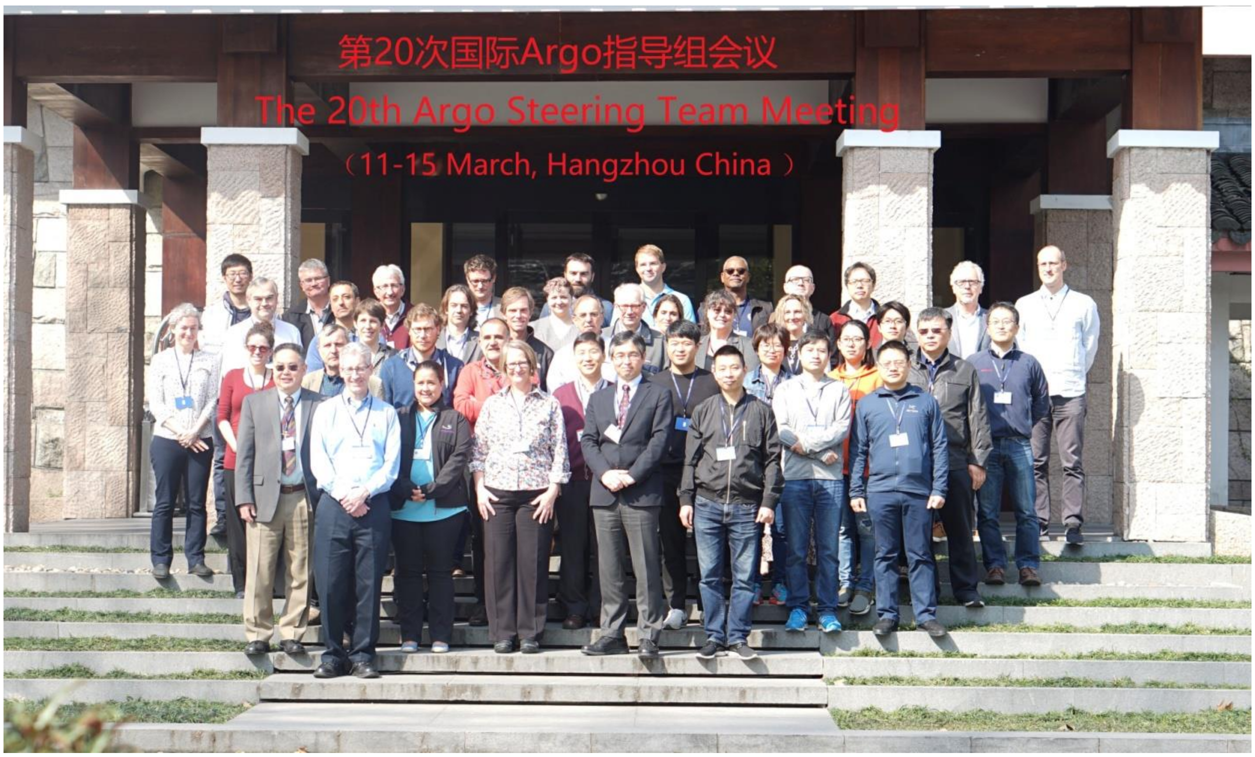
20th meeting of the International Argo Steering Team



Hangzhou, China
March 13-15, 2019

Contents

1. Welcome

Dr. Fei Chai, director of the SOED lab, welcomed everyone to Hangzhou, China for the 20th AST meeting. He reminded the audience that the 5th and the 10th AST meetings were also located in Hangzhou. In the past year, SOED has changed from under OSA to the Ministry of Natural Resources (MNR). He described the different labs in Hangzhou, their functions and the new option for graduate students at SOED. Dr. Chai runs a large lab that has put some BGC Argo floats in the water and focuses on modeling.

Action item 1: Write letter of thanks to local host SOED, Dr. Fei Chai and Professor Jianpin Xu. AST co-chairs.

2. Local arrangements

Xiaofen Wu informed the group on the logistics of the hotel and meeting rooms.

3. Objectives of the meeting/adoption of the agenda

S. Wijffels outlined the objectives of the meeting which revolve around how Argo will evolve in the future. She said that the Argo community started thinking about this with the Ocean Obs19 White paper and the 6th Argo Science Workshop, and that now is the time for the AST to consider the expansion and challenges associated with it. The theme of the AST-20 meeting will be to look hard at the expansion proposal and to find a successful path forward.

4. Status of action items from AST-19

M. Scanderbeg reported on the action items from AST-19 that had not been completed in the previous year and would not be discussed during the meeting. There was an action item on the Argo data paper which had not been addressed in the previous year. S. Wijffels reported that she has discussed the idea and outline of the paper with Annie Wong who is willing to be the lead author on the paper. So, the data paper will be moving forward in 2019 with Annie as the coordinating lead author. There was also an action item on setting up private mailing lists with techs and PIs within Argo to share technical information. This was not done, but could still be set up if desired. M. Belbéoch said it is easy to create and maintain these lists and is happy to do whatever is requested of Argo.

5. Update commitments table including global Argo, extensions and equivalent floats

M. Scanderbeg updated the commitments table on the JCOMMOPS website according to estimates sent to her with National Reports. Additionally, we went around the room and added a few more commitments. There are several columns in which to add floats: Argo core, Argo equivalent, Argo BGC, Argo Deep, Argo 2020. If floats carried only one BGC sensor, they were put into the Argo BGC column. The Argo 2020 column is meant to capture floats in other Argo mission areas like Western Boundary Currents, Equatorial regions, Polar regions, and Marginal Seas. The outlook for 2019 is good with 1064 floats scheduled to be deployed. 781 of those are core, 48 are equivalent, 161 are BGC, 62 are Deep and 12 are in the Argo2020 column.

6. Argo's Future Design

S. Wijffels introduced this topic with a short presentation on the future vision of the Argo 2020 array that was introduced at the 6th Argo Science Workshop in Japan in October 2018. The vision is one array that is global in extent, full depth and multi-disciplinary. She noted the benefits of having one array which include shared platforms, logistics, resources, science, data management, and EEZ protocols. She also noted the strong synergies between the different missions. The new target number of floats would be 4600, with 1200 of those to be deep floats and 1000 to be BGC floats. The key for this new array to work is that all floats must deliver profiles on at least a 10 day cycle to 2000db and park at 1000db in between.

The new array must be well articulated in order to be fully funded. Benefits of this new array include more fundamental ocean research, new dimensions of climate assessment, educational engagement, and improved long and short term ocean, climate and ecosystem state estimates and forecasts. These improvements will enable better climate intelligence to sensitive industries such as agriculture, energy, aquaculture, fisheries, insurance and resource extraction. In addition, it will empower governments to better manage pollution dispersion, search and rescue and national defense. Syntheses with satellite observations will help to close global and regional sea level rise and energy budgets which are vital for tracking global change. All of which will help make more accurate climate projections to better enable societal adaptation.

Susan ended by reiterating that significant new resources are needed to establish this array – roughly three times the current investment. So, the case for the new array needs to be well articulated and consistent at OceanObs19 and beyond. It would help to identify new high level champions in key agencies around the world.

6.1. BGC Argo Status and challenges (K. Johnson and H. Claustre)

The first meeting of the BGC-Argo Steering Team was held on Monday and Tuesday. The BGC-Argo array continues to evolve with increasing numbers of floats each year. In 2018, commitments for 123 floats were made, and 132 were deployed. Commitments for 2019 are 160 with deployments planned by Australia, Canada, China, Euro-Argo, France, Germany, India, Italy, Japan, Poland, UK, and USA. A proposal has been submitted by a US consortium of MBARI, UW, SIO, WHOI, and Princeton to acquire 500 BGC floats and implement the US half of the 1000 float BGC array. Costs in the proposal are similar to estimates in the BGC-Argo Science and Implementation Plan. The status of BGC data in the Argo system was summarized. Significant improvements in data useability have been made through the development of the Synthetic Profile files (Sprof files). Processing of BGC data continues to improve with most of the chlorophyll data, as well as newer chemical sensor data in a good state. However, a large amount (2/3) of the oxygen data still require quality control and adjustment. PIs are being contacted and plans to process this older data are being developed. Much of this process at the SOCCOM data center has been automated with improvements in data quality and a large reduction in time required to process data.

The BGC-Argo Science and Implementation Plan was revisited with a goal to rewrite several sections. In particular, the definition of the desired, 6 sensor load will be revisited. Few 6 sensor floats have been deployed, due to technical limitations.   This will be recognized by allowing 4 and 5 sensor floats to contribute to the global objectives during a transitional period. The overall goal of 1000, 6 sensor floats will remain as the ultimate objective. There was also discussion of the science mission for a BGC float. Many programs deploy floats with cycle times less than 10 days, which will require a larger replacement rate for the array. While short term science objectives may lead to faster cycle times, float deployers will need to recognize that this degrades our ability to maintain a large array and they should not consider floats on short cycle times to contribute fully to the 1000 float array. The Implementation Plan will be amended to reflect this. In addition, float lifetime and recovery were discussed and having commercially available floats with good lifetimes and reliability will be necessary to help achieve the new Argo array.

In other discussions, the IOC Executive Council approval for the 6 BGC sensors on an Argo float was recognized and appreciated as a significant accomplishment. Thanks to all who made this possible. Improvements to the BGC-Argo website (http://biogeochemical-argo.org) were noted. The Biogeochemical Float Workshop at the University of Washington, sponsored by the US OCB program was discussed and plans for future workshops were considered. Finally, it was noted that several significant papers are in development.

6.2. Deep Argo Status and challenges (N. Zilberman and G. Johnson)

Regional Deep Argo pilot arrays are currently active in the Southern Ocean, the Southwest Pacific Basin, and the North Atlantic Basin. A new Deep Argo pilot array will be implemented in the Brazil Basin in 2019-2020. Deep Argo pilot arrays are located in abyssal plains, on the pathway of recently-formed abyssal water, in regions with logistical support from Argo partners, with frequent float deployment opportunities, and where reference data are available. There are 75 active Deep Argo floats, including 50 Deep SOLO, 3 MRV Deep SOLO, 17 Deep Arvor, 2 Deep NINJA, and 3 Deep APEX floats. About 70 additional Deep Argo floats will be deployed through 2020. Deep Argo provides new estimates of deep-ocean warming, fluctuation in deep watermass characteristics near formation regions, and spatial structure of the deep-ocean circulation. A Deep Argo workshop will be held in Hobart, May 13-15th 2019. Technical challenges, including to improve the accuracy and stability of the conductivity and pressure sensors, and to reduce thermal mass error, will be overcome in 1-2 years, paving the way for the global implementation.

Action item 2: AST states that it is a high priority to make Deep Argo data publicly available in a timely manner on the GDACs. Deep Argo PIs and DACs

6.3. Regional enhancements and spatial completeness (M. Belbéoch)

M. Belbéoch presented the status of the regional enhancements that are part of the Argo2020 plan including Marginal Seas, Western Boundary Currents and Equatorial Regions. All three of these enhancements would be around 200 floats to reach completeness. He noted that improving float lifetimes would really help with improved coverage and that for some Marginal Seas float retrieval and re-deployment is being considered.

He recommended that Argo transition to this new array design from 2020 to 2025 and that new, improved communication is needed to relay this message to our partners, funding agencies and the public.

6.4. Argo2020 concept and feedback from National Programs

In the discussion following the presentations, each country gave feedback on the status of Argo within their nation and how they envision moving forward to try and achieve the new Argo array. Many countries said that they will need to find additional funding for BGC and Deep Argo floats and that this will take time. Several countries stated that they will be buying floats from commercial manufacturers and will need these floats to be reliable and reasonably priced. Several countries also expressed the need to accommodate research funding for BGC and Deep Argo missions in order to move towards operational funding in the future. Floats with research funding may perform more cycles than needed to contribute to the 2000m Argo mission which means that they will not last as long and will need to be replaced more quickly. A couple of countries said that in order to secure more funding, high level advocates are needed. In conclusion, all the AST members agreed to the new Argo array vision and will work to secure additional funding to help accomplish it. An implementation plan would help to keep communication consistent across countries and give realistic guidelines as to the speed of expansion.

B. King showed figures on how the internal governance structure of the Argo array may change to accommodate the new missions. The AST would continue to oversee the array and there would be three missions: the 2000db mission (formerly known as 'core Argo'), the BGC Argo mission and the Deep Argo mission. The ADMT will continue to serve all Argo missions. There was a discussion on who will attend AST meetings and it was noted that each country cannot send three different representatives each year, so the AST member must become familiar with their country's entire program and not just their specialty. This does not bar additional experts from coming from time to time as needed, but it should not be the standard every year.

When the implementation plan and governance structure are finalized, they should be posted on Argo websites.

Action item 3: Write a prospectus and road map for Argo2020 array design build-up; publish on AST site and others as appropriate. AST co-chairs, B. Greenan, D. Roemmich

Action item 4: Develop a talk on the Argo2020 array design and share with AST. AST co-chairs and AST.

Action item 5: Give national talks to promote idea and get feedback. AST

Action item 6: Promote Argo's new design at upcoming conferences and workshops starting with OceanPredict. P. Oke, P-Y. LeTraon, G. Maze, AST co-chairs, AST members.

Action item 7: Finalize governance structure and meeting organization. Ask mission teams to establish Terms of Reference. Post finished graphics of governance structure on AST website and update accompanying text. AST co-chairs, B. King, K. Johnson, H. Claustre, N. Zilberman, M. Scanderbeg

Action item 8: Convert documentation on BGC, AST and other websites to reflect the new Argo array with the various missions including the 2000db mission, the BGC mission and the deep mission. Add new governance structure diagram describing how the missions work together onto all the Argo websites. M. Scanderbeg, BGC website, JCOMMOPS, etc.

7. Implementation issues

7.1. AIC Report on the Status of Argo (M. Belbéoch)

M. Belbéoch presented the status of the Argo array which relied on the report created for the AST-20 meeting (http://www.argo.ucsd.edu/AIC_Rep_AST20.pdf). The array has been sitting at just under 4000 floats for the past year, with the majority of floats using Iridium communications now, but a third still using Argos. He noted that core Argo is short by about 15% and that more floats are needed to sustain the global array. There continue to be areas of too many floats like in the NW Pacific, Mediterranean Sea, and NW Atlantic, and areas of too few floats like the Southern Ocean. BGC floats make up 10% of the total Argo array.

Argo needs more floats that last longer – only 60% of the array reaches the 150 cycle goal. M. Belbéoch encouraged AST members to put number of cycles desired in their tenders. At the current float mortality rate, the array will decay if more floats are not deployed or if floats do not improve their reliability.

In terms of deployment needs, the Southern Indian Ocean and South East Pacific Ocean need more deployments and hopefully the Kaharoa will help with this. He suggested deploying fewer floats in the North Atlantic in the coming year and trying to put those floats elsewhere. Also, he suggested finding more implementers to help deploy in some Marginal Seas and areas of the Southern Ocean that are hard to get to or have additional deployment hurdles. Every float counts and Argo should try to optimize each deployment and consider investing in low-cost ship time.

Action item 9: M. Belbéoch to add Arctic targets to JCOMMOPS statistics and maps to better monitor this region

Action item 10: M. Belbéoch to work with BGC Argo co-chairs to develop BGC Argo targets at JCOMMOPS to better monitor statistics.

7.2. JCOMM Observing Program Support Centre (M. Belbéoch)

JCOMMOPS was reviewed in the past year and the results were very positive overall. The governance structure was clarified, more responsibilities were given and JCOMMOPS will shortly become an official centre of WMO. The structure of JCOMMOPS was reviewed. There are 7 people on the JCOMMOPS team: 4 Technical Coordinators, 2 IT people, 1 oceanographer/science communicator/outreach specialist. JCOMMOPS is hosted by IFREMER and powered by CLS. It is funded by yearly contributions from many countries and the European Union.

As part of the review, JCOMMOPS made a report card which can be found here: www.jcommops.org/reportcard

7.3. EEZ guidelines and strategies (M. Belbéoch)

M. Belbéoch wanted to remind all AST members and those deploying floats under the Argo Program that floats must be notified prior to deployment and follow all LOS guidelines to ensure continued ability to deploy Argo floats. Given that about 30% of the ocean is an EEZ, the rules must be followed. Toshio Suga reiterated that for experimental sensors on Argo floats, UNCLOS must always be followed. If this is ignored, Argo could be in jeopardy of losing this approval. It is strongly suggested to deploy such experimental floats in international waters. If a float looks like it is going to drift into an EEZ, please use M. Belbéoch's warning message to send the appropriate notification to that country.

7.4. IOC and BGC variables update (S. Wijffels and B. Owens)

The IOC Executive Committee meeting in July 2018 were Breck Owens presented Argo's two requests was extremely successful. Breck wanted to thank all AST members and supporters who spoke to their IOC representative in support of Argo's proposal. The IOC agreed to the proposed 6 BGC Argo parameters to be measured in EEZs on Argo floats under the current IOC resolutions. The IOC also agreed to the new framework for adding parameters to Argo. This means that new sensors are allowed on Argo floats in experimental and global pilot stages under the governance of the AST and Argo needs to go to the IOC General Assembly only when global implementation of a new sensor would start.

7.5. China Argo (Zenghong Liu)

Zenghong Liu reported the implementation status of the China Argo. Relying on the non-operational funding from the Ministry of Science and Technology, SOA, and Ministry of Finance, China Argo sustained a yearly deployment of 15-25 floats during 2016-2018, maintaining a national array of about 100 operational floats. A BGC-Argo array in the northwestern Pacific is being developed by SOED/CSIO as an important effort to the global array, in which several full-equipped floats with 6 BGC sensors and Sea-TREC rechargeable battery will be deployed. A pilot project for testing the performance of SBE 41CP CTD sensor in deep oceans is being carried out. He also introduced the progress on the HM2000 float and the development of Chinese deep floats. The Argo data receiving and processing system established at CSIO enables them to process data from various float models using different communication systems. Finally, he summarized the China Argo perspectives before 2020. With 34 secured floats, almost secured funding for 75 floats, and funding TBD in 2019 for 220 floats, China is expected to enhance their contribution to the Argo program. Their float deployment will be focused on the northwestern Pacific, Indian and Southern Ocean.

7.6. Euro-Argo Status (C. Gourcuff)

Claire Gourcuff presented the Euro-Argo Research Infrastructure and Euro-Argo contribution to the Argo network. She first described the organization of the Euro-Argo ERIC (European Research Infrastructure Consortium), which now involves 13 countries. The Research Infrastructure consists in distributed national facilities and a central office of 6 persons.

In terms of network implementation, Euro-Argo is slowly but constantly increasing its contribution towards ¼ of the global network. Claire highlighted the importance of the EU-funded floats in recent years, as well as contributions from new countries such as Norway, Bulgaria, Ireland, Poland, etc. Euro-Argo has developed its strategy in coherence with Argo international, in a reference document (doi:10.13155/48526) which provide targets for different regions and types of floats (Deep/BGC/T-S-O2). There is a strong European interest in marginal Seas and an increasing interest in high latitudes that translate to higher numbers of floats to be deployed in these regions in 2019 compared to 2018 and compared to targets. The European contribution to Deep-Argo is of 1/5 of the current network (mainly France, UK & EU, but also Norway starting in 2019) and the contribution to BGC-Argo was 30% in January 2019, through deployments done mainly by France but also few floats deployed by many different countries. Both Deep-Argo and BGC-Argo European deployments are increasing.
A new EU funded (4M€) project has started this year and will continue for four years, with 19 European (plus JCOMMOPS) partners involved: Euro-Argo RISE. The project aims at developing Euro-Argo in all aspects: float technology, data management, deployment strategy, services to users, Euro-Argo visibility, membership, link with other observing networks.

During the last 5 years, Euro-Argo has extended its membership from 9 to 12 countries, and its contribution to the global network has increased from 17% to 22%. Euro-Argo has proved its capacity to extend the network to biogeochemistry, greater depths and higher latitudes. The European user community has developed through communication activities and organization of events, and new services have been created for members (centralized procurement, tools for live fleet monitoring). Links with other environmental RIs have been fostered, and the office has succeeded in setting-up proposals for EU funds, such as the new Euro-Argo RISE project which should help to make significant progress on all aspect of Argo in the next few years.

7.7. Argo Best Practices paper (S. Riser)

S. Riser presented an outline for an Argo Best Practices paper for submission in Frontiers. The purpose of this paper would be to summarize how Argo has been successfully carried out for the past 20 years, how the organization has addressed problems, and how Argo's structure and organization might change in the future in response to new missions. Authors have been identified for many sections of the outline and the paper is due 15 April 2019.

7.8. Discussion items from National Reports and a quick oral round table of highlights or key issues

Due to the long discussion on Argo 2020, where every country was asked to respond, this section of the Agenda only included a few discussion items rather than an oral round table from each country. Please see the National Reports at the end of the meeting report for more details.

8. Data Management and related issues

8.1. Feedback from ADMT-19

M. Scanderbeg reported on the status of the ADMT in the past year. She noted that the number of DMQC files was up from previous years, indicating that the transition to v3.1 is mostly complete. This is good news since the risk of high salinity drift in certain batches of CTD serial numbers will be an additional burden on the DMQC operators in the coming years. In fact, the overall quality of salinity has gone down 2% in the past year, indicative of the larger number of drifting CTDs. This is something that Argo and the ADMT needs to monitor this situation and work to quickly mark salinity data with appropriate QC flags for these floats in particular. There were discussions at the ADMT meeting on the need to prioritize floats for DMQC, the need to transfer knowledge to new DMQC operators, and on how to better quantify DMQC work to reward operators who take time to deal with harder floats rather than simple DMQC throughput. Several tools were suggested to help prioritize floats for DMQC including floats that show up on near-real time tests including the altimetry comparison, the OA test run monthly at Coriolis, the new MinMax climatology test to be run monthly at Coriolis, plots created by S. Wijffels to be updated regularly, and CTDs with serial numbers in the 6000 – 7100 range and in the 8000 – 8500 range. To help transfer knowledge to new DMQC operators, a couple of tasks were identified. The first is that Euro-Argo will begin developing a DMQC cookbook with instructions and examples. The second is a DMQC mentor program where new comers can contact DMQC mentors identified by region for help and advice on how to do DMQC in their region. Finally, the need for additional indicators on DMQC work was discussed and an initial step will be having DMQC operators keep track of their progress on CTD serial numbers 6000 – 7100.

Another issue that was discussed at the ADMT-19 meeting was the size and content of the greylist. The greylist grew from 887 entries to 1870 entries in one year and this was mostly due to BGC sensors being added to the list. The greylist is likely to continue to grow as it was decided that DACs without resources to look at floats with CTD serial numbers in the 6000 – 7100 range in near real time should be greylisted with QC flags of '2'. In a related issue, Argo stopped sending TESAC messages onto the GTS this year and now only sends BUFR formatted messages which include QC flags. Given these developments, it was decided that DACs should send all data onto the GTS in BUFR format with appropriate QC flags and that the greylist should no longer be used to prevent float data from being sent to the GTS. These changes will need to be communicated to users. The greylist should now be thought of as a monitoring tool for Argo rather than a list used to filter out bad data. In fact, the AST suggested going one step further to stop the greylist entirely so as not to confuse users. This suggestion will be taken back to the ADMT for a decision. It was noted that some DACs use the greylist to process floats in real time.

Data was sent onto the GDACs and GTS in a timely and stable manner last year. It was requested by some operational centers that the data appear more quickly than within the 24 hour target that currently exists for Argo. The ADMT requested that DACs evaluate their processing time and procedure for Iridium floats and report back at the next ADMT with a reasonable new hourly target that could be achieved. Currently, 80% of Iridium float data is available with 6 hours on the GTS and close to 90% by 9 hours. The new python 2.7 BUFR decoder for T/S floats written by the UK Met Office was released this year (https://doi.org/10.17882/57596). There are plans to validate the DOXY BUFR format GTS message this year and other BGC variables can be added as desired by operational users.

Two quality control tests are being considered to compare against climatologies based on delayed mode Argo profiles. One is a MinMax climatology created by J. Gourrion that is being tested in near real time at the Coriolis DAC. The potentially anomalous profiles identified by the test are visually confirmed and sent to the DACs via C. Coatanoan. These profiles could be used to more rapidly detect sensor drift in real time and help prioritize DMQC work. Further turning of the MinMax climatology will occur over the coming year and results will be reported back at ADMT-20. The second test is against a gradient climatology developed by B. Owens on a uniform latitude and longitude grid with a search radius of ~500km to identify nearby profiles. Various statistics will be compiled on different vertical coordinates for T, S, N^2, dT/dp, and dS/dp. The method needs to be finalized, but could be used in near real time to identify anomalous profiles or as a first guess for objectively mapped fields needed in the OWC procedure.

The size of the GDAC directory is getting quite large – about 550 GB. This makes the DOI monthly file size large. Therefore, at the ADMT-19 meeting, it was agreed that the DOI monthly file will still be available with one click, but that inside the download, the GDAC holdings will be split into two compressed files per DAC: one for core Argo and one for BGC files. In addition, the Coriolis GDAC will stop serving these monthly zipped GDAC files on their server and they will only be available via the DOI page. It is also hoped that the newly formatted BGC multi-profile files should be significantly reduced in size. The GDAC File Checker is set to move from warnings to rejections around AST-20. In addition, the GDACs are to stop accepting d-files in anything other than v3.1 by AST-20. Some time before the ADMT-20 meeting, the GDAC File Checker will be run on all v3.1 files on the GDACs as some files made it onto the GDAC before the File Checker became live. Almost 90% of all files are in v3.1.

The trajectory files were mentioned and it was noted that work is being done to start producing more dmode trajectory files. A working group was formed at ADMT-19 to develop procedures and tools to create DMQC trajectory files. The ADMT asked the AST to consider how to make d-mode trajectory files.

Action item 11: AST asks National programs to consider how to better support production of DMQC trajectory files. Argo National Programs

Action item 12: AST co-chairs to write a letter of acknowledgment to ADMT to recognize the improvement in data utility, quality and consistency by moving to format v3.1 and introducing the file checker. AST co-chairs

Action item 13: Work with BGC forecasting groups to determine speed and quality of data desired for different parameters for inclusion in models. H. Claustre, K. Johnson, P. Oke, ADMT co-chairs

Action item 14: AST asks ADMT to consider holding a one-day do-a-thon workshop aside the next ADMT meeting. Possible outcomes would be improved data visualization tools for the general public. H. Claustre, ADMT co-chairs, S. Diggs, M. Belbéoch

8.2. 6th DMQC Workshop report (B. King)

B. King reported on the 6th DMQC Workshop held prior to the ADMT-19 meeting in La Jolla in December 2018. This was the first such workshop in 10 years and it covered the DMQC process, tools used to identify salinity drift, reference datasets, DQMC for trajectory files, and DMQC revisit times. The report is available online (http://www.argo.ucsd.edu/DMQC6_workshop_report.pdf). One of the outcomes was that the OW tool was renamed to OWC to recognize Cecile Cabanes work to improve the tool. All DM groups were encouraged to upgrade to Cecile's OWC version 2.0 tool available on the DMQC GitHub site (https://github.com/ArgoDMQC). Further updates were agreed to be implemented in OWC with a version 3 to be released in the future.

Other tools were presented to help with DMQC. The first was John Lyman's PMEL GUI which is written in Matlab, used to analyze OWC output and is available on the DMQC GitHub site. Jenny Lovell presented the CSIRO GUI which is also written in Matlab and allows visualization of float data by visual examination against two climatologies. Depending on the results, OWC can be run and salinity adjustments applied. S. Wijffels quick QC assessments tools showing Brunt Vaisala frequency plots and salinity anomaly plots were shown and are available online (https://github.com/ArgoDMQC).

Time was spent talking with SeaBird representatives about cell thermal lag and CTD salty drifts for some batches of CTDs. It was agreed that, if possible, floats with CTD serial numbers in the 6000 – 7100 range be looked at quickly in DMQC and repeatedly looked at every few months to try and identify fast high salinity drift. Any patterns in failure, drifts not correctable by simple pressure-independent salinity offsets and floats with CTDs outside the identified serial number range should be reported to John Gilson, Megan Scanderbeg and SeaBird.

The topic of frequency of DM visits was discussed again and it was decided that floats should be DMQC'd annually. When this is not possible, near-automatic tools should be used to triage real time data to identify floats that may have drifts so that biased real time data can either be flagged or adjusted in DMQC.

8.3. Including estimated positions in profile and trajectory files (M. Scanderbeg)

M. Scanderbeg presented the results of the working group assigned to figuring out how to include estimated positions in profile and trajectory files without doing a major re-write of either file type. Many of these estimated positions will be for under-ice profiles, but some may be the result of a faulty antenna making GPS fixes difficult to achieve. For Profile variables, it is more straight forward; two optional variables can be used: POSITION_ERROR and POSITION_COMMENT. Both can be filled in either real time or delayed mode. POSITION_ERROR may contain the uncertainty of estimated positions in meters. POSITION_COMMENT may contain a description of the estimation method used. If something other than linear interpolation is used, it is strongly encouraged to fill both optional variables. POSITION_QC will be '8' to indicate an estimated position. POSITIONING_SYSTEM occurs in each profile file. If a single system is used to estimate a position, POSITIONING_SYSTEM should record that system. If more than one system is used or if another method is used that does not rely on positioning system, POSITIONING_SYSTEM should be 'NONE. The POSITION_COMMENT field can be used to record the estimation method.

For trajectory files, in the past, only Argos and GPS positions have been allowed. However, after much discussion, it was agreed to allow lower accuracy positions including estimated ones and Iridium ones in limited cases into the trajectory files. RAFOS positions should also be included when they become available. The reasons for this change include more consistency between profile and trajectory files and that users should be able to find profile positions in either set of files without having to use both. In addition, with the move into v3.1 and the change from only Argos floats to ones with GPS fixes, it is hoped that users are more familiar with how to use the variables within the trajectory file to help them decide if they want to use a position or not.

Even with this change in philosophy on how trajectory files are filled, POSITIONING_SYSTEM will not be expanded into an N_MEASUREMENT array. Therefore, POSITIONING_SYSTEM in trajectory files will record the primary positioning system on the float (Argos, GPS, BEIDOU, etc). POSITION_ACCURACY, POSITION_QC and MEASUREMENT_CODE (all N_MEASUREMENT arrays) will be used to indicate when other positioning systems are used. This means an update to Ref Table 5 (POSITION_ACCURACY) and Ref Table 9 (POSITIONING_SYSTEM). Both will have additions to reflect new positioning systems that may come online soon as well as 'U' and 'NONE' for estimated positions without the use of a positioning system.

A couple examples were given including how to include an Iridium position, based off several Iridium fixes, when no GPS is available. In all cases of estimated positions, real time and delayed mode operators are urged to fill the AXES_ERROR_ELLIPSE* variables with estimated errors to help users decide whether or not to use the positions in their work. A question was asked as to how to deal with RAFOS positions and M. Scanderbeg said that RAFOS positions will be given their own measurement code and accuracy in Ref Table 5, but that POSITIONING_SYSTEM should stay with the primary one, likely GPS.

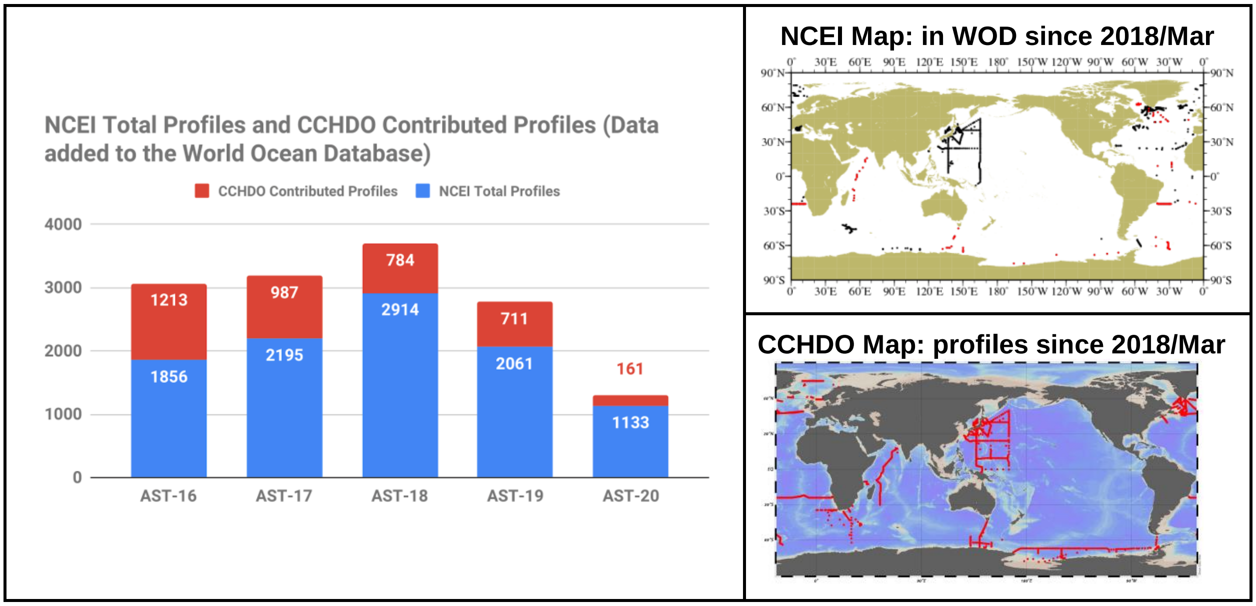
All these changes will be documented in the User Manual, on ADMT web pages and in the Argo data guide.

8.4. CTD Reference data and developing a reference dataset for Deep Argo (S. Diggs and S. Purkey)

CCHDO's overall number of available profiles added since AST-19 was consistent with previous annual contributions, while NCEI reported a reduction in the number of profiles that were added to the World Ocean Database (WOD) for the same period. CCHDO and NCEI will look further into this issue to figure out if the decrease in profiles uploaded to WOD is real or the result of a technical oversight in this informal data exchange system.

