21st meeting of the International Argo Steering Team

Virtual Meeting

14 – 17 April, 2020

Contents

Argo Steering Team Meeting (AST-21)
Virtual Meeting 14 – 17 April, 2020

1. Welcome (S. Wijffels)

Susan Wijffels welcomed everyone to the virtual AST-21 meeting and thanked participants for agreeing to a virtual meeting instead of the actual meeting that was to take place in Southampton, UK earlier in March but which had to be canceled due to COVID-19 related travel restrictions. Ground rules were set, roles were explained and the meeting started.

2. Argo's Future Design

2.1. Towards global coverage: commitments, spatial completeness and regional enhancements (M. Belbéoch)

M. Belbéoch reported briefly on the status of Argo and the main message was that there are just over 4000 operational floats that cover the ocean pretty well. In addition, float performance has clearly improved for the newer float models, but that more effort may still be needed for the Apex APF11. It is good news that floats are performing better since less floats are being deployed each year. There are some exciting potential new contributions coming to Argo in the next few years, notably from China, and possibly from the US BGC community and in Europe.

There were some things he pointed out that could be improved including the fact that some areas of the ocean are overpopulated while others are under populated. Some of this could be due to the BGC and Deep Argo pilots, but it is worth thinking about especially since COVID-19 might accelerate the decay in some basins. To help address the overpopulation of the North Atlantic, he suggested an Atlantic basin deployment planning meeting which went well. Following this success and with the decreased float deployment opportunities due to COVID, he suggested holding basin deployment planning calls regularly. This could also help identify potential areas where countries could work together to charter a vessel for deployment.

He reported on the status of the various extensions and BGC and Deep Argo pilot missions. Some of these are having difficulty gaining traction and expanding with Deep Argo as the exception. It was noted that while there are many floats counted as BGC by JCOMMOPS, but many of which only carry an oxygen sensor. He plans on trying to implement coverage by BGC parameter rather than float to better monitor the status of the BGC Argo mission.

2.2. Environmental impact statement (S. Riser, S. Wijffels)

The presentation noted that in public presentations there are often questions about the environmental impact of the floats in the ocean after they have completed their missions, and whether the floats are recovered. This issue was repeatedly raised at the Ocean Obs '19 meeting, and after the meeting a small group of AST members decided to try to address this issue in a written document. The document is now in a nearly-final draft; it has been circulated for comments by the AST and is now open for final comments by others in the Argo community. The document serves as an Argo environmental assessment. It examines in detail the sources of pollution and environmental contamination arising from Argo floats and concludes these are minor compared to natural and other anthropogenic inputs. Additionally, the document concludes that Argo is far less polluting than other global programs that are ship-based. In addition to their environmental impact, these programs are financially much costlier than Argo. The document recognizes that most floats cannot be recovered in a cost effective manner, however some recoveries could be carried out where ship resources are already in place for other nearby field programs or prototype testing is underway. The document will be completed very soon, with final comments addressed. Publication plans are not yet finalized.

Action item 1: Finalize Argo Environmental Impact statement(s) created by S. Riser, S. Wijffels and EuroArgo. Please send comments, especially ones that can help put some of the numbers into context for the general public. When finalized, the statement information will be featured on the redesigned AST website.

2.3. BGC Argo Status, challenges and pathway paper (K. Johnson and H. Claustra)

Ken Johnson provided an update on BGC-Argo. The BGC-Argo Steering Team met virtually on Friday, April 10. This meeting focused on national BGC-Argo reports, planning for future deployments and implementation of the global array, development of a new BGC-Argo Project Office, and reorganization of the Steering Team to match the Beyond Argo 2020 design. National reports were received from Australia, Canada, China, the EU, France, Germany, India, Japan, South Africa, the UK and the USA. There is strong enthusiasm with planning for multiple future deployments. The national representatives identified numerous science accomplishments and the number of BGC papers is growing at a rapid pace with numerous papers in high profile journals. Currently 15 nations have BGC floats operating and several additional nations have begun to acquire and deploy floats (Norway, Mexico, Saudi Arabia, Finland). The JCOMMOPS web tools indicate that there are 400 BGC floats in the water and they report 40% of the desired array is established. However, nearly half of the 400 floats carry only one sensor, primarily O_2. The Steering Team will work with JCOMMOPS to develop new metrics that reflect the need for a multi-sensor array. This issue will also be addressed in a revision of the BGC-Argo Science and Implementation Plan. Development of the multi-sensor array faces several challenges. The most pressing is the extraordinarily high price that sole source vendors are charging for sensors. This is forcing some nations to reevaluate their float acquisitions and some to consider other science avenues. Finally, the development of a BGC-Argo Project Office in Villefranche was reviewed. The office will receive support from Exploration de Monaco and from China. It will work on a number of areas, including development of BGC-Argo.

Action item 2: Ask M. Belbeoch to monitor O_2 only floats separately from the 5-6 sensor BGC floats. Ask M. Belbeoch to track coverage & KPIs by BGC parameter.

Action item 3: Ask BGC Mission Team to explore ways to reduce the cost of BGC floats for countries purchasing only a small number of floats.

2.4. Deep Argo Status, challenges and pathway paper (N. Zilberman and B. King)

Deep Argo regional pilot arrays have been implemented in the Atlantic, Pacific, Indian, and Southern Oceans. There are 141 Deep Argo floats currently active, including 89 Deep SOLO floats (56 SIO and 33 MRV), 28 Deep APEX, 20 Deep Arvor, and 4 Deep NINJA, with 9 National Programs contributing to the float deployments. The number of active Deep Argo floats has increased every year since 2016, and the float deployment rates from 2018 to 2020 average around 50 floats per year. The Deep Argo CTD models currently in use are the 4000-m capable SBE-41 and the 6000-m SBE-61, developed by Sea-Bird Scientific. The temperature accuracy (~0.001 °C) of the SBE-61 meets the expectations of the manufacturer, and the salinity accuracy (~0.005 PSS-78) and pressure accuracy (~4.5 dbar) of the SBE-61 are approaching the aspirational targets. SBE-41 measurements show a fresh salinity offset of 0.005 PSS-78 compared to reference data. Both the SBE-41 and SBE-61 CTDs show a fresh bias that is pressure dependent and related to the overall compressibility of the conductivity cell. Two types of salty drift have been observed from SBE-41 and SBE-61 measurements including steep/uncorrectable and slow/correctable drift. Some SBE-41 CTDs show significant fresh drift. An ongoing NOPP project is aimed to improve the performance of the SBE-61 CTD. A third Deep Argo CTD, the 6000-m RBR model, is currently in its regional pilot phase. Milestones for the transition period of Deep Argo from the regional pilot phase to the global implementation phase and for integration with Core and BGC, are described in the Deep Argo pathway paper. Deep Argo mission parameters compatible with Core and BGC include 10-day cycle time, 1000-m nominal parking depth, aspirational mean float lifetime > 4 years, and Deep Argo float's ability to sample from the sea surface to 4000-6000 m or close to the sea floor if shallower, and at high latitude (under-ice).

Action item 4: Ask Deep & BGC Mission Teams to do an in-depth analysis on the utility and practicality of adding O2 sensors to all Deep floats.

2.5. Argo's updated governance structure (B. King)

B. King presented a slightly updated governance structure diagram with the AST being responsible for delivering core data in the top 2000m; this includes data from the BGC and Deep missions. All three missions report to and engage with the ADMT. There was a brief discussion on whether there needs to be a core Argo mission team, but ultimately it was decided it was not necessary. All three missions are committed to delivering data that contributes to the core mission and so all missions should be monitoring the core mission. There was a brief discussion on the membership of AST and it was agreed that the BGC and Deep Argo mission chairs should be part of the AST. It was also agreed that AST members should, if possible, be ready and able to report on any of the missions, including BGC and Deep.

The updated governance model was accepted and will be posted on the AST website.

2.6. Status in each nation: plans, challenges and prospects

Several nations contributed bullet points on the status of their nation, with some including how COVID-19 might affect things.

EuroArgo said it has been working with member states and the European Commission to extend its contribution to 25% of the new Argo global, full depth and multidisciplinary design. It noted that it will be important to increase coordination at the basin level to accommodate the development of the BGC and Deep Argo pilots while also filling gaps in the array. EuroArgo is also assessing the impact of data lost due to the SBE high salinity drift failures. They urged other nations to do the same so that this could be evaluated on an international level to consider jointly asking for compensation from SeaBird

Argo Germany established a BGC Argo in 2019 and are continuing discussions at ministerial levels to increase their BGC Argo contribution.

Argo France is seeing an impact from the SBE high salinity drifting CTDs on their RT and DM datasets and related products. Their DMQC activities continue to focus on containing and evaluating the impacts of this drift and the Argo dataset quality.

Argo Norway started to deploy Deep and BGC Argo floats in the Nordic Seas in 2019 and plan to continue doing so.

China Argo's infrastructure expansion has been secured. They plan to purchase 400 HM2000 floats with Beidou with the possibility of expanding outside of the Western Pacific, South China Sea and Indian Ocean by the end of 2020. COVID-19 is challenging their ability to get CTDs, deploy floats and optimize deployments farther away.

Argo Australia plans to deploy 72 core floats and 6 BGC floats in the next year. There are 18 core floats from MRV with RBR sensors which will be deployed with buddy floats with SBE sensors in different regions in hopes to provide a good test for the RBR sensors. Argo Australia is also developing a pre-deployment app for mobile devices which they hope will simplify pre-deployment testing.

Japan Argo has purchased 50 core, 25 Deep and 10 BGC floats to contribute to Argo in 2018. After that, it has begun assessing how to transition to One Argo. The Japanese ocean science community's large research project proposal which includes a global Deep and BGC Argo array has been selected as one of several key research projects with a 10% chance of getting funded.

The US Argo Programs each contributed their own statements:

AOML: The AOML data assembly center data pipeline remains active through remote telework. AOML-led GO-SHIP cruise A13.5 continues to transit to a US port. A total of 6 BGC-Argo (from UW), 10 core Argo (from WHOI), 34 SVP drifters and 5 SVP-Barometer drifters will have been deployed before the ships return April 17th to Norfolk. Other AOML activities that helped to deploy floats in the Atlantic have been suspended. Deployment opportunities continue to be essentially on hold and will likely result in data gaps in the future.

PMEL Argo float testing and deployment activities have been slowed by production slowdowns or shutdowns by our commercial partners, as well as reductions of hours spent in the lab to maintain social distance. Some PMEL floats have been deployed in late March through early April, and there may be a few even into June. However, they anticipate a hiatus in deployments of unknown duration thereafter. Data management activities are proceeding through telework.

SIO Argo float production and development continue at a reduced pace, while data management activities are sustained by working remotely. Planned US/NZ/AUS collaborative cruises on RV Kaharoa and RV Tangaroa for float deployment and CTD improvement are subject to possible delay or reduced programs.
The float lab at UW is closed, and no operations have been conducted since early March. We have received the components for many floats, and fabrication was underway when we were forced to close. We have 26 floats prepared and ready to ship for this summer's Kaharoa cruise, with 16 more nearly ready, although it is possible that the cruise will be delayed with a revised ship track. A number of BGC-Argo floats are also partially completed, with scheduled cruises in the fall that might be in jeopardy.
Due to the impact of COVID19 on ship operations, float deployments have largely been halted, and some floats are being returned to WHOI. Ballasting, checkout and deployment preparation is ongoing at WHOI, at a reduced pace and we expect to build an inventory of 'ready to deploy floats' during the COVID-impacted months. Deliveries from our supplier (MRV) are tailing off due to a lack of available CTDs from SeaBird. Data management has largely continued via remote work.

During the discussion, it was suggested that when the COVID-19 crisis is over, the AST should work together to try and identify potential weak spots in the array to target for deployments. National Programs could discuss how to distribute SBE CTDs in such a manner as to consider array health, National Program budgeting and constraints, float production ability, float deployment opportunities, etc.

Action item 5: Following the COVID-19 crisis as well as the build-up of the BGC and Deep Argo Missions, the AST supports basin deployment planning discussions twice per year for each basin.

Action item 6: When COVID-19 crisis is over, ask AST to work together to try and identify potential weak spots in the array to target for deployments. Discuss how to distribute SBE CTDs in such a manner as to take into account array health, National Program budgeting constraints, float production ability, float deployment opportunities, etc.

Action item 7: Ask each PI/ National Program to consider asking for exceptions to budget constraints due to COVID-19 to continue buying and deploying floats. For example, perhaps floats can be purchased in advance.

2.7. EEZ issues, IOC discussion, guidelines and strategies (M. Belbéoch, B. Owens)

The Observations Coordination Group (OCG) of GOOS organized a meeting, January 15-16, 2020, to develop a 5-year strategy for JCOMMOPS so that it can better provide the vital services to the expanding climate observing networks. The JCOMMOPS Vision and Mission statements were revised to better articulate the challenges and the contributions from the networks to enable monitoring, coordinating and integration of data and metadata for the climate observing system. These challenges include clarification of governance between OCG, IOC and WMO. Prioritizing and managing requests between existing core and emerging programs needs to be improved. The current funding model for JCOMMOPS is ineffective. The small national contributions funneled through observing networks needs to be replaced with significant contributions provided through the parent organizations, i.e. GOOS, IOC and WMO. A draft strategy document should be available shortly.

A two day experts meeting, hosted by IOC and held February 12-13 at UNESCO in Paris, on Ocean observations in areas under national jurisdiction. The focus of the meeting was on making observations from ships or steerable autonomous vehicles or the deployment of assets directly in the EEZ of a coastal state. The development and implementation of the procedure to notify Coastal States when a float is likely to enter their EEZ was viewed as the gold standard for how to develop a strategy for the broader community. An interesting possibility for access to EEZs is UNCLOS Article 247, which necessitates the approval from an intergovernmental body after which the notification process is greatly reduced. Article 247 has never been used and the IOC Executive will work with some of the legal experts to research this further and present their findings to the IOC Executive Council in July 2020. Further progress on this issue is likely to be slow and piecemeal. A draft meeting report should be available in the summer of 2020.

Action item 8: AST is officially adopting the new governance model which describes a single infrastructure which can deliver data streams from all the missions. Post this information on the AST website, including Terms of Reference for AST, BGC Argo Mission Team and Deep Argo Mission Team and pathway papers for BGC and Deep.

Action item 9: Ask BGC and Deep Mission Teams to draft implementation pathway paper to assist National Programs in their planning.

Action item 10: Ask AST members to be ready to reach out to their National IOC reps to gather their support for Argo and efforts to facilitate deployments and measurements within EEZs.

Action item 11: AST reminds all PIs that standard Argo floats cannot be deployed into EEZs without prior clearance. If you add an experimental sensor to an Argo float that may drift into an EEZ, prior clearance from the coastal state is needed. This is critical to maintaining good standing with the IOC. When the sensor looks ready for a global pilot, please approach the AST to seek approval for the global pilot phase.

3. Recent float performance across array: Current technical issues with core floats

(Led by B. King with input from M. Belbeoch and community)

B. King showed statistics on float lifetimes and noted that, most float lifetimes are increasing, with several groups doing extremely well. He noted these groups do pre-deployment testing, take care during shipping and storage and often take extra precautions during deployments. He showed that for the four major float types currently in use (SOLO-II, APEX, NAVIS, ARVOR), their performance has increased in the current five year period (deployed in 2016-2019) as opposed to the previous five year period (deployed in 2010-2014). This is a good sign as not all groups are able to do all the additional steps taken by the most successful groups.

3.1. SOLO-II Tadiran fleet (D. Roemmich)

Many of Argo's biggest challenges, including program cost, environmental impact, and deployment opportunity scale inversely with the "effective lifetime" of Argo floats. Doubling the lifetime reduces: the cost by half, the environmental impact by half, and the need for deployment opportunities by half. Effective float lifetime has 3 elements: battery life, early failures, and CTD stability. Several models of floats are beginning to achieve failure rates of ~2% per year or less, accomplished by identifying and eliminating common failure causes. Sensor stability in CTDs is challenging but ongoing efforts with pressure and conductivity sensors are showing much promise.

In order to match the future longevity of advanced float models and sensors, battery lifetime should be longer than 10 years – a large increase over the early years of Argo. SIO Argo is trialing Tadiran hybrid lithium batteries which mitigate the energy losses in primary lithium batteries due to the SOLO float duty cycle (short periods of high current draw for buoyancy pumping interspersed with 10-day idle periods).

A SOLO-II float, having an energy requirement of 8.5 kJ per 2000 m cycle, with 2 Tadiran battery packs (of 8 D cells each) was deployed in late 2015. This float completed 320 short cycles. In late 2016, 25 SOLO-IIs with 3 battery packs and a slightly reduced energy requirement of 8.1 kJ were deployed in the SW Pacific. All 25 of these floats are still active, each having completed 135 10-day cycles in 3.5 years. It is estimated they will complete 400 to 500 cycles, thus achieving the goal of > 10 years. This experiment is ongoing, but interim results are very promising.

3.2. Apex APF11 controller performance and issues (Riser, P. Oke)

Peter Oke reported that the problems with APF1 firmware that were reported at last year's AST meeting have all been resolved. There have been a few minor issues – all of which that have been addressed by Teledyne. Peter also reported that CSIRO are developing an Application for mobile devices (both iOS and Android) to perform pre-deployment tests. We hope to make the App work for all mainstream float types, and it will be freely available.

3.3. NAVIS (G. Johnson)

PMEL began deploying SeaBird Scientific Navis floats in January 2012, and is the biggest user of this float within the Argo community. Hence this report was requested of PMEL for AST-21. The performance of the first float model, Navis-A, was hampered by several failure modes, which were addressed by SeaBird first by a series of patches over time, and then by the introduction of a new model, the Navis-EBR, in 2015. PMEL deployed 306 Navis-A floats. The longest lived to date of that model, WMO 4901459, reported its 262nd profile on 14 March 2020. PMEL-deployed Navis-A floats exhibited a relatively constant failure rate over time in their first four years, dropping to about 50% survival at the end of that period. Almost all of the Navis A floats that survived that long persisted to about 6 years (220 profiles), at which point some began to fail owing to using all available battery energy, with a few lasting until 7 years. PMEL has deployed 312 Navis-EBR floats. The first of those, WMO 4902299, deployed on 15 November 2015, reported its 162nd profile on 12 April 2020. The performance of the Navis-EBR floats to date has been quite good, with a survival rate of 90% at three years of age. Data are insufficient to characterize the survival rate of the PMEL fleet of Navis-EBR floats beyond 3 years. However, SeaBird Scientific says they are more efficient than the previous model, and should be capable of noticeably more profiles before using all available battery energy, relative to the Navis-A models.

3.4. Provor/Arvor Tech workshop highlights (B. Greenan)

A three-day workshop was held at Ifremer in Brest, France on 28-30 January 2020 with 58 attendees. This workshop was organized by Argo Canada and Argo France for Arvor-Provor Argo float users with the objective of improving the level of technical expertise and to share best practices. In addition to scientists and technicians that deploy floats, the workshop also included representatives of the Argo data management community, and the Arvor/Provor float manufacturer (NKE) and sensor providers (Sea-Bird, RBR, JFE). The format of the workshop combined classroom presentations and discussions with hands-on training at the Ifremer test tank.

Day 1 of the workshop began with an overview of previous float technical workshops held at the University of Washington, with a summary of lessons learned. This was followed by a presentation on the status of the Arvor and Provor floats in the context of the global Argo array and included a discussion of the lifetime and performance of these platforms. The potential to support new scientific research initiatives was highlighted in presentations on the Provor biogeochemical float and the Deep-Arvor platform. In the afternoon, the Arvor/Provor manufacturer (NKE) provided the workshop attendees with an overview of the company and its various products along with information on customer support. This was followed by presentations on float sensors by RBR, NKE and JFE. The day finished with a presentation on new technical developments for the Provor CTS5 at LOV, and an update on Argos and Iridium communications from CLS.

Day 2 began with a presentation from Sea-Bird on the various sensors that the company provides for Argo floats along with information on best practices for handling, storage and preparation of BGC sensors. This was followed with an update on two Ifremer R&D projects, one to incorporate an ADCP on a Deep-Arvor and the second on the 3-head Deep-Arvor with the SBE41, SBE61 and RBR CTDs mounted on a float. The remainder of the morning focused on best practices for both floats and sensors as well as metadata and data management. In the afternoon, workshop attendees had the chance to get some hands-on experience with floats at the Ifremer test tank facility. This aspect of the workshop was very well received given the interactive nature of the activity, and lots of discussion was generated.

The morning of Day 3 provided an overview of the Argo file structure at the Global Data Assembly Centres (GDAC), naming conventions, file types, etc. An introduction to the R oce package provided attendees with information on how to visualize Argo data from GDAC NetCDF files with minimal effort or training required. A presentation of the Euro-Argo online fleet monitoring tool was demonstrated to show how this can be used to access technical information on all floats in the global array; this tool is an excellent complement to the JCOMMOPS application for the Argo program. In the afternoon of Day 3, two case studies (float recovery, under ice behaviour) were presented as well as an introduction to the Provor CTS5 graphical user interface for mission planning. The workshop concluded with a discussion about key issues and potential recommendations generated over the preceding three days.

All the materials from the workshop are available online at:
https://github.com/euroargodev/techworkshop

3.5. HM2000 (Z. Liu)

Zenghong (CSIO) presented the progress for HM2000 float that was developed by Qingdao Hisun Ocean Equipment Company (HSOE). Recently HSOE successfully installed Iridium communication module on their float which will allow the float to be deployed outside of the BDS-1 satellite's coverage. The BDS-3 will become a global network by the end of this year, so hopefully in the near future, HM2000 float will benefit from it and has the capability to be deployed anywhere in the global ocean. HSOE is presently developing a BGC float (e.g. float installed with DO sensor and float installed with FLBB & ED4 sensors). The relatively higher energy consumption is the main technical problem that HSOE must improve. In the upcoming project of China Argo Infrastructure construction, over 400 HM2000 floats are expected to be deployed.

3.6. RBR Pilot (S. Wijffels, B. Owens)

S. Wijffels presented an update on the RBR data noting that sensor stability looks competitive and that accuracy appears to be good as well. She noted that Argo needs to do a careful analysis with ship board comparison data sets to confirm and quantify this. She also noted that much progress has been made on the RBR dynamic error.

She then presented the plans different National Programs within Argo have for purchasing RBR sensors and deploying them in the next year or so. She noted that RBR would like the size of the pilot array to be increased quickly and substantially. She suggested forming a working group to analyze ship-based comparison data sets to confirm and refine both static and dynamic corrections. She would also like to see work begin on DMQC practices for RBR floats.

Action item 12: A new Task Team will be formed focused on RBR CTD pilot float and ship-based intercomparison data, to refine and validate corrections needed to complete DMQC. These processes will be documented in the Argo data manual system.

3.7. Argo under the ice (S. Jayne to lead with input from B. Greenan, B. Klein, and S. Riser)

S. Jayne reported on the various efforts to use Argo floats under the ice in both the Arctic and the Antarctic. He began with efforts in Germany to develop an ice-sensing algorithm for use in the Arctic based on temperature thresholds which can get tricky due to warm water near the surface. Due to this difficulty, other avenues have been explored to prevent floats from hitting ice including monitoring pressure changes to determine when the float is no longer ascending, or using satellite or ice date masks to prevent floats from surfacing in certain regions or times. He then reported on his work to deploy ALAMO and ALTO floats in the Canada basin that will contribute to a database of ice-tethered profilers and profiling float data for the region. B. Greenan reported on the NKE pro-ice floats that have been deployed in Baffin Bay. S. Riser reported on floats under-ice in the Southern Ocean and noted that being under ice reduces the UW float lifetimes by about a year. However, he noted that there have been a couple of significant science results using Argo under-ice data published in the last year.

3.8. Garmin GPS Atlas issues

S. Riser reported on this briefly to say that all floats affected by this bug are still able to obtain GPS surface fixes for now and that we remain optimistic that this will be the case for a long time. This issue was discussed at the ADMT-20 meeting and the excerpt from the meeting report can be found here: http://www.argo.ucsd.edu/GarminGPS_floats.pdf

In addition, the ADMT assigned two Action Items to help the data system keep track of affected floats.

4. Technical updates on BGC-Argo

4.1. BGC-Argo float to accommodate additional sensors (H. Claustre)

H. Claustre reported on the development of a BGC float that can capture some essential biogeochemical processes that are hard to catch with the standard 10-day, 2000db Argo sampling scheme. This PROVOR float will carry sensors to measure the six core BGC Argo variables, but it will be 20cm taller and carry 60% more batteries. The hope is that by developing floats that can carry the BGC sensors, yet still be efficient and long-lived, it will become more cost effective to the BGC Argo mission. H. Claustre plans to test about 25 of these jumbo floats starting in late 2021.

4.2. Chla sensor (H. Claustre)

H. Claustre reported the relationship between Chla by fluorescence vs Chla by HLPC is highly variable and shows regional dependency, especially in the Southern Ocean. He showed that the SeaBird/Wetlabs fluorometer@470nm does not excite Chla. In addition, Chla retrieval from fluorometer@440nm is less sensitive to phytoplankton population composition (and thus to regions). A new SeaBird fluorometer@440-@470 will soon be tested on floats. He concluded that there might be possible ways to better estimate Chla and to evaluate correction of the current Fchla@470nm database.

4.3. Float longevity – SOCCOM + others (K. Johnson)

The longevity of BGC-Argo floats was assessed several ways. Web tools on the JCOMMOPS web site report a mean survival rate of 50% at 4 years for Core-Argo floats and 3 years for BGC-Argo floats (including O2 only floats). This 25% penalty in lifetime probably represents an upper limit, as many of the early BGC losses reflect developmental efforts. University of Washington BGC Apex floats deployed in the SOCCOM program have lifetimes nearly similar to UW ice floats and probably reflect a lifetime penalty of ~10% or less. BGC float effectiveness also depends on the lifetime of the additional sensor load carried by floats. Loss of one or more of these sensors results in a fractional decrease in the float effectiveness, but does not eliminate a float's utility. Assessments were based on ~240 BGC floats deployed by UW/MBARI. Oxygen sensors have >90% survival at 5 years. Nitrate sensors have 75% survival at 5 years. The situation for all pH sensors, the newest development, is lower, with 30% survival at 5 years. However, significant engineering effort has been applied and current pH sensors built by both MBARI and by Sea-Bird have much higher survival rates, with no failures seen in the latest generation of Sea-Bird instruments. Multiple publications have assessed data quality (Johnson et al., JGR 2017, doi:10.1002/2017JC012838; Mignot, GRL, 2018, doi:10.1029/2018GL080541). Excellent performance has been found. Bio-optical sensors are also performing exceptionally well with little or no detectable drift.

5. Technical updates on Deep Argo floats:

5.1. Deep SOLO (D. Roemmich)

Table 1: Deep SOLO Prototype and Regional Pilot Deployments

Month/Year Array	Deployment Vessel	Number of Deep SOLOs	Batteries No. Packs and type	Serial Numbers	Recovered/ Shipped home/ Redeployed	Active
Deep SOLO						
Jan 2013	Bell Shimada	1	4E	6002 Prototype	1 /1/1 (Sep 2013)	0
June 2014 SW Pac	Tangaroa	2	4E	6002-6003 Prototypes	2/2/0 (Sep 2015)	0
Jan 2016 SW Pac	Kaharoa	7	4E	6004-6007, 6009-6011	5/1/4 (Jun 2016)	5
Jun 2016 SW Pac	Kaharoa	3	4E	6008, 6014, 6015	2/0/2 (Aug 2018)	3
Aug 2016 SW Pac	Investigator	2	4E	6012-6013	0/0/0	2
Oct 2016 S Australian	Kaharoa	8	4E	6016-6020, 6022-6024	1/1/0 (Feb 2019)	7
Mar 2017 NW Atlantic	James Cook	6	4T (3 floats) 4E (3 floats)	6021, 6025-6029	1/1/0 (Nov 2018)	5
Aug 2017 SW Pac	Palmer	3	4E	6030-6032	0/0/0	3
Oct 2017 SW Pac	Kaharoa	5	4T	6033-6037	0/0/0	5
Jan 2018	Investigator	5	4T	6038-6042	0/0/0	5

Aus Antarctic						
Jul 2018 SW Pac	**Kaharoa**	**10**	**5T**	**6043-6052**	**0/0/0**	**10**
Jan 2019 SW Pac	**Tangaroa**	**5**	**5T**	**6053-6055 6057-6058**	**1/1/0 (Feb 2019)**	**2**
Dec 2019 – Jan 2020 SW Pac	**Kaharoa**	**10**	**5T**	**6056, 6059-6061, 6063-6068**		**10**
Total		**67 deployed**			**13/7/7**	**57 active**
Deep SOLO-MRV						
May-June 2018 NPac	**K-Kanaloa, Kilo Moana**	**3**	**5T**	**12001-12003**	**0/0/0**	**3**
Jan-Feb 2019 Aus Antarctic	**Kaiyo Maru**	**3**	**5T**	**12006-12008**	**0/0/0**	**3**
May 2019-Feb 2020	**Thompson, Discovery, Petrel, Brown**	**30**	**5T**	**12004-5 12009-36**	**2/1/1**	**27**
Total		**36 deployed**				**33 active**

Deep SOLO Issues Encountered
An impedance mismatch between float and CTD caused partial data losses (salinity truncations) and occasional "long vacations" in the 7 floats deployed in Jan 2016. 4 floats had new firmware installed at sea which overcame the problem. A 5th had a broken antenna during recovery and was returned to the laboratory. The remaining 2 were on "long vacation" during the recovery cruise and could not be recovered. The impedance problem was fixed in all subsequent deployments.

Battery life: Early Deep SOLOs carried 4 Electrochem battery packs and were capable of about 120 deep profiles. Addition of a 5th battery pack and conversion to Tadiran hybrid lithium cells increased battery capacity to > 200 cycles (to be determined). Increased battery life makes the float more economical and makes the array more sustainable.

Bottom drag: Original firmware did not ensure that floats would lift off the bottom to reach drift depth. It is hypothesized that 6055 and 6058 were snagged while on the bottom. In subsequent floats, firmware ensures that floats lift off the bottom for drift period.

CTD cable failure: 6053 and 6054 both had total data loss at mid-depth and below, due to CTD cable failure. 6053 was recovered by RV Tangaroa and returned to the lab. 6054 is active but shoaled. 12011 is inactive as a result of CTD cable failure.

CTD cable intermittent failure: 12004, 12005, 12010, 12012,12015, and 12020 all have had intermittent CTD cable failures that have resulted in partial loss of data from some profiles or triggered emergency beacon mode. 12012 was recovered, recabled, and redeployed and has not had issues since. 12004 was recovered and is being brought back for repair. The rest of the floats are still active, and all are reporting full-depth profiles most of the time.

Rapidly drifting salinity: Two Deep SOLOs with rapidly drifting salinity (6008, 6015) were recovered. The CTDs were swapped out and shipped to SeaBird. The floats were immediately re-deployed. 12002 is also exhibiting a salty drift and has since been recovered.

Of the 12 Deep SOLO floats deployed and no longer active, 7 were recovered and returned to the lab. 6004 failed from low batteries.6055 and 6058 have failed (possibly bottom-snagged, as noted above). 12023 has failed, perhaps from a leak, and 12010 failed from a CTD cable failure.

5.2. Deep APEX (S. Hosoda)

JAMSTEC has launched 27 Deep APEXs mainly in the North Pacific, Indian Ocean and the Southern Ocean since 2018, and 25 of them are in operation as of 5th April. The deep APEXs are mostly stable operations but some problems still occur, showing technical messages like "Buoyancy engine failure“, "download CP data attempt 1 failed“. Further, it is problematic to renew frequent firmware versions with format change, and to waste too much energy when bottom touches during drift. We are now requesting improvements from TWR. Also, SBE61 and Oxygen (Aanderaa Optode4831 and RINKO AROD-FT) sensors are still biased, thus we are also requesting improvement to each sensor manufacturer.

The UK deployed 5 Deep APEX at 26N in the N Atlantic in Jan/Feb 2020. One of them is still operating from previous deployments, which has passed 150 Deep cycles. The new floats are cycling to 6000 metres or the seabed, with the bottom-avoidance chain, which is working well. Deeps 12 and 13 carry Aanderaa optode and are returning good oxygen data, with surface oxygen. The Deep APEX/SBE61 comms problem is not yet solved.

5.3. Deep float from China (Z. Chen)

China began its development of deep float in 2016. The ‘Wenhai’ project was initiated and funded by both local government and QNLM with over 3 million US dollars. There will be an additional 1.5 million US dollars after 2020 to further support the manufacture and pilot deployment.

In 2019, 10 deep floats were tentatively deployed in the South China Sea, east of Luzon, Kuroshio Extension and North Equatorial current regions. Seven floats have finished over 100 cycles but the lifetime of the floats should be further validated.

In 2020, 10 deep floats will be deployed in the Argentine Basin and 10 in the Western Pacific. SEB61 or RBR-Argo CTD will be mounted on the floats.

In the next 10 years, China will maintain at least 300 deep Argo floats in the North Pacific and the Southern Ocean, providing data down to 6000-m for the scientific community.

5.4. Deep NINJA (T. Suga and T. Kobayashi)

T. Suga reported on progress of the 29 Deep NINJA floats deployed since 2012. Previous deployments have been split between the Pacific (10 floats) and the Indian (19 floats). In FY2020, there are plans to deploy one of Antarctica. The Deep Ninja does have ice detection capabilities, but of 17 floats deployed in seasonal sea ice, eight were lost under the ice. Work continues to evaluate the SBE41CP at depths greater than 2000db. CTD casts have been taken at 19 Deep NINJA deployments and when compared with float data, a fresh salinity bias with a negative pressure dependence is found for almost all the floats. Finally, five Deep NINJAs have been outfitted with a Rinko dissolved oxygen sensor which is rated to 6,800db and has a fast response time of less than 1 sec in water. It can also take a series of measurements at the sea surface. When compared with reference CTD casts, there is agreement within 1 to 5 micro-mol/kg. It seems that a bias develops after the first several cycles, but pressure aging may be able to improve its stability.

5.5. Deep Arvor (X. Andre)

The Deep-Arvor is a 4000-m depth profiling float, fully compliant with the Argo scheme (profile done during ascent). It monitors and controls its speed of descent and ascent in the whole water column. It acquires up to 4,000 CTD/CTDO samples, and is fitted with the ISA algorithm. Until the end of 2017, 50 Deep-Arvor were deployed, but some units faced technical defects, due to hydraulic problems, and a bug in the grounding management; these problems have been addressed and qualified at sea since 2018. Ifremer intends to deploy 50 more Deep-Arvor in 2020-2021. The Deep-Arvor has also proven its ability to embed additional sensors, thanks to its high payload capacity: a DO optode, an ADCP with its own battery pack on a bottom nacelle, or 2 additional CTDs for data quality inter-comparison.

6. Data Management and related issues

6.1. DMQC of high salinity drift floats (J. Gilson)

Following a directive from the ADMT20, a working group was established to investigate the temporal and depth dependent behavior of Seabird 41 and 61 CTDs which exhibit fast, salty drift. The timeline is to reach a consensus and to distribute recommendations in the summer 2020. Depth dependent salinity drift has been identified within strongly drifting Deep SOLO floats (ΔS>+0.05psu). The onset of depth dependence roughly coincides with the start of strong drift. Several Core Argo floats have been identified as displaying likely depth dependence, again with strong amplitude of drift. In the case of mild/moderate salinity drift (ΔS<+0.05psu), depth dependence was not discernible from two Deep SOLO floats. The results to date do not suggest a change of standard DMQC protocol from flagging as bad, PSAL_QC='4' and PSAL_ADJUSTED_QC='4', when overall ΔS>+0.05psu and/or ΔS>+0.01psu from one cycle to the next. DMQC guidance should reinforce that changes in drift behavior (e.g. jumps, change in rate of drift) can indicate sensor failure. A parsable standardized string(s) will be developed for the profile netCDF SCIENTIFIC_CALIBRATION_COMMENT variable, analogous to the string used for TNPD cycles.

6.2. Flagging and calculated adjusted Deep Argo data in real time (N. Zilberman)

The technology readiness of the extended-depth SBE-41 and SBE-61 CTDs has been tested on Deep Argo floats for > 6 years. Comparisons with reference data show that the temperature, salinity, and pressure accuracies are approaching the manufacturer's expectations. Temperature, pressure, and salinity data from both Sea-Bird CTDs are flagged 1 at pressure between 0-2000-dbar, and pressure and temperature are flagged 2 and salinity 3 at pressure > 2000-dbar. The RBR CTD has started its regional pilot phase whose objectives are to demonstrate the performance and accuracy of the sensors. The temperature, pressure, and salinity of the RBR CTD are flagged 3 over the whole water column.

Tentative recommendations for RT Deep Argo flagging include

- To keep RT data flag of 3 for all RBR parameters until the regional pilot phase is completed.

- To change SBE-41 and SBE-61 RT flag to 1 for all parameters at pressure > 2000 dbar. Salinity adjustments will include corrections for pressure-independent salinity offset, for pressure-dependent salinity bias, and for time-dependent salinity drift.

- To agree on a "best estimate" of CPcor for an automatic adjustment of salinity for all Deep Argo floats equipped with SBE-41 or SBE-61 CTD that would minimize differences with reference data; and to provide an estimate of salinity error. In addition, DMQC operators could provide refined float-by-float estimate of CPcor when nearly co-located high-quality reference data are available.

- To provide a Deep Argo cookbook describing best practices for DMQC in order to ensure that the data is corrected in a consistent and effective manner.

6.3. Machine Learning and Argo QC (G. Maze)

G. Maze gave an update on machine learning work done to improve the quality control workflow with the idea being that data that raises alarms after existing QC tests is redirected through the machine learning (ML) algorithm. Then, the ML algorithm can use a collection of features to learn and predict the status of the alarm. Selecting the most appropriate set of features is very difficult. Possible features include meta data such as position, time, cycle number, etc.), per-point data such as surrounding temperature, salinity, density or vertical gradients, and per-profile metrics such as average distance to climatologies, number of surrounding reference points and deepest observation point.

After implementing this ML algorithm for some time, it has been found to reduce the workload by up to 25% at best and that per-profile metrics are most useful as per-point metrics do not generalize well. Furthermore, we have concluded that learning what is bad data with so few examples as compared to the number of good data is very difficult. Improving or creating new tests is better than trying to address issues afterward. Right now, existing QC tests mostly fail because of inappropriate references. Therefore, we should improve reference selection with un-supervised classification of profiles and neural-network predictions of the ocean state.

6.4. CTD Reference data & developing a reference dataset for Deep Argo (S. Purkey, S. Diggs)

S. Diggs reported on the status of the CTD reference data submitted in the last year which included 1126 GO-SHIP CTD stations from CCHDO and roughly 700 casts from NCEI. As requested by Argo, there is now a high quality, up-to-date GO-SHIP data product created by K. Katsumata, B. Sloyan, R. Crowley, S. Diggs, T. Moore, S. Purkey, J. Swift and L. Talley available on the CCHDO website. This product includes 44 GO-SHIP lines and all CTD salinity data has been calibrated to salinity bottle samples. The data is available as stations and in a gridded format. There are plans to continuously update this product as GO-SHIP data becomes available.

6.5. Cpcorr update (G. Johnson, S. Purkey)

Comparisons of SBE-61 (and SBE-41 deep) salinity data to SBE-9+ CTD reference salinity data have revealed a fresh bias in the float CTD data that increases apparently linearly with increasing pressure. The likely culprit for this bias is the use of the nominal correction coefficient for the compressibility of borosilicate glass for the SBE-61 (and SBE-41 deep) conductivity cell, Cpcor=-9.57e-8 dbar-1. Comparisons by several investigators (G. Johnson, J. Lyman, & S. Purkey; V. Thierry & C. Cabanes; T. Kobayashi, K. Sato, & B. King; K. Martini, D. Murphy, & N. Larson) of SBE-61 (and SBE-41 deep) profiles to co-located (e.g., on the same platform), nearby (in space and time), or nearby (in space) reference CTD profiles suggest that compressibility coefficients somewhere in the range of -11e-8 to -14e-8 dbar (depending on the study) are more appropriate, in that their use removes the bias. Furthermore, the values of a depth-independent multiplicative conductivity adjustment (nearly equivalent in effect to an additive salinity adjustment) and the Cpcor estimates are well correlated, suggesting that they are not entirely independent variables in the estimation. A Deep Argo Cpcor working group including representatives from all four groups mentioned above and N. Zilberman, led by G. Johnson, has been tasked with making a recommendation regarding the determination and application of the conductivity cell compressibility coefficient to the Deep Argo data.

Action item 13: A Task Team will be formed to agree on a new CPcor value for Deep Argo data. When the value is agreed upon, please share with AST and ADMT so instructions can be given to DACs to implement procedures and changes to QC flags.

6.6. Update on high salinity drift from SBE CTD SN 6100 – 7000, 8100 – 9200, 10,600 – 11,400 (G. Johnson, S. Wijffels, J. Gilson, D. Murphy)

G. Johnson updated the group that 100+ PMEL floats have CTD S/Ns in the range of 10,600 – 11,400 and the majority of these floats have been deployed, some of them for more than one year. All floats have been either DMQC'd or visually inspected and many of them show signs of strong salty drift which means that this CTD S/N range is also one to monitor closely.

6.7. Feedback from ADMT-20 (S. Pouliquen)

S. Pouliquen reported on ADMT activities and the status of the data system. In general, the data system continues to function very well and in a timely manner. All the KPIs from JCOMMOPS except PSAL quality are hitting their target or higher. The DMQC status is up to 79% which is the highest it has been in the past few years, probably due in part to DMQC work to identify fast salty drifters in certain CTD S/N bands. The percentage of good salinity data has fallen to around 80%

due to fast salty drifting floats being flagged with bad QC flags in real time to prevent the operational community from using known bad data. To help identify which floats may be showing anomalous behavior for DMQC operators to check quickly, the MinMax test has been running at the Coriolis GDAC every hour on profiles less than 120 days old. Possible drifting profiles are flagged automatically when it crosses thresholds at depth. An operator visually confirms or rejects flagged profiles by looking at surrounding salinity profiles in time and space, theta-S diagrams for that float's profiles and all salinity profiles from that float. In the past year that this test has been operating, 20 – 25 alerts occurred per day with 85% of alerts found to be problematic profiles. These alerts are included in the monthly report Coriolis produces in a table at the top of the report. It was agreed at the ADMT-20 meeting that for floats with a profile that was flagged as bad by the MinMax test, DACs should put the float onto the greylist starting with that profile, until the float can be DMQC'd. This should help quickly identify fast salty drifting floats and quickly flag them with QC flags less than '1' to indicate to users that this data should be used with caution or not at all.

The ADMT also re-evaluated it's timeliness target for Iridium floats and reduced it to 12 hours instead of 24. For 2019, 80% plus of Iridium floats had data available on the GTS within 12 hours. The ADMT encouraged DACs to consider processing data more frequently to try and get to 90% Iridium data delivered within 12 hours. Right now, only core data is delivered via GTS. There is an oxygen BUFR template in the testing process and it should become available later in 2020. The ADMT asked the AST and wanted to ask the OceanPredict modeling community if adding other BGC data onto the GTS is a priority as it will take 2-3 years to develop the BUFR format, request approval from the WMO and test it. P. Oke said that yes, modelers are ready to use the BGC Argo data which is good initial input. The ADMT co-chairs can work with BGC AST members and the OceanPredict community to try and determine BGC parameter order for dissemination onto the GTS. It was also pointed out that Deep Argo data is available on the GTS, but with lower quality flags due to the sensors and that the Deep SOLO does its deep profile upon descent making the profile 10 days old when it is sent on the GTS. The ADMT needs to also reach out to the OceanPredict community on this to alert them to the profile delay.

