18th meeting of the International Argo Steering Team

Hobart, Tasmania
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Meeting Summary

1. Welcome and Introduction

S. Wijffels welcomed everyone to CSIRO in Hobart. She thanked E. van Wijk for helping organize the meeting and introduced her Australian Argo colleagues including Peter Oke and Rebecca Cowley in addition to Esmee.

Action item 1: Write letter of thanks to local host CSIRO. D. Roemmich

2. Objectives of the meeting

D. Roemmich stated an objective of the meeting was to begin a discussion of Argo's long-term sustainability. The complete Argo array has been in place for a decade and it is important to keep it going for several more decades. Argo needs to focus on challenges that make it difficult to do so. He suggested that Argo consider actions to take in both the short term and the long term to ensure survivability of the Argo program. To that end, he prepared a first draft of a document on Argo's sustainability that he asked the AST to think about it in preparation for a discussion at the end of the meeting. Please see section 9 for the discussion and the path forward for this sustainability document towards a possible OceanObs'19 paper.

3. Action items from AST-17

M. Scanderberg reported on progress from action items from the previous AST meeting. Actions progressed well for the most part and there were updates for several during the meeting's Agenda. The main items that were still in progress, but not yet complete related to the AST website and additions for each Argo extension and adding ocean heat content variability plots. This will be discussed in section 9.2. The Argo data paper also keeps progressing and AST members were asked again to send an author list to S. Wijffels, J. Buck and M. Scanderberg for recognition. This author list is meant to be inclusive and should include PIs, real time and delayed mode data managers, etc. See section 4.8 for more details. Much work was done by M. Belbeoch to add an improved Commitments table to the JCOMMOPS website. See section 4.1 for details on that. There were several issues related to data management and reducing the strain on the ADMT and the complexity of the Argo data stream. See section 5 for more details.

4. Implementation issues

4.1. Update commitments table

M. Scanderberg presented the new JCOMMOPS online Commitments table. The table can be reached via the JCOMMOPS website (http://argo.jcommops.org/) and then click on 'Metrics' and then 'Commitments'. The table is similar to the previous excel spreadsheet maintained by M. Scanderberg in that it lists countries that have deployed floats in the past, but now a drop down menu at the top allows for the choice of different years and 'By Networks' or 'By Basins'. Instead of just Argo and Argo equivalent floats, countries are asked to estimate the number of Core Argo, Argo equivalent, BGC Argo and Deep Argo floats expected to be deployed that year. There is also a place to add comments. Usually, M. Scanderberg added a comment when a float might fit into more than one category – ie a BGC and Polar float or a BGC equivalent float. An Argo Equivalent float is defined as one that does not come through the traditional Argo National Programs. Often times these are research floats or used for increasing density, but sometimes they are part of core Argo or its extensions. The totals are tabulated for each country and for each column of the table. For 2017, the estimates are as follows: 798 for core Argo, 120 for Argo equivalent, 97 for BGC Argo and 29 for Deep Argo. Currently, only M. Scanderbeg and M. Belbeoch can modify this table, but if AST members are interested in making changes themselves, this is a possibility that can be explored.

In the discussion following the presentation of the new table and the oral commitments from each country, it became clear that Argo is interested in estimating how many core Argo floats are represented in the Argo equivalent column. In other words, it would be helpful to estimate how many core floats the Argo equivalent and even Argo extension floats are equal to. A small working group was established to consider this issue.

> **Action item 2:** Establish a working group to better describe how equivalent floats fit into global Argo. The AST would like to see the equivalent floats "converted" into 'core' Argo floats. M. Belbeoch, B. Owens

4.2. AIC report on the status of Argo

Read yearly report

Implementation
The Argo Technical Coordinator, M. Belbéoch, presented his yearly report on the Argo implementation status including 26 recommendations to optimize the array distribution.

After a review of the global array design, the AST agreed to decrease the target in the Arctic Ocean and increase it in the Southern Ocean. The AST also suggested communicating the Argo design enhancements (Argo 2020) while highlighting the fact that most of the proposed evolutions are not funded.

The TC presented a survey on 2012-2016 practices showing that the sum of national contributions, practices and priorities was providing a well-balanced array. He remarked also that i) Core Argo was under funded by 23% and ii) more cooperation was required in the Atlantic Ocean to avoid overlaps, in particular in the Northern part. He suggested organizing regular teleconferences to better coordinate basin implementation.

The TC presented a set of performance indicators implemented routinely which demonstrate that overall Argo is doing well with regard to activity (number of operating floats), intensity (number of units deployed every year) and coverage (spatial distribution). However he raised a warning with regard to the Pacific Ocean, which is lacking about 30% of deployments, and suggested an additional deployment of 100 units in 2017 (for a total of about 500 floats) to cover the anticipated gap, hidden for now by the good performance of floats. In particular, in the TPOS region, many floats are 10 years old and could stop operating at any moment. The intensity of deployment in the Southern Ocean would need to be doubled.

The TC demonstrated as well that the North Atlantic was routinely showing an excess of intensity and called for the concerned partners to contribute further outside the basin (Southern Ocean and Pacific Ocean e.g.), in particular in the context of a growing European contribution.

He proposed to develop routine performance indicators for the sub basin perspective to keep track of potential misbalances.

He showed that very good spatial coverage could be obtained either through higher intensity of deployments or use of dedicated ship time (charters). The latter seems more cost effective.

He concluded that Argo was doing well but remains fragile. Its core part is still underfunded. If the deployments dramatically slow down for a year due to industrial or technical issues, or any major budget cuts in national programmes, we have very little “reserve” to absorb the impact.

Instrumentation
The instruments’ reliability (see report) may offer some optimistic perspectives. Overall, the reliability of the main float models keeps improving. It is around 100-125 profiles where we see two groups of floats with diverging results (see table of performance in annex). The excellent performance of the SIO/WHOI/MRV floats deserved to be remarked. The mortality rate, for the global array, however increased in 2016 so it needs to be carefully monitored. It is to be noted that some float experts and power users, have excellent performances. The switch to Iridium is now clearly visible. In 2016, 80% of floats deployed use Iridium.

Design Enhancements
The TC provided the status of Marginal Seas, WBC and Equatorial (proposed) enhancements. WBC regions are all decreasing except the Gulf Stream and the East Australian current. The Kuroshio still has the best coverage and the AST agreed it was probably the only extension regularly funded.

For the last 5 years, we divided per two the number of floats deployed in the WBC. Equatorial enhancement is not implemented in the Atlantic, and is appropriate in the Indian and Pacific.

Implementation for the Caribbean Sea and Gulf of Mexico shows progress and the Med. Sea has very good activity, intensity and coverage. Many remaining marginal seas cannot be implemented without increased level of regional coordination.

> **Action item 3:** Revisit percentage targets for quality, timeliness and spatial completeness on the AIC website because 95% may be too high. M. Belbeoch, AST co-chairs, ADMT co-chairs

4.3. JCOMM Observing Program Support Centre

JCOMMOPS Lead, M. Belbéoch, presented the recent achievements and developments of the infrastructure. Core services such as monthly maps were operationalized, the Argo Information Centre website finalized, and hundreds of performance indicators set up.

He recalled that Argo investment through its staff, and also funding, was crucial for the development of the infrastructure. He congratulated A. Lizé (IT developments) and E. Rusciano (Administration, Science, Communication, PhD) for their excellent work. He mentioned as well that M. Kramp’s efforts in developing the Cruise Information Centre have shown substantial progress and that main R/V cruises plans for 2017/2018 were available on-line.

He made a demonstration of the website capacities at a side event which was appreciated by the AST, noting the potential of the toolbox developed.

4.4. AIC funding

In 2016, contributions were received in support of the Argo Information Centre from 9 countries, Argentina, Australia, China, France, Germany, India, Japan, UK and the USA. Thank you to all. Contributions in 2016 were unusually large because the Argo Director forgot to remind countries in 2015 and this led to a mad scramble at year end that was not very successful. The result was several double-up payments made in 2016, the 2015 and the 2016 contributions. Thank you to all countries that supply funds to support the AIC.

H. Freeland has not been able to get a formal financial statement from Albert Fischer's office, again, this year. The conclusion is that this was a strong year for contributions thanks to the double payments from the UK and France. Having the Argo Director proactively ask countries for their contributions is helpful.

Canada has been a long-term supporter of the AIC but missed in both 2015 and 2016. This has arisen because Blair is trying to establish a long-term, secure method of paying the annual contribution as well as increasing it by 50%. It seems all is in place now for this to start in 2017. Also in 2017, we already have a new contribution from Euro Argo: thank you. Italy has also promised a contribution this year. Looking at expectations for 2017, including Canada returning, and the new contributions, it appears that Argo will finally arrive at a long-held objective to get enough contributions from outside the USA to get the dominant US contribution down to 50% or less of the total. The estimate is either 46% or 48% for the US contribution, depending how one *quid pro quo* item is handled. In summary, while there is not a financial statement from the IOC or WMO, H. Freeland believes the AIC component of the JCOMMOPS Office is in good shape.

Finally, H. Freeland would like to thank the countries that have supported the Argo Director's travel fund in the last 12 months. Direct financial support from Australia, thank you, and direct support of the AD travel by Japan and the USA, thanks to both. It is estimated that the AD fund will have a balance of about US$8k at the end of AST-18.

4.5. Australian Argo

Susan Wijffels described the goals, origins and current status of the Argo Australia program. The facility goals are to:

- Contribute to the global Argo program by maintaining about 50% coverage in the oceans 'around Australia' ~ nominally 90E-180E, equator to the ice edge: **deploy about 50-60 "core" floats per year**

- Contribute to Argo's international coordination and data system

• Work nationally and internationally to ensure uptake of Argo data; liaise with national operational users to ensure Argo meets their requirements

Argo Australia's array is around 380 active floats and is sustained by about 50-60 deployments per year. The facility has been fairly successful via some key technical decisions including: adopting lithium batteries very early; compensating for our long and sometimes fraught shipping pathway, opening and inspecting nearly every float where possible; moving rapidly to all Iridium acquisitions (most cost effective option and gave a major improvement in data quality/coverage, positioning accuracy and also stopped most float grounding incidents). In addition, coverage in our target oceans can only be maintained via access to dedicated shiptime – and thus the Facility has co-invested over many years in RV Kaharoa time with US and New Zealand Argo programs.

Some challenges discussed were:

• Securing support for the original mission from operational users while resources from research partners is being attracted to Argo extensions

• **Retaining** and diversifying our **DMQC team**: keeping this interesting for our staff and making this more efficient- machine learning; triage of floats to focus on; mix DMQC with other duties (products/analysis)

• **Developing and maintaining realtime and DMQC code** is extremely expensive (time consuming) – can Argo move more rapidly to community shared code-sets: one source code set used and maintained by many?

• How can we change our **national governance** to include Argo's extensions and input for those PI's while maintaining our success in the original mission?

4.6. Japan Argo

Toshio Suga reported on the updated status of Japanese Argo Program. After a reduction in the number of both technical staff devoted to delayed mode QC and PARC activities and purchased floats at JAMSTEC in recent few years, AST-17 held in Yokohama last year helped to prepare for a re-energization of JAPAN Argo. Owing to ocean monitoring enhancement recommendations from the G7 Ise-Shima Summit, especially the Science and Technology Ministers' Meeting in Tsukuba, funding for JAMSTEC Argo was boosted in FY2016. The additional funding has secured JAMSTEC's continuous contribution to the core Argo mission and expanded its contribution to Argo enhancements, mainly Deep Argo and BGC Argo. Further increases in funding for the Argo extension is expected in FY2017. JMA has been continuing to allocate an operational budget for 27 floats per year; 12 of them are identified as part of the WBC Argo enhancement in FY2017 for the first time.

4.7. Discussion from National Reports

Each country was asked to report on one highlight from their National Report.

Canada: B. Greenan reported that he is continuing to make improvements in core funding in Canada. For a long time, money had to be found each year, but over the last few years, he's been able to get more stable, long-term funding which includes a three year agreement to fund the AIC.

China: Last year China began to deploy floats in the South China Sea and share the data with the Argo community. It could be viewed as the beginning of a South China Sea Argo regional observing network. In 2016 – 2020, the government is expected to increase support to China Argo as part of China's strategic initiative for a '21st century maritime silk road'. A proposal has been made to put 400 floats in the South China Sea, the NW Pacific and Indian Ocean. If granted, the 400 floats will be a mix of types and some will use the Beidou communication system.

EuroArgo: The EuroArgo team is now comprised of 5 people. The goal is to deploy an additional 130 Core Argo floats in 2016 – 2017. The EuroArgo strategy for the next decade has been initiated and it includes Core, BGC and Deep Argo.

France: Least year was a small year for deployments due to difficulties with the tendor and float purchasing process. 2017 should be a more typical year for deployments. There were a couple of French PhDs this year that focused on Argo data analysis.

India: Like France, 2016 was a small year for float deploys due to procurement issues. The new plans through 2020 call for increased float deployments in the Indian and Southern Oceans. In India, Argo data are being assimilated into ocean models and used by agencies for seasonal forecasting which has shown significant improvement.

New Zealand: The Argo program in New Zealand is in a solid state. The Kaharoa is stable, much thanks to S. Piotrowicz for help with that. There will be Southern Ocean deployment opportunities in 2018, so please contact Phil Sutton if you are interested.

South Korea: We plan to deploy 13 floats in 2017 and are very interested in shallow marginal seas. We have an established assimilation system and a new goal is to try and assess the impact of Argo data on this system. We are interested in the Yellow Sea and think that we should maybe work with China on this issue.

Spain: Argo Spain is halfway through it DMQC log, and plan to end the DMQC for all the Argo Spain floats before the end of 2017.

UK: The greatest threat is to core Argo funding in the UK. The funding has been dropped by one department and has not, as yet, been picked up by another department. Research funding is way up, but this is mostly for Argo extensions (Deep and BGC). It has been difficult for BODC DAC to handle the decoding of extension floats (six different new sensor/float combinations) and is way behind on DMQC.

US: D. Roemmich: There are 13 active Deep Argo floats in the SW Pacific Ocean and the US is working to expand this array. Already the array is becoming increasingly valuable for technical and scientific reasons. S. Jayne: WHOI has made a good dent in the NAVO DMQC work. S. Riser: We are heavily involved in BGC Argo and SOCCOM. Half of the SOCCOM floats are funded as core Argo floats. We just completed a large deployment in the Southern Ocean and everything is going well. We have a Deep Argo float that has been working for a year now. M. Baringer: AOML has been struggling, but she was happy to say that v3.1 is fully implemented for active floats. They hope to conquer B-files in the second part of 2017.

4.8. An Argo data paper and advancement of Argo DOIs

Argo currently has a single DOI (http://doi.org/10.17882/42182) with monthly snapshots added as keys at the end of the root DOI. The AST prefers this single DOI for its dataset rather than several DOIs for different versions or times and has worked with others to develop this solution which allows for changes in the dataset over time described by an additional key added to the single Argo DOI. It makes citing and searching for Argo data in papers simpler and more accurate as the Argo data set is always changing and does not have official versions released every so often.

The benefits of publishing an Argo data paper include the ability to document the **structure and accuracy** of the first 18 years of Argo data, to capture the work Argo has done on **checking sensors** and **correcting drift/bias** in a single authoritative and peer reviewed paper, to provide a **citeable and indexed** paper (like any research paper) and to **give credit** to those who have contributed to Argo via authorship of what is likely to be a highly cited publication – IAST members, ADMT members, all major contributing PIs, DMQC operators, sensor engineers, etc.

S. Wijffels and J. Buck suggest submitting the paper to the open access journal Earth System Science Data. In addition, through the nascent **Data Linking Service**, the paper will enable **direct link** to the DOI and the data set: **https://dliservice.research-infrastructures.eu/#/query/q=argo** This will also track **secondary** and **tertiary citations**, so that we should be able to track where Argo contributes to data products.

The path forward include the following steps: Justin Buck and Susan Wijffels will act as Coordinating Lead Authors (CLAs) and will produce a draft outline in the next month. They will then solicit Lead Authors for short sections from Argo community. They will aim for a rough draft by ADMT-18 and submission by IAST-19. There will a **companion technical data management paper** (led by Justin Buck) on how a dynamic DOI for Argo will work and OceanSITES and other observing systems will adopt this groundbreaking design.

The Argo data paper will focus on the original mission (T/S only). It is envisioned that companion data papers can be written for deep, BGC, etc as those data become more stable and better understood. It is envisioned that the Argo data paper will be updated as the sensor and platform technology continue to evolve and impact the nature of the data (coverage, quality).

Action item 4: Produce a draft outline for the Argo data paper with S. Wijffels and J. Buck to be coordinating lead authors. Seek other Argo authors to contribute sections as needed. Request list of authors from each National Program keeping in mind scientists, data managers, DMQC operators, etc. S. Wijffels, J. Buck, National Programs.

5. Data Management Issues

5.1. Feedback from ADMT-17

S. Pouliquen provided feedback on the Argo data management activities. The real-time processing is functioning mostly as designed. The transition to format 3.1 is still on-going but nearly over for active floats in most DACS, conversion of historical data has started but it will take longer. Some of the v3.1 real time trajectory and meta file content needs to be improved, but the main transition has been made. The implementation at the two GDACs of a file checker (format and consistency checks within a file) prevents poorly formatted data and data with discrepancies from entering the GDACs. This tool will contribute to the quality of the Argo dataset.

ARC work is becoming more and more important but this activity is underfunded and ARCs are focusing on different tasks. Finally, with new types of floats, sensors, and transmission, the Argo data are more complex and we should consider organizing training for users so that they really understand the formats and make the best possible use of the data.

There was discussion on how to get the PIs/DM-Operators to provide feedback and eventually correct their data when their floats are flagged by the altimetry checks performed by S. Guinehut. There was an agreement that the AIC will provide more reminders on the pending anomalies to PIs and that the AST co-chairs will be warned if after six months no action has been taken. At that point, a DAC could put these floats on the greylist while waiting for action to be taken.

> **Action item 5:** Ask WHOI, UW, India, NAVO, and PMEL to take immediate action for floats that continually fail Altimetry comparison and OA tests by Coriolis. If no action is taken, the AST co-chairs will follow-up. Ask other programs need to continue providing feedback quarterly. Can be found on JCOMMOPS website under 'Quality Control'. Under QC Feedback, check the Pending feedback box and choose 'Coriolis/CLS Altimetry QC' from the drop down menu. WHOI, UW, India, Navo, PMEL, AST co-chairs

5.2. Proposal on definition of an Argo float and how to handle non-approved sensors and parameters

M. Scanderbeg presented on two related topics: the proposed definition of an Argo float and how to handle data from non-approved parameters. She provided some background for this topic from the prior AST meeting where it was noted that the Argo Data Management Team was overwhelmed due to the Argo data stream becoming more and more complex. There are a variety of reasons for this additional complexity including new sensors, new parameters, more data being sent back by floats, the need to curate much more meta and tech data, new Argo missions, etc. At AST-17, it was decided that accepting floats into the Argo data stream is beneficial to both the PI and the Argo program as float data is freely available within 24 hours, assigned a DOI and keeps the Argo array healthy. Therefore, it was decided that a compromise was needed to balance encouraging technological development and the corresponding burden on the ADMT and DACs.

The suggestion was to clearly define what an Argo float is and then to ask the GDACs to serve the additional, non-Argo approved data in a non-curated fashion. This satisfies the requirement that all data from an Argo float is freely available, but does not put the burden on DACs to learn how to decode every experimental sensor that comes along and prevents the ADMT from finding appropriate vocabulary to describe the parameters and corresponding meta and technical data.

The proposal on the definition of an Argo float has been seen at a couple ADMT and one previous AST meeting, so there was no need to go into great detail. Additionally, the document has been circulated a few times on Argo email lists. There are general requirements covering things like an Argo float and its data are consistent with Argo governance (IOC XX-6; IOC-EC_XLI.4), the float must have a contact point for its entire lifetime and for the data processing after the float is dead and that the PI will recover the float safely if beached. In terms of data requirements, the data must have an established end-to-end pathway and the data must meet Argo targets for accuracy and vertical sampling characteristics. The PI should have agreed data management arrangements with an Argo DAC, a d-mode group and must supply all meta and tech data. Additional sensors and parameters must be endorsed by the AST and ADMT. During the discussion following this, the AST suggested that the vertical sampling characteristics need to be well defined, so a small working group was formed to address this issue. Otherwise, the proposal was accepted.

The second part of the talk focused on the details of how non-Argo approved data would end up on the GDACs. It was agreed that Argo would consider the parameters found in Reference Table 3 to be the Argo approved parameters and that any other parameters would have to reside in the 'Auxiliary Directory'. There was some discussion over sensors and it was finally agreed that the only currently Argo approved sensor is the SBE41. It was suggested that data from non-approved sensors, but with approved parameters, be kept in the regular Argo data stream with increased errors and lower qc flags to indicate it was not yet approved. This needs to be clearly documented on Argo websites and in User Manuals.

Therefore, a float with approved and non-approved parameters should have the approved parameters handled in the usual manner through the DACs and GDACs. The data for the non-approved parameters should be kept on the Auxiliary directory and should be completely decoded by the PI. The PI (or the DAC, if agreed upon by PI and DAC) must generate ASCII or NetCDF files that are easily readable. The PIs must also include a README file with a description of the sensor, what has been reported (including parameters and units), and how the data are organized. PIs will be encouraged to use recognized IODE names for new parameters, if possible. The SPECIAL_FEATURS variable in the DAC meta.nc file must be filled by the DAC to indicate that there are Auxiliary data files. There is no SPECIAL_FEATURES variable in single-cycle profile files, so it is not possible to match single cycle profile files and auxiliary data files. The PIs need to work with DACs to get the auxiliary files uploaded to the GDACs who will serve the data in a parallel auxiliary directory. The GDACs will provide an inventory of files, but the file checker will not be run on these files.

Suggestions were made about file naming conventions which meant adding 'AUX' in front of the WMO number. It is recognized that there may be both general files that apply to all cycles like a trajectory file and single profile files. A few details were noted about the SPECIAL_FEATURES string including that 'AUX' must be included for machine parsing. Also, the AST requested that the AIC track the contents of this string to try and provide meta data about what other types of parameters are being reported and on what floats. It was also noted that for notification purposes, the SPECIAL_FEATURES string must clearly describe all auxiliary measurements so that the AIC can quickly notify what data is on the float when needed.

The path moving forward is to tighten up the definition of the Argo float by clearly defining what the vertical sampling requirements are. After that, the information can be posted to Argo web pages. In the meantime, GDACs should move forward with setting up and testing the Auxiliary directory. A couple of groups of EM-APEX floats have been designated as special test cases. Finally, information about the auxiliary directory needs to be posted and progress can be monitored at the ADMT meeting in the fall.

Action item 6: Add description of sampling requirements to documents describing what is an Argo float. Change approved sensors to only SBE. When complete, post information on Argo websites. M. Scanderbeg, B. King, B. Owens, S. Wijffels

Action item 7: AST endorses the Auxiliary directory and information about it should be posted on Argo websites. AST, M. Scanderbeg

5.3. Proposal on mandatory and highly desirable CONFIG parameters and maintenance of meta and tech tables

Esmee van Wijk presented a talk to AST prepared by John Gilson, on behalf of a small group (Gilson, van Wijk, Klein and Scanderbeg) tasked with reviewing the status of the configuration parameters within the Argo metafiles intersessionally. The group conducted a review of the existing configuration parameter list and also a census of how well configuration parameters are populated in the files by each DAC.

The main issues are:

1) The number of configuration parameters is increasing quickly with more complicated float types (185 parameters in the core Argo table) requiring significant resources for curation.
2) The inclusion of the mandatory configuration parameters is inconsistent across DACS/floats.
3) Currently, there is no formal procedure to confirm that mandatory configuration parameters are found within the metafiles.

The WG has reviewed the current list, removing redundant or duplicate parameters, adding in categories to help group related parameters and mapping config parameters to specific float types. The WG proposes that only a small subset of mission-critical parameters should be mandatory, i.e (i) those that define the mission (i.e. cycle time, park pressure, profile pressure, etc.) (ii) those that measure the accuracy or biases of the float (i.e. surface pressure offset, float rise rate, etc.) or (iii) those that provide information on the health or behavior of the float (i.e. voltages, internal vacuum etc.). Most of the other configuration parameters would be *optional*. DACs can add as many optional parameters to the files as they wish to, but are only required to populate the *mandatory/highly desirable* parameters. It is expected that most DACs will only populate this small subset.

To help guide DACs, the WG will circulate the revised core Argo configuration parameters list shortly after AST for information and feedback. The AST supported the review and the philosophy behind the mandatory configuration parameter subset.

The AST also discussed possible ways to improve the population of the configuration parameters in the metafiles. As this is the first census of the configuration parameters, the AST felt that the first steps should be to disseminate the census results to DACs and ask them to fix their files. Census results could be updated and circulated again before ADMT and steps to implement a GDAC file checker for these variables should be discussed then.

The AST agreed that configuration parameters that are mandatory and apply across all float types could be easily implemented in a GDAC file checker. However variables that are not mandatory or vary across float type would need an accurate mapping of variable to float type before this could be added to a GDAC file checker. These checks could be implemented in a two-stage process. The AST also preferred that a “warning” was issued in the event of the metafiles failing any future GDAC checks.

> **Action item 8:** AST endorses the idea that configuration missions should be minimized. AST, ADMT

> **Action item 9:** AST endorses the concept of mandatory CONFIG parameters and understands that DACs may need to estimate or calculate some of these. AST, ADMT

> **Action item 10:** Ask E. van Wijk and J. Gilson to send out new version of the meta table and the results of the census on the contents of the meta files. Ask DACs to study and respond. E. van Wijk and J. Gilson, DACs

5.4. Status of Trajectory V3.1 files

M. Scanderbeg reported on the status of the v3.1 trajectory files at the GDAC. She noted that most DACs have moved to producing at least some v3.1 trajectory files in real time and that progress is better in real time than in delayed mode. In preparation for the meeting, she performed an inventory at most DACs to look at the contents of the v3.1 files to check for consistency across DACs, whether DACs were following the DAC Trajectory Cookbook, whether timing information was being included in the primary (mandatory) and secondary (optional) measurement codes, if there was basic agreement between N_MEASUREMENT and N_CYCLE arrays, the order of events in the array and whether P/T/S information was included.

Most DACs responded to the query for example WMO numbers by float type and comparison across DACs was possible for all float types except the SOLO and SOLO-II. In general, mandatory measurement codes (MCs) related to timing information were being included, even if they contained FillValue which sometimes is the only value possible depending on float type. The exception here was for APEX APF9 floats for which some of this timing information comes in the engineering messages that some DACs have never opened and looked at. Optional timing measurement codes varied a lot across DAC and float type. There were several inconsistencies between the N_CYCLE and N_MEASUREMENT arrays at almost every DAC. The good news here is that the Trajectory File Checker that is in test mode is designed to catch these inconsistencies and a couple DACs confirmed they were receiving warnings from the File Checker about this. M. Scanderbeg noted that she found it not to be a trivial task to make these cross comparisons since the ‘best’ timing information was supposed to be in the N_CYCLE array and one must go cycle by cycle to determine this. The order of events in the trajectory files looked good except for Iridium floats at a few DACs. For those DACs, they were treating all files the same even though Iridium floats have a different order of events when the float arrives at the surface. MCs are being assigned, but incorrectly and it is impossible to know what time corresponds with what measurement in this case. The category with the best news was the P/T/S study since all files included at least some of these measurements and the addition of the MC makes it immediately clear when in the cycle the measurement was taken and what type of measurement it is (ie, average, spot-sampled, etc.). This is a huge improvement over the previous version of trajectory file. The overall conclusion from this survey was that the contents are not much different than V2 trajectory files and that not all DACs are using the DAC Trajectory Cookbook. The most consistency was seen for Arvor floats where MCs are now included in the float user manual and for PROVOR floats where decoders are now being shared across DACs. SOLO-II decoders are also being shared across the two PIs at AOML which makes these files consistent as well.

The feeling from the AST was that this inconsistency problem and other errors in the v3.1 trajectory files should be addressed. It was suggested to hold a DAC Trajectory Workshop aside an upcoming Argo meeting where time can be spent going through each float type in detail so that all DACs learn how to properly code and fill the v3.1 trajectory files. In addition, it was suggested that DACs consider more code sharing and that Argo reach out to other manufacturers to try and include MCs in user manuals.

M. Scanderbeg also delivered a quick update on the status of the Trajectory File Checker. It has been in live testing mode for a couple of months now and DACs are receiving warning messages, but all floats are being accepted onto the GDACs. It appears from the brief comparison between February and the beginning of March that some of these errors are being fixed at the DACs. The ADMT will need to evaluate when the Trajectory File Checker will become operational.

Finally, M. Scanderbeg suggested that a delayed mode workshop on trajectory files would probably be most effective once the real time v3.1 trajectory files are improved. M. Scanderbeg also pointed out that many dmode operators are currently behind and adding the task of dmoding trajectory files will not help. She suggested that perhaps outside groups may produce trajectory file products that will help provide a higher quality data set until Argo is able to do this itself. A working group interested in trajectory file dmqc continues to consider these matters.

> **Action item 11:** Work with manufacturers to adopt Argo language in their manuals. Explore the possibility of adding measurement codes for trajectory files into the manuals as well. AST, manufacturers
>
> **Action item 12:** AST suggests ADMT consider holding a decoding workshop for v3.1 trajectory files for DACs at an upcoming meeting to help produce more accurate and consistent v3.1 trajectory files. ADMT, DAC managers

5.5. DMQC frequency

Both the number of floats and their lifetime have increased in the past years. The original requirement "perform DMQC when the float is 1 year old and revisit the float series every 6 months" is not achievable for a significant number of teams. Moreover in some regions, like the North Atlantic, it is often safer to wait for two years to have a time series long enough to avoid correcting good files. To ensure a high quality dataset, the AST wants to keep the requirement to perform the first DMQC after one year, but agreed to relax the salinity revisit time to one year. Point-wise DQMC should be performed every six months and files will be submitted as ‘A’ files. It was also agreed that DMQC should be prioritized and that DMQC operators should first process floats with possible detected large salinity bias based on the quarterly Altimetry checks done by S. Guinehut and the Monthly Objective Analysis performed at Coriolis. If we could have a method to automatically detect floats that are suspicious, we would be able to streamline the processing more efficiently. Finally it was agreed that we should monitor more closely DM progress and also collect information on the revisit rate and deep-ocean adjustment performs that would provide the Data and Steering teams with objective indicators to revisit these requirement in the future.

Action item 13: AST endorses prioritizing DMQC for possible anomalous floats identified using Altimetry Comparison and OA tests. AST agrees to relax drift DMQC revisit frequency to 1 year, but point-wise DMQC should be done more frequently. Explore making revisit time dependent upon float age. Consider ways to monitor this at the GDAC or AIC level. ADMT, DMQC operators, Thierry Carval, M. Belbeoch

Action item 14: AST asks that ADMT consider holding another DMQC workshop to study consistency across operators and share tools. ADMT, DAC managers

5.6. Positioning for under-ice floats

A short presentation on under-ice positioning in DMQC was presented to the AST. Several Delayed Mode groups work with data from under-ice floats and cannot currently convey all of the position information required in the data files. In order to use the data from under-ice floats it is useful to know the position error and/or accuracy, the qc, the positioning system, or the method used to derive the position if it was not directly returned by a positioning system. A small subgroup (van Wijk, Klein, Gilson, Rannou, Schmid, Cowley, Kobayashi, Scanderbeg, Carvel) was tasked with finding solutions to these issues intersessionally and presenting options for AST to decide on.

<u>RAFOS floats:</u>
The WG has been working towards finding a solution for RAFOS-equipped floats and had recommended that this data be placed in the trajectory file. It was proposed that estimated positions received a MEASUREMENT_CODE of MC603. These are not data, so should not have a MC703. The estimated position is the best estimate of the location of surfacing (MC600), thus MC603 is applicable to this portion of the cycle. The AST felt that the amount of data required for RAFOS processing would include substantial amounts of data not only returned by the floats but also from the moored sound sources and that all of this data would be better placed in the auxilliary files rather than in the trajectory file.

<u>Position Error:</u>
Two options were presented for position error.
1). The creation of an *optional* new variable called POSITION_ERROR in the profile files and/or the trajectory files, only for the subset of floats where it can be calculated.
2). Populating the existing field in the trajectory files:
AXES_ERROR_ELIPSE_MAJOR(MINOR)(ANGLE)
Neither of the two proposals require re-processing of files as they are both *optional.* The AST supported option 1 and agreed that a new variable for POSITION_ERROR can be used when required.

<u>Position Accuracy:</u>
The existing reference table for position accuracy was developed when only Argos floats were available. Subsequently, a general GPS and Iridium category were added and additional Argos classes added in at the last ADMT. However interpolated or estimated positioning accuracy was not catered for. The WG proposed that existing reference table for location classes be renamed to remove the reference to "ARGOS" and be replaced with the expanded table below. This recommendation was supported by the AST.

Location classes

Value	Estimated accuracy in latitude and longitude
0	Argos accuracy estimation over 1500m radius
1	Argos accuracy estimation better than 1500m radius
2	Argos accuracy estimation better than 500 m radius
3	Argos accuracy estimation better than 250 m radius
G	GPS positioning accuracy
I	Iridium accuracy
A	Argos no accuracy estimation (3 messages received)
B	Argos no accuracy estimation (1 or 2 messages received)
Z	Argos invalid location
J	Estimated accuracy less than 25m
K	Estimated accuracy less than 100m
L	Estimated accuracy less than 250m
M	Estimated accuracy less than 500m
N	Estimated accuracy less than 1000m
O	Estimated accuracy less than 1500m
P	Estimated accuracy less than 5km
Q	Estimated accuracy less than 20km
R	Estimated accuracy less than 50km
S	Estimated accuracy less than 100km
T	Estimated accuracy greater than 100km ('offscale')

Position Method:
Currently, when a float is unable to surface and the position for that cycle is interpolated, extrapolated or determined by some other method, it is confusing to have the *float* positioning system given for that cycle, i.e. GPS if this system was not able to deliver the position. Three proposals were presented to AST from an original 5, after feedback from within the WG.

Proposal 1 was for "None" or "FillValue" to be placed in the POSITIONING_SYSTEM variable. Proposal 2 was to expand the POSITIONING_SYSTEM reference table to include INTER, EXTRAP and CUSTOM.
Proposal 3 was to include an optional new variable called POSITION_METHOD.

The pros and cons of each proposal were discussed by AST and the group recommended that Proposal 2 be implemented.

> **Action item 15:** AST suggests that intermediate RAFOS timing information reside in AUX files. Previously agreed upon format for v3.1 trajectory file can be used. RAFOS PIs

5.7. Argo BUFR format for BGC floats

TESAC to BUFR migration

At ADMT-17 it was reported that during the year October 2015 to August 2016 there were 12,449 TESAC and 11,446 BUFR (Binary Universal Form for the Representation of data) messages transmitted on the WMO (World Meteorological Organization) GTS (Global Telecommunications System) each month. With 92% and 89% of TESAC and BUFR messages available to users within 24 hours of the float surfacing.

At that time China (NMDIS) and France (CLS) had ceased issuing their data in TESAC, India (INCOIS) were issuing far more data in TESAC than in BUFR, no BUFR messages had been received from Korea (KMA) since March 2016, prior to August 2016 both France (Coriolis) and Japan had issued many more TESAC messages than BUFR messages.

At present we should continue to exchange data on GTS in both formats until we can be confident that data from all operating floats are being exchanged in BUFR, at which time the legacy TESAC format can be withdrawn. This would require advance (say 3 months) notification to users through the WMO Operational Newsletter. Ideally, we should be in a position to notify intent shortly after ADMT-18 by the end of 2017.

Status of the Argo BUFR format

At present, the Argo BUFR format used to exchange data on the GTS is able to handle:

(i) core Argo CTD profiles (template 3-15-003)
(ii) secondary temperature and/or temperature and salinity profiles (additional sequences 3-06-017 and 3-06-018 respectively) which map to the Argo netCDF reference table 16
(iii) dissolved oxygen profiles (additional sequence 3-06-037).

However, the JMA-provided netCDF to BUFR (Perl) conversion code, as used widely across the Argo Program, is only able to encode the core CTD profile.

At AST-17, further enhancements (i.e. additional sequences) to the BUFR format were proposed to enable it to represent profile data for chlorophyll-A, nitrate, CDOM and pH. With some amendments post AST-17, the proposals were submitted to the WMO IPET-DRMM meeting (30 May to 3 June 2016) at which they were approved for validation. This involves two or more centres encoding BUFR messages and decoding those from the other centres in order to demonstrate compliance with and consistency of the messages. The template/ sequences for validation are for chlorophyll-A (3-06-044), nitrate (3-06-045), pH (3-06-046) and backscatter (3-06-047). It is hoped that they can be successfully validated this year and approved for operational use in 2018.

Development of Argo BUFR conversion code

Following AST-17, the Met Office started work towards the development of a new netCDF to BUFR converter that will be able to handle both secondary temperature and salinity profiles and bio-geochemical variables. The format converter software has been written in Python, a modern open source object-oriented language that can be implemented on a wide range of platforms, where the intention is to make it freely available to the wider Argo community.

Specifications for the software have been written by the Met Office and a prototype version that can handle core temperature and salinity profiles has been developed. This work has been contracted out to a software company that the Met Office has used for similar work previously. The prototype version can be used with netCDF v2 to v3.1files and has been tested by the Met Office against a random selection of netCDF files taken from the Coriolis GDAC and the resulting BUFR formatted output has been checked and validated. The prototype is now being set up to run in an automated mode taking as input real-time netCDF v3.1 files routinely generated by BODC where the system will be fully tested before being implemented operationally at the Met Office and retiring the JMA perl converter run at BODC. Once proven for operational use the Met Office intends to release the Python code to the wider Argo community later in 2017. The software has been designed and written in such a way that it can readily be expanded to include secondary temperature and salinity profiles in the first half of 2017 and dissolved oxygen before end 2017, with the additional bio-geochemical capability to be added later and made available in 2018 (at which time it is hoped the additional sequences will have been approved for operational use).

Action item 16 AST co-chairs, J. Turton, P. Oke to liase with operational modelers to find out if they are using BUFR or TESAC messages from the GTS. AST co-chairs, P. Oke, J. Turton

Action item 17: K. Johnson, H. Claustre, J. Turton explore adding BUFR format template for appropriate BGC parameters. BGC-Argo co-chairs, J. Turton

5.8. CTD Reference Data

6. Technical Issues

6.1. Recent float performance evaluation of array

Brian King repeated the analysis of float survival statistics that was presented at AST17. The statistics can be extracted by float type or by PI group. A version of the statistics was presented that excluded floats carrying BGC sensors or that had visited latitude greater than 60, so that group statistics would not be adversely influenced by ice or by extra drain on batteries.

The questions posed for this analysis, and which should be monitored into the future are: (1) Is there any evidence that float performance is dropping over time? and (2) Is there clear evidence that different groups have different performance?

The overall drop-off rate for each float group was not expected to change significantly since AST17, since for most float groups the extra year of data provided only a small percentage of new cycles. However, the slow evolution of fleet statistics should be monitored. Broadly, the most and least successful float types and operator groups were apparent. The answer to question (1) is that the overall fleet performance was stable with the inclusion of an extra year of data, and the answer to question (2) was necessarily unchanged.

The only apparent change in statistics that BAK drew attention to was the improved performance of ARVOR floats. This is a relatively small, but growing, collection. The first year with a significant number of ARVOR deployments (over 100 floats) was 2012, and survival rates for that cohort were not very good: only 60% of deployments survived to 108 cycles (equivalent to 3 years at 36 per year), compared with an all-time fleet average of 70%. However, ARVOR statistics have improved in each successive year: For ARVORs deployed in 2013, 80% survived to 108 cycles, which is above the fleet average. That is the last year for which 3-year survival can be calculated. The 1- and 2-year ARVOR survival rates for later year deployments are above the fleet average. These ARVOR statistics are still a bit below the SOLO-2 rates and the most successful APEX groups (CSIRO, UW, PMEL) but recall that the ARVOR statistics include deployments in marginal seas, especially the Med. In future, as ARVOR numbers grow, a separate statistic of open-ocean ARVORs should be maintained. Note for example that SOLO-2 survival was also below average for the first two years of deployments (2010-2011), with substantial improvement in following years.

Battery type: Battery type can be monitored through the BATTERY_TYPE variable in the V3.1 meta.nc files. At AST17, insufficient DACs had converted to V3.1 to make an analysis possible. At AST18, around 90% of meta files can now be parsed. Since this is a text string, it generates variations due to DAC inconsistency and even typo errors. It would enable more automated parsing if the format group could work with DACs to make this more consistent. However, the values can broadly be grouped as Alkaline (3421), Lithium (6156), mixed (1683) and unknown (V2 metafiles or not filled, 1383). Note also, all we have is battery type. We do not generally have information about number of cells.

