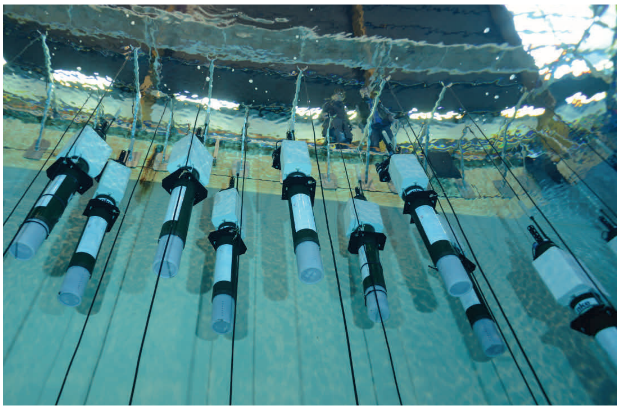
NAOS project
Special issue : Mid-Term Scientific Report

Newsletter n° 7 - February 2018



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Observation of the global ocean - Preparation for the new decade of Argo

Editorial

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Welcome to this special issue of the NAOS Newsletter.

This special issue provides an overview of NAOS activities and achievements since the start of the project in late 2011. NAOS reached major milestones in 2017. All the required equipments (float prototypes, float series) have been procured. All float prototypes have been successfully tested at sea.

The three scientific experiments are now well advanced and are already providing outstanding results. NAOS paves the way for the implementation of the Deep and BiogeoChemical extensions of the Argo international programme (see BGC Argo Box).

The project issued in mid 2017 its mid-term scientific report and was audited by an international panel (see Audition box). The international panel congratulated the team for its achievements which is a strong incentive for our future activities.

Enjoy reading this Newsletter !

Project objectives

Argo is an international array of more than 3800 profiling floats that measure temperature and salinity throughout the deep global oceans, down to 2,000 meters. Argo is the first-ever global, in-situ oceanobserving network in the history of oceanography, providing an essential complement to satellite systems, to understand the role of the ocean on the earth's climate and to predict the evolution of the ocean, weather and climate. Maintaining the full array over multi-decadal time scales, and extending its present capability is crucial both for climate studies and their environmental and social implications.

The objective of the NAOS project (www.naos-equipex.fr) is to consolidate and improve the French contribution to the international Argo program. France is leading the Euro-Argo research infrastructure that organizes and federates European contributions to Argo. Euro-Argo evolved in 2014 into a sustained long-term European organization and legal structure (Euro-Argo ERIC) that is hosted by France. NAOS is designed as a complement to Argo France and Euro-Argo ERIC.

The project has two main objectives:

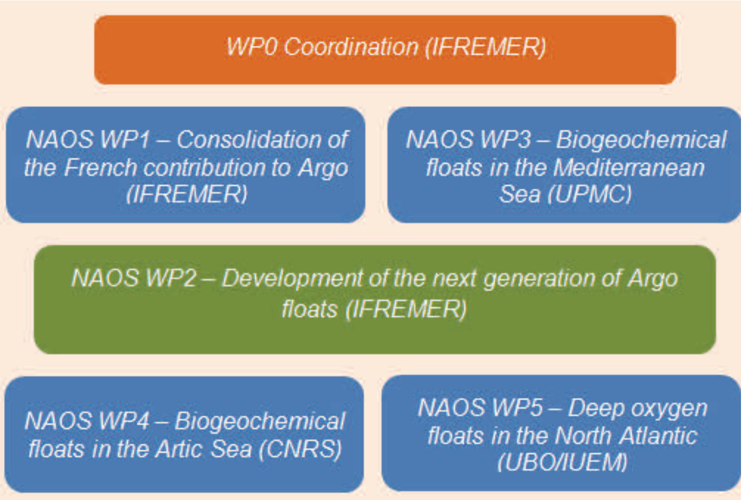
1. to consolidate the French contribution to the Argo international array deploying 10 to 15 additional floats per year from 2012 to 2019.
2. to develop and validate the next generation of Argo profiling floats. New float capabilities will include: improved performances, integration of biogeochemical sensors, deeper measurements (4000 m) and under-ice operations in the polar seas. New generation floats will be deployed in three pilot areas: Mediterranean, Arctic and North Atlantic.

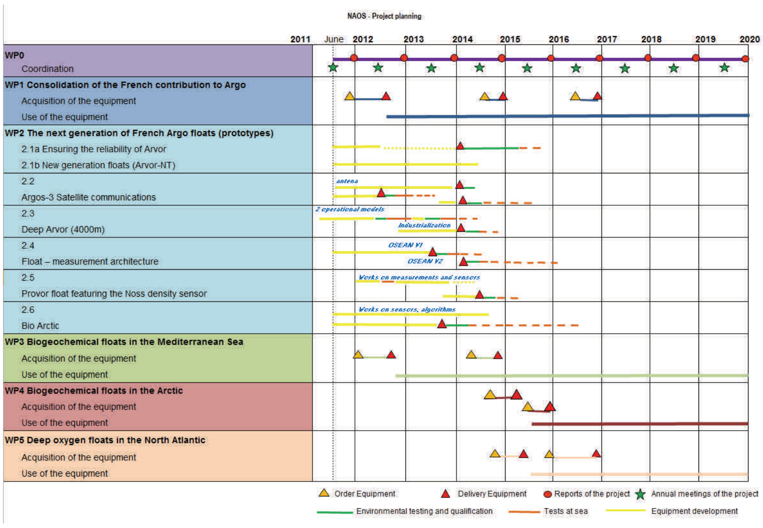
These innovative research and development activities are done in partnership between IFREMER (coordinator), UPMC (co-coordinator), CNRS (INSU), UBO/IUEM (UEB), SHOM, and two private companies: CLS for satellite telecommunication aspects and the NKE SME which is in charge of the industrialization and commercialization of French Argo floats.

