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European Research Infrastructure
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Consisting of:

Organisation/Natural person	Represented by	Statute	Contributing entities[1]
Euro-Argo ERIC	N/A	Coordinator	N/A
The French Republic	Ifremer	Member	SHOM, INSU/CNRS, Meteo-France, IRD, IPEV
The Federal Republic of Germany	BSH	Member	GEOMAR, University of Hamburg, Alfred-Wegener-Institute for Polar and Marine Research (AWI), Institute for Chemistry and Biology of the Marine Environment (ICBM)
The Hellenic Republic	HCMR	Member	N/A
The Italian Republic	OGS	Member	N/A
The Kingdom of the Netherlands	KNMI	Member	N/A
The Republic of Finland	FMI	Member	N/A
The Republic of Bulgaria	IO-BAS	Member	University of Sofia, National Institute of Meteorology and Hydrology
The United Kingdom of Great Britain and Northern Ireland	Met Office	Member	NOCS, BODC, PML
The Kingdom of Spain	IEO and SOCIB	Member	N/A
The Kingdom of Norway	IMR	Member	N/A
The Republic of Ireland	MI	Member	Marine Institute
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[1] As indicated in the "Technical and Scientific description of the Euro-Argo ERIC" April 2018 attached to the Euro-Argo Statutes.

[2] Integers correspond to submitted versions.

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1. INTRODUCTION

This document summarises the activities on Real-Time (RT) processing of the MOCCA fleet. **Data processing for MOCCA floats is compliant and makes use of the Argo Data System. It is organised through Euro-Argo data centres.**

1.1. Argo Data System Overview

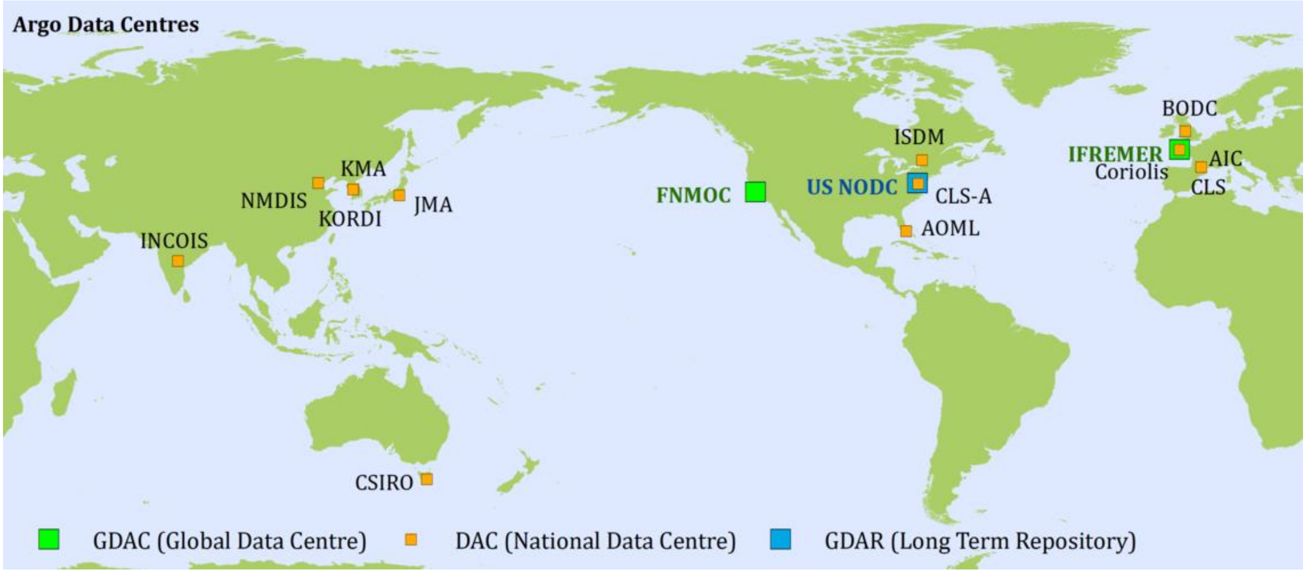

Figure 1: Argo Data System (© Argo Information Centre)

The international Argo Data System is based on two Global Data Assembly Centres, a series of 11 national Data Assembly Centres and several Argo Regional Centres. Their functions are summarised below:

- **GDACs** (Global Data Assembly Centres), located at Ifremer/France and FNMOC/USA, are in charge of collecting the processed Argo data from the 11 DACs and to provide users with access to the best version of an Argo profile. Data are available, in a standard NetCDF format both on FTP and WWW. The two GDACs synchronise their database every day.

- **DACs** (Data Assembly Centres), they receive the data from the satellite operators, decode and quality control the data according to a set of 19 real time automatic tests agreed by the international Argo programme. Erroneous data are flagged, corrected where possible and then passed to the two GDACs and to the WMO GTS. The GTS data stream does not presently include quality flags and bad data and grey-listed data are not transmitted on the GTS.

- **ARCs** (Argo Regional Centres) provide wide expertise on specific geographical ocean regions in order to provide the most comprehensive data sets (including non-Argo data) of the highest quality. ARCs provide three main services: act as the delayed mode operator for "orphan" floats (i.e. float deployed by an institute that does not have a capability to perform delayed mode QC); gather the recent complementary in situ ship-based data needed for delayed mode validation; check the overall consistency of the Argo dataset in an area.

