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PONTOS

Common borders. Common solutions.

Black Sea CROSS BORDER COOPERATION

Chlorophyll Calculation through Satellite Images

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March 10, 2022

AUA ACOPIAN CENTER for the ENVIRONMENT

CERTH CENTRE FOR RESEARCH & TECHNOLOGY HELLAS

Green Alternative

1865

Eutrophication

Eutrophication is the increase in the rate of the supply of organic matter to an ecosystem, which is related to nutrient enrichment in the primary production in the system. Eutrophication processes:

- contribute to an accelerated algal bloom and higher forms of plant life that produce an undesirable disturbance of the equilibrium of the organisms present in the water
- may affect benthic primary producers through increases in water column light attenuation and depleted oxygen concentration at the bottom
- deterioration of the water quality, harmful algal blooms, fish kills, reduction of essential fish habitats

Why we measure chlorophyll-a

- The photosynthetic pigment Chl-a is a key indicator of phytoplankton biomass. Thus, the estimation of Chl-a concentration is essential for monitoring of water quality

- Phytoplankton is the group of organisms responding first to nutrient enrichment, with an excessive growth

- The increase in phytoplankton reflects symptomatic signs of alteration in both the nutrient cycles and the structure of the trophic network, both related to eutrophication

- **The biomass of phytoplankton, represented by chlorophyll-a, is an important indicator to evaluate the state of eutrophication of water bodies**

Why remote sensing monitoring is important

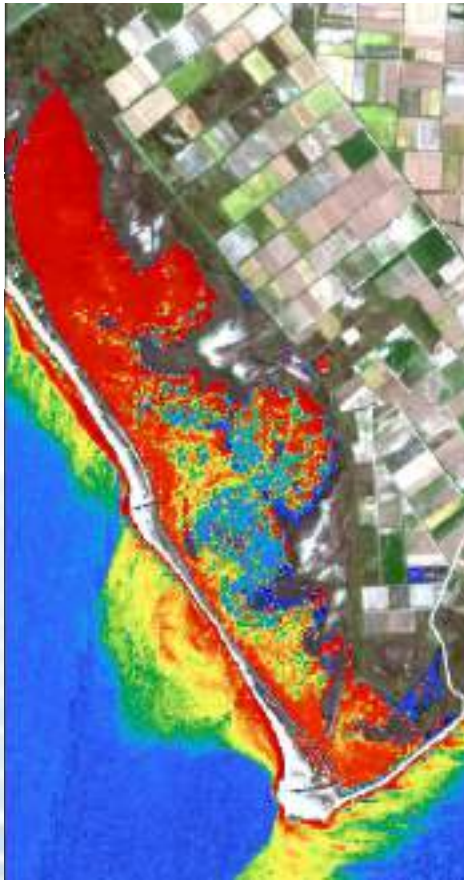
- Coastal systems and lakes provide key ecosystem services, such as human welfare and wellbeing, climate, water and natural hazard regulation, primary production, biotic diversity, habitat and food for bivalves, crustaceans, fish and birds, erosion prevention and wild life refuge

- There is a high need for monitoring water quality

- Frequent in-situ monitoring is limited and requires a lot of effort and funding

- Satellite remote sensing is a feasible way to monitor water quality over large regions with reasonable frequency

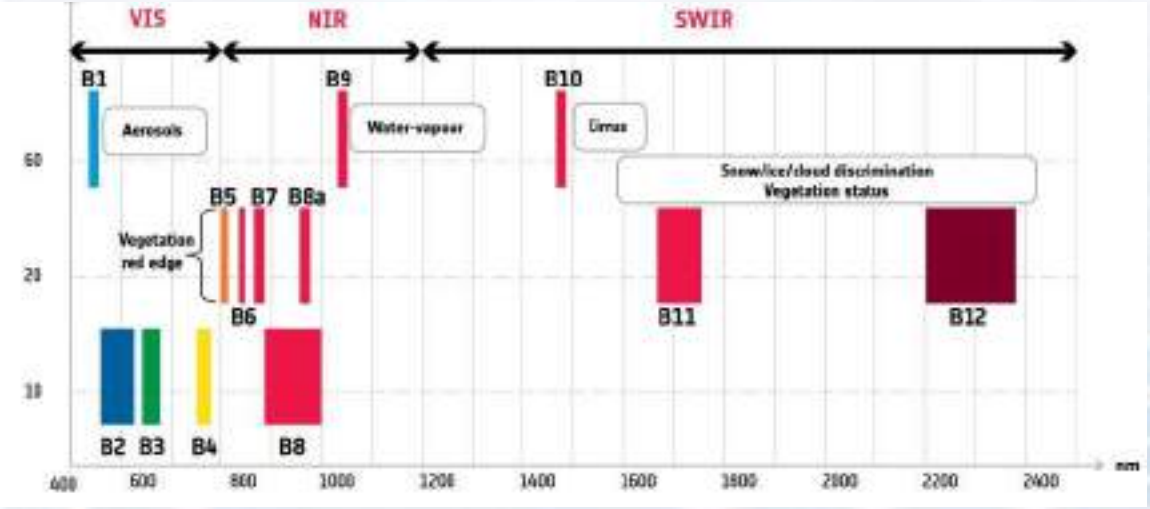
How we measure chlorophyll-a



Satellites used in remote sensing

Time period: 2015 – 2021

- **Sentinel 2A and 2B**: polar orbit, phased at 180° to each other
- Equipped with multispectral instrument (MSI) with 13 spectral bands
- Wide swath width (290 km)
- Revisit: 5 days at equator (2 satellites)
- Level 1C and 2A (atmospherically corrected)



Atmospheric Bands

Red edge and shortwave infrared Bands

Visible and Near-infrared Bands

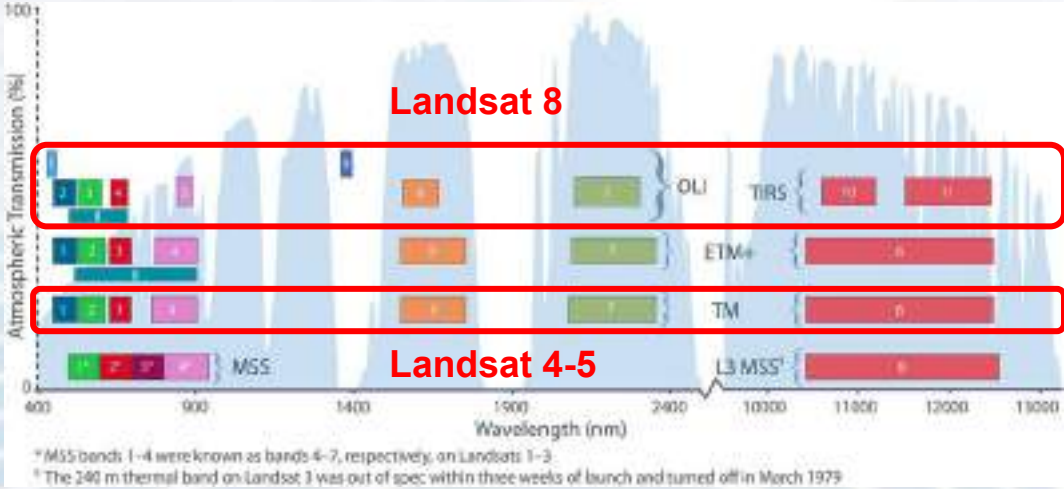
Satellites used in remote sensing

Time period: 2009-2011

- **Landsat 4-5 TM**
- Equipped with Thematic Mapper (TM) sensor with 6 spectral bands and 1 thermal infrared band
- Revisit: 16 days

Time period: 2013-2015

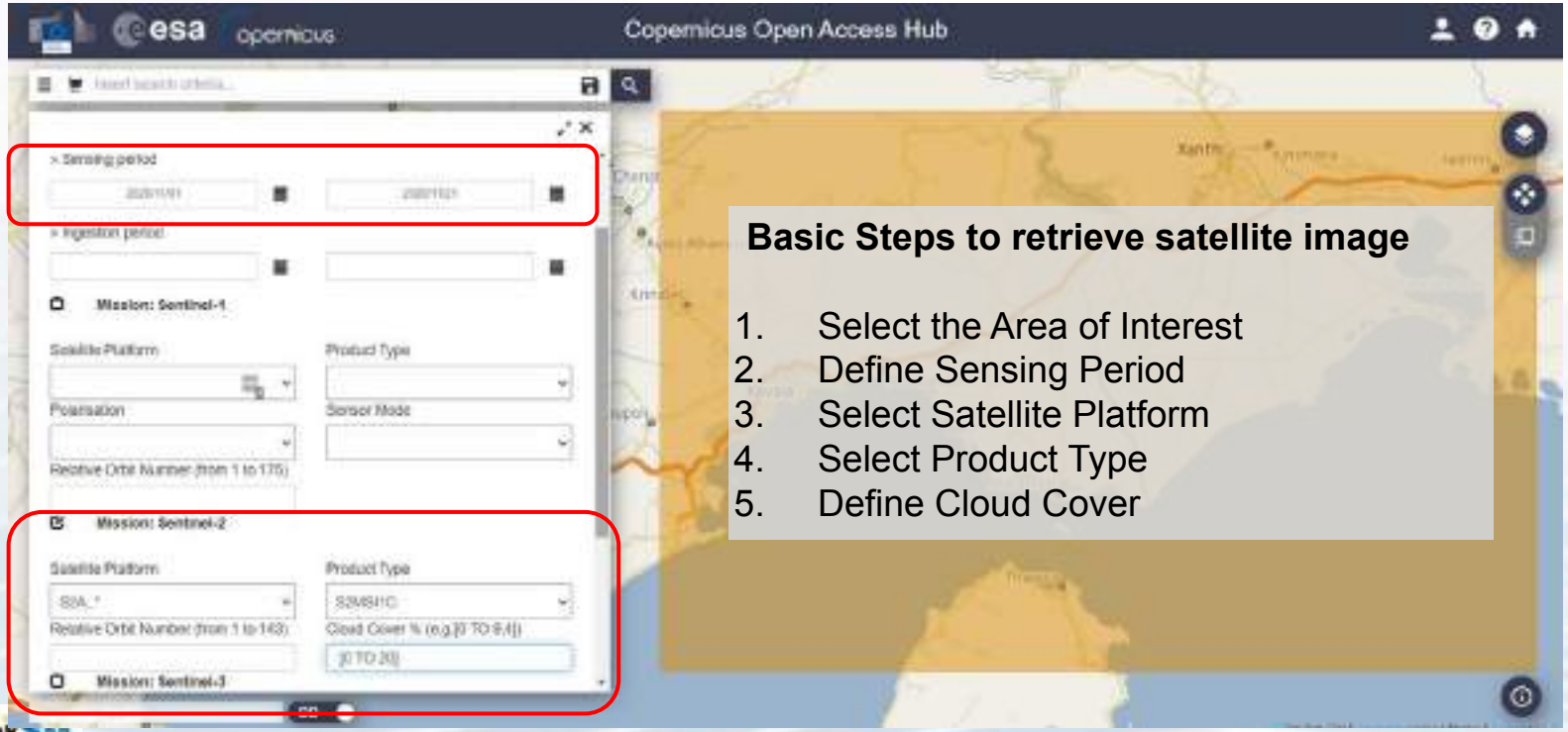
- **Landsat 8**
- Equipped with Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS) with 9 spectral bands
- Revisit: 5 days



