



**D5.4 Report on gaps identification in data acquisition of the Arctic region. Definition of the new architecture of SIOS infrastructure; procedures for implementation of the observatory platforms**



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## 1. INTRODUCTION

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, responding to the major challenges of the United Nations Decade (2021-30) for the Ocean Science for Sustainable Development. The marine realm is the largest component of the Earth's system that stabilizes climate and supports life on Earth and human well-being. However, the First and the Second World Ocean Assessment of the United Nations found that much of the ocean is now seriously degraded, with changes and losses in the structure, function and benefits from marine systems. In this context, the Arctic is undergoing rapid change and to understand the effects on ecological and socio-economic systems, as well as to implement mitigation and adaptation measures, sustained and holistic observations are vital.

D5.4 report aims to provide the current overview of available facilities, equipment, and measured Essential Ocean Variables and the type of access for Arctic SIOS Research Infrastructure (RI) in WP5. The report also identifies bottlenecks and gaps and provides actions in ITINERIS to fill the gaps, showing the future design of SIOS-RI facilities.

### **SIOS-RI - Svalbard Integrated Arctic Earth Observing System Research Infrastructure**

SIOS (<https://sios-svalbard.org/>) is a collaborative effort to develop and maintain a regional observational system for long-term in situ and remote sensing (RS) measurements in and around Svalbard to address key Earth System Science (ESS) questions related to Global Change. SIOS entered the operational phase in January 2018, after a three-year long interim phase (November 2014 – January 2018) and a four year long preparatory phase (October 2010 – November 2014). It coordinates, develops and optimizes RI owned by the member institutions. Their common goal is to establish a cooperating and transparent RI which will give better estimates of the future environmental and climate changes in the Arctic. The observing system and research facilities offered by SIOS build on the extensive observation capacity and diverse world-class research infrastructure provided by many institutions already established in Svalbard. This includes a substantial capability for utilizing remote sensing resources to complement ground-based observations. From this solid foundation, SIOS envisions a significant contribution to the systematic development of new methods and observational design in Svalbard. This knowledge can advance other observational networks in the Arctic and elsewhere. Although SIOS focuses on the Svalbard region, it works on integration with other regional, pan-Arctic and European initiatives. SIOS plays an active role in several international networks and projects (e.g., SAON/IASC, EU Polar Cluster, Arctic PASSION, CRIOS, ENRIITC, AASCO, ENVRI community, WMO/WIGOS) and has recently established cooperation with the Greenland Integrated Observing System (GIOS).

At present, SIOS is an international consortium of 29 member institutions from 10 countries and 12 marine sites. Italy participates in SIOS through the CNR (National Research Council), providing 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.

## 2. IDENTIFICATION OF RELEVANT VARIABLES CONNECTED WITH SIOS-RI: GAPS IN EOVS AND ECV

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. According to Global Ocean Observing System (GOOS) led by the Intergovernmental Oceanographic Commission (IOC) of UNESCO, the development of sampling requirements for

various ocean applications, including in-situ and satellite observing platforms has enabled the possibility to define the Essential Ocean Variables (EOVs). These variables are defined by the GOOS Expert Panels on two aspects<sup>1</sup>:

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

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 climate<sup>2</sup>. ECVs are defined by the Global Climate Observing Systems (GCOS).

The full list of EOV and ECV can be found at the following links:

[https://www.goosocean.org/index.php?option=com\\_content&view=article&id=14&Itemid=114](https://www.goosocean.org/index.php?option=com_content&view=article&id=14&Itemid=114)

[https://library.wmo.int/index.php?lvl=notice\\_display&id=22135](https://library.wmo.int/index.php?lvl=notice_display&id=22135)

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, they provide the measurements needed to understand and predict climate evolution, guiding mitigation and adaptation measures. They 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.

RI 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 Economy<sup>3</sup>.

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<sup>1</sup> [https://www.goosocean.org/index.php?option=com\\_content&view=article&id=14&Itemid=114](https://www.goosocean.org/index.php?option=com_content&view=article&id=14&Itemid=114)

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

<sup>3</sup> The United Nations Decade of Ocean Science for Sustainable Development 2021-2030– IOC (2018) <https://unesdoc.unesco.org/ark:/48223/pf0000261962>

To collect the most updated information about available facilities, equipment and related measured variables in the arctic region, a survey was conducted among SIOS-RI WP5 ITINERIS participants. The final picture, therefore, allows investigating the extent of the coverage for relevant variables of the marine SIOS-RI.

Fixed stations, buoys, networks of research sites and equipment, mobile vehicles, etc. are all considered facilities. A general disclaimer is here made, since the recognition of a measured variable as EOV/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.

According to the D5.3 report, to characterize 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 the EOV/ECVs are needed (they are 39). The list of EOV/ECV considered is shown in Table 1.

The survey collected information on fixed facilities (moorings). A total number of 3 facilities were declared and the full list of sensors and relative measured variables are listed and the status for each past measured variable was tracked (Annex 1, Tab.1).

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 (model and year of purchase, 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 RI in measuring EOVs/ECVs.
- Corresponding access to the data.

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

Table 1 - Counting table of the number of sensors on fixes stations (moorings), belonging to SIOS- RI measuring EOVs/ECVs. This first survey needs a thorough check to assure the full correctness of declared variables. Some adjustments are foreseen in the proceeding of the project.

