QUALITY INFORMATION DOCUMENT

For REProcessed IN SITU product (ADCP):

INSITU_GLO_UV_L2_REP_OBSERVATIONS_013_044
GLOBAL_REP_ADCP

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CHANGE RECORD

Issue	Date	§	Description of Change	Author	Checked By
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I EXECUTIVE SUMMARY

I.1 Products covered by this document

The document describes the Quality of the Delayed Mode or REProcessed (REP) ADCP product delivered by the CMEMS In Situ Thematic Assembly Center (In Situ TAC or INSTAC).

The following document applies to the following list of products described in CMEMS Catalogue:

Short Description	Product code	Area	Delivery Time
GLOBAL REP	INSITU_GLO_UV_L2_REP_OBSERVATIONS_013_044	GLOBAL	Twice a year since 2020

Table 1: List of INSTAC products for which this document applies.

This product integrate observation aggregated and validated from the Regional EuroGOOS consortium (Arctic-ROOS, BOOS, NOOS, IBI-ROOS, MONGOOS) and Black Sea GOOS as well as from National Data Centers (NODCs), JCOMM global systems (Argo, GOSUD, OceanSITES, GTSPP, DBCP) and the Global telecommunication system (GTS) used by the Met Offices.

Data are distributed on full level (no interpolation). They are available in a dedicated directory to ADCP (INSITU_GLO_ADCP_REP_OBSERVATIONS_013_044) of CMEMS Dissemination System in one file per platform. This directory is updated twice a year since 2020.

Four of the INSTAC regions (BAL, NWS, IBI and MED) are performing their own ADCP validation over the data contained in their respective files ("BO_", "NO_", "IR_" and "MO_"). These REP files are distributed also in the corresponding REP regional directories. The GLOBAL Production Unit gets these files together with the validated "GL_" files and distributes the final ADCPS product in the dedicated directory mentioned above.

I.2 Summary of the results

The ADCP observations are aggregated by the INSTAC and the data set is provided to users together with metadata information on the platforms that were used to perform the observations. The quality of the observation is tested using automatic procedures, visual inspection and comparison to other sources. Quality flags are positioned to inform the users of the level of confidence attached to the observations (see Table 4).

The INSTAC relies on observing systems maintained by institutes that are not part of the "in situ TAC" and CMEMS service is not contributing to the maintenance and setting up of the observing systems it uses.

- The platforms mostly used to measure ADCP are research vessels. There are deep water platforms but also coastal stations that are affected by local bathymetry and coastal processes, so it should be considered.
- In some regions the number of available platforms is on a critical low level to provide an adequate representative overall view of the state of the ocean. Some of the areas are clearly undersampled and in some other data is not available. The INSTAC is dedicating a great effort

to gather all the ADCP observations that will continue in the following months for both operational stations and historical data sets.

- The percentage of data flagged as 'good data' is quite high (over 95%).
- The temporal coverage of ADCP measurements starts with a low and stable number of platforms in the early 90's. At the beginning of the second decade (about 2002) it starts to grow, and, during the last five years, the increase is higher due to the effort in integration of new providers and stations.

I.3 Estimated Accuracy Numbers

The following table summarizes the accuracy of the measurements 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" (see Table 4) 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.

Technical Specifications

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 2. Accuracy numbers for measured time series and ADCP estimated parameters for different ADCP sensors.

II PRODUCTION SUBSYSTEM DESCRIPTION

The INS-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 doesn't deploy any observing system and relies on data that are obtained exclusively funded by other sources than CMEMS.

