French National Report on Argo - 2013

Present status and future plans

Mar. 20th, 2014

G. Maze, C. Cabanes, C. Coatanoan, F. D'Ortenzio, N. Lebreton, S. Le Reste, P.Y. Le Traon, E. Mamaca, S. Pouliquen and V. Thierry

Table of Contents

Ifremer LPO report #14-02

1 BACKGROUND, ORGANIZATION AND FUNDING OF THE FRENCH ARGO ACTIVITIES

1.1 Organization

Argo France[1] 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[2] European research infrastructure (ERIC) that organizes and federates European contribution to Argo. Ministries from 12 European countries have agreed to form a new legal European entity to organize a long-term European contribution to Argo. The ERIC will be set up in May 2014. The Euro Argo infrastructure is made up of distributed national facilities and a central infrastructure based in France (Ifremer, Brest) which is owned and controlled by the Euro-Argo ERIC. The distributed national facilities operate with direct national resources. As part of the Euro-Argo research infrastructure, they agree to a multi-annual commitment of resources (in particular in terms of floats to be deployed and for the data system), and to coordinate their activities through the Euro-Argo ERIC.

Euro-Argo and its French component (Argo France) is part of the Ministry of Research national roadmap on large research infrastructure (TGIR). Argo France is organized through the Coriolis[3] partnership (IFREMER, SHOM, INSU, IRD, Meteo France, CNES and IPEV) and its governance bodies. Two research laboratories are leading the Argo France scientific activities: the "Laboratoire de Physique des Océans[4]" (LPO, Brest, France) and the "Laboratoire d'Océanographie de Villefranche[5]" (LOV, Villefranche, France). Argo France has been recognized in January 2011 as a long-term observing service. The agreement is valid for 10 years. Coriolis and Argo France have strong links with Mercator Ocean[6] (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 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[7] and funded by the CPER of the Brittany region.

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). Together with its European partners, Ifremer also works with the European commission to set up a long term direct EU funding for Argo.

Since 2000, more than 757 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[8] 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 will also develop the new generation of French Argo floats and set up pilot experiments for biogeogeochmical floats (Mediterranean Sea, Arctic) and deep floats (Atlantic). A 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[9] 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
Total (2000-2013)			*721*		**796**
2014	**1400k€**	**12**	**80**	**2**	**82**

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 2014.

1.3 Long term evolution of Argo

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 (see Strengthening International Dimension of Euro-Argo Research Infrastructure, SIDERI[10] project). At French level, the plan for the next 10 years is to continue deploying between 70 to 80 floats/years but to include Argo oxygen, bio-Argo, deep Argo long term components (from 2016/2017 after the NAOS pilot projects). A plan was submitted this year to the French Ministry of Research (TGIR). The goal is to contribute to 30 floats/year (T&S), 10 to 15 deep floats/year, 15 to 20 floats with oxygen sensors and 15 floats/year with biogeochemical sensors. This will require additional funding for floats, sensors and data processing.

2 FLOAT DEVELOPMENT

Based on Ifremer expertise in acoustically tracked Lagrangian floats named "Marvor", the PROVOR profiling float has been developed in the late 90s. In collaboration with the NKE[11] manufacturer, Ifremer has designed the ARVOR float to complete the float offer meeting the Argo requirements to the Argo community. When PROVOR leads toward a "multi-sensors" configuration, ARVOR tends to agree with performances improvement, easy deployment (lighter weight < 20kg) and costs reduction.

Since 2011, Ifremer together with NKE and CNRS is working on PROVOR/ARVOR floats improvement within the NAOS project 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 2013, new prototypes have been completed.

The ARVOR has evolved to meet several requirements like reinforced self-tests, simplification of deployment protocol, securing the vector and the return of technical information and assistance for decoding the data. Improvements also include user driven possibilities such as being able to bind on a single float two missions (for Argos transmission system) with different parameters. 5 of these ARVOR floats will be tested at sea in 2014. The implementation of an oxygen measurement on ARVOR is still on going. As part of the E-AIMS[12] EU project, a 4330 Anderaa optode and a SBE63 oxygen sensor will be mounted on a single float for comparison.

Improving Argos satellite transmission has been one of our concerns, with the objective to transmit a complete Argo profile on a single satellite pass and to remotely control the float. Confirmation of this capabilities has been given by the experiment of an ARVOR fitted with Argos3 in the bay of Biscay during one year: at the end of 2013, about 140 cycles have been done by synchronizing its surface time with satellite pass and transmitting Argo profiles (CTD 100 points) spending 10 minutes. Energy balance is divided by five compared to an Argos-2 transmission, the transmission cost is reduced and the battery life is increased by 25%. The next step is to assess this transmission in marginal seas (e.g Mediterranean area).

The development of the ARVOR deep model has continued in 2013. The 2nd deep ARVOR prototype, deployed at sea in October 2012, was recovered in February 2013 after presenting an intermittent communication failure due to a manufacturing defect on the Iridium antenna. The profiler was reintegrated and then redeployed in November. At the end of February 2014, 50 cycles (two days period) have been performed. 2 other prototypes made by NKE will be delivered in March and will be deployed in the Atlantic Ocean during the GEOVIDE cruise (June-July). The expected performance of the deep ARVOR is at least 150 cycles to 4000 m depth. Deep ARVOR is fitted with an Aanderaa optode as well as high sampling capabilities. A pilot experiment will start from the end of the year using about 20 deep ARVOR floats in North Atlantic Ocean.

Another main aspect of the development concerns the bio-geochemical applications which are embedded on the PROVOR float. These developments focused on the addition of extra sensors by designing electronic architecture evolution (separation of vector management board from measurement board). This work first led to the PROVOR CTS4 (named ProvBio float). Then, additional work has been done by CNRS and NKE in order (i) to have a float being able to perform different cycle schemes than the standard Argo ones, and (ii) to modify its programmed mission itself depending on measurements or on results of mixed measurement computations. This PROVOR CTS5 float has been successfully tested at the end of 2013 and will be used in the Arctic area next year.

3 THE STATUS OF IMPLEMENTATION*

3.1 Floats deployed and their performance

81 floats have been deployed in 2013 (see Figure 1 and Figure 2). The deployment areas are chosen to meet French requirements in terms of research and operational activities (Atlantic, Indian and Southern Oceans) but also to contribute to establishing the global array (especially in the Southern Ocean).