Present State Measured EOVs/ECVs	SIOS	Present State Measured EOVs/ECVs	SIOS
ECV - Atmosphere, Surface: Precipitation	0	EOV - Biogeochemistry: Dissolved Organic Carbon	0
ECV - Atmosphere, Surface: Surface Sea Level Pressure	0	ECV - Ocean, Biological/Ecosystems: Marine Habitats	0
ECV - Atmosphere, Surface: Surface Radiation Budget	0	EOV - Biology and Ecosystems: Phytoplankton Biomass and Diversity	1
ECV - Atmosphere, Surface: Surface Air Temperature	0	EOV - Biology and Ecosystems: Zooplankton Biomass and Diversity	0
ECV - Atmosphere, Surface: Surface Water Vapour	0	EOV - Biology and Ecosystems: Fish Abundance and Distribution	0
ECV - Atmosphere, Surface: Surface Wind Speed and Direction	0	EOV - Biology and Ecosystems: Seagrass Cover and Composition	0
ECV - Aerosols	0	EOV - Biology and Ecosystems: Macroalgal Canopy Cover and Composition	0
ECV - Carbon Dioxide, Methane & Other Greenhouse Gases	0	EOV - Biology and Ecosystems: Microbe Biomass and Diversity (*emerging)	0
ECV - Ozone	0	EOV - Biology and Ecosystems: Invertebrate Abundance and Distribution (*emerging)	0
ECV - Precursors for Aerosols and Ozone	0	ECV - Ocean, Physical: Ocean Surface Heat Flux	0
EOV - Cross-Disciplinary: Ocean Sound	0	ECV - Ocean, Physical: Sea Level	0
EOV - Cross-Disciplinary: Marine debris (*emerging)	0	ECV - Ocean, Physical: Sea State	0
ECV - Ocean, Biogeochemical: Inorganic Carbon	0	ECV - Ocean, Physical: Sea Surface Currents	0
ECV - Ocean, Biogeochemical: Nitrous Oxide	0	ECV - Ocean, Physical: Sea Surface Salinity	0
ECV - Ocean, Biogeochemical: Nutrients	0	ECV - Ocean, Physical: Sea Surface Stress	0
ECV - Cross Disciplinary: Ocean Colour	0	ECV - Ocean, Physical: Sea Surface Temperature	0
ECV - Ocean, Biogeochemical: Oxygen	7	ECV - Ocean, Physical: Subsurface Currents	6
ECV - Ocean, Biogeochemical: Transient Tracers	0	ECV - Ocean, Physical: Subsurface Salinity	7
EOV - Biogeochemistry: Particulate Matter	5	ECV - Ocean, Physical: Subsurface Temperature	14
EOV - Biogeochemistry: Stable Carbon Isotopes	0	EOV - Cross-Disciplinary: Ocean Sound	1
<b>TOTAL EOVs/ECVs = 39</b>		<b>7</b>	
<b>Relative RI EOVs/ECVs coverage</b>		<b>18%</b>	

In Figure 1 the percentage of measured EO/ECV (on the total of 39 here considered) by SIOS-RI is shown. The computation is performed by counting that an EO/ECV is measured if at least one sensor is measuring it. 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 ITINERIS 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.

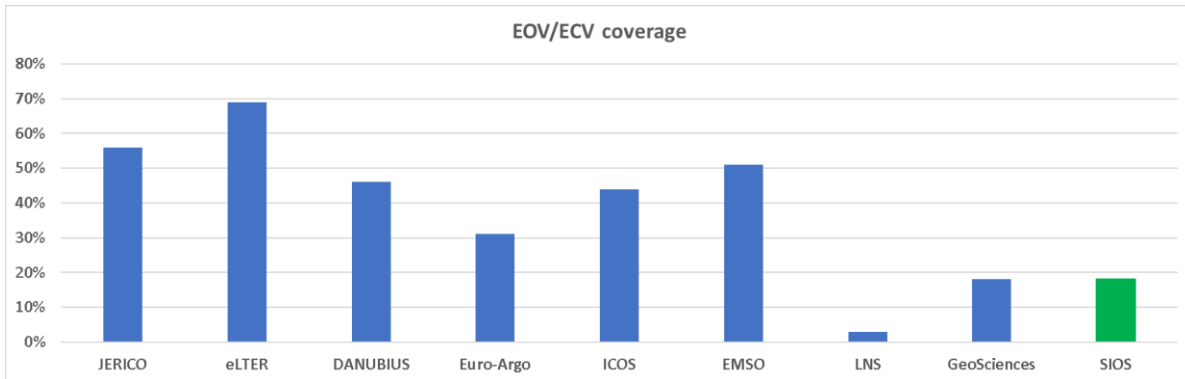


Figure 1 - percentage of EO/ECVs measured by each RI on the 39 EO/ECVs considered. SIOS-RI is coloured in green and compared to the other RI (blue) involved in the ITINERIS project.

The SIOS-RI contribution to EO/ECVs measurement is multidisciplinary and focused on the ECV Ocean Physical subsurface categories, ocean biogeochemical and biogeochemistry, (Figures 2, 3). For some variables there is a quite large coverage of sensors, e.g., for ECV – Ocean, Physical: subsurface Temperature, Salinity and Currents.

Each EO/ECV can be composed of several sub-variables which can be measured with different sensor techniques. Four GOOS expert panels have defined the specification sheet for each variable and the survey conducted on SIOS-RI facilities highlights the state of the sub-variable measurement and the sensor technique used (Table 2).

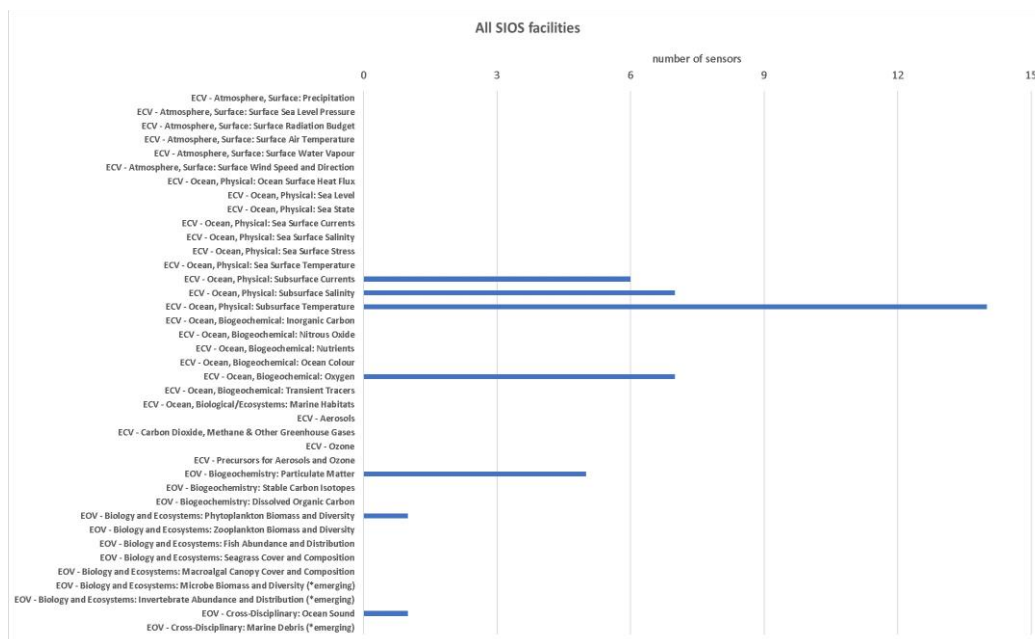


Figure 2 - SIOS contribution for the measurement of specific EO/ECVs.

