



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"



- 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

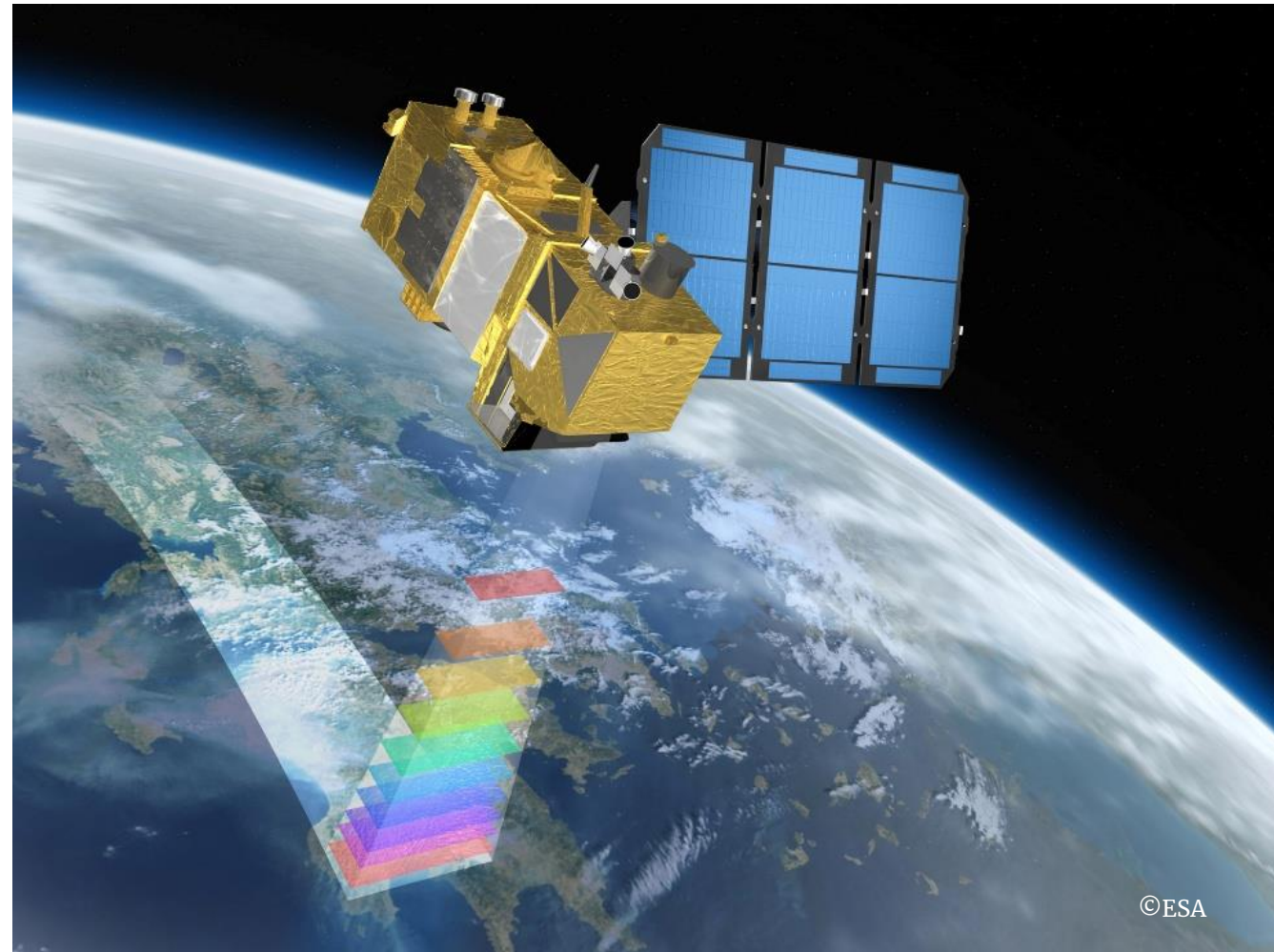
Defining Earth Observation (EO)

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

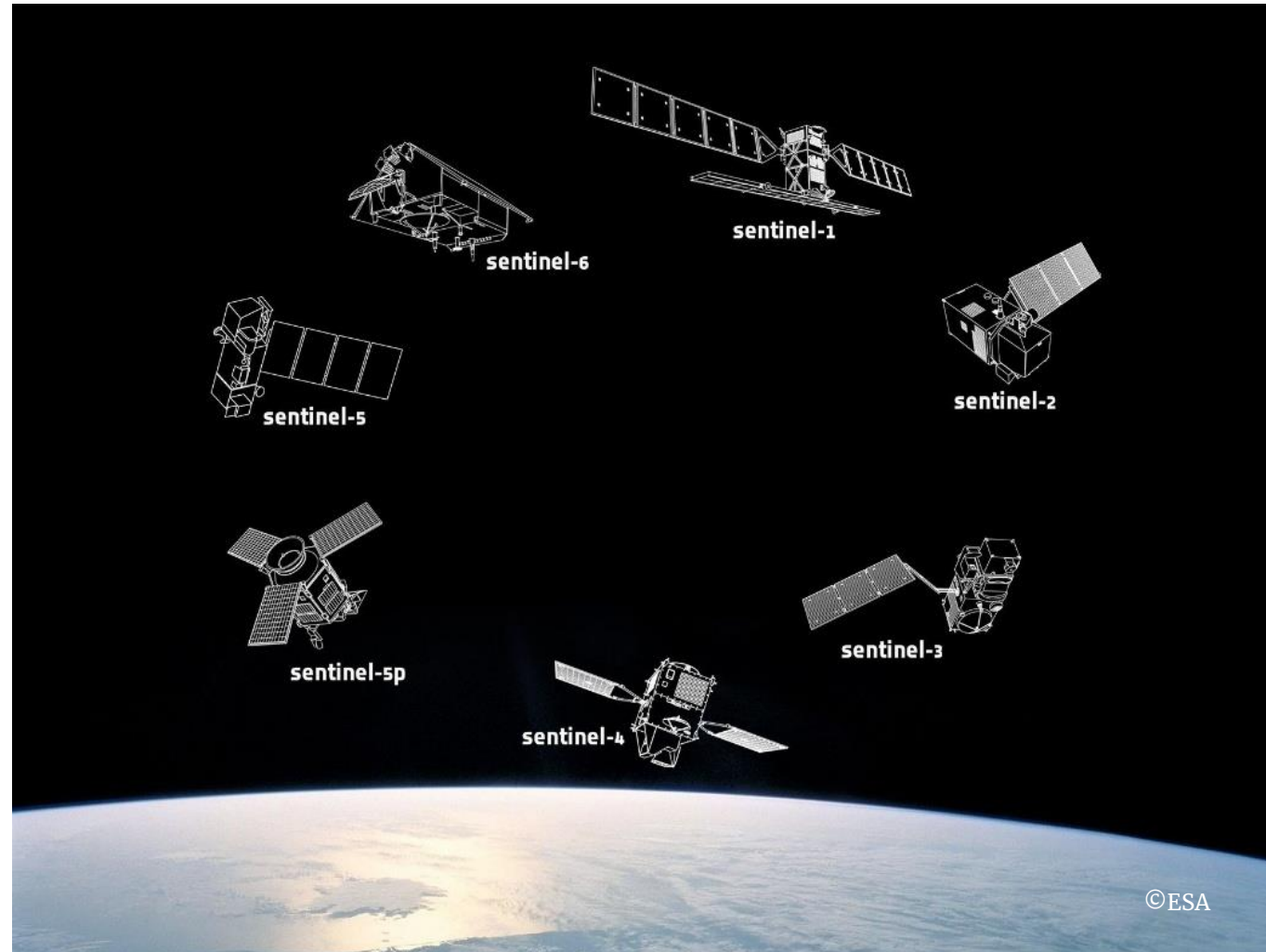
Copernicus is the Earth observation component of the European Union's Space programme, observing our planet's environment and systems. It offers raw data and derived products that draw from satellite Earth Observation and in-situ (non-space) data.

- 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.

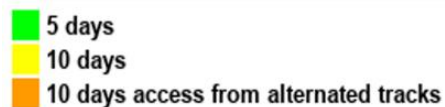
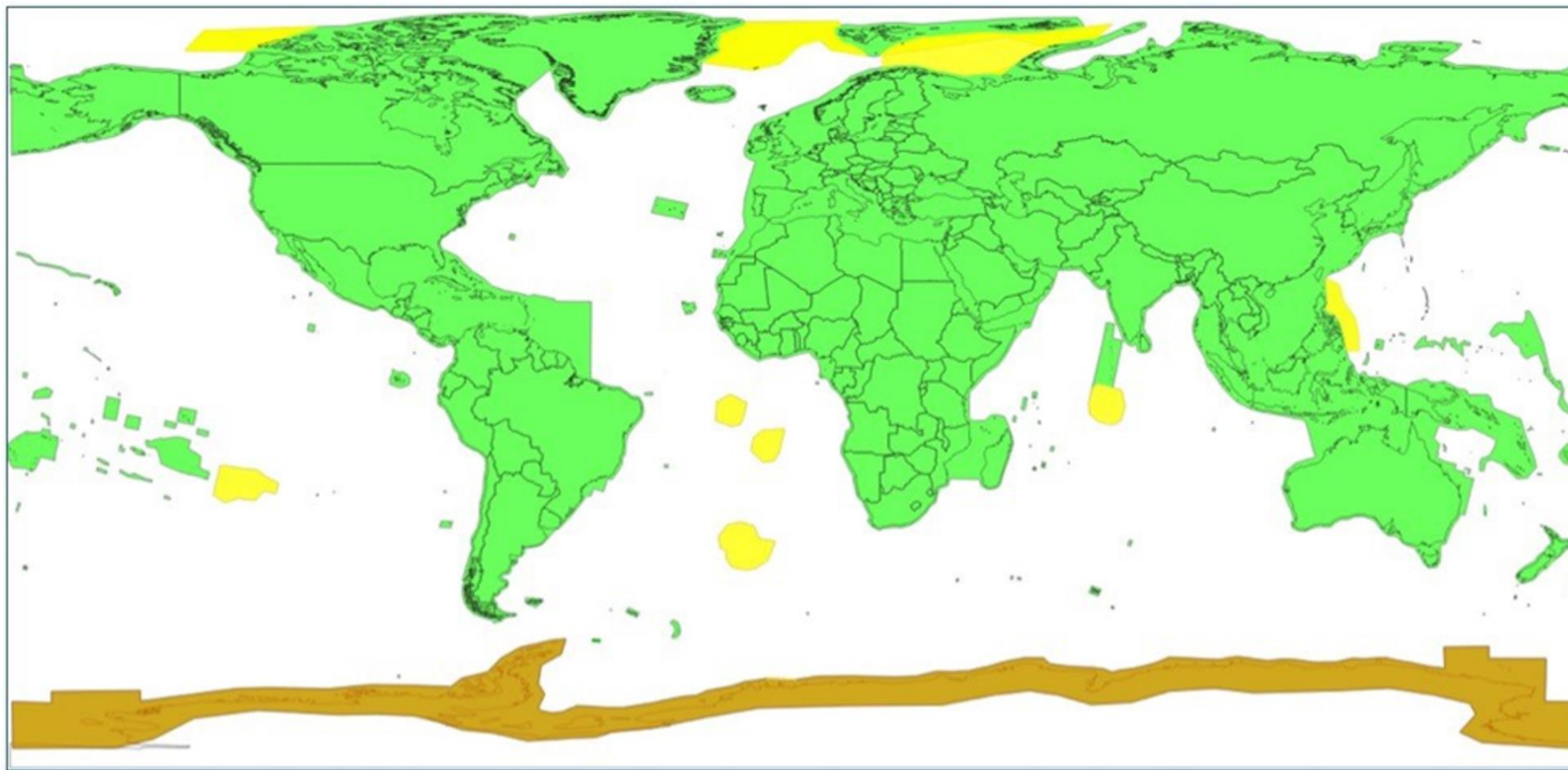