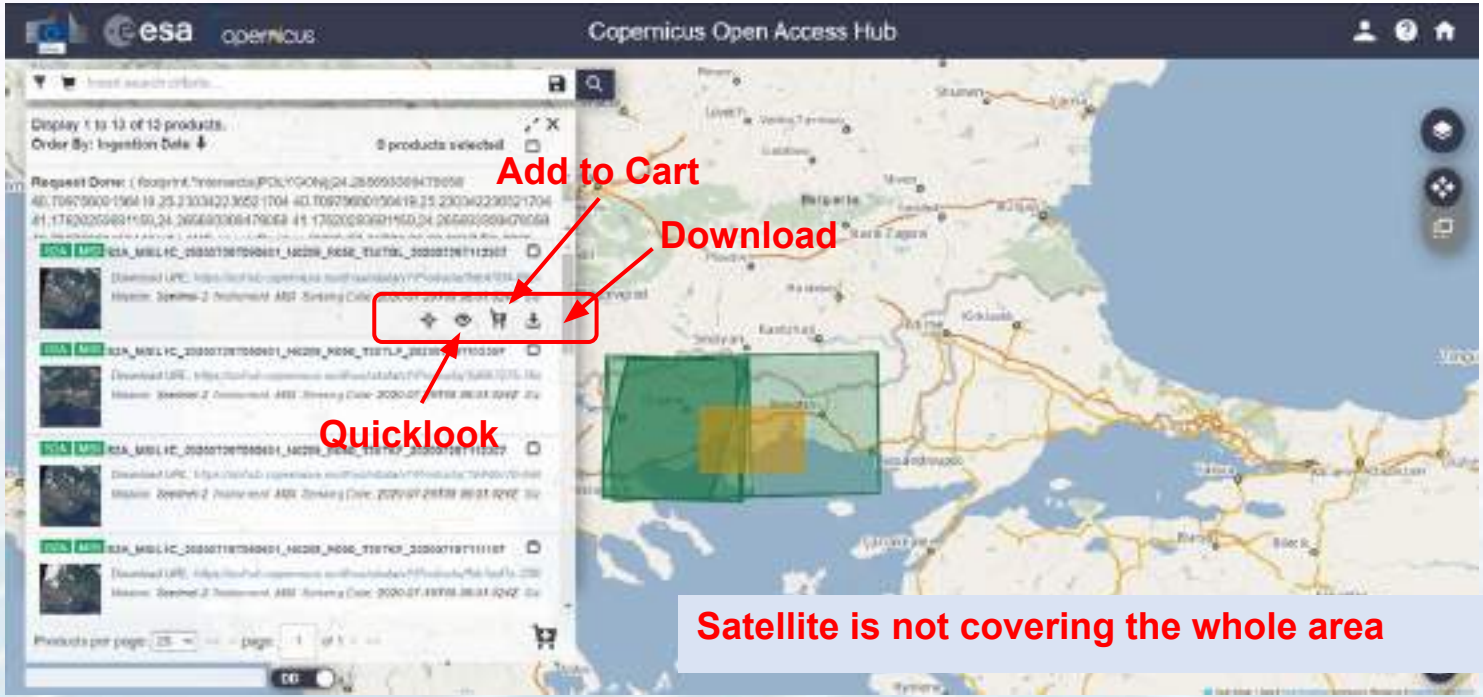
How to access Satellite Images
Copernicus Open Access Hub

Copernicus Open Access Hub

https://scihub.copernicus.eu/dhus/



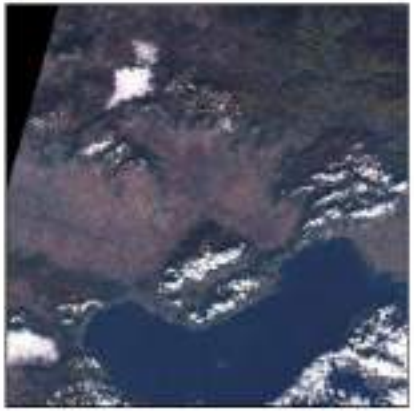
Copernicus Open Access Hub



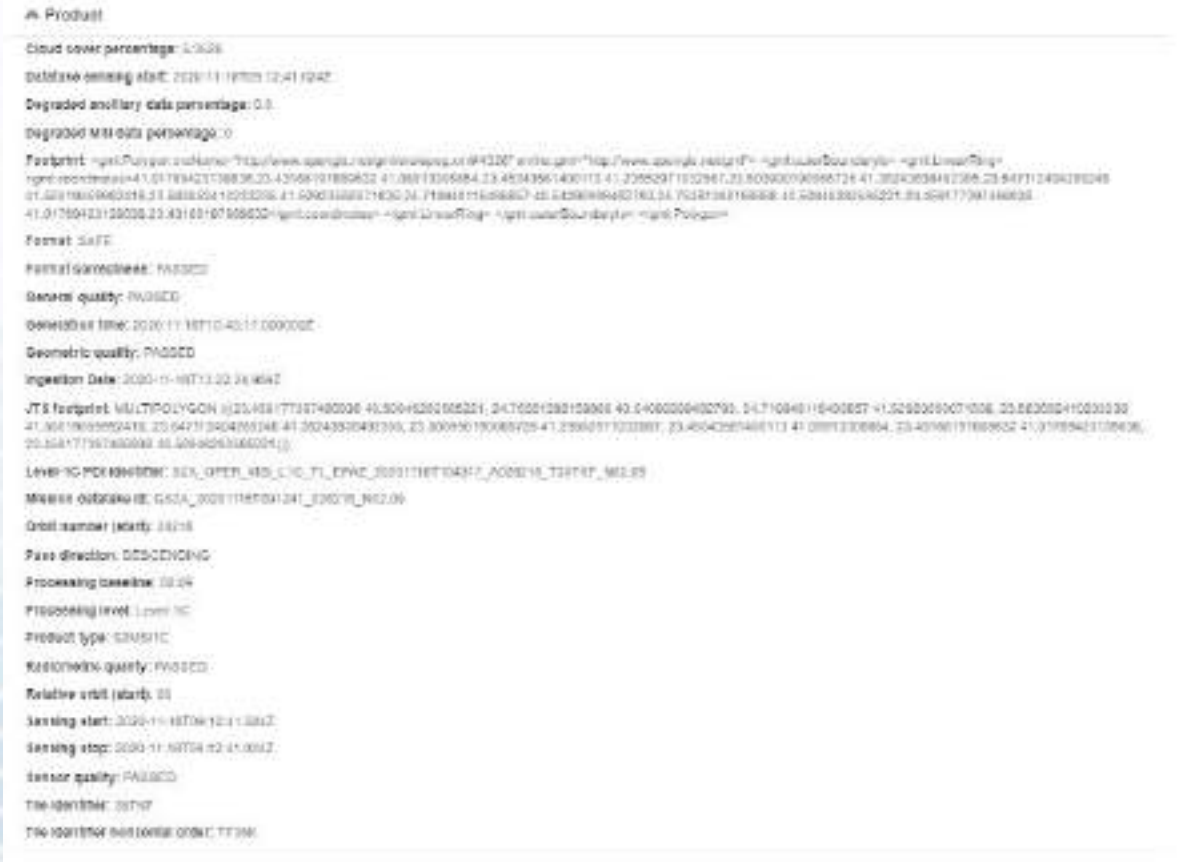
Copernicus Open Access Hub

Footprint

Quicklook



Copernicus Open Access Hub



Copernicus Open Access Hub

https://sentinelsat.readthedocs.io/en/stable/

```
from sentinelsat import SentinelAPI, read_geojson, geojson_to_wkt
from datetime import date

api = SentinelAPI('user', 'password', 'https://scihub.copernicus.eu/dhus')

# search by polygon (WKT format), time, and SciHub query keywords
footprint = geojson_to_wkt(read_geojson('/path/to/map.geojson'))

products = api.query(footprint,
            date = ('20151219', date(2015, 12, 29)),
            order_by = 'ingestiondate',
            orbitdirection: 'DESCENDING',
                        platformname = 'Sentinel-2',
            producttype = 'S2MSI1C',
                        cloudcoverpercentage = (0, 20))

# download all results from the search
api.download_all(products)

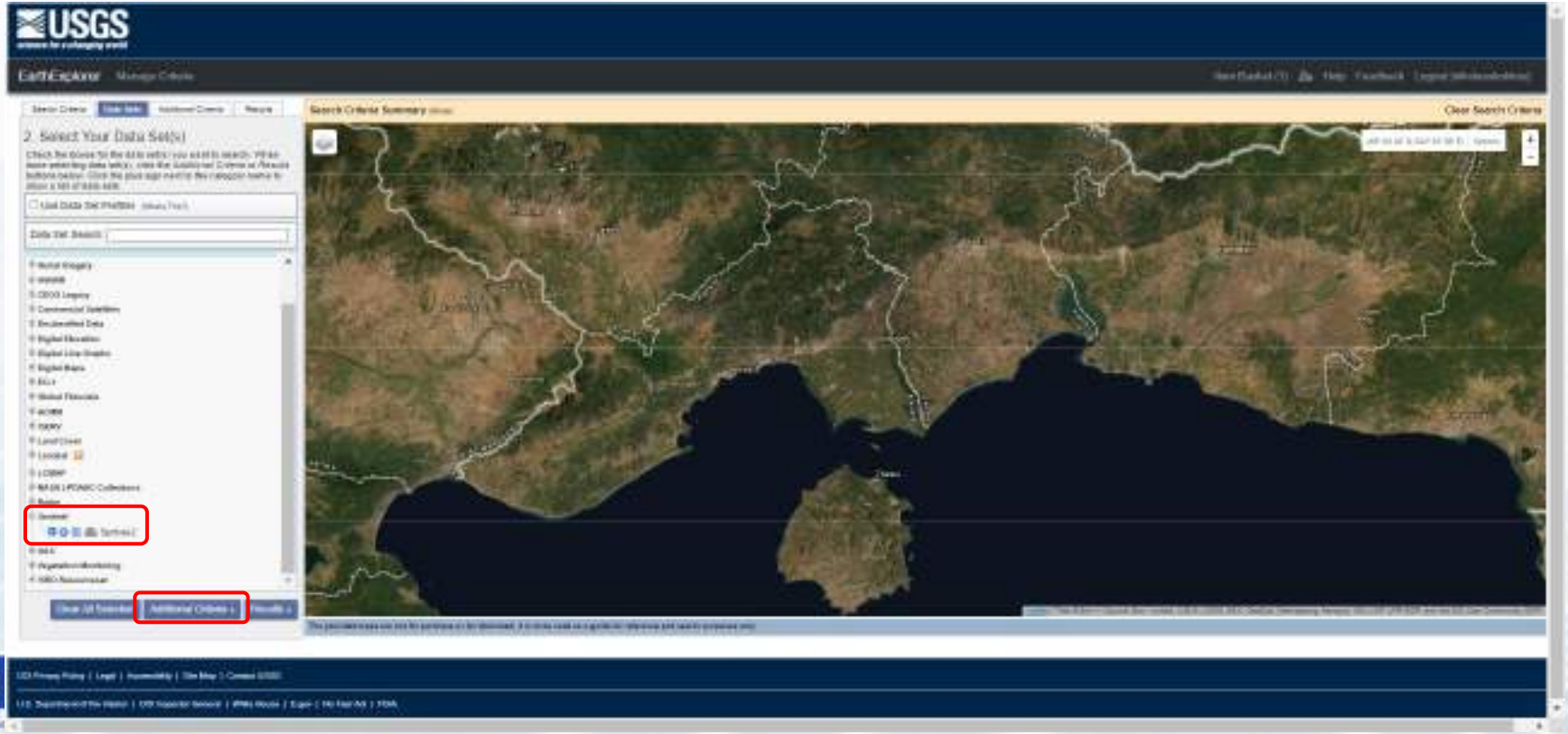
# GeoJSON FeatureCollection containing footprints and metadata of the scenes
api.to_geojson(products)
```

