17th meeting of the International Argo Steering Team

Yokohama, Japan
March 22-24, 2016

Contents

1. Welcome and Introduction

Naomi Harada, Deputy Director of RCGC, JAMSTEC, welcomed everyone to JAMSTEC and wished us to have a productive meeting.

Action item 1: Write letter of thanks to local host JAMSTEC. AST co-chairs

2. Objectives of the meeting

D. Roemmich opened the meeting by stating the objectives for the meeting and thanking our host, JAMSTEC, for their hospitality throughout the week.

The objectives of the meeting were as follows:

- Ensure that Core Argo remains healthy and continues to improve platform and sensor technology, data quality, coverage and utility
- Review the status and progress of Argo enhancements (Deep Argo, BGC-Argo, Equator, western boundary regions, marginal seas, high latitudes)

3. Action items from AST-16

M. Scanderbeg reported on action items from AST-16 that were still pending. There were a few that had not yet been completed that were not going to be addressed somewhere in the AST-17 Meeting Agenda. The first was to ensure that citation information is included in all data downloading services. It is not clear if this has been done and M. Scanderbeg needs to follow up on this with the ADMT co-chairs and GDACs. The second unfulfilled action item was about running Argo indices/metrics/quality plots and how to keep track of them. Some work had been done by B. King on this in the past and it is still considered useful. The action item can be carried forward to the next meeting.

4. Implementation issues

4.1 Update commitments table

The commitments table was presented and updated for the coming years, if possible. The Argo Program is looking to predict the future growth or decline of the array and decided it is important to break the float commitments into several categories: core Argo, Argo extensions, and Argo equivalents. The definition of a core Argo float will follow Argo's new target of being spatially complete. This means including sea-ice zones and marginal seas. The definition of Argo extension floats is a Deep float, a BGC float, near-equatorial float, or Western Boundary Current float. The definition of an Argo equivalent float is one that is purchased outside of the main Argo funding sources. It will be important to weight the number of floats to be similar to the standard Argo mission.

The number of Argo floats predicted to be deployed in the coming year is over 100 less than the target of 800 deployments per year. See the commitments table in the Appendix for the exact numbers.

Action item 2: Improve commitments table by breaking it out into Argo target mission, extensions, and equivalent. Ensure that equivalents are weighted by mission frequency. M.

Scanderberg, AST co-chairs.

4.2 AIC report on the Status of Argo

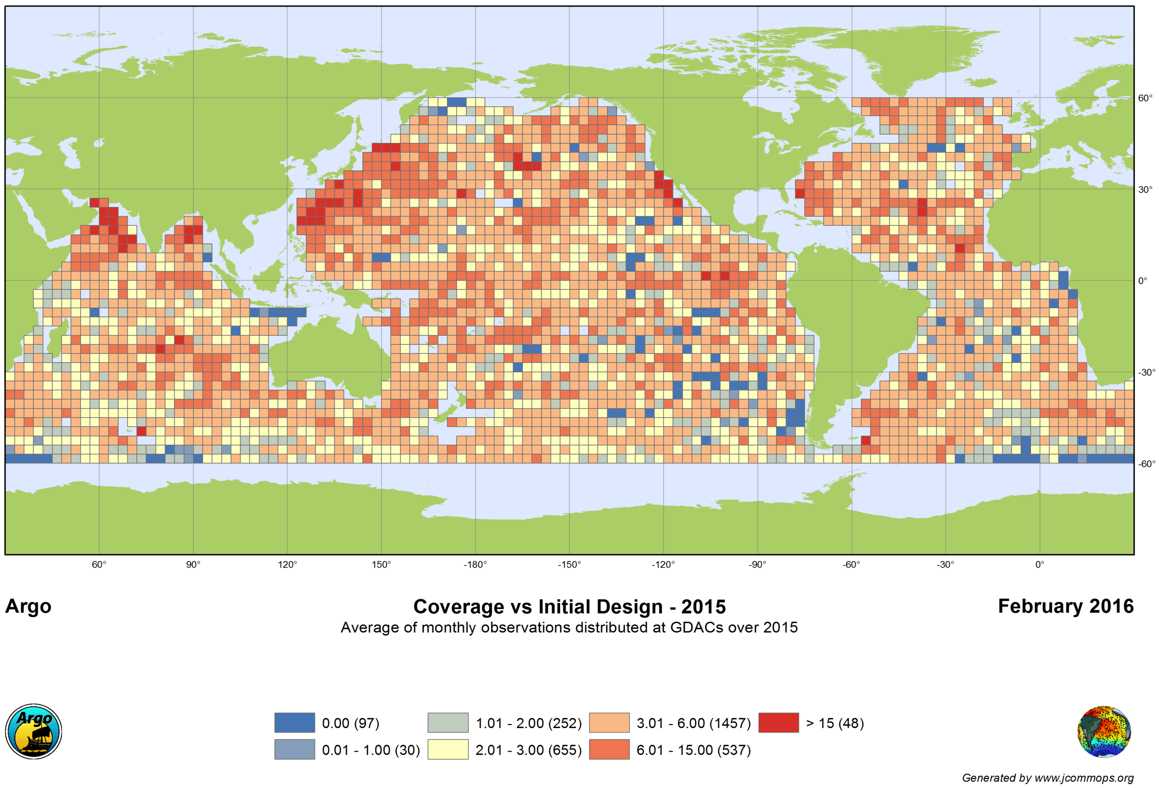
The report on Argo's status was introduced with a focus on Japan Argo, the second float implementer in Argo's history (1500 units). Japan has clearly decreased their contribution in the last years which has resulted in a decrease from 400 operational units to 200. The TC highlighted however the excellent coverage achieved in the North West Pacific, in particular in the WBC region, and the expertise learned from using many float types and sensors.