The Sentinel missions

- **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

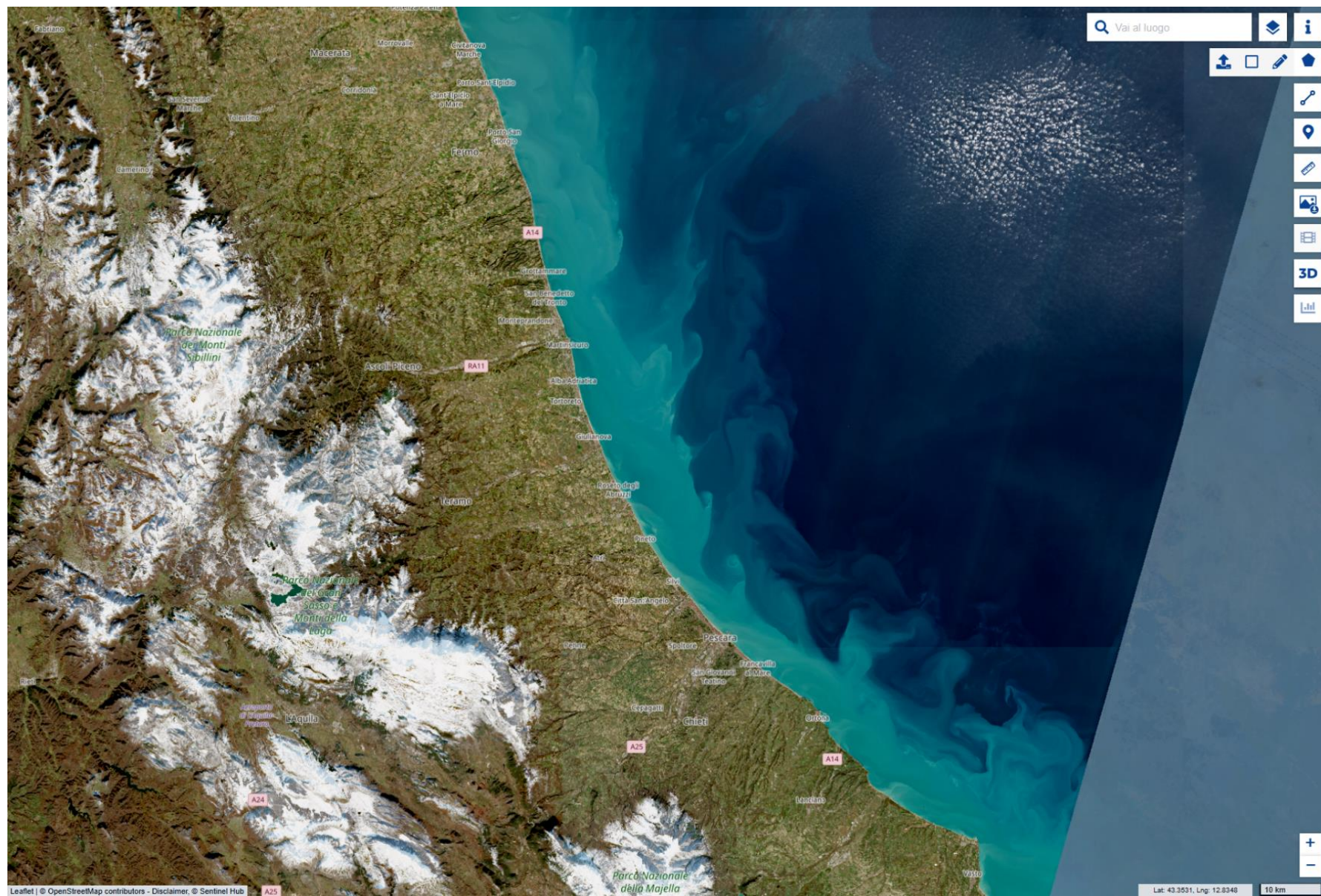
	BAND	WAVELENGTH (min-max in micrometers)	SPATIAL RESOLUTION (meters)
<i>Band 1</i>	Costal aerosol	0.421 – 0.457	60
<i>Band 2</i>	Blue	0.439 – 0.535	10
<i>Band 3</i>	Green	0.537 – 0.582	10
<i>Band 4</i>	Red	0.646 – 0.685	10
<i>Band 5</i>	Vegetation red edge	0.694 – 0.714	20
<i>Band 6</i>	Vegetation red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

EO Applications: Sentinel-2

True color

$R = B_4, G = B_3, B = B_2$











	True color Based on bands B4, B3, B2	+ Aggi... </> v
	False color Based on bands B8, B4, B3	
	Highlight Optimized Natural Color Enhanced natural color visualisation	
	NDVI Based on a combination of bands $(B8 - B4)/(B8 + B4)$	
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	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 of ESA's Scene classification algorithm.	

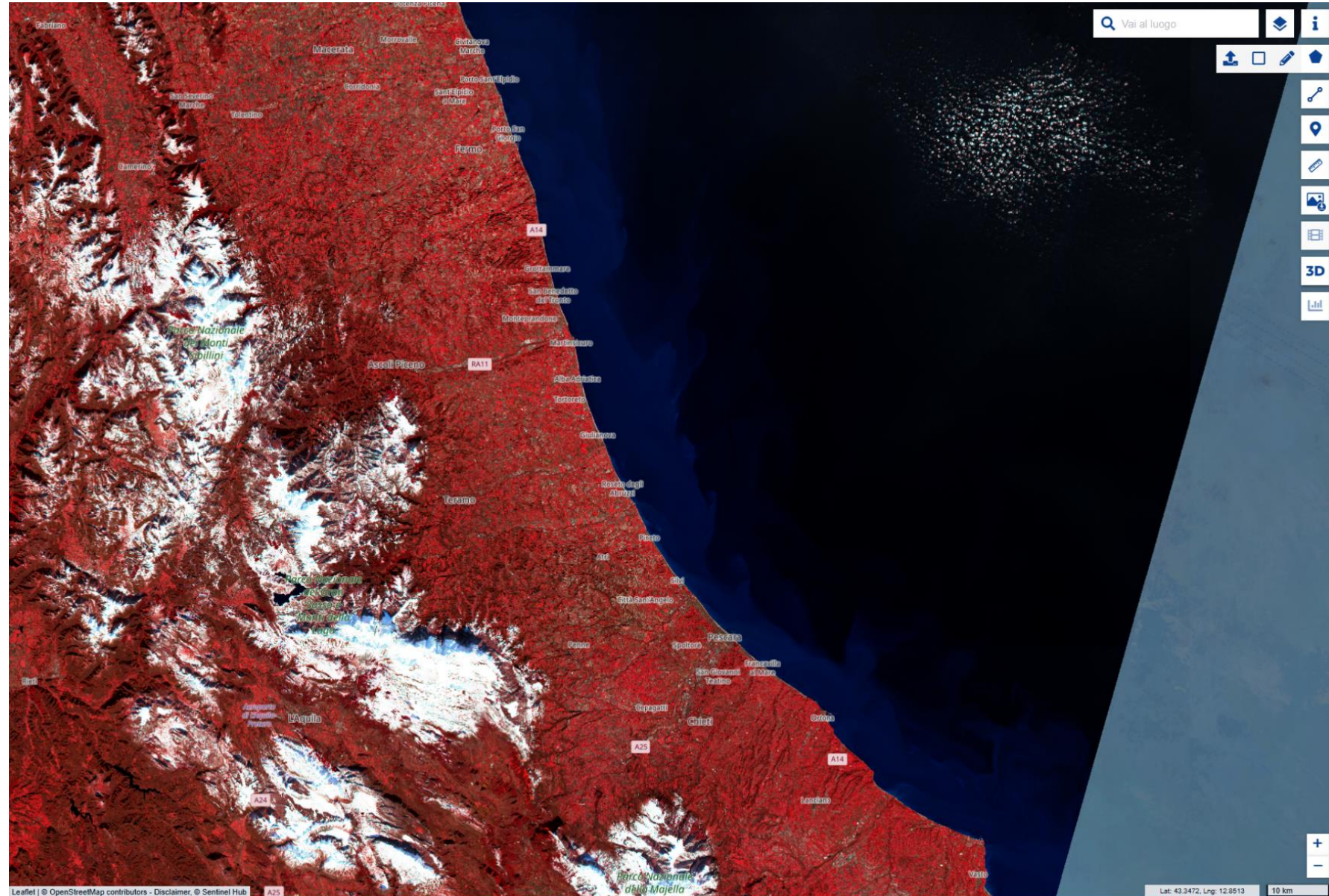


EO Applications: Sentinel-2

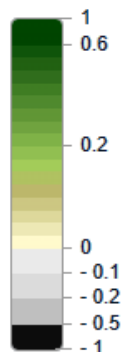
False color

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

	True color Based on bands B4, B3, B2
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







