

# French National Report on Argo - 2015

## Present status and future plans

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## 1 BACKGROUND, ORGANIZATION AND FUNDING OF THE FRENCH ARGO ACTIVITIES

### 1.1 Organization

Argo France<sup>1</sup> 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<sup>2</sup> 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<sup>3</sup> 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 pPhysique et Spatiale"<sup>4</sup> (LOPS, Brest, France; former LPO) and the "Laboratoire d'Océanographie de Villefranche"<sup>5</sup> (LOV, Villefranche, France). Coriolis and Argo France have strong links with Mercator Ocean<sup>6</sup> (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<sup>7</sup> 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 918 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, the NAOS<sup>8</sup> 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<sup>9</sup> 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).

<b>Year</b>	<b>Funding</b>	<b>Man/Year</b>	<b>French floats</b>	<b>Co-funded EU floats</b>	<b>Total</b>
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
<b>Total (2000-2015)</b>			<b>918</b>		<b>993</b>
<b>2016</b>	<b>1400k€</b>	<b>14</b>	<b>65</b>		<b>65</b>

**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 2016.**

### 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).
- 2017-2021: Continuation of the core Argo mission with the addition of an extended mission.

For the upcoming phase 2017-2021, France proposes an over-fitting strategy of a 70-80 floats/year sustained fleet with:

- 10-15 deep floats
- 15-20 with oxygen sensors
- 15 with biogeochemical sensors
- 30 core T/S.

Deep floats and oxygen sensors are funded until 2021 (CPER Brittany region), biogeochemical mission is partially funded (CPER PACA region) and requires new sources of funding.

France strategy will be adjusted according to international recommendations with regard to the deep and Bio-Argo extensions. Euro-Argo has been working on 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. 2015 was the year of testing the developments at sea. More informations on technological float developments can be found in the NAOS project webpage (<http://www.naos-equipex.fr/>) and its last newsletter ([Jan2016\\_English\\_version\\_v1.pdf](#)) from which the following information are gathered:

The **Arvor** float has been improved: the deployment procedure has been simplified, the auto-test process has been extended and the monitoring of pressure during certain critical phases has been intensified. A “dual-mission” mode enables the user to split the float life into two phases. Two new floats were programmed using the “dual-mission” mode (500 dbars/1000 dbars every two days followed by 100 dbars/2000 dbars every ten days). Since their deployment in March 2015, those floats had completed nearly 40 cycles.

The success of Arvor's **Argos-3** transmission was confirmed by further experimentation launched in 2015. The floats transmit an Argo profile of ~110 points in just a few minutes. Compared to Argos-2, which has to transmit continuously for up to ten hours, the float uses five times less energy and has increased its autonomy by 25% with a cheaper transmission costs. A scientific article has been published on the subject of the Argos-3 transmissions: Xavier André, Bertrand Moreau, and Serge Le Reste, 2015: "Argos-3 satellite communication system: implementation on the arvor oceanographic profiling floats". *J. Atmos. Oceanic Technol.*, **32**, 1902–1914. <http://dx.doi.org/10.1175/JTECH-D-14-00219.1>

Four **Deep Arvor** floats, part of a first series of 12 floats, were fine-tuned during the production phase and then deployed during the Reykjanes Ridge Experiment (RREX) campaign in June 2015. Three of them were functioning as planned at the end of the year. Deep-Arvor enables an Argo profiling float to descend to 4000m, doubling its depth, and thus to explore nearly 90% of the volume of the world's oceans. One of the two industrially manufactured prototypes, deployed in May 2014, completed its cycles successfully before

running out of battery power: 142 CTD cycles, of which 60 featured oxygen measurements at a depth of between 3500 and 4000m with successful seafloor grounding. The predicted energy balance has confirmed that there is potential to achieve 150 cycles at 4000m. NKE has been awarded a licence to manufacture and commercialize the floats until January 2019. A scientific article has been published on the subject: Le Reste, Serge and Dutreuil, Vincent and André, Xavier and Thierry, Virginie and Renaut, Corentin and Le Traon, Pierre-Yves and Maze, Guillaume: "Deep-Arvor": A new profiling float to extend the Argo observations down to 4000m depth." Journal of Atmospheric and Oceanic Technology 2016. <http://dx.doi.org/10.1175/JTECH-D-15-0214.1>

Another main aspect of the development concerns the bio-geochemical applications. The **Provor-CTS5 (Prov-bio)** developed in 2013 is 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.