1.2. Euro-Argo Data Centres

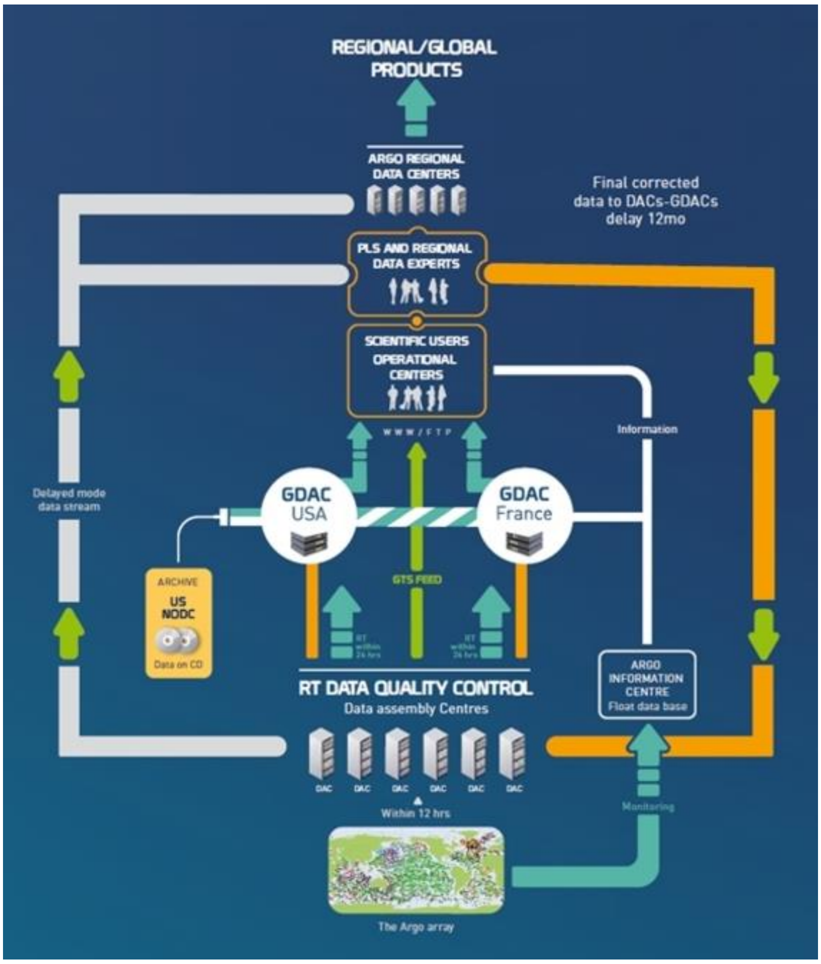

Figure 2: Argo Data Flow (© Argo Information Centre)

The Euro-Argo RI plays an active role in Argo data management:

- France **(Ifremer) hosts one of the two Global Data Assembly Centres (GDAC)**

- **Two DACs are operated by France (Coriolis) and UK (BODC)**:

    - The French DAC: The French Argo Data Assembly Centre, Coriolis, which is located within Ifremer-Brest and operated by Ifremer with support of SHOM, processes float data deployed by France and from other European (Germany, Spain, Netherlands, Norway, Italy, Finland, Greece, Bulgaria) and several non-European countries (e.g. Chile, Mexico).
    - The UK DAC: The UK Argo Data Assembly Centre, which is established at BODC, processes all UK, Irish and Mauritian float data.

- Euro-Argo partners lead and contribute to three ARCs:

    - Atlantic ARC (NA-ARC): France has taken the lead in establishing the NA-ARC, which is a collaborative effort between Germany (IFM-HH, BSH), Spain (IEO), Italy (OGS), Netherlands (KNMI), UK (NOCS, UKHO), Ireland (IMR), Norway (IMR), Canada (DFO), and USA (AOML). Within the NA-ARC BSH and Hamburg University coordinate the activities in the Nordic Seas.

- Mediterranean and Black Seas ARC (Med-ARC): Italy (OGS) has taken the lead in establishing the MED-ARC, which is a collaborative effort between Greece (HCMR), Spain (IEO), France (IFREMER, UPMC/LOV), Bulgaria (IOBAS, USOF).

- Southern Ocean ARC (SOARC): UK has taken the lead in establishing the SOARC. This is a collaborative effort between BODC, CSIRO (Australia), BSH (Germany) and a representative from the SOCCOM project partners (USA).

1.3. Real-Time and Delayed-Mode processing

RT processing is carried out by DACs. Procedures flag the gross errors in the data but some subtle errors may remain like sensor drift, float trajectory problems, etc. Elaborate procedures have been devised, based on statistical methods, and scientific expertise from principal investigators (PIs). The procedures are constantly assessed and updated as necessary. A minimum of 1 year of data is needed before the delayed mode processing can be performed.

2. MOCCA REAL-TIME PROCESSING

As agreed in the project Grant Agreement, MOCCA RT data processing is done by the Euro-Argo DACs (Ifremer/Coriolis, NERC/BODC jointly with the Met Office) and GDAC (Ifremer). **The number of floats is shared equally between BODC and Coriolis.**