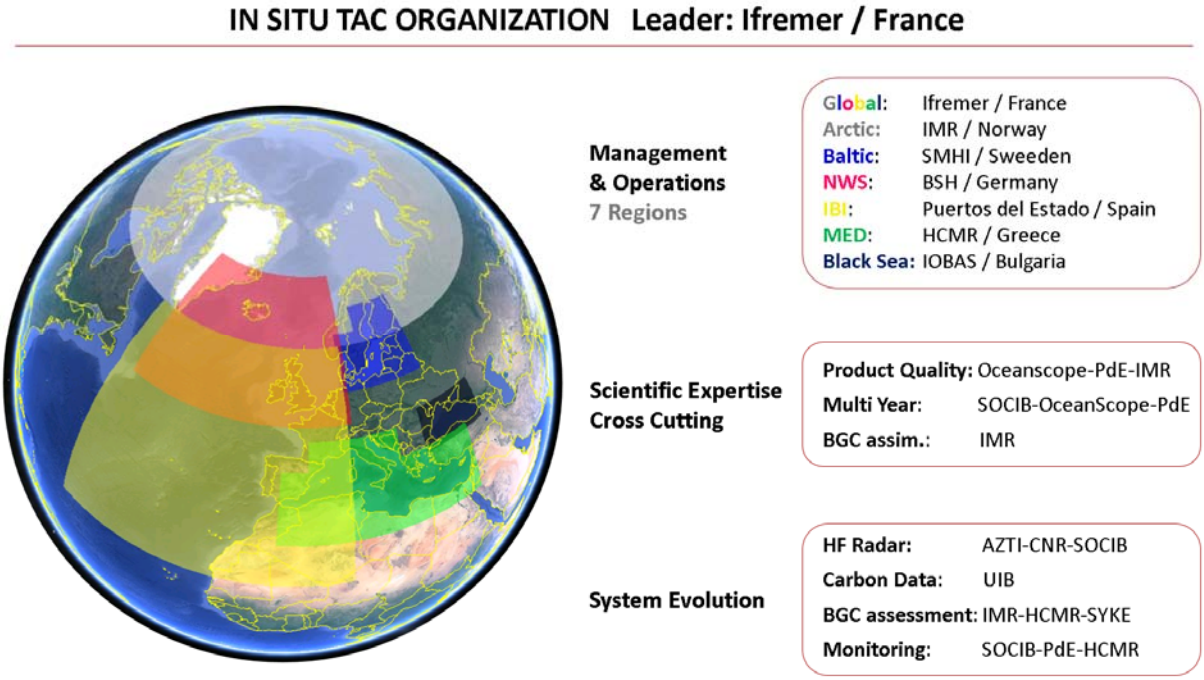

Figure 1 : The INSTAC components

The INSTAC architecture is decentralized. However, 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 INSTAC are summarized in Figure 2.

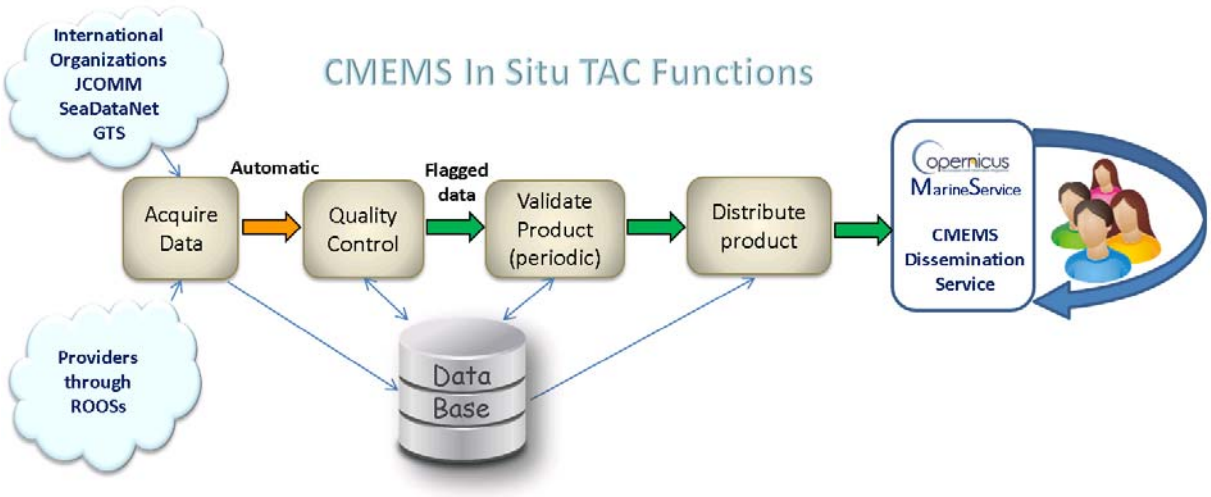

Figure 2: Functions implemented by an INSTAC component

Each region implements the four core functions:

- Data Acquisition: Collect data available on international networks or through collaboration with regional partners
- Data Quality control: Apply automatic quality controls (QC) that have been agreed at the INSTAC level. These procedures are defined by parameter, elaborated in coherence with international agreement, in particular SeaDataNet, and documented in CMEMS Catalogue.
- 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 QC.
- Product distribution: Make the data available through CMEMS Dissemination Service.

