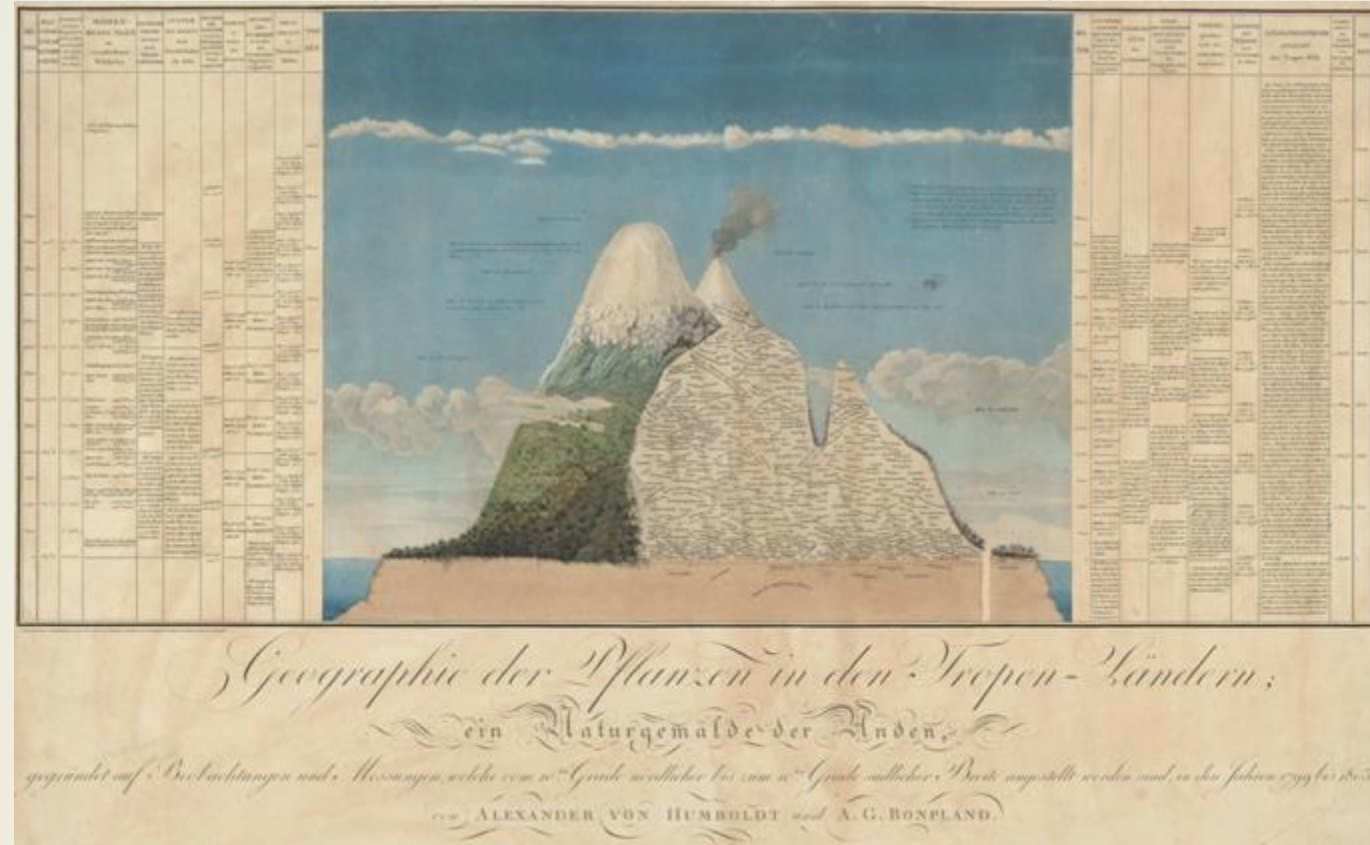


# Virtual Research Environments

Antonello Provenzale, CNR-IGG  
Eugenio Trumpy, CNR-IGG



von Humboldt and Bonpland, Naturgemälde

IR0000032 – ITINERIS, Italian Integrated Environmental Research Infrastructures System (D.D. n. 130/2022 - CUP B53C22002150006) Funded by EU - Next Generation EU PNRR-Mission 4 "Education and Research" - Component 2: "From research to business" - Investment 3.1: "Fund for the realisation of an integrated system of research and innovation infrastructures"

**Biosphere**

**Atmosphere**

**Ecosystems**

**Humans**

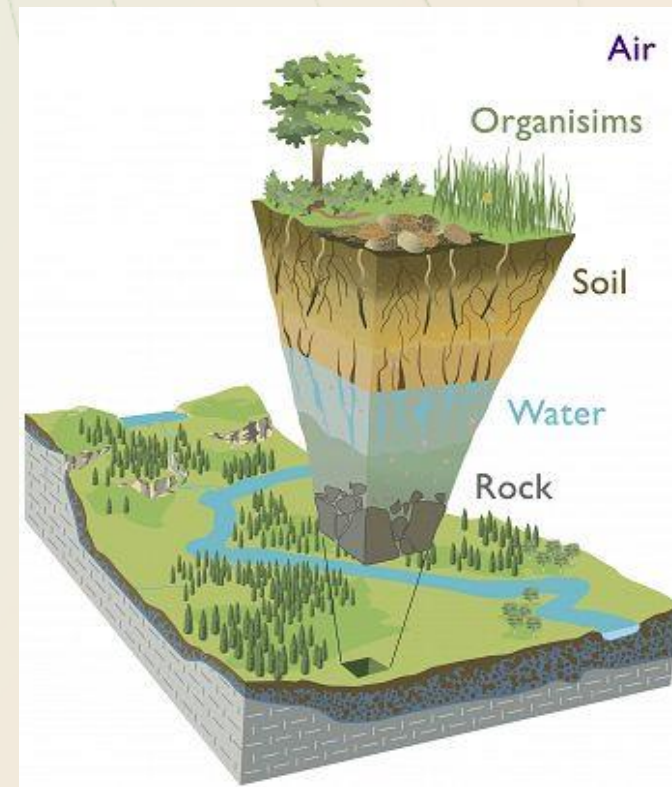
**Hydrosphere**

**Surface geosphere**

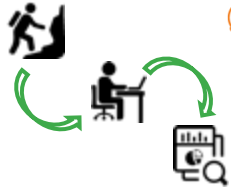
**Towards a  
One-Health  
Approach**

## 8.1 Critical Zone VRE

***Marta S., Gennaro S., Bove P., Caparrini F., Baneschi I.,  
Coro G., Costanza L., D’Incecco S., Donato A., Forni P.,  
Giamberini M. S., Menichini M., Pennisi M., Raco B.,  
Vivaldo G. & Provenzale A.***



# Critical Zone Virtual Research Environment (CZ VRE)



is dedicated to Critical Zone Observatories (CZOs) and provides dataset and tools for data visualization, data analysis, and modeling of CZ dynamics.

enhance collaboration



custom-built



**Data - Acquired & published**  
(and for other dataset publication is in progress!)

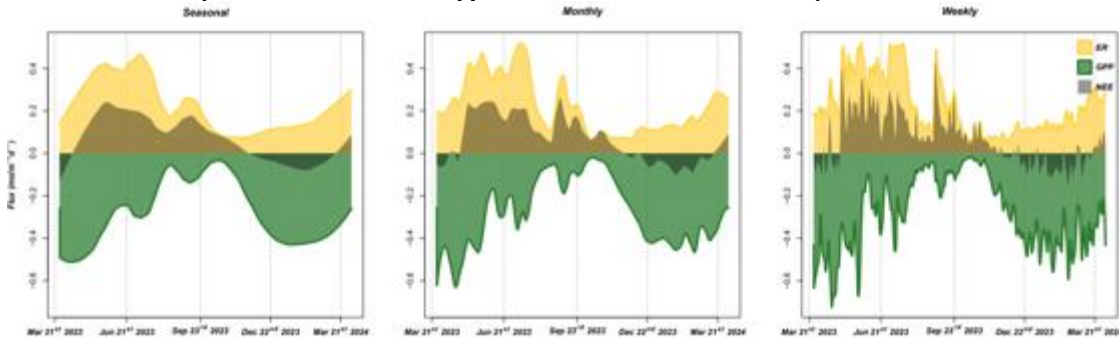
Site	Instrument	Data type	N records
Ny Ålesund (Arctic env.)	Portable chamber	CO <sub>2</sub> flux, vegetation class, atmospheric pressure, soil volumetric water content, soil temperature, air temperature, air relative humidity, solar irradiance, green fractional cover	496 (248 paired)
Pianosa (semi-arid env.)	Automated chambers	CO <sub>2</sub> flux, atmospheric pressure, soil volumetric water content, soil temperature, air temperature, air relative humidity, wind direction, wind speed, rain gauge	29,768
Proglacial areas – 5 study areas (mountain env.)	Portable chamber	CO <sub>2</sub> flux, atmospheric pressure, soil volumetric water content, soil temperature, air temperature, air relative humidity, solar irradiance	452 (226 paired)
Nivolet (mountain env.)	Portable chamber	CO <sub>2</sub> flux, atmospheric pressure, soil volumetric water content, soil temperature, air temperature, air relative humidity, solar irradiance	7,180 (3,590 paired)
	Automated chambers	CO <sub>2</sub> flux, H <sub>2</sub> O flux, atmospheric pressure, soil volumetric water content, soil temperature, air temperature	3,550
Massaciuccoli basin	Eddy covariance	CO <sub>2</sub> flux, air temperature, air relative humidity, wind direction, wind speed, maximum wind speed, wind direction	2,008
		Species distribution / Env: 148 high-res environmental, geomorphologic and socioeconomic datasets (75 variables - 1950 to 2100)	6,540 180 species



# Critical Zone VRE: Codes – R, Fortran, Python

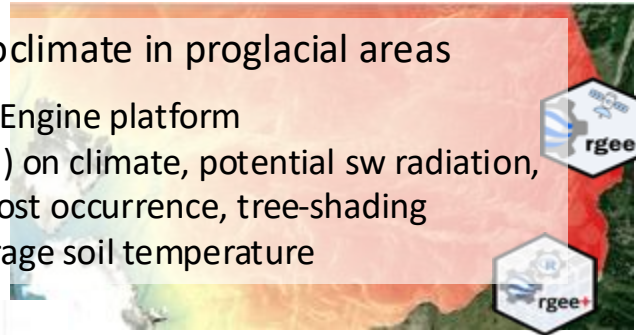
**RStudio** and **JupyterLab** are integrated allowing codes' customization and models' development. Some examples:

- calculation of GPP, fitting a simple locally-weighted polynomial regression (i.e., LOWESS) and smoothing of timeseries of CO<sub>2</sub> fluxes from automated chambers data

