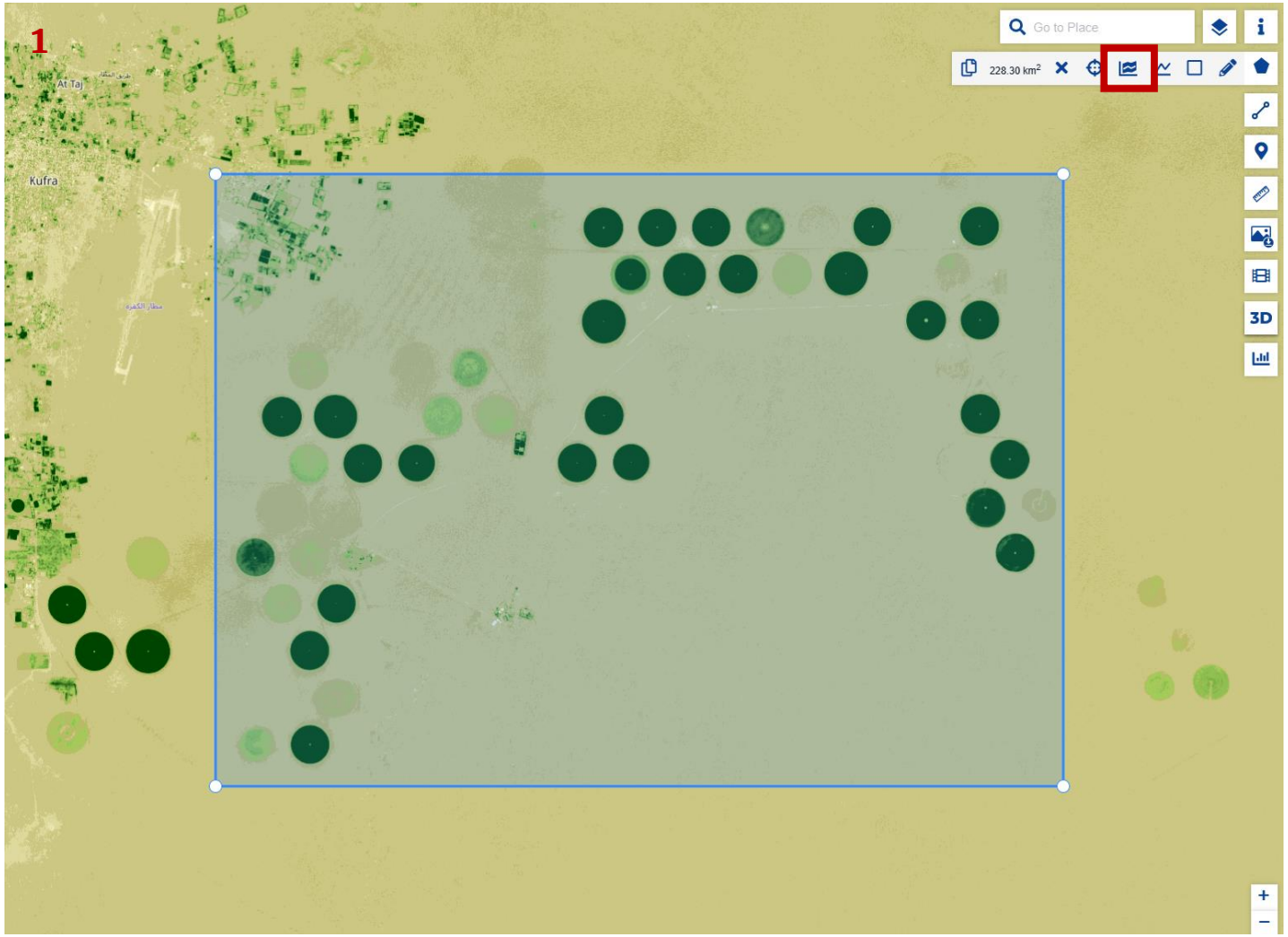
Max. cloud coverage: 10%

Date: 2025-02-15

Layer: NDVI

View Statistical Info

1



2

3

- *What are the first and last dates visible in the chart?*
- *What are the mean, standard deviation (st. dev), minimum (min), and maximum (max) values corresponding to these two dates?*

Feel free to export the CSV file if needed.

Statistical Info results

- *What are the first and last dates visible in the chart?*
- *What are the mean, standard deviation (st. dev), minimum (min), and maximum (max) values corresponding to these two dates?*

