Copernicus Marine Service

QUALITY INFORMATION DOCUMENT

In Situ TAC multiparameter products:

INSITU_GLO_PHYBGCWAV_DISCRETE_MYNRT_013_030
INSITU_ARC_PHYBGCWAV_DISCRETE_MYNRT_013_031
INSITU_BAL_PHYBGCWAV_DISCRETE_MYNRT_013_032
INSITU_IBI_PHYBGCWAV_DISCRETE_MYNRT_013_033
INSITU_BLK_PHYBGCWAV_DISCRETE_MYNRT_013_034
INSITU_MED_PHYBGCWAV_DISCRETE_MYNRT_013_035
INSITU_NWS_PHYBGCWAV_DISCRETE_MYNRT_013_036

Issue: 2.3

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Approval date by the CMEMS product quality coordination team: 09/12/2023

CHANGE RECORD

When the quality of the products changes, the QuID is updated and a row is added to this table. The third column specifies which sections or sub-sections have been updated. The fourth column should mention the version of the product to which the change applies.

Issue	Date	§	Description of Change	Author	Validated By
0.1	25/01/2012	all	First version of document	H. Wehde, K. V. Schuckmann, S. Pouliquen, A. Grouazel, T. Bartolome, J. Tintore	
1.0	24/02/2012	all	Document for V2	H. Wehde, K. V. Schuckmann, S. Pouliquen, A. Grouazel, T. Bartolome, J. Tintore	
1.1	30/10/2012	Page 4	Merge NRT products	S. Pouliquen	
1.2	28/02/2013	all	Move to MyO2 template. The QuID describes the Near Real time products of Version 3	S. Pouliquen	
1.3	02/05/2013	all	Update of the document	H. Wehde	
1.4	May 1 2015	all	Change format to fit CMEMS graphical rules		L. Crosnier
1.5	Dec 9 2015	all	Change MyOcean in CMEMS	S. Pouliquen	S. Pouliquen
1.6	Nov 15 2016	all	Update with NRT Wave product	M. de Alfonso	L. Petit de la Villéon
1.7	09/04/2019	all	Generalrevisionfor NetCDF4 transition	T. Carval	L. Petit de la Villéon
2.0	04/09/2020	all	References for Biogeochemical data. New metrics for spatial and vertical coverage, minor updates and typo corrections	V. Racapé T. Carval M. de Alfonso	-
2.1	07/01/2021	2.1	Add data sources chapter	V. Racapé T. Carval	S. Tarot
2.1	07/01/2021	2.2	Add data sources references, including EMODnet Chemistry	V. Racapé	S. Tarot
2.1	07/01/2021	3	Add flag 6 for EMODnet chemistry	V. Racapé	S. Tarot
2.2	25/08/2022	all	New names of products/datasets Use new template	In Situ TAC Partners	S. Tarot
2.3	30/08/2023	all	Update document for Nov. 2023 release (update charts, text)	In Situ TAC Partners	S. Tarot

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I EXECUTIVE SUMMARY

I.1 Products covered by this document

This document applies to the following list of Copernicus Marine In Situ Thematic Assembly Centre (In Situ TAC) products described in the Copernicus Marine Service Catalogue and presented in Table 1.

All these products gather in one place and in one format measures of :

- Temperature & salinity,
- Current,
- Sea-level,
- BGC (BioGeoChemical parameters),
- Waves

Short Description	Product code	Area	Delivery Time
Global NRT[1]	INSITU_GLO_PHYBGCWAV_DISCRETE_MYNRT_013_030	Global	daily
Arctic NRT	INSITU_ARC_PHYBGCWAV_DISCRETE_MYNRT_013_031	Arctic	daily
BAL NRT	INSITU_BAL_PHYBGCWAV_DISCRETE_MYNRT_013_032	Baltic	daily
IBI NRT	INSITU_IBI_PHYBGCWAV_DISCRETE_MYNRT_013_033	Iberian-Biscay-Ireland	daily
Black Sea NRT	INSITU_BS_PHYBGCWAV_DISCRETE_MYNRT_013_034	Black Sea	daily
Med NRT	INSITU_MED_PHYBGCWAV_DISCRETE_MYNRT_013_035	Mediterranean	daily
NWS NRT	INSITU_NWS_PHYBGCWAV_DISCRETE_MYNRT_013_036	North West Shelf	daily

Table 1: List of In Situ TAC products for which this document applies.

These products integrate observation aggregated from the Regional EuroGOOS consortium (Arctic-ROOS[2], BOOS[3], NOOS[4], IBI-ROOS[5], MONGOOS[6]) and Black Sea GOOS[7] as well as from SeaDataNet2[8] National Data Centers (NODCs), EMODnet chemistry[9] and JCOMM[10] global systems (Argo[11], GOSUD[12], OceanSITES[13], GTSPP[14], DBCP[15]) and the Global telecommunication system (GTS[16]) used by the Met Offices.

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[1] NRT: Near Real Time within a few hours, maximum one week from acquisition
[2] Arctic Regional Ocean Observing System: https://arctic.eurogoos.eu/
[3] Baltic Operational Oceanographic System: http://www.boos.org/
[4] North West European Shelf Operational Oceanographic System: https://noos.eurogoos.eu/
[5] Iberia-Biscay-Ireland Operational Oceanographic System https://ibiroos.eurogoos.eu/
[6] The Mediterranean Oceanographic Network https://mongoos.eurogoos.eu/
[7] Black Sea Global Ocean Observing System http://old.ims.metu.edu.tr/black_sea_goos/
[8] SeaDataNet : https://www.seadatanet.org/
[9] EMODnet Chemistry : https://emodnet.ec.europa.eu/en/chemistry
[10] Joint WMO/IOC Technical Commission for Oceanography and Marine Meteorology: https://www.goosocean.org/index.php?option=com_oe&task=viewGroupRecord&groupID=78
[11] Argo : https://argo.ucsd.edu/
[12] GOSUD : https://www.gosud.org/
[13] OceanSITES : http://www.oceansites.org/
[14] Global Temperature Salinity Profile Program : https://www.iode.org/index.php?option=com_content&view=article&id=19:global-temperature-and-salinity-profile-program-gtspp&catid=14&Itemid=58
[15] Data Buoy Cooperation Panel : https://www.ocean-ops.org/DBCP/
[16] Global Telecommunication System : https://community.wmo.int/en/activity-areas/global-telecommunication-system-gts

I.2 Summary of the results

The accuracy of the In Situ observation depends on the platforms and sensors that have been used to acquire them (see next §I.3). All observations are aggregated by the In Situ TAC and provided to users together with metadata information on the platforms that were used to perform the observations. In Near Real Time NRT (within a few hours, maximum one week from acquisition) the quality of the observations is tested using automatic procedures and flags are positioned to inform the users of the level of confidence attached to the observations.

The In Situ TAC relies on observing systems maintained by institutes that are not part of the In Situ TAC, and Copernicus Marine Service project is not contributing to the maintenance and setting up of the observing systems it uses. That means that:

- The variety of platforms available to monitor the status of the ocean is very diverse within the different regions. Key performance indicators (KPIs) were developed to provide an overview of the system status.
- In some regions the number of available platforms is at a critically low level to be able to provide an adequate representative overall view of the state of the ocean. In particular:
    - The coverage of the underway instruments is rather homogeneous, while for fixed platforms the coverage is diverse, with most of the stations concentrated in the Northern Hemisphere and more specifically along the coasts of Europe and North America.
    - The Black Sea observing network lacks platforms that monitor the region
    - Within the Arctic most of the data are obtained by regular vessel cruises or dedicated scientific expeditions. The availability of data from these scientific expeditions is often delayed, so they are not available for the NRT data stream. As a result, these data are not available for assimilation in the operational models.
- The percentage of data flagged as ‘good data’ is variable from region to region.

Within the Black Sea and in the Arctic region there are a critically low numbers of available observations which impact the provision of a good and representative real time data product over the temporal frame of the project. The same counts for the availability of observations on the deep areas within the Mediterranean Sea. In all the regions biogeochemical data are relatively scarcely available.

The sustainability of the Global Ocean network is still not guaranteed and highly relies on project funds.

I.3 Estimated Accuracy Numbers

The following tables summarize the accuracy of the measurements that can be expected depending on the platforms and sensors. These five tables represent accuracy for:

- Table 2: Temperature & Salinity
- Table 3: Current
- Table 4: Sea-level
- Table 5: BGC (Biogeochemical parameter)
- Table 6: Waves

This is the best accuracy then a user can expect for the in situ data to which a quality flag "Good data" (see Table 4) has been applied after the validation process.

The definition of the reference values is obtained from different sources. The specific reference is given in Tables 2, 3, 4, 5 and 6. The values are given for the different parameters. Platform specific references that differ from the common ones are given for the specific value.

Data-type	**Temperature[17] [°C]**	**Salinity[16] []**
CTD	0.005-0.001	0.02-0.003
XBT	0.1	
XCTD	0.02	0.003
PFL (profiling floats)	0.01[18]	0.01[17]
Moored buoy data: Tropical Moored Buoy (TRITON/TAO PIRATA/RAM[19]) surface Subsurface	0.002 0.01-0.3 0.01-0.09	0.003
Drifting buoy data	0.01	0.01
Marine mammals	0.005	0.01
Glider	0.005	0.02
Underway (Ferrybox, Research vessel TSG)	0.001-0.1[20]	0.003-0.2[18]

Table 2: Accuracy numbers for temperature and salinity observations for the different platforms in the In Situ TAC.

Data-type	**Current [cms^{-1}][21]**
Moored instruments	0.5-1[22]
Drifter	1[23]
Underway data	1

Table 3: Accuracy numbers for Current observations for the different platforms in the In Situ TAC.

Data-type	**Sea level [cm][24]**
Tide gauges	1
Barometers	1

Table 4 : Accuracy numbers for Sea level observations for the different platforms in the In Situ TAC.

[17] NOAA, 2009
[18] ARGO Buoys
[19] Tropical Moored Buoy Array https://www.pmel.noaa.gov/gtmba/
[20] Depending on sensor type
[21] Aquadopp
[22] Depending on resolution of data bins
[23] Hansen and Poulain (1996)
[24] IOC 1997, IOC, 2006

Data-type	Chlorophyll fluorescence[25]	Oxygen[26]	Nutrients[27] [µmol kg^{-1}]
CTD	0.05	8myMol/5% 0.2 %	Discrete samples
PFL (profiling floats)	0.05	2% of saturation or 2mbar [28]	1[29]
Moored buoy data: TRITON/TAO PIRATA/RAMA surface Subsurface	0.05	<8 mM or 5% Of concentration (Whichever is greater)	Not available
Drifting buoy data	0.05		Not available
Glider	0.05	2% of saturation	1[30]
Ferrybox	0.05	8myMol/5% 0.2 %	typically better 2% of the full scale. Repeatability: better than 2%

Table 5: Accuracy numbers for biogeochemical parameter observations for the different platforms in the In Situ TAC.

Wave sensor	Measured time series		
	Vertical displacement (heave)	**Period**	**Direction**
Waverider (Datawell)	0.5% of the measured value	0.5% of the measured value	0.4 - 2 deg (dep. on latitude)
Wavesense (Oceanor)	0.1 m	0.15 s	1 deg
Triaxys (Axys)	1% of the measured value	1%	3 deg
	Estimated parameters (due to the statistical variability)		
	Wave heights[31]	**Wave periods[26]**	**Wave directions[26]**
All wave sensors	< 5% of the estimated value	< 5% of the estimated value	< 10 deg

Table 6: accuracy numbers for measured time series and wave estimated parameters for different wave sensors.