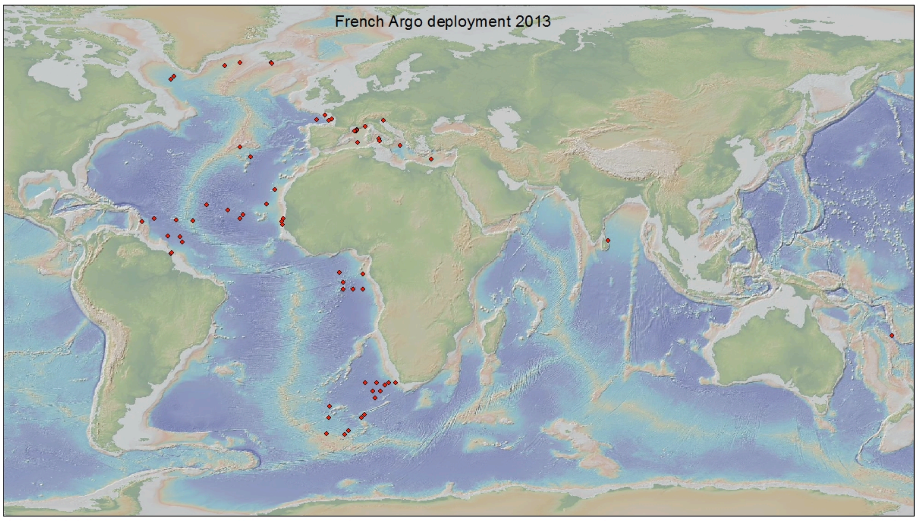


Figure 1: Deployment positions (red marks) of the 81 French floats deployed in 2013.

* Major achievements and problems in 2013

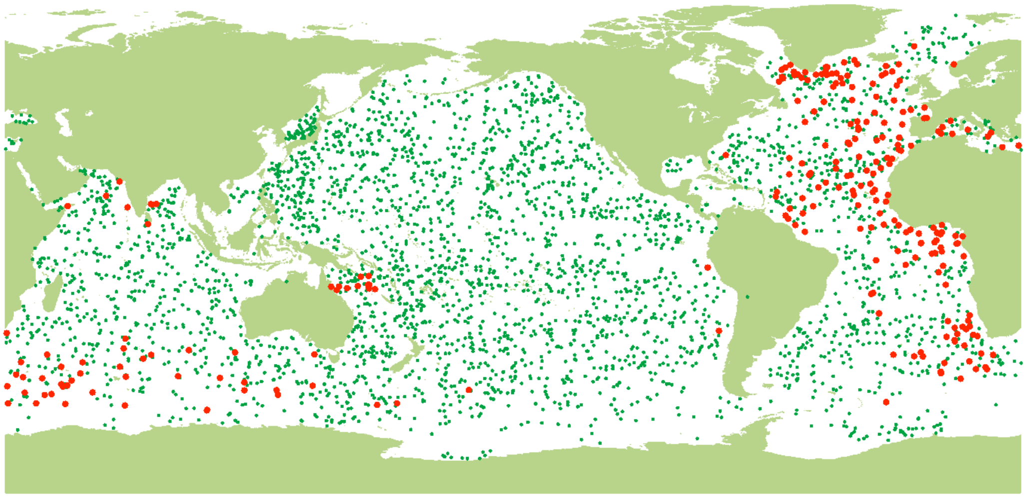


Figure 2: Positions (red marks) of the French active floats as of Feb.10th, 2014.

3.2 Technical problems encountered and solved

In 2013, ARVOR floats bought by IFREMER (30), SHOM (13) and project NAOS (30) were equipped with a new software version. This version turned out to be carrying a bug between date management and response of SBE sensors. This resulted in the loss of 10 ARVOR floats early in 2013, most of which deployed in the South Atlantic during the annual Goodhope cruise.

This problem led to the temporary suspension of the deployment of floats equipped with this software version. A new software version with the bug fixed, has been developed and ported to all the floats already received and accepted. Deployments have resumed once possible.

3.3 Status of contributions to Argo data management

Within Argo-France, Argo data management is undertaken by Coriolis which play three roles: Argo 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[13] (French only).

Since October 2013, data from the PROVOR Remocean project are processed in real-time. A work is underway among Argo data management group to integrate these data in the Global Data Assembly Centre (GDAC). The data from Provor Remocean floats are available by ftp:

ftp://ftp.ifremer.fr/ifremer/argo/etc/coriolis-custom/probio-draft

In December 2013 the ftp server counted 40 floats and 3421 vertical profiles. The data available from the above ftp server are a first trial to manage data from advanced bio-Argo floats. A series of Probio-Remocean floats are deployed and sending data.

3.3.1 Data Assembly Center[14]

Coriolis processes in Real Time and Delayed Mode float data deployed by France and 7 European countries (Germany, Spain, Netherlands, Norway, Italy, Greece, Bulgaria). Coriolis data center processes data coming from 21,954 profiles from 657 floats including 116 active floats in February 2014 (see Figure 3). In addition to these 657 floats, Coriolis is developing a new data processing chain based on Matlab to manage data and metadata from Provor-Remocean floats. These are advanced type of floats performing biogeochemical measurements. Data are processed and distributed according to Argo recommendations.

Real time profiles are available in Argo NetCDF V3.0, delayed mode profiles are still in Argo NetCDF V2.4 format. Since May 17th 2013, the new profile files from Coriolis DAC are distributed in Argo NetCDF version 3.0. On October 7th 2013, all the existing real-time profile files from Coriolis DAC where transformed into version 3.0 files (43 964 files resubmitted). To convert the remaining delayed-mode profile files to version 3.0, a patch is under development. In version 3, profile files report a vertical sampling scheme. On October 2013, Coriolis data files reported 14 different vertical sampling schemes.

