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Module 2: The application of EO for Coastal line changes with the example of assessments via PONTOS platform

VIRTUAL TRAINING MODULES

2022

PONTOS-EU.AUA.AM

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Module 2
The application of EO for Coastal line changes with the example of assessments via PONTOS platform

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Responsible Partner Democritus University of Thrace
Supporting Partner – Environmental Protection and Monitoring Inspection Body of RA
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This module is developed in the frames of the BSB 889 PONTOS Project

LEARNING OBJECTIVES OF MODULE 2

Familiarize with the open source satellite image platforms

Download historical satellite images

Process of shoreline extraction from satellite images

Evaluation of shoreline movements through the years

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MODULE STRUCTURE

- Introduction in Coastal Erosion and Remote Sensing
- Description of the Methodology Workflow
- Results Visualization

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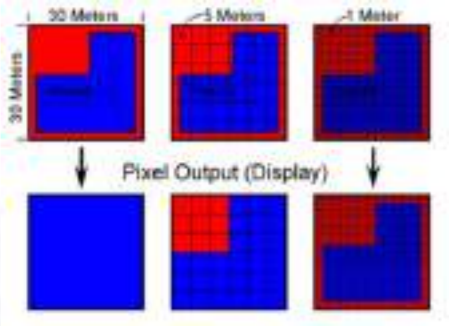
Introduction to satellite sensors characteristics

Spatial Resolution

The spatial resolution specifies the pixel size of satellite images covering the Earth surface.

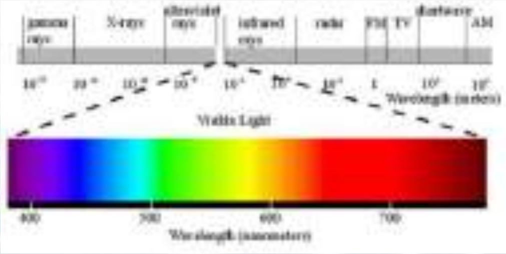


Temporal Resolution

The temporal resolution specifies the revisiting frequency of a satellite sensor for a specific location.

Spectral Resolution

The number of spectral bands in which the sensor can collect reflected radiance. But also the position of bands in the electromagnetic spectrum.



Introduction to satellite sensors characteristics

Cloud percentage	Percentage of the image covered by clouds
Ground sample distance	The distance in meters between pixel centers measured on the ground
Pixel Resolution	Pixel resolution of the image in meters
Off-nadir angle	Spacecraft across-track off-nadir viewing angle used for imaging, in degrees ("+" being East and "-" being West)
Sun elevation	Elevation angle of the sun in degrees (0-90)
Sun azimuth	Angle from the true North to the sun vector projected on the horizontal plane in degrees (0-360)

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Methodology applied in a coastal erosion assessment

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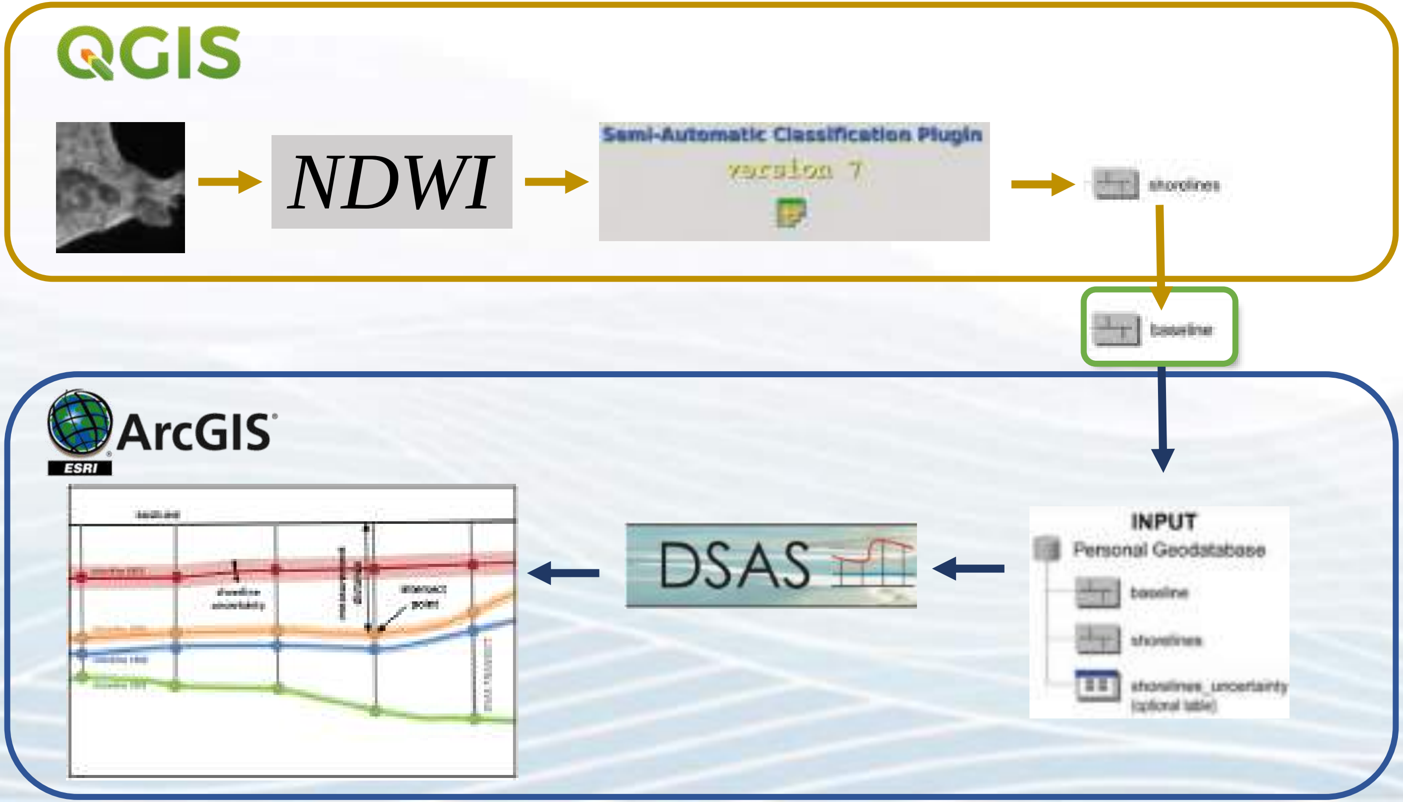

Open source databases for satellite images

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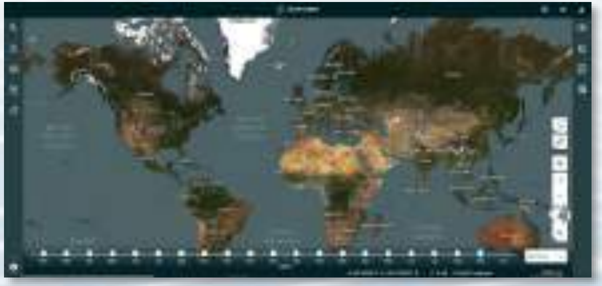
Open source databases for satellite images

https://earthexplorer.usgs.gov/

https://scihub.copernicus.eu/dhus



https://www.planet.com/explorer/

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Open source databases for satellite images

https://sentinel.esa.int/web/sentinel/sentinel-data-access

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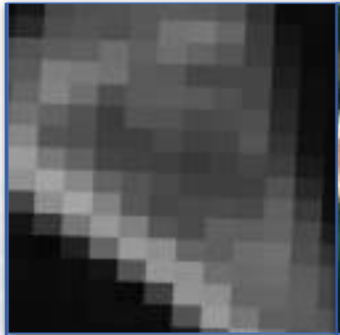
Open source products

Earth Explorer



Landsat 5 ETM

- Spatial Res.: 30m
- 1984 – 2013
- Number of Bands: 7

Landsat 8

- Spatial Res.: 30m
- 2013 – Still active
- Number of Bands: 8

Copernicus Hub

Sentinel 2A & 2B

- Spatial Res.: 10, 20, 60m
- 2015 – Still active
- Number of Bands: 13
- Number of Sat.: 2

Planet Explorer

RapidEye

- Spatial Res.: 5 m
- 2009 – March 2020
- Number of Bands: 5
- Number of Sat.: 5

Planet Explorer

PlanetScope

- Spatial Res.: 3.6 m
- 2016 – Still active
- Number of Bands: 4
- Number of Sat.: more than 120 optical satellites

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Earth Observation Tools

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Earth Observation Tools

GIS Software

QGIS

https://qgis.org/en/site/forusers/download.html

ArcGIS

https://pro.arcgis.com/en/pro-app/get-started/install-and-sign-in-to-arcgis-pro.htm

Plug-ins

Semi-Automatic Classification Plugin version 7

https://plugins.qgis.org/plugins/SemiAutomaticClassificationPlugin/

DSAS

https://www.usgs.gov/centers/whcmsc/science/digital-shoreline-analysis-system-dsas?qt-science_center_objects=0#qt-science_center_objects

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Install QGIS

https://qgis.org/en/site/forusers/download.html

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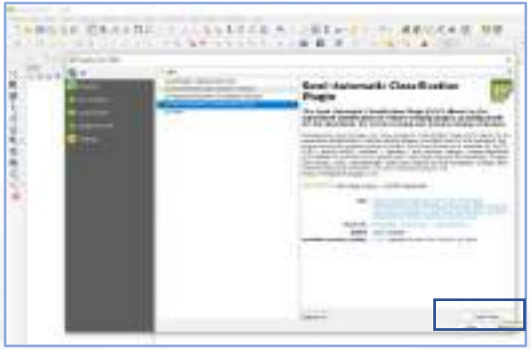
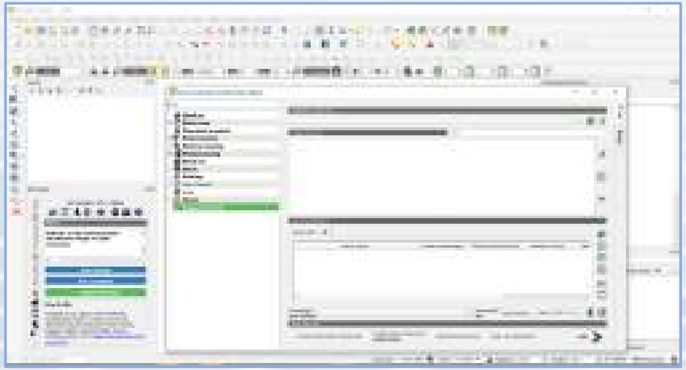
Install Semi Automatic Classification plugin in QGIS

1.

2.



3.



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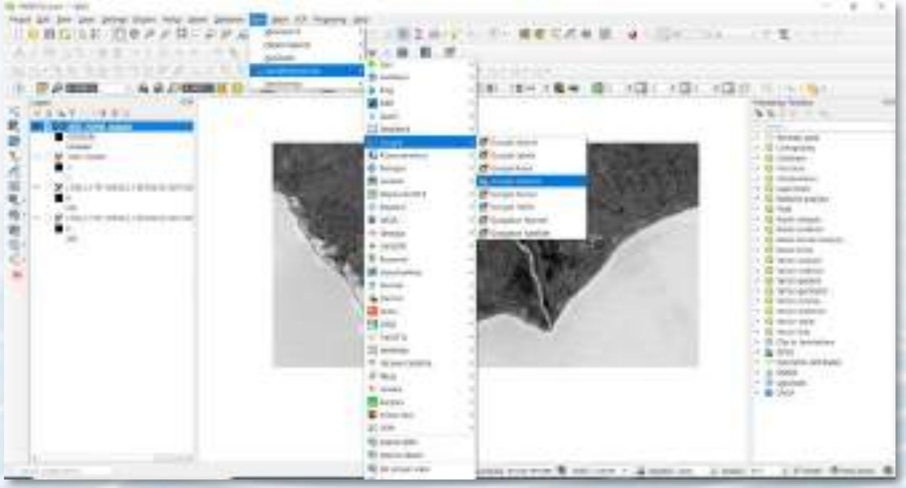
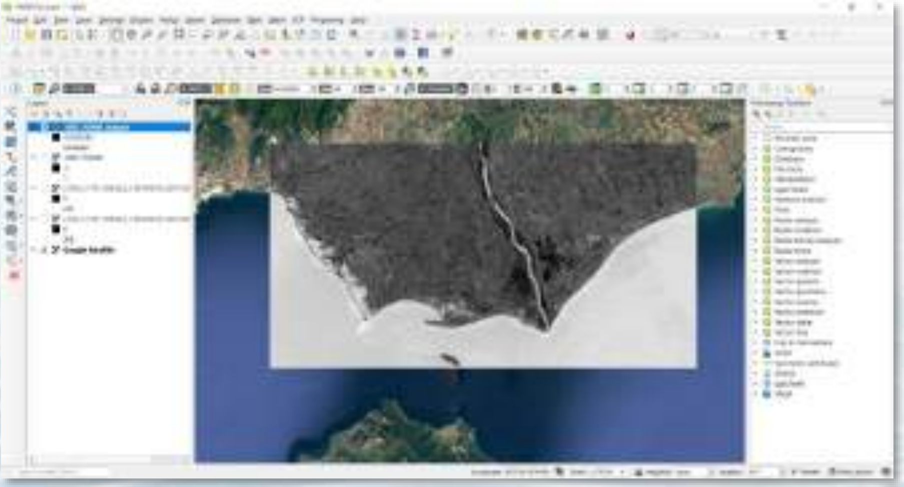
Install QuickMapServices plugin in QGIS

- Plugins → Manage and Install Plugins… → search QuickMapServices → install
- Web → QuickMapServices → Settings → More Services → Get Contributed pack → Save
- Web → QuickMapServices → select your basemap