First date	2024-08-19
Mean	0.11
St. dev	0.09
Min – max	-0.05 – 0.92

Last date	2025-02-15
Mean	0.14
St. dev	0.17
Min – max	-0.07 – 1.00

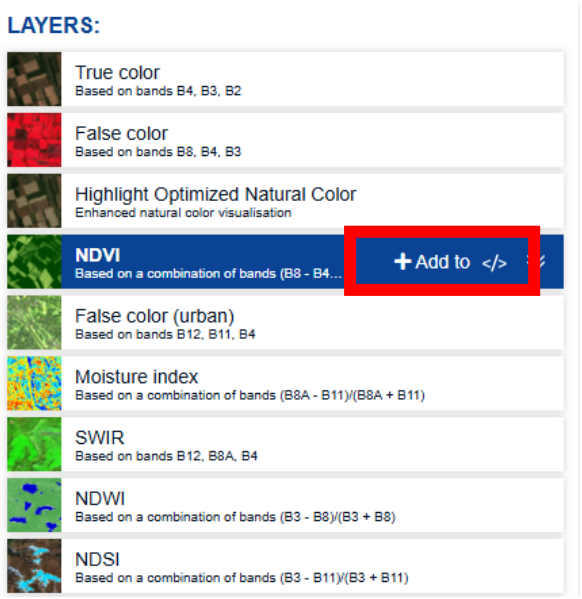
