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QGIS Exercises

Data & Tools for characterizing the Amazon River Plume

Stefania A. Ciliberti

Nologin Oceanic Weather Systems

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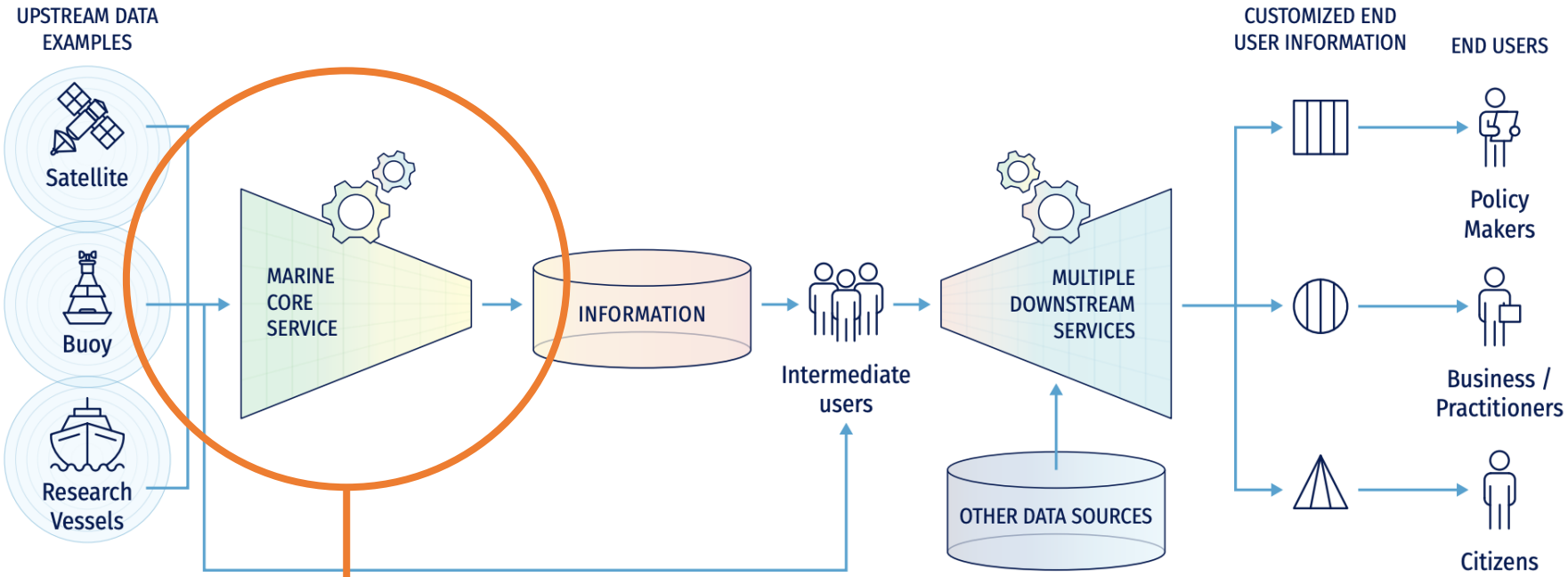
Outline

- Introduction to QGIS and Copernicus Marnine products
- Discussion on implemented workflow for ocean data analysis using QGIS
- Summary of the main results
- References

Operational Ocean Value Chain



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Implemented by MERCATOR OCEAN INTERNATIONAL

- Geospatial Data Management
- Data Analysis
- Data Science for the Ocean

*Picture of OOVC from **ETOOFS Guide***

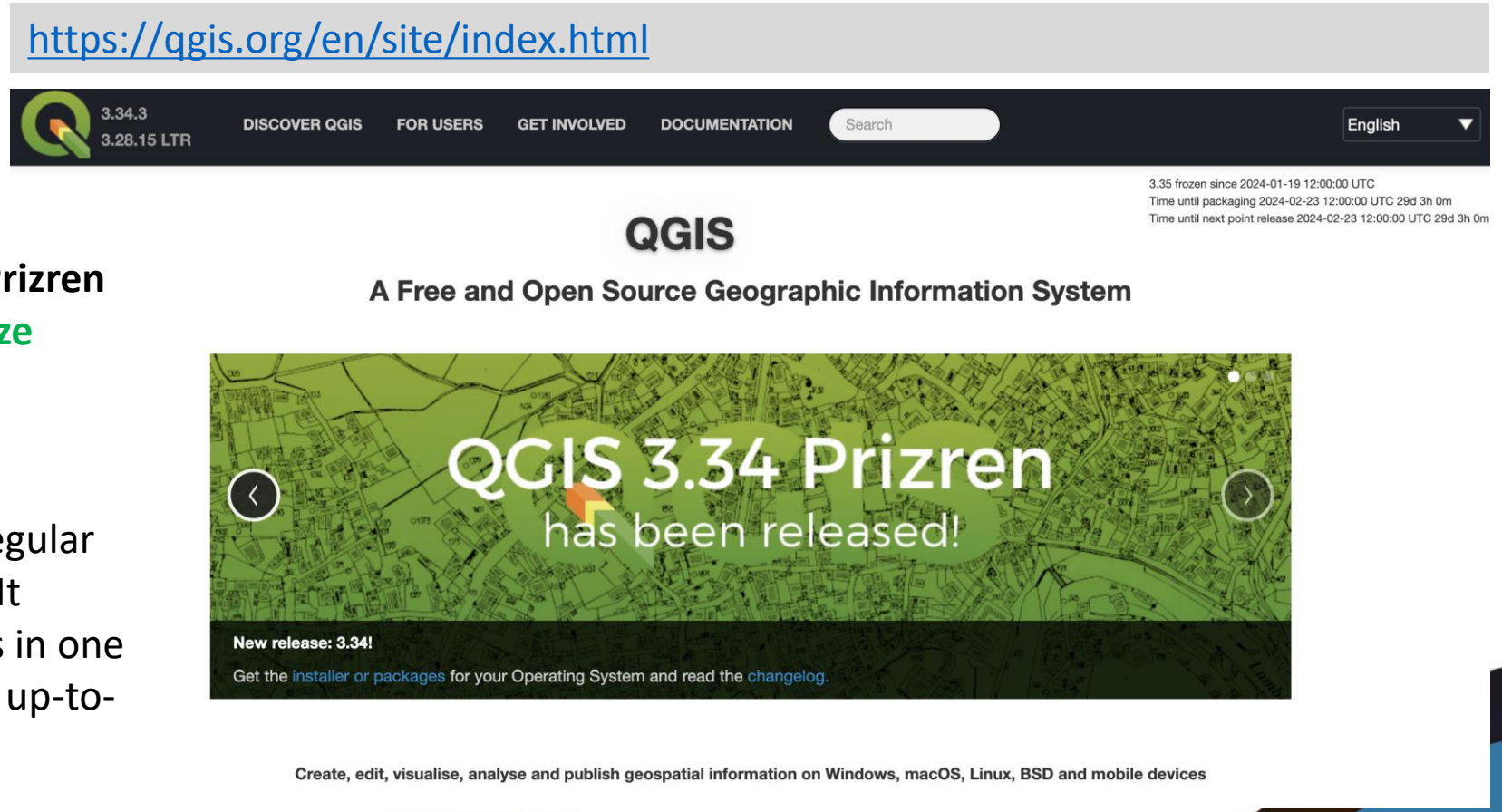
How to perform Geospatial Analysis of Copernicus Marine Data?

QGIS is a Geographical Information System that provides basic and **advanced** functionalities that are helpful for managing and analyzing Copernicus Marine products:

- View data
- Explore data and compose maps
- Create, edit, manage and export data
- Analyze data
- Publish maps on the Internet
- Extedn QGIS functions through plugins
- Python Console

QGIS Installation: an introduction

https://qgis.org/en/site/index.html



<u>Standalone installation</u>:

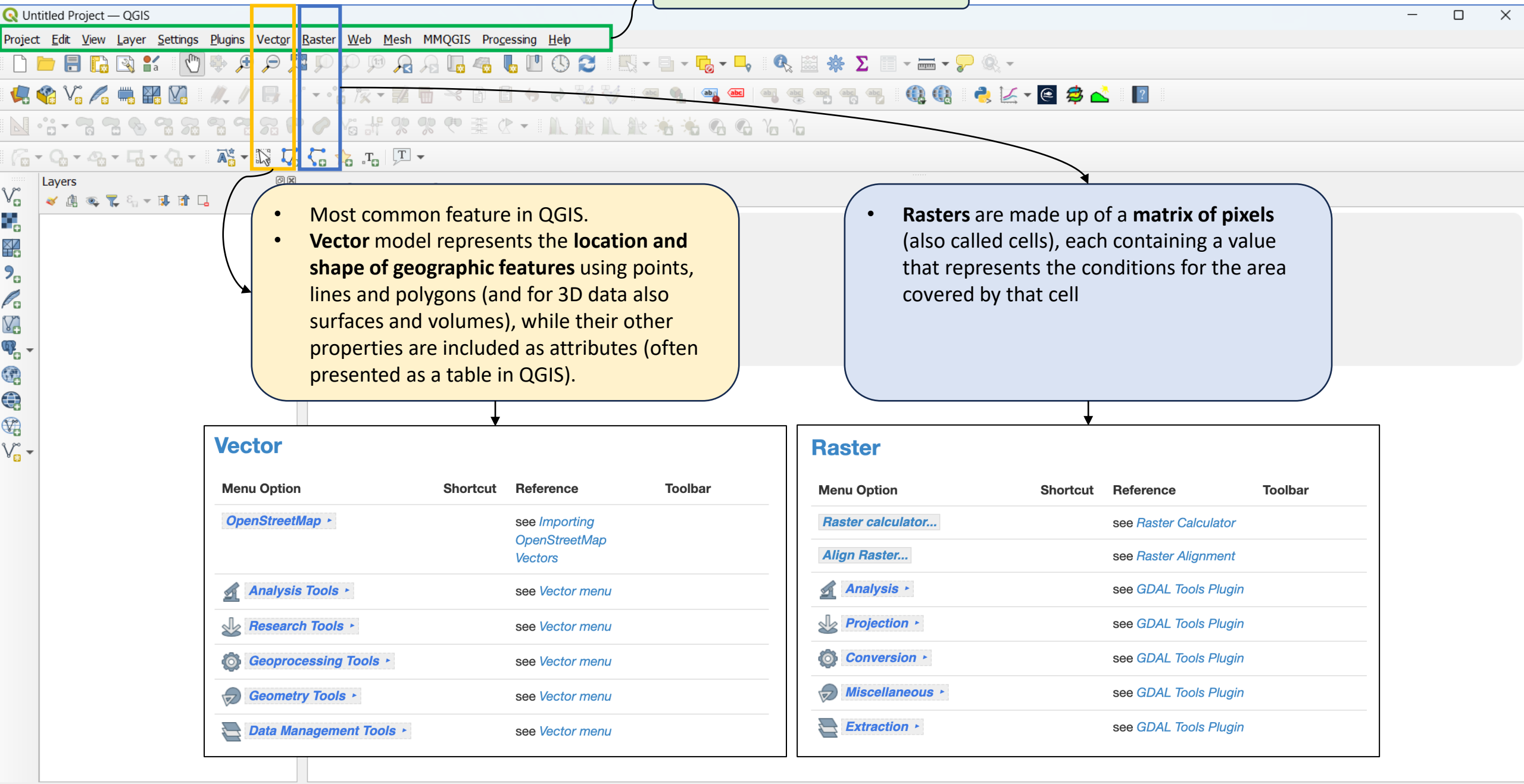
- Last developed version: **QGIS 3.34 Prizren**
- Long Term Release: **QGIS 3.28 Firenze (used in this training!)**

<u>Advanced installation</u>:

- OSGeo4W: it is recommended for regular users or organization deployments. It allows to have several QGIS versions in one place, and to keep each component up-to-date individually without having to download the whole package.

