Dossier de demande de renouvellement du label ‘Service National d’Observation’ (INSU/CNRS) 2020-2024

Service National d’Observation Argo-France

Ref: AF-2019-LABEL-SNO2019

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Version soumise à la SCOA le 31/04/2019

Dossier à remplir pour le bilan et la labellisation 2020-2024 d'un Service National d'Observation (SNO)

Nota : Ce dossier ne doit pas excéder **40 PAGES (hors annexe)**, avec une police de caractère et un interligne raisonnables. La liste exhaustive des publications et des conférences au cours de la période (2015-2019) ainsi que les lettres de soutien sont à fournir en annexe. Pour faciliter les évaluations, il est recommandé aux porteurs de suivre la trame proposée.
Les porteurs de projet sont invités à lire très attentivement la définition des services labellisés du domaine OA de cet appel à labellisation 2019 qui présente des nouveautés importantes.

DESCRIPTION GÉNÉRALE DU SERVICE (5 PAGES MAXIMUM)

A1- Appartenance du service (ANO 1-> 5) :
Service National d'Observation

A2- Nom du service :
SNO Argo-France

A3- Adresse URL du site web du service :
http://www.argo-france.fr
http://www.umr-lops.fr/SNO-Argo

A4- Résumé du service (1/2 page maximum) :

Depuis le début des années 2000, un effort international sans précédent s'est développé autour du programme Argo visant à mettre en place sur le long terme (~50 ans), un réseau global d'observations de la température et de la salinité dans les 2000 premiers mètres de l'océan à partir de flotteurs profileurs autonomes dérivants. La couverture spatio-temporelle nominale du réseau Argo (3°x3°/10 jours) nécessite une présence de plus de 3000 flotteurs en permanence en activité dans les océans). Atteinte dès 2007, cette couverture permet de fournir des données en temps quasi-réel pour l'océanographie opérationnelle et donne la possibilité d'observer l'océan avec une précision suffisante pour répondre aux questions scientifiques majeures concernant la variabilité de l'océan et du climat.

Le Service National d'Observation (SNO) Argo-France, rattaché à l'OSU IUEM (Institut Universitaire Européen de la Mer), structure les activités françaises liées au programme international Argo, en coordination avec l'infrastructure Européenne ERIC Euro-Argo et la TGIR Euro-Argo.

Le SNO Argo France a pris en charge la responsabilité du Centre Régional Argo pour l'Atlantique Nord (NA-ARC) afin de contrôler la consistance des données dans cette région et de fournir une expertise scientifique à chaque étape de la chaîne de traitement des données Argo. Le SNO Argo France met également en place des outils pour élaborer et fournir des produits de haut niveau à partir des données Argo destinés à la recherche scientifique. Il contribue au développement des nouvelles générations de flotteurs (profonds) et de nouveaux capteurs (bio-géochimiques et physique). Enfin, il participe à la gouvernance du programme en assurant la représentation de la France dans les instances internationales du programme (AST, ADMT, Euro-Argo).

A5- Nom du responsable : (nom, titre, adresse électronique) :
Nicolas Kolodziejczyk
Physicien Adjoint (CNAP)
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A6- Laboratoire :
LOPS (UMR6523)

A7- OSU ou établissement/organisme de rattachement :
OSU IUEM (UBO)

A8- Autres organismes associés :
Coriolis : CNES, INSU, IRD, IPEV, Ifremer, Météo-France, SHOM

A9- Signature du responsable :

A10- Signature du directeur OSU gestionnaire (ou établissement/organisme de rattachement) :

Frédéric JEAN
Directeur de l'IUEM

A11- Autres laboratoires et OSU intervenant dans le fonctionnement du service (pour chaque laboratoire concerné ou équipe impliquée, indiquer le nom et l'adresse électronique du responsable, et donner en deux lignes maximum, la nature de l'implication dans le service, hors exploitation scientifique) :
LOV - IMEV
Fabrizio D'Ortenzio (CNRS)
dortenzio@obs-vlfr.fr
Composante BGC (BioGeoChimique) d'Argo-France
OSU Ecce Terra
Catherine Schmechtig (CNRS)
Composante BGC (BioGeoChimique) d'Argo-France

A12- Le service proposé consiste-t-il en une demande
de labellisation dans la continuité d'une labellisation existante (oui/non) ?
Le cas échéant, décrire l'évolution du service (si pertinent, sinon indiquer 'pas d'évolution'):
oui, pas dévolution

A13- Lien avec une IR ou TGIR (oui/non) :
Si oui, préciser la (les) IR/TGIR (*inclure une lettre de soutien de la ou des IR/TGIR en annexe au dossier*) :

- Le SNO Argo France fait partie de la TGIR Euro-Argo, elle-même composante nationale de l'ERIC Euro-Argo
- Le centre de données Argo pour la France est le Centre de Donnée Coriolis, composante du pôle de données "Marines", ODATIS, de la future IR Système Terre
- Les activités transverses de contrôle qualité des données se font en coordination avec le SOERE CTDO2 qui est prolongé jusqu'en 2020, et évoluera le cas échéant dans le cadre de la future IR OHIS

A14- Le service proposé comprend-il des activités stratégiques pour le spatial (oui/non) :

Se reporter à l'annexe 'lien avec le domaine spatial et les activités du CNES'
Si oui, préciser la (les) mission(s) :
***(et intégrer les réponses aux questions listées dans l'Annexe* D dans les différentes rubriques du document de réponse à l'appel à proposition de labellisation)**
Production de données pour la cal/val des données des satellites d'observation des océans (température, salinité, altimétrie, couleur de l'eau)

A15- Le service proposé comprend-il des activités stratégiques pour le polaire (oui/non) :
Se reporter à l'annexe 'lien avec le domaine polaire et les activités de l'IPEV'
Si oui, préciser la (les) mission(s) :
(*et remplir l'Annexe* E)
La technologie des flotteurs Argo a évolué dans le cadre de l'equipex NAOS et certains modèles sont maintenant capables d'évoluer dans les zones temporairement recouvertes de glace. Le nouveau design du réseau global Argo, inclut les régions polaires et participera donc à l'avenir à l'acquisition de mesure in situ de la colonne d'eau dans ces régions.

A16- Le service proposé relève-t-il
d'autres domaines de l'INSU, c.-à-d. SIC, TS ou AA (oui/non) ? et le(s)quel(s) ?
d'autres instituts du CNRS (oui/non) ? et le(s)quel(s) ?

A17- Lien avec un pôle ou un centre de données (oui/non) :
Si oui, préciser le(s)quel(s) (*inclure une preuve d'appartenance ou d'adhésion en annexe au dossier*) :
Centre de Données Coriolis (composante du pôle de données "Marines", ODATIS, de la future IR Système Terre).

DESCRIPTION DÉTAILLÉE DU SERVICE (35 PAGES MAXIMUM)

B1. Context, motivations et scientific objectives

In 2000, the international Argo observational program was launched by the IOC and WMO to observe the global *in situ* ocean temperature and salinity, in order to monitor the ocean's variability and understand its role in climate. To reach this scientific goal, the prerequisite was to provide in near-real time profiles of ocean state parameters every 10 days for each 3x3 degrees area of the global ocean. This corresponds to about 3000 floats operating permanently at sea (*Riser et al.*, 2016). Given the autonomous floats technology available at the beginning of the program in 2000, parameters were limited to temperature and salinity (P/T/S, so called "core-Argo" mission), sampling depth was limited to the first 2000m of the water column and sampling area was limited to the open ocean, away from marginal seas as well as high latitudes. It took about 8 years to the international community to reach this sampling target (from 2000 to the end of 2007). Then, more than ten years later (2018), about 2 millions quality controlled profiles have been provided, overwhelming in one decade the amount of profiles ever carried out in the history of oceanography. In addition to the major increase in high quality data quantity due to Argo, the historical northern hemisphere and near-coastal biases in data coverage are suppressed by the uniform global sampling design of the array. Argo also has rectified a major seasonal bias in sampling, particularly in the subpolar oceans. It is thus not surprising that the Argo program is now the backbone of in situ Global Ocean Observing System (GOOS) and hence revolutionizes our vision and understanding of the ocean in unexpected ways days after days.

The international Argo program aims to build and sustain a global real-time observational network of in-situ measurements integrated to other observational systems of the Earth in order to:

- observed climate variability from the seasonal to decadal timescale and to observe climate change of the oceans. This includes regional and global changes in oceanic heat, fresh water content, sea surface steric height and large scale circulation.
- provide observations for calibration and validation satellite remote measurements.
- provide observations to initialize and constraint numerical model simulations and operational ocean forecasting systems.
- promote new parameters and observation sites (biogeochemical parameters, deeper layers, high latitude, marginal seas) to foster emergence of an interdisciplinary in situ network measurement (physic, biogeochemical,...) to fill the observational gaps of the core-Argo mission.

The French Argo national program is the French contribution to the international Argo program and to do so, relies on the SNO Argo-France and the Coriolis partnership. Argo France gathers all the French activities related to Argo and its extension toward deep and biogeochemical measurements. Argo France scientific activities are organized through the SNO Argo-France, which is affiliated to the OSU IUEM (Institut Universitaire Europeen de la Mer). Two research laboratories are leading Argo France scientific activities: the "Laboratoire d'Océanographie Physique et Spatiale" (LOPS, Brest, France) and the "Laboratoire d'Océanographie de Villefranche – Institut Marin de l'environnement de VilleFranche" (LOV-IMEV, Villefranche, France). Argo France operational activities are organized through the Coriolis partnership (IFREMER, SHOM, INSU, IRD, Météo France, CNES and IPEV) and its governance bodies. The Euro-Argo TGIR and Argo France are part of the Ministry of Research national roadmap on research infrastructure.

The objectives of the SNO Argo-France as defined in 2011 for the first SNO accreditation, have been updated in 2015 and now 2019 as the following:

- to provide research quality Argo data to the French scientific community in order to foster and promote the French contribution to climate studies, and more generally to oceanographic research conducted with Argo data (physical and biogeochemical parameters) either directly or through re-analysis or assimilation products.
- to consolidate and organize the French contribution to the international Argo program and to the European research infrastructure Euro-Argo ERIC.
- to provide biogeochemical parameters measurements from Argo floats and to participate to the BGC-Argo (BioGeoChemical-Argo) global network development.

- to promote deep Argo measurements and to participate to the deep Argo network development.

The initial sampling target being achieved in 2007, the optimal Argo time series is thus 11 years long as of January 2019. The improvement in sampling homogeneously the global large scale ocean is dramatic compared with the previous century of measurements. However, we are still far from being able to study the low-frequency variability of the ocean at the targeted decadal time scale, hence the justification for a multi-decadal observation network. If one account for the scientific target of a correct sampling of a decadal signal (50 years), in 2019, Argo provided only 22% of the full time series.

Moreover, given the societal requirements, as manifested by the emergence of operational oceanography, in the European framework of CMEMS Copernicus and Mercator International, it remains crucial to be able to monitor the state of the ocean as well as to provide *in situ* observation continually in order to constrain operational forecasting systems. In one decade, Argo has became the backbone of operational oceanography.

After 15 years of Argo program, the Argo role within the Global Observing Systems will be clearly re-stated during the Ocean Obs 2019 international conference. The objective and mission of SNO Argo-France for the next decade will be in line with International Argo program as described in the Ocean Obs 2019 *Roemmich et al.* (2019)[1] white paper (co-authoring SNO Argo-France members). Also, it has been stated during the last Argo Steering Team meeting (AST20, March 2019, Hangzhou, China) that Argo extensions are integrated in one "global, full-depth and interdisciplinary" Argo program, including Core (P/T/S), BGC and Deep missions. Each country contributing to the program seeks to maintain its contribution to the network for at least 20 more years.

B2. Observation Mission

The observation missions of the global Argo array is the following:

- **Core-Argo**: To measure Pressure/Temperature/Salinity from the surface to 2000m
- **BGC-Argo**: To measure 6 BGC variables (O2 (DOXY), pH (PH_IN_SITU_TOTAL), Nitrate (NITRATE), Chlorophyll-A (CHLA), suspended particles (BBP) and downwelling irradiance (DOWN_IRR) from the surface to 2000m.
- **Deep-Argo**: To measure Pressure/Temperature/Salinity from the surface to the deepest depth possible (4000m or 6000m)
- To measure these variables **globally**, following a nearly random but uniform sampling strategy of at least **1 profile per 3°x3° every 10 days**

The observation mission of the Argo France is to contribute to about 10% of the global Argo array observation mission described above. Over the last 4 years the SNO Argo-France contributed to the consolidation of this contribution and to the performance of the network through the different project (NAOS, CPER, RemOcean). To achieve its mission, Argo France has set-up clear objectives and reached the following achievements:

1) To provide research quality data to the scientific community

From January 2015 to December 2018, the SNO Argo-France provided 62 693 new qualified 0-2000 m profiles of the parameters pressure/temperature/salinity (P/T/S) and 21 426 new profiles of the Biogeochemical parameters to the French scientific community through Coriolis DAC (the national Argo Data Assembly Center). These variables are among the so-called Essential Ocean Variables (EOVs), Ecosystem EOVs (eEOVs), or Essential climate variables (ECVs) to address significant scientific and societal ocean/climate-related issues.

These profiles were quality controlled (QC) in real (RT) and delayed time (DM) with peer reviewed methods to ensure the best data quality for operational oceanography and climate research (see Section B4; *Wong et al.*, 2019; *Schmechtig et al.*, 2019; *Cabanes et al.*, 2019). Since 2015, Argo-France provides more than 1200 P/T/S profiles per month and 450 BGC profiles per month.

[1] The draft of the article (about accepted) is provided on : https://cloud.ifremer.fr/index.php/s/p9qUfiZNCmpRrzo.

Figure 1a represents the time evolution of the number of profiles, from the beginning of the Argo France program, qualified and distributed by the French DAC (Coriolis). Over the period 2015-2018, the number of P/T/S (BGC) profiles has increased by +34% (+64%) in comparison to the period 2010-2014. Note that since 2000, the International Argo program has collected more than 2 millions P/T/S profiles, of which, 7% are of France origin).

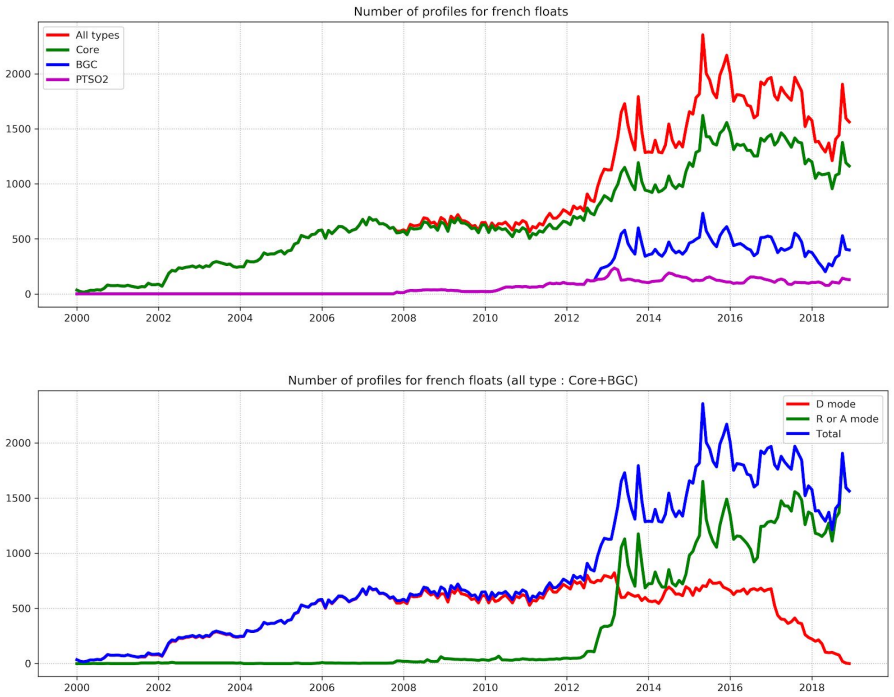


Figure 1: a) Total number of French Argo profiles (red) managed by Argo-France from 2000 to 2018 for P/T/S core-Argo (green), BGC (blue), BGC with only O2 sensor (purple). b) Total number of French Argo profiles (blue) managed by Argo-France from 2000 to 2018, with a delayed-mode statue (red) and Real or Adjusted mode statue (green).

Figures 2 represents the location of the French profiles. Deployed by French scientific teams, they are localized in regions with national scientific interests: the Atlantic and Southern Ocean, the Mediterranean Sea, North Indian and East/Western Pacific regions.

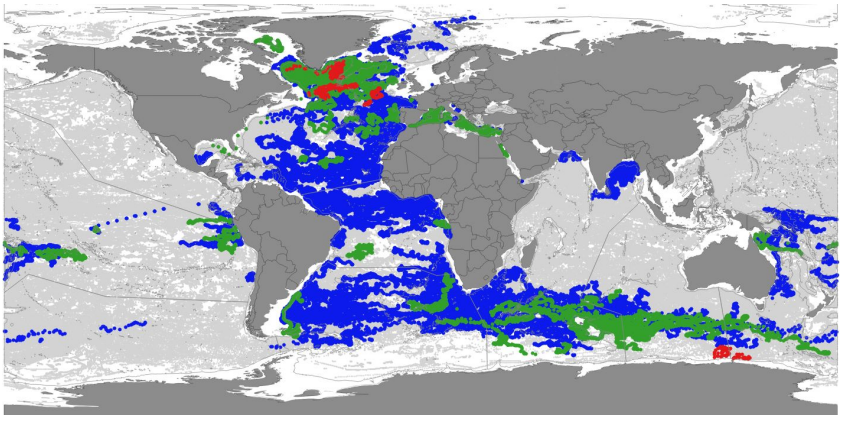


Figure 2: Map of Argo-France profile positions carried out over the period 2015-2019: Core-Argo (blue), BGC (green); Deep-Argo (red). The light gray positions are the non-French Argo profiles carried out over the same period.

Figure1b provide details of the fraction of distributed profiles in real-time and delayed mode. As of February 2019, around 56% of the profiles managed by Coriolis DAC are in delayed mode (P/T/S: 64% and BGC:23%). There is always a delay of a couple of years between the distribution of a profile in real-time and in delayed-mode. It is due to the necessary delay for a careful validation with complex methods and operator's

expertise. Concerning the BGC delayed-mode quality control, correction methods are still not fully developed, as they still wait for international consensus.

Beyond the distribution and qualification of the core parameters in the form of vertical profiles, the SNO Argo-France also provided research quality data in the form of **high level products**: gridded dataset and indicators. The SNO Argo-France developed and maintained the **In-Situ Analysis System** (**ISAS**, *Gaillard et al.*, 2016), which designates both a software designed to produce a gridded version of the irregularly sampled Argo data, but also any *in situ* measurement (Marine Mammals, Moorings, ITP, CTD) and the gridded dataset itself. ISAS implements an objective interpolation method to produce monthly, global, 1/2°x1/2°, 152 vertical levels (from the surface down to 2000m) temperature and salinity fields. ISAS is used for research (a gridded monthly time-series is produced regularly by the SNO using qualified data from the previous year, *Kolodziejczyk et al.*, 2017; doi: 10.17882/52367) and is distributed to operational oceanography (a gridded monthly snapshot is produced every month by Coriolis using real-time data and distributed by CMEMS Copernicus Marine Services). ISAS is also used as a validation tool, both in real-time and delayed mode (using residuals from the objective analysis one can detect outliers and bad profiles). ISAS is a tool that is evolving to specific products as Sea Surface Salinity including SSS data from non-Argo plate-forms (ISAS-SSS, doi: 10.17882/55600) and is being adapted to manage new parameters such as global oxygen (ISAS-DOXY; Fig. 4) or, deep measurement (ISAS17) or local configurations (higher resolutions over specific regions). This evolutions are planned for the next 5 years.

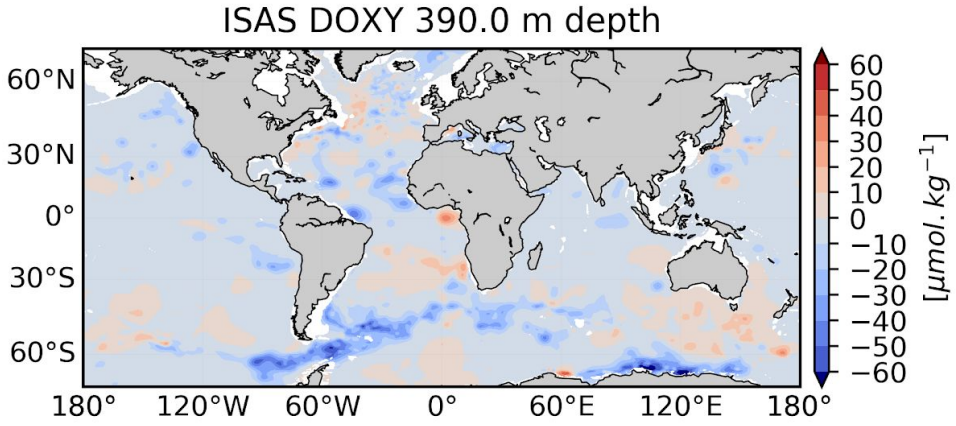


Figure 4: (Upper) Global ISAS interpolated dissolved oxygen anomaly (compared to WOA13) estimated from 2010-2018 Argo and CTD dissolved Oxygen measurements (developpement in progress).

In 2013, the SNO Argo-France released ANDRO: the first ever dataset of Argo deep trajectory (mostly 1000 dbar) files qualified for research. **In 2018, the dataset, developed at LOPS (*Ollitrault and Rannou*, 2013) has been updated and now contains research-qualified information about 884 621 deep displacements of Argo floats**, from which North Atlantic 2011-2015 1000db averaged velocities are given as an example (Fig. 6). ANDRO files lead to the first ever delayed mode trajectory files distributed by Argo GDAC. From displacements, absolute ocean currents, heat and freshwater fluxes can be derived (*Colin de Verdière et al.*, 2019, submitted). Over the 2015-2019 period, SNO Argo-France and Coriolis maintained a regular update of the ANDRO products (doi: 10.17882/47077), and will go on during following 2020-2024 period.