Compare NDVIs

Data collections: Sentinel-2 *Date:* 2024-08-19

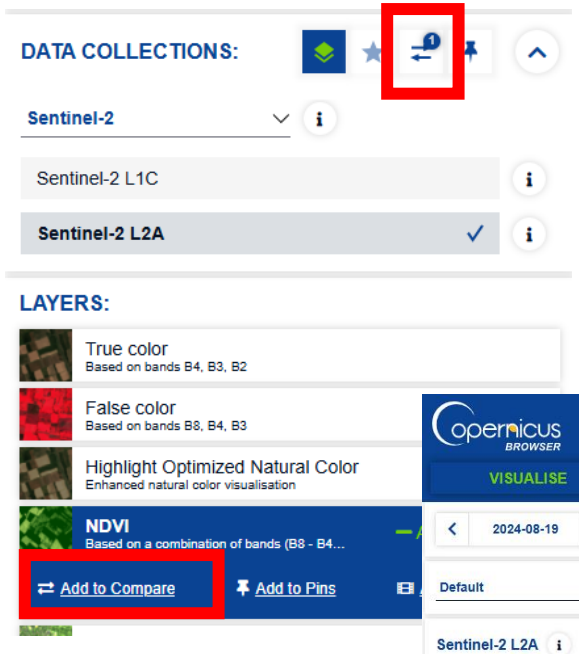
Product: Sentinel-2 L2A *Layer:* NDVI

Max. cloud coverage: 10%

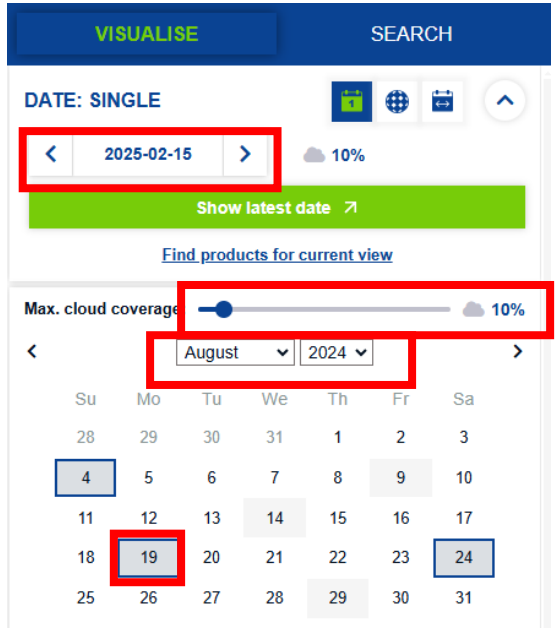