[25] Exemplary TriOS Microflu sensor. There is quite a range of sensors with quite a variety of accuracy available.
[26] Values given by a number of sensor providers, Aanderaa Instruments, Endress and Hauser
[27] Exemplary Systea MicroMac sensor. There is a limited number of different sensors available.
[28] Thierry et al., 2021. Argo Quality control manual for dissolved oxygen concentration. http://dx.doi.org/10.13155/46542
[29] Johnson et al., 2023. BGC-Argo quality control manual for nitrate concentration. http://dx.doi.org/10.13155/84370
[30] Krahmann et al., OceanGlider Nitrate Standard Operating Procedure. https://oceangliderscommunity.github.io/Nitrate_SOP/README.html

II PRODUCTION SYSTEM DESCRIPTION

The In Situ TAC is a distributed system built on the existing activities and services developed previously within the European Commission supported projects and the activities carried out in the EuroGOOS Regional alliances (ROOSes). The In Situ TAC aims to provide a research and operational framework to develop and deliver in situ observations and derived products based on such observations and to address progressively global but also regional needs either for monitoring, modelling or downstream service development.

The In Situ TAC provides the interface between centres, distributing in situ measurements from national and international observing systems. The MERSEA[29] project established the global component of the In Situ TAC for the physical parameters needed by the Marine Forecasting Centres (MFC) that are using the data for assimilation and validation of the forecasting systems. These efforts result in the strong enhancement of the French Coriolis data centre. The goal within Copernicus Marine Service has been to consolidate and integrate the regional components, based on expertise developed within the ROOSes, and to initiate the setup of the bio- geochemical part of the In Situ TAC. In addition, experience has been gained in terms of in situ product choice, service, timeliness, quality, robustness and accuracy. As an operational infrastructure, the In Situ TAC sets the necessary production capacities and quality control procedures to answer to Europe's request for service level agreements with the external users as defined in the Copernicus Marine Service.

The In Situ TAC Version 0 is a heritage of all the work performed during previous projects. The operational products proposed for this version are near real time and re-analyzed data for the global ocean via the Coriolis data centre. Version 1 of the In Situ TAC complements these products by delivering suitable products for all European regions, new lines of products (real time, biogeochemistry) and to apply improved validation procedures for the products and services. Versions 2 and 3 of the In Situ TAC prepare re-analyzed datasets for reanalysis activities performed by the Copernicus Marine Service MFCs and external users in collaboration with the SeaDataNet infrastructure.

In Situ TAC products provided within Copernicus Marine Service include:

- Temperature and salinity: global and regional, produced in Real Time and Delayed Mode
- Currents: global and regional, produced in Real Time
- Sea level: regional, produced in Real Time
- Biogeochemical: global and regional, produced in Real Time
- Waves: global and regional, produced in Real Time

The In Situ TAC is a distributed centre organized around 7 oceanographic regions: the global ocean and the 6 EUROGOOS regional alliances (see Figure 1). It involves 17 partners from 11 countries in Europe. It does not deploy any observing system and relies on data that are obtained by sources other than Copernicus Marine Service.

[29] MEARSEA: Marine Environment and Security for the European Area

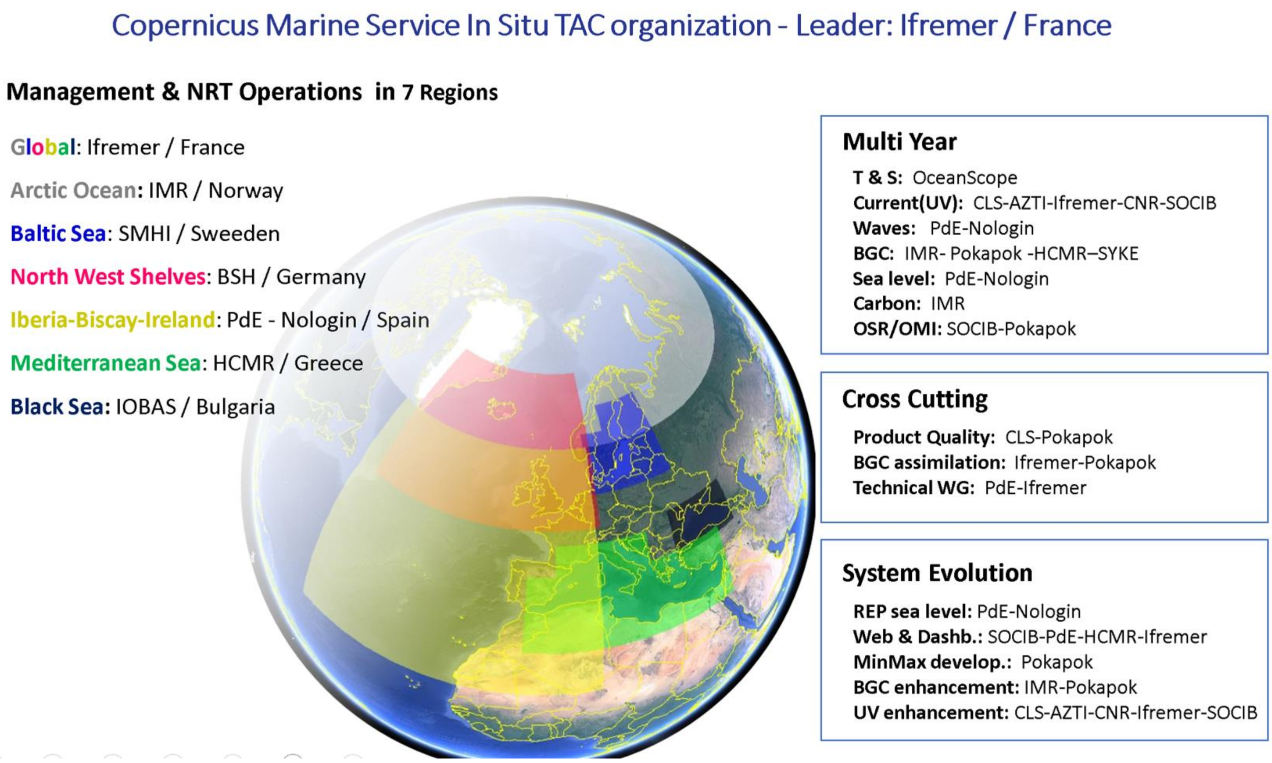

Figure 1: The In Situ TAC components.

The In Situ TAC architecture is decentralized. However, the quality of the products delivered to users must be equivalent wherever the data are processed. The different functions implemented by the global and regional components of the In Situ TAC to this scope are summarized in Figure 2.

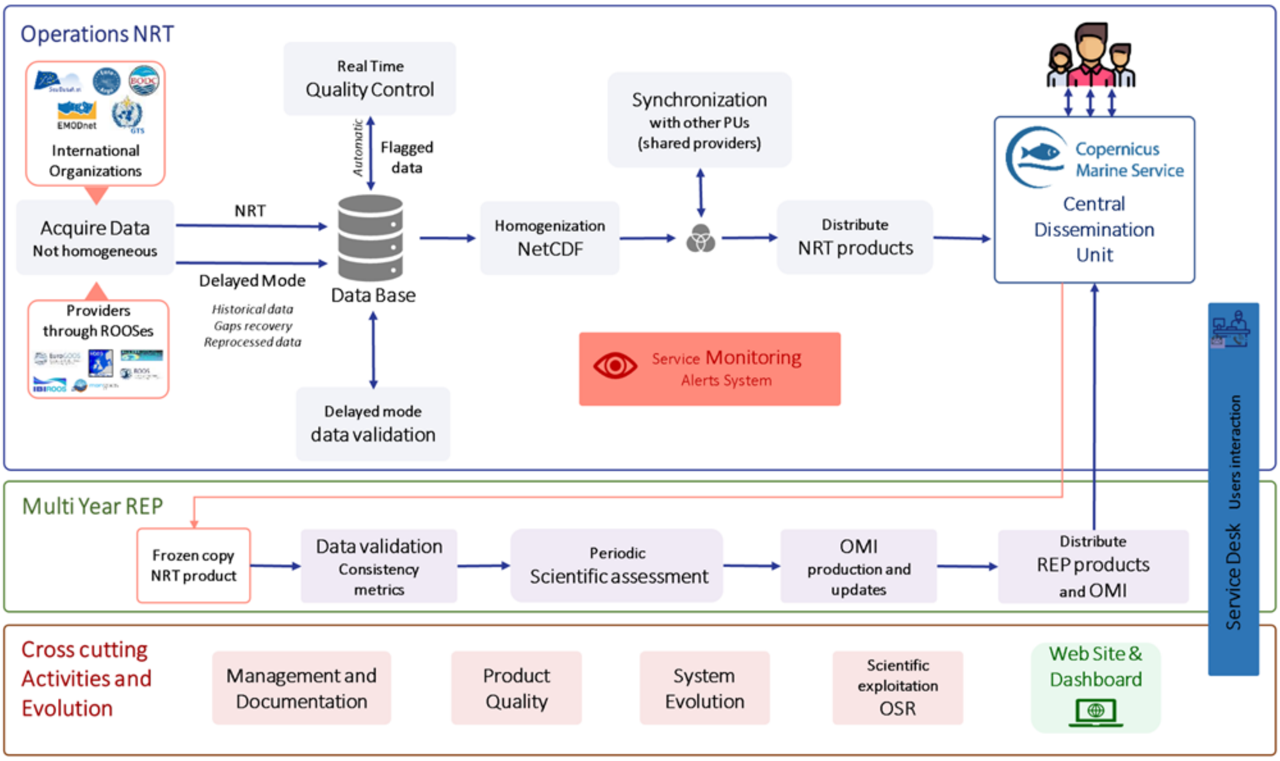

Figure 2: Functions implemented by the In Situ TAC components

Each region implements 4 core functions:

- Data Acquisition: Gather data available on international networks or through collaboration with regional partners
- Data Quality control: Apply automatic quality controls that have been agreed at the In Situ TAC level. These procedures are defined by parameter, elaborated in coherence with international agreements, in particular SeaDataNet[30], and documented in the Copernicus Marine Service Catalogue[31]
- Product validation: Assess the consistency of the data over a period of time and an area to detect data that are not coherent with their neighbours but could not be detected by automatic Quality Control (QC)
- Product distribution: Push the data available to Copernicus Marine Service Distribution Unit (DU). The DU is responsible for data distribution to end users.

In any case, the Global component of the In Situ TAC collects the data from the regional components and integrates them into the global product acting as a backup of the regional centres.

[30] https://www.seadatanet.org/

[31] https://data.marine.copernicus.eu/products

III VALIDATION FRAMEWORK

The Near Real Time Quality control procedure approved by the Copernicus Marine Service In Situ TAC follows the recommendations endorsed in 2010 by EuroGOOS that are available at http://eurogoos.eu/increasing-eurogoos-awareness/working-groups/data-management-exchange-quality-working-group-data-meq/

Unlike Marine Forecasting Centres (MFCs), TAC In Situ aims to guarantee the accuracy of in situ observations, mainly by means of a first validation method supplemented by a second one for temperature and salinity parameters.

These two methods consist of the Real Time Quality Control (RTQC) of the in situ observations and product evaluation based on quality-controlled data sets. For the first method a set of metrics were developed for temperature, salinity, ocean current, sea level, oxygen, nutrients and wave observations. These metrics are described in detail in the following documents for the real time quality control:

1. Temperature and salinity data (von Schuckmann et al., 2010; Gourrion, Leroy 2023).
2. Current measurements (Hammarklint et al., 2010).
3. Current measurements inferred from drifter data (Notarstefano et al., 2010).
4. Sea level in Situ data (Perez et al., 2010).
5. Biogeochemical data (Jaccard et al. 2021
6. Copernicus Marine In Situ TAC BGC quality control group (2023)).
7. Wave data (Copernicus Marine In Situ Tac Data Management Team, 2020).