Recommendation: That DACs/ADMT be asked to work with PIs to consider a way to try to capture the amount of energy stored on the float at deployment. Even though not all energy is useable, a total energy variable would be a useful parameter to parse when trying to interpret float survival stats. It is probably not feasible to ask DACs to do this retrospectively, but perhaps it could be captured for new floats.

Later in the meeting, BAK presented the all-time survival statistics for ‘alkaline’ vs ‘lithium’ or ‘mixed’ floats. Floats with lithium batteries out-perform alkaline at all stages of life, even early in life. Eg for floats deployed since 2012, around 95% of lithium floats reach 50 cycles compared with around 85% of alkaline floats. This could be because the new and highly-successful float designs all use lithium, and alkalines are biased towards either older, shorter-lived floats or are used by groups who take floats ‘fantail ready’. However the difference between survival is really striking around 150 cycles. More than 80% of lithium floats deployed since 2012 reach 150 cycles, compared with 45% of alkaline floats. Using lithium batteries would apparently add at least two years lifetime to a high proportion of alkaline-only floats.

Difference across groups: As reported at AST17, different groups achieve different levels of success with what should be equivalent floats. It is understood that strategy or restrictions in national programs means there is wide variation in procedures between float deployment groups for float acceptance and testing. This ranges from ‘none, the float must be fantail ready’ , to substantial testing including opening some or all floats. This provides strong motivation for holding workshops on particular float types, to exchange information on best practice, to try to help improve the performance of all float groups towards the most successful. This is further discussed in Agenda 10.4, Proposal for technical workshops.

> **Action item 18:** AST suggests updating Argo User manual with suggested words for BATTERY_TYPE variable in meta file. Important to capture three categories for now: Alkaline, Lithium, Hybrid Lithium, “mixed”. E. van Wijk, T. Carval

6.2. Sensor progress

6.2.1. RBR

Significant progress has been made analyzing the results from RBR equipped floats that were previously described at AST-17 and from the WHOI test tank with a sharp double diffusive interface. Comparisons between an RBR and SBE equipped floats that were deployed in the western South Pacific Ocean show that over the present 6 month deployment the RBR CTD appears to be at least stable as the SBE CTD. At depths where there is a sharp interface, the RBR CTD conductivity measurements appears to have a significant delayed response due to a thermal mass issue in which the inductive cell temperature response is significantly delayed compared to the in situ temperature measurement. This produces unrealistic density inversions in the reported temperature and salinity values. This thermal effect has been confirmed in the test tank. In the model used in these measurements, the thermistor and inductive cell are not aligned vertically. In addition, flow measurement around the cell show that this cell sheds significant vortices that further affects the temperature measurement.

The measurement cell has been significantly redesigned to produce smoother flow around the inductive cell and to also align the temperature measurement with the center of the inductive cell. Results from the test tank confirm that this has significantly reduced the dependence on flow rate and also show that the dynamic response is greatly improved. An additional thermistor has also been embedded near the inductive cell coil so that the temperature of the coil can be measured directly. APEX and Solo S2A floats will be deployed this year with the new configurations. ALAMO floats with an RBR CTD will also be deployed during the 2019 hurricane season. It is expected that these improvements should address the thermal mass issue and remove the issues associated with the thermal mass response.

6.2.2. SBE61

Nathalie Zilberman presented the current status of the Deep Argo pilot array in the Southwest Pacific Ocean. This region was chosen for pilot Deep Argo deployments because it has a significant multi-decadal warming signal at depths greater than 4000 m; it is located on the meridional pathways of deep-ocean water masses including Antarctic Bottom Water; it has a stable and spatially invariant (within the array) θ-S relationship in the abyssal layer—useful for CTD calibration, and there is reference data available from 3 GO-SHIP sections: P06, P15S, and P16S. There are now 13 Deep Argo floats active in the Southwest Pacific Deep Argo array: 11 Deep SOLOs and 2 Deep APEXs. Over 359 Deep SOLO float profiles have been collected to date. All Deep SOLO floats are currently cycling to or near the bottom every 10 days. Using data from all SBE-61 CTDs mounted on the Deep SOLO floats, we found a fresh bias in salinity of 0.0036 at 0.7°C potential temperature that may be due to an incorrect value of the conductivity cell compressibility, and a salinity scatter of ± 0.004 psu. Results indicate a fresh bias of 0.0014 at 2.0°C, smaller than at 0.7°C. This suggests that the observed salinity bias is pressure dependent. Comparisons between SBE-61 and shipboard CTD—from the RV Investigator during the P15S cruise in June 2016—show that pressure sensor accuracy of the SBE-61 CTDs is ±5 dbar. This could generate a ± 0.002 psu error, and explain part of the salinity scatter. The temperature from SBE-61 CTDs mounted on the Deep SOLO floats is meeting the target accuracy of ± 0.001°C. Most SBE-61 CTDs are stable. The pilot array in the Southwest Pacific is an example of how collaboration within the international Argo community, and between Argo and other programs (GO-SHIP) helped create deployment opportunities.

6.2.3. SBE41 below 2000db

Updated results of the analysis comparing the first profile from Deep NINJA floats and the shipboard CTD at deployment presented by Taiyo Kobayashi (JAMSTEC) at AST-17 was reported. The number of the pairs is now 13, increased by 2 since AST-17, from 6 cruises of 5 ships including a GO-SHIP cruise. The updated comparison confirms the previous conclusion that salinity measurements of all floats, besides an offset component for some, had a pressure dependence component which makes the deeper measurements fresher. Technically, the fresher-ward pressure dependency can be corrected well by adjusting an “internal” parameter of the sensor. However, its basic cause is not yet identified. It is also confirmed that float temperature and pressure had deviated negatively from shipboard reference on average, especially in the depth below 2000 dbar, but were not concluded statistically to be “biased” (95% confidence level).

6.3. Procedures to prepare SBE CTDs for storage

At AST-18 some preliminary recommendations for preparing SBE 41CP CTDs were presented. Just prior to AST-19, Seabird posted a technical report, AN97, http://www.seabird.com/document/an97-best-practices-shipping-and-deploying-profiling-floats-sbe-4141cp-ctd, that presents recommendations on how to test that the conductivity measurement offset is still within specification, to store the CTDs in the lab, and to prepare them for shipping to the deployment vessel. It is recommended that all groups who prepare floats for deployment in the Argo float program download and implement the recommendations in this report.

6.4. Documenting pressure sensor performance

The University of Washington float group has been monitoring the calibration of CTD pressure sensors on floats for the past 7 years. As each float is constructed, the pressure on its SeaBird 41cp CTD unit is measured at several pressures between 0 and 2000 decibars using a dead-weight tester, and at the temperatures of 20°C and 3°C. As a result, the calibration error in the sensor can be estimated as a function of pressure and temperature. Similar tests have been carried out at Scripps and JAMSTEC. Using values from over 700 sensors tested since 2010, we find a general trend (using data from all three laboratories) for the sensors to have an error of less than 1 decibar at zero pressure, with an error of 3-5 decibars at a pressure of 2000 decibars; the sensors typically read low of correct. The error appears to increase slightly (by 1-2 decibars) at lower temperatures. An examination of the importance of this pressure error in estimates of heat content and other inferred climate variables is now underway.

7. Completing the global mission and exploring extensions

Action item 19: Adjust monitoring maps for increased density and spatial extensions to reflect which parts are funded and which are not. Consider graying out regions that are not funded. AST co-chairs, M. Belbeoch

Action item 20: Reach out to regional GOOS alliances to seek their assistance in deployment in unsampled areas. AST co-chairs, T. Moltmann

7.1. Status of Deep Argo pilot arrays and float technical updates

Deep Apex

The University of Washington has continued to deploy prototype versions of Deep Apex floats and to monitor their performance. A float deployed northeast of New Zealand in 2016 has now been in the water for over one year. The float is collecting samples at 2 decibar intervals from the sea surface to 5500 m. While the float is generally performing well, the prototype SeaBird 61 CTD shows a drift in salinity from the beginning of the deployment through the first 80 profiles, encompassing a time interval of about 14 months. The drift has slowed since the first 25 profiles or so but nonetheless continues. Another Deep Apex float deployed by the UW in the same region, and also one in the Indian Ocean west of Australia, are performing well and show more stable salinity data over deployment times of 6-10 months.

7.1.1. South Atlantic

7.1.2. North Atlantic

The North Atlantic Ocean is a very dynamically active regions (both in the subpolar and subtropical gyres) with large signals of variability in the deep layers assuring a scientific interest of the data on the short term. In July 2017, there will be about 10 Deep-Arvor float deployments in the subpolar gyre of the North-Atlantic as part of the RREX and AR7W cruise (maybe more if technological issues are resolved). Additionally, 6 Deep SOLO floats were deployed in the North Atlantic western subtropical gyre along the moored array (RAPID) line at 26°N onboard R/V James Cook in March 2017.

7.1.3. Indian Ocean

In the western Indian Ocean, 2 Deep NINJA floats were deployed onboard R/V Hakuho-Maru in January and February 2016 by JAMSTEC, profiling to 4000 dbar with 10 - 30 day cycles. One of them terminated functions after 18 cycles; the other is still active.

In the South Australian Basin, 8 Deep SOLO floats and 1 Deep APEX float were deployed onboard R/V Kaharoa in October 2016 by Scripps Institution of Oceanography. Deep SOLO floats are presently cycling to or near the ocean bottom every 10 days. The Deep APEX float is cycling to 5200 every 5 days.

JAMSTEC plans to deploy 1 Deep NINJA float in the eastern Indian Ocean in November 2017, and 2 DO-Deep Apex in the South Australian Basin in December 2017.

7.1.4. Pacific Ocean

JAMSTEC plans to deploy 1 RINKO Deep NINJA float in the northwestern North Pacific in July 2017, 1 Deep NINJA float in the northeastern North Pacific in June 2017 and 2 DO-Deep Apex floats in the western North Pacific in December 2017 and March 2018, respectively.

7.1.5. Southern Ocean

The status of the Deep Argo Pilot Array in the Australian-Antarctic Basin presented at AST-17 was updated. This pilot array targets primarily seasonal and interannual variability, both to understand dynamics and to help interpret trends from sparse deep hydrography, by using a mix of deep float types: Deep NINJA/Arvor over the slope and Deep SOLO/APEX in the deeper basin. Interest in this pilot array has been shown by Japan (1 Deep NINJA, 1 RINKO-Deep NINJA), France (3+ deep Arvor), Australia (~4 MRV) and possibly others. Deep hydrography at SR3 (140E) and southern end of P11 (150E) is planned in Jan 2018 and deep floats will be deployed during this cruise. Another survey at I9S (115E) in Jan 2020 is to be proposed and also additional “CTDs of opportunity” will be possible on resupply voyages.

Action item 21: Ask Mathieu to study Deep Argo deployment plans and active Deep Argo floats to ensure that everything is in the AIC database.

Action item 22: Ask CCHDO to work to get CTD casts with Deep Argo deployments for inclusion into Argo Ref DB. CCHDO Deep Argo deployers

Action item 23: Ask CCHDO to collect and hold SBE61 test data taken on CTD voyages to allow community analysis. Can be privately held for Argo users. CCHDO Deep Argo deployers

7.2. Status of Argo extensions

7.2.1. BGC Argo

In January 2016, a BGC-Argo science and implementation meeting was organized in Villefranche-sur-mer (France) with more than 30 attendees from different fields and complementary expertise. A science and implementation document was prepared in the following six months and subsequently released to the community for discussions and review. The final document is presently downloadable from the BGC-Argo website (http://biogeochemical-argo.org). Basically, the key points of this document are that BGC-Argo aims at developing a global observational network addressing six major scientific questions (Carbon uptake, OMZs and nitrate cycling, Acidification, Biological carbon pump, Phytoplankton communities). This network will rely on the systematic measurements of six core BGC-Argo variables, namely O2, NO3, pH, Chla, suspended particles and downwelling irradiance. The ultimate operational global target is a fleet of 1000 floats of which ¼ would be replaced each year. As for today, twelve countries are presently engaged in BGC-Argo. The presentation at AST was reporting these recent advances in establishing a BGC-Argo community with unified and shared goals, as well as the specific deployment plan and objectives of each participating country. Most countries are already engaged in looking for funding source that would help BGC-Argo reach its network density goal as well as sustaining it over the long-term. It is estimated that 105 BGC Argo floats will be deployed in 2017. In the discussion following the presentation, it was suggested that float lifetimes be compared with core Argo floats to see if there is a difference.

7.2.2. Western Boundary Currents

It was noted at AST-17 that quantitative estimates about the impacts of the Argo array enhancement in the western boundary current regions by taking advantage of the already enhanced array in the Kuroshio Extension region would be a useful next step to advocate this enhancement. Following these remarks, a brief report on the evaluation of the impact of Argo data in the Kuroshio Extension region based on Four-dimensional variational ocean ReAnalysis for the western North Pacific over 30 years (FORA-WNP30) provided by Norihisa Usui (MRI/JMA) was presented. RMSE was estimated by comparing forecast and observation during the 10-day assimilation window. It was shown that RMSE of 100-600 m temperature has been notably reduced since 2005 when double sampling in the Kuroshio extension region was achieved. This result should help to better articulate Argo targets in the WBC enhancement.

The comments from OOPC co-chairs on the WBC enhancement of Argo were briefly given. While OOPC supports the Argo WBC initiatives, they are also focusing on the boundary and shelf interactions and ocean property fluxes across shelf-open ocean boundary. In this region, they feel that the required observations will best be achieved with an optimal mixed-platform observing system that includes – Argo floats, gliders, moorings, and satellites. Regarding an evaluation study in the Kuroshio Extension region, they suggest to us to consider the benefit of the combined multi-platform system for provision of the required spatial and temporal sampling necessary to monitor WBCs and their extensions.

It was also noted that the areas of WBC enhancement, especially for the Kuroshio Extension region, should be reviewed.

Action item 24: M. Belbeoch and T. Suga work together to redefine WBC regions

7.2.3. Near-equatorial enhancements

D. Roemmich reported on the status of Argo enhancements in the equatorial Pacific. 41 floats were deployed along the equator between 160E and 100W in early 2014. This deployment resulted in doubling of Argo coverage along the equator. With 7-day cycling these Iridium floats have completed about 170 cycles each in a little more than 3 years. Their RMS distance from the equator is 1-degree, compared with 4.5-degrees for earlier equatorial floats having ARGOS communications, over a similar 3-year interval. The shortened surface time of Iridium floats has effectively eliminated the problem of floats diverging off-equator. The increased coverage in the equatorial Pacific came at an opportune time, as the evolution of the subsurface ocean leading up to and following the strong 2015-16 El Nino episode was observed in rich detail. A sequence of equatorial Kelvin waves was seen propagating eastward across the Pacific, deepening the equatorial thermocline and contributing to surface warming in the eastern Pacific. The report also mentioned that the TPOS 2020 re-design of the Tropical Pacific Observing System has issued its First Report (http://tpos2020.org/) and has recommended that Argo coverage be doubled (to 2 floats per 3-degree by 3-degree box) between 10S and 10N in the Pacific.

7.2.4. Polar Argo

Esmee van Wijk presented a joint talk (with Birgit Klein) on the Status of Polar Argo. There are two types of Polar Argo floats; those that contribute to the core Argo array and those that are specialized pilot floats deployed in more extreme under-ice environments. The former consist of floats that are identical to regular Argo floats and are deployed in the seasonally ice-covered seas. These floats comprise the same hardware, cost the same as a regular float and carry software modifications that allow them to store winter profiles and avoid ice via an ice sensing algorithm. Eighty percent of profiles from these floats are sampled in open water and contribute to the core Argo array. The remaining twenty percent of profiles are under ice and also contribute to core Argo data but require an estimated position for their winter profiles. These under-ice floats have been deployed since the early 2000's and, since the advent of Iridium communication, have lifetimes and reliability comparable to regular floats (4 to 6 years).

The pilot under-ice floats are either regular floats deployed in harsher, more ice-covered environments or those that carry new sensors (biological, BGC, optical or acoustic). These floats may have shorter lifetimes due to the harsher conditions to which they are exposed or due to the additional power consumption of extra sensors.

The target number of floats for the Southern Ocean at the nominal density of 1 float every 3 x 3 degrees, is 360 floats south of 60°S. Currently, 159 floats are active in the Southern Ocean with the array growth stalling at 45% of the design goal. Sustained deployments of 80 floats per year are required to meet the target. Presently, deployments vary widely from approximately 10 to 50 floats per year. Since the beginning of the Argo program, 484 floats have returned > 47000 observations south of 60°S. Forty five percent of Argo profiles south of 60°S are sampled during winter, returning seven times the amount of winter data compared to profiles obtained from ship-board hydrography. The SOCCOM project currently has 76 active BGC floats in the Southern Ocean with a target of 200 floats. In addition to biological parameters such as dissolved oxygen, pH and nitrate, these floats also return core Argo pressure, temperature and salinity data. In the Weddell Gyre, 18 floats are currently active, falling short of the target of 80 floats. AWI has recently maintained the array of sound sources in the Weddell with 11 sources currently active and have deployed 11 new RAFOS-equipped floats. A number of studies are underway aiming to improve the estimation of position for floats under winter ice, with four papers currently in preparation.

In the Arctic Ocean north of 60°S, approximately 120 floats fulfill the nominal design density, however a specific target is not set as it is recognized that a mix of platforms is more appropriate for regions with persistent multi-year ice. In the Arctic, under-ice floats can sample the seasonally ice-free regions such as the Chukchi, East Siberia, Laptev, Kara and Barents seas. In the central Arctic, which remains ice-covered year round, ice-tethered profilers are probably more appropriate. Currently, 67 floats are active in the Arctic Ocean with deployments ranging between 5 and 30 floats per year. The Euro-Argo ERIC has a target of maintaining 39 active floats in the Nordic Sea, plus 80 floats for the Weddell Gyre. Deployments will come from European national plans and EU contributions.

An increasing number of pilots are pushing the boundaries of Polar Argo by deploying floats into more extreme ice regimes in the far north and south. These projects include shelf floats (CSIRO), Ross Sea oxygen floats (UW), WAPITI project in the Weddell Sea (JB Sallee), PRO_Ice floats in Baffin Bay (Takuvic), the IAOOS ITP project (Christine Provost) and SODA Beaufort Sea project (Steve Jayne and others) in the Arctic.

If Argo is to maintain its truly global coverage, increased commitments of floats are required to fill gaps and maintain the array both south and north of 60.

7.2.5. Marginal Seas

The implementation of Argo in marginal seas was presented by M. Belbeoch for P-M Poulain. In early 2017, about 200 floats were active in the following marginal seas: Sea of Japan, South China Sea, Indonesian Seas (Sulu, Flores, Makassar, Celebes), Gulf of Mexico, Caribbean Sea, Red Sea/Gulf of Aden, Persian Gulf/Gulf of Oman, Sea of Okhotsk, Baltic Sea, Mediterranean and Black Sea (Fig. 1). Assuming a metric of twice the standard Argo density (i.e., 2 floats in 3° x 3° cells), some seas were still very much under-sampled (Gulf of Mexico, Caribbean, South China Sea, Indonesian Seas, Sea of Okhotsk, Persian Gulf/Gulf of Oman) whereas others like the Sea of Japan, the Mediterranean and the Black Sea appear to have reached, or even exceeded, the target density. The numbers of floats operating in the marginal seas in early 2017, as well as the target density based on twice the Argo standard, are listed in Table 1. Overall, the implementation of the marginal seas has reached the target density. Note that some seas are substantially over-sampled (Sea of Japan). In addition, adequately sampled seas, like the Mediterranean, are not necessarily well homogenously sampled in all their sub-basins (most floats are in the northern areas).

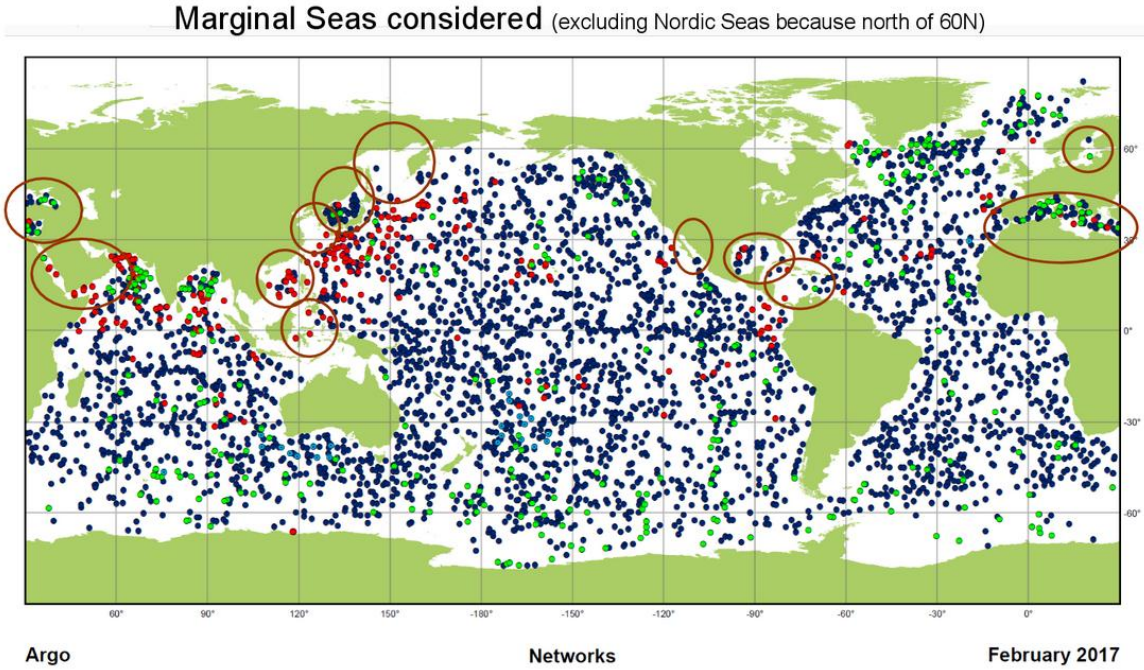

Figure 1. Argo worldwide network in February 2017 with major marginal seas highlighted.

Regarding the cycling period, the majority of the marginal seas have floats with the standard 10-day cycle. However, in the Mediterranean and Black most floats cycle every 5 days, usually alternating between shallow and deep profiles.

Some marginal seas are sampled by floats with biogeochemical sensors. In particular about 30% of the Argo fleet in the Mediterranean and Black Seas, i.e., 27 floats, are equipped with such sensors. A biogeochemical float upgraded to measure simultaneously concentrations of nitrate and hydrogen sulphide has been operating in the Black Sea since May 2015.

Iridium two-way telemetry has been recommended in order to increase the float operating lives in the marginal seas (decreases the surfacing time and, therefore, reduces the possibility of beaching or of being stolen at the surface). This has been implemented in some marginal seas. In particular, for the Mediterranean and Black Seas, about 74% of the floats are using Iridium telemetry and the downlink has been used occasionally to change the cycling and sampling parameters of some floats.

In 2017, two deep floats (Deep Arvor with maximum depth of 4000 m) have been deployed in the deepest areas of the Mediterranean (NE Ionian Sea). In early 2017, one of these floats was still alive, providing profiles as deep as 3000 m.

A major issue mostly specific to the marginal seas is the operation of floats in many EEZs and territorial waters of different countries. The notification of deployments through the AIC and the notification by sending a report letter to the Argo national focal points when floats are entering the EEZs of some countries (e.g., Turkey, Egypt, see list in the AIC) should be a common routine practice.

Marginal Sea	Floats alive in early 2014	Floats alive in early 2015	Floats alive in early 2016	Floats alive in early 2017	Target density
Sea of Japan	40	40	40	50	**16**
South China Sea	8	12	8	**16**	**22**
Gulf of Mexico	8	15	15	**15**	**20**
Caribbean	8	10	12	**13**	**38**
Red Sea/Gulf of Aden	2	2	2	8	**8**
Persian Gulf/Gulf of Oman	8	8	5	**4**	**10**
Mediterranean	60	60	74	80	**56**
Black Sea	10	10	9	11	**10**
Indonesian Seas	1	2	6	**3**	**14**
Sea of Okhotsk	0	2	2	**0**	**8**
TOTAL	**145**	**177**	**176**	**200**	**201**

Table 1. Implementation of Argo in Marginal Seas in early 2017

8. Demonstrating Argo's value

8.1. Argo bibliography

M. Scanderbeg opened her presentation on the status of the Argo bibliography by noting that there were slightly fewer papers published last year in 2016 than in 2015. Fearing that some may have been missed in her searches, she looked at all the papers submitted in the National Reports for the meeting and had that her searches had about the same success rate as for the past several years. Therefore, she thinks that papers might be missing because they are using secondary and tertiary sources of Argo and no longer citing them. For example, model outputs or gridded products that use Argo, but authors no longer mention this. One way to solve this problem would be to search for papers based on model outputs or grids that use Argo data.

M. Scanderbeg also began trying to make more use of the Argo bibliography by sorting papers into categories like Oceans, Argo extensions and various subjects. The idea being that capsule bibliographies could be formed on various subjects that can be used to quickly show research Argo has been involved in. This idea was met with interest and each AST member agreed to send in a PowerPoint slide featuring a favorite Argo paper including a figure and a short paragraph describing the paper and why it is interesting. In addition, more collaboration with IFREMER and JCOMMOPS to improve statistics from the Argo bibliography were encouraged.

M. Scanderbeg noted that the various Argo DOIs are being cited more than in 2015, but most papers are still not using them. She hopes this will improve over time with more knowledge of the DOIs, with Fred Merceur from IFREMER emailing authors with papers in press using Argo data, with an Argo Data Paper and with more journals requiring DOIs for data sources.

Finally, M. Scanderbeg showed the thesis citation list and noted that the number of theses using Argo data continues to grow and thanked all AST members who sent theses to her for inclusion on the list since gaining full access to theses is more difficult than for papers.

> **Action item 25:** Reach out to OceanView GODAE community and seasonal forecasting community to find Argo papers. Continue to track regions and topics. M. Scanderbeg, P. Oke
>
> **Action item 26:** Ask AST members to nominate their favorite Argo discovery papers. This request for one slide with text and figures will be into the National Reports request annually. M. Scanderbeg will assemble the slides into a slide package available to the AST and other Argo scientists for use in talks, outreach, etc. AST members

8.2. Argo Steering Team Website

M. Scanderbeg reported on several possible updates to the AST website. Most of them were related to Action Items from AST-17. She presented the wording on the description of Argo and its extensions and received feedback that the emphasis was incorrect. Instead of sounding like Argo was not successful prior to the expansion to global Argo, the words need to be adjusted to show Argo was great before and even better now.

Next, she presented on the Standard Depth Levels products proposed to be added by G. Maze. Everything looked fine and these products will be added to the 'Argo Products' page, formally known as the 'Gridded Fields' page.

S. Wijffels came to Scripps during the year and was able to work with M. Scanderbeg on updating some of the plots on the 'Global Change Analysis' page. These were presented and the AST suggested changing the name to 'Global Research' to reflect the actual content of the pages.

At the previous AST meeting, it was requested that each Argo extension draft a document describing the status. This was modified a bit and decided it would be great to make available on the AST website as many people are wondering about the status and content of these extensions. To this end, each extension was asked to submit the following information in order to create a web page: design, technical challenges (if applicable), pilot arrays, links to related pages and task team leads. Polar Argo submitted a draft that was presented at the meeting. http://www.argo.ucsd.edu/Polar_Argo.html BGC-Argo also has a document, but the web page has not yet been created. The other extensions were reminded of their task and agreed to work on this.

In the discussion following the presentation, the AST wanted to make sure it was clear that these extensions are endorsed by Argo, but that does not mean that they are funded. Different extensions are at different stages of development and funding and it was requested that each extension add to its page a statement about the cost to make the extension happen.

M. Scanderbeg noted that J. Gilson was working with S. Wijffels to get some ocean heat content anomaly plots updated regularly based on several different gridded Argo products. During discussion, N. Kolodziejezyk offered that he may have some plots showing this type of information already and it was agreed to explore this option.

Finally, M. Scanderbeg noted that several photos, movies and outreach material had been added in the last year. If anyone is interested in adding media or outreach stories, please contact M. Scanderbeg. This material is always welcome.

> **Action item 27:** Update wording on Future Argo to reflect that increased funding is needed in order to implement all the extensions. Ask extensions to provide estimated cost if possible. M. Scanderbeg

> **Action item 28**: Work on improving Global Research page. M. Scanderbeg, interested AST members

8.3. New Argo Brochure

The draft new Argo brochure was circulated and discussed. Some useful feedback was received. Many countries expressed a desire to receive an editable pdf file so that the text can be retained, but translated. We believe this can be accommodated. The committee preparing this was encouraged to complete this project and we were pleased to hear that China remains willing to offer printing services in multiple languages.

> **Action item 29:** Finalize Argo Brochure, print and distribute. M. Scanderbeg, H. Freeland, B. Greenan, M. Belbeoch, E. Rusciano, China Argo

8.4. Upcoming science conferences and workshops

8.4.1. Argo Science Workshop

Ideally, the AST felt that an Argo Science Workshop (ASW) should be held about a year before OceanObs'19 which would mean the fall of 2018. There has been an offer to hold an ASW aside the next AST-19 meeting, but it was thought that this would be too early. T. Suga offered that JAMSTEC could host an ASW in the fall of 2018 and this idea was well received. There was some discussion about whether the ASW should be held in conjunction with another group as has been done in the past. The general feeling was that the meeting in Galway, held in conjunction with GO-SHIP, had been very successful. The AST suggested that perhaps JAMSTEC could explore this idea of a co-sponsored workshop through its Japanese GO-SHIP partners.

> **Action item 30:** Form working group to plan Argo Science Workshop in fall of 2018 at JAMSTEC. AST executive committee, other volunteers.

8.4.2. OceanObs'19

Argo is planning on submitting several papers to OceanObs'19 and holding an Argo Science Workshop a year prior will help in the preparation. In addition, the discussion on Argo's sustainability, later in the Agenda, could also turn into a white paper submission. In general, the AST encouraged members to think about how Argo will prepare for this important meeting.

8.4.3. Technical Workshops

B. King presented a proposal for technical workshops, based on ideas assembled by Wijffels, Riser and King. The last such workshop was an APEX workshop in 2005. The main drivers for this would be twofold: (1) Re-establish connections across technical teams to exchange best practices and improve outcomes (2) Increase vigilance of technical performance of the array, eg by examining in detail the evolution of new controllers and hardware in float types used across many user groups.

The workshops would include days dedicated to particular platforms with a wide user base, eg APEX, NAVIS, ARVOR, and to particular sensors, eg the established SBE41, and the CTDs whose performance is being evaluated: SBE61, deep SBE41 and RBR. The discussion will need to be partitioned into discrete workshops so that manufacturers can be asked to participate in the discussions pertinent to their products.

The proposed timing is September 2017 in Seattle, hosted by UW, probably the week of September 11-15. It is anticipated that discussion will run over 4 or 5 days. The agenda and structure will be developed by Wijffels, Riser, and King.

It is anticipated the discussions will include the following topics: acceptance and pre-deployment testing; mission programming, including energy budget and sampling strategy (near-surface or deep); sensor performance: bias and drift.

It was noted that the selection of topics to discuss was not comprehensive of all platforms and sensors used across Argo, and does not indicate a preference or endorsement of those platforms and sensors by AST. The specific workshops are not sponsored or requested by AST. Rather, a subset of Argo users with common interests and concerns will gather to discuss their practices and to engage their suppliers on current developments. AST encourages all user groups to examine the performance of their programs and take whatever steps are appropriate to make improvements.

> **Action item 31:** User groups are encouraged to move ahead with planning CTD and float platform workshops. B. King, S. Riser, S. Wijffels

8.4.4. Deep/DOOS

There was a DOOS workshop recently at Scripps Institution of Oceanography and Argo representatives were present. It was agreed that Argo is on DOOS's Agenda and that things seem to be working well for now. The idea of another Deep Argo workshop was briefly discussed and one may be needed, but nothing was planned.

8.5. 1st Ocean Observers Workshop

E. Rusciano, JCOMMOPS Science & Communication Coordinator, reported on the educational workshop, the 1st Ocean Observers workshop, which will be held during 13-14 June 2017, in Brest, France, at the Océanopolis Aquarium.

E. Rusciano illustrated how the workshop is organized and structured, the objectives of the workshop, she mentioned some financial aspects of the organization and she concluded with some actions to be taken during the next three months.

The Ocean Observers workshop is jointly organized by JCOMMOPS and the European contribution to the Argo Program with some help several partners. The aim of the workshop is to bring together ocean scientists, educational authorities and teachers, the sailing community, and marine communicators who are willing to share and gather experiences on educational activities related to several *in situ* ocean observations.

E. Rusciano explained that even if most of the activities and talks presented during the 2 day-workshop will be mainly focused on Argo activities, the organizers decided to open the workshop to several in situ ocean observers, including floats, drifters, marine mammals and ships.

E. Rusciano showed the workshop presentation flyer provided by "*mon ocean & moi*" website, developed by the *Laboratoire d'Océanographie de Villefranche (LOV)*. Thanks to the LOV the image was modified and adapted to suit the workshop.

E. Rusciano identified the main workshop objectives:
1. To give educators marine science information (which they could apply to their unique environments according to education/public level, internet accessibility, technical aspects, etc.) to raise awareness of the importance of the ocean for human life among school children and local communities.
2. To encourage discussions and collaboration between people engaged in marine science outreach activities.
3. To engage "new schools", educators, the general public and private associations in ocean observing outreach activities.
4. To assemble all existing educational materials in a unique repository under the UNESCO auspices (*e.g.* OceanTeacher Global Academy).
5. To build a global ocean observations learning platform using Argo, Buoys and other networks as multidisciplinary educative vectors.
6. To ensure that marine science research can be integrated into School Sciences and ocean observations can remain a priority for communities.

The workshop is organized around four sessions that will take place over two days. After a 30 minute OPENING SESSION, given by the Brest Aquarium and Science Park Directors, there will be a **SCIENCE SESSION** covering the role of the ocean and its impact on the planet's life, the meteorological and oceanographic observations using different platforms (Argo floats, drifters, marine mammals and ships). The session will be convened by four scientists and several representatives of scientific institutes to illustrate scientific initiatives carried out worldwide to promote ocean observations. A visit to the aquarium and a cocktail hour will close the first day.

The second day of the workshop will focus on **EDUCATION & GENERAL PUBLIC activities.** The morning will be focused on teachers and educators, aquarium, sailing communities, and associations who will illustrate the activities conducted with schools and the general public to disseminate knowledge in ocean science through ocean observations or for those institutes. Associations which are not yet involved in ocean observations will illustrate how to integrate observations in their outreach programs.

During the FINAL SESSION there will be open discussion and brainstorming to study the future possibility of creating an ocean observing learning platform where all educational materials will be checked and validated by a commission composed by different representatives of observing networks.

E. Rusciano illustrated also some technical and financial aspects of the workshop:
Only Jcommops and EuroArgo are financially contributing to the workshop organization.
E. Rusciano listed the workshop needs: conference venue, staff venue and catering for a total amount of about 5kEuros. Rusciano explained that some needs (travel support for teachers coming from New Zealand and simultaneous translation from French to English and vice-versa for French teachers who are not familiar with English) are not yet confirmed because of a lack of budget at the moment.

To conclude the presentation on Argo education workshop E. Rusciano prepared a short list of what actions the organizers intend going forward in the next 3 months:

- Fix the agenda according to the keynote speakers' responses
- Look for others ongoing initiatives, over and above those already mentioned
- Select keys attendees and send out invitations considering that the number of participants is limited to 60 people; (the room can accommodate up to 84 people)
- Look for more sponsors.

On these bases, E. Rusciano asked the Argo community to let the organizers know about other outreach activities and school authorities/teachers who would be interested to participate in the workshop.

Action item 32: Explore how to implement Twitter better. M. Scanderbeg, M. Belbeoch, E. Rusciano

8.6. Earth.nullschool.net

9. Discussion of Argo's sustainability

D. Roemmich opened the discussion on Argo's sustainability by noting that he had drafted the current document but that it should evolve collaboratively in its next version. Several AST members agreed to review the paper and provide tracked changes versions. T. Suga and M. Baringer agreed to co-edit the revision process. The thought is that this document can become a white paper for OceanObs'19.

Roemmich stated that there will be interest in this document, as other observing systems with similar issues will be watching to see how Argo proceeds. He noted that first Argo needs to recognize the challenge in sustaining Argo and then it can look at what can be done to sustain it. He noted that the AST tends to focus on Argo one year at a time, but that we need to consider longer time scales as well. When he rotates out of the AST co-chair position, he envisions being able to take this long viewpoint and to be helpful in this perspective.

Can Argo attract new scientific and technical leadership?
The first topic covered was whether Argo can attract new science and technical leadership. D. Roemmich pointed out that only 25% of Argo papers are written by Argo PIs and that there are few tangible rewards in creating the Argo dataset. He posed a series of questions

including how do we attract new scientific and technical leaders? How can we convince institutions of this value? There has been some improvement as institutions are starting to give credit for the creation of databases, but this likely is not enough. S. Wijffels stated that AST members come from different nations and institutions and it would be valuable to hear about how this question might be answered across these diverse places. B. King said that within the UK, several revisions have been made to the criteria for advancement and that Argo should be mindful of what those criteria are so that it can provide an attractive career opportunity. S. Wijffels said that in Australia, the number of papers and products created is useful, but she is also asked what her research can do for society. Argo is great for this and maybe Argo as a program should more clearly articulate its socio-economic impacts.

P. Oke mentioned that mentoring students and post-docs might be useful since many of the scientists in the room are involved in Argo because they feel it is the right thing to do, regardless of papers written or the dataset created.

S. Piotrowicz feels that there is a general problem with PhD students not being interested in going to sea, developing instruments, etc. Instead, most students are interested in modeling or using currently available datasets like Argo.

S. Wijffels wondered if it would be useful to invite a few young scientists to some of the Argo meetings to see how it works. Overall, this idea was met with approval and agreed that it should be pursued. Offering float deployment opportunities might be another way to get young scientists and students involved. Even reaching out to undergraduate students could be helpful.

Can Argo preserve its essential nature while renewing its leadership team?

Argo is more varied now and not everyone may be centered on the global scale perspective of Argo's founding generation. New view points are valuable, but there is need to preserve the global perspective. The question is what is the appropriate balance? B. King mentioned that WOCE did this through a very detailed implementation plan whereas Argo relies more on corporate memory. He suggested that some of this memory could be better documented. There was some discussion on core Argo and Argo extensions and that Argo needs to continually evaluate how to incorporate these extensions without sacrificing core Argo.

Next the discussion focused on the idea of involving major user group representatives at the meetings. For example, Argo could invite people from the satellite community or the climate reanalysis community to keep pushing for global Argo.

Can Argo take on new missions without endangering Core Argo?

Everyone agrees that new programs are more exciting to funders than ones that have been going on for 20 years and BGC and Deep Argo are very exciting new programs. The AST has tried to be clear that these new programs should not infringe on core Argo, but this may prove to be difficult to do in practice.

B. Greenan pointed out that BGC Argo and Argo do not have to be mutually exclusive – that BGC Argo floats often perform the core Argo mission. However, additional money is needed to replace a BGC float which usually dies prior to a core Argo float and to do the data processing which is more involved and can involve several different experts rather than one dmode processor.

The AST came to the general conclusion that Argo as a program needs to do a better job of promoting itself and its usefulness to other communities like meteorological and satellite ones. Both Korean and Indian AST members noted that once a clear link was established between Argo float data and meteorological centers/weather predictions, funding for Argo flowed much more easily.

The flat funding issue: Is Argo best framed as research or Operational Oceanography?
D. Roemmich pointed out that some countries fund Argo as an operational program while others view it as a research program. In general, research funding only decreases or disappears while operational challenges include achieving good lifetimes and high quality data. Neither of these is an ideal solution.

EuroArgo, France and Australia all have a research infrastructure where funding is still subject to changing, but less frequently and usually not as drastically. If other countries could move towards this research infrastructure funding, it would be very beneficial to Argo.

Can the integrated observing system be sustained along with Argo?
It was pointed out that each part of the observing system is reviewed separately, but that the real value is in its integration. The AST agreed that it would be difficult for Argo to exist if GO-SHIP stopped.