1



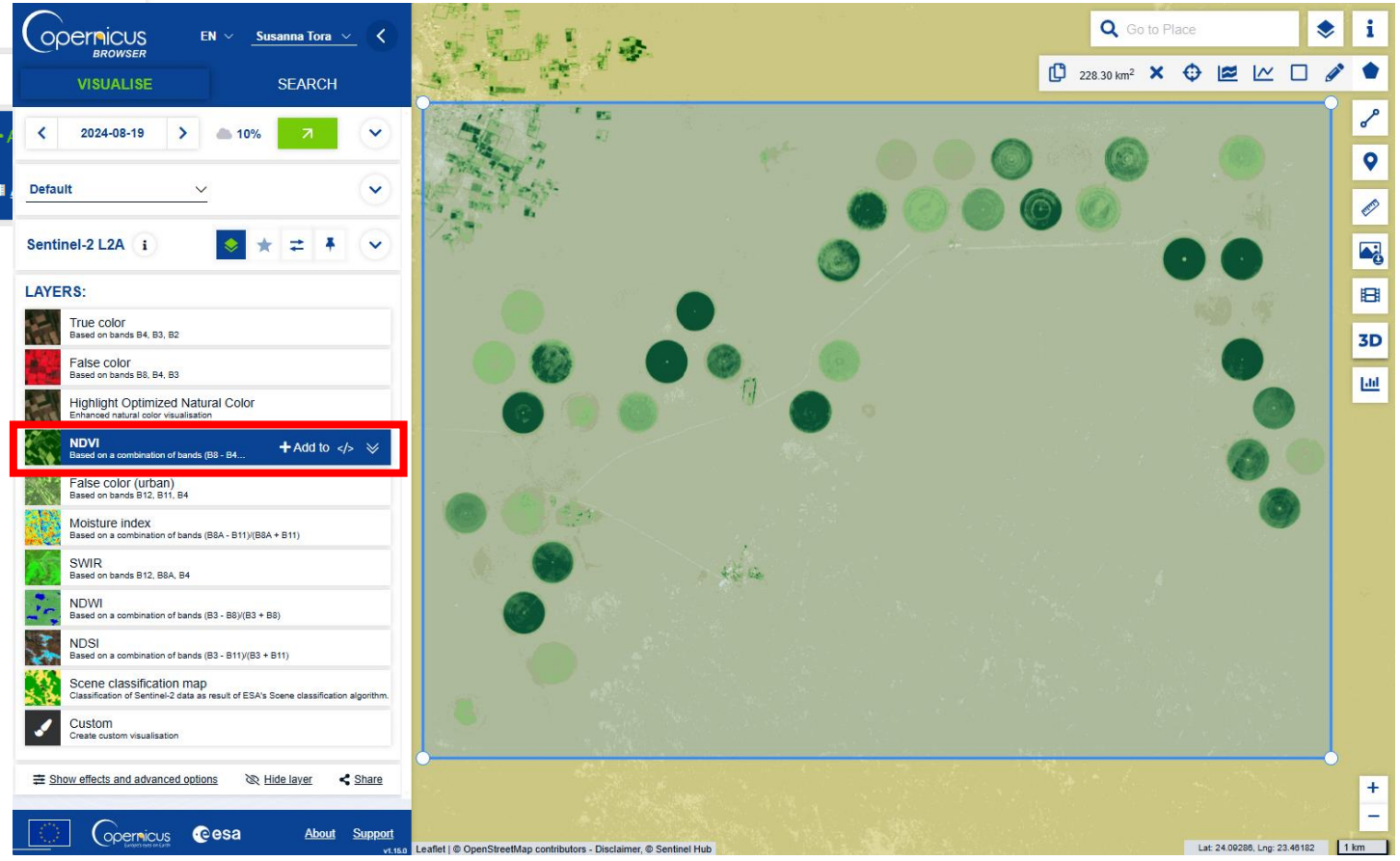
2



3

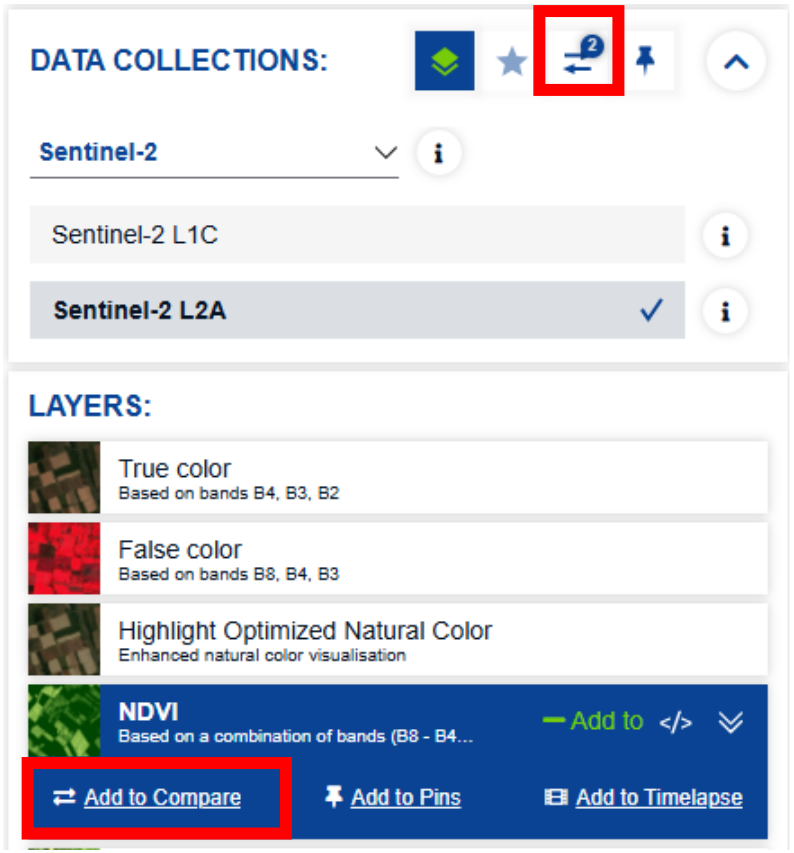


4

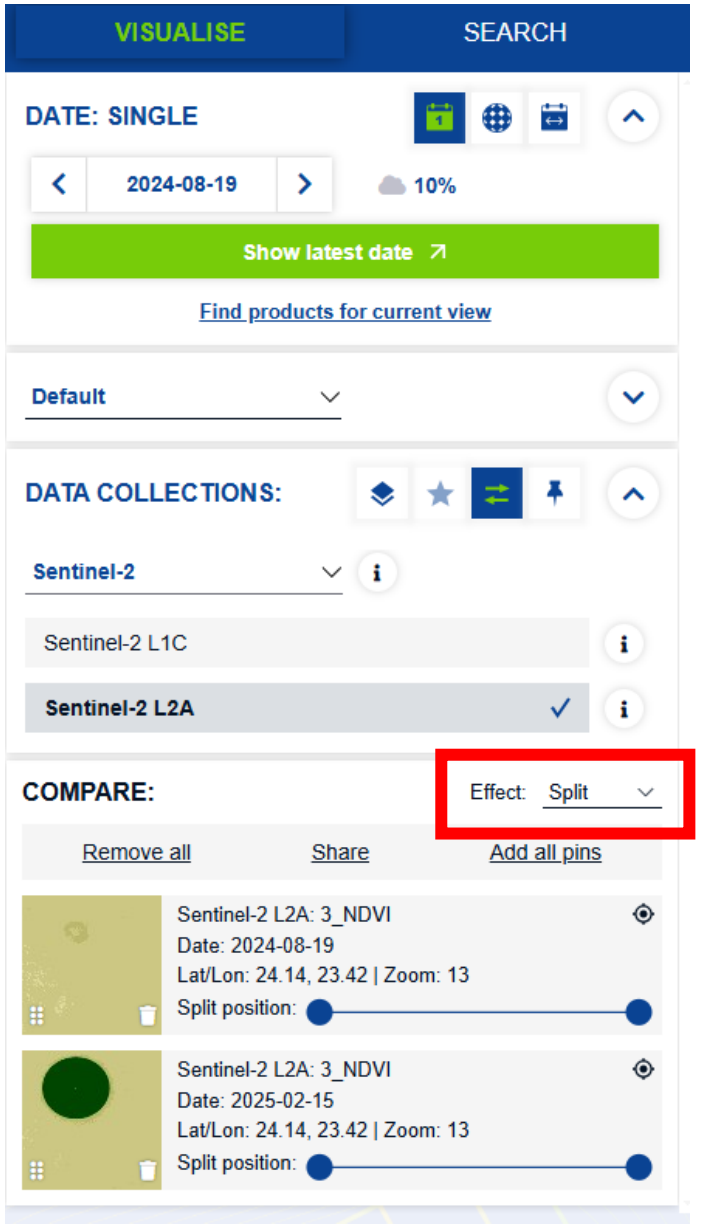


Compare NDVIs

5