By performing the QC tests, QC flags are allocated to the obtained observational data. The QC flags follow the definitions in the RTQC manuals developed for the Copernicus Marine Service parameters and are presented in Table 7.

Code	Meaning	Comment
0	No QC was performed	-
1	Good data	All real-time QC tests passed.
2	Probably good data	These data should be used with caution
3	Bad data that are potentially correctable	These data are not to be used without scientific correction.
4	Bad data	Data have failed one or more of the tests.
5	Value changed	Data may be recovered after transmission error.
6	Value below detection/quantification	The level of the measured phenomenon was too small to be quantified/detected by the technique employed to measure it. The accompanying value is the quantification/detection limit for the technique or zero if that value is unknown
7	Nominal value	-
8	Interpolated value	Missing data may be interpolated from neighbouring data in space or time.
9	Missing value	-

Table 7: Quality control flags.

Currently, QC flag 6 qualifies BGC data from the EMODnet chemistry aggregated products only.

The second validation method setting up for temperature and salinity consists of metrics that are area-dependent and are described in detail in von Schuckmann and Cabanes (2010). The main features of this plan are as followed:

For the Global data a set of metrics is applied:

1. Comparison to a reference climatology to detect gross errors and deviations.
    a. Objective analyses and residual analyses.
    b. Anomaly method.
2. Comparison with altimetry.
3. Argo floats inter-comparison to complement existing Delayed Mode Quality Control.
4. Visual quality control by an operator in the Global region TAC.

For the Regional data a set of metrics is applied:

1. Visual quality control by an operator.
2. Comparison to a reference climatology to detect gross errors and deviations.
3. Objective analysis and residual analysis.
4. Assessment of drifter data.

IV VALIDATION RESULTS

The overall quality and its representativeness for the specific region of a product is severely dependent on the amount of good data available, i.e. the number of platforms that are providing data for the region.

The variety of platforms available to monitor the status of the ocean is very diverse within the different regions.

The actual performance of the near real time data delivery system can be highlighted by the provision of so called Key Performance Indicators (KPI). KPIs are quantifiable performance indicators used to define success factors and measure progress toward the achievement of the organisation/system goals. They can be defined as an item of information collected on a regular interval to track the performance of a system. Hence, KPIs are important pointers to the functioning of a system and keeping track of them is one aspect of Quality Control (QC). KPIs should be seen as:

- Key: of fundamental importance indicating the success or failure of the system
- Performance: can be clearly measured, quantified and easily influenced the system providers
- Indicator: providing leading information on future performance.

A central theme of the definition of KPIs is the need to adapt performance indicators to the particular circumstances of the systems and procedures involved. Quality indicators need to be robust, i.e. show continuity in time. They need to be easy to implement and to automate and need to permit a delivery on a regular basis. They need to allow easy access for the user, and hence to be characterized by clarity and readability. The main criteria for KPI definition within the In Situ TAC include:

- Criteria I: Is the control information key to the success of the system?
- Criteria II: Can we measure it and influence it?
- Criteria III: Does it provide leading edge indications of future developments?

The aim is to provide the user information on the three different validation steps, i.e. RTQC, quarterly assessment and delayed mode assessment.

Four indicators were developed providing information on

- Data availability
- Monitoring continuity
- Metadata quality
- Output data quality

The detailed description of the definition of the KPIs can be found in von Schuckmann et al., 2011. The actual performance of the near real time data delivery system can be found at:

- http://www.marineinsitu.eu/monitoring/ (see Figure 5)

In addition to the KPIs, specific assessment metrics have been developed to assess the products, depending on the variable, to show the spatial (horizontal and vertical) and temporal coverage.

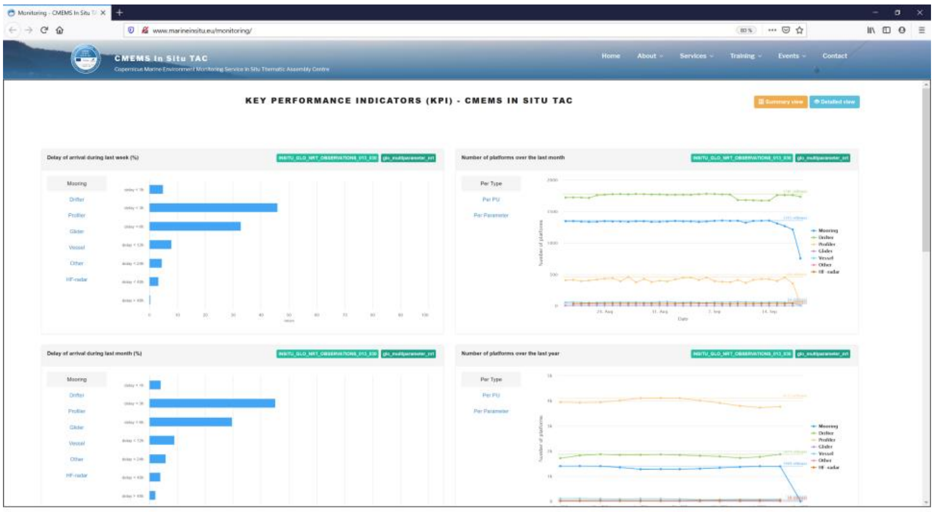

Figure 5: Copernicus Marine Service in situ TAC KPIs dashboard (screenshot taken 18/09/2023)

IV.1 Temperature and Salinity observations

T&S observations are reported as vertical profiles, underway data and time series. Compared to 2021, the total number of vertical profiles increased by 4% in 2022 (see Table 8). and the total number of underway data increased by 8.6% in 2022 (see Table 9).

During the 1970-1999 period, fixed buoys and vessels were the main observation platform type (see figure 6). In the 2000-2022 period, drifting buoys and Argo floats significantly complemented the T&S observation networks (see figure 6). Although small in absolute number, sea-mammal profiles significantly increased the spatial coverage in Northern and Southern latitudes (see pink dots in figure 7).

Vertical profiles (temperature, Salinity, Oxygen, ...)

Description	nb measures 2022	nb measures 2021	Evolution
Argo profiling floats	3914404	3620406	7.51 %
Buoys, moorings	8098107	7669365	5.29 %
Vessels (XBT, CTD)	10116263	10084880	0.31 %
Total	27467054	26325697	4.16 %

Table 8: number of T&S vertical profile.

Underway data (Temperature, Salinity, Oxygen, ...)

Description	Nb measures 2022	Nb measures 2021	Evolution
Argo profiling float	22381465	21791312	2.64 %
Drifting Buoys, Moorings, Tide-gauges, ...	650987172	605123144	7.05 %
Vessels (TSG, Ferryboxes)	119572307	112941994	5.55 %
Total	1664421064	1520623031	8.64 %

Table 9: number of T&S underway data.

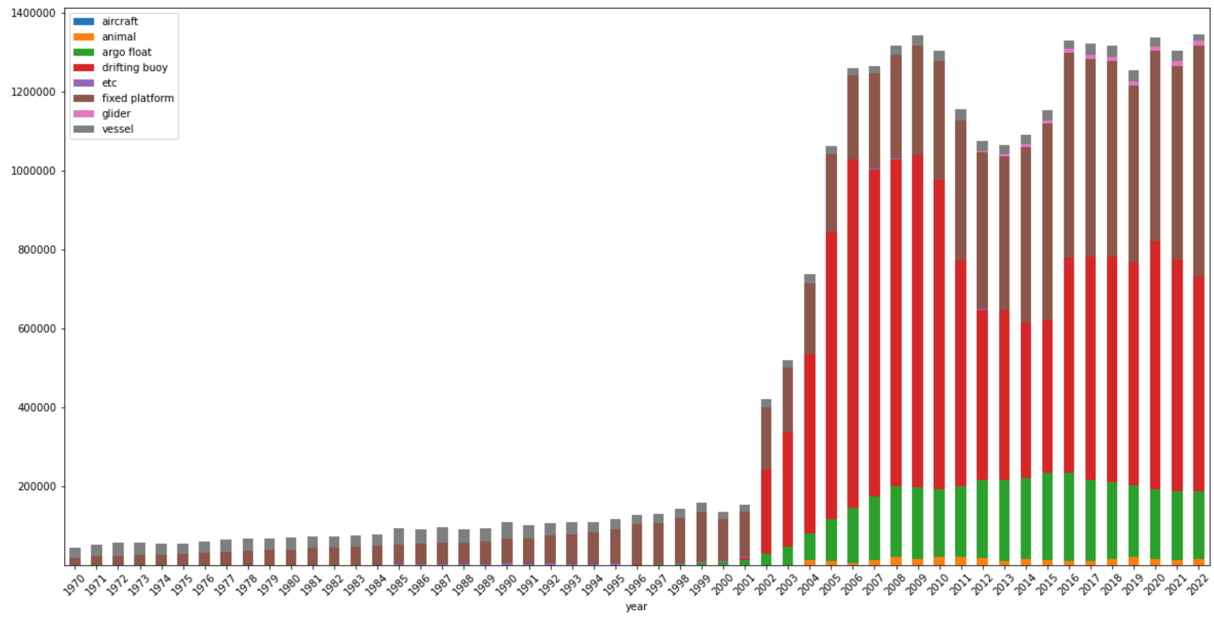

Figure 6: Evolution of type of platform since 1970.

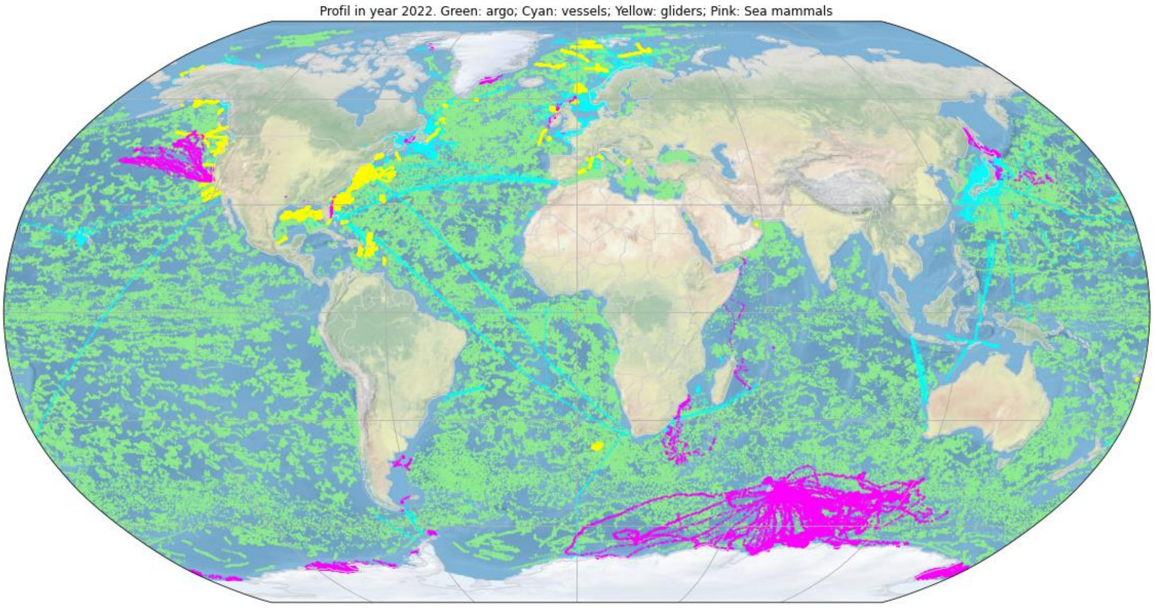

Figure 7: Profiles in year 2022: Green Argo, Cyan: vessels, Yellow: gliders, Pink: Sea Mammals