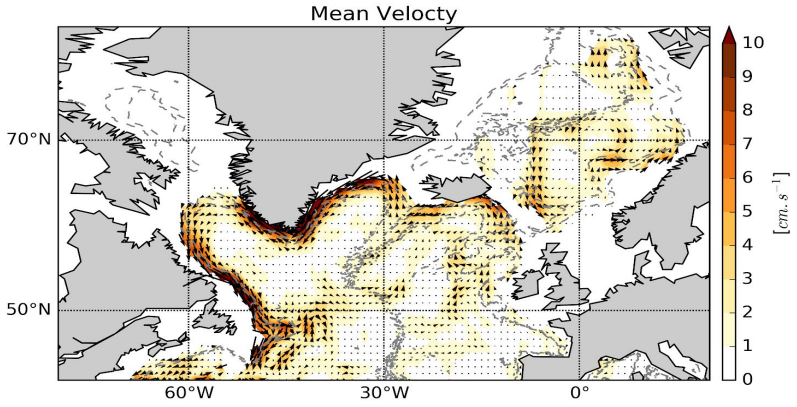
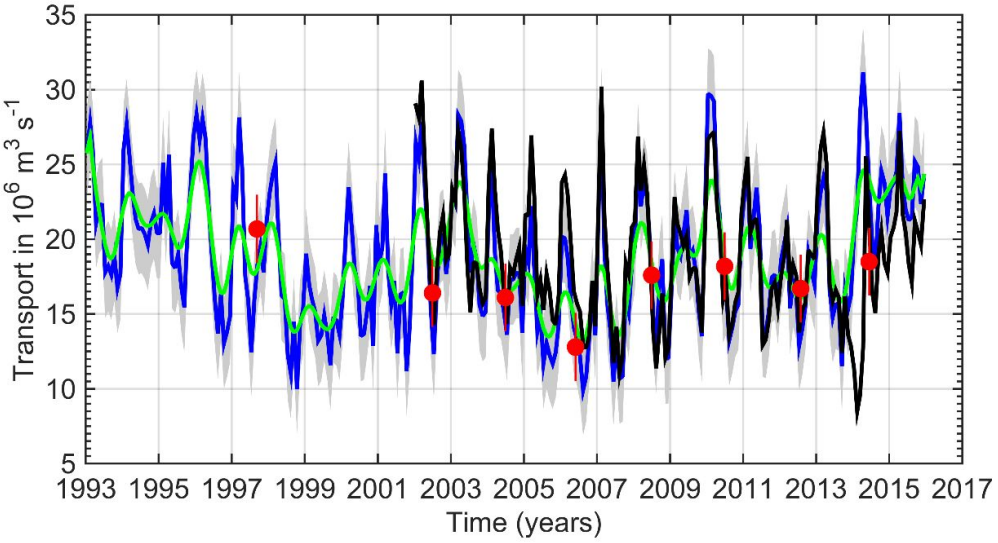


Figure 6 : 1000 dbar ocean mean circulation between 2011-2015 deduced by ANDRO updated dataset.

One important feature of ANDRO is that pressures measured during float drifts at depth, and suitably averaged, are preserved. To reach this goal, it was necessary to reprocess most of the Argo raw data, because of the many different decoding versions (roughly 100) not always applied by the DACs to the displacement data because they were mainly focused on the P/T/S profiles. The result of this work was the production of comprehensive files containing all the possibly retrievable float data. Argo data have previously been used to study ocean currents, but it is the very first time that a research quality dataset of float trajectories is developed in close interaction with Argo Data Management teams and benefits the community for a long term improvement of the dataset. Indeed, it led to an improvement in the format of the trajectory file and in the decoding of the raw data (format v3.1; *Scanderberg et al;* 2017, doi: 10.13155/29824).

The SNO Argo-France also developed indicators of the ocean state and variability based on the quality controlled data and peer reviewed published indicators. In particular, **Global Ocean Indicators (GOI)** were developed such as the global ocean heat content, fresh water content, steric sea level, and Atlantic Meridional Overturning Circulation (Fig. 5; *Mercier et al.* 2016; doi:10.17882/46445), using ISAS fields. The developed GOIs are carefully determined and distributed with error estimates that provide a clear and solid basis for climate research and in particular IPCC and WCRP statements of global ocean long-term changes (IPCC report, 2013; *Cazenave et al.*, 2018; see: www.umr-lops.fr/SNO-Argo/Products/ISAS-T-S-fields/Climatology-and-climate-indices). GOI methods developed by SNO Argo-France are now used by the Copernicus Marine Service and updated on a yearly basis (marine.copernicus.eu/science-learning/ocean-monitoring-indicators/catalogue/).



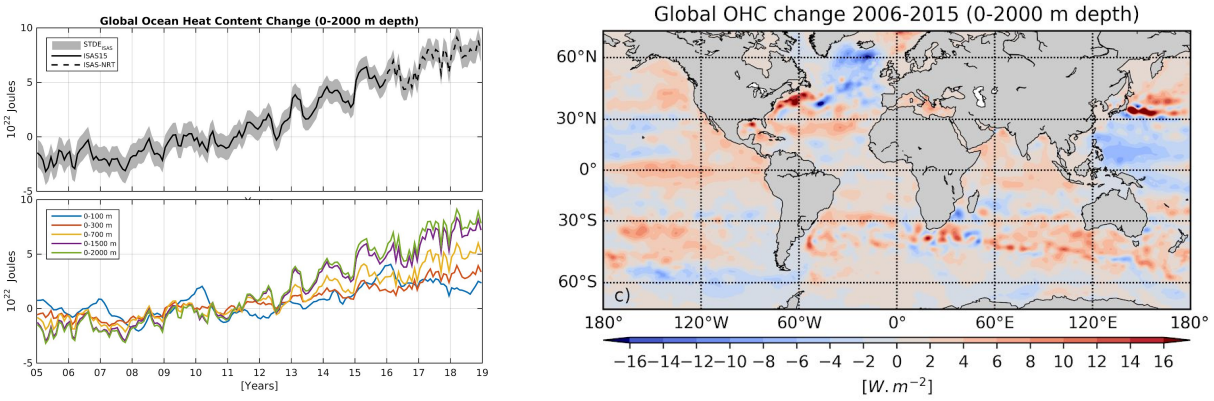


Figure 5: upper: Meridional Overturning Circulation (in Sv) computed along the Ovide transect between Portugal and Greenland from ISAS (black); satellite altimetry (blue and 2 years low-pass filtered in green) and compared to Ovide cruises observations (red dots; *Mercier et al.*, 2016). Lower: Global Ocean Heat content anomalies computed from ISAS products between 0-2000 m depth over the Argo period 2002-2018 (left); and Decadal Ocean Heat Content trend over 2006-2015 computed from ISAS (from *Kolodziejczyk et al.*, in revision).

From the Argo time series, tremendous progress was made in many directions: (i) our knowledge and understanding of the ocean seasonal variability, especially for salinity and circulation and (ii) our estimate of the post 2000s ocean reference state at global scale (*Feucher et al.*, 2019); (iii) interannual variability and regional understanding of the ocean heat and freshwater uptake and storage, as well as interpretation of the thermo-halosteric contribution of the sea level rise have been allowed (*Kolodziejczyk et al.*, 2012, 2013, 2014; *Llovel et al.*, 2014). (iv) But also unexpected scientific question have been addressed due to the density of the sampling achieved and the lagrangian nature of the plate-form, among them : ocean energetic state (*Capet et al.*, 2016), mesoscale eddy monitoring , internal waves observation at parking depth (*Hennon et al.*, 2014). (vi) A growing part of the Argo literature is coming from the biogeochemical field due to the emergence of BGC Argo (see *Claustre and Johnson*, 2017 and reference therein. (vii) France has published the first peer reviewed publications about deep Argo floats and their scientific analysis (LOPS laboratory; *Racape et al.*, 2019, submitted, and *Le Reste et al.*, 2016). See *Riser et al.* (2016), for a comprehensive review of Argo lead discoveries and accomplishments

It is obviously impossible to review here the diversity of the research activities and achievements based on Argo data and conducted in France. So perhaps the single most powerful metric of the value of Argo and the achievements of the SNO Argo-France is the widespread use by the national community of the data that the program produces: **since 2015, at least 218 papers (+68% in comparison to the period 2011-2014) in the peer reviewed science literature have used Argo observations and have been co-authored by a French contributor**, attesting to the array's value in expanding our fundamental understanding of the oceans and climate within the national community (the complete list is given at : www.argo-france.fr/publications). This is a very significant contribution to the international achievements of the Argo program because it represents between 15 and 20% of the global scientific production (~ 1000 papers between 2015-2018) and France is ranked 3rd, just after USA and China (source: www.argo.ucsd.edu/Bibliography.html) and is leader in Europe (www.euro-argo.eu/Outreach/Bibliography). Moreover, about 2 PhD using Argo data in a significant way are defended in a French university every year (full list here: www.argo-france.fr/liste-des-theses). This metric reveals the adoption of the Argo dataset by the upcoming generation of new research scientists.

The SNO Argo-France also has the lead on the **Argo Regional Center for the North Atlantic** (NA-ARC). Regional centers have the role to ensure the consistency of the validation procedures between all the operators for a given oceanic region. Details will be provided in the upcoming sections but one can highlight here that since 2015, the NA-ARC made significant improvements to the dataset by detecting erroneous delayed-mode corrections of salinity data (*Cabanes et al.*, 2016, www.umr-lops.fr/SNO-Argo/Activities/NAARC).

2) To consolidate and organize the French contribution to the international program

France is one of the leader in the international governance bodies of the Argo program. Every year since the early stage of the program in 1999 and up to now, France participated to all annual international meetings

of the Argo Steering Team (AST), Argo Data Management Team (ADMT) and Delayed Mode Quality Control (DMQC) workshops. **The financial support from INSU and OSU to the SNO Argo-France was critical to these participations and helped to organize the program at the national and international levels**.

In order to consolidate the historical Argo mission, to develop its extensions and to provide a European level for the management of the international Argo program, Argo France has lead the creation of a **European research infrastructure (ERIC) called Euro-Argo**. Argo France is the French contribution to the Euro-Argo ERIC that organizes and federates European contributions 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 Euro Argo infrastructure is made up of distributed national facilities and a central infrastructure hosted 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. In 2019, European partners, including SNO Argo-France, have started the H2020 European project Euro-Argo-RISE (www.euro-argo.eu/EU-Projects/Euro-Argo-RISE-2019-2022) to consolidate and develop the Euro-Argo activities and contribution to the Argo network.

Argo-France operational activities (deployment, data management) are managed by the **Coriolis** consortium based on a consortium agreement valid for 5 years. The present agreement is valid over the 2014-2020 period. The partnership was accepted in June 2014 and signed by the 7 participating institutes and organisms (Ifremer, CNRS, SHOM, IRD, IPEV, Meteo-France and CNES). Coriolis gather several SNO and SO (Argo, PIRATA, SSS, MEMO), assembles data into a common data center and provide integrated services for operational oceanography (Mercator Ocean, Copernicus Marine Core Services) and research laboratories.

The 2011-2019 period was marked by accomplishment in technological breakthroughs led by multimillions flagship **project EQUIPEX NAOS**. During phase 1 (2011-2014), technological developments were conducted with success and data from new parameters are now available in the Argo database. 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. Then, phase 2 of NAOS project (2015-2019, extended to 2020) provide consolidation of the French Argo contribution including testing, validation and deployment of the new generation of French Argo profiling floats. More informations on technological float developments and test can be found on the NAOS project webpage (www.naos-equipex.fr). The NAOS outcomes have significantly consolidated the French Argo fleet and contributed to implement the extension of Argo, in particular **BGC-Argo** and **Deep-Argo**.

Given the aforementioned large number of activities in organization, development, and consolidation of the Argo array, we created an **Argo-France management board in 2014.** The management board coordinates national efforts and provide a formal body to discuss a long-term strategy for the national contribution to the Argo program, independently from short-term projects constraints. The committee has worked to produce a program strategy to face three challenges over the next 10 years: (i) sustain the core program at its current state of excellence, (ii) sustain the BGC-Argo global network build up and propagation of the core standard of data quality and (iii) sustain the contribution to the Deep-Argo extension towards the achievement of full-depth multidisciplinary network. Since its creation in 2014, the committee has met 3 to 4 times a year. In 2018, a Memorandum Of Understanding has been elaborated by Ifremer, CNES and SHOM in order to organise their contributions to the TGIR Argo France.

3) Toward a BGC-Argo global network

The French community was an historical leader in the **development, promotion and scientific exploitation of BGC-Argo extensions of the core Argo network**. Since 2016, the international community using biogeochemical sensors on Argo floats has structured within the framework of the BGC-Argo program for the development and implementation of the original objective: a global BGC-Argo network as part of the Argo program. The BGC-Argo program promotes 6 official core parameters: Dissolved Oxygen (DOXY), Chlorophyll-a (CHLA), Suspended Particles (BBP), Nitrate concentration (NITRATE), pH (PH_IN_SITU_TOTAL), downwelling irradiance (DOWN_IRR) that allow to better constrain the biogeochemical cycles of carbon, oxygen, nitrogen,

and biomass. These variables are the fundamental measurements that are required to address significant scientific and societal ocean/climate-related issues (www.biogeochemical-argo.org).

The effort to realize a global array of new parameters has been initially devoted to implementing regional networks over specific regions: Atlantic Ocean, Southern Ocean, and Mediterranean Sea (*Johnson and Claustre*, 2017). The extension to a global array has been decided at Argo International level and will be achieved, then, by a progressive increase of float density in specific areas and by a further enlargement (*Roemmich et al.*, 2019). France has been strongly active since 2010 in establishing the firsts regionals BGC-Argo network (*Claustre et al.*, 2010). Since 2015, SNO Argo-France has been involved in the major development and implementation of BGC QC at international level. Thus, Argo-France is now in a leading position, especially for data management: in 2019, 36% of global BGC-Argo profiles are managed and distributed by French DAC Coriolis. The biogeochemical branch of the SNO Argo-France is under the responsibility of the LOV-IMEV (all biogeochemical parameters, except DOXY) and LOPS (DOXY), ensuring the respect of international protocols for the national fleet, providing the required assistance for the BGC-Argo floats scientific use and promoting the BGC-Argo activity at national level.

During the period 2015-2019, the SNO Argo-France has strongly contributed to maturate **a rigorous data management and quality control of the BGC data**, that are a prerequisite to reach the high standard of the international Argo program. The SNO Argo-France worked in close collaboration with the international community to define format, processing delayed mode procedures for these parameters. This is done through the participation of the SNO to the SCOR WG 142 on "Quality Control Procedures for Oxygen and Other Biogeochemical Sensors on Floats and Gliders" (scor-int.org/group/142). But also to the active participation to Argo BGC meetings and ADMT, to discuss the BGC-Argo community agreement for data management and quality control procedure (www.argo.ucsd.edu/meetings.html). SNO Argo-France was particularly involved in developing methods for data processing for DOXY (*Thierry et al.*, 2018, doi: 10.13155/39795) and CHLA and BBP (*Schmechtig et al.*, 2018, doi : *10.13155/39459*) sensors. SNO-Argo France strongly contributed to set up quality control procedure implementation for BGC-Argo parameters (*Schmechtig et al.*, 2016, doi: 10.13155/40879), in particular DOXY (*Thierry et al.*, 2018, doi: 10.13155/46542), BBP and CHLA (*Schmechtig et al.*, 2018, doi: 10.13155/35385). The SNO-Argo France also developed the LOCODOX software that provides the necessary correction to DOXY values that are generally biased toward low oxygen concentration and subject to a temporal drift (*Takeshita et al.*, 2013, *Bittig and Kortzinger* 2015, *Bittig et al.,* 2018). Examples of DOXY data corrected owing to LOCODOX are available in *Gallian and Thierry* (2018, doi: 10.13155/58314). LOCODOX is available on demand.

Thanks to these substantial progress, the BGC-Argo DAC (Data Assembly Center), which was initially operated by Catherine Schmechtig at LOV, was transferred at operational level to the DAC Coriolis in 2017. This was a major achievement for the BGC-Argo data management, and success for the SNO Argo-France, that now allows to move on towards a global BGC-Argo network.

In parallel, further downstream the data processing chain the ISAS tool is being adapted to full depth oxygen data to produce gridded fields of DOXY (code available on demand). After complete validation and correction of all global oxygen profiles gridded global fields of DOXY will be produced (Fig. 4).

Additionally, successful collaborations between **Argo/BGC-Argo community and Ocean Color scientists** have been achieved in the last years. Ocean Color space data could be considered the satellite equivalent of the altimetry for BGC-Argo. Consequently, space agencies (CNES, ESA, NASA) have already realized that, although not enough accurate to a real calibration of space sensors, BGC-Argo could provide a cost-efficient and global scale network to validate ocean color products. By continuously involving in BGC-Argo the national ocean color community, the SNO Argo France aims to a larger utilization of BGC-Argo national fleet and to the development of high level products, merging floats and ocean color data (see later).

These developments are directly connected to the **enlargement of the national BGC community**. Since 2015, between 2 and 13 BGC-Argo floats per year are distributed to the national community, through a specific call, after validation by Scientific Committee (GMMC LEFE see later). In the last 4 years, scientists from five different French laboratories (MIO, LOCEAN, LOPS, LOV-IMEV, SHOM) received, deployed and scientifically

exploited BGC-Argo floats. In this context, the SNO Argo-France, furnished all the necessary assistance in the float utilization and in the data management. As a counterpart, and exactly as for historical Argo, BGC-Argo PIs are involved in the data validation and contribute to the national effort for the establishment of BGC-Argo protocols.

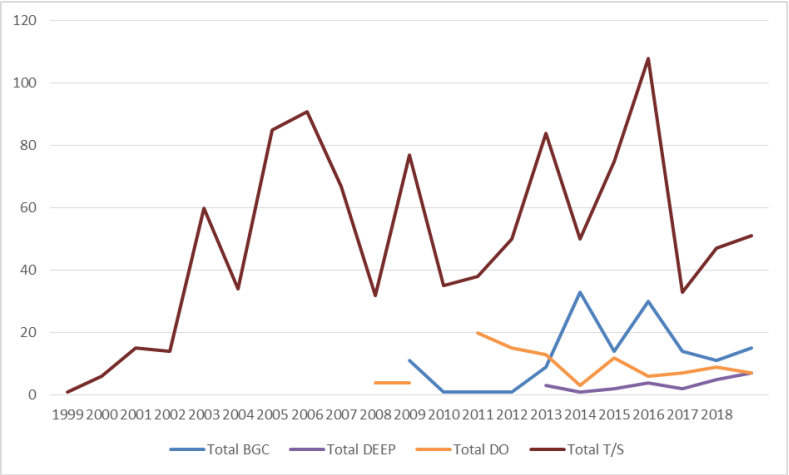


Figure 7 : Number of GMMC-LEFE float deployed by French PIs between 1999 and 2018 for core-Argo floats (brown); BGC-Argo floats (blue); P/T/S/O2 (orange) and deep-Argo floats (purple).

Finally, the promotion of those new biogeochemical parameters measurements is done through dedicated BGC-Argo sessions at the Argo-France and Euro-Argo science meetings (July 2017,Paris, see: www.euro-argo.eu/News-Meetings/Meetings/Users-Meetings and workshop Argo-France in June 2016, Toulon, France).

4) To promote the buildup of a Deep-Argo network

Deep-Argo is motivated by the substantial, but largely undocumented, oceanographic variability found in the 50% of ocean volume below the 2000-dbar profiling depth of conventional Argo floats. Development of floats and CTDs capable of accurate measurements down to 4000 or 6000 dbar makes global full-depth Argo implementation feasible, allowing sampling of bottom-intensified ocean variability. During 2015-2019, the French community has been recognized as **leader in the emergence of Deep-Argo technology and to build-up the future full depth Argo international network.** France has co-organized the 1st Deep-Argo implementation workshop in 2015 (*Zilberman & Maze*, 2015, archimer.ifremer.fr/doc/00281/39238/) and will co-organized the 2nd one in 2019 (Hobart, Australia).

Since 2011, France contributed to the emergence of the Deep-Argo technology owing to the institutional and industrial partnership within the EQUIPEX NAOS (2011-2019) project. This partnership led to the development and commercialization of the Deep-Arvor float that can dive down to 4000m (NKE instrumentation) (*Le Reste et al.*, 2016).

Besides the technological challenges for the platform to reach 4000 m depth, sensor issues appears during the first deployments of the NAOS deep-Arvor floats. Indeed, in contrast to the 0-2000 m depth, greater accuracy of temperature and salinity sensor are required to measure T/S changes that can be as small as few milli°C and mille pss per decade. SNO Argo-France is specifically involved in testing available CTD sensors to help define the most suitable sensor for the deep Argo network, both in terms of accuracy and long-term stability. To do so, three different sensors were mounted on two three-headed float that will be deployed in 2019 and 2020.

The international Argo Steering Committee (AST19; Deep-Argo workshop 2015) now recommends to the scientific groups involved in Deep-Argo to build-up pilot arrays in area of scientific interest as a proof of concept and as a milestone on the road of a global network (*Roemmich et al.*, 2019). LOPS laboratory is involved in deploying such a pilot array in the North Atlantic (see Fig. 2) since the first deployment in 2013. While 16 floats have already been deployed there owing to funding from Equipex NAOS and the AtlantOS projects (H2020) the CPER Euro-Argo funding will provide an additional fleet of 15 floats/year until 2021. Those floats will

be used to maintain the pilot array in the North-Atlantic but also to contribute to the southern ocean pilot array. Note the first successful under ice deep Arvor mission (www.euro-argo.eu/News-Meetings/News/Latest-News/First-deep-ARVOR-profiles-under-the-ice). Hence, one of the first scientific paper using deep Argo will be published in 2019 by the LOPS laboratory co-authoring SNO Argo-France member (*Racape et al.*, 2019, submitted).

SNO Argo-France also promotes the deployment of deep floats during cruises of opportunity (South Atlantic, Tropical Atlantic) and through a national call (LEFE GMMC, see later) for scientific projects.

Real-time and delayed mode deep-Argo profiles are freely available at Coriolis DAC since 2015. Data processing, real-time quality control procedure and delayed-mode processing tools are currently the same as those for the core P/T/S/DOXY Argo data. However, because of still unsolved, but non systematic, offset problem in salinity on the CTD SBE41CP sensor (widely use on Argo floats), it is mandatory to deploy deep Argo floats along with a reference CTD, in order to calibrate the Argo CTD for potential salinity bias. The Delayed-mode QC procedure is still under elaboration and will require high quality reference CTD data.