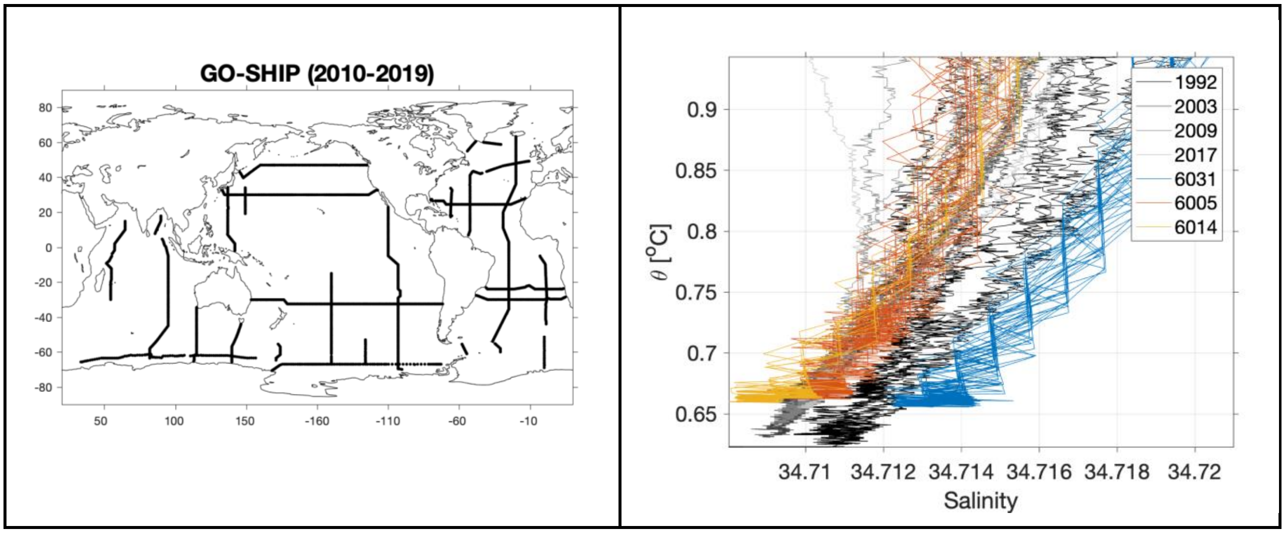
Of note was the South African contribution of 177 casts as well as Japan's 342 profiles specifically for Argo via CCHDO since March 2018.

NCEI and CCHDO contributions to Argo CTD Reference Database



The CTD Reference database discussion directly addressed the extra effort that Coriolis expends dealing with slight variations in CCHDO's data format, parameter names, and QC flags. ADMT-19 attendees with expertise and/or interest in the efficacy of the CTD Reference database convened a side meeting last December in La Jolla. The AST-20 presentation covered the agreed upon solution, timeline, and current progress to date. CCHDO has completed the scheduled progress on this action item, a prototype file is now available for examination, and the presentation including a detailed comparison of the existing netCDF and new netCDF-CF files for Coriolis. Comments were welcomed through ADMT-20 in Villefranche.

The final comments in the first half of the presentation proposed under utilized sources of GO-SHIP quality CTD data from our Chinese colleagues (e.g. the Chinare/Xuelong annual expeditions to Prydz Bay), routine South African surveys, and CTD data from Deep Arvor deployments.



In the second half of the talk, Sarah Purkey discussed a need to develop a new ship-based reference database in-order to DMQC the deep Argo floats. This reference database needs to be of the highest salinity accuracy and therefore, will likely be limited to post 2000 GO-SHIP (or GO-SHIP quality) full depth CTD data that has been calibrated to bottle salinities. This database will be sparse and might still need further QC to ensure salinity accuracy.

9. Technical issues

9.1. Sensor progress

9.1.1. RBR CTD (S. Wijffels)

S. Wijffels presented an update on the RBR CTD.

At the end of her presentation, she said that very few people are participating in the RBR pilot project and she hoped that others would seriously consider doing so. RBR would like to know if others are interested to help them decide how to proceed with CTD development. Please let Susan know if you plan on using RBR CTDs so she can relay this information to RBR.

Action item 15: National Programs interested in using RBR CTDs, please email S. Wijffels.
Action item 16: AST to request RBR implement onboard dynamic corrections for salinity and have float transmit both raw and corrected salinity to help Argo assess the efficacy of the corrections. AST co-chairs, G. Maze

9.1.2. RBR Argo6000 (G. Maze)

G. Maze presented new tests of the RBR CTD for deep Argo. In July 2018 the deep RBR|6000 was mounted onto the rosette during the OVIDE2018 cruise in the North Atlantic. About 50 stations were performed with the RBR, the deepest one going down to 5500db. Pressure, temperature and conductivity measurements were evaluated against the SBE911 of the rosette and bottle measurements. We found that pressure is within specification of the manufacturer and within deep Argo requirements. However a small non-linear and systematic bias was observed, with the same structure as the RREX17 test bias. RBR then developed a new correction model to take this into account. Temperature measurements were correct and appropriate for deep Argo. Conductivity measurements were good at the first and deepest station, however they showed a non-negligible drift with time during the rest of the cruise. RBR could not reproduce this during a pressure tank experiment and attributed this drift to a fault in the cell that was found a posteriori. The conclusion is that the deep RBR CTD remains very promising but still needs work to prove recurrent accuracy and appropriate conductivity measurements.

9.1.3. SBE41 under 2000db (S. Hosoda)

JAMSTEC evaluated measurements on the Deep NINJA compared to the shipboard CTD observations carried out at deployment. The comparisons were conducted for 18 float/shipboard CTD pairs (by 11 cruises of 6 ships). Based on the comparisons, negative pressure dependency for salinity could be reproduced by changing the parameter (CPcorr) of the current setting (-9.57 x10^-8) to about -13.5 x10^-8.

However, the current setting by the sensor manufacturer is derived from the physical property of the measuring cell (Pyrex©) in a theoretical manner (SBE, 2013). Actual structure of the measuring sensor for conductivity is modeled as dual-cells, using Pyrex© for inner-cell and Polyurethane for outer-cell. Due to stronger stress at the interface between the two cells under a higher pressure environment, the inner-cell is deformed in the radial direction more than the single-cell model, while the deformation in z-direction is less. Based on the model for a condition of slip case at interface, it provides CPcorr of about -15 to -18 x 10^-8, which is a smaller value than the current setting. The result could possibly explain the negative pressure dependency of the salinity bias except for its smaller value than the observation.

Action item 17: Ask SBE about the surface salinity offset in SBE41 extended depth version. Continue evaluating SBE41 extended depth version. SBE41 extended depth version PIs, SBE.

9.1.4. SBE61 (N. Zilberman)

Most Deep Argo SBE-61 CTDs deployed in the Southwest Pacific Deep Argo array, show stable salinity measurement in dense water mass layer. Some technical challenges remain for accuracy and stability of pressure and conductivity sensors. Out of 18 CTDs deployed in 2016-2017, 14 CTDs show salinity accuracy within ±0.004 PSS-78 in comparison with shipboard data, 3 CTDs show an exponential drift and 1 CTD shows linear drift 1 year after deployment. A National Oceanographic Partnership Program (NOPP) proposal will validate the stability of salinity and pressure, and advance the technology readiness of the SBE-61 CTD to meet Deep Argo's targets of temperature, salinity, and pressure accuracies (0.001°C, 0.002 PSS-78, and 3 dbar respectively) within 1-2 years.

9.1.5. Update on high salinity drift from SBE CTD serial numbers 6000 – 7100 (S. Wijffels, J. Gilson, D. Murphy)

S. Wijffels presented an update on the high salinity drift seen in some SBE CTDs. She noted that many of these problem cells have been identified and flagged properly, but not all for the 6000 – 7100 serial number range. The AST agreed this was a top priority and asked that DM operators and DACs continue to do look carefully at this data and flag it appropriately.

In addition, it appears there could be another cohort of high drift CTDs with serial numbers 8000 – 8500. She pointed out a MOCCA float (3901897) that drifted fresh and then salty with a similar pattern to the 6000 – 7100 CTD salinity behaviour. SeaBird is working on the problem.

Please continue to look at all salinity carefully in DMQC and if floats with CTD serial numbers greater than 7100 show this behaviour, email Kim Martini at SBE (kmartini@sbe.com), John Gilson and Megan Scanderbeg.

Action item 18: Ask DM operators to continue identifying and flagging suspect S/N CTDs. Report problems to SBE and DM operators for CTDs with serial numbers higher than 7000, especially in the 8000 – 8500 S/N group.

Action item 19: Working group to explore implications of variability in Cpcorr for 2000db dataset. G. Johnson, T. Kobayashi, G. Maze.

9.2. Recent float performance evaluation of array

B. King presented an updated evaluation of float lifetimes across the Argo array. As before, he looked at various groups of floats, sometimes by float type, sometimes by PI, sometimes by DAC. The general message was that float lifetimes do not look like they are getting worse, but many of them are not improving. It was quite apparent that when a new float type/generation is introduced, the initial floats do not work as well and time is needed to improve them. However, after that initial time period, many of the new generation floats are performing better.

S. Wijffels asked if the float technical workshop that was held in Seattle in 2017 had any impact on National Programs and if that improved float reliability. B. King said that the UK Argo group learned quite a bit about testing prior to deployment for NAVIS floats and this has helped them identify a float likely to fail. The workshop also pointed out that float tenders should be set up in terms of cost per profile and that the number of profiles should be 200 – 300, not 150. B. King also said that the workshop was helpful for Arvor floats and improvements in float lifetimes in Arvor floats should be coming.

The AST discussed how best to relay information like this to groups who acquire new float types. There are some workshop reports available, but it was suggested that the best option is to send someone to float expert group to learn what is done.

Action item 20: Ask NAVIS and Arvor float deployers to correctly identify in metadata files which float model they have. Work with M. Belbéoch to help identify NAVIS-EBR and Arvor-lite floats that may be incorrectly labeled in metadata files. M. Belbéoch, Navis and Arvor float deployerers.

9.2.1. Apex controller performance issues (S. Riser, P. Oke)

Steve Riser described the firmware development at UW, by Dana Swift, for APF11s. The firmware has been well-tested, and is being used on recently-deployed floats. The firmware could be made available to other groups – but there may be implications for warranties that should be carefully considered.

Peter Oke described some experiences with recent versions of APF11 firmware. As new versions of the APF11 firmware have been developed, some bugs have been introduced. These have resulted in floats not performing properly. Researchers from Australia, UK, and China have engaged in a series of discussions with TWR to understand the problems. TWR have released updated firmware that have addressed most of the known problems. TWR have also agreed to establish a User Forum, so users can know who has used each version of the firmware. It is hoped that this can promote communication within the Argo community to avoid instances where floats might be deployed with problems that are known to other users. TWR have also indicated a willingness to develop a firmware version that is specifically for core float missions – not a single version for all float missions (e.g., core, BGC, Deep).

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

Since 2015, the SIO Argo team has been making side-by-side comparisons of the performance of Electrochem primary lithium batteries and Tadiran hybrid lithium batteries in SOLO-II Argo floats (http://sio-argo.ucsd.edu/Tadiran_web.html). Interim results of these tests were reported at the Seattle Technical Workshop and at AST-19. Passivation problems are substantial in the SOLO-II Electrochem batteries because of the combination of large current drain by the SOLO-II pump and its intermittent use in 10-day cycles. Following trials of single Tadiran-powered floats on 1-day and 7-day cycles to 2000 dbar, a much larger test included 25 Tadiran and 24 Electrochem SOLO-II floats deployed in late 2016 by RV Kaharoa. With about 90 cycles completed, the voltage under load of the Electrochem has dropped from about 13 V to 11 V, as is typical in past performance of SOLO-IIs. The Tadiran voltage under load has decreased by only about 0.2 V (14.7 V to 14.5 V). The expectation is that about 75% of the total energy stored in the Tadirans will be available in SOLO-II applications, leading to battery lifetime of 4.16 MJ (available) / 8.11 KJ per cycle > 500 cycles. In Deep SOLO floats with 5 Tadiran battery packs, about 250 cycles may be attainable.

If Argo floats can continue to become more energy-efficient and to exploit new battery technologies, it will be possible not only to complete very long Argo missions (> 10 years) but also to have reserve energy for additional sensors and for secondary missions.

9.2.3. NAVIS (G. Johnson)

PMEL deployed 306 SeaBird Navis-A floats and 225 Navis-EBR floats as of 26 February 2019, all on nominal 10-day cycles with 1000-dbar park pressure and continuous sampling from 2000 dbar to the surface, reported as 2-dbar averages. The longest lived PMEL-deployed Navis-A float to date reported its 247th profile on 18 February 2019 and the longest-lived PMEL-deployed Navis-EBR float to date reported its 120th profile on 26 February 2019. The Navis-A floats had 6 major failure modes, most of which were patched serially until the Navis-EBR, a major redesign which addressed these problems more completely, was released. The Navis-A fleet to date has an average estimated life expectancy of 142 profiles (3.9 years), and on average the near-end-of-life change voltage change in Electrochem batteries starts somewhere between 180 and 220 profiles. Numerous warrantee floats received boost the estimated lifetimes by about 4/3. About 3 years ago Seabird began shipping Navis-EBR floats. The performance of Navis-EBR floats has been substantially better than that of the Navis-A to date, although already several warrantee floats have been received. With only 3 years of Navis-EBR deployments, it is too early to verify that improvements in efficiency reported by SeaBird have led to longer battery life, or to estimate the average life expectancy of this new model.

9.3.Thermal float (S. Wijffels)

S. Wijffels presented on a thermal float engine developed by SEATREC and Yi Chao that can be mounted on a NAVIS float. It's possible to mount up to two of these engines (SL1s) onto an Navis float. The floats equipped with two SL1 engines should be able to perform multi-year missions when sampling in a fast sample mode (4 profiles/day). Yi Chao has eight SL1 thermal engines that can be made available to the Argo community for testing on Navis floats. Please contact him if interested. yi@seatrec.com

626-602-6186
http://seatrec.com

10. Regional science, education and outreach

10.1. Lijing Cheng– "Crucial role of Argo data in estimating and understanding ocean heat content change"

10.2. Fei Chai – "BGC Argo observations and physical-biological modeling"

10.3. Tamaryn Morris- "Outreach in South Africa"

Argo in South Africa is primarily a program of assisting with float deployments, validation data transfer to the CCHDO, education and outreach and research using Argo float technologies. Here we present three campaigns for outreach – the Adopt-a-Float initiative involving marginal schools and schools trialing the Marine Science curriculum at Grade 10-12 level, integration of marine technologies within the Marine Science curriculum and the UCT-led SEAmester initiative aimed at postgraduate students from throughout South Africa.

The team is also looking at research in the Agulhas Current, and the Southern Ocean using BGC floats. These projects are currently being written up. Students at postgraduate level are encouraged to use Argo floats as part of their research and many students from the secondary level education have come through the ranks to complete diplomas, degrees and masters degrees having been exposed to marine science in schools and especially hands-on training of oceanographic instrumentation such as Argo floats and drifters.

Lastly, South Africa supports the CCHDO by supplying deep-cast CTD data wherever possible and providing opportunities for deployments particularly in the Southern Ocean, South Atlantic and Southwest Indian Oceans.

For any further details on any of the above, please contact Tamaryn Morris at:
tamaryn.morris@weathersa.co.za

11. Argo 2020: completing the global mission and exploring extensions

11.1. Technical updates on Deep Argo floats

11.1.1. Deep SOLO (D. Roemmich)

A Deep SOLO float descends from the sea surface off San Diego. The 33 cm diameter spherical glass pressure housing is inside the protective hardhat. The Iridium/GPS antenna, SBE-61 CTD and passive "bottom finder" wire can all be seen. The float's pancake bladder is inside the bottom cowling, behind the CTD. (Photo by SIO Instrument Development Group)

Notes and features of Deep SOLO performance:

- Total mass is 27 kg, including the 33 cm diameter glass pressure housing, its contents, and external parts.
- 26.9 KJ total energy (21.1 kg pumping energy) are needed per 6000 m cycle
- Pump is a strengthened version of SOLO-II pump.
- 59 Deep SOLOs deployed; 53 active, 12 recovered (of which 6 were redeployed)
- The SBE-61 CTD cable has proven vulnerable to failure at high pressure (3 floats) with resulting loss of data. A lab testing procedure has been implemented.
- Early Deep SOLOs (4 Electrochem lithium battery packs) had battery lifetimes of about 120 cycles;
- Newer floats use Tadiran hybrid lithiums (5 battery stacks), increasing battery lifetime to 251 cycles. (6750 KJ / 26.9 KJ)
- Passive bottom-detection allows profiling to < 3 m above the ocean bottom.
- A commercial version of Deep SOLO is available from MRV Systems.

11.1.2. Deep APEX (S. Hosoda)

Deep Apex manufactured by TWR have been deployed from JAMSTEC and NOC.

Up to now, JAMSTEC has deployed 12 deep APEXs, however, hardware/ firmware troubles occurred on many of them.

1. Salinity and Oxygen profiles are largely biased and drift with time (S/N:29). The cause is still unknown and is under discussion with TWR.
2. Delivered oxygen profiles are too shallow and only above 1000 dbar depth (S/N:26). TWR concluded that the cause is a miscommunication with the RINKO sensor under low temperature (< 6°C). This has been improved with an electric link to the RINKO sensor.
3. In all profiles, sampled levels are sparse - less than 10 (S/N:27). This is caused by miscommunication between the sensors and the board due to an inconsistency of clocks. The problem was fixed by releasing improved firmware.
4. Several deep APEX experienced buoyancy engine failure after deployment. Two of them went into emergency mode and drifted at the sea surface. In addition, all deep APEXs are manually controlled by TWR, changing deep profile depth, parking depth and piston position. Because of this failure trouble, deployment is now stopped. TWR decided to implement a potentiometer change with a microcontroller to interface between the potentiometer and the APF 11 expansion board to provide more reliable positioning readings. Also, software modifications were needed for above issues which are handled with the potentiometer and there was a new firmware release 2.12.2.4.

At this time, only three of the deployed floats are in normal operation. However, the problems seem to be getting fixed and it seems to be gradually getting more stable. JAMSTEC owns 15 pre-deployed deep APEXs and a few deep APEX floats are expected as warranty replacements. Because of this reason, JAMSTEC's deployment plans for deep Argo are now under discussion and will be renewed soon.

11.1.3. Deep NINJA (T. Suga)

An update on the Deep NINJA was presented by Toshio Suga on behalf of Taiyo Kobayashi (JAMSTEC). A failure mode of the float hardware was identified. Failure of a motor for the three-way valve results in tightening the valve too strongly. If this failure mode happens, the float cannot control its surfacing/descending at all. It was confirmed that at least 3 floats, and possibly more, died due to this failure mode. An improved model of the Deep NINJA, resolving this failure mode, was released in 2018. Two new model floats have been deployed so far. Since August 2012, JAMSTEC has deployed more than 25 floats of Deep NINJA (including two prototypes). A recent scientific result based on the deep profile data obtained near the Antarctica was briefly showed. Deep NINJA detected rapid volume reduction in Antarctic Bottom Water (AABW) off the Adélie/George V Land coast since 2013 (Kobayashi, 2018). The detected AABW volume reduction of 50 m/year suggests sea level rise by 5.0 mm/year due to expansion in deeper ocean below 1900dbar.

11.1.4. Deep Arvor (G. Maze)

An update on the Deep Arvor was given by G. Maze. The software patch correcting inappropriate grounding management is now applied to all floats and should considerably increase float lifetimes. He showed a Deep Arvor prototype equipped with 3 CTDs: the SBE41CP for deep, the SBE61 and the deep-RBR. The float was tested at sea for a few days and recovered. A new platform/electronic test is scheduled for the fall 2019 before a real deployment in 2020. As part of the NAOS and EARISE project, more tri-CTD and bi-CTD Deep Arvor will manufactured and deployed in real conditions in order to evaluate and inter-compare each of the CTDs available to the Deep Arvor.

11.2. Technical and scientific updates on under-ice floats (S. Riser)

S. Riser updated the AST on UW floats with sea ice encounters. Almost 500 UW floats have encountered sea-ice. Of those, 233 did not have the ice avoidance algorithm. The UW group has analyzed the under-ice temperature profiles near the surface to check on limits set in ice-avoidance algorithm for the

Southern Ocean. Ideally, floats would always surface if no ice is above and never surface if ice is above, and the group is trying to determine how to get closest to this ideal. S. Riser also showed a comparison of float lifetimes for UW floats in and out of sea ice. For floats in non-ice regions (464), 50% make it to 6.8 years. For floats in ice (170), 50% make it to 5.5 years. So, there is a reduction in float lifetime, but it is not large.

In the discussion following the presentation, it was noted that there is not an ice avoidance algorithm for the Arctic. Several groups stated this was something they were either already working on or would begin to do so soon.

> **Action item 21:** Form working group on ice avoidance in the Arctic. Also consider examining other CTD sources. EuroArgo, WHOI, Canadian Argo

12. Demonstrating Argo's value

12.1. Earth.nullschoo.net (S. Diggs)

S. Diggs presented the latest status of Argo layers on the earth.nullschool.net platform (see prototype: http://data.scripps.earth/argoviz. As a reminder, this platform has millions of users and reaches schools across the United States. There are several layers of Argo temperature and salinity data from the Roemmich and Gilson Gridded Argo Climatology (RG Climatology) on the platform, but it would be great to have more months of data added and potentially a few more layers. With some additional funding, the process to get Argo data from the RG Climatology onto the earth.nullschool.net platform in a uniform, timely and automatic manner could be finalized.

12.2. Argo bibliography (M. Scanderbeg)

M. Scanderbeg reported on the status of the Argo bibliography noting that less papers were found in 2018 than in 2017. It is certainly possible that Argo has reached a leveling off period for the number of papers published per year and it is likely that many will be published in 2019 from OceanObs19. However, M. Scanderbeg did some investigations into likely causes for missing papers. One possible reason is that papers based on secondary sources like model outputs and gridded Argo fields may no longer mention 'Argo' in the paper. This is because Argo is used in almost all model assimilation systems and is now often not mentioned since it is understood. Additionally, some gridded Argo products have names that do not include Argo and are also well established and not explained in detail. Another possible reason was not looking in the correct journals. As more authors are choosing to publish in open access journals, she wondered whether she should expand to include these in her searches. It was suggested that Megan should search for secondary source papers by their citations. Peter Oke agreed to help her with identifying the citations/search terms for model outputs associated with GODAE OceanView. It was noted during the discussion that these secondary source papers should be better identified on the website and not used to artificially inflate Argo citation statistics.

M. Scanderbeg showed ways to identify BGC Argo, Deep Argo and secondary source papers on the website by putting a unique symbol in front of the papers. She can also make individual web pages for each of these categories and link everything from the main webpage. These ideas were well received and will occur in the coming months.

The thesis citation list continues to grow and get easier to compile are more theses are put online.

Action item 22: Move ahead with identifying Deep Argo, BGC Argo and secondary sources of Argo with symbols on Bibliography page. Also create links to bibliography web pages for these subsets. M. Scanderbeg

Action item 23: M. Scanderbeg to search for secondary source papers using citations from secondary sources. P. Oke to help identify model output secondary source papers.

12.3. Argo Steering Team Website Updates and Argovis website (M. Scanderbeg)

M. Scanderbeg presented on the status and updates to the AST website over the year since AST-19. She noted the two large spikes in visits to the AST website which correspond to media covering surrounding the Nature article by Resplandy et al on heat content (https://doi.org/10.1038/s41586-018-0651-8) and a New York Times article in January 2019 on ocean warming featuring Argo (https://www.nytimes.com/2019/01/10/climate/ocean-warming-climate-change.html). She presented the new pages added which include one featuring the ocean temperature anomaly plot automatically updated each month at WHOI based on the RG climatology. She also noted updated wording on the global change page that is more in line with the wording on the updated WHOI page that indicates Argo is showing changes in the ocean. She also showed where the new pages on the Argo framework and guidelines sit on the website. Finally, she showed the Steve Piotrowicz memorial float page (www.argo.ucsd.edu/Piotrowicz_float.html) which includes a description of Steve, photos, a video of his memorial float deployment from the R/V Kaharoa and a map of the float's location which updates automatically when new profiles arrive at the GDAC.

Some new media were added over the course of the year including new float cartoons for core, BGC and Deep Argo floats. These are in png format and can be downloaded from the picture page (http://www.argo.ucsd.edu/pictures.html). Most of the media used to make the Argo Story Map was also posted on the ftp site, including an animation showing the density of Argo profiles in one degree boxes over time.

The Global Argo Marine Atlas stopped working for Windows users in July 2018 because the RG climatology fields became too large (> 2GB) to load into the Windows version of Ferret that is used to make the plots. A solution has been found for now which is to turn the fields from double to single precision using a scale factor, but this will not last for more than a few years. The Linux and Mac versions still use the full resolution fields. See the web page for more details (http://www.argo.ucsd.edu/Marine_Atlas.html).

M. Scanderbeg spent the last part of the talk re-introducing www.argovis.com which was a statistics student's Master thesis project (Tyler Tucker). Argovis is a RESTful web application which allows for easy navigation of T, S, p and BGC profiles from Argo GDACs. The idea is to offer a simple interface that allows both scientists and the general public to:

- Select profiles by region, date and pressure range by drawing polygons on an interactive map
- Query by platform and view platform history
- Access Argovis database via customizable API
- Visualize gridded Argo products

Only T/S/p data with a QC flag of '1' are included in Argovis, but all BGC data are included and QC flag appears when hovering over plots. There are four API calls (metadata, profile, platform and region) and example calls in Matlab and Python along with beginning tutorials are available on the website.

There is a gridded Argo component as well that features the RG climatology, the IPRC Argo climatology and the MOAA-GPV JAMSTEC climatology. Side by side viewing is possible and there are T and S plots in maps and sections for means and anomalies.

Argovis is in a transition period as D. Giglio has moved to CU Boulder where she hopes to host Argovis. She is looking for more funding to help support Argovis and Tyler. The hope is to build on the Argovis platform to add more features like co-located Argo and satellite observations, expanded Argo gridded field capabilities and more learning modules for use in secondary and higher education.

Action item 24: Make an ftp site to hold talks, media, etc. for AST members. M. Scanderbeg

12.4. 2 millionth profile story map (E. Smith)

Emily Smith the new NOAA Argo Program manager presented on the celebration of Argo's 2 millionth profile that occurred at the fall AGU meeting and centered around the Argo Story Map that was developed to celebrate this milestone. The Story Map can be found here (http://www.argo.ucsd.edu/Argo_StoryMap.html) and if you click on the image in the lower right hand corner, it opens up full screen in another tab in your browser. While the Story Map was released to coincide with the two millionth profile, it is really about Argo in general. It was compiled mostly by Cora Hersch from WHOI and Mathieu Belbéoch but included input from many involved in Argo including Breck Owens and Megan Scanderbeg. There is some great media in there that could be used in future talks about Argo.

Action item 25: Improve the www.argo.net webpage for the general public by adding images, plots, animations, Story Map, etc. that showcase what Argo is measuring now. Can link to other Argo pages from there, but this page will be a place where media and the general public can be referred to in order to learn about Argo. Consider getting outside help with creating this webpage and crafting the message on it. M. Belbéoch, M. Scanderbeg, S. Wijffels.

Action item 26: S. Wijffels and M. Scanderbeg to work with NOAA communication team to develop a communication strategy to reach the public. Coordinate this work with E. Rusciano from JCOMMOPS as well.

Action item 27: AST to explore producing a TED talk on Argo. AST co-chairs

12.5. 6th Argo Science Workshop Report (T. Suga)

The 6th Argo Science Workshop was held in Tokyo, Japan on October 22-24, 2018, sponsored by JAMSTEC, co-sponsored by Japan Meteorological Agency (JMA) and the Japan Argo Promotion Committee, and endorsed by Ministry of Education, Culture, Sports, Science and Technology (MEXT), Ministry of Foreign Affairs, Fishery Agency, Ministry of Land, Infrastructure, Transport and Tourism, and Japan Coast Guard. A brief summary of ASW-6 was presented by Toshio Suga, who led the program committee consisting of the AST Executive members and several volunteers. The JAMSTEC Argo team was the core local organizing committee, supported by JMA colleagues. The total number of ASW-6 participants was 131 from 11 countries. The opening address was given by Ms. Keiko Nagaoka, State Minister, MEXT, indicating high national interest in the Argo Program. A particular objective of ASW-6 was to prepare for OceanObs'19 by providing an opportunity to share ideas presented in the Argo Community White Paper (CWP) among the Argo community and to connect them to other observing networks and user communities including research/operational and other application areas. The sessions were organized around the structure of the CWP: Core Argo, Deep Argo, BioGeoChemical Argo, Argo Data System, ArgoMix and other extension, and End user engagement. A Dr. Stephan Pitrowicz Memorial Session was also organized to recognize Steve's dedication to the Argo Program, followed by a panel discussion on issues and challenges for sustaining and growing Argo. The outcomes are summarized as follows. The main objective was achieved and the participants put a sort of Argo Community stamp on the CWP. The panel/roundtable discussion provided an opportunity to finalize recommendations to OceanObs'19 based on the CWP. The ArgoMix community interacted directly with Argo for the first time; they learned the process for a new parameter to be included in Argo. The Argo community interacted with operational user communities, including those working on ocean prediction, seasonal prediction and fishing grounds predictions during the workshop. It was noted that the workshop was the opportunity to initiate discussion on "Argo 2020 following an emerging new initiative by US Argo.

The International Argo Steering Team (IAST) was awarded the 11th PICES (North Pacific Marine Science Organization) Ocean Monitoring Service Award 2018 (POMA 2018) during the PICES annual meeting held in Yokohama on October 29, 2018. The POMA aims to recognize organizations, groups and outstanding individuals that have contributed significantly to the advancement of marine science in the North Pacific through long-term ocean monitoring and data management. Toshio Suga received the award on behalf of the IAST, giving the acceptance remarks which concluded as follows:
"…Such a major extension requires increased engagement with wider communities, including ecosystem science and fisheries science. The Argo program is expecting PICES' leadership in this regard. I believe this award will give momentum to stronger future collaboration between Argo and PICES. Thank you very much."

Action item 28: Reach out to satellite altimetry, ocean color and assimilation groups to think about a joint science workshop. P. Oke, H. Claustre

12.6. Upcoming science conferences and technical workshops – OceanObs19

S. Wijffels noted that she put in a request for a breakout session at OceanObs19 and requested that Argo be well represented at the meeting in as many different sessions as possible. She stressed the need to be consistent in the messaging done at OceanObs19 about the new Argo array design and steps to reach it. It was suggested that Argo submit a poster to OO19.

Action item 29: Participate in OceanObs19 to promote Argo's new design. When the OO19 program matures, coordinate AST member coverage for each session. AST, AST co-chairs, M. Scanderbeg

Action item 30: Submit an Argo poster to OceanObs19. AST co-chairs

2nd Deep Argo Science Workshop (N. Zilberman)
The 2nd Deep Argo Workshop will be hosted by CSIRO in Hobart, Tasmania on 13 – 15th May, 2019. The objectives include: reviewing the objectives of the Deep Argo Program, describing the Deep Argo float mission in support of Deep Argo's scientific objectives, confirming Deep Argo float and CTD readiness timetable for implementation of the global pilot array, reviewing plans for the deployment of Deep Argo pilot arrays and presenting Deep Argo-based scientific results.

EuroArgo Science Workshop in Athens, Greece (C. Gourcuff)
The 7th Euro-Argo Science Meeting will be organized in Athens, Greece on 22-23 October 2019 (the week after the ADMT20 meeting). These meetings are organized every other year to bring together users of Argo data and provide an opportunity for high-level science interactions in link with Argo, in Europe. Each session will include a key-note speakers who should be identified and invited soon. Everyone is welcome. See https://www.euro-argo.eu/News-Meetings/News/Latest-News/7th-Euro-Argo-Science-Meeting for more information.

Ocean Observers Workshop (C. Gourcuff)
The Ocean Observers network was initiated after a first international educational workshop co-organized by Euro-Argo ERIC and JCOMMOPS in Brest (France) in June 2017. The workshop gathered different actors (scientists, communicators, teachers, educational authorities etc.) involved in marine sciences outreach and education to share science-based educational resources and experiences and explore the possibility to establish new collaborative partnerships. The workshop was a success and the main outcome was the will to continue the initiative. This will be enabled thanks to the EU funded Euro-Argo RISE project through the setting-up of an international working group composed of volunteers identified after the 1st workshop. The group's term of reference will be defined by this summer and a second workshop with renewed content and format will be organized in October 2020.

13. Future meetings

13.1. ADMT-20 October 14 – 18, 2019 in Villefranche, France
The next ADMT meeting will take place in Villefranche. During discussions on outreach and communication, it was suggested that a one day workshop is held in conjunction with this meeting to allow programmers around the world to come together and work on improving the outreach platforms that are currently under development including earth.nullschool.net, www.argovis.com, work at JCOMMOPS, and in the French Argo group.

13.2. AST-21 in Southampton, UK
The UK Argo group offered to host AST-21 in Southampton next year. Possible dates in March will be circulated shortly. The schedule for the meeting should also be finalized and may include a manufacturer's day and possible BGC and Deep Argo sessions either before or during the AST-21 plenary meeting. The AST encouraged national programs to consider bringing along younger scientists who may be interested in working on Argo.

13.3. Technical workshop on NKE floats at IFREMER in Brest, France
There was discussion on holding a float technical workshop on NKE floats and IFREMER offered to host this workshop in Brest, close to NKE. As more National Programs are choosing to buy NKE floats, it was felt that a technical workshop to discuss float preparation, characteristics, reliability, data and

improvements would be helpful. More information about this workshop will be made available on the AST website when details are finalized.

Action item 31: Organize a technical workshop for NKE floats. B. Greenan, G. Maze, S. Riser

14. AST Membership and leadership

There was a short discussion on how the make up of the AST membership might change with the new phase of Argo. S. Wijffels reiterated that there will be mission teams (ie, Deep, BGC), but that the AST member will be a representative of the entire national program and should be familiar with all missions that country participates in. It will not be possible for every country to send 3+ PIs to every AST meeting.

15. Other business: name for next phase of Argo

There was discussion on whether Argo should have a new name for the next phase of Argo. Argo2020 had been suggested at the 6th Argo Science Workshop, but feedback received in the meantime and at the meeting was not positive for this new name as it implied either that the array would be complete by 2020 or that after 2020, Argo would not be relevant. Therefore, after much discussion, it was decided to keep the name Argo and add a new tagline under the logo: global, full-depth, and multidisciplinary. The new array design will be called the Argo 2020 design and there will be three missions: the 2000db mission (formerly core Argo), the deep mission and the BGC mission.

Action item 32: Add a new tagline under current Argo logo: global, full-depth, and multidisciplinary. M. Scanderbeg

16. Agenda

Argo Steering Team Meeting (AST-20)
Hangzhou, China 11 – 15 March, 2019
Host: State Key Laboratory of Satellite Ocean Environment Dynamics (SOED), Second Institute of Oceanography, Ministry of Natural Resources

AST Exec meeting: 12 March 13h00

Location: No. 3 meeting room (2nd floor)

AST-20: 13 March 9h00 – 15 March 15h00

Location: Jinxi Hall (2nd floor)

Lunch: SOED will provide lunch tickets to all guests for the buffet lunch at JINXI Hotel.

1. 9h00 Welcome (Fei Chai)
2. 9h15 Local arrangements (Xiaofen Wu)
3. 9h20 Objectives of the meeting/adoption of the agenda
   Challenges of Argo 2020

4. 9h30 Status of action items from AST-19 (M. Scanderbeg)
5. 9h45 Update commitments table including global Argo, extensions and equivalent floats (M. Scanderbeg)

10h00 – 10h30 break (group photo)

6. Argo's Future Design
- **6.1.** 10h30 BGC Argo Status and challenges (K. Johnson and H. Claustre)
- **6.2.** 11h00 Deep Argo Status and challenges (N. Zilberman and G. Johnson)
- **6.3.** 11h30 Regional enhancements and spatial completeness (M. Belbéoch)
- **6.4.** 11h50 Argo 2020 concept and feedback from National Programs (led by S. Wijffels)
  - **6.4.1.** Prospects for gaining support
  - **6.4.2.** Implementation and technology challenges
  - **6.4.3.** How do we sell it?