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Practical Session 1

Earth Explorer and Copernicus Open Access Hub

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Earth Explorer

Satellite image selection criteria

Image selection should be based on:

- **Clarity** from cloud cover
- The correct **geo-reference & Orthorectification**
- The **seasonality** (e.g. all images retrieved in the summer months)
- **Sea surface height** (CMEMS data) / Tidal phase

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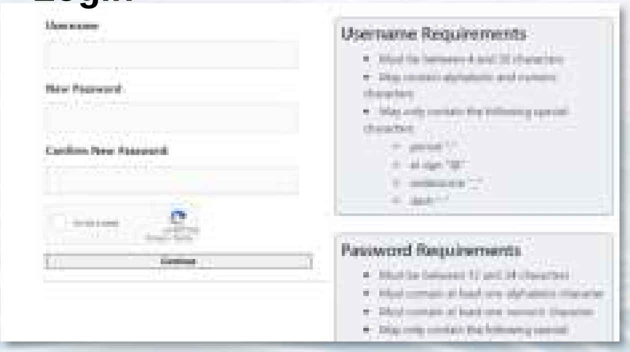
Step 1: Create an account and login the Earth Explorer or sign in

Login



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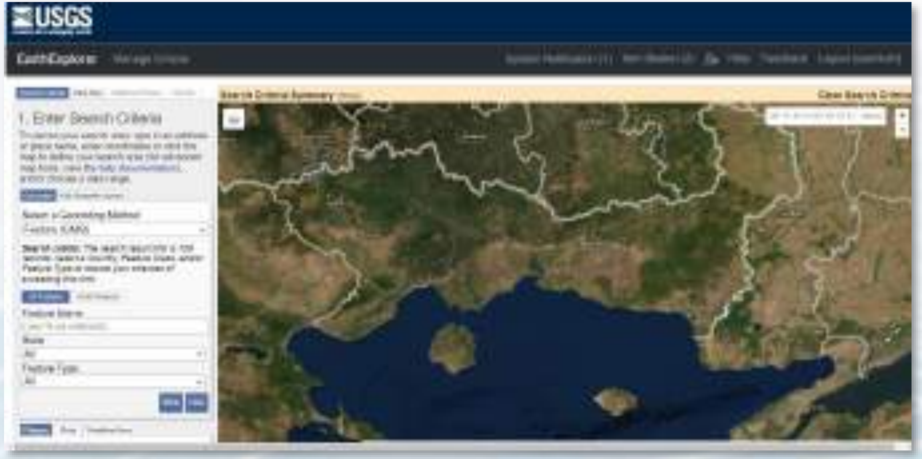
Step 2: Define the Area of Interest

- Use the interactive map and zoom to you area of Interest
- In the *“Enter Search Criteria”* tab select *“use map”* and the area enclosed to the screen is selected



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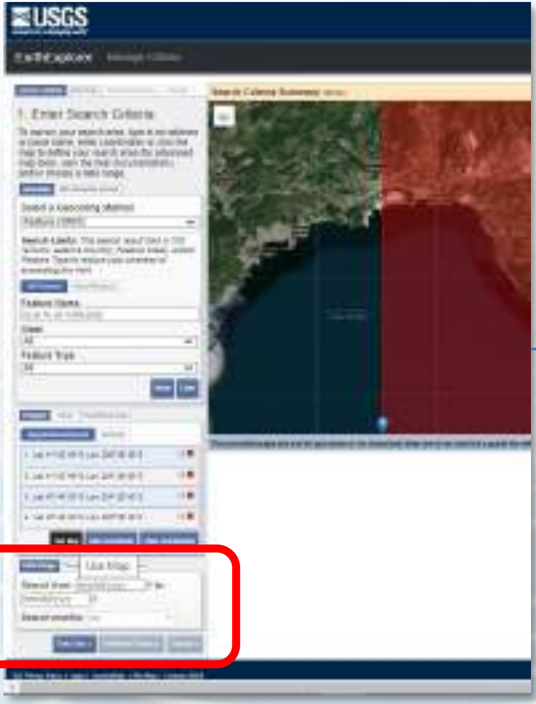
Step 3: Define the *“Date Range”* for satellite images search



Define the Date Range

Search images only for summer months

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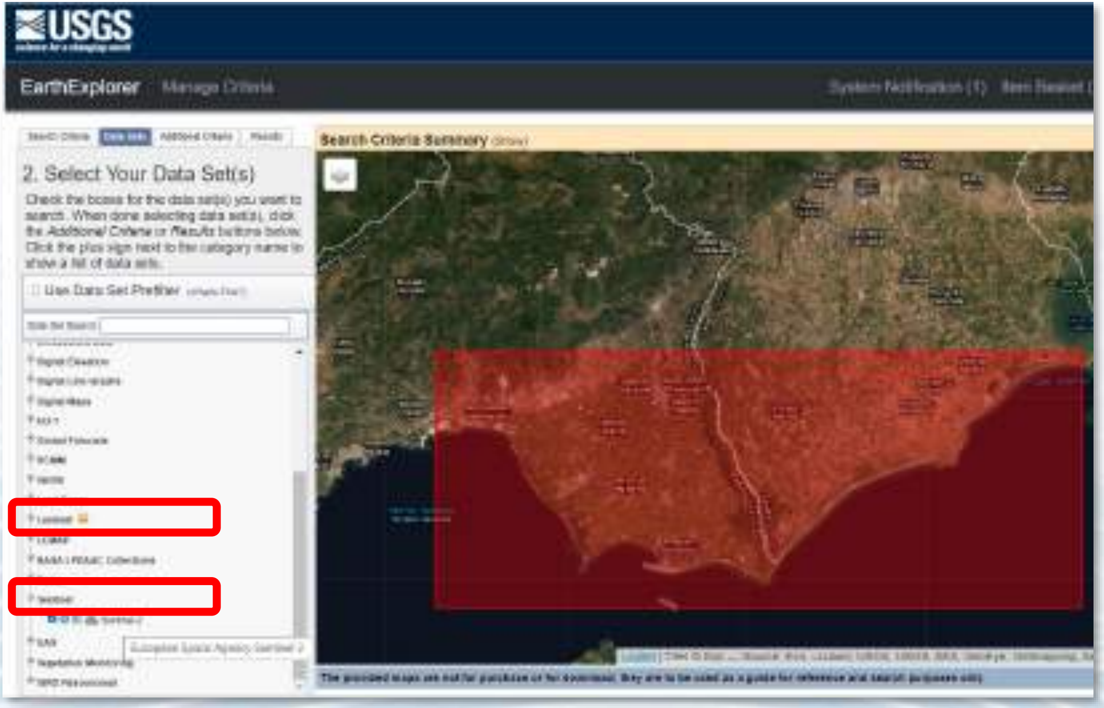
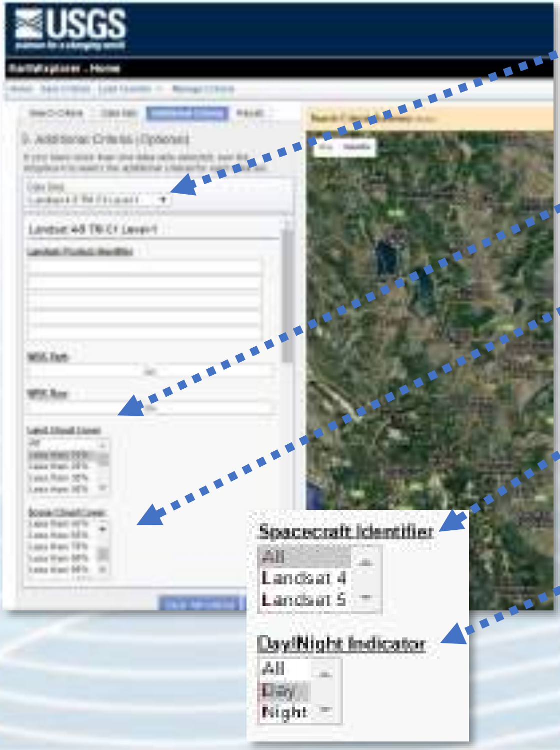
Step 4: Select your Data Sets



In the *“Data Sets”* tab
- Select your data set Landsat or Sentinel

Step 5: Additional criteria



1. Data Set
2. Land Cloud Cover
3. Cloud Cover in the image
4. Spacecraft Identifier
5. Day / Night Indicator

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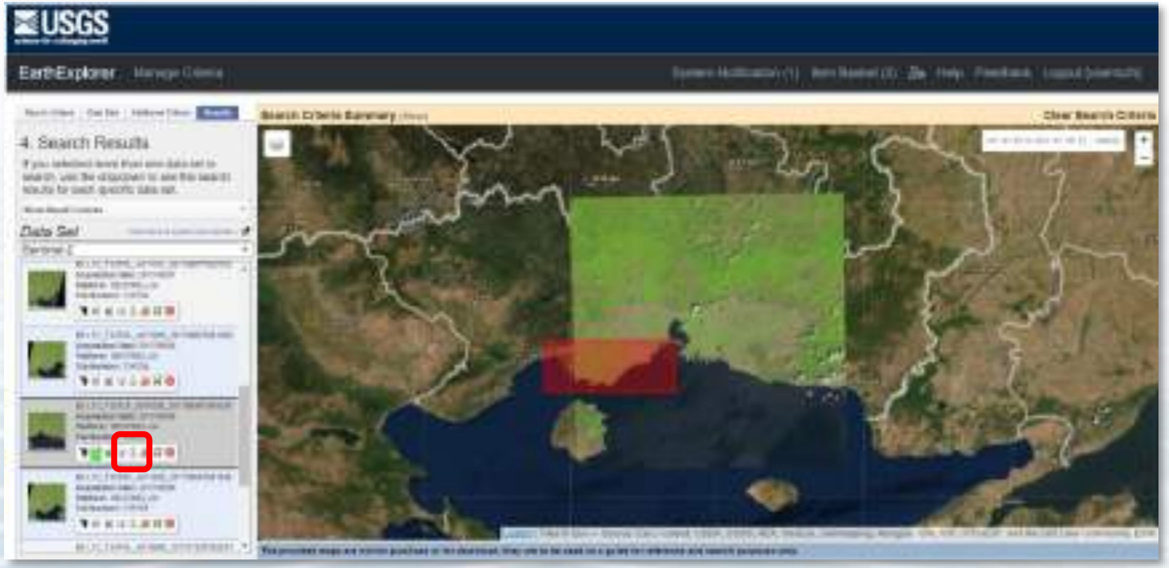
Step 6: image selection

In the tab “Results”

- Select the Data Set and a list of images is shown

- Download images with no cloud cover



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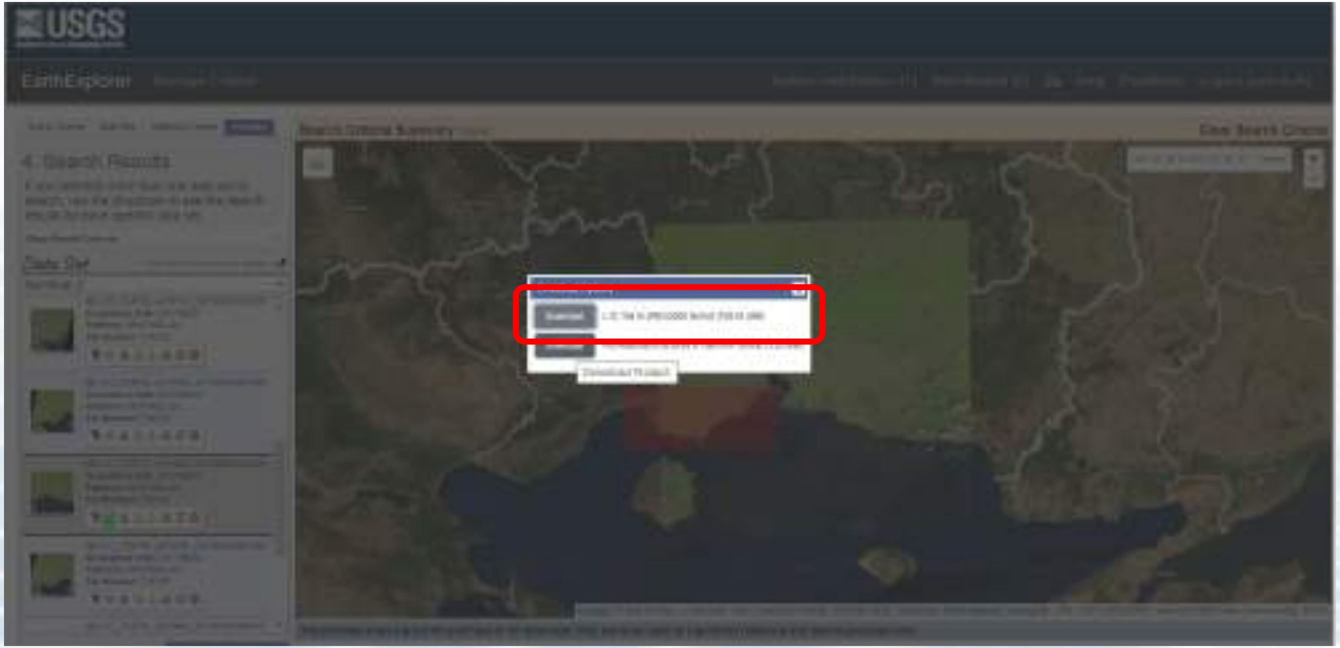
Step 8: Download image



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Copernicus Open Access Hub

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Step 1: Open Copernicus Open Access Hub

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Step 2: Create an account and Login or sign in

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Step 4: Zoom in you Region of Interest