B3. Ouverture et Insertion du SNO, lien avec les IR/TGIR

1) Regional integration: OSUs and CPERs

At the regional level, Argo-France integrates within the OSU IUEM and was supported by CPER projects. The *Institut Universitaire Européen de la Mer* (IUEM) is the *Observatoire des Sciences de l'Univers* (OSU) to which the SNO Argo-France is affiliated to. IUEM is the only OSU where all observational time series have a coherent domain of application: the ocean. Three domains are particularly of interest for the OSU IUEM: ocean climate and circulation, geophysics and coastal environment. The SNO Argo-France supports the ocean climate and circulation domain for the two key regions of interest identified by the OSU IUEM: the North-Atlantic and Atlantic-Indian exchange zone. The SNO Argo-France provides the large-scale, open ocean, boundary conditions to many of the coastal and more regional time series supported by the OSU. The IUEM engaged in 2010 to support the North-Atlantic Argo Regional Center (NA-ARC). In 2012, C. Cabanes (IR CNRS) was affiliated to the UMS IUEM and SNO Argo-France to take in charge the NA-ARC. Since 2015, the SNO Argo-France has welcomed the CNAP researcher, Nicolas Kolodziejczyk, who has taken the administrative responsibility of the SNO in 2017. Since 2018, he is the national scientific coordinator to the Argo-France management board.

To account also for the increasing potentialities of the BGC-Argo scientific activity, in particular in the French communities, the SNO Argo-France developed in 2014 a new component, which was formalized by the co-responsibility of the SNO. Note, also, that discussions take place in this moment (April 2019) about the formation of a new OSU « Stations Marines » , which will federate the observational activities of the three marine stations in France (Villefranche, Roscoff, Banyouls). The future OSU “Marines Stations” will support the BGC-Argo activities that are presently managed by the IMEV at Villefranche sur Mer. In this framework, a CPER project has been submitted by the IMEV in 2018, which should consolidate the BGC-Argo component in the PACA region and sustain the national effort.

A CPER project for the 2015-2020 period has been funded by the Region Bretagne. This so-called "Euro-Argo" CPER project has allowed to support the central infrastructure of the ERIC and to consolidate the national Argo program by funding new floats, especially deep profiling and dissolved oxygen floats.

2) National integration: Coriolis and SOERE CTD-O2

At the national level, SNO Argo-France integrates with the consortium Coriolis. Coriolis is a partnership between all national institutions involved in oceanography (CNES, Ifremer, INSU, IPEV, IRD, Météo France and SHOM). The Coriolis objective is to consolidate and operate in situ observing system from data acquisition to data assembly, data validation and data distribution in real and delayed time from in situ operating platforms, like Argo. Coriolis is dedicated to provide integrated in-situ services to oceanic forecasting and analysis systems for operational and research oceanography communities at the national, European and international levels. Operational activities managed by Coriolis are vital for the deployment and maintenance of the global observational systems (e.g. Argo, sea surface salinity measurements from ships, surface drifters and moorings).

It is within this framework that a large bulk of Argo-France activities are achieved. The Coriolis partnership has been renewed in 2014 for the 2014-2020 period.

The SNO Argo-France provides scientific and technological expertise to Coriolis.. Four particular items were addressed over the 2015-2019 period:

1. the ISAS tool development (V7, N. Kolodziejczyk) which has been transmitted to Coriolis for quality control (both real and delayed time) of all data managed at Coriolis (not only Argo) and for production of L3 and L4 products using merged dataset of in-situ observations (CORA, ISAS-NRT, CMEMS-Copernicus products). For each new version of ISAS, the Coriolis staff in charge of gridded tools is trained on the ISAS tools by the SNO Argo-France.
2. the regular update of the ANDRO atlas of Argo floats deep displacements which remain the only one research-quality controlled trajectory dataset (*delayed-mode* trajectory files).
3. research-quality validation procedures for North-Atlantic Argo data within the NA-ARC framework (C. Cabanes). A Web page have been created to monitor the suspicious floats whos PIs or delayed-mode operator (Coriolis) have been warned: www.umr-lops.fr/en/SNO-Argo/Activities/NAARC/Consistency-checks-of-DM-salinity-corrections.
4. a new data flow for biogeochemical parameters which has reached the Argo data management system through the development of a new file format dedicated to BGC-Argo data.

All these items have been discussed during more than 10 regular meetings between the SNO Argo-France and Coriolis over the 2015-2019 period. More issues have been discussed: oxygen data decoding, detection of density inversions, problems linked to pressure sensor drifts, QC of surface salinity data, reprocessing of CHLABBP, DOXY and NITRATE, after calibration issues and all successive evolutions of data formats.

The SNO Argo-France integrates at the national level with the SOERE CTD-O2 ("Coriolis-temps différé Observations Océaniques"). The SOERE CTD-O2 aggregates all national SNO relevant to Coriolis mission to provide validated oceanic observations: SNO Argo-France, SNO Sea Surface Salinity, SNO Pirata and SNO MEMO. Argo-France participated to SOERE-CTDO2 annual meetings. Consequently, the SNO Argo-France will integrate with the future IR OHIS, if the later is favorably evaluated. More specific discussions between the biogeochemical component of Argo-France took place with the SNO MEMO. ISAS tools have been shared with the SNO-SSS to produces their gridded SSS product. P. Téchiné, engineer at LEGOS and in charge of the SSS-SNO tools has been trained on the ISAS tools (05/10/2018 in Brest).

The SNO Argo-France naturally integrates at the national level with the research community. Argo-France organizes annual meetings and workshops to federate the national community and promote the use of Argo data. Moreover, 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)in the INSU LEFE program. 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 offers to the community "standard" Argo floats as well as deep floats and floats equipped with oxygen and biogeochemical sensors. Additionally, the BGC-Argo floats distributed by the GMMC (which are acquired by a specific CNES funding) have specific aim to consolidate synergies between Argo and satellite ocean color observations. These new opportunities strengthen ties between the French scientific community and Coriolis with regard to the development of qualification procedures for "Argo extensions" floats. Joint national workshop and meeting with GMMC have been organized (more details here: www.argo-france.fr/fr/category/animation/).

3) European integration: ERIC Euro-Argo

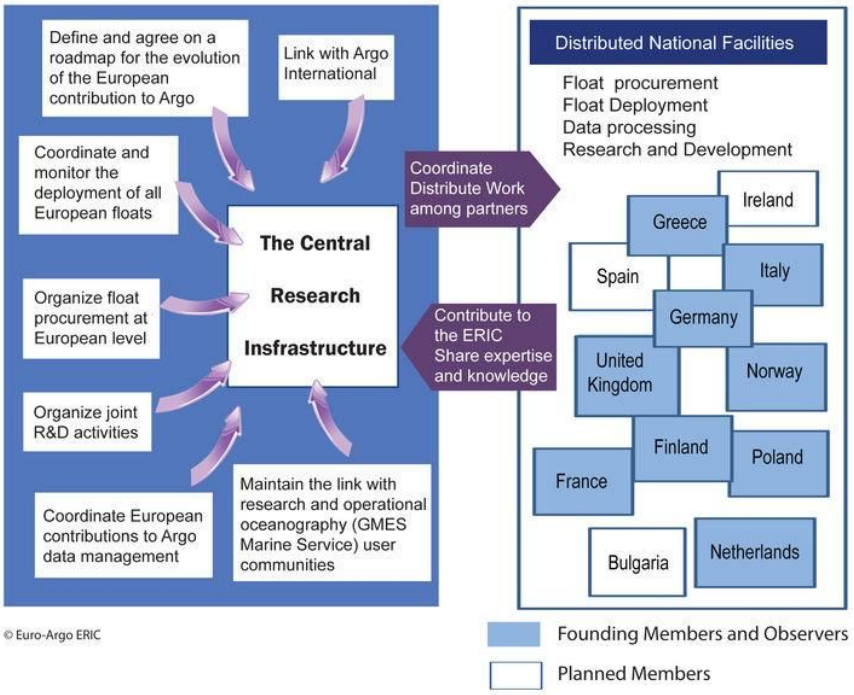


Figure 8: ERIC Euro-Argo organization

The SNO Argo-France integrates at the European level with the Euro-Argo ERIC. Euro-Argo is the European contribution to the international Argo program. The main objective of the Euro-Argo research infrastructure consortium is to organize and consolidate the European contribution by maintaining 1/4 of the network and to sustain a research infrastructure in support of the global Argo program. The Euro-Argo project involves 25 organizations from 12 countries, including France, Germany and UK who are the 3 major European contributors to Argo (Fig. 8). All partners join their efforts to optimize their collective contribution to relevant EU policies, programs and projects. Euro-Argo having been endorsed by the Esfri (European Strategic Forum on Research Infrastructures) in 2006, the Euro-Argo ERIC was then officially set-up in May 2014 after a 6 year process. The Euro-Argo organization is given in the schematic Fig.8. V. Thierry was France representative to the Euro-Argo management board from 2014 to 2016 and has been replaced by G. Maze, SNO Argo-France coordinator for the period 2014-2018, since 2016. S. Pouliquen, head of Coriolis, is the Euro-Argo ERIC Program manager. Extensive details on Euro-Argo can be found at: www.euro-argo.eu.

4) International integration

Argo-France is the French contribution to the Argo array. As such, Argo-France is integrated to the international Argo program and has keep playing over the last 5 years an already existing very active role by engaging in the multiple groups that structure and coordinate the program at the international level: the steering committee AST, the data management group ADMT and the data quality control group DMQC.

Moreover, the Argo network has been defined historically to be a key element and perfectly integrated to the international Global Climate Observing System (GCOS) and Global Ocean Observing System (GOOS).

Argo also provides a mean to extent equatorial/tropical moorings array: TAO/TRITON in the Pacific, PIRATA in the Atlantic and RAMA in the Indian ocean. Argo and PIRATA are two SNOs which have been in tight contact within the SOERE CTD-O2 since 2011. The added value of Argo to TAO/TRITON was spectacularly demonstrated in 2012 when the later array was disrupted by the USA dropout of the program. Now the TPOS2020 project is building up a new integrated Tropical Pacific Observing Network base on optimal sampling from Argo floats and Moorings (French PI: S. Cravatte). Argo-France will be committed to contribute to the building up of such network.

Argo data also complement full water column high accuracy measurements from the GO-SHIP program that provides better resolution of small scales and boundary currents.

Furthermore, the Argo data are strategic for spatial mission among them: ocean color, Sea Surface Salinity (ESA-SMOS)... More details are provided in Annexe D.

B4. Measurement protocol

1) The Argo international network target

All core Argo floats systematically measure pressure (P), salinity (S) and temperature (T) from the surface down to 2000m depth of the water column while deep Argo can reach 4000 m depth (deep Arvor, French; deep Ninja, Japan) or 6000 m depth (Deep Apex and Solo, developed by US) . **P/T/S from surface to 2000 m depth in *global* ocean (0-2000m, 60N-60S) are the core parameters of the international Argo array and of the SNO Argo-France**. These parameters are measured using a conductivity-temperature-depth sensor (CTD). The most used sensor is manufactured by Seabird (SBE41CP, see:www.seabird.com/sbe-41-argo-ctd, now the SBE61 (deep floats) is available see:www.seabird.com/sbe-61-deep-argo-ctd and two RBR (for core and deep floats) are also available, see:rbr-global.com/products/standard-loggers#CTD). Complementary to Argo core parameters, in the framework of BGC-Argo extension, **6 new parameters are now provided by the international BGC-Argo program and SNO Argo-France (DOXY, CHLA, BBP, NITRATE, DOWN_IRR, PH_IN_SITU_TOTAL)** However, other parameters are regularly carried out including : CDOM, BISULFIDE.

France has historically a particular scientific interest in the Atlantic and Southern Ocean as well as the Mediterranean Sea. So, the SNO Argo-France has a special engagement in providing research quality data for the Atlantic Ocean through its leading role in the North-Atlantic Argo Regional Center (see below section) and the North Atlantic deep Argo Pilot array implementation. Furthermore, recent extension provide profiles poleward than 60°N-S including under ice profile (in South Atlantic/near Antarctic and Baffin sea for the French community) and in marginal seas (Mediterranean Sea).

The SNO Argo-France has engaged in 2010 in providing a research-quality dataset (Delayed Mode) of P/T/S profiles as measured from autonomous Argo profiling floats (delayed mode), in the *global* ocean. Table 1 and 2 indicates units, accuracy, resolution and site of the distributed data. Accuracy is generally worst than what is announced by sensor manufacturers because of our incapacity to post-calibrate sensors at the end of a float life: floats are not recovered at the end of their mission.

Table 1: Properties of the core parameter of the SNO Argo-France

Parameters	Unit	Accuracy	Resolution	Observation site
Core Pressure	dbar	2.4	0.1	Argo-Global/0-2000m
Core Temperature	°C	0.01	0.001	Argo-Global/0-2000m
Core Salinity	PSU	0.01	0.001	Argo-Global/0-2000m

Table 2: Properties of the "extension" parameters and observation site of the SNO Argo-France. NA: Not available. These properties depends on float technology and scientific target which are still being defined at the international level (n.b.: SNO Argo-France co-organizes an international Argo-Deep implementation workshop in May 2015 and May 2019).

Parameters	Unit	Accuracy	Resolution	Observation site	Status
Displacements	cm/s	2	0.1	Argo-Global/1000m	operational
Oxygen	µMol/kg	8	0.001	Argo-Global/0-2000m	operational
Chlorophyll-a	$mg.m^{-3}$	0.01	0.001	Argo-Global/0-2000m	operational
Suspended particles	m^{-1}	0.0002	0.00002	Argo-Global/0-2000m	operational
Nitrates	µMol/kg	0.5	0.1	Argo-Global/0-2000m	operational
Downwelling irradiance	$W.m^{-2}\ nm^{-1}$	depends on lambda		Argo-Global/0-2000m	operational

PH		0.005	0.0004	Argo-Global/0-2000m	operational
Deep Pressure	dbar	NA	NA	Argo-Global/0-4000m	eligible
Deep Temperature	°C	NA	NA	Argo-Global/0-4000m	eligible
Deep Salinity	PSU	NA	NA	Argo-Global/0-4000m	eligible
Deep Oxygen	µMol/kg	NA	NA	Argo-Global/0-4000m	eligible

Depending on the Quality Control (QC) procedures, data has been categorized into different product levels. Following a nomenclature widely used by the remote sensing community, we constructed Table 2 to synthesize such product levels. The table is also color-coded to reflect product status with regard to their proximity to operational distribution, ether by Coriolis DAC/GDAC or research laboratories involved in the SNO Argo-France. For most products, this reflects the degree of achievement and international agreement on quality control procedures (see next section for more details). To evaluate the activities conducted by the SNO Argo-France during the 2015-2019, one has to compare this table with the one of the 2015 state provided in Annexe F. Over the 2020-2024, SNO Argo-France will maintain the high standard of research P/T/S data quality, and contribute to development of RT/DMQC methods and high level products for BGC parameters and deep measurements.

Table 3: SNO Argo-France products and parameters (2019 status)

January 2019 Status						
Product level	**L0**	**L1**	**L2**	**L3**	**L4**	**L5**
Description	**Raw** data transmitted by floats and decoded	**Profiles** Data QC in near **real**-time	**Profiles** Data QC in **delayed**-time	**Mapped** Data QC in near **real**-time	**Mapped** Data QC in **delayed**-time	**Oceanic indicators**
Core P/T/S	raw data, meta and tech.nc files	A-R mode prof.nc files	D-mode prof.nc files	ISAS-NRT (CMEMS-Copernicus)	ISAS-SNO monthly analysis	GOIs-Copernicus
Displacements	raw data, meta and tech.nc files	R mode traj.nc files	D-mode traj.nc files, based on ANDRO	Testing	ANDRO based 1000m absolute currents	R&D
Oxygen	raw data, meta and tech.nc files	A-R mode Mprof.nc files	testing	ISAS-O2-Coriolis climatology	ISAS-O2-SNO climatology	R&D
Chlorophyll-a	raw data, meta and tech.nc files	A-R mode Sprof.nc files	testing	R&D	3DBGC	
BBP	raw data, meta and tech.nc files	A-R mode Sprof.nc files	testing	R&D	3DBGC	
Nitrate	raw data, meta and tech.nc files	A-R mode Sprof.nc files	testing	R&D	R&D	

Radiometry	raw data, meta and tech.nc files	A-R mode Sprof.nc files	testing	R&D	R&D	
pH [3]	raw data, meta and tech.nc files	A-R mode Sprof.nc files	testing	R&D	R&D	
Deep P/T/S	raw data, meta and tech.nc files	A-R prof.nc file	testing	ISAS-17	ISAS-17	
Deep Oxygen	raw data, meta and tech.nc files	A-R Bprof.nc file	testing	ISAS-17-DOXY	ISAS-17-DOXY	

Status	**Definitions (**of product and QC procedures)
Achieved	The protocols and the methods are developed (i.e. published), implemented at DAC/GDAC level, and operational. International consensus.
Testing	The protocols and the methods are developed (i.e. published) and being implemented at DAC/GDAC level. International consensus on the methods is depending on tests (i.e. consolidation of consensus). Still in test phase to verify pertinence and performance.
R&D	The protocols and the methods are being developed (not published). No implementation at DAC/GDAC level. Discussions in the framework of the dedicated task teams (BGC-Argo and Argo-deep)
10 years target	Technology is being developed. Methods not yet identified.

2) Physical measurements

Core P/T/S Argo

The "physical" component of Argo relates to physical parameter measurements: pressure, temperature, salinity and displacements. Argo floats are autonomous platforms profiling every 10 days and measuring pressure, temperature and salinity between 0 and 2000m depth. Between two profiles, floats drift freely at a constant parking depth, generally 1000m depth. Displacements provide estimates on the oceanic currents. Once the float reaches the surface, data are transmitted through satellite communication systems to data centers, which then distribute data in near-real time, less than 24 hours.

The core sampling strategy is one P/T/S core profile in box of 3°x3° every 10 days between 60°S and 60°N out of marginal seas. This sampling, proposed by the Argo International Steering Team (AST) and accepted by all participants to the network, has been defined based on studies: of the global XBT network, statistics from altimetry and hydrographic sections from WOCE.

The vertical sampling scheme depend on the communication capacity of the float. The vertical sampling scheme is chosen by the PIs or following the Argo-France recommendation when the float is deployed by opportunity (see: *Kolodziejczyk et al.*, 2019, doi.org/10.13155/59297). With the Argos communication system, the vertical sampling is typically one measurement every 10 or 25 dbar, depending on the chosen configuration. With Iridium, now available on the majority of the floats, measurements can be taken every 1 or 2 db. Since 2013, more than 1 float over 2 deployed globally is equipped with Iridium. It has been chosen to profile every 10 days in order to ensure independent measurements over a seasonal cycle and longer time

scales. At least 3000 floats are permanently at sea to fulfill the nominal sampling of the global network. To sustain such a fleet, around 800 new floats must be deployed every year. Europe (through the Euro-Argo ERIC) aims to consolidate a contribution to ¼ of the network France has engaged in contributing to 65 of these floats.

Deep Argo

As the deep-Argo component does not yet benefit from any international nominal sampling recommendation, the SNO Argo France provided its own recommendations : 10-day sampling, between 1 and 7 db of vertical resolution, no parking depth recommendation. (see: doi.org/10.13155/59297). Those recommendations will be updated following the international Deep-Argo roadmap that should be established at the upcoming Deep-Argo workshop (Hobart, May 2019).

3) BGC measurements

The functioning of the BGC-Argo floats is identical to the standard P/T/S floats (as described in the previous paragraph). Compared to the Argo P/T/S, they are additionally equipped with more sensors (see later) and systematically with Iridium (or equivalent) double-way transmission (see previous paragraph), because it provides greater data flux and more flexible sampling strategies (i.e. higher vertical resolution, high profiling frequency).

4) Quality Control procedures

It should be reminded that the profiling float are not recovered after their mission, thus no post-calibration can be operated on the sensors neither bottle cast during the time life of the floats. For the Argo-core P/T/S data, then adopted by BGC-Argo program, the Argo Data Management Team (ADMT) has set up 3 systems to quality control the dataset in order to fulfill requirements from its wide user community:

- The first system is the ***real-time*** QC that performs a set of international agreed automatic checks on all float measurements. Real-time data with assigned quality flags are available to users within the 24-48hrs timeframe. They feed product levels L1 and L2 (see Table 1) and they target operational oceanographic system.
- The second system of quality control is the ***delayed-mode***. Operators responsible for floats use their expertise and complex methods published in peer-reviewed literature to validate profiles data. These data feed product levels L3 (see Table 1). They target research applications with possibly climate studies.
- The third system of quality control is the ***regional center***. This ultimate system is required to verify that *delayed-mode* QC conducted on floats by different operators, from different countries and different DACs are consistent with each others. This last stage ensures a coherent global dataset. Five regions of the ocean have been identified by the ADMT/AST groups and placed under supervision of 5 regional centers or ARC. The SNO Argo-France has the responsibility with Coriolis of the North-Atlantic Argo Regional Center or NA-ARC. Data validated by this system are incorporated into L3, L4 and L5 products (see Table 2).

These 3 systems are organized and coordinated as follows. Automatic quality control tests, performed in near *real-time* are agreed on and applied by all Argo data assembly center (DACs) similarly. A working group, associated to the Argo Data Management Team (ADMT), is more specifically in charge of the *delayed-mode* quality control issues. This so-called "DMQC" group meet when needed (typically every year). A manual describes all QC procedures, for both real and delayed time. These procedures are accepted by the entire community and the manual is updated regularly, several times a year if necessary (last version is available here: *Wong et al*, 2019,doi: 10.13155/33951). Activities conducted by *regional centers* are discussed within the DMQC group. Argo data from the SNO Argo-France are processed along these procedures. It is an important mission of the SNO Argo-France to develop new, and maintain existing, QC procedures in line with scientific progress and technological evolution of the platforms. At the national level, the SNO Argo-France QC activities are coordinated and discussed between: the R&D Coriolis component, research laboratories LOPS and LOV-IMEV and the SOERE CTD-O2.

With regard to biogeochemical (see Section B4c) and deep measurements (P/T/S and oxygen), the QC strategy is exactly the same than for the Argo-core P/T/S: to develop a 3 stages system with procedures agreed

upon at the international level by the ADMT, DMQC and AST groups. The advancement of the QC procedures is, however, different for each new extension. This advancement is color-coded in Table 2) and will be described in more details below for each product level. Since 2016, agreed procedure for delayed-mode quality control have been published in a cookbook with the leadership of the SNO Argo-France (*Schmechtig et al., 2016,* doi:doi.org/10.13155/40879). Most of the QC procedure have been extracted from peer-reviewed scientific literature, including a strong contribution of the French contribution (*Roesler et al.*, 2017; *Sauzède et al.*, 2017 ; *Xing et al.*, 2012, 2018 ; *Organelli et al.*, 2016 ; *Pasqueron de Fommervault et al.,* 2015; *Cabanes et al.*, 2016, 2019). It is thus a paramount achievement of the SNO Argo-France to have over the last 5 years created and disseminate QC procedures from scratch for the BGC parameters. Most of the developments now internationally agreed upon were proposed by the biogeochemical branch of the SNO-Argo France (see list of contributors of the ADMT documents).

