

French National Report on Argo - 2019



By the Argo-France Management Board

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Background, organization and funding of the French Argo activities

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 European research infrastructure (ERIC) that organizes and federates European contributions to Argo.

All Argo-France activities are lead and coordinated by:

- a scientific committee shared with the CNRS/LEFE Group Mission Mercator Coriolis (GMMC),
- a [steering team](#) with: a national coordinator (G. Maze), scientific coordinators for the physical and bio-geochemical missions (N. Kolodziejczyk, F. D'Ortenzio, H. Claustre), technical coordinators for the physical and bio-geochemical missions (S. Pouliquen, F. D'Ortenzio), head of the data center (T. Carval), data center officer for BGC (C. Schmechtig), heads of operational and infrastructure activities (N. Lebreton, N. Poffa, A. Poteau) and heads of quality control activities (C. Cabanes and R. Sauzède).

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 partnership (IFREMER, SHOM, INSU, IRD, Météo France, CEREMA, CNES and IPEV). Two research laboratories are leading the Argo-France scientific activities: the ["Laboratory for Ocean Physics and Satellite remote sensing" \(LOPS, Brest, France\)](#) and the ["Laboratoire d'Océanographie de Villefranche"/"Institut de la Mer de Villefranche" \(IMEV/LOV, Villefranche-sur-Mer, France\)](#). Coriolis and Argo-France have strong links with Mercator Ocean International (the French operational ocean forecasting center).

Funding

Argo-France is mainly funded by the ministry of Research through Ifremer as part of the 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, SU and IUEM). At regional scale, Argo-France is supported by the IUEM OSU and funded by the Brittany and Provence Alpes-Cote d'Azur regions (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 1406 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 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 15 to 20 floats per year from 2012 to 2019, which allows Ifremer to increase its long-term contribution to Argo from 50 to 65-70 floats/year. NAOS also has developed the new generation of French Argo floats and set up pilot experiments for biogeochemical floats (Mediterranean Sea, Arctic), under Ice BGC floats (baffin bay) and deep floats (North Atlantic).

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	<i>French floats</i>	<i>Co-funded EU floats</i>	<i>Total</i>
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€	12	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
2017	1400k€	14	65		65
2018	1400k€	14	95		95
2019	1400k€	14	74		74
<i>Total (2000-2019)</i>			1210		1285

2020	1400k€	15	60		60
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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 2019 (more expected).

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 (PIA3) and new CPER from Brittany region.

Argo-France strategy will be adjusted according to national interests and international recommendations with regard to the deep and Bio-Argo extensions and their implementation plans currently being developed. 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.

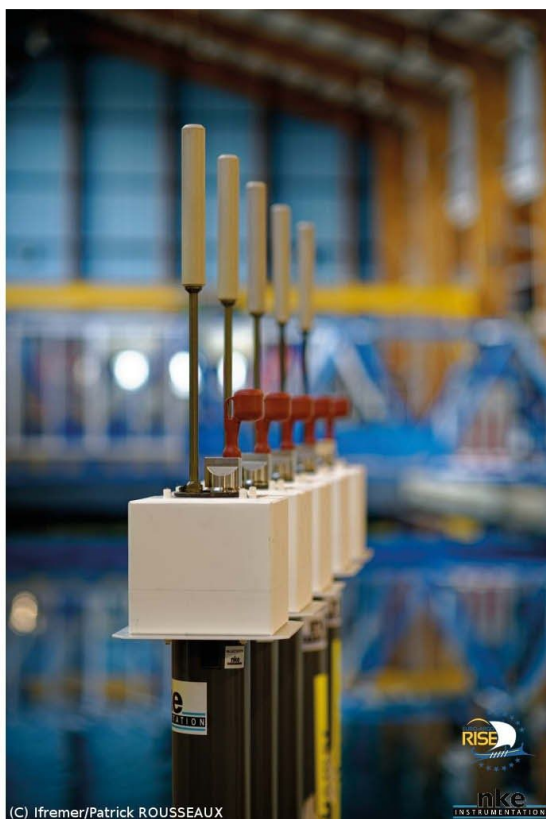
Float development

As part of the [EA-RISE 2019-2022 H2020 project](#):