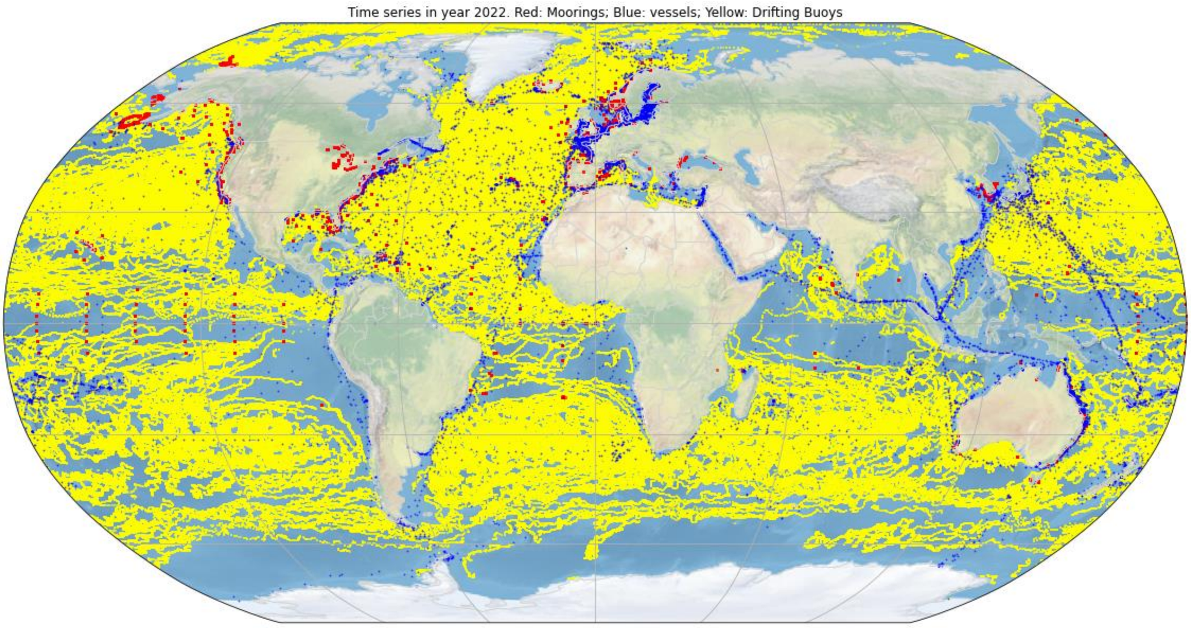

Figure 8: Time series for 2022.Red: Moorings, Yellow: drifting buoys, blue: vessels

IV.2 Biogeochemical observations (BGC)

In Situ TAC aggregates and provides to users a large panel of BGC variables together with useful metadata information on the platforms. The main parameters available in the NRT In Situ TAC products are: dissolved oxygen concentration, nutrients (nitrate, silicate and phosphate), chlorophyll-*a*, fluorescence and pH. Figure 9 shows evolution of the platform file number for each BGC variable available in the NRT In Situ TAC products since the entry into service in 2022. One file contains all the observations from the platform.

BGC variables are stored and made available within their original unit only (original units means unit in which observations were delivered). BGC variable unit depends either on the kind of sensor or chemical method used for measurement, or on the data provider.

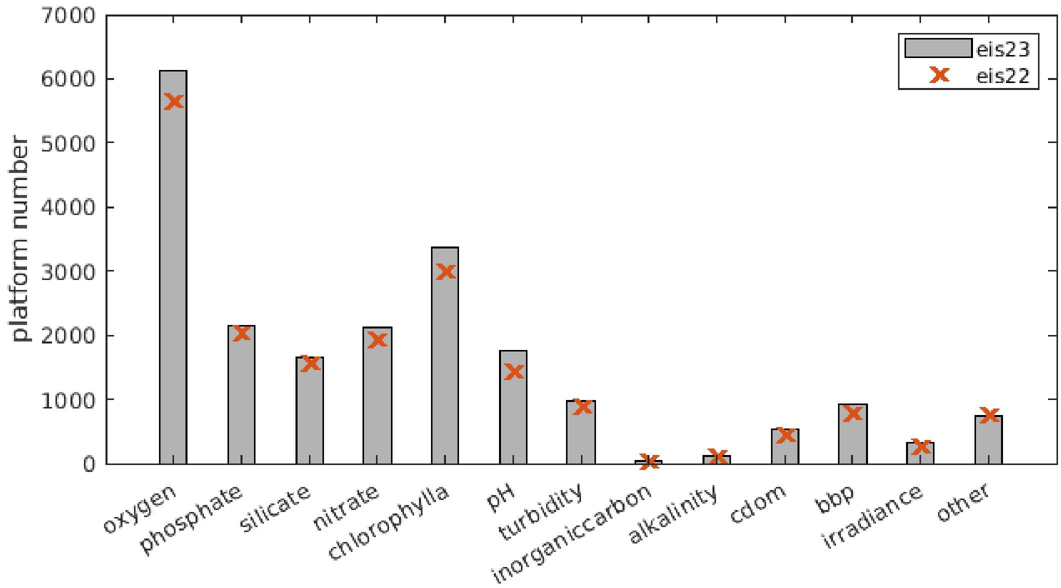

Figure 9: number of platform files measuring oxygen, phosphate, silicate, nitrate, chlorophyll-a, pH, turbidity, inorganic carbon, alkalinity, colored dissolved organic matter (cdom), particle backscattering (bbp) and irradiance and other minor BGC variables available in the NRT In Situ TAC product for its Entry Into service(EiS) in 2022 (x) and 2023 (bars) .

The following sections are focused on the quality control procedure for dissolved oxygen concentration, named “oxygen” hereafter, and the nutrients that are subject to contract. It will be progressively updated with other BGC parameters such as chlorophyll-*a* planned for November 2024 (EIS24).

IV.2.1 Dissolved oxygen

Oxygen observations are either in ml/l (volume fraction of oxygen) or in mmol/m3, equivalent to µmol/l (the mole concentration of dissolved molecular oxygen) or in µmol/kg (moles of oxygen per unit mass) or in % (fractional saturation of oxygen in sea water). It is easy to move from one unit to another one unit using the conversion factor of 44.6596 µmol/mL, the corresponding potential temperature and salinity to get the potential density of seawater referenced to a hydrostatic pressure of 0 dbar, or the solubility of oxygen in seawater as recommended by the SCOR WG 142 (Bittig et al., 2016). Unit standardization is a part of the reprocessing tools available in the In Situ TAC REP product.

Figure 10 represents the oxygen observations spatial distribution and Figure 11 the oxygen profiles yearly distribution. Both figures show that most of the dissolved oxygen profiles included in the MYNRT products have been measured by bottle (BO) and CTD-O2 (CT) during the 20th century and covered the global Ocean. This has progressively evolved over the last two decades with the implementation of the ARGO-O2 profiling float network (PF). The spatial coverage of the profiling floats remains nevertheless insufficient.

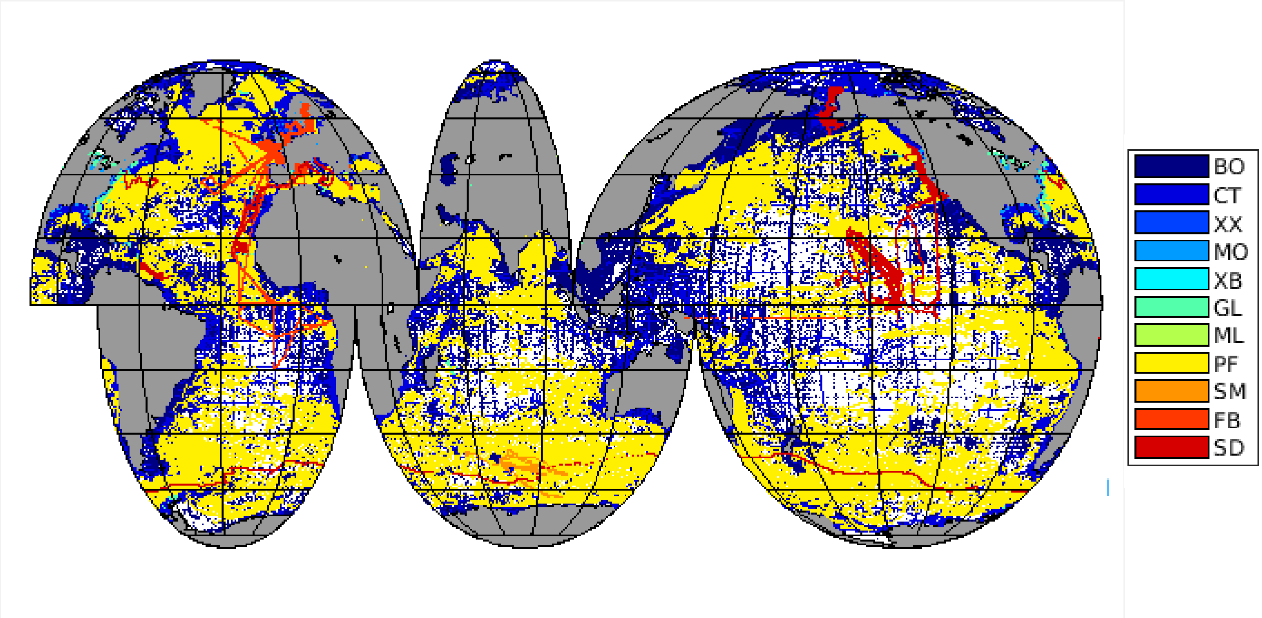

Figure 10: good oxygen profiles (i.e., those with a QC flag of 1,2,5,6,8) spatial distribution per instrument type. (BO for bottle, CT, for CTD sensors, XX for unknown instrument type, MO for mooring, XB for XBT sensor, GL for gliders, ML for mini-log, PF for profiling floats, SM for sea mammals, FB for ferry boxes and SD for saildrones).

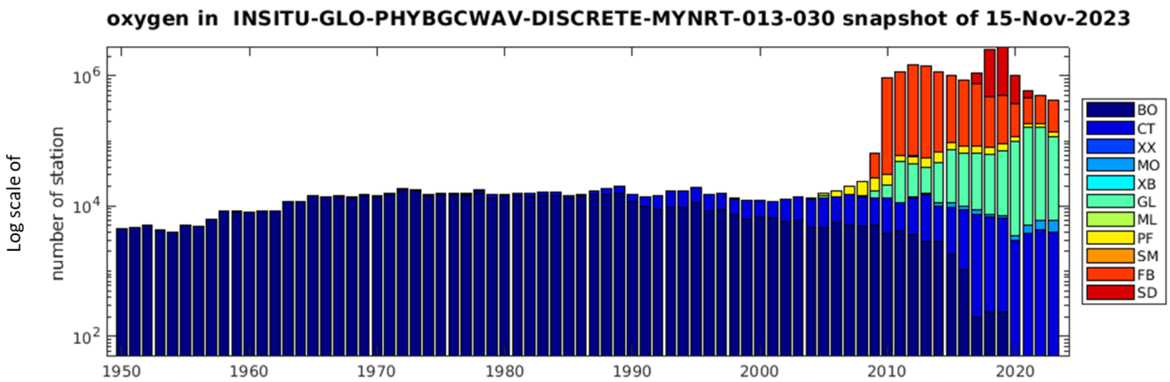

Figure 11: log scale of the number of good oxygen profiles (i.e., those with a QC flag 1, 2, 5, 6, 8) collected per year (1950 – 2023) per instrument type (BO for bottle, CT, for CTD sensors, XX for unknown instrument type, MO for mooring, XB for XBT sensor, GL for gliders, ML for mini-log, PF for profiling floats, SM for sea mammals, FB for ferry boxes and SD for saildrones) .

