



D5.3 Report on gap analysis of the national marine facilities and equipment and access procedures



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1. INTRODUCTION

Ocean and waters need to be observed to improve climate change forecasts, manage marine resources to mitigate the effects of natural disasters, and use the coastal zone and coastal ocean more effectively. This challenge was taken up globally by many countries with the establishment in 1991 of the Global Ocean Observing System (GOOS) by the Intergovernmental Oceanographic Commission (IOC) of UNESCO. At European level, within the GOOS context, an international non-profit association of national governmental agencies and research organisations, committed to European-scale operational oceanography was founded in 1994 providing operational oceanographic services and carrying out marine research, EuroGOOS.

In this context, the development of sampling requirements for various ocean applications, including in situ and satellite observing platforms led to the possibility to define the Essential Ocean Variables (EOVs). These variables are defined by the GOOS Expert Panels on two aspects¹:

1. Impact: the variable addresses climate, operational ocean services and ocean health and also contributes to understanding from a scientific perspective or application from a service perspective (GOOS website).
2. Feasibility: it is technically, politically and economically feasible to observe or derive the variable on a global scale using proven, scientifically understood methods (GOOS website).

Many EOVs are also Essential Climate Variables (ECVs): a physical, chemical or biological variable or a group of linked variables that critically contributes to the characterization of Earth's climate². ECVs are defined by the Global Climate Observing Systems (GCOS).

The EOVs/ECVs are critical to describe the ocean behaviors interpreting the links between the ocean and elements such as the atmosphere, biosphere, hydrosphere, cryosphere, and anthroposphere. Moreover, ECVs provide the measures needed to understand and predict climate evolution, guiding mitigation and adaptation measures. ECV are identified based on the following criteria:

1. Relevance: The variable is critical for characterizing the climate system and its changes.
2. Feasibility: Observing or deriving the variable on a global scale is technically feasible using proven, scientifically understood methods.
3. Cost effectiveness: Generating and archiving data on the variable is affordable, mainly relying on coordinated observing systems using proven technology, taking advantage where possible of historical datasets.

At the EU level, within the European Forum for Research Infrastructure³ (ESFRI), the Roadmap for Research Infrastructures 2021 highlighted the fact that marine and fresh water RIs are diverse and range from fixed observatories, data centers to research vessels and autonomous vehicles that generate, analyze and apply in situ, remote sensed and modelled data. These data and associated services are essential for ocean and coastal sea monitoring, biological and ecological research and for numerous established, and emerging, industries in the Blue Economy⁴.

In this context, ITINERIS WP5 has as objective to implement the Italian Integrated Ocean Observing System (IOOS) able to contribute to the European and International efforts on ocean observations

¹ https://www.gooscean.org/index.php?option=com_content&view=article&id=14&Itemid=114

² <https://gcos.wmo.int/en/essential-climate-variables/about>

³ <https://www.esfri.eu>

⁴ The United Nations Decade of Ocean Science for Sustainable Development 2021-2030– IOC (2018) <https://unesdoc.unesco.org/ark:/48223/pf0000261962>

(EOOS and GOOS), responding to the major challenges of the Ocean Decade and for the Mediterranean Sea. WP5 will enhance the digital automatization of Italian Research Vessels, and IOOS will improve quality and interoperability of ocean sensors, infrastructures and data at the national level for three critical themes: climate, operational services, and marine ecosystem health. WP5 will also show how data integration from RIs can improve monitoring of coastal waters and the 4D view of the ocean state, thus building the digital twin of the ocean. D5.3 aims to provide the landscape of available facilities, equipment, analysis of the related measured Essential Ocean Variables and typology of access, for each RI considered in WP5, allowing to identify bottlenecks and gaps. Within the ITINERIS project, the plans to strength the different RIs in terms of EOVs/ECVs, in connection with their specific scientific research questions, are also provided.

The RIs involved in this ITINERIS WP5 task are DANUBIUS-RI, eLTER-RI, EMSO-ERIC, ICOS-ERIC, JERICO-RI, Euro-Argo ERIC, LNS, GeoSciences. The RIs analyzed in D5.3 will be DANUBIUS-RI, eLTER-RI, EMSO-ERIC, ICOS-ERIC, JERICO-RI, Euro-Argo ERIC, LNS, GeoSciences, while EuroFleet RI, RV Laura Bassi and SIOS will have dedicated deliverables.

DANUBIUS-RI - The International Center for Advanced Studies on River – Delta – Sea Systems

DANUBIUS-RI is a pan-European Research Infrastructure (RI) to support the Research and Innovation (www.danubius-ri.eu) needed to achieve healthy River-Sea Systems: enabling state-of-the-art, holistic, R&I from river source to sea and providing the integrated knowledge to manage River-Sea Systems, utilizing a source-to-sea perspective to understand their evolution and functioning. DANUBIUS-RI is presently in the Implementation Phase, running in 2022-2025 DANUBIUS-IP project, to reach the establishment of the DANUBIUS-ERIC, the legal entity providing the governance framework to coordinate, manage and communicate the work of the RI, and the operational phase. DANUBIUS-RI will offer services integrating capabilities from: remote and *in-situ* observation platforms, experimental facilities, laboratories, modelling tools and resources for Knowledge Exchange along the river source to sea continuum.

DANUBIUS-RI comprises components (Hub, Data Centre, Nodes, Supersites (living labs), e-Learning Office and Technology Transfer Office) distributed across Europe. Harmonized regulations, methods, procedures and standards will be achieved through the DANUBIUS Commons to ensure that outputs are comparable, and transferable.

In Italy two components of DANUBIUS-RI are developed, the DANUBIUS Modelling Node, with the leadership of CNR-ISMAR, which also participate to the DANUBIUS Supersite “Po River and North Adriatic Lagoons”, coordinated by CORILA.

eLTER - RI Integrated European Long-Term Ecosystem, Critical Zone & Socio-Ecological Research Infrastructure

eLTER-RI is a pan-European in-situ research infrastructure whose mission is to study long-term ecological changes in terrestrial, freshwater and transitional ecosystems through a holistic 'whole system' approach, based on the integration of different environmental disciplines, to understand the role and interactions of multiple and complex ecosystem variables.

The RI consists of 26 national networks, 500 research sites and 50 LTER platforms, providing broad and systematic coverage of key European ecosystems, integrating the socio-ecological components as well. eLTER-RI comprises National Research Infrastructures (NRIs), and European level Central Services (CS), such as data access, training and harmonized methods and parameters (standard observations).

eLTER is now in the preparatory phase on the way to becoming a fully-fledged RI and ERIC (presumably in 2025) and is funded by the European Commission through the H2020 projects eLTER PPP and eLTER PLUS.

The Italian participation in eLTER-RI is coordinated by the CNR and involves various Italian institutions including universities, research bodies and local authorities. The LTER-Italy network consists of 72 research sites spread all over the territory and representative of the main ecosystem typology of our country. 19 of these sites represent the marine and transitional water component of the Italian eLTER-RI.

EMSO ERIC - European Multidisciplinary Seafloor and water column Observatory

EMSO ERIC is a distributed infrastructure whose observation facilities are in key sites of the European seas, from the northern and north-eastern Atlantic, to the Mediterranean and the Black Sea, in various climatic zones, from the sub-arctic zone to the sub-tropical zone. EMSO's mission is to support scientific and technological research to understand the complex interactions between the geosphere-biosphere-hydrosphere through the acquisition of long time-series of observables by means of fixed platforms in the deep marine environment, related to different disciplinary sectors (from oceanography to seismology and biology) to offer a data suitable for promoting a multidisciplinary approach for studying climate and marine ecosystems evolution, and the outbreak and evolution of extreme events both of natural and anthropic origin.

The acquisition of measurements in extreme environments such as the deep marine environment requires very specific knowledge of marine technologies and extensive field and logistics experience; these skills, acquired by the technical-scientific personnel who take care of the functioning of the facilities, are made available to scientific and industrial users who require physical and remote access to the infrastructure for purely scientific or for commercial purposes.

EMSO's vision is to position the RI among the leading institutions in the marine sciences, and among the main actor in the landscape of European Environmental research infrastructures and providing scientific and technological services to address the environmental challenges that affect the quality of life on our planet.

EMSO has been included in the ESFRI Roadmap since 2008 and was established in the legal form of European Research Infrastructure Consortium (ERIC) in 2016 by the governments of 8 Countries: France, United Kingdom, Greece, Ireland, Italy, Portugal, Romania, Spain to which Norway joined in 2021. EMSO is currently recognized in the latest ESFRI Roadmap as a 'Landmark' infrastructure, i.e., it has entered the operational phase.

ICOS ERIC - Integrated Carbon Observation System

ICOS ERIC, is a European-wide greenhouse gas research infrastructure. ICOS mission is to produce standardised, high-precision and long-term observations and facilitate research to understand the carbon cycle and to provide necessary information on greenhouse gases. ICOS promotes technological developments and demonstrations related to greenhouse gases by linking research, education and innovation. The high-precision data provided by ICOS aims to support policy- and decision-making to combat climate change and its impacts.

The basis of ICOS' operations is the ICOS Station Networks, belonging to three domains (Atmosphere, Ecosystem and Ocean) coordinated and run by the ICOS National Networks. Within each domain, a Thematic Centre coordinates the observations and supports the stations. In addition to the Thematic Centres, there are Central Analytical Laboratories that provide gas analyses and calibration gases.

ICOS Ocean stations are based on instrumented Ships of Opportunity (SOO) and Fixed Ocean Stations (FOS).

The network of ICOS Ocean stations provides long-term observations from 23 stations in eight countries. The stations monitor carbon uptake and fluxes in the Atlantic and the Nordic, Baltic and Mediterranean Seas. The measuring methods include sampling from research vessels, moorings, buoys and commercial vessels. They all have been equipped with state-of-the-art carbonate system sensors.

In Italy there are five FOS. They provide near-real-time data that also contains information from greater depths, for example, about temperature anomalies.

All Ocean stations are strongly standardized, utilizing similar methodologies and equipment. The ICOS standards cover recommendations on the best methods for making the measurements through to quality control and management of the data. All labelled stations have an ICOS-agreed data quality and will use the same procedures for submitting the data.

JERICO-RI - Joint pan-European Research Infrastructure for Coastal Observations

The objective of JERICO-RI is to formally design, implement and operate a pan-European Research Infrastructure, dedicated to set up a system of observation and related services for European coastal seas, thus empowering European research excellence and expertise for the benefit of society.

JERICO-RI is an essential component of the worldwide efforts to a better understanding of coastal marine systems. JERICO-RI also aims at being the future coastal component of the European ocean observing effort, as part of the Global Ocean Observing System. Through multidisciplinary pan-European observations, JERICO-RI seeks to improve the knowledge on how coastal marine systems respond to global and local drivers. By doing so, JERICO-RI is strengthening the interactions between observations, experimentations, and numerical modelling.

Since 2011, JERICO-RI has developed conceptual and practical expertise aimed at providing high-quality coastal observations and services to the marine scientific community and to a range of local, regional and European end-users.

JERICO-RI, as an integrative system working across coastal disciplines, is progressing towards the definition of a sustainable infrastructure, harmonized at EU level with capabilities to deliver high-quality environmental data, access to solutions and facilities as services for researchers and users of the coastal domain.

JERICO-RI benefits from both national efforts put forth to better address the national coastal priorities and other European initiatives and aims at closing the critical gap of not having an integrated European Research Infrastructure addressing the complexity of marine coastal systems. JERICO-RI is proposing to bridge the existing continental, atmospheric and open ocean RIs, thus filling a key gap in the ESFRI ecosystem.

The JERICO-RI consortium is coordinated by the French lead partner IFREMER (Institut Français de Recherche pour l'Exploitation de la Mer) and is currently working on two active projects, JERICO-S3, which provides access to marine infrastructures and their data and experimentation at the transnational level, and JERICO-DS, for the design of the ESFRI phase.

Italy participates in JERICO-RI through the CNR (National Research Council) and OGS (National Institute of Oceanography and Experimental Geophysics), making a fundamental contribution thanks to its long and strong tradition of research on marine issues and technological innovation assets related to the monitoring of the marine coastal environment.

Euro-Argo ERIC

Euro-Argo ERIC is part of the international Argo programme (for more details, see <http://www.argo.ucsd.edu/>), that was initiated in 1999 as a pilot project endorsed by the Climate Research Program of the World Meteorological Organization, GOOS, and the Intergovernmental Oceanographic Commission. The Argo network is a global array of more than 3500 autonomous instruments, deployed over the world ocean, reporting subsurface ocean properties to a wide range of users via satellite transmission links to data centres.

The initial target of the Argo international programme was to achieve data coverage of 1 float per 3x3° grid cell and month over the global ocean. This data coverage is deemed to be sufficient to resolve many of the important global climate signals and support the enhanced real-time requirements of operational modelling applications in oceanography and meteorology.

Euro-Argo aims to provide, deploy and operate ¼ of the global Argo floats array and Italy is one of the countries contributing to this goal. Started in January 2008 as a European project involving 25 organisations from 12 countries, Euro-Argo gained the status of a European Research Infrastructure Consortium (ERIC) in May 2014.

The Euro-Argo ERIC focuses to provide enhanced coverage in the European regional seas, to implement the new phase of Argo, with extensions towards biogeochemistry, greater depths and high latitudes and to provide quality controlled data and access to the data sets and data products to the research (climate and oceanography) and operational oceanography (e.g. Copernicus Marine Service) communities.

Argo must be considered in its ensemble: not only the instruments, but also the logistics necessary for their preparation and deployments, field operations, the associated data streams and data centers. That's why Euro-Argo establishes a high level of cooperation between partners in all implementation aspects:

- operation at sea,
- array monitoring and evolution,
- technological and scientific developments,
- improving data access for research and operational oceanography (Copernicus Marine Service),
- link to the international management of the Argo programme,
- promote Argo, enlarge the Argo data user community and help answering its needs.

LNS - Laboratori Nazionali del Sud [INFN]

The INFN-LNS (www.lns.infn.it) is a national infrastructure, part of the National Institute of Nuclear Physics the Italian research institute that promotes, coordinates and carries out scientific research in the field of nuclear, subnuclear and astro-particle physics and fundamental interactions, as well as the technological development necessary for the activities in these sectors. The LNS research infrastructure INFN Laboratori Nazionali del Sud, based in Catania, is an international laboratory hosting about 250 units of personnel plus ca 200 associate researchers. The LNS activities are mainly concerned with the fundamental research in the field of Nuclear Physics, Nuclear and Particle Astrophysics and Applied Research.

Since 20 years LNS hosts and manages submarine infrastructures offshore East Sicily: Catania 2100 water depth and Capo Passero 3500 m w.d.. LNS is one of the leading Laboratories for the KM3NeT-ARCA project: an underwater detector for high-energy cosmic neutrinos. The deep-sea infrastructure

of Catania hosts the first cabled node of the EMSO European Research infrastructure, the FOCUS-ERC experiment and to acoustic monitoring observatories.

Within the ITINERIS project LNS will provide:

1. access to deep sea cabled infrastructures (high speed data connection and power supply) as:
 - a. access to sensors
 - b. access to power/data seafloor hub
2. access to real-time ocean sound data from seafloor observatories
3. access to stored ocean sound data repository
4. and data from abyssal seafloor observatories.

GeoSciences - Rete italiana per le geoscienze [ISPRA]

The National Wave Network (RON) and national tide gauge network (RMN) is the network managed and developed by ISPRA to provide data and information on waves and sea level changes in the Italian waters. RON is made by 16 bouys in a range depth of 40 to 90 mt and RMS is composed by 36 monitoring stations. Both networks have been active by 90's and are going to be further developed with the addition of ADCP sensors in RON for the measurements of currents and GNSS stations in RMN to have a sound and consolidated data to improve the accuracy of sea level measurements. Also an offshore network of bouys will be implemented with n. 12 bouys ranging from 800 to 3000 mt depth with wave and complete currents profiles. A new research vessel is being acquired with instruments for water column and sea bottom monitoring with a specific focus on morpho-bathymetry and habitat mapping.