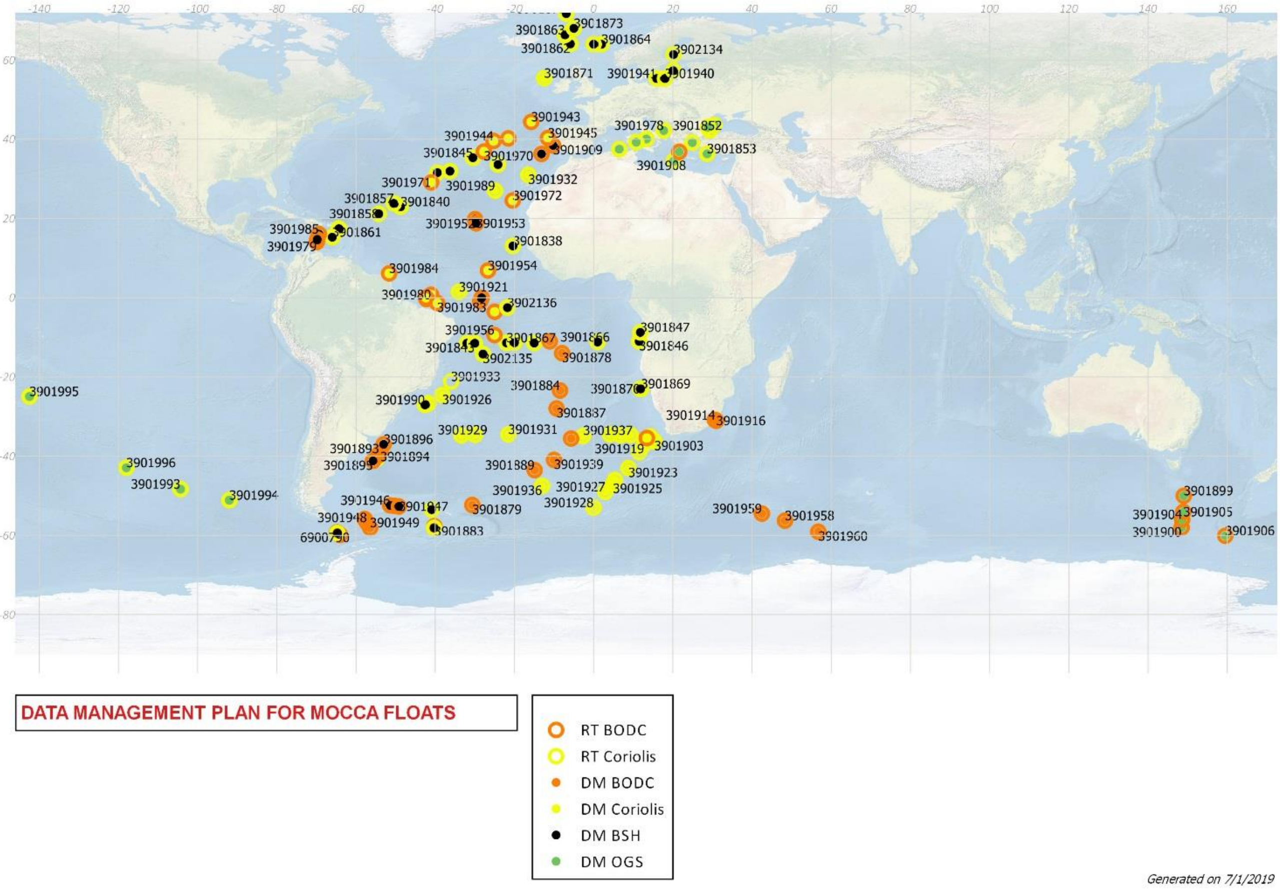

Figure 3: Geographic partition of RT processing by DAC. Points show deployment locations.

Ifremer is also integrating all the MOCCA data into the GDAC and provide users access mode adapted to different modes of use: ftp access allowing data download for operational users, and Web access allowing data visualisation, selection and extraction with specific temporal and geographical criteria specified by users.

Real-Time data processing is applied on the MOCCA fleet according the Argo standard procedures. See Argo Data Management (*http://www.argodatamgt.org/*) for further details.

The Real-Time processing phase started in May 2016 with the deployments of first floats. The processing chain developed by Ifremer is available to the Euro-Argo and Argo communities. Ifremer/Coriolis DAC (Data Assembly Centre) implemented the chain for processing the first floats in May 2016. In December 2016, the integration of the processing chain at BODC was complete, and BODC processed their first MOCCA floats.

Coriolis MOCCA float data processing chain:
http://dx.doi.org/10.17882/45589

The processing chain has been updated to enable the handling of floats with **under-ice capabilities**: some of the MOCCA floats have been deployed or drifted near Arctic and Antarctic ice edges. These floats were upgraded with a firmware that allows the detection of ice at the surface during the ascent of the float cycle (through a temperature threshold). When triggered, this ice-avoidance algorithm (ISA) induces a buoyancy inversion of the float, that descents back to its parking depth until the next possible ascent to the surface (ice-free). The collected data under ice is stored into internal memory and transmitted during the next transmission session. This feature required a significant redesign of the Coriolis processing chain, but the added value of data collection in high-latitude regions is clearly stated in many of the observation networks including Argo, and is a key point of Euro-Argo strategy document. (Strategy for evolution of Argo in Europe. EA-2016-ERIC-STRAT. https://doi.org/10.13155/48526)

BODC/Met Office float data processing chain

As noted above, in December 2016, BODC processed their first MOCCA floats, delivering QC'd realtime data to the GDACs (in netCDF) and to the Met Office (in TESAC and BUFR) for distribution on the GTS. From September 2017 the Met Office have operated a system to collect the netCDF files from BODC's SFTP server and to convert these into BUFR using a new Python2.7 netCDF to BUFR converter, the system is run automatically every six hours. After 10 months of parallel running, in June 2018, BODC generation of BUFR messages ceased and only Met Office generated BUFR messages are now distributed on to the GTS. In July 2018 the issue of TESAC messages to the GTS was also stopped. Throughput from the Met Office netCDF to BUFR converted is regularly monitored in case of a system failure. During the year specifications have been developed for the addition of supplementary temperature and salinity, and dissolved oxygen profiles into the BUFR formatted data.