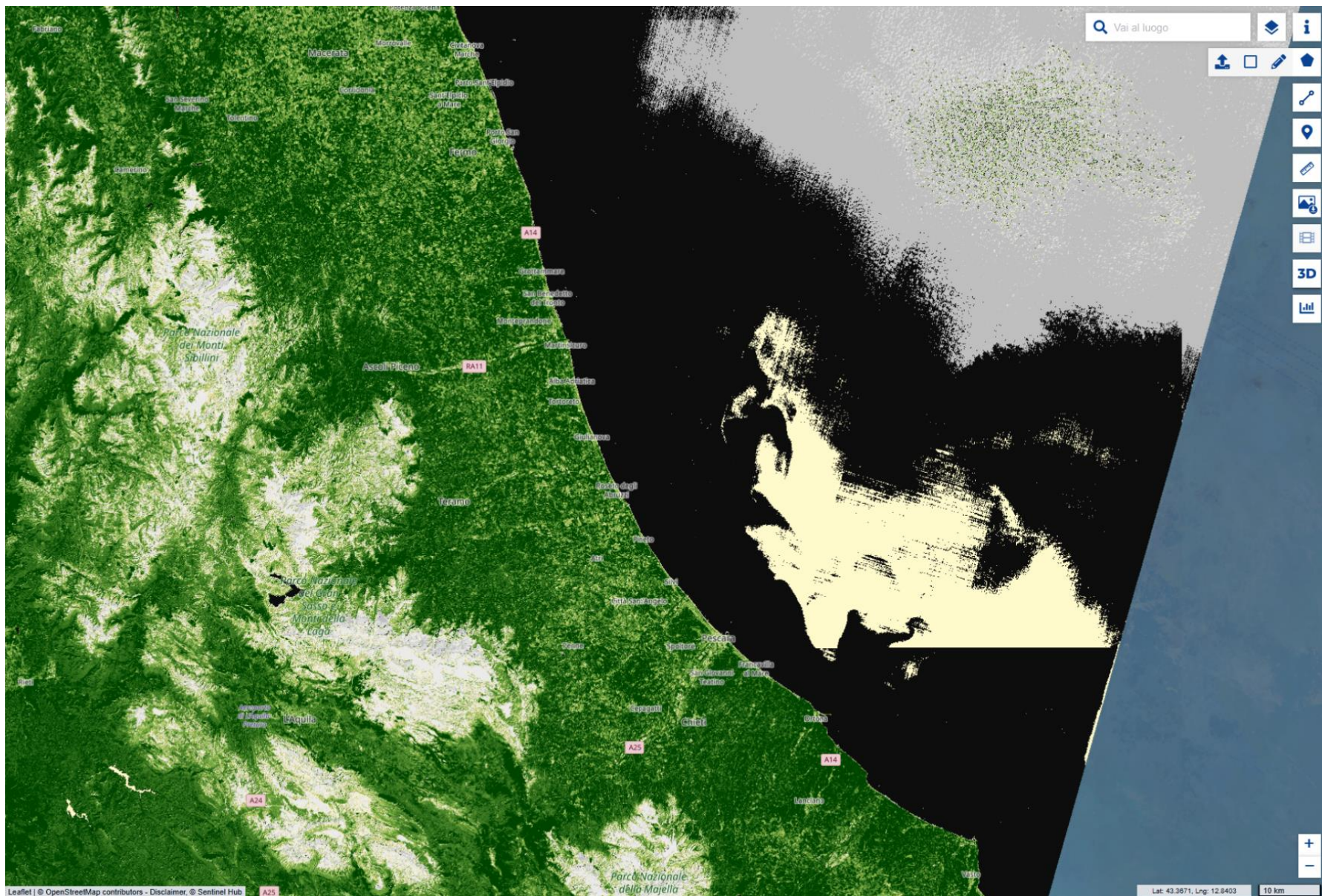
EO Applications: Sentinel-2



NDVI

$$(B8 - B4) / (B8 + B4)$$











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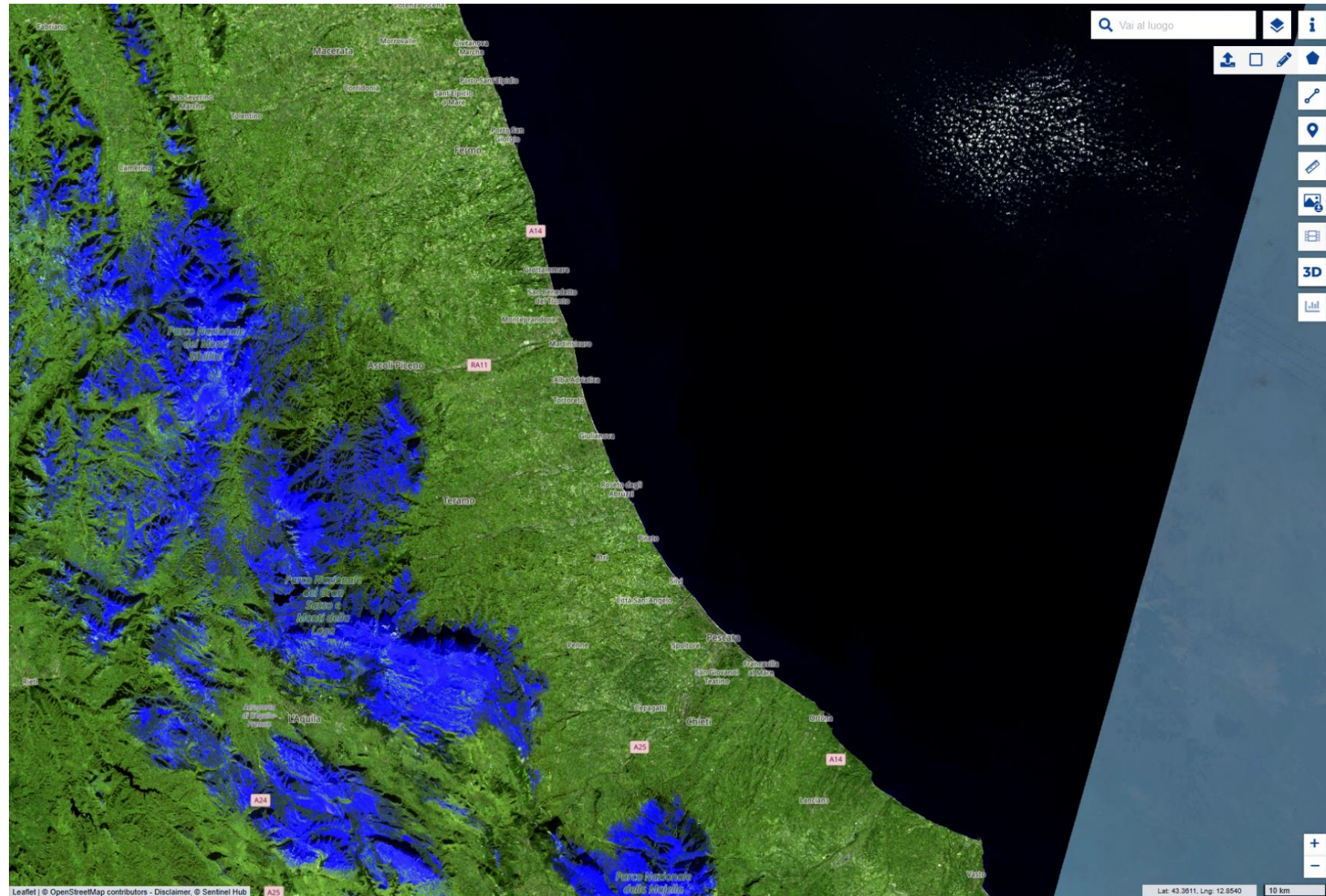


EO Applications: Sentinel-2

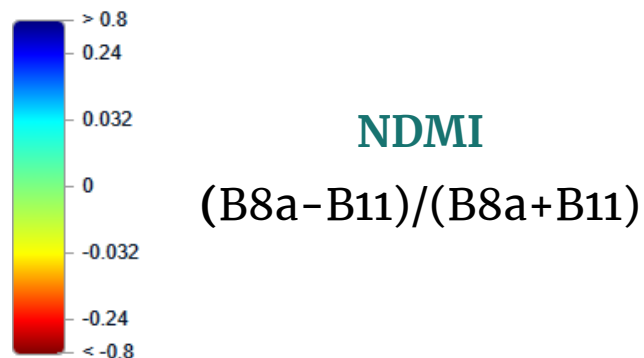
False color (urban)











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

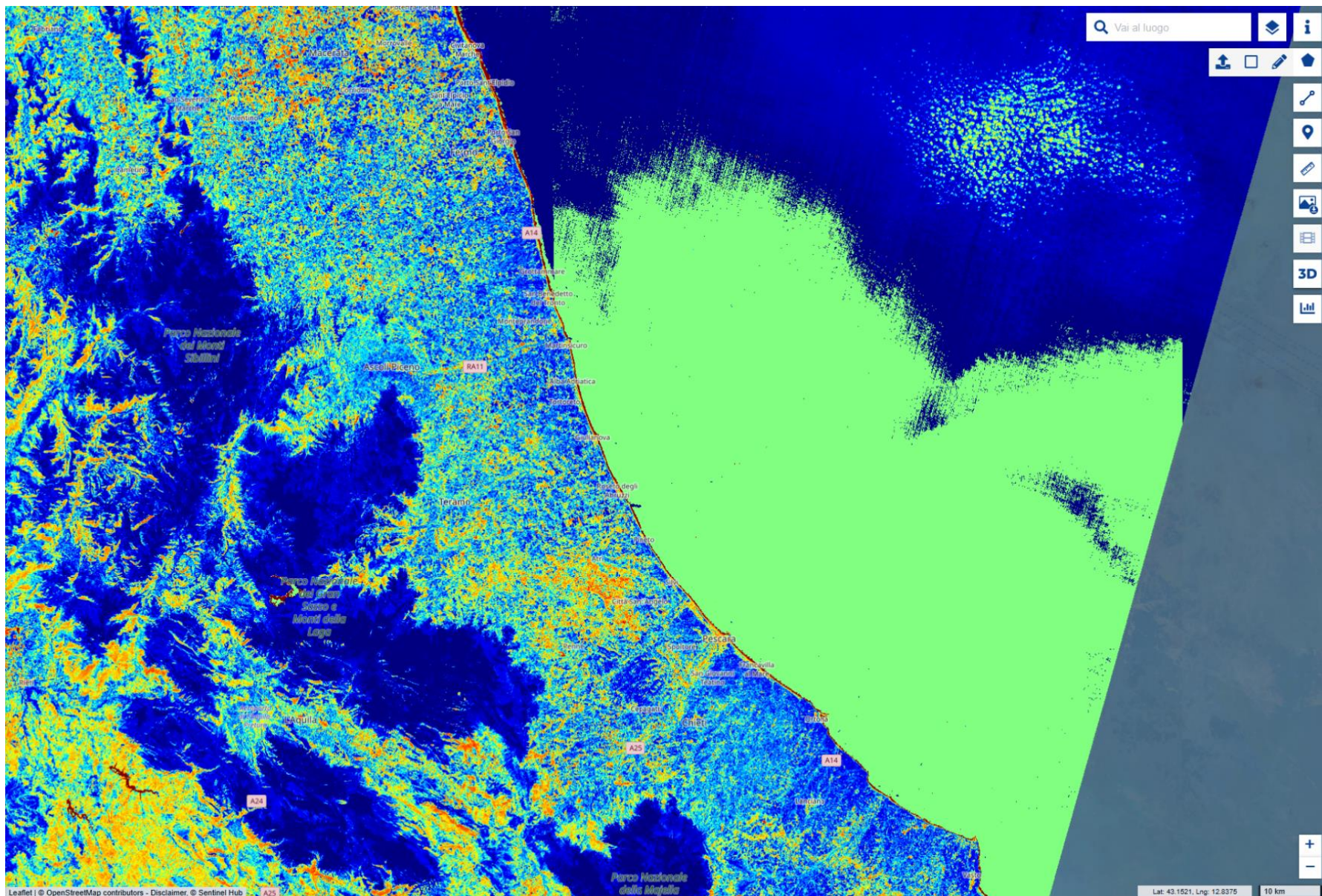
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EO Applications: Sentinel-2




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EO Applications: Sentinel-2

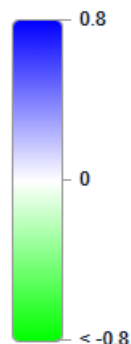
SWIR

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

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









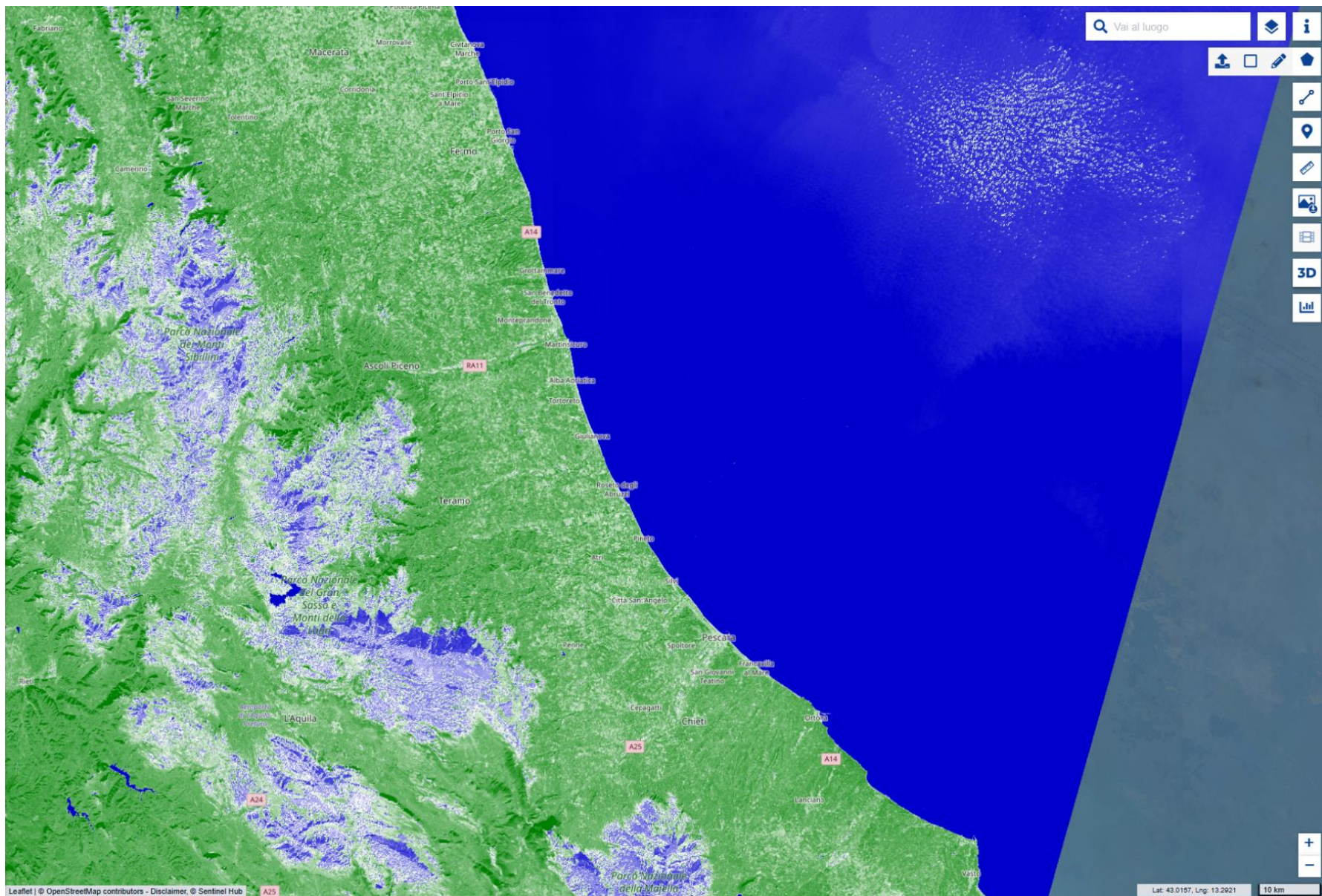
EO Applications: Sentinel-2



NDWI

$$(B3 - B8) / (B3 + B8)$$











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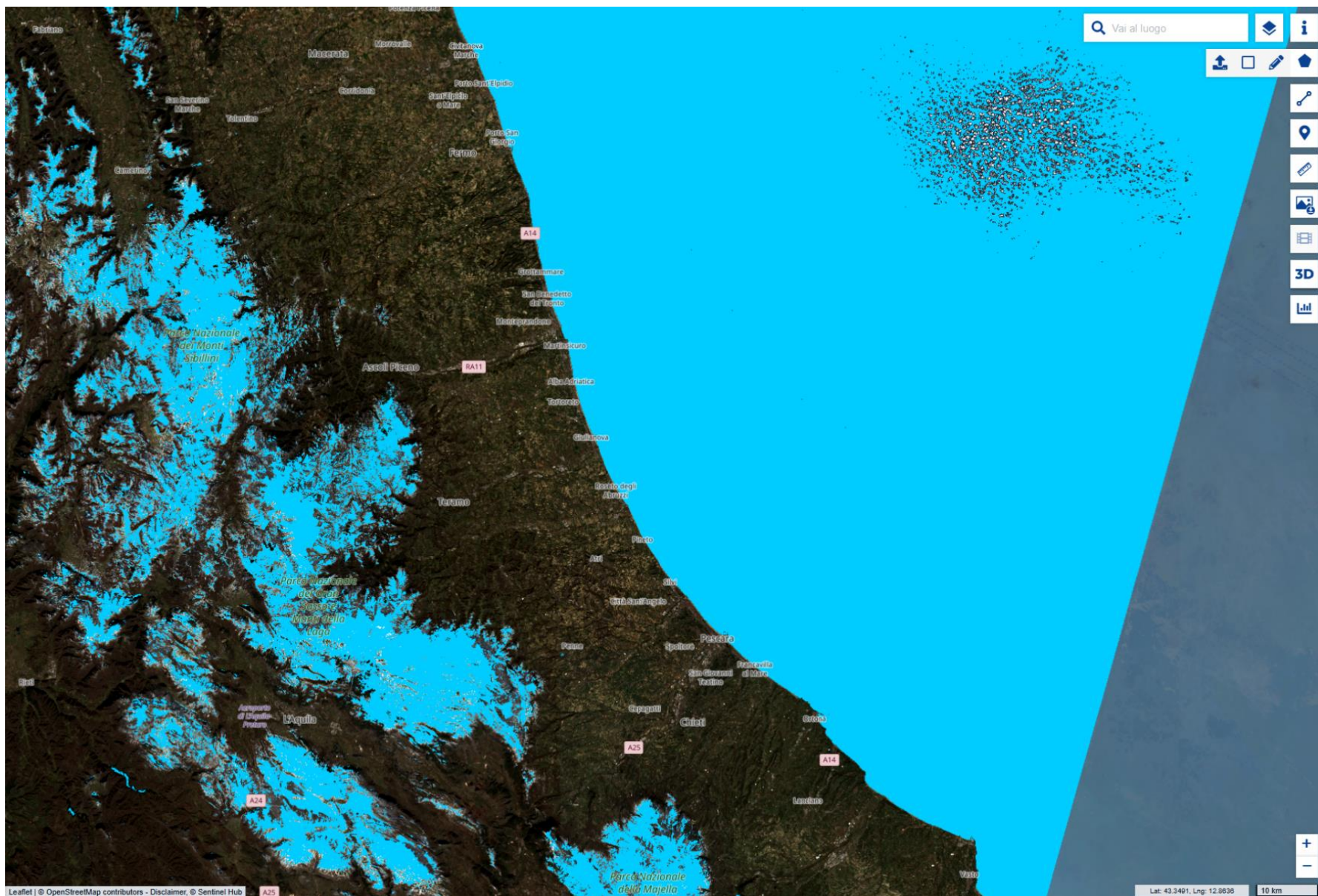