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Step 3: Create a polygon to define your ROI

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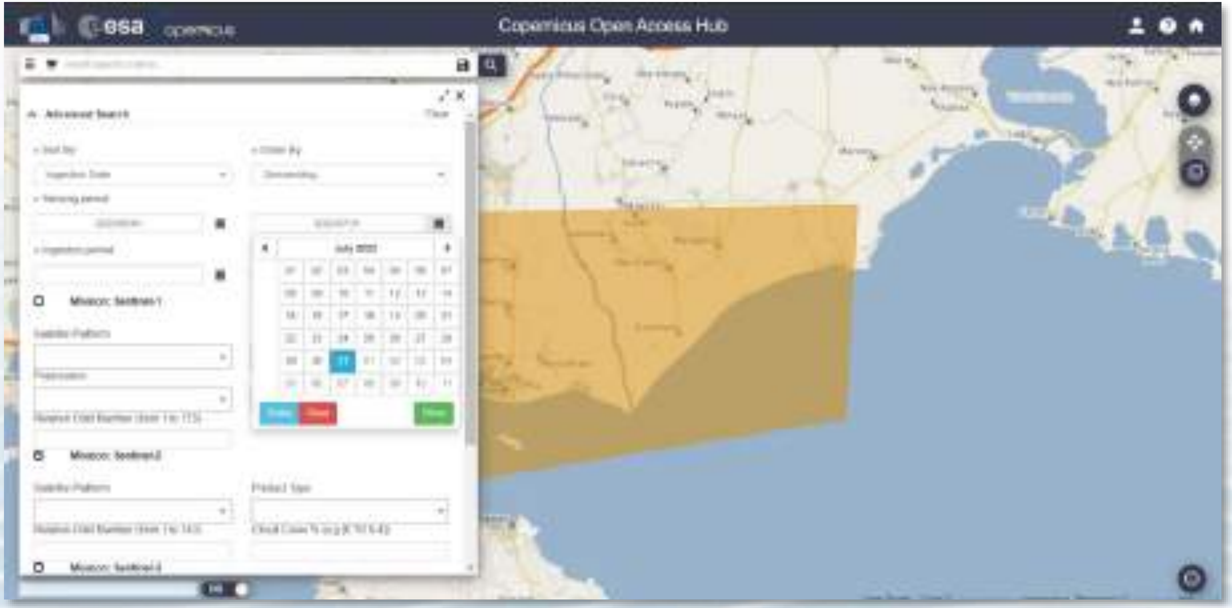
Step 4: Define the date range for satellite image selection



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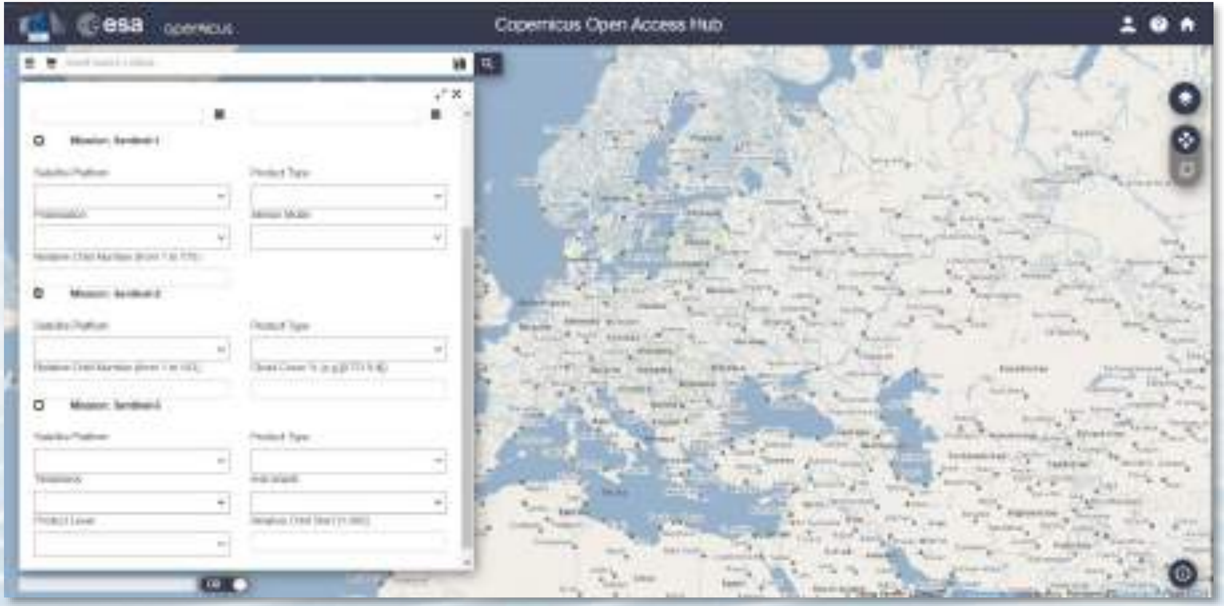
Step 5: Select the Mission Sentinel 2 and search for results



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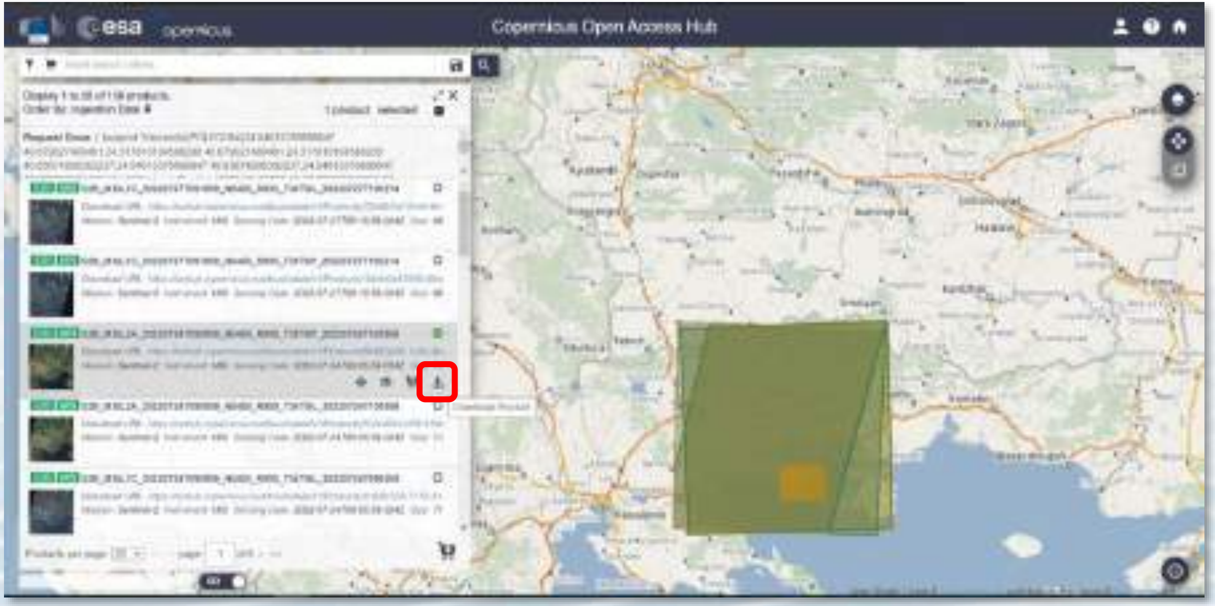
Step 6a: Select and download the satellite image



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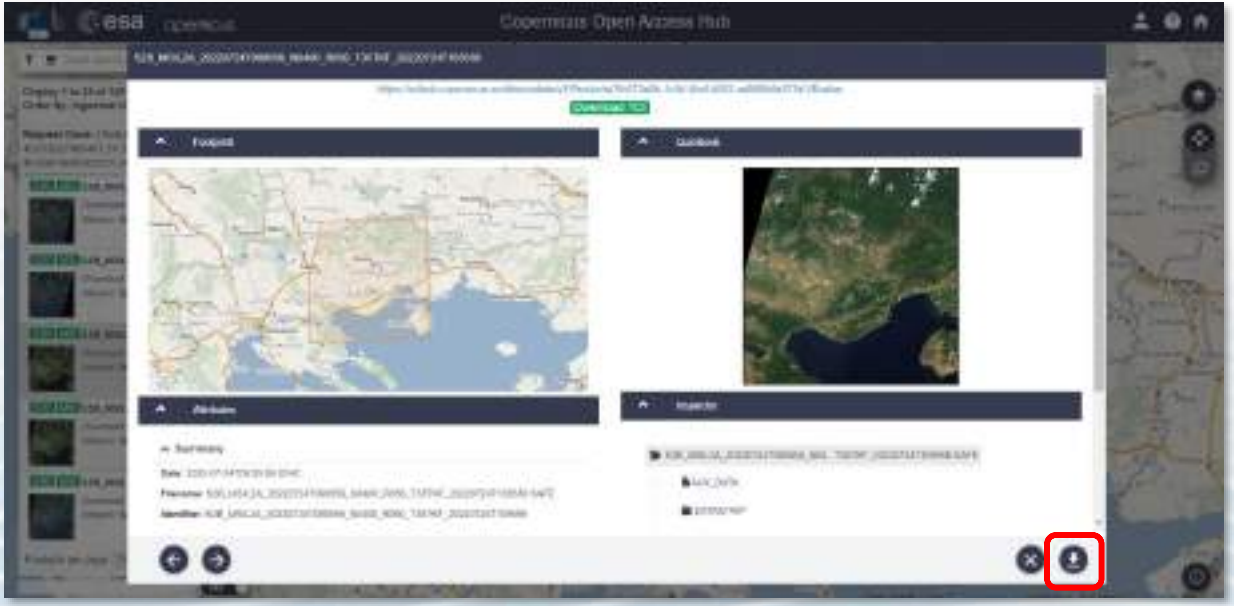
Step 6b: Preview and download the satellite image



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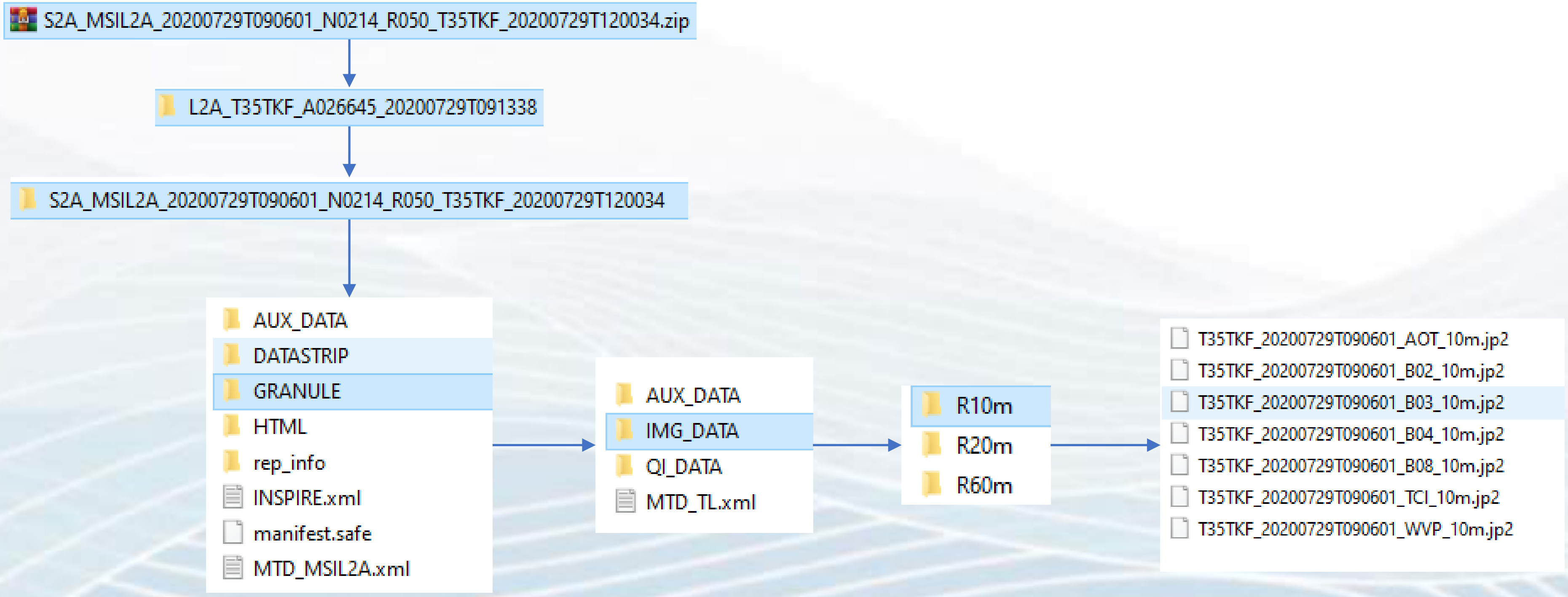
Step 9: Open Sentinel 2 Downloaded file



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Practical Session 2

Shoreline Extraction

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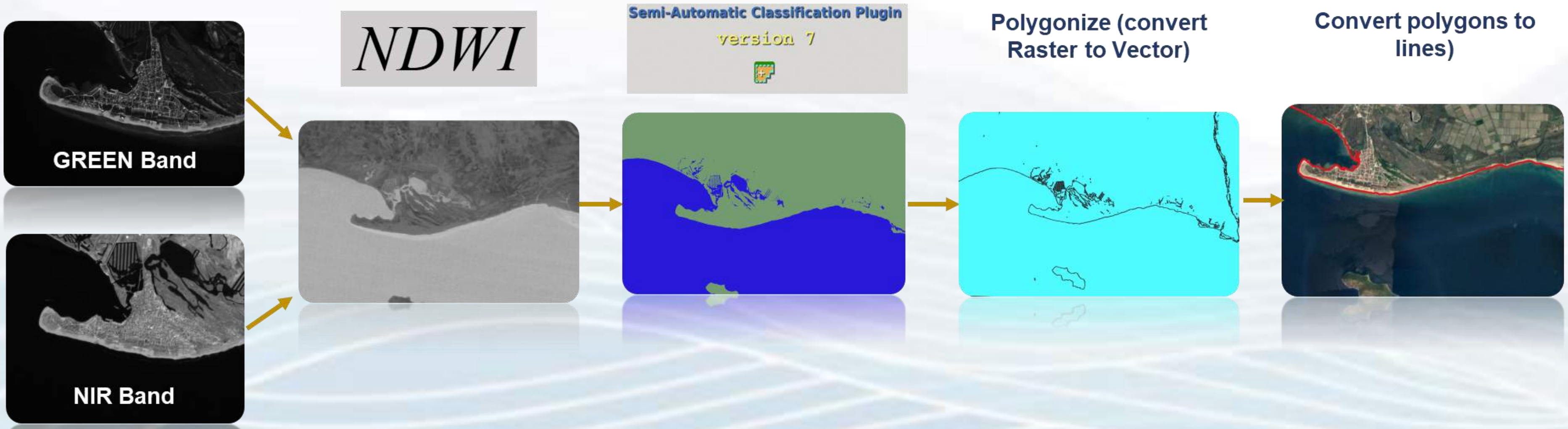
Shoreline extraction methodology - Step by Step

QGIS



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Step 1: Import the Green and NIR Band images

I. Decompress the downloaded file
II. Find the **GREEN** and **NIR** band images
III. Import band images in the QGIS (Drag & Drop or Copy & Paste).