Then the TC presented the performance indicators for Argo, tested over the last year and still being stabilized.

	Indicator	Initial	Global	Deep	Bio
IMPLEMENTATION	Activity	113	90	2	31
	Operationality	112	88	2	30
	Intensity	106	84	6	31
	Coverage (Yearly)	70	55		
	Coverage (monthly)	54	43		
DATA FLOW	Delivery		94		
	Quality (TEMP, PSAL)		93, 91		
	DM Processing		69		
	Timeliness (FR, US)		85, 84		
INSTRUMENTATION	Reliability (75, 150)		75, 48		

Very good	Good	Average	Bad

He presented then an overview for all the indicators and a new map for evaluating Argo's coverage over a year period.



An overview of Argo's projection calculation was given in reaction to P. Durack's paper and the introduction of the website tool. This tool will be connected to the national commitments table for a more accurate projection. With 850 deployments per year, a failure rate of 20% per year, and an inflation rate of 2% per year, Argo may reach a maximum of around 4000 units in the next couple of years and then start a slow decrease. The reliability of floats will be a key factor to sustain the array.

He presented the status of instrumentation and recalled that reliability has not improved since 2004 even if new float generations seems promising.

He noted the delayed mode processing effort was also decreasing.

He then provided a detailed report on each indicator. National contributions were presented and increasing/decreasing contributions were highlighted.

He presented all indicators for activity, intensity of deployments, and coverage, with global and basin perspectives, and as well expansion areas for the global Argo.

In summary, Argo is in good shape and close to reaching a maximum of 4000 units and staying on it for awhile. The initial designed is achieved, rather well sustained, but we should take care of the Indian Ocean (addressed accordingly by a future cruise of the Karahoa). It was noted that some large parts of the Pacific were getting old. While the coverage indicator (70%) for the initial design is very good, there may be a margin for improvement.

The global design is in sight, but not on all expansion areas (equatorial and WBC not implemented).

Technology shows no progress yet and impacts dramatically network status.

Data distribution could be optimized in volume, delays and quality.

The TC concluded, mentioning that Argo's future depends on its capacity to sustain its initial design and partner with the multi-disciplinary demand, ineluctable, but providing more T/S data, a larger user community, and ensuring long term visibility for the program.

4.3 JCOMM Observing Program Support Centre

M. Belbeoch presented the status and development of the JCOMMOPS infrastructure. The office is now properly staffed, funded, experienced and at the service of the networks to provide assistance on reporting, promotion and operations. Practically four new staff were recruited in the last three years which definitely boosts the centre's capacity.

A number of key products (such as monthly maps) are now automated, using a new template, and the information system is globally more autonomous. This frees up some time for the TCs to provide analysis and to develop specific monitoring tools.

The TC highlighted the clear benefits of the new Science and Communications Coordinator (E. Rusciano), after five months of team work and training on the JCOMMOPS environment and services. This facilitated the administrative, communication, educational initiatives where JCOMMOPS is involved. The close cooperation of Emanuela with the TC will enhance productivity to panels with a physical oceanography perspective.

After a short introduction of the new website capacity (by H. Freeland), the TC made a live demonstration. A number of AST members have been successfully using the website (including reporting to AST), while some other requested further training and documentation as they were confused by the interface. While most of the hard work is done for the website, including making it function smoothly, considering feedback from key testers, removing most bugs and stabilizing the base engine, it is time to interact further with the different users of the website to adapt and finalize it. Priority will be given to creating a user manual, making videos, and working with key users to ensure they know how to effectively use the website.

The TC mentioned that the argo.jcommops.org website was an on-line software more than a website, and needed some experience to discover its full capabilities.

4.4 **AIC funding**

About one week before AST-17, Howard Freeland received a financial statement for calendar year 2014 from Albert Fischer at the IOC. Then within a few hours of the start of the meeting HJF received a preliminary statement for 2015.

The deposits made in 2014 were unusually low. The explanation is simple, I (HJF) waited until too late in the year to remind contributors that the amounts were due. This was an error on my part. The contributors who had failed to make their contributions scrambled and completed these mainly in the early weeks of 2015. Hence the IOC shows these contributions on the 2015 statement. Following that incident, I checked with all contributing nations to ask when they would like to be reminded. Most selected May of each year.

I have not had time to explore the 2015 statement and determine whether or not I agree, this will have to wait for a suitable time soon after I return to my office. The carry forward into 2016 for all of JCOMMOPS is disturbingly low. However, I am pleased that after 6 years it was finally possible to get a statement.