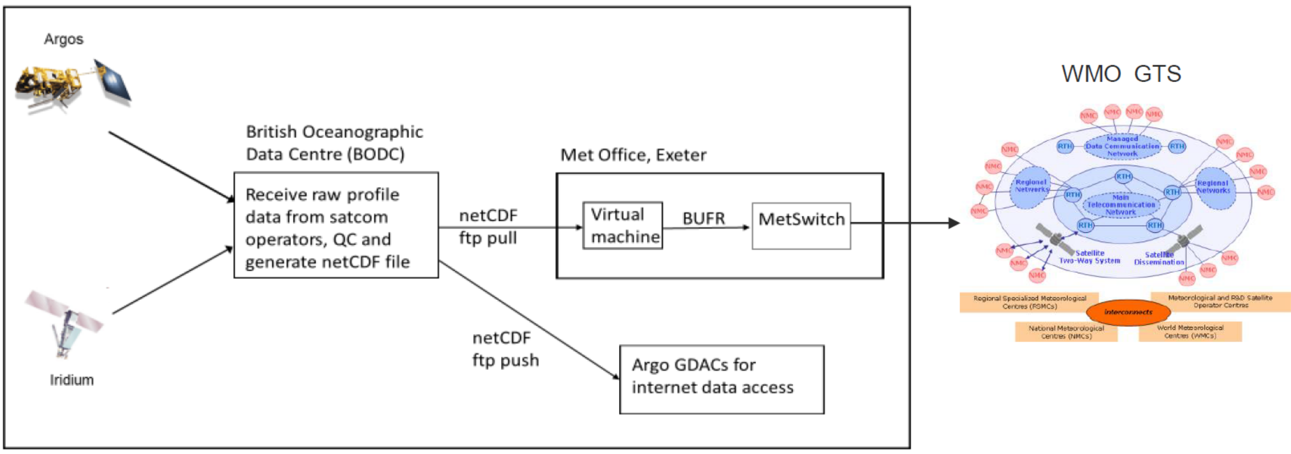

Figure 4: Argo netCDF to BUFR processing system (© Met Office)

All MOCCA data are accessible through the Argo Global Data Centre: *ftp://ftp.ifremer.fr/ifremer/argo* and at *https://fleetmonitoring.euro-argo.eu/dashboard* (search for MOCCA group using the magnifying glass button in the top left corner).

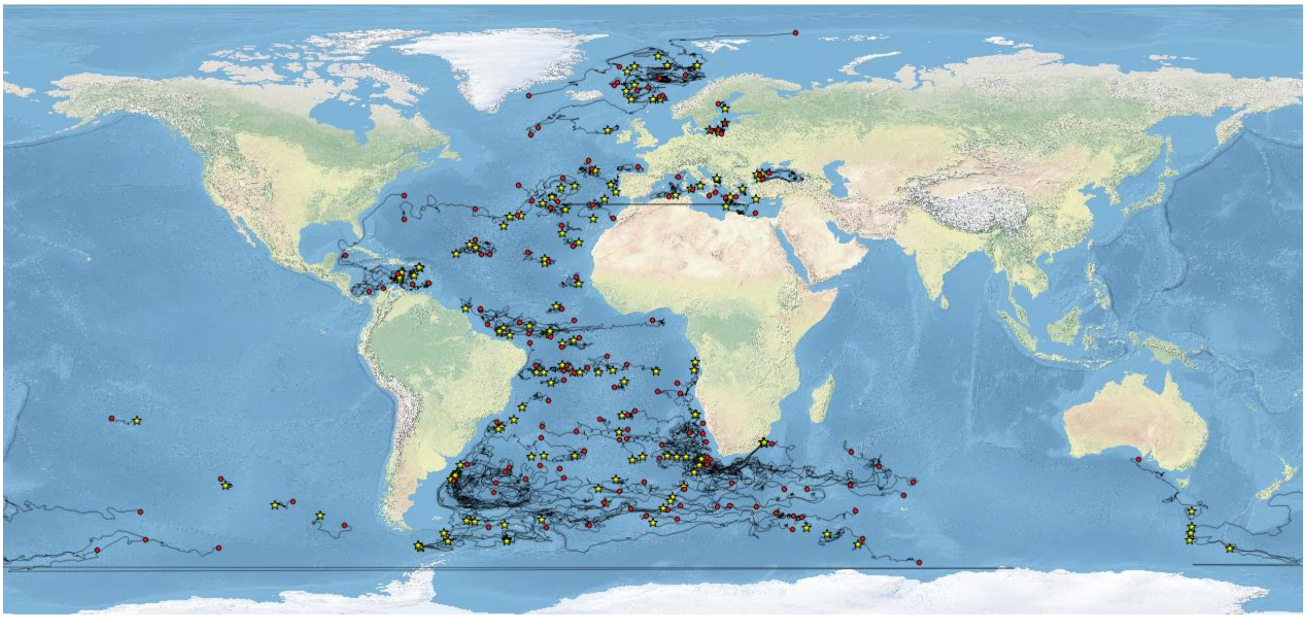

Figure 5: MOCCA deployment locations (yellow stars), latest locations (red circle) and trajectories of floats (black line).

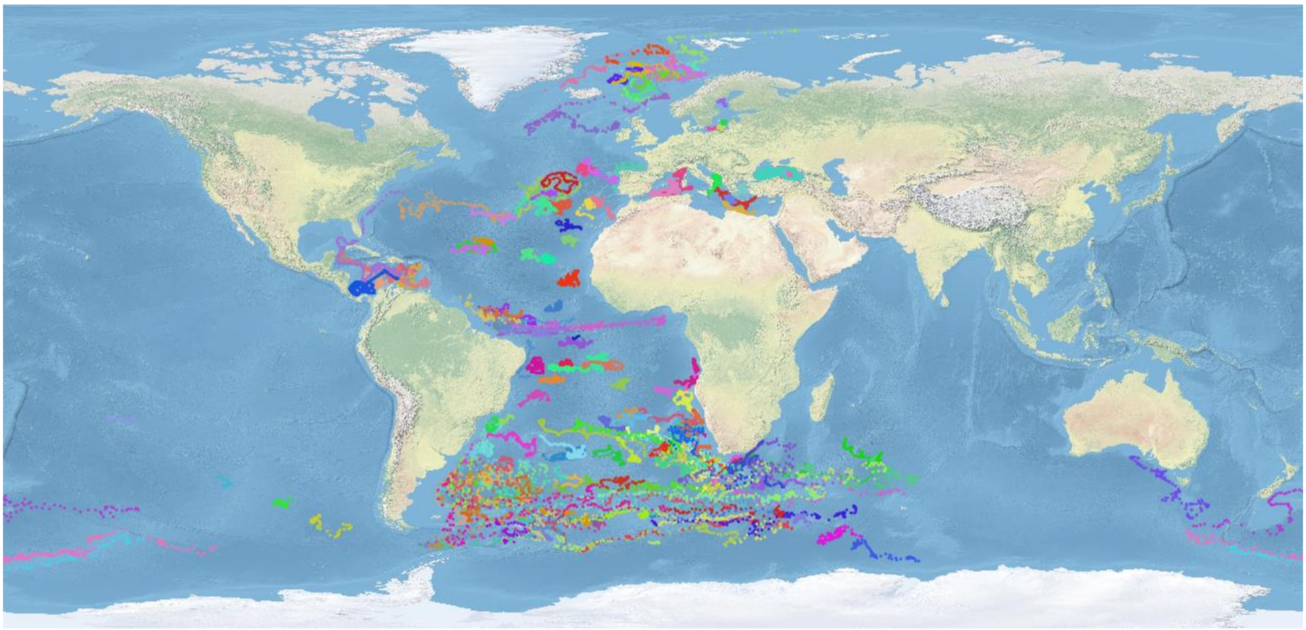

Figure 6: MOCCA observation locations (1 colour per float).