We now review QC procedures and 2015-2019 SNO Argo-France activities for each of the product levels described in Table 2. Document and detailed procedure are available on the Argo Data management website (www.argodatamgt.org).

Level 0 : meta-data, technical data and raw measurements

L0 product level is a collection of meta-data, technical files and raw measurements transmitted by floats through satellite. These data are decoded by different operators. In France, Coriolis DAC is in charge of the decoding of the P/T/S and oxygen from French float. Since 2016, the BGC floats processing chain have been fully operational and integrated within the Coriolis data management stream (Coriolis Argo floats data processing chain, core, doi:10.17882/45589). Since 2015, Coriolis and the SNO Argo France have maintained decoders up to date with new floats and telecommunication technologies, including trajectories and, since 2016, BGC measurements. This work on trajectory and BGC data has lead to an improved dataset and more precise decoders used by DACs.

Level 1: realtime-mode data

L1 product level is a collection of netcdf files filled with profiles and trajectory data and distributed in near real time (24 to 48 hours after sampling). The netcdf profile and trajectory files format follows precise recommendation agreed at international level (ADMT). **So, L1 primary users are operational oceanographic centers and operational systems**. The L1 product is based on automatically validated L0 raw data. For a few specific floats and sensors, it may be possible to adjust L0 data in real-time to known and documented drift or bias. L1 data adjusted automatically are said in "A" mode, standing for real-time but Adjusted; all other L1 data are said in "R" mode, standing for Real-time. In both cases, the L0 raw data of P/T/S from the Argo global-0-2000 m subset are quality controlled by DACs with 19 successive automatic tests to produce L1 data. These tests are summarized in Table 4:

Table 4: List of automatic tests performed on data distributed in near real-time.

Order	Test ID	Test name
1	19	Deepest pressure
2	1	Platform identification
3	2	Impossible date
4	3	Impossible location
5	4	Position on land
6	5	Impossible speed
7	6	Global range
8	7	Regional range

9	8	Pressure increasing
10	9	Spike
11	10	Top and bottom spike, deprecated
12	11	Gradient
13	12	Digit rollover
14	13	Stuck value
15	14	Density inversion
16	15	Grey list
17	16	Gross salinity or temperature sensor drift
18	18	Frozen profile
19	17	Visual QC

In January 2015, the L1 product were only available for P/T/S, displacements (*Wong et al., 2019*, doi:10.13155/33951), dissolved oxygen and chlorophyll-a (*Schmechtig et al.*, 2019; doi: 10.13155/35385) parameters. The quality control method and tools are distributed and regularly improved and updated. During 4 last years, lot of activities have focused on other BGC parameters such as nitrates, suspended particles, CDOM and irradiance parameters. The French community participated to the discussions and propose method (*D'ortenzio et al.*, 2014), which results to a consensus now adopted at international level for providing L1 BGC data (*Schmechtig et al.*, 2016, doi: 10.13155/40879). Since 2015, the SNO Argo-France, in strong coordination with Coriolis, has maintained its international leadership for developing data processing and control methods that have built up the international standard for the real-time Argo data (L1) for all the Argo physical and biogeochemical parameters.

In strong coordination with Coriolis, Argo-France has also developed and implemented automatic test based on a daily objective analysis of temperature and salinity (*Gaillard et al.,* 2009). A new profile can be objectively mapped using a climatology and the residual analysis allows to detect anomalous profiles automatically. For flag correction on those profiles, daily automatic feedbacks (in text files, by email) are sent to the appropriate operators. The email message contains the list of Argo profiles highlighted by the objective analysis, and examined by a Coriolis operator, with the recommended flag correction listed at the end.

Concerning the deep-Argo float P/T/S measurement, no data flow is available for the moment at DAC level and sensor testing are still on going. Therefore, these data are not yet distributed in delayed-mode (only L1).

Furthermore, The sensor SBE41CP which equipe the deep-arvor operated by Argo-France have encountered some offset in salinity measurements (randomly distributed in sensor lots). The reader is reminded that the magnitude of the T/S signal at 4000 m depth is of the order of 0.002°C and 0.002 pss, which is barely larger than the expected accuracy from the SBE41 CTD. In order, to detect and correct this CTD offset, SNO Argo-France recommends to carried out a CTD cast at each deep-Argo float deployment. Further test, have also revealed pressure bias with SBE41CP measurements. Therefore, Argo-France along with international deep-Argo community have operated tests on SBE61 and deep-RBR CTDs. From the NAOS project, Ifremer RDT in collaboration with SNO Argo-France, has designed a new 'tri-headed' deep-float prototype to test the 3 available CTDs on the market, named SBE41CP, SBE61 and RBR, in order to operate inter-comparison tests

between CTD over a float's life. The 'tri-headed' prototype have been tested in north Atlantic. Results analysis are on going.

Level 2: delayed-mode data

L2 product level is a collection of netcdf files filled with profiles and trajectory data distributed with a delayed time (one or more years after sampling). So, **L2 primary users are from the research community** with stronger requirements than operational oceanographic centers. L2 data are said in "D" mode for Delayed time. The L2 product is a research-quality controlled version of L1 data. QC procedures are applied by the *delayed-mode* and *regional-center* systems. It is important to note that most, around 90%, of L1 core P/T/S data controlled by the *delayed-mode* and *regional-center* systems populate unchanged the L2 product. This is a significant achievement of the core Argo program that highlights the robustness and sustained quality of the observational platforms. This is also true for the subset of French data acquired by floats developed and produced in France.

For research applications, and more specifically for studies on global climate change, Argo data must have high accuracy and systematic errors must be minimized. To do so, once L1 data are more than 1 year old, they are carefully controlled and possibly corrected by floats PIs, data centers and regional Argo centers like the NA-ARC under France responsibility. This research quality control process is made of both the *delayed-mode* and *regional-center* systems described above and lead to the generation of L2 product level. Obviously, one of Argo top priority is to work on the detection and correction of measurements errors and more especially on those inducing systematic errors and biases. QC methods are developed by research laboratories, like LOPS and LOV for the SNO Argo-France, as well as the R&D component of Coriolis because some methods can be implemented by data centers to detect as soon as possible bad data, which have been through automatic tests in the early stages of the data flow.

The research-quality validation of Argo data is particularly difficult because floats are not recovered at the end of their life time and hence, sensors cannot be post-calibrated. This explains why temperature and salinity accuracy is about 0.01 (see Table 1), less than one could expect from manufacturers fact sheets. Temperature is rarely corrected because it is measured by a sensor very stable in time. Historical salinity measurements can be used to correct if necessary a possible drift on the conductivity sensor (*Owens et Wong*, 2009). But it is impossible to list here all validation methods. One can simply say that they mostly rely on comparisons with some co-localized statistics (for instance a range of possible values determined with all historical measurements). Thus, QC methods evolve constantly because this research-quality validation is based on fine statistics and on scientific knowledge at a given time. Note that high precision CTD data acquired during hydrographic campaigns and possibly at the time of float deployment, are crucial for the research-quality validation and generation of L2 products. In practice, the added information with regard to L1, is into finely grained quality flags attributed carefully by operators to each measurements, down to each parameter and vertical levels. These flags reflecting the quality of the data are summarized in Table 5.

Table 5: Quality flags for the research-quality dataset

Flag ID	Flag name	Definition for L3/L4/L5 product levels (issued by *delayed-mode* and *regional-center* systems)
0	No QC was performed	No QC was performed
1	Good data	The adjusted value is statistically consistent and a statistical error estimate is supplied
2	Probably good data	Probably good data
3	Bad data that are potentially correctable	An adjustment has been applied, but the value may still be bad.
4	Bad data	Bad data. Not adjustable.
5	Value changed	Value changed

6	Not used	Not used
7	Not used	Not used
8	Interpolated value	Interpolated value
9	Missing value	Missing value

It may happen that previous flagging or corrections are revisited according to new discoveries and improvements. Indeed, this situation has been encountered by France in 2013. The SNO Argo-France, by its contribution to the NA-ARC, has improved a widely used salinity correction method applied in delayed time (OWC method, *Owens et Wong*, 2009; *Cabanes et al.*, 2016). This improvement was based on a recent better understanding of the interannual variability of the North Atlantic subpolar gyre and lead to updates in over-corrected data (see *Cabanes et al.*, 2016). Recently, the improvement proposed in *Cabanes et al.*, 2016, has been added to the original OWC method and DM operators are now encouraged to use the new correction method (https://github.com/ArgoDMQC/matlab_owc).

Additional review of basin-wide data quality is crucial especially for salinity data to harmonize the QC and correction among different group of PIs or from different lots of float. This has been regularly performed at the NA-ARC level since 2013. A Web page have been created to monitor the suspicious floats whos PIs or delayed-mode operator have been warned: www.umr-lops.fr/en/SNO-Argo/Activities/NAARC/Consistency-checks-of-DM-salinity-corrections. In addition, SNO Argo-France participates in the training of new operators on delayed-mode QC procedures and tools. SNO Argo-France made a significant contribution to the first European DMQC workshop organised in April 2018 by Euro-Argo ERIC and its partners as part of the MOCCA project. More recently, SNO Argo-France was asked to participate in the training of the new UK delayed-mode operator, which was hosted at Ifremer during 2 days in March 2019. As part of the European project EA-RISE, Argo-France experts will take the lead on writing a Delayed-mode QC cookbook that will help to harmonize delayed-mode QC procedures among differents delayed-mode operators.

In 2016-2017, DMQC teams, including Argo-France experts, warn the community on dramatic salinity drift records among a serial of SBE41CP CTD (serial nb. : 8000-8500). This failure mode of CTDs has been reported to be a SBE defect. Since few years, Argo community urge the necessity of testing alternative CTD from SBE. Argo-France has took the lead in testing the new RBRs inductive CTD, promising results have been achieved during inter-comparison experiments with Argo SBE CTD and CTD ship casts during recent LOPS cruises (RREX, OVIDE). A work package, from European project EA-RISE, including Argo-France expert plans to implement and deploy the RBR on group of Euro-Argo floats. This aims at break the monopoly on seabird on Argo CTDs and Argo community hope the completion among the CTD deals will lower the cost of the fleet.

Since 2017 the SNO Argo-France has taken the lead on developing new DMQC procedures based on machine learning of the existing knowledge extracted from the Argo datasets and human expertise. These approaches are being developed at LOPS for T/S measurements and LOV for BGC ones. Preliminary results are very encouraging both in terms of productivity gain and dataset quality improvement. However, the Argo QC human expertise remains very complex to modelise because it involves quality assessment at different levels (point, profile, flotat, region) and rely on both climatology and operator repetitivity hypothesis that remained to be demonstrated.

Over the 2015-2019 period, **L2** delayed-mode QC procedure for all BGC parameters are be strongly developed in complete coordination to the international instances (BGC-Argo task team at the ADMT). Since 2015, the SNO Argo-France has worked on moving BGC-Argo data from the research and development, and testing QC procedures. At the SNO Argo-France, an highlighting example of this success is the development of the LOCODOX tools which facilitates delayed mode QC and correction on dissolved oxygen using reference climatology and/or measurements of oxygen in air. Thanks to the technological improvement and test during the 2015-2019 phase of the NAOS, the device for measuring the DOXY in air is now operational on Provor/Arvor

float and ready to be use to calibrate the DOXY profiles. Then relying on fully qualified DOXY measurements, neural network approach (Sauzede et al., 2017, Bittig et al., 2018) can be used to qualify NITRATE and PH_IN_SITU_TOTAL.

The SNO Argo-France strongly contributes to the definition of these methods in an international framework, at European (Euro-Argo) and Global (ADMT, BGC-Argo task team) levels. In this context, a whole work package of the european project E-A-RISE, lead by and including experts of SNO Argo-France, is completely devoted to ensure and organize the BGC-Argo DMQC mode at european level.

Level 3 & 4: gridded products

The **L3** and **L4** product levels are the respective gridded versions of the L1 and L2 products. **L3** and **L4** products are collection of netcdf files filled with gridded data. L3 is distributed in near real time, L4 is distributed once a year. The Argo dataset is irregular in space and time. To facilitate its use for research and modeling, it is crucial to map the irregular dataset onto a regular space/time grid. Over the last 4 years, the SNO Argo-France has developed and maintained such a mapping tool (named ISAS) based on an objective analysis of profiles. There is no specific QC procedure for L3 and L4 products, they rely solely on L1 and L2 quality, respectively. However, the objective analysis provides a statistical error estimate of the mapping based on the distance of the data to the climatology for a given local co-variance matrix. This error estimate is used to quality control the objectively mapped data. This system is used in near real time for L3 (ISAS-NRT) and in delayed-time for L4 (ISAS15). It is a strong achievement from Argo-France that L3 is now computed automatically and distributed in near-real time by Coriolis DAC and in the CMEMS Copernicus Marine Services. One must note that ISAS is the same numerical code that is used for the daily automatic validation (see previous paragraph on L1 QC) and for the mapping of profiles. **Given its multi-usage, ISAS is a strategic tool for Argo-France.** During the last 4 years software improvement has been achieved to increase optimal interpolation code execution speed. Multi configuration have been released: using only Argo data (suggested by AST), configuration including other delayed mode in situ data (Marine Mammals and ITP to cover the under-ice high latitudes, mooring in the Tropical band), also Sea Surface Salinity analysis including the research and merchant Thermosalinograph Salinity measurements. These new configurations were set in the context of research collaboration and they are freely available using doi reference(doi:10.17882/52367 and doi: 10.17882/55600).

Anticipating the BGC and deep Argo extension, ISAS tools and products are evolving towards full depth and oxygen configuration. The code is actually ready to produce this fields and is currently tested with the new datasets. In 2019, ISAS17 full depth monthly field (covering the 2002-2017 period) and the ISAS-DOXY full depth climatology (including delayed mode Argo DO data and CTD) will be released.

Finally, ISAS very last version is permanently made available, through the SVN server at Ifremer, to provide updated code to Coriolis data center experts. On demand any user can be included on this repository and commit its own version. The SNO SSS (UPS, Toulouse) is currently working with ISAS to produce its own SSS interpolated products distributed by the SNO SSS.

In parallel to the ISAS extensions to the BGC parameters (which is limited to the O2 parameter), others **L3 BGC products are developed in the framework of the SNO (3DBGC;** Table 1**)**. THe 3DBGC products are based on a merging of satellite maps and floats profiles, in particular for parameters accessible by both platforms. Dedicated statistical methods (*Sauzade et al.* 2016), based on neural network approach, have already be successfully applied to generate gridded 3D product of POC (from bb parameter). Tests to generate similar product for the Chl parameter are ongoing

Last, **L5** products are oceanic highest level indicators. L5 products are based on peer reviewed methods and aim to provide a synthetic information for a given component of the ocean and its long-term monitoring. Over the last 5 years, there has been a tremendous amount of studies exploiting the growing length of the Argo time series, which culminated in the last and futur IPCC report being largely based on Argo data. Since 2015, global ocean indicators (GOIs) such as: global ocean heat content, global ocean fresh water content and global ocean sea level were are now routinely computed and distributed by CMEMS Copernicus Marine Services. The SNO Argo-France supports produces GOIs based on peer reviewed validation methods (*Roemmich et al.*, 2015; *Cazenave et al.,* 2018, www.umr-lops.fr/SNO-Argo/Products/ISAS-T-S-fields/Climatology-and-climate-indices).

Finally, on annual base the SNO Argo-France provides the French contribution to the North Atlantic Ocean state report of the ICES international group (*Gonzales-Paola et al.*, 2019; www.ices.dk; www.umr-lops.fr/SNO-Argo/Products/ISAS-T-S-fields).

B5. Archivage des données et leur mise à disposition

Argo core P/T/S data are decoded, processed and archived by 11 national data centers (so called DAC) which have the responsibility of their float fleet. All DACs must synchronize their dataset with 2 global DACs (so called GDAC) which have the responsibility to distribute the entire Argo dataset to the community. The long-term Argo data archive is managed by the U.S. National Oceanographic Data Center (NODC). At the French level, Argo data are archived by SISMER/Ifremer, the national center for long term ocean data storage.

Argo core P/T/S and oxygen data from the SNO Argo-France are decoded, processed and archived by the Coriolis data center. Coriolis is one of the two European DAC and one of the two global GDAC.

In 2020, Coriolis 2014-2020 agreement will end. A working group has been set up in 2019 with representatives of the seven institutes to propose what will be the future collaboration. In any-case the Coriolis data center which manage the Argo data system will continue as one element of the future ODATIS Research Infrastructure (www.odatis-ocean.fr).

Data processing and management procedures are made uniform at the international level and coordinated during annual meetings of the Argo Data Management Team (ADMT, www.argodatamgt.org). S. Pouliquen, head of the Coriolis data center, is co-chair of the ADMT since its creation in 2000. Validation procedures were described in section B4. Note that the compliance of file formats to international agreements as described in the Argo User manual has to be verified by GDACs.

Data can be organized into different product levels as described in Table 3: SNO Argo-France products and parameters, and data availability can be summarized as follows:

- Meta-data and technical data are made available as conventional netcdf files after each float deployment, and are updated by DACs within 24 to 48 hours after each new profile. These netcdf files are distributed by GDAC on their ftp servers. They are part of the L0 product category.
- Measurements validated in near real-time are set in "R" or "A" modes and are available to users within 24 to 48 hours in conventional netcdf files on GDAC ftp servers. These files are in the L1 product category. Note that unlike meta and technical data, raw measurements transmitted by satellite are only accessible to float operators. Indeed, it has been decided by the ADMT at the beginning of the program to distribute measurements only once they have passed a series of automatic tests (described in section B4).
- Measurements processed through research-quality validation methods are set in "D" mode and are distributed in conventional netcdf files on GDAC ftp servers generally around 1 year after sampling. These files are in the L2 product category.

All data are freely available to users, whether it is parameter measurements or technical or meta-data. The Argo official file format is netcdf and data format convention is determined at the international level by the ADMT group. Data can be downloaded from the ftp server: ftp://ftp.ifremer.fr/ifremer/argo but also through web services like opendap. In 2018 Ifremer has set up an erddap server (for T/S and BGC variables) to give an API access to Argo data. The legal status of these data is set at the international level by the 1999 Resolution XX-6 of the Twentieth IOC (International Oceanographic Commission) Assembly requiring that *"the concerned coastal states must be informed in advance, through appropriate channels, of all deployments of profiling floats which might drift into waters under their jurisdiction, indicating the exact location of such deployments."* This resolution states that a country must be notified when a float enters its Exclusive Economic Zone (EEZ). This notification is handled at the international level by the Argo Information Center (AIC) and the Joint Commission in situ Observing Platform Support Centre (argo.jcommops.org, M. Belbeoch).

Since 2012, Argo BGC data from the SNO Argo-France are now decoded, processed and archived by the DAC Coriolis . Coriolis also manages the BGC-Argo floats of the European fleet (850 profiles from Argo-Italy, Argo-UK and E-Aims). BGC-Argo data are processed and archived following exactly the same strategy than the

P/T/S data, as explained above. In 2015, the DAC coriolis suggested a new file format (V3.1) that allowed the cohabitation of BGC argo data (+P) (developing phase) stored in the so called “B file“and core argo data P/T/S (mature phase) stored in the so called “C File”. In order to ease the manipulation of the data, two files format are also distributed: the so-called "synthetic" profile netcdf files or ‘Sprof.nc’ that allows an optimisation of the pressure alignment for all the sensors and the so-called “merge file” or ‘Mprof.nc’ that contained only the final parameters (and no longer the intermediate parameters needed for the calculation). The double format strategy provides a two-fold aim: an easy and rapid distribution of all the ocean variables in a unique file (i.e. the second version), although provides all the information (i.e. the first version) required by expert users to reprocess the data with non-standard algorithms.

To acknowledge Argo, it is recommended to use the following sentence and place the appropriate Argo doi (10.17882/42182) afterwards as described below : *" These data were collected and made freely available by the International Argo Program and the national programs that contribute to it. (http://www.argo.ucsd.edu, http://argo.jcommops.org). The Argo Program is part of the Global Ocean Observing System. " (www.argo.ucsd.edu/Acknowledging_Argo2.html*).

B6. Dissemination and scientific outreach

1) Teams and programs using the dataset

Argo is now one of the essential datasets used in oceanographic studies. At the French level, the list of teams using the Argo dataset can precisely be done by looking at the affiliations of French co-authors in the bibliography (see below). These are mostly from the following groups:

LOPS (UMR 6523, Laboratoire d’Océanographie Physique et Spatiale, Brest)
LOV (UMR 7093, Laboratoire Océanographique de Villefranche-sur-mer)
IMEV (UMS 829, Institut de la Mer de Villefranche)
LOCEAN (UMR 7159, Laboratoire d'Océanographie et du Climat, Paris)
LEGOS (UMR 5566, Laboratoire d’Etudes en Géophysique et Océanographie Spatiales, Toulouse)
MIO (UMR, Institut Méditerranéen d’Océanologie, Marseille)
LGGE, MEOM group (UMR 5183, Laboratoire de Glaciologie et Géophysique de l'environnement)
SHOM (Service Hydrographique de la Marine)
LOG
LOMIC

and from many other different groups within institutions, most notably: DT INSU, ISI/TSI/SISMER Ifremer, US Imago IRD and CNES.

At the national level, the following program is using Argo data:

Mercator Ocean International

At the European level:

Copernicus (Copernicus Marine Environment Monitoring Services)
GODAE Ocean View (former Global Ocean Data Assimilation Experiment)

At the international level:

GCOS (Global Climate Observing System)
GOOS (Global Ocean Observing System)
WCRP (World Climate Research Program)
OOPC (Ocean Observation Panel for Climate) sponsored by GCOS, GOOS and WCRP
CLIVAR (Climate and Ocean - Variability, predictability and Change)

2) Scientific production

The complete lists of the 3613 peer-reviewed articles and 305 PhD thesis to date, based or using Argo data, are available online at www.argo.ucsd.edu/Bibliography.html and www.argo.ucsd.edu/argo_thesis.html.

The specific list of French peer-reviewed article and PhD thesis are available on : www.argo-france.fr/publications.

3) Data and products

For a better traceability, the Argo dataset downloads have a DOI (Digital Object Identifier) and are monitored since 2016: more than 740 Argo downloads (Fig. 9) have been recorded from Seanoe (www.seanoe.org) doi services (www.argodatamgt.org/Access-to-data/Argo-DOI-Digital-Object-Identifier).