Operational issues
The first issue to come up under this topic is that only three countries pay for a dedicated deployment ship: the R/V Kaharoa which has deployed many, many floats in hard to reach areas and global coverage for Argo would not be possible without it. M. Belbeoch pointed out that JCOMMOPS has tried to offer other such ships to deploy floats and encouraged AST members to contact him if interested.

Both S. Riser and E. van Wijk agreed that under-ice floats seem to be achieving good lifetimes and that this technological difficulty will be overcome.

At that point, the AST needed to close the discussion in the interest of finishing the meeting on time. More work will be done on the document and further sustainability discussions were encouraged.

> **Action item 33:** Review, edit and send tracked changes version of the Argo Sustainability paper to AST-chairs, M. Scanderbeg, T.Suga and M Barringer. AST co-chairs, M. Scanderbeg, T. Suga, M. Baringer, H. Freeland, S. Riser, S. Piotrowicz, E. van Wijk, M. Belbeoch, B. King, S. Poliquen, B. Owens, P. Sutton, P. Rao, E. Rusciano

> **Action item 34:** Create a presentation for operational communities demonstrating Argo's importance.

10. Future meetings
10.1. ADMT-18

The ADMT-18 meeting will be held at BSH in Hamburg, Germany during the last week of November. A BGC-Argo data management meeting will take place just prior to the ADMT plenary meeting that week.

10.2. AST-19

The AST-19 meeting will be held at IOS in Victoria, BC, Canada.

11. AST membership, BGC Argo, Argo Director

S. Wijffels is moving to Woods Hole Oceanographic Institute later this year and has agreed to take over as the US AST co-chair leaving D. Roemmich free to step down from that position, but maintain his role as a US AST member. The new international AST co-chair will be T. Suga, but he is unable to take over duties until the next AST meeting due to prior commitment as chair of his department at Tohoko University. Therefore, for a period of six months, both S. Wijffels and D. Roemmich will be US AST co-chairs.

H. Freeland is stepping down as Argo Director and his wonderful service to Argo was recognized. He will help prepare for and attend the AST-19 meeting next year, but will not travel anymore for Argo. Instead, B. Owens was nominated to accept the Argo Director position and he agreed.

In other AST member changes, Ravi is stepping down as the Indian AST member due to the fact that he is now the director for the National Centre for Antarctic and Ocean Research in India. Mr. Pattabhi Rama Rao will be taking over as the Indian AST member. He has been involved in data management at INCOIS.

With Susan's absence from CSIRO, Peter Oke will be taking over for her as the Australian AST member. Peter comes from the ocean modeling community.

Action item 35: Ask BGC Argo to nominate people for both AST and ADMT executive committees. BGC Argo

Action item 36: AST endorses BGC Argo as a subcommittee. AST

12. Other business: G7 Report

B. Greenan reported on the G7 Science Ministers meeting in Tsukuba, Japan which took place in May 2016. Ministers recognised that the seas and oceans are changing rapidly, with overuse and destruction of marine habitats, warming, increased ocean acidity and depleted oxygen. They agreed that the health of the oceans has rightly been recognised as a crucial economic development issue through the adoption of a specific United Nations (UN) sustainable development goal (SDG 14 - to 'conserve and sustainably use the oceans, seas and marine resources for sustainable development'). In support of achieving this goal, and other relevant goals, including the closely related SDG 13 (to 'take urgent action to combat climate change and its impacts'), Ministers supported further action to develop the far stronger scientific knowledge necessary to assess ongoing ocean changes and their impact on economies, and to develop appropriate, coordinated policies to ensure the sustainable use of the oceans and seas. Five action items were identified as priorities in the communique.

A workshop of technical and policy experts from G7 countries was then held in November 2016 at the UK's National Oceanography Centre in Southampton to discuss and refine the communique action proposals. The expert group recognizes that the complexity of the challenges for long-term sustained action to achieve an effective advancement in our observation of the oceans and seas. Broadly, experts suggest that the G7 nations use this initiative to strengthen international collaboration, particularly on areas beyond national jurisdiction. To this end, the goal of the expert suggestions is to realize a more efficient and effective network of scientific ocean observing which supports the conservation and sustainable use of resources from the seas and oceans. Extension of the Argo network (BGC-Argo, Deep Argo) is provided as one example of the programs under Action 1(Enhanced Ocean Observation) that should be a priority for the G7.

Action item 37: Write short piece on float contamination for circulation to general public S. Wijffels, S. Riser

Argo Steering Team Meeting (AST-18)
Hobart, Tasmania, March 14-16, 2017
Host: CSIRO

AST Exec meeting: 13 March

AST-18: 14 March 9h00 – 16 March 15h00

Location: Waterside Meeting Room at CSIRO Marine Laboratories

1. 9h00 Welcome ()

2. 9h10 Local arrangements

3. 9h20 Objectives of the meeting/adoption of the agenda

   Argo's sustainability

4. 9h40 Status of action items from AST-17 (M. Scanderbeg)

5. Implementation issues
   - 5.1 9h50 Update commitments table including global Argo, extensions and equivalent floats (M. Scanderbeg)
   - 5.2 10h10 AIC Report on the Status of Argo (M. Belbéoch)

10h30 – 11h00 break

   - 5.3 11h00 JCOMM Observing Program Support Centre (M. Belbéoch)
   - 5.4 11h15 AIC Funding (H. Freeland)
   - 5.5 11h30 Australian Argo (S. Wijffels)
   - 5.6 11h50 Japan Argo (T. Suga)
   - 5.7 12h00 Discussion items from National Reports

12h00 tour of R/V Investigator and lunch

   - 5.8 13h30 An Argo Data Paper and advancement of Argo DOIs (S. Wijffels, J. Buck)

6. Data Management and related issues
   - 6.1 13h45 Feedback from ADMT-17 (S. Pouliquen)
   - 6.2 14h15 Proposal on definition of Argo float and handling non-approved sensors and parameters (M. Scanderbeg)
   - 6.3 14h45 Proposal on mandatory and highly desirable CONFIG parameters and maintenance of meta and tech tables (E. van Wijk)

15h15 – 15h45 break

   - 6.4 15h45 Trajectory V3.1 files (M. Scanderbeg)
   - 6.5 16h00 DMQC frequency (S. Pouliquen)
   - 6.6 16h15 Positioning for under-ice floats (E. van Wijk, B. Klein)

6.7 16h45 CTD Reference data & how to describe the quality of each station (S. Diggs)
6.8 BUFR format for BGC floats (J. Turton)

End of day one

17h45 – 18h45 evening reception

19h00 – Public lecture by Ken Johnson

7. Regional science, education and outreach
   7.1 9h00: "The impact of Argo data in the latest Bluelink ReANalysis" by Peter Oke
   7.2 9h20: "East Australian Current eddies from Argo float data" by Tatiana Rykova
   7.3 9h40: "Crucial ocean observations for multi-year prediction" by Terence O'Kane

10h00 – 10h30 break

8. Technical issues
   8.1 10h30 Recent float performance evaluation of array (M. Belbéoch, B. King)
   8.2 Sensor progress:
      11h00 RBR – B. Owens
      11h15 SBE61 and SW Pacific Pilot array status – N. Zilberman and D. Roemmich with contributions from others (B. Sloyan/RV Investigator cruise)
      11h30 SBE41cp below 2000db – T. Suga and G. Maze resolving source of the biases and general accuracy
      12h00 Procedures to prepare SBE CTDs for storage (B. Owens)
   8.3 12h15 Documenting pressure sensor performance (S. Riser)

12h30 – 14h00 lunch

9. Completing the global mission and exploring extensions

   9.1 Review of Deep Argo Pilot Arrays and any technical updates on Deep Argo floats:
      14h00 North Atlantic – V. Thierry & G. Maze, N. Zilberman
      14h15 South Atlantic – G. Johnson, N. Zilberman
      14h30 Indian Ocean – T. Suga, N. Zilberman
      14h45 Southern Ocean – T. Suga with input from S. Rintoul et al

15h00 – 15h30 break

   9.2 15h30 Status of Argo extensions (M. Belbéoch)
      15h45 BGC-Argo (K. Johnson, H. Claustre)
      16h00 Western Boundary Currents (T. Suga)
      16h15 Near-equatorial enhancements (D. Roemmich)
      16h30 Polar Argo - Arctic/SOOS (B. Klein/E. Van Wijk)
      16h45 Marginal Seas (M. Belbeoch for P-M Poulain)

End of day two

10. Demonstrating Argo's value
    10.1 9h00 Argo bibliography (M. Scanderbeg)
    10.2 9h15 Argo Steering Team Website Updates (M. Scanderbeg)
    10.3 9h30 New Argo Brochure (JCOMMOPS, H. Freeland, M. Scanderbeg)
    10.4 9h45 Upcoming science conferences and technical workshops –
        ASW?
        OceanObs 19
        Technical Workshops (S. Wijffels, S. Riser, B. King)
        Deep?/DOOS?

10h00 – 10h30 break

    10.5 10h30 1st Ocean Observers Workshop (E. Rusciano)
    10.6 10h45 Earth.nullschool.net (S. Diggs)
    10.7 Other Argo outreach activities –

11. 11h00 Discussion on Argo's sustainability

12h30 – 14h00 lunch

12. Future meetings
    12.1 14h00 ADMT-18
    12.2 14h15 AST-19

13. AST Membership, BGC Argo, Argo Director

14. Other business: G7 report (B. Greenan)

15. Review of action items

Meeting adjourns Thursday 16 March, 5 p.m.

Last Name	First name	Affiliation
Baringer	Molly	NOAA/AOML
Belbeoch	Mathieu	JCOMMOPS
Cao	Minjie	Second Institute of Oceanography
Claustre	Herve	CNRS
Cowley	Rebecca	CSIRO
Diggs	Steve	Scripps Institution of Oceanography
Freeland	Howard	Institute of Ocean Sciences
Greenan	Blair	Fisheries and Oceans Canada
Hosoda	Shigeki	JAMSTEC
Jayne	Steven	Woods Hole Oceanographic Institute
Johnson	Ken	MBARI
Kang	KiRyong	Korea Meteorological Administration
King	Brian	National OceanographyCentre
Kolodziejezyk	Nicolas	IFREMER
Lee	Jong-ho	Korea Meteorological Administration
Liu	Zenghong	Second Institute of Oceanography
Maze	Guillaume	IFREMER
Nakano	Toshiya	JAMSTEC
Owens	Brechner	Woods Hole Oceanographic Institute
Piotrowicz	Stephen	NOAA
Pouliquen	Sylvie	IFREMER
Rama Rao	Pattabhi	INCOIS
Riser	Stephen	University of Washington
Roemmich	Dean	Scripps Institution of Oceanography
Rusciano	Emanuela	JCOMMOPS
Scanderbeg	Megan	Scripps Institution of Oceanography
Suga	Toshio	JAMSTEC/ Tohoku University
Sutton	Phil	NIWA
van Wijk	Esmee	CSIRO
Wan	Fangfang	National Marine Data and Information Service
Wijffels	Susan	CSIRO

Zilberman	Nathalie	Scripps Institution of Oceanography

	Action	Responsibility	Status
1	Write letter of thanks to local host CSIRO	D. Roemmich	
2	Establish a working group to better describe how equivalent floats fit into global Argo. The AST would like to see the equivalent floats “converted” into ‘core’ Argo floats.	M. Belbeoch, B. Owens	
3	Revisit percentage targets for quality, timeliness and spatial completeness on the AIC website because 95% may be too high.	M. Belbeoch, AST co-chairs, ADMT co-chairs	
4	Produce a draft outline for the Argo data paper with S. Wijffels and J. Buck to be coordinating lead authors. Seek other Argo authors to contribute sections as needed. Request list of authors from each National Program keeping in mind scientists, data managers, DMQC operators, etc.	S. Wijffels, J. Buck, National Programs	
5	Ask WHOI, UW, India, NAVO, and PMEL to take immediate action for floats that continually fail Altimetry comparison and OA tests by Coriolis. If no action is taken, the AST co-chairs will follow-up. Ask other programs need to continue providing feedback quarterly. Get website link to JCOMMOPS	WHOI, UW, India, Navo, PMEL, AST co-chairs	
6	Add description of sampling requirements to documents describing what is an Argo float. Change approved sensors to only SBE. When complete, post information on Argo websites	M. Scanderbeg, B. King, B. Owens, S. Wijffels	
7	AST endorses the Auxiliary directory and information about it should be posted on Argo websites.	AST, M. Scanderbeg	
8	AST endorses the idea that configuration missions should be minimized.	AST, ADMT	
9	AST endorses the concept of mandatory CONFIG parameters and understands that DACs may need to estimate or calculate some of these	AST, ADMT	
10	Ask E. van Wijk and J. Gilson to send out new version of the meta table and the results of the census on the contents of the meta files. Ask DACs to study and respond.	E. van Wijk and J. Gilson, DACs	
11	Work with manufacturers to adopt Argo language	AST,	

	in their manuals. Explore the possibility of adding measurement codes for trajectory files into the manuals as well.	manufacturers	
12	AST suggests ADMT consider holding a decoding workshop for v3.1 trajectory files for DACs at an upcoming meeting to help produce more accurate and consistent v3.1 trajectory files.	ADMT, DAC managers	
13	AST endorses prioritizing DMQC for possible anomalous floats identified using Altimetry Comparison and OA tests. AST agrees to relax drift DMQC revisit frequency to 1 year, but point-wise DMQC should be done more frequently. Explore making revisit time dependent upon float age. Consider ways to monitor this at the GDAC or AIC level	ADMT, DMQC operators, Thierry Carval, M. Belbeoch	
14	AST asks that ADMT consider holding another DMQC workshop to study consistency across operators and share tools	ADMT, DMQC operators	
15	AST suggests that intermediate RAFOS timing information reside in AUX files. Previously agreed upon format for v3.1 trajectory file can be used.	RAFOS PIs	
16	AST co-chairs, J. Turton, P. Oke to liase with operational modelers to find out if they are using BUFR or TESAC messages from the GTS	AST co-chairs, P. Oke, J. Turton	
17	K. Johnson, H. Claustre, J. Turton explore adding BUFR format template for appropriate BGC parameters	BGC-Argo co-chairs, J. Turton	
18	AST suggests updating Argo User manual with suggested words for BATTERY_TYPE variable in meta file. Important to capture three categories for now: Alkaline, Lithium, Hybrid Lithium, “mixed”.	E. van Wijk, T. Carval	
19	Adjust monitoring maps for increased density and spatial extensions to reflect which parts are funded and which are not. Consider graying out regions that are not funded.	AST co-chairs, M. Belbeoch	
20	Reach out to regional GOOS alliances to seek their assistance in deployment in unsampled	AST co-chairs, T. Moltmann	

	areas.		
21	Ask Mathieu to study Deep Argo deployment plans and active Deep Argo floats to ensure that everything is in the AIC database.	M. Belbeoch	
22	Ask CCHDO to work to get CTD casts with Deep Argo deployments for inclusion into Argo Ref DB.	CCHDO, Deep Argo deployers	
23	Ask CCHDO to collect and hold SBE61 test data taken on CTD voyages to allow community analysis. Can be privately held for Argo users.	CCHDO, Deep Argo deployers	
24	M. Belbeoch and T. Suga work together to redefine WBC regions	M. Belbeoch, T. Suga	
25	Reach out to OceanView GODAE community and seasonal forecasting community to find Argo papers. Continue to track regions and topics.	M. Scanderbeg, P. Oke, ?	
26	Ask AST members to nominate their favorite Argo discovery papers. This request for one slide with text and figures will be into the National Reports request annually. M. Scanderbeg will assemble the slides into a slide package available to the AST and other Argo scientists for use in talks, outreach, etc.	AST members	
27	Update wording on Future Argo to reflect that increased funding is needed in order to implement all the extensions. Ask extensions to provide estimated cost if possible.	M. Scanderbeg, AST co-chairs	
28	Work on improving Global Research page.	M. Scanderbeg, interested AST members	
29	Finalize Argo Brochure, print and distribute	M. Scanderbeg, H. Freeland, B. Greenan, M. Belbeoch, E. Rusciano, China Argo	
30	Form working group to plan Argo Science Workshop in fall of 2018 at JAMSTEC	AST exec committee, other volunteers	
31	User groups are encouraged to move ahead with planning CTD and float platform workshops.	B. King, S. Riser, S. Wijffels	

32	Explore how to implement Twitter better	M. Scanderbeg, M. Belbeoch, E. Rusciano	
33	Review, edit and send tracked changes version of the Argo Sustainability paper to AST-chairs, M. Scanderbeg, T.Suga and Molly B.	AST co-chairs, M. Scanderbeg, T. Suga, M. Barringer, H. Freeland, S. Riser, S. Piotrowicz, E. van Wijk, M. Belbeoch, B. King, S. Poliquen, B. Owens, P. Sutton, P. Rao, E. Rusciano	
34	Create a presentation for operational communities demonstrating Argo's importance		
35	Ask BGC Argo to nominate people for both AST and ADMT executive committees.	BGC Argo	
36	AST endorses BGC Argo as a subcommittee	AST	
37	Write short piece on float contamination for circulation to general public	S. Wijffels, S. Riser	

	2017 core estimated	2017 equiv estimated	2017 BGC Argo estimated	2017 Deep Argo estimated	2017 Polar Argo estimated	2017 Marginal Seas estimated	2017 WBC estimated	2017 Equatorial regions estimated	2018 estimated	2018 equiv estimated	2018 BGC Argo estimated	2018 Deep Argo estimated	2018 Polar Argo estimated	2018 Marginal Seas estimated	2018 WBC estimated	2018 Equatorial regions estimated		Notes
Argentina																	Argentina	
Australia	38	2							32								Australia	
Brazil																	Brazil	
Bulgaria																	Bulgaria	Argo program in Bulgaria is uncertain with no commitment decided
Canada	31	8 (polar)	5		3 (also BGC)				25	4 (polar)	2 (also polar)						Canada	
Chile																	Chile	
China	15	30							15	30							China	China is formulating the 13th five-year plan (2016-2020), the number of deployed float in the next few years depends entirely on the amount of funding.
Costa Rica																	Costa Rica	
Denmark																	Denmark	
Ecuador																	Ecuador	
European Union	**90**		**6**	**4**		**5**											**European Union**	7 argo deep and 6 Bio bought in 2016 deployed in 2017 within ATLANTOS project MOCCA EC bought in 2016 130 additionnal T&S floats deployed in 2016-2017 Discussion going on with EC for Deep and BCG floats but nothing is signed so far
Finland		3								3							Finland	3/yr 2016-2020
France	65	15							65	15							France	80/yr 2016-2020
Germany	40	13			9		5		34	12			9		5		Germany	The 25 equivalent floats for 2017 are those going to be deployed by Olaf Böbel at the end of2016/early 2017 in the Weddell Gyre
Greece		5								5							Greece	5/yr 2016-2020
India	30		10						30		10						India	40 floats/yr 2012-2017
Ireland	3								3								Ireland	3/yr 2016-2020
Italy			3		15	12			15	20							Italy	20/yr in marginal seas; 15/yr in open ocean
Japan	20	24	4	3	0	0	12	0				2					Japan	
Korea (Republic of)						13											Korea (Republic of)	
Lebanon																	Lebanon	
Mauritius																	Mauritius	floats provided by UK, aim for up to 4 per year
Mexico																	Mexico	
Netherlands	10								5								Netherlands	5/yr 2016-2020
New Zealand	2								2								New Zealand	
Norway	3								3								Norway	3/yr 2016-2020
Peru																	Peru	
Poland	3								3								Poland	3/yr 2016-2020
South Africa																	South Africa	
Spain	2					3			5					3			Spain	3/yr 2016-2020
Turkey																	Turkey	
UK	34	6							34	6							UK	40/yr 2016-2020
USA																	USA	
	386	98	28	7	24	33	17	0	271	91								
	2017 estimated	2017 equiv estimated	2017 BGC Argo estimated	2017 Deep Argo estimated	2017 Polar Argo estimated	2017 Marginal Seas estimated	2017 WBC estimated	2017 Equatorial regions estimated	2018 estimated	2018 equiv estimated	2018 BGC Argo estimated	2018 Deep Argo estimated	2018 Polar Argo estimated	2018 Marginal Seas estimated	2018 WBC estimated	2018 Equatorial regions estimated		

Page 3

Argo Australia – 2016 Activities

Report to the 18th Argo Steering Team Meeting

Susan Wijffels, Bec Cowley, Esmee Van Wijk,
Catriona Johnson, Alan Poole, Craig Hanstein

CSIRO Oceans and Atmosphere

Lisa Krummel
Australian Bureau of Meteorology

1. Status of implementation

Floats deployed and their performance

Australia currently has 386 floats actively reporting good data across the Indian, Pacific and Southern Oceans (Figure 1).

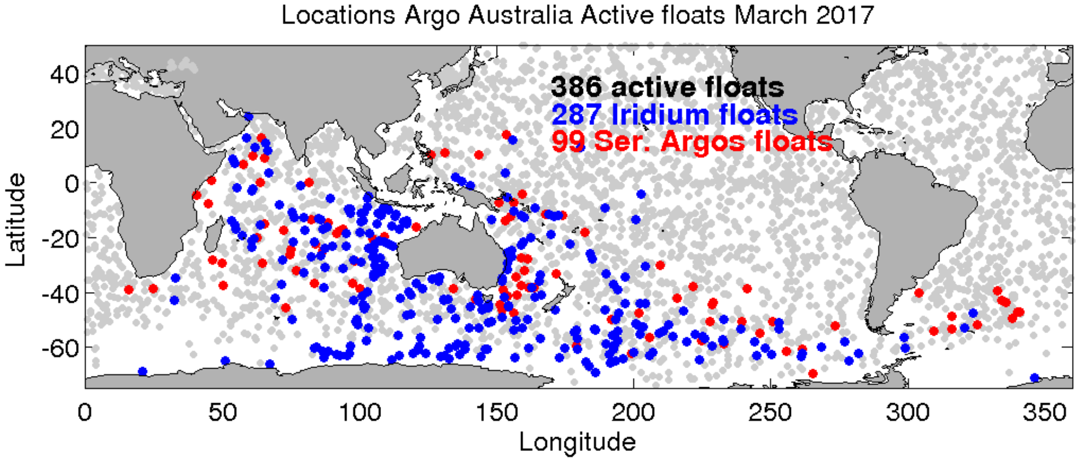

Figure 1. Locations of active Argo Australia floats (colours – defined as float reporting in the last 15 days north of 55°S, in the last half year south of 55°S) as of January 2016 with active international floats in gray. Australian floats using Iridium Communications are in blue and those using Service Argos in red.

In the calendar year 2016, the program deployed 75 floats mainly spread throughout the western Pacific, Indian and in the Southern Oceans (see Figure 2). Our focus on seeding the area between Indonesia and northwest Australia continued. Again, we particularly thank Katsurou Katsumata from JAMSTEC for his outstanding assistance and we thank BPPT, Indonesia who facilitated clearance). This is a very hard area to reseed, often having poor coverage and so this opportunity was invaluable. Other key vessels were the RV Kaharoa and the RV Investigator, Australia's new research vessel, which entered its first year of science voyages.

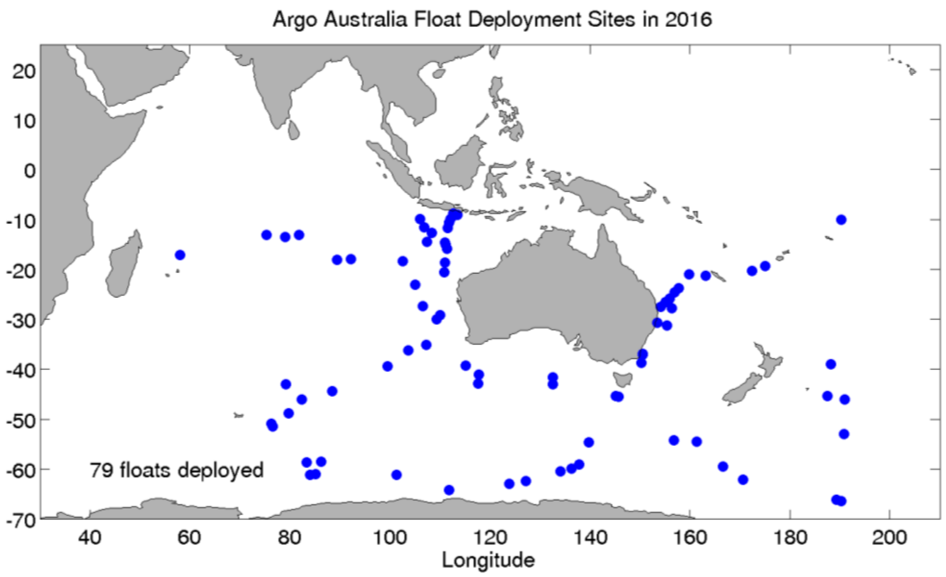

Figure 2. Locations of float deployments in 2016.

We also facilitated many float deployments from the P15S GO-SHIP reoccupation on RV *Investigator*, deploying over 45 floats in total, including deep SOLOs, many SOCCOM and core Argo floats for the US Argo program.

Several floats were deployed on the Antarctic shelf and slope and returned interesting data. However, many of these had very short lifetimes and have not re-emerged.

Technical problems encountered and solved

Rerouting our backup satellite communications to a direct Iridium reception antenna was completed due to the phasing out of dial-up options at the CSIRO. Our Iridium servers were also subject to illegal hacks and had to be taken down for several hours, checked, cleaned and reconfigured.

In house float testing and inspection continues to pay off with faulty batteries and leaks found, all of which were fixed before deployment.

Some Navis floats have been turning on prematurely. This is being investigated with SeaBird.

This year we have suffered an unusual number of failures on deployment and are not sure why. The mooted technical workshops will be much appreciated and this should be one of the topics.

Status of contributions to Argo data management

Ann Thresher attended her last meeting as ADMT co-chair and has now retired from the CSIRO. She continues to work as an Honorary Fellow on the IQuOD project. We thank Ann for her tremendous contributions to Argo and to international ocean data management in general. Rebecca Cowley has taken over Ann's position as Scientist in Charge of Operations, and she has joined the Argo Data Management Team.

Collaboration with INCOIS India and NMDIS China: We continue to work with the Indian Argo program and NDMIS as they use our ArgoRT software. Work includes coding for new data formats, Bio-Argo data and version 3.1 formats. A visit by a NMDIS programmer to Hobart greatly expedited the adaptation of the software for their program.

Metadata and Technical file Standardisation: Esmee van Wijk continues to work on standardization of metadata files and technical files. This requires substantial effort to review the name lists and understand the parameters, with the lists becoming large and complicated. A key issue is how much technical data needs to be published with a common syntax and how much can be kept in house with the archive raw data.

Status of delayed mode quality control (as of Feb 2017)

Total array including BGC, Bio, etc.			
Number of profiles	**category**		**Number of profiles**
33682	R files		27976
17079	eligible R files		15109
115621	D files		80438
132700	total eligible R + D		95547
149303	total files		108414
87.12961567	D as % of eligible		**84%**
77.44050689	D as % of total R + D		**74%**

Table 1. Delayed Mode processing statistics for the Australian array.

After a huge effort, the new DM processing software that is written for V3.1 and includes oxyen DMQC capabilities, is now stable and being used routinely. Several new operators have been trained and are working on processing floats.

With the new software in place and again, after a substantial effort, DM statistics are getting closer to our goal. Another major achievement has been the QC of our oxygen data using the new software. Many of these data had languished for years in R format and their DMQC is a great milestone. Es Van Wijk, Tom Trull. Luke Wallace and Hugh Doyle are to thank for moving these data through.

DMQC of Trajectory data remains untouched challenge to date.

We also assisted SeaBird with the testing and development of the SBE61 for Deep Argo by mounting two instruments on our CTD frame during the P15S reoccupation. The preliminary results will be presented by Nathalie Zilberman during the meeting.

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

Argo Australia remains part of Australian Government initiative: an Australian Integrated Marine Observing System (IMOS; www.imos.org.au) for research infrastructure funded under the Education Infrastructure Fund (EIF) and the National Collaborative Research Infrastructure Strategy (NCRIS). Argo Australia also gets direct funding from CSIRO Ocean and Atmosphere (overheads and float acquisition), some salary support through the NESP Earth Systems Science Hub, in kind assistance (and sometimes acquisition) from the Bureau of Meteorology and also logistical assistance from the Royal Australian Navy. The Antarctic Climate and Ecosystem Cooperative Research Centre (ACE) has partly restored a key Southern Ocean contribution to Argo Australia through around 5 deployments per year for core Argo, and via floats to be used very close to the ice-shelves (PI: Dr. Steve Rintoul). Bio-Argo floats are being deployed as part of an Australia-India Strategic Research Initiative (PI Nick Hardman Mountford).

The IMOS contribution to Argo has been at levels of around 20-30% on past funding rates, and it was hoped that a five-year renewal of its host program, the National Collaborative Research Infrastructure Strategy, would occur in the May 2017 budget. This appears unlikely and another period of bridging funds at this flat level appears likely. On this basis, Argo Australia's deployment rate would drop from around 50 floats per year to around 25-30 floats per year. A positive development to combat this decline has been the establishment of an Australian Ocean Observation Partnership between IMOS, the Bureau of Meteorology and the Royal Australian Navy. A key activity is to secure ongoing support for key ocean data streams that have large operational uptake, such as that generated by Argo.

Argo Australia has about 2.5 full time equivalents (FTE) in data management, 1.5 FTE in technical support and preparation and 0.3 FTE in leadership and management.

3. Summary of deployment plans (level of commitment, areas of float deployment)

Based on the information in hand, Argo Australia my only deploy around 25 floats in the coming year. Part of this has to do with a suspension of deployments in sea ice zones as the currently available versions of the new NAVIS and APEX controllers lack either the capability or clear track record of successful ice-avoidance.

In addition, we will continue to assist in funding R/V *Kaharoa* voyages for as long as we are able and hope to provide floats for her next trip.

As always, we will rely on the R/V *Aurora Australis*, the Australian Antarctic Division's research vessel, to assist with deployments in the Southern Ocean, the RV *Investigator* and have been recruiting Tuna fishing boats for deployments into the Coral and Tasman Seas.

It is possible that several Argo extensions might be funded when the NCRIS funding renewal does take place, including an ice, deep and BGC component. However, the level and target areas remain unfixed at present.

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

- Argo data are routinely used in the operational upper ocean analyses Australian Bureau of Meteorology (http://www.bom.gov.au/bmrc/ocean/results/climocan.htm).
- The dynamical seasonal forecasting system POAMA heavily uses Argo data for forecast initialization, including assimilating salinity which great improves the analysis – Oscar Alves, Australian Bureau of Meteorology
- CSIRO Oceans and Atmosphere Flagship, in collaboration with the Bureau of Meteorology Research Center, has developed an ocean model/data assimilation system for ocean forecasting and hindcasting. Argo data is the largest *in situ* data source for this system. The ocean reanalysis products can be found here: http://wp.csiro.au/bluelink/global/bran/.
- The OceanMap forecasts are now routinely published and are available via the Bureau of Meteorology website.
- Many students in the CSIRO/University of Tasmania QMS graduate program and University of New South Wales are utilizing Argo data in their thesis studies.
- The NESP ESS Hubs Ocean Change program heavily uses Argo data and its products for sea level rise, ocean change detection, model validation and development work.
- The major e-Reefs project, a shelf downscaling and forecasting system, relies on Argo data to set the offshore ocean conditions.
- The Antarctic Climate and Ecosystem Cooperative Research Centre's Ocean program also heavily relies on Argo data, and are particularly interested in data in the sea-ice zone.

Argo Australia's web site is: http://imos.org.au/argo.html

Real Time data documentation:
http://www.marine.csiro.au/~gronell/ArgoRT/http://www.marine.csiro.au/~gronell/ArgoRT/

5. Issues to be raised with the Argo Steering Team

We are concerned about the reliability of the new controllers on two key platforms used by Argo Australia, and are interested in collaborating across the international programs in efficiently trouble shooting and debugging these in order to minimize premature failures in this next generation of platform.

6. CTD cruise for Argo calibration purposes

The P15S GOSHIP section of 110 stations was completed in July 2016. The data have been sent to CCHDO and hopefully will rapidly make their way into the Argo Reference data base.

7. Argo Publications

We routinely update and synchronize our publications list. (http://imos.org.au/imospublications.html) with that on the IAST website.

2016 Argo Canada report of activities
(submitted by Blair Greenan, Fisheries and Oceans Canada)

18th meeting of the Argo Steering Team (AST-18)
Tasmania, Australia
13-17 March 2017

1. Status of implementation (major achievements and problems in 2016)

- *floats deployed and their performance*

From March 2016 to January 2017, Argo Canada deployed 26 MetOcean (NOVA and DOVA) floats (11 in the northeast Pacific, and 15 in the northwest Atlantic). Of these 26 floats, 5 died prematurely. The 21 remaining floats are still active and functioning properly. “Active” assumes that less than 3 of the last 4 profiles have been missed. Of the 26 floats, 1 was a replacement. Of the 5 that died prematurely, 3 are being replaced under warranty, and 1 needs to be replaced under warranty. One warranty replacement for a float deployed in the previous year has yet to be deployed. The Government of Canada Standing Offer with MetOcean Data Systems Ltd. (now MetOcean Telematics Ltd.) requires that if a float fails to complete 18 profiles the manufacturer must provide a replacement float. Argo Canada also deployed a MetOcean NAMI float with an RBR CTD sensor, but it was not part of the Argo array and only reported 14 profiles. As of 31 January 2016, Argo Canada has 68 active floats in the Argo array.

- *technical problems encountered and solved*

A recurring problem, caused by the communications provider not forwarding decoded data to Argo Canada when the data stream was incomplete, has been resolved in 2017.

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

MEDS, a section of DFO’s Ocean Science Branch, continues to acquire data from 68 active floats and to seek potential data transmissions from 9 additional floats which have not reported data for at least one month. Data are issued to the Global Telecommunication System (GTS) and GDACs hourly in TESAC, BUFR and netCDF format. Statistics and scientific data products of Canadian floats together are posted on a daily updated website: http://www. meds-sdmm.dfo-mpo.gc.ca/isdm-gdsi/argo/index-eng.html.
On average 94% of data from January 2016 to January 2017 data were issued to the GTS within 24 hours of the float reporting in TESAC and BUFR format.

Since AST-17, we have worked on / completed the following tasks:

- netCDF profile files conversion to v3.1 (~96% complete)
- netCDF metadata and technical files conversion to v3.1 (completed)

- reprocessing Argo floats with dissolved oxygen sensors and making data available at GDACs in netCDF v3.1 (ongoing)
- implementing changes in Argo real-time quality control tests (completed)
- monitoring the distribution and timeliness of Argo data in TESAC and BUFR format on the GTS, and providing ADMT with quarterly reports on the performance of Argo data on the GTS (ongoing)

- *Status of delayed mode quality control process*

As of January 31st 2017, 33% of all eligible floats, active and inactive, had their profiles visually QCed and adjusted for pressure and salinity according to the latest delayed-mode procedures at least once. The salinity component of DMQC has been performed on 61% of cycles of eligible floats at least once.

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

During 2016 Canada transitioned to having ongoing funding for the O&M expenditures related to the Argo program. Shared Services Canada (SSC) is now responsible for the costs related to Iridium telecommunications as part of an initiative to centralize these services with the Federal government. In the Federal Budget of March 2016, a reinvestment in DFO Science was announced and this has resulted in a commitment to ongoing O&M expenditures for Argo Canada. However, 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 $396k for purchases of 24 core Argo floats in 2016. Department of National Defence (Canada) also commited $160k for the purchase of 10 MetOcean NOVA floats (3 for core Argo, 7 supporting the Year of Polar Prediciton – YOPP). The enabled the acquisition of a total of 34 floats. Funding is expected to remain stable at approximately this level for the next few years.

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

Human resources

On 1 April 2015, Blair Greenan of the Bedford Institute of Oceanography (BIO, DFO) replaced Denis Gilbert 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 at the Institute of Ocean Sciences (DFO) has taken over responsibility for Pacific deployments for Argo Canada.

In terms of FTE (Full-Time Equivalent) units, the following persons contribute to Argo Canada:

Anh Tran (ISDM, Ottawa, 0.9 FTE)
Mathieu Ouellet (ISDM, Ottawa, 0.1 FTE)
Blair Greenan (BIO, Halifax, 0.2 FTE)
Ingrid Peterson (BIO, Halifax, 0.8 FTE)
Igor Yashayaev (BIO, Halifax, 0.2 FTE)
Tetjana Ross (IOS, Sidney, 0.2 FTE)
Doug Yelland (IOS, Sidney, 0.1 FTE)
Denis Gilbert (IML, Mont-Joli, 0.1 FTE)

Denis Gilbert is assisting Argo Canada with issues related to dissolved oxygen. In particular, he has been providing expert advice and support on quality control and data processing of DO data from the 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.

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

In 2017, we plan to deploy 30 new floats (firm commitment), all of which have already been purchased (21) or will be received as replacements (9): 12 will be deployed in the North Pacific (11 NOVA, 1 DOVA), 10 in the Labrador Sea (7 NOVA, 3 DOVA), and 8 in the Gulf Stream's northern recirculation gyre and off Newfoundland (7 NOVA, 1 DOVA). There is also potential for several additional float deployments with replacement floats for those that failed within the warranty period.

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 Canadian CONCEPTS Global Ice Ocean Prediction System (GIOPS) assimilates Argo data on a weekly basis. The GIOPS assimilation system has been updated in 2015 to use a smoother increment update called IAU. In this process the results of the assimilation are progressively added to the model solution over a model period of 1 day. This ensures that the ocean model is more receptive to Argo data. The new version of GIOPS operational since Jun 2016, now uses the IAU update in it assimilation scheme.

Inter-comparisons with observations (profiles, drifters), demonstrate increased forecast precision as a result of the updated assimilation scheme in GIOPS V2. Validations with Argo on GIOPS are also compared with four other international groups under the GODAE OceanView Intercomparison Validation Task team using class4 metrics. In addition to the operational GIOPS v2 system, CONCEPTS has implemented a Regional Ice Ocean Prediction System (RIOPS) covering the Arctic and Atlantic Oceans. This system is operational, there is no data assimilation, but RIOPS is spectrally nudged to GIOPS which assimilated Argo data. Future updates of CONCEPTS RIOPS systems will include its own assimilation scheme.

All CONCEPTS systems run operationally at Environment and Climate Change Canada's Canadian Meteorological Center (Dorval, Quebec). CONCEPTS is an MOU for a collaboration between the Department of National Defence, Environment and Climate Change Canada and Fisheries and Oceans Canada.

The Department of National Defence Navy scientists routinely use real time Argo vertical profiles of temperature into their Ocean Work Station to aid in the computation of sound velocity profiles for support of at-sea operations.

Argo floats deployed in the Labrador Sea are an important element of an NSERC Climate Change and Atmospheric Research project entitled VITALS (Ventilation, Interactions and Transports Across the Labrador Sea). This research network is attempting answer fundamental questions about how the deep ocean exchanges carbon dioxide, oxygen, and heat with the atmosphere through the Labrador Sea. New observations and modelling will determine what controls these exchanges and how they interact with varying climate, in order to resolve the role of deep convection regions in the Carbon Cycle and Earth System. VITALS is a pan-Canadian initiative involving scientists from 11 Canadian universities as well as multiple federal government laboratories (Fisheries and Oceans Canada, as well as Environment and Climate Change Canada), industrial and foreign partners. http://knossos.eas.ualberta.ca/vitals/

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.

Most of the recent CTD data collected by DFO researchers are transferred to MEDS and then to NOAA NCEI and CCHDO. MEDS (Ottawa) is responsible for dissemination of Canadian CTD data. CCHDO sometimes obtain data directly from Canadian PI's at DFO labs.

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.

Journal Publications

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3. 2016 Riser, S. C., Freeland, H. J., Roemmich, D., Wijffels, S., Troisi, A., Belbeoch, M., Gilbert, D., Xu, J., Pouliquen, S., Thresher, A., Le Traon, P.-Y., Maze, G., Klein, B., Ravichandran, M., Grant, F., Poulain, P.-M., Suga, T., Lim, B., Sterl, A., Sutton, P., Mork, K.-A., Velez-Belchi, P. J., Ansorge, I., King, B., Turton, J., Baringer, M. & Jayne, S. R., Fifteen years of ocean observations with the global Argo array. Nature Clim. Change, 6, 145-153, doi: 10.1038/nclimate2872.
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Ph.D./M.Sc. Thesis

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The 18th Argo Steering Team Meeting, Hobart, Australia, March 14-16, 2017

Argo Chinese National Report 2016

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

1. The status of implementation

- floats deployed and their performance

From the last AST meeting, China deployed 24 floats (11 APEX, 1 PROVOR and 12 HM2000) in the South China Sea (SCS), the northwestern Pacific and Indian Ocean via 4 cruises. It was the first time for China to deploy profiling floats in the SCS and share data within Argo community. It could be regarded as the beginning of the SCS Argo regional observing network (~25 operational floats) that will be dominated by China Argo. The 10 floats deployed in the SCS are HM2000 floats which use BeiDou satellite for data transmission and GPS for positioning. One float (WMO: 2902699) did not transmit data after its deployment, and it was recovered by fisherman from Vietnam in this February and is kept by the Sub Department of Fisheries of Binh Thuan Province of Vietnam. Until now the other 9 HM2000 floats are all active and report good TS profiles with a 5-day cycle time. About 376 floats have been deployed by China from 2000, and 118 floats are still active as of 25 February 2016.

