WP8. Virtual Research Environments and cross-disciplinary activities

- *Lead*: Antonello Provenzale, CNR-IGG
- *Co-lead*: Eugenio Trumpy, CNR-IGG
- *Support group*:
  Gianpaolo Coro, CNR-ISTI;
  Letizia Costanza, CNR-IGG;
  Laura Criscuolo, CNR-IGG,
  Alessandro Oggioni, CNR-IREA

von Humboldtd and Bonpland, Naturgemalde

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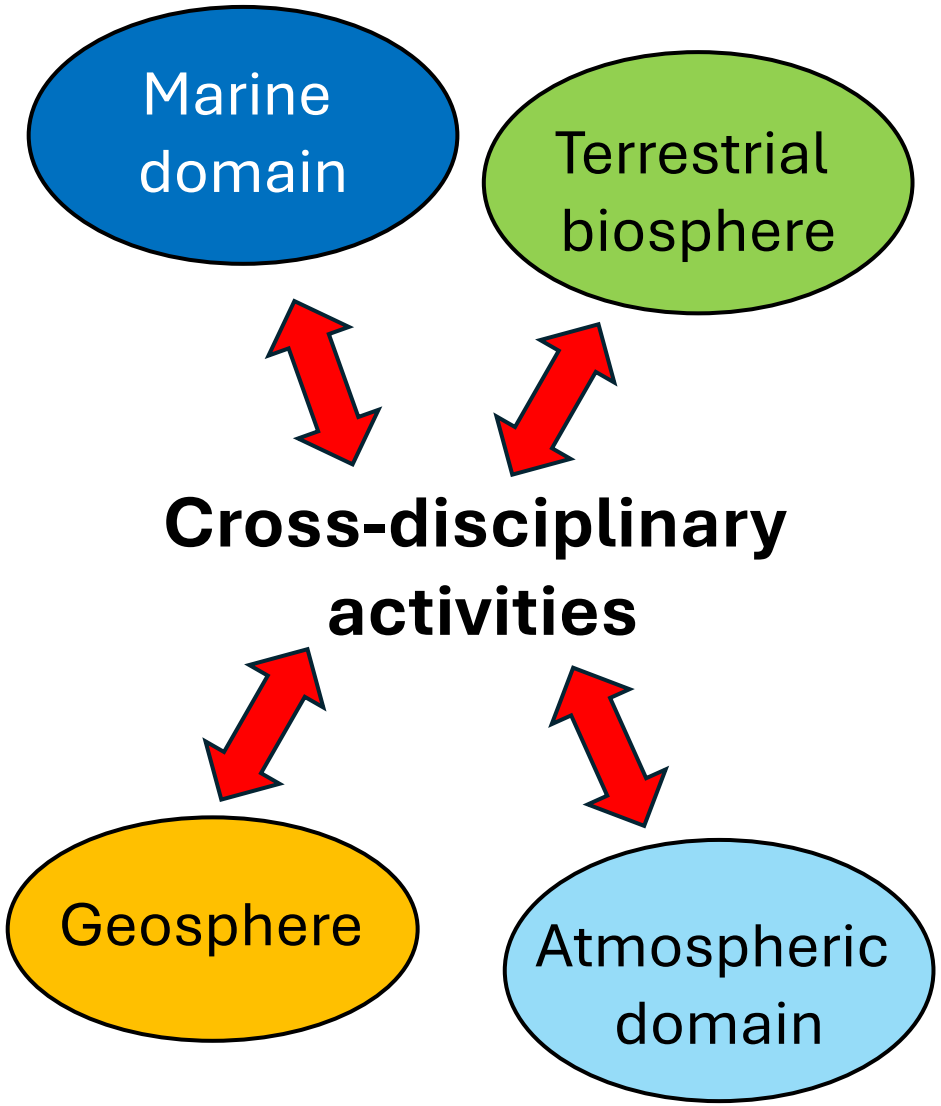
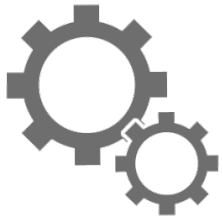


The activities of WP8 use data, information and knowledge generated by the individual RI to create **a system of Virtual Research Environments (VRE)**, and provide **services where RIs from different domains are harmonized to deal with scientifically and societally relevant topics**.

This **systemic approach** will support the Italian role in several RIs and help taking a leading role to address complex, multi-disciplinary challenges.

What is a Virtual Research Environment?

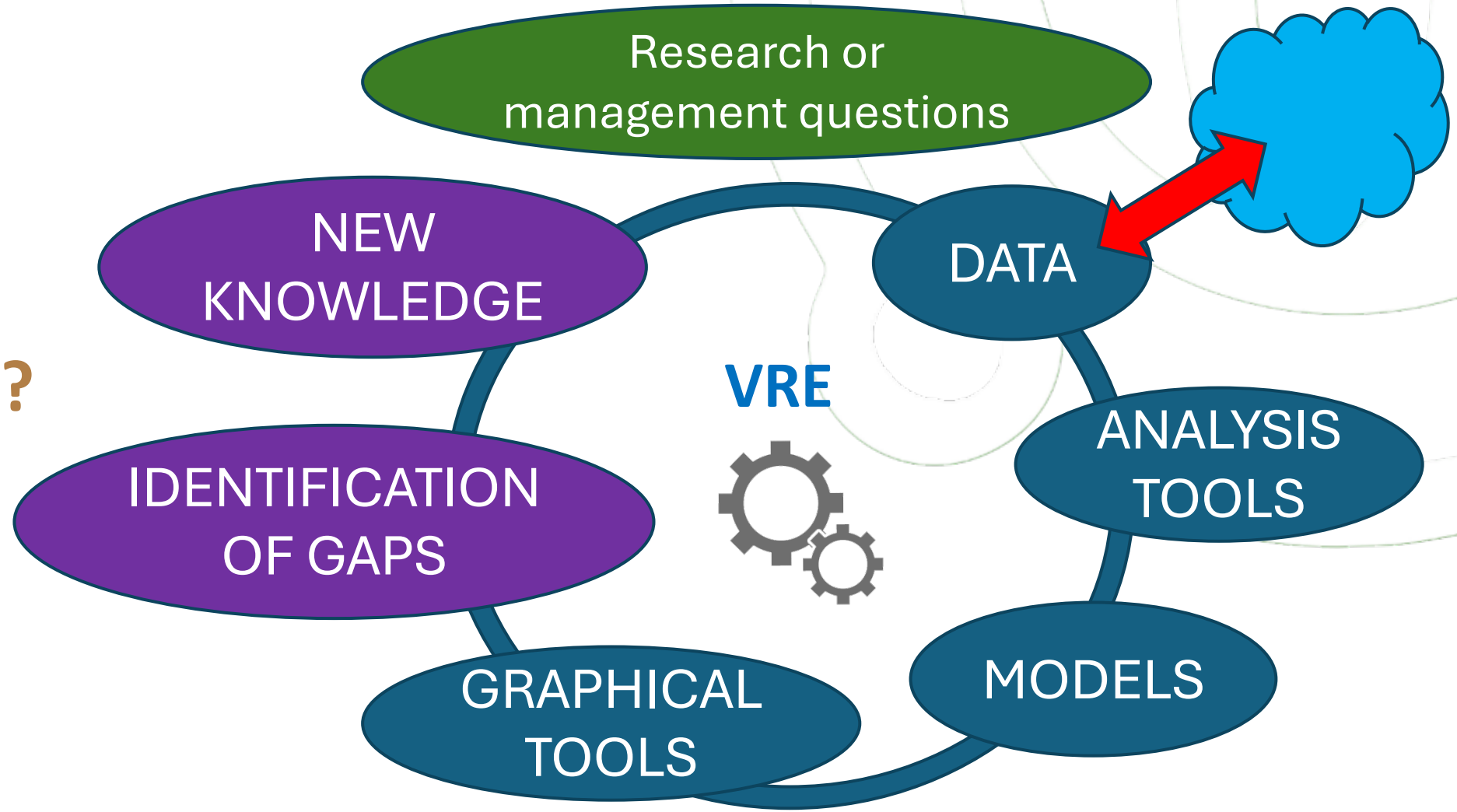
VRE



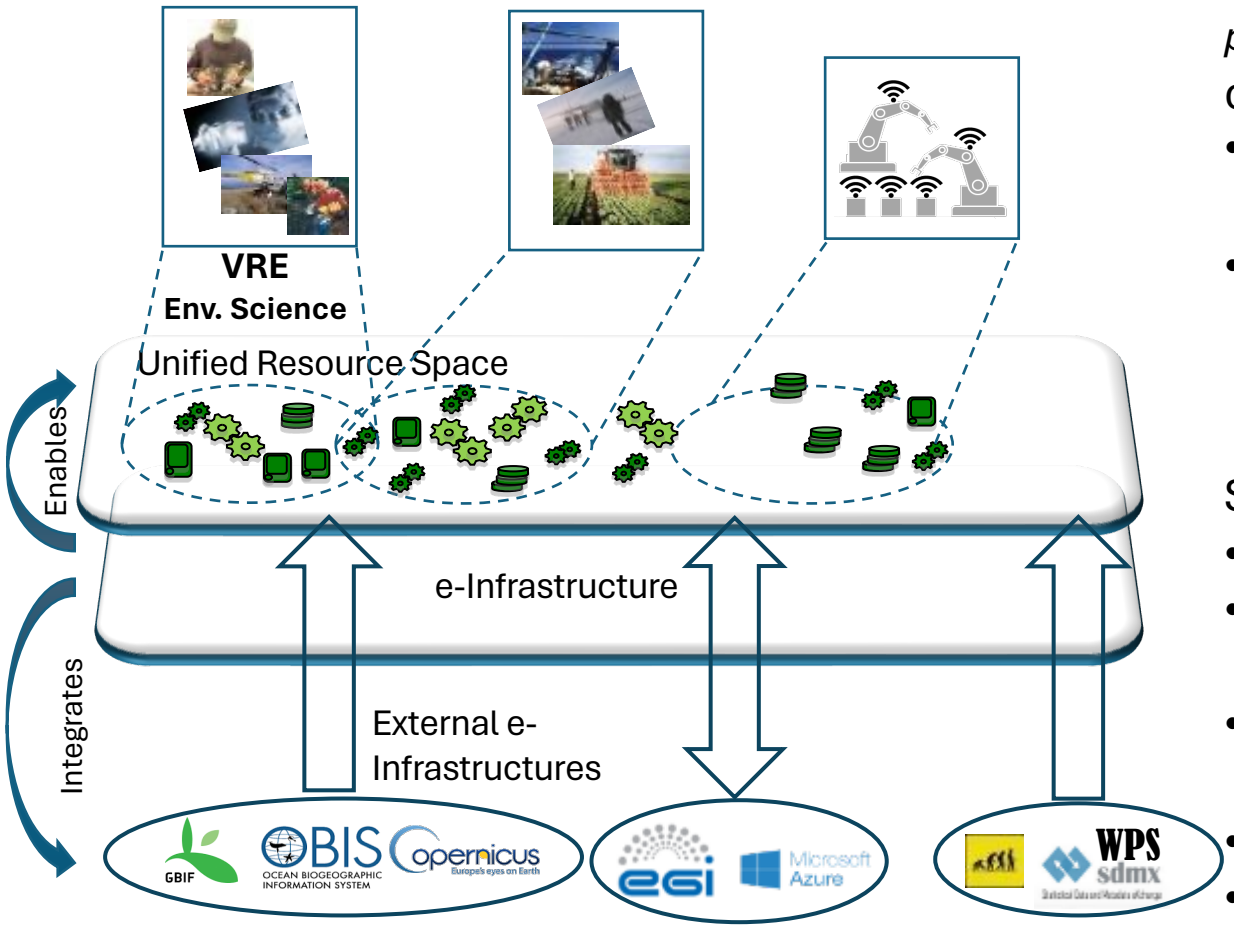
An e-Science online environment favouring collaborations and shared solutions **to answer specific scientific and/or management questions** that require an ensemble of data, analysis tools, modelling solutions and graphical tools, in the spirit of the **open science principles**.

Researchers can upload/download and share knowledge, contributing to the construction of the VRE. **Users** can access to a simplified version of the VRE to tackle specific issues.

What is a Virtual Research Environment?



The D4Science e-Infrastructure



A network of hardware and software resources *(databases, processes, services, machines, AI models)* that supports collaborative and data-intensive Science:

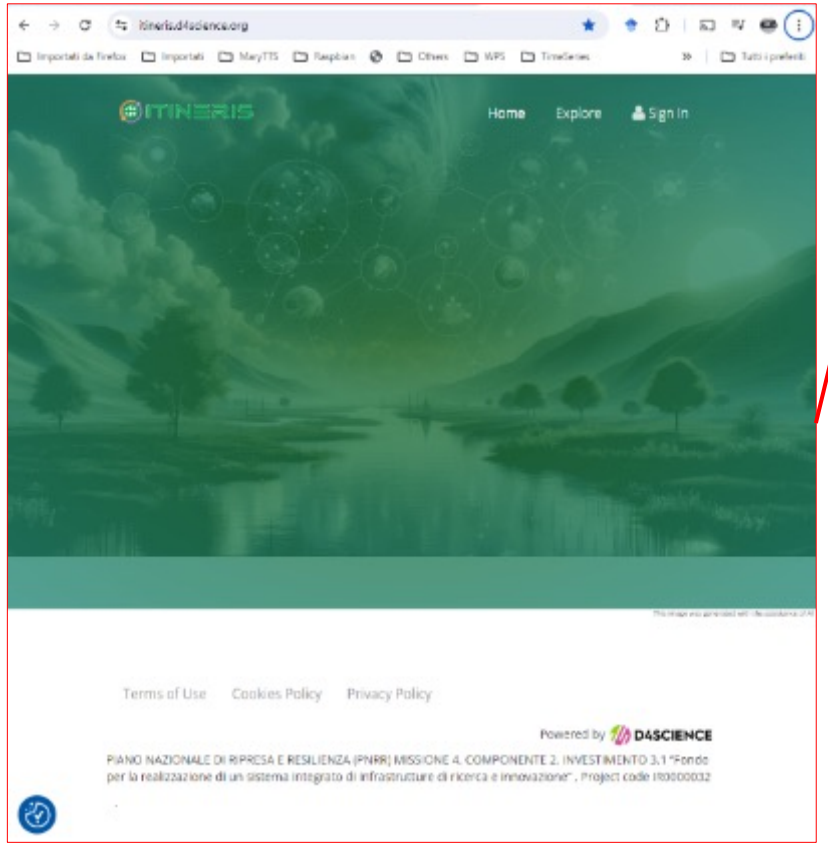
- Enables collaboration between researchers across countries;
- Researchers work together having shared access to the same facilities (data, instruments, computing, and communication).