- an Arvor model equipped with the RBR CTD is being developed. Prototypes are ready and first full tests in the ocean are expected in 2020.
- two Deep-Arvor equipped with 2-CTDs (the RBRargoDeep|OEM and the SBE61) are being developed. Due to delay in sensor provisioning, these floats should be deployed in 2021.
- Two Provor floats with SUNA + OPUS + O2 + EcoTriplet and with OC4 + RAMSES + O2 + EcoTriplet are developed, tested in the Mediterranean Sea and will be deployed in the Baltic.

As part of the new [ERC REFINE project](#) (see details in the National research section) technological developments are expected to provide:

- Extended battery packs for longer mission
- New electronic for targeted exploration and adaptative sampling
- New sensors for particles and zooplankton characterization



New RBR CTD mounted on the head of the Arvor float.



The deep-Arvor prototype equipped with 3 CTDS: RBR, SBE41 and SBE61.

The status of implementation

Floats deployed and their performance

74 floats have been deployed by France in 2019 (53 T/S Core, 10 T/S/O2, 7 BGC and 2 CTS5 ICE). 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.



Technical problems encountered and solved

No technical problems *specific* to Argo-France were encountered in 2019 with regard to operational T/S floats.

Seabird batch of drifting CTDs is being assessed and monitored.

- 10 Floats QCed by LOPS and affected by the issue are documented here:

<https://docs.google.com/spreadsheets/d/1qzuJqw8yAZhiWTSL9j3AMatbBWaD6ZsapTsfFofkDXA/edit#gid=0>

- The SBE CTD drift is likely to impact near real time (NRT) Argo analysis products at Coriolis using both DM and RT profiles (for recent years). Since 2015, global averaged salinity issued from Coriolis NRT analysis is suspectly increasing over the whole water column (+0.001 to 0.003 pss). This could be explained by the large amount of RT profile suffering from SBE salinity drift (still in late 2019). The potential impact of SBE salinity drift on global salinity analysis is an ongoing work.

- A more complete assessment of the impact on the national fleet is in preparation and [QC analysis is available on this issue of the public Argo QC forum](#).

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 and CNRS. Since 2016, the BGC floats processing chain have been fully operational and integrated within the Coriolis data management stream.