Landsat 4-5 = Green B2 & NIR B4
Landsat 8 = Green B3 & NIR B5
Sentinel 2 = Green B3 & NIR B8

T35TLF_20210729T090559_AOT_10m.jp2
T35TLF_20210729T090559_B02_10m.jp2
T35TLF_20210729T090559_B03_10m.jp2
T35TLF_20210729T090559_B04_10m.jp2
T35TLF_20210729T090559_B08_10m.jp2
T35TLF_20210729T090559_TCI_10m.jp2
T35TLF_20210729T090559_WVP_10m.jp2

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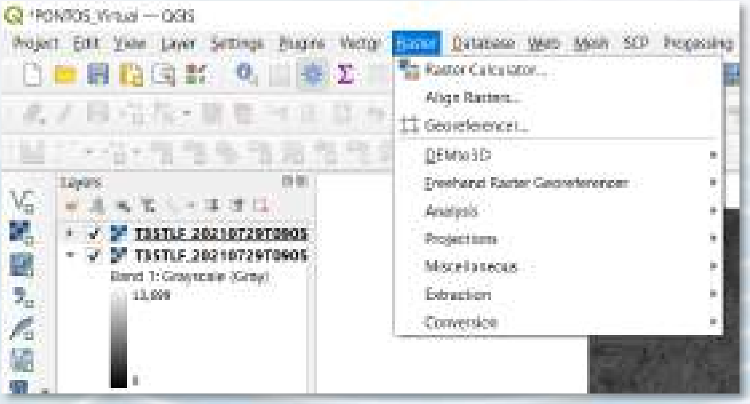
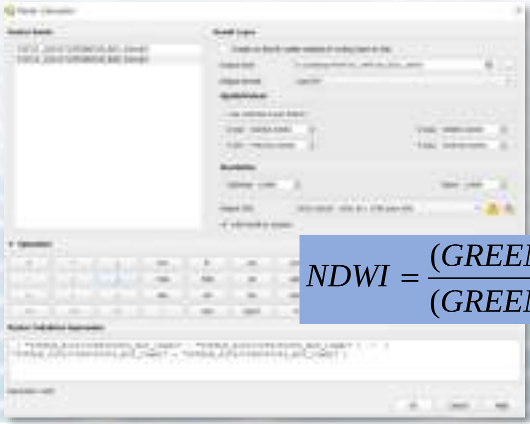
Step 2: NDWI calculation using raster calculator

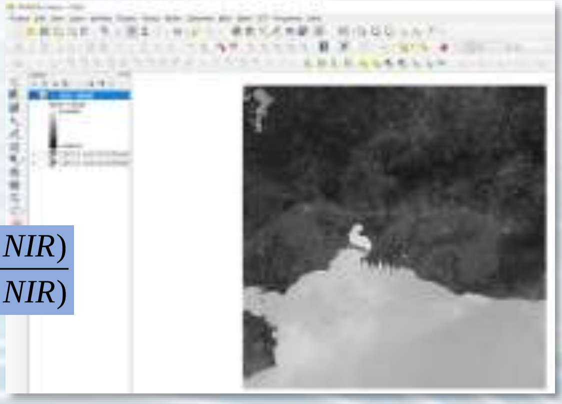
From the top bar select **Raster** → **Raster Calculator**, and the raster calculator window opens

- In the "***output layer***" field select the file to save the new layer (2021_NDWI.tif)
- In the field "***Raster calculator expressions***", import the **NDWI equation** using the bands from the "***raster bands***" field
- Import the brackets and the equation symbols from the "***Operations***" field
- Then press **OK**
- The new NDWI image (2021_NDWI.tif) is created and uploaded in the layer panel





$$NDWI = \frac{(GREEN - NIR)}{(GREEN + NIR)}$$



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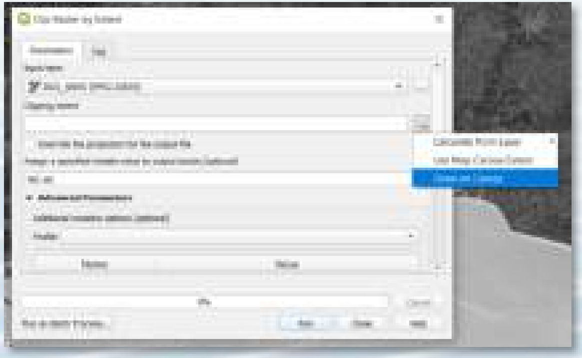
Step 3: Clip NDWI image

From the top bar select **Raster** → **Extraction** → **Clip Raster by Extent…**, and the **Clip Raster by Extent** window opens

- In the “***input layer***” field select the NDWI image
- In the “***Clipping extent***” field, select the button on the right and select the ***“Draw on canvas”***
- Select the area of interest on the QGIS map by drawing a rectangular
- In the field ***“Clipped (extent)”*** define the name of the new image (2021_NDWI_clip.tif) and save it to the working directory file
- Press **RUN** and a new raster file will be generated



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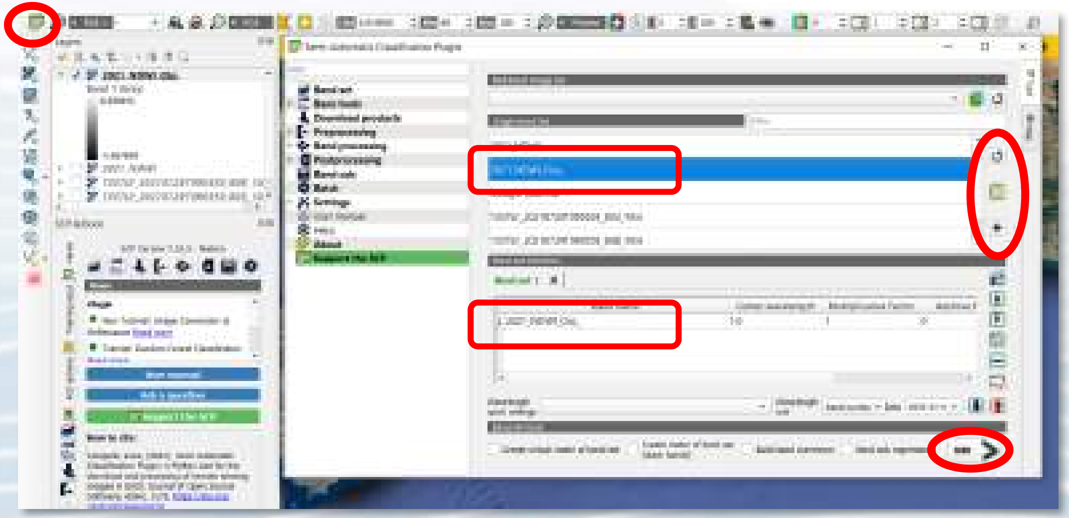
Step 4: SCP Working file definition and training file creation

Open the Semi-Automatic Classification Plug-in window from the button (1), and select the tab “***Band set***”

- In the field “***band list***” press the button refresh, select the NDWI clipped file (2021_NDWI_clip.tif) and then press the + button to import the file in the band set definition field and in the tab “***Band set 1***”
- Press **RUN** and the working file is set

(1)



Step 5: Create Regions of Interest (ROI)

Create a training file to save the ROIs

- Select the Training input tab from the SCP Dock. Select the button "***Create SCP training input***", name as train.scp and save in the working directory file

Train the Algorithm for <u>Sea cover</u>

- In the ROI & Signature list and in the field MC Name set ***Water***, in the field C Name set ***Sea***
- From the SCP toolbar select the *"**Activate ROI pointer**"*
- Select Sea pixels on the 2021_NDWI_clip layer
- Press the *"**Save Temporary ROI**"* Button to import the Sea ROI into the ROIs list
- Import more than 10 Sea ROIs into the ROI Signature list with the same procedure

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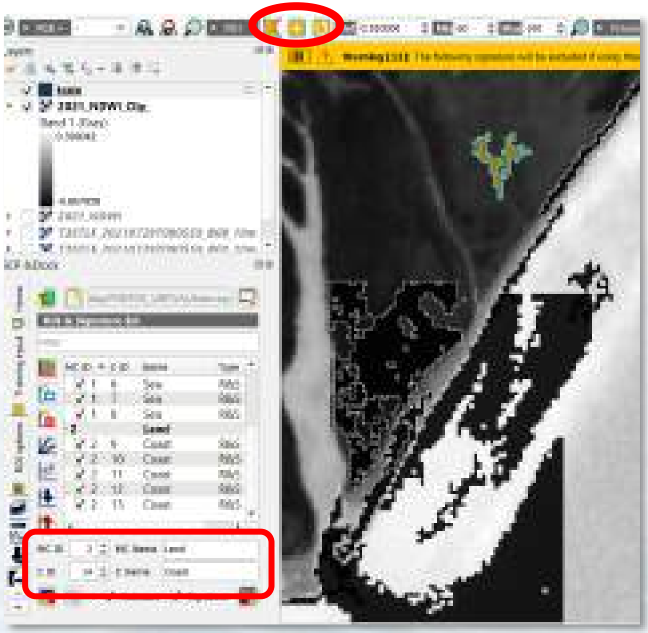
Step 5: Create Regions of Interest (ROI)

Train the Algorithm for <u>Coast cover</u>

- In the ***ROI & Signature*** list and in the field ***MC Name*** set ***Land***, in the field ***C Name*** set ***Coast***
- Change the MC ID to 2
- From the SCP toolbar select the *"**Activate ROI pointer**" or "Create a ROI polygon"*
- Select Land pixels on the 2021_NDWI_clip layer
- Press the button *"**Save Temporary ROI**"* Button to import the Land ROI into the ROIs list
- Import more than 10 Land ROIs into the ROI Signature list with the same procedure



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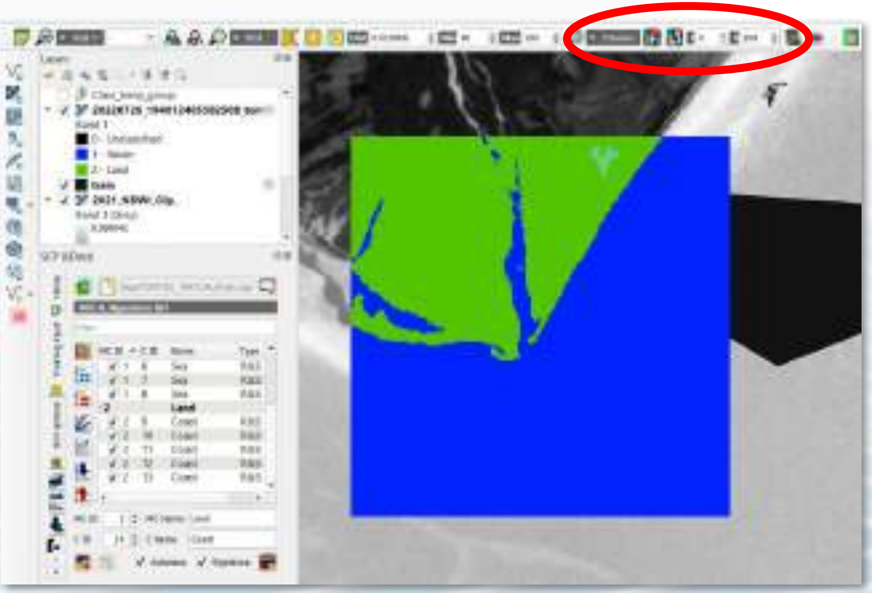
Step 6: Satellite image Classification Preview