Table 2 - Table of the sub-variables for each measured EO/ECV and the sensor technique used in each facility belonging to SIOS- RI. This first survey refers to the sub-variables stated in the data sheet of each EO/ECV defined by GOOS.

EOVs/ECV	Sub-variable	MDI	KIM	S1
ECV - Ocean, Biogeochemical: Oxygen	Dissolved Oxygen (O <sub>2</sub> )	Optical Oxygen sensor	Optical Oxygen sensor	Optical Oxygen sensor
EOV - Biogeochemistry: Particulate Matter	Particulate Organic Matter (POM)	Sediment trap	Sediment trap	Sediment trap
	Particulate Organic Carbon (POC)	Sediment trap	Sediment trap	Sediment trap
	Particulate Organic Nitrogen (PON)	Sediment trap	Sediment trap	Sediment trap
	Particulate Organic Phosphorus (POP)	-	-	-
	Particulate Inorganic Carbon (PIC)	Sediment trap	Sediment trap	Sediment trap
	Total Suspended Matter (TSM)	Sediment trap / Optical Turbidity sensor	Sediment trap	Sediment trap
	POC flux	Sediment trap	Sediment trap	Sediment trap
	Calcium Carbonate (CaCO <sub>3</sub> ) flux	Sediment trap	Sediment trap	Sediment trap
	Biogenic Silica (BSi) flux	Sediment trap	Sediment trap	Sediment trap
EOV - Biology and Ecosystems: Phytoplankton Biomass and Diversity	Presence/Absence/Relative Abundance	Optical Fluorescence sensor	-	-
	Diversity/Taxonomy	-	-	-
	Genomic information	-	-	-
	In vitro/in vivo pigment fluorescence	-	-	-
	Pigment concentration by spectrophotometry (chlorophyll a, b, HPLC pigments)	-	-	-
	Spectral reflectance (ocean color/remote sensing methods)	-	-	-
	Primary productivity (different methods)	Optical Fluorescence sensor	-	-
ECV - Ocean, Physical: Subsurface Currents	3-dimensional velocity components	Acoustic Current Meter	Acoustic Current Meter	Acoustic Current Meter
	geostrophic velocities	-	-	-
	Ekman currents	-	-	-
	tidal currents	-	-	-
	quasi-Lagrangian drift	-	-	-
	speed	Acoustic Current Meter	Acoustic Current Meter	Acoustic Current Meter
ECV - Ocean, Physical: Subsurface Salinity	Foundation and bulk SSS	CTD	CTD	CTD
ECV - Ocean, Physical: Subsurface Temperature	Foundation and bulk SSS	CTD	CTD	CTD
EOV - Cross-Disciplinary: Ocean Sound	sound pressure p(t)	Hydrophones	-	-
	particle motion (displacement, velocity, acceleration)	-	-	-

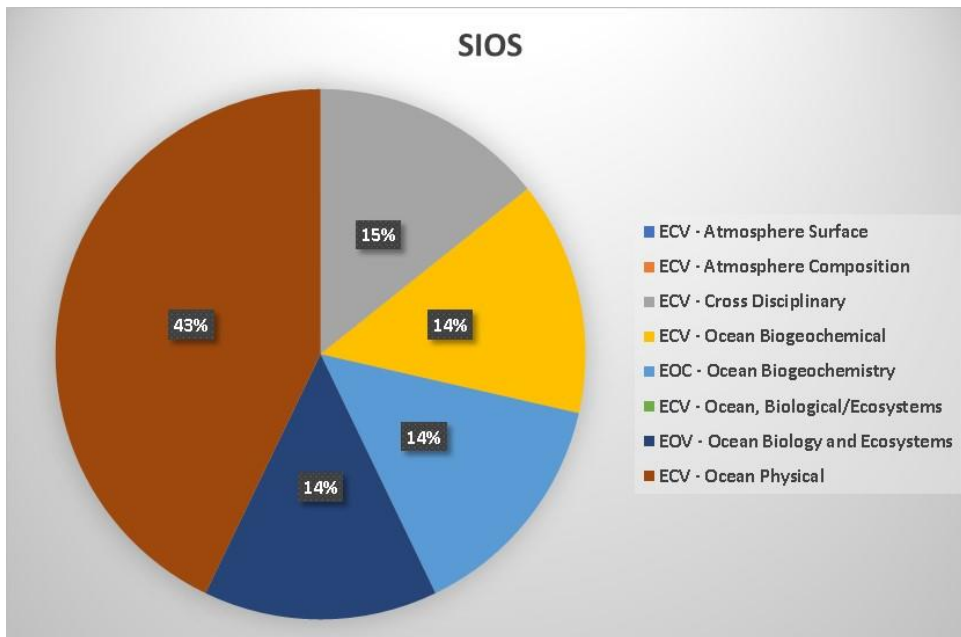


Figure 3 - Relative coverage of EOVs/ECVs categories by SIOS.

### 3. STATE OF THE ART OF THE SIOS FACILITIES, EQUIPMENT AND ACCESS PROCEDURES

From the survey described in the previous chapter, the most updated information on the current state of facilities contributing to the Italian SIOS-RI part of ITINERIS was collected.

In this section the Figure 4 shows the coverage of the Italian SIOS-RI facilities in the Kongsfjorden–Krossfjorden and in the southwest of the Svalbard Islands.