The project is structured into 5 main workpackages:

- WP1: Consolidation of the French contribution to Argo (Lead: Ifremer).
- WP2: Development of the next generation of French Argo floats (Lead: Ifremer).
- WP3: Biogeochemical floats in the Mediterranean Sea (Lead: UPMC/LOV).
- WP4: Biogeochemical floats in the Arctic Sea (Lead: CNRS/UMI Takuvik).
- WP5: Deep oxygen floats in the North Atlantic (Lead: UBO/IUEM/LPO).

Project status





The development of different prototypes of French Argo floats have been completed (WP2). All prototypes have been successfully tested at sea. These R&D results have been transferred to our industrial partner (NKE) through license agreements. All industrial series of present and new generation Argo profiling floats (WP1, WP3, WP4 and WP5) have been ordered following open procurement rules and the deliveries have been validated following acceptance tests.

The scientific experiments (WP1, WP3, WP4 and WP5) are running very well (see below). French contribution to Argo mission has been significantly improved thanks to the deployment of more than 100 NAOS standard Argo profiling floats. Real time and delayed mode processing of NAOS floats is in place and all data are made available to the scientific community. Data management and quality control methods developed in the framework of NAOS have been proposed as new standards and accepted by the Argo international program. The scientific experiment with biogeochemical floats in the Mediterranean Sea started in 2012. Unique observations have been collected thanks to an excellent data return. Outstanding results have been obtained and new findings on biogeochemical cycles in the Mediterranean Sea have been revealed. Experiments in the Arctic (floats with biogeochemical sensors) and in the North Atlantic (deep floats with oxygen sensors) started in 2015 and are already showing promising results.

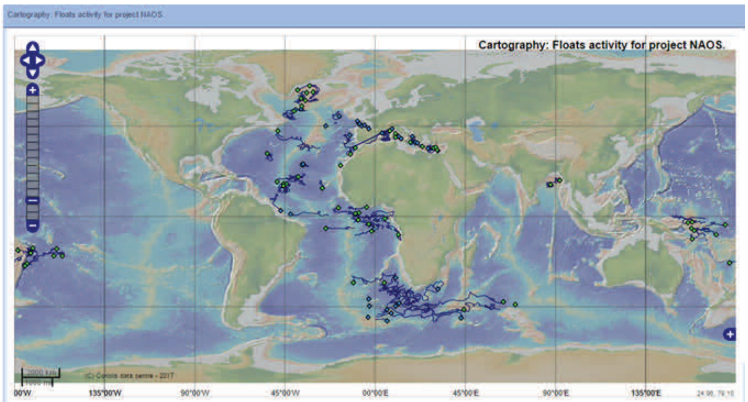
Data from the NAOS scientific experiments are made freely available to the scientific and operational communities following the open data policy of the Argo international programme. NAOS contributes to French Argo activities (TGIR Euro-Argo) and are fully integrated in the European (Euro-Argo ERIC) and international (Argo international) activities.

Overview of NAOS activities and achievements

WP1: Consolidation of the French contribution to Argo

Presently, the French contribution to Argo is of 65 floats per year. Ifremer contributes every year with about 50 floats while SHOM contributes with 15 floats. Through the Euro-Argo European Research Infrastructure (ERIC) agreements, France has proposed to augment its long term contribution from 65 to 80 floats per year (i.e. about 10% of the global effort) up to 2020. The floats purchased within WP1 contribute to increase the French contribution to Argo by 15 floats per year from 2012 to 2017.

Within NAOS WP1 67 floats have been purchased and deployed, 30 in 2012/2013 and 37 in 2014/2015. They are presently processed by the Coriolis Data Centre and provided to Argo international, to Copernicus Marine Service and more widely to the research community. These floats have been deployed in various oceans (see figure below): North and South Atlantic, Gulf of Guinea, South Pacific and Gulf of Bengal, either from scientific cruises (80%) or from opportunity vessels such as commercial ships, or sailing boats. These floats operate according to specification and have provided nearly 4000 profiles since 2012. In case of scientific deployments, floats have been assigned on the basis of a scientific evaluation, in the framework of the annual GMMC-INSU call for proposals (http://www.mercator-ocean.fr/en/science-publications/gmmc/). A new call for tender was issued in 2016 for the purchase of the last batch of floats (34 floats). As for the previous tenders, the tender was awarded to NKE. All floats have been delivered and went through acceptance test in Ifremer tank. They have been deployed in 2017.



Part of these floats is equipped with Iridium transmission and benefit from improvement carried out in WP2 (as for WP3, WP4 and WP5 floats). In 2017, thanks to the additional capabilities provided by downlink transmission, floats can now be configured with mission characteristics fitting with scientific experiment needs at the beginning of the mission and be configured in a standard Argo mission when the float leaves the area of interest after a few weeks.