Within ITINERIS project ISPRA will provide:

1. Access to data in near real time to RON and RMN
2. Access to consolidated and validated data elaborated starting from raw RON and RMN

2. IDENTIFICATION OF RELEVANT VARIABLES CONNECTED WITH EACH RIS: GAPS IN EOVS AND ECV

To collect the most updated information about available facilities, equipment and related measured variables, a survey was conducted among all WP5 ITINERIS participants. Involved institutions contributed relatively to their specific effort in each of the above-mentioned RIs. The final picture, therefore, allows investigating, for each RI and in a collective way, the extent of the coverage for relevant variables for the marine investigation.

Fixed stations, bouys, networks of research sites and equipment, mobile vehicles, etc. are all considered facilities. A total number of 128 facilities were declared and the full list of sensors and relative measured variables are listed (Annex 1, Tab.1). In the list the 8 RON stations from Geosciences are also considered, since they can provide in the past real time data, with archived past dataset (3_RON_Cagliari, 4_RON_Catania, 5_RON_Cetraro, 6_RON_Civitavecchia, 11_RON_Ortona, 12_RON_Palermo, 14_RON_Siniscola, 15_RON_Venezia).

The full list of EOVS can be found at the link:

https://www.goosocean.org/index.php?option=com_content&view=article&id=14&Itemid=114

An Essential Climate Variable (ECV) is a physical, chemical or biological variable (or group of linked variables) that critically contributes to the characterization of Earth's climate. The full list of ECV can be found at the link: https://library.wmo.int/index.php?lvl=notice_display&id=22135

A general disclaimer is here made, since the recognition of a measured variable as ECV requires given levels of accuracy and should follow prescribed indication. A thorough analysis on the effective adherence of each declared dataset to these rules is out of the scope of this deliverable but this aspect will be considered in the future, to assure the correct collection of EOVs/ECVs with the planned ITINERIS equipment.

In the Italian context, when characterizing the marine domain (and the related interfaces, e.g., air-sea, adding to the marine, also atmosphere and cross-domain variables), a subset of all EOV/ECV are needed (they are 39). In our survey the list of EOV and ECV considered is expressed as in Table 1.

The survey collected information both for fixed facilities (e.g., platforms, buoys) and autonomous mobile vehicles (e.g., Gliders and Argo floats). The current status for each past measured variable was tracked.

The survey asked to provide the following information:

- Typology of variable.
- Corresponding EOV/ECV.
- Measuring depth or range.
- Ownership of the sensor/equipment measuring the variable.
- Accuracy.
- Temporal resolution and coverage.
- Spatial coverage (if any).
- Equipment (brand and year, average lifetime).
- Data format (standards, metadata).
- Typology of access (time needed for data release, quality control, options of access).

Given the wide range of sensors and different typology of equipment devoted to EOV/ECV measurements, the survey showed a certain level of complexity in thoroughly evaluate/analyze technical declarations on accuracy, spatial and temporal coverage, and technical characteristics of the equipment. Therefore, in the present document, the focus on the analysis is more devoted to the following aspects:

- Number and typology of EOVs/ECVs measured.
- Relative contribution of each RI in measuring EOVs/ECVs.
- Corresponding access to the data.

The additional information collected will be more appropriately discussed in the coming deliverables in comparison with the new equipment planned in ITINERIS, to evaluate the improvement in EOV/ECV measurements.

Table 1 - Table counting the number of sensors on fixes stations, buoys, mobile vehicles belonging to a specific RI measuring EOVs/ECVs. This first survey needs a thorough check with all RIs to assure the full correctness of declared variables. Some adjustments are foreseen in the proceeding of the project.

Present State Measured EOVs/ECVs	JERICO	eLTER	DANUBIUS	Euro-Argo	ICOS	EMSO	LNS	GeoSciences
ECV - Atmosphere, Surface: Precipitation	2	2	2	0	0	1	0	0
ECV - Atmosphere, Surface: Surface Sea Level Pressure	7	5	3	0	3	2	0	43
ECV - Atmosphere, Surface: Surface Radiation Budget	1	3	1	0	1	1	0	0
ECV - Atmosphere, Surface: Surface Air Temperature	9	6	3	0	3	2	0	43
ECV - Atmosphere, Surface: Surface Water Vapour	8	6	2	0	3	2	0	43
ECV - Atmosphere, Surface: Surface Wind Speed and Direction	9	6	3	0	4	2	0	40
ECV - Aerosols	0	0	0	0	0	0	0	0
ECV - Carbon Dioxide, Methane & Other Greenhouse Gases	0	0	0	0	2	0	0	0
ECV - Ozone	0	0	0	0	0	0	0	0
ECV - Precursors for Aerosols and Ozone	0	0	0	0	0	0	0	0

EOV - Cross-Disciplinary: Ocean Sound	0	3	2	0	0	6	6	0
EOV - Cross-Disciplinary: Marine debris (*emerging)	0	0	0	0	0	0	0	0
ECV - Ocean, Biogeochemical: Inorganic Carbon	0	6	0	0	2	1	0	0
ECV - Ocean, Biogeochemical: Nitrous Oxide	0	0	0	0	0	0	0	0
ECV - Ocean, Biogeochemical: Nutrients	1	11	3	0	1	0	0	0
ECV - Cross Disciplinary: Ocean Colour	1	1	0	6	2	0	0	0
ECV - Ocean, Biogeochemical: Oxygen	5	12	3	25	4	5	0	0
ECV - Ocean, Biogeochemical: Transient Tracers	1	2	0	0	1	0	0	0
EOV - Biogeochemistry: Particulate Matter	1	3	2	6	0	3	0	0
EOV - Biogeochemistry: Stable Carbon Isotopes	0	0	0	0	0	0	0	0
EOV - Biogeochemistry: Dissolved Organic Carbon	0	0	0	7	0	0	0	0
ECV - Ocean, Biological/Ecosystems: Marine Habitats	0	0	0	0	0	1	0	0
EOV - Biology and Ecosystems: Phytoplankton Biomass and Diversity	3	14	3	9	1	1	0	0

EOV - Biology and Ecosystems: Zooplankton Biomass and Diversity	0	4	2	6	0	0	0	0
EOV - Biology and Ecosystems: Fish Abundance and Distribution	0	1	1	0	0	1	0	0
EOV - Biology and Ecosystems: Seagrass Cover and Composition	0	0	0	0	0	0	0	0
EOV - Biology and Ecosystems: Macroalgal Canopy Cover and Composition	0	1	0	0	0	0	0	0
EOV - Biology and Ecosystems: Microbe Biomass and Diversity (*emerging)	0	1	0	0	0	0	0	0
EOV - Biology and Ecosystems: Invertebrate Abundance and Distribution (*emerging)	0	1	0	0	0	0	0	0
ECV - Ocean, Physical: Ocean Surface Heat Flux	1	0	0	0	0	1	0	0
ECV - Ocean, Physical: Sea Level	3	3	2	0	0	0	0	36
ECV - Ocean, Physical: Sea State	12	3	3	0	2	0	0	7
ECV - Ocean, Physical: Sea Surface Currents	9	1	0	19	0	0	0	0
ECV - Ocean, Physical: Sea Surface Salinity	1	3	0	2	2	1	0	0
ECV - Ocean, Physical: Sea Surface Stress	1	0	0	0	0	1	0	0
ECV - Ocean, Physical: Sea Surface Temperature	4	3	0	47	2	3	0	43

ECV - Ocean, Physical: Subsurface Currents	4	2	1	2	0	9	0	0
ECV - Ocean, Physical: Subsurface Salinity	8	13	3	47	3	9	0	0
ECV - Ocean, Physical: Subsurface Temperature	10	14	7	47	4	7	0	0
	JERICO	eLTER	DANUBIUS	Euro-Argo	ICOS	EMSO	LNS	GeoSciences
TOTAL EOVS/ECVs = 39	22	27	18	12	17	20	1	7
Relative RI EOVS/ECVs coverage	56%	69%	46%	31%	44%	51%	3%	18%

In Figure 1 the percentage of measured EO/ECV (on the total of 39 here considered) by each RI is shown. The computation is performed by counting that an EO/ECV is measured if at least one sensor is measuring it. The reason for the different percentage for each RI relies in the peculiarity of topics covered and also by the capability of the platform itself; as an example, an Argo float will never be able to host all the 39 variables because 1) it is not designed for atmospheric measurements and 2) beyond a given number of sensors, new sensors cannot be installed on due to logistic but also due to the lack of miniaturized instruments. This is valid also for other platforms.

It is obvious that those RIs which are more multidisciplinary could cover a wider range of EO/ECV to support research performed by their community. On the other hand, the relative contribution of those RIs more focused on specific EO/ECVs contribute probably having higher temporal and/or spatial coverage. The goals of the project, in fact, are to assure the availability of what is already measured, increasing the digitalization, further increase the number of EO/ECVs, but also improve the spatial/temporal coverage and assure that areas of relevance for specific studies are properly covered.

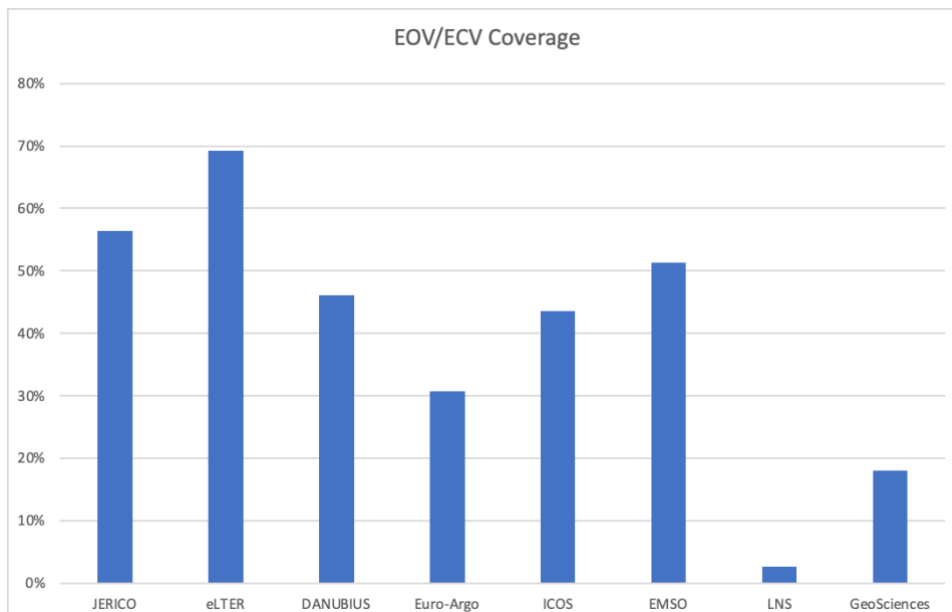


Figure 1 - percentage of EO/ECVs measured by each RI on the 39 EO/ECVs considered.

The joint contribution of all involved RI is summed up in Figure 2, while each RI contribution is singularly shown from Figure 3 to Figure 17.

Figure 2 highlights how many RIs contribute to each EO/ECV. The majority of EO/ECV are measured by many RIs, with few exceptions, in those connected with the atmospheric composition (e.g., ozone, aerosol) covered by other RIs not involved in WP5. It is clear how certain EO/ECVs are considered relevant for a wide range of studies, intercepting activities of many RIs. This particularly applies to the following categories or variables: ECV – Ocean, Physical, EO – Biology and Ecosystem: Phytoplankton Biomass and diversity, ECV – Ocean Biogeochemical: Oxygen and the full category ECV – Atmosphere, surface. On the other hand, there are EO/ECVs which are peculiarities of just one RI. This shows how there are variables which suggest a major cooperation among RIs, while the presence of many different RIs assures a wider coverage of EO/ECV based on their peculiarities.

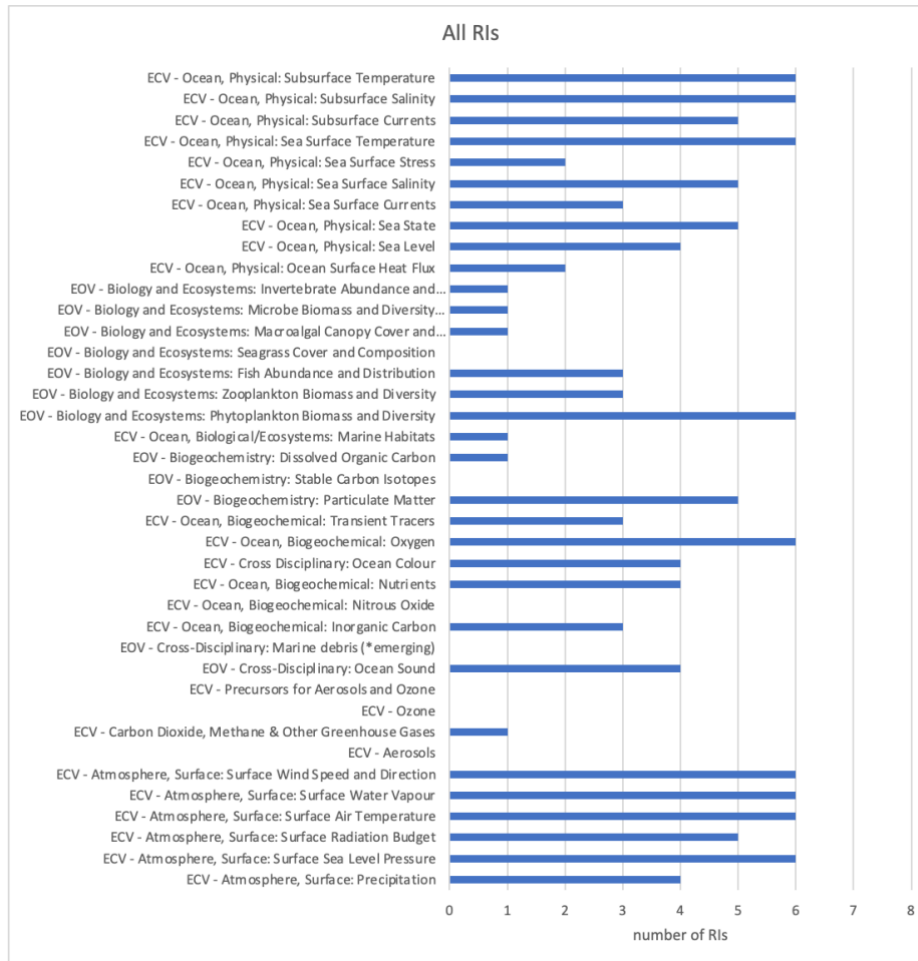


Figure 2 - Number of RIs contributing to the measurement of specific EOVs/ECVs.

The JERICO-RI contribution to EOVs/ECVs measurement is mainly in the ECV Ocean Physical and Atmosphere, Surface categories and biogeochemistry (Figure 3, Figure 4). For some variables there is a quite large coverage of sensors, e.g., for ECV – Ocean, Physical: subsurface Temperature and Sea State (through HF Radars).