Each region has organized the activities according to the expertise and background in data management for operational oceanography.

1. The four functions are implemented in one institute per region.
2. Acquisition and QC is done by platforms and one institute takes care of the validation and distribution is centralized.

In any case, the Global component of the INSTAC collects the data from the regional components and integrates them into the global product acting as a backup of the regional centres. The main distribution channel for the INSTAC is authenticated FTP. OGC viewing service (WMS) and subsetter access are developed within CMEMS.

III VALIDATION FRAMEWORK

The INSTAC is, in contrast to the MFCs, dedicated to assuring the accuracy of in situ observations through mainly two validation channels. These two channels consist of the real time quality control (RTQC) of the in situ observations and the validation in delayed mode and assessment of the product out of the quality controlled data sets.

The assessment performed by providers is not described in this document because it is different for each platform and variable in the time. Most of the times they are not even documented in the metadata attached to the provided data.

I.1 Real-time quality control

For the first channel, a set of metrics were developed, and it is illustrated in Table 3. These metrics are described in detail in the document for the Real Time Quality Control for ADCPs: Copernicus Marine In Situ TAC Data Management Team (2016).

By performing the QC tests, the QC flags proposed by the method are assigned to the data. The QC flag scale is presented in Table 4.

Short description	Applicability of metrics for Time Series
Impossible date	X
Impossible location	X
Position on land	
Global range	X
Regional range	X
Pressure increase	
Spike	X
Stuck value	X
Grey list	
Sensor Drift	
Rate of change	

Table 3: Metrics used for the quality control of ADCP data

Code	Meaning	Comment
0	No QC was performed	-
1	Good data	All real-time QC tests passed.
2	Probably good data	-
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	Not used	-
7	Not used	-
8	Interpolated value	Missing data may be interpolated from neighbouring data in space or time.
9	Missing value	-

Table 4: Quality control flag scale

I.2 Delayed mode quality control : Cascade data processing

The second channel consists of a series of additional procedures that have been performed of on the REP product and are listed below:

- **Automatic delayed mode quality checks.**

  Some data is recovered in delayed mode (not transmitted in real time). The checks performed are the same as in real time (Table 3). It allows a better detection of spikes due to it's not performed over the last value received, but we have the previous and the next value.

- **Visual inspection of ADCP parameters series.**

Each vessel transect is checked by a specialist with the Cascade software.

The data was gathered by Ifremer and SHOM oceanographic vessels. The following vessels are with an Acoustic Doppler Current Profiler Ocean Surveyor 150 kHz (OS175) and an Acoustic Doppler Current Profiler Ocean Surveyor 38 kHz (OS38) : the Pourquoi Pas?, the Atalante, the Beautemps-Beaupré, the Thalassa. The Suroît is equipped with an Acoustic Doppler Current Profiler Broad Band 150 kHz (BB150). The data is controlled and validated by SISMER according to a pre-defined protocol.

An A.D.C.P 150kHz is an Acoustic Doppler Current Profiler built by the American company R.D.I (http://www.rdinstruments.com/). With each acoustic impulse, the current in the entire water column is measured down to depths of 200m. An A.D.C.P 38kHz is an Acoustic Doppler Current Profiler built by the American company R.D.I (http://www.rdinstruments.com/). With each acoustic impulse, the current in the entire water column is measured down to depths of 850m. Both are attached to the hull of the vessel. They simultaneously emit four acoustic beams, the main frequency

of which is around 38 kHz or 150kHz. These beams are oriented at 30° from the vertical of the ship. The acoustic wave emitted is reflected on the substance in suspension and is shifted proportionately to the speed of the reflectors (the Doppler effect). These particles are assumed to move at the speed of the water mass. A current is thus calculated in the direction of each beam. As the orientation of the sensor in relation to the ship, the orientation of the ship in relation to a point of reference on land, and the speed of the vessel are known, an absolute current can be calculated.