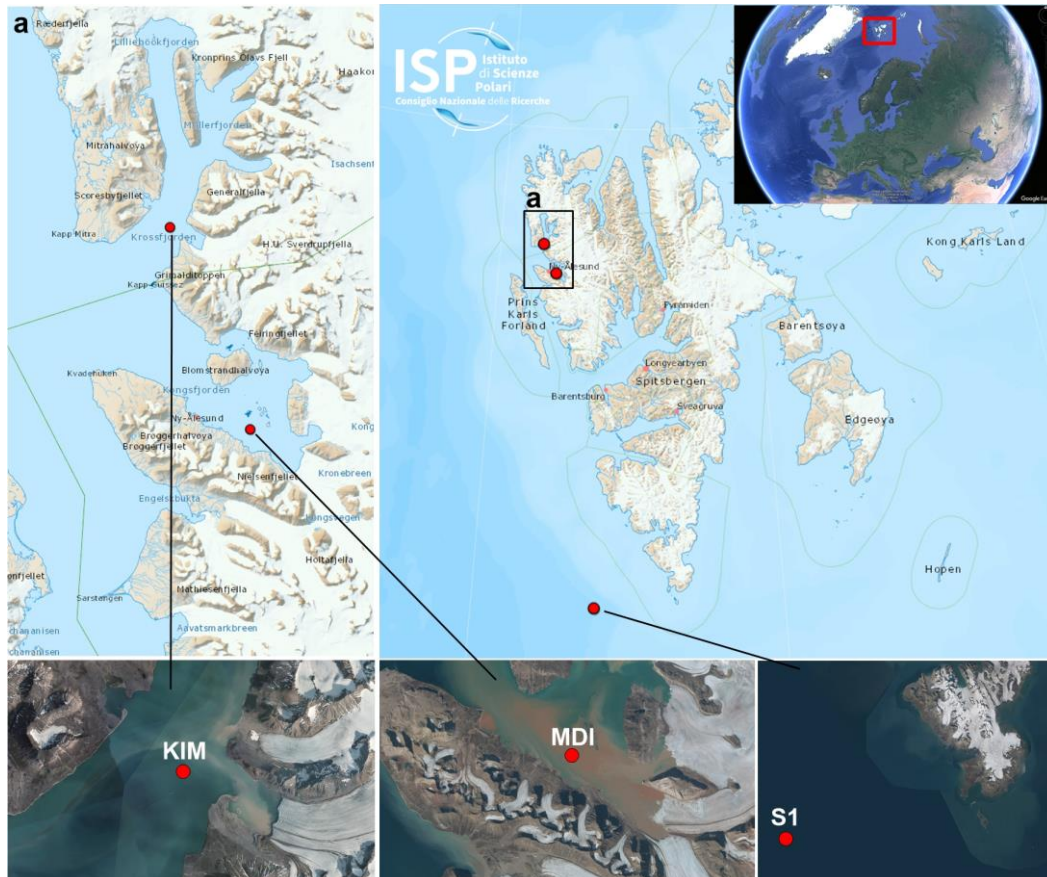


Figure 4 - Location of existing facilities related to the SIOS-RI considered in WP5 of ITINERIS.

The facilities declared by the ITINERIS SIOS-RI are listed in Annex 1 and Table 1. The facilities declared are 3, comprising mooring fixed platforms.

A broad collection of technical information about the present state of equipment in SIOS-RI 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 of the location and structure of facilities and based on the declarations done on the full set of variables and sensors, an overview of the present status of data access is discussed. The technical characteristics of mooring and sensors mounted on every facility resumed in Figure 5.

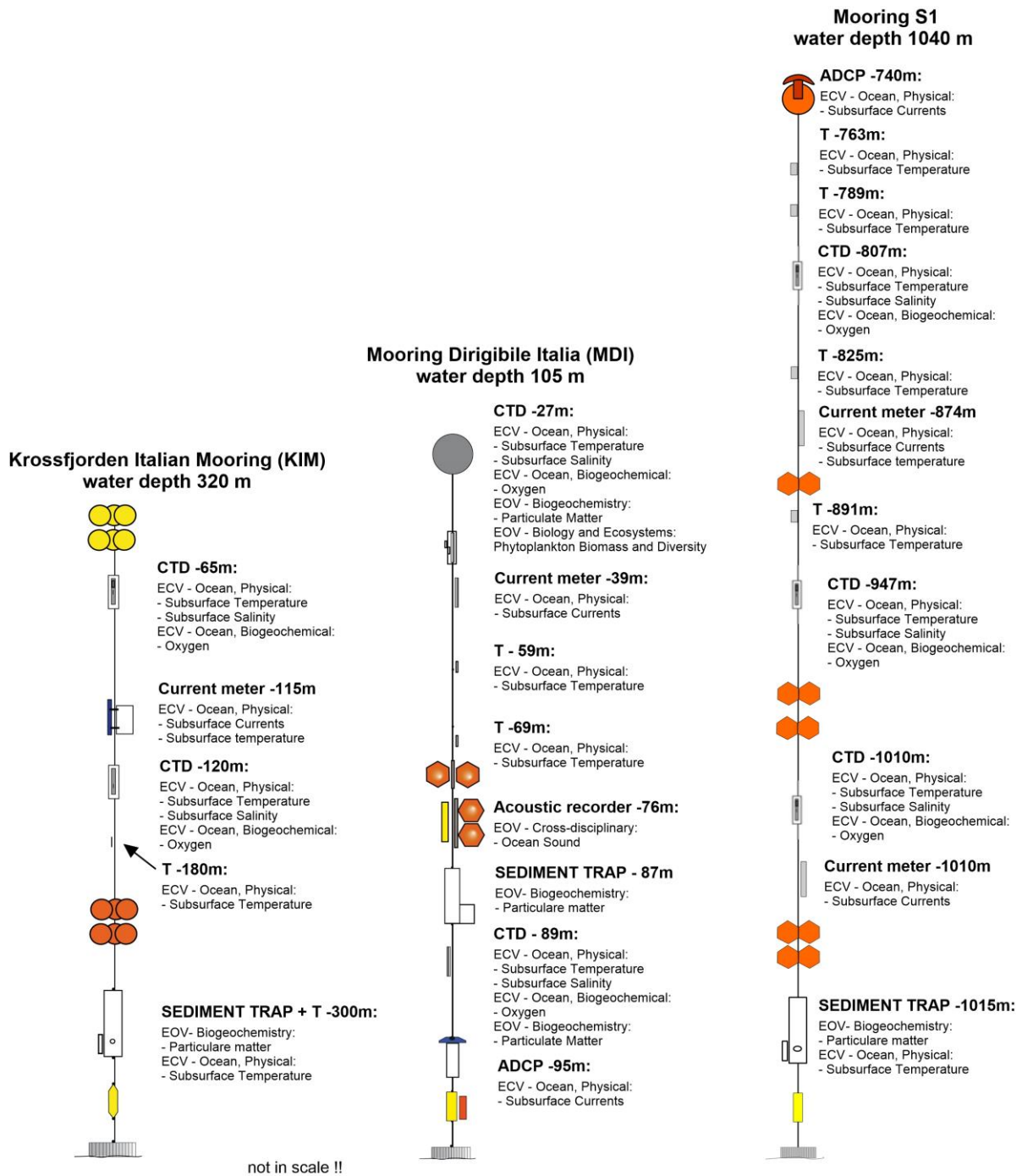


Figure 5 – Structure and configuration of facilities related to the SIOS RI considered in WP5 of ITINERIS

### 3.1 Facilities

The Italian SIOS-RI facilities are located: a) in the Kongsfjorden–Krossfjorden system (MDI, KIM), that in recent decades, has been experiencing rapid loss of sea ice coverage and retreat of local glaciers as a result of the progressive increase in ocean and air temperatures, and b) in the eastern Fram Strait, south-West offshore Svalbard region (S1), where water masses, strongly influenced by the interaction between Atlantic and Arctic waters and by local atmospheric forcing, substantially contribute to driving the global thermohaline circulation (Figure 4).