Based on the expertise developed by Ifremer within NAOS, Ifremer also collaborates with the European Research Infrastructure Euro-Argo ERIC to set up a suite of tools that will allow an at sea-monitoring of the European Argo fleet and of the national Argo fleets. A first prototype has been available mid-2017.

All NAOS floats are now distributed in the new Argo format V3.1 developed by Argo International that allow the distribution of Iridium T&S floats as well as BioGeoChemical and Deep floats. The processing chain developed within NAOS has been upgraded and made available to the international community (http://dx.doi.org/10.17882/45589). This chain also implements the Argo recommendations for BioGeoChemical float processing in real-time.

WP2: Developing the next generation of French Argo floats

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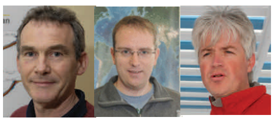


The objective of WP2 was to design, develop and test Argo float prototypes, in order to prepare the next generation of French Argo floats. Status for the different tasks of WP2 is given below.

T2.1- reliability and cost reduction of the "Arvor" float

The aim of this task was to maintain the industrial leading role of the manufacturer NKE, by improving many features of the standard Argo float (Arvor). The work focused on the reliability of the instrument design and manufacturing process, on the robustness of the float control algorithms, as well as on simplification of the operations carried out by users before deployments. Despite the difficulties to reduce costs while maintaining performance (e.g motorization, antenna), potential gains were identified (flat top plate, composite tube and buoyancy foam suppression) and significant cost reductions were obtained. After at sea validation of the prototypes in 2015, the "new" Arvor has been manufactured in series and 40 floats were successfully deployed in 2016.

Instrumentation developed as part of NAOS WP2

T2.2- Argos3 satellite communication on Argo floats

The purpose of this task was to assess the third generation of Argos satellite system to reduce energy and duration spent at surface for transmission of the profile data, as well as to be able to receive remote commands. The Arvor float was equipped with a transmitter and a specific antenna (bidirectional link), and the ascent time of the float was computed for synchronization with the satellite pass. Two modes of transmission were assessed: the high data rate was abandoned because of high variability in performance, sensitivity to radio noise, and complexity of implementation, whereas the interactive low data rate was successfully implemented and tested at sea: a few minutes are needed to transmit the data (instead of several hours in the Argos-2 mode), and the energy budget for transmission is divided by 5. However, the global efficiency remains limited when compared to the concurrent Iridium system. These results are described in a scientific publication (André et al, 2015).

T2.3- Deep Arvor

The Deep Arvor was developed to answer the need to monitor the deep oceans (below 2000m), for temperature, salinity and oxygen parameters. By diving, up to 150 times from surface to 4000 m depth, it covers more than 85% of the total ocean volume. The main design difficulties were to combine lightness and resistance to the pressure; this was solved by using carbon epoxy filament winding for the housing. Two prototypes were developed at Ifremer in 2011-2012 and tested at sea. Their technical file was then transferred to NKE in 2013 and two industrial prototypes were procured and deployed in 2014 (Geovide cruise in the North Atlantic). One float completed its cycles successfully before running out of battery power: 142 CTD cycles, of which 60 featured oxygen measurements at a depth varying between 3500 and 4000m. The first industrial floats (WP5) were then successfully tested at sea in 2015 (RREX cruise) and then in 2016 (BOCATS cruise). The Deep Arvor is now available for sale. A few improvements still need to be addressed (motorization and salinity sensors) for a better reproducibility of performances. Deep Arvor development and tests are described in a scientific publication (Le Reste et al, 2016).

T2.4 - Electronic architecture

This task consisted in the re-design of the electronic architecture of the Provor profiling float (which is the NKE float model used for WP3 and WP3 NAOS BioGeoChemical floats). This new Provor (5th generation) float is dedicated to embed several additional sensors for biogeochemical studies. Its architecture is based on the association of two electronic boards: one is used to control the float motion and satellite communication, the second one controls the sensors, compute the data and is able to ask the first board to modify the float motion, depending on results of sensor computations. This architecture demonstrated its good behavior during tests in the Mediterranean Sea. The modularity of the concept has been confirmed by the development of new sensor applications (ocean color satellite data validation, passive acoustics, and ice detection, see also Task 2.6).

T2.5 - Density measurement

In 2013, the NOSS (NKE Optical Salinity Sensor) was re-designed by NKE to be used on an Argo profiling float. By measuring the deviation of an in-situ laser beam, the principle is to compute the density and the absolute salinity of sea water. After their successful calibration (SHOM) and their hyperbaric pressure tests (Ifremer), two Provor floats were adapted in 2014 to embed the NOSS in order to compare their measurements with reference salinity sensors (Seabird CTD). The two floats were deployed in 2015 for a week experiment in Mediterranean Sea, and recovered for post calibration. This experiment demonstrated that the sensor is able to provide good quality salinity data with salinity bias < = 0.02 g/kg, that is the order of magnitude of known salinity anomalies in this area.