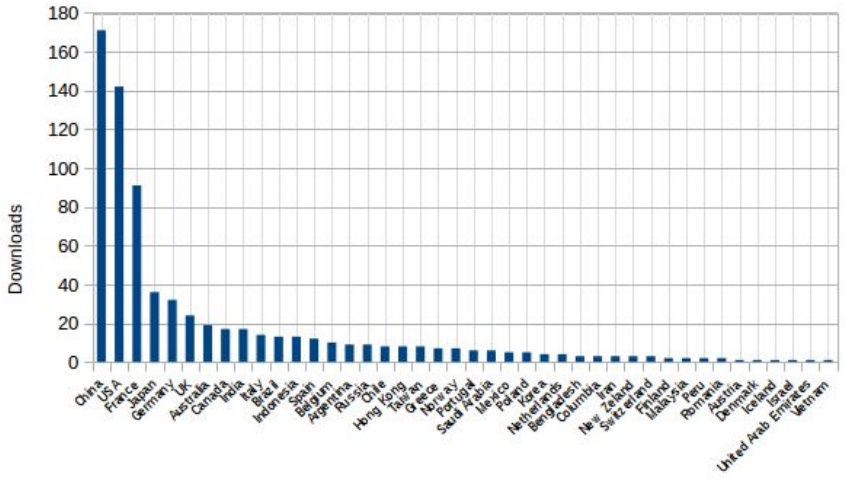


Figure 9 : Argo data and meta-data number of downloads as a function of country of origin of the downloading over the period 2016-2018 on doi https://doi.org/10.17882/42182.

ISAS temperature and salinity products downloads are also monitored since 2016: more than 1091 downloads have been recorded from many countries over the five continents. ANDRO DMQC Argo trajectory products have been downloaded more than 107 times since 2016. The complete count of SNO Argo-France products downloads and country of origin are provided by Seanoe doi services and displayed on Figure 10. It should be noted that such a visibility of ISAS and ANDRO products is made possible since there are included on the international project web page : www.argo.ucsd.edu/Gridded_fields.html.

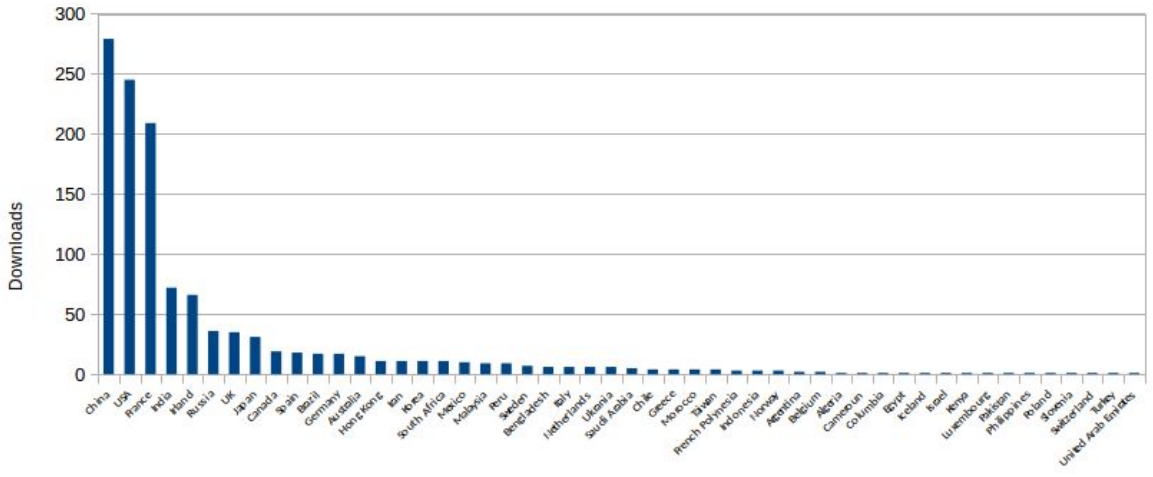


Figure 10 : SNO Argo-France products, including ISAS (1091) and ANDRO (107), number of downloads as a function of country of origin of the downloading over the period 2016-2018.

4) Link with numerical modeling

Both physical and biogeochemical Argo data are used in numerical models for:

- Data assimilation in near-real time in oceanographic and meteorological operational systems;
- Data assimilation for seasonal forecast (e.g. ECMWF)
- Data assimilation in oceanic re-analysis for research and climate studies

Physical data are assimilated for global and regional ocean forecasts at the national (Mercator Ocean), European (Copernicus Marine and Climate Services) and international levels (GODAE Ocean View). These models are in turn used to initialize seasonal forecast simulations. Note that Mercator oceans re-analysis assimilate Argo data. Besides assimilation, Argo data can be used by hindcast or free forward numerical simulations as initial conditions. This is the case most notably within the international DRAKKAR research group.

Physical Argo data are also used to validate numerical simulations. With more than 2 millions profiles evenly distributed over the global ocean, Argo data provide a robust and precise climatology of the global ocean for the early 21th century against which numerical models can be validated. Over the last few years, Argo data have also been started to be used to compute higher order moments of the ocean reference state. Beside the mean and standard deviation, the Argo data set is now rich enough to compute skewness and kurtosis of local measurement probability density functions. This allows for a characterization of the observed internal structure of small scale eddy activities (e.g. *Roullet et al.*, 2014; *Feucher et al.*, 2019) and thus provide a reference state against which to validate statistics from eddy resolving numerical simulations.

Biogeochemical Argo data are used in combination with numerical models. This activity, which is organized at national level in the framework of several already funded GMMC projects (MERCATOR Vert, SIMED, AmicoBio, DEWEXTEND, CIENPERU, EXPLORE, SOFRESH, GREEN-GROG, PISCO), implies the whole spectrum of scientific researches around data-model interactions: initialization, assimilation tests, validation, OSSEs, network design. Most of the activities focus on the CHLA and NITRATE parameters, which are considered the most innovative in the data-model framework. A specific effort is also dedicated to the satellite-in situ merging/intercalibration, as, before BGC-Argo, satellite data were the only data set having the required spatio-temporal resolution to be used in this context. Finally, operational models are also used to drive BGC-Argo deployments and to adapt sampling strategies (GMMC project MESOLAB, FP7 project OSS2015, H2020 project AtlantOS), in order to provide scientific results on the BGC-Argo network implementation.

B7. Man power

The Argo-France program gathers all French activities linked to the international Argo program. These activities are organized in 4 domains as represented :

1. **Technological developments**: are conducted and operated by institutes (Ifremer, CNRS, SHOM,...) with flagship projects like the EQUIPEX NAOS and ERC RemOcean.
2. **Data acquisition at sea**: operated by Coriolis, this domain encompasses: floats acquisition, deployment and monitoring.
3. **Data management**: the data center is operated by Coriolis (DAC and GDAC), the data quality control is operated by Coriolis (*real-time* system) and conducted with the SNO Argo-France expertise (for *delayed-mode* and contribution to NA-ARC *regional-center* systems).
4. **Scientific steering**: is coordinated by SNO Argo-France and conducted jointly by LOPS, IMEV-LOV and Coriolis at the national (SOERE, GMMC), European (Euro-Argo management board) and international level (AST, ADMT, DMQC).

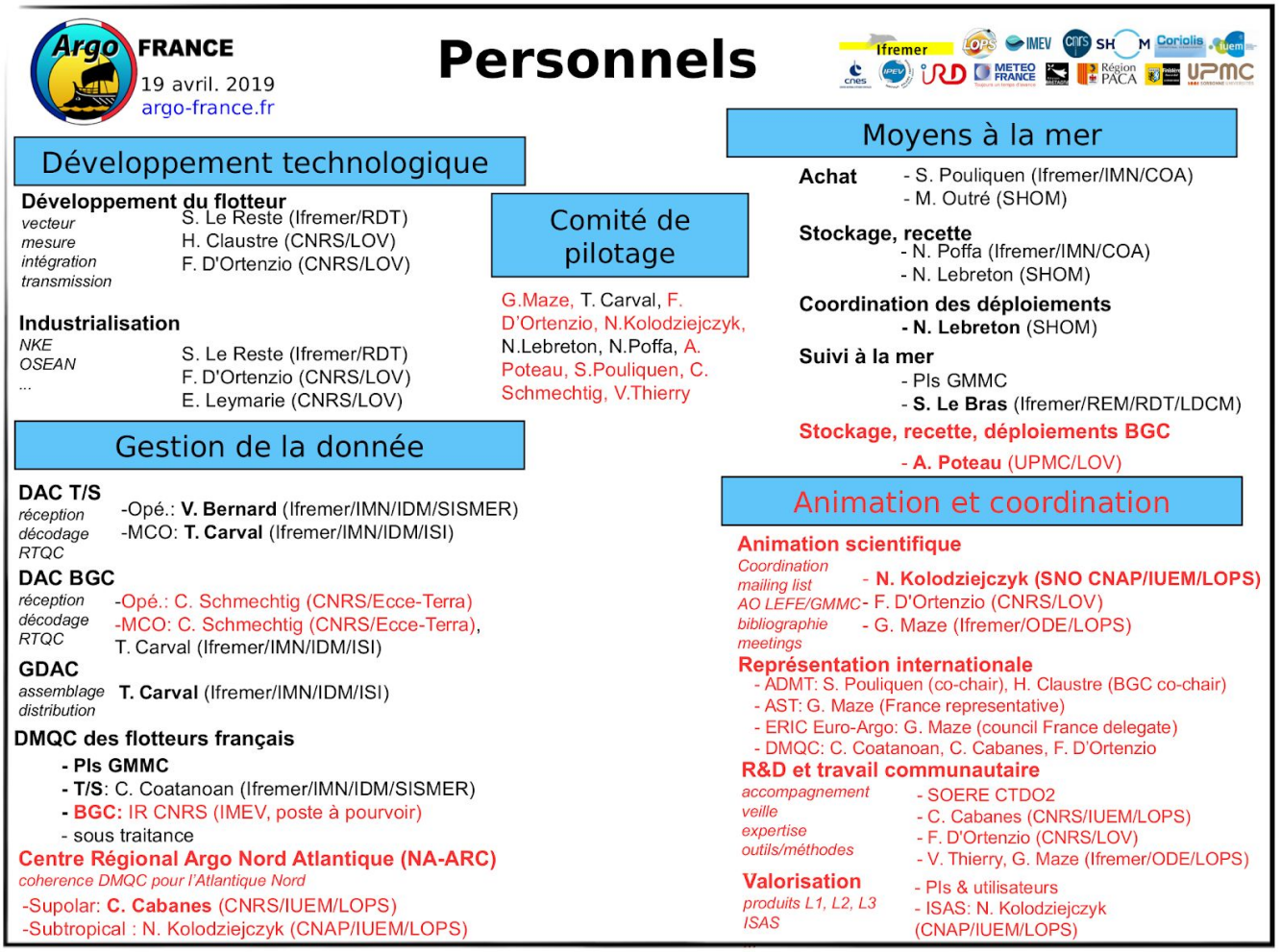


Figure 11: "Organigram" of Activity and Man Power of TGIR Argo-France **including SNO Argo-France activities in red.**

Last 3 domains with the Euro-Argo ERIC central infrastructure are accredited as a "Large Scale Research Infrastructure" (**TGIR**) by the French Ministry of Higher Education and Research. Operational activities are managed within Coriolis, research and animation within SNO Argo-France.

Thus, with resources from CNRS, OSU-IUEM and institutional contributions through research laboratories (LOPS and IMEV-LOV), the SNO Argo-France takes in charge the main following activities (in red Fig. 11; in Fig. 12):

- **Scientific coordination and animation** of the national program in close interactions with Argo international and Euro-Argo. This is done by G. Maze with N. Kolodziejczyk, F. D'Ortenzio, V. Thierry and S. Pouliquen.
- **QC protocols development and expertise** for: all French floats and the North-Atlantic Argo Regional Center (post delayed-mode assessment of research-quality procedures for floats in the North-Atlantic). This is done under the supervision of N. Kolodziejczyk, C. Cabanes for physical parameters and F. D'Ortenzio for biogeochemical ones.
- **Coordination with operational Coriolis activities** (deployments, DAC, TGIR). This is done by S. Pouliquen with C. Cabanes, A. Poteau and C. Schmechtig.
- **Promotion** of new measurements (biogeochemical) and observation sites (deep ocean). This is done by F. D'Ortenzio, V. Thierry and G. Maze.

Note that 2015-2019 achievements and developpement for these activities have been reviewed throughout the previous sections of this document.

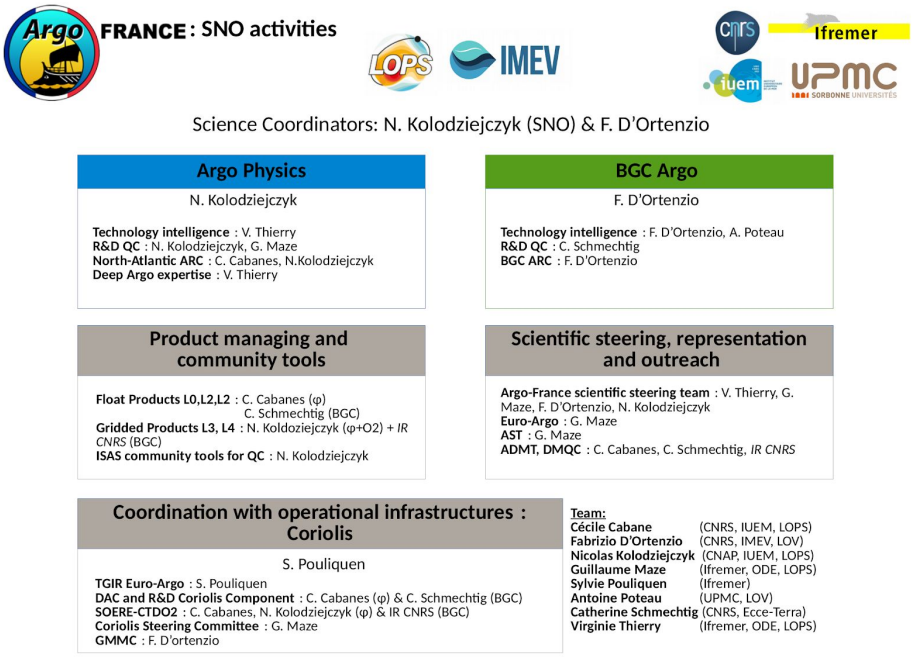


Figure 12: Focus on organisation of SNO Argo-France activities and team.

All Argo-France activities are organized since 2010 as in Figure 11. Note that we decided to show the combined organigramme of SNO and TGIR to highlight the strong links between the two structures. The role of the SNO, in the larger framework of the TGIR, is to ensure, consolidate and develop the scientific animation and coordination of the Argo activity in France. In this sense, the SNO is a critical instance to pilot the TGIR operational tasks and to coordinate all the link with the scientific community (i.e. users, GMMC, others SNO etc). G. Maze was SNO coordinator from 2013 up to 2017; N. Kolodziejczyk from 2017 up to now. F. D'Ortenzio is the coordinator of the BGC component since 2014. The SNO Argo-France aims to maintain existing and develop new expertise with regard to physical, biogeochemical and deep measurements from Argo floats. There is thus a strong activity linked to the R&D of new floats and sensors conducted within projects (NAOS, RemOcean). Note that the SNO Argo-France provides qualified Argo data in different products levels constantly under improvement and development, hence the emphasis on products. Human resources badging to SNO activities are summarized in Table 6. Contributions are in man.month. SNO gathers a total of 23.5 person-month.

Name	Position	Affiliation	p.m	Role in SNO Argo-France (2019)
Cabanes, Cecile	Engineer	CNRS	8	Coordination on P/T/S with Coriolis and SOERE, expertise on DMQC and North-Atlantic, product development (P/T/S, trajectories), NA-ARC
D'Ortenzio, Fabrizio	Scientist	CNRS	1	Coordination, animation, expertise on BGC-Argo extension
Kolodziejczyk, Nicolas	Scientist	CNAP	4	Scientific coordination, animation, expertise and product development (P/T/S, trajectories), expertise ISAS, NA-ARC
Maze, Guillaume	Scientist	Ifremer	2	Coordination, animation, expertise on DMQC, Argo-Deep extension and CTD sensors
Pouliquen, Sylvie	Engineer	Ifremer	0.5	Coordination with TGIR Euro-Argo
Schmechtig, Catherine	Engineer	CNRS	5	Coordination on BGC-Argo with Coriolis, expertise on DMQC

Thierry,Virginie	Scientist	Ifremer	2	Animation, expertise on BGC-Argo (oxygen) and Deep-Argo extensions, float deployment in the North-Atlantic, DMQC (S, O2)
Poteau, Antoine	Engineer	SU	1	Logistic, sensors performances and support to the users for BGC component
		Total SNO:	**23.5 person-month**	

Table 6: Human resources in person-month annually badging to SNO Argo-France as of 2019

All other human resources contributing to the Argo-France program are badging to operational infrastructure in the Coriolis consortium. Their averaged contributions for the 2015-2019 period is summarized Table 7 for each institutes and each Coriolis components. More details are provided in the Coriolis annual report : www.coriolis.eu.org/Documentation/on-the-CORIOLIS-infrastructure. A average of 110.5 person-month are contributing to Argo-France program through the Coriolis consortium. The respective contributions of all human resources are listed in Table 7.

Institute	Coordination	Data acquisition at sea	Data center	R&D	Total
IFREMER	14.5	17	25	20	76.5
SHOM		7.5			7.5
CNRS-INSU	4	6	5	10	25
IRD		0.5			0.5
Météo-France					
CNES					
Total Coriolis	18.5	32	30	30	**110.5 person-month**

Table 7: Coriolis human resources in person-month annually dedicated to the Argo-France program, on average 2015-2019.

B8. Steering

1) Internal instances

To reach its objectives, Argo-France partners represented in a Board of Directors (BD) relies on a management board.

The Board of Directors (BD)

The Argo-France Board of Directors is that of the Coriolis consortium. The BD brings together the directors (or their representatives) of the Argo-France partner organizations. As such, he:

- sets the general orientations and objectives of Argo-France,
- approves the annual activity plan and the distribution of the budgets and resources allocated to Argo-France by each organization,
- validates the composition of the management board,
- validates the organization proposed by the management board, decides on the issues and problems raised by the management board,
- interface with the Ministry of Research,
- decides on the evolution of the scope of Argo-France in relation to Euro-Argo ERIC.

The BD meets once a year at the initiative of the President and at any time at the request of one of its members. Decisions are made by consensus between the representatives of the Parties within the BD. A report

and a statement of decisions is drawn up after each meeting by the Executive Secretary. The minutes and record of decisions are approved by the members of the BD.

The Scientific Council (common to Coriolis and Mercator Ocean)

The Argo-France Scientific Council is that of the joined Coriolis and Mercator Ocean councils (*i.e.* GMMC). It is an advisory body whose mission is to make recommendations on the strategic scientific orientations of Mercator Ocean and Coriolis taking into account the national, European and international context. Vis-à-vis Argo-France, he gives opinions, in particular, on:

- deployment strategies
- the scientific articulation of Argo-France's activities with those of national, European or international projects having the same purpose,
- evolution of observation strategies (sampling, sensors, technology).

The Scientific Council evaluates the proposals submitted in response to the annual call for tender of the Mission Mercator Coriolis Group (GMMC). The Scientific Council ensures the adequacy of the proposals with the recommendations of the Argo international committee on float deployment strategies.

The Scientific Council may also be required to formulate opinions for deployments of opportunity.

It may be referred by the management board to any scientific question concerning the activities of Argo-France, on which it wishes opinion, proposal or recommendation.

The management board

Since 2014, an Argo-France management board is in charge of the coordination of the Argo-France program activities in order to provide to each component of the program (from both operational and research communities) a mid-to-long term perspective on the evolution of Argo in France.

The management board objectives are:

- to ensure that strategic choices made in different domains of activity are coherent and in line with needs of the national research community and the international requirements,
- to promote interactions between projects and operational activities, especially between technological floats development, at sea operations, Coriolis DAC and research conducted in laboratories,
- to develop a strategy for mid-term deployments (>2 ans) for the French Argo fleet (core mission and extensions),
- to provide a recommendation on the annual deployment plan elaborated by the operational team before validation by the Scientific Council.

The management board:

- is responsible for maintaining these objectives,
- establishes an annual plan of activities of the program and associated human and financial resources,
- proposes technical and scientific orientations and objectives as well as strategic choices to the BD,
- ensures the establishment of the material, scientific and technical environment necessary for the advancement of Argo-France,
- prepares and maintains an organizational note of Argo-France,
- organizes interfaces with Mercator Océan and other operational oceanographic systems (e.g., data quality, impact of observations in analysis and forecasting systems, future requirements),
- defines, in liaison with the Scientific Council, the scientific priority axes necessary for Argo-France and contributes to the preparation of the annual call for tender of the Mission Mercator Coriolis Group (GMMC),
- educates and proposes the admission of a new partner.

As of 2019, the management board is composed of:

- a national coordinator (G. Maze),
- a SNO scientific coordinator (N. Kolodziejczyk, physics),
- a BGC coordinator/ GMMC representative (F. D'Ortenzio)
- a technical coordinator (S. Pouliquen),

- two operational coordinators (T/S: N. Poffa and BGC: A. Poteau),
- two data management coordinators (T/S: T. Carval and BGC: C. Schmechtig),
- a technology coordinator (X. Andre, Ifremer/RDT, replace S. Le Reste).

The management board is helped with thematic experts when necessary (V. Thierry, H. Claustre, C. Coatanoan, C. Cabanes). The management board has met 3 to 4 times a year since 2014. All reporting, expertise and recommendations are available upon request to: pilotage-argo-france@listes.ifremer.fr or online at: www.argo-france.fr

2) External instances

Different members of the Argo-France community are involved in external governance instances. From the national to the European and international levels, responsibilities and representations are explained in Table 9

Table 9: Participation of SNO Argo-France in external governance instances.

Level	Instance	Name	Responsibility
France	Coriolis Steering Committee	G. Maze	Argo-France
	SOERE CTD-O2	C. Cabanes	Coordination SNO - SOERE
	TGIR Euro-Argo	S. Pouliquen	Coordination with ERIC
Europe	ERIC Euro-Argo	JM Flaud	Council France delegate
		G. Maze	Management Board France delegate
		S. Pouliquen	Program Manager
International	ADMT	S. Pouliquen	Co-chair
		H. Claustre	BGC co-chair
	DMQC	C. Cabanes	P/T/S/Traj expertise (SNO, NA-ARC)
		C. Coatanoan	P/T/S/Traj expertise (R&D Coriolis)
		IR CNRS	BGC delayed mode operateur
	AST	P.Y. Le Traon	European Union GODAE
		G. Maze	France delegate
		S. Pouliquen	ADMT co-chair
		H. Claustre	AST-BGC co-chair

B9. Budget

The reader is reminded that, the ensemble of Argo-France activities (except for SNO Activities) are directly funded via the TGIR. The yearly recurrent funding are provided on the road map of the Ministry (up to 2027). The 2000-2018 Argo-France time series of funding is provided in Table 10.