- technical problems encountered and solved

A set of (5) Iridium APEX floats stopped transmitting data prematurely after about 110 cycles and showed an energy drop at the end of their lifetime. These floats observed intensive profiles during the passages of several typhoons. To estimate the energy consumption with Alkaline batteries, we sent the technical data from those floats to TWR as well as UW. The results based on their energy budget models supported the observed data. So we suggest each Iridium APEX float should be installed Lithium battery packs either by the manufacturer or by float users before deployment.

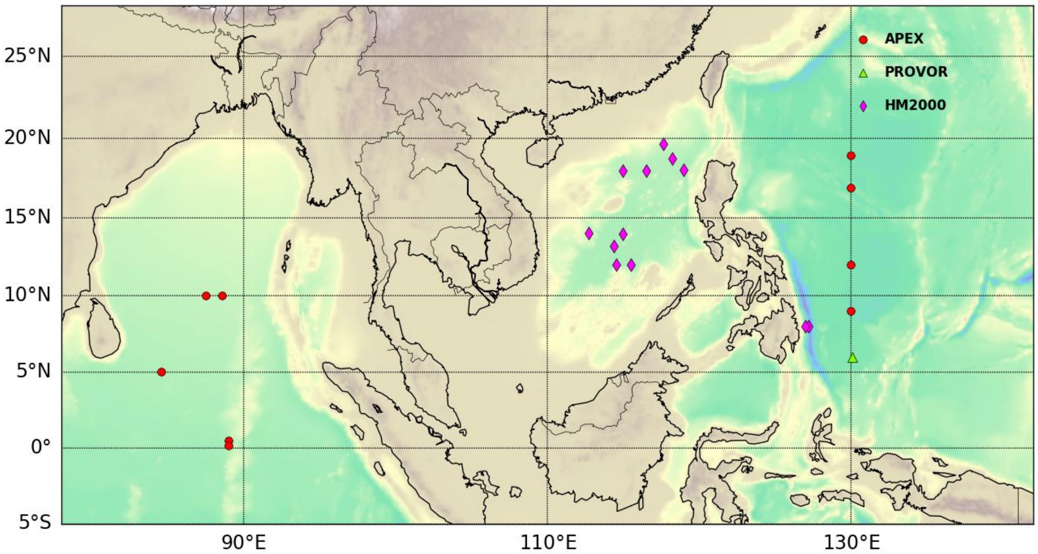

Fig.1 Launch positions of the floats from Mar. 2016 to Feb. 2017.

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

From the last AST meeting, CSIO received data from 177 active floats (69 APEX, 89 PROVOR, 14 HM2000 and 5 ARVOR) and submitted 5383 TS profiles to GDACs. CLS still helps us to insert profiles from the old floats into GTS, moreover, CSIO distributes all data into GTS via Chinese Meteorological Agency (Beijing). All Argo profiles are converted to BUFR format through a Perl script developed by JMA. However, there were a few interruptions in 2016 because the breakdown of FTP server at Zhejiang Meteorological Bureau. In 2016, we took a lot of time to convert historical profile, technical and trajectory files into Version 3.1. Now all of the metafiles, and most of the technical and trajectory files have been updated.

- status of delayed mode quality control process

In the past year, CSIO didn't submit any D-files to GDAC because the lack of manpower. We plan to restore DMQC and to eliminate the backlog this year. A construction of the SCS reference CTD dataset is scheduled for DMQC of all Argo floats in the SCS.

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

Unlike other countries, China Argo is mainly supported by research programs, which leads to an unstable number of yearly deployment. In the past two years, the number of the operational floats reduced because the number of new deployments relied on related research programs. The situation is expected to be changed this year with the appeals from PIs. In the period of the "13th Five-Year Plan" (2016-2020), the government is expected to increase the support to China Argo as a part of implementing China's strategic initiative of the "21st Century Maritime Silk Road", and to help the countries along "Maritime Silk Road" to strengthen capability of addressing climate change, as a result, China will make more contribution to global Argo. If this proposal is granted, about 200 floats (100 HM2000, 50 Iridium APEX and 50 PROVOR) will be deployed during its first implement year (2017). During its second year, 400 floats will be deployed, then the Chinese Argo real-time observing network consisted of 400 operational floats will be constructed. Following 2019, ~200 floats/year will be routinely deployed to maintain the network for at least 5 years.

Currently there are 6 staffs working for float deployment, data processing and data application at CSIO.

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 identified number of floats to be purchased this year is 45 including 15 Iridium floats, 10 BGC-Argo, 15 HM2000 and 5 deep-Argo. These floats are funded by the Ministry of Finance who will support the purchase of scientific instruments for those state key laboratories passed a 5-year assessment. China Argo Real-time Data Centre is an important basic platform for SOED (state key laboratory of Satellite Ocean Environment Dynamics). As a result, China will deploy ~45 floats at least this year, however, the number will be more than 200 if the proposal of China Argo real-time observing network along Maritime Silk Road could be granted. Of course, it is a great challenge to deploy so many floats via various investigation cruises and volunteer ships.

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 has become an important data source in basic research and operational application. CSIO maintains a monthly global Argo gridded dataset (called BOA_Argo) and updates once a year. We are preparing an English version of the user manual of this dataset and put it into Argo-UCSD website.

There are two websites maintained by China, one is maintained by NMDIS (www.argo.gov.cn) at Tianjin (China Argo data center), and another is maintained by CSIO (www.argo.org.cn) at Hangzhou (China Argo Real-time data center). The implement status of China Argo, real-time data display including T/S/O2 profiles, float trajectory, profile data, the derived products and status of global Argo are provided.

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

No.

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

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ARGO National Report 2017 – 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:
    - 83 floats have been purchased
    - 10 await deployment
    - 15 are working

In total 14 floats have been purchased in 2015 and 2016. Four of them have already been deployed. The other ten are currently on board of a ship and will be deployed until April.

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, a level that could be kept during the past years. However, the budget is currently under pressure, and it is likely that less floats can be purchased in 2017 and beyond.
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).
Fourteen floats are to be deployed in the Southern Atlantic Ocean (including the Southern Ocean) in the austral summer 2016/17. Four have already been deployed. Further plans are currently under consideration.

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**
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Argo Report 2017 – Euro-Argo ERIC

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. Ministries from **9 European countries (Finland, France, Germany, Greece, Italy, Netherlands, UK, Norway and Poland)** agreed to form a legal European entity to organize a long-term European contribution to Argo. The Euro-Argo ERIC 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. The Euro-Argo infrastructure is made up of a central infrastructure based in France (Ifremer, Brest) which is owned and controlled by the Euro-Argo ERIC and distributed national facilities. 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 2016 Ireland joined the ERIC followed by Spain early 2017 (Figure 1)**

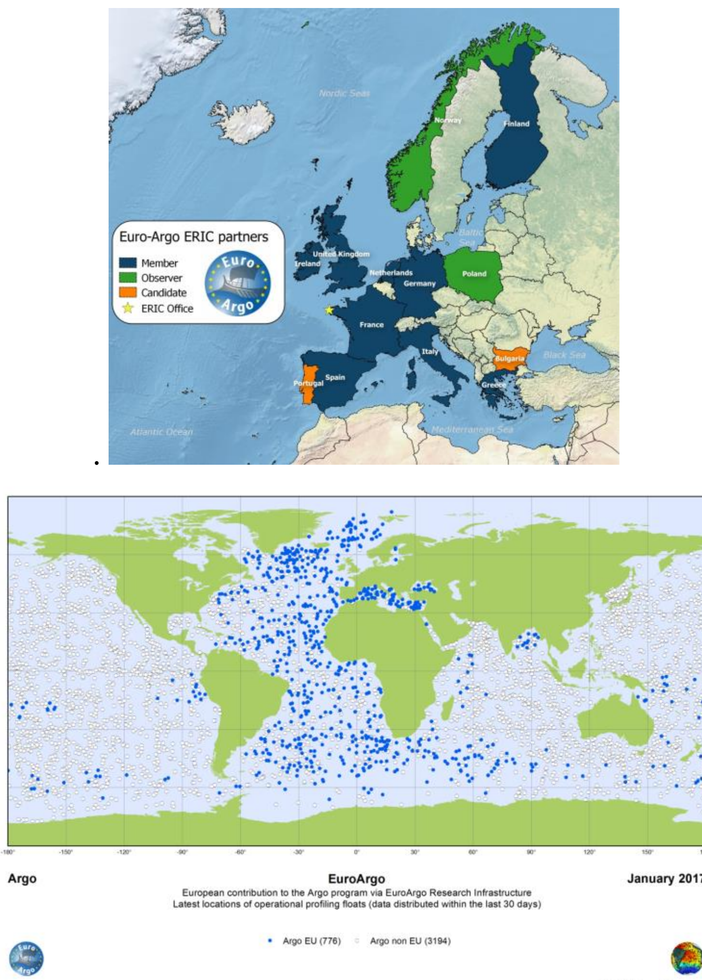

Figure 1: Euro-Argo partners and European contribution to Argo in January 2017

1) Status of implementation

The Euro-Argo ERIC was set up in May 2014 and its office is located in France, hosted by Ifremer, Brest. This infrastructure enables Europe to build and sustain a contribution to the global array while providing enhanced coverage in sea areas of particular European interests (e.g. the Nordic Seas, Mediterranean and Black Seas). The Euro-Argo ERIC coordinates the European contribution to Argo and monitor it with the **aims of maintaining ¼ of the Argo array.**

Since 2008 Euro-Argo have 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.

Contribution to the Argo array:

- E-AIMS (2013-2014): 14 Floats deployed;
- MOCCA (2015-2019): 120 T&S Floats purchased, 45 deployed in 2016, 75 planned in 2017 (Figure 2);
- AtlantOS (2015-2019): 6 BGC and 7 DEEP purchased in 2016, planned to be deployed in 2017.

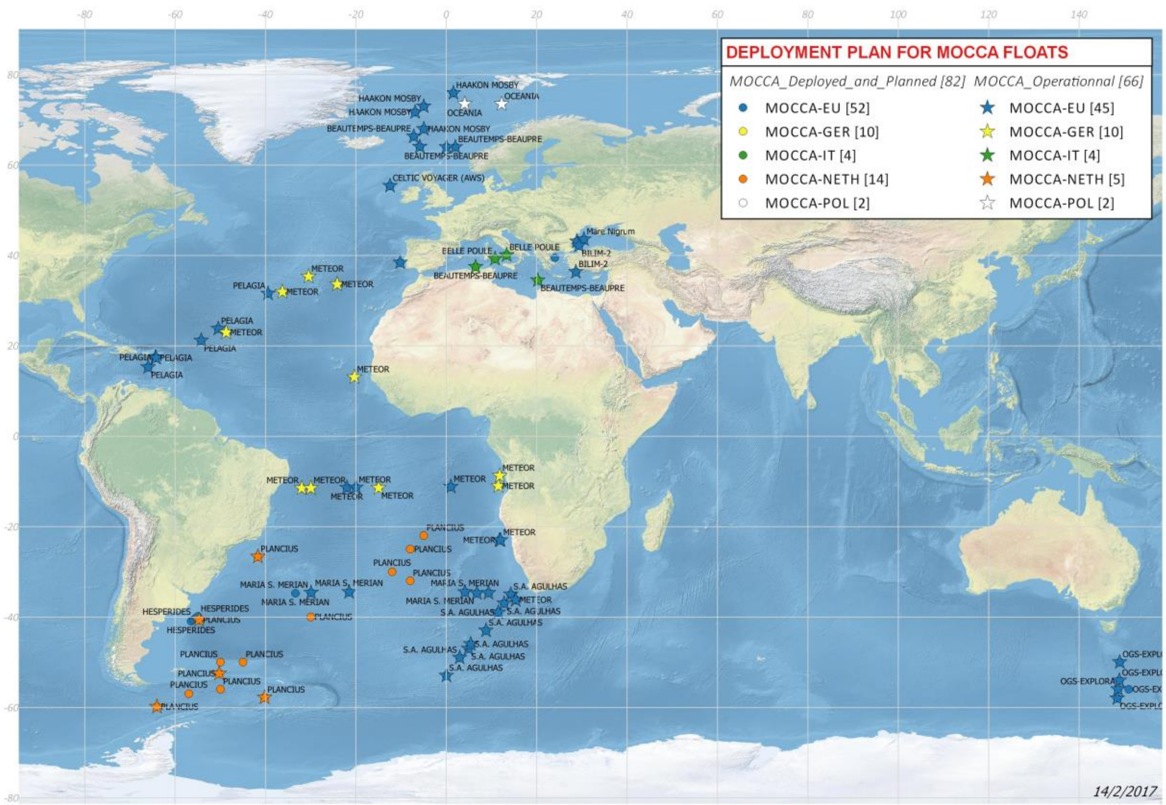

Figure 2: MOCCA floats deployment plan. Stars show floats already operational and dots the current plans (including floats already deployed) for the end of 2016 and 2017.

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

   The Euro-Argo ERIC Office is a team of 5 persons with project management, technical and scientific background.

   The Euro-Argo ERIC developed a strategy for the development of Argo for the next decade. This document has been reviewed by the Euro-Argo STAG (Scientific and Technical Advisory Group) in which Argo International is represented by one of its co-chair Susan Wijffels. A new version will soon be published on Euro-Argo website at http://www.euro-argo.eu/Outreach/Documents. An implementation plan of this Strategy is under development and should progress in 2017-2018 taking into account Argo International priorities.

   The Euro-Argo ERIC office team is also developing with its partners tools for at-sea monitoring that will allow to have a better view of the European fleet, its status, its efficiency and weaknesses. The Euro-Argo ERIC office team is also working on KPIs to document European contribution to the international network and plan to work with AIC on these issues.

   Euro-Argo is working with the European Commission to develop a plan for BGC (BioGeoChemical) and DEEP European contribution to Argo that would complement the European national contributions.

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)**
   In 2017, 75 T&S floats, 6 BGC and between 4-7 DEEP floats will be deployed by the ERIC with the help of its partners. The deployment plan is still under development and will take into account the known plans at AIC, the priorities identified at AST18 as well as the deployment opportunities available and the cost for float shipments to remote areas.

4) **Summary of national research and operational uses of Argo data**
   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 (see E-AIMS booklet) and for research carried on by the Euro-Argo ERIC partners (see national reports for details).

5) **Issues that your country wishes to be considered (and resolved) by AST regarding the international operation of Argo**
   None at the writing of this report.

6) **CTD data uploaded to CCHDO**
   Done by Euro-Argo ERIC members.

7) **Bibliography**
   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)

French National Report on Argo - 2016

Present status and future plans

v3.1 - Mar.1st, 2017

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

1 BACKGROUND, ORGANIZATION AND FUNDING OF THE FRENCH ARGO ACTIVITIES

1.1 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[1] European research infrastructure (ERIC) that organizes and federates European contribution to Argo.

Euro-Argo and its French component (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[2] partnership (IFREMER, SHOM, INSU, IRD, Météo France, CNES and IPEV) and its governance bodies. Two research laboratories are leading the Argo France scientific activities: the "Laboratoire d'Océanographie Physique et Spatiale[3]" (LOPS, Brest, France) and the "Laboratoire d'Océanographie de Villefranche[4]" (LOV, Villefranche, France). Coriolis and Argo France have strong links with Mercator Ocean[5] (the French ocean forecasting center).

1.2 Funding

Argo France is mainly funded by the ministry of Research through Ifremer as part of 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[6] and funded by the Brittany and Provence Alpes-Cote d'Azures regions (through 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 1070 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[7] 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 10 to 15 floats per year from 2012 to 2019, which allows Ifremer to increase its long-term contribution to Argo from 50 to 60-65 floats/year. NAOS also develops the new generation of French Argo floats and set up pilot experiments for biogeochemical floats (Mediterranean Sea, Arctic) and deep floats (North Atlantic). An European Research Council (ERC) advanced grant has also been obtained by LOV to work on the development of a biogeochemical component for Argo, the REMOCEAN[8] project (REMotely sensed biogeochemical cycles in the OCEAN, 2010-2015)**.** Overall, as part of the NAOS and REMOCEAN projects, 150 additional floats should be deployed before 2019.

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€		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**
Total (2000-2016)			***976***		**1051**
2017	**1400k€**	**14**	**97**		**97**

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 2017.

1.3 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.

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.

2 FLOAT DEVELOPMENT

Since 2011, Ifremer together with NKE and CNRS has been working on PROVOR/ARVOR floats improvement in order to develop, validate and deploy the next generation of French Argo profiling floats. The new float capabilities include: longer life-time, more efficient design of the vehicle, improved transmission rates, integration of biogeochemical sensors, deeper measurements and under ice operations in the polar seas. In 2016, prototype designs were industrialised by NKE and some deployed by Operational Center. More informations on technological float developments can be found in the NAOS project webpage (http://www.naos-equipex.fr/) and its last newsletter (Feb 2017, French version.pdf) from which the following information are gathered:

Arvor floats deployed in 2015 have now performed more than 60 cycles. More than 40 new Arvor floats have been deployed in 2016 with success, thanks to a simplified procedure.

Deep Arvor floats have been deployed since 2015. The general behavior of the float is satisfactory although performances are variable. The sensor manufacturer was made aware of the analysis of measurements quality and salinity biais at initial calibration. The Deep-Arvor technology was described in Le Reste et al (JAOT, 2016, http://dx.doi.org/10.1175/JTECH-D-15-0214.1

For all float models, CTD heads are now systematically tested at the beginning of the manufacturing line and a CTD cleaning protocol enforced during pool tests prior to deployments.). A soft “dual-mission” mode enables the user to split the float life into two phases.

Another main aspect of the development concerns the bio-geochemical applications. The **Provor-CTS5 (Prov-bio)** and its under-ice twin (**Pro-Ice**) developed since 2013 are dedicated, i) to embed additional optical sensors, ii) to do other cycle schemes than Argo standard ones, iii) to modify its programmed mission itself depending on measurements or on results of mixed measurement computations and iv) to detect and avoid ice during ascent.

After trials in the Mediterranean Sea, **Pro-ice** floats were deployed in the Baffin Sea (2015) and Austral Ocean (2016). The later sampled and stored more than 130 profiles with success.

In 2015, a three-week oceanographic cruise (BioArgoMed, onboard the INSU's Tethys-11, Pls F. D'Ortenzio & V. Taillandier) was carried out, within the framework of the development and operational maintenance of a pilot network of BioArgo biogeochemical floats in the Mediterranean Sea by teams from the French laboratories LOV, MIO and LOCEAN. During the cruise, 10 **Prov-bio** floats were deployed and 5 recovered. Argo floats from Argo-Italy and from Germany were also deployed. The recover of Prov-bio (some of them after 3 years at sea) provided excellent technical information on the float performance at sea. Additionnaly, observations from ship obtaind during the recover of floats (i.e. with Rosette sampling of Chl-a, O2 and NO3) provided calibration profile of biogeochemical parameters at the end of mission, which are further used to verify the performances of the BGC-Argo QC tests and for sensor calibrations.

3 THE STATUS OF IMPLEMENTATION

3.1 Floats deployed and their performance

57 T/S floats (21 BGC) have been deployed by France in 2016 (see map below). 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.

3.2 Technical problems encountered and solved

No particular technical problems were encountered in 2016 with regard to operational T/S floats.

3.3 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. In 2016, BGC floats processing chain have been fully operational and integrated within the Coriolis data management stream.

Hervé Claustre (CNRS-LOV) became co-chair of the Argo ADMT for BGC-Argo and Catherine Schmechtig (CNRS-Ecce-Terra) France DAC focal point for BGC.

All Argo data management details are in the Coriolis DAC and GDAC annual report (english) : http://archimer.ifremer.fr/doc/00350/46128/

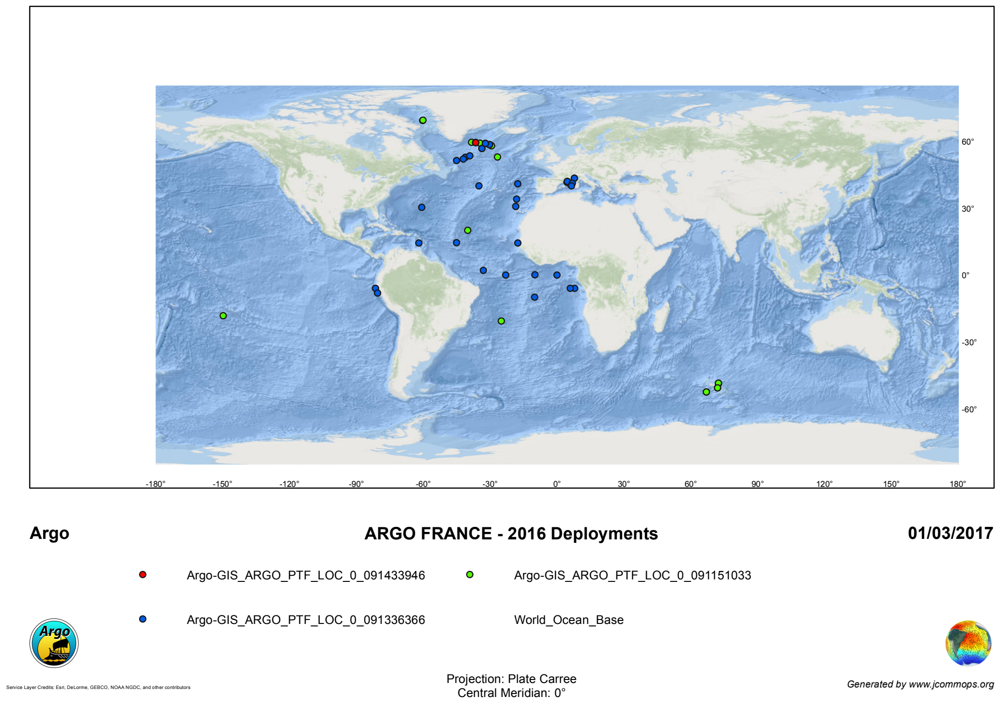

Figure 1 : Argo-France 58 deployments in 2016

3.3.1 Data Assembly Center[9]

Coriolis processes in Real Time and Delayed Mode float data deployed by France and 7 European countries (Germany, Spain, Netherlands, Norway, Italy, Greece, Bulgaria). Details information can be found the 2016 Coriolis DAC / GDAC data management report (http://archimer.ifremer.fr/doc/00350/46128/).

These last 12 months (sep15-aug16), 29 683 profiles from 740 active floats were collected, controlled and distributed. Compared to 2015, the number of profiles increased by 16%, the number of floats increased by 1%. The increase in profile number is mainly explained by a better lifetime of active floats. The 740 floats managed during that period had 57 versions of data formats. Coriolis DAC provides data for 321 BGC-Argo floats from 5 families and 46 instrument versions. They performed 38 376 cycles.

All (real and delayed time) Coriolis Provor/Arvor floats files are converted to Argo NetCDF 3.1 version. In 2016, 10 versions of Apex floats were reprocessed into Argo NetCDF version 3.1. For Apex floats, the delayed mode files from 10 versions are still in version 3.0. They will probably be entirely reprocessed by the delayed mode operators, as the reprocessed real-time profiles have a higher quality than the former files. The rest of 14 versions of still active Apex floats will be gradually converted (probably in 2016-2017). The 35 versions no more active will be converted to V3.1.

Figure: Maps of the 29 683 profiles from the 740 active floats managed by Coriolis DAC in 2016. Apex, Navis, Nemo, Nova, Provor

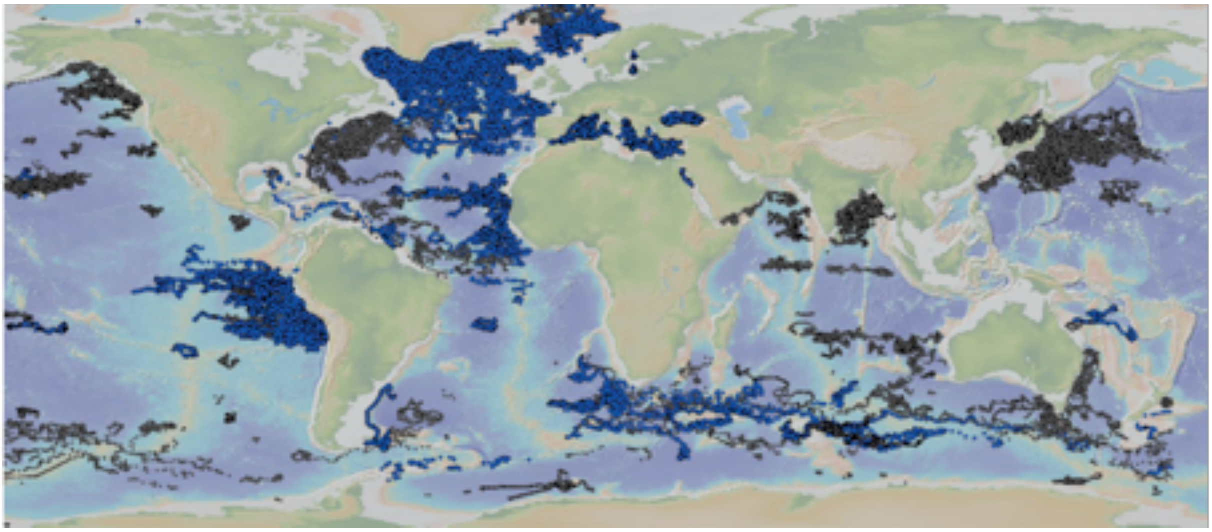

Figure: Map of the 321 BGC-Argo float profiles (blue) managed by France in 2016 (grey dots: the others DACs bio-Argo floats)

3.3.2 Global Argo Data Centre[10]

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 (see Figure). There is a monthly average of 321 unique visitors, performing 4229 sessions and downloading 3 To of data files. On the last 12 months, the weekly average ftp performance was 99.51%. The 0.49% of poor performances represents 36 hours and 38 minutes minutes (that mainly occured in early March and 3rd week of May).

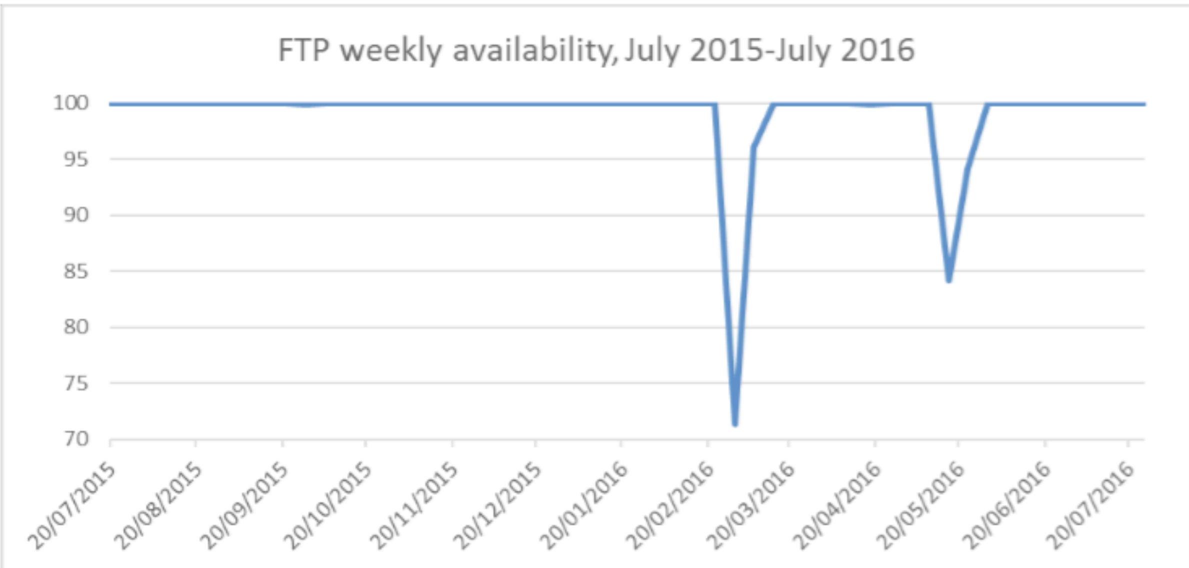

Figure: Nagios monitoring: between July 2015 and July 2016.

3.3.3 North Atlantic Argo Regional Centre[11]

See section 5.4

3.4 Status of delayed mode quality control process

During the last year (from February 2016 to February 2017), 10676 new delayed mode profiles where produced and validated by PIs. A total of 135673 delayed mode profiles where produced and validated since 2005. In February 2017, 59% of the floats and 56.8% of the profiles processed by the Coriolis DAC were in delayed mode (see Figure below).

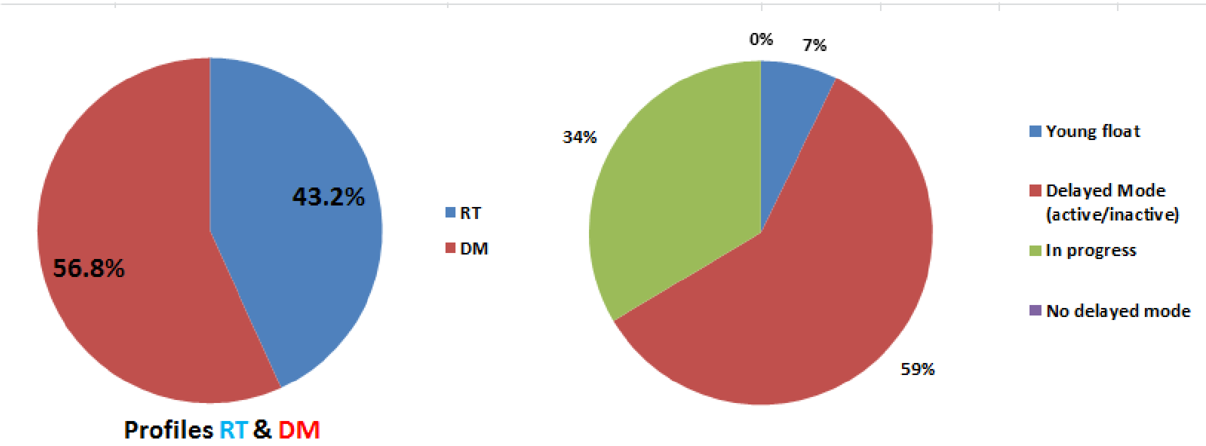

Figure 6. Status of the floats processed by Coriolis DAC. Left: in terms of float percent and right: in terms of profile percent (DM : delayed mode – RT : real time).

The status of the quality control done on the Coriolis floats is presented in the following plot. The codes 2 and 3 show the delayed mode profiles for respectively active and dead floats. . In the last 2 years, we have accumulated delay on the DMQC dataset for some floats due to a new program/language to decode PROVOR and APEX floats. We had to wait for the new procedure to work on the delayed mode files but since few months, we have worked on those versions and we have now updated most of the floats. There are still some Remocean floats that need to be reviewed in real time before working on DMQC.

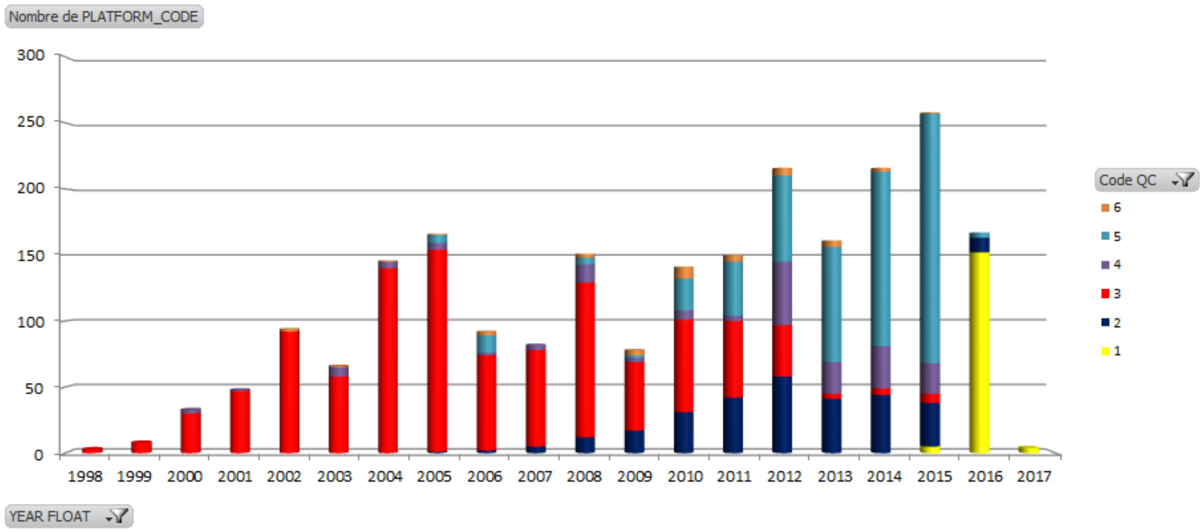

Figure: Status of the quality control done on profiles sorted by launch's year, code 1: young float, code 2: active float, DM done, code 3 : dead float, DM done; code 4 : DM in progress, code 5 : waiting for DM, code 6 : problems with float.

4 SUMMARY OF DEPLOYMENT PLANS* AND OTHER COMMITMENTS TO ARGO† FOR THE UPCOMING YEAR AND BEYOND WHERE POSSIBLE

According to the current deployment plan, 97 floats are scheduled to be deployed in 2017 (44 ARVOR ARGOS , 24 ARVOR Iridium, 1 AR DO, 8 CTS3DOI, 5 CTS4, 16 DEEP, 1 CTS5 proval, 7 CTS5 ICE).

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

France also contributes to the funding of the AIC.

5 SUMMARY OF NATIONAL RESEARCH AND OPERATIONAL USES OF ARGO DATA AS WELL AS CONTRIBUTIONS TO ARGO REGIONAL CENTERS

5.1 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

* Level of commitment, areas of float deployment
† Data management

MERCATOR-Ocean[5] structure. MERCATOR also operates the Global component of the European Copernicus Marine Environment Monitoring Service (CMEMS).

5.2 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 tender. Its task is to support the Mercator and Coriolis scientific activities and to participate in product validation. The call for tender proposes to the community "standard" Argo floats as well as floats equipped with oxygen and biogeochemical sensors. These new opportunities strengthen ties between the French scientific community and Coriolis with regard to the development of qualification procedures for "Argo extensions" floats.

5.3 National Research

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

5.4 Argo-Regional Center: North Atlantic

France has taken the lead in establishing 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.

The NA-ARC website provides information about float data and status in the North-Atlantic Ocean. NA-ARC also provides a web API to access metadata about Argo profiles in the North Atlantic region (http://api.ifremer.fr/naarc/v1).

All the floats that have been processed in delayed time in the North Atlantic ARC, north of 30°S, were checked again using a modified OW method that has been published in a scientific article (Cabanes et al, http://dx.doi.org/10.1016/j.dsr.2016.05.007). Among the 1514 floats checked, we found 19 floats for which it may be necessary to revise the original DM correction. Reports have been send to the Pis.

6 ISSUES THAT YOUR COUNTRY WISHES TO BE CONSIDERED AND RESOLVED BY THE ARGO STEERING TEAM REGARDING THE INTERNATIONAL OPERATION OF ARGO.

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

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7 CTD CRUISE DATA IN THE REFERENCE DATABASE

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

The last version CTD_for_DMQC_2017V01 has been provided in January 2017, this is an updated version (correction of bugs in some boxes) of the CTD_for_DMQC_2016V01 dataset provided in September 2016 which takes into account new CTD provided by the CCHDO API (following figure), CTD from scientists as well as feedbacks from users on quality of some profiles. Concerning the CCHDO API, all cruises have been imported but only 30% have been kept after duplicates check with data in Coriolis database.

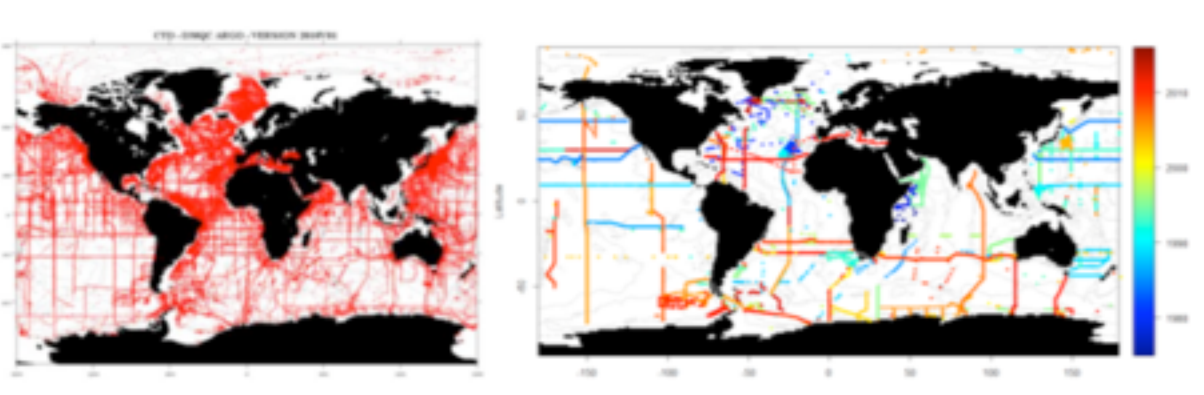

Figure: ***Version 2016 V01 & New CTD datasets downloaded from the CCHDO API***

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

In 2016, at least 57 articles with a scientist affiliated in France as a coauthor have been published in peer reviewed journals. The list is reported hereafter. Note that the list of all publications in which a scientist from a French laboratory is involved is available on the Argo France website[12] and on the Argo Bibliography[13] webpage. To date, around 290 articles have been listed.

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Yin, X., Boutin, J., Dinnat, E., Song, Q., and Martin, A., 2016: Roughness and foam signature on SMOS-MIRAS brightness temperatures: A semi-theoretical approach. *REMOTE SENSING OF ENVIRONMENT*, **180** (**SI**), 221-233, doi: 10.1016/j.rse.2016.02.005.

Footnotes

[1] Euro-Argo: http://www.euro-argo.eu
[2] Coriolis: http://www.coriolis.eu.org
[3] Laboratoire d'Océanographie Physique et Spatiale: http://www.umr-lops.fr/
[4] Laboratoire d'Océanographie de Villefranche: http://www.obs-vlfr.fr/LOV
[5] Mercator: http://www.mercator-ocean.fr
[6] IUEM OSU: http://www-iuem.univ-brest.fr/observatoire
[7] NAOS project: http://www.naos-equipex.fr
[8] REMOCEAN project: http://www.oao.obs-vlfr.fr
[9] Coriolis DAC: http://www.coriolis.eu.org/Observing-the-ocean/Observing-system-networks/Argo
[10] Coriolis FTP: http://www.coriolis.eu.org/Data-Services-Products/View-Download/Download-via-FTP
[11] NA-ARC data mining website: http://www.ifremer.fr/lpo/naarc
[12] French bibliography: http://www.argo-france.fr/publications
[13] Argo PhD list: http://www.argo.ucsd.edu/argo_thesis.html

1. The status of implementation (major achievements and problems in 2016)

- floats deployed and their performance

Most of the floats deployed by Germany are operated by BSH but additional funding has been acquired by various research institutes. BSH will have deployed 45 floats (21 APEX, 24 ARVOR) by the end of 2016, 5 floats purchased in 2016 will used for a deployment cruise early 2017. No floats have been deployed by GEOMAR and AWI this year. All of the German floats deployed in 2016 were standard TS floats. Deployment was carried on research vessels. The scientific research vessels comprised Canadian, German and UK ships. The deployment locations for 2016 are shown in Fig. 1.

