French National Report on Argo - 2016

Present status and future plans

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1 BACKGROUND, ORGANIZATION AND FUNDING OF THE FRENCH ARGO ACTIVITIES

1.1 Organization

Argo France (http://www.argo-france.fr) gathers all the French activities related to Argo and its extension toward deep and biogeochemical measurements. Argo France is the French contribution to the Euro-Argo[1] European research infrastructure (ERIC) that organizes and federates European contribution to Argo.

Euro-Argo and its French component (Argo France) is part of the Ministry of Research national roadmap on large research infrastructure (TGIR). Argo France operational activities are organized through the Coriolis[2] partnership (IFREMER, SHOM, INSU, IRD, Météo France, CNES and IPEV) and its governance bodies. Two research laboratories are leading the Argo France scientific activities: the "Laboratoire d'Océanographie Physique et Spatiale[3]" (LOPS, Brest, France) and the "Laboratoire d'Océanographie de Villefranche[4]" (LOV, Villefranche, France). Coriolis and Argo France have strong links with Mercator Ocean[5] (the French ocean forecasting center).

1.2 Funding

Argo France is mainly funded by the ministry of Research through Ifremer as part of national roadmap on large scale infrastructures and contribution to Euro-Argo (TGIR). This is a long term commitment. Argo France is also funded through Ifremer, SHOM (Ministry of Defense), CNRS/INSU and other French institutes involved in oceanography (CNES, IRD, Météo-France). At regional scale, Argo France is supported by the IUEM OSU[6] and funded by the Brittany and Provence Alpes-Cote d'Azures regions (through CPER).

The French contribution to the Argo global array is at the level of 60 to 65 floats per year with funding from Ifremer (50 floats/year) and SHOM (about 10 to 15 floats/year).

Since 2000, around 1070 French floats have been deployed in a number of different geographic areas. Deployments have been focused on meeting specific French requirements while also contributing to the global array.

To complement Argo-France, the NAOS[7] project (Novel Argo Ocean observing System, 2011-2019) has been funded by the Ministry of Research to consolidate and improve the French contribution to Argo and to prepare the next scientific challenges for Argo**.** The project provides an additional funding of 10 to 15 floats per year from 2012 to 2019, which allows Ifremer to increase its long-term contribution to Argo from 50 to 60-65 floats/year. NAOS also develops the new generation of French Argo floats and set up pilot experiments for biogeochemical floats (Mediterranean Sea, Arctic) and deep floats (North Atlantic). An European Research Council (ERC) advanced grant has also been obtained by LOV to work on the development of a biogeochemical component for Argo, the REMOCEAN[8] project (REMotely sensed biogeochemical cycles in the OCEAN, 2010-2015)**.** Overall, as part of the NAOS and REMOCEAN projects, 150 additional floats should be deployed before 2019.

The level of support, additional to float purchase, is as indicated in Tableau 1 (man power for coordination activities, float preparation, deployment and data management activities).

Year	**Funding**	**Man/Year**	**French floats**	**Co-funded EU floats**	**Total**
2000	300k€		11		11
2001	633k€	3	12		12
2002	980k€	6	7	4	11
2003	900k€	9	34	20	54
2004	1400k€	15	85	18	103
2005	450k€	15	89	11	100
2006	900k€	12	51	14	65
2007	900k€	12	36		36
2008	1200k€	12	90		90
2009	1200k€	12	35	8	43
2010	1400k€	12	55		55
2011	1400k€		53		53
2012	1400k€	12	82		82
2013	1400k€	12	81		81
2014	1400k€	12	96		96
2015	1400k€	14	101		101
2016	1400k€	14	58		**58**
Total (2000-2016)			***976***		**1051**
2017	**1400k€**	**14**	**97**		**97**

Tableau 1: (*Man/year* column) Man power dedicated to Argo for coordination activities, float preparation, deployment and data management activities (GDAC, DAC, NAARC, DMQC) within Argo-France. (*French floats* column) French floats contributing to Argo deployed by year. (*Co-funded EU floats* column) EU floats are the additional floats co-funded by European Union within the Gyroscope, Mersea and MFSTEP projects. Estimated value is given for 2017.

1.3 Long term evolution of Argo

At the national level, the proposal for Argo-France is in two phases:

- 2011-2016: Core Argo mission (temperature and salinity – 0 to 2000m) and pilot experiments on the new phase of Argo (notably via the NAOS project).