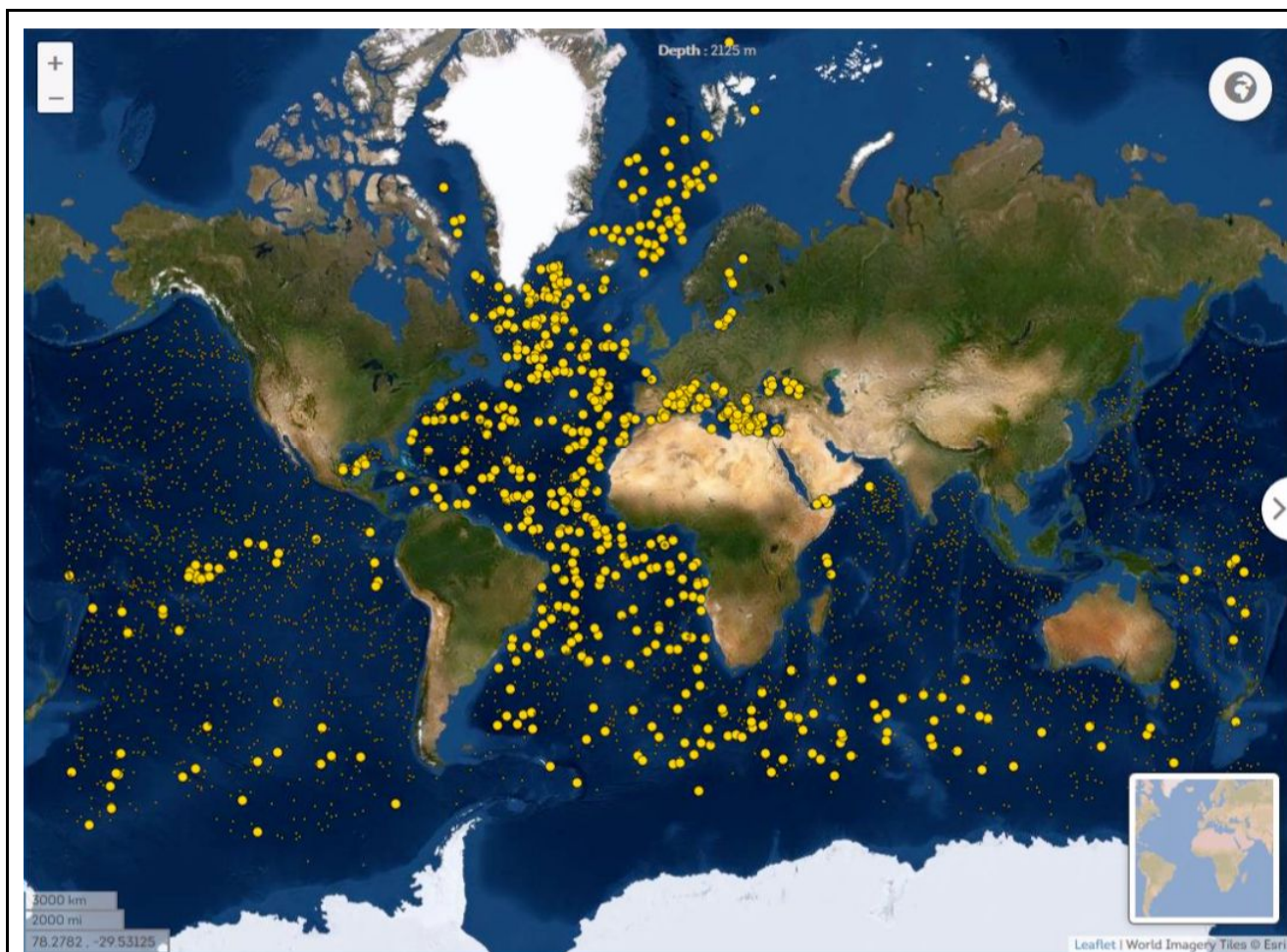
All Argo data management details are in the Coriolis DAC and GDAC 2019 annual report (english) : <https://doi.org/10.13155/69679>

Data Assembly Center

Coriolis processes in Real Time and Delayed Mode float data deployed by France and 7 European countries (Germany, Spain, Netherlands, Norway, Italy, Greece, Bulgaria).

These last 12 months **34.921 profiles from 827 active floats** were collected, controlled and distributed. Compared to 2018, **the number of profiles is significantly increasing (+15%), the number of floats increased by 4%**. These figures illustrate a good momentum in Coriolis DAC activity. The 827 floats managed during that period had 51 versions of data formats.

In July 2019, Coriolis stopped the TESAC messages distribution; only BUFR messages are now distributed.

