



Project title: Copernicus assisted environmental monitoring across the Black Sea Basin

Project number: BSB 889

Project Acronym: PONTOS

Type: Research and innovation actions

Work program topics addressed: ENI CBC Black Sea Basin Joint Operational Programme 2014 - 2020

DELIVERABLE No: D.T1.1.4

DATA VISUALIZATION MODULE

Main Authors: Eleftherios Katsikis (Centre for Research and Technology Hellas - CERTH), Ioannis Manakos (CERTH), Nikolaos Kokkos (Democritus University of Thrace - DUTH), Georgios Sylaios (DUTH)

DOCUMENT METADATA

Project number	BSB 889
Project title	Copernicus assisted environmental monitoring across the Black Sea Basin

Deliverable title	Data visualization module
Deliverable number	D.T1.1.4
Deliverable version	V1
Contractual date of delivery	30.04.2022
Actual date of delivery	30.04.2022
Document status	Final
Document version	V4
Activity number	A.T1.4
Partner responsible	Centre for Research and Technology Hellas - CERTH
Author(s)	Eleftherios Katsikis (CERTH), Ioannis Manakos (CERTH), Nikolaos Kokkos (DUTH), Georgios Sylaios (DUTH)
Editor(s)	Eleftherios Katsikis (CERTH)
Reviewed by	Ioannis Manakos (CERTH)
JTS Project Officer	

Abstract	The design of the interactive visualization tools that will make up the PONTOS platform's front end is covered in this deliverable. The design methodology is initially presented and then the platform functionalities.
Keywords	Datacube, Web Application, WebGIS



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ABBREVIATIONS AND ACRONYMS

ARD	Analysis Ready Data
CMEMS	Copernicus Marine Service
CSS	Cascading Style Sheets
EMODnet	European Marine Observation and Data Network
EODESM	Earth Observation Data for Ecosystem Monitoring
GIS	Geographic Information Science
NDVI	Normalized Difference Vegetation Index
NDWI	Normalized Difference Water Index
NetCDF	Network Common Data Form
OGC	Open Geospatial Consortium
TSM	Total Suspended Matter

1. INTRODUCTION

The objective of this document is to provide a report about the interface of the PONTOS platform towards the user, including an overview of the platform functionalities. The document outlines the technologies, and integration points of the services that make up the framework for visualizing and monitoring the PONTOS platform. The present deliverable serves as a companion text to the software platform that has been produced and is already released.

This document is structured into 3 major chapters according to the components of the platform:

- Chapter 2 presents the PONTOS Data Cube.
- Chapter 3 presents the PONTOS Web Application.
- Chapter 4 presents the PONTOS WebGIS.

2. DATACUBE

Common borders. Common solutions.



PONTOS Data Cube enables end-users with the ability of easy exploration, management, analysis and visualisation of medium resolution (10 - 30m/pixel) data from satellite missions for each PONTOS pilot area (Figure 1).



It offers:

- Ease of use and access to satellite-based data;
- Multiple dataset interoperability and spatial consistency;
- Use of Analysis Ready Data (ARD) Products;
- A Shift in Paradigm from Scenes to Pixels

PONTOS Data Cube contains Landsat 5, 7 and 8 ARD in a spatial resolution of 30m from 1984 to present and Sentinel-2 ARD in a spatial resolution of 10 m from 2015 to present. For more information about the backend infrastructure please refer to DT1.1.1.

2.1 DATA CUBE MANAGER MENU ITEM

Submenu item 'Data Cube Visualization' visualizes the areas, for which ingested data exist in the database using an OpenStreetMap and the Leaflet.js package (Figure 2).



Figure 2: PONTOS Data Cube Visualization

Submenu 'Dataset Types' presents information about the satellites and sensors of origin for the data per area ingested in the database (Figure 3).

Dataset Types

ID	Name	Resolution	Frequency	Product Type	Acquisition	Area	Area Type	Area Code
1	SPOT 4 - VEGETATION INDEX	270m	10	VI	2005-2015	Black Sea	Land	1
2	SPOT 4 - VEGETATION INDEX	270m	10	VI	2005-2015	Black Sea	Land	2
3	SPOT 4 - VEGETATION INDEX	270m	10	VI	2005-2015	Black Sea	Land	3
4	SPOT 4 - VEGETATION INDEX	270m	10	VI	2005-2015	Black Sea	Land	4
5	SPOT 4 - VEGETATION INDEX	270m	10	VI	2005-2015	Black Sea	Land	5
6	SPOT 4 - VEGETATION INDEX	270m	10	VI	2005-2015	Black Sea	Land	6
7	SPOT 4 - VEGETATION INDEX	270m	10	VI	2005-2015	Black Sea	Land	7
8	SPOT 4 - VEGETATION INDEX	270m	10	VI	2005-2015	Black Sea	Land	8
9	SPOT 4 - VEGETATION INDEX	270m	10	VI	2005-2015	Black Sea	Land	9
10	SPOT 4 - VEGETATION INDEX	270m	10	VI	2005-2015	Black Sea	Land	10

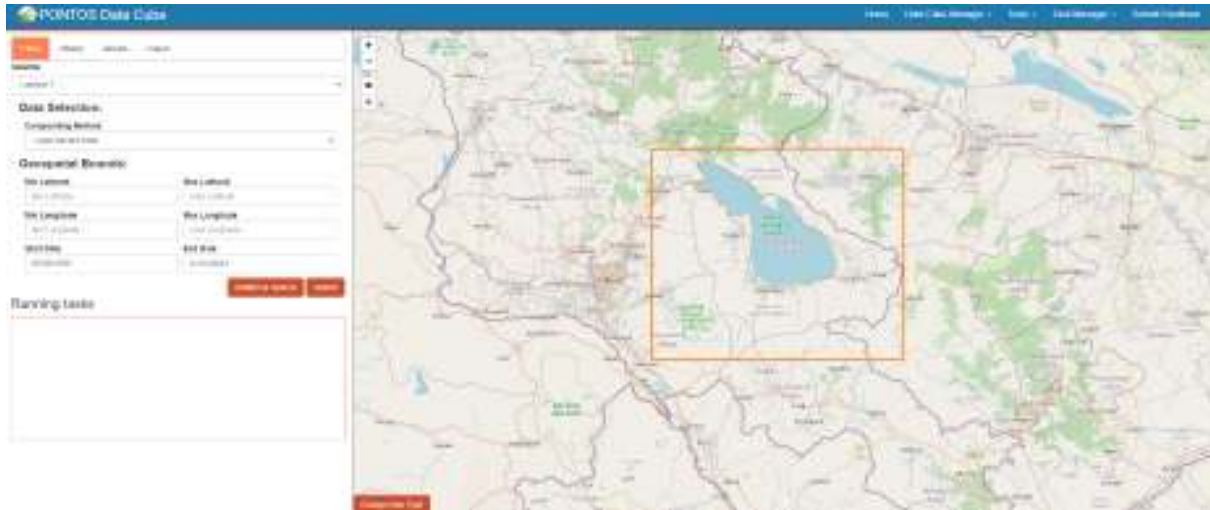


Figure 5: PONTOS Data Cube Tools webpage (on the example of the Armenian pilot area)

The available submenu tools are:

- Land (Urbanization, Spectral Anomaly, Fractional Cover, Spectral Indices)
- Water (Water Detection, Water Quality TSM, Coastal Change)
- General (Custom Mosaic, Cloud Coverage)

When the user fills in the form with the required input and submits a task, a progress bar starts loading. When the task is completed, the output appears on the map with the option to visualize the legend on the right side of the screen (Figure 6).

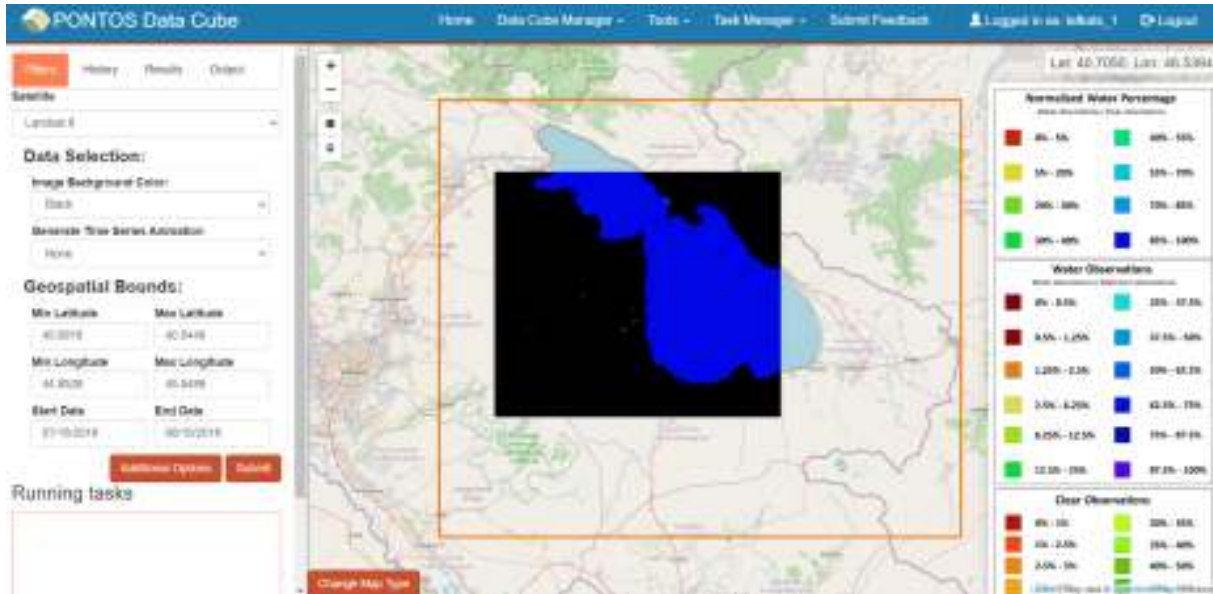


Figure 6: PONTOS Data Cube Water Detection tool (on the example of the Armenian pilot area)