12h30 – 13h30 lunch break

7. Implementation issues
- **7.1.** 13h30 AIC Report on the Status of Argo (M. Belbéoch)
- **7.2.** 13h45 JCOMM Observing Program Support Centre (M. Belbéoch)
- **7.3.** 14h00 AIC Funding (M. Belbéoch)
- **7.4.** 14h10 EEZ guidelines and strategies (M. Belbéoch)
- **7.5.** 14h15 IOC and BGC variables update (S. Wijffels, B. Owens)
- **7.6.** 14h40 China Argo (Zenghong Liu)

15h00 – 15h30 break

- **7.7.** 15h30 EuroArgo Status (C. Gourcuff)
- **7.8.** 15h45 Argo Best Practices paper (S. Riser)
- **7.9.** 16h00 Discussion items from National Reports and a quick oral round table of highlights or key issues

8. Data Management and related issues
- **8.1.** 16h15 Feedback from ADMT-19 (M. Scanderbeg)
- **8.2.** 16h35 6th Delayed Mode Quality Control Workshop report (B. King)
- **8.3.** 16h45 Including estimated positions in profile and trajectory files (M. Scanderbeg)

End of day one

18h30 Welcome dinner hosted by SOED (JINXI Hotel)

Continue with section 8 after regional science talks at start of Day two

- **8.4.** 10h50 CTD Reference data & developing a reference dataset for Deep Argo (S. Diggs, S. Purkey)

9. Technical issues
- **9.1.** Sensor progress:

9.1.1. 11h20 RBR (S. Wijffels)
9.1.2. 11h35 RBR Argo6000 (G. Maze)
9.1.3. 11h50 SBE41 under 2000db (S. Hosoda)
9.1.4. 12h05 SBE61 (N. Zilberman)
9.1.5. 12h20 Update on high salinity drift from SBE CTD serial numbers 6100 – 7000 (S. Wijffels, J. Gilson, D. Murphy)

12h30 – 13h30 lunch on Day two

9.2. 13h30 Recent float performance evaluation of array
Current technical issues with core floats (Led by B. King with input from community)
9.2.1. 13h50 Apex controller performance and issues (Riser, P. Oke)
9.2.2. 14h10 SOLO-II Tadiran fleet (D. Roemmich)
9.2.3. 14h40 NAVIS (G. Johnson)
9.3. 15h00 Thermal float (S. Wijffels)

15h00 – 15h30 break – go to Section 11 after break

Start of day two

10. Regional science, education and outreach
10.1. 9h00: Crucial role of Argo data in estimating and understanding ocean heat content change (Lijing Cheng)
10.2. 9h20: BGC Argo observations and physical-biological modeling (Fei Chai)
10.3. 9h40: Outreach in South Africa (T. Morris)

10h00 – 10h30 break – go back to section 8 from Day one

11. Argo 2020: Completing the global mission and exploring extensions
11.1. Technical updates on Deep Argo floats:
15h30 Deep SOLO (D. Roemmich)
15h45 Deep APEX (S. Hosoda)
16h00 Deep NINJA (T. Suga)
16h15 Deep Arvor (G. Maze)
11.2. 16h30 Technical and scientific updates on under-ice floats (S. Riser)

End of Day two

12. Demonstrating Argo's value
12.1. 9h00 earth.nullschool.net (S. Diggs)
12.2. 9h15 Argo bibliography (M. Scanderbeg)
12.3. 9h35 Argo Steering Team Website Updates and Argovis website (M. Scanderbeg)

10h00 – 10h30 break

12.4. 10h30 2 millionth profile story map (E. Smith)
12.5. 10h45 6th Argo Science Workshop Report (T. Suga)
12.6. 11h00 Upcoming science conferences and technical workshops –
OceanObs 19
2nd Deep Argo Science Workshop (N. Zilberman)
Ocean Observers Workshop in 2020 (C. Gourcuff)
EuroArgo Science Workshop in Athens, Greece 21 – 25 October 2019
12.7. 11h15 Other Argo outreach activities

12h00 – 13h30 lunch

13. Future meetings
    13.1. 13h30 ADMT-20: 14 – 18 October 2019 in Villefranche, France
    13.2. 13h40 AST-21

14. 13h50 AST Membership

15. Other business – Argo2020/ name for next phase of Argo

16. 14h00 Review of action items

Meeting adjourns Friday 15 March, 3 p.m.

17. Attendees

No	First name	Surname	Gender	Nationality	Institute
1.	Guillaume Olivier	Maze	M	France	Ifremer(法国海洋开发研究院)
2.	Mathieu	Belbéoch	M	France	Ifremer(法国海洋开发研究院), AIC 协调员
3.	Claire	Gourcuff	F	France	Euro-Argo ERIC （欧洲 Argo-欧洲研究基础设施联合体）
4.	Hervé Jean	Claustre	M	France	法国 LOV 海洋学实验室
5.	Nicolas	Kolodziejczyk	M	France	Insititue Universitaire Européenne de la Mer Université de Bretagne Occidentale

					欧洲大学海洋研究所西布列塔尼大学
6.	Brian Anthony	King	M	UK	National Oceanography Centre (NOC) （英国国家海洋中心）
7.	Giorgio	Dall'Olmo	M	UK	Plymouth Marine Laboratory
8.	Jan	Reißmann	M	Germany	BSH （德国联邦海洋与水文测量局）
9.	Waldemar	Walczowski	M	Poland	Institute of Oceanology, Polish Academy of Sciences （波兰科学院海洋研究所）
10.	Peter Robin	OKe	M	Australia	CSIRO （澳大利亚联邦工业研究院）
11.	Peter Geoffrey	Strutton	M	Australia	Institute for Marine and Antarctic Studies University of Tasmania
12.	Philip	Sutton	M	New Zealand	National Institute of Water & Atmospheric Research Ltd (NIWA) 新西兰国家水文和大气研究所
13.	Blair	Greenan	M	Canada	Fisheries and Oceans Canada （加拿大渔业和海洋局）
14.	Emmanuel	Boss	M	USA	University of Maine（缅因大学）
15.	Nathalie	Zilberman	F	USA	Scripps Institute of Oceanography
16.	Megan	Scanderbeg	F	USA	Scripps Institute of Oceanography
17.	Dean	Roemmich	M	USA	Scripps Institute of Oceanography
18.	Sarah	Purkey	F	USA	Scripps Institute of Oceanography
19.	Susan	Wijffels	F	USA	Woods Hole Institute of Oceanography
20.	Kenneth S.	Johnson	M	USA	Monterey Bay Aquarium Research Institute， CA 蒙特利湾水族馆研究所(加州)
21.	Stephen C.	Riser	M	USA	University of Washington
22.	Alison	Gray	F	USA	University of Washington
23.	Emily Anne	Smith	F	USA	University Corporation for Atmospheric Research (UCAR)
24.	Molly	Baringer	F	USA	NOAA/AMOL(大西洋气象与海洋实验室)

25.	Greg	Johnson	F	USA	NOAA/PMEL(太平洋海洋环境实验室)
26.	Toshio	Suga	M	Japan	JAMSTEC / Tohoku University（东北大学）
27.	Shigeki	Hosoda	M	Japan	JAMSTEC （日本海洋与地球科学技术厅）
28.	Katsunari	Sato	M	Japan	Japan Meteorological Agency（日本气象局）
29.	Tetsuichi	Fujiki	M	Japan	JAMSTEC
30.	KiRyong	Kang	M	Korea	Korean Meteorological Administration (韩国气象局)
31.	Hyeong-Jun	Jo	M	Korea	Korean Meteorological Administration (韩国气象局)
32.	Tamaryn	Morris	F	South Africa	South African Weather Service (南非气象服务中心)
33.	Mingmei 明媚	董 Dong	F	China	NMDIS 国家海洋信息中心
34.	Lijing 里京	成 Cheng	M	China	IAP/ CAS; 中科院大气物理研究所
35.	Haili 海黎	王 Wang	M	China	Xiamen University 厦门大学
36.	Zenghong	Liu	M	China	CSIO,MNR
37.	Xiaogang	Xing	M	China	CSIO,MNR
38.	Fei	Chai	M	China	CSIO,MNR
39.	Xiaofen	Wu	F	China	CSIO,MNR
40.	Stephen	Diggs	M	USA	Scripps Institution of Oceanography
41.	Pierre Marie	Poulain	M	Italy	OGS

Argo Australia National Report 2019 – AST-20

Peter Oke[1], Rebecca Cowley[1], Craig Hanstein[1], Catriona Johnson[1], Jenny Lovell[1], Pat McMahon[1], Beatriz Pena-Molino[1], Tatiana Rykova[1], Peter Strutton[2], Tom Trull[1], Esmee Van Wijk[1]

[1]CSIRO Oceans and Atmosphere, Hobart, Tasmania, Australia

[2]University of Tasmania, Hobart, Tasmania, Australia

7 February 2019

1. The status of implementation (major achievements and problems in 2018)

During 2018, Argo Australia deployed 42 core floats. This includes 15 Apex floats, 23 Navis floats, and 4 NKE floats. Deployments include 19 in the Indian Ocean, 5 in the Southern Ocean, and 18 in the Pacific Ocean. One Navis float was dead on deployment and one NKE float (deployed near the ice) has been problematic (sending split SBD messages).

We also deployed 2 BGC Navis floats in the Southern Ocean. Both performed poorly. Both were top heavy, and had trouble reporting data. This resulted in significant telecommunications costs and loss of data.

We encountered significant problems with APF11 firmware from Teledyne. Rebecca Cowley engaged closely with Teledyne to resolve the issues, and has solicited input from the Argo community. Teledyne plan to build a customer portal to specify who uses what firmware – hoping to improve transparency. Issues are still not fully resolved.

All data managed by Argo Australia follow the V3.1 file format for delayed-mode operations. We've also now upgraded to V2.0 of OWC. As of February 2019, 91% of eligible floats (both active and inactive) have been DMQC-ed.

Argo Australia currently manage 353 operational floats. Their latest locations are shown in Figure 1 Argo Australia have deployed 49 floats since February 2018. Their deployment locations are shown in Figure 2.

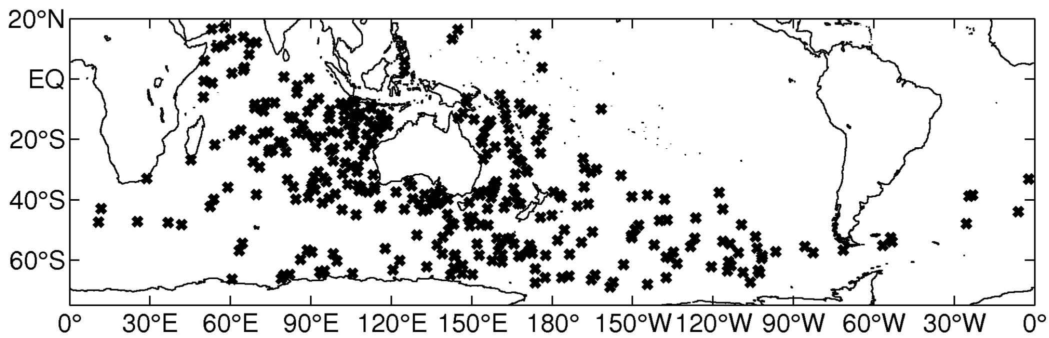


Figure 1: Latest locations of floats managed by Argo Australia. There are currently 353 operational floats managed by Argo Australia.

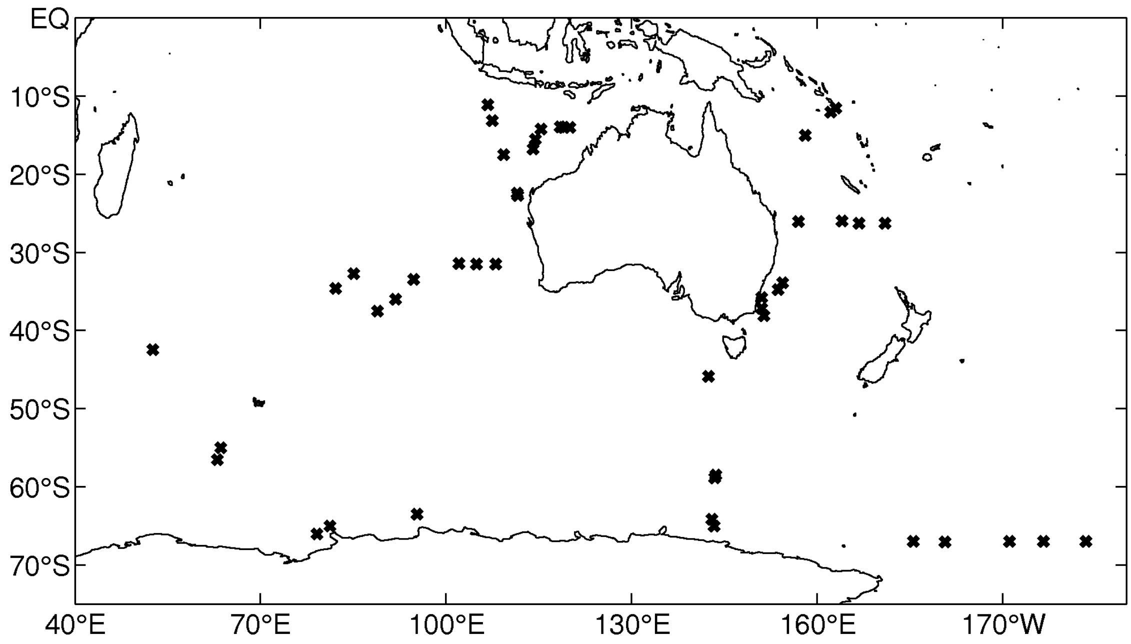


Figure 2: Deployment locations of floats deployed by Argo Australia between February 2018 and February 2019. Argo Australia deployed 44 floats in the year since February 2018.

2. Resourcing

Argo Australia is currently finalising contracting (until June 2022) with IMOS to secure funding for salary, operating, and float purchases needed to support the Australian effort. Funding for the core Argo program has increased slightly (to ~$6.4M over 4 years) and new funding for a BGC Argo Program is expected (~$2M over 4 years). Commitment from Australian partners (IMOS, CSIRO, Defence, ACE CRC, BoM) remains strong. Together the Australian partners are expected to purchase about 42 core floats per year on an ongoing basis. CSIRO also secured additional (one-off) funding to purchase an additional 70-80 floats between September 2018 and August 2020. IMOS has committed to funding the purchase of 2-3 BGC floats per year for the next 4 years. The ACE CRC (and its follow-on) plans to purchase ~2 Deep floats per year and possible some core floats (negotiations are ongoing).

For the core mission, Argo Australia has (some fraction of) two technical officers, three staff running real-time operations (one for software development), five staff contributing to the delayed-mode operations (one for software development), and two research scientists. Australian Argo supports 4.4 full-time-equivalent (FTE) staff per year to cover technical, real-time, and delayed-mode operations; and science leadership and applications. The BGC effort will likely include one full-time staff (at UTAS) dedicated to delayed-mode BGC operations and scientific applications, and some fraction of a science lead (Peter Strutton and Tom Trull will be Australia's BGC Argo leaders).

Argo Australia intends to continue providing funding to support operations of the RV Kaharoa (and its successor) and has secured funding for this out to 2022.

3. Summary of Deployment plans

For the remainder of 2019, Argo Australia intends to deploy 89 core floats and 3 BGC floats between April 2019 and January 2020. Approximate locations are denoted in Figure 3. This include 41 floats in the Pacific Ocean (Coral Sea, Tasman Sea, and east of New Zealand – including 3 BGC floats), 16 floats in the Indian Ocean (north of 39S), 27 floats in the Indian Ocean sector of the Southern Ocean (south of 39S, and west of 115E), and 8 floats in the Southern Ocean, south of Australia.

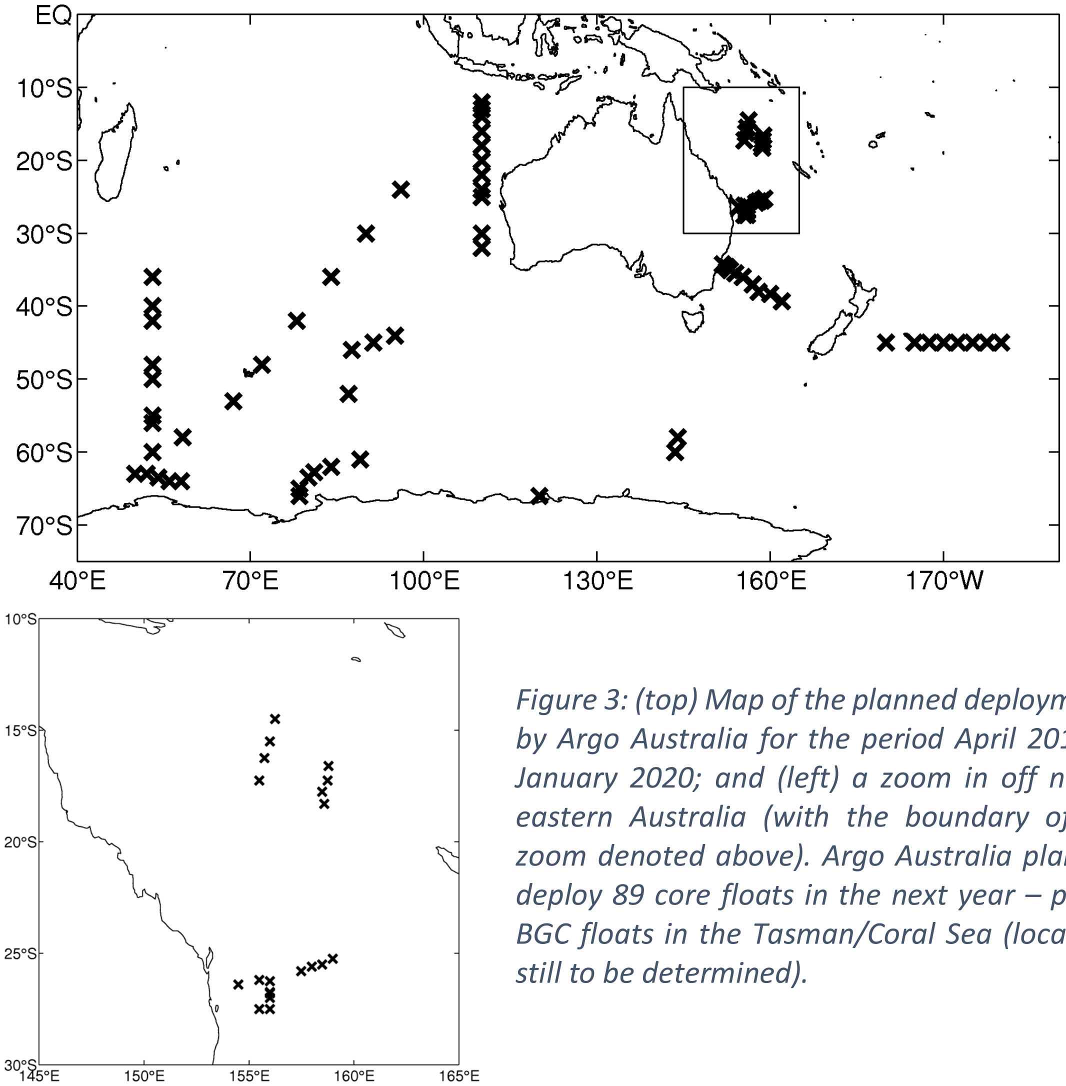


Figure 3: (top) Map of the planned deployments by Argo Australia for the period April 2019 to January 2020; and (left) a zoom in off north-eastern Australia (with the boundary of the zoom denoted above). Argo Australia plans to deploy 89 core floats in the next year – plus 3 BGC floats in the Tasman/Coral Sea (locations still to be determined).

4. Summary of national research and operational uses

Argo data are used operationally to underpin Australia's short-range ocean forecast system (OceanMAPS; www.bom.gov.au/oceanography/forecasts/) and seasonal prediction systems (POAMA; www.bom.gov.au/climate/ocean/outlooks/). Science applications include the investigation of decadal prediction, many climate applications (e.g., ocean heat content estimates), and some studies into eddy variability around Australia (e.g., Tasman Sea and Great Australian Bight).

5. Issues

The change from APF9 to APF11 controller boards for Apex floats has seen some bugs and improvements that have previously not been documented and shared with the community. Both the manufacturer and the users need to be responsible for publicising bugs. An online community forum where bug fixes and firmware improvements are listed is envisaged to help address the problem for Apex floats. It would be useful to see something similar developed for other float types to help prevent deployments of floats with known bugs.

We experienced a problem with the Navis BGC floats deployed during 2018. They were poorly balanced and didn't perform, we later found that others knew about the problem and it could have been easily fixed before deployment. We need to encourage better communication between the manufacturers and the users.

6. Reference data

All locally-collected measurements on Australian research vessels are made publicly available via the CSIRO data centre and the NCEI World Ocean Database.

2018 Argo Canada report of activities
(submitted by Blair Greenan, Fisheries and Oceans Canada)

20th meeting of the Argo Steering Team (AST-20)
Hangzhou, China
11-15 March 2019

1. Status of implementation (major achievements and problems in 2018)

- *floats deployed and their performance*

From January 2018 to December 2018, Argo Canada deployed 25 MetOcean NOVA floats and 7 NKE Arvor floats (9 in the northeast Pacific, and 23 in the northwest Atlantic). Of these 32 floats, 7 died prematurely. The 25 remaining floats are still operational and functioning properly. Of the 32 floats, 3 were replacements. Of the 7 that died prematurely, 4 are being replaced under warranty and one was a replacement. The Government of Canada Standing Offer with MetOcean requires that if a float fails to complete 18 profiles the manufacturer must provide a replacement float.

In addition, 7 Argo-equivalent floats were deployed by Argo Canada eq. in the Beaufort Sea, Labrador Sea, and Baffin Bay. As of 23 January 2019, Canada has 84 operational floats in the Argo Canada program and 7 operational floats in the Argo Canada eq. program.

As of 10 January 2018, the Government of Canada signed a new standing offer with NKE Instrumentation for a 3-year period (10 January 2021) for suppling core Argo float. This contract has the option of two additional years.

- *technical problems encountered and solved*

Of the 7 floats that failed, two did not transmit any profiles and another stayed at the surface, transmitting every 8 hours.

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

MEDS, part of DFO Ocean Sciences Branch, continues to acquire data from 84 Argo floats. Data are issued to the GTS and GDACs hourly in BUFR TM315003 and netCDF formats. On July 2018, MEDS stopped the transmission of TESAC on the GTS. 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 2018 to October 2018, 93 % of the data were issued to the GTS in BUFR format within 24 hours of the float reporting. This rate decreased to 75% between November 26 and December 13 2018 when one of the servers used for Argo processing broke; ad-hoc procedures were put in place during this period to mitigate the problems. Since AST-19, we have worked on the following:

- All of the profiles netCDF in version 2.2 were converted to version 3.1.
- Developing new decoder software, and modifying the existing netCDF software in order to handle data reported by NKE Arvor-I float.
- Providing ADMT with quarterly reports on the performance of Argo data on the GTS in TESAC and BUFR formats and assist DACs that have difficulty with BUFR transmission
- Developing new procedures to migrate the system to a solution supported by the corporate IT service of Fisheries and Oceans Canada

- *Status of delayed mode quality control process*

As of January 2019, 51% 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 70% of eligible cycles. 31% of B-files had been visually QC'd, and 15% were fully DMQC'd. In addition to DMQC of new profiles, 22 previously-processed floats received either updates to the visual QC or new adjustments in 2018 in response to feedbacks (e.g., reports of density inversions) or to address known issues (e.g., higher likelihood of salinity drift for salinity sensors in the serial number range 6100-7000).

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

Financial resources

Argo Canada has ongoing funding for the O&M expenditures related to the International Argo program. Shared Services Canada (SSC) is responsible for the costs related to Iridium telecommunications as part of an initiative to centralize these services with the Federal government and will cover the costs for up to 85 core Argo floats. If Argo Canada has more than 85 active Argo floats, DFO is responsible for the additional telemetry charges. Ongoing capital for float purchases has not been identified and, therefore, it remains necessary to request capital resources on an annual basis to obtain the funding required to purchase new floats. Fisheries and Oceans Canada (DFO) committed $432k for purchases of core NKE Arvor-I Argo floats in the Fiscal Year 1 April 2018 to 31 March 2019. Department of National Defence (Canada) purchased of 15 NKE Arvor-I floats core Argo. The combined DFO and DND funding resulted in acquisition of 33 Argo floats in this fiscal year. The development of close links between the Argo Canada program and both the operational meteorology and operational oceanography R&D activities at the Canadian Meteorological Centre (Dorval, Québec) has been beneficial. An inter-departmental (Environment and Climate Change Canada, Department of National Defence, Fisheries and Oceans) Memorandum of Understanding entitled CONCEPTS (Canadian Operation Network of Coupled Environmental PredicTion Systems) has provided strong advocacy for the Argo program.

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

Human resources

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

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

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

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

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

National Coordination

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

a. Canadian Argo Program Director (CAST Chair – Blair Greenan).
b. Scientists and technical experts contributing to the Canadian Argo Program.
c. Manager of the DFO Marine Environmental Data Section (MEDS) or designate.
d. Chair of the DFO Ocean Science Observation and Monitoring (OSOM) National Sub-Committee.
e. Chair of the Canadian Biogeochemical Argo Sub-Committee.
f. Representative of Environment and Climate Change Canada (ECCC).
g. Representative of the Department of National Defence (DND).

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

a. Canadian representative on the International Biogeochemical-Argo Steering Committee (Chair – Katja Fennel).
b. Scientists and technical experts contributing to the Canadian Biogeochemical-Argo Program. Representation from DFO and universities should be approximately equal.
c. Manager of the DFO Marine Environmental Data Section (MEDS) or designate.
d. Chair of the DFO Ocean Science Observation and Monitoring (OSOM) National Sub-Committee.
e. Chair of the Canadian Argo Steering Team (CAST).

Both of these committees held a virtual meeting in 2018.

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

In 2019 and early 2020, Argo Canada plans to deploy 38 floats (firm commitment), all of which have already been purchased or are replacements: 20 will be deployed in the North Pacific (18 ARVORs, 2 NOVAs), and 18 ARVORs in the Atlantic. Two of the ARVORS in the Atlantic will have oxygen sensors. In addition, NAOS-Canada plans to deploy 3 BGC floats in Baffin Bay.

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

The Government of Canada CONCEPTS initiative (Canadian Operational Network for Coupled Environmental Prediction Systems;

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

As part of the Year of Polar Prediction (YOPP) running from 2017-2019, CONCEPTS has also been producing experimental 32-day ensemble forecasts of sea ice and ocean conditions initialized from GIOPS analyses. A coupled version of this system is expected to be implemented operationally in 2019 based on the success of this system in predicting sea ice conditions and demonstrated benefits for weather forecasting. An observational effort was initiated by CONCEPTS to look at addressing somewhat the gap in Argo coverage in ice-infested areas. Several Argo floats were deployed to determine if observations taken during the ice-free season could provide a benefit for predictions systems. In total 8 floats were deployed: 5 in the Beaufort/Chukchi Seas, 2 in Baffin Bay and 1 along the Labrador coast. Despite the anticipated loss of the floats following ice formation, the Argo floats nonetheless provided a relatively low-cost method to provide profile observations in poorly observed areas. Work is ongoing to assess the overall benefit of the floats in terms of prediction skill.

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

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

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

Nothing to report this year.

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

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

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

Buehner, M., L. Bertino, A. Caya, P. Heimbach and G. Smith, 2017. Chapter 4, In Carrieres T., M. Buehner, J.-F. Lemieux and L. T. Pedersen (eds.), Sea Ice Analysis and Forecasting: Towards an Increased Reliance on Automated Prediction Systems. Cambridge University Press. pp 109-143. DOI: 10.1017/9781108277600.

Burt, W.J. and Tortell, P.D (2018). Observations of Zooplankton Diel Vertical Migration from High-Resolution Surface Ocean Optical Measurements. Geophysical Research Letters, 45. https://doi.org/10.1029/2018GL079992

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Ph.D./M.Sc. Thesis

Castro de la Guardia, L. Modelling the Response of Arctic and Subarctic Marine Systems to Climate Warming, Ph.D. Thesis, University of Alberta

Epstein, J.-L. The Impact of Internal Tide Mixing Parameterizations in an Eddy-Permitting Model of the Arctic Ocean, M.Sc. Thesis, University of British Columbia

Liuqian Yu, Improved Prediction of the Effects of Anthropogenic stressors in the Gulf of Mexico Through Regional-Scale Numerical Modeling and Data Assimilation., PhD thesis, Dalhousie University, 2018
https://dalspace.library.dal.ca/handle/10222/75005

Books

Kelley, Dan E. Oceanographic Analysis with R. New York: Springer-Verlag, 2018.
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Argo Chinese National Report 2018

(Jianping Xu & Zenghong Liu, The Second Institute of Oceanography, MNR)

1. The status of implementation

- floats deployed and their performance

From the last AST meeting, China deployed 21 floats (12 APEX, 9 PROVOR BGC floats) in the northwestern Pacific Ocean. These floats were deployed by 2 PIs from the Second Institute of Oceanography, MNR (CSIO). In total, China Argo has deployed 423 floats, and approximately 95 floats are operational as of 19 Feb., 2019.

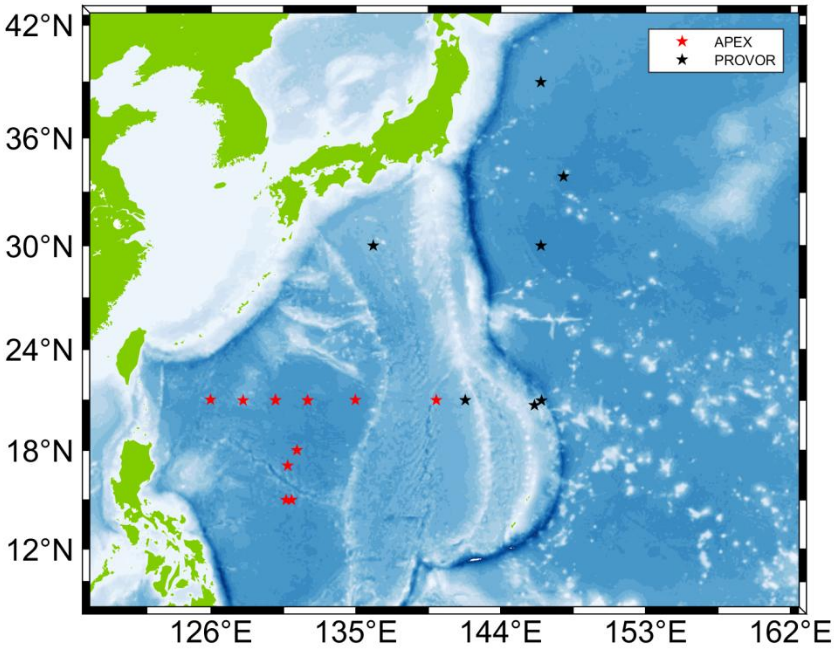

Fig.1 Launch positions of the floats from Mar. 2018 to Feb. 2019.

- technical problems encountered and solved

Technical problem for APF11: occasionally missing files on the CLS RURICS host have been found in some cases. GPS fix obtaining difficulty is also found in some cases. The problem has been reported to Brian King for a further investigation.

Technical problem for BGC PROVOR: Among 9 BGC PROVOR floats deployed in 2018, 2 floats failed to start their mission owing to an improper mission configuration.

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

From the last AST meeting, CSIO received data from 120 active floats (42 APEX, 61

PROVOR, 12 HM2000, 3 ARVOR and 2 NAVIS) and submitted 6,144 TS profiles (plus 209 DOXY, 398 CHLA, 398 BBP, 310 CDOM, 360 DOWN_IRRIDIANCE, 120 NITRATE) to GDACs. All the profile data are converted into BUFR bulletin and send to the GTS via Chinese Meteorological Agency (Beijing). An update of the historical profile files into V3.1 has been finished before the ADMT-19 meeting.

- status of delayed mode quality control process

There is a severe backlog for delayed QC. The situation has not been changed until the ADMT-19. We expected to restore the DMQC this year after an exercise of the DMQC GUI.

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

A post-processing method about the global Argo data set has been designed at CSIO, in which 15 QC tests are being applied including a climatological test using DMQC_Argo CTD data set and a new spike test presented by Racape at the ADMT-19. A high-quality global Argo data set is expected to be generated during the first half of this year.

- status of Chinese COPEX float

The COPEX profiling float is developed by the National Ocean Technology Center (NOTC) and its prototype was manufactured 15 years ago. The NOTC has finished several field self-tests, but it has not been adopted by China Argo until now. During 2017-2018, 3 COPEX (with BeiDou satellite system) were deployed as part of its pilot deployments, however, some technical problems related to the float performance and data format were found. At the end of 2018, NOTC provided another 2 refurbished floats for a further field test.

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

The level of national funding for Argo deployment before 2020 is as follows:

<u>**Float secured (35)**</u>

Core Argo: 8 HM2000, 2 APEX

BGC Argo: 2 HM2000 (O2), 17 PROVOR (2 full-equipped), 2 NAVIS (full-equipped with Sea TREC), 1 APEX (O2)

Deep Argo: 3 ARVOR_D

<u>**Funding almost secured**</u>

75 Core Argo floats in 2019

Funding TBD in 2019

120 floats (15 BGC Argo) in the western Pacific Ocean (as part of TPOS 2020)

60 floats (15 BGC Argo) in the Indian Ocean

There are 9 staffs at CSIO who are working for float deployment, data processing and data applications (including BGC Argo), as well as the operational running of the Beidou profiling float data service center (Hangzhou, CHINA).

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

Two cruises have been confirmed to deploy about 8 BGC floats in the northwestern Pacific Ocean in this March and December, respectively. A cruise in the northern Indian Ocean is being designed, in which about 15 Core Argo floats are planned to be deployed if the funding is secured in the first half of this year. The Ocean University of China plans to deploy 12 PROVOR floats (with O2 sensor) in the Southern Ocean this year, but the cruise has not been confirmed yet.

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

There are two websites maintained by China. One is maintained by CSIO (http://www.argo.org.cn) at Hangzhou (China Argo Real-time data center), 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 provided. Another is maintained by NMDIS, now as part of the CMOC/China website (http://www.cmoc-china.cn).