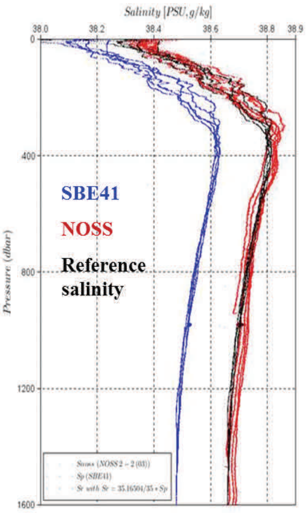
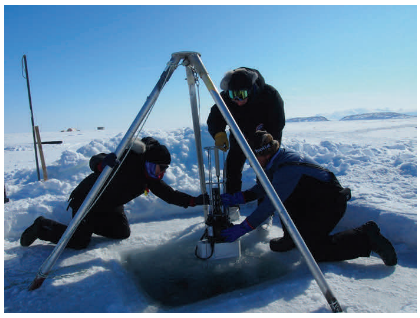


Figure 1: The NOSS sensor has shown good raw data results during its first deployement at sea. Work remains to be done on the salinity estimation.

T2.6 - BioGeoChemical float for Arctic areas

The "Pro-Ice" profiling float results from the joint work of NKE, LOV and Takuvik, and is based on task 2.4 results. It is a Provor float that is fitted with an ice sensing algorithm (ISA) adapted for Arctic areas (Baffin Bay) and able to dive again after ice detection; data are then memorized and their transmission postponed to a date when the surface is free of ice. Additionally, an inverted altimeter is combined to the ISA to detect echoes from possible icebergs. Before its operational deployment, the Pro-Ice float was first tested in Mediterranean Sea. It was further tested with a set of biogeochemical sensors in real cold conditions in a lake in Quebec, and finally tested at sea in 2015. This first operational deployment demonstrated that some software adjustments were required. In 2016 five operational floats were deployed following by seven floats in 2017. Despite two sensors failure and grounding issues, they show a good behavior and provide a unique dataset (see WP4).

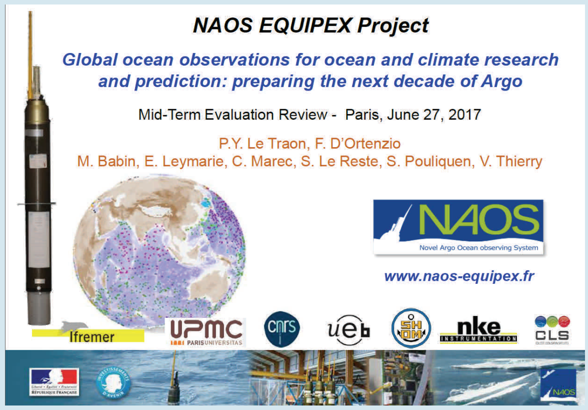


Deployment in cold and Icy condition in captive mode. © Claudie Marec

Outcomes of the audition by an international jury

NAOS, as all Equipex projects, was audited by an international jury in mid 2017. The mid term scientific report was evaluated and a formal presentation was made in front of the jury. The jury was impressed by NAOS achievements and congratulated the whole team. A few quotations from their report is given below:

- *"NAOS reached fully the initial targets of the project in an excellently organized project".*
- *"The French Argo program and the creative solutions of the technical problems developed by NAOS that led to the tremendous improvement of the floats and their capabilities needs to be preserved and continued in the future"*
- *"One of the major strengths of the project is the excellent efficient, logistical, and organisational management, and the close collaboration between the science institutions and industry"*
- *"The review panel is impressed by the technical progress"*
- *"The technical improvements and new developments of NAOS fit very closely with the future international Argo goals, of which NAOS and the French Argo program will be one of the main players. To be thus embedded and being part of the international Argo is one of the strong points of the NAOS project. NAOS acted proactively to secure funds for the future part of the French Argo program"*



WP3: Biogeochemical floats in the Mediterranean Sea

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The NAOS WP3 is dedicated to the design and the implementation of a BioGeoChemical (BGC) Argo pilot network at the scale of the Mediterranean basin. Guidelines for a BGC Argo pilot project have been identified during the OceanObs09 conference (Claustre et al. 2010) and have been recently confirmed (by using also NAOS results) by Johnson and Claustre (2016). The NAOS BGC Argo floats are the biogeochemical version of Argo floats. They are systematically equipped of Chlorophyll and Colored Dissolved Organic Matter fluorimeters, a backscatterometer, and irradiance (at 3 wavelengths) and PAR sensors.

More than a half of the NAOS WP3 floats were also equipped of Oxygen and Nitrate concentrations sensors. WP3 NAOS BGC floats are derived from the prototype (based on the NKE Provor CTS-4 model) developed in the framework of the remOcean ERC project (PI H. Claustre) and the Previmer project (Ifremer, Funding from the Brittany region CPER project). At the beginning of the NAOS project, the BGC remOcean floats were fully operational (i.e. no more technological tests were required).

WP3 floats have been deployed in Mediterranean following two consecutive waves (in 2012 and 2015): the first wave from different research vessels (in collaboration with the involved teams), the second wave by a dedicated cruise (BioArgoMed, PI F. D'Ortenzio). Overall, 28 floats have been acquired, 22 deployed and 11 still operational (in March 2017). During the second wave deployment cruise, 4 floats have been recovered and have been reconditioned. The 8 remaining floats will be then deployed during a third wave (in July 2018), which was not planned at the beginning of NAOS. A roadmap for the deployments in the Mediterranean (i.e. sampling strategies, focused regions) was defined by an international panel specifically devoted to this task (https://goo.gl/XA5d8s).