- 2017-2020: Continuation of the core Argo mission with the addition of an extended mission.

For the upcoming phase 2017-2020, France will conduct an over-fitting strategy of a 66 floats/year sustained fleet with:

- 15 deep floats
- 7 with biogeochemical sensors including O2 sensors for 4 of them
- 11 with oxygen sensors
- 33 core T/S.

Core T/S, deep floats and oxygen sensors are fully funded until 2020 (CPER Brittany region), the biogeochemical mission is partially funded (CPER PACA and Brittany regions until 2020) and thus requires new sources of funding that are being requested for the 2018-2023 period as part of the Research Infrastructure second phase.

France strategy will be adjusted according to international recommendations with regard to the deep and Bio-Argo extensions. Euro-Argo has published a long term roadmap for the next phase of Argo and as part of the ERIC Euro-Argo countries will work on the implementation of a new sustained phase for Argo in Europe.

2 FLOAT DEVELOPMENT

Since 2011, Ifremer together with NKE and CNRS has been working on PROVOR/ARVOR floats improvement in order to develop, validate and deploy the next generation of French Argo profiling floats. The new float capabilities include: longer life-time, more efficient design of the vehicle, improved transmission rates, integration of biogeochemical sensors, deeper measurements and under ice operations in the polar seas. In 2016, prototype designs were industrialised by NKE and some deployed by Operational Center. More informations on technological float developments can be found in the NAOS project webpage (http://www.naos-equipex.fr/) and its last newsletter (Feb 2017, French version.pdf) from which the following information are gathered:

Arvor floats deployed in 2015 have now performed more than 60 cycles. More than 40 new Arvor floats have been deployed in 2016 with success, thanks to a simplified procedure.

Deep Arvor floats have been deployed since 2015. The general behavior of the float is satisfactory although performances are variable. The sensor manufacturer was made aware of the analysis of measurements quality and salinity biais at initial calibration. The Deep-Arvor technology was described in Le Reste et al (JAOT, 2016, http://dx.doi.org/10.1175/JTECH-D-15-0214.1

For all float models, CTD heads are now systematically tested at the beginning of the manufacturing line and a CTD cleaning protocol enforced during pool tests prior to deployments.). A soft “dual-mission” mode enables the user to split the float life into two phases.

Another main aspect of the development concerns the bio-geochemical applications. The **Provor-CTS5 (Prov-bio)** and its under-ice twin (**Pro-Ice**) developed since 2013 are dedicated, i) to embed additional optical sensors, ii) to do other cycle schemes than Argo standard ones, iii) to modify its programmed mission itself depending on measurements or on results of mixed measurement computations and iv) to detect and avoid ice during ascent.

After trials in the Mediterranean Sea, **Pro-ice** floats were deployed in the Baffin Sea (2015) and Austral Ocean (2016). The later sampled and stored more than 130 profiles with success.

In 2015, a three-week oceanographic cruise (BioArgoMed, onboard the INSU's Tethys-11, Pls F. D'Ortenzio & V. Taillandier) was carried out, within the framework of the development and operational maintenance of a pilot network of BioArgo biogeochemical floats in the Mediterranean Sea by teams from the French laboratories LOV, MIO and LOCEAN. During the cruise, 10 **Prov-bio** floats were deployed and 5 recovered. Argo floats from Argo-Italy and from Germany were also deployed. The recover of Prov-bio (some of them after 3 years at sea) provided excellent technical information on the float performance at sea. Additionnaly, observations from ship obtaind during the recover of floats (i.e. with Rosette sampling of Chl-a, O2 and NO3) provided calibration profile of biogeochemical parameters at the end of mission, which are further used to verify the performances of the BGC-Argo QC tests and for sensor calibrations.

3 THE STATUS OF IMPLEMENTATION

3.1 Floats deployed and their performance

57 T/S floats (21 BGC) have been deployed by France in 2016 (see map below). The deployment areas are chosen to meet French requirements in terms of research and operational activities but also to contribute to establishing the global array (especially in the Southern Ocean) using AIC tools/map.

3.2 Technical problems encountered and solved

No particular technical problems were encountered in 2016 with regard to operational T/S floats.