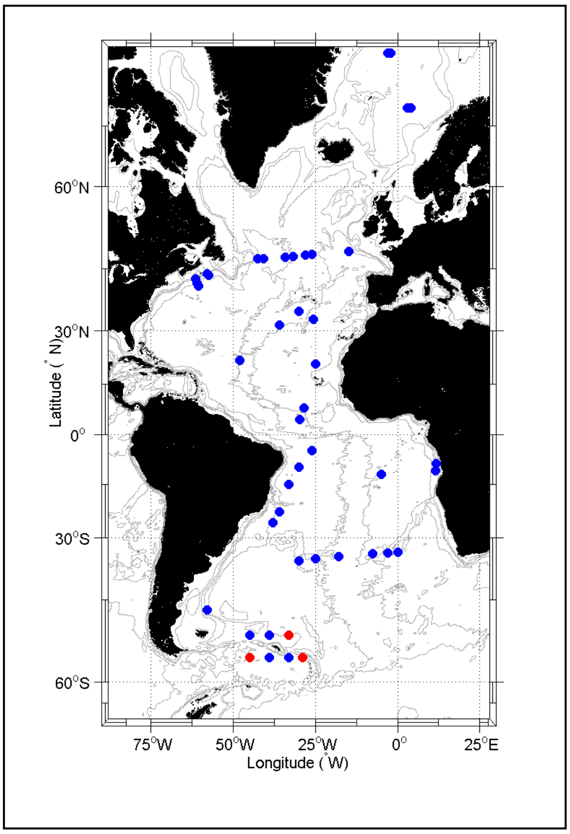


Fig. 1: Deployment positions for floats operated by BSH in 2016 in the Atlantic Ocean. At positions marked in blue the deployment has been carried out in 2016 and those in red will be achieved in the next few weeks.

Currently (February 10th, 2017) 143 German floats are active (Fig.2) and the total number of German floats deployed within the Argo program increased to 853. 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. TWR has provided 9 more floats during 2016 from the warranty agreement for lost floats. In total 34 floats were provided by TWR between 2014 and 2016 to replace floats suffering from battery flue. 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.

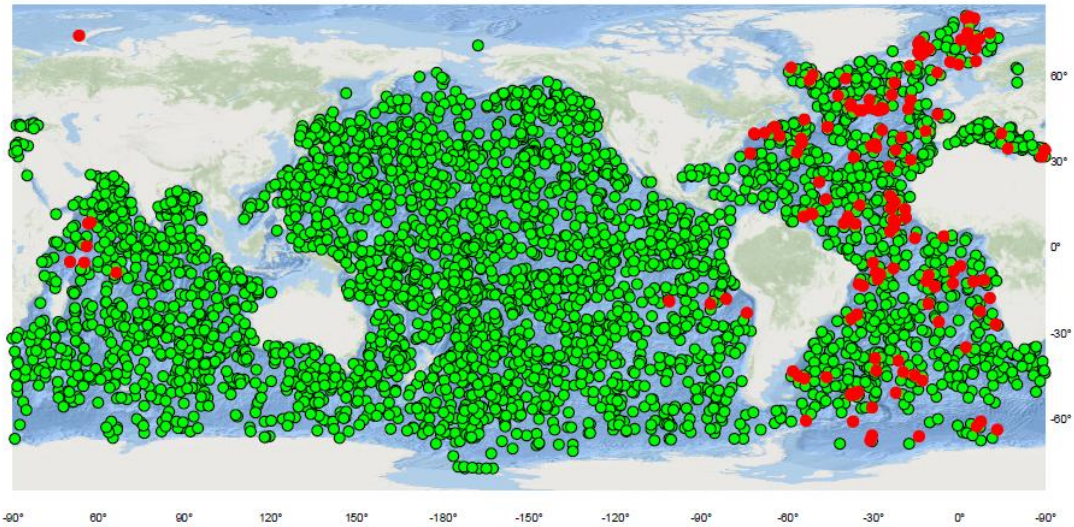


Fig. 2: Locations of active German floats (red) and active international floats (green) (Argo Information Centre, February 2017).

- technical problems encountered and solved

The major technical problems with the alkaline batteries in our APEX floats deployed since 2010 is slowly fading out. Until February 2017 more than 74 floats, deployed between 2010 and 2014, expired early with life cycles of about 700-800 days. The technical data send back from the floats indicate a sudden loss of battery voltage to values of around 7 volt during the last profile and increased battery consumption during the previous cycles due to 'energy flue'. WEBB/TELEDYNE has already replaced floats 34 floats in three batches (14 floats in 2014, 11 floats in 2015 and 9 floats in 2016). We expect to finish all warranty issues from that tender with TWR in 2017.

As has been reported in last year's national report the Canadian NOVA floats appear to have an extremely high early death rate. According to the analysis of the entire NOVA fleet in the Argo program the survival rate after 6 months was only 81%, i.e. 19% were lost in the first 6 months. In the smaller sample of 22 German NOVA floats 11 have died within the first year (<40 cycles) and 4 more before reaching 100 cycles. These floats are covered by our warranty agreement and we will work with the company to settle the issue. Additional to the high early failure rate the floats also show very noisy salinity profiles which have abundant spikes and inversion which are unstable in salinity.

- 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 will deploy deep-floats and bio-Argo floats within this project. Germany will be responsible in the framework of the ERIC for the delayed-mode quality control of the ERIC floats in the Nordic Seas and at-sea monitoring of the fleet. Germany has adopted a few (9) of the orphaned US Navy floats and will provide quality control for these floats. Germany is also acting as delayed mode quality control for European contributions from Denmark, Finland, Norway, the Netherlands and Poland.

Birgit Klein has taken on duties from Ann Thresher on the standardization of the technical files. This is an ongoing issue as more names will be required for new float models and sensors. This work is carried out in cooperation with John Gilson and Esmee van Wijk to ensure consistency to the meta-files.

- status of delayed mode quality control process

The delayed mode processing is distributed between the various German institutions contributing to Argo, depending on their area of expertise. The Alfred-Wegener Institute is responsible for the Southern Ocean and GEOMAR is processing floats with oxygen data. 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. Delays in delayed-mode data processing have occurred in the last year at AWI due to changes in personal and delays in replacement. The processing of the RAFOS information on the under ice floats needs reformatting of the files to file format 3.1. The intermediary RAFOS amplitudes and time-of-arrival will be stored in the trajectory data. AWI is presently enhancing their decoders for the remaining NEMO floats to solve issues with the dating of under-ice profiles and will resubmit these data to Coriolis soon. These files will then be transformed to file format 3.1.

We are in continuous contact with Coriolis because the re-processing of APEX floats at Coriolis required a replacement of already existing D-files with files based on the new decoders and format conversion to V3.1. The process has been finished for most APEX float types and we hope it will be finished for NEMO floats in 2017.

The DMQC process is continuing, and delays have been encountered due to format issues with file format 3.1 and updates in hardware/software are resolved now. It is expected the number of delayed mode files submitted to Coriolis and the frequency of delayed-mode will go back to normal levels during 2017.

All delayed mode profiles from BSH have been sent to the Coriolis GDAC node. The total number of available profiles from German floats is 61086 (February 10th, 2017), the number of DM profiles is 45589. The percentage of DM profiles with respect to the total number of profiles has increased to about 81%.

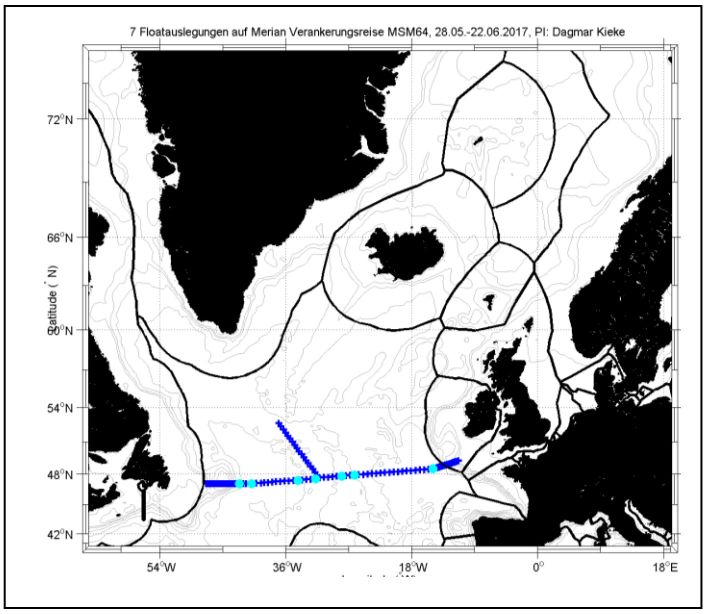
2. Present level of and future prospects for national funding for Argo including a summary of the level of human resources devoted to Argo.

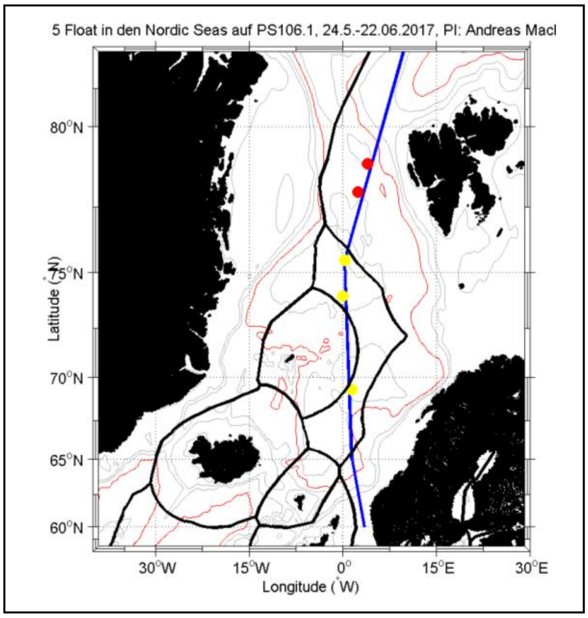
The present level of national funding for Argo has remained at flat levels during the last years, but we hope for an increase in funding in 2018 which would allow us to increase the number of floats purchased per year from ~40 back to 50 as originally envisioned.

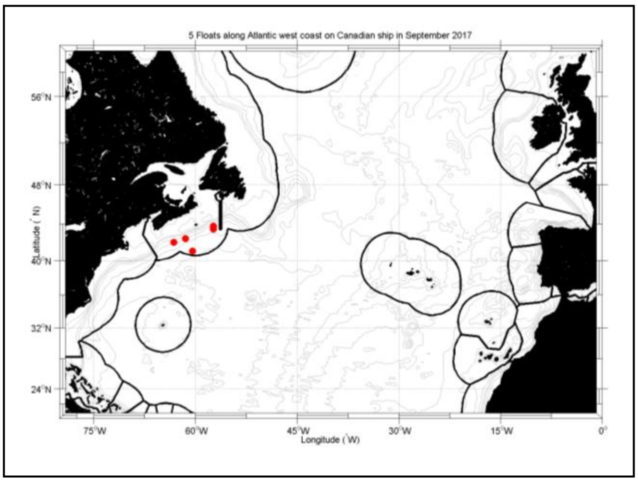
At BSH three staff members (Birgit Klein, Jan-Hinrich Reissmann and Anja Schneehorst) are involved in the Argo project and cover all activity areas from purchase, deployment to data quality control and representation in national and international teams. As part of our Euro-Argo activities Hartmut Heinrich and Bernd Brügge are involved as Council and Management Board members. Birgit Klein is member of the Scientific and Technical Advisory Group.

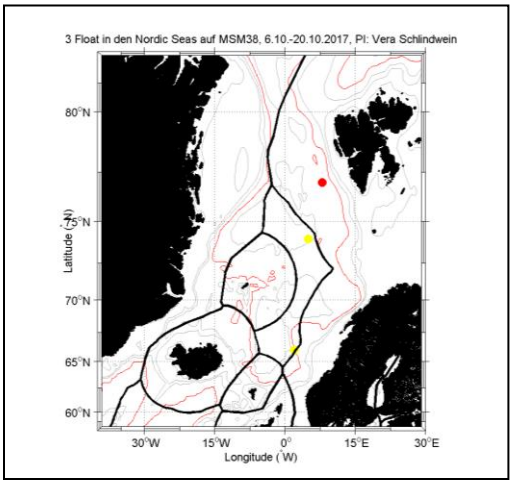
3. Summary of deployment plans (level of commitment, areas of float Deployment, low or high resolution profiles, Argo extensions) and other commitments to Argo (data management) for the upcoming year and beyond where possible.

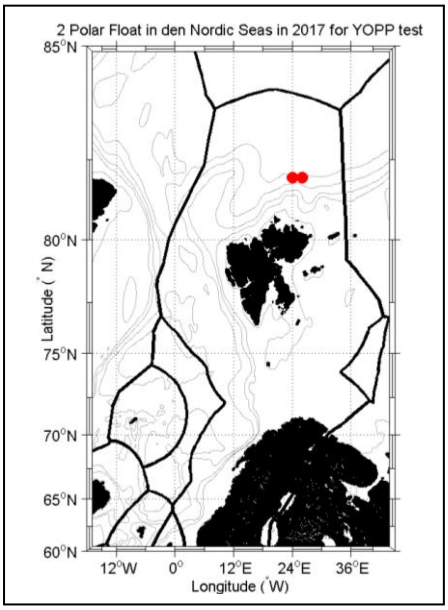
Purpose is gapping filling in the Atlantic, main focus areas are southern ocean and Nordic Seas from the priority list of the ERIC. A minimum deployment of 39 floats is planned, 5 from these have purchased in 2016. A maximum of 56 float deployments is planned if more funds become available (warranty floats).

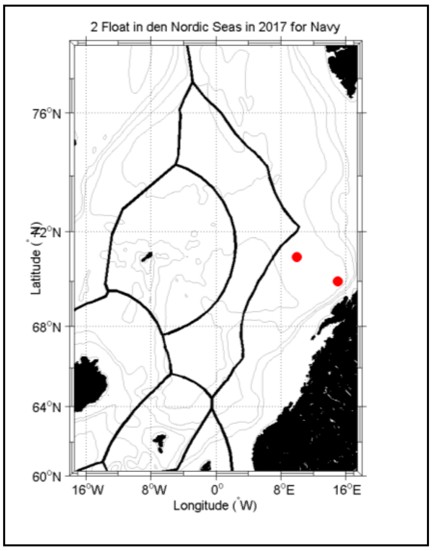


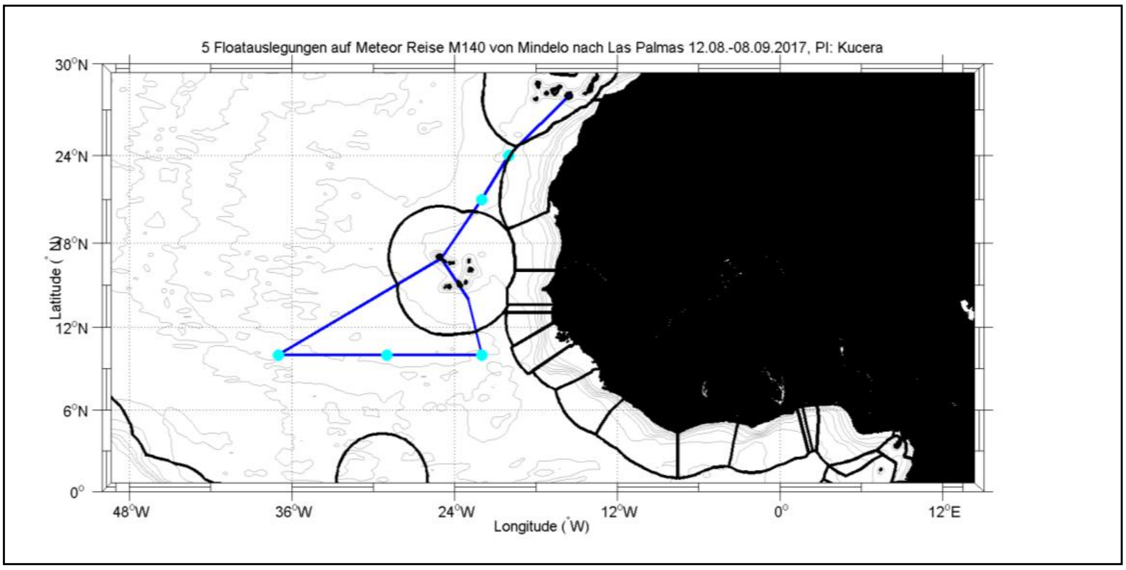






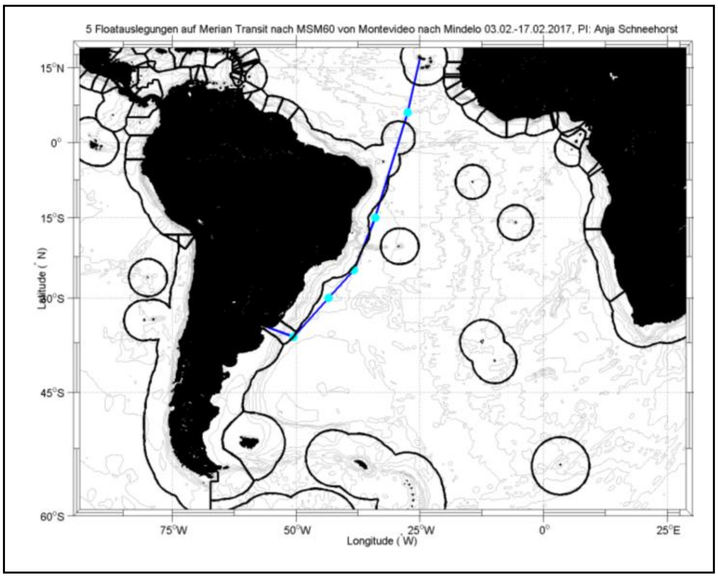


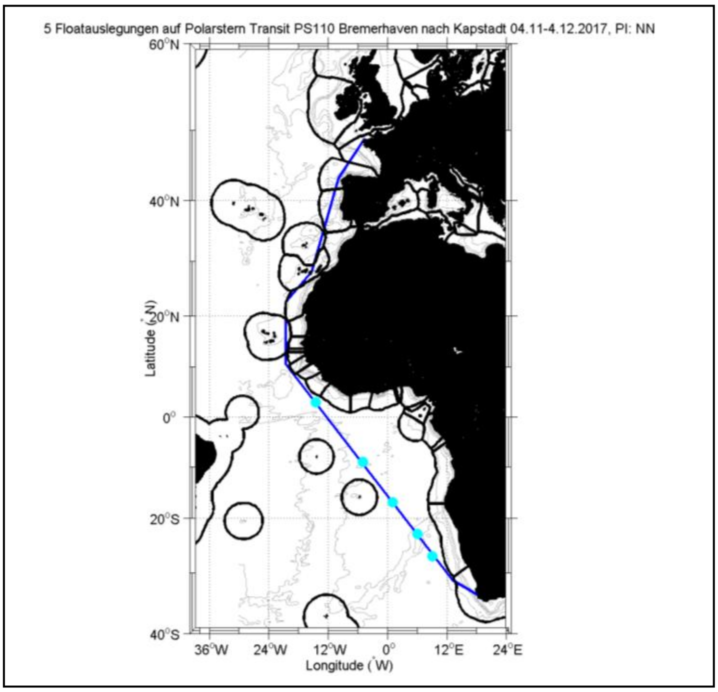


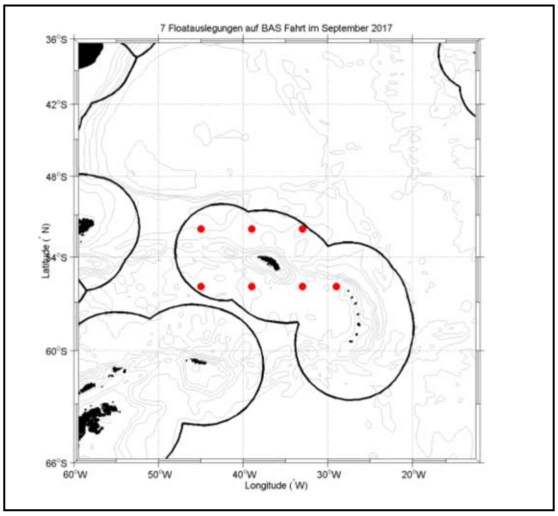


Additional floats will be deployed in the tropical Atlantic and 2 floats are reserved for the German Navy for the Nordic Seas. The field phase of the YOPP is postponed until 2018, testing of 2 polar floats could be carried out in 2017, positions and times for floats not yet clear, potentially in the Norwegian EEZ to avoid problems with requiring permits for Russian territory.

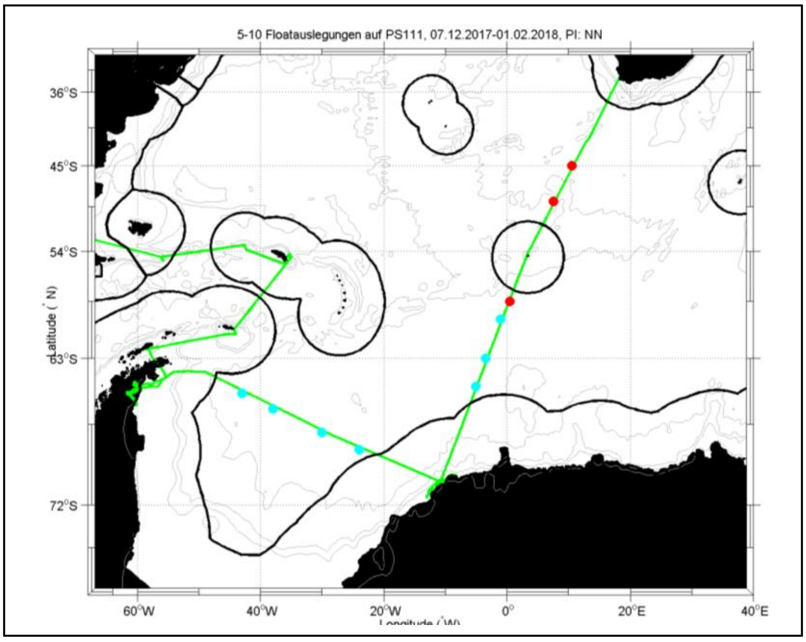
Gap filling in the Southern Ocean:







Gap filling in the Weddell Gyre:



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. The URL for the Argo Germany is:

http://www.german-argo.de/

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 held on 22.06.2016 at BSH was attended by a mixed group; it included users from the modelling community and users performing observational studies. The three institutions contributing floats to the German program outside of BSH were also represented.

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.

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:

Merian cruises MSM-39, MSM-43 and MSM53 were provided by Uni Bremen (PI: Dagmar Kieke)

Meteor cruises M130 and M131 were provided by GEOMAR (PI: Peter Brandt)

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.

Stendardo, I., M. Rhein, and R. Hollmann (2016), A high resolution salinity time series 1993-2012 in the North Atlantic from Argo and altimeter data, J. Geophys. Res., 121, 2523-2551, doi:10.1002/2015JC011439.

Burmeister, K., P. Brandt, and J. F. Lübbecke (2016), Revisiting the cause of the eastern equatorial Atlantic cold event in 2009, J. Geophys. Res. Oceans , 121 , 4777–4789, doi:10.1002/2016JC011719.

Schütte, F., Brandt, P. und Karstensen, J. (2016) Occurrence and characteristics of mesoscale eddies in the tropical northeast Atlantic Ocean Ocean Science, 12 (3). pp. 663-685. DOI 10.5194/os-12-663-2016.

Stramma, L., Czeschel, R., Tanhua, T., Brandt, P., Visbeck, M. und Giese, B. S. (2016) The flow field of the upper hypoxic Eastern Tropical North Atlantic oxygen minimum zone Ocean Science, 12 (1). pp. 153-167. DOI 10.5194/os-12-153-2016.

Stammer, D.; Balmaseda, M.; Heimbach, P.; Köhl, A.; Weaver, A.. “Ocean Data Assimilation in Support of Climate Applications: Status and Perspectives”. Annual Review of Marine Science 8. (2016): S. 491-518. doi: 10.1146/annurev-marine-122414-034113

Jochumsen, K.; Schnurr, S.M.; Quadfasel, D.. “Bottom temperature and salinity distribution and its variability around Iceland”. Deep Sea Research Part I: Oceanographic Research Papers 111. (2016): S. 79-90. doi: 10.1016/j.dsr.2016.02.009

K. Latarius, D. Quadfasel: Water mass transformation in the deep basins of the Nordic Seas: Analyses of heat and freshwater budgets, Deep_Sea Research I, 114 (2016): 23-42, http://dx.doi.org/10.1016/j.dsr.2016.04.012

Myriel Horn (2015), Frontal analysis on the shelf region of the western North Atlantic, M.Sc. Marine Environmental Sciences, University of Oldenburg

GREEK ARGO PROGRAMME

PRESENT STATUS AND FUTURE PLANS

G. Korres and D. Kassis
HCMR
February, 2017

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 2016, 3 Argo floats were successfully deployed in the Greek Seas under the framework of the Greek Argo Project. All 3 floats are NOVA/DOVA types and were purchased by the Greek Argo RI. They were deployed by the Greek-Argo team in the North, South and Central Aegean basin. The floats integrate an Iridium satellite telemetry system which provides a dual telecommunication capability allowing modification of the configuration in real-time. The first (WMO number: 6903275) was deployed at the 18th of May 2016 at the Northern Aegean, near Athos Peninsula. The float integrates a Dissolved Oxygen sensor. Two months later, the second float (WMO: 6903276) was deployed at the center of the Cretan Sea. At the end of 2016 (6/12), a third float (WMO: 6903277) was deployed in the Myrtoan Sea, east of the Hydra Island. During 2016, 10 floats had been active however, 7 were still active by the end of the year since 3 terminated their operation.

The deployments during 2016 are presented in the Table 1 and in Figure 1:

Table 1. Deployments performed from Greek Argo team during 2015

A/A	Type	WMO	IMEI NUMBER	S/N	Deployment date	Deploym ent time	Latitude	Longitude	Acquired profiles by the end of 2016	Current Status
1	DOVA	6903275	300234062953200	247	18/5/2016	11:00	39.92	24.25	40	Inactive
2	NOVA	6903276	300234063609400	271	13/7/2016	8:00	35.09	25.05	34	Active
3	NOVA	6903277	300234063600410	274	6/12/2016	21:00	37.00	24.02	6	Active

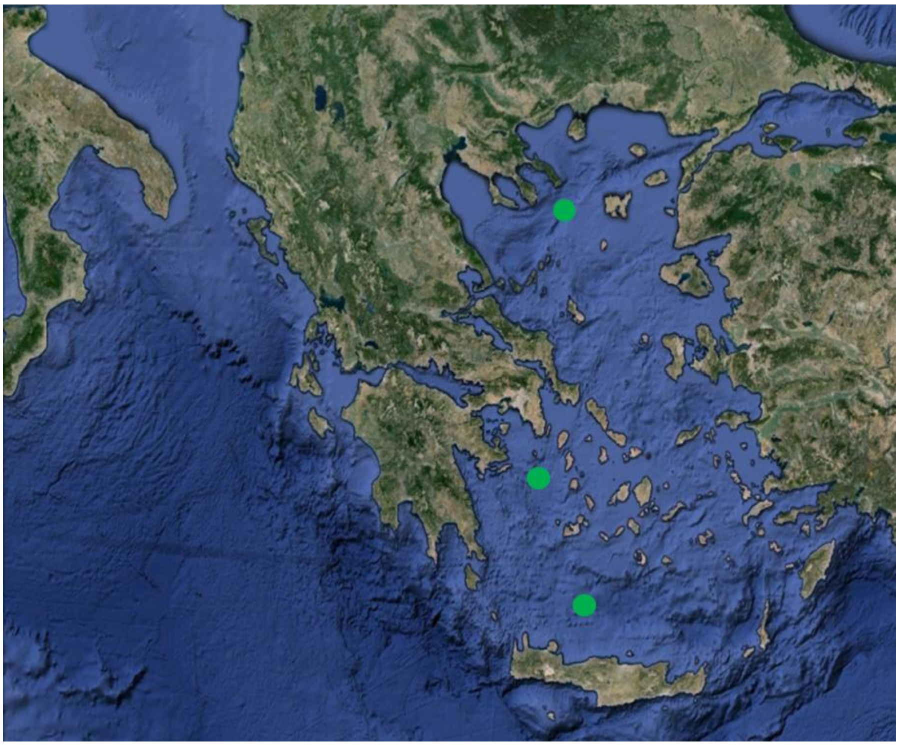


Figure 1. Greek Argo 2016 deployment locations

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

1.2 Float Development

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

1.3 Data management

HCMR has run an extended network of buoys within the Aegean and Ionian Seas including the multi-parametric M3A observatory of the Cretan Sea and a deep sea (2000 m) bottom platform deployed in the Ionian Sea (POSEIDON & POSEIDON-II monitoring, forecasting and information systems). HCMR also operates the Hellenic National Oceanographic Data

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

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 MyOcean project. 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, in the frame of the Greek Euro-Argo programme (which will demonstrate the Argo value) is the development of the capabilities in order to exploit 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

<u>Ocean science</u>

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. Mediterr. Mar. Sci. (In press, accepted on October 2016)

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

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. A tender regarding the procurement of 25 new floats during the next 3 years period has been accomplished. During 2014 the first 13 floats have been delivered while the remaining 12 have been delivered during 2015.

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 coordination: 1.5
- Float preparation, deployment, procurement: 1.5
- Delayed mode QC: 2

Greece has deployment capabilities for the Aegean, the Ionian Sea and the central Levantine basin. Float deployments in 2016 will be performed according to the plans of the Greek-Argo research infrastructure. The main goal within 2016 is to continue the development of the Greek-Argo infrastructure array in accordance with MEDARGO and the EuroArgo 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 2017 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 float deployment in the North Aegean
- 1 float deployment in the Ionian Sea
- 2 float deployments in the Levantine Sea

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

Within 2016 several dissemination activities were carried out by the Greek Argo RI. The Euro-Argo RI leaflet was disseminated at the 48th Liege Colloquium that was held at the University of Liege in May 2016. A leaflet promoting the Bio-Argo component was also disseminated at the 51st European Marine Biology Symposium (EMBS) that was held in Rhodes, Greece in September 2016. A presentation of the Greek Argo RI and Euro-Argo RI activities was carried out at the University of the Aegean – Department of Marine Sciences in November 2016.
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 - March 2017

(Submitted by M. Ravichandran and Pattabhi Rama Rao)

1. The status of implementation

1.1a Floats deployment

During the year 2016–17, 22 floats were deployed in the Indian Ocean, taking the total to 418. The new deployment includes 7 Bio-Argo floats with additional sensors like Doxy, FLBB, Chl-a.

1.1b performance Analysis of Floats deployed

Out of 418 floats deployed so far 140 floats are active. Out of these 140 active floats, 96 (63) floats are less than 3 (2) years old.

1.2 Technical problems encountered and solved

None

1.3 Status of contributions to Argo data management

- **Data acquired from floats**

  India had deployed 418 floats so far. Out of these 140 floats are active. All the active floats data are processed and sent to GDAC.

- **Data issued to GTS**

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

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

  All the active floats (140) 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. ¬ This data is also used for validation of Biogeochemical model outputs like ROMS with Fennel module.

INCOIS Argo web page statistics (for the past one year) are as shown below:

Page	Hits and Visitors
Argo Web pages	3333
Argo Data Bank	6916

Products generated from Argo data

1. 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 seen in the RDAC functions.

2. Version 2.1 of DVD on "Argo data and products for the Indian Ocean" is released to public for use with data corresponding to 2016 being updated. This DVD consists of ~ 2,85,000 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.

3. 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 from 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 archive initiative, data from our own sister concerns is being obtained and put to use in the delayed mode processing.
- About 54% 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:

A total of 408 trajectory netcdf files were processed and uploaded to the GDAC. The process of generation of trajectory netcdf files undergoes quality checks like position, time, cycle number, etc., and corresponding quality status is assigned to each parameter. Trajectory files in Ver 3.1 format for all APEX floats is being uploaded to GDAC and trajectories wrt to PROVOR floats need to generated.

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 a 5 year Program (April 2012 to March 2017) fully funded by Ministry of Earth Sciences, (MoES), Govt. of India. Funding is secured for the deployment of 200 Argo floats (40 floats per year including 10 Bio-argo floats), Data management activities, Data analysis, etc. until 2017. During the next plan 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 40 floats per year until 2017 (10 floats each in the Southern Ocean, Bay of Bengal, equatorial Indian Ocean and Arabian Sea). Out of 40 floats, 10 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 2017. During the next plan period 2017-2020, India plans to deploy 50 floats/per (40 in the Tropical Indian Ocean and 10 in the Southern ocean)

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)

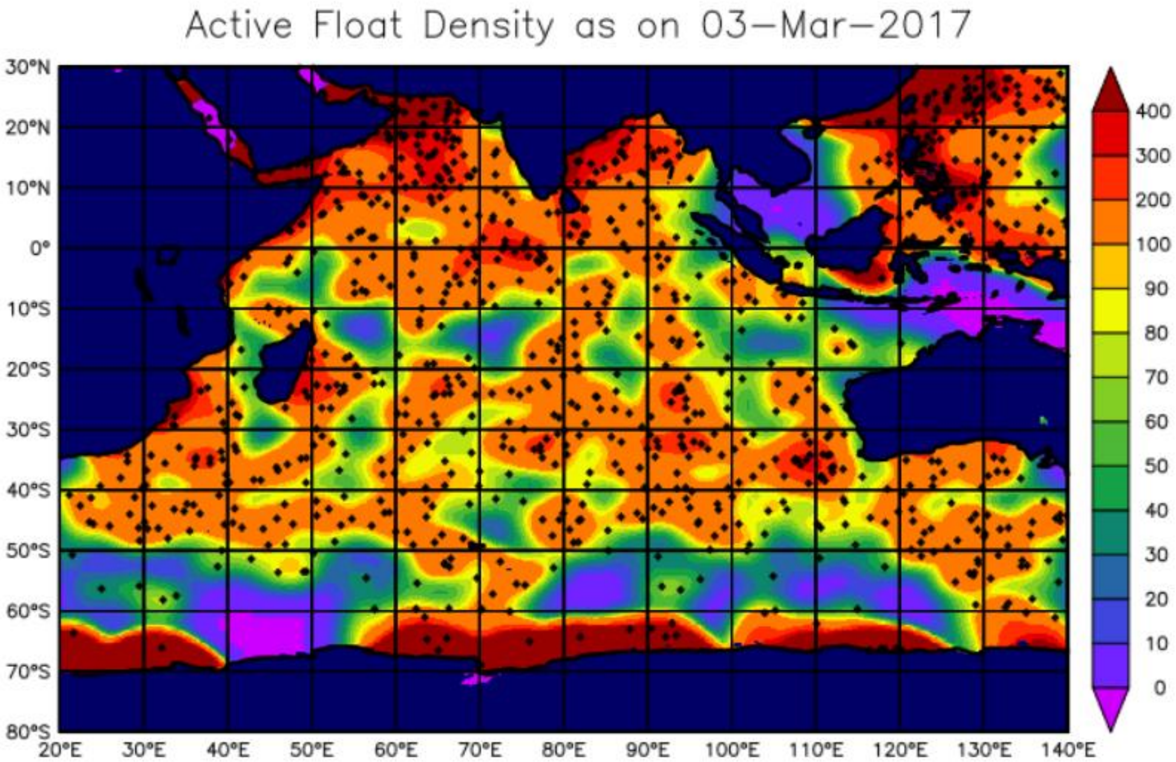
- Acquisition of Argo data from GDAC corresponding to floats other than deployed by India and made them available on INCOIS web site.
- All these data sets are made available to the user through a s/w developed with all GUI facilities. This s/w is made available through FTP at INCOIS and UCSC web sites.
- 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.
- Efforts are underway to setup ERDDAP for the data and data products 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 03 Mar 2017 is shown below.



Further, as part of the ARC activities of Indian ocean, INCOIS has undertaken the following activities:

1. Conducted several user awareness and data utilization workshops to bring about awareness of Argo among the students of various universities. This is also our mandate as a part of our International Training Center for Operational Oceanography (ITCOO) centre.

2. Developed Graph theoretical based algorithms for performing QC of Argo data. This has been tested with some typical floats deployed by Indian and found to yield good results. A manuscript is prepared and will be submitted for peer review. Once published it can be expanded to other ocean basins.

3. Continued data search and archaeology of high quality CTD for updating the Argo reference data base and also for use in DMQC of Argo data from various sister concerns.

4. Continued archiving of temperature and salinity profile data from floats deployed by Indian and other countries in the Indian Ocean and making them available through Web-GIS.

5. Sustaining generation of value added products based on gridded products obtained from Objective and Variational Analysis methods. These value added products are made available on the web and also on the Live Access Server. Also monitoring the publications that are arising out of the Argo and derived products.

6. Continued to synchronize the "Argo data and product for Indian Ocean" products being made available on INCOIS and UCSD website. These products have GUI features catering to students and other researchers with low bandwidth capabilities.

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.

All the CTD data outside EEZ was identified which will be submitted to CCHDO for adding to the reference database.

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Argo National Report 2015-2016: Ireland

1) The status of implementation (major achievements and problems in 2016):

   a) Irish Argo float Overview

ARGO: Marine Institute Operational & Stock ARGO Floats (as of: 21/02/2017)				
Deployed / Operational ARGO Floats				
# of Floats	WMO (Global Identifier) #	Float Identifier #	Make/Model	Deployed
1	6900444		NKE/AVOR	08/03/2011
2	6900658		NKE/AVOR	07/03/2011
3	6901913		NKE/AVOR	06/09/2012
4	6901914		NKE/AVOR	26/03/2013
5	6901919	7244	Teledyne/Apex	22/03/2015
6	6901920	7245	Teledyne/Apex	22/04/2015
7	6901921	7243	Teledyne/Apex	23/03/2016
8	6901922	7242	Teledyne/Apex	14/04/2016
9	6901923	7241	Teledyne/Apex	09/04/2016
Argo floats to be deployed in 2017				
# of Floats	WMO (Global Identifier) #	Float Identifier #	Make/Model	Deployed
1	6901924	7240	Teledyne/Apex	
2	6901925	7841	Teledyne/Apex	
3	6901926	7842	Teledyne/Apex	
ARGO Floats Awaiting Deployment (in stock)				
# of Floats	WMO (Global Identifier) #	Float Identifier #	Make/Model	Deployed
1	TBC	7843	Teledyne/Apex	

   b) Irish floats deployed in 2016 and their performance*

WMO (Global Identifier) #	Float Identifier #	Make/Model	Deployed
6901921	7243	Teledyne/Apex	23/03/2016
6901922	7242	Teledyne/Apex	14/04/2016
6901923	7241	Teledyne/Apex	09/04/2016
*			

*Ireland via the Marine Institute also deployed a float on behalf of the MOCCA project: WMO# 3901871

   c) Technical problems encountered and solved

   None

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

   Carried out by BODC for us.

e) **Status of delayed mode quality control process**
Carried out by BODC for us.

2) **Present level of and future prospects for national funding for Argo including a summary of the level of human resources devoted to Argo.**
Ireland is now a full member of the Euro-Argo ERIC and will comply with the minimum requirement of deploying 3 floats per annum. Ireland via the Marine Institute will deploy addition funds where funding allows and will also assist the ERIC in deploying project specific floats where appropriate e.g. The MI deployed an additional float in 2016 via the EU funded MOCCA project.

3) **Summary of deployment plans (level of commitment, areas of float Deployment, low or high resolution profiles, extra sensors, Deep Argo) and other commitments to Argo (data management) for the upcoming year and beyond where possible.**
It is our goal to ensure three floats will be deployed during 2017 in alignment with the requirements of the Euro Argo ERIC. Multi-annual funding for the programme remains elusive but efforts continue towards that end on the national level. Float procurement via the Euro-Argo ERIC may allow for an increased number of floats to be procured but this is dependent on final tender specifications.

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 is primarily used to validate ROMS models in the Oceanographic Services section of the Marine Institute. Argo data will also be utilised by a number of PhD students within the Marine Institute and 3rd level institutes across Ireland.

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

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

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

N/A although anticipated during 2017.

Report on the Italian Argo Program for 2016

1. The status of implementation (major achievements and problems in 2016).

- floats deployed and their performance:

In total, **28 Italian floats** were deployed in 2016 (see Tables 1 and 2 for details). These floats were Arvor, Deep Arvor and Provor designs manufactured by NKE (France), Apex floats produced by Teledyne Webb Research (USA) and Nova/Dova profilers manufactured by MetOcean (Canada). The majority of the floats transmit data via Iridium telemetry (Arvor-I, Provor Bio, Provor Nut, Nova/Dova) and only a few have Argos telemetry (Apex).

Mediterranean and Black Sea deployments

One float was deployed in the Black Sea and 12 units were released in the Mediterranean (Table 1). In the Mediterranean, most floats have a parking depth at 350 dbar and maximal profiling depths alternating at 700 and 2000 dbar. In the Black Sea, the parking depth was set to 200 dbar. They all have cycles of 5 days, except the deep float WMO 6903200 which has cycles of 10 days.