Table 10: The 2000-2018 Argo-France time series of funding.

Year	Funding (k€)	Floats deployed	QC profiles
2000	300	11	990

2001	633	12	2109
2002	980	7	4674
2003	900	34	5773
2004	1400	85	6672
2005	450	89	10939
2006	900	51	12935
2007	900	36	13326
2008	1200	90	13156
2009	1200	35	13879
2010	1400	55	18044
2011	1400	53	17872
2012	1400	82	17781
2013	1400	81	18175
2014	1400	96	18612
2015	1400	101	23035
2016	1400	58	21598
2017	1400	65	21636
2018	1400	95	17850
Total	**22863**	**1136**	**259056**
Total 2015-2018	**5600**	**319**	**84119**

The specific SNO Argo-France activities (expertise, coordination, steering and representation) are not funded by the TGIR but directly funded by CNRS-INSU and OSU-IUEM (Table 11). The expenses, which are mainly missions for international coordination and representation, are summed up in the Table 12.

Table 11: CNRS-INSU and OSU-IUEM funding for 2015-2018 period.

Regular funding 2015-2018			Occasional funding		
Source	*Amount (k€)*	*Comment*	*Source*	*Amount (k€)*	*Comment*
CNRS	10	SNO dotation 2015	Equipex	10	*NAOS WP3*
CNRS	10	SNO dotation 2016	ERC project	10	*RemOcean*
CNRS	10	SNO dotation 2017	CNRS-INSU	5	*project*
CNRS	10	SNO dotation 2018			
OSU-IUEM	3.1	SNO dotation 2015			
OSU-IUEM	3.1	SNO dotation 2016			

OSU-IUEM	3.1	SNO dotation 2017
OSU-IUEM	3.5	SNO dotation 2018
Total	52.8	

Note that human resources can be funded by other institutes, like Ifremer, through their support to SNO research laboratories: UMR LOPS and LOV-IMEV (Table 6).

Table 12: SNO Argo-France activities expenses (expertise, coordination, steering and representation) for 2015-2018 period.

Regular expenses 2015-2018				Occasional expenses			
Nature	*Origin*	*Amount (k€)*	*Comment*	***Nature***	*Origin*	*Amount (k€)*	*Comment*
Other expenses	*CNRS/OSU*	*1.3*	*Workshop Argo-france org., siteweb...*	***other expenses***	*CNRS/ OSU*	*1.5*	*communication*
Missions	*CNRS/OSU*	*40*	*Argo-France, EuroArgo, AST, ADMT, DMQC, Argo Science Workshop...*				
Equip.	*CNRS/OSU*	*10*	*computer equip.*				
TOTAL	***Dotation SNO***	***51.3***		***TOTAL***		***1.5***	
Missions	*NAOS (Equipex)*	*10*	*ADMT,AST (BGC)*				
Missions	*RemOcean (ERC)*	*10*	*ADMT,AST (BGC)*				
Mission	*CNRS-INSU*	*5*	*Deep-Argo Workshop, Argo Science Workshop*				
TOTAL	***Projects***	***25***					

For the 2020-2024 period the annual SNO dotation required will be doubled (25k€/year), to support enlarged requirements for SNO scientific coordination and representativity (Table 13) at international level. Given the new BGC and Deep Argo missions added to the historical Core mission, the number of SNO Argo-France experts and steering teams have doubled. They are required to travel towards the international Argo steering meetings AST, ADMT and Argo scientific meetings, and workshop associated with BGC and deep extension. Currently beyond the CNRS/OSU dotation, the missions are funded by scientists own projects. The SNO was not always able to send all its experts to steering committees. Up to now, especially for the BGC component, these missions have been founded by the WP3 of NAOS project and ERC project (ended project RemOcean). After, the end of NAOS project (2020), BGC component will have to be funded on SNO Argo-France INSU/OSU budget. This will be a critical issue for the international representation of SNO Argo-France BGC component.

Table 13: SNO Argo-France activities expenses (expertise, coordination, steering and representation) for 2015-2018 period.

Demande de soutien sur 2020-2024 (y compris soutien CNES)		
Nature[2]	***Montant (k€)***	***Commentaire***

Travel	*100*	*Argo-France, AST, ADMT, DMQC, Argo Science Meeting and workshop for BGC, Core and deep missions*
equipement	*5*	*computer for OSU and CNAP*
stages	*5*	
occasional expenses	*15*	*sensor, techno dev., website, outreach*
TOTAL	*125*	

B10. Communication, teaching, Outreach

The Argo data set is becoming one of the most important tool for oceanographic studies. Over the last 4 years, Argo France has promoted the use of the data for research and education through outreach activities conducted within projects.

1) Teaching

Since 2015, the Argo data and observing system are a full part of the In Situ Measurement teaching in Physical Oceanography Master 2 from Marine and Coastal Science Master at IUEM/UBO. The course largely presents the Argo float technology, the built up of the global networks, the issues and achievements that makes the Argo data management as a case study among the most elaborated data flow. Argo data are used as training material during training sessions (UE/MIS/25h; N. Kolodziejczyk: www.formations.univ-brest.fr).

Argo data and usage have also been taught in various summer schools and workshops (*e.g.:* Data Science and Environment Summer School. 3-7 July 2017, Brest). Some teaching supports (presentations, codes) were also provided to the Sentinel North International PhD School on board the CCGS Amundsen canadian research ice breaker, July 12-24, 2018, to introduce remote sensing technologies.

2) Outreach

The "Adopt a float" initiative (more details on the webpage here www.monoceanetmoi.com/web/index.php/fr/adopt-a-float) was launched in 2012 and continued over the 2015-2019 period. The concept is based on the idea that a class could adopt an Argo float and follow it during its scientific journey. The trajectory of the float brings the pupils into an oceanic zone (e.g. the Mediterranean or the North Atlantic) and, in real-time, allows them to participate in the observations collected by this float as well as to the sciences that are associated. The scientific voyage of a profiling float can last between 2 and 4 years. All during this time, it can be accompanied to better understand the marine environment and the scientific approach including the questions posed by the researchers.

The summer school at IUEM “Mer Education” was dedicated to observing the “Changing Ocean” (www-iuem.univ-brest.fr/mer-education/objectifs). This yearly outreach event is dedicated to develop the ocean science literacy toward the middle school teachers in order to broaden (‘teach the teachers’) the dissemination toward the middle schools pupils. The summer school schedules researcher talk, pedagogic activities and immersion in the research laboratories at IUEM and Ifremer. In 2018, a full session was dedicated to the Argo scientific questions and observations including Core-Argo network, BGC Argo and deep-Argo.

SNO Argo contributes to the Euro-Argo/Jcommops outreach activities, in particular to the first Ocean Observer workshop (13-14 June 2017, Oceanopolis, Brest, France), which was the first international meeting gathering scientific, teachers and education actors who are invested in outreach with oceanographic data including Argo.
(see:www.euro-argo.eu/News-Meetings/News/News-archives/2017/Ocean-Observers-Workshop-13-14-June-Brest)

Since October 2018, Argo is at museum of 'Cité des Sciences et de l'Industrie', Paris. SNO Argo-France, tightly collaborates with the 'Argonaute' exhibitor to build up the new permanent exhibition entitle 'Sous l'Océan' including basic physical oceanographic concepts, presentation of the Argo global observing system, float exhibitions and outreach activities .
(see:www.cite-sciences.fr/fr/au-programme/expos-permanentes/sous-locean)

B11. Issues and difficulties

The SNO has and continues to face challenges related to:

- insufficient budgetary resources for the SNO to ensure the representativeness of Argo-France in international governance bodies. In particular, it is sometimes difficult to involve our national experts and coordinators at meetings where important decisions are taken (eg technical recommendations, network design, given procedures). This is due to the enlarged mission of Argo now including Core, BGC and deep Argo missions. Up to now, especially for the BGC component, these missions and travel have been founded by the WP3 of NAOS project. After, the end of NAOS project (2020), BGC component will have to fund on SNO Argo-France INSU budget.
- a lack of visibility of the evolution of the research landscape; including IR and TGIR structures, SOERE
- long-term financing of the new BGC and DEEP missions, since the proposal submitted to PIA3 in 2017 (TGIR Euro-Argo Phase 2) is out. Including BGC and DEEP missions to the TGIR recurrent funding is key to the Argo-France success in the coming decade.
- the supply of quality CTD probes from the manufacturer SeaBird. More and more problems arise on the probes with less and less reactivities and transparent responses from the manufacturer. These difficulties are not yet critical to the maintenance of the network and its quality but increases the workload of the operators and underlines the urgent need to diversify the CTD sensors used on the Argo floats.

References cited in the document:

Bittig, H. C., A. Körtzinger, C. Neill, E. van Ooijen, J. N. Plant, J. Hahn, K. S. Johnson, B. Yang, and S. R. Emerson, 2018: Oxygen Optode Sensors: Principle, Characterization, Calibration, and Application in the Ocean. *Frontiers in Marine Science*, **4**, https://doi.org/10.3389/fmars.2017.00429

Bittig, H. C. and A. Körtzinger, 2017: Technical note: Update on response times, in-air measurements, and in situ drift for oxygen optodes on profiling platforms. *Ocean Science*, **13,** 1-11, http://dx.doi.org/10.5194/os-13-1-2017

Boutin, J., J. L. Vergely, S. Marchand, F. D'Amico, A. Hasson, N. Kolodziejczyk, N. Reul, G. Reverdin, and J. Vialard, 2018: New SMOS Sea Surface Salinity with reduced systematic errors and improved variability. *Remote Sensing of Environment*, **214,** 115-134, https://doi.org/10.1016/j.rse.2018.05.022

Boutin, J. and N. Martin, 2006: ARGO upper salinity measurements: perspectives for L-band radiometers calibration and retrieved sea surface salinity validation. *Ieee Geoscience and Remote Sensing Letters*, **3,** 202-206, https://doi.org/10.1109/LGRS.2005.861930

Cabanes C., V. Thierry and C. Lagadec, 2016: Improvement of bias detection in Argo float conductivity sensors and its application in the North Atlantic, Deep-Sea Research Part I, 114, 128-136.

Capet et al, 2016: Intensification of Upper-ocean submesoscale turbulence through Charney baroclinic instability. Journal of Physical Oceanography, doi: 10.1175/JPO-D-16-0050.1

Cazenave et al.: WCRP global sea level budget group, 2018: Global sea Level budget from 1993-present. Earth Syst. Sci. Data, 10, 1–41, doi.org/10.5194/essd-10-1-2018.

Claustre, H. and co-authors, 2010: Bio-optical Profiling Floats as New Observational Tools for Biogeochemical and Ecosystem Studies. *Proceedings of OceanObs'09: Sustained Ocean Observations and Information for Society* J. Hall, D. E. Harrison, and D. Stammer, Eds., ESA Publication, http://dx.doi.org/10.5270/OceanObs09.cwp.17.

Colin de Verdière, A., T. Meunier, and M. Ollitrault, 2019: Meridional overturning and heat transport from Argo floats displacements and the Planetary Geostrophic Method (PGM). Application to the subpolar North Atlantic. *Submitted to Journal of Geophysical Research-Ocean*.

Cossarini, G., L. Mariotti, L. Feudale, A. Mignot, S. Salon, V. Taillandier, A. Teruzzi, and F. D'Ortenzio, 2019: Towards operational 3D-Var assimilation of chlorophyll Biogeochemical-Argo float data into a biogeochemical model of the Mediterranean Sea. *Ocean Modelling*, **133,** 112-128, https://doi.org/10.1016/j.ocemod.2018.11.005

Daniault, N., H. Mercier, P. Lherminier, A. Sarafanov, A. Falina, P. Zunino, F. Perez, F. Fiz, A. F. Rios, B. Ferron, T. Huck, V. Thierry, and S. Gladyshev, 2016 : The northern North Atlantic Ocean mean circulation in the early 21st century. Progress in Oceanography, 146, 42-158.

Feucher, C., G. Maze, and H. Mercier, 2019: Subtropical Mode Water and Permanent Pycnocline Properties in the World Ocean. Journal of Geophysical Research: Ocean, 124, 2, 1139-1154. doi: 10.1029/2018jc014526.

Gaillard F., T. Reynaud, V. Thierry, N. Kolodziejczyk, K. von Schuckmann, 2016. In-situ based reanalysis of the global ocean temperature and salinity with ISAS: variability of the heat content and steric height. J. Climate, 29, 1305–1323. doi: http://dx.doi.org/10.1175/JCLI-D-15-0028.1

Gaillard, F., E. Autret, V. Thierry, P. Galaup, C. Coatanoan, and T. Loubrieu, 2009: Quality Control of Large Argo Datasets. *Journal of Atmospheric and Oceanic Technology*, **26,** 337-351, http://dx.doi.org/10.1175/2008jtecho552.1

González-Pola, C., P. Fratantoni, K. M. Larsen, N. P. Holliday, S. Dye, K.-A. Mork, A. Beszczynska-Möller, H. Valdimarsson, A. Trofimov, H. Parner, H. Klein, B. Cisewski, A. Fontán, K. Lyons, N. Kolodziejczyk, R. Fernández-Graña, J. Linders, T. Wodzinowski, I. Goszczko, and C. Cusack, 2019 : The ICES Working Group on Oceanic Hydrography: A bridge from in-situ sampling to the remote autonomous observation era, Froniers in Marine Science. doi: 10.3389/fmars.2019.00103

Hennon, T., Riser, S. & Alford, M. Observations of internal gravity waves from Argo floats. *J. Phys. Oceanogr.* **44**, 2370–2386 (2014).

IPCC, 2013: *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 1535 pp, doi:10.1017/CBO9781107415324.

Johnson, K. S. and H. Claustre, 2016: Bringing Biogeochemistry into the Argo Age. *Eos*, **97**, https://doi.org/10.1029/2016EO062427

Lavigne, H., F. D'Ortenzio, H. Claustre, and A. Poteau, 2012: Towards a merged satellite and in situ fluorescence ocean chlorophyll product. *Biogeosciences*, **9,** 2111-2125, http://dx.doi.org/10.5194/bg-9-2111-2012

Le Reste, S., V. Dutreuil, X. André, V. Thierry, C. Renaut, P.-Y. L. Traon, and G. Maze, 2016: "Deep-Arvor": A New Profiling Float to Extend the Argo Observations Down to 4000-m Depth. *Journal of Atmospheric and Oceanic Technology*, **33,** 1039-1055, http://dx.doi.org/10.1175/JTECH-D-15-0214.1

Llovel, W., J. K. Willis, F. W. Landerer, and I. Fukumori, 2014: Deep-ocean contribution to sea level and energy budget not detectable over the past decade. *Nature Clim. Change*, **4,** 1031-1035, http://dx.doi.org/10.1038/nclimate2387

Kolodziejczyk, N., W. Llovel, and E. Portela, 2019: internannula variability of the upper ocean water masses as inferred from Argo array, in revision for Journal of Geophysical Research.

Kolodziejczyk, N., J. Boutin, J.-L. Vergely, S. Marchand, N. Martin, and G. Reverdin, 2016: Mitigation of systematic errors in SMOS sea surface salinity. *Remote Sensing of Environment*, **180,** 164-177, http://dx.doi.org/10.1016/j.rse.2016.02.061

Kolodziejczyk, N., G. Reverdin, F. Gaillard, and A. Lazar, 2014 : Low-frequency thermohaline variability in the Subtropical South Atlantic pycnocline during 2002-2013, Geophysical Research Letters, 41, doi:10.1002/2014GL061160.

Kolodziejczyk, N., and F. Gaillard, 2013: Variability of the Heat and Salt Budget in the Subtropical South-Eastern Pacific Mixed Layer between 2004 and 2010: Spice Injection Mechanism, Journal of Physical Oceanography, 43, 1880–1898. doi:10.1175/JPO-D-13-04.1.

Kolodziejczyk, N., and F. Gaillard, 2012 : Observation of spiciness inter-annual variability in the Pacific pycnocline, Journal of Geophysical Research-Oceans, 117, C12018, doi:10.1029/2012JC008365.

Ollitrault M., and J.-P. Rannou (2013). ANDRO: An Argo-Based Deep Displacement Dataset. *Journal Of Atmospheric And Oceanic Technology*, 30(4), 759-788. Publisher's official version : https://doi.org/10.1175/JTECH-D-12-00073.1

Organelli, E., H. Claustre, A. Bricaud, C. Schmechtig, A. Poteau, X. Xing, L. Prieur, F. D'Ortenzio, G. Dall'Olmo, and V. Vellucci, 2016: A Novel Near-Real-Time Quality-Control Procedure for Radiometric Profiles Measured by Bio-Argo Floats: Protocols and Performances. *Journal of Atmospheric and Oceanic Technology*, **33,** 937-951, http://dx.doi.org/10.1175/JTECH-D-15-0193.1

D'Ortenzio, F., H. Lavigne, F. Besson, H. Claustre, L. Coppola, N. Garcia, A. Laës-Huon, S. Le Reste, D. Malardé, C. Migon, P. Morin, L. Mortier, A. Poteau, L. Prieur, P. Raimbault, and P. Testor, 2014: Observing mixed layer depth, nitrate and chlorophyll concentrations in the northwestern Mediterranean: A combined satellite and NO3 profiling floats experiment. *Geophysical Research Letters*, **41,** 2014GL061020, http://dx.doi.org/10.1002/2014GL061020

Pasqueron de Fommervault, O., F. D'Ortenzio, A. Mangin, R. Serra, C. Migon, H. Claustre, H. Lavigne, M. Ribera d'Alcalà, L. Prieur, V. Taillandier, C. Schmechtig, A. Poteau, E. Leymarie, A. Dufour, F. Besson, and G. Obolensky, 2015: Seasonal variability of nutrient concentrations in the Mediterranean Sea: Contribution of Bio-Argo floats. *Journal of Geophysical Research: Oceans*, **120,** 8528-8550, http://dx.doi.org/10.1002/2015JC011103

Racapé, V. , V. Thierry, H. Mercier, and C. Cabanes, 2019: ISOW spreading and mixing as revealed by Deep-Argo floats launched in the Charlie Gibbs Fracture Zone. Submitted to JGR-Ocean.

Riser, S. C., H. J. Freeland, D. Roemmich, S. Wijffels, A. Troisi, M. Belbéoch, D. Gilbert, J. Xu, S. Pouliquen, A. Thresher, P.-Y. Le Traon, G. Maze, B. Klein, M. Ravichandran, F. Grant, P.-M. Poulain, T. Suga,B.Lim, A. Sterl,P. SuttonK.-A. Mork,P. J. Vélez-Belchí,I. Ansorge,B. King, J. Turton,M. Baringer,S. .R. Jayne, 2016: Fifteen years of ocean observations with the global Argo array. Nature Climate Change, 6, 145, doi:10.1038/nclimate2872.

Rommeich et al., 2019: On the future of Argo : An enhanced global array of physical and biogeochemical sensing floats. Oceanobs19 white paper. Frontiers in Marine Science.

Roemmich, D., J. Church, J. Gilson, D. Monselesan, P. Sutton, and S. Wijffels, 2015: Unabated planetary warming and its ocean structure since 2006. *Nature Clim. Change*, **5,** 240-245, http://dx.doi.org/10.1038/nclimate2513

Roesler, C., J. Uitz, H. Claustre, E. Boss, X. Xing, E. Organelli, N. Briggs, A. Bricaud, C. Schmechtig, A. Poteau, F. D'Ortenzio, J. Ras, S. Drapeau, N. Haëntjens, and M. Barbieux, 2017: Recommendations for obtaining unbiased chlorophyll estimates from in situ chlorophyll fluorometers: A global analysis of WET Labs ECO sensors. *Limnology and Oceanography: Methods*, **15,** 572-585, https://doi.org/10.1002/lom3.10185

Roullet, G., X. Capet, and G. Maze, 2014: Global interior eddy available potential energy diagnosed from Argo floats. *Geophysical Research Letters*, **41,** 1651-1656, http://dx.doi.org/10.1002/2013GL059004

Sauzède, R., H. C. Bittig, H. Claustre, O. Pasqueron de Fommervault, J.-P. Gattuso, L. Legendre, and K. S. Johnson, 2017: Estimates of Water-Column Nutrient Concentrations and Carbonate System Parameters in the Global Ocean: A Novel Approach Based on Neural Networks. *Frontiers in Marine Science*, **4,** https://doi.org/10.3389/fmars.2017.00128

Sauzède, R., H. Claustre, J. Uitz, C. Jamet, G. Dall'Olmo, F. D'Ortenzio, B. Gentili, A. Poteau, and C. Schmechtig, 2016: A neural network-based method for merging ocean color and Argo data to extend surface bio-optical properties to depth: Retrieval of the particulate backscattering coefficient. *Journal of Geophysical Research: Oceans*, **121,** 2552-2571, http://dx.doi.org/10.1002/2015JC011408

Takeshita, Y., T. R. Martz, K. S. Johnson, J. N. Plant, D. Gilbert, S. C. Riser, C. Neill, and B. Tilbrook, 2013: A climatology-based quality control procedure for profiling float oxygen data. *Journal of Geophysical Research: Oceans*, **118,** 5640-5650, http://dx.doi.org/10.1002/jgrc.20399

Xing, X., H. Claustre, E. Boss, C. Roesler, E. Organelli, A. Poteau, M. Barbieux, and F. D'Ortenzio, 2017: Correction of profiles of in-situ chlorophyll fluorometry for the contribution of fluorescence originating from non-algal matter. *Limnology and Oceanography: Methods*, **15,** 80-93, http://dx.doi.org/10.1002/lom3.10144

Data management, workshop reports and documents:

Gallian Marine, Thierry Virginie (2018). Delayed-mode quality control of dissolved oxygen concentration measured by ARGO floats in the North-Atlantic with LOCODOX - Floats deployed in 2012, 2014, 2015, 2016 and 2017. https://doi.org/10.13155/58314.

González-Pola, C., Larsen, K. M. H., Fratantoni, P., and Beszczynska-Möller, A. (Eds). 2018. ICES Report on Ocean Climate 2017. ICES Cooperative Research Report No. 345. 119 pp. http://doi.org/10.17895/ices.pub.4625

González-Pola, C., Larsen, K. M. H., Fratantoni, P., Beszczynska-Möller, A., and Hughes, S. L. (Eds). 2018. ICES Report on Ocean Climate 2016. ICES Cooperative Research Report No. 339. 110pp. https://doi.org/10.17895/ices.pub.4069

Larsen, K. M. H., Gonzalez-Pola, C., Fratantoni, P., Beszczynska-Möller, A., and Hughes, S. L. (Eds). 2016. ICES Report on Ocean Climate 2015. ICES Cooperative Research Report No. 331. 79 pp.