IV.2.2 Nutrients

Nitrate, Phosphate and Silicate are the three nutrients quality controlled in real time by the In Situ TAC. Nutrient observations are available either in mmol/m3, equivalent to µmol/l the mole concentration of dissolved molecules) or in µmol/kg with NTAW, PHOW and SLCW (moles of nutrient per unit mass). Except for Argo nutrient data, most of the observations are provided in mmol/m3.

Figure 12 represents the spatial distribution of nutrient observations and Figure 13 the yearly distribution of nutrient stations. Nutrient measurements are essentially (if not exclusively) chemical (BO), but it is possible to find them in CTD (CT) instrument files to keep information with CTD-O2 (CT) observations. BGC-ARGO profiling floats (PF) and GLIDER (GL) network measure nitrate only.

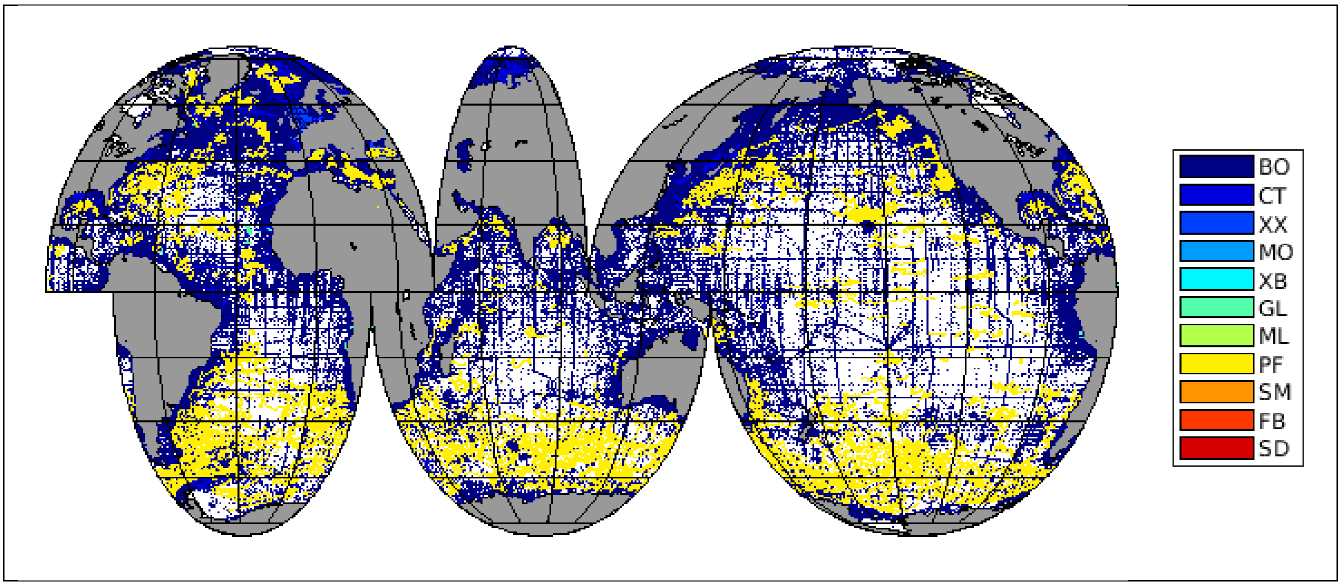

Figure 12: Good nutrient observation (i.e., those with a QC flag 1, 2, 5, 6, 8) spatial distribution per instrument file type (BO for bottle, CT, for CTD sensors, XX for unknown instrument type, MO for mooring, XB for XBT sensor, GL for gliders, ML for mini-log, PF for profiling floats, SM for sea mammals, FB for ferry boxes and SD for saildrones)

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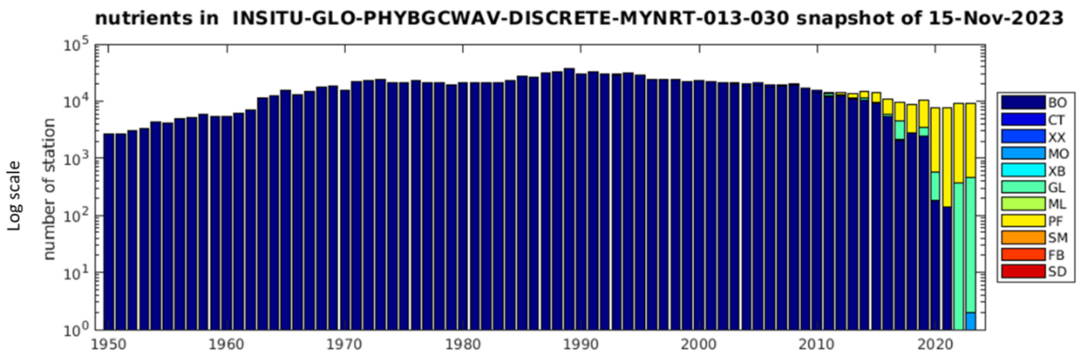

Figure 13: log scale of nutrient station yearly distribution per instrument file type (BO for bottle, CT, for CTD sensors, XX for unknown instrument type, MO for mooring, XB for XBT sensor, GL for gliders, ML for mini-log, PF for profiling floats, SM for sea mammals, FB for ferry boxes and SD for saildrones).

IV.3 Wave observations

Figure 14 shows the temporal coverage with the evolution of the number of platforms from 1970 to 2023 distinguishing between wave height, period, direction, and wave spectra. The spatial coverage is presented through a map with the distribution of platforms (Figures 15 and 16), where the colour of the dots represents the number of years for which there was data coverage and distinguishing between active and non-active platforms. For both scalar and directional waves the increase in the number of platforms over the period from 1970 to 2023 can be clearly seen, especially over the last two decades. For wave spectra there is no coverage until the 1990's and then it increases significantly in the last decade. Regarding the spatial coverage, most of the stations that provide wave information are concentrated in the Northern Hemisphere and close to the coast. In the European Seas there are differences between regions with high coverage in all of them except in the Southern Black Sea, the Arctic and the Southern and Eastern Mediterranean.

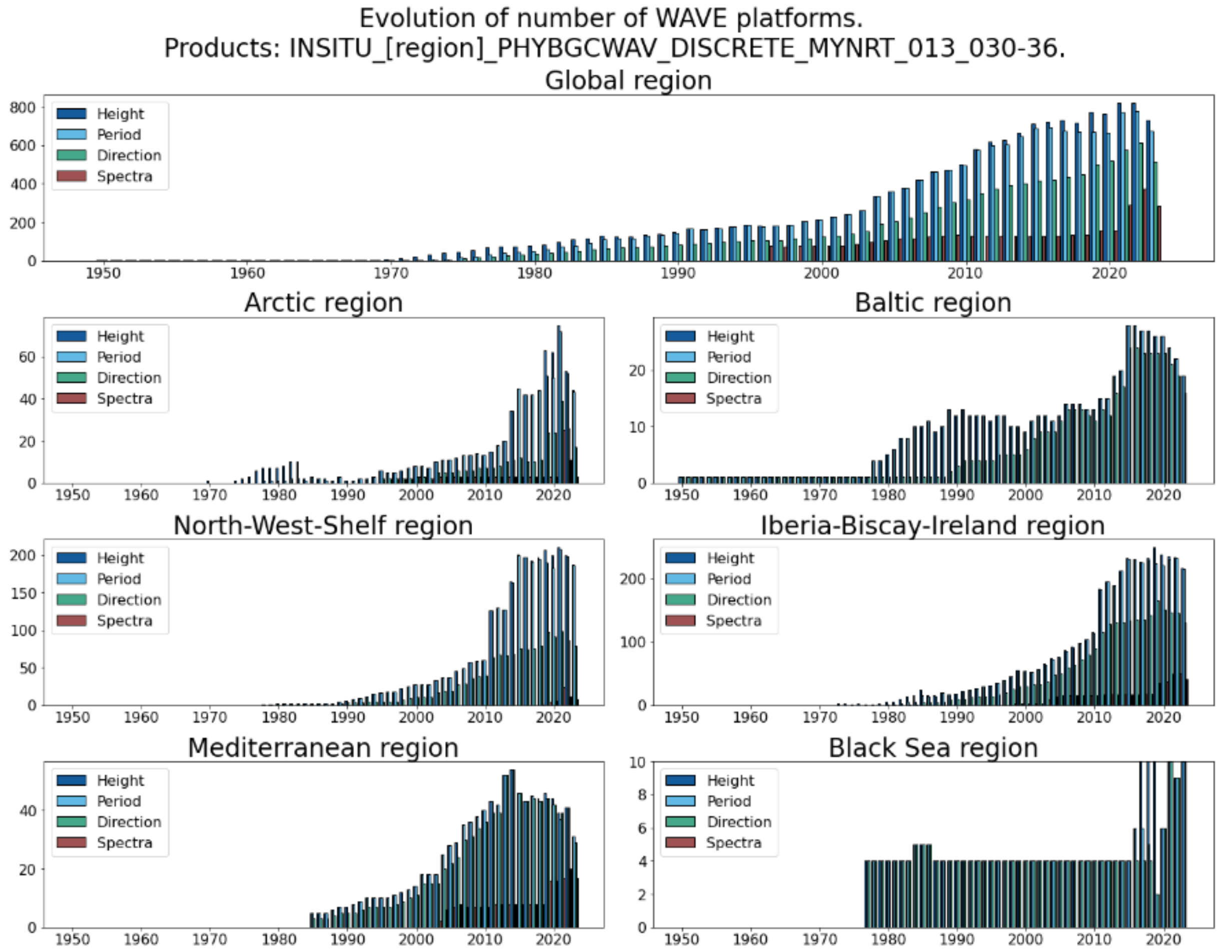

Figure 14: evolution of the number of wave platforms from 1970 to 2023 at global scale.

