22nd meeting of the International Argo Steering Team

Virtual Meeting

23 – 26 March, 2021

Google drive folder for AST-22
Sched page

Contents

Welcome (5min) - S. Wijffels, T. Suga

Toshio Suga welcomed everyone to the second virtual AST meeting and thanked everyone for taking the time to participate in the meeting sessions this week. Each open day of the AST-22 plenary virtual meeting had close to 150 participants and the closed day had 95.

Towards Realizing Argo Beyond 2020

Towards global coverage: commitments, spatial completeness and regional enhancements (M. Belbéoch) 10min

M. Belbéoch reported that the Argo array is still healthy with 3900+ operational floats and improving coverage even with fewer floats and a COVID-19 year in 2020. However, deployments have become critically low and 2021 needs to have 1000+ deployments to help keep the array healthy. Depending on deployments, float projections show 3750 – 4000 operational floats in 2022. If there is another difficult year, the array could drop down to 3500 floats.

In terms of float density, the Southern Ocean, Marginal Seas, Southeast Pacific and BGC array are the primary challenges for 2021. Routinely there are too many floats deployed in the North Atlantic which could be deployed in the Southern Ocean, WBC, and equatorial extension zones. Cooperation and planning are becoming increasingly important to maximize float value and to realize the new Argo missions. A basin wide deployment planning meeting for the Atlantic was held in 2020 and additional ones could be organized for the other ocean basins to help National Programs leverage available floats and deployment opportunities.

The BGC Mission is stable and will have a boost for the next five years from GO-BGC in the US. The Deep Mission is slowly growing but could use more commitments. The TPOS2020 region is beginning to be well implemented, but it needs monitoring or the number of floats will decrease. Some WBC regions have benefitted from strong collaborations (Gulf Stream, Kuroshio, Mindanao), but there is not always good float coverage. Besides the TPOS region, no other equatorial extensions are being addressed. The Marginal Seas are stable with lots of interest in the Mediterranean Sea, Gulf of Mexico, Baltic and Black Sea, but others are not well implemented.

Many National Programs are progressing towards implementing the OneArgo design, but some still to invest more in deep floats to better balance their float types. Ideally, core would be half of a program’s floats, with deep and BGC floats each comprising another quarter of floats.

He suggested that ship time requests are done at a funding agency level to organize low cost charters across institutions. This may be necessary with BGC and Deep float deployments which are more expensive, have sparser arrays and possibly shorter lifetimes.

Action item 1: Ask OceanOPS to split commitments table for BGC floats into variables. M. Belbéoch

Action item 2: AST encourages OceanOPS to expand its monitoring to coverage by BGC parameter. M. Belbéoch

Implementing the new design:

BGC Argo Status, challenges and pathway paper (K. Johnson and H. Claustre) 15min

K. Johnson reported on the status of the BGC Argo Mission and began by noting that there were 266 BGC floats in the commitments table which is more than the target of 222 deployments per year. Some of the floats are oxygen-only ones, but many plan to have 4 – 6 sensors on them. He mentioned that in the US, the SOCCOM program has been renewed for four years (2021-2024) with 120 float deployments planned. In addition, the GO-BGC array was funded in late 2020 by NSF which plans to deploy 500 5/6 BGC sensor floats in the next five years.

He thanked the BGC ADMT teams for making the BGC Argo dataset more useful by rapidly implementing agreed upon QC procedures in near-real time and delayed mode. He noted that parameter-specific global audits are helping DACs identify bad profiles that need adjustment. There is some code sharing occurring for DMQC, but this will be enhanced in the coming year.

He noted that deployment coordination is essential and would like to make better use of the OceanOPS deployment tools.

He showed science work done to look at oxygen cycles, but found that the majority of floats sampled at specific times which made the analysis more difficult. He also noted that different float types have different vertical sampling resolutions which can affect bio-optical measurements. The issue of float sampling at specific times and vertical sampling resolution will be discussed in more detail in the presentation by S. Riser later in the Agenda.

In the discussion, there were questions about whether sensor manufacturers will be able to provide a reliable supply of sensors for the increased number of BGC float deployments in the coming years. There was a related question about whether BGC sensor costs would decrease with more demand.

Ken acknowledged that the biggest challenge to the BGC Mission is ramping up the supply of floats, while shortening the delivery time, and lowering the cost. Having a stable demand from a large program like GO-BGC should help with this, but there will be a difficult transition period as manufacturers go to a more regular production rate.

Deep Argo Status, challenges and pathway paper (N. Zilberman and B. King) 15min

N.Z. presented an update of the status and challenges of Deep Argo on behalf of the Deep Argo Mission Team (DAMT). As of March 2021, the Deep Argo array consists of 167 active Deep Argo floats, that includes 60 Scripps Deep SOLO, 36 MRV Deep SOLO, 42 Deep Arvor, 25 Deep APEX, and 4 Deep NINJA floats. The 4000-m capable Deep Argo float model HM4000 from China will be tested in May 2021 in the Northwest Pacific Basin. Two 6000-m capable Deep Argo float models are under development, including the HM6000 from China and the new Deep Arvor from France. A total of 107 Deep Argo floats will be deployed in all ocean basins in 2021. This represents a 72% increase compared to the 62 deployments of 2020. All regional pilot arrays have increased in size compared to 2020, and a new array has been implemented in March 2021 in the Argentine Basin. Close collaboration between the Deep Argo PIs and manufacturers continues to focus on increasing the accuracy and stability of the Deep Argo CTDs. Occurrences of Fast salty Drifters have been observed from 11% of SBE-61 and 7% of SBE-41 CTDs on active Deep Argo floats 1.5-2 years after deployment. A NOPP project is underway to improve the performances of the SBE-61 CTD. A three-headed Deep Arvor float equipped with RBR CTD, SBE-61 and extended-depth SBE-41 CTDs will provide valuable comparisons of the sensor performances.

In the chat, it was noted that some Deep Argo floats profile on descent and that the DAMT may need to consider adding sampling on ascent to deliver timely profiles to operational partners. This will be discussed further after another presentation later in the AST-22 Agenda. It was also noted that Deep Argo salinity data are still flagged with a qc flag of ‘3’ which means that operational users will not use it. This will be discussed during the presentation on the new cpcor recommendations for both Deep and core floats.

Action item 3: 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

Data management challenges adapting to new missions (S. Pouliquen and M. Scanderbeg) 10 min

The Argo data system set up for the Core mission has shown its efficiency but is presently facing challenges to process Deep and BGC Argo floats which increase the complexity of the processing chains, the number of different float versions to be processed due to rapidly evolving technology, and the number of different payloads to process. Moreover, the NRT procedures are still under development and need to be adapted to take into account sea behavior and as a consequence data need to be reprocessed to take into account new procedures while the DMQC is being set up for both Deep and BGC missions.

It is urgent to reduce the stress on the data system and it requires first that the new missions bring additional resources to the data system. If each project budgeted 15-20% of the equipment cost to fund the data processing up to DMQCed data delivered to the GDAC it would already improve the situation. The second aspect that the ADMT identified is to reinforce collaboration between DACs by better sharing the workload whenever possible. The DAC data system is too complex to collaborate on entire end-to-end processing chains, but we can collaborate on toolboxes /libraries/ utilities. BGC is the next decade's challenge and QC tools as well as monitoring tools could be developed jointly as long as they are properly designed as plug-and-play elements that any DAC could use.

Finally, DACs identified that closer collaboration and more machine2machine services for metadata exchanges, documentation updates, failure tracking and information are essential to avoid reinventing the wheel in each DAC.

Future DAC workshops need to be planned to identify jointly the elements where collaborative effort can be developed and that activity is led by M Donnelly and C Schmid.

Action item 4: AST suggests a workshop between Argo and operational centers to discuss BGC data quality and timeliness. The goal of the workshop would be a paper with recommendations. OceanPredict, SOCCOM, coastal operational community, P. Oke, BGC Mission Team, K. Johnson, M. Mazloff

Status in each nation: plans, challenges and prospects (T. Suga based on one bullet from National Programs, trends) 10min

EuroArgo: a consolidated viewpoint (C. Gourcuff) 10 min

Claire Gourcuff provided an overview of Argo implementation in Europe, presenting the sum of national and the European Commission contributions. In 2019 & 2020, Europe deployed less floats than in the previous years, due to (i) delays (this induced decrease will be compensated in 2021) and (ii) less funds from the European Commission (end of the MOCCA project). Euro-Argo has started to implement the new Argo design, with targets defined for the thematic and regional extensions. The new associated European strategy documents are in preparation for 2022. Euro-Argo has deployed 57 BGC-Argo floats in 2020, all equipped with oxygen sensors, and 20% with Chl-a, backscatter & irradiance sensors. These BGC deployments should almost double in 2021, with new countries planning to deploy 6 variable BGC floats (Spain & Ireland). 6 out of the 12 Euro-Argo members are involved in Deep-Argo, accounting for 26% of the international effort in terms of operational floats (43/162 as of March 2021). Euro-Argo is active in many aspects of the Argo Program, namely data management, technology, services, community enhancement and outreach. The future plans were presented in terms of float deployments: Europe plans to deploy 292 floats in 2021, including 17 BGC with 6 variables and 37 Deep floats. Current EU-funded projects will continue, and Euro-Argo is lobbying both at national and European levels to allow funding for the new phase of Argo.

Impact of fast salty drifters on sea level rise (W. Llovel) 15min

Global mean sea level rise is a perfect indicator of actual global warming. This rise is due to both global ocean warming and continental ice melting (from Greenland, Antarctica and mountain glaciers).

However, non-closure of the budget was recently reported after 2016 when using Jason-3 (the reference satellite altimetry mission used for the GMSL computation since 2016), Argo and GRACE/GRACE Follow-On data to estimate changes in the steric sea level and ocean mass respectively (Chen et al., GRL, 2020). This non-closure may result from errors in the data sets used to estimate the GMSL and its components.

This study investigates possible sources of errors affecting satellite altimetry and Argo data used to compute the GMSL budget. Good stability is found between Jason-3 data and other altimetry missions (SARAL/AltiKa and Sentinel-3A) to assess the GMSL after 2016-present.

Concerning Argo data, salinity data from different processing groups display strong discrepancies since 2016 with a global mean halosteric decrease denoting an increase of global mean salinity. This decrease is not in line with continental ice melting and floating sea ice shrinking and is attributed to fast salinity drift affecting a large part of Argo floats.

On the other hand, good agreement is found between all available Argo-based thermosteric products. Given that the halosteric component should be negligible in terms of global average, we re-examined the sea level budget since 2016 using only the thermosteric component and found significant improvement in the budget closure. We conclude that Argo-based halosteric component largely contributes to the non-closure of the GMSL budget since 2016.

In the chat, it was pointed out that a very high proportion of the near real time profiles that have major salty drift should now be flagged as bad and recent analysis should not be influenced by those profiles. However, even though the ADMT has worked hard to remove these biased profiles, there are many products available that provide RT monthly fields with many profiles that have not been updated recently. The last reanalyses were in 2017 for most of them.

In addition to Argo product producers not refreshing their internal Argo data bases frequently, many operational centers only apply simple QC tests, and otherwise use all available data to initialize forecasts and generate products, and they don’t update their databases regularly.

Therefore, it was suggested that better communication is needed between Argo, the product creators and operational centers around which data to use and how frequently Argo profiles need to be refreshed.

This issue of salinity bias in not from Fast Salty Drifters alone. As John Gilson notes, at SIO there is an increase in the percentage of floats that drift and not all reach the level of greylist. There is more chance that this salty data will reach the DM dataset (uncorrected). I do see this within the Argo_for_DMQC data set.

The link for a joint spreadsheet by the dm-operators collecting information on fast salty drift addressed in this talk can be found here:
https://docs.google.com/spreadsheets/d/1TA7SAnTiUvCK7AyGtSTUq3gu9QFbVdONj9M9zAq8CJU/edit?usp=sharing

Finally, S. Pouliquen stated that we have tools to detect FSD automatically in near real time, but not all DACs are automatically greylisting these detected FSD floats. She suggests Argo make users more aware of what can be captured at each level and push DACs to implement things more automatically to remove suspicious floats quickly. After that, DMQC operators could look at identified floats more quickly.

Action item 5: AST to ask a working group to find more effective ways of communicating with its users about how to use data quality flags, the importance of refreshing Argo data in observation collections maintained on their machines, the importance of using DM quality data for climate-level studies, etc. This includes the use of Argo data in products and models. Communication could include improvement of web pages, outreach or science workshops, leaflets, etc. M. Scanderbeg, B. King, P. Oke, EuroArgo, N. Zilberman, C. Gourcuff, S.Hosoda, A. Wong, S. Purkey

Action item 6: AST encourages the FSD working group to continue monitoring the status of FSD CTDs and CTDs with S/N > 11250. Ask working group to meet with SBE prior to ADMT-22 to collaborate on this assessment of CTDs from after 2018. National DMQC teams should report any FSD occurrences after SN 11250 to the Birgit Klein, chair Working Group. John Gilson, Nathalie Zilbermann; Annie Wong Kanako Sato; Cecilie Cabanes; Luca Plaisant; Virginie Thierry; Kim Martini; Matt Alkire

Action item 7: AST highly encourages DACs to automatically put floats that are flagged by the monthly MinMax test test by Coriolis on the greylist. (also an ADMT-21 action item). These float data should be put high on the priority list for DMQC. AST, DACs

Ongoing Technical Innovation: How can Argo test and implement incremental improvements? (Argo manufacturers) 10min

K. Martini's presentation dealt with the need to innovate while minimizing the impact on the Argo program. She noted that core Argo is now an advanced observational program that is a sustaining phase. However, different types of innovation are needed for the core, Deep and BGC Missions to continue to grow and thrive. She showed a suggested timeline starting with

NOPP grants, moving through PI experimentation, new manufacturers, pilot programs, new sensors and finally new observation networks which can take 5 – 10 years.

When a sensor is determined to be good, there is reluctance to change it. However, this is unrealistic. Instead, she suggests taking incremental steps to improve good sensors where the overall risk to the program is low, but iteration is possible to keep pace with changing technologies.

She would like to continue open collaborations between Argo scientists and manufacturers to implement incremental improvements. This would involve both groups deciding what is most important to test and how much risk stakeholders are willing to assume.

The AST co-chairs encouraged Argo scientists to engage with manufacturers to work on implementing incremental improvements.

Action item 8: AST suggests forming working groups to study how best to collaborate with manufacturers to implement incremental technical improvements, to discuss emerging issues in Argo sensors and platforms, and to collaborate on issues related to data management. These working groups would be formed around manufacturers and meetings would be done on a single manufacturer basis. K. Johnson, B. King, RBR, V. Thierry, K. Martini, N. Zilberman, P. Oke, Matt Donnelly, Violetta Paba, S. Hosoda, R. Cancouet, A. Wong

Deployment coordination, including Deep and BGC Argo (M. Belbéoch, S. Wijffels, M. Donnelly, M. Kramp) 10min

M. Kramp presented on work being done within OceanOPS to find deployment opportunities including using ships of opportunity, XBT lines, GO-SHIP cruises, etc. He noted the Marine Facilities Planning website that gathers cruise information from NERC, NIOZ, GEOMAR and CSIC. He showed the proposed lines for the LEGOS TSG-SSS and Ocean Race 2022-2023 which may provide deployment opportunities. OceanOPS is part of the Ocean Decade Odyssey Application which plans to partner with Citizen Science and Private Sector Initiatives to complement existing GOOS networks with third party contributors. OceanOPS continues to explore ships that could be chartered to deploy Argo floats and Argo National Programs are encouraged to reach out to OceanOPS for help with deployment coordination.

Action item 9: AST endorses basin-wide float deployment coordination across core, BGC and Deep floats. M. Donnelly and M. Belbéoch to consider how best to coordinate this and involve the ARCs and/or OceanOPS. M. Donnelly, M. Belbéoch, T. Morris, S. Hosoda

EEZ issues, IOC discussion, guidelines and strategies (B. Owens) & WMO update (J. Turton) 10min

WMO and IOC are making slow progress towards the development of new facilitated procedure for notification of deployments in national waters. IOC organized a workshop in February 2020 to develop a strategy within the UNCLOS framework and to explore solution spaces for facilitated access to EEZ, *sine qua non* condition to complete the array at a regional level. A final report is expected shortly. Use of UNCLOS Article 247, which has never been used, is a real possibility for organizing regional MSR clearance requests through an international organization such as IOC for regional deployment planning. This could build as well on the existing notification system set up at OceanOPS.

WMO is also developing a new data policy “Resolution 42” that is intended to cover all earth-system data and aims to broaden and enhance the free and unrestricted international exchange of such data. The new policy retains a two-tier approach with ‘Mandatory’ data that shall be exchanged and ‘Recommended’ data that should be exchanged. The ocean data content has been developed in consultation with the Observations Coordination Group (OCG) and GOOS Steering Committee, where physical variables as measured by Core Argo are designated as Mandatory and biogeochemical variables, e.g. BGC Argo, as Recommended. Plans are to have the new data policy approved by the WMO Congress in the Fall.

With the reorganization of WMO, the WMO-IOC Joint Commission for Oceanography and Marine Meteorology (JCOMM) was disbanded in 2020, and WMO now has just 2 Technical Commissions, one for Infrastructure and one for Services. The ocean observing networks and OCG now fall under the IOC-led GOOS. A Joint WMO-IOC Collaborative Board (JCB) has been established as a high-level coordination mechanism and a Study Group on Ocean Observations and Infrastructure Systems (SG-OOIS) is examining where functional connections will need to be made between GOOS and WMO.

Five workshops are being planned for the week before the May OCG annual meeting. Subjects are: Metadata/Data, Environmental Stewardship, Boundary Currents, BioEco and OCG networks and Report Card Review. An AST volunteer for the Boundary Currents organizing committee needs to be identified. Once the workshops are organized, the schedule will be announced by the OCG office.

The OCG representative for developing countries is Zulfikar Begg (ZulfikarB@spc.int) and is involved in outreach. OCG is also managing educational outreach in the Pacific Islands Region. As part of NOAA OCG funding, NOAA supports the PI-GOOS director for the Pacific Islands, including 3 courses related to climate change and Argo. WMO has also a strong engagement with the SIDS through the GBON and SOFF mechanisms.

The expected annual 2020 contributions in support of OceanOPS have been received from all but one country. In addition, Monaco is now contributing support for a new OceanOPS position to support the BGC-Argo mission and Mediterranean Sea observing systems. China is also contributing to this new position. Support from other Argo member countries is encouraged to support expanded OceanOPS Argo related activities. WMO has just committed to support the OceanOPS lead position through its regular budget which will automatically enable more resources for network support, and for Argo in particular, which has invested a lot in the OceanOPS infrastructure since its establishment .

Since WMO is interested in moving toward Earth System Model, facilitating the use of BGC data by the model community would help make BGC variables mandatory.

In the chat following the presentation, it was noted that the status of biogeochemical variables may need to be 'Mandatory' to help make this data available to the ocean modeling community. J. Turton agreed that this could be re-evaluated at a later stage if the BGC Argo data are being heavily used by the modeling community.

> **Action item 10:** The AST recommends a meeting between the AST exec, A. Fischer and A. Troisi to discuss the possibility of invoking IOC resolution 247. AST exec, A. Fischer, A. Troisi

> **Action item 11:** AST asks for a volunteer to help T. Morris on OCG Boundary current workshop

2K Mission

Recent float performance across array: Current technical issues with core floats (M. Belbéoch) 10min

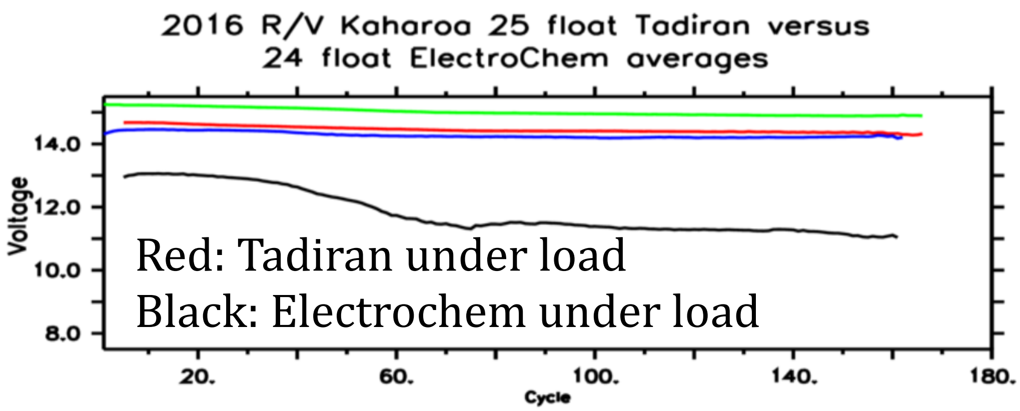
Overall float performance is slowing down its progress and sits at about 225 cycles for an average float lifetime. There was an increase of early failures (less than 10 cycles) that needs careful monitoring. The mortality rate has increased from 20 to 25% which is probably due to fewer deployments in 2020; it is even higher for BGC floats and high latitude floats.

The average age of failures is 5 years for core, 4 for global, 3 for BGC, 1.5 for Deep. It was noted that some of the BGC and Deep floats may have been recovered and it was unclear how that influenced the statistics.

SOLO-II Tadiran fleet (D. Roemmich) 5min

Many of Argo's biggest challenges scale with float lifetime (cost, environmental impact, array re-deployment). Doubling the lifetime reduces operational costs by half. Float lifetime has 3 elements: battery life, early failures, CTD stability. Several models of floats, including SOLO-II, are achieving early failure rates of ~4% per year or less. Battery life can be ***at least 10 years***. CTD stability (p and S) remains a challenge. It is anticipated that extending the battery life of floats will extend overall float lifetime.

Hybrid lithium batteries combine rechargeable cells that can efficiently deliver the high current required by the SOLO-II pumping system with primary cells that trickle-charge the rechargeable cells. With this combination, batteries performing Argo missions deliver a higher fraction of their total energy – about 70% - than with primary cells alone.
25 SOLO-II floats with Tadiran hybrid batteries were deployed by RV Kaharoa in Nov-Dec of 2016 and have completed 160 cycles to 2000 dbar. All 25 are active as of March 2021. SOLO-II floats require 8.1 kJ per cycle. They have total battery energy of 5.4 MJ, which is de-rated to 70% (3.8 MJ) for time and temperature. The Tadiran-equipped floats are, on that basis, expected to yield over 450 cycles. The plot shows battery voltage (under load) versus time for the Tadiran-equipped floats as well as Electrochem-equipped floats deployed at the same time. The much smaller degradation (voltage drops under load) of the Tadiran batteries is clear. This experiment is ongoing, but all new SIO floats are being equipped with Tadiran hybrid lithium batteries.



The SOLO-II float has both a very low rate of early failures and a very long battery life. Of 484 SOLO-II floats deployed since 2016, 463 (96%) remain active as of March 2021.

NAVIS (G. Johnson) 5min

G. Johnson updated the AST on the status of the Navis fleet and showed that the Navis-EBR is performing better than the Navis-A after a few early failures. In total, 306 Navis-A floats were deployed by PMEL with the longest-lived one (5904044) reporting its 288th profile on 11 Feb 2021. 203 of 299 reported a 100th profile. There were four major failure modes that were addressed through serial patches, but with numerous warrantee floats, the effective lifetimes were boosted by about 4/3. 367 redesigned Navis-EBR floats have been deployed by PMEL with the longest lived one (4902299) reporting its 19th profile on 11 March 2021. The redesign addressed many of the major Navis-A failure modes and is working well despite some hiccups in early builds. 148 of 158 reported a 100th profile. There have been several warrantee floats received and some high pressure valve issues have been seen in recent floats.

Apex air bladder issues (S. Riser) 5 min

S. Riser reported on systemic problems found at UW with Apex float air bladders. The entire report can be found in a technical update on the AST website. Air loss from floats is caused when air remains trapped in the air bladder after the float descends from the surface. As the float descends, there is a Darcy's Law flow into the ocean through the bladder wall (an also into the oil bladder). This results in decreasing internal air pressure in the float which continues on each cycle. It is likely caused by a change in bladder curing by the manufacturer after 2017 which results in bladders that are too smooth and partially fused under pressure. A symptom of this is that eventually the loss of internal air and the resulting poor inflation prevents a float from fully extending its antenna out of the water while on the surface, resulting in a loss of GPS fixes and increased power consumption. UW floats also collect an Iridium fix, which is of much lower quality and is a fallback. It is likely that other user groups are affected and Teledyne Webb has been informed and is investigating.

Action item 12: AST encourages APEX float user groups to check for symptoms of the air bladder problem reported by Steve Riser and share the information to address the problem. APEX users, S. Hosoda

Provor/Arvor (X. André) 5min

The Arvor was the most deployed profiling float type by the Argo community in 2018 and 2019. This is likely due to its improved performance, achieved by nke instrumentation as part of the NAOS project, and summarized in https://doi.org/10.3389/fmars.2020.577446. Note: an enhanced self-test (that does not require any external equipment), and the addition of a buzzer that now clearly indicates that the float can be deployed. Arvor that benefit from these improvements are those produced since 2016. Now, after 1000 days at sea, 96% of the Arvor are still in operation, compared to 76% before this work!

The Arvor now exists with an RBR CTD. The first 2 Arvor-I RBR were deployed by Ifremer and IEO in December 2020. 5 more BSH units have been deployed in Jan 2021. Altogether, they have accumulated 140 profiles at sea by 20 March 2021. The data are currently being analyzed.

In addition, the ISA implemented on the Arvor has shown its good performance, both in the Arctic and Antarctic.

S. Wijffels congratulated NKE on the increase in Arvor lifetime noting how important it is for the health of the array.

HM2000 (Z. Liu) 5min

Zenghong Liu presented an update on HM2000 float developed by HSOE. Currently, HM2000 float is able to transmit data both with BDS and Iridium satellite systems. Based on the observations over the past few years, the lifetime of HM2000 is not sufficient to meet the target of Argo observation. The improvement for HM2000 should be put on the agenda.

ALTO (S. Jayne) 5min

S. Jayne reported on the ALTO which is manufactured by MRV Systems. The ALTO has the same form factor and weight as the S2A/SOLO-II float but has a higher efficiency hydraulic buoyancy system. The firmware is more flexible and it can carry a SeaBird or RBR CTD as well as other sensors including oxygen, optics and surface waves. Firmware issues have continued to cause problems, but MRV has worked through many of them. Currently WHOI has 20 ALTOs in house (15 RBR and 5 SBE) that will be deployed when the firmware is updated.

RBR pilot (S. Wijffels, B. Owens) 10min

S. Wijffels presented the status of the RBR working group and the challenges the task team is working on which include characterizing and quantifying the sensor accuracy. Both static and dynamic accuracy are being examined as well as the long term drift and stability and how to make DMQC tools and protocols for RBR CTD data.

Data from three sources confirms temperature and pressure accuracy and the salinity stability looks competitive with the accuracy on deployment showing a slightly higher spread. RBR will move to calibrate each cell individually to address conductivity cell compressibility. There has been major progress on the dynamic error and a manuscript is in development.

The next steps in the RBR pilot are as follows:

1. Continue deploying floats and grow the pilot array. It is important to have a sampling rate of ~1 Hz or more before binning. It is ideal to have the ability to send back some raw data around gradient regions.
2. Obtain more laboratory data to improve the slow CTcoeff
3. Finalize and publish paper on CTD and dynamic corrections
4. Test the dynamic and static corrections on pilot float data.
5. Work with RBR and float manufacturers to speed on-board implementation of dynamic corrections for salinity.
6. Continue testing the Deep RBR CTD

Action item 13: AST encourages national programs to continue to contribute to the RBR pilot to grow our experience with this sensor suite. AST members, National Programs

Increasing stability in SBE CTD (N. Zilberman on behalf of SeaBird) 10min

SeaBird reported on efforts to improve the stability of the SBE Argo CTD. They have developed in-house capability to monitor the performance of SBE CTDs in the Argo fleet and have identified mechanisms responsible for salty drift in CTDs. They are working to improve CTD design and the manufacturing process.

They have identified two types of salty drift: abrupt and progressive. In terms of the abrupt salty drift, they are recalling SBE CTDs at risk for this (see note). They believe that a production issue was resolved in October 2018 and that this type of drift should no longer occur after that manufacturing change was implemented.

Much work has been done to find the root cause of the progressive salty drift, but no cause or mechanism has yet been identified. Two hypotheses exist: (1) water ingress between encapsulation and glass cell and (2) change in encapsulant properties over time.

SeaBird will continue to work on this and would appreciate help in recovering salty drifters and in further communication with dmode operators to continue to identify these floats.

Action item 14: Ask M. Belbéoch & B. Klein to track the s/n of at-risk CTDs and immediately warn PIs of the hull numbers of floats that are in the at-risk range. M. Belbéoch, B. Klein, K. Martini

Action item 15: AST recommends that floats with CTD s/n in the at-risk ranges should not be deployed, per the recall announcement by SBE

Argo under the ice (S. Jayne, B. Greenan, I. Angel, E. van Wijk, S. Riser) 10min

S. Riser reported on mapped climatologies from floats in the Antarctic Sea Ice Zone. CSIRO reported 15 deployments are planned for south of 60S in 2021/22. In addition, there is work being done to adapt an algorithm for navigating deep floats under-ice. Canada continues to deploy BGC pro-ice floats in Baffin Bay.

Summary of the European Argo Under-Ice Activities (Ingrid Angel Benavides, BSH)

1. Floats in ice covered regions in the Northern Hemisphere (Arctic, Nordic Seas, Baltic Sea)

Country	Currently Operating	Deployments 2019	Deployments 2020	Planned Deployments 2021	Observations
Finland	2 Barents Sea, 1 Baltic	1 Barents Sea 2 Bothnian Sea		2 in the Northern Baltic	
France	2 Baffin Bay, 1 Eurasian Basin	2 (2019) Baffin Bay		2 BGC floats in Baffin Bay.	One of the planned deployments is a float with video profiling system
Germany	2 Eurasian Basin		2 North of Svalbard	4 WSC	
Norway	2 Barents Sea + 1 Greenland Sea	1 Barents Sea 3 Greenland Sea	1 Barents Sea 2 Greenland Sea	1 Barents Sea w. oxygen + 1 North of Svalbard + 4 Greenland Sea	
Poland	3 Eurasian Basin	1 West Spitzbergen Current	1 West Spitzbergen Current	2 WSC (If delivered)	
Euro-Argo				2 in the Northern Baltic	FMI (Finland) and LOV (France) collaboration. Experimental BGCs: Suna Nitrate sensor, Hyperspectral radiometry sensor, also RBR CTD sensor

2. Euro-Argo RISE Activities regarding Argo float operation in the Arctic (to be completed in Dec. 2021)

- *Report on the current state of ice avoidance methods and recommendations for deploying Argo floats in the Arctic Ocean* (BSH/Germany, FMI/Finland, IO-PAN/Poland, SU/France, IMR/Norway)
- A tool for local tuning of the main of Ice Sensing Algorithm (ISA) parameters (temperature threshold and pressure range) will be made available in the EuroArgo Github https://github.com/euroargodev. This will be accompanied of an ISA reference database (T(S) profiles with its distance to sea ice) for the Arctic Eurasian Basin and the Greenland Current.
- Locally tuned ISA parameters available

Region	**P range (dbar)**	**Threshold (°C)**	
Baffin Bay**	10 – 30	-1.3 or -1.5	** ice in this region is mostly avoided by preventing surfacing in given months (calendar strategy)
Barents Sea	10 – 20	-1.0	
North of Svalbard	10 – 30	- 1.4	

3. Southern Ocean

- Deployments south of 50°S (60°S)

	2019	2020	2021
France	2	1	1
Germany	2	5	9(2)
European Union	0	1	3(1)
Italy	10(5)	15(10)	7(7)
United Kingdom	0	6(4)	4(2)

- Deep floats: 28 Deep floats have been deployed in the Southern Ocean (inc.19 by Japan). Deep Arvor float 6902814 spent 3 winters under ice totalizing over a year of under-ice data.

4. New float features

Teledyne Webb IceApex floats + AWI (Germany)

- RAFOS hydrophone equipped for under-ice positioning. These are now the only RAFOS equipped floats after closure of Optimare and cease production of NEMO.
- Other features: Pok-em-on– repeated attempts to surface at the end of a cycle to try to find a gap in sea-ice cover – and Hover-over feature – to keep floats above the same portion of the seabed. Season check – periods without attempt to surface – and mission sequencing.
- A single float has been deployed in the South Scotia Arc, although there has been some unusual behaviour from the bladder at the surface.
- Deployment plans: 2021: 5 floats on the shelf-break in the Weddell Sea, along with 3 RAFOS sound sources. In 2022, 23 floats are planned for deployment to make use of the HAFOS (Hybrid Antarctic Float Observation System).

NKE new Provor CTS5

General script calendar feature: Pre-program the same parameter changes that can be made remotely by Iridium. Parameter changes according to date. Allows for different ice avoidance strategies depending on the season (including avoiding surfacing altogether)

MERMAID/EarthScope-Oceans (Y. Hello, F. Simons, M. Belbéoch, N. Zilberman)

F. J. Simons reported on MERMAID floats as part of EarthScope-Oceans. MERMAID stands for Mobile Earthquake Recording in Marine Areas by Independent Divers. The floats which are spherical, are built by Géoazur and OSEAN SAS. 50 MERMAIDs have been deployed in French Polynesia by Géoazur and partners at Princeton, Kobe, JAMSTEC and SUSTECH. The plan is to create an array of 500 MERMAID floats in the next decade, coordinated by the EarthScope-Oceans consortium. Their goal is to partner with the Argo community since MERMAID floats can carry up to 8 additional sensors like the SBE CTD which is currently optional and commercially available from OSEAN. MERMAID floats can temporarily land and can be easily adapted to dive to 6000 m. They are also able to change their mission (dive depth, length, etc) as instructed, per two-way Iridium communications.

In the discussion, it was agreed that there were good possibilities for collaboration between Argo and EarthScope-Oceans. A working group was set up to study how to collaborate between Argo and MERMAID.

Action item 16: AST suggests forming a working group to study how best to collaborate with EarthScope program and MERMAID array. N. Zilberman, B. King, S. Hosoda, Y. Hello, F. J. Simons, M. Belbéoch, T. Ross

BGC Mission: Technical updates on BGC-Argo 20mn

Overview of performance of BGC floats (Mathieu) 5 min

Scripps/MRV BGC solo float (S. Purkey) 5min

BGC SOLO (Purkey): Development work is underway to add the 6 BGC sensors to the SOLOII/S2A float model. The body will be a slightly longer version of the SOLOII with mostly the same internal components. The new BGC measured parameters will include: Nitrate (Deep SUNA), Backscatter/Chlorophyll fluorescence/CDOM (SBE ECO-triplet), Downwelling Irradiance (OCR-504), pH (Deep Sea DuraFet) and Dissolved oxygen (SBE83) with out of air sampling capability. The BGC SOLO will be commercially available through MRV Systems likely by the end of 2021. The float is being designed to be very adaptable so that it should be able to take different sensors with minimal software development and new mast.

PROVOR CTS5 Jumbo BGC float (H. Claustre) 5mn

H. Claustre presented updates on the PROVOR CTS5 Jumbo BGC float which can carry 8 BGC sensors including PAR, bbp, Chla, O2, NO3, pH, transmissometer and underwater vision profiler to look at particle size and zooplankton. The goal is to make a BGC float that is long-lived, can carry sensors for the six variables and has flexibility to extend the lifetime. A GUI has been created for mission settings that helps estimate the configuration impact and allows many parameters to be changed. The standard BGC-Argo PROVOR, the estimated float lifetime goes down to about 4 years with all 6 parameters, plus bpp and Chla at metric resolution and the underwater vision profiler. The JUMBO float will have an estimated 6.3 year lifetime with the same sensors due to a larger hull and 60% more batteries. It weighs approximately 70kg.

Chla and radiometry sensor (H. Claustre) 5mn

A working group is being formed to study the pros and cons of using a dual channel Chla sensor to measure two wavelengths.

Additional radiometric measurements are required for DMQC including measurements during parking drift to capture the drift of the sensor’s dark and a night profile when there is maximum stratification to find the temperature dependence of the sensor's dark. Different wavelengths of SBE sensors have been used in the BGC Argo dataset.

Deep Mission: 30mn

Deep SOLO (D. Roemmich) 5mn

Status of Deep SOLO and Deep SOLO MRV floats

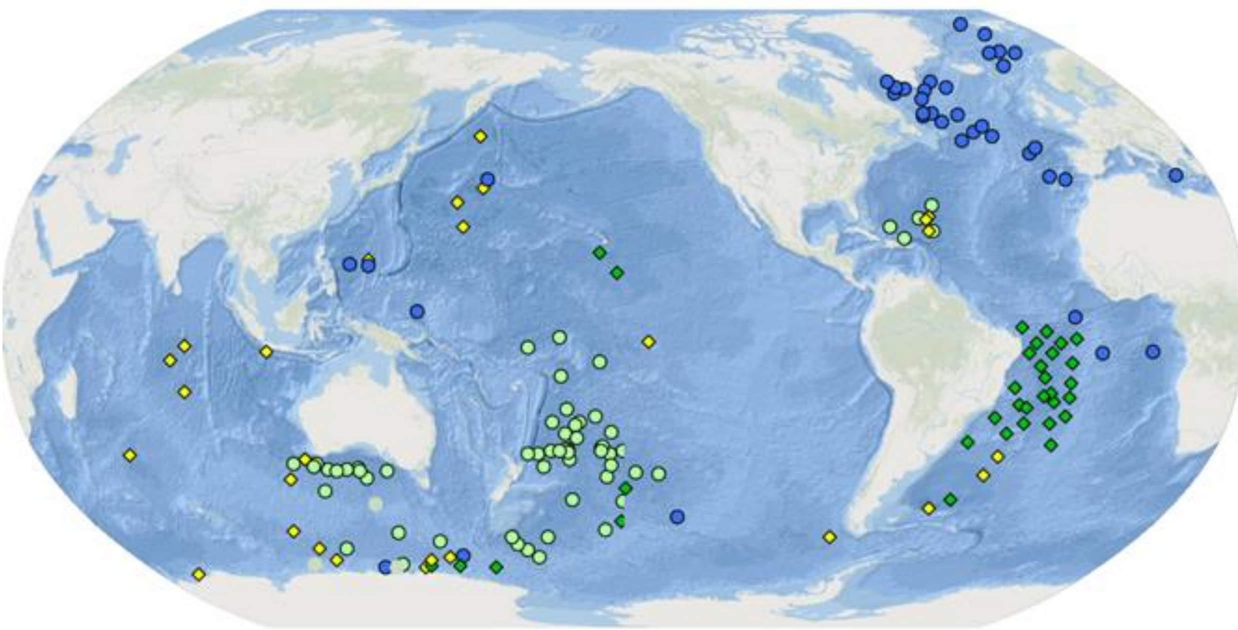


Figure 1: OceanOPS latest location of 58 active Deep SOLO (light green) and 33 active Deep SOLO MRV (dark green) floats.

Table 1: Deep SOLO Regional Pilot Deployments

Month/Year Array	Deployment Vessel	Number of Deep SOLOs	Batteries No. Packs and type	Serial Numbers	Active
Deep SOLO				6002, 6003 prototypes	

Jan 2016 SW Pac	Kaharoa	7	4E	6004-6007, 6009-6011	3
Jun 2016 SW Pac	Kaharoa	3	4E	6008, 6014, 6015	3
Aug 2016 SW Pac	Investigator	2	4E	6012-6013	1
Oct 2016 S Aus	Kaharoa	8	4E	6016-6020, 6022-6024	6
Mar 2017 NW Atlantic	James Cook	6	4T (3 floats) 4E (3 floats)	6021, 6025-6029	5
Aug 2017 SW Pac	Palmer	3	4E	6030-6032	3
Oct 2017 SW Pac	Kaharoa	5	4T	6033-6037	5
Jan 2018 Aus Ant	Investigator	5	4T	6038-6042	4
Jul 2018 SW Pac	Kaharoa	10	5T	6043-6052	8
Jan 2019 SW Pac	Tangaroa	5	5T	6053-6055 6057-6058	4
Dec 2019 – Jan 2020 SW Pac	Kaharoa	10	5T	6056, 6059-6061, 6063-6068	9
S Aus Aug 2020	Kaharoa	5	5T	6062, 6069-6072	5
SW Pac Jan 2021	Tangaroa	3	5T	6073-6075	2

Total		**72 deployed**			**58 active**
Deep SOLO-MRV					
May-June 2018 NPac	**K-Kanaloa, Kilo Moana**	**3**	**5T**	**12001-12003**	**2**
Jan-Feb 2019 Aus Ant	**Kaiyo Maru**	**3**	**5T**	**12006-12008**	**3**
May 2019-Feb 2020 Brazil	**Thompson, Discovery, Brown, & Petrel**	**30**	**5T**	**12004-5 12009-36**	**22**
Dec 2020 Brazil & Argentine	**James Cook**	**3**	**5T**	**12037-38, 12002**	**3**
Jan 2021 SW Pac	**Revelle**	**2**	**5T**	**120040-41**	**2**
Total		**41 deployed**			**32 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. Both floats reappeared later. 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 and 12004 were both recovered, recabled, and redeployed. They have not had issues since. The rest of the floats are still active and reporting full-depth profiles most of the time, except for 12005 which recently went missing after 21 months of operation.

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 was also exhibiting a salty drift, was recovered, the CTD swapped out, and should be redeployed in March 2021. Salty drift is discussed in a different AST-22 agenda item.

CTD Failure: One Deep SOLO (12014) exhibited strong drift in surface pressures around profile 28, very large, irregular shifts towards high salinity starting at profile 45, and an inability to navigate effectively after profile 54.

Improvements to Deep SOLO have included enhanced battery life for 6+ year missions, upgraded float/CTD cabling, ice avoidance, and an option for a secondary profile on ascent (for near real-time transmission)

The survival rates of Deep SOLO and Deep SOLO MRV are less than those of the best surviving Core Argo float models but better than the Core Argo fleet as a whole. Of 93 DS and DS_MRV floats deployed since 2017, 77 are active (failure rate ~6% per year)

Deep APEX (B. King) 5mn

B. King presented on the UK and Japanese experience with the Deep APEX. The UK has had a total of 23 Deep APEX deployments, including 4 floats recovered and redeployed and 10 floats carrying the Aanderaa oxygen optode. These deployments have been in the N. Atlantic, Drake Passage and Argentine Basin. Overall, the statistics are as follows:

- 5 immediate failures (<10 cycles); 4 leaked, 1 never reported

- 3 lost communication with the CTD (2 SBE61, 1 RBR)

- 2 bad CTD data (1 Fast Salty Drifter)

- 7 failed after 18, 45, 50, 62, 117, 204 and 209 cycles

- 6 active and working correctly after 2, 2, 12, 13, 14, 48 cycles up to 6000 dbar.

The UK anticipates it has one or two more Deep APEX to deploy.

Since 2017, JAMSTEC have deployed 24 deep APEXs in the Pacific, Indian and Southern Ocean and 20 of them are currently alive. Six deep APEX have DO sensors (4 optodes, 2 RINKO AROD-FT). The statistics are as follows:

- 1 has observed salinity drift with another one possibly showing drift
- 6 had buoyancy failures; 5 operational floats have partly failed buoyancy
- 3 of 6 deep APEX with DO sensors are still alive

JAMSTEC will purchase one deep APEX with a RINKO sensor in 2021 and has received one deep APEX as a warranty float.

To summarize the key points for floats that have not suffered other failures:

- When ballasted correctly, floats function well down to 6000 dbar
- Deep APEX now has a bottom approach algorithm and chain which allows for profiling to the seabed
- UK floats have reached end of battery life and have completed a good number of cycles
- 3 of 30 long surviving floats have shown FSD behavior
- TWR has indicated that the Benthos spheres used in Deep APEX will become unavailable and no alternative has been announced.
- A deep APEX RBR float was deployed but suffered early failure
- Aanderaa optodes have worked OK on Deep floats

Deep HM4000 (Zhaohui Chen) 5mn

by Zhaohui Chen*, Zenghong Liu* and Chong Ren

* Deep Argo Mission Team member

In 2020, the Deep float R&D team from HSOE has upgraded the HM4000 prototype in terms of improving the testing processes, production and manufacturing after 2019-test in the western Pacific.

Deep float for 6000 m (HM6000) is currently under development.

Due to COVID-19, the cruise to Argentine basin, where 10 floats were planned to be deployed, was cancelled due to unavailability of deployment opportunities.

In 2021, there will be 10 HM4000 floats to be deployed in the Western Pacific in May/June, with 9 of them equipped with RBRARGO CTD and only one with SEB61.

Deep Arvor, triple headed float (V. Thierry) 5mn

V. Thierry presented the first results from a Deep-Arvor float equipped with three different CTD probes: SBE41-CP, RBRconcerto and SBE61. The comparison of the pressure sensors reveals pressure dependent differences ranging from 0 at the surface to almost 10 dbar when comparing RBRconcerto and SBE61. Differences in temperature sensors lie within sensor accuracy (less than 0.002°C). The three conductivity sensors need to be corrected by (1) a pressure dependent correction term (Cpcor correction for the SBE sensors and an equivalent term for the RBR sensor) and (2) a conductivity ratio (equivalent to a salinity offset). Before correction, the deviation from reference at depth is larger than 0.01 for both RBR and SBE61. The temporal evolution of the sensors will be monitored in the future. This work is a good opportunity to collaborate with Seabird and RBR.

SBE 61 Update (N. Zilberman) 5min

In situ observations indicate that while the SBE-61 temperature shows 0.001°C agreement with high-quality shipboard data, the salinity and pressure accuracies are close to but not quite reaching Deep Argo’s targets (±0.002 PSS-78 and ±3 dbar). Occurrences of Fast salty Drifters have been observed for 11% of SBE-61 CTDs and 7% extended-depth SBE-41 CTDs on active Deep Argo floats 1.5-2 years after deployment. A NOPP project was funded to improve the accuracy and stability of the Deep Argo SBE-61 CTD. This project is a joint effort between Scripps, Sea-Bird Scientific, NIWA, and PMEL. The contribution of Phil Sutton at NIWA has been instrumental in providing resources and technical support. Sea-Bird Scientific has conducted extensive research to identify pressure sensor candidates for replacement of the Kistler pressure sensor currently used on the SBE-61 CTD. In addition, experimental conductivity cells with new encapsulant epoxy materials and modified electrical circuit have been developed. A Deep SOLO float model equipped with standalone high-quality quartz resonant pressure sensor from Quartzdyne has been developed at the Instrumental Development Group at Scripps. A 14-day research cruise on the Tangaroa is scheduled 03/27-04/11 from Wellington to the deep region northeast of New Zealand offshore of the Tonga Kermadec Ridge. The first objective of the Tangaroa voyage is to define the accuracies of the pressure sensor candidates and experimental conductivity cells based on comparisons with shipboard data from CTD casts. The second objective is to study the stability of the Kistler pressure sensor and candidates for replacement using comparisons between SBE-61 CTD and

Quartzdyne pressure sensor on 6 Deep SOLO floats.

In the discussion, it was noted that progress on the encapsulant and pressure sensor could be of value on entire SBE fleet, not just the SBE61. SeaBird will probably be approaching Argo to test some of these sensors and this could be a chance to think about how to progress incremental improvements to sensors in a careful and deliberate manner.

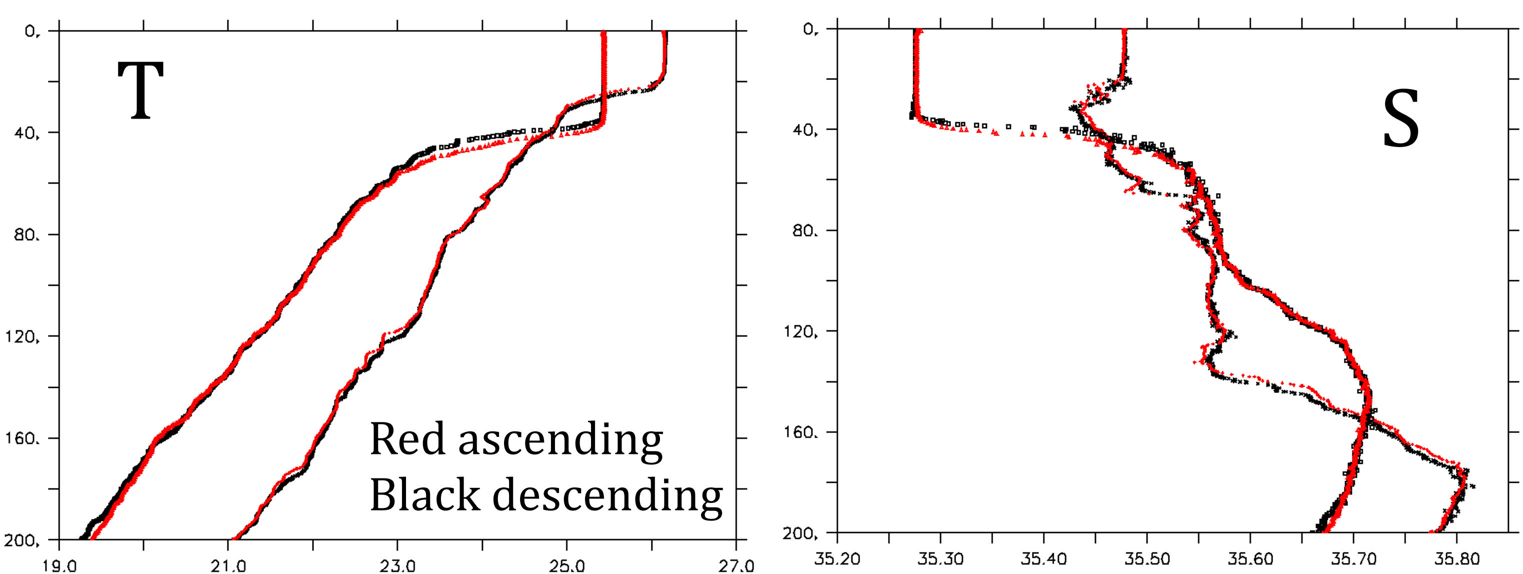
Data Management: 50 min

Deep SOLO profile on ascent from 1000dbar: costs, benefits (D. Roemmich) 10min

The SIO Deep SOLO 6000 m profiling float transfers oil from its external bladder to its internal reservoir only near the sea surface. So, for an unbroken full-depth profile, DS must profile on descent and park during ascent. The SBE-61 CTD is mounted below the glass sphere for added stability and is offset for no flow blocking on ascent. Early version of DS controller did not have the option for an ascending profile after parking. New versions have this option. Operational users of Argo require near real-time data; 10 day delay is not acceptable.

Energy for 1 cycle of DS to 6000 dbar, with only a descending profile, requires 26.9 kJ. Deep SOLO's available energy, from 5 Tadiran battery stacks, (9000 kJ total, de-rated to 70%), is 6300 kJ. Without an ascending profile, this is expected to provide (6300/26.9 =) 234 cycles, or 6.4 years of 10-day cycles.

Suppose now that an ascending profile is collected above a standard parking depth of 1000 dbar. Further suppose the profile consists of 90 discrete data points at 10 dbar spacing plus a continuous profile from 100 dbar to the sea surface. The additional profile requires 1.2 kJ, and so the total number of cycles is reduced to (6300/28.1 =) 224, or 6.1 years of 10-day cycles.



2 up/down pairs of 5905764 from cycles about 1 month apart
Cycle N-up and cycle N+1 down are close together in time

Action item 17: The AST urges the Deep Argo Mission Team to continue studying the costs and benefits of the Deep SOLO floats profiling on ascent from 1000db to contribute to the core array and provide a profile that is useful to the operational community. A proposal for how to send this data on the GTS could be presented at ADMT-22. Report back with a recommendation at AST-23. Deep Argo co-chairs, P.Oke, J. Turton

Cpcor correction in RT and DM for Deep floats (V. Thierry) 10min

V. Thierry reported, on behalf of the Ad-hoc CPcor working group, recommendations on how to implement CPcor correction in RT and DM mode.

In RT, Deep-Argo data should be corrected using the following standard Cpcor values:

- CPcor_new = -12.5 (±1.5) e-08 $dbar^{-1}$ for SBE-61 data.
- CPcor_new = -13.5 (±1.5) e-08 $dbar^{-1}$ for SBE-41 Deep CTD

The standard Cpcor value should be used in DM, except if an optimized value, estimated from nearby shipboard reference CTD profiles, is robust and obviously provides better results than the standard value.

The RT adjustment procedures are detailed and documented in the Argo Quality Control Manual for CTD and Trajectory Data, Section 2.6. Implementation of the RT correction by the DACs with Cpcor recommended values to allow the Deep-Argo data to be used is of highest priority.

The DM adjustment procedures are currently in draft mode. This will be sent out to the DMQC operators to solicit feedback and refinement.
Note that to compute refined estimates of Cpcor, Matlab code are available on:
https://github.com/ArgoDMQC/DM_CPcor

Float sampling and timing strategies (S. Riser) 10min

S. Riser gave a presentation on Argo float sampling and timing strategies. He began by reminding the audience of the AST's original recommendation of floats profiling to 2000m at 10-day intervals which is still the primary sampling strategy in Argo today. Core-Argo has been a primary contributor to improving estimates of upper-ocean heat content and it is implicit that the profiles are collected at quasi-random times at 10-day intervals. When the BGC Argo and Deep Argo Missions are mature, all Missions will be executing this same mission.

Riser noted that one float sampling at high frequency can resolve the local oxygen cycle, but cannot sustain a global array. However, a sustainable global array of floats sampling at low frequency can also resolve the oxygen cycle and the results are global in nature.

Several time histograms for all Argo floats deployed in the past year were presented and showed a large number of floats surfacing at certain times and not randomly. This is largely driven by float type since NKE floats come programmed to surface at a certain time, but this can be adjusted. The timing at DACs varies widely.

Riser suggested forming a diverse working group including core, deep and BGC users, modelers, operational users, etc. to address the following topics:

- Cycle timing and frequency
- Effects of departures from quasi-300km, 10 day global sampling
- Use of multi-variable park level sampling (BGC variables)

Action item 18: The AST recommends forming a working group to study sampling frequency and cycle timing questions and the possible effects of changing from the recommended 10 day global sampling currently in place. This group could also study the use of multi-variable park level sampling. Report back at AST-23. S. Riser to chair.

Feedback from ADMT-21 (M. Scanderbeg) 10min

M. Scanderbeg presented feedback from the ADMT on behalf of both ADMT co-chairs (S. Pouliquen and M. Scanderbeg). One of the main concerns is the continuing Fast Salty Drifters (FSD) which have reduced the percentage of good quality salinity data and increased the work of delayed mode operators and DACs to qc and monitor the data stream. At ADMT-21, the results of the FSD DMQC working group were presented and consisted of best practices for DMQC of FSD SBE 41 & 61 CTDs and a request for all dmode operators to track their FSD in a Google Spreadsheet. By AST-22, all dmode operators have input their statistics into the spreadsheet and several graphs are automatically produced to monitor the number and percentage of affected cycles. Currently, 2015 - 2017 are the years hardest hit by FSDs, but it was suggested that further monitoring of all floats is needed to see if more batches of CTDs are at risk for FSD. At AST-22, it was requested that the FSD working group partner with SeaBird to monitor these floats and to try and understand better why the salty drift occurs to help prevent future problems.