Classification Preview

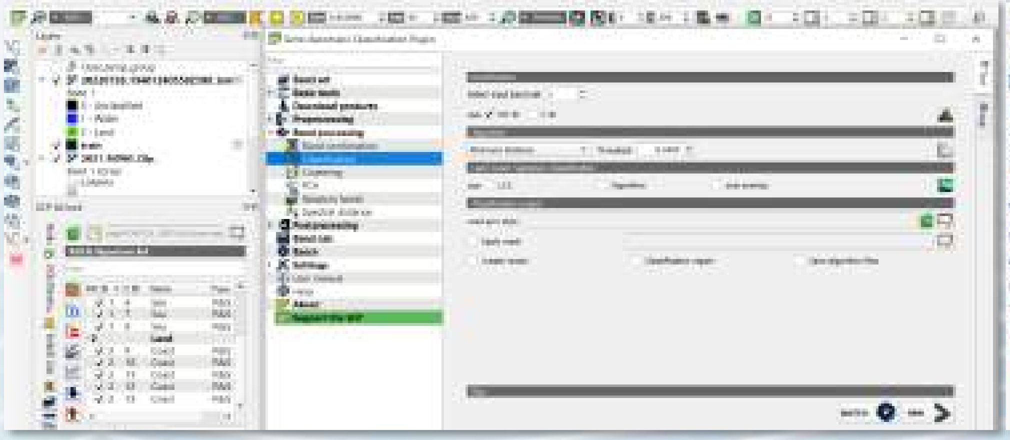
- Select the button *“**Activate Classification preview Pointer**”* to activate the classification preview
- Select the (T) to set the Preview transparency and (S) to Set the Preview size (in pixel unit)

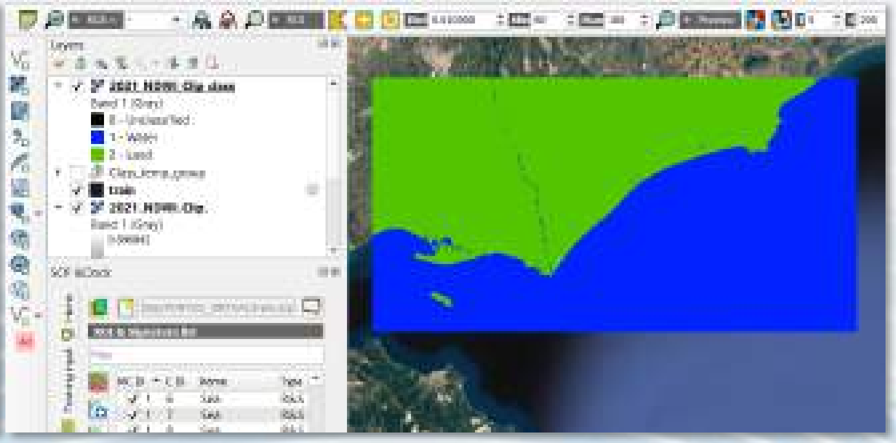


Step 7: Satellite image Classification

Open the Semi Automatic Classification Plug-in window and **s**elect from the Band Processing the tab Classification

- in the field Classification Check the box MC ID
- In the Algorithm field select the Minimum distance classification method
- Press **RUN** and save the classified raster file (*2021_NDWI_Clip_class.tif*) in the working directory
- A new classified raster file is created

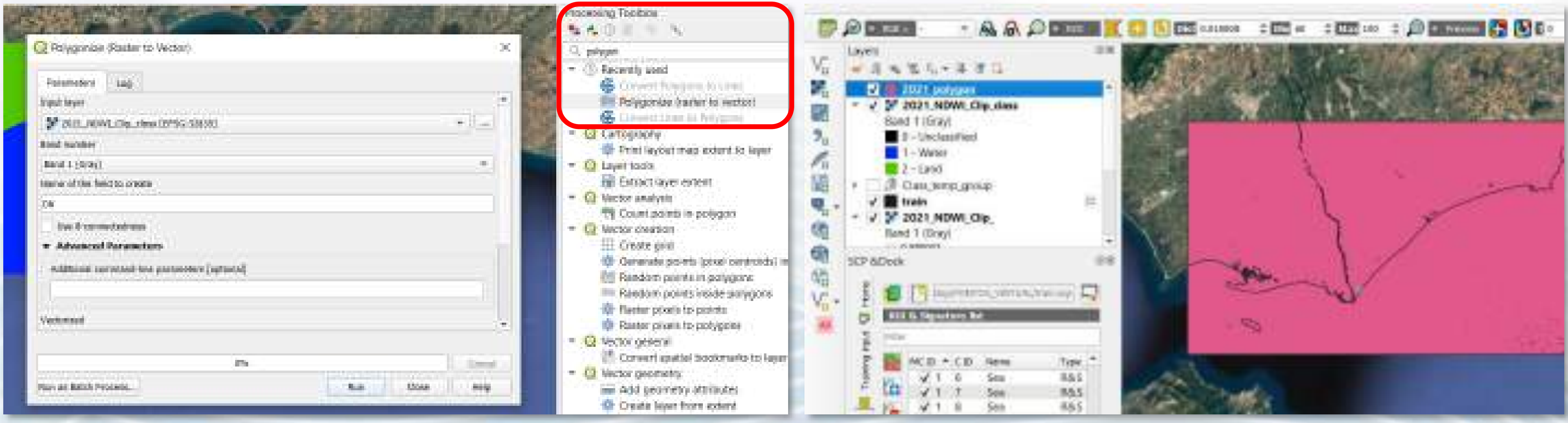




Step 8: Convert the Classified Raster file to Vector

Search on Processing Toolbox the ***Polygonize (Raster to Vector)*** tool

- In the field ***Input layer*** select the classified raster file
- In the field ***Vectorized*** define the name of the new file and the folder to save (*2021_polygon.shp*)
- Select **Run** and a new vector file will be generated



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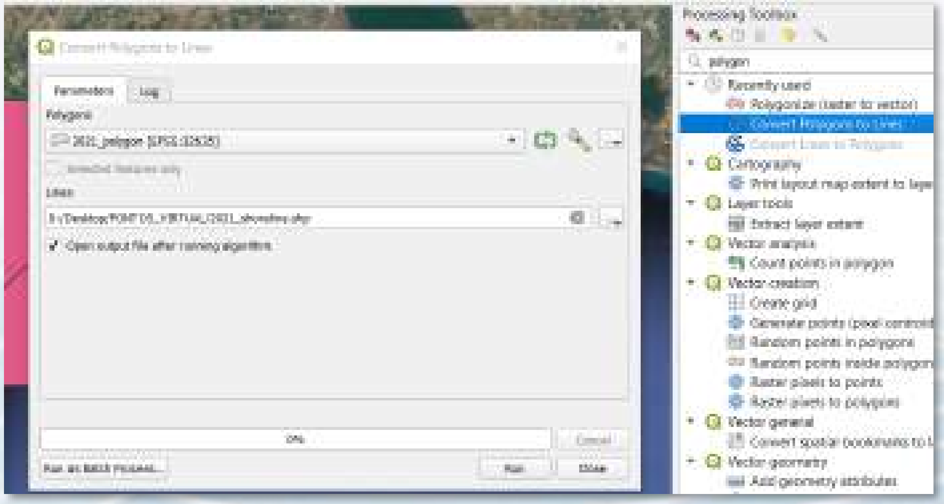
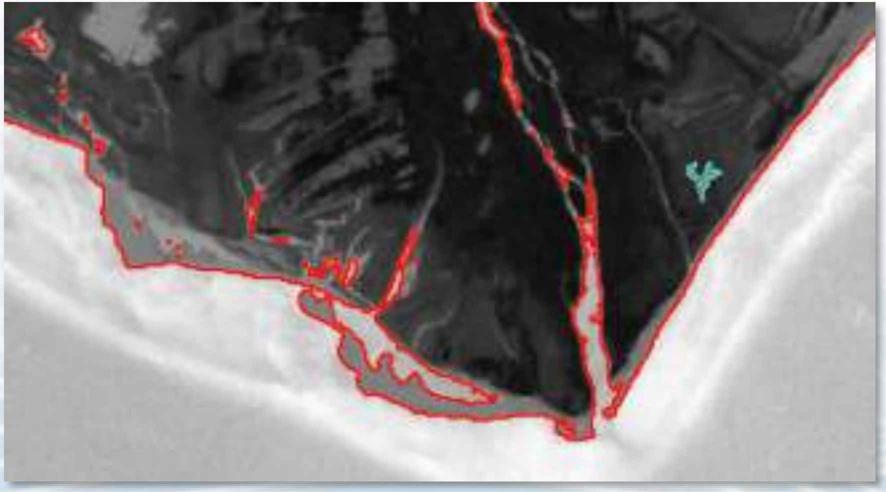
Step 9: Convert the Polygons to Lines

Search on Processing Toolbox the ***Convert Polygons to Lines*** tool

- In the field ***Polygons*** select the Polygon file (*2021_Polygon*)
- In the field ***Lines*** define the name of the new file and the folder to save (*2021_Shoreline.shp*)
- Select **Run** and a new vector file will be generated





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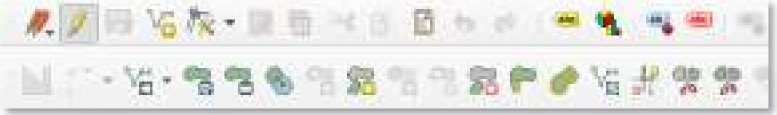
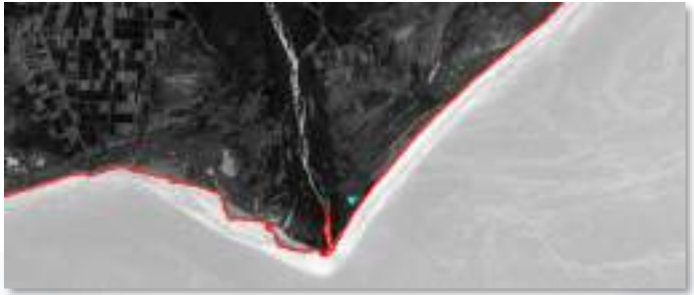
Step 10: Edit and smooth shoreline

- Select the shoreline file (2021_shoreline.shp)
- Select ***Toggle editing*** tool and edit the shoreline using the tools:
  - Split Parts
  - Split Features
  - Vertex Tool etc



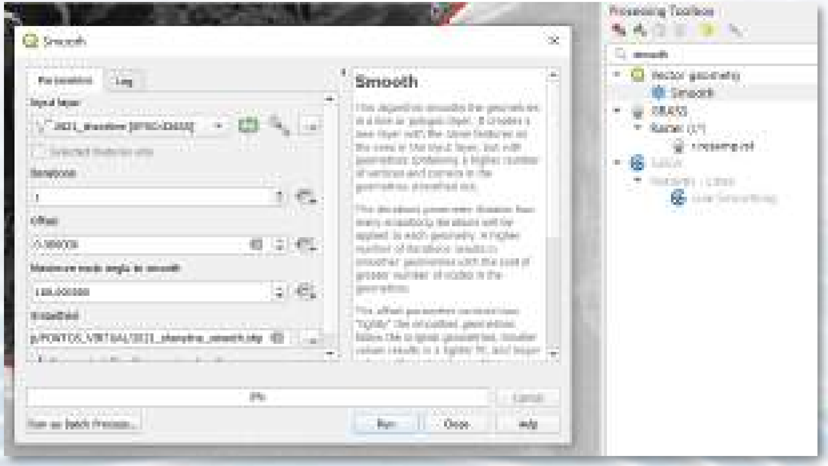


- Delete the outer lines and keep only the main shoreline
- For stop editing press Toggle editing tool

Smooth Shoreline

Select ***Smooth*** tool from the Processing Toolbox

- Input layer → 2021_shoreline
- Offset → 0.5
- Smoothed → save as 2021_shoreline_smooth.shp



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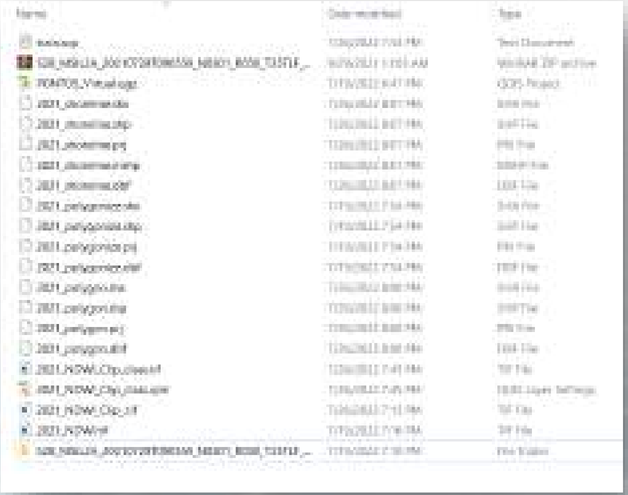
Step 11: Extract every historical shoreline

- Apply the same steps for every historical satellite images to extract the historical shorelines



List of generated files

Historical shorelines

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Practical Session 3
Evaluation of the Shoreline Evolution

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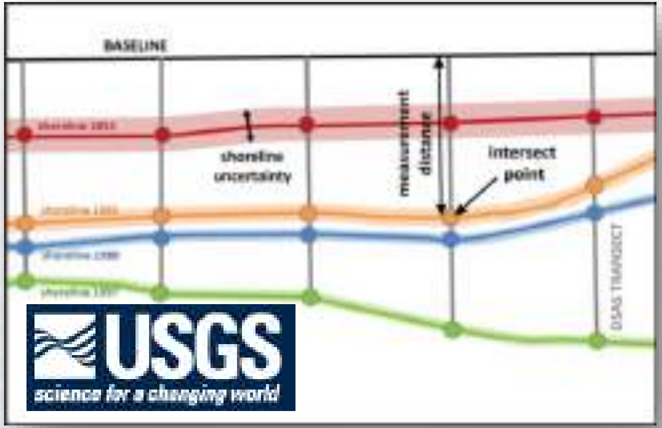
Introduction in DSAS tool