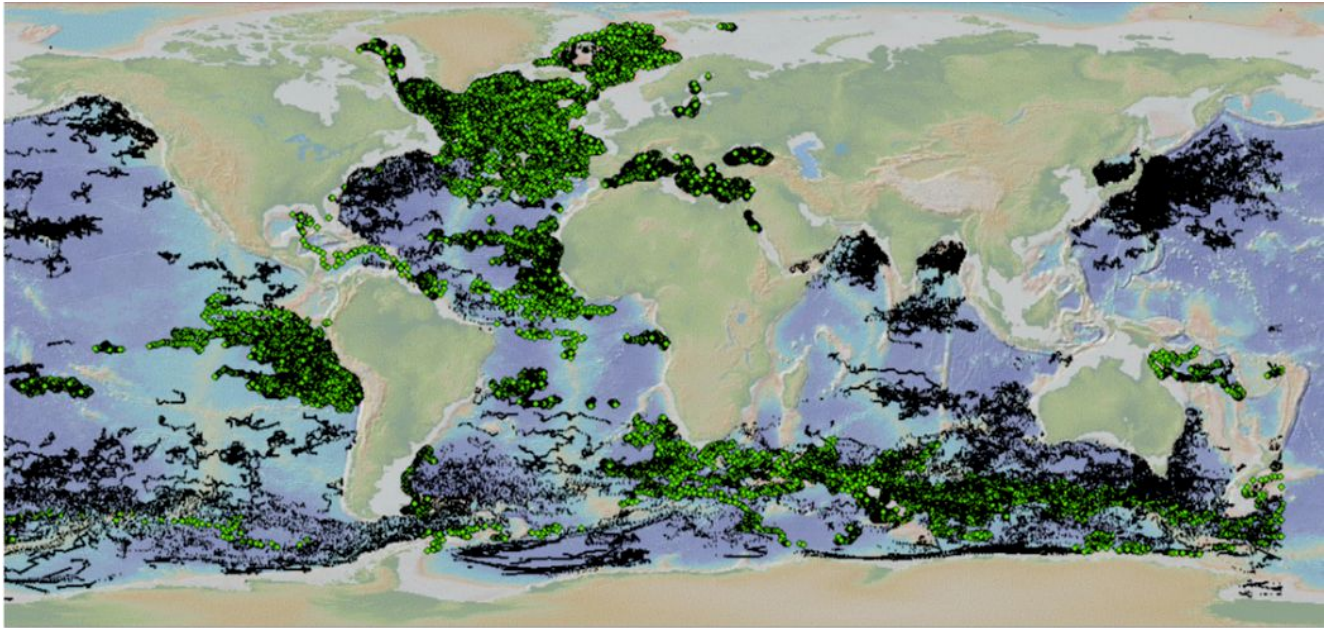


Map of the 827 active floats decoded by Coriolis DAC this year (yellow dots), among other DACs (small dots). Map obtained from <https://fleetmonitoring.euro-argo.eu/dashboard>

The data processing chain based on Matlab to manage data and metadata from Coriolis BGC-floats is continuously improved. Coriolis DAC manages 453 BGC-Argo floats from 4 families. They performed 63 634 cycles. The data processing chain is freely available:

- Coriolis Argo floats data processing chain, <http://doi.org/10.17882/45589>

In 2019, the Oxygen manual was updated: “Processing Argo oxygen data at the DAC level cookbook” <http://doi.org/10.13155/39795>. To implement the updates, all oxygen profiles were reprocessed during spring 2019. More than 42 000 files containing oxygen data were resubmitted on the GDAC ftp server.



Map of the 453 BGC-Argo floats managed by Coriolis DAC (grey dots: the others DACs bio-Argo floats). They measure parameters such as oxygen, chlorophyll, turbidity, CDOM, back-scattering, UV, nitrate, bisulfide, pH, radiance, irradiance, PAR.

Global Argo Data Centre

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. There is a monthly average of around 550 unique visitors, performing 4300 sessions and downloading about 6 terabytes of data files.

Within the [EU AtlantOS project](#), Ifremer is setting up a dashboard (Semaphore) to monitor data distribution and give credit to data providers such as Argo floats.

FTP downloads log files are ingested in an Elasticsearch index. A link between downloaded files, download originators, floats included in the downloaded files and institution owners of the floats is performed. These links are displayed in a Kibana dashboard.