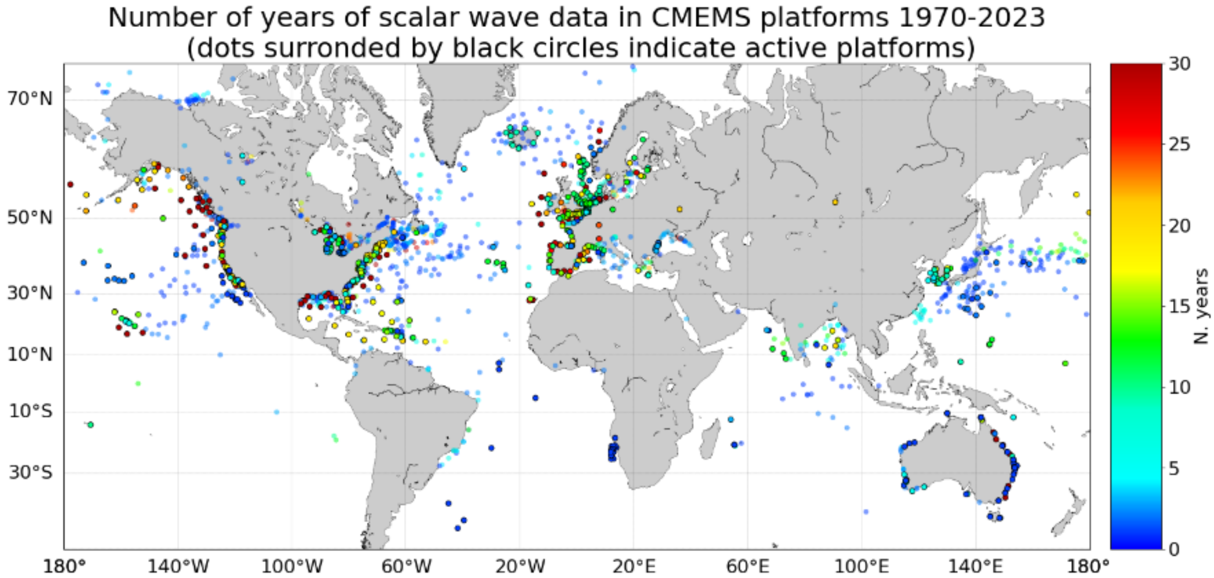

Figure 15: wave data geospatial coverage at global scale, coloured by time coverage

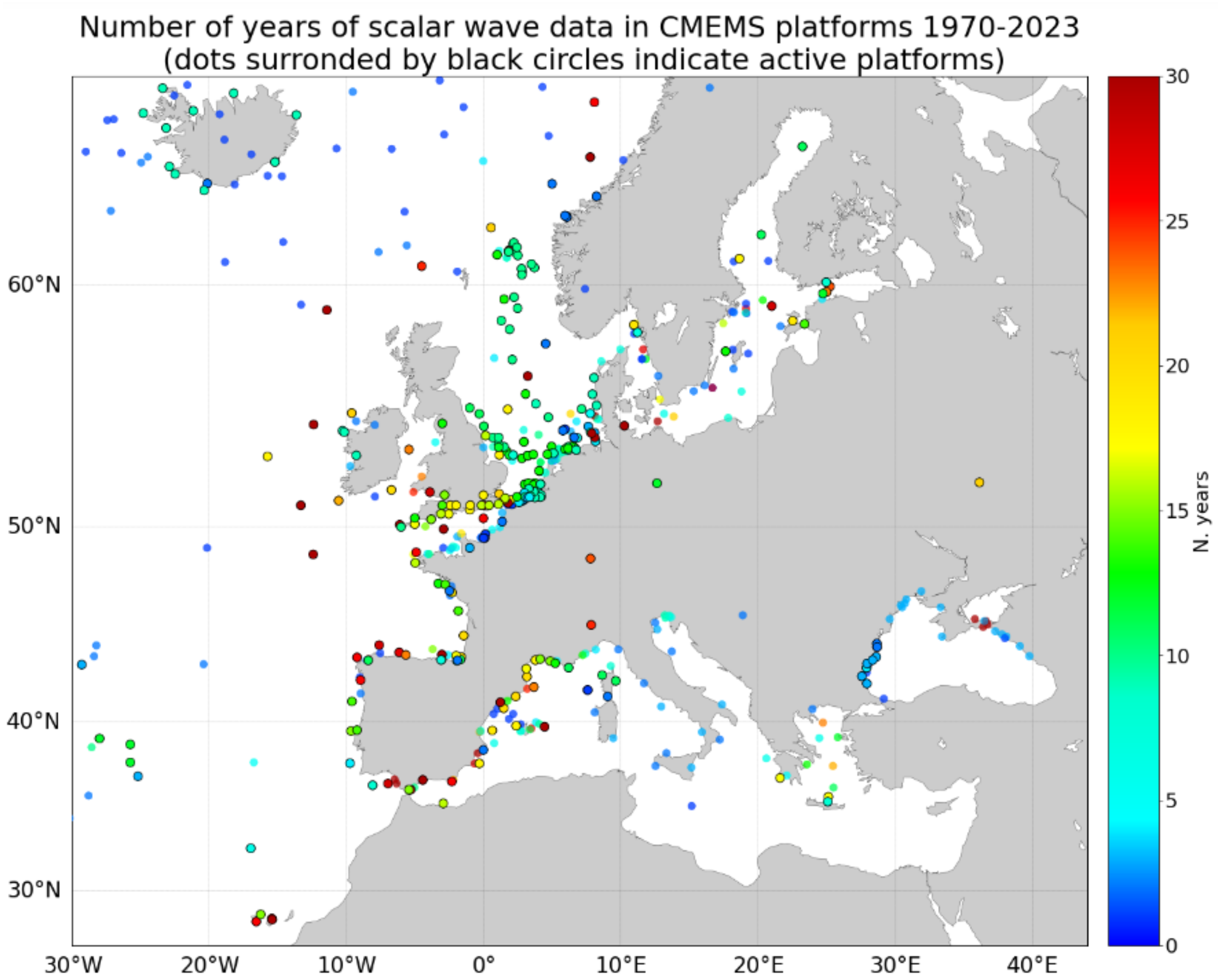

Figure 16: wave data geospatial coverage at European seas, coloured by time coverage

IV.4 Sea-level observations

Sea level observations are aggregated in real-time. The evolution of the number of platforms between 1840 and 2023 is shown in Figure 17. The number is increasing slowly in the first decades. In the two decades from 1990 to 2010 the number of platforms doubled from 200 to 400 and in the last decade the increase is even more marked. The spatial distribution maps (Figures 18 and 19) show how the coverage is high in European Seas except in the Southern Mediterranean, Black Sea and the Arctic and very scarce outside of Europe due to the fact that we do not recover yet data outside Europe.

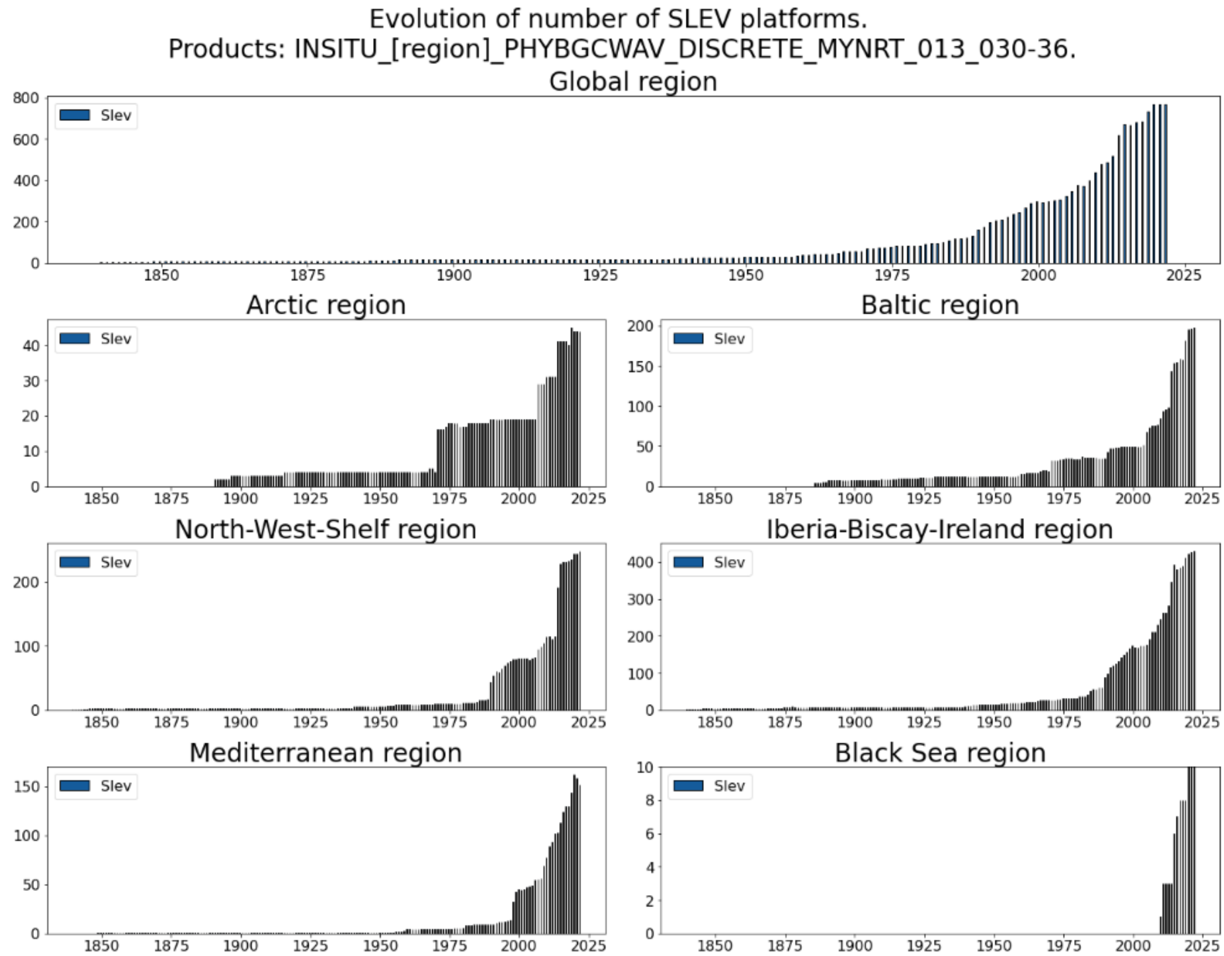

Figure 17: evolution of number of sea level platforms between 1840 and 2023 at global scale.

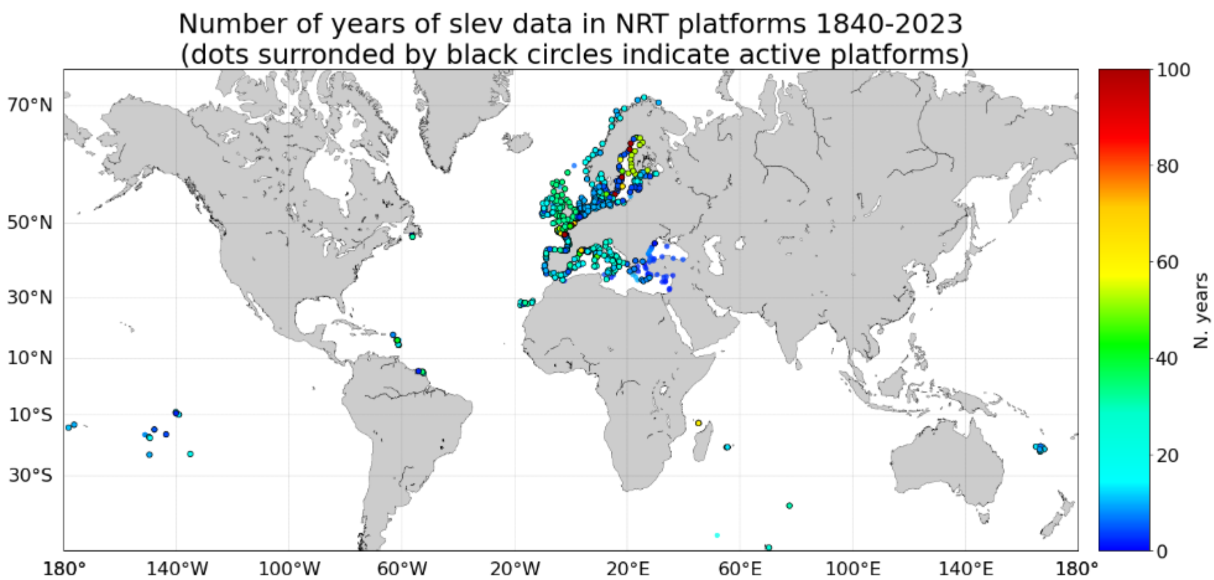

Figure 18: sea-level data geospatial coverage at global scale, coloured by time coverage.