More details on the new format an its adoption process by Coriolis DAC can be found here:

News from May 17th, 2013: http://www.argodatamgt.org/Data-Mgt-Team/News/Coriolis-DAC-real-time-data-distributed-in-Argo-NetCDF-3.0

News from Oct. 9th, 2013: http://www.argodatamgt.org/Data-Mgt-Team/News/Coriolis-DAC-all-real-time-profiles-converted-in-Argo-NetCDF-3.0

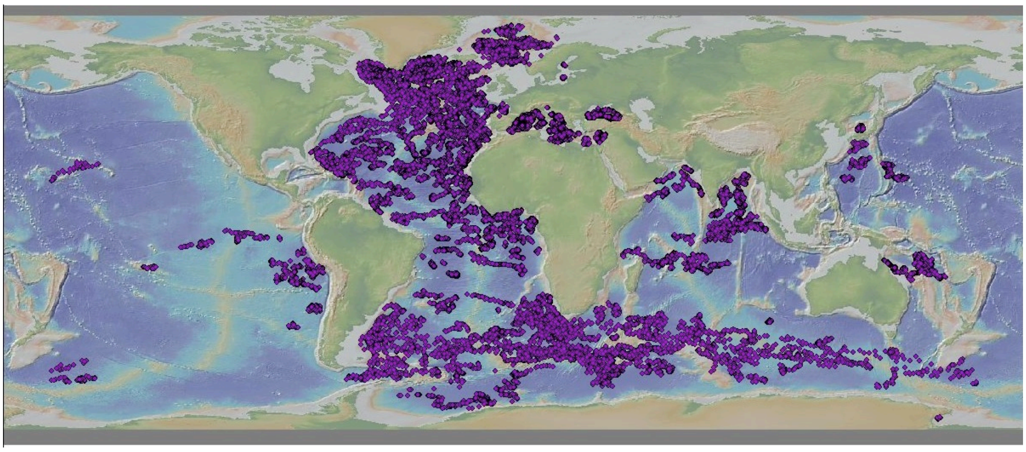


Figure 3: Maps of the 21 954 profiles from the 657 floats managed by Coriolis DAC in 2013.

3.3.2 Global Argo Data Centre[15]

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 4).

From January to November 2013 the ftp server was available for 99.992% of the time (compared to 99.98% last year). The 0.008% of failure represents 31 minutes of interruption (compared to 1 hour 52 minutes and 54 seconds last year).
The main problem occurred on week 34, in August 2013. The ftp server failed down, but was reactivated on another node of the cluster.

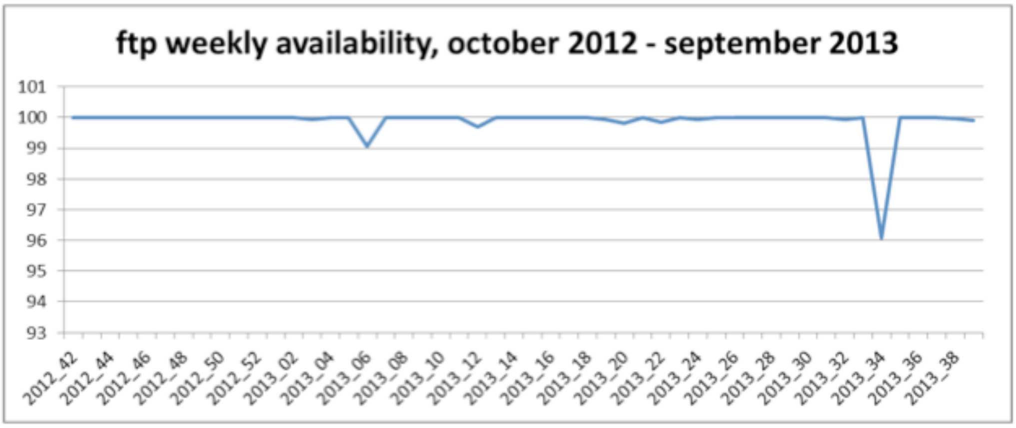


Figure 4 : Nagios monitoring: between October 2012 and September 2013.

3.3.3 North Atlantic Argo Regional Centre[16]

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 meta data about Argo profiles in the North Atlantic region (http://api.ifremer.fr/naarc/v1).

3.4 Status of delayed mode quality control process

In 2013, a total of 16 429 new delayed mode profiles where produced and validated by PIs. The number of delayed mode profiles increased by 15%. A total of 111 595 delayed mode profiles where produced and validated since 2005 (see Figure 5). In February 2014, 71% of the floats and 74% of the profiles processed by the Coriolis DAC were in delayed mode, compared to 69% and 73.6% last year, respectively (see Figure 6).

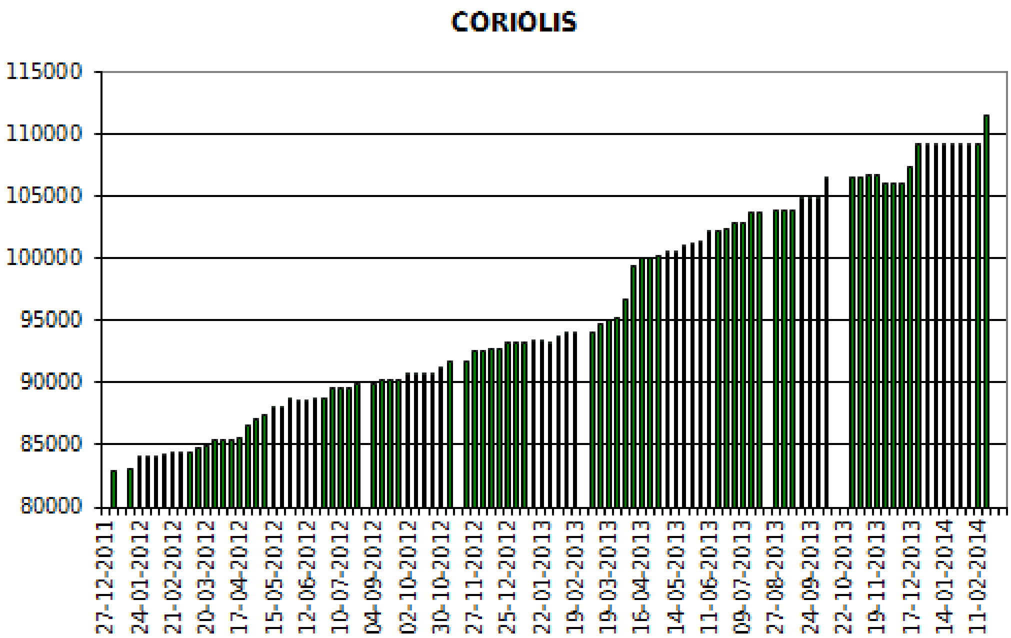
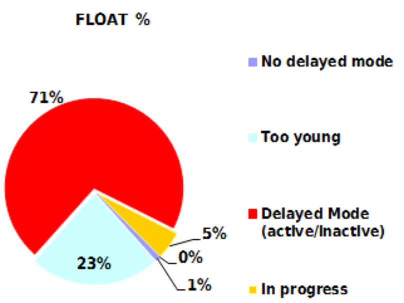