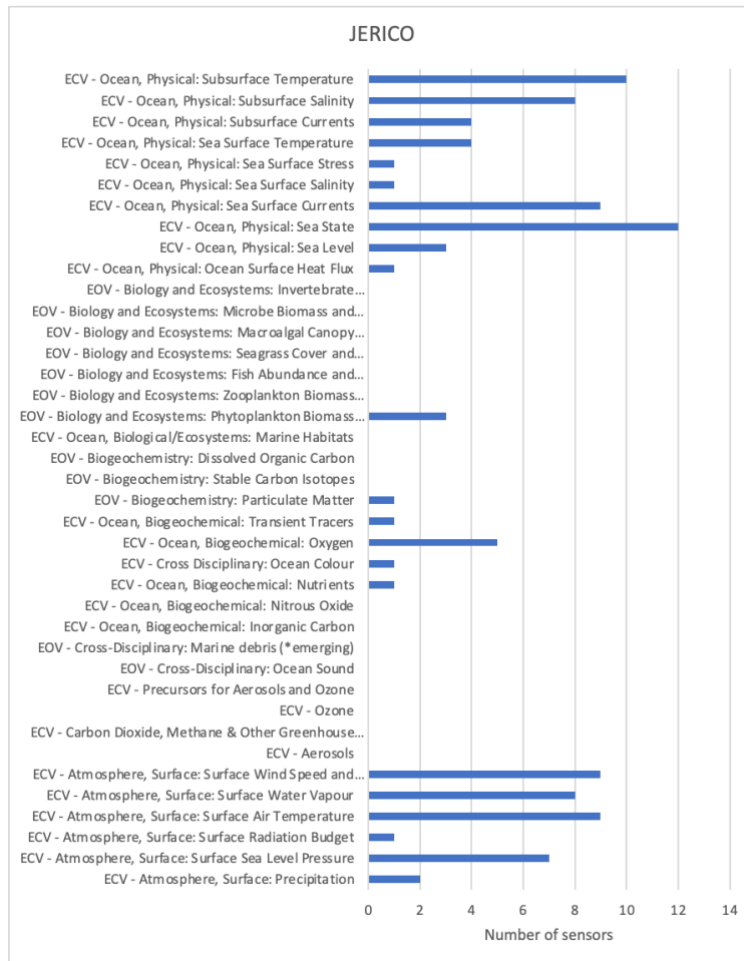


Figure 3 - JERICO contribution for the measurement of specific EOVs/ECVs.

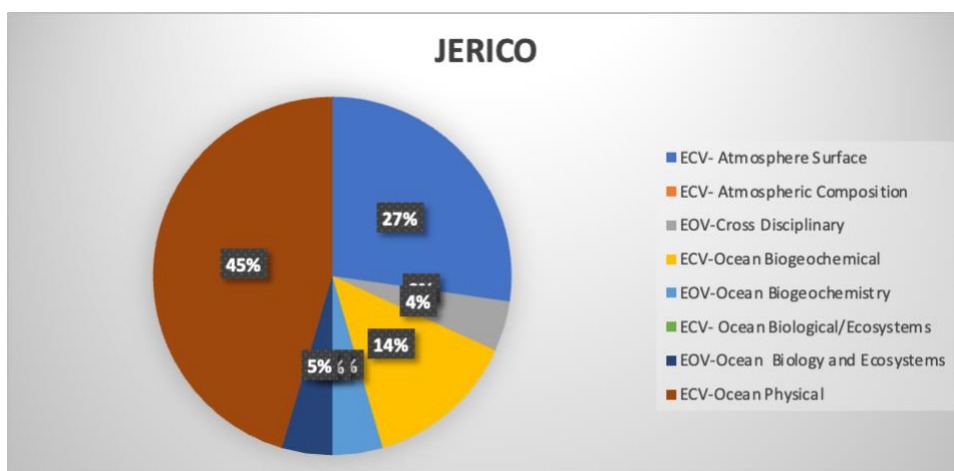


Figure 4 - Relative coverage of EOVs/ECVs categories by JERICO.

eLTER-RI has many research sites (see list in Annex 1) with core measurements on Phytoplankton Biomass and diversity and subsurface temperature and salinity and oxygen. As for other RIs, the

category more measured is ECV – Ocean Physical, but the RI has also a peculiarity on EOVS – Biological/Ecosystems (Figure 5, Figure 6).

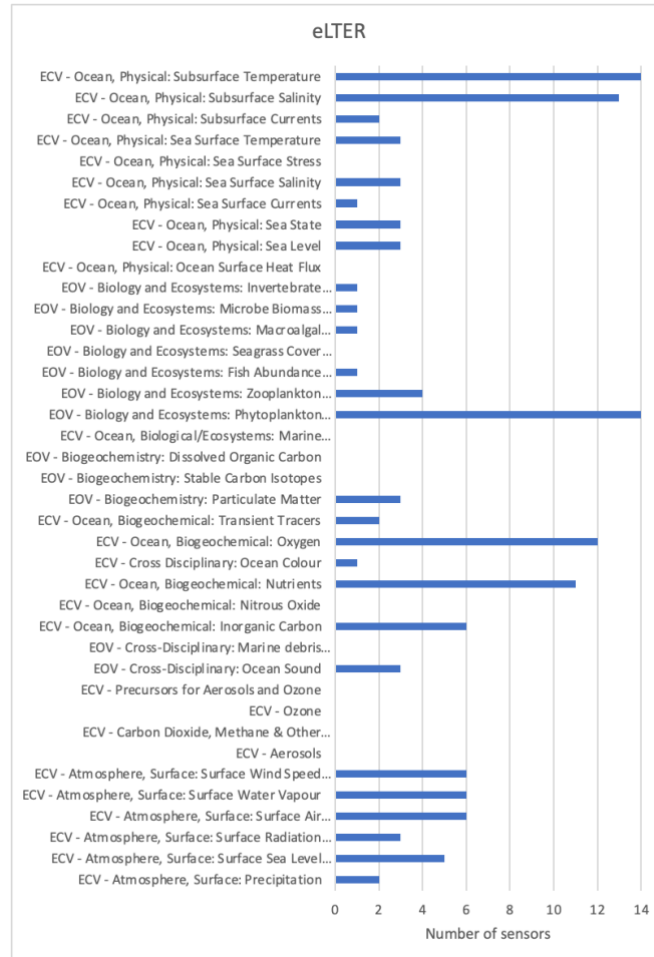


Figure 5 - eLTER contribution for the measurement of specific EOVS/ECVs.

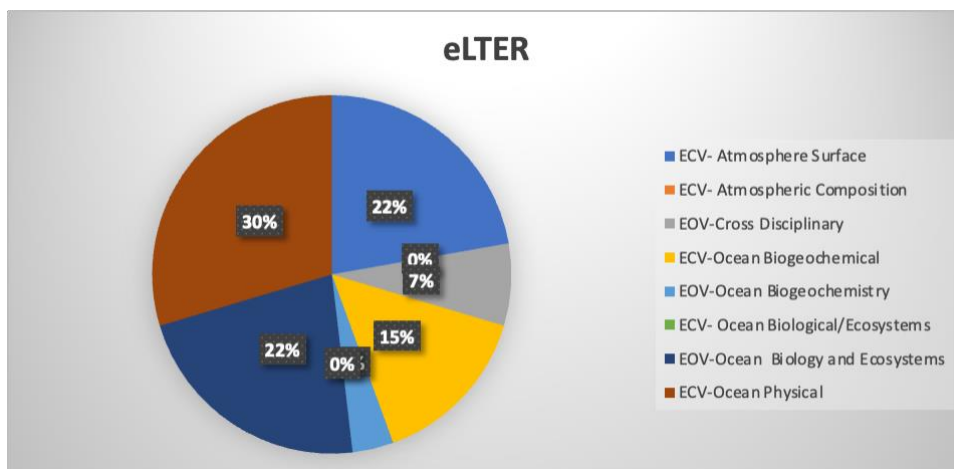


Figure 6 - Relative coverage of EOVS/ECVs categories by eLTER.

DANUBIUS-RI covers a large range of variables in different EO/ECV categories, as its interdisciplinary mission requires. There is a synergy with eLTER and JERICO in measuring and sharing variables, but Physical and Atmospheric Surface variables are measured also for the specific need connected to the modelling activity DANUBIUS rely on. In-situ observation finds in the RI an increased importance for modeling cal/val procedures and data assimilation (Figure 7, Figure 8).

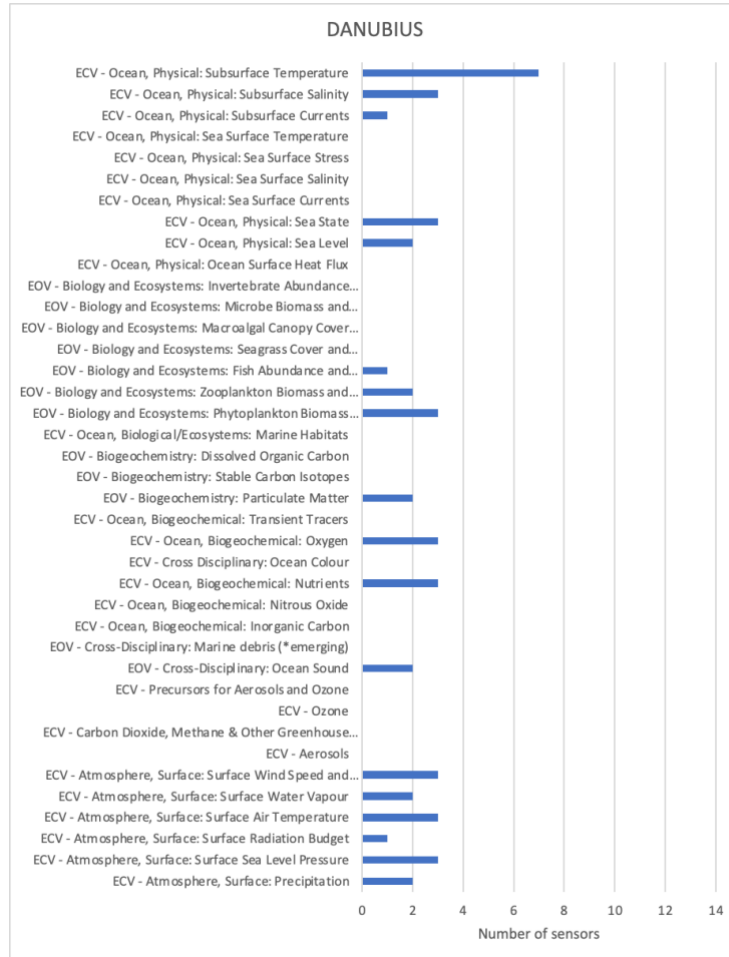


Figure 7 - DANUBIUS contribution for the measurement of specific EO/ECVs.

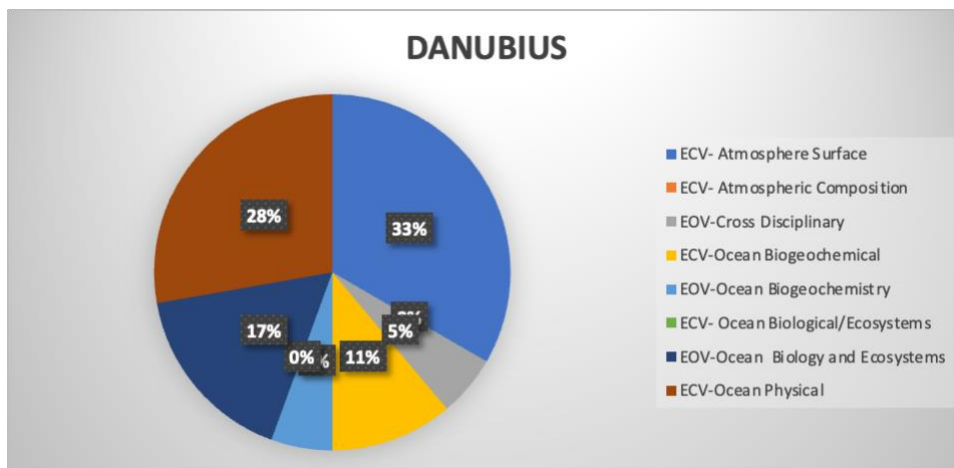


Figure 8 - Relative coverage of EOVs/ECVs categories by DANUBIUS.

Euro-Argo ERIC mainly covers ECV – Ocean, Physical variables though it started including also biogeochemical and biological variables thanks to the novel technological capabilities provided by BioGeoChemical Argo floats. These floats are indeed equipped with optical and biogeochemical sensors (Figure 9, Figure 10).

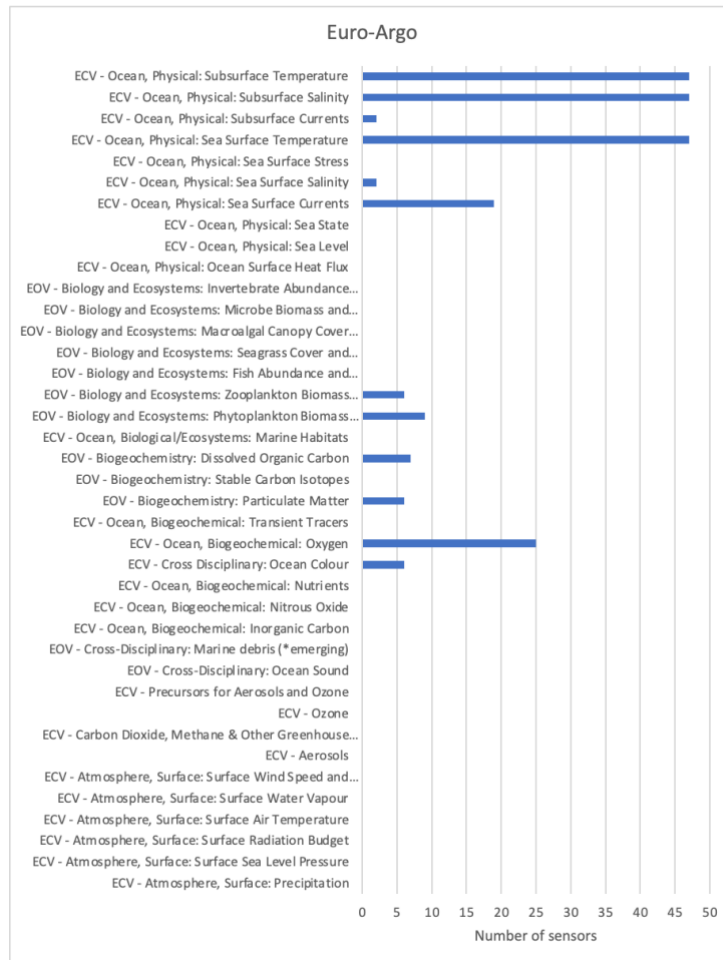


Figure 9 - Euro-Argo contribution for the measurement of specific EOVs/ECVs.

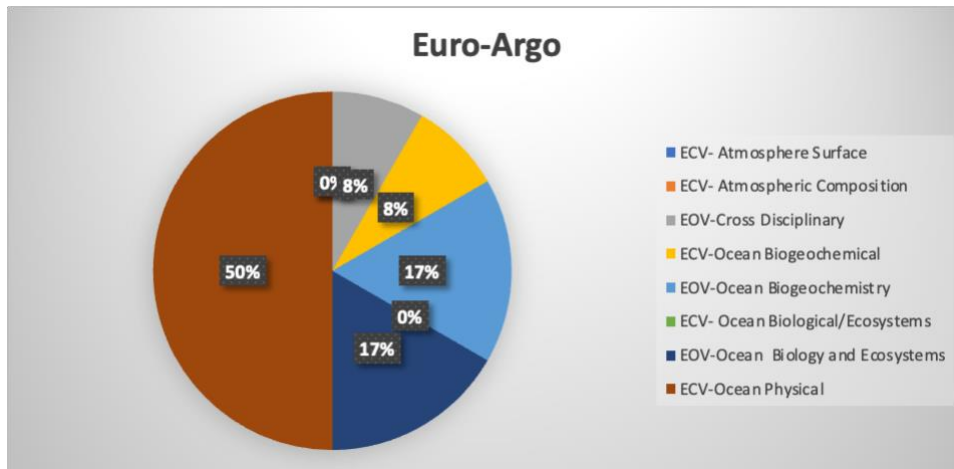


Figure 10 - Relative coverage of EOVs/ECVs categories by Euro-Argo.