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

From the beginning of the China Argo, the implementation of the project relies on research programs rather than fiscal budget. The situation has not been improved in recent years. We suggest that the AST should appeal to the all Argo member states to take more responsibilities and obligations under the guidance of IOC Argo resolutions, making the Argo program better serve the international community.

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

No CTD data were submitted.

7. Keeping the Argo bibliography

The following articles are not listed in Argo Bibliography:

Chen G, and Geng D. 2018. A "mirror layer" of temperature and salinity in the ocean. Climate Dynamics, https://doi.org/10.1007/s00382-018-4495-6.

Huang Y , Yang B , Chen B , et al. 2018. Net community production in the South China Sea Basin estimated from in situ O 2 measurements on an Argo profiling float. Deep Sea Research Part I Oceanographic Research, 131: 54-61. https://doi.org/10.1016/j.dsr.2017.11.002.

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Wang X, Zhang W, Wang P, Yang J, and Wang H. 2018. Research on mid-depth current of basin scale in the South China Sea based on historical Argo observations. Haiyang Xuebao (in Chinese), 40(6): 1-14.

Euro-Argo report 2018 – AST20

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

In 2018, the Euro-Argo ERIC involves 13 countries: **11 Members, 1 Observer** and 1 Candidate.

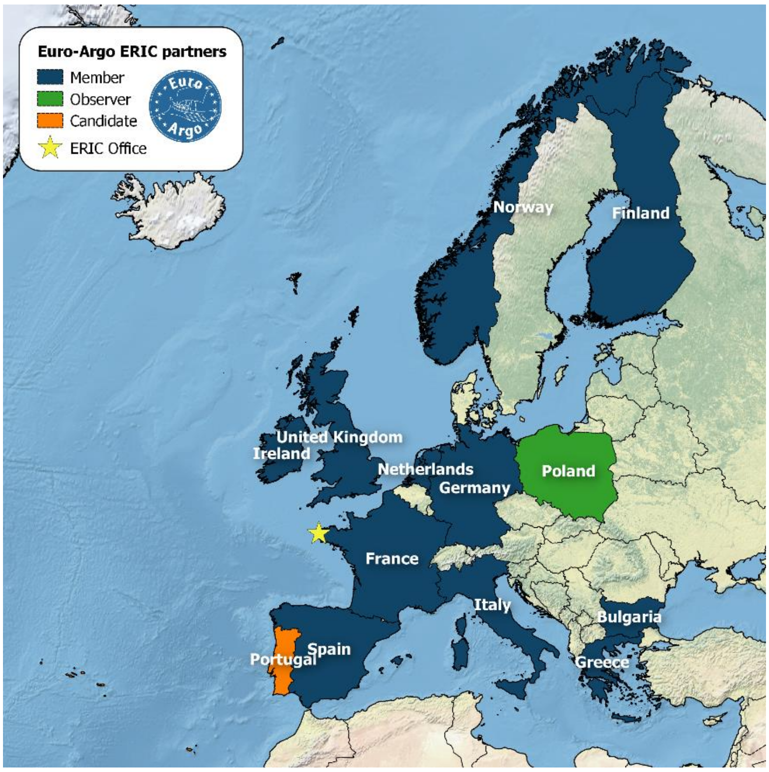


Figure 1. Euro-Argo ERIC membership in 2018

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

1. The status of implementation (major achievements and problems in 2018)

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

- status of contributions to Argo data management (including status of conversion to V3 file formats, pressure corrections, etc)
- status of delayed mode quality control process

Since 2008 Euro-Argo has been working with the European commission to develop a European contribution in addition to the national ones. This is done through projects funded by EC and documented on Euro-Argo website.

In 2018, 31 T/S "EU" floats have been deployed, funded under the EASME/EMFF MOCCA project (2015-2020) and 2 BGC & 7 DEEP floats under the AtlantOS H2020 EU project (2015-2019) (Table 1).

In total (EU + national), 281 floats have been deployed in 2018 (see Table 1, and Figure 2 for the geographical repartition).

Table 1. European floats deployed in 2018, by type of floats

2018	T/S	T/S/O2	BGC	DEEP	**TOTAL**
EU funded	*31*	*0*	*2*	*7*	***40***
Total Europe (EU funded + national)	215	18	28	20	**281**

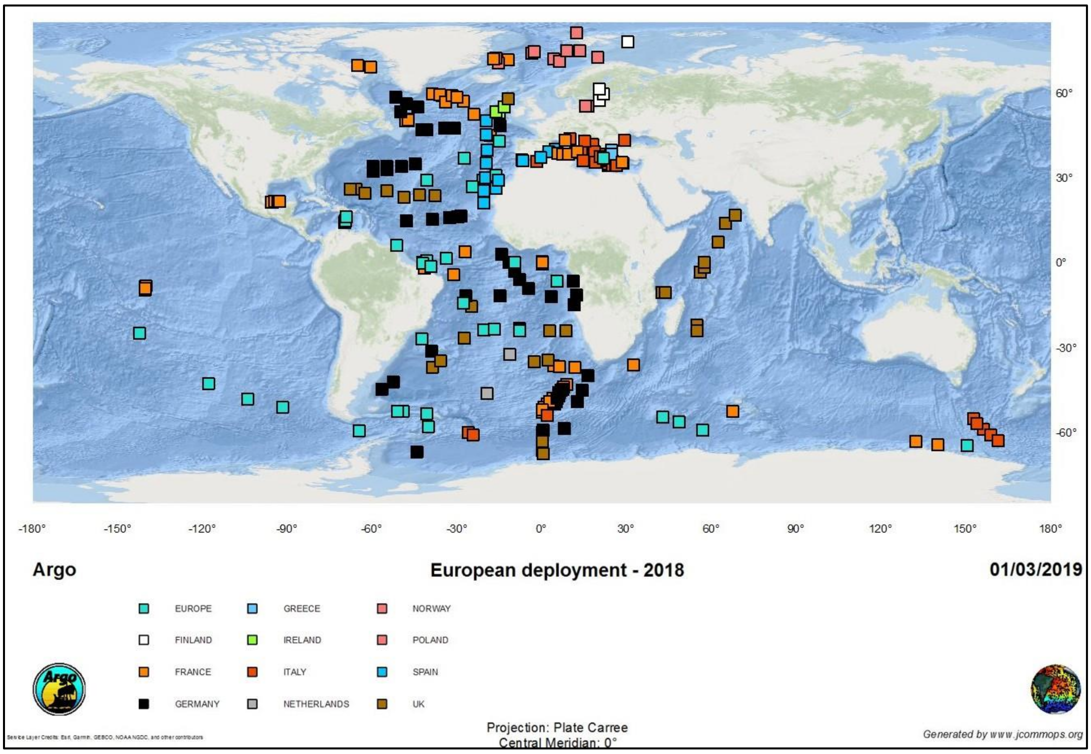


Figure 2. European deployments – 2018

All the European floats are processed by the European DACs (Coriolis and BODC) and all data are provided in V3.1. Delayed mode QC of the MOCCA floats data has started. It is done by the European DM-Operators (BODC, BSH, Ifremer and OGS) and data are provided to the GDAC. Some of the MOCCA floats have been identified as presenting the SBE salty drift anomaly.

In total, 150 MOCCA floats have been deployed between 2016 and 2018 (median age of approximatively 2 years), all with SBE CTD S/N higher than 7900, and among which 75% have been processed in Delayed Mode. 14 out of these 150 floats show a salinity drift (9% of the fleet), with 9 of the 14 on the greylist (data not correctable).

European partners are working together to develop checks on the European fleet, in particular using the MINMAX test developed by Ocean-Scope (Gourrion et al. 2018), able to generate alerts on potential early salinity drifts, and facilitate triage on the profiles eligible for DMQC and then identify the ones that need DM processing rapidly. First tests are promising. An analysis has been performed on a daily basis on the GDAC since mid-November 2018, with approximatively 4 new floats subject to drift/bias suspicion per week.

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

The Euro-Argo ERIC is coordinating a new EU H2020 4 years project named Euro-Argo RISE starting on January, 1st 2019, in which most of the Euro-Argo participating countries are involved. Euro-Argo RISE will enable significant improvement of the European contribution to Argo, through both float deployments (17 in total) and personal time to work on improving the network, data management as well as developing training and outreach material. The Euro-Argo RISE project has been granted a total amount of 4M€.

Euro-Argo is also involved in the ENVRI-FAIR H2020 EU project (2019-2022), through the participation of the Euro-Argo ERIC, Ifremer and BODC (nearly 1M€ funds) Euro-Argo tasks within ENVRI-FAIR are dedicated to improvements in terms of data management, in particular the development of standardised vocabularies for Argo, enhancement of interoperability with other Marine Research Infrastructures and development of new services based on big data technologies.

The Euro-Argo ERIC office consists in a team of 6 persons with project management, technical & scientific background.

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

2019	T/S	T/S/O2	BGC	DEEP	**TOTAL**
EU funded	*18*	*0*	*2*	*3*	***23***
Total Europe (EU funded + national)	205	20	28	12	**260***

Table 2. European floats deployed in 2018, by type of floats
** UK contribution not final*

Euro-Argo will continue to deploy floats following its strategy defined in Euro-Argo ERIC (2017), and regularly updated following technological developments and recommendations from Argo international. Europe is slowly getting closer to its targets for BGC & Deep extensions (50 BGC & 50 Deep floats deployed per year), with new countries entering the game (e.g. Norway & Finland) for BGC Argo. Plans for 2019 show an increased contribution of Europe in high latitudes regions, but also in the Pacific Ocean, compared to previous years (Figure 3).

Figure 3 shows Euro-Argo total implementation for 2018 and planned for 2019, versus the targets identified in Euro-Argo ERIC (2017) (line), by basin.

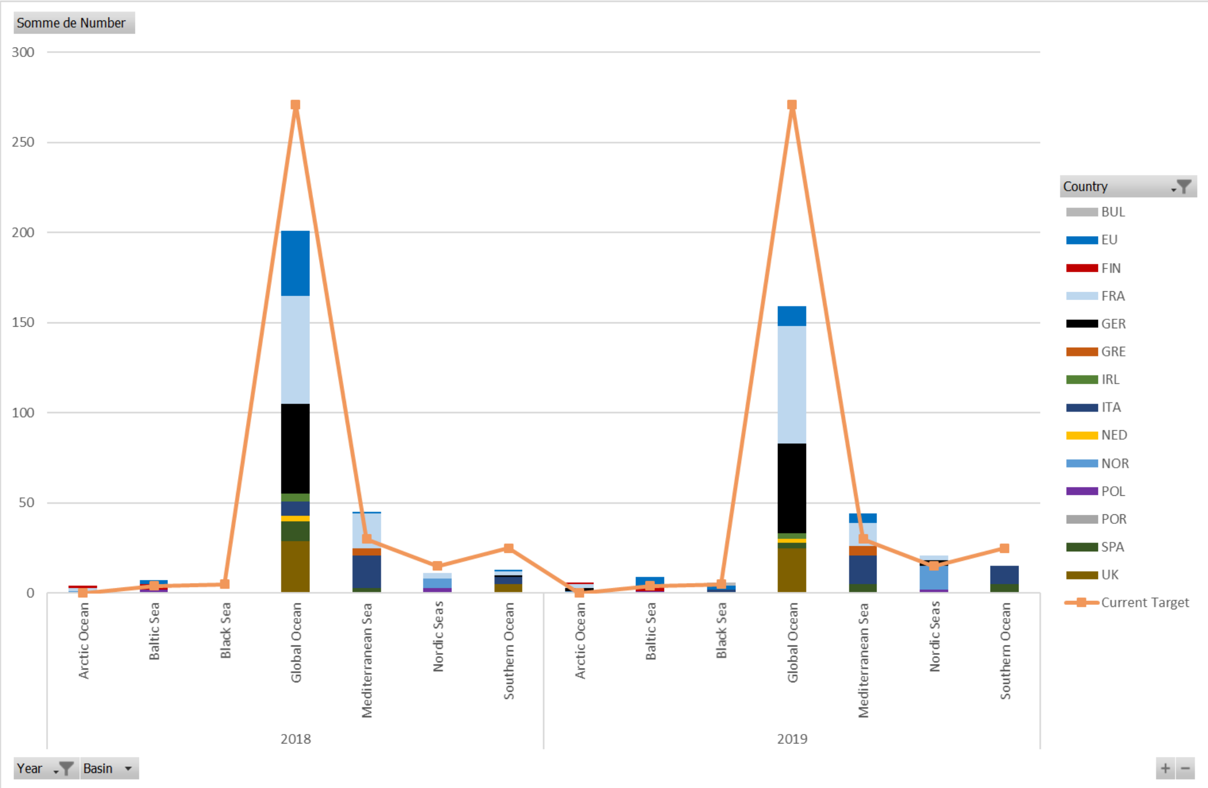


Figure 3. Geographical repartition of European deployments in numbers of floats – 2018 (left) and 2019 (planned, right)

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/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). Website: www.euro-argo.eu.

Within the EU project Euro-Argo RISE, European contribution to Argo ARCs will be reinforced, in particular in the Southern Ocean ARC.

Within the EU project ENVRI-FAIR, an Argo vocabulary service will start to be developed using the BODC vocabulary server as presented at last ADMT in San Diego.

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

None at the writing of this 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.

See national reports.

Deployment CTDs for MOCCA floats have been sent to Coriolis in order to be included in the reference database. For AtlantOS deployments (BGC & Deep floats) , the CTD data will be retrieved in 2019.

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

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

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

The Euro-Argo ERIC maintains a summary of the European bibliography at http://www.euro-argo.eu/Bibliography and advertise publications on the Euro-Argo website (http://www.euro-argo.eu/Main-Achievements/European-Contributions/Scientific-Results), including a list of thesis.

For lists of PIs see national reports.

8. As discussed at the AST-18, I'm making an additional request to help Argo scientists who are asked to give talks or do outreach programs. This action item asks for each National Program to submit a slide with figures and text describing their favorite Argo discovery paper. I will collect these slides and make them available to AST members. The idea is that when an AST member is asked to give a talk on Argo, they could choose from a collection of slides describing key Argo discovery papers. Please consider contributing a slide to this collection.

For EU AtlantOS deep floats: https://www.euro-argo.eu/News-Meetings/News/Latest-News/First-deep-ARVOR-profiles-under-the-ice

Improvement in the Artic Ocean from EU and National floats : https://www.euro-argo.eu/News-Meetings/News/Latest-News/Euro-Argo-floats-in-the-Arctic

References:

Euro-Argo ERIC (2017). **Strategy for evolution of Argo in Europe**. EA-2016-ERIC-STRAT. https://doi.org/10.13155/48526

Gourrion, Jérôme, T. Szekely, R. Killick, B. Owens, G. Reverdin, and B. Chapron, Improved statistical method for quality control of hydrographic observations, *submitted to JAOT (2018).*

French National Report on Argo - 2018

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

All Argo-France activities are lead and coordinated by:

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

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 "Laboratoire d'Océanographie Physique et Spatiale" (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 OSU and funded by the Brittany and Provence Alpes-Cote d'Azur regions (CPER).

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

Since 2000, around 1350 French floats have been deployed in a number of different geographic areas. Deployments have been focused on meeting specific French requirements while also contributing to the global array.

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

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

Year	Funding	**Man/Year**	***French floats***	***Co-funded EU floats***	***Total***
2000	300k€		*11*		*11*
2001	633k€	3	*12*		*12*
2002	980k€	6	*7*	*4*	*11*
2003	900k€	9	*34*	*20*	*54*
2004	1400k€	15	*85*	*18*	*103*
2005	450k€	15	*89*	*11*	*100*
2006	900k€	12	*51*	*14*	*65*
2007	900k€	12	*36*		*36*
2008	1200k€	12	*90*		*90*
2009	1200k€	12	*35*	*8*	*43*
2010	1400k€	12	*55*		*55*
2011	1400k€	12	*53*		*53*
2012	1400k€	12	*82*		*82*
2013	1400k€	12	*81*		*81*
2014	1400k€	12	*96*		*96*
2015	1400k€	14	*101*		*101*
2016	1400k€	14	58		*58*
2017	1400k€	14	65		65
2018	1400k€	14	95		95
Total (2000-2018)			*1136*		*1211*
2019	**1400k€**	**14**	83		

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 2018.

Long term evolution of Argo

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

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

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

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

Core T/S, deep floats and oxygen sensors are fully funded until 2020 (CPER Brittany region), the biogeochemical mission is partially funded (CPER PACA and Brittany regions until 2020) and thus requires new sources of funding that are being requested for the 2018-2023 period as part of the Research Infrastructure second phase (PIA3).
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

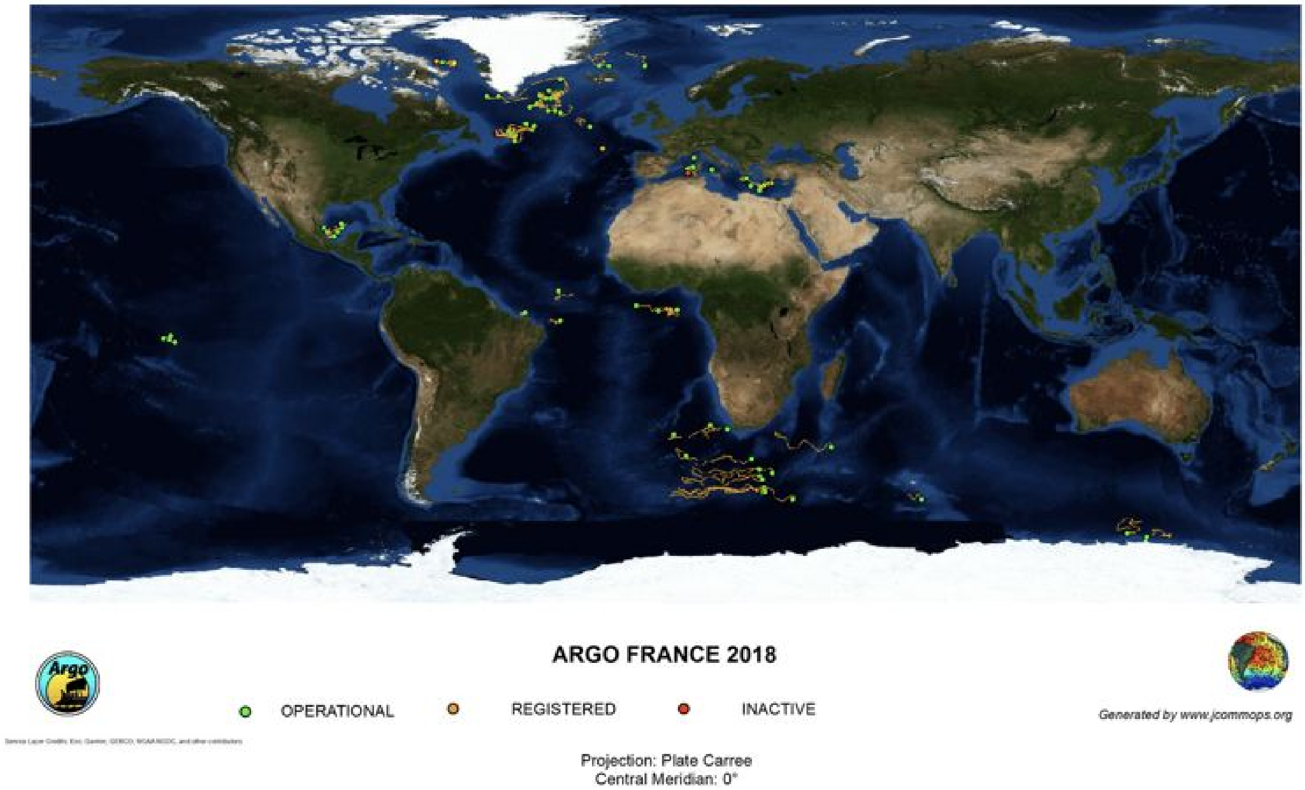
Development of a Deep-Arvor equipped with 3 CTDS: the SBE41CP, SBE61 and deep RBRargo is achieved and preliminary test at sea in preparation. Within the EA-RISE 2019-2022 H2020 project, another 3-CTDs Deep-Arvor will be assembled as well as two other floats with 2-CTDs (the RBRargoDeep|OEM and the SBE61). These floats should be deployed in 2020.

In 2018, the deep RBRargo was tested during the OVIDE 2018 cruise in the North-Atlantic. Intercomparison of pressure, temperature and conductivity/salinity with the rosette SBE911 and bottle measurements is still ongoing. Preliminary results show a systematic pressure bias very close to that obtained during the RREX17 test, but within the manufacturer specification. Temperature shows a median warm bias of 0.0011degC or 0.0006degC with corrected pressure. This is satisfactory and within the bounds of the manufacturer specification and Argo-Deep requirements. Conductivity and salinity are still ongoing analysis.

The status of implementation

Floats deployed and their performance

86 floats have been deployed by France in 2018 (56 T/S Core, 7 T/S/O2, 15 BGC, 8 DEEP). The deployment areas are chosen to meet French requirements in terms of research and operational activities but also to contribute to establishing the global array (especially in the Southern Ocean) using AIC tools/map.



Technical problems encountered and solved

No technical problems specific to Argo-France were encountered in 2018 with regard to operational T/S floats. Seabird batch of drifting CTDs is being assessed and monitored.

Status of contributions to Argo data management

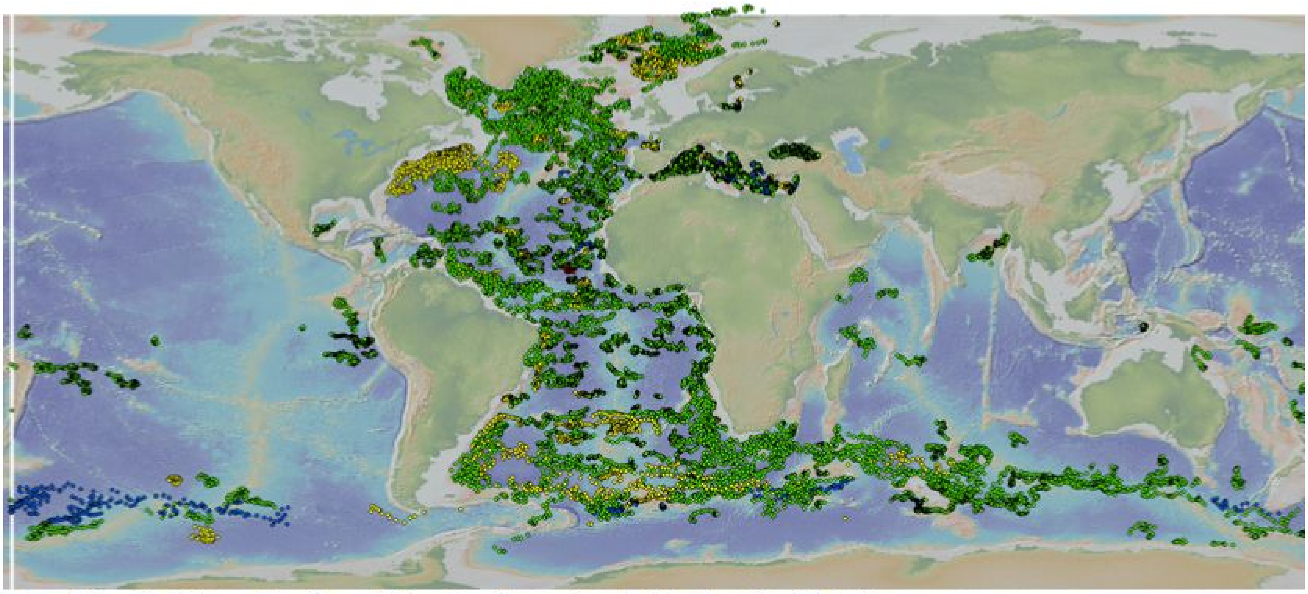
Within Argo-France, data management is undertaken by Coriolis, which play three roles: Data Assembly Centre, Global Data Centre, and leader of the North Atlantic Argo Regional Centre. Coriolis is located within Ifremer-Brest and is operated by Ifremer with support of SHOM. Since 2016, the BGC floats 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 2018 annual report (english) : https://doi.org/10.13155/58109

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 (nov17-oct18), 30 434 profiles from 794 active floats were collected, controlled and distributed. Compared to 2017, the number of profiles is stable (+0.2%), the number of floats increased by 1%. These figures show a fair stability in Coriolis DAC activity. The 794 floats managed during that period had 57 versions of data formats.

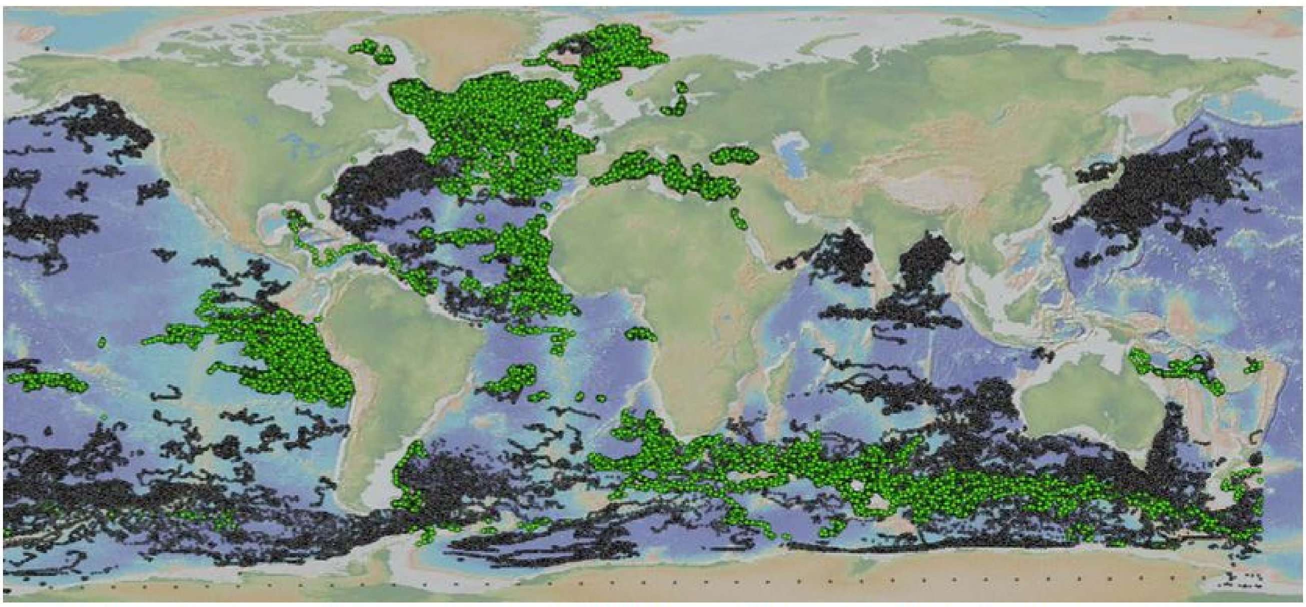


Map of the 30.434 profiles from 794 active floats decoded by Coriolis DAC this current year
Apex Navis Nova Provor

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 409 BGC-Argo floats from 5 families and 57 instrument versions. They performed 53.509 cycles. The data processing chain is freely available:

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



Map of the 409 BGC-Argo floats managed by Coriolis DAC (grey dots: the others DACs bio-Argo floats). They measure parameters such as oxygen, chlorophyll, turbidity, CDOM, back-scattering, UV, nitrate, bisulfide, pH, radiance, irradiance, PAR.

Global Argo Data Centre

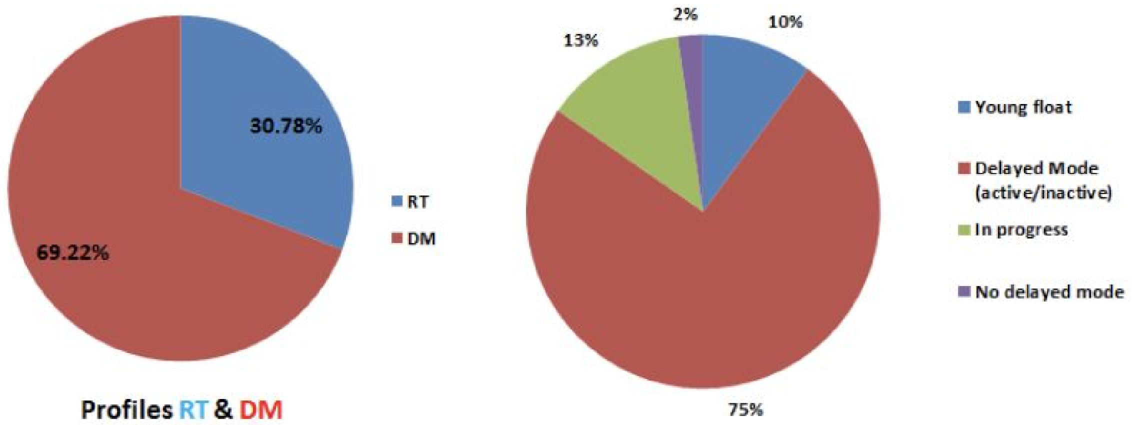
Coriolis hosts one of the two global data assembly centres (GDAC) for Argo that contains the whole official Argo dataset. The Argo GDAC ftp server is actively monitored by a Nagios agent (see http://en.wikipedia.org/wiki/Nagios). Every 5 minutes, a download test is performed. The success/failure of the test and the response time are recorded. There is a monthly average of 561 unique visitors, performing 4302 sessions and downloading 5.9 terabytes of data files.

North Atlantic Argo Regional Centre

See section 5.4

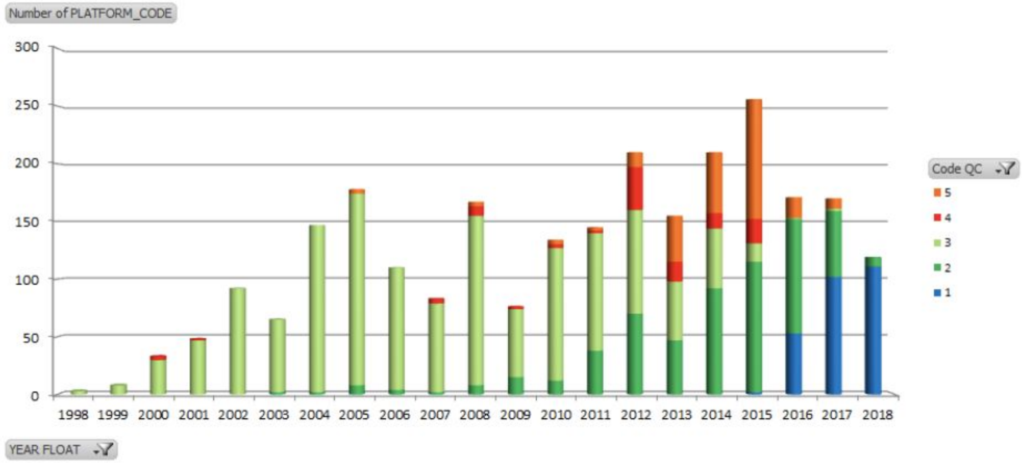
Status of delayed mode quality control process

Last year, 60,598 new delayed mode profiles where produced, validated by PIs and sent to GDACs. A total of 198,769 delayed mode profiles where produced and validated since 2005. In February 2019, 75% of the floats and 69% of the profiles 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 (2017- 2018), 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.



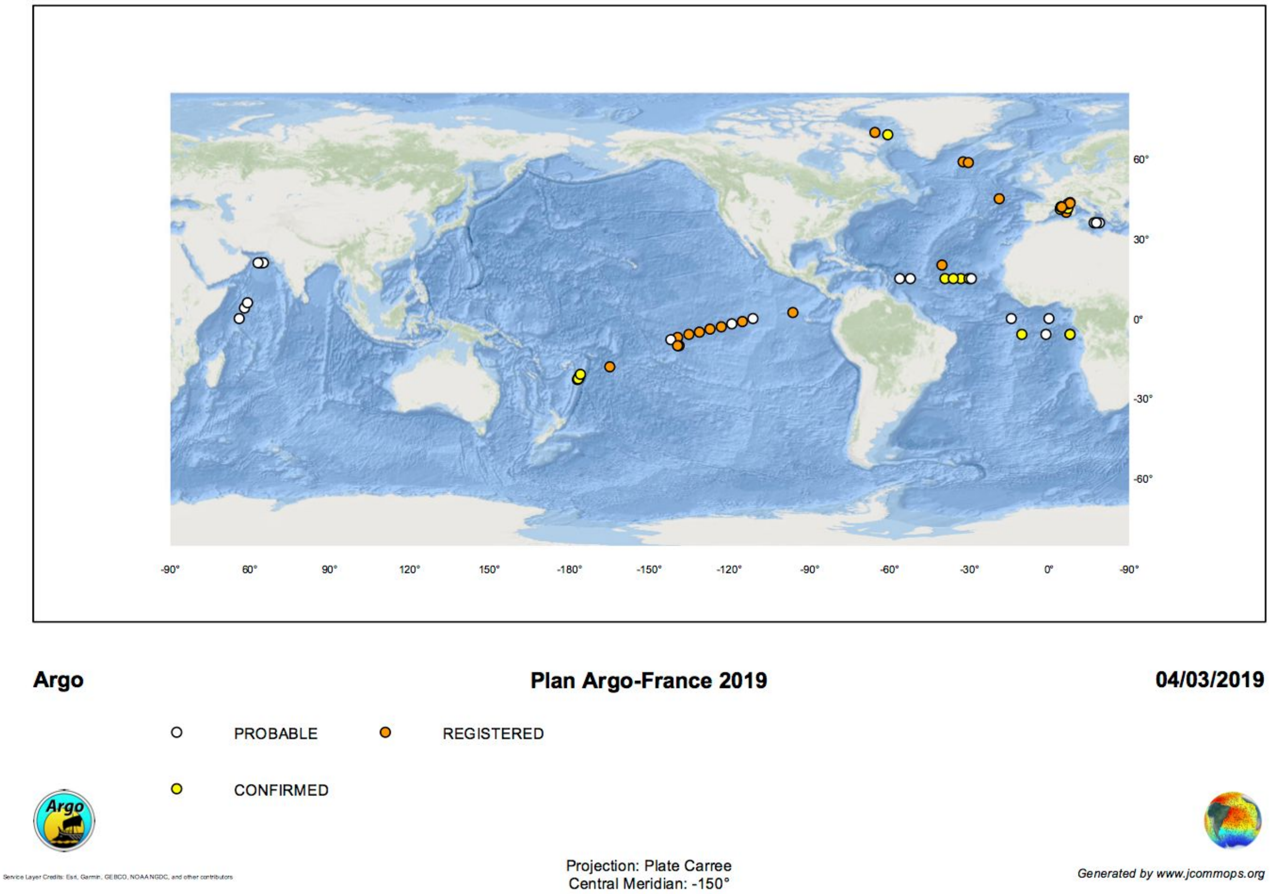
Status of the quality control done on profiles sorted by launch's year, code 1: young float, code 2: active float, DM done, code 3 : dead float, DM done; code 4 : DM in progress, code 5 : waiting for DM, code 6 : problems with float.

