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CHANGE RECORD

When the quality of the products changes, the QuID is updated and the SQO is updated. A line is added to this table and the version of the SQO document is the same than that of the REFERENCE QUID. The third column specifies which sections or sub-sections have been updated.

Issue	Date	§	Description of Change	Authors	Validated By
2.0	30/03/20	All	Creation of the document for the 3 datasets (radar_total, drifter, adcp)	A Rubio, M. Chifflet, L. Corgnati, C. Mantovani, E. Reyes, J. Mader, H Etienne, T. Carval	Stéphane Tarot
2.1	04/09/20	Exec. Sum. and §1	Update of the document, concerning the radar_total dataset	A. Rubio L.Solabarrieta	
2.1	28/11/2020	New version following requested changes	Update of the document and contents regarding the 3 datasets	N. Verbrugge T. Carval L. Solabarrieta A. Rubio	
3.0	06/01/2021	Exec. Sum. and §1 “radar” dataset” §4 minor change	Update of the document, concerning the addition of a new radar_radial dataset	A. Rubio L. Solabarrieta N. Verbrugge	S. Tarot
3.1	01/09/2021		Update of the document, concerning the addition of new radar_radial and radar_total datasets	A. Rubio L. Solabarrieta N. Verbrugge	S. Tarot
3.2	16/02/2022	§3	Version number update to follow the one of the QUID + updated figure for drifter	N. Verbrugge	S. Tarot
3.3	31/05/2022	Exec. Sum. §1 and §3	Correction following SQO reviewers + new product name + updated table 2	A. Rubio L. Solabarrieta N. Verbrugge	S. Tarot
3.3	31/08/2022	§2	Figure update	N. Verbrugge	S. Tarot
3.5	31/05/2023	§1, §3, §4	Update of values and figures for drifters and HF Radar	H. Etienne, L. Solabarrieta	S. Tarot

Issue	Date	§	Description of Change	Authors	Validated By
3.5	31/05/2023	§2	Additionnal Argo velocities dataset	T. Carval	S. Tarot
3.5	23/06/2023	§2	ADCP dataset update	T. Carval	S. Tarot

Contents

Executive summary

The quality of the INSITU_GLO_PHY_UV_DISCRETE_MY_013_044 product from the Copernicus Marine Service distribution is assessed through the horizontal and vertical data coverage along time for the following variables/datasets:

- **SURFACE WATER VELOCITY From High Frequency Radars ("cmems_obs-ins_glo_phy-cur_my_radar-radial_irr" & "cmems_obs-ins_glo_phy-cur_my_radar-total_irr"; radar_radial & radar_total datasets hereafter)** In case of the radar_radial dataset, the SURFACE WATER VELOCITY consists in maps of near-surface zonal and meridional components of raw radial velocities measured by High Frequency radars (HF radars, as acronym HFR). These variables are distributed along with magnitude and direction of near-surface zonal and meridional components of raw radial velocities, standard deviation of near-surface zonal and meridional components of raw radial velocities, quality flags and metadata.
  In the case of the radar_total data set, the SURFACE WATER VELOCITY consists in maps of near-surface zonal and meridional velocities measured by HFRs. These variables are distributed along with standard deviation of near-surface zonal and meridional velocities, Geometrical Dilution of Precision (GDOP), quality flags and metadata.

  The systems are distributed along the European & US coasts. Their horizontal coverage strongly varies among the different systems and periods.

  The high spatio-temporal resolution maps of ocean surface currents contained in the radar_total dataset is suitable for many applications for coastal management, like monitoring and predicting the surface drift of floating objects, and are also key for the study of coastal ocean processes, their interplay, air sea interactions and connectivity between marine areas. Radar_radial currents can be used for model and satellite products assessment and validation and for data assimilation.