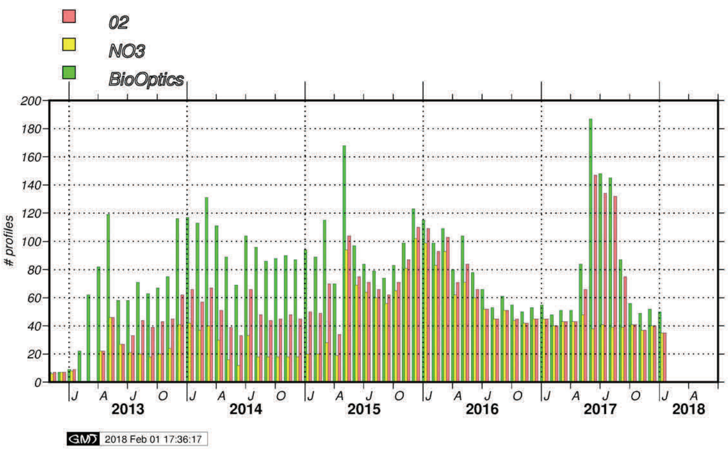

Figure 2: NAOS Med # Profiles by month.

Thanks to an excellent data return, almost 4000 biogeochemical profiles have been acquired during the period 2012-2017, which makes the Mediterranean Sea the basin with the highest density of autonomously acquired biogeochemical profiles (Johnson and Claustre, 2016). At the beginning of NAOS, the protocols and the methods for the Quality Control (QC) of BGC parameters were not identified. The WP3 NAOS contributed to this activity: for the chlorophyll (Mignot et al. 2014, Lavigne et al. 2015; Sauzed et al. 2015), nutrients (Pasqueron de Fommervault, 2015a,b,c), backscattering (Schmechtig et al. 2016), oxygen (Thierry et al. 2016) and irradiance (Organelli et al. 2016) parameters. Additionally, a web-based QC interface has been developed (by ACRI-ST) and available in free access to all the BGC users (www.seasiderendezvous.com).

The scientific objectives of NAOS WP3 (i.e. the confirmation and interpretation of satellite derived bioregions in the Mediterranean basin) have been addressed in several papers published using NAOS observations: in the NorthWestern area of the basin (D'Ortenzio et al. 2015; Pasqueron de Fommervault et al. 2015b, Houpert et al. 2017) and in the whole Mediterranean (Lavigne et al. 2013; Lavigne et al. 2015, Pasqueron de Fommervault et al. 2015c; Mayot et al. 2016).

The NAOS WP3 data contributed to the "Chantier Mediterranée" activity of the INSU-CNRS, in particular during the DEWEX cruises (NAOS data are used in 8 papers submitted to a JGR special edition planned for end 2017).

WP4 : Biogeochemical floats in the Arctic

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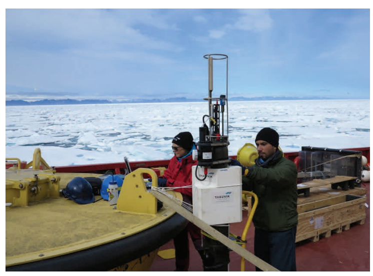
Progress made with regard to ice detection (in connection with WP2.6)

WP4 is dedicated to the deployment of biogeochemical Provor floats in the Arctic Ocean (Pro-Ice) to study the dynamics of ice-edge spring phytoplankton blooms and to specify sources of nutrients. The selected study area is the Baffin Bay where spring blooms occur systematically.
At the beginning of the NAOS project, WP4 activities were carried out in interaction with WP2 and were dedicated to the implementation of selected sea-ice detection techniques in the floats to prevent them to surface in case of ice cover. A white paper about the various techniques of sea-ice detection was written. The selected technique for the Pro-Ice floats is to combine: a reversed altimeter (active acoustics), an Ice Sensing Algorithm (ISA) (based on sea-water freezing temperature) and an optical sensor. The work of Takuvik focused mainly on the detection of ice using ISA and optical detection methods. For ISA, Takuvik collected a considerable amount of CTD data and ice concentration data correlated with these profiles to adapt the temperature algorithm (ISA) to the Baffin Bay. In the meantime, the Takuvik team was leading the development of the optical sensor for ice-detection (depolarizing signature of sea-ice). Optical ice detection uses the light depolarizing properties of sea ice. The first miniaturized prototype was tested in May 2014 under the floe at Qikiqtarjuaq (Nunavut). It has enabled us to discriminate between different layers of ice. In 2015, new trials of the optical detection were conducted at Qikiqtarjuaq, during the GreenEdge ice-camp as well as tests of a Pro-Ice float equipped with sensors in very cold conditions.

Baffin Bay represents navigational challenges for floats in terms of bathymetry, ice cover and circulation. Simulations of trajectories, combined with observations from ice charts (climatology and real time charts) are necessary to ensure the safe running of the deployment.



J.Lagunas and C.Marec onboard CCGS Amundsen July 2017: Preparing the ProIce for deployment

In 2016, Pro-Ice floats were deployed as part of the GreenEdge project with Marcel Babin as PI. The project consisted of two ice floe expeditions lasting four months in 2015 and in 2016 and a 42-day campaign on the icebreaker Amundsen in the summer of 2016 (June 3rd – July 14th) in Baffin Bay. During this mission 5 Pro-Ice floats were deployed (4 in Baffin Bay and 1 in the Labrador Sea).