How to access Satellite Images
Earth Explorer

Earth Explorer

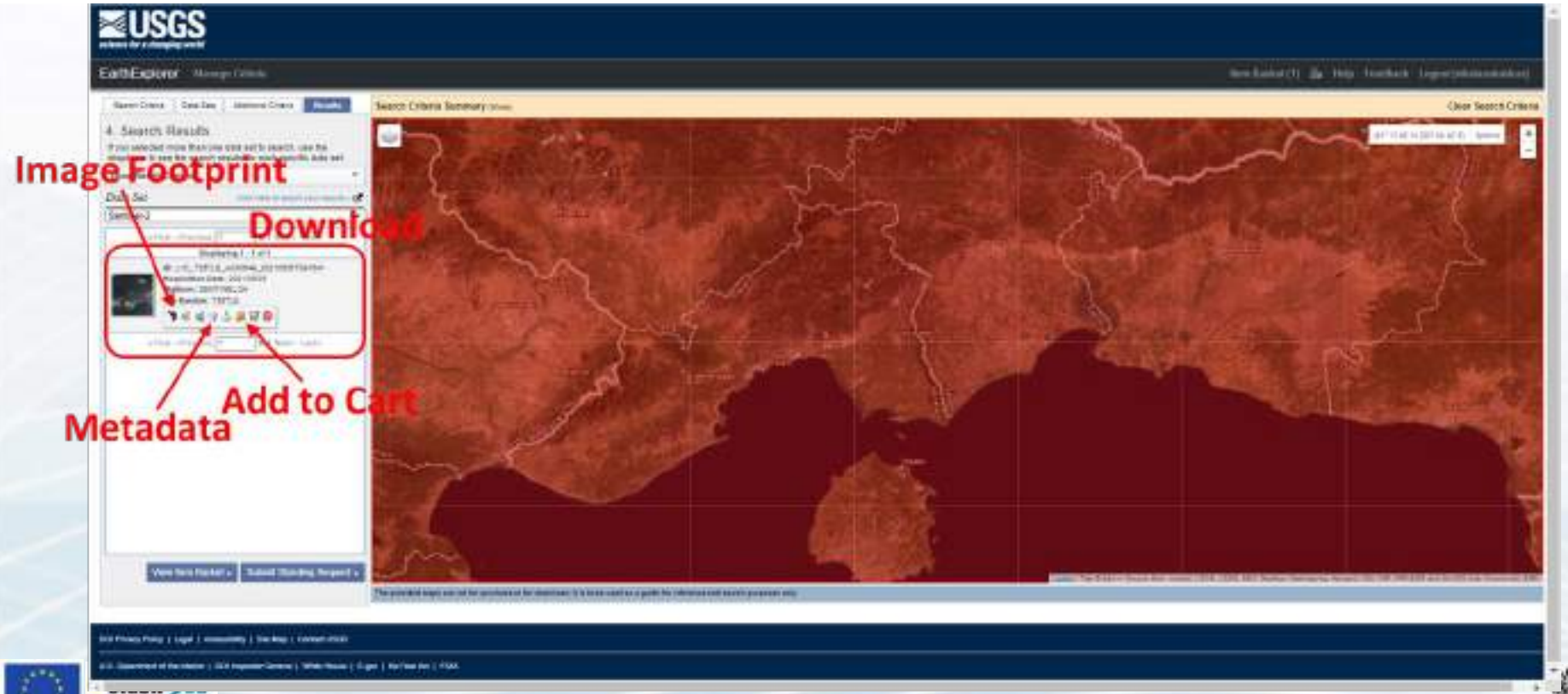
https://earthexplorer.usgs.gov/

Earth Explorer



Earth Explorer

Earth Explorer



Sentinel filename scheme

S2A_MSIL1C_20200729T090601_N0209_R050_T35TKF_20200729T112307.SAFE

mission ID

Product Level

sensing start time

PDGS Processing Baseline number

Relative Orbit number

Tile Number field

Product Discriminator

Identifies a **Level-1C** product acquired by **Sentinel-2A** on the **29th of July, 2020 at 9:06:01 AM**. It was acquired over **Tile 35TKF** during **Relative Orbit 050**, and processed with **PDGS Processing Baseline 02.09**.

- All the bands included in the file are in JPEG2000 format.
- In addition, a "**True Colour Image**" in JPEG2000 format is included within the Tile folder of Level-1C products in this format and a **manifest** xml file that tells the computer what is inside the file.

Calculate Chlorophyll from Sentinel-2 and Landsat 8 Images

Sentinel 2 and Landsat 8 Products to Chlorophyll

Level-1C Product

Resampling to Higher Resolution of the Bands

Subset with Polygon

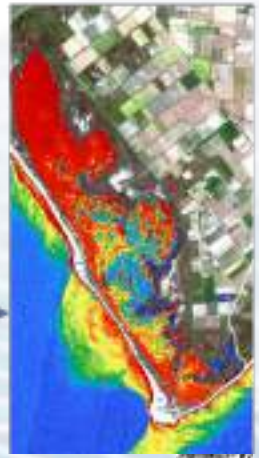
(WKT of the area is required)

Apply Land Mask

(Optional)

CR2CC Processor

Chlorophyll



C2RCC Processor

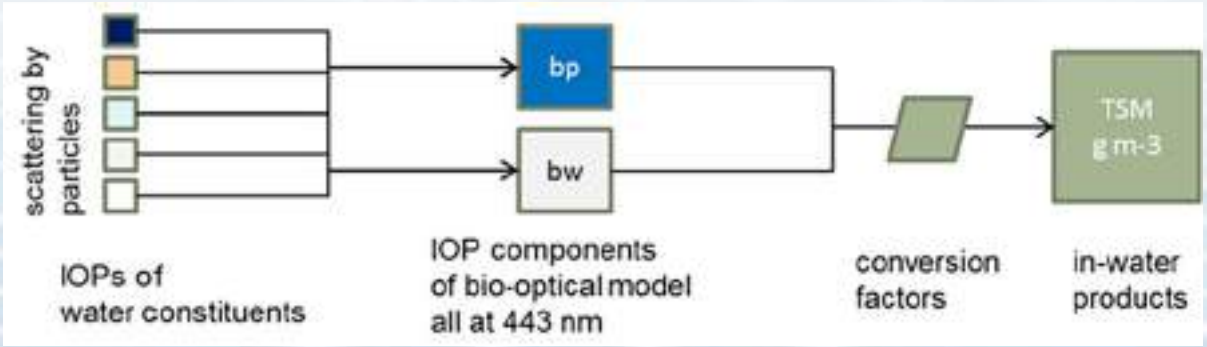
The Case-2 Regional CoastColour (C2RCC) processor **relies on a large database of simulated water leaving reflectances**, and related **top-of atmosphere radiances**.

Neural networks are trained in order to perform:

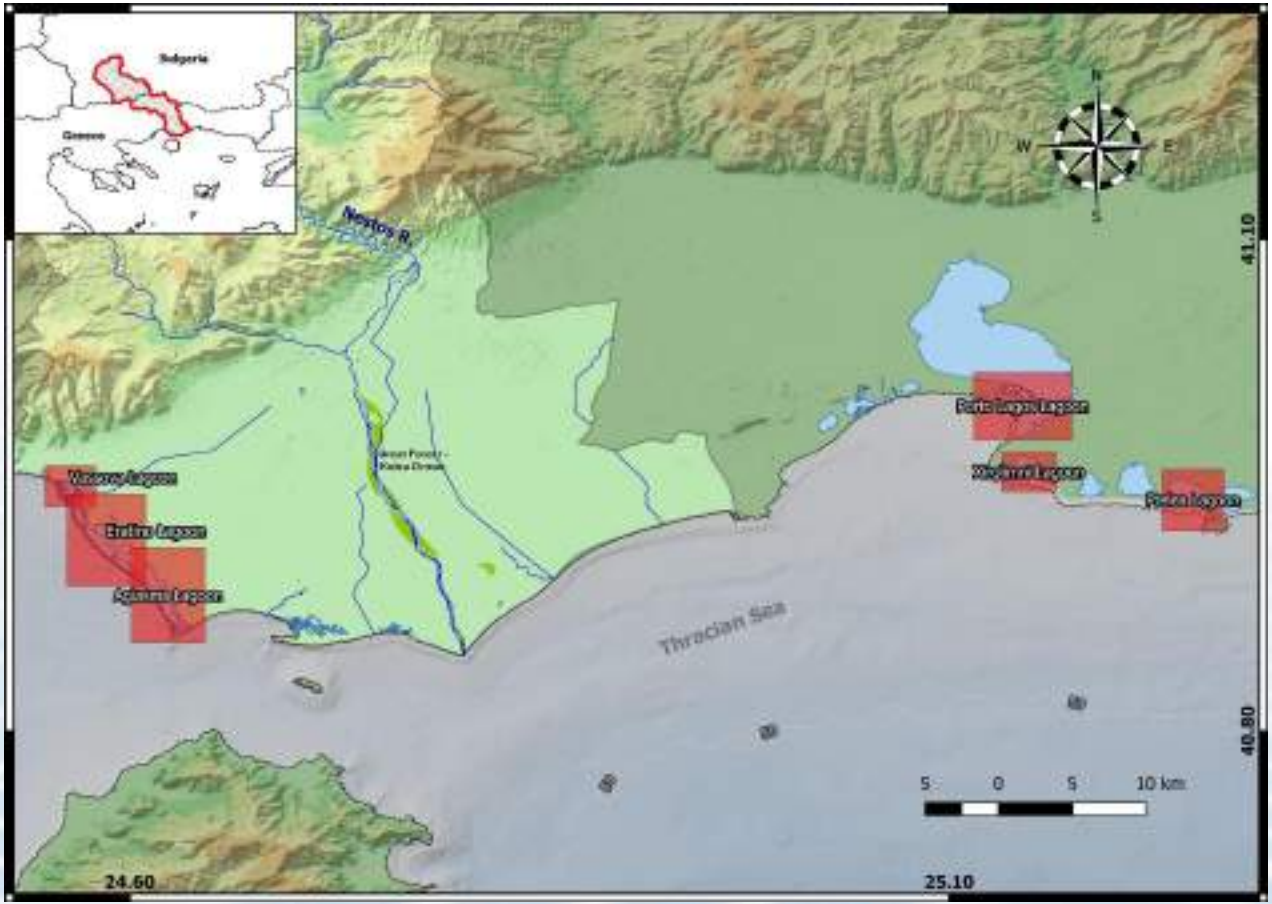
- the **determination of the water leaving radiance** from the top of atmosphere radiances, as well as
- the **retrieval of inherent optical properties (IOP)** of the water body.

The **conversion from IOPs to concentration** is done using **scaling factors**.

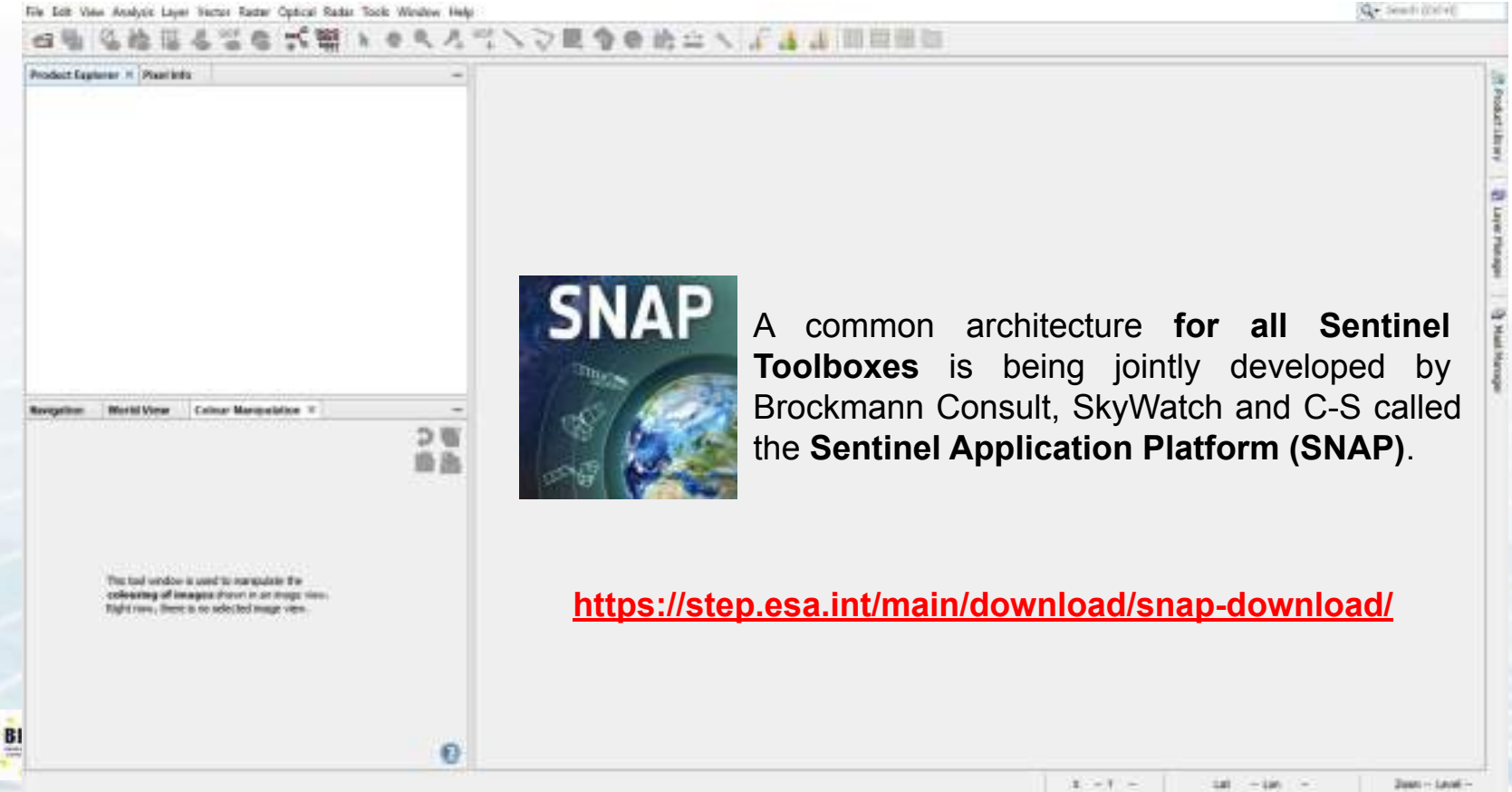
CR2CC is capable of processing data from **Sentinels–2 and 3, MERIS, VIIRS, MODIS, and Landsat-8**.