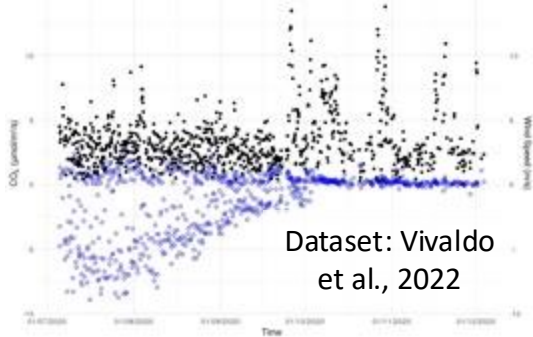


- high-resolution soil microclimate in proglacial areas

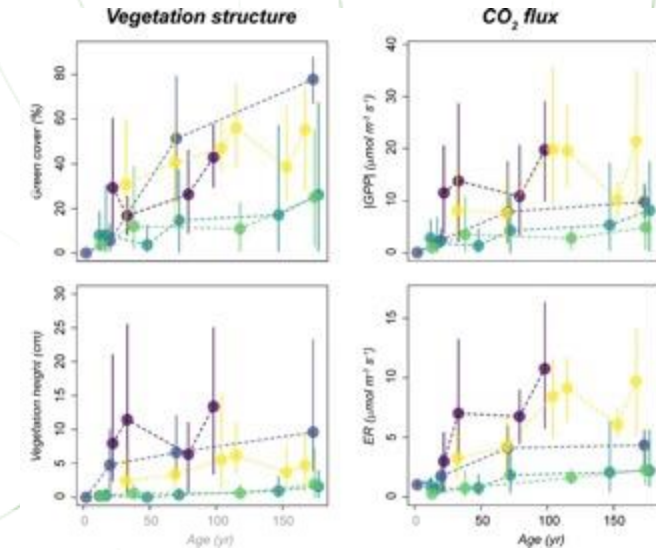
- ✓ Integrate the Google Earth Engine platform
- ✓ Retrieve information (maps) on climate, potential sw radiation, snow-free season, permafrost occurrence, tree-shading
- ✓ Predict (map) monthly average soil temperature



- analysis of CO<sub>2</sub> fluxes and environmental variables from eddy covariance data

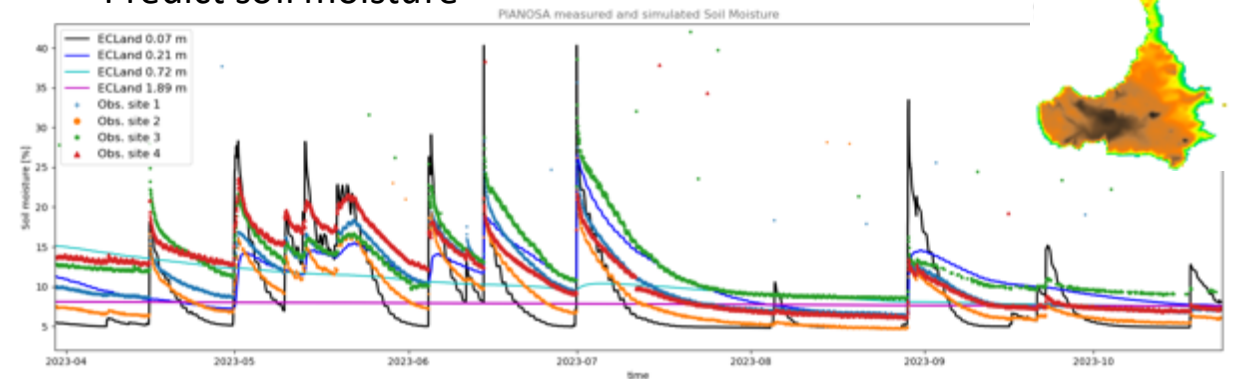


- summarizing data, calculation of GPP and visualization of trends in CO<sub>2</sub> fluxes measured using the accumulation chamber method along different glacier forelands



## CHTESSEL / ECLand

- ✓ Model land-atmosphere fluxes (H<sub>2</sub>O, CO<sub>2</sub>,...)
- ✓ Predict soil moisture

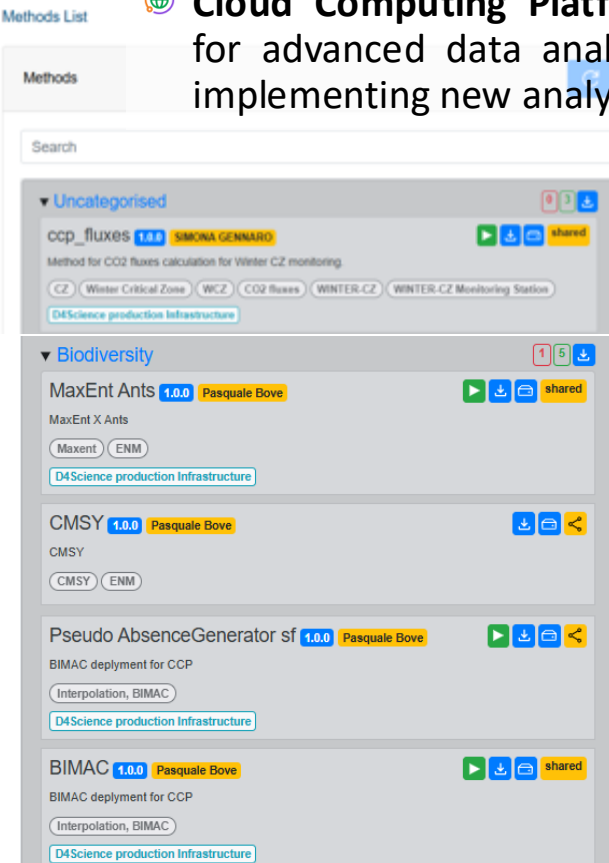


# The Critical Zone VRE - New Tool for Open Science

Other services available:

**Collaborative Storage Framework**, which promotes teamwork among users and offers a collaborative space to share digital objects.

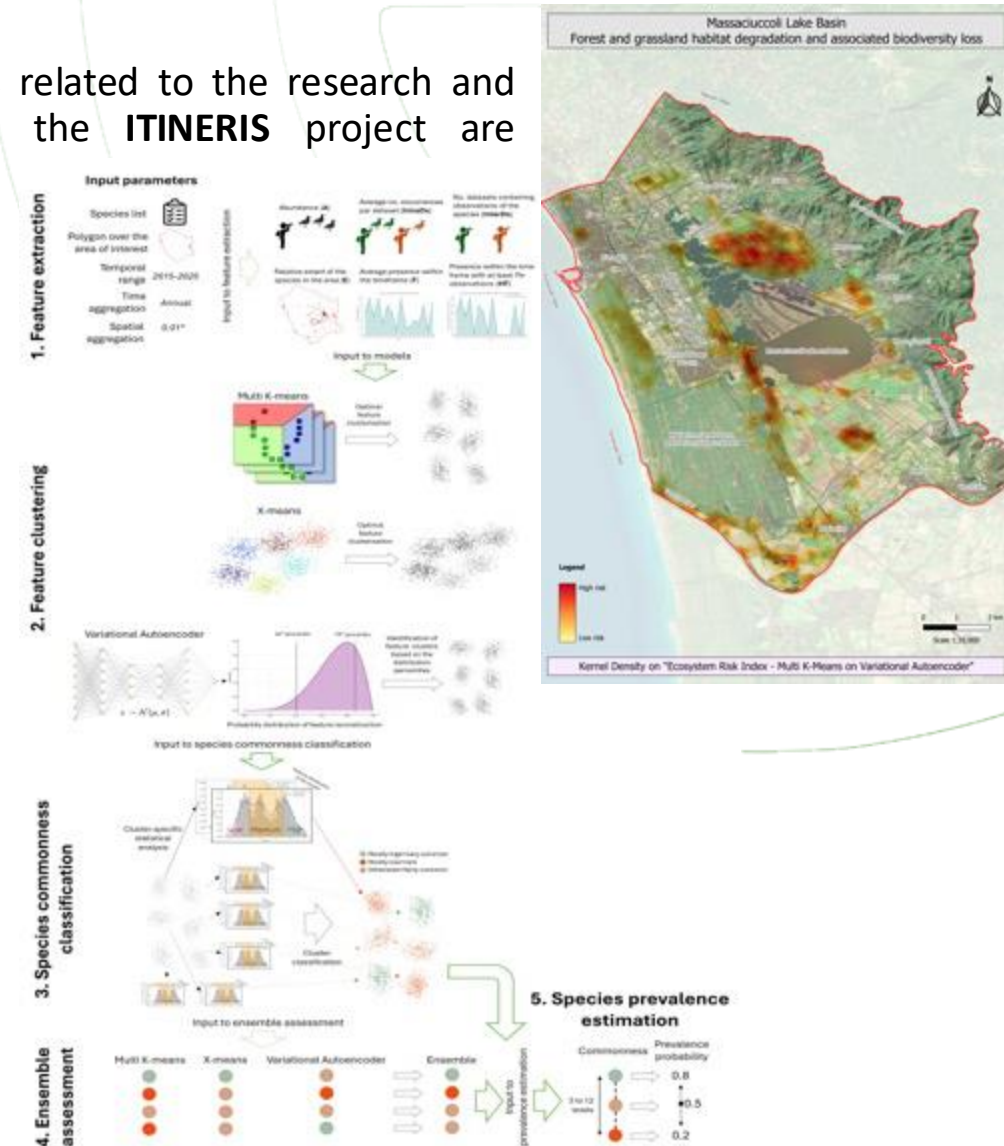
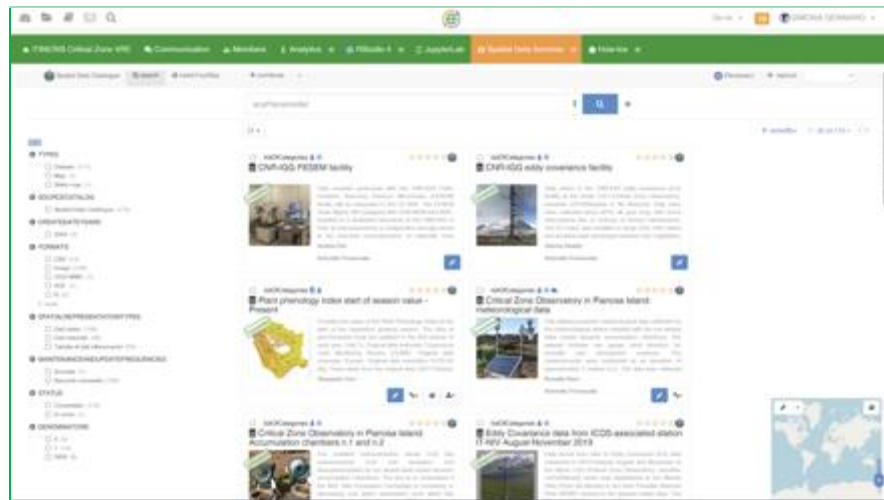
**Cloud Computing Platforms (CCPs)** for advanced data analysis and for implementing new analysis methods.



**Results, papers, and workflows** related to the research and the **ITINERIS** project are available.

The latest submissions focus on workflows for ecological risk assessment and automatic prevalence estimation of species within a region's ecosystem.

**Metadata and spatial data catalogues** for data publishing of research outcomes organized to make outcomes available to the broader scientific and multidisciplinary community.