- **SEA WATER VELOCITY VERTICAL PROFILES From "cmems_obs-ins_glo_phy-cur_my_adcp_irr" dataset (adcp dataset hereafter)**

The ADCP (Acoustic Doppler Current Profiler) is an essential measuring device for the in-situ characterization of hydrodynamic processes. It is used to measure phenomena such as:

- Intensity and direction of currents in the water column
- Turbulent energy fluctuations in the water column

The acoustic profilers are used mainly in 2 ways. The first measurement method, called Bottom Tracking, is to attach the ADCP to the hull of a moving boat. The current meter then continuously measures the intensities and direction of the currents in the water column under the boat. The second is on fixed anchorage on the bottom in structures adapted to the characteristics of the deployment area.

- The French research oceanographic vessels are equipped with ADCP that measure ocean current profiles along the vessel tracks.

More on "The current profilers of the French Oceanographic Fleet".

Observations from Research vessel mounted ADCP are processed in delayed mode by "Cascade data processing chain" operated by Ifremer/Sismer specialists.

- **SURFACE & NEAR_SURFACE WATER VELOCITY, WIND SLIPPAGE CORRECTION From "cmems_obs-ins_glo_phy-cur_my_drifter_PT6H" dataset (drifter dataset hereafter)**
  The SVP drifter's data are collected, quality controlled and distributed by the AOML Data Assembly Center (DAC). Then a wind slippage correction is computed by the In Situ TAC (CLS).

  Most of the quality control procedures are performed by AOML. Quality of drifter's measurements depends on the platform and on its physical integrity, in particular the loss of the drogue. If the drifter's measurement is in nominal mode, it is considered that its velocity corresponds to the 15m depth velocity (drogue-on). If not, it is considered that the drifter's velocity provides an estimation of the surface current (drogue-off). The drogue loss information is provided in the data set and defines the way the wind slippage correction has to be used.

  In some regions and time periods, the number of measurements can be critically low due to the drifter launch time schedule and their geographical locations.

  Moreover, by construction, the wind slippage correction is not available in some small basins (like the Mediterranean Sea) and before 1993.

- **SEA WATER VELOCITY from cmems_obs-ins_glo_phy-cur_my_argo_irr dataset**

  The Argo current product generated by Copernicus In Situ TAC is derived from the Andro trajectory dataset (Ollitraut et al., 2022)

  The ocean current product contains a NetCDF file for each Argo float. For each cycle it contains the surface and deep current variables.

  Validation consists of inspection a global Argo current speed map and individual float current graphics.

➔ For additional information regarding the in-depth validation of this product, the calculation of the assessment metrics presented in this product and other detailed information in quality and noticeable events please refer to the reference Quality Information Document (QuID) CMEMS-INS-QUID-013_044

Important notice:

The contents of this document are an assessment based on the best set of observations available for evaluation at the time the operational system was validated. The validation methodology was defined and agreed within Copernicus Marine Service, inheriting the long experience of inheriting the long experience of MyOcean and MERSEA series of projects (Hernandez et al., 2018) but also the HFR EU node and the HFR-related activities in the CMEMS-INCREASE and H2020 – JERICO-Next research projects (HFR data). The estimated accuracy numbers (EAN) given in this document mainly come from literature. Other results illustrate the data coverages in time and space. The reader is invited to use complementary information from reference QUID (error maps for instance, when available).

1. High Frequency Radar datasets: obs-ins_glo_phy-cur_my_radar-radial_irr & obs-ins_glo_phy-cur_my_radar-total_irr

Expected accuracy of radar_total currents is provided in Table 1 based on comparisons of HFR currents against independent in situ measurements from literature. A significant number of studies provide results on validation exercises; however, these estimations can be limited by the fact that part of the discrepancies observed through these comparisons are due to the specificities and own inaccuracies of the different measuring systems (Kalampokis et al., 2016, Solabarrieta et al., 2014).

Dataset	Reference	Current (m/s)
radar_total	Ohlmann et al., 2007; Molcard et al., 2009; Liu et al., 2010; Kalampokis et al., 2016 ; Corgnati et al. 2018	0.03 – 0.12

Table 1: Accuracy of the radar_total measurements expected from literature (in comparison between HF radar and surface drifters or ADCP data

Coverage area and spatial resolution depend respectively on HFR operating frequency and available bandwidth (Rubio et al. 2017). Moreover, data coverage is not always regular. Spatial and temporal data gaps may occur at the outer edge, as well as inside the measurement domain due to several environmental and electromagnetic causes: (e.g. lack of Bragg scattering ocean waves or severe ocean wave conditions, low salinity environments, the occurrence of radio interference). For more information on the quality of the different HFR systems (spatial and temporal distribution, quality control outcomes, status, …), you can refer to specific system reports in CMEMS-INS-QUID-013_044. Table 2 shows 80/80 scores (see QUID for more detailed information, Figures 32 and 33, and the reports in Table 13 and for updated metrics please refer also to the system reports).