Test Site


Bulgaria
Greece
Nestos R.
Thracian Sea
41.10
40.80
24.60
25.10
5 0 5 10 km

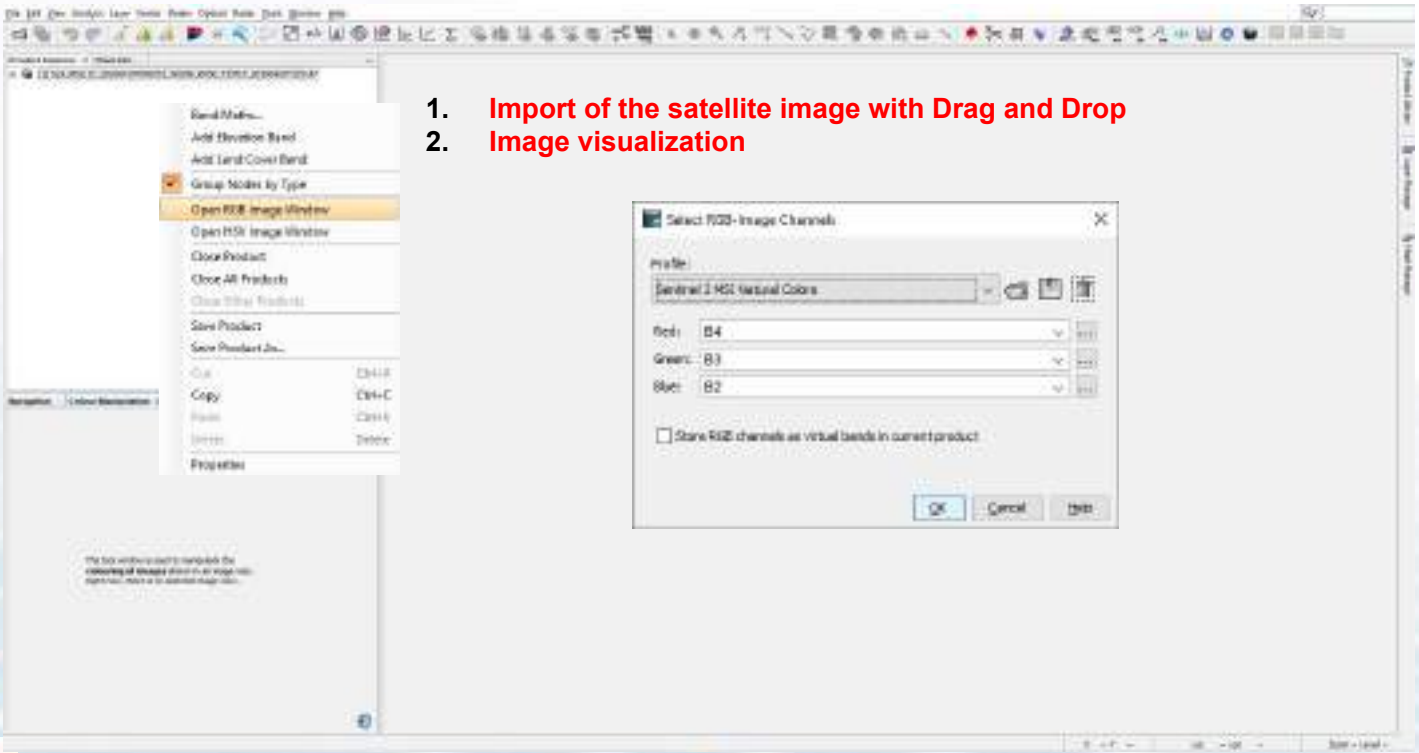
Sentinel Application Platform (SNAP)



A common architecture **for all Sentinel Toolboxes** is being jointly developed by Brockmann Consult, SkyWatch and C-S called the **Sentinel Application Platform (SNAP)**.

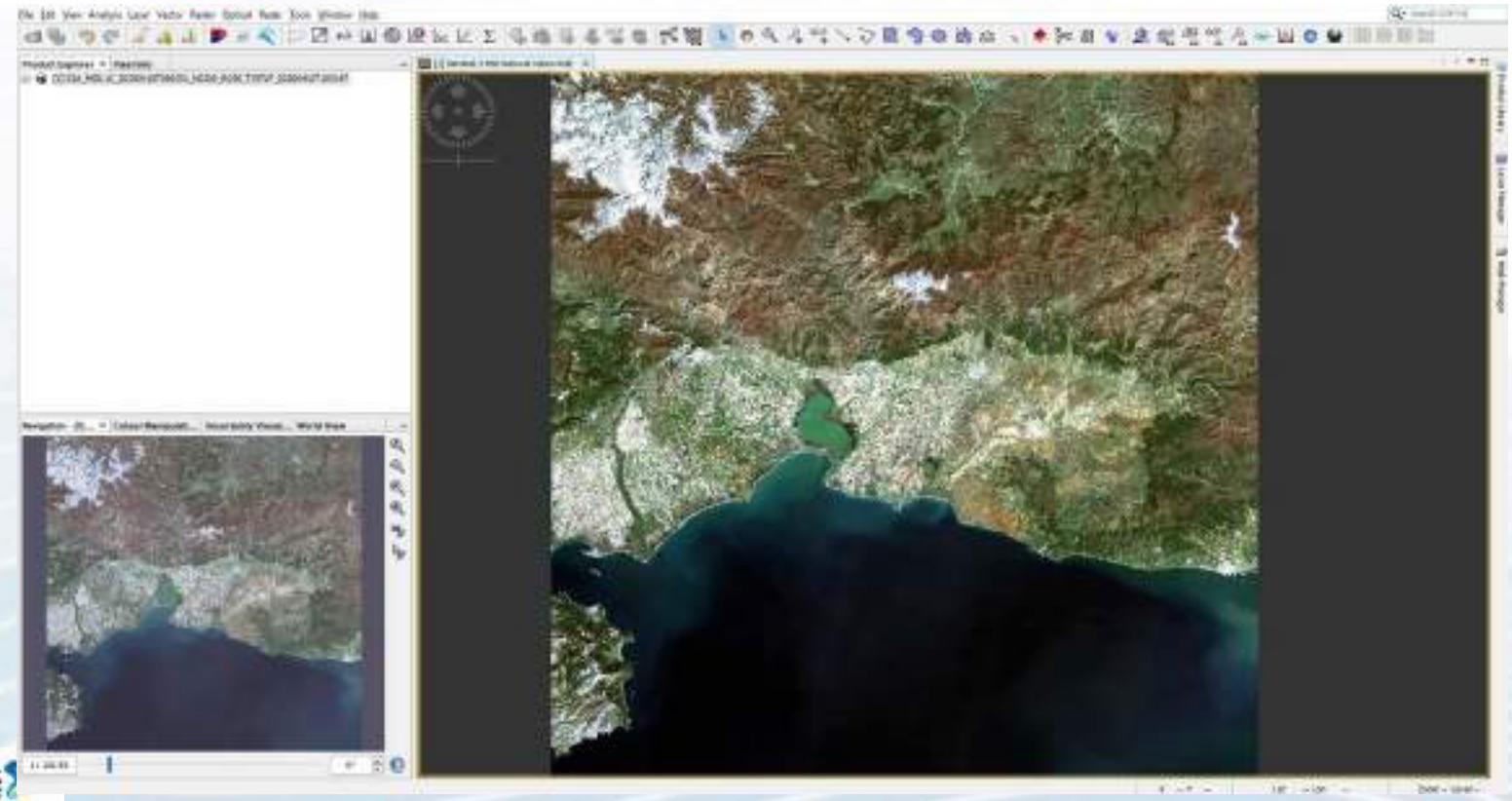
https://step.esa.int/main/download/snap-download/

SNAP – Import of the satellite image

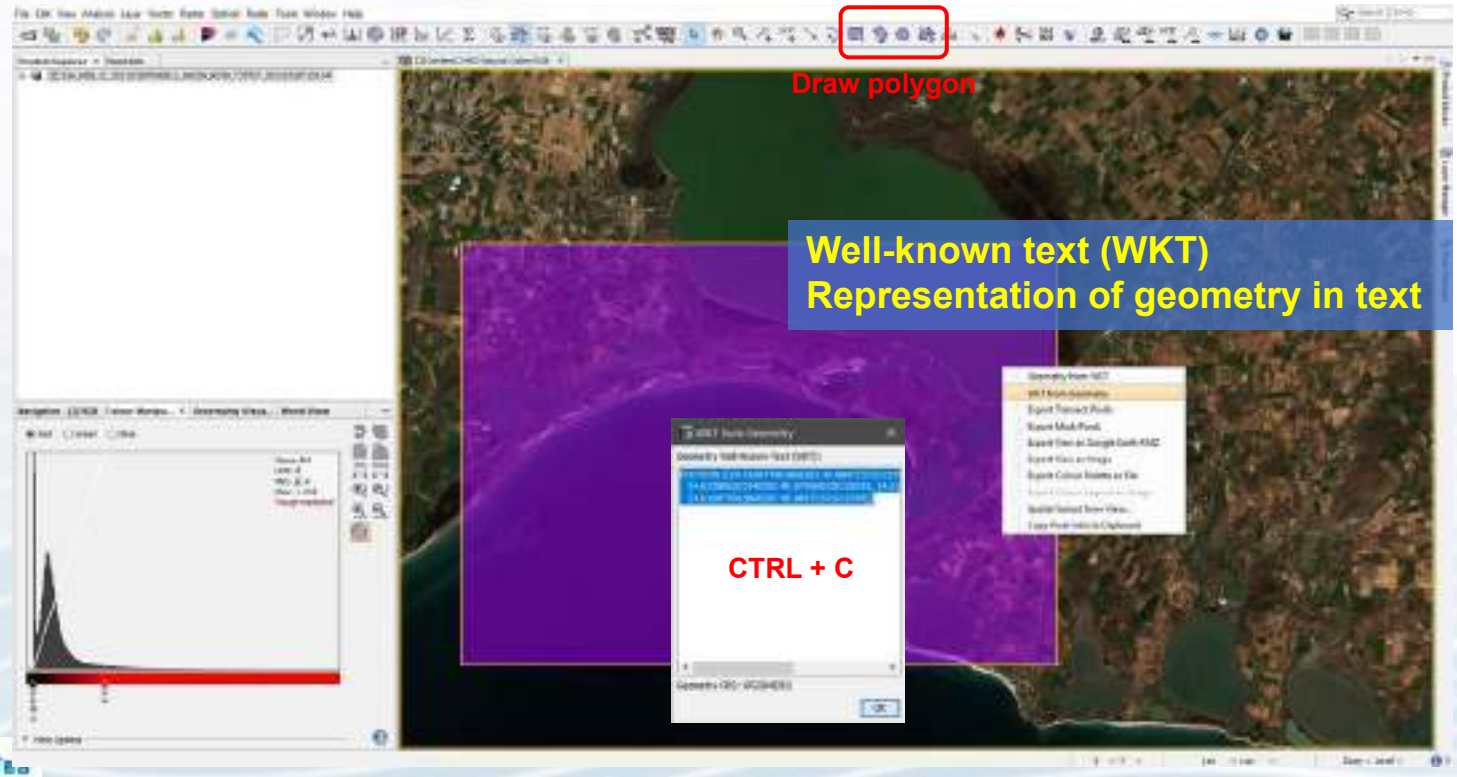


1. **Import of the satellite image with Drag and Drop**
2. **Image visualization**