# LifeWatch ERIC High Mountains Working Group

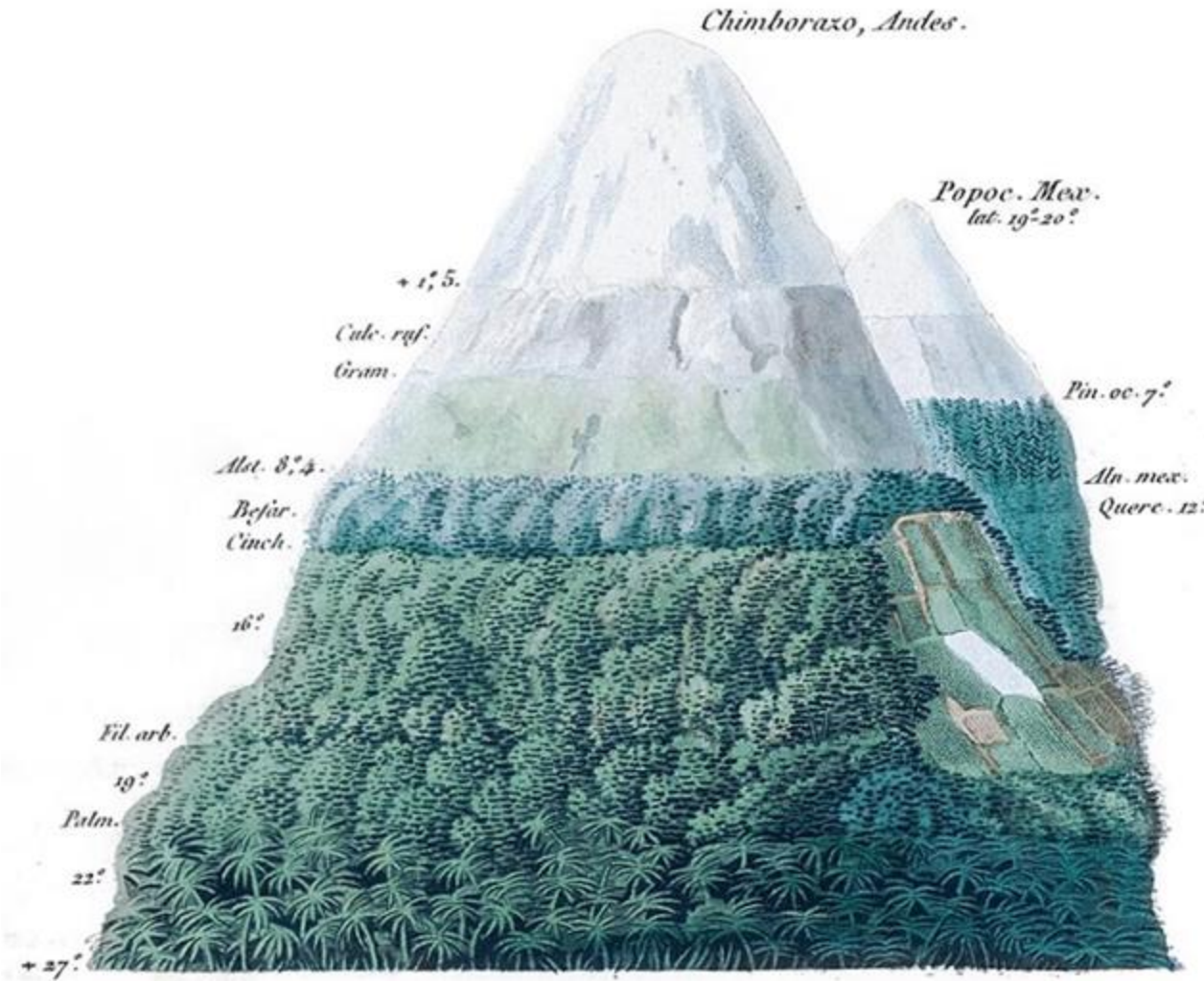
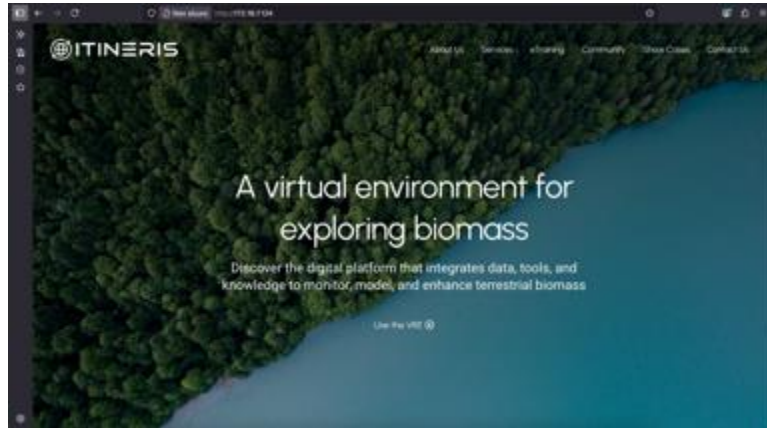


ILLUSTRATION: ALEXANDER VON HUMBOLDT/LIBRARY OF CONGRESS



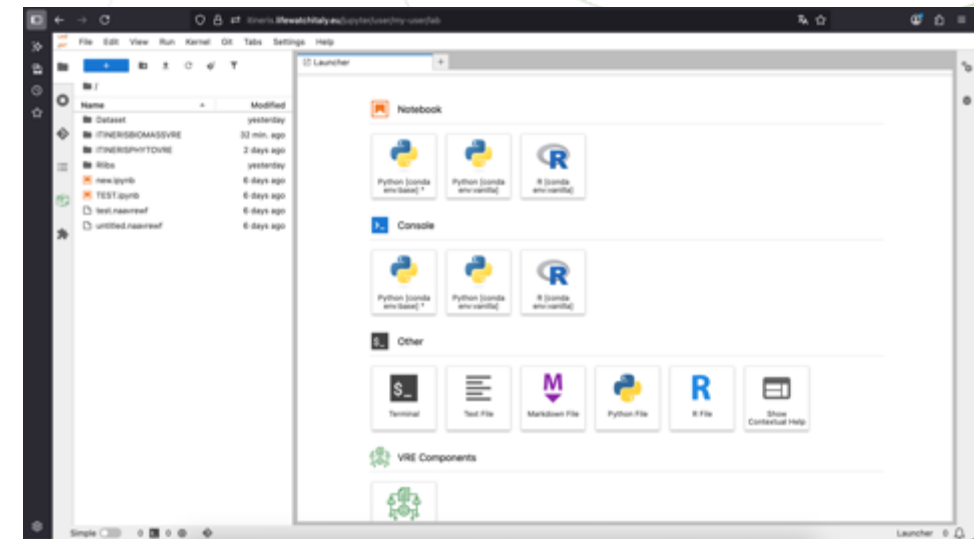
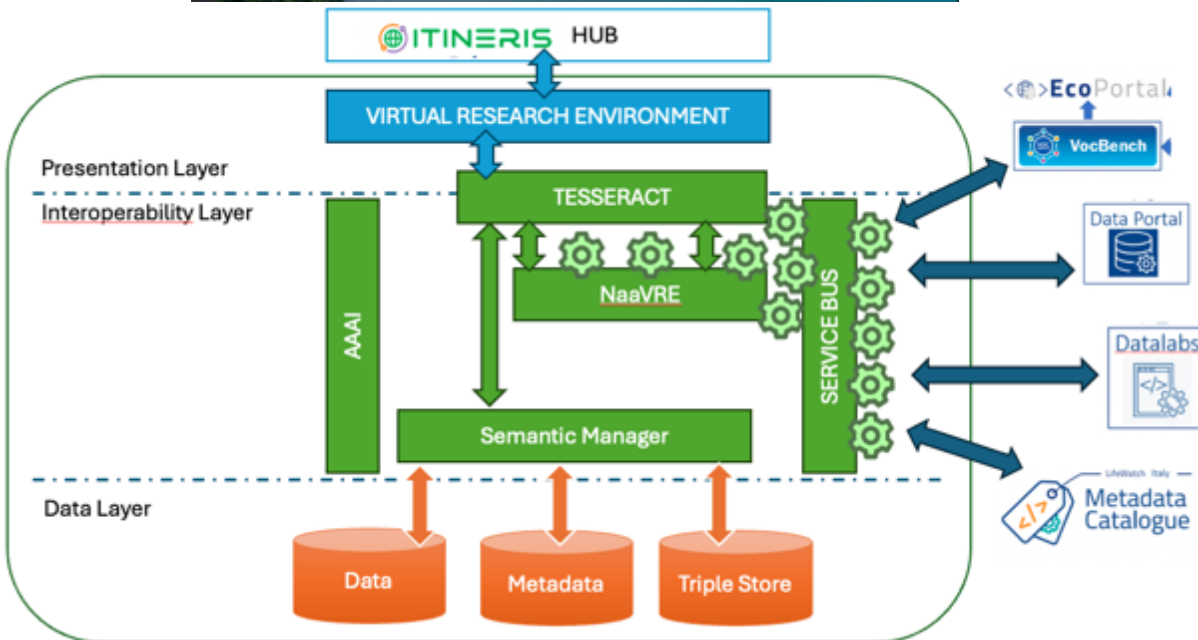
**EuroGEO Action Group  
«Biodiversity, Ecosystems  
and Geodiversity»**

## 8.2: Virtual Research Environment – Biomass



Release of the BIOMASSVRE using the LifeWatch ERIC NaaVRE and Tesseract architectural technologies

<https://itineris.lifewatchitaly.eu/vreapp>



6 workflows and additional web services

# WP8.2: Virtual Research Environment - Biomass

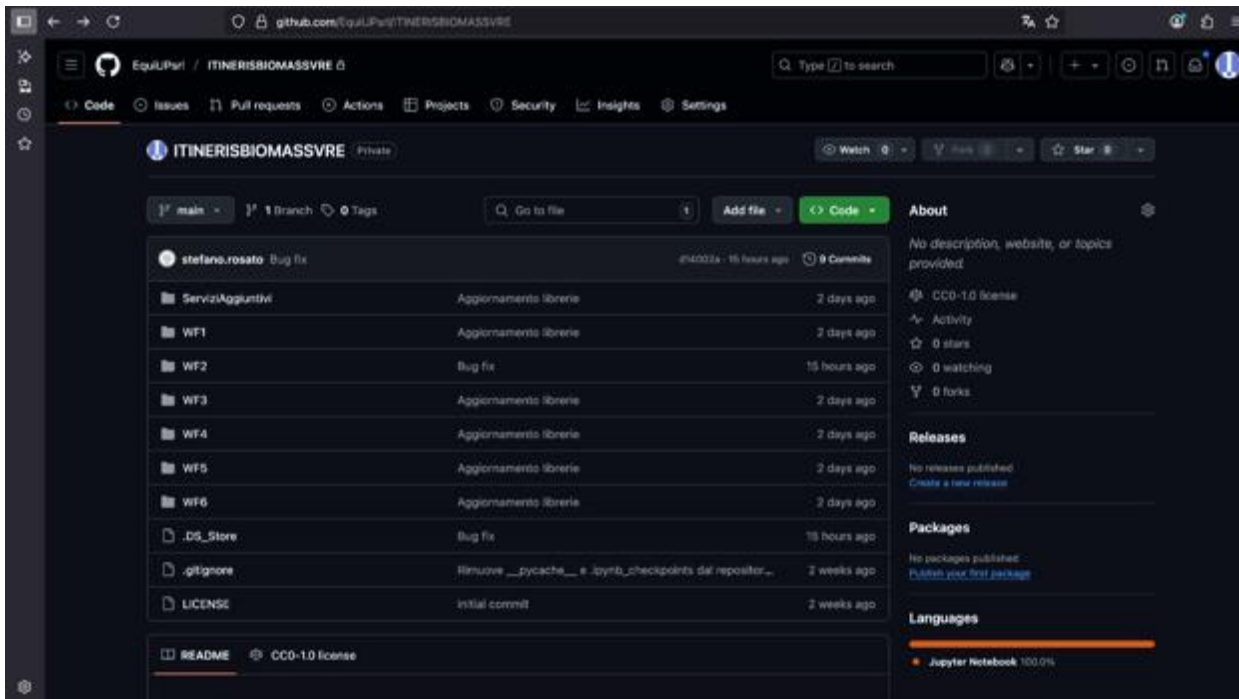
*The WF scripts have been developed, published on GitHub, and deployed on NaaVRE and Tesseract*