The access and maintenance of the sites in the Kongsfjorden–Krossfjorden system takes place with the support of the Italian base of the CNR "Dirigibile Italia" with a small boat (r/v Teisten), while for the same activities in the eastern Fram Strait (site S1) are carried out through the use of different oceanographic vessels (Helmer Hansen, G.O. Sars, Polastern, Alliance, Laura Bassi) in synergy between CNR-ISP and OGS, which share and co-manage this mooring.

### 3.2 Data Access

In terms of Access, the definition given in the European Charter for Access to Research Infrastructures<sup>1</sup> 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 for SIOS within WP5 for this gap analysis highlights the virtual procedures of data access at the several EOV/ECVs measured by the current RI 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 SIOS-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.

The survey results provide a first picture on three main aspects:

- The method for delivering the product;
- Access options;
- Data release timing.

The Table 3 resumes all the different options for the SIOS-RI and provides different information: I) n. facilities refer 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 gives a higher degree of granularity, providing the number of datasets/EOVs/ECVs with a given method of delivery, access option and data release time.

Some variables (Temperature and Salinity) measured at depth 35 and 85 m on MDI site and at 1000 m on S1 are available on IADC (Italian Arctic Data Center) data repository in delayed mode, approximately 6 months after annual data retrieval. The data can be downloaded and visualised through the IADC-ERDAPP data server at the address <https://data.iadc.cnr.it/erddap/tabledap/index.html?page=1&itemsPerPage=1000V>. The data showed are checked and formatted with a proper metadata catalogue compliant with SIOS data management system requirements which is linked to IADC data repository.

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<sup>1</sup> European Charter for Access to Research Infrastructures <https://op.europa.eu/en/publication-detail/-/publication/78e87306-48bc-11e6-9c64-01aa75ed71a1/>

Table 3 - List of the different accesses for SIOS-IR.

Method of delivery of the product	SIOS	
	n. facilities	n. of EOV/ECV
Upon request to the data owner/manager	3	13
accessible on database	0	0
accessible on international database (NOT OPEN)	0	0
accessible on international database (OPEN)	2	4
accessible on any other national database (NOT OPEN)	0	0
Access Option		
visualization, download, subsetting	0	0
visualization, download	2	4
download	0	0
visualization	0	0
not accessible	3	13
restricted access	0	0
Data release time		
real time (<2h)	0	0
<24h	0	0
<7 days	0	0
<30 days	0	0
<365 days	3	17
never	0	0

Table 3 gives an idea of 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 6 (a, b, c) represent the number of facilities where at least one EOV/ECV dataset has a specific method of delivery, access option and data release time.

The general results for data provision highlighted that:

- the 24% of the overall ECV/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 76% is upon request to the data owner.

The general results for access highlighted that:

- The 24% is accessible through international open database;
- The 76% is not open, not accessible or with restricted access.



Figure 6 - Histograms show respectively: a) method of delivery of the product; b) access option; c) data release time.

### 3.3 Recognized bottlenecks

The above analyses shed some light on the overall availability of facilities and related equipment for EO/ECV measurement. However, from these analyses some aspects are not immediately evident. For example, considering also that even if a given EO/ECV is measured, this does not guarantee either a large spatial (horizontal and vertical) and short (2 years) and long temporal (10 years) coverage or an appropriate location of the specific station for the research connected.

The major aspects that were considered for the ITINERIS planning for the design of the facility upgrade, below described, are:

The spatial distribution of Italian observing facilities in the SIOS adequately represents a polar environment such as the Svalbard Islands, including both fjord areas and the open sea, but does not allow for a complete observation of the polar environment.

A given EO/ECV can be studied in completely different environments. In polar areas, extreme meteorological conditions pose a constant challenge for logistics and access to measurement sites. Considering also that some facilities may be reached once a year, it is necessary to develop stable and reliable systems to ensure continuous measurements over time during long survey periods.

The current EO/ECV measurements within SIOS are all with sub-surface moorings with the aim to observe the seasonal and interannual dynamics of Atlantic Water (AW) and West Spitsbergen Current entering the fjords. It is necessary to implement the measurements at the air sea interaction and sea surface layer relevant for biological processes and strongly influenced by seasonal glaciers runoff which is the main source of the fresh water entering the fjords.

Concerning the biological compartment is important to improve on coastal monitoring at ecosystem level with real time and near real analysis and transmission (e.g., use of powerful, portable, real-time DNA and RNA sequencing devices – MinION).

There is a need to improve the SIOS-RI through increasing the number of EO/ECVs investigated, ensuring the accuracy of measurements, and harmonizing observation among sites.

At present only some variables are available on IADC (Italian Arctic Data Center) data repository in delayed mode. The goal is to extend the procedure to all EO/ECVs collected by all SIOS facilities, improve the quality control procedure (quality control flag for each measurement), adopt a metadata format according to IOOS directive for producing FAIR data.

The establishment of a real-time data transmission system for designated Essential Ocean Variables (EOV) and Essential Climate Variables (ECV) is desired, particularly from coastal and oceanographic buoys, wherever logistical feasibility permits such progress.

## 4. ACTION IN ITINERIS TO FILL THE GAPS

The above description on the present state of SIOS-RI facilities shows the number of EO/ECV already measured, the main research key point to be addressed and the access needs that sheds light on the main actions needed for the development of the SIOS-RI:

- Increase the number of EO/ECV measured together with the improvement of the quality control procedure for produce reliable dataset for the increasing request from the research community and for the increase in interdisciplinary studies.

- Improve the spatial (vertical and horizontal) and temporal coverage addressing the needed measurement frequency and the scientific goals.
- Increase the prompt availability of corresponding datasets and effort to support digitalization and, where possible, real-time or near real-time data transfer.

The specific actions for SIOS-RI, are the most relevant for the scientific goal and especially of the FAIRNESS of data produced and drive the plan on equipment that will be tested within ITINERIS:

The oceanographic observations on facilities are extended along the water column implementing the vertical spatial coverage resolution for currents measurements. (KIM e S1).