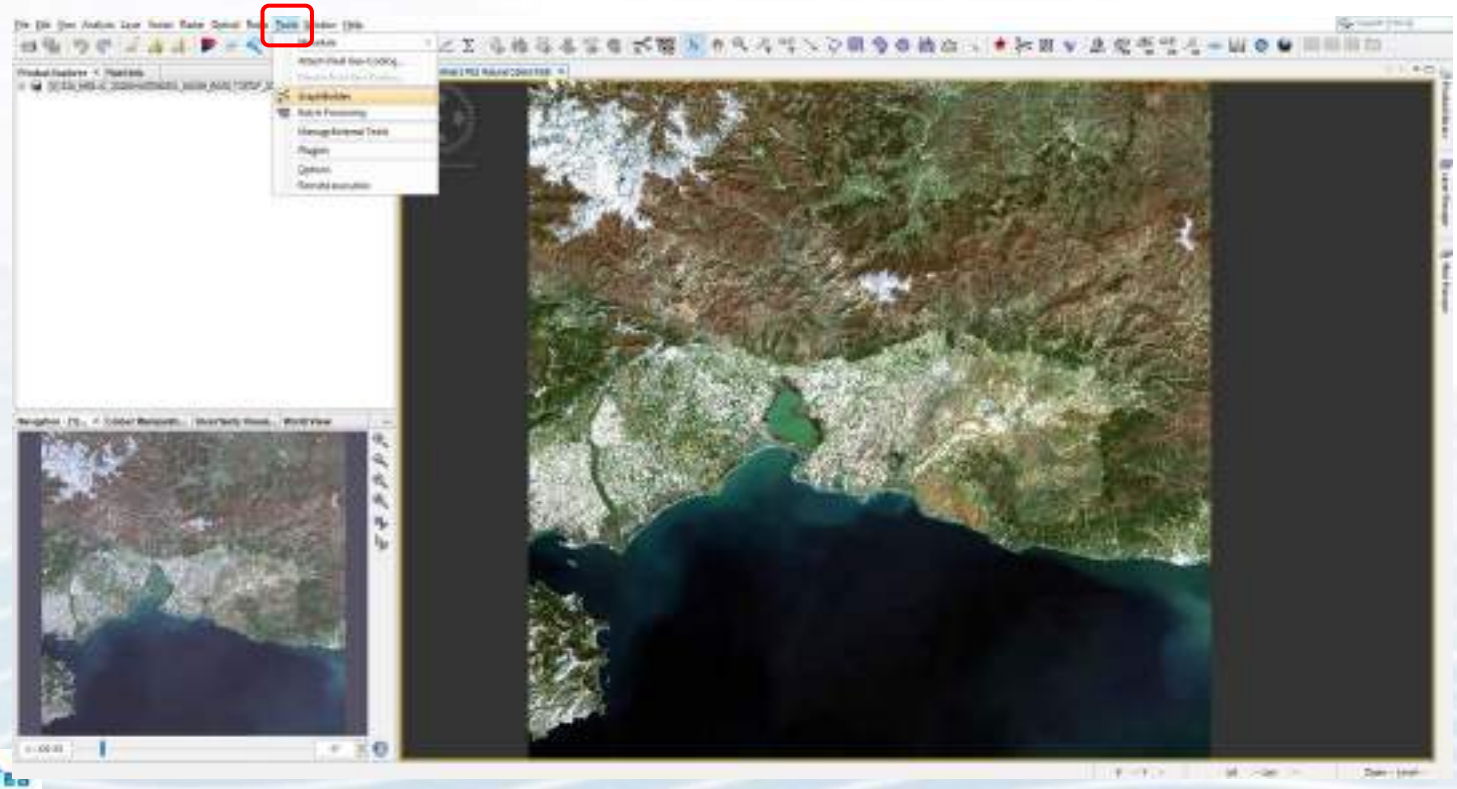
SNAP – Image visualization



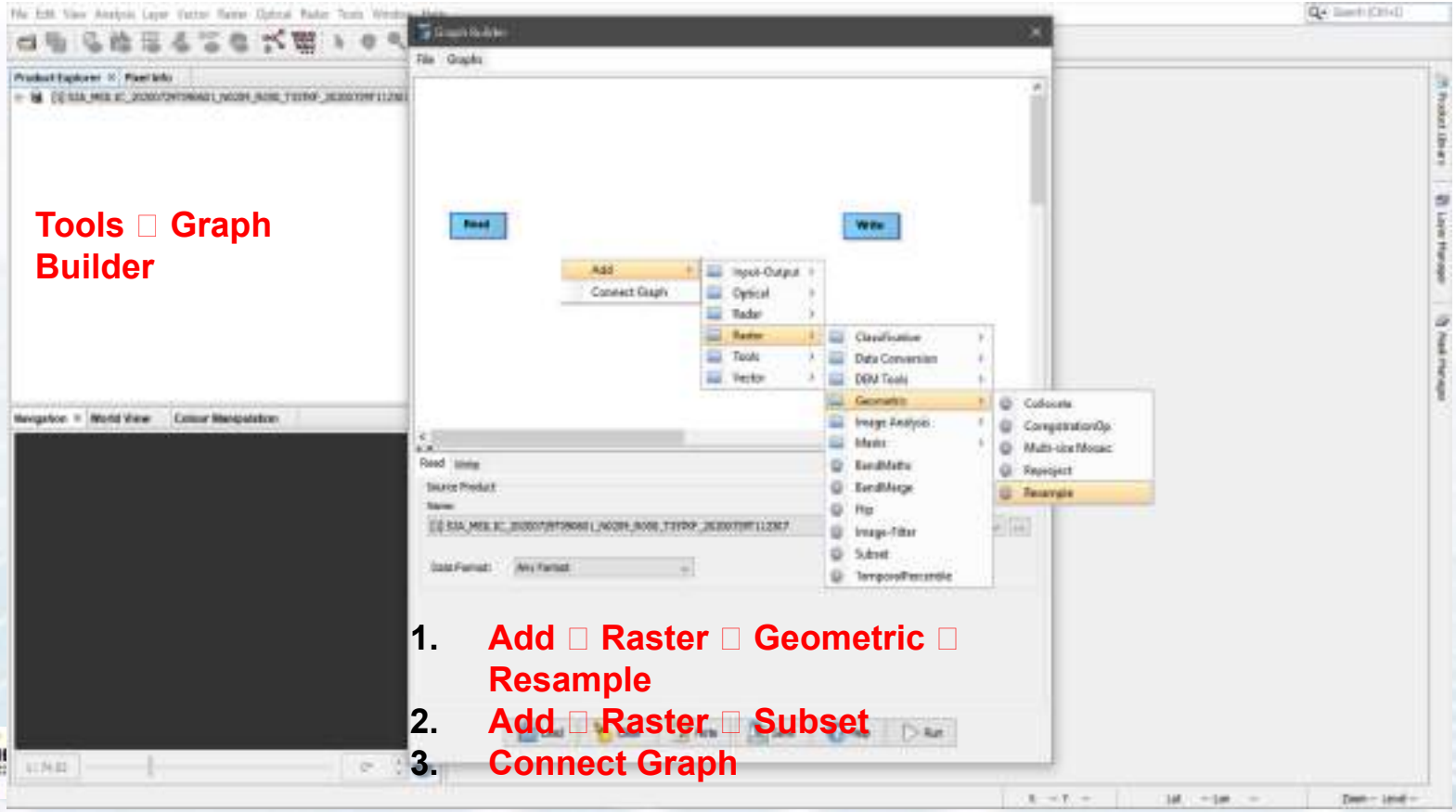
SNAP - Area of Interest



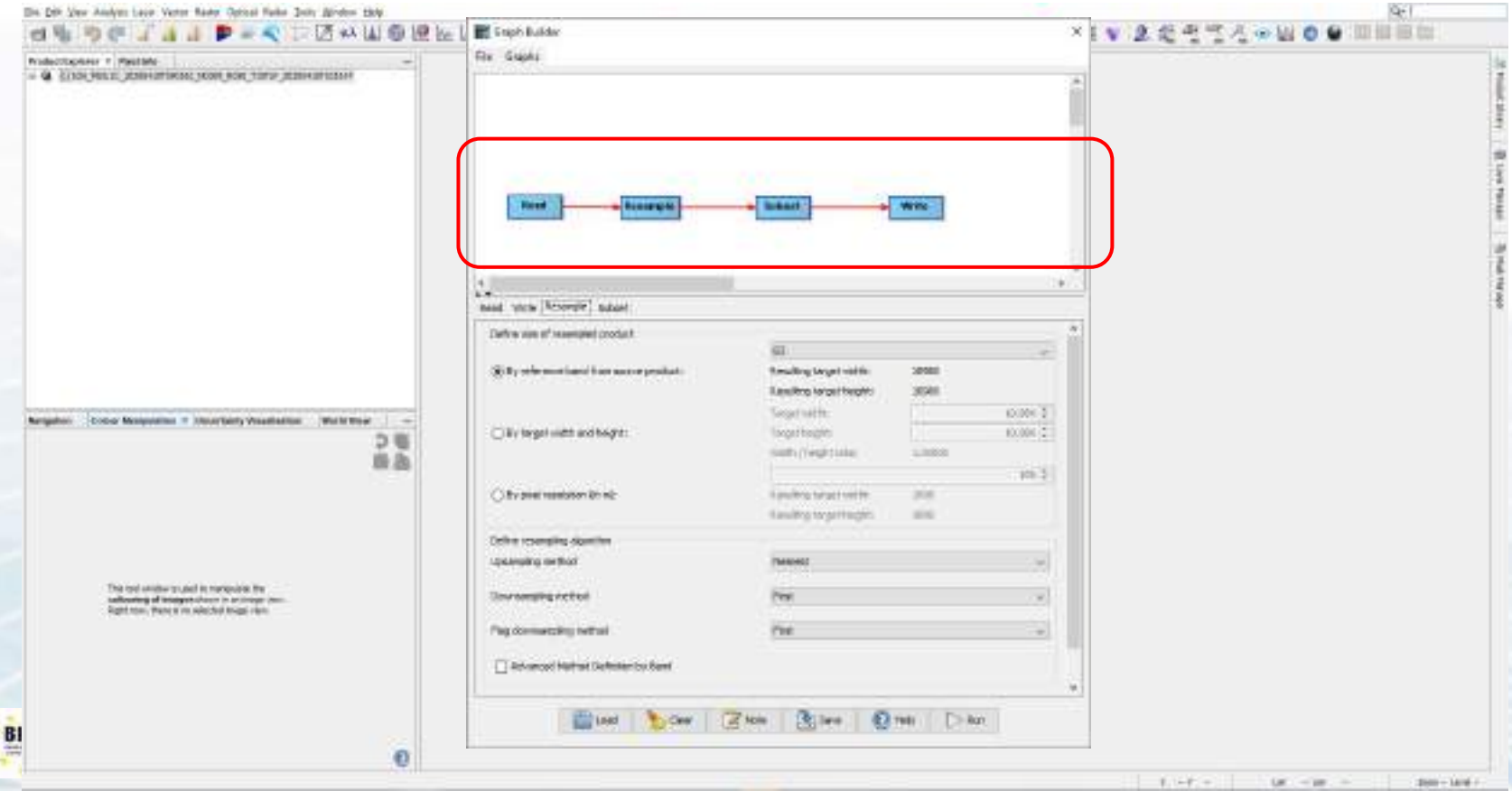
SNAP – Graph Builder



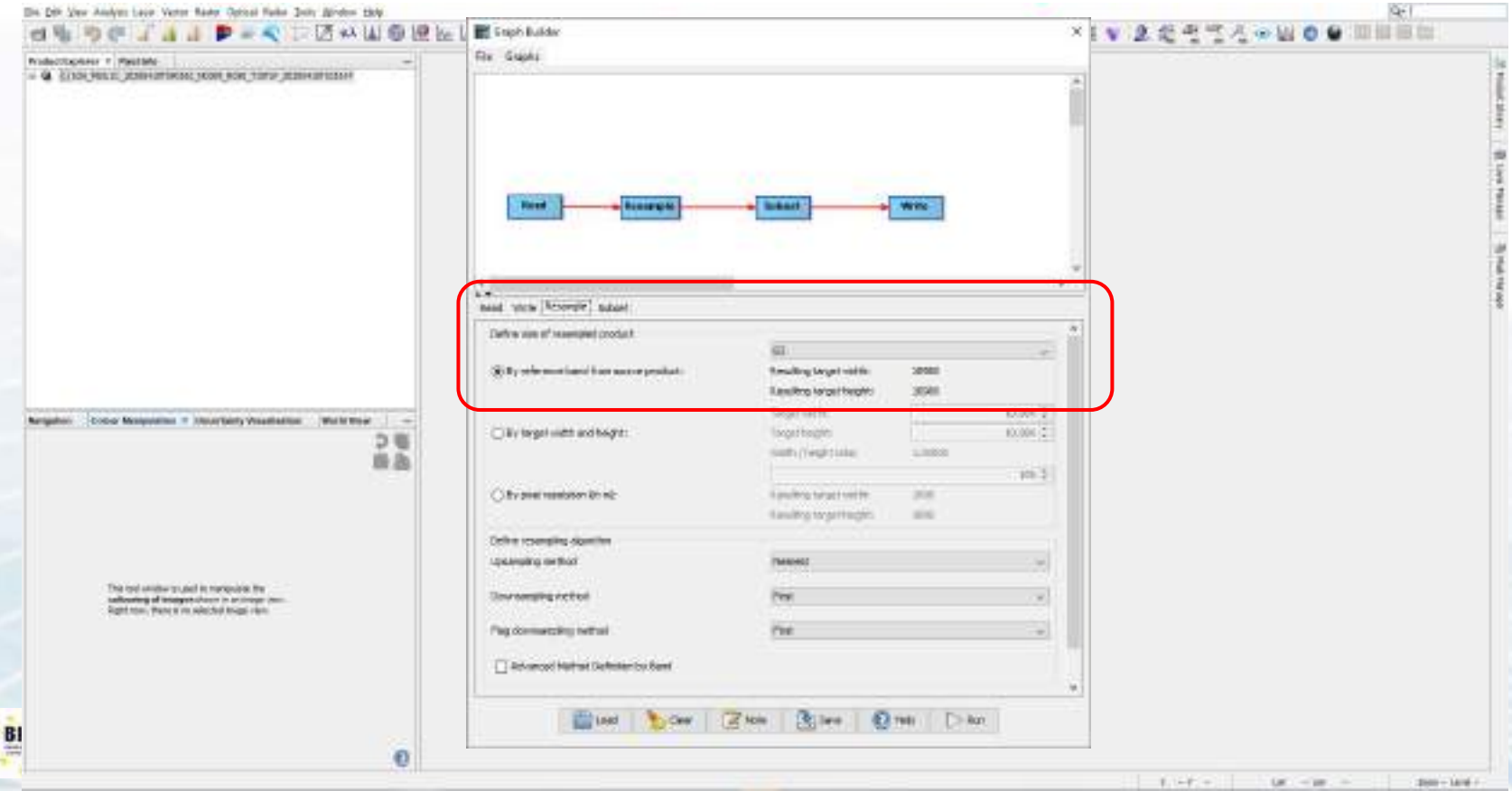
SNAP – Graph Builder



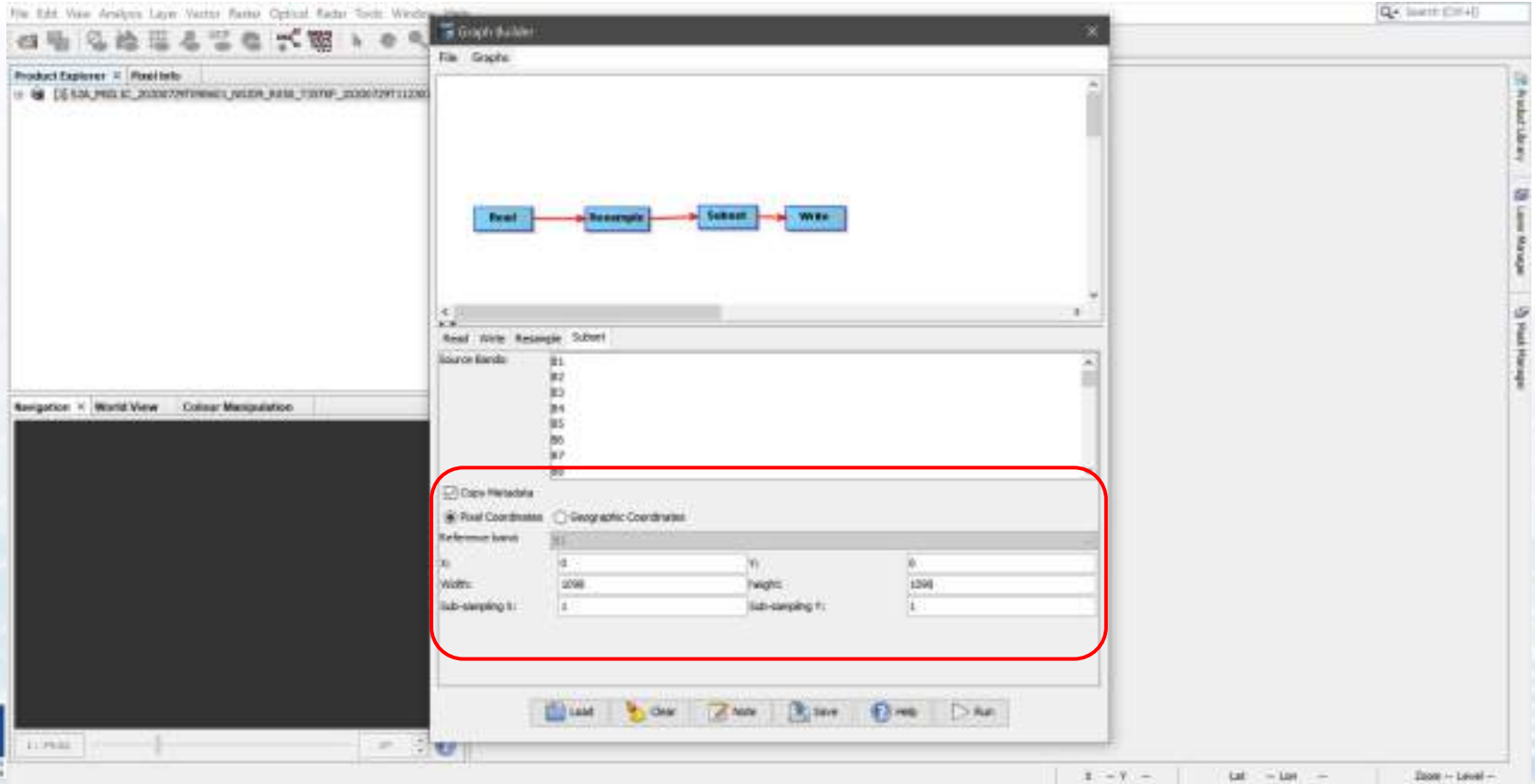
SNAP – Graph Builder



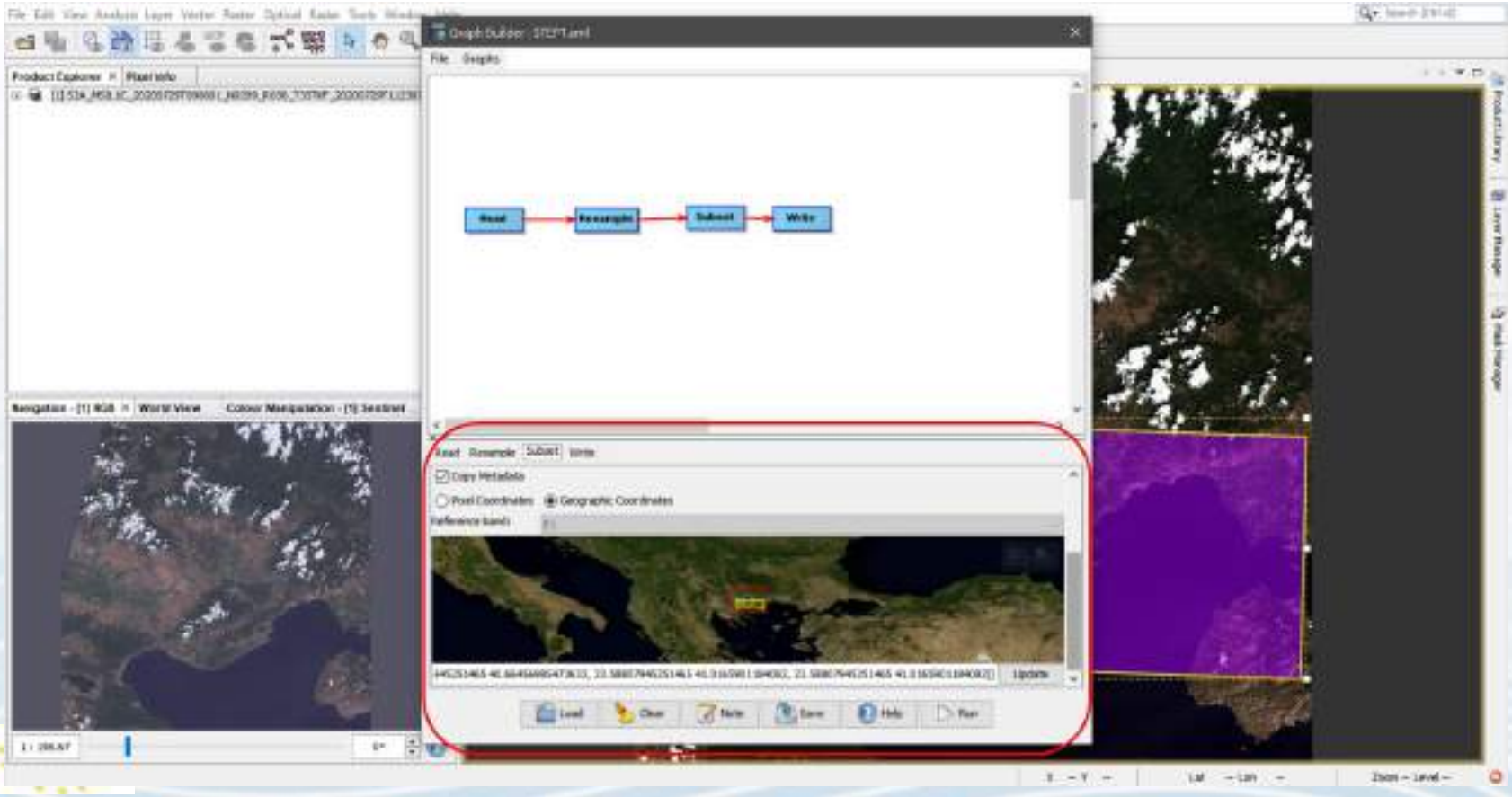
SNAP – Graph Builder - Resample



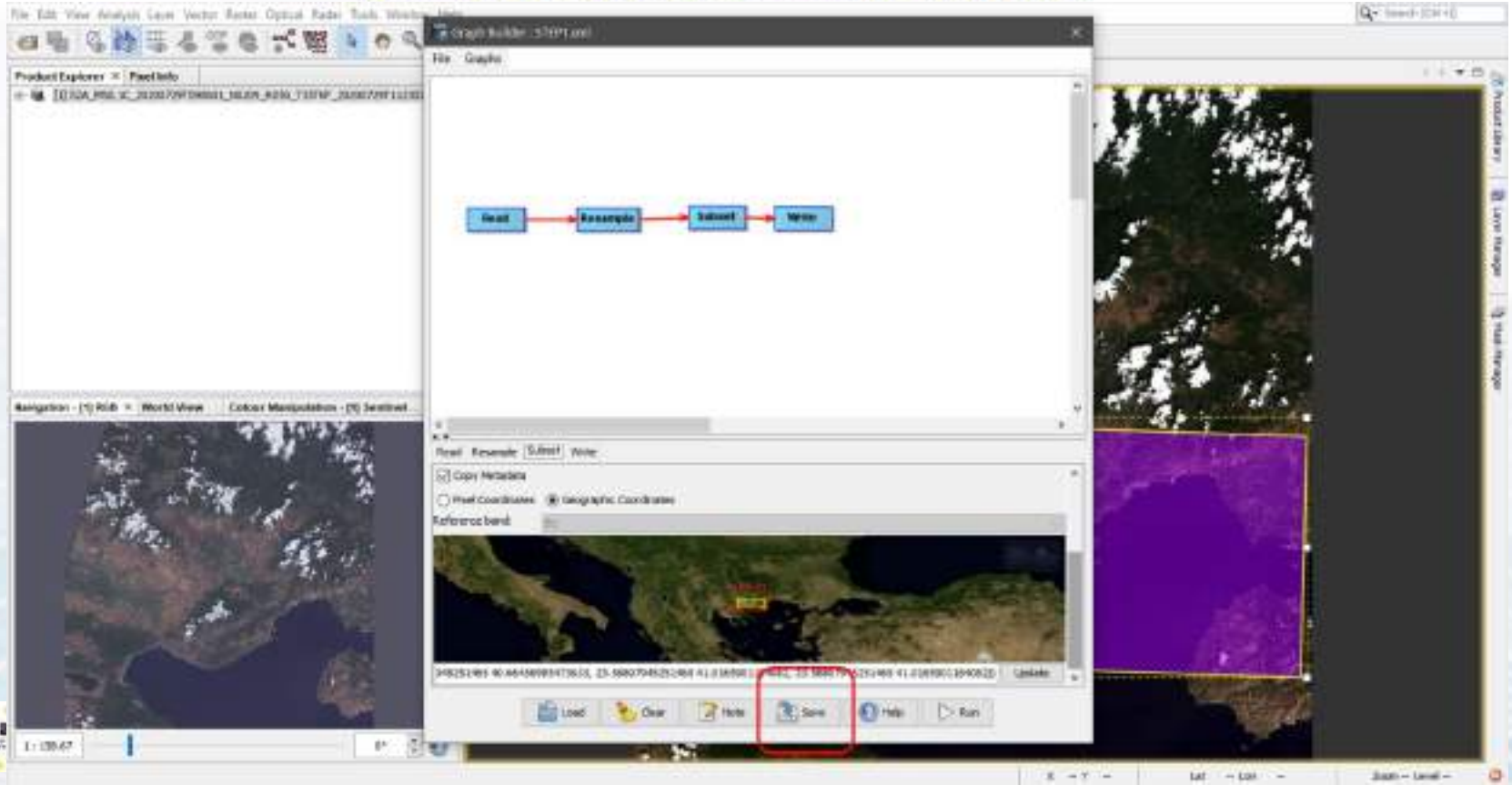
SNAP – Graph Builder - Subset



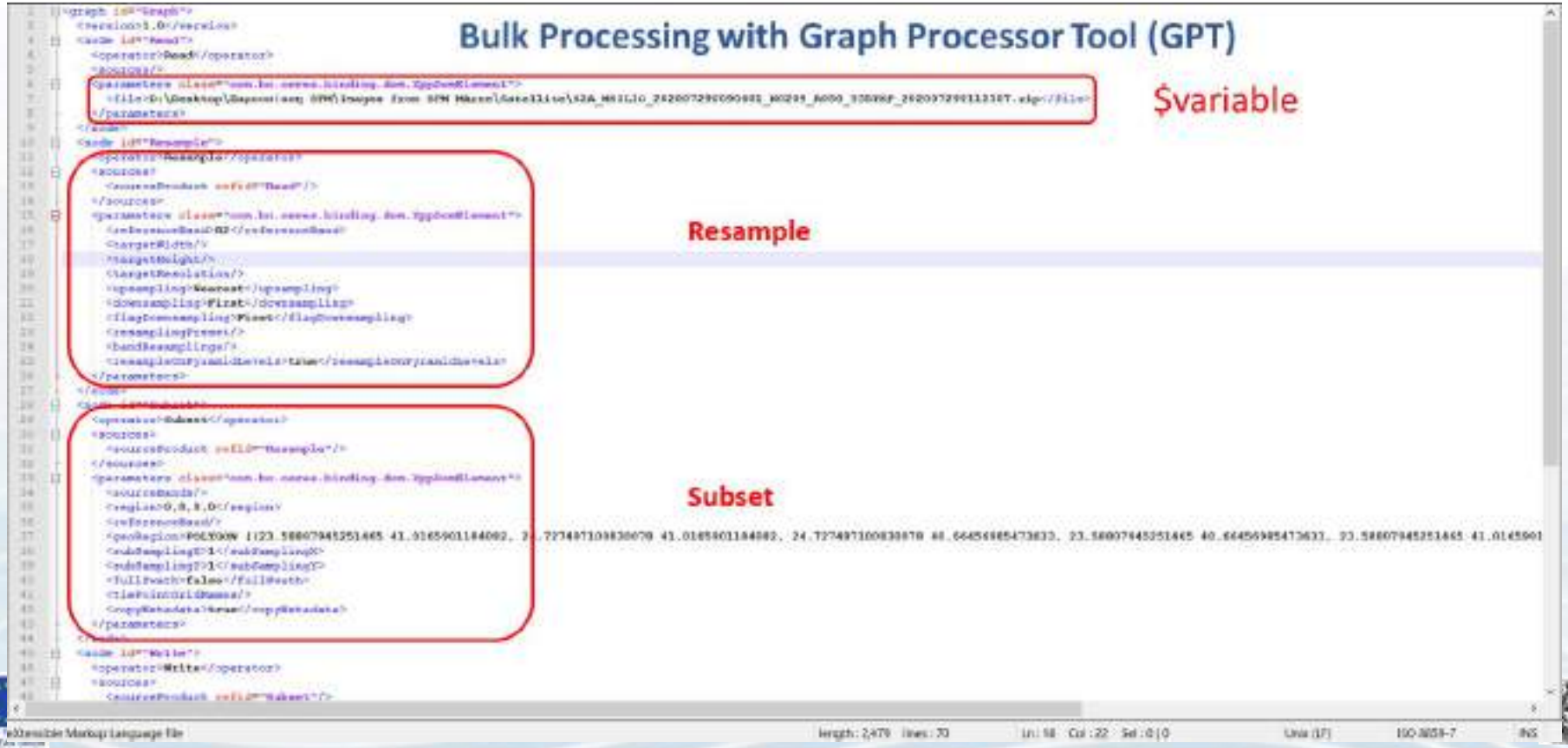
SNAP – Graph Builder - Subset



SNAP – Graph Builder



SNAP – Graph Builder

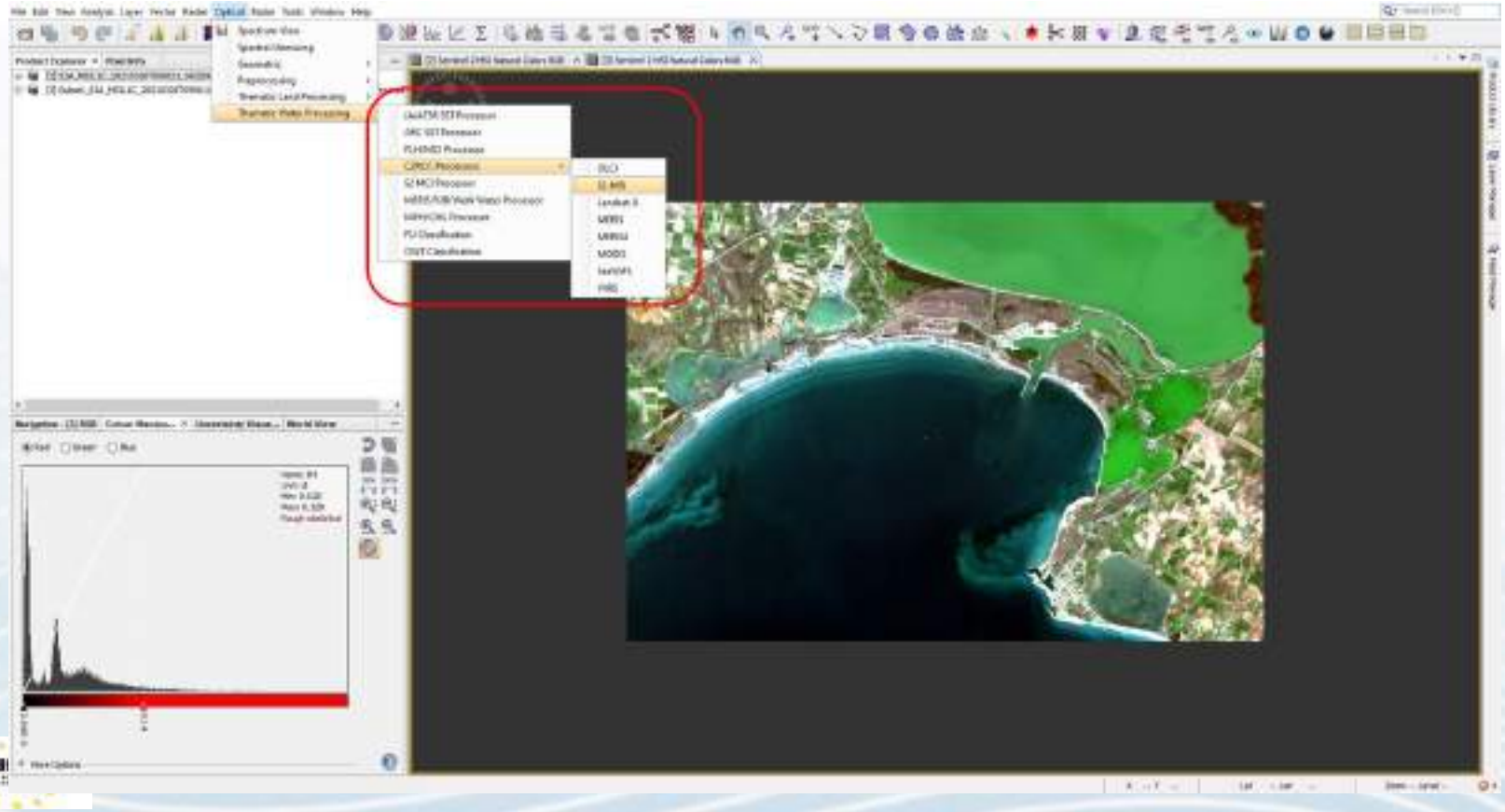


SNAP – Graph Builder

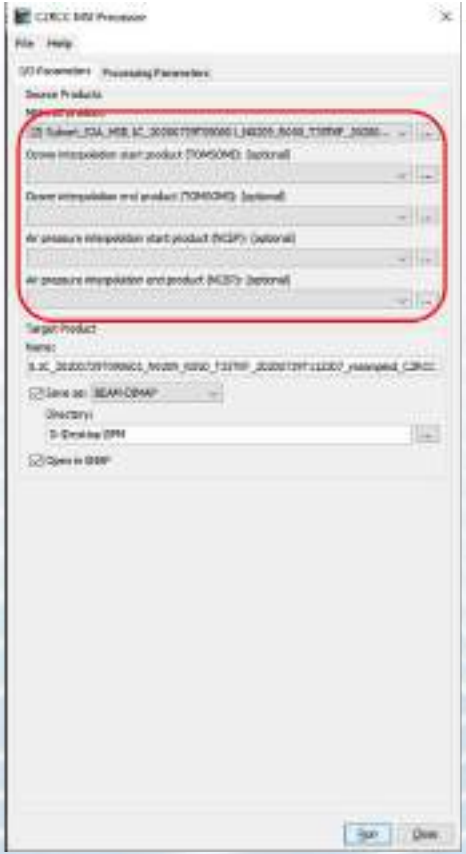
Initial