Figure 5: Evolution of the DM profiles' submission versus dates



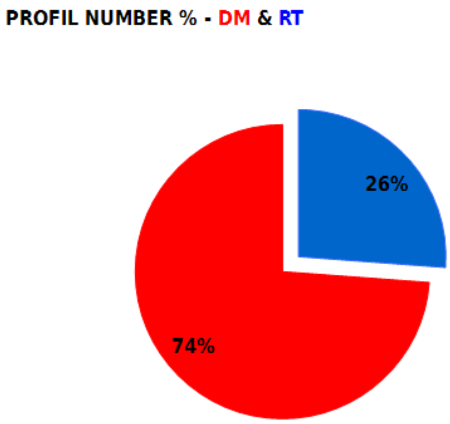


Figure 6 Status of the floats processed by Coriolis DAC. Left: in terms of float percent and right: in terms of profile percent (DM : delayed mode – RT : real time).

Status of pressure corrections, technical files : For APEX floats, the real-time pressure correction has been implemented at the Coriolis data center and it is operational. The implementation of the pressure correction of NEMO floats is still on-going.

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

According to the current deployment plan, 80 floats will be deployed in 2014. They will be deployed in 2014 in the Mediterranean Sea, in the North and the South Atlantic Oceans, in the Southern Ocean and in the Indian Ocean. during the following cruises:

- GMMC PIRATA: Guiny Gulf (6 floats)
- "Voiles sans frontières": Bay of Biscay and West Africa (10 floats)
- GMMC ZEBRE: New Caledonia (7 floats)
- GMMC AMOP: Off the coast of Peru (9 floats)
- GMMC GEOVIDE: North Atlantic (11 floats)
- GMMC MOOXY: Mediterranean Sea (7 floats)
- GMMC SAGAR: Gulf of Bengale (6 floats)
- GOODHOPE Opportunity: Southern Ocean, Atlantic sector (10 floats)
- SHOM Opportunity: Persian Golf (2 floats)
- Opportunity: Atlantic Ocean (12 floats)

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 MERCATOR-Ocean[6] 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"

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

Argo floats as well as floats equipped with oxygen and biogeochemical sensors. These new opportunities strengthens ties between the French scientific community and Coriolis with regard to the development of qualification procedures for "Argo extensions" floats.

In 2012, MERCATOR-Ocean support organisms ask the GMMC scientific committee for a prospective report covering all national operational efforts. The goal was to identify a common vision of the challenges and research activities to conduct over the next 10 years, taking into consideration the European context and previous national efforts. The final prospective report was publicly released in October 2013. The report contains about 20 recommendations and 10 new challenges, among which one can note the strong proposition to develop the multidisciplinary dimension of operational oceanography through: an improved and more homogeneous multiscale integration, an extension of the essential variables to estimate toward biology and biogeochemistry, and a shift from forced to coupled systems. More details on the prospective can be found here (in French):
http://www.mercator-ocean.fr/fre/science/gmmc/Prospective-Oceanographie-Operationnelle

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 2013's publications involving Argo data and a scientist from a French laboratory is reported. We cannot report here on all those studies' results, so we selected three of them particularly highlighting French activities on Argo data use (i) to reconstruct the 3D velocity field, (ii) to validate satellite data and (iii) to improve phytoplankton phenology.

➤ A significant research effort has been toward the description and analysis of the ocean circulation inferred from Argo data. They are synthesized in a study published by M. Ollitrault and A. Colin de Verdière in Journal of Physical Oceanography this January 2014. The mean ocean circulation near 1000-m depth was estimated with 100-km resolution from the Argo float displacements collected before 1 January 2010 (see Figure 7). After a thorough validation, the 400 000 or so displacements found in the 950–1150 dbar layer and with parking times between 4 and 17 days allowed the currents to be mapped at intermediate depths with unprecedented details. The Antarctic Circumpolar Current (ACC) is the most prominent feature, but western boundary currents (and their recirculations) and alternating zonal jets in the tropical Atlantic and Pacific are also well defined. Eddy kinetic energy (EKE) gives the mesoscale variability (on the order of 10 cm2 s22 in the interior), which is compared to the surface geostrophic altimetric EKE showing e-folding depths greater than 700 m in the ACC and northern subpolar regions. Assuming planetary geostrophy, the geopotential height of the 1000-dbar isobar was estimated to obtain an absolute and deep reference level worldwide. This was done by solving numerically the Poisson equation that results from taking the divergence of the geostrophic equations on the sphere, assuming Neumann boundary conditions.
For more details: Michel Ollitrault and Alain Colin de Verdière. (2013). The Ocean general circulation near 1000 m depth. *Journal of Physical Oceanography*. doi:10.1175/JPO-D-13-030.1