Source: https://docs.qgis.org/3.28/en/docs/

Access to QGIS features



- Most common feature in QGIS.
- **Vector** model represents the **location and shape of geographic features** using points, lines and polygons (and for 3D data also surfaces and volumes), while their other properties are included as attributes (often presented as a table in QGIS).

- **Rasters** are made up of a **matrix of pixels** (also called cells), each containing a value that represents the conditions for the area covered by that cell

Vector

Menu Option	Shortcut	Reference	Toolbar
OpenStreetMap		see *Importing OpenStreetMap Vectors*	
Analysis Tools		see *Vector menu*	
Research Tools		see *Vector menu*	
Geoprocessing Tools		see *Vector menu*	
Geometry Tools		see *Vector menu*	
Data Management Tools		see *Vector menu*	

Raster

Menu Option	Shortcut	Reference	Toolbar
Raster calculator...		see *Raster Calculator*	
Align Raster...		see *Raster Alignment*	
Analysis		see *GDAL Tools Plugin*	
Projection		see *GDAL Tools Plugin*	
Conversion		see *GDAL Tools Plugin*	
Miscellaneous		see *GDAL Tools Plugin*	
Extraction		see *GDAL Tools Plugin*	

Source: https://events.marine.copernicus.eu/marinedata4southamerica-2024/content/qgis

E-Learning Materials

Access our tutorials online, accompanied by videos, code, and more.

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QGIS

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Practical Session Guidelines

This guide includes a few steps you will need to take to start your QGIS practice!

Guidelines

STEP 1: download open-source software

If you don't have access to a QGIS software yet, download the open-source software

Download

STEP 2: Download Copernicus Marine QGIS Plugin

To open NetCDF files, which is the file format of Copernicus Marine Service products, in QGIS you will need to download the Copernicus Marine Service QGIS Plugin CMEMS-NetCDF

Plugin

Stefania Ciliberti
Senior Scientist
Nologin Oceanic Weather Systems

QGIS Installation Notes

QGIS Installation notes

This video presents basic steps on how to download and install QGIS in your computer using the standalone installer and the OSGeo4W advanced one. Examples are given for Windows OS. You can also download the PDF by clicking on the following button:

Download PDF

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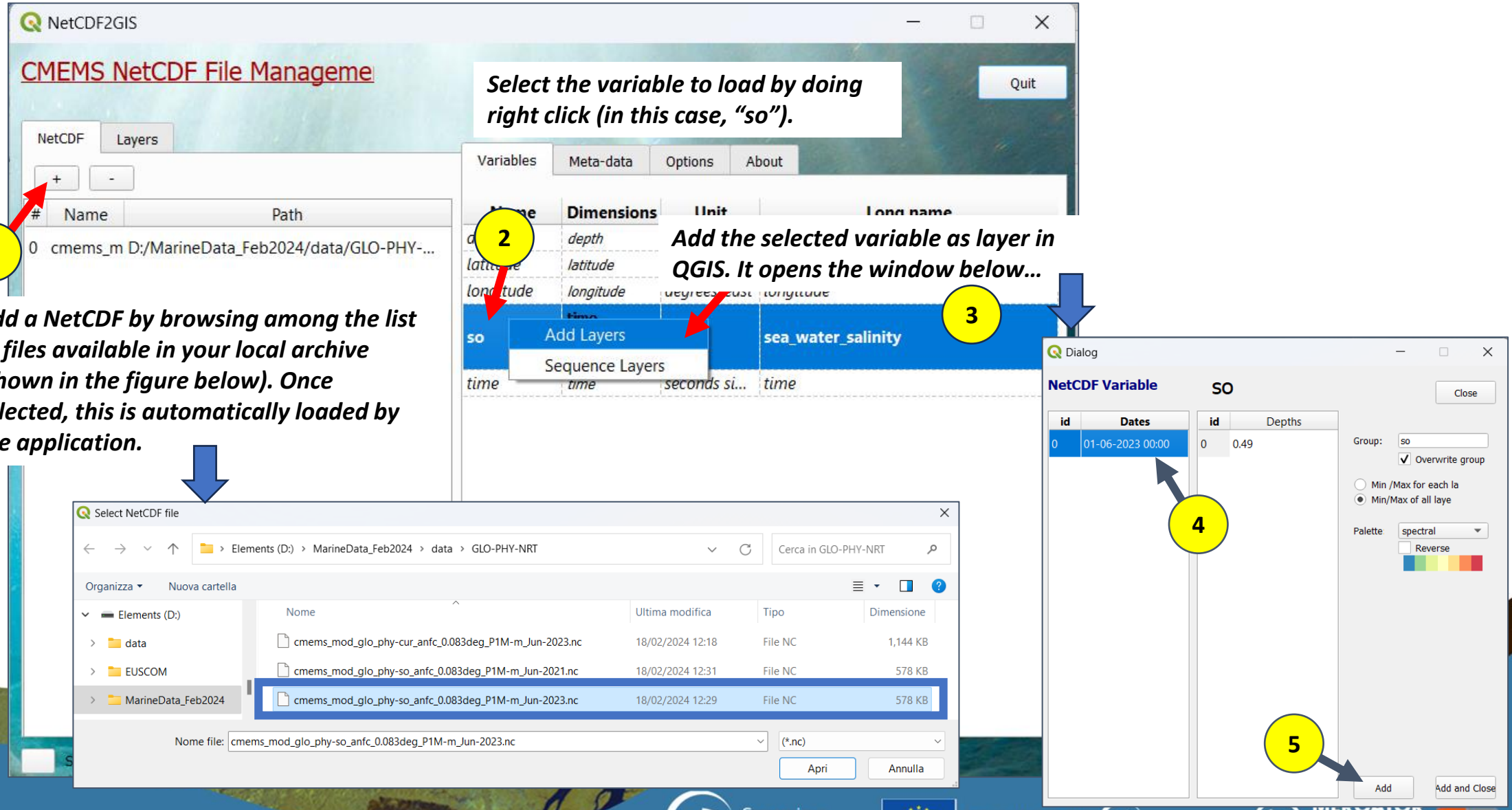
Copernicus Marine NetCDF Plugin



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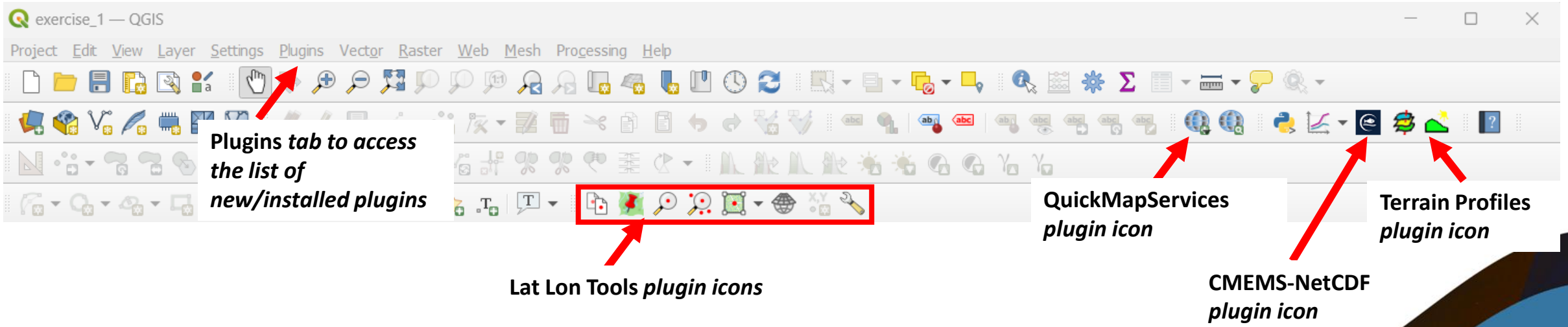
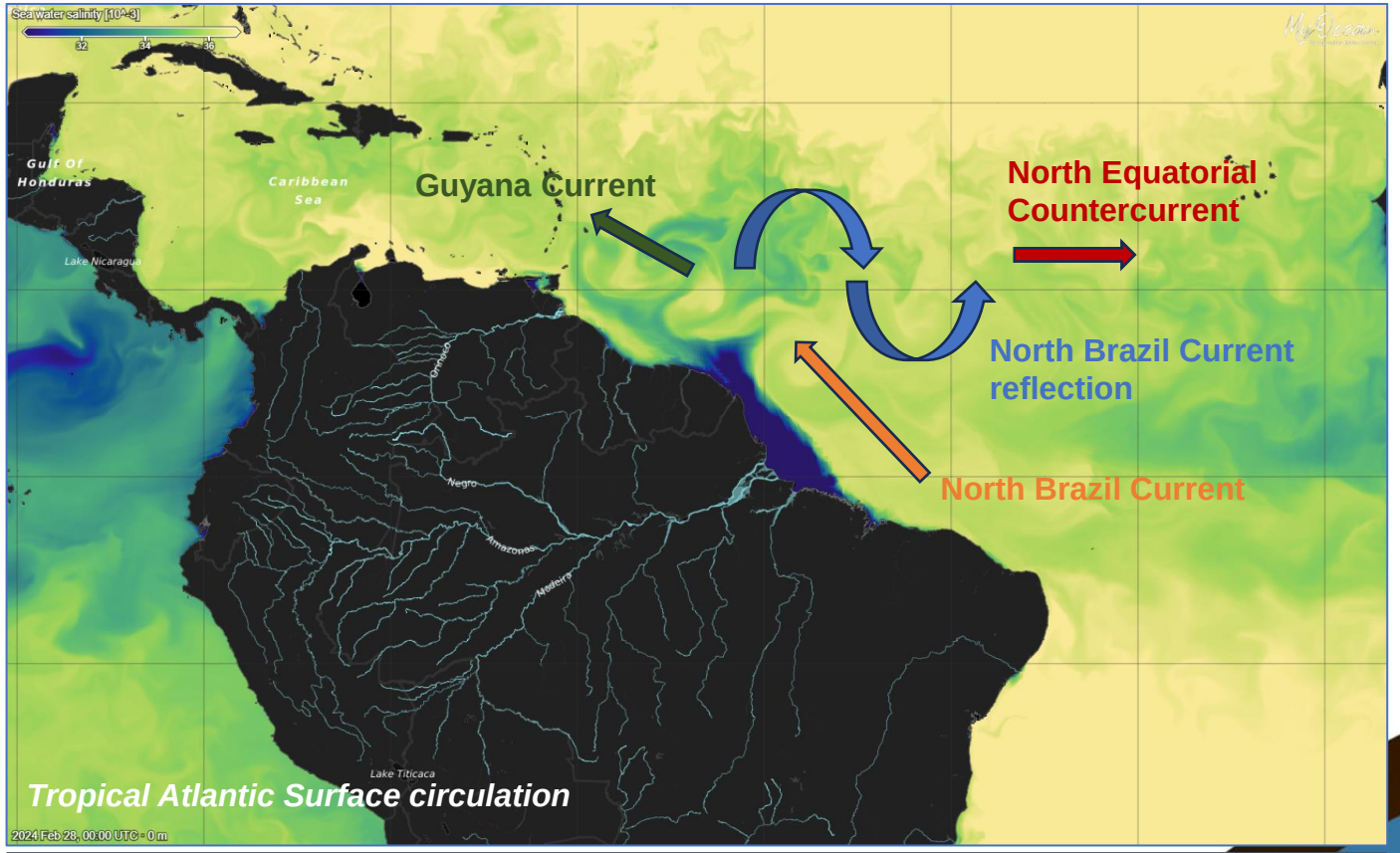
Additional Plugins used in this Training

