





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

VIRTUAL TRAINING MODULES

2022

AUA ACOPIAN CENTER for the ENVIRONMENT



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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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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







MODULE STRUCTURE



Introduction in Coastal Erosion and Remote Sensing



Description of the Methodology Workflow



Results Visualization







Common borders. Common solutions. 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.











Common borders. Common solutions. 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)	







Methodology applied in a coastal erosion assessment















Open source databases for satellite images







Common borders. Common solutions. Open source databases for satellite images



https://earthexplorer.usgs.gov/



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



https://scihub.copernicus.eu/dhus







Common borders. Common solutions. Open source databases for satellite images

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





Number of Bands: 8





Common borders. Common solutions. **Open source products Earth Explorer Copernicus Hub Planet Explorer Planet Explorer** Landsat 5 ETM Sentinel 2A & 2B RapidEye **PlanetScope** •Spatial Res.: 30m •Spatial Res.: 10, 20, •Spatial Res.: 5 m Spatial Res.: 3.6 m 60m $\cdot 1984 - 2013$ •2016 - Still active •2009 - March 2020 •Number of Bands: 7 2015 – Still active Number of Bands: 5 •Number of Bands: 4 •Number of Bands: 13 Number of Sat.: 5 Number of Sat.: more Landsat 8 •Number of Sat.: 2 than 120 optical Spatial Res.: 30m satellites 2013 – Still active







Earth Observation Tools







Common borders. Common solutions. Earth Observation Tools

GIS Software

QCIS

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



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

Plug-ins

Semi-Automatic Classification Plugin version 7

https://plugins.qgis.org/plugins/SemiAutom aticClassificationPlugin/



https://www.usgs.gov/centers/whcmsc/science/d igital-shoreline-analysis-system-dsas?qtscience_center_objects=0#qtscience_center_objects







Common borders. Common solutions. Install QGIS

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









Install Semi Automatic Classification plugin in QGIS



3









Install QuickMapServices plugin in QGIS

- Plugins \rightarrow Manage and Install Plugins... \rightarrow search QuickMapServices \rightarrow install
- Web \rightarrow QuickMapServices \rightarrow Settings \rightarrow More Services \rightarrow Get Contributed pack \rightarrow Save
- Web \rightarrow QuickMapServices \rightarrow select your basemap









Practical Session 1 Earth Explorer and Copernicus Open Access Hub







Earth Explorer







Common borders. Common solutions. 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









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











Step 3: Define the "Date Range" for satellite images search









Step 4: Select your Data Sets

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









Step 5: Additional criteria









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









Step 8: Download image









Copernicus Open Access Hub







Step 1: Open Copernicus Open Access Hub









Step 2: Create an account and Login or sign in









Step 4: Zoom in you Region of Interest









Step 3: Create a polygon to define your ROI









Step 4: Define the date range for satellite image selection









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

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Step 6a: Select and download the satellite image








Step 6b: Preview and download the satellite image









Step 9: Open Sentinel 2 Downloaded file



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 T35TKF_20200729T090601_B02_10m.jp2
 T35TKF_20200729T090601_B03_10m.jp2
 T35TKF_20200729T090601_B04_10m.jp2
 T35TKF_20200729T090601_B08_10m.jp2
 T35TKF_20200729T090601_TCI_10m.jp2
 T35TKF_20200729T090601_WVP_10m.jp2







Practical Session 2 Shoreline Extraction







Shoreline extraction methodology - Step by Step









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).

andsat 4-5 = Green B2 & NIR B4 andsat 8 = Green B3 & NIR B5 entinel 2 = Green B3 & NIR B8
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T35TLF_20210729T090559_B04_10m.jp2
T35TLF_20210729T090559_B08_10m.jp2
T35TLF_20210729T090559_WVP_10m.jp2







- Step 2: NDWI calculation using raster calculator
 - From the top bar select $Raster \rightarrow Raster Calculator$, 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









Step 3: Clip NDWI image

From the top bar select Raster \rightarrow Extraction \rightarrow 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









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 Sea cover

- 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











Step 5: Create Regions of Interest (ROI)

- Train the Algorithm for Coast cover
- 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 select 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

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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
- ※回応な・回転×0回ちゃ。● 4 4 1 M (1・Va・1818 6 13 8 13 8 年 4 4 月 19 19
- 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 \rightarrow 2021_shoreline
- Offset $\rightarrow 0.5$
- Smoothed \rightarrow 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