The data is processed using CASCADE (Automated chain for following embedded acoustic Doppler current meters) software. CASCADE is a piece of validation and visualization software for ADCP hull measurements initiate in 1998 at LPO (Laboratory of Ocean Physics - Ifremer) to meet its research needs to processing and analyzing ADCP measurements and has been updated regularly. It was then implemented operationally by the SISMER data centre. It is comprised of a set of matlab programmes.

After processing ADCP data with CASCADE software, data is available and downloadable in Netcdf format. For a cruise, we will find: 1) 3 Netcdf files (or more, if different modes of acquisition were analyzed with CASCADE) - 1 raw data file * _0_osite.nc: It represents the concatenation of STA (or LTA) files from VMDAS. The currents are absolute or relative currents, expressed in the geographical reference and georeferenced. They are accompanied by additional measures to evaluate these data (amplitude of the echo received, estimation of the error, measurements of attitude and speed of ship, speed on the bottom). It therefore contains raw U and V data flown without modification of pitch, amplitude or alignment. - 1 data file (1E.nc or 0E.nc), intermediate between the raw data and the final filtered data - they are validated, corrected and assigned quality information - 1 validated data file (aggregated) * _fhv * .nc: It represents validated, corrected, quality information (flag) and filtered data. 2) 1 compressed file (in UNIX.tar format) of figures from the CASCADE software: This file contains figures (in .png format) of vectors, bathymetry, road, various plots, ... 3) A record of the treatment available on Nautilus on the relevant campaign page. The document contains all campaigns processed for a year and by ship if they are public. And for each campaign, the images collected during data processing with the CASCADE software (trip, bathymetry map, quality of data received, percentages of good data, vector plots) and problems encountered.

Guided by the necessity of using high-quality current data for its research projects, the Laboratory of Physical Oceanography developed a software called CASCADE to process and analyse the data provided by the Acoustic Doppler Current Profilers mounted on the hull of the research ships (VMADCP or SADCP). This software has been used for several years in an operationnal context by the SISMER data center.

Following the recent advances in ADCP technology, CASCADE is composed of 2 parts:

- **CASCADE_TRAITEMENT**: it is used for old VMADCP (narrow and broad bands) and converts raw binary datafiles from the acquisition RDI software **Transec** (*r.* et *n.*) into a single NetCDF survey file after incorporating the best navigation data and averaging over a few tens of pings (20 to 50 typically). The resulting data can then be processed further using CASCADE_EXPLOITATION (see below).
  Since very few ADCPs of this type are still operating, and since this part of the software has only be tested on matlab R14-sp3 (7.1.0), CASCADE_TRAITEMENT is not distributed.
- **CASCADE_EXPLOITATION**: this part is available below. It can be used easily on *STA or *LTA files generated by the acquisition RDI software **VMDAS** (in terrestrial coordinates).
  CASCADE_EXPLOITATION converts the *TA files in a single NetCDF survey file and cleans the data according to adjustable parameters. It is possible to diagnose and correct for a misalignment or a bad amplitude of the ADCP. It also adds useful auxillary variables: the barotropic tide and the bathymetry. Data can then be filtered or averaged along specific sections or stations. Graphic outputs of many kinds are displayed and saved to check the processing and illustrate a report.

This version of CASCADE_EXPLOITATION requires at least Matlab 2008b (7.7.0) since it uses the NetCDF toolbox provided by Matlab. The necessary files are:

- Software (843 Ko)
- Bathymetry files (329 Mo)
- Toolboxes (218Mo)
- Documentation (still in French, sorry! 5.8 Mo)

Tide binary files are not provided with the software. They can be downloaded on http://volkov.oce.orst.edu/tides/global.html and using them must be acknowledged by the proper reference. The lastest high resolution database can be downloaded at ftp://ftp.oce.orst.edu/pub/lana/TPXO8_compact/tpxo8_atlas_compact.tar.Z. The downloaded binary files (*tpxo8.0) must be copied in the folder "./exploitation/tide/model". Please edit the texte file "Model_tpxo8.0" to verify the path to the 3 data files (remove "DATA/" is necessary).