ICOS ERIC, given its mission on carbon cycle in the climate change perspective, covers a number of ECV Biogeochemical. Fixed platforms also provide Surface atmospheric and Atmospheric composition variables. This latter category is a peculiarity of ICOS compared to the other RIs (Figure 11, Figure 12).

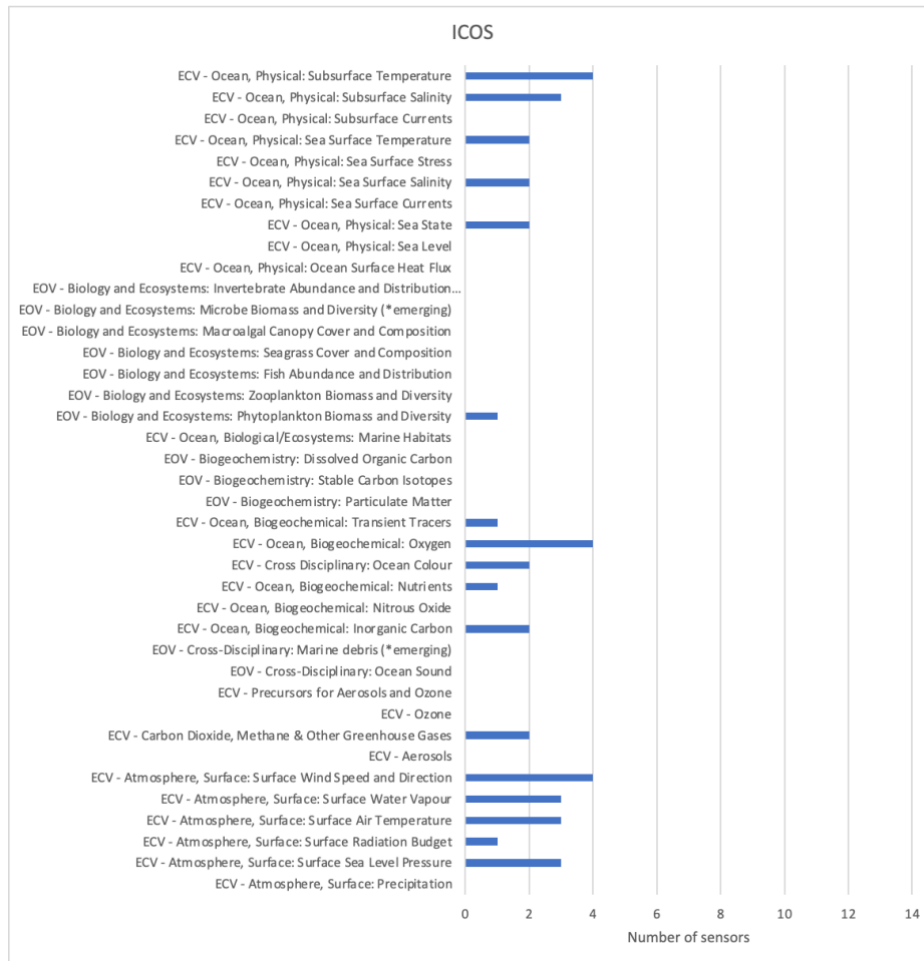


Figure 11 - ICOS contribution for the measurement of specific EOVs/ECVs.

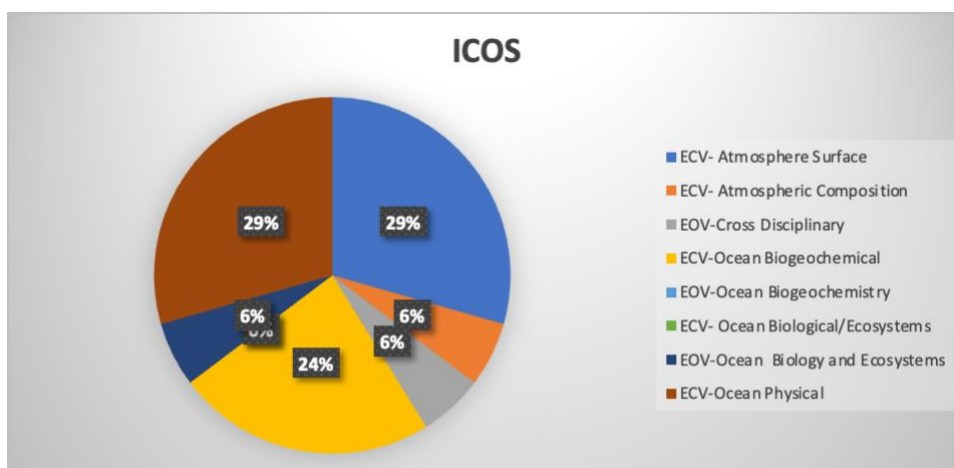


Figure 12 - Relative coverage of EOVs/ECVs categories by ICOS.

EMSO ERIC covers a large range of variables and intercepts the highest number of ECV/EOV categories, spanning from Ocean, Physical to Biological/Ecosystem, Biogeochemical and Atmosphere (Figure 13, Figure 14).

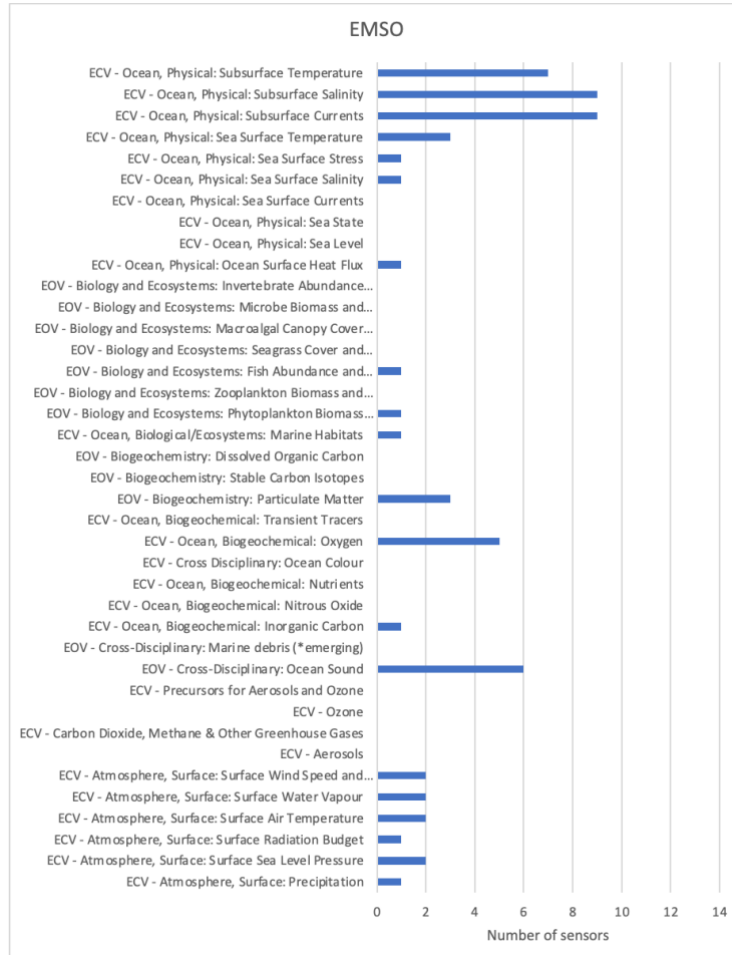


Figure 13 - EMSO contribution for the measurement of specific EOVs/ECVs.

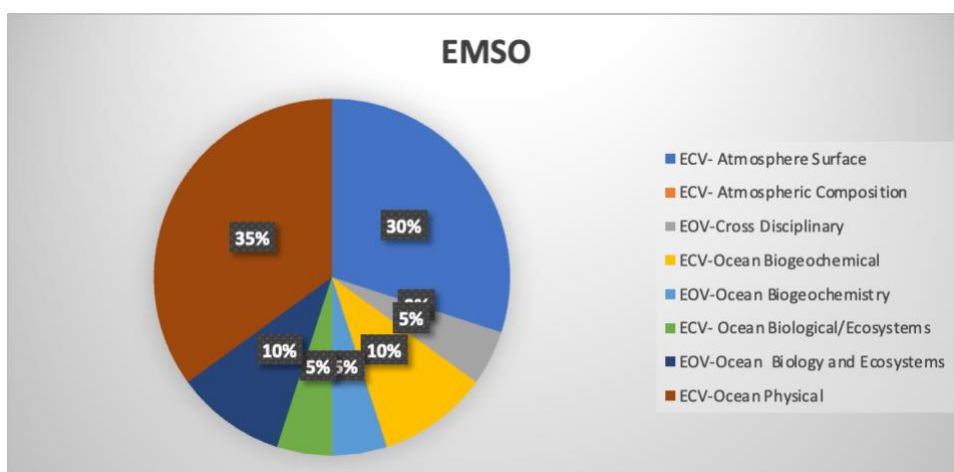


Figure 14 - Relative coverage of EOVs/ECVs categories by EMSO.

LNS has a specific focus and covers the EOVS – Cross Disciplinary Ocean Sound variable. Despite the variable coverage is naturally limited, the RI is planning to further improve the measurement and the level of availability of this variable (with possible synergies with EMSO ERIC, eLTER RI, DANUBIUS-RI), Figure 15.

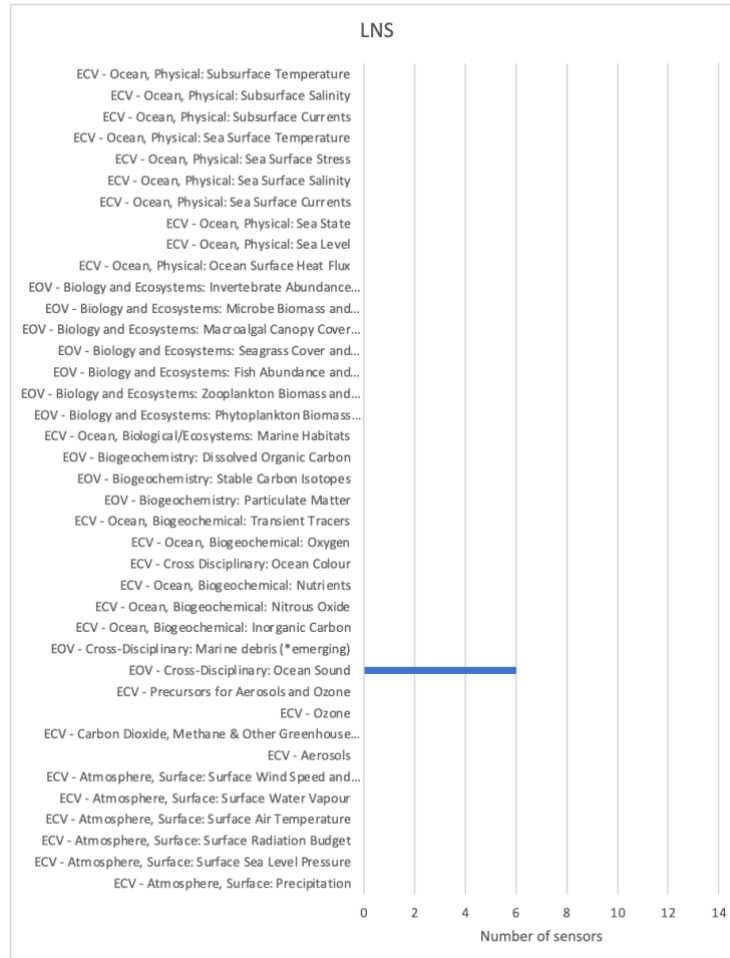


Figure 15 - LNS contribution for the measurement of specific EOVS/ECVs. The variable is part of the Cross Disciplinary category.

GeoSciences is the RI with the highest number of facilities spread across the Italian waters, bringing in the project the measurements of RMN and RON systems from ISPRA. A large coverage of atmosphere and physical variables is registered (Figure 16, Figure 17).

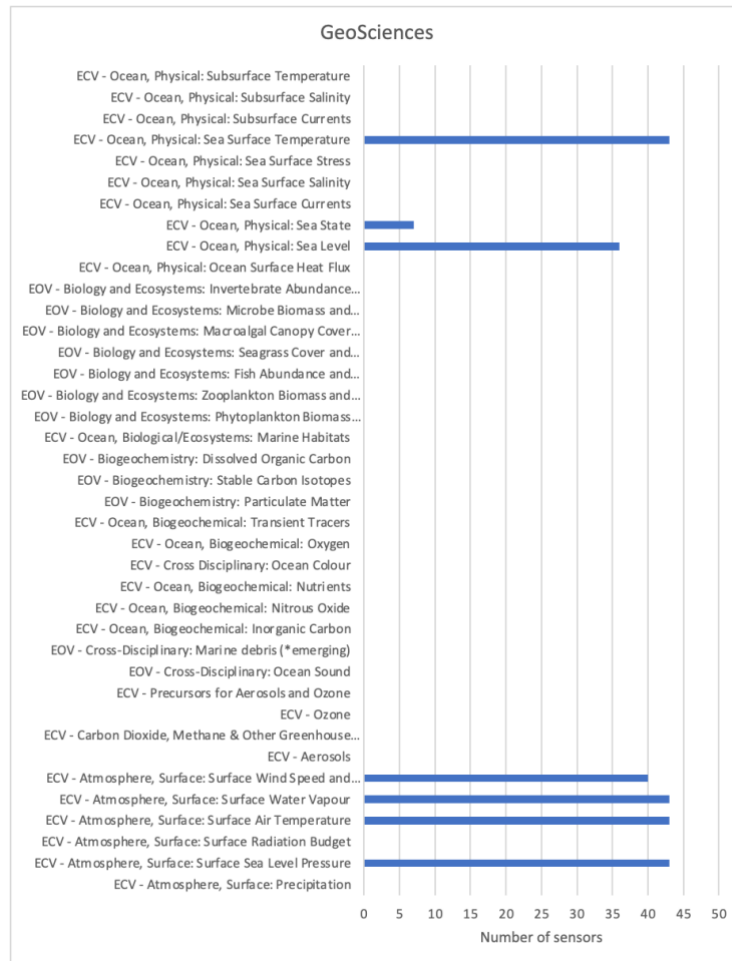


Figure 16 - GeoSciences contribution for the measurement of specific EOVs/ECVs.

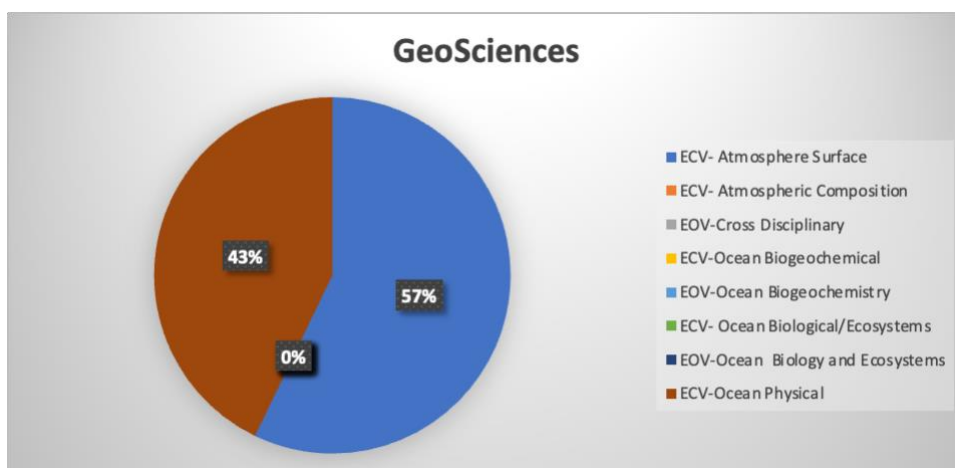


Figure 17 - Relative coverage of EOVs/ECVs categories by GeoSciences.