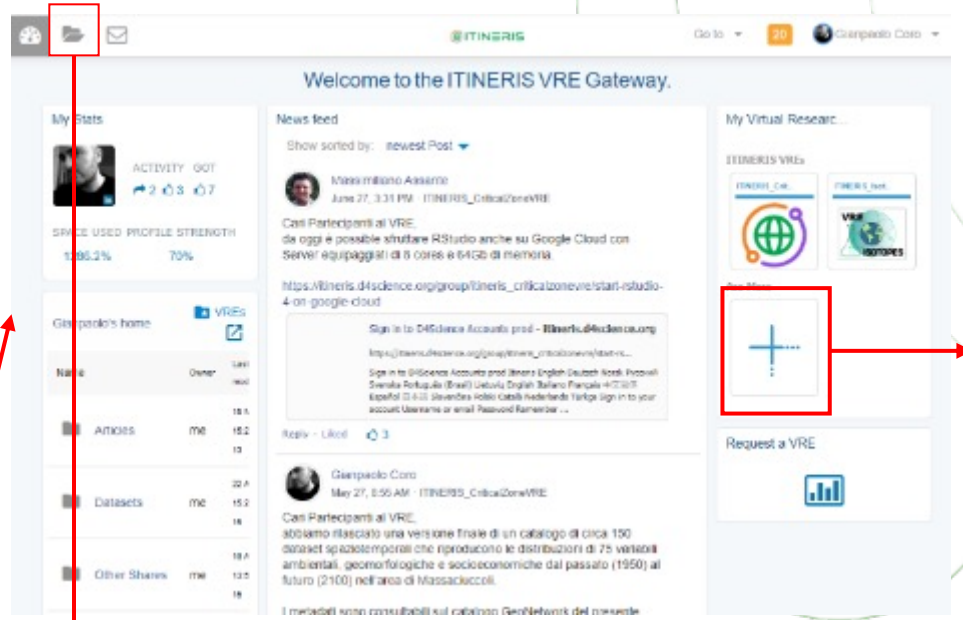
Supports the creation of **Virtual Research Environments** to:

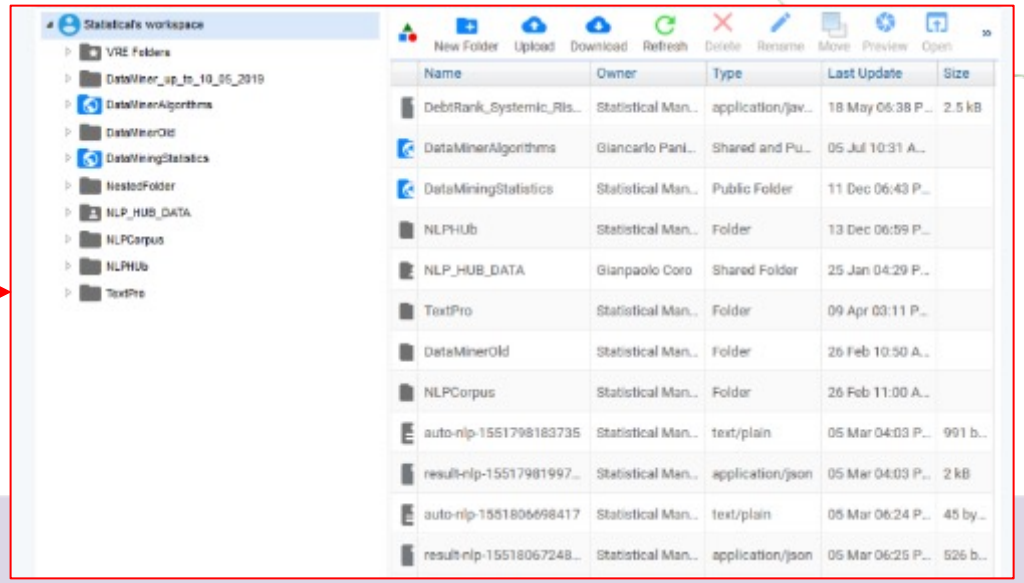
- Define sub-communities of practice;
- Allow temporary dedicated assignment of computational, storage, and data resources;
- Manage heterogeneous data and processes access policies;
- Support data and information sharing;
- Allow sharing competences and creating multi-disciplinary applications.

The ITINERIS D4Science Gateway: itineris.d4science.org

1. A gateway to the D4S-based VREs
2. Allows to request access to VREs
3. Allows to upload files on the VREs and to the private users' workspace







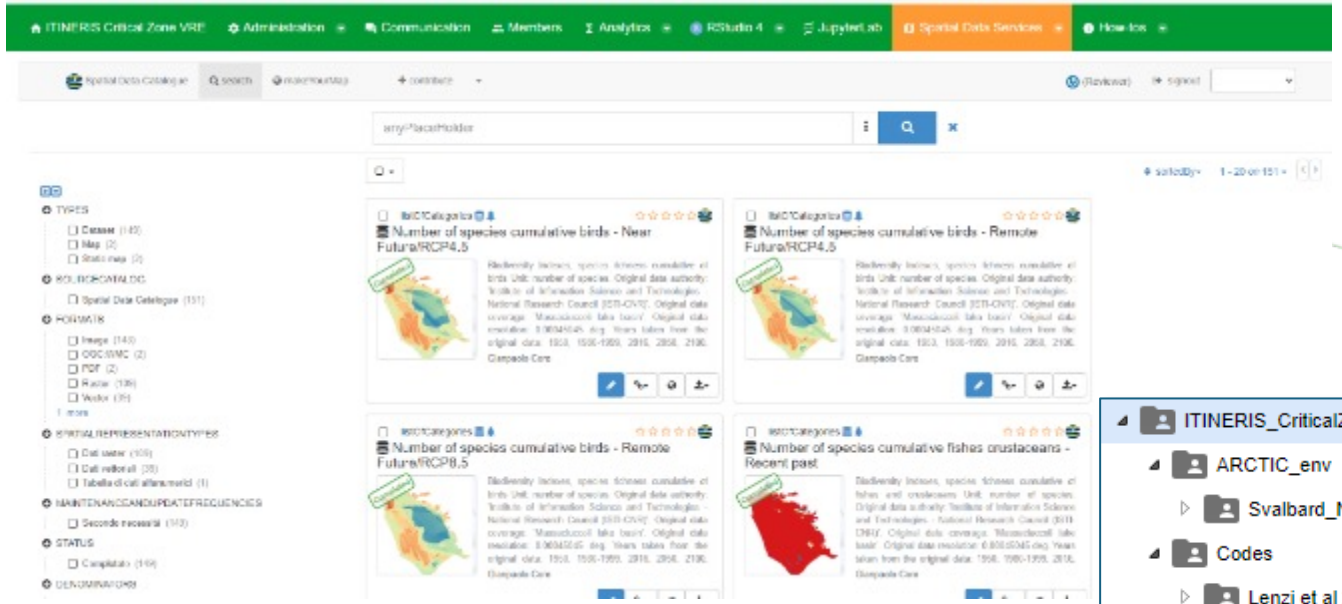
The Critical Zone (CZ) VRE

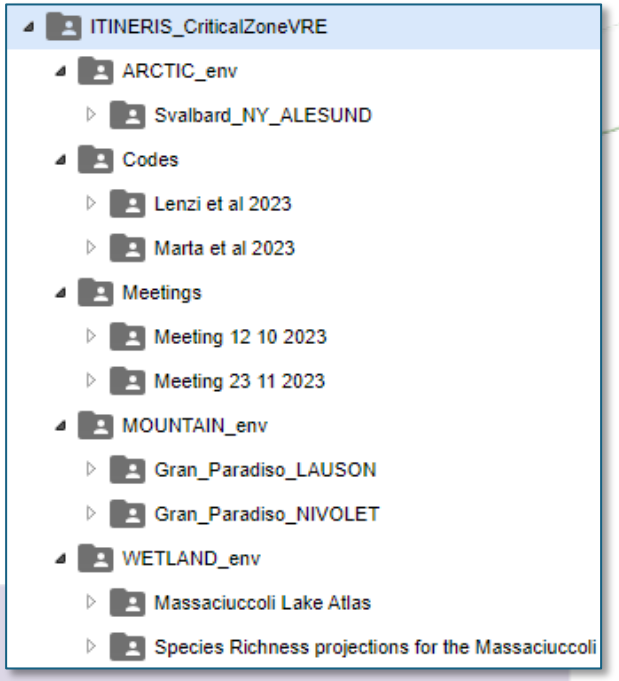
- 28 members
- 149 datasets published in the catalogue
- 11 processes and models available
- Social networking facilities

Machine and service types available for each user:

- RStudio: 4 Cores / 8G RAM (at Isti-Cnr)
- RStudio: 8 Cores / 32G RAM (at Isti-Cnr and on the Garr network)
- RStudio: 8 Cores / 64G RAM (on the Google Cloud connected to D4S)
- Linux/Python/Julia/Notebooks: 4 Cores / 16G RAM (at Isti-Cnr)

VRE manager: Pasquale Bove





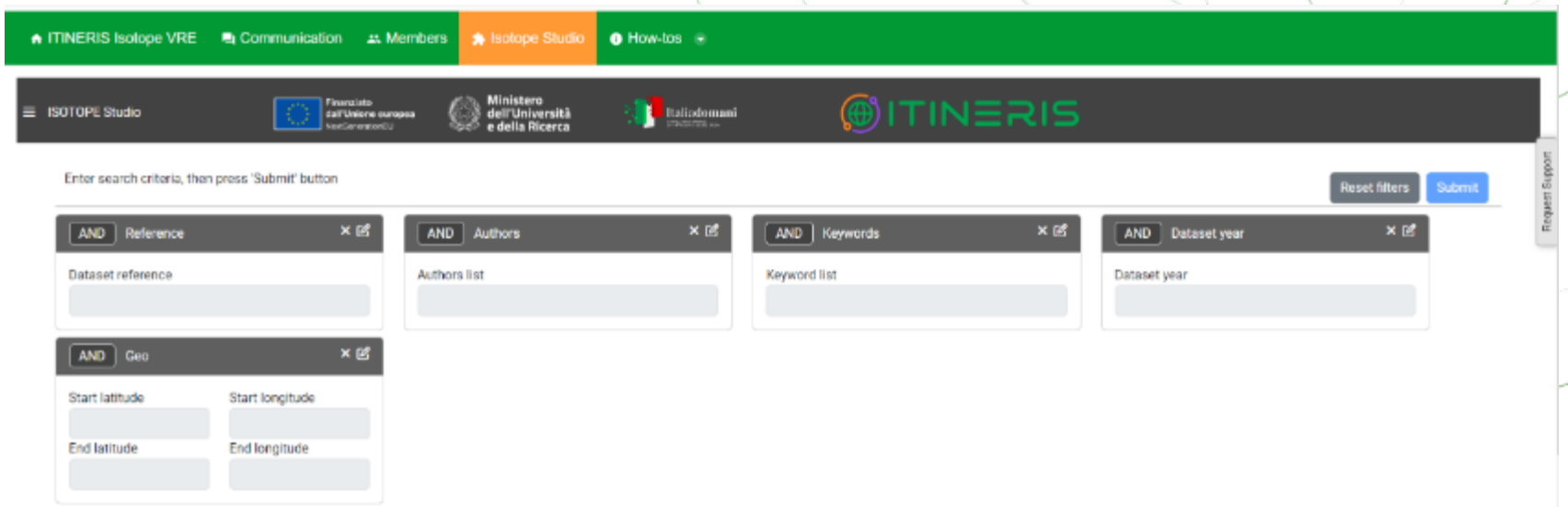
VRE Workspace organisation snapshot
containing data available for all VRE members

The Isotope VRE

VRE manager: Eugenio Trumpy

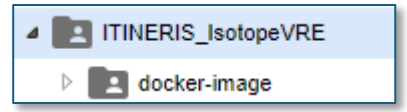
- 13 members
- Hosts the first-ever **full-suite for isotope data management, manipulation, harmonisation, and analysis**

- Uses machines with 8 Cores / 32G RAM hosted by Isti-Cnr and on the Garr network



VRE Workspace organisation snapshot

contains the docker image of the applications that all VRE members can download and use



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.