After trials in the Mediterranean Sea, the **Provor CTS5 (Pro-Ice)** float was deployed in the Baffin Sea. The Pro-Ice profiling float targets the Arctic zone. The float deployed in the Mediterranean Sea carried out approximately one hundred profiles during two missions in the Boussole area. The tests demonstrated the float's capability to reverse its ascent speed if ice is detected. Ice detection and avoidance strategies are possible via two systems. The ISA (Ice Sensing Algorithm) compares the median temperature near the surface with a critical temperature. It has been adapted for Baffin Bay by using data from 392 CTD profiles. Furthermore, the float's distance from the surface measured by a reverse altimeter is compared to the depth (calculated from measurements of pressure). Each of the two algorithms (ISA and altimetry) provides an indicator which triggers the decision to end the ascent. Lastly, a different strategy is adopted according to the season (surfacing is prohibited or only permitted at regulated intervals). The Takuvik team tested the Pro-Ice float in intense cold conditions in a Quebec Lake and during the "Green Edge" camp at Qikiqtarjuaq. Those tests revealed certain discrepancies that were corrected accordingly.

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 (**Provor-CTS4**) in the Mediterranean Sea by teams from the French laboratories LOV, MIO and LOCEAN. The cruise provided better targeting of specific zones and also more flexibility in recovering the operational floats (i.e. after recovery of existing floats, refitting and further deployment is possible) than previous deployments by opportunity ships. Ten floats were deployed and four of the initial phase were recovered. Several methods for calibrating the BioArgo floats biogeochemical sensors were tested. Measurements of oxygen in the air were obtained and calibrations of floats was carried out between floats, in particular for nitrate concentration observations .

### 3 THE STATUS OF IMPLEMENTATION

#### 3.1 Floats deployed and their performance

**109 T/S floats** have been deployed by France in 2015 (see map and table below). The deployment areas are chosen to meet French requirements in terms of research and

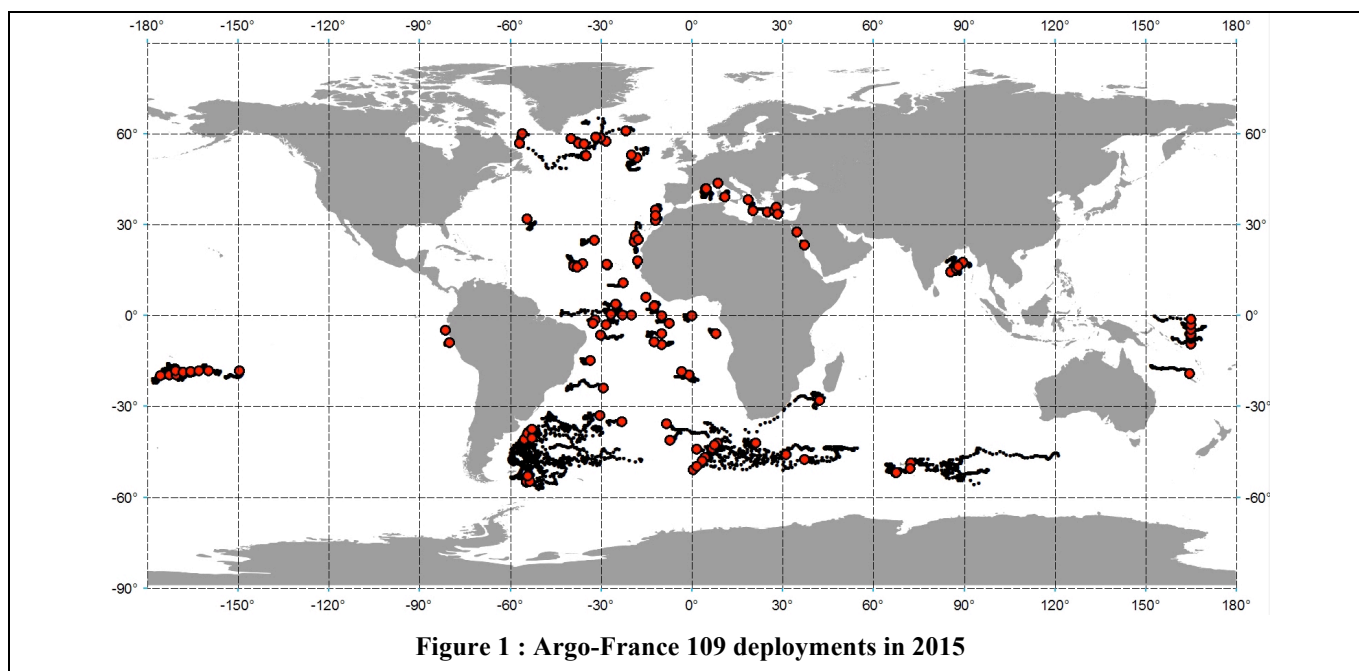


Figure 1 : Argo-France 109 deployments in 2015

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 2015.