Resample - Subset

SNAP – C2RCC Processor



SNAP – C2RCC Processor



- Salinity
- Temperature
- Ozone
- Pressure

SNAP – C2RCC Processor

```
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    <temperature>15.1</temperature>
    <ozone>330.0</ozone>
    <press>1060.0</press>
    <elevation>0.0</elevation>
    <TSMfac>1.72</TSMfac>
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    <thresholdRtosaOOS>0.05</thresholdRtosaOOS>
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    <atmosphericAuxDataPath/>
    <netSet>C2RCC-Nets</netSet>
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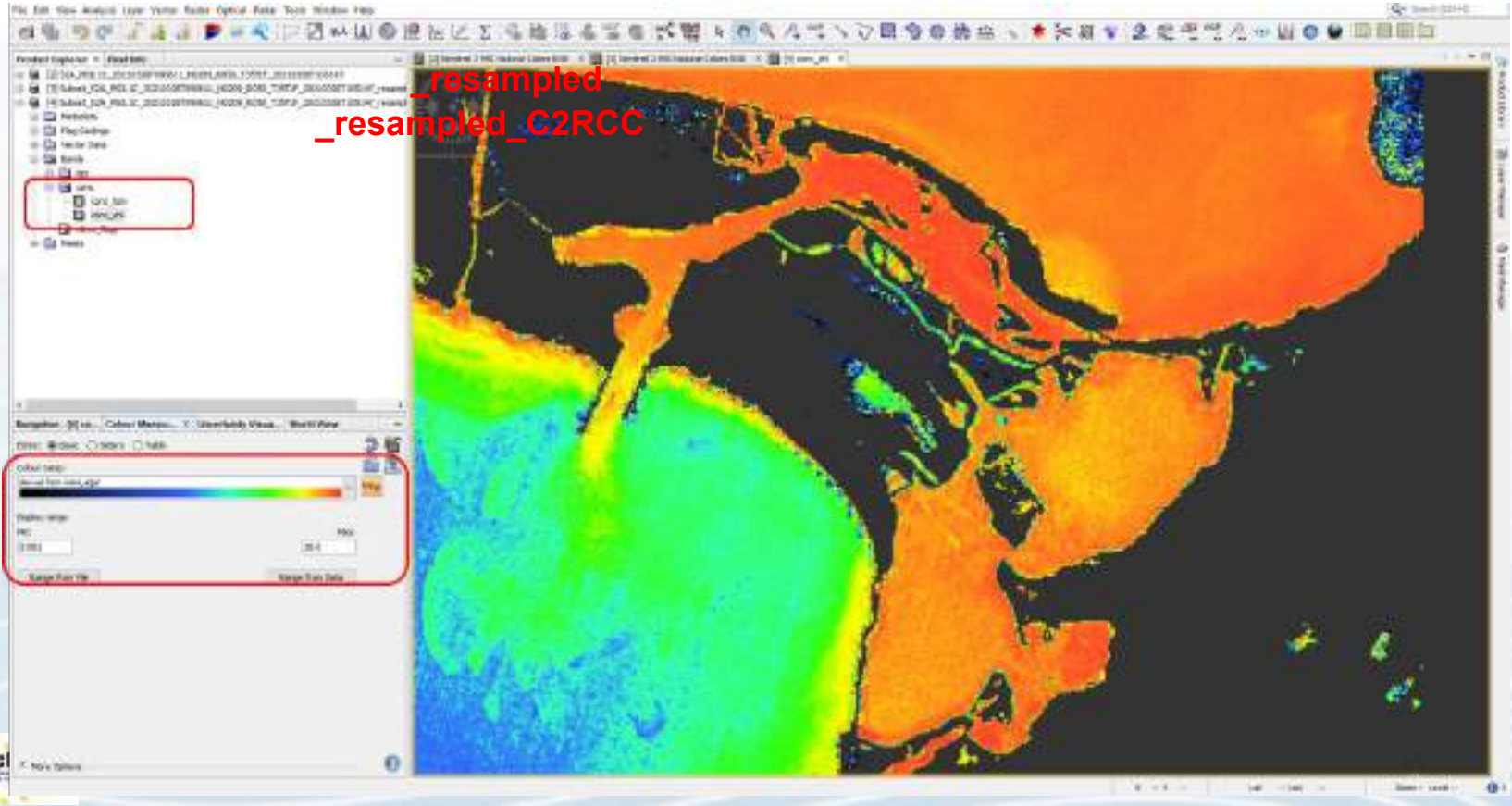
Variables

SNAP – C2RCC Processor



Calculate Chlorophyll from Landsat 4-5