## Key OBJECTIVES

1. Supporting accurate assessments of primary productivity patterns in aquatic ecosystems;
2. Deepen understanding on the scaling up of increasing metabolic costs to sustainable standing biomass;
3. Bringing new knowledge on phytoplankton productivity responses to CC

## WORKFLOWS:

- Workflow 1: Variation in primary productivity in aquatic environments in relation to global warming.
- Workflow 2: Estimating variation in primary productivity in terrestrial environments using single variables or already modelled data from MODIS.
- Workflow 3: Response of Stable Consumer Biomass to Global Warming: Impact of temperature increase on metabolic costs and spatial use of trophic resources by heterotrophs.
- Workflow 4: Application of Machine Learning Models for Ecological Analyses.
- Workflow 5: Can variation in NPP be a limiting factor for the development of aquatic biodiversity?
- Workflow 6: How is aquatic primary productivity/Chl-a related to temperature and nutrients?



# 8.4. ESSENTIAL VARIABLES (EV VRE)

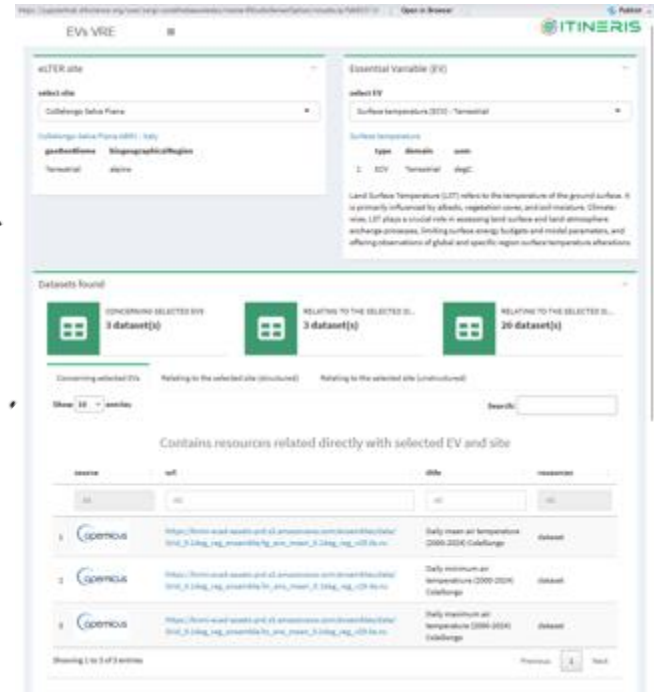


The ITINERIS.VRE-EV package ([github.com/oggioniale/ITINERIS-EVsVRE](https://github.com/oggioniale/ITINERIS-EVsVRE)) compiles and elaborates existing repositories of terrestrial, marine and freshwater study areas belonging to the eLTER network.

- Locations (eLTER sites)**
- Lago Maggiore
  - Delta del Po e Costa Romagnola
  - Collelongo – Selva Piana

**Location's descriptors**

- Datasets type:**
- Structured DBs concerning Evs
  - Structured DBs concerning site
  - Non structured DBs



- Selecting EVs:**
- Climate EV
  - Biological EV

- Harvested repositories:**
- Research infrastructures (eLTER, ICOS)
  - EU repositories (Copernicus, EEA, ESA, CEDA)
  - Other repositories (Zenodo, B2Share, PANGAEA, iNaturalist, GBIF, ...)

**Participants:**

- Alessandro Oggioni, Paolo Tagliolato, Vladimiro Boselli, CNR-IREA
- Sergi Costafreda Aumedes, Giorgio Matteucci, CNR-IBE

**Description:**

- Runs in both **Rstudio** and **Jupyter notebooks** (R based)
- **Environments:** Terrestrial, marine, freshwater
- **Data availability:** +50 DBs for both ECVs and EBVs
- **Data access** through ReLTER package (Oggioni et al., 2025).
- **Data exploration and download** through a Shiny interface or R scripts.

**Publications**

- Tagliolato P, Oggioni A, Costafreda Aumedes S, Boselli V, Matteucci G. 2024. Deliverable 8.14 – Operational implementation of the EV VRE including the selected EBVs and ECVs. ITINERIS, Italian Integrated Environmental Research Infrastructures System.
- Costafreda-Aumedes, S., Tagliolato, P., Giusti, R., Iannuccilli, M., Matteucci, G., Mazzenga, F., Messeri, A., Oggioni, A. 2025. Implementation of a Virtual Research Environment (VRE) to the study of forest environments, EGU General Assembly 2025. Vienna, Austria. 27 Apr–2 May 2025. EGU25-17240.

**Metadata:**

Dataset, Variable, Measurement unit, Type, Repository, Spatial Coverage, Spatial resolution, Temporal resolution, Temporal extent, Description, License, URL





## 8.5 AERO-VRE

- 🌐 A user-friendly tool for Desert dust and Typing visualization based on reliable and accessible datasets
- 🌐 Building on existing datasets available on international datahub
- 🌐 Pointing on the visualization added value for communication
- 🌐 Including on top of it ITINERIS produced datasets
- 🌐 The visual interface allows the users to select:
  - Spatio temporal domain
  - Topics of interest to be explored.
  - Specific data product to be visualized.
  - Possibility to download numerical data.

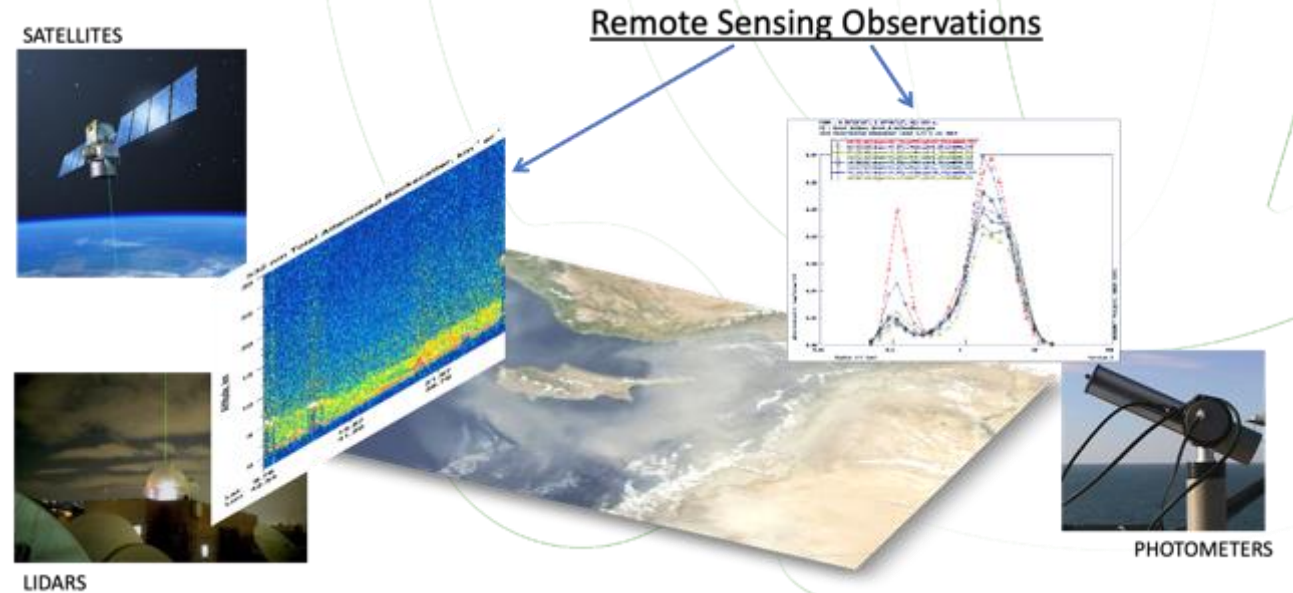


[https://itineris.d4science.org/group/itineris\\_aero](https://itineris.d4science.org/group/itineris_aero)

# AERO-VRE potential impacts and use

Interesting tool for researchers for accessing and visually analysing reference datasets providing:

- regional insight (WMO-SDS WAS, MONARCH and CAMS models)
- columnar information (AERONET measurements + models)
- Vertical profiles (ACTRIS/EARLINET data and derived products + models)



The aerosol speciation is also relevant for Air Quality impacts.

The new Air Quality directive calls for the identification and quantification of dust (and other natural sources) contribution to the PM at the ground.

AERO VRE can support the analysis by the air quality managers.