### 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. **More details on the Coriolis activities as DAC and GDAC can be found in Coriolis annual reports<sup>10</sup>** (French only).

The data processing chain based on Matlab to manage data and metadata from Provor-Remocean floats is now fully operational and is continuously improved. These are advanced type of floats performing bio-geo-chemical measurements. In 2015, data and metadata from these floats have been distributed on Argo GDAC. They feature version 3.1 core and bio profiles, core and bio trajectories, metadata and technical data. The other bio-Argo floats (Apex, Navis, Nemo and Nova) are distributed in V3.0 data files. Data are available in real-time from Argo GDAC when the new version of the format checker is deployed. More information at: <http://www.coriolis.eu.org/Data-Products/Data-Delivery/Argo-bio-floats-from-Coriolis>

#### 3.3.1 Data Assembly Center<sup>11</sup>

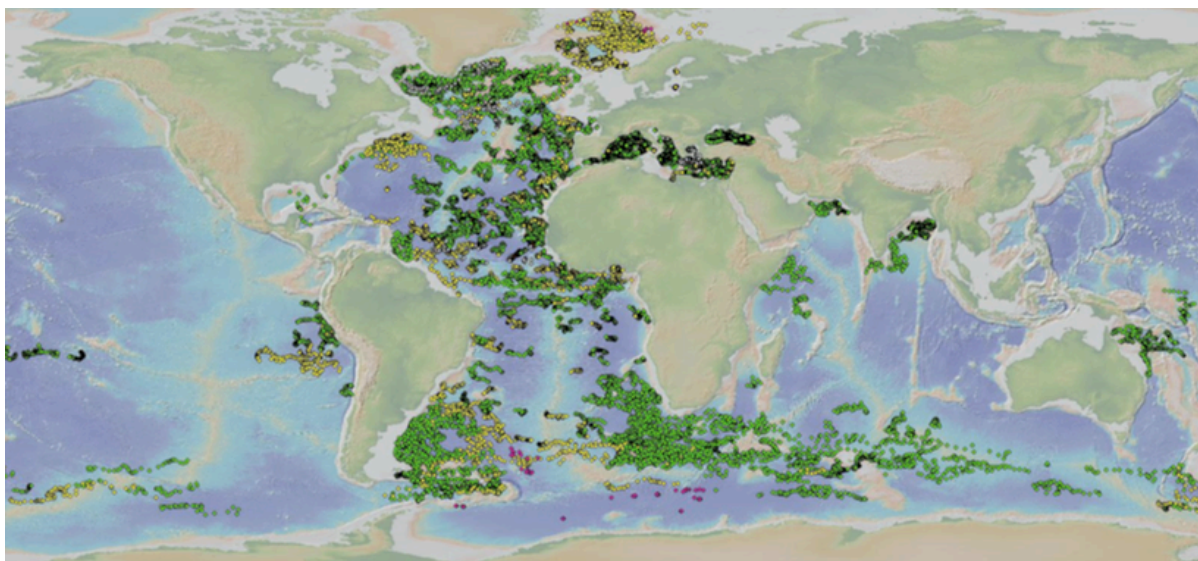
Coriolis processes in Real Time and Delayed Mode float data deployed by France and



7 European countries (Germany, Spain, Netherlands, Norway, Italy, Greece, Bulgaria). Details information can be found the 2015 Coriolis DAC 7 GDAC data management report (<http://doi.org/10.13155/39749>).

These last 12 months (oct14-sep15), 25 568 profiles from 745 active floats were collected, controlled and distributed. Compared to 2014, the number of profiles increased by 18%, the number of floats increased by 14%. The increase in both profile and platforms number is mainly explained by new bio-Argo floats. The 745 floats managed during that period had 54 versions of data formats.