90% of core data are available on the GTS in a timely manner (within 12 hours for Iridium/Beidou and 24 hours for Argos). DACs successfully worked to improve their speed over the past year, but further speed improvements could be difficult to implement. It was requested that strategies be discussed and developed at the next DAC workshop. Currently, only oxygen is able to be sent on the GTS in the Argo BUFR format. Other BGC variables can be added to the format, but the ADMT would like to work with the BGC ADMT and operational centers to establish guidelines on data quality and timeliness before moving forward with putting BGC data onto the GTS. For Deep data, with the new cpcor value, data may be flagged of higher quality and be put onto the GTS. It was noted that for floats that profile upon descent (mainly Deep SOLOs), their profile is ten days prior and may not be of use to the operational centers. If these floats were to also provide an ascending profile, this could be transmitted, along with the descending profile, to the GTS and would likely be more useful to operational centers.

Most of the Argo reference tables have been transferred to the NERC Vocabulary Server (NVS) where the master copy now resides. This allows for machine to machine readability as well as better version control. A new procedure has been developed to implement changes to Argo reference tables in between yearly ADMT meetings. The NVS version of the Argo ref tables will be well documented on the ADMT website.

The GO-SHIP Easy Ocean Product has been incorporated into the Argo CTD ref db making it useful for both core and Deep Argo DMQC. High quality profiles can be selected using qclevel = GSD in OWC.

The ADMT is exploring the possibility of serving Argo data via the cloud and will hear updates on this at ADMT-22. Within EuroArgo, a collaborative framework has been started to improve the quality of Argo data and all are encouraged to contribute to this GitHub repository.

Argo and the modeling community (P. Oke) 5min

The modelling community are important stakeholders of the Argo community, offering demonstrations of impact, advocacy, and feedback on the observing system. Engagement between our communities is important to ensure that Argo are doing what we can to meet user needs, and that best-practice data-usage is adopted. Options for enhancing engagement include inclusive, joint meetings; individual AST members tasked to promote collaboration; development of an “Argo for ocean forecasting” community presentation; and possibly some recorded presentations.

Action item 19: The AST endorses the creation of a community talk aimed at the modeling and operational community to demonstrate the need to incorporate the highest possible quality Argo data into their datastreams. This talk could be shared among the AST and possibly recorded and featured on the AST website. P. Oke, S. Wijffels

Action item 20: The AST asks the planning committee for the Argo Science Workshop in 2022 to consider having a modeling session to facilitate communication between Argo and the modeling community.

Communications: 20 min

Argo bibliography (M. Scanderbeg) 5min

M. Scanderbeg presented the status of the Argo bibliography over the past year and noted that the number of papers published using Argo data has started increasing again with over 500 papers published in 2020. Other trends in the papers continue with the Argo data source continuing to move away from GDACs and toward secondary sources, with new countries continuing to publish papers (Cyprus & Vietnam in 2020) and with the percentage of Argo PI authors trending down to 15%. M. Scanderbeg requested that authors and national programs continue to send lists of citations as some journal interfaces are not ideal for searching, and thus, papers are missed. She noted that 80% of papers using Argo GDAC data cited the DOI - this is a huge improvement. Updating the bibliography will continue to happen, with the aim of 3 -4 times per year.

Upkeep of Argo Steering Team Website (M. Scanderbeg) 5min

M. Scanderbeg presented the status of the AST website in the past year, including the transition from the old website to the new one in September 2020. She thanked everyone who helped with the new design and provided input on the content, design, structure and functionality. The AST website usage statistics were presented and although the number of users was down about 20% as compared to the previous year, this could be partly attributed to the huge spikes in access around the New York Times article on Argo which brought thousands of visitors to the website. The good news was that visitors to the website, on average, visited more pages and stayed longer than the previous year and this was amplified even more after the switch to the new website. In the summer, she plans to update the science highlights page, the Deep, BGC, and Polar mission pages, and the educational pages. There are also plans to add a best practices page and to improve the descriptions and advertising of the Argo data products and visualizations. Finally, OceanOPS should be better advertised and not just listed as a link in the footer.

Argo Best Practices (T. Morris & M. Scanderbeg) 5 min

T. Morris presented proposed work to create and identify Argo Standards and Best Practices that can be endorsed by the AST, issued a DOI by Ocean Best Practices System (OBPS) and then made available on their website. The plan is to develop this for core floats only as BGC Argo has already done a BGC-Argo Guide on planning, deployment, data handling and usage in Frontiers. The core Argo Standards and Best Practices can be added to the AST website with links to the OBPS website and manufacturer pages as needed for additional information. Videos and tutorials can also be added or linked. There are several main areas to gather information: shipment of Argo floats, setup of floats, deployment methods, metadata acquisition, description of data processing, how to access Argo data and how to reference it. If a set of Argo Standards and Best Practices is endorsed by the AST, this would be indicated on the OBPS website which might give the user more confidence in the documents as anyone can upload standards and best practices documents to this website.

T. Morris plans to work with a group of people to collect and create these documents and hopes to present progress at AST-23.

Environmental impact leaflet by EuroArgo (M Bollard /C. Gourcuff) 5min

Euro-Argo ERIC presented a first draft of a leaflet about the environmental impact of Argo floats. The objective of this leaflet is to transform the paper “Environmental Issues and the Argo Array” by Stephen C. Riser and Susan Wijffels, that was endorsed by the AST21, into a simple leaflet that could be used more widely. The target audience is public at large, ministry and stakeholders. The leaflet was well received by the AST and it was agreed that it will be a useful tool to communicate with a wider community.

M Bollard solicited the AST for volunteers that would agree to review the leaflet in the coming weeks, before the end of April 2021. These persons should contact Marine Bollard at marine.bollard@euro-argo.eu.

When finalized, the raw files (indesign and adobe-Illustrator formats) will be provided with copyrights to the Argo community for translation in country language and for customization to country/institute projects.

OceanOPS updates (M. Belbéoch) 5min

M. Belbéoch updated the AST on OceanOPS whose mission is to monitor and report on the status of the global ocean observing system and networks, to use its central role to support efficient observing system operations, to ensure the transmission and timely exchange of high quality metadata and to assist free and unrestricted data delivery to users across operational services, climate and ocean health.

Planned developments in 2021 include better BGC variable monitoring, improved planning and float performance monitoring tools, more controlled metadata established through discussions with manufacturers, the ADMT, OCG workshops and machine-to-machine capabilities. There are plans to hold basin wide coordination meetings and purse charters in the Atlantic.

There will be a new focal point for Argo: Victor Turpin and a new Argo BGC focal point will also be recruited.

There are plans to create a OneArgo brochure, update the argo.net website and produce quarterly bulletins in addition to the Report Card.

> **Action item 21:** AST encourages revising the focus of the www.argo.net portal to one that points users to the variety of other Argo sites available: the AST, BGC Argo, ADMT, OceanOPS, visualizations, national programs, etc. M. Belbéoch, J. Gould, J. Mkitarian, S. Diggs, T. Morris, EuroArgo, M. Scanderbeg

UN Decade (Argo proposal and others) (T. Suga) 10min

T. Suga reported on the UN Decade Argo proposal, 'OneArgo: an integrated global, full depth and multidisciplinary ocean observing array for beyond 2020', that was submitted as an Ocean Decade programme. Over 210 Decade programmes were submitted and Argo is waiting to hear back about setting up a conversation between the Interim Decade Advisory Board and Argo to provide more information on our application.

Upcoming science conferences and technical workshops: 20 min

1. Virtual 2nd Ocean Observers Workshop in 2021: stay tuned for more information
2. Virtual Regional Seas workshop: Baltic/Med Sea/Arctic Workshops (C. Gourcuff)
3. 7th Argo Science Workshop in 2022 (C Gourcuff) 5min
4. 7th DMQC Workshop Update (B. King) 5min
5. Deep Argo Workshops in fall 2021 (V. Thierry) 5min
6. BGC Workshop in fall 2021 (H. Claustre) 5min
7. Future meetings 5min

    1. ADMT-22: AOML, Miami with virtual options

    2. AST-23 – Monaco (March, 2022); AST-24 Canada; AST-25 UK?

Action item 22: Form a planning committee to help H. Claustre develop a schedule and plan an effective AST-23 meeting during Monaco Ocean Week in 2022. H. Claustre, AST co-chairs, B. Owens, T. Morris, E. Smith, M. Scanderbeg

Action item 23: The AST exec will study how to include a virtual component to upcoming AST meetings to provide access to more people and to encourage collaboration and involvement with them. AST exec

AST membership & AST executive membership: 5min

The AST executive committee has been redesigned to include 1 representative and 1 alternate for the following regions:

- N. America
- Europe (G. Maze, B. Klein)
- N. & E. Asia (T. Suga, J. Xu)
- S. Hemisphere (P. Oke, R. Pattabhi)

This has been updated on the AST website. When N. America decides on their reps, the website will be updated.

	Action item	Person responsible	Status
1	Ask OceanOPS to split commitments table for BGC floats into variables	M. Belbeoch	
2	AST encourages OceanOPS to expand its monitoring to coverage by BGC parameter	M. Belbeoch	
3	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	
4	AST suggests a workshop between Argo and operational centers to discuss BGC data quality and timeliness. The goal of the workshop would be a paper with recommendations.	OceanPredict, SOCCOM, coastal operational community, P. Oke, BGC Mission Team, K. Johnson, M. Mazloff	
5	AST to ask a working group to find more effective ways of communicating with its users about how to use data quality flags, the importance of refreshing Argo data in observation collections maintained on their machines, the importance of using DM quality data for climate-level studies, etc. This includes the use of Argo data in products and models. Communication could include improvement of web pages, outreach or science workshops, leaflets, etc.	M. Scanderbeg, B. King, P. Oke, EuroArgo, N. Zilberman, C. Gourcuff, S.Hosoda, A. Wong, S. Purkey	
6	AST encourages the FSD working group to continue monitoring the status of FSD CTDs and CTDs with S/N > 11250. Ask working group to meet with SBE prior to ADMT-22 to collaborate on this assessment of CTDs from	John Gilson, Nathalie Zilbermann; Annie Wong Kanako Sato; Cecilie	

	after 2018. National DMQC teams should report any FSD occurrences after SN 11250 to the Birgit Klein, chair Working Group.	Cabanes; Luca Plaisant; Virginie Thierry; Kim Martini; Matt Alkire	
7	AST highly encourages DACs to automatically put floats that are flagged by the monthly MinMax test test by Coriolis on the greylist. (also an ADMT-21 action item). These float data should be put high on the priority list for DMQC.	AST/DACs	
8	AST suggests forming working groups to study how best to collaborate with manufacturers to implement incremental technical improvements, to discuss emerging issues in Argo sensors and platforms, and to collaborate on issues related to data management. These working groups would be formed around manufacturers and meetings would be done on a single manufacturer basis.	K. Johnson, B. King, RBR, V. Thierry, K. Martini, N. Zilberman, P. Oke, Matt Donnelly, Violetta Paba, S. Hosoda, R. Cancouet, A. Wong	
9	AST endorses basin-wide float deployment coordination across core, BGC and Deep floats. M. Donnelly and M. Belbeoch to consider how best to coordinate this and involve the ARCs and/or OceanOPS.	M. Donnelly, M. Belbeoch, T. Morris, S. Hosoda	
10	The AST recommends a meeting between the AST exec, A. Fischer and A. Troisi to discuss the possibility of invoking IOC resolution 247.	AST exec, A. Fischer, A. Troisi	
11	AST asks for a volunteer to help T. Morris on OCG Boundary current workshop		
12	AST encourages APEX float user groups to check for symptoms of the air bladder problem	APEX users,	

	reported by Steve Riser and share the information to address the problem.		
13	AST encourages national programs to continue to contribute to the RBR pilot to grow our experience with this sensor suite.	AST members/National programs	
14	Ask M. Belbeoch & B. Klein to track the s/n of at-risk CTDs and immediately warn PIs of the hull numbers of floats that are in the at-risk range.	M. Belbeoch, B. Klein, K. Martini	
15	AST recommends that floats with CTD s/n in the at-risk ranges should not be deployed, per the recall announcement by SBE		
16	AST suggests forming a working group to study how best to collaborate with EarthScope program and MERMAID array.	N. Zilberman, B. King, S. Hosoda, Y. Hello, F. J. Simons, M. Belbeoch, T. Ross	
17	The AST urges the Deep Argo Mission Team to continue studying the costs and benefits of the Deep SOLO floats profiling on ascent from 1000db to contribute to the core array and provide a profile that is useful to the operational community. A proposal for how to send this data on the GTS could be presented at ADMT-22. Report back with a recommendation at AST-23.	Deep Argo co-chairs, P.Oke, J. Turton	
18	The AST recommends forming a working group to study sampling frequency and cycle timing questions and the possible effects of changing from the recommended 10 day global sampling currently in place. This group could also study the use of multi-variable park level sampling. Report back at AST-23.	S. Riser to chair.	

19	The AST endorses the creation of a community talk aimed at the modeling and operational community to demonstrate the need to incorporate the highest possible quality Argo data into their datastreams. This talk could be shared among the AST and possibly recorded and featured on the AST website.	P. Oke, S. Wijffels	
20	The AST asks the planning committee for the Argo Science Workshop in 2022 to consider having a modeling session to facilitate communication between Argo and the modeling community.		
21	AST encourages revising the focus of the www.argo.net portal to one that points users to the variety of other Argo sites available: the AST, BGC Argo, ADMT, OceanOPS, visualizations, national programs, etc.	M. Belbeoch, J. Gould, J. Mkitarian, S. Diggs, T. Morris, EuroArgo, M. Scanderbeg	
22	Form a planning committee to help H. Claustre develop a schedule and plan an effective AST-23 meeting during Monaco Ocean Week in 2022	H. Claustre, AST co-chairs, B. Owens, T. Morris, E. Smith, M. Scanderbeg	
23	The AST exec will study how to include a virtual component to upcoming AST meetings to provide access to more people and to encourage collaboration and involvement with them.	AST exec	

Argo Australia National Report 2021 – AST-22

Peter Oke[1], Craig Hanstein[1], Catriona Johnson[1], Lisa Krummel[2], Jenny Lovell[1], Pat McMahon[1], Beatriz Pena-Molino[1], Gabriela Pilo[1,3], Steve Rintoul[1], Tatiana Rykova[1], Christina Schallenberg[1,3], Roger Scott[1], Dirk Slawinski[1], Peter Strutton[3], Tom Trull[1], Esmee Van Wijk[1]

[1]CSIRO Oceans and Atmosphere; [2]Bureau of Meteorology; [3]University of Tasmania

1. The status of implementation of the new global, full-depth, multidisciplinary Argo array (major achievements and problems in 2020)

a. Floats deployed and their performance

During 2020, Argo Australia deployed 78 floats, including 76 Core floats and 2 BGC floats. We also supported the deployment of 2 EM-Apex floats (by UTAS) in the Southern Ocean (although they are not part of the Argo Program). We deployed floats from 9 different vessels[1], over 12 different voyages. The locations of the floats deployed in 2020 are show in in Figure 1. All floats performed as expected, with the exception of 4 ALTOS (described in the next section).

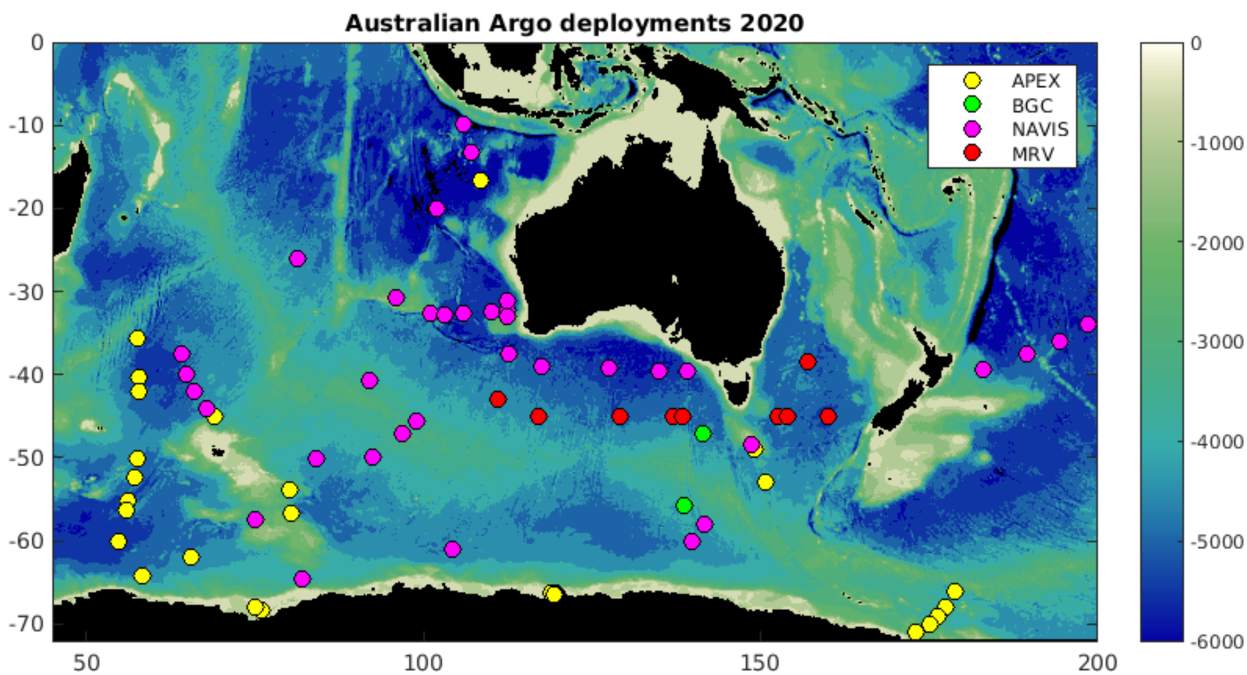


Figure 1: Map showing the deployment locations for floats deployed by Argo Australia in 2020. The colours of the dots denote the float types.

[1] Aurora Australis, RV Investigator, RV Sonne, RV Kaharoa, RV Mirai, RV Laura Bassi, Shirase, MV L'Astrolabe, Swan River Bridge.

b. Technical problems encountered and solved

Possible issue with batteries in 2018 Apex floats

We've noticed a cohort of Apex floats showing a premature drop of battery voltage after 50 to 75 profiles (e.g., Figure 2, right). These are floats purchased in 2018. All of the affected floats have the same firmware.

We first noticed the problem in floats fitted with N2 Compensators (Figure 2, left). These floats have one less 4DD Li battery pack, and therefore we have seen the voltage drop earlier in the float's life.

We suspect there may have been a batch of faulty Electrochem DD Li cells. We've discussed this with Teledyne and are working with them to try to understand the root cause of the problem.

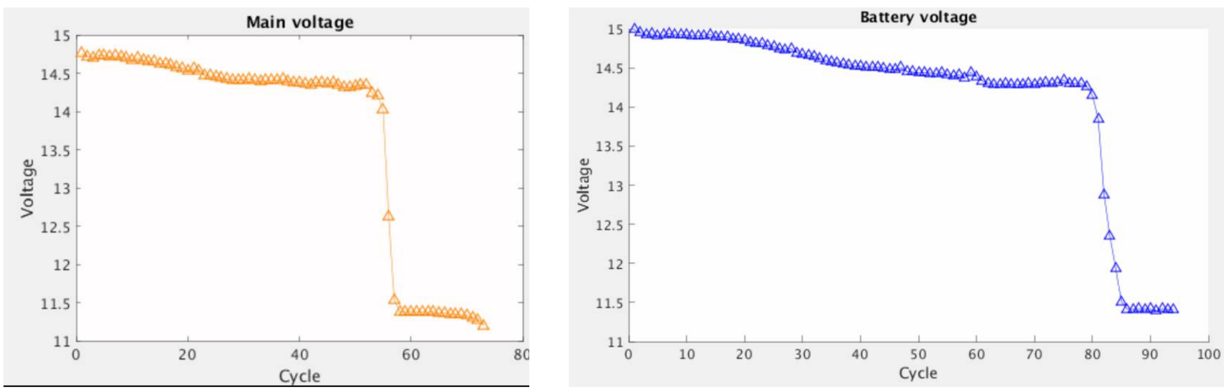


Figure 2: Main voltage as a function of profile number for floats with hull numbers 8428 and 8442. Float 8428 is fitted with a N2 Compensator. To fit the N2 Compensator, 1 pack of batteries are removed, rendering the floats with 25% less stored energy and showing the problem earlier in the float's life.

Faulty Check Valves

We routinely perform 12-hour bladder checks on all of our floats prior to deployment. In 2020, these tests identified 3 Apex floats with leaking check valves (out of 17 tested). The check valves (non-return valves) stop air from leaking from the inflated bladder back into the hull. These leaks were addressed before deployment (TWR sent us replacement valves) and the floats performed as expected. We note that NAVIS floats are built with two check-valves in series. We haven't detected any leaks in check valves in NAVIS floats, and suspect that this may be due to the extra level of redundancy the additional check valve offers.

MRV ALTOs with RBRargo^3 CTDs

We had intended to deploy 18 core floats with RBR sensors (all MRV ALTOs) as our contribution to the RBR global pilot array. However, when we encountered problems with floats, we replanned our deployments to allow the manufacturers time to address the issues identified. To date, we have deployed 9 core floats with RBR sensors. A summary of events relating to our RBR deployments follows:

- Float #11100 (WMO ID: 5905468) was the first to be deployed. It failed to return any profile data. The MRV controller did not properly communicate with the RBRargo^3 CTD. We were using firmware v7.3.5. MRV addressed the issue and provided revised firmware (v8.0.2). The float subsequently failed. The cause of the terminal failure in the float is unknown. MRV have offered to replace this float.

- Float #11154 (WMO ID: 5905482) was the first float we deployed with the revised firmware (v8.0.2), but the RBRargo³ CTD failed. The float's operation went as follows:
    - float 11154 with RBRargo³ C.T.D S/N 203995 behaved correctly up to cycle 9, and returned data that looked reasonable.
    - at beginning of cycle 9, the CTD stared reporting higher temperatures than expected for the internal temperature of the conductivity cell
    - during ascent, around 1000 dbar, the CTD started reporting salinity lower than 6 PSU
    - at the surface, the float controller was unable to communicate with the CTD
    - for subsequent cycles (10+), the float controller reported identical stale values for the "fall/rise" series. This is because the float controller stores old values of time and pressure in its volatile memory and used those 'most recent' values since it was unable to acquire a response from the CTD.
    - a float reset was attempted in order to power cycle the CTD, unsuccessfully. #11154 has not called in since the reset attempt.
    - MRV has confirmed that if the ALTO controller does not get a response from the RBRargo³ CTD, it returns a previous value (e.g., on each dive cycle the struct that holds this data is not reset, but is populated with data as soon as it is read from the CTD). MRV has been unable to replicate this issue during bench tests, but after a close inspection of the controller code and analysis of the packets returned in dives 9 and 10, there is convincing evidence that the CTD on #11154 did not return data after dive 9.
    - This sequence of failure on an RBR instrument, either RBRargo³ CTD or standalone instrument, has never been observed in the field nor at the RBR factory. RBR is still actively looking for a potential explanation. It is highly unlikely that the pressure sensor of the RBRargo³ CTD is at fault.
- Float #11155 (WMO ID: 5905483) performed 3 profiles, and then failed to report again. The root cause of the failure is unknown. There is no evidence of any issue with the RBRargo³ CTD on this float.
- Float #11159 (WMO ID: 5906619), with firmware v8.02, is still operating, but encountered an issue. The float reset to dive 0. This has been explained to us as "rarely-exercised code path that would result in a float reset", but we can't yet confirm that it is the root cause of the problem.
    - Other MRV floats have reset in the field before, with SBE sensors. It is apparently a rare event, and doesn't preclude further normal operation of the float. For example, we understand that WHOI's ALAMO float #9245 encountered a similar reset and went on to profile for an additional 1043 cycles. (v8.0.2)
    - We have experienced problems with the float building up a backlog of SBD packets and we are working with MRV to resolve the problem.
- Floats #11105 (WMO ID: 5905483), 11099 (WMO ID: 5906615), 11103 (WMO ID: 5906616), 11157 (WMO ID: 5906617) and 11156 (WMO ID: 5906618) seem to all be performing well. All are running with firmware v8.0.2.
    - Some profiles where high-resolution sampling was attempted ran into encoding limitations on the MRV controller side. MRV has developed a post-processing tool that can recover the data from these high-resolution sampling dives.

Of the 9 ALTOs deployed by Argo Australia so far, one failed to communicate with the RBRargo³ CTD (with firmware v7.3.5), and of the 8 floats deployed with firmware v8.0.2, 2 are lost, and 1 had a reset that is rare and recoverable (with an admittedly large impact on shoreside processing), and 5 encountered no serious problems.

Regarding the RBRargo^3 CTDs, which we are motivated to assess under the global pilot, we note that only one RBRargo^3 CTD has shown suspicious behaviour. The 6 operational ALTOs look to be returning reasonable data. We suspect that the issue observed with RBRargo^3 CTD S/N 203995 (on #11154) is an outlier.

We understand that MRV is currently bench- and tank-testing v8.04 of the float controller firmware, which addresses a known (but rare) cause of the float reset issue discovered by reviewing the controller code. We also understand that MRV are working on a White Paper to describe and address the root cause of the reset condition.

Argo Australia are waiting on the abovementioned White Paper, and on results of the v8.0.4 tank tests, before deciding on a path forward for deployment of the 9 ALTOs with RBRargo^3 sensors that we have in the laboratory.

At the outset of this activity, we knew that we should expect some issues. Although there were a few more issues than we had hoped, we commend the MRV team for their transparency and responsiveness to the issues we encountered. At times, we were in daily contact with engineers from MRV, and participating in weekly video-conferences to identify how best to proceed. This level of collaboration, engagement, transparency, and honesty is important, and gives us confidence to continue contributing to this important global pilot program.

c. Status of contributions to Argo data management (including status of high salinity drift floats, decoding difficulties, ramping up to include BGC or Deep floats, etc)

Decoding

We currently maintain a Matlab- and Python-based Real-Time (RT) system for decoding float data. We're currently in the process of implementing some new tests in our RT system, at the request of the ADMT. These include the global range test on Rtraj files (completed in January 2021), MEDD test (started), and adding the new grounded flags to the Rtraj files (planned).

BGC efforts

One of the challenges for BGC Argo this year has been the fact that we bought floats from different suppliers, with differing programming and decoding requirements. As a result, programming and decoding efforts (and ancillary questions) have taken up a lot of time. However, looking ahead, we are now in a position where we can decode a number of different floats, so less time should be needed to get new floats into the system, leaving more time for fine-tuning of RTQC efforts.

So far, RT Quality Control (RTQC) is implemented for new floats (except for the CHLA variable, as the protocol for RTQC is currently being revised, see below), but has not been retro-actively applied to legacy floats in our system. Nearly all our DOXY data is either in "A" or "D" mode, and systems are in place to adjust DOXY on newly deployed floats within ~2 months. Efforts are also underway to adjust NITRATE and

PH, using the SAGE system. We expect this to be achieved for all live floats by April 2021. Real-time flagging to QC=3 for raw data of DOXY, CHLA, NITRATE and PH has been implemented for live floats but will still need to be addressed for legacy floats.

Around 88% of eligible DOXY profiles have been Delayed-Mode Quality Controlled (DMQC-ed), with BD-files uploaded to the GDACs. None of the other BGC variables have received DMQC, but the CSIRO BGC operator has led the effort to update the CHLA RTQC documentation, with final decisions on crucial aspects of the QC process to be decided very soon. The BGC operator will subsequently incorporate the decisions into an updated CHLA RTQC document for the BGC Argo community, and DMQC of CHLA (and BBP) will commence shortly thereafter, followed by DMQC on other BGC variables.

Deep efforts

Real Time processing: We are looking into the implementation of the RT corrections for Deep floats recommended in the most recent release of the manual.

Delayed Mode processing: Initial modifications to the DMQC software have been made to allow deep floats to pass through our system, so that data can be viewed. At this stage, it only includes removing the maximum pressure check so that deep data can pass through the software, however the data is not yet QC'd. Once DMQC recommendations are made available to the community, we will also begin to implement these in the DM software.

Analysis of high salty drift floats

We have submitted information on 28 floats (out of 304 in our fleet with CTD SN≥6000) that meet the criteria for Fast Salty Drift (FSD) as described in the ADMT-21 meeting report. This addresses action item 39 from ADMT.

The report below was submitted to ADMT in November 2020, and is presented again here, with updated numbers. We aim to perform the first DMQC on floats six months after deployment, with a 3-month lag; and we then aim to perform DMQC every year, with a 6-month lag. We assess PSAL against CARS09 and nearby-Argo at multiple theta levels. If after assessment, it is decided that the PSAL drift or offset is real, we run OWC and apply piece-wise, linear adjustments where necessary. If the required adjustment in DMQC is large, we greylist the float for PSAL in RT QC (QC3 if PSAL is well-behaved and we expect we can correct the data with DMQC, QC4 if un-correctable).

We performed an assessment on our fleet to assess the percentage of floats showing a salty drift prior to the 2020 ADMT. At that time, of our entire fleet (846 floats), 77 had not yet been assessed, 658 (78%) showed no drift; 177 (21%) showed a salty offset or drift; 12 (1.4%) showed a fresh offset or drift; and 38 returned bad PSAL data (these were not included in the percentages reported here). These results are summarized in **T**able **1**. Based on experience, we expected to find the percentage of salty drifters to be closer to 10-12%. We repeated this analysis for floats with SBE41 CTDs with SN6000-7100, and SN8000-8999. The results are in Table 2 and 3. We find that there is a much higher percentage of salty drifters with SN6000-7100 (Table 2). But we find no evidence (in our small sample) for more than usual salty drifters with SN8000-8999 (Table **3**).

Table 1: Analysis of PSAL drifts in SBE41 CTDs for all floats deployed by Argo Australia.

Code	Meaning	Frequency	Percentage
0	Not assessed	77	
1	No drift	658	77.7%
2	Salty drift	177	20.9%
3	Fresh drift	12	1.4%
4	Bad PSAL	38	
		Total assessed: 847	

Table 2: Analysis of PSAL drifts for SBE41 CTDs with SN6000-7100. Of those not assessed, one has a problem being processed through our DMQC system (software issues) and six are from floats in the high latitudes with sparse reference data that need further analysis.

Code	Meaning	Frequency	Percentage
0	Not assessed	7	
1	No drift	35	50%
2	Salty drift	35	49%
3	Fresh drift	1	1%
4	Bad PSAL	3	
		Total assessed: 71	

Table 3: Analysis of PSAL drifts for SBE41 CTDs with SN8000-8999.

Code	Meaning	Frequency	Percentage
0	Not assessed	0	
1	No drift	28	76%
2	Salty drift	6	16%
3	Fresh drift	3	8%
4	Bad PSAL	0	
		Total assessed: 37	

d. Status of delayed mode quality control process

Our Matlab-based DMQC system is actively maintained to ensure that all of our data can be processed efficiently. Our system used OWC-v2, and we will soon upgrade to OWC-v3. We are using the ARGO_for_DMQC_2020V03 reference database. We currently have three DMQC Operators regularly performing DMQC on our data, and one software engineer supporting the code.

To date, we have processed about 94% of eligible T/S/P data.

Our over-all capacity in DMQC is temporarily reduced for 2021, as staff effort has shifted between projects. This may impact our through-put. We will likely need to recruit a new DMQC Operator.

2. **Present level of and future prospects for national funding for Argo including a summary of the level of human resources devoted to Argo, and funding for sustaining the core mission and the enhancements: BGC, Deep, Spatial (Polar, equator, WBCs)**

Argo Australia has secured funding for salary and operating costs to support our Argo operations until June 2022 from the Australian Integrated Marine Observing System (IMOS). We expect this funding to continue until at least 2028 at an equivalent level. This includes support for salary and operating costs for the Australian Argo Program.

In 2021, we expect to acquire 40-45 Core floats, 3 Deep floats, and deploy 7 BGC floats (as shown in Table 4). Core floats are funded from a strong partnership between IMOS (likely until 2028), CSIRO (reviewed annually), the Australian Department of Defence (reviewed annually), BoM (reviewed annually), and AAPP (funded until 2029). BGC floats are funded by IMOS, CSIRO, UTAS, and AAPP. Deep floats are funded by AAPP and CSIRO.

Of the 7 BGC floats we plan to purchase, we will likely deploy only 3 or 4 floats in 2021, and will deploy the final 3 or 4 in 2022. A summary of our efforts to obtain and deploy BGC Argo floats is presented in Table 4.

Table 4: A summary of our efforts to obtain and deploy BGC-Argo floats are increasing are presented below; * indicates that floats have been ordered; and "?" indicates deployments are pending funding, choice of float/type, and/or voyage allocations.

Date	Quantity	Deployment region	Float Type	Sensors	Purchasing Partners	Status
Oct-19	2	Tasman Sea	APEX	5	IMOS	certain
Dec-20	2	Southern Ocean	NKE	6 + UVP	IMOS, UTAS	certain
Feb-21	3	Southern Ocean	TWR*	6	IMOS, AAPP	certain
May-21	2	Tasman Sea	NKE*	6	IMOS	certain
Jun-21	1	Coral Sea	NKE*	6	IMOS	certain
Oct-21	1	Eastern Indian Ocean	TWR*	6	IMOS, CSIRO	certain
Feb-22	1-2	Southern Ocean	NKE*,?	6	IMOS, SOTC, AAPP	expected
Jun-22	2-3	Southern Ocean or Tasman	??	??	IMOS, CSIRO, AAPP	expected

All 3 Deep floats that we plan to purchase will be deployed to enhance the pilot array in the Australian Antarctic Basin.

Argo Australia has (some fraction of) two technical officers; one scientist running real-time operations and maintaining our Matlab-based RT system; one programmer developing a new Python-based system and doing most of the decoding; six scientists contributing to the delayed-mode operations (including one scientist dedicated to BGC and one programmer dedicated to software development and maintenance). Our operational team supports activities of Core, BGC, and Deep Argo. Argo Australia also has (some fraction of) two scientists working on Core Argo, two scientists working on BGC Argo, and two scientists working on Deep Argo – although the lines distinguishing between these efforts is becoming blurred – something that our program is embracing. In total, Australian Argo draws on ~6 FTE, with ~4.5 FTE for operations; ~0.5 FTE for Core Argo leadership and applications, ~0.5 for BGC Argo leadership and applications, and ~0.5 FTE for Deep Argo leadership and applications.

Argo Australia intends to continue providing AUD$100K funding to support operations of the RV Kaharoa (and its successor), and AUD$30K funding to support OceanOps. This funding has been secured until June 2022, but we expect it to continue until 2028.

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.**

We currently have 82 Core floats, 8 BGC floats, and 2 Deep floats either in our laboratory or on order. Of the Core floats 76 have been assigned to specific cruises for deployment (see Figure 4), but the target locations for 9 Apex floats that are intended to be deployed from the September 2021 Kaharoa Cruise are yet to be determined. We will coordinate with others involved in the cruise to identify the most suitable locations.

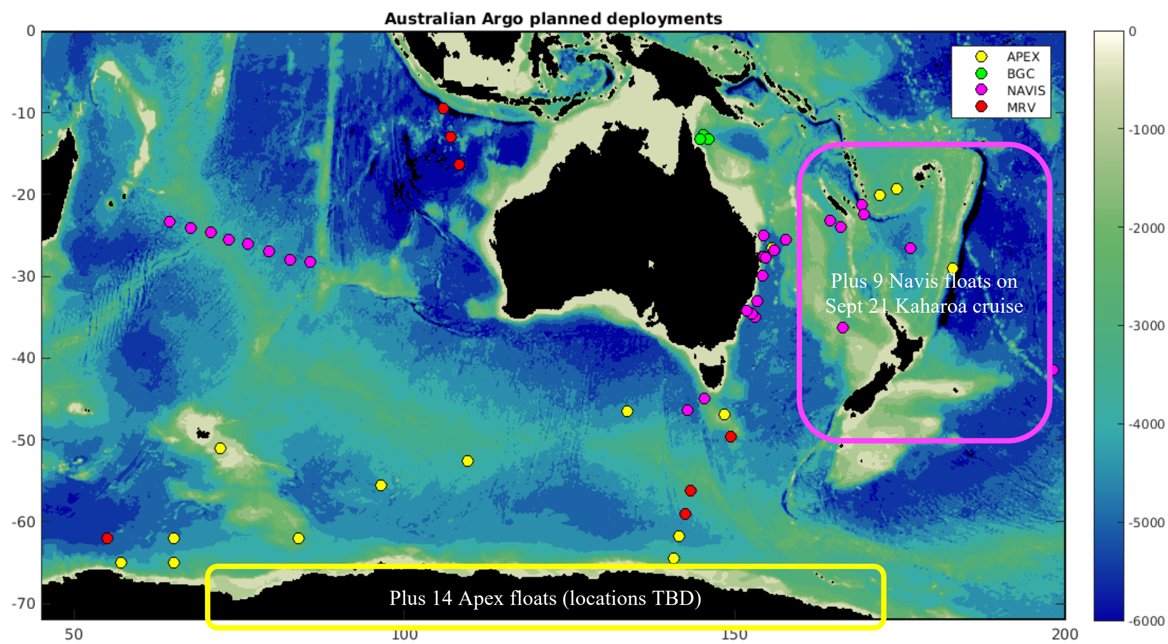


Figure 3: Map of planned deployments for 2021.This includes 20 Apex floats, 40 Navis floats, 7 ALTOs (with RBR sensors), and 3 NKE BGC floats. We also have an additional 9 Navis floats that we plan to deploy in the South Pacific on the September 2021 RV Kaharoa Cruise (to be coordinated with others), plus 15 additional Apex floats: 14 ballasted for under ice, and one ballasted for 25S.

We also have 15 Core floats (Apex floats) that have not been assigned to cruises (their original cruise was cancelled). Of these floats, 14 are ballasted for ice conditions, and will likely be deployed next Austral summer, and one is ballasted for 25S and will be deployed in the South Pacific (off the Tangaroa in May 2021).

We have 2 Deep floats that we have not yet assigned to a cruise. The Deep floats will be deployed to enhance the pilot array in the Australian Antarctic Basin. Options we're considering for 2021-22 include: AAD resupply mission, L'Astrolabe, Japanese vessel, or Investigator trip to Cape Darnley. Only the last two of these options will allow CTD on deployment.

Plans for BGC floats are shown in Table 4.

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.**

Argo data are used operationally to underpin Australia's short-range ocean forecast system (OceanMAPS; www.bom.gov.au/oceanography/forecasts/), ocean, and seasonal prediction systems (POAMA; www.bom.gov.au/climate/ocean/outlooks/). Science applications include the investigation of decadal prediction, climate studies, biogeochemical response to dust and smoke, and some studies into mesoscale variability around Australia.

A new ocean reanalysis, called Bluelink ReANalysis 2020 (BRAN 2020), has just been completed and will soon be made publicly available (once the paper describing the reanalysis has been submitted). BRAN2020 assimilates Argo data, altimetry, and satellite SST data, plus other in situ data sources.

A new gridded product, called Blue Maps, has been developed. Data from Blue Maps – likely to span 2005-present, will soon be made publicly available (once the paper describing the methods employed has been submitted). Blue Maps grids data from Argo, satellite altimetry, and satellite SST.

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.**

It appears that the practice of only sampling with Deep Argo floats on descent is inconsistent with the spirit of the OneArgo array. This will mean that Deep floats are not equivalent to Core floats. Core floats report profile data within 24 hours of measurement. However, when Deep floats perform 10-day missions and only sample on descent, they report data 10-11 days after measurement. This renders Deep floats – at least the shallow measurements from Deep floats – irrelevant to operational systems that typically use data from T-3 days until present. With the current mode of operation, data from Deep floats will not be assimilated into operational models. Shifting the Argo design from ~4000 Core floats to 2700 Core, 1200 Deep, and 1000 BGC floats will effectively mean that the array of floats for operational applications will be diminished to 3700 floats. If that is acceptable to the AST, then it is suggested that this implication is clearly explained to the operational community.

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.**

Many deployments included accompanying high-quality CTD profiles. All of those cruises are listed in the first section of this report. However, we have failed to routinely including the details of CTD station data in the float's metadata. But we will try to find the resources to address this gap in our program. However, details for the four BGC floats deployed off the RV Investigator Cruise (on INV2019_T01 and IN2020_V08) are included in Table 5.

Table 5: Details of CTD casts accompanying deployments of BGC floats in 2019 and 2020.

WMOID	Date deployed	Ship	Voyage #	CTD #	P/mts	POC	Alk	DIC	Nutrients	Oxygen	Salinity
5905441	4.10.2019	R/V Investigator	IN2019_T02	1	x	x	x?	x?	x	x	x
5905442	4.10.2019	R/V Investigator	IN2019_T02	1	x	x	x?	x?	x	x	x
5906623	12.12.2020	R/V Investigator	IN2020_V08	23	x	x	x	x	x	x	x
5906624	27.12.2020	R/V Investigator	IN2020_V08	53	x	x?	x	x	x	x	x

7. **Bibliography**

We use the Argo Bibliography, maintained by UCSD, as the definitive source of papers that use Argo data. We know of no additional publications that should be included.

8. **How has COVID-19 impacted your National Program's ability to implement Argo in the past year? This can include impacts on deployments, procurements, data processing, budgets, etc.**

COVID-19 has impacted all areas of our operation, but we have actively adapted to restrictions to maintain the overall performance. Impacts on each area of our work is summarized below:

- Deployments
  - Some deployment opportunities were lost, when cruises were cancelled or postponed. In those instances, we changed our deployment plans and shifted floats to other opportunities. This resulted in deployments in locations that were not our first choice. But we tried to make sensible choices that would positively contribute to the global array.
  - Our usual practice has been to ship floats to their final port, and then one of our Argo Technicians travels to that port to perform final pre-deployment checks. This wasn't possible. Instead, we recruited suitably-skilled technicians near each final port, and worked with them to perform the final tests for us. This turned out to be a significant cost saving, and is something we may consider continuing in the future, regardless of travel restrictions.
- Data processing
  - Our work-force was not directly impacted by COVID-19. However, staff all worked from home for most of 2020. This had mixed impacts on productivity. For some, it resulted in greater productivity, but for some it posed a challenge. One of our team members encountered one work-place incident (a serious back injury that required surgery and extended time of work for recovery) that took her out of action for 3 months. Although this is not a direct result of the pandemic – had the pandemic not interrupted our lives, it may not have occurred.
- Budgets
  - Our travel budgets were all frozen. We adapted to this, as noted above, but it's possible that post-pandemic travel budgets may be lean.
- Pre-deployment script/Application further development
  - COVID-19 travel bans encouraged us to continue developing pre-deployment scripts and applications to simplify final shipside tests so any person can perform a thorough test and

identify outliers. We see it as an opportunity to further adapt our operations to reduce our dependency on travel.

9. **Argo is still interested in piloting the RBR CTD. Does your National Program have any deployment plans for RBR floats in the next couple years? If so, please indicate how many floats will you be buying in 2021 and 2022 (if known) and where they might be deployed.**

Despite the challenges we've faced during our initial deployment of ALTOs with RBR sensors, it is our intention to include some portion of floats with RBR sensors each year. We still have 11 floats with RBR sensors in our labs that are awaiting deployment, so we may not order floats with RBR sensors this year. But once we have ironed out the issues with manufacturers, we will purchase floats with RBR sensors each year – perhaps 4-8 floats per year (representing ~10-20% of our annual investment).

Bulgarian Argo Activities

Present status and further plans

A. Palazov, V.Slabakova and N. Valcheva

February 2021

BulArgo programme is a component of the project MASRI – Infrastructure for Sustainable Development of Marine Research and Participation in the European Infrastructure (Euro-Argo). (http://masri.io-bas.bg/), a part of the National roadmap for scientific Infrastructure (2020-2027) 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 2020, five Argo floats in total were deployed in the western Black Sea. Three under the framework of BulArgo activities and two under the Italian Argo programme and EA-RISE project. The BulArgo floats were ARVOR-I and ARVOR-DO type and were purchased by Institute of oceanology-BAS thought the EA- ERIC tender procedure. The floats were deployed by the Bulgarian Argo team in the western Black Sea form the 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 6903866 and 6903867) floats were deployed on November 17th and 22th in Bulgarian EEZ at depths 1500m and 1450m, respectively. The floats were programmed to cycle between the surface and 1500 dbar every 5 days and to drift at the parking depth of 750 dbar. Both floats are still active. The BulArgo float with WMO 6903868 was launched at the sea on 11th of December 2020 but due to very bad weather and sea state conditions immediately after its deployment the float went under the vessel hull and was destroyed by the ship's propellers. The status information for the Bulgarian floats deployed in the Black Sea during 2020 is presented on Table 1. Surface positions of the BulArgo active floats are shown on Figure1.

Table 1. Status information for the Bulgarian floats deployed in the Black Sea during 2020

Model	WMO	Deployment date	Deployment time	Latitude	Longitude	№ of Cycles	Status
Arvor-I	6903866	22/11/2020	21:14	42.5006	29.155	19	Active
Arvor-I-DO	6903867	17/11/2020	21:33	43.1745	28.64	20	Active
Arvor-I-DO	6903868	11/12/2020	23:47	43.16665	29.16707	N/A	Inactive

Figure 1. Trajectories of the active BulArgo floats deployed in the western Black Sea during 2020 (WMO 6903867 -grey line and WMO-6903866 –red line)

Additionally, Bulgarian Argo team deployed on 23th July an Italian ARVOR-I float (WMO 6903782) in the western Black Sea from the 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 deployed an Euro-Argo RISE Argo float (model Arvor – I, WMO 6903865) on 24th of July 2020 off the Bulgarian Black Sea shelf at 50 m depth to test its potential as a virtual mooring using a fishing line with neutral buoyancy. Since 15th of November 2020 the float has stopped transmissions.

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 (expected to be extended till 2027), deployment and communication cost.

For 2021 the Bulgarian Ministry of Education and Science provided funding to buy 3 Argo floats with dissolved oxygen sensors. The Ministry is committed to provide funding in order to sustain the Bulgarian contribution to Argo beyond 2021 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 2. The area of floats deployment is western Black Sea.

Year	Month	Programme/Project	Float type	Quantity
2021	Aug - Dec	BulArgo	Arvor DO-I	3

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 the researchers from the Black Sea countries to improve the understanding of Black Sea physical and biogeochemical properties. 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. The CTD profiles were provided to EA-ERIC office.

7. Bibliography

1. Valcheva, N., Marinova, V., Peneva, E., Lima, L., Celiberti, S. & Masina, S. (2020). Spatio-temporal variability of the Black Sea Cold Intermediate Layer properties derived from in situ data. The Copernicus Marine Environment Monitoring Service Ocean State Report. J. of Operational Oceanography, 33-41, https://doi.org/10.1080/1755876X.2020.1785097

2. Lima, L., Peneva, E., Ciliberti, S., Masina, S., Lemieux, B., Storto, A. & Chtirkova, B. (2020). Ocean heat content in the Black Sea. The Copernicus Marine Environment Monitoring Service Ocean State Report. J. of Operational Oceanography, 41-48, https://doi.org/10.1080/1755876X.2020.1785097
3. Stanev, E., Chtirkova, B., Peneva, E, Geothermal Convection and Double Diffusion Based on Profiling Floats in the Black Sea, doi - 10.1029/2020GL091788, Geophysical Research Letters, 2020, Q1, IF=4.5
4. Stanev E. and Chtirkova B.2020, Interannual change in mode waters: Case of the Black Sea, Journal of Geophysical Research Oceans doi - 10.1029/2020JC016429, Q1, IF=3.5
5. Kubryakov A., Mikaelyan, S., Stanichny V., Kubryakova E. 2020. Seasonal Stages of Chlorophyll-a Vertical Distribution and Its Relation to the Light Conditions in the Black Sea From Bio-Argo Measurements, JGR Oceans, Volume125, Issue12, https://doi.org/10.1029/2020JC016790

2020 Argo Canada report of activities

(submitted by Blair Greenan, Fisheries and Oceans Canada)

22nd meeting of the Argo Steering Team (AST-22)
Location: Virtual
22-26 March 2021

1. The status of implementation of the new global, full-depth, multidisciplinary Argo array (major achievements and problems in 2020)

- *floats deployed and their performance*

From January 2020 to December 2020, Argo Canada deployed 33 NKE Arvor floats (12 in the northeast Pacific, and 21 in the northwest Atlantic). Of these 33 floats, 1 float failed immediately after deployment and another 2 were equipped with dissolved oxygen sensors. The 32 remaining floats are still operational and functioning properly. As of 20 January 2021, Canada has 106 operational floats in the Argo Canada program.

- *technical problems encountered and solved*

One RBR Arvor float failed to initialize just before deployment, and was returned to the manufacturer for repair. The failure turned out to be a communication issue with the CTD, which was diagnosed as an internal component failure by RBR, and was not believed to be a risk for future RBR Arvor deployments.. One DOXY Arvor float also failed to initialize just before deployment, was later reset successfully in the lab, and will be deployed in Feb 2021. Another SBE Arvor float failed during testing in the lab due to low bladder pressure, and is being returned to the manufacturer for repair.

- *Status of contributions to Argo data management (including status of high salinity drift floats, decoding difficulties, ramping up to include BGC or Deep floats, etc)*

The MEDS DAC continues to acquire data from 106 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 2020 to December 2020, 86 % of the data were issued to the GTS in BUFR format within 12 hours of the float reporting. During the month of October and November, the timeliness was dropped to approximately 60% due to upgrade of the mail server and the Argo processes were run manually.

Since AST-21, we have worked on the following:

- Correct DOXY data using the quarterly reports provided by Monterey Bay Aquarium Research Institute.
- Creating a python tool for calculating DOXY gain and performing DMQC on oxygen, based on the Matlab tool SAGE-O2.
- Migrating the current real-time QC tests from Fortran to Python.
- Provide ADMT reports on the performance of Argo data on the GTS in BUFR formats to assist DACs in monitoring the BUFR timeliness transmission.

\- *Status of delayed mode quality control process*

As of January 2021, 70% 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 72% of eligible cycles. 14% of B-files had been visually QC'd, and 12% were fully DMQC'd. The low percentages of QCed B-files are due to the latest launch of new BGC floats and our work priority on the development of a python package performing DMQC on B-files. The package is now operational and therefore the percentages of QCed B-files are expected to increase significantly in 2021. In addition to DMQC of new profiles, 8 previously-DMQCed floats received either updates to the visual QC or new adjustments in 2020 in response to feedback (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 or thermal mass errors).

2. Present level of and future prospects for national funding for Argo including a summary of the level of human resources devoted to Argo, and funding for sustaining the core mission and the enhancements: BGC, Deep, Spatial (Polar, equator, WBCs)

Financial resources

Argo Canada has ongoing funding for the O&M expenditures related to the International Argo program. Shared Services Canada (SSC) and DFO signed an agreement in late 2019 that resulted in DFO assuming responsibility for all Iridium telecommunications cost for the department, including the Argo program. This has resulted in an extra financial burden being placed on the Argo Canada program.

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 (DFO and Department of National Defence – DND) committed $1.33M for purchases of core NKE Arvor-I and Provor CTS4 floats in the Fiscal Year 1 April 2020 to 31 March 2021. The funding will result in acquisition of 36 core Argo floats, 6 BGC-Argo floats (3- BGC sensors) and 4 NKE Arvor floats with RBR CTDs. The Canadian-Pacific Robotic Ocean Observing Facility (C-PROOF) is contributing funding for 7 dissolved oxygen sensors to be added to DFO Argo floats. C-PROOF is based at the University of Victoria (http://cproof.uvic.ca/) and is funded by the Canadian Foundation for Innovation (CFI, https://www.innovation.ca/).

Ocean Networks Canada (https://www.oceannetworks.ca/) has also received funding from CFI to procure BGC-Argo floats (https://www.oceannetworks.ca/canadas-ocean-intelligence-gets-a-boost).

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 ending in March 2023). 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. This initiative also links to Canada's leadership on the Ocean Observations Action Group under the Commonwealth Blue Charter.

In addition, funding for "A BGC Argo Program for the NW North Atlantic Ocean" led by Dalhousie University and the Memorial University of Newfoundland, is conditionally approved by CFI for a total cost of $8.8M. Final approval is contingent on a confirmation of provincial matching funds, on finalization of lab renovation plans at Dalhousie, and on a final agreement with Compute Canada for hosting of IT infrastructure supported by the project. The plan is to acquire about 40 BGC-Argo floats for deployment in the NW North Atlantic.

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.

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 people contribute to the logistics and data management for Argo Canada:

Anh Tran (DFO, MEDS, Ottawa) – DAC lead, RTQC Operator
Zhimin Ma (DFO, MEDS, Ottawa) – DMQC Operator (core Argo)
Jenny Chiu (DFO, MEDS, Ottawa) – RTQC support
Andrew Stewart (DFO, OSB, Ottawa) – National Manager, Ocean Monitoring and Observing
Tyler Emmott (DFO, OSB, Ottawa) – Float procurement, contracting
Blair Greenan (DFO, BIO, Halifax) – AST member, Argo Canada lead
Ingrid Peterson (DFO, BIO, Halifax) – deployment planning, logistics, performance monitoring

Chris Gordon (DFO, BIO, Halifax) – DMQC Operator (BGC)
Clark Richards (DFO, BIO, Halifax) – Research scientist, RBRArgo data task team member, ArgoFloats R package development
Jaimie Harbin (DFO, BIO, Halifax) – ArgoFloats R package developer
Igor Yashayaev (DFO, BIO, Halifax) – Atlantic deployment planning
Adam Hartling (DFO, BIO, Halifax) – Field support
Tetjana Ross (DFO, IOS, Sidney) – Pacific deployment planning
Lindsay Mazzei (DFO, IOS, Sidney) – Field support

Katja Fennel (Dalhousie University, Halifax) – Canadian member of the International BGC-Argo Steering Committee

In addition to the above persons, we benefit from the technical support of many 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 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.

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.

Here is a link to the commitments table at OceanOPS. If you cannot edit the online table, please send a list of deployment plans for each of the columns in the table as needed.

Argo Canada (with financial contributions from Fisheries and Oceans Canada and the Department of National Defence) will procure the following by March 2021 (end of fiscal year):

- 22 NKE Arvor-I with SBE41 CTD
- 14 NKE Arvor-I with SBE41 CTD + DO
- 4 NKE Arvor with RBR CTD
- 6 NKE Provor CTS4 with SBE41 CTD + DO + chla + backscatter

In 2021 and early 2022, Argo Canada plans to deploy about 40 of the floats (firm commitment). Fourteen will be deployed in the Northeast Pacific, and about 25 in the Atlantic. Seven Arvors with DO will be deployed in both the Pacific and Atlantic Oceans.

Of the 25 floats planned for the Atlantic, we are currently planning to deploy 12 Arvor floats on a dedicated charter if NOAA and WHOI are successful in securing a vessel. We also plan to deploy some of the Atlantic floats in Baffin Bay in the summer 2021 which will provide under-ice capability. This deployment is planned to be on the CCGS Amundsen. We are seeking deployment opportunities for the Arvor-RBR floats, with a planned deployment of one float in the Caribbean on the A20/A22 GO-SHIP cruise departing Woods Hole in March 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 and Regional Ice Ocean Prediction Systems (GIOPS and RIOPS) provide daily estimates (analyses) of 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). RIOPS analyses are produced in a model that includes tides and provides daily three-dimensional state of the ocean estimates for Canada's three coastlines on a domain covering the North Pacific, Arctic, and North Atlantic Oceans. Coastal forecasts are produced for the east and west coast of Canada at 2km resolution using a spectrally nudging to RIOPS analyses. RIOPS analyses are also used to initialize the oceanic component of the pan-Arctic high-resolution Coupled Canadian Arctic Prediction System (CAPS) put in place for the Year of Polar Prediction (2017-19).