- **QuickMapService**, for loading a basemap (e.g., Google, ESRI, etc.)
- **Lat Lon Tools**, for querying the map and facilitating the creation of bounding box by identifying its coordinates
- **Terrain Profile**, for extracting sections/transects in interactive way



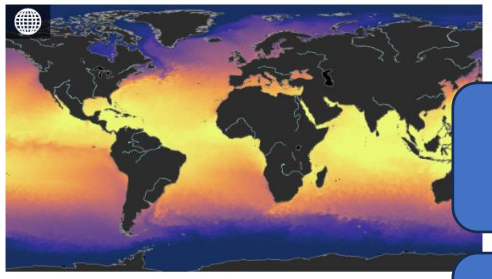
Scope of the Training Session

- Visualize the Copernicus Marine products in the **Western Tropical Atlantic**, extracting Essential Ocean Variables (EOV) values in same specific locations.
- Perform a geospatial analysis of physical and biogeochemical conditions in the **Amazon River plume region and in its delta**.



Schematic representation of surface circulation affecting the Amazon River Plume adapted from Gouveia et al. 2019.

Upstream Data used in QGIS

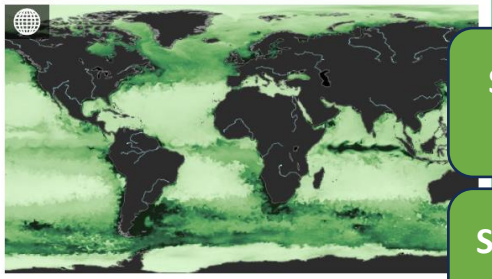


Global Ocean Physics Analysis and Forecast

GLOBAL_ANALYSISFORECAST_PHY_001_024
Models
Global, 0.083° × 0.083° × 50 levels
1 Nov 2020 to 3 Mar 2024, hourly, daily, monthly
Mixed layer thickness, salinity, sea ice, sea surface height, temperature, velocity, wave

Sea Surface Salinity – *Monthly Mean*

Sea Surface Currents – *Monthly Mean*



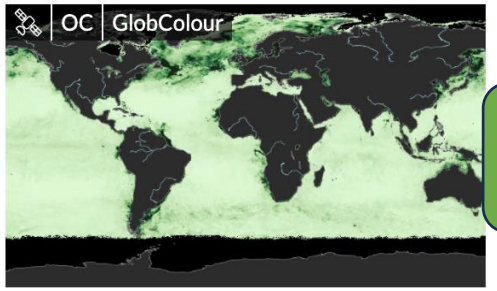
Global Ocean Biogeochemistry Analysis and Forecast

GLOBAL_ANALYSISFORECAST_BGC_001_028
Models
Global, 0.25° × 0.25° × 50 levels
1 Oct 2021 to 1 Mar 2024, daily, monthly
Carbonate system, nutrients, optics, oxygen, plankton

Surface Chlorophyll – *Monthly Mean*

Surface Phytoplankton – *Monthly Mean*

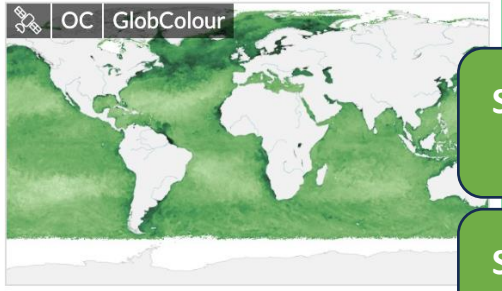
Dissolved Oxygen – *Monthly Mean*



Global Ocean Colour (Copernicus-GlobColour), Bio-Geo-Chemical, L4...

OCEANCOLOUR_GLO_BGC_L4_NRT_009_102
Satellite (L4)
Global, 4 × 4 km
1 Apr 2023 to 21 Feb 2024, daily, monthly
Optics, plankton

Surface Chlorophyll at 300 m res. - *Monthly*



Global Ocean Colour (Copernicus-GlobColour), Bio-Geo-Chemical, L4...

OCEANCOLOUR_GLO_BGC_L4_MY_009_104
Satellite (L4)
Global, 4 × 4 km
1 Sep 1997 to 14 Feb 2024, daily, monthly
Optics, plankton

Surface Chlorophyll at 300 m res. - *Monthly*

Surface Chlorophyll at 4 km res. - *Monthly*

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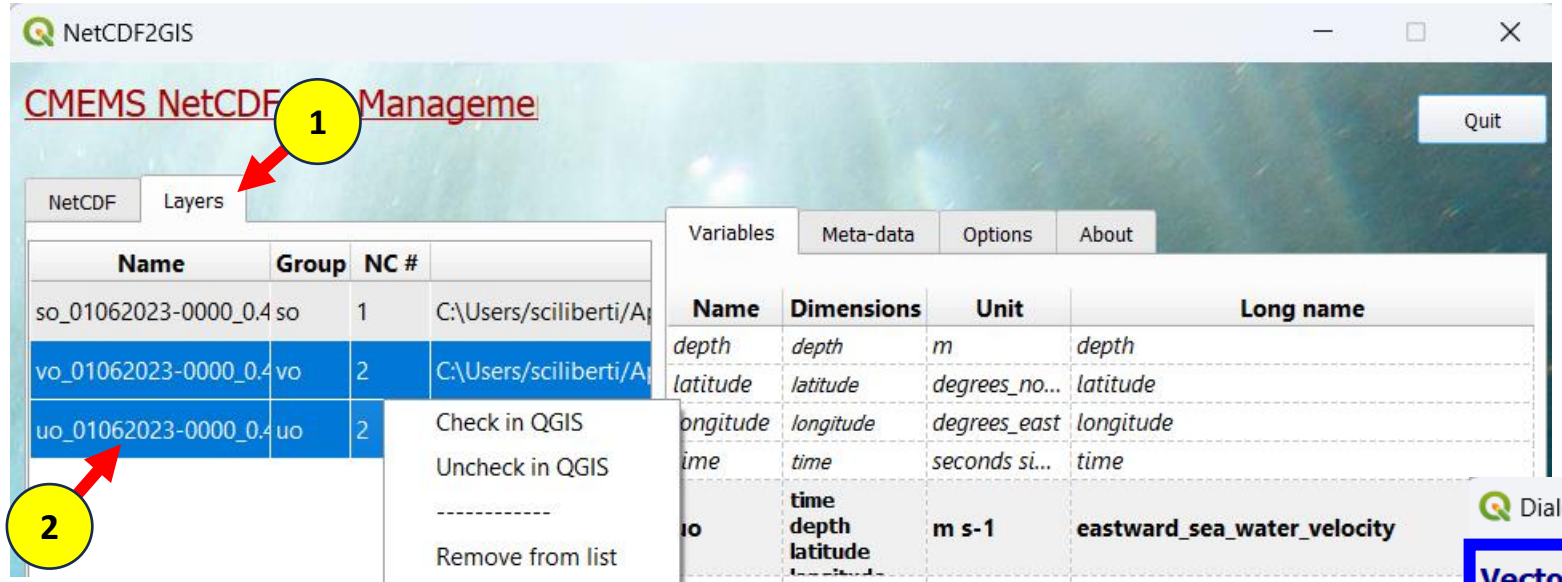
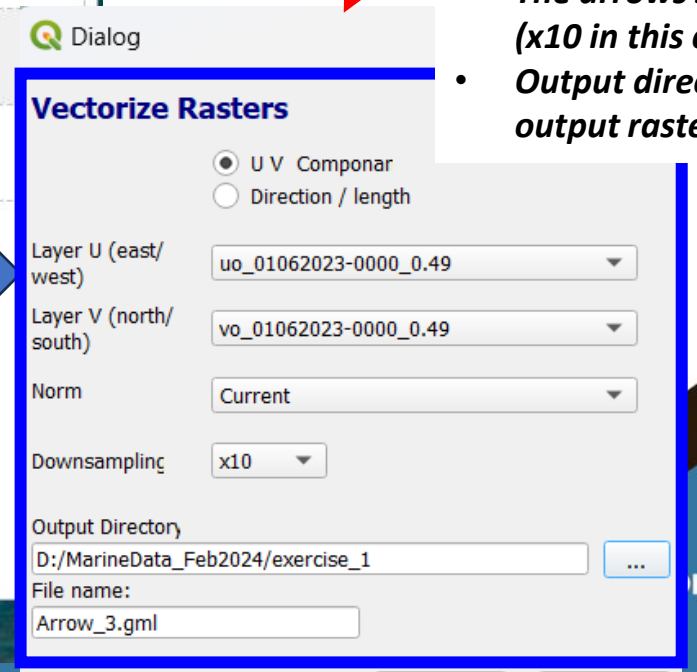
Exercise 1: Visualization of Copernicus Marine EOV

Sea Surface Currents – *Monthly Mean*

- To visualize EOV from Copernicus Marine Catalogue in QGIS, we use the **CMEMS NetCDF plugin**.