Action item 3: Analyze long term budget issues for the Argo Information Centre (AIC) and encourage more countries to support it. M. Belbeoch, H. Freeland

4.5 Japan Argo

Toshio Suga reported on the Japanese Argo Program, its origin, evolution and prospects. Japan Argo started in 2000 as one of the Prime Minister's Millennium Projects for innovation to address urgent issues in the 21st century. Because of this high-level national project status, Japan Argo got off on the right foot, developing its fleet and data management facilities quickly. Another important benefit of this status was the establishment of a National Committee for the Promotion of the Argo Program from the outset, which has been facilitating the smooth implementation of Japan Argo, even after the end of the millennium project in 2004, with collaboration among relevant ministries/agencies including the science and technology ministry (MEXT), the Ministry of Foreign Affairs, the Fisheries Agency and the Japan Coast Guard.

JMA and JAMSTEC are the main implementers of Japan Argo both during the millennium project and after that. The two agencies have been collaborating closely and playing complementary roles in Japan Argo. JMA has been serving as a DAC, taking care of real-time QC as its operational activity. JMA also has been deploying Argo equivalent floats (5-day cycle) operationally and intensively in the northwestern North Pacific to be fed into its data assimilation system since 2005, contributing greatly to enhanced sampling in and around the Kuroshio/Kuroshio Extension region. JAMSTEC has been deploying core Argo floats, taking care of delayed-mode QC and operating PARC as its research activities. While the focus of JAMSTEC Argo has been the completion of the core Argo until now, it has extended to the enhancement/expansion of Argo, including Deep Argo and BGC Argo, since 2009, which led to the interdisciplinary project (INBOX) and the development of the Deep NINJA float. The global state estimate (ESTOC) which makes full use of the Argo data has been another focus since 2014. JAMSTEC's activities are reported in the regional science section of this report.

Japan Argo has been evolving to sustain its activities for core Argo and to contribute to the enhancement/expansion of Argo under difficult budgetary conditions. The bad news is that its annual deployment rate has been decreasing in recent years; the good news is that its basic structure keeps working and is still robust, enabling continuous Japanese contribution to the international Argo Programme.

4.6 Limiting the complexity of the Argo data stream

It was recognized at ADMT-16 that several DACs are failing to keep up with basic activities like DMQC, because of the requirements to handle increasing numbers of novel floats and sensors. In order to document what had been hearsay at ADMT-16, King and Scanderbeg had sent round a questionnaire, giving RT and DM operators the chance to explain extra tasks they had adopted, and whether these had adequate new resources or were being absorbed in existing funding envelopes. 9 responses were received, covering activities in 10 Argo countries. Groups mostly reported having to absorb between 6 and 12 months of effort within existing resources, particularly in the conversion to V3.1 NetCDF files.

This endorsed the feeling at ADMT-16 that action is required to help limit the demands put on

DACs/DMQC operators, and to enable them to secure adequate resources for any extra tasks they may be asked or expected to carry out.

One step that would help DACs would be to limit future growth in the complexity of the Argo data system. The conversion to V3.1 NetCDF files allows for a very wide range of Bio variables to be included. The system now needs several years of stability while DACs consolidate their capability and catch up with tasks that have been neglected during the transition.

Limiting the new tasks that might be asked of DACs has several aspects, each of which attracted some discussion. These include: (1) what steps do we take to ensure DACs have adequate resources to accept extra floats that already conform to Argo requirements ? (2) What is the procedure for having new sensors and parameters accepted into the Argo data system ? (3) How should data be handled that fall outside the Argo data system, to ensure they are transparently available in an acceptable form?

Questions (1) and (2) were addressed in a presentation by Brian King. At the end of ADMT-16 King and Wong had drafted a series of bullet points summarizing requirements for new floats or new data types to be accepted into Argo. BAK presented those points as requirements, amplified with explanation and comment so that they could be understood by PIs/potential float providers not already familiar with the Argo data system. The requirements should be revised to reflect discussion at AST-17. They should then be circulated to AST and ADMT for final comment, and could then be posted on the AST website, for example in the FAQ section, where DACs can point float providers to the document. The purpose of the requirements is to ensure that floats have a properly identified point of contact, conform to Argo governance, and that data from floats have a properly identified pathway and procedures for RT and DM QC, distribution, and long-term archive. The document describes who in Argo should ensure that the requirements are being met by float-providing PIs.

Question (3) generated quite a lot of discussion. There are many existing examples of floats that are in the Argo data system, but which send extra data that fall outside the set of parameters that Argo can handle. The working example is UW floats that carry passive acoustic listeners (PAL) to measure wind and rain at the sea surface. At present those data are all publicly available at a UW web site, but not at an Argo GDAC. The Argo data system does not want to expand in an unconstrained way to make it possible to include all such parameters in Argo NetCDF files. There is a very considerable overhead in adding parameters, including additions to the documentation and to the file checking system. Equally, Argo does not want to exclude the possibility of such floats, which could stifle innovations or remove a significant number of floats form the global array. The idea of a hard gateway requiring such floats to be refused by Argo was thought to be too severe. Instead, it was agreed that so long as all parameters were publically and transparently available somewhere, this would satisfy Argo obligations. BAK has drafted some documents discussing and describing options, that will be circulated around AST and the GDACs for comment. The proposal is that auxiliary data do not enter the Argo data system, but instead are served on PI websites. They may be mirrored and served by GDACs in a parallel directory to the 'dac' directory. Argo meta.nc files for a float will contain links to web sites where auxiliary data can be obtained by FTP. Discussion should be completed in time for endorsement at ADMT-17.