Most floats were deployed from research vessels of opportunity (i.e., R/V Minerva I, R/V Tethys II, R/V Aegaeo and R/V OGS Explora for the Mediterranean and R/V Mare Nigrum for the Black Sea) with the help of colleagues from Italy, France, Greece, Romania and Bulgaria. The French Navy deployed three floats in the Tyrrhenian Sea from the F/S Belle Poule (Figure 1).

Figure 1. Arvor-I float being deployed in the Tyrrhenian Sea by the French Navy in June 2016.

Two Nova floats equipped with SBE 63 optical dissolved oxygen sensor (also called Dova) were deployed in the Tyrrhenian and Levantine Seas in spring and fall 2016, respectively.

One float equipped with biogeochemical and optical sensors (Provor Nut) was deployed in the South Adriatic Sea. The Provor Nut is a Provor CTS 4 with Iridium global telephone network

(RUDICS) for data telemetry and a GPS receiver for position. It measures at 1 dbar vertical resolution not only temperature and salinity (SBE CTD) but also irradiance at three wavelengths (412 nm, 490 nm, 555 nm), fluorescence of colored dissolved organic matter, fluorescence of chlorophyll-a, backscattering coefficient (530nm) and attenuation coefficient (660 nm), dissolved oxygen (Aanderaa optode) and nitrate (SUNA) concentrations.

Two deep floats (Deep Arvor) were deployed in the deep areas of the Mediterranean Sea southwest of Greece. For the first one (Figure 2, see also Pacciaroni et al., 2016) the maximal profiling depth and the parking depth were both set to 4000 dbar in order to ground the float on the sea floor and minimize its horizontal displacement. In contrast, the second float was programmed to sample from, and drift at, a pressure level of 3000 dbar in order to avoid frequent grounding.

Figure 2. Deep Arvor float (WMO 6903200) before deployment on the R/V Aegaeo on 8 June 2016.

Model	WMO	Deploy date	Lat	Lon	Cycles	Last_TX date	Lat	Lon	Status*	Cycle**
Nova	6903179	25-Feb-2016 12:39	41.25	10.5	35	13-Feb-2017 11:04	40.43	13	AS	5
Provor Nut	6903197	07-Apr-2016 21:46	41.57	17.38	83	10-Feb-2017 10:37	41.17	18.14	A	5
Apex	6903196	14-May-2016 04:24	37.1	17.4	44	09-Feb-2017 02:29	38.39	18.22	A	5
Dova	6903180	31-May-2016 21:42	41.33	12.08	52	10-Feb-2017 12:03	39.67	9.94	A	5
Arvor-I	6901833	01-Jun-2016 08:59	42.24	39.87	51	13-Feb-2017 09:06	44.38	35.32	A	5
Arvor-I	3901848	04-Jun-2016 16:32	40.08	13.34	42	10-Feb-2017 12:16	40.63	12.06	A	5
Arvor-I	3901849	05-Jun-2016 11:43	39.26	10.77	41	11-Feb-2017 12:10	39.52	6.62	A	5
Apex	6903198	06-Jun-2016 09:15	34.4	26.02	46	12-Feb-2017 06:09	32.82	30.89	A	5
Arvor-D	6903200	08-Jun-2016 05:47	35.25	22.77	11	03-Aug-2016 06:12	35.16	22.44	D	10
Apex	6903199	24-Jun-2016 10:09	43.73	9.69	16	10-Feb-2017 08:36	42.61	9.67	A	5
Nova	6903201	21-Oct-2016 00:24	33	33	36	03-Feb-2017 01:53	33.99	32.4	A	5
Arvor-D	6903203	07-Dec-2016 23:51	35.35	22.98	15	12-Feb-2017 06:12	35.61	22.67	A	5
Dova	6903204	08-Dec-2016 14:38	34.18	25.25	14	11-Feb-2017 04:03	33.87	25.83	A	5

**Status in early February 2017: A = active, D = dead; AS = active but drifting at surface.*
***Cycle: Length of cycle in days.*

Table 1. Status information for the 13 Italian floats deployed in the Mediterranean and Black Sea (grey rows) during 2016.

Southern Hemisphere deployments

Ten Italian floats were deployed in the South Pacific Ocean and the Pacific sector of the Southern Ocean (Table 2) with the help of Italian colleagues on-board the R/V Italica while sailing from New Zealand to the Ross Sea (Figure 3). These floats included 8 Nova and 2 Dova floats. 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.

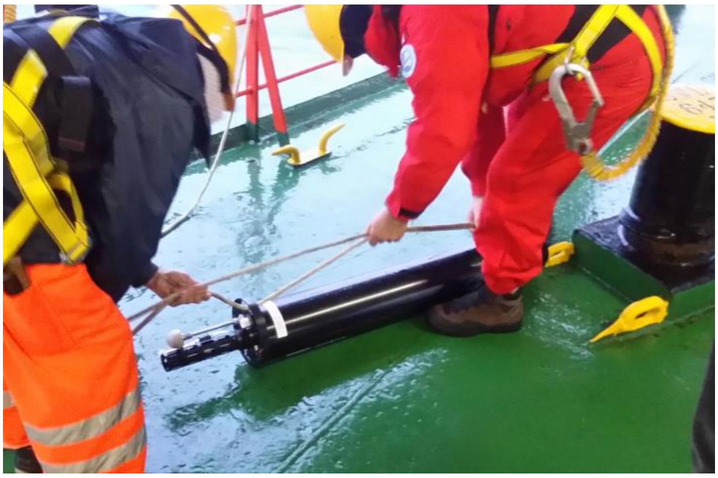

Figure 3. A Nova float ready to be deployed on R/V Italica in January 2016.

Five Italian floats were also deployed in the South Atlantic Ocean (Table 2) with the help of Italian colleagues on-board the South African R/V Agulhas II. These floats included 4 Nova and 1 Dova floats and were programmed to cycle between the surface and 2000 dbar every 10 days and to drift at the parking depth of 1000 dbar.

Overall status at the end of 2016

In summary, at the end of 2016, the ARGO-ITALY program had a total of **62 active floats**, including 37 instruments in the Mediterranean Sea, 5 in the Black Sea (Figure 4) and 20 in the South Pacific, South Atlantic and Southern Oceans (south of 60˚S) (Figure 5).

Since 18 February 2012, a total of **109 ARGO-ITALY floats** have been deployed. In less than 5 years, they have provided about **11000 CTD profiles**. In total, 12 floats (11 %) have failed just after deployment.

The temporal evolution of the number of active floats is shown in Figure 6 with weekly resolution, along with the annual numbers of float deployments and float deaths for the period 2012-2016. The float population in 2012-2016 is essentially increasing and reaching 60-70 active instruments in 2016. In 2015 and 2016 the annual numbers of deployments (26 and 28, respectively) were related to annual losses of 13 in 2015 and 14 in 2016.

Model	WMO	Deploy date	Lat	Lon	Cycles	Last_TX date	Lat	Lon	Status*	Cycle**
Nova	6903181	17-Jan-2016 16:41	-50.98	173.15	0	28-Jan-2016 00:44	-50.62	173.65	D	10
Dova	6903183	17-Jan-2016 21:55	-51.98	173.19	57	13-Feb-2017 02:20	-52.34	179.59	A	10
Nova	6903182	18-Jan-2016 03:09	-53.01	173.17	72	11-Feb-2017 11:16	-43.92	177.7	A	10
Nova	6903184	18-Jan-2016 12:29	-54.99	173.53	20	26-Jul-2016 13:59	-56.13	177.17	D	10
Nova	6903185	18-Jan-2016 17:01	-55.99	173.4	0	18-Jan-2016 17:22	-56.02	173.44	D	10
Nova	6903186	19-Jan-2016 02:10	-58	173.28	26	15-Sep-2016 13:57	-56.46	179.81	D	10
Nova	6903187	19-Jan-2016 11:20	-60	173.32	40	12-Feb-2017 14:08	-55.59	-164.17	A	10
Nova	6903189	19-Jan-2016 16:06	-61	173.33	40	02-Feb-2017 13:53	-60.65	-166.46	A	10
Dova	6903190	19-Jan-2016 20:41	-62	173.4	40	12-Feb-2017 14:19	-60.96	-167.34	A	10
Nova	6903188	20-Jan-2016 01:09	-63	173	0	20-Jan-2016 01:26	-62.96	173.6	D	10
Nova	6903193	04-Feb-2016 06:50	-58	0	0	04-Feb-2016 07:11	-58.02	0	D	10
Nova	6903192	04-Feb-2016 21:23	-55	-0.03	38	08-Feb-2017 13:53	-51.19	20.9	A	10
Dova	6903191	05-Feb-2016 15:10	-51.5	0	13	15-May-2016 13:45	-50.69	4.71	D	10
Nova	6903194	06-Feb-2016 11:14	-48.01	3.6	38	10-Feb-2017 14:03	-50.46	38.37	A	10
Nova	6903195	07-Feb-2016 09:45	-44.96	6.55	38	11-Feb-2017 13:56	-44.43	19.99	A	10

**Status in early February 2016: A = active, D = dead; ANP = active without positions.*
***Cycle: Length of cycle in days.*

Table 2. Status information for the 15 Italian floats deployed in the Southern Ocean during 2016.

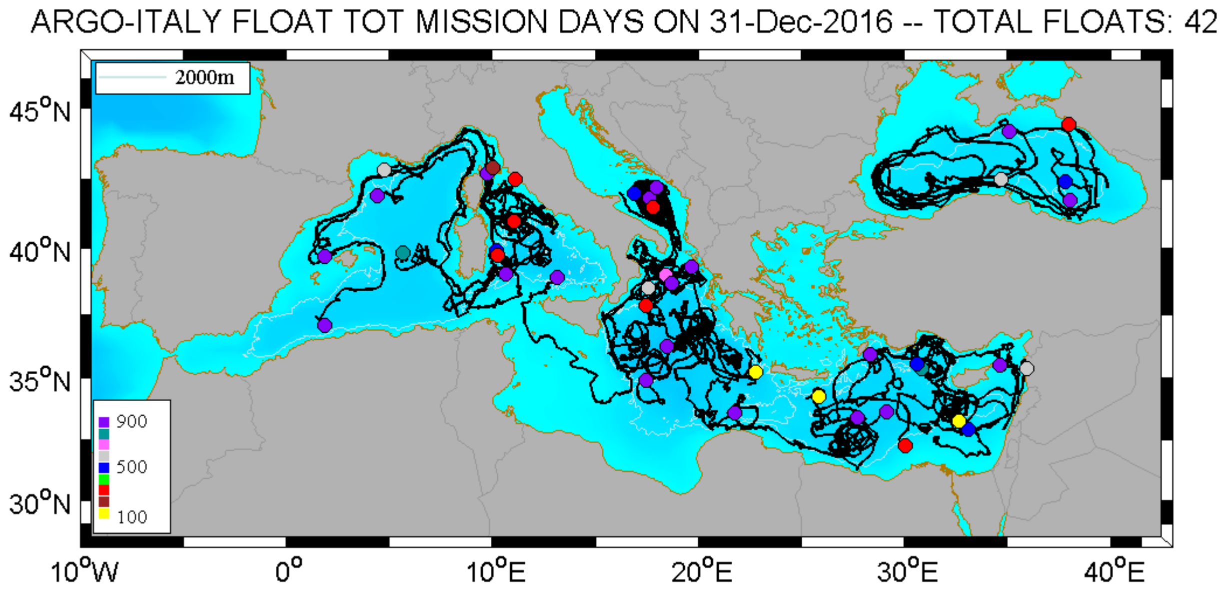

Figure 4. Trajectories and positions (circle symbols) on 31 December 2016 of the 42 ARGO-ITALY floats active in the Mediterranean and Black Sea at the end of 2016. The circle symbols are color-coded as a function of float age in days.

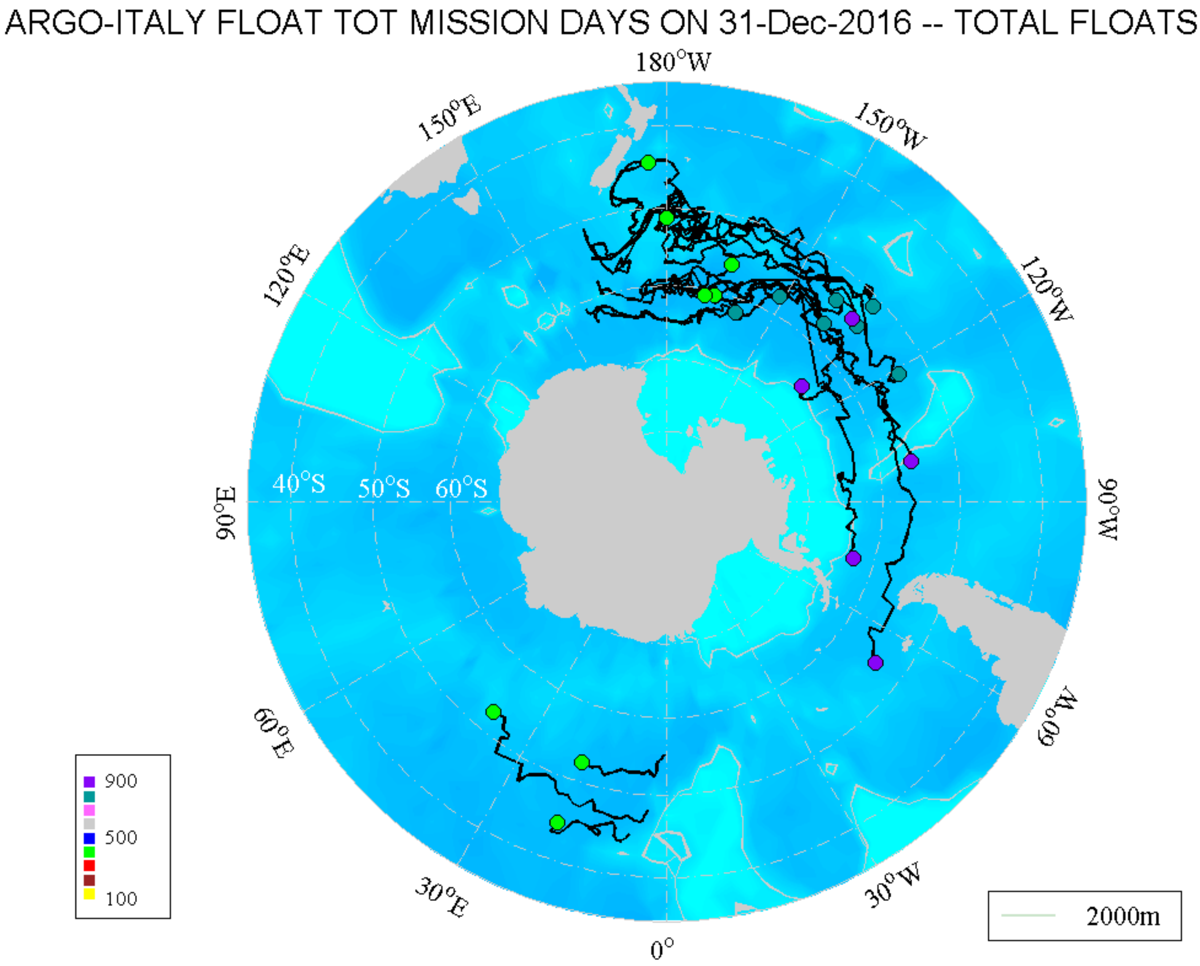

Figure 5. Trajectories and positions (circle symbols) on 31 December 2016 of the 20 ARGO-ITALY floats in the South Pacific, South Atlantic and Southern Oceans. The circle symbols are color-coded as a function of float age in days.

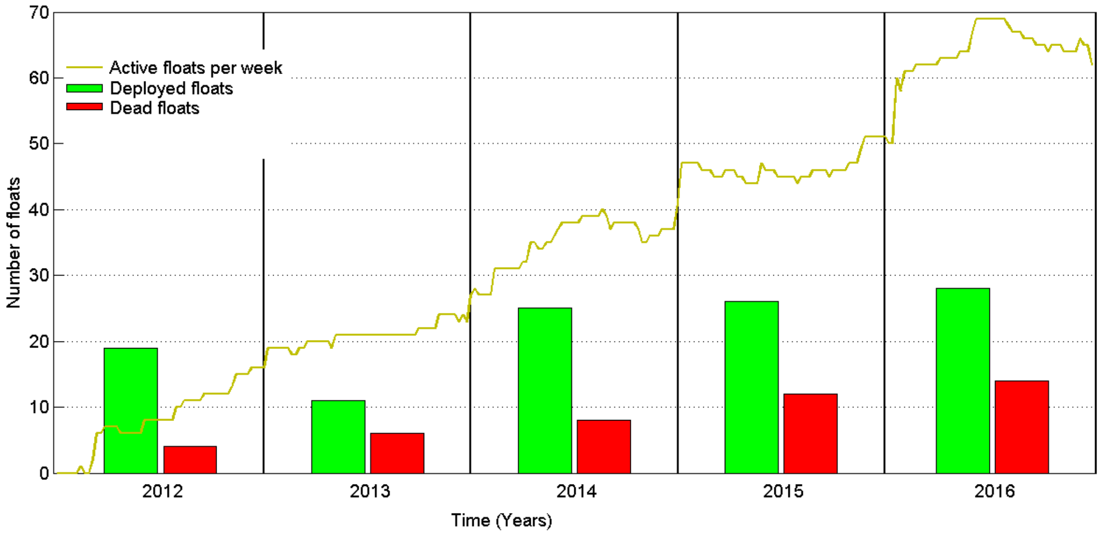

Figure 6. Temporal evolution of the number of active floats with weekly resolution and histogram of the annual float deployments and losses.

- technical problems encountered and solved

Mediterranean and Black Sea

The Nova float WMO 6903179 deployed in the Tyrrhenian Sea on 13 February 2016 suffered a malfunction after cycle 35 (on 9 August 2016) and subsequently remained at the surface. The deep Arvor float WMO 6903200 which was deployed on 8 June 2016 provided only 10 profiles and stopped transmitting after 3 August 2016. The cause of this failure has still to be investigated but we suspect that excessive grounding could have created problems. The second deep Arvor float WMO 6903203 deployed in December 2016 and programmed to profile down to 3000 dbar and to drift at a parking depth of 3000 dbar did not show problems and was still alive in early 2017, although its oxygen profiles appeared drastically erroneous.

Southern Hemisphere

The Nova/Dova floats deployed in the Southern Hemisphere in early 2016 have low survival rates and after a year (in early 2017) only 8 floats (out of 15 units, i.e., about 53%) were still fully operational.

In the South Pacific and Southern Ocean (Pacific Sector south of 60ºS) float WMO 6903181 stayed at the surface and stopped transmitting after about 9 days. Float WMO 6903184 stopped transmitting after 20 cycles. Floats WMO 6903185 and 6903188 failed right after deployment. Float WMO 6903186 stopped transmitting after 26 cycles.

In the South Atlantic Ocean float WMO 6903193 failed at deployment and the Dova float WMO 6903191 stopped transmitting after only 13 cycles.

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

The data management for the Italian float was 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 37 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 2010-2016. 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. 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 adopt 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 the reliability of the analysis. The DMQC of the Italian floats deployed in the Southern Ocean, the South Pacific and South Atlantic) is kindly performed by CSIRO in Hobart, Tasmania.

References

Pacciaroni M., Poulain P.-M., Civitarese, G., Pavlidou A., Velaoras D. and Bussani, A. (2016) Deep-Arvor programming and deployment in the Western Cretan passage. Rel. 2016/56 Sez. OCE 28 MAOS, 18 pp.

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 30 floats in 2016, including 5 instruments with dissolved oxygen sensors and 10 floats with Ice Sensing Algorithm (ISA). 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 2016. It is expected that the same level will be maintained in 2017, including the procurement of 20 additional standard floats and 3 floats with biogeochemical/optical sensors. The Italian Ministry of Research is committed to provide funding in order to sustain the Italian contribution to Argo beyond 2017 as founding member of the Euro-Argo Research Infrastructure Consortium. In addition to the Italian national funding, OGS has funding from EC (CMEMS, MOCCA) and ONR (CINEL) 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 2017 and 2018 are detailed in Table 3. The main areas of interest are the Mediterranean and Black seas and the Southern Ocean.

Year	T/S floats (some of them with DO)		BGC floats		Deep floats		Total
	Quantity	Area	Quantity	Area	Quantity	Area	
2017	15 2 15	Mediterranean Black Sea Southern Ocean	2 1	Mediterranean Black Sea	0	Mediterranean	**35**
2018	13 2 15	Mediterranean Black Sea Southern Ocean	2 1	Mediterranean Black Sea	2	Mediterranean	**35**

Table 3. Italian float deployment plans for 2016-2017.

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 Sea as part of the CMEMS and MOCCA 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/ .

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.

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 2016.

N/A

7. Italian contribution to Argo bibliography in 2016.

Buongiorno Nardelli, B., R. Droghei, and R. Santoleri (2016) Multi-dimensional interpolation of SMOS sea surface salinity with surface temperature and in situ salinity data. Remote Sensing of Environment, 180, 392-402, http://dx.doi.org/10.1016/j.rse.2015.12.052

Capet, A., E. V. Stanev, J. M. Beckers, J. W. Murray, and M. Grégoire, 2016: Decline of the Black Sea oxygen inventory. Biogeosciences, 13, 1287-1297, http://dx.doi.org/10.5194/bg-13-1287-2016

Fratianni, C., N. Pinardi, F. Lalli, S. Simoncelli, G. Coppini, V. Pesarino, A. Bruschi, M. L. Cassese, and M. Drudi (2016) Operational oceanography for the Marine Strategy Framework Directive: the case of the mixing indicator. Journal of Operational Oceanography, 9, s223-s233, http://dx.doi.org/10.1080/1755876X.2015.1115634

Riser, S. C., H. J. Freeland, D. Roemmich, S. Wijffels, A. Troisi, M. Belbeoch, D. Gilbert, J. Xu, S. Pouliquen, A. Thresher, P.-Y. Le Traon, G. Maze, B. Klein, M. Ravichandran, F. Grant, P.-M. Poulain, T. Suga, B. Lim, A. Sterl, P. Sutton, K.-A. Mork, P. J. Velez-Belchi, I. Ansorge, B. King, J. Turton, M. Baringer, and S. R. Jayne, 2016: Fifteen years of ocean observations with the global Argo array. Nature Clim. Change, 6, 145-153, http://dx.doi.org/10.1038/nclimate2872

Japan National Report

(Submitted by Toshio Suga)

1. The Status of implementation (major achievements and problems in 2016)

1.1 Floats deployed and their performance

The current positions of all the active Japanese Argo floats are shown in Fig.1.

Japan Agency for Marine-Earth Science and Technology (JAMSTEC) deployed 31 Argo and Argo equivalent floats from January to December 2016: 11 ARVOR, 17 Navis, and 3 DeepNINJA floats. All the floats except one described below were deployed with the aid of R/Vs of 7 domestic organizations.

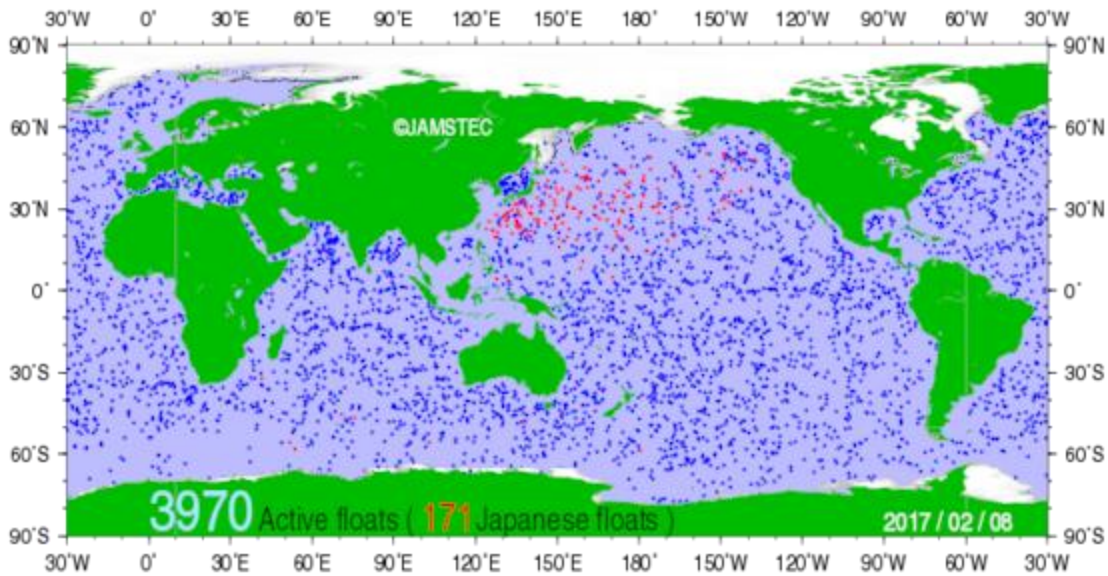

Figure 1: The distribution of active Argo floats. The red dots represent active Japanese floats.

Two Navis floats of JAMSTEC were deployed by a voluntary cargo ship owned by a Japanese merchant ship company, NYK Line, in July 2016. 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.

From 1999 to the end of December 2016, JAMSTEC deployed 1156 (1168) Argo and Argo equivalent floats (the number in parenthesis includes floats deployed as non Argo floats; most of their data are to be released as Argo data later) in the Pacific, Indian and Southern Oceans: 759 (764) APEX, 141 (143) PROVOR, 123 (123) ARVOR, 33 (39) NEMO, 66 (66) Navis, 11 (11) NINJA, 15 (15) Deep NINJA, 6 (6) POPS and 2 (2) SOLO floats. As of the end of December 2016, 128 (128) floats [6 (6) APEX, 77 (77) ARVOR, 41 (41) Navis, and 4 (4) Deep NINJA floats] are in normal operation. The other 1029 (1041) floats terminated their missions, including 1(1) floats drifting at the sea surface and 12 (13) floats recovered. JAMSTEC deployed 5 floats [2 ARVOR, 1

Navis, 1 DeepNINJA, 1 DeepAPEX equipped with Optode4835 floats) in January and February 2017.

The Japan Meteorological Agency (JMA) deployed 20 Argo equivalent floats (4 APEX and 16 ARVOR floats) in the seas around Japan from January to December 2016. All the floats get 2,000 dbar T/S profiles every 5 days for operational ocean analysis and forecast.

Among 226 floats (16 PROVOR, 167 APEX and 27 ARVOR floats) which JMA has deployed from 2005 to 2016, 53 floats (13 APEX and 40 ARVOR floats) are active as of the end of December 2016, while 19 floats (16 APEX and 3 ARVOR floats) terminated the transmission in 2016. JMA deployed 5 APEX floats from January to February 2017.

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. At the beginning of 2016 two Deep NINJA floats were operated off the Budd Coast, the Antarctica and one of them lost contact from February 2016. In 2016, two Deep NINJA floats were deployed in the Indian Ocean in January/February and one float in the subtropical North Pacific in March. Unfortunately, two of them had lost contact. 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 16 Argo equivalent floats from 2011 to 2014. Two floats (2 NEMO floats) are active as of end of December 2016.

1.1.1 Float deployment for synchronous array observation

JAMSTEC has been conducting a small synchronized float array observation since 2014 to investigate formation and dissipation process of the North Pacific central mode water (CMW) in detail, aiming for, for example, quantification of temporal variations of surface and subsurface vertical mixing process forced by wind and surface cooling.. In 2016, we further deployed 7 Navis floats for the array as Argo floats, to get finer vertical resolution (2 meters from the surface through 2000m) data every 10 days, synchronizing sampling interval with the other array floats. Through a 3-year array observation, active internal waves below subsurface layer were identified related to wind energy from atmospheric disturbances. The internal wave enhances vertical diffusivities in fall to winter, which makes the CMW diffused effectively. The result of this synchronized Argo array gives us a new application for ocean observation using Argo floats.

1.1.2 Float deployment for the research project "Impact of bomb cyclones on physical and biogeochemical changes in the ocean"

Two Navis floats were deployed as Argo equivalent floats in the northwestern Pacific in 2016 fall season to investigate the impact of bomb cyclones on the interior oceanic changes. The bomb cyclones break out in winter season and rapidly grow in a short time, having impacts on deeper layer ocean variability. Since 2014 8 Navis floats in total had been deployed; the mission of these floats is to be switched to 6-hour cycle when approaching bomb cyclones are predicted. From the very frequent observations, it is found that the upward vertical velocity of the Navis float itself during measurement is related to timing of passing bomb cyclones. The obtained data are opened and processed in real time, being available from GDACs and through an objective analyses dataset. The funding for this mode of deployment has been provided by JSPS (JSPS KAKENHI Grant Numbers 26707025, PI: Akira Kuwano-Yoshida, APL, JAMSTEC).

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

Three Navis floats were deployed as Argo equivalent floats 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. The Navis floats were deployed among TRITON moorings along 137E line in February; they make measurement down to 2000m every 2 days. The obtained data are opened and processed in real time, being available from GDACs as well as through an objective analyses dataset.

1.2 Technical problems encountered and solved

1.2.1 Float hardware troubles on Navis float

Thirteen Navis floats suffered hardware troubles, which were possibly caused by pump, bulb or bladder system failure, and are still operating without proper measurement in 2016. The symptom of these troubled Navis floats were drifting at the sea surface or not being able to control their drifting or profiling depth. New version of the Navis float (Navis-EBR), which had been released from SBE since 2015, seems to be free from the problem owing to modification by the manufacturer based on diagnosis of the troubles and errors.

1.2.2 RINKO sensor on S3A

As reported last year, One S3A float equipped with RINKO sensor was operated to measure dissolved oxygen (DO) in the sea from July 2014 to January 2016. CTD and DO data were sampled at 2-dbar interval from 2000 dbar to the surface. We obtained 107 profiles of pressure, temperature, salinity and dissolved oxygen observed by it for one year and a half. The RINKO sensor mounted on S3A float is relatively stable, because the time drift of DO data in the deep water is less than 0.5 μmol/kg·year. Unfortunately, the float terminated its operation late January, 2016.

1.2.3 Deep Ninja with RINKO sensor

In 2016, JAMSTEC began to develop a new model of Deep NINJA with RINKO DO sensor in cooperation with JFE Advantech Co. Ltd. and Tsurumi Seiki Co. Ltd. We are going to make two prototypes and they will be deployed for field tests in 2017. The RINKO DO sensor for deep float is under development at JFE Advantech now, and it will be available in near future.

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 171 active floats as of February 8, 2017. 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 GDAC. JMA has converted almost all of Japanese tech-files and submitted them to GDAC. 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 GDAC. JMA has converted about 30% of Japanese traj-files from v2 to v3.1 and submitted them to GDAC.

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 102,286 profiles to GDACs as of December 2016. JAMSTEC had submitted D-Core files of about 7,000 profiles in 2016 and will accelerate the submission of D-Core files in 2017. .

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 Argo extensions (mainly Deep Argo and BGC Argo) was allocated and some Deep and BGC Argo floats were purchased for feasibility study. Further increase of fund for the Argo extensions is expected in FY2017. JMA allocates operational budget for 27 floats in FY2017.

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 2017, JAMSTEC will deploy about 20 floats in total in the Pacific for the Argo core mission. The main purposes of deployment is to fill the blank of 3x3 degree bins in the global Argo array. We will also deploy 9 Argo equivalent floats, the purpose of which is to investigate internal tide wave related to turbulent mixing, observing temporal and vertical high density profiles in the subtropical North Pacific Ocean. Three Deep NINJA floats will be deployed as Deep Argo floats in FY2017 in the North Pacific, Pacific part of Southern Ocean and equatorial Indian Ocean. One APEX float equipped with oxygen, chlorophyll-a, and BBP will be deployed as part of BioGeoChemical Argo in July 2017 at the mooring station K2 operated by JAMSTEC. We have a plan to deploy 3 Deep floats equipped with oxygen during 2017 as non-Argo. Two of them are Deep NINJA equipped with RINKO DO sensor. Their data are to be released as Argo data later. Since several Japanese scientists are applying for competitive research funding to purchase Argo floats, deep floats and BGC Argo floats, the number of floats to be deployed in FY2017 may be increased.

JMA plans to deploy 15 Argo equivalent floats and 12 Argo WBC floats around Japan in FY2017 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) since October 2014. We add our own new flag to real time profile data which tells whether it passed each check or not. 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. JAMSTEC will support the activities of the Southern Ocean ARC (SOARC) in the Pacific sector.

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 for 55 years during 1957-2011 (See the web site in JAMSTEC, http://www.godac.jamstec.go.jp/estoc/e/top/).

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 24 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 Fisheries Research 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 appreciates that some countries have registered their NFPs since AST-16 and 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 686 CTD casts conducted by JMA in the western North Pacific from October 2015 to September 2016 were uploaded to the CCHDO website.

7. Argo bibliography

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(2) Doctorate thesis

None

New Zealand National Report March 2017

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 22 floats to date. Purchases and deployments are likely to continue at the 2 floats/year level.

Information on the New Zealand floats, designated (WMO#): 2039 (5900106), 2042 (5900109), 2137 (5900205), 2138 (5900206), 2331 (5900631), 2332 (5900632), 2463 (5901028), 2547 (5901227), 2555 (5901239), 2585 (5901271), 2693 (5901763), 2659 (5901804), 2739 (5901843), 2750 (5901853), 2859 (5902224), 2860 (5902225), 2872 (5903332), 2873 (5903333), 8035 (5903756), 8064 (5903777), 8097 (5904062), 8116 (5904076)*, 8131 (5904332)*, 8179 (5904274)*, 8323 (5902384)*, 8322 (5902383)*, 8427 (5902440)*, 8426 (5902439)*, 8513 (5902503)*, 8511 (5902502)* can be found at: http://sio-argo.ucsd.edu/weqpac_web.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. There is an Antarctic (Ross Sea) voyage planned for February 2018 with the opportunity to deploy floats.

An R/V Kaharoa deployment voyage from New Zealand to South America is planned for late 2017..

Finally, NIWA is also available to facilitate float deployments being mobilized out of New Zealand ports.

Status of Argo Norway, March 2017

Kjell Arne Mork, Institute of Marine Research, Norway

1. The status of implementation

Argo Norway is the Norwegian contribution to the Euro-Argo European research infrastructure (ERIC) and to the global Argo programme.

Argo Norway has in total purchased and deployed 25 floats. Floats are mainly deployed in the Norwegian Sea and several of these included oxygen and fluorescence sensors. In 2016 two floats were deployed (in the Norwegian Sea) where one float included oxygen and fluorescence sensors. All floats are APEX floats and the last years these had only Iridium telemetry.

In total, independent of country, nearly 20 000 Argo profiles have been taken in the Nordic Seas since the start of deployment in 2001. Figure 1 shows the numbers of Argo profiles taken each year for all floats located in the Nordic Seas. The numbers have been around 1800-2000 the last three years.

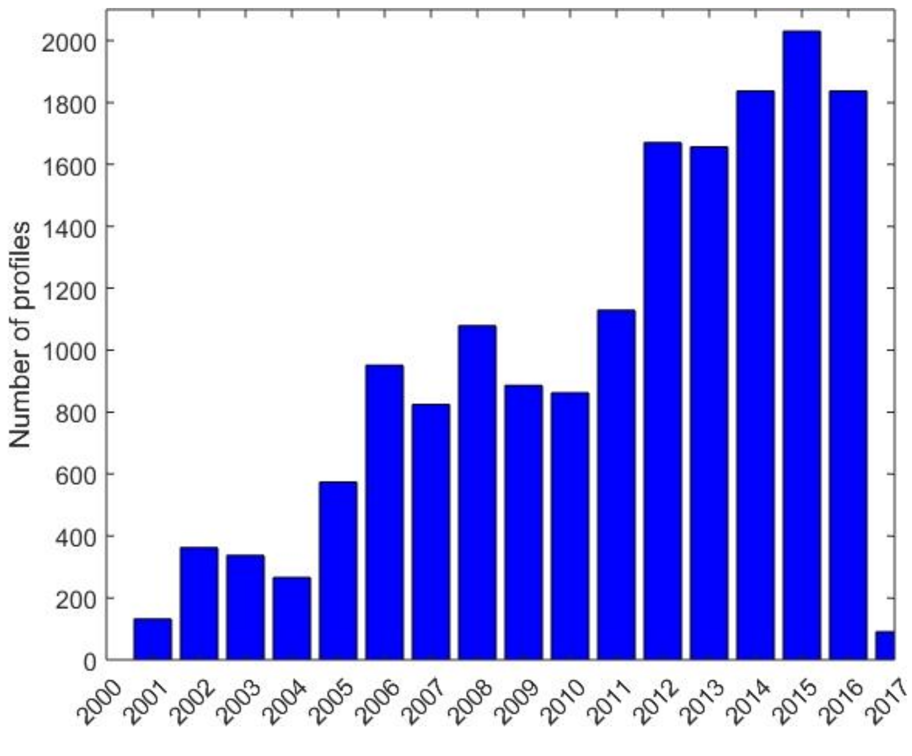

Figure 1. Number of taken profiles in the Nordic Seas (updated 9. March 2017).

At present (9th March 2017) there are 44 operational floats in the Nordic Seas (figure 1). Argo Norway have ten operational floats.

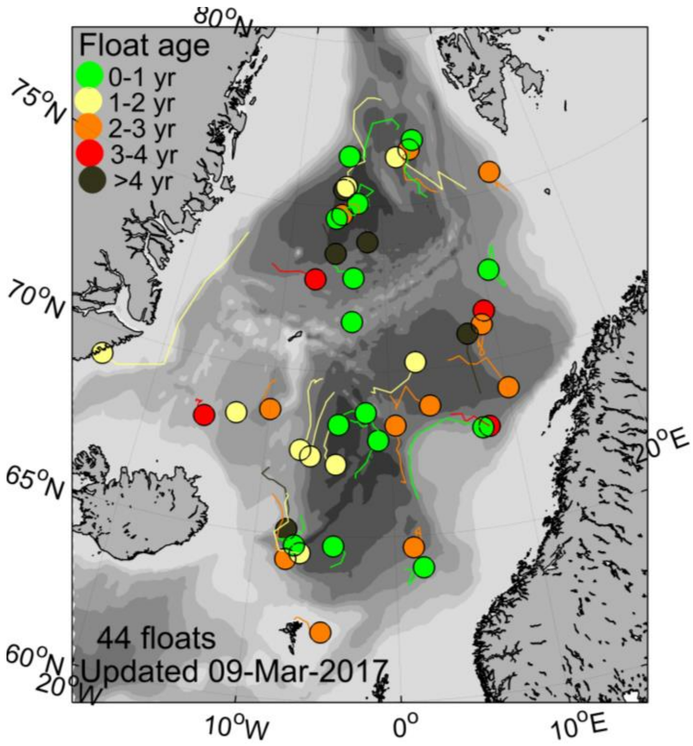

Figure 2. Active Argo floats within the Nordic Seas, updated 9th March 2017. The colours indicate age in years while the thin lines are the drift over the last 2 months.

Delayed mode quality control

Regarding the "Delayed mode" Argo Germany have been doing the delayed mode quality control for all floats in the Nordic Seas including our floats.

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

The funding has been self-financed (i.e. funded by our institute) until 2012. In 2012 IMR received funding from the Norwegian Research Council (NRC, Ministry of Education and Research) for funding of three Argo floats per year the next three years (2013-2015). The future funding of Argo is uncertain, but in October 2016 Argo Norway have submitted a new proposal to the Norwegian Research Council for long-term funding of Argo floats.

3. Summary of deployment plans

In 2016 we deployed two Argo (APEX) floats in the Norwegian Sea; one standard and one that includes dissolved oxygen and fluorescence+backscatter sensors. Additional one APEX Electro Magnetic (EM) float will be deployed spring 2017 in the Norwegian Sea. Estimates of future deployments (from 2018) depends on the outcome of the proposal to the Norwegian Research Council. If the proposal is successful Norway will the next 5 years deploy ~20 floats per year. This includes ~2 BGC floats, 2-3 equivalent BGC floats, ~1 deep float, and ~4 core floats.

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. Approximately 3 scientists in 3 projects are directly involved in Argo Norway but also other people contribute with technical expertise, data management, ship time for deployments, and processing and analysing the data. There is an increasing interest in using Argo data in Norway, and two climate centres are now using the data operationally in climate models.

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 oxygen and fluorescence+backscatter sensors on the Argo floats.
- Studies that involve changes in the mixed layer.

5. Issues we wish to be considered and resolved

At the moment we have no suggestion.

Argo-Poland National Report 2016

Waldemar Walczowski, Małgorzata Merchel
IO PAS, Sopot, Poland, 31.12.2016 r.