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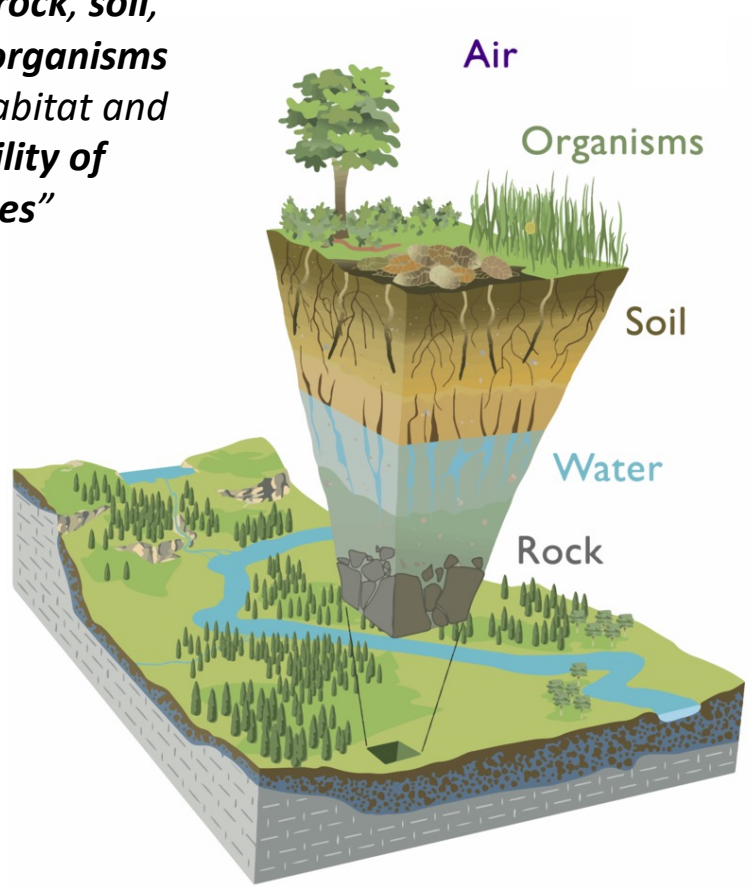
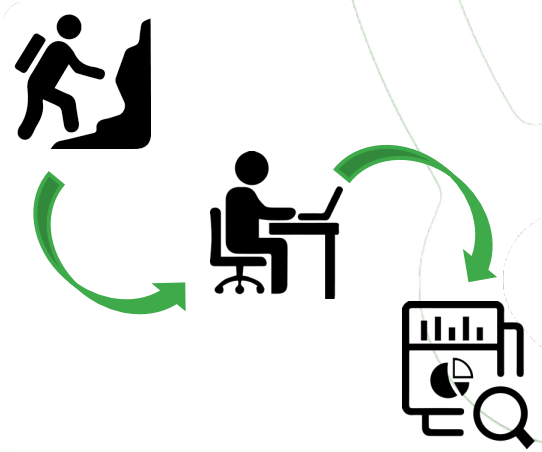
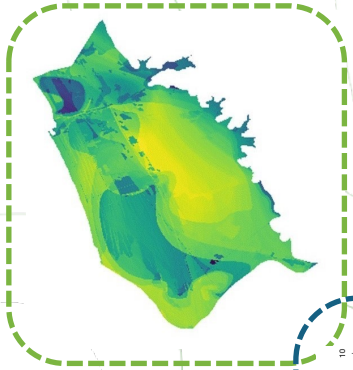
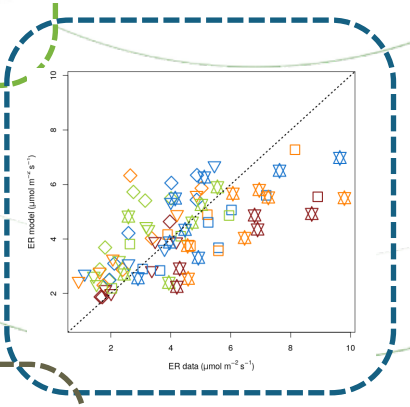
Critical Zone VRE

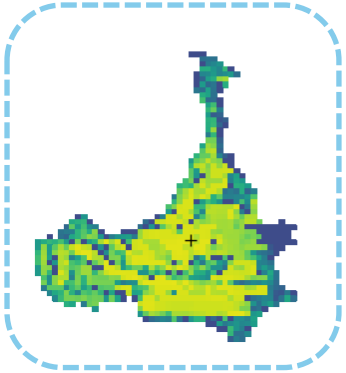
*"**heterogeneous**, near surface environment in which complex **interactions** involving **rock**, **soil**, **water**, **air**, and **living organisms** regulate the natural habitat and determine the **availability of life-sustaining resources**"*
(NRC, 2001)

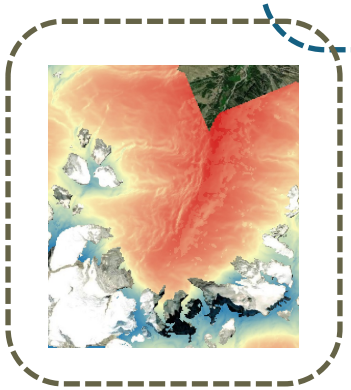












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Data - Acquired & published

Portable flux chambers (Nivolet CZO - PNGP - IT)	**CO_2 fluxes (ER + NEE) / 2017-2023 / 3,590 records** **Env**: radiation + airT + airRH + soilVWC + soilT + pressure + coordinates
Portable flux chambers (Ny Ålesund - Spitzbergen - NO)	**CO_2 fluxes (ER + NEE) / 2019 / 248 records** **Env**: radiation + airT + airRH + soilVWC + soilT + pressure + GFC + coordinates
Eddy covariance tower (IT-Niv - Nivolet CZO - PNGP - IT)	**CO_2 flux (NEE) / 2020-2021 / 1,500 records** **Env**: airT + airRH + wind speed + wind dir + coordinates
Massaciuccoli basin - IT	**Species distribution / 180 species / 6,540 records** **Env**: 148 high-res environmental, geomorphologic and socioeconomic datasets (75 variables - 1950 to 2100)

Data - Acquisition / publication in progress (embargoed)

Long-term monitoring (Nivolet CZO - PNGP - IT)	**CO_2 fluxes: portable chambers / 2017 - ongoing / summer - 15 days / 4,000+** **CO_2 fluxes: automated chambers / 2022 - ongoing / summer - 1 rec h^{-1} / 5,000+** **CO_2 fluxes: eddy tower / 2019 - ongoing / summer - 2 rec h^{-1} / 5,000+**
Long-term monitoring (Ny Ålesund - Spitzbergen - NO)	**CO_2 fluxes: portable chambers / 2019 - ongoing / summer - on mission / 1,500+** **CO_2 fluxes: eddy tower / 2019 - ongoing / yearly - 2 rec h^{-1} / 15,000+** **CO_2 fluxes: snowpack tower / 2024 - ongoing / 'winter' - 60 rec h^{-1} / 0+**
Continuous monitoring (Etna CZO - IT)	**CO_2 fluxes: portable chambers / 2021 - ongoing / on mission / 700+** **CO_2 fluxes: automated chambers / 2021 - ongoing / yearly - 1 rec h^{-1} / 10,000+** **CO_2 fluxes: eddy tower / 2022 - ongoing / yearly - 2 rec h^{-1} / 10,000+**
Continuous monitoring (Pianosa - PNAT - IT)	**CO_2 fluxes: automated chambers / 2023 - ongoing / yearly - 4 rec h^{-1} / 40,000+**
Portable flux chamber (CO_2 fluxes - various projects)	**PNGP**: Levionaz / Noaschetta / Lavassey / Dres /…(**on mission / 500+**) **GLORIA**: M. Cimone / A. Mommio (**on mission / 100+**) **Delta Po**: Bosco Mesola / **yearly - 30 days / 200+**

Codes - R

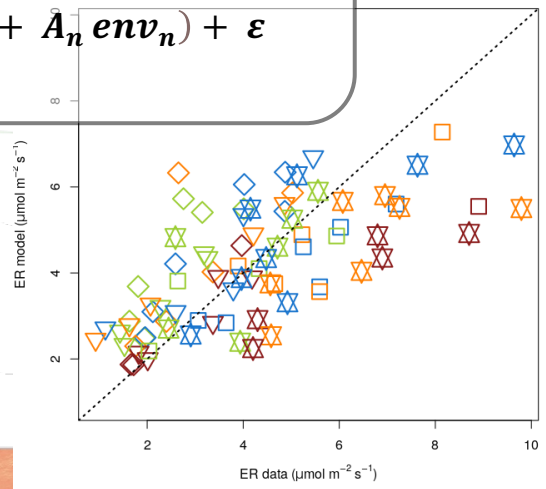
$$ER = e^{b_0 T}(a_0 + a_1 env_1 + \ldots + a_n env_n) + \varepsilon$$

$$GPP = \frac{\alpha_0 rad}{1 + \frac{\alpha_0}{F_0} rad}(A_1 env_1 + \ldots + A_n env_n) + \varepsilon$$

Fit of non-linear models for ER and GPP

- ✓ Perform a forward AIC-based model selection
- ✓ Summarize model outputs
- ✓ Plot observed-expected

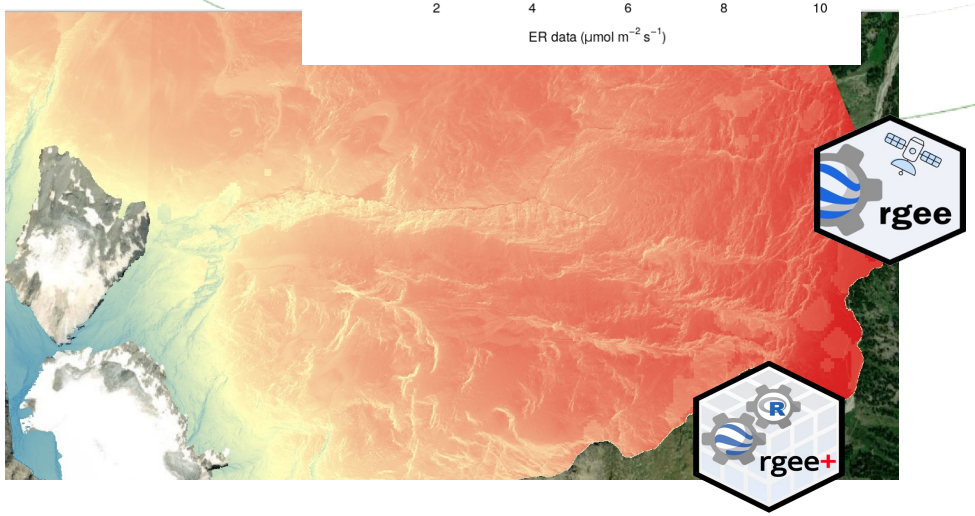
Input: dataset (.csv) with flux measures and environmental variables



High-res 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

Input: DEM, glacier outline(s), selection on the period of interest (Y, M)



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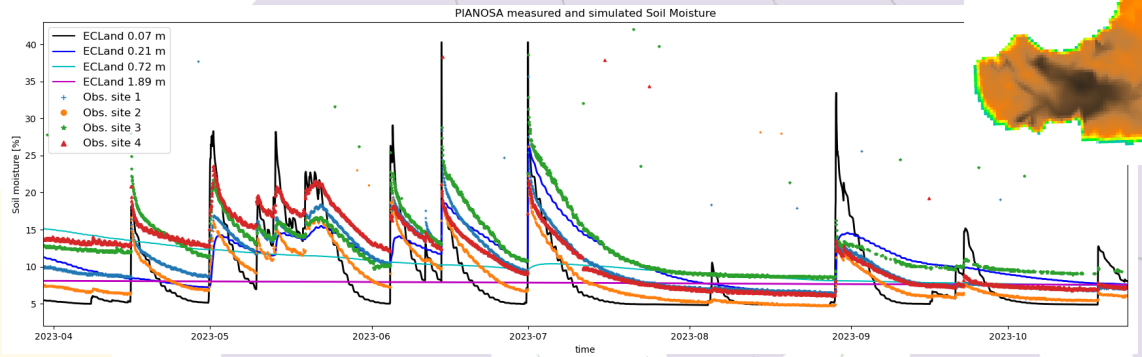
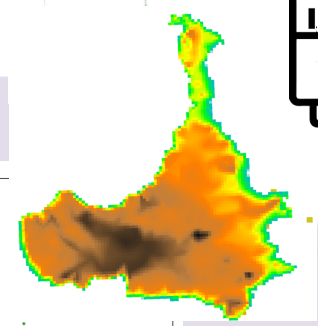
Codes - Fortran / Python (in progress)





ECMWF

CHTESSEL / ECLand

- ✓ Model land-atmosphere fluxes (H_20, CO_2,…)
- ✓ Predict soil moisture

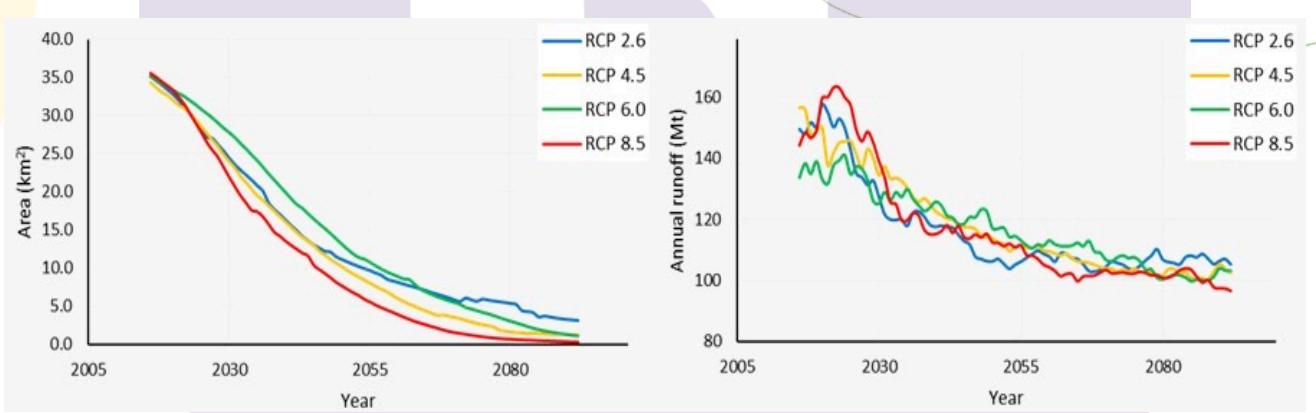
Input: Precipitation, radiation, wind speed, pressure, airT, airRH

OGGM
Open Global Glacier Model

Open Global Glacier Model

- ✓ Run-off trends under different RCP scenarios
- ✓ Prediction of glacier snout position

Input: DEM, glacier outline(s)