3. STATE OF THE ART OF THE NATIONAL MARINE FACILITIES, EQUIPMENT AND ACCESS PROCEDURES

From the previously mentioned survey the most updated information on the present state of facilities contributing, at the Italian scale, to the ITINERIS RIs were collected.

The Figure 18 shows the large coverage of RI facilities along all the Italian coasts and open sea. There are areas where the joint presence of several RIs can be registered as, for example, the North and South Adriatic regions. The autonomous platforms, such as Euro-Argo floats and others, are indicated on the map on the West coast of Sardinia as an indicative location. Please refer to figures 23 and 24 for the real location of the floats.

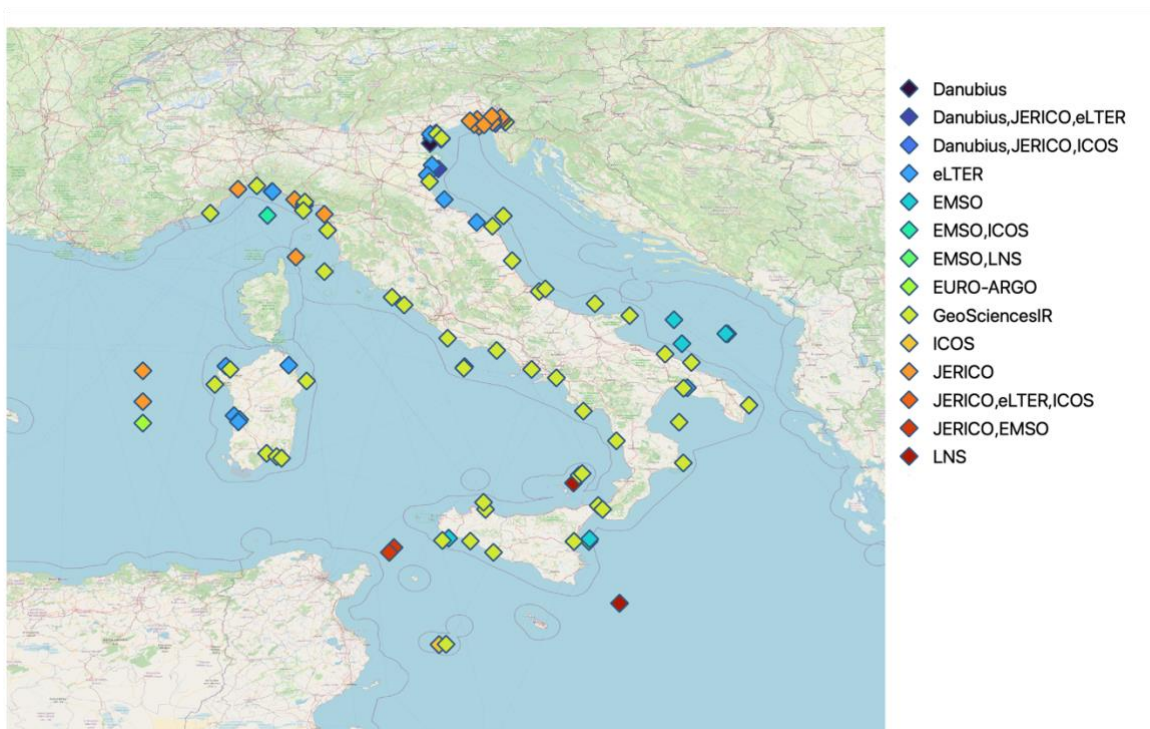


Figure 18 - Location of facilities related to the RIs considered in WP5 of ITINERIS, Euro-Argo floats and JERICO drifters' locations are indicative, for the real locations of them refer to the specific figures (23, 24).

The facilities declared by the ITINERIS RIs are listed in Annex 1 - Table 1. The facilities declared in the Annex are 106, comprising fixed platforms, buoys and movable vehicles (e.g. Argo floats).

A broad collection of technical information about the present state of equipment in each facility was performed, leading to the above-mentioned review of the measured EOv and ECV at the Italian level. This collection will be the baseline for the future evaluation of the quality and accuracy of the measurements, to assure the requirements for a proper monitoring of EOv and ECV.

In this section, an overview is given on the location of facilities and on the level of synergy and coexistence among RIs on same facilities.

Moreover, based on the declarations done on the full set of variables and sensors, an overview of the present status of data access is discussed.

This first survey suggests that a further and deeper analysis of the technical characteristics of sensors is needed and is not presented here but it will be presented in connection with the new pool of equipment planned during the lifetime of the project.

3.1 Facilities

Since the summary map shows many facilities in a limited space, it is not always easy to clearly identify the connections to each RI. The following maps summarize all facilities where a given RI is present (also in synergy with others).

The DANUBIUS-RI facilities are all located in a limited geographical area, the North Adriatic and its lagoons, corresponding to the DANUBIUS Supersite (Figure 19). The DANUBIUS Supersite relates to the Po Delta and the North Adriatic Lagoons, therefore the present location of facilities is connected to the possibility to study the ROFI⁵ processes and the influence of freshwater inflows on the semi-enclosed basin of the Adriatic Sea.

Collaboration among CNR and OGS in providing access and measurements in these facilities is in place. In the map the net of turbidimeters located at the Venice Lagoon is shown. Synergies among different RIs on CNR “Acqua Alta” Platform in the Gulf of Venice and PALOMA station in the Gulf of Trieste is evident; the platforms are jointly used and managed by DANUBIUS, JERICO and eLTER, the former, while the latter by ICOS, DANUBIUS, JERICO and eLTER. Another focus is close to the Po Delta, where the elastic beacon S1-GB is installed, given the important location to infer on river-sea interaction.

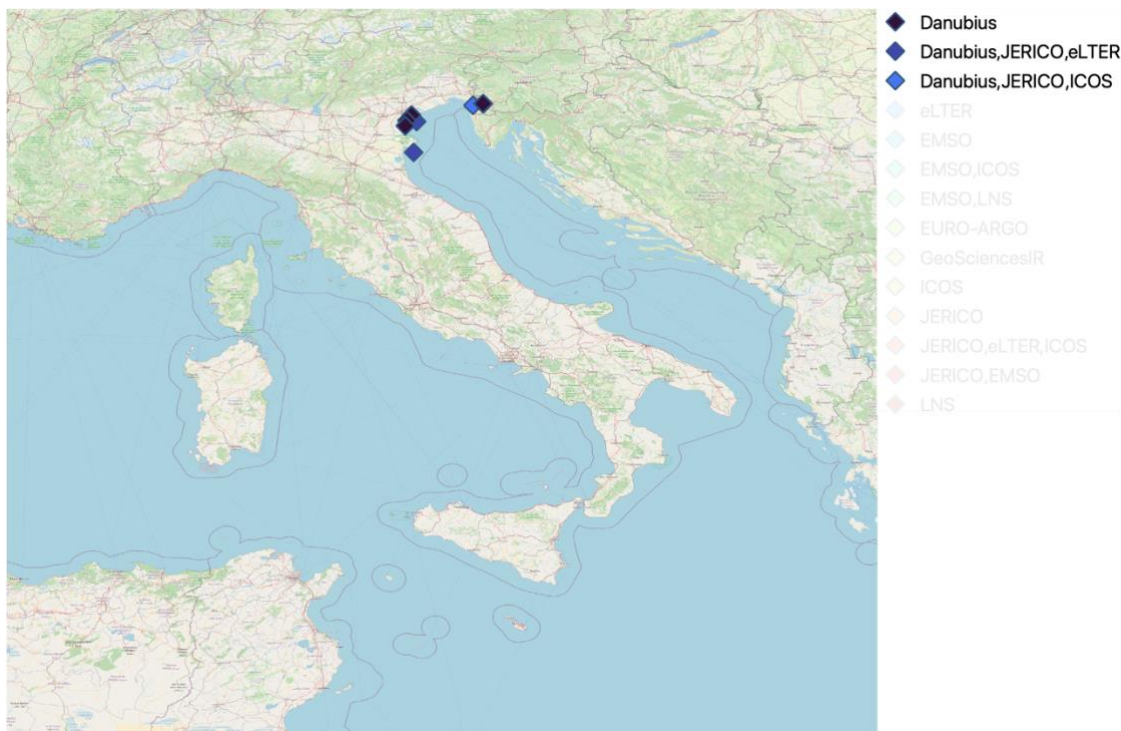


Figure 19 - Distribution of facilities belonging to DANUBIUS.

⁵ ROFI: Region Of Freshwater Influence

eLTER has 19 marine and transitional water research sites spread along the Italian territory. The sites represented here in the map are the ones that will be implemented in the project (Sacca di Goro, Valli di Comacchio, Laguna di Venezia, Golfo di Venezia (Acqua Alta Platform), Delta del Po and Costa Romagnola (S1-GB and E1) Senigallia-Susak Transect, Mar Piccolo di Taranto, Golfo dell 'Asinara, Golfo di Olbia, Laguna di Cabras, Laguna di Santa Giusta, Laguna di S'Ena Arrubia, Promontorio di Portofino, Mar Ligure Orientale) The higher density of research sites and fixed-point observatories is in the North Adriatic and along the Emilia Romagna coast (Figure 20)

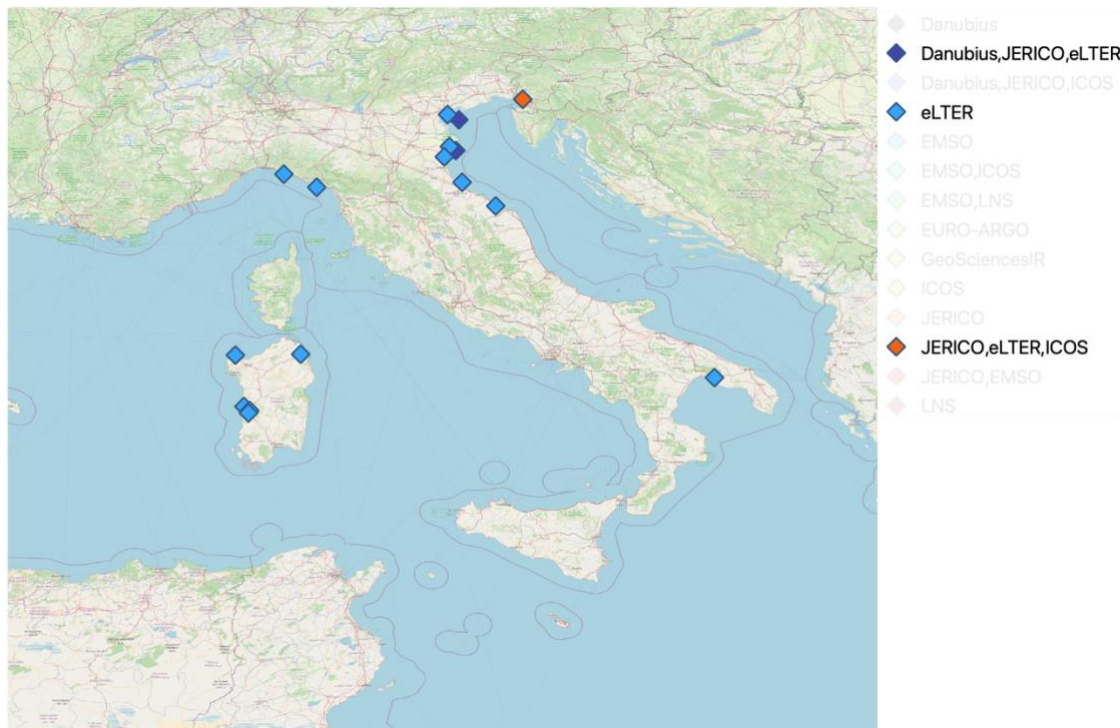


Figure 20 - Distribution of facilities belonging to eLTER. Paloma station, in the gulf of Trieste, has only archived eLTER data set.

JERICO-RI relies on the observation network developed in the past decades that covers both the North Adriatic and the Mar Ligure area. The peculiar facility offered by JERICO consists of the nets of HF Radars both located along the Ligurian coast and around the Gulf of Trieste. Added to this there are the common facilities shared with DANUBIUS, eLTER and ICOS in the North Adriatic. In

addition to this there is the provision of drifters, in the map represented, as approximate location, by the two diamonds west to the Sardinia Island (Figure 21).



Figure 21 - Distribution of facilities belonging to JERICO. Drifters, in the map are represented, as approximate location, by the two diamonds west to the Sardinia Island

EMSO has permanent observatories in the Western Ionian Sea, Southern Adriatic, and Mar Ligure. These facilities are seafloor cabled observatories, buoys and moorings and some of them are shared and co-managed also by ICOS (Mar Ligure and Southern Adriatic) in respect to shallow and sea-surface measurements, and LNS (Capo Passero and Catania). Some new sites in the Sicily Channel and in the area of Lampedusa, are foreseen to be candidate for next future inclusion in EMSO (Figure 22).

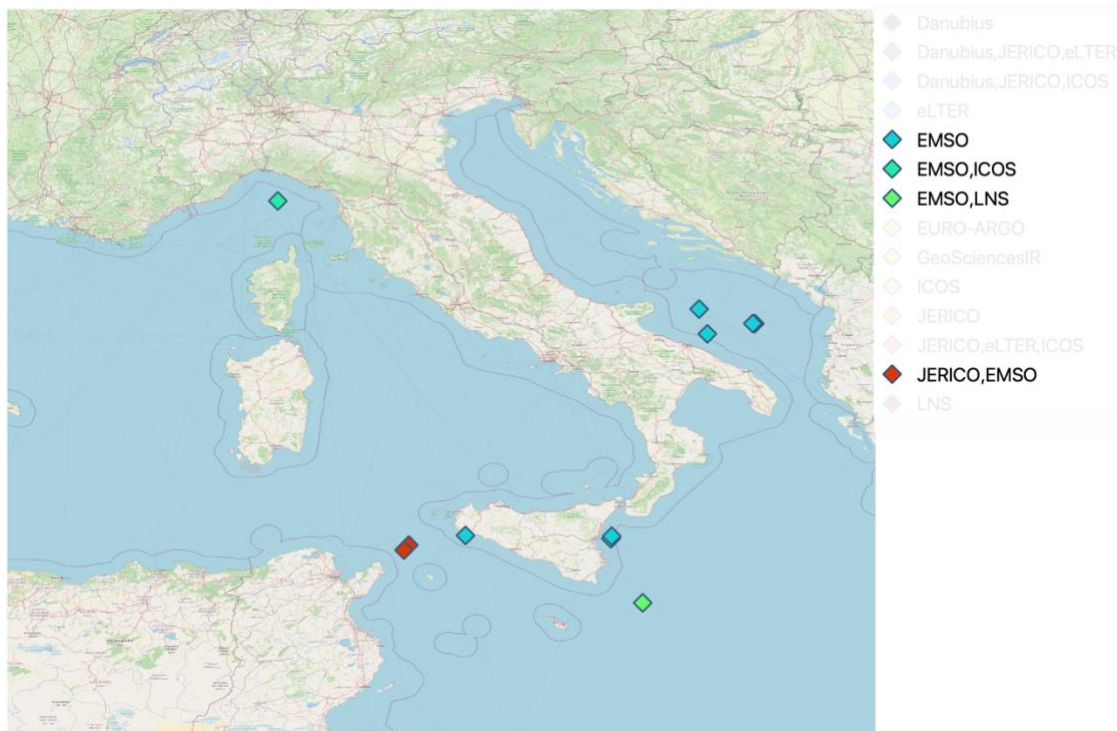


Figure 22 - Distribution of facilities belonging to EMSO-ERIC.