1. The status of implementation

The Polish Argo Program is carried out by the Institute of Oceanology Polish Academy of Sciences (IOPAS). Since 2009 IOPAS has deployed twelve Argo floats in the Nordic Seas and one float in the Baltic Sea: two in June 2009 and 2010, one in July 2012, two in July 2014, three in 2015.

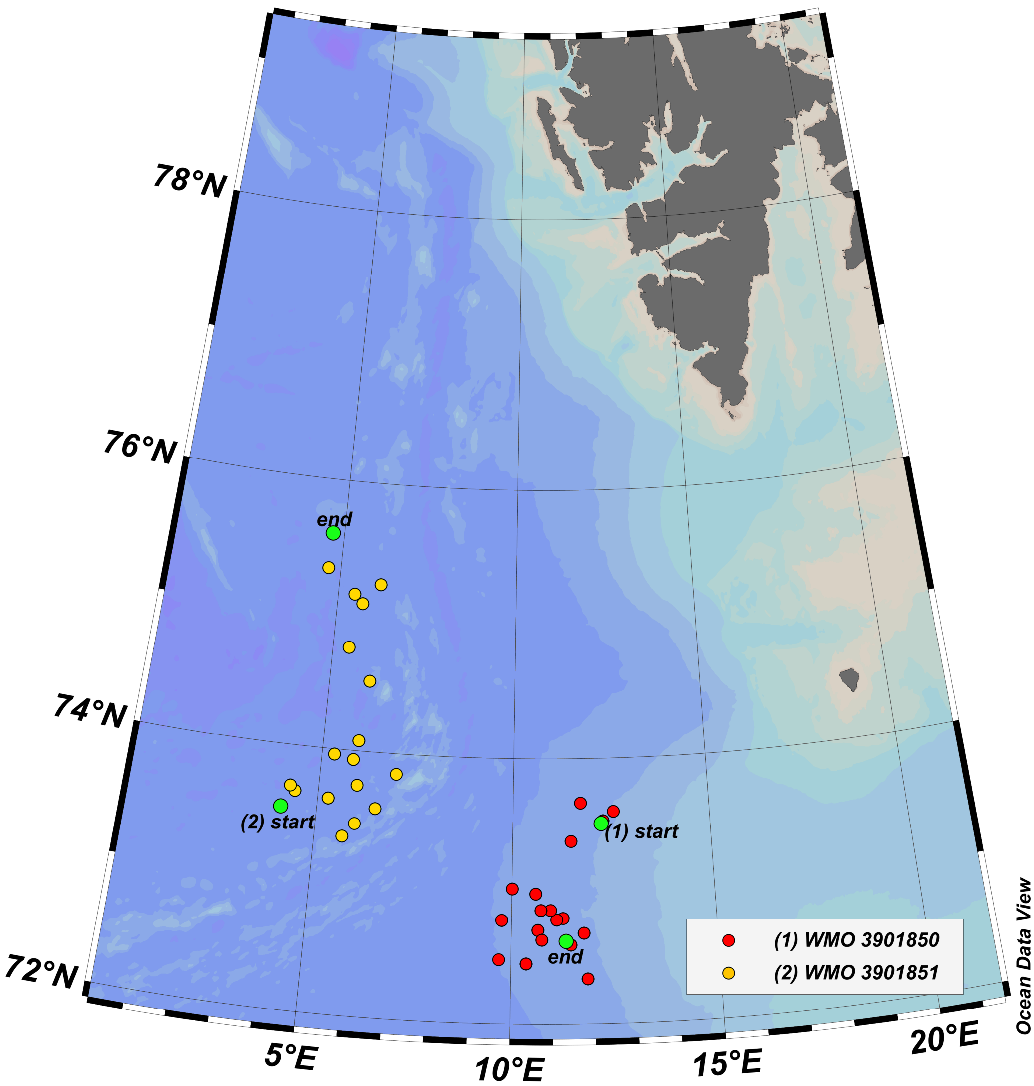

Figure 1. Surface position of two Argo floats deployed in the Norwegian and Greenland Seas in June 2016

Two Argo floats (WMO 3901850, 3901851) were deployed in the Norwegian and Greenland Seas from the board of *r/v Oceania* at the end of June 2016 (Fig.1). All instruments are the ARVOR-I floats with Iridium transmission system. Both floats were deployed under the EU MOCCA Project. The parking depth was set at 1000 dbars and profiling depth at 2000 dbars. They all have cycles of 10 days. Fortunately, there were no technical problems with the two instruments. Every float was operated for the whole 2016 and have sent 19 complete sets of hydrographic data by the end of year.

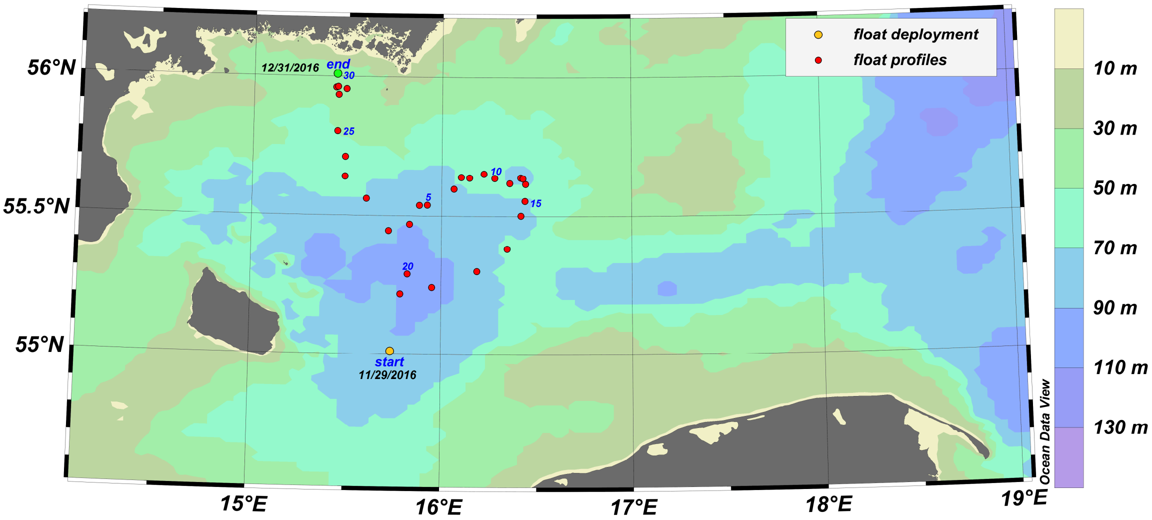

Figure 2. Surface position of Argo float deployed in the Baltic Sea in November 2016

The first Polish Argo float in the Baltic Sea was deployed from the board of *r/v Oceania* at the end of November 2016 (Fig. 2). The instrument is the APEX float with Iridium transmission system. The parking depth was set at 50 dbars and profiling depth at 100 dbars. It had cycles of 2 days for the first week and then cycles of 1 day. By the end of 2016 year the float has sent 30 sets of data. Some technical problems were encountered with that instrument. The float did not come down below pycnocline because it was not ballast properly. Poland, after Finland is the second country, which deploy Argo floats in the Baltic Sea.

Three floats deployed in September 2015 (WMO 6902038, 6902039, 6902040) was also active during almost the whole 2016 year. Unfortunately, one of the instrument stopped transmission of the data on the 14th December 2016, probably due to drifting to close to the shore. The other two are still active. During their whole operating time, the floats have been sent respectively WMO 6902038 - 92, WMO 6902039 - 92, WMO 6902040 - 89 sets of hydrographic data.

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

The present level of the Polish national funding allow for purchase and deployment of two Arctic floats per year and one Baltic Sea float per one-two years (depending on price). There are some funds for coordination, technician works and PhD student. Travel, deployment, technical maintenance is covered. This level of funds is secured to 2020. At the Baltic Sea the data buoy in the region of planned deployments will be moored.

3. Summary of deployment plans

Poland committed to launching three Argo floats per year. In 2017 we plan to deploy 3 floats: two in the Nordic Seas region during the IOPAS Arctic cruise and one in the Baltic Sea during the IOPAS Baltic cruise. All of the floats will be launched from the board of *r/v Oceania*.

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

IOPAS has been carried the scientific program aimed at investigation of the Atlantic Water inflow into the Arctic Ocean and climatic aspect of this process for over 20 years. Every summer expedition of IOPAS research vessel ‘Oceania’ to the Nordic Seas and Arctic Ocean is organized. Polish Argo floats are usually deployed during these cruises. The data obtained from the Argo floats support this research, in particular those concerning the advection of the warm Atlantic Water through the Nordic Seas and changes of Atlantic water properties. The Argo results are compared with data from standard *in situ* measurements, used in calculation of the signal propagation velocities, currents pathways. The Argo measurements complement the lack of data in winter season.
We also use Argo floats to investigate hydrography and dynamics of the Baltic Sea.
The Argo Poland program’s website is regularly updated by IO PAS:

http://www.iopan.gda.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 2016 two Polish floats were deployed during IOPAS Arctic cruise AREX, when 270 CTD profiles have been done including the stations performed just before the floats deployment (Fig 3). IOPAS can provide this two stations CTD data to compare it with Argo floats. The Ago floats were deployed at section ‘H’, station H11, φ 73° 30.447' N, λ 012° 14.115E E, station H15, φ 73° 31.657' N, λ 004° 02.423 E.
Rest of the data (270 stations) from the Nordic Seas will be available via IOPAS database. Contact point: Waldemar Walczowski, walczows@iopan.pl.

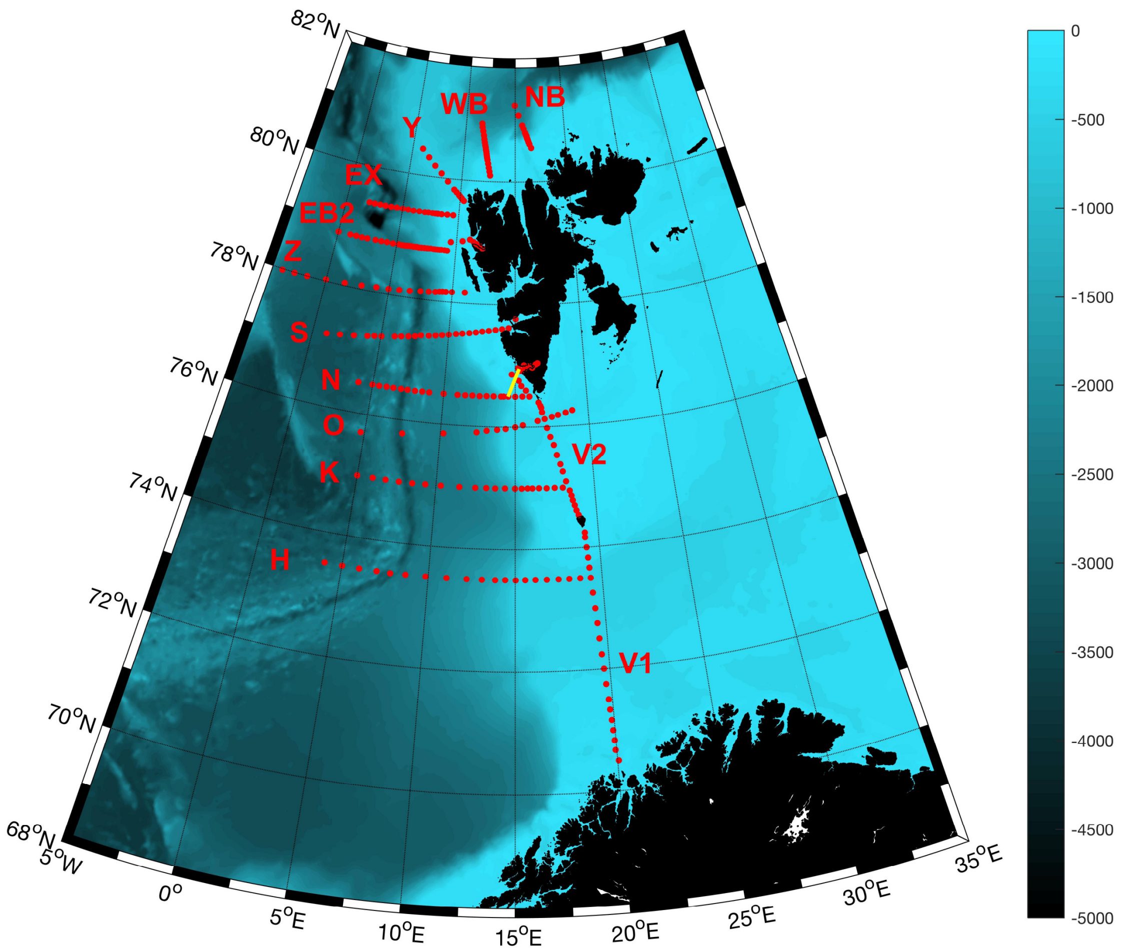

Figure 3. Location of CTD stations measured during the open ocean part of AREX 2016 (June 21- July 24, 2016) cruise of r/v Oceania.

7. The Argo bibliography

There is PhD thesis using the Argo data in progress. There were no published scientific articles in the past year.

Argo National Report – South Africa

Report to Argo Steering Team Meeting: March 2017

Compiled by: Tamaryn Morris – SAEON Egagasini Node.

For any queries or deployment requests, please email tammy@saeon.ac.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 2016):**

Floats deployed and their performance (please refer to Figure 1 for schematics of transect placements)

<u>Southern Ocean and South Atlantic Ocean:</u>

SANAE 56 Cruise (RV SA *Agulhas II*) – December 2016-February 2017

8 ARVOR floats were deployed on behalf of the French team. One float needed to be shipped back as it was at the end of its lifespan.

WMO numbers: 3901918, 3901919, 3901920, 3901923, 3901924, 3901925, 3901927, 3901928

<u>Indian Ocean:</u>

ASCA Cruise (RV *SA Agulhas II*) – 5-15 July 2016

4 Apex floats were deployed on behalf of the UK MetOffice. These floats were 'adopted' by our education team and their associated secondary schools and described further below.

WMO numbers: 1901862, 1901863, 1901864, 1901865

Technical issues encountered and solved:

No updates on the issues reported on in AST-16 (March 2015) report.

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:**

Dedicated Argo funding to procure new floats to seed the global array is currently being investigated through the South African Environmental Observation Network (SAEON). 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 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, extra sensors, Deep Argo) 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 2017.

This cruise follows the CrossRoads Transect on Figure 1.

available for Argo float deployments

Gough Island Cruise (RV SA *Agulhas II*) – September 2017. .

This cruise follows the SAMBA Transect on Figure 1.

available for Argo float deployments

SANAE Cruise (RV SA *Agulhas II*) – December 2017 / January 2018.

This cruise follows the GoodHope Transect on Figure 1.

available for Argo float deployments

Indian Ocean:

Agulhas System Climate Array (ASCA) deployment cruise – November 2017 / February 2018.

Refer to Figure 1 for positions.

2 APEX floats will be deployed on behalf of UK Met Office in to the Agulhas Current. Additional deployment opportunities are available

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. 2 APEX floats from the UK Met Office are available for a cruise in to the Mozambique Channel, however additional deployment opportunities are available.

Atlantic Ocean:

SAMBA Mooring Array (RV *Algoa*) – April 2017.

Refer to Figure 1 for positions.

> 4 APEX floats will be deployed on behalf of UK Met Office in to the South Atlantic. Additional deployment opportunities are available

SEAmester Training Cruise (SA Agulhas II) – July 2017.

The cruise will service CPIES along the SAMBA transect. Refer to Figure 1 for positions.

> 4 APEX floats will be deployed on behalf of UK Met Office in to the South Atlantic. Additional deployment opportunities are available

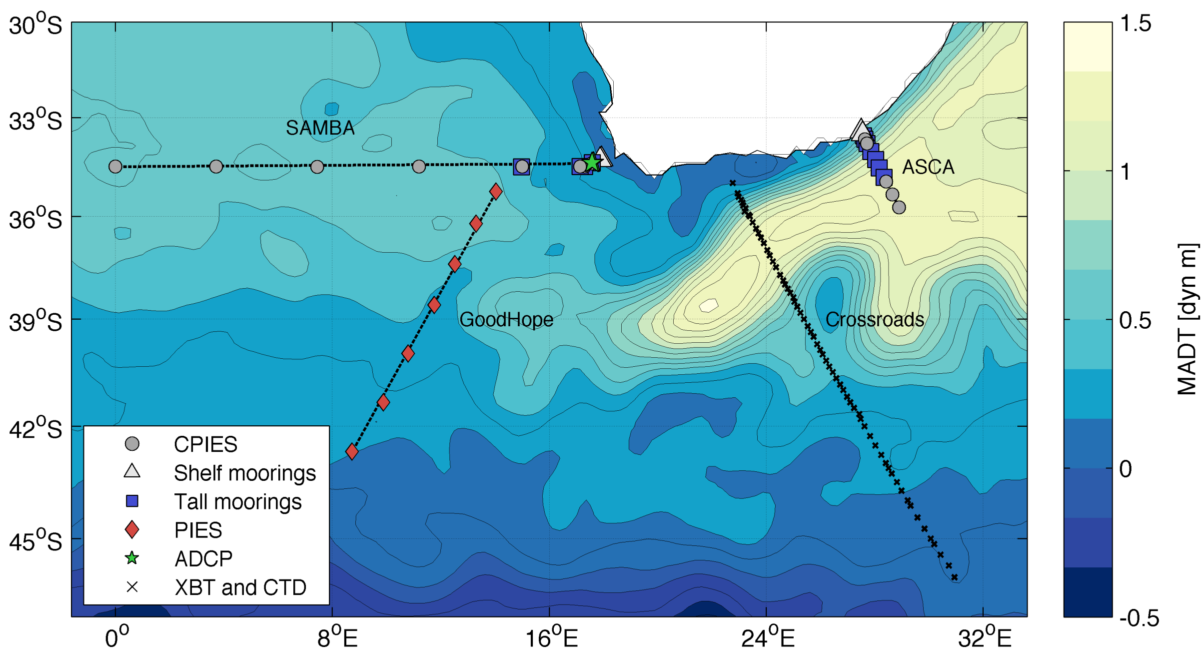

Figure 1: Large mooring array and CrossRoads transects around South Africa where floats could be deployed if available (Morris et al submitted).

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:

Three research and two outreach project are noted below:

a) SOCCOM:

Isabelle Ansorge

The Southern Ocean Carbon and Climate Observations and Modeling (SOCCOM) are a focused group developing a new ocean observing system for carbon, nutrients and oxygen that will complement the already established observing system for heat and freshwater. To this end, 150-200 profiling floats equipped with biogeochemical sensors will be deployed throughout the

Southern Ocean and the cruises run by UCT (Prof. Ansorge) in this region (i.e. SANAE and Gough Island) will be used as a platform for deployments.

b) Southern Ocean Seasonal Cycle Experiments (SOSCEx) I –IV and ongoing:

Pedro M.S. Monteiro, Sebastiaan Swart, Sandy Thomalla and Thato Mtshali

SOSCEX is the focus of a suite of five NRF-SANAP projects funded for the 2015 – 2017 cycle. This forms a central part of the new Climate focused research theme in the Southern Ocean as articulated in both ARESSA as well as the emerging Antarctic and Southern Ocean strategy of the NRF-DST. It is our aim to attract wider collaboration from national, regional and international partners into this unique Climate – Carbon – Ecosystems research platform. SOSCEx focuses on understanding the role of the Southern Ocean in driving large-scale carbon-climate sensitivities through sub-seasonal scale observations of the influence of fine scale upper ocean physical dynamics on CO_2 fluxes and primary production. Bio-Argo floats (Fluorescence, Oxygen, PAR, two wavelengths of backscattering and an with upward facing transmissometer for flux estimates) were deployed on both SOSCEx I, II and III with little success (sensor issue with Wetlabs Puck on SOSCex I, deployment error on SOSCEx II and on SOSCEx III all communication with the float was lost after 3 days of deployment during which time it completed 6 profiles and one drift session for flux estimates). One bio-optics float remains with the CSIR and is planned to be deployed as part of the GoodHope +11 seasonal cycle cruise with multiple occupations of the GoodHope line in Winter and Summer 2018.

www.socco.org.za

www.csir.co.za/nre/coasts_and_oceans/osc.html

c) Validating Hycom-EnOI in the Agulhas using Argo profiling floats - The Nansen-Tutu Centre for Marine Environmental Research (UCT)

Charine Collins, Björn Backeberg, François Counillon and Johnny Johannessen

The greater Agulhas Current system, one of the most energetic systems in the world, plays a key role in the global ocean circulation, regional weather, and the marine environment. A prediction system of the marine environment around southern Africa would not only be beneficial to regional commercial, industrial, and leisure activities, but it would also aid search and rescue activities, and the monitoring of accidental pollutants and harmful algal blooms.

Despite the emergence of various global prediction (operational data assimilation) systems (e.g. MyOcean, Blue-Link), there is hitherto no system for the southern African regional ocean. As a first attempt towards an ocean prediction system for southern Africa, A regional data assimilation system of the greater Agulhas system was developed recently (Backeberg et al., 2014). This system, while not operational yet, assimilates satellite altimeter along-track sea level anomaly (SLA) data into a HYbrid Coordinate Ocean Model (HYCOM) simulation of the Agulhas Current System using the Ensemble Optimal Interpolation (EnOI) data assimilation scheme (hereafter referred to as HYCOM-EnOI). While HYCOM-EnOI improved the meso-scale dynamics in the Agulhas Current system, as well as the water mass characteristics and velocities at ~1000m, there was a slight degradation of the SST distribution.

In this study, we assess the limitations of HYCOM-EnOI in reproducing the water mass properties of the Agulhas Current region through a detailed comparison with Argo profiling floats. A comparison between HYCOM-EnOI and the Argo profiling floats is made in terms of temperature and salinity differences at various depths, differences in water mass characteristics, and mixed layer depth.

The temperature values in the upper 100m simulated in HYCOM-EnOI are, for most of the region, in close agreement (±1°C) with the observations (Figure 3a). On the contrary there is an overestimation of the salinity values in the upper 100m simulated in HYCOM-EnOI by about 0.1psu (Figure3b). In the 500-1000m depth range, HYCOM-EnOI tends to underestimate temperature (Figure 3c) and salinity (Figure 3d) values south of the Agulhas bank, in the vicinity of the Agulhas Retroflection region and the Agulhas Return Current. West of the Agulhas bank, the temperature of HYCOM-EnOI is in good agreement with the observations (±1°C), however, there is again an overestimation of the salinity values by more than 0.1psu. In the deeper layers (1000-2000m, HYCOM-EnOI tends to underestimate the temperature and salinity throughout the region, except east of the Agulhas Bank where there is a good agreement with the observations.

d) Comparing Argo and animal-borne observations in the Southern Ocean

Anne Treasure

The polar oceans play crucial roles in regulating the Earth's climate system. Nevertheless, adequately sampling these regions is extremely difficult. Consequently, autonomous oceanographic sampling devices such as Argo floats have become a major component of the ocean observing system and have proven invaluable to the polar ocean science community. However, these devices currently do not operate regularly in sea ice and tend to be advected to the north in the Southern Ocean (SO), resulting in very few Argo profilers south of 60°S. Instrumented animals provide a solution to this problem. Since 2002, they have dramatically extended the spatial and temporal reach of ship-based observations and overcome some of the issues with other devices such as Argo operating in polar waters. The instruments, conductivity-temperature-depth satellite relay data loggers (CTD-SRDLs), are deployed as animal-borne platforms to sample vertical temperature and salinity profiles. These loggers provide novel observations of the SO, particularly in areas where data collection would otherwise not be possible, and provide valuable research opportunities for physical and biological oceanographers alike. While studies have already used both Argo and CTD-SRDL data, little is known about how well the two data sets complement each other in both spatial and temporal extent, and how comparable they are in data quality. Therefore, my research examines data from CTD-SRDLs and Argo to assess the comparative value of the two data sources to increasing our understanding of SO ocean dynamics. This includes a spatial and temporal comparison, as well as an ongoing investigation on the efficacy of the two data sources in identifying the characteristics, position and structure of SO fronts. Understanding the structure and location of SO fronts is of considerable importance due to their influence on climate and ecosystems.

e) Educational Outreach – The Argo Floats Program by SAEON Egagasini:

Thomas Mtontsi and Tamaryn Morris

Five secondary schools have been identified in the Western Cape region to track changes at sea from data collected on floats 1901469 and 1901470 purchased by SAEON/SANAP with support from SAWS and deployed in 2009. Both these floats have stopped reporting now, but the data is still used as described below:

In 2016 school monitoring teams were encouraged to do schools science projects on:

1. The Identification of deep water masses and their direction using temperature
2. Relationships between salinity and depth
3. Relations of temperature, pressure and salinity

The overall focus of the SAEON Egagasini education programme is to:
- primarily encourage awareness of science skills to learners

- to create a platform where Marine Science Research can be integrated into School Sciences curriculum by encouraging interactions between learners, educators and scientists
- to promote an understanding of, create awareness and generate an interest about our oceans

Four Argo floats deployed on the ASCA cruise in July 2016 were also “adopted” by the schools themselves to monitor in near-real time as ongoing school projects in 2017. Each school got a chance to visit the research vessel and officially adopt their float as part of a school excusion. The deployment of the floats at sea in July were documented for the schools and they were notified by email so they can begin their projects and monitor how the floats behave in particular within the Agulhas Current. This work will be presented at the 1st Ocean Observers meeting in France in June 2017 and be used as part of the Eskom Young Scientist Expo run in South Africa each year.

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.**

   No data was loaded this year, but new data is available from the east coast of South Africa and will be loaded shortly.

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**

   None at this stage.

Argo-KOREA Annual Report 2016

by Korea Meteorological Administration

18th Argo Steering Team Meeting(AST-18)
Hobart, Tasmania, Australia, 13-17 March 2017

1. Status of Implementation

The Korea Meteorological Administration (KMA) and Korea Institute of Ocean Science & Technology (KIOST, former KORDI) have been involved in the International Argo Program since 2001. KMA has deployed 217 Argo floats in the East Sea of Korea and North Pacific Ocean including 53 active floats as of February 23, 2017. And total 16 floats were deployed in 2016. (10 and 6 floats in July and August, respectively)

-Status of contributions to Argo data management

- netCDF profile files conversion to v.3.1. (realtime data completed)
- netCDF meta, technical and trajectory file conversion to v.3.1. (completed)
- transmission of converted netCDF data to GDAC (France/USA)
- implementing the Argo data format check program.

-Delayed Mode QC

- total 23,028 delayed mode files sent to GDAC during Nov. 2015 to Sept. 2016

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

KMA has tried to keep same level of deployment about 16 floats per year. The float number deployed around Korea this year is 13, which is a bit decreased due to the budget decrease.

-Human resources

- The following persons contribute to Argo Korea:
  - KiRyong KANG, Jong-sook PARK, Hyeong-jun JO (KMA)
  - Joon-soo LEE (NIFS)
  - Sung-Dae KIM (KIOST)

3. Summary of deployment plans

KMA has a plan to deploy 13 floats (all APEX float) in 2017, all of which were purchased in 2016. 9 floats will be deployed in the northern part of the East Sea, 2 in the Yellow Sea and 2 in the South Sea of Korea. Since the Yellow Sea and South Sea are relatively shallow (44 m and 101 m in average depth respectively), the feasibility of the Argo float in the shallow area will be checked out, and the role of sea state change in marine weather of west coastal area of Korea could be investigated.

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

KMA operates the Global Ocean Data Assimilation and Prediction System (GODAPS), based on the NEMO-CICE coupled models and NEMOVAR assimilation. This system has 1/4 degree in horizontal and 75 levels in vertical resolution including the daily cycle with 1-day hindcast and 1-day forecast. Global Argo profiles obtained thru GTS network (TESAC and BUFR formatted data) are assimilated with 24-hour time window. The general information about the KMA Argo program with profiles, track, and number of acting float, etc, can be found at the home page: http://argo.nims.go.kr.

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

-None

6. CTD data uploaded to CCHDO

No.

<The End>

Argo-Spain Annual Report 2016

Present status and future plans

Pedro Vélez Belchí, Alberto González Santana

1. Introduction.

In 2002, Argo Spain began its contribution to the Argo program through a European project where a total of 80 Argo profilers were deployed in the North Atlantic. Since then, Argo Spain gives support to all the operators in Spain that use Argo floats as part of their observational strategy.

Two institutions are mainly involved in Argo Spain, the Spanish Institute of Oceanography (IEO, *Instituto Español de Oceanografía*) and the Coastal Ocean Observing and Forecasting System of the he Balearic Islands (SOCIB; *Sistema de Observación Costero y de Predicción de las Islas Baleares*)

2. The status of implementation

Since 2003, 63 floats have been deployed by Argo Spain. At the end of 2016, 7 Argo floats were active.

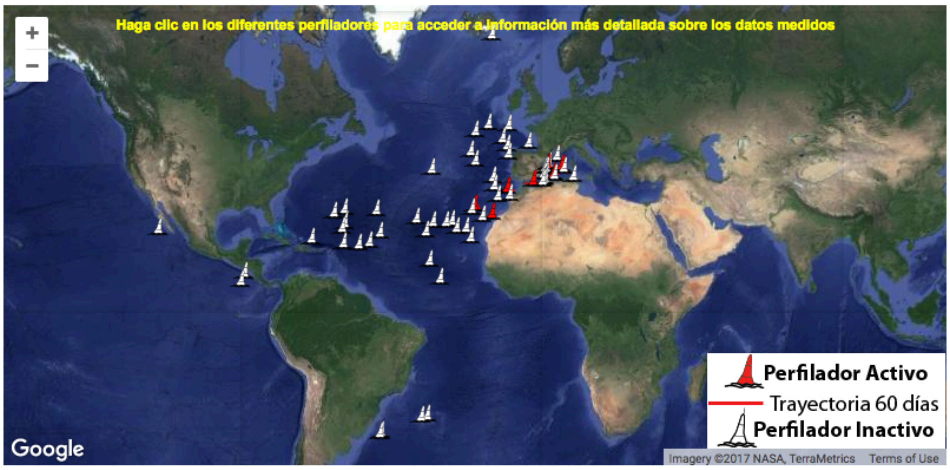

Figure 1. Status of the Argo Spain program on November 24th 2016. Altogether, 63 floats have been deployed.

The following table shows information of each Argo SPAIN profiler deployed:

WMO ID	Status	PROJECT_NAME	FLOAT_OWNER	PLATFORM_TYPE	CONTROLLER_BOARD_TYPE_PRIMARY	Depl. Date (DD/MM/YYYY)
1900275	**EOWL**	Argo SPAIN	IEO	APEX	APF8C	21/09/2003
1900276	**EOWL**	Argo SPAIN	IEO	APEX	APF8C	22/09/2003
1900277	**EOWL**	Argo SPAIN	IEO	APEX	APF8C	24/09/2003
1900278	**EOWL**	Argo SPAIN	IEO	APEX	APF8C	19/09/2003
1900279	**EOWL**	Argo SPAIN	IEO	APEX	APF8C	27/09/2003
1900377	**EOWL**	Argo México	IEO	PROVOR		04/05/2005
1900378	**EOWL**	Argo Costa Rica	IEO	PROVOR		07/12/2005
1900379	**EOWL**	Argo Costa Rica	IEO	PROVOR		07/12/2005
4900556	**EOWL**	Argo SPAIN	IEO	PROVOR		05/03/2005
4900557	**EOWL**	Argo SPAIN	IEO	PROVOR		10/09/2004
4900558	**EOWL**	Argo SPAIN	IEO	PROVOR		10/09/2004
6900230	**EOWL**	Argo SPAIN	IEO	APEX	APF8C	13/09/2003
6900231	**EOWL**	Argo SPAIN	IEO	APEX	APF8C	18/12/2003
6900506	**EOWL**	Argo SPAIN	IEO	APEX		13/09/2006
6900633	**NW**	Argo SPAIN	ICM	APEX	APF8C	14/02/2012
6900634	**NW**	Argo SPAIN	ICM	APEX	APF8C	14/02/2012
6900635	**EOWL**	Argo SPAIN	ICM	APEX	APF8C	09/11/2011
6900636	**Active**	Argo SPAIN	ICM	APEX	APF8C	28/07/2012
6900659	**EOWL**	Argo SPAIN	SOCIB ICTS	APEX		12/01/2011
6900660	**EOWL**	Argo SPAIN	SOCIB ICTS	APEX	APF8C	08/09/2011
6900661	**EOWL**	Argo SPAIN	SOCIB ICTS	APEX	APF8C	22/06/2011
6900662	**EOWL**	Argo SPAIN	SOCIB ICTS	APEX	APF8C	10/06/2012
6900760	**EOWL**	Argo SPAIN	IEO	APEX	APF9A	05/09/2010
6900761	**EOWL**	Argo SPAIN	IEO	APEX	APF9A	06/09/2010

6900762	**EOWL**	Argo SPAIN	IEO	APEX	APF9A	11/09/2010
6900763	**EOWL**	Argo SPAIN	IEO	APEX	APF9A	10/09/2010
6900764	**EOWL**	Argo SPAIN	IEO	APEX	APF9A	01/02/2011
6900765	**EOWL**	Argo SPAIN	IEO	APEX	APF9A	03/02/2011
6900766	**EOWL**	Argo SPAIN	IEO	APEX	APF9A	16/12/2010
6900767	**EOWL**	Argo SPAIN	IEO	APEX	APF9A	24/12/2010
6900768	**EOWL**	Argo SPAIN	IEO	APEX	APF9A	27/12/2010
6900769	**EOWL**	Argo SPAIN	IEO	APEX	APF9A	04/02/2011
6900770	**EOWL**	Argo SPAIN	IEO	APEX	APF9A	07/02/2011
6900771	**EOWL**	Argo SPAIN	IEO	APEX	APF9A	07/02/2011
6900772	**EOWL**	Argo SPAIN	IEO	APEX	APF9A	27/10/2010
6900773	**EOWL**	Argo SPAIN	IEO	APEX	APF9A	15/02/2011
6900774	**EOWL**	Argo SPAIN	IEO	APEX	APF9A	20/02/2011
6900775	**EOWL**	Argo SPAIN	IEO	APEX	APF9A	23/02/2011
6900776	**EOWL**	Argo SPAIN	IEO	APEX	APF9A	25/02/2011
6900777	**EOWL**	Argo SPAIN	IEO	APEX	APF9A	26/02/2011
6900778	**EOWL**	Argo SPAIN	IEO	APEX	APF9A	01/12/2010
6900779	**EOWL**	Argo SPAIN	IEO	APEX	APF9A	01/12/2010
6900780	**EOWL**	Argo SPAIN	IEO	APEX	APF9A	25/01/2011
6900781	**EOWL**	Argo SPAIN	IEO	APEX	APF9A	26/01/2011
6900782	**EOWL**	Argo SPAIN	IEO	APEX	APF9A	27/01/2011
6900783	**EOWL**	Argo SPAIN	IEO	APEX	APF9A	01/12/2010
6900784	**EOWL**	Argo SPAIN	IEO	APEX	APF9A	05/09/2010
6900785	**EOWL**	Argo SPAIN	IEO	APEX	APF9A	06/09/2010
6900786	**EOWL**	Argo SPAIN	SOCIB ICTS	APEX	9I-8373	01/05/2012
6900787	**EOWL**	Argo SPAIN	SOCIB ICTS	APEX	9I-8500	15/07/2013
6900788	**EOWL**	Argo SPAIN	SOCIB ICTS	APEX	9I-8496	15/04/2013
6900789	**EOWL**	Argo SPAIN	IEO	APEX	APF9A	13/12/2012

6901237	**EOWL**	Argo SPAIN	IEO	APEX	APF9A	21/12/2012
6901238	**EOWL**	Argo SPAIN	IEO	APEX	APF9A	17/09/2013
6901239	**EOWL**	Argo SPAIN	IEO	APEX	APF9A	27/07/2015
6901240	**Active**	Argo SPAIN	IEO	APEX	APF9A	20/04/2014
6901241	**EOWL**	Argo SPAIN	IEO	APEX	APF9A	10/12/2012
6901242	**EOWL**	Argo SPAIN	SOCIB ICTS	APEX	APF 9i-9253	01/10/2014
6901243	**Active**	Argo SPAIN	SOCIB ICTS	APEX	9i-9271	22/11/2014
6901244	**EOWL**	Argo SPAIN	SOCIB ICTS	APEX	9i-9283	11/27/2015
6901245	**Active**	Argo SPAIN	SOCIB ICTS	ARVOR		21/11/2014
6901246	**Active**	Argo SPAIN	Euro Argo	ARVOR_D	70-10-444-000	03/02/2015
6901247	**Active**	Argo SPAIN	SOCIB ICTS	APEX	APF 9i-9253	01/10/2014
6901248	**Active**	Argo SPAIN	IEO	ARVOR_D	70-10-444-000	01/11/2016
6901249	**TBD**	Argo SPAIN	SOCIB ICTS	ARVOR	70-10-596	
6901250	**TBD**	Argo SPAIN	SOCIB ICTS	ARVOR	70-10-596	
6901251	**TBD**	Argo SPAIN	SOCIB ICTS	ARVOR	70-10-596	

Floats deployed and their performance

During 2016, 1 Argo float was deployed by Spain:

1 Deep Arvor float (WMO 6901248) in the Eastern Atlantic (Canary Islands) by the R/V Angeles Alvariño. The float was deployed on November 1st 2016 at 29, 10.00 LAT and -18,29.78 LON by the *Instituto Español de Oceanografía* researchers from Ángeles Alvariño vessel during the RAPROCAN 2016 survey.

This float was deployed as part of the Argo Spain contribution to the pilot program to extended the Argo program deeper than 2000 m.

After 70 days at sea, the Deep – Arvor continues drifting towards to open sea. The float was initially programmed to dive every 5 days measuring temperature and salinity during the ascending phase. After that, the float was reconfigured to dive every 10 days reaching also 4000 meters of depth.

As can be observed in Figure 3, after 2 months and 18 profiles there is not bias or drift in the salinity sensor so far. However, the accuracy in salinity (0.02) of the SBE41CP sensor installed it is not enough to detect long term trends (>5 years) in the area.

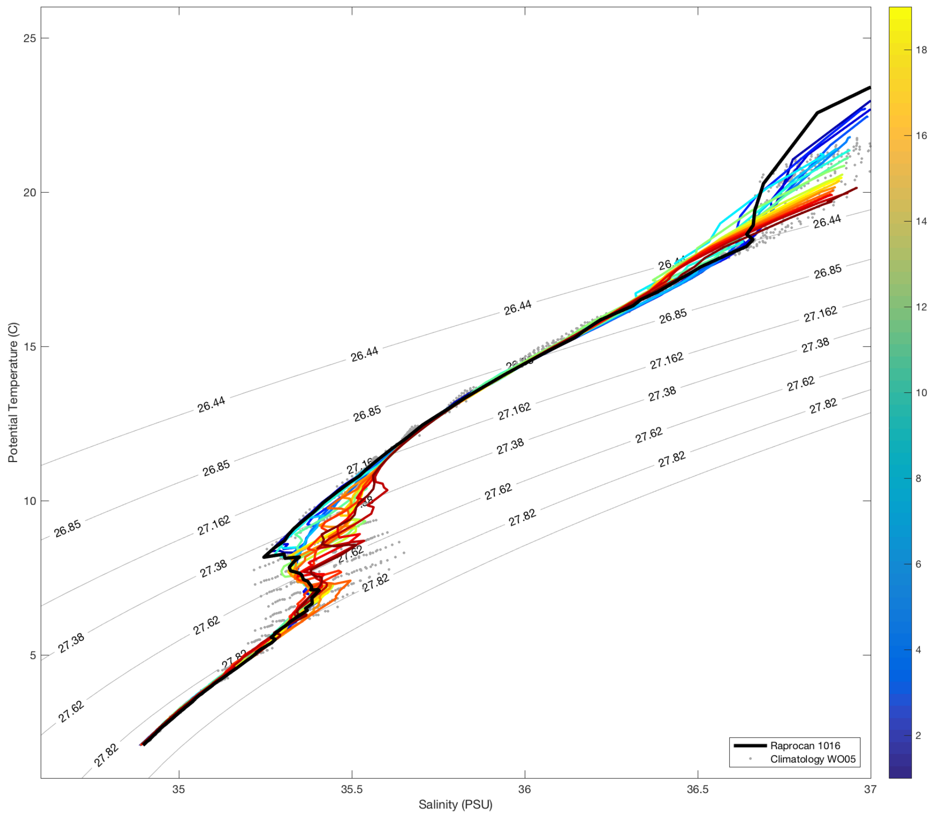

Figure 2. T-S diagram of the Deep Arvor float WMO 6901248

Technical problems encountered and solved

No major technical problems were encountered in 2016.