Argo data is used in the verification of Canadian and international prediction systems to enable predicted and observed profile comparison. Part of OceanPredict Inter-comparison and Validation Task Team. Comparisons of Argo based class 4 is visible on https://navigator.oceansdata.ca under the class 4 tab.

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.

Argo data are used in the preparation of Fisheries and Oceans Canada's State of the Ocean reporting (e.g. https://www.dfo-mpo.gc.ca/oceans/publications/soto-rceo/2019/index-eng.html).

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 2021. This project is planning to deploy BGC-Argo floats along Line P in future years.

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.

CCHDO currently acquires Line-P data up directly from the https://waterproperties.ca/linep website. MEDS will send CTD data collected by other DFO institutions to NOAA NCEI and then the data will be available to CCHDO.

7. Keeping the Argo bibliography (Bibliography | Argo (ucsd.edu)) 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 (Thesis Citations | Argo (ucsd.edu)). 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.

Journal Publications

Atamanchuk, D., J. Koelling, U. Send, and D.W.R. Wallace, 2020. Rapid transfer of oxygen to the deep ocean mediated by bubbles, *Nature Geosciences*, **13(3)**, 232-237, https://doi.org/10.1038/s41561-020-0532-2

Chai, F., K.S. Johnson, H., Claustre, X. Xing, Y. Wang, E. Boss, S. Riser, K. Fennel, O. Schofield and A. Sutton, 2020. Monitoring ocean biogeochemistry with autonomous platforms, *Nature Reviews Earth & Environment*, **1**, 315-326, https://doi.org/10.1038/s43017-020-0053-y

Courtois, P., Y. Garcia-Quintana, X. Hu and P. G. Myers, 2020. Kinematic subduction rate of Labrador Sea Water from an eddy-permitting numerical model. *Journal of Geophysical Research*, **125**, e2019JC015475. https://doi.org/10.1029/2019JC015475

Gordon, C., K. Fennel, C. Richards, L.K. Shay, J.K. and Brewster, J. K., 2020. Can ocean community production and respiration be determined by measuring high-frequency oxygen profiles from autonomous floats?, *Biogeosciences*, **17**, 4119–4134, https://doi.org/10.5194/bg-17-4119-2020 , 2020

Lin, H., W. J. Merryfield, R. Muncaster, G. C. Smith, M. Markovic, F. Dupont, F. Roy, J.-F. Lemieux, A. Dirkson, S. Kharin, W.-S. Lee, M. Charron, A. Erfani, 2020. The Canadian Seasonal to Interannual Prediction System Version 2 (CanSIPSv2). *Weather and Forecasting*, **35**, 1317-1343. https://doi.org/10.1175/WAF-D-19-0259.1

Nezlin, N. P., M. Dever, M. Halverson, J.-M. Leconte, G. Maze, C. Richards, I. Shkvorets, R. Zhang, and G. Johnson, 2020. Accuracy and Long-Term Stability Assessment of Inductive Conductivity Cell Measurements on Argo Floats. *Journal of Atmospheric and Oceanic Technology*, **37**, 2209–2223. https://doi.org/10.1175/JTECH-D-20-0058.1

Pennelly, C., and P. G. Myers, 2020. Introducing LAB60: A 1/60degree NEMO 3.6 numerical simulation of the Labrador Sea. *Geosci. Model Dev.*, **13**, 4959–4975, https://doi.org/10.5194/gmd-13-4959-2020

Randelhoff, A.. L. Lacor, C. Marec, E. Leymarie, J. Lagunas, X. Xing, G. Darnis, C. Penkerc'h, M. Sampei, L. Fortier, F. D'Ortenzio, H. Claustre and M. Babin, 2020. Arctic mid-winter phytoplankton growth revealed by autonomous profilers. *Science Advances*, **6**, https://doi.org/10.1126/sciadv.abc2678

A. Randelhoff, J. Holding, M. Janout, M. Kristian Sejr, M. Babin, J.-É. Tremblay and M. B. Alkire, 2020. Pan-Arctic Ocean Primary Production Constrained by Turbulent Nitrate Fluxes. *Frontiers in Marine Science*, **7**. https://doi.org/10.3389/fmars.2020.00150

Wang, B., K. Fennel, L. Yu and C. Gordon, 2020. Assessing the value of biogeochemical Argo profiles versus ocean color observations for biogeochemical model optimization in the Gulf of Mexico, *Biogeosciences*, **17**, 4059–4074, https://doi.org/10.5194/bg-17-4059-2020 , 2020

Ph.D./M.Sc. Thesis
Nothing to report

Books
Nothing to report

8. How has COVID-19 impacted your National Program's ability to implement Argo in the past year? This can include impacts on deployments, procurements, data processing, budgets, etc.

In 2020, COVID-19 restrictions did put pressure on our procurement process with delivery of floats in March 2020 being delayed, but ultimately all floats were delivered before the end of our fiscal year (31 March 2020). Deployments of floats were impacted by the cancellation of some cruises (e.g., DFO Maritimes Region Atlantic Zone Monitoring Program on the Scotian Shelf, March-April 2020). However, overall the impact of COVID-19 on deployments was limited and Canada deployed 33 Arvor floats, which is within our normal range. COVID-19 has not had an impact on data processing at the MEDS DAC. The impact on our budget was minimal for 2020 and going forward will not be known until after the Federal Budget is released in March 2021.

9. Argo is still interested in piloting the RBR CTD. Does your National Program have any deployment plans for RBR floats in the next couple years? If so, please indicate how many floats will you be buying in 2021 and 2022 (if known) and where they might be deployed.

Argo Canada is still interested in piloting the RBR CTD. We have purchased 3 Arvor floats with the RBR CTD in 2020 and are expecting delivery of 4 additional floats before the end of March 2021. The plan for procurement of floats for 2022 is yet to be determined by we will likely purchase 2-4 additional floats in the upcoming fiscal year. In terms of deployment plans, one float is planned for deployment on the upcoming GO-

SHIP A20/A22 mission departing Woods Hole in the spring 2021. The deployment locations for the remainder of the floats is open for discussion.

The 22th Argo Steering Team Meeting, Virtual meeting, March 22-26, 2021

Argo Chinese National Report 2020

Zenghong Liu[1], Jianping Xu[1], Xiaogang Xing[1], Zhaohui Chen[2], Jinkun Yang[3], and Xiaofen Wu[1]

[1]State Key Laboratory of Satellite Ocean Environment Dynamics, the Second Institute of Oceanography, MNR, Hangzhou

[2]Ocean University of China, Qingdao

[3]National Marine Data and Information Service, MNR, Tianjin

1. The status of implementation of the new global, full-depth, multidisciplinary Argo array (major achievements and problems in 2020)

a. floats deployed and their performance

From last February, China deployed 34 floats (6 HM2000, 21 PROVOR, 2 AROVR_D, 4 BGC PROVOR and 1 BGC NAVIS) in the northwestern Pacific Ocean, Bay of Bengal and the South China Sea. All these floats transmit data with Iridium satellite system, and were deployed by 4 PIs from the Second Institute of Oceanography (SIO), Ministry of Natural Resources and Zhejiang University. It is worth noting that 21 PROVOR floats were deployed in the tropical western Pacific as part of China TPOS2020 project. In total, China has deployed 495 floats, and approximately 87 floats are operational as of 28 February 2021.

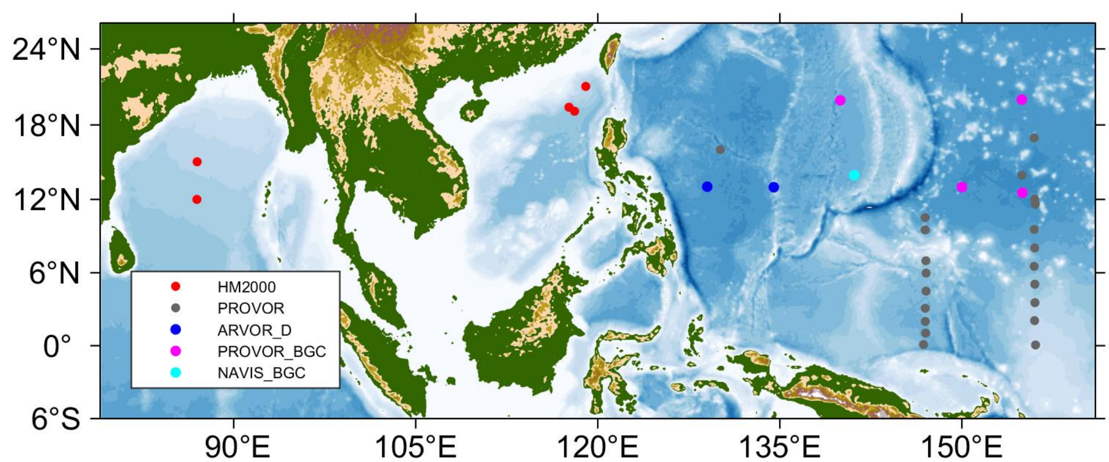


Fig.1 Launch positions of the floats from March 2020 to February 2021.

b. technical problems encountered and solved

4 out of 6 HM2000 floats which we deployed in 2020 have been found message packet loss problem even if HM2000 has the capacity to re-transmit lost messages in the previous cycle. The problem has been

submitted to HSOE. Their analysis indicated that these floats were manufactured in 2017, due to a long period of storage before deployment, the performance of the communication model has degraded.

The ECO sensor failure problem was found in a PROVOR float (WMO: 2902751) that we deployed in the northwest Pacific (20.36°N, 127.73°E) on 9th July, 2020. The float profiled normally and CTD worked well, but there was no ECO sensor data received since its first profile. The failure was unable to be fixed through remote commands. CSIO contacted a nearby fishing boat to recover this float on 11th October. Now it is going to be sent to NKE for a full test and battery replacement.

c. status of contributions to Argo data management (including status of high salinity drift floats, decoding difficulties, ramping up to include BGC or Deep floats, etc)

CSIO: CSIO is maintaining a Matlab-based data system for data decoding. The MEDD test has been added into this system. From the last February, CSIO received data from 127 active floats (including 5 Deep Argo and 13 BGC floats) and submitted 4,629 TS profiles (plus 487 DOXY, 465 CHLA, 465 BBP, 392 CDOM, 894 DOWN_IRRIDIANCE, 363 NITRATE and 115 pH) to GDACs. All the profile data are converted into BUFR bulletin and sent to the GTS via Chinese Meteorological Agency (CMA, Beijing).

NMDIS: The data processing system of NMDIS is developed with C # language. The quality control methods are updated in time according to Argo quality control manual. The system is upgraded in 2020 in order to further refine the data processing. The quality control methods and parameters released by other plans and organizations are sorted out and combined, and the detailed qc results are recorded so as to improve the parameters, methods and processes during QC.

d. status of delayed mode quality control process

Based on the CSIRO DMQC system and the OWC tools, about 37,275 D-files have been submitted to GDACs from CSIO. Except those floats deployed in late 2020, almost all of the core Argo data have been DMQC'ed. In addition, the DMQC for HM2000 floats has been carried out smoothly with the help from CSIRO. Here, we still want to express our sincere gratitude to Australian Argo group, especially their DMQC team, and professor Annie Wong. Thanks for your help in this task.

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

CSIO: CSIO maintains a global Argo data set which is derived from the profiles provided by GDAC. A fast receiving and post-quality-control system has been established which enable us to synchronize with the GDAC server four times per day. 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/.

NMDIS: Relying on the automatic processing system, NMDIS synchronizes the data from the GDAC every day. NMDIS carries out format conversion, quality control and duplication removing during post-processing of the profile data. Both the original NC data files and post-processing data files are delivered through the website of China Argo data center for public use. The quality control methods are specified in Argo quality management manual. The duplication is determined mainly based on platform number, data center, position, time and observation data, etc. The results of the duplication were feedback to the GDAC in France. China Argo data center website: https://www.argo-cndc.org.

f. update of Chinese COPEX float

In May 2020, CSIO helped NOTC deploy 3 COPEX floats in the South China Sea for a field test. Each float had operated for about 3 months (daily cycle) and observed about 110 TS profiles in depths of 0-2000 dbar. The main technical problems are the platform does not tend to park stably at 1000 dbar and the lifetime is too short to meet the goal of long-term observation. CSIO has provided a technical report to NOTC, in which some suggestions are proposed to improve the performance of COPEX. During August-September 2020, NOTC deployed 4 COPEX floats installed with NOTC Argo CTD sensor in the northwestern Pacific Ocean. The results from TS observations show that 3 out of 4 sensors have the salinity bias within 0.02 psu from the historical CTD dataset, while the one remaining float's salinity bias is as large as 0.04 psu. The Argo community is very careful to permit the usage of new sensor on a float, therefore we ought to inspect the performance of this CTD sensor in a long term.

g. update of Chinese HM2000 & HM4000 floats

An internal meeting was held between CSIO and HSOE in last December. The discussion referred to the performance of HM2000 float according to observations from those floats that have been deployed by China Argo. Some technical problems were raised from the summary accomplished by CSIO. Suggestions have been proposed for improvement of HM2000 float. HSOE also agreed to install Tadiran battery packs into several HM2000 floats for a comparison of energy consumption between Tadiran and battery currently used.

With respect to HM4000 float, the deep float R&D team of HSOE have upgraded the HM4000 prototype in terms of improving the production and testing processes after 2019-test in the western Pacific. In addition, the power supply module and main control system have been improved, and the power consumption test has been conducted. Currently, the measurement module can be compatible with both SBE61 and RBRArgo^3 CTD|deep 6k sensors.

The team has also carried out the development of deep floats for 6000 m in terms of some key techniques like design and test of pressure casing, buoyancy-driven module, and buoyancy compensation module. They have finished the design of pressure casing structure and buoyancy-driven scheme, while manufacturing of pressure casing and buoyancy-driven system is under way.

2. Present level of and future prospects for national funding for Argo including a summary of the level of human resources devoted to Argo, and funding for sustaining the core mission and the enhancements: BGC, Deep, Spatial (Polar, equator, WBCs)

The new China Argo program has been named China Argo Infrastucture construction, with the goal of maintaining 400 floats in the northwestern Pacific Ocean, Indian Ocean and the South China Sea. HM2000 float (with Beidou satellite system for data transmission) has been selected as the main instrument to build the array.

The pilot project of China Deep Argo sponsored by Pilot National Laboratory for Marine Science and Technology (Qingdao, QNLM) was also impacted by COVID-19 in 2020. The manufacturer, HSOE is still waiting for the deliveries of CTD sensors (both from RBR and SBE). QNLM plans to organize a cruise in the mid of 2021 to deploy 10 HM4000 floats in the Kuroshio extension.

CSIO: About 9 staffs at CSIO contribute to the logistics and data management for China Argo and BGC-Argo.

NMDIS: 6 staffs, of which two are IT professionals, responsible for system development and website maintaining, one is working for RT data processing, and one for DM processing, and two for product making.

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.

In the upcoming cruise in the northwestern Pacific Ocean, 10 HM4000 floats will be deployed in the Kuroshio Extension during May-June 2021. 9 of these floats are equipped with RBRargo^3 CTD|deep 6k and the one remaining is equipped with SEB61. To verify observations from these deep floats, a Guidline salinometer will be taken to the vessel. All data derived from the deployed HM4000 floats will be transmitted to CSIO and HSOE.

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 the global Argo data set (synchronize with the GDAC server four times per day), and also provides a free download of the BOA_Argo (the Argo product developed by CSIO) as well as the post-quality-controlled global Argo data set (quarterly updated). Argo data and data product 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. A new global Argo data visualization application is being developed by a company.

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.

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.**

CSIO: One CTD cast was submitted.

NMDIS: Under the European Union-China Marine Data Network Partnership, NMDIS shared 27 cruises and 521 in total CTD TS casts from July 1992 to September 2017. Over 65% of profiles are deeper than 2000m and 33% are deeper than 4000m. All these data have been uploaded to the Argo reference database. The data could be download on the website: http://www.cmoc-china.cn/pages/dataService.html

7. **Keeping the Argo bibliography (Bibliography | Argo (ucsd.edu)) 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.**

The following articles are not listed in Argo Bibliography:

Wang D L and Zhang S W. 2020. Design and application of a real-time temperature and salinity profile observation system under ice for polar regions. Chinese Journal of Polar Research (in Chinese). 32(4):523-532.

Wang T Y, Chen F J, Zhang S W, et al., 2020. Remote Sensing and Argo Float Observations Reveal Physical Processes Initiating a Winter-Spring Phytoplankton Bloom South of the Kuroshio Current Near Shikoku. Remote Sensing, 12(24):4065. https://doi.org/10.3390/rs12244065.

Guan S D and Hou Y J. 2020. Super Typhoon Tembin (2012) induced sea surface cooling and enhanced diapycnal mixing in the northwest Pacific ocean. OCEANOLOGIA ET LIMNOLOGIA SINICA (in Chinese).51(6):1301-1309.

Nie X W, Wei Z X, Li Y. 2020. Decadal Variability in Salinity of the Indian Ocean Subtropical Underwater During the Argo Period. Geophysical Research Letters, 47(22), DOI: 10.1029/2020GL089104.

Xing X G, Wells M L, Chen S L, et al., Enhanced Winter Carbon Export Observed by BGC-Argo in the Northwest Pacific Ocean. , 47(22), DOI: 10.1029/2020GL089847.

Xu H B, Yu R Z, Tang D L, et al., Effects of Tropical Cyclones on Sea Surface Salinity in the Bay of Bengal Based on SMAP and Argo Data. Water. 12(11): 2975, DOI: 10.3390/w12112975.

Wang T Y, Gille S T, Mazloff M R, et al., Eddy-Induced Acceleration of Argo Floats. Journal of Geophysical Research: Oceans, 125(10), DOI: 10.1029/2019JC016042.

Zhang C L, Wang Z F, Liu Y. An Argo-based experiment providing near-real-time subsurface oceanic environmental information for fishery data. Fisheries Oceanography, 30(1): DOI: 10.1111/FOG.12504.

Guo W Y, Qiu Y, Lin X Y. 2020, The interannual variability of barrier layer in the Bay of Bengal and its relationship with IOD events. Haiyang Xuebao (in Chinese).42(9):38-49.

Li X, Yuan D L. 2020, An assessment of the CMIP5 models in simulating the Argo geostrophic meridional transport in the North Pacific Ocean, Journal of Oceanology and Limnology, 38(5).

Zang N, Wang F, Sprintall J.2020. The intermediate water in the Philippine Sea. Journal of Oceanology and Limnology,38(5).

Li Z L, Zuo J C, Ji Q Y, et al., 2020, Reconstruction of 3D sea temperature field based on Argo profile, SST and SLA data. Marine Forecasts (in Chinese),37(4): 66-75.

Mao K, Liu C X, Li Z Q, et al., 2020, Response of the upper salinity to the super typhoon Sarika in the South China Sea, Transactions of Oceanology and Limnology (in Chinese),4:7-13.

Su H, Zhang H J, Geng X P, et al., 2020. A New Estimation of Global Ocean Heat Content for Upper 2000 Meters from Remote Sensing Data. Remote Sensing. 12(14), DOI: 10.3390/rs12142294.

Liu Y P, Tang D L, Liang W Z. 2020. Chlorophyll a concentration response to the typhoon "wind pump" and the Kuroshio in the northeastern South China Sea. Haiyang Xuebao (in Chinese).42(7):16-31.

Liu Y, Yan Y F, Ling Z. 2020. Preliminary analysis on climatological and seasonal variation of barrier layer thickness in the northern Indian Ocean and it's mechanism. Journal of Tropical Oceanography, 39(5):98-108.

Shi H Y, Du L, Xu D H,2020. The robust salinity anomaly event during 2015−2017in the tropical Pacific Ocean. Haiyang Xuebao (in Chinese).42(3):47-58.

8. How has COVID-19 impacted your National Program's ability to implement Argo in the past year? This can include impacts on deployments, procurements, data processing, budgets, etc.

The COVID-19 pandemic has little impact on our float deployment and DAC's operation, however, the deliveries of CTD sensors may significantly influence the implementation of our program. CSIO DAC work-force was not impacted by the COVID-19, and staffs worked normally since March 2020. A cruise to Argentine basin, where 10 HM4000 deep floats were planned to be deployed was cancelled due to unavailability of the ocean fishing vessel.

9. Argo is still interested in piloting the RBR CTD. Does your National Program have any deployment plans for RBR floats in the next couple years? If so, please indicate how many floats will you be buying in 2021 and 2022 (if known) and where they might be deployed.

We plan to purchase 18 RBRargo CTDs to be installed on HM2000 floats for a field test which could be the contribution we have known.

The Deep Argo Mission Team in China has fixed a short-term plan that floats manufactured by HSOE are suggested to involve the pilot testing of RBR CTDs. This year 9 HM4000 floats equipped RBRargo^3 CTD|deep 6k will be deployed in the northwestern Pacific, which will be a part of China Argo's contribution to RBR CTD. At present it's difficult to confirm how many RBR CTDs to be installed on our floats in the next couple years before RBR CTD receives an approval from Argo Steering Team.

ARGO National Report 2021 – 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:
   - 94 floats have been purchased since 2004
   - 18 are working
   - 5 are waiting for deployment

   Five floats have been purchased in 2020, but could not be deployed due to COVID restrictions. Three floats will probably be bought in 2021.

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 lead to a reduction to 3-5. The financial pressure will probably last for some more years.
Presently, the Netherlands only contributes to the core mission.
One person (Andreas Sterl) is working on ARGO. He does so besides his other duties.

3) **Summary of deployment plans.**
The five floats already bought are planned to be deployed later this year in the Atlantic Ocean.
Three floats in 2021, 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**
van der Boog, C. G., de Jong, M. F., Scheidat, M., Leopold, M. F., Geelhoed, S. C. V., Schulz, K., et al. (2019). Hydrographic and biological survey of a surface-intensified anticyclonic eddy in the Caribbean Sea. Journal of Geophysical Research: Oceans, 124, 6235– 6251. https://doi.org/10.1029/2018JC014877

National Report - Europe – AST22

The Euro-Argo Research Infrastructure organizes and federates European contribution to Argo (www.euro-argo.eu). 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 European Commission in May 2014, with 9 funding members. Since then membership has grown, and in 2020 the Euro-Argo ERIC involves 13 countries, 11 members, 1 Observer, and 1 Candidate. The Euro-Argo ERIC 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.

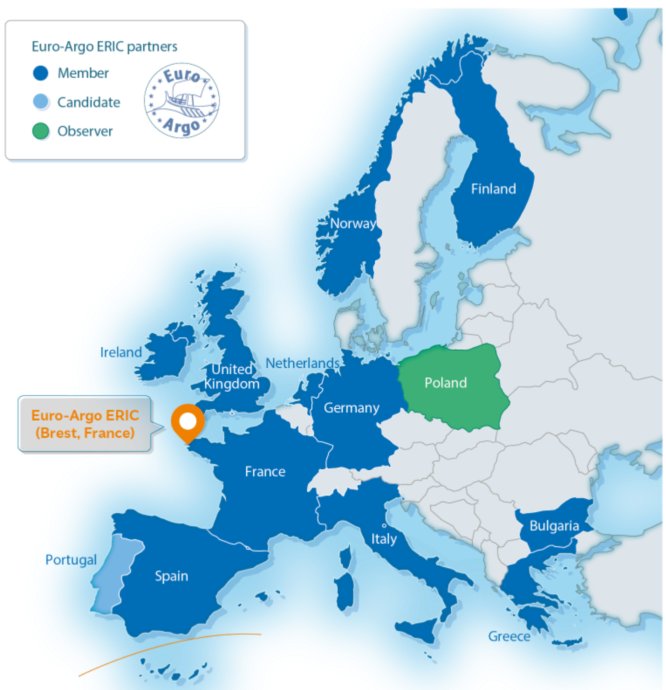


Figure 1. Euro-Argo ERIC membership in 2020

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 of the new global, full-depth, multidisciplinary Argo array (major achievements and problems in 2020)**

   a. **floats deployed and their performance**

In 2020, 7 EU-funded floats were deployed: 1 float (T/S/O2) funded under the Euro-Argo ERIC budget, deployed in the South Atlantic, and 6 T/S floats in the framework of the EU H2020 Euro-Argo RISE project in European marginal Seas (2 in the Mediterranean Sea, 2 in the Black Sea and 2 in the Baltic Sea), aiming at evaluating Argo possibilities in shallow water coastal areas. These floats come in addition to the 156 floats deployed by the members. The table below shows the floats deployed, both as number of measurements per variable and per type of float.

Table 1. European floats deployed in 2020, 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	*7*	*1*	*0*	*0*	*0*	*0*	*0*	*0*	***1***	***0***	***6***	***7***
Member states	156	52	10	9	2	10	4	29	**25**	**5**	**93**	**156**
total	**163**	**53**	**10**	**9**	**2**	**10**	**4**	**29**	**26**	**5**	**93**	**163**

A total of 163 floats have been deployed in 2020, with 70% of them being NKE floats, and 8% with Argos communication (92% Iridium). 7 out of the 163 floats have been recovered, most of them in the marginal seas.

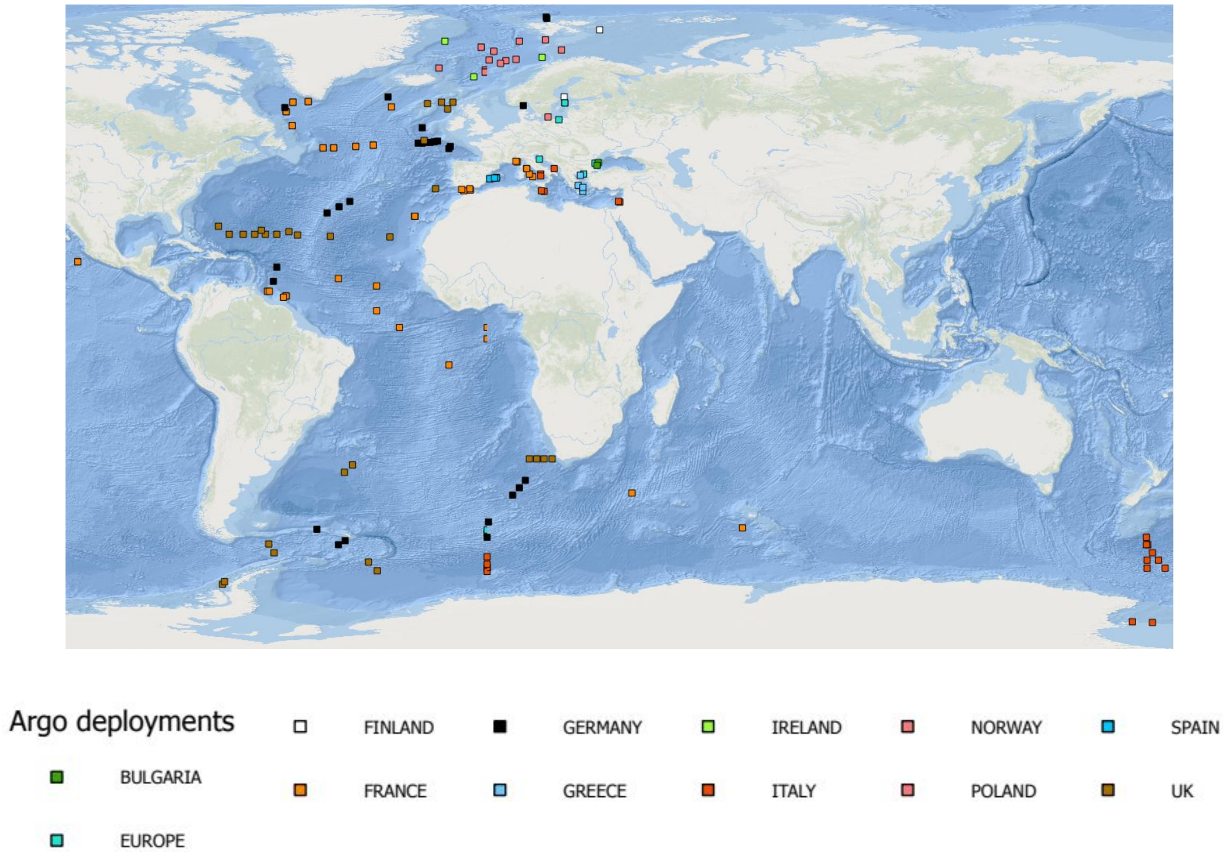


Figure 2. Deployment positions of the European floats deployed in 2020 (Credit OceanOPS)

Figure 3 represents the evolution of Euro-Argo deployments since 2008. The number of floats deployed in 2020 is still low compared to the period 2014-2015. The low values both in 2019 and 2020 are mainly due to delays in deployments by several European partners. Floats not deployed in 2019 were supposed to be deployed in 2020 but this did not happen due to the pandemic situation, when most of the European research vessels were stuck at harbor for nearly 6 months. However, the drop should be compensated by a much higher number of floats to be deployed in 2021 (see section 3).

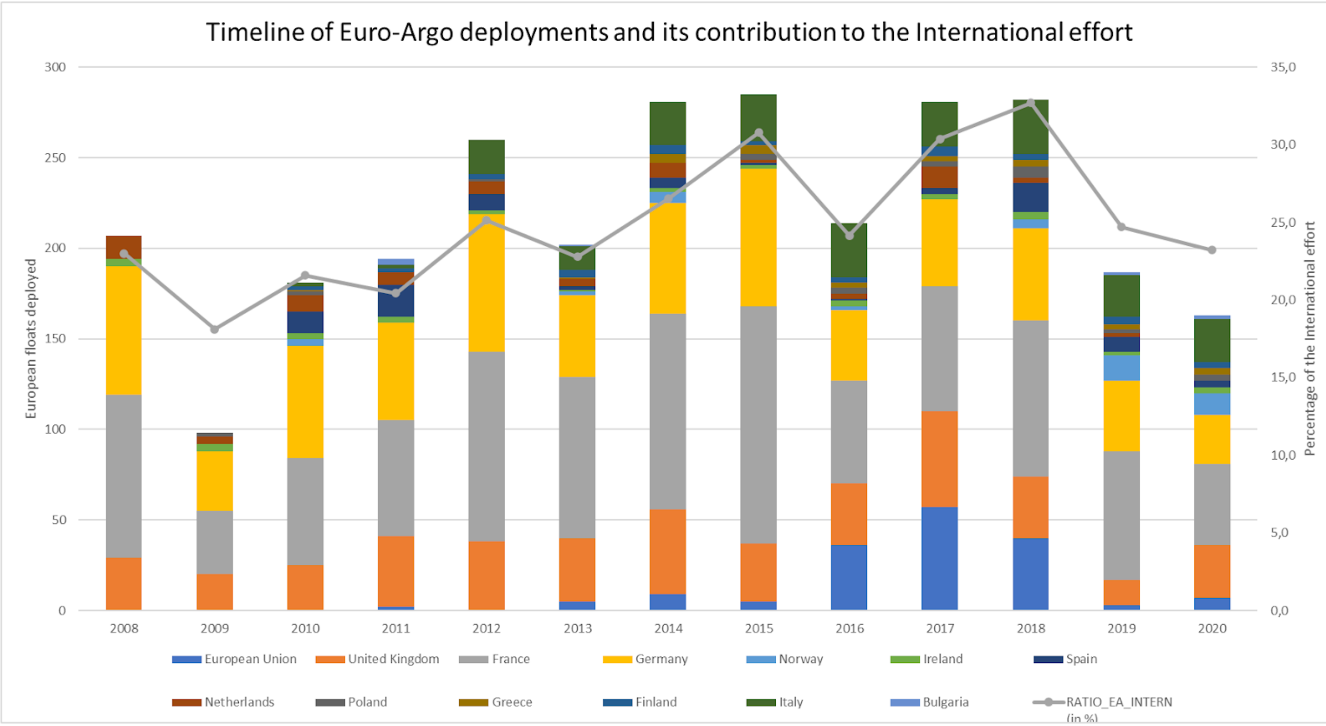


Figure 3. Timeline of Euro-Argo deployments (in number of floats, colored bars, left axis) and its contribution to the international effort (in %, grey line, right axis).

b. technical problems encountered and solved

Out of the 163 floats deployed in 2020, 19 are now inactive. Some of these inactive floats have been recovered, some are currently located under-ice but are expected to surface again in ice-free waters; these are actually not considered to have failed. 3 NOVA floats from Greece have failed right after or a few cycles after deployment. A few floats seem to have failed prematurely, possibly because of grounding. There have been some early losses with the Deep floats (2 ARVOR_D, 2 APEX_D) as well. The other floats have failed without clear explanations.

c. status of contributions to Argo data management (including status of high salinity drift floats, decoding difficulties, ramping up to include BGC or Deep floats, etc)

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 European fleet is impacted by the high salinity drift on SBE sensors and Euro-Argo had started to investigate this issue from a DMQC point of view in 2019 (see Euro-Argo github public Forum: https://github.com/euroargodev/publicQCforum/issues/11). In the Google spreadsheet maintained by the international WG on this subject, the tab on statistics of the issue for European floats shows that (as of 12/03/2021) for the 4435 cycles processed for European floats deployed in 2020, 34 had to be corrected and 16 were lost (Figure 4). See German report for more details.

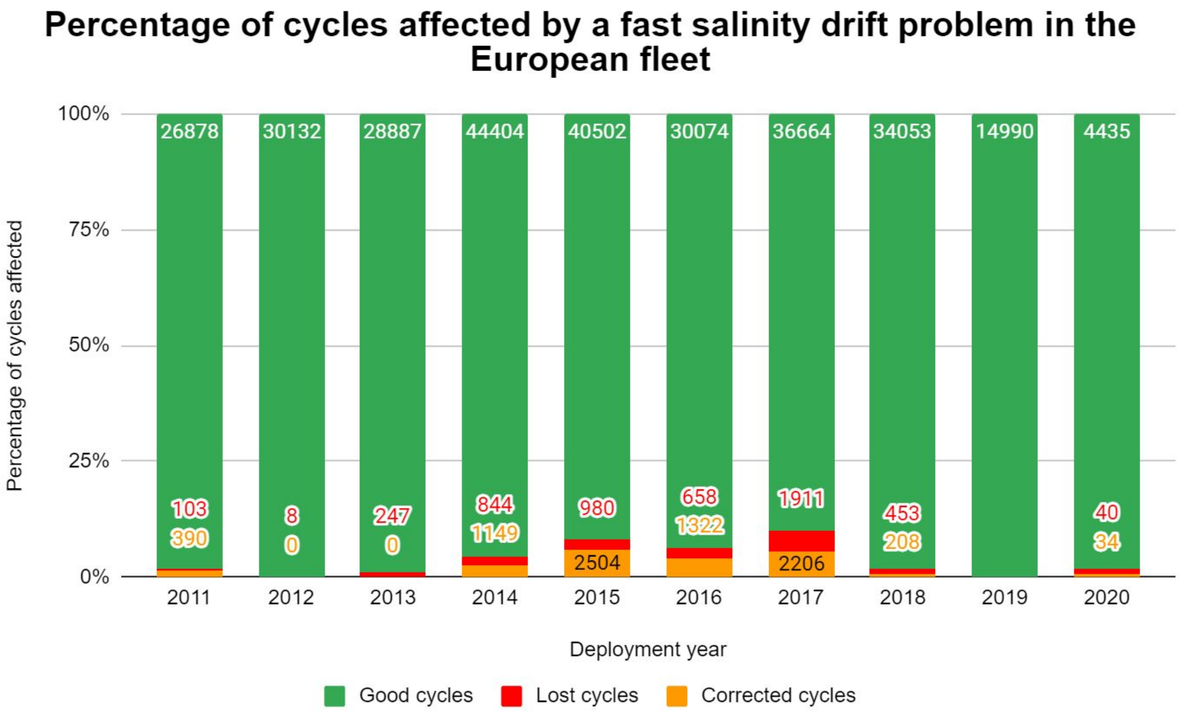


Figure 4. Percentage of cycles affected by fast salinity drift problem in the European fleet

d. status of delayed mode quality control process

The percentage of EU-funded floats processed in Delayed Mode (for floats deployed up to the end of 2020) amongst eligible floats is 80%, and 80% if we consider the whole European fleet (EU-funded + National). On the GDAC, 75% of European profiles are available in Delayed Mode.

2. Present level of and future prospects for national funding for Argo including a summary of the level of human resources devoted to Argo, and funding for sustaining the core mission and the enhancements: BGC, Deep, Spatial (Polar, equator, WBCs)

In 2020, the Euro-Argo ERIC coordination office was a team of 5 Full Time Equivalent (3.5 permanent and 1.5 project-funded). This team supports European countries to sustain and optimize the European contribution to the Argo International programme, and comes in addition to the national members personnel.

The European contribution to Argo is still benefiting from the Euro-Argo RISE EU project (Euro-Argo Research Infrastructure Sustainability and Enhancement), that involves all the Euro-Argo ERIC members except Netherlands for a 4 years duration (until December 2022). The project 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 funded **5 Deep floats and 5 BGC floats** to be deployed in 2021 as well as the organisation of workshops on Deep and BGC, 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).

The new EU project DOORS (Developing Optimal and Open Research Support for the Black Sea), starting in 2021 will also allow Europe to further develop Argo in the Black Sea and demonstrate the importance of BGC-Argo for Blue Growth development in the Black Sea as part of a multiplatform integrated observing system. The project includes the funding of 2 BGC floats.

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. European deployment plans for 2021: total [national + EU-funded] & (EU-funded in brackets). “BGC” stands for floats equipped with the sensors able to measure the 6 BGC variables, “T/S/O2” for core floats equipped with an additional oxygen sensor (DEEP floats equipped with an oxygen sensors are counted in the DEEP column) “Bio” stands for other floats equipped with only some of the BGC sensors.

	Core	T/S/O2	Bio	BGC	DEEP	**Total**
Nordic	9	3	3	4	2	**21**
Med Sea	14	6	3	1	2	**26**
Black Sea	1	3	1			**5**
Baltic	1	3	2			**6**
Southern	19					**19**
Arctic		2				**2**
Global	142	15 (10)	11	12 (5)	33 (5)	**213 (20)**
Total	**186**	**32 (10)**	**20**	**17 (5)**	**37 (5)**	**292 (20)**

Float deployments planned for 2021 are presented in Table 2 per region and type of float. In total, Europe plans to deploy 292 floats, including a lot of floats that could not be deployed in 2020 due to the pandemic situation.

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. Euro-Argo is for instance developing a Leaflet based on the work of Riser et al. to show the environmental impact of Argo floats (cost/benefits) to be able to communicate on this subject to a wide audience. We have also started to work on a way to promote the new Argo design to policy makers, through an analysis of the impact of the new Argo design on society.

4. Here is a link to the commitments table at OceanOPS. If you cannot edit the online table, please send a list of deployment plans for each of the columns in the table as needed.

The commitments table is up-to-date for all the European partners, including the EU-funded floats ("Europe").

5. 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.

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 is being reinforced, in particular in the Southern Ocean ARC (see UK national report).

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

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.
- Continue to evaluate the impact of SBE high salty drift failure (data lost, impact on Argo data products).
- Reinforce the links with operational community (ocean and weather forecasting centers) to better assess their needs and difficulties in particular with the development of the One Argo mission

7. **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.

8. **Keeping the Argo bibliography (Bibliography | Argo (ucsd.edu)) 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 (Thesis Citations | Argo (ucsd.edu)). 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 https://www.euro-argo.eu/Outreach/Bibliography. A new subsection "Read of the Month" has been created in 2020 that includes plain language summaries of scientific publications, one each month. Work is foreseen to enhance this section of the website: it is planned to present the bibliography in a "sortable" table (similar to BGC-Argo bibliography) and to advertise European scientific publications related to Argo on a regular basis through Twitter.

9. **How has COVID-19 impacted your National Program's ability to implement Argo in the past year? This can include impacts on deployments, procurements, data processing, budgets, etc.**

Many cruises have been cancelled or postponed in 2020, which lead to fewer floats deployed (163 in total). However, the floats that could not be deployed will be deployed in 2021 (total 292) and Euro-Argo is also contributing with USA and Canada to an Atlantic charter that aims at filling gaps in the Atlantic Ocean in complement to member states plans.

10. Argo is still interested in piloting the RBR CTD. Does your National Program have any deployment plans for RBR floats in the next couple years? If so, please indicate how many floats will you be buying in 2021 and 2022 (if known) and where they might be deployed.

Europe is involved in RBR CTD pilot studies, with 3 head-float prototypes (for intercomparison with SBE CTDs) and Arvor-I RBR developed within the Euro-Argo RISE project and successfully deployed in 2020. The data are being analysed. 2 more floats equipped with RBR CTDs will be deployed in 2021, and Europe will continue to investigate the potential of these new CTD in the coming years. In particular, Germany is conducting a pilot study with 5 floats deployed in early 2021, UK has 3 floats equipped with RBR sensors ready to be deployed, Poland plans to buy one float with an RBR CTD, and France 10% of its core-Argo fleet.

Argo National Report 2020 – Finland

1. Status of implementation

The Finnish Argo program is run by the Finnish Meteorological Institute (FMI). Since 2010 FMI has deployed altogether 12 floats in the Nordic Seas, including two on Barents sea 2018 and 2020. In addition of oceanic operations, 23 floats (starting 2012) have also been deployed into the shallow and low salinity Baltic Sea. Six of the Baltic float deployments have bio-optical sensor suite.

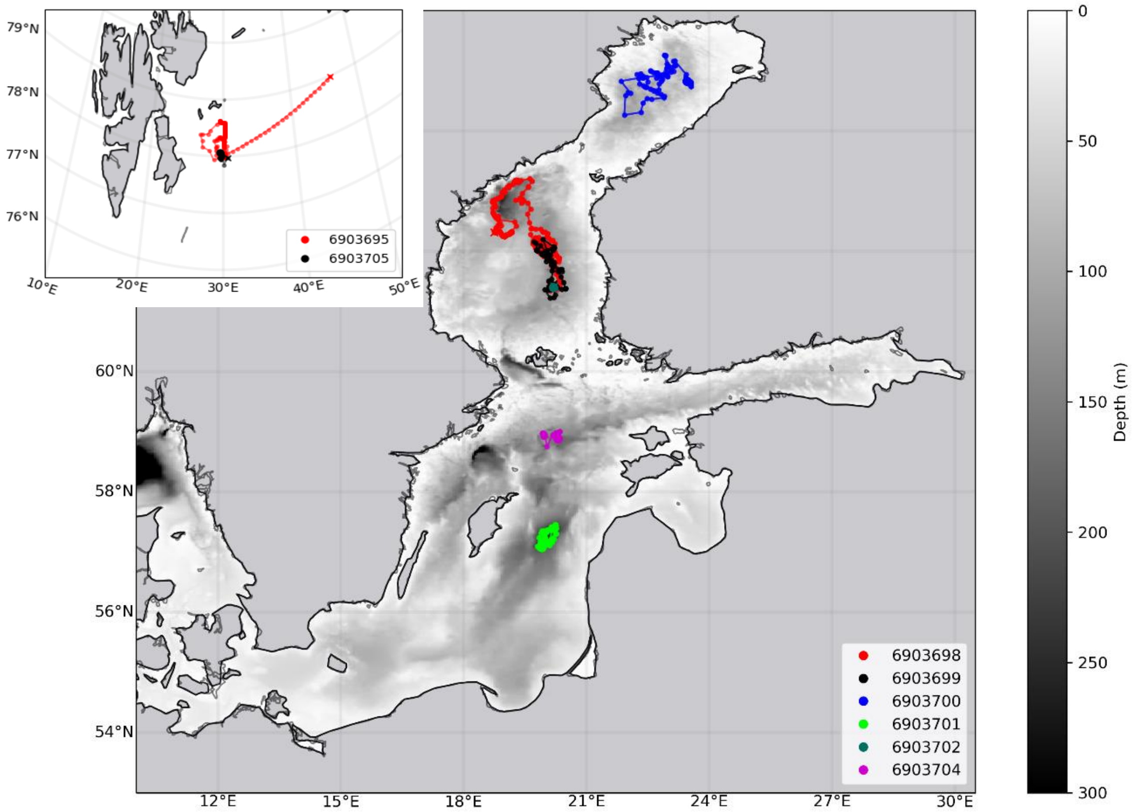


Figure 1, Routes of FMI Argo floats which operated in the Baltic Sea in 2019-2020. Upper left inset shows the trajections of the Barents Sea floats. The dot indicates the deployment location. Cross indicates the recovery point or latest measurement for each Argo float.

In 2020 FMI deployed total of 3 floats in 2020. One Apex float (6903704) was deployed in new area on the Baltic Proper. One Arvor-C float (6903702) was deployed to the Bothnian Sea. One Apex float (903705) was deployed on Barents Sea as continuation of our experiments with the ice avoidance, and extensions towards high latitudes.

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

FMI has committed to purchase and deploy three floats in a year, at minimum. Our main geographical operation area is the Baltic Sea. Currently we are further developing the operation of

Argo floats in shallow, and ice-covered seas. First experiments with ice-avoidance on the Baltic Sea has been performed during winter 2015-1016. 2018 one float (6802026) has been successfully under ice on Bay of Bothnia. In summer 2019 another float (6903700) was deployed in same area. A float deployed on Barents Sea in autumn 2018 (6903695) has spent successfully two winters under ice, and another (6903705) was deployed on Barents Sea autumn 2020. Its ice avoidance algorithm was activated at the beginning of December 2020.

3. Summary of deployment plans

FMI plans to deploy total of 3 floats in 2021. One floats will be deployed on Gotland Deep, one to replace the current float (6903701). One will be deployed on Bothnian Sea, and one on Bay of Bothnia.

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

Argo data sets gathered from Baltic Sea are used for validating the operational and research circulation models, studies in hydrography and currents. Operating Argo floats in the Baltic Sea has been a research on the limits of usability of Argos in shallow seas. On this work three papers and one doctoral thesis were published on 2018-2019. (Haavisto et al. 2018, Roiha et al. 2018 and Siiriä et al. 2018, Roiha 2019) Ongoing research is done on assimilating Argo data in the operational Baltic Sea circulation models for enhancing their forecasting skills, further developing the operations in both shallow, and icy conditions, as well as quality control of the Baltic Sea Argo data.

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

Finland considers that more resources should be allocated for the environmental monitoring of the Arctic Ocean. The Euro-Argo could coordinate developments and deployments of ice-tethered Argos.

6. CTD data uploaded to CCHDO

No data uploaded.

7. Bibliography

Haavisto N, Tuomi L, Roiha P, Siiria SM, Alenius P, Purokoski T. 2018. Argo floats as a novel part of the monitoring the hydrography of the Bothnian Sea. Frontiers in Marine Science. 5:324. https://www.frontiersin.org/article/10.3389/fmars.2018.00324.

Roiha P, Siiria SM, Haavisto N, Alenius P, Westerlund A, Purokoski T. 2018. Estimating currents from Argo trajectories in the Bothnian Sea, Baltic Sea. Frontiers in Marine Science. 5:308. Available from: https://www.frontiersin.org/article/10.3389/fmars.2018.00308.

Roiha P 2019 Dissertation, Advancements of operational oceanography in the Baltic Sea, Finnish Meteorological Institute Contributions 157, http://hdl.handle.net/10138/308506

Siiria S, Roiha P, Tuomi L, Purokoski T, Haavisto N, Alenius P. 2018. Applying area-locked, shallow water argo floats in baltic sea monitoring. Journal of Operational Oceanography. 0(0):1–15. Available from: https://doi.org/10.1080/1755876X.2018.1544783.

8. Effects of COVID-19

COVID-19 situation has forced part of cruises to be rescheduled or cancelled which had caused challenges for deployment planning. So far, the challenges have been manageable however.

9. RBR CTD piloting and deployment plans

Within the Euro Argo Rise project two deployments with RBR sensors are planned for 2021. The results obtained from these are used to determine FMI further plans.

French National Report on Argo - 2020

AST 22

By the Argo-France Management Board

G. Maze, C. Cabanes, T. Carval, H. Claustre, C. Coatanoan, F. D'Ortenzio, N. Kolodziejczyk, N. Lebreton, A. Poteau, S. Le Reste, C. Schmechtig, P.Y. Le Traon, N. Poffa, S. Pouliquen and V. Thierry

Background, organization and funding of the French Argo activities

Organization

Argo-France (https://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 led 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) and 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). At regional scale, Argo-France is supported by the IUEM/University of Brest OSU (Observatory) and funded by the Brittany and Provence Alpes-Cote d'Azur regions (CPER projects).

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). Additional funding from research project (Equipex NAOS) allowed Ifremer to increase its long-term contribution to Argo from 50 to 65-70 floats/year. Since 2000, around 1400 French floats have been deployed in different geographic areas. Deployments focused on meeting specific French requirements while also contributing to the global array.

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	*59*		*59*
2011	1400k€	12	*64*		*64*
2012	1400k€	12	*105*		*105*
2013	1400k€	12	*89*		*89*
2014	1400k€	12	*108*		*108*
2015	1400k€	14	*131*		*131*
2016	1400k€	14	57		*57*
2017	1400k€	14	69		69
2018	1400k€	14	86		86
2019	1400k€	14	71		71
2020	1400k€	15	45		45
Total (2000-2020)			*1334*		*1409*
2021	**1400k€**	**15**	80		

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 2021.

Long term evolution of Argo

At the national level, Argo-France will contribute to the new phase of Argo with about 69 floats/year with the following repartition:

- 30 core Argo floats /year

- 15 core Argo floats with O2 sensor /year
- 15 Deep-Argo-4000 floats /year (+ 22 Deep-Argo-6000 floats)
- 9 BGC-Argo floats /year (+ 14 BGC-ECO floats)

Core T/S, deep floats and oxygen sensors will be funded until 2027 (CPER Brittany region), the biogeochemical mission is funded triugh different projects (CPER PACA and Brittany regions, ERC Refine, Argo-2030 and PIANO projects).

Argo-France strategy will be adjusted according to international recommendations with regard to the deep and Bio-Argo extensions. 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 has been developed and deployed in December 2020. Analyses are on-going.
- One Deep-Arvor equipped with the SBE41-CP, the SBE61 and the RBR sensors were deployed in December 2020. Analyses are on-going.
- 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

As part of the new Ifremer PIANO project the expected technological developments are :

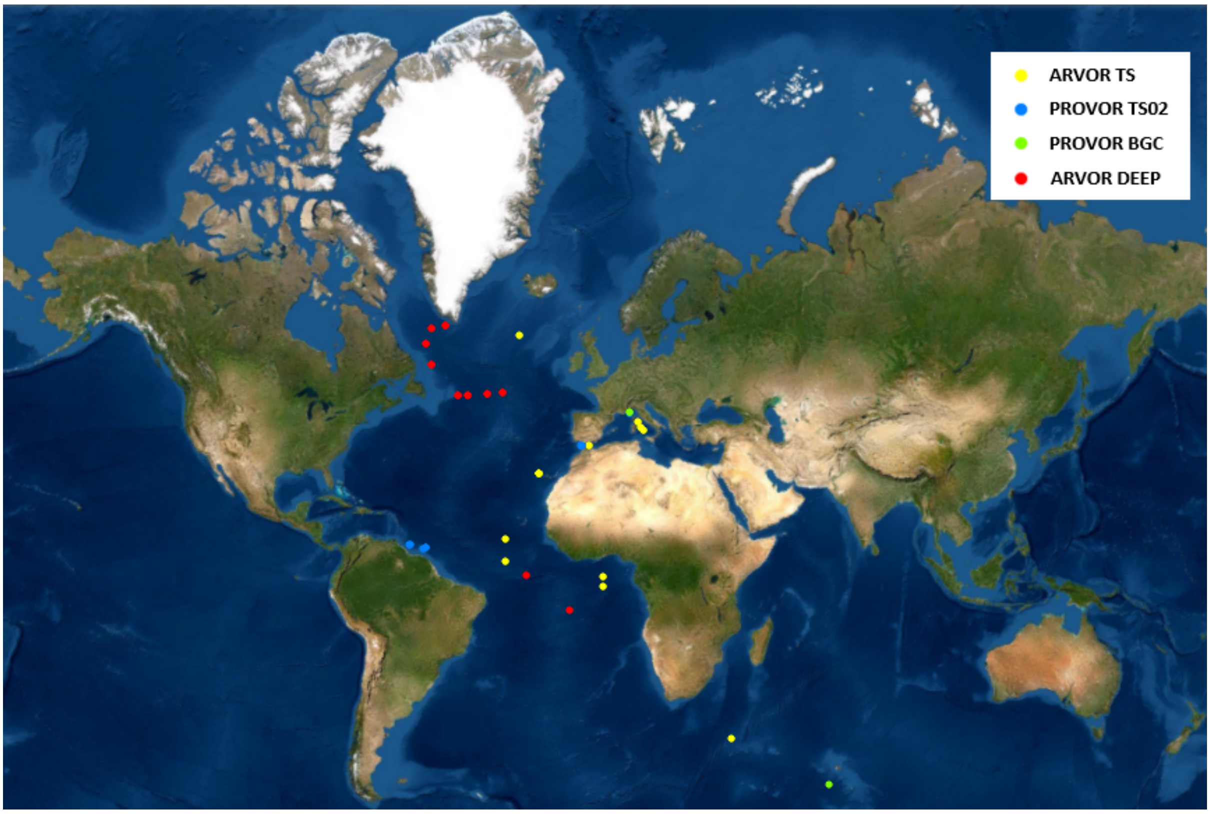
- New T/S and BGC sensors (absolute salinity sensor, optical sensors, sonar, chemical sensor)
- improvment of Deep-Argo 4000 and development of new Deep-Argo 6000 m
- Improve float technology (communications and electronics)

The status of implementation

Floats deployed and their performance

45 floats have been deployed by France in 2020 (15 T/S Core, 8 T/S/O2, 4 BGC, 18 DEEP). We deployed those floats from French RV Pourquoi Pas?, Atalante and Thalassa but also from the German RV Meteor and Maria S. Merian thanks to a fruitful collaboration with BSH and Argo-Germany. A cruise was also conducted from Spain's RV Ramón Margalef and 4 floats were deployed using sailing vessels including 3 on the Vendée Globe race. 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. Note that due to COVID19 pandemia ship

opportunities from the French Scientific fleet have been postponed to 2021. In 2020, only 57% of the planned deployments have been successfully operated.



Deployment locations of Argo-France floats in 2020 by float types.

Technical problems encountered and solved

Technical problems on Deep Arvor.

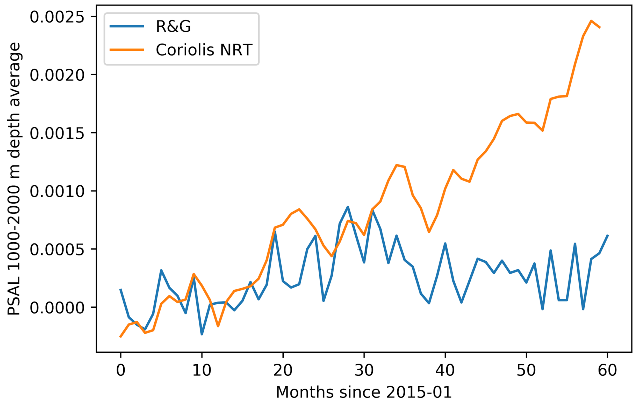
- 2 Deep Arvor have been lost due to suspected water leak after less than 15 cycles.

Seabird batch of drifting CTDs is being assessed and monitored.

- 16 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 0.0025 pss below 1000 m depth). This could be explained by the large amount of RT profile suffering from SBE salinity drift (still in late 2020). The potential impact of SBE salinity drift on global salinity and halosteric height analysis is an ongoing work.