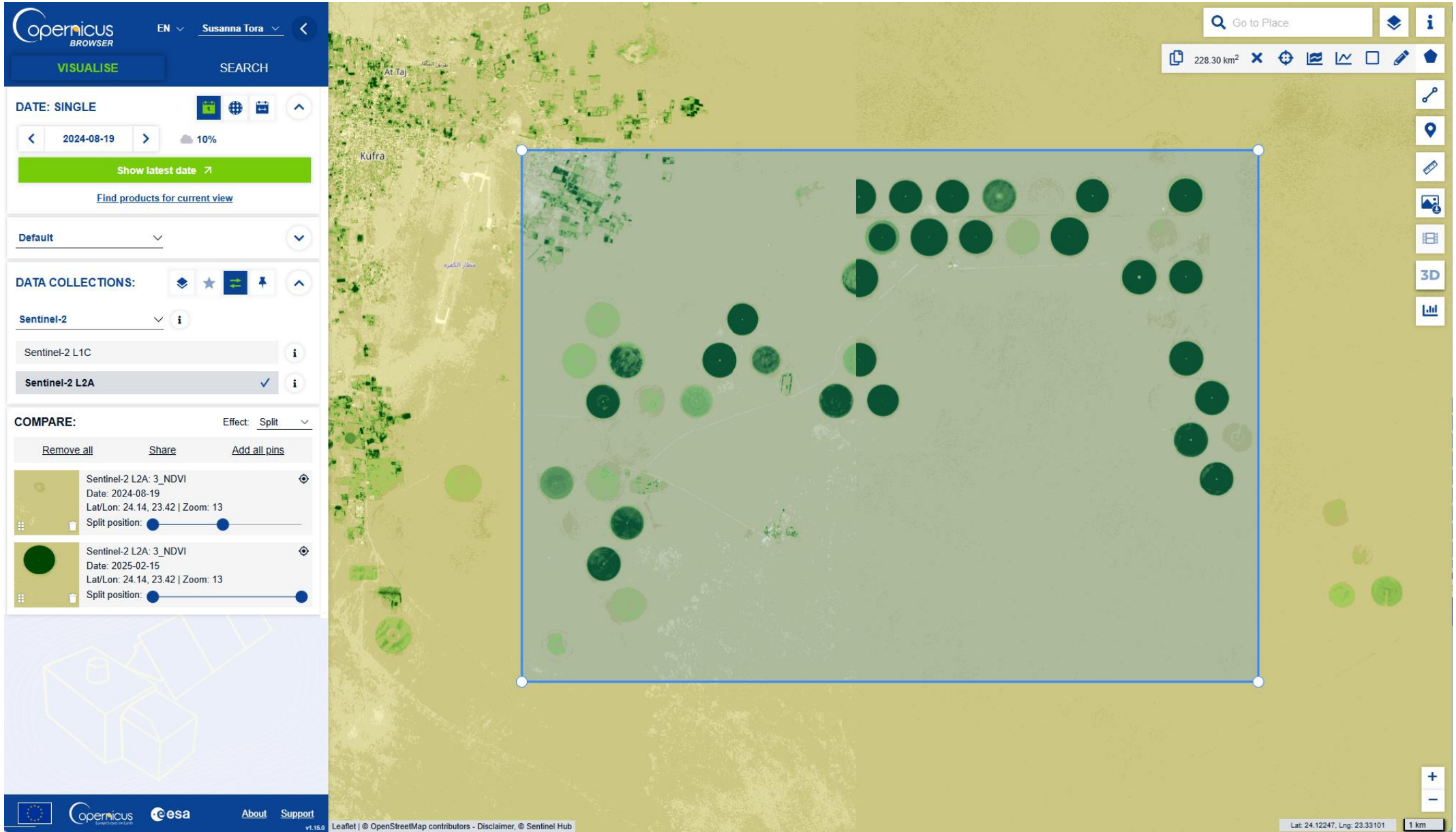
6



Choose the effect you prefer **Split** or **Opacity**

Move the slider to compare images

NDVI comparison result



NDVI comparison result