Euro-Argo ERIC, by definition, does not have fixed facilities and relies on autonomous mobile vehicles, i.e., Argo Floats. As an example, the figures below represent the geographical areas reached by the floats (Figure 23, Figure 24). Two areas of interests are currently covered by the Italian array of Argo floats: Mediterranean Sea and Black Sea (Figure 23) and Southern Ocean/Antarctica (Figure 24). In detail, OGS provides 1 active DEEP Argo float (plus 1 in storage), 18 active CORE Argo float (plus 3 in storage), 15 active BGC float (plus 2 in storage). CNR-ISMAR provides 1 BGC Argo float (in storage).



Figure 23 - Real time location of the Euro-Argo float in the Mediterranean Sea (from <https://fleetmonitoring.euro-argo.eu/>). Argo floats spread all over the world, but in this case we focused on the MED area.

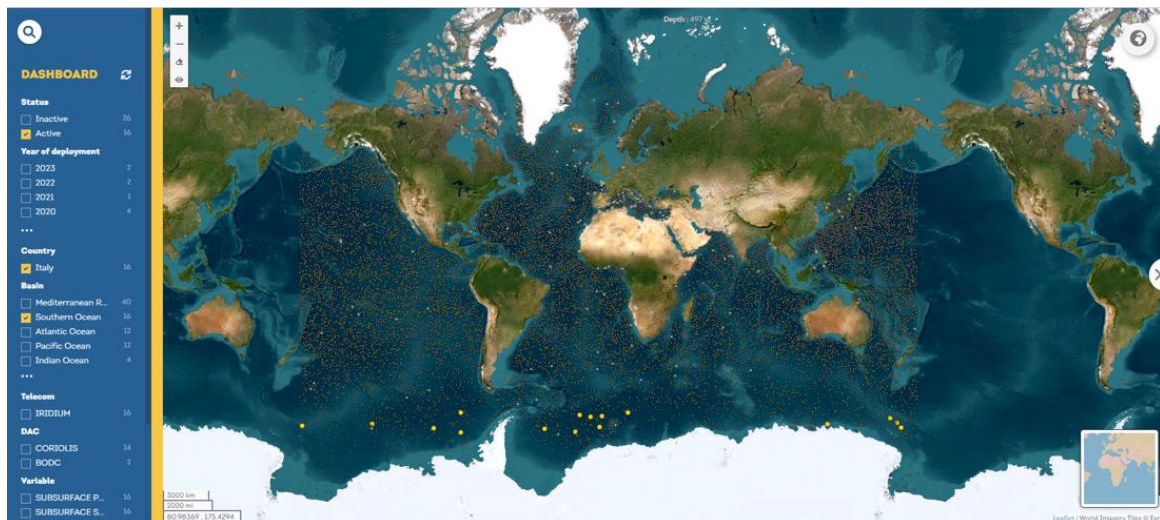


Figure 24 -Location of the Italian Argo floats in the Antarctica. These Argo floats are not considered in this survey.

ICOS has the peculiar observatory in Lampedusa, directly managed by the RI. The other Italian ICOS facilities are shared with other RIs, such as PALOMA, LAMPEDUSA, CNR-IAS_W1M3A, OGS-E2M3A –Buoy, Mambo Miramare (Figure 25).

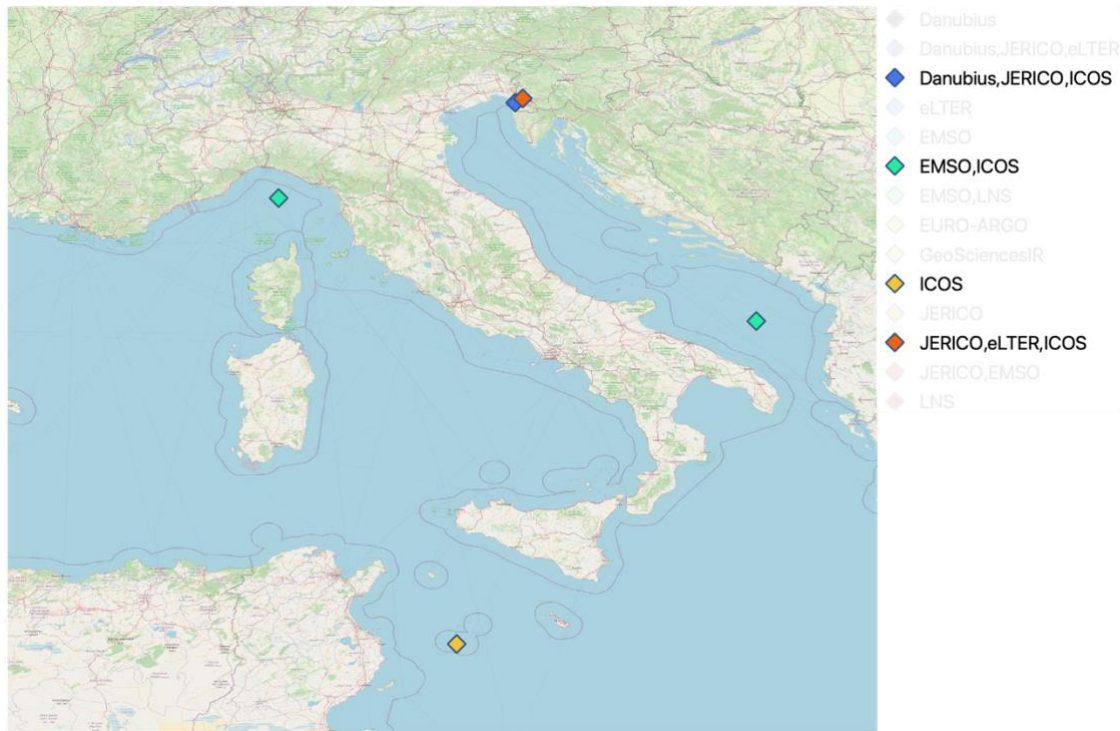


Figure 25 - Distribution of facilities belonging to ICOS.

LNS manages the following cable facilities: Capo Passero and Catania. Capo Passero is the largest deep-sea (3500 m w.d.) infrastructure in the Mediterranean Sea served by 2 electro-optical cables (58 fibers, 100 kW in total). The Catania infrastructure (2500 m w.d) is served by 1 electro-optical cable (10 fibers, 10 kW). Both infrastructures hosts seafloor ocean noise observatories and may host mooring lines. Another acoustic observatory has been recently deployed by INFN, offshore Panarea. The Catania infrastructure is co-managed with EMSO (Figure 26).

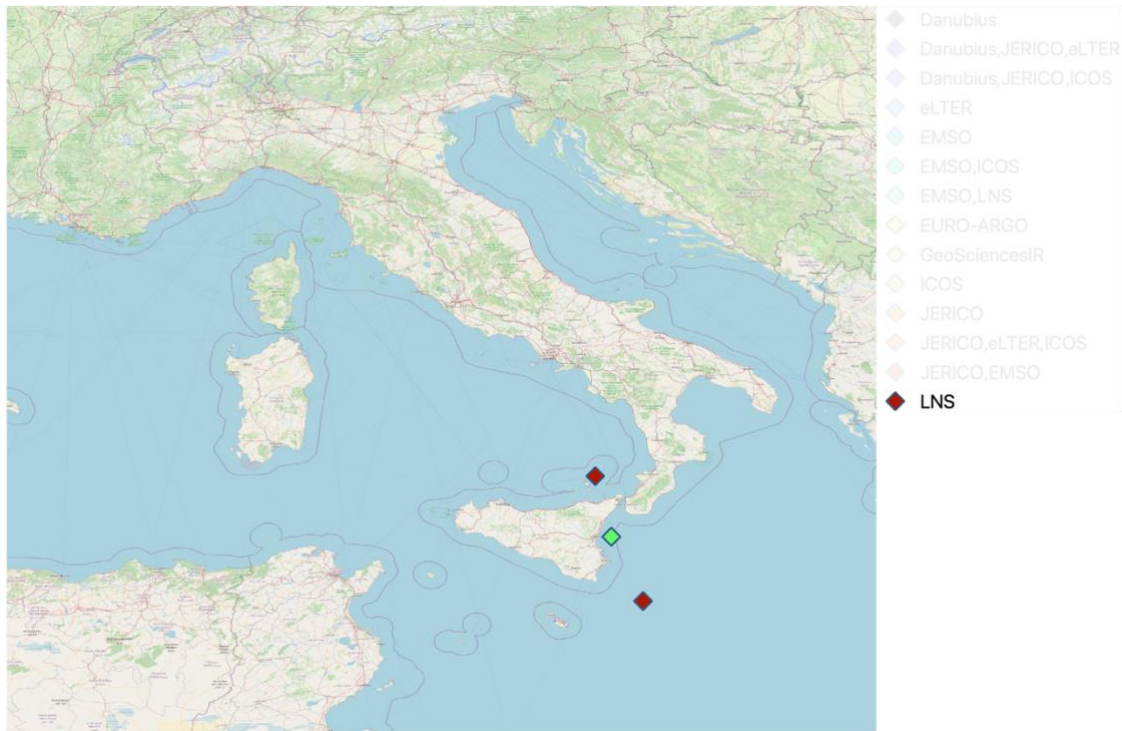


Figure 26 - Distribution of facilities belonging to LNS.

The GeoSciences IR facilities include the whole mareographic and wave network managed by ISPRA. Refer to the table in Annex 1 for the full list (Figure 27).



Figure 27 -Distribution of facilities belonging to Geosciences IR

As evident from both the maps above and list of facilities in Annex 1 - Table 1, for some locations there is joint presence and effort of RIs that, generally, concur in providing a larger range of EOJ/ECV. In some cases, the same EOJ/ECV are made available to more than one RI, since there is a joint effort of RIs in guaranteeing the availability of the measurements and the maintenance.

3.2 Data Access

In terms of Access, the definition given in the European Charter for Access to Research Infrastructures⁶ is the following:

“Access refers to the legitimate and authorized physical, remote and virtual admission to, interactions with and use of Research Infrastructures and to services offered by Research Infrastructures to Users. Such Access can be granted, amongst others, to machine time, computing resources, software, data, data-communication services, trust and authentication services, sample preparation, archives, collections, the set-up, execution and dismantling of experiments, education and training, expert support and analytical services.”

The survey proposed to the different actors involved in WP5 for this gap analysis, allows us to collect information about the data access virtual procedures to the several EOJ/ECVs measured by the current RIs facilities and the data provision options.

This information, related to the specific variable, will feed the ITINERIS catalogue within the metadata, while information on current procedures, modalities, and policies for access implemented within each RI will be included in the WP2. This survey was not designed to map the physical access to some of the facilities, which is regulated by the Trans-National Access mode, and it is specific for each RI.

The survey results provide a first picture on three main aspects: the method for delivering the product, access options and the data release timing. **Error! Reference source not found.** resumes all the different options for all the RIs. The table provides different information: I) n° facilities refers to the number of facilities where at least one dataset has a specific method of delivery; II) access option and data release time. The second column for each RI gives a higher degree of granularity, providing the number of datasets/EOJ/ECVs with a given method of delivery, access option and data release time, as an overall count on all RI facilities.

⁶ European Charter for Access to Research Infrastructures <https://op.europa.eu/en/publication-detail/-/publication/78e87306-48bc-11e6-9c64-01aa75ed71a1/>

	JERICO		eLTER		DANUBIUS		Euro-Argo		ICOS		EMSO		LNS		GeoSciences	
Method of delivery of the product	n. facilities	n of EOJ/ECV	n. facilities	n of EOJ/ECV	n. facilities	n of EOJ/ECV	n. facilities	n of EOJ/ECV	n. facilities	n of EOJ/ECV	n. facilities	n of EOJ/ECV	n. facilities	n of EOJ/ECV	n. facilities	n of EOJ/ECV
Upon request to the data owner/manager	4	31	12	35	7	61	1	5	2	23	7	38	6	6	0	0
accessible on database (by link)	3	37	5	40	2	31	0	0	1	18	0	0	0	0	0	0
accessible on international database (NOT OPEN)	0	0	0	203	0	0	0	0	0	0	0	0	0	0	0	0
accessible on international database (OPEN)	17	94	2	111	3	10	5	188	4	29	7	79	0	0	43	352
accessible on any other national database (NOT OPEN)	0	0	0	15	0	0	0	0	0	0	1	6	0	0	0	0
Access Options																
visualization, download, subsetting	20	127	8	128	4	46	0	0	4	40	3	35	0	0	43	352
visualization, download	3	19	0	0	2	6	1	10	1	7	3	41	0	0	0	0
download	2	11	0	0	3	11	1	5	2	20	7	20	6	6	0	0
visualization	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
not accessible	0	0	2	57	1	4	0	0	0	0	3	14	0	0	0	0
restricted access	1	5	10	120	4	32	0	0	1	3	0	0	0	0	0	0
Data release time																
real time (<2h)	20	136	7	101	6	62	0	0	3	35	1	7	0	0	43	352
<24 h	2	10	0	0	0	0	5	171	2	12	5	31	3	3	0	0
<7 days	0	0	1	4	1	1	0	0	0	0	1	1	2	2	0	0
<30 days	0	0	10	115	4	27	0	0	1	10	0	0	0	0	0	0
<365 days	4	16	7	84	4	14	1	1	2	13	6	57	1	1	0	0
never	0	0	0	0	0	0	0	0	0	0	3	14	0	0	0	0

Table 2 . Table that lists, for each RI, the different accesses.

The table gives an idea on the wide range of options to access the available data and, excluding those datasets that are already stored and organized in European Portals, the level of harmonization is low. The survey done should be considered a first step toward the collection of needed information leading to the IOOS.

The histograms in Figure 28 (a, b, c) represent the number of facilities where at least one EOJ/EOV dataset has a specific method of delivery, access option and data release time. Looking at the Geosciences facilities network, as a first example, it is evident that the full list of the platforms declared by the RI provide data in real time, storing the datasets in an international open database, allowing visualization, download and subsetting.

The general results for access and data provision highlighted that:

- the 67% of the overall EOJ/EOV measured for all RIs is compliant with the A of FAIR principles being accessible via open international databases with options for visualization, download, sub setting.
- The 20 % is upon request to the data owner.
- The 12 % is accessible through database by link with hybrid access options.
- The 1% is not open, not accessible or with restricted access.