Relevant observations of ecosystem functioning within the surface layer (at least at the MDI and KIM sites) for biogeochemical and biological parameters (partial background CO<sub>2</sub>, fluorescence and photosynthetically active radiation - PAR) will be implemented.

Ocean sound measurements will be performed at all remaining sites (KIM, S1, Coastal Buoy).

To optimize the operational efficiency of our instruments and uphold the enduring accuracy of long-term datasets during the next decade, we will procure supplementary spare instrumentation. These acquisitions will play a crucial role in facilitating turnover and conducting periodic certified calibrations.

Purchase of hardware and software to implement marine data repository of Italian Arctic data Centre IADC.

Implementation of a coastal buoy that will operate with real-time and near real-time data transmission and will give useful information on the variability of EOVS/ECV observations in surface waters and will improve the understanding of the variability in the ecosystem functioning and microbial communities' biodiversity (Environmental DNA/RNA, Omics).

Strong efforts are directed at reducing data latency for users, which involves implementing near-real-time and real-time data communication for some parameters and reducing data delivery time for autonomous mooring points. An acoustic modem coupled with CTD (Conductivity temperature and Depth) sensors will be installed on the MDI mooring to facilitate data transfer to the surface buoy and then to land through real-time data transmission.

The map in figure 7 summarizes the geographical location of the facilities, highlighting the location of the future new Ny-Alesund coastal buoy (yellow point). The new assessment of each facility is shown in Figure 8, 9, 10. Regarding the implementation of EOVS/ECV of the SIOS-RI, Table 4 highlights changes from the present state.

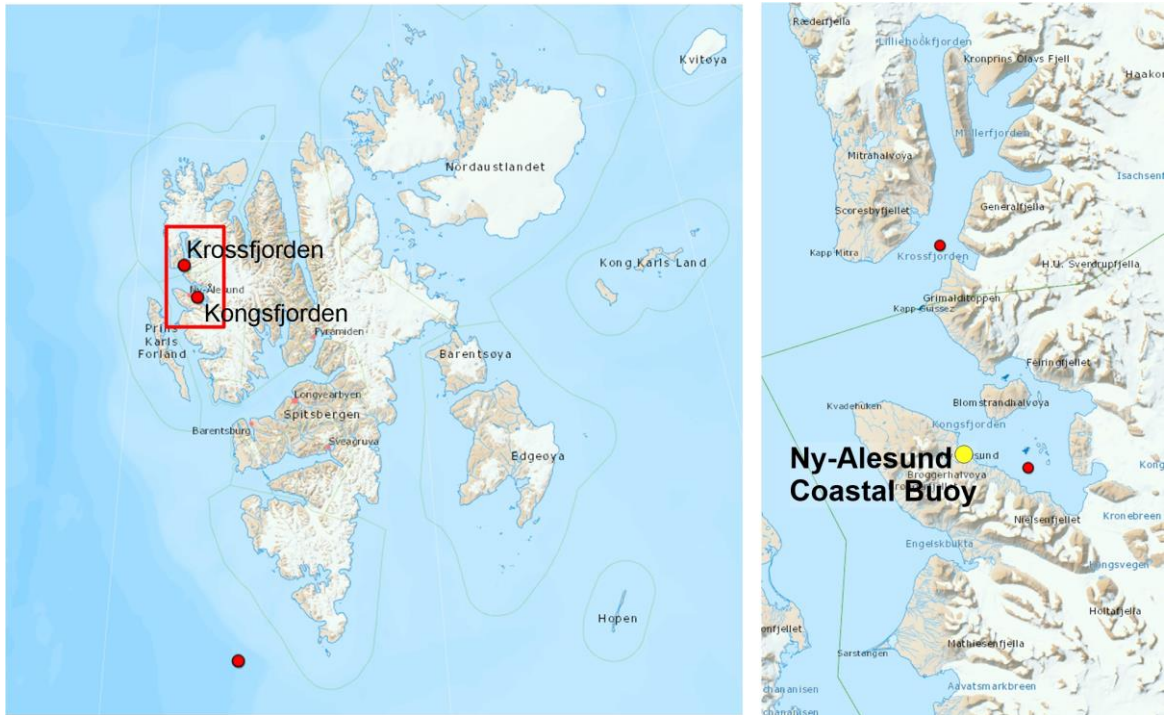


Figure 7 – Geographical location of facilities in Svalbard region. The yellow point indicates the location of future new Ny-Alesund coastal buoy.

Table 4 - Table of the sub-variables for each measured EO/ECV and the sensor technique used in each facility belonging to SIOS-RI. This first survey refers to the sub-variables stated in the data sheet of each EO/ECV defined by GOOS. Planned implementations are written in green.

EOVs/ECV	Sub-variable	FACILITIES			
		MDI + BOA ITALIA	KIM	S1	COASTAL BUOY
ECV- Surface - Surface Wind Speed and direction	Surface Wind Speed and direction	Sonic Anemometer	-	-	Sonic Anemometer
ECV- Surface - Temperature	Temperature	Thermistor	-	-	Thermistor
ECV- Surface - Pressure	Pressure	Pressure sensor	-	-	Pressure sensor
ECV- Surface - Water Vapour	Water Vapour	Igrometer	-	-	Igrometer
ECV- Surface - Surface Radiation Budget	Surface Radiation Budget	Pyranometers	-	-	Pyranometers
EOV- Biology and Ecosystem. Microbe biomass and diversity	Microbe biomass and diversity	-	-	-	DNA/RNA, Omics
ECV - Ocean, Biogeochemical: Oxygen	Dissolved Oxygen (O <sub>2</sub> )	Optical Oxygen sensor	Optical Oxygen sensor	Optical Oxygen sensor	Optical Oxygen