The GDACs are functioning well and continue to increase in size (~600GB in total on the Coriolis GDAC). The M profs have been replaced by S profs which are smaller in size and easier for BGC scientists to use. The S profs are produced at Coriolis and mirrored at the US GDAC. There are still several file checker updates that need to be implemented as well as the trajectory file checker could start rejecting files rather than just issuing warnings. The ADMT is exploring how to do this in a timely manner.

Finally, the ADMT has voted to combine the core and b-trajectory files into one new format. This new format, v3.2 will be finalized and documented in preparation for the ADMT-21 meeting. Only floats with BGC parameters will need to switch to v3.2 trajectory files. The ADMT asked the AST for endorsement of this trajectory file combination.

Action item 14: AST endorses the combination of core and b-trajectory files and agrees with plan to create a new v3.2 format for the combined trajectory file.

Action item 15: AST encourages ADMT to begin the process to deliver BGC data on the GTS for the modeling community. Consult with OceanPredict community to establish priority BGC parameter order after O2. Report to ADMT-21.

6.8. Argo data paper (A. Wong, S. Riser, S. Wijffels)

Annie Wong presented a brief account on the progress of the Argo data paper. This paper aimed to describe and assess the temperature, pressure, salinity, and subsurface velocity data from the core Argo Program 1999-2019. It was initiated sometime in 2018 by Susan Wijffels and Steve Riser. Collection of material, literature review, and solicitation of other contributing authors began in March 2019. It took almost a year to assemble various material into a coherent manuscript. The first draft of the manuscript was sent out to the contributing authors and members of the AST/ADMT for comments in March 2020. Further collection of additional material on PROVOR/ARVOR floats was coordinated by Sylvie Pouliquen. As of April 2020, the final version of the manuscript was being prepared for submission to a peer-review journal.

Action item 16: AST supports the finalization and submission of the Argo data paper led by A. Wong.

7. Communications & Outreach talks

7.1. Argo bibliography (M. Scanderbeg)

M. Scanderbeg showed the latest numbers for the Argo bibliography and noted the large increase in papers in 2019, due mostly, but not entirely to OceanObs19. There was still a dip in 2018, and the numbers could be leveling off, but she guessed that many scientists were busy in 2018 working on OO19 papers rather than submitting other papers. She notes there continues to be an increase in the number of papers published using secondary sources of Argo rather than Argo data from the GDACs which will make it more difficult to track papers if 'Argo' is not mentioned directly.

She reported that after the AST-20 meeting, P. Oke sent a good list of model output papers for the past 1-2 years which could be included in the Argo bibliography. When looking through these, most of them did not mention Argo directly. She then tried searching for more model output papers using keywords suggested by Peter, but it ended up being very time consuming. That combined with the fact that only including model output articles for a limited number of years would artificially inflate the numbers, she decided not to purse this. Instead, a line will be added to the Argo bibliographies website to note that many papers now use secondary sources of Argo which may not be included in the bibliography. There will also be links to secondary sources cataloged on the AST webpage as well as model outputs known to include Argo.

7.2. New Argo Steering Team Website (M. Scanderbeg)

M. Scanderbeg showed the draft AST website available at https://argo.sioword.ucsd.edu. She explained that the goal was to transfer over the old content and add a public wrapper on top. She requested feedback for several new content areas and said that when the new website is ready, the URL will be switched to the current one (www.argo.ucsd.ed) so that the old link will still work. Several people offered to help review the website and add more content.

Action item 17: M. Scanderbeg to work with a small group to finalize the content on the new AST website. AST encourages a set of pages to be linked together that are targeted at journalists and the public with basic information.

7.3. H2O project (M. Belbeoch)

M. Belbeoch reported on a partnership between H2O, Help the Planet and JCOMMOPS for an ambitious project during the UN decade for ocean science. The goals of the partnership include collecting more ocean observations, education, outreach and communication. The H2O ship is 45 m, certified for ice areas and sails under the French flag. There are 25-30 permanent crew, but up to 200 people can be onboard in port. The ship plans to sail around the world from 2021-2024 with a stop in Brest around the Olympic Games which will be held in Paris. There will be tangible contributions to GOOS through ocean observation. It is hoped that communication and outreach materials on ocean observation can be developed and that it will raise the visibility of the IOC, WMO and JCOMMOPS.

7.4. Argo communications group (E. Smith, J. Mkitarian)

During the virtual AST, NOAA Program Manager Emily Smith provided an update on the recent Argo communications efforts. The October ADMT included a "do-a-thon" and a focus on Argo data visualizations. At the do-a-thon, web developers came together to share information and data, and communicators came together to discuss communications needs for the international Argo Program. The communications group identified a need to reach external audiences and coordinate Argo communications efforts internationally. The group discussed increasing a social media presence for Argo and creating a website to provide general Argo Program information. Following the meeting, NOAA Communications Specialist and do-a-thon-er Jessica Mkitarian wrote the article 8 Ways to Visualize Argo Data which was shared on NOAA Research's social media with great insights. This article was the first attempt to bring all the Argo data viz platforms together into one resource. In December 2019, Jessica led a telecon to follow up on these efforts. Notes and attendance from the telecon can be viewed here. Next steps forward are to create social media accounts that can provide general Argo information to reach external audiences and excite the general public about Argo and its importance, and to develop either the Scripps Argo website or argo.net site. The intention of these efforts is to help spread information and education about Argo's role in ocean science and society, engage external audiences that could become partners, and encourage a new generation of oceanographers and Argo Program stewards. Accomplishing these goals will require time commitments and management from a dedicated group. I think these efforts have been loosely coordinated so far, and a formal group (VOX?) could help move these initiatives forward.

8. Upcoming science conferences and technical workshops –

8.1. 2nd Ocean Observers Workshop in 2020 (C. Gourcuff)

The Ocean observers is an international outreach and education network related to all in situ ocean observations. It is made up of different actors involved in marine sciences outreach and education (scientists, teachers, communicators, etc.), all willing to gather and share science-based educational resources and experiences as well as to establish new collaborations.

The initiative was born in 2017 with the co-organisation of a first successful Ocean Observers workshop by JCOMMOPS and Euro-Argo in Brest. A website was created afterwards (www.oceanobservers.org) to gather existing educational activities and tools presented during the workshop, and the international Ocean Observers Working Group was set up (OOWG) to pursue the initiative and keep this community alive.

The OOWG has now started to organise the 2nd Ocean Observers workshop, that will be held on 17-19 November 2020 in the Balearic Island, in Spain (if the health and travel situation allows). The workshop should be held on 3 full days, hosted by the Balearic Islands Coastal Observing and Forecasting System (SOCIB) and funded through the Euro-Argo RISE H2020 project. The workshop content and agenda will be finalized by the OOWG during next meeting, end of April 2020. It will include a few plenary talks, opportunities for attendees to present their educational activities (talks & “innovative” posters), some break-out sessions with practical activities (4 in parallel, repeated twice). Moreover, social events will be organised every day to encourage discussions between participants. Once the content will be finalized by the OOWG, a call for abstract will be distributed, and AST members help will be requested to spread the information. In parallel, it was agreed with the OOWG that the oceanobservers.org website should be redesigned.

8.2. 7th DMQC Workshop in Liverpool, UK in May 2020 (G. Maze, B. King)

B. King reported on the proposed 7th DMQC Workshop which had been planned for May 2020, but needed to be canceled due to COVID-19. The planned 3.5 day workshop was to include

- Best practices for salty-drifting CTDs
- Deep Argo QC
- Presentation and training around a BODC-led python-conversion of the OWC tool
- Development of tools for code repositories and a QC forum
- Other issues: machine learning, reference data, visualization tools, etc.
- Interactive sessions

The group agrees that these issues still need to be worked on, but that a meeting cannot be held this year, so they plan to progress some of these topics via working groups that can report back to ADMT-21 at the end of 2020.

The group will explore holding the workshop in 2021, possibly in conjunction with the proposed Deep Argo workshop.

8.3. 7th Argo Science Workshop in 2021 (S. Pouliquen)

S. Pouliquen offered hosting a 7th Argo Science Workshop at the Royal Belgian Institute of Natural Sciences in Brussels where the EuroGOOS office is hosted. She suggested in September or October of 2021. The EuroArgo ERIC and EuroArgo Rise project would support the meeting and representatives of the European Commission could be invited. The meeting could also be identified as an even linked to the UN Decade of the Ocean.

8.4. Deep Argo Workshop hosted by EuroArgo in 2021

Euro-Argo proposed to hold the next Deep-Argo workshop as part of the Eurosea European project. Considering that a few workshops will take place in 2021, it is proposed to organize back-to-back the Deep-Argo and the DMQC workshops, possibly in May 2021. It would be interesting to invite GOSHIP and Oceansites representatives to this workshop to address DMQC and deployment issues, deep ocean observation strategy and joint scientific analyses. The organisation of this workshop will be further discussed as part of the Deep Argo Mission Team Meeting in the coming weeks.

Action item 18: AST encourages the various proposed workshops in 2020-2021. Given the possible difficulties in traveling, please consider holding some meetings back to back. The Deep Argo Workshop and the 7th DMQC workshop may consider holding meetings back to back in spring 2021. The 7th Argo Science Workshop might aim for fall of 2021 in Belgium. Consider a technical workshop in 2022 hosted in China.

9. Future meetings

9.1. ADMT-21: November 2020 in Miami, FL, USA

The ADMT-21 meeting is scheduled to be hosted by AOML in Miami, FL on 29 November – 4 December, 2020. There will be the usual ADMT plenary, 1.5 days of BGC ADMT and a 1 day workshop for DACs to find ways to harmonize their efforts going forward to reduce the burden on DACs when new float types arrive, format changes occur, etc. The ADMT co-chairs acknowledge that the meeting may not be able to occur in person due to continued COVID-19 travel restrictions, but that virtual sessions could occur that week instead.

9.2. AST-22

H. Claustre has secured the opportunity to have the AST-22 meeting in conjunction with Monaco Ocean Week in 22 – 26 March, 2021. This is a great opportunity for outreach for Argo and there will likely be a joint session Argo can participate in to interact with others at the meeting. The OceanPredict community also requested holding their workshop this week as well and H. Claustre is working on finding rooms to accommodate the AST-22 plenary, a BGC AST, the OceanPredict workshop and a vendor session.

B. Greenan has offered to host AST-23 in Halifax, Canada.

Action item 19: AST to provide volunteers to form a planning committee to help H. Claustre develop a schedule and plan an effective AST-22 meeting during Monaco Ocean Week in 2021, potentially with a sub group for outreach.

10. AST & AST Exec Membership

As Argo grows, it will likely need to rely more on the AST executive committee to help coordinate and communicate with National Programs. In light of that, there is a proposal to ensure that regional AST exec members identify another person who can help them and be a back up if they are not available. For some members of the exec, there are already alternates due to co-chairs. Here is the make-up of the exec committee:

- Co-chairs of AST, as representatives of the global, full depth, multidisciplinary network
- Co-chairs of Deep and BGC missions in charge of liaising the Deep and BGC missions with the core mission
- Co-chairs of ADMT in charge of data management aspects to advise the AST and receive scientific guidance
- Argo director
- Argo Technical coordinator
- Argo Program Office coordinator
- OceanPredict or modeling community representative
- 5 AST members and 5 alternate AST members selected in order to provide an appropriate regional distribution and to reflect the major contributions to the Argo Program. These members are in charge of coordinating with other AST members in their region in the following ways:
    - From nations in their region to Exec on items that the region would like addressed
    - From Exec to nations in their region to communicate decisions taken at the AST and actions to be managed

Action item 20: AST executive committee is adjusting membership to include 1 representative per region, with 1 alternate. Regions defined as: N. America, Europe, N. Asia (Japan, Korea, China), S. Asia/S. Hemisphere (India, Aus, NZ, S. Africa). When the two people are identified, please send the choices to S. Wijffles, T. Suga, B. Owens and M. Scanderbeg. Update AST webpage accordingly.

Action Items

	Action	Responsibility	Status

1.	Finalize Argo Environmental Impact statement(s) created by S. Riser, S. Wijffels and EuroArgo. Please send comments, especially ones that can help put some of the numbers into context for the general public. When finalized, the statement information will be featured on the redesigned AST website.	Riser, Wijffels, EuroArgo, AST, Scanderbeg	
2.	Ask M. Belbeoch to monitor O2 only floats separately from the 5-6 sensor BGC floats. Ask M. Belbeoch to track coverage & KPIs by BGC parameter.	Belbeoch	
3.	Ask BGC Mission Team to explore ways to reduce the cost of BGC floats for countries purchasing only a small number of floats.	BGC Mission Team	
4.	Ask Deep & BGC Mission Teams to do an in-depth analysis on the utility and practicality of adding O2 sensors to all Deep floats.	Deep & BGC Mission teams	
5.	Following the COVID-19 crisis as well as the build-up of the BGC and Deep Argo Missions, the AST supports basin deployment planning discussions twice per year for each basin.	M. Belbeoch, National Programs	
6.	When COVID-19 crisis is over, ask AST to work together to try and identify potential weak spots in the array to target for deployments. Discuss how to distribute SBE CTDs in such a manner as to take into account array health, National Program budgeting constraints, float production ability, float deployment opportunities, etc.	AST & National Programs	

7.	Ask each PI/ National Program to consider asking for exceptions to budget constraints due to COVID-19 to continue buying and deploying floats. For example, perhaps floats can be purchased in advance.	PIs	
8.	AST is officially adopting the new governance model which describes a single infrastructure which can deliver data streams from all the missions. Post this information on the AST website, including Terms of Reference for AST, BGC Argo Mission Team and Deep Argo Mission Team and pathway papers for BGC and Deep.	AST, BGC & Deep Mission Teams, Scanderbeg	
9.	Ask BGC and Deep Argo Mission Teams to draft implementation pathway paper to assist National Programs in their planning.	BGC Mission Team	
10.	Ask AST members to be ready to reach out to their National IOC reps to gather their support for Argo and efforts to facilitate deployments and measurements within EEZs.	AST members	
11.	AST reminds all PIs that standard Argo floats cannot be deployed into EEZs without prior clearance. If you add an experimental sensor to an Argo float that may drift into an EEZ, prior clearance from the coastal state is needed. This is critical to maintaining good standing with the IOC. When the sensor looks ready for a global pilot, please approach the AST to seek approval for global pilot phase.	PIs	

12.	A new Task Team will be formed focused on RBR CTD pilot float and ship-based intercomparison data, to refine and validate corrections needed to complete DMQC. These processes will be documented in the Argo data manual system.	S. Wijffels, B. Owens,	
13.	A Task Team will be formed to agree on a new CPcor value for Deep Argo data. When the value is agreed upon, please share with AST and ADMT so instructions can be given to DACs to implement procedures and changes to QC flags.	G. Johnson to lead, B. King, N. Zilberman, V. Thierry, S. Purkey, S. Hosoda	
14.	AST endorses the combination of core and b-trajectory files and agrees with plan to create a new v3.2 format for the combined trajectory file.	AST, ADMT	
15.	AST encourages ADMT to begin process to deliver BGC data on the GTS for the modeling community. Consult with OceanPredict community to establish priority BGC parameter order after O2. Report to ADMT-21.	ADMT co-chairs, P. Oke, PYLeTraon, F. Carse	
16.	AST supports the finalization and submission of the Argo data paper led by A. Wong.	A. Wong, S. Riser, S. Wijffels	

17.	M. Scanderbeg to work with small group to finalize the content on the new AST website. AST encourages a set of pages to be linked together that are targeted at journalists and the public with basic information.	M. Scanderbeg, I. Angel, M. Bollard, F. Carse, M. Donnelly, C. Gordon, C. Gourcuff, B. Greenan, B. Klein, T. Morris, P. Oke, N. Zilberman, M. Belbeoch, J. Gould, J. Mkitarian, S. Diggs, T. Morris, EuroArgo, S. Hosoda, G. Maze et al.	
18.	AST encourages the various proposed workshops in 2020-2021. Given the possible difficulties in traveling, please consider holding some meetings back to back. The Deep Argo Workshop and the 7th DMQC workshop may consider holding meetings back to back in spring 2021. The 7th Argo Science Workshop might aim for fall of 2021 in Belgium. Consider a technical workshop in 2022 hosted in China.	AST, Deep Argo Mission chairs, DMQC workshop leaders, EuroArgo, F. Chai	
19.	AST to provide volunteers to form a planning committee to help H. Claustre develop a schedule and plan an effective AST-22 meeting during Monaco Ocean Week in 2021, potentially with a sub group for outreach.	H. Claustre, M. Scanderbeg, T. Morris for outreach possibilities, ?	
20.	AST executive committee is adjusting membership to include 1 representative per region, with 1 alternate. Regions defined as: N. America, Europe, N. Asia (Japan, Korea, China), S. Asia/S. Hemisphere (India, Aus, NZ, S. Africa). When the two people are identified, please send the choices to S. Wijffles, T. Suga, B. Owens and M.	Regions, Scanderbeg	

	Scanderbeg. Update AST webpage accordingly.		

11. Agenda

12. National Reports

Bulgarian Argo Activities

Present status and further plans

V.Slabakova, A. Palazov and N. Valcheva

March 2020

BulArgo programme is a component of the project MASRI – Infrastructure for sustainable development of marine research including the participation of Bulgaria in the European Infrastructure Euro-Argo. (http://masri.io-bas.bg/), a part of the National roadmap for scientific Infrastructure of Republic of Bulgaria. The BulArgo comprises a consortium of three scientific organizations: Institute of Oceanology (IO-BAS) in Varna, Sofia University "St. Kliment Ohridski" and National Institute of Meteorology and Hydrology in Sofia.

1. The status of implementation

During 2019, three Argo floats were successfully deployed in the Black Sea under the framework of BulArgo activities and the Italian Argo programme. Two of the floats were ARVOR-I and ARVOR-DO type and were purchased by Institute of oceanology-BAS whilst, one standard Arvor-I float was deployed under the Italian Argo programme. The floats were tested and deployed by the Bulgarian Argo team in the western Black Sea form board of R/V Akademik. All floats integrate Iridium satellite telemetry system which provides a dual telecommunication capability allowing modification of the configuration in real-time.

The BulArgo (WMO 7900595 and 7900595) floats were deployed on August, 10th and December, 5th in Bulgarian EEZ at depths 1480m and 1100, respectively. Both floats were programmed to cycle between the surface and 2000 dbar every 10 days and to drift at the parking depth of 1000 dbar. The floats are still active. The status information for the Bulgarian floats deployed in the Black Sea during 2019 is presented on Table 1. Their surface positions are shown on Fig 1.

Model	WMO	Deployment date	Deployment time	Latitude	Longitude	Cycles	Status	Cycle
Arvor-I	7900595	10/08/2019	11:27	43.16	29.15	23	Active	10
Arvor-I-DO	7900596	05/12/2019	22:59	42.48	28.64	11	Active	23

Table 1. Status information for the Bulgarian floats deployed in the Black Sea during 2019

Additionally, Bulgarian Argo team deployed on 2nd December an Italian ARVOR-I float (WMO 6903766) in the western Black Sea from board of R/V Akademik. The float has a parking depth at 200 dbar and maximal profiling depth at 1500 dbar. In the frame of EA-RISE project, Institute of oceanology -BAS was purchased an ARVOR-I float. It will be deploy in late summer of 2020.

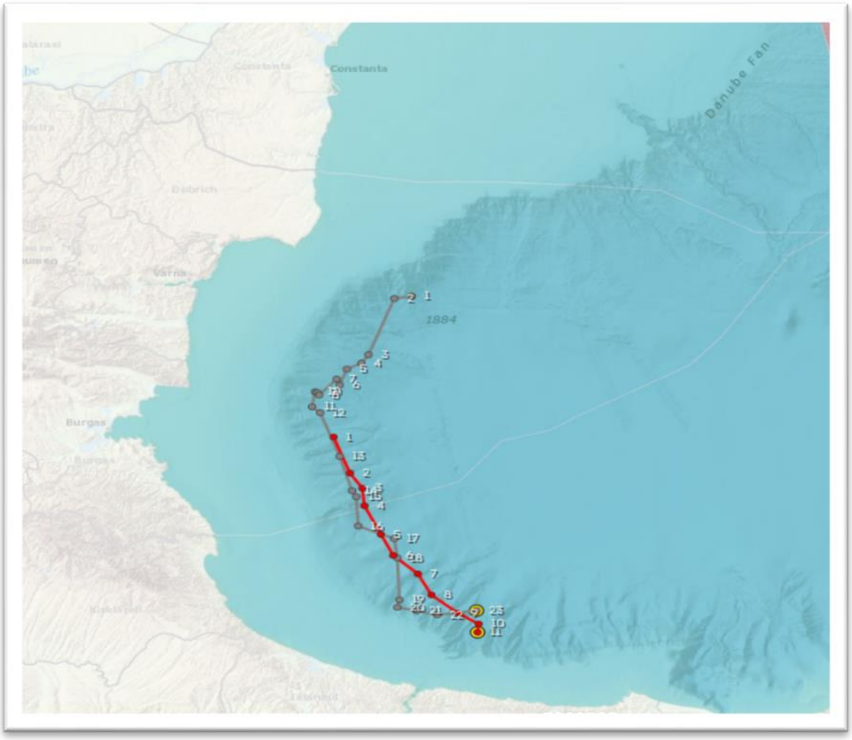

Figure 1. Surface positions of Argo floats deployed in the Black Sea

a) *__status of contributions to Argo data management (including status of pressure corrections, technical files, etc)__*

The data management for the BulArgo floats was done by the Coriolis GDAC. Metadata and data are available through the Coriolis web site in near real-time.

b) *__status of delayed mode quality control process__*

At present the standard procedures for delayed mode data processing and quality control of BulArgo data are performed at the IO-BAS.

2. Present level of and future prospects for national funding for Argo

On April 5th, 2018, Bulgaria has become a regular member of Euro-ARGO ERIC and as such has the obligation to ensure deployment of at minimum of 3 Argo floats per year. The funding covers float procurements in the period 2019-2023, deployment and communication coasts and part-time personnel support.

For 2020 the Bulgarian Ministry of Education and Science provided funding to buy 3 Argo floats, including 2 instruments with dissolved oxygen sensors. The Ministry is committed to provide funding in order to sustain the Bulgarian contribution to Argo beyond 2020 as a member of the Euro-Argo Research Infrastructure Consortium.

3. Summary of deployment plans

The Bulgarian Argo deployment plan for 2020 is detailed in Table 1. The area of floats deployment is western Black Sea.

Year	Month	Programme/Project	Float type	Quantity
2020	Aug - Dec	BulArgo	Arvor DO-I	2
2020	Aug - Dec	BulArgo	Arvor -I	1
2020	Jul - Dec	EA-RISE	Arvor -I	1

4. Summary of national research and operational uses of Argo data

BulArgo focuses on both research topics and marine climate monitoring of the Black Sea.

All Argo data are routinely assimilated into the BS-MFC operational Black Sea forecasting system of the Copernicus Marine Environment Monitoring Service (CMEMS).

Argo data are being used by researchers in Bulgaria to improve the understanding of Black Sea properties (e.g. deep red fluorescence signal, water mass disappearance, IOPs). A list of bibliography is available at the end of this report.

5. Issues that your country wishes to be considered and resolved by the Argo Steering Team regarding the international operation of Argo.

At the moment we have no suggestion.

6. Number of CTD cruise data added to the Argo reference database

The CTD casts were performed just before the floats deployment. No data uploaded to the Argo reference database.

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2019 Argo Canada report of activities
(submitted by Blair Greenan, Fisheries and Oceans Canada)

21st meeting of the Argo Steering Team (AST-21)
Southampton, UK
16-20 March 2020

1. Status of implementation (major achievements and problems in 2019)

- *floats deployed and their performance*

From January 2019 to December 2019, Argo Canada deployed 2 MetOcean NOVA floats in the northeast Pacific and 36 NKE Arvor floats (18 in the northeast Pacific, and 18 in the northwest Atlantic). Of these 38 floats, 1 MetOcean NOVA float died prematurely. The 37 remaining floats are still operational and functioning properly. As of 21 January 2020, Canada has 95 operational floats in the Argo Canada program.

- *technical problems encountered and solved*

Several Arvor floats stayed at the surface immediately after deployment. However by resetting the floats remotely, the problem was solved.

- *Status of contributions to Argo data management* *(including status of conversion to V3 file formats, pressure corrections, etc)*

DFO Ocean Sciences Branch, continues to acquire data from 95 Argo floats. Data are issued to the GTS and GDACs hourly in BUFR TM315003 and NetCDF formats. Data are available for delayed mode QC as soon as they are sent to the GDACs. The data of all Canadian floats together with some graphics are posted on a website and updated daily: http://www.meds-sdmm.dfo-mpo.gc.ca/isdm-gdsi/argo/index-eng.html.

From January 2019 to October 2019, 82 % of the data were issued to the GTS in BUFR format within 12 hours of the float reporting. This reporting in the month March 2019 was affected by one of the DFO servers being unavailable. Ad-hoc procedures were put in place during this period to mitigate the problems.

Since AST-20, we have worked on the following:

- Process the oxygen data which have been adjusted by Henry Bittig using the method described in "Oxygen Optode sensors: Principle, Characterization, Calibration, and application in the Ocean" by Henry Bittg et al. (2018), ORCID 0000-0002-8621-3095. These oxygen data were collected by 24 floats which equipped Aanderra Optode sensor and performed in-air oxygen measurements. These floats were deployed between 2004 and 2010. Data for these floats are now available at the GDAC in “A” mode.

- Implement SAGEO2-Argo software developed by Monterey Bay Aquarium Research Institute to evaluate oxygen collected by Nova floats which didn’t collect any in-air oxygen measurements.

  Provide ADMT with quarterly reports on the performance of Argo data on the GTS in TESAC and BUFR formats and assist DACs that have difficulty with BUFR transmission.

- *Status of delayed mode quality control process*

As of January 2020, 48% of all eligible floats, active and inactive, had their profiles QC’d visually and adjusted for pressure according to the latest delayed-mode procedures at least once. The salinity component of DMQC had been performed at least once on 65% of eligible cycles. 71% of B-files had been visually QC’d, and 14% were fully DMQC’d. In addition to DMQC of new profiles, 11 previously-processed floats received either updates to the visual QC or new adjustments in 2019 in response to feedbacks (e.g., reports of density inversions) or to address known issues (e.g., higher likelihood of salinity drift for salinity sensors in the serial number range 6100-7000).

2. Present level of and future prospects for national funding for Argo including a summary of the level of human resources devoted to Argo.

Financial resources

Argo Canada has ongoing funding for the O&M expenditures related to the International Argo program. Shared Services Canada (SSC) is responsible for the costs related to Iridium telecommunications as part of an initiative to centralize these services with the Federal government and will cover the costs for up to 85 core Argo floats. If Argo Canada has more than 85 active Argo floats, DFO is responsible for the additional telemetry charges. Ongoing capital for float purchases has not been identified and, therefore, it remains necessary to request capital resources on an annual basis to obtain the funding required to purchase new floats. The Government of Canada committed $1.31M for purchases of core NKE Arvor-I Argo floats in the Fiscal Year 1 April 2019 to 31 March 2020. The funding resulted in acquisition of 53 core Argo floats in this fiscal year. The Government of Canada also procured three Arvor float equipped with RBR CTDs to contribute to the global pilot for this sensor.

The development of close links between the Argo Canada program and both the operational meteorology and operational oceanography R&D activities at the Canadian Meteorological Centre (Dorval, Québec) has been beneficial. An inter-departmental (Environment and Climate Change Canada, Department of National Defence, Fisheries and Oceans) Memorandum of Understanding entitled CONCEPTS (Canadian Operation Network of Coupled Environmental PredicTion Systems) has provided strong advocacy for the Argo program.

At the G7 meeting in Halifax in October 2018, the Government of Canada announced new funding for the International Argo Program (up to $5.6M over 4 years). The primary intention of this investment is to support the implementation of the BGC-Argo array with a strong emphasis on having ocean observations benefit Small Island Developing States. https://g7.gc.ca/en/environment-oceans-energy-ministers-ready-take-action-oceans-seas-conclude-g7-joint-meeting-healthy-oceans-seas-resilient-coastal-communities/

Human resources

Since 1 April 2015, Blair Greenan of the Bedford Institute of Oceanography (BIO) has acted as national leader of the Argo Canada program. The logistics related to float deployments and satellite data transmission has been handled by Ingrid Peterson, also at BIO. On the west coast, Tetjana Ross (DFO, Institute of Ocean Sciences) is responsible for Pacific deployments for Argo Canada.

The following DFO staff contribute to the logistics and data management for Argo Canada:

Anh Tran (MEDS, Ottawa)
Mathieu Ouellet (MEDS, Ottawa)
Isabelle Gaboury (MEDS, Ottawa)
Blair Greenan (BIO, Halifax)
Ingrid Peterson (BIO, Halifax)
Igor Yashayaev (BIO, Halifax)
Adam Hartling (BIO, Halifax)
Tetjana Ross (IOS, Sidney)
Lindsay Mazzei (IOS, Sidney)
Denis Gilbert (IML, Mont-Joli)

Denis Gilbert (DFO) and Roberta Hamme (University of Victoria) are assisting Argo Canada with issues related to dissolved oxygen. In particular, they have been providing expert advice and support on quality control and data processing of DO data from the MetOcean DOVA floats deployed in the Labrador Sea.

In addition to the above persons, we benefit from the technical support of sea-going staff that follow pre-deployment protocols and perform the float deployments.

National Coordination

With increasing participation in the Argo program within Canada, both in core Argo and BGC-Argo, it was decided to establish a new governance structure in 2018. The Canadian Argo Steering Team (CAST) provides scientific leadership and oversees the development and implementation of the Canadian contribution to the International Argo Program. The CAST is chaired by Blair Greenan.

The Canadian Biogeochemical-Argo Committee (henceforth the Committee) facilitates the implementation of the Canadian contribution to the Biogeochemical-Argo program by coordinating and advising national efforts, and acting as liaison to the International Biogeochemical-Argo Steering Committee. The Committee is chaired by Katja Fennel.

Both of these committees held at least one virtual meeting in 2019.

The Canadian BGC Argo committee had two poster presentations at the OceanObs19 Meeting in Hawaii: one representing Canadian BGC Argo efforts overall (led by Blair Greenan) and one describing an effort to raise funding for a BGC Argo array in the northwest North Atlantic (led by Katja Fennel). The committee frequently interacted via e-mail and in person at conferences. A dedicated website was set up at http://bgc-argo.ocean.dal.ca/.

3. Summary of deployment plans (level of commitment, areas of float Deployment, low or high resolution profiles, Argo extensions) and other commitments to Argo (data management) for the upcoming year and beyond where possible..

Argo Canada will procure 56 new NKE ARVOR floats by March 2020. In 2020 and early 2021, Argo Canada plans to deploy about 40 of the floats (firm commitment). Twenty will be deployed in the Northeast Pacific, and about twenty in the Northwest Atlantic. Seven of the ARVORS in the Pacific will have oxygen sensors, and three of the ARVORs in the Atlantic will have RBR CTD sensors. We are currently seeking deployment opportunities for the remaining 16 floats, some of which may be deployed in 2021.

4. Summary of national research and operational uses of Argo data as well as contributions to Argo Regional Centers. Please also include any links to national program Argo web pages to update links on the AST and AIC websites.

The Government of Canada CONCEPTS initiative (Canadian Operational Network for Coupled Environmental Prediction Systems; http://science.gc.ca/eic/site/063.nsf/eng/h_97620.html) uses observations from the Argo array for a variety of operational and research applications. These include direct assimilation into operational weather and environmental prediction systems, monitoring of forecast quality (verification), and well as detailed research to improve model physics (e.g. further development and optimization of model parameterizations) and data assimilation (e.g. Observing System Experiments). The CONCEPTS Global Ice Ocean Prediction System (GIOPS) provides daily estimates (analyses) of global ocean and sea ice properties using a multi-variate data assimilation system assimilating Argo observations together with other sources of in situ temperature and salinity, satellite altimetry, and sea surface temperature data. GIOPS analyses are used to initialize the ice-ocean components of the coupled Global Deterministic Prediction System (GDPS), responsible for providing operational medium-range weather forecasts for Canadians. GIOPS analyses are also used to initialize the operational forecasts from the Canadian Seasonal-Interannual Prediction System (CanSIPS). An update to the Regional Ice Ocean Prediction System (RIOPS) was accepted for operational implementation in December 2018 that will now include a regional data assimilation system package (including Argo), as well as extend the domain to include the North Pacific Ocean in addition to the Arctic and North Atlantic Ocean. This system will provide a daily three-dimensional state of the ocean estimate for Canada's three coastlines.

The Department of National Defence scientists, operational oceanographers and sonar operators routinely use real time Argo vertical profiles to assess model performance and in some instances use as data to compute acoustic range predictions (both at sea and in the Meteorology and Oceanography Centres (Esquimalt and Halifax)). DND uses the web-based Ocean Navigator tool (http://navigator.oceansdata.ca/public/) to assist with these activities.

The Canadian-Pacific Robotic Ocean Observing Facility (C-PROOF, http://cproof.uvic.ca/) is funded by the Canadian Foundation for Innovation (CFI) and B.C. Knowledge Development Fund (BCKDF) to build ocean observing capacity off the British Columbia coast. C-PROOF is based at the University of Victoria. A fleet of autonomous gliders, Argo floats, and moorings will provide ocean scientists with long-term monitoring of the ocean at the small scales important to resolve upper ocean physical and biological properties. C-PROOF will add dissolved oxygen sensors to 7 of the DFO core Argo floats that will be deployed in the Northeast Pacific in 2020. This project is planning to deploy BGC-Argo floats along Line P in future years.

Argo data have proven to be invaluable to understanding marine heatwaves in the Northeast Pacific. The lingering influence of the "Blob" in the NE Pacific was revealed through Argo data. Argo data are regularly used in preparing DFO's State of the Pacific Ocean and (new in 2019) State of the Salmon reports.

The Argo Canada web site is maintained by Fisheries and Oceans Canada at http://www.isdm.gc.ca/isdm-gdsi/argo/index-eng.html.

The Canadian BGC Argo website is maintained by Katja Fennel at http://bgc-argo.ocean.dal.ca/.

5. Issues that your country wishes to be considered and resolved by the Argo Steering Team regarding the international operation of Argo. These might include tasks performed by the AIC, the coordination of activities at an international level and the performance of the Argo data system. If you have specific comments, please include them in your national report.

Nothing to report this year.

6. To continue improving the quality and quantity of CTD cruise data being added to the reference database by Argo PIs, it is requested that you include any CTD station data that was taken at the time of float deployments this year. Additionally, please list CTD data (calibrated with bottle data) taken by your country in the past year that may be added to the reference database. These cruises could be ones designated for Argo calibration purposes only or could be cruises that are open to

the public. To help CCHDO track down this data, please list the dates of the cruise and the PI to contact about the data.

CTD data collected by DFO researchers are routinely transferred to MEDS and from there to NOAA NCEI on a yearly basis. CCHDO acquires data directly from scientists. In 2018, MEDS contacted CCHDO to resume exchanges for Line-P. CCHDO can acquire Line-P data up to June 2018 directly from the https://waterproperties.ca/linep website. Once the Line-P data has been ingested by CCHDO, MEDS will work to complete the AR07W (Labrador Sea) data.

7. Keeping the Argo bibliography (http://www.argo.ucsd.edu/Bibliography.html) up to date and accurate is an important part of the Argo website. This document helps demonstrate the value of Argo and can possibly help countries when applying for continued Argo funding. To help me with this effort, please include a list of all papers published by scientists within your country in the past year using Argo data, including non-English publications.
There is also the thesis citation list (http://www.argo.ucsd.edu/argo_thesis.html). If you know of any doctorate theses published in your country that are missing from the list, please let me know.
Finally, if you haven't already sent me a list of Argo PIs in your country, please do so to help improve the statistics on how many papers are published including an Argo PI vs no Argo PIs.

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Ph.D./M.Sc. Thesis

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Gordon, C., 2019: Autonomous measurement of physically and biologically driven changes in dissolved oxygen in the northern Gulf of Mexico, MSc thesis, Dalhousie University, http://hdl.handle.net/10222/76822

Lundrigan S., 2019: Mean and Eddy Induced Transport in the Ocean Region Adjacent to the Greenland-Scotland Ridge, Ph.D. thesis, Memorial University of Newfoundland, 188 pp.

Books

The 21th Argo Steering Team Meeting, Southampton, U.K., March 16-20, 2020

Argo Chinese National Report 2019

(Zenghong Liu & Jianping Xu, The Second Institute of Oceanography, Ministry of Natural Resources)

1. The status of implementation

- floats deployed and their performance

During 2019, China deployed 11 floats (2 APEX, 2 full-equipped BGC PROVOR, 1 PROVOR-DO, 4 PROVOR and 2 HM2000) in the northwestern Pacific Ocean and Indian Ocean. Most of these floats are China-Argo-equivalent floats, and were deployed by 3 PIs from the Second Institute of Oceanography (SIO), Ministry of Natural Resources (MNR). It is worth noting that 5 floats were deployed from a joint investigation cruise between China and Sri Lanka in Indian Ocean during December 2019. In total, China has deployed 434 floats, and approximately 70 floats are operational by the end of 2019.

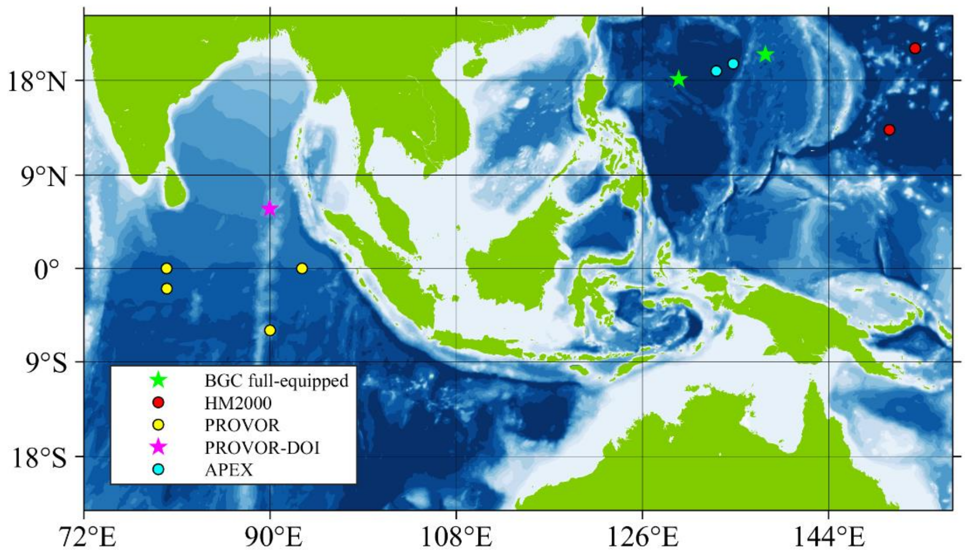


Fig.1 Launch positions of the floats during 2019.

- technical problems encountered and solved

Technical problem for APF11: There are still some cases for APEX APF11 (V2.8.3-STD-SAIL) float that miss GPS fix in science log file, which means the float was difficult to get GPS fix during the sea surface. We have to find the missing GPS fix information in the system log file of the subsequent cycle.

-status of contributions to Argo data management (including status of pressure corrections, technical files, etc)

During 2019, CSIO received data from 107 active floats (37 APEX, 54 PROVOR, 12 HM2000, 3 ARVOR and 1 NAVIS) and submitted 7,207 TS profiles (plus 552 DOXY, 741 CHLA, 741 BBP, 593 CDOM, 1,335 DOWN_IRRIDIANCE, 445 NITRATE and 235 pH) to GDACs. All the profile data are converted into BUFR bulletin and send to the GTS via Chinese Meteorological Agency (CMA, Beijing). Due to occasional breakdown of the FTP server in the Meteorological Bureau of Zhejiang Province, CSIO established a FTP connection with the CMA in last December for data distribution on GTS.

- status of delayed mode quality control process

Last August CSIO sent a technician to CSIRO for receiving a DMQC training under the support from the Ministry of Science and Technology (MOST). We thank CSIRO for their sincere help to China Argo. Based on the OWC tools, about 11,689 D-files (6,018 D-files and 5,671 BD-files) were submitted to GDACs this year from CSIO. The backlog is still there, about 3,7000 profiles are DM pending.

- status of post-processing of the global Argo data set

CSIO quarterly updates the global Argo data set which is derived from all the profile files provided by GDAC. 15 QC tests including a climatological test and MEDD test are being applied prior to generating new QC flags. The global BGC-Argo data set with originally allocated QC flags is also updated at CSIO. Both the data sets are accessible from ftp://ftp.argo.org.cn/pub/ARGO/global/.

- status of Chinese COPEX float

At the end of 2019, the National Ocean Technology Center (NOTC), MNR decided to cooperate with Tianjin Deepinfar Ocean Technology CO., Ltd for COPEX profiling float's development and manufacture. They deployed 2 COPEX floats (installed with SBE41 CTD) using BeiDou satellite for data transmission in last December for field test. Till now both the floats are operational and reporting observations. CSIO is going to conduct an assessment and provide a technical report to NOTC 3 months after floats' deployment. Before this, COPEX float is still recommended not to be used by China Argo Project.

- status of Chinese HM2000 float

Due to the limited coverage of the BeiDou transmission system, the manufacturer of the HM2000 float, HSOE developed the float using Iridium satellite for data transmission last year. Two prototypes were deployed in the northwestern Pacific Ocean during September-October 2019. After that, a batch of HM2000 (17 floats) with Iridium communication were deployed by FIO during January-February 2020. All the floats have transmitted good T/S profiles.

HSOE also developed HM2000-DO float last year. Aanderaa 4330 Optode was mounted on the top of float which allows sampling in the air. One HM2000-DO float was deployed in this February, but it did not report any data. HSOE is trying to investigate this issue.

- status of Chinese deep float

Three organizations are developing deep profiling float with the support from the Pilot National Laboratory for Marine Science and Technology, Qingdao (QNLM), they are HSOE, Tianjin University (TJU) and Ocean University of China (OUC). Ten floats (1 TJU_D float, 5 OUC_D floats, and 4 HM4000 floats manufactured by HSOE) were deployed in the northwestern Pacific Ocean last year for a pilot test of different products. Except TJU_D float (installed with a CTD sensor produced by NOTC), all of these floats are installed with SBE 37 CTD sensor, having a maximum profiling depth 4000 dbar and 24-hour cycle time. The OUC_D and HM4000 floats completed over 100 cycles during their lifetime (< 6 months), while the TJU_D float survived only 1.5 months. After a careful analysis on their observations, a technical report was provided by CSIO. The SBE61 and RBR Argo CTD sensors are recommended to replace SBE 37 CTD (designed for profiling observing), because many small hooks are found in each salinity profile.

2. Present level of and future prospects for national funding for Argo including a summary of the level of human resources devoted to Argo.

This year is very important to China Argo. We estimate that funding for approximately 500 floats has been secured. If we want more floats to be deployed in 2020, the main difficulty may come from the uncertainty of manufacturer's delivery time and deployment opportunity. We expect 150~200 floats (including 22 BGC Argo and 3 Deep Argo) can be deployed in the western Pacific Ocean, Indian Ocean and the South China Sea during 2020.