2.3. TASK MANAGER MENU ITEM

The Task Manager option of the menu bar includes the outputs of the user's completed tasks (Figure 7). The outputs include the:

- Task Details
- Task Metadata
- Task Parameters
- Task outputs
- Scene Metadata
- Visualization of the output images

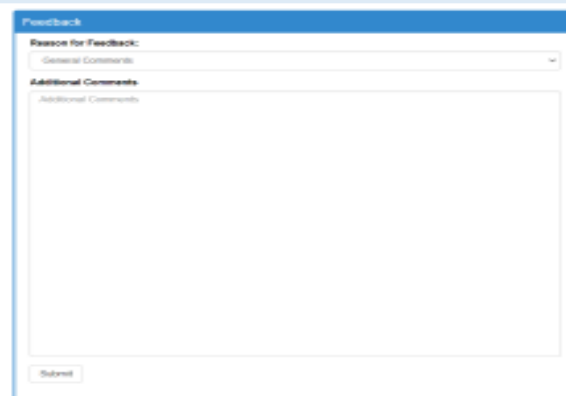


Figure 7: PONTOS Data Cube Task Manager (on the example of the Armenian pilot area)

2.4. SUBMIT FEEDBACK MENU ITEM

The Submit Feedback option (Figure 8) of the menu bar provides the ability to the users to send feedback to the PONTOS Data Cube's developers about any issues that arose. Users may select one of the three reasons for feedback:

- Bug report
- Feature request
- Problems with account





Then users may fill the form with additional comments.
Figure 8: PONTOS Data Cube Feedback Form

3. WEB APPLICATION

3.1 HOME MENU ITEM

Through the PONTOS Web Application user interface users may make useful visualizations and export outputs following requested processes on space- and air-borne images or in-situ data (Figure 9). Moreover, data uploads and their analyses by the users are enabled. In the ‘home’ entry page the application and its goal is presented, including instructions of use.



Figure 9: PONTOS Web Application Home Page

Further menu items are offered and a login-subscribe option reassures the user for a non-public session. Latter requires only the user’s name and password to the platform to login and obtain a token to sign all other requests and identify the user. Consent for GDPR purposes is asked.

3.2 DATASET VIEWER MENU ITEM

The menu item ‘Dataset Viewer’ informs the users about the dates with available satellite data in the Web Application’s database. The Web Application’s database includes all the

available Level-2 data from the satellites Landsat 5, Landsat 8 and Sentinel-2 for the period 1984 to 2021, which are cloud and ice free in order to avoid noisy outputs by the application of the ‘Tools’. The available data are already clipped in the extent of the PONTOS pilots (Armenia - Sevan Lake and Sevan Lake Basin, Georgia - Kolkheti Lowlands and Black Sea coastline, Greece - Nestos River and River Delta, Ukraine - Dniester River Delta area and adjacent estuary). The users can view the available data in a list of four columns (one per pilot area), which is ordered by the date (from 2021 to 1984) with a yyyy-mm-dd format (y for year, m for month and d for day) (Figure 10).



AM - Sevan Lake & Sevan Lake Basin	GE - Rioni River Delta & Kolkheti National Park	GR - Nestos River & River Delta	UA - Dniester River Delta area & adjacent estuary
2021-11-17	2021-06-08	2021-08-29	2021-06-26
2021-09-14	2021-05-14	2021-08-04	2021-05-22
2021-09-13	2021-05-12	2021-05-10	2021-03-26
2021-02-19	2021-05-09	2021-04-30	2021-03-23
2019-11-14	2021-04-14	2021-03-31	2021-03-09
2019-08-28	2021-04-04	2021-03-26	2021-02-26
2016-06-10	2021-03-26	2021-03-01	2021-01-22
2016-04-04	2021-03-06	2021-02-04	2021-01-17
2015-09-09	2021-02-11	2021-01-20	2021-01-02
2015-01-28	2021-02-03	2020-01-15	2020-10-14
2014-11-09	2021-02-01	2020-01-06	2020-08-19
2014-02-18	2021-01-24	2020-11-28	2020-06-14
2013-11-00	2021-01-22	2020-10-22	2020-05-09
2013-03-21	2021-01-07	2020-08-27	2020-08-00

Data within the date range 03-01-1984 and 31-12-2011 are acquired with Landsat 5 TM (Thematic Mapper)
 Data within the date range 01-04-2013 and 31-12-2018 are acquired with Landsat 8 OLI (Operational Land Imager) / TIRS (Thermal Infrared Sensors)
 Data within the date range 01-01-2017 and 29-06-2021 are acquired with Sentinel 2B (Multispectral Imager)

Figure 10: PONTOS Web Application Dataset Viewer

3.3 SERVICES MENU ITEM

The services offered by PONTOS platform provide data presentation and information in a user-friendly manner. Tools activation may rely on existing data or the user may upload own airborne or in situ data to feed into the PONTOS platform algorithms and create own outputs.

By using the already existing data, users have the possibility to perform (Figure 11):

- in-situ data analysis by creating graphs and calculating statistical parameters;



- visualization and calculation of NDVI and NDWI indices using airborne data; and
- calculation of Phenology Metrics, Phenology Changes, Watermask, Hydroperiod (see more information about these services at <http://www.ecopotential-project.eu/images/ecopotential/documents/D6.3.pdf>), and Land Use/ Land Cover maps (EODESM) using satellite data. Specifically, for EODESM results, they rely on the reflectance acquired in an unsupervised manner. Strict thresholds are applied on algebraic combinations of the satellite sensor bands in this case to facilitate the derivation of an output (for demonstration purposes only). Most probably there is a need for a calibration per date (due to the prevailing atmospheric and vegetative conditions on the ground) in order to receive a credible result. This means that the service provision team is not bound for the accuracy of the results per area and date, unless environmental descriptors input to EODESM are fine tuned. In case a more accurate result is required, then please contact us.

By using their own data, the users can upload one's data in the PONTOS Web Application and initiate the analysis of one's preference. Following tools are available (Figure 12):



- In-situ data analysis by creating graphs and calculating statistical parameters;
- Visualization and calculation of NDVI and NDWI indices using airborne data; and
- Extraction of NDVI from NetCDF to GeoTiff.

3.3.1 IN-SITU DATA ANALYSIS

PONTOS Web Application's users can use the in-situ data analysis service either utilizing data collected by the project partners from the pilot areas (Armenia: Sevan Lake and Sevan Lake Basin, Georgia: Kolkheti Lowlands and Black Sea coastline, Greece: Nestos River and Nestos River Delta, Ukraine: Coastline from Odessa city to the Danube River delta as well as Dniester River delta area and adjacent estuary) or uploading their own data in csv or xlsx format. Users are able to analyse in-situ data by visualizing them in time-series charts (line and bar charts). Simultaneously with the generation of time-series charts the descriptive statistics of the analyzed parameter is being calculated and visualized in the screen (Figure 13). This information can be downloaded in csv format.

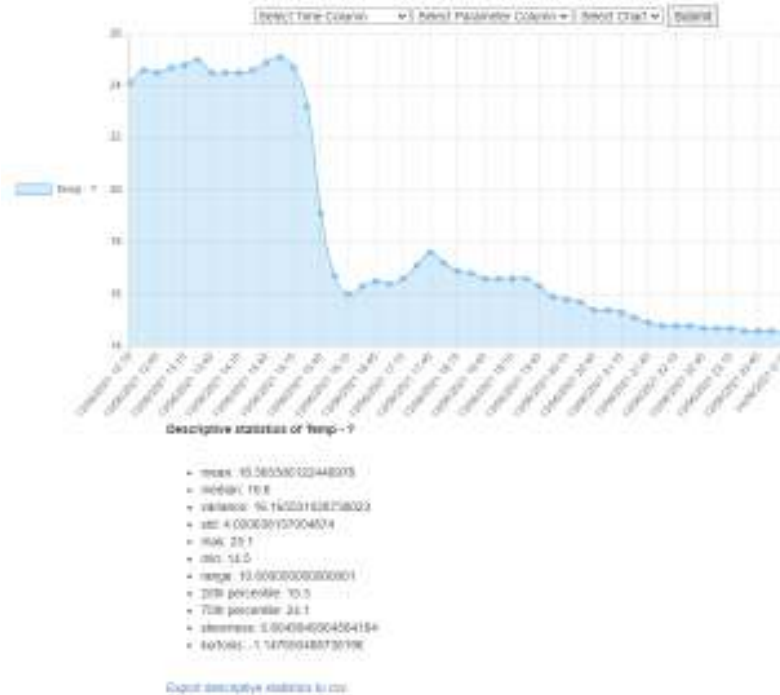


Figure 13: PONTOS Web Application in-situ data analysis (on the example of the Ukraine’s pilot area)

3.3.2 AIRBORNE DATA ANALYSIS

PONTOS Web Application’s users can use the airborne data analysis service either utilizing data collected by the project partners from the pilot areas (Armenia: Sevan Lake and Sevan Lake Basin, Georgia: Kolkheti Lowlands and Black Sea coastline, Greece: Nestos River and Nestos River Delta, Ukraine: Coastline from Odessa city to the Danube River delta as well as Dniester River delta area and adjacent estuary) or uploading the required bands in GeoTIFF format. Users can download the outputs in png or GeoTIFF format. They are able to visualize airborne images (Figure 14). A map from OpenStreetMap is also generated by clicking “show location on the map”, so the users can find the exact location where the images were taken (Figure 15).