Critical Zone VRE

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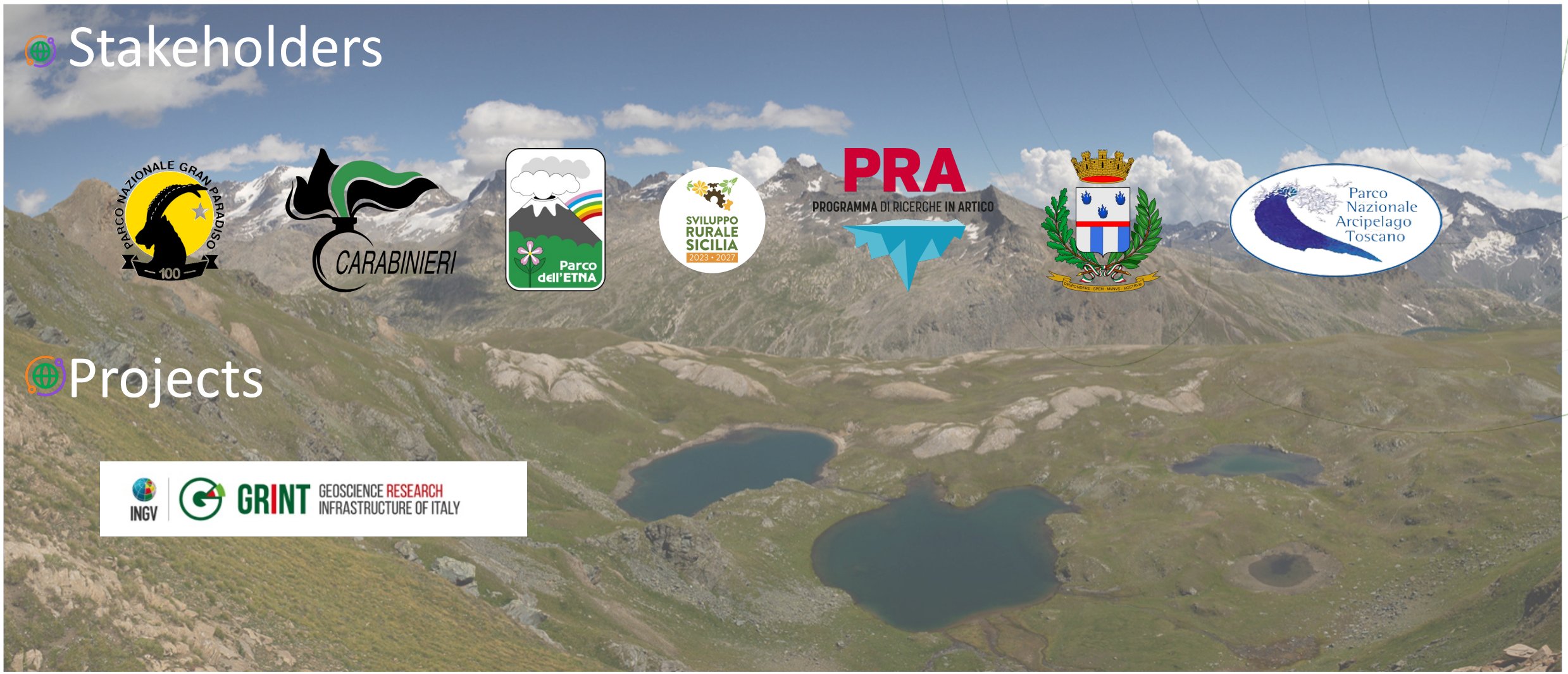
Stakeholders



Projects

INGV | GRINT GEOSCIENCE RESEARCH INFRASTRUCTURE OF ITALY

Effects of Global Warming on Aquatic Biomass and Phytoplankton Production

- VRE : Investigation of the temporal variation of Chl-a and net primary production in the aquatic component in relation to temperature

Scientific coordinator: Prof. Alberto Basset

Working group: Teodoro Semeraro, Jessica Titocci, Flavio Monti, Lorenzo Liberatore, Francesco De Leo,

IRET-URT Lecce, CNR

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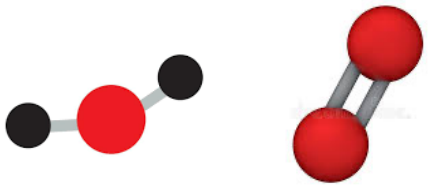
Data of VRE

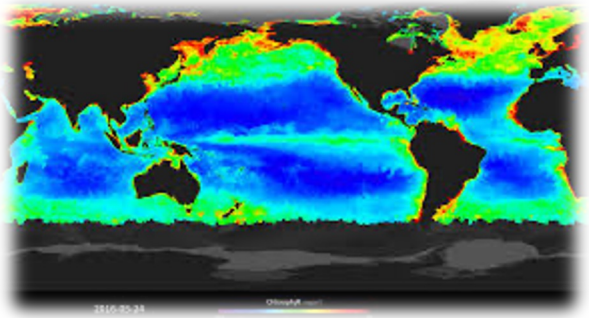
- Field data
  - Chl-a 
  - Sea Temperature 
  - Net Primary Production



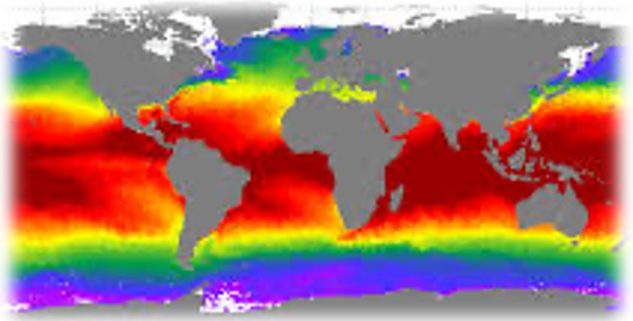
$^{14}CO_2$ O_2

- Remote Sensing Data

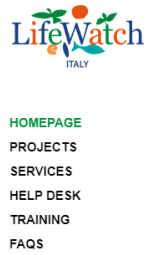
MODIS *Chl-a*



MODIS *SST*



VRE Workflows



Prototype development on Datalabs:

DataLabs: LifeWatch's Collaborative Coding Platform for Biodiversity and Ecosystem Research

https://datalabs.lifewatchitaly.eu/dashboard/ui/home

- Workflow 1: Assessment of Chl-a and NPP variations in relation to the thermal gradient. Application of linear regression and random forest models to field data

↓

Calibration of Net Primary Production field data resulting from ^{14}C based analytical methods and from model estimates based on satellite imagery

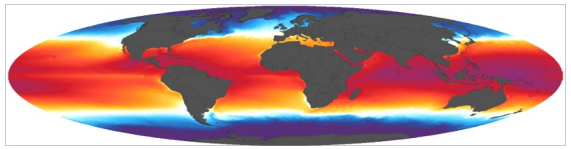
↓

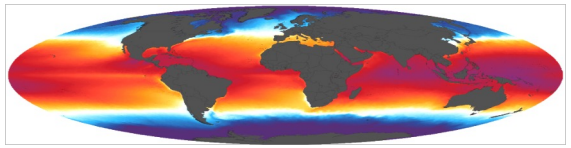
- Workflow 2 & 3: Assessment of Chl-a and NPP variations in relation to the thermal gradient. Application of linear regression and random forest models to remote sensing data for the development SST, Chl-a and NPP time series and make their projection in time.

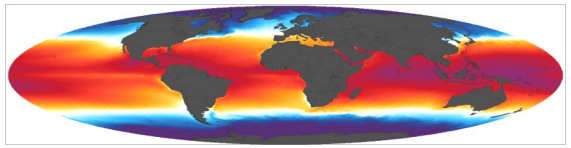
- Workflow 4: The use of remote sensing data to assess the spatial correlation between SST and Chl-a, and the temporal projection of Chl-a in relation to SST variability.

Tools Implemented in the WFs

Study area

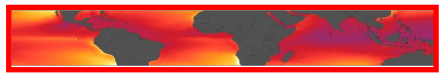


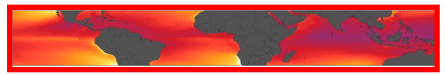




Clipping of satellite data considering the study area

From 01/2003





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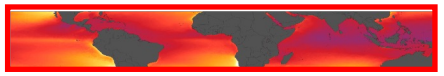
to 12/2023

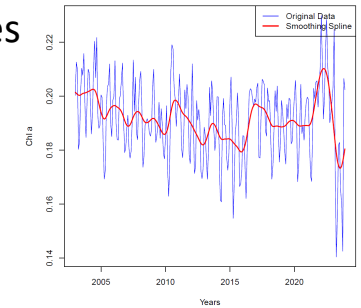


Definition of a good regression model and its application to satellite data in order to obtain new products:

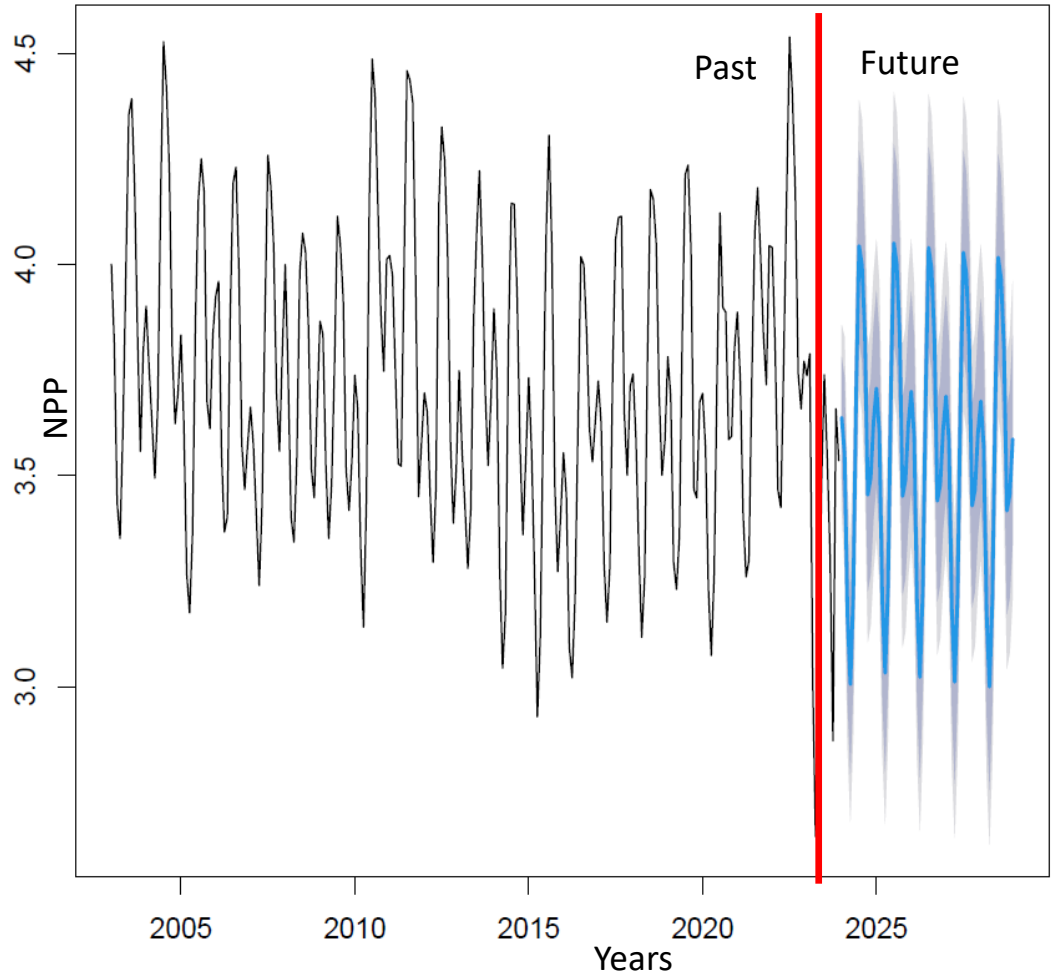
- NPP
- Chl-a

Realization of time series and perform statistical analysis on:

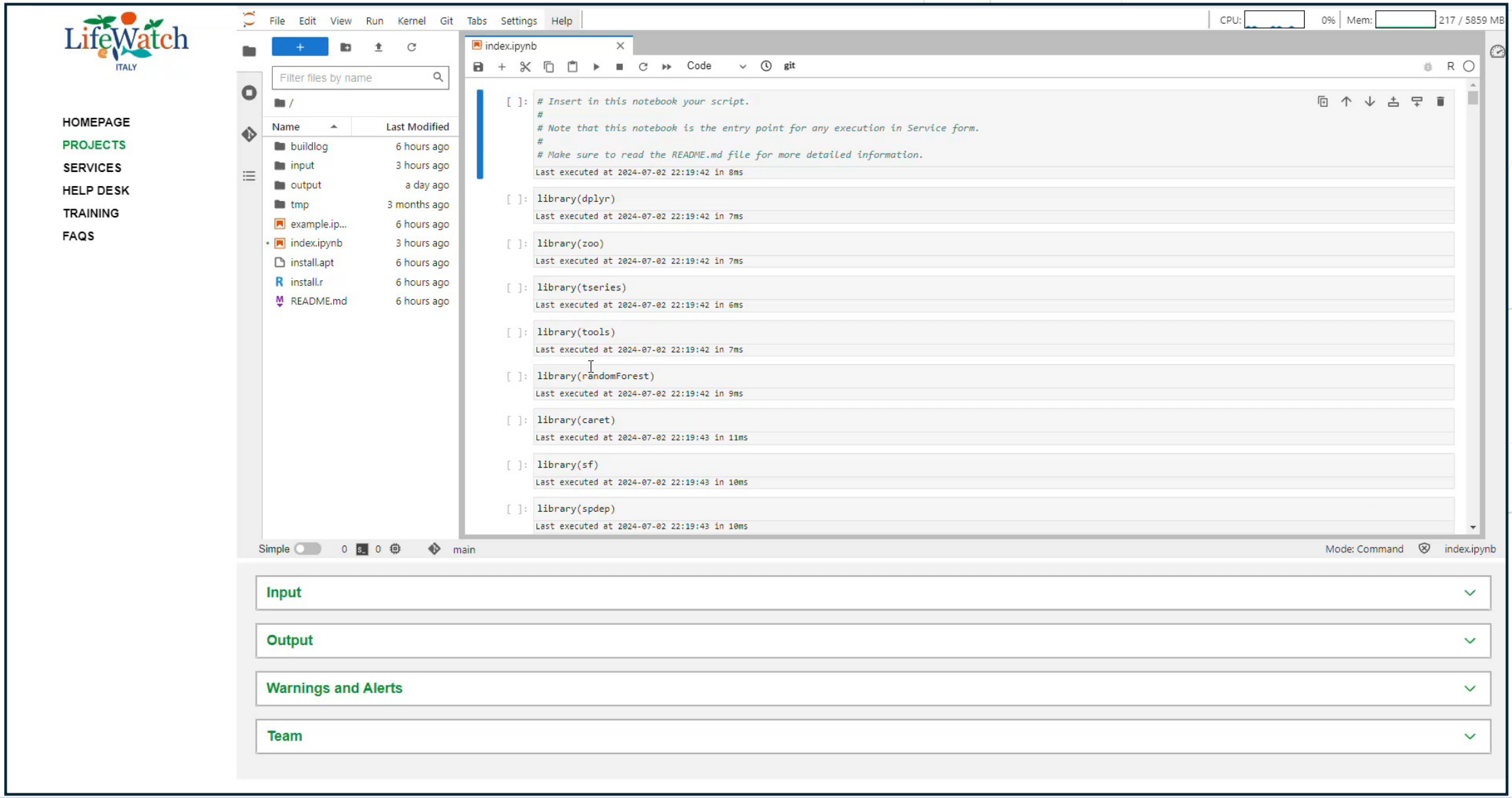
- SST
- Chl-a
- NPP



Temporal projection of time series of SST, Chl-a and NPP



E.g. Workflow 2



VRE applications and utilities

- **Who is it for:**
  - Researchers who work with field or laboratory data and want to try to apply/spread their study at a higher spatial-temporal scale.
  - Economists and Planners who can use prospective analysis to build scenarios in their studies.
- **Time saved:**
  - It provides a basic approach for those without remote sensing skills, with a time saving of around 2-3 months.
  - Without programming skills, a researcher would need at least 3-4 months to develop the codes.
  - The first approach to the study of time series can take about 1-3 months to acquire the necessary scientific knowledge
  - Economic Savings
- **Performance**
  - It is possible to run the calculation process on a PC that is not very powerful. All you need is a connection.
  - Processing takes many hours and can be carried out without the PC being switched on.
  - Avoid using software whose licence is not free.