About 9 staffs at CSIO contribute to the logistics and data management for China Argo and BGC-Argo. Two staffs at NMDIS are contributing to the Argo data collection.

3. Summary of deployment plans (level of commitment, areas of float Deployment, low or high resolution profiles) and other commitments to Argo (data management) for the upcoming year and beyond where possible.

During January-February 2020, two cruises in Indian Ocean are being organized by the First Institute of Oceanography and CSIO, respectively, from which 28 floats have been deployed. One cruise organized by QNLM has been confirmed to deploy 12 floats in the South China Sea and northwestern Pacific Ocean. 20 core Argo floats are to be deployed in the TPOS-2020 region, but the cruise has not been confirmed yet. CSIO is designing a special deployment cruise from which about 80 HM2000 floats will be deployed in the South China Sea and the northwestern Pacific Ocean. 2 BGC-Argo (measuring 5 core BGC variables except pH) is going to be deployed in northeastern Pacific Ocean (station Papa), and another one (with ECO sensor) is going to be deployed in the northwestern Pacific Ocean (subtropical gyre center) with the 2020 summer cruise organized by Xiamen University. However, many floats have to find appropriate opportunities for deployment in the western Pacific Ocean, Indian Ocean and the South China Sea.

4. Summary of national research and operational uses of Argo data as well as contributions to Argo Regional Centers. Please also include any links to national program Argo web pages to update links on the AST and AIC websites.

CSIO currently provides a mirror access to all the profile files, and also provides a free download of the BOA_Argo (the Argo product developed by CSIO) and post-processed global Argo data set (quarterly updated). Argo data have been widely used in scientific research and operational forecasts.

CSIO maintains the website of the China Argo Real-time Data Center (http://www.argo.org.cn) where the implementation status of China Argo, real-time data display including observed profiles, float trajectory, profile data, the derived products and status of global Argo are accessible. CSIO also maintains a WEB-GIS based website (http://platform.argo.org.cn:8090/flexArgo/out/argo.html) for global Argo data query, display and downloading. A BGC-Argo data visualization website is also being developed under the cooperation with Zhejiang University.

5. Problems encountered during the operation of international Argo and suggestions

The implementation of the Argo 2020 will need extensive collaborations from those coastal countries (e.g. Sri Lanka, Myanmar, Pakistan, etc) who have not been Argo member states. They usually do not have a capability to purchase and deploy floats, but they might to be able to provide float deployment/recovery opportunities for those areas we haven't enough ship time. It is therefore necessary to advertise Argo program and obtain point of contact in those countries.

6. To continue improving the number of CTD cruise data being added to the reference database by Argo PIs, it is requested that you include the number and location of CTD cruise data uploaded by PIs within your country to the CCHDO website in the past year.

No CTD data were submitted in 2019. It has been found that laboratory salinometer is barely taken during most cruises, resulting in low quality of CTD data. We have reminded those PIs this issue, and also encouraged them to provide high quality CTD casts for Argo DMQC community in the future.

7. Keeping the Argo bibliography

The following articles are not listed in Argo Bibliography:

Li X, and Luo Y-Y. 2019. Inter-annual variations of the eastern subtropical mode waters in the Pacific Ocean and their formation mechanisms. Periodical of Ocean University of China (in Chinese), 49(2): 1-13.

Zhou C, Zhang J, Yang J, Xu M, and Zhang Q. 2019. 4 DVAR assimilation of SST and SSH data in the South China Sea based on ROMS. Haiyang Xuebao (in Chinese), 41(1): 32-40.

Yang X, Wu X, Liu Z, and Yuan C. 2019. A preliminary study on an upper ocean heat and salt content of the western Pacific warm pool region. Acta Oceanologica Sinca, 38(3): 60-71. https://doi.org/10.1007/s13131-019-1399-1.

Cao K, Sun W, Meng J, and Zhang J. 2019. Assessment and comparison of Sea Surface Salinity data derived from SMAP and SMOS based on Argo measurements. Advances in Marine Science (in Chinese), 37(4): 574-587.

Wang Y, Han Z, Zhou W, and Wu Y. 2019. Quality assessment of the SMAP Sea Surface Salinity in western Pacific Ocean based on Argo buoy data. Advances in Marine Science (in Chinese), 37(3): 387-397.

Liu Y, and Xing X. 2019. An improvement on climatology-based correction method of Argo-observed dissolved oxygen data. Oceanologia et Limnologia Sinica (in Chinese), 50(5): 994-1001.

Liu Y, and Xing X. 2019. Sensor principle and quality control of the dissolved oxygen data observed using Argo floats. Marine Sciences (in Chinese), 43(1): 28-37.

Ma T, Qi Y, and Cheng X. 2019. Intraseaonal-semiannual variability of barrier layer thickness in the eastern equatorial Indian Ocean and Bay of Bengal. Journal of Tropical Oceanography (in Chinese), 38(5): 18-31.

ARGO National Report 2020 – The Netherlands

1) **Status of implementation**
The Dutch Argo program started in 2004 and is run by the Royal Netherlands Meteorological Institute (KNMI).
The Netherlands are a founding member of the Euro Argo ERIC.
Contribution to the Argo array:
   - 89 floats have been purchased since 2004
   - 25 are working

Two floats have been purchased in 2019, and probably three will be bought in 2020.

2) **Present level of (and future prospects for) national funding for Argo including summary of human resources devoted to Argo**.
In their observation strategy adopted in 2006 KNMI has expressed the intention to deploy about 7 floats per year. However, budget constraints meant that to no floats could be bought in 2018, and only two in 2019. The financial pressure will probably last for some more years.
One person (Andreas Sterl) is working on ARGO. He does so besides his other duties.

3) **Summary of deployment plans** (level of commitment, areas of float deployment) and for other commitments to Argo for the coming year (and beyond where possible).
Three floats in 2020, planned for deployment later this year in the southern Atlantic Ocean.

4) **Summary of national research and operational uses of Argo data**
Argo data and/or products derived from Argo data are used to initialize climate models by groups at KNMI and Utrecht University.
Process studies using Argo data are performed at the Netherlands Institute for Sea Research (NIOZ), especially in the Caribbean Sea.

5) **Issues that your country wishes to be considered (and resolved) by AST regarding the international operation of Argo**
Nothing.

6) **CTD data uploaded to CCHDO**
No.

7) **Bibliography**

Euro-Argo report 2019 – AST21

The Euro-Argo research infrastructure organizes and federates European contribution to Argo (www.euro-argo.eu); it is part of the European ESFRI roadmap on large research infrastructures. The Euro-Argo ERIC (European Research Infrastructure Consortium) and its governance structure (Council, Management Board and Science and Technological Advisory Group) was set up by the Commission Implementing Decision (2014/261/EU) of May 5, 2014, with 9 funding members. The Research Infrastructure is made up of a central office based in France (Ifremer, Brest) and distributed national facilities (Figure 1). 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. The Euro Argo ERIC delegates some of its activities to the national facilities who have the relevant expertise (e.g. data management and quality control, float deployment), and according to their areas of responsibility.

In 2019, the Euro-Argo ERIC involves 13 countries: **11 Members, 1 Observer** and 1 Candidate.

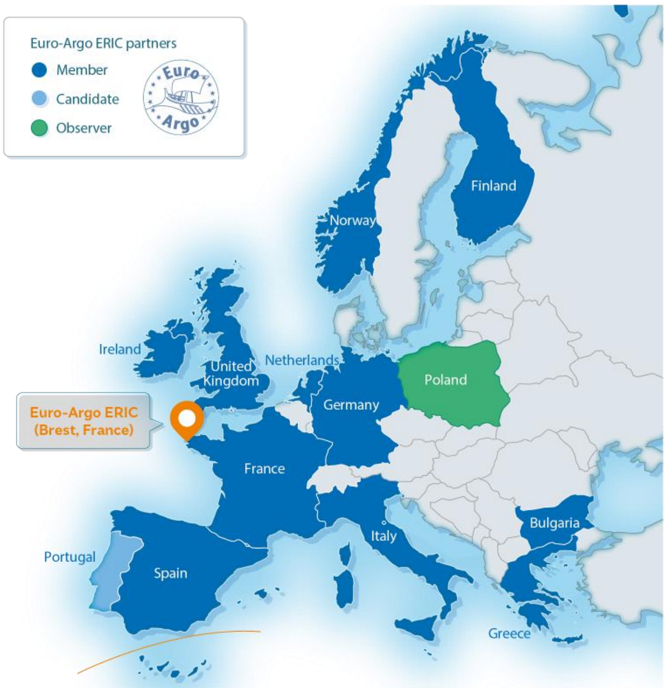


Figure 1. Euro-Argo ERIC membership in 2019

The Euro-Argo ERIC coordinates the European contribution to Argo and monitors it with the aims of maintaining ¼ of the Argo array.

This report presents the contribution of EU funded Argo activities as well as the integrated view of EU plus national European contributions.

1. **The status of implementation** (major achievements and problems in 2019)

- floats deployed and their performance
- technical problems encountered and solved

In 2019, 3 EU-funded floats were deployed: one BGC float funded under the EU H2020 AtlantOS project, deployed in the Mediterranean Sea, and two floats in the framework of the EU H2020 Euro-Argo RISE project, in the Mediterranean (BGC) and Black (T/S) Seas, aiming at evaluating Argo possibilities in shallow water coastal areas. These floats come in addition to the 186 floats deployed by the members. The table below shows the total number of floats deployed, both as number of measurements per variable and per type of float.

Table 1. European floats deployed in 2019, per parameter measured (blue, 7 first columns) and per type of float (green, 5 last columns).

	T&S	O2	Chla	BBP	NO3	Irradiance	pH	Deep	Bio	BGC	core	**Total (floats)**
EU funded	*3*	*1*	*2*	*2*	*1*	*2*	*0*	*0*	***1***	***1***	***1***	***3***
Member states	186	43	18	18	5	16	6	4	**36**	**3**	**143**	**186**
total	**189**	**44**	**20**	**20**	**6**	**18**	**6**	**4**	**37**	**4**	**144**	**189**

The decrease compared to previous years (189 floats deployed in 2019 vs 281 in 2018) is mainly due to delays in deployments of EU-funded floats and UK floats, as well as Deep French floats: the EU-funded floats encountered delays in float purchase, UK was impacted by the Seabird CTD recall (some floats missed their deployment opportunities due to repair/turnaround time at TWR) and France encountered technical issues during Deep float testing, that prevented the planned deployments.

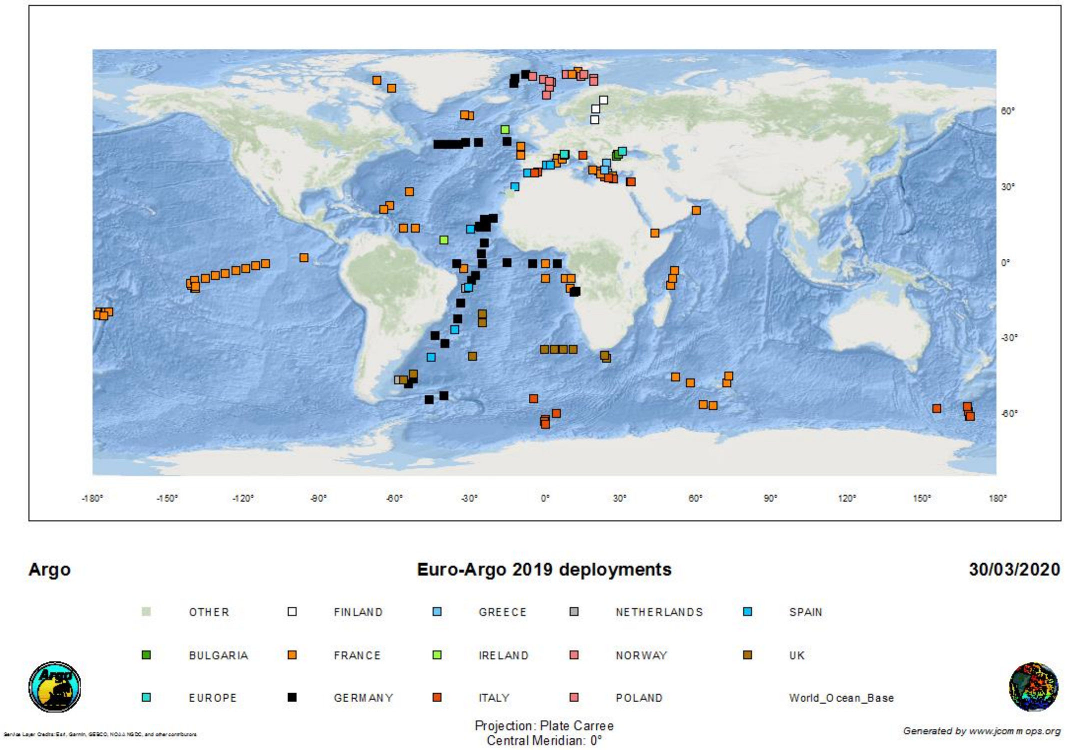


Figure 2. Position of European floats deployed in 2019

- status of contributions to Argo data management (including status of high salinity drift floats, decoding or production difficulties, etc)
- status of delayed mode quality control process

All European floats are processed by Coriolis and BODC DACs (respectively 78% and 22% of the global European fleet), and DMQC is currently shared between four institutes (BSH, OGS, Ifremer, BODC). The percentage of EU-funded floats processed in Delayed Mode (for floats deployed up to the end of 2019) amongst eligible floats is 79%, and 73% if we consider the whole European fleet (EU-funded + National).

The European fleet is impacted by the high salinity drift on SBE sensors (more than 10% of the MOCCA EU-funded floats) and Euro-Argo has started to investigate this issue from a DMQC point of view. Details on this work can be found on the Euro-Argo github public Forum: https://github.com/euroargodev/publicQCforum/issues/11.

2. Present level of and future prospects for national funding for Argo including a summary of the level of human resources devoted to Argo.

The Euro-Argo ERIC coordination Office is a team of 5 permanent and 3 project persons in 2019. This team supports European countries to sustain and optimize the European contribution to the Argo International programme. In 2019, the Euro-Argo ERIC performed an evaluation of its first 5 years activities (*Euro-Argo ERIC, 2019a*) and elaborated its plan for the next 5 years (*Euro-Argo ERIC, 2019b),* with commitments from the 12 countries to support this 5-year plan. Both documents are available at: https://www.euro-argo.eu/Outreach/Euro-Argo-general-documents)

The Euro-Argo RISE EU project (Euro-Argo Research Infrastructure Sustainability and Enhancement), that has started in January 2019 and involves all the Euro-Argo ERIC members except Netherlands for a 4 years duration (December 2022), has been granted 4M€, including funds for float purchase (**12 floats in total including Deep and BGC floats**) and a total of more than **100 men months per year** dedicated to Argo activities in all aspects (technological development, science, data management, outreach, legislation, etc.). Euro-Argo RISE is coordinated by the Euro-Argo ERIC.

Euro-Argo is also involved in the **EuroSea EU project** that will fund **5 Deep floats and 5 BGC floats** to be deployed in the coming years as well as the organisation of workshops, and in the **ENVRI-FAIR EU project** in which Euro-Argo is funded to work on improving **FAIRness** (FAIR: Findable, Accessible, Interoperable, Reusable) of **Argo data**, through the involvement of the two European Argo DACs (BODC & Ifremer).

3. Summary of deployment plans (level of commitment, areas of float deployment, Argo missions and extensions) and other commitments to Argo (data management) for the upcoming year and beyond where possible.

Table 2 summarizes European deployment plans for year 2020, per variable, type of float and region. Amongst the 236 floats that should be deployed in total, 10 are EU-funded.

Table 2. European deployment plans for 2020: total EU-funded + national (EU-funded in brackets). "BGC" stands for floats equipped with the sensors able to measure the 6 BGC variables, and "Bio" stands for other floats equipped with only some of the BGC sensors.

	T&S	O2	Chla	BBP	NO3	Irr	pH	Deep	Bio	BGC	core	**Total**
Nordic	18	13	8	8	3	8	3	4	3	6	5	18
Med Sea	27 (3)	11	1	1	1	1	1	2	2	7	16 (3)	27 (3)
Black Sea	5	2	0	0	0	0	0	0	0	2	3	5
Baltic	11 (2)	7	5	5	3	3	3	0	3	4	4	11
Southern	16	0	0	0	0	0	0	0	0	0	16 (2)	16
Arctic	4	0	0	0	0	0	0	0	0	0	4	4
Global	155 (7)	48 (5)	7	7	7	7	7	24	7 (5)	18	106 (2)	155 (7)
Total	**236 (12)**	**81 (5)**	**21**	**21**	**14**	**19**	**14**	**30**	15 (5)	37	154 (5)	**236 (10)**

Data from all the European floats will be processed in Real Time by Coriolis and BODC DACs, and in DMQC by European teams in their national institutes.

In addition to the data processing, European institutes are continuing their R&D work for improving data quality, through the development of new DMQC methods, both for T/S and for BGC parameters. Collaboration at European level is being enhanced and this will continue in the coming years, thanks to work carried out in Euro-Argo RISE & ENVRI-FAIR projects. BGC data management is also being organised at European level and this work will continue in the coming years.

European Research teams are also involved in technological activities, in particular regarding ice avoidance systems and tests of alternative sensors (RBR, TRIOS, etc.), and work carried out in current EU projects also includes outreach and training activities, as well as community strengthening.

4. Summary of national research and operational uses of Argo data as well as contributions to Argo Regional Centres. Please also include any links to national program Argo web pages to update links on the AST and AIC websites.

Argo data and/or products derived from Argo data are used for operational oceanography within the Copernicus Marine Environment Monitoring Service (http://marine.copernicus.eu/), for satellite calibration and validation and for research carried on by the Euro-Argo ERIC partners (see national reports for details).

Within the Euro-Argo RISE EU project, European contribution to Argo ARCs will be reinforced, in particular in the Southern Ocean ARC (see UK national report).

5. Issues that your country wishes to be considered and resolved by the Argo Steering Team regarding the international operation of Argo. These might include tasks performed by the AIC, the coordination of activities at an international level and the performance of the Argo data system. If you have specific comments, please include them in your national report.

Here is a list of several items that Euro-Argo would like to be addressed at AST level:

- Increase coordination at basin scale level to take into account the development of deep and BGC pilot array and adjust CORE+DEEP+BGC deployment to fill gaps.
- Coordinate priorities in term of SBE delivery to partners taking into account cruise plan/projects milestones and network gaps rather than letting SBE decide on their own.
- Evaluate the impact in term of data lost due to SBE high salty drift failure. Compensation from SBE should be studied.

6. To continue improving the quality and quantity of CTD cruise data being added to the reference database by Argo PIs, it is requested that you include any CTD station data that was taken at the time of float deployments this year. Additionally, please list CTD data (calibrated with bottle data) taken by your country in the past year that may be added to the reference database. These cruises could be ones designated for Argo calibration purposes only or could be cruises that are open to the public. To help CCHDO track down this data, please list the dates of the cruise and the PI to contact about the data.

See national reports

7. Keeping the Argo bibliography (http://www.argo.ucsd.edu/Bibliography.html) up to date and accurate is an important part of the Argo website. This document helps demonstrate the value of Argo and can possibly help countries when applying for continued Argo funding. To help me with this effort, please include a list of all papers published by scientists within your country in the past year using Argo data, including non-English publications.

There is also the thesis citation list (http://www.argo.ucsd.edu/argo_thesis.html). If you know of any doctorate theses published in your country that are missing from the list, please let me know. Finally, if you haven't already sent me a list of Argo PIs in your country, please do so to help improve the statistics on how many papers are published including an Argo PI vs no Argo PIs.

The Euro-Argo ERIC maintains a summary of the European bibliography at http://www.euro-argo.eu/Bibliography and has been advertising publications at http://www.euro-argo.eu/Main-Achievements/European-Contributions/Scientific-Results for several years. Work is currently in progress to enhance these sections of the website: it is planned to present the bibliography in a “sortable” table (similar to BGC-Argo bibliography) and to reduce the number of “Scientific results” summaries, as they are thought to be unappropriated (not understandable by large public). Instead, only 3 papers will be highlighted per year, through their abstract in “Plain Language”. Euro-Argo also plans to advertise European scientific publications related to Argo on a regular basis through Twitter.

References:

Euro-Argo ERIC (2019)a, **Euro-Argo ERIC Activity Report 2014-2018,** https://doi.org/10.13155/71339

Euro-Argo ERIC (2019)b, **Euro-Argo ERIC Five-year plan 2019-2023**, https://doi.org/10.13155/71936

French National Report on Argo - 2019

By the Argo-France Management Board
G. Maze, X. André, C. Cabanes, T. Carval, H. Claustre, C. Coatanoan, F. D'Ortenzio, N. Kolodziejczyk, N. Lebreton, P.Y. Le Traon, A. Poteau, N. Poffa, S. Pouliquen, R. Sauzède, C. Schmechtig and V. Thierry

Background, organization and funding of the French Argo activities

Organization

Argo-France (http://www.argo-france.fr) gathers all the French activities related to Argo and its extension toward deep and biogeochemical measurements. Argo-France is the French contribution to the Euro-Argo European research infrastructure (ERIC) that organizes and federates European contributions to Argo.

All Argo-France activities are lead and coordinated by:

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

Argo-France is part of the Ministry of Research national roadmap on large research infrastructure (TGIR). Argo-France operational activities are organized through the Coriolis partnership (IFREMER, SHOM, INSU, IRD, Météo France, CEREMA, CNES and IPEV). Two research laboratories are leading the Argo-France scientific activities: the "Laboratory for Ocean Physics and Satellite remote sensing" (LOPS, Brest, France) and the "Laboratoire d'Océanographie de Villefranche"/"Institut de la Mer de Villefranche" (IMEV/LOV, Villefranche-sur-Mer, France). Coriolis and Argo-France have strong links with Mercator Ocean International (the French operational ocean forecasting center).

Funding

Argo-France is mainly funded by the ministry of Research through Ifremer as part of the national roadmap on large scale infrastructures and contribution to Euro-Argo (TGIR). This is a long term commitment. Argo-France is also funded through Ifremer, SHOM (Ministry of Defense), CNRS/INSU and other French institutes involved in oceanography (CNES, IRD, Météo-France, SU and IUEM). At regional scale, Argo-France is supported by the IUEM OSU and funded by the Brittany and Provence Alpes-Cote d'Azur regions (CPER).

The French contribution to the Argo global array is at the level of 60 to 65 floats per year with funding from Ifremer (50 floats/year) and SHOM (about 10 to 15 floats/year).

Since 2000, around 1406 French floats have been deployed in a number of different geographic areas. Deployments have been focused on meeting specific French requirements while also contributing to the global array.

To complement Argo-France, the NAOS project (Novel Argo Ocean observing System, 2011-2019) has been funded by the Ministry of Research to consolidate and improve the French contribution to Argo and to prepare the next scientific challenges for Argo**.** The project provides an additional funding of 15 to 20 floats per year from 2012 to 2019, which allows Ifremer to increase its long-term contribution to Argo from 50 to 65-70 floats/year. NAOS also has developed the new generation of French Argo floats and set up pilot experiments for biogeochemical floats (Mediterranean Sea, Arctic), under Ice BGC floats (baffin bay) and deep floats (North Atlantic).

The level of support, additional to float purchase, is as indicated in Tableau 1 (man power for coordination activities, float preparation, deployment and data management activities).

Year	Funding	**Man/Year**	***French floats***	***Co-funded EU floats***	***Total***
2000	300k€		*11*		*11*
2001	633k€	3	*12*		*12*
2002	980k€	6	*7*	*4*	*11*
2003	900k€	9	*34*	*20*	*54*
2004	1400k€	15	*85*	*18*	*103*
2005	450k€	15	*89*	*11*	*100*
2006	900k€	12	*51*	*14*	*65*
2007	900k€	12	*36*		*36*
2008	1200k€	12	*90*		*90*
2009	1200k€	12	*35*	*8*	*43*
2010	1400k€	12	*55*		*55*
2011	1400k€	12	*53*		*53*
2012	1400k€	12	*82*		*82*
2013	1400k€	12	*81*		*81*
2014	1400k€	12	*96*		*96*
2015	1400k€	14	*101*		*101*
2016	1400k€	14	58		*58*
2017	1400k€	14	65		65
2018	1400k€	14	95		95
2019	1400k€	14	74		74
Total (2000-2019)			*1210*		*1285*

2020	**1400k€**	**15**	60		60

Tableau 1: (*Man/year* column) Man power dedicated to Argo for coordination activities, float preparation, deployment and data management activities (GDAC, DAC, NAARC, DMQC) within Argo-France. (*French floats* column) French floats contributing to Argo deployed by year. (*Co-funded EU floats* column) EU floats are the additional floats co-funded by European Union within the Gyroscope, Mersea and MFSTEP projects. Estimated value is given for 2019 (more expected).

Long term evolution of Argo

At the national level, the proposal for Argo-France is in two phases:

- 2011-2016: Core Argo mission (temperature and salinity – 0 to 2000m) and pilot experiments on the new phase of Argo (notably via the NAOS project).
- 2017-2020: Continuation of the core Argo mission with the addition of an extended mission.

For the upcoming phase 2017-2020, France will conduct an over-fitting strategy of a 66 floats/year sustained fleet with:

- 15 deep floats
- 7 with biogeochemical sensors including O2 sensors for 4 of them
- 11 with oxygen sensors
- 33 core T/S.

Core T/S, deep floats and oxygen sensors are fully funded until 2020 (CPER Brittany region), the biogeochemical mission is partially funded (CPER PACA and Brittany regions until 2020) and thus requires new sources of funding that are being requested for the 2018-2023 period as part of the Research Infrastructure second phase (PIA3) and new CPER from Brittany region.
Argo-France strategy will be adjusted according to national interests and international recommendations with regard to the deep and Bio-Argo extensions and their implementation plans currently being developed. Euro-Argo has published a long term roadmap for the next phase of Argo and as part of the ERIC Euro-Argo countries will work on the implementation of a new sustained phase for Argo in Europe.

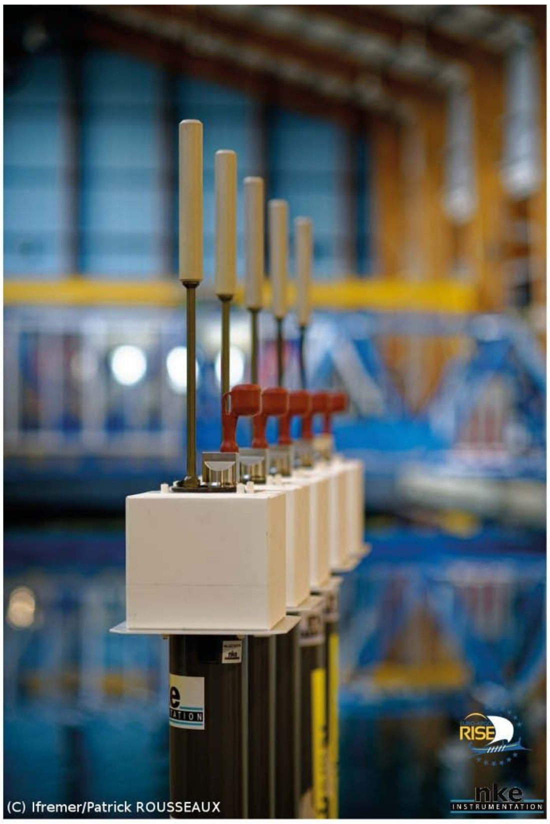
Float development

As part of the EA-RISE 2019-2022 H2020 project:

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

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

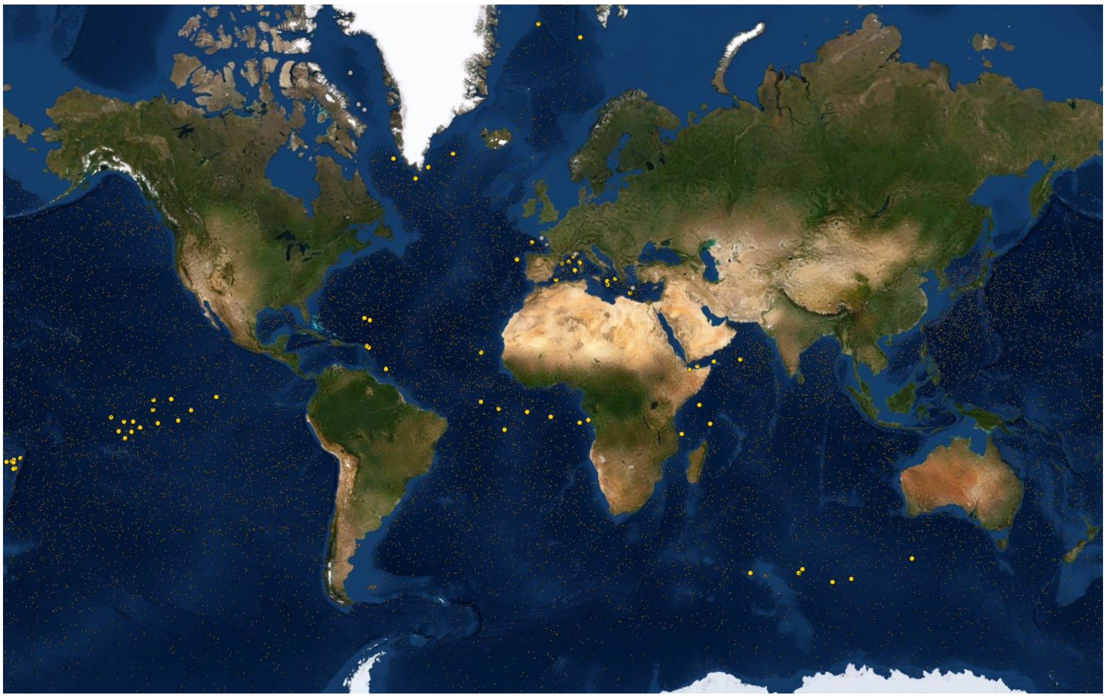
- Extended battery packs for longer mission
- New electronic for targeted exploration and adaptative sampling
- New sensors for particles and zooplankton characterization

	
New RBR CTD mounted on the head of the Arvor float.	The deep-Arvor prototype equiped with 3 CTDS: RBR, SBE41 and SBE61.

The status of implementation

Floats deployed and their performance

74 floats have been deployed by France in 2019 (53 T/S Core, 10 T/S/O2, 7 BGC and 2 CTS5 ICE). The deployment areas are chosen to meet French requirements in terms of research and operational activities but also to contribute to establishing the global array (especially in the Southern Ocean) using AIC tools/map.



Technical problems encountered and solved

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

Seabird batch of drifting CTDs is being assessed and monitored.

- 10 Floats QCed by LOPS and affected by the issue are documented here: https://docs.google.com/spreadsheets/d/1qzuJgw8yAZhiWTSL9j3AMatbBWaD6ZsapTsfFofkDXA/edit#gid=0
- The SBE CTD drift is likely to impact near real time (NRT) Argo analysis products at Coriolis using both DM and RT profiles (for recent years). Since 2015, global averaged salinity issued from Coriolis NRT analysis is suspectly increasing over the whole water column (+0.001 to 0.003 pss). This could be explained by the large amount of RT profile suffering from SBE salinity drift (still in late 2019). The potential impact of SBE salinity drift on global salinity analysis is an ongoing work.

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

Status of contributions to Argo data management

Within Argo-France, data management is undertaken by Coriolis, which play three roles: Data Assembly Centre, Global Data Centre, and leader of the North Atlantic Argo Regional Centre. Coriolis is located within Ifremer-Brest and is operated by Ifremer with support of SHOM and CNRS. Since 2016, the BGC floats processing chain have been fully operational and integrated within the Coriolis data management stream.

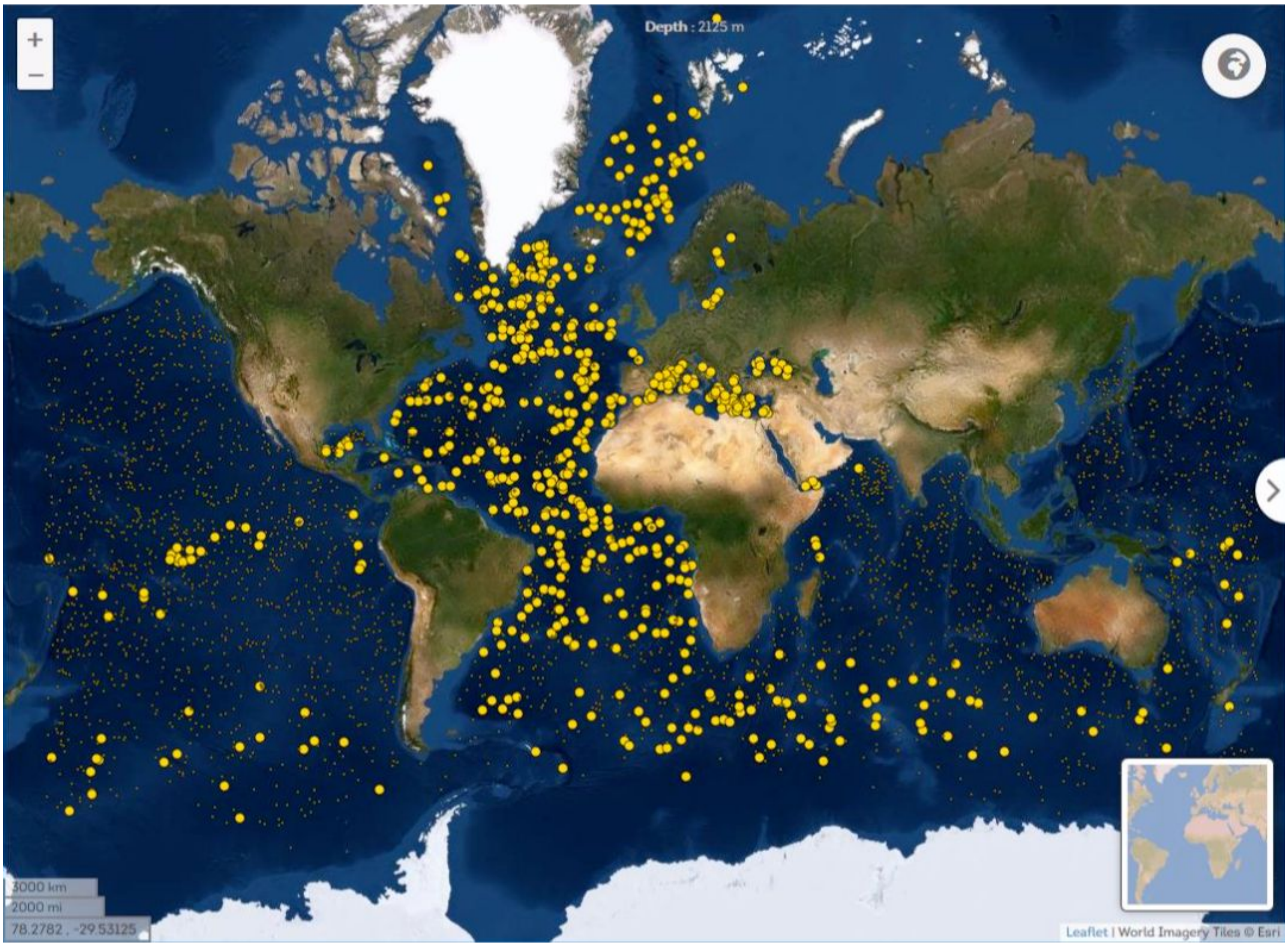
All Argo data management details are in the Coriolis DAC and GDAC 2019 annual report (english) : https://doi.org/10.13155/69679

Data Assembly Center

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

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

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

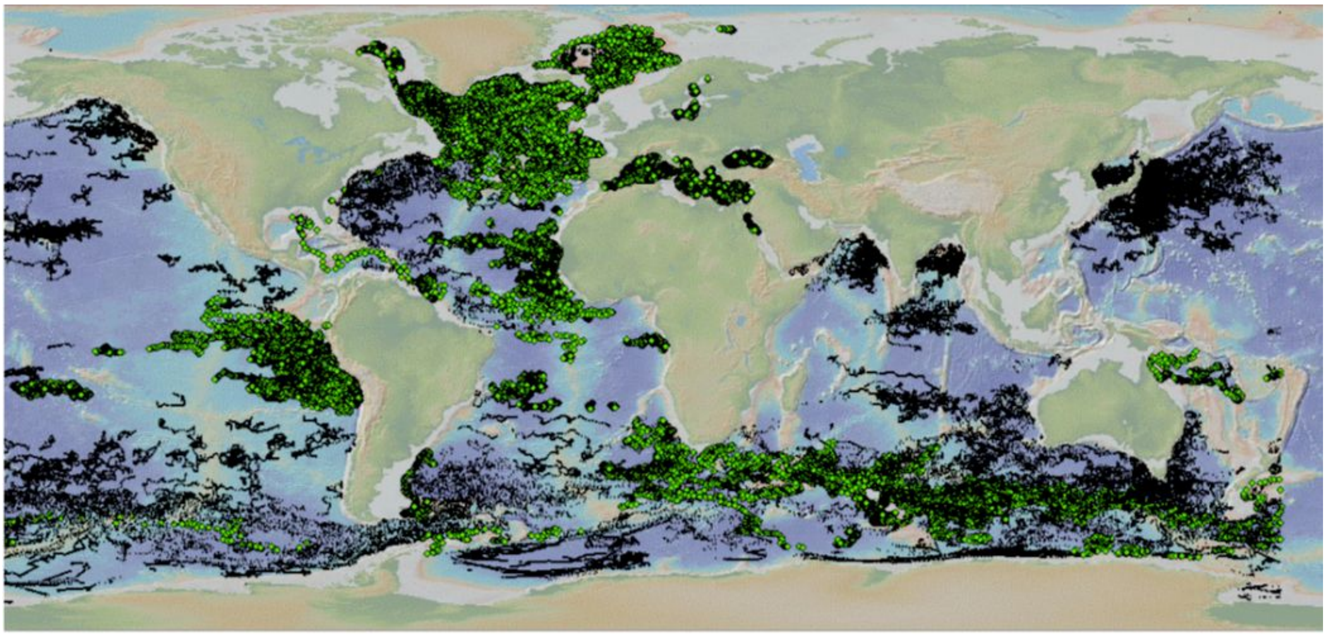


Map of the 827 active floats decoded by Coriolis DAC this year (yellow dots), among other DACs (small dots). Map obtained from https://fleetmonitoring.euro-argo.eu/dashboard

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

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

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



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

Global Argo Data Centre

Coriolis hosts one of the two global data assembly centres (GDAC) for Argo that contains the whole official Argo dataset. The Argo GDAC ftp server is actively monitored by a Nagios agent (see http://en.wikipedia.org/wiki/Nagios). Every 5 minutes, a download test is performed. The success/failure of the test and the response time are recorded. There is a monthly average of around 550 unique visitors, performing 4300 sessions and downloading about 6 terabytes of data files.

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

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

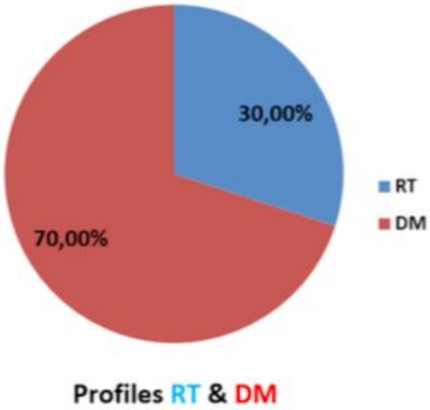
This dashboard will offer the possibility to give credit to Floats owner institutions such as how many data from one particular institution was downloaded, by whose data users.

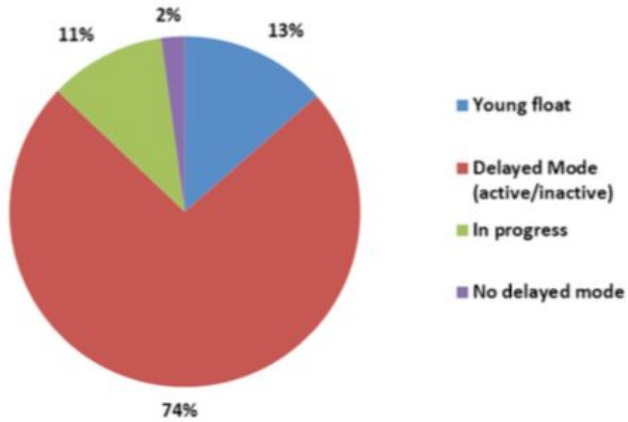
North Atlantic Argo Regional Centre

See NAARC activities in the Research section.

Status of delayed mode quality control process

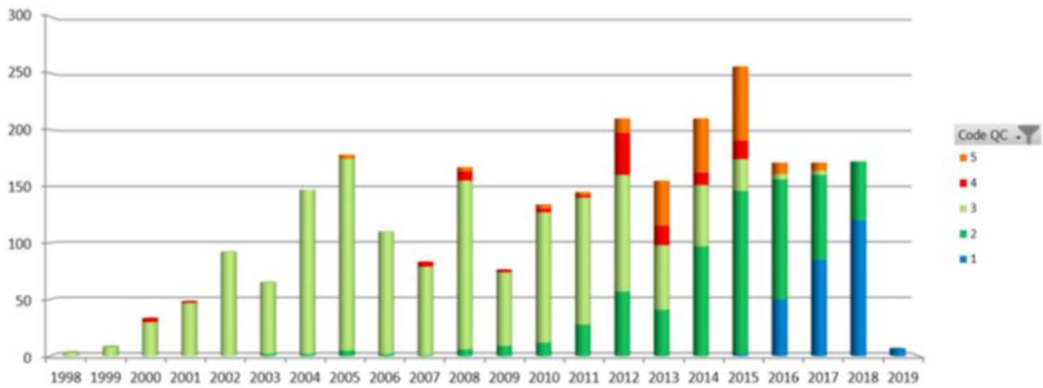
Last year, 115 892 new or updated delayed mode profiles were produced, validated by PIs and sent to GDACs. A total of 222 641 delayed mode profiles were produced and validated since 2005. 75% of the floats and 70% of the profiles processed by the Coriolis DAC are in delayed mode (see Figure below).





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

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



Status of the quality control done on profiles sorted by launch's year, code 1: young float, code 2: active float, DM done, code 3 : dead float, DM done; code 4 : DM in progress, code 5 : waiting for DM, code 6 : problems with float.

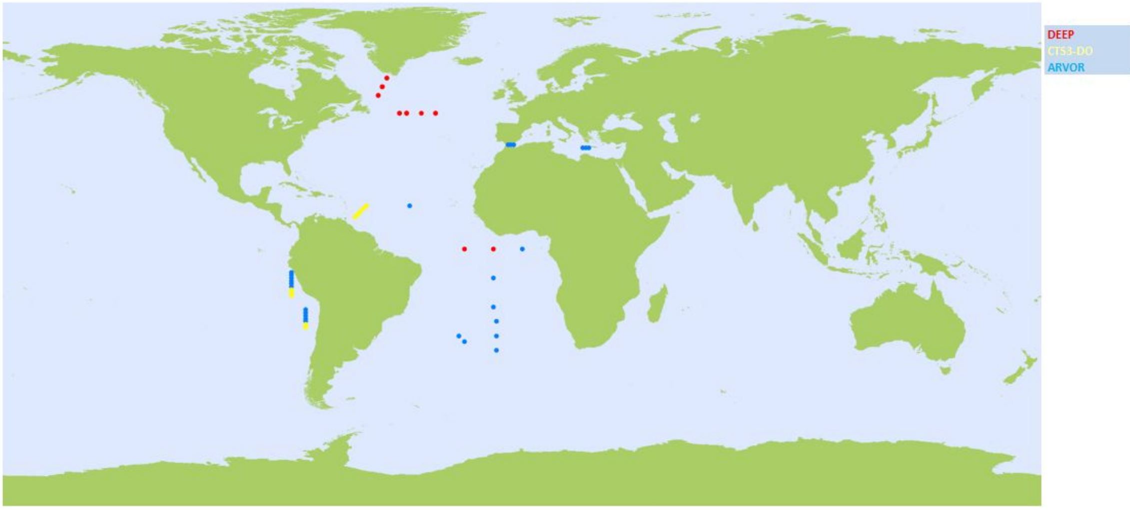
Summary of deployment plans and other commitments to Argo for the upcoming year and beyond where possible

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

Coriolis will continue to run the Coriolis DAC and the European GDAC as well as coordinating the North Atlantic ARC activities. Within Euro-Argo, development will be carried out to improve anomalies detection at GDAC both in RT and DM, to monitor in real time the behaviour of the European fleet and to improve data consistency checks within NA-ARC.