Continue from previous page

EOVs/ECV	Sub-variable	FACILITIES			
EOVs/ECV	Sub-variable	MDI + BOA ITALIA	KIM	S1	COASTAL BUOY
EOV - Biogeochemistry: Particulate Matter	Particulate Organic Matter (POM)	Sediment trap	Sediment trap	Sediment trap	-
	Particulate Organic Carbon (POC)	Sediment trap	Sediment trap	Sediment trap	-
	Particulate Organic Nitrogen (PON)	Sediment trap	Sediment trap	Sediment trap	-
	Particulate Inorganic Carbon (PIC)	Sediment trap	Sediment trap	Sediment trap	-
	Total Suspended Matter (TSM)	Sediment trap / Optical Turbidity sensor	Sediment trap / Optical Turbidity sensor	Sediment trap	Optical Turbidity Sensor
	POC flux	Sediment trap	Sediment trap	Sediment trap	-
	Calcium Carbonate (CaCO <sub>3</sub> ) flux	Sediment trap	Sediment trap	Sediment trap	-
	Biogenic Silica (BSi) flux	Sediment trap	Sediment trap	Sediment trap	-
EOV - Biogeochemistry: Inorganic Carbon	Partial pressure of carbon dioxide (pCO <sub>2</sub> )	Infrared detection	-	-	-
	pH	ISFET Sensor + CTD-DO sensor	-	-	MARE_FET Sensor
EOV - Biology and Ecosystems: Phytoplankton Biomass and Diversity	Presence/Absence/ Relative Abundance	Optical Fluorescence sensor	Optical Fluorescence sensor	-	-
	Primary productivity (different methods)	Optical Fluorescence sensor	Optical Fluorescence sensor	-	Optical Fluorescence sensor
	PAR*	Photosynthetically Active Radiation Sensor	Photosynthetically Active Radiation Sensor	-	-
ECV - Ocean, Physical: Subsurface Currents	3-dimensional velocity components	Acoustic Current Meter	Acoustic Current Meter	Acoustic Current Meter	-
	speed	Acoustic Current Meter	Acoustic Current Meter	Acoustic Current Meter	-
ECV - Ocean, Physical: Subsurface Salinity	Foundation and bulk SSS	CTD	CTD	CTD	-
ECV - Ocean, Physical: Surface Salinity	Foundation and bulk SSS	CTD	-	-	CTD
CV - Ocean, Physical: Subsurface Temperature	Foundation and bulk SSS	CTD	CTD	CTD	-
ECV - Ocean, Physical: Surface Temperature	Foundation and bulk SSS	CTD	-	-	CTD
EOV – Ocean Colour	CDOM*	-	-	-	Optical Fluorescence sensor
EOV - Cross-Disciplinary: Ocean Sound	sound pressure p(t)	Hydrophones	Hydrophones	Hydrophones	Hydrophones



**Real-time and  
Near-Real time data transmission**

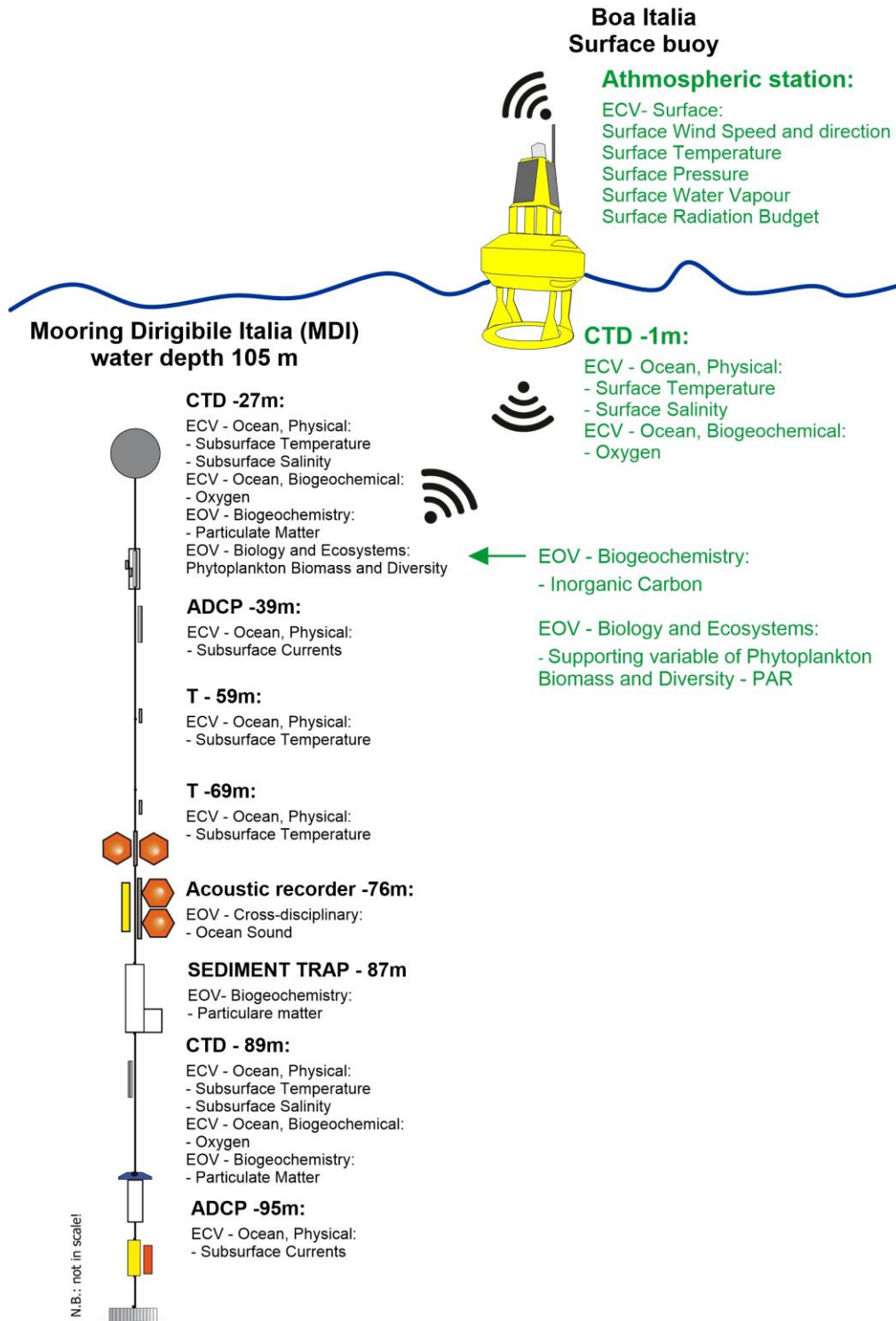


Figure 7 – Planned future assessment (in green) of the facilities MDI in Kongsfjorden.