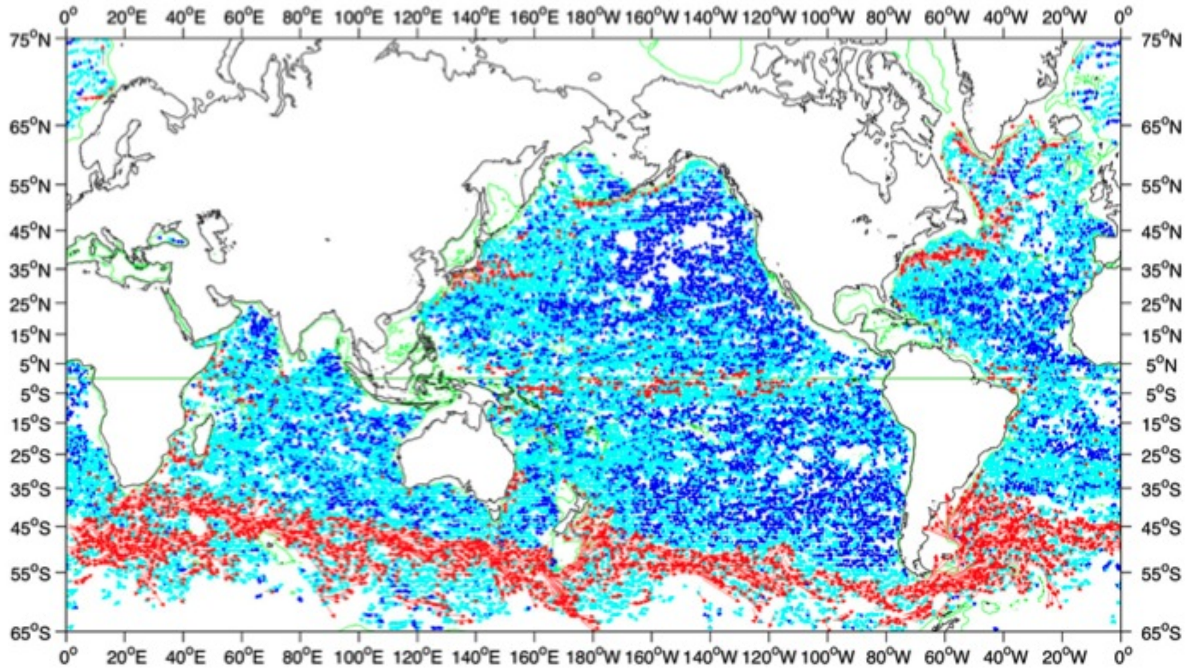


Figure 7: Average currents within 150-km-diameter disks, in the layer 950–1150 dbar and with at least 90 float days. Currents with speed greater than 5 cm.s^{-1} (red) are represented as 45-day displacements. Currents with speed less than 1 cm.s^{-1} (blue) are given as 90-day displacements. Currents with in between speeds (cyan) are shown as 45-day displacements.

➤ Argo data are also used intensively by Jacqueline Boutin and the Soil Moisture and Ocean Salinity (SMOS) scientific team to validate salinity measurements from the satellite mission and also surface drifters. They showed that biases close to land and ice from the sea surface salinity (SSS) measured from space by the SMOS mission greatly decrease with respect to the previous version. The accuracy of SMOS SSS averaged over 10 days, 100 × 100 km^2 in the open ocean and estimated by comparison to ARGO SSS is on the order of 0.3–0.4 in tropical and subtropical regions and 0.5 in a cold region. The averaged negative SSS bias (−0.1) observed in the tropical Pacific Ocean between 5◦ N and 15◦ N, relatively to other regions, is suppressed when SMOS observations concomitant with rain events, as detected from SSM/Is (Special Sensor Microwave Imager) rain rates, are removed from the SMOS–ARGO comparisons. The SMOS freshening is linearly correlated to SSM/Is rain rate with a slope estimated to −0.14 mm^{-1} h, after correction for rain atmospheric contribution. This tendency is the signature of the temporal SSS variability between the time of SMOS and ARGO measurements linked to rain variability and of the vertical salinity stratification between the first centimeter of the sea surface layer sampled by SMOS and the 5 m depth sampled by ARGO. However, given that the whole set of collocations includes situations with ARGO measurements concomitant with rain events collocated with SMOS measurements under no rain, the mean −0.1 bias and the negative skewness of the statistical distribution of SMOS minus ARGO SSS difference are very likely the mean signature of the vertical salinity stratification. In the future, the analysis of ongoing in situ salinity measurements in the top 50cm of the sea surface and of Aquarius satellite SSS are expected to provide complementary information about the sea surface salinity stratification.

For more details: J. Boutin, N. Martin, G. Reverdin, X. Yin, and F. Gaillard. (2013). Sea surface freshening inferred from SMOS and ARGO salinity: Impact of rain. *Ocean Sci.* doi:10.5194/os-9-183-2013

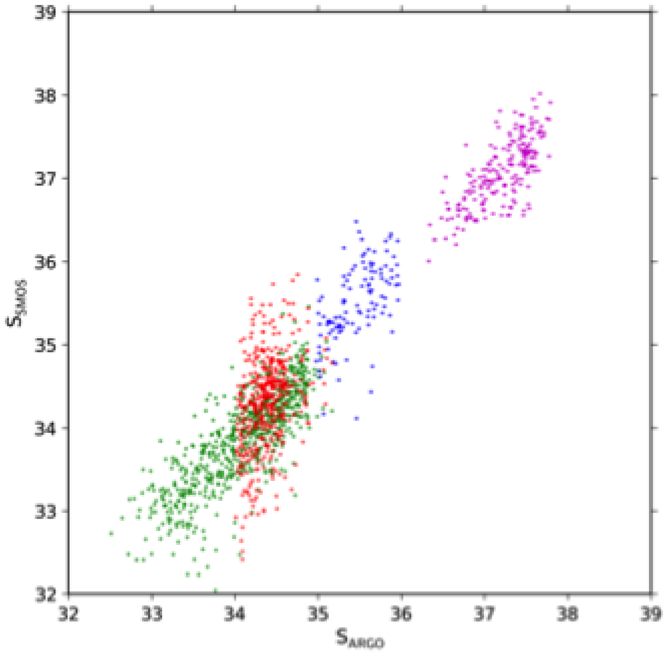


Figure 8: Scatter plot of SMOS SSS versus ARGO SSS for various regions (green: tropical Pacific Ocean; purple: subtropical Atlantic Ocean; blue: Soutern Indian Ocean; red: Southern Pacific Ocean).