Year /System	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
HFR-COSYNA											8.28	19.75	29.45	21.50
HFR-MATROOS												86.72	78.00	86.73
HFR-EUSKOOS	3.82	1.06	89.80	96.60	96.81	87.68	42.25	14.01	90.65	88.74	1.06	64.54	81.31	79.40
HFR-Galicia			25.12	52.78	29.76	74.95	29.00	8.09	0.00	26.13	44.60	11.63	34.06	61.29
HFR-Lisboa				82.89	64.81	80.15	91.16	90.32	76.85	92.99	95.8	98,72	98.37	96.35
HFR-South								39.48	76.85	65.44	62.92	9.47	3.37	1.49
HFR-Gibraltar				31.98	3.99	9.18	22.31	33.02	38.00	38.79	36.67	30.75	0.04	65.69
HFR-Ibiza				89.56	89.13	89.13	89.56	90.43	13.69	82.17	90.43	71.73	70.65	67.60
HFR-DeltaEbro						62.56	67.83	76.53	77.51	73.11	76.14	48.68	52.98	48.87
HFR-TirLig								78.33	89.81	35.64	26.73	11.53	36.96	24.20
HFR-Vigo		89.38	95.22	93.98	94.86	98.40	98.76	98.23						
HFR-PLOCAN									99.79	99.30	99.30	99.10	99.44	98.54
HFR-NAdr													6.46	3.24
HFR-Finnmark												0.00	0.00	0.00
HFR-Skagerrak											0.00	12.40	4.27	0.00
HFR-WHub													98.10	99.02
HFR-US-Alaska											4.42	0.53	0.00	0.00
HFR-US-EastGulfCoast											22.02	20.78	25.08	17.83
HFR-US-Hawaii											32.02	45.36	39.63	6.25
HFR-US-PuertoRicoVirginIslands											20.04	2.76	3.17	0.00
HFR-US-WestCoast											55.56	66.80	59.68	58.93

Table 2: Summary of QA/QC analysis of REP data up to Dec 2022. Results of the 80/80 metrics. Percent of spatial coverage available for each of the systems in the displayed periods. Green: systems achieving or approaching the 80/80 goal; Orange: systems with spatial coverage between 40 and 70%; Red: systems with spatial coverage under 40%. For the US systems (bottom, darker blue) the metrics are computed for very large geographical areas.

2. ADCP datasets: obs-ins_glo_phy-cur_my_adcp_irr dataset

ADCPs observe sea water velocity vertical profiles. For research vessel ADCP observations (Figure 1), each cruise is processed by a data processing chain such as Cascade (Le Bot & al., 2011), quality controlled and visually inspected.

The final inspection and assessment of the In Situ TAC is performed on a series of graphics. For each vessel file, the following variables are plotted and inspected: eastward_sea_water_velocity; northward_sea_water_velocity; & upward_sea_water_velocity & depth (see CMEMS-INS-QUID-013_044**)**.