Select both uo and vo by clicking ctrl + uo_* and vo_* simultaneously.
Do right click on the multiple selection and select "Vectorize"



"Vectorize" opens a new dialog window where to specify:

- ***The raster related to U component (uo)***
- ***The raster related to V component (vo)***
- ***The type of normalization (Current)***
- ***The arrows sampling (x10 in this case)***
- ***Output directory and output raster name***

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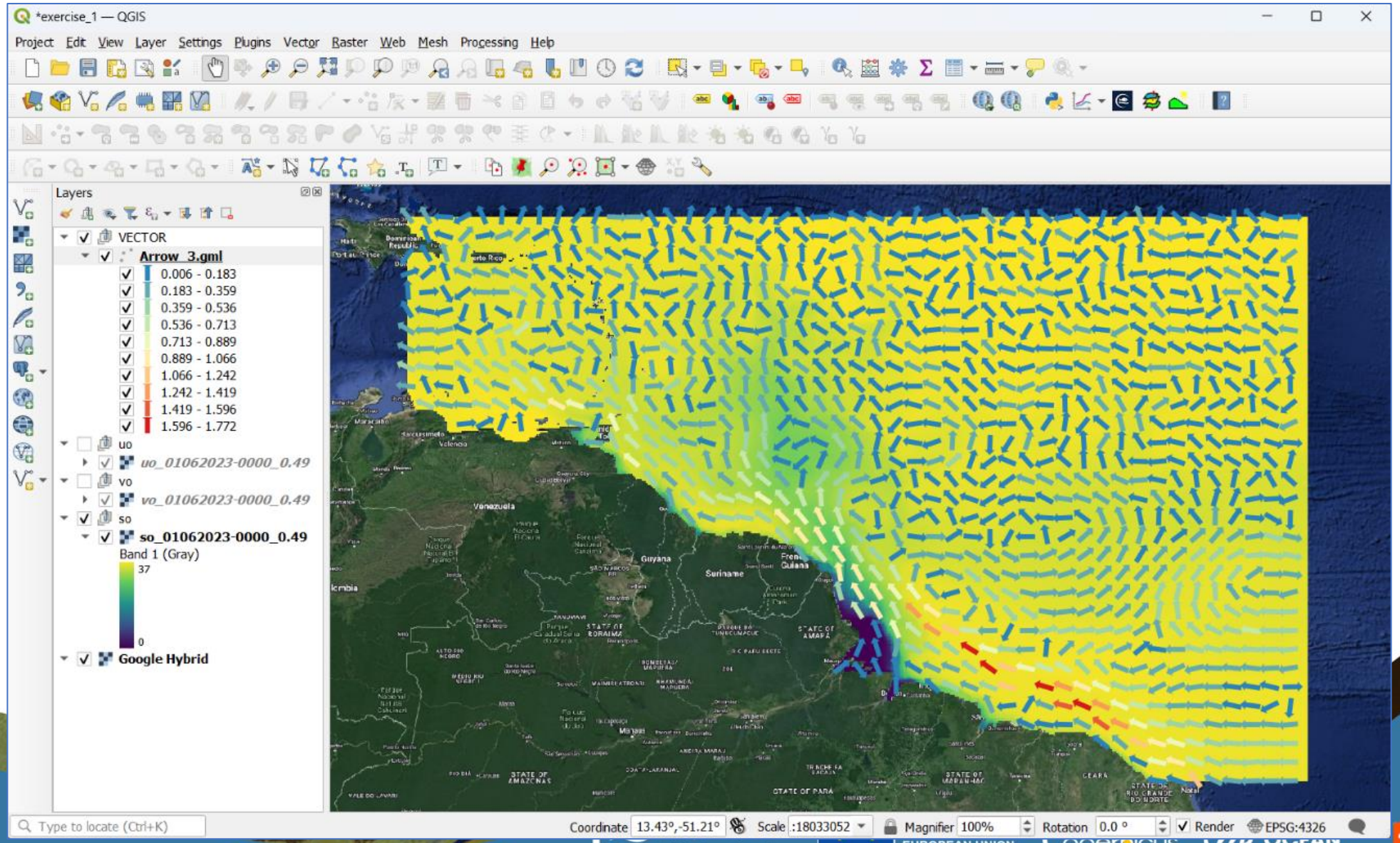
Exercise 1: Visualization of Copernicus Marine EOV

Sea Surface Currents – *Monthly Mean*



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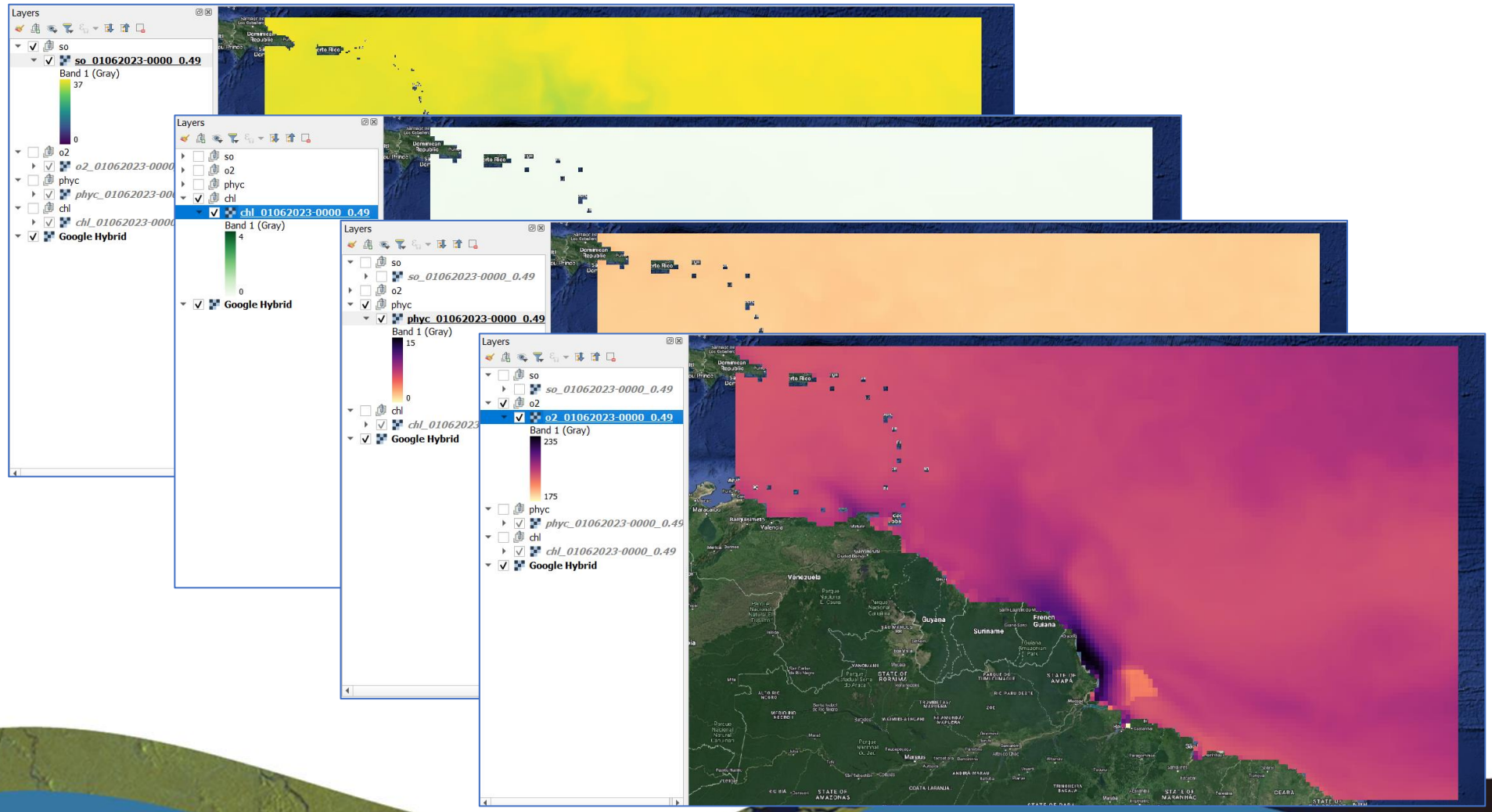
Exercise 2: Characterization of the physical & biogeochemical sea state in Jun 2023