On the question of what is required when new sensors/parameters need to be brought inside the Argo data system, BAK offered to produce a draft list of steps required, that could be circulated to ADMT for endorsement at ADMT-17.

Action item 4: B. King to describe proposals about storing data from sensors not yet approved and send them to AST and ADMT. Have a telecom with AST, ADMT, GDACs, etc. in a couple months to discuss. B. King, AST co-chairs, ADMT co-chairs.

Action item 5: Review and publish table of requirements to be an Argo float created by B. King. B. King, M. Scanderbeg, ADMT website, AIC website.

4.7 **Discussion items from National Reports**

The only item brought up in the National Reports for discussion was the continued need for an Argo focal point.

Action item 6: Update the list of national focal points on AIC. M. Belbeoch to send current link of focal points to AST members. National Programs, M. Belbeoch

4.8 An Argo Data Paper and advancement of Argo DOIs

S. Wijffels gave a report on the work being done by Fred Merceur at IFREMER to advance a single DOI for Argo to become closer to the RDA recommendations about dynamic data citation without additional cost to IFREMER. There will now be a single DOI for Argo created by SEANOE: http://doi.org/10.17882/42182. The monthly snapshots will be listed below the general description and are cited by adding a 'key' to the end of the single DOI. For example, the DOI for the February 2016 snapshot is: http://doi.org/10.17882/42182#42350 where the key, 42350, follows the # sign. All this can be understood from clicking on either the information button or the snapshot link. When this single DOI goes live, the previous DOIs will be directed to the new one appropriately.

J. Buck reports that this new single DOI puts Argo in a much better position to write a data paper as there is less need for future revisions. The data paper would enable the data to be cited in the ***references*** rather than the main body of text in papers which makes tracking of closed journal citations easier. The draft of the data paper is mostly complete, but the issue of how to assign authorship remains. As receiving credit for adding to datasets becomes more important for advancement, giving appropriate authorship credit is important. After discussion, it was suggested that each national program send a list of authors to M. Scanderbeg. Based on the list and other factors, a list of authorship will be decided.

Action item 7: Ask national programs to send an author list to M. Scanderbeg. Find way to list authors appropriately. M. Scanderbeg, J. Buck, S. Wijffels.

4.9 New AIC Website

Howard Freeland and Megan Scanderbeg demonstrated what they had learned about the new web site. It does a lot of things and we appreciate being so well connected to the AIC database. This allows for users to create their own statistics and plots very quickly and without reliance on the ATC. We do find it to be slow and some of the terminology inside the web site to be obscure. We demonstrated, for example, that choosing to display all "Active floats" produced a very unexpected result, one needs instead to select "Operational floats". It is not obvious why one should be selected rather than the other and it would be helpful to either better define these choices, or better yet, to reduce the number of options.

The interactive maps are clever and it is impressive how lines can be drawn on the map and this could be a great aid to planning a deployment cruise. However, it is a concern that nowhere can we determine what kind of a line is being drawn. A Great Circle is profoundly different in length and trajectory from a straight line.

This is potentially useful, but needs more documentation to make it more user-friendly. Perhaps on the opening page there should be some kind of user guide or a link to videos showing how to use the site.

4.10 Float deployment opportunities

Mr. Mathieu Belbeoch reported on behalf of the JCOMMOPS Ship Coordinator, Mr. Martin Kramp, on activities and developments in JCOMMOPS regarding deployment opportunities and highlighted several items of interest to the meeting.

Mr. Belbeoch demonstrated how the new JCOMMOPS system now permits the manual registration and management of i) cruises on reference sections (GO-SHIP, SOOP), and ii) cruises from any type of ship on any route, in particular through the help of an interactive free-hand mapping tool. He also reported on already automated gathering and processing of research cruise information from external sources. The International Research Ship Operators (IRSO) community, with members such as UNOLS, has proven to be an excellent forum for information exchange in this regard.

The JCOMMOPS Ship Coordinator, Mr. Martin Kramp, helped to establish deployments from various volunteer ships in the last intersessional period. In addition to rather common deployments from research and commercial vessels, the meeting also noted the successful establishment of innovative top-down pilot projects, which i) involved ship suppliers to facilitate logistic issues, ii) used sailing ships in organized events to better access areas without regular shipping, and iii) now permit regular deployments in the piracy zone off Somalia.

The meeting noted that the involvement of the Hamburg Süd ship supplier and DWD PMO in Hamburg had significantly reduced shipping costs for the instrument operator, and also facilitated logistics for the PMO. The instruments had been received, stored, and eventually brought onboard the identified ship by the ship supplier together with other goods, and the PMO only came onboard for a courtesy visit. Mr. Belbeoch stressed that the top-level agreement achieved between Hamburg Süd and JCOMMOPS targeted repeat operations of the same kind from all ships of the company and on all routes they occupy, but has not been requested anymore by the community in the meantime; it could disappear again shortly if not requested again.