EO Applications: Sentinel-2

NDSI

$$(B3 - B11) / (B3 + B11)$$

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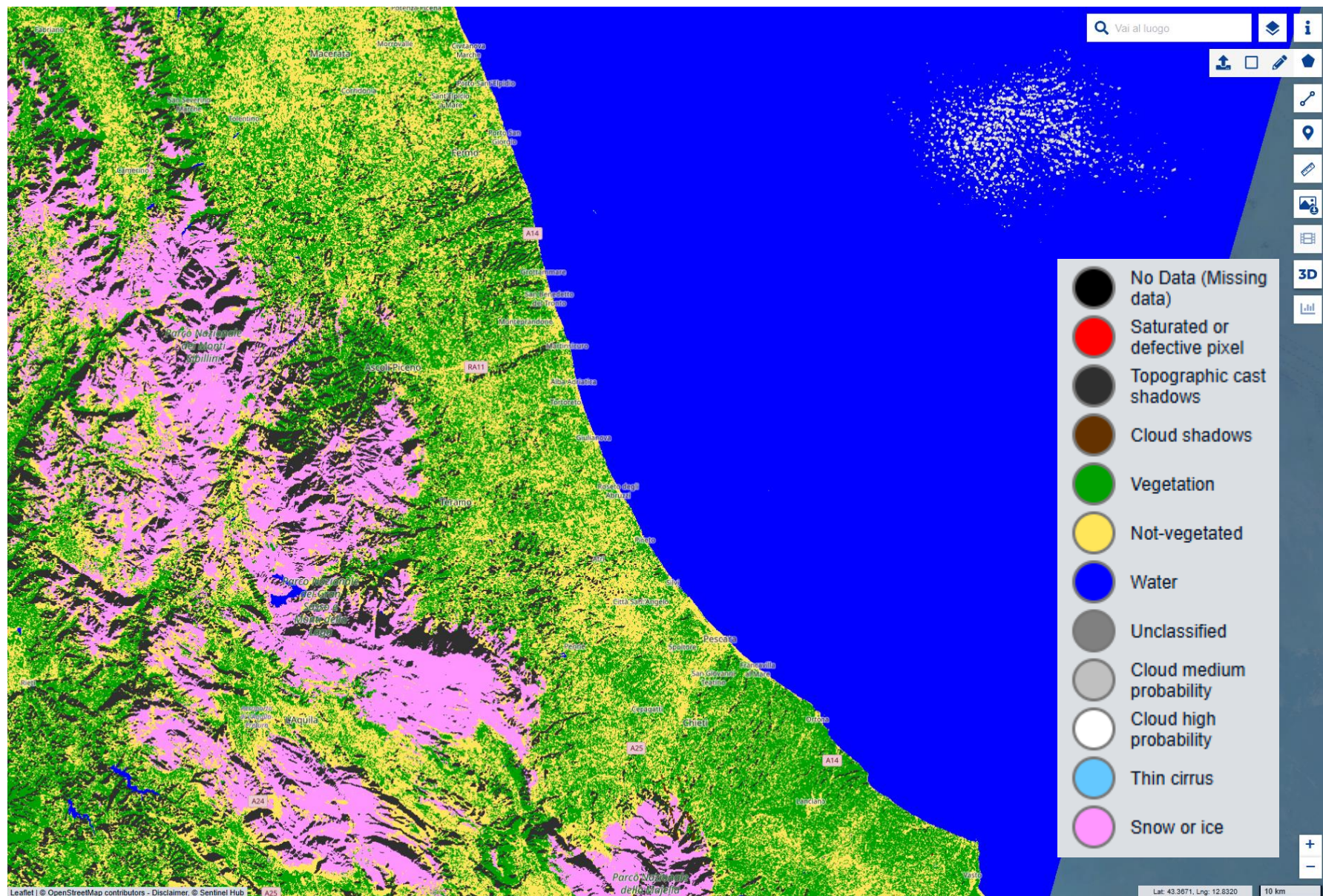


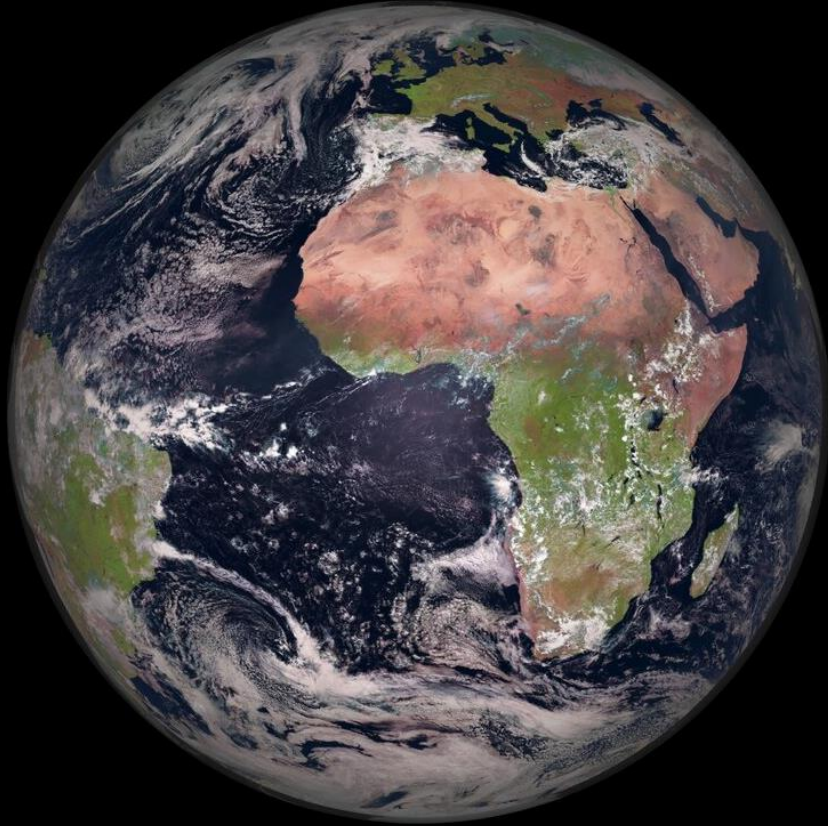
EO Applications: Sentinel-2

Scene classification map

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+ Aggiu... </>





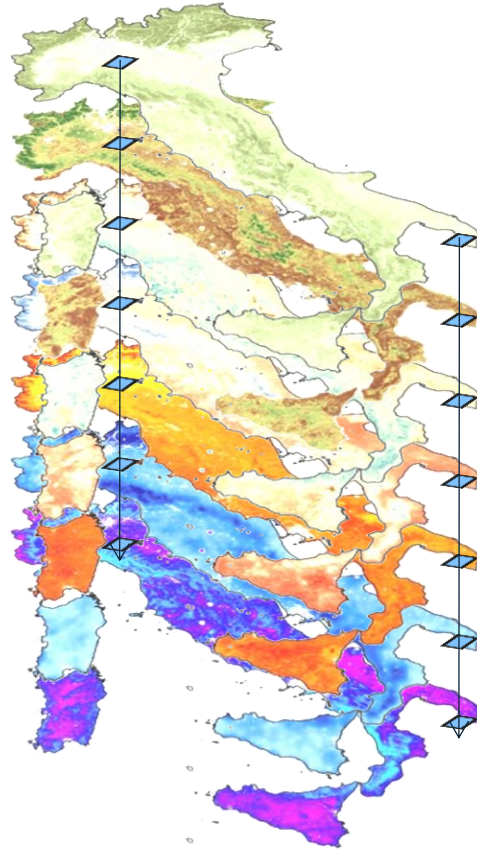
Example of satellite data application: Ecoregions

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

Ecoregions

- ✓ 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

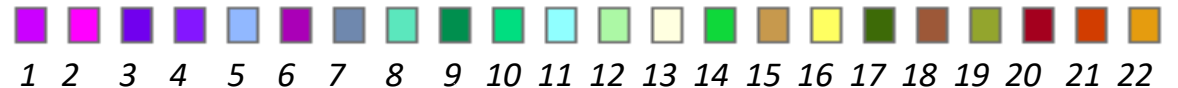
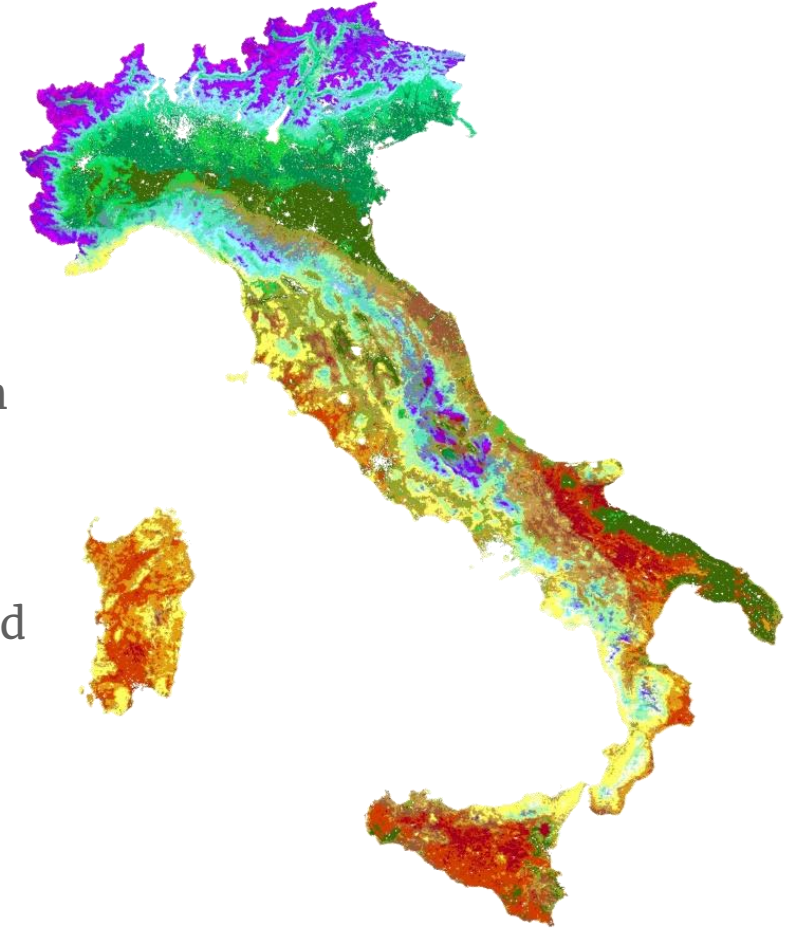
Fourier transformation