Landsat Products to Chlorophyll

The Blue-Green Ratio Model

$$Chl-a \propto R(\lambda_{Blue}) / R(\lambda_{Green})$$

$R(\lambda_{Blue})$ reflectance in the blue region at 440 nm, Chl-a strongly absorb light

$R(\lambda_{Green})$ reflectance in the blue region at 550 nm, reflectance is minimally absorbed by pigments

Landsat Products to Chlorophyll

The Two-Band NIR-Red Ratio Model

$$Chl-a \propto R(\lambda_{NIR}) / R(\lambda_{Red})$$

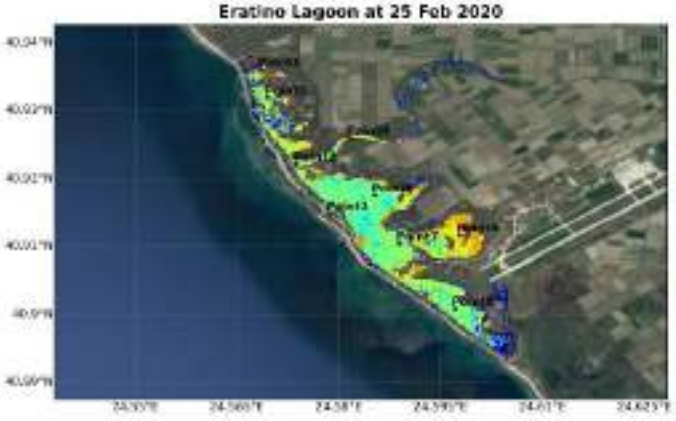
$R(\lambda_{Red})$ reflectance in the red region, wavelength usually located around the point of maximum chlorophyll-a absorption 660 nm < λ_{Red} < 690 nm

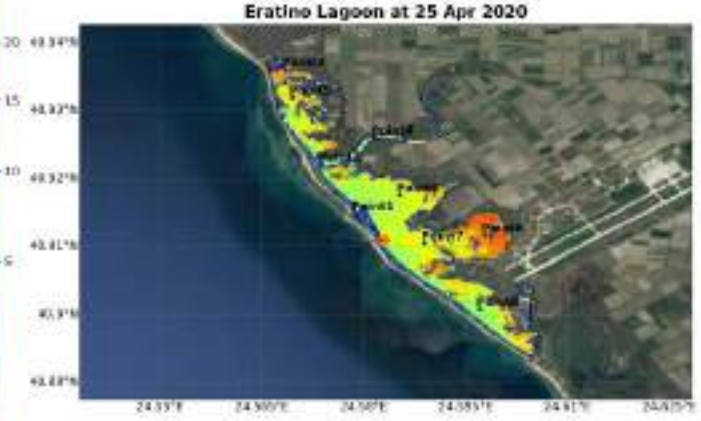