DSAS DIGITAL SHORELINE ANALYSIS SYSTEM



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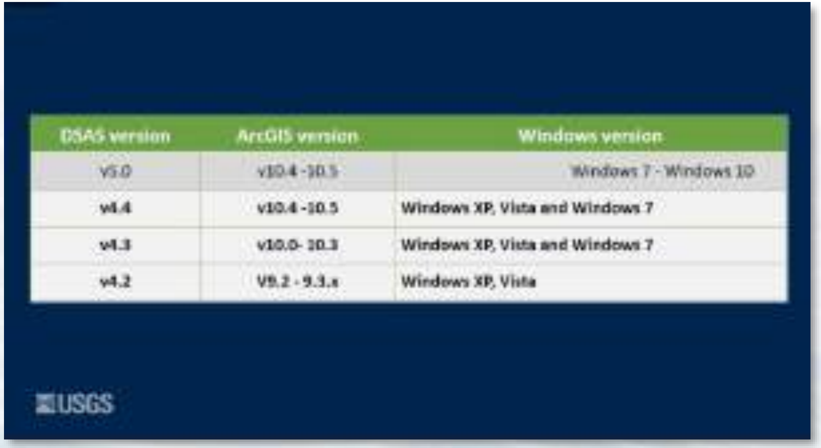
Introduction in DSAS tool



DSAS version	ArcGIS version	Windows version
V5.0	v10.4 - 10.5	Windows 7 - Windows 10
v4.4	v10.4 - 10.5	Windows XP, Vista and Windows 7
v4.3	v10.0 - 10.3	Windows XP, Vista and Windows 7
v4.2	V9.2 - 9.3.x	Windows XP, Vista

Project funded by EUROPEAN UNION

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Introduction in DSAS Statistics

NSM	Net Shoreline Movement
SCE	Shoreline Change Envelope
EPR	End Point Rate
LRR	Linear Regression Rate
LSE	Standard Error of Linear Regression
LCI	Confidence Interval of Linear Regression
LR2	R-squared of Linear Regression
WLR	Weighted Linear Regression Rate
WSE	Standard Error of Weighted Linear Regression
WCI	Confidence of Weighted Linear Regression
WR2	R-squared of Linear Regression
LMS	Least Median of Squares

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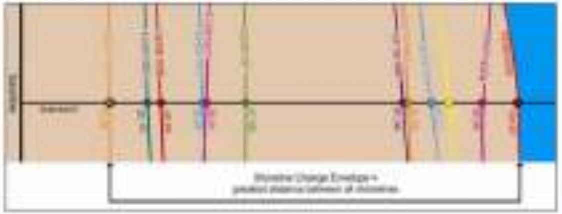
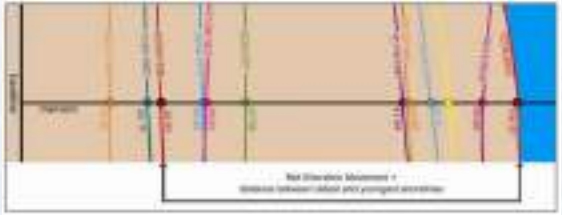
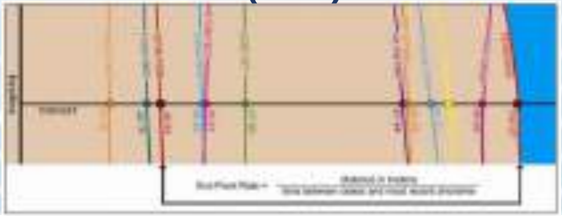
Shoreline Change Envelope (SCE)



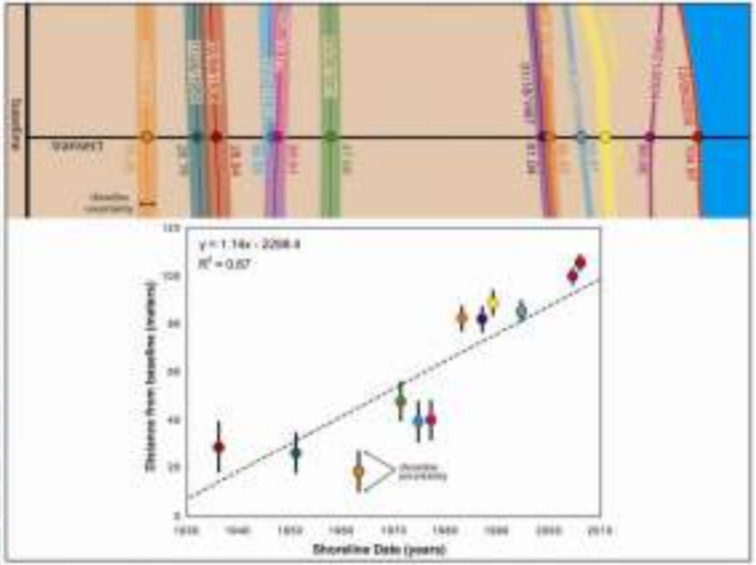
Net Shoreline Movement (NSM)



End Point Rate (EPR)



Weighted Linear Regression (WLR)



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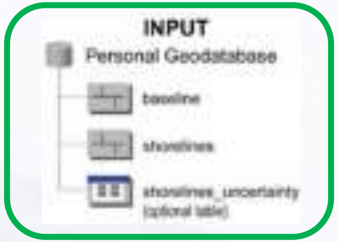
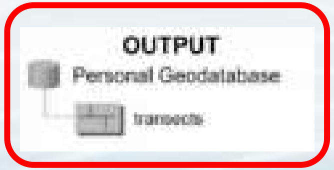
Methodology in steps - ArcMap & DSAS





Step 1st: Create a Personal Geodatadase (.mdb) and new Feature Classes

Step 2nd: Import the historical shorelines In ArcMap

Step 3rd: Pre-process of the shorelines and Edit the Shorelines Feature class

Step 4th: Pre-process of the baseline and import in baseline Feature Class

Step 5th: Define the technical characteristics of the vertical Transects in DSAS toolbox

Step 6th: Edit Transects

Step 7th: Calculate the Statistical Parameters

Step 8th: Visualization of the results

Step 9th: Open the Attribute tables from the generated files

Step 10th: Export the parameters in .txt file

Step 11th: Indicative Results – East Nestos Estuaries

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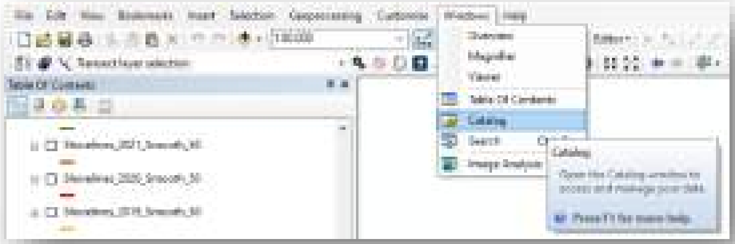
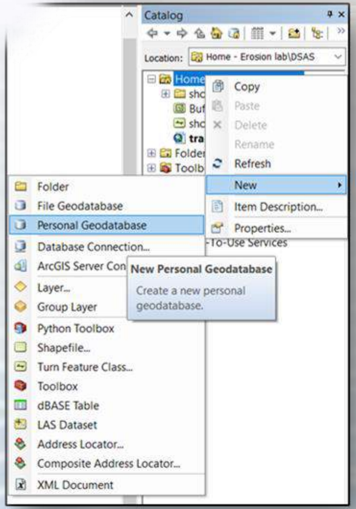
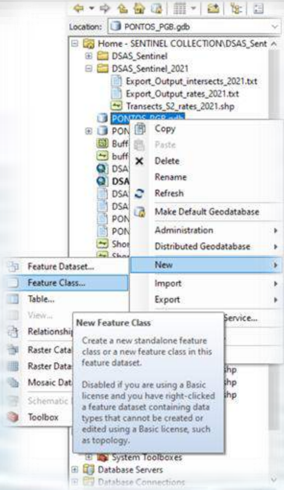
Step 1: Create a new Personal Geodatabase and two Feature Classes



- Open **ArcMap 10.9**
- Define the **Working directory** saving the file in the **DSAS_Transects** folder:

  File → **Save as** → File name: **DSAS_Transects.mxd**





Create a new Personal Geodatabase

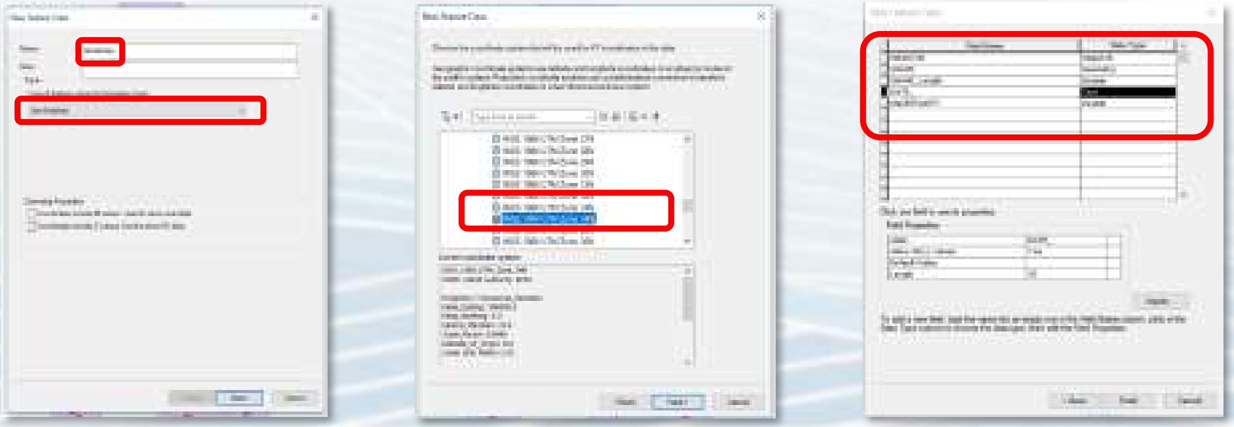
- **Catalog** → **New Personal Geodatabase**
- **Rename** → **PONTOS_ PGB.mdb**

Create 2 Feature Classes (shoreline & baseline)

- **PONTOS_PGB.mdb** (Right click) → **New** → **Feature class…**

Step 1a: Create a new shoreline Feature Classes

- In the Tab **Catalog** → **PONTOS_PGB.mdb** (right click) → **New** → **Feature class…**
- In the field ***Name*** type shorelines
- Select Line Features in the field "**Type of features stored…**", press next
- Select the coordinate system of your study site, and press next
- Fill the table with the Field name and the Data Type as given in the figure
  - In the field **DATES_** in the **"Field Properties"** in **Length** type **10**



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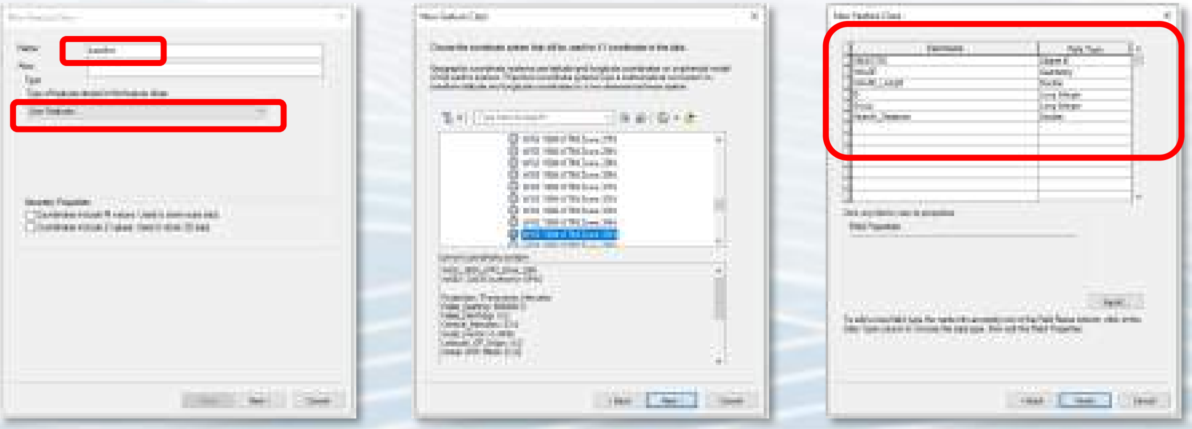
Step 1b: Create a new baseline Feature Classes

- In the Tab **Catalog** → **PONTOS_PGB.mdb** (right click) → **New** → **Feature class…**
- In the field ***Name*** type baseline
- Select Line Features in the field "Type of features stored…", press next
- Select the coordinate system of your study site, and press next
- Fill the table with the Field name and the Data Type as given in the figure



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Step 2: Import the historical shorelines In ArcMap

i. Create a new Folder (e.g. **DSAS_Transects**)

ii. Copy the **shoreline shapefiles** to the **DSAS_Transects** folder

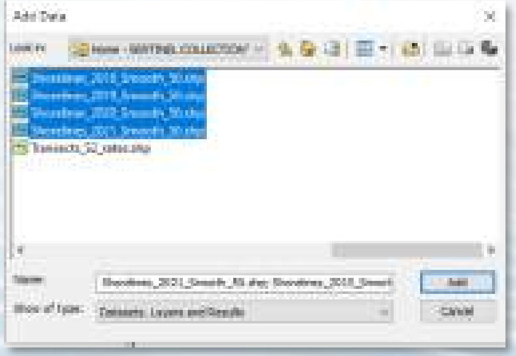
iii. Right click on the layers panel

iv. Add Data…

v. Select all the shoreline files

vi. Select **Add**

vii. The shorelines are imported in the ArcMap



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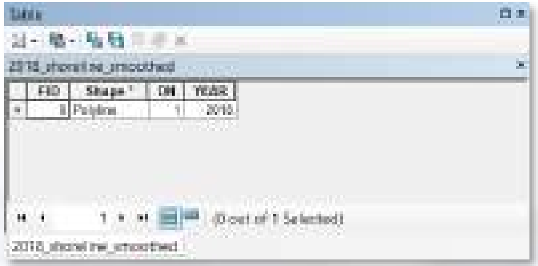
Step 3a: Pre-process of the shorelines and Edit the Shorelines Feature class