The meeting noted that the successful pilot projects with the ocean racing community permitted the establishment of a long-term partnership agreement between IOC-UNESCO and the International Monohull Open Class Association (IMOCA), with technical coordination support from JCOMMOPS. Beyond contributions as volunteer vessels, this partnership comprises financial support by third party sponsors, organized through IMOCA's partner Open Sports Management (OSM) for e.g. the funding of instruments.

Mr. Belbeoch highlighted the commitment of the Dutch three master Bark Europa: The ship i) has been sailing in the Southern Ocean every season for many years, thereby following traditional, under sampled trade wind routes, ii) contributes to SOT (VOS and SOOP), Argo and DBCP (deployments), takes riders free of charge on crucial legs, and recently even welcomed the whole JCOMM – OCG at its last session for a courtesy visit in Cape Town.

A number of no-cost deployments had also been realized by the Blue Planet Odyssey fleet. The family crews had picked up floats and drifters in San Diego and Miami and later on left with a few boats the direct route across the Pacific to establish deployments in positions of highest priority.

The meeting noted that based on a request from SIO (GDP) to find a ship for repeat deployments off the coast of Somalia, JCOMMOPS had identified a suitable container vessel (monthly route UAE-Kenya-Somalia-UAE) run by CMA CGM and established a high-level agreement with the company. With support from the likewise involved PMO office in Mombasa (Kenya), this agreement allows loading and deploying instruments recurrently in an area subject to piracy, and extremely difficult to service. The agreement was achieved under the JCOMM-OPA umbrella, with IOC/ WMO secretariats and OCG co-chairs, for high-level recognition and reliability. After the successful test with drifters, first deployments of Argo floats (lowered by rope to the sea surface) are imminent.

With regard to other innovative deployment platforms, Mr. Belbeoch also reported on deployments of from Kontiki rafts in the Southern Pacific. The project targeted scientific applications and contributed through various contributions to the Global Ocean Observing System; no Argo floats had been available, but 16 surface drifters were successfully deployed.

Mr. Belbeoch also reported on the involvement of sailing vessel Lady Amber in the SPURS-2 project (2016-17, approximately 150 instruments on 9 planned legs between Mexico and Hawaii with a total of 400 days at sea). JCOMMOPS had stressed that the project should be set up based on the memorandum of understanding, established with captain, owner, the marine operator ProLarge and JCOMMOPS in August 2013, in order to provide an appropriate framework and security for all involved parties, including the crew of the ship. This had been rejected, and JCOMMOPS is formally not involved in the project management; piggy-back deployments are however welcome and can be coordinated by JCOMMOPS. With sadness, the community heard about the sudden death of Captain Peter Flanagan during the transit of the ship to the Pacific.

The meeting noted that the JCOMMOPS-ProLarge consortium can provide deployment solutions through chartered vessels of various kinds in all ocean areas. In particular the development of a cost-effective multihull survey vessel (OE43) has progressed well with sea trials in the last intersessional period. Different scenarios exists, i) free-of-cost on the regular route of the ship(s), ii) with costs only for additional days at sea /de-routing the ship, or iii) complete dedicated deployment missions of the ship. Coordinated operations across all observing networks could help to make such dedicated missions achievable in terms of funding.
The meeting thanked JCOMMOPS for the progress with regard to deployment opportunities and strategies, and made the following recommendations:

1. Use JCOMMOPS services more actively, and provide feedback to JCOMMOPS (Members, continuously)
2. Share deployment opportunities, in particular through JCOMMOPS cruise registration (Members, continuously)
3. Continue with the development of cooperation agreements with shipping companies and research ship operators, in particular through IRSO (Ship TC, ongoing)
4. Continue with the development of innovative deployment solutions, in particular with the sailing community (Ship TC, ongoing)

5. Foster the professional approach with ProLarge to develop a standard for deployment missions with chartered vessels, which cover all aspects of such operations appropriately (Ship TC, ongoing)
6. Consider setting up cross-cutting deployment missions with chartered ships through the JCOMMOPS-ProLarge consortium (Members, ongoing

Action item 8: Ask National Programs to inform Martin Kramp who manages ships/cruises in your country. National Programs

5. Data Management Issues

5.1 Feedback from ADMT-16

ADMT 16 was held in Bermuda in conjunction with a Bio-Argo meeting, in November 2015. Discussion was diverse but one theme was repeated over and over again. The DACs are struggling with the complexity of the data system and core activities such as DMQC are suffering because of the requirements of coding to produce version 3.1 files, handle ever increasing Bio data and new Bio variables, and maintaining the quality of the RT and DM data.

Version 3.1 was designed so the Argo data system could handle Iridium floats with changing missions, manage near surface measurements and other variables that require a 'secondary' axis for pressure, and carry data from Argo extensions and in particular Bio-Argo. As part of this we can now carry multi-profiles in one file and have an approval process for new Bio, Tech, Traj and Configuration parameters.

Progress on conversion to format version 3.1, however, is not consistent or complete, either across DACs or across file types. This is a difficult process and requires significant effort by all DACs. And this has had a major impact on DQMC – all DACs are now between 12 and 18 months behind. We have been working on this format conversion for more than 2 years and are not yet done. Hopefully more progress will be made before ADMT17.