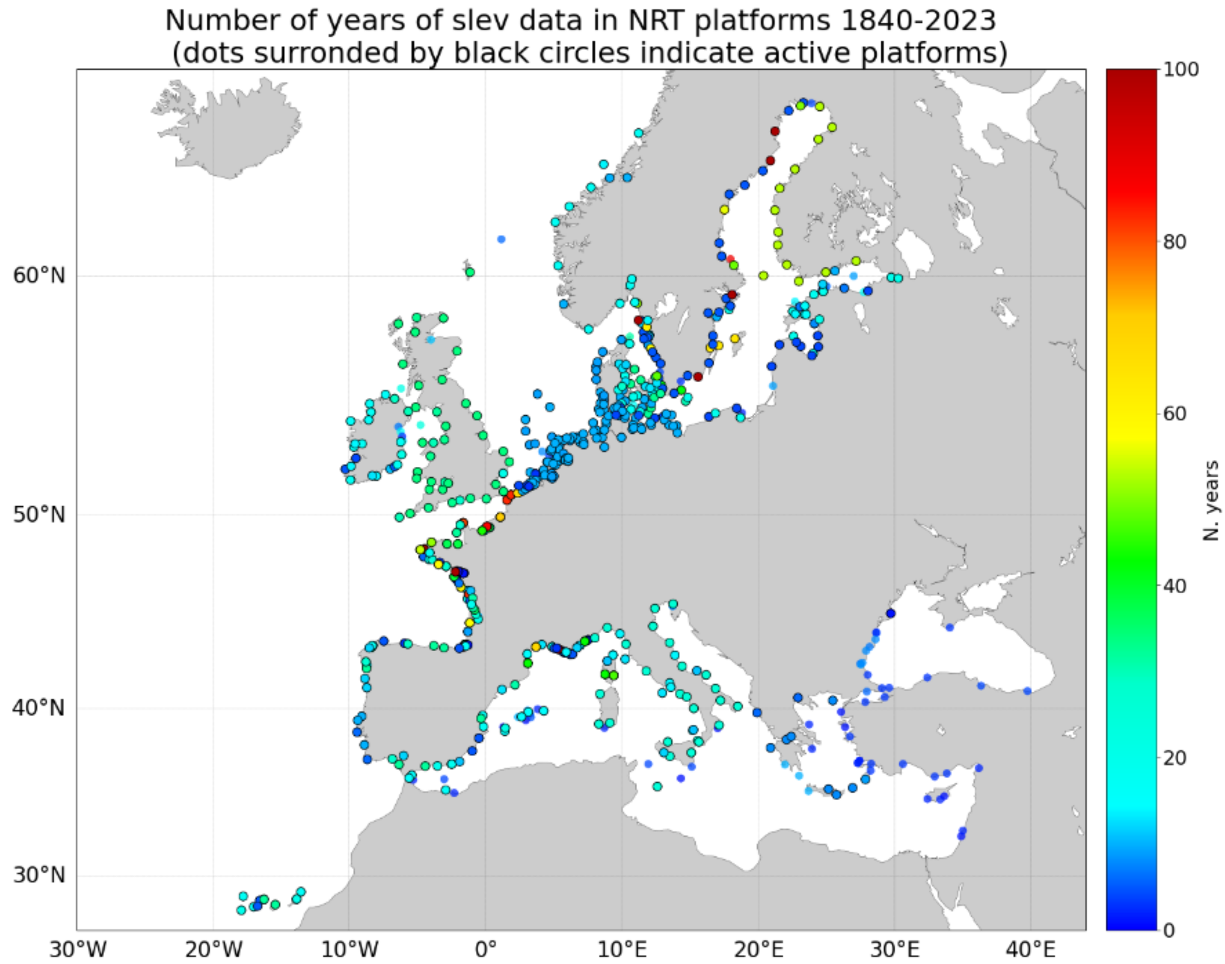

Figure 19: sea level data geospatial coverage at European seas, coloured by time coverage.

IV.5 Ocean currents

Ocean currents data are aggregated from platforms such as HF-radars (HFRs), vessels or fixed sites. They are reported as 7 variables (see table 9). The number of platforms was quite low until the end of the 20th century (less than 200 platforms) and then substantially increased to more than 800 in 2020 (see Figure 20).

name	long name
HCSP	Horizontal current speed
HCDT	Current to direction relative true north
EWCT	West-east current component
NSCT	South-north current component
VCSP	Bottom-top current component
RDVA	Radial sea water velocity away from instrument
DRVA	Direction of radial vector away from instrument

Table 9: ocean currents are reported in NetCDF files with 7 variables

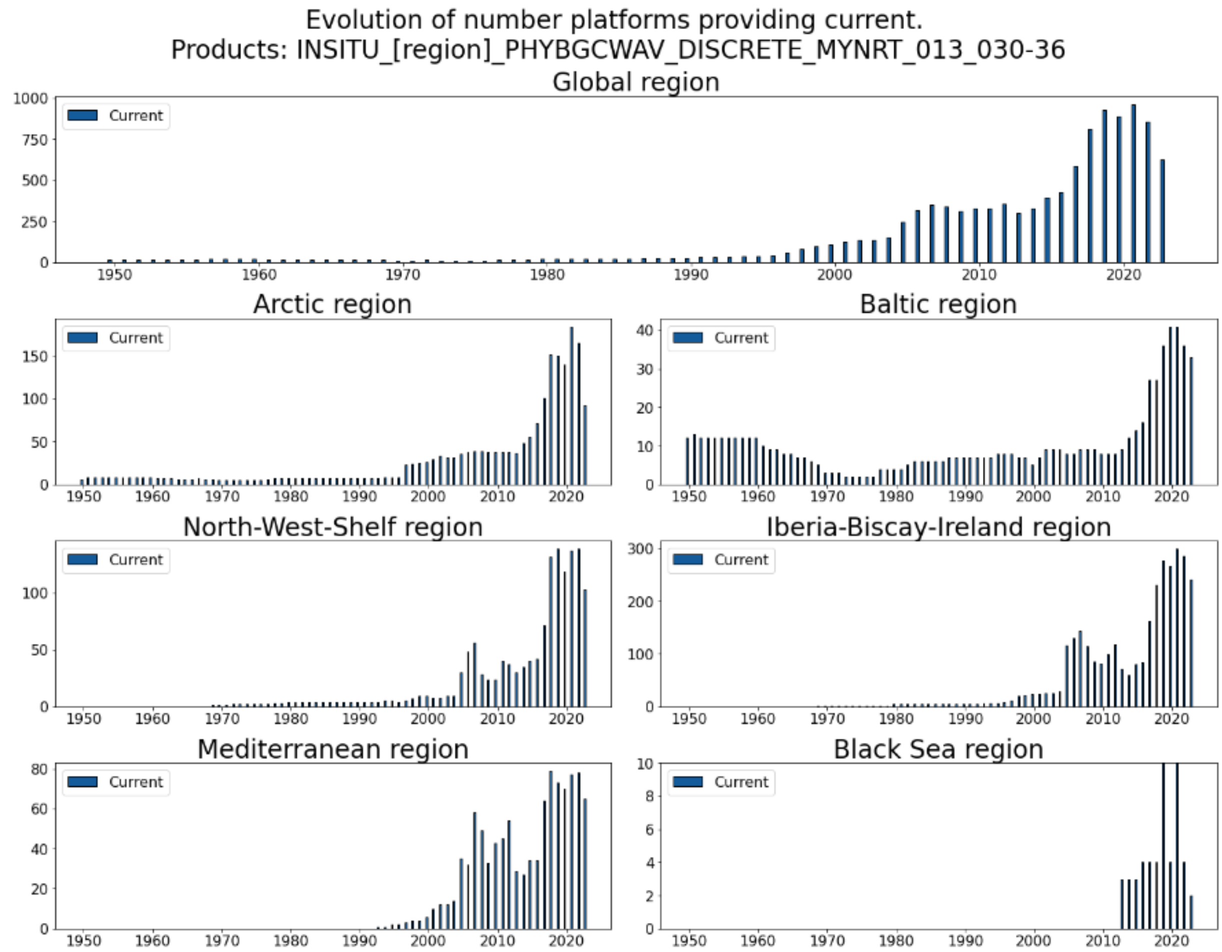

Figure 20: evolution of number of platforms providing current between 1950 and 2023 at global scale

A focus on HF radars

The last inventory (March 2020) shows that there are 72 HFRs currently deployed and active in various coastal areas of the European seas (Figure 21). This number is growing with seven new HFRs installed per year. The EU HFR node delivers in near real-time and on an hourly basis, maps of surface current velocities from the HF radars that are actively processing and/or delivering their (formatted or raw) data to the node. The HFR node also collects and processes near real time HFR for advanced QA/QC and aggregation of files to build the REP dataset of historical surface current velocity data from those operators connected to the node. In the European framework, the EU HFR Node is now managing data from 12 HFR networks (built by 35 radar sites) and is expected to manage 20 networks (for a total of 50 radar sites) by end 2020. From these 12 networks, 10 are sending data in NRT since 2019, and 4 have provided time series of historical data before 2019.

HF radars are distributed amongst the different Regional Ocean Observing Systems (ROOS) areas coordinated by the European Global Ocean Observing System (EuroGOOS): 56% in MONGOOS (Mediterranean Operational Network for the Global Ocean Observing System), 32% in IBI-ROOS (Ireland-Biscay-Iberia Regional Operational Oceanographic System) and 5% in NOOS (north West European Shelf Operational Oceanographic System) (Last update of the inventory, March 2020 as shown in Figure 21).

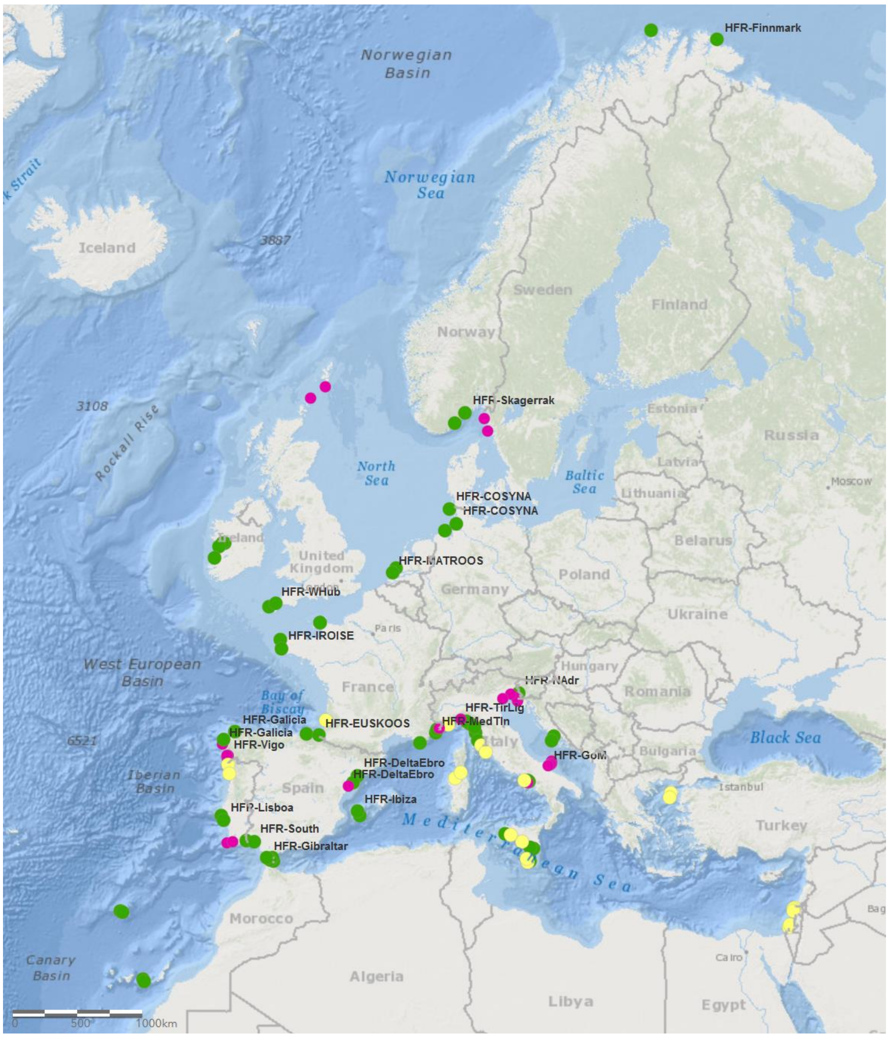

Figure 21: distribution of HFR systems in Europe. The operational systems are plotted in green, future installations in yellow and past deployments in magenta. Source: http://eurogoos.eu/high-frequency-radar-task-team/

IV.6 Meteorological and miscellaneous observations

The in situ TAC has no specific commitment to manage in situ meteorological and non-ocean observations. However, when such parameters are reported along with ocean in situ parameters, they are preserved in the NetCDF files, with no additional quality control.