The NAOS Pro-Ice floats, deployed in Baffin Bay, are the biogeochemical version of Argo floats dedicated to Arctic navigation. They are equipped with Chlorophyll and Colored Dissolved Organic Matter fluorimeters, a backscatterometer, a dissolved oxygen sensor, an irradiance (at 3 wavelengths) and PAR sensors. 2 out of 4 floats are equipped with a Nitrates sensor.

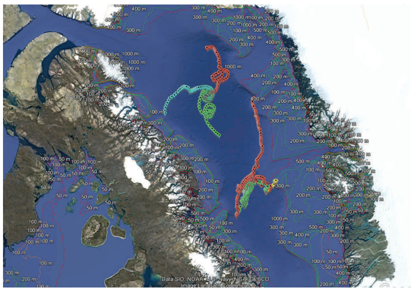


Figure 3: Trajectories of 7 floats deployed in July 2017 from the dropping zone to their winter descent on early November 2017

The ISA algorithm and the inverted altimeter are used to detect the ice and postpone their surfacing. One float is equipped with the optical sea-ice detector developed by Takuvik. The floats register profiles from depths of between 0 and 1000m. In winter months, they only rise to 15m below the ice due to ice cover.

This is the 1rst time that such a set of data is collected in the Arctic Ocean. The data will allow an optimal definition of the environmental conditions of phytoplankton blooms.

The fleet of Pro-Ice is composed of 20 floats: 11 funded by NAOS and 9 funded by FCI (Canadian Contribution to the project). 2 floats were deployed in 2015 (unfortunately lost), 4 were deployed in Baffin Bay in 2016 +1 (as a prototype on behalf of WP2.6) in Labrador Sea, 7 floats were deployed in Summer 2017. There are 7 more floats to be deployed by 2018.

WP5: Deep oxygen floats in the North Atlantic

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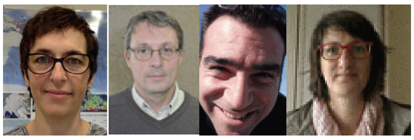

Due to the limited observational data, the deep ocean (below 2000 m) remains largely unknown to this day. Questions have been raised regarding mean circulation in deep water (Daniault et al. 2016) and its variability, on the interannual, decadal, and long term variability of deep water masses, on their role in storing ocean heat and in the sea level rise, and more generally on the role of ocean dynamics in the propagation of climatic anomalies. In order to answer these questions, the Argo program has been supporting the development of a Deep Argo component (Riser et al. 2016).

The objectives of WP5 are to demonstrate the feasibility of measuring high-quality data from Argo floats at depths greater than 2000 m, to study the ventilation of the ocean as well as the formation and evolution of intermediate and deep waters in the subpolar gyre and to contribute to the extension of the Argo network toward the deep ocean. To achieve those objectives, WP5 aims at deploying 23 Deep-Arvor floats (0-4000m) equipped with oxygen sensor in the North-Atlantic Ocean. In preparation for the deployment of those floats, an engineer was hired during 18 months to establish, in close interaction with WP2, the Deep-Arvor pre-deployment validation procedure. This pre-deployment validation procedure details the tests to be performed on the float prior to deployment in order to minimize the risk of float failure after deployment. A dedicated software was developed to facilitate float programming and to facilitate report on acceptance tests in downloading results of the tests on a dedicated computer and summarizing them in a pdf file.

In parallel, we wrote and maintained up to date the manual describing the oxygen data management processing (Thierry et al, 2016a) and we established the real-time and delayed mode quality control procedure for oxygen data acquired by Argo floats (Thierry et al, 2016b, Schmechtig et al., 2016). Those procedures take into account results from recent R&D activities on the behavior of the optical sensors equipping Argo floats (Bittig and Kortzinger, 2015; Bittig et al., 2015; Bittig et al, 2016a,b). They are implemented in the Argo Data Centers. We also developed, through subcontract with the Altran company, the LOCODOX software to correct Argo-oxygen data from any sensor bias and drift. The correction is done either by comparison with in situ reference data following Takeshita et al. (2013) or with in air measurements following Bittig and Kortzinger (2015). This software has been used to correct oxygen data from Deep-Argo floats as well as from Argo-O_2 floats (0-2000m), deployed in the North Atlantic by the LOPS since 2011. Those data are available in the Argo database and some of them have been used to investigate deep convection in the North-Atlantic Ocean during winter 2011- 2012 and 2014-2015 (Piron et al. 2016 ; Piron et al. 2017). In collaboration with WP2, we analyzed data from the first four prototypes of Deep-Arvor floats deployed in 2012 and 2014 (Le Reste et al, 2016). Comparing the salinity data of those floats with a reference CTD data revealed an underestimation of the salinity of about 0.01 and 0.02 psu, which was not pressure dependent. Further investigations revealed that such bias is also observed on regular (0-2000m) Argo floats. Understanding the bias origin is currently discussed at international level. Deep-Argo data also revealed that sampling with standard Argo floats (0-2000m) the highly variable intermediate layers hinders the detection of bias with this amplitude . Those results highlight the importance of extending the measurements beyond 2000m in order to improve the quality of the salinity data. After correcting the salinity measurements with historical measurements, the θ/S diagrams match perfectly the reference CTD data taken during deployment, demonstrating the high degree of reliability of the Deep-Arvor measurements.