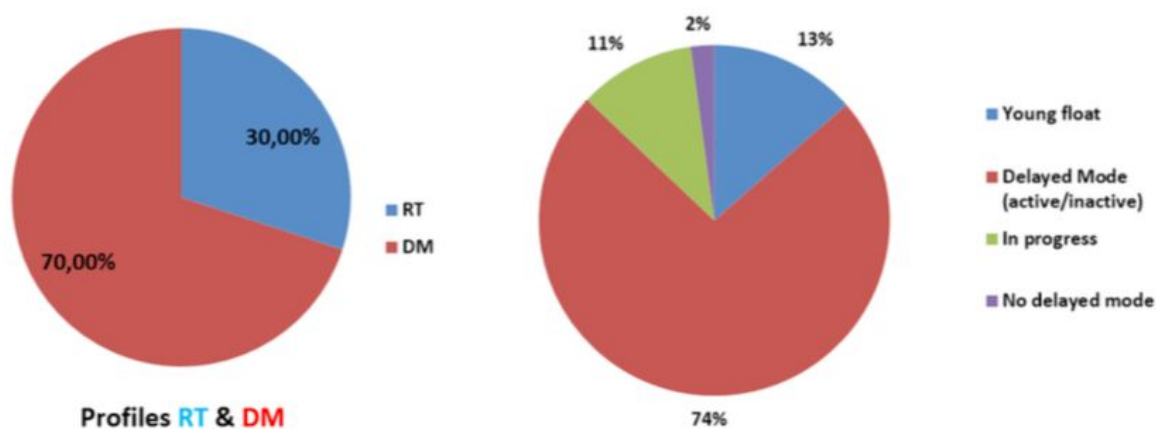
This dashboard will offer the possibility to give credit to Floats owner institutions such as how many data from one particular institution was downloaded, by whose data users.

North Atlantic Argo Regional Centre

See NAARC activities in the Research section.

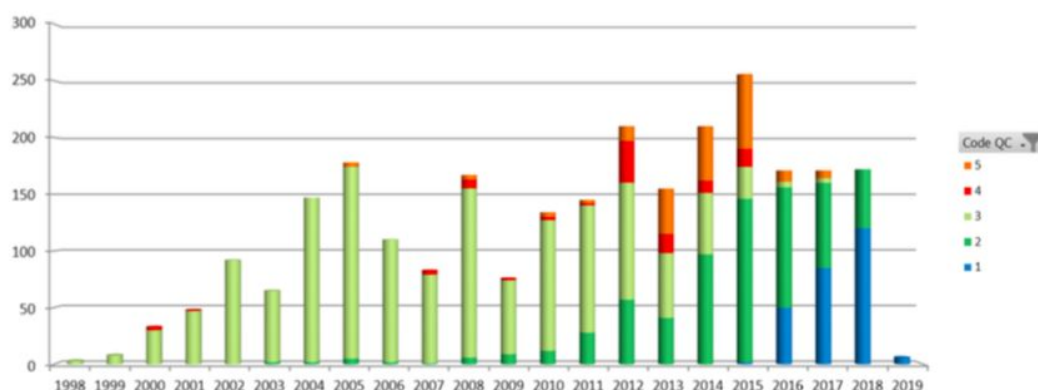
Status of delayed mode quality control process

Last year, 115 892 new or updated delayed mode profiles were produced, validated by PIs and sent to GDACs. A total of 222 641 delayed mode profiles were produced and validated since 2005. 75% of the floats and 70% of the profiles processed by the Coriolis DAC are in delayed mode (see Figure below).



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

The status of the quality control done on the Coriolis floats is presented in the following plot. For the two last years (2018- 2019), most of the floats are still too young (code 1) to be performed in delayed mode. For the years 2012-2013-2014, we are still working on the DMQC of some floats. The codes 2 and 3 show the delayed mode profiles for respectively active and dead floats.



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.