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

After each deployment, the detailed technical information is provided to the DAC in charge of the floats (Coriolis) and to the AIC. The Argo-Spain program is aware of the changes in the technical and metadata data formats, and is providing the necessary information. A metadata updating for the Argo Spain floats, including the mandatory information in format version 3.1 was sent to Coriolis DAC at the end of 2016.

Some of the earlier floats deployed by Spain were affected by TNPD. Not all of these floats have been corrected, but the remainder corrected files will be submitted during 2017.

Status of delayed mode quality control process

Argo Spain began the DMQC during 2016. So far, the DMQC for floats 6900506, 6900765, 6900767, 6900768, 6900769, 6900778, 6900779, 6900780, 6900781 6900782, 6900783 has been carried out and the netcdf files sent to the Coriolis DAC.

During 2017 we plan to carry out DMQC to all the Argo Spain float that stopped transmitting before July 1, 2016.

3. 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 Spain program does not have a long tem funding for deployments of Argo floats. However, the contribution to the Euro-Argo fee for the next 4 years is secured, since Spain has joined the Euro-Argo Infrastructure. This contribution is funded by the IEO and SOCIB.

The IEO funds the scientific coordination (1.5 man x month per year) and the transmission costs. In addition, a specific budget from Ministry of Economy has been assigned to incorporate one full – time research technician for the next three years to the Argo Spain program from 2017. There are also plans to purchase a total of 25 floats for the period 2017-2019. SOCIB funds the purchase and deployment of 3 Argo floats per year in the Western Mediterranean until 2020.

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

The deployment of Argo floats in Argo Spain are designed to support ongoing research programs of the Spanish marine sciences community but taking into account the overall needs of Argo. Based on that, the current plans for 2017/2018 are:

- Deployment of 3 floats in the Western Mediterranean Sea in 2017 and 2018
- Deployment of 2 floats in the subtropical North/ South Atlantic in 2017 and 5 in 2018

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

Argo is used by many Spanish researches to improve the understanding of the climate and ocean variability. Ocean and weather forecast operational models also use Argo data.

The web page of the Argo Spain program is: http://www.argoespana.es

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

None.

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

A CTD cast is performed after most of the Argo-Spain deployments. However, the data have not been submitted to the CCHDO website due to lack of personnel during 2016. A new member of the Argo Spain was hired during 2016 and will provide the CCHDO with the CTD cast. However, the DMQC is currently carried out using also the CTD cast performed after most of the Argo-Spain deployments.

8. List of all papers published by scientists within Spain in the past year using Argo data, including non-English publications.

Aguiar-González, B., L. Ponsoni, H. Ridderinkhof, H. M. van Aken, W. P. M. de Ruijter, and L. R. M. Maas, 2016: Seasonal variation of the South Indian tropical gyre. Deep Sea Research Part I: Oceanographic Research Papers, 110, 123-140

Alvera-Azcárate, A., A. Barth, G. Parard, and J.-M. Beckers, 2016: Analysis of SMOS sea surface salinity data using DINEOF. Remote Sensing of Environment, 180, 137-145

Aznar, R., M. G. Sotillo, S. Cailleau, P. Lorente, B. Levier, A. Amo-Baladrón, G. Reffray, and E. Álvarez-Fanjul, 2016: Strengths and weaknesses of the CMEMS forecasted and reanalyzed solutions for the Iberia–Biscay–Ireland (IBI) waters. Journal of Marine Systems, 159, 1-14

Capó, E., A. Orfila, J. M. Sayol, M. Juza, M. G. Sotillo, D. Conti, G. Simarro, B. Mourre, L. Gómez-Pujol, and J. Tintoré, 2016: Assessment of operational models in the Balearic Sea during a MEDESS-4MS experiment. Deep Sea Research Part II: Topical Studies in Oceanography, 133, 118-131

Castellanos, P., E. J. D. Campos, I. Giddy, and W. Santis, 2016: Inter-comparison studies between high-resolution HYCOM simulation and observational data: The South Atlantic and the Agulhas leakage system. Journal of Marine Systems, 159, 76-88

González-Gambau, V., E. Olmedo, A. Turiel, J. Martínez, J. Ballabrera-Poy, M. Portabella, and M. Piles, 2016: Enhancing SMOS brightness temperatures over the ocean using the nodal sampling image reconstruction technique. Remote Sensing of Environment, 180, 205-220

Hernández-Guerra, A. and L. D. Talley, 2016: Meridional overturning transports at 30°S in the Indian and Pacific Oceans in 2002–2003 and 2009. Progress in Oceanography, 146, 89-120

Hernández-Molina, F. J., A. Wåhlin, M. Bruno, G. Ercilla, E. Llave, N. Serra, G. Rosón, P. Puig, M. Rebesco, D. Van Rooij, D. Roque, C. González-Pola, F. Sánchez, M. Gómez, B. Preu, T. Schwenk, T. J. J. Hanebuth, R. F. Sánchez Leal, J. García-Lafuente, R. E. Brackenridge, C. Juan, D. A. V. Stow, and J. M. Sánchez-González, 2016: Oceanographic processes and morphosedimentary products along the Iberian margins: A new multidisciplinary approach. Marine Geology, 378, 127-156

Rodríguez-Cabello, C., C. González-Pola, and F. Sánchez, 2016: Migration and diving behavior of Centrophorus squamosus in the NE Atlantic. Combining electronic tagging and Argo hydrography to infer deep ocean trajectories. Deep Sea Research Part I: Oceanographic Research Papers, 115, 48-62

UK ARGO PROGRAMME

REPORT FOR 18TH ARGO STEERING TEAM MEETING, MARCH 2017

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, 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.

The most pressing issue for the UK programme remains on securing ongoing funding for UK Argo, in particular for core Argo floats, and ensuring that data is delivered (in real-time and delayed-mode) from our non-core (e.g. float with additional sensors) to the WMO GTS and GDACs.

Internationally, it is imperative to the UK that the core Argo array is complemented by the Argo extensions into deeper profiling, bio-geochemistry and high latitudes, such that these do not lead to a reduction in core Argo below its target density or its ability to deliver core data to users.

1. Floats procured and deployed

Figure 1 shows the number of floats purchased each year and the number deployed. The number purchased each year has been somewhat variable as it has largely been reliant on the release of additional in-year or end-year (under-spend) funding. As a result, the number of deployments each year has also been variable, with 37 floats deployed in 2016, with over the last five years an average of 38 floats/year having been deployed.

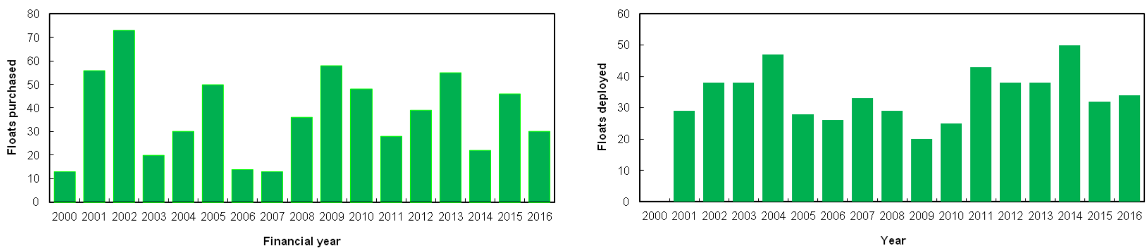

Figure 1. Showing (left) the number of floats procured each financial year (Apr-Mar) and (right) the number deployed in each calendar year.

In 2016 float deployments have been made in the North Atlantic, South Atlantic, Western Indian, Bay of Bengal and the Eastern Tropical Pacific. The 37 floats deployed include: 20 core Argo floats, five deep floats (three of which were subsequently recovered), four STS (surface temperature and salinity) floats, three floats with radiometers, two bio-geochemical (BGC) floats and three floats with the experimental RBR CTD. Of these three floats failed on or shortly after deployment - one core float, one deep float and one RBR float. Also six oxygen floats were deployed in January 2017 in the South Atlantic. At present only data from the core floats are being processed by BODC and delivering data to the GTS and GDACs.

With the floats deployed the number of UK floats presently contributing data to Argo (including those provided to and deployed by Mauritius) is around 130, as shown in Figure 2, with their geographic distribution shown by Figure 3.

Figure 2. Number of UK (including Mauritius) floats with data on Coriolis GDAC by month.

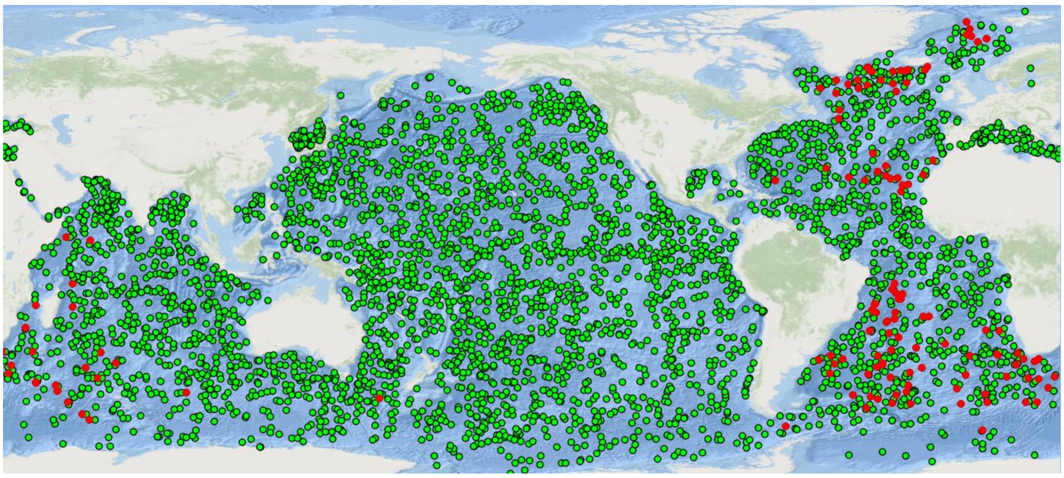

Figure 3. Showing the locations of reporting UK (and Mauritius) floats (in red) as at 1st March 2017.

However, as noted above, there are a number of active floats (additional sensors, deep, RBR CTD) deployed in recent years for which data processing has not yet been set up (so are not shown in Figures 2 or 3). At end February 2017, in addition to the core floats, we have in operation:

4 STS floats
3 floats with radiometers
6 floats with dissolved oxygen
2 floats with RBR CTD sensor
14 bio-geochemical floats
3 deep floats.

At this time, we have 82 un-deployed core floats, four deep floats, three bio-geochemical floats, two oxygen floats and two with the RBR CTD in our inventory, with a further six Apex floats with oxygen and pH, two Apex with oxygen and four Apex Deep with oxygen to be delivered before end March 2017. This should allow for continuity of deployments for several years if there is a funding shortfall over the coming years (see §7).

2. Float technology

Bio-geochermical Argo. During the year PML arranged for the deployment of their last two ProvBio floats on the P18 line in the eastern Tropical Pacific. The data from these floats, together with all our ProvBio floats are available at http://www.oao.obs-vlfr.fr/bioargo/summary_UK-Bio-Argo.html and a priority will be to get the floats set up for GTS (temperature and salinity) and GDAC data distribution.

Deep Argo. In December 2015 and January 2016 we deployed two Apex Deep and two Deep Arvor floats in the North Atlantic. All of these are presently operating apart from one Deep Arvor that failed after one cycle. In December 2016 we deployed three Deep Apex from the James Clark Ross (JCR) during the Drake Passage section. One started leaking after two cycles and entered emergency abort mode, returning to surface and staying there, and was picked up by the ship on its way back north. Subsequently, the other two also started leaking after around seven cycles, while the JCR was then operating near South Georgia, but the US National Science Foundation (NSF) R/V Laurence M. Gould was nearby and the NSF agreed that the Gould could take a few hours to go hunting for our deep floats. By changing the float position transmissions to hourly and then to 15-minute updates as the Gould got closer and by sending position updates to the Gould we were able to successfully recover the two floats. This would not have been possible without a multi-way cooperation between NOC, BAS, CLS, Teledyne Webb, NSF and the Gould, for which we are most grateful. The three Deep AEPXs have all been shipped back to Teledyne Webb for investigation, to find out the cause of the leak.

BoBBLE (Bay of Bengal Boundary Layer Experiment). In June/July 2017 7 floats were deployed from the Indian RV Sindhu Sadhana for BoBBLE, this included four STS floats to provide detailed measurements through the surface freshwater layer, together with three floats with radiometers. In addition a float with the new RBR CTD sensor was deployed for comparison but this failed so the second RBR float was not deployed and returned to India for a firmware upgrade, this float was subsequently deployed in February 2017 but failed (in spite of passing all pre-deployment checks).

3. Float performance

Float lifetime. At last year's Argo Steering Team meeting it was reported that float longevity had improved up to 2005, but since then there have been dips in longevity. There is also great diversity in performance across programs, some achieving long life (50% reaching 200 profiles) and others short lifetimes (50% only reaching 100 profiles). This behaviour is clearly evident in the UK's floats, the vast majority of which have been Webb Apex floats, as shown in Figure 4. For floats deployed 2004-2006 50% of floats exceeded 160 cycles, for 2007-2009 floats 48% reached 170 cycles but for floats deployed 2010-2012 only 47% of floats reached 160 cycles. Since 2007 we have fitted lithium batteries in over 50% of Apex floats deployed, so those floats deployed 2007-2009 are showing the greatest longevity. However, for floats deployed 2013-2015 it looks as if fewer than 50% of floats will exceed 120 cycles, suggesting a downturn in longevity of our core Apex floats.

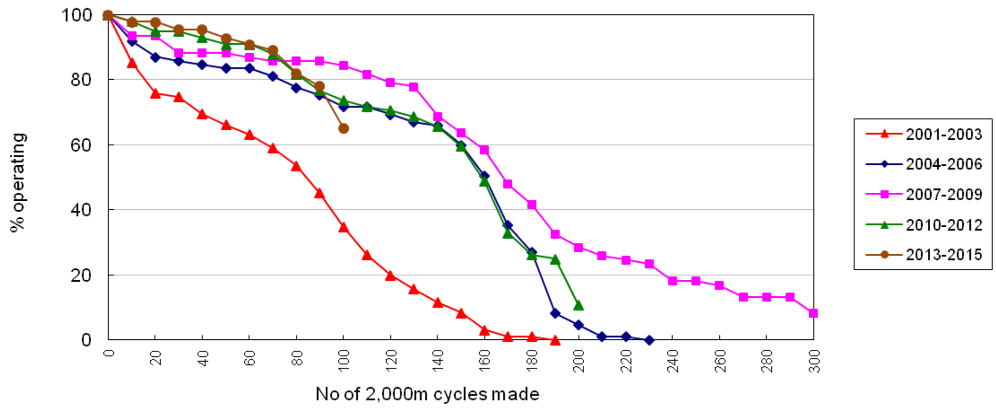

Figure 4. Number of (normalised to 2,000m) cycles made by UK standard Apex floats deployed in 2001-2003, 2004-2006, 2007-2009, 2010-2012 and 2013-2015.

4. Outline deployment plans for 2017

So far in 2017 we have deployed six floats with oxygen sensors in the South Atlantic and the second Apex RBR float in the Bay of Bengal (which has failed). At present planned deployments for 2017 include:

4 core floats North Atlantic (26N RAPID cruise, February)
5 core floats South Atlantic (Royal Navy, Drake Passage/Argentine Basin, March)
4 core floats Drake Passage / Orkney Deep (DynoPO cruise, March)
4 core floats SE Atlantic / Agulhas (SAMBA cruise, April)
4 core floats Rockall Trough/Iceland Basin (Extended Ellett Line, May)
4 core floats SE Atlantic / Agulhas (SEAmester cruise, July)
4 core floats S Atlantic (AMT cruise, October)
4 core floats N Atlantic (AMT cruise, October) (2 RBR & 2 Iridium) **
4 core floats Mozambique Channel (ASCA and/or IIOE2 cruise, November)

** We aim to deploy two pairs of RBR and Iridium floats to compare the RBR sensor with the high resolution Iridium profiles. They will only be deployed after the 2 RBRs are returned from Webb's, where they are currently being refurbished.

Possible deployments in 2017, still to be arranged:

2 core floats for Mauritius
2 core floats for Arabian Sea (VOS)
2 core floats Somali Basin (VOS)

Other deployments will be arranged as opportunities arise. The aim is to deploy a minimum of 35 floats (but ideally as many as 44) during the year, including those provided to Mauritius.

5. Data management

<u>BODC</u>
BODC is the data centre for UK Argo funded by NERC and is responsible for data management of UK and Irish floats. UK Argo is a member of Euro-Argo and is managing

European floats as part of the MOCCA project. BODC is also the lead for the Southern Ocean Argo Regional Centre (SOARC).

During 2016 the priorities for data management were set as follows (highest priority first):

1. Core UK Argo near real-time & core Euro-Argo near real-time
2. Core UK Argo delayed-mode QC & core Euro-Argo delayed-mode QC
3. Bio-geochemical UK Argo near real-time
4. AST/ADMT ratified extensions to Argo near real-time (deep, NST etc)
5. Argo equivalent near real-time (AST/ADMT non-ratified extensions to Argo).

In a time of limited resource (and a growing number and diversity of floats to manage) this year BODC have concentrated efforts on processing near real-time data and improving the efficiency and resilience of the near real-time data system. Unfortunately, the Argo team at BODC have been affected by disruption to IT infrastructure, which has resulted in limited resources being stretched even further. However, the team have recovered system performance, protected the integrity of the Argo data and made progress with system development. The improved efficiency of the near real-time system will enable us to progress the development required to process BGC and Deep floats in the coming year.

Progress this year includes the replacement of the data retrieval method from CLS for Argos floats with the CLS Web Service and working with CLS to migrate to a new SFTP service for Iridium floats. The CLS SFTP service will be extended to include older Iridium floats in the near future. For the first time BODC has delivered V3.1 Argo NetCDF metadata files for >95% of our legacy and active floats as well as V3.1 Argo NetCDF profile files for over 50% of the >60,000 profiles that we hold data for. The development of V3.1 NetCDF files continues for the remaining profile files and for technical and trajectory files.

BODC are also currently processing nine MOCCA floats in near real-time. It is expected that a total of 75 floats will be hosted by BODC from the MOCCA project. System development and processing carried out for this project includes:·

- Development of new retrieval and archiving methods for raw data from short burst data (SBD) Iridium floats including handling emails and attachments, safely archiving raw data and preparation of files for decoding.
- Integration and testing of the Coriolis decoder into our existing system. The decoder also requires interaction with existing database and file infrastructure so these processes have been developed and tested.
- Preparation for new floats including review of float manuals and database population of metadata in advance of float deployment.
- Improving resilience of near real-time data systems and efficiency of monitoring process so that BODC can handle the increase in float numbers expected over the next year and can process data efficiently and without loss of performance of existing workflows.
- Loading new floats into our system with the minimum of delay and decoding the data in near real-time for delivery to the GTS and GDACs.

All delayed-mode QC for BODC hosted floats is done within BODC (when resource is available). The OW (Owens-Wong) software is used along with the latest reference data available from Coriolis (CTD climatology and Argo profile climatology) for guidance. 55 % of BODC hosted profiles eligible for delayed mode QC have been processed and submitted to the GDACs in delayed mode. Addressing the backlog in the delayed mode QC for core Argo floats is the second highest priority after the real-time delivery. We have also begun training for newer members of the BODC team to expand the number of DMQC operators at

BODC. This year we have also provided introductory training on DAC and DMQC operations to South Africa as part of a POGO grant.

With increasing numbers of enhanced floats with oxygen, radiometers, bio-geochemical sensors, there is a recognised need to ensure that (at least) the temperature and salinity data are made available in real-time and this should be addressed in 2017. The integration of the Coriolis decoder into our existing system for the MOCCA project opens the way for processing much of the existing biogeochemical and deep data. Work has started to prepare the BODC system for decoding these data.

Met Office
The UK Met Office has commissioned the development of a Python-based Argo netCDF to BUFR converter that will be implemented operationally at Exeter. The code is presently undergoing pre-operational testing. It is expected that the software will be made freely available when fully tested and proven operationally. At present the code is for temperature and salinity only, but has been designed so that the addition of oxygen (and other bio-geochemical variables) can be added relatively easily (with oxygen at least to be included before the end of the year).

The bio-geochemical (chlorophyll-A fluorescence, dissolved nitrate, pH and backscatter) enhancements to the BUFR format have been approved by the WMO for validation, but resources have precluded this during 2016. It is hoped that the enhancements will be validated in 2017 such that the enhanced BUFR message can be approved by WMO for operational use in 2018.

6. Scientific and operational use of Argo data

Operational oceanography.
Argo profiles are assimilated into the global and shelf-seas FOAM (Forecasting Ocean Assimilation Model) systems run operationally in near real-time to produce short-range (out to 6 days) ocean forecasts of the 3D ocean temperature, salinity, and currents as well as sea-ice variables (Blockley et al. 2014). FOAM is also used to provide the initial ocean and sea-ice conditions for coupled seasonal forecasts using the GloSea5 system (MacLachlan et al., 2015), so the Argo data have an impact on forecasts out to months ahead. See http://www.metoffice.gov.uk/research/weather/ocean-forecasting.

Recent and on-going developments relevant to Argo include:

- The use of near-surface Argo measurements in assessing a new operational global product of the diurnal cycle of SST (While et al. 2017) which is freely available through the Copernicus Marine Environment Monitoring System (CMEMS; http://marine.copernicus.eu/).
- A coupled ocean/atmosphere prediction system is being developed on weather forecasting timescales, including assimilating Argo data in a coupled data assimilation framework (Lea et al. 2015). A demonstration coupled NWP system is being run operationally at the Met Office. The timeliness constraints on Argo for this application are even more stringent than for operational ocean forecasting systems. The impact of Argo on this system was assessed as part of the E-AIMS EU project (King et al. 2015). The ocean component of global short-range coupled forecasts are freely available through CMEMS.
- FOAM is also being used to contribute to AtlantOS, an EU project to assess the observing system in the Atlantic, including potential Argo sampling changes, deep Argo and other in situ observing network extensions.

Blockley, E. W., M. J. Martin, A. J. McLaren, A. G. Ryan, J. Waters, D. J. Lea, I. Mirouze, K. A. Peterson, A. Sellar, and D. Storkey, 2014: Recent development of the Met Office operational ocean forecasting system: an overview and assessment of the new Global FOAM forecasts. Geosci. Model Dev., 7, 2613–2638, doi:10.5194/gmd-7-2613-2014.

King, R.R., M. Martin, A. Stearl, 2015. Weather, seasonal and decadal forecasting: OSE/OSSE results and recommendations. E-AIMS deliverable report D3.323. http://www.euro-argo.eu/content/download/88659/1093576/file/E-AIMS_D3.323-v2.pdf?version=1

Lea, D. J., I. Mirouze, M. J. Martin, R. R. King, A. Hines, D. Walters, and M. Thurlow, 2015: Assessing a New Coupled Data Assimilation System Based on the Met Office Coupled Atmosphere–Land–Ocean–Sea Ice Model. Monthly Weather Review, 143, 4678–4694, doi: 10.1175/MWR-D-15-0174.1.

While, J., C. Mao, M. Martin, J. Roberts-Jones, P. Sykes, S. Good and A. McLaren. An operational analysis system for the global diurnal cycle of sea surface temperature: implementation and validation. Accepted subject to minor corrections in QJRMS.

Climate monitoring.
The Hadley Centre maintains two data products that incorporate Argo observations:

- EN4 contains in-situ ocean temperature and salinity profiles and objective analyses. It is updated monthly using real-time Argo profiles, and annually using delayed-mode Argo profiles. EN4 is freely available for scientific research use (see http://www.metoffice.gov.uk/hadobs/en4/).
- HadIOD is an integrated database of surface and sub-surface temperature and salinity observations for the period 1850 to present. It includes quality flags, bias corrections and uncertainty information (Atkinson et al., 2014). At present, HadIOD obtains sub-surface profile data from EN4. Public release of the data are expected in spring 2017. HadIOD is expected to supersede the HadGOA data product, which had not been updated for approximately 5 years (http://www.metoffice.gov.uk/hadobs/hadgoa/).

The datasets are used for climate and global change studies, including ocean heat content analysis.

Atkinson, C. P., N. A. Rayner, J. J. Kennedy, and S. A. Good (2014), An integrated database of ocean temperature and salinity observations, J. Geophys. Res. Oceans, 119, 7139–7163, doi:10.1002/2014JC010053.

Science use.
Data from Argo and Bio-Argo floats are currently used in combination with satellite ocean colour measurements to investigate the ocean biological carbon pump. Specific research focuses on the dynamics of oceanic organic particles in the upper ocean (0-1000 m), their stocks, fluxes, disaggregation and remineralization. Satellite data and Bio-Argo floats are also exploited to better understand the effect of Saharan dust deposition on upper ocean biogeochemistry. Finally, satellite altimetry, ocean colour, Argo and Bio-Argo data are used to study eddy transport of heat, salt and biogeochemical properties.

Dall'Olmo, G.; Dingle, J.; Polimene, L.; Brewin, R. J. W. & Claustre, H. Substantial energy input to the mesopelagic ecosystem from the seasonal mixed-layer pump. Nature Geoscience, 2016, 9, 820-823.

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

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

Schabetsberger, R.; Miller, M. J.; Dall'Olmo, G.; Kaiser, R.; Okland, F.; Watanabe, S.; Aarestrup, K. & Tsukamoto, K. Hydrographic features of anguillid spawning areas: potential signposts for migrating eels. Marine Ecology Progress Series, 2016, 554, 141-155.

7. Funding

Over the last five years funding for the UK Argo Programme has been provided by DECC, NERC and (since 2012) the Met Office. The Met Office and DECC-funded element of the UK Argo Programme supports the Met Office's activities and includes: programme management and coordination, float procurement, preparation of floats for deployment, organisation of float deployments and representation in the international Argo Steering Team and Euro-Argo. Argo science and data management aspects are funded by NERC and led by NOCS and BODC respectively. NERC has also provided ad-hoc funding for floats, which has been directed through NOC, PML and other delivery partners.

During 2016 DECC advised that as a consequence of savings to be made under the Government's Comprehensive Spending Review their funding for Argo will cease from April 2018. Since then the majority of the activities previously delivered by DECC have been moved into the new Department for Business, Energy and Industrial Strategy (BEIS) which is also the owning department for the Met Office and NERC. The Met Office are actively pursuing the issue to see if there is a way to recover the position, as the DECC funding provided for the majority of our core Argo floats.

From 2018 it is expected that NERC will continue to fund deep and bio-geochemical floats through projects (e.g. ORCHESTRA, BoBBLE and ACSIS), but they are unlikely to fund many (if any) core Argo floats.

BODC NERC National Capability funding, which funds Argo data management, is currently under long-term review. For the coming year we expect funding to remain at the same cash amount as it has been for the previous few years, which, when inflation is taken into account, is a net reduction in real terms. Data management for the BoBBLE floats has been funded but data management budgets for ORCHESTRA and ACSIS are still to be confirmed. The European funded MOCCA project will support real time processing of 75 Euro-Argo ERIC floats and delayed mode quality control for 38 ERIC floats for 4 years. AtlantOS will support delayed-mode QC of bio-geochemical Argo data over the next two years.

8. Euro-Argo ERIC

The Euro-Argo ERIC (European Research Infrastructure Consortium) was formally established on 12th May 2014 following notification in the OJEU (Official Journal of the European Union). UK is one of the founding members of Euro-Argo alongside Finland, France, Germany, Greece, Italy, Netherlands, Norway (Observer) and Poland (Observer). The key Euro-Argo ERIC project that the UK is involved in is MOCCA as noted above.

U.S. Argo National Report to AST-18, March 2017.

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). SOCCOM, with support from the National Science Foundation and in partnership with U.S. Argo, has 65 operational floats at present (source: AIC) equipped with biogeochemical sensors in the Southern Ocean, and has plans to increase the size of its array to 200 floats in the coming years. 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.

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 will be integrated with planned contributions of international partners.

Status:

The support level for U.S. Argo is determined on a year-to-year basis. Support levels for Core U.S. Argo have remained flat since 2004, during which time the number of floats deployed has diminished by about 11 floats per year due to inflation. Through technology improvements leading to increases in the mean lifetime of floats, the number of active U.S. floats remains approximately equal to the high levels achieved since 2008. Further increases in lifetime will be realized by a changeover in SOLO-II floats to hybrid lithium batteries to mitigate passivation losses. However, the present number of yearly deployments is not sufficient to sustain U.S. Argo. An augmentation by about 46 floats in 2016 increased the number of deployments last year and it is hoped this increase will continue.

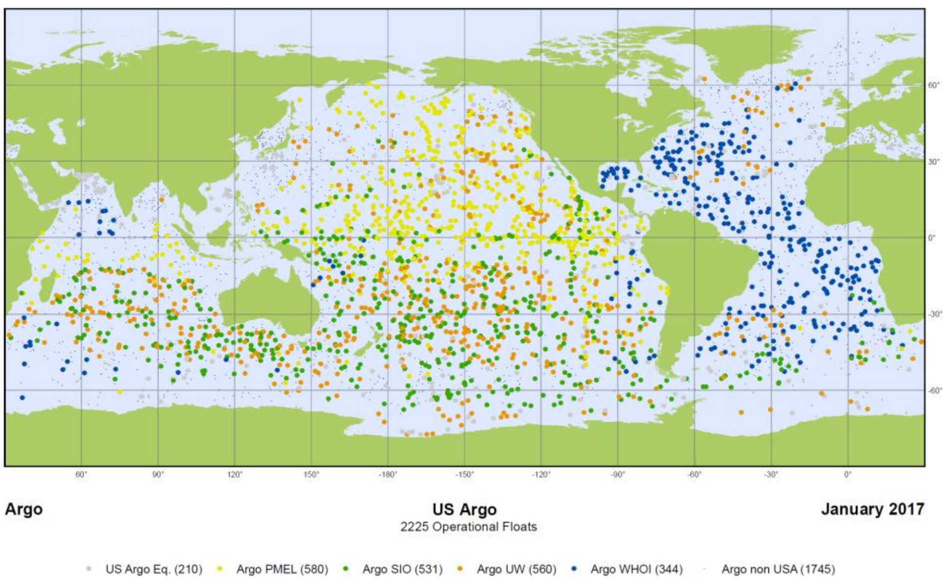

***Fig. 1**: Location of operational U.S. Argo Program and U.S. Argo Equivalent floats as of January 2017. (Source: AIC)*

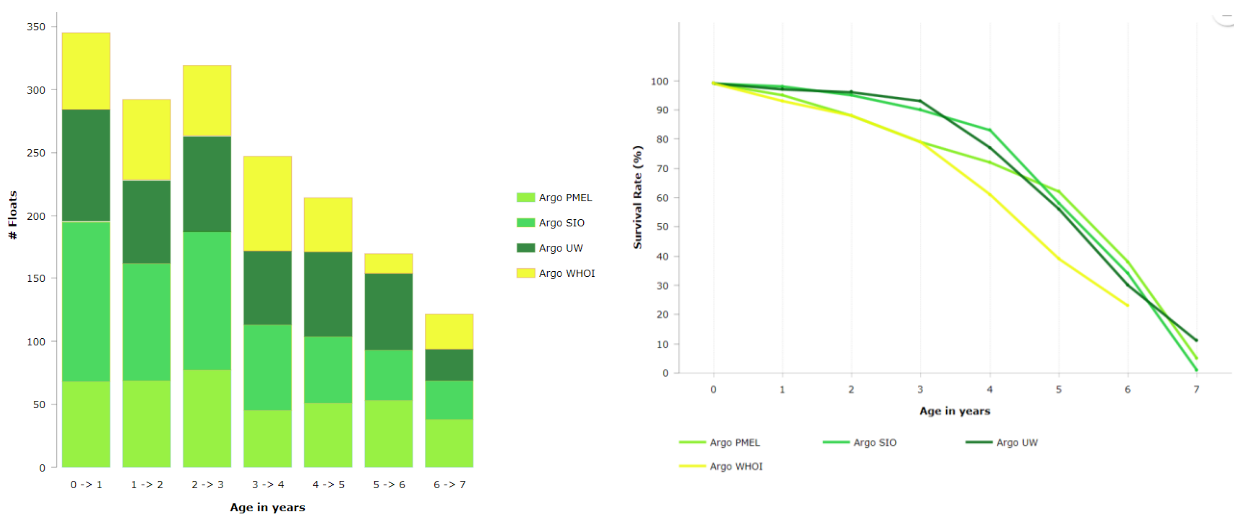

***Fig. 2:** Left panel – Age distribution of operational U.S. Argo Program floats deployed since 2010. Right panel: Survival rate of U.S. Argo Program floats deployed since 2010. (Source: AIC)*

There are presently 2015 operational U.S. Argo Program floats (Fig. 1) as of January 2017. The age distribution of operational floats deployed since 2010 is shown in Fig. 2, along with the failure rate for that sample. Of those floats that are at least 56 months old, 50% remain active (Float half-life = 56 months).

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.

Deep Argo:

Since 2011, U.S. Argo carried out development and testing of Deep Argo floats. These instruments profile to pressures as great as 6000 dbar, and are capable of more than 100 cycles. Successful prototype float deployments were carried out in 2013 – 2015, Deployment of regional pilot arrays was carried out in the SW Pacific Basin (Fig. 3 upper panel) in early and mid- 2016, and in the South Australian Basin in late 2016 (Fig 3 lower panel).

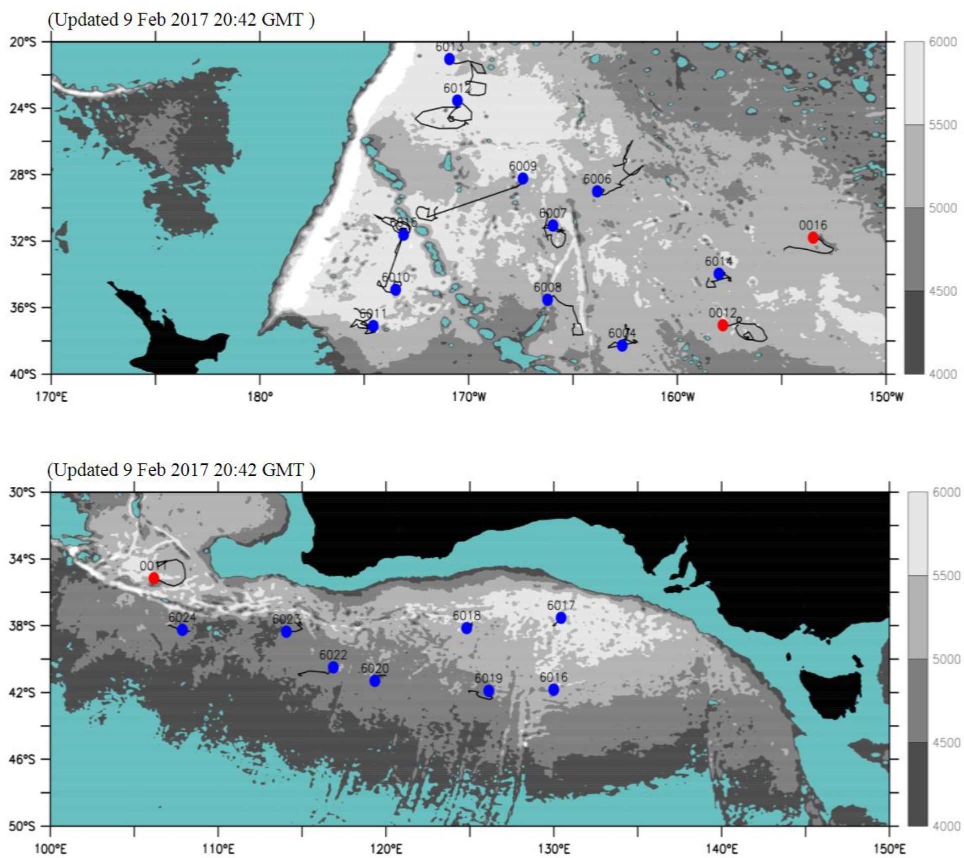

***Fig. 3**: Location of 13 U.S. Deep Argo floats in the SW Pacific Basin (upper panel) and 8 in the South Australian Basin (lower panel). Deep SOLO floats are indicated in blue and Deep APEX floats in red.*

Testing of deep float models continues as well as testing of SBE-61 CTD accuracy. The SBE-61 has not yet achieved it aspirational goals of (± .001C, ±.002 psu, and ± 3 dbar) but is progressing relative to those goals (Fig. 4).

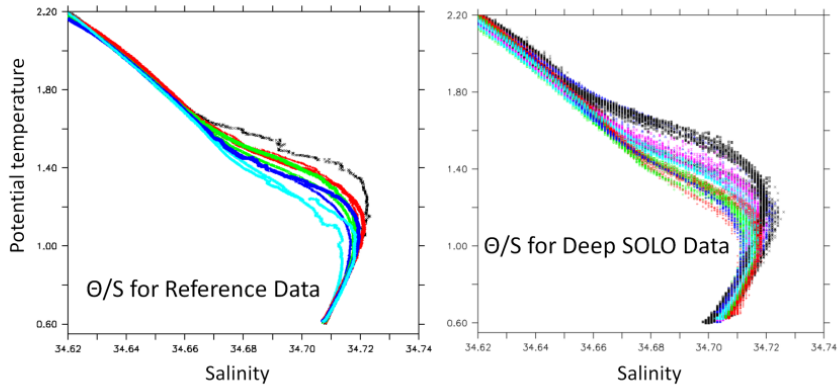

Fig. 4: *Deep Θ/S relation for CTD reference data (CLIVAR line P15S in 2009, left panel) in the SW Pacific Basin and for 11 Deep SOLO/SBE-61 floats in the SW Pacific Basin (right panel)*

Plans:

The highest priority for U.S. Argo is to sustain the Core Argo array. Specific plans for float deployments in 2017, 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 Mauritius and back on RV Kaharoa was carried out in late 2016. This voyage deployed 118 Core Argo floats in the South Indian Ocean and 8 Deep Argo floats in the South Australian Basin (Fig. 3 lower panel). A Kaharoa cruise to Chile is planned in October 2017 to deploy Core Argo floats in the South Pacific, with 5 Deep Argo floats to be added to the regional array in the SW Pacific Basin. Three additional Deep Argo floats will be deployed in the same basin along CLIVAR line P06 (30°S) in mid-2017 by RV Palmer. A third regional pilot array, consisting of 6 Deep Argo floats, will be deployed along the moored array (RAPID) in the North Atlantic in March by RV James Cook (Fig. 5)

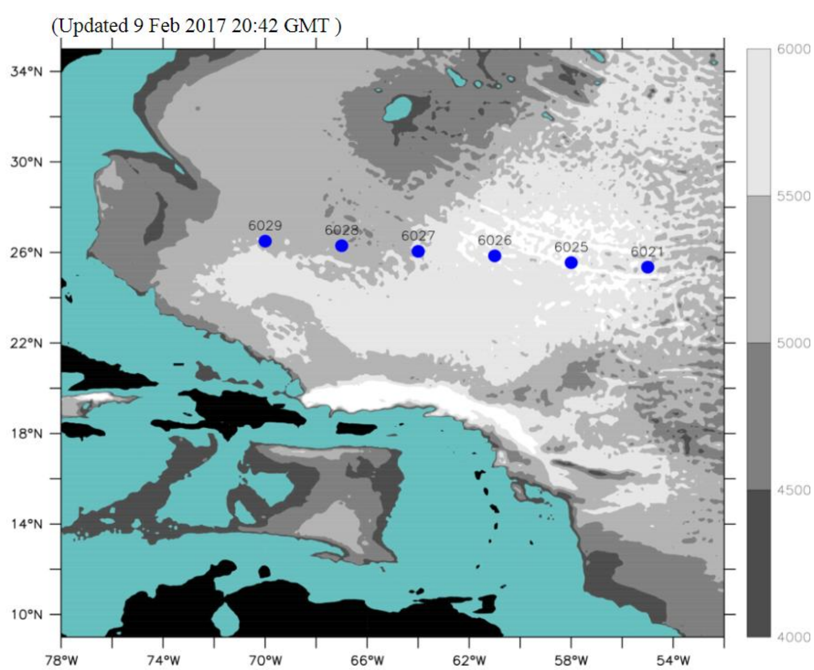

Fig. 5: Planned U.S. Deep SOLO deployments by RV James Cook in March 2017 in the NW Atlantic deep Argo regional pilot array.

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. During 2016, processing of delayed-mode files continued but was slowed somewhat by adoption of new file formats.

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.