Create new field in the attribute table of the historical shoreline files

- **Right click** on the **Shoreline Layer**
- **Open attribute table → Table options → Add Field**
  - Name: **YEAR**
  - Type: **Short Integer**
  - → **OK**
- **Editor → Start Editing**
- In the field **YEAR** define the shoreline date e.g. **2018**
  - → **Stop Editing**
- Apply the same process on every historical shoreline file

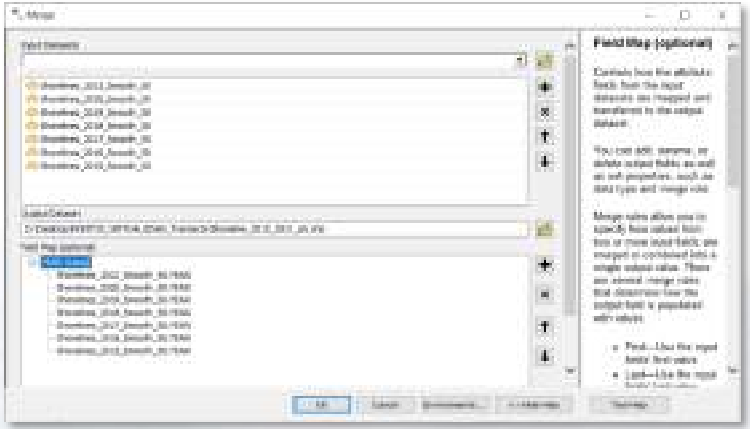


Step 3b: Pre-process of historical shorelines

<u>Create **a new shapefile** Merging the historical shorelines.</u>

Open **Search** tab → **Merge** → **Merge Data Management**

- In the field Input, insert the historical shorelines (**Drag and Drop)**
- In the field output, define the file name and the saved folder
  Save as → Shoreline_2015_2021_sm
- In the Field Map, **Delete** the all fields e.g. **DN (Long), K**eep **only** the field **YEAR,** press **OK**



Open attribute table to check the fields

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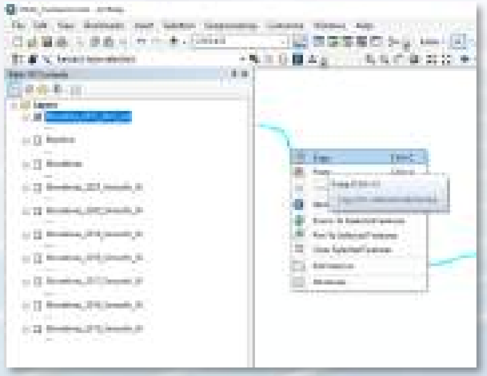
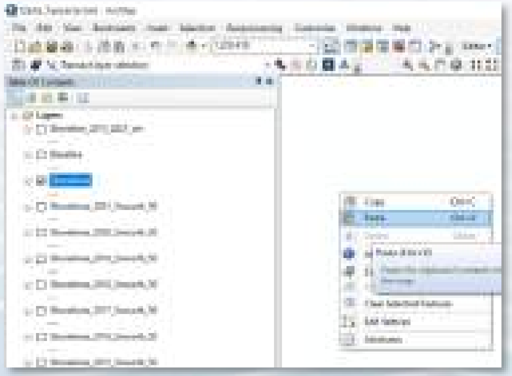
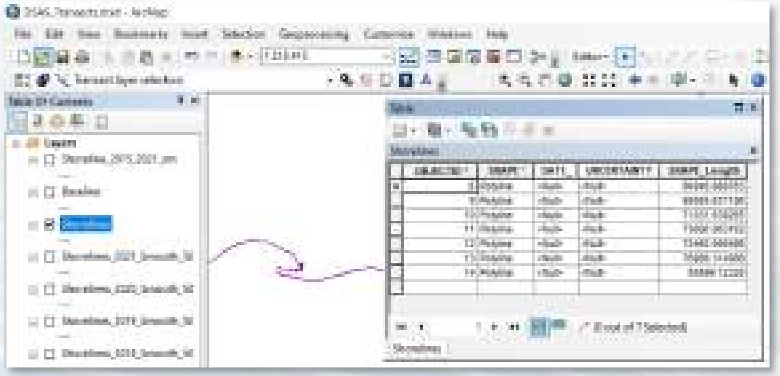
Step 3c: Edit the Shorelines Feature class

- Editor → Start Editing → shorelines → OK
- Copy the shorelines from the layer Shoreline 2015-2020
- Paste to Shorelines layer







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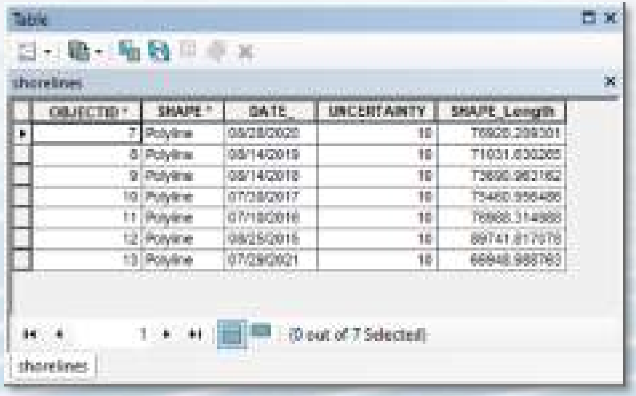
Step 3d: Edit the Shorelines Feature class

- Select **shorelines** layer (right click) → **Open Attribute Table**
- **Editor** → **Start Editing** → **shorelines**

Un the fields **DATE_** και **UNCERTAINTY**

- **DATE_**: the format is related to your PC settings (e.g. **DAY/MONTH/YEAR** or **MONTH/DAY/YEAR**)
- **UNCERTAINTY**: set the uncertainty in meters (e.g. 10 m for SENTINEL historical shorelines)



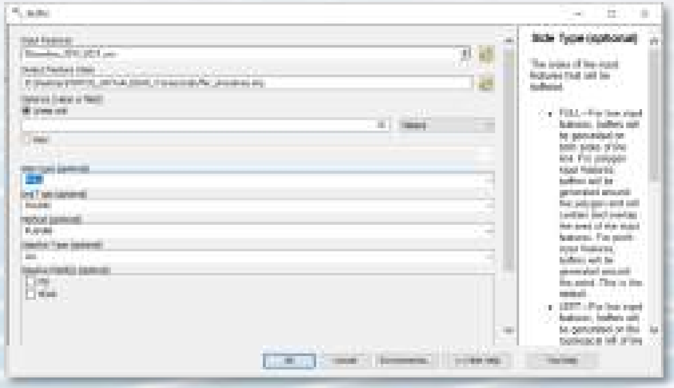
OBJECTID *	SHAPE *	DATE_	UNCERTAINTY	SHAPE_Length
7	Polyline	08/28/2020	10	[illegible]
8	Polyline	08/14/2019	10	[illegible]
9	Polyline	08/14/2018	10	[illegible]
10	Polyline	07/28/2017	10	[illegible]
11	Polyline	07/18/2016	10	[illegible]
12	Polyline	08/25/2015	10	[illegible]
13	Polyline	07/29/2021	10	[illegible]

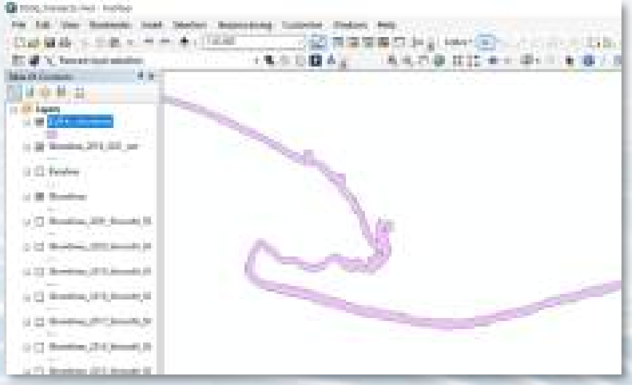
Step 4a: Pre-process of the baseline and import in baseline Feature Class

Create a baseline parallel to the coastlines either creating a buffer line or editing manually a new polyline

<u>Create a buffer:</u>

- In the tab **Search** → type **Buffer** → select **Buffer Analysis (Tool)** and the **Buffer** window opens
- In the field ***input feature*** select the Shoreline_2015_2020 file
- In the ***Output Feature Class*** define the name of the buffer file and the saved file\
- In the field ***Distance*** (value or field) → select the buffer width in meters
- In the ***Dissolve Type*** → All
- Press **OK**
- A new buffer file is created





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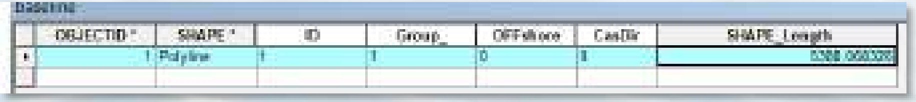
Step 4b: Create a baseline layer

- **Editor** ⟶ **Start Editing** ⟶ **baseline** ⟶ **OK**
- **Create Features** ⟶ select **baseline**
- Select the **Editor** from the toolbar, then select **Create Features**

- In the tab **Create Features** select **baseline**
- From the toolbar **Editor** select the tool **Trace**

- Set the pointer on the **Buffer_shorelines** ⟶ Left click ⟶ slide the pointer on the **Buffer_shorelines**
- Finish the sketch: **left – right** click and from the pop up window **Finish Sketch**
- **Stop Editing**



baseline

OBJECTID *	SHAPE *	ID	Group_	OFFshore	CastDir	SHAPE_Length
1	Polyline	1	1	0	[illegible]	[illegible]

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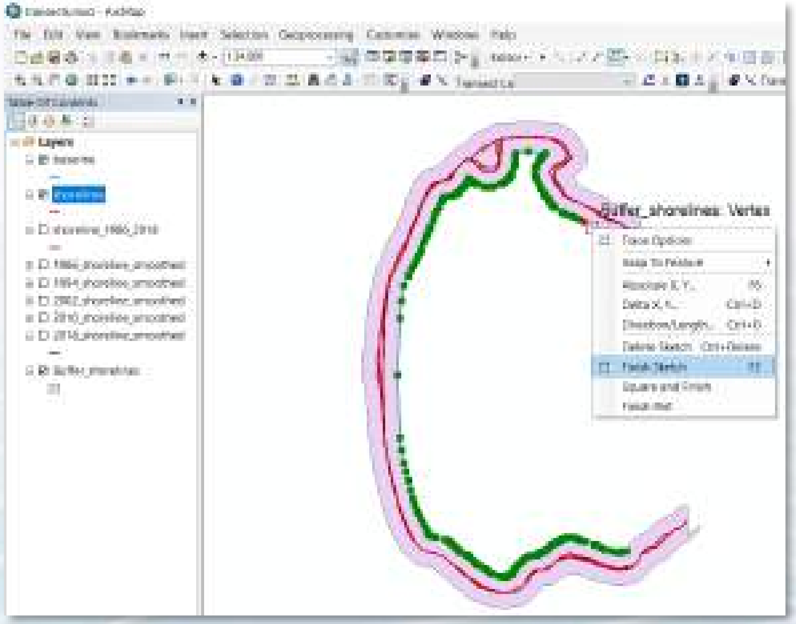
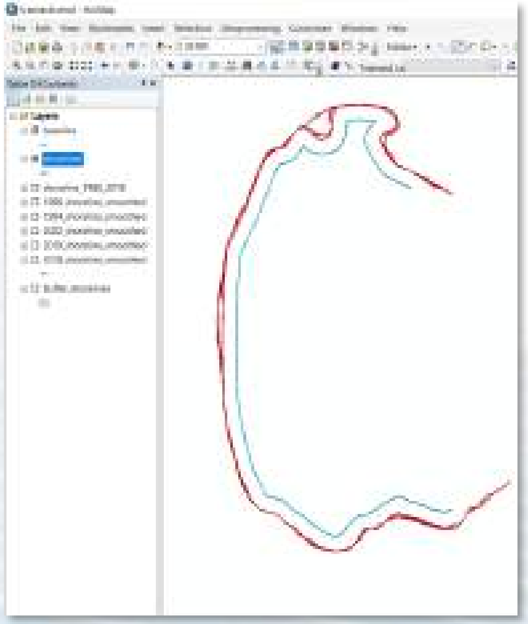
Step 4c: Create a baseline layer





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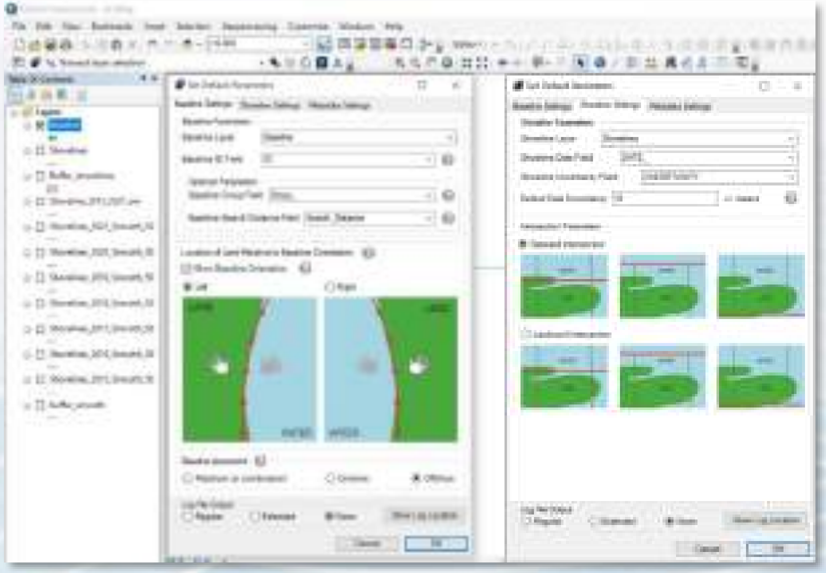
Step 5a: Define the technical characteristics of the vertical Transects in DSAS toolbox



Select “Set Default Parameters” button from the DSAS toolbar

Select the Baseline Settings tab

- Baseline Layer → baseline
- Baseline ID Field → ID
- In the field Location of Land relative to Baseline Orientation, select Left or right.