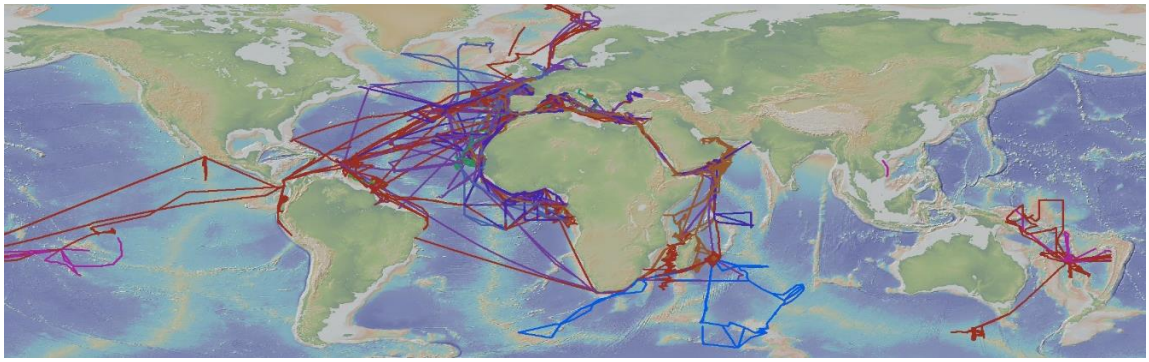

Figure 1. Map of In Situ TAC vessel ADCP observations.

The following table summarizes the accuracy of the measurements for the ADCPs that can be expected depending on the sensors. This is the best accuracy then a user can expect for the in situ data to which a quality flag “Good data” has been applied after validation process. The definition of the reference values is obtained from different sources. The specific reference is given in the tables below and the values are given for the different parameters. Table 3 shows EANs.

Water Profiling						
Long-Range Mode	**38kHz**		**75kHz**		**150kHz**	
Vertical Resolution Cell Size[1] (m)	Max Range[2] (m)	Precision[3] (cm/s)	Max Range[2] (m)	Precision[3] (cm/s)	Max Range[2] (m)	Precision[3] (cm/s)
4					*325–350*	*30*
8			*520–650*	*30*	*375–400*	*19*
16	*800–1000*	*30*	*560–700*	*17*		
24	*800–1000*	*23*				
High-Precision Mode	**38kHz**		**75kHz**		**150kHz**	
Vertical Resolution Cell Size[1] (m)	Max Range[2] (m)	Precision[3] (cm/s)	Max Range[2] (m)	Precision[3] (cm/s)	Max Range[2] (m)	Precision[3] (cm/s)
4					*200–250*	*12*
8			*310–430*	*12*	*220–275*	*9*
16	*520–730*	*12*	*350–450*	*9*		
24	*730–780*	*9*				

[1] Ranges at 1 to 5 knots ship speed are typical and vary with situation.
[2] Single-ping standard deviation.
[3] User’s choice of depth cell size is not limited to the typical values specified.

Table 3: Accuracy numbers for measured time series and ADCP estimated parameters for different ADCP sensors.

3. Drifter dataset: obs-ins_glo_phy-cur_my_drifter_PT6H

Drifter velocities are computed by AOML: after the QC and editing of drifter positions, trajectory positions are re-interpolated regularly by the Krigging technique on 6 hours interval (Hansen and Herman, 1989; Hansen and Poulain, 1996). Then velocities are derived from finite differences of their position fixes using a 12-h centered scheme.

SVP drifter's velocity is not the perfect measurement of the water column averaged over the drogue depth. The water can sink, or the drifter can slip due to wind influence on the surface float. Hence the resulting drifter velocity is the addition of the 15 meters depth large-scale current, the upper-ocean wind-driven flow, the influence of tides and Stokes Drift and other forces on the drogue and the surface body of the drifter, and the slip. The slip depends on the drogue loss status of the buoy and the windage is provided within the dataset.

Table 4 summarizes the accuracy of the measurements that can be expected from the drifters This is the best accuracy that a user can expect for the data:

Dataset	Reference	Current (m/s)
drifter	Niiler et al, 1995	0.01

Table 4: Accuracy of the drifter measurements expected from literature.

The number of SVP drifters has continuously increased from the early 90's (Figure 2). But with the use of new drifter's design during the mid-2000s and the displacement of the buoys in the Antarctic Circumpolar Current, the number of undrogued instruments has raised (Lumpkin et al, 2013).

The spatial distribution of the drifters is not homogeneous, and the number of measurements can be critically low in some regions (as in high latitudes, along the equator due to circulation divergence, Indian Ocean). Maps of spatial distribution of the drifters (drogue-on and drogue-off are available in the CMEMS-INS-QUID-013_044.