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

According to the current deployment plan, 83 floats are scheduled to be deployed in 2019 (with 60 T/S, 18 BGC, 5 DEEP), see map below.

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

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



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

Operational ocean forecasting

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

Support to the Mercator and Coriolis scientific activities

Coriolis has developed together with MERCATOR (The French operational oceanography forecast center) a strong connection with the French research community via the Mercator-Coriolis Mission Group (GMMC). It consists of about one hundred researchers (with some turnover each year) following a scientific announcement of opportunities and call for scientific proposal. 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 link between the French scientific community and Coriolis with regard to the development of qualification procedures for "Argo extensions" floats.

National Research

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

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

Argo-Regional Center: North 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 North-Atlantic ARC activities and in particular the float deployment in Atlantic.

1903 floats that have been processed in delayed time in the North Atlantic ARC, north of 20°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.

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

-

CTD cruise data in the reference database

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

In beginning of 2017, a new version 2017V01 has been provided with some updates on a few boxes, following the feedback sent by some scientists. Since March 2018, a new version 2018V01 including OCL updates, CTD from PI, correction from feedbacks is available on the ftp site.

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

New works are in progress and a new version (2018V02) should be delivered by the end of this year. This version will take into account CTD from the GO-SHIP program (data from 2016 to 2018) and downloaded from the CCHDO Website, as well as a few CTD from scientists.

Bibliography

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

In 2018, at least 46 articles with a scientist affiliated in France as a coauthor have been published in peer reviewed journals. Note that the list of all publications in which a scientist from a French laboratory is involved is available on the Argo France website and on the Argo Bibliography webpage. To date, around 350 articles have been listed.

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

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

1. The status of implementation (major achievements and problems in 2018)

- floats deployed and their performance

All of the floats deployed by Germany in 2018 are operated by BSH, but in other years additional funding had been acquired by various research institutes. BSH has deployed 51 floats (16 APEX, 35 ARVOR) by the end of 2018. No floats have been deployed by GEOMAR and AWI in 2018. 49 of the German floats deployed in 2018 were standard TS floats, 3 floats deployed in the Labrador Sea carried ph/O_2 sensors. Deployment was carried out on research vessels which comprised Canadian, German and UK ships. The deployment locations for 2018 are shown in Fig. 1.

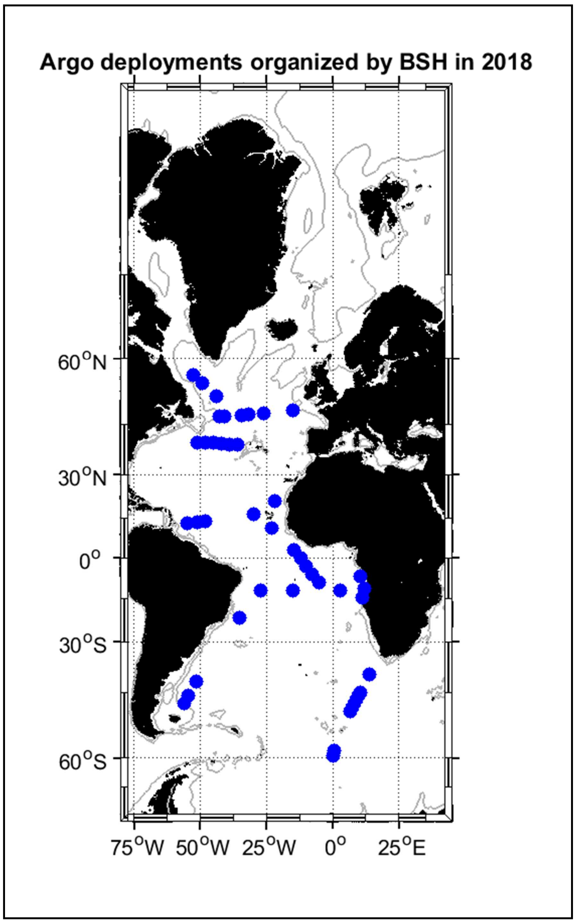


Fig. 1: Deployment positions for floats operated by BSH in 2018 in the Atlantic Ocean.

Currently (February 15th, 2019) 154 German floats are active (Fig.2) and the total number of German floats deployed within the Argo program increased to 866. The number of German floats in the network is stiller lower than anticipated due to the loss rate of APEX floats in the previous years. Some of the under-ice floats deployed by AWI in the previous years are assumed to be still active under the ice and could resurface again in the next austral summer and deliver their stored data.

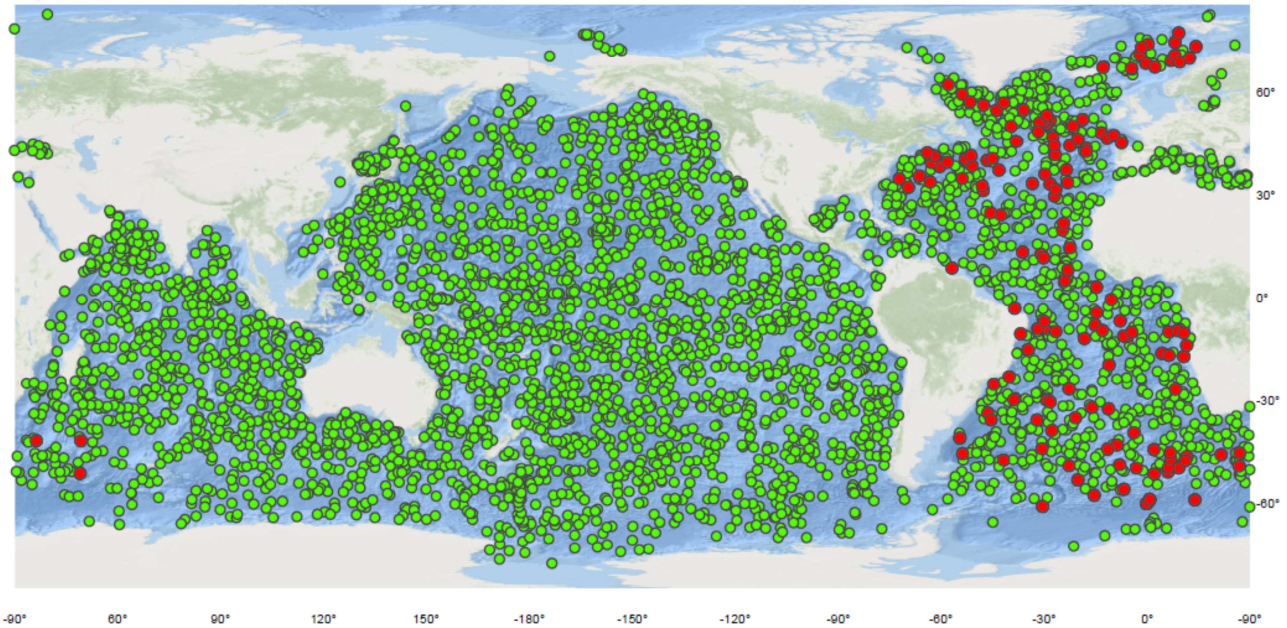


Fig. 2: Locations of active German floats (red) and active international floats (green) (Argo Information Centre, February 2019).

- technical problems encountered and solved

The major technical problem with the alkaline batteries in our APEX floats deployed between 2010-2014 has faded out. We are still experiencing problems with the new APF-11 controller boards provided by TWR and some of the missions settings needed to be changed in extensive interaction with TWR. One of the three APEX floats equipped with ph- and O2-sensor is malfunctioning due to a defect pressure sensor. A replacement for this float has been offered and we are in contact with our colleagues from Bedford Institute in Canada in an effort to retrieve the float from the central Labrador Sea.

After the audit by John Gilson on availability of SBE serial numbers in the meta files, efforts were taken to provide Coriolis with missing information and check the proper assignment of serial numbers to individual sensors.

Special attention has been given to floats in the SN range 6000-7100, all floats have been through dmqc and have been corrected if necessary.

Sudden salty drift is also detected for more recent SNs and some of the floats show depth dependent corrections. Contact with Kim Martini from SBE has been established to understand the behavior.

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

Germany has continued to work in the new European Research Infrastructure Consortium EURO-ARGO-ERIC which was established in July 2014 in Brussel by 9 founding countries (France, Germany, United Kingdom, Italy, Netherlands, Norway, Greece, Poland and Finland). GEOMAR and AWI are members of the EU-funded ATLANTOS project and have deployed deep-floats and bio-Argo floats within this project. Germany is responsible in the framework of the MOCCA project (coordinated by the ERIC) for the delayed-mode quality control of about 50 MOCCA floats, in the Nordic Seas, the subpolar gyre and Southern Ocean and contributes to the at-sea monitoring of the fleet. Within MOCCA an ice-algorithm has been developed for the Arctic ocean from a combination of quality controlled hydrographic data and ice-edge information. At present we are starting to process all the Argo data in the Nordic Seas, trying to eliminate small biases in the data set and will also work on updating the CTD reference data set for the Nordic Seas and Arctic.

Germany has adopted a few of the orphaned US Navy floats and has provided quality control for these floats, as well as for some floats belonging to the University of Maine. Germany is also acting as delayed mode quality control operator for European contributions from Denmark, Finland, Norway, the Netherlands and Poland.

Coriolis is still in the process of reformatting older floats into V3.1, with priority on floats carrying BGC parameters. This leads to changes of existing D-files into R-files and needs additional work on dmqc. The amount of floats to be processed is decreasing and most floats concerned have been reformatted by now.

- status of delayed mode quality control process

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

BSH is also processing the German/Finnish/Norwegian floats in the Nordic Sea, and is covering the tropical, subtropical and subpolar Atlantic. German floats in the Mediterranean on the other hand are processed by MEDARGO. The sharing of delayed-mode data processing will be continued in the coming years, but BSH will cover all German floats which have not been assigned to a PI.

All German institutions have been working in close collaboration with Coriolis and delayed mode data have been provided on a regular basis (6 month). The processing of the RAFOS information on the under ice floats needs to be performed by AWI experts, the intermediary RAFOS amplitudes and time-of-arrival are stored in the in the aux-files directory.

The DMQC process for German floats is continuing, and the frequency of delayed-mode visits has increased during 2017 and continues at these levels in 2018. The total number of available profiles from German floats is 72758 (February 28th, 2019), the number of DM profiles is 62976. The percentage of DM profiles with respect to the total number of profiles has at about 87% in 2018. The main delays remain with the floats in the Southern Ocean owned by AWI, for the other float programmes managed by BSH the delayed mode is at 91%. All delayed mode profiles have been sent to the Coriolis GDAC node.

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

Program Name	Number of profiles	Number of D-files	D-files pending	Comments
Argo BSH	47394	42405	1624	
Argo AWI	7388	3597	3791	Are on priority list
Argo GEOMAR	13490	12552	928	Due to reprocessing
Argo U. HH	3331	3096	235	
Argo Poland	1907	744	312	Baltic floats mostly
Argo Finland	2756	795	1576	Baltic floats mostly
Argo Denmark	360	360	0	Old floats associated with U. HH
Argo Netherlands	10194	9656	226	
Argo Norway	4140	2232	1489	Due to reprocessing

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

The present level of national funding for Argo had remained at flat levels during the last years, but in negotiations with the ministry we have received an increase in funding for the floats in 2019 which allows us to increase the number of floats purchased per year from ~35 back to 50, as originally envisioned. The human resources remain at the same level as before and Birgit Klein, Jan-Hinrich Reissman, Anja Schneehorst and Simon Tewes cover activities such as purchase, technical inspection, deployment, data quality control and representation in national and international teams. As part of our Euro-Argo activities Birgit Klein and Bernd Brügge are involved as management board and council.

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

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

Purpose is gapping filling in the Atlantic, main focus areas are southern ocean and gaps in the subtropical/subpolar areas from the priority list of the ERIC (see maps below). A maximum number of 55 will be deployed in 2019. 3 floats with BGC sensors are contributed by the University of Oldenburg and are financed by the ministry of research (BMBF). All profiles will be high resolution profiles.

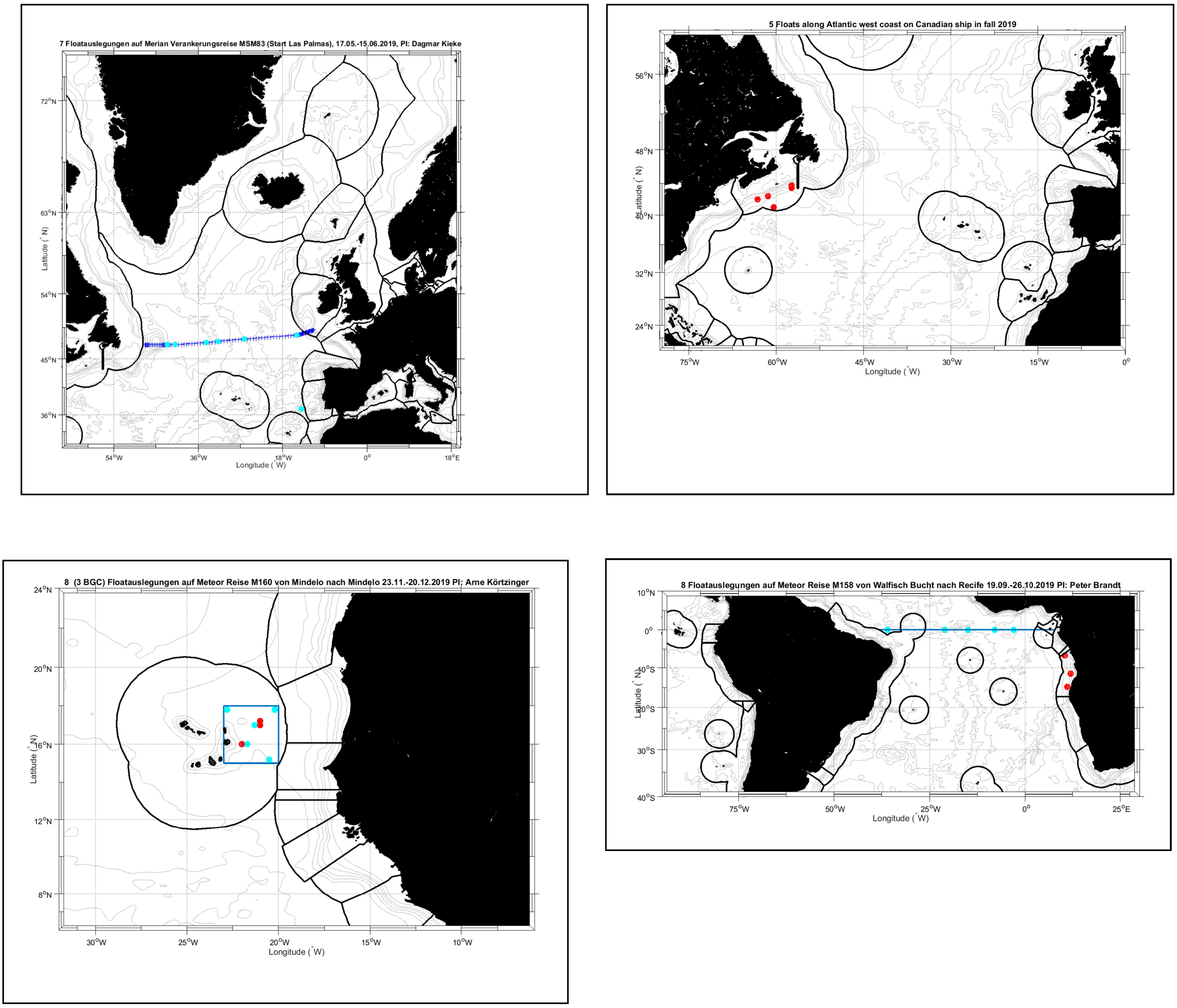


Fig.3: Planned deployments in the North Atlantic in 2019

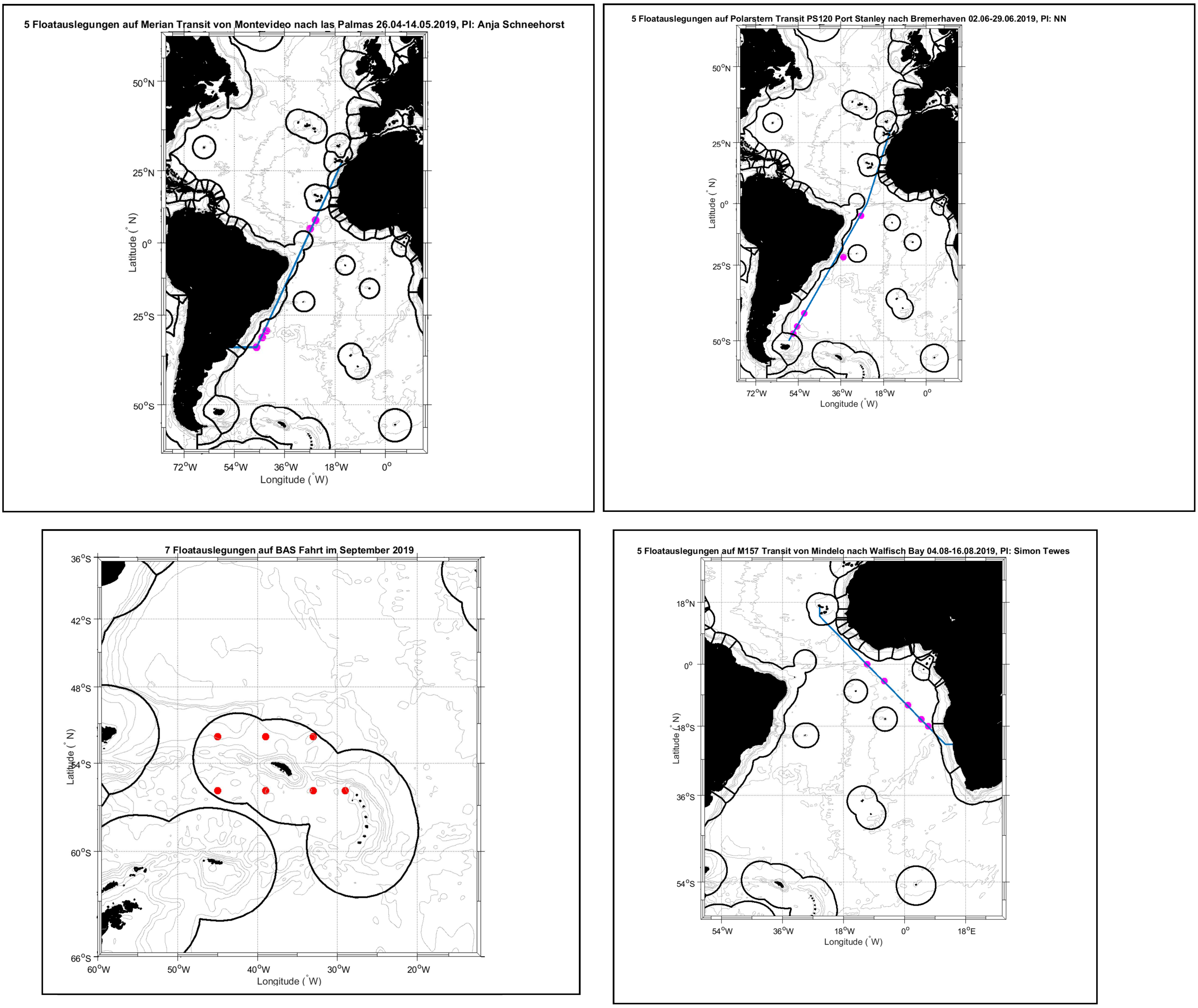
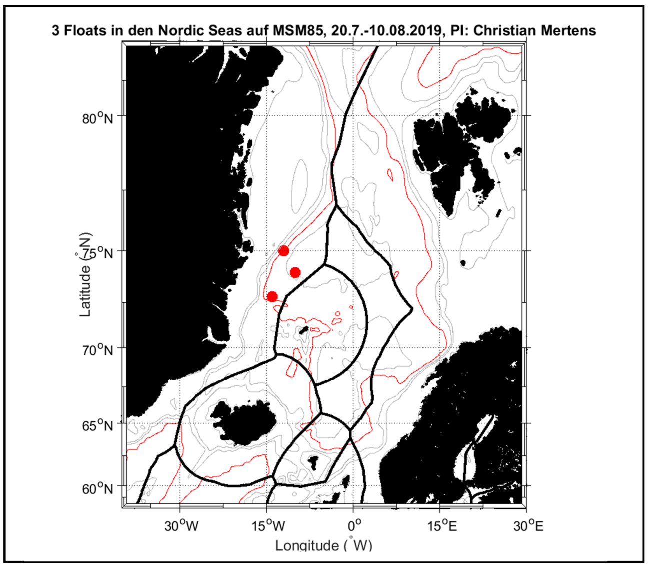


Fig. 4: Planned deployments in the South Atlantic in 2019



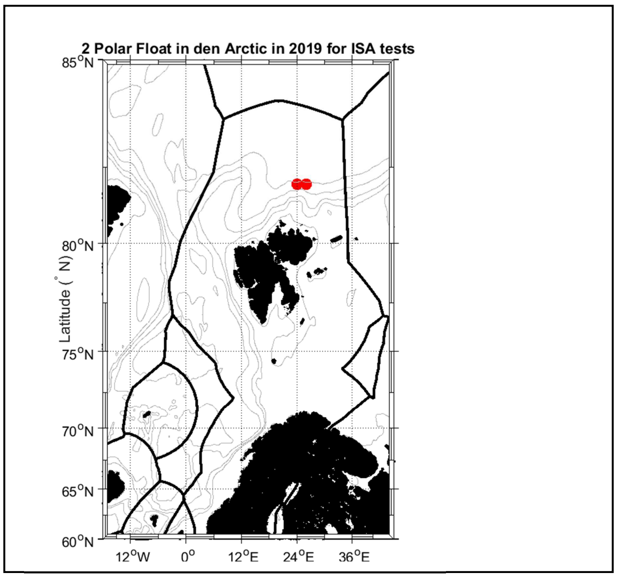


Fig. 5: Planned deployments in the ice covered areas

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

GER	2019						
	Total	T/S Core	T/S/O2	BGC	Bio	Deep	
Nordic Seas	3	3					
Mediterranean Sea							
Black Sea							
Baltic Sea							
Southern Ocean							
Arctic Ocean	2	2					
Global Ocean	50	47		3			
Total	**55**	52		3			

GER	2020						
	Total	T/S Core	T/S/O2	BGC	Bio	Deep	
Nordic Seas	3	3					
Mediterranean Sea							
Black Sea							
Baltic Sea							
Southern Ocean	10		10				
Arctic Ocean	2	2					
Global Ocean	48	45		3			
Total	**63**	50	10	3			

Deployment plans for 2019/2020

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

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

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

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

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

The user workshop was held in 29.06.2018. It was well attended. It provided a good forum for users to share their scientific work and methods.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

GREEK ARGO PROGRAMME

PRESENT STATUS AND FUTURE PLANS

G. Korres and D. Kassis
HCMR
February, 2019

1. Background and organization of GREEK ARGO activities

Greece established national contribution to the ARGO project through national funding to the Greek Argo programme (2012-2015). The programme was co-financed by Greece and the European Union.

1.1 Deployed floats

During 2018, 5 Argo floats were successfully deployed in the Greek Seas under the framework of the Greek-Argo RI activities and the MOCCA project. Four (4) of the floats were NOVA-DOVA type and were purchased by the Greek Argo RI whilst, one (1) Arvor type float was deployed under the framework of MOCCA project. The floats were deployed by the Greek-Argo team in the North, Central and South Aegean basin and in the South Ionian Sea. All floats integrate Iridium satellite telemetry system which provides a dual telecommunication capability allowing modification of the configuration in real-time. The ARVOR 3901957 float was sent to the Greek Argo Infrastructure by the Euro-Argo ERIC. It was deployed on May the 20th along with the EMSO-HELLENIC SITE multi-parametric sea-bed platform at 1520 m depth in the South Ionian area, and has been an important step in promoting collaboration between the European Research Infrastructures of Euro-Argo and EMSO ERIC. The float is a standard T / S float purchased by Euro-Argo under the framework of MOCCA project and was configured to record the profile of the water column at a depth of 1600 meters and drift to a depth of 1000 meters for the first 5 days cycle before returning to the standard Argo settings. The active floats and new deployments during 2018 are presented in Table 1:

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

A/A	Float Type	WMO	IMEI NUMBER	SERIAL NUMBER	Deployment date	Deployment time	Latitude	Longitude	Available profiles	Status
1	NOVA	6901885	300234061647120	134	8/10/2014	20:00	35.79	25.12	299	Active
2	NOVA	6903276	300234063609400	271	13/7/2016	8:00	35.09	25.05	180	Active
3	ARVOR	3901890	300234063609200		4/4/2017	1:15	39,16	24,93	125	Active
5	ARVOR	3901957	300234064702860		20/5/2018	09:15	36,84	21,60	55	Active
6	NOVA	6903281	300234061645120	132	23/5/2018	00:30	36,01	23,75	32	Inactive
7	NOVA	6903282	300234061661440	139	23/5/2018	17:15	36,92	23,55	44	Active
8	DOVA	6903283	300234062954200	245	17/6/2018	16:00	39,76	24,36	39	Active
9	NOVA	6903284	300234062956200	235	19/06/2018	21:00	38,41	25,43	40	Inactive

All floats have been integrated in the MedArgo project. Taking into account the proposed sampling strategy for the Mediterranean Sea and the bathymetry of the deployment site and the adjacent areas, the mission parameters of the floats were set as follows: The parking depth of the floats was set to 350 m, its profiling depth to 1000 m and the cycle period to 5 days. The raw data of the Greek float are delivered at the Coriolis data Centre where the real time quality control takes place while the delayed mode quality control of the data will be processed by the MedArgo Centre at OGS. The 3901890 Arvor float is configured to alternate its profile depth between 700 and 1000 m and the 3901957 Arvor float is configured to alternate its profile depth between 1600 and 1000 m.

1.2 Float Development

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

1.3 Data management

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

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

1.4. Operational and scientific use of Argo data

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

Operational ocean forecasting:

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

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

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

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

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

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

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

Ocean science

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

Publications in scientific journals and conferences proceedings:

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

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

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

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

Kassis, D., Konstantinidou, A., Perivoliotis, L., Korres, G., 2015. Inter-comparing numerical model simulations in the Ionian Sea with Argo T/S profiles for the period 2008-2012. In proceedings of the 11th Panhellenic Symposium on Oceanography and Fisheries, p.945-948, ISBN 978-960-9798-08-2

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

Doctorate theses:

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

Scientific Sheets in Greek Argo web page:

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

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

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

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

Scientific Sheets in Euro-Argo web page:

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

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

Presentations in the EURO ARGO users meeting:

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

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

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

2. Funding

2.1 Existing funding for Greek Argo

Currently there is no existing funding for the 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.

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

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

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

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

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

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

Greece has deployment capabilities for the Aegean, the Ionian Sea and the central Levantine basin. Float deployments in 2019 will be performed according to the plans of the Greek-Argo research infrastructure. The main goal within 2019 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 2019 generally includes:

- 1 float deployment in the South Aegean (where Myrtoan and Cretan Sea meet)-one of which will concern a DOVA Argo float (equipped with dissolved oxygen sensor)
- 1-2 float deployments in the North Aegean
- 1 float deployment in the Ionian Sea

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

Within 2018 several dissemination activities were carried out by the Greek Argo RI such as the participation of Greek Argo in the 2018 Researchers Night and the educational activities for high school students throughout the year. In 2017, under the framework of the 1st Ocean Observers Meeting (June 2017) Greek Argo presented its educational and outreach activities whilst, during the 6th Euro-Argo Users Workshop (July 2017) the Greek Argo Infrastructure activities and achievements were presented.
By the end of 2013 Greek Argo has launched its web page: www.greekargo.gr that demonstrates and promotes Greek-Argo and Euro-Argo activities. At the end of 2014 Greek-

Argo web portal was upgraded providing information and data access from all floats operating in the Mediterranean and presenting all Greek Argo activities, news and data from Greek Argo floats. A continuous upgrade is ongoing integrating more images and videos from Greek Argo deployment activities. Furthermore, new education material has been released and a school visit programme has been established since 2015.
The Euro-Argo infrastructure is also demonstrated on the POSEIDON updated web page, http://www.poseidon.hcmr.gr/article_view.php?id=57&cid=28&bc=28. The POSEIDON system is the operational monitoring and forecasting system for the Greek Seas and many of its forecasting components use T/S Argo profiles for data assimilation purposes. The POSEIDON web page is also hosting the links to the EuroArgo educational web site as well as to the floats from each European country. The above links along with other informative material (Euro Argo leaflet, focused questionnaire) were forwarded directly to all active and potential users of Argo data in Greece. Many research groups filled and sent back the questionnaire providing valuable feedback to HCMR team. Furthermore, the EuroArgo poster and leaflet translated in Greek and they are hosted in the POSEIDON website.

National report of India (2018)

(Submitted by E. Pattabhi Rama Rao)

1. The status of implementation

1.1a Floats deployment

During the year 2018, 15 floats were deployed in the Indian Ocean, and five floats in Jan 2019, taking the total to 459. The new deployment includes 2 Bio-Argo floats with additional sensors like Doxy, FLBB, Chl-a and 1 Ice Float.

1.1b Performance Analysis of Floats deployed

Out of 15 floats deployed during 2018 all 14 are active and providing profiles. One Ice float died after providing 9 profiles.

1.2 Technical problems encountered and solved

None

1.3 Status of contributions to Argo data management

- **Data acquired from floats**

  India has deployed 459 floats so far (till Jan 31, 2019). Out of these 138 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 (138) 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:

  http://www.incois.gov.in/incois/argo/argo_home.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. These data is also used for validation of Biogeochemical model outputs like ROMS with Fennel module.

INCOIS Argo web page statistics during the year 2018 are as shown below:

Page	Number
Argo Web Page Views	2862

Argo Data Download	1516
Argo Products	18419

Products generated from Argo data

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

1.4 Status of Delayed Mode Quality Control process

- INCOIS started generating and uploading D files to GDAC form July 2006, and as of today, profiles belonging to all eligible floats have been subjected to DMQC.
- Advanced Delayed Mode Quality Control s/w developed by CSIRO is being put to use successfully. Using this s/w all the eligible floats are reprocessed to tackle pressure sensor offset problems, salinity hooks, thermal lag corrections, salinity drifts.
- 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 51% 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 trajectories wrt to PROVOR and ARVOR floats will be uploaded shortly.

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

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

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

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

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

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).

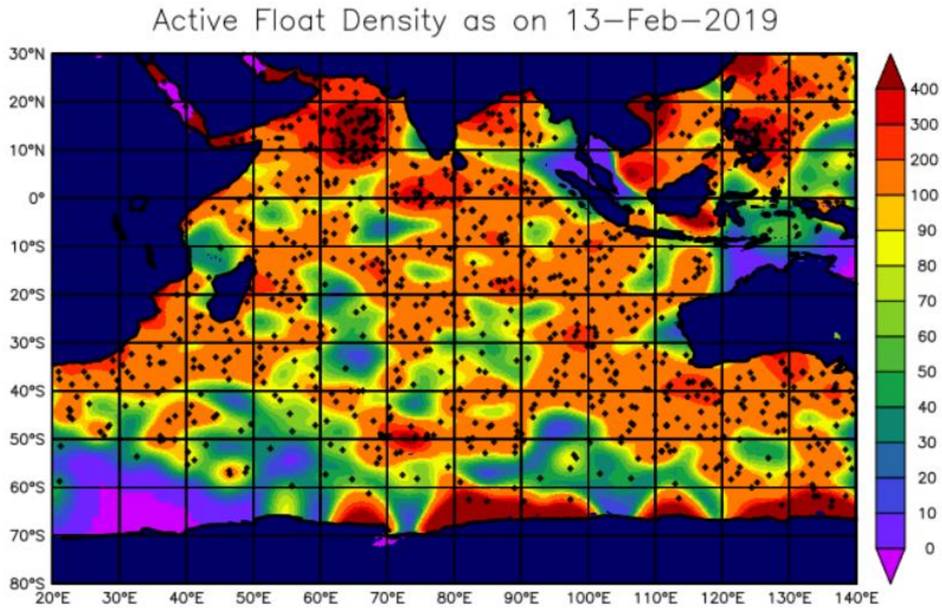
Research: Argo data are being widely used for many applications to understand the Indian Ocean dynamics, cyclone and monsoon system in relation to heat content, thermosteric component of sea level and validation of OGCM by various Indian institutions and university students.

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.
- Additionally SST from TMI, AMSRE and Wind from ASCAT, Chla from MODIS and OCM-2 are also made available on daily and monthly basis.
- Global wind products from OSCAT is also generated and made available on LAS along with TROP flux data sets.
- Data Sets (CTD, XBT, Subsurface Moorings) are being acquired from many principle investigators. These data are being utilized for quality control of Argo profiles.
- Value added products: Two types of products are currently being made available to various user from INCOIS web site. They are:
  (i) Time series plots corresponding to each float (only for Indian floats).
  (ii) Spatial plots using the objectively analysed from all the Argo floats data deployed in the Indian Ocean.

  These valued added products can be obtained from the following link http://www.incois.gov.in/Incois/argo/products/argo_frames.html
- Regional Co-ordination for Argo floats deployment plan for Indian Ocean. The float density in Indian Ocean as on 13 Feb, 2019 is shown below.



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

None

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

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

7. Argo bibliography

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

1. V. V. S. S. Sarma, T. V. S. Udaya Bhaskar, Ventilation of Oxygen to Oxygen Minimum Zone Due to Anticyclonic Eddies in the Bay of Bengal, Journal of Geophysical Research, https://doi.org/10.1029/2018JG004447.

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3. Karmakar, A., A. Parekh, J. S. Chowdary, and C. Gnanaseelan, 2018: Inter comparison of Tropical Indian Ocean features in different ocean reanalysis products. Climate Dynamics, 51, 119-141, https://doi.org/10.1007/s00382-017-3910-8.

4. Lotliker, A. A., S. K. Baliarsingh, V. L. Trainer, M. L. Wells, C. Wilson, T. V. S. Udaya Bhaskar, A. Samanta, and S. R. Shahimol, 2018: Characterization of oceanic Noctiluca blooms not associated with hypoxia in the Northeastern Arabian Sea. Harmful Algae, 74, 46-57, https://doi.org/10.1016/j.hal.2018.03.008.

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8. Santhanam, H. and T. Natarajan, 2018: Short-term desalination of Pulicat lagoon (Southeast India) due to the 2015 extreme flood event: insights from Land-Ocean Interactions in Coastal Zone (LOICZ) models. Ecological Processes, 7, 10, https://doi.org/10.1186/s13717-018-0119-7.