IRET Montelibretti: *Gaia Vaglio Laurin, Alessandro Sebastiani, Paolo Sconocchia*
IRET Porano: *Francesca Chiocchini, Gabriele Guidolotti, Olga Gavrichkova*
IRET Lecce: *Flavio Monti, Teodoro Semeraro, Jessica Titocci, Lorenzo Liberatore*
IRET Firenze: *Alessandro Montaghi*

VRE CARBON

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

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VRE CARBON

VRE C aims:

- Storing spatially explicit C-related datasets to promote data sharing, analysis, innovative research
- Providing tools for on-demand geospatial analyses
- Facilitating reporting activities for administrations

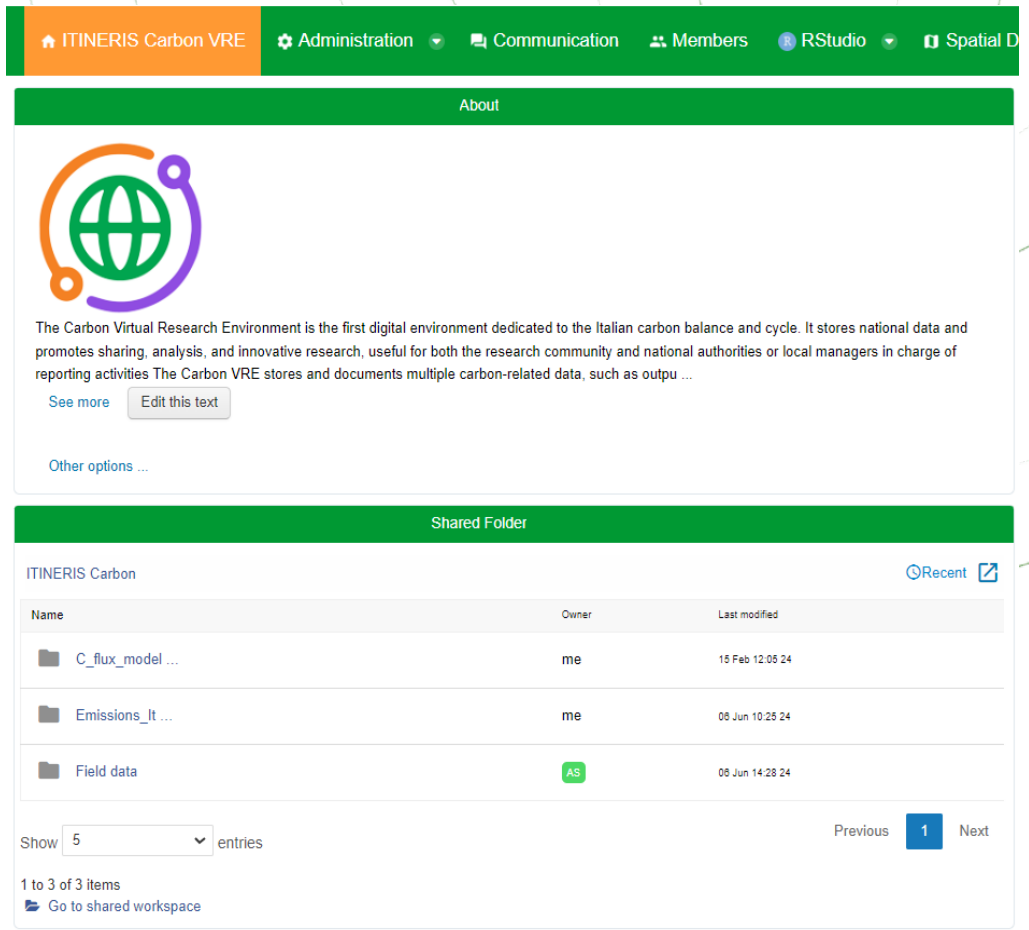
(end user-oriented)

Target data:

- variables from large-scale models
- ground observations
- modeling results

The Carbon VRE integrates:

- Harmonized and georeferenced data on ecosystems carbon dynamics
- Re-elaborated emission data
- Tools and facilities for independent analyses
- Field data
- Modeling



Harmonized ecosystem C dynamics for Italy

GPP, NEE, Ra data, from main flux-based models:

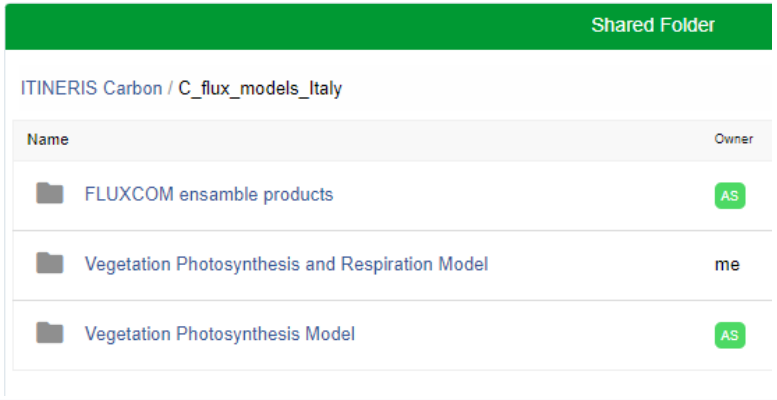
- spatial resolution > 0.05°, in agreement with Italian landscape fragmentation
- Harmonization includes monthly aggregation for several years
- Model comparison and infographics

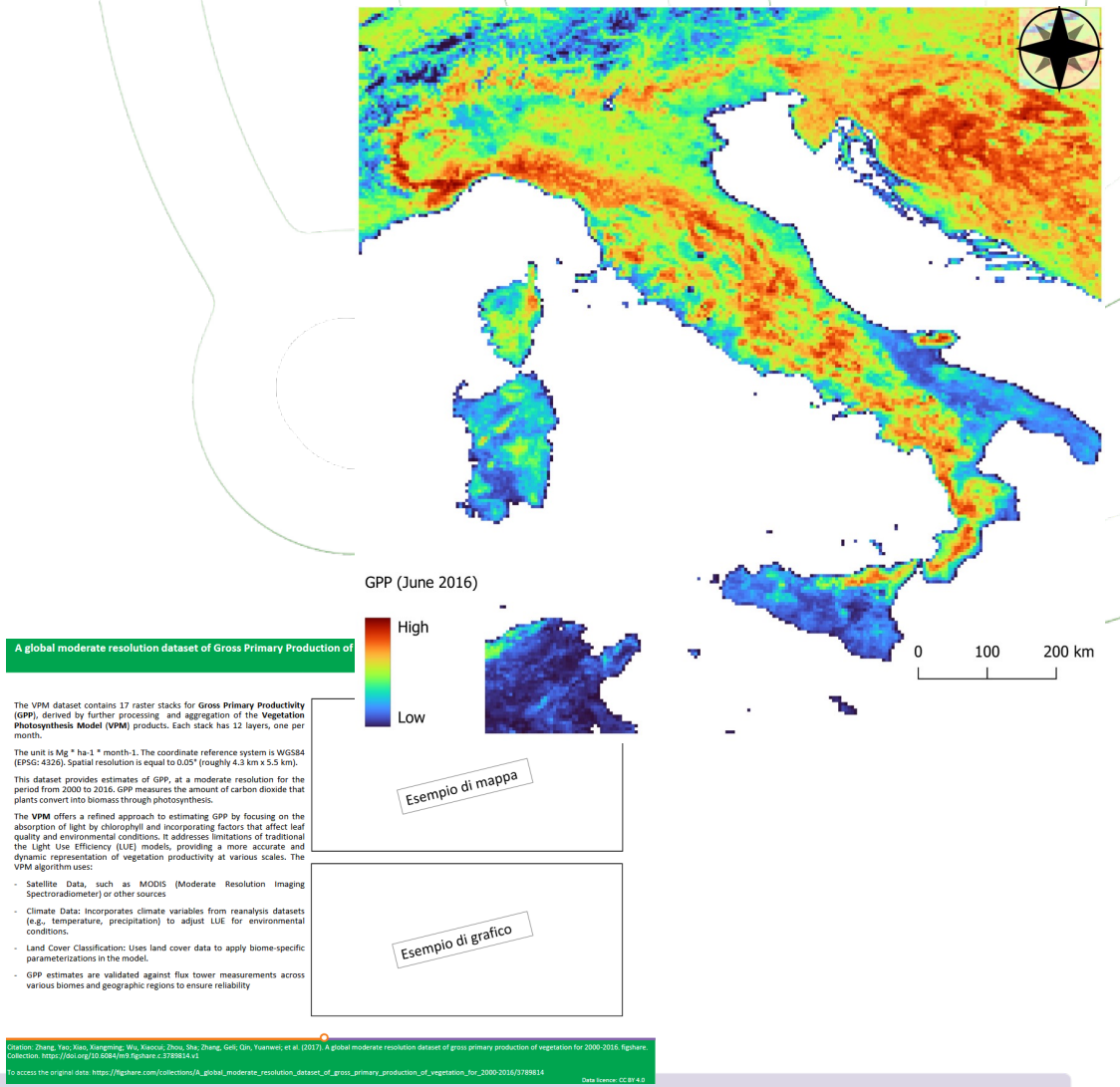
Now including 3 families and 144 monthly products:

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

Now in workspace, to be uploaded in Geoserver

Other models to be soon included!

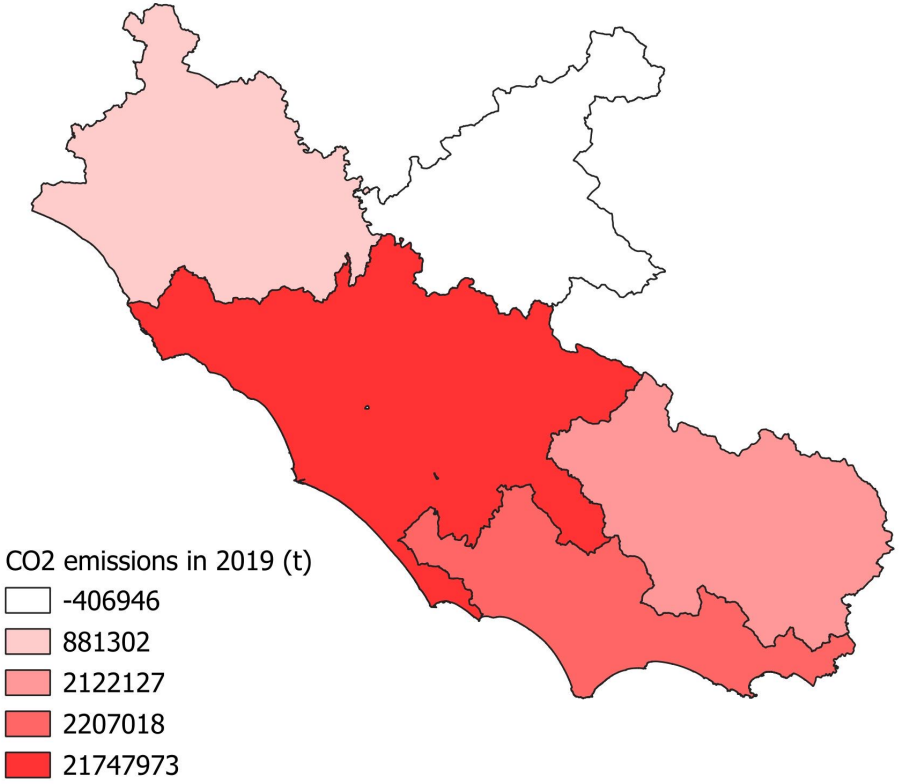




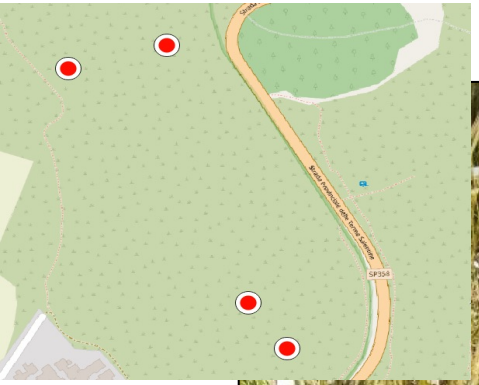
GHG emissions

Spatially explicit data, derived from national GHG tabular inventory

- spatialization of main GHG at Province
- source characterization
- grouped by time intervals since 1990



