NASA SPACE APPS CHALLENGE

Challenge Accepted: Automated Detection of Hazards

Application: NEED (Natural Events Exposure & Detection)

Team: Do It For The EARTH

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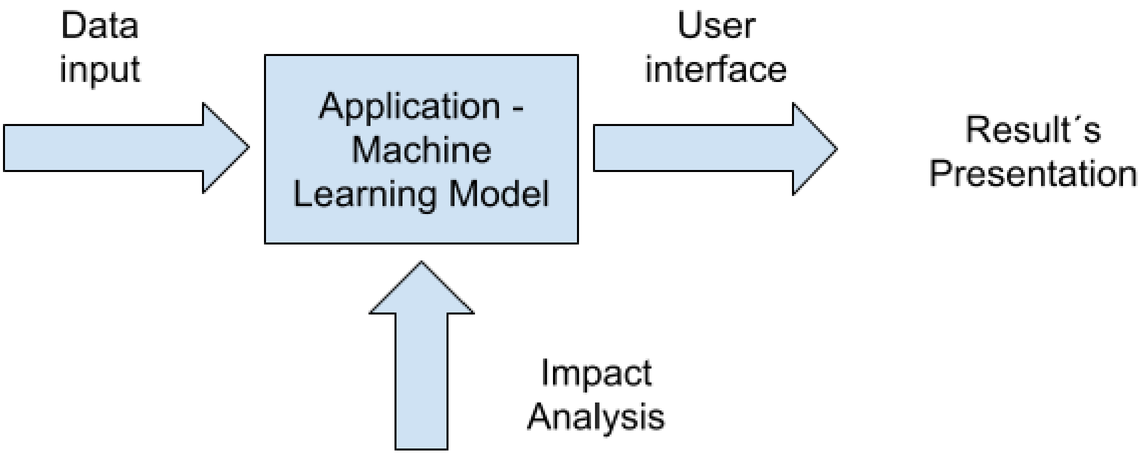
PRESENTATION

Our planet is constantly exposed to climate and non-climate events (that have consequences) that threaten health, security, economy and productivity of nations and their inhabitants. That is why we have decided to tackle this problem in order to synthesise a method and/or application that using the amount of satellite information that we have today can weight different phenomena, analyze it and provide relevant information for researchers and organizations in the same struggle to mitigate the impact of these catastrophic events generate at the social level, they can take or suggest actions, and thus involve the political actors in taking on the matter.

The information will be presented in such a way the general public can access it freely and interactively in order to achieve the most flexible channel possible with reliable and objective information, to enable them to understand the impact of poor human interaction on the environment. At the same time, to be able to educate about these phenomena, how to prevent and act in this situation.

With pleasure and great satisfaction we present below the application of the *NEED (Natural Events Exposure & Detection.)* system**.**

NEED SYSTEM SCHEME



Data input: It consists of defining the phenomenon/s analysed by the application and the reliable source from which the data come.

Application- Machine Learning System: Consists of generating (at least structurally or conceptually) the block or code that will analyse the input data and submit the analysis of the information to the user, using an interface.

User interface: Will be responsible for providing a visualization of the results, to the user in a friendly and interactive way so that the user can navigate the website and information according to what is in their interest.

Impact Analysis: While it may be part of the machine-learning model and results, it has more to do with how the information processed impacts on society, for example, in their economy and productive activities, health, safety, etc. This analysis is based on information on events of similar magnitude to those analysed, which can help the predictive model and identify behaviour patterns and thus be able to model the evolution of the phenomenon in question.

Presentation of Results: Based on the objectives of the challenge, in principle the way in which the current events are presented must be able to be reflected in a map, as far as possible interactive, so that the user can travel based on information of interest and with it, auxiliary information appears to give context to the result.

DEVELOPMENT

The idea is to integrate satellite data mainly from NASA into our application by means of an automatic learning method which will process the data and yield statistical results and modelling using dynamic graphics and simulator.

Interaction with the user will mainly be an interactive map where the user can click on any highlighted event or go through a picklist that will allow to filter through the type of phenomenon he or she is interested in and thus focus the course for a better browsing experience.

Each item of the picklist will open a new window with information related to the event: Historic events of similar characteristics, magnitude of the same, sites affected, etc.

In order to exemplify the use of our application, we will base ourselves on the detection and use of data to warn about the possible origin of tsunamis, although in principle it would not be limited to this.

Before, a little context: A tsunami can arise according to several factors. Some of them are the shape of the ocean floor, the distance and direction of an earthquake. Basically, this phenomenon can be powered by a telluric movement caused by the displacement of the tectonic plates which can give rise to an earthquake or activation of a volcano and as a consequence, the movement of water bodies that can lead to a tsunami.

As a predictive method we use the calculation of kinetic energy that an earthquake under the sea transfers to the ocean to cause a tsunami. This method of detection allows modelling the force of the phenomenon determined by the amount of sea bottom moved vertically and horizontal movements of the continental slope of a failure.