Select the Shoreline Settings tab

- Shoreline Layer → shoreline
- Shoreline Data Field → DATE_
- Shoreline Uncertainty Field → UNCERTAINTY
- In the intersection parameter select if the transects are seaward or landward

Press **OK** and the window closes

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Step 5b: Define the technical characteristics of the vertical Transects in DSAS toolbox

Select “Cast Transects” button from the DSAS toolbar

<u>In the tab “Cast Transects” in the fields:</u>

- “***Transect Storage Parameter***” select the Geodatabase (PONTOS_PGB.mdb)
- “***Select Existing or Enter New Transect Name***” type a name for the new transects

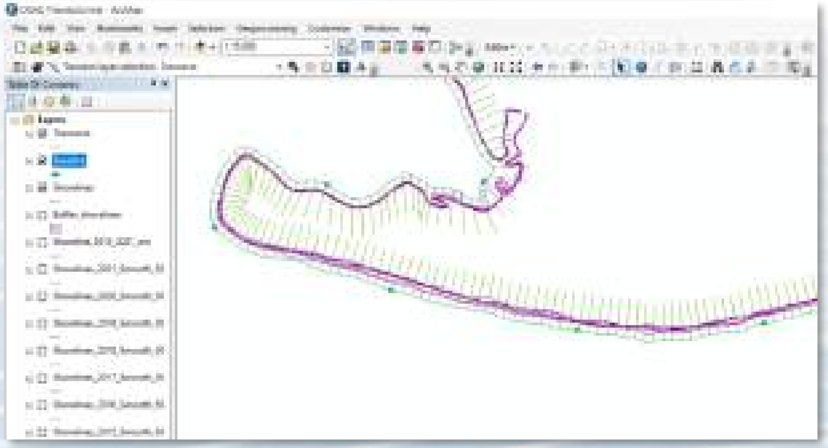
In maximum Search Distance

- In baseline field select the transect length in meters
- In Transect spacing field select the space between new Transects
- In Smoothing Distance select the smoothing value (500)

Press OK and vertical transects to the shoreline are generated, as Shapefile

Step 6: Edit Transects

We can **edit** (Delete, Add new transect or Rotate or move in space) **transects**, using the editing tools, we can:
Select the layer transects → Editor → Start editing → transects
To end the proccess select → Stop Editing



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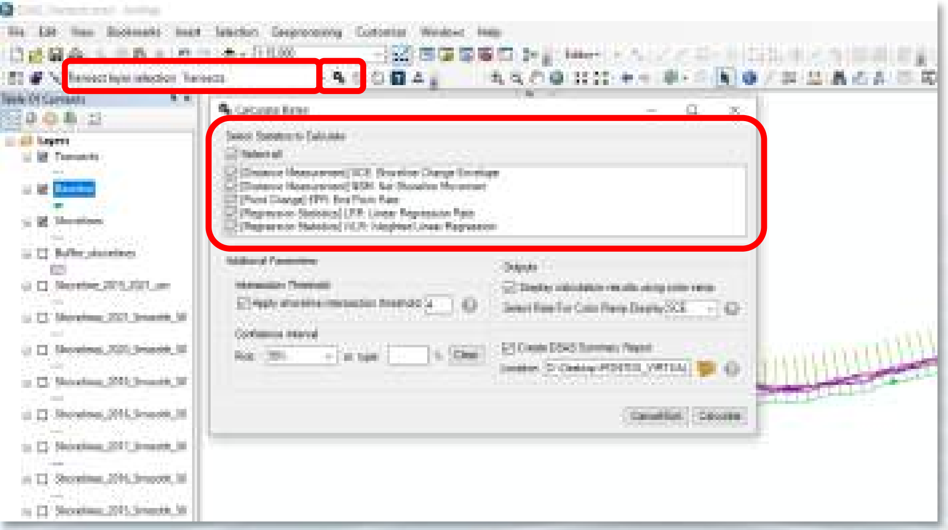
Step 7: Calculate the Statistics from DSAS tool



Select “***Calculate Rates***” button from the DSAS toolbar

- In the field “***Select Statistics to Calculate***” select the parameters you wish to calculate

In the field additional parameters

- Select the to apply a shoreline intersection threshold
- The confidence interval
- The output options
- And the Folder where the DSAS Summary Report is saved

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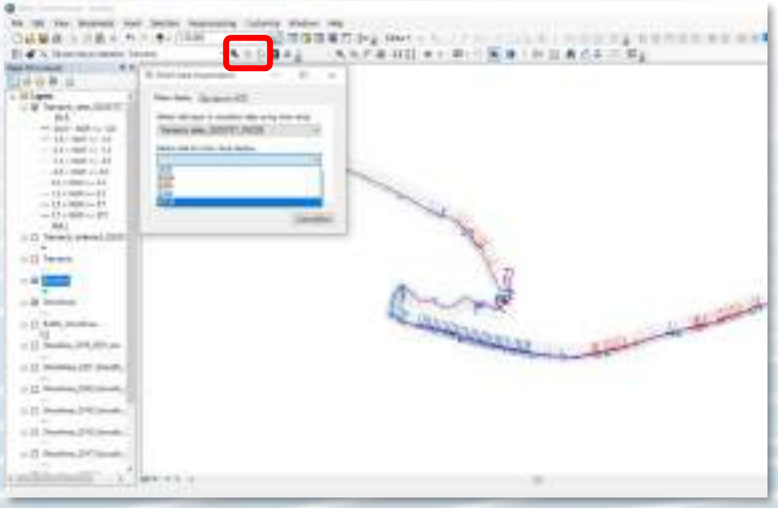
Step 8: Visualization of the DSAS results in ArcGIS

Select “DSAS Data Visualization” button from the DSAS toolbar

- In the field “***Select rate to visualize using color ramp***” ⟶ select the Transects_rates layer
- In the field “***Select rate for color ramp display***” ⟶ select the statistic parameter to visualize
- Select “***Scale to my data***” or “***Apply color ramp***”



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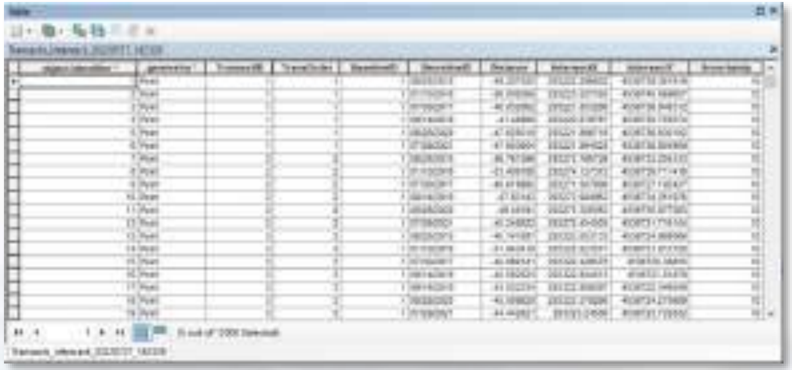
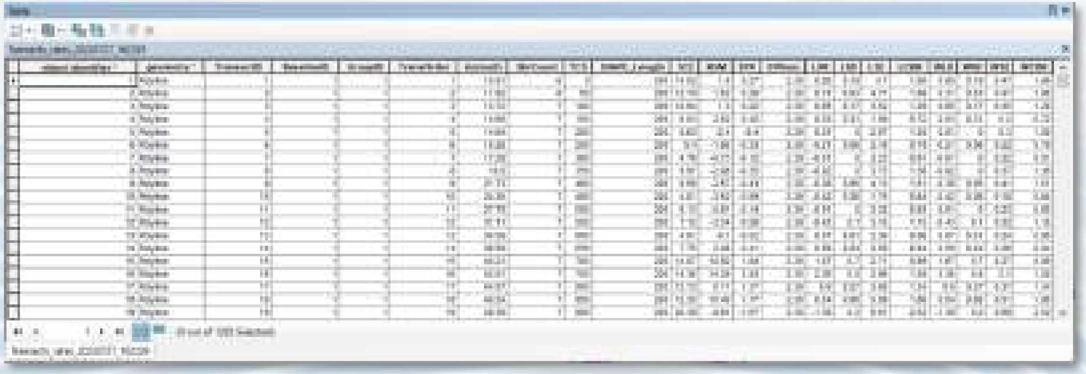
Step 9: Open the Attribute tables from the generated files



- Open the Attribute tables of Transects intersect



- Open the Attribute table of Transect rates

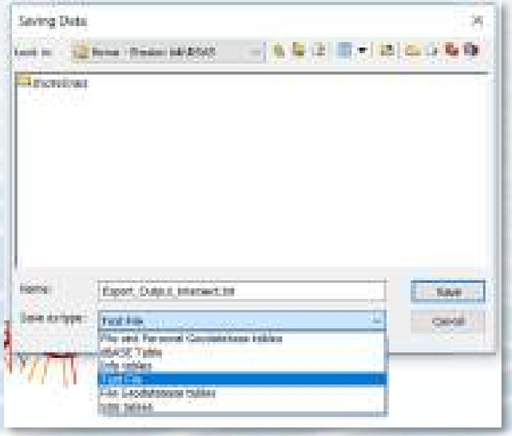
Step 10: Export the parameters in .txt file

The parameters estimated from DSAS are:

- **TRANSECT INTERSECT** (data of the transect position)
- **TRANSECT RATES** (results of the **Statistical Analysis** for each transect)

Save the file as “.txt”:

Table of Contents → List by source → **transects_intersects** (right click) → **Data** → **Export** → **Save**



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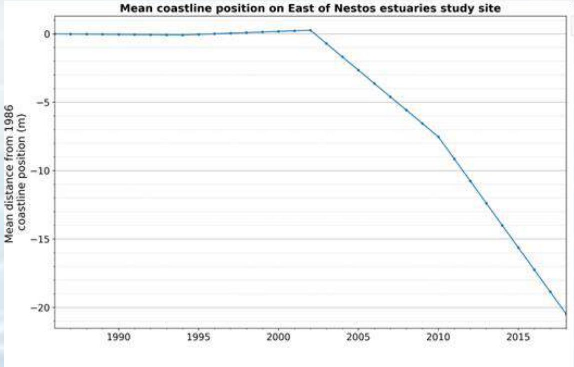
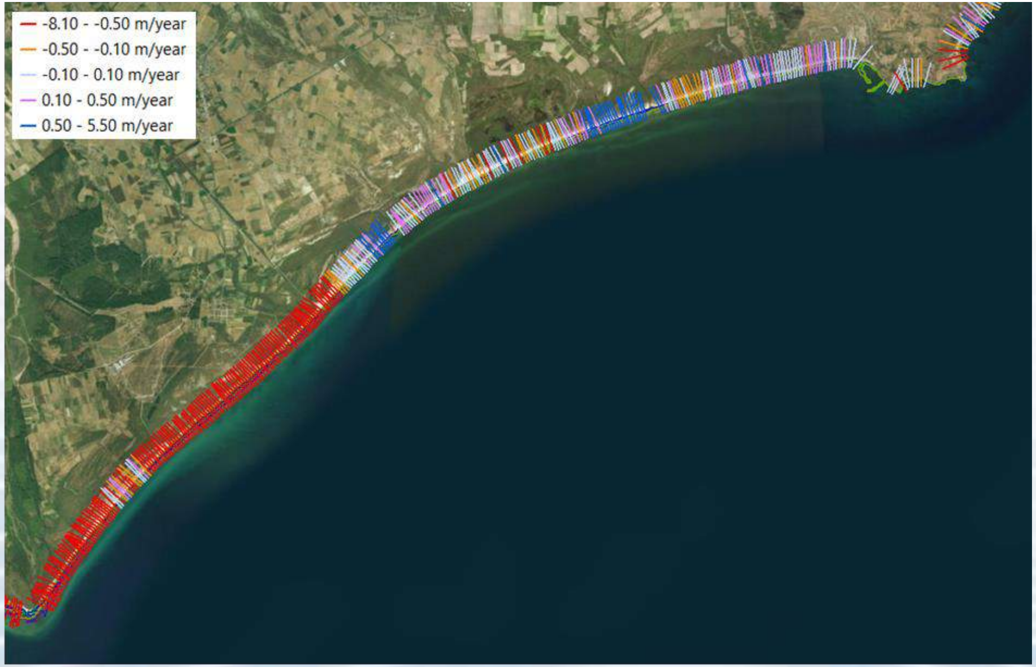
Step 11: Indicative Results – East Nestos Estuaries

	Value	Units
Average rate	-0.70	m/year
max accretic	1.93	m/year
max erosion	-3.78	m/year
Average Erro	0.35	m





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2022

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