Field data

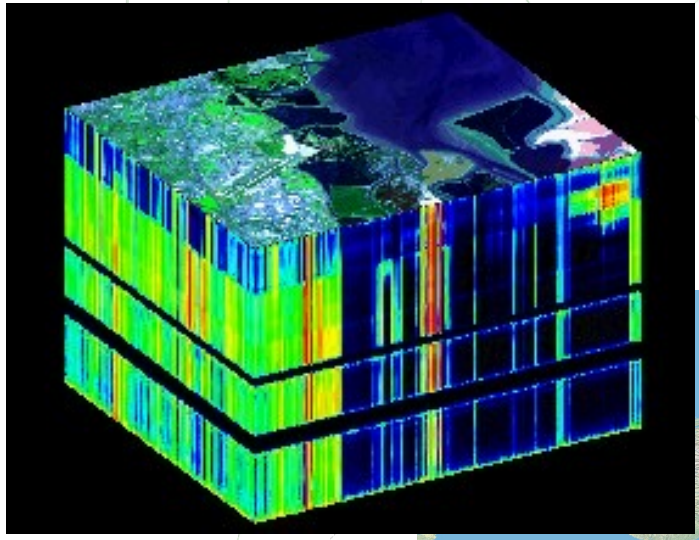


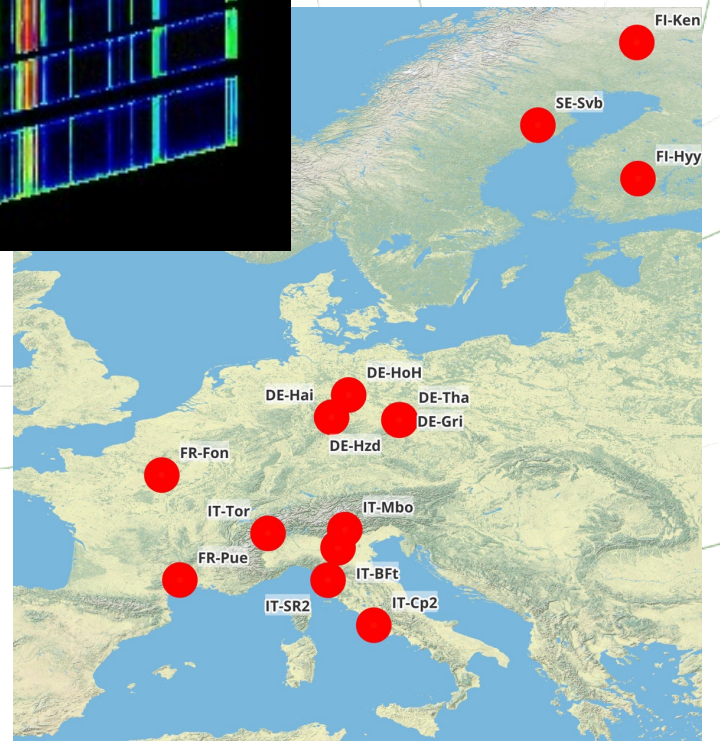
Different IRET groups are collecting ground new data on **grasslands** for calibration and validation of above ground biomass experimental models, based on SAR + optical remote sensing and machine learning

Courtesy of IRET Lecce

Modeling

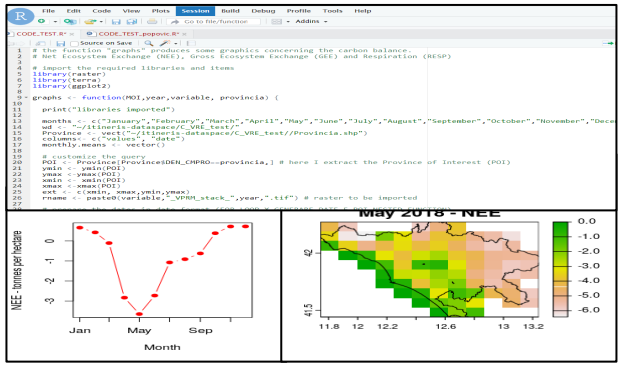
Data/results from experimental research and models.
Example:
Ecosystem Functional Properties (EFPs) and Hyperspectral imagery





-WUE, LUE, and GPP are EFPs that help in explaining the ecosystems functioning
-EFPs are derived from the ICOS research infrastructure
-EFP are linked to PRISMA hyperspectral data to explore the capability to predict ecosystem functioning from space.

Tools



R script to customize data processing and extract information

Data plotting and modelling based on Element Ratios and Isotopic Composition using ITINERIS Isotope VRE and the capabilities of Isotope Studio

Paolo Di Giuseppe CNR-IGG (Pisa)
Erico Perrone CNR-IGG (Pisa)
Simona Gennaro CNR-IGG (Pisa)

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ISOTOPE VRE

Isotope Community

Data Modelling

Data Upload

VREs Cooperation

- Data Upload
- Data Querying
- Explore External Sites
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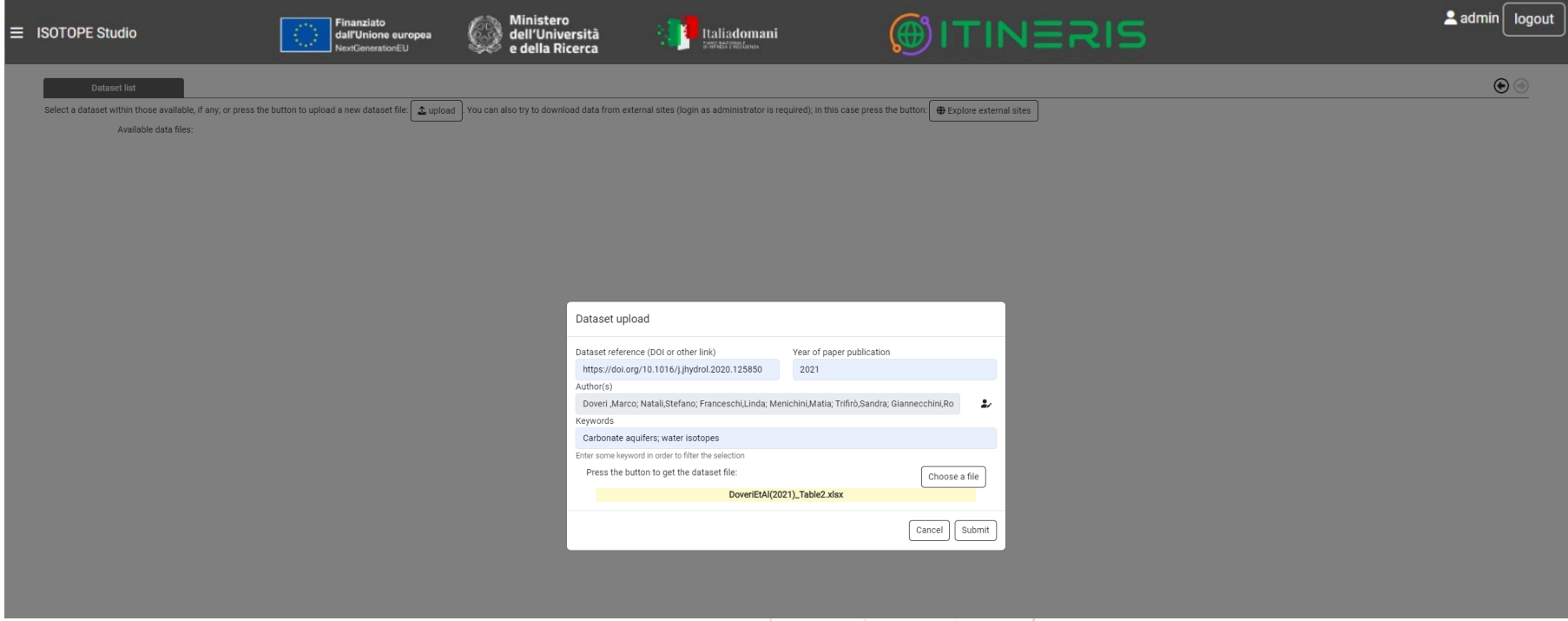

Journal of Hydrology 593 (2021) 125850

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Research papers

Carbonate aquifers threatened by legacy mining: hydrodynamics, hydrochemistry, and water isotopes integrated approach for spring water management

Marco Doveri [a], Stefano Natali [a,b,c,*], Linda Franceschi [a,c], Matia Menichini [a], Sandra Trifirò [a], Roberto Giannecchini [a,c]

[a] IGG-CNR, Institute of Geosciences and Earth Resources, via Moruzzi 1, 56124 Pisa, Italy
[b] Department of Earth Sciences, University of Florence, via G. La Pira 4, 50121 Florence, Italy
[c] Department of Earth Sciences, University of Pisa, via S. Maria 53, 56126 Pisa, Italy

- Data Upload
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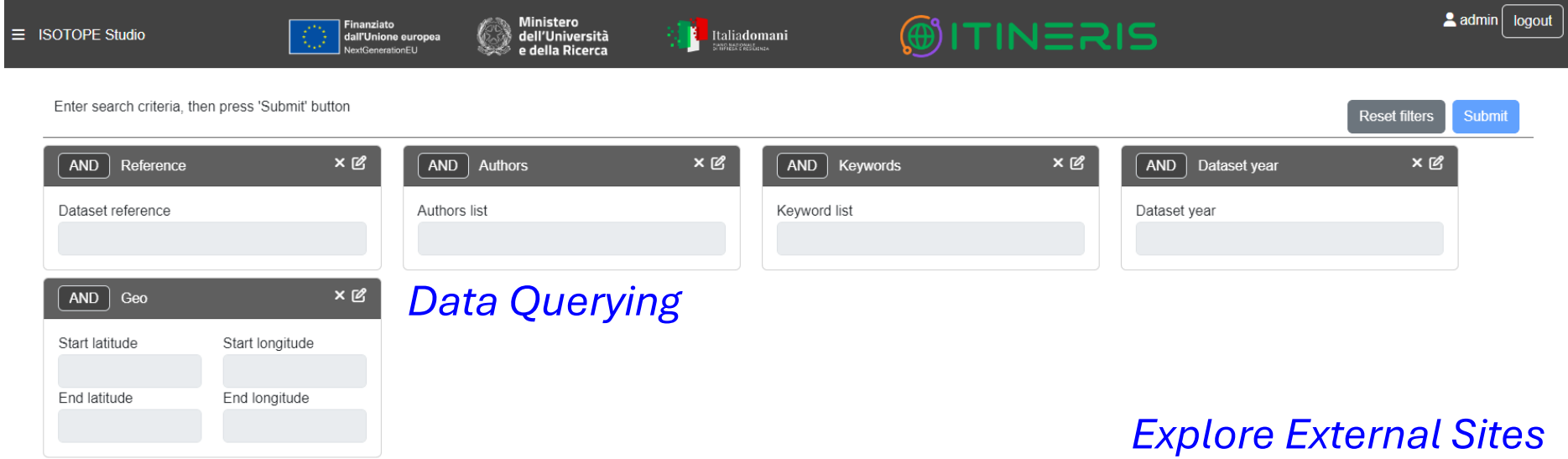
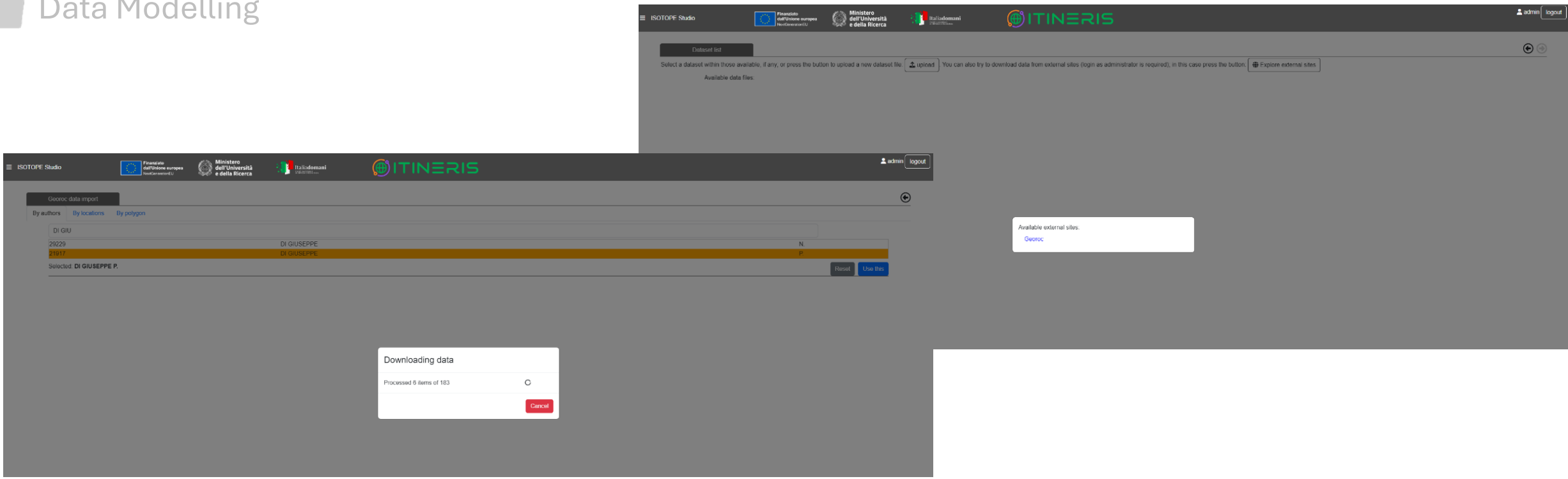