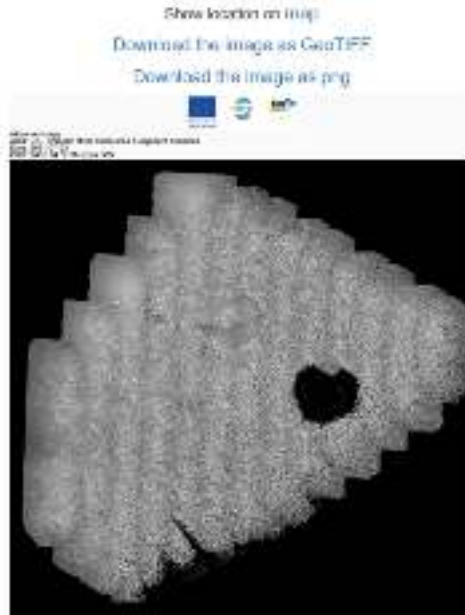


Figure 14: PONTOS Web Application airborne image visualization (on the example of the selected site within the Dniester estuary in the Ukrainian pilot area)



Figure 15: PONTOS Web Application polygon of the airborne image in OpenStreetMap (on the example of the Ukrainian pilot area)

Users can also calculate the indices NDVI and NDWI (Figures 16 & 17). The NDVI index (Normalized Difference Vegetation Index) is a vegetation index used for the monitoring of plants and vegetation density. It is calculated based on the following formula $NDVI =$

$(\text{NIR}-\text{RED}) / (\text{NIR}+\text{RED})$, where NIR and RED are the spectral reflectance measurements in the Near-Infrared (NIR) and Red regions of the spectrum respectively (Gao, 1995)¹.



Figure 16: PONTOS Web Application NDVI index from airborne data (on the example of the selected site in the Dniester estuary)

The NDWI index (Normalized Difference Water Index) is a water related index and used for the monitoring of water content and delineation of open surface water features. Due to the fact that SWIR data are not available in airborne images from drones, the index calculation utilizes the Green and NIR bands available using the formula: $\text{NDWI} = (\text{GREEN} - \text{NIR}) / (\text{GREEN} + \text{NIR})$ (McFEETERS, 1996)².

¹ Gao, B.-C. (1995). Normalized difference water index for remote sensing of vegetation liquid water from space. In M. R. Descour, J. M. Mooney, D. L. Perry, & L. R. Illing (Eds.), *Remote sensing of environment* (Vol. 58, Issue 3, p. 225). <https://doi.org/10.1117/12.210877>

² McFEETERS, S. K. (1996). The use of the Normalized Difference Water Index (NDWI) in the delineation of open water features. *International Journal of Remote Sensing*, 17(7), 1425–1432. <https://doi.org/10.1080/01431169608948714>

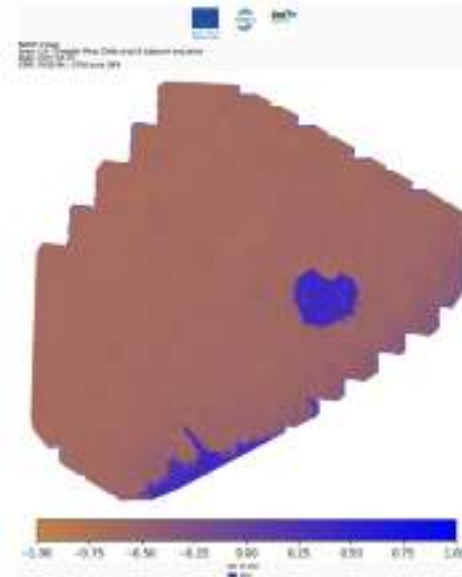


Figure 17: PONTOS Web Application NDWI index from airborne data (on the example of the selected site in the Dniester estuary)

3.3.3 SATELLITE DATA ANALYSIS

PONTOS Web Application provides satellite data analysis tools, which utilize data from the missions Landsat 5, Landsat 8 and Sentinel-2 for the PONTOS pilot areas (Armenia: Sevan Lake and Sevan Lake Basin, Georgia: Kolkheti Lowlands and Black Sea coastline, Greece: Nestos River and Nestos River Delta, Ukraine: Coastline from Odessa city to the Danube River delta as well as Dniester River delta area and adjacent estuary). The available tools are:

- Watermask
- Hydroperiod
- Phenology Metrics
- Phenology Changes
- EODESM

The Watermask tool is used to classify an area in four different classes (land, open surface water, floating vegetation and emergent vegetation) (Figure 18).

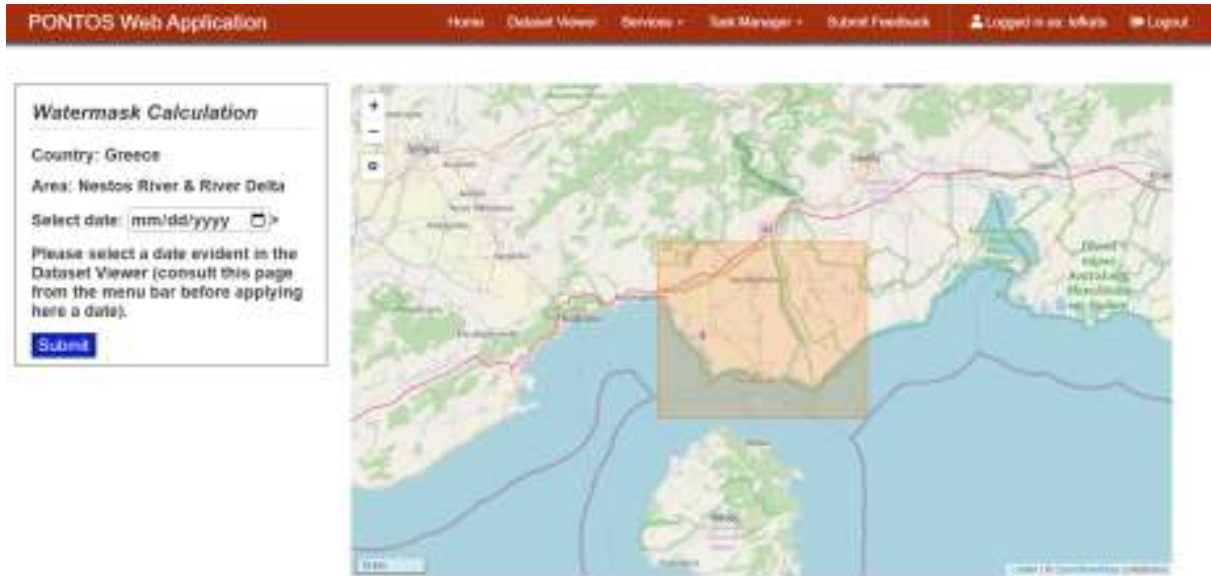


Figure 18: PONTOS Web Application Watermask task submit (on the example of the Greek pilot area)

The Hydroperiod tool utilizing a series of Watermask outputs, which are estimated for dates falling in the time period between the starting and the ending date of Hydroperiod, by applying the following interpolation approach. For two dates separated by n days, the occurrence of water is compared. If a pixel is inundated on both dates, then it is assumed inundated for n -days, but $n/2$ days otherwise. Users select pilot area, start and end date and click submit to start the task (Figure 19). The results of the Hydroperiod appear in the task

manager menu (see section 3.4), when the task is completed.