Creation of version 3.1 files has allowed more rigorous checking by the GDACs for file contents as well as formats. This relies on tables with well defined vocabularies for variables but table updates have been slow and relied on only one person. We have now identified two who will be responsible for each table, with the tables on line and edited only by these people. Each parameter or variable name will have a status associated with it indicating whether it is ready for use ('active') as opposed to under development. Updating of the file checker will hopefully be faster using this scheme but this has not yet been implemented.

Several action items came out of the meeting. We saw that the Real Time data delivery had some problems and propose to investigate by monitoring all TESAC and BUFR messages that arrive at various nodes during a specific time period. DACs will be asked to send lists of the messages submitted during that time period so we can identify any blockages in the system. Issues with BUFR formats have been solved by distribution of updated Perl scripts provided by Japan that convert version 3.1 files directly to BUFR.

Brian King showed us that the Argo core data is very good generally with little or no correction required in DMQC. This is good news and we now have better KPIs available at the AIC. The bad news is that regularly-run tests such as OA, Altimetry and Unrealistic Density inversions consistently identify the same profiles with questionable data. We expect the DACs to either correct these files or follow up with the PIs but this has not happened for a significant number of floats. ADMT therefore needs a plan to deal with the degradation of the Argo data stream which is impacted by these questionable profiles remaining in the data set.

ADMT therefore proposed to AST that files containing *errors identified repeatedly, without correction or feedback from the DACs and after multiple notifications of these problems* to the DACs, be removed from the GDACs:

- **through flagging this data as bad (class 3)** or
- removal of the files from the GDAC directories

The recommendation of ADMT that these data be flagged as class 3 was tentatively approved by AST but only **AFTER** notification of the DACs or PIs that individual profiles would be removed if feedback were not received. If neither correction nor feedback is then received, the specific issue will be raised with the AST co-chairs for follow-up. Some details remain to be worked out and ADMT will work on a plan to implement this.

Similarly, floats without a clear DMQC operator may represent data of questionable quality within the dataset. ADMT asked AST for permission to apply the same process to these profiles: that these also be flagged as class 3 thereby effectively removing them from the active dataset. There was general agreement with this approach, including from some PIs with these floats, but only after the PI is notified of our intentions and with approval from the AST co-chairs. We now need to identify those profiles and floats, and notify the PI that these will be flagged as 'bad' unless action is taken to provide DMQC. Both of these plans will require the GDAC have a mechanism to re-flag this data and that remains to be discussed with the GDACs.

Another aspect of data complexity is the explosion of technical and configuration parameters that are available with changing missions, iridium communications and the expansion of the Bio-Argo program. The question for AST was whether we could prioritize this data and identify those tech/config parameters that are useful for scientific purposes or tell you something about the health of the float and should be mandatory. Can we accept that other variables are of little or no use and so will become optional? Or is it necessary to report everything that is delivered by a float?

Discussion of this concluded that we will maintain tables of mandatory variables with a controlled vocabulary and attributes that will be checked by the format checker and ADMT will devise a method to identify parameters which will NOT be checked. The suggestion was made that these be prefaced by 'OPT_' and that would tell the file checker to skip these variables.

Alternatively, we could have an Auxiliary table and this could be edited by anyone but a name would need to be present in this table before the variable was accepted by the GDAC. This would force people to consult the table and would perhaps help control the number of new variables but there would be no validation of this table – it would simply allow the format checker to ensure that the name exists. We need to consult with the GDACs before deciding on how to implement this.

The use of iridium and the delivery of Bio data have focused attention on the expansion of timing information now provided by the floats. It is now possible to decode a 'profile' of time for the core and Bio data, as well as increased 'sparse' time data within the cycle. The questions is whether we need to store and deliver this within the existing data system, whether this is necessary information for DMQC of variables or whether we can store this only when we see a probability that it will be needed by a PI. And if we store it, where do we put it?

We concluded that this would probably not be useful for QC of core variables and so the profile of times would not be mandatory. Some Bio variables need this information and so it becomes optional and will reside in the B files with a new parameter name (to be defined) if a DAC reports it. Sparse data will be carried in the trajectory file. This is what it was designed to do and Megan will report further on this.

Despite the complexities introduced by the expansion of Bio-Argo, this has been a very useful collaboration, made easier because the Bio-Argo meeting is held in conjunction with ADMT. We recommend this continue.

Finally, ADMT Co-Chair Ann Thresher will retire at the end of this year and Megan Scanderbeg has been selected to replace her. Megan was warmly welcomed by AST.