3.3 Status of contributions to Argo data management

Within Argo-France, data management is undertaken by Coriolis, which play three roles: Data Assembly Centre, Global Data Centre, and leader of the North Atlantic Argo Regional Centre. Coriolis is located within Ifremer-Brest and is operated by Ifremer with support of SHOM. In 2016, BGC floats processing chain have been fully operational and integrated within the Coriolis data management stream.

Hervé Claustre (CNRS-LOV) became co-chair of the Argo ADMT for BGC-Argo and Catherine Schmechtig (CNRS-Ecce-Terra) France DAC focal point for BGC.

All Argo data management details are in the Coriolis DAC and GDAC annual report (english) : http://archimer.ifremer.fr/doc/00350/46128/

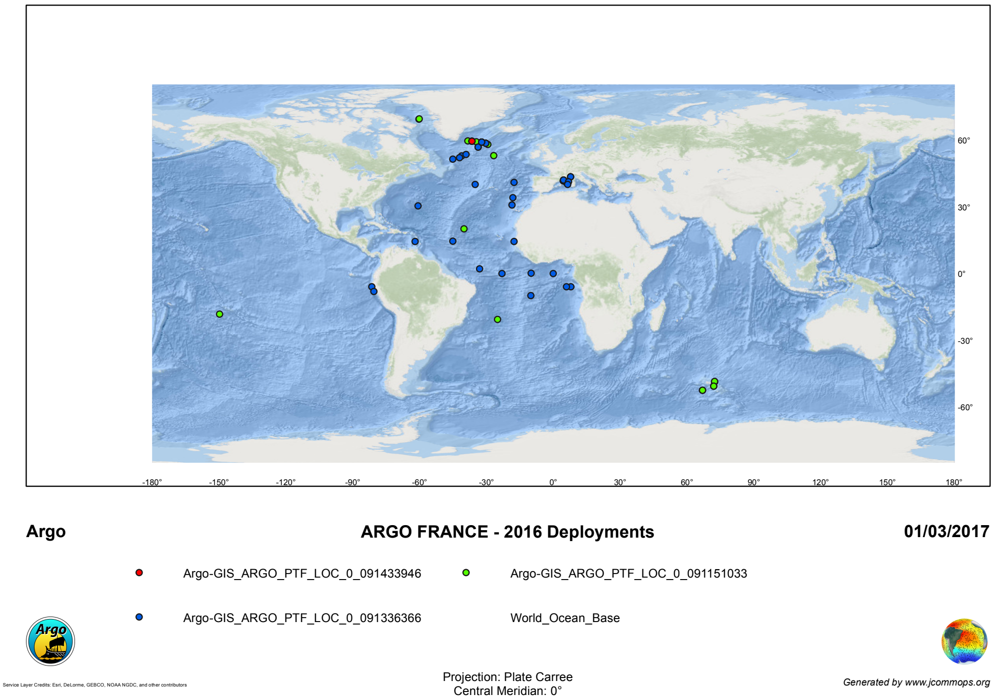

Figure 1 : Argo-France 58 deployments in 2016

3.3.1 Data Assembly Center[9]

Coriolis processes in Real Time and Delayed Mode float data deployed by France and 7 European countries (Germany, Spain, Netherlands, Norway, Italy, Greece, Bulgaria). Details information can be found the 2016 Coriolis DAC / GDAC data management report (http://archimer.ifremer.fr/doc/00350/46128/).

These last 12 months (sep15-aug16), 29 683 profiles from 740 active floats were collected, controlled and distributed. Compared to 2015, the number of profiles increased by 16%, the number of floats increased by 1%. The increase in profile number is mainly explained by a better lifetime of active floats. The 740 floats managed during that period had 57 versions of data formats. Coriolis DAC provides data for 321 BGC-Argo floats from 5 families and 46 instrument versions. They performed 38 376 cycles.

All (real and delayed time) Coriolis Provor/Arvor floats files are converted to Argo NetCDF 3.1 version. In 2016, 10 versions of Apex floats were reprocessed into Argo NetCDF version 3.1. For Apex floats, the delayed mode files from 10 versions are still in version 3.0. They will probably be entirely reprocessed by the delayed mode operators, as the reprocessed real-time profiles have a higher quality than the former files. The rest of 14 versions of still active Apex floats will be gradually converted (probably in 2016-2017). The 35 versions no more active will be converted to V3.1.