Data Querying

Explore External Sites



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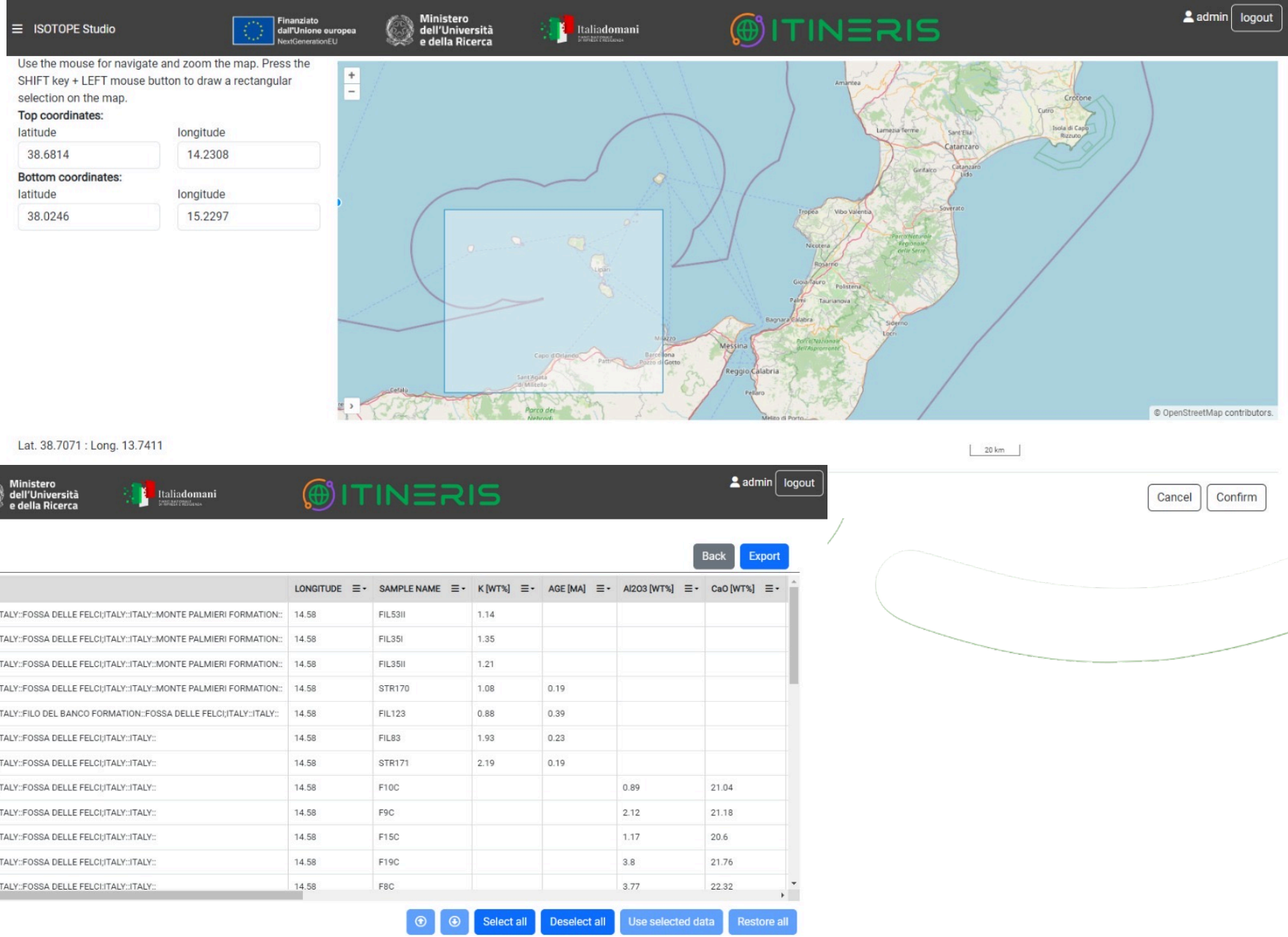

ITINERIS_ID	GEOROC_ID	LATITUDE	LOCATIONS	LONGITUDE	SAMPLE NAME	K [WT%]	AGE [MA]	Al2O3 [WT%]	CaO [WT%]
19936	63933	38.58	AEOLIAN ARC::FILICUDI;ITALY::FOSSA DELLE FELCI;ITALY::ITALY::MONTE PALMIERI FORMATION::	14.58	FIL53II	1.14			
19937	63934	38.58	AEOLIAN ARC::FILICUDI;ITALY::FOSSA DELLE FELCI;ITALY::ITALY::MONTE PALMIERI FORMATION::	14.58	FIL35I	1.35			
19938	63935	38.58	AEOLIAN ARC::FILICUDI;ITALY::FOSSA DELLE FELCI;ITALY::ITALY::MONTE PALMIERI FORMATION::	14.58	FIL35II	1.21			
19939	63936	38.58	AEOLIAN ARC::FILICUDI;ITALY::FOSSA DELLE FELCI;ITALY::ITALY::MONTE PALMIERI FORMATION::	14.58	STR170	1.08	0.19		
19940	63937	38.58	AEOLIAN ARC::FILICUDI;ITALY::FILO DEL BANCO FORMATION::FOSSA DELLE FELCI;ITALY::ITALY::	14.58	FIL123	0.88	0.39		
19941	63938	38.58	AEOLIAN ARC::FILICUDI;ITALY::FOSSA DELLE FELCI;ITALY::ITALY::	14.58	FIL83	1.93	0.23		
19942	63939	38.58	AEOLIAN ARC::FILICUDI;ITALY::FOSSA DELLE FELCI;ITALY::ITALY::	14.58	STR171	2.19	0.19		
19927	59157	38.58	AEOLIAN ARC::FILICUDI;ITALY::FOSSA DELLE FELCI;ITALY::ITALY::	14.58	F10C			0.89	21.04
19928	59158	38.58	AEOLIAN ARC::FILICUDI;ITALY::FOSSA DELLE FELCI;ITALY::ITALY::	14.58	F9C			2.12	21.18
19929	59170	38.58	AEOLIAN ARC::FILICUDI;ITALY::FOSSA DELLE FELCI;ITALY::ITALY::	14.58	F15C			1.17	20.6
19930	59171	38.58	AEOLIAN ARC::FILICUDI;ITALY::FOSSA DELLE FELCI;ITALY::ITALY::	14.58	F19C			3.8	21.76
19931	59185	38.58	AEOLIAN ARC::FILICUDI;ITALY::FOSSA DELLE FELCI;ITALY::ITALY::	14.58	F8C			3.77	22.32

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  - Ternary Plot
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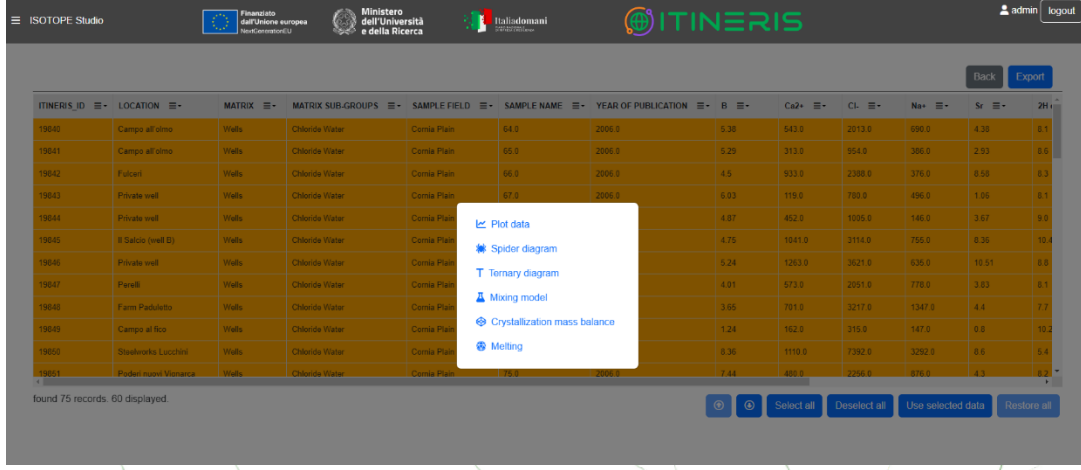

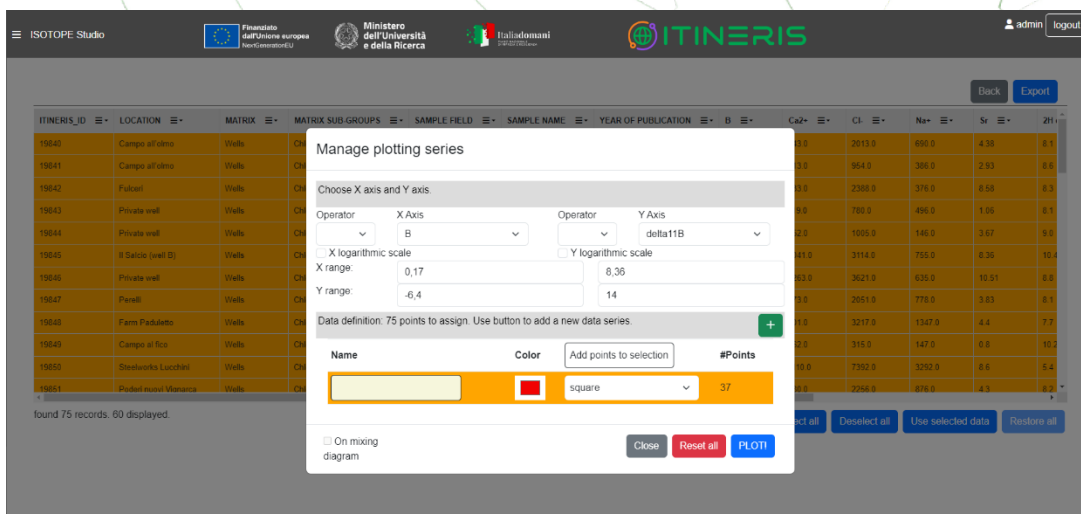

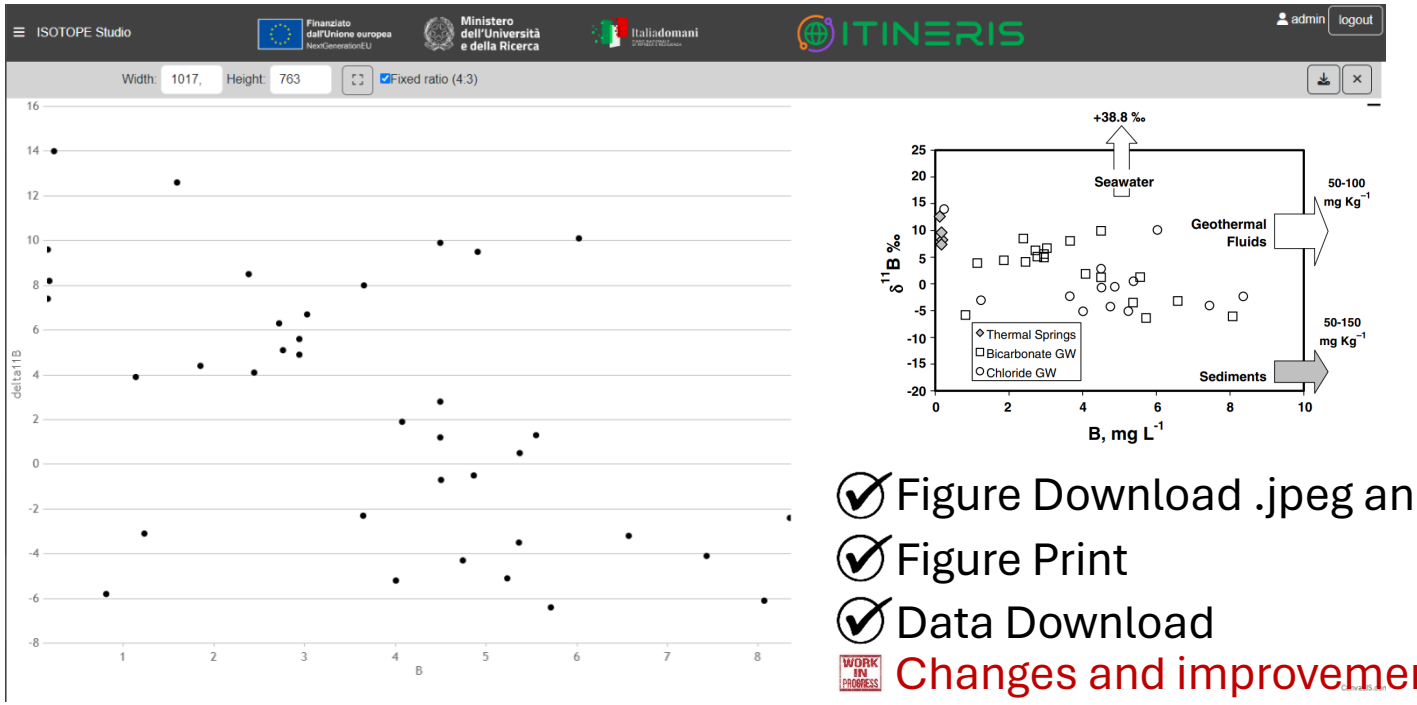

Data from Pennisi et al (2006)_Applied Geochemistry

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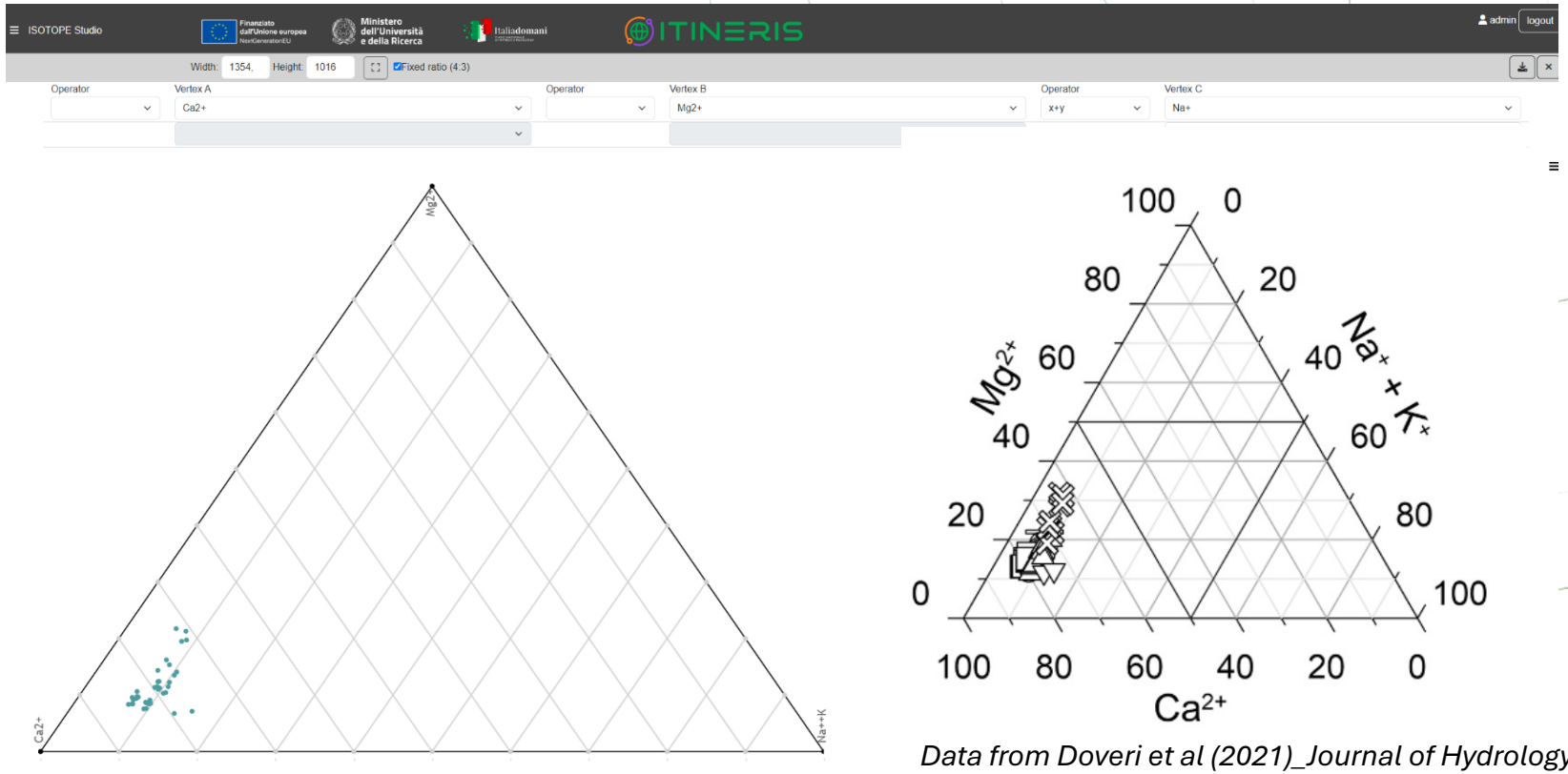