With the data obtained by different tools and satellites it is possible for us to develop a machine learning model that allows us to evaluate and predict phenomena like this. This is a very useful tool for researchers and political actors to have the necessary information and in advance of the event in order to take preventive action and to have the opportunity to save as many lives as possible.

As a data entry to the system we can mention as the main provider of data that NASA and ESA offer freely.

- Use of Terra Telescope tools: MISR and MODIS.

On the one hand, MISR consists of a satellite which has nine cameras oriented at different angles of land and at different wavelengths so that, when flying over a certain region, the information collected is as comprehensive as possible. In this way, we can use the information of the MISR to monitor the sunlight by reflecting on the waves and thus determine the depth of the intervals of the waves and consequently their height.

MODIS has a display strip 2330 km wide, very wide in truth. It is able to see every point of the planet approximately every two days and in 36 discrete spectral bands.

- AMSR Satellite Sensor:

This is an environment viewer designed to display global earth observation data from the advanced microwave scanning series (Advanced Microwaves Series Radiometers). This system consists of the radiometers GCOM-W / AMSR2 and Aqua / AMSR-E.

The information you provide allows us to estimate various geophysical amounts related to the water cycle according to the characteristics of the microwaves captured by the sensor sensitive to the natural emissions of various materials that make up our planet.

The collection of this data will allow us to obtain data on sea surface temperature and wind speed on its surface, snow depth, soil moisture content, total rainfall water, marine ice concentration, earth surface temperature, etc.

- Landsat satellites:

The series of NASA/US Geological Survey Landsat satellites are similar to Sentinel-2 (they capture visible and infrared wavelengths) and can also capture thermal infrared (Landsat 8). The Landsat series has a long history of images covering almost five decades. This platform gives you access to images acquired by Landsat 5, 7 and 8.

Its spatial resolution is 15 m, 30 m and 100 m back to 30 m, depending on the wavelength (i.e., you can only see details greater than 10 m and 30 m). Landsat 8 data has eight spectral bands with 30 m spatial resolutions - exceptions are thermal bands with a resolution of 120 m and panchromatic bands with 15 m. The visit time of each one, Landsat 7 and Landsat 8, is 16 days, with the two spacecraft compensated so that one or the other visits the same place again every 8 days. There are different sensors on board each satellite; Operational Land Imager (OLI) and infrared thermal sensor (TIRS) on board Landsat 8, Enhanced Thematic Mapper Plus (ETM +) on board Landsat 7 and Thematic Mapper (TM) on board Landsat 5.

The data contained in this series of satellites are used for vegetation monitoring, land use, land cover maps, change monitoring, etc. In this work the stored data from Landsat 8 will be used.

- Proba-V Satellite:

The Proba-V satellite is a small satellite designed to map Earth coverage and vegetation growth worldwide every two days. EO Browser provides derivative products that minimize cloud coverage by combining cloud-free measurement over a period of 1 day (S1), 5 days (S5) and 10 days (S10).

The space resolution is 100 m for S1 and S5, 333 m for S1 and S10, 1000 m for S1 and S10. Its review time is 1 day for latitudes 35-75 ° N and 35-56 ° S, 2 days for latitudes between 35 ° N and 35 ° S.

Common use corresponds to land coverage observation, vegetation growth, climate impact assessment, water resources management, agricultural monitoring and food security estimates, monitoring of continental water resources and monitoring of the constant expansion of deserts and deforestation.

- SENTINEL mission

ESA is developing five SENTINEL mission families that will provide a unique set of observations specifically for Copernicus.

Sentinel-1 images are provided by two satellites in polar orbit, operating day and night and performing synthetic C-band opening radar images, allowing them to acquire images independently of the weather. The main applications are to monitor sea ice, oil spills, sea winds, waves and currents, land use change, land deformation, among others, and to respond to emergencies such as floods and earthquakes. The identical satellites orbit the Earth at 180 ° distance and at an altitude of almost 700 km, offering a global visit time of 6 to 12 days depending on the area (check the observation scenario). The radar of the Sentinel-1 can operate in four modes. The spatial resolution depends on the mode: approx. 5 mx 20 m for IW mode and approx. 20 mx 40 m for EW mode