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

Dossier Scientifique	PI	Type de demandes	ARVOR IRIDIUM	ARVOR ARGOS	CTS3-DO	BGC	DEEP	CTS5 ICE	SVP MET	XBT	Zone de déploiement	Navire	Campagne	Date de campagne	Port d'expédition	Date d'expéditio
OISO	Blain	BGC				1					Kerguelen	MARION DUFRESNE	OISO	janv.-20	LA REUNION	Décembre
SIO 2020		BGC				2										
NORTH ATL.		BGC				2										
PIRATA FR30	BOURLES Bernard - IRD	OPPORTUNITE	3				2			7	Golfe de Guinée	THALASSA	PIRATA FR30	16/02 au 23/03	BREST	07/02/2019
RARA AVIS 2020	COATANOAN C; - Ifremer	OPPORTUNITE		1							Transatlantique	RARA AVIS	RARA AVIS	fevrier 2020	Brest	Janvier
PERLE 3	SHOM / DUMAS F.	SHOM	3								Mediterranée SE	POURQUOI PAS ?	PERLE3	mars-20	Toulon	Fevrier
SAGA	PROVOST C. PELEGRI J.L	OPPORTUNITE	5								Atlantique central	HESPERIDES	SAGA1	mai-20	BARCELONE	Novembre
SEPICAF CHILI	DEWITTE Boris LEGOS	GMMC 2018	5		2	1					Pacifique SE	ls in Peru and RV in Chile + Fa	Variées	Mi 2020	CALLAO & VALPARAISO	Début 2020
SEPICAF PEROU	DEWITTE Boris LEGOS	GMMC 2018	6		3						Pacifique SE	ls in Peru and RV in Chile + Fa	Variées	Mi 2020	CALLAO & VALPARAISO	Début 2020
DEEP CORE	DESBRUYERES D.	DEEP					16				AN	MARIA S. MERIAN	MSM92/94	juil.-20	BREST	Juin
GIBRALTAR	SHOM / DUMAS F.	SHOM	3								Gibraltar	ATALANTE	PROTEUS GIB	octobre	BREST	Juillet
EUREC4A-AO	BELLENGER Hugo	GMMC 2018			5					7	Atlantique Tropical NO	ATALANTE	EUREC4A-O2	févr.-20	PAP	déc.-20
		TOTAL 2020	*25*	*1*	*10*	*6*	*18*	*0*	*0*	*14*						
			60													



COVID19:

Because of the global pandemic outbreak in early 2020, Argo-France foresees a significant impact on its operations for 2020 and probably 2021. This impact is still being assessed and will be reported at the JCOMMOPS and Euro-Argo level for possible coordinations to sustain the array (https://docs.google.com/spreadsheets/d/1ofo5ipeBLFRpNVKpcbTZuiKjpCmWwVU2TPI3-bBO0BM/edit?usp=sharing).

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

Operational ocean forecasting

All Argo data (alongside with other in-situ and remotely sensed ocean data) are routinely assimilated into the MERCATOR operational ocean forecasting system run by the MERCATOR-Ocean structure. MERCATOR also operates the Global component of the European Copernicus Marine Environment Monitoring Service (CMEMS).

Support to the Mercator and Coriolis scientific activities

Coriolis has developed together with MERCATOR (The French operational oceanography forecast center) a strong connection with the French research community via the Mercator-Coriolis Mission Group (GMMC). It consists of about one hundred researchers (with some turnover each year) following a scientific announcement of opportunities and call for scientific proposals. Its task is to support the Mercator and Coriolis scientific activities and to participate in product validation. The call for scientific proposals proposes to the community "standard" Argo floats as well as floats equipped with oxygen and biogeochemical sensors. These new opportunities strengthen the link between the French scientific community and Coriolis with regard to the development of qualification procedures for "Argo extensions" floats.

National Research

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

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

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

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

Key projects activities

ANDRO Trajectory dataset

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

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

ICES North Atlantic Ocean State Report (IROC)

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

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

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

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

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

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

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

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

Argo-Regional Center: Atlantic

France leads the A-ARC (previously NA-ARC but renamed after the extension of the region up to 35°S), which is a collaborative effort between Germany (IFM-HH, BSH), Spain (IEO), Italy (OGS), Netherlands (KNMI), UK (NOCS, UKHO), Ireland (IMR), Norway (IMR), Canada (DFO), and USA (AOML), Greece (HCMR) and Bulgaria (IOBAS). Coriolis coordinates the Atlantic ARC activities and in particular the float deployment in Atlantic.

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

The 2019 reports are available here:
https://www.umr-lops.fr/en/SNO-Argo/Activities/NAARC/Consistency-checks-of-DM-salinity-corrections/NAARC-reports-2019

Issues that your country wishes to be considered and resolved by the Argo Steering Team regarding the international operation of Argo.

These might include tasks performed by the AIC, the coordination of activities at an international level and the performance of the Argo data system. If you have specific comments, please include them in your national report.

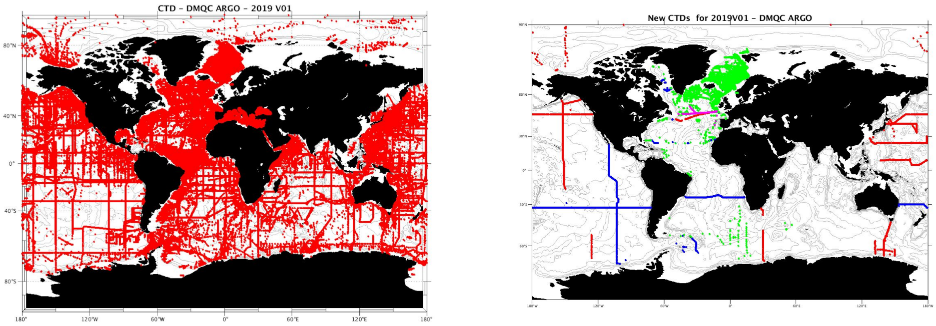
-

CTD cruise data in the reference database

To continue improving the number of CTD cruise data being added to the reference database by Argo PIs, it is requested that you include the number and location of CTD cruise data uploaded by PIs within your country to the CCHDO website in the past year. These cruises could be used for Argo calibration purposes only or could be cruises that are open to the public as well.

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

This new version includes 12 new cruises from the GO-SHIP program (downloaded from the CCHDO website), updates from OCL, ICES and MSM cruise provided by a scientist. A work has also been done for the boxes in the North Sea, with Ingrid Angel from BSH. Expertise on data has been realized to improve the quality and new data has been added (from UDASH and ICES).



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

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

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

Bibliography

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

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

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

Argo-France: http://www.argo-france.fr
French bibliography: *http://www.argo-france.fr/publications*
Argo PhD list: http://www.argo.ucsd.edu/argo_thesis.html
NA-ARC data mining website: http://www.ifremer.fr/lpo/naarc
Coriolis FTP: http://www.coriolis.eu.org/Data-Services-Products/View-Download/Download-via-FTP
Coriolis DAC: http://www.coriolis.eu.org/Observing-the-ocean/Observing-system-networks/Argo
IUEM OSU: http://www-iuem.univ-brest.fr/observatoire
NAOS project: http://www.naos-equipex.fr
Euro-Argo: http://www.euro-argo.eu
Coriolis: http://www.coriolis.eu.org
Laboratoire d'Océanographie Physique et Spatiale: http://www.umr-lops.fr/
Laboratoire d'Océanographie de Villefranche: http://www.obs-vlfr.fr/LOV
Mercator: http://www.mercator-ocean.fr

1. **The status of implementation (major achievements and problems in 2019)**

- floats deployed and their performance

Most of the floats deployed by Germany in 2019 are operated by BSH, but in this year ICBM (Institute for Chemistry and Biology of the Marine Environment) had acquired additional funding. ICBM deployed 4 BGC APEX floats while BSH has deployed 36 floats (all ARVOR) by the end of 2019. GEOMAR and AWI have not deployed floats in 2019. 36 of the German floats deployed in 2019 were standard TS floats, 4 ICBM floats deployed in the Mediterranean carried a suite of BGC sensors. Deploymenta were carried out on research vessels, which comprised Canadian, German and UK ships. The BSH deployment locations for 2019 are shown in Fig. 1. Deployment of a few floats projected for 2019 has been delayed and will happen early 2020.

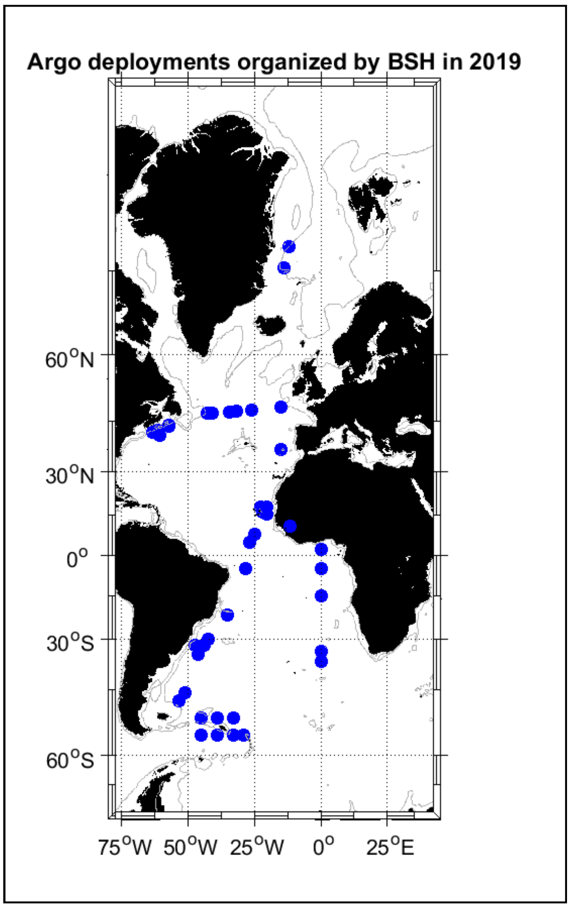


Fig. 1: Deployment positions for floats operated by BSH in 2019 in the Atlantic Ocean.

Currently (April 3rd, 2020) 162 German floats are active (Fig.2) and the total number of German floats deployed within the Argo program increased to 911. Two floats intended for deployment in the Arctic are stored in a bonded warehouse in Norway and will go on a Norwegian cruise with an icebreaker in summer 2020.

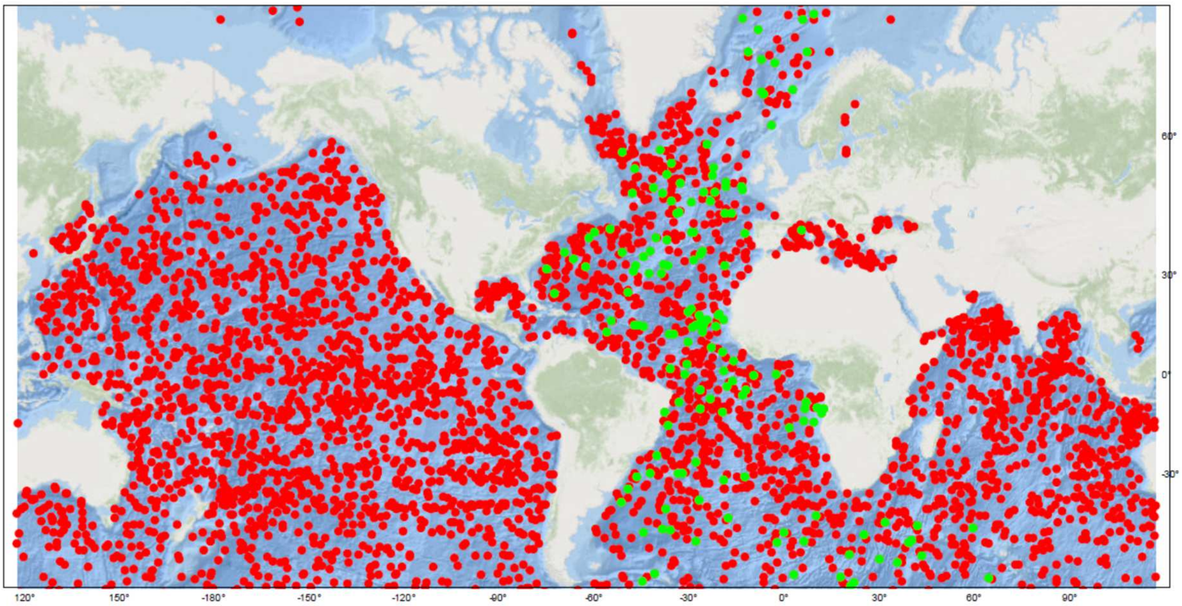


Fig. 2: Locations of active German floats (green) and active international floats (red) (Argo Information Centre, April (2020).

- technical problems encountered and solved

One of our three APEX floats equipped with ph- and O2-sensor deployed in 2018 had been malfunctioning due to a defect pressure sensor. A replacement for this float has been received and the replacement float will be deployed at its original location in the Labrador Sea. One float in the Nordic Seas was caught in a net by a fishing trawler and turned over to our colleagues in Norway. Since it was in good shape, it was returned TWR for refurbishment and recalibration of the CTD. Another float had beached at Faeroe Islands. It was returned to Germany with the assistance of Martin Kramp (ship coordinator at AIC) and sailed back to Germany on the sailboat Germania (Fig.3).

Fig. 3: Martin Kramp (middle) and colleagues are returning a beached German float.

Inspection of floats suspected of fast salinity drift in the SN range 6000-7100 have all been finished and data are completely d-moded. Sudden salty drift is also detected for SNs that are far more recent and some of the floats show depth dependent drift. Kim Martini from SBE is continuously informed when a float with fast salty drift is discovered in dmqc. In preparation for AST21 a report is being prepared with diagnostic plots from all floats that show fast salty drift. The report is shared through github with all European DMQC operators and has been send to the working group led by John Gilson.

- status of contributions to Argo data management (including status of conversion to V3 file formats, pressure corrections, etc.)

Germany has continued to work in the new European Research Infrastructure Consortium EURO-ARGO-ERIC which was established in July 2014 in Brussel by 9 founding countries (France, Germany, United Kingdom, Italy, Netherlands, Norway, Greece, Poland and Finland). GEOMAR and AWI are members of the EU-funded ATLANTOS project and have deployed deep-floats and bio-Argo floats within this project. Germany is responsible in the framework of the MOCCA project (coordinated by the ERIC) for the delayed-mode quality control of 65 MOCCA floats, in the Nordic Seas, the subpolar gyre and Southern Ocean and contributes to the at-sea monitoring of the fleet. Within MOCCA an ice-algorithm has been developed for the Arctic ocean from a combination of quality controlled hydrographic data and ice-edge information. In 2019 we have stared reprocessing all the Argo data in the Nordic Seas after updating the CTD reference data set for this area and check for small biases still remaining due to lack of recent CTD data in previous versions of the reference data set. We are also preparing a reference data set for the Arctic from the UDASH CTD data set collected and quality controlled by AWI.

Germany has adopted a few of the orphaned US Navy floats and has provided quality control for these floats, as well as for some floats belonging to the University of Maine. Germany is also acting as delayed mode quality control operator for European contributions from Denmark, Finland, Norway, the Netherlands and Poland. In December 2019 we have held a week long dmqc training session for Poland and Norway. Malgorzata Merchel from IOPAN (Poland) and Jan Even Øie Nilsen from Havforskningsinstituttet (Norway) participated in the training and will act as DM-operators for the national programs in future. In 2020 a follow-up training session is planned and will include the new DMQC operator for Finland (Petra Roiha, FMI).

Coriolis had just finished the process of reformatting Nemo floats from AWI into V3.1 at the end of 2019, and the newly decoded files are on a priority list for DMQC.

The annual user meeting was held at BSH on 22.08.2019 and was attend by more than 20 people. User presentations were given and showed the wide range of application from science to data assimilation in forecast models. As a result of the meeting a BGC group was established which includes ICBM (Oliver Zielinski), GEOMAR (Arne Körtzinger, Tobias Steinhoff) and IOW (Henry Bittig) and provides national expertise for all BGC parameters. BSH and the BGC group have prepared a science briefing to advocate the new multidisciplinary Argo strategy and gave a presentation at the BMVI on 25.02.2020. The federal ministry of transportation and digital infrastructure (BMVI) funds the operational core Argo floats at a level of ~50 floats per year. Several other ministries were invited but only the science ministry (BMBF) could attend the meeting. In general the new capabilities of the multidisciplinary Argo were appreciated and it was decided to continue discussions about the budget for the implementation at inter-ministerial level to find a way forward for the 2022 national budget negotiations. The science ministry (BMBF) has offered to provide some interim funds for 2020/2021 and a proposal has been submitted.

- status of delayed mode quality control process

In the past the delayed mode processing had been distributed between the various German institutions contributing to Argo, depending on their area of expertise. The Alfred-Wegener Institute had been responsible for the Southern Ocean and GEOMAR was processing floats in the Pacific with oxygen data. The DMQC for the core Argo parameters is now performed by BSH, including the AWI floats. Reprocessing of these has been finished by Coriolis and the floats are on the priority list for DMQC. DMQC on oxygen will still be performed at PI level and work is carried out by GEOMAR respectively Henry Bittig now at IOW. The processing of the pH-data is carried out by Arne Körtzinger's group at GEOMAR.

BSH is also processing the German/Finnish/Norwegian floats in the Nordic Sea, and is covering the tropical, subtropical and subpolar Atlantic. German floats in the Mediterranean on the other hand are processed by MEDARGO. The sharing of delayed-mode data processing will be continued in the coming years, but BSH will cover all German floats which have not been assigned to a PI. The national programs of Finland, Norway and Poland will start their own dmqc operations now that trained dm-operators are available. BSH will finish dmqc for all floats from these programs which have already been started.

The DMQC process for German floats is continuing without major problems, and the frequency of delayed-mode visits has remained at ~ half-yearly levels in 2019 to check for fast salty drift. The total number of available profiles from German floats is 76544 (April 3rd, 2020), the number of DM profiles is 68506. The percentage of DM profiles with respect to the total number of profiles has increased to about 90% in 2019. The main delays remain with the floats in the Southern Ocean owned by AWI, for the other float programmes managed by BSH the delayed mode is at 94%. All delayed mode profiles have been sent to the Coriolis GDAC node.

The table below lists the status of dmqc efforts for the various national and adopted international programs.

Program Name	Number of profiles	Number of D-files	D-files pending	Comments
Argo BSH	52483	48307	1147	
Argo AWI	7240	3548	3692	Are on priority list
Argo GEOMAR	13474	13393	81	
Argo U. HH	3347	3258	89	
Argo Poland	2949	975	1126*	*Baltic floats mostly
Argo Finland	3214	795	2017*	*Baltic floats mostly
Argo Denmark	360	360	0	Old floats associated with U. HH
Argo Netherlands	11147	10665	184	
Argo Norway	5100	3632	621	

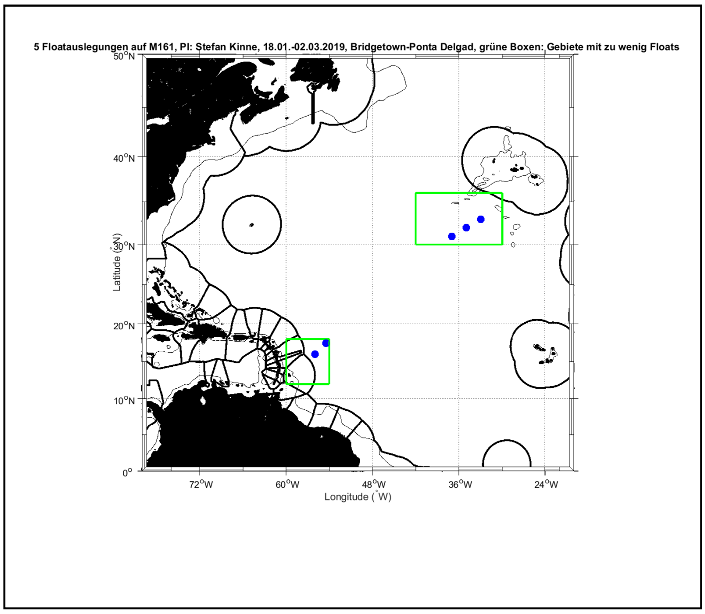
2. Present level of and future prospects for national funding for Argo including a summary of the level of human resources devoted to Argo.

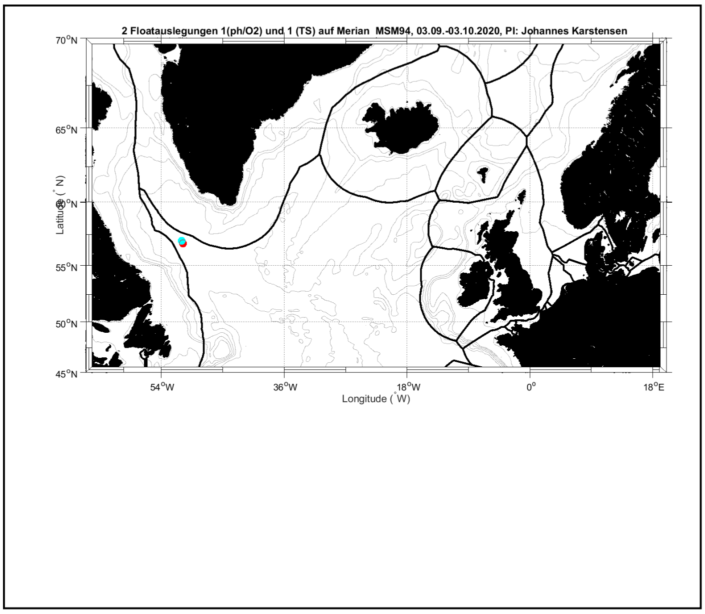
The present level of national funding for Argo been increased in 2019 from a previously flat funding and the number of floats purchased per year is now closer to 50, as originally envisioned. The human resources remain at the same level as before in 2019 and Birgit Klein, Jan-Hinrich Reissman, Anja Schneehorst and Simon Tewes cover activities such as purchase, technical inspection, deployment, data quality control and representation in national and international teams. As part of our Euro-Argo activities Birgit Klein and Bernd Brügge are involved as management board and council. Ingrid Angel Benavides has been employed with funding of European Union.

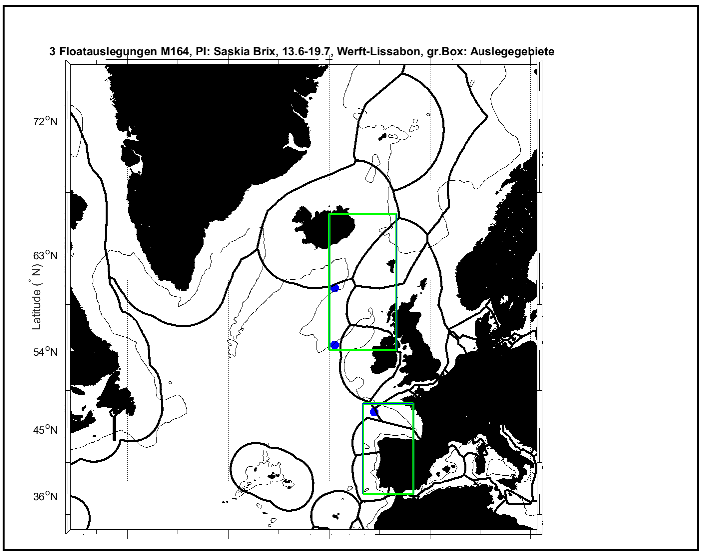
Funding for complementary oxygen and ph-sensors has been provided by the science ministry (BMBF) and three floats equipped with these sensors had been deployed in the Labrador Sea in 2018. One float is malfunctioning due to a defect in the pressure sensor, and a replacement float was delivered in 2019 by Webb Research. The University of Oldenburg has received funds from BMBF to buy 6 BGC floats and test new hyperspectral sensors. Four of the floats have deployed in 2019.

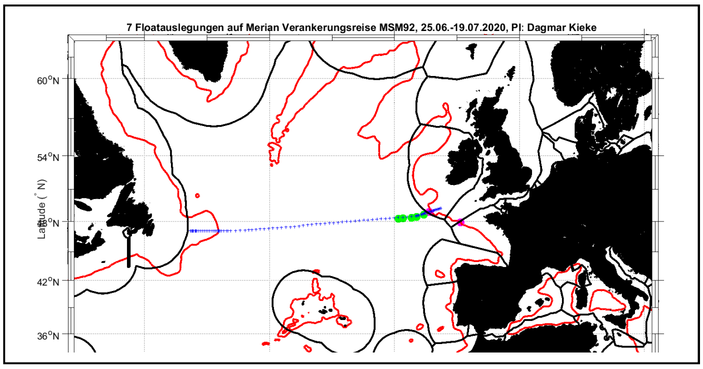
3. Summary of deployment plans (level of commitment, areas of float Deployment, low or high resolution profiles, Argo extensions) and other commitments to Argo (data management) for the upcoming year and beyond where possible.

Purpose is gapping filling in the Atlantic, main focus areas are southern ocean and gaps in the subtropical/subpolar areas from the priority list of the ERIC (see maps below). For national science questions the eastern boundary currents in the North Atlantic also remain a priority. A maximum number of 48 will be deployed in 2020. 4 floats with BGC sensors are contributed by the University of Oldenburg and are financed by the ministry of research (BMBF). All profiles will be high resolution profiles. To assist the German Navy during a maneuver in fall 2020 a float will be deployed in the Norwegian Trench in the North Sea.









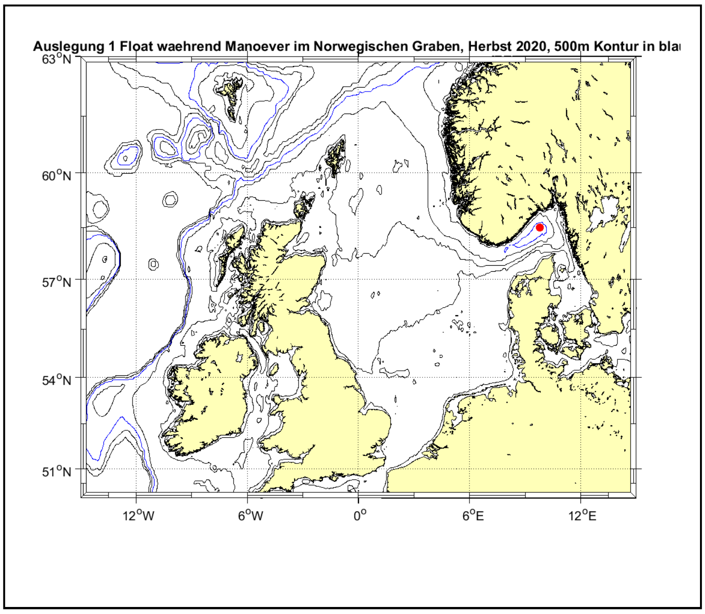
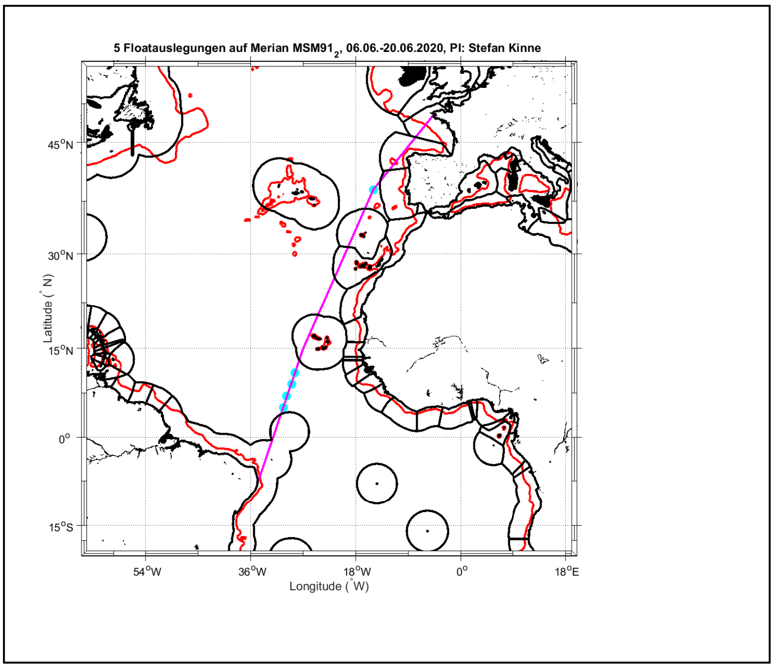
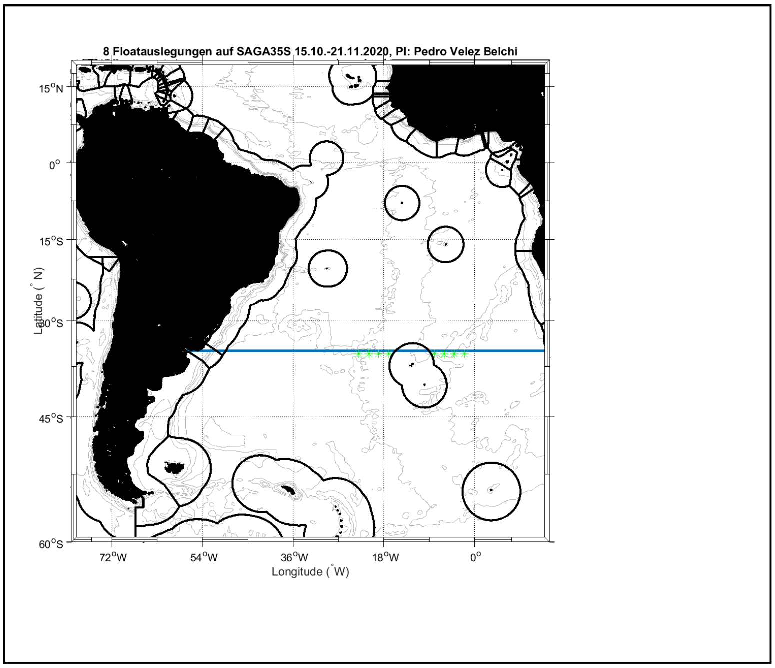
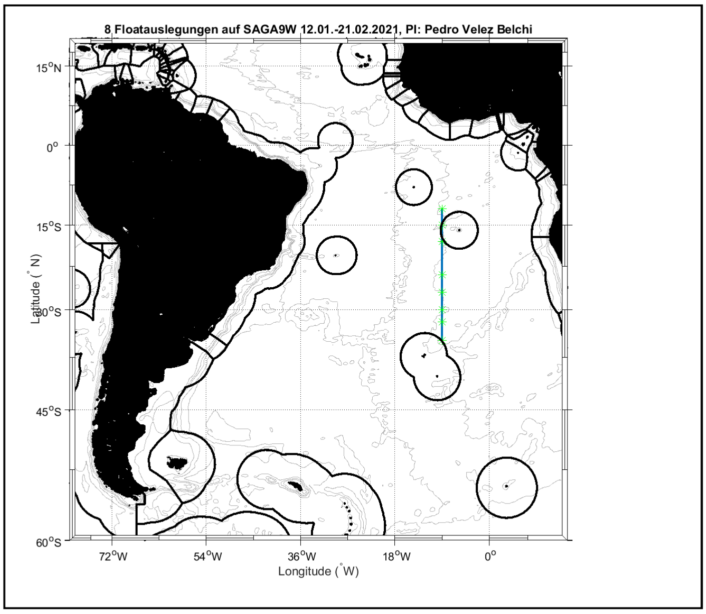
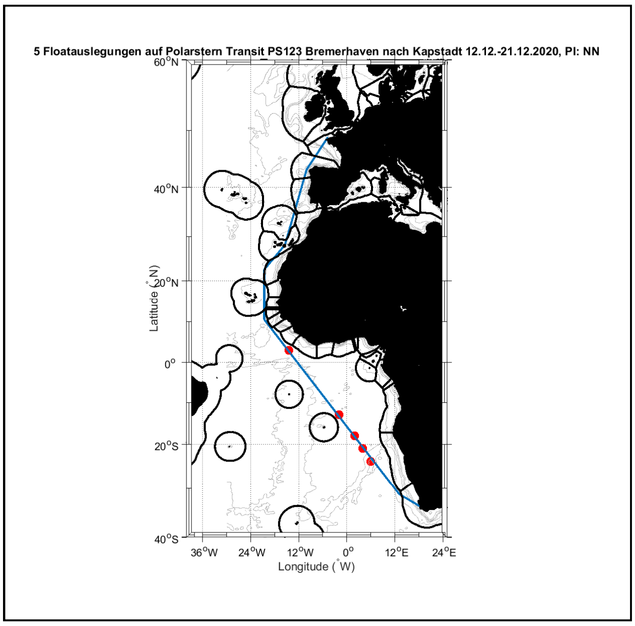


Fig.4: Planned deployments in the North Atlantic\North Sea in 2020









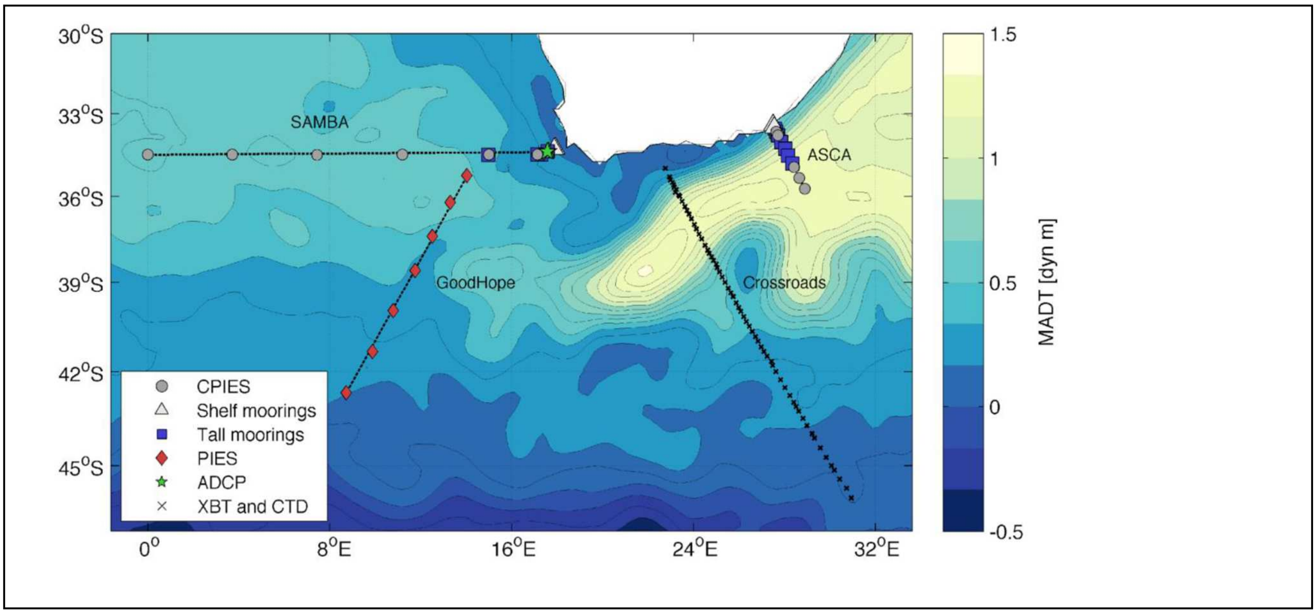


Fig. 5: Planned deployments in the South Atlantic in 2020. 5 Floats will be stored with South African Weather service to be deployed on their regular cruises.

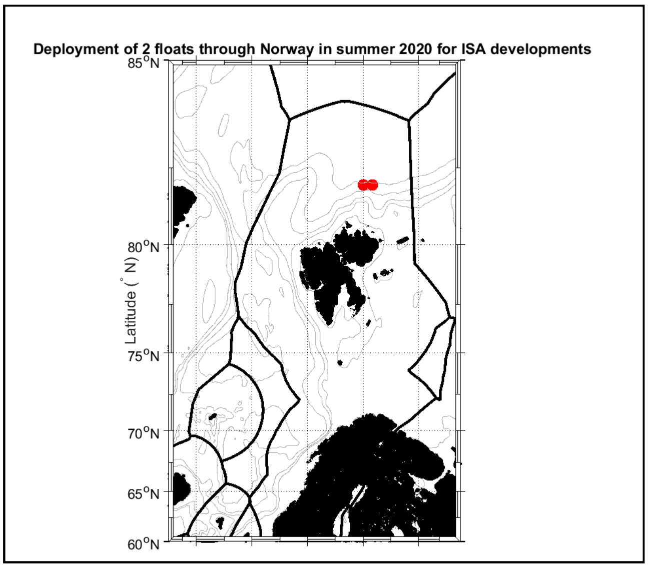


Fig. 6: Planned deployments in the ice covered areas

Summary of deployment plans by area and float type and sensor additions

GER	2020						
	Total	T/S Core	T/S/O2	BGC	Bio	Deep	
Nordic Seas							
Mediterranean Sea	1			+1			
Black Sea							
Baltic Sea/North Sea	3	1		+2			
Southern Ocean							
Arctic Ocean	2	2					
Global Ocean	42	41		1			
Total	**48**	44		4			

GER	2021						
	Total	T/S Core	T/S/O2	BGC	Bio	Deep	
Nordic Seas	1			+1			
Mediterranean Sea							
Black Sea							
Baltic Sea	1			+1			
Southern Ocean	11	5+6					

Arctic Ocean	2	2					
Global Ocean	43	43					
Total	**58**	56		2			

Deployment plans for 2020/2021

4. Summary of national research and operational uses of Argo data as well as contributions to Argo Regional Centers. Please also include any links to national program Argo web pages to update links on the AST and AIC websites.

BSH is maintaining the Argo Germany Web site. We have recently moved our updated webpage to our institutional page and have added content.

https://www.bsh.de/DE/THEMEN/Beobachtungssysteme/ARGO/argo_node.html

It provides information about the international Argo Program, German contribution to Argo, Argo array status, data access and deployment plans. It also provides links to the original sources of information.

Currently no statistics of Argo data usage are available. The German Navy uses Argo data on a regular basis for the operational support of the fleet and uses their liaison officer at BSH to communicate their needs. The SeaDataNet portal uses German Argo data operationally for the Northwest European Shelf. Argo data are routinely assimilated in the GECCO reanalysis, which is used for the initialisation the decadal prediction system MiKlip. At BSH the data are used within several projects such as KLIWAS, RACE, MiKlip, ICDC and Expertennetzwerk BMVI.

The user workshop was held in 22.08.2010. It was well attended. It provided a good forum for users to share their scientific work and methods.

A key aspect of the use of Argo data at BSH is to develop a data base for climate analysis, to provide operational products for interpretation of local changes and to provide data for research applications for BSH related projects (KLIWAS, RACE, MiKlip, ICDC and Expertennetzwerk BMVI).

Argo data are being used by many researchers in Germany to improve the understanding of ocean variability (e.g. circulation, heat storage and budget, and convection), climate monitoring and application in ocean models.

Germany contributes to the NAARC and also recently joined the SOARC. Researchers from German institutions have continued to contribute recent CTD data to the Argo climatology. Within the MOCCA project we are presently working on establishing services for the Nordic Seas.

5. Issues that your country wishes to be considered and resolved by the Argo Steering Team regarding the international operation of Argo. These might include tasks performed by the AIC, the coordination of activities at an international level and the performance of the Argo data system. If you have specific comments, please include them in your national report.

6. To continue improving the quality and quantity of CTD cruise data being added to the reference database by Argo PIs, it is requested that you include any CTD station data that was taken at the

time of float deployments this year. Additionally, please list CTD data (calibrated with bottle data) taken by your country in the past year that may be added to the reference database. These cruises could be ones designated for Argo calibration purposes only or could be cruises that are open to the public. To help CCHDO track down this data, please list the dates of the cruise and the PI to contact about the data.

A variety of CTD data sets from recent research groups were provided to Coriolis, mostly reference profiles from floats deployments from various cruises of Merian, Meteor and Polarstern. Additonally all data from Merian cruise MSM73 were provided by Uni Bremen (143 stations).

7. Keeping the Argo bibliography (http://www.argo.ucsd.edu/Bibliography.html) up to date and accurate is an important part of the Argo website. This document helps demonstrate the value of Argo and can possibly help countries when applying for continued Argo funding. To help me with this effort, please include a list of all papers published by scientists within your country in the past year using Argo data, including non-English publications.

Fischer, J., Karstensen, J., Oltmanns, M., and Schmidtko, S.: Mean circulation and EKE distribution in the Labrador Sea Water level of the subpolar North Atlantic, Ocean Sci., 14, 1167-1183, https://doi.org/10.5194/os-14-1167-2018, 2018.

Oltmanns, M., J. Karstensen, J. Fischer. Increased risk of a shutdown of ocean convection posed by warm North Atlantic summers. Nature Climate Change, http://dx.doi.org/10.1038/s41558-018-0105-1, 2018.

Testor, P., Bosse, A., Houpert, L., Margirier, F., Mortier, L., Legoff, H., Dausse, D., Labaste, M., Karstensen, J., Hayes, D., … Conan, P. Multiscale observations of deep convection in the northwestern Mediterranean Sea During winter 2012–2013 using multiple platforms. J. of Geophysical Research: Oceans, 123, 1745–1776. doi.org/10.1002/2016JC0126712017, 2018.

Tchipalanga, P.C.M., M. Dengler, P. Brandt, R. Kopte, M. Macuéria, , P. Coelho, M. Ostrowski and N. S. Keenlyside (2018) Eastern boundary circulation and hydrography off Angola – building Angolan oceanographic capacities, Bulletin of American Meteorological Society, 8, 1589-1605, doi: 10.1175/BAMS-D-17-0197.1.

Lübbecke, J. F., P. Brandt, M. Dengler, R. Kopte, J. Lüdke, I. Richter, M. S. Martins, P. C. M. Tchipalanga (2018) Causes and evolution of the southeastern tropical Atlantic warm event in early 2016, Clim. Dyn., published online Dec. 8, 2018, doi: 10.1007/s00382-018-4582-8.

Czeschel, R., Schütte, F., Weller, R. A., Stramma, L. (2018) Transport, properties, and life cycles of mesoscale eddies in the eastern tropical South Pacific, Ocean Science, 14, 731-750, https://doi.org/10.5194/os-14-731-2018.