Data from Doveri et al (2021)_Journal of Hydrology

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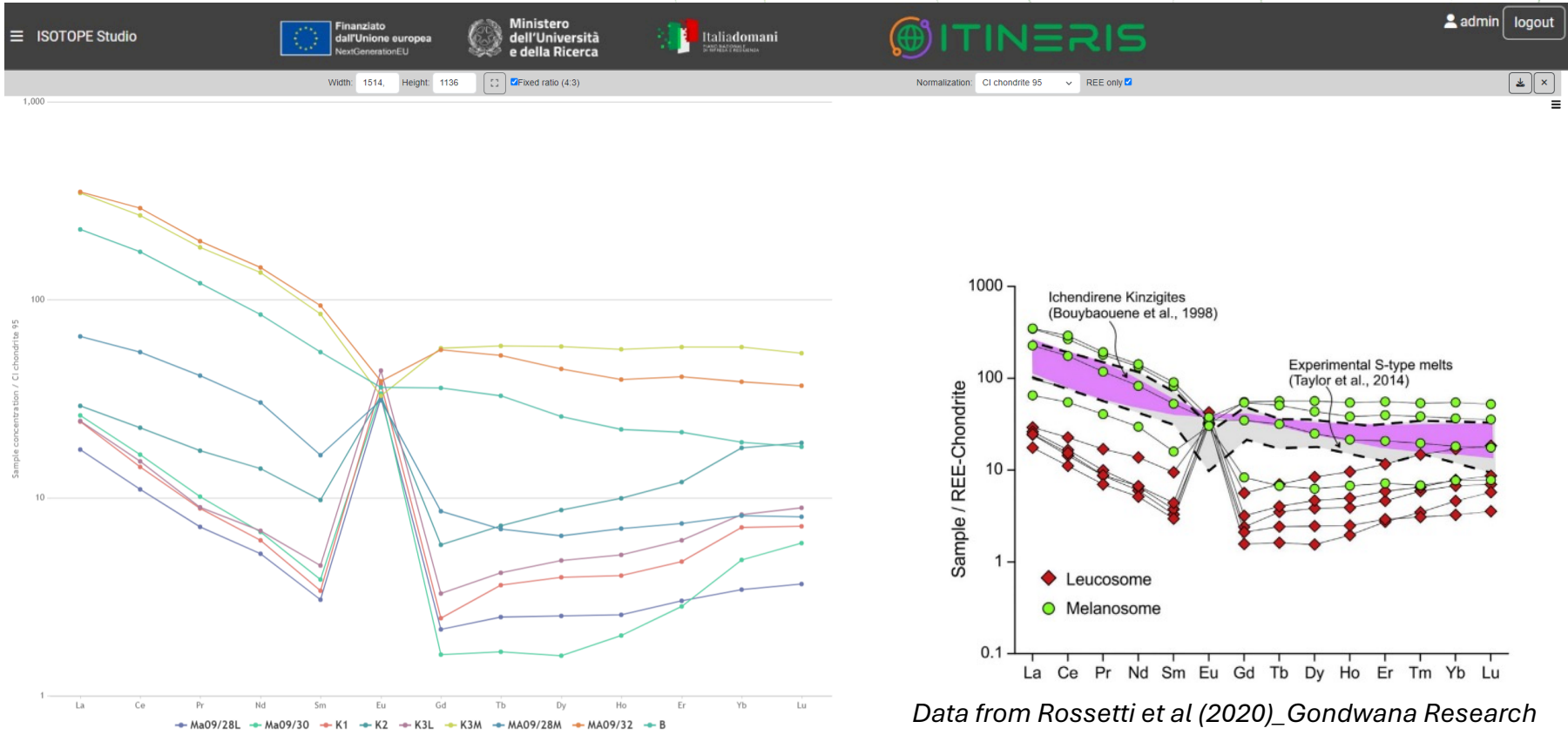

Data from Rossetti et al (2020)_Gondwana Research

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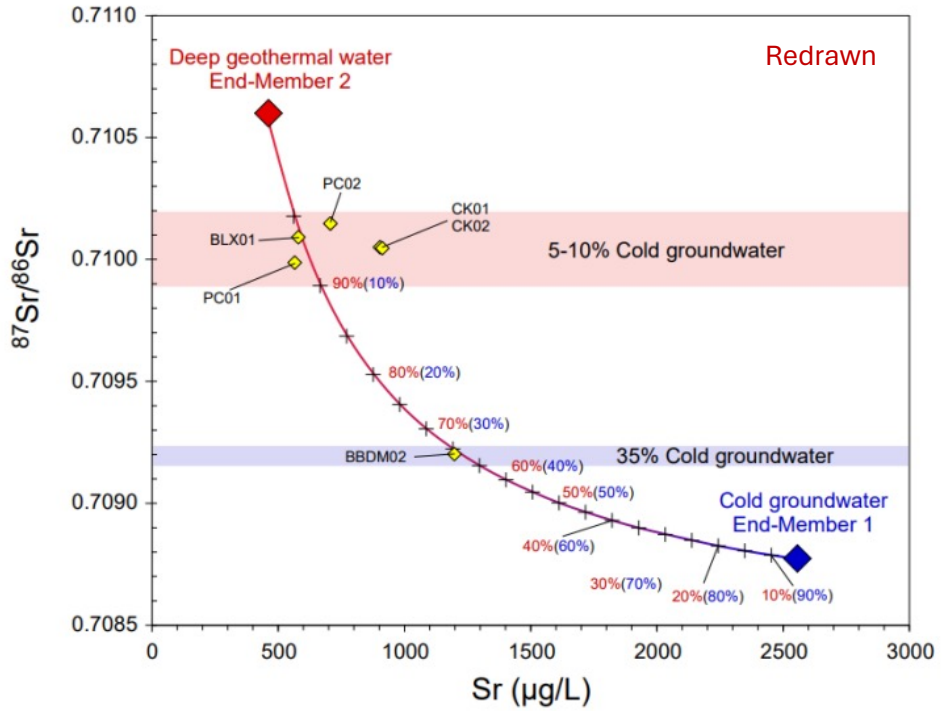
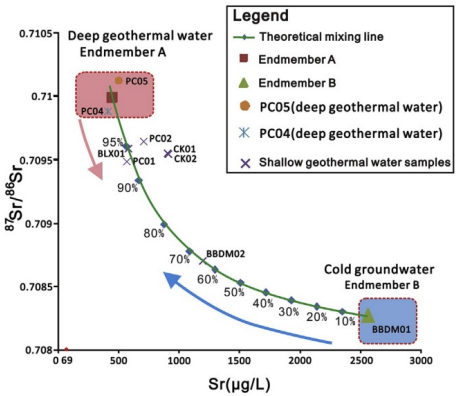


Di Giuseppe et al (2023)_CNR Internal Report

ITINERIS

Example of Data Download

SR	87SR86/SR	BBDM01: 87SR/86SR	Average PC04-PC05: 87SR/86SR
456	0.710005	0.000	1.000
561	0.709609	0.050	0.950
666	0.709339	0.100	0.900
771	0.709142	0.150	0.850
877	0.708992	0.200	0.800
982	0.708874	0.250	0.750
1087	0.708780	0.300	0.700
1192	0.708701	0.350	0.650
1297	0.708636	0.400	0.600
1402	0.708580	0.450	0.550
1508	0.708532	0.500	0.500
1613	0.708491	0.550	0.450
1718	0.708454	0.600	0.400
1823	0.708422	0.650	0.350
1928	0.708393	0.700	0.300
2033	0.708367	0.750	0.250
2138	0.708344	0.800	0.200
2244	0.708323	0.850	0.150
2349	0.708304	0.900	0.100
2454	0.708286	0.950	0.050
2559	0.708270	1.000	0.000



Original

Data from Wang et al (2020)_Geoscience Frontiers

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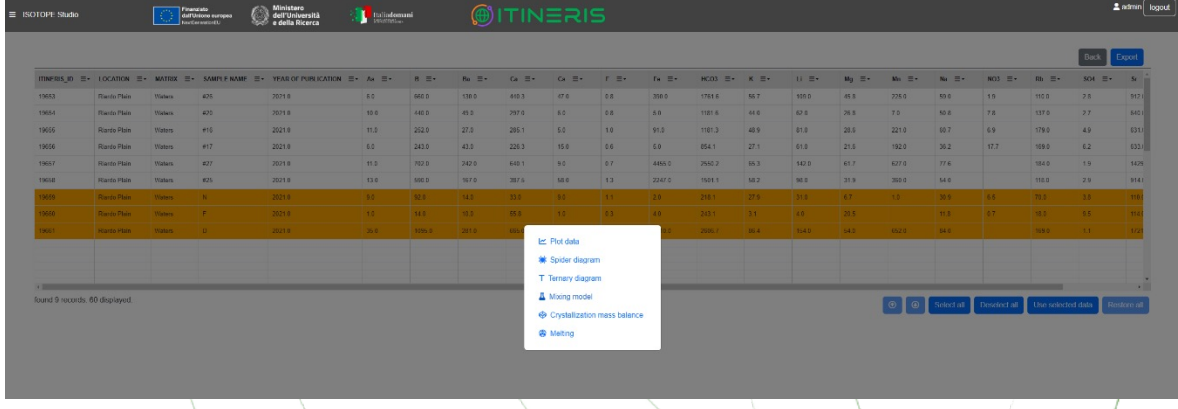
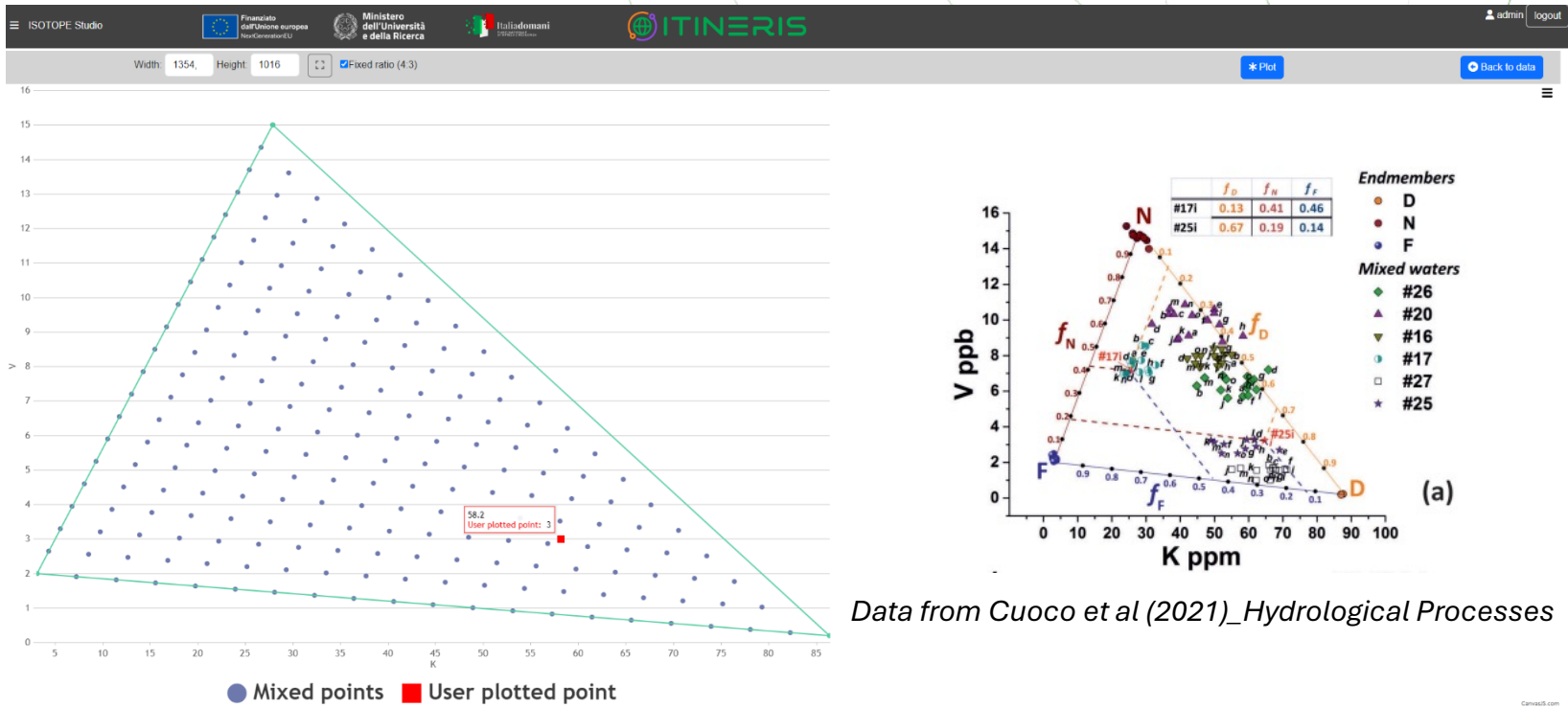


Sample	Results	N	F	D
#25	Isotope Studio	0.15	0.25	0.59
	Cuoco Et al. (2021)	0.16	0.24	0.60
	EMMA	0.16	0.24	0.58
#17	Isotope Studio	0.43	0.41	0.16
	Cuoco Et al. (2021)	0.44	0.41	0.15
	EMMA	0.44	0.41	0.15
#26	Isotope Studio	0.38	0.09	0.53
	Cuoco Et al. (2021)	0.41	0.08	0.51
	EMMA	0.41	0.05	0.53



Data from Cuoco et al (2021)_Hydrological Processes

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