Kolodziejczyk Nicolas, Carval Thierry, Claustre Hervé, D'Ortenzio Fabrizio, Lebreton Nathanaele, Le Traon Pierre-Yves, Maze Guillaume, Poffa Noe, Pouliquen Sylvie, Poteau Antoine, Schmechtig Catherine, Thierry Virginie (2019). Stratégie nationale pour les déploiements d'opportunité des profileurs du réseau global Argo / National Strategy for Argo Global Network Profiling floats Deployments of Opportunity. Comité de pilotage Argo-France/Argo-France management board. AF-2019-DEP-STRAT. https://doi.org/10.13155/59297

Rannou Philippe, Carval Thierry, Fontaine Laure, Bernard Vincent, Coatanoan Christine (2018). Coriolis Argo floats data processing chain. SEANOE. https://doi.org/10.17882/45589

Scanderbeg Megan, Rannou Jean-Philippe, Buck Justin, Schmid Claudia, Gilson John (2017). Argo DAC trajectory cookbook. https://doi.org/10.13155/29824

Schmechtig Catherine, Poteau Antoine, Claustre Hervé, D'Ortenzio Fabrizio, Dall'Olmo Giorgio, Boss Emmanuel (2018). Processing Bio-Argo particle backscattering at the DAC level. Argo data management. https://doi.org/10.13155/39459

Schmechtig Catherine, Claustre Herve, Poteau Antoine, D'Ortenzio Fabrizio (2018). Bio-Argo quality control manual for the Chlorophyll-A concentration. https://doi.org/10.13155/35385

Schmechtig Catherine, Claustre Herve, Poteau Antoine, D'Ortenzio Fabrizio (2018). Bio-Argo quality control manual for the Chlorophyll-A concentration. https://doi.org/10.13155/35385

Thierry Virginie, Bittig Henry, Gilbert Denis, Kobayashi Taiyo, Kanako Sato, Schmid Claudia (2018). Processing Argo oxygen data at the DAC level. https://doi.org/10.13155/39795

Wong Annie, Keeley Robert, Carval Thierry, Argo Data Management Team (2019). Argo Quality Control Manual for CTD and Trajectory Data. https://doi.org/10.13155/33951

Zilberman, N, Maze G. 2015. Report on the Deep Argo Implementation Workshop. Deep Argo Workshop. , Hobart, Tasmania

Dataset:

Argo (2019). Argo float data and metadata from Global Data Assembly Centre (Argo GDAC). SEANOE. https://doi.org/10.17882/42182

Feucher Charlene, **Maze Guillaume**, Mercier Herle (2018). 2000-2015 climatology of the Subtropical Mode Waters and Permanent Pycnocline properties in the World Ocean. SEANOE. https://doi.org/10.17882/56503

Feucher Charlene, **Maze Guillaume**, Mercier Herle (2016). 2000-2014 climatology of the North Atlantic permanent pycnocline properties. SEANOE. https://doi.org/10.17882/42386

Mercier Herle, Daniault Nathalie, Lherminier Pascale (2016). Time series of the Meridional Overturning Circulation intensity at OVIDE. SEANOE. https://doi.org/10.17882/46445

Kolodziejczyk Nicolas, Prigent-Mazella Annaig, Gaillard Fabienne (2018). ISAS-SSS: In situ Sea Surface Salinity gridded fields. SEANOE. https://doi.org/10.17882/55600

Kolodziejczyk, N., A. Prigent-Mazella, F. Gaillard (2017). ISAS-15 temperature and salinity gridded fields. SEANOE. http://doi.org/10.17882/52367

Maze Guillaume (2017). A Profile Classification Model from North-Atlantic Argo temperature data. SEANOE. https://doi.org/10.17882/47106

Ollitrault Michel, Rannou Philippe, Brion Emilie, **Cabanes Cecile**, Reverdin Gilles, **Kolodziejczyk Nicolas** (2017). ANDRO: An Argo-based deep displacement dataset. SEANOE. https://doi.org/10.17882/4707

Annexe A: Production scientifique des <u>acteurs</u> du SNO (publications de rang A, conférences, thèses)

[Production pour laquelle le premier auteur appartient au service]

Publications

Barbieux, M., Uitz, J., Bricaud, A. Organelli, E., **Poteau, A., Schmechtig, C.**, Gentili, B., Obolensky, O., **D'Ortenzio F**.and H. Claustre. (2018). Assessing the variability in the relationship between the particulate backscattering coefficient and the chlorophyll a concentration from a global Biogeochemical-Argo database, Journal of Geophysical Research. 123 (2), 1229-1250.

Boutin J., J.L. Vergely, S. Marchand, F. D'Amico, A. Hasson, **N. Kolodziejczyk**, N. Reul and G. Reverdin, 2018: Revised mitigation of systematic errors in SMOS sea surface salinity: a Bayesian approach, Remote Sensing of Environment, 214, 115-134, doi.org/10.1016/j.rse.2018.05.022

Boutin, J., N. Martin, **N., Kolodziejczyk**, G. Reverdin, 2016: Interannual anomalies of SMOS Sea Surface Salinity, Remote Sensing of Environment, doi:10.1016/j.rse.2016.02.053.

Boutin, J., Y. Chao, W.E. Asher, T. Delcroix, R. Drucker, K. Drushka, **N. Kolodziejczyk**, T. Lee, N. Reul, G. Reverdin, J. Schanze, A. Soloviev, L. Yu, J. Anderson, L. Brucker, E. Dinnat, A.S. Garcia, W. L. Jones, C. Maes, T. Meissner, W. Tang, N. Vinogradova, and B. Ward, 2016: Satellite and In Situ Salinity : Understanding Near-Surface Stratification and Sub-footprint Variability, Bulletin of American Meteorological Society, doi:10.1175/BAMS-D-15-00032.1.

Cabanes, C. , V. Thierry and C. Lagadec. Improvement of bias detection in Argo float conductivity sensors and its application in the North Atlantic, Deep-Sea Research Part I, 114, 128-136, 2016

Camara, I., **N. Kolodziejczyk**, Mignot, J., A. Lazar, Gaye, A. T., 2015 : On the seasonal variations of salinity of the tropical Atlantic mixed layer, Journal of Geophysical Research-Oceans, 120, 4441–4462, doi:10.1002/2015JC010865.

Capet, Roullet, Klein and **Maze**, 2016: Intensification of Upper-ocean submesoscale turbulence through Charney baroclinic instability. Journal of Physical Oceanography, doi: 10.1175/JPO-D-16-0050.1

Cazenave et al.: **WCRP global sea level budget group**, 2018: Global sea Level budget from 1993-present. Earth Syst. Sci. Data, 10, 1–41, doi.org/10.5194/essd-10-1-2018

Da-Allada, C. Y., J. Jouanno, F. Gaillard, **N. Kolodziejczyk**, C. Maes, N. Reul, and B. Bourlès, 2017: Importance of the Equatorial Undercurrent on the sea surface salinity in the eastern equatorial Atlantic in boreal spring, J. Geophys. Res. Oceans, 122, 521–538, doi:10.1002/2016JC012342.

Da-Allada, C. Y., F. Gaillard, and **N. Kolodziejczyk**, 2015 : Mixed-layer salinity budget in the tropical Indian Ocean: seasonal cycle based only from observations, Ocean Dynamics, 65(6), 845-857, doi: 10.1007/s10236-015-0837-7.

De Lavergne Casimir, Madec Gurvan, Capet Xavier, **Maze Guillaume**, Roquet Fabien (2016). Getting to the bottom of the ocean. Nature Geoscience, 9(12), 857-858. Publisher's official version : https://doi.org/10.1038/ngeo2850 , Open Access version : https://archimer.ifremer.fr/doc/00359/46988/

D'Ortenzio F., Lavigne H., Besson F., Claustre H., Coppola L., Garcia N., Laës-Huon A., Le Reste S., Malardé D., Migon C., Morin P., Mortier L., **Poteau A.**, Prieur L., Raimbault V., Testor P., (2014), "Observing mixed layer depth, nitrate and chlorophyll concentrations in the northwestern Mediterranean: A combined satellite and NO3 profiling floats experiment", Geophysical Research Letters 41: 6443-6451 | doi: 10.1002/2014gl061020.

Feucher Charlene, **Maze G.**, Mercier Herle (2019). Subtropical Mode Waters and Permanent Pycnocline properties in the World Ocean. Journal of Geophysical Research: Oceans IN PRESS. Publisher's official version : https://doi.org/10.1029/2018JC014526 , Open Access version : https://archimer.ifremer.fr/doc/00480/59176/

Feucher Charlene, **Maze G.**, Mercier Herle (2016). Mean structure of the North Atlantic subtropical permanent pycnocline from in-situ observations. Journal Of Atmospheric And Oceanic Technology, 33(6), 1285-1308. Publisher's official version : https://doi.org/10.1175/JTECH-D-15-0192.1 , Open Access version : https://archimer.ifremer.fr/doc/00326/43710/

Gaillard F., T. Reynaud, **V. Thierry, N. Kolodziejczyk**, K. von Schuckmann, 2016. In-situ based reanalysis of the global ocean temperature and salinity with ISAS: variability of the heat content and steric height. J. Climate, 29, 1305–1323. doi: http://dx.doi.org/10.1175/JCLI-D-15-0028.1

González-Pola, C., P. Fratantoni, K. M. Larsen, N. P. Holliday, S. Dye, K.-A. Mork, A. Beszczynska-Möller, H. Valdimarsson, A. Trofimov, H. Parner, H. Klein, B. Cisewski, A. Fontán, K. Lyons, **N. Kolodziejczyk**, R. Fernández-Graña, J. Linders, T. Wodzinowski, I. Goszczko, and C. Cusack, 2019 : The ICES Working Group on Oceanic Hydrography: A bridge from in-situ sampling to the remote autonomous observation era, Frontiers in Marine Science. doi: 10.3389/fmars.2019.00103.

Le Reste S., V. Dutreuil, X. André, **V. Thierry**, C. Renaut, P.-Y. Le Traon, **G. Maze**, 2016 «Deep-Arvor » : A new profiling float to extend the Argo observations down to 4000m depth. Journal of Atmospheric and Oceanic Technology, 23, 1039-1055. http://doi.org/10.1175/JTECH-D-15-0214.1

Kolodziejczyk, **N**., P. Testor, A. Lazar, V. Echevin, G. Krahman, S. Faye, M. Wade, P. Estrade, X. Capet, P. Brehmer, Florian Schütte and Johannes Karstensen, 2018: Fine scale structure of an Anticyclonic eddy off Cape Verde observed from Glider, Journal of Geophysical Research, 123, doi.org/10.1029/2018JC014135

Kolodziejczyk, N., J. Boutin, J.-L. Vergely, S. Marchand, N. Martin, and G. Reverdin, 2016: Mitigation of systematic errors in SMOS sea surface salinity, Remote Sensing of Environment, doi:10.1016/j.rse.2016.02.061.

Kolodziejczyk, N., G. Reverdin, J. Boutin, and O. Hernandez, 2015 : Observation of the surface horizontal thermohaline variability at meso- to submesoscales in the North-Eastern Subtropical Atlantic Ocean, Journal of Geophysical Research-Oceans,120 , doi:10.1002/2014JC010455.

Kolodziejczyk, N., G. Reverdin, and A. Lazar, 2015 : Interannual variability of the mixed layer winter convection and spiciness generation in the Eastern Subtropical North Atlantic, Journal of Physical Oceanography, 45(2), 504-525. doi:10.1175/JPO-D-14-0042.1.

Kolodziejczyk, N., O. Hernandez, J. Boutin, and G. Reverdin, 2015 : SMOS salinity in the subtropical north Atlantic salinity maximum : 2. Bi-dimensional horizontal thermohaline variability, Journal of Geophysical Research-Ocean, SMOS/Aquarius Special issue, 120, 972–987, doi: 10.1002/2014JC010103.

Kounta., L., X. Capet, J. Jouanno, **N. Kolodziejczyk**, B. Sow, and A. T. Gaye, 2018: A model perspective on the dynamics of the shadow zone of the eastern tropical North Atlantic. Part 1: the poleward slope

currents along West Africa. Ocean Science, 14, 971–997, doi.org/10.5194/os-14-971-2018

Maze G., Mercier Herle, Fablet Ronan, Tandeo Pierre, Radcenco Manuel Lopez, Lenca Philippe, Feucher Charlene, Le Goff Clement (2017a). Coherent heat patterns revealed by unsupervised classification of Argo temperature profiles in the North Atlantic Ocean. Progress In Oceanography, 151, 275-292. Publisher's official version : https://doi.org/10.1016/j.pocean.2016.12.008 , Open Access version : https://archimer.ifremer.fr/doc/00363/47431/

Organelli, E., Barbieux, M., Claustre, H., **Schmechtig,** C., **Poteau, A.**, Bricaud, A., Boss, E., Briggs, N., Dall'Olmo, G., **D'Ortenzio F**., Leymarie, E., Mangin, A., Obolensky, G., Penkerc'h, C., Prieur, L., Roesler, C., Serra, R., Uitz, J. and X. Xing (2017). "Two databases derived from BGC-Argo float measurements for biogeochemical and bio-optical applications at the global scale." Sous press sur Earth System Science Data.

Penduff Thierry, Serazin Guillaume, Leroux Stephanie, Close Sally, Molines Jean-Marc, Barnier Bernard, Bessieres Laurent, Terray Laurent, **Maze Guillaume** (2018). Chaotic Variability of Ocean: Heat Content Climate-Relevant Features and Observational Implications. Oceanography, 31(2), 63-71. Publisher's official version : https://doi.org/10.5670/oceanog.2018.210 , Open Access version : https://archimer.ifremer.fr/doc/00448/55959/

Piron, A., **V. Thierry**, H. Mercier, and G. Caniaux (2017), Gyre-scale deep convection in the subpolar North Atlantic Ocean during winter 2014–2015, Geophys. Res. Lett., 44, 1439–1447, doi:10.1002/2016GL071895.

Piron A., **V. Thierry**, H. Mercier and G. Caniaux, 2016: Observation of basin-scale deep convection in the Irminger Sea with Argo floats in the 2011-2012 winter, Deep-Sea Research Part I, 109, 76-90, doi: 10.1016/j.dsr.2015.12.012

Poteau, A, Boss E, Claustre H (2017) Particulate concentration and seasonal dynamics in the mesopelagic ocean based on the backscattering coefficient measured with Biogeochemical-Argo floats. Geophys Res Lett | doi: 10.1002/2017GL073949.

Racapé, V. , **V. Thierry,** H. Mercier and **C. Cabanes**, ISOW spreading and mixing as revealed by Deep-Argo floats launched in the Charlie Gibbs Fracture Zone. Submitted to JGR.

Reverdin, G, S. Morisset, L. Marié, D. Bourras, G. Sutherland, B. Ward, J. Salvador, J. Font, Y. Cuypers, L. Centurioni, V. Hormann, **N. Kolodziejczyk**, J. Boutin, F. D'Ovidio, F. Nencioli, N. Martin, F. Diverres, G. Alory, and R. Lumpkin, 2015: Meso-scales, fronts and mixing in the stratified surface ocean during the STRASSE/SPURS summer 2012 cruises, Oceanography, 28(1):84–93, doi:10.5670/oceanog.2015.09.

Roemmich **et al**., 2019: On the future of Argo : An enhanced global array of physical and biogeochemical sensing floats. in revision in Frontiers in Marine Science. in review.

Roesler, C., Uitz, J., Claustre, H., Boss, E., Xing, X., Organelli, E., Briggs, N., Bricaud, A., **Schmechtig, C., Poteau, A**., **D'Ortenzio F.,** Ras, J., Drapeau, S., Haëntjens, N. and Barbieux, M. (2017), "Recommendations for obtaining unbiased chlorophyll estimates from in situ chlorophyll fluorometers: A global analysis of WET Labs ECO sensors". Limnology Oceanography: Methods, 15: 572–585. doi:10.1002/lom3.10185.

Roullet Guillaume, Capet Xavier, **Maze Guillaume** (2014). Global Interior Eddy Available Potential Energy Diagnosed from Argo Floats. Geophysical Research Letters, 41(5), 1651-1656. Publisher's official version : https://doi.org/10.1002/2013GL059004 , Open Access version : https://archimer.ifremer.fr/doc/00175/28579/

Sauzede, R., Claustre H., Uitz J., Jamet C., Dall'Olmo G., **D'Ortenzio, F.**, Gentili B., **Poteau A., Schmechtig C**., (2016), « A neural network-based method for merging ocean color and Argo data to extend surface bio-optical properties to depth: Retrieval of the particulate backscattering coefficient », Journal of Geophysical Research-Oceans, doi:10.1002/2015JC011408

Smith, S., G. Alory, A. Andersson, W. Asher, A. Baker, D. I. Berry, K. Drushka, D. Figurskey, E. Freeman, P. Holthus, T. Jickells, E. C. Kent, **N. Kolodziejczyk,** P. Poli, U. Schuster, E. Steventon, S. Swart, O. Tarasova, L. Petit de la Villéon, and Nadya Vinogradova-Shiffer, 2019: Ship Contributions to Global Ocean, Weather, and Climate Observing Systems, Frontiers in Marine Science. in review.

Sommer, A., G. Reverdin, **N. Kolodziejczyk**, J. Boutin, 2015:Sea surface salinity and temperature budgets in the North Atlantic subtropical gyre during SPURS experiment: August 2012-August 2013, Frontiers in Marine Science,2:107, doi: 10.3389/fmars.2015.00107.

Vinogradova, N., T. Lee, J. Boutin, K. Drushka, S. Fournier, R. Sabia, D. Stammer, E. Bayler, N. Reul, A. Gordon, O. Melnichenko, L. Li, E. Hackert, M. Martin, A. Hasson, **N. Kolodziejczyk** and E. Lindstrom, 2018: Satellite Salinity Observing System: Recent Discoveries and the Way Forward, accepted in Frontiers in Marine Science.

Xing, X, Claustre H., Boss E., Roesler C., Organelli E., **Poteau A.**, Barbieux M., **D'Ortenzio F.**, Qiu G. and H. Wang H., (2016), « Correction of in-situ chlorophyll fluorometry for contribution by dissolved organic matter », Limnology and Oceanography methods, 15 (1), 80-93

Conference

Feucher Charlene, **Maze Guillaume**, Mercier Herle (2016). Mean structure of the North Atlantic subtropical permanent pycnocline from in-situ observations. Ocean Sciences Meeting 2016, 21-26 February, New Orleans, Louisiana, USA. https://archimer.ifremer.fr/doc/00318/42870/

Feucher Charlene, **Maze Guillaume**, Mercier Herle (2015). A complex North Atlantic permanent pycnocline revealed by Argo data. EGU 2015 - European Geosciences Union General Assembly, 12-17 avril 2015, Vienne, Autriche. https://archimer.ifremer.fr/doc/00257/36818/

Kolodziejczyk, N., P. Testor, A. Lazar, V. Echevin, G. Krahman, S. Faye, M. Wade, P. Estrade, X. Capet, P. Brehmer, Florian Schütte and Johannes Karstensen, 2018: Fine scale structure of an Anticyclonic eddy off Cape Verde observed from Glider. EGU 2019, Vienna, Austria 7-12 April 2019.

Kolodziejczyk, **N**., W. Llovel, and E. Portela: internannula variability of the upper ocean water masses as inferred from Argo array. (Invited). 6th Argo Science Workshop. 22-24 October 2018, Tokyo.

Kolodziejczyk, N., W. Llovel, and E. Portela: internannula variability of the upper ocean water masses as inferred from Argo array. Ocean Science Meeting 2018, New Orleans, USA, 11-16 Feb. 2018

Kolodziejczyk, N., M. Hamon, J. Boutin, S. Marchand, J.-L. Vergely and G. Reverdin : A SMOS optimal interpolation, Journées du GMMC, USA, 21-23 jun. 2017

Kolodziejczyk, N., M. Hamon, J. Boutin, S. Marchand, J.-L. Vergely and G. Reverdin : A SMOS optimal interpolation, Global OCean Salinity and Freshwater workshop, USA, 22-26 May 2017.

Kolodziejczyk, N., C. Maes : Spatial and seasonal change of meso- to submesoscale surface thermohaline variability in Indian Ocean, Ocean Science Meeting, New-Orleans, USA, 21-26 February 2016.

Kolodziejczyk, N., G. Reverdin, F. Gaillard, and A. Lazar : Low-frequency thermohaline variability in the Subtropical South Atlantic pycnocline during 2002–2013 , Aquarius-SAMOC Meeting, Buenos Aires, Argentina, 23-26 Nov. 2015

Kolodziejczyk, N., G. Reverdin, F. Gaillard, and A. Lazar : Low-frequency thermohaline variability in the Subtropical South Atlantic pycnocline during 2002–2013 , EGU General Assembly, Vienne, Autriche, 13-17 Apr. 2015.

Kolodziejczyk, N., G. Reverdin, J. Boutin, and O. Hernandez :Observation of the surface horizontal thermohaline variability at meso- to submesoscales in the North-Eastern Subtropical Atlantic Ocean , EGU General Assembly, Vienne, Autriche, 13-17 Avril 2015.

Maze Guillaume, Cabanes Cecile, Lagadec Catherine, Tandeo Pierre, Perez Florent, Szekely Tanguy (2018). Machine Learning of Argo QC. ASW6 - 6th Argo Science Workshop "The Argo program in 2020 and beyond : Challenges and opportunities". October 22-24, 2018, Tokyo, Japan.

Maze Guillaume, Mercier Herlé, Feucher Charlène, Fablet Ronan, Lenca Philippe, Radcenco Manuel, Le Goff Clément (2016). Ocean heat content structure revealed by un-supervised classification of hydrographic profiles. 2016 Ocean Sciences Meeting. 21-26 Feb. 2016, New Orleans, Louisiana, USA.

Maze Guillaume, Mercier Herlé, Feucher Charlène, Fablet Ronan, Lenca Philippe, Radcenco Manuel, Tandeo Pierre, Le Goff Clément (2015). Using Gaussian Mixture Model to characterize the North Atlantic climatology and variability or Ocean heat content structure revealed by un-supervised classification of hydrographic profiles. 5th Euro-Argo User Meeting. 16-17 March 2015, Brest, France.

Maze Guillaume, Thierry Virginie (2014). International Strategy: Argo-Deep. 3rd NAOS annual meeting. 16-17 June 2014, Brest, France.

Maze Guillaume, Feucher Charlene, Mercier Herle, Dewar William (2018). Large-scale structure of the pycnocline stratification in subtropical gyres. 2018 Ocean Sciences Meeting. 11–16 February 2018, Portland, Oregon. https://archimer.ifremer.fr/doc/00435/54641/**Schmechtig C.** BioGeoChemical (BGC) Argo data management (Invited). 6th Argo Science Workshop. 22-24 October 2018, Tokyo.