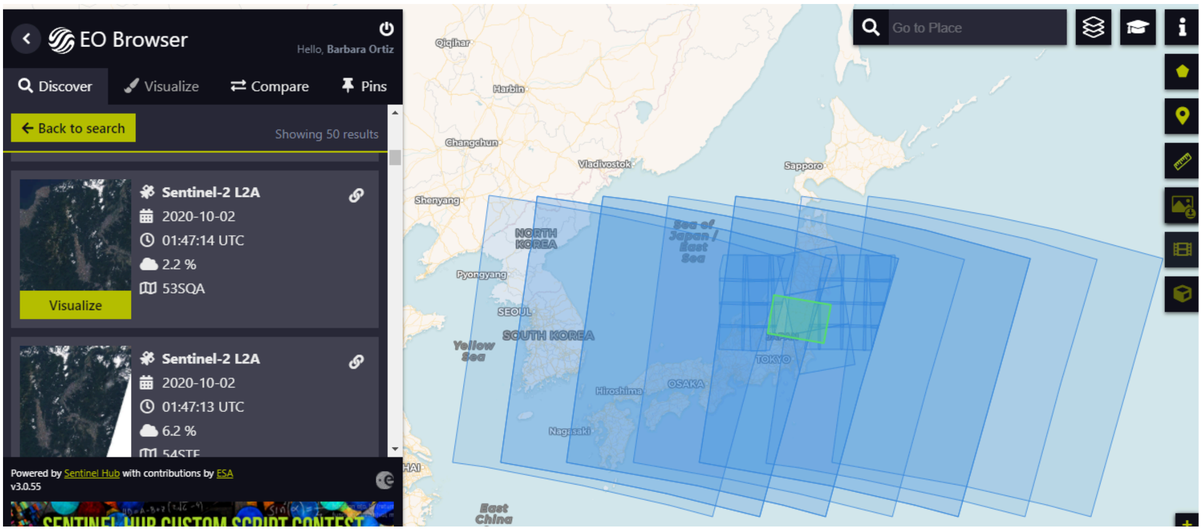
Sentinel-2 carries a multispectral imaging (MSI) instrument, which offers high-resolution optical images for earth monitoring, emergency response and security services, with a common purpose for coverage and land change detection maps, Vegetation monitoring and burnt areas. The MSI provides a set of 13 spectral bands: 4 visible (10 m spatial resolution), 6 nearby infrared (20m) and 3 short wave infrared (60 m). Sentinel-2A and Sentinel-2B have a review time of 5 days. Your acquisitions are available in L1C and L2A processing modes, being atmospherically corrected L2A.

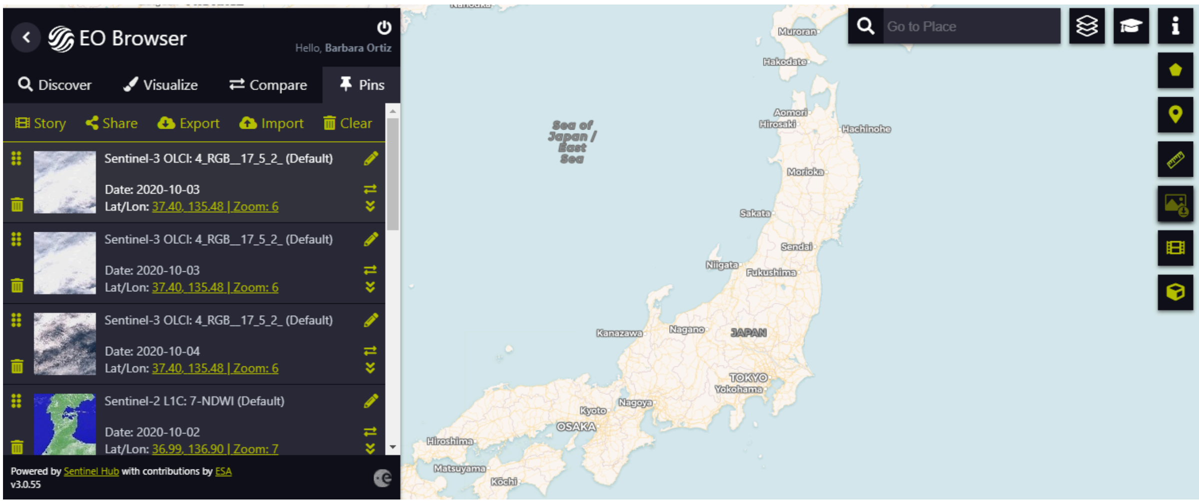
Sentinel-3 is a moderate low-terrestrial orbit-size satellite compatible with small launchers, including VEGA and ROCKOT. The main objective of the mission is to measure the topography of the sea surface, the temperature of the sea surface and the land, and the color of the surface of the ocean and the earth with high precision and reliability to support the ocean prognostic systems, environmental monitoring and climate monitoring. The Ocean and Land Colour Instrument (OLCI) provides a set of 21 bands ranging from visible light to nearby infrared light (400 nm <λ <1020 nm). The Sea and Earth Surface Temperature Instrument (SLSTR) provides a set of 11 bands ranging from near infrared visible to thermal infrared (554,27 nm <λ <10854 nm) The Sentinel-3 has less than 2 days of review time and provides images with a space resolution of 300 m for OLCI and a resolution of 500-1000 m

Sentinel-5P provides atmospheric measurements related to air quality, climate forcing, ozone and ultraviolet radiation. Its data are used to monitor concentrations of carbon monoxide (CO), nitrogen dioxide (NO2) and ozone (O3) in the air, as well as the UV aerosol index (AER_AI) and different geophysical cloud parameters (CLOUD). EO Browser offers level 2 geophysical products. The TROPOspheric Monitoring Instrument (TROPOMI) on board the satellite operates in the ultraviolet short wave infrared range with 7 different spectral bands: UV-1 (270-300nm), UV-2 (300-370nm), VIS (370-500nm), NIR-1 (685-710nm), NIR-2 (755 Its spatial resolution is less than 8 km for wavelengths exceeding 300 nm and below 50 km for wavelengths less than 300 nm.