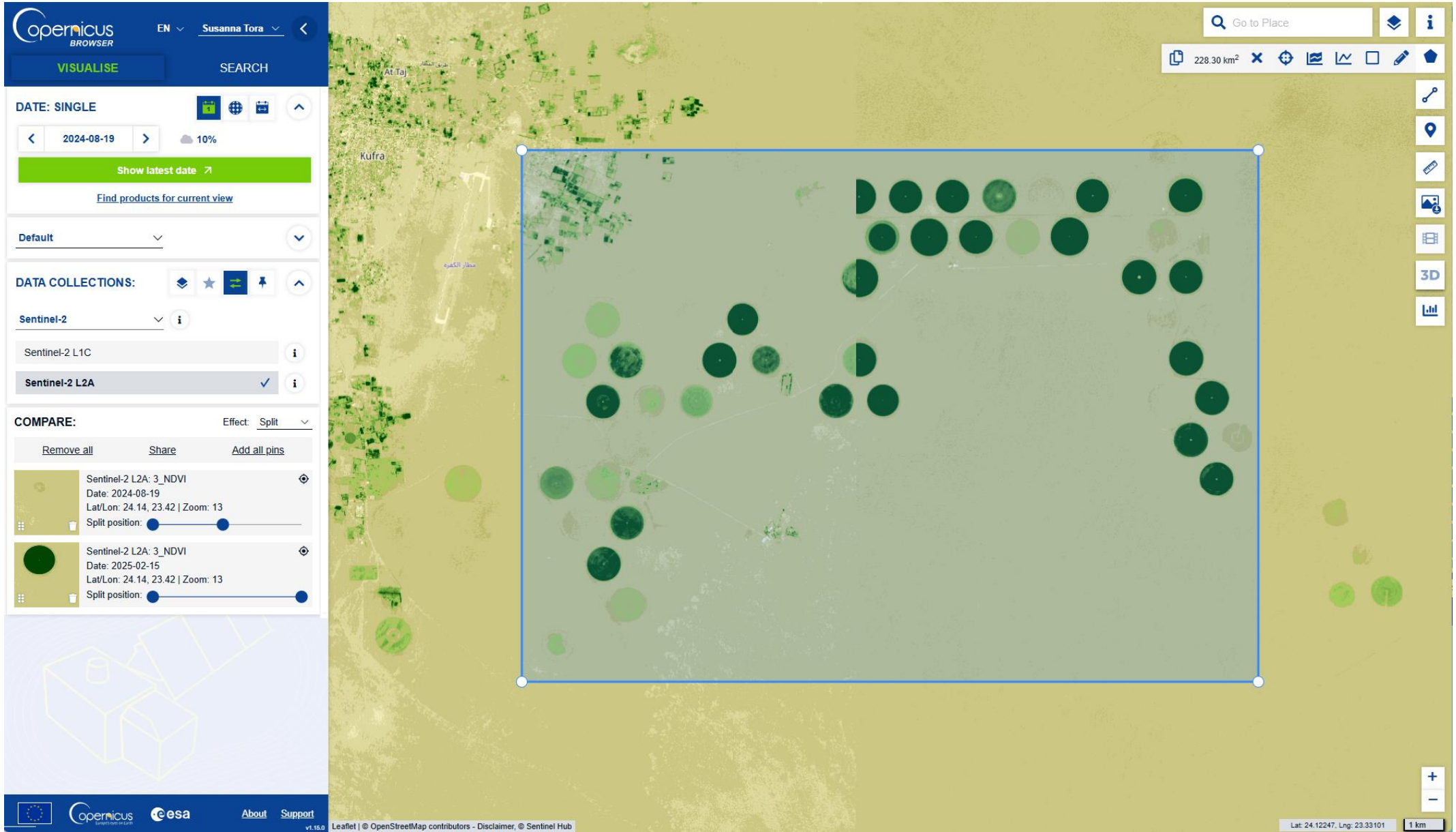
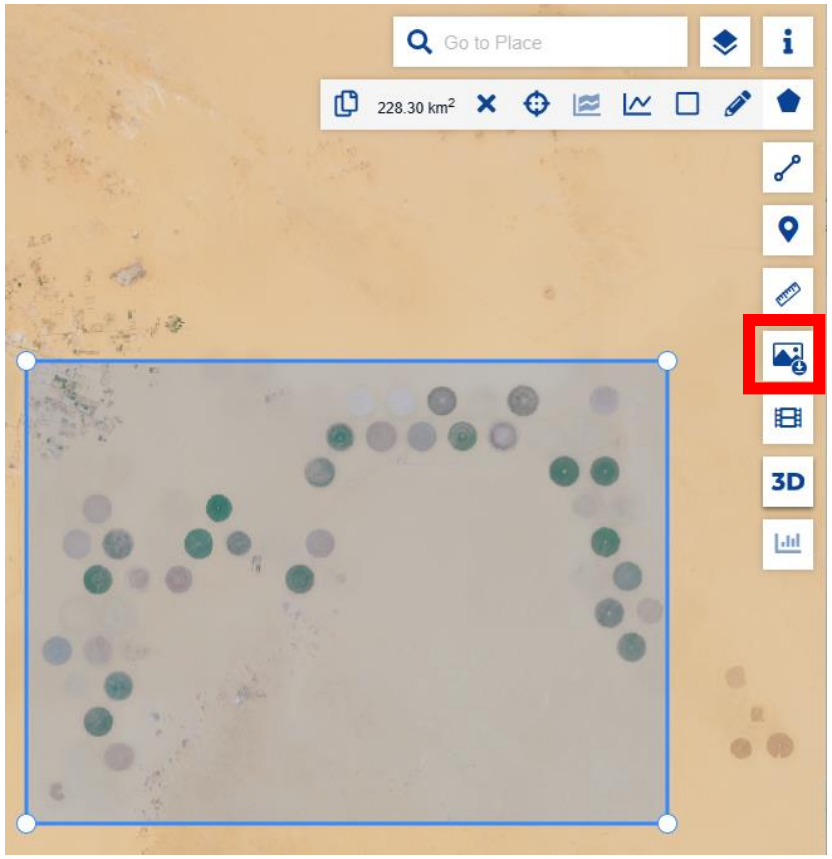
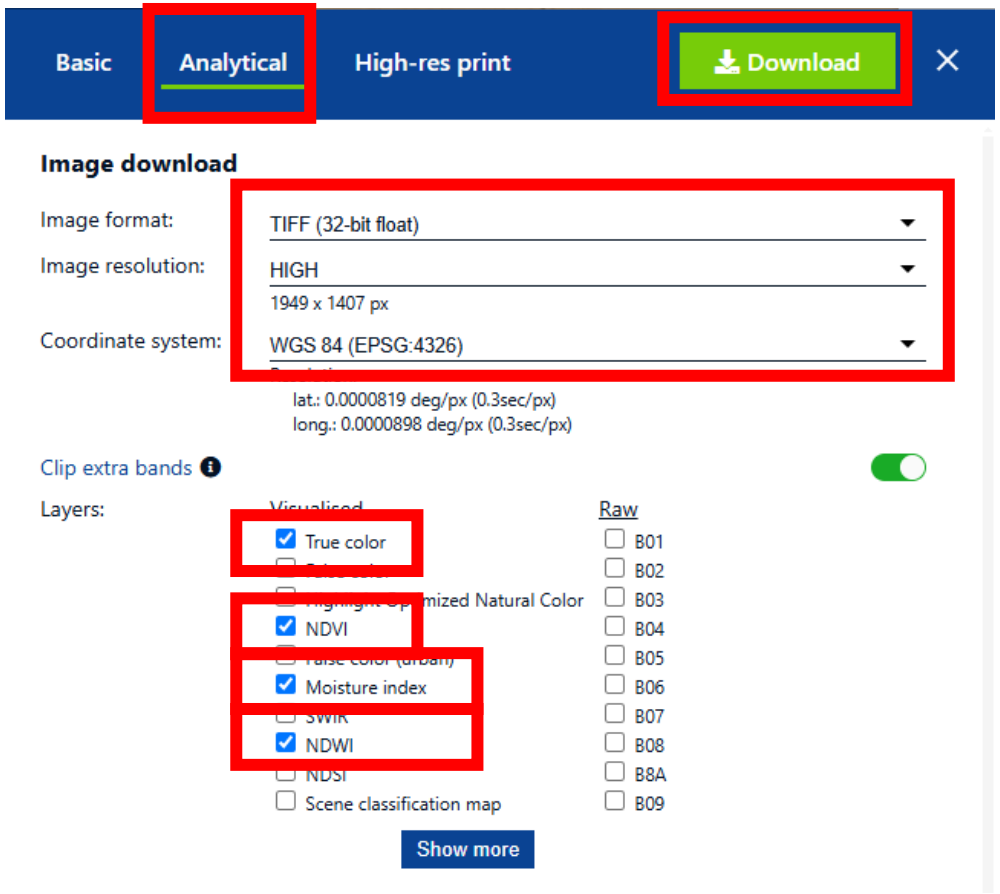


Image download

1



2



3

Image format: TIFF (32-bit float)