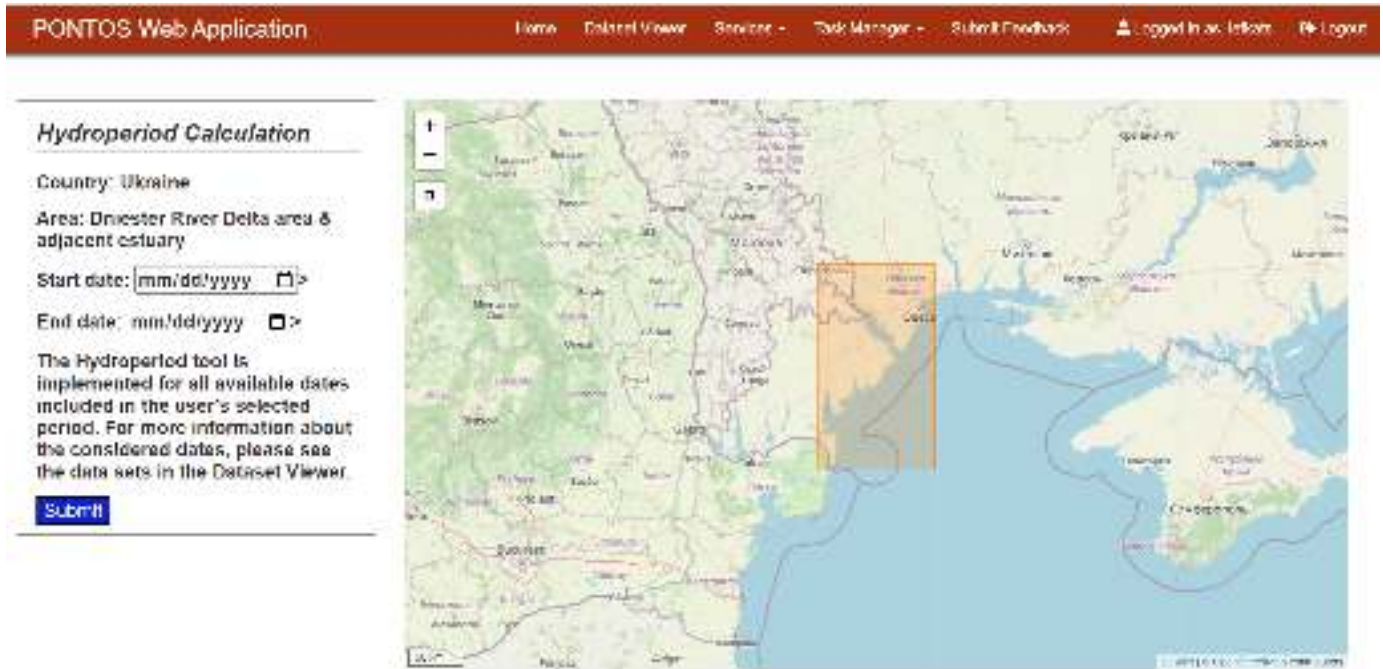


Figure 19: PONTOS Web Application Hydroperiod task submit (on the example of the Ukrainian pilot area)

The Phenology Metrics tool utilizes a time-series of NDVI images to identify the day that the Start of Season, the Peak of Season and the End of Season occurred in one year. The outputs include the GreenUp day of the year, the day of the year that the maximum value of the NDVI occurred and the Senescence day of the year, which can be downloaded as maps by the users in png or GeoTIFF format (Figure 20).

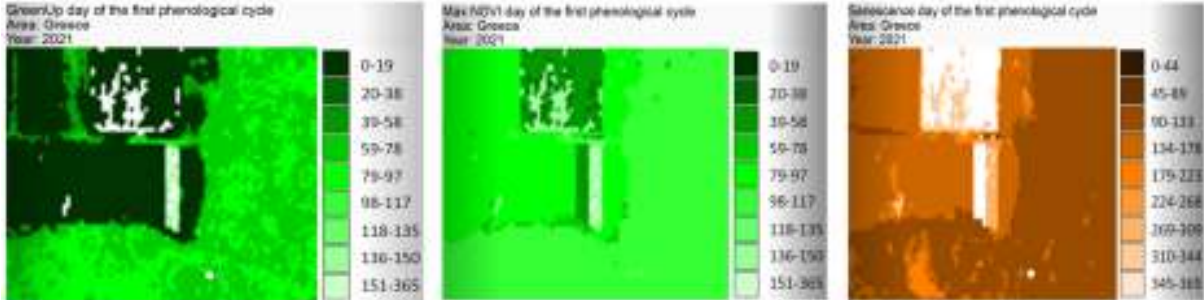
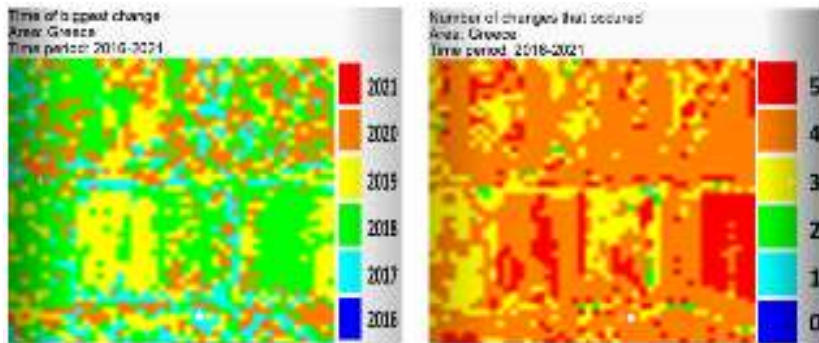


Figure 20: PONTOS Web Application Phenology Metrics outputs (on the example of the greek pilot area)

The Phenology Changes tool utilizes a time-series of NDVI images to monitor the changes along annual vegetation cycles of consequent years. The outputs include images, which represent the year of the biggest change in the pilot area's phenology and the number of changes that occurred in a specific time period (Figure 21).



The EODESM (Earth Observation Data for Ecosystem Monitoring) tool facilitates the classification of land cover and change by combining environmental variables (EVs) retrieved primarily from Earth Observation (EO) data (see DT.1.1.3 for more information) (Figure 22).

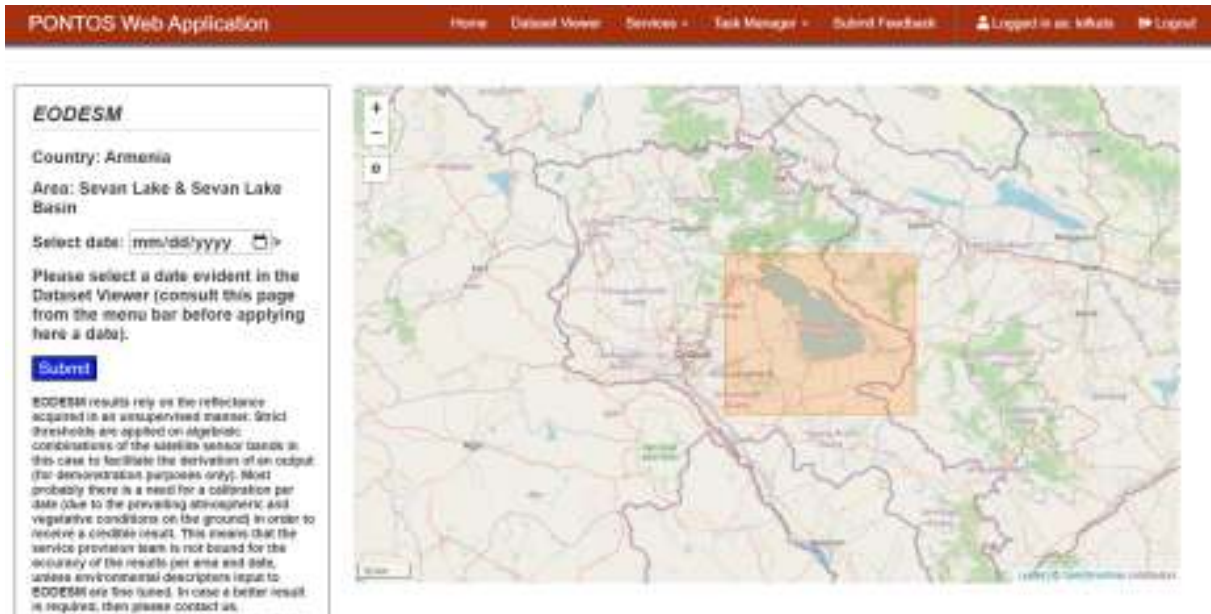


Figure 22: PONTOS Web Application EODESM task submit (on the example of the Armenian pilot area)

3.4 TASK MANAGER MENU ITEM

The modules Watermask, Hydroperiod and EODESM require time to be executed and the outputs cannot be presented immediately to the user. These tasks are implemented asynchronously and the outputs are saved and uploaded to the task manager menu. Users have to select “Details” of the requested task to visualize the outputs (Figure 23).

Pilot Area	Date	
Ukraine	2021-10-10	Details
Ukraine	2021-08-02	Details
Ukraine	2020-08-05	Details
Ukraine	2020-07-11	Details

Figure 23: PONTOS Web Application Task Manager

The Watermask outputs include a png image on screen that visualizes the pilot area in four different classes (floating vegetation, emergent vegetation, open water, land) and provides information about the task (country, area, date and legend) (Figure 24). Users have also the ability to download the output image as png or GeoTIFF format.

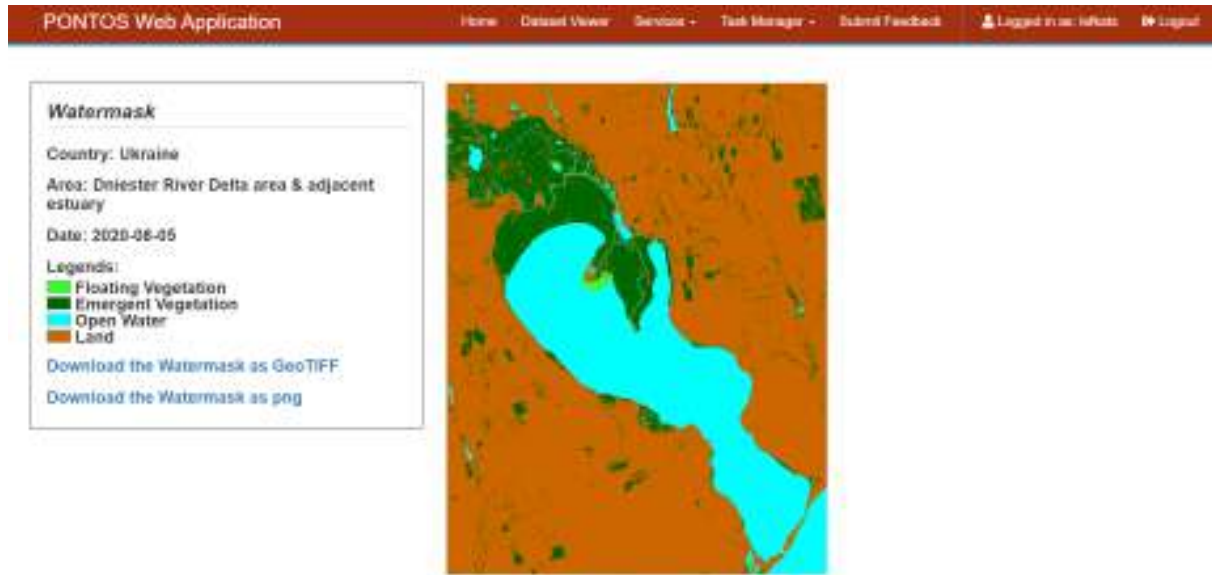


Figure 24: PONTOS Web Application Watermask output (on the example of the Ukrainian pilot area)

The Hydroperiod output includes a png image on screen that visualizes how many days there was water evident on the surface at a pixel of the selected area for the requested time period and provides information about the task (country, area, date and legends) (Figure 25). Users have also the ability to download the output image as png or GeoTIFF format.