Action item 9: For tests run regularly to monitor quality of Argo data close to real time, if files with large errors in dmode are repeatedly notified with no response, email DACs to request approval to flag the data bad. If no response, please email AST co-chairs. Test operators, GDACs, AST co-chairs

5.2 CTD measuring up to 1 db

D. Roemmich presented an updated report from J. Gilson on SIO floats having a shallow pump cutoff. In 2011, 61 SIO Iridium SOLO-II floats were deployed with the pump cutoff set to 1 dbar. In the same year, 42 SIO Argos SOLO floats were deployed, with the conventional pump cutoff set to 5 dbar. After an average of 170 cycles, no significant difference was found in the fraction of floats requiring salinity adjustment in DMQC (2 out of 61 Iridium/1 dbar and 5 out of 42 Argos/5 dbar). Similarly low levels of salinity adjustment have been required in subsequent year-classes of SIO SOLO-II deployments. The report also showed example profiles having large salinity stratification (0.5 psu) above 5 dbar, and estimates of the mean stratification in the upper 5 dbar. A calculation by F. Gasparin of the mean diurnal cycle above 5 dbar was also shown. There is strong scientific interest in having Argo sample the surface layer, up to 1 dbar if that is found to be feasible.

In discussion following this presentation, the AST recommended that the pump cutoff be set to 2 dbar in new Iridium floats. Further testing is needed to determine whether setting the pump cutoff to 1 dbar results in pumped profiling to that level or whether this is prevented by a range restriction in the SBE-41cp. If pumping does continue to 1 dbar, then additional Argo groups should determine whether a 1 dbar pump cutoff increases the incidence of salinity drift.

Action item 10: The AST recommends that the CTD pump cutoff be set to 2 dbars in new Iridium floats. Argo PIs

5.3 What float engineering data needs to be in Argo files?

As discussed at the ADMT-16 meeting last November, the Argo data stream is becoming more and more complex and the task of maintaining the meta and tech configuration parameters tables has become too huge a task for one person. There are several reasons for this including the inclusion of new sensor types, requests by PIs to include every piece of information sent by the floats to be somewhere in the Argo files, the need to record mission changes and requests from the AIC to make metadata changes to help monitor the Argo dataset independently.

Prior to the meeting, a small working group came up with two different solutions to mitigate the work to maintain the current meta and tech configuration tables. Both solutions involved keeping a 'curated table' for meta-core, meta-bio, and tech files. These curated tables would be maintained by two people to ensure clear definitions, correct naming characteristics and scientific value in each entry. These tables will be available online and will be checked by the GDAC file checker. To help guide the curators, a parameter would be included and considered scientifically useful if it (i) measure the accuracy or biases of the float (i.e. surface pressure offset, float rise rate, etc) or (ii) provides information on the health of the float (i.e. voltages, internal vacuum, etc).

If a new parameter does not fall into one of those two categories of being scientifically useful, two options were presented for storing this data. The first option is to have a discretionary table that is not curated and would be available online for anyone to add entries as they wish. The entries will not be checked, so duplicates may exist. Additionally, these parameters could not be checked by the GDAC file checker. The second option is to have an ASCII version of decoded float data archived and available at the DACs. This would keep the data set smaller and less complex and would allow users access to the additional information if necessary, but puts an additional demand on the DACs to both decode and turn all data into ASCII as well as to archive and serve the files.

After discussion, the first option was preferred. So, the ADMT co-chairs will pursue the option of having two versions of the meta and tech configuration parameter tables; one curated and one discretionary. Some details need to be worked out with M. Ignaszewski to ensure that the GDAC file checker can check the curated tables and not the discretionary tables.

Action item 11: Propose to ADMT that meta and tech configuration parameter tables be split into 'curated' and 'open' tables. Work with Mark Ignazewski to find a way to implement this with the GDAC file checker. M. Scanderbeg, ADMT co-chairs, M. Ignazewski

5.4 Trajectory V3.1 files

M. Scanderbeg reported on the trajectory files and started by showing that more than 100 papers have been published using the Argo trajectory files. Most of these are regional studies that use the trajectory files on the GDACs, but some use velocity products like YoMaHa, ANDRO and G-YoMaHa. The transition to v3.1 is going slowly. Most DACs are not yet producing the v3.1 files, but some have started and there are a variety of float types in v3.1. This is important since different floats send different timing information in real time. M. Scanderbeg has been in contact with many of the DACs and has been providing feedback on test production v3.1 files.

Some updates were done on the Trajectory Cookbook over the past year to make it more user friendly and to include the Deep NINJA. It was noted that the newer float versions include the cycle timing information that Argo has requested and that, unless using v3.1, not all that timing information is being distributed. It was noted that the majority of deployments being done now are with Iridium which allows for much more timing information to be sent and the ADMT is struggling a bit with where to store this information. Currently, sparse profile timing information is being stored in the trajectory file. However, the question was where to store timing information for the entire profile. After discussion, it was deemed that this type of timing information is valuable to specific user groups like BGC, mixing, etc. and so the solution was to include timing as an optional parameter in the b-files. That way the information will be available for groups who want it, but it will not affect core Argo users.

M. Scanderbeg showed work done on trajectory files in the Southern Pacific ocean to calculate the velocity at depth. To do this, the extrapolation method based on background velocity and inertial current developed by Park et al, 2004 is used to estimate the location of rise and fall of Argos floats. In order to the extrapolation, the time of the rise and fall must be known and this is not always available unless using v3.1 files. She noted that for the region of study, 992 floats were available. 873 were used, with 73 APEX Argos floats rejected due to bad timing information or a corrupt file. Two extrapolation plots were shown to demonstrate that this method can change subsurface velocity calculations by as much as 25% at times.