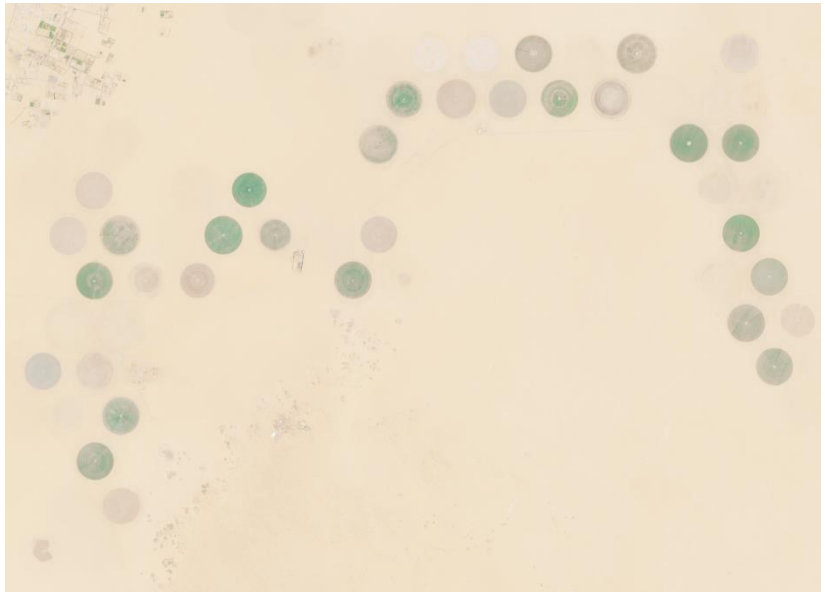
Image resolution: HIGH

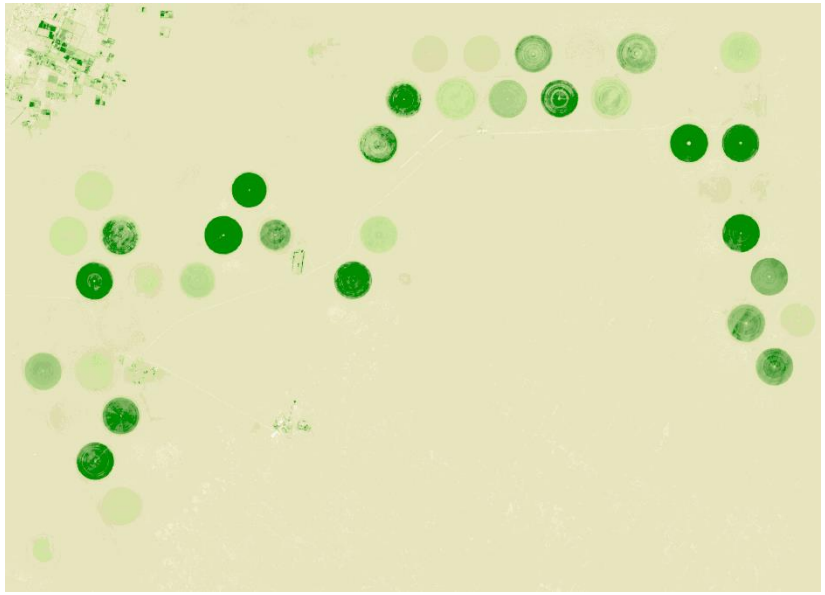
Coordinate system: WGS 84 (EPSG: 4326)