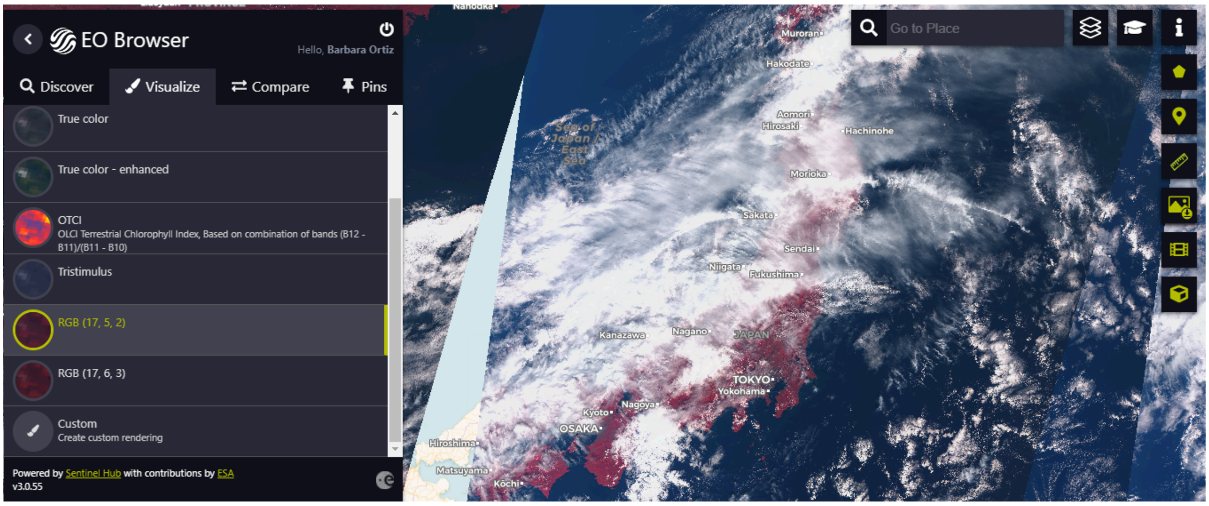
Applications are divided into six main categories: land management services, marine environment services, air-related services, emergency response services, security-associated services and climate change services.

For the use of this data you can use the EO browser or Sentinel Hub Playground, we use EO. First we select the place, in this case Japan, Fukushima, then the satellite that covers the area and contains the data that interest us, according to the phenomenon to be studied. We chose Sentinel-3.