Sea Surface Salinity – *Monthly Mean*

Surface Chlorophyll – *Monthly Mean*

Surface Phytoplankton – *Monthly Mean*

Dissolved Oxygen – *Monthly Mean*



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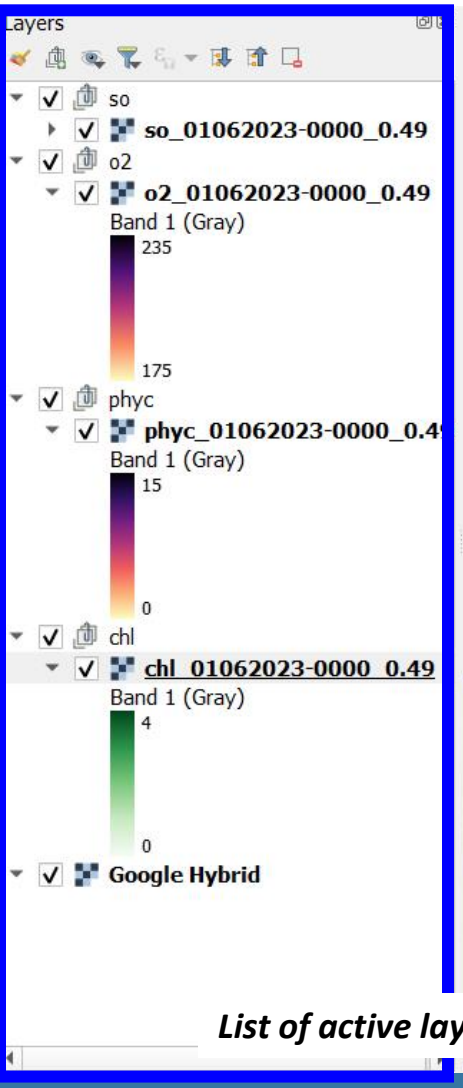
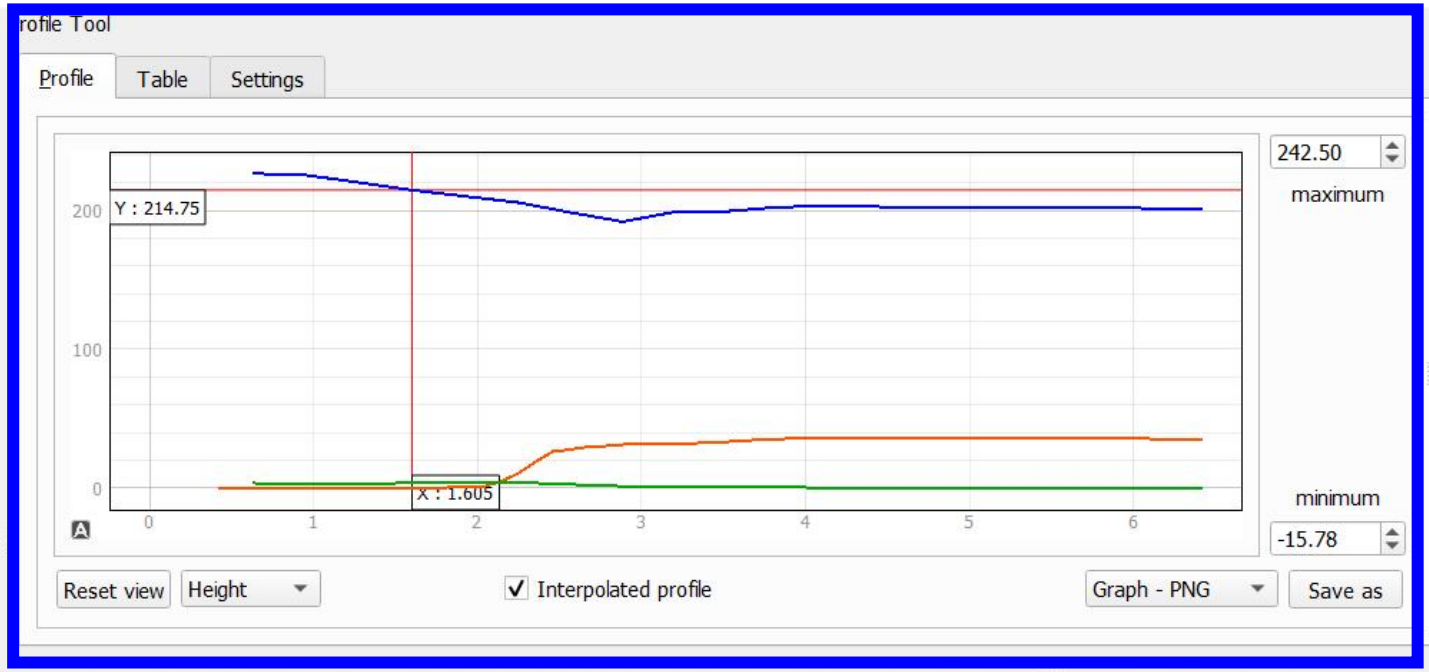
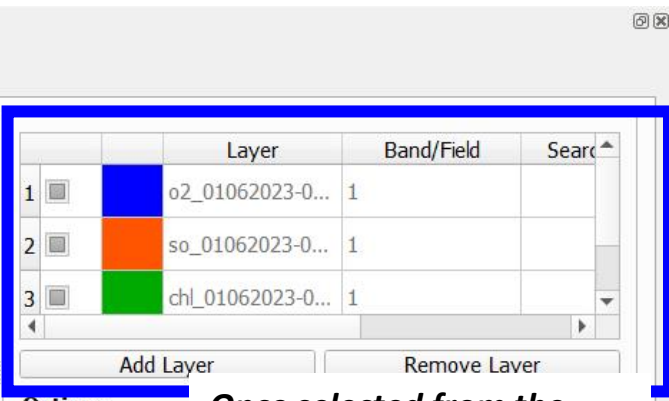
Exercise 2: Characterization of the physical & biogeochemical sea state in Jun 2023

- To extract EOV spatial variability along a specific section *on the fly*, we use the **Terrain Profiles plugin**.



List of active layers





Once selected from the Layer board, the active layers are loaded in the Terrain Profile tool and ready to be queried

Section as drawn in the map

Exercise 2: Characterization of the physical & biogeochemical sea state in Jun 2023

- To extract EOV spatial variability along specific transects, we use the **Transects QGIS function.**

Workflow

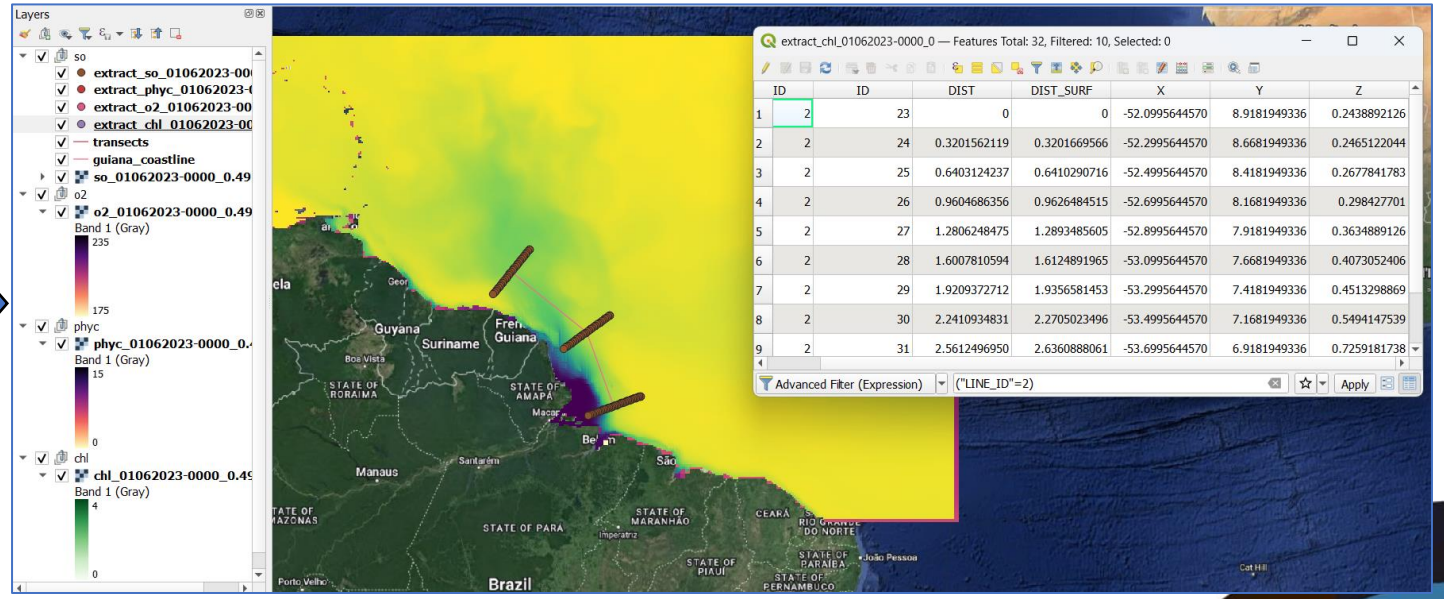
Selection of the input fields ***chl_*, o2_*, so_*, phyc_**

Creation of the baseline and sections layout ***transects***

Profile by lines

Run as batch process

EOV extracted in the given sections *transect_chl*, transect_o2*, transect_so*, transect_phyc*

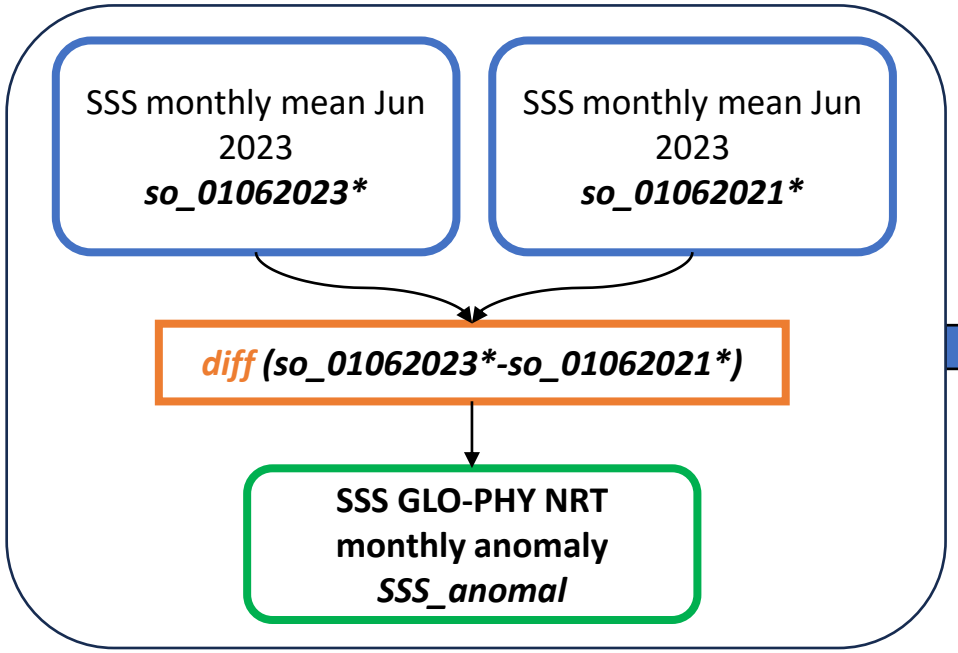


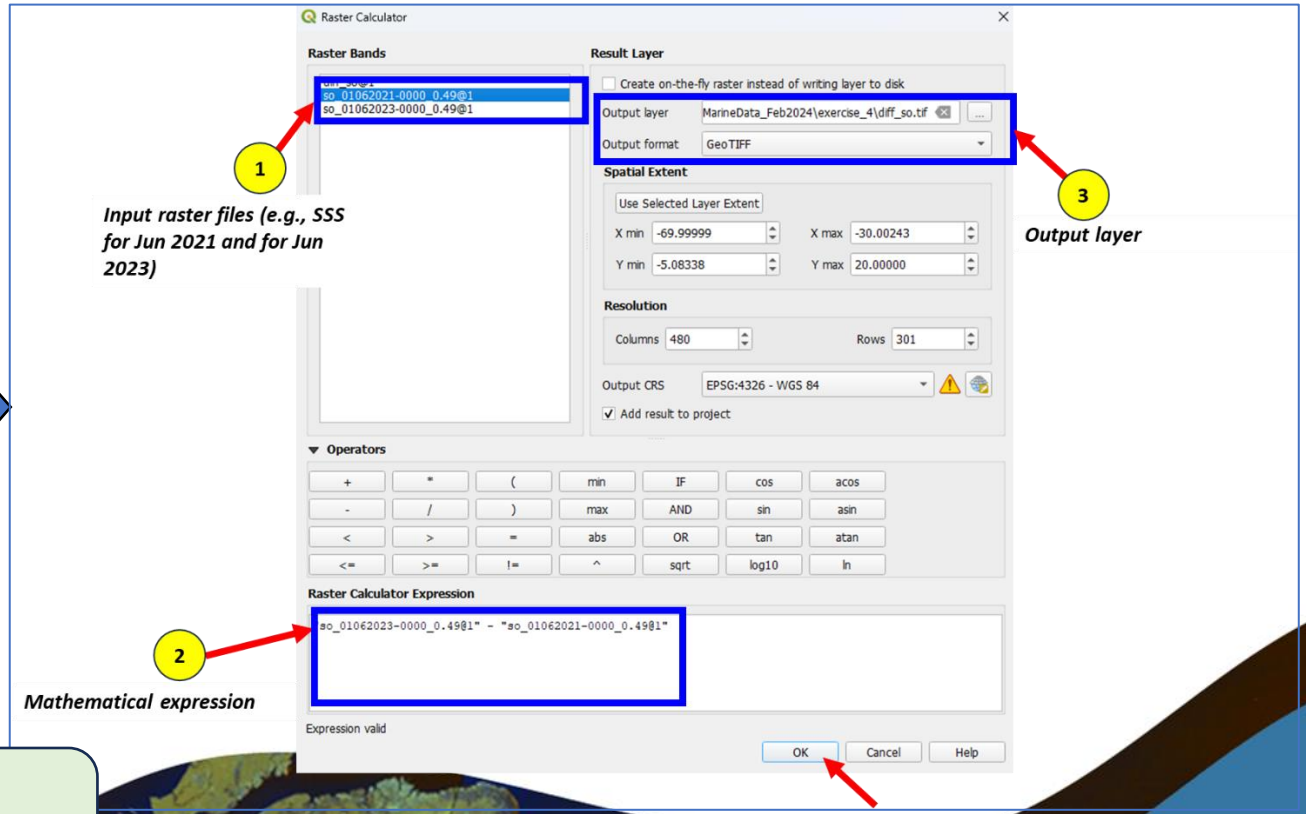
- **Transects function** provides an easy way to design linear transects with sampling stations distributed at a given distance along the transect.