Keppler, L., Cravatte, S., Chaigneau, A., Pegliasco, C., Gourdeau, L., & Singh, A. (2018).
Observed characteristics and vertical structure of mesoscale eddies in the southwest tropical Pacific.
Journal of Geophysical Research: Oceans, 123, 2731–2756. doi.org/10.1002/2017JC013712

Featured also in the Euro-Argo Newsbrief (Science & Technology Highlights): https://www.euro-argo.eu/Activities/Data-Use-and-Applications/Scientific-Results/Global-core-Argo/Observed-Characteristics-and-Vertical-Structure-of-Mesoscale-Eddies-in-the-SouthWest-Tropical-Pacific

Kieke, D, W. Böke, S. Büttner, K. Bulsiewicz, C. Danek, T. Hempel, D. Khordakova, B. Mirau, A. Rochner, A. Roessler, N. Rohlfs, A. Schneehorst, R. Steinfeldt, P. Sültenfuß, H.-H. Uhde, S. Wett, K. Wiegand, F. Wischnewski (2018), Subpolar Gyre Variability, Cruise No. MSM53, March 31 - May 09, 2016, Kiel (Germany) - St. John's (Canada). *MARIA S. MERIAN-Berichte*, DFG-Senatskommission für Ozeanographie, doi:10.2312/cr_msm53

GREEK ARGO PROGRAMME

PRESENT STATUS AND FUTURE PLANS

G. Korres and D. Kassis
HCMR
February, 2020

1. Background and organization of GREEK ARGO activities

Greece established national contribution to the ARGO project through national funding to the Greek Argo programme (2012-2015). The programme was co-financed by Greece and the European Union. Through the national programme Hellenic Integrated Marine Inland water Observing Forecasting and offshore Technology System (HIMIOFoTS) www.himiofots.gr (2018-2021), HCMR has established further contribution to the ARGO project.

1.1 Deployed floats

During 2019, 4 Argo floats were successfully deployed in the Greek Seas under the framework of the Greek-Argo RI activities and the Argo-Italy project. Three (3) of the floats were NOVA-DOVA type and were purchased by the Greek Argo RI whilst, one (1) Deep-Arvor type float was deployed under the framework of joint activities with Argo-Italy. The floats were deployed by the Greek-Argo team in the North, Central and South Aegean basin and in the South Ionian Sea. All floats integrate Iridium satellite telemetry system which provides a dual telecommunication capability allowing modification of the configuration in real-time. The DEEP-ARVOR 6903267 float was sent to the Greek Argo Infrastructure by OGS Italy. It was deployed on July the 19th at the Deep Hellenic Trench in the South Ionian Sea at 4500 m depth, and has been an important step in promoting deep float expansion in the Mediterranean and the collaboration between the European Research Infrastructures of Euro-Argo. The float integrated a Dissolved Oxygen sensor along with the standard CTD instrumentation and was configured to record the profile of the water column at a depth of 4000 meters and drift to a depth of 2000 meters for the first 5 cycles. Unfortunately after the first cycles the float was lost. The active floats and new deployments during 2019 are presented in Table 1:

Table 1. Active floats and new deployments performed from Greek Argo team during 2018

A/A	Float type	WMO	IMEI NUMBER	SERIAL NUMBER	Deployment Date	Deployment time	Deployment Latitude	Deployment Longitude	Available profiles	Status
1	NOVA	6901885	300234061647120	134	8/10/2014	20:00	35.79	25.12	343	Inactive
2	NOVA	6903276	300234063609400	271	13/7/2016	8:00	35.09	25.05	213	Inactive
3	ARVOR	3901890	300234063609200		4/4/2017	1:15	39,16	24,93	182	Active
4	ARVOR	3901957	300234064702860		20/5/2018	09:15	36,84	21,60	103	Active
5	DOVA	6903283	300234062954200	245	17/6/2018	16:00	39,76	24,36	90	Active
6	NOVA	6903285	300234061648140	135	12/7/2019	12:45	39.85	24.47	16	Active
7	NOVA	6903287	300234061661410	137	15/7/2019	11:00	35.75	25.1	14	Active
8	ARVOR-I DEEP	6903267		AD2700 18 EU 001	19/7/2019	21:30	36.496	21.476	6	Inactive
9	DOVA	6903286	300234062958210	246	23/7/2019	05:00	36.9	23.9	4	Inactive

All floats have been integrated in the MedArgo project. Taking into account the proposed sampling strategy for the Mediterranean Sea and the bathymetry of the deployment site and the adjacent areas, the mission parameters of the floats were set as follows: The parking depth of the floats was set to 350 m, its profiling depth to 1000 m and the cycle period to 5 days. The raw data of the Greek float are delivered at the Coriolis data Centre where the real time quality control takes place while the delayed mode quality control of the data will be processed by the MedArgo Centre at OGS.

1.2 Float Development

In 2013, HCMR has constructed an Argo float's detection system after the process of locating a float has been described and the various approaches have been indicated. A prototype active locator unit has been developed, and the principle of operation has been demonstrated. The unit has been tested successfully in land and at sea at the SIDERI workshop at 17-18 September 2013 that took place at Heraklion, Greece. The deck unit communicates via Bluetooth with any mobile phone which is used for interface and control. Future work includes the study of a pressure housing and antenna design. This activity was under the task of proposing and testing simple methods of tracking and recovery Argo floats in short time and range scales in the framework of SIDERI FP7 project.

1.3 Data management

HCMR has run an extended network of buoys within the Aegean and Ionian Seas including the multi-parametric M3A observatory of the Cretan Sea and a deep sea (2000 m) bottom platform deployed in the Ionian Sea (POSEIDON & POSEIDON-II monitoring, forecasting and information systems). HCMR also operates the Hellenic National Oceanographic Data Centre (HNODC) established in 1986, as part of the National Centre for Marine Research (NCMR). HNODC operates as a National Agency and is responsible for processing, archiving and distributing marine data. HNODC is also developing techniques for oceanographic data processing and data base maintenance. Furthermore it promotes the International Exchange of Data in the frame of its cooperation with the "Intergovernmental Oceanographic Commission IOC) of UNESCO as it is responsible for the coordination of International Data Exchange (IODE) in Greece. The HNODC manages a variety of oceanographic data and information collected by several Hellenic Marine Research Laboratories and in particular from the Institute of Oceanography of the Hellenic Centre for Marine Research-HCMR as well as from HNODC's participation in international projects (MTP-II MATER, MEDAR/MEDATLAS II, HUMBOLDT, SEADATANET). Moreover within the My Ocean project (GMES MCS) HCMR will consolidate and improve its in-situ data services for the Eastern Mediterranean region building on the capacity developed under POSEIDON, MFSTEP (coordination of M3A time-series network, analysis and provision of basin scale data), and MERSEA projects (coordination of Mediterranean in situ observations). Currently, HCMR through HIMIOFoTS project operates a large scale integrated infrastructure that includes the marine observational systems together with ocean engineering infrastructures.

Delayed-mode data processing. HCMR has not developed yet a delayed-mode quality control capability for the Greek Argo data. The delayed mode quality control of the data delivered from the Greek Argo float will be processed by the MedArgo data centre. HCMR considers the possibility of developing delayed-mode data processing for ARGO profiles collected within the Eastern Mediterranean region. HCMR may also contribute to the improvement of the delayed mode quality control processing conceding CTD data collected through several HCMR research cruises. HCMR operates the Med Sea data portal that was set up for the needs of Copernicus CMEMS services. Within this framework HCMR is in charge of validating biochemical data from Argo floats that are operating in the Mediterranean.

1.4. Operational and scientific use of Argo data

A very important activity, under the framework of the Greek-Argo activities is the exploitation of Argo data for operational forecasting as well as for research applications. Along this direction, HCMR established a network of relevant Greek scientific groups mainly from Universities and Research Institutes which constitute the Greek Argo Users group/network. These different groups are already using or will be using ARGO data in ocean/atmospheric forecasting, climate studies and for educational purposes. It is expected that the Greek Argo Users Group will further grow and expand its activities concerning the scientific exploitation of Argo data and the cooperation among Greek scientists. The next step will be the expansion of the Greek Argo network in more members. The network is already in contact with many organizations / agencies / institutions and it is foreseen that the establishment of the E-A ERIC will increase the interaction of the Greek Argo Users Group with the European and international ARGO scientific community in the near future.

Operational ocean forecasting:

Med-Argo data have been already used as independent data in order to assess the impact of remote sensed and Ferry-box SSS data assimilation into the Aegean Sea hydrodynamic model component of the POSEIDON system running operationally at HCMR within the framework of POSEIDON system.

Med-Argo data are routinely assimilated (using localized Singular Evolutive Extended Kalman filtering techniques) on a weekly basis in three different modelling forecasting components (Mediterranean $1/10^o$ resolution, Aegean Sea $1/130^o$ resolution and Ionian – Adriatic Sea at $1/50^o$ resolution) of the POSEIDON operational system.

Some of the results of the works described above are included in the following scientific publications:

Korres, G., K. Nittis, I. Hoteit, and G. Triantafyllou, 2009: A high resolution data assimilation system for the Aegean Sea hydrodynamics. *Journal of Marine Systems*, 77, 325-340.

Korres, G., K. Nittis, L. Perivoliotis, K. Tsiaras, A. Papadopoulos, I. Hoteit and G. Triantafyllou, 2010. Forecasting the Aegean Sea hydrodynamics within the POSEIDON-II operational system. *Journal of Operational Oceanography*, Vol. 3, nu. 1, 37-49,

Korres, G., K. Nittis, L. Perivoliotis, G. Triantafyllou and M. Chatzinaki, 2009. The Aegean Sea –Poseidon model. Hellenic Centre For Marine Research, Greece.

Korres, G., M. Ntoumas, M. Potiris and G. Petihakis, 2014. Assimilating Ferry Box data into the Aegean Sea model. Journal of Marine Systems, 140 (2014) 59–72

Ocean science

Med-Argo data are currently used by a small group of researchers in Greece for studies of water mass characteristics of the different deep basins of the Mediterranean Sea and as a continuous record of T/S characteristics providing insight in the seasonal and inter-annual variability of the Mediterranean Sea and its sub-basins. A number of publications and scientific results have been released regarding the Greek Argo acquired data during the last 4 years.

Publications in scientific journals and conferences proceedings:

Petihakis, G., Perivoliotis, L., Korres, G., Ballas, D., Frangoulis, C., Pagonis, P., Ntoumas, M., Pettas, M., Chalkiopoulos, A., Sotiropoulou, M., Bekiari, M., Kalampokis, A., Ravdas, M., Bourma, E., Christodoulaki, S., Zacharioudaki, A., Kassis, D., Potiris, E., Triantafyllou, G., Tsiaras, K., 2018: An integrated open-coastal biogeochemistry, ecosystem and biodiversity observatory of the eastern Mediterranean-the Cretan Sea component of the POSEIDON system. *Ocean Science, 14*(5), 1223-1223.

Kassis D., Korres G., 2018: Recent hydrological status of the Aegean Sea derived from free drifting profilers. In proceedings of the 12th Panhellenic Symposium on Oceanography and Fisheries, «Blue Growth for the Adriatic-Ionian Macroregion and the Eastern Mediterranean», Ionian University, Corfu, 30 May – 3 June 2018

L. Perivoliotis , G. Petihakis , M. Korres , D. Ballas , C. Frangoulis , P. Pagonis , M. Ntoumas , M. Pettas , A. Chalkiopoulos , M. Sotiropoulou , M. Bekiari , A. Kalampokis , M. Ravdas , E. Bourma , S. Christodoulaki , A. Zacharioudaki , D. Kassis , M. Potiris , G. Triantafyllou , A. Papadopoulos , K. Tsiaras and S. Velanas, 2017. The POSEIDON system, an integrated observing infrastructure at the Eastern Mediterranean as a contribution to the European Ocean Observing System. Proceedings of the 8th EuroGOOS International Conference, 03-05 October 2017, Bergen, Norway

Kassis, D., Korres, G., Konstantinidou, A., Perivoliotis, L., 2017. Comparison of high-resolution hydrodynamic model outputs with in situ Argo profiles in the Ionian Sea. Mediterranean Marine Science, 0, 22-37. doi:10.12681/mms.1753

Kassis, D., Korres, G., Perivoliotis, L., 2016. Sub-mesoscale features of the Eastern Ionian Sea as derived from Argo floats operating during 2014-2015, in: Submesoscale Processes: Mechanisms, Implications and New Frontiers. Presented at the 48th Liege Colloquium, University of Liege, Liege, Belgium.

Kassis, D., Krasakopoulou, E., Korres, G., Petihakis, G., Triantafyllou, G.S., 2016. Hydrodynamic features of the South Aegean Sea as derived from Argo T/S and dissolved oxygen profiles in the area. Ocean Dyn. 1–18. doi:10.1007/s10236-016-0987-2

Kassis, D., Korres, G., Petihakis, G., Perivoliotis, L., 2015. : Hydrodynamic variability of the Cretan Sea derived from Argo float profiles and multi-parametric buoy measurements during 2010–2012. Ocean Dynamics, 15-00058. doi: 10.1007/s10236-015-0892-0

Kassis, D., Konstantinidou, A., Perivoliotis, L., Korres, G., 2015. Inter-comparing numerical model simulations in the Ionian Sea with Argo T/S profiles for the period 2008-2012. In

proceedings of the 11th Panhellenic Symposium on Oceanography and Fisheries, p.945-948, ISBN 978-960-9798-08-2

Kassis D., Perivoliotis L. & G. Korres, 2014. Greek Argo: Towards monitoring the Eastern Mediterranean - First deployments preliminary results and future planning. In proceedings of the 7th International Conference on EuroGOOS, Lisbon – Portugal, 28-30 October 2014

Doctorate theses:

Kassis, D., 2017: Operational in - situ monitoring of the Greek seas as a tool to describe hydrodynamic variability and its effect on the biochemical distribution, National Technical University of Athens (NTUA),
https://www.didaktorika.gr/eadd/handle/10442/40700?locale=en

Scientific Sheets in Greek Argo web page:

"Use of Lagrangian methods in optimizing Argo float deployment locations in the Mediterranean Sea" Summary of the scientific report of the University of Aegean in the framework of the Greek Argo Project.

"The integration of Argo floats in numerical weather prediction" Summary of the scientific report of the Harokopio University in the framework of the Greek Argo Project.

"Use of Argo data in ocean numerical simulations" Summary of the scientific report of the Aristotle University of Thessaloniki in the framework of the Greek Argo Project.

"Evaluation of climate and biochemical models using Argo data" Summary of the scientific report of the University of Crete in the framework of the Greek Argo Project.

Scientific Sheets in Euro-Argo web page:

Kassis D., Konstantinidou A., Perivoliotis L. and Korres G., 2014: Comparison of Argo profiles observations against numerical model simulations in Ionian Sea. Euro Argo RI web page http://www.euro-argo.eu/Main-Achievements/European-Contributions/Science/Regional-Seas/Med-Black-Seas/

Kassis D. and Korres G., 2014: Hydrological variability derived from the first Argo mission in the Cretan Sea basin. Euro Argo RI web page http://www.euro-argo.eu/Main-Achievements/European-Contributions/Science/Regional-Seas/Med-Black-Seas/

Presentations in the Euro-Argo users meeting and Euro-Argo Science meetings:

Kassis D., Von Schuckmann K., Korres G., 2013: Hydrographic properties of Cretan Sea derived from Argo float's profiles and buoy data measurements during 2010-2012. In proceedings of the 4th Euro-Argo Science Meeting and Workshop, June 2013, Southampton, UK http://www.euro-argo.eu/News-Meetings/Meetings/Users-Meetings/4th-Users-meeting-June-2013

Kassis, D., Perivoliotis, L., Korres, G., 2015: Hydrological variability of the Eastern Ionian and Adriatic Seas derived from two new Argo missions in 2014. In proceedings of the 5th Euro-Argo User Workshop - Brest, March 16-17 2015 http://www.euro-argo.eu/News-Meetings/Meetings/Users-Meetings/5th-User-Workshop-March-2015/Workshop-Programme

Kassis D., Korres G., 2019: Argo missions and synergies with other platforms in marginal seas: The north Aegean and south Ionian test cases. In proceedings of the 7th Euro-Argo Science Meeting Workshop - Athens, October 22-23 2019

Kassis D., Varlas G., 2019: Investigating the impacts of a strong Medicane on the upper layers of the Eastern Mediterranean Sea. In proceedings of the 7th Euro-Argo Science Meeting Workshop - Athens, October 22-23 2019

Additionally, Argo data are used for educational purposes in some Greek University Departments. Due to HCMR initiatives within Euro Argo, Greek Argo and SIDERI programmes to contact potentially interested Greek and other scientists from the eastern Mediterranean region and inform them about the benefits of Argo programme. An increasing demand for Argo data along the Aegean and Ionian Sea for both scientific and educational purposes has been registered. Furthermore, a presentation of Greek Argo and Euro-Argo activities was made at the University of Aegean (Marine Sciences department) in November 2016.

2. Funding

2.1 Existing funding for Greek Argo

The procurement, deployment and operation costs of the first Greek float launched in 2010/2011 were covered by HCMR internal funds. During 2012, Greece established national funding to the Greek Argo programme through the General Secretariat of Research and Technology (GSRT), Ministry of Education, Lifelong Learning and Religious Affairs (funding agency). A major achievement is that Greece participates to the European infrastructure E-A ERIC as a full member. Currently the only existing national funding for the Greek Argo is through HIMIOFoTS project through which the purchase of 6 floats is planned within 2020.

2.2 On the future funding, organization and planning for Greek Argo

Efforts from the Institute of Oceanography of HCMR for further national funding for the long-term sustainability of Greek Argo are ongoing. As part of the Euro-Argo, HCMR has undertaken all necessary efforts and managed to establish long term national funding for the E-A ERIC infrastructure and to meet the standards of a full member. Regarding the Greek Argo RI annual contribution to Euro-Argo RI an indicative estimation is the following:

Personnel committed/dedicated to Euro-Argo activities (man months/year):

- National representation, member commitments: 2.5
- Float preparation, deployment, procurement: 1

Personnel committed/dedicated to Greek-Argo activities (man months/year):

- Greek Argo coordination and management: 3
- Float preparation, deployment, procurement, fleet operation and data monitoring: 4.5

Greece has deployment capabilities for the Aegean, the Ionian Sea and the central Levantine basin. Float deployments in 2019 will be performed according to the plans of the Greek-Argo research infrastructure. The main goal within 2020 is to continue the development of the Greek-Argo infrastructure array in accordance with the Euro-Argo infrastructure. Future deployments are a function of the operational needs of the Greek Argo network and the current coverage of areas of interest. Although the final decisions for the areas that floats will be deployed may change, the plan for 2020 generally includes:

- 1 float deployment in the South Aegean
- 1-2 float deployments in the North Aegean
- 1 float deployment in the Ionian Sea

3. Dissemination activities of the Greek Argo– links with Euro-Argo infrastructure

Within 2019 several dissemination activities were carried out by the Greek Argo RI such as the participation of Greek Argo in the 2019 Researchers Night and the educational activities for high school students throughout the year. In 2017, under the framework of the 1st Ocean Observers Meeting (June 2017) Greek Argo presented its educational and outreach activities whilst, during the 6th Euro-Argo Users Workshop (July 2017) the Greek Argo Infrastructure activities and achievements were presented.
By the end of 2013 Greek Argo has launched its web page: www.greekargo.gr that demonstrates and promotes Greek-Argo and Euro-Argo activities. At the end of 2014 Greek-Argo web portal was upgraded providing information and data access from all floats operating in the Mediterranean and presenting all Greek Argo activities, news and data from Greek Argo floats. A continuous upgrade is ongoing integrating more images and videos from Greek Argo deployment activities. Furthermore, new education material has been released and a school visit programme has been established since 2015.
The Euro-Argo infrastructure is also demonstrated on the POSEIDON updated web page, http://www.poseidon.hcmr.gr/article_view.php?id=57&cid=28&bc=28. The POSEIDON system is the operational monitoring and forecasting system for the Greek Seas and many of its forecasting components use T/S Argo profiles for data assimilation purposes. The POSEIDON web page is also hosting the links to the EuroArgo educational web site as well as to the floats from each European country. The above links along with other informative material (Euro Argo leaflet, focused questionnaire) were forwarded directly to all active and potential users of Argo data in Greece. Many research groups filled and sent back the questionnaire providing valuable feedback to HCMR team. Furthermore, the EuroArgo poster and leaflet translated in Greek and they are hosted in the POSEIDON website.

Argo National Report of India (2019)

(Submitted by E. Pattabhi Rama Rao, INCOIS, India)

1. The status of mplementation

1.1a Floats deployment

During the year 2019 - 20, 34 floats were deployed in the Indian Ocean taking the total to 493. The new deployment includes 14 Bio-Argo floats (APF-11) with additional sensors like Doxy, FLBB, Chl-a and one float with Nitrate Sensor deployed in Arabian Sea.

1.1b Performance Analysis of Floats deployed

Out of 34 floats deployed during 2019 - 20, 33 are active and providing profiles.

1.2 Technical problems encountered and solved

None

1.3 Status of contributions to Argo data management

- **Data acquired from floats**

  India has deployed 493 floats so far (till Apr 06, 2020). Out of these 156 floats are active. All the active floats data are processed and sent to GDAC.

- **Data issued to GTS**

  BUFR format messages from these floats are being sent to GTS via RTH, New Delhi RTH.

- **Data issued to GDACs after real-time QC**

  All the active floats (156) data are subject to real time quality control and are being sent to GDAC.

- **Web pages**

  INCOIS is maintaining Web-GIS based site for Indian Argo Program. It contains entire Indian Ocean floats data along with trajectories. Further details can be obtained at following the link:http://www.incois.gov.in/incois/argo/argo_home.jsp.

  Apart from the floats deployed by India, data from floats deployed by other nations in the Indian Ocean are received from the Argo Mirror and made available in the INCOIS website. User can download the data based on his requirement..

  Statistics of Indian and Indian Ocean floats are generated and maintained in INCOIS web site. The density maps for aiding people for new deployments are made available on a monthly basis. For full details visit http://www.incois.gov.in/Incois/argo/argostats_index.jsp.

- **Statistics of Argo data utilisation**

  Argo data is widely put to use by various Organisations/ Universities/ Departments. Indian Meteorological Department (IMD) is using Argo data for their operational purpose. Scientists, Students and Researchers from INCOIS, NIO, SAC, C-MMACS, NRSA, IITM, NCMRWF, IISc etc are using Argo data in various analysis. Many paper based on Argo data were also published in reputed journals. See the references below. The demand for Bio-Argo data is increasing and the same is being supplied for research interest by various research institutes and universities. These data is also used for validation of Biogeochemical model outputs like ROMS with Fennel module.

INCOIS Argo web page statistics during the year 2019 are as shown below:

Page	Number
Argo Web Page Views	4743
Argo Data Download	2013
Argo Products	37191

Products generated from Argo data

- Value added products obtained from Argo data are continued. Continued to variational analysis method while generating value added products. Many products are generated using Argo temperature and salinity data. The Argo T/S data are first objectively analysed and this gridded output is used in deriving value added products. More on this can be see in the RDAC functions.
- Version 2.2 of DVD on "Argo data and products for the Indian Ocean" is released to public for use with data corresponding to April 2018 updated. This DVD consists of ~ 3,30,000 profiles and products based on the Argo T/S. A GUI is provided for user to have easy access to the data. DVD product is discontinued and it is being made available via INCOIS and UCSD web sites.
- To cater to many users of INCOIS LAS, it is enhanced in term of capacity and new products viz., model outputs, new wind products (OSCAT), fluxes are made available. New products as per the request received from the users in future are being made available. For further details visit http://las.incois.gov.in.

1.4 Status of Delayed Mode Quality Control process

- INCOIS started generating and uploading D files to GDAC form July 2006, and as of today, profiles belonging to all eligible floats have been subjected to DMQC.
- Advanced Delayed Mode Quality Control s/w developed by CSIRO is being put to use successfully. Using this s/w all the eligible floats are reprocessed to tackle pressure sensor offset problems, salinity hooks, thermal lag corrections, salinity drifts.
- Additionally updated version of DMQC software i,e COW is now being used for performing DMQC.
- Under the data search and archeology data from our own sister concerns is being obtained and put to use in the delayed mode processing.
- About 46 % of the eligible profiles are subjected to DMQC and the delayed mode profiles are uploaded on to GDAC.

1.5 Trajectory files status:

Trajectory files in Ver 3.1 format for all APEX floats are being uploaded to GDAC and trajectories wrt to PROVOR and ARVOR floats is still underway.

2. Present level of and future prospects for national funding for Argo including a summary of the level of human resources devoted to Argo.

Indian Argo Project is fully funded by Ministry of Earth Sciences, (MoES), Govt. of India. Funding is secured for the deployment of 50 Argo floats per year including (3:2 Normal and Bio), Data management activities, Data analysis, etc. for the period 2017-2020. India plans to deploy 50 floats/per (40 tropical Indian Ocean and 10 in the Southern ocean) during the period 2020-2025.

Three Permanent and one temporary scientific/technical personnel are working under Indian Argo project, which include personal for deployment of Argo floats, Data system, Analysis of Data, etc.

3. Summary of deployment plans (level of commitment, areas of float deployment) and other commitments to Argo (data management) for the upcoming year and beyond where possible.

India is committed to deploy floats in the Indian Ocean wherever gap exists. India has committed 50 floats per year during 2017-2020 (40 in the Tropical Indian Ocean and 10 in the Southern ocean). Out of 50 floats, 20 floats will be bio-argo floats. After ascertaining the gap region and cruise plan of MoES research vessels, these floats will be deployed. The existing data management resources will continue until 2025.

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

Operational: All Argo data are being routinely assimilated in Ocean Model for providing Global ocean analysis. This analysis is being used by Indian MET department for initialization of coupled ocean-atmosphere forecast of the Monsoon. From the year 2011, India is providing seasonal forecast of monsoon using dynamical model wherein Ocean analysis (with assimilation of Argo) is an important contribution. The analysis products are being made available through INCOIS live access server (las.incois.gov.in).

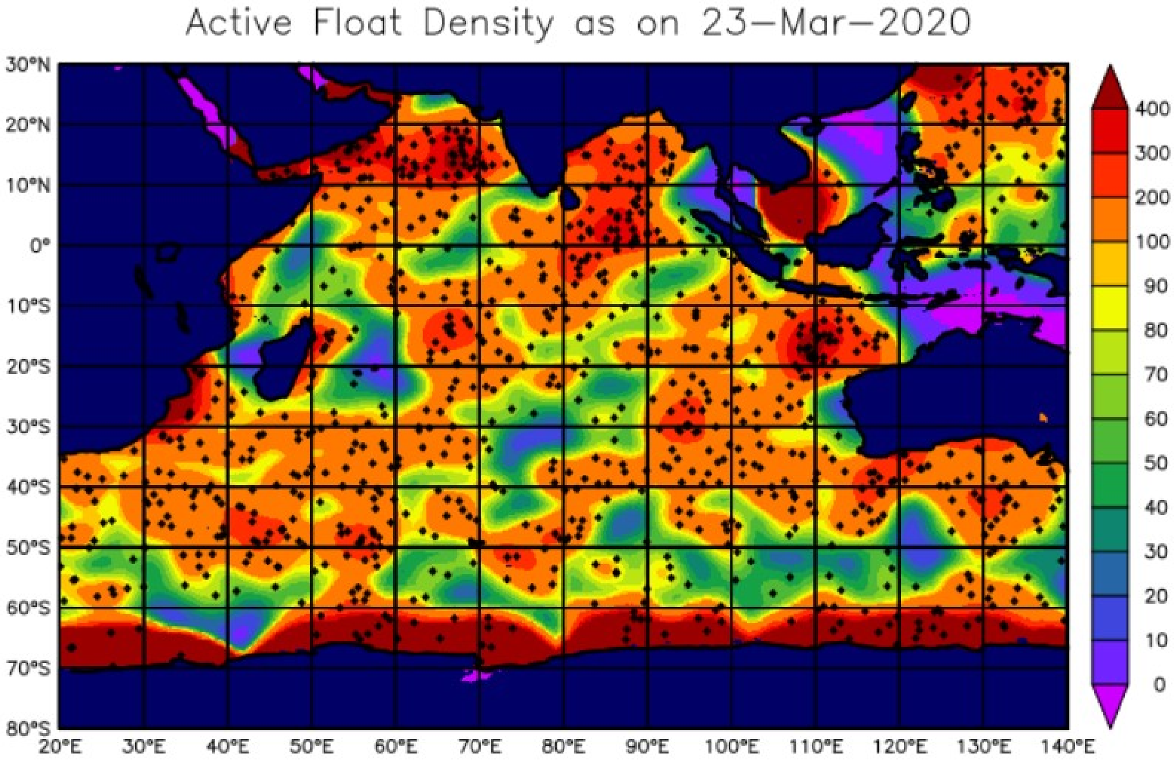
Research: Argo data are being widely used for many applications to understand the Indian Ocean dynamics, cyclone and monsoon system in relation to heat content, thermosteric component of sea level and validation of OGCM by various Indian institutions and university students.

Argo Regional Centre (ARC) - Indian Ocean

(http://www.incois.gov.in/argo/ARDCenter.js)

- Acquisition of Argo data from GDAC corresponding to floats other than deployed by India and made them available on INCOIS web site.
- All these data sets are made available to the user through a s/w developed with all GUI facilities. This s/w is made available through FTP at INCOIS and UCSC web sites.
- Delayed Mode Quality Control (Refer 1.4 above)
- Data from the Indian Ocean regions are gridded into 1x1 box for monthly and 10 days and monthly intervals. These gridded data sets are made available through INCOIS Live Access Server (ILAS). Users can view and download data/images in their desired format.
- ERDDAP site was set up for the data and data products derived from Argo floats.
- Additionally SST from TMI, AMSRE and Wind from ASCAT, Chla from MODIS and OCM-2 are also made available on daily and monthly basis.
- Global wind products from OSCAT is also generated and made available on LAS along with TROP flux data sets.
- Data Sets (CTD, XBT, Subsurface Moorings) are being acquired from many principle investigators. These data are being utilized for quality control of Argo profiles.
- Value added products: Two types of products are currently being made available to various user from INCOIS web site. They are:
  - (i) Time series plots corresponding to each float (only for Indian floats).
  - (ii) Spatial plots using the objectively analysed from all the Argo floats data deployed in the Indian Ocean.

  These valued added products can be obtained from the following link http://www.incois.gov.in/Incois/argo/products/argo_frames.html
- Regional Co-ordination for Argo floats deployment plan for Indian Ocean. The float density in Indian Ocean as on 23 Mar, 2020 is shown below.



5. Issues that your country wishes to be considered and resolved by the Argo Steering Team regarding the international operation of Argo. These might include tasks performed by the AIC, the coordination of activities at an international level and the performance of the Argo data system. If you have specific comments, please include them in your national report.

None

6. To continue improving the quality and quantity of CTD cruise data being added to the reference database by Argo PIs, it is requested that you include any CTD station data that was taken at the time of float deployments this year. Additionally, please list CTD data (calibrated with bottle data) taken by your country in the past year that may be added to the reference database. These cruises could be ones designated for Argo calibration purposes only or could be cruises that are open to the public. To help CCHDO track down this data, please list the dates of the cruise and the PI to contact about the data.

Data Sets (CTD, XBT, Subsurface Moorings) are being acquired from many principle investigators. These data are being utilized for quality control of Argo profiles.

7. Argo bibliography

INCOIS is actively involved in utilization of Argo data in various studies pertaining to Indian Ocean. Also INCOIS is encouraging utilization of Argo data by various universities by funding them. Some of the publications resulted from Argo data which includes scientists from INCOIS during the year 2019 are listed below:

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3. Chakraborty, K., A. A. Lotliker, S. Majumder, A. Samanta, S. K. Baliarsingh, J. Ghosh, P. P. Madhuri, A. Saravanakumar, N. S. Sarma, B. S. Rao, and P. Shanmugam, 2019: Assessment of model-simulated upper ocean biogeochemical dynamics of the Bay of Bengal. Journal of Sea Research, 146, 63-76, https://doi.org/10.1016/j.seares.2019.01.001.
4. Chakraborty, K., N. Kumar, M. S. Girishkumar, G. V. M. Gupta, J. Ghosh, T. V. S. Udaya Bhaskar, and V. P. Thangaprakash, 2019: Assessment of the impact of spatial resolution on ROMS simulated upper-ocean biogeochemistry of the Arabian Sea from an operational perspective. Journal of Operational Oceanography, 1-27, https://doi.org/10.1080/1755876X.2019.1588697.
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10. Hermes, J. C., Y. Masumoto, L. M. Beal, M. K. Roxy, J. Vialard, M. Andres, H. Annamalai, S. Behera, N. D’Adamo, T. Doi, M. Feng, W. Han, N. Hardman- Mountford, H. Hendon, R. Hood, S. Kido, C. Lee, T. Lee, M. Lengaigne, J. Li, R. Lumpkin, K. N. Navaneeth, B. Milligan, M. J. McPhaden, M. Ravichandran, T. Shinoda, A. Singh, B. Sloyan, P. G. Strutton, A. C. Subramanian, S. Thurston, T. Tozuka, C. C. Ummenhofer, A. S. Unnikrishnan, R. Venkatesan, D. Wang, J. Wiggert, L. Yu, and W. Yu, 2019: A Sustained Ocean Observing System in the Indian Ocean for Climate Related Scientific Knowledge and Societal Needs. Frontiers in Marine Science, 6, https://doi.org/10.3389/fmars.2019.00355.
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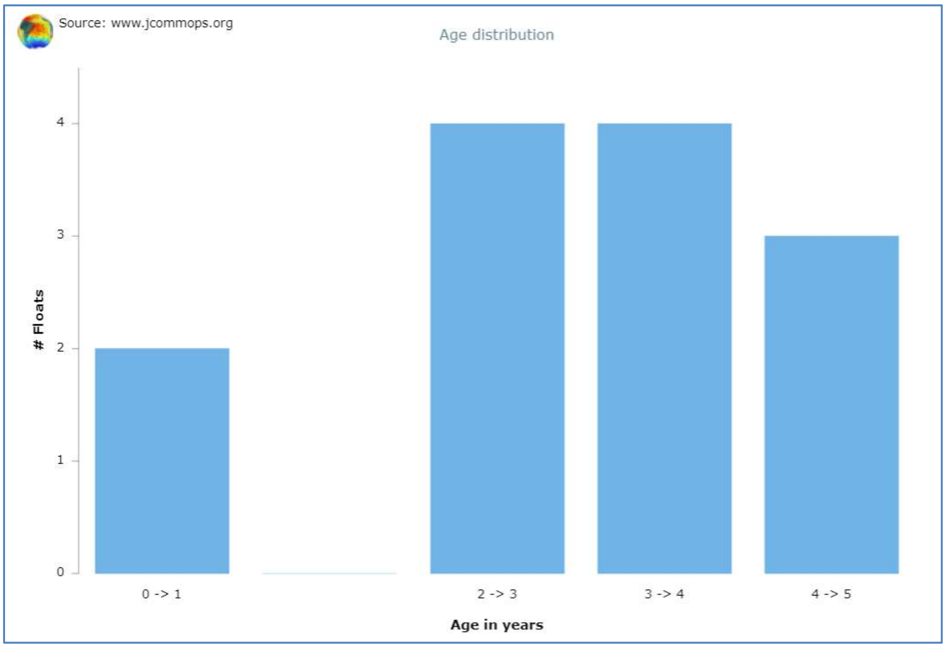
Argo National Report 2019: Ireland

1) The status of implementation (major achievements and any issues in 2019):

a) Irish Argo float Overview

In 2019, Ireland deployed a total of three Argo floats, two core T&S floats, as well as one core & O2 float.



Above: *Age distribution of Ireland's Argo Fleet.*

There is an ongoing data processing issue with regards to the data from float WMO#6901933 which was deployed on the 28/05/2019. The float is a core & O2 float. The float is operational and data is being received as normal. The Marine Institute has been in contact with our colleagues in BODC and have been informed of a difficulty in processing the data being returned from this float. The Marine Institute will continue working with its partners in BODC and indeed in the EURO Argo ERIC to solve this issue.

The Marine Institute deployed its southernmost float in 2019. On the 6th of December 2019 a float was deployed at Lat: 9.2816, Lon: -40.0591. This float was deployed by a member of staff of the Marine Institute who was taking part in a transatlantic voyage with her family on their sailing vessel Danú.

2019 will see the Irish fleet increase to ~ 14 floats (depending on existing float lifecycles) which would be an all-time high number of profiling floats within the Irish Argo fleet. The planned deployment of a further 2 core floats and a BGC float in 2020 will add considerably to the amount of data being received as well as to the research capabilities within the Irish Argo fleet.

Marine Institute Argo Float Overview (2019)					
Deployed/ Operational Floats (2019)					
Float	WMO #	Float Identifier	Make/ Model	Deployed	Status
1	6901921	7243	TWR/APEX	23/03/2016	OPERATIONAL
2	6901923	7241	TWR/APEX	09/04/2016	OPERATIONAL
3	6901919	7244	TWR/APEX	22/04/2015	OPERATIONAL
4	6901920	7245	TWR/APEX	22/04/2015	OPERATIONAL
5	6901922	7242	TWR/APEX	14/04/2016	OPERATIONAL
6	6901924	7240	TWR/APEX	10/02/2017	OPERATIONAL
7	6901925	7841	TWR/APEX	11/02/2017	OPERATIONAL
8	6901926	7842	TWR/APEX	20/05/2017	OPERATIONAL
9	6901928	7844	TWR/APEX	12/02/2018	OPERATIONAL
10	6901929	AI2600-17EU001	NKE/ARVOR	12/02/2018	OPERATIONAL
11	6901930	AI2600-17EU002	NKE/ARVOR	27/03/2018	OPERATIONAL
12	6901931	AI2600-17EU003	NKE/ARVOR	06/12/2019	OPERATIONAL
13	6901932	AI2600-17EU004	NKE/ARVOR	29/05/2019	OPERATIONAL
14	6901933	AI2632-18EU038	NKE/ARVOR + (O2)	28/05/2019	OPERATIONAL
Floats to be deployed in 2020.					
Float	WMO #	Float Identifier	Make/ Model	Deployed	Status
1	6901934	AI2600-18EU030	NKE/ARVOR	TBC	REGISTERED
2	6901935	AI2600-18EU032	NKE/ARVOR	TBC	REGISTERED
3	6901936	8350	TWR/APEX BGC	TBC	REGISTERED
Floats Awaiting Deployment (In stock)					
1	TBC	AI2600-18EU029	NKE/ARVOR	TBC	N/A
2	TBC	AI2600-18EU031	NKE/ARVOR	TBC	N/A
3	TBC	AI2632-18EU039	NKE/ARVOR	TBC	N/A
4	TBC	OIN 13IR ARL03	NKE/ARVOR	TBC	N/A

b) Irish floats deployed in 2019 and their performance

WMO #	Float Identifier	Make/ Model	Deployed	Status
6901931	AI2600-17EU003	NKE/ARVOR	06/12/2019	OPERATIONAL
6901932	AI2600-17EU004	NKE/ARVOR	29/05/2019	OPERATIONAL
6901933	AI2632-18EU038	NKE/ARVOR + (O2)	28/05/2019	OPERATIONAL

c) Technical problems encountered and solved

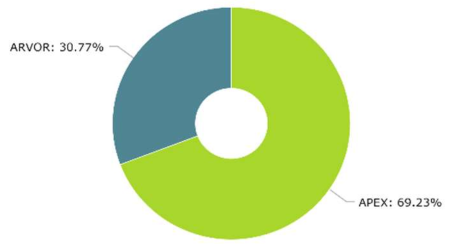
There is an issue with processing the data being returned from a core & O2 float, WMO# 6901933. Work is ongoing towards finding a solution to this issue.

d) **Status of contributions to Argo data management (including status of conversion to V3 file formats, pressure corrections, etc.)**
Carried out by BODC for the Marine Institute (Ireland).

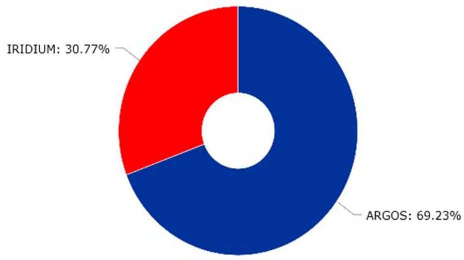
e) **Status of delayed mode quality control process**
Carried out by BODC for the Marine Institute (Ireland).

2) **Present level of, and future prospects for; national funding for Argo including a summary of the level of human resources devoted to Argo.**
Ireland continues to be a committed member of the Euro-Argo ERIC and will comply with the minimum requirement of deploying 3 floats per annum. Ireland via the Marine Institute will deploy additional floats where funding allows and will also assist the ERIC in deploying project specific floats where appropriate.

3) **Summary of deployment plans (level of commitment, areas of float Deployment, low or high resolution profiles, extra sensors, Deep Argo) and other commitments to Argo (data management) for the upcoming year and beyond where possible.**
The Marine Institute has ensured a minimum of three profiling floats were deployed during 2019 in alignment with the requirements of the Euro Argo ERIC. 2020 will see the deployment of Ireland's first BGC sensing float (as one of the 3 floats deployed in 2020). Multi-annual funding for the programme remains elusive but efforts continue towards that end on the national level. Float procurement via the Euro-Argo ERIC may allow for an increased number or more sensing capabilities (I.e. 02) of floats to be procured.



Above Right: *Illustrating the breakdown of Irish floats (NKE (ARVOR) and Teledyne Webb (APEX). With NKE being the Euro-Argo ERIC tender winning bid, Ireland should see the number of ARVOR deployed floats increase over the coming years.*



Right: *Graph showing the number of Irish floats using ARGOS or Iridium communications. With floats procured via Euro-Argo ERIC having Iridium communication systems the number of Irish floats with iridium communications will increase over the coming years.*

4) **Summary of national research and operational uses of Argo data as well as contributions to Argo Regional Centres. Please also include any links to national program Argo web pages to update links on the AST and AIC websites.**
   Argo data is primarily used to validate ROMS models in the Oceanographic Services section of the Marine Institute. Argo data will also be utilised by a number of PhD students within the Marine Institute and 3rd level institutes across Ireland. Irish deployed Argo float data may also be used by researchers on an international level as all data is open and freely available.

   Irish Argo National Webpage (hosted by the Marine Institute):
   https://www.marine.ie/Home/site-area/areas-activity/oceanography/euro-argo

   Irish Argo Float Data*:
   https://www.digitalocean.ie/
   *May not visualise correctly via Internet Explorer web browser

5) **Issues that your country wishes to be considered and resolved by the Argo Steering Team regarding the international operation of Argo. These might include tasks performed by the AIC, the coordination of activities at an international level and the performance of the Argo data system. If you have specific comments, please include them in your national report.**
   N/A. Any issues can be dealt with via the Euro-Argo ERIC office.

6) **To continue improving the quality and quantity of CTD cruise data being added to the reference database by Argo PIs, it is requested that you include any CTD station data that was taken at the time of float deployments this year. Additionally, please list CTD data (calibrated with bottle data) taken by your country in the past year that may be added to the reference database. These cruises could be ones designated for Argo calibration purposes only or could be cruises that are open to the public. To help CCHDO track down this data, please list the dates of the cruise and the PI to contact about the data.**
   No CTD data are uploaded to the CCHDO website. However, all CTD data are emailed to Else Juul Green (else@ices.dk) who checks the data before it is uploaded to the ICES Oceanographic data portal annually:
   http://ocean.ices.dk/HydChem/HydChem.aspx?plot=yes

7) **Keeping the Argo bibliography (http://www.argo.ucsd.edu/Bibliography.html) up to date and accurate is an important part of the Argo website. This document helps demonstrate the value of Argo and can possibly help countries when applying for continued Argo funding. We reached more than 2000 papers published using Argo data! To help me with this effort, please include a list of all papers published by scientists within your country in the past year using Argo data, including non-English publications.**
   N/A.