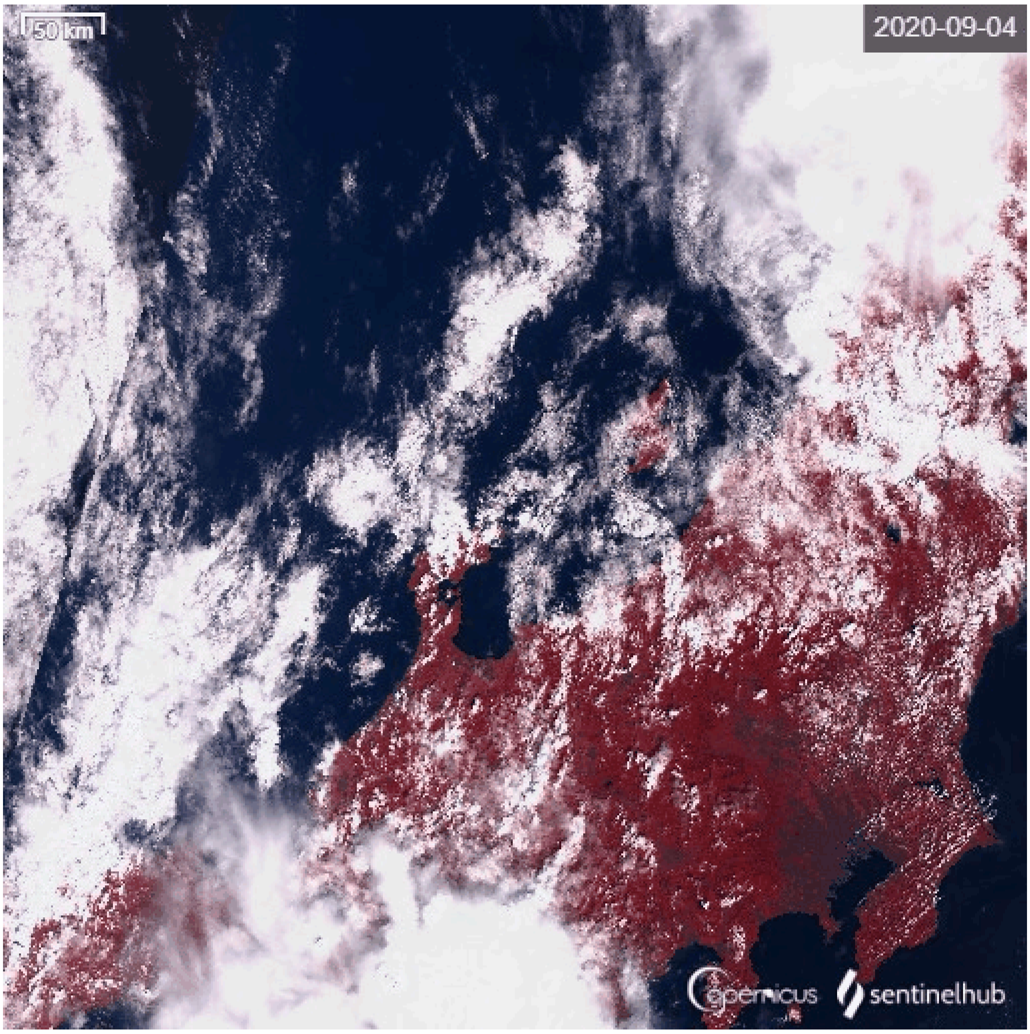




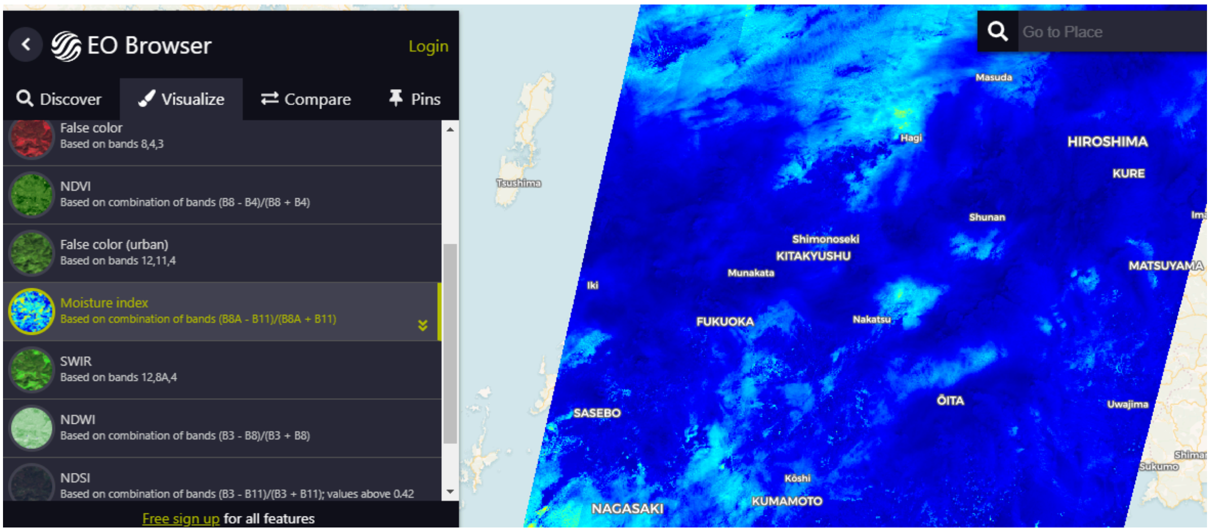
You can use the default options or customize the display of different satellite bands, multiplying by a certain factor to manipulate their brightness. Each band shows the reflective characteristics with the assigned red, green or blue colour (the first band will appear red, the second green and the third blue).



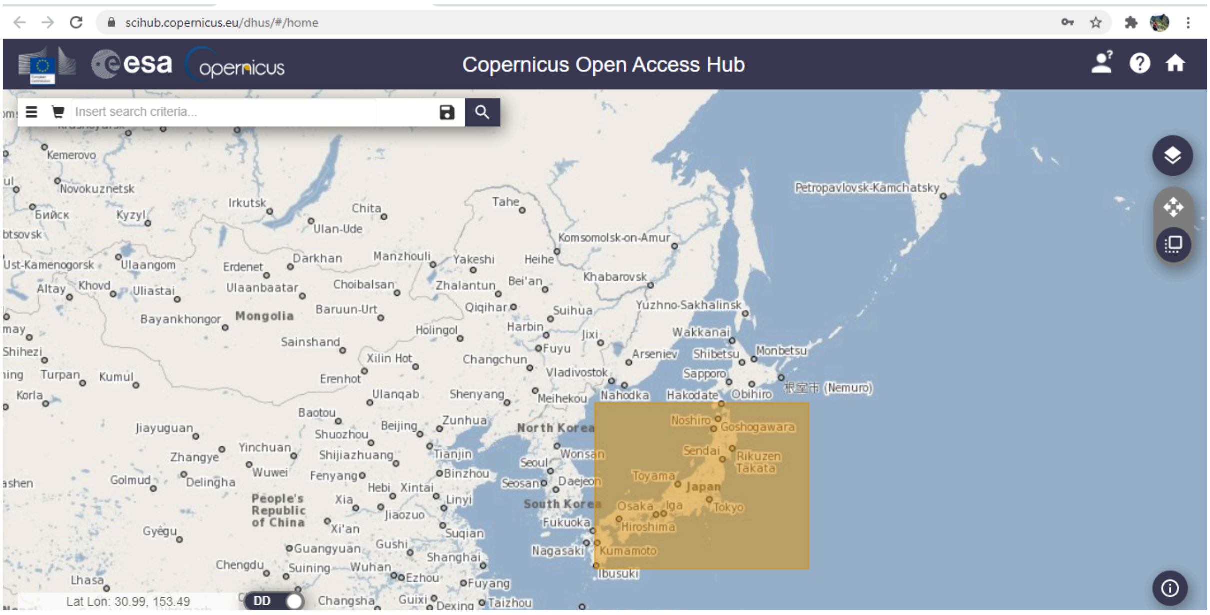
It creates a time period in true color, created in EO Browser. This time period does not show us much about the behaviour of the sea.