Summary of deployment plans and other commitments to Argo for the upcoming year and beyond where possible

According to the current deployment plan, at least **60 floats are scheduled to be deployed in 2020** (with 18 deep, 6 BGC, 11 DO), see map below.

Coriolis will continue to run the Coriolis DAC and the European GDAC as well as coordinating the North Atlantic ARC activities. Within Euro-Argo, development will be carried out to improve

anomalies detection at GDAC both in RT and DM, to monitor in real time the behaviour of the European fleet and to improve data consistency checks within NA-ARC.

France also will continue to contribute to the funding of the AIC.

Dossier Scientifique	PI	Type de demandes	ARVOR IRIDIUM	ARVOR ARGOS	CT53-DO	BGC	DEEP	CT55-ICE	SVP MET	XBT	Zone de déploiement	Navire	Campagne	Date de campagne	Port d'expédition	Date d'expédition
OISO	Blain	BGC				1					Kerguelen	MARION DUFRESNE	OISO	janv.-20	LA REUNION	Décembre
SIO 2020		BGC				2										
NORTH ATL		BGC				2										
PIRATA FR30	BOURLES Bernard - IRD	OPPORTUNITÉ	3				2			7	Golfe de Guinée	THALASSA	PIRATA FR30	16/02 au 23/03	BREST	07/02/2019
RARA AVIS 2020	COATANOAN C. - Ifremer	OPPORTUNITÉ		1							Transatlantique	RARA AVIS	RARA AVIS	février 2020	Brest	Janvier
PERLE 3	SHOM / DUMAS F.	SHOM	3								Méditerranée SE	POURQUOI PAS ?	PERLE3	mars-20	Toulon	Février
SAGA	PROVOST C. PELEGRI J.L.	OPPORTUNITÉ	5								Atlantique central	HESPERIDES	SAGA1	mai-20	BARCELONE	Novembre
SEPICAF CHILI	DEWITTE Boris LEGOS	GMMC 2018	5		2	1					Pacifique SE	Is in Peru and RV in Chile + Fa	Variées	Mi 2020	CALLAO & VALPARAISO	Début 2020
SEPICAF PEROU	DEWITTE Boris LEGOS	GMMC 2018	6		3						Pacifique SE	Is in Peru and RV in Chile + Fa	Variées	Mi 2020	CALLAO & VALPARAISO	Début 2020
DEEP CORE	DEBRUYERES D.	DEEP					16				AN	MARIAS, MERIAN	MSM92/94	juil.-20	BREST	Juin
GIBRALTAR	SHOM / DUMAS F.	SHOM	3								Gibraltar	ATALANTE	PROTEUS GIB	octobre	BREST	Juillet
EURECA-AO	BELLENGER Hugo	GMMC 2018			5					7	Atlantique tropical	ATALANTE	EURECA-AO	févr.-20	PAP	déc.-20
TOTAL 2020			25	1	10	6	18	0	0	14						
			60													



COVID19:

Because of the global pandemic outbreak in early 2020, Argo-France foresees a significant impact on its operations for 2020 and probably 2021. This impact is still being assessed and will be reported at the JCOMMOPS and Euro-Argo level for possible coordinations to sustain the array (<https://docs.google.com/spreadsheets/d/1of05ipeBLFRpNVKpcbTZuiKjpCmWwVU2TPI3-bBO0BM/edit?usp=sharing>).

Summary of national research and operational uses of Argo data as well as contributions to Argo Regional Centers

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

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 scientific proposals. Its task is to support the Mercator and Coriolis scientific activities and to participate in product validation. The call for scientific proposals proposes to the community "standard" Argo floats as well as floats equipped with oxygen and biogeochemical sensors. These new opportunities strengthen the link between the French scientific community and Coriolis with regard to the development of qualification procedures for "Argo extensions" floats.

National Research

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

A list of France bibliography is available at the end of this report.