2.1. Workflow

2.1.1. Ifremer/Coriolis

Coriolis internal procedures include:

- Loading of float metadata, including configuration and technical metadata, to Coriolis database for enabling automated data processing;
- Incoming data is saved to a secure archive;
- The MATLAB chain is used to process raw data, generate Argo netCDF files and apply the RTQC tests on the profiles;
- The generated NetCDF files are loaded in Coriolis database and send on the Argo GDAC;
- The Coriolis system manages generation of formats for the WMO GTS;
- Operators can change the flags if any alert is detected by the Objective analysis (run daily) by using Scoop3 software;

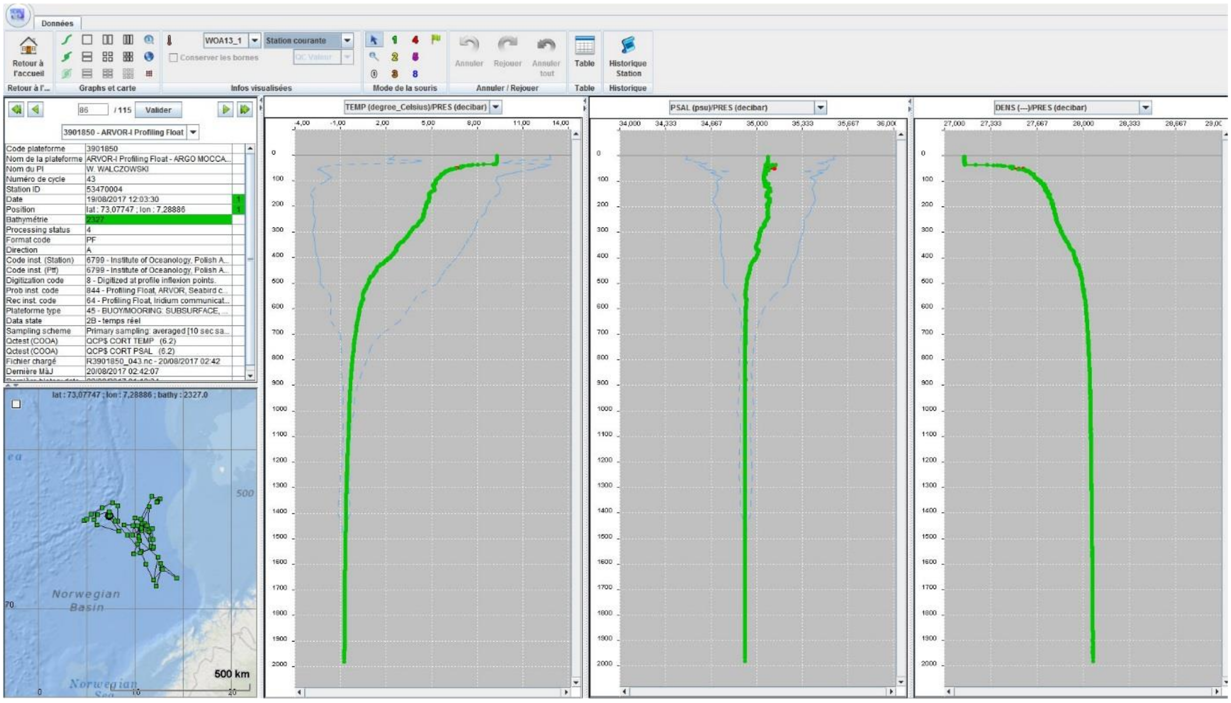

Figure 7: Scoop3 software screenshot

- Daily system monitoring is undertaken by the Coriolis Argo team to identify any processing issues and action undertaken to resolve them when they are encountered.

Figure 8: Ifremer real-time processing dashboard

2.1.2. BODC

BODC internal procedures are pretty similar and include:

- Loading of float metadata, including configuration and technical metadata, to BODC database in advance of float deployment;
- Updating final elements of deployment metadata following deployment enabling automated data processing;
- Incoming data is saved to a secure archive;
- The BODC database is used to automatically generate driver files for automated processing;
- Automated checks are performed to ensure processing is functioning correctly;
- The Coriolis processing stream deployed at BODC is used to process data and generate Argo netCDF files;
- The BODC system manages delivery of netCDF files to the GDACs;
- The Met Office system now manages generation of BUFR files for the WMO GTS;
- Daily system monitoring is undertaken by the BODC Argo team to identify any processing issues and action undertaken to resolve them when they are encountered.

2.1.3. Example for a MOCCA float

As soon as a float is deployed on a scientific cruise or from a ship of opportunity, essential metadata is gathered by the Euro-Argo ERIC technical team. Then a standardised metadata deployment sheet is filled and sent to one of the DACs (Coriolis or BODC), which is used by the MATLAB processing chain.