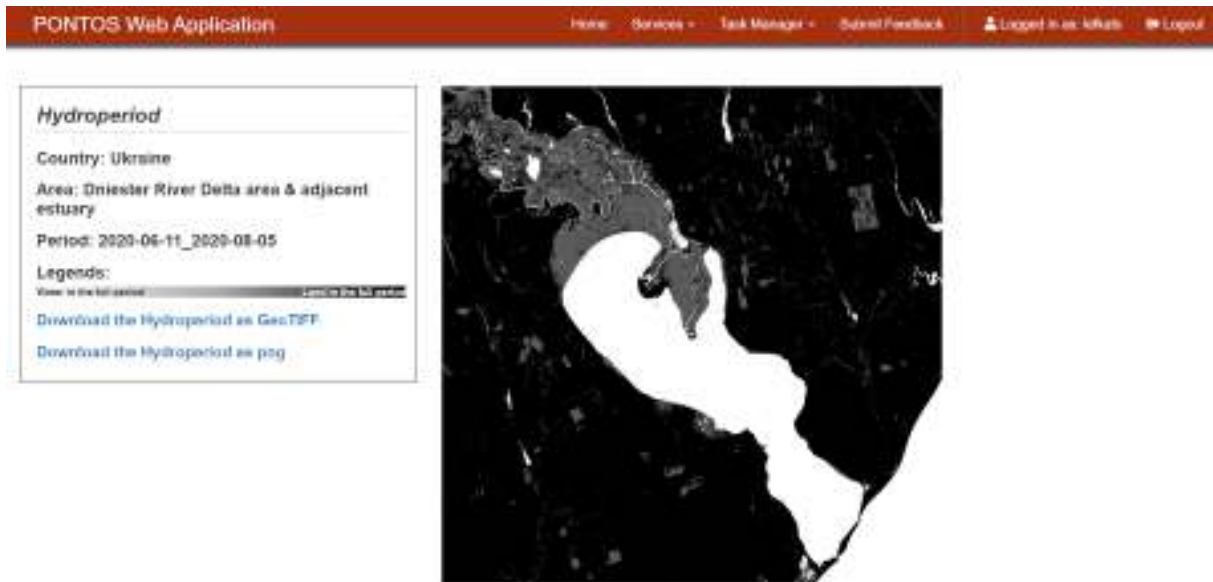


Figure 25: PONTOS Web Application Hydroperiod outputs (on the example of the Ukrainian pilot area)

The EODESM output includes a png image on screen that visualizes the selected pilot area classified in seven different classes:

- Cultivated Terrestrial Vegetation
- Natural Terrestrial Vegetation
- Cultivated Aquatic Vegetation
- Natural Aquatic Vegetation
- Artificial Surface
- Natural Surface
- Natural Water

Moreover, it provides information about the task (country, area, date and legends). Users have also the ability to download the output image as png or GeoTIFF format.

3.5 SUBMIT FEEDBACK MENU ITEM

One of the most important aspects of the Web Application is the ability for users to provide continuous feedback via the “Submit Feedback” option (Figure 26) of the menu bar. Users may thus provide feedback and suggest improvements about the services of the PONTOS Web



Application. The name and the email of the user is only required before the feedback is submitted. GDPR rules apply.

Figure 26: PONTOS Web Application Feedback Form

4. THE WEBGIS SERVICE

PONTOS webGIS service is a website for interactive visualization of the spatial data collected by the Project and organized in a common spatial infrastructure. The website is based in the Leaflet.js library, as described above, and combines Geographic Information Science (GIS) principles and tools to harmonize the relatively large and multi-dimensional datasets, including several themes like elevation, land uses, shoreline evolution, hydrography, weather, monitoring and oceanography. The tool was created using cutting edge technologies and combines intelligent web maps together with charts and text to unlock, make accessible and re-usable geospatial data to the broad public in a coordinated manner.

More specifically, the tool aims to allow users and stakeholders with special interest on the four selected pilot areas, to easily access, select data layers and visualize data, obtained:

- a) from external data sources, like the Copernicus Marine Service (CMEMS) and European Marine Observation and Data Network (EMODnet) repositories,
- b) the external data from national/regional databases, and
- c) the data produced by the PONTOS Consortium within the frame of the project like coastal erosion.

These Earth Observation Data were eventually organized into well-structured layers imported in the PONTOS Geographic Information System (GIS) web-environment, aiming to:

Common borders. Common solutions.

- a) aid decision-makers at Municipal, Regional and National level to formulate policies on ICZM matters,
- b) provide reliable datasets to scientists and engineers,
- c) engage active citizens and the broader public into coastal zone issues,
- d) promote the distribution of information among coastal managers, stakeholders and the general public.

4.1 SYSTEM ARCHITECTURE

As is illustrated in Figure 27, PONTOS webGIS system architecture is based on three parts that cooperate in harmony. Starting from the last part (Client side), the user is interacting with a web mapping application that is created with Leaflet.js library and sends queries of screen visualization to a server. This server is established at the Laboratory of Ecological Engineering and Technology, Department of Environmental Engineering, Democritus University of Thrace and consists of two different Servers: a Web Server that hosts the PONTOS webGIS website and handles Python Server scripts and a Map server that handles all the uploaded data or pushes the user's queries to external Data Servers. These external Data Servers after receiving the queries respond to the PONTOS Map Server with the requested data. These data are internally transformed in the appropriate georeferenced format and finally the Web Server pushes the requested data back to the Web mapping application and data is visualized in a user-friendly and understandable map.

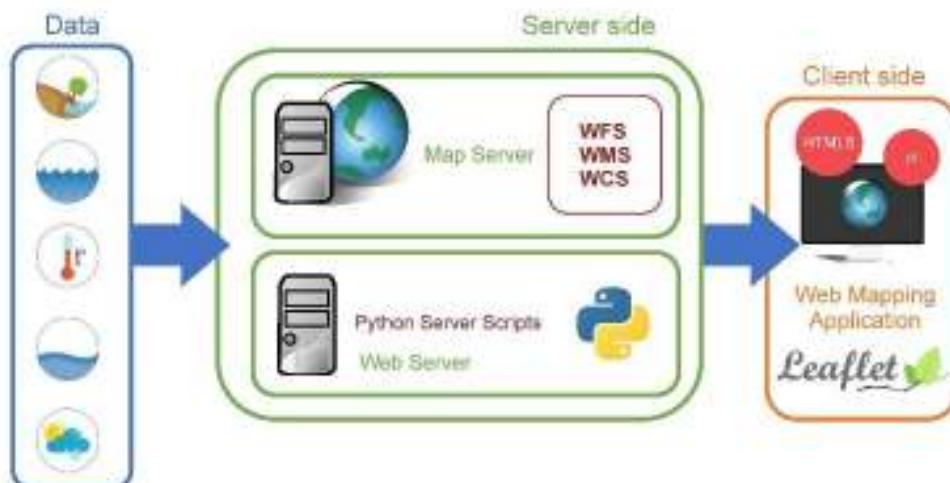


Figure 27: PONTOS webGIS system architecture



4.2 HOME PAGE

The initial screen of PONTOS webGIS is divided into two main elements:

- the Navigation bar, and
- the Map visualization element.

Starting from above (navigation bar) the website can be divided into 5 parts:

- At the upper left part, the user may find the “**Zoom Control**” element which consists of two buttons to control the zoom level of the screen view (plus and minus buttons). Each time the user interacts with these buttons all tiles and other elements loaded on the map respond to this action and smoothly change to the requested zoom level. Additionally, zoom levels can change using the mouse scroll wheel on desktop PCs or by pitching on mobile devices (touch interaction). This shows the great compatibility of Leaflet.js with various types of devices.
- Just below the Zoom Control, one additional tool is available: the “**Opacity Control**” tool. With the Opacity Control slider, the user can change the transparency of the loaded layer to the desired percentage of opacity.
- At the upper right part, the user may find two separate buttons: the “**Region Control**” and the “**Project Information**” button. The first control allows the user to switch between the four pilot sites. More specifically, the user can select the desired country (Greece, Armenia, Georgia and Ukraine) and the map will fly to the pilot site of the selected country. When the user clicks on the Project Information button then an overlay slide will be shown on the screen with information about the PONTOS project and the partners of the project (Figure 30).
- Below these two controls the user may find the “**Layer Control**”, located at the upper right corner of the map. This manager gives the ability to select the appropriate thematic layer to be shown on the map. This tool will be further described in the next chapter.
- Finally, at the lower right part of the map user may find the “**Basemaps Control**”. This tool, illustrated as a globe, allows the user to select between several tiled basemaps to be loaded on the screen. In the PONTOS webGIS, five basemap modes may be used: Transport, Transport Dark, Watercolor, Satellite and Terrain. Each one of the basemaps was selected for a different reason. Transport was selected as the default basemap in order to be easier for the user to understand what is displayed on the map due to its intimacy with the most popular web map platform (Google Maps) and provides the user Roads and Places’ Names of the area. Transport Dark provides the user a basemap with high contrast which is useful for layers with animated components or emphasizes

details of some layers. Watercolor was selected to provide teachers a tool for the kids that is easy to understand. Satellite was selected to provide to the user a clear cloudless satellite view of the area. Terrain was selected to provide to the user an illusion of the land elevation as the hill shade of the area is displayed. A typical presentation of these basemaps is shown in Figure 31.