The first Italian digital environment for Carbon-related data and dynamics

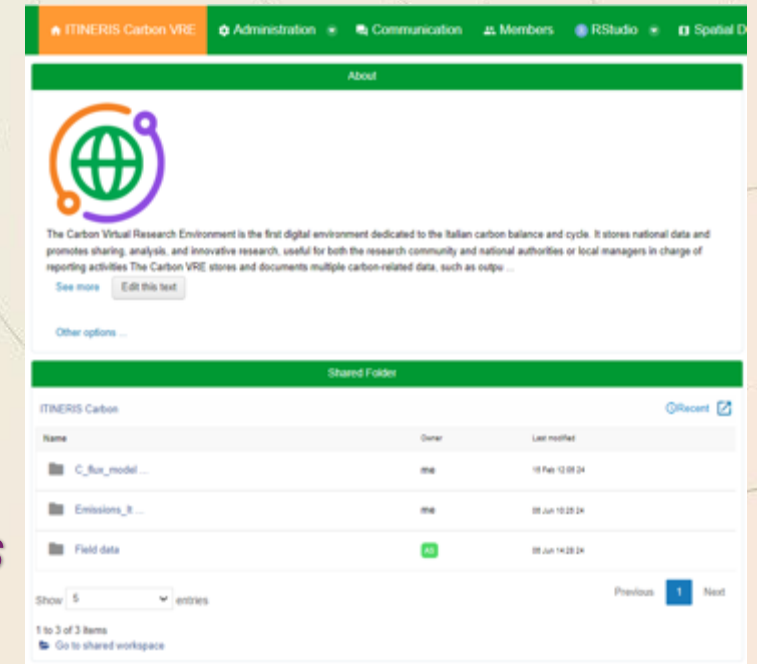
**The service was delivered and includes:**

- Italian Carbon and ecosystem fluxes
- Italian emission data
- Tools and facilities for analyses
- Research field data and models

*Promotes data sharing, analysis, innovative research*

*End user-oriented: facilitates reporting for administrations*

[https://itineris.d4science.org/group/itineris\\_carbon](https://itineris.d4science.org/group/itineris_carbon)





## GPP, NEE, Ra for Italy

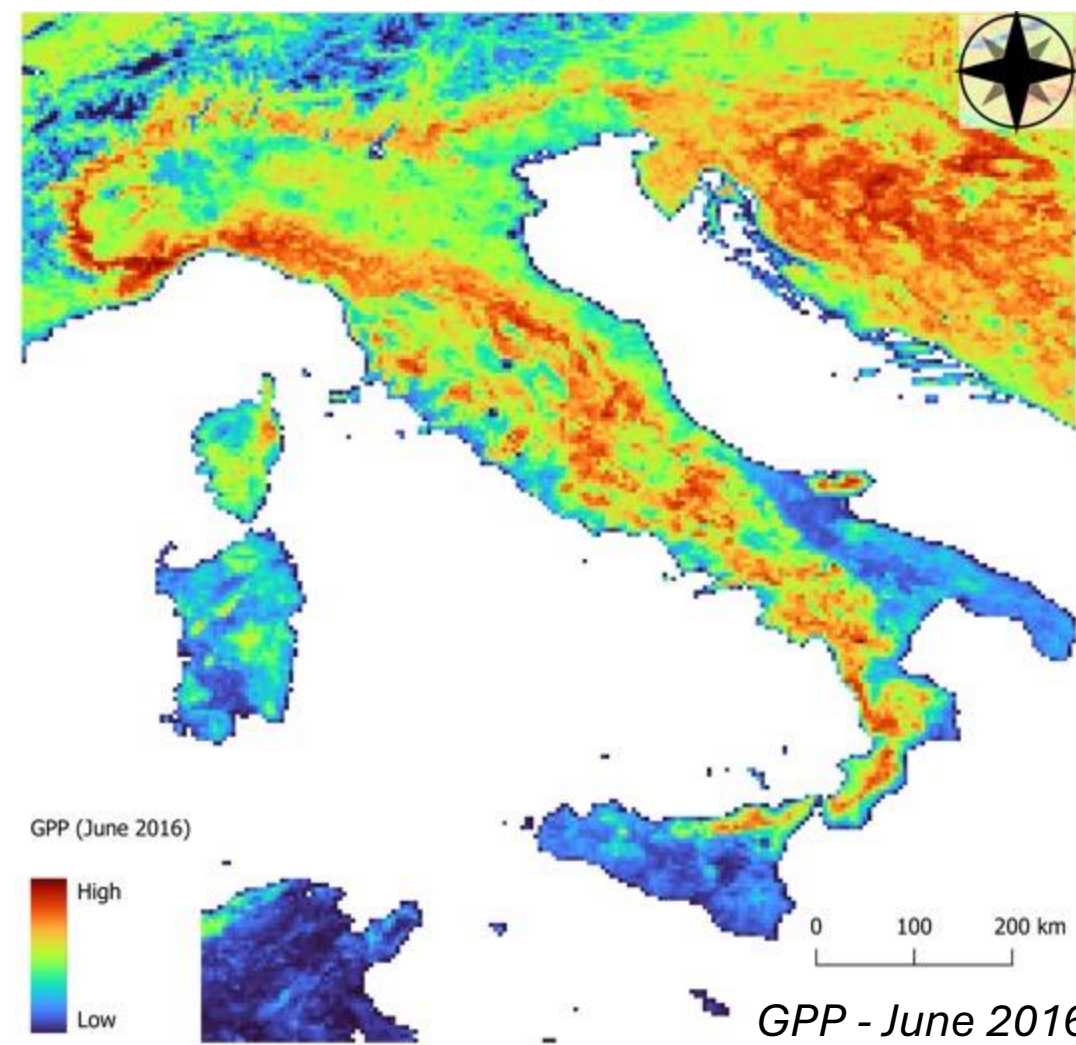
### Data for Italy are derived by main modeling families:

- dataset at spatial resolution  $> 0.05^\circ$ , in agreement with Italian landscape fragmentation
- monthly aggregated datasets for different years

### Now including 3 families and 144 monthly products:

- Fluxnet Ensemble Modeling products
- Vegetation Photosynthesis and Respiration Model
- Vegetation Photosynthesis model

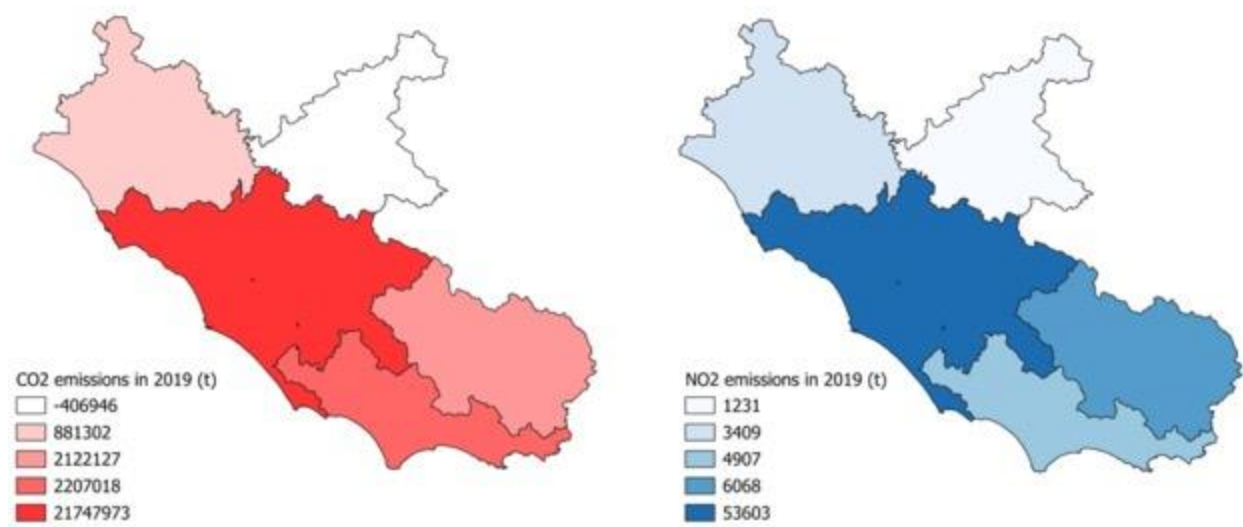
Shared Folder	
Name	Owner
ITINERIS Carbon / C_flux_models_Italy	
FLUXCOM ensemble products	AS
Vegetation Photosynthesis and Respiration Model	me
Vegetation Photosynthesis Model	AS



## Emissions

Data for Italy are derived by ISPRA

- spatialization of main GHG (NO+N<sub>2</sub>O, CO<sub>2</sub>, CO, CH<sub>4</sub>) at Province level with source characterization and grouped by temporal intervals since 1990



## Ground data

Collaboration among IRET groups to collect new data for calibration and validation of experimental C aboveground biomass models based on SAR + optical remote sensing and machine learning in grasslands



# Mycorrhizal symbioses and tree diversity in global forest communities

Cornell University

arXiv > q-bio > arXiv:2505.19199

Quantitative Biology > Populations and Evolution

[Submitted on 25 May 2025]

## Pan-tropical plant functional trait variation from space

David Schimel, Andres Baresch, Adam Chlus, Phil Townsend, Fabian Schneider, Gaia Vaglio Laurin, I

Ecological Indicators  
Volume 172, March 2025, 113254

## Monitoring habitat diversity with PRISMA hyperspectral and lidar-derived data in Natura 2000 sites: Case study from a Mediterranean forest

Gaia Vaglio Laurin <sup>a</sup>, Chiara Zabeo <sup>b</sup>, Diego Giulirelli <sup>b</sup>, Birhane Gebrehiwat Tesfamariam <sup>b</sup>, Alexander Cotrina-Sanchez <sup>b</sup>, Riccardo Valentini <sup>b</sup>, Basil Tufail <sup>c</sup>, Bartolomeo Ventura <sup>c</sup>, Carlo Calfapietra <sup>a</sup>, Anna Barbati <sup>b</sup>

Ecological Informatics  
Volume 84, December 2024, 102867

## A multi-source approach to mapping habitat diversity: Combination of multi-date multispectral satellite imagery and comparison with single-date hyperspectral results in a Mediterranean Natural Reserve

Chiara Zabeo <sup>a</sup>, Gaia Vaglio Laurin <sup>a</sup>, Birhane Gebrehiwat Tesfamariam <sup>a</sup>, Diego Giulirelli <sup>a</sup>, Riccardo Valentini <sup>a</sup>, Anna Barbati <sup>a</sup>

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## Linking hyperspectral PRISMA data with ecosystem functional properties at ICOS sites

Gaia Vaglio Laurin, Alessandro Sebastiani, Lorenza Nardella, Carlo Calfapietra, Anna Barbati, Bartolomeo Ventura, Dario Papale

Proceedings Volume 13191, Remote Sensing for Agriculture, Ecosystems, and Hydrology, XXVI: 1319100 (2024) <https://doi.org/10.1117/12.3033908>  
Event: Remote Sensing, 2024, Edinburgh, United Kingdom

Remote Sensing Applications: Society and Environment  
Volume 36, November 2024, 101329

## Monitoring ink disease epidemics in chestnut and cork oak forests in central Italy with remote sensing

Alessandro Sebastiani <sup>a</sup>, Matteo Bertozzi <sup>c</sup>, Andrea Vannini <sup>b</sup>, Carmen Morales-Rodriguez <sup>b</sup>, Carlo Calfapietra <sup>a</sup>, Gaia Vaglio Laurin <sup>a</sup>

The VRE C served to support several research activities, e.g. linking Carbon-related resources with:

- Habitat Biodiversity
- Ecosystem Functional Properties at ICOS sites
- Pan-tropical forest trait variations
- Forest health