PCA

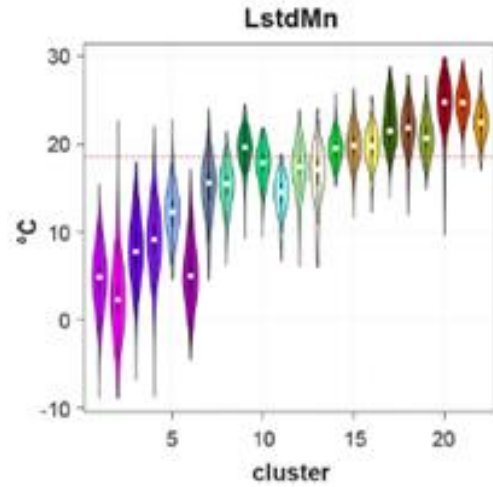
Unsupervised k-medoid

Clustering

RGB channels

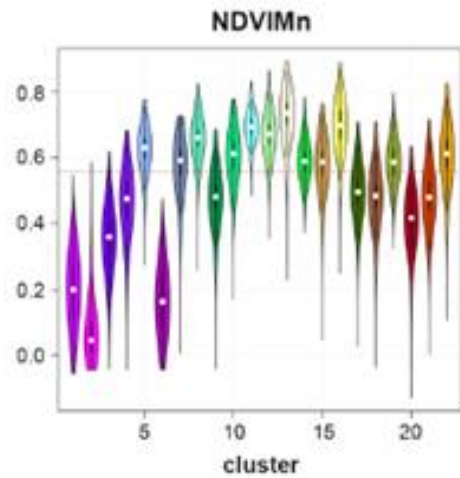


Ecoregions

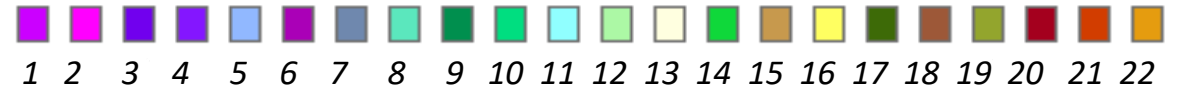
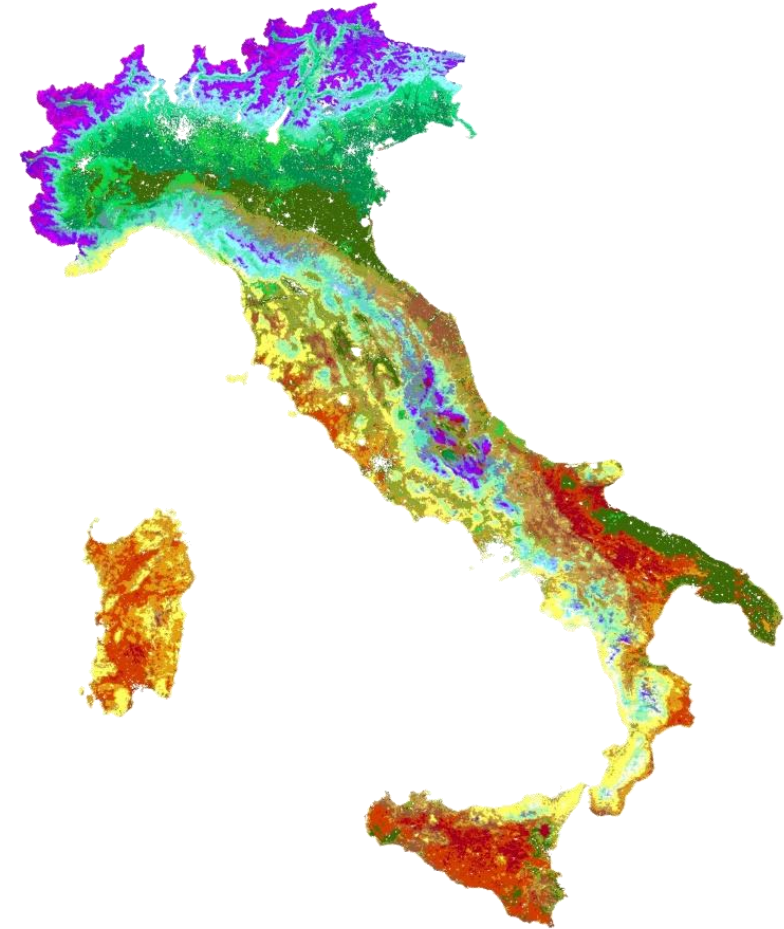
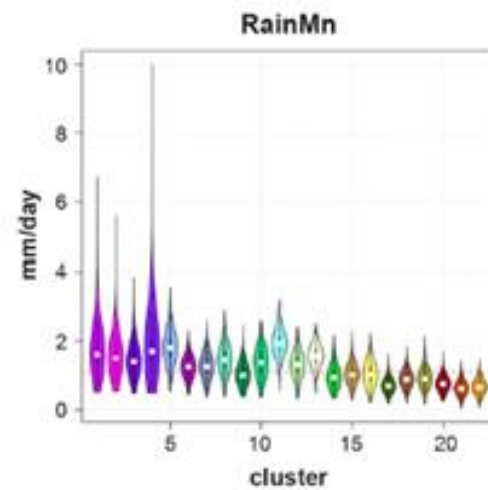


temperature

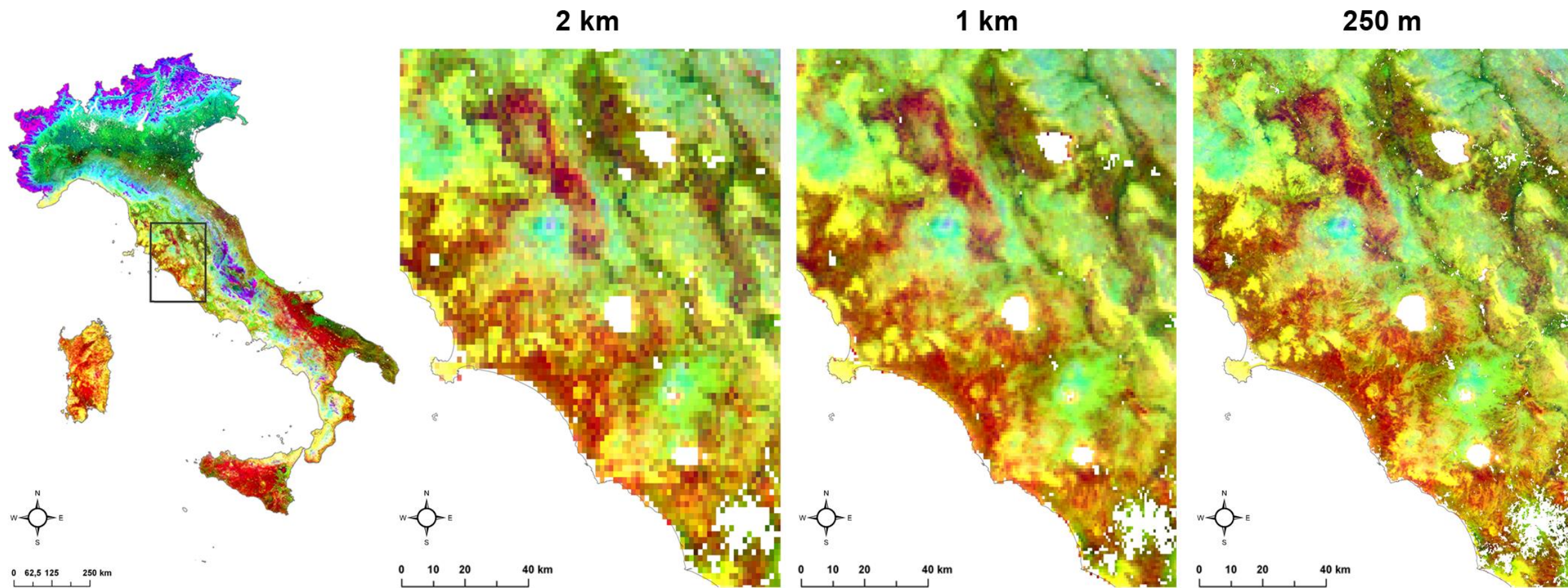
NDVI



rainfall



Spatial resolutions

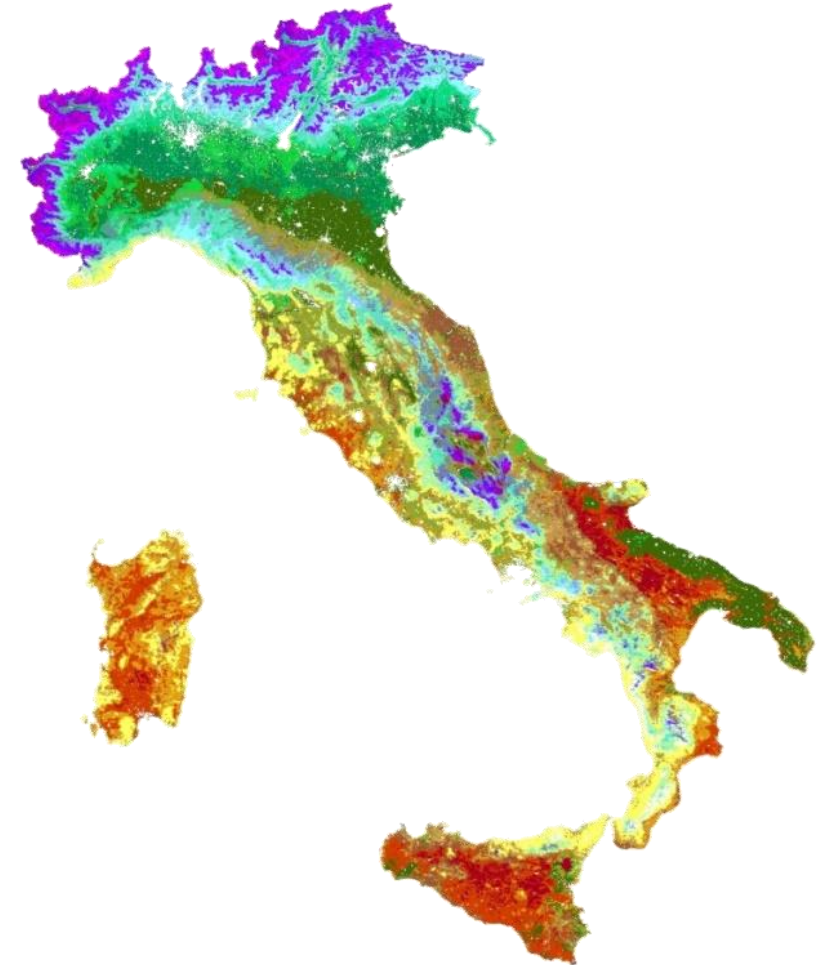
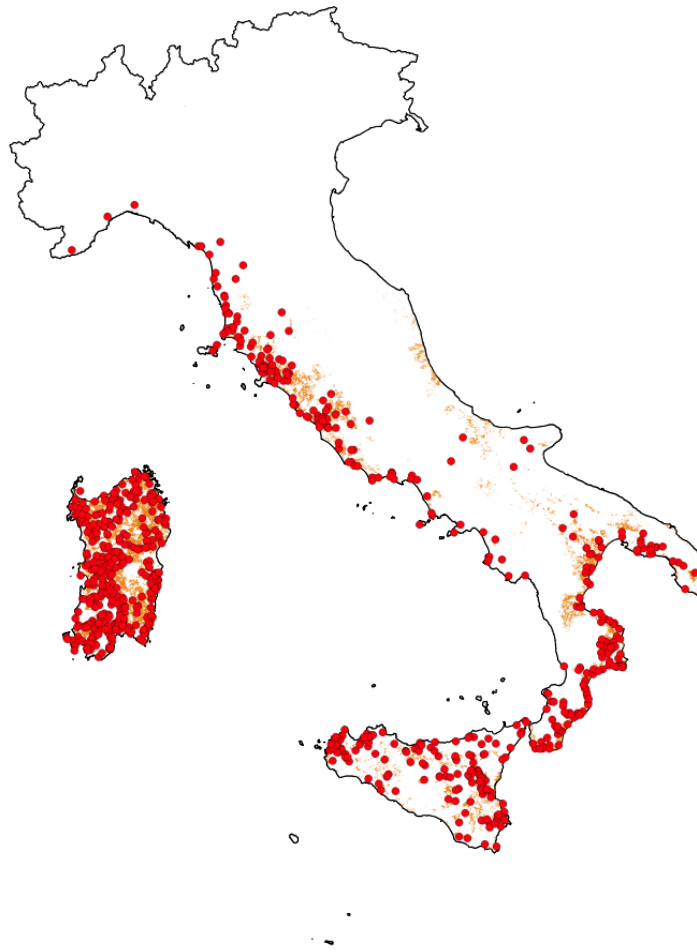
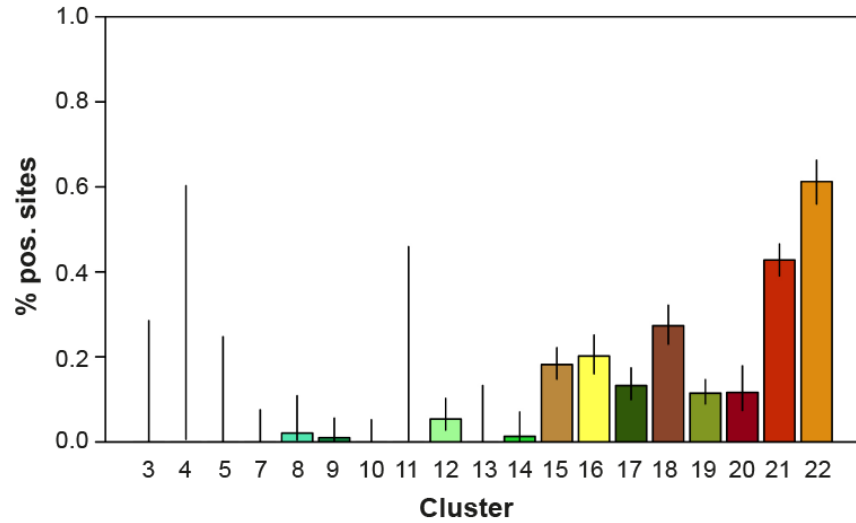


Number of pixels per resolution (Italy)