9. Sarangi, R. K., S. K. Shrinidhi, P. Chauhan, and B. R. Raghavan, 2018: Remote sensing and in situ platform based study on impact of Bay of Bengal cyclones (Phailin, Helen, Lehar, and Madi) on ocean chlorophyll and associated physical parameters. Natural Hazards, 93, 413-451, https://doi.org/10.1007/s11069-018-3307-y

10. Seelanki, V., P. Sreenivas, and K. V. S. R. Prasad, 2018: Impact of Aquarius SeaSurface Salinity Assimilation in Improving the Ocean Analysis Over Indian Ocean. Marine Geodesy, 41, 144-158, https://doi.org/10.1080/01490419.2017.1422817.

11. Sherin, V. R., F. Durand, V. V. Gopalkrishna, S. Anuvinda, A. V. S. Chaitanya, R. Bourdallé-Badie, and F. Papa, 2018: Signature of Indian Ocean Dipole on the western boundary current of the Bay of Bengal. Deep Sea Research Part I: Oceanographic Research Papers, 136, 91-106, https://doi.org/10.1016/j.dsr.2018.04.002.

12. Tyagi, G., K. N. Babu, A. K. Mathur, and H. A. Solanki, 2018: INSAT-3D and MODIS retrieved sea surface temperature validation and assessment over waters surrounding the Indian subcontinent. International Journal of Remote Sensing, 39, 1575-1592, https://doi.org/10.1080/01431161.2017.1407051.

13. Valsala, V., S. Singh, and S. Balasubramanian, 2018: A Modeling Study of Interannual Variability of Bay of Bengal Mixing and Barrier Layer Formation. Journal of Geophysical Research: Oceans, 123, 3962-3981, https://doi.org/10.1029/2017JC013637.

14. Venkatesan, R., A. Tandon, D. Sengupta, and K. N. Navaneeth, 2018: Recent Trends in Ocean Observations. Observing the Oceans in Real Time, R. Venkatesan, A. Tandon, E. D'Asaro, and M. A. Atmanand, Eds., Springer International Publishing, 3- 13, https://doi.org/10.1007/978-3-319-66493-4_1.

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Report on the Italian Argo Program for 2018

1. The status of implementation (major achievements and problems in 2018).

- floats deployed and their performance:

In total, **30 Italian floats** were deployed in 2018 (see Tables 1 and 2 for details). These floats were Provor, Arvor-I, Arvor-Ice and Arvor-Deep designs manufactured by NKE (France), and one Dova profiler produced by MetOcean (Canada). All floats transmit data via Iridium telemetry.

Mediterranean and Black Sea deployments

One float was deployed in the Black Sea and 21 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 2 Arvor-I floats (WMO 6903242 and 6903248) which had short cycles of 3 h during most of their operating life to measure high-frequency processes.

Most floats were deployed from research vessels of opportunity (i.e., R/V Atalante, R/V Maria S. Merien, R/V Alliance, R/V OGS Explora, R/V Dallaporta, R/V Leonardo for the Mediterranean and R/V Akademik for the Black Sea) with the help of colleagues from France, Italy, Malta and Bulgaria. In the framework of the Seakeepers Society (https://www.seakeepers.org), two floats were deployed in the Tyrrhenian and Ionian seas from the maxi-yatch Reo.

South Atlantic, South Pacific and Southern Ocean

Five Italian floats were deployed in the South Pacific Ocean and the Pacific sector of the Southern Ocean (Table 2) with the help of Italian colleagues onboard the R/V Palmer while sailing from New Zealand to the Ross Sea. These floats included 1 Dova and 4 Arvor-Ice floats. The Arvor-Ice uses an Ice Sensing Algorithm (ISA) based on temperature readings to abort surfacing when sea ice is present at the sea surface. All floats were programmed to cycle between the surface and 2000 dbar every 10 days and to drift at the parking depth of 1000 dbar. The floats were still active in early 2019.

Three Italian floats were also deployed in the South Atlantic Ocean (Table 2) with the help of Italian colleagues onboard the R/V Agulhas II. These floats were all Arvor-I instruments. 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 2019.

Two Arvor-Ice floats (WMO 6903229 and 6903230) drifted in areas with a presence of surface sea ice south of 62°S and the ISA prevented the floats to perform their usual surfacing. More specifically, float WMO 6903229 did not surface between early August and mid October (6 cycles without surfacing). Float WMO 6903230 stayed longer under the ice, from mid June to mid December (17 cycles). Profile data while under the ice were recorded internally and transmitted later when surfacing was possible.

Model	WMO	Depl. Date	Lat	Lon	Cycles	Last Date	Lat	Lon	Status*	Cycle**
Arvor-I	6903234	04-Mar-2018 20:39	34.27	24.60	66	20-Jan-2019 06:12	33.78	22.62	A	5
Arvor-I	6903236	11-Mar-2018 11:09	37.38	20.33	64	22-Jan-2019 06:20	40.52	18.70	A	5
Provor Bio	6903235	11-Mar-2018 22:50	38.40	20.03	54	02-Sep-2018 10:55	40.19	16.93	D	5
Arvor-I-DO	6903237	16-Mar-2018 19:58	35.49	18.50	64	22-Jan-2019 06:29	35.01	17.92	A	5
Arvor-I-DO	6903238	21-Mar-2018 13:42	39.18	13.33	63	22-Jan-2019 06:11	40.22	10.11	A	5
Arvor-I	6903239	22-Mar-2018 06:08	39.22	11.75	63	23-Jan-2019 06:04	39.46	13.04	A	5
Provor Nut	**6903240**	**29-Mar-2018 04:32**	**43.17**	**29**	**61**	**05-Jan-2019 04:44**	**42.49**	**34.65**	**A**	**5**
Arvor-I	3901974	30-May-2018 11:10	35.84	-2.21	191	22-Jan-2019 16:12	36.59	-4.21	A	5
Arvor-I	6903241	04-Jul-2018 02:46	39.38	17.86	41	22-Jan-2019 06:07	37.82	15.98	A	5
Arvor-I	3901975	04-Jul-2018 18:12	38.95	13.74	42	22-Jan-2019 06:09	40.23	12.70	A	5
Arvor-I	3901973	21-Jul-2018 06:49	42.87	14.82	37	13-Jan-2019 06:19	42.74	15.28	A	5
Arvor-I	6903242	20-Aug-2018 08:14	35.93	14.17	907	13-Dec-2018 09:16	34.20	15.99	D	0.125
Arvor-I	6903248	26-Sep-2018 10:20	43.84	9.82	181	19-Jan-2019 12:25	42.89	5.54	A	0.125, 5
Provor Nut	6903249	06-Oct-2018 11:19	39.10	18.22	37	23-Jan-2019 12:37	38.92	17.34	A	5
Provor Nut	6903250	08-Oct-2018 22:31	39.10	18.22	34	22-Jan-2019 12:35	42.02	17.65	A	5
Arvor-I	6903245	18-Oct-2018 04:35	34.21	26.05	18	20-Jan-2019 06:16	34.21	25.69	A	5
Provor Nut	6903247	18-Oct-2018 04:40	34.21	26.05	38	24-Jan-2019 09:51	34.19	26.91	A	5
Arvor-I	3901977	22-Oct-2018 04:20	35.61	28.23	20	21-Jan-2019 06:10	35.04	27.39	A	5
Arvor-Deep	6903243	24-Oct-2018 00:00	35.56	28.18	1	24-Oct-2018 06:16	35.56	28.18	D	5
Arvor-I	6903244	25-Oct-2018 10:13	35.82	25.01	20	24-Jan-2019 06:21	36.01	25.91	A	5
Arvor-I-DO	6903246	25-Oct-2018 22:50	34.98	23.25	20	24-Jan-2019 06:25	34.35	24.02	A	5
Arvor-I	3901976	05-Nov-2018 09:50	36.11	21.61	17	20-Jan-2019 06:06	35.79	21.29	A	5

**Status in early January 2018: A = active, D = dead;*
***Cycle: Length of cycle in days.*

Table 1. Status information for the 22 Italian floats deployed in the Mediterranean and Black Sea (bold) during 2018.

Model	WMO	Depl. Date	Lat	Lon	Cycles	Last Date	Lat	Lon	Status*	Cycle**
Arvor-I	3901961	29-Jan-2018 23:22	-61	-24.44	37	16-Jan-2019 21:25	-54.26	15.09	A	10
Arvor-I	3901963	30-Jan-2018 05:35	-60	-26.28	36	17-Jan-2019 03:32	-60.01	-26.28	A	10
Arvor-I	3901962	06-Feb-2018 23:11	-53.98	1.67	36	14-Jan-2019 21:05	-52.57	16.27	A	10
Arvor-I-ICE	6903229	23-Feb-2018 16:54	-63.02	161.09	35	21-Jan-2019 05:53	-61.62	155.8	A	10
Arvor-I-ICE	6903230	24-Feb-2018 09:06	-61	158.34	32	02-Jan-2019 05:45	-63.99	174.68	A	10
Arvor-I-ICE	6903231	25-Feb-2018 00:41	-59.02	155.82	35	23-Jan-2019 05:51	-64.67	-174.04	A	10
Arvor-I-ICE	6903232	25-Feb-2018 17:30	-56.98	153.44	35	23-Jan-2019 05:31	-55.57	174.47	A	10
Dova	6903233	26-Feb-2018 07:22	-55.03	152.5	34	22-Jan-2019 04:46	-56.55	170.01	A	10

**Status in early January 2017: A = active, D = dead.*
***Cycle: Length of cycle in days.*

Table 2. Status information for the 8 Italian floats deployed in the Southern Ocean, South Atlantic and South Pacific during 2018.

Overall status at the end of 2018

In summary, at the end of 2018, the ARGO-ITALY program had a total of **65 active floats**, including 30 instruments in the Mediterranean Sea Figure 1), 6 in the Black Sea (Figure 1) and 29 in the South Pacific, South Atlantic and Southern Oceans (south of 60˚S) (Figure 2).

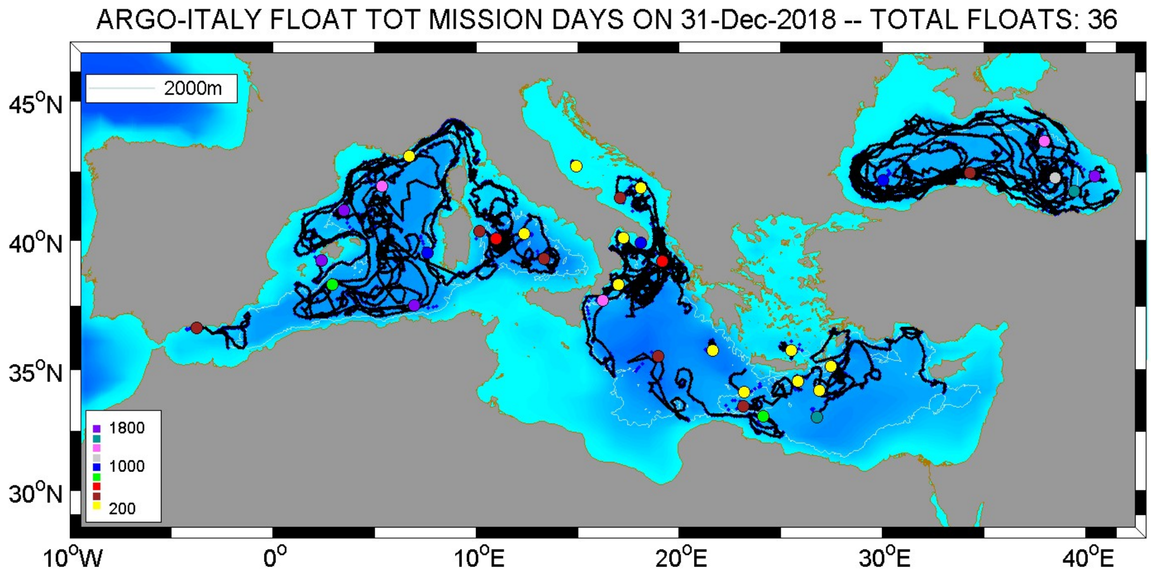

Figure 1. Trajectories and positions (circle symbols) on 31 December 2018 of the 36 ARGO-ITALY floats active in the Mediterranean and Black Sea at the end of 2018. The circle symbols are color-coded as a function of float age in days.

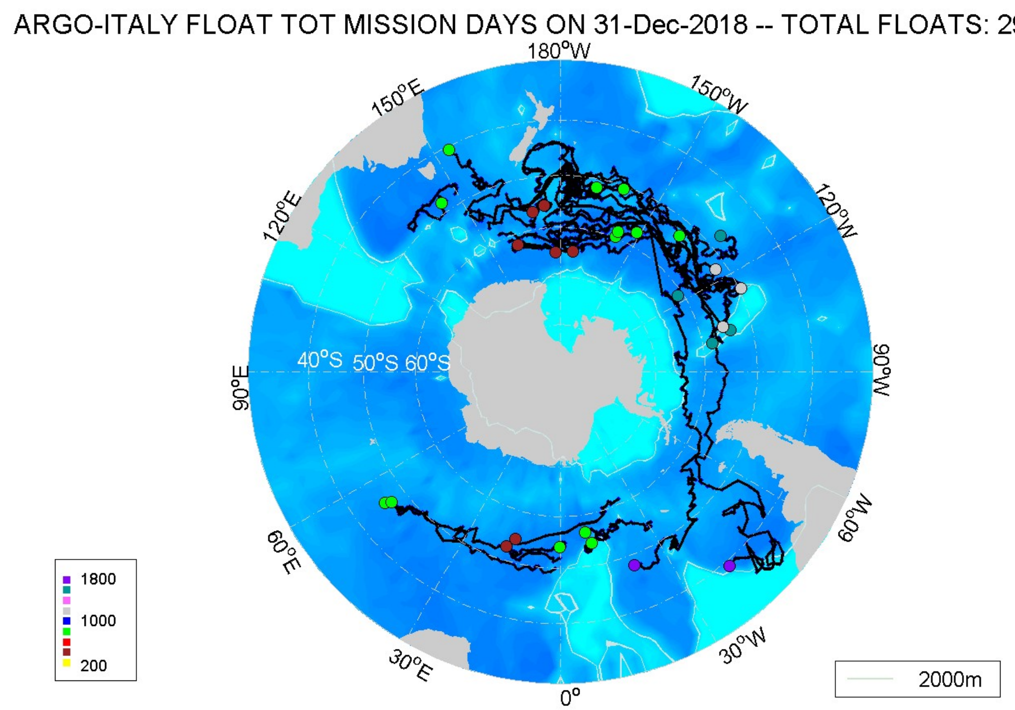

Figure 2. Trajectories and positions (circle symbols) on 31 December 2018 of the 29 ARGO-ITALY floats in the South Pacific, South Atlantic and Southern Oceans. The circle symbols are color-coded as a function of float age in days.

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 2012-2018. The float population in 2012-2018 is essentially increasing and reaching 60-70 active instruments in 2018, although we notice a slight decrease starting in 2017. In 2018, the number of floats which stopped transmitted was rather high (32) probably due to the natural aging of the ARGO-ITALY network and also due to the short operating lifes of some float types.

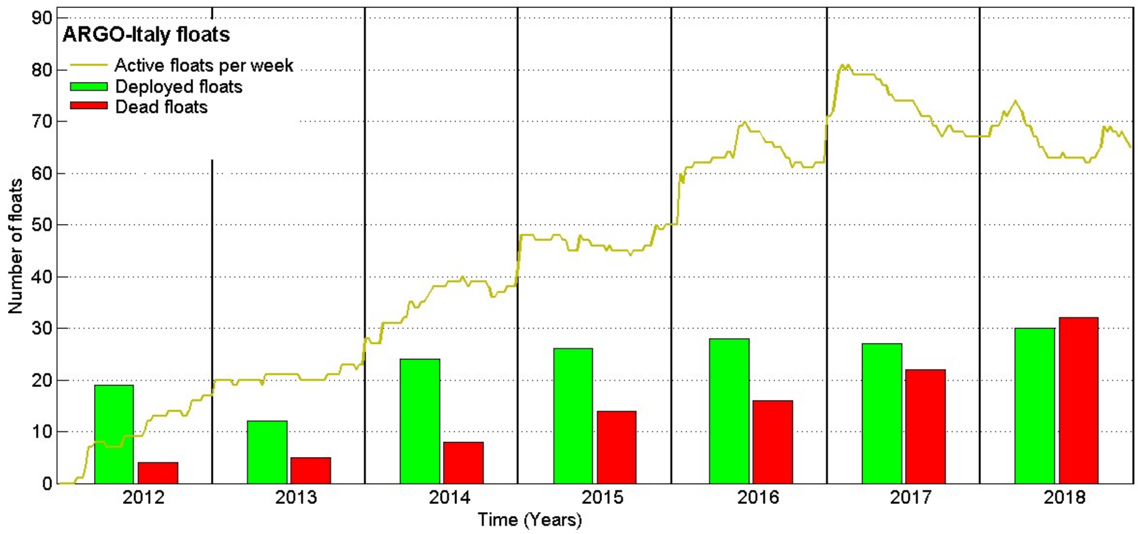

Figure 3. Temporal evolution of the number of ARGO-ITALY active floats with weekly resolution and histogram of the annual float deployments and losses.

Since 18 February 2012, a total of **166 ARGO-ITALY floats** have been deployed, 104 in the Mediterranean and Black seas, and 62 in the oceans of the Southern Hemisphere. In less than 7 years, they have provided about **19700 CTD profiles**. In total, 14 floats (~8 %) have failed just after deployment.

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

Mediterranean and Black Sea

Two floats stopped functioning prematurely before the end of the year 2018. The Arvor-Deep float (WMO 6903243) deployed southeast of Rhodes stopped transmitting data after its first cycle. Provor CTS 4 (WMO 6903235, equipped with biogeochemical sensors) was deployed in the northern Ionian in March 2018 and stopped functioning at cycle 55 in the Gulf of Taranto in September 2018. This float was a refurbished instrument. Reasons for these early failures are still under investigation.

Nova/Dova floats

In general, the Nova and Dova floats have significantly lower survival rates. After a little more than 3 years since their first deployments in October 2015, only 12 floats (out of 40 units, i.e., 30%) were still fully operational in early 2019. It appears that these floats are not produced anymore!

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

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

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

The Italian Ministry of Research has provided funding to buy 23 floats in 2018, including 5 instruments with dissolved oxygen sensors and 3 deep floats. 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 2018. It is expected that the same level will be maintained in 2019, including the procurement of 20 additional standard floats and 2 BGC floats. The Italian Ministry of Research is committed to provide funding in order to sustain the Italian contribution to Argo beyond 2019 as a founding member of the Euro-Argo Research Infrastructure Consortium. In addition to the Italian national funding, OGS has funding from EC (CMEMS, MOCCA, Euro-Argo RISE) and the Italian Ministry of Foreign Affairs (MELMAS) projects for several activities related to Argo.

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

The Italian deployment plans for 2019 and 2020 are detailed in Table 3. The main areas of interest are the Mediterranean and Black seas and the oceans of the South Hemisphere.

Year	T/S floats (some of them with DO)		BGC floats		Deep floats		Total
	Quantity	Area	Quantity	Area	Quantity	Area	
2019	14 2 10	Mediterranean Black Sea South Hemisphere	0 1	Mediterranean Black Sea	1	Mediterranean	**28**
2020	14 2 10	Mediterranean Black Sea South Hemisphere	1 0	Mediterranean Black Sea	1	Mediterranean	**28**

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, MOCCA and Euro-Argo RISE projects over the next years.

The website for the Italian contribution to Argo (Argo-Italy) was improved and upgraded (http://argoitaly.ogs.trieste.it/). The link to the Mediterranean & Black Sea Argo Centre (MedArgo) is http://nettuno.ogs.trieste.it/sire/medargo/. A completely new web site for Argo-Italy is still in development and will be operational in 2019.

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

Operational ocean forecasting.

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

Ocean science.

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

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

N/A

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

N/A

7. Italian contribution to Argo bibliography in 2018.

Droghei, R., B. Buongiorno Nardelli, and R. Santoleri, 2018: A New Global Sea Surface Salinity and Density Dataset From Multivariate Observations (1993–2016). Frontiers in Marine Science, 5, https://doi.org/10.3389/fmars.2018.00084

Gentile, V., S. Pierini, P. de Ruggiero, and L. Pietranera, 2018: Ocean modelling and altimeter data reveal the possible occurrence of intrinsic low-frequency variability of the Kuroshio Extension. Ocean Modelling, 131, 24-39, https://doi.org/10.1016/j.ocemod.2018.08.006

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Japan National Report

(Submitted by Toshio Suga)

1. The Status of implementation (major achievements and problems in 2018)

1.1 Floats deployed and their performance

Japan Agency for Marine-Earth Science and Technology (JAMSTEC) deployed 50 Argo, deep Argo, Biogeochemical (BGC) Argo and Argo equivalent floats from January to December 2018: 5 ARVORs, 2 NAVISs, and 25 APEXs for Core Argo, 8 Deep APEXs, 3 Deep NINJAs, and 2 RINKO-Deep NINJA for deep Argo, 1 BGC APEX and 4 BGC NAVISs for BGC Argo. Since 1999, JAMSTEC had deployed 1277 Argo, deep Argo, BGC Argo and Argo equivalent floats mainly in the Pacific, Indian and Southern Oceans. The current positions of all the active Japanese Argo floats are shown in Fig.1. Collaborating with Japanese voluntary agencies, institutes and schools, all the floats were deployed in 18 cruises. Two floats were deployed by a voluntary cargo ship owned by a Japanese merchant ship company, NYK Line, in July 2018. The arrangement of the semi-regular float deployment by cargo ships was made under the cooperative relationship between JAMSTEC and NYK line, which was established in 2011 to increase float deployment opportunity.

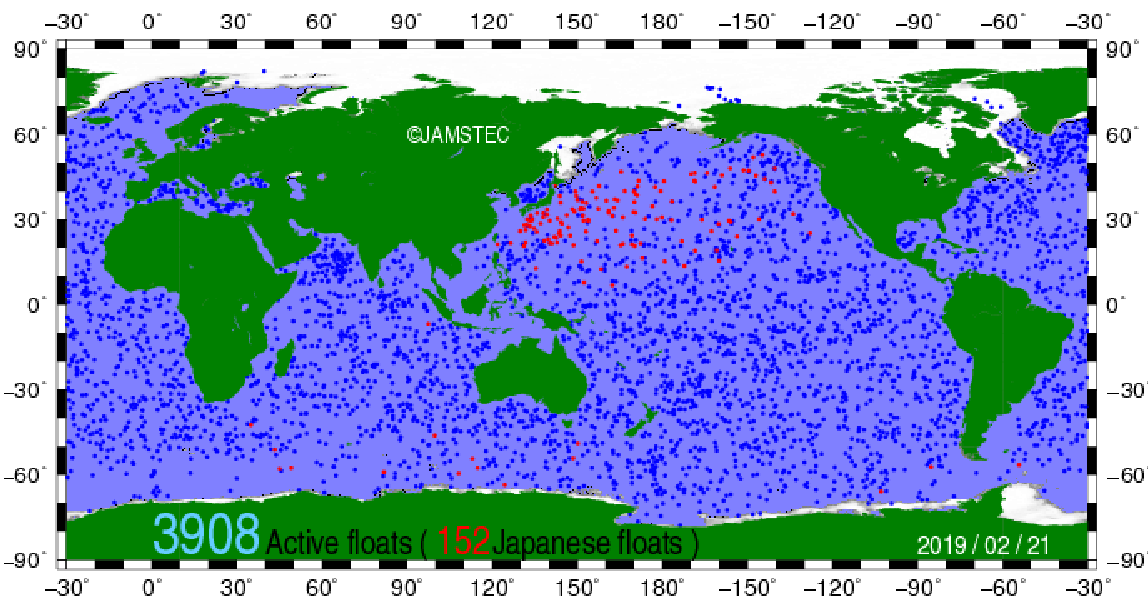

Figure 1: The distribution of active Argo floats. The red dots represent active Japanese floats.

The Japan Meteorological Agency (JMA) deployed 19 Argo equivalent and WBC floats (19 ARVOR floats) in the seas around Japan from January to December 2018. All the floats get 2,000 dbar T/S profiles every 5 days for operational ocean analysis and forecast.

Among 279 floats (14 PROVOR, 167 APEX and 98 ARVOR floats) which JMA has deployed from 2005 to 2018, 54 floats (54 ARVOR floats) are active as of the end of December 2018, while 15 floats (4 APEX and 11 ARVOR floats) terminated the transmission in 2018. JMA deployed 6 ARVOR floats from January to February 2019.

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 2018, three Deep NINJA floats were operated. In December 2018, 2 Deep NINJA floats (including a model with RINKO DO sensor) were deployed; one in the tropical Pacific, and the other in the Indian sector of the Southern Ocean. Unfortunately, the latter had lost contact due to a failure at deployment. 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.

Okinawa Institute of Science and Technology Graduate University (OIST) deployed 21 Argo equivalent floats from 2011 to 2017. Four Argo equivalent floats (NEMO floats) are active in December 2018.

1.1.1 Deployment of RBRargo CTD APEX float

JAMSTEC deployed two RBRargoCTD APEXs in February 2018 at 27N, 165E where characteristics of water mass at 2000 dbar is stable enough to evaluate the CT sensor accuracy manufactured by RBR. Comparing with shipboard CTD data obtained at the same point, positive biases in salinity (+0.05 PSS-78) were detected in both float data. Based on discussions with RBR technicians, they reproduced a salinity pressure correction scheme to estimate salinity values from conductivity, pressure and temperature sensors, referring all RBRargo CTDs from some contributors. The result is shown in the web site: http://www.argo.ucsd.edu/RBR_CondPres_Correction_31Jan2019.pdf.

1.1.2 Float deployment for the research project "Optimization of tropical Pacific Ocean observation system"

Argo equivalent floats were deployed in the western tropical Pacific to investigate interior ocean disturbances and their source region related to ENSO. The purpose of this project is to make suggestion on effective design of tropical Pacific Observation System (TPOS) for the ENSO prediction, contributing to TPOS2020. Following there NAVIS floats deployed around TRITON moorings along 137E line in 2017, one Deep NINJA was deployed 10S, 130W for a feasibility study in 2018, which try monitoring tropical ocean state by using deep float as a virtual moored array. The obtained data will be compared with some Peruvian coastal ocean monitoring equipment.

1.2 Technical problems encountered and solved

1.2.1 Float hardware troubles on NAVIS float

NAVIS floats, which were purchased in 2013-2015, suffered hardware troubles. The accumulated number of which are 43 of all purchased Navis float for Core, BGC Argo, 42 of them were possibly caused by pump, bulb or bladder system failure, 1 of them was possibly connection trouble, and 2 of them were communication error between sensors and float body. Some of the troubled Navis drifting at sea surface without proper measurement, or missing measurement levels. Because of efforts for improvement of hardware by SBE, recent version of Navis floats are almost stable. Following the warranty policy, JAMSTEC has received 18 warranty floats until 2018 and 4 floats are still on the watch list.

1.2.2 Deep Ninja with RINKO sensor

In 2018, JAMSTEC developed a new model of Deep NINJA with RINKO DO sensor in cooperation with JFE Advantech Co. Ltd. and Tsurumi Seiki Co. Ltd. In 2018, we made three floats in October 2018. One float was deployed in the Indian sector of the Southern Ocean in December 2018 from R/V Kaiyo-maru, however, it has lost because of a failure at deployment. One of the rests was deployed in the Southern Ocean in January 2019 from R/V Umitaka-maru, and the other was canceled to be deployed there due to a miss-operation of an operator onboard. The float will be deployed in 2019 in the Southern Ocean after several tests of its RINKO sensor. The RINKO DO sensor for deep float (AROD-FT) is already available at JFE Advantech.

1.2.3 Deep APEX

In 2018, JAMSTEC deployed 8 Deep APEXs including 2 dissolved oxygen Deep APEX. One of the floats drifted at sea surface just after deployment, 6 of them appeared in the same situation after a few cycles without acquiring proper data. All troubled Deep APEXs recorded buoyancy control failure in technical logging file. Examination of the cause of trouble is going on, and Teledyne Webb Research, manufacturer of Deep APEX, is trying to improve their firmware APF-11. Because of this troubles, our deployment plan in 2019 will be modified, their deployment to be moved to next FY.

1.3 Status of contributions to Argo data management

The Japan DAC, JMA has operationally processed data from all the Japanese Argo and Argo-equivalent floats including 152 active floats as of February 19, 2019. Ten Japanese PIs agree to provide data to 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 TESAC and 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. Accordingly, JMA has converted the Rprof-files of Japanese ARGOS floats, except floats with NST sampling scheme and Iridium floats. JAMSTEC has converted all v2 Dprof-files of Japanese floats to v3.1 and submitted them to GDACs. JMA has converted about 30% of Japanese traj-files from v2 to v3.1 and submitted them to GDACs.

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

1.4 Status of delayed mode quality control process

JAMSTEC has submitted the delayed-mode QCed Core data (P, T, and S) of 119,234 profiles to GDACs as of December 2018. JAMSTEC had submitted D-Core files of 4180 profiles in 2018.

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

Japan Argo had been conducted in a 5-year program from FY1999 to FY2004, as a part of Millennium Project implemented under cooperation among the Ministry of Education, Culture, Sports, Science and Technology (operation: by JAMSTEC), the Ministry of Land, Infrastructure and Transport, JMA and Japan Coast Guard. After the Millennium Project terminated in March

2005, JAMSTEC has continued the operation until FY2013 nearly in the same scale (about 80 floats to be deployed every year and associated delayed-mode data management) under its two consecutive mid-term programs for FY2004-2008 and FY2009-2013. JAMSTEC continues the float deployment and delayed mode data management but in the scale somewhat lower than ever before under its new 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 will start new mid-term programs for 7 years. Deployment plan for Core, Deep and BGC Argo are not yet fixed but will be decided soon. JMA allocates operational budget for 27 floats in FY2019..

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

Based on the additional fund, larger number of Core/Deep/BGC Argo floats will be deployed in 2019. To maintain Core Argo array, JAMSTEC will deploy 40 floats mainly in the North Pacific, where the index of deployment intensity is not good and the age of floats tend to be higher than the other area, based on the information from Argo Information Center. Those deployment will help to improve North Pacific Core Argo array. Regarding Deep and BGC Argo, 1 RINKO (DO) Deep NINJA, 8 Deep APEX, 6 BGC Navis with Nutrient (2) and pH (4) floats will be deployed in the Pacific, Indian Oceans and the Southern Ocean. However, the deployment plan might be changed, since some BGC and Deep Argo floats are in troubles as described in section 1.2.

JMA plans to deploy 27 Argo equivalent floats (12 floats are deployed in western boundary region) around Japan in FY2019 and in the coming years. All the JMA floats are identical with the core Argo floats except that they are operated in a 5-day cycle, synchronized with JMA's real-time ocean data assimilation and forecast system.

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

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

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

The global Argo TESAC and BUFR messages are used for operational ocean analysis and forecast by JMA. Daily and monthly products of subsurface temperatures and currents for the seas around Japan and western North Pacific, based on the output of the real-time ocean data assimilation system (MOVE/MRI.COM-WNP), are distributed through the JMA web site (in

Japanese). Numerical outputs of the system are available from the NEAR-GOOS Regional Real Time Data Base (http://www.data.jma.go.jp/gmd/goos/data/database.html) operated by JMA. Monthly diagnosis and outlook of El Niño-Southern Oscillation based on the outputs of the Ocean Data Assimilation System and the El Niño Prediction System (an ocean-atmosphere coupled model) are also operationally distributed through the JMA web site (in Japanese) and the Tokyo Climate Center (TCC) web site (http://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 http://ds.data.jma.go.jp/tcc/tcc/products/elnino/move_mricom-g2_doc.html, and http://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 (http://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 high 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.

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 3a in March 2018 to cover 58-year period during 1957-2014 (See the web site in JAMSTEC, http://www.godac.jamstec.go.jp/estoc/e/top/). The ESTOC continue being improved by introducing new observational elements (e.g., ocean mixing, a global sea level). Deep and BGC float data can be assimilated into the system after 2016. Some methodology for deep float data to be integrated was developed and published in 2018.

JCOPE2 (Japan Coastal Ocean Predictability Experiment 2) is the model for prediction of the oceanic variation around Japan which is operated by Application Laboratory of JAMSTEC. JCOPE2 is the second version of JCOPE1, developed with enhanced model and data assimilation schemes. The Argo data are used by way of GTSPP. The reanalysis data 25 years back (from 1993 to present) and the forecast data 2 months ahead are disclosed on the following web site: http://www.jamstec.go.jp/frcgc/jcope/. More information are shown in http://www.jamstec.go.jp/frcgc/jcope/htdocs/jcope_system_description.html.

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

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

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

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

Data of 342 CTD casts conducted by JMA in the western North Pacific from October 2017 to May 2018 were uploaded to the CCHDO website.

7. Outreach activity.

In October, 2018, an Argo public lecture was held with the 6th Argo Science Workshop at Hitotsubashi Hall in Tokyo. The public lecture was sponsored by Japan Meteorological Agency and the Japanese Argo Promotion Committee, endorsed by Ministry of Foreign Affairs of Japan, Ministry of Education, Culture, Sports, Science and Technology, Ministry of Land, Infrastructure, Transport and Tourism and Japan Coast Guard. Over 120 public citizens participated and three talks related to recent Argo activities and results were given by Dr. K. Johnson, Dr. G.C. Johnson and Dr. T. Suga. .

There are two press releases in 2018: scientific one by Dr. T. Kobayashi about a new finding of deep-water changes in the Southern Ocean with Deep floats, and the other on 2,000,000 profile celebration. Both make some articles on several Japanese newspapers.

Two public events were led by JAMSTEC in Yokosuka and Mutsu, where Argo float series are introduced and some related contents are exposed.

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Argo-KOREA Annual Report 2018

by National Inst. of Meteorological Sciences/KMA

20th Argo Steering Team Meeting (AST-20)
Hangzhuo, China, 11-15 March 2019

1. Status of Implementation

The National Institute of Meteorological Sciences of Korea Meteorological Administration (NIMS/KMA) has deployed 241 Argo floats around the Korea peninsula and the North Pacific Ocean since 2001, including 40 active floats as of February 2019. In 2018, NIMS/KMA deployed 11 Argo floats in the East Sea and Yellow Sea (Fig.1). Seven floats were deployed in the East Sea on July 18 and November 20, 2018 with 800 m of parking depth and seven-day profiling scheme, and four were in the Yellow Sea on July 25 and November 11, 2018, for the shallow sea observation with one-day profiling scheme and 60 m of parking depth. Especially all floats deployed at the Yellow Sea by using the Gisang1, the KMA'a research vessel, could obtain the one-day profile since the starting day, and those were lasted over three months.