In 2019, Argo-France scientific activities have seen the renewal of the CNRS/INSU support for 5 years. **A complete summary of the last 5 years activities and the next 5 years plan is available in english here:**

Kolodziejczyk Nicolas, Cabanes Cecile, D'Ortenzio Fabrizio, Maze Guillaume, Pouliquen Sylvie, Poteau Antoine, Schmechtig Catherine, Thierry Virginie (2019). Application file for renewal of the 'National Observation Service' label (INSU/CNRS) 2020-2024: SNO Argo-France. <https://doi.org/10.13155/61055>

Key projects activities

ANDRO Trajectory dataset

Argo-France contributes to the DMQC on Argo float trajectories and provides updates to the ANDRO product (Atlas of Argo trajectories). An update for the period 2010-2018 including the floats of the AOML, CSIRO, JMA DACs was published in 2019. The delayed-time QCs of the Argo float trajectory data have been updated, as well as the Andro Atlas of float travel velocities at DOI:

Ollitrault Michel, Rannou Philippe, Brion Emilie, Cabanes Cecile, Reverdin Gilles, Kolodziejczyk Nicolas (2019). ANDRO: An Argo-based deep displacement dataset. SEANOE.doi: <https://doi.org/10.17882/47077>

ICES North Atlantic Ocean State Report (IROC)

As every year, in 2019, Argo-France contributed and assembled the French contribution to the ICES report on the state of the North Atlantic Ocean in 2018. The ISAS temperature and salinity fields are used in its "Ocean State Report" (www.ices.dk):

Kolodziejczyk Nicolas, Reverdin Gilles, Desbruyères Damien (2019). Contribution to the ICES Report on Ocean Climate : North Atlantic Ocean in 2018. National report: France, June 2019. LOPS-WGOH-2018-01.doi: <https://doi.org/10.13155/59296>

H2020 EARISE (Euro-Argo Research Infrastructure Sustainability and Enhancement)

The H2020 EARISE project has seen its first year of activities show initial results:

- design of the integration of the new RBR probes on the Arvor and Arvor-Deep
- start of the implementation of a DAC for the BGC extension (Coriolis)
- integration design of new bio-optical sensors on PROVOR
- Implementation of a collaborative framework for the Argo community. Collaborative tools are available on github.com/euroargodev. All these tools are free and available for the European Argo community, among others:
 - A public forum on Argo QC to be used by the Argo-France community: github.com/euroargodev/publicQCforum
 - Hosting of digital codes for distribution and development (repositories),
 - Tools for team organization and discussion
 - Project management tools.

ERC REFINE (Robots Explore plankton-driven Fluxes in the marine twilight zoNE)

After obtaining a first ERC in 2011 ([remOcean](https://remOcean.org)), Hervé Claustre obtained in 2019 a second ERC (Advanced Grant) for the [REFINE project](#). The scientific objective of **REFINE** is to understand and quantify the physical, biological and biogeochemical processes that control the biological carbon pump, a key element in CO₂ sequestration. It is in the mesopelagic zone (or twilight zone), between 200 m and 1000 m, that most of the key processes occur. Yet this zone represents one of the least well known ecosystems on our planet. The REFINE project will therefore focus on exploring the meso-pelagic zone and will be implemented through four major coordinated actions:

1. Development of a new generation of multidisciplinary profiling floats, focusing in particular on the composition of phyto- and zooplankton communities.
2. Realization of ~4 years of robotic studies in five ocean areas, representative of the diversity of biogeochemical conditions and responses to climate change in the world ocean, on a continuum of time scales from diurnal to interannual.
3. In-depth analysis of the REFINE dataset, enabling carbon flux budgets to be established for each of the five areas, and understanding the physical and biogeochemical mechanisms involved in the transfer of organic carbon to the deep ocean.
4. "Upscaling" regional processes to the global ocean, notably through the use of artificial intelligence that takes advantage of multi-source observations from REFINE robots and Earth observation satellites.