Figure 28 represents the initial display of PONTOS webGIS website for the Greek pilot area, covering the Nestos deltaic zone as long as the main components of the page and Figure 29 the same display in mobile view.



Figure 28: PONTOS webGIS initial display and main components (on the example of the Greek pilot area)



Figure 29: PONTOS webGIS mobile initial display (on the example of the Greek pilot area)



Figure 30: Project information as loaded on PONTOS webGIS



Figure 31: Basemap modes available in PONTOS webGIS: Transport, Transport Dark, Watercolor, Satellite, and Terrain (on the example of the Greek pilot area)

All the developed tools in the PONTOS webGIS platform support localization, therefore all captions in the website are automatically translated to the local language.

4.3 LAYER CONTROL COMPONENT

In PONTOS webGIS, a series of well-selected thematic layers (or operational layers) are available to be placed on top of the Basemaps (or Background layer), thus providing easy access to Copernicus data while allowing processing the web-maps. This feature could be described as a “map sandwich” approach, where the basemap is the bottom layer and all thematic layers are placed one on top of the other.

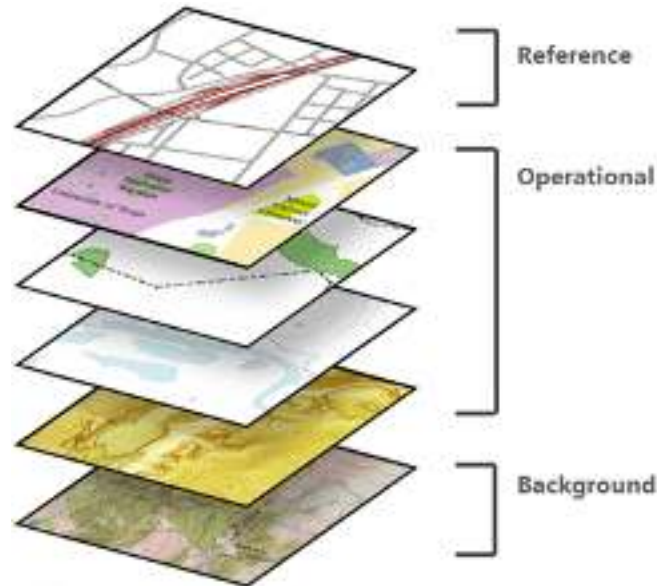


Figure 32: “Map sandwich” of basemaps and thematic layers (ESRI, 2019)³

Usually, thematic layers are created locally and remotely by a Geographical Information System (GIS) software and then are uploaded on a Map server, which can handle different types of geospatial data, or can come directly from other servers via a server-to-server interaction. There are various web services that comply with the Open Geospatial Consortium (OGC) Standards, such as WMS, WCS, WMTS or WFS, etc., designed to draw maps “on the fly” by displaying thematic layers as tiles. In addition, using queries to these services the user might receive data for a specific location providing the ability to create interactive elements, such as popups.

Thematic layers can be several vectorized layers with sublayers, or a single web service with multiple sublayers, or multiple web services that each contains a single layer, i.e., the Layer Control allows the web mapping developer to include all these types of thematic layers and display them using a CSS style in a user-friendly and easy-to-understand manner. Therefore, this plugin allows the users to toggle the layer they prefer to visualize through an “on” and “off” button.

In PONTOS webGIS the Layer Control follows the well proven method that other websites use, like Windy (<https://www.windy.com/>) or Zoom Earth (<https://zoom.earth/>). More specifically, it uses icons for each of the layers, enhanced with a description of this layer on

³ ESRI. (2019). Basemaps. ArcGIS Pro. Retrieved from <https://pro.arcgis.com/en/pro-app/help/mapping/map-authoring/author-a-basemap.htm>

hovering over the icon. Therefore, the Layer Control consists of many icons where each one corresponds to a specific layer or a specific stack of layers, as is defined in the Map Server. Despite the description on hover each of these icons, it is designed to explain in a visual manner the data that will be loaded on the map.

As described above, each user's query on the visualization of any of the existing data layers will allow the visualization of the appropriate web-map, either through the created Map Server. The innovation of this webGIS is that the Layer Control is automatically modified based on user selection. Each time a user selects a region, new layers are loaded in the layer control panel, based on the available datasets for each pilot site.



Figure 33: Available layers for the Greek pilot site with the description for all layers be shown

The layers that are currently available in PONTOS webGIS are the following:

- **Topographic Data and Maps:** retrieved from the SRTM30 Database;
- **Bathymetric Data and Maps:** retrieved from the EMODnet Bathymetry Portal and the American University of Armenia;
- **Land Use/cover Data and Maps:** retrieved from the Copernicus Land Monitoring Service (CLMS) or other local services;
- **Hydrologic Data:** retrieved from the Swedish Meteorological and Hydrological Institute (SMHI) and the American University of Armenia, for each of the major rivers of the pilot sites;

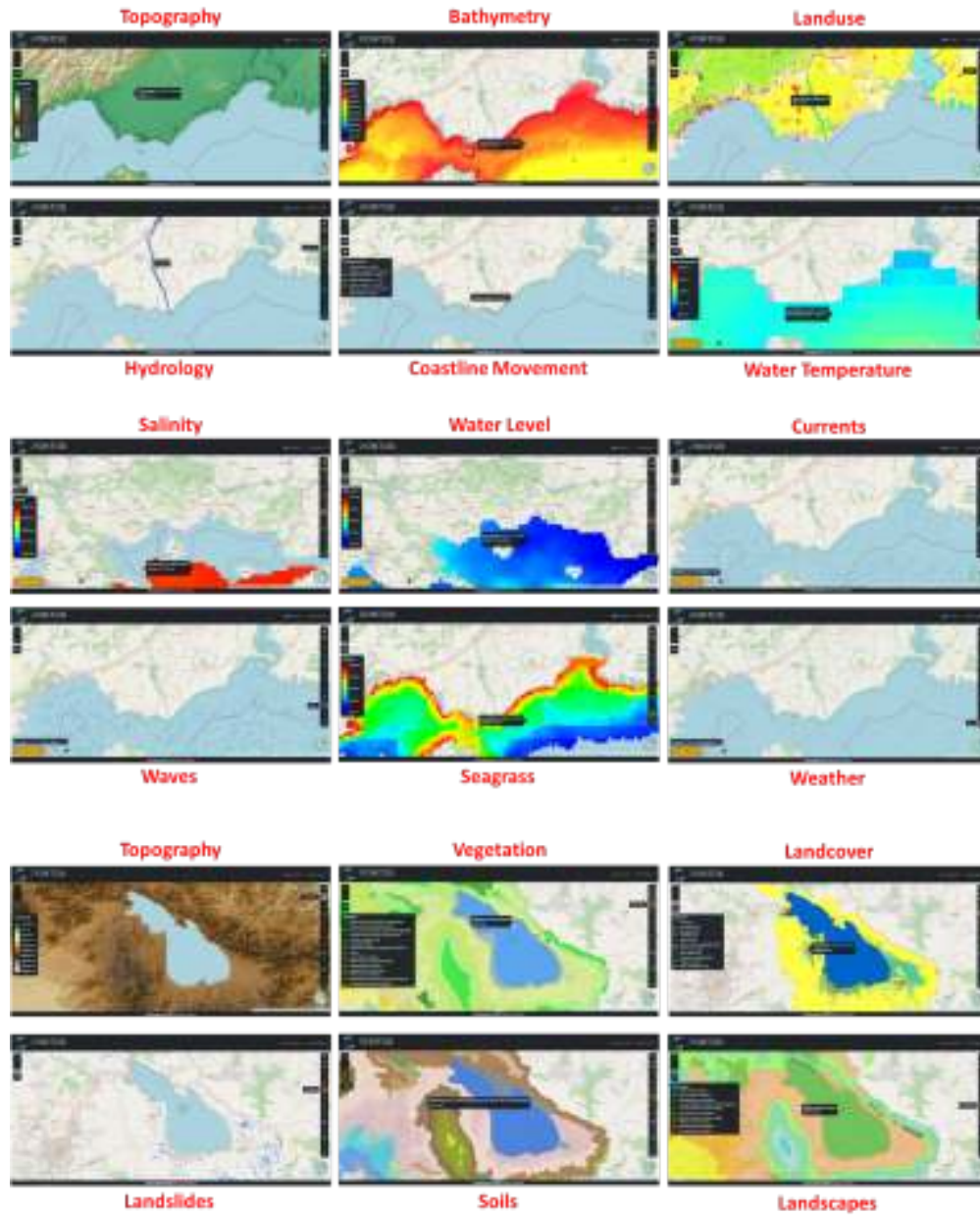


- **Shoreline Evolution Data:** retrieved from historic satellite images analyzed according to the methodology developed by the Laboratory of Ecological Engineering and Technology, Democritus University of Thrace;
- **Oceanographic Data:** such as water temperature, salinity, water level, currents, waves and seagrass, retrieved from Copernicus Marine Environmental Monitoring Service (CMEMS) and the EMODnet Seabed Habitats Portal;
- **Meteorological Data:** such as wind speed and direction retrieved from Global Forecasting System (GFS) of NOAA;
- **Vegetation Data:** retrieved from the American University of Armenia;
- **Landslides Data:** retrieved from the American University of Armenia;
- **Soils Data:** retrieved from the American University of Armenia;
- **Landscapes Data:** retrieved from the American University of Armenia;
- **Geology Data:** retrieved from the American University of Armenia;
- **Hydrogeology Data:** retrieved from the American University of Armenia;
- **Floods Data:** retrieved from the American University of Armenia;
- **Debris Flows Data:** retrieved from the American University of Armenia.