Report on the Italian Argo Program for 2019

1. The status of implementation (major achievements and problems in 2019).

- floats deployed and their performance:

In total, **23 Italian floats** were deployed in 2019 (see Tables 1 and 2 for details). These floats were Provor, Arvor-I and Arvor-Ice designs manufactured by NKE (France). All floats transmit data via Iridium telemetry.

Mediterranean and Black Sea deployments

One float was deployed in the Black Sea and 12 units were released in the Mediterranean (Table 1). In the Mediterranean, most floats have a parking depth at 350 dbar and maximal profiling depths alternating at 700 and 2000 dbar. In the Black Sea, the parking depth was set to 200 dbar. They all have cycles of 5 days except for 3 Arvor-I-DO floats (WMO 6903265, 6903264 and 6903266) which had short cycles of 3 h during most of their initial operating life to measure high-frequency processes in the Alboran Sea. Two Arvor-Deep floats were deployed in the Hellenic Trench (Ionian Sea). One of them (WMO 6903267) stopped working after 6 cycles. The second deep Arvor (WMO 6903268) was deployed at about the same location in October 2019 and has performed 22 up to February 2020; it is configured with a parking depth of 3500 m and a maximal profiling depth of 4000 m.

Most floats were deployed from research vessels of opportunity (i.e., R/V Dallaporta, R/V Laura Bassi, R/V Pourquoi Pas?, R/V Aegaeo, R/V Bat-Galim for the Mediterranean and R/V Akademik for the Black Sea) with the help of colleagues from France, Italy, Greece, Israel and Bulgaria.

South Atlantic, South Pacific and Southern Ocean

Five Italian floats were deployed in the South Pacific Ocean and the Pacific sector of the Southern Ocean (Table 2) with the help of Italian colleagues onboard the R/V Araon while sailing from New Zealand to the Ross Sea. All these floats are ice detection type. The Arvor-Ice uses an Ice Sensing Algorithm (ISA) based on temperature readings to abort surfacing when sea ice is present at the sea surface. All floats were programmed to cycle between the surface and 2000 dbar every 10 days and to drift at the parking depth of 1000 dbar. The floats were still active in early 2020.

Five Italian floats were deployed in the South Atlantic Ocean in February 2019 (Table 2) with the help of Italian colleagues onboard the R/V Agulhas II. These floats are Arvor-Ice model. All the floats were programmed to cycle between the surface and 2000 dbar every 10 days and to drift at the parking depth of 1000 dbar. They were all still active in early 2020.

Model	WMO	Depl. Date	Lat	Lon	Cycles	Last Date	Lat	Lon	Status*	Cyc.**
Arvor-I	6903259	03-Mar-2019 00:05	34.44	23.73	69	02 -Feb-2020 06:05	35.89	21.87	A	5
Arvor-I	6903260	05-Mar-2019 00:05	34.06	25.33	69	04-Feb-2020 06:09	34.30	22.84	A	5
Arvor-I-DO	6903262	18-Mar-2019 14:35	37.09	18.86	66	02-Feb-2020 06:20	39.54	19.57	A	5
Arvor-I-DO	6903263	23-Mar-2019 16:02	43.01	15.11	65	02-Feb-2020 06:32	42.90	15.27	A	5
Arvor-I	6903264	30-Mar-2019 00:30	35.96	-4.28	410	02-Feb-2020 21:02	36.47	-10.77	A	5
Arvor-I-DO	6903265	30-Mar-2019 18:50	36.01	-4.27	98	13-May-2019 14:29	35.81	-5.74	D	5
Arvor-I-DO	6903266	05-Apr-2019 11:37	36.17	-3.01	207	05-Feb-2020 06:29	36.68	0.31	A	5
Arvor-D	6903267	19-Jul-2019 21:30	36.50	21.48	6	30-Jul-2019 21:25	36.55	21.32	D	10
Arvor-I	6903269	11-Sep-2019 16:15	32.32	34.31	31	04-Feb-2020 21:11	33.56	35.08	A	5
Arvor-I	6903270	12-Sep-2019 00:44	32.50	33.89	31	05-Feb-2020 20:53	34.52	32.07	A	5
Arvor-D	6903268	22-Oct-2019 22:00	36.60	21.47	23	06-Feb-2020 04:25	35.60	22.00	A	5
Arvor-I-DO	6903765	25-Oct-2019 11:49	33.47	27.14	22	03-Feb-2020 06:13	33.50	26.31	A	5
Arvor-I	**6903766**	**02-Dec-2019 19:24**	**43.18**	**29.00**	**15**	**06-Feb-2020 06:05**	**42.01**	**30.00**	**A**	**5**

**Status in early February 2020: A = active, D = dead;*
***Cycle: Length of cycle in days.*

Table 1. Status information for the 13 Italian floats deployed in the Mediterranean and Black Sea (bold) during 2019.

Model	WMO	Depl. Date	Lat	Lon	Cycles	Last Date	Lat	Lon	Status*	Cyc.**
Arvor-I-ICE	6903252	08-Feb-2019 04:15	-48.60	168.00	38	04-Feb-2020 20:38	-44.73	177.42	A	10
Arvor-I-ICE	6903254	09-Feb-2019 08:45	-57.00	168.18	37	27-Jan-2020 21:19	-52.42	-154.51	A	10
Arvor-I-ICE	6903253	10-Feb-2019 03:07	-59.01	168.58	37	28-Jan-2020 20:33	-56.78	-163.47	A	10
Arvor-I-ICE	6903251	10-Feb-2019 11:35	-61.01	168.94	37	28-Jan-2020 20:43	-59.93	-157.53	A	10
Arvor-I-ICE	6901880	10-Feb-2019 20:27	-63.00	169.33	37	28-Jan-2020 05:48	-64.14	-171.71	A	10
Arvor-I-ICE	6903255	28-Feb-2019 17:35	-63.99	0.00	36	05-Feb-2020 06:12	-66.06	-9.32	A	10
Arvor-I-ICE	6903256	28-Feb-2019 21:53	-63.00	0.00	36	05-Feb-2020 21:11	-59.56	-1.63	A	10
Arvor-I-ICE	6903257	01-Mar-2019 03:45	-62.00	0.00	35	27-Jan-2020 21:04	-62.00	0.00	A	10
Arvor-I-ICE	6903258	01-Mar-2019 21:07	-59.92	-4.50	35	27-Jan-2020 21:00	-60.06	1.22	A	10
Arvor-I-ICE	6903261	08-Mar-2019 19:59	-54.03	-4.50	35	03-Feb-2020 21:10	-52.22	-3.83	A	10

**Status in early February 2020: A = active, D = dead.*
***Cycle: Length of cycle in days.*

Table 2. Status information for the 10 Italian floats deployed in the Southern Ocean, South Atlantic and South Pacific during 2019.

Overall status at the end of 2019

In summary, at the end of 2019, the ARGO-ITALY program had a total of 69 active floats, including 33 instruments in the Mediterranean Sea, 1 in the Atlantic Ocean (it escaped from the Mediterranean through the Strait of Gibraltar), 5 in the Black Sea (Figure 1) and 36 in the South Pacific, South Atlantic and Southern Oceans (south of 60˚S) (Figure 2).

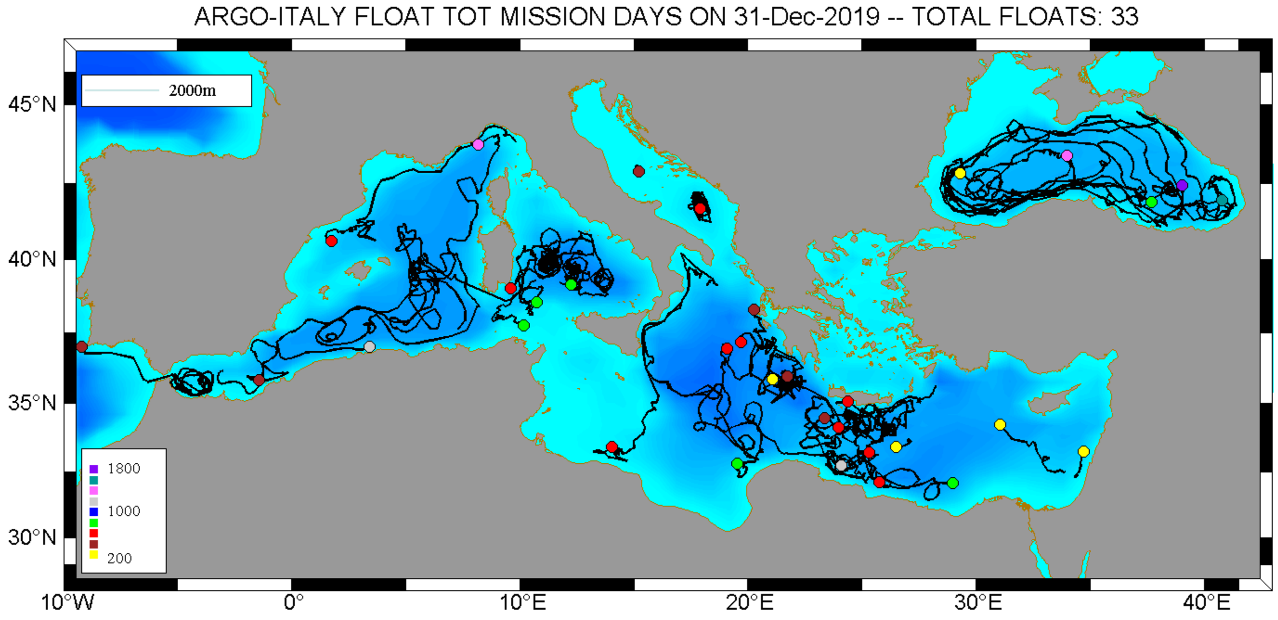


Figure 1. Trajectories and positions (circle symbols) on 31 December 2019 of the 33 ARGO-ITALY floats active in the Mediterranean and Black Sea. The circle symbols are color-coded as a function of float age in days.

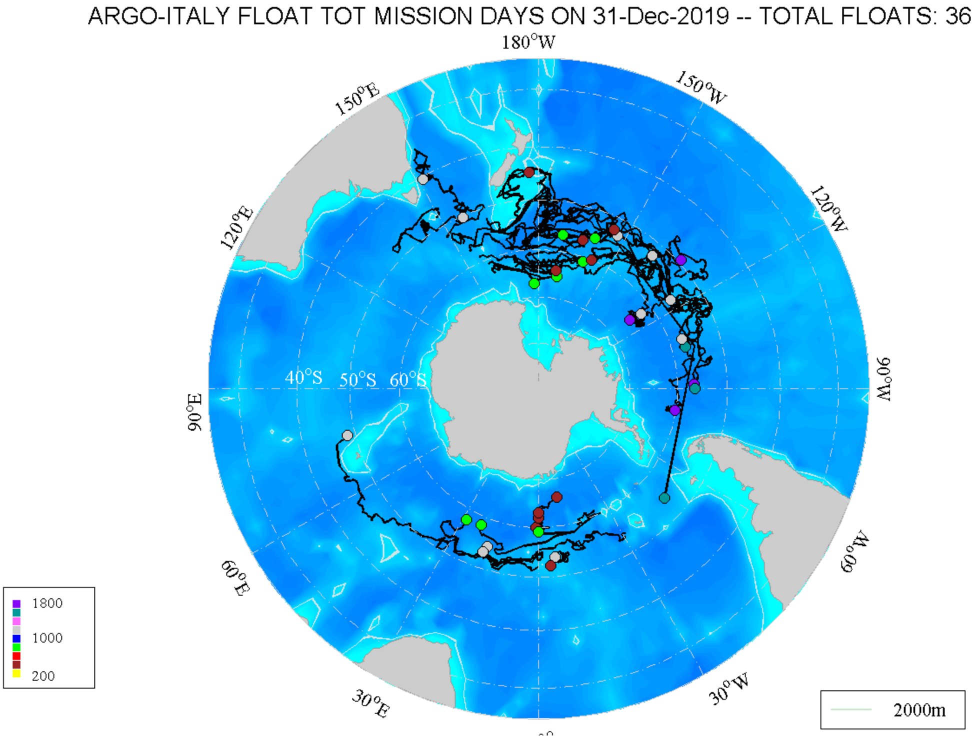


Figure 2. Trajectories and positions (circle symbols) on 31 December 2019 of the 36 ARGO-ITALY floats in the South Pacific, South Atlantic and Southern Oceans. The circle symbols are color-coded as a function of float age in days.

The temporal evolution of the number of active floats is shown in Figure 3 with weekly resolution, along with the annual numbers of float deployments and float deaths for the period 2012-2019. The float population in 2012-2019 is essentially increasing and reaching a plateau around 70 active instruments in 2017-2019. In 2019, the number of deployments exceeded the number of dead floats.

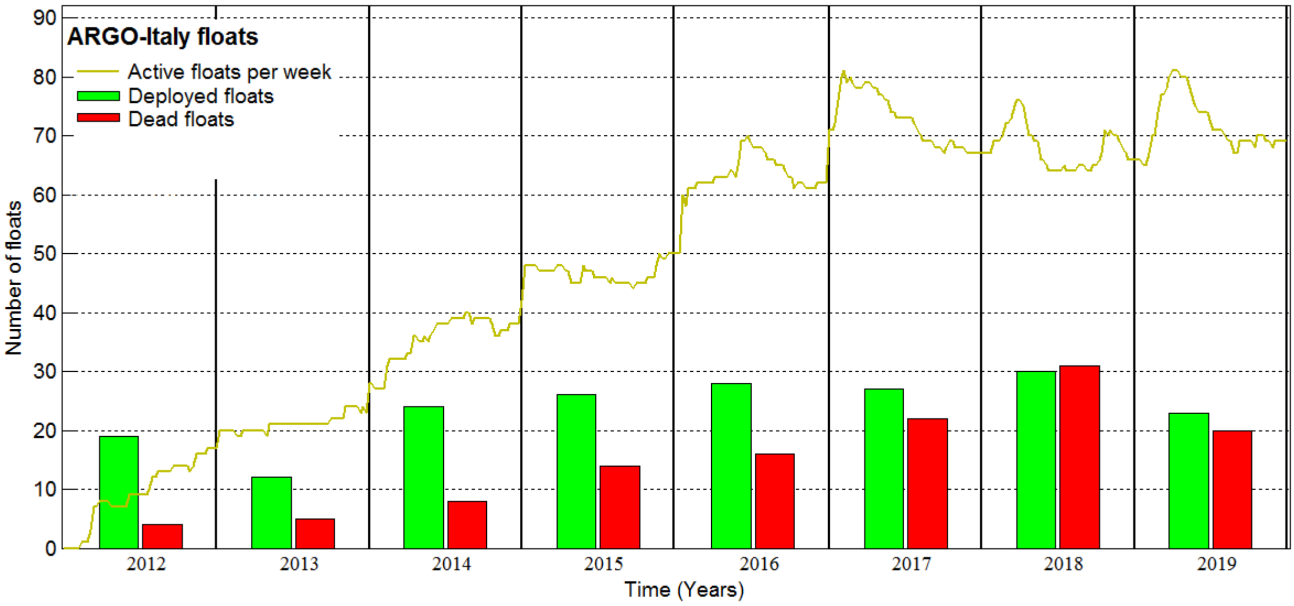


Figure 3. Temporal evolution of the number of ARGO-ITALY active floats with weekly resolution and histogram of the annual float deployments and losses.

Since 18 February 2012, a total of **189 ARGO-ITALY floats** have been deployed, 117 in the Mediterranean and Black seas, and 72 in the oceans of the Southern Hemisphere. In less than 8 years, they have provided about **24300 CTD profiles**. The histograms of number of CTD profiles per float is shown in Figure 6. Fortyfour floats have done more than 180 profiles. In total (during 2012-2019), ~6 % of the floats have failed just after deployment, while 100 % of those deployed in 2019 successfully worked after deployment.

- <u>technical problems encountered and solved</u>

Mediterranean and Black Sea

Two floats stopped functioning prematurely before the end of the year 2019. The Arvor-Deep float (WMO 6903267) deployed southeast of Greece stopped transmitting data after 6 cycles. The cause for this malfunction is still under investigation by NKE. The Arvor-I (WMO 6903265, equipped with an oxygen optode) was deployed in the Alboran Sea in March 2019 with fast cycles of 3 h. This float had problems to profile correctly and eventually stranded on the Moroccan coast. It was recovered and we are still trying to have it shipped back to NKE in France for repair.

- <u>status of contributions to Argo data management (including status of pressure corrections, technical files, etc)</u>

The data management for the Italian float is mostly done by the Coriolis GDAC. Metadata and data are available through the Coriolis web site in near real-time.

- <u>status of delayed mode quality control process</u>

The delayed mode quality control (DMQC) of the physical data (pressure, temperature and salinity) provided by the Italian floats in the Mediterranean and Black seas was done for 58 floats (all information and statistics to create the D-files sent to Coriolis). The temperature and salinity data of those floats were quality controlled following the standard Argo procedure, covering the period 2010-2018. The float salinity calibration needs an accurate reference dataset and these data have to be quite close in time and space to the float measurements. The latter is necessary, in order to reduce the effects both of the inter-annual and the seasonal variability of the Mediterranean Sea, mostly in the upper and intermediate layers of the water column. For this reasons, OGS collected CTD data in complement of the official reference dataset using two approaches: personal contacts and regional data services. The standard statistical method adopted by the Argo community for the salinity correction is strictly affected by the natural changes in the water column of the Mediterranean Sea and hence a careful interpretation of the method results is necessary. For this reason, we adopted other qualitative checks (i.e., the comparison between nearby floats and analysis of the deepest portion of the temperature-salinity diagram) in order to increase reliability of the analysis. The DMQC of the Italian floats deployed in the Southern Ocean (and South Pacific and Atlantic oceans) started in 2019 and was applied to 22 floats.

2. Present level of and future prospects for national funding for Argo including a summary of the level of human resources devoted to Argo.

The Italian Ministry of Research has provided funding to buy 21 floats in 2019, including 5 instruments with dissolved oxygen sensors and 1 full BGC float. In addition, the Italian human resources per year devoted to Argo-Italy was about 50 man-months for technical, administrative and scientific personnel involved in the project in 2019. It is expected that the same level will be maintained in 2020, including the procurement of 20 additional standard floats and 2 deep floats. The Italian Ministry of Research is committed to provide funding in order to sustain the Italian contribution to Argo beyond 2020 as a founding member of the Euro-Argo Research Infrastructure Consortium. In addition to the Italian national funding, OGS has funding from EC projects (e.g. Euro-Argo RISE) for several activities related to Argo.

3. Summary of deployment plans (level of commitment, areas of float Deployment, low or high resolution profiles) and other commitments to Argo (data management) for the upcoming year and beyond where possible.

The Italian deployment plans for 2020 and 2021 are detailed in Table 3. The main areas of interest are the Mediterranean and Black seas and the oceans of the South Hemisphere.

Year	T/S floats (some of them with DO)		BGC floats		Deep floats		Total
	Quantity	Area	Quantity	Area	Quantity	Area	
2020	12 2 12	Mediterranean Black Sea South Hemisphere	1 0	Mediterranean Black Sea	1	Mediterranean	**28**
2021	12 2 12	Mediterranean Black Sea South Hemisphere	0 1	Mediterranean Black Sea	1	Mediterranean	**28**

Table 3. Italian float deployment plans for 2020-2021.

On the longer time frame, Italy is interest to maintain contributions to the Argo Core mission and the BGC and Deep Argo extensions with numbers similar to those listed in Table 3. OGS is committed to carry out the DMQC for all the Argo floats of the Mediterranean and Black seas and for some floats in the World Ocean as part of the ARGO-ITALY and Euro-Argo RISE projects over the next years.

The website for the Italian contribution to Argo (Argo-Italy) was improved and upgraded (http://argoitaly.ogs.trieste.it/). The link to the Mediterranean & Black Sea Argo Centre (MedArgo) is http://nettuno.ogs.trieste.it/sire/medargo/. A completely new web site for Argo-Italy is also available at http://maos.inogs.it/#/projects/argo-italy .

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

Operational ocean forecasting.

All Argo temperature and salinity data in the Mediterranean (along with other in-situ and remotely sensed data) are routinely assimilated into the Mediterranean Forecasting System (MFS) operational forecasting system run by the Italian Istituto Nazionale di Geofisica e Vulcanologia (INGV) and which is a component of the Copernicus Marine Environment Monitoring Service (CMEMS). Assessments have clearly demonstrated the positive impact of Argo data on ocean analyses and predictions. In particular, studies on the optimization of float sampling and cycling characteristics for the Mediterranean have been performed, as well as the development of methodology for the assimilation of Argo float sub-surface velocities into numerical models.

Ocean science.

Argo data are being used by several researchers in Italy to improve the understanding of marine properties (e.g. circulation, heat storage and budget, and mixing) in both the Mediterranean Sea and the Southern Ocean (see some examples in the bibliography below).

5. Issues that your country wishes to be considered and resolved by the AST.

N/A

6. Number of CTD cruise data added to the Argo reference database by Italian PIs in 2017.

N/A

7. Italian contribution to Argo bibliography in 2019.

Callieri, C., Slabakova, V., Dzhembekova, N., Slabakova, N., Peneva, E., Cabello-Yeves, P. J., Di Cesare, A., Eckert, E. M., Bertoni, R., Corno, G., Salcher, M. M.; Kamburska, L., Bertoni, F., Moncheva, S. (2019). The mesopelagic anoxic Black Sea as an unexpected habitat for Synechococcus challenges our understanding of global “deep red fluorescence”. The ISME Journal 13, pages 1676–1687(2019)

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Ciappa, Achille (2019). A study on causes and recurrence of the Mid-Mediterranean Jet from 2003 to 2015 using satellite thermal and altimetry data and CTD casts. Journal of Operational Oceanography. https://doi.org/10.1080/1755876X.2019.1632617

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Pinardi, N., Cessi, P., Borile, F., Wolfe, C. L. P. (2019). The Mediterranean Sea Overturning Circulation. Journal of Physical Oceanography. https://doi.org/10.1175/JPO-D-18-0254.1

Salon, S., Cossarini, G., Bolzon, G., Feudale, L., Lazzari, P., Teruzzi, A., Solidoro, C., Crise, A. (2019). Novel metrics based on Biogeochemical Argo data to improve the model uncertainty evaluation of the CMEMS Mediterranean marine ecosystem forecasts. Ocean Sci. 15, 997–1022

Sciascia, R., Magaldi, M. G, Vetrano, A. (2019). Current reversal and associated variability within the Corsica Channel: The 2004 case study. Deep Sea Research Part I: Oceanographic Research Papers Volume 144, February 2019, Pages 39-51

Storto, A., Masina, S., Simoncelli, S., Iovino, D., Cipollone, A., Drevillon, M., Drillet, Y., von Schuckman, K., Parent, L., Garric, G., Greiner, E., Desportes, C., Zuo, H., Balmaseda, M. A., Peterson, K. A. (2019). The added value of the multi-system spread information for ocean heat content and steric sea level investigations in the CMEMS GREP ensemble reanalysis product. Climate Dynamics 53, pages 287–312

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The 21st Argo Steering Team Meeting, Southampton, UK, March 18-20, 2020

Japan National Report

(Submitted by Toshio Suga)

1. The Status of implementation (major achievements and problems in 2019)

1.1 Floats deployed and their performance

Japan Agency for Marine-Earth Science and Technology (JAMSTEC) deployed 68 Argo, deep Argo, Biogeochemical (BGC) Argo and Argo equivalent floats from January to December 2019: 7 NAVIS and 41 APEX floats for Core Argo, 15 Deep APEX and 1 RINKO-Deep NINJA floats for deep Argo, 4 BGC NAVIS floats for BGC Argo. Since 1999, JAMSTEC had deployed 1316 Argo, deep Argo, BGC Argo and Argo equivalent floats mainly in the Pacific, Indian and Southern Oceans. The current positions of all the active Japanese Argo floats are shown in Fig.1. Collaborating with Japanese voluntary agencies, institutes, university and high schools, all the floats were deployed in 23 cruises. Two floats were deployed by a voluntary cargo ship owned by a Japanese merchant ship company, NYK, in August 2019. The arrangement of the semi-regular float deployment by cargo ships was made under the cooperative relationship between JAMSTEC and NYK, which was established in 2011 to increase float deployment opportunity. In deep collaboration with CSIRO, R/V Investigator of CSIRO, having two Deep Argo floats provided by JAMSTEC on board, left Fremantle on May 13rd, 2019 for her special cruise along 110°E under IIOE-2 program. These two deep Argo floats were successfully deployed by a team lead by Prof. Linneth Beckley of Murdoch University at 39.5°S and 11.5°S on the observation section.

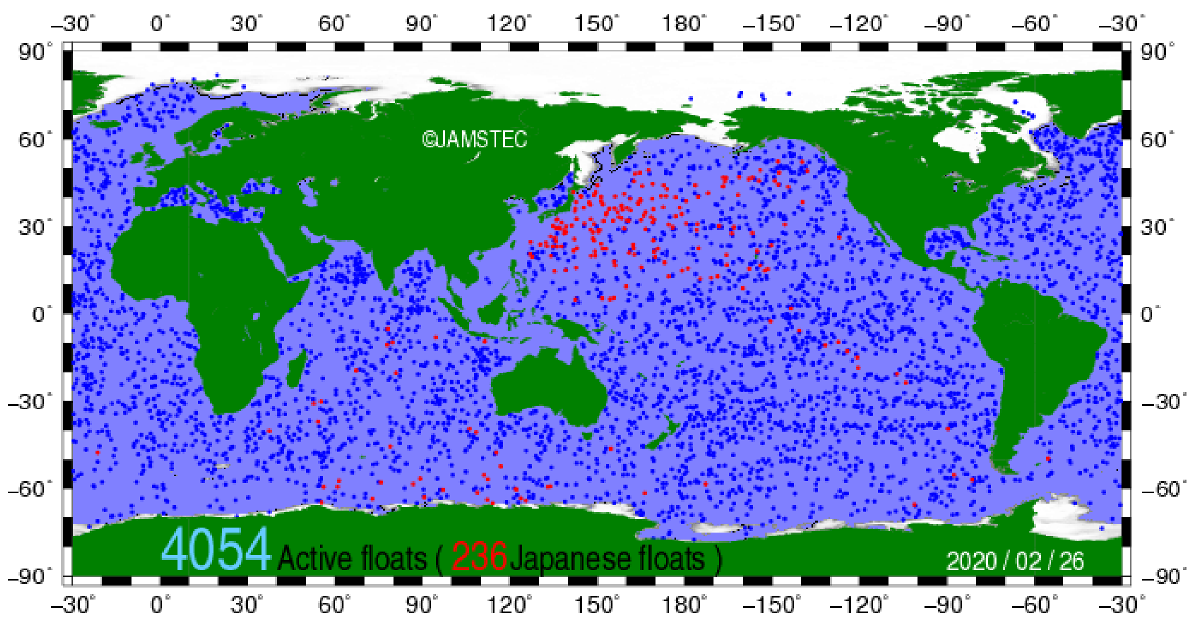

Figure 1: The distribution of active Argo floats. The red dots represent active Japanese floats.

The Japan Meteorological Agency (JMA) deployed 35 Argo equivalent floats (23 APEX floats and 12 ARVOR floats) in the seas around Japan from January to December 2019. All the floats get 2,000 dbar T/S profiles every 5 days for operational ocean analysis and forecast.

Among 314 floats (14 PROVOR, 190 APEX and 110 ARVOR floats) which JMA has deployed from 2005 to 2019, 53 floats (23 APEX floats and 30 ARVOR floats) are active as of the end of December 2019, while 36 floats (36 ARVOR floats) terminated the transmission in 2019. JMA deployed 3 APEX floats and 2 ARVOR floats from January to February 2020.

A profiling float for deep ocean observation, Deep NINJA, was developed by JAMSTEC and Tsurumi Seiki Co. Ltd. and has been available for public since April 2013. In December 2019, 4 Deep NINJA floats were operated. In January 2019, 1 Deep NINJA float with RINKO DO sensor was deployed in the Indian sector of the Southern Ocean. The data measured by these Deep NINJA floats were transferred to GDAC in accordance with the AST consensus on the data observed by Deep Argo floats.

1.2 Technical problems encountered and solved

1.2.1 Float hardware troubles on NAVIS floats

NAVIS floats, which were purchased in 2013-2018, suffered hardware troubles. The purchased NAVIS floats are totally 71 for Core, 13 for BGC Argo; about 1/3 of them were possibly troubled on pump, bulb, bladder system, connection and/or communication error between sensors and float body. Because of efforts for improvement of hardware by SBE, recent version of NAVIS floats are mostly stable. Following the warranty policy, JAMSTEC has received 18 warranty floats for Core and 3 for BGC until 2019. However, 15 core floats are still on the watch list, and a few floats are under negotiation with SBE whether they need to be included into the watch list.

1.2.2 Deep Ninja with RINKO sensor

In 2018, JAMSTEC developed a new model of Deep NINJA with RINKO DO sensor in cooperation with JFE Advantech Co. Ltd. and Tsurumi Seiki Co. Ltd. Among three floats made in October 2018, we deployed the second float in the Indian sector of the Southern Ocean in January 2019 from R/V Umitaka-maru. The float was lost probably due to damage from sea ice at surfacing. The last float was deployed in January 2020 from R/V Umitaka-maru in the Indian sector of the Southern Ocean after several tests of its RINKO sensor. The RINKO DO sensor for deep float (AROD-FT) is already available at JFE Advantech.

1.2.3 Deep APEX

In 2019, JAMSTEC deployed 8 Deep APEX floats in the North Pacific Ocean, Indian Ocean and Southern Ocean. Most of troubles on Deep APEX floats, which were recorded as buoyancy control failure in technical logging file, have been fixed, although sometime the same trouble occurred. Teledyne Webb Research, manufacturer of Deep APEX floats, has been trying to improve their firmware of APF-11 and now they mostly have become stable. However, because of this trouble, our deployment plan in 2019 was forced to be modified; their deployment was to be moved to the next year.

By the comparisons with shipboard CTD measurements at deployments, salinity biases with the negative pressure dependency were identified in almost all of Deep APEX floats with SBE61. These features were different from those of Deep NINJA with SBE41 deep at several points: milder pressure dependency, almost no salinity bias expected at the sea surface, and less changeable features of the bias over time.

1.2.4 New screening method for SBE41

JAMSTEC developed a new screening system, J-Calibration, for use with the SBE41 CTD sensor on the Argo float (Sea Bird Scientific). The system is similar to that used in UW and other institutes, but has some advantages for the use of SBE3 and 4 as reference sensors to screen SBE41 more accurately. Also, the J-Calibration does not require removal of the CTD sensor unit from the Argo float body, enabling to allow the manufacturer's warranty. The J-Calibration reduces the screening time to 1/6th of that SBE-Calibration requires and does not require a large amount of artificial seawater by conducting calibration at only 1 temperature point (22 °C). Although the J-Calibration system requires careful temperature control of the artificial seawater as it is critical to maintain a uniform water temperature, it is suitable for use in laboratory screening prior to deployment. Now we use the J-Calibration system as operational mode.

1.3 Status of contributions to Argo data management (including status of high salinity drift floats, decoding or production difficulties, etc.)

The Japan DAC, JMA has operationally processed data from all the Japanese Argo and Argo-equivalent floats including 235 active floats as of February 21, 2020. Ten Japanese PIs agree to provide data for the international Argo. All the profiles from those floats are transmitted to GDACs in the netCDF format and are also issued to GTS using the BUFR codes after real-time QC on an operational basis. Argo BUFR messages have been put on GTS since May 2007.

JMA and JAMSTEC have converted the almost all of Japanese meta-files, except a few Iridium floats, from v2 to v3.1 and submitted them to GDACs. JMA has converted almost all of Japanese tech-files and submitted them to GDACs. JMA has converted the Rprof-files of Japanese ARGOS floats, except floats with NST sampling scheme and Iridium floats. JAMSTEC has converted all v2 Dprof-files of Japanese floats to v3.1 and submitted them to GDACs. JMA has converted about 30% of Japanese traj-files from v2 to v3.1 and submitted them to GDACs.

JMA has made meta-, tech-, traj-, and Rprof-files v3.1 of the floats newly deployed since March 2016 and JAMSTEC has made meta-files in v3.1 of JAMSTEC's floats newly deployed since October 2015. JAMSTEC has made Dprof-files in v3.1 since January 2016.

1.4 Status of delayed mode quality control process

JAMSTEC has submitted the delayed-mode QCed Core data (P, T, and S) of 160,302 profiles to GDACs as of December 2019. JAMSTEC had submitted D-Core files of 42,528 profiles in 2019.

1.5 Positive salinity drift of SBE41

JAMSTEC has 43 floats with SBE41cp whose serial number is larger than 6000, which had been deployed since 2015. Eight floats of them has clearly with high salinity drift, differences between salinity observed by float and climatology near 2000dbar are larger than 0.01. Salinity of these floats started drifting from about 50-60 cycles. Four floats of them seem to have salinity drift with vertical dependence. Our floats with high salinity drift were all launched into the North Pacific, and almost all of them are active. We continue to monitoring salinity data of Japanese floats as well as our floats, detecting floats with high salinity drift, and understanding features of high salinity drift found in floats. We will share this information and join the discussion about this issue through ADMT and working group of this issue, so that we contribute to improve salinity data quality.

2. Present level of and future prospects for national funding for Argo including a summary of the level of human resources devoted to Argo

Japan Argo had been conducted in a 5-year program from FY1999 to FY2004, as a part of

Millennium Project implemented under cooperation among the Ministry of Education, Culture, Sports, Science and Technology (operation: by JAMSTEC), the Ministry of Land, Infrastructure and Transport, JMA and Japan Coast Guard. After the Millennium Project terminated in March 2005, JAMSTEC has continued the operation until FY2013 nearly in the same scale (about 80 floats to be deployed every year and associated delayed-mode data management) under its two consecutive mid-term programs for FY2004-2008 and FY2009-2013. JAMSTEC continues the float deployment and delayed mode data management but in the scale somewhat lower than before under its recent mid-term program FY2014-2018. Because of budget cuts in FY2014-2015, the number of technical staff devoted to delayed mode QC and PARC activities has been decreased from 5 to 4 since FY 2015 and also the number of purchased floats had been reduced to about 12-15. In FY2016, owing to ocean monitoring enhancement recommended by G7 Ise-Shima Summit, especially its Science and Technology Ministers' Meeting in Tsukuba, additional fund for Core Argo and Argo extensions (Deep and BGC Argo) was allocated for aiming to sustain Core Argo array and to enhance Deep and BGC Argo. Furthermore, following its communique and our original research plans, JAMSTEC had got extra research fund to purchase 50 Core, 25 Deep and 10 BGC Argo floats in FY2017, and are being deployed in the Pacific, Indian and Southern Ocean in FY2018-19.

From FY2019, JAMSTEC has started new mid-term programs for 7 years. In FY2019, 60 Argo floats were deployed in the Pacific, Indian and Southern Oceans, including 40 Core, 16 Deep and 4 BGC floats, following JAMSTEC's research purposes. In FY2020, the level of human resources for Argo deployment and QC is the same as those in FY2018 and FY2019. Deployment plan for Core, Deep and BGC Argo in FY2020 are not yet fixed but will be decided soon. JMA allocates operational budget for 27 floats in FY2020.

3. Summary of deployment plans (level of commitment, areas of float deployment, low or high resolution profiles, Argo extensions) and other commitments to Argo (data management) for the upcoming year and beyond where possible

To maintain Core Argo array and to achieve its research purposes, JAMSTEC will deploy 27 floats mainly in the North Pacific, where the index of deployment intensity is not good and the age of floats tends to be higher than other areas, based on the statistics provided by Argo Information Center. Regarding Deep and BGC Argo, 1 Deep NINJA, 1 Deep APEX, 4 BGC NAVIS with Nutrient (1) and pH (3) floats will be deployed in the Pacific, Indian Oceans and the Southern Ocean.

Additionally, a team of DCOP in JAMSTEC will deploy 3 RBR-CTD APEX floats in the tropical western Pacific Ocean as Argo equivalent floats to investigate air-sea interaction process for MJO.

A "hot-spot" research team of special research fund "Grant- in Aid for Scientific Research in Innovative Area", being supported by JSPS KAKENHI, will deploy 13 BGC APEX floats with RINKO oxygen sensor (9) and RINKO oxygen + pH sensor (4) around the subtropical region south of the Kuroshio Extension (Fig. 2). The deployment will be conducted in 4 cruises by 3 ships (JMA and JAMSTEC). The target area of this project is the Far East and western North Pacific, where the most distinct "hot-spot" in the extratropical climate system is situated. Under the "meridional contiguousness"

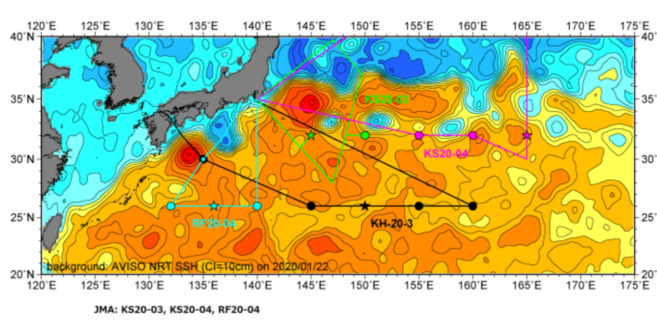

Figure 2: Deployment plan by the "hot-spot" research team. See text for details.

between the tropical heat and the polar cold caused by the Kuroshio and Oyashio and the East-Asian Monsoon, there are various interactions between the atmosphere and the ocean, accompanying a huge amount of heat release from the ocean.

Another 3 APEX floats will be deployed as Equivalent Argo floats around the Kuroshio Extension based on the Grant in Aid for Scientific Research (A) being supported by JSPS KAKENHI. The purpose of research is to investigate water mass structure and its modification into mesoscale eddies and heat content change through a process of air-sea interaction.

JMA plans to deploy 27 Argo equivalent floats (12 floats are deployed in western boundary region) around Japan in FY2020 and in the coming years. All the JMA floats are identical with the core Argo floats except that they are operated in a 5-day cycle, synchronized with JMA's real-time ocean data assimilation and forecast system.

JMA continues serving as the Japan DAC. JAMSTEC continues running the Pacific Argo Regional Center for the upcoming year.

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

Many groups in JAMSTEC, JMA, FRA and Japanese universities are using Argo data for oceanographic researches on water mass formation and transport in the Pacific Ocean, the mid-depth circulation, the mixed layer variation, the barrier layer variation, and tropical atmosphere-ocean interaction in the Pacific and Indian Ocean and so on. Japanese fisheries research community is conducting their biogeochemical studies using Argo floats equipped with chlorophyll and/or oxygen sensors.

JMA issues operationally ocean analysis and forecast by using the global Argo BUFR messages. Daily and monthly products of subsurface temperatures and currents for the seas around Japan and western North Pacific, based on the output of the real-time ocean data assimilation system (MOVE/MRI.COM-WNP), are distributed through the JMA web site (in Japanese). Numerical outputs of the system are available from the NEAR-GOOS Regional Real Time Data Base (http://www.data.jma.go.jp/gmd/goos/data/database.html) operated by JMA. Monthly diagnosis and outlook of El Niño-Southern Oscillation based on the outputs of the Ocean Data Assimilation System and the El Niño Prediction System (an ocean-atmosphere coupled model) are also operationally distributed through the JMA web site (in Japanese) and the Tokyo Climate Center (TCC) web site (https://ds.data.jma.go.jp/tcc/tcc/products/elnino/). These systems were upgraded in June 2015 (for descriptions of the new systems, please refer to https://ds.data.jma.go.jp/tcc/tcc/products/elnino/move_mricom-g2_doc.html, and https://ds.data.jma.go.jp/tcc/tcc/products/model/outline/cps2_description.html). The ocean-atmosphere coupled model is also used for seasonal forecast of climate in Japan. The model products for seasonal forecast are available from the TCC web site (https://ds.data.jma.go.jp/tcc/tcc/products/model/).

JAMSTEC is providing a variety of products including objectively mapped temperature and salinity field data (Grid Point Value of the Monthly Objective Analysis using Argo float data: MOAA-GPV: http://www.jamstec.go.jp/ARGO/argo_web/MapQ/Mapdataset_e.html), objectively mapped velocity field data based on YoMaHa'07 (version September 2010) (http://www.jamstec.go.jp/ARGO/argo_web/G-YoMaHa/index_e.html), and gridded mixed layer depth with its related parameters (Mixed Layer data set of Argo, Grid Point Value: MILA-GPV http://www.jamstec.go.jp/ARGO/argo_web/MILAGPV/index_e.html). JAMSTEC have released Argo temperature and salinity profile data put through more advanced automatic checks than real-time quality controls (Advanced automatic QC Argo Data version 1.2a) since October 2014. JAMSTEC has also provided scientifically quality controlled data of Deep NINJA for convenient use on scientific or educational purposes (http://www.jamstec.go.jp/ARGO/deepninja/). The QC is based on comparisons with highly accurate shipboard CTD observations conducted nearby float observations.

JAMSTEC is also providing information about consistency check of float data related to delayed-mode QC for the Pacific Argo Regional Center (PARC) web site as a main contributor. Since 2006, PARC and its website had been operated by JAMSTEC and IPRC in collaboration with several coastal states of the Pacific region. Because IPRC found it difficult to continue maintaining the PARC website which IPRC had been in charge of in part due to limited funding and human resources, JAMSTEC and IPRC decided to maintain the website mainly by JAMSTEC, with IPRC supporting through producing useful scientific products. According to this decision, JAMSTEC is going to construct a new PARC website, through which float PIs and DMQC operators can get various information about data quality of floats, DMQC, scientific products, etc., and can exchange them interactively to improve Argo data and the status of Argo array in the Pacific Ocean.

ESTOC (Estimated state of ocean for climate research) is a JAMSTEC product; an integrated dataset of ocean observations including Argo data by using a four dimensional variational (4D‐VAR) data assimilation approach. ESTOC is the open data that consists of not only physical but also biogeochemical parameters. It is upgraded to version 3b in May 2019 to cover 58-year period during 1957-2014 (See the web site in JAMSTEC, http://www.godac.jamstec.go.jp/estoc/e/top/). The ESTOC continue being improved by introducing new observational elements (e.g., ocean mixing, a global sea level). Deep and BGC float data can be assimilated into the system after 2016. Some methodology for deep float data to be integrated was developed and published in 2018. We plan to release a 60-year state estimation (version 4) within 2020. Especially, Dr. S. Masuda provided a scientific paper entitled" Determining subsurface oceanic changes in the Indian sector of the Southern Ocean using Argo float data" published in the Polar Science in 2019. He was focusing on the relationship between Southern Annular Mode and the surface-to-2000-m oceanic state using ESTOC 4D-Var data assimilation. As a result, he showed the interannual changes in the wintertime subsurface condition in the Indian sector of the Southern Ocean are consistent with the faster response to the SAM than proposed by previous model studies.