➤ Phytoplankton phenology is primarily affected by physical forcing. However, its quantification is far from being completely understood. Among the physical forcing factors, the mixed layer depth (MLD) is considered to have the strongest impact on phytoplankton dynamics, and consequently, on their phenology. The role of MLD variations in shaping the phytoplankton phenology was explored in the Mediterranean Sea, a basin displaying contrasting phenological regimes. A database of MLD estimations was merged with ocean color chlorophyll concentrations ($[Chl]_{SAT}$) to generate concomitant annual MLD and $[Chl]_{SAT}$ cycles. Several indices were calculated to quantitatively analyze these cycles. The relevance of indices summarizing the temporal difference between main characteristics of MLD and $[Chl]_{SAT}$ cycles was emphasized. As previously observed, two dominant phenological regimes coexist in the Mediterranean Sea (see Figure 9). The first is marked by a typical spring bloom, as in temperate regions. The second displays a low seasonality and an absence of an intense $[Chl]_{SAT}$ peak as in subtropical areas. The MLD is shown to play a key role in determining the dominant phenological regime in a given area. Results also show that regions having low seasonality display concomitant MLD and $[Chl]_{SAT}$ maxima, whereas $[Chl]_{SAT}$ peaks are generally observed 30 days after MLD peaks in regions with strongest seasonality. Over the whole basin, $[Chl]_{SAT}$ increase starts 1 month after the initiation of MLD deepening. Finally, after examining the impact of MLD on light and nutrient availability for phytoplankton, mechanisms were proposed to explain the time lags between MLD and $[Chl]_{SAT}$ increase and MLD and $[Chl]_{SAT}$ maxima.

For more details: Lavigne, Héloïse and D'Ortenzio, Fabrizio and Migon, Christophe and Claustre, Hervé and Testor, Pierre and d'Alcalà, Maurizio Ribera and Lavezza, Rosario and

Houpert, Loïc and Prieur, Louis (2013): "Enhancing the comprehension of mixed layer depth control on the Mediterranean phytoplankton phenology", *Journal of Geophysical Research: Oceans*, doi: 10.1002/jgrc.20251.

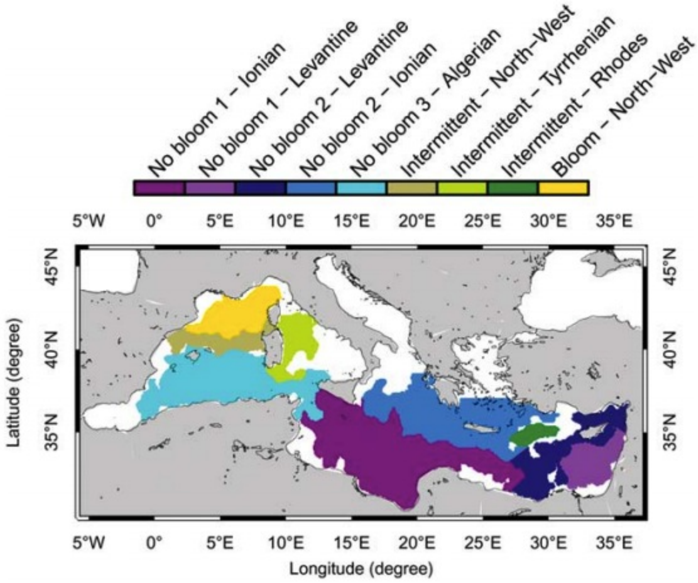


Figure 9: Spatial bioregions distribution of D'Ortenzio and Ribera d'Alcala (2009), redrawn for the purpose of the Lavigne et al. (2013) analysis.

French-Argo meeting: The French Argo Users' Group provides a forum for engagement between these scientists and the French Argo program. In 2013, French Argo Users met as part of the 4th Euro-Argo Science Meeting that was held in Southampton 18-20 June 2013.

5.4 Argo-Regional centre: North Atlantic

In 2013, we continued to investigate the performance of the OW method in the North-Atlantic. Our objective is to propose a cookbook on how to use OW to detect and correct salinity sensor bias or drift in the North-Atlantic.

We have modified the OW method in order to better take into account the large decadal/ interannual variability that was shown to induce spurious corrections with the standard OW method settings. Particularly, we have added a Gaussian decay with a time scale of 2 yr when computing the covariance matrix that is used to estimate the large scale field at the float profile position. Thus it is given greater weight to contemporaneous reference data. The original OW method takes into account the temporal variability but only when the small scale field is estimated and the large scale field is assumed to be constant. We have also modified the way the error on the best linear piecewise fit is computed. Indeed, errors on the fit are more realistic when a lateral covariance of mapped errors is taken into account.

The modified OW method was run for a subset of unbiased floats with a time scale of 2 years. The corrections proposed are less systematically biased (see Figure 10) although in some regions it may have been necessary to modify the configuration parameters (i.e. chosen θ levels) to obtain corrections closer to zero. Most of the offset proposed by the method are now close to zero within the error bar, which is much more consistent with the PI's decision for these floats.

Finally, we have checked again the correction for 186 floats corrected in delayed mode for a salinity offset or drift. Among these floats, we have found 32 floats for which we think it is necessary to revise the DM correction. 21 floats have been checked again by the PI, the correction has been modified and transmitted to the DAC. 15 floats have been checked again by the PI, the correction has been modified but not yet transmitted to the DAC. The others floats have not been checked again yet. The full list of these floats will be found soon on the NA-ARC website.

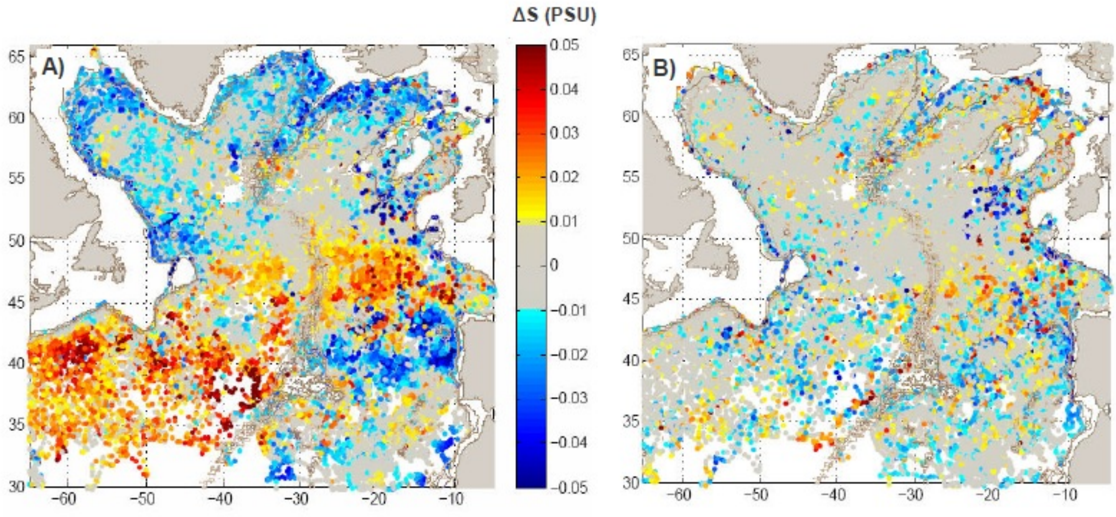


Figure 10: Corrections proposed by the OW method for all floats for which no salinity correction was judged necessary by the PIs. A) CTD reference database is used for calibration. B) Argo and CTD reference databases are used for calibration and a Gaussian decay with a time scale of 2 yr is added when the large scale field is estimated.