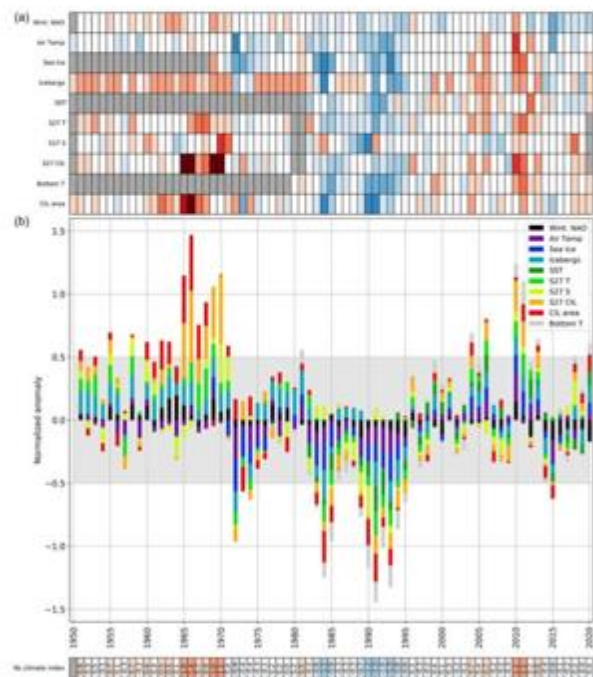
## Clima VRE: a Virtual Research Environment on indicators and impacts of climate change

Lagomarsino-Oneto D.<sup>1</sup>, Lira-Loarca A.<sup>2</sup>, Sciascia R.<sup>1</sup>, Corgnati L.P.<sup>1</sup>, Mantovani C.<sup>1</sup>,  
Besio G.<sup>2</sup>, Magaldi M.G.<sup>1</sup>

<sup>1</sup>National Research Council (CNR) – Institute of Marine Sciences (ISMAR), La Spezia, Italy,

<sup>2</sup>University of Genoa (UNIGE), Department of Civil, Chemical and Environmental Engineering (DICCA), Genoa, Italy

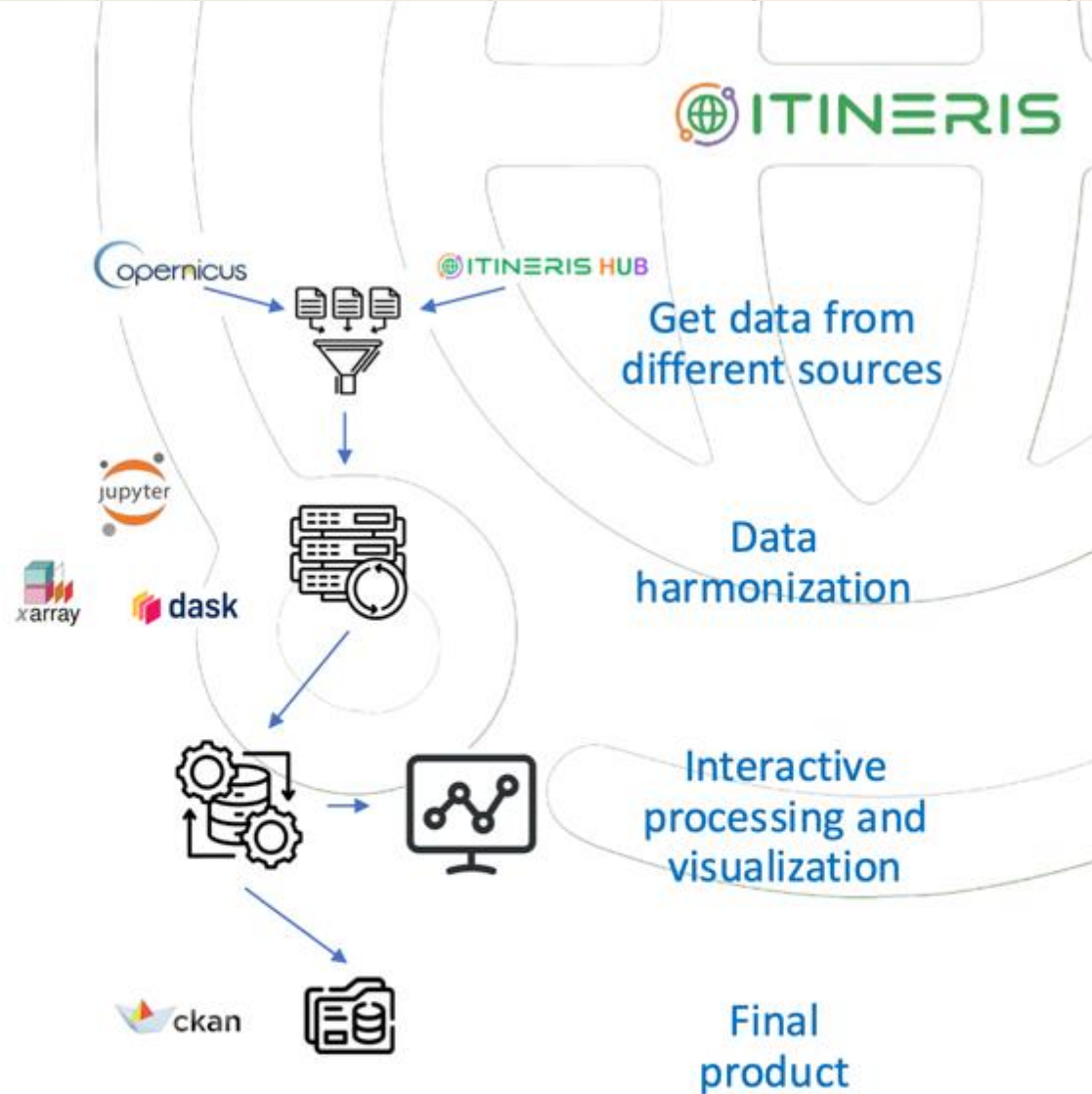
# Goals and workflow



1) Develop Climatic Indices

2) Study impacts of Climate change

Cyr e Galbrath, 2021 Earth System Science Data



# SST anomaly on Italian Seas

Dataset: cmems\_satellite\_sst

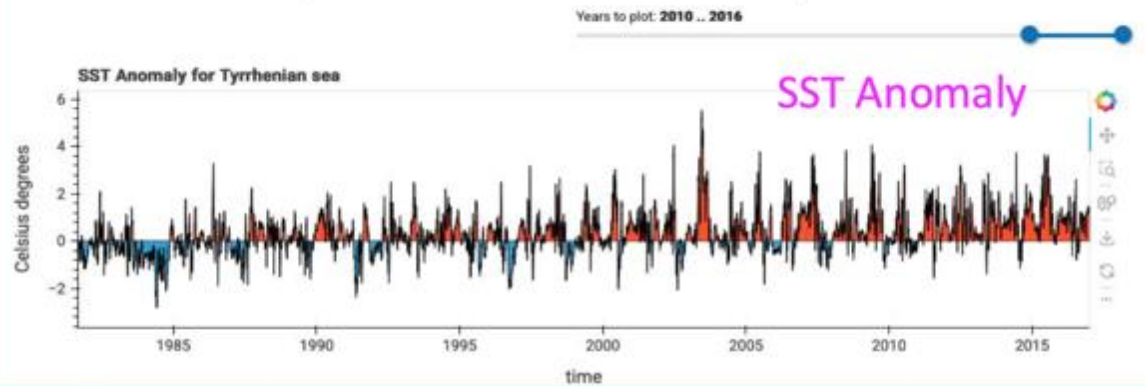
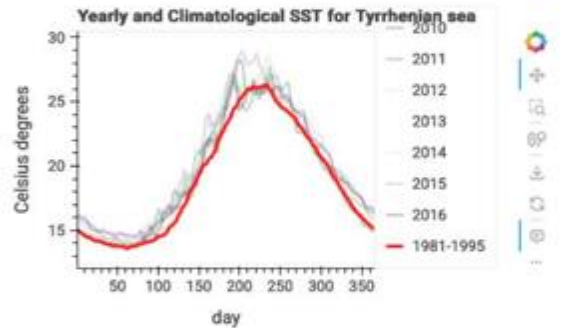
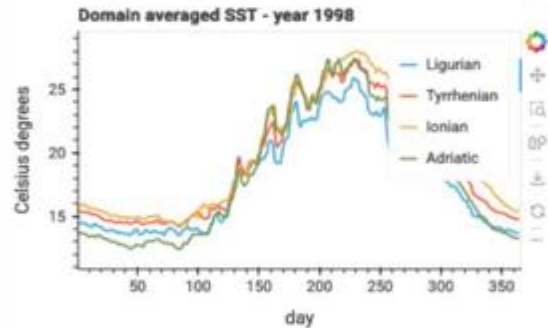
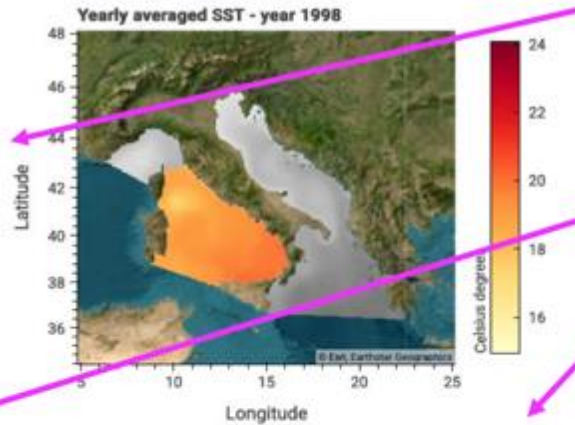
**Load Data**

Ligurian  Tyrrhenian  Ionian  Adriatic

Year: 1998

Reference period: 1981 .. 1995

**Download**

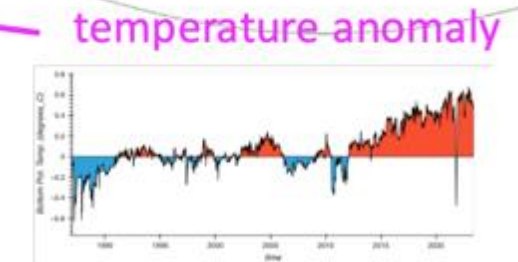
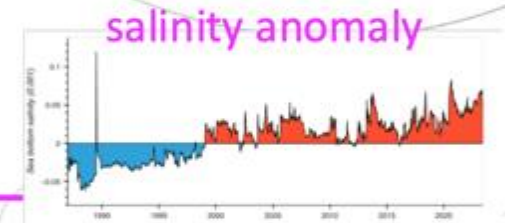
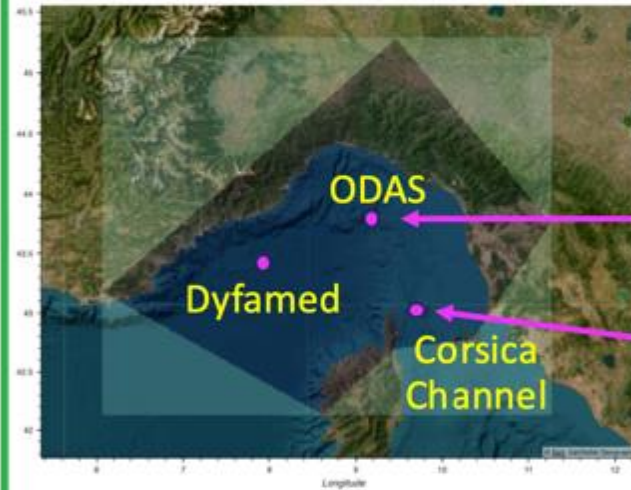


Interactive customization of: dataset, geographical domain and reference period



Interactive plots of SST signal across Italia basins and reference climatology

## Climatic Index for Ligurian Sea



Combine model data and observed data (e.g. from buoys) to build an index for the climatic state of Ligurian Sea