Figure 34 illustrates these layers loaded on different basemaps.



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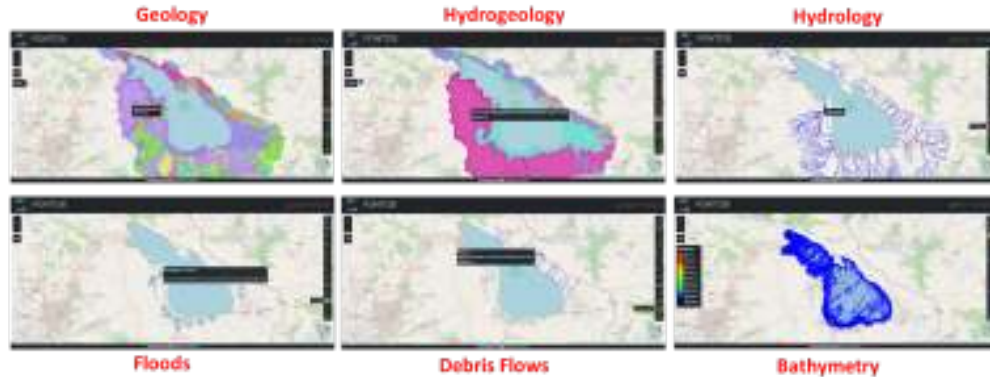


Figure 34: Available layers in PONTOS webGIS (on the example of the Greek and Armenian pilot areas)

4.4 HIDDEN COMPONENTS OF PONTOS WEBGIS

As can be seen on Figure 34 there are several layers available in the PONTOS webGIS that require a different visualization approach. Based on that, many tools-components that are not included in the initial screen have been developed to support complex visualizations (e.g., arrows for currents). Each of these components is loaded on the map based on the layer that the user has selected.

4.4.1 DEPTH AND TIME CONTROL

When the user selects one of the ocean layers then a map of the desired layer appears on screen. More specifically, the map that appears corresponds to the top layer (or surface) of this dataset. As oceanographic data are three-dimensional (two dimensional distributions of one parameter on a specific depth level and various depth levels from surface to the bottom), a special tool was developed to handle these 3D datasets and show all depth levels per parameter. This tool/component is the “**Depth Control**”. Whenever a layer with more than one level is loaded, this component appears below the opacity control tool. Then the user, just by hovering over this control can find a slider that allows the visualization of the distribution of the selected parameter at the required depth level.

In addition, as Figure 35 illustrates the other control that appears with the selection of Ocean or Weather layers is the “**Time control**” component, a tool that allows the user to move in time and display the distribution of selected parameter(s) on the date/time of request. With this tool the user is able to see up to 5 days before and 5 days after the day of webpage operation.



Figure 35: Depth and Time control in PONTOS webGIS (on the example of the Ukrainian pilot area)

4.4.2 LEGEND AND INFORMATION BOX

One of the features that a user discovers when selecting any of the provided layers is the ability to easily visualize the exact value of the selected parameter displayed on the webGIS map. PONTOS webGIS is equipped with two different tools for this functioning: the “**Legend box**” and the “**Information Box**” (Figure 36). More specifically, when users select a layer the Legend box automatically appears below the Opacity or the Layer control. This box illustrates in a graphical way, either by a colorbar or by discrete lines, the data that appear on map. This is a quick way to find the value of a point on the map just by looking at the legend. A most precise way to identify the value of a specific point is by clicking on the pixel representing this point and an information box will appear with the coordinates and the value of the selected parameter for the selected point. Moreover, the user can hide the legend by clicking on the legend (the same way the user can show legend again) or hide the information box by right clicking on the map.

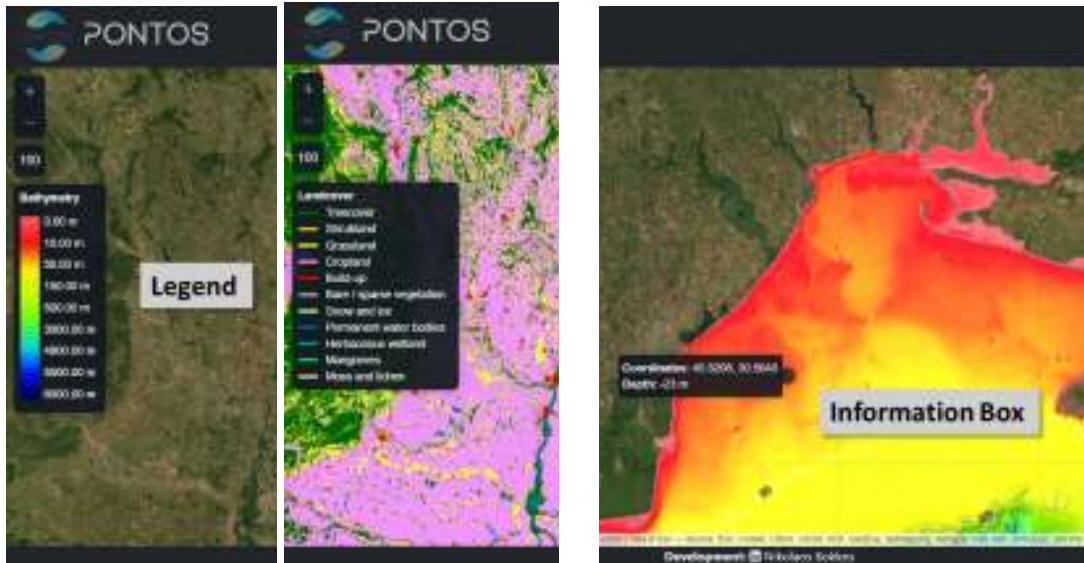


Figure 36: Legend and Information Box in PONTOS webGIS (on the example of the Ukrainian pilot area)

Information about the value of a specific point on map is also provided to the user through another tool: the “**Value display**” tool illustrates the value of the selected parameter at the specific point, just by hovering the mouse over the map on the exact requested location (Figure 37). This tool is useful for layers that have an animated visualization, as explained below.



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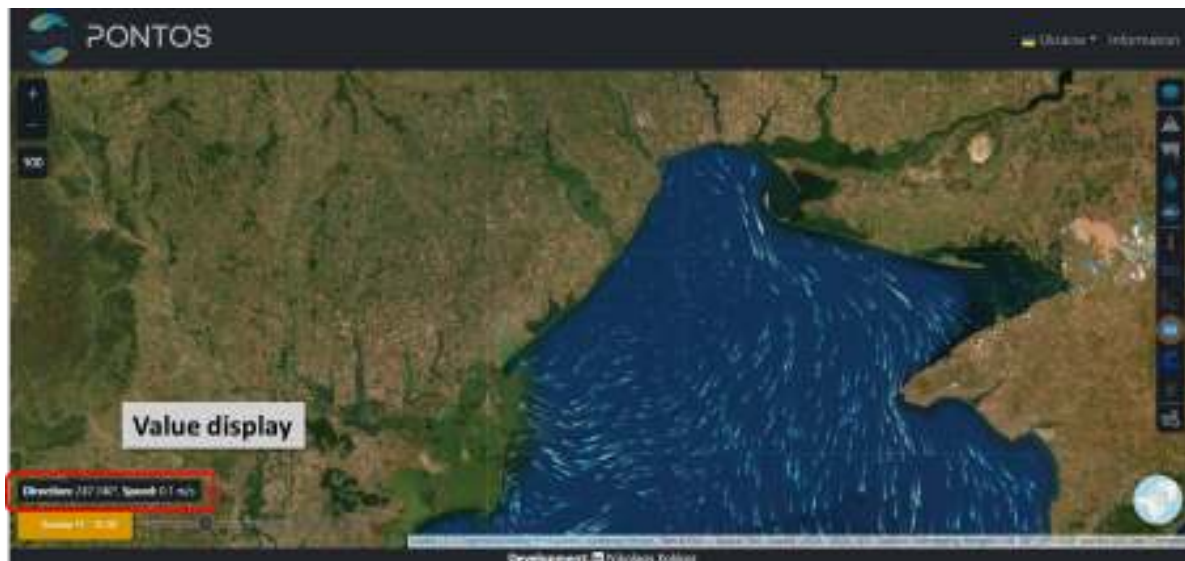


Figure 37: Value display tool in PONTOS webGIS (on the example of the Ukrainian pilot area)

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4.4.3 DATASET SWITCHER

An additional tool that users may find useful is the “**Dataset switcher**” (Figure 38). This tool allows the user to switch between dataset features. For example, when the user selects and visualizes the coastal erosion rate, by clicking on this button the easy visualization and switch between the “Coastal behavior” and “Coastline movement rate” layers is provided. This tool was developed for all types of vector datasets that have multiple attributes, but in PONTOS webGIS is currently used only on coastal erosion layer.