JCOPE2M (Japan Coastal Ocean Predictability Experiment 2 Modified) is the model for prediction of the oceanic variation around Japan which is operated by Application Laboratory of JAMSTEC. JCOPE2M is the updated version of JCOPE2, developed with enhanced model and data assimilation schemes. The Argo data are used by way of GTSPP. The reanalysis data 27 years back (from 1993 to present) and the forecast data 2 months ahead are disclosed on the following web site: http://www.jamstec.go.jp/frcgc/jcope/. More information are shown in http://www.jamstec.go.jp/frcgc/jcope/htdocs/jcope_system_description.html.

FRA-ROMS is the nowcast and forecast system for the Western North Pacific Ocean developed by Japan Fisheries Research and Education Agency (FRA) based on the Regional Ocean Modeling System (ROMS). Instead of FRA-JCOPE, which was the previous system of providing the hydrographic forecast information around Japan, FRA started the FRA-ROMS operation in May 2012. Argo has been one of important sources of in-situ data for the FRA-ROMS data assimilation system. The forecast oceanographic fields are provided every week on the website http://fm.dc.affrc.go.jp/fra-roms/index.html/.

5. Issues that our country wishes to be considered and resolved by the Argo Steering Team regarding the international operation of Argo

As reported in 2011, EEZ clearance procedure for Argo float deployed by Japanese PIs has been simplified following IOC Resolution XLI-4. This change reduced our time and effort for the process of EEZ clearance significantly. However, the traditional EEZ clearance is still needed for some key countries because Argo national focal points (NFPs) of those countries are not registered on the list at AIC. Japan Argo hopes for more NFPs especially of nations in and around the Pacific Ocean to be registered to facilitate more timely and optimal deployment of Argo floats. This could be also helpful for smooth implementation of any future extension of Argo.

The other issue is wrong e-mail address of Focal Point (FP) listed at AIC. Some floats were drifted into Russian EEZ and JAMSTEC informed to the FP following the procedure of IOC resolution. However, because of wrong e-mail address of the FP, error e-mails were returned, thus we sent letters to the address of FP to inform drifting floats. These might be caused by a change of e-mail address due to re-construction of organization. To maintain the notification system effective, checking and updating e-mail addresses of FPs are desired.

6. Summary of the number and location of CTD cruise data to the CCHDO website

Data of 657 CTD casts conducted by JMA in the western North Pacific in 2019 were uploaded to the CCHDO website. CTD cast information (PI, location and date), which have been carried out at float launching points and used for Argo dQC, is attached as an Excel file "CTD_list_JAMSTECArgoDB_20200303."

7. Outreach activity

Deep NINJA and its scientific result were demonstrated in COP25 JAPAN Pavilion at Madrid, Spain in Dec. 2019. In the Pavilion, the deep Argo observation and future plan were introduced through a poster panel and movie, displaying a model of Deep NINJA. Two public events were led by JAMSTEC in Yokosuka and Mutsu, where Argo float series are introduced and some related contents are exposed.

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Argo-KOREA Annual Report 2019

by the National Institute of Meteorological Sciences/KMA

1. Status of Implementation

The National Institute of Meteorological Sciences of Korea Meteorological Administration (NIMS/KMA) has deployed 247 Argo floats around the Korean peninsula and the North Pacific Ocean since 2001, including 31 active floats as of March 2020. In 2019, NIMS/KMA deployed 6 Argo floats in the East Sea and the Yellow Sea by using the KMA research vessel, Gisang 1(Fig.1). Four floats were deployed in the East Sea on October 24, 2019 with 800m of parking depth and seven-day profiling scheme, and two floats in the Yellow Sea on November 8~9, 2019, for the shallow sea observation with two-day profiling scheme and 60m of parking depth. Of these floats deployed in 2019, three floats in the East Sea and one float in the Yellow Sea have so far performed well.

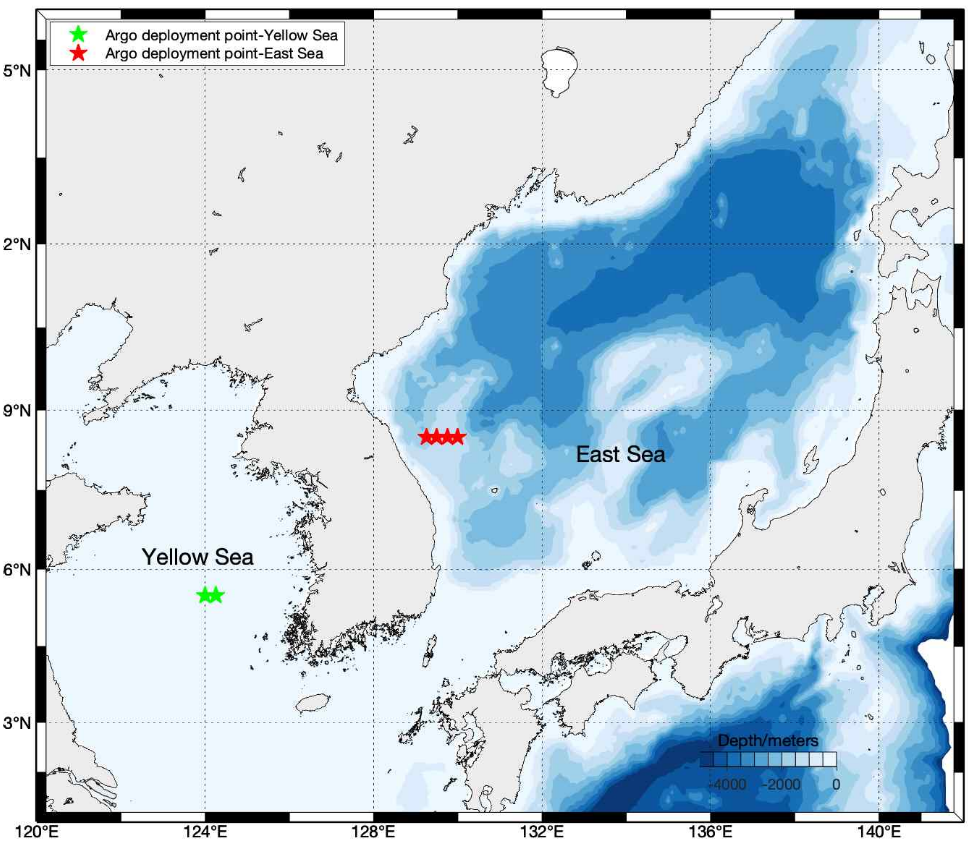


Fig. 1. Initial position of Argo floats deployed by the NIMS/KMA in 2019

- Status of contributions to Argo data management

- Development of quality control program for the regional sea (East Sea).
  - Spike test range of temperature (0~400m: 0.3℃ / 400m~: 0.05℃) and salinity (0~400m: 0.08psu / 400m~: 0.01psu)
  - Gradient test range of temperature (Surface temp. inversion) and salinity (0~500m: 2psu / 500m~: 0.02psu)
  - Density inversion test range (0~300m: 0.03 / 300m~: 0.005)
- CTD sensor serial number has been checked, as a result total 10 floats deployed (sensor error issue)

- Delayed Mode QC

- We are currently processing new R-files that have been collected since 2013 in the East Sea and Western North Pacific. Those **10,125 files**(8,816 files from the East Sea and 1,309 files from the Western North Pacific) will be revised to D-files with NetCDF format(ver. 3.1) and will be sent to the GDACs by the end of this October, or at the earliest when the surface pressure issue is resolved. It has been identified that the surface pressure values in tech.nc files are missing, and we are trouble shooting the cause of these missing values for accurate DMQC process.

2. Present level of (and future prospects for) national funding for Argo including summary of human resources devoted to Argo.

NIMS/KMA purchased and successfully deployed the 6 ARGO floats around Korean peninsula (East and Yellow Seas) in 2019. In 2020, we plan to purchase and deploy 6 ARGO floats as well as in 2019.

- Following persons contribute to the Argo-Korea program:
  - KiRyong KANG, Sang Myeong OH, Hyeong-Jun JO (NIMS/KMA)
  - Sung-Dae KIM, Hyuk-Min PARK (KIOST)
  - Jong-Jin PARK (Kyungpook National University)

3. Summary of deployment plans

NIMS/KMA has a deployment plan for 6 ARGO floats in 2020: four floats will be deployed at the East Sea to keep the observation network and two at the Yellow Sea to continue the shallow sea observation scheme in the regional ocean. Continuing the observation in the Yellow Sea, observation program using the Argo float will be preformed to investigate the ocean environment variation in west sea of Korea.

4. Summary of National Research and Operational Uses of Argo data as well as contributions to Argo Regional Centers.

The ARGO observation data deployed by NIMS/KMA are used in the Global Ocean Data Assimilation System (GODAPS). The initial input field with improved accuracy through the GODAPS is used for the KMA climate forecasting system. The ARGO observation data are also used to verify the prediction results of KMA climate forecasting system.

In 2019, the ARGO float QC methods in real and delay mode was improved to reflect the ocean characteristics of the East Sea and the Yellow Sea. As a results, a number of observed profiles that could not be used previously can be used.

The NIMS/KMA runs a Regional Data Assembly Center (RDAC) in order to provide the ARGO profile data which can be found at the home page: http://argo.nims.go.kr.

5. Issues that your country wishes to be considered (and resolved) by AST regarding the international operation of Argo.

- Regional ocean observation using the Argo floats.

6. CTD data uploaded to CCHDO

- No

<The End>

New Zealand National Report April 2020

NIWA is the New Zealand participant in Argo. NIWA has purchased 2 floats per year since 2001, with no floats being purchased in 2003 because of float availability. We have also deployed floats for other providers and are collaborating on large deployments by contributing towards vessel costs.

New Zealand's floats
NIWA has purchased and deployed 37 floats to date. A funding application has been made for a further two floats in 2020/2021. There is growing interest in BGC Argo, and funding for one BGC float has been applied for.

Deep Argo Development Voyage
A Deep Argo development voyage focusing on SBE-61 sensor performance is planned for October 2020. This R/V Tangaroa is primarily funded by NIWA, with cofunding from NOAA. It is planned to mount several SBE-61s on a 911plus rosette to provide simultaneous measurements. It is also hoped that dual pressure sensor floats developed by SIO will be deployed.
The timing and nature of this voyage have come into question because of COVID-19. The dual sensor floats are now unlikely to be completed by the October voyage date, and New Zealand currently has border restrictions that would prevent foreign participation.

Providing deployment opportunities
NIWA has provided deployment opportunities for other nation's floats in the southwest Pacific and Southern Ocean. This is a very important contribution to Argo, given that these regions had poor float coverage and limited deployment opportunities from commercial vessels.

In an ongoing collaboration, NIWA is funding 15% of the vessel costs of R/V Kaharoa deploying floats for University of Washington (USA), Scripps Institution of Oceanography (USA) and CSIRO (Australia).

NIWA's larger research vessel, R/V Tangaroa has also deployed floats in the Southern Ocean, both as part of the same collaboration and opportunistically when other research takes place in the Southern Ocean. An Antarctic (Ross Sea) voyage in February 2019 deployed 12 SOLO IIs and 5 DEEP SOLOs floats. The next Tangaroa Antarctic voyage is planned for February 2021.

An R/V Kaharoa deployment voyage from New Zealand to Mauritius is planned for July 2019,, but may be impacted by COVID-19.

Other logistics
NIWA is available to facilitate any Argo-related work in the New Zealand region- recent examples include recovering floats and returning beached floats to manufacturers.

Vessel replacement
R/V Kaharoa is nearing replacement. Argo needs and requirements are being considered in the replacement process, but any input is welcome.

National report of Norway (2019)

Kjell Arne Mork, Institute of Marine Research, Norway (28.02.2020)

1. The status of implementation

Argo Norway (NorArgo, http://www.norargo.no) is the Norwegian contribution to the Euro-Argo European research infrastructure (ERIC) and to the global Argo programme. The main focus area for Argo Norway is the Nordic Seas (Greenland, Iceland and Norwegian Sea).

Floats deployed and their performance

In 2019, Norway deployed 14 Argo floats (6 core Arvor floats, 3 BGC-Provor floats, 2 Deep Arvor floats, and 3 equivalent APEX floats). The deployment locations and drift are shown in Fig. 1. All 14 floats have so far performed well with exception of one APEX (APF11) float. This float got communication (IRIDIUM) problem after about 6 months, and now data transmitting occurs irregular.

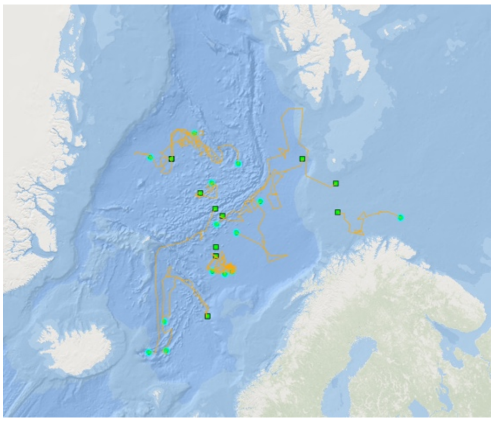


Figure 1. Locations of deployed Argo floats in 2018.

Technical problems encountered and solved

One APEX (APF11) float got communication (IRIDIUM) problems after about 6 months, and data transmitting occurs irregular. This is not solved, and we plan to recover the float this spring.

Status of contributions to Argo data management and delayed mode quality control process

Regarding data management and delayed mode quality control, Argo Germany have done the delayed mode quality control for all floats in the Nordic Seas including our floats. We have provided with expertise regarding the DMQC when we have been asked (e.g., for difficult floats). However, we plan to take over the DMQC of our new floats.

2. Present level of and future prospects for national funding

The funding has been a combination of self-financed (i.e. funded by Institute of Marine Research) and funding from the Norwegian Research Council (NRC, Ministry of Education and Research) during 2012-2015.

For 2018-2023 we have received funding from the NRC for an extension of the national Argo infrastructure project. Within this project we will purchase and deploy approximately 13 floats per year including core, bio, bgc and deep floats. The infrastructure will have approximately 36 person months per year.

3. Summary of deployment plans

<u>In 2020</u>, mainly in April/May, we plan to deploy <u>15 floats</u> including: 3 BGC-floats (PROVOR), 5 Bio-floats (all BGC-sensors except nitrate and pH sensors, APEX), 4 Deep-floats (Arvor), and 3 core floats (Arvor). These floats will be deployed in the Nordic Seas. Figure 2 shows the planned deployments.

<u>For the years 2021-2022</u> we plan to deploy about 13 floats each year, including 4-5 core, 3-4 bio, 2-3 bgc and 1-3 deep floats. The deployment areas will similar as in 2020.

Variables / Sensors	Core	Bio	BGC	Deep
Press, temp., salinity	X	X	X	X
Oxygen		X	X	X
Chlorophyll-Fluor.		X	X	
Particle conc. (backsc.)		X	X	
Irradiance, PAR		X	X	
pH			X	
Nitrate			X	

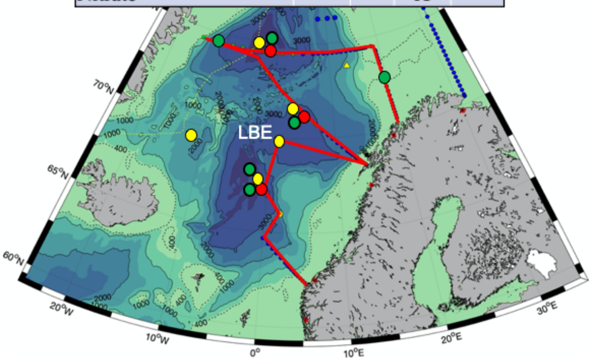


Figure 2. Planned Argo deployments for 2020.

4. Summary of national research and operational uses of Argo data

Argo Norway focuses on both research topics and marine climate monitoring of the Nordic Seas. There is an increasing interest in using Argo data in Norway, and two climate centres are now using the data operationally in climate models. For instance, the operational TOPAZ4 modeling system assimilates Argo data into the ocean model to provide forecast product for the Nordic Seas and Arctic Ocean under the EUs Copernicus Marine Environment Monitoring Services (CMEMS, http://marine.copernicus.eu/).

The present scientific topics are mainly within the Nordic Seas (Norwegian, Iceland and Greenland Seas) and include:

- Studies of the deep ocean circulation in the Nordic Seas. These studies have so far brought new insights in the circulation of the Nordic Seas.
- Water mass changes and also in relation with biological activities. This topic is also one of the reasons that we have included bio/bgc sensors on the Argo floats.
- Studies that involve changes in the mixed layer.

Link to Argo Norway (NorArgo): https://norargo.hi.no

5. Issues we wish to be considered and resolved

Estimates of available battery/energy capacity during the mission would be nice.

6. Improving the quality and quantity of CTD cruise data

All our ship CTD-data are sent regular to the ICES, EUs CMEMS, and World Ocean Database.

7. The Argo bibliography

No new articles to add that are not included in the Argo bibliography.

Argo-Poland National Report 2019

Waldemar Walczowski, Małgorzata Merchel
IO PAN, Sopot, Poland, 31.12.2019 r.

1. *The status of implementation.*

In 2019 Poland deployed 2 floats from the board of *r/v Oceania*. The Argo floats (WMO 3902107, 3902108) were deployed in the Nordic Seas at the end of June 2019 (Fig.1). All instruments are the ARVOR floats with Iridium transmission system. The parking depth was set at 1000 dbars and the profiling depth at 2000 dbars. They have cycles of 10 days. Both floats were operated for the whole of 2019 and have sent about 20 complete sets of hydrographic data by the end of the year.

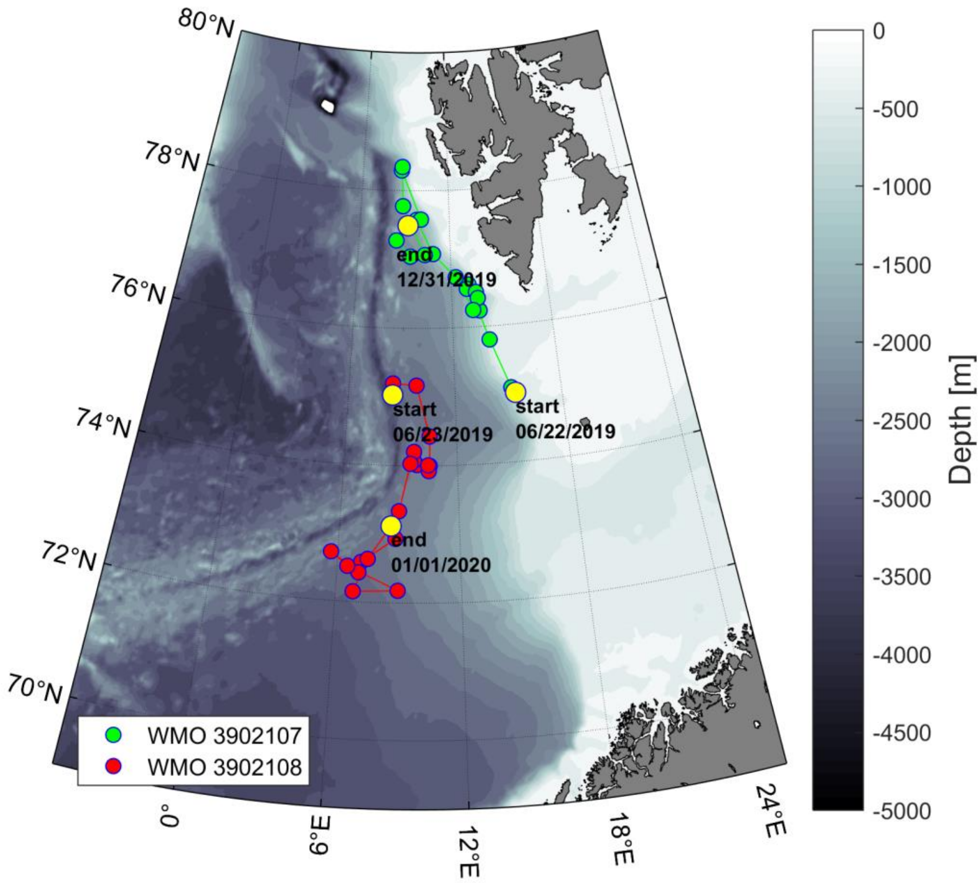
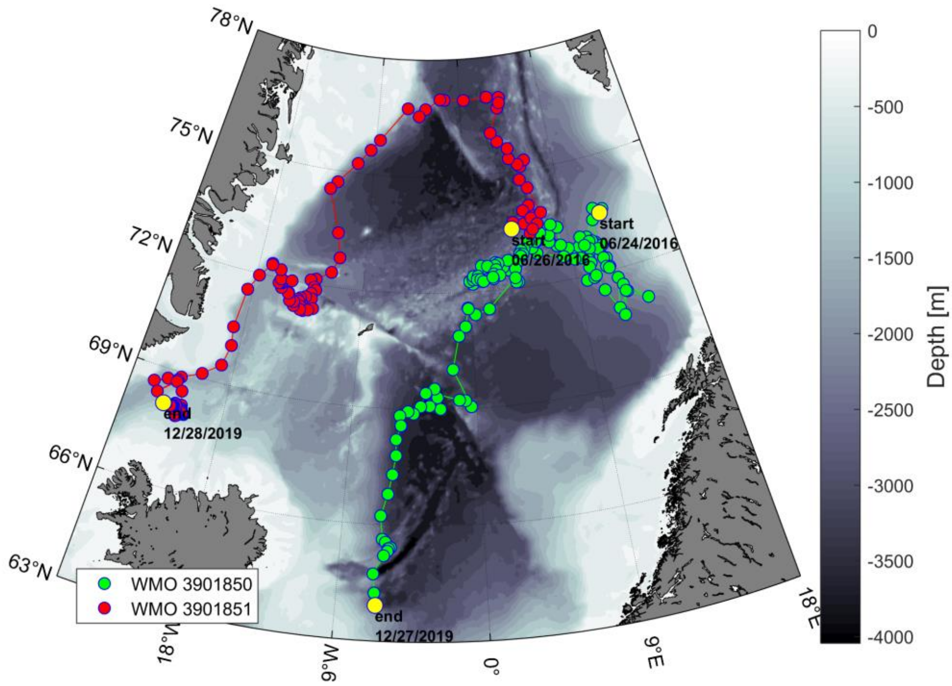
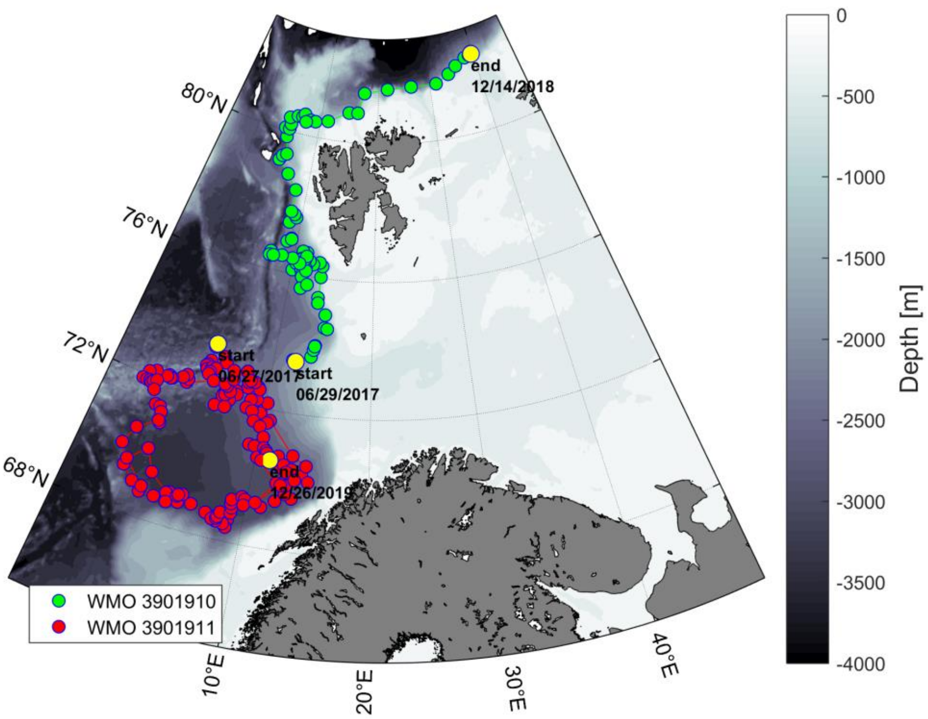


Fig. 1. Positions deployment and trajectories of two Argo floats deployed in the Nordic Seas by Argo Poland program in June 2019.

Two floats launched in June 2016 (WMO 3901850, 3901851) (Fig. 2) and one float deployed in June 2017 (WMO 3901911) (Fig. 3) were also active during the 2019 year. During their whole operating time, the floats have sent 129 (WMO 3901850, 3901851) and 131 (WMO 3901911) sets of hydrographic data.





Figs 2, 3. Track of the Arctic floats deployed in June 2016 (upper) and June 2017 (lower).

Also, two floats deployed in June 2018 (WMO 3902102, 3902103) were active during the 2019 year and have sent 55 complete data sets. One float deployed in June 2018 (WMO 3902105) stopped transmission in September 2019. The float has sent 52 sets of data (Fig. 4).

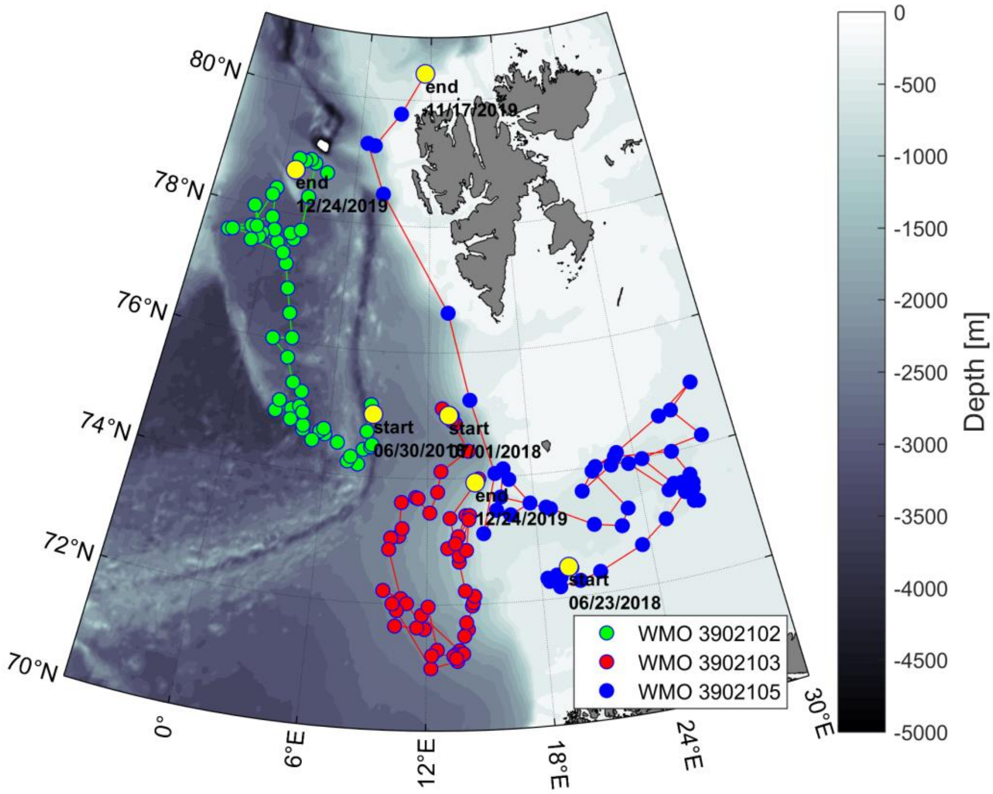
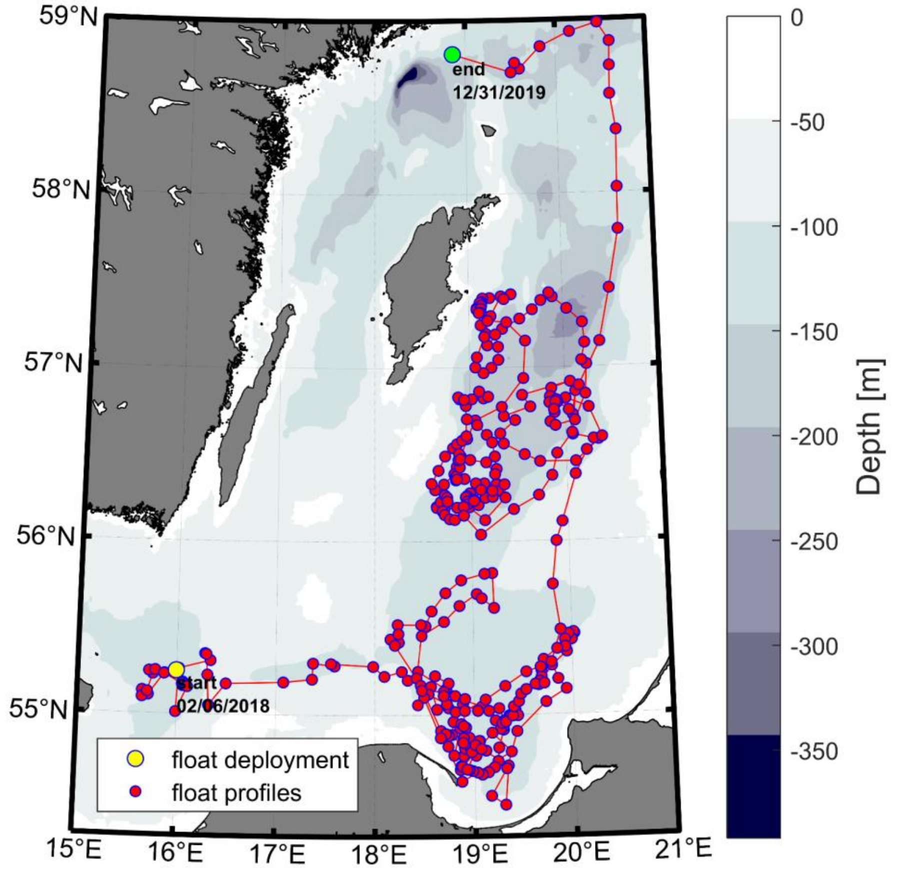
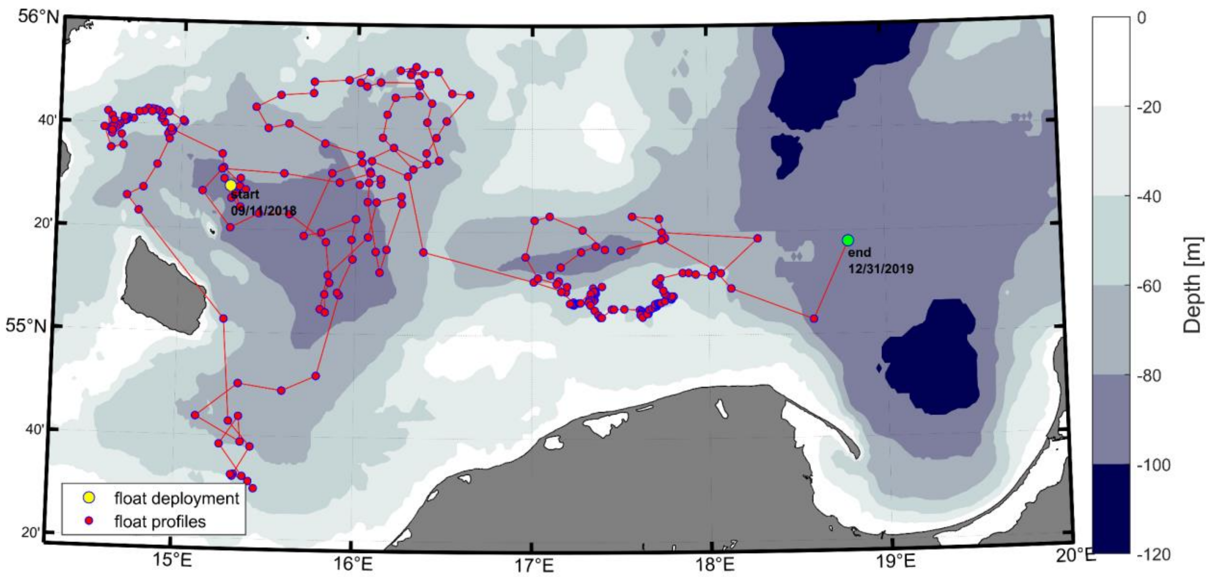


Fig. 4. Track of the Arctic floats deployed in June 2018.

This year, we did not launch Argo floats at the Baltic Sea, but two floats deployed in 2018 (WMO 3902101, 3902106) (Figs 5, 6) are still active and by the end of 2019 have sent 348 and 248 sets of hydrographic data, respectively.





Figs 5, 6. Track of the Baltic floats deployed in February 2018 (upper) and September 2017 (lower).

The Polish floats were deployed under the Argo Poland program, which is Polish contribution to the Euro Argo ERIC infrastructure. The data from floats is provided to the Ifremer Argo Center and processed in the Center. All data is available online. All floats were deployed by Institute of Oceanology Polish Academy of Sciences (IOPAN) form the board of the Institute research vessel ‘Oceania’. There were no technical problems with floats.

2. Present level of and future prospects for national funding for Argo including a summary of the level of human resources devoted to Argo.

The Argo Poland program is financed by the Ministry of Sciences and Higher Education, grant DIR/WK/2016/12. The current financing allows us to buy 2-3 floats/year, launching, covering costs of the data transmission. Additionally, we have funds for conducting innovative works. The grant covers part of the IOPAN employees' work, in total approx. 7 man-months. We also support PhD students.

This level of funding is guaranteed until the end of 2020.

3. Summary of deployment plans.

Poland is going to continue deployment of 2 floats in the Nordic Seas region during the yearly expedition *of r/v Oceania*, AREX. Additionally, we are going to deploy 1 CT/O_2 Argo float at the Baltic Sea in 2020. In the end of 2020 or beginning of 2021 Argo Poland plans deployment of the BGC float at the Baltic Sea.

4. Summary of national research and operational uses of Argo data as well as contributions to Argo Regional Centers. Please also include any links to national program Argo web pages to update links on the AST and AIC websites.

Data from the Arctic are used in the dissertation written by PhD student Malgorzata Merchel. The Baltic Argo data are used (together with the synoptic data from *r/v Oceania* cruises) for investigating the North Sea water inflows to the Baltic Sea and transports of this water mass in the Southern Baltic. After 3 years of using floats at the Baltic Sea, Argo data is an important source of information about the deep-water dynamics. The significant part is dissolved oxygen data - two floats are equipped with oxygen sensors. The paper about oxygen conditions at the Baltic sea utilizing Argo data was submitted. Both, Arctic data and Baltic Sea data are provided to Ifremer Argo Data Center.

Baltic Argo data are also provided to the SatBaltic system:

http://www.satbaltyk.pl/en/

Additional IOPAN contribution is CTD/O_2 profiles from the launching, synoptic data from the Nordic Seas. At the Baltic Sea, during synoptic cruises (4 times per year) we make CTD/O_2 profiles in the region of the last Argo float data transmission.

The Argo Poland webpage:

https://www.iopan.pl/hydrodynamics/po/Argo/argo.html

5. Issues that your country wishes to be considered and resolved by the Argo Steering Team regarding the international operation of Argo.

We have no suggestion at the moment.

6. CTD data

In 2019 two Polish floats were deployed during IOPAN Arctic cruise AREX, when 203 CTD profiles have been done. The CTD stations were also performed just before the floats deployment. IOPAN can provide the data from these stations to compare it with Argo floats.

Rest of the data from the Nordic Seas are available via IOPAN database. Contact point: Waldemar Walczowski, walczows@iopan.pl.

7. The Argo bibliography

There is a PhD thesis using the Argo data in progress.

We also submitted a research article:

1. Walczowski W., Merchel M., Wieczorek P., Rak D., Argo floats – drones in the service of oceanography, Sea and underwater drones – Unidentified Sea Objects, Gdynia, Poland, 14.11.2019 – oral presentation.
2. Walczowski W., Goszczko I., Merchel M., Wieczorek P., Rak D., Argo floats - an important element of oceanographic observations in the Southern Baltic Sea, 7th Euro-Argo Science Meeting, Athens, Greece, 22-23.10.2019 – oral presentation.
3. Merchel M., Walczowski W., Temporal variability of the Nordic Seas intermediate and deep water properties based on Argo floats data in 2008-2017 period, 7th Euro-Argo Science Meeting, Athens, Greece, 22-23.10.2019 – poster presentation.
4. Walczowski W., Merchel M., Wieczorek P., Rak D., Argo floats - a modern monitoring tool of the Baltic Sea, II Scientific Conference of Polish Sea Researchers, Gdynia, Poland, 24-25.09.2019 – oral presentation.
5. Walczowski W., Merchel M., Wieczorek P., Beszczynska-Möller A., Goszczko I., An increasing role of Argo floats in Arctic oceanographic observations, II Scientific Conference of Polish Sea Researchers, Gdynia, Poland, 24-25.09.2019 – poster presentation.
6. Walczowski W., Goszczko I., Merchel M., Wieczorek P., Rak D., An increasing role of Argo floats in Baltic Sea oceanographic observations, Baltic Sea Science Congress (BSSC), Stockholm, Sweden, 19-29.08.2019 – oral presentation.
7. Rak D., Merchel M., Walczowski W., Goszczko I., Wieczorek P., Argo floats at the Southern Baltic Sea, Baltic Operational Oceanography System (BOOS) workshop, Rostock, Germany, 12.06.2019– oral presentation.

8. Walczowski W., Merchel M., Goszczko I., Wieczorek P., An increasing role of Argo floats in Arctic oceanographic observations, ASSW - Arctic Science Summit Week, Arkhangielsk, Russia, 22-29.05.2019 – poster presentation.
9. Walczowski W., Merchel M., Wieczorek P., Beszczynska-Moeller A., Goszczko I., An increasing role of Argo floats in Arctic oceanographic observations, EGU General Assembly, Vienna, Austria, 7-12.04.2019 – poster presentation.
10. Walczowski W., An increasing role of the Argo floats in Arctic oceanographic Observations, St Petersburg, 5-7 December 2019. IX International Forum Arctic - today and the future, oral presentation
11. Jakacki J., Muzyka M., Konik M., Przyborska A., Stramska M., Baltic Sea sea ice extent, concentration and thickness in winter 2017/2018 – comparison of observational data and model simulations, MDPI.
12. Walczowski W., ……, Argo floats in the Southern Baltic, Oceanologia, submitted

ARGO COUNTRY REPORT

South Africa

1. The status of implementation (major achievements and problems in 2019)

- floats deployed and their performance

Floats were deployed for WHOI (1902221, 1902222, 1902223, 1902224, 1902225, 1902226) and the UK MetOffice (1901911, 1901912, 1901913) on the Marion take-over cruise (April / May 2019).

Floats deployed on behalf of the UK MetOffice (1901914, 1901915, 1901916, 1901917) on the SAMBA Cruise (October 2019).

No problems noted with deployments.

- technical problems encountered and solved

None noted

- status of contributions to Argo data management (including status of high salinity drift floats, decoding or production difficulties, etc)

None contributed

- status of delayed mode quality control process

Not applicable

2. Present level of and future prospects for national funding for Argo including a summary of the level of human resources devoted to Argo.

Bleaker than usual!

However, as a community we are working on a Southern Ocean proposal for infrastructure, including autonomous robotics. We have included in here requests for standard (T/S, 2000 m) and Deep Argo floats. These will hopefully contribute to the understudied nature of the Southern Ocean. Simultaneously, we continue to look for funding to instrument the Agulhas Current periodically.

Human resources: At this stage – 1 (Tamaryn Morris). Through some internships we are looking at the role ocean observations play in forecast skill to increase the knowledge thereof and thus funding capabilities. We are also looking to demonstrate this through assimilation of float data in to models used for regional forecasts.

3. Summary of deployment plans (level of commitment, areas of float deployment, Argo missions and extensions) and other commitments to Argo (data management) for the upcoming year and beyond where possible.

Several cruises are available for Argo float deployments (as per Fig 1). Please liaise with Tamaryn Morris (tamaryn.morris@weathersa.co.za) for further information:

a) Marion Island take-over
   April / May 2020 (may be too short notice), SA Agulhas II vessel
b) SEAmester Cruise (along ASCA line)
   13-24 July 2020, SA Agulhas II vessel
c) Gough Island take-over
   September 2020, SA Agulhas II vessel
d) SAMBA moorings
   September / October 2020, RV Algoa vessel
e) SANAE take-over
   December 2020 – February 2021, SA Agulhas II vessel
f) Marion Island take-over (2021)
   April / May 2021, SA Agulhas II vessel

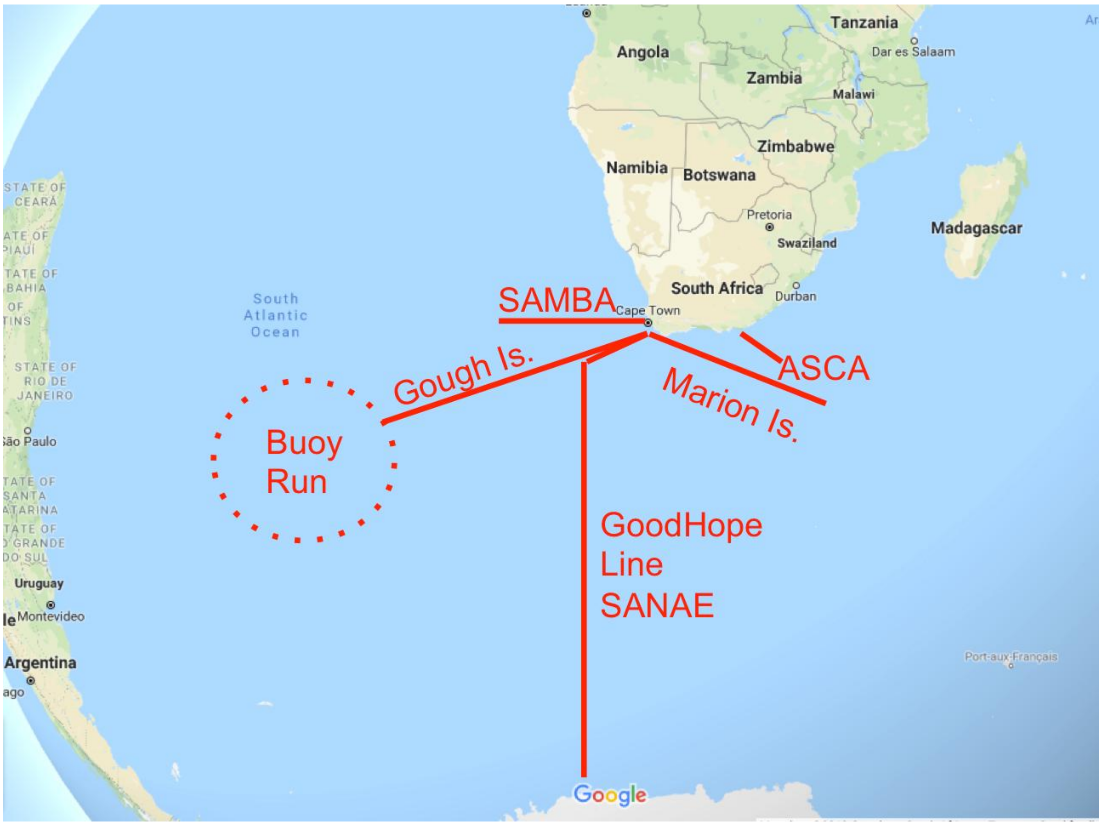


Figure 1: Schematic representation of cruise tracks for potential Argo float deployments.