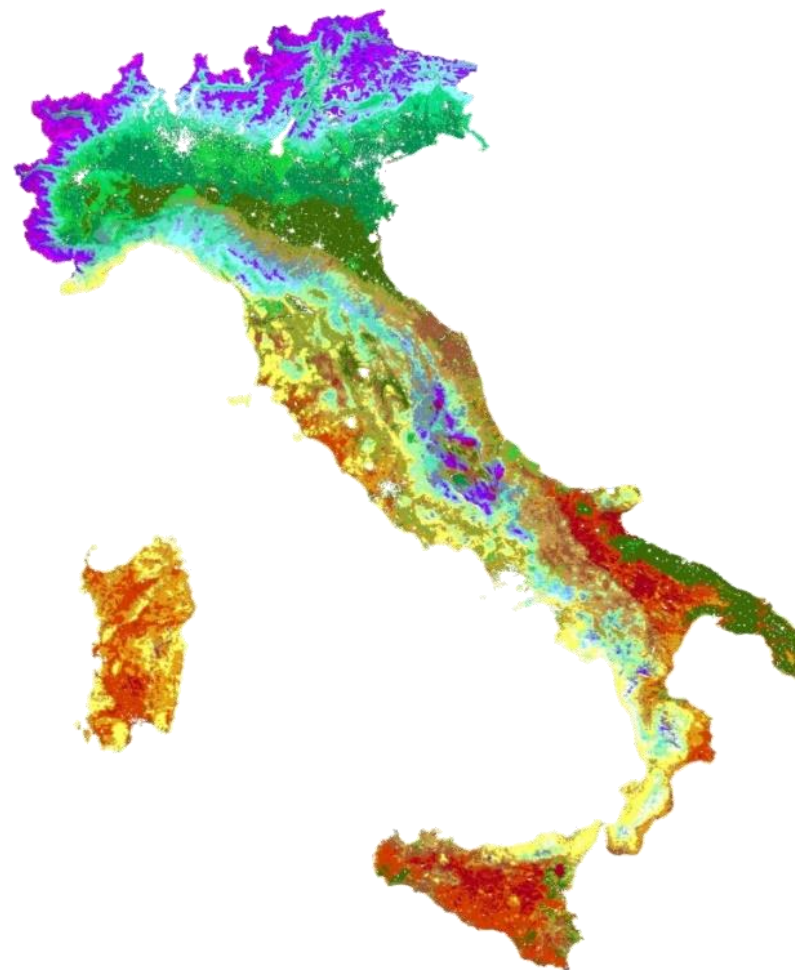
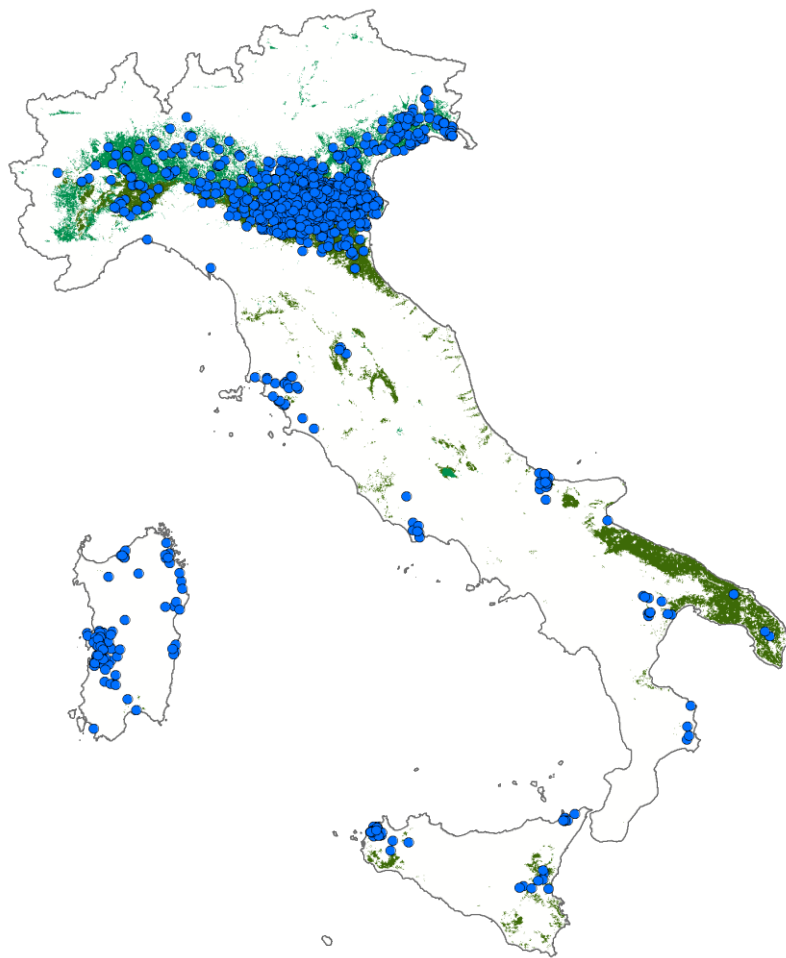
2 km	1 km	250 m
79,619	312,673	4,869,825

C. imicola

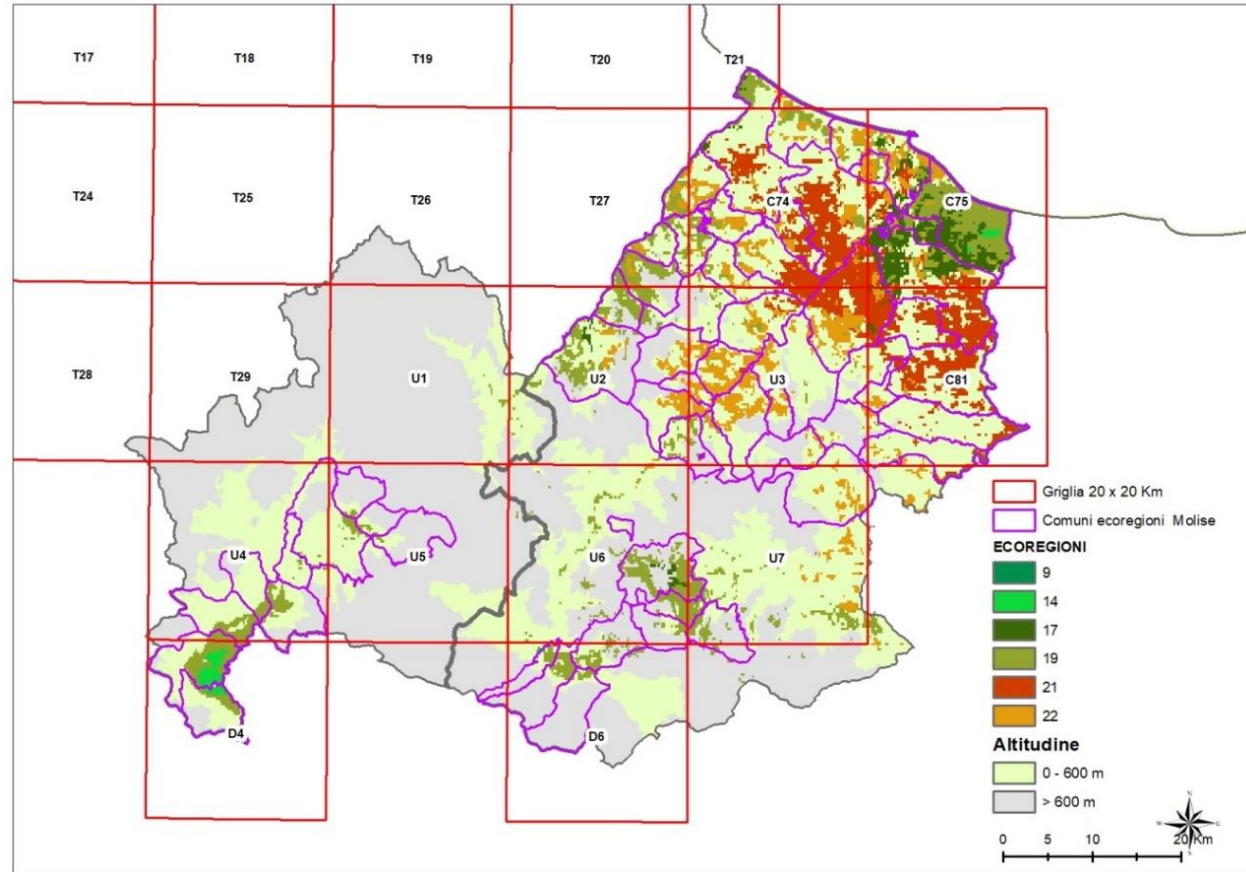
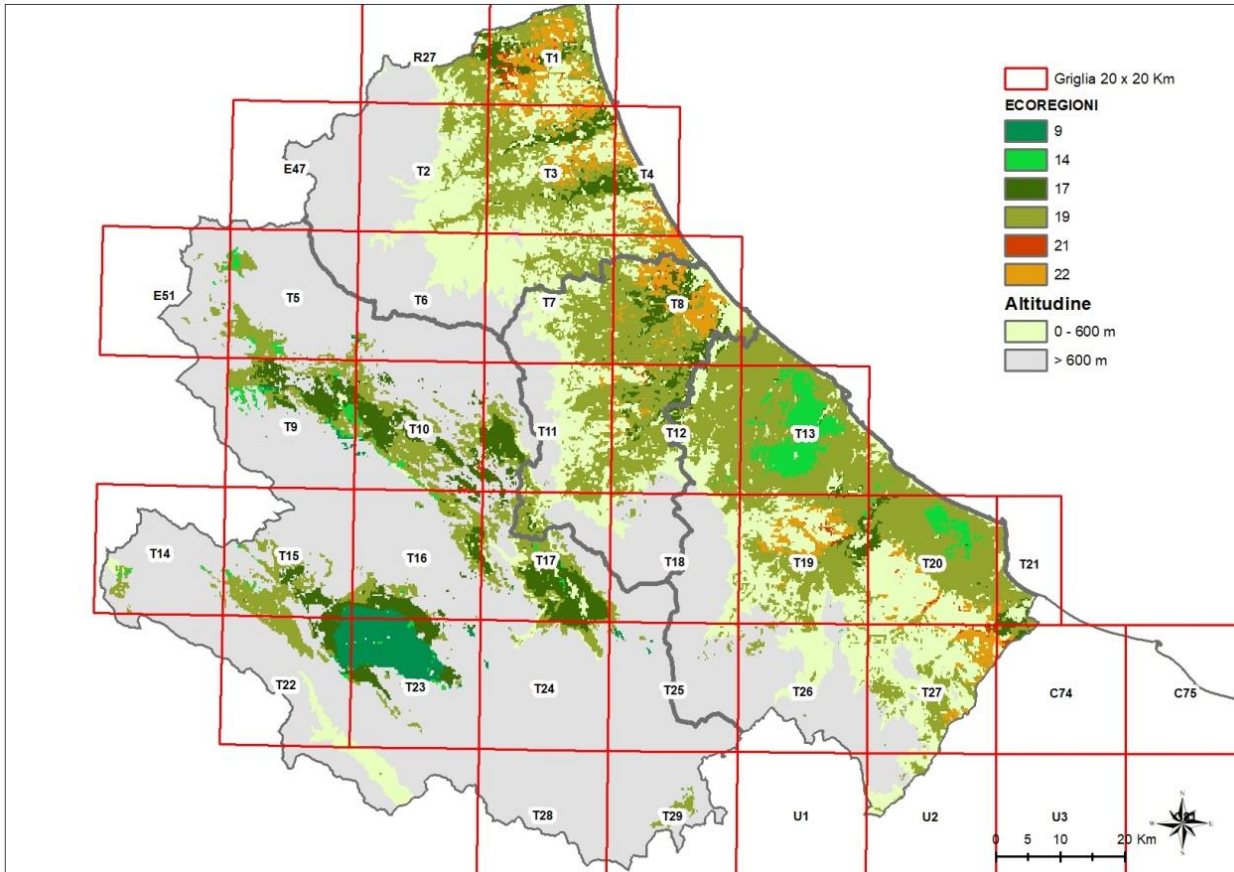
A) *C. imicola*