Exercise 3: The Amazon River Plume

Objective: to show QGIS functionalities for performing some geospatial analysis for characterizing the Amazon River plume, considering 2 specific periods: Jun 2021, during which an extreme flood occurred (Espinoza et al., 2022), and Jun 2023, characterized by prolongated droughts.

Workflow





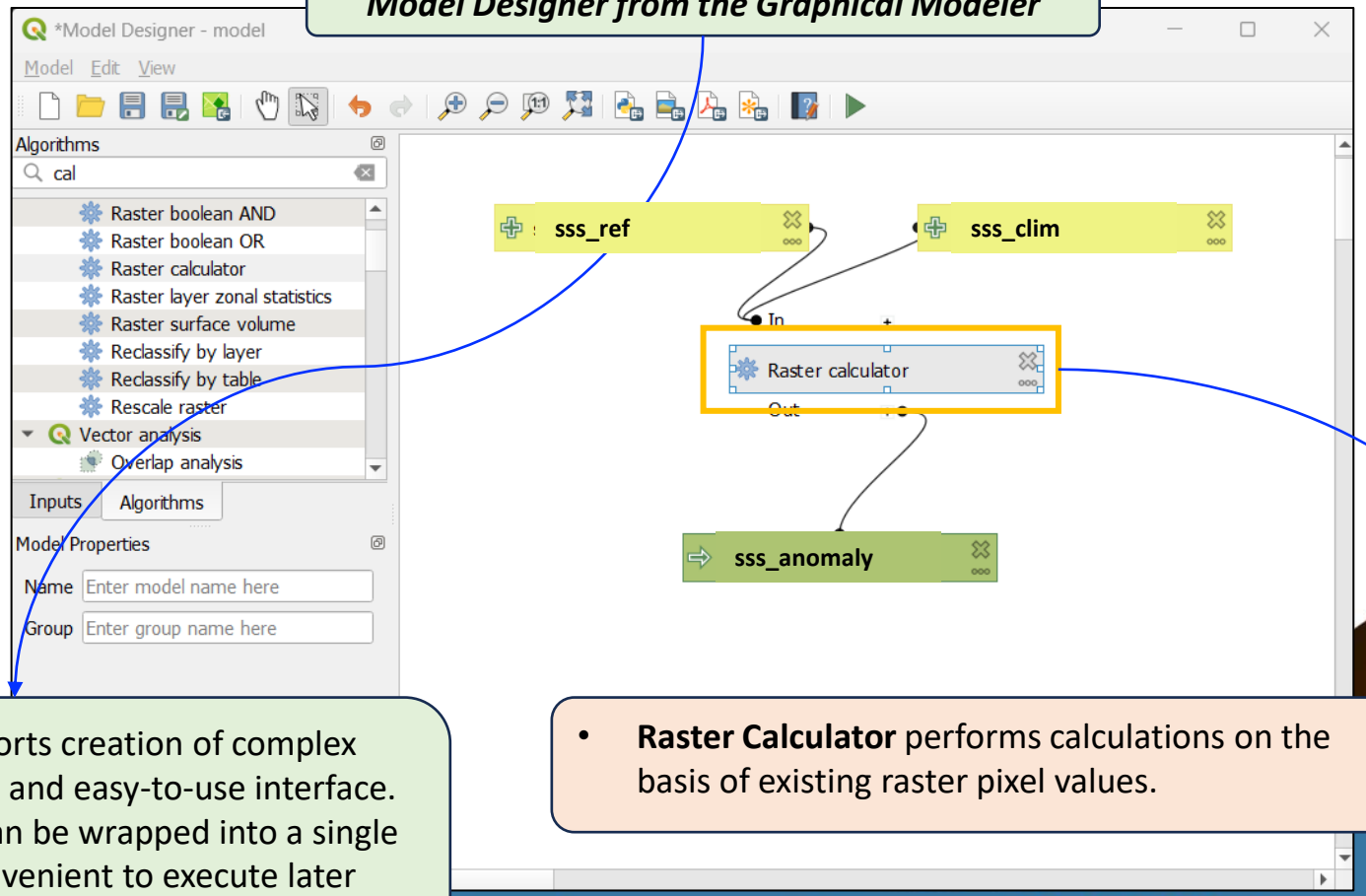
- **Raster Calculator** allows you to perform calculations on the basis of existing raster pixel values

Exercise 3: The Amazon River Plume

Objective: to show QGIS functionalities for performing some geospatial analysis for characterizing the Amazon River plume, considering 2 specific periods: Jun 2021, during which an extreme flood occurred (Espinoza et al., 2022), and Jun 2023, characterized by prolongated droughts.

Tips & Tricks: if you would compute SSS anomaly for a longer timeseries, you can build the workflow through the **Graphical Calculator**

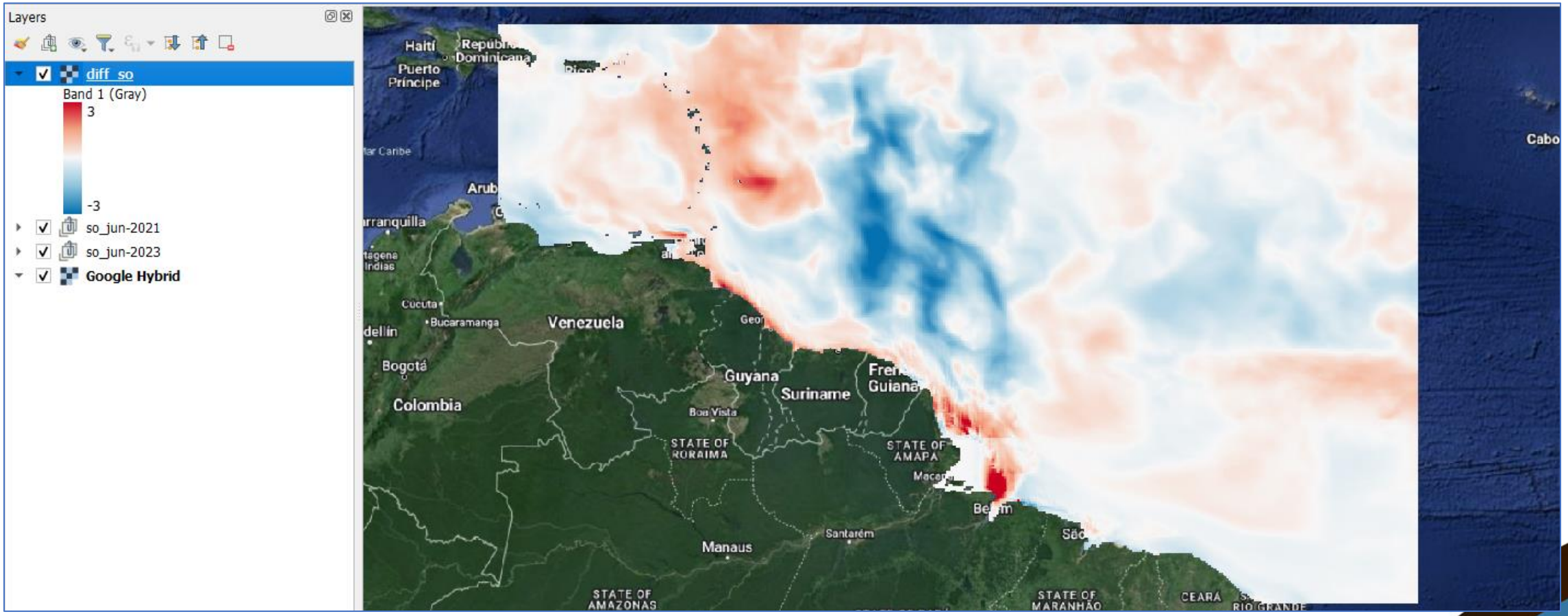
Model Designer from the Graphical Modeler



- **Model Designer** supports creation of complex models using a simple and easy-to-use interface.
- Chain of operations can be wrapped into a single process, making it convenient to execute later with a different set of input.

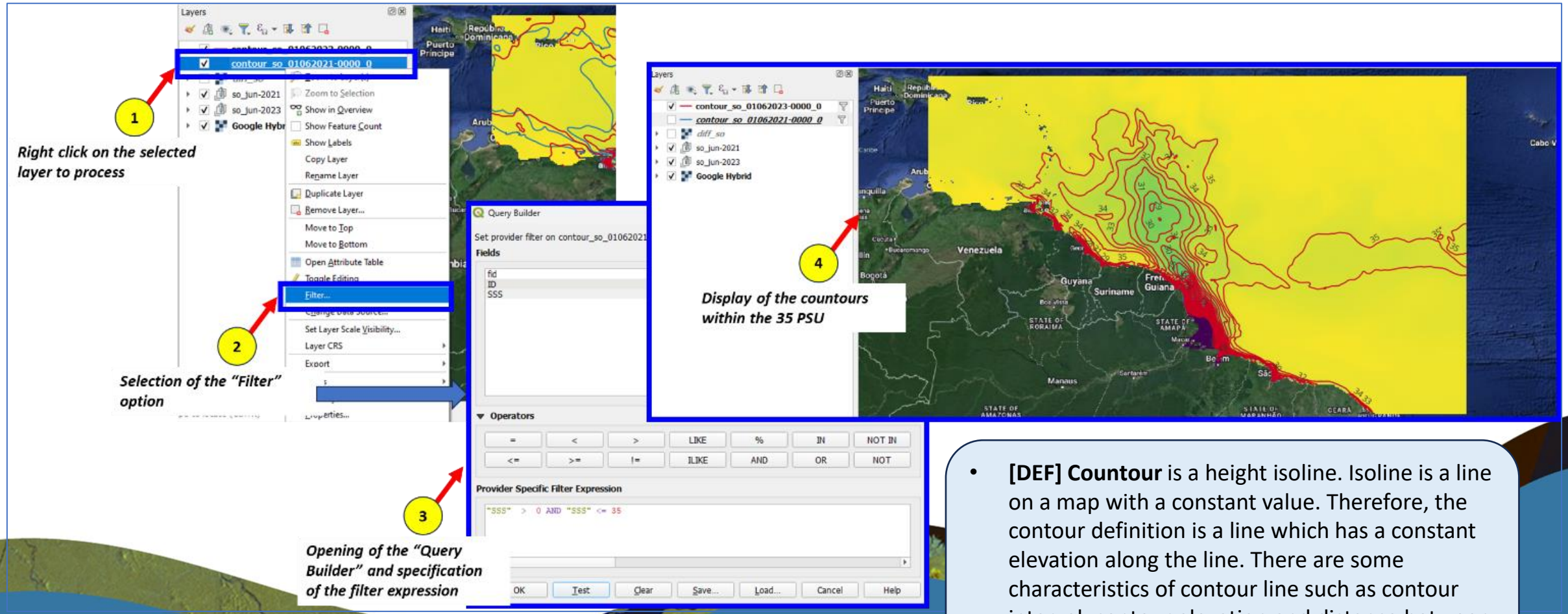
- **Raster Calculator** performs calculations on the basis of existing raster pixel values.