Global (60°N-60°S) averaged salinity anomaly (referred to the period 2006-2015) between 1000-2000 m depth from Roemmich and Gilson Argo analysis (blue; with corrected salinity) and from NRT Coriolis analysis (yellow; including RT profiles).

- 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.
- The DMQC analyis of French floats is updated and concatenated at European level :https://docs.google.com/spreadsheets/d/e/2PACX-1vS041PxmjzJcyYbczT_XbBIG62WYAaMGo7U0F3qz_yxzDQgYIlf-9bKT18lDvaDxV60Dqut4GVJUprG/pubhtml?urp=gmail_link&gxids=7628#

Status of contributions to Argo data management

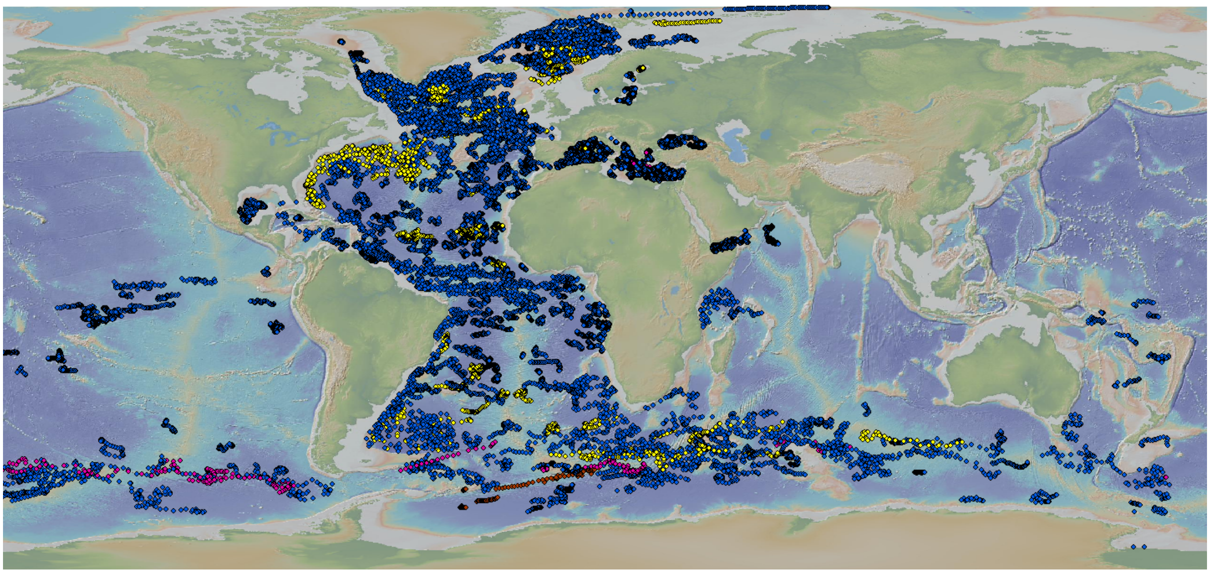
Within Argo-France, data management is undertaken by Coriolis, which play three roles: Data Assembly Centre, Global Data Centre, and leader of the North Atlantic Argo Regional Centre. Coriolis is located within Ifremer-Brest and is operated by Ifremer with support of SHOM. Since 2016, the BGC floats 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 2020 annual report (english) : https://doi.org/10.13155/77033

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).

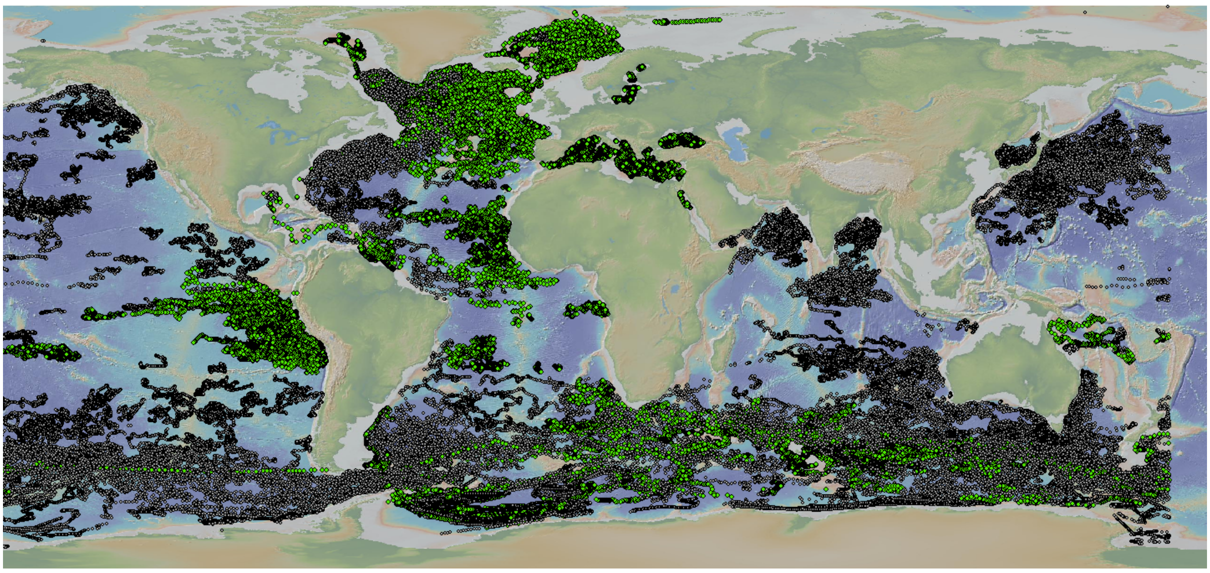
These last 12 months, 52,160 profiles from 787 active floats were collected, controlled and distributed. Compared to 2019, the number of profiles has significantly increased (+49%), the number of floats increased by 5%. These figures show a fair stability in Coriolis DAC activity. The 787 floats managed during that period had 48 versions of data formats.



Map showing the 52,160 profiles from 787 active float décoded by Coriolis DAC in 2020
Apex Nova Provor Nemo

The data processing chain based on Matlab to manage data and metadata from Coriolis BGC-floats is continuously improved. These are advanced types of floats performing bio-geo-chemical (BGC) measurements.
Coriolis DAC manages 513 BGC-Argo floats from 5 families and 57 instrument versions. They performed 68,978 cycles. The data processing chain is freely available:

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



Map of 513 flotteurs BGC-Argo managed by Coriolis DAC (gray: BGC floats from other DACs). Measurements are dissolved oxygen, chlorophyll, turbidity, CDOM, backscattering, UV, nitrates, le bisulfit, pH, 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 560 unique visitors, performing 4300 sessions and downloading 5.9 terabytes of data files.

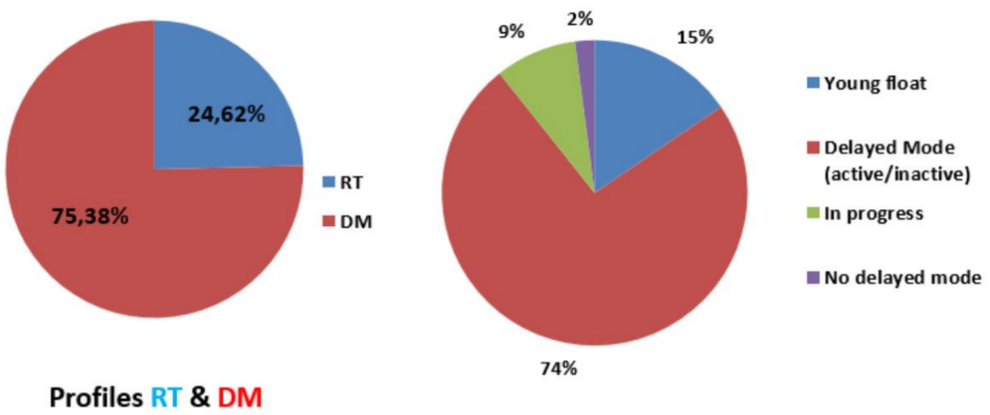
Within the EMODnet and CMEMS-INSTAC projects , in continuity of the prototype developed in the EU AtlantOS project, Ifremer is setting up a dashboard (Semaphore) to monitor data distribution and give credit to data providers such as Argo floats partner institutes. FTP downloads log files are ingested in an Elasticsearch index. A link between downloaded files, download originators, floats included in the downloaded files and institution owners of the floats is performed. These links are displayed in a Kibana dashboard.This dashboard will offer the possibility to give credit to Floats owner institutions such as how many data from one particular institution was downloaded, by whose data users

North Atlantic Argo Regional Centre

See section 5.4

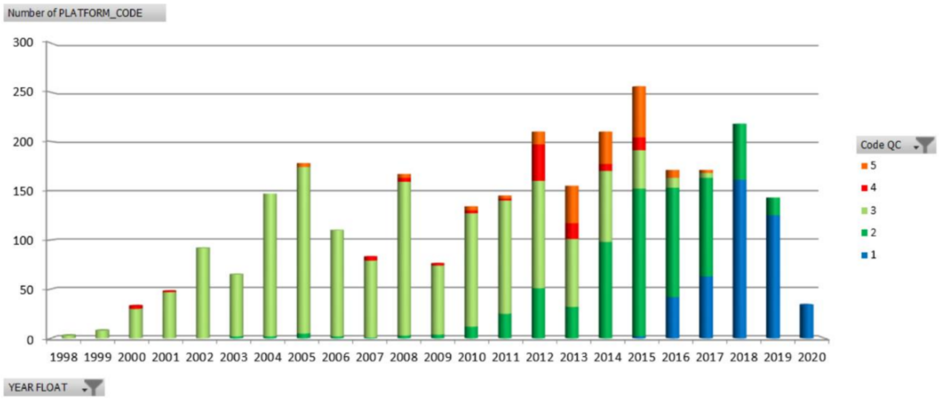
Status of delayed mode quality control process

Last year (october 2019-November 2020), 50,641 new delayed mode profiles were produced, validated by PIs and sent to GDACs. A total of 273779 delayed mode profiles were produced and validated since 2005. In February 2021, 75.38% (74%) of the profiles (floats) processed by the Coriolis DAC were 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).

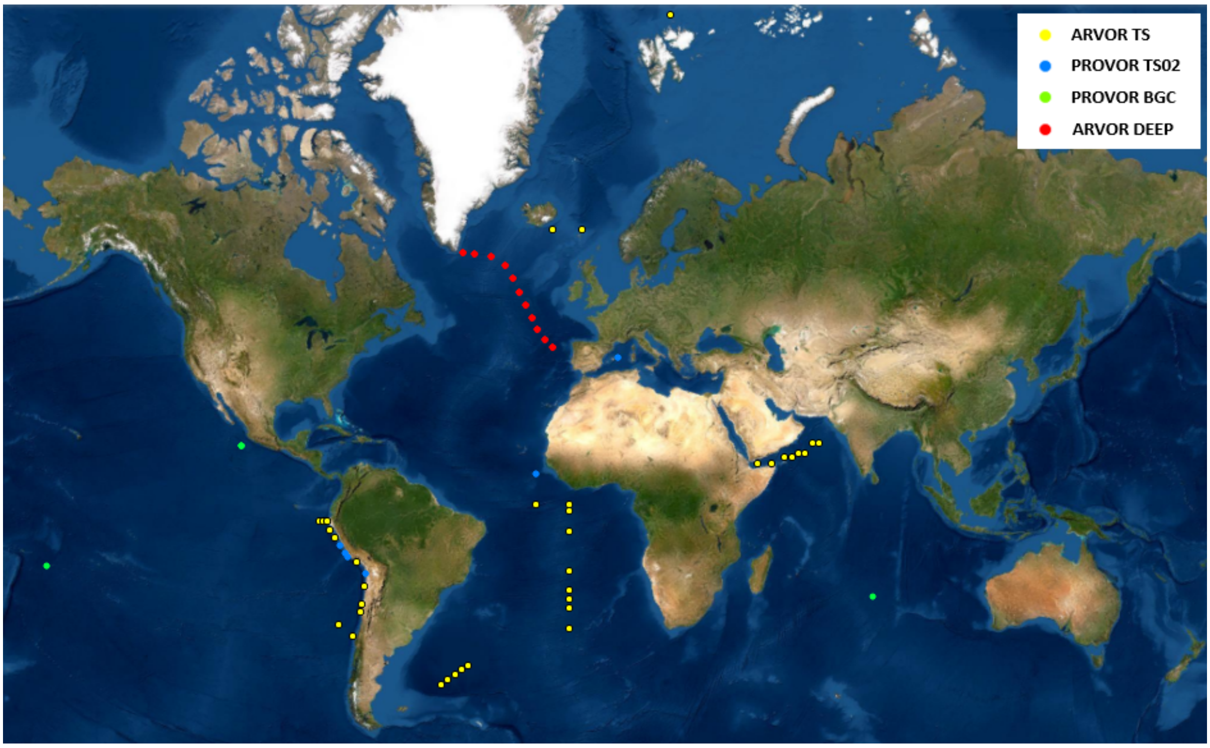
The status of the quality control done on the Coriolis floats is presented in the following plot. For the two last years (2019- 2020), most of the floats are still too young (code 1) to be performed in delayed mode. For the years 2012-2013-2014, we are still working on the DMQC of some floats. The codes 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, 80 floats are scheduled to be deployed in 2021 (75 are confirmed with 43 T/S, 10 BGC, 22 DEEP), see map below.
Coriolis will continue to run the Coriolis DAC and the European GDAC as well as coordinating the Atlantic ARC (A-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 check within A-ARC.
France also will continue to contribute to the funding of the AIC.



Deployment locations of Argo-France floats planned in 2021 by float types.

COVID19: Because of the global pandemic outbreak in early 2020, Argo-France has reported a significant impact on its operations for 2020 (57% of scheduled deployments). Argo-France foresees possible perturbations in 2021. This impact is still being assessed and will be reported at the OceanOPS and Euro-Argo level for possible coordinations to sustain the array (https://docs.google.com/spreadsheets/d/1ofo5ipeBLFRpNVKpcbTZuiKjpCmWwVU2TPI3-bBO0BM/edit#gid=0). Contribution of France to the Atlantic charter that is organised jointly between USA,Euro-Argo and Canada is a possibility that may allow to deploy core floats according to plans.

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

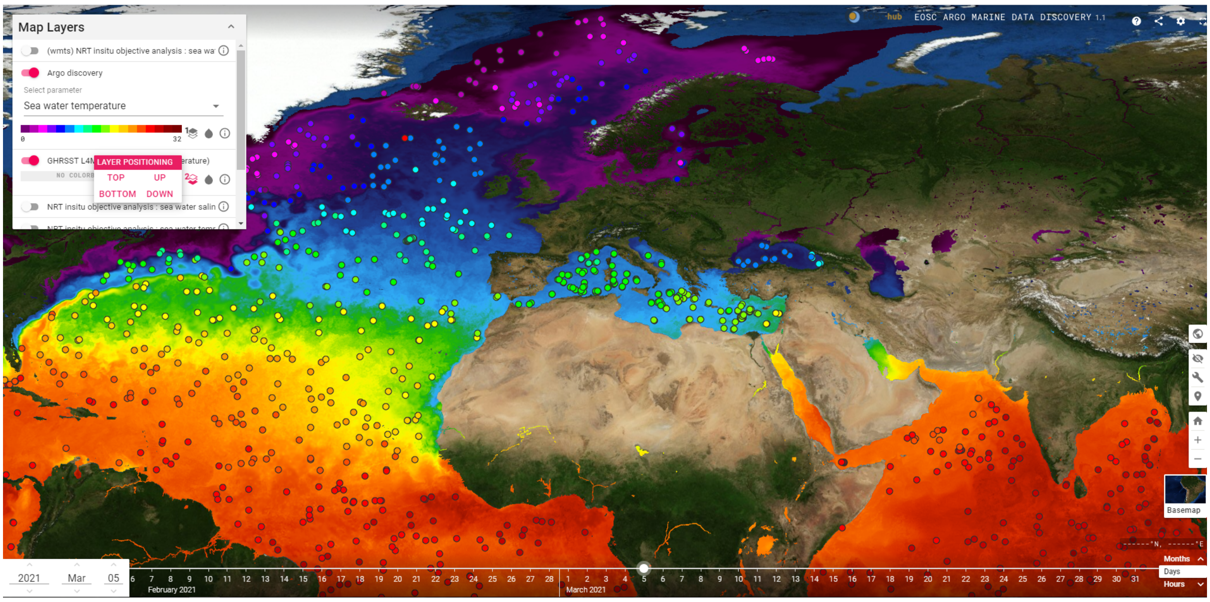
Coriolis has developed together with MERCATOR (The French operational oceanography forecast center) a strong connection with the French research community via the Mercator-Coriolis Mission Group (GMMC). It consists of about one hundred researchers (with some turnover each year) following a scientific announcement of opportunities and a 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.

European Argo-data project involving French Argo community

- Argo MOCCA (2017-2020):
  - Machine learning to help DMQC operator
- Euro-Argo RISE (2019-2022): https://www.euro-argo.eu/EU-Projects/Euro-Argo-RISE-2019-2022/News/Euro-Argo-RISE-progress-already-halfway-there
  - Development & Implementation of DMQC machine learning methods
  - Improvement of data access
  - Sensors: addressing SBE61 accuracy and stability & testing RBR on core and deep floats
  - DMQC method for Argo extended missions (Deep, BGC)
  - Viewing service : https://dataselection.euro-argo.eu/
  - Outreach
- ENVRI-FAIR: connecting ERICs (Euro-Argo) to EOSC Blue Cloud:

- Improving data access to European data base including Argo dataset through new API on Coriolis GDAC

- EOSC-Blue cloud
    - Improving visualization tools for Argo data combined with satellite information (http://bluecloud.odatis-ocean.fr/)



Map of Argo-Float surface temperature overloaded with satellite SST

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.

Key project activities

ANDRO Trajectory dataset

Argo-France contributes to the DMQC on Argo float trajectories and provides updates to the ANDRO product (Atlas of Argo trajectories). An update for the period 2010-2020 including the floats of the AOML and Coriolis DACs was published in 2020. 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 2020, Argo-France contributed and assembled the French contribution to the ICES report on the state of the North Atlantic Ocean in 2019. The ISAS temperature and salinity fields are used in its "Ocean State Report" (www.ices.dk): Desbruyeres Damien, Kolodziejczyk Nicolas (2020).

Contribution to the ICES Report on Ocean Climate : North Atlantic Ocean in 2019. National report: France, May 2020. LOPS-WGOH-2020-05. https://doi.org/10.13155/77447.

H2020 EARISE (Euro-Argo Research Infrastructure Sustainability and Enhancement, 2019-2022)

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, 2019-2022)

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.

PIE Ifremer PIANO (Argo Novel Observations Investment Plan ; 2021-2025)

The objective of the PIE PIANO project (Argo New Observations Investment Plan) is to carry out innovative technological developments on Argo floats, on sensors (for T/S and BGC-Argo) and to implement the French contribution to the new Argo phase over 2021-2027. This will involve:

- procurement of BGC-Argo floats (3 floats/year over 5 years)
- to test a new version of the NOSS optical salinity sensor
- to develop a French offer of BGC sensors (active optics, passive optics, micro sonar and pH chemini)

- to develop a Deep-Argo 6000 m float
- to improve float technology (electronics, communication)
- finally to ensure the processing of project data including the development of innovative methods

Equipex+ Argo-2030 (3[td] Investment Plan of French Research Ministry; 2021-2028)

The objective of the Equipex PIA3 Argo-2030 project is to acquire BGC floats to consolidate the French contribution to the BGC component of the Argo network (20 floats, i.e. 2-3 floats/year over 8 years). Argo-2030 also plans scientific experiments to test and validate the new generations of BGC and Deep floats developed in complementary projects (ERC Refine for the platform, PIE Ifremer PIANO for “Made in France” sensors) :

- The new generation of French BGC-Argo floats (referred to as "BGC-ECO" Argo) will add unique imagery and active acoustics capabilities. These floats will allow the exploration of the mesopelagic zone (100-1000 m)including its biological/fishering dimension (it is believed that the protein resources of this zone are underestimated by at least an order of magnitude) assuming the it is the main site of the remineralization of CO2, and therefore it is decisive for CO2 sequestration.
- The new generation of French Deep-Argo floats (the Deep-Arvor “6000”) will target 6000 m depth (the floats developed and successfully tested in the NAOS Equipex are designed to target 4000 m depth). It will offer a high capacity for carrying additional sensors (oxygen in particular), allowing the Deep-Arvor “6000” to be positioned as the first Deep + BGC mixed float. These floats will help estimate the role of the deep ocean on the planet's energy balance, sea level rise, deoxygenation, acidification in key regions (Atlantic, Southern Ocean). Their deployment will be combined with Deep-Argo 4000 floats to best resolve geographic structures and seasonal to interannual variations in heat and freshwater content, steric height and circulation at the basin scale within deep (> 2000 dbar) and abyssal (> 4000 dbar) oceanic layers.

Argo-Regional Center: Atlantic

France leads the NA-ARC, which is a collaborative effort between Germany (IFM-HH, BSH), Spain (IEO), Italy (OGS), Netherlands (KNMI), UK (NOCS, UKHO), Ireland (IMR), Norway (IMR), Canada (DFO), and USA (AOML), Greece (HCMR) and Bulgaria (IOBAS). Coriolis coordinates the Atlantic ARC activities and in particular the float deployment in Atlantic.

1903 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

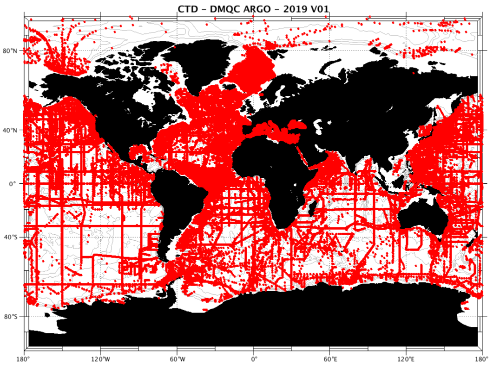
Issues that your country wishes to be considered and resolved by the Argo Steering Team regarding the international operation of Argo.

We would like to warn AST on the impact of the Argo salty drifters on sea level budget.The sea level community is not able to close the sea level budget since 2016 (Chen et al., 2020 https://doi.org/ 10.1029/2020GL090656). We think that the non closure of the sea level budget is partly related to the salty drift that affects 25% of the Argo floats since 2016 (Wong et al 2020) because most products used by the sea level community are mainly based on RT data. We propose a short presentation on this issue at the AST.

CTD cruise data in the reference database

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

The 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 alsobeen 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). In March 2020, a new version will be available, including CTD for deep Argo PIs.



Coriolis manages the Argo reference databases for the DMQC (CTD boat casts and Argo floats). In order to facilitate access by QC software, Ifremer undertakes to serve these databases via the ERDDAP API: https://www.ifremer.fr/erddap/info/ArgoFloats-ref/index.html. For the moment, only Argo reference data is available (because it is freely accessible). Ship data will also be provided via a simple authentication system. The new Argo simplified data access library (such as Argopy library) also provides access to reference data.

Bibliography

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

In 2020, at least 65 articles with a scientist affiliated in France as a coauthor have been published in peer reviewed journals (see below). 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, more than 400 articles have been listed. http://www.argo-france.fr/references

How has COVID-19 impacted your National Program's ability to implement Argo in the past year?

Argo France program

The Argo France program has been impacted by the Covid-19 pandemic. The steering meetings could be carried out remotely. This mainly concerns the deployment activity, dependent on the activity of the French Oceanographic Fleet, which has been reduced by around 43%. The campaigns providing for deployments of Argo floats are mostly postponed to 2021.

Purchases and tests

The activity was nominal, with no postponed deliveries, the usual tests (pressure tests, basin tests) were not impacted. The teams remained mobilized and Ifremer's test resources adapted with great responsiveness. The slots were shared with the Euro-Argo ERIC team, with an optimization of the weeks in terms of the quantity of instruments tested.

Deployments at sea

About forty floats were deployed in 2020 against around 70 initially planned. This is mainly linked to two postponement of french campaigns due to COVID pandemic (~30 floats). These two projects are confirmed for early 2021.
So far , due to the lifespan of the floats, the impact on the network will take time to be visible and is likely to be small if the deployments are not canceled but only postponed.
Monitoring of GAP formation in Atlantic will be carried on with Euro-Argo and USA partners and mitigating some of the gaps through the Atlantic charter is planned

DAC/GDAC and data management

Data management activities (DAC, GDAC, DMQC, A-ARC)) have been carried on as planned despite the fact that most people were working from home thanks to the services set up by the IT departments of Ifremer and CNRS.).

Meeting/outreach

AST 21 in visio conference March 2020
ADMT 21 in visio conference December 2020
Most of meeting and outreach events were postponed to 2021

Does your National Program have any deployment plans for RBR floats in the next couple years?

Two “three-head” deep floats equipped with an SBE41CP, an SBE61 and an RBR sensor were deployed during the Spanish RAPROCAN2020 campaign off the Canary Islands in December 2020. The data are under processing and analysis at LOPS.
As part of the H2020 Euro-Argo-RISE project, Ifremer has developed the Arvor-I / RBR which is therefore a standard Arvor-I float equipped with the CTD RBR. 2 floats of this type were deployed during the Spanish RAPROCAN2020 campaign off the Canary Islands in December 2020. The data are under processing and analysis at LOPS.
Two Arvor-RBR remained to be deployed. This should be done in 2021.
We also plan to buy 10% of the core-Argo floats with RBR sensors in the coming years.

New RBR CTD mounted on the head of the Arvor float (left) and deep-Arvor prototype equipped with 3 CTDS: RBR, SBE41 and SBE61 (right).

Annex

Useful links

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

Peer reviewed publications – 2020 (62)

1. Aguiar, E., B. Mourre, M. Juza, E. Reyes, J. Hernández-Lasheras, E. Cutolo, E. Mason, and J. Tintoré, 2020: Multi-platform model assessment in the Western Mediterranean Sea: impact of downscaling on the surface circulation and mesoscale activity. Ocean Dynamics, 70, 273-288, https://doi.org/10.1007/s10236-019-01317-8
2. Akhil, V. P., J. Vialard, M. Lengaigne, M. G. Keerthi, J. Boutin, J. L. Vergely, and F. Papa, 2020: Bay of Bengal Sea surface salinity variability using a decade of improved SMOS re-processing. Remote Sensing of Environment, 248, 111964, https://doi.org/10.1016/j.rse.2020.111964
3. Albert, J. and P. K. Bhaskaran, 2020: Ocean heat content and its role in tropical cyclogenesis for the Bay of Bengal basin. Climate Dynamics, https://doi.org/10.1007/s00382-020-05450-9
4. André, X., Le Traon, P.-Y., Le Reste, S., Dutreuil, V., Leymarie, E., Malardé, D., et al. (2020). Preparing the New Phase of Argo: Technological Developments on Profiling Floats in the NAOS Project. Front. Mar. Sci. 7, 577446. doi:10.3389/fmars.2020.577446.
5. Balaguru, K., G. R. Foltz, L. R. Leung, J. Kaplan, W. Xu, N. Reul, and B. Chapron, 2020: Pronounced Impact of Salinity on Rapidly Intensifying Tropical Cyclones. Bulletin of the American Meteorological Society, 101, E1497-E1511, https://doi.org/10.1175/BAMS-D-19-0303.1
6. Barton, B. I., C. Lique, and Y.-D. Lenn, 2020: Water Mass Properties Derived From Satellite Observations in the Barents Sea. Journal of Geophysical Research: Oceans, 125, e2019JC015449, https://doi.org/10.1029/2019JC015449
7. Beadling, R. L., J. L. Russell, R. J. Stouffer, M. Mazloff, L. D. Talley, P. J. Goodman, J. B. Sallée, H. T. Hewitt, P. Hyder, and A. Pandde, 2020: Representation of Southern Ocean Properties across Coupled Model Intercomparison Project Generations: CMIP3 to CMIP6. Journal of Climate, 33, 6555-6581, https://doi.org/10.1175/JCLI-D-19-0970.1
8. Biló, T. C. and W. E. Johns, 2020: The Deep Western Boundary Current and Adjacent Interior Circulation at 24°–30°N: Mean Structure and Mesoscale Variability. Journal of Physical Oceanography, 50, 2735-2758, https://doi.org/10.1175/JPO-D-20-0094.1

9. Boutin, J., J.L. Vergely, E. Dinnat, P. Waldteufel, F. D'Amico, N. Reul, A. Supply, C. Thouvenin-Masson (2020), Correcting Sea Surface Temperature Spurious Effects in Salinity Retrieved From Spaceborne L-Band Radiometer Measurements, IEEE Transactions on Geoscience and Remote Sensing, 1-14, doi:10.1109/tgrs.2020.3030488.
10. Briggs, N., G. Dall'Olmo, and H. Claustre, 2020: Major role of particle fragmentation in regulating biological sequestration of CO₂ by the oceans. Science, 367, 791, http://dx.doi.org/10.1126/science.aay1790
11. Brokaw, R. J., B. Subrahmanyam, C. B. Trott, and A. Chaigneau, 2020: Eddy Surface Characteristics and Vertical Structure in the Gulf of Mexico from Satellite Observations and Model Simulations. Journal of Geophysical Research: Oceans, 125, e2019JC015538, https://doi.org/10.1029/2019JC015538
12. Chai, F., K. S. Johnson, H. Claustre, X. Xing, Y. Wang, E. Boss, S. Riser, K. Fennel, O. Schofield, and A. Sutton, 2020: Monitoring ocean biogeochemistry with autonomous platforms. Nature Reviews Earth & Environment, 1, 315-326, https://doi.org/10.1038/s43017-020-0053-y
13. Claustre, H., K. S. Johnson, and Y. Takeshita, 2020: Observing the Global Ocean with Biogeochemical-Argo. Annual Review of Marine Science, 12, 23-48, https://doi.org/10.1146/annurev-marine-010419-010956
14. D'Ortenzio, F., V. Taillandier, H. Claustre, L. M. Prieur, E. Leymarie, A. Mignot, A. Poteau, C. Penkerc'h, and C. M. Schmechtig, 2020: Biogeochemical Argo: The Test Case of the NAOS Mediterranean Array. Frontiers in Marine Science, 7, https://doi.org/10.3389/fmars.2020.00120
15. de Lavergne, C., C. Vic, G. Madec, F. Roquet, A. F. Waterhouse, C. B. Whalen, Y. Cuypers, P. Bouruet-Aubertot, B. Ferron, and T. Hibiya, 2020: A Parameterization of Local and Remote Tidal Mixing. Journal of Advances in Modeling Earth Systems, 12, e2020MS002065, https://doi.org/10.1029/2020MS002065
16. de Marez, C., X. Carton, P. L'Hégaret, T. Meunier, A. Stegner, B. Le Vu, and M. Morvan, 2020: Oceanic vortex mergers are not isolated but influenced by the β-effect and surrounding eddies. Scientific Reports, 10, 2897, https://doi.org/10.1038/s41598-020-59800-y
17. de Marez, C., T. Meunier, M. Morvan, P. L'Hégaret, and X. Carton, 2020: Study of the stability of a large realistic cyclonic eddy. Ocean Modelling, 146, 101540, https://doi.org/10.1016/j.ocemod.2019.101540
18. de Marez, C., T. Meunier, P. Tedesco, P. L'Hégaret, and X. Carton, 2020: Vortex–wall interaction on the β-plane and the generation of deep submesoscale cyclones by internal Kelvin Waves–current interactions. Geophysical & Astrophysical Fluid Dynamics, 114, 588-606, https://doi.org/10.1080/03091929.2020.1772779
19. Delpech, A., S. Cravatte, F. Marin, C. Ménesguen, and Y. Morel, 2020: Deep Eddy Kinetic Energy in the Tropical Pacific From Lagrangian Floats. Journal of Geophysical Research: Oceans, 125, e2020JC016313, https://doi.org/10.1029/2020JC016313
20. Delpech, A., S. Cravatte, F. Marin, Y. Morel, E. Gronchi, and E. Kestenare, 2020: Observed Tracer Fields Structuration by Middepth Zonal Jets in the Tropical Pacific. Journal of Physical Oceanography, 50, 281-304, https://doi.org/10.1175/JPO-D-19-0132.1
21. Desbruyères, D. G., B. Sinha, E. L. McDonagh, S. A. Josey, N. P. Holliday, D. A. Smeed, A. L. New, A. Megann, and B. I. Moat, 2020: Importance of Boundary Processes for Heat Uptake in the Subpolar North Atlantic. Journal of Geophysical Research: Oceans, 125, e2020JC016366, https://doi.org/10.1029/2020JC016366
22. Estella-Perez, V., J. Mignot, E. Guilyardi, D. Swingedouw, and G. Reverdin, 2020: Advances in reconstructing the AMOC using sea surface observations of salinity. Climate Dynamics, 55, 975-992, https://doi.org/10.1007/s00382-020-05304-4
23. Gasparin, F., M. Hamon, E. Rémy, and P.-Y. L. Traon, 2020: How Deep Argo Will Improve the Deep Ocean in an Ocean Reanalysis. Journal of Climate, 33, 77-94, https://doi.org/10.1175/JCLI-D-19-0208.1

24. Gopika, S., T. Izumo, J. Vialard, M. Lengaigne, I. Suresh, and M. R. R. Kumar, 2020: Aliasing of the Indian Ocean externally-forced warming spatial pattern by internal climate variability. Climate Dynamics, 54, 1093-1111, https://doi.org/10.1007/s00382-019-05049-9
25. Gourrion, J., T. Szekely, R. Killick, B. Owens, G. Reverdin, and B. Chapron, 2020: Improved Statistical Method for Quality Control of Hydrographic Observations. Journal of Atmospheric and Oceanic Technology, 37, 789-806, https://doi.org/10.1175/JTECH-D-18-0244.1
26. Haëntjens, N., A. Della Penna, N. Briggs, L. Karp-Boss, P. Gaube, H. Claustre, and E. Boss, 2020: Detecting Mesopelagic Organisms Using Biogeochemical-Argo Floats. Geophysical Research Letters, 47, e2019GL086088, https://doi.org/10.1029/2019GL086088
27. Hausmann, U., J. B. Sallée, N. C. Jourdain, P. Mathiot, C. Rousset, G. Madec, J. Deshayes, and T. Hattermann, 2020: The Role of Tides in Ocean-Ice Shelf Interactions in the Southwestern Weddell Sea. Journal of Geophysical Research: Oceans, 125, e2019JC015847, https://doi.org/10.1029/2019JC015847
28. Holliday, N. P., M. Bersch, B. Berx, L. Chafik, S. Cunningham, C. Florindo-López, H. Hátún, W. Johns, S. A. Josey, K. M. H. Larsen, S. Mulet, M. Oltmanns, G. Reverdin, T. Rossby, V. Thierry, H. Valdimarsson, and I. Yashayaev, 2020: Ocean circulation causes the largest freshening event for 120 years in eastern subpolar North Atlantic. Nature Communications, 11, 585, https://doi.org/10.1038/s41467-020-14474-y
29. Huang, B., M. L'Heureux, Z.-Z. Hu, X. Yin, and H.-M. Zhang, 2020: How Significant Was the 1877/78 El Niño? Journal of Climate, 33, 4853-4869, https://doi.org/10.1175/JCLI-D-19-0650.1
30. Ioannou, A., A. Stegner, T. Dubos, B. Le Vu, and S. Speich, 2020: Generation and Intensification of Mesoscale Anticyclones by Orographic Wind Jets: The Case of Ierapetra Eddies Forced by the Etesians. Journal of Geophysical Research: Oceans, 125, e2019JC015810, https://doi.org/10.1029/2019JC015810
31. Jackson, R. L., A. J. Gabric, M. T. Woodhouse, H. B. Swan, G. B. Jones, R. Cropp, and E. S. M. Deschaseaux, 2020: Coral Reef Emissions of Atmospheric Dimethylsulfide and the Influence on Marine Aerosols in the Southern Great Barrier Reef, Australia. Journal of Geophysical Research: Atmospheres, 125, e2019JD031837, https://doi.org/10.1029/2019JD031837
32. Jones, D. C., E. Boland, A. J. S. Meijers, G. Forget, S. Josey, J.-B. Sallée, and E. Shuckburgh, 2020: The Sensitivity of Southeast Pacific Heat Distribution to Local and Remote Changes in Ocean Properties. Journal of Physical Oceanography, 50, 773-790, https://doi.org/10.1175/JPO-D-19-0155.1
33. Laxenaire, R., S. Speich, and A. Stegner, 2020: Agulhas Ring Heat Content and Transport in the South Atlantic Estimated by Combining Satellite Altimetry and Argo Profiling Floats Data. Journal of Geophysical Research: Oceans, 125, e2019JC015511, https://doi.org/10.1029/2019JC015511
34. Le Corre, M., J. Gula, and A. M. Tréguier, 2020: Barotropic vorticity balance of the North Atlantic subpolar gyre in an eddy-resolving model. Ocean Sci., 16, 451-468, https://doi.org/10.5194/os-16-451-2020
35. Le Traon, P.-Y., D'Ortenzio, F., Babin, M., Leymarie, E., Marec, C., Pouliquen, S., et al. (2020). Preparing the New Phase of Argo: Scientific Achievements of the NAOS Project. Frontiers in Marine Science 7, 838. doi:10.3389/fmars.2020.577408.
36. Martinez, E., M. Rodier, M. Pagano, and R. Sauzède, 2020: Plankton spatial variability within the Marquesas archipelago, South Pacific. Journal of Marine Systems, 212, 103432, https://doi.org/10.1016/j.jmarsys.2020.103432
37. Mayot, N., P. A. Matrai, A. Arjona, S. Bélanger, C. Marchese, T. Jaegler, M. Ardyna, and M. Steele, 2020: Springtime Export of Arctic Sea Ice Influences Phytoplankton Production in the Greenland Sea. Journal of Geophysical Research: Oceans, 125, e2019JC015799, https://doi.org/10.1029/2019JC015799

38. Maze Guillaume, Balem Kevin (2020). argopy: A Python library for Argo ocean data analysis . Journal of Open Source Software , 5(33), 2425 (4p.) . Publisher's official version : https://doi.org/10.21105/joss.02425 , Open Access version : https://archimer.ifremer.fr/doc/00645/75674/
39. Meunier, T., J. Sheinbaum, E. Pallàs-Sanz, M. Tenreiro, J. Ochoa, A. Ruiz-Angulo, X. Carton, and C. de Marez, 2020: Heat Content Anomaly and Decay of Warm-Core Rings: the Case of the Gulf of Mexico. Geophysical Research Letters, 47, e2019GL085600, https://doi.org/10.1029/2019GL085600
40. Morvan, M., X. Carton, P. L'Hégaret, C. de Marez, S. Corréard, and S. Louazel, 2020: On the dynamics of an idealised bottom density current overflowing in a semi-enclosed basin: mesoscale and submesoscale eddies generation. Geophysical & Astrophysical Fluid Dynamics, 114, 607-630, https://doi.org/10.1080/03091929.2020.1747058
41. Nezlin Nikolay P., Dever Mathieu, Halverson Mark, Leconte Jean-Michel, Maze Guillaume, Richards Clark, Shkvorets Igor, Zhang Rui, Johnson Greg Accuracy and long-term stability assessment of inductive conductivity cell measurements on Argo floats . Journal of Atmospheric and Oceanic Technology, 37(12), 2209-223 . https://doi.org/10.1175/JTECH-D-20-0058.1
42. Olivier, L., Reverdin, G., Hasson, A. & Boutin, J. (2020). Tropical instability waves in the atlantic ocean: Investigating the relative role of sea surface salinity and temperature from 2010 to 2018. Journal of Geophysical Research: Oceans, 125, e2020JC016641. https://doi.org/10.1029/2020JC016641.
43. Pellichero, V., J. Boutin, H. Claustre, L. Merlivat, J.-B. Sallée, and S. Blain, 2020: Relaxation of Wind Stress Drives the Abrupt Onset of Biological Carbon Uptake in the Kerguelen Bloom: A Multisensor Approach. Geophysical Research Letters, 47, e2019GL085992, https://doi.org/10.1029/2019GL085992
44. Pinker, R. T., A. Bentamy, S. A. Grodsky, and W. Chen, 2020: Annual and seasonal variability of net heat flux in the Northern Indian Ocean. International Journal of Remote Sensing, 41, 6461-6483, https://doi.org/10.1080/01431161.2020.1746858
45. Portela, E., N. Kolodziejczyk, C. Maes, and V. Thierry, 2020: Interior Water-Mass Variability in the Southern Hemisphere Oceans during the Last Decade. Journal of Physical Oceanography, 50, 361-381, https://doi.org/10.1175/JPO-D-19-0128.1
46. Portela, E., N. Kolodziejczyk, C. Vic, and V. Thierry, 2020: Physical Mechanisms Driving Oxygen Subduction in the Global Ocean. Geophysical Research Letters, 47, e2020GL089040, https://doi.org/10.1029/2020GL089040
47. Randelhoff, A., Holding, J., Janout, M., Sejr, M. K., Babin, M., Tremblay, J.-É., et al. (2020a). Pan-Arctic Ocean Primary Production Constrained by Turbulent Nitrate Fluxes. Front. Mar. Sci. 7, 150. doi:10.3389/fmars.2020.00150.
48. Randelhoff, A., Lacour, L., Marec, C., Leymarie, E., Lagunas, J., Xing, X., et al. (2020b). Arctic mid-winter phytoplankton growth revealed by autonomous profilers. Sci Adv 6, eabc2678. doi:10.1126/sciadv.abc2678.
49. Reul, N., S. A. Grodsky, M. Arias, J. Boutin, R. Catany, B. Chapron, F. D'Amico, E. Dinnat, C. Donlon, A. Fore, S. Fournier, S. Guimbard, A. Hasson, N. Kolodziejczyk, G. Lagerloef, T. Lee, D. M. Le Vine, E. Lindstrom, C. Maes, S. Mecklenburg, T. Meissner, E. Olmedo, R. Sabia, J. Tenerelli, C. Thouvenin-Masson, A. Turiel, J. L. Vergely, N. Vinogradova, F. Wentz, and S. Yueh, 2020: Sea surface salinity estimates from spaceborne L-band radiometers: An overview of the first decade of observation (2010–2019). Remote Sensing of Environment, 242, 111769, https://doi.org/10.1016/j.rse.2020.111769
50. Roberts, M. J., L. C. Jackson, C. D. Roberts, V. Meccia, D. Docquier, T. Koenigk, P. Ortega, E. Moreno-Chamarro, A. Bellucci, A. Coward, S. Drijfhout, E. Exarchou, O. Gutjahr, H. Hewitt, D. Iovino, K. Lohmann, D. Putrasahan, R. Schiemann, J. Seddon, L. Terray, X. Xu, Q. Zhang, P. Chang, S. G. Yeager, F. S. Castruccio, S. Zhang, and L. Wu, 2020: Sensitivity of the Atlantic

Meridional Overturning Circulation to Model Resolution in CMIP6 HighResMIP Simulations and Implications for Future Changes. Journal of Advances in Modeling Earth Systems, 12, e2019MS002014, https://doi.org/10.1029/2019MS002014

51. Rosso, I., M. R. Mazloff, L. D. Talley, S. G. Purkey, N. M. Freeman, and G. Maze, 2020: Water Mass and Biogeochemical Variability in the Kerguelen Sector of the Southern Ocean: A Machine Learning Approach for a Mixing Hot Spot. Journal of Geophysical Research: Oceans, 125, e2019JC015877, https://doi.org/10.1029/2019JC015877
52. Saux Picart, S., A. Marsouin, G. Legendre, H. Roquet, S. Péré, N. Nano-Ascione, and T. Gianelli, 2020: A Sea Surface Temperature data record (2004–2012) from Meteosat Second Generation satellites. Remote Sensing of Environment, 240, 111687, https://doi.org/10.1016/j.rse.2020.11168.
53. Sauzède, R., E. Martinez, C. Maes, O. Pasqueron de Fommervault, A. Poteau, A. Mignot, H. Claustre, J. Uitz, L. Oziel, K. Maamaatuaiahutapu, M. Rodier, C. Schmechtig, and V. Laurent, 2020: Enhancement of phytoplankton biomass leeward of Tahiti as observed by Biogeochemical-Argo floats. Journal of Marine Systems, 204, 103284, https://doi.org/10.1016/j.jmarsys.2019.103284
54. Séférian, R., S. Berthet, A. Yool, J. Palmiéri, L. Bopp, A. Tagliabue, L. Kwiatkowski, O. Aumont, J. Christian, J. Dunne, M. Gehlen, T. Ilyina, J. G. John, H. Li, M. C. Long, J. Y. Luo, H. Nakano, A. Romanou, J. Schwinger, C. Stock, Y. Santana-Falcón, Y. Takano, J. Tjiputra, H. Tsujino, M. Watanabe, T. Wu, F. Wu, and A. Yamamoto, 2020: Tracking Improvement in Simulated Marine Biogeochemistry Between CMIP5 and CMIP6. Current Climate Change Reports, 6, 95-119, https://doi.org/10.1007/s40641-020-00160-0
55. Sérazin, G., F. Marin, L. Gourdeau, S. Cravatte, R. Morrow, and M. L. Dabat, 2020: Scale-dependent analysis of in situ observations in the mesoscale to submesoscale range around New Caledonia. Ocean Sci., 16, 907-925, https://doi.org/10.5194/os-16-907-2020
56. Smith, G. C., Allard, R., Babin, M., Bertino, L., Chevallier, M., Corlett, G., et al. (2019). Polar Ocean Observations: A Critical Gap in the Observing System and Its Effect on Environmental Predictions From Hours to a Season. Frontiers in Marine Science 6, 429. doi:10.3389/fmars.2019.00429.
57. Solodoch, A., J. C. McWilliams, A. L. Stewart, J. Gula, and L. Renault, 2020: Why Does the Deep Western Boundary Current “Leak” around Flemish Cap? Journal of Physical Oceanography, 50, 1989-2016, https://doi.org/10.1175/JPO-D-19-0247.1
58. Stevens, S. W., R. J. Johnson, G. Maze, and N. R. Bates, 2020: A recent decline in North Atlantic subtropical mode water formation. Nature Climate Change, https://doi.org/10.1038/s41558-020-0722-3
59. Supply, A., J. Boutin, J.-L. Vergely, N. Kolodziejczyk, G. Reverdin, N. Reul, and A. Tarasenko, 2020: New insights into SMOS sea surface salinity retrievals in the Arctic Ocean. Remote Sensing of Environment, 249, 112027, https://doi.org/10.1016/j.rse.2020.112027
60. Taillandier, V., L. Prieur, F. D’Ortenzio, M. Ribera d’Alcalà, and E. Pulido-Villena, 2020: Profiling float observation of thermohaline staircases in the western Mediterranean Sea and impact on nutrient fluxes. Biogeosciences, 17, 3343-3366, https://doi.org/10.5194/bg-17-3343-2020
61. Tchilibou, M., L. Gourdeau, F. Lyard, R. Morrow, A. Koch Larrouy, D. Allain, and B. Djath, 2020: Internal tides in the Solomon Sea in contrasted ENSO conditions. Ocean Sci., 16, 615-635, https://doi.org/10.5194/os-16-615-2020
62. von Schuckmann, K., Cheng, L., Palmer, M. D., Hansen, J., Tassone, C., Aich, V., Adusumilli, S., Beltrami, H., Boyer, T., Cuesta-Valero, F. J., Desbruyères, D., Domingues, C., García-García, A., Gentine, P., Gilson, J., Gorfer, M., Haimberger, L., Ishii, M., Johnson, G. C., Killick, R., King, B. A., Kirchengast, G., Kolodziejczyk, N., Lyman, J., Marzeion, B., Mayer, M., Monier, M., Monselesan, D. P., Purkey, S., Roemmich, D., Schweiger, A., Seneviratne, S. I., Shepherd, A., Slater, D. A., Steiner, A. K., Straneo, F., Timmermans, M.-L., and Wijffels, S. E., 2020: Heat

stored in the Earth system: where does the energy go?, Earth Syst. Sci. Data, 12, 2013–2041, https://doi.org/10.5194/essd-12-2013-2020, 2020.

63. Wong, A. P. S., S. E. Wijffels, S. C. Riser, S. Pouliquen, S. Hosoda, D. Roemmich, J. Gilson, G. C. Johnson, K. Martini, D. J. Murphy, M. Scanderbeg, T. V. S. U. Bhaskar, J. J. H. Buck, F. Merceur, T. Carval, G. Maze, C. Cabanes, X. André, N. Poffa, I. Yashayaev, P. M. Barker, S. Guinehut, M. Belbéoch, M. Ignaszewski, M. O. N. Baringer, C. Schmid, J. M. Lyman, K. E. McTaggart, S. G. Purkey, N. Zilberman, M. B. Alkire, D. Swift, W. B. Owens, S. R. Jayne, C. Hersh, P. Robbins, D. West-Mack, F. Bahr, S. Yoshida, P. J. H. Sutton, R. Cancouët, C. Coatanoan, D. Dobbler, A. G. Juan, J. Gourrion, N. Kolodziejczyk, V. Bernard, B. Bourlès, H. Claustre, F. D'Ortenzio, S. Le Reste, P.-Y. Le Traon, J.-P. Rannou, C. Saout-Grit, S. Speich, V. Thierry, N. Verbrugge, I. M. Angel-Benavides, B. Klein, G. Notarstefano, P.-M. Poulain, P. Vélez-Belchí, T. Suga, K. Ando, N. Iwasaska, T. Kobayashi, S. Masuda, E. Oka, K. Sato, T. Nakamura, K. Sato, Y. Takatsuki, T. Yoshida, R. Cowley, J. L. Lovell, P. R. Oke, E. M. van Wijk, F. Carse, M. Donnelly, W. J. Gould, K. Gowers, B. A. King, S. G. Loch, M. Mowat, J. Turton, E. P. Rama Rao, M. Ravichandran, H. J. Freeland, I. Gaboury, D. Gilbert, B. J. W. Greenan, M. Ouellet, T. Ross, A. Tran, M. Dong, Z. Liu, J. Xu, K. Kang, H. Jo, S.-D. Kim, and H.-M. Park, 2020: Argo Data 1999–2019: Two Million Temperature-Salinity Profiles and Subsurface Velocity Observations From a Global Array of Profiling Floats. Frontiers in Marine Science, 7, https://doi.org/10.3389/fmars.2020.00700
64. Zika, J. D., J. B. Sallée, A. J. S. Meijers, A. C. Naveira-Garabato, A. J. Watson, M. J. Messias, and B. A. King, 2020: Tracking the spread of a passive tracer through Southern Ocean water masses. Ocean Sci., 16, 323-336, https://doi.org/10.5194/os-16-323-2020
65. Zunino, P., H. Mercier, and V. Thierry, 2020: Why did deep convection persist over four consecutive winters (2015–2018) southeast of Cape Farewell? Ocean Sci., 16, 99-113, https://doi.org/10.5194/os-16-99-2020

Thèses (2):

1. Lee, Ke (15/12/2020),Ekman transport: a trigger of interannual extreme formation rates of Eighteen Degree Water. Université de Bretange Occidentale (co-direction : Herlé Mercier, Guillaume Maze)
2. Supply, Alexandre (17/12/2020), Étude des dessalures à la surface d'un océan stratifié à partir d'observations satellitaires et de mesures in-situ. Sorbonnes Université (direction : Jacqueline Boutin)

German National Report 2020 for the Argo Steering Team Meeting AST22

Submitted by Birgit Klein on behalf of Argo Germany

1. **The status of implementation of the new global, full-depth, multidisciplinary Argo array (major achievements and problems in 2020)**
   a. **floats deployed and their performance**

All floats deployed by Germany in 2020 were operated by BSH. Due to cancellation of cruises because of the COVID pandemic only 27 of the planned 48 German floats could be deployed. The remaining deployments had to be redirected to other ships or had to be delayed until 2021. The South African Weather Service (Tamaryn Morris) kindly accepted to store 21 of our floats on their premises to be picked up by German Ships calling into Cape Town and to be deployed on the regular South African cruises (SANAE, SAMBA, Good Hope). All deployments have been carried out on research vessels, which comprised German, Norwegian, South African and UK ships. The deployment locations for 2020 are shown in Fig. 1. All deployed floats except for one were Arvor floats with TS sensor only, one APEX float deployed in the Labrador Sea carried additional pH and O_2 sensors. In 2020 we deployed our first two floats in the Arctic proper and tested our newly developed ISA algorithm.

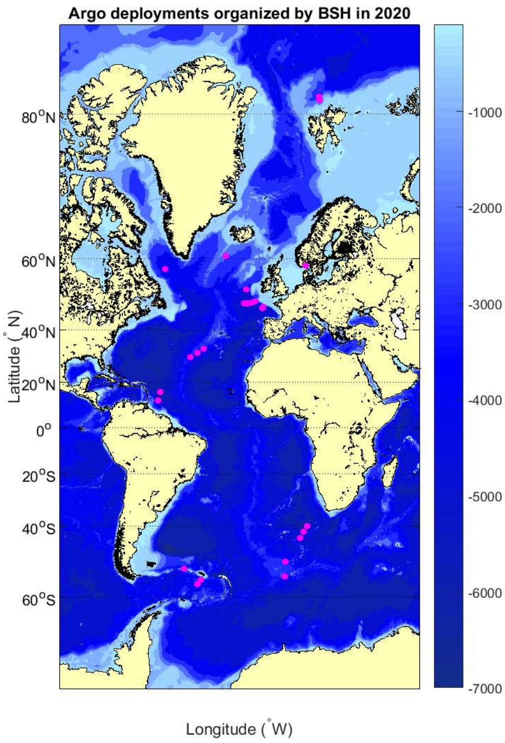


Fig. 1: Deployment positions for floats operated by BSH in 2020 in the Atlantic Ocean.

b. technical problems encountered and solved

None of our floats deployed in 2020 has experienced serious technical problems. One of our three APEX floats equipped with a pH- and O2-sensor deployed in 2018 had been malfunctioning due to a defect pressure sensor. The replacement for this float has been received and was deployed at its original location in the Labrador Sea in 2020.

c. status of contributions to Argo data management (including status of high salinity drift floats, decoding difficulties, ramping up to include BGC or Deep floats, etc.)

Germany has continued its work in the European Research Infrastructure Consortium EURO-ARGO-ERIC, which was established in July 2014. In 2020, the EuroArgo ERIC has started a joint census of floats affected by fast salinity drift at European level to estimate the effects on the data stream. Initially, the list was established on GitHub and shared as a google-docx document. The working group on fast salinity drift reported at ADMT-21 on the issue. It was decided to collect the information in a joint spreadsheet. BSH has offered to update the spreadsheet with information from all DMQC operators. The link to the spreadsheet is given below and entries can be entered either from all DMQC operators directly or be send as lists to Birgit.klein@bsh.de for inclusion in the table.

https://docs.google.com/spreadsheets/d/1TA7SAnTiUvCK7AyGtSTUq3gu9QFbVdONj9M9zAq8CJU/edit?usp=sharing

The spreadsheet has been updated with all the contributions received so far and progress will be reported at AST-22.

d. status of delayed mode quality control process

BSH had adopted floats from all German universities and agreed last year to perform similar services for the AWI floats. The status of delayed mode quality process for German floats is good. The overall percentage of D-files from all German programs is remaining at a quota of 89%. A preliminary DMQC for the subset of re-processed AWI floats (now in V3.1) has now been performed, but the submission of D-files has been postponed to increase the reference data base in the Weddell gyre which is outdated. Therefore, only 42% of the AWI files are available as D-files so far. For all other German floats (741 floats) the DMQC quota is at 95%. The census of the delayed mode quality control is given in detail in the data management report from November 2020. Additional time was spend to check files updated to format V3.1 and repeat DMQCs (if necessary), particular for old floats from the universities with BGC sensors with format inconsistencies in the older formats. Occasionally also new R-files are created during reprocessing.