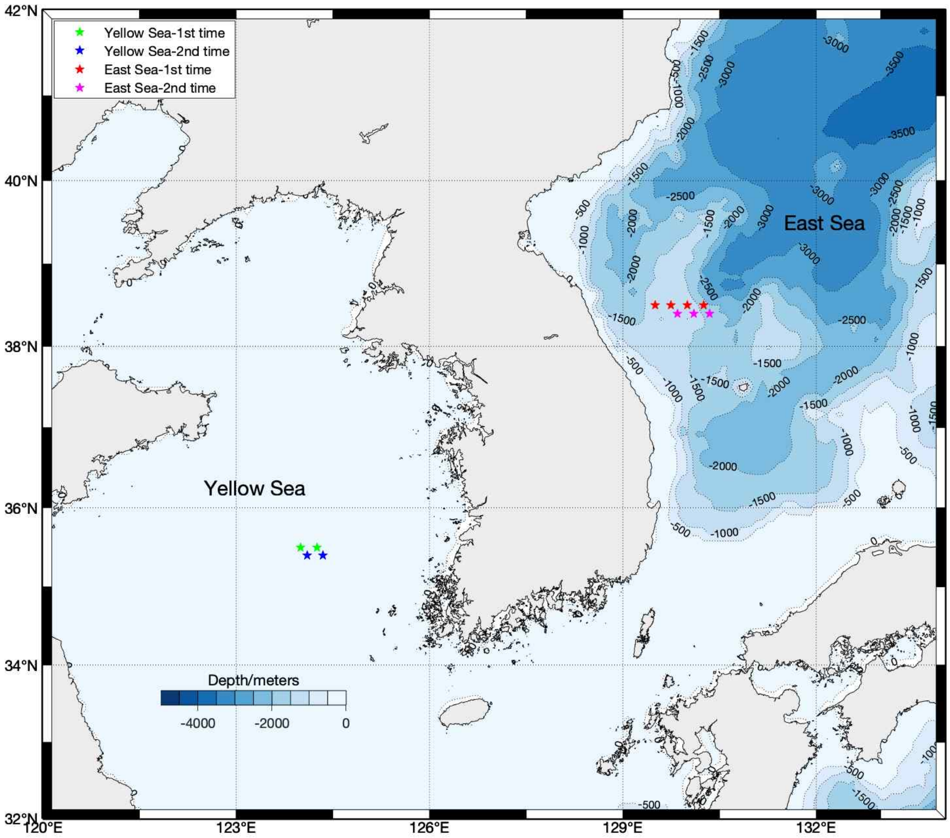


Fig. 1. Initial position of Argo floats deployed by the NIMS/KMA in 2018.

- Status of contributions to Argo data management

- Reproduction of NetCDF data of dead floats.
  - Meta, technical and trajectory files sent to GDAC (Dec. 2018)
- Transmission of converted NetCDF data to US-GDAC
  - solved the network issue (Trajectory files)
- Implementing the Argo data format check program (new version)
- CTD sensor serial number has been checked, as a result total 16 floats deployed (sensor error issue)

- Delayed Mode QC

- We thoroughly reprocessed all the previous D-files in the East Sea and sent 19,007 of the revised D-files with NetCDF format (ver. 3.1) to the GDAC in November 2018. A precise quality control precess is also being taken for the reference database in the East Sea at this moment. The new database will be applied for the DMQC in the next year, and total 1,791 of the new D-files for the floats in the western North Pacific will be uploaded, too.

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

We purchased 11 floats in 2018 and successfully deployed all around Korea this year, however 6 floats could be possibly purchased due to the budget decrease in 2019

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

3. Summary of deployment plans

NIMS/KMA has a deployment plan for 6 floats (ARVOR or APEX float) in 2019: four will be deployed at the East Sea to keep the observation network and two at the Yellow Sea to continue the shallow sea observation scheme in the regional ocean. Continuing the last year’s program in the Yellow Sea, observation program using the Argo float will be preformed to investigate the ocean environment variation in west coast of Korea.

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

The shallow Argo observation was conducted on July and November 2018 in Yellow Sea, Korea. The daily temperature and salinity profiles obtained from this observation campaign showed well the mixed layer fluctuation during summer and fall seasons, especially including typhoon Soulik(1819) passage on August 23, 2018 (Fig. 2). NIMS/KMA runs a Regional Data Assembly Center (RDAC) in order to provide the profile data, float-track, and number of acting float, and etc, which can be found at the home page: http://argo.nims.go.kr. And the main system of data processing including the file-checker program has been upgraded to automatically apply the real-time profile data on Nov. 2018.

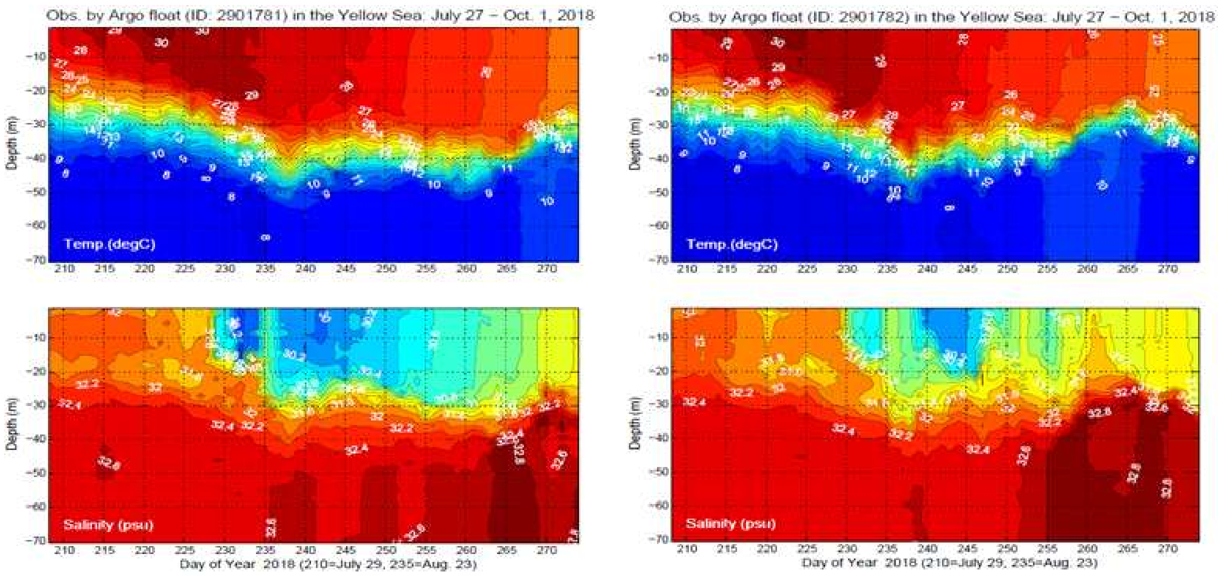


Fig. 2. Daily variation of temperature and salinity profiles from July 27 to Oct. 1(2901781, 2901782), 2018, in the Yellow Sea, Korea.

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

- Regional ocean observation using the Argo floats.

6. CTD data uploaded to CCHDO

- No

<The End>

ARGO National Report 2019 – 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:
    - 87 floats have been purchased
    - 24 are working

No floats have been purchased in 2018. Two will be bought in 2019.

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 led to no floats being bought in 2018, an only two will be bought in 2019. The financial pressure will probably last for some more year.
One person (Andreas Sterl) is working on ARGO. He does so besides his other duties.

3) **Summary of deployment plans** (level of commitment, areas of float deployment) and for other commitments to Argo for the coming year (and beyond where possible).
Two floats in 2019, 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).

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**
Yes.

7) **Bibliography**

New Zealand National Report March 2018

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

New Zealand's floats
NIWA has purchased and deployed 35 floats to date. Purchases and deployments are likely to continue at the 2 floats/year level.

Information on the New Zealand floats, designated (WMO#): 8711 (5905726)*, 8658 (5905681)*, 8599 (5905266)*, 8597, (5905265)*, 8513 (5902503)*, 8511 (5902502)*, 8427 (5902440)*, 8426 (5902439)*, 8323 (5902384)*, 8322 (5902383)*, 8179 (5904274)*, 8131 (5904332), 8116 (5904076), 8097 (5904062), 8064 (5903777), 8035 (5903756), 2873 (5903333), 2872 (5903332), 2860 (5902225), 2859 (5902224), 2750 (5901853), 2739 (5901843), 2693 (5901763), 2659 (5901804), 2585 (5901271), 2555 (5901239), 2547 (5901227), 2463 (5901028), 2332 (5900632), 2331 (5900631), 2138 (5900206), 2137 (5900205), 2042 (5900109), 2039 (5900106), can be found at: http://sio-argo.ucsd.edu/historical.html

*=active

The data from the NZ floats are administered by Scripps Institution of Oceanography and are available on the Argo Global Data Assembly Centers (GDACS).

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

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

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

An R/V Kaharoa deployment voyage from New Zealand to South America is planned for December 2019.

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

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

National report of Norway (2018)

Kjell Arne Mork, Institute of Marine Research, Norway (07.03.2019)

1. The status of implementation

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

Floats deployed and their performance
In 2018, Norway deployed 5 core Argo floats (1 APEX, 4 Arvor). The deployment locations and drift are shown in Fig. 1. All floats have so far performed well. One of the floats (Arvor), deployed June 2018 in the Arctic Ocean, north of Svalbard, came under the sea-ice from December 2018. The float includes an Ice Avoidance Algorithm.

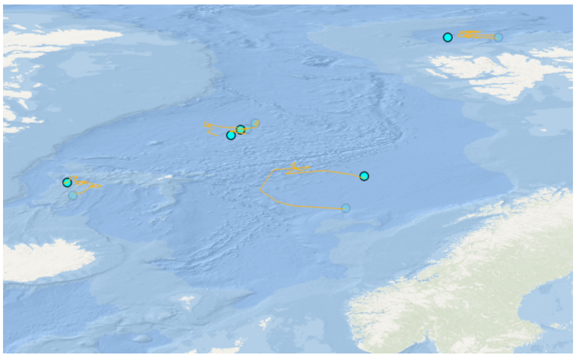


Figure 1. Locations of deployed Argo floats in 2018

Technical problems encountered and solved
So far, we have not had any technical problems with the floats deployed in 2018.

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

2. Present level of and future prospects for national funding

The funding has been a combination of self-financed (i.e. funded by Institute of Marine Research) and funding from the Norwegian Research Council (NRC, Ministry of Education and Research) during 2012-2015.
For 2018-2023 we have received funding from the NRC for an extension of the national Argo infrastructure project. Within this project we will purchase and deploy approximately 13 floats per year including core, bio, bgc and deep floats. The infrastructure will have approximately 36 person months per year.

3. Summary of deployment plans

<u>In 2019</u>, mainly in May/June, we plan to deploy 13 floats including: 3 BGC-floats (PROVOR), 4 Bio-floats (all BGC-sensors except nitrate and pH sensors, APEX), 3 Deep-floats (Arvor), and 4 core floats (Arvor). Primary, these floats will be deployed in the Nordic Seas, but also one float in each of the Arctic Ocean and Barents Sea. Figure 2 shows the planned deployments.

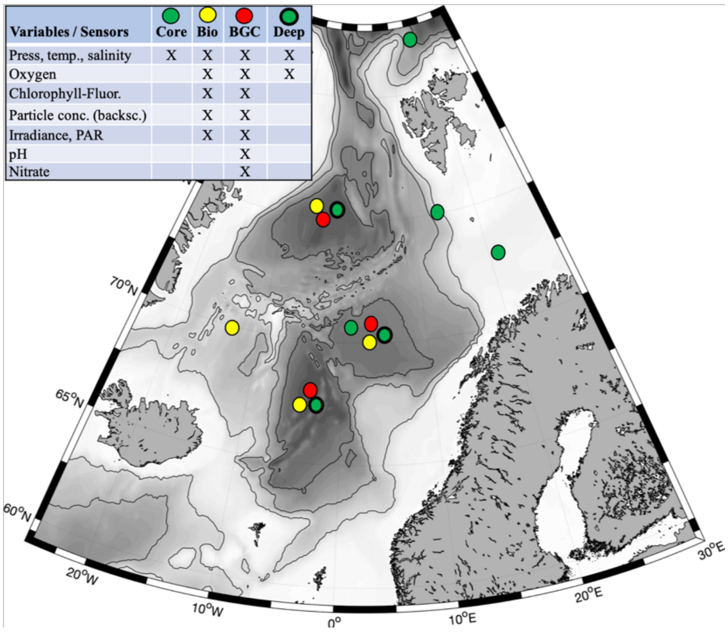


Figure 2. Planned Argo deployments for 2019.

<u>For the years 2020-2022</u> we plan to deploy about 13 floats each year, including 4-5 core, 3-4 bio, 2-3 bgc and 1-3 deep floats. The deployment areas will similar as in 2018 (see above).

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

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

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

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

Link to Argo Norway (NorArgo): http://www.norargo.no

5. Issues we wish to be considered and resolved

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

6. Improving the quality and quantity of CTD cruise data

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

7. The Argo bibliography

One publication that is not in the http://www.argo.ucsd.edu/Bibliography.html:

M. Femke de Jong,, H. Søiland, A.S. Bower, and H.H. Furey, 2018, The subsurface circulation of the Iceland Sea observed with RAFOS floats, Deep Sea Res. I, 141, 1–10.

Argo-Poland National Report 2018

Waldemar Walczowski, Małgorzata Merchel
IO PAN, Sopot, Poland, 01.03.2019 r.

1. *The status of implementation.*

In 2018 Poland deployed 5 floats from the board of *r/v Oceania*. Three Argo floats (WMO 3902102, 3902103, 3902105) were deployed in the Arctic (Nordic Seas) at the end of June 2018 (Fig.1). All instruments are the ARVOR floats with Iridium transmission system. The parking depth was set at 200 dbars (WMO 3902105) and 1000 dbars (WMO 3902102, 3902103). The profiling depth was set at 2000 dbars in all floats. They all have cycles of 10 days. Every float was operated for the whole of 2018 and has sent 20 complete sets of hydrographic data by the end of the year.

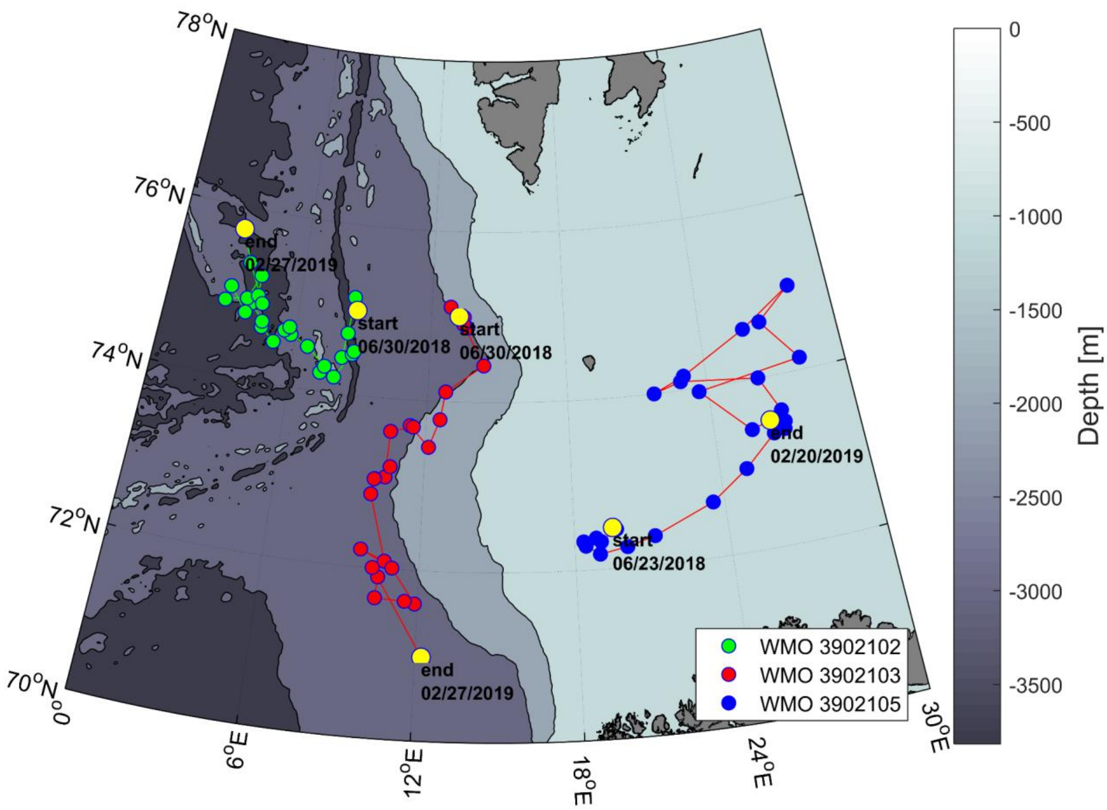


Fig. 1. Positions deployment and trajectories of three Argo floats deployed in the Nordic Seas by Argo Poland program in June 2018.

Two Argo floats were deployed in the Baltic Sea (WMO 3902101 – 06/02/2018, WMO 3902104 – 31/05/2018) (Figs. 2, 3). One Baltic float (WMO 3902104) (Fig. 4) was recovered and redeployed in September 2018 (with new WMO 3902106). All instruments are the ARVOR floats with Iridium transmission system. The parking depth was set at 100 dbars (WMO 3902101), 80 dbars (WMO 3902104) and 80 dbars (WMO 3902106). The profiling depth was set at 200 dbars in all floats. They all have cycles of 2 days. In 2018 the floats sent 168 – WMO 3902101, 85 – WMO 3902104 and 52 – WMO 3902106 complete data sets, respectively.

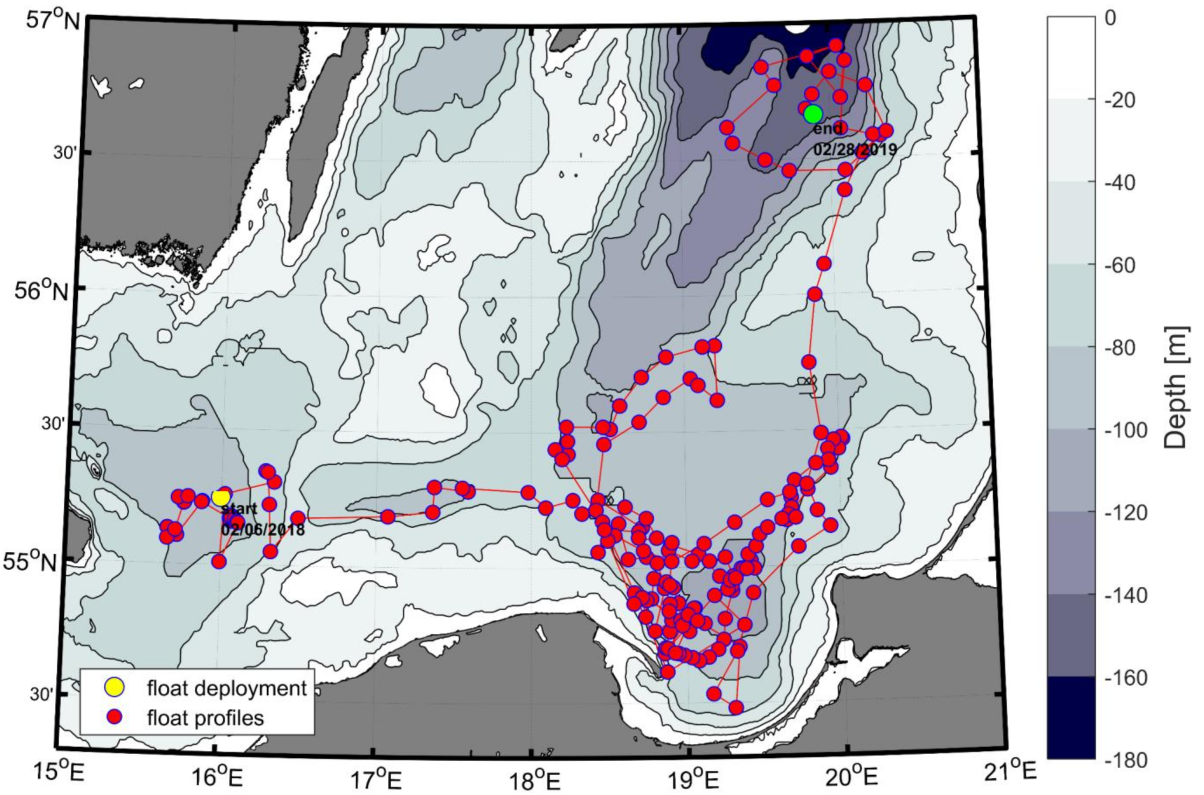


Figure 2. Surface position of Argo float deployed in the Baltic Sea in February 2018.

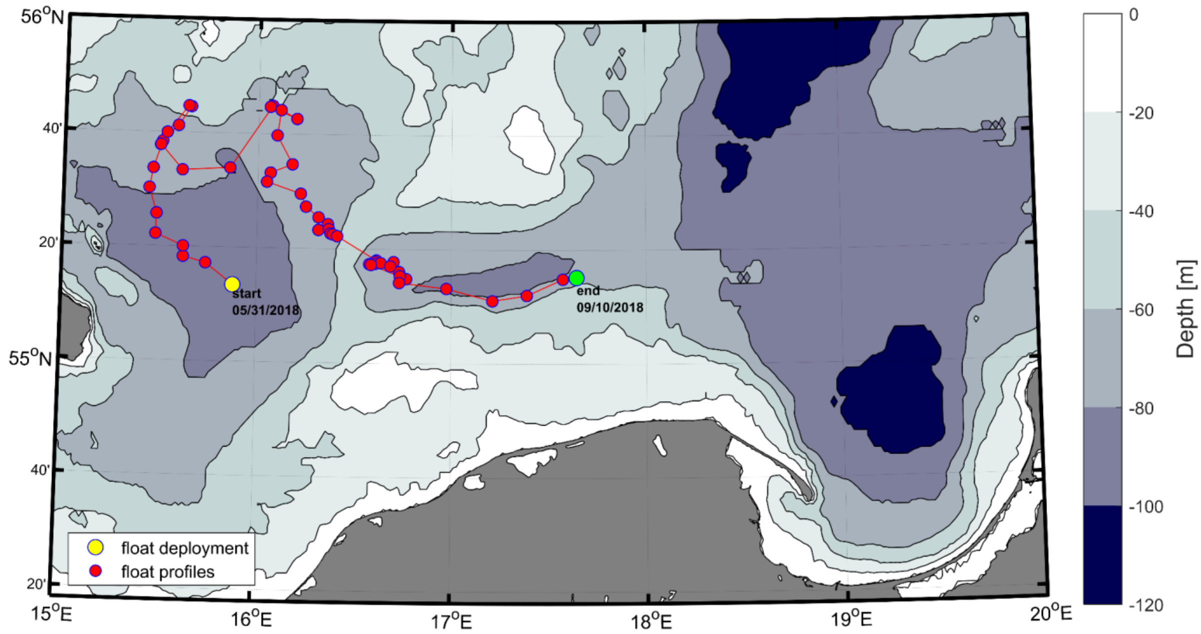


Figure 3. Surface position of Argo float deployed in the Baltic Sea in May 2018.

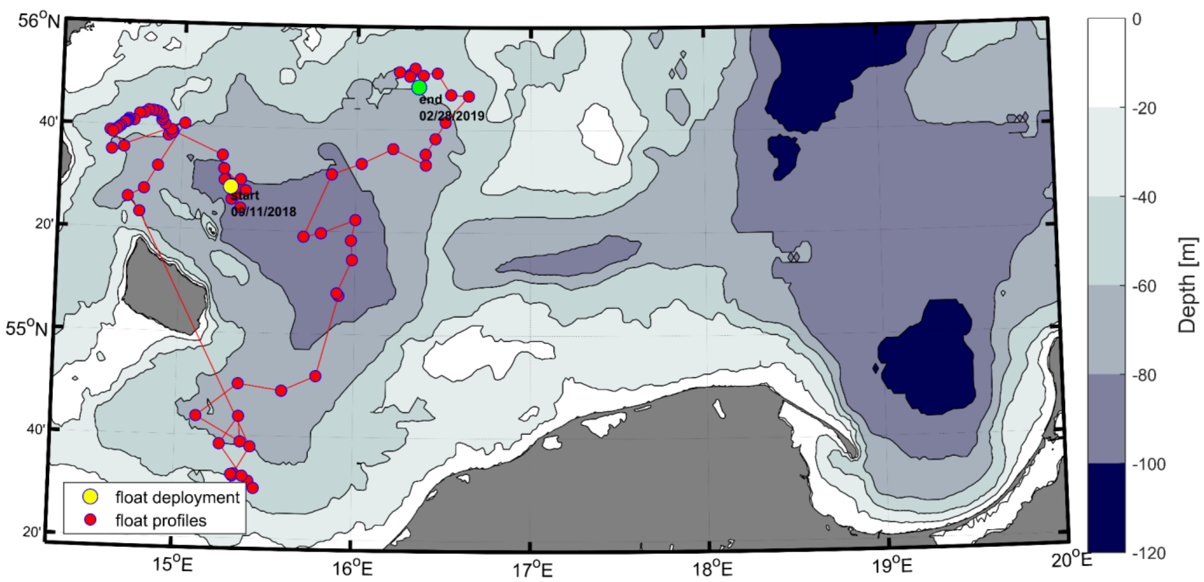


Figure 4. Surface position of Argo float redeployed in the Baltic Sea in September 2018.

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

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

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

This level of funding is guaranteed until 2020.

3. Summary of deployment plans.

Poland is going to continue deployment of 2 floats in the Nordic Seas region during the yearly expedition of R/V Oceania, AREX. Additionally, we are going to deploy 1 Argo float at the Baltic Sea in 2019 and 2020. In 2019 we plan the deployment of the BGC float at the Baltic Sea.

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

The Argo data were used in the Ilona Goszczko PhD dissertation (Water mass transformation in the region influenced by the West Spitsbergen Current) defended in 2018. Data from the Arctic are also used in the dissertation written by PhD student Malgorzata Merchel. The Baltic Argo data are used (together with the synoptic data from *r/v Oceania* cruises) for investigating the North Sea water inflows to the Baltic Sea and transports of this water mass in the Southern Baltic. After 2 years of using floats at the Baltic Sea, Argo data is an important source of information about the deep-water dynamics. Significant part is dissolved oxygen data - two floats are equipped with oxygen sensors. The paper about oxygen conditions at the Baltic sea utilizing Argo data has been submitted. Both, Arctic data and Baltic Sea data are provided to Ifremer Argo Data Center.

Baltic Argo data are also provided to the SatBaltic system:

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

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

The Argo Poland webpage:

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

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

We have no suggestion at the moment.

6. CTD data

In 2018 three Polish floats were deployed during IOPAN Arctic cruise AREX, when 160 CTD profiles have been done. Two floats were launched in the Baltic Sea, and one Baltic float was recovered and redeployed (with new WMO number) during the Baltic cruises. The CTD stations were also performed just before the floats deployment. IOPAN can provide the data from this six stations to compare it with Argo floats.

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

7. The Argo bibliography

There is PhD thesis using the Argo data in progress.

We also submitted two research articles:

1. Rak D., Walczowski W., Dzierzbicka-Glowacka L, Shchuka S., Dissolved oxygen variability (2013-2018) in the Southern Baltic Sea and its impact on the Baltic cod, Continental Shelf Research, 2019.

Argo National Report – South Africa

Report to Argo Steering Team Meeting: March 2019

Compiled by: Tamaryn Morris – Marine Unit, South African Weather Service

For any queries or deployment requests, please email tamaryn.morris@weathersa.co.za

The South African Argo Program presently is one of deployment opportunities and educational outreach as opposed to procuring of floats and seeding the global Argo array. However, we are striving to develop projects and funding opportunities in that direction. Given South Africa's unique position geographically of bordering three oceans – The Atlantic, Indian and Southern Oceans – we are able to provide numerous deployment opportunities for Argo floats to the global array. We are also working on dynamic research programs and experiments using Argo floats to a) study physical forcing dynamics and b) contribute to the development of biogeochemical floats particularly in the Southern Ocean. The research groups currently involved in the South African Argo program are: The South African Weather Services (SAWS) – who are the National Focal Point, University of Cape Town (UCT), the Department of Environmental Affairs (DEA), The Council for Scientific and Industrial Research (CSIR), The South African Environmental Observation Network (SAEON), and the Nansen-Tutu Centre for Marine Environmental Research.

1. **Status of implementation (major achievements and problems in 2018):**

Floats deployed and their performance (on behalf of UK MetOffice)

Indian Ocean:

IIOE-2 Cruise (RV SA *Agulhas II*) – June 2018

2 x floats deployed on behalf of UK MetOffice within the Mozambique Channel

(sn: 8463,8464)

Atlantic Ocean:

Gough Island supply cruise (RV SA *Agulhas II*) – September 2018

2 x floats deployed on behalf of UK MetOffice along the Gough Island supply cruise transect

(sn: 8467,8468)

Technical issues encountered and solved:

None at this stage.

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

None

Status of delayed mode quality control processes:

Not applicable

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

   Individuals from organisations (listed above) work on different projects involving Argo floats and have come together under the auspices of the South African Argo program to share knowledge, resources, cruise time where applicable and information regarding Argo. We are working towards taking this forward now.

   We have one Argo representative (T. Morris, SAWS) for the South African Marine Science community who is also looking to drive the Argo float procurements and data management plans in future endevours.

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

   Southern Ocean:

   Marion Island Cruise (RV SA *Agulhas II*) – April/May 2019.

   This cruise follows the CrossRoads Transect on Figure 1.

   Six floats from WHOI and four from UK MetOffice will be sent for this cruise.

   SCALE Winter Cruise (RV SA *Agulhas II*) – July / August 2019

   This cruise follows the GoodHope Transect on Figure 1 to the Marginal Sea Ice Zone.

   available for Argo float deployments

   SCALE Spring Cruise (RV SA *Agulhas II*) – ~ November 2019

   This cruise follows the GoodHope Transect on Figure 1 to the Marginal Sea Ice Zone (if possible).

   available for Argo float deployments

   SANAE Cruise (RV SA *Agulhas II*) – December 2019 / January 2020.

   This cruise follows the GoodHope Transect on Figure 1.

   available for Argo float deployments

   Indian Ocean:

   SEAmester Training Cruise (SA Agulhas II) – July 2019.

   The cruise will undertake CTD stations along the ASCA transect. Refer to Figure 1 for positions.

   available for Argo float deployments

   International Indian Ocean Expedition (IIOE-2) Expeditions

   Cruises are being developed for both the eastern and western Indian Ocean and these can be communicated for interested countries wanting to deploy Argo floats into the Indian Ocean. Currently, the Department of Environmental Affairs is looking to do additional cruises this year and next in to the western Indian Ocean. Thus deployment opportunities may become available.

Atlantic Ocean:

Gough Island Cruise (RV SA *Agulhas II*) – September 2019.

This cruise follows the SAMBA Transect on Figure 1.

available for Argo float deployments

SAMBA Mooring Array (RV *Algoa*) – September / October 2019.

Refer to Figure 1 for positions. Note: The CPIES will need to be service on this cruise, so the vessel will sail to the 0 degree latitude.

available for Argo float deployments

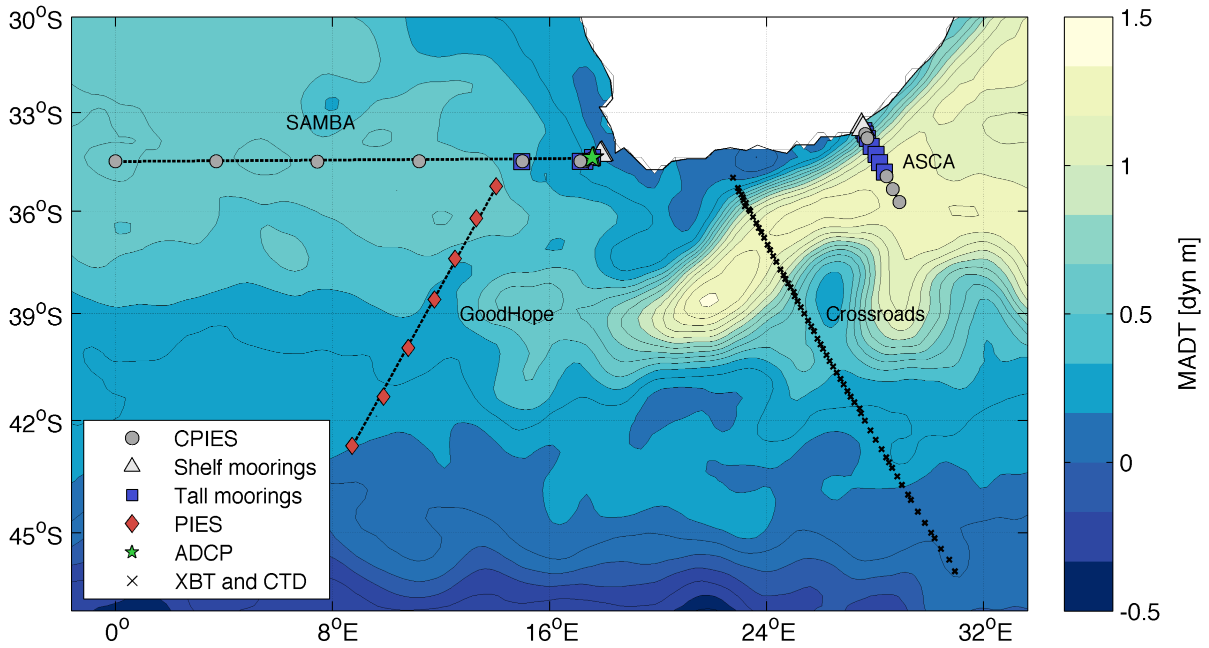


Figure 1: Large mooring array and CrossRoads transects around South Africa where floats could be deployed if available (Morris et al 2017).

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:**

   Projects and initiatives reported on in the AST report for South Africa from 2017 are ongoing. Publications stemming from some of the work are listed 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 at this stage.

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

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

Twelve cruises with CTD casts deeper than 2000 m have been loaded on to the CCHDO. These cruises are from the Indian, Atlantic and Southern Oceans:

SA Agulhas II Cruises:

1.	AGU019	Marion Island Cruise	April 2016
2.	AGU020	ASCA SEAmester Cruise	July 2016
3.	AGU024	Marion Island Cruise	April 2017
4.	AGU025	Winter Cruise (Southern Ocean)	June 2017
5.	AGU026	SAMBA SEAmester Cruise	July 2017
6.	AGU027	Gough Island Cruise	September 2017
7.	AGU030	Marion Island Cruise	April 2018
8.	AGU032	IIOE-2 (Mozambique Channel)	June 2018
9.	AGU033	ASCA SEAmester Cruise	July 2018

Algoa Cruises:

1.	ALG237	SAMBA Cruise	April 2017
2.	ALG241	Transkei Winter Cruise	July 2017
3.	ALG253	SAMBA Cruise	October 2018

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

Dilmahamod AF, Aguiar-Gonzalez B, Penven P, Reason CJC, De Ruijter WPM, Malan N, Hermes JC. 2018. SIDDIES corridor: A major east-west pathway of long-lived surface and subsurface eddies crossing the subtropical south Indian Ocean. Journal of Geophysical Research: Oceans, 123, https://doi.org/10.1029/2018JC013828

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

8. **As discussed at the AST-18, I'm making an additional request to help Argo scientists who are asked to give talks or do outreach programs. This action item asks for each National Program to submit a slide with figures and text describing their favorite Argo discovery paper. I will collect these slides and make them available to AST members. The idea is that when an AST member is asked to give a talk on Argo, they could choose from a collection of slides describing key Argo discovery papers. Please consider contributing a slide to this collection.**

   Not yet for South Africa. Will work on this and submit shortly.