All Coriolis DAC real time files (including from Provor CTS3 bio floats) have been converted to Argo NetCDF 3.1 version. Delayed mode files are still being converted (50% done).



**Figure: Maps of the 25 568 profiles from the 745 floats managed by Coriolis DAC in 2015.**

### **3.3.2 Global Argo Data Centre<sup>12</sup>**

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 2). There is a monthly average of 483 unique visitors, performing 4518 sessions and downloading 4 teraoctets of data files. On the last 12 months, the weekly average performance was 99.84%. The 0.16% of poor performances represents 15 minutes for a week. For the last 12 months, the cumulative poor performances period is of 24 hours. We faced 3 significant events these last 12 months.

- First week of January: 8 hours of Internet poor performances
- Last week of January 2015: disk storage instability: 7 hours and 35 minutes of poor performances of ftp.
- Mid-August 2015 : 4 hours of poor Internet performances

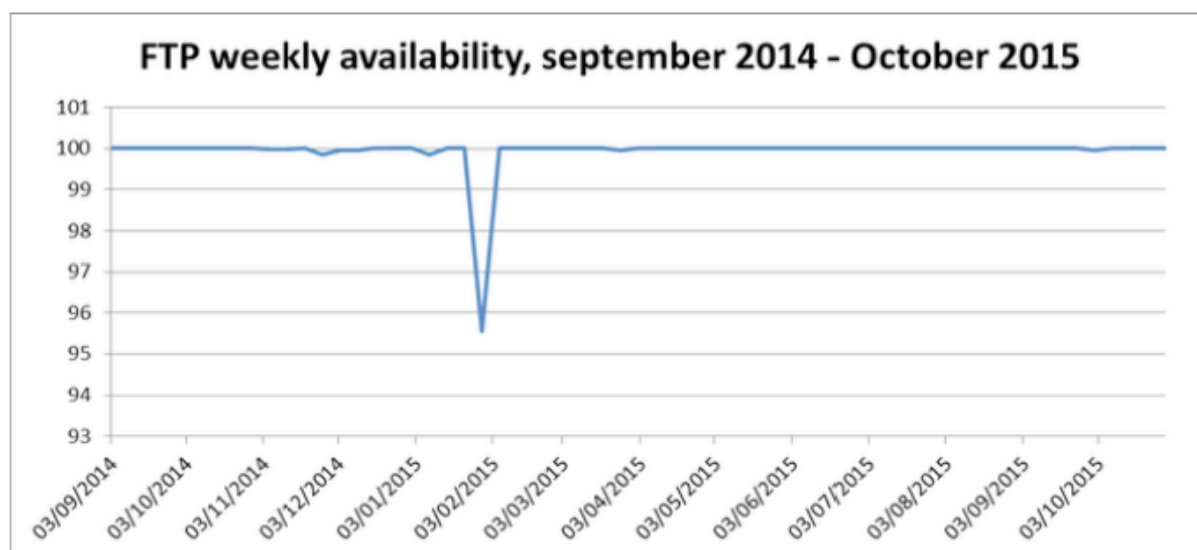


Figure 2 : Nagios monitoring: between October 2014 and September 2015.

### 3.3.3 North Atlantic Argo Regional Centre<sup>13</sup>

See section 5.4

### 3.4 Status of delayed mode quality control process

In 2015, a total of 8118 new delayed mode profiles (628 floats) were produced and validated by PIs. A total of 124 997 delayed mode profiles were produced and validated since 2005 (see Figure 5). In February 2016, 59% of the floats and 60% of the profiles processed by the Coriolis DAC were in delayed mode (see Figure 6). Main DM operators are Coriolis, LOPS, BSH, OGS.