BSH has also adopted floats from Finland (37 floats), the Netherlands (92 floats), Norway (58 floats) and Poland (26 floats) for DMQC and 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 the Southern Ocean. The progress in these programs providing D-files is generally good. Since Argo-Norway has received funding from the national research council to increase the number of Norwegian floats deployed per year, the program will get more involved in the DMQC activities. We organized a DMQC training workshop for Norway and Poland in 2019 and floats deployed from 2020 onward will be covered by Norwegian DMQC operators. The same is true for Argo-Poland, which already submitted D-files for their newer 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, and funding for sustaining the core mission and the enhancements: BGC, Deep, Spatial (Polar, equator, WBCs)

In 2020, we have held several meetings at government level to prepare the transition to the new multidisciplinary Argo strategy. Among these was a meeting at BMVI (Federal Ministry of Transportation and Digital Infrastructure) in February 2020, which included participation from the Federal Ministry of Science (BMBF). During the year, we have also given reports at inter-ministerial meetings in April and August. In September, we have opened budget negotiations with BMVI to increase our budget to implement both BGC and Deep contributions nationally. At the moment all our funding is for core Argo only. The aim is to switch our contribution to a mix of 36 core floats, 14 deep floats and 12 BGC floats annually. The budget proposal for 2022-2026 was approved at BMVI level but the negotiations for the national budget are presently continuing at federal level. The final decision is expected during the first half of 2022 the latest.

The Federal Ministry of Science (BMBF) has provided considerable funding in 2020 to start the transition into the new multidisciplinary strategy. The project DArgo2025 (08/2020-12/2021) received funding in 2020 for 20 floats, 15 of which are BGC floats and 5 core floats, but equipped with RBR CTDs. The proposal was submitted jointly by BSH and the newly created BGC group (GEOMAR, ICBM and IOW). Deployments of all DArgo2025 floats are scheduled for 2021 and will address open technological questions. Some of the BGC floats will carry novel sensors such as a nitrate sensors and hyperspectral sensors from the German TRIOS company. In the project C-Scope (01/2021-12/2023) additional funding has been received to promote pH measurements on floats. In 2022-2023 six floats will be upgraded with pH and O_2 sensors and a new sensor of pCO_2 will be tested.

In the context of the European Project EuroArgo-Rise the BSH has worked on a contribution for the Arctic and has developed a decision tool for selecting parameters for Ice Avoidance algorithms (ISA). Two floats from national funding were deployed in 2020 north of Svalbard.

Birgit Klein of the Federal Maritime and Hydrographic Agency (BSH) has continued to act as national leader of the Argo Germany program and is also responsible for data management of the floats. The BSH logistics related to technical aspects, float deployments and satellite data transmission are handled by Anja Schneehorst and Simon Tewes. Ingrid Angel Benavides and Corinna Jensen are involved in Argo in project related matters. For the Southern Ocean AWI has restarted its activities in float deployments including RAFOS technology. The national BGC group established in 2020 involves three research institutes: GEOMAR, ICBM and IOW. A complete list of people involved is given below.

The following people contribute to the logistics and data management for Argo Germany

Name and institution	Area of expertise
Ingrid Angel-Benavides (BSH)	Research scientist (EuroArgo Rise) and related DMQC obligations
Henry Bittig (IOW)	Research scientist (DArgo2025, C-Scope), BGC group, DMQC operator (BGC sensors)
Hendrik Bünger (ICBM)	Research engineer, BGC group, DMQC operator (BGC sensors)
Corinna Jensen (BSH)	Research scientist (DArgo2025) and related DMQC obligations
Birgit Klein (BSH)	National program lead, research scientist (DArgo2025, C-Scope, EuroArgo Rise), DMQC operator (core Argo)
Arne Körtziner (GEOMAR)	Research scientist, BGC Argo, DMQC operator (BGC sensors)
Anja Schneehorst (BSH)	Technician, float procurement, contracting, deployment logistics and performance monitoring
Tobias Steinhoff (GEOMAR)	Research scientist, BGC group, DMQC operator (BGC sensors)
Simon Tewes (BSH)	Technician, technical support, and performance monitoring
Malin Waern (IOW)	Research scientist, BGC group
Oliver Zielinski (ICBM)	Research scientist, BGC group
Olaf Boebel (AWI)	Research scientist, RAFOS technology

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.**

Because of the COVID related deployment delays in 2020 and additional floats funded by research projects the total number of floats scheduled for deployment in 2021 is nearly twice as high as usual. A total of 92 German floats is scheduled for 2021 (see figure 2) including 5 floats with RAFOS capability from AWI. Deployment opportunities come mostly from regular research cruises but also from the Atlantic Charter organized by the AST and the co-operation with the South African Weather Service. German research cruise providers have already issued a warning, that in the second half of 2021 cruises might be cancelled, and ships might need to operate to and from German ports exclusively. We are presently reviewing our agreements with PIs and will adapt our plans were necessary. The commitment table at OceanOPS (link) has been edited based on the present plans and will be modified when the situation is clearer.

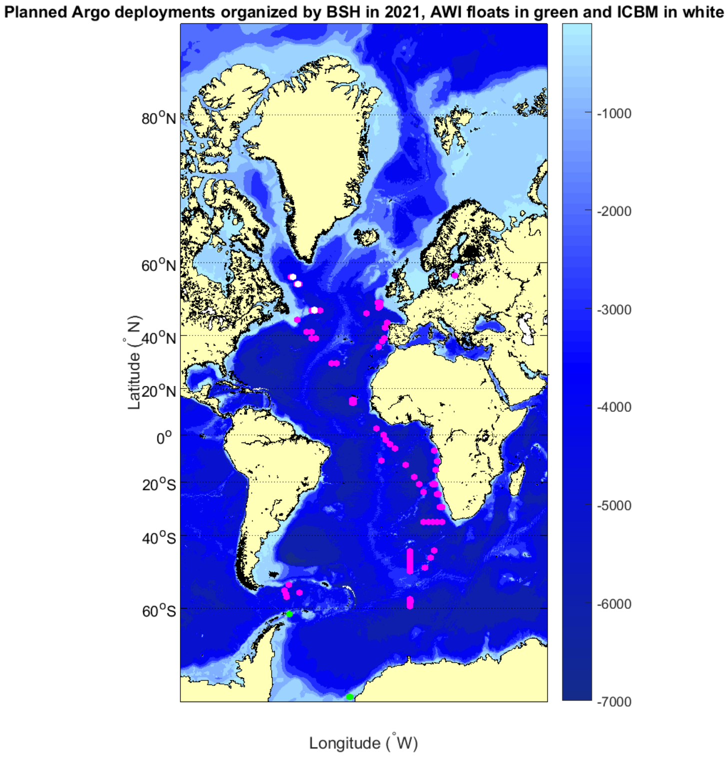


Fig. 2: Deployment positions for floats operated by BSH in 2021 in the Atlantic Ocean. Included are also the planned deployments in the Weddell Gyre by AWI (in green) and the ICBM (in white).

GER	2021						
	Total	T/S Core	T/S/O2	BGC	Bio	Deep	
Nordic Seas							
Mediterranean Sea	3				3*		
Black Sea							
Baltic Sea/North Sea	2				2		
Southern Ocean	5	5					
Arctic Ocean							
Global Ocean	82	71			11		
Total	**92**	76			16		

Table 2: German (BSH, AWI, ICBM) deployments in 2021 according to area and subprogram. * ICBM floats from the DArgo2025 project with hyperspectral sensors will be tested in the Mediterranean.

The numbers in for 2022 depend on the national budget negotiations for 2022, at minimum there will be 50 core TS floats from the operational BSH budget, 23 floats from AWI in the Southern Ocean and 3 Bio-floats from the C-Scope project. Deployment positions are not yet determined, the AWI Floats will all be deployed in the Southern Ocean and the remaining floats will go mostly to the Global Ocean.

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

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

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. Their needs are communicated by a liaison officer stationed at BSH . The SeaDataNet portal uses German Argo data operationally for the Northwest European Shelf. Argo data are routinely assimilated into the GECCO reanalysis, which is used for the initialisation the decadal prediction system MiKlip. At BSH, the data are used within several projects for data interpretation in the eastern North Atlantic and the Expert Network on climate change of the BMVI.

The annual user workshop for 2020 was cancelled due to COVID and postponed until 2021. Due to the ongoing COVID pandemic we held virtual meeting held early in 2021 on 18.02.2021. The meeting was well attended and 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 data for research applications for

BSH related projects (e.g. 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 joined recently the SOARC. Researchers from German institutions have continued to contribute recent CTD data to the Argo climatology.

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.

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.**

   BSH regularly ask PIs from our deployment cruises to provide us with any CTD profiles recorded after float deployments for calibration and comparison. These data are shared with Coriolis. A list of CTD data collected in 2020 is given below. In addition, we have collected reference data for the Arctic and performed quality checks on the soon to be released update of the global CTD reference data base.

WMO	Float type	Date	Ship / Cruise	Lat	Lon	Extra Sensors	Float ID	cast name acc. cruise report
7900576	Arvor I	29.12.2020	SA Agulhas II / SANAE	-44.015	6.760		AI2600-20DE036	
6904073	Arvor I	28.12.2020	SA Agulhas II / SANAE	-40.003	10.060		AI2600-20DE027	
6904071	Arvor I	28.12.2020	SA Agulhas II / SANAE	-42.009	8.439		AI2600-20DE029	
6904067	Arvor I	31.12.2020	SA Agulhas II / SANAE	-51.060	0.399		AI2600-20DE033	
6904068	Arvor I	31.12.2020	SA Agulhas II / SANAE	-55.032	0.006		AI2600-20DE032	
7900566	Apex	21.08.2020	RV Maria S. Merian / MSM94	57.582	-53	O2, PH	8903	MSM94_098
7900567	Arvor I	02.07.2020	RV Meteor / M164	48.368	-18.047		AI2600-20DE001	M164_028
7900568	Arvor I	01.07.2020	RV Meteor / M164	48.422	-17.038		AI2600-20DE002	M164_027
7900569	Arvor I	01.07.2020	RV Meteor / M164	48.476	-16.032		AI2600-20DE003	M164_027
7900570	Arvor I	01.07.2020	RV Meteor / M164	48.517	-15		AI2600-20DE004	M164_026
7900571	Arvor I	30.06.2020	RV Meteor / M164	48.748	-13.813		AI2600-20DE005	M164_023
7900572	Arvor I	29.06.2020	RV Meteor / M164	48.925	-12.956		AI2600-20DE006	M164_020
7900573	Arvor I	26.06.2020	RV Meteor / M164	47.383	-9.667		AI2600-20DE012	M164_001

7900539	Arvor I	15.08.2020	Navy	58.269	9.521		AI2600-20DE013	no
7900556	Arvor I	11.07.2020	RV Sonne / SO276	60.5372	-26.0482		AI2600-20DE009	SO276_099
7900557	Arvor I	19.07.2020	RV Sonne / SO276	52.367867	-17.104667		AI2600-20DE010	SO276_125
7900558	Arvor I	22.07.2020	RV Sonne / SO276	46.9737	-9.9404		AI2600-20DE011	SO276_140
7900549	Arvor I	02.10.2020	RV Kronprins Haakon / 2020706	81.03553	15.59796	ISA	AI2600-19DE044	nearby
7900550	Arvor I	02.10.2020	RV Kronprins Haakon / 2020706	81.30828	15.35910	ISA	AI2600-19DE045	nearby
7900548	Arvor I	27.02.2020	FS Meteor / M161_2	31.6705	-38.8119		AI2600-19DE028	M161_254
6900894	Arvor I	26.01.2020	FS Meteor / M161_2	12.187	-56.117617		AI2600-19DE031	M161_057
3901687	Arvor I	26.02.2020	FS Meteor / M161_2	30.0038	-41.978		AI2600-19DE033	M161_250
3901686	Arvor I	21.02.2020	FS Meteor / M161_2	15.81185	-55.2719		AI2600-19DE034	M161_239
7900538	Arvor I	28.02.2020	FS Meteor / M161_2	33.093167	-36.01955		AI2600-19DE038	M161_257
7900551	Arvor I	27.03.2020	BAS	-56.941	-38.936	ISA	AI2600-19DE039	no
7900552	Arvor I	22.03.2020	BAS	-52.9935	-44.628	ISA	AI2600-19DE040	no
7900555	Arvor I	27.03.2020	BAS	-55.948667	-37.336833	ISA	AI2600-19DE043	no

7. **Keeping the Argo bibliography (Bibliography | Argo (ucsd.edu)) 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 (Thesis Citations | Argo (ucsd.edu)). 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.

Keppler, L., Landschützer, P., Gruber, N., Lauvset, S. K., & Stemmler, I. (2020). Seasonal carbon dynamics in the near-global ocean. Global Biogeochemical Cycles, 34, e2020GB006571. doi.org/10.1029/2020GB006571 <https://doi.org/10.1029/2020GB006571>

Keppler, Lydia; Landschützer, Peter; Gruber, Nicolas; Lauvset, Siv K.; Stemmler, Irene (2020). Mapped Observation-Based Oceanic Dissolved Inorganic Carbon (DIC), monthly climatology from January to December (based on observations between 2004 and 2017), from the Max-Planck-Institute for Meteorology (MOBO-DIC_MPIM) (NCEI Accession 0221526). NOAA National Centers for Environmental Information. Dataset. https://doi.org/10.25921/yvzj-zx46

Kieke, D., K. Bulsiewicz, I. Deschepper, O. Huhn, M. Kastens, A. Kersting, M. Köllner, L. Krisztian, I. Leimann, B. Mirau, M. Moritz, N. Rohlfs, A. Schneehorst, R. Steinfeldt, I. Stendardo, J. Stiehler, and R. Tao (2020), Long-term observations of the Atlantic Meridional Overturning Circulation, Cruise No. MSM83, May 17 - June 15, 2019, Las Palmas (Spain) - St. John's (Canada). MARIA S. MERIAN-Berichte, doi:10.2312/cr_msm83 <https://doi.org/10.2312/cr_msm83> .

Nowitzki H, Rhein M, Roessler A, Kieke D, Mertens C (2021). Trends and transport variability of the circulation in the subpolar eastern North Atlantic. J. Geophys. Res. Oceans, 126, doi:10.1029/2020JC016693.
https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2020JC016693

Schmidt, H., Czeschel, R. und Visbeck, M. (2020) Seasonal variability of the Arabian Sea intermediate circulation and its impact on seasonal changes of the upper oxygen minimum zone. Open Access Ocean Science, 16 . pp. 1459-1474. DOI 10.5194/os-2020-9.

Schmidt, H., Czeschel, R. und Visbeck, M. (2019) Ventilation dynamics of the Oxygen Minimum Zone in the Arabian Sea. Open Access Biogeosciences Discussions . pp. 1-32. DOI 10.5194/bg-2019-168.

Stendardo, I., Rhein, M., & Steinfeldt, R. (2020). The North Atlantic Current and its volume and freshwater transports in the subpolar North Atlantic, time period 1993–2016. Journal of Geophysical Research: Oceans, 125, e2020JC016065. https://doi.org/10.1029/2020JC016065

Tuchen, F. P. , Lübbecke, J. F. , Brandt, P. und Fu, Y. (2020) Observed transport variability of the Atlantic Subtropical Cells and their connection to tropical sea surface temperature variability. Open Access Journal of Geophysical Research: Oceans, 125 (12). Art.Nr. e2020JC016592. DOI 10.1029/2020JC016592.

Tuchen, F. P. (2020) The Atlantic Subtropical Cells - mean state and variability from an observational perspective. Open Access (PhD/Doktorarbeit), Christian-Albrechts-Universität zu Kiel, Kiel, Germany, 101 pp. (https://macau.uni-kiel.de/receive/macau_mods_00000769)

Tuchen, F. P. , Lübbecke, J. F. , Schmidtko, S. , Hummels, R. und Böning, C. W. (2019) The Atlantic Subtropical Cells inferred from observations. Open Access Journal of Geophysical Research: Oceans, 124 (11). pp. 7591-7605. DOI 10.1029/2019JC015396.

8. **How has COVID-19 impacted your National Program's ability to implement Argo in the past year? This can include impacts on deployments, procurements, data processing, budgets, etc.**

   Nearly half of our deployments in 2020 had to be postponed and had to be shifted to 2021. Fortunately, budgets were not affected since the procurements could be finished in time in 2020, even though the delayed deliveries were rather last minute.

9. **Argo is still interested in piloting the RBR CTD. Does your National Program have any deployment plans for RBR floats in the next couple years? If so, please indicate how many floats will you be buying in 2021 and 2022 (if known) and where they might be deployed.**

BSH has just deployed a small ensemble of 5 RBR CTDs together with 5 SBE CTDs in January 2021 in the North Atlantic (Fig. 3 and 4) in the framework of the DArgo2025 project. The 10 floats were deployed in an eddy to minimize dispersion and reporting at a two-day cycle for the time being. The analysis of the data will be carried out during 2021 and a similar deployment can follow in 2022.

Fig.3: Deployment of Arvor floats equipped with RBR and SBE CTDs in January 2021 on RV Sonne cruise SO280.

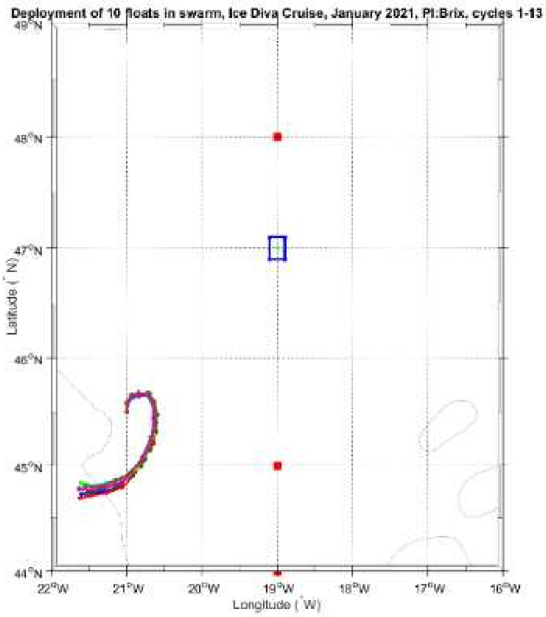


Fig. 4: Deployment positions for RBR pilot and trajectories of the swarm for the first 13 cycles.

GREEK ARGO PROGRAMME

PRESENT STATUS AND FUTURE PLANS

G. Korres and D. Kassis
HCMR
February, 2021

1. Background and organization of GREEK ARGO activities and implementation status

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 Floats deployed and their performance

During 2020, five (5) Argo floats were deployed in the Greek Seas under the framework of the Greek-Argo RI activities and the Euro-Argo RISE project. Four (4) of the floats were NOVA type purchased by the Greek Argo RI whilst, one (1) APEX 11 type float was purchased under the framework of the Euro-Argo RISE project. The floats were deployed by the Greek-Argo team in the North, Central and South Aegean basin. All floats integrate Iridium satellite telemetry system which provides a dual telecommunication capability allowing modification of the configuration in real-time. The performance of NOVA floats has not been satisfactory since one did not perform~~ed~~ any cycles and its signal was lost one day after deployment whilst, other two performed only few cycles (see Table 1). The APEX 6903288 float was deployed on the 9th of February 2020 at a deep but coastal plateau of the North Aegean under the Euro-Argo RISE project task 6.1 activities within the context of the potential of Argo to contribute on the monitoring of coastal areas. Its mission was successful with 121 valid cycles. Further information on this mission is available in the relevant deliverable of Euro-Argo RISE project (D6.2). Currently, the only active float is the NOVA 6903291 which still operates in the South Aegean area.

Table 1. Active floats and new deployments performed from Greek Argo team during 2020

A/A	Float type	WMO	IMEI NUMBER	SERIAL NUMBER	Deployment Date	Deployment time	Deployment Latitude	Deployment Longitude	Available profiles	Status
1	APEX 11	6903288	881600005135	021-3219	9/2/2020	13:50	40.40	25.40	121	Inactive
2	NOVA	6903289	300234062950200	0237	8/10/2014	20:00	37.20	23.87	15	Inactive
3	NOVA	6903290	300234061543610	0131	13/7/2016	8:00	35.75	25.10	16	Inactive
4	NOVA	6903291	300234062952200	0236	27/11/2020	15:30	35,75	25,10	16	Active
5	NOVA	6903292	300234062957190	0238	16/12/2020	12:00	39,85	24,49	0	Inactive

All floats have been integrated in the MedArgo project. The 6903288 float was configured to cycle every 2 days, drift and acquire profiles from 800 m under its special test mission. All the other floats were configured 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 Technical problems encountered and solved

Based on previous experience on platform monitoring systems, HCMR has been utilizing an automatic alerting system (http://poseidonsystem.gr/alerts/?m=2) for the monitor of basic parameters of the floats' location and data transmission. This system has been partially updated to enhance the operational monitoring needs of the 6903288 float. The automatic alerting system incorporated additional features for the real-time monitoring of crucial parameters that described the float's operation. Such are the bathymetry and the maximal depth reached by the float in order to keep track of grounding events. The alerting system is based in pre-defined thresholds and an alert message is transmitted in cases the monitored parameters overcome these thresholds. Thus, similar to the alerting messages whether there are delays or major differences in the transmission time, alert messages were sent to the PI when profiling or parking pressure was recorded to be less than 155.0 dbar.

1.3 Status of contribution to Argo infrastructure, data management and delayed mode quality control process

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 which is part of the EMSO network and has been 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.
Currently, HCMR through HIMIOFoTS national research infrastructure operates a large scale integrated infrastructure that includes all marine observational systems together with ocean engineering infrastructures.
Regarding the delayed mode data processing HCMR has a capability of a delayed-mode quality control for the Greek Argo data. The delayed mode quality control of the data delivered from the Greek Argo float are currently processed by the MedArgo data centre. HCMR considers the possibility of further developing a 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.

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

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 national RI through which the purchase of 6 floats is finalized and will cover the deployment needs for the next 2 years.

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. Since HIMIOFoTS RI ends in mid-2021, several actions have been undertaken by the Greek Argo team towards the General Secretariat of Research and Innovation (GSRI) in order the latter to contribute for the Greek Argo programme continuation and sustainability.
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 (person months/year):

- National representation, member commitments: 2.5
- Float preparation, deployments, procurements: 1

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

- Greek Argo coordination and management: 2
- Float preparation, deployments, procurements: 2
- Monitoring of the fleet performance: 2
- Data management and analysis: 3

3. Summary of deployment plans

Greece has deployment capabilities for the Aegean, the Ionian Sea and the central Levantine basin. Float deployments in 2021 will be performed according to the plans of the Greek-Argo research infrastructure. The main goal within 2021 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 2021 generally includes:

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

4. Summary of national research and use of Argo data

4.1. Operational and scientific use of Argo data

An important part 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 Euro-Argo ERIC will increase the interaction of the Greek Argo Users Group with the European and international ARGO scientific community in the near future.

Additionally, Argo data are used for educational purposes in some Greek University Departments. Due to HCMR initiatives within Euro-Argo, Greek Argo, Euro-Argo RISE, 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.

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

During 2019 the Greek Argo RI hosted the 7th Euro-Argo Science Meeting that took place in Athens on 22-23 October. The meeting has been successful and managed to bring together users of Argo data providing an opportunity for high-level science interactions. Within 2019 several dissemination activities were also 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. However, during 2020, similar activities were cancelled due to the Covid-19 situation.

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 Greek Argo and Euro-Argo Research Infrastructures, along with the Euro-Argo RISE project, are demonstrated on the POSEIDON updated web page, https://poseidon.hcmr.gr/components/observing-components/argo-floats. 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 Euro-Argo 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 Euro-Argo poster and leaflet translated in Greek and they are hosted in the POSEIDON website.

5. Greek Argo contribution to Argo bibliography

5.1 Operational oceanography and 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:

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.

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., 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

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

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

5.2 Ocean science and environmental studies

Med-Argo data are currently used by a small group of researchers in Greece for studies of water mass characteristics and climatic signals of the different deep basins of the Mediterranean Sea. The continuous record of T/S characteristics provides 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:

Kassis, D., and G. Varlas, 2020: Hydrographic effects of an intense "medicane" over the central-eastern Mediterranean Sea in 2018. Dynamics of Atmospheres and Oceans, 2020, 101185, ISSN 0377-0265, https://doi.org/10.1016/j.dynatmoce.2020.101185

Kassis, D., and G. Korres, 2020: Hydrography of the Eastern Mediterranean basin derived from argo floats profile data. *Deep Sea Research Part II: Topical Studies in Oceanography*, *171*, 104712, https://doi.org/10.1016/j.dsr2.2019.104712

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

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

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., 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

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., 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

16 National report of India (2021)

(Submitted by E. Pattabhi Rama Rao)

1. The status of implementation

1.1a Floats deployment

During the year 2020 - 21, 11 floats were deployed in the Indian Ocean, taking the total contribution to 494. The new deployments in 2020-21 include 05 Bio-Argo floats with additional sensors like Doxy, FLBB, Chl-a.

1.1b Performance Analysis of Floats deployed

Out of 494 floats deployed, 110 floats 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 had deployed 494 floats so far (till March 31, 2021). Out of these 110 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 (110) 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 by following the link:

  https://incois.gov.in/argo/argo.jsp

- **Statistics of Argo data usage**

  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.

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.

- Value added products from argo floats and many other data (fluxes, winds, satellite data products, model analysis outputs etc) are available through INCOIS Live Access Server (LAS). 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.
- 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 44% of the eligible profiles are subjected to DMQC and the delayed mode profiles are uploaded on to GDAC. Majority of the old dead float which are passed through DMQC are converted to Ver 3.1 and uploaded to GDAC

1.5 Trajectory files status:

Trajectory files in Ver 3.1 format for all APEX floats are being uploaded to GDAC and format errors wrt trajectories of PROVOR and ARVOR floats are being resolved.

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 request for the deployment of 40 Argo floats per year including (3:2 Normal and Bio), Data management activities, Data analysis, etc. for the period 2021-2026 is under consideration.

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 40 floats per year during 2021-2026. Out of 40 floats, 17 floats will be bio-argo floats. After ascertaining the gap region and cruise plan of MoES research vessels, these floats will be deployed.

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).

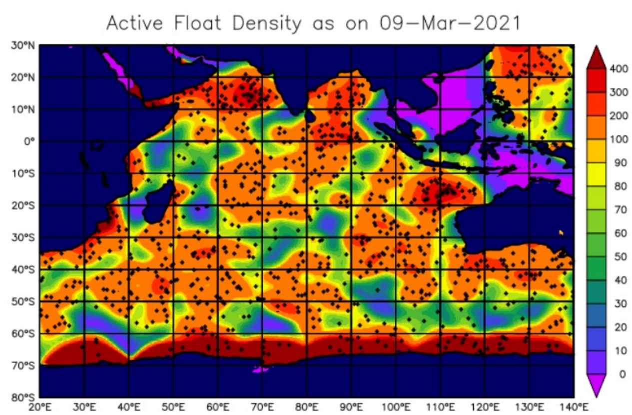
Research: Argo data are being widely used for many applications to understand the Indian Ocean dynamics, cyclone and monsoon system in relation to heat content, thermosteric component of sea level and validation of OGCM by various Indian institutions and university students.

Argo Regional Centre (ARC) - Indian Ocean

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

- 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 2.0 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.
- 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 https://incois.gov.in/argo/ANDCProducts.jsp
- Regional Co-ordination for Argo floats deployment plan for Indian Ocean. The float density in Indian Ocean as on 09 Mar, 2021 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 in 2020 resulted from Argo data which includes scientists from INCOIS and other Indian institutions are given below:

1. Akhil, V. P., J. Vialard, M. Lengaigne, M. G. Keerthi, J. Boutin, J. L. Vergely, and F. Papa, 2020: Bay of Bengal Sea surface salinity variability using a decade of improved SMOS re-processing. *Remote Sensing of Environment*, **248,** 111964, https://doi.org/10.1016/j.rse.2020.111964
2. Albert, J. and P. K. Bhaskaran, 2020: Ocean heat content and its role in tropical cyclogenesis for the Bay of Bengal basin. *Climate Dynamics*, https://doi.org/10.1007/s00382-020-05450-9
3. Ali, S. A., Z. Mao, J. Wu, X. Chen, Q. Zhu, H. Huang, F. Gong, and T. Wang, 2020: Satellite Evidence of Upper Ocean Responses to Cyclone Nilofar. *Atmosphere-Ocean*, **58,** 13-24, https://doi.org/10.1080/07055900.2019.1700097
4. Amaya, D. J., A. J. Miller, S.-P. Xie, and Y. Kosaka, 2020: Physical drivers of the summer 2019 North Pacific marine heatwave. *Nature Communications*, **11,** 1903, https://doi.org/10.1038/s41467-020-15820-w
5. Anandh, T. S., B. K. Das, J. Kuttippurath, and A. Chakraborty, 2020: A Comparative Analysis of the Bay of Bengal Ocean State Using Standalone and Coupled Numerical Models. *Asia-Pacific Journal of Atmospheric Sciences*, https://doi.org/10.1007/s13143-020-00197-z
6. Anju, M., M. G. Sreeush, V. Valsala, B. R. Smitha, F. Hamza, G. Bharathi, and C. V. Naidu, 2020: Understanding the Role of Nutrient Limitation on Plankton Biomass Over Arabian Sea Via 1-D Coupled Biogeochemical Model and Bio-Argo Observations. *Journal of Geophysical Research: Oceans*, **125,** e2019JC015502, https://doi.org/10.1029/2019JC015502
7. Dandapat, S., C. Gnanaseelan, and A. Parekh, 2020: Impact of excess and deficit river runoff on Bay of Bengal upper ocean characteristics using an ocean general circulation model. *Deep Sea Research Part II: Topical Studies in Oceanography*, **172,** 104714, https://doi.org/10.1016/j.dsr2.2019.104714
8. Dey, S. P., M. K. Dash, K. Sasmal, S. Jana, and N. J. Raju, 2020: Impact of river runoff on seasonal sea level, Kelvin waves, and East India Coastal Current in the Bay of Bengal : A numerical study using ROMS. *Regional Studies in Marine Science*, **35,** 101214

9. Francis, P. A., A. K. Jithin, J. B. Effy, A. Chatterjee, K. Chakraborty, A. Paul, B. Balaji, S. S. C. Shenoi, P. Biswamoy, A. Mukherjee, P. Singh, B. Deepsankar, S. S. Reddy, P. N. Vinayachandran, M. S. G. Kumar, T. V. S. U. Bhaskar, M. Ravichandran, A. S. Unnikrishnan, D. Shankar, A. Prakash, S. G. Aparna, R. Harikumar, K. Kaviyazhahu, K. Suprit, R. V. Shesu, N. K. Kumar, N. S. Rao, K. Annapurnaiah, R. Venkatesan, A. S. Rao, E. N. Rajagopal, V. S. Prasad, M. D. Gupta, T. M. B. Nair, E. P. R. Rao, and B. V. Satyanarayana, 2020: High-Resolution Operational Ocean Forecast and Reanalysis System for the Indian Ocean. *Bulletin of the American Meteorological Society*, **101,** E1340-E1356, https://doi.org/10.1175/BAMS-D-19-0083.1

10. Gopalakrishnan, G., A. C. Subramanian, A. J. Miller, H. Seo, and D. Sengupta, 2020: Estimation and prediction of the upper ocean circulation in the Bay of Bengal. *Deep Sea Research Part II: Topical Studies in Oceanography*, **172,** 104721, https://doi.org/10.1016/j.dsr2.2019.104721

11. Gopika, S., T. Izumo, J. Vialard, M. Lengaigne, I. Suresh, and M. R. R. Kumar, 2020: Aliasing of the Indian Ocean externally-forced warming spatial pattern by internal climate variability. *Climate Dynamics*, **54,** 1093-1111, https://doi.org/10.1007/s00382-019-05049-9

12. Jangir, B., D. Swain, S. K. Ghose, R. Goyal, and T. V. S. U. Bhaskar, 2020: Inter-comparison of model, satellite and in situ tropical cyclone heat potential in the North Indian Ocean. *Natural Hazards*, **102,** 557-574, https://doi.org/10.1007/s11069-019-03756-4

13. Jing, F., A. Chauhan, R. P Singh, and P. Dash, 2020: Changes in Atmospheric, Meteorological, and Ocean Parameters Associated with the 12 January 2020 Taal Volcanic Eruption. *Remote Sensing*, **12,** 1026, https://doi.org/10.3390/rs12061026

14. Jithin, A. K. and P. A. Francis, 2020: Role of internal tide mixing in keeping the deep Andaman Sea warmer than the Bay of Bengal. *Scientific Reports*, **10,** 11982, https://doi.org/10.1038/s41598-020-68708-6

15. Kakatkar, R., C. Gnanaseelan, and J. S. Chowdary, 2020: Asymmetry in the tropical Indian Ocean subsurface temperature variability. *Dynamics of Atmospheres and Oceans*, **90,** 101142, https://doi.org/10.1016/j.dynatmoce.2020.101142

16. Karmakar, N. and V. Misra, 2020: Differences in Northward Propagation of Convection Over the Arabian Sea and Bay of Bengal During Boreal Summer. *Journal of Geophysical Research: Atmospheres*, **125,** e2019JD031648, https://doi.org/10.1029/2019JD031648

17. Lakshmi, R. S., A. Chatterjee, S. Prakash, and T. Mathew, 2020: Biophysical Interactions in Driving the Summer Monsoon Chlorophyll Bloom Off the Somalia

Coast. *Journal of Geophysical Research: Oceans*, **125,** e2019JC015549, https://doi.org/10.1029/2019JC015549

18. Mallick, S. K., N. Agarwal, R. Sharma, K. V. S. R. Prasad, and S. S. V. S. Ramakrishna, 2020: Thermodynamic Response of a High-Resolution Tropical Indian Ocean Model to TOGA COARE Bulk Air–Sea Flux Parameterization: Case Study for the Bay of Bengal (BoB). *Pure and Applied Geophysics*, **177,** 4025-4044, https://doi.org/10.1007/s00024-020-02448-6

19. Rahaman, H., U. Srinivasu, S. Panickal, J. V. Durgadoo, S. M. Griffies, M. Ravichandran, A. Bozec, A. Cherchi, A. Voldoire, D. Sidorenko, E. P. Chassignet, G. Danabasoglu, H. Tsujino, K. Getzlaff, M. Ilicak, M. Bentsen, M. C. Long, P. G. Fogli, R. Farneti, S. Danilov, S. J. Marsland, S. Valcke, S. G. Yeager, and Q. Wang, 2020: An assessment of the Indian Ocean mean state and seasonal cycle in a suite of interannual CORE-II simulations. *Ocean Modelling*, **145,** 101503, https://doi.org/10.1016/j.ocemod.2019.101503

20. Raj, R. P., O. B. Andersen, J. A. Johannessen, B. D. Gutknecht, S. Chatterjee, S. K. Rose, A. Bonaduce, M. Horwath, H. Ranndal, K. Richter, H. Palanisamy, C. A. Ludwigsen, L. Bertino, J. E. Ø. Nilsen, P. Knudsen, A. Hogg, A. Cazenave, and J. Benveniste, 2020: Arctic Sea Level Budget Assessment during the GRACE/Argo Time Period. *Remote Sensing*, **12,** 2837, https://doi.org/10.3390/rs12172837

21. Roman-Stork, H. L., B. Subrahmanyam, and V. S. N. Murty, 2020: The Role of Salinity in the Southeastern Arabian Sea in Determining Monsoon Onset and Strength. *Journal of Geophysical Research: Oceans*, **125,** e2019JC015592, https://doi.org/10.1029/2019JC015592

22. Royston, S., B. Dutt Vishwakarma, R. Westaway, J. Rougier, Z. Sha, and J. Bamber, 2020: Can We Resolve the Basin-Scale Sea Level Trend Budget From GRACE Ocean Mass? *Journal of Geophysical Research: Oceans*, **125,** e2019JC015535, https://doi.org/10.1029/2019JC015535

23. Ruma, S. and C. Shaji, 2020: Seasonal variability and long-term trends of the surface and subsurface circulation features in the Equatorial Indian Ocean. *Environmental Monitoring and Assessment*, **191,** 810, https://doi.org/10.1007/s10661-019-7707-6

24. Sabu, P., S. A. Libera, R. Chacko, N. Anilkumar, M. P. Subeesh, and A. P. Thomas, 2020: Winter water variability in the Indian Ocean sector of Southern Ocean during austral summer. *Deep Sea Research Part II: Topical Studies in Oceanography*, **178,** 104852, https://doi.org/10.1016/j.dsr2.2020.104852

25. Shroyer, E. L., A. L. Gordon, G. S. Jaeger, M. Freilich, A. F. Waterhouse, J. T. Farrar, V. V. S. S. Sarma, R. Venkatesan, R. A. Weller, J. N. Moum, and A. Mahadevan, 2020: Upper layer thermohaline structure of the Bay of Bengal during the 2013 northeast monsoon. *Deep Sea Research Part II: Topical Studies in Oceanography*, **172,** 104630, https://doi.org/10.1016/j.dsr2.2019.07.018

26. Sridevi, B. and V. V. S. S. Sarma, 2020: A revisit to the regulation of oxygen minimum zone in the Bay of Bengal. *Journal of Earth System Science*, **129,** 107, https://doi.org/10.1007/s12040-020-1376-2

27. Sukhatme, J., D. Chaudhuri, J. MacKinnon, S. Shivaprasad, and D. Sengupta, 2020: Near-Surface Ocean Kinetic Energy Spectra and Small-Scale Intermittency from Ship-Based ADCP Data in the Bay of Bengal. *Journal of Physical Oceanography*, **50,** 2037-2052, https://doi.org/10.1175/JPO-D-20-0065.1

28. Tejas, D. M., C. Gnanaseelan, A. K. Rashmi, and J. S. Deepa, 2020: Indian Ocean Warming Trends and Forcing Mechanism with Emphasis on Northeastern Tropical Indian Ocean. *Journal of Coastal Research*, **89,** 15-19, 5, https://doi.org/10.2112/SI89-003.1

29. Thandlam, V., U. B. T.V.S, R. Hasibur, P. D. Luca, E. Sahlée, A. Rutgersson, R. M, and R. S.S.V.S, 2020: A sea-level monopole in the equatorial Indian Ocean. *npj Climate and Atmospheric Science*, **3,** 25, https://doi.org/10.1038/s41612-020-0127-z

30. Thushara, V. and P. N. Vinayachandran, 2020: Unprecedented Surface Chlorophyll Blooms in the Southeastern Arabian Sea During an Extreme Negative Indian Ocean Dipole. *Geophysical Research Letters*, **47,** e2019GL085026, https://doi.org/10.1029/2019GL085026

31. Turner, J., M. V. Guarino, J. Arnatt, B. Jena, G. J. Marshall, T. Phillips, C. C. Bajish, K. Clem, Z. Wang, T. Andersson, E. J. Murphy, and R. Cavanagh, 2020: Recent Decrease of Summer Sea Ice in the Weddell Sea, Antarctica. *Geophysical Research Letters*, **47,** e2020GL087127, https://doi.org/10.1029/2020GL087127

32. Vidya, P. J., M. Ravichandran, M. P. Subeesh, S. Chatterjee, and N. M, 2020: Global warming hiatus contributed weakening of the Mascarene High in the Southern Indian Ocean. *Scientific Reports*, **10,** 3255, https://doi.org/10.1038/s41598-020-59964-7

33. Yesubabu, V., V. K. Kattamanchi, N. K. Vissa, H. P. Dasari, and V. B. R. Sarangam, 2020: Impact of ocean mixed-layer depth initialization on the simulation of tropical cyclones over the Bay of Bengal using the WRF-ARW model. *Meteorological Applications*, **27,** e1862, https://doi.org/10.1002/met.1862

34. Zaba, K. D., D. L. Rudnick, B. D. Cornuelle, G. Gopalakrishnan, and M. R. Mazloff, 2020: Volume and Heat Budgets in the Coastal California Current System: Means, Annual Cycles, and Interannual Anomalies of 2014–16. *Journal of Physical Oceanography*, **50,** 1435-1453, https://doi.org/10.1175/JPO-D-19-0271.1

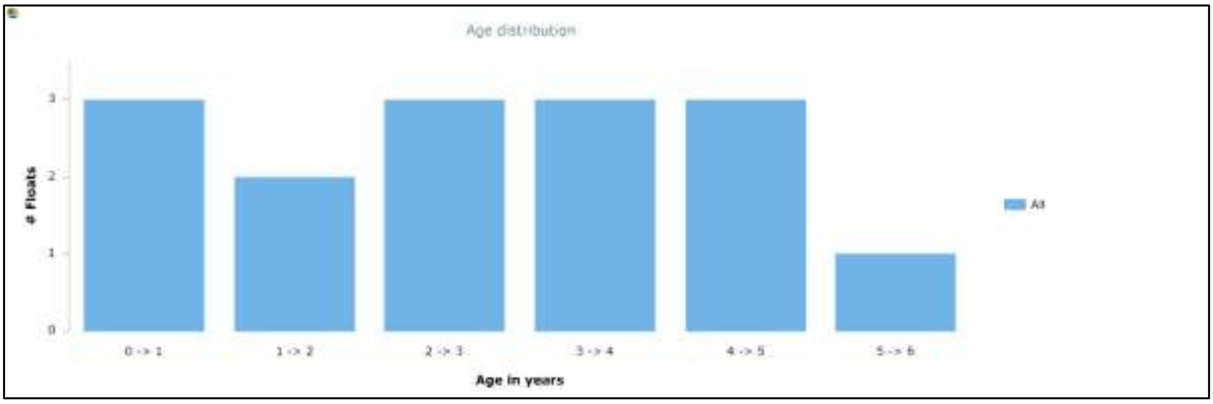
Argo National Report 2020: Ireland

1) The status of implementation (major achievements and any issues in 2020):

a) Irish Argo float Overview

In 2020, Ireland deployed a total of three Argo floats. The floats were all core T&S Arvor floats.

The Marine Institute deployed the most northerly float of its fleet in 2020. On the 5th of September 2020 float 6901937 was deployed at Lat: 74.998, Lon: -11.0933. This float was deployed by the Marine Institute research vessel RV Celtic Explorer during a month long cruise in the Greenland and Norwegian Seas. A further two floats, 6901934 and 6901035 were also deployed during the CIAAN cruise.



Above: *Age distribution of Irelands Argo Fleet.*

2020 saw the Irish fleet increase to 16 floats which is an all-time high number of profiling floats within the Irish Argo fleet. The planned deployment of a three further floats in 2021 will add considerably to the amount of data being received as well as to the research capabilities within the Irish Argo fleet. Some of the older floats in the fleet are now coming to the end of their life cycles and it is expected a number of these floats will stop transmitting in 2021.

There remains an ongoing data processing issue with regards to the data from float 6901933 which was deployed on the 28/05/2019. Work is ongoing to resolve the issue

Marine Institute Argo Float Overview (2020)					
Operational Floats (2020)					
Float	WMO #	Float Identifier	Make/ Model	Deployed	Status
1	6901919	7244	TWR/APEX	22/04/2015	OPERATIONAL
2	6901921	7243	TWR/APEX	23/03/2016	OPERATIONAL
3	6901922	7242	TWR/APEX	14/04/2016	OPERATIONAL
4	6901923	7241	TWR/APEX	09/04/2016	OPERATIONAL
5	6901924	7240	TWR/APEX	10/02/2017	OPERATIONAL
6	6901925	7841	TWR/APEX	11/02/2017	OPERATIONAL
7	6901926	7842	TWR/APEX	20/05/2017	OPERATIONAL

8	6901928	7844	TWR/APEX	12/02/2018	OPERATIONAL
9	6901929	AI2600-17EU001	NKE/ARVOR	12/02/2018	OPERATIONAL
10	6901930	AI2600-17EU002	NKE/ARVOR	27/03/2018	OPERATIONAL
11	6901931	AI2600-17EU003	NKE/ARVOR	06/12/2019	OPERATIONAL
12	6901932	AI2600-17EU004	NKE/ARVOR	29/05/2019	OPERATIONAL
13	6901933	AI2632-18EU038	NKE/ARVOR + (O2)	28/05/2019	OPERATIONAL*
14	6901934	AI2600-18EU030	NKE/ARVOR	31/08/2020	OPERATIONAL
15	6901935	AI2600-18EU032	NKE/ARVOR	10/09/2020	OPERATIONAL
16	6901937	AI2600-18EU031	NKE/ARVOR	05/09/2020	OPERATIONAL

b) Irish floats deployed in 2020 and their status.

	WMO #	Float Identifier	Make/ Model	Deployed	Status
14	6901934	AI2600-18EU030	NKE/ARVOR	31/08/2020	OPERATIONAL
15	6901935	AI2600-18EU032	NKE/ARVOR	10/09/2020	OPERATIONAL
16	6901937	AI2600-18EU031	NKE/ARVOR	05/09/2020	OPERATIONAL

c) Technical problems encountered and solved

There is an ongoing issue with processing the data being returned from Core&O2 float WMO# 6901933. 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.

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

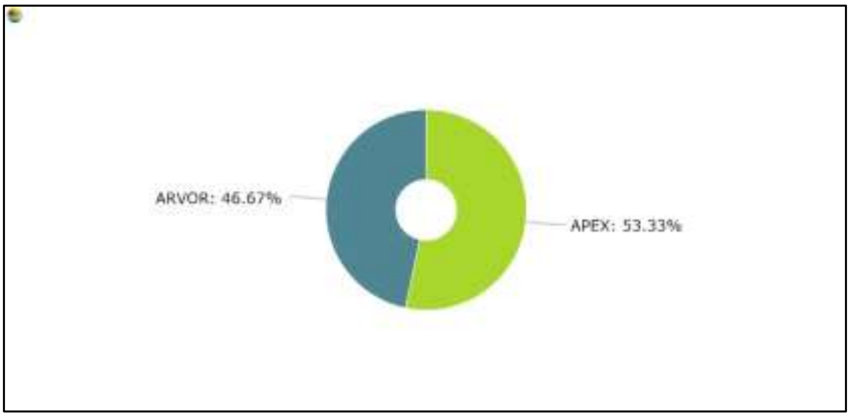
Carried out by BODC for the Marine Institute (Ireland).

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

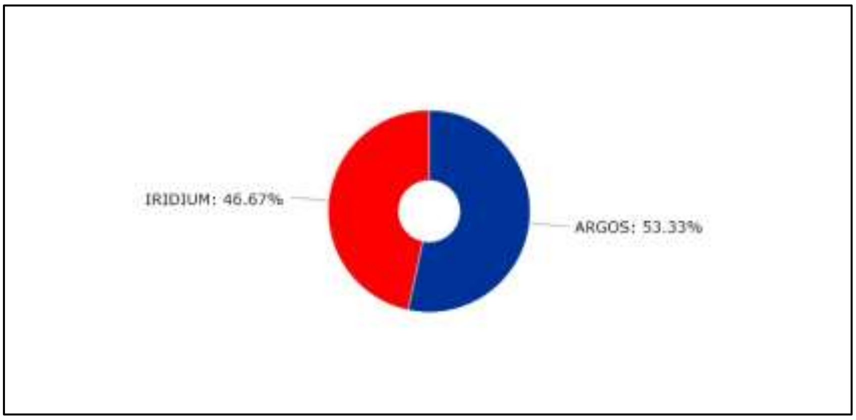
Ireland continues to be a committed member of the Euro-Argo ERIC and will comply with the minimum requirement of deploying 3 floats per annum. Ireland via the Marine Institute will deploy additional floats where funding allows and will also assist the ERIC in deploying project specific floats where appropriate.

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 2020 in alignment with the requirements of the Euro Argo ERIC. It was envisaged that 2020 would see the deployment of Ireland's first BGC sensing float. Impacts on survey schedules due to the Covid-19 pandemic did not allow for this. A new opportunity to deploy the float will be investigated in 2021. Efforts continue towards securing multi-annual funding for Ireland's Argo programme on the national level.



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



Above: *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 continue to 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 are 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 2020

1. The status of implementation of the new global, full-depth, multidisciplinary Argo array (major achievements and problems in 2020)

a. floats deployed and their performance

In total, 24 Italian floats were deployed in 2020 (see Tables 1 and 2 for details). These floats were 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 8 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 one Arvor-I float (WMO 6903784) which had short cycles of 3 h during most of their initial operating life to measure high-frequency processes in the Sicily Channel.

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

South Atlantic, South Pacific and Southern Ocean

Ten 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 Laura Bassi while sailing from New Zealand to the Ross Sea. Two Italian floats were deployed in the Ross Sea polynya. Seven floats out of 10 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 (with the exception of those in the Ross Sea polynya) were programmed to cycle between the surface and 2000 dbar every 10 days and to drift at the parking depth of 1000 dbar. The adopted configuration for the polynya area was a drifting and profiling depth of 1000 dbar and a cycling period of 5 days. The floats were still active in early 2021.

Five Italian floats were deployed in the South Atlantic Ocean in February 2020 (Table 2) with the help of Italian colleagues onboard the R/V Agulhas II. Three out of 5 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 2021.

Model	WMO	Depl. Date	Lat	Lon	Cycles	Last Date	Lat	Lon	Status*	Cyc.**
Arvor - T/S Core	6903780	14-Mar-2020 09:43	40.18	13.99	66	03-Feb-2021 06:16	41.97	10.68	A	5
Arvor - T/S Core	6903779	17-Mar-2020 11:45	41.59	10.40	66	01-Feb-2021 05:56	40.27	11.61	A	5
Arvor - T/S Diss. Oxy	6903781	25-Jun-2020 16:20	41.62	17.62	43	17-Jan-2021 06:22	42.40	17.98	A	5
Arvor - T/S Core	**6903782**	**23-Jul-2020 22:52**	**43.03**	**28.75**	**40**	**31-Jan-2021 06:06**	**43.30**	**35.96**	**A**	**5**
Arvor - T/S Core	6903784	24-Aug-2020 10:20	35.92	14.17	230	03-Feb-2021 05:56	37.19	16.92	A	5
Arvor - T/S Core	6903785	16-Sep-2020 07:26	32.95	34.77	1	17-Sep-2020 02:31	32.91	34.78	D	5
Arvor - T/S Diss. Oxy	6903786	16-Sep-2020 09:01	33.06	34.5	29	04-Feb-2021 06:16	34.04	35.21	A	5
Arvor - T/S Core	6903787	25-Oct-2020 19:23	39.81	14.12	21	03-Feb-2021 05:59	39.48	13.24	A	5
Arvor - T/S Core	6903788	28-Oct-2020 14:20	35.6	14.88	164	04-Feb/2021 05:57	35.57	17.76	A	5

**Status in early February 2021: A = active, D = dead*
***Cycle: Length of cycle in days*

Table 1. Status information for the 9 Italian floats deployed in the Mediterranean and Black Sea (bold) during 2020.

Model	WMO	Depl. Date	Lat	Lon	Cycles	Last Date	Lat	Lon	Status*	Cyc.**
Arvor-T/S Diss. Oxy	6903767	09-Jan-2020 06:36	-55.00	173.04	41	04-Feb-2021 06:14	-54.15	-148.91	A	10
Arvor-T/S Diss. Oxy	6903768	09-Jan-2020 16:39	-57.03	173.30	41	04-Feb-2021 06:08	-55.64	-169.97	A	10
Arvor-T/S ICE	6903769	10-Jan-2020 03:30	-59.03	174.61	40	05-Feb-2021 04:38	-56.48	-159.57	A	10
Arvor-T/S ICE	6903770	10-Jan-2020 13:27	-61.03	176.18	40	05-Feb-2021 11:30	-60.25	-155.24	A	10
Arvor-T/S ICE	6903771	10-Jan-2020 23:18	-63.04	177.85	40	04-Feb-2021 19:29	-60.39	-157.88	A	10
Arvor-T/S ICE	**6903772**	**28-Jan-2020 04:20**	**-77.37**	**174.56**	**99**	**16-Jan-2021 06:47**	**-75.71**	**171.10**	**A**	**5**
Arvor-T/S ICE	**6903773**	**28-Jan-2020 17:35**	**-77.20**	**169.32**	**89**	**31-Jan-2021 05:41**	**-75.26**	**163.97**	**A**	**5**
Arvor-T/S ICE	6903774	17-Feb-2020 04:12	-64.00	0.02	37	03-Feb-2021 06:18	-60.37	-9.25	A	10
Arvor-T/S ICE	6903775	17-Feb-2020 08:41	-63.00	0	37	03-Feb-2021 05:24	-64.43	-7.41	A	10
Arvor-T/S ICE	6903776	17-Feb-2020 13:56	-62.00	0	37	03-Feb-2021 06:14	-60.61	6.59	A	10
Arvor-T/S Diss. Oxy	6903777	18-Feb-2020 10:56	-60.24	0.13	37	04-Feb-2021 06:30	-58.81	6.66	A	10
Arvor-T/S Core	6903778	19-Feb-2020 19:55	-53.98	-0.02	36	05-Feb-2021 06:03	-52.93	-1.32	A	10
Arvor-T/S Core	6903789	27-Dec-2020 04:47	-57.03	173.04	5	06-Feb-2021 05:46	-56.18	174.67	A	10
Arvor-T/S ICE	6903791	28-Dec-2020 00:43	-61.03	173.16	5	07-Feb-2021 05:46	-61.91	174.71	A	10
Arvor-T/S ICE	6903790	28-Dec-2020 09:45	-63.04	173.18	5	07-Feb-2021 05:46	-65.14	-179.88	A	10

**Status in early February 2021: A = active, D = dead*
***Cycle: Length of cycle in days*

Table 2. Status information for the 15 Italian floats deployed in the Southern Ocean, South Atlantic and South Pacific during 2020. Two Arvor-I in the Ross Sea polynya (bold).

Overall status at the end of 2020

In summary, at the end of 2020, the ARGO-ITALY program had a total of 85 active floats, including 37 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 48 in the South Pacific, South Atlantic and Southern Oceans (south of 60˚S) (Figure 2).