## 8.8 Downstream VRE

R. Franceschini<sup>1</sup>, N.C. Reyes Suárez<sup>1</sup>, A. Altenburger<sup>1</sup>, G. Rossi<sup>1</sup>, and A. Giorgetti<sup>1</sup>

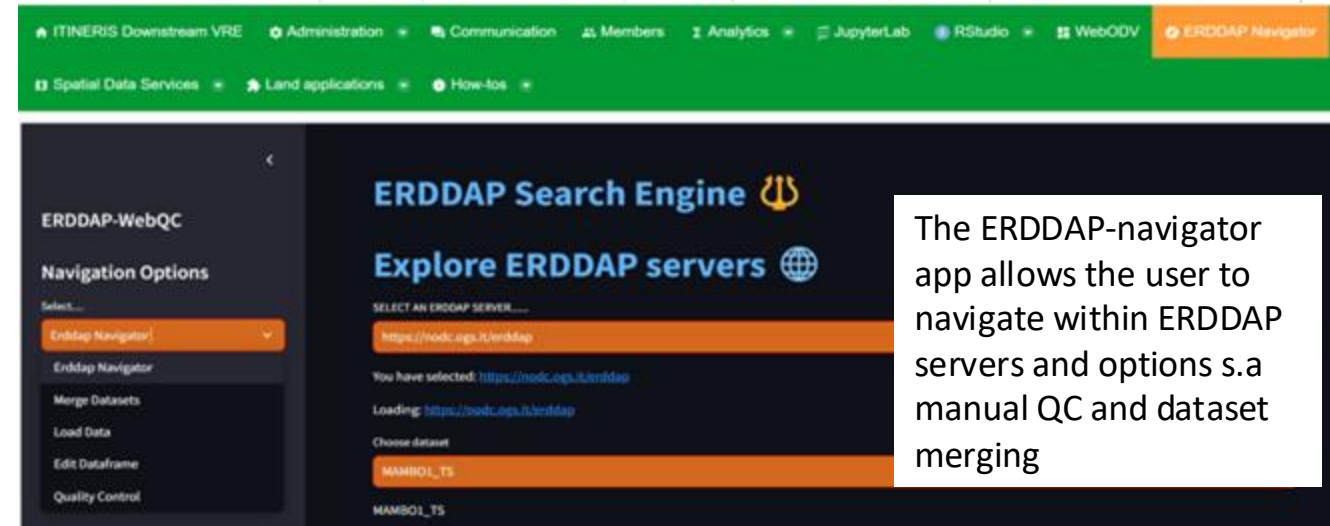
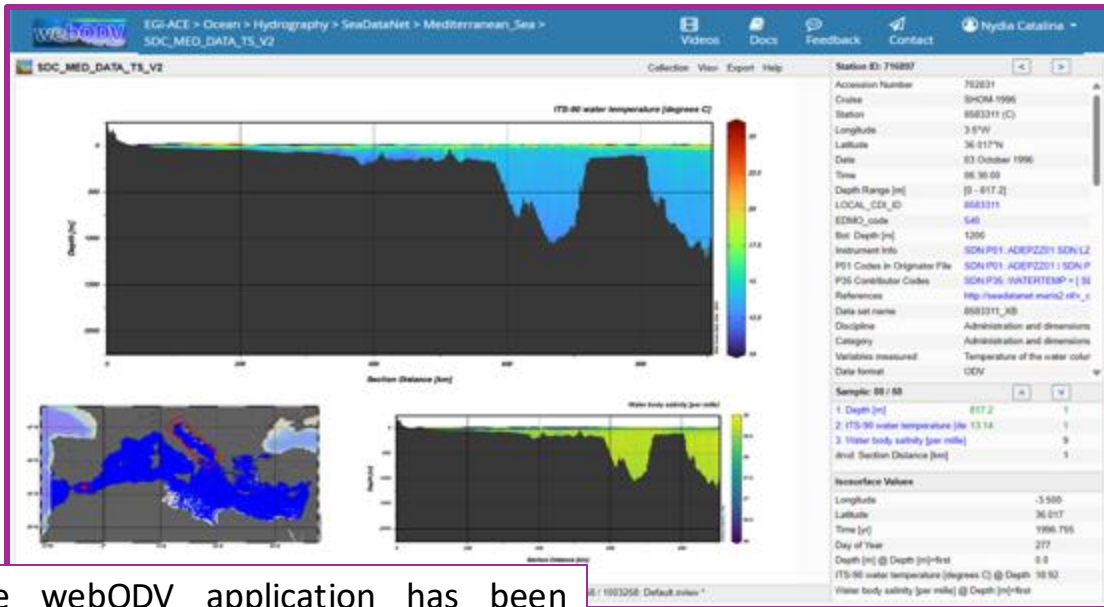
<sup>1</sup>*National Institute of Oceanography and Applied Geophysics – OGS, Italy*

IR0000032 – ITINERIS, Italian Integrated Environmental Research Infrastructures System  
(D.D. n. 130/2022 - CUP B53C22002150006) Funded by EU - Next Generation EU PNRR-  
Mission 4 "Education and Research" - Component 2: "From research to business" - Investment  
3.1: "Fund for the realisation of an integrated system of research and innovation infrastructures"



# Marine Domain

The marine domain toolbox focalizes in carbon cycling and acidification data available in the North Adriatic Sea mainly pH, pCO<sub>2</sub>, fCO<sub>2</sub>, temperature and salinity within the different Ris in the ITINERIS project.



The webODV application has been linked to the Downstream VRE for data extraction, analysis, exploration and visualization restricted for Argo (TS & BGC) and SeaDataNet (TS) products.

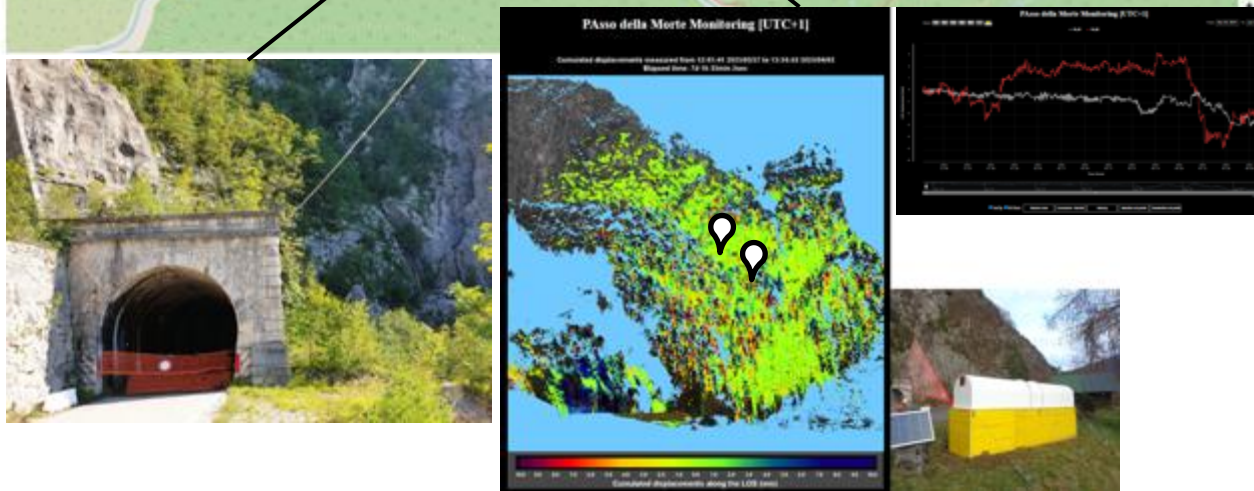
Implementing the ICOScp python library in the VRE by means of jupyter notebooks allows the user to explore ICOS data. ICOScp shows OGS station (IT-FOS-MIRAMARE ) use case.



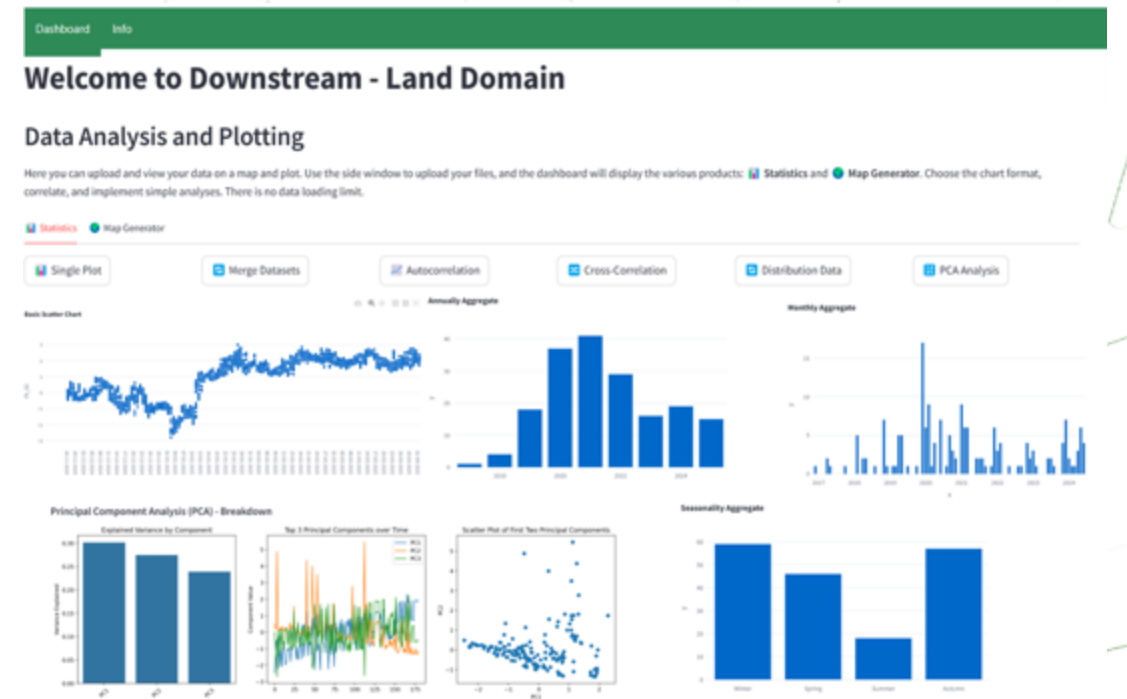
# Land Domain

## Geoserver, Geonetwork and monitoring systems

A geoserver and geonetwork have been implemented hosting regional and local scale. By means of Downstream VRE it is possible to see currently monitoring systems which have been installed at Passo della Morte close to Forni di Sotto (UD) to delineate possible ground instabilities.



## Land instability application



To quickly analyze time series, an application was created with the help of Streamlit with python language. The application allows you to create graphs, make analyses (merge datasets, auto-correlation, cross-correlation, seasonality, PCA) and map the data in csv, txt and xlsx format.