Figure: Maps of the 29 683 profiles from the 740 active floats managed by Coriolis DAC in 2016. Apex, Navis, Nemo, Nova, Provor

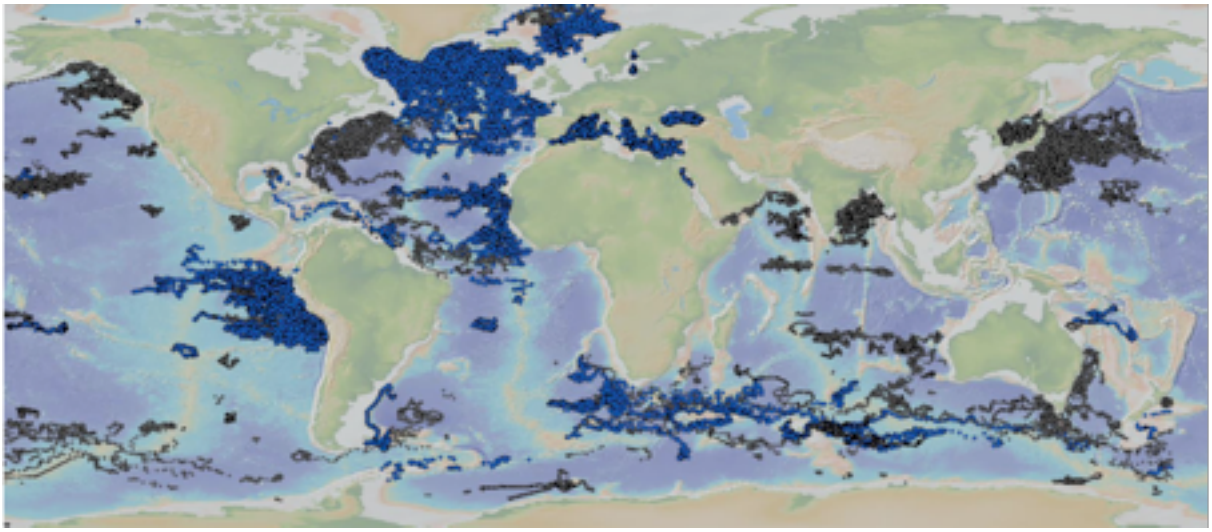

Figure: Map of the 321 BGC-Argo float profiles (blue) managed by France in 2016 (grey dots: the others DACs bio-Argo floats)

3.3.2 Global Argo Data Centre[10]

Coriolis hosts one of the two global data assembly centres (GDAC) for Argo that contains the whole official Argo dataset. The Argo GDAC ftp server is actively monitored by a Nagios agent (see http://en.wikipedia.org/wiki/Nagios). Every 5 minutes, a download test is performed. The success/failure of the test and the response time are recorded (see Figure). There is a monthly average of 321 unique visitors, performing 4229 sessions and downloading 3 To of data files. On the last 12 months, the weekly average ftp performance was 99.51%. The 0.49% of poor performances represents 36 hours and 38 minutes minutes (that mainly occured in early March and 3rd week of May).