To launch the English version of CASCADE, use the following command in matlab : ce('en')

What is included in the files above but not proper to CASCADE:

m_map 1.4h was downloaded from http://www.eos.ubc.ca/~rich/map.html. Note that m_vec.m was corrected for a minor bug.

High resolution coastlines are also included (in m_map1.4/private), and were downloaded from http://www.ngdc.noaa.gov/mgg/shorelines/gshhs.html

Bathymetric files must be copied in "./exploitation/bathymetrie", unless otherwise precised in the "Configuration" tab of CASCADE_EXPLOITATION (see the documentation)

This software was tested on Linux, Windows and Mac. It is made available to the research community for free, but we cannot guarantee that it is free of bugs. For further information, contact: Catherine.Kermabon@ifremer.fr and Philippe.Le.Bot@ifremer.fr

References:

- Le Bot, P., C. Kermabon, P. Lherminier, F. Gaillard (2011): CASCADE V6.1: Logiciel de validation et de visualisation des mesures ADCP de coque. Rapport technique OPS/LPO 11-01. Ifremer, Centre de Brest, France.
- Lherminier, Pascale, Herle Mercier, Thierry Huck, Claire Gourcuff, Fiz F. Perez, Pascal Morin, Artem Sarafanov, Anastasia Falina (2010): The Atlantic Meridional Overturning Circulation and the subpolar gyre observed at the A25-OVIDE section in June 2002 and 2004. Deep Sea Research Part I: Oceanographic Research Papers, Volume 57, Issue 11, November 2010, Pages 1374-1391, DOI: 10.1016/j.dsr.2010.07.009.
- Gaillard, F., H. Mercier and C. Kermabon, 2005: A synthesis of POMME physical data set: one year monitoring of the upper layer. J. Geophys. Res., 110, C07S07, doi:10.1029/2004JC002764

Links:

- Centre français de données océanographiques: (Ifremer-SISMER)
- Compte-rendus du groupe de travail VMADCP français
- Base de données informative, relative au suivi et à la gestion des capteurs et systèmes d'acquisition: Ifremer-MADIDA
- La flotte océanographique d'Ifremer
- RDI Ocean Surveyor ADCP

IV VALIDATION RESULTS

IV.1 Coverage in time of the ADCP product

The following figures give an overview of the number of ADCP measurements of 11 complete years of observations (one year = 365 days for one platform).

A total of 6 research vessels reported 310 million current observations.