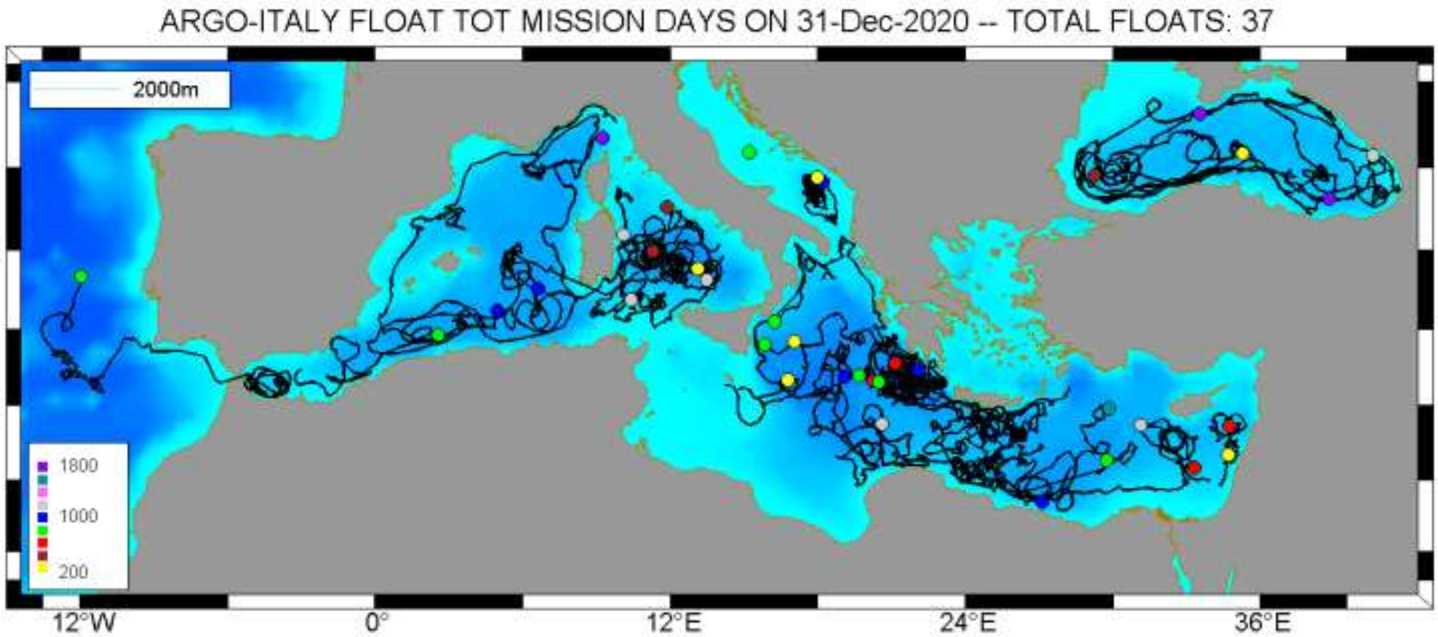


Figure 1. Trajectories and positions (circle symbols) on 31 December 2020 of the 37 ARGO-ITALY floats active in the Mediterranean and Black Sea. The circle symbols are color-coded as a function of float age in days.

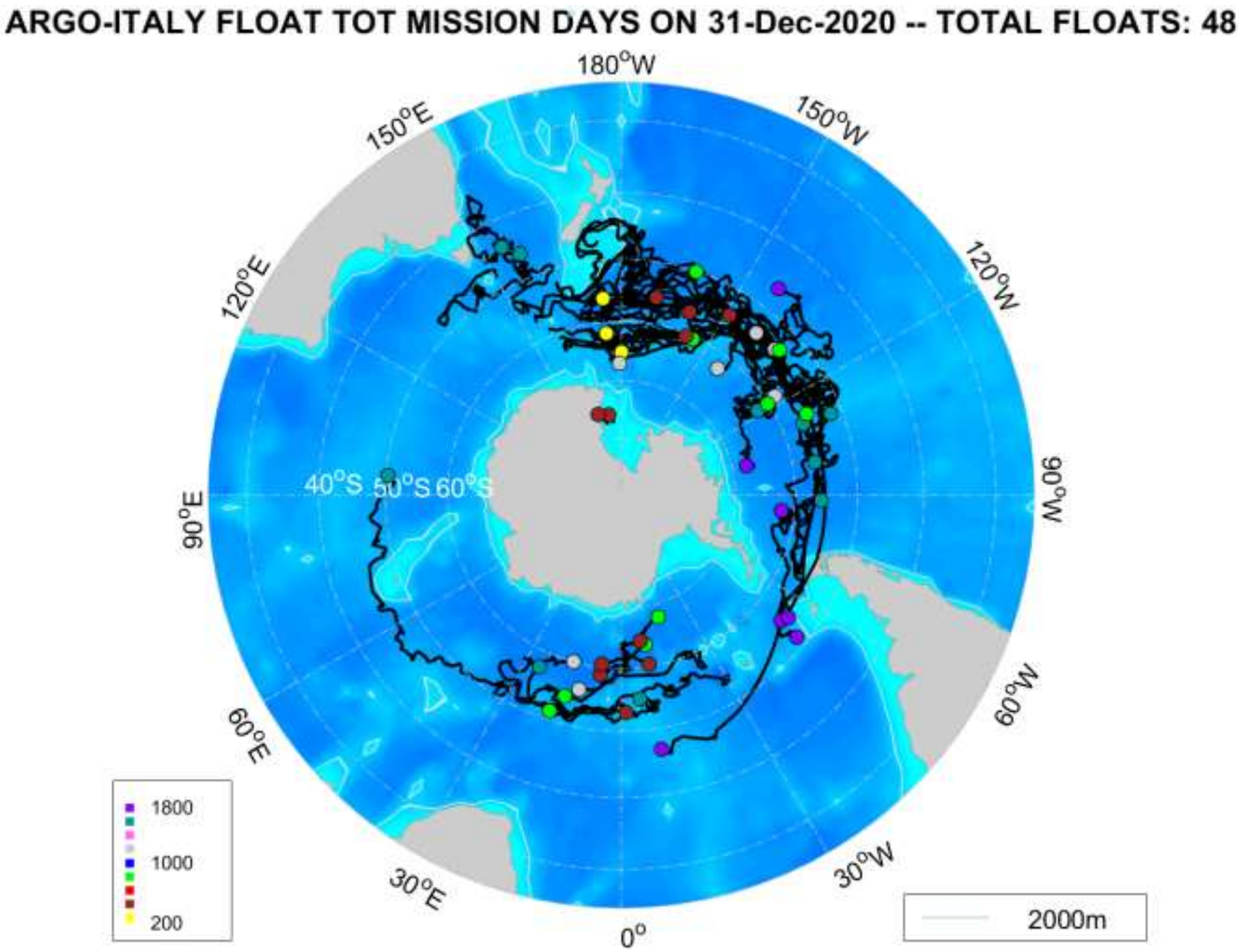


Figure 2. Trajectories and positions (circle symbols) on 31 December 2020 of the 48 ARGO-ITALY floats in the South Pacific, South Atlantic and Southern Oceans. The circle symbols are color-coded as a function of float age in days.

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 2012-2020. The float population in 2012-2020 is essentially increasing and with a maximum of 85 active instruments in 2020. In 2020, the number of deployments exceeded the number of dead floats.

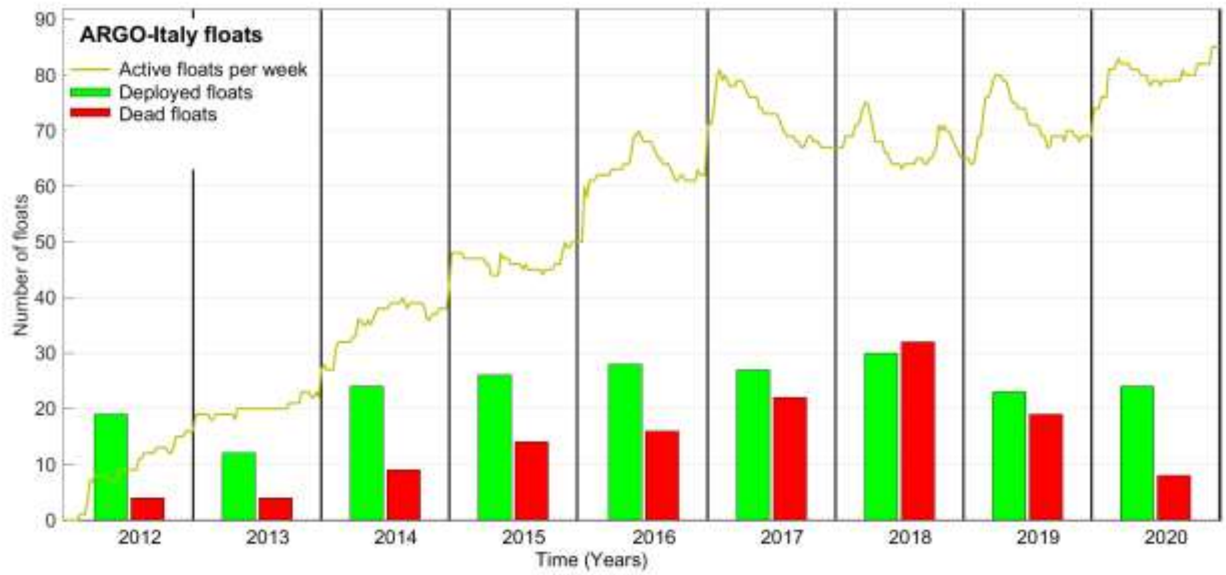


Figure 3. Temporal evolution of the number of ARGO-ITALY active floats with weekly resolution and histogram of the annual float deployments and losses.

Since 18 February 2012, a total of **213 ARGO-ITALY floats** have been deployed, 126 in the Mediterranean and Black seas, and 87 in the oceans of the Southern Hemisphere. In less than 9 years, they have provided about **28700 CTD profiles**. The histogram of the number of CTD profiles per float is shown in Figure 4. Sixtyseven floats have done more than 180 profiles. In total (during 2012-2020), ~6 % of the floats have failed just after deployment, while only one of those deployed in 2020 did not work after deployment.

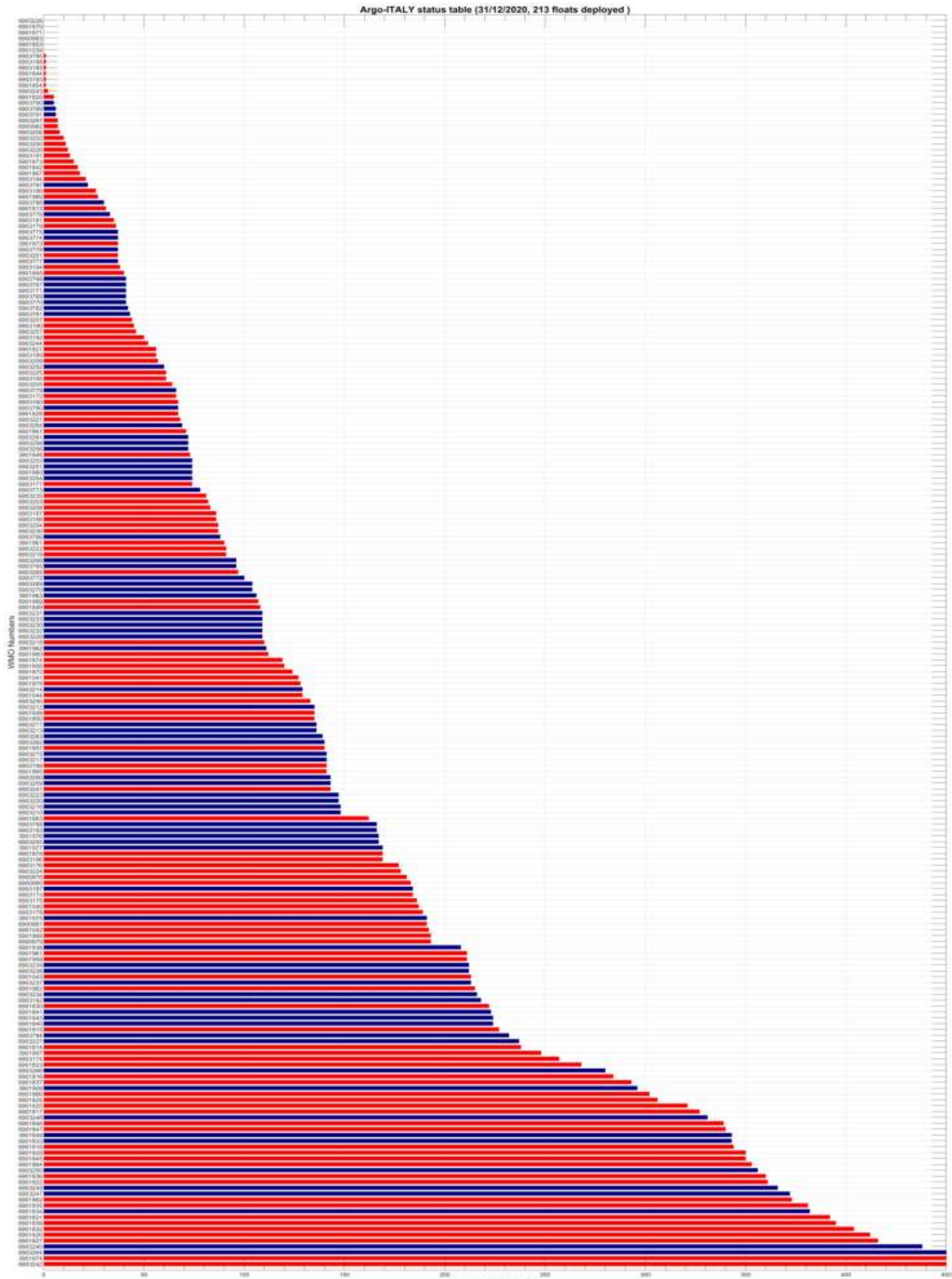

Argo-ITALY status table (31/12/2020, 213 floats deployed)
WMO Numbers
Number of CTD profiles
0
50
100
150
200
250
300
350
400
450

Figure 4. Histogram of the number of CTD profiles per float (red: dead float, blue: alive at the end of 2020).

b. technical problems encountered and solved

Mediterranean Sea

In 2020, one float stopped functioning prematurely just after the deployment. The Arvor-I float (WMO 6903785) deployed in the Levantine Sea stopped transmitting data after one cycle. The cause for this malfunction is due to the internal vacuum problem. The value was around 730 instead of the normal value of 610. The float was tested at OGS before being shipped to Israel and the internal vacuum was in the right range of values. We did not have the chance to test again the float before the deployment and we eventually lost it at sea.

c. status of contributions to Argo data management (including status of high salinity drift floats, decoding difficulties, ramping up to include BGC or Deep floats, etc)

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. The status of high salinity drift is regularly updated on the dedicated share file available at https://app.activecollab.com/186315/projects/45?modal=Task-4086-45

d. status of delayed mode quality control process

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 about 80 out of about 120 eligible 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 2010-2019. 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 45 out of about 70 eligible floats. A new delay-mode operator was hired in October 2020. She is currently under training and she will be mainly involved with floats deployed in the Mediterranean and Black Seas.

2. **Present level of and future prospects for national funding for Argo including a summary of the level of human resources devoted to Argo, and funding for sustaining the core mission and the enhancements: BGC, Deep, Spatial (Polar, equator, WBCs)**

The Italian Ministry of Research has provided funding to buy 22 floats in 2020, including 5 instruments with dissolved oxygen sensors, 8 standard T/S floats, 7 standard T/S floats with Ice Detection Algorithm implemented and 2 Deep floats with dissolved oxygen sensors. 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 2020. It is expected that the same level will be maintained in 2021, including the procurement of 16 additional standard floats, 3 bio floats and an ALAMO float. The Italian Ministry of Research is committed to provide funding in order to sustain the Italian contribution to Argo beyond 2021 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, Argo missions and extensions) and other commitments to Argo (data management) for the upcoming year and beyond where possible.**

The Italian deployment plans for 2021 and 2022 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/BIO floats		Deep floats		Total
	Quantity	Area	Quantity	Area	Quantity	Area	
2021	10 1 7	Mediterranean Black Sea South Hemisphere	1 1	Mediterranean Black Sea	2	Mediterranean	**22**
2022	10 1 10	Mediterranean Black Sea South Hemisphere	2 0	Mediterranean Black Sea	0	Mediterranean	**23**

Table 3. Italian float deployment plans for 2019-2020.

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 websites for the Italian contribution to Argo (Argo-Italy) are http://argoitaly.ogs.trieste.it/ and http://maos.inogs.it/#/projects/argo-italy. The link to the Mediterranean & Black Sea Argo Centre (MedArgo) is http://nettuno.ogs.trieste.it/sire/medargo/.

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.

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 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

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.**

7. **Keeping the Argo bibliography (Bibliography | Argo (ucsd.edu)) 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 (Thesis Citations | Argo (ucsd.edu)). 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.

8. **How has COVID-19 impacted your National Program's ability to implement Argo in the past year? This can include impacts on deployments, procurements, data processing, budgets, etc.**

   We experienced some delays related to float procurements and deployments but the impact was not too strong

9. **Argo is still interested in piloting the RBR CTD. Does your National Program have any deployment plans for RBR floats in the next couple years? If so, please indicate how many floats will you be buying in 2021 and 2022 (if known) and where they might be deployed.**

   Not planned yet

Japan National Report

(Submitted by Toshio Suga)

1. The status of implementation of the new global, full-depth, multidisciplinary Argo array (major achievements and problems in 2020)

a. Floats deployed and their performance

Japan Agency for Marine-Earth Science and Technology (JAMSTEC) deployed 25 Core Argo, Deep Argo, Biogeochemical (BGC) Argo and Argo equivalent floats from January to December 2020: 19 floats for Core Argo (APEX), 4 floats for Deep Argo (Deep APEX and Deep NINJA), 2 floats for BGC Argo (BGC-NAVIS). Since 1999, JAMSTEC had deployed 1342 Core Argo, Deep Argo, BGC Argo and Argo equivalent floats mainly in the Pacific, Indian and Southern Oceans. Because COVID-19 influenced cruse plans, the number of our float deployment was largely decreased. The current positions of all the active Japanese Argo floats are shown in Fig.1. Under the limited cruise conditions, collaboration with Japanese voluntary agencies, institutes, universities and high schools were still ongoing, enabling deployment in 12 cruises. One float was deployed by a voluntary cargo ship owned by a Japanese merchant ship company, NYK, in October 2020. 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.

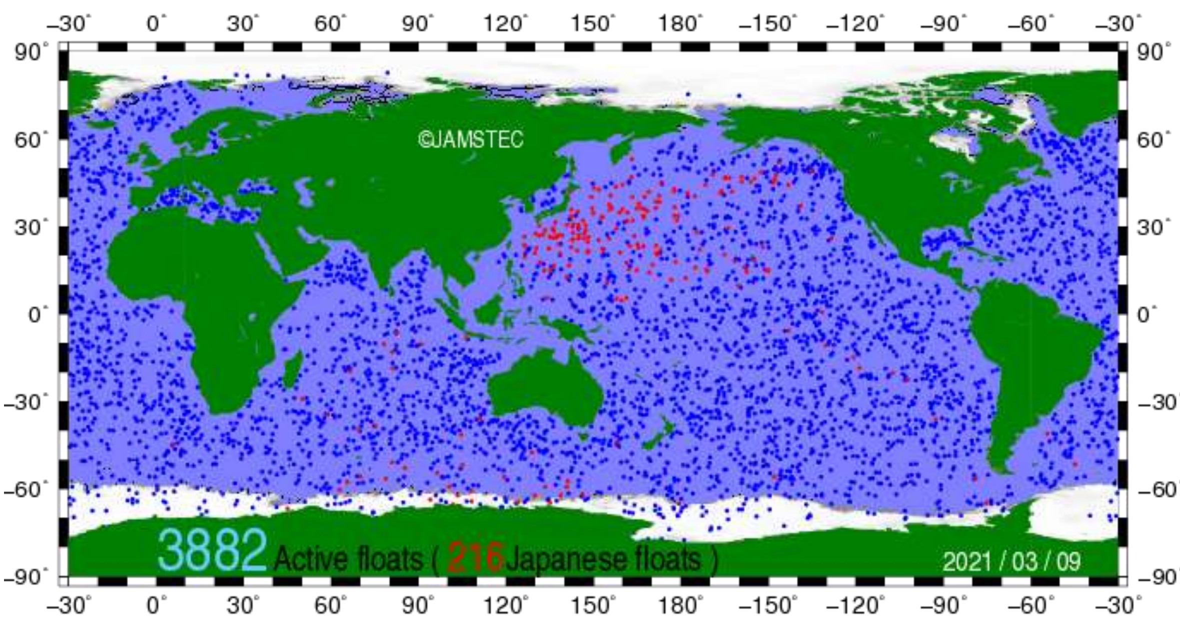


Figure 1: The distribution of active Argo floats. The red dots represent active Japanese floats.

The Japan Meteorological Agency (JMA) deployed 28 Argo equivalent floats (4 APEX floats and 24 ARVOR floats) in the seas around Japan from January to December 2020. All the floats get 2,000 dbar T/S profiles every 5 days for operational ocean analysis and forecast.

Among 342 floats (14 PROVOR, 194 APEX and 134 ARVOR floats) which JMA has deployed from 2005 to 2020, 51 floats (5 APEX floats and 46 ARVOR floats) are active as of the end of December 2020, while 30 floats (22 APEX and 8 ARVOR floats) terminated the transmission in 2020. JMA deployed 7 ARVOR floats from January to February 2021.

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 2020, 4 Deep NINJA floats were operated. In January 2020, One 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.

b. Technical problems encountered and solved

1) Float hardware troubles and updates

Three BGC NAVIS floats (F0885, F0953, and F0955) suffered hardware troubles. Two of them were missing communication of BGCi SUNA sensors, one of them was failure ballasting of float in the manufacture. The recent version of BGC NAVIS floats is mostly stable due to hardware improvements. Although those floats were over 1 year after purchasing and some got over 100 profiles regulated by the warranty policy, SBE records on the warranty list and will back to us as alternative floats.

Some of Deep APEX floats with APF11 controller recorded buoyancy control failure in technical logging file. Teledyne Webb Research, manufacturer of Deep APEX floats, has been trying to improve their firmware of APF-11 and now they mostly become stable. As warranty of the troubled float, one Deep APEX float will be delivered in this year.

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. One 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 and it had survived the Antarctic winter of 2020. The RINKO DO sensor for deep float (AROD-FT) is already available at JFE Advantech.

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.

2) New screening method for SBE41 conductivity and pressure sensors

JAMSTEC developed a new CT sensor screening system, J-Calibration, for use with the SBE41 on the Argo float and now in operation, which was introduced in the previous national report. 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. As for now, the J-Calibration has been conducted for 122 CTD sensors, we found 2 doubt C sensors and were sent back to manufacturer.

We also conduct P sensor screening using DWT. As for now 122 pressure sensors were checked and 2 failure sensors were found. The two sensors were sent back to the manufacturer for repair.

c. Status of contributions to Argo data management (including status of high salinity drift floats, decoding difficulties, ramping up to include BGC or Deep floats, etc.)

The Japan DAC, JMA has operationally processed data from all the Japanese Argo and Argo-equivalent floats including 218 active floats as of February 21, 2021. 11 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.

High salinity drift floats

Japan has 387 floats with SBE41/SBE41cp whose serial number is larger than 6000, which had been deployed since 2013. 54 floats of them had clearly high salinity drift, and 36 floats of them had differences larger than 0.05 between salinity observed by float and climatology near 2000dbar. Salinity of most of these floats started drifting from about 40-100 cycles. Four floats of them seem to have salinity drift with vertical dependency. Japanese floats with high salinity drift were all launched into the North Pacific, and about half of them were deployed in 2017. Unfortunately, the number of floats with this issue has increased by 7 in the last six months. Moreover, one Deep APEX with SBE61 has clearly high salinity drift. While about 90 active floats with SBE41/SBE41cp whose serial number is larger than 6000 and 22 active Deep APEX floats have not suffered from this issue, we continue to monitor salinity data of Japanese floats for detecting floats with high salinity drift and understanding features of high salinity drift found in floats. We have shared 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.

We checked status of PSAL_QC flag for profiles with remarkable high salinity drift (hereafter, FSD) in the global ocean for several years. We confirmed that PSAL_QC flags of them are mostly 4 in the whole profile (Profile_PSAL_QC='F'). It means that Argo data processing of DACs and DMQC is working well. The rate of profiles whose Profile_PSAL_QCs are 'F' to all profiles measured in each year has increased by about 15% in 2020. Such profiles are globally distributed and have no regional bias. We inferred whether the profile with Profile_PSAL_QC of F will increase in the future or not, by checking the number of cycles of active floats. Once float has FSD, it cannot be restored. Therefore, when Profile_PSAL_QC of the latest cycle of a float is 'F', it is suspected that the float suffers from FSD. The number of active floats with the latest cycle between 150 and 160 is the largest in the number of active floats suspected to suffer from FSD (Fig. 1). This peak matches the average cycle of floats (Fig. 1). If the number of floats suffer from FSD do not increase, the number of profiles with Profile_PSAL_QC of 'F' may peak now and decrease in the future. However, it is possible that active floats will newly suffer from FSD, because the latest cycles of active floats with SBE41CP whose SNs are under 11250 are less than 100. The situation that the rate of profiles whose Profile_PSAL_QCs are 'F' to all profiles measured in each year has increased by about 15% is expected to continue.

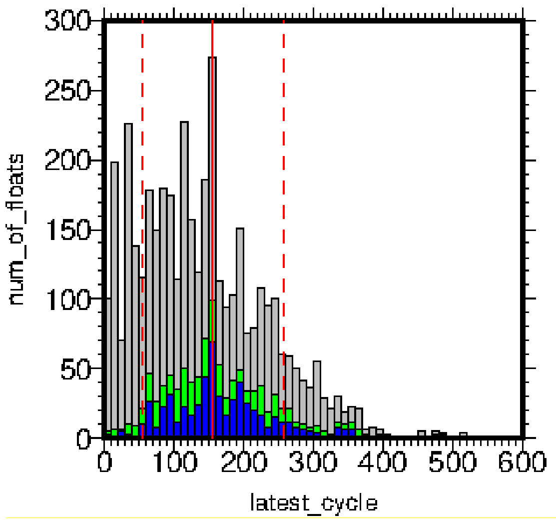


Figure 2: Histogram of number of active floats by the latest cycles. Gray denotes floats not suffering from FSD, blue denotes floats suspected to suffers from FSD, and green denotes floats whose Profile_PSAL_QC of the latest cycle is not 'F' but have past experience of Profile_PSAL_QC of 'F'. Red line and red dashed line denote mean average cycle and width of its standard deviation, respectively, calculated by using inactive floats' information.

d. Status of delayed mode quality control process

JAMSTEC has submitted the delayed-mode QCed Core data (P, T, and S) of 202,830 profiles to GDACs as of December 2020. JAMSTEC had submitted D-Core files of 15,943 profiles in 2020.

2. Present level of and future prospects for national funding for Argo including a summary of the level of human resources devoted to Argo, and funding for sustaining the core mission and the enhancements: BGC, Deep, Spatial (Polar, equator, WBCs)

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 FY2020, 25 Argo floats were deployed, including 19 Core, 4 Deep and 2 BGC floats, following JAMSTEC's research purposes. In FY2021, the level of human resources for Argo deployment and QC is decreased from 4 to 3 including temporal staff. Deployment plan for Core, Deep and BGC Argo in FY2021 is not yet fixed but will be decided soon. JMA allocates operational budget for 27 floats in FY2021.

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

To maintain Core Argo array and to achieve its research purposes, JAMSTEC will deploy 20 floats mainly in the North Pacific, including 2 Deep and 3 BGC Argo in FY2021.

A "hot-spot" research team of special research fund "Grant- in Aid for Scientific Research in Innovative Area", being supported by JSPS KAKENHI, 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. Already 9 of them have been successfully deployed and now in healthy operation.

JMA plans to deploy 27 Argo equivalent floats (12 floats are deployed in western boundary region) around Japan in FY2021 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
*** Please also include any links to national program Argo web pages to update links on the AST and AIC websites.**

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, 10 day mean and monthly products of subsurface temperatures and currents for the seas around Japan and North Pacific, based on the output of the real-time ocean data assimilation system (MOVE/MRI.COM-JPN), are distributed through the JMA web site (in Japanese). MOVE/MRI.COM-JPN replaced the previous version (MOVE/MRI.COM-WNP) in October 2020 and numerical outputs of the new system will be available from the NEAR-GOOS Regional Real Time Data Base (https://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. JAMSTEC mainly operates PARC, and will construct a new PARC website soon as the mentor of the Pacific Ocean. Float PIs and DMQC operators can exchange various information about deployment and technical information, data quality of floats, DMQC, scientific products, etc. to improve status of the Pacific Argo array.

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 04a in April 2020 to cover 58‐year period during 1957‐2014 (See the web site in JAMSTEC, http://www.godac.jamstec.go.jp/estoc/e/top/). Version 04a added two observational elements of ocean mixing and geothermal heating. Deep and BGC float data can be assimilated into the system after 2016. We plan to release a 60‐year state estimation (version 4b) within 2021. Some scientific papers related to the ESTOC were published (e.g., Osafune et al, 2020, Masuda and Osafune 2021).

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 28 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.

JCOPE-T DA , a downscaled version of JCOPE2M, has been recently developed by collaboration of JAMSTEC and JAXA . It is designed for real-time (daily-basis) assimilation of satellite and in-situ data including the Argo data and 10-day lead forecast updated every day. The latest available forecast information is available from: https://www.eorc.jaxa.jp/ptree/ocean_model/index.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
*** 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.**

As reported in 2011, EEZ clearance procedure for Argo float deployed had been simplified following IOC Resolution XLI-4. This change reduced our time and effort for the process of EEZ clearance. 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, especially about the southern islands in the Pacific Ocean. This could be also helpful for smooth implementation of any future extension of Argo.

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.

After the last upload of CTD data to the CCHDO website in January 2020, which was included in the last national report, we didn’t upload any data, unfortunately.

7. Outreach activity

JAMSTEC sent an appreciation letter to schools, commercial company and institutes for contribution to Argo float deployments by voluntary ships. JAMSTEC deployed lots of Argo floats since the Argo project was started, in cooperation with voluntary ships, which is quite essential to achieve the Argo array in the North Pacific Ocean. Over 20 years after starting Argo, we presented the letter to thank and construct further collaborative relationship.

Also, JAMSTEC carried out lectures of Argo and related ocean research and investigation to high school and elementary school students , gathering in the JAMSTEC Mutsu blanch in Aomori Prefecture. At the end of the lectures, they wrote messages on the ocean environment and expectations for Argo float on float body (Fig.3). One of the floats had been deployed from Hakuho cruise in late winter, another will be deployed from Mirai cruise this summer.

Figure 3: (Upper) Writing messages on Argo float by high school students. (Lower) Deployment from Hakuho maru in Feb. 2021.

8. Argo bibliography

(1) Articles

Kobayashi, T. (2021), **Salinity bias with negative pressure dependency caused by anisotropic deformation of CTD measuring cell under pressure examined with a dual-cylinder cell model**, *Deep-Sea Research Part-I*, 167, 103420, https://doi.org/10.1016/j.dsr.2020.103423.

Horii, T., I. Ueki, and K. Ando (2020), **Coastal upwelling events, salinity stratification, and barrier layer observed along the southwestern coast of Sumatra**, *Journal of Geophysical Research: Oceans*, 125[12], 10.1029/2020JC016287.

Kobashi, F., T. Nakano, N. Iwasaka, and T. Ogata (2020), **Decadal-scale variability of the North Pacific subtropical mode water and its influence on the pycnocline observed along 137°E**, *Journal of Oceanography*, 10.1007/s10872-020-00579-x.

Sugimoto, S., B. Qiu, and A. Kojima (2020), **Marked coastal warming off Tokai attributable to Kuroshio large meander**, *J. Oceanography*, 141-154, 76[2], doi:10.1007/s10872-019-00531-8.

Sugiura, N., S. Kouketsu, S. Masuda, S. Osafune, and I. Yasuda (2020), **Estimating the population mean for a vertical profile of energy dissipation rate**, *Scientific Reports* , 10, 10.1038/s41598-020-77414-2.

Motoki Nagura (2020), **Variability in Meridional Transport of the Subtropical Circulation in the South Indian Ocean for the Period From 2006 to 2017**, *Journal of Geophysical Research: Oceans*, e2019JC015874, 124, https:// doi.org/10.1029/2019JC015874.

Takeshi Doi, Swadhin Behera, Toshio Yamagata (2020), **Wintertime Impacts of the 2019 Super IOD on East Asia**, *Geophysical Research Letters*, https://doi.org/10.1029/2020GL089456.

Takeshi Doi, Swadhin Behera, Toshio Yamagata (2020), **Predictability of the Super IOD Event in 2019 and Its Link With El Ni?o Modoki**, *Geophysical Research Letters*, https://doi.org/10.1029/2019GL086713.

Nozomi Sugiura, Shigeki Hosoda (2020), **Machine learning technique using the signature method for automated quality control of Argo profiles**, *Earth and Space Science*, e2019EA001019, 7[9], 10.1029/2019EA001019.

Annie P. S. Wong, Susan Elizabeth Anne Wijffels, Stephen C Riser, Sylvie Pouliquen, Shigeki Hosoda, Dean Roemmich, John Gilson, Gregory C Johnson, Kim Martini, Dave J Murphy, Megan Scanderbeg, TVS Udaya Bhaskar, Justin James Henry Buck, Frederic Merceur, Thierry Carval, Guillaume Maze, C?cile Cabanes, Xavier Andr?, No? Poffa, Igor Yashayaev, Paul Barker, St?phanie Guinehut, Mathieu Belb?och, Mark Ignaszewski, Molly O'Neil Baringer, Claudia Schmid, John M. Lyman, Kristene E. McTaggart, Sarah Purkey, Nathalie Zilberman, Matthew Buckley Alkire, Dana Swift, W. Brechner Owens, Steven Robert Jayne, Cora Hersh, Pelle Robbins, Deb West-Mack, Frank Bahr, Sachiko Yoshida, Philip John Sutton, Romain Cancou?t, Christine Coatanoan, Delphine Dobbler, Andrea Garcia Juan, Jer?me Gourrion, Nicolas Kolodziejczyk, Vincent Bernard, Bernard Bourl?s, Herv? Claustre, Fabrizio D'ortenzio, Serge Le Reste, Pierre-Yves Le Traon, Jean-Philippe Rannou, Carole Saout-Grit, Sabrina Speich, Virginie Thierry, Nathalie Verbrugge, Ingrid M. Angel-Benavides, Birgit Andrea Klein, Giulio Notarstefano, Pierre-Marie Poulain, Pedro V?lez-Belch?, Toshio Suga, Kentaro Ando, Naoto Iwasaska, Taiyo Kobayashi, Shuhei Masuda, Eitarou Oka, Kanako Sato, Tomoaki Nakamura, Katsunari Sato, Yasushi Takatsuki, Takashi Yoshida, Rebecca Cowley, Jenny L Lovell, Peter R. Oke, Esmee Van Wijk, Fiona Carse, Matthew Donnelly, W. John Gould, Katie Gowers, Brian A King, Stephen Gordon Loch, Mary Mowat, Jonathan David Turton, E. Pattabhi Rama Rao, M Ravichandran, Howard J. Freeland, Isabelle Gaboury, Denis Gilbert, Blair John William Greenan, Mathieu Ouellet, Tetjana Ross, Anh Tran, Mingmei Dong, Zenghong Liu, Jianping Xu, Kiryong Kang, Hyeongjun Jo, Sung-Dae Kim, Hyuk-Min Park (2020), **Argo data 1999-2019: two million temperature-salinity profiles and subsurface velocity observations from a global array of profiling floats**, *Frontier in Marine Science: Review*, doi: 10.3389/fmars.2020.00700.

Yoshimi Kawai, Shigeki Hosoda, Kazuyuki Uehara, Toshio Suga (2020), **Heat and salinity transport between the permanent pycnocline and the mixed layer due to the obduction process evaluated from a grided Argo dataset**, *Journal of Oceanography*, Accepted.

R. Mugo, S. Saitoh, H. Igarashi, T. Toyoda, S. Masuda, T. Awaji, Y. Ishikawa (2020), **Identification of skipjack tuna (Katsuwonus pelamis) pelagic hotspots applying a satellite remote sensing-driven analysis of ecological niche factors: a short-term run**, *PROS ONE*, Accepted .

K. Yamazaki, S. Aoki, K. Shimada, T. Kobayashi, Y. Kitade (2020), **Structure of the Subpolar Gyre in the Australian-Antarctic Basin Derived From Argo Floats**, *Journal of Geophysical Research: Oceans*, 125[8], 10.1029/2019JC015406.

Motoki Nagura (2020), **Variability in meridional transport of the subtropical circulation in the south Indian Ocean for the period from 2006 to 2017.**, *Journal of Geophysical Research: Oceans*, https://doi.org/10.1029/2019JC015874.

Sasaki, H., B. Qiu, P. Klein, Y. Sasai, M. Nonaka (2020), **Interannual to Decadal Variations of Submesoscale Motions around the North Pacific Subtropical Countercurrent**, *Fluids*, 116, 5[3], https://doi.org/10.3390/fluids5030116.

Oka, E., S. Kouketsu, D.Yanagimoto, D.Ito, Y.Kawai, S.Sugimoto and B.Qiu (2020), **Formation of Central Mode Water based on two zonal hydrographic sections in spring 2013 and 2016**, *J.Oceanogr*, https://doi.org/10.1007/s10872-020-00551-9.

Katsura, S. and J. Sprinall (2020), **Seasonality and Formation of Barrier Layers and Associated Temperature Inversions in the Eastern Tropical North Pacific**, *Journal of Physical Oceanography*, DOI: 10.1175/JPO-D-19-0194.1.

Yuma Kawakami, Yoshiteru Kitamura, Toshiya Nakano, Shusaku Sugimoto (2020), **Long-term Thermohaline Variations in the North Pacific Subtropical Gyre From a Repeat Hydrographic Section Along 165°E**, *Journal of Geophysical Research: Oceans*, 125[1], 10.1029/2019JC015382.

Earl R. Duran, Helen E. Phillips, Ryo Furue, Paul Spence, Nathaniel L. Bindoff (2020), **Southern Australia Current System based on a gridded hydrography and a high-resolution model**, *Progress in Oceanography*, 181, 10.1016/j.pocean.2019.102254.

Wagawa, T., Y. Kawaguchi, Y. Igeta, N. Honda, T. Okunishi, and I.Yabe (2020), **Observations of oceanic fronts and water-mass properties in the central Japan Sea**, *Repeated surveys from a glider*. *J. Mar. Sys.*, 201, https://doi.org/10.1016/j.jmarsys.2019.103242.

Katsura, S., H. Ueno, H. Mitsudera, S. Kouketsu (2020), **Spatial Distribution and Seasonality of Halocline Structures in the Subarctic North Pacific**, *Journal of Physical Oceanography*, 95-109, 50[1], 10.1175/JPO-D-19-0133.1.

(2) Doctorate thesis

Shoichiro Kido (2020), **Mechanisms and impacts of salinity anomalies associated with the positive Indian Ocean Dipole**, Doctorate Thesis, The University of Tokyo.

8. How has COVID-19 impacted your National Program's ability to implement Argo in the past year? This can include impacts on deployments, procurements, data processing, budgets, etc.

Due to COVID-19, many cruise plans are cancelled or modified, strongly affected for JAMSTEC's deployment plan. Because of these troubles, about a half of float deployments were cancelled, which forced the number of float deployments were decreased.

From April 2020, JAMSTEC controlled the number of researchers and technicians working at office and forced to stay at home. Due to the change of work style within short time, data processing and dmqc operations were delayed for several months. This makes us the number of dmqc data submission to be decreased.

9. Argo is still interested in piloting the RBR CTD. Does your National Program have any deployment plans for RBR floats in the next couple years? If so, please indicate how many floats will you be buying in 2021 and 2022 (if known) and where they might be deployed.

JAMSTEC does not have any plan to deploy RBR Argo float at this time. However, we strongly concern to gather further RBR data and will continuously submit the data obtained from 3 active floats with RBR CTD.

Argo-KOREA Annual Report 2020

by the National Inst. of Meteorological Sciences/KMA

22nd Argo Steering Team Meeting (AST-22)
Virtual, 22-26 March 2021

1. Status of Implementation

In 2020, The National Institute of Meteorological Sciences of Korea Meteorological Administration (NIMS/KMA) deployed 6 Argo floats in the East Sea and Yellow Sea (Fig.1). Four floats were deployed in the East Sea on November 15, 2020 with 800 m of parking depth and seven-day profiling scheme, and two floats were deployed in the Yellow Sea on November 10, 2020, for the shallow sea observation with two-day profiling scheme and 60 m of parking depth. Especially all deployment processes were carried out by the KMA'a research vessel, called GISANG1, and temperature and salinity profiles were successfully obtained from the starting day in the Yellow Sea and the East Sea. In addition, the NIMS/KMA has deployed 253 Argo floats around the Korea peninsula and the Northwestern Pacific Ocean since 2001, and 18 floats are in acting as of March 2021.

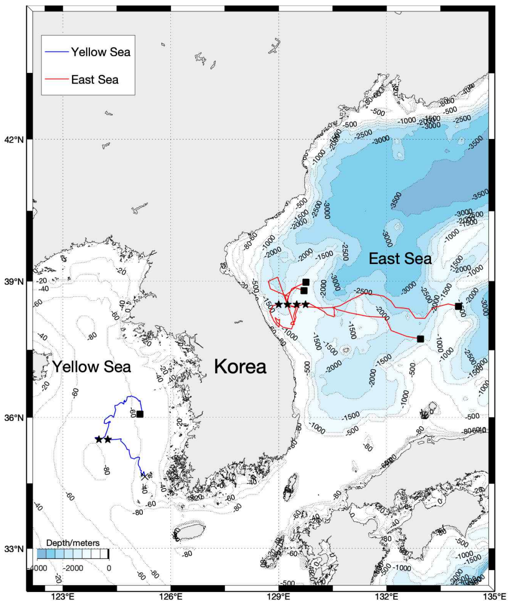


Fig. 1. Deployment position and moving track of Argo floats deployed by the NIMS/KMA in 2020. Stars: initial position, Squares: acting, Cross-symbol: inacting.

a. Status of contributions to Argo data management

A prototype of quality control process for the shallow sea (Yellow Sea) was developed, and tested it on 793 profiles observed from September 2017 to July 2020. We used OW version 1.1.2 (the same OW version used in the East Sea and the Northwestern Pacific), with new reference data-base and new parameters. Since the shallow sea is prone to change its distinctive salinity characteristic every season, only shipboard CTD data collected at the similar time and location were used for OW. The DMQC prototype will be tested for the shallow sea data and the processed D-files will be sent to the GDAC by next year. We also have done MEDD test for profile data from the East Sea and the Northwestern Pacific area.

b. Delayed Mode QC

We completed DMQC operation on 1,875 profiles (1,524 from the East Sea and 351 profiles from the western North Pacific), which had been observed until early July 2020. The profile data formatted by NETCDF had been sent to the Ifremer GDAC on November 19, 2020. However, we found that 22,477 D-files submitted to the Ifremer GDAC in 2018-2019 had not been updated successfully. We are keeping closely in touch with the Ifremer, and will fix this issue soon.

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

The NIMS/KMA Argo program has been funded by the Korea government since 2001. We purchased 6 floats in 2020 and successfully deployed all around Korea peninsular this year, and the funding in 2021 would be same scale and purchasing 6 floats.

Following persons contribute to the Argo-Korea program:

- KiRyong KANG, Hyeong-Jun JO (KMA)
- Sung-Dae KIM, Hyuk-Min PARK (KIOST)
- Jong-Jin PARK, Min-Ji Park (Kyungpook National University)

3. Summary of deployment plans

The NIMS/KMA has a deployment plan in 2021: two floats for the East Sea to keep the observation network, two floats for the Yellow Sea to continue the shallow sea observation, and two for near Jeju Island to monitoring low salinity issue from the Changjiang diluted water especially during the summer season (Fig. 2). Continuing same deployment scheme in the Yellow Sea and East Sea will help keeping regular observation network to investigate the long-term oceanic environment variation in this area. The summer low salinity issue near Jeju Island has affected seriously on the aquaculture industry, which requires time series of salinity profiles off southwest of Jeju Island.

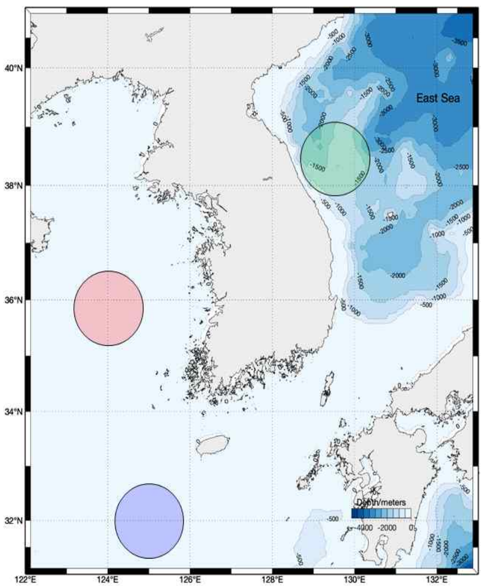


Fig. 2 Area map of Argo floats deployment in 2021 by the NIMS/KMA

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

There were three Argo floats activated in 2020 in the Yellow sea. Even there were two floats deployed in 2020, there was one more float (ID 2901797) which was deployed in 2019 and lasted 480 days from Nov. 8, 2019. It is a surprising result since the expected life span of this case was about 240-300 days.

The NIMS/KMA upgraded the operational Argo web page (http://argo.nims.go.kr) in 2020. It included the trajectory of float based on the Google dynamic map, temperature and salinity profile data and status of floats showing vertical profile and T-S diagram (Fig. 3). It has shown **39,903 hits** by visitors in monthly average.

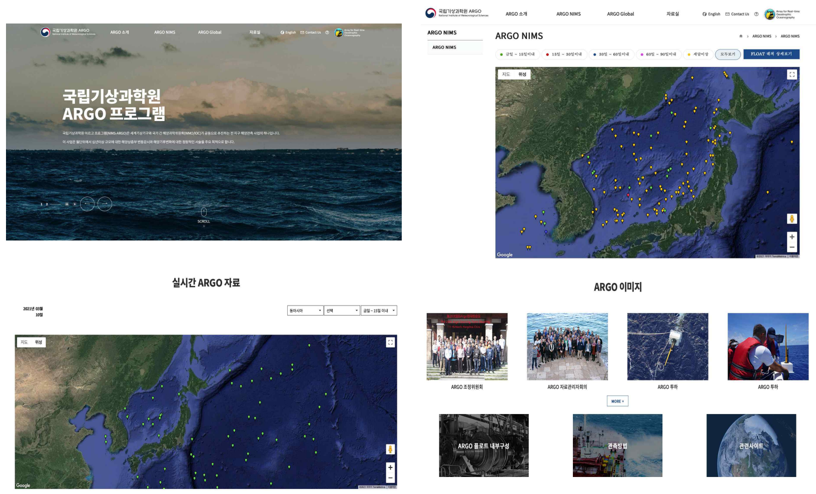


Fig. 3. Upgraded Argo homepage of the National Institute of Meteorological Sciences, Korea Meteorological Administration (http://argo.nims.go.kr).

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

- Extension of Argo float to the shallow and regional seas

6. CTD data uploaded to CCHDO

- No CTD data uploaded to the CCHDO website.

7. Bibliography

KiRyong Kang, HyeongJun Jo, YoonJae Kim. 2020. Ocean responses to typhoon Soulik (1819) around Korea. Ocean Sci J. **55**(3):445-457. doi:10.1007/s12601-020-0030-x

8. Effects of COVID-19

We experienced some delays in the float procurements but there was no essential impact on carrying the Argo float deployment into the planned area.

9. RBR CTD piloting and deployment plans

We have no deployment plans for RBR floats.

Argo New Zealand National Report, March 2021.

Phil Sutton. National Institute of Water and Atmospheric Research (NIWA), Wellington, New Zealand

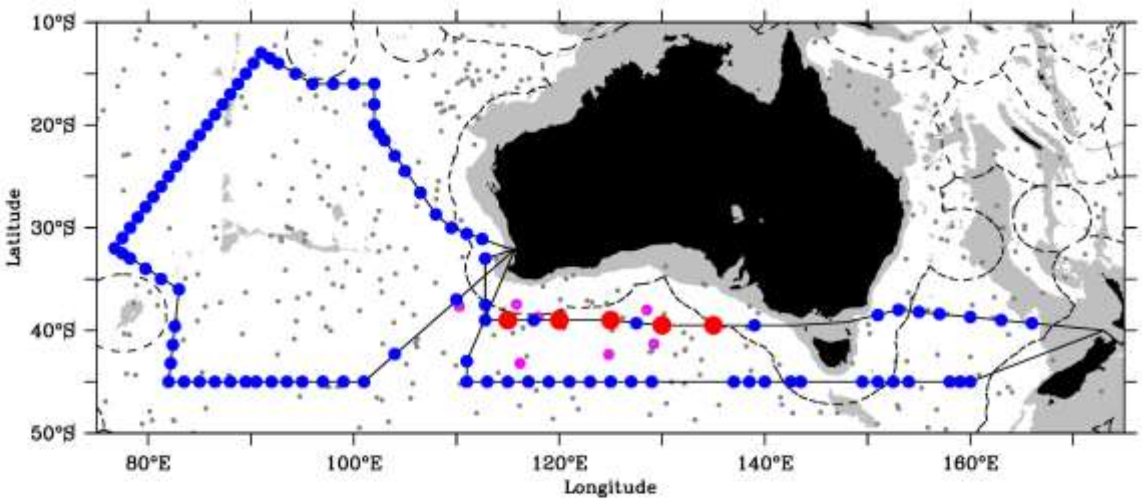
1. The status of implementation of the new global, full-depth, multidisciplinary Argo array (major achievements and problems in 2020)

a. floats deployed and their performance:

2 Solo2 floats were purchased and deployed (WMO #s 5906408 and 5906409).

New Zealand also deployed floats for other organisations on two voyages:

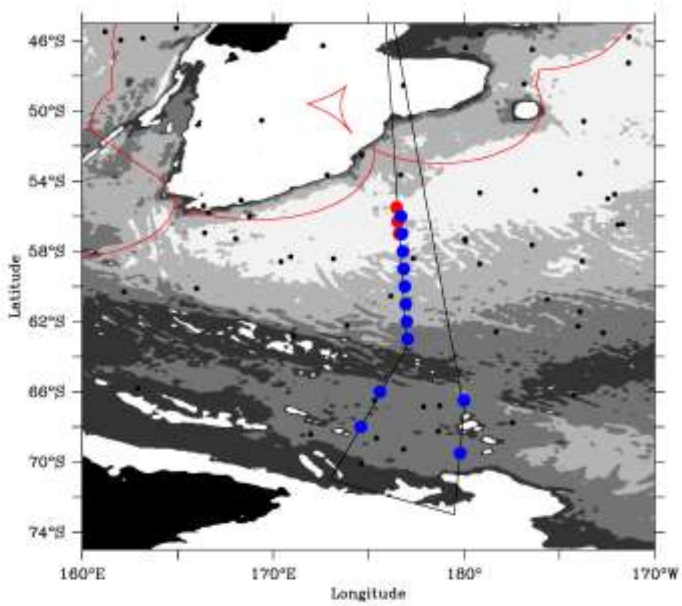
i) R/V Kaharoa Voyage (Indian Ocean):



R/V Kaharoa deployments August-September 2020. Blue = Core, Red = Deep.

- 5 Scripps Institution of Oceanography Deep Solo
- 42 Scripps Institution of Oceanography Solo2
- 42 University of Washington Apex
- 10 CSIRO Navis
- 9 CSIRO MRV

ii) R/V Tangaroa Voyage (Southern Ocean):



R/V Tangaroa deployments January-February 2021. Blue = Core, Red = Deep.

- 2 NZ Solo2
- 10 Scripps Institution of Oceanography Solo2
- 3 Scripps Institution of Oceanography Deep Solo

b. technical problems encountered and solved:

The NZ floats are functioning well. Other partners will report on their floats.

c. status of contributions to Argo data management (including status of high salinity drift floats, decoding difficulties, ramping up to include BGC or Deep floats, etc):

none

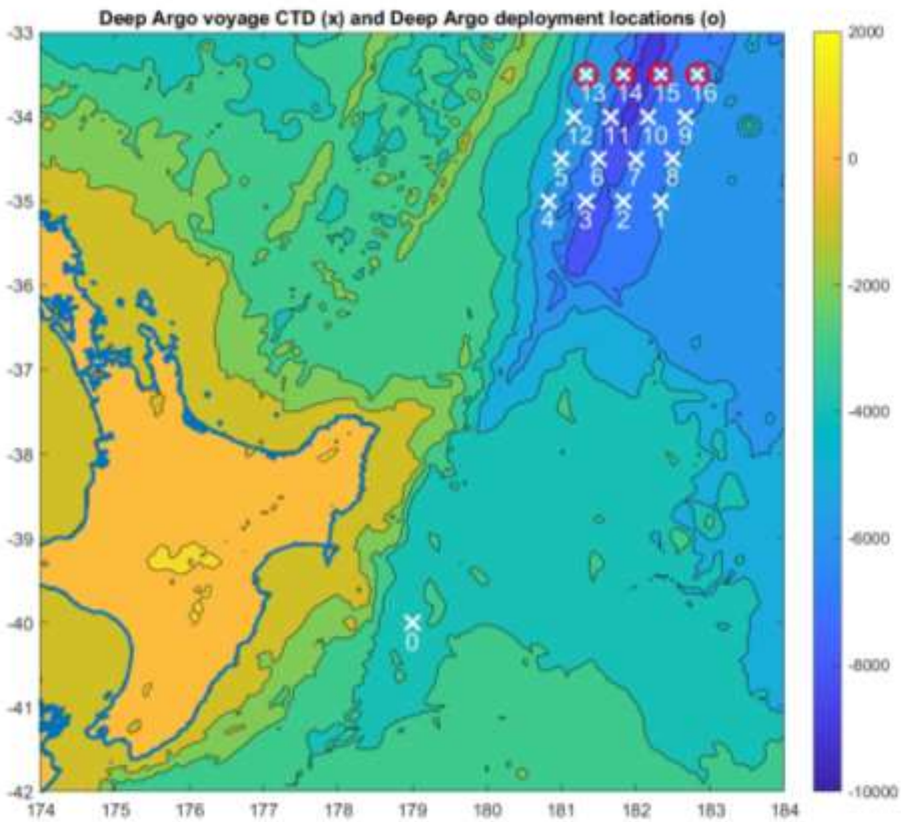
d. status of delayed mode quality control process:

DMQC on NZ floats is performed by Scripps Institution of Oceanography (John Gilson).

2. Present level of and future prospects for national funding for Argo including a summary of the level of human resources devoted to Argo, and funding for sustaining the core mission and the enhancements: BGC, Deep, Spatial (Polar, equator, WBCs)

New Zealand Argo float funding continues on a year-to-year basis at the level of two floats per year. Funding for personnel is via a research programme also funded year-to-year and a contract with Scripps Institution of Oceanography associated with the R/V Kaharoa charter.

NZ is contributing to Deep Argo via a Deep Argo Development Voyage on R/V Tangaroa in March/April 2021 aiming at improving Deep Argo (SBE-61) sensor performance. 6 Scripps Deep Solo floats will be deployed. This work is in partnership with Nathalie Zilberman (SIO) and Dave Murphy (SBE).



Deep Argo Development Voyage plans: x=CTD, o=Deep Solo deployment

NZ (NIWA) is also purchasing 2 Apex floats with ice-avoiding software for deployment in the Ross Sea sometime after December 2021. This work is being led by Craig Stewart (NIWA) with assistance from Esmee van Wijk (CSIRO). It is currently uncertain whether there will be more purchases and deployments in the future.

There is enthusiasm in New Zealand for BGC floats, but they have not as yet been funded.

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.**

New Zealand floats:

a. planned purchase and deployment of 2 Solo2 floats in the South Pacific
b. 2 Apex floats to be deployed in the Ross Sea after December 2021.

Deployments for other countries:

a) Deep Argo Development Voyage: R/V Tangaroa March/April 2021:
   6 Scripps Institution of Oceanography Deep Solo
b) R/V Tangaroa Dart Voyage May/June 2021:
   12 Scripps Institution of Oceanography Solo2
   5 CSIRO
c) Planned 2021 Kaharoa Voyage (~ September 2021)
   121 Core floats split between Scripps Institution of Oceanography, University of Washington, CSIRO and New Zealand.

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.**

Argo data and products are routinely used in research, including physical oceanography, marine ecosystems, climate and fisheries.