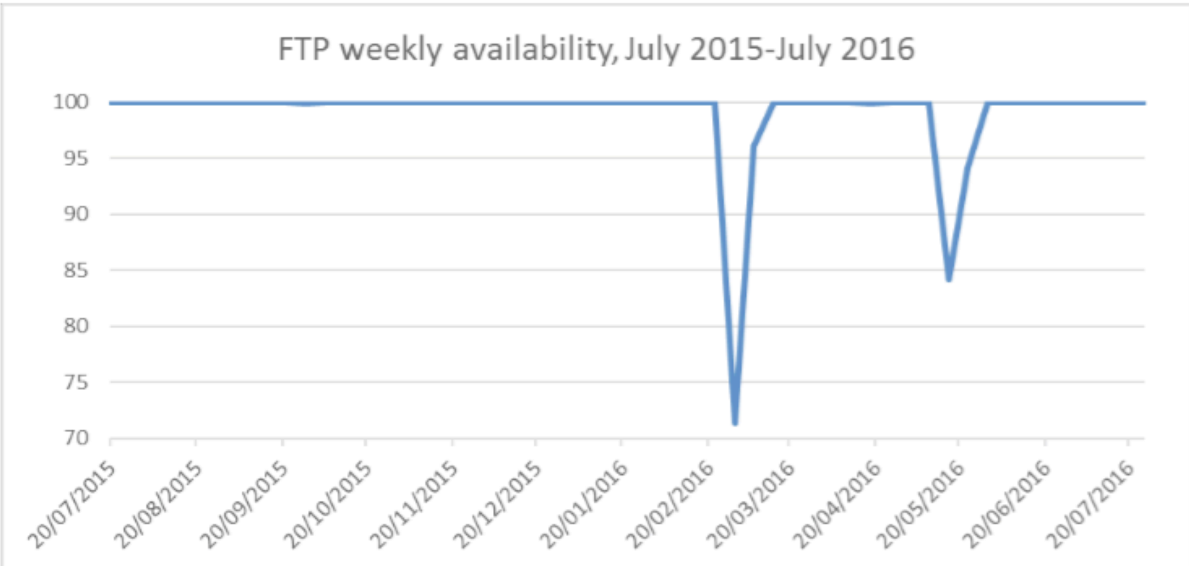

Figure: Nagios monitoring: between July 2015 and July 2016.

3.3.3 North Atlantic Argo Regional Centre[11]

See section 5.4

3.4 Status of delayed mode quality control process

During the last year (from February 2016 to February 2017), 10676 new delayed mode profiles where produced and validated by PIs. A total of 135673 delayed mode profiles where produced and validated since 2005. In February 2017, 59% of the floats and 56.8% of the profiles processed by the Coriolis DAC were in delayed mode (see Figure below).

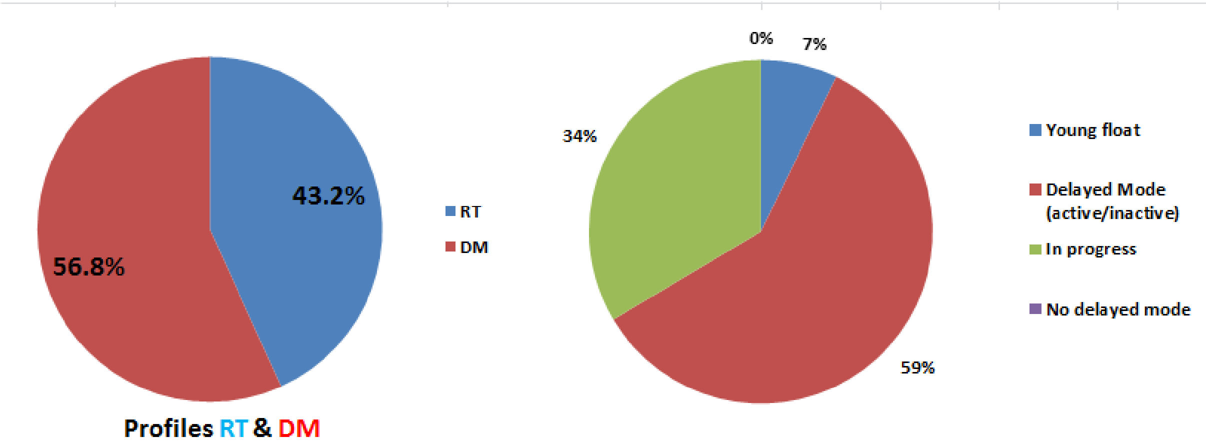

Figure 6. Status of the floats processed by Coriolis DAC. Left: in terms of float percent and right: in terms of profile percent (DM : delayed mode – RT : real time).

The status of the quality control done on the Coriolis floats is presented in the following plot. The codes 2 and 3 show the delayed mode profiles for respectively active and dead floats. . In the last 2 years, we have accumulated delay on the DMQC dataset for some floats due to a new program/language to decode PROVOR and APEX floats. We had to wait for the new procedure to work on the delayed mode files but since few months, we have worked on those versions and we have now updated most of the floats. There are still some Remocean floats that need to be reviewed in real time before working on DMQC.