Exercise 3: The Amazon River Plume



Exercise 3: The Amazon River Plume

Objective: to extract contours from given raster files and filter the ones within 35 PSU.
This is done by using the **Countour QGIS function (batch process)**



- **[DEF] Countour** is a height isoline. Isoline is a line on a map with a constant value. Therefore, the contour definition is a line which has a constant elevation along the line. There are some characteristics of contour line such as contour interval, contour elevation and distance between contour lines.

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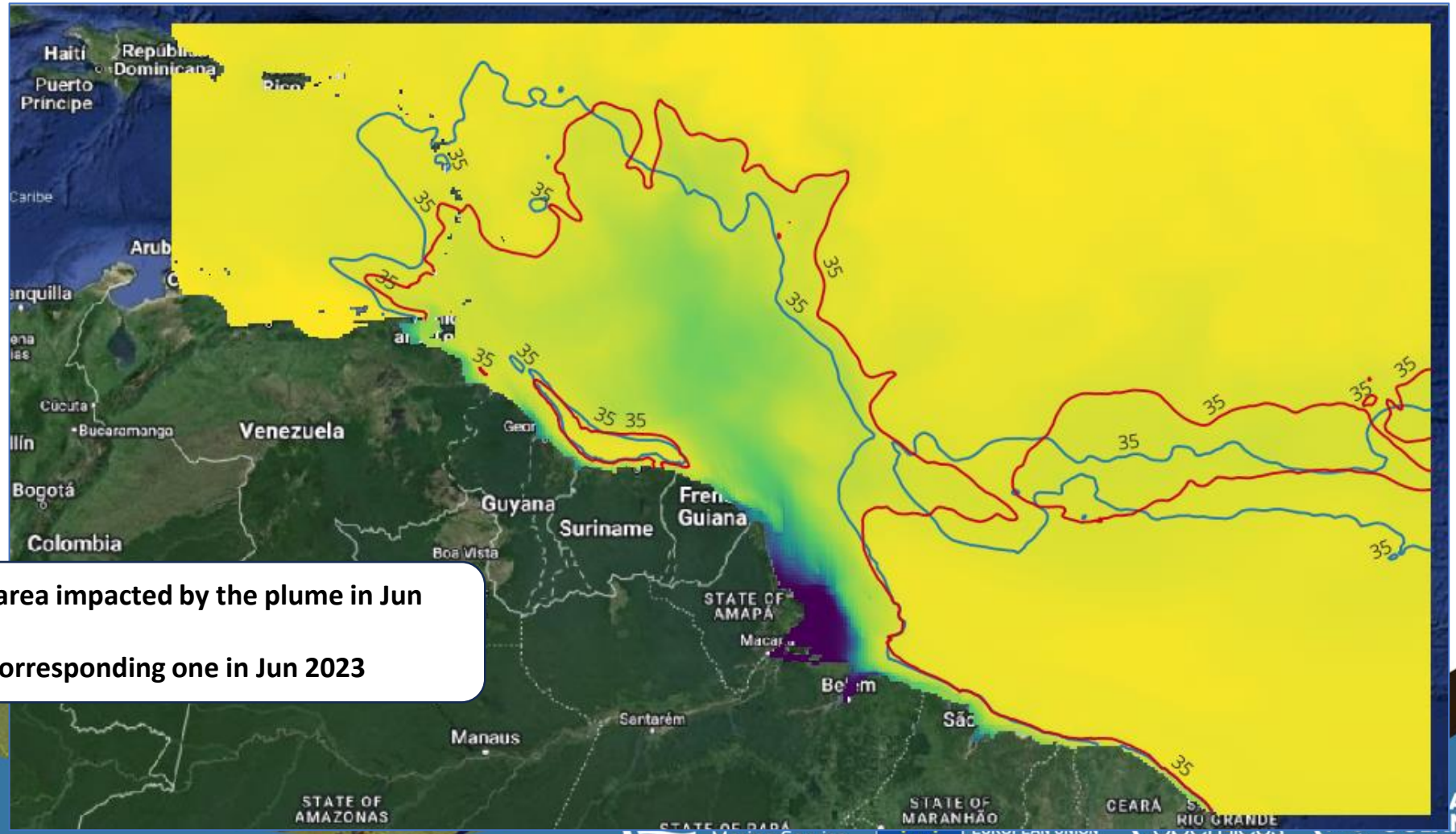
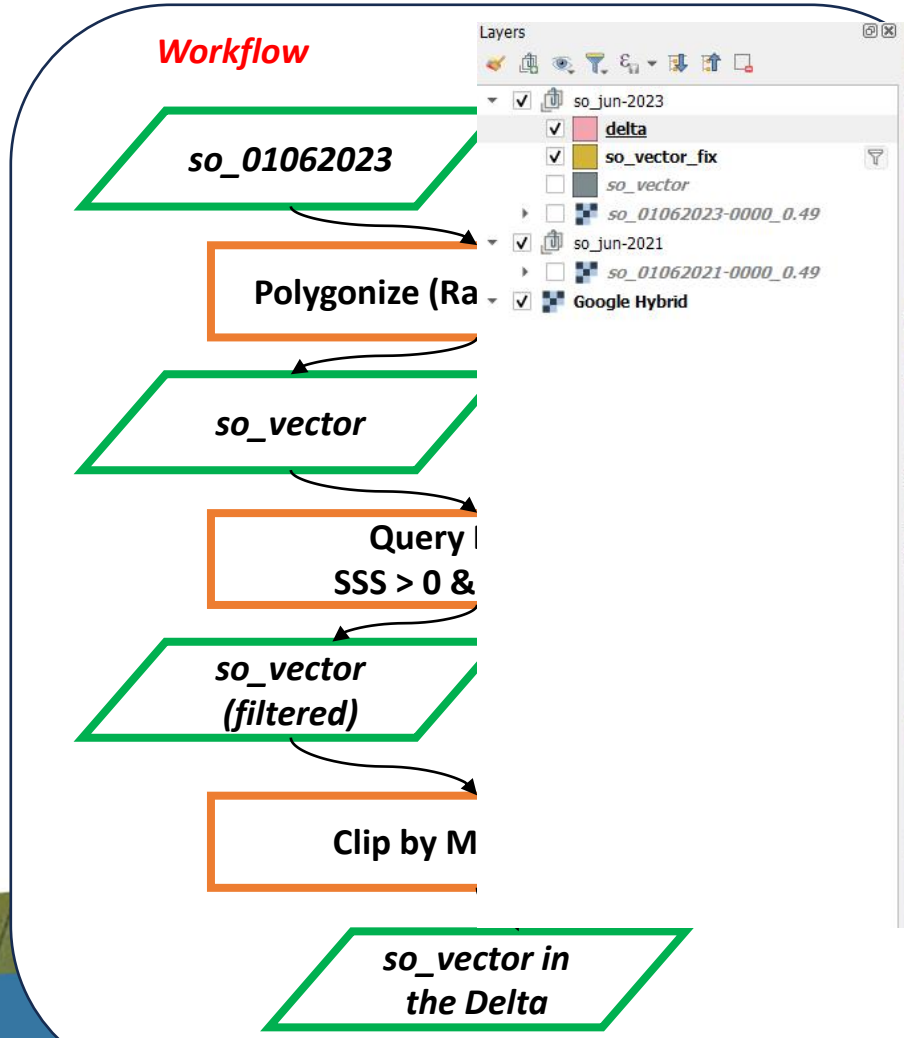
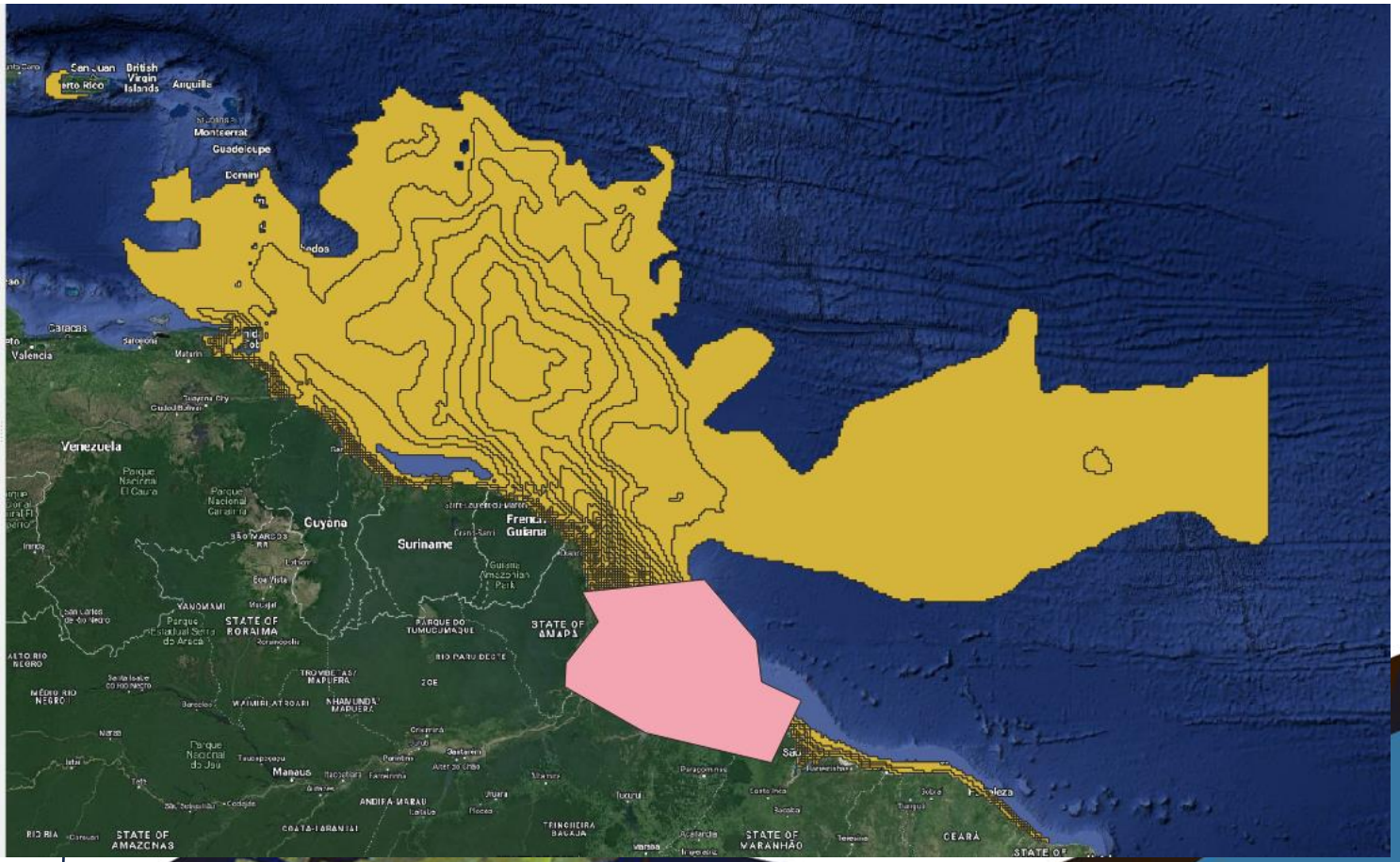