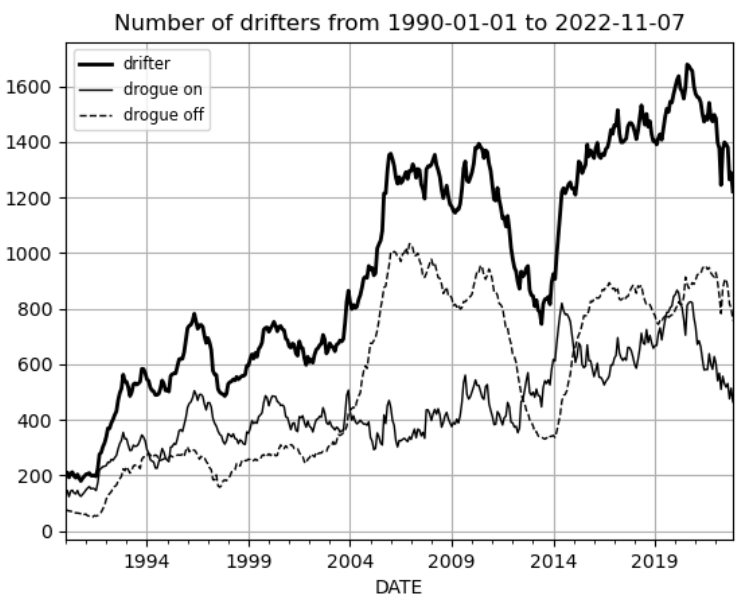

Figure 2: Count of transmitting drifters per month from 1990 to November 2022. ***Thick line is the total number of drifters; dashed line is the undrogued drifters; solid thin line is the number of drogued drifters.***

4. Wind-slippage correction dataset: obs-ins_glo_phy-cur_my_drifter_PT6H

A direct wind slippage correction, also called “windage”, of zonal and meridional velocity is estimated by the In Situ TAC following Rio (2012) method.

The total drifter velocity $\mathbf{U}_d$ is decomposed into different contributions:

- geostrophic current $\mathbf{U}_g$
- Ekman/Stokes current $\mathbf{U}_e$ (wind-driven current)
- ageostrophic current $\mathbf{U}_a$, including tides and other high frequency signals
- the slippage from the wind $\mathbf{U}_s$, estimated here.

As the wind-driven model is not a fully global product, no wind slippage correction is available in the Mediterranean Sea. $\mathbf{U}_g$ is provided by altimetric missions since 1993 only. Moreover, no correction is provided ±5° from the equator for the drogued drifters. Elsewhere, this new data base provides a wind slippage correction of the entire drifter’s trajectories from 1993.

We compare the satellite altimetry derived geostrophic current U_{geo} to equivalent U_g signal from drifters:

$U_g \approx (U_d - U_e)_f$

When undrogued, the wind slippage correction is also removed:

$U_g \approx (U_d - U_e - U_s)_f$

The RMS difference from the geostrophy derived from altimetry is checked to estimate the error reduction (Table 5, compare line 1 with line 3 and line 2 with line 4) when the undrogued drifters are corrected from direct wind slippage.

Drogue off	Correlation	RMS difference (m/s)	RMS difference/RMS geost (%)
Ug vs Ugeo	0.75	0.13	78.9
Vg vs Vgeo	0.69	0.13	94.38
Ug-Us vs Ugeo	0.77	0.12	66.59
Vg-Vs vs Vgeo	0.71	0.12	84.46

Table 5: Statistical validation results of the undrogued drifter’s velocity Ug/Vg versus satellite altimeter derived geostrophy Ugeo/Vgeo when the data is corrected or not from the wind-slippage Us/Vs. Statistics have been computed on 20 076 597 data.

5. ARGO dataset: obs-ins_glo_phy-cur_my_argo_irr

The Argo currents dataset is derived from the Andro trajectory dataset (Ollitraut et al., 2022). The Andro trajectories are a full reprocessing of Argo floats raw data. The raw data are the original data received from satellite, decoded and quality controlled into a trajectory file. Each trajectory is checked by a data scientist. The positions measured during the surface drift are used to estimate the velocities at the surface and at the level of the Argo parking pressure (around 1000dbar).