WN cases 08-16



Ecoregions for entomological surveillance in the national arbovirosis plan





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 ▼ i

Sentinel-2 L1C i

Sentinel-2 L2A ✓ i

Login

Copernicus Data Space Ecosystem Browser

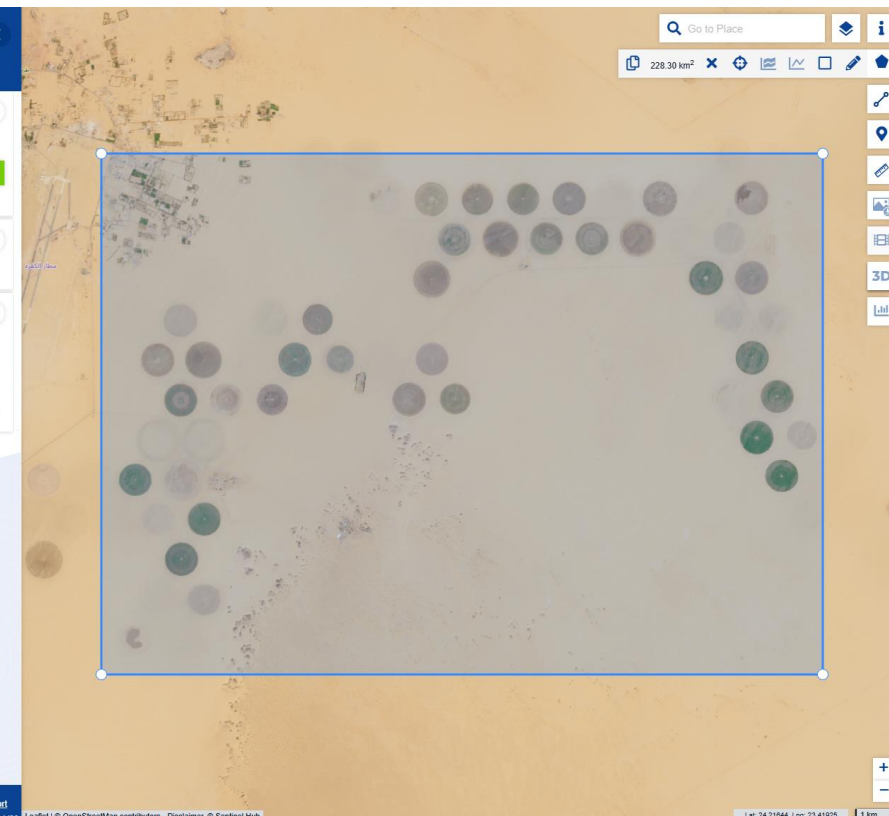
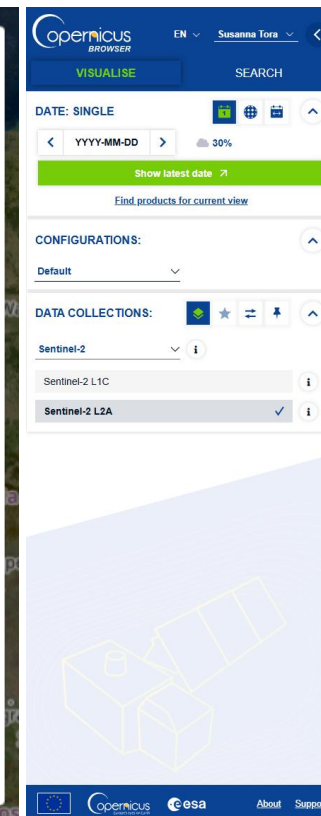
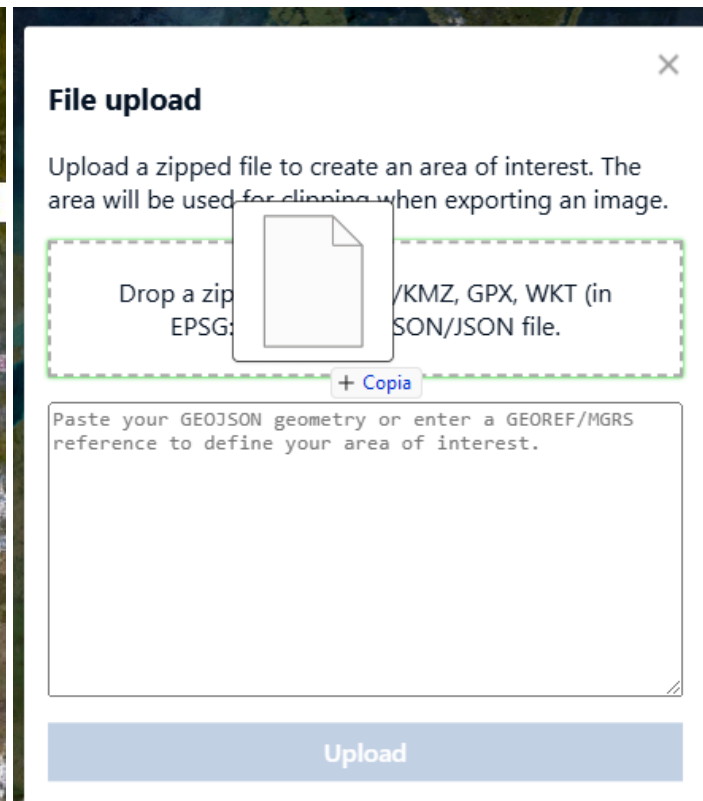
*The data distribution
service is open and free.*

<https://browser.dataspace.copernicus.eu/>



How to use them:
exercise

Upload a file to create an AOI



What area is this?

Select layer

Copernicus BROWSER EN Susanna Tora

VISUALISE SEARCH

4 < 2025-02-15 > 10% 3

Default

DATA COLLECTIONS:

1 Sentinel-2

Sentinel-2 L1C

2 Sentinel-2 L2A ✓

LAYERS:

True color
Based on bands B4, B3, B2

False color
Based on bands B8, B4, B3

Highlight Optimized Natural Color
Enhanced natural color visualisation

5 NDVI
Based on a combination of bands (B8 - B4...)

6 Add to </>

Add to Compare Add to Pins Add to Timelapse

False color (urban)
Based on bands B12, B11, B4

7 Moisture index
Based on a combination of bands (B8A - B11)/(B8A + B11)

SWIR
Based on bands B12, B8A, B4

Show effects and advanced options Hide layer Share

Go to Place 228.30 km²

At Taj Kufra

Lat: 24.1424, Lng: 23.5488 3 km

Data collections: Sentinel-2

Product: Sentinel-2 L2A

Max. cloud coverage: 10%

Date: 2025-02-15

Layer: NDVI

View Statistical Info



- 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?*



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

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

Compare NDVIs

LAYERS:

- 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...)
+ Add to </>
- 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)

2

DATA COLLECTIONS:

Sentinel-2

Sentinel-2 L1C

Sentinel-2 L2A

LAYERS:

- 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...)
+ Add to Compare

Copernicus BROWSER

EN Susanna Tora

VISUALISE SEARCH

2024-08-19 10%

Default

Sentinel-2 L2A

LAYERS:

- 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...)
+ Add to </>
- 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 of ESA's Scene classification algorithm.
- Custom
Create custom visualisation

Show effects and advanced options Hide layer Share

EUROPEAN COMMISSION Copernicus CESA About Support

Data collections: Sentinel-2

Date: 2024-08-19

Product: Sentinel-2 L2A

Layer: NDVI

Max. cloud coverage: 10%

3

VISUALISE SEARCH

DATE: SINGLE

< 2025-02-15 >

Show latest date

Find products for current view

Max. cloud coverage: 10%

August 2024

Su	Mo	Tu	We	Th	Fr	Sa
28	29	30	31	1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31

4



Compare NDVIs

5

DATA COLLECTIONS:

Sentinel-2

Sentinel-2 L1C

Sentinel-2 L2A

LAYERS:

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...)

Add to Compare Add to Pins Add to Timelapse

6

VISUALISE **SEARCH**

DATE: SINGLE

2024-08-19 10%

Show latest date

Find products for current view

Default

DATA COLLECTIONS:

Sentinel-2

Sentinel-2 L1C

Sentinel-2 L2A

COMPARE:

Remove all Share Add all pins

Effect: Split

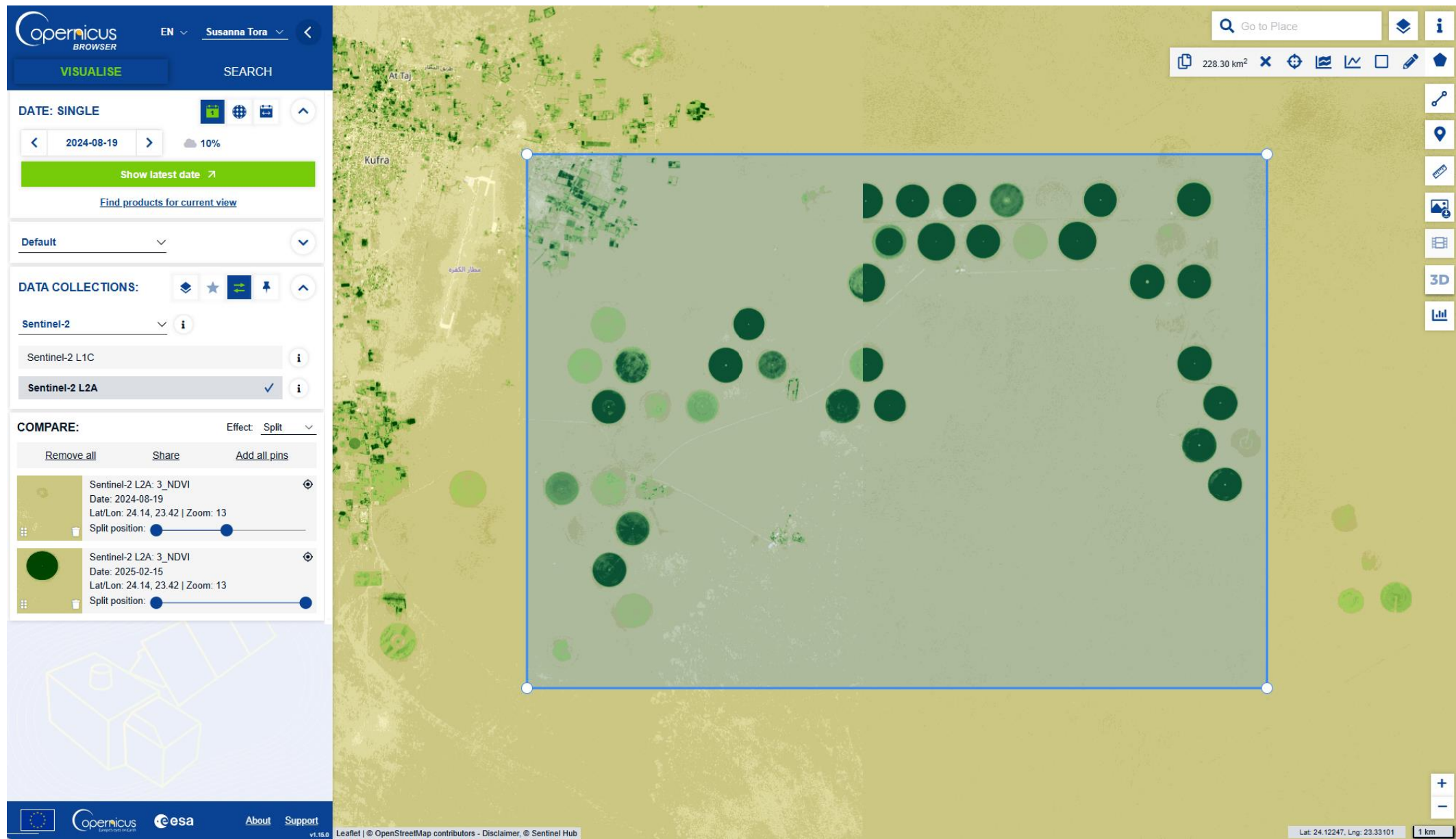
Sentinel-2 L2A: 3_NDVI
Date: 2024-08-19
Lat/Lon: 24.14, 23.42 | Zoom: 13
Split position:

Sentinel-2 L2A: 3_NDVI
Date: 2025-02-15
Lat/Lon: 24.14, 23.42 | Zoom: 13
Split position:

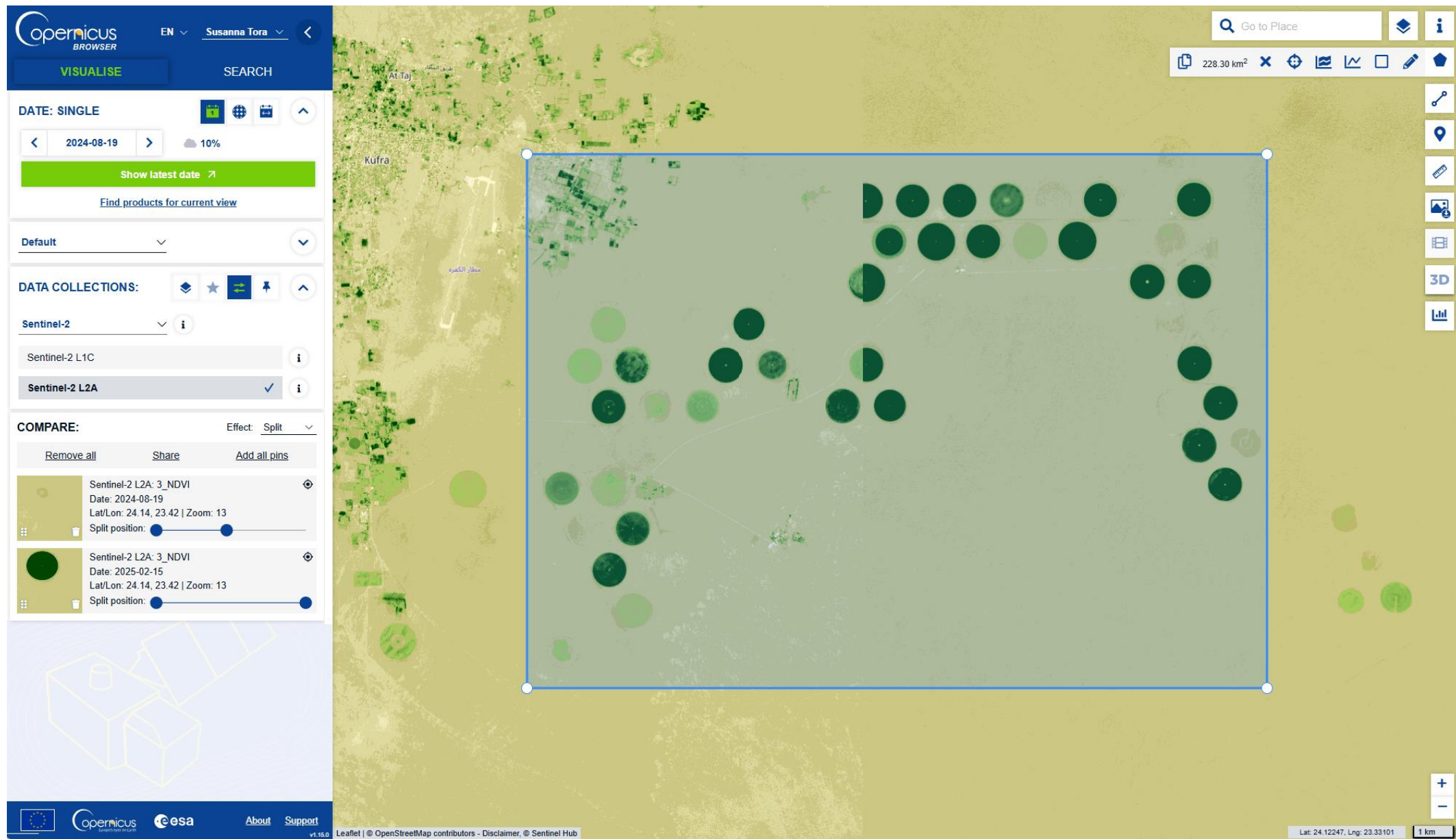
Choose the effect you prefer **Split** or **Opacity**