Schmechtig C. French contribution to Bio-Argo float deployment as part of GO-SHIP and other cruises: implementation of good practices. GAIC 2015, GO-SHIP/Argo/IOCCP Conference 2015. Galway.

Thierry, V., V. Racapé, H. Mercier, **C. Cabanes,** ISOW spreading and mixing from the Charlie Gibbs Fracture Zone as revealed by Deep-Argo floats. ASW6 meeting, Tokyo (Japon), October 2018.

Thierry, .V, Piron A., H. Mercier and G. Caniaux, Argo float observations of basin-scale deep convection in the Irminger Sea during winter 2011-2012. Ocean Sciences meeting, New Orleans, Fevrier 2016.

Thierry V., Mercier H., **Maze G.**, Le Reste S., Dutreuil V., Andre X., Lenault Y., 2015: Deep-Arvor floats (4000m) : first results and future plans. GAIC2015 - "Sustained ocean observing for the next decade" A combined GO-SHIP/Argo/ IOCCP conference on physical and biogeochemical measurements of the water column. 14-18 September 2015, Galway, Ireland. http://archimer.ifremer.fr/doc/00281/39195/

Thierry, V., Euro-Argo Management Board, H. Mercier and G. Maze, European contributions to Deep Argo and scientific objectives. 1st meeting of the Scientific Advisory Group of the ERIC Euro-Argo. Brest, Avril 2017.

Documentation

Gallian, M., **V. Thierry** (2018). Delayed-mode quality control of dissolved oxygen concentration measured by ARGO floats in the North-Atlantic with LOCODOX - Floats deployed in 2012, 2014, 2015, 2016 and 2017 . https://doi.org/10.13155/58314

González-Pola, C., Larsen, K. M. H., Fratantoni, P., and Beszczynska-Möller, A. (Eds). 2018. ICES Report on Ocean Climate 2017. ICES Cooperative Research Report No. 345. 119 pp. http://doi.org/10.17895/ices.pub.4625

González-Pola, C., Larsen, K. M. H., Fratantoni, P., Beszczynska-Möller, A., and Hughes, S. L. (Eds). 2018. ICES Report on Ocean Climate 2016. ICES Cooperative Research Report No. 339. 110pp. https://doi.org/10.17895/ices.pub.4069

Larsen, K. M. H., Gonzalez-Pola, C., Fratantoni, P., Beszczynska-Möller, A., and Hughes, S. L. (Eds). 2016. ICES Report on Ocean Climate 2015. ICES Cooperative Research Report No. 331. 79 pp.

Kolodziejczyk Nicolas, Carval Thierry, Claustre Hervé, D'Ortenzio Fabrizio, Lebreton Nathanaele, Le Traon Pierre-Yves, Maze Guillaume, Poffa Noe, Pouliquen Sylvie, Poteau Antoine, Schmechtig Catherine, Thierry Virginie (2019). Stratégie nationale pour les déploiements d'opportunité des profileurs du réseau global Argo / National Strategy for Argo Global Network Profiling floats Deployments of Opportunity. Comité de pilotage Argo-France/Argo-France Steering Committee. AF-2019-DEP-STRAT. https://doi.org/10.13155/59297

Kolodziejczyk, N., J. Boutin, O. Hernandez, A. Sommer, G. Reverdin, S. Marchand, N. Martin,J.-L. Vergely, and X. Yin , Argo and SMOS SSS combination helps monitoring SSS variability from basin scale to mesoscale, Newsletter Mercator/Coriolis, May 2015.

Kolodziejczyk Nicolas, Gaillard Fabienne, Reverdin Gilles, Cariou T, Bozec Y, Morin Pascal (2017). Contribution to the ICES Working Group on Oceanic Hydrography. National report: France, April 2017.

Kolodziejczyk Nicolas, Reverdin Gilles, and D. Desbruyères (2018). Contribution to the ICES Working Group on Oceanic Hydrography. National report: France, June 2018.

Kolodziejczyk Nicolas, Gaillard Fabienne, Reverdin Gilles, Cariou T, Bozec Y, Morin Pascal (2017). Contribution to the ICES Working Group on Oceanic Hydrography. National report: France, April 2017. LOPS-WGOH-2017-01. http://archimer.ifremer.fr/doc/00391/50260/

Kolodziejczyk Nicolas, Gaillard Fabienne, Reverdin Gilles, Cariou T, Bozec Y, Morin Pascal (2016). Contribution to the ICES Working Group on Oceanic Hydrography. National report: France, June 2016.

Maze Guillaume, Cabanes Cecile, Carval Thierry, Coatanoan Christine, D'Ortenzio Fabrizio, Kolodziejczyk Nicolas, Lebreton Nathanaele, Le Traon Pierre-Yves, Poffa Noe, Pouliquen Sylvie, Thierry Virginie (2016). French National Report on Argo - 2015. Present status and future plans. LPO/16-01. https://archimer.ifremer.fr/doc/00318/42967/

Maze Guillaume, Cabanes Cécile, Carval Thierry, Coatanoan Christine, D'Ortenzio Fabrizio, Lebreton Nathanaelle, Le Reste Serge, Le Traon Pierre-Yves, Pouliquen Sylvie, Thierry Virginie (2015). French National Report on Argo - 2014. Present status and future plans. LPO-15-01. https://archimer.ifremer.fr/doc/00254/36504/

Maze Guillaume, Cabanes Cecile, Coatanoan Christine, D'Ortenzio Fabrizio, Lebreton Nathanaele, Le Reste Serge, Le Traon Pierre-Yves, Mamaca Emina, Pouliquen Sylvie, Thierry Virginie (2014). French National Report on Argo - 2013. Present status and future plans. LPO/14-02. https://archimer.ifremer.fr/doc/00180/29100/

Rannou Philippe, Carval Thierry, Fontaine Laure, Bernard Vincent, Coatanoan Christine (2018). Coriolis Argo floats data processing chain. SEANOE. https://doi.org/10.17882/45589

Scanderbeg M., J.-P. Rannou, J. Buck, C. Schmid, J. Gilson (2017). Argo DAC trajectory cookbook. https://doi.org/10.13155/29824

Schmechtig Catherine, Poteau Antoine, Claustre Hervé, **D'Ortenzio Fabrizio**, Dall'Olmo Giorgio, Boss Emmanuel (2018). Processing

Schmechtig C., Thierry V., The Bio Argo Team (2016). Argo quality control manual for biogeochemical data. https://doi.org/10.13155/40879

Schmechtig C., Claustre H., **Poteau A., D'Ortenzio F.,** 2018: Bio-Argo quality control manual for the Chlorophyll-A concentration. https://doi.org/10.13155/35385

Thierry V., Bittig H., The Argo-Bgc Team, 2018: Argo quality control manual for dissolved oxygen concentration . https://doi.org/10.13155/46542

Thierry V., Bittig H., Gilbert D., Kobayashi T., Kanako S., Schmid C., 2018: Processing Argo oxygen data at the DAC level . Bio-Argo particle backscattering at the DAC level. Argo data management. https://doi.org/10.13155/39459

Schmechtig Catherine, Claustre Herve, **Poteau Antoine, D'Ortenzio Fabrizio** (2018). Bio-Argo quality control manual for the Chlorophyll-A concentration. https://doi.org/10.13155/353

https://doi.org/10.13155/39795.**Thierry, V**., L. Coppola, C. Lagadec, G. Reverdin, H. Bittig (2017) A national working group on O2 data acquisition and processing, Mercator Ocean Journal, Special Issue with Coriolis, 55, 21-24

Thierry, V., H. Mercier and V. Racapé (2017) Implementation of an Argo-O2 array in the North-Atlantic Ocean, Mercator Ocean Journal, Special Issue with Coriolis, 55, 57-60

Wong Annie, Keeley Robert, Carval Thierry, Argo Data Management Team (2019). Argo Quality Control Manual for CTD and Trajectory Data. https://doi.org/10.13155/33951

Zilberman, N, **Maze G.** 2015. Report on the Deep Argo Implementation Workshop. Deep Argo Workshop. , Hobart, Tasmania.

Annexe B: Production scientifique des utilisateurs du SNO (publications de rang A, conférences, thèses)

Given the length of peer reviewed bibliography and Phd thesis list (more than 300 pages) the reader is invited to go on the following on-line links:

- The complete lists of the 3613 peer-reviewed articles and 305 PhD thesis to date, based or using Argo data, are available online at http://www.argo.ucsd.edu/Bibliography.html and http://www.argo.ucsd.edu/argo_thesis.html.
- The specific list of French peer-reviewed articles and PhD thesis are available on : http://www.argo-france.fr/publications.

Annexe C: lettres de soutien et d'engagement

Lettres de soutien et preuve d'appartenance:

1. Susan Wijffels (WHOI,USA, AST co-chair, Argo International program)
2. Mathieu Belbeoch (JCOMMOPS/IOC/UNESCO, Technical Coordinator, Argo International, program)
3. Sylvie Pouliquen (ADMT co-chair, Argo International program)
4. Sylvie Pouliquen (**preuve d'appartenance et engagement**, **TGIR Argo-France/Euro-Argo**)
5. Pierre-Yves le Traon (Mercator International)
6. Pierre-Yves le Traon (Coriolis)
7. Sylvie Pouliquen (Coriolis/**preuve d'appartenance ODATIS**)
8. Bernard Barnier (GMMC)
9. Gilles Reverdin & Sylvie Pouliquen (**preuve d'appartenance SOERE-CTDO2/futur IR OHIS**)
10. Bernard Bourlès (SNO PIRATA)
11. Gael Alory (SNO SSS)
12. Jacqueline Boutin(co-PI SMOS-ESA) & Nicolas Reul (co-PI SMOS-ESA)
13. Sophie Cravatte (PI TPOS2020)

Lettres d'engagement:

14. Frédéric Jean (Directeur IUEM/OSU IUEM) & Fabrice Ardhuin (Directeur UMR LOPS) + validation explicite de l'organigramme
15. Loïc Segalen (Directeur OSU Ecce Terra)
16. Rodolphe Lemée (Directeur UMR LOV) + validation explicite de l'organigramme
17. Elisabeth Christians (Directeur UMS IMEV) + validation explicite de l'organigramme

Annexe D : SNO stratégique pour les activités spatiales (5 pages maximum)

Les éléments attendus pour permettre l'évaluation de la pertinence pour le spatial sont les suivants :

- *Intérêt stratégique pour le spatial*
- *Bilan global RH / Financier / Scientifique des activités sur 2017 – 2019, en mettant en évidence la part spécifique (ressources / résultats) liée au spatial*
- *Travaux prévus pour 2020 - 2024, en insistant sur la contribution aux missions spatiales et les moyens mis en œuvre*
- *Description des données acquises et produits dérivés, incluant leur gestion/traitement/archivage (lien avec Aeris)*
- *Demande de soutien attendu de la part du CNES. Les dépenses éligibles à un soutien de CNES sont : les frais de mission, les consommables, petit matériel, publications… Les CDD ne sont pas éligibles.*

Ces éléments sont également à intégrer dans les différentes rubriques du document de réponse à l'appel à proposition de labellisation.

SNO Argo-France is strategic for space activities because it is one of the main sources of in situ surface data necessary for calibration / validation of satellite measurements. CNES does not directly found Argo activities but can participate through project financing (notably BGC and the purchase of floats, TOSCA SMOS OCEAN), but also through Coriolis consortium. For the BGC component, CNES contribute by financing 3-4 sensors/year, which are distributed by the GMMC LEFE commitee.The acquired data relevant for space are:

- surface salinity and SSS analysis for the SMOS mission,
- the temperature profile (sterile sea height for altimetry, eg CryoSat-2 mission),
- chlorophyll-a for all bio-optical products from satellite water color measurements (eg SeaWifs, Claustre et al., 2010b, IOCCG, 2011, 2015, Gerbi et al., 2016, Haëntjens et al ., 2017)

Argo data are used in the calibration/validation of satellite measurements of the sea surface temperature and salinity. Argo is the most reliable global in situ observation network of salinity. As such it is crucial to the cal/val of salinity measurements from space, like those of the SMOS mission. Since 2010, SMOS provides sea surface salinity validated with Argo data (e.g. *Boutin et al.*, 2013). Moreover, Argo data and ISAS SSS products are used in calibration reference in algorithm used to correct SMOS salinity bias and errors (*Kolodziejczyk et al*., 2016; *Boutin et al*., 2018).

Successful collaborations between Argo/BGC-Argo community and Ocean Color scientists have been achieved in the last years. Ocean Color space data could be considered the satellite equivalent of the altimetry for BGC-Argo. Consequently, space agencies (CNES, ESA, NASA) have already realized that, although not enough accurate to a real calibration of space sensors, BGC-Argo could provide a cost-efficient and global scale network to validate ocean color products. By continuously involving in BGC-Argo the national ocean color community, the SNO Argo France aims to a larger utilization of BGC-Argo national fleet and to the development of high level products, merging floats and ocean color data (as for example the 3DBGC product of the SNO Argo-France).

Additionally, the BGC-Argo floats distributed by the GMMC (which are acquired by a specific CNES funding) have specific aim to consolidate synergies between Argo and satellite ocean color observations.

Ocean color data and BGC-Argo observations are strongly complementary and, for this reason, they are considered crucial in the roadmaps of space agencies. This implies satellite Cal/Val activities (Val with the existing network, Cal with a specific type of BGC-Argo floats exclusively dedicated to calibration of space sensors; PROVAL CNES project), space/in situ data merging (to generate climatology and/or L3-L4 derived products, *Lavigne et al.* 2012), assimilation tests for operational biogeochemical models (*Cossarini et al.*, 2018).

Annexe E : SNO stratégique pour les activités polaires (8 pages maximum)

Précisions et compléments au dossier de labellisation

Tableau E1 : Cochez les sites concernés (en précisant si besoin dans la case commentaires)

Zone	*Sites*	*Opérations Été*	*Opérations Hiver*	*Commentaires*
Arctique				
Svalbard	Station AWIPEV			
Îles Subantarctiques				
Crozet	Station Alfred Faure			
	Sites isolés (préciser)			
Kerguelen	Station Port aux Français			
	Sites isolés (préciser)			
Amsterdam	Station Martin-de-Viviès			
	Sites isolés (préciser)			
Saint-Paul				
Antarctique				
Terre Adélie	Station Dumont d'Urville			
	Station Robert Guillard (Cap Prud'homme			
	Autre (préciser)			
Concordia				

Parties B1 à B7 et B10, B11 :

Les spécificités liées au volet polaire ou subpolaire des activités devront être clairement identifiées, au besoin dans des paragraphes dédiés (en particulier le contexte, les objectifs, les enjeux et les particularités méthodologiques, également dans les collaborations internationales et les insertions dans des dispositifs plus larges, nationaux, européens ou internationaux).

Partie B5. Données : Complément IPEV

Les données polaires ou subpolaires, de tous niveaux, sont-elles clairement identifiables dans la ou les base(s) de données ?	
☐ Oui	☐ Non
Si oui, précisez comment :	
Si elles sont identifiées à part et accessibles directement, indiquez le lien :	
Si non, est-il envisagé de les rendre clairement identifiables et dans le cas positif, à quelle échéance ? :	

Partie B7. RH : Complément IPEV[2]

Indiquer clairement dans la colonne « Rôle dans le SNO »), les personnels travaillant sur le volet polaire ou subpolaire et identifier ceux susceptibles d'aller sur le terrain.

[2] Notez que les soutiens pour la saison 2019-2020 antarctique/subantarctique et la saison arctique 2019 sont déjà validés pour l'IPEV. Considérez que dans votre demande, pour les soutiens IPEV la demande 2019 correspondra à ce qui soutiendra les activités terrain pour la saison 2020-2021 dans l'hémisphère sud et la saison 2020 en Arctique, la demande 2020 soutiendra la saison 2021-2022 dans l'hémisphère sud et la saison 2021 en Arctique, etc...

Tableau E2 : le dupliquer et le remplir pour chacun des sites indiqués au tableau E1

	Saison 2020-2021	***Saison 2021-2022***	***Saison 2022-2023***	***Saison 2023-2024***
Nombre de personnels des unités françaises en campagne d'été				
Nombre de collaborateurs étrangers en campagne d'été				
ETPT de personnels hivernants				
Besoins en personnel logistique IPEV (oui / non)				

Rappel :

Les personnels des unités françaises et les collaborateurs étrangers peuvent accéder au terrain en été. Tous les frais liés aux missions sont pris en charge pour les personnels des unités. Pour les collaborateurs étrangers, ne sont pas pris en charge :

- Vers les îles subantarctiques et l'Antarctique : les frais d'acheminement jusqu'au port ou aéroport d'embarquement pour les Stations (La Réunion pour les îles Subantarctiques et Hobart ou Christchurch pour l'Antarctique) ; ils sont hébergés et nourris sans frais sur les navires de desserte et sur site ;
- Vers la station AWIPEV en Arctique : les frais de transport et de repas (vol Longyearbyen- Ny-Ålesund et repas à régler à la Kings Bay, l'opérateur local) ; ils sont toutefois hébergés sans frais dans les bâtiments AWIPEV.

Partie B9. Budget : Complément IPEV[2] [3]

Identifier clairement les activités polaires ou subpolaires en utilisant la colonne commentaire pour préciser :

- Dans les ressources passées : celles obtenues via l'IPEV ou via un autre organisme et destinées aux activités polaires ou subpolaires (l'objectif étant d'avoir le panorama complet des origines du financement pour les activités dans ces régions) ;
- Dans les dépenses récurrentes passées : celles qui ont effectivement été dépensées pour tout ou partie sur les activités polaires ou subpolaires, qu'elles proviennent du soutien direct par l'IPEV ou par un autre organisme.

Dans le tableau de demande de soutien sur la période de la vague de labellisation, distinguer et identifier clairement les demandes de soutien à l'IPEV et celles faites auprès d'autres organismes, mais qui pourraient être destinées aux activités polaires ou subpolaires.

Attention : les **crédits demandés à l'IPEV** doivent être indiqués **TTC**

Tableau E3 : ventilation des demandes de soutien financier direct à l'IPEV

1) Investissement (immobilisation de valeur unitaire supérieure ou égale à 600 euros TTC), ajouter autant de lignes que nécessaire pour chaque saison

Désignation	***Quantité***	***Montant total TTC***	***Commentaire***
Saison 2020-2021			
Saison 2021-2022			

[3] La ventilation des demandes en personnels est demandée de manière à pré-positionner les moyens. Cependant, ces demandes devront précisées et ajustées dans les dossiers annuels de campagnes terrain/hivernage.

Saison 2022-2023			
Saison 2023-2024			

2) Fonctionnement (fournitures ou services n'ayant pas le caractère durable, donc appelés à être consommés dans l'année, matériels qualifiés de pièce détachée ou d'accessoires à une immobilisation, dont le montant est strictement inférieur à 600 euros TTC.), ajouter autant de lignes que nécessaire pour chaque saison.

Désignation	***Quantité***	***Montant total TTC***	***Commentaire***
Saison 2020-2021			
Saison 2021-2022			
Saison 2022-2023			
Saison 2023-2024			

Ces éléments sont également à intégrer dans les différentes rubriques du document de réponse à l'appel à proposition de labellisation.

Rappel :
L'IPEV n'étant pas une agence de financement de la recherche, mais un opérateur de terrain, les crédits qu'il attribue à un projet :

- Ne peuvent être utilisés que pour les opérations se déroulant sur le terrain ou à bord des navires ;
- Doivent impérativement être utilisés durant l'exercice concerné ;
- Leur gestion est assurée à l'IPEV (ils ne sont pas versés au laboratoire ou OSU porteur).

Notez par ailleurs que :

- Les engagements de dépenses sont réalisés à l'initiative du responsable du projet ;
- L'IPEV étant doté de l'autonomie administrative et financière, tous les équipements acquis sur crédits d'investissement IPEV sont inscrits aux immobilisations de l'IPEV.

Annexe F : 2015-2019 data management target table in 2015

Argo-France, 2019 target						
Product level	**L0**	**L1**	**L2**	**L3**	**L4**	**L5**
Description	**Raw** data transmitted by floats and decoded	**Profiles** Data Quality-controlled in near **real**-time	**Profiles** Data Quality-controlled in **delayed**-time	**Mapped** Data Quality-controlled in near **real**-time	**Mapped** Data Quality-controlled in **delayed**-time	**Oceanic indicators**
Core P/T/S	raw data, meta and tech.nc files	A-R mode prof.nc files	D-mode prof.nc files	ISAS-Coriolis	ISAS-SNO (Arivo)	GOIs-GMES
Displacements	raw data, meta and tech.nc files	Rtraj.nc files	Dtraj.nc files	Maps of absolute currents	Maps of absolute currents	WBC & NA-MOC index
Oxygen	raw data, meta and tech.nc files	A-R mode Bprof.nc files	D-mode Bprof.nc files	ISAS-Coriolis	ISAS-SNO	O2 content, OMZ
Chlorophyll-a	raw data, meta and tech.nc files	A-R mode Bprof.nc files	D-mode Bprof.nc files	ISAS-Coriolis	ISAS-SNO	Biomass basin scale long term evolution[1]
BBP	raw data, meta and tech.nc files	A-R mode Bprof.nc files	D-mode Bprof.nc files	ISAS-Coriolis	ISAS-SNO	Biomass basin scale long term evolution[1]
Nitrate	raw data, meta and tech.nc files	A-R mode Bprof.nc files	D-mode Bprof.nc files	ISAS-Coriolis	ISAS-SNO	Nitrate basin scale long term evolution[1]
Deep P/T/S	raw data, meta and tech.nc files	A-R mode prof.nc files	R&D	ISAS-Coriolis	ISAS-SNO	
Deep Oxygen	raw data, meta and tech.nc files	A-R mode prof.nc files	R&D	ISAS-Coriolis	ISAS-SNO	
Radiometry [2]	raw data, meta and tech.nc files	A-R mode Bprof.nc files	R&D	R&D	R&D	
pH [3]	raw data, meta and tech.nc files	A-R mode Bprof.nc files	R&D	R&D		

Status	**Definitions** (of product and QC procedures)
Achieved	The protocols and the methods are developed (i.e. published), implemented at DAC/GDAC level, and operational. International consensus.
Testing	The protocols and the methods are developed (i.e. published) and being implemented at DAC/GDAC level. International consensus on the methods is depending on tests (i.e. consolidation of consensus). Still in test phase to verify pertinence and performance.
R&D	The protocols and the methods are being developed (not published). No implementation at DAC/GDAC level. Discussions in the framework of the dedicated task teams (Argo-bio and Argo-deep)
10 years target	Technology is being developed. Methods not yet identified.