	A	B	C	D	E	F	G	H
1		SECTION	DIM LEVEL	KEY	VALUE	DEFAULT VALUE	UNIT	SHORT NAME
2	6							
3	6	TITLE	1	TITLE	ARVOR			Title of the deployment file
4	6							
5	6	ARGO PROJECT INFORMATION	1	PI NAME	Romain Cancouët			Name of the Principal Investigator of the float
6	6	ARGO PROJECT INFORMATION	1	PROJECT NAME	MOCCA-EU			Name of the project which operates the profiling float
7	6	ARGO PROJECT INFORMATION	1	FLOAT OWNER	Euro-Argo			The owner of the float (may be different from the data centre and operating institution)
8	6	ARGO PROJECT INFORMATION	1	OPERATING INSTITUTION	Euro-Argo			The operating institution of the float (may be different from the float owner and data
9	6							
10	6	PLATFORM INFORMATION	1	PLATFORM FAMILY	FLOAT			Category of instrument
11	6	PLATFORM INFORMATION	1	PLATFORM TYPE	ARVOR			Type of float
12	6	PLATFORM INFORMATION	1	WMO INST TYPE	844			Instrument type from WMO code table 1770
13	6	PLATFORM INFORMATION	1	PLATFORM MAKER	NKE			Name of the manufacturer
14	6	PLATFORM INFORMATION	1	BATTERY TYPE	Lithium			Describes the type of battery packs in the float
15	6	PLATFORM INFORMATION	1	BATTERY PACKS	2WILPA2234			Configuration of battery packs
16	6	PLATFORM INFORMATION	1	ARGOS PROGRAM	6127			Argos program number
17	6	PLATFORM INFORMATION	1	FLOAT SAIL ID	16FR034			Float sail ID
18	6	PLATFORM INFORMATION	1	FLOAT SERIAL NUMBER	AL2500-16FR034			Float serial number
19	6	PLATFORM INFORMATION	1	CONTROLLER BOARD TYPE PRIMARY	I535			Describes the type of controller board
20	6	PLATFORM INFORMATION	1	CONTROLLER BOARD SERIAL NO PRIMARY	C142455-0115			The serial number for the primary controller board
21	6	PLATFORM INFORMATION	1	WMO NUMBER	3901936			Float WMO number
22	6	PLATFORM INFORMATION	1	ID ARGOS	163468			Float Argos Id (decimal)
23	6	PLATFORM INFORMATION	1	BLUETOOTH NUMBER	2015 09 115			Float bluetooth number
24	6	PLATFORM INFORMATION	1	FIRMWARE VERSION	5605B04			Float firmware version
25	6	PLATFORM INFORMATION	1	STANDARD FORMAT ID	102003			Standardised format number as described in the online reference table:
26	6	PLATFORM INFORMATION	1	MANUAL VERSION	33-16-026			Float manual version date or number
27	6	PLATFORM INFORMATION	1	FIRMWARE_CHECKSUM	DDDF			Firmware checksum (copy of PRE DEPLOY FIRMWARE CHECKSUM parameter value)
28	6	PLATFORM INFORMATION	1	CORIOLIS_DECODER_VERSION	4.52			Coriolis decoder version
29	6							
30	6	DEPLOYMENT CHECKS	1	DEPLOY VISUAL CHECK	OK			Comment after visual inspection of the float
31	6	DEPLOYMENT CHECKS	1	DEPLOY_BALLAST_CHECK	OK			Comment after visual inspection of the ballast
32	6	DEPLOYMENT INFORMATION	1	DEPLOY MISSION	GOUGH			Deployment mission name (cruise name)
33	6	DEPLOYMENT INFORMATION	1	DEPLOY SHIP	RV Agulhas II			Deployment ship name
34	6	DEPLOYMENT INFORMATION	1	DEPLOY OPERATOR NAME	Tahlia Henry			Name of the operator in charge of the deployment
35	6	DEPLOYMENT INFORMATION	1	DEPLOY PROFILE DONE	yes			CTD or XBT profile done during deployment (yes/no)
36	6	DEPLOYMENT INFORMATION	1	DEPLOY MAGNET REMOVAL TIME	20/09/2017 08:05:00			Magnet removal time (dd/mm/yyyy hh:mm)
37	6	DEPLOYMENT INFORMATION	1	DEPLOY FLOAT INTERNAL CHECK	OK			Comment on float internal checks (valve and pump actions, argos transmission check)
38	6	DEPLOYMENT INFORMATION	1	DEPLOY TIME	20/09/2017 08:20:00			Deployment time (dd/mm/yyyy hh:mm)
39	6	DEPLOYMENT INFORMATION	1	DEPLOY LATITUDE	47°30S			Deployment latitude (dd°mm,mm N/S or dd°mm'ss" N/S)
40	6	DEPLOYMENT INFORMATION	1	DEPLOY LONGITUDE	13°0 W			Deployment longitude (ddd°mm,mm E/W or ddd°mm'ss" E/W)
41	6	DEPLOYMENT INFORMATION	1	DEPLOY BUOYANCY	OK			Buoyancy description
42	6	DEPLOYMENT INFORMATION	1	DEPLOY METHOD	By hand			Deployment method (release box, manual, expendable cardboard, etc...)
43	6	DEPLOYMENT INFORMATION	1	DEPLOY HEIGHT	1			Deployment height (m)
44	6	DEPLOYMENT INFORMATION	1	DEPLOY SHIP SPEED	2.5			Ship speed (kts)
45	6	DEPLOYMENT INFORMATION	1	DEPLOY WIND SPEED	7			Wind speed (Beaufort)
46	6	DEPLOYMENT INFORMATION	1	DEPLOY SEA STATE	Very rough (4 to 6 m)			Sea state (calm, smooth, slight, moderate, rough, very rough, high, very high, phenomenal)
47	6	DEPLOYMENT INFORMATION	1	DEPLOY BATHYMETRY	3837			Bathymetry at deployment position (m)
48	6	DEPLOYMENT INFORMATION	1	DEPLOY NB DAYS UNTIL FIRST ASCENDING PROFILE	2			Number of days until the first ascending profile (copy of the PM2 parameter value)
49	6	DEPLOYMENT INFORMATION	1	DEPLOY COMMENT	Deployed on a CTD station which was a calibration cast for a			Miscellaneous comment on the deployment
	6				VALIDATION			
50								
51	6	SENSOR INFORMATION	1	SENSOR	CTD PRES			Sensor name
52	6	SENSOR INFORMATION	1	SENSOR MAKER	SBE			Sensor manufacturer
53	6	SENSOR INFORMATION	1	SENSOR MODEL	SBE41CP			Sensor model
54	6	SENSOR INFORMATION	1	SENSOR SERIAL NUMBER	8503			Sensor serial number
55	6	SENSOR INFORMATION	2	SENSOR	CTD TEMP			Sensor name
56	6	SENSOR INFORMATION	2	SENSOR MAKER	SBE			Sensor manufacturer