Move the slider to compare images

NDVI comparison result



NDVI comparison result



Copernicus BROWSER EN Susanna Tora

VISUALISE SEARCH

< 2024-08-19 > 10%

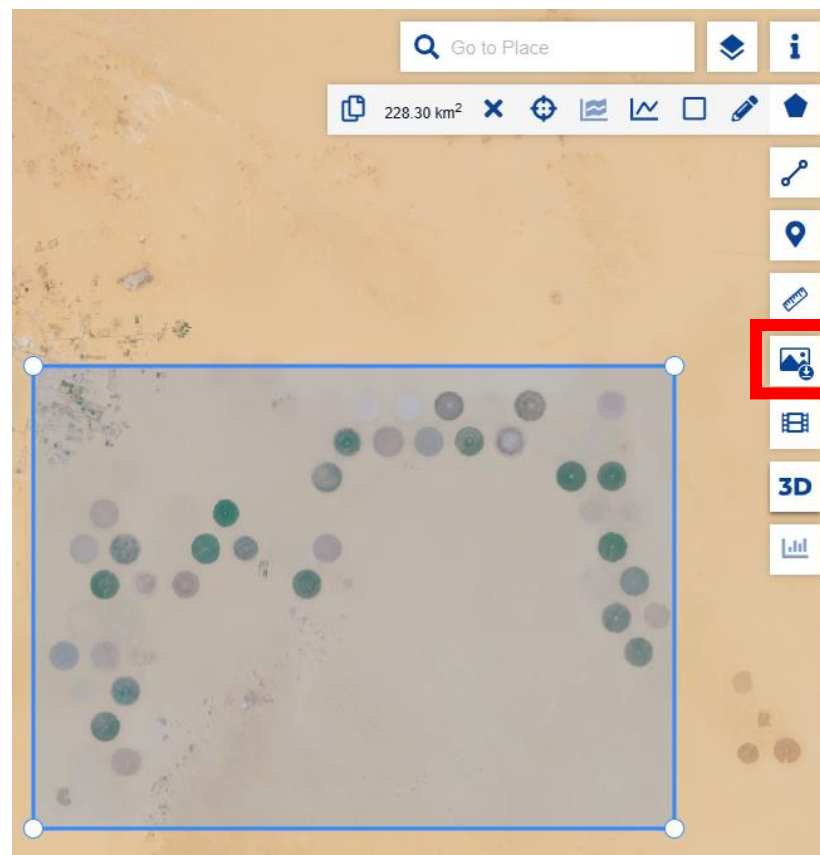
Default

Sentinel-2 L2A

LAYERS:

- True color**
Based on bands B4, B3, B2
Add to Compare Add to Pins Add to Timelapse
- 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)

1



2

Image download

Basic **Analytical** High-res print **Download**

Image download

Image format: TIFF (32-bit float)
Image resolution: HIGH
1949 x 1407 px
Coordinate system: WGS 84 (EPSG:4326)
lat.: 0.0000819 deg/px (0.3sec/px)
long.: 0.0000898 deg/px (0.3sec/px)

Clip extra bands

Layers:

Visualised	Raw
<input checked="" type="checkbox"/> True color	<input type="checkbox"/> B01
<input type="checkbox"/> False color	<input type="checkbox"/> B02
<input type="checkbox"/> Highlight Optimized Natural Color	<input type="checkbox"/> B03
<input checked="" type="checkbox"/> NDVI	<input type="checkbox"/> B04
<input type="checkbox"/> False color (urban)	<input type="checkbox"/> B05
<input checked="" type="checkbox"/> Moisture index	<input type="checkbox"/> B06
<input type="checkbox"/> SWIR	<input type="checkbox"/> B07
<input checked="" type="checkbox"/> NDWI	<input type="checkbox"/> B08
<input type="checkbox"/> NDSI	<input type="checkbox"/> B8A
<input type="checkbox"/> Scene classification map	<input type="checkbox"/> B09

Show more

3

Image format: TIFF (32-bit float)

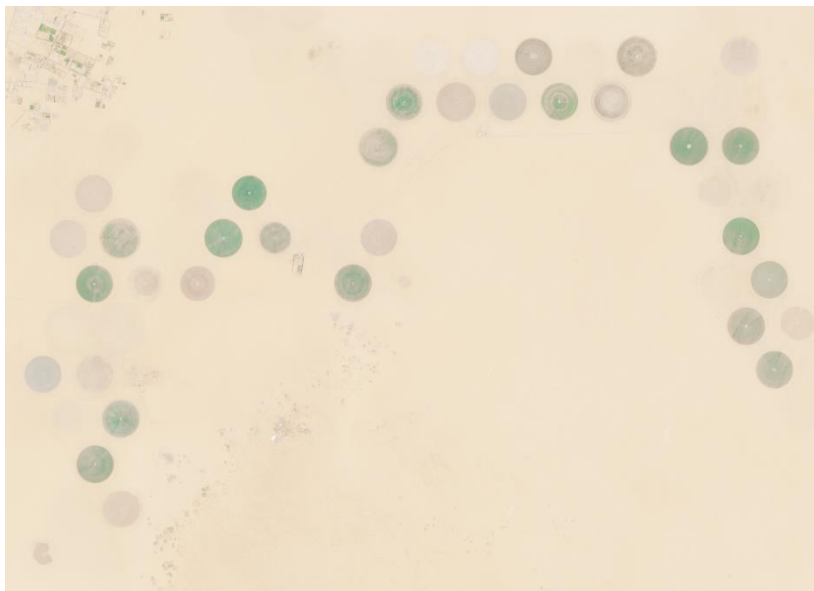
Image resolution: HIGH

Coordinate system: WGS 84 (EPSG: 4326)

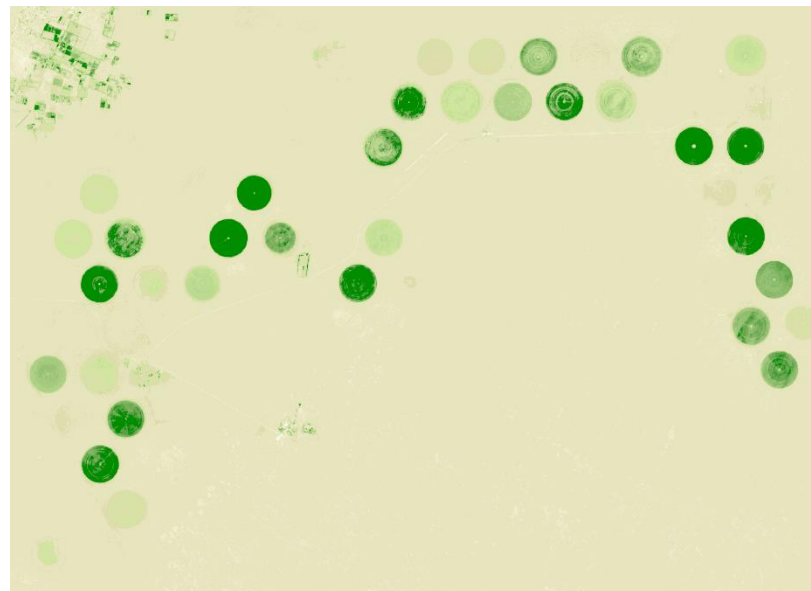
Layers: True color, NDVI, Moistur index, NDWI

Image download results

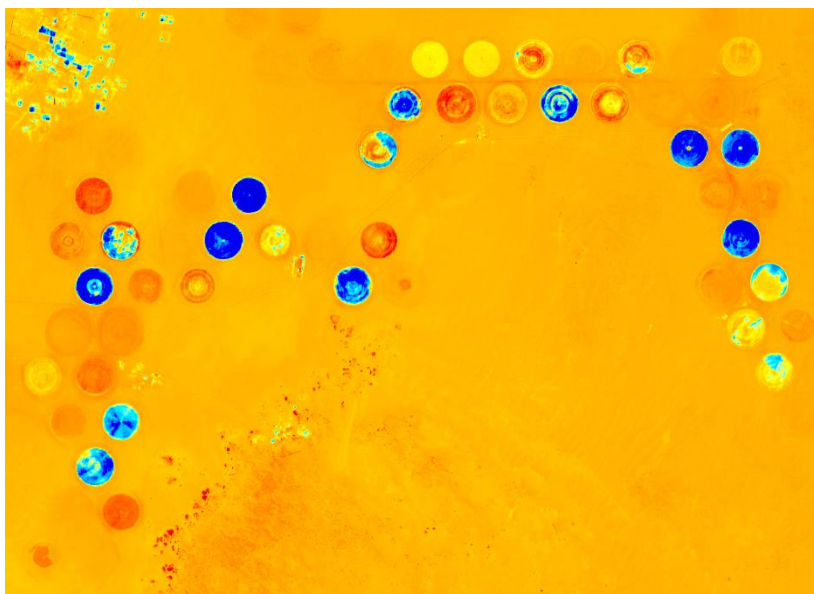
True color



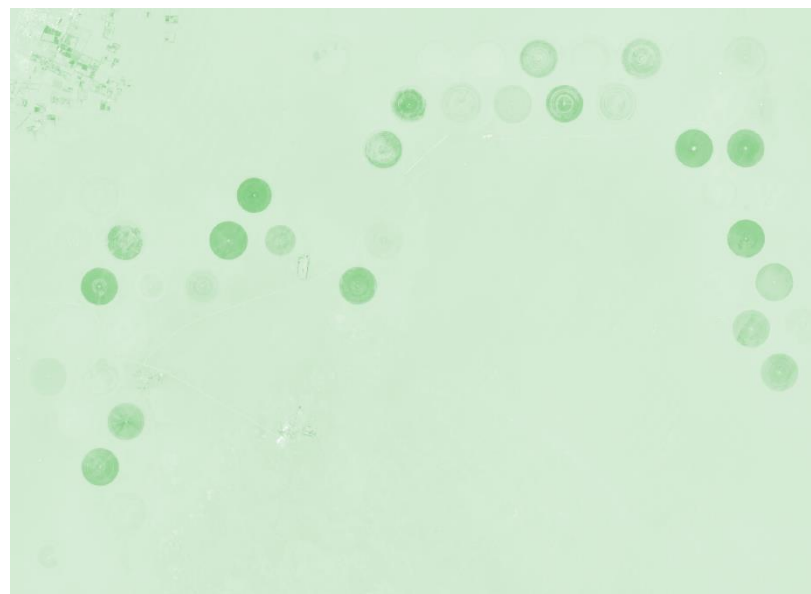
NDVI



Moisture index



NDWI



Create timelapse animation

Step 1: Map and Layer Selection

- Open the Copernicus Browser.
- Search for the location (e.g., Kufra).
- Under the **LAYERS:** section, select **NDVI** (Based on a combination of bands (B8 - B4...)).
- Click **Add to Timelapse**.
- Click the **Timelapse** icon (film strip) in the right sidebar.

Step 2: Timelapse Configuration

- Set the date range: **2024-08-19** to **2025-02-15**.
- Filter by months: ☐ orbit ☒ day ☐ week ☐ month ☐ year.
- Select 1 image per: ☒ day ☐ week ☐ month ☐ year.
- Min. tile coverage: 80%.
- Max. cloud coverage: 10%.
- Click **Select All**.
- Click **Search**.

Step 3: Animation Player

- Click the **Play** button.
- Speed: 1 fps.
- Transition: None.
- Download the animation.

1

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

2

Timelapse animation result



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