4. Summary of national research and operational uses of Argo data as well as contributions to Argo Regional Centers. Please also include any links to national program Argo web pages to update links on the AST and AIC websites.

Research in South Africa using Argo floats has stalled somewhat. A proposal is being submitted to create some media material on the SEAmester cruise of Argo deployments and create learning materials for students at tertiary level to engage more readily with Argo data in a South African context. Additionally, more Honours and Masters level projects need to be initiated with South African universities (NMU, CPUT, UCT in particular) to make use of Argo data as the basis of research projects.

5. Issues that your country wishes to be considered and resolved by the Argo Steering Team regarding the international operation of Argo. These might include tasks performed by the AIC, the coordination of activities at an international level and the performance of the Argo data system. If you have specific comments, please include them in your national report.

None at this stage

6. To continue improving the quality and quantity of CTD cruise data being added to the reference database by Argo PIs, it is requested that you include any CTD station data that was taken at the time of float deployments this year. Additionally, please list CTD data (calibrated with bottle data) taken by your country in the past year that may be added to the reference database. These cruises could be ones designated for Argo calibration purposes only or could be cruises that are open to the public. To help CCHDO track down this data, please list the dates of the cruise and the PI to contact about the data.

Two cruises are available for the CCHDO – SEAmester 2019 (ASCA transect oocupation) and SAMAB 2019 (SAMBA mooring turnover). However, the data technician who would load these data is unavailable until March 2020. So this place-holder input for Steve Diggs and the CCHDO for now.

7. Keeping the Argo bibliography (http://www.argo.ucsd.edu/Bibliography.html) up to date and accurate is an important part of the Argo website. This document helps demonstrate the value of Argo and can possibly help countries when applying for continued Argo funding. To help me with this effort, please include a list of all papers published by scientists within your country in the past year using Argo data, including non-English publications.

Morris, T. and Lamont, T. 2019. Using ocean robots on high-resolution profiling to capture the fast-flowing Agulhas Current. South African Journal of Science, 115 (1/2), DOI:10.17159/sajs.2019/5523

Morris, T., Aguiar González, B. Ansorge, I. and Hermes, J. 2019. Lagrangian evolution of two Madagascar cyclonic eddies: geometric properties, vertical structure and fluxes. Journal of Geophysical Research: Oceans. DOI: 10.1029/2019JC015090

There is also the thesis citation list (http://www.argo.ucsd.edu/argo_thesis.html). If you know of any doctorate theses published in your country that are missing from the list, please let me know.

None at this stage.

Finally, if you haven't already sent me a list of Argo PIs in your country, please do so to help improve the statistics on how many papers are published including an Argo PI vs no Argo PIs.

1. Tamaryn Morris
2. Isabelle Ansorge
3. Sandy Thomalla

UK ARGO PROGRAMME

REPORT FOR 21ST ARGO STEERING TEAM MEETING
APRIL 2020

1. Status of Implementation

Floats deployed and their performance

During the last year (2019) 14 floats were deployed. These were all core floats (temperature and salinity only). They were deployed in the North and South Atlantic and south-west Indian oceans. Two of these floats failed soon after deployment: an older APF9a float deployed in the SW Indian Ocean (SN 3902), and an APF11a float at 40S in the Atlantic (SN 8578 – sending positions but no data profiles). The number of deployments was less than planned as we were impacted quite badly by the Seabird CTD recall, with 26 APEX floats having to be returned, hence some of these missed their planned deployments due to the recalibration turnaround time with SeaBird and Teledyne Webb Research (TWR).

As at the time of writing the UK has 153 operational floats (i.e. for which real-time data are presently being distributed), as shown in Figure 1.

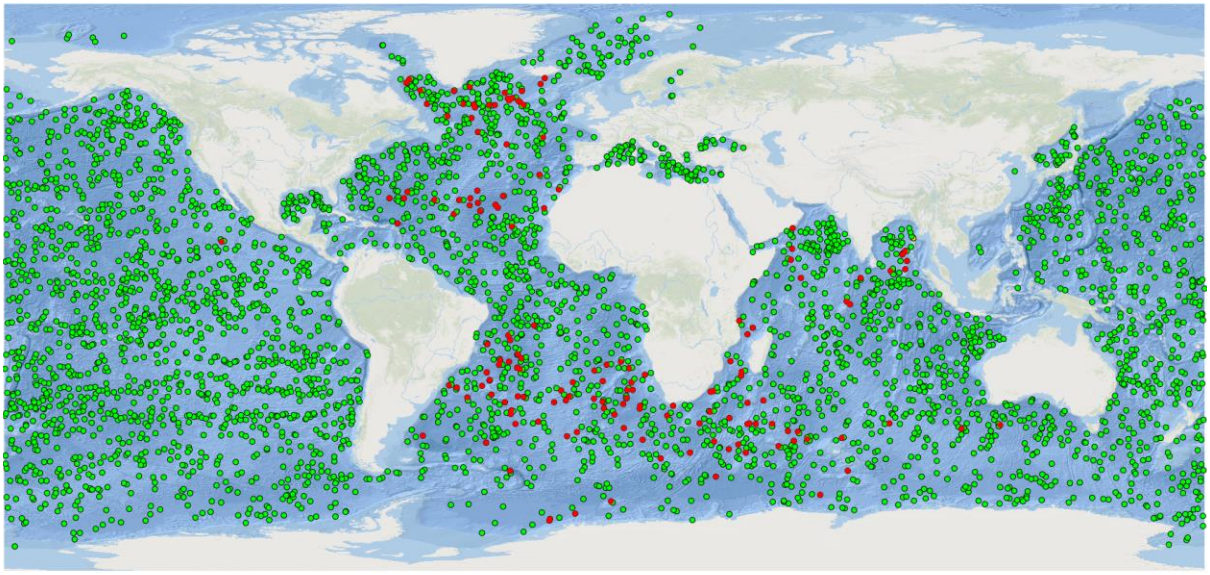


Figure 1. Showing the locations of reporting UK floats (in red, 153) with the global network (in green, 4056), as at 20th February 2020.

Technical problems encountered and solved

<u>Bio-geochemical Argo</u>

One of the two Navis BGCi floats deployed in December 2018 has exhibited problems (unable to go into continuous profiling mode due to the SBE41 being unresponsive), the other has failed to report after going under winter ice. A third float from that batch failed pre-deployment testing and was sent back to SeaBird for repair and a firmware upgrade and has subsequently been returned. Two other Navis BGCi floats purchased in 2019 have also been returned to SeaBird for the firmware upgrade.

APEX Deep activity since March 2019

The UK has one working APEX Deep float (without oxygen) at 26N in the Atlantic, deployed Nov 2018, which has presently completed 150 x 3-day cycles to 5,400m.

The UK deployed five APEX Deep floats, (four with Oxygen, one without O2) at 26N in the Atlantic in Jan/Feb 2020. Of these, three are working normally (2 with oxygen, 1 without) on 10-day cycles, cycling to the seabed (or 6,000 metres, whichever is shallower), with a grounding chain, and two have problems.

On the Jan/Feb 2020 A05 GO-SHIP cruise, the UK deployed 4 x RBR 6,000m deep CTDs on 135 full-depth (up to 6,000 metres) CTD stations in collaboration with RBR to help characterise the pressure response of the RBR Conductivity cell, working towards deploying RBR CTDs on Deep floats.

The UK expects to take delivery of 5 APEX Deep warranty replacement floats later in 2020 and has funding to procure one Deep SOLO float to develop UK capability with that technology.

APEX floats with RBR CTD

Six of these were procured in 2015. Two were planned to be deployed during the BoBBLE (Bay of Bengal Boundary Layer Experiment) cruise in June 2016. The first failed immediately after deployment so the second was returned to India for a firmware upgrade. This was done under TWR supervision and subsequently deployed in February 2017, but still failed in spite of passing all pre-deployment checks. Two other RBR CTD floats were deployed in the North Atlantic in June 2016 and both are transmitting data. The other two RBR-CTD floats were returned to TWR for upgrade/repair – one of which was deployed in the North Atlantic in October 2017 and failed, the other failed pre-deployment tests and is still with TWR for repair/upgrade.

Status of contributions to Argo data management

Real-time data processing

At present the British Oceanographic Data Centre (BODC) are processing data from 153 operational UK floats, 13 Irish floats and 71 Euro-Argo MOCCA floats (during 2018, 74 MOCCA floats were being processed, but three have since failed). From 5th June 2018, all BUFR messages distributed on the WMO Global Telecommunications System (GTS) have been generated by the Met Office from the real-time NetCDF files produced by BODC, for all the floats listed above. In 2020 it is planned to include the capability to include supplementary profiles and oxygen into the BUFR files generated by the Met Office.

However, at present there remains a significant number of APF11i floats deployed over the last five years for which the data are not yet being processed, 17 active at the end of 2019 plus a number that have failed, these are all listed below.

Deployed in 2015
2 APEX Deep (both failed)

Deployed in 2016
2 Arvor Deep (both failed)
3 APEX RBR (1 failed on deployment, 2 are operational)
3 APEX Deep (all subsequently recovered)

Deployed in 2017
2 APEX RBR (both failed)
6 APEX with O2 & pH
4 APEX Deep with O2 (2 have failed)

Deployed in 2018
2 APEX with O2
4 APEX Deep

Deployed in 2019
1 core APEX

Deployed in 2020
4 APEX Deep with O2
1 APEX Deep
2 core APEX with ice avoidance

The current priority is to implement APF11i processing which will be needed for all our newer APEX core floats, as well as for the APEX Deep and oxygen/pH floats. The focus will be on ensuring that the real-time data (even if only temperature and salinity) are processed and delivered to the GTS and GDACs from all the above float types. The work for delivering the APF11i float data is advancing well.

Delayed-mode QC processing

The BODC DAC hosts 95,064 profiles as of 3rd April 2020, of which 55,294 profiles are now in delayed-mode. This represents 58% of all profiles, or approximately 64% of eligible profiles (i.e. all profiles from expired floats and profiles over one-year old from active floats). This is a significant improvement on past years, with around 16,750 profiles having been through delayed-mode QC performed by BODC in the past year, plus DMQC submitted by partners on floats from the MOCCA project. BODC has been tracking floats affected by the high salinity drift issue and will feed-in to this monitoring and analysis.

BODC undertook a survey of core DMQC operators and issued a report to inform future development of DMQC software and practices. NOC/BODC/PML held a UK O2 and pH workshop in Southampton in December 2019 as part of our development of capability in this area, focusing on the use of SAGE developed by MBARI for A-mode adjustments.

Southern Ocean Argo Regional Centre

In the past year BODC has compiled a guide to 'Argo and the Antarctic Treaty' and begun a review of CTD on deployment metadata in support of DMQC. BODC has also worked with the University of Bristol to develop a piece of software to perform Southern Ocean zone classifications, and co-supervised a Masters student project making use of these classifications to look at Southern Ocean zone variability.

Argo and the NVS

In the past year, the policy and governance for managing the Argo reference tables on the BODC-hosted NERC Vocabulary Server (NVS) have been established, a prioritised work plan for the migration work has been developed, and this work has begun with a number of initial vocabularies either created or in-progress.

2. Funding and human resources

The UK Argo programme is undertaken by a partnership between the Met Office, the National Oceanography Centre (NOC, which includes BODC) and Plymouth Marine Laboratory (PML). The Met Office are responsible for programme management and coordination, procurement of floats, organizing float deployments, preparation of floats for deployment, telecommunications (costs) and international contributions. NOC and BODC have responsibility for Argo science and data management respectively. PML play a leading role in the recent expansion of the UK programme into BGC-Argo.

UK Argo funding to the Met Office is presently provided by BEIS (Department for Business, Energy and Industrial Strategy) mainly through the Hadley Centre Climate Change Programme (HCCCP), but with an additional contribution through the Public Weather Service Programme. The HCCCP funding is agreed for a 3-year period to end March 2021 and provides ongoing funding for around 20 core floats per year. With this Argo funding now part of the HCCCP it should be less vulnerable to being cut.

NERC funding for Argo is primarily directed through NOC under its National Capability (NC) funding line. On 1st November 2019 NOC became an independent self-governing organisation – a charitable company limited by guarantee. With this independence NOC has discretion on the allocation of NC funds from NERC, which covers Argo data management at BODC and Argo science at NOC. In addition, it is expected that up to ten floats per year for the Argo extensions (deep and bio-geochemical) could be provided through bids to NERC for funding.

Staff members working on UK Argo, their institution and an estimate of their fraction of full time equivalent time spent on Argo during FY2019/20 (April 2019 – March 2020) are listed below:

Jon Turton, Met Office (0.25) – UK Argo manager
Fiona Carse, Met Office (0.4) – UK Argo manager
John Hankins, Met Office (0.1) – float testing, set-up and shipping.
Brian King, NOCS (0.25) – Core and Deep Argo science lead [estimated on BK's behalf]
Giorgio Dall'Olmo, PML (0.1) – BGC Argo science lead
Matt Donnelly, BODC (1.0) - DAC operations, DAC development, DMQC support, Argo Vocabs support, SOARC lead
Clare Bellingham, BODC (1.0) - DAC operations, DMQC operator
Kamila Walicka (0.6) - DMQC operator and tools
Ed Small (0.6 - 1 year project) - DMQC tools
Violetta Paba, BODC (0.6) - DAC operations, BGC QC, Argo Vocabs lead
Katie Gowers, BODC (0.3) - DAC development
Paul McGarrigle, BODC (0.1) - DAC system support
Justin Buck, BODC (0.1) - Argo Vocabs support
Roseanna Wright (0.05) - SOARC task
Sarah Chapman (0.02) - SOARC task

Total: 6.57 FTE.

3. Summary of deployment and data management plans

Deployment plans

At the time of writing we have 46 core APEX floats available for deployment. We also have three Navis BGCi floats (with another two presently with Seabird for upgrading) and seven deep APEX floats in stores (with five APEX Deep warranty replacements expected later in 2020). PML also have one ProvBio float that was recovered in 2018. In addition, in April 2020, there are 23 new (Argo-equivalent) APF11i floats funded through the Royal Navy (RN).

So far in 2020, UK Argo has deployed 8 core floats and 4 deep floats, although deployments are now on hold due to the Covid-19 pandemic. Over the coming year (April 2020 to March 2021) it is hoped that UK Argo will deploy around 20 core floats (North and South Atlantic, Southern Ocean and Indian Ocean), although this will be highly dependent on the timing of easing of Covid-19 restrictions. Tentative deployment plans are:

2 - 4 APEX (2 Argos, 2 Iridium): North Atlantic, Rockall Trough/Iceland Basin (June 2020)
2 - 3 APEX (Argos): SW Indian from SA Agulhas (ACSA line, July 2020)
2 - 3 APEX (Argos): SE Atlantic from SA Agulhas (Gough line, Sept 2020)
4 APEX: Drake Passage and/or Weddell Sea (DY126 Jan/Feb 2021)
6 - 8 APEX (Argos and Iridium): North and South Atlantic, on AMT cruise (March 2021)
2 APEX (Argos): Indian Ocean, to be deployed by Mauritius Met Service (2020)

The above is not a complete list and other deployment opportunities will be investigated. If suitable opportunities become available, we may also deploy up to 7 deep floats (3 CTD only, 4 with oxygen) and up to 5 bio-geochemical floats (Navis BGCi).

The 23 RN floats (18 of which have the RBR CTD) will be deployed as ‘Argo-equivalents’ by the RN in the North Atlantic at locations and times of their choice, but the real-time data will not be available internationally for at least sometime after deployment. However, it is expected the data will eventually be made available to the global system in slower time.

Data management plans for the coming year

- BODC will deliver all APF11i core data before ADMT-21;
- BODC aspires to release of all BGC data by ADMT-21;
- BODC will release a Python version of the OWC DMQC software as part of the MOCCA project;
- NOC/BODC will work to further support the development of core DMQC under the Euro-Argo RISE WP2 and with NERC NC funding;
- NOC/BODC are contributing to the development of deep Argo QC, which will include a survey of the Deep Argo community on current approaches, under EuroArgo RISE WP3 and NERC NC;
- NOC/BODC will implement their first oxygen and pH calibrations under EuroArgo RISE WP4 and NERC NC;
- BODC will migrate most of the Argo reference tables onto the NVS vocabulary server as part of ENVRI-FAIR project in the coming year - this is already advancing well;
- BODC will begin work on SOARC regional data quality assessments under EuroArgo RISE WP5 in the coming year;
- BODC and the Met Officer aspire to further improve GTS timeliness and are considering ways to move towards a 3 hrs target;
- BODC will work with AOML to convene the 1st DAC Workshop during ADMT-21.

4. Uses of Argo data in the UK

Argo data are used widely within NOC, where the science applications include:
- measurement of evolution and drivers of mixed layer processes in the (Indian Ocean);
- Inventory and evolution of heat and freshwater establishing controls on budgets (both regional and global);
- deep heat content (N Atlantic).

PML have the lead for BGC Argo in the UK, where the data are used for:
- investigating different aspects of the biological carbon pump (e.g., mixed-layer pump, fragmentation);
- investigating export fluxes and efficiency in hypoxic ocean regions;
- providing a description of the physical environment in the framework of biological (e.g. mapping eel migration routes) and biogeochemical studies;
- developing techniques to generate 3D fields of biogeochemical variables by merging ocean-colour and in-situ data;
- investigating mesoscale structures by combining altimetry and in-situ profiles with a special focus on Agulhas rings.

At the Met Office Argo data are used operationally:
- they are routinely assimilated into its FOAM (Forecasting Ocean Assimilation Model) suite which is run daily and produces 2 analysis days and a 7-day forecast;
- fields from global FOAM are also used to initialise the ocean component of coupled monthly-to-seasonal forecasts;

- Argo data are also used in the initialization of ocean conditions in climate models run to make decadal predictions;
- a coupled ocean/atmosphere prediction system has been developed for weather forecasting timescales, and is now being run operationally, delivering ocean forecast information to the Copernicus Marine Environment Monitoring Service (CMEMS);
- near-surface Argo data are used to validate the output from the Met Office's OSTIA (Operational Sea Surface Temperature and Sea Ice Analysis), where the OSTIA fields are used as a lower boundary condition in numerical weather prediction models run by both the Met Office and ECMWF.

Two new Met Office systems which are in the process of being made ready for operational implementation are:

- an improved resolution version of global FOAM with 1/12 degree horizontal resolution, due for operational implementation in 2020. This will continue to make use of Argo data to constrain the T/S fields in the same way as the existing ¼ degree resolution system.
- a coupled weather forecasting system which is initialised using coupled data assimilation, due for operational implementation in 2021. Once this is implemented operationally Argo data will directly contribute to operational weather forecasts as well as ocean forecasts. An assessment of the impact of Argo in a lower atmospheric resolution version of that coupled system was detailed in King et al., 2019.

Met Office research & development applications (non-operational) which have made significant use of Argo data:

- David Ford has done some OSSEs looking at the impact of the planned BGC-Argo array of floats in a global physical-biogeochemical model where he assimilates synthetic versions of the BGC Argo profiles in conjunction with satellite ocean colour data. A paper based on that work is currently in preparation.
- one other project where we made good use of Argo data was in the assimilation of satellite sea surface salinity data from SMOS, Aquarius and SMAP. The near-surface salinity data from Argo was used to bias correct the satellite salinity data and was crucial for the performance of the assimilation of SSS data. That work is written up in Martin et al., 2019.

In the Hadley Centre for Climate Science, Argo data is used to make the following products:

- EN4 contains in-situ ocean temperature and salinity profiles and objective analyses. It is updated monthly using real-time Argo profiles and GTSPP data, and annually using delayed-mode Argo profiles (and WOD, GTSPP and ASBO data). EN4 is freely available for scientific research use (see http://www.metoffice.gov.uk/hadobs/en4/). In 2019 a user requirements survey was undertaken about EN4 and an updated version incorporating more uncertainty information and an updated analysis system is due for release this year (EN5).
- HadIOD (Hadley Centre Integrated Ocean Database) is a database of in situ surface and subsurface ocean temperature and salinity observations supplemented with additional metadata including bias corrections, uncertainties and quality flags. The dataset is global from 1850-present with monthly updates. The current version is HadIOD.1.2.0.0, the chief sources of data are ICOADS.2.5.1, EN4 and CMEMS drifting buoy data. Public release will be in mid-2020 via https://www.metoffice.gov.uk/hadobs/.

Met Office science uses of the EN4 product include OHC analysis, contributions to BAMS, Ocean Obs'19 White Paper and an upcoming Earth Energy Imbalance paper (Schuckmann et al., submitted).

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5. Issues from UK to be considered by AST

None.

6. Cruise CTD data

When the UK notifies float deployments with JCOMMOPS, we include any information about nearby or simultaneous CTD casts if the scientists on board the deploying ship provide this. It is written in the Description free text box in the notification form. All CTD data from UK cruises is best obtained from BODC, using the enquiries@bodc.ac.uk email contact address.

7. Bibliography for UK Argo

UK Argo PIs are Jon Turton, Fiona Carse, Brian King and Giorgio Dall'Olmo.

Included below is a list of 34 papers published during 2018 to 2020, with at least one author based at a UK institution. There are 8 papers in 2018, 25 in 2019, and 1 in 2020. The search was carried out using Web Of Science, using keyword "Argo" and refining by country (England, Scotland, Wales, Northern Ireland). PhD theses are not included in this list.

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U.S. Argo National Report to AST-21, March 2020

Organization of U.S. Argo:

The U.S. Argo Program is supported with major funding provided by the National Oceanic and Atmospheric Administration (NOAA), and additional participation of the U.S. Navy. It is implemented by a U.S. Float Consortium that includes principal investigators from six institutions: Scripps Institution of Oceanography (SIO), Woods Hole Oceanographic Institution (WHOI), the University of Washington (UW), the Atlantic Oceanographic and Meteorological Laboratory (AOML), the Pacific Marine Environmental Laboratory (PMEL), and the Naval Research Laboratory (NRL/Monterey). Float technology development, production, logistics, deployment, array monitoring, and data management functions are distributed among these institutions on a collaborative basis.

In addition to U.S. Argo's float-providing and data management activities, U.S. Argo works collaboratively with closely related programs including:

- Southern Ocean Carbon and Climate Observations and Modeling (SOCCOM, Fig. 4), a regional pilot array of BGC Argo floats supported by NSF and NOAA.
- A NOPP project for validation and improvement of the SBE-61 CTD.
- A NOPP project for development of a BGC SOLO float.
- A partnership of NOAA/PMEL and the Paul G Allen Family Foundation that provided 33 Deep Argo floats and carried out deployment of 29 of those in the Brazil Basin.
- National Academy of Sciences Gulf Research Program's support for 25 Argo floats in the Gulf of Mexico

The contributions of these and other Argo partner projects are gratefully acknowledged.

The present 5-year cycle of U.S. Argo implementation began in July 2015, and extends through June 2020. A Work Plan for a new 5-year cycle of U.S. Argo, to begin in July 2020, has been submitted by the U.S. Float Consortium, externally reviewed, and accepted by NOAA. The Work Plan includes milestones and growth of the U.S. contribution toward a unified Core/BGC/Deep Argo Program (Argo Beyond 2020).

Objectives:

The U.S. Argo Program is funded by NOAA on a year-to-year basis. There is uncertainty in the level of funding that will be available to support the 5-year Work Plan. The projections included in the Plan are optimistic. The assumptions guiding Work Plan scenarios are that (i) Core Argo budgets will increase by 10% per year above the FY2019 institutional funding levels, and (ii) incremental funding of $1M per year will be available for each of U.S. Deep and BGC Argo Programs. The increases for Core Argo are meant first to restore a healthy number of deployments for sustaining the Core Argo array, and second to fund coverage increases, beginning with those proposed for high latitudes and the equatorial Pacific. A distribution of institutional effort between the Deep and BGC programs has been planned by the U.S. Argo institutional partners. All 4 float-providing institutions will participate in both Deep and BGC

Programs, and the U.S. Argo DAC will carry out the corresponding data management. Actual funding levels may be less than the ideal scenarios, in which case the highest priority will be sustaining the Core Argo array.

Status of U.S. Core Argo implementation:

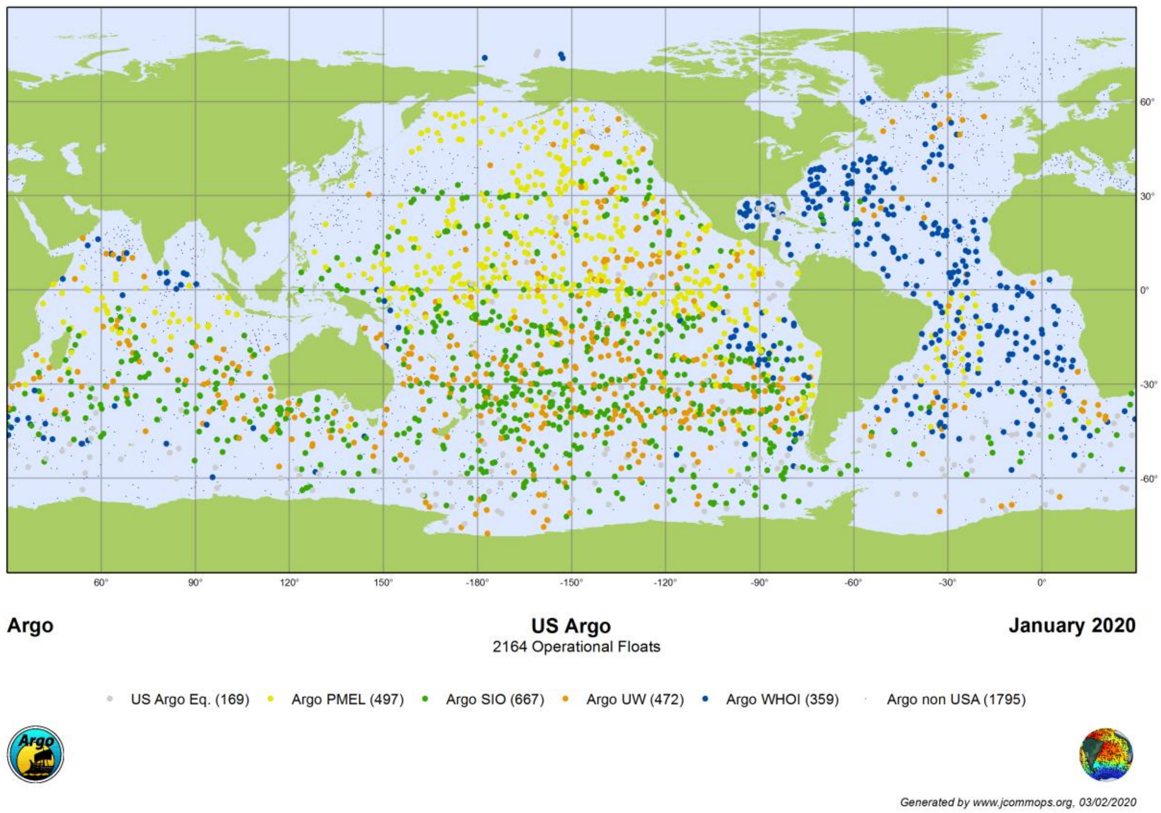

***Fig. 1**: Location of operational U.S. Argo Program and U.S. Argo Equivalent floats as of January 2020. (Source: AIC)*

Support levels for Core U.S. Argo have remained relatively flat since 2004, with some recent augmentations. Inflationary losses have been offset by increases in float lifetime, so the number of operational U.S. Argo Program floats remains approximately 2000, equal to the high levels achieved since 2008. Further increases in lifetime are expected through continuing identification of short-term and long-term failure modes and improved battery technologies. However, the present number of yearly deployments may not be sufficient to sustain the level of U.S. Argo floats.

There were 2052 operational U.S. Argo Program floats (Fig. 1) as of January 2020. A timeline of the number of operational U.S. Argo Program floats is shown in Fig. 2. Table 1 indicates the number deployed and operational for each year since 2012 (Source: JCOMMOPS).

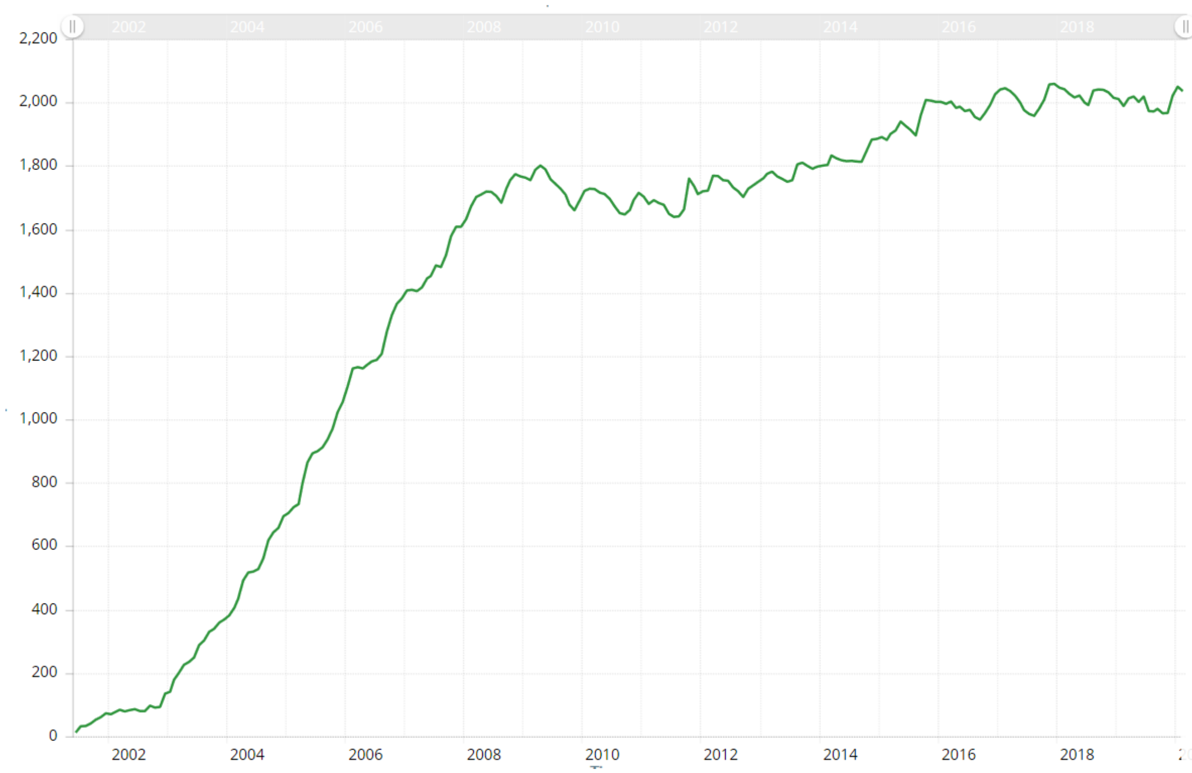

Fig. 2: *Timeline of the number of operational U.S. Argo Program floats (Source: JCOMMOPS)*

Table 1: Number of U.S. Argo Program floats deployed in each year since 2012 and the number still active as of 3/2020 (Source: JCOMMOPS). A major focus of U.S. Argo is extension of float lifetimes and reduction of early float failures.

Year deployed	Number deployed	Number active 3/2020	% active (3/2020)
2012	341	62	18%
2013	329	121	37%
2014	376	243	65%
2015	346	253	73%
2016	346	313	90%
2017	365	336	92%
2018	286	272	95%
2019	268	252	94%

Support for U.S. Argo includes float production and deployment, technology improvement, communications, data system development and implementation for real-time and delayed-mode data streams, participation in international Argo coordination and in technical and science workshops, Regional Centers, and outreach activities. Work is ongoing to assess the accuracy of CTD data used for the core Argo mission. Salinity drift in recent cohorts of Argo floats is being closely monitored collaboratively with the CTD manufacturer.

Deep Argo:

In 2011–2015, U.S. Argo carried out development and testing of Deep Argo floats, with successful prototype float deployments in 2013–2015. U.S. Deep Argo floats profile to pressures as great as 6000 dbar, and recent versions with hybrid lithium batteries are capable of more than 200 cycles. Deployment of U.S. Deep Argo regional pilot arrays began in the SW Pacific Basin in 2016–present, in the South Australian Basin in late 2016 (and planned for 2020), in the Australian Antarctic Basin in early 2018, and in the western North Atlantic in early 2017. In 2019–2020, 29 Deep Argo floats were deployed in the Brazil Basin through a partnership of PMEL/U.S. Argo and the Paul G. Allen Family Foundation (Figure 3).

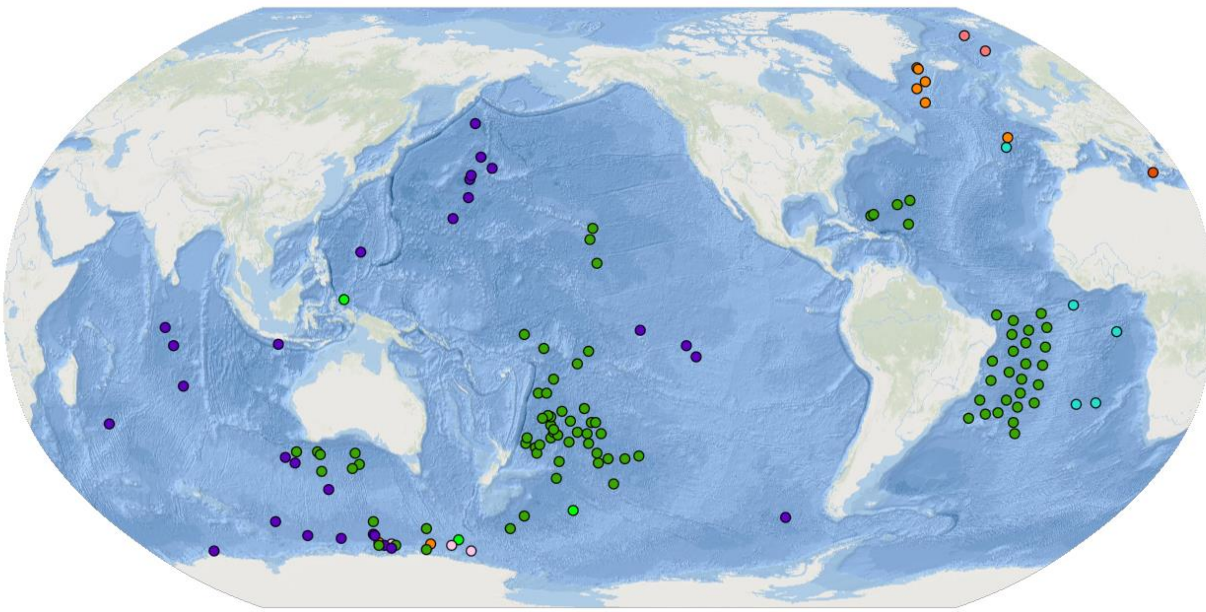

Fig. 3*: Location of all 136 active Deep Argo floats, as of 3/2020, by National Program. The 86 active U.S. Deep Argo floats floats are indicated by dark green symbols.*

Testing of deep float models continues as well as testing of SBE-61 CTD accuracy and stability. The SBE-61 has not yet achieved its aspirational goals of ± .001C, ±.002 psu, and ± 4 dbar, but is progressing relative to those goals. In partnership with U.S. Argo, a 3-year National Ocean Partnership Program award is funded for improvement of the SBE-61.

BGC Argo:

Since 2012 the US has carried out testing and deployment of Biogeochemical (BGC) Argo floats. The present versions of these floats cycle 0-2000 m at 10-day intervals and, in addition to the CTD, carry sensors for dissolved oxygen, nitrate, pH, chlorophyll fluorescence, and particulate backscatter. The SOCCOM BGC float array in the Southern Ocean now contains 154 operational BGC floats, progressing towards a goal of 200 floats by the end of 2021 (see Fig. 4). The floats are performing well with lifetimes roughly comparable to Core Argo floats. A continuation of SOCCOM has been proposed and will be supported, and a major NSF proposal for up to 500 BGC floats is pending. A funded NOPP proposal will develop a BGC SOLO float to increase the number of available BGC float models. As part of pilot activities, NOAA has funded two BGC-Argo floats to be deployed into the North Atlantic, and with NASA funding, a third. All of these Argo-related projects are coordinated with U.S. Argo.

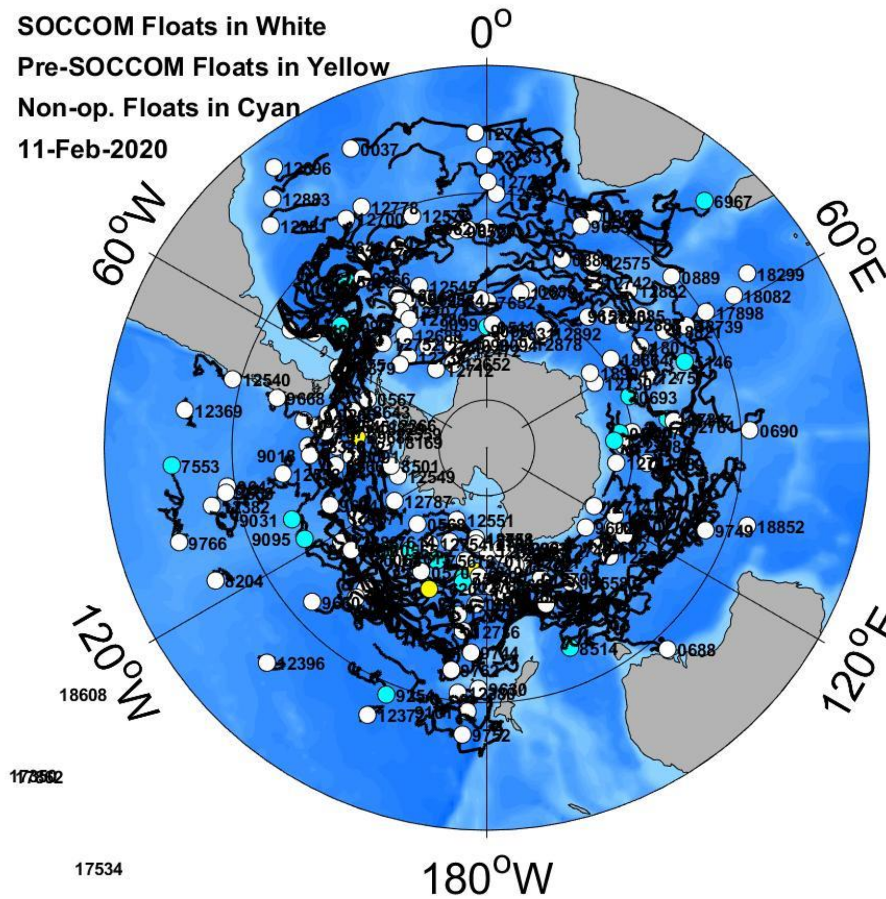

Fig. 4 *Locations of 154 active BGC-Argo floats (white symbols) deployed as part of the SOCCOM project in the Southern Ocean.*

Plans:

The highest priority for U.S. Argo is to sustain the Core Argo array. Specific plans for float deployments in 2020, as they evolve, are posted on the AIC deployment planning web page. Funding levels for the U.S. Argo Program in FY2020 are not yet set but are expected to include increases relative to FY2019 levels.

A major U.S./New Zealand/Australia Argo deployment cruise from New Zealand to Chile and back on RV Kaharoa was carried out in late-2019/early 2020. This voyage deployed 92 U.S. Core Argo floats in the South Pacific Ocean plus 10 U.S. Deep Argo floats in the SW Pacific Basin, enlarging the regional pilot array there (Fig. 3). A deployment cruise on RV Kaharoa, from New Zealand to Mauritius, is planned beginning July 2020 to deploy 5 U.S. Deep Argo floats in the South Australian Basin, plus 100 U.S. Core Argo floats in the South Pacific and South Indian Oceans. Over 1900 Argo floats have been deployed by RV Kaharoa in 2004-2020 (Fig. 5). A Deep Argo SBE-61 CTD validation cruise is planned for October 2020 on RV Tangaroa, with support from NIWA/New Zealand, NOAA/U.S. Argo, and Seabird Scientific.

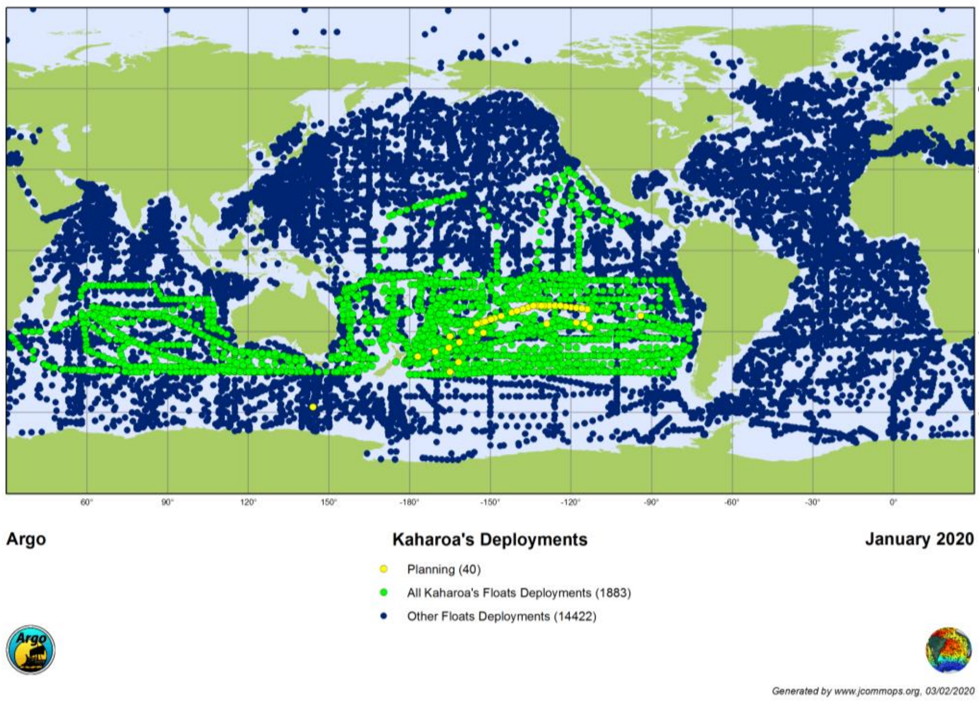

Fig. 5: *Locations of over 1900 Argo floats deployed by RV Kaharoa since 2004 (Green and yellow symbols). Those marked "planning" in the January 2020 map have been deployed. Deployment voyages are supported by U.S., New Zealand, and Australia Argo Programs. Argo could not have achieved and cannot sustain global coverage without dedicated deployment voyages in the South Pacific and South Indian Ocean. (Source: AIC)*

The U.S. Argo Data Assembly Center (DAC) is based at NOAA/AOML. Real-time data from all U.S. Argo floats are distributed via the GTS and internet. GTS transmission uses parallel systems developed at AOML and housed at AOML and at Collect Localisation Satellites (CLS), implementing internationally-agreed quality control tests. The AOML data center serves as the national focus for data management and is the conduit for delayed-mode data to pass between the PIs and the GDACs.

In addition to the national DAC, a Global Data Assembly Center (GDAC) is run as part of the GODAE server, located at the Naval Research Laboratory, Monterey. The two GDACs at NRL/Monterey and IFREMER/Brest are mirror images in their assemblies of Argo data from all international partners, and are responsible for dissemination of the data. Several U.S. institutions participate in Argo Regional Center activities, including AOML's role as focus for the South Atlantic ARC.