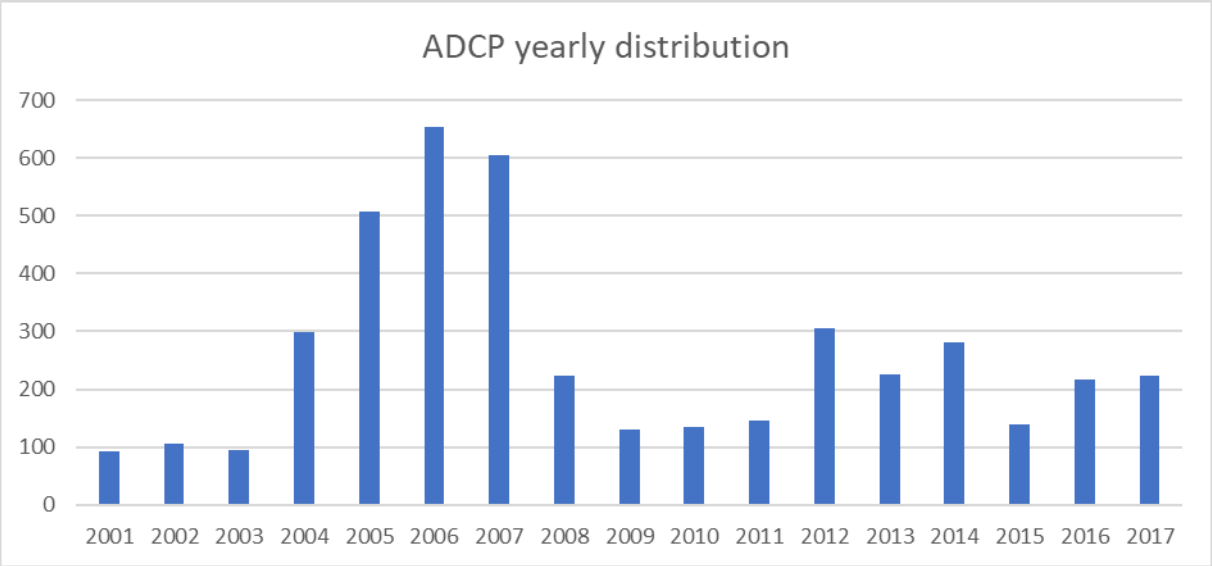

Figure 3: Bar diagram providing the number of ADCP measurements per year since 2001 for the whole GLOBAL in situ TAC, figures are in platform-day (one platform one day = +1)

IV.2 Coverage in space of the ADCPS product

The following figure provides a synoptic view of the coverage in space of the ADCP product within “in situ TAC”.

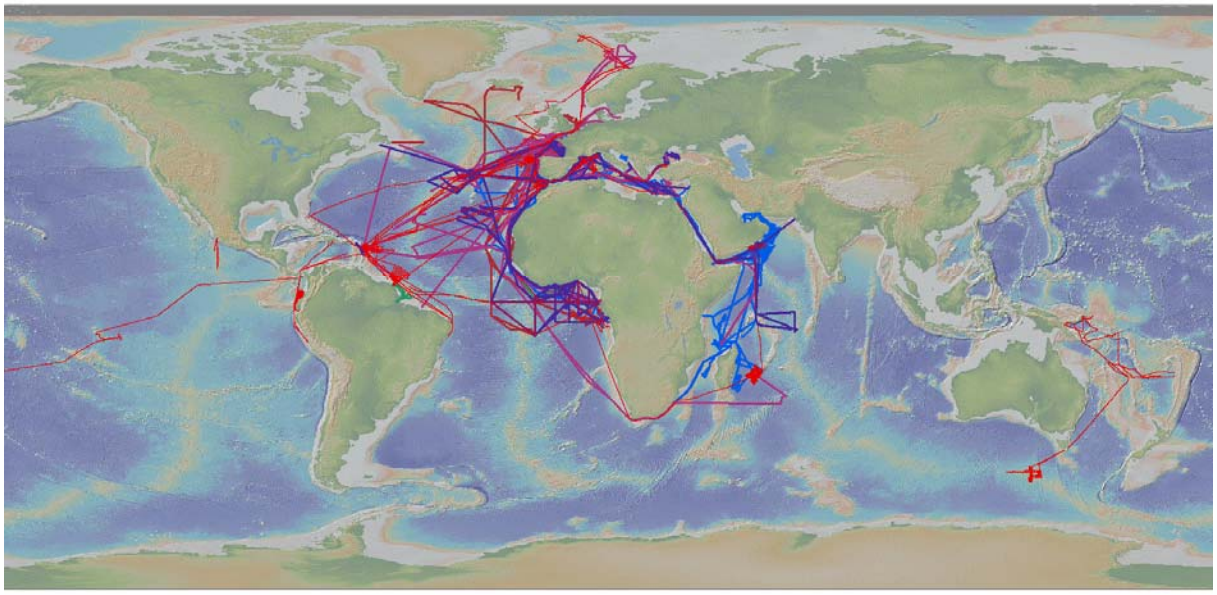

Figure 9. Map of in situ TAC vessel ADCP observations

PLATFORM_CODE	NAME	NB_DAY_OBS
FNCM	L'ATALANTE	1271
FZVN	LE SUROIT	924
FABB	BEAUTEMPS-BEAUPRE	907
FMCY	POURQUOI PAS?	781
FNFP	THALASSA	445
FNUR	ANTEA	49