### Krossfjorden Italian Mooring (KIM) water depth 320 m

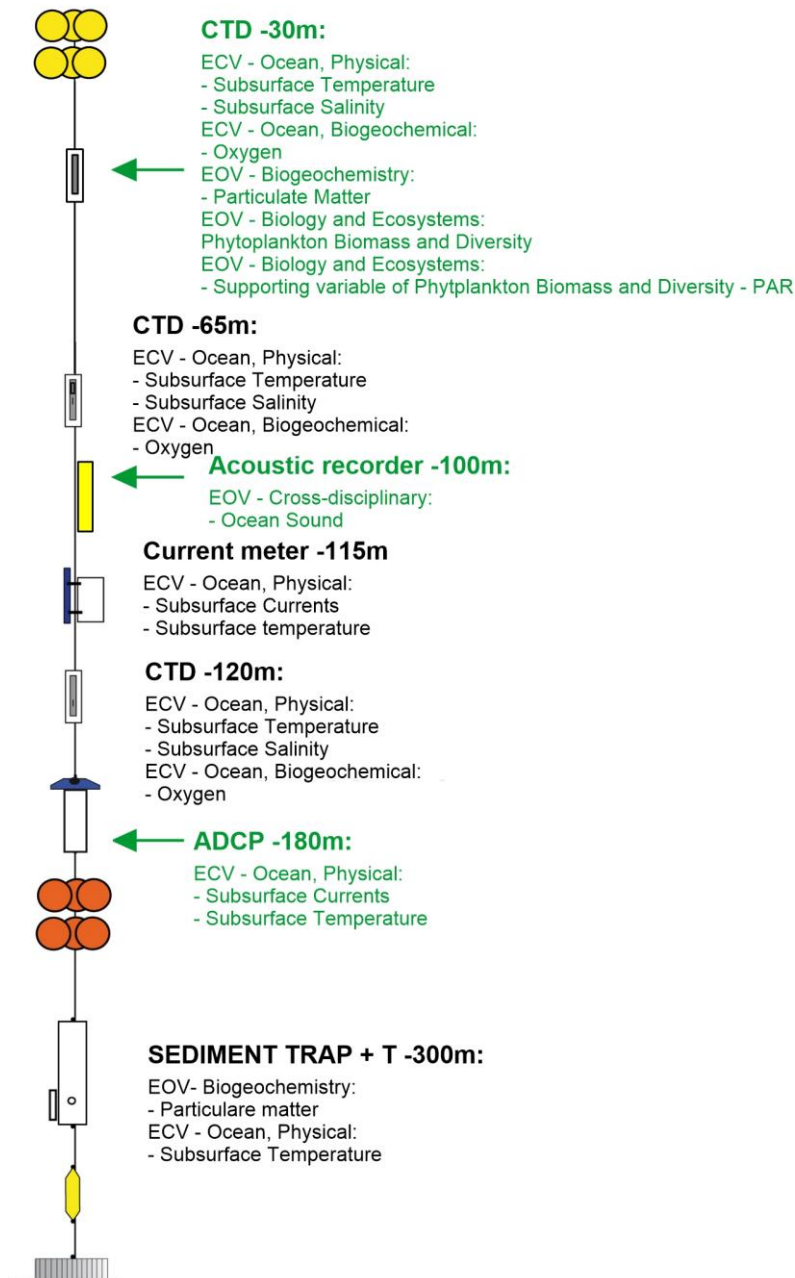


Figure 8 – Planned future assessment (in green) of the facilities KIM in Krossfjorden.

**Mooring S1**  
water depth 1040 m

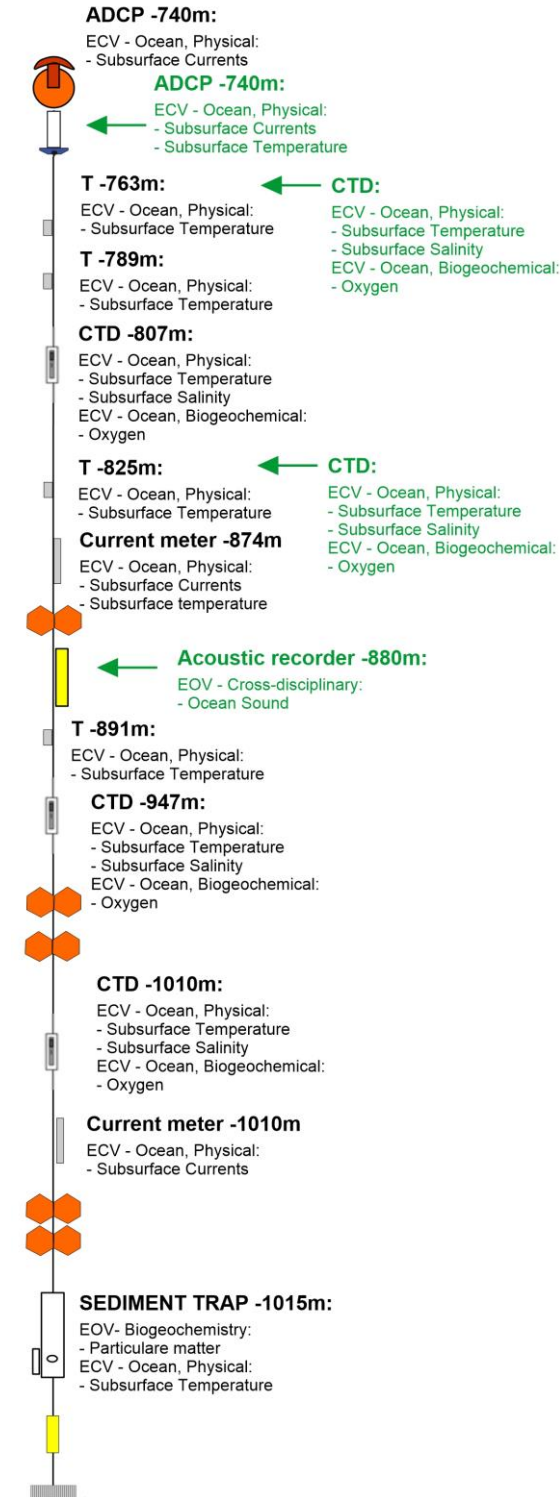


Figure 9 – Planned future assessment (in green) of the facilities S1 in the eastern Fram Strait.

## ANNEX 1: TABLES OF FACILITIES FOR ITALIAN SIOS-RI

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

Facility	Latitude [°N]	Longitude [°E]	Property	Reference RI
S1	76.433333	13.950000	CNR-ISP-OGS	SIOS
KIM	79.127117	11.724883	CNR-ISP	SIOS
MDI	78.914500	12.236767	CNR-ISP	SIOS