UK ARGO PROGRAMME

REPORT FOR 20TH ARGO STEERING TEAM MEETING, MARCH 2019

1. Status of Implementation

Floats deployed and operating

During the last year (2018) 34 floats were deployed: this includes 24 core (temperature and salinity only), 4 oxygen, 2 bio-geochemical (BGC) and 4 deep floats. These were deployed in the North and South Atlantic, western Indian and Southern oceans. As at the time of writing we have 146 operational floats (i.e. for which real-time data are presently being distributed), as shown in Figure 1.

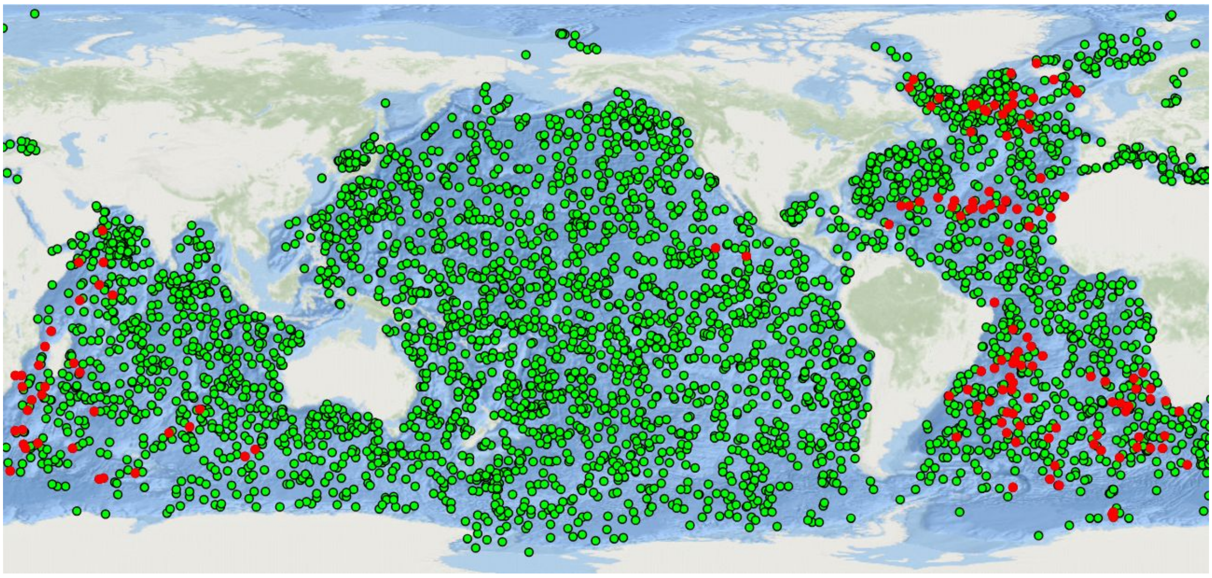


Figure 1. Showing the locations of reporting UK floats (in red) with the global network (in green), as at 14th February 2019.

Data processing

At present BODC are processing data from those 146 UK floats, 11 Irish floats and 74 Euro-Argo MOCCA floats. From 5th June 2018, all BUFR messages distributed on the WMO Global Telecommunications System (GTS) have been generated by the Met Office from the real-time netcdf files produced by BODC. In 2019 it is planned to include the capability for oxygen profiles into the BUFR files generated by the Met Office.

As of 19th February 2019 there were 40,722 real-time profiles and 31,921 delayed-mode profiles from core (standard CTD-only) UK floats available on the Coriolis GDAC, for the delayed-mode this represents 50% of the eligible profiles (i.e. all profiles from expired floats and profiles over one-year old from active floats).

However, at present there remains a significant number of floats deployed over the last three years for which the data are not yet being processed.

Deployed in 2016

- 2 Deep Arvor (both failed)
- 3 Apex RBR (1 failed on deployment)
- 4 Apex STS (1 failed)
- 3 Navis N1 with radiometer
- 2 Navis N1 (1 failed on deployment)
- 3 Apex Deep (all subsequently recovered)

Deployed in 2017

- 6 Navis N1 with oxygen
- 2 Apex RBR (both failed)
- 6 Apex with O2 & pH
- 4 Apex Deep with O2 (2 have failed)

Deployed in 2018

- 2 Navis N1 O2
- 2 Apex with O2
- 6 core Apex (APF11a)
- 4 Apex Deep
- 2 Navis N2 BGCi (1 has problems)

Despite the best efforts of BODC, little progress on handling these float types was made in 2018 and the backlog of floats needing to be processed has increased. As such, the highest priority for the coming year must be to ensure that the real-time data (even if only temperature and salinity) are processed and delivered to the GTS and GDACs from all the above float types apart from the Apex Deep.

Technical problems encountered and solved

Apex Deep. In December 2015 two Apex Deep floats were deployed in the North Atlantic. These performed 50 profiles and 127 profiles, lasting until June 2016 and April 2017 respectively. Three Apex Deep with O2, deployed and recovered during December 2016 after leaking, were shipped back to Teledyne Webb alongside one other for investigation and repair. Four other Apex Deep with oxygen were deployed in the Drake Passage during December 2017, of these one never transmitted, one transmitted one cycle, then went to sleep for 6 months and then reappeared. It is now cycling normally on a 3-day cycle. The other two are cycling normally on 3-day cycles, but one has been producing noisy salinity data since cycle 3. Three Apex Deep were deployed in the Atlantic in Nov 2018. One leaked on cycle 1 and is now drifting on the surface. The other two are cycling normally on 3-day cycles and are producing good data. The data from the working Apex Deep have allowed some evaluation of the SBE61 CTD.

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

Bio-geochemical floats. We have deployed Apex, Navis and Provor biogeochemical floats with a mix of radiometers, fluorometers, backscattering meters, pH sensors, Aanderaa and SeaBird oxygen sensors. We have seen creep on SBE ODO sensors when deployed on long-term moorings and kept at pressure. This has promoted further examination of ‘park’ oxygen data, and a similar effect can be seen in NAVIS floats parked at 1000m for 10 days. This will be further investigated. We have also deployed 6 Apex with O2 and pH sensors with the first batch of SBE pH sensors, and are examining the stability and performance.One of the two Navis BGCi floats deployed in December 2018 has exhibited problems (unable to go into continuous profiling mode due to the SBE41 being unresponsive). Currently, the root cause of this issue is unknown.

2. Funding and human resources

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

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

NERC funding is primarily directed through NOC (which includes BODC) through its National Capability (NC) funding line. NOC is expected to become independent from NERC in 2019 subject to Ministerial approval. Post-independence, NOC will continue to be eligible to receive NC funds from NERC. Its NC funding, which is expected to remain level in cash terms for a few years, covers Argo data management at BODC and Argo science at NOC. In addition, it is expected that up to ten floats per year for the Argo extensions (deep and bio-geochemical) could be provided through bids to NERC for funding.

3. Summary of deployment plans

At the time of writing we have 54 core Apex floats available for deployment. Over the coming year it is expected that UK Argo will deploy 25 core floats (North and South Atlantic, Southern Ocean and Indian Ocean) and two bio-geochemical floats. Full deployment plans have not yet been prepared, but the following deployments are tentatively anticipated.

1 Apex (Iridium), 1 Apex-RBR: North Atlantic Gyre (AMT-29 Oct 2019)
2 Apex: Subtropical South Atlantic (AMT-29 Oct 2019)
4 Apex: South Atlantic (Argentine Basin) (AMT-29 Oct 2019)
4 Apex: Drake Passage (DY113 Feb 2020)
2 Apex (Iridium): West Antarctic Peninsula
4 Apex: South Indian Ocean (SA Agulhas II April/May 2019 - these four floats have still be located)
4 Apex: South-east Atlantic/Southern Ocean (SA Agulhas II Sept/Oct/Nov 2019)

The above is not a complete list and other deployment opportunities, primarily in the western Indian Ocean will be investigated.

We will also shortly take delivery of two Navis BGCi floats for which deployment will be arranged once the continuous profiling mode problem has been corrected.

At this stage we have six Deep APEX floats under refurbishment/repair at TWR. These will be deployed in the North and South Atlantic in late 2019/early 2020 depending on deployment opportunities as the floats become available.

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 the seasonal dynamics of the biological carbon pump;
- 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;
- investigating particle dynamics in oxygen minimum zones.

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.

U.S. Argo National Report to AST-20, March 2019

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, deployment, array monitoring, and data system functions are distributed among these institutions on a collaborative basis.

In addition to U.S. Argo floats, Argo-equivalent floats have been provided from a number of U.S. float groups, programs, and principal investigators. A notable U.S. Argo-equivalent program is Southern Ocean Carbon and Climate Observations and Modeling (SOCCOM). See "BGC Argo" below. The contributions of all Argo-equivalent partners are gratefully acknowledged.

The present 5-year cycle of U.S. Argo implementation began in July 2015, and extends through June 2020. A new 5-year cycle of U.S. Argo, to begin in July 2020, is presently being planned, and will include milestones and growth of the U.S. contribution toward a unified Core/BGC/Deep Argo Program (Argo 2020).

Objectives:

During the present 5-year cycle, U.S. Argo will sustain its contribution of half of the Core Argo array, while enhancing coverage on a regional basis (high latitudes, western boundary and equatorial regions, marginal seas) as recommended through sustained ocean observing system community activities and endorsed by the AST. These coverage enhancements will only be implemented if sufficient resources are available to maintain the original Argo coverage and the data quality of the Argo array. Further improvements in data quality, timeliness, and resolution are planned, along with ongoing extensions to float lifetimes and cost-effectiveness.

A major enhancement to Argo is the implementation of Deep Argo to extend sampling to the ocean bottom (to pressures as high as 6000 dbar). As a key component of the Deep Ocean Observing Strategy (DOOS), Deep Argo is needed to close regional and global budgets of heat, freshwater, and steric sea level, and for exploration of deep ocean circulation. Deployment of several regional Deep Argo pilot arrays is being undertaken to test floats and sensors, to aid in global array design, and to demonstrate the capability to deploy on a regional basis. U.S. Deep Argo deployments are integrated with planned contributions of international partners.

Status of implementation:

The support level for U.S. Argo is determined on a year-to-year basis. 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.

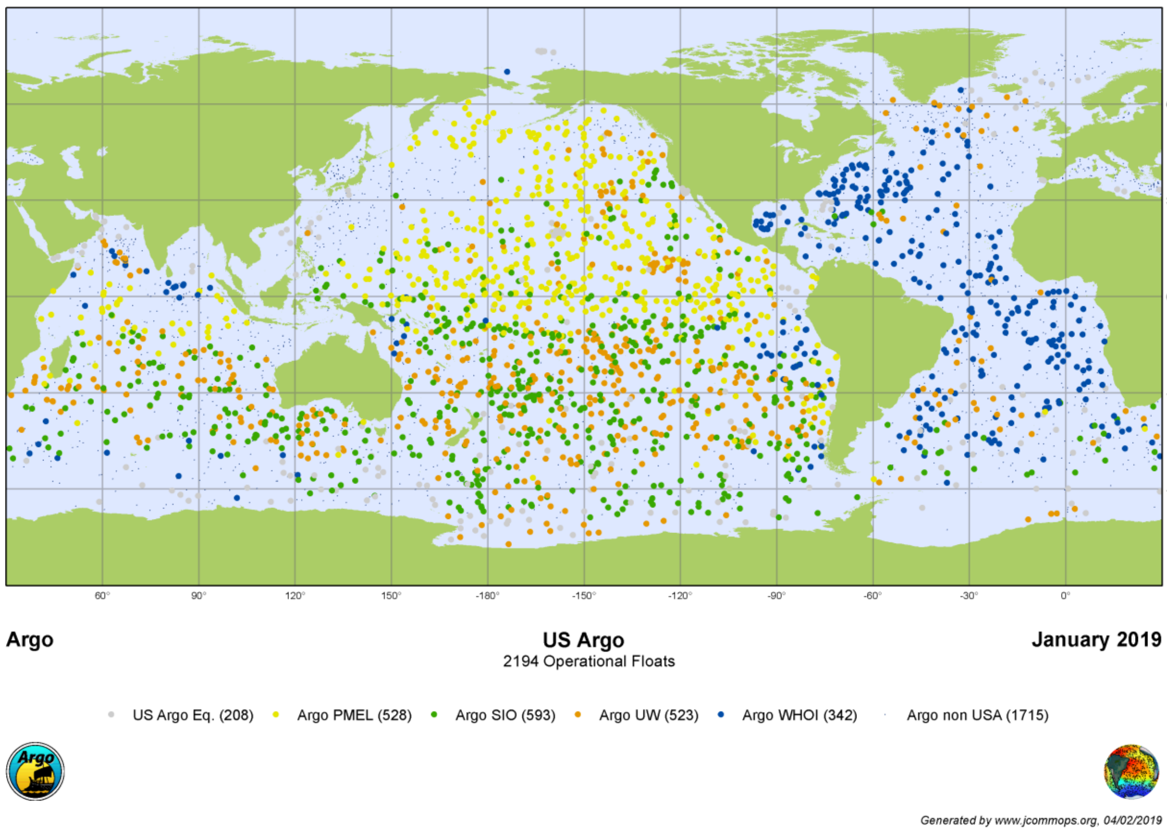


***Fig. 1**: Location of 2194 operational U.S. Argo Program and U.S. Argo Equivalent floats as of January 2019. (Source: AIC)*

There are presently 1986 operational U.S. Argo Program floats (Fig. 1) as of January 2019. A timeline of the number of operational U.S. Argo Program floats is shown in Fig. 2. Table 1 indicates the number of U.S. Argo Program floats deployed and operational for each year since 2012 (Source: AIC).

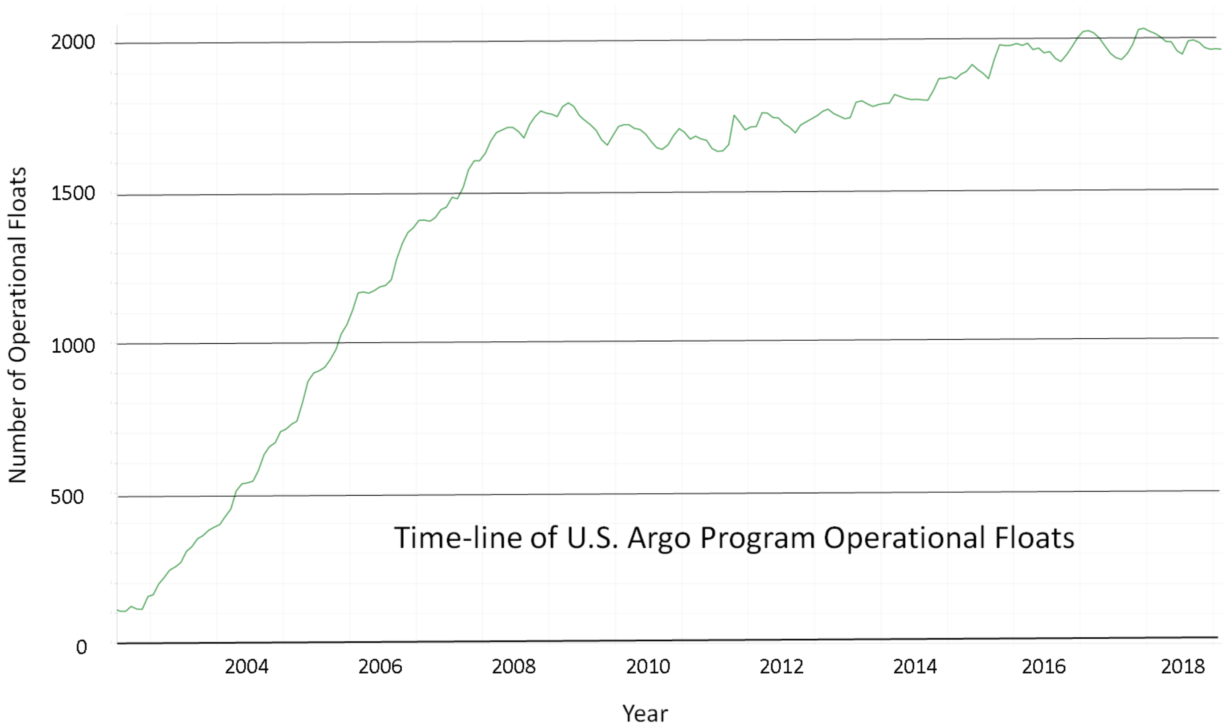


Fig. 2: *History of the number of operational U.S. Argo Program floats (Source: AIC)*

Table 1: Number of U.S. Argo Program floats deployed in each year since 2012 and the number still active as of 2/2019. A major focus of U.S. Argo is extension of float lifetimes and reduction of early float failures. (Source: AIC)

Year deployed	Number deployed	Number active	% active (2/2019)
2012	341	92	27%
2013	329	167	51%
2014	376	276	73%
2015	346	276	80%
2016	346	326	94%
2017	362	344	95%
2018	259	251	97%

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, and participation in international Argo coordination, Regional Centers, and outreach activities.

Work is also being done to bound and check errors in CTD data used for the core Argo mission. Both SBE41CP and RBR ArgoCTDs were taken to sea in November 2018 with data collected in parallel to the ship-board system. The analysis of these data is underway, and results will be presented at the ADMT-20.

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 - 2017, in the South Australian Basin in late 2016, in the Australian Antarctic Basin in early 2018, and in the western North Atlantic in early 2017 (Fig. 3). A three year collaboration between PMEL and Paul G. Allen Philanthropies has provided resources to procure, test, and deploy a regional Deep Argo pilot array of up to 30 Deep SOLO floats in the western South Atlantic.

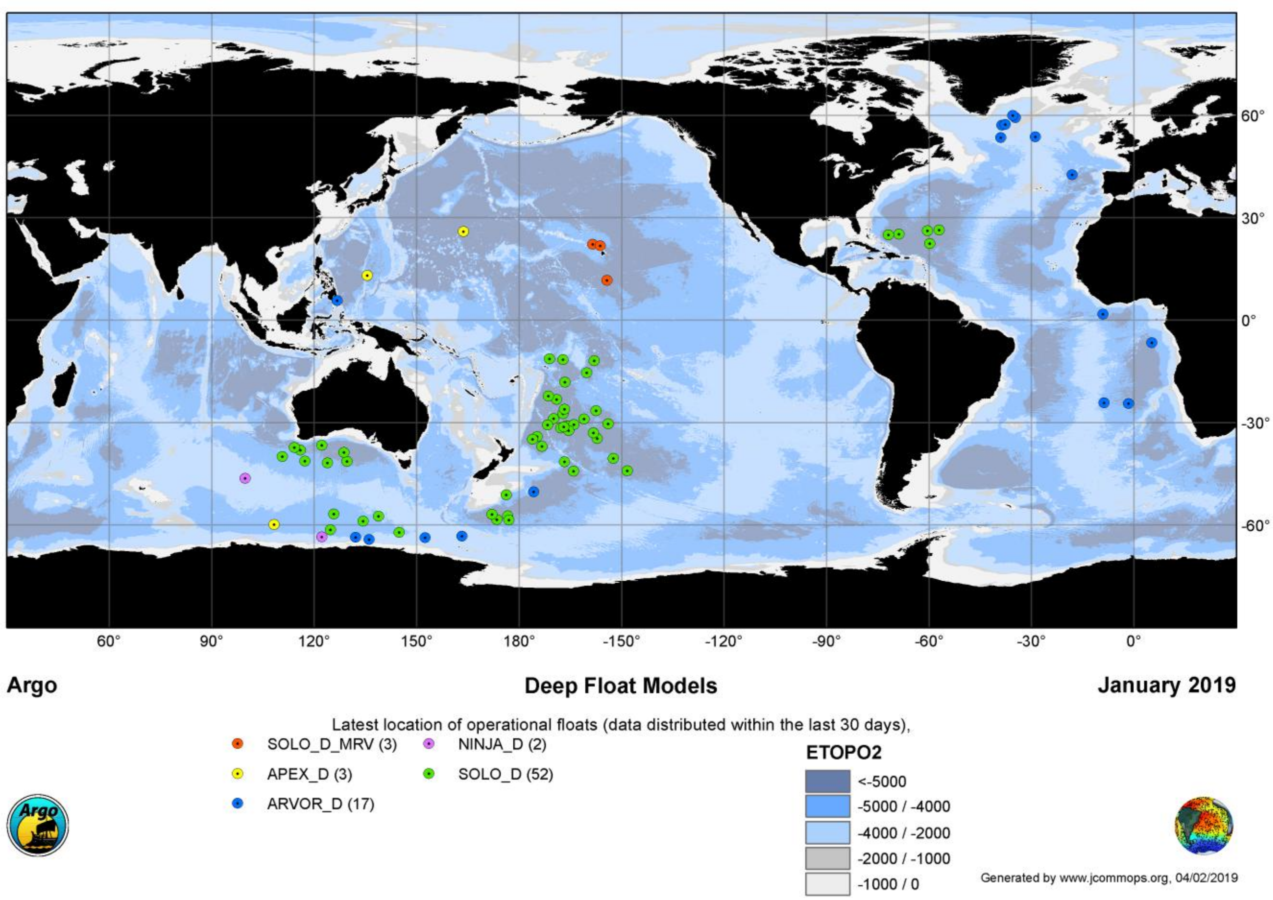
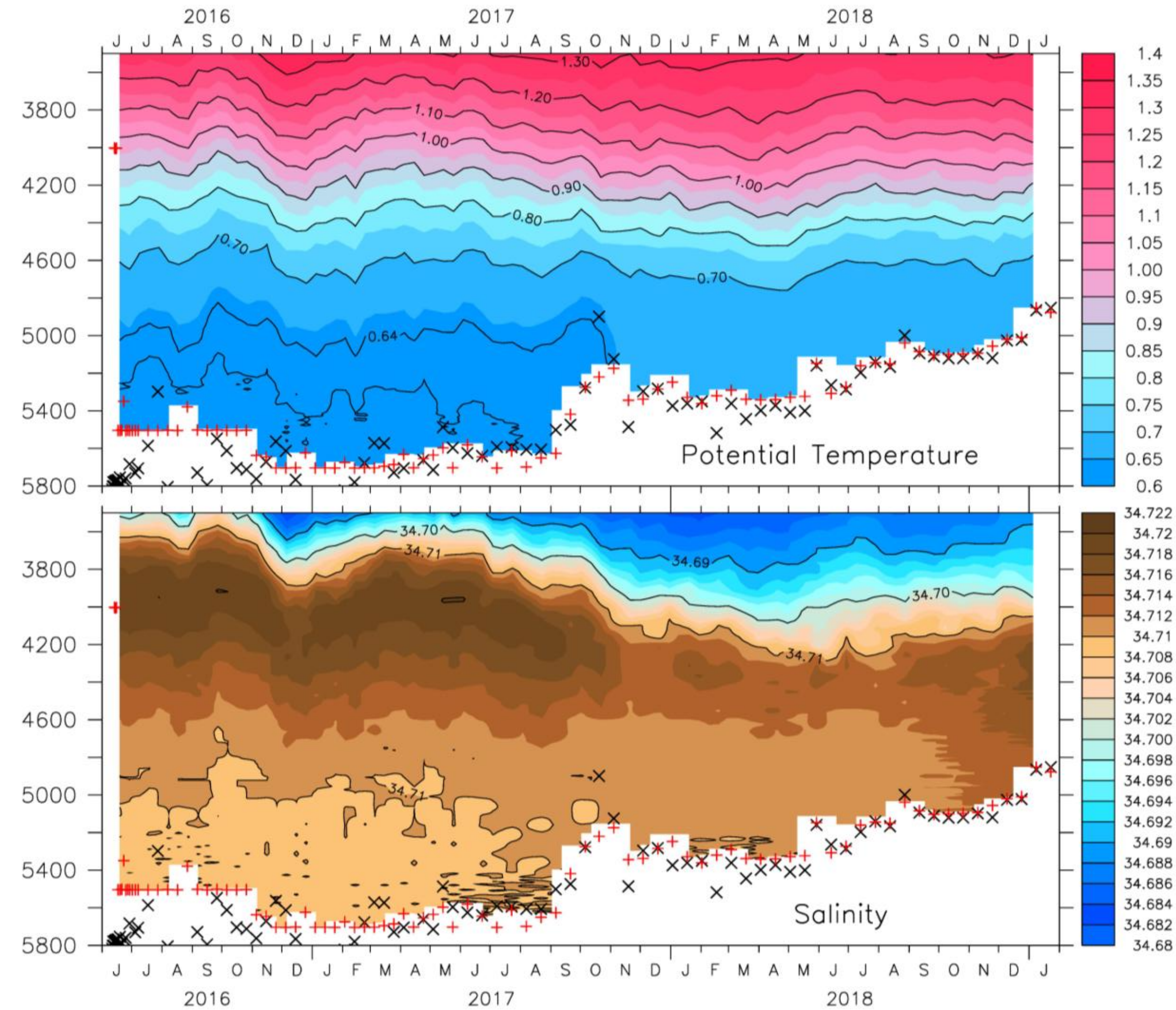


Fig. 3*: Location of all Deep Argo regional pilot array floats. U.S. 6000 dbar floats include 52 Deep SOLOs (Argo Program) in the Southwest Pacific Basin, South Australian Basin, Australian Antarctic Basin, and western North Atlantic, as well as 3 MRV Deep SOLOs near Hawaii.*

Testing of deep float models continues as well as testing of SBE-61 CTD accuracy and stability. The SBE-61 has not yet achieved it aspirational goals of (± .001C, ±.002 psu, and ± 3 dbar) but is progressing relative to those goals. A 3-year National Ocean Partnership Program award is funded for improvement of the SBE-61. An example of potential temperature and salinity data along the path of a single Deep Argo float is shown in Fig. 4



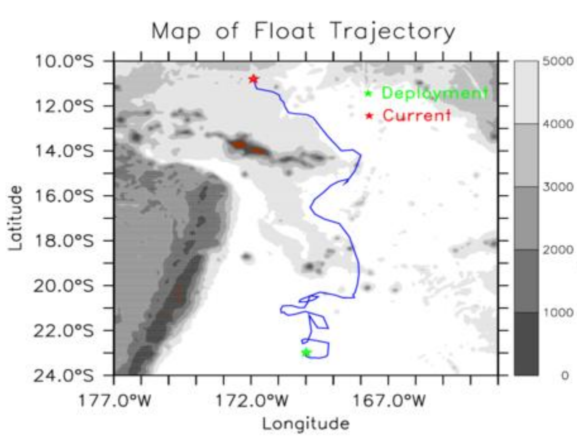


Fig. 4 *(Above) Potential temperature and salinity along the path (left) of Deep Argo float WMO ID 5902457, January 2016 to January 2019. As the float drifted northward from the Southwest Pacific Basin to the Samoa Basin, the increasing temperature of the abyssal layer and the decay of the North Atlantic Deep Water salinity maximum are clearly seen. The float's parking* pressure was 5000 dbar. The estimated bottom pressure from published bathymetry (x) and deepest pressure from the float (+) are shown.*

BGC Argo:

Since 2012 the US has carried out testing and deployment of Biogeochemical (BGC) Argo floats. The present versions of these floats cycle 0-2000 m at 10-day intervals and, in addition to the CTD, carry sensors for dissolved oxygen, nitrate, pH, chlorophyll fluorescence, and particulate backscatter. The SOCCOM BGC float array in the Southern Ocean now contains 125 operational BGC floats, pointing towards a goal of 200 floats by the end of 2021 (see Figure 5). The floats are performing well with lifetimes roughly comparable to core-Argo floats. There is now an active planning effort to expand the SOCCOM array into a global BGC-Argo array that might consist of up to 1000 BGC floats. Initial BGC-Argo expansion might proceed into the North Atlantic and Equatorial Pacific. Potential funding sources are being identified.

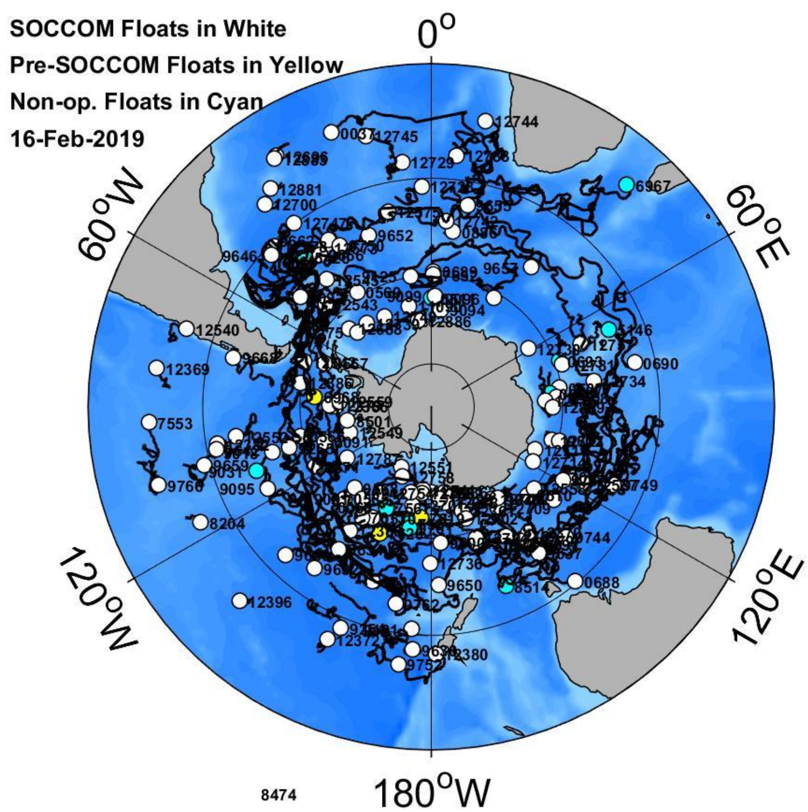


Fig. 5 *Locations of 125 BGC-Argo floats deployed as part of the SOCCOM program in the Southern Ocean.*

Plans:

The highest priority for U.S. Argo is to sustain the Core Argo array. Specific plans for float deployments in 2019, as they evolve, are posted on the AIC deployment planning links. A major U.S./New Zealand/Australia Argo deployment cruise from New Zealand to Tahiti and back on RV Kaharoa was carried out in mid-2018. This voyage deployed 96 Core Argo floats in the South Pacific Ocean plus 10 Deep Argo floats in the SW Pacific Basin, enlarging the regional pilot array there (Fig. 3). In addition, 2 Deep Argo floats with rapidly drifting salinity were recovered by Kaharoa. The CTDs were replaced onboard and the floats were re-deployed. A deployment cruise on RV Kaharoa, from New Zealand to Valparaiso, is planned in December 2019 to deploy 10 Deep Argo floats in the SW Pacific Basin, plus 94 additional Core Argo floats in the South Pacific. Over 1800 Argo floats have been deployed by RV Kaharoa since 2004 (Fig. 6).

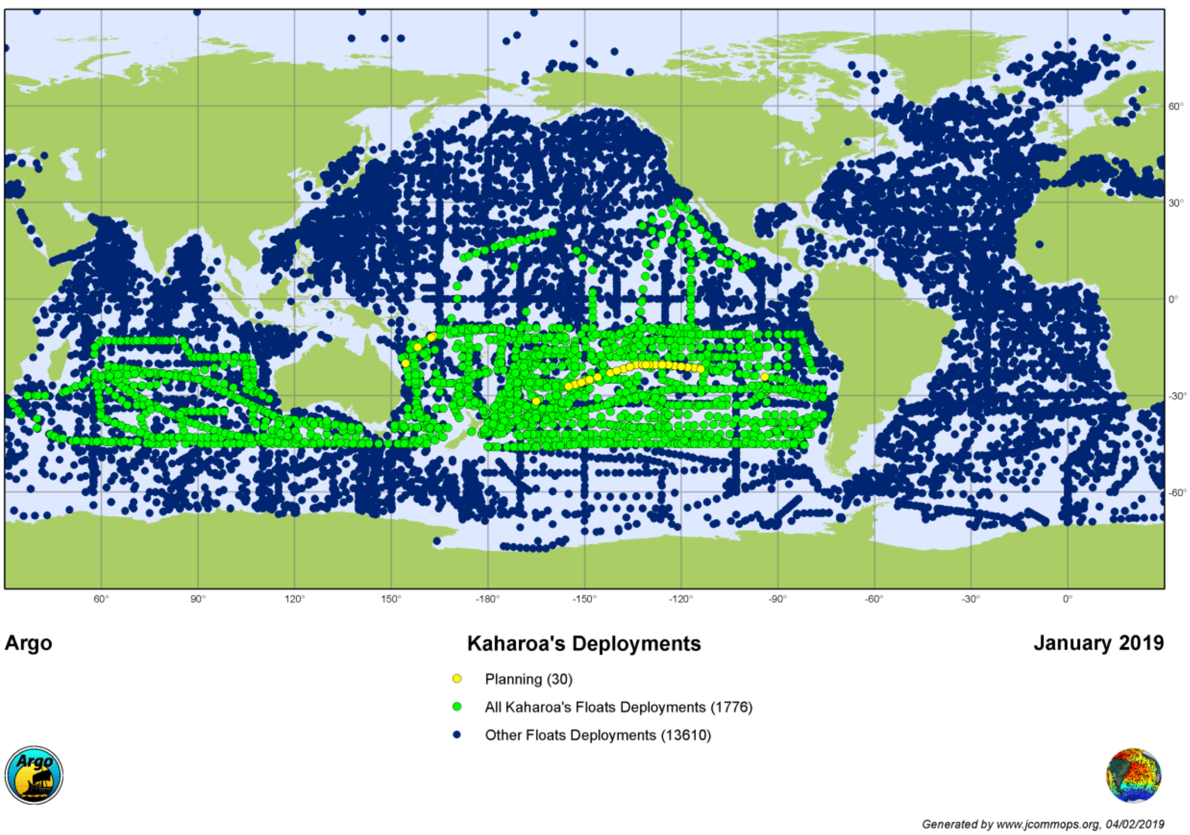


Fig. 6: *Locations of over 1800 Argo floats deployed by RV Kaharoa since 2004 (Green and yellow symbols). Deployment voyages are supported by U.S., New Zealand, and Australia Argo Programs. Argo could not have achieved and cannot sustain global coverage without dedicated deployment voyages in the South Pacific and South Indian Ocean. (Source: AIC)*

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

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