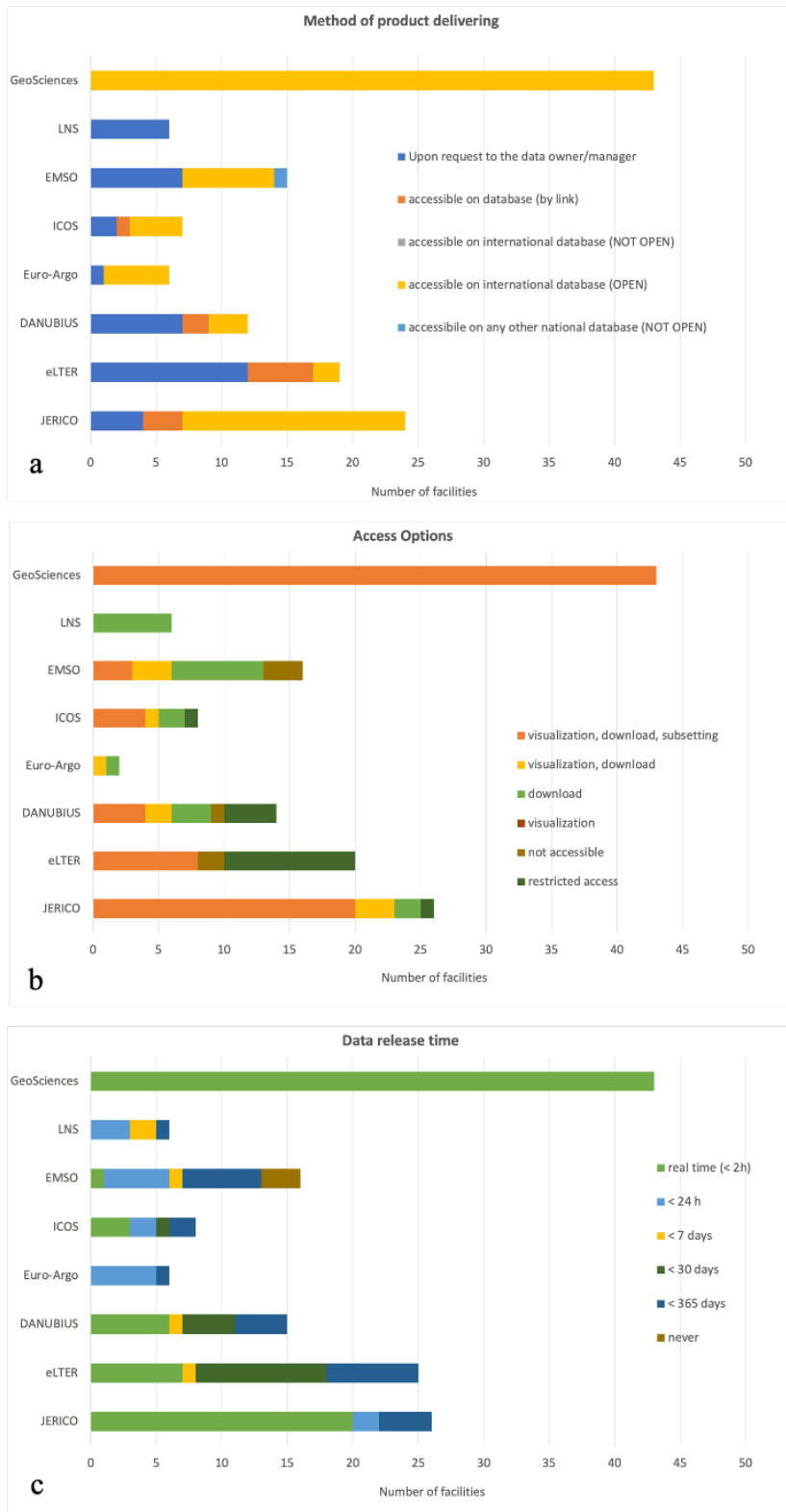


Figure 28 - Histograms show respectively: a) the number of stations (floats are counted as categories) that gives access to at least one EO/ECV of the five specific modes considered; b) n. of stations that allows at least one of the six access options; c) n. of stations delivering data in at least one of the six options provided.

3.3 Recognized bottlenecks

The above analyses shed some light on the overall availability of facilities and related equipment for EOV/ECV measurement. However, from these analyses some aspects are not immediately evident. For example, even if a given EOV/ECV is measured, this does not guarantee either a large spatial and long temporal coverage or an appropriate location of the specific station for the research connected.

The major aspects that were considered for the ITINERIS planning for new equipment, below described, are:

- A certain EOV/ECV can be investigated in a too limited geographic area, or key areas are totally not covered. Need for increase in spatial coverage, allowing also comparisons among different areas/basins.
- A certain EOV/ECV can be investigated in limited temporal periods, lacking in continuity and/or, being limited not to the recent past/present. Need for continuous measurements in time.
- For autonomous platforms, increasing the number of ECV/EOV that can be measured by a single platform
- A certain EOV/ECV can be investigated by using a wide range of different sensors, even in the same place, not meeting the needs in accuracy to properly being defined a EOV or an ECV. Need for appropriate accuracy and harmonization.
- Need for an update through new generation sensors, allowing continuity in the data collection but increasing accuracy and reliability
- Need for a thorough quality check on measured EOV/ECV.
- Some quantities are measured regularly but digital data are not promptly formatted, stored and made available. Need for an organized and near real time approach for producing FAIR data.
- Some datasets are, at the present state, not present in any organized database, therefore not accessible. Even if with different approaches connected to the multiple initiatives data belong too, there is the need for a common and interoperable way to access the highest amount of available data.

4. ACTION IN ITINERIS TO FILL THE GAPS

The above picture on the present state of RI facilities shows how a large number of EOV and ECV are already measured but evidences also what could be needed actions to: a) increase their number for the increasing request from the research community and for the increase in interdisciplinary studies; b) increase their spatial and temporal coverage, in order to cover the focus areas and the needed measurement frequency; c) to increase the prompt availability of corresponding datasets and effort to support digitalization and, where possible, real time or near real time data transfer. These aspects, with specific action for each RI, are the most relevant driving the plan on equipment that will be tested within ITINERIS.

DANUBIUS-RI

The present DANUBIUS-RI SRIA (Strategic Research and Innovation Agenda) already monitored the major requests from the research community in terms of Research Goals. These can be summarized under the following main thematic pillars:

- Water sufficiency
- Sediment management
- Ecosystem health

In the Italian DANUBIUS Supersite “Po River Delta and North Adriatic Lagoons”, these themes are further elaborated with a focus on the coexistence of different anthropic uses and the cultural and social relevance of transitional areas, such as, for example the Venice Lagoon, evaluating the studied systems as hot spot to evaluate effects due to climate change.

DANUBIUS-RI considers that main actions are needed to support research in River-Sea systems within its mission:

- the quantification of lateral sources of water, sediment and nutrient loads coming from the rivers need to be improved, both in terms of measurement frequency and in coverage of the lateral sources.
- The need to be able to cover the ROFI (Region of Freshwater Influence) requires having a good coastal coverage for the same EOVS measured for rivers, in terms of hydrodynamic, turbidity and nutrients.
- Considering the river-sea system as a continuum, where freshwater and saltier waters are meeting and being characterized by feedbacks and physical interaction processes, there is the need to measure not only the variables but also to quantify if the land sea interface is varying in width and to what drivers this change is connected. This means to complement measurements in fixed stations with other EO tools able to provide a picture with large geographic coverage (from satellite and models). In this case, the in-situ measurements are concurring in validating the other two sources of information and the measured variables should be comparable with those measured from satellites and models. Therefore, the equipment plans are also shaped to calibrate and validate modelling tools and tailor-made EO algorithms.

In this perspective, the activities and the corresponding planned increase in equipment will cover:

- The major North Adriatic River branches, in their final part, with stations to measure discharge flows and where possible also sediments and nutrients.
- Increase, in synergy with the major monitoring entities, the water quality (salinity, temperature, oxygen, nutrients) in the Venice Lagoon.
- The Venice lagoon inlets to improve the information on lagoon-sea exchanges.
- The improvement of digitalization for the relevant EOVS and ECVs in the CNR fixed platforms along the North Adriatic coast (e.g., Acquafredda Platform and PALOMA).
- The improvement of relocatable in-situ equipment to be used to validate EO sat products (and corresponding algorithms), e.g., Radiometers.

EMSO-ERIC

The spatial distribution of the Italian observational facilities in EMSO, in spite Italy provides a larger number of facilities compared to other Countries, is not able to illuminate many crucial areas around our peninsula (e.g., Tyrrhenian Basin). It is worth outlining that EMSO peculiarity respect to other RIs, is the focus on the deep and open marine environment and that the deepsea observations are rarely used in the computation of deep circulation models. The actions which address gaps mainly relates the EOVS and ECVs spatial coverage expansion, the reduction of the ‘data latency’ for the user (implementation of near-real and real-time data communication), the increment

One of the next EMSO objectives is the improvement of the monitoring capability offshore of the Ligurian Sea and in the Sicily channel, expanding the horizontal and vertical spatial coverage of EOVS and ECVs with near real-time data transmission. In the Ligurian Sea, the reduction of the existing gap of near real time EOVS and ECVs measurements in deep water will be filled through the implementation of a data link that will allow the transmission of data from the instruments deployed in deep sea on the WIM3A observatory. Specifically, two acoustic modems coupled with CTDs will be installed on the WIM3A facility and the data transfer will be enhanced by installing

servers and land stations onshore using both a satellite system and a radio link. The updated land stations will also expand the computing power and storage capacity of W1M3A 's dedicated servers and, in turn, the capability to provide external users with new observations EOVs related. The servers will be further enhanced with professional software that will support the researcher in the analysis of backscatter acoustic data provided by the ADCP, already part of the scientific equipment of the W1M3A observatory.

In the Sicilian Channel the number of shallow water acoustic measurements will be increased to spatially (both vertically than horizontally) extend and the development of a web-portal section will favor sharing and managing data of the marine shallow water observatory.

Offshore eastern Sicily, the EMSO Western Ionian Sea facility will be enhanced with a new electro-optical cable about 30 km long with junction boxes for hosting a wide range of sensor equipment's from a wider range of disciplines than presently. The purpose is to extend the range of the observables and the depth range of measurements (i.e., including water-column observation), provide hosting service to other disciplines (ie., marine biology) and access (physical and virtual) to unprecedented deep-sea experiments , increase the real time data transfer from deep sea site to shore station and extend the operation of the facility for the next 20 years

[The Southern Adriatic Regional Facility will enhance the observational capacity of the Southern Adriatic by implementing and enhancement of more stable and continuous real-time data transmission of physical and biochemical variables using an inductive cable and sensor-coupled inductive data links. This action, and the harmonization with data from Argo floats and gliders, should increase Italy's capacity for deep-sea and open-sea observations.](#)

[In addition, the deployment of new sensors at the site aims to complement the observational capabilities of biogeochemical and biological parameters \(partial bottom CO₂, ocean sounding, and photosynthetically active radiation - PAR\) at the ecosystem level and to fill gaps in EOV measurements, especially at the bottom and surface levels. The development and installation of a land station will enhance communication and real-time data transmission of observations of nearly the entire open ocean water column through satellite transmission. This upgraded land station will also expand the computational power and storage capacity of the E2M3A system, and thus the capability to provide external users with new observations related to EOVs.](#)

eLTER-RI

Currently, the main research themes of marine and transitional Italian eLTER sites are:

- Abiotic component - physical and chemical characteristics of the marine habitat
- Planktonic component - phytoplankton and zooplankton (community structure, seasonal variations, long-term variations)
- Benthic component - phytobenthos and zoobenthos (community structure, biodiversity, ecology and distribution)

The main implementations foreseen during the project are aimed at filling crucial gaps in the EV observation framework. A proper integration between oceanographic and biological/ecological research and monitoring is essential to broaden the spectrum of observing actions, holding the ecological connectivity concept as one of the main driving forces of marine ecosystems' functioning. Thus, both the understanding of the marine ecosystems and the assessment of their state and changes over time and space could be effectively enhanced.

In this context, the main activities and the corresponding planned increase in equipment will be:

- Implementation of the number of biological variables measured (innovative instrumentation will allow to map and monitor, e.g., fish and gelatinous macroplankton with RT imaging and an Automatic Identification System (AIS))
- Implementation and/or integration of instrumentation for acquisition of physical-chemical variables in the marine environment (e.g., Photosynthetically active radiation-PAR, solar net radiation, Turbidity)
- Implementation of synergies between eLTER sites, enabling comparability between areas/basins (instrumentation will be acquired for covering observations at multiple sites, e.g., cytometers, Guard-1, Underwater Video Profiler-UVP)
- Enhance the automated acquisition of biological variables (e.g., phytoplankton/cytometer - innovative instrumentation will allow to acquire near-real time data with an unprecedented time resolution (1 h) and to facilitate the broad taxonomic classification)
- Purchase of fixed instrumentation to guarantee temporal continuity of long-term series
- Purchase of hardware and software to implement marine data repository national node eLTER
- Implementation of data transmission for fixed point observing systems.

JERICO-RI

The scientific strategy for the JERICO-RI has been developing during the on-going JERICO-S3 and JERICO-DS projects and is currently based on the following three Key Scientific Challenges (KSCs):

- Assessing and predicting changes of coastal marine systems under the combined influence of global and local drivers (KSC#1);
- Assessing the impact of extreme events on those changes (KSC#2);
- Unravelling the impacts of natural and anthropogenic drivers of climate change (KSC#3).

The development strategy of the JERICO-RI is taking place at the regional level. It is mainly constituted by the implementation of Pilot Super Sites (PSSs) and Integrated Regional Sites (IRSs), which both work towards establishing integrated observational and science strategies and serve as implementation of different actions, aimed at:

- Testing how coastal observations could be best integrated via the JERICO-RI multiplatform approach.
- Interfacing with regional user communities.
- Hosting demonstration experiments for new technological developments.
- Interacting with other RIs or, more in general, with other observing initiatives in the regions.

In Italy the JERICO strategy is currently declined both in the North-Western Mediterranean PSS and in the North-Adriatic IRS. Its main objective is aimed at increasing, via a multiplatform approach, the national monitoring level of the complex interplays between biogeochemical and physical processes taking place in the coastal environment. The activities and the corresponding acquisitions at observational sites of physical and biogeochemical variables with new platforms and sensors will:

- Extend the JERICO geographical coverage towards the southern Italian regions mainly through the JERICO network of HF radar systems.
- Increase the communication and data storage systems of the existing JERICO platforms.
- Enlarge the number of the JERICO autonomous vehicles and smart devices with new gliders, drifters, profilers, smart observatories and cameras.

- Strengthen the data management of the national component of JERICO via a new datacentre used also for the development of a Virtual Research Environment on climate indicators.

Euro-Argo ERIC

The Italian Euro Argo ERIC scientific strategy has been primarily designed to observe, in Near-Real-Time (NRT), the physical state of the upper 2000 m of the oceans to assess and understand Earth's climate. This has yielded to a critical gap in NRT observation of marine biota and biogeochemistry in the upper 2000 m of open seas. Because marine biodiversity and related ecosystem functions occur over a continuum of spatial and temporal scales, a fit-for-purpose sampling is mandatory. The necessary observational breakthrough can only be achieved through deployment of Biogeochemical (BGC)-Argo profiling floats. These autonomous robots are the most flexible and cost-effective platforms to measure a wide range of EOVs and ECVs. BGC-Argo floats allow for adaptive sampling (i.e., both vertical and temporal resolutions) to track changes in the processes and their scales of occurrence in NRT thanks to the iridium antenna for a two-way communication then transmits via satellite the acquired data to land. In ITINERIS, cutting-edge multi-sensor/multi-process Argo robots will fill the gap of biological and biogeochemical observations in open seas over a continuum of spatial-temporal scales, also thanks to synergies with cameras for marine microfauna and optical sensors installed on floats measuring biology and biogeochemistry at the surface at high frequency.

The actions will:

- Consolidate and empower observational needs: EOVs and ECVs in under sampled seas. Besides CTD and oxygen, the number of floats hosting optical sensors (chlorophyll, scattering, radiometry) and imaging cameras to better observe marine microfauna (e.g., zooplankton) will increase. Some floats will also be dedicated to resolving the nitrate cycle. Several floats will thus be prepared, tested and deployed from vessels. Implement international Argo accepted quality-control (QC) procedures and develop tailored QC protocols for the new sensors and variables to guarantee open access and distribution for the whole portfolio of EOVs and ECVs. A few floats will house sensors from different manufacturers to compare the quality of sensors to incentivize future cost reduction.
- Investigate synergies between BGC-Argo, drifters and satellite optical measurements (such those from operationally available EU Copernicus services) to strengthen assessment and understanding of current ocean and ecosystem health over multiple spatial and temporal scales.
- Sampling of the entire ocean depth contributes to closing the planetary heat and freshwater budget and the global sea level balance.

ICOS ERIC

Currently, the focus is on high-quality measurements of the CO₂ system in surface waters and on the global and local drivers of temporal variability and CO₂ exchanges with the atmosphere. The main actions planned under the project aim to better understand ocean acidification (including pH measurements), the influence of biological factors (including measurements of fluorescence and PAR) and the link with the processes of CO₂ assimilation or production that take place below the ocean surface and in deeper waters (additional pCO₂ probes). This is critical because mixing and dense water formations can rapidly alter the exchanges at the air-water interface.

The recent integration of the Lampedusa fixed ocean station in the Italian network, will allow CO₂ to be measured in all three domains (ocean, ecosystem and atmosphere), in a unique case, providing a better understanding of the processes taking place in a relatively remote area of the central Mediterranean Sea.