- In Blue: the area impacted by the plume in Jun 2021
- In Red: the corresponding one in Jun 2023

Exercise 3: The Amazon River Plume

Objective: to perform geospatial analysis in the Delta region.





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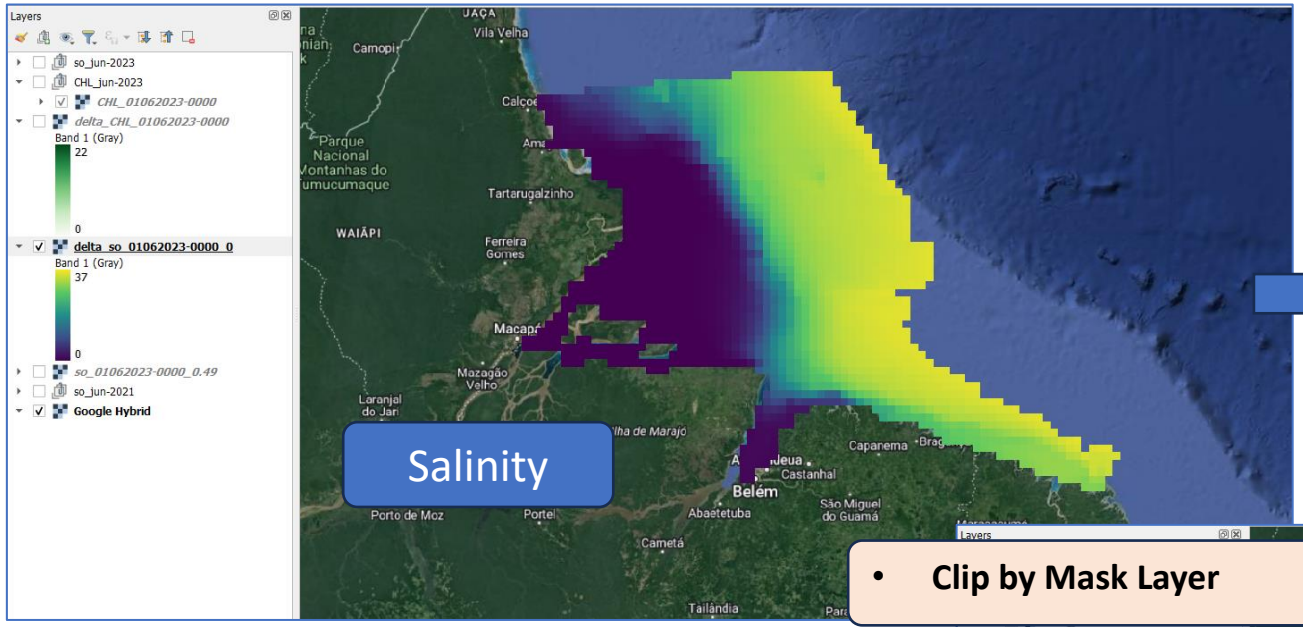
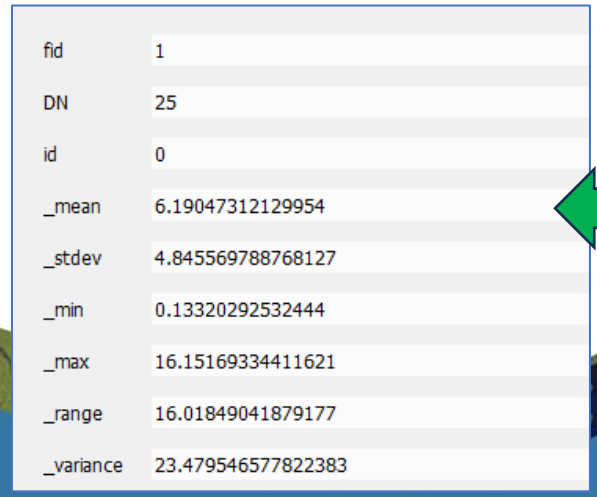


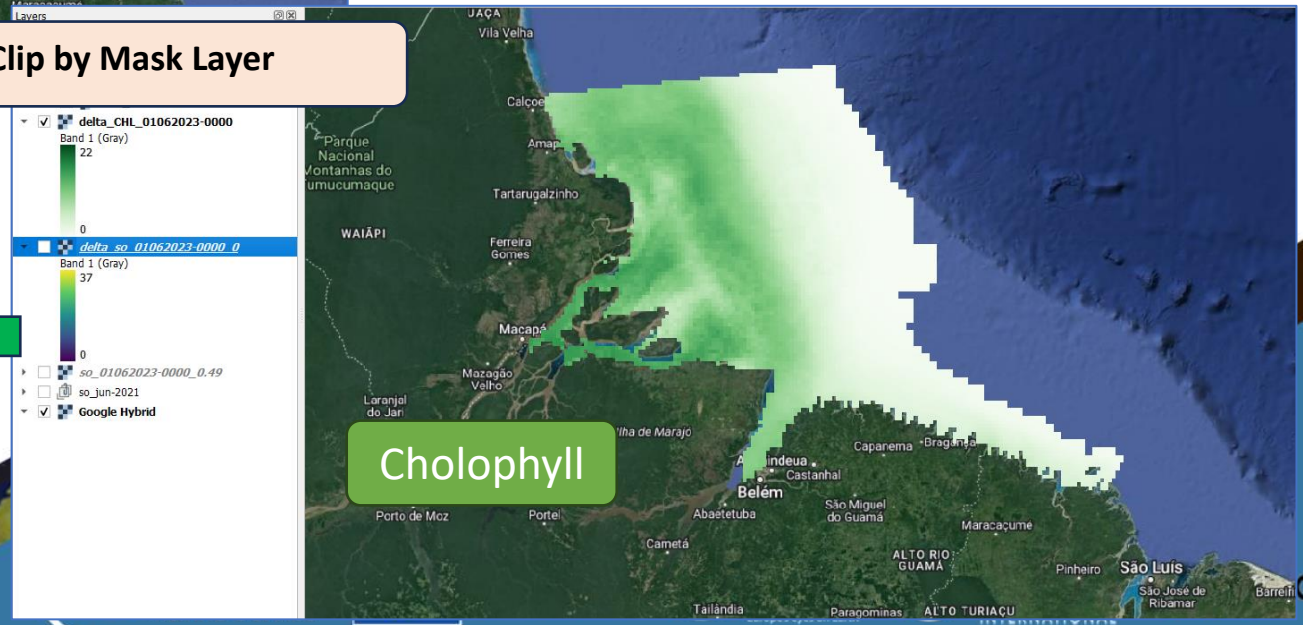
fid	1
DN	25
id	0
_mean	18.681636268764194
_stdev	14.578451066194102
_min	0.0016336377011612058
_max	35.494956970214844
_range	35.49332333251368
_variance	212.53123548941596

- **Zonal Statistics** calculates statistics of a raster layer for each feature of an overlapping polygon vector layer.

- **Clip by Mask Layer**



fid	1
DN	25
id	0
_mean	6.19047312129954
_stdev	4.845569788768127
_min	0.13320292532444
_max	16.15169334411621
_range	16.01849041879177
_variance	23.479546577822383



Source: https://events.marine.copernicus.eu/marinedata4southamerica-2024/content/qgis

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QGIS

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To open NetCDF files, which is the file format of Copernicus Marine Service products, in QGIS you will need to download the Copernicus Marine Service QGIS Plugin CMEMS-NetCDF

Plugin

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Summary of the main outcomes

- QGIS offers capacity for **geospatial analysis of Copernicus Marine products**.
- Functions like ”Raster Calculator”, “Transects” and “Countour” offer the possibility to **execute automatically numerical algorithms**:
  - Calculating SSS anomalies over a given period.
  - Extracting countour line from salinity to detect the area of influence of the Amazon River plume.
- It has been shown how to **extract raster values over an assigned shapefile** (e.g., irregular polygon)
- Using “Zonal Statistics” it is possible to compute automatically **averaged EOV quantities** for monitoring and validation purposes.

References

- Espinoza, J.-C., Marengo, J.A., Schongart, J., Jimenez, J.C. (2022). The new historical flood of 2021 in the Amazon River compared to major floods of the 21st century: Atmospheric features in the context of the intensification of floods. Weather and Climate Extremes, 35, 100406. https://doi.org/10.1016/j.wace.2021.100406

- Fournier, S., Chapron, B., Salisbury, J., Vandemark, D., Reul, N. (2015). Comparison of spaceborne measurements of sea surface salinity and colored detrital matter in the Amazon plume. J. Geophys. Res. Oceans, 120. https://doi.org/10.1002/2014JC010109

- Gouveia, N.A., Gherardi, D.F.M., Wagner, F.H., Paes, E.T., Coles, V.J., Aragao, L.E.O.C. (2019). The Salinity Structure of the Amazon River Plume Drives Spatiotemporal Variation of Oceanic Primary Productivity. Journal of Geophysical Research: Biogeosciences, 124, 147-165. https://doi.org/10.1029/2018JG004665

- Copernicus Webinar - MarineData4SouthAmerica2024: https://events.marine.copernicus.eu/marinedata4southamerica-2024


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Thank you all!