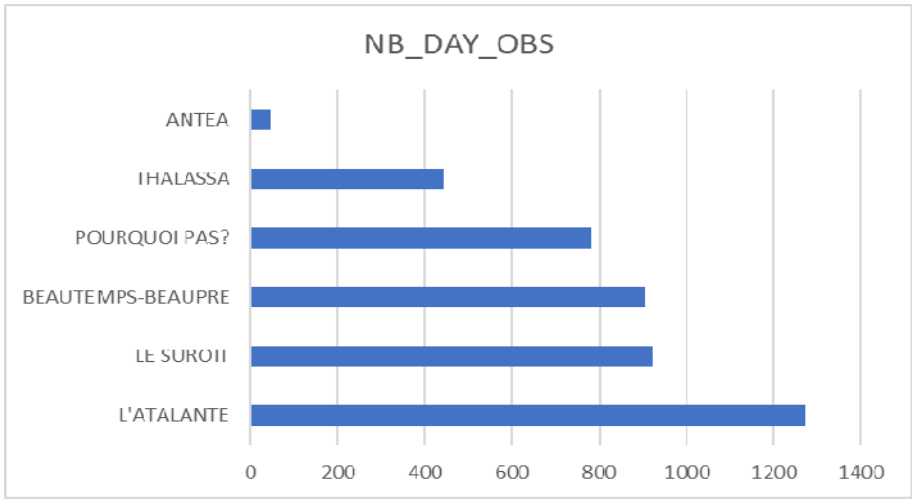

Figure 10. Distribution per Research Vessel of ADCP days of observations

IV.3 Information on the quality of the data

These diagrams give a synoptic view on the quality of the data available in the historical product per region.

The output data quality information about ADCP provided by the GLOBAL INSTAC is displayed in the Figure 4, providing the percentage of observations flagged with a good data quality flag.

After quality control, 95% of ADCP observations are flagged as ‘good data’; 5% of ADCP observations are flagged ‘bad data’.

QC flag	QC label	nb observation
4	bad data	15 217 270
1	good data	295 290 446
nb observations		**310 507 716**

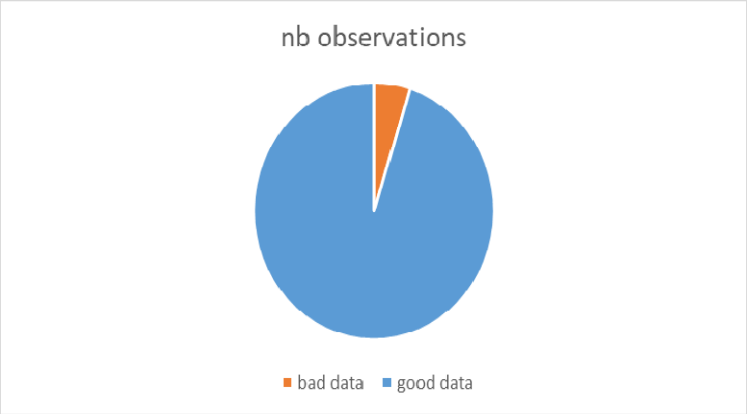

Figure 4. ADCP observations flags: 95% ´good data’, 5% of ‘bad data’

V REFERENCES

- Le Bot, P., C. Kermabon, P. Lherminier, F. Gaillard (2011): CASCADE V6.1: Logiciel de validation et de visualisation des mesures ADCP de coque. Rapport technique OPS/LPO 11-01. Ifremer, Centre de Brest, France.
- Lherminier, Pascale, Herle Mercier, Thierry Huck, Claire Gourcuff, Fiz F. Perez, Pascal Morin, Artem Sarafanov, Anastasia Falina (2010): The Atlantic Meridional Overturning Circulation and the subpolar gyre observed at the A25-OVIDE section in June 2002 and 2004. Deep Sea Research Part I: Oceanographic Research Papers, Volume 57, Issue 11, November 2010, Pages 1374-1391, DOI: 10.1016/j.dsr.2010.07.009.
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    - ADCP data from French research data quality control report Pourquoi-Pas? https://www.ifremer.fr/datasismer/campagnes/documents/ADCPPP2018.pdf
    - ALIS https://www.ifremer.fr/datasismer/campagnes/documents/ADCPALIS2018.pdf
    - Thalassa https://www.ifremer.fr/datasismer/campagnes/documents/ADCPTHALASSA2018.pdf
    - Marion-Dufresnes https://www.ifremer.fr/datasismer/campagnes/documents/ADCPMD2018.pdf