$R(\lambda_{NIR})$ reflectance in the near-infrared, near-infrared wavelength, λ_{NIR}, may be found at two different positions in the NIR:

a. between 700 nm and 720 nm, known as λ_2, where absorption of the water constituents is minimal or

b. beyond 710 nm, known as λ_3

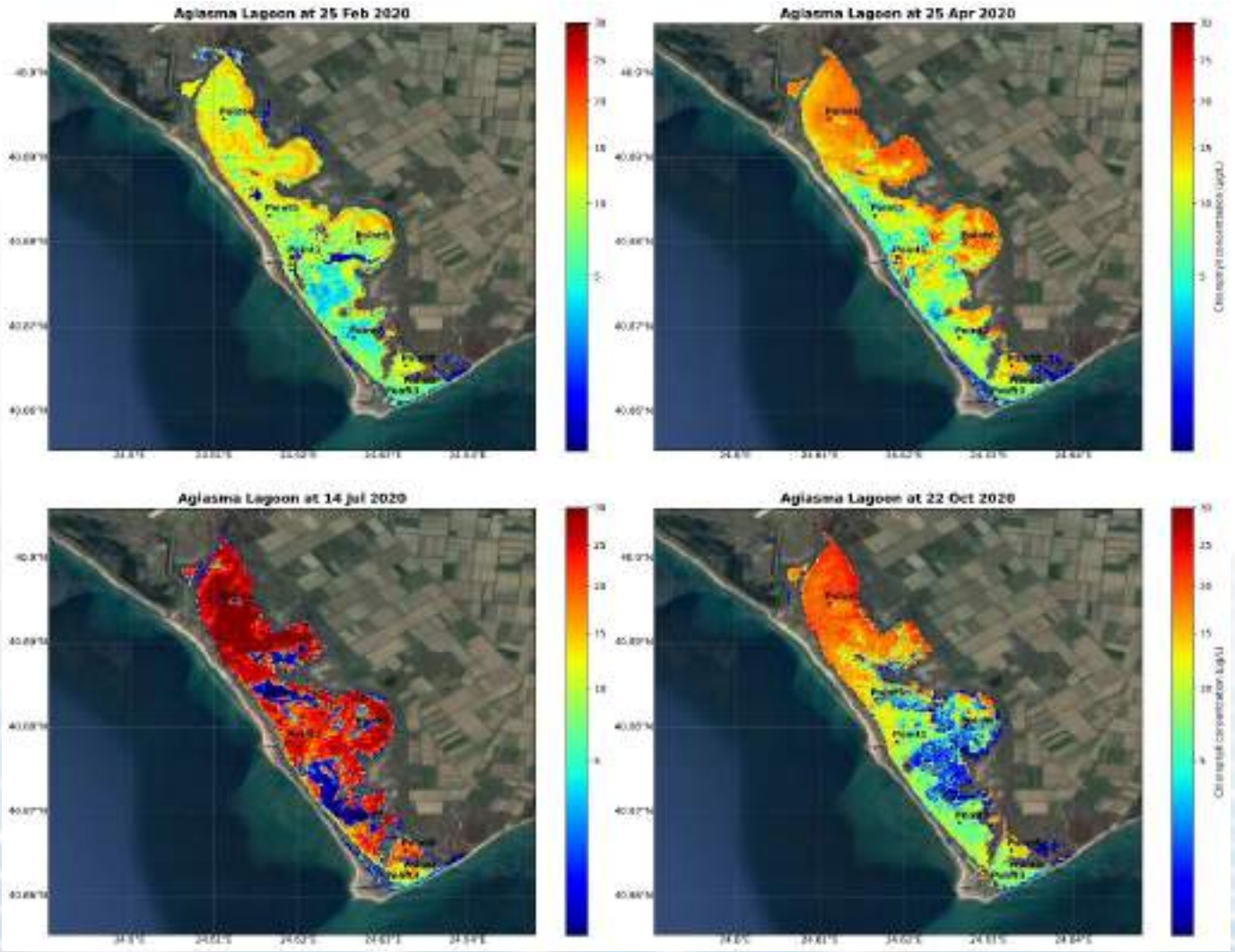
Results


Eratino Lagoon at 25 Feb 2020


Eratino Lagoon at 25 Apr 2020


Eratino Lagoon at 14 Jul 2020


Eratino Lagoon at 22 Oct 2020


Aglasma Lagoon at 25 Feb 2020
Aglasma Lagoon at 25 Apr 2020
Aglasma Lagoon at 14 Jul 2020
Aglasma Lagoon at 22 Oct 2020

Project funded by EUROPEAN UNION

PONTOS

Common borders. Common solutions.

Black Sea CROSS BORDER COOPERATION

Thank You

Maria Zoidou
Democritus University of Thrace, Greece