Upgrading of infrastructure science payload with instrumentation is a priority to ensure continuity of ongoing time series (e.g., temperature, salinity, O₂, pCO₂, pH) and to implement the measurements of the key parameters.

In this context, the main activities and the corresponding planned increase in equipment will include the acquisition of automatic instruments in the ocean fixed stations to measure pCO₂, O₂, pH, fluorescence and photosynthetically active radiation in surface water and in some sites also pCO₂/pH in deeper waters.

Another implementation will be to transmit the data collected below the ocean surface in Near Real Time so that it is available along with the surface data for visualization and integration with data from other RIs (DANUBIUS, JERICO, EMSO, eLTER), depending on the specific location of the fixed ocean station.

LNS

The focus of LNS in the project is aimed at two main goals:

- 1) provide a deep-sea scientific hub with large bandwidth and power connection to install seafloor and water-column observatories in Mediterranean abysses, allowing connection of instrumentation with real-time data acquisition of instrumentation for monitoring of marine EO/ECV.
- 2) provide real-time measurement of Ocean Sound EO/ECV from Catania and Capo Passero. Recorded data from Capo Passero, Catania and Panarea.

With respect to the item 1, ITINERIS funding will strongly help the Italian marine community in acquiring an open science high-reliability/high-availability/high-speed deep-sea hub. Measurement of EO/ECV in marine abysses is indeed still very much limited by technological constraints, that are expected to be (at least partially) overcome in activity 5.7. Strong synergy with EMSO-ERIC, mainly, and other RI's is in place to re/de-fine communication protocols. Use of high precision (ns accuracy) data stamping using PtP White Rabbit technology is foreseen, paving the way to underwater GPS systems.

With respect to item 2, the ITINERIS funding will be used to create a network of ocean sound detectors (hydrophones) deployed on deep seafloor that (as demonstrated by the OnDE and SN1 acoustic data) allow monitoring of large marine areas. Acquired ocean sound EO/ECV data will be used to evaluate anthropogenic pressure (air guns and ship noise mainly from single vessel and cumulative), biological source detection, geophysical and atmospheric originated noise. MSFD recommendations for noise monitoring will be applied. Data formats and analysis procedures will be harmonized with JERICO, EMSO, Danubius to maximize synergy.

GeoSciences

The aim of ISPRA in the project is the following:

- 1) provide monitoring data collected by its own present and future infrastructures, considering ongoing investments foreseen by other components of Italian Recovery and Resilience Plan (e.g., national wave network, national tide network, offshore buoys, 1 new research vessels). These infrastructures are also part of GeoSciences.
- 2) Integrate, harmonize and validate data sets to support the following issues:
 - Assessment of GEnS for MSFD, characterization of pelagic and benthic habitats for the identification of new marine protected areas for the implementation of EU Biodiversity Strategy 2030

- Identification of suitable areas for the implementation of renewable energy plants
- Environmental Impact and Strategic Assessment procedures for coastal and marine infrastructures and for programmes and plans as MSP.

ITINERIS founding will be used to develop the software infrastructures to Integrate, harmonize and validate data sets with extensive use of GIS tools and statistical analysis tools. Web services will be implemented to acquire and share data with efficient and sound methods.

ANNEX 1: TABLES OF FACILITIES FOR EACH CONTRIBUTOR/OR RIS

Table 1 – List of facilities included in ITINERIS RIs – Present State

Facility	Latitude [°N]	Longitude [°E]	Property	Reference Ris
Piattaforma Oceanografica Acqua Alta	45,314247	12,508248	CNR-ISMAR	Danubius, JERICO, eLTER
Meda elastica Paloma	45,61828300	13,565217	CNR-ISMAR	Danubius, JERICO, ICOS
Meda S1-GB	44,73848300	12,452633	CNR-ISMAR	Danubius, JERICO, eLTER
Boa meteo-oceanografica E1	44,14325000	12,5701	CNR-ISMAR	eLTER
torbidimetro Stazione San Nicolo (SN)	45,43254000	12,41006	CNR-ISMAR	Danubius
torbidimetro Stazione Treporti (TRP)	45,43448000	12,41407	CNR-ISMAR	Danubius
torbidimetro Stazione Malamocco (MAL)	45,33393000	12,32694	CNR-ISMAR	Danubius
torbidimetro Stazione Chioggia (CH)	45,23391000	12,2958	CNR-ISMAR	Danubius
MEDA Lampedusa	35,49350000	12,4678	ENEA	ICOS
Corsica (Codice WMO: 6101020)	43,02500000	9,683333	CNR-ISMAR	JERICO
Canale Sicilia C01 (Codice WMO: 6101021)	37,38000000	11,591	CNR-ISMAR	JERICO, EMSO
Canale Sicilia C02 (Codice WMO: 6101022)	37,28500000	11,5	CNR-ISMAR	JERICO, EMSO
Stazione radar HF LIGW	44,34575300	8,558285	CNR-ISMAR	JERICO
Stazione Radar HF PFIN	44,29870000	9,21836	CNR-ISMAR	JERICO
Stazione Radar HF PCOR	44,14350000	9,6593	CNR-ISMAR	JERICO
Stazione Radar HF TINO	44,02640000	9,84922	CNR-ISMAR	JERICO

Stazione Radar HF VIAR	43,85790000	10,2373	CNR-ISMAR	JERICO
Stazione Mareografica Trieste	45,64730000	13,7595	CNR-ISMAR	Danubius
Stazione Meteo-Marina Trieste	45,65000000	13,7522	CNR-ISMAR	Danubius
EMSO SN1 – Water Column	37,54004300	15,397313	CNR-ISMAR	EMSO
GRANSEA - shallow water station	37,56100000	12,654833	CNR-IAS	EMSO
Osservatorio W1M3A	43,83451700	9,131633	CNR-IAS	EMSO, ICOS
Biogeochemical-SVP (BGC-SVP)	drifters	drifters	CNR-ISMAR	JERICO
SVP Salinity (SVP-S)	drifters	drifters	CNR-ISMAR	JERICO
DEEP-Argo	Floats (1 active – 2 storage)	floats	OGS	EURO-ARGO
CORE-Argo	Floats (18 active – 3 storage)	floats	OGS	EURO-ARGO
Biogeochemical-Argo (BGC-Argo) Nitrates Float	Floats (2 active – 1 storage)	floats	OGS	EURO-ARGO
Biogeochemical-Argo (BGC-Argo) TS-DO float	Floats (13 active – 1 storage)	floats	OGS	EURO-ARGO
Biogeochemical-Argo (BGC-Argo) WMO2903797	floats (1 storage)	floats	CNR-ISMAR	EURO-ARGO
ONDE	37,49992500	15,383778	INFN	EMSO,LNS
SMO Tower Capo Passero	36,29670000	15,979183	INFN	EMSO,LNS
SMO-ONDE Catania test Site	37,499925	15,383778	INFN	EMSO,LNS
ONDE Panarea	38,63333300	15,083333	INFN	LNS
ITINERIS Capo Passero	36,29670000	15,979183	INFN	LNS
ONDE 3 Catania test Site	37,49992500	15,383778	INFN	EMSO,LNS
Western Ionian Sea	37,54765000	15,3975	INGV	EMSO
Sacca di Goro	44,81195000	12,3315	Uni_ferrara	eLTER
Valli di Comacchio	44,62058300	12,23685	Uni_ferrara	eLTER

Laguna di Venezia	45,41306000	12,29722	CNR-ISMAR	eLTER
Transetto Senigallia-Susak (Meda TeleSenigallia)	43,70000000	13,2	CNR-IRBIM- Uni_Marche	eLTER
Mar Piccolo di Taranto	40,48475400	17,299609	CNR-IRSA	eLTER
Golfo dell'Asinara	40,90597200	8,321056	Uni_Sassari	eLTER
Golfo di Olbia	40,92341700	9,544278	Uni_Sassari	eLTER
Laguna di Cabras	39,94380600	8,48125	Uni_Sassari	eLTER
Laguna di Santa Giusta	39,86744400	8,59125	Uni_Sassari	eLTER
Laguna di S'Ena Arrubia	39,822472	8,566167	Uni_Sassari	eLTER
Promontorio di Portofino (Boa Oceanografica MEDA2)	44,29661700	9,229417	Uni_Genova	eLTER
Mar Ligure Orientale (from Magra River mouth and Cinque Terre National Park promontory)	44,05000000	9,845	ENEA	eLTER
E2M3A -BOA	41,533667	18,083333	OGS	EMSO, ICOS
E2M3A -MOORING	41,534833	18,0465	OGS	EMSO
Mooring BB EMSO ERIC_South Adriatic	41,341317	17,193417	CNR-ISP	EMSO
Mooring FF EMSO ERIC_South Adriatic	41,806117	17,038267	CNR-ISP	EMSO
Stazione meteo mareografica RMN di Ancona	43,62485083	13,50625483	ISPRA	GeoSciencesIR
Stazione meteo mareografica RMN di Anzio	41,44685833	12,63479167	ISPRA	GeoSciencesIR
Stazione meteo mareografica RMN di Bari	41,14012778	16,86604444	ISPRA	GeoSciencesIR
Stazione meteo mareografica RMN di Cagliari	39,210197	9,114235	ISPRA	GeoSciencesIR
Stazione meteo mareografica RMN di Carloforte	39,14802	9,309699	ISPRA	GeoSciencesIR
Stazione meteo mareografica RMN di Catania	37,49808056	15,093825	ISPRA	GeoSciencesIR

Stazione meteo mareografica RMN di Civitavecchia	42,09395833	11,78964722	ISPRA	GeoSciencesIR
Stazione meteo mareografica RMN di Crotone	39,81606667	17,13703889	ISPRA	GeoSciencesIR
Stazione meteo mareografica RMN di Gaeta	41,20999167	13,58973611	ISPRA	GeoSciencesIR
Stazione meteo mareografica RMN di Genova	44,410101	8,924698	ISPRA	GeoSciencesIR
Stazione meteo mareografica RMN di Ginostra	38,782995	15,19244556	ISPRA	GeoSciencesIR
Stazione meteo mareografica RMN di Imperia	43,87836167	8,018725	ISPRA	GeoSciencesIR
Stazione meteo mareografica RMN di La Spezia	44,09512	9,85876	ISPRA	GeoSciencesIR
Stazione meteo mareografica RMN di Lampedusa	35,49982778	12,60443889	ISPRA	GeoSciencesIR
Stazione meteo mareografica RMN di Livorno	43,54632778	10,29932778	ISPRA	GeoSciencesIR
Stazione meteo mareografica RMN di Marina di Campo	42,7429	10,23766667	ISPRA	GeoSciencesIR
Stazione meteo mareografica RMN di Messina	38,19631389	15,56351389	ISPRA	GeoSciencesIR
Stazione meteo mareografica RMN di Napoli	40,84140556	14,26919444	ISPRA	GeoSciencesIR
Stazione meteo mareografica RMN di Ortona	42,35617111	14,41467778	ISPRA	GeoSciencesIR
Stazione meteo mareografica RMN di Otranto	40,14719444	18,49722222	ISPRA	GeoSciencesIR
Stazione meteo mareografica RMN di Palermo	38,12141111	13,37133056	ISPRA	GeoSciencesIR
Stazione meteo mareografica RMN di Palinuro	40,03147222	15,27496944	ISPRA	GeoSciencesIR
Stazione meteo mareografica RMN di Ponza	40,89517778	12,96558889	ISPRA	GeoSciencesIR

Stazione meteo mareografica RMN di Porto Empedocle	37,28575556	13,52684444	ISPRA	GeoSciencesIR
Stazione meteo mareografica RMN di Porto Torres	40,84220389	8,40398083	ISPRA	GeoSciencesIR
Stazione meteo mareografica RMN di Ravenna	44,49202306	12,28291694	ISPRA	GeoSciencesIR
Stazione meteo mareografica RMN di Reggio Calabria	38,12171944	15,64891667	ISPRA	GeoSciencesIR
Stazione meteo mareografica RMN di Salerno	40,67664167	14,75083889	ISPRA	GeoSciencesIR
Stazione meteo mareografica RMN di S.Benedetto del Tronto	42,95516806	13,88968	ISPRA	GeoSciencesIR
Stazione meteo mareografica RMN di Scacca	37,50454167	13,07645556	ISPRA	GeoSciencesIR
Stazione meteo mareografica RMN di Strombolicchio	38,81729167	15,252375	ISPRA	GeoSciencesIR
Stazione meteo mareografica RMN di Taranto	40,47546389	17,22391667	ISPRA	GeoSciencesIR
Stazione meteo mareografica RMN di Tremiti	42,11898056	15,50174444	ISPRA	GeoSciencesIR
Stazione meteo mareografica RMN di Trieste	45,64963889	13,75882972	ISPRA	GeoSciencesIR
Stazione meteo mareografica RMN di Venezia	45,4181	12,42638972	ISPRA	GeoSciencesIR
Stazione meteo mareografica RMN di Vieste	41,88804167	16,17696667	ISPRA	GeoSciencesIR
Stazione meteo ondometrica RON di Ancona	43,82388889	13,71944444	ISPRA	GeoSciencesIR
Stazione meteo ondometrica RON di Alghero	40,54861111	8,10694444	ISPRA	GeoSciencesIR
Stazione meteo ondometrica RON di Cagliari	39,115	9,405	ISPRA	GeoSciencesIR
Stazione meteo ondometrica RON di Catania	37,44	37,44	ISPRA	GeoSciencesIR

Stazione meteo ondamentrica RON di Cetraro	39,45333333	15,91833333	ISPRA	GeoSciencesIR
Stazione meteo ondamentrica RON di Civitavecchia	42,24472222	11,55388889	ISPRA	GeoSciencesIR
Stazione meteo ondamentrica RON di Crotone	39,02361111	17,22	ISPRA	GeoSciencesIR
Stazione meteo ondamentrica RON di La Spezia	43,92916667	9,82777778	ISPRA	GeoSciencesIR
Stazione meteo ondamentrica RON di Mazara del Vallo	37,51805556	12,53333334	ISPRA	GeoSciencesIR
Stazione meteo ondamentrica RON di Monopoli	40,975	17,37777778	ISPRA	GeoSciencesIR
Stazione meteo ondamentrica RON di Ortona	42,40666667	14,53666667	ISPRA	GeoSciencesIR
Stazione meteo ondamentrica RON di Palermo	38,25833333	13,33333336	ISPRA	GeoSciencesIR
Stazione meteo ondamentrica RON di Ponza	40,86666669	12,95000003	ISPRA	GeoSciencesIR
Stazione meteo ondamentrica RON di Siniscola	40,61666669	9,89166667	ISPRA	GeoSciencesIR
Stazione meteo ondamentrica RON di Venezia	45,33333336	12,51666667	ISPRA	GeoSciencesIR
MIRAMARE-MAMBO1	45,69866667	13,7065	OGS	JERICO,eLTER,ICOS
HF-Radar Gulf of Trieste (GoT)	45,74118611	13,66932222	OGS	JERICO
Boa Ondamentrica Direzionale DWRG1	45,5655	13,24835	OGS	JERICO
Boa Ondamentrica Direzionale DWRG2	45,69944444	13,20917222	OGS	JERICO
Boa Ondamentrica Direzionale DWRG3	45,68821667	13,52146667	OGS	JERICO
Boa Meteo Oceanografica MAMBO2	45,60266667	13,15066667	OGS	JERICO

Boa Meteo Oceanografica MAMBO3	45,644	13,51133333	OGS	JERICO
Boa Meteo Oceanografica MAMBO4	45,59446667	13,34381389	OGS	JERICO
Stazione correntometrica Isonzo	45,7616	13,49612222	OGS	JERICO
Stazione piezometrica Tagliamento (Bevazzana)	45,67156667	13,06858889	OGS	JERICO