The strategy behind the deployment of the 23 Deep-Arvor floats within WP5 is part of a long-term plan for setting up a Deep-Argo network in the subpolar gyre, which is carried out in close cooperation with the OVIDE and RREX projects. The ability to set up this network swiftly is essential as this area is subject to a strong interannual and decadal variability, and detecting long-term trends requires extended time series. The first decade of the 21st century saw weak convective periods and a rather warm, salty gyre whereas the subpolar gyre is currently in the process of becoming colder with more intense convective periods similar to those observed at the beginning of the 90s (Piron et al. 2016; Piron et al. 2017). Setting up a network of Deep-Argo floats will enable us to understand and define these changes and to monitor how anomalies develop and are transported by the lower branch of the Meridional Overturning Circulation (MOC). Eleven Deep-Arvor floats were already deployed in deep water veins (ISOW, DWBC) of the lower branch of the MOC during the RREX and BOCATS/OVIDE surveys in 2015, 2016 and 2017. Owing to a programming with a 2-day cycle, one float realized 144 cycles revealing excellent performances, whereas most of the other floats are coping successfully with frequent grounding on the seafloor. These groundings are inevitable in this area due to the highly irregular topography. They are also essential in order to reach dense water masses that are often located close to the seabed. Analyses of their data are on-going by V. Racapé (post-doc co-funded by AtlantOS and Ifremer). Results from the three Deep-Argo floats deployed in 2015 in the Charlie Gibbs Fracture Zone (CGFZ) are unforeseen. None of these floats circulated northward in the Irminger basin as expected. On the contrary, they initially moved westward in the deep pathways dominated by the ISOW (Figure 4). The float data analysis also reveals the influence of the surface circulation in shaping the deep circulation.

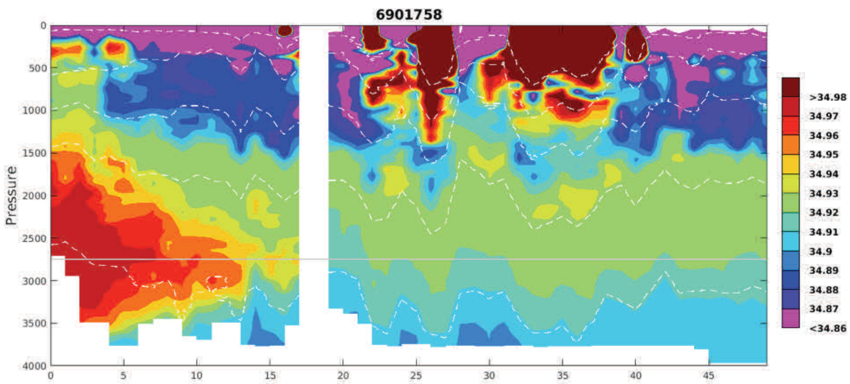

Figure : Salinity measured by a Deep Arvor float along its trajectory (from cycle 1 to 49). The horizontal grey line indicates the pressure of the float drift (2750 dbar).

The remaining floats will be deployed this year as part of the OVIDE2018 surveys. These floats will be deployed again in the deep water veins of the lower branch of the MOC, and, if possible, in the convection zone in the Labrador Sea (in collaboration with I. Yashayaev).

NAOS paves the way to the future BGC Argo design

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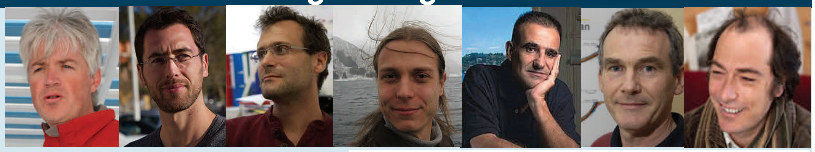
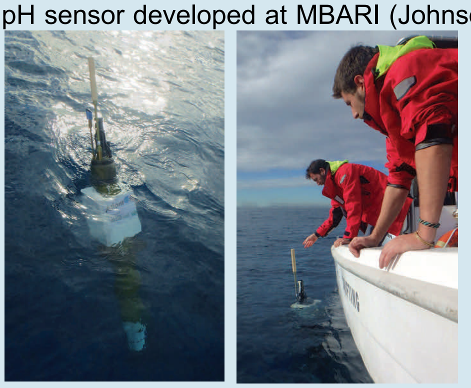


Thanks to several projects, but in particular through work packages 3 and 4 of NAOS, Argo floats have progressively been used to monitor additional properties, relevant for biogeochemical and bio-optical studies. An outcome of this evolution is the Biogeochemical Argo (BGC-Argo) program, launched in 2016, recommending the global implementation of 1000 floats measuring six core variables in addition of the CTD (K. Johnson and H. Claustre, 2016). These recommended variables are: Oxygen, Nitrate, pH, Chlorophyll a, Suspended particles and downward Irradiance. Floats used on work packages 3 and 4 of NAOS were able to measure all these variables except pH for which a sensor has been recently developed.

The new Provor CTS5 developed within the task 2.4 of NAOS has been used to setup the first BGC-Argo float able to implement all required variables on the same float. In addition of the five variables already measured, this new float implement the pH sensor developed at MBARI (Johnson et al., 2016) and commercialized by Sea-Bird Scientific (Float Deep SeaFET). This work has been realized in the context of the AtlantOS project. It includes a modification of the mechanical design of the float tape (included hyperbaric testing) and a modification of the sensor's electronic and float embedded software. The float has been deployed on 5th December 2017 out of Nice (DYFAMED) and the new pH sensor works as expected.