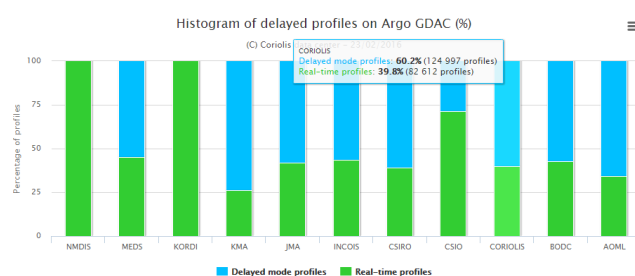


Figure 5: Evolution of the DM profiles' submission versus dates

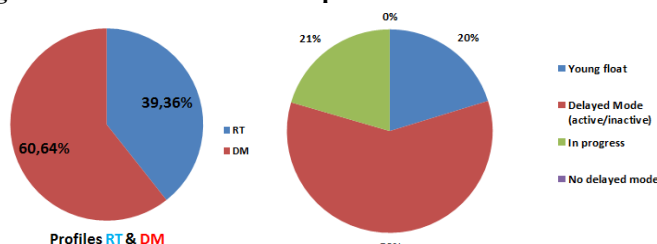
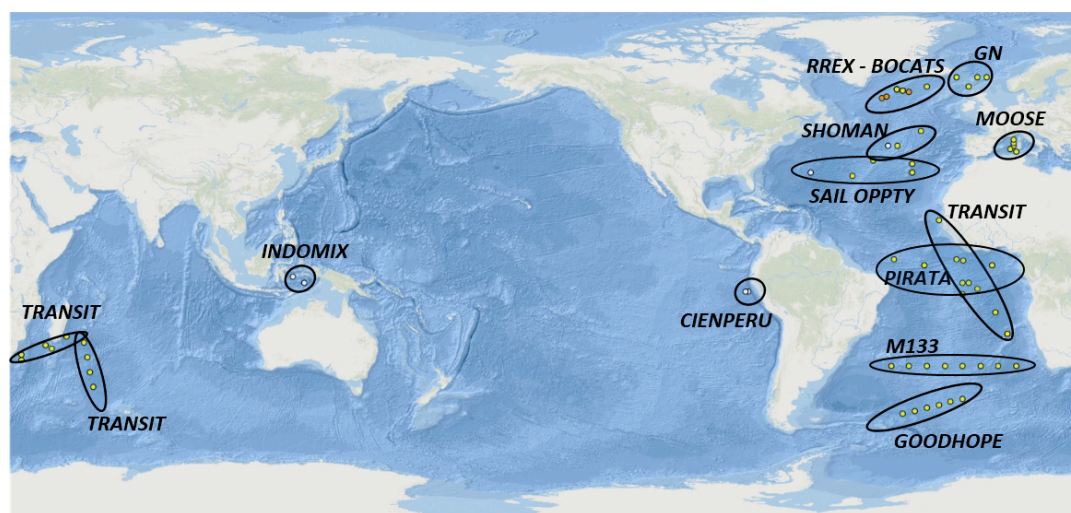


Figure 6. Status of the floats processed by Coriolis DAC. Left: in terms of float percent and right: in terms of profile percent (DM : delayed mode – RT : real time).

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

According to the current deployment plan, 65 core T/S floats will be deployed in 2016. They will be deployed in the Mediterranean Sea, in Atlantic (North and South), in the Southern Ocean and in the Indian Ocean. During the following cruises:

CRUISE	AREA	PERIOD	CTD FLOATS
CIENPERU	Peru	December	2
INDOMIX	Indonesia	May	2
MOOSE	Mediterranean Sea	May	5
OPPORTUNITY (SAIL)	North Atlantic	June	2
OPPORTUNITY (SAIL) VSF	North Atlantic	June	2
OPPORTUNITY (TRANSIT) BR-DKR-LR	South Atlantic	August	3
OPPORTUNITY (TRANSIT) BR-DUR	South Atlantic	November	7
OPPORTUNITY (TRANSIT) TAAF	South Indian Ocean	November	4
OPPORTUNITY GN	North Atlantic	August	4
OPPORTUNITY GOODHOPE	South Atlantic	December	6
OPPORTUNITY M133	South Atlantic	December	8
OPPORTUNITY SHOMAN	North Atlantic	September	4
PIRATA FR26	Gulf of Guinea	April	6
RREX-BOCATS	North Atlantic	June	10
<b>TOTAL :</b>			<b>65</b>



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

\* Level of commitment, areas of float deployment

† Data management



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 MERCATOR-Ocean<sup>6</sup> structure.

### **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, ...). In section 8 a non-exhaustive list of 2015's publications involving Argo data and a scientist from a French laboratory is reported.

### **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>).

We have checked 627 floats processed in delayed mode (DM) in the North Atlantic, North of 30°N. Among the 627 floats, 24 floats show a significant salinity drift or bias according and have been corrected according to the PI decision. A scientific article reporting the modified OW method have been submitted: "Improvement of bias detection in Argo float conductivity sensors and its application in the North Atlantic". C.Cabanes, V.Thierry, C.Lagadec. Submitted to Deep Sea Research part1, 2015.