Figure 9: Example of a MOCCA deployment sheet

Then the DAC processes all the incoming float data (SBD files, received from a generic email address) within a few hours after float transmission. The decoding chain generates standardised netCDF v3.1 files and submits them to the GDAC.

Index de /ifremer/argo/dac/coriolis/3901842

[répertoire parent]

Nom	Taille	Date de modification
3901842_Rtraj.nc	841 kB	04/12/2017 16:02:00
3901842_meta.nc	62.2 kB	04/12/2017 16:02:00
3901842_prof.nc	1.9 MB	04/12/2017 16:48:00
3901842_tech.nc	724 kB	04/12/2017 16:02:00
profiles/		04/12/2017 16:02:00

Figure 10: Example of MOCCA float data on the GDAC repository.

Data from the GDAC is used by operational centres like Copernicus Marine Services. It is freely available for download. Data is also imported into the Coriolis Database host by Ifremer. Each float data is available on a specific webpage.

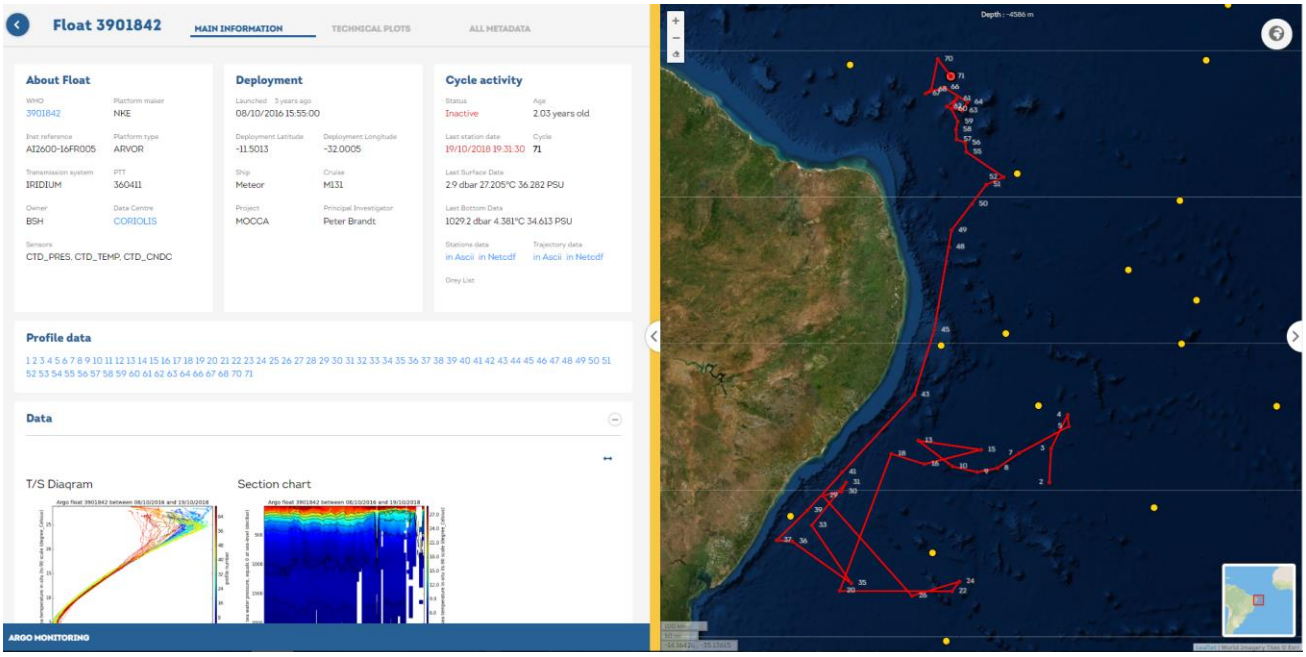

Figure 11: Example of float webpage with metadata, trajectory and oceanographic profiles displayed. https://fleetmonitoring.euro-argo.eu/float/3901842

2.2. Indicators

In April 2020 more than **20,000 CTD profiles have been collected by the MOCCA fleet**. It is growing to **about 500 new profiles each month** by now.

The delay from float completing its upward profile to completion of processing at the different DACs is monitored and shows that for the last 3 months BODC achieved a median of 10 hrs and a mean of 20 hrs, both within the Argo target of 24 hrs. During the final month of the reporting period BODC have improved delivery such that the median delay remains stable at 11 hrs and the mean has significantly improved to just 17 hrs. The improved delays at BODC in the end of 2019 and beginning of 2020 is due to the update of the processing chain needed to handle float that went under ice.