- Expedient analysis
- Upload one or more data
- Analyze data by means of Statistics or Map Generator
- Different analysis can be chosen
- Downloadable data plot

# WP 8.9 – ISOTOPEVRE



Laser Ablation (LA) - MC-ICP-MS Thermo Scientific Neoma



Nu Vitesse Time of Flight (TOF) ICP-MS



NewTec Scientific MT1000



iCAP Plus ICP-MS Thermo Scientific



Thermo Scientific DELTA Q IRMS and GAS BENCH III



Thermo Scientific 253 Plus 10 kV IRMS



The Zeiss Sigma 360 FE-SEM



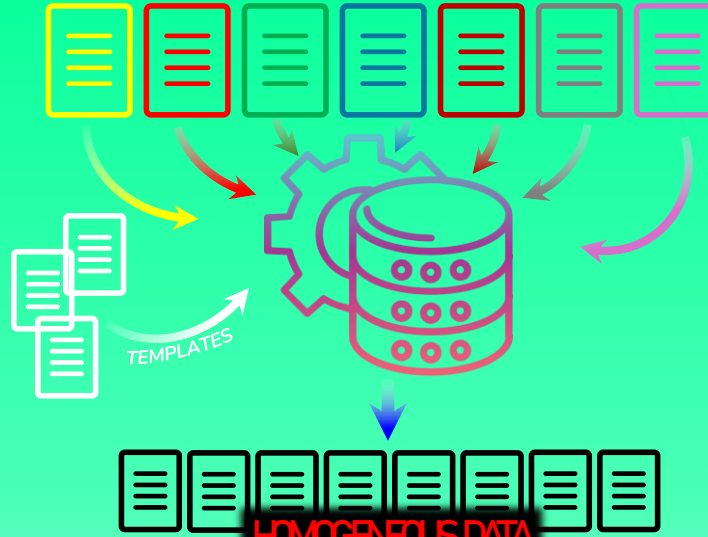
**NEW DATA**

**TEMPLATE**

N.	Type	Field Name
1	Mandatory	ITINERIS_Document
2	Mandatory	Sample_name
3	Mandatory	Location
4	Optional	Location_details
	Desidered	Latitude
	Desidered	Longitude
5	Desidered	EPDG
	Desidered	Matrix
6	Mandatory	Matrix
7	Optional	Matrix_details
8	Desidered	DOI
9	Desidered	Authors
10	Optional	Year of publication
11*	Desidered	Descriptive Parameters
	Desidered	Unit
12	Mandatory	Name of Chemical element/compound
	Mandatory	Unit
	Optional	Technique
13	Mandatory	Isotope Ratio
	Optional	Unit
	Desidered	Uncertainty
	Desidered	Types_uncertainty
	Optional	Technique
	Optional	Ref_Std
14	Mandatory	Age
	Mandatory	Unit
	Desidered	Uncertainty
	Desidered	Types_uncertainty
	Optional	Method
	Optional	Technique

**PUBLISHED DATA**

**HETEROGENEOUS DATA**

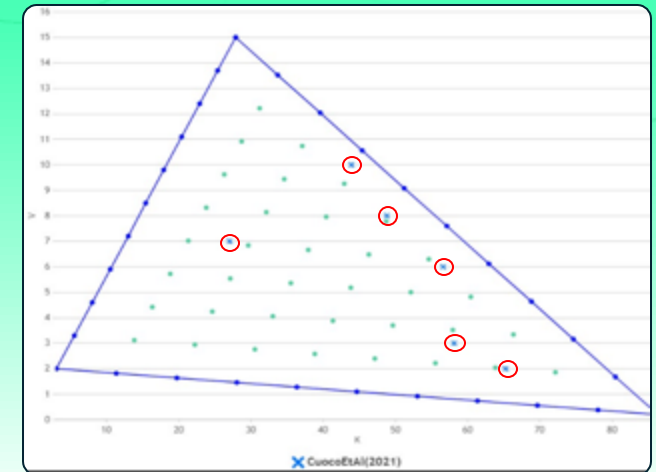
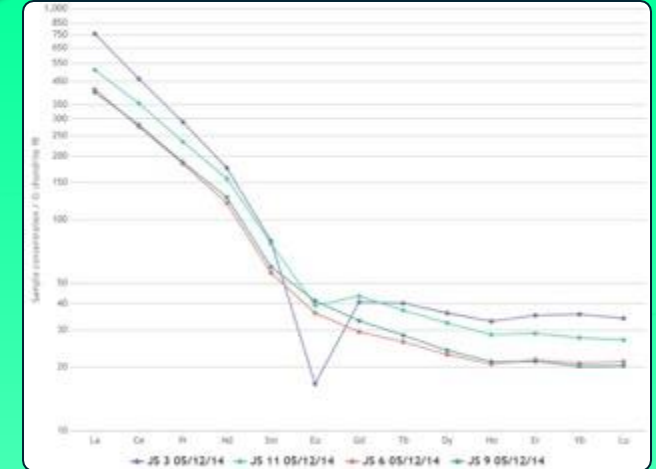


**DATA HARMONIZATION**

Sample definition  
Select the fields defining the sample. Select also the chemical elements/isotopes if available. Select 'None' if you don't want to import some field in the database. When done, proceed to upload data.

Sample Name	Unit	<input checked="" type="radio"/> Sample field <input type="radio"/> Chem. element <input type="radio"/> Isotope <input type="radio"/> None
Si	Unit	<input type="radio"/> Sample field <input checked="" type="radio"/> Chem. element <input type="radio"/> Isotope <input type="radio"/> None
Sr	Unit	<input type="radio"/> Sample field <input checked="" type="radio"/> Chem. element <input type="radio"/> Isotope <input type="radio"/> None
Sm	Unit	<input type="radio"/> Sample field <input checked="" type="radio"/> Chem. element <input type="radio"/> Isotope <input type="radio"/> None
27Sm/147Sm	Unit	<input type="radio"/> Sample field <input checked="" type="radio"/> Chem. element <input checked="" type="radio"/> Isotope <input type="radio"/> None
147Sm/144Sm	Unit	<input type="radio"/> Sample field <input type="radio"/> Chem. element <input checked="" type="radio"/> Isotope <input type="radio"/> None

**DATA MODELLING**



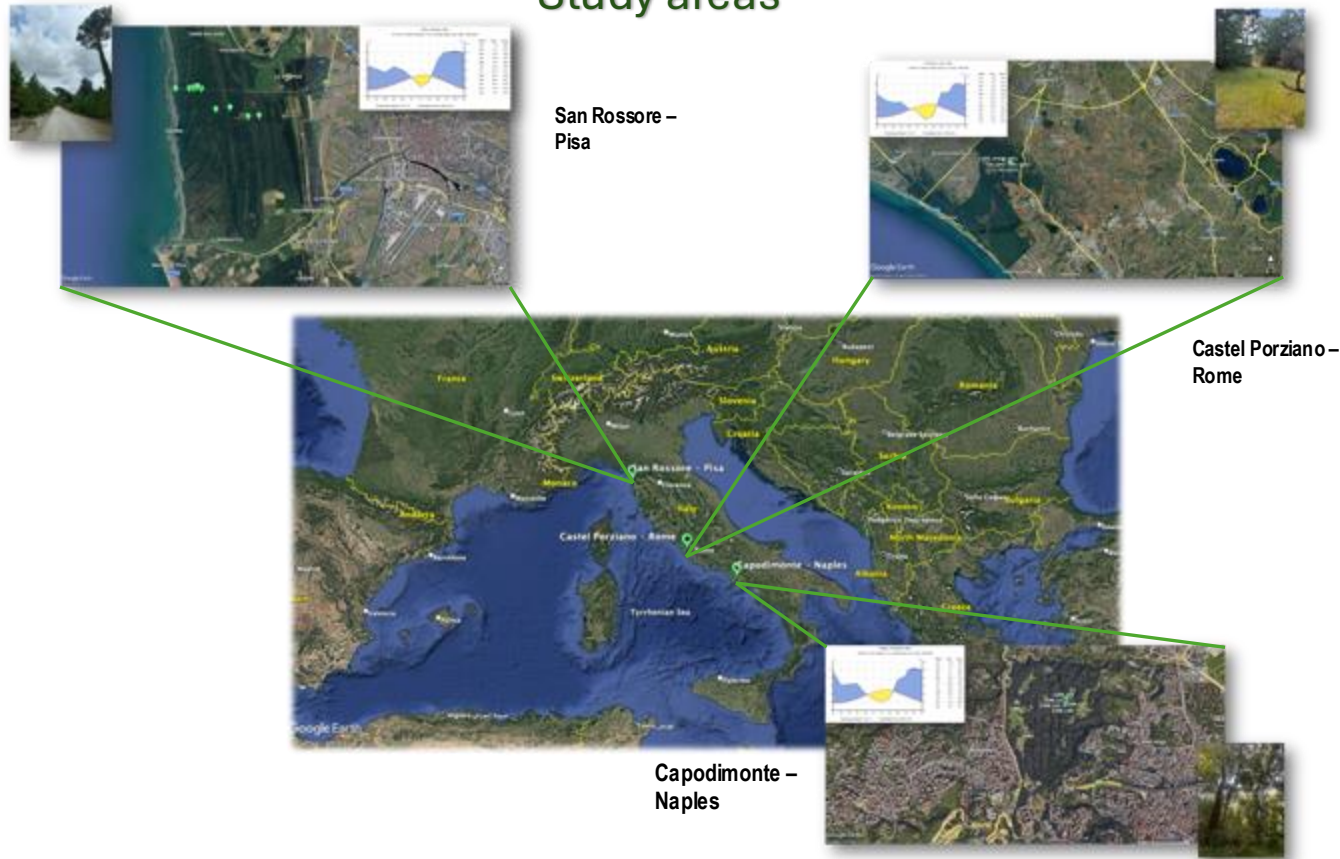


# Stable isotope analysis along a Mediterranean latitudinal transect

Three sites were selected along a latitudinal transect on the Mediterranean coast to conduct C and N stable isotope analyses of plant organs and soils under different human impact. The aim of the study is to identify bioindicators of anthropogenic disturbance across different climatic conditions. The sites were selected among the ICOS (Integrated Carbon Observation System) network.

The isotope data will contribute to the VRE Isotope database.

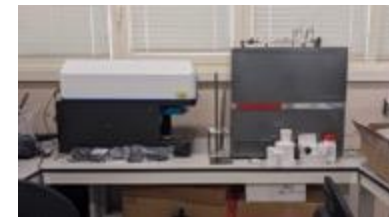
## Study areas



## Sampling and analysis

- 3 sampling campaigns (May-Jun and Oct-Nov 2024, May 2025)
- 3 sites (Capodimonte, Castelporziano, San Rossore)
- 8 species
- ~70 trees
- ~400 samples (vegetation + soil)
- >1300 subsamples
- ~1000 C %, N%,  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$  analysis

## IRMS – Lab Montelibretti



- IRMS
- GHG
- Laser Ablation System
- IsoToC



The isotope analysis will be conducted also on varying plant components, e.g. pollen extracts, using new methodologies like Laser ablation system to better understand the response of Mediterranean species to climate change and human impact

**Next steps:**

**Complete all VRE by Dec 2025**

**Devote Jan-March 2026 to harmonization of the different VRE**

**End of March 2026: All VRE are operational and integrated**