Layers: True color, NDVI, Moistur index, NDWI

Image download results

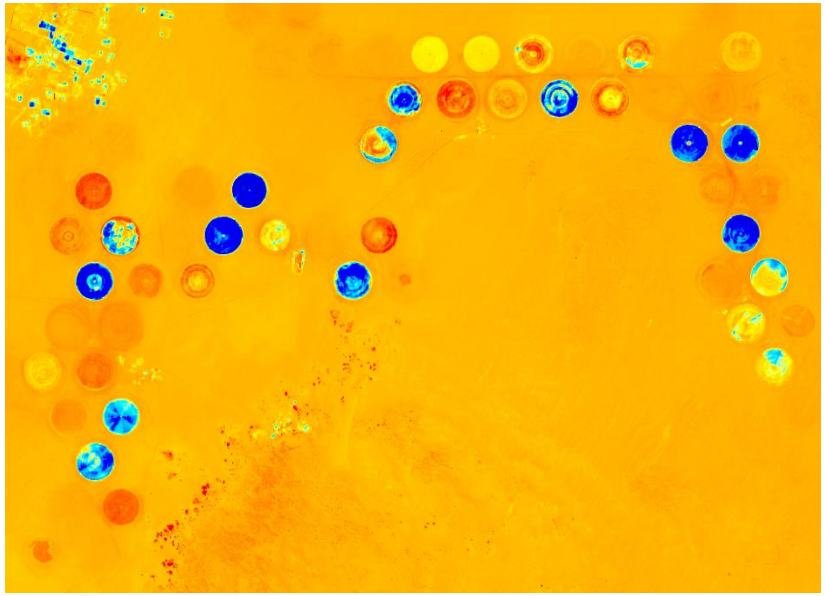
True color

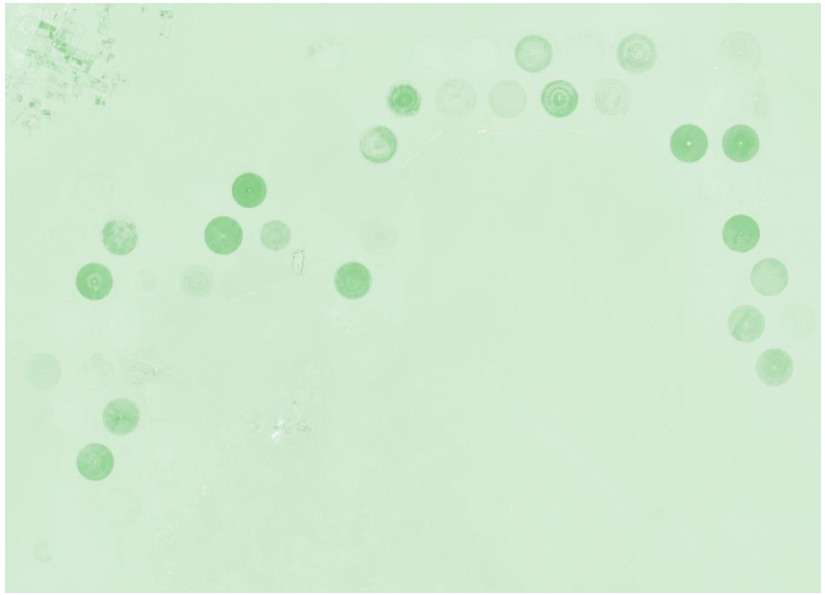




NDVI

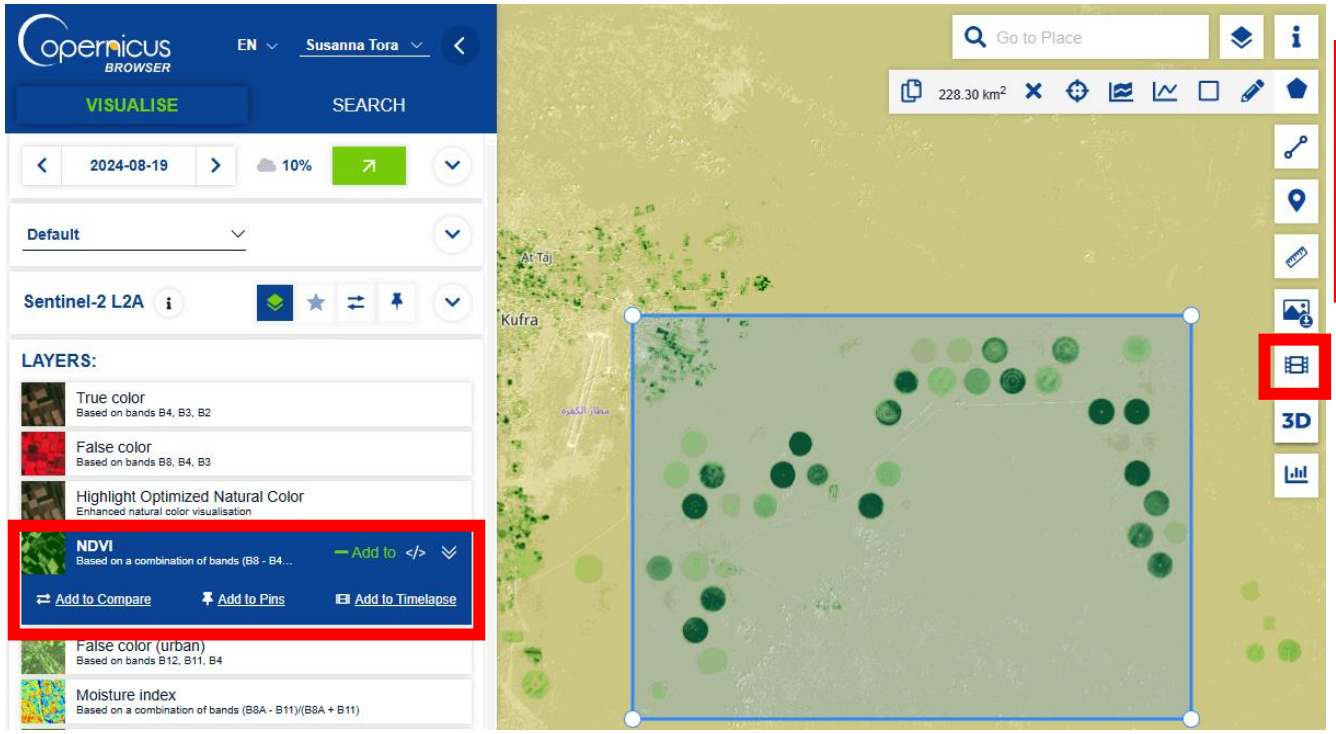
Moisture index





NDWI

Create timelapse animation



1

2

Date from 2024-08-19 *to* 2025-02-15

Select 1 image per: day

Sentinel-2 L2A: NDVI

Min. tile coverage: 80%

Max. cloud coverage: 10%

Select All image

Timelapse animation result

Final step

Try to download the image of the day

2025-02-15

in TIFF format for the *True color*, *NDVI*,

Moisture index and *NDWI* layers.

Tip: *Open the 'Pins panel'* 📌 *to retrieve the previously saved image, just select it in the list to view it again.*

Thank you