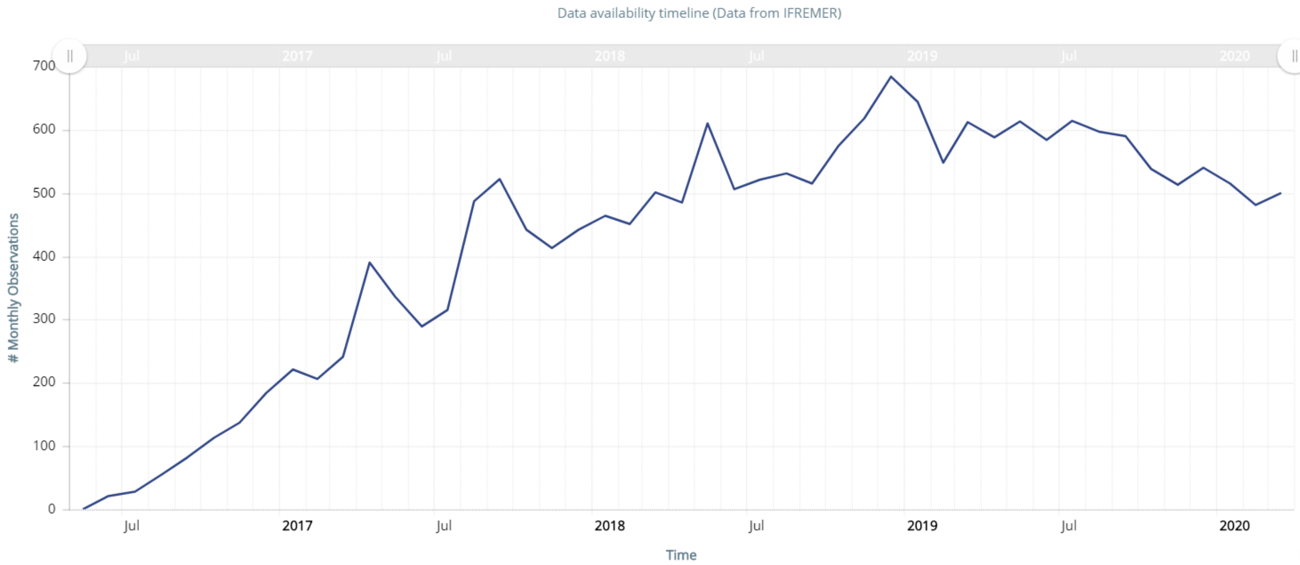

Figure 12: Number of monthly observations collected by MOCCA floats. Source: AIC/JCOMMOPS.

In terms of the current partition of observations processed, Coriolis accounts for less 2/3 and BODC more than 1/3. This is expected due to the later start of RT processing by the BODC and the Baltic floats with many profiles that are handled by Coriolis; it will be balanced in the future.

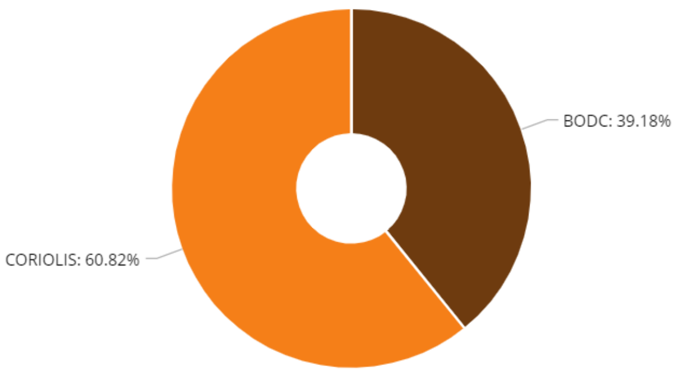

Figure 13: Observations distribution by DAC. Source: AIC/JCOMMOPS.

Most importantly, the **median delay between a float observation and its availability on the GDAC is about 4 hours**, much less than the Argo objective of 24 hours.

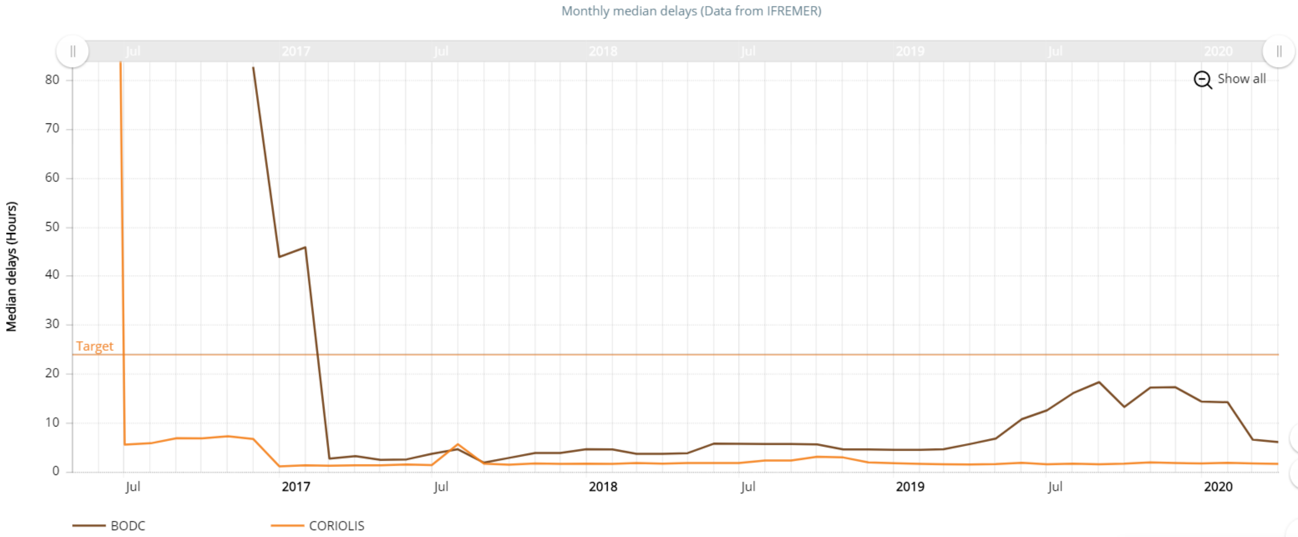

Figure 14: Median delays between float observations and their availability on the GDAC. Source: AIC/JCOMMOPS.

2.3. Next steps

MOCCA deployment phase has been completed. All floats are processed in RT with the relevant decoder version (4 in use). No further steps are expected. The processing chain might be updated if needed (minor bugs, etc.).

3. CONCLUSION

Real-Time processing of the MOCCA fleet is well underway. No particular difficulties are anticipated.