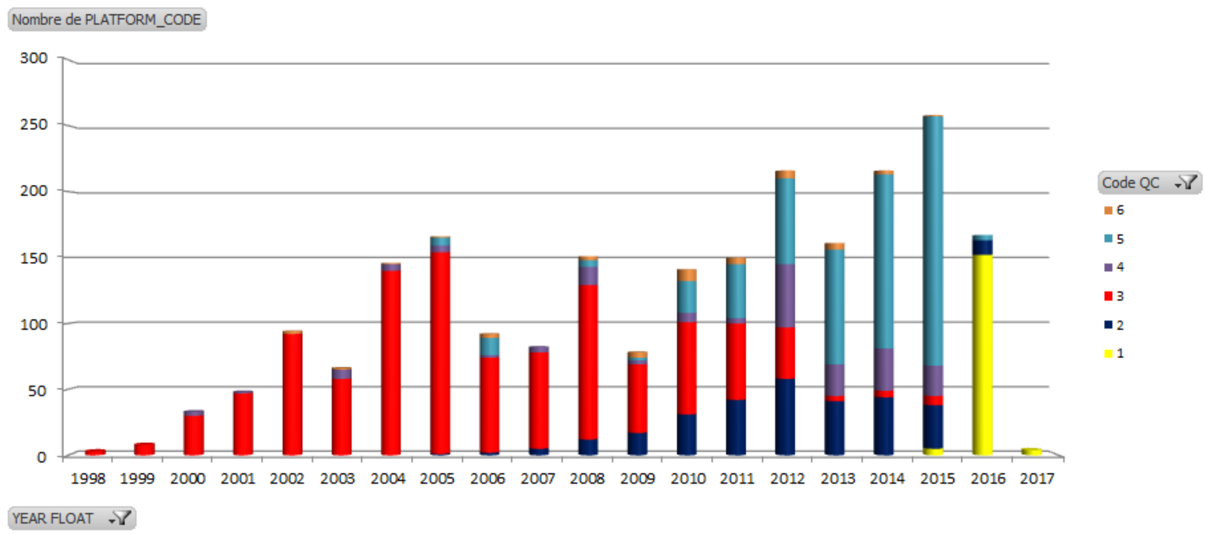

Figure: Status of the quality control done on profiles sorted by launch's year, code 1: young float, code 2: active float, DM done, code 3 : dead float, DM done; code 4 : DM in progress, code 5 : waiting for DM, code 6 : problems with float.

4 SUMMARY OF DEPLOYMENT PLANS* AND OTHER COMMITMENTS TO ARGO† FOR THE UPCOMING YEAR AND BEYOND WHERE POSSIBLE

According to the current deployment plan, 97 floats are scheduled to be deployed in 2017 (44 ARVOR ARGOS , 24 ARVOR Iridium, 1 AR DO, 8 CTS3DOI, 5 CTS4, 16 DEEP, 1 CTS5 proval, 7 CTS5 ICE).

Coriolis will continue to run the Coriolis DAC and the European GDAC as well as coordinating the North Atlantic ARC activities. Within the Euro-Argo project, development will be carried out to improve anomalies detection at GDAC both in RT and DM, to monitor in real time the behavior of the European fleet and to improve data consistency check within NA-ARC.

France also contributes to the funding of the AIC.

5 SUMMARY OF NATIONAL RESEARCH AND OPERATIONAL USES OF ARGO DATA AS WELL AS CONTRIBUTIONS TO ARGO REGIONAL CENTERS

5.1 Operational ocean forecasting

All Argo data (alongside with other in-situ and remotely sensed ocean data) are routinely assimilated into the MERCATOR operational ocean forecasting system run by the

* Level of commitment, areas of float deployment
† Data management

MERCATOR-Ocean[5] structure. MERCATOR also operates the Global component of the European Copernicus Marine Environment Monitoring Service (CMEMS).

5.2 Support to the Mercator and Coriolis scientific activities

Coriolis has developed together with MERCATOR (The French operational oceanography forecast center) a strong connection with the French research community via the Mercator-Coriolis Mission Group (GMMC). It consists of about one hundred researchers (with some turnover each year) following a scientific announcement of opportunities and call for tender. Its task is to support the Mercator and Coriolis scientific activities and to participate in product validation. The call for tender proposes to the community "standard" Argo floats as well as floats equipped with oxygen and biogeochemical sensors. These new opportunities strengthen ties between the French scientific community and Coriolis with regard to the development of qualification procedures for "Argo extensions" floats.

5.3 National Research

Argo data are being used by many researchers in France to improve the understanding of ocean properties (e.g. circulation, heat storage and budget, and mixing), climate monitoring and on how they are applied in ocean models (e.g. improved salinity assimilation, …).

5.4 Argo-Regional Center: North Atlantic

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), Greece (HCMR) and Bulgaria (IOBAS). Coriolis coordinates the North-Atlantic ARC activities and in particular the float deployment in Atlantic.