## **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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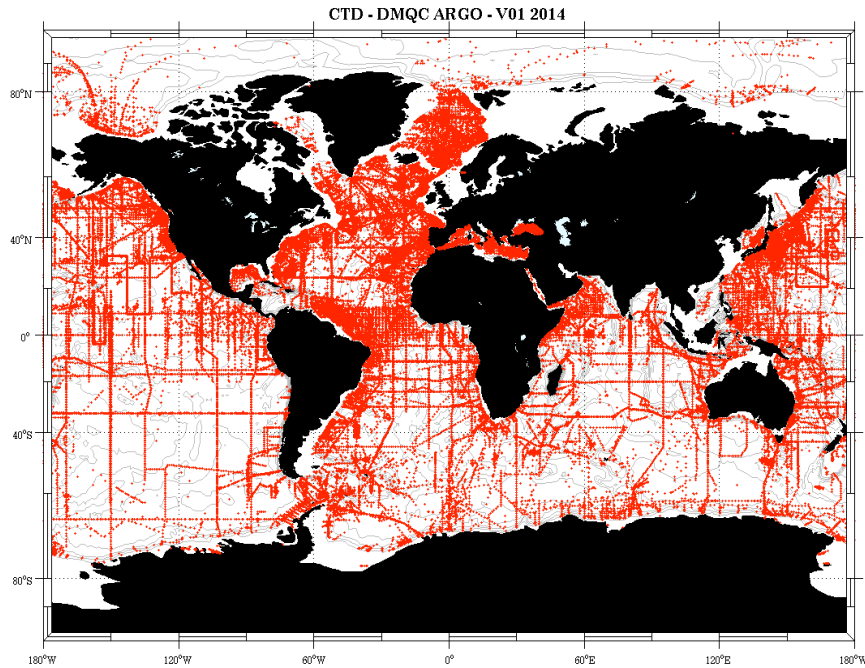
## **7 CTD CRUISE DATA IN THE REFERENCE DATABASE**

*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 number of CTD cruise data uploaded by PIs within France in 2015 to the CCHDO website is not known.

Since december 2014, no new version of the Argo CTD reference database has been generated. The last one is the version 2014V0, available on the ftp site (see Figure 11). In 2015, the work has been focused on the CCHDO API to get all the CTD data. In May 2015, API was made accessible to Ifremer to get the data, then after Coriolis was working on the association of platform\_code and expocode available in the CCHDO dataset. In 2016, those data will be integrated in a new version.

In 2015, some corrections have also been done after checking quality on the deep water to remove bad data. This work of correction has been done for the boxes with wmo number started with 3 and in progress for the others areas.



**Figure 11: CTD reference database (2014V01)**

## 8 BIBLIOGRAPHY

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

In 2015, at least 42 articles with a French scientist 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<sup>14</sup> and on the Argo Bibliography<sup>15</sup> webpage. To date, around 265 articles have been listed.

### **Argo-France Bibliography (44 references):**

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## Footnotes

<sup>1</sup> Argo France: <http://wwz.ifremer.fr/lpo/SO-Argo>

<sup>2</sup> Euro-Argo: <http://www.euro-argo.eu>

<sup>3</sup> Coriolis: <http://www.coriolis.eu.org>

<sup>4</sup> Laboratoire d'Océanographie Physique et Spatiale: <http://www.umar-lops.fr/>

<sup>5</sup> Laboratoire d'Océanographie de Villefranche: <http://www.obs-vlfr.fr/LOV>

<sup>6</sup> Mercator: <http://www.mercator-ocean.fr>

<sup>7</sup> IUEM OSU: <http://www-iuem.univ-brest.fr/observatoire>

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- <sup>8</sup> NAOS project: <http://www.naos-equipex.fr>
- <sup>9</sup> REMOCEAN project: <http://www.oao.obs-vlfr.fr>
- <sup>10</sup> Coriolis report as DAC/GDAC: <http://doi.org/10.13155/39749>
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- <sup>12</sup> Coriolis FTP: <http://www.coriolis.eu.org/Data-Services-Products/View-Download/Download-via-FTP>
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- <sup>15</sup> Argo PhD list: [http://www.argo.ucsd.edu/argo\\_thesis.html](http://www.argo.ucsd.edu/argo_thesis.html)