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List of generated files



Historical shorelines







Practical Session 3 Evaluation of the Shoreline Evolution







Common borders. Common solutions. Introduction in DSAS tool











Common borders. Common solutions. Introduction in DSAS tool



DSAS version	ArcGIS version	Windows version
V5.0	v30.4-30.5	Windows 7 - Windows 10
96.6	v10.4 -10.5	Windows XP, Vista and Windows 7
91.3	v10.0- 10.3	Windows XP, Vista and Windows 7
94.2	V9.2 - 9.3.8	Windows XP, Vista

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Common borders. Common solutions. 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







Shoreline Change Envelope (SCE)



Net Shoreline Movement (NSM)



End Point Rate (EPR)



Weighted Linear Regression (WLR)









Methodology in steps - ArcMap & DSAS

INPUT Personal Geodatabase tossine tossine thostines thostines_uccertainty
OUTPUT Personal Geodatabase
OUTPUT Personal Geodatabase

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







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:

 $\textbf{File} \rightarrow \textbf{Save as} \rightarrow \textbf{File name: } \textbf{DSAS} \textbf{Transects.mxd}$

Create a new Personal Geodatabase

- Catalog \rightarrow New Personal Geodatabase
- Rename \rightarrow PONTOS_ PGB.mdb

Create 2 Feature Classes (shoreline & baseline)

PONTOS_PGB.mdb (Right click) → New → Feature class...

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- Step 1a: Create a new shoreline Feature Classes
- In the Tab Catalog \rightarrow PONTOS_PGB.mdb (right click) \rightarrow New \rightarrow 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









Step 1b: Create a new baseline Feature Classes

- In the Tab Catalog \rightarrow PONTOS_PGB.mdb (right click) \rightarrow New \rightarrow 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 \rightarrow Table options \rightarrow Add Field
 - Name: YEAR
 - Type: Short Integer
 - \rightarrow OK
- Editor \rightarrow Start Editing
- In the field YEAR define the shoreline date e.g. 2018
 - \rightarrow Stop Editing
- Apply the same process on every historical shoreline file

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Step 3b: Pre-process of historical shorelines

Create a new shapefile Merging the historical shorelines.

 $\mathsf{Open}\; \textbf{Search}\; tab \to \textbf{Merge} \to \textbf{Merge}\; \textbf{Data}\; \textbf{Management}$

- 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

Not hereits	Field Map (optional)
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Step 3c: Edit the Shorelines Feature class

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









Step 3d: Edit the Shorelines Feature class

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

1	OBJECTID*	SHAPE*	DATE_	UNCERTAINTY	SHAPE Longth
1	7	Polyline	05/28/2020	10	T6920,209301
	8	Polylina.	08/14/2019	10	71031.030205
	9	Polyine	05/14/2018	10	T3690.963162
	10	Polykie	07/38/2017	10	75460.956486
	11	Polyine	diviacióté.	10	76968.314988
	- +2	Polyine	08/25/2015	10	89741,817078
	13	Polyline	07/29/2021	18	66948.988763







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

Create a buffer:

- 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) \rightarrow select the buffer width in meters
- In the **Dissolve Type** \rightarrow All
- Press OK
- A new buffer file is created

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Step 4b: Create a baseline layer

- Editor \rightarrow Start Editing \rightarrow baseline \rightarrow 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
 Editor
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- 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

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Step 4c: Create a baseline layer









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

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Select "Set Default Parameters" button from the DSAS toolbar Select the Baseline Settings tab

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

Select the Shoreline Settings tab

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

Press OK and the window closes







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

- Select "Cast Transects" button from the DSAS toolbar In the tab "Cast Transects" in the fields:
- "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

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Step 6: Edit Transects

We can <u>edit</u> (Delete, Add new transect or Rotate or move in space) transects, using the editing tools, we can: Select the layer transects \rightarrow Editor \rightarrow Start editing \rightarrow transects To end the process select \rightarrow Stop Editing








Step 7: Calculate the Statistics from DSAS tool

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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







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"









Step 9: Open the Attribute tables from the generated files

• Open the Attribute tables of Transects intersect

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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 \rightarrow List by source \rightarrow transects_intersects (right click) \rightarrow Data \rightarrow Export \rightarrow Save

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Step 11: Indicative Results – East Nestos Estuaries

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











Joint Operational Programme Black Sea Basin 2014-2020 Copernicus Assisted Environmental Monitoring across the Black Sea Basin - PONTOS 2022

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