The Andro-Argo dataset was validated with maps and statistics (global map of deep-ocean currents (1000 meters deep), global map of ocean surface current, Temporal and Depth coverage, Histogram of current values, Trajectory maps and Current time series of individual floats)

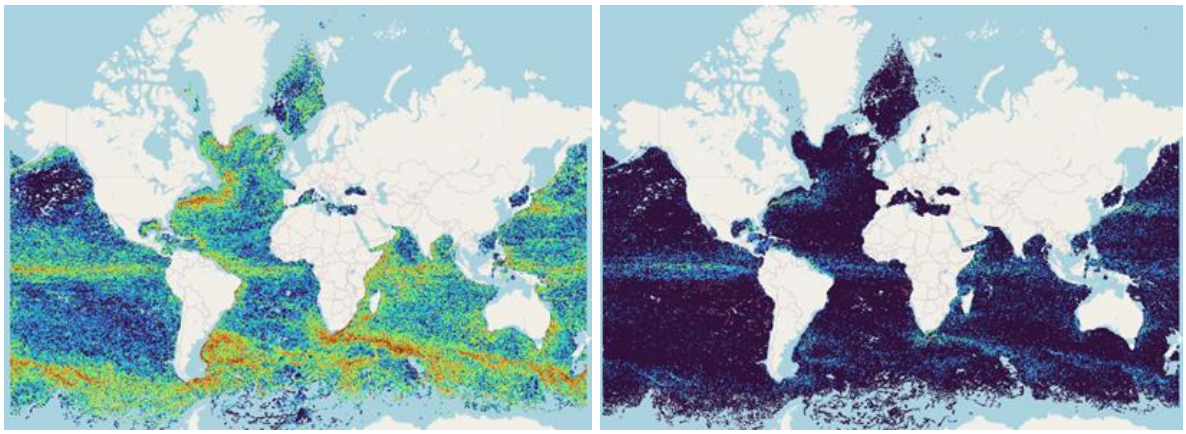

Figure 3: Density map of Argo each dot represents the ocean current from one cycle (typically 10 days for deep currents and a few hours at the surface) from one float. (left panel) deep current observations, (right panel) surface current observations. . Colour scale from dark blue dot: 0 meter/second, to red dot: 2 m/s.

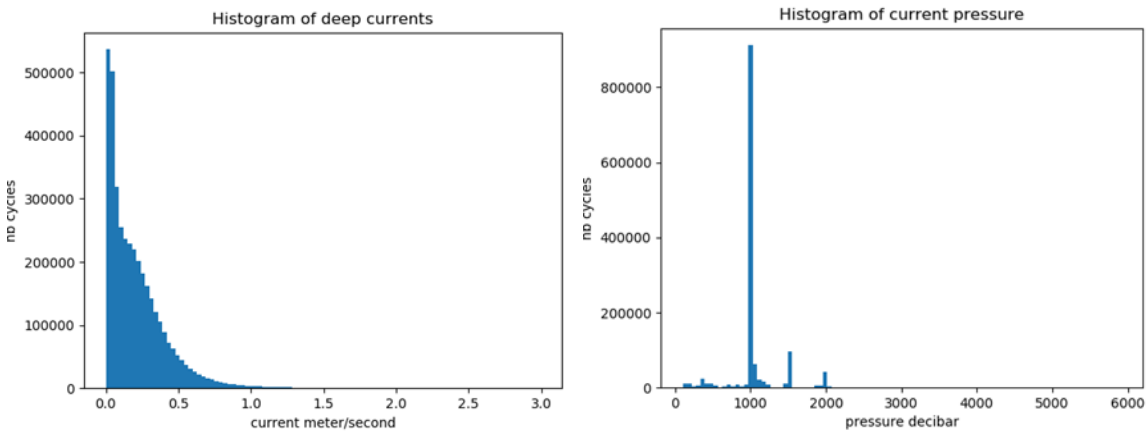

Figure 4: Argo-Andro histogram of deep ocean current and parking pressure.

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