The NA-ARC website provides information about float data and status in the North-Atlantic Ocean. NA-ARC also provides a web API to access metadata about Argo profiles in the North Atlantic region (http://api.ifremer.fr/naarc/v1).

All the floats that have been processed in delayed time in the North Atlantic ARC, north of 30°S, were checked again using a modified OW method that has been published in a scientific article (Cabanes et al, http://dx.doi.org/10.1016/j.dsr.2016.05.007). Among the 1514 floats checked, we found 19 floats for which it may be necessary to revise the original DM correction. Reports have been send to the Pis.

6 ISSUES THAT YOUR COUNTRY WISHES TO BE CONSIDERED AND RESOLVED BY THE ARGO STEERING TEAM REGARDING THE INTERNATIONAL OPERATION OF ARGO.

These might include tasks performed by the AIC, the coordination of activities at an international level and the performance of the Argo data system. If you have specific comments, please include them in your national report.

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7 CTD CRUISE DATA IN THE REFERENCE DATABASE

To continue improving the number of CTD cruise data being added to the reference database by Argo PIs, it is requested that you include the number and location of CTD cruise data uploaded by PIs within your country to the CCHDO website in the past year. These cruises could be used for Argo calibration purposes only or could be cruises that are open to the public as well.

The last version CTD_for_DMQC_2017V01 has been provided in January 2017, this is an updated version (correction of bugs in some boxes) of the CTD_for_DMQC_2016V01 dataset provided in September 2016 which takes into account new CTD provided by the CCHDO API (following figure), CTD from scientists as well as feedbacks from users on quality of some profiles. Concerning the CCHDO API, all cruises have been imported but only 30% have been kept after duplicates check with data in Coriolis database.

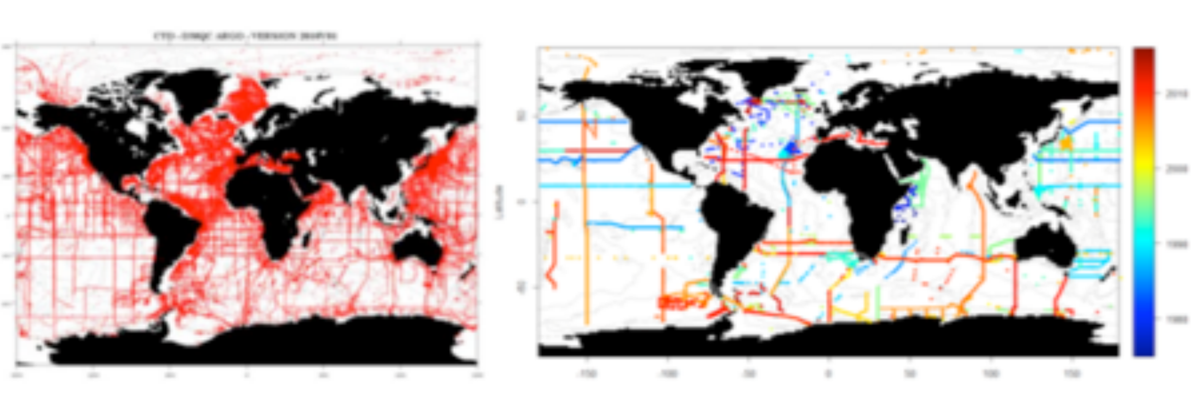

Figure: ***Version 2016 V01 & New CTD datasets downloaded from the CCHDO API***

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List of publications in which a scientist from a french laboratory is involved

In 2016, at least 57 articles with a scientist affiliated in France as a coauthor have been published in peer reviewed journals. The list is reported hereafter. Note that the list of all publications in which a scientist from a French laboratory is involved is available on the Argo France website[12] and on the Argo Bibliography[13] webpage. To date, around 290 articles have been listed.

Argo-France 2016 Bibliography ***(57 references):***

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Footnotes

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[1] Euro-Argo: http://www.euro-argo.eu
[2] Coriolis: http://www.coriolis.eu.org
[3] Laboratoire d'Océanographie Physique et Spatiale: http://www.umr-lops.fr/
[4] Laboratoire d'Océanographie de Villefranche: http://www.obs-vlfr.fr/LOV
[5] Mercator: http://www.mercator-ocean.fr
[6] IUEM OSU: http://www-iuem.univ-brest.fr/observatoire
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[10] Coriolis FTP: http://www.coriolis.eu.org/Data-Services-Products/View-Download/Download-via-FTP
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