Argo-Regional Center: Atlantic

France leads the A-ARC (previously NA-ARC but renamed after the extension of the region up to 35°S), 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 Atlantic ARC activities and in particular the float deployment in Atlantic.

Floats that have been processed in delayed time in the Atlantic ARC, north of 35°S, with a check made using a modified OW method that has been published by Cabanes et al (<http://dx.doi.org/10.1016/j.dsr.2016.05.007>). Floats for which it may be necessary to revise the original DM correction are reported to PIs. The list is available online at:

<http://www.umar-lops.fr/en/SNO-Argo/Activities/NAARC/Consistency-checks-of-DM-salinity-corrections>

The 2019 reports are available here:

<https://www.umar-lops.fr/en/SNO-Argo/Activities/NAARC/Consistency-checks-of-DM-salinity-corrections/NAARC-reports-2019>

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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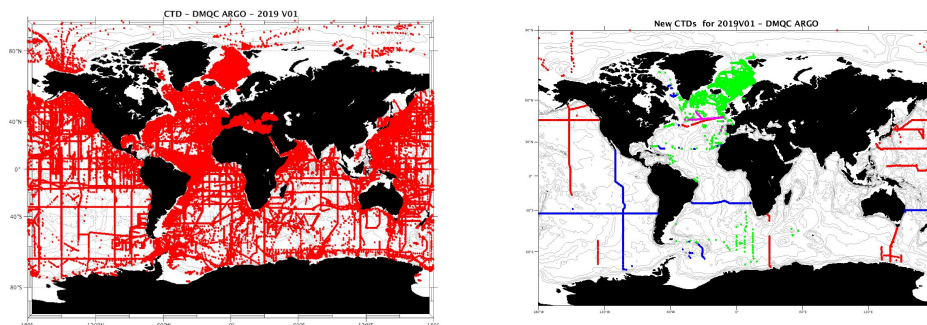
CTD cruise data in the reference database

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.

A new version 2019V01 including CCHDO, OCL and ICES updates, CTD from PI, correction from feedback have been provided on the ftp site in the middle of October 2019.

This new version includes 12 new cruises from the GO-SHIP program (downloaded from the CCHDO website), updates from OCL, ICES and MSM cruise provided by a scientist. A work has also

been done for the boxes in the North Sea, with Ingrid Angel from BSH. Expertise on data has been realized to improve the quality and new data has been added (from UDASH and ICES).



Left : Version 2019_V01. Right : new data [GO-SHIP – OCL- ICES-MSM].

This version is divided into smaller tar balls, one by wmo box area (1-3-5-7): for instance, CTD_for_DMQC_2018V01_1.tar.gz for all boxes starting with wmo 1, then we will have 4 tar files.

As part of the EARISE project activities, [the Argo data component of the DMQC reference database is now available with the Ifremer Erddap](#). An Python library ([argopy](#)) and [notebooks examples](#) are available to demonstrate how to use it. The goal of this new access point is to provide an efficient and always up-to-date access to reference data to improve DMQC software performances.

Bibliography

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

In 2019, at least 77 articles with a scientist affiliated in France as a coauthor have been published in peer reviewed journals. Note that the list of all publications in which a scientist from a French laboratory is involved is available on the Argo France website and on the Argo Bibliography webpage. To date, around 430 articles have been listed.

<http://www.argo-france.fr/references>

Argo-France: <http://www.argo-france.fr>

French bibliography: <http://www.argo-france.fr/publications>

Argo PhD list: http://www.argo.ucsd.edu/argo_thesis.html

NA-ARC data mining website: <http://www.ifremer.fr/lpo/naarc>

Coriolis FTP: <http://www.coriolis.eu.org/Data-Services-Products/View-Download/Download-via-FTP>

Coriolis DAC: <http://www.coriolis.eu.org/Observing-the-ocean/Observing-system-networks/Argo>

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

NAOS project: <http://www.naos-equipex.fr>

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

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

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

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

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