Deployment of the BGC-Argo float on 5th December out of Nice.

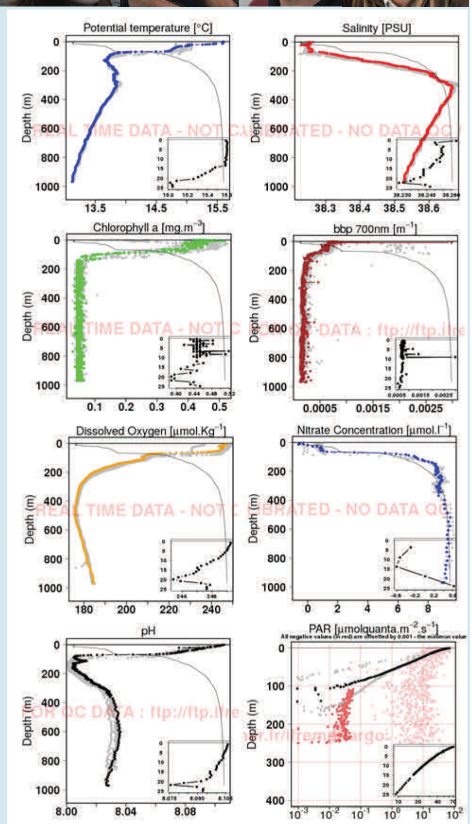


Figure 5: Different variables (CTD, Oxygen, Nitrate, pH, Chlorophyll a) mesured by the BGC-Argo float.

Main publications from the project

- Andre X., B. Moreau, S. Le Reste (2015). Argos-3 Satellite Communication System: Implementation on the Arvor Oceanographic Profiling Floats . Journal Of Atmospheric And Oceanic Technology , doi:10.1175/JTECH-D-14-00219.1.
- Le Reste S., Dutreuil V., André X., Thierry V., Renaut C., Le Traon P.Y., Maze G. (2016), Deep-Arvor: A New Profiling Float to Extend the Argo Observations Down to 4000-m Depth, Journal of Atmospheric and Oceanic technology doi:10.1175/JTECH-D-15-0214.1.
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- Lavigne, H. D'Ortenzio, F., Migon, C., Claustre, H., Testor, P., Ribera d'Alcalà, M., Lavezza, R., Houpert, L. and L. Prieur (2013). Enhancing the comprehension of mixed layer depth control on the Mediterranean phytoplankton phenology, Journal of Geophysical Research, Vol. 118, Issue 7, P. 3416–3430, doi:10.1002/jgrc.20251.
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- Mayot, N., D'Ortenzio, F., Taillandier, V., Prieur, L., Pasqueron de Fommervault, O., Claustre, H., Bosse, A., Testor, P. & P. Conan (2017), Physical and Biogeochemical Controls of the Phytoplankton Blooms in North Western Mediterranean Sea: A Multiplatform Approach Over a Complete Annual Cycle (2012–2013 DEWEX Experiment) . Journal of Geophysical Research, 122, doi:10.1002/2016JC012052.
- Pasqueron de Fommervault, O., D'Ortenzio, F., Mangin, A., Serra, R., Migon, C., Claustre, H., Lavigne, H. Ribera d'Alcalà, M., Prieur, L., Taillandier, V., Schmechtig, C., Poteau, A., Leymarie, E., Besson, F. and G. Obolensky (2015). Seasonal variability of nutrient concentrations in the Mediterranean Sea: Contribution of Bio-Argo floats. Journal of Geophysical Research, Vol. 120, Issue 12, P. 8528–8550, doi: 10.1002/2015JC011103.
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- Organelli E., Claustre H., Bricaud A., Schmechtig C., Poteau A., Xing W., Prieur L., D'Ortenzio F., Dall'Olmo G., Velluci, V. (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, Vol. 33, P. 937-951, doi: 10.1175/JTECH-D-15-0193.1.
- Piron A., Thierry V., Mercier H., Caniaux G. (2016), Argo float observations of basin-scale deep convection in the Irminger sea during winter 2011–2012, Deep-Sea Research, Part I, Vol. 109, p. 76-90, doi: 10.1016/j.dsr.2015.12.012.

Meetings and coming events

- Euro-Argo User Workshop, 4th-5th July 2017, Maison des Océans, Paris.
- Copernicus Marine Week, 25th-29th September 2017, Brussels.
- Euro-Argo ERIC Management Board Meeting, October 25th-26th 2017, Dublin.
- Euro-Argo ERIC Council Meeting, 16th November 2017, Paris.
- Atlantos 3rd AGM, November 21st-23rd 2017, Gran Canaria.
- Argo Data Management Team Meeting, November 27th-1st December 2017, Hamburg.
- 20th NAOS Steering Committee Meeting, December 11th 2017, Ifremer, Brest.
- 21th NAOS Steering Committee Meeting, March 26th 2018, Ifremer, Brest.
- 9th NAOS Governing Board Meeting, March 27th 2018, Ifremer, Issy-les-Moulineaux.

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NAOS
Novel Argo Ocean observing System

Convention ANR-10-EXPQ-40-01

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