The expertise acquired during this study is also being used at Coriolis and LPO for delayed mode quality control of French Argo floats localized in the Southern Ocean. A diagnostic of the OW method under two different configurations is performed and improvements will be proposed in 2014.

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.

None.

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 2013 to the CCHDO website is not known.

In March 2013, a new version of the Argo CTD reference database[17] (2013V01) was made available on the ftp site. This version takes into account update from WOD2009 and some corrections on data (see Figure 11).

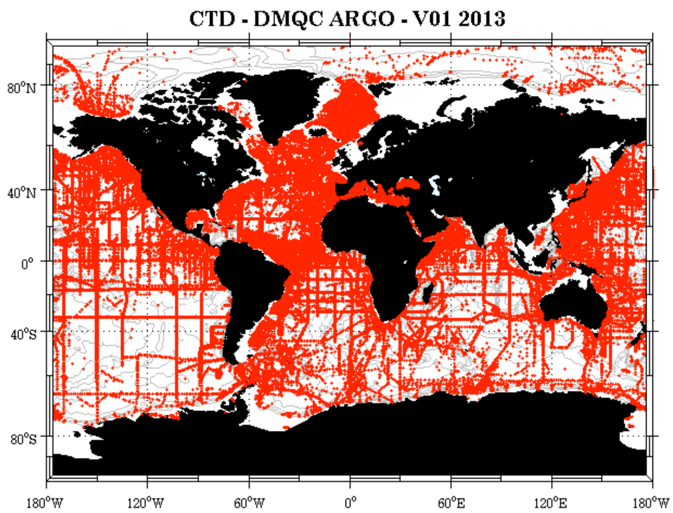


Figure 11: CTD reference database (2013V01)

The Coriolis reference database CORA[18] has been updated with ICES data from Coriolis database for V3 of MyOcean. An updated version (3.4) of the reference database was provided to the Argo community in April 2013.

8 BIBLIOGRAPHY

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

In 2013, at least 14 articles with a French scientist as a coauthor have been published in peer reviewed journals. The list is reported herefater. Note that the list of all publications in a which a scientist from a French laboratory is involved is available on the Argo France website[19] and on the Argo Bibliography[20] webpage. To date, 153 articles have been listed (see Figure 12).

In May 2013, we setup an online form dedicated to the French community to report as easily as possible PhDs and Master internships using Argo data. So far, 25 PhDs have been reported. The form is available here: http://goo.gl/XjBxC0. In 2013, 3 PhDs using Argo data have been defended.

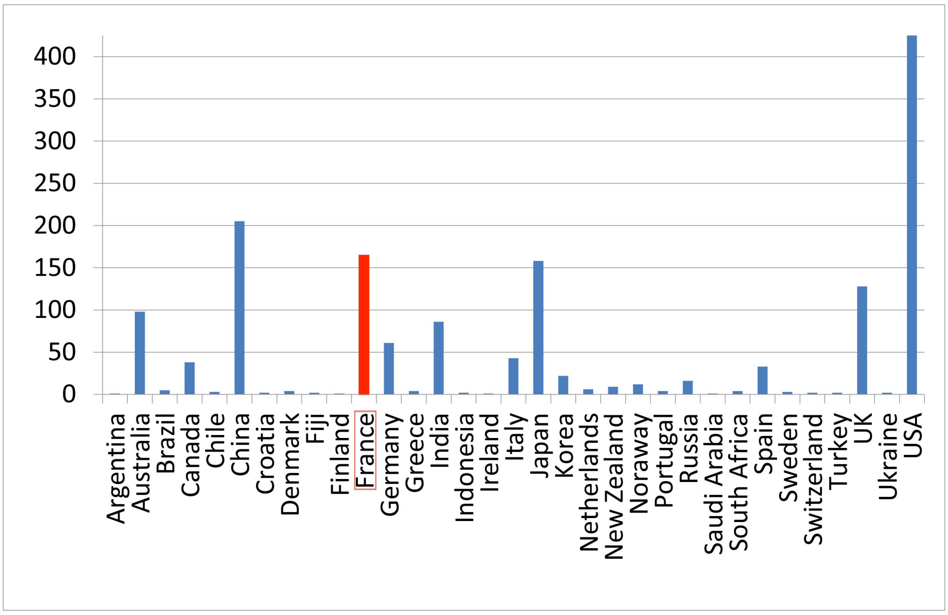


Figure 12: Number of paper using Argo data as function of the country of the lead author. France contribution is highlighted in red.

2013 French scientific bibliography:

1. Boutin, J. and Martin, N. and Reverdin, G. and Yin, X. and Gaillard, F. (2013): "Sea surface freshening inferred from SMOS and ARGO salinity: impact of rain", Ocean Science, DOI: 10.5194/os-9-183-2013.
2. Cabanes, C. and Grouazel, A. and von Schuckmann, K. and Hamon, M. and Turpin, V. and Coatanoan, C. and Paris, F. and Guinehut, S. and Boone, C. and Ferry, N. and de Boyer Mont\'egut, C. and Carval, T. and Reverdin, G. and Pouliquen, S. and Le Traon, P.-Y. (2013): "The CORA dataset: validation and diagnostics of in-situ ocean temperature and salinity measurements", Ocean Science, DOI: 10.5194/os-9-1-2013.
3. Xavier Carton and Bernard Le Cann and Alain Serpette and Jesus Dubert (2013): "Interactions of surface and deep anticyclonic eddies in the Bay of Biscay", Journal of Marine Systems, DOI: 10.1016/j.jmarsys.2011.09.014.
4. Da-Allada, C. Y. and Alory, G. and du Penhoat, Y. and Kestenare, E. and Durand, F. and Hounkonnou, N. M. (2013): "Seasonal mixed-layer salinity balance in the tropical Atlantic Ocean: Mean state and seasonal cycle", Journal of Geophysical Research: Oceans, DOI: 10.1029/2012JC008357.
5. De Souza,João Marcos Azevedo Correia and De Moraes Paiva,Afonso and Von Schuckmann,Karina (2013): "New estimates for the heat flux across the Polar Front: spatial and temporal variability in recent years", Antarctic Science, DOI: 10.1017/S0954102012001113.
6. Fan, Xue and Send, Uwe and Testor, Pierre and Karstensen, Johannes and Lherminier, Pascale (2013): "Observations of Irminger Sea Anticyclonic Eddies", Journal of Physical Oceanography, DOI: 10.1175/JPO-D-11-0155.1.
7. Hasson, Audrey and Delcroix, Thierry and Dussin, Raphaël (2013): "An assessment of the mixed layer salinity budget in the tropical Pacific Ocean. Observations and