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.**

No issues beyond those faced universally, i.e. funding and Covid-19 disruptions.

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 from the Deep Argo Development Voyage will be provided for the reference database.

7. Argo bibliography (Bibliography | Argo (ucsd.edu))

Behrens, E., Williams, J., Morgenstern, O., Sutton, P., Rickard, G., Williams, M. 2020. Local Grid Refinement in New Zealand's Earth System Model: Tasman Sea Ocean Circulation Improvements and Super-Gyre Circulation Implications. *Journal of Advances in Modelling Earth Systems, 12, e2019MS001996.* https://doi.org/10.1029/2019MS001996.

Chiswell, S., Sutton, P., 2020. Relationships between ocean warming and primary production in the New Zealand region. *New Zealand Journal of Marine and Freshwater Research*. DOI: 10.1080/00288330.2020.1713181

Holland, L., A. Rowden, J. Hamilton, M. Clark, S.M. Chiswell, and J.P.A. Gardner, *Genetic connectivity of deep-sea corals in the New Zealand region*, in *New Zealand Aquatic Environment and Biodiversity*. 2020

Morrongiello, J.R., Horn, P.L., Ó Maolágain, C, Sutton, P.J.H. 2020. Synergistic effects of harvest and climate drive synchronous somatic growth within key New Zealand fisheries. Global Change Biology. DOI:10.1111/gcb.15490

Salinger, M.J., Renwick, J., Diamond, H.J., Behrens, E. Fernandez, D., Mullan, A.B., Smith, R.O., Parker, A.K., Johnstone, P., Teixeira, E., Woodward, A., Sirguey, P., Cullen, N.J., Fitzharris, B.B., Herold, N., Hales, S., Hepburn, C.D., Trought, M.C.T. and Sutton P.J. 2020. Unparalleled coupled ocean-atmosphere summer heatwaves in the New Zealand region: drivers, mechanisms and impacts. Climatic Change. https://doi.org/10.1007/s10584-020-02730-5.

8. How has COVID-19 impacted your National Program's ability to implement Argo in the past year? This can include impacts on deployments, procurements, data processing, budgets, etc.

There has been minimal impact in the past year except for having to mobilise deployment voyages and the Deep Argo Development Voyage without foreign support. This has been possible with some extra resources.

There could be budget impacts in the future resulting from COVID-19

9. Argo is still interested in piloting the RBR CTD. Does your National Program have any deployment plans for RBR floats in the next couple years? If so, please indicate how many floats will you be buying in 2021 and 2022 (if known) and where they might be deployed.

New Zealand currently has no intention to purchase RBR CTD floats. We will deploy other nations' RBR-equipped floats (e.g. CSIRO).

National report of Norway (2020)

Submitted by Kjell Arne Mork, Institute of Marine Research (IMR), on behalf of Argo Norway (26.02.2021)

1. The status of implementation

Argo Norway (NorArgo, https://norargo.hi.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) and Arctic.

a. Floats deployed and their performance

In 2020, Norway deployed 12 Argo floats:

- 2 core Arvor floats
- 1 BGC-Provor CTS4 floats (all six variables)
- 4 Deep Arvor floats (with DO)
- 5 bio floats (APEX floats: DO, fluor., bbp, irrad.)

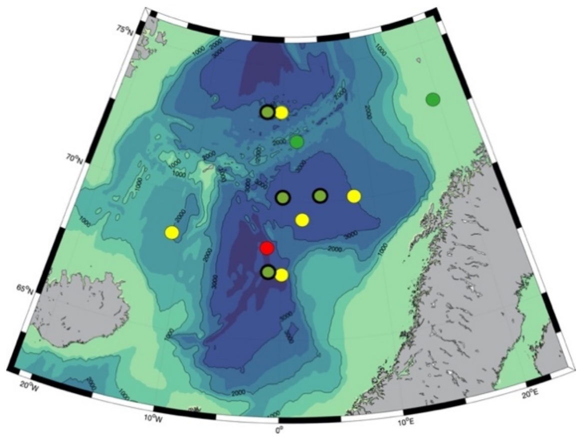


Figure 1. Locations of deployed Argo floats in 2020.

The deployment locations are shown in Fig. 1. All 12 floats have so far performed well, but there are some issues with decoding one of the APEX floats (see below) and OCR-calibration of four APEX floats.

At present, Argo Norway has 30 operative Argo floats.

b. Technical problems encountered and solved

- WMO 6903552 (APEX float) deployed November 2020. There are some issues with the decoding of the OCR-value (calibration coefficient). Also, the time stamp for the oxygen is missing and is interpolated from other time stamps.
- WMO 6903553 (APEX float) deployed May 2019. Communication problems after about 6 months, and data transmitting occurs irregular. This is not solved.
- WMO 6903567-6903570. Deployed May-August 2020. Some issues with the OCR, and these floats have probably not the standard wave lengths for the Irradiance. It is not solved.

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

We have recently started to do the DMQC of our floats that were deployed in 2018 and later (Argo Germany have done the DMQC for our “older” floats). We do DMQC of core, bio, bgc and deep floats. For the Bio and BGC-floats we have done DMQC for oxygen (8 floats) and nitrate (3 floats). DMQC-work of the other variables is ongoing and will be done within 2021. NORCE is responsible for the DMQC of oxygen and pH, while IMR is responsible for the DMQC of T/S, nitrate, chlorophyll, backscatter and irradiance.

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 received funding from the NRC for the extension of the national Argo infrastructure project (NorArgo2). Within this project we purchase and deploy approximately 13 floats per year in the Nordic Seas and the Arctic that include core, bio, BGC and deep floats. The infrastructure has approximately 36 person months per year. The Norwegian Argo Infrastructure (NorArgo, https://norargo.hi.no) is coordinated by Kjell Arne Mork, Institute of Marine Research, who also is the leader of the NorArgo2 project. To keep the target of having minimum 30 operative Argo floats beyond 2023, submission of a new project proposal to the NRC is needed.

Summary of deployment plans

In 2021, mainly in April/May, we plan to deploy 17 floats including:

- 4 BGC-floats (PROVOR CTS4: 6 BGC-variables)
- 3 Bio-floats (APEX, 4 BGC-variables: DO, CHL, BBP, Irraddiance)
- 2 Deep-floats (Arvor + DO)
- 8 core floats (Arvor, including 3 floats + DO)

These floats will be deployed in the Nordic Seas and Arctic.

In 2022 we plan to deploy about 13 floats each year, including 4-5 core, 3-4 bio, 2-3 bgc and 1-3 deep floats.

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 Arctic, including:

- Heat and fresh water contents in the Nordic Seas are regular updated
- Water mass changes in relation with biological activities. This topic is also one of the reasons that we have included bgc sensors on the Argo floats.
- Studies that involve the mixed layer, primary production and carbon cycle.

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

Issues we wish to be considered and resolved

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

Improving the quality and quantity of CTD cruise data

At all deployment locations a CTD station with water samples are taken. The ship CTD-data are sent regular to the ICES, EUs CMEMS, and World Ocean Database. The ship-data will this year also be sent to Argo (Reference Database).

The Argo bibliography

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

The COVID-19 impact

There were some delays in the BGC-float deliveries. The result of this was that we were not able to deploy BGC-floats in the Greenland Sea in 2020, and instead they will be deployed in 2021.

RBR CTD

We have no deployment plans for RBR floats.

Argo-Poland National Report 2020

Waldemar Walczowski, Małgorzata Merchel

IO PAN, Sopot, Poland, 04.01.2021 r.

1. The status of implementation of the new global, full-depth, multidisciplinary Argo array (major achievements and problems in 2020)
    a. floats deployed and their performance

In 2020 Poland launched 4 floats from the board of Institute of Oceanology Polish Academy of Sciences (IO PAN) vessel *r/v Oceania*. Three floats were deployed under the Argo-Poland program, which is Polish contribution to the Euro-Argo ERIC infrastructure, one Baltic Sea float were deployed under the H2020 Euro-Argo Research Infrastructure Sustainability and Enhancement (E-A RISE) EU project.

Two Argo floats (WMO 3902111, 3902112) were deployed in the Nordic Seas at the end of June 2020 at positions 75.36N, 15.36E and 75.01N, 08.47E respectively (Fig. 1). Both instruments are the NKE manufactured ARVOR floats with Iridium transmission system, ice avoidance algorithms. The parking depth was set at 1000 dbars and the profiling depth at 2000 dbars. Floats have cycles of 10 days. One float (WMO3902112) was operated for the whole of 2020 and has sent 18 complete sets of hydrographic data by the end of the year. In addition to standard CTD measurements, second of the float (WMO 3902111), also has taken measurements of dissolved oxygen. Unfortunately, the float drifted north through the Fram Strait into the Arctic Ocean. In early October, the float stopped sending the data. Most likely the cause was that the float drifted under the sea ice.

Two floats deployed in Nordic Seas in June 2016 (WMO 3901850, 3901851), one in June 2017 (WMO 3901911), one in June 2018 (WMO 3902102) and one in June 2019 (WMO 3902108), were also active during the whole 2020 year.

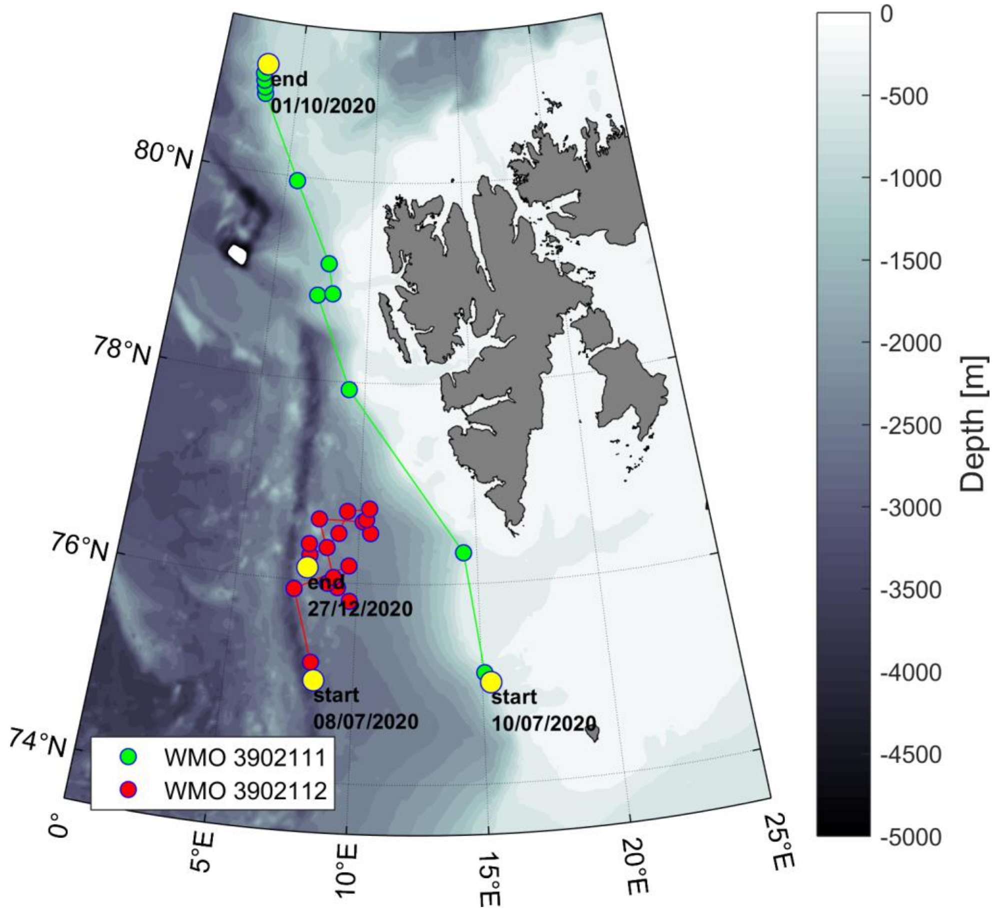


Fig. 1. Positions of deployment and trajectories of two Argo floats deployed in the Nordic Seas by Argo-Poland program in June 2020.

In addition to launching Argo floats in the Arctic, since 2016 IO PAN has been researching the Baltic Sea using Argo floats. At the end of May and the beginning of June 2020, two Argo floats (WMO 3902110, 3902109) were deployed in the Baltic Sea from the board of *r/v Oceania* (Figs 2, 3). The first float was launched in the Bornholm Basin. The parking depth is 50 m, float profiles water column from surface to bottom, with two days frequency. In addition to standard CTD measurements, it also take measurements of dissolved oxygen. The second float was launched within the E-A RISE project in the Gulf of Gdansk. The target of the mission is to keep the float in limited area and use it as a ‘virtual mooring’. Float parks at the bottom, profiles water column with frequency one day. Both floats are NKE ARVOR instruments.

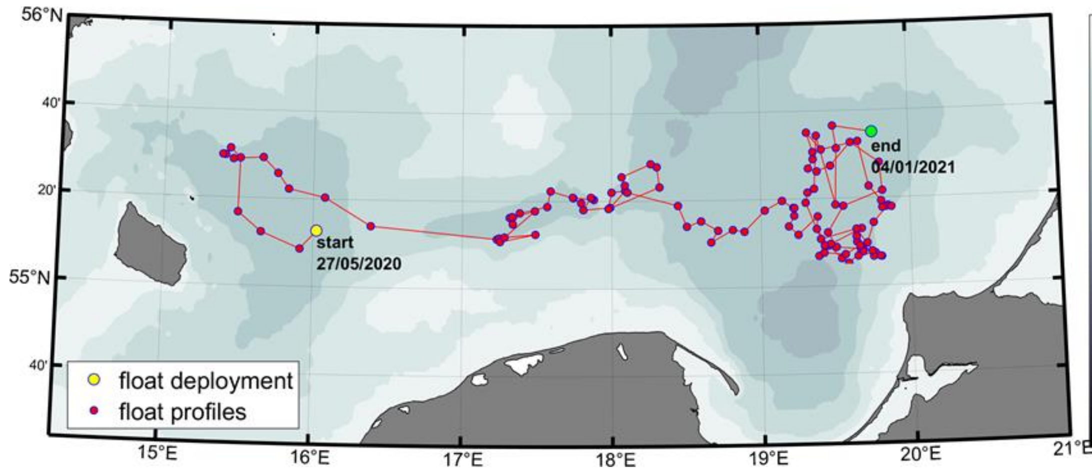


Fig. 2. Position of deployment and trajectory of the Argo float (WMO 3902110) deployed in the Baltic Sea (Bornholm Basin) by Argo-Poland program in May 2020.

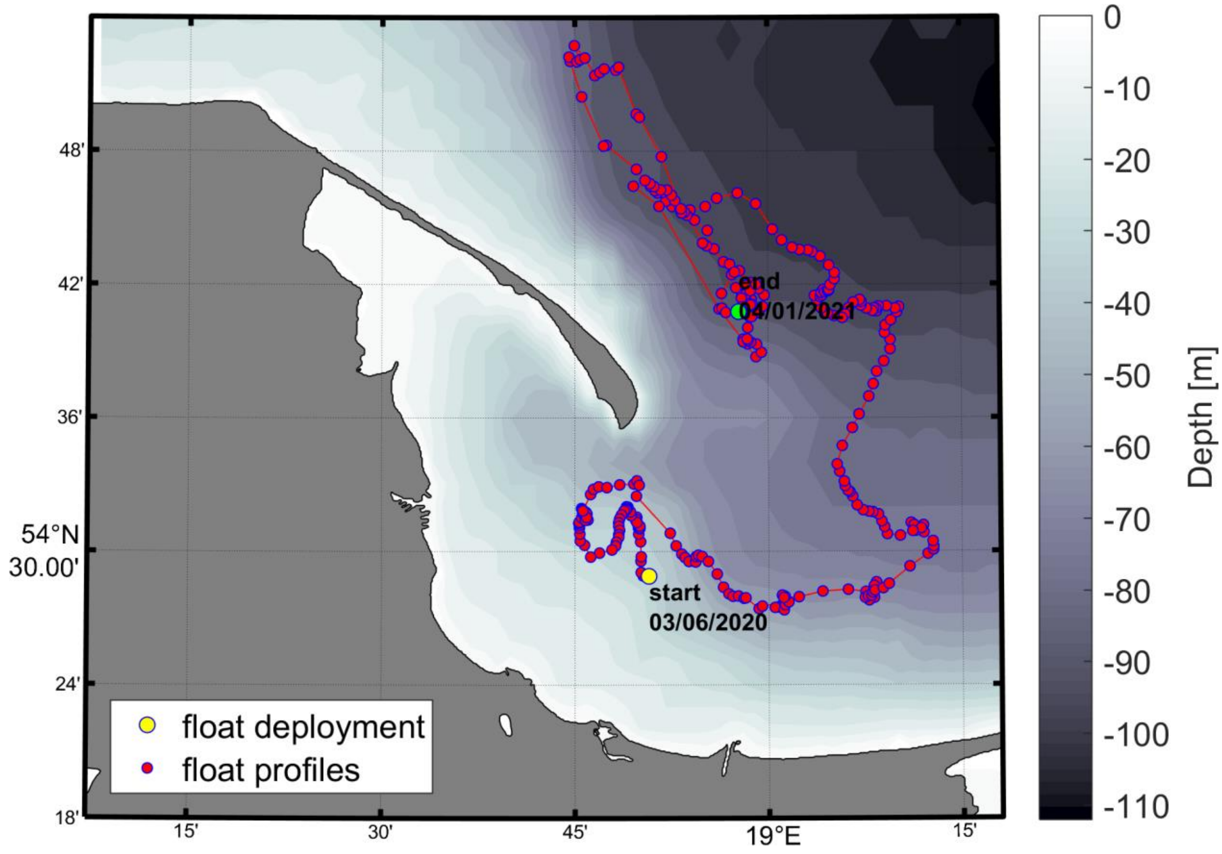


Fig. 3. Position of deployment and trajectory of the Argo float (WMO 3902109) deployed in the Baltic Sea (Gulf of Gdansk) by Argo-Poland program in June 2020.

The small size of the Baltic Sea makes the recovery of floats economically justified. In February 2020, the Baltic float WMO3902101 (Fig. 4) launched by IO PAN in 2018 within the Bornholm Basin, was recovered by IO PAN employees from the deck of the yacht *r/v Magnus Zaremba.* The recovered float will be sent for sensor calibration and it will be used for further missions. During 2 years of work in the Baltic Sea, the float made 373 profiles of temperature, salinity and dissolved oxygen content in sea water. At that time, the float was drifting from the Bornholm Basin to the Western Gotland Basin.

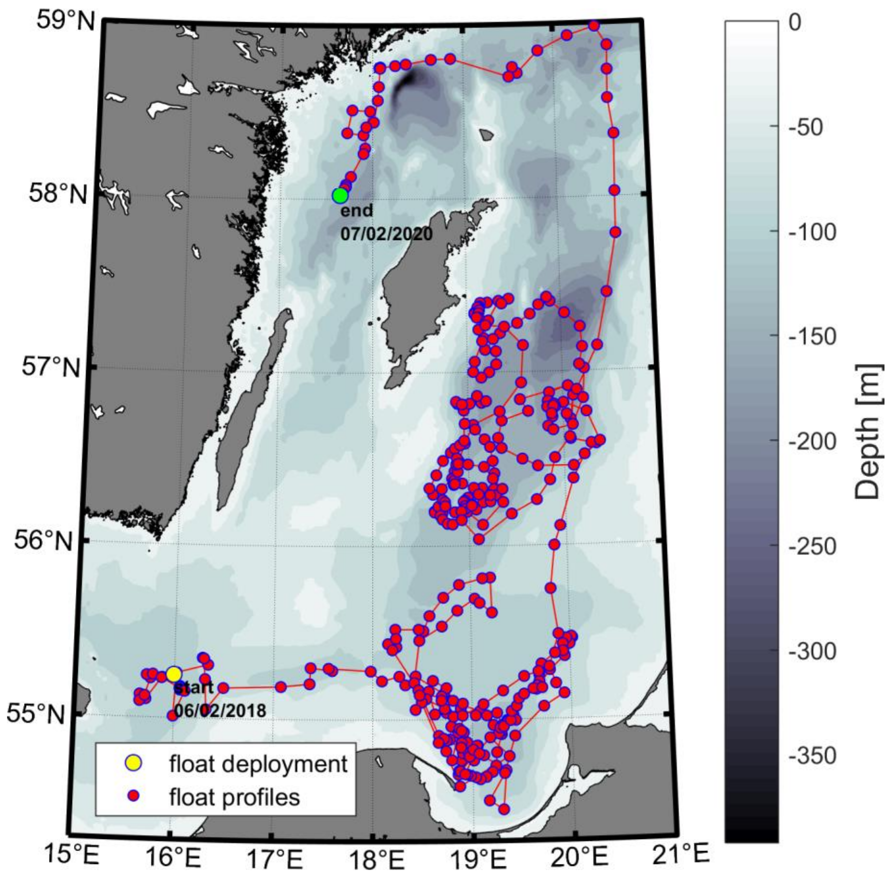


Fig. 4. Position of deployment and trajectory of the Argo float (WMO 3902101) deployed in the Baltic Sea (Bornholm Basin) by Argo-Poland program in February 2018.

In December 2020, the Baltic float WMO3902106 (Fig. 5) deployed by IO PAN in 2018 in the Bornholm Basin was recovered by the Estonian vessel *r/v Salme* north of the Hiiumma Island. We thank Estonian friends for their help in this difficult operation. This is the next, important stage of cooperation in the Baltic Sea. The float has been taking measurements for over two years, since September 11, 2018. During this time, it made 418 profiles, providing valuable CTD/O_2 data. Also, examining the condition of the float (batteries, sensors) will certainly be a valuable contribution to the EA RISE program.

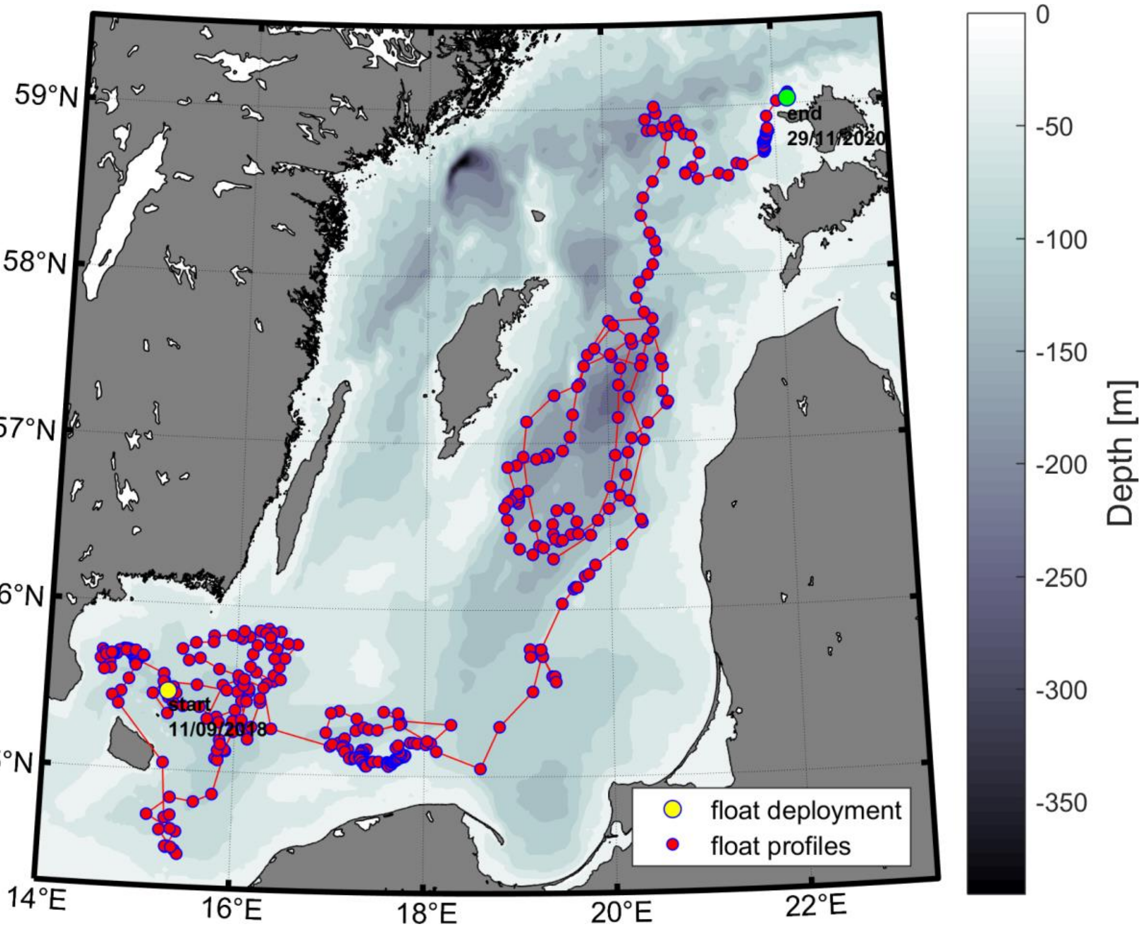


Fig. 5. Position of deployment and trajectory of the Argo float (WMO 3902101) deployed in the Baltic Sea (Bornholm Basin) by Argo-Poland program in September 2018.

b. technical problems encountered and solved

All floats were deployed by Institute of Oceanology Polish Academy of Sciences (IOPAN) from the board of the Institute research vessel 'Oceania'. There were no technical problems with floats.

c. status of contributions to Argo data management (including status of high salinity drift floats, decoding difficulties, ramping up to include BGC or Deep floats, etc)

The data from floats are provided to the Ifremer Argo Center and processed in the Center. All data are available online. IO PAN provided the data collected by *r/v Oceania* during AREX cruises in the Nordic Seas (2000-2018) and in the Baltic Sea (2016-2019) to the Argo references data base.

d. status of delayed mode quality control process

Standard DMQC procedures have been used by DMQC operator from IOPAN for the following Arctic floats:

3902102 – Salinity correction was needed.

3902103 – Salinity correction was needed.

3902107 – No salinity correction was needed.

3902108 – No salinity correction was needed.

2. Present level of and future prospects for national funding for Argo including a summary of the level of human resources devoted to Argo, and funding for sustaining the core mission and the enhancements: BGC, Deep, Spatial (Polar, equator, WBCs)

Present level of national funding for Argo-Poland is about 560 000 PLN (125 000 Euros). We are currently waiting for a decision regarding further funding.

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.

Argo - Poland has not yet received a decision on funding in the following years.

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.

IO PAN runs the long-term Nordic Seas observation program AREX. Argo floats are a valuable source of data complementing the measurement data obtained by r/v Oceania. This applies in particular to the variability of the seasonal properties of water masses (cruises are conducted only in summer) and sea currents pathways in the Svalbard region.

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

At the Baltic Sea Argo floats data are used to monitor inflow of salty waters from the North Sea. Also data on the oxygen content in the depths of the Baltic Sea and currents pathways are especially valuable. Argo data are also used for the modelling in the SatBaltyk project.

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

Also project SufMix (Turbulent Mixing in the Slupsk Furrow) uses Argo data.

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.

7. Keeping the Argo bibliography (Bibliography | Argo (ucsd.edu)) 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 (Thesis Citations | Argo (ucsd.edu)). 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.

Papers:

- Walczowski W., Merchel M., Rak D., Wieczorek P., Goszczko I., Argo floats in the southern Baltic Sea. Oceanologia, 2020, 62 (4), 478-488, https://doi.org/10.1016/j.oceano.2020.07.001 ;

- Merchel M., W. Walczowski, 2020. Increases in the temperature and salinity of deep and intermediate waters in the West Spitsbergen Current region in 1997–2016, Oceanologia, 62/4, https://doi.org/10.1016/j.oceano.2020.08.001.

- Rak Daniel, Walczowski Waldemar, Dzierzbicka-Głowacka Lidia, Shchuka Sergey. Dissolved oxygen variability in the southern Baltic Sea in 2013–2018. Oceanologia, 2020, 62(4), 525-537. https://doi.org/10.1016/j.oceano.2020.08.005

8. How has COVID-19 impacted your National Program's ability to implement Argo in the past year? This can include impacts on deployments, procurements, data processing, budgets, etc.

No problems with floats deployment and recovery. There are delays in the delivery of BGC float due to cooperation problems with sensor manufacturers.

9. Argo is still interested in piloting the RBR CTD. Does your National Program have any deployment plans for RBR floats in the next couple years? If so, please indicate how many floats will you be buying in 2021 and 2022 (if known) and where they might be deployed.

We are planning to buy a float with a RBR CTD sensor for the Baltic Sea.

Portuguese Argo Activities

Report 2020 for the Argo Steering Team Meeting (AST22)

Submitted by A. Miguel Piecho-Santos

IPMA-Portuguese Institute for the Sea and the Atmosphere

March 2021

Activities

1. Launch of two Argo PROVOR CTS3 CTD + OD floats in the Gulf of Cadiz, under the European project Euro-Argo RISE (Euro-Argo Research Infrastructure Sustainability and Enhancement; Contract No 824131), funded by the EU Horizon 2020. This activity was a collaboration with the Argo-France Program and SHOM (see press release in annex).

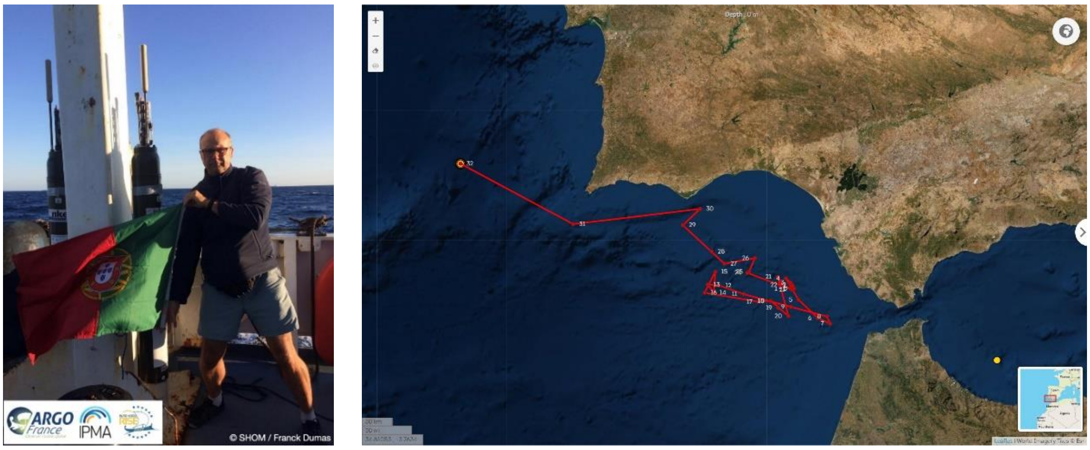


Figure 1. Argo floats on board RV "Atalante" (Franck Dumas, SHOM) ready to be dropped in the Gulf of Cadiz. Map of the trajectory of one of the floats until March 13th, 2021.

2. Participation in the European project "Euro-Argo Research Infrastructure Sustainability and Enhancement (Euro-Argo RISE)", namely in the WP2-Evolution of the core Argo mission / Task 2.3-Improve Argo observation of boundary regions. In this context, one

of the activities was the survey of all floats launched and that entered the Gulf of Cadiz. TS variability and retention times were analysed. This work gave rise to a MSc Thesis in Marine and Coastal Systems from the University of Algarve (Almeida, 2020).

3. Preparation for Portugal's participation as a full member of Euro-Argo ERIC.

Plan for 2021

1. Signature of Portugal's admission to Euro-Argo ERIC, during the Portuguese Presidency of the EU.

2. Acquisition of one full biogeochemical Argo float and one nuclear Argo float with dissolved oxygen sensor.

3. Acquisition of four Argo nuclear floats.

4. Continuation of task 2.3 of the Euro-Argo RISE project with the simulation of various configurations of Argo floats to propose a methodology for observing the Gulf of Cadiz with these floats.

References

Almeida, V. (2020). Analyzing Variability of Northeast Atlantic Ocean Conditions Using Argo Floats. MSc Thesis, Marine and Coastal Systems, Univ. Algarve, 15 pp.

ARGO.PT
Observar para Conhecer

Annex

IPMA Instituto Português do Mar e da Atmosfera

Launch of 2 Argo floats in the Gulf of Cadiz
Two floats (Fig. 1) were launched on board the RV "L'Atalante" of the Hydrographic and Oceanographic Services of the French Navy (SHOM-Service hydrographique et océanographique de la Marine). These floats were offered by Argo-France to IPMA, within the scope of the European project Euro-Argo RISE (Euro-Argo Research Infrastructure Sustainability and Enhancement; Contract No 824131), funded by Horizon 2020 of the European Union. The floats are of the PROVOR CTS3 type and have, in addition to the conductivity (salinity), pressure and temperature sensors, dissolved oxygen sensors. They were launched in the Gulf of Cadiz, near the Strait of Gibraltar.

Instituto Português do Mar e da Atmosfera, I.P.
Rua C - Aeroporto de Lisboa
1749-077 Lisboa, Portugal
Tel: (+351) 21 844 70 00
Fax: (+351) 21 840 23 70
www.ipma.pt
info@ipma.pt

Call for National Reports for Argo Steering Team Meetings
South Africa

The AST requests a National Report from each country involved in implementing the Argo array prior to the yearly AST meetings. These reports help inform all Argo participants of the status of each National Program and help guide the AST meetings. Please use the questions below to help produce your report and send it to Megan Scanderbeg two weeks prior to the annual AST meeting.

Note: Take-over cruises = cruises to maintain bases on sub-Antarctic Islands (Marion and Gough) and Antarctica

1. The status of implementation of the new global, full-depth, multidisciplinary Argo array (major achievements and problems in 2020)
    a. floats deployed and their performance

       None procured by us. Deployed on behalf of other teams. Six Argo floats on the Gough Island cruise (September 2020) and 28 floats on the SANAE VI cruise (December 2020 – February 2021).

    b. technical problems encountered and solved

       None.

    c. status of contributions to Argo data management (including status of high salinity drift floats, decoding difficulties, ramping up to include BGC or Deep floats, etc)

       None. Available to assist with deployment of Deep and BGC floats only where sufficiently competent Research team onboard. Most deployments currently take place on take-over cruises.

    d. status of delayed mode quality control process

       n/a

2. Present level of and future prospects for national funding for Argo including a summary of the level of human resources devoted to Argo, and funding for sustaining the core mission and the enhancements: BGC, Deep, Spatial (Polar, equator, WBCs)

   <u>Present:</u> One person on AST team (Dr. Morris). One person on BGC team (Dr. Thomalla). Limited input to data management teams. Make available deployment opportunities to assist with core mission and enhanced missions where possible.

<u>Future:</u> An infrastructure funding initiative is being pursued through the Department of Science and Innovation (DSI) in South Africa. Progress has slowed due to current global pandemic. The initiative will allow for the procurement of core and BGC floats to be deployed in South Atlantic, South Indian and Southern Oceans if approved.

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.

   Take-over cruises 2021/2022:

   - **<u>Marion Island cruise</u>: April / May 2021. Four floats from UK MetOffice have already for this cruise. Transect goes from Cape Town to Marion Island and returns directly to Cape Town again.**
   - **<u>Gough Island cruise</u>: September 2021. Transect goes from Cape Town to Tristan da Cunha, then on to Gough Island. The vessel returns via the same route.**
   - **<u>SANAE IV cruise</u>: December 2021 – February 2022. Transect goes from Cape Town along the GoodHope Line to Antarctica.**

   Potential research cruises 2021/2022 (COVID-19 dependent):

   - **<u>SEAmester cruise</u>: July 2021. Vessel will transect from Cape Town to just north of Port Elizabeth and undertake a CTD transect across the Agulhas Current. Thereafter returning to Cape Town.**
   - **<u>SAMBA mooring cruise</u>: September / October 2021. Vessel will transect from Cape Town directly westwards into the South Atlantic to service moorings.**
   - **<u>SANAE / SO-CHIC Weddell Gyre: Dec 2021 – Feb 2022.</u> Vessel will follow the Goodhope line between Cape Town and Antarctica with a dedicated scientific voyage planned to the Weddell Gyre as part of the EUH2020 SO-CHIC project.**

   Here is a link to the commitments table at OceanOPS. If you cannot edit the online table, please send a list of deployment plans for each of the columns in the table as needed.

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.

   Dr Sandy Thomalla from SOCCO, CSIR is a member of BGC-Argo scientific committee that met in April and November 2020.

   Research from SOCCO that utilizes Argo data:

   Ryan-Keogh, T., Thomalla, S., Monteiro, PMS., Tagliabue, A. Long term trend of increasing iron stress in Southern Ocean phytoplankton, In review. Also presented at SOCCOM virtual Southern Ocean Mini-AGU meeting, January 2021.

Potential plans for deployment of BGC-Argo PROVOR float with chlorophyll, backscatter, PAR, Oxygen and upward facing transmissometer (for flux estimates) on SANAE / SO-CHIC voyage to Southern Ocean in December 2021.

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.

   Standards and Best Practices (S+BP) for Argo deployments, data processing, etc. Working with the OCG S+BP team lead (Prof. Juliet Hermes), the South African Argo team would be happy to assist further in this regard.

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.

   There may be some additional data from the SAMBA Mooring cruise from September 2020. This needs to be ascertained and uploaded for the CCHDO.

7. Keeping the Argo bibliography (Bibliography | Argo (ucsd.edu)) 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.

   McMonigal, K., Beal, L., Elipot, S., Gunn, K., Hermes, J., Morris, T., & Houk, A. (2020). The impact of meanders, deepening and broadening, and seasonality on Agulhas Current temperature variability. Journal of Physical Oceanography, 50 (12), 3529-3544.

   Ryan-Keogh, T., Thomalla, S., Monteiro, PMS., Tagliabue, A. Long term trend of increasing iron stress in Southern Ocean phytoplankton, In review.

   There is also the thesis citation list (Thesis Citations | Argo (ucsd.edu)). 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.

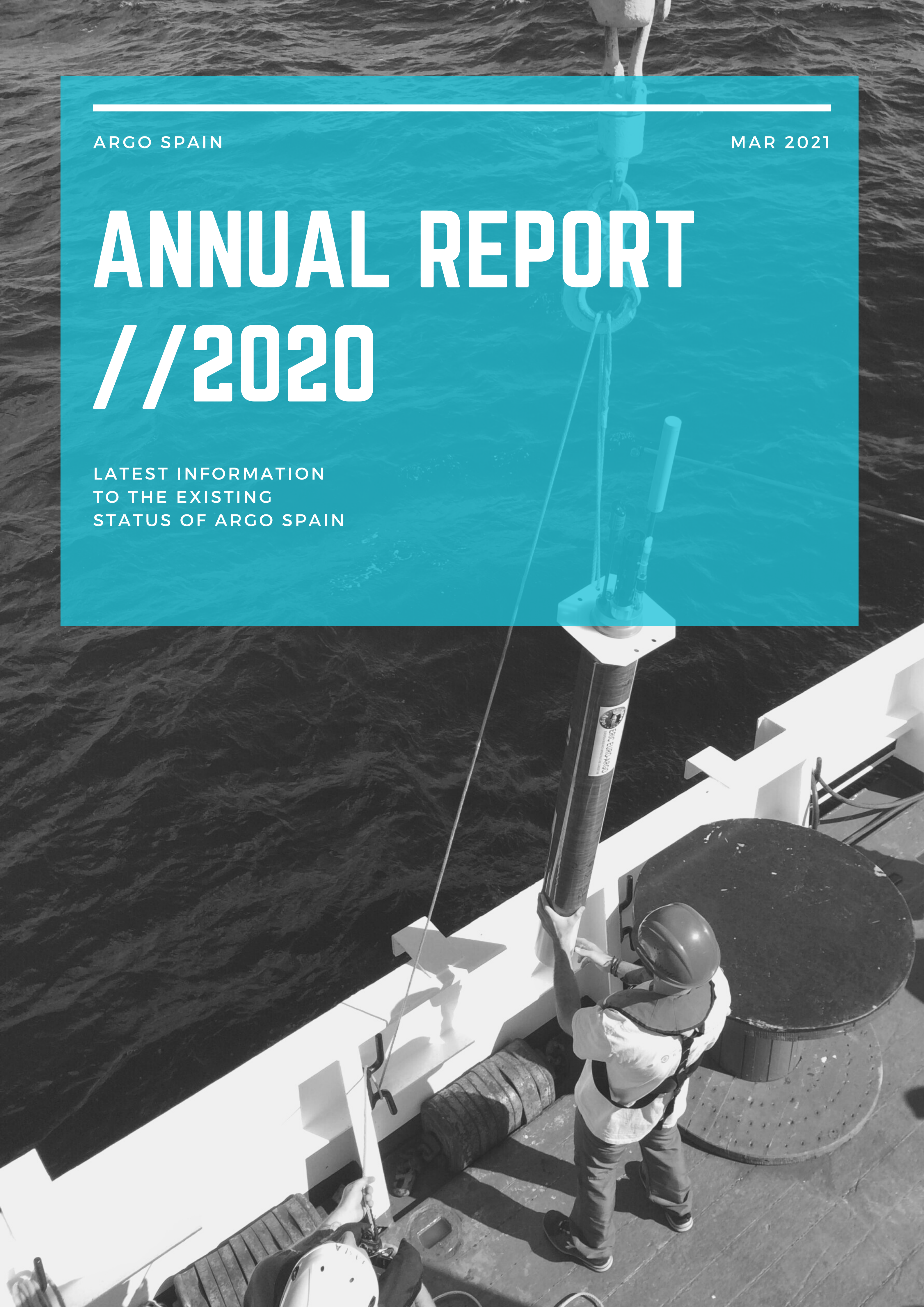
   Morris, T. 2020: *Downstream evolution of ocean properties and associated fluxes in the Greater Agulhas Current System: Ad hoc Argo experiments and modeling*. University of Cape Town, Cape Town, South Africa.

8. How has COVID-19 impacted your National Program's ability to implement Argo in the past year? This can include impacts on deployments, procurements, data processing, budgets, etc.

   Technically none, other than being unable to undertake research cruises limiting our deployment opportunities to take-over cruises only.

9. Argo is still interested in piloting the RBR CTD. Does your National Program have any deployment plans for RBR floats in the next couple years? If so, please indicate how many floats will you be buying in 2021 and 2022 (if known) and where they might be deployed.

   None. However happy to assist with deployment of floats where possible.



ARGO SPAIN

MAR 2021

ANNUAL REPORT //2020

LATEST INFORMATION
TO THE EXISTING
STATUS OF ARGO SPAIN

Argo-España

Parte de la estrategia global de observación del océano

Argo – Spain Annual Report 2020

ARGO ESPAÑA – IEO - SOCIB / 21 – 59

Argo – Spain Annual Report

Feb 15, 2021

Alberto González - Santana, Pedro Vélez - Belchí (IEO)

Inmaculada Ruiz – Parrado, Lara Díaz – Barroso, Irene Lizarán - Esperilla, Joaquín Tintoré - Subirana (SOCIB)

INSTITUTO ESPAÑOL DE OCEANOGRAFÍA

SOCIB Balearic Islands Coastal Observing and Forecasting System

Argo - Spain Annual Report 2020

Present status and future plans

1. Introduction.

a. Organization.

Argo – Spain (www.argoespana.es) takes care of the development and consolidation of the Spanish contribution to Argo. Its activities are mainly focused on the international Argo core and its extension toward the deep ocean.

Thus, the following team, detailed below, coordinates all the activities of Argo – Spain:

- **IEO:** National and scientific coordinator of deployments in the Atlantic Ocean (P. Vélez) and head of quality control activities (A. González).

- **SOCIB:** Scientific coordination of deployments in the Mediterranean Sea (J. Tintoré, I. Ruiz, L.. Díaz and I. Lizarán).

b. Funding.

Spain has participated in the international Argo program since its inception and is currently a member of the European Research Infrastructure Consortium Euro-Argo (ERIC). Spanish participation in Argo began in 2002 through a first European project and a total of 93 Argo profilers have been deployed in the North Atlantic and the Mediterranean Sea since then.

The Argo Spain program does not have proper long-term funding for deployments of Argo floats. However, the contribution to the Euro-Argo ERIC is secured and sustained, based on IEO's access to infrastructures calls from the Spanish Ministry of Science, Innovation, and Universities and from the SOCIB's contribution, which has ensured deployments of at least 3 floats per year since 2015. Both institutions have also assumed the financial commitment that Spain participates as a full member of the ERIC Euro-Argo. The interest in such participation was demonstrated in the process of prioritizing Spain's participation in European research infrastructures, as detailed in the document on the Spanish Strategy for participation in scientific infrastructures and international organizations.

The IEO funds the scientific coordination (1.5 man x month per year) and the transmission costs. Also, in 2020 a technician was incorporated permanently at the IEO, as head of the quality control data and support the scientific coordination. Besides, through the financing of the Euro-Argo EA-RISE project (Euro-Argo Research Infrastructure Sustainability and Enhancement), a technician has been hired full-time at SOCIB for one year.

c. Long-term evolution of Argo – Spain.

This has been Argo's proposal at the Spanish national level:

- 2020: Core Argo mission, temperature, and salinity (0 to 2000m).
- 2015 – 2020: Participation in the pilot array for the extension of the Argo network to the deep ocean with Australia, China, France, Japan, New Zealand, Norway, the UK, and the USA.

Core T/S floats are fully funded by IEO and SOCIB, while deep floats have been funded by the Ministry of Science. Argo Spain strategy will be set according to national interests and guidelines, as is shown in the Euro – Argo's long-term road map for the implementation of a new sustained phase for Argo in Europe.

d. Float development.

All the developments during 2020 with the participation of Argo Spain have been made under the EA - RISE Project (https://www.euro-argo.eu/EU-Projects/Euro-Argo-RISE-2019-2022). The IEO has participated in the development of 2 Deep Arvor floats with three heads, consisting of 3 mounted sensors (SBE41, SBE61, and RBR), especially in the deployment phase and in the comparative study phase to assess the accuracy of the sensor measurements. Under the same project, the SOCIB has participated in terms of float development by improving floats sampling in boundary regions, optimizing configuration and life expectancy's floats, and improving technical floats' aspects in marginal seas.

2. The status of implementation.

Since the beginning of Argo Spain, 93 floats have been deployed so far, of which 24 were active at the end of 2020. All deployments are chosen based on Spanish research criteria, as well as the operational activities of each of the institutions, mainly in the Atlantic Ocean and the Mediterranean Sea.

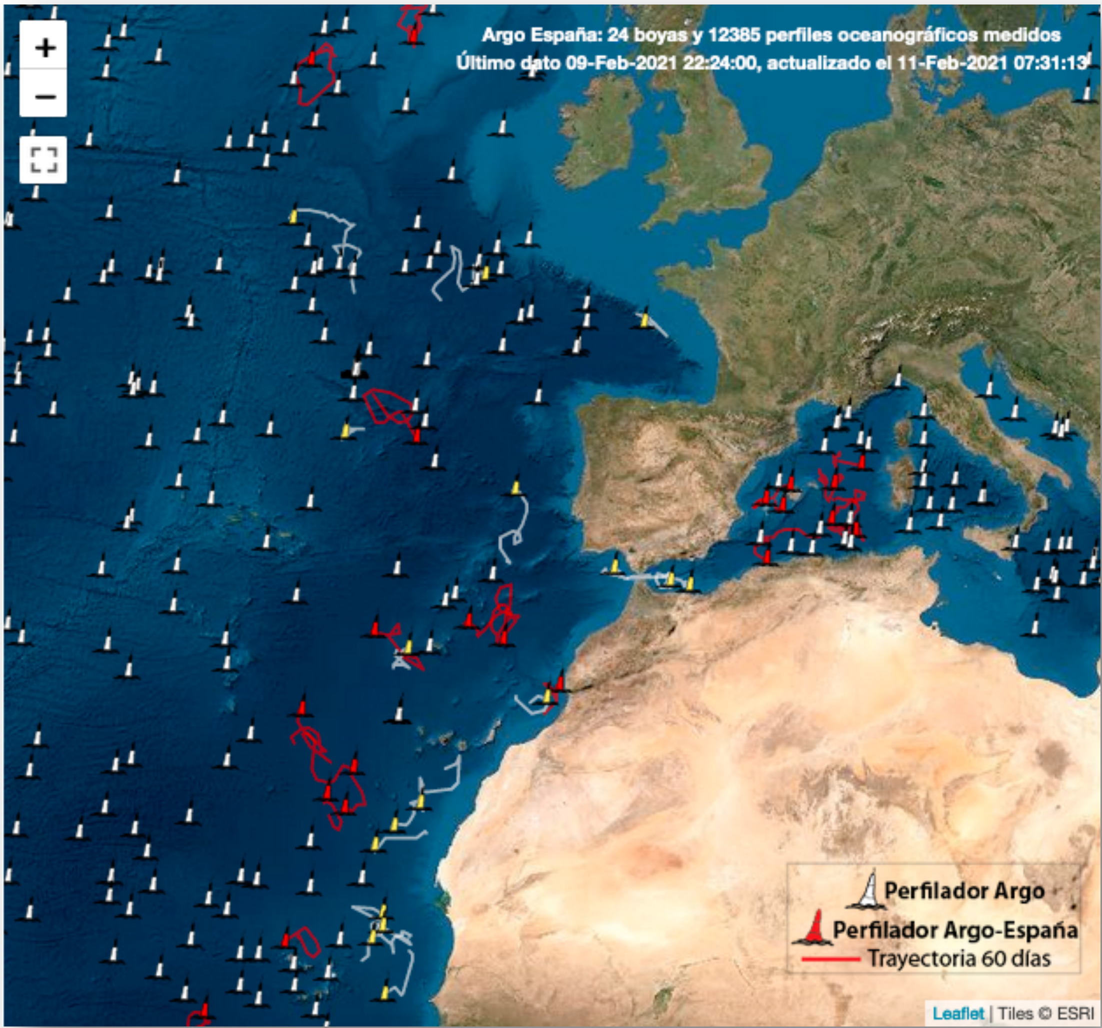


Figure 1. Status of the Argo Spain program on February 15th 2021.

The following table shows relevant information about each Argo-Spain float. It is a database that records information of some features from the deployment until the floats stop completely.

WMO	Status	Project Name	Float Owner	Platform Type	Controller Board	Deployment Date
6901253	Active	Argo SPAIN	IEO	ARVOR_L	70-10-444	29/05/2018
6901254	Active	Argo SPAIN	IEO	ARVOR_L	70-10-444	15/10/2018
6901255	Active	Argo SPAIN	IEO	ARVOR_L	70-10-444	16/6/2019
6901256	Active	Argo SPAIN	IEO	ARVOR_L	70-10-444	01/06/2018
6901257	Active	Argo SPAIN	IEO	ARVOR_L	70-10-444	06/02/2019
6901258	Active	Argo SPAIN	IEO	ARVOR_L	70-10-444	04/06/2018
6901259	Active	Argo SPAIN	IEO	ARVOR_L	70-10-444	11/03/2019
6901262	Active	Argo SPAIN	IEO	ARVOR_L	70-10-444	08/06/2018
6901263	Active	Argo SPAIN	IEO	ARVOR_L	70-10-444	06/02/2019
6901265	Active	Argo SPAIN	IEO	ARVOR_L	70-10-444	10/06/2018
6901266	Active	Argo SPAIN	IEO	ARVOR_L	70-10-444	13/06/2018
6901268	Active	Argo SPAIN	IEO	ARVOR_L	70-10-444	18/03/2019
6901269	Active	Argo SPAIN	IEO	ARVOR_L	70-10-444	16/06/2018
6901270	Active	Argo SPAIN	IEO	ARVOR_L	70-10-444	18/08/2018
6901271	Active	Argo SPAIN	IEO	ARVOR_L	70-10-444	30/10/2018
6901272	Active	Argo SPAIN	IEO	ARVOR_L	70-10-444	26/03/2019
6901273	Active	Argo SPAIN	IEO	ARVOR_L	70-10-444	11/12/2018
6901277	Active	Argo SPAIN	IEO	ARVOR_L	70-10-444	31/07/2019
6901278	Active	Argo SPAIN	EA-RISE SOCIB ICTS	ARVOR_I	I535	12/03/2020
6901280	Active	Argo SPAIN	SOCIB ICTS	ARVOR_I	I535	12/08/2020
6901281	Active	Argo SPAIN	SOCIB ICTS	ARVOR_I	I535	04/11/2020
6904065	Active	Argo SPAIN	SOCIB ICTS	ARVOR_I	I535	14/08/2020

Table 1. Extract of current Argo Spain floats database.

3. The status of implementation of the new global, full-depth, multidisciplinary Argo array (major achievements and problems in 2020).

a. Floats deployed and their performance.

During 2020, a total of 4 Argo floats were deployed by Argo-Spain:

- 4 ARVOR – I floats (Argo Spain in the Mediterranean Sea).
    - 3 of them under the framework of Argo Spain's minimum annual coverage commitment for the Euro – Argo contribution and purchased by SOCIB.
    - 1 of them under the framework of the EA-RISE project.
    - 1 recovery and next redeployment.

The contribution of Argo Spain to extend the international Argo network during 2020 was focused on the Med sea, deploying a total of 4 ARVOR – I floats. These deployment missions were coordinated by SOCIB ICTS – IEO and developed by SOCIB ICTS in collaboration with partners who cooperated for the success of the missions. One of the floats (WMO 6901278) deployed has been managed under the Euro-Argo Research Infrastructure Sustainability and Enhancement (EA – RISE) project, deployed by SOCIB ICTS. If more information is required about this project, please find the next link: https://cutt.ly/OlEVIDc

As an example, the ARVOR – I float WMO 6901280 is currently diving northeast of Mallorca island after 37 profiles developed (Fig. 3). The float was programmed to dive up to 2000m every 5 days measuring temperature and salinity during the ascending phase, developing a profile depth of 2000m within a parking depth of 1000m.

Figure 2. R/V SOCIB operator moments before the deployment of WMO 6901280 float under safety measures at *Canales Summer 2020* survey.