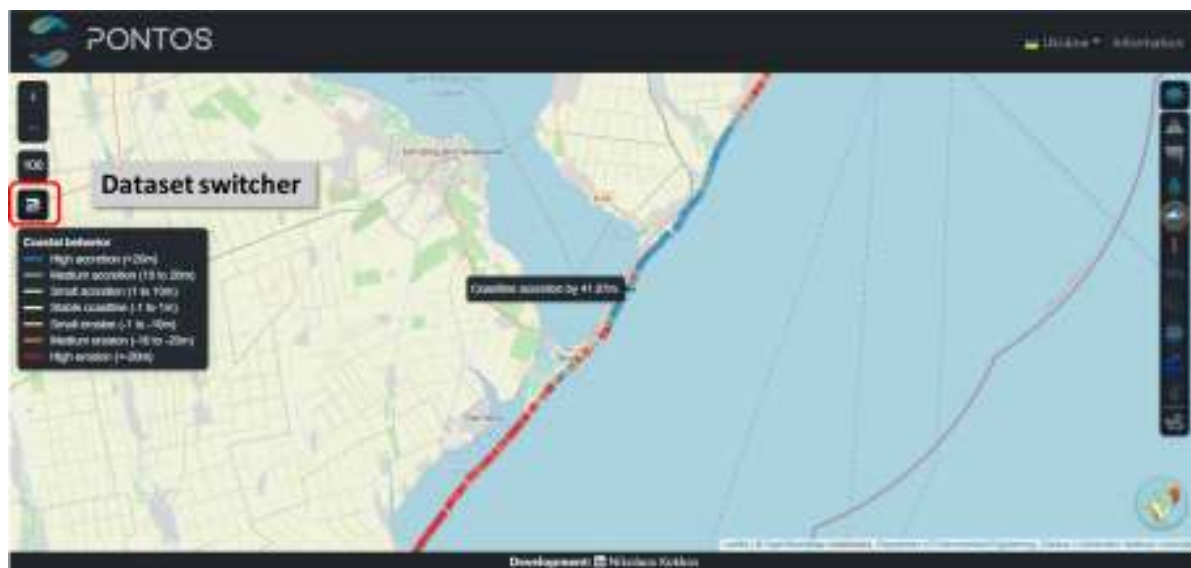


Figure 38: Dataset switcher in PONTOS webGIS (on the example of the Ukrainian pilot area)

4.4.4 RIVER DISCHARGE VISUALIZER

One very useful feature that was created for the PONTOS webGIS is the visualization of river discharge tools. One may select the hydrology layer, then the hydrology network and major rivers of each pilot site will appear on the map. If the user clicks on a specific river, a window will appear on the map (Figure 39) with the name of the river shown in local language (Figure 39-1). In parallel, a time-series graph of river discharge will be shown covering the period from 1981 to 2010. This is a fully interactive graph as the user can select to see a smaller time period, by selecting it on the graph or on the sub-graph (Figure 39-2) or select a specific time range (Figure 39-3). In addition, user may also view a forecast version of the graph (15 days ahead) by clicking on the forecast button (Figure 39-4). All these data can be downloaded either in raster format (png, jpeg) or vector format (pdf, svg) or as data file (csv, xls) (Figure 39-5).

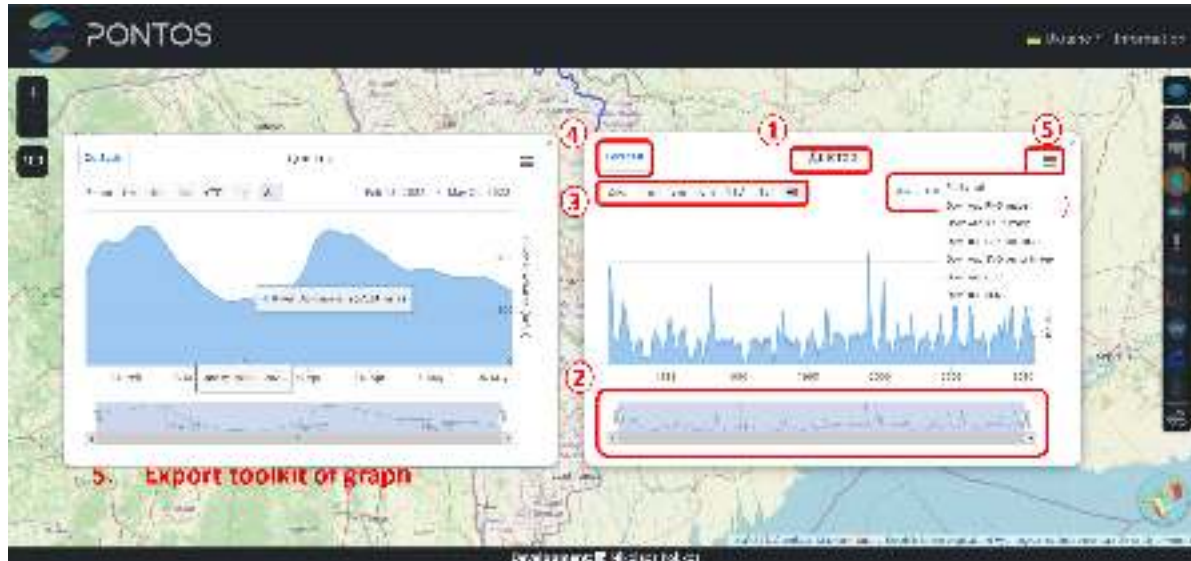


Figure 39: River discharge graph as presented in PONTOS webGIS (on the example of the Ukrainian pilot area)

4.4.5 WEATHER SYNOPTIC INFO WINDOW

Finally, one of the most interesting tools of the PONTOS webGIS is the “**Weather synoptic info window**”. This tool is loaded only if the user selects the weather layer in the Layer control. If the user makes this selection, wind will appear in an animated visualization manner. Animation displays white moving arrows with length proportional to wind speed and direction in accordance to wind direction data given by the respective dataset. If the user right clicks on a specific point on the map, a new window will be presented with synoptic information about the current weather, as recorded by the nearest local weather station (Figure 40). This information is enhanced by a series of images showing the status of the weather.

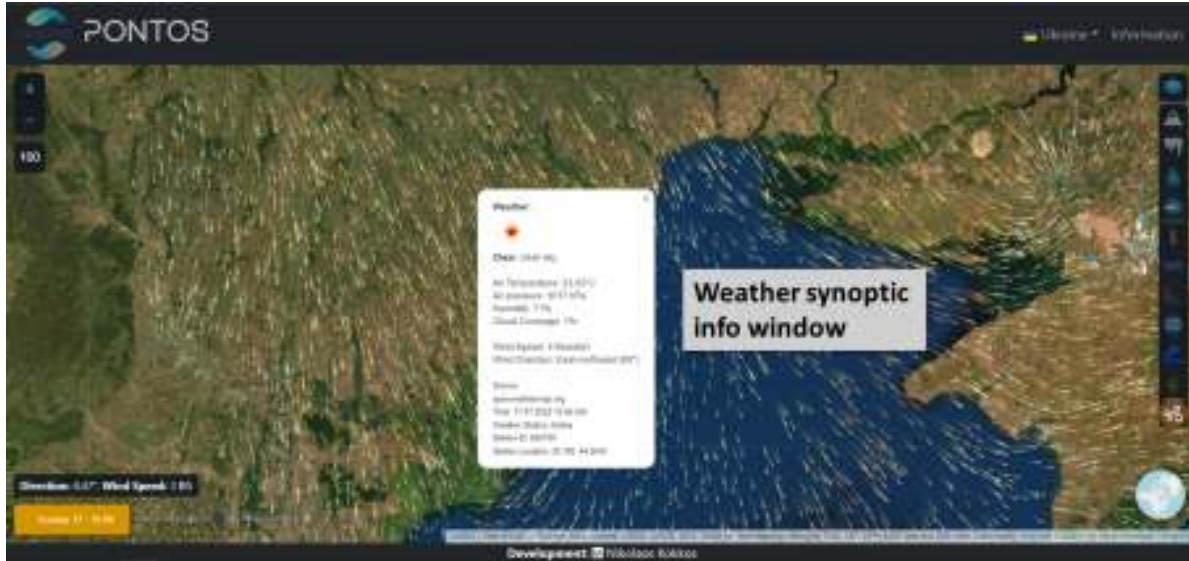


Figure 40: Weather synoptic info window as presented in PONTOS webGIS (on the example of the Ukrainian pilot area)

Copernicus assisted environmental monitoring across the Black Sea Basin-PONTOS

Joint Operational Programme Black Sea Basin 2014-2020 is co-financed by the European Union through the European Neighbourhood Instrument and by the participating countries: Armenia, Bulgaria, Georgia, Greece, Republic of Moldova, Romania, Turkey and Ukraine.

This publication has been produced with the financial assistance of the European Union. The contents of this publication are the sole responsibility of the Center for Research and Technology Hellas and can in no way be taken to reflect the views of the European Union.

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