modelling (1990–2009)", Ocean Dynamics, DOI: 10.1007/s10236-013-0596-2.

8. Keerthi, M. G. and Lengaigne, M. and Vialard, J. and Boyer Montégut, C. and Muraleedharan, P. M. (2013): "Interannual variability of the Tropical Indian Ocean mixed layer depth", Climate Dynamics, DOI: 10.1007/s00382-012-1295-2.
9. Kolodziejczyk, Nicolas and Gaillard, Fabienne (2013): "Variability of the Heat and Salt Budget in the Subtropical Southeastern Pacific Mixed Layer between 2004 and 2010: Spice Injection Mechanism", Journal of Physical Oceanography, DOI: 10.1175/JPO-D-13-04.1.
10. Lavigne, Héloïse and D'Ortenzio, Fabrizio and Migon, Christophe and Claustre, Hervé and Testor, Pierre and d'Alcalà, Maurizio Ribera and Lavezza, Rosario and Houpert, Loïc and Prieur, Louis (2013): "Enhancing the comprehension of mixed layer depth control on the Mediterranean phytoplankton phenology", Journal of Geophysical Research: Oceans, DOI: 10.1002/jgrc.20251.
11. Le Traon, P. Y. (2013): "From satellite altimetry to Argo and operational oceanography: three revolutions in oceanography", Ocean Science, DOI: 10.5194/os-9-901-2013.
12. Lellouche, J.-M. and Le Galloudec, O. and Dr\'evillon, M. and R\'egnier, C. and Greiner, E. and Garric, G. and Ferry, N. and Desportes, C. and Testut, C.-E. and Bricaud, C. and Bourdall\'e-Badie, R. and Tranchant, B. and Benkiran, M. and Drillet, Y. and Daudin, A. and De Nicola, C. (2013): "Evaluation of global monitoring and forecasting systems at Mercator Ocean", Ocean Science, DOI: 10.5194/os-9-57-2013.
13. Ollitrault, Michel and Rannou, Jean-Philippe (2013): "ANDRO: An Argo-Based Deep Displacement Dataset", Journal of Atmospheric and Oceanic Technology, DOI: 10.1175/JTECH-D-12-00073.1.
14. Reverdin, G. and MARIE,Louis, L. and Lazure, P. and d'Ovidio, F. and Boutin, J. and Testor, P. and Martin, N. and Lourenco, A. and Gaillard, F. and Lavin, A. and Rodriguez, C. and Somavilla, R. and Mader, J. and Rubio, A. and Blouch, P. and Rolland, J. and Bozec, Y. and Charria, G. and Batifoulier, F. and Dumas, F. and Louazel, S. and Chanut, J. (2013): "Freshwater from the Bay of Biscay shelves in 2009", Journal of Marine Systems, DOI: http://dx.doi.org/10.1016/j.jmarsys.2011.09.017.

2013 French PhD:

1. C., Da Allada (2013): "Rôle de la salinité océanique de surface sur la dynamique du Golfe de , Guinée – apport des données satellitales", Université Paul Sabatier et Université d'Abomey Calavi. http://tel.archives-ouvertes.fr/tel-00925720.
2. K. Guihou (2013): "Study of the Northern Current dynamics in the Toulon region, using modelling, in-situ observations and satellite data.". Université de Toulon. http://tel.archives-ouvertes.fr/tel-00917904.
3. S., Mulet (2013): "Apport de la mission gravimetrique GOCE pour l'analyse de la circulation oceanique ", Université Paul Sabatier.

Footnotes

[1] Argo France: http://wwz.ifremer.fr/lpo/SO-Argo
[2] Euro-Argo: http://www.euro-argo.eu
[3] Coriolis: http://www.coriolis.eu.org
[4] Laboratoire de Physique des Océans: http://wwz.ifremer.fr/lpo
[5] Laboratoire d'Océanographie de Villefranche: http://www.obs-vlfr.fr/LOV
[6] Mercator: http://www.mercator-ocean.fr
[7] IUEM OSU: http://www-iuem.univ-brest.fr/observatoire
[8] NAOS project: http://www.naos-equipex.fr
[9] REMOCEAN project: http://www.oao.obs-vlfr.fr
[10] SIDERI project: http://www.euro-argo.eu/EU-Projects-Contribution/SIDERI2
[11] NKE manufacturer: http://www.nke-corporate.com
[12] E-AIMS project: http://www.euro-argo.eu/EU-Projects-Contribution/E-AIMS
[13] 2013 Coriolis report as DAC/GDAC: http://www.coriolis.eu.org/All-news/News/Argo-data-management-Coriolis-DAC-GDAC-report-2013
[14] Coriolis DAC: http://www.coriolis.eu.org/Observing-the-ocean/Observing-system-networks/Argo
[15] Coriolis FTP: http://www.coriolis.eu.org/Data-Services-Products/View-Download/Download-via-FTP
[16] NA-ARC data mining website: http://www.ifremer.fr/lpo/naarc
[17] Argo CTD reference database: http://www.argodatamgt.org/Reference-data-base/Latest-Argo-Reference-DB
[18] CORA database: http://www.coriolis.eu.org/Science/Data-and-Products/CORA2
[19] French bibliography: http://wwz.ifremer.fr/lpo/SO-Argo-France/Publications
[20] Argo PhD list: http://www.argo.ucsd.edu/argo_thesis.html