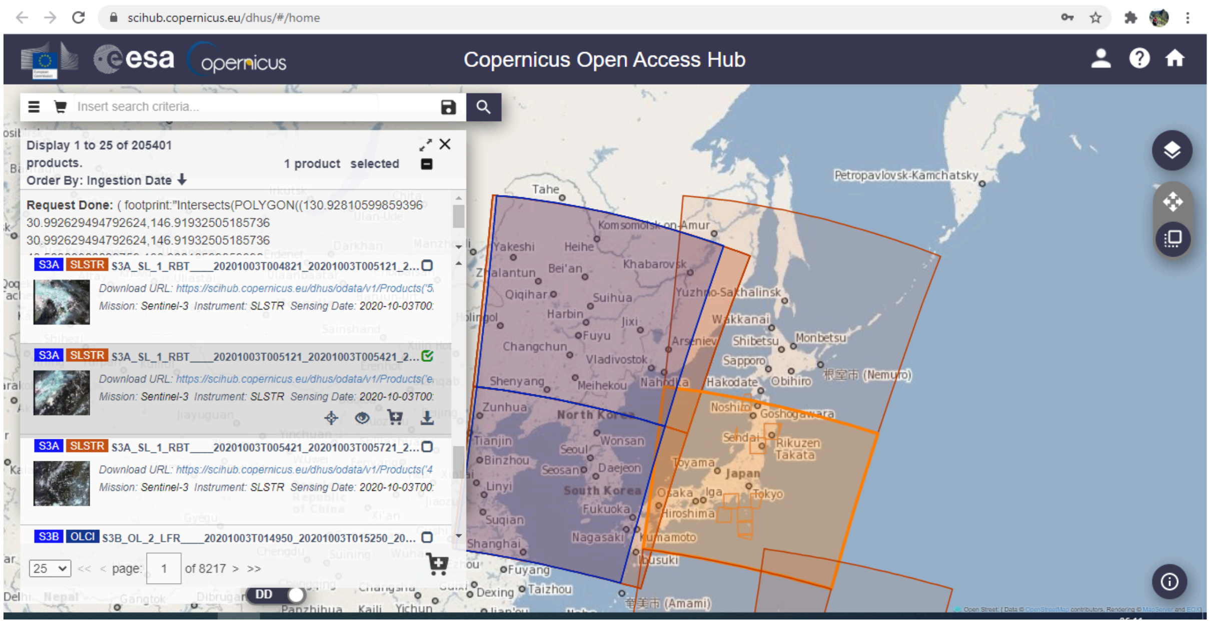
The moisture index tab is available in the EO Browser view tab. The moisture index uses a continuous colour scale, which is also made with custom scripts. “Continuous” means that colors extend between the border values, rather than being classified. The bands used in the moisture index above the color scale are made of the band B8A, which can be used to detect vegetation, and the infrared band of short wave B11, bands B11 and B12 can be used to detect heat.



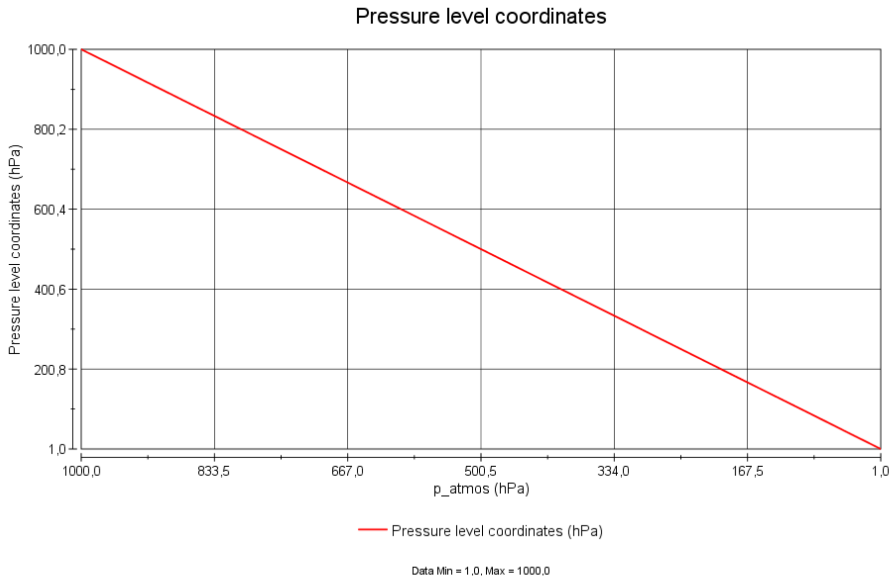
In addition to EO Browser, another powerful tool is the Copernicus program, which will allow us to access the above-mentioned Satellites and obtain files with specific information.
We select by a figure the site on the map of our interest, in this case Japan, Fukushima:

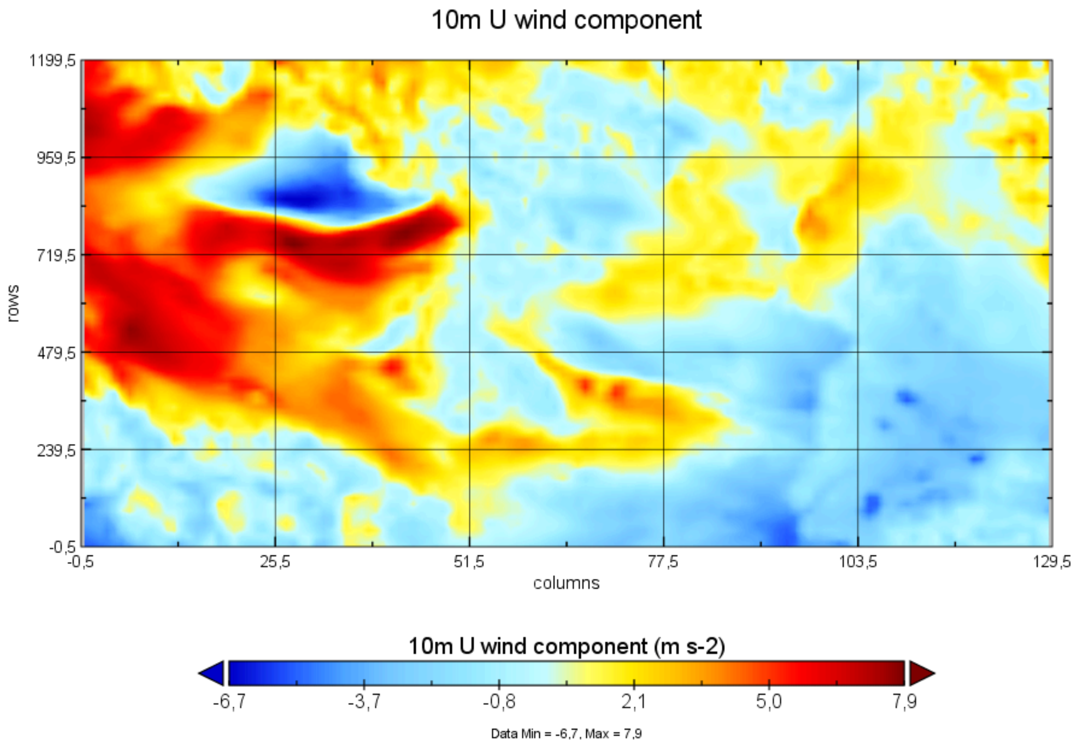


The location and data of our interest correspond to the Sentinel-3 satellite.
We download the selected satellite files on the selected date.



Some data obtained from our interest in the analysis of possible tsunamis:



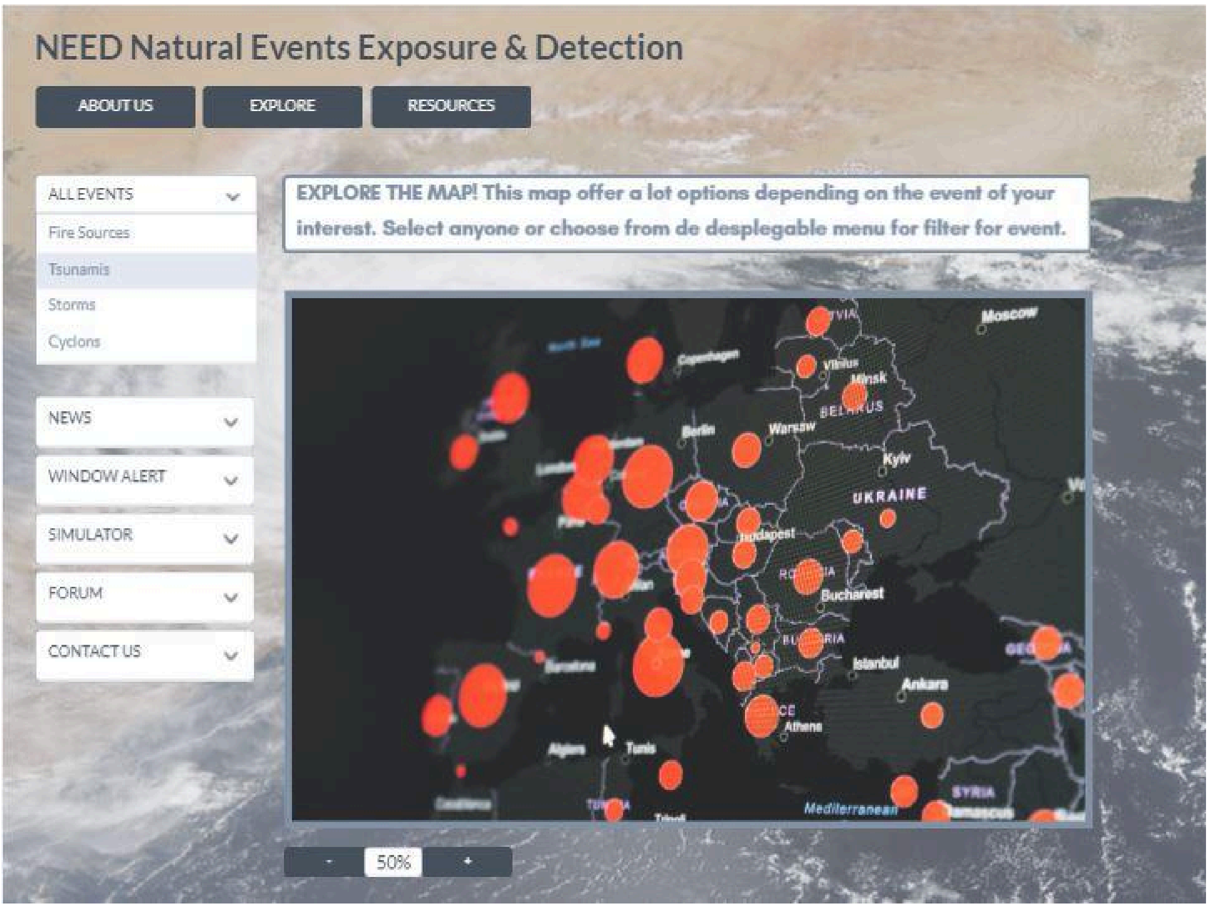


The use of the tools cited as EO Browser, Copernicus (as a complement to the download and processing of data, is also notable MATLab) are planned within what would make up our machine learning model. With this, it will be able to analyse the content of each information package separately, evaluate the complement of one source with another by using the telemetry satelital and metadata to create an even larger package, with even richer features that opt for a statistical analysis of the data by presenting results through a simulator and an interactive map available for user manipulation.

This model includes the use of a double-entry cross-matrix which will be responsible for assessing the input of data on the one hand and on the other the impact analysis generated by previous events and of similar magnitude in order to give a frame of reference to our artificial intelligence and thus it can be possible to estimate the magnitude of the event and possible consequences if this were the natural course of phenomenon and thereby enable the relevant actor to take preventive action and alert the population to considerable time in advance.

USER INTERFACE

The following is a conceptual prototype of the system implementation using its graphical interface:



The user will be able to navigate through the interface offered on an interactive map where there will be highlighted points related to natural events where the user will be able to click as he or she wishes. There will also be a drop-down menu that will serve as a filter in case the user has a preference for a theme. This will clean up the map of the other events so that you will better focus the information.

There will also be a button to display related news (after filtering the event) to show additional information using metadata and tags to relate the news to the content offered.

As the integration and dissemination of the whole is important, the **WINDOW ALERT** tab will make visible the alert level in which the event is located, issued by a body dedicated to the nature of the phenomenon and/or give notice to organizations and entities dedicated to mitigating the impact to which these events submit to us and thereby form a two-way communication of data between these entities with the

As information is power and knowledge if it is not shared, it dies; a **FORUM** will be available in which researchers will be able to discuss issues related to the event, sharing hypotheses, essays, theses and so on, encouraging international cooperation.

On the top button **RESOURCES** you will find the entire repository of information used for the analysis and presentation of the data such as being: satellite links, tracking of them, papers processed for impact analysis, etc.

In **EXPLORE**, the user will be able to navigate a wiki that presents objective information about phenomena, historical backgrounds, decisions taken, etc.

An important feature of the application will be the implementation of **SIMULATOR**, as can already be inferred, it is a simulator that will allow the user to see the evolution of a phenomenon under certain conditions primarily modelled under the intake data to the system. We have already seen the potential of by presenting statistical data and images representative of the evolution of one of the events with the processing of the information provided by the mission SENTINEL and dedicated software.

BIBLIOGRAPHY

Resources Consulted:

MISR. You can see the sunlight reflecting on the waves

https://terra.nasa.gov/about/terra-instruments/misr

MISR Website (Jet Propulsion Laboratory)

https://www-misr.jpl.nasa.gov/

MODIS Website (Goddard Space Flight Center)

https://modis.gsfc.nasa.gov/

AMSR SATELLITE SENSOR

https://www.eorc.jaxa.jp/AMSR/viewer/index.html

Sentinel Website (Hub)

https://www.sentinel-hub.com/explore/apps-and-utilities/

Sentinel Website (Esa)

https://sentinel.esa.int/web/sentinel/user-guides/sentinel-1-sar/applications/maritime-monitoring

Copernicus Open Access Hub Website (Esa)

https://scihub.copernicus.eu/

MATLAB

https://www.mathworks.com/products/matlab.html