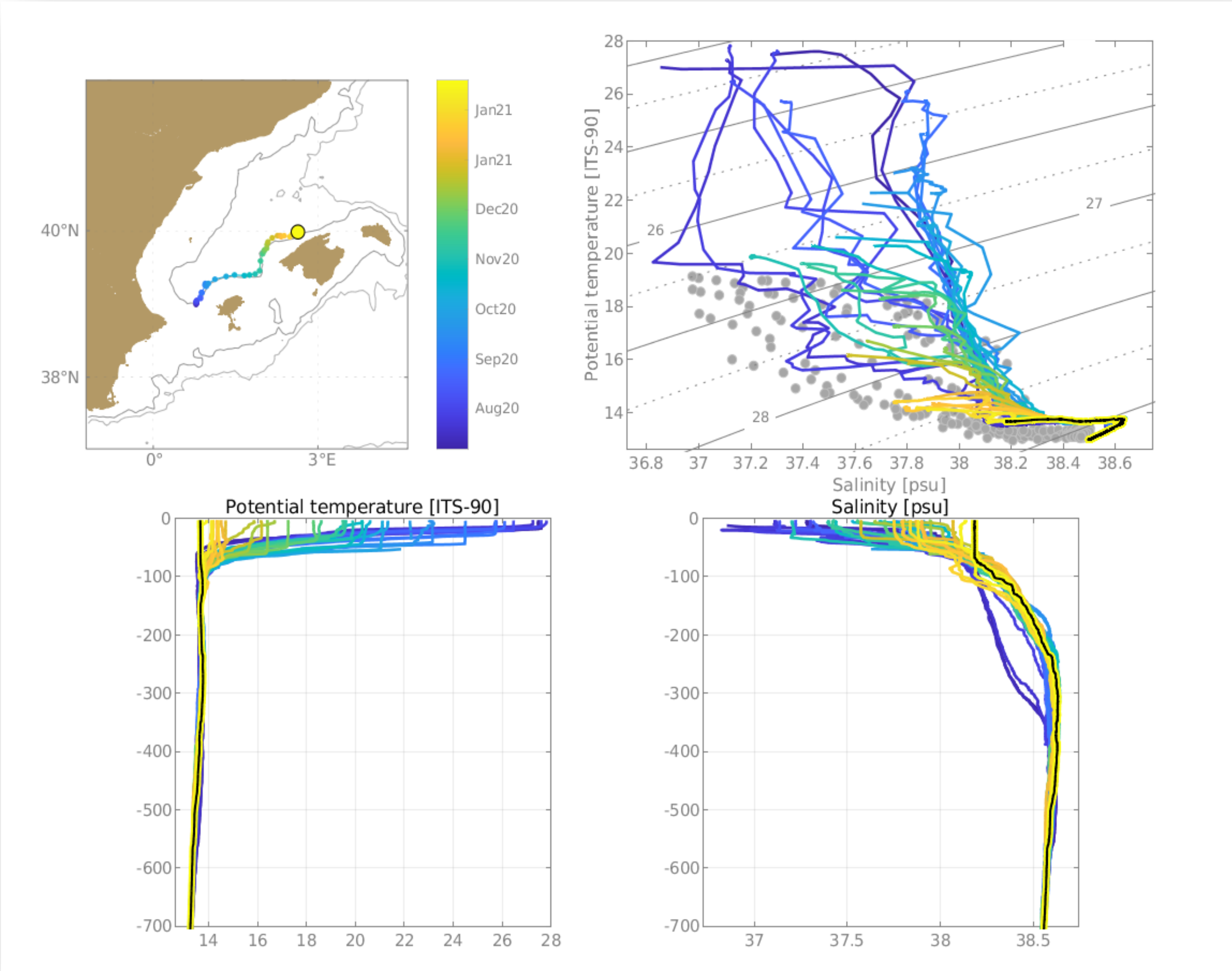


Figure 3. The trajectory of the float since the deployment is shown in the upper left side of the picture. T-S diagram of the data collected by WMO 6901280 is shown on the upper right side of the picture. The grey points are the climatology of the area. The black line is the first profile carried out by the float. Potential Temperature and Salinity profiles are also shown on the lower side of the picture.

The ARVOR – I float WMO 6901279 also as an example, which was deployed between Mallorca and Ibiza islands, performed a northwest trajectory until it was captured by a local boat (fig. 4). The float was delivered to SOCIB ICTS and it was redeployed on Aug 14th, 2020 under a new WMO 6904065. The float was programmed to dive up to 2000m every 5 days measuring temperature and salinity during the ascending phase, developing a profile depth of 2000m within a parking depth of 1000m (fig. 5).

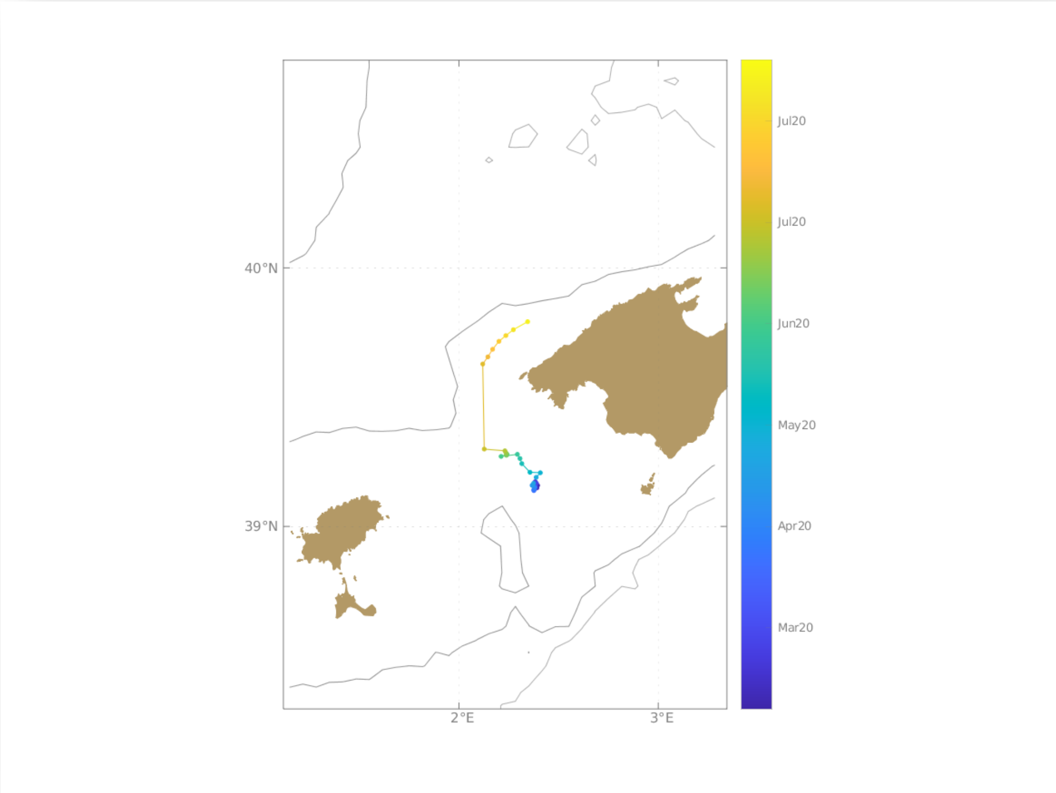


Figure 4. The trajectory of the float WMO 6901279 from the deployment until its capture.

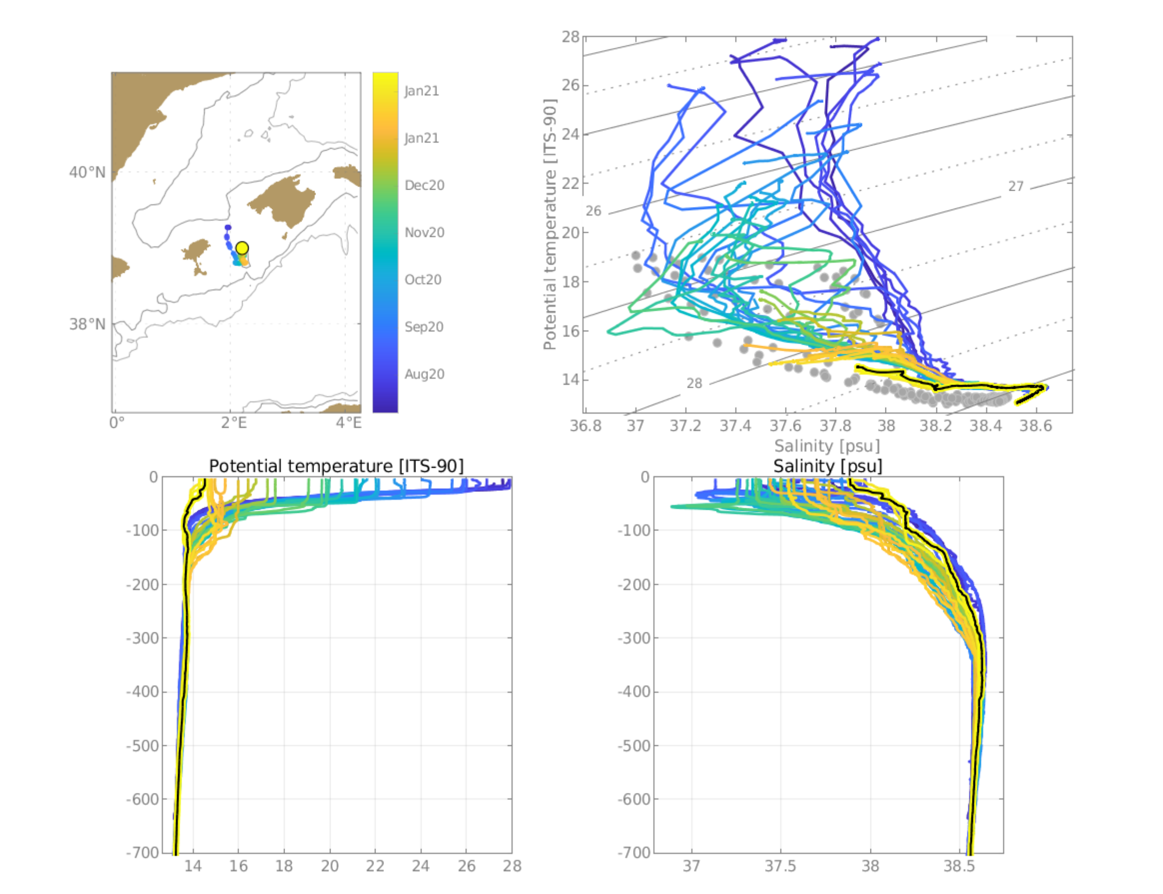


Figure 5. The trajectory of the float since the deployment is shown in the upper left side of the picture. T-S diagram of the data collected by WMO 6904065 is shown on the upper right side of the picture. The grey points are the climatology of the area. The black line is the first profile carried out by the float. Potential Temperature and Salinity profiles are also shown on the lower side of the picture.

b. Technical problems encountered and solved.

- The ARVOR – I float WMO 6901279 was deployed on March 13th, 2020 at the Mediterranean Sea. The float worked as expected, developing a total of 31 profiles in total until it was captured by a local boat. The float was delivered and, after inspection, redeployed on Aug 14th, 2020 under a new WMO 6904065.
- According to SOCIB ICTS, the ARVOR – I float WMO 6901278 had performed some emergency ascents during its last cycles (fig. 6). This issue was reported to NKE.

NKE identified the issue: The float had reached for 5 cycles pressure slightly higher than 2100 dBar (2102, 2123, 2109, 2125 & 2105) and entered into emergency ascent mode. A solution was provided by NKE and the float hasn't performed any emergency ascent so far.

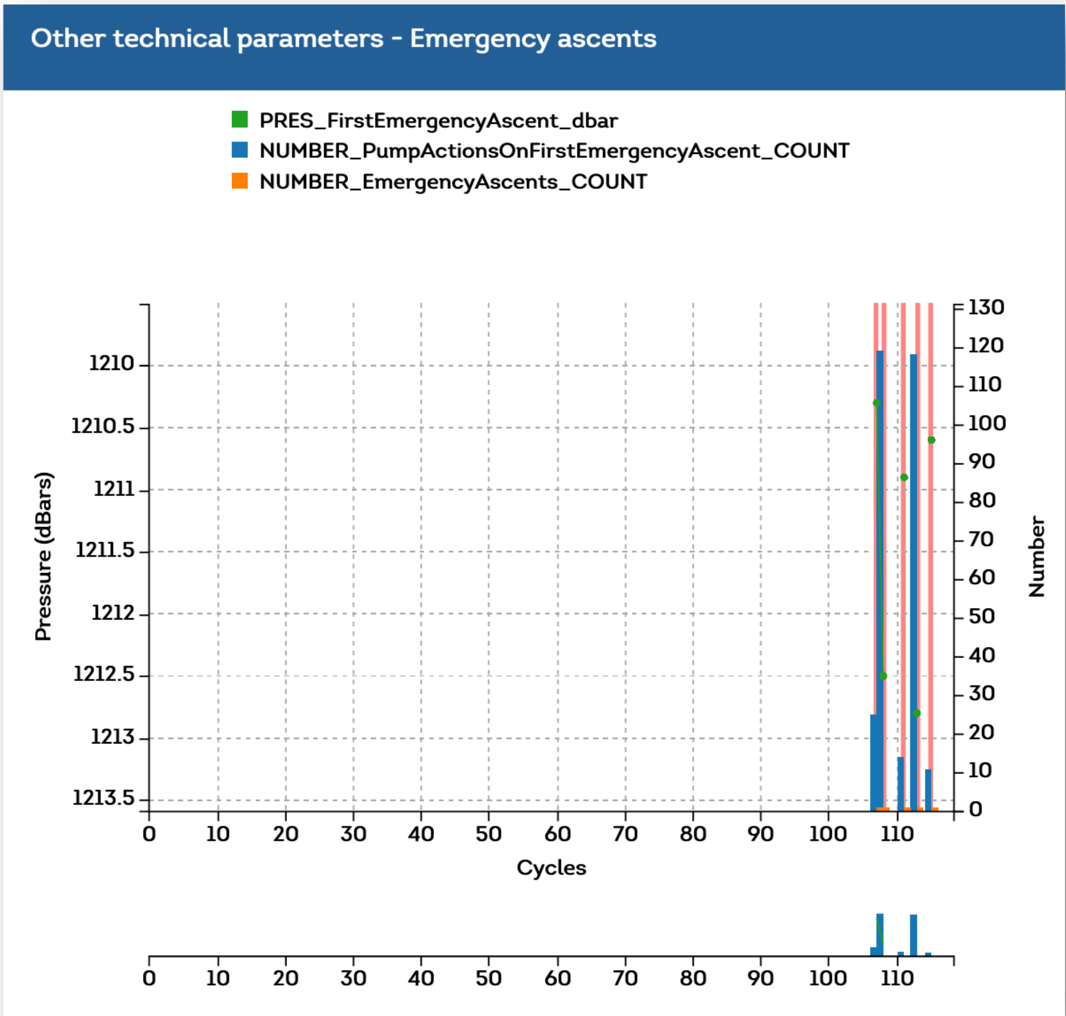


Figure 6. The ARVOR – I WMO 6901278 has been experiencing emergency ascents in the last cycles.

c. Status of contributions to Argo data management (including the status of pressure corrections, technical files, etc).

After each deployment, detailed technical information is provided to the DAC in charge of the floats (Coriolis) and the AIC. The Argo-Spain program is aware of the changes in the technical and metadata data formats and is providing the necessary information.

d. Status of delayed mode quality control process.

Argo-Spain mainly deploys floats in the Atlantic Ocean and the Mediterranean Sea. In terms of DMQC, Argo-Spain manages its floats that operate in the Atlantic Ocean and the Instituto Nazionale di Oceanografia e di Geofisica Sperimentale (OGS) manages all the floats that operate in the Mediterranean Sea, including floats of Argo-Spain. The DMQC of the Argo-Spain floats that operate in the Mediterranean Sea will be assumed by Argo-Spain itself at some point, subject to personnel availability. In successive meetings, a transfer of DMQC knowledge from the IEO to the SOCIB ICTS will be scheduled so that SOCIB ICTS is in charge of the DMQC of the Argo Spain profilers deployed in the Mediterranean.

Argo-Spain fleet is comprised of 92 floats deployed so far. A total of 63 floats have been deployed in the Atlantic Ocean and 29 floats deployed in the Mediterranean Sea (fig. 7).

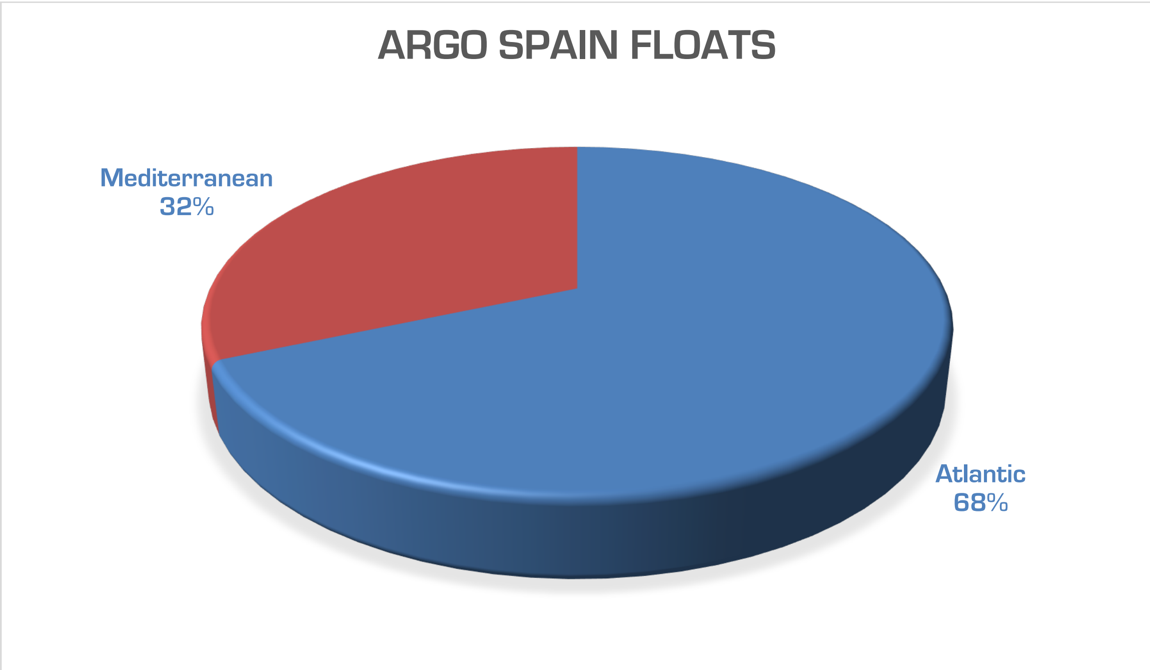


Figure 7. Argo-Spain floats fleet.

DMQC has been carried out for 16 floats in 2016 (35,5%), for 19 floats (42,2%) in 2017, for 4 floats in 2018 (8'8%), and no DMQC has been developed during 2019 and 2020 (fig. 8).

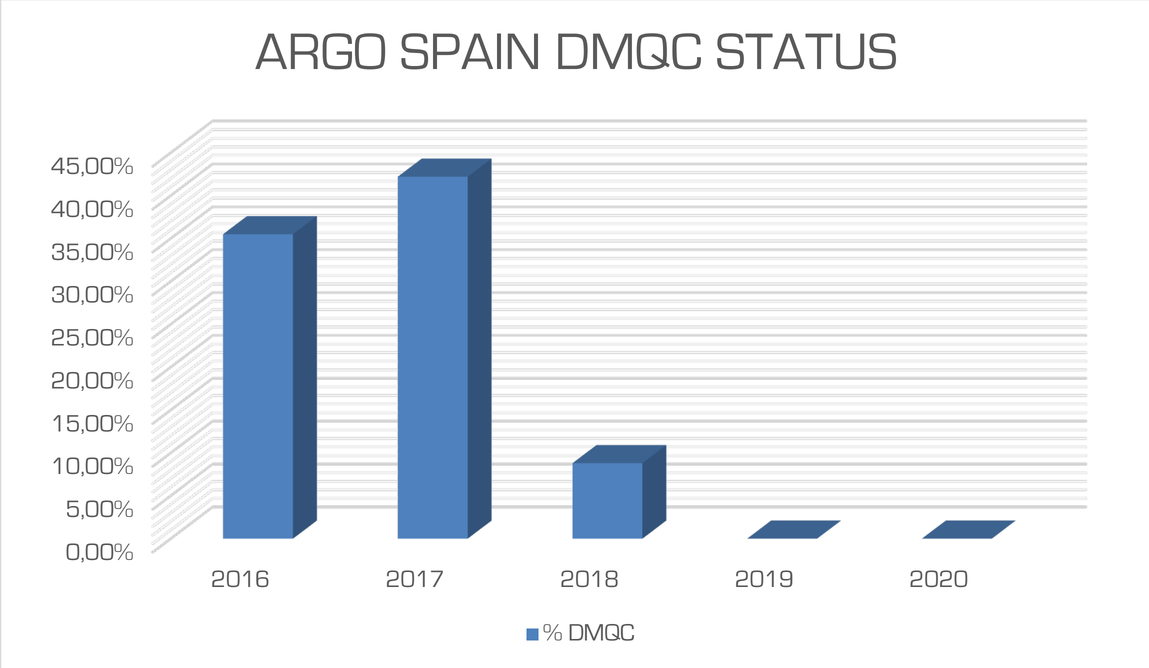


Figure 8. Argo-Spain floats fleet.

4. The present level of and future prospects for national funding for Argo including a summary of the level of human resources devoted to Argo.

Argo-Spain has increased its manpower since a new technician (1) got a permanent position at the IEO and another technician (1) has been hired full-time at SOCIB under the framework of the EA-RISE project. Also, there is a knowledge transfer on the DMQC between SOCIB and IEO scheduled for this year 2021. The IEO's funding covers float procurement in the period 2021-2022, transmission costs, and part-time personnel support. The IEO funds the scientific coordination and delayed mode in the Atlantic (1 FTE). Besides the long-term support from the IEO, SOCIB will deploy 3 Argo floats per year in the Western Mediterranean until 2021.

5. Summary of deployment plans and other commitments to Argo for the upcoming year and beyond where possible. Here is a link to the commitments table at OceanOPS. If you cannot edit the online table, please send a list of deployment plans for each of the columns in the table as needed.

Although the potential deployments may change following feedback from the Spanish research community, the current plan for the upcoming year is:

- 3 standard floats (ARVOR – I) to be deployed in the Mediterranean Sea during 2021 (SOCIB).
- 10 standard floats (ARVOR - I) to be deployed in the Atlantic Ocean during 2021 and 2022 (IEO).
- 5 Deep Argo floats (DEEP ARVOR) to be deployed in the Atlantic Ocean during 2021 and 2022 (IEO).

- 1 BGC float to be deployed in the Atlantic Ocean during 2021 or 2022 (IEO).

6. 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.

Argo is used by many Spanish researchers to improve the understanding of climate and ocean variability. Ocean and weather forecast operational models also use Argo data. The web page of the Argo Spain program is: http://www.argoespana.es

7. 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.

8. 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 CTD cast is performed after most of the Argo-Spain deployments. However, the data have not been submitted to the CCHDO yet., it will be done during 2021.

9. Keeping the Argo bibliography (Bibliography | Argo (ucsd.edu)) 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 (Thesis Citations | Argo (ucsd.edu)). 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.

Agulles, M., Jordà, G., Jones, B., Agustí, S., Duarte, C.M., 2020. Temporal evolution of temperatures in the Red Sea and the Gulf of Aden based on in situ observations (1958–2017). Ocean Science 16, 149–166. https://doi.org/10.5194/os-16-149-2020

Álvarez, M., Fajar, N.M., Carter, B.R., Guallart, E.F., Pérez, F.F., Woosley, R.J., Murata, A., 2020. Global Ocean Spectrophotometric pH Assessment: Consistent Inconsistencies. Environ. Sci. Technol. 54, 10977–10988. https://doi.org/10.1021/acs.est.9b06932

Caballero, A., Mulet, S., Ayoub, N., Manso-Narvarte, I., Davila, X., Boone, C., Toublanc, F., Rubio, A., 2020. Integration of HF Radar Observations for an Enhanced Coastal Mean Dynamic Topography. Front. Mar. Sci. 7. https://doi.org/10.3389/fmars.2020.588713

Dañobeitia, J.J., Pouliquen, S., Johannessen, T., Basset, A., Cannat, M., Pfeil, B.G., Fredella, M.I., Materia, P., Gourcuff, C., Magnifico, G., Delory, E., del Rio Fernandez, J., Rodero, I., Beranzoli, L., Nardello, I., Iudicone, D., Carval, T., Gonzalez Aranda, J.M., Petihakis, G., Blandin, J., Kutsch, W.L., Rintala, J.-M., Gates, A.R., Favali, P., 2020. Toward a Comprehensive and Integrated Strategy of the European Marine Research Infrastructures for Ocean Observations. Front. Mar. Sci. 7. https://doi.org/10.3389/fmars.2020.00180

Olivé, A., Pelegrí, J.L., Machín, F., 2020. Property balances in the Scotia Sea as deduced from inverse modeling. https://doi.org/10.13039/501100006368

Olmedo, E., González-Haro, C., Hoareau, N., Umbert, M., González-Gambau, V., Martínez, J., Gabarró, C., Turiel, A., 2020. Nine years of SMOS Sea Surface Salinity global maps at the Barcelona Expert Center. Earth System Science Data Discussions 1–49. https://doi.org/10.5194/essd-2020-232

Sergi, S., Baudena, A., Cotté, C., Ardyna, M., Blain, S., d'Ovidio, F., 2020. Interaction of the Antarctic Circumpolar Current With Seamounts Fuels Moderate Blooms but Vast Foraging Grounds for Multiple Marine Predators. Front. Mar. Sci. 7. https://doi.org/10.3389/fmars.2020.00416

10. How has COVID-19 impacted your National Program's ability to implement Argo in the past year? This can include impacts on deployments, procurements, data processing, budgets, etc.

The IEO has funding secured in 2020 to purchase floats for two years. Despite problems related to the COVID-19 in 2020, it was possible to begin the purchasing processes that will be done in 2021.

SOCIB tried to purchase 3 profilers but the procedure was canceled because of the pandemic. However, it was also possible to begin the purchasing processes for 2021.

11. Argo is still interested in piloting the RBR CTD. Does your National Program have any deployment plans for RBR floats in the next couple years? If so, please indicate how many floats will you be buying in 2021 and 2022 (if known) and where they might be deployed.

- IFREMER, EURO-Argo, and the IEO deployed on December 2020 two '3-Headed' Deep Argo floats (range 4000 m depth) in the Canary basin under the framework of the EA-RISE and NAOS projects. Both floats are equipped with an RBR Concerto sensor. If more information is required, please find the next link: https://cutt.ly/ykOmOhV
- Two ARVOR – I floats equipped with RBRargo sensor were also deployed by IFREMER, EURO-Argo, and the IEO on December 2020 under the EA-RISE project.
- It is also planned for the end of 2021 that IFREMER, EURO-Argo, and the IEO will deploy two '2-Headed' floats equipped with RBRargo under the EA-RISE project.

UK ARGO PROGRAMME

REPORT FOR 22ND ARGO STEERING TEAM MEETING MARCH 2020

1. Status of Implementation

Floats deployed and their performance

During 2020 we were able to deploy 29 floats; 13 of these were deployed early in the year before the Covid-19 pandemic curtailed deployment opportunities, with the other 16 deployed from October 2020 when research cruises restarted.

Of these, 17 were standard core APEX, four were core APEX with RBR CTDs, seven were APEX Deep (one with RBR CTD and oxygen) and one Navis BGCi (bio-geochemical) float.

Also, we deployed two APEX Deep and two core APEX in the Argentine Basin in January 2021, four core APEX in the Drake Passage in early March 2021 and two APEX DEEP in mid-March 2021.

As at 18th March the UK has 170 operational floats (i.e. for which real-time data are presently being distributed), as shown in Figure 2. This does not show the two APEX DEEP floats deployed in mid-March 2021 as these are not yet being processed.

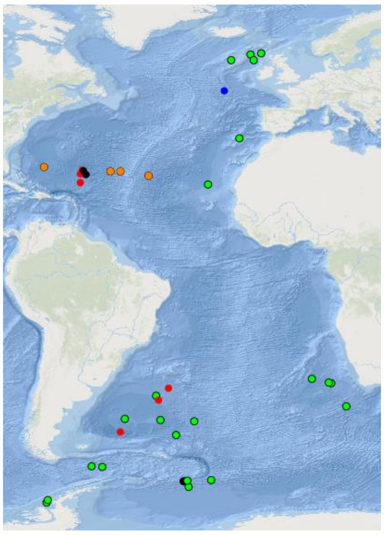


Figure 1. Showing the latest reported locations of the UK Argo floats deployed between 1st January 2020 and 31st January 2021, active core APEX floats in green, active APEX-RBR in orange, active APEX-Deep in red and active Navis BGCi in blue. Failed floats are shown in black.

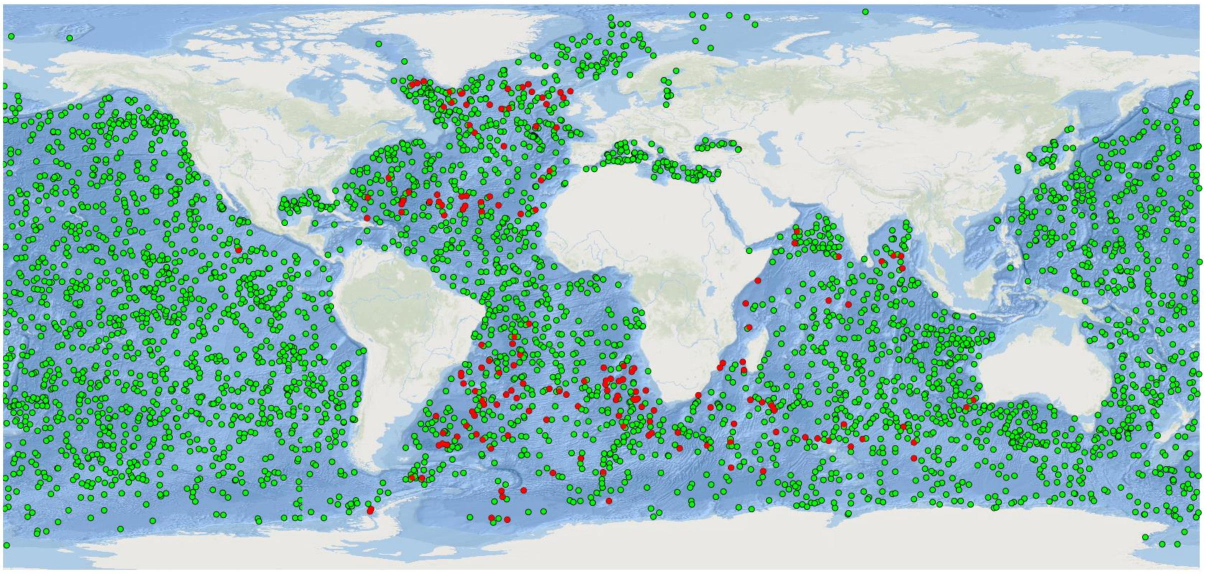


Figure 2. Showing the locations of all UK floats delivering data in red with the global network of ~3,900 floats in green, as at 18th March 2021.

Technical problems encountered

APEX Core

We are experiencing issues with at least 3 core APEX floats failing to obtain GPS fixes after surfacing, but often transmitting a GPS fix at the start of the next cycle. This is causing delays in data delivery and is thought to be due to buoyancy issues after entering the surface mission.

APEX Deep

As noted above UK has deployed nine APEX Deep in the last year or so. Five were deployed in January/February in the North Atlantic, three of these are presently working (although one has bad salinity data) having completed over 40 cycles, the other two failed in March 2020. A recovered and refurbished APEX Deep, with RBR CTD, was deployed in the North Atlantic in December and failed during its eighth cycle having lost communication with the CTD while parked at 4,000 dbar. Three other APEX Deep were deployed in December 2020/January 2021 in the South Atlantic, one of which has failed to report. Two more APEX Deep were deployed in mid-March and are not yet being processed. We presently have one Deep SOLO on order scheduled for delivery later this year.

Bio-geochemical Argo

Both of the two Navis BGCi floats deployed in December 2018 have now failed. A third float from that batch which failed pre-deployment tests was sent back to SeaBird for repair and a firmware upgrade and has subsequently been returned and was deployed in November near the Porcupine Abyssal Plain (PAP) mooring. The float is presently working normally. We presently have four other Navis BGCi floats (two of which have been returned to SeaBird for a firmware upgrade) and one which will deployed on the upcoming PAP mooring cruise, plus one recovered PML ProvBio float that will require refurbishing.

APEX floats with RBR CTD

We procured our first six APEX-RBR floats in 2015. Five have been deployed with three having failed early, the other two are still operating; two replacements for the early failures were provided in 2020. The sixth has since been upgraded and was deployed in the North Atlantic in December 2020 alongside the two replacements and one new APEX-RBR. These four APEX-RBR are all presently operating normally and the profiles will shortly be assessed with a view to collecting 1 Hz data in the region of strong gradients. Three other APEX-RBR are available for deployment.

Status of contributions to Argo data management

Real-time data processing

As at 18th February the British Oceanographic Data Centre (BODC) were processing data from 170 active UK floats, 16 Irish floats and 61 Euro-Argo MOCCA floats. During the last year processing was set up for APEX APF11i floats so that temperature and salinity from all our APF11i floats can now be handled. Work remains to deliver the UK BGC data to the GDACs, and this will be a high priority for the coming year. However, the two APEX DEEP floats deployed in mid-March 2021 have still to be set up for processing.

Real-time processing is run four times a day with NetCDF files distributed to the GDACs and the Met Office, where the BUFR files are generated and disseminated on the WMO Global Telecommunications System (GTS). The capability now exists to include supplementary profiles and oxygen into the BUFR files. However, we have not yet been able to progress the extension of the BUFR capability to include other biogeochemical variables. Within the Euro-Argo RISE project, UK Argo is also developing real-time tests for BBP, as well as a technique for producing uncertainty estimates for BBP.

Delayed-mode QC processing

As at 18 February 2021 BODC had delivered 89,044 profiles from UK floats, of which 64,746 profiles have been subjected to delayed-mode QC. This represents 73% of all profiles, and 77% 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 last year, as an additional 19, 224 profiles across 156 floats have been through DMQC, clearing a significant backlog.

NOC, including BODC, have also played a key role in coordinating the development of deep DMQC methods as part of the Euro-Argo RISE project WP3. Progress on BGC DMQC has been limited due to temporary staffing issues, but this will become a significant focus in the coming year as part of the Euro-Argo RISE project WP4.

Southern Ocean Argo Regional Centre (SOARC)

BODC has led the development of the SOARC Partnership, which has expanded to include the Alfred Wegener Institute, Scripps and the University of Washington. This in addition to the current partners of CSIRO, BSH and MBARI. The result is that the SOARC Partnership now includes expertise across the range of ARC responsibilities.

During 2020 SOARC, in cooperation with the Atlantic ARC and Mediterranean ARC through the Euro Argo Management Board, worked to develop a proposal on ‘Evolving the Argo Regional Centres’. This was presented to ADMT-21 and received support from the Pacific ARC and Indian ARC. The proposal centred around rethinking the responsibilities of Argo Regional Centres into a value cycle, starting at deployment planning, through to data quality assessments, intercomparison with models, feeding back into observing design, and future deployment planning. As part of this, SOARC has reviewed the ‘Southern Ocean deployment gap’ and is considering how best to work with the Argo and wider Southern Ocean community in how to address it.

Research cruise CTD data

When the UK notifies float deployments with OceanOPS, 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.

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 core floats, organizing float deployments, preparation of floats for deployment, telecommunications (costs) and international funding contributions (OceanOPS and Euro-Argo). NOC and BODC have responsibility for Argo science and data management respectively. NOC have lead on deep Argo and PML play a leading role in the expansion of the UK programme into BGC-Argo.

Funding

UK funding for Argo comes through various channels – the Met Office, NOCS and PML. Both the Met Office and NERC (Natural Environment Research Council) funding originates from BEIS (Department for Business, Energy and Industrial Strategy). At this time UK Government has not set out departmental budgets beyond April 2022.

Argo funding to the Met Office is presently provided directly from BEIS mainly through the Hadley Centre Climate Programme (HCCP), but with an additional contribution through the Public Weather Service Programme. The HCCP workplan and funding for 2021 to 2024 is presently awaiting approval by BEIS and Defra (Department for Environment, Food and Rural Affairs) and includes UK Argo for the period April 2021 to March 2024. In September 2020 a seminar was given to BEIS staff which provided an opportunity to highlight the benefits that will arise from a multi-disciplinary global 'Argo2020' array.

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. During the last year two successful bids for funding were made by NOC that will provide for 25 to 27 (depending on their actual cost) six-parameter BGC floats to be procured and deployed over the next two years or so. Non-NC funding is also provided through participation in EU-funded Argo-related projects.

Our aspirations are to contribute 10% of each of the BGC and Deep Argo arrays, and continue to provide 5% of the Core floats deployed. This could be achieved by deploying 25 BGC floats per year, with a projected lifetime of four years this would lead to a sustained fleet of 100 BGC floats. Deployment of 25 each of Deep and Core floats per year, with a five-year lifetime would ramp up to a sustained fleet of 125 of each float type. The UK would then maintain a fleet of 350 floats (100 BGC, 125 each Core and Deep), about 8% of the total anticipated global fleet. However, funding for this, at around five times the present level, is not in place and would require significant additional investment primarily from BEIS.

Human resources

Staff members working on UK Argo, their institution and estimates of effort on Argo during 2020 are given below; this will have been reduced below previous years effort due to Covid-99 lockdowns and associated home-schooling demands.

Met Office – 0.65 FTE
Jon Turton, Fiona Carse, John Hankins

NOC, Southampton – 0.25 FTE (estimated)
Brian King

NOC, BODC – 4.3 FTE
Primarily Matt Donnelly, Kamila Walicka, Clare Bellingham and Violetta Paba, with others providing additional support

PML – 0.1 FTE
Giorgio Dall'Olmo

3. Summary of deployment and data management plans

Deployment plans

As noted earlier, as at 18th March, so far in 2021 UK Argo has deployed six core APEX and two APEX-Deep floats, with four APEX in Cape Town for deployment from SA Agulhas II, two APEX in Mauritius and one Navis BGCi for deployment on the upcoming PAP mooring cruise.

At the time of writing we also have 40 core APEX, three APEX-RBR, three Navis BGCi floats (two of which are at SeaBird for updating) available. PML also have one ProvBio float that was recovered in 2018.

Deployments presently anticipated are:
One Navis BGCi: North Atlantic (PAP cruise, March/April 2021)
Four APEX: South-west Indian Ocean (Marion Island cruise Apr/May 2021)
Two APEX: Indian Ocean (to be arranged with Mauritius Met Service 2021)

Other deployment opportunities later in the year will be investigated. A reasonable estimate for the year 2021 would be twenty core floats, four deep floats and two biogeochemical floats.

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, respiration of both dissolved and particulate organic matter);
- 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.

Recent 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 has recently been published.
- 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.
- A study on the impact on FOAM of expanding the Argo array was published (Mao et al., 2020). For example, this looked at the effect on ocean heat content estimates from additional deep Argo floats.

Argo data are also used in the following Hadley Centre datasets that are freely available for scientific research uses:

- EN4 that consists of two products (i) observed subsurface ocean temperature and salinity profiles with data quality information, and (ii) objective analyses formed from the profile data with uncertainty estimates. Data are available from 1900 to the present and there are separate files for each month. See https://www.metoffice.gov.uk/hadobs/en4/).

- 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. See https://www.metoffice.gov.uk/hadobs/hadiod/.

References

Mao C, King RR, Reid R, Martin MJ and Good SA (2020) Assessing the Potential Impact of Changes to the Argo and Moored Buoy Arrays in an Operational Ocean Analysis System. *Front. Mar. Sci.* 7:588267. doi: 10.3389/fmars.2020.588267.

Martin MJ, King RR, While J, Aguiar AB. Assimilating satellite sea-surface salinity data from SMOS, Aquarius and SMAP into a global ocean forecasting system. Q J R Meteorol Soc, 2019;145:705–726. https://doi.org/10.1002/qj.3461.

Ford, D.: Assimilating synthetic Biogeochemical-Argo and ocean colour observations into a global ocean model to inform observing system design, Biogeosciences, 18, 509–534, https://doi.org/10.5194/bg-18-509-2021, 2021.

5. Issues from UK to be considered by AST

Performance of APEX APF11i floats.

Southern Ocean deployment planning

Also, it would be helpful to promote the deployment on ships the same BGC sensors that are installed on floats. These ship-based deployments would make the BGC-Argo data more familiar to the oceanographic community and would allow us to further test and validate the sensors.

U.S. Argo National Report to AST-22, March 2021

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:

- Argo New Zealand is the largest deployer of U.S. Argo floats through designed deployment voyages of RV Kaharoa (jointly supported by Argo USA, New Zealand, and Australia) and deployment opportunities on RV Tangaroa.
- Global Ocean Biogeochemistry array (GO-BGC), supported by NSF to establish the baseline rates of photosynthetic production, respiration, and nutrient supply in present ocean ecosystems
- Southern Ocean Carbon and Climate Observations and Modeling (SOCCOM), a regional pilot array of BGC Argo floats supported by NSF and NOAA.
- A NOPP project for validation and improvement of the Deep Argo 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 30 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.

A new 5-year cycle of U.S. Argo implementation began in July 2020, and extends through June 2024. The Work Plan for this cycle of U.S. Argo includes milestones and growth of the U.S. contribution toward a unified Core/BGC/Deep international Argo Program termed ***OneArgo***.

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 were that (i) Core Argo budgets should 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 are likely to 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:

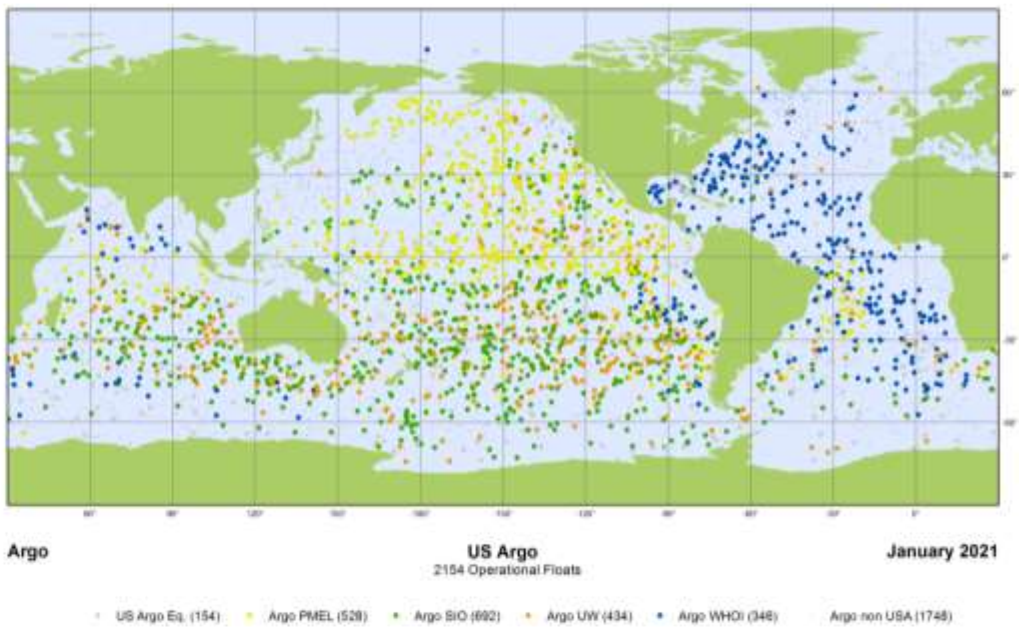


Fig. 1*: Location of operational U.S. Argo Program and U.S. Argo Equivalent floats as of January 2021. (Source: OceanOPS)*

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 2000 operational U.S. Argo Program floats (Fig. 1) as of January 2021. A timeline of the number of operational U.S. Argo Program floats is shown in Fig. 2. Table 1 indicates the number deployed in each year since 2012 and the number presently operational (Source: OceanOPS).

Impacts of the Covid-19 pandemic include limitations on all institutional laboratory activities for physical distancing, a large reduction in available deployment opportunities by the research fleet, sea freight delays, and some delays in deliveries of floats, sensors, or parts from manufacturers. There were 228 US Argo Program floats deployed between March 2020 and February 2021 (Fig. 3), substantially below the number of floats funded per year. Continuing limitations of the research fleet are causing some hard to reach regions to become sparsely covered. The relatively long life of Argo floats mitigates the year-long Covid-19 reduction in activities, as illustrated by the continuing nearly-constant number of active US Argo Program floats (Fig. 2).

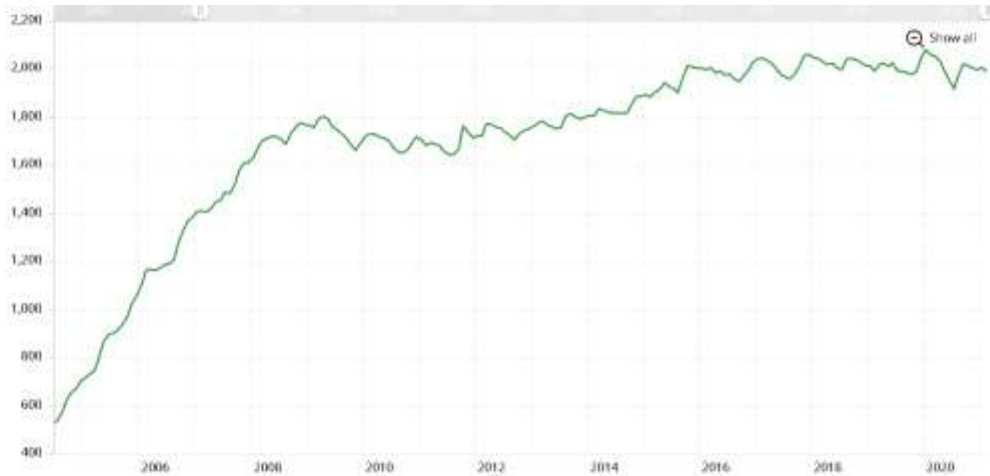


Fig. 2: *Timeline of the number of operational U.S. Argo Program floats (Source: OceanOPS)*

Year deployed	Number deployed	Number active as of 3/2021	% active (3/2021)
2012	341	39	11%
2013	329	55	17%
2014	376	180	48%
2015	346	236	68%
2016	346	292	84%
2017	365	320	88%
2018	283	259	92%
2019	294	261	89%
2020	282	266	94%

Table 1: *Number of U.S. Argo Program floats deployed in each year since 2012 and the number still active as of 3/2021 (Source: OceanOPS). A major focus of U.S. Argo is extension of float lifetimes and reduction of early float failures.*

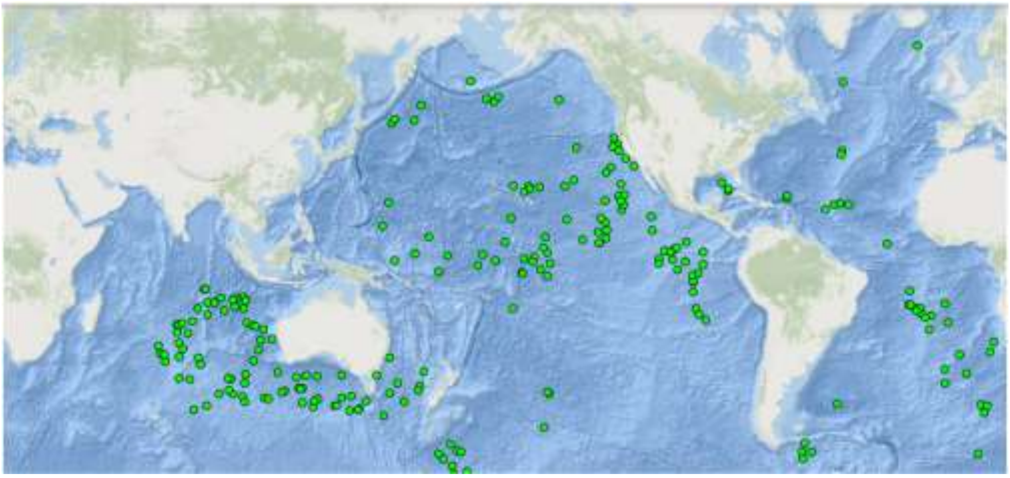


Fig. 3: *Most recent locations of 228 US Argo Program floats deployed during the first year of the Covid-19 pandemic, March 2020 – February 2021*

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. An alternative Core CTD manufacturer is entering pilot status with the intent of limiting risk to the Argo Program.

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 2020, in the Australian Antarctic Basin in early 2018, and in the western North Atlantic in early 2017. In 2019–2020, 30 Deep Argo floats were deployed in the Brazil Basin through a partnership of PMEL/U.S. Argo and the Paul G. Allen Family Foundation (Fig. 4).

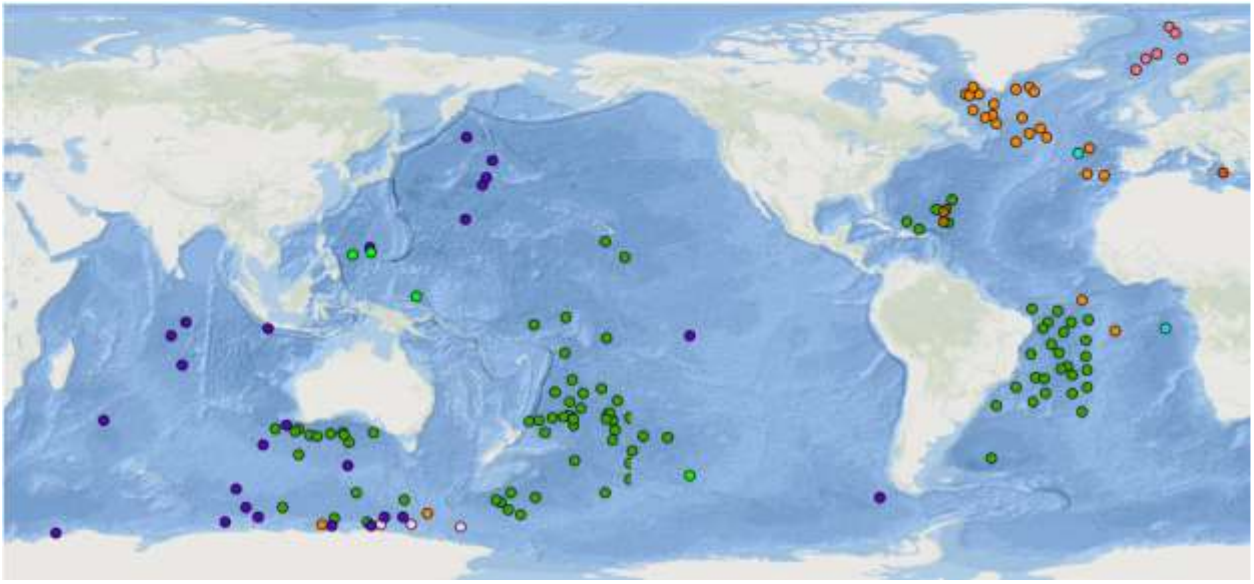


Fig. 4*: Location of all 157 active Deep Argo floats, as of 3/2021, by National Program. The 89 active U.S. Deep Argo floats are indicated by dark green symbols.*

Testing of Deep Argo 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 ± .001°C, ±.002 PSS-78, 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. A collaborative U.S./New Zealand/SeaBird Scientific cruise on RV Tangaroa will take place in March 2021 for testing/validation of new SBE-61 conductivity and pressure sensors.

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, may carry sensors for dissolved oxygen, nitrate, pH, chlorophyll fluorescence, and particulate backscatter. The latest positions of all (with at least 1 BGC sensor) 381 active BGC Argo floats includes the 169 active US BGC Argo and Argo Equivalent floats are indicated in Fig. 5. A major NSF proposal (GO-BGC) for up to 500 BGC floats over a 5-year period, is pending. A funded NOPP proposal is developing a BGC SOLO float to increase the number of available BGC float models.

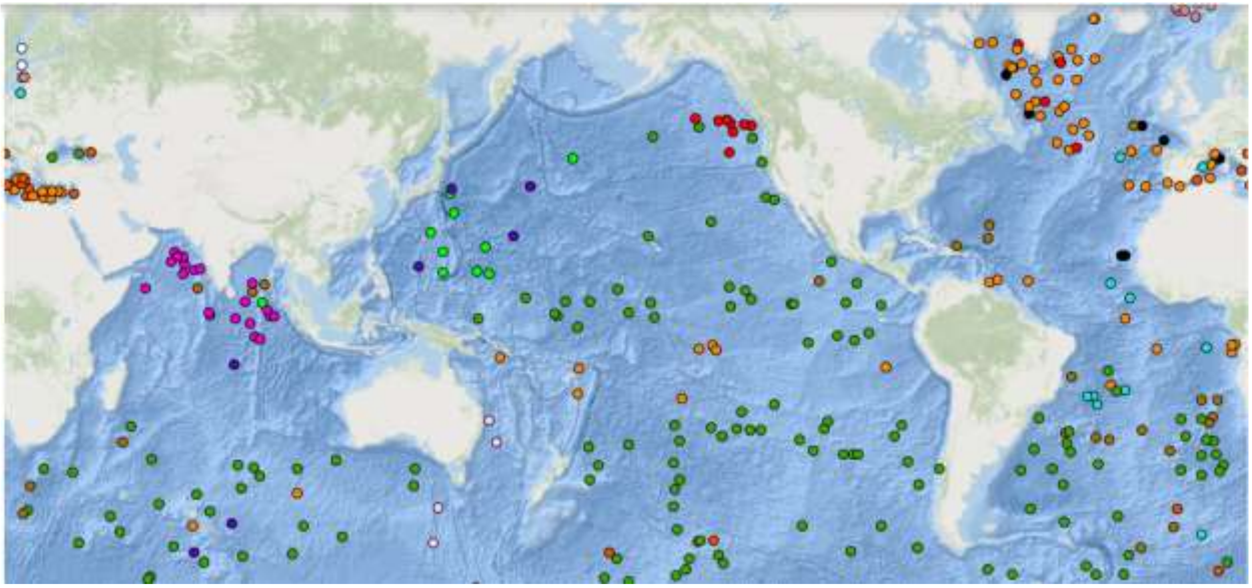


Fig. 5: *Locations of 381 active BGC-Argo floats, including 169 US Argo and Argo Equivalent BGC floats. US BGC floats are indicated as dark green symbols.*

Plans:

The highest priority for U.S. Argo is to sustain the Core Argo array. Specific plans for float deployments in 2021, as they evolve, are posted on the AIC deployment planning web page. Funding levels for the U.S. Argo Program in FY2021 are not yet set but are expected to equal FY2020 levels.

A deployment cruise on RV Kaharoa, from New Zealand to Kiribati, Cairns Australia, and back to NZ (Fig. 6), is tentatively planned beginning about September 2021, to deploy 8 U.S. Deep Argo floats in the SW Pacific Basin, about 100 U.S. Core Argo floats in the South and equatorial Pacific, plus additional Australia Core Argo floats. Since 2004, 23 voyages on RV Kaharoa have deployed 2086 Argo floats (Source: OceanOPS).

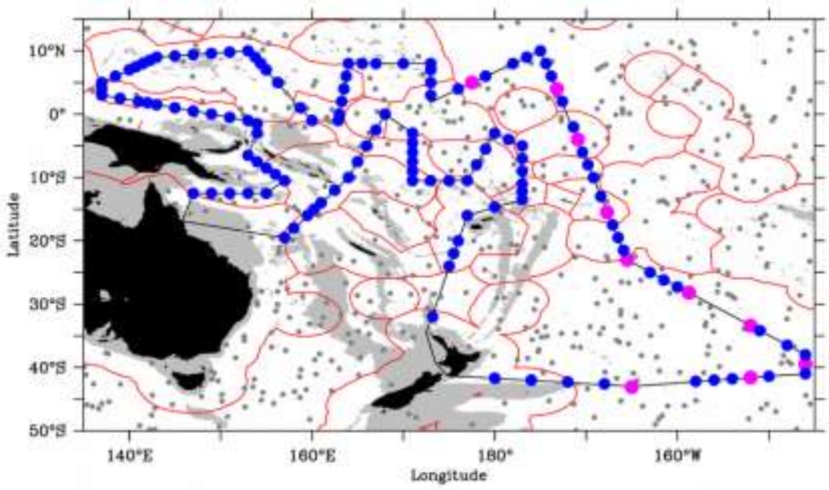


Fig. 6: *Tentative cruise track and deployment plan for the Kaharoa Argo-24 voyage. Blue dots indicate Core Argo floats and magenta dots indicate Deep Argo floats.*

Data management

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. Delayed-mode quality control and some other data management functions are carried out by the float-providing institutions.

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.