Meteorological and miscellaneous observations include, among others, wind, air temperature, humidity, precipitation, atmospheric pressure and river flows.

As an example, Figure 22 shows the evolution of the number of platforms measuring atmospheric parameters between 1970 and 2023. It shows a clear increase from the middle of the 2000´s . Figure 23 shows the distribution of the platforms providing wind data at global scale and Figure 24 at European Seas scale.

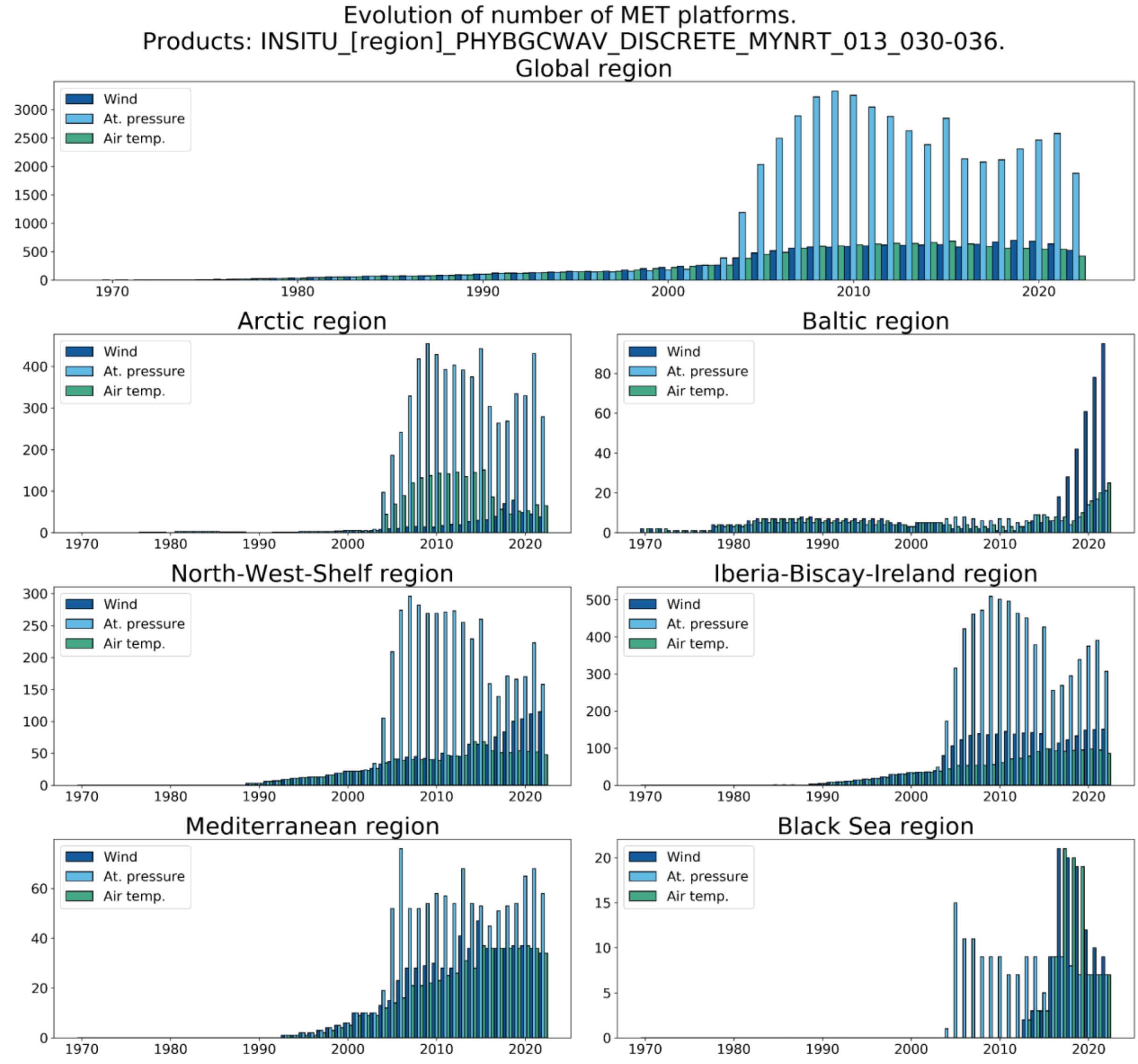

Figure 22: evolution of number of meteorological platforms between 1970 and 2020 for every region.

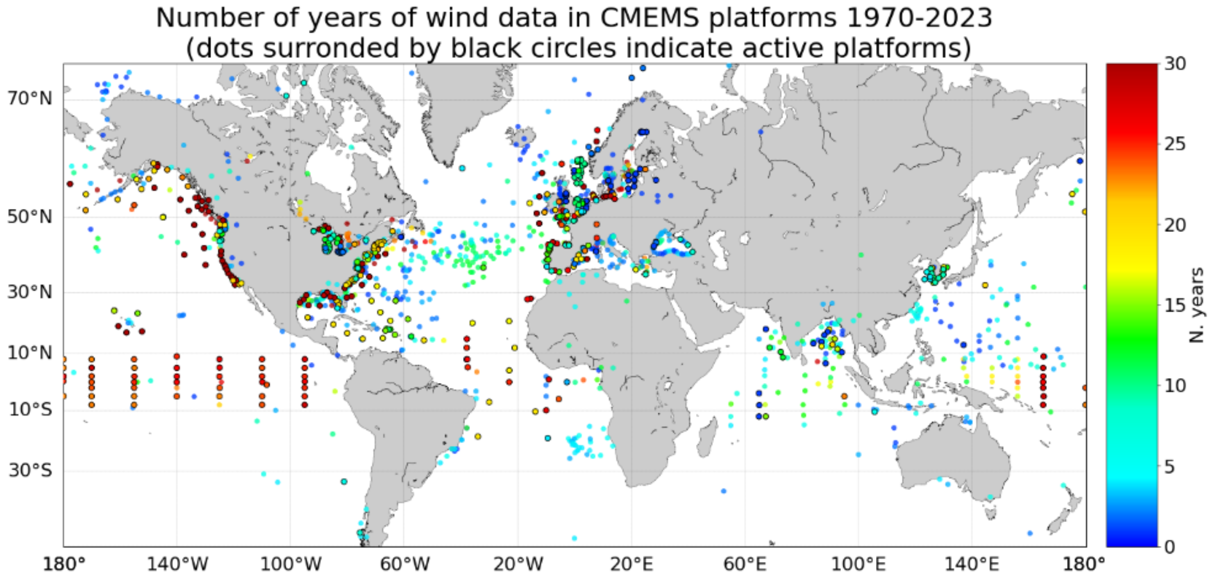

Figure 23: wind data geospatial coverage at global scale, coloured by time coverage.

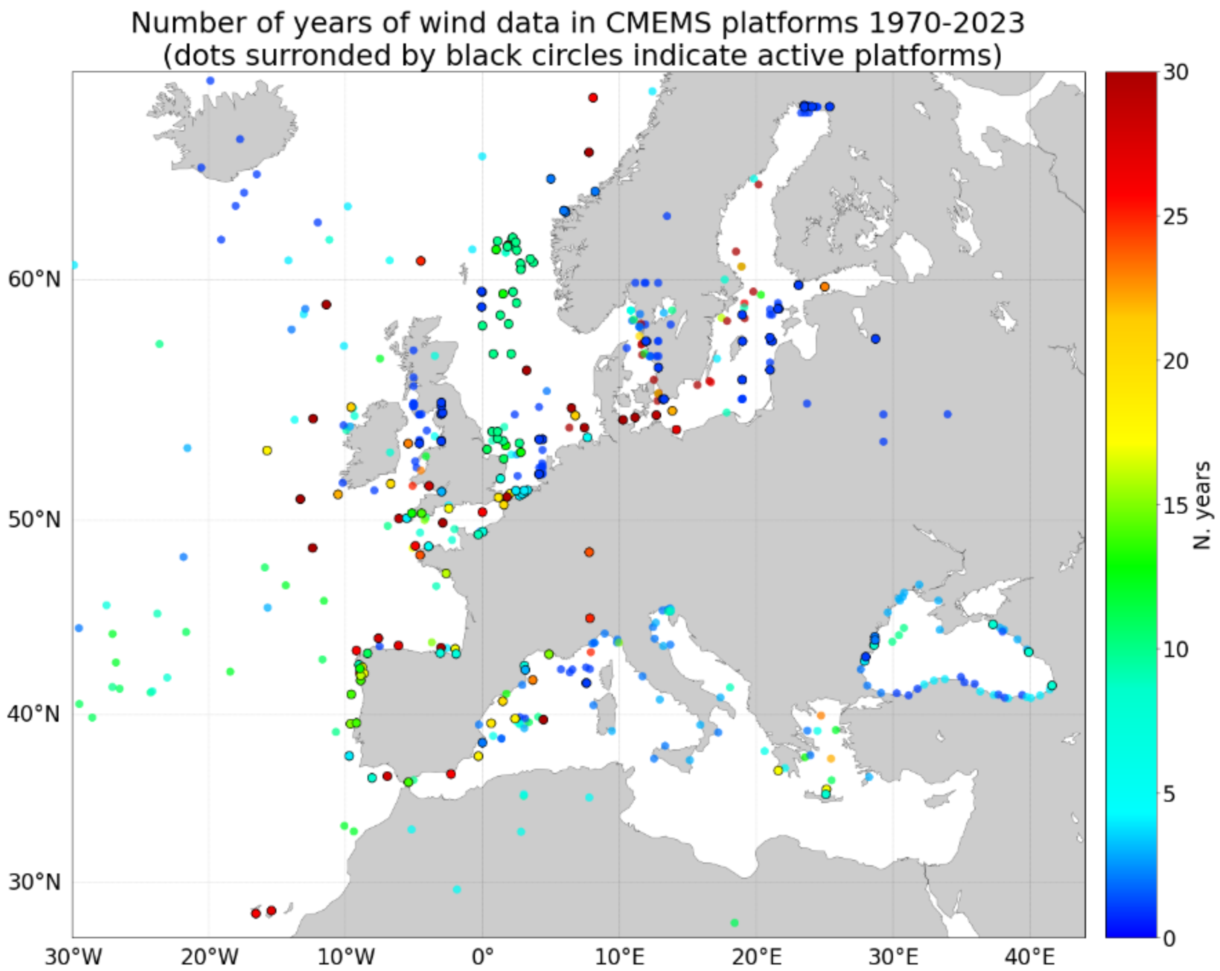

Figure 24: wind data geospatial coverage at European seas, coloured by time coverage.

V SYSTEM'S NOTICEABLE EVENTS, OUTAGES OR CHANGES

There is nothing to report for this version

VI QUALITY CHANGES SINCE PREVIOUS VERSION

There is nothing to report for this version

VII REFERENCES

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