The v3.1 format has a lot of flexibility that allows for lots of information to be inserted into the trajectory file, but it should have scientific value. Over the past year, several tech configuration parameters have been moved into the trajectory file. Indeed, the b-trajectory file format needs to be finalized and documented. Much time has been spent over the past year trying to figure out how to fit some of the b-parameters into the file including surface in-air measurements needed for calibration of oxygen sensors and intermediate RAFOS timing information. M. Scanderbeg is not an expert on BGC Argo and suggested that there might need to be a b-traj file cookbook and that a BGC expert should lead this effort.

Finally, the issue of delayed mode trajectory files was discussed. J. Gilson has produced delayed mode trajectory files on some of his floats. Annie Wong and M. Scanderbeg are considering holding a dmode workshop for trajectory files in 2017.

5.5 Floats without a clear DMQC pathway

There are some floats on the GDACs for which there is no identified delayed mode quality control operator. The majority of these floats are NAVOCEANO floats from the U.S. Navy. S. Piotrowicz updated the AST that he has gotten approval to fund delayed mode quality control on NAVOCEANO floats outside of the Mediterranean Sea which accounts for about 400 floats. The floats in the Mediterranean Sea have been adopted by the Italian Argo program and are being dmoded as part of the Med-Argo ARC. T. Suga said JAMSTEC could propose to do delayed mode quality control on the NAVOCEANO floats in the Pacific Ocean if this funding proposal does not work out.

5.6 BUFR format for BGC floats

Jon Turton gave an update on proposals to enhance the BUFR format to allow for the exchange of near real-time bio-geochemical data on the WMO Global Telecommunications System (GTS), noting that WMO policy is to move to TDCF (Table Driven Code Forms) for exchange of data on the GTS and to cease using the legacy TAC (Traditional Alphanumeric Codes). At present Argo is in pretty good shape in distributing its core T&S data in BUFR (3-15-003) alongside the legacy TESAC format. BUFR sequence 3-15-003 is used for the primary core-Argo CTD profile, and can be followed by additional sequences that define any additional data (3-06-037 for dissolved oxygen profiles, 3-06-017 for supplementary temperature and 3-06-018 for supplementary temperature & salinity profiles, that map to Argo netCDF reference table 16).

For bio-geochemical variables BUFR descriptors already exist for dissolved oxygen, pCO2, chlorophyll fluorescence, turbidity, dissolved nitrate, pH and backscattering; however new descriptors would need to be defined for CDOM, pH scale (seawater, free or total) and backscattering. New sequences are proposed for profiles of chlorophyll-A, dissolved nitrates, CDOM, pH - with backscattering to be added. These all follow the structure of the agreed sequence for dissolved oxygen profiles (which includes quality flags) so should not be controversial.

The proposals have also been passed to the ADMT and the JCOMM Task Team on Table Drive Codes for comment by mid April, following which they will be amended as necessary and submitted to the WMO IPET-DRMM (Inter Programme Expert Team on Data Representation Maintenance and Monitoring) meeting (30 May to 6 Jun). It would be expected that IPET-DRMM accept the proposals for validation during the summer/autumn (during which further changes can be made as necessary) and, if successfully validated, could then be given pre-operational status before the end of 2016 allowing the formats to be used on GTS.

In discussion we considered that such data would be required in the future for validation of and assimilation into bio-geochemical ocean prediction models. However, it was recognised that the DACs are presently overloaded with work and did not have the capacity to develop the necessary netCDF to BUFR converters, and that to enable these data to be disseminated on GTS in future, a format converter would need to be developed and made available to them to use, which the Met Office would in the first instance take the lead on.

Action item 12: UK Met Office will take the lead on providing BUFR conversion tools for BGC floats. J. Turton

5.7 CTD reference data and how to describe the quality of each station

Steve Diggs (CCHDO) presented a progress report on CCHDO and NCEI contributions to the Argo Steering Team. A year ago at AST-16 in Brest, several issues were raised by the Coriolis personnel regarding the availability, format consistency and overall quality of CTD profiles provided by the CCHDO for the Argo CTD Reference Database.

At that time, the CCHDO presented a detailed plan, as well as a schedule, to resolve all of the issues prior to ADMT-16 in November. The CCHDO has completed an 18-month internal retooling effort which resulted in the creation and launch of the CCHDO v1.0 API. Every issue has been positively resolved ahead of schedule, partly due to the fact that the aforementioned API v1.0 has completely replaced the previous cumbersome data discovery and access method for both Coriolis and NCEI.

A brief discussion followed regarding the amount of ship-based CTD profiles that have been made available to Coriolis for inclusion in the RefDB:

- CCHDO added 33 cruises /1987 profiles (March 2015 - March 2016)
- NCEI added 2195 profiles, 987 coming from CCHDO (March 2015 - March 2016)

An on-going concern is the paucity of ship-based CTD data and metadata that the CCHDO receives regarding new cruises of interest from Argo regional center personnel. Information regarding upcoming and recently completed cruises is essential for the acquisition of early-release CTD data that the RefDB relies on.

Source (AST-17) Nat'l Reports	# CTD profiles	Explanation	Additional information
Australia	N/A	Weblink? & New R/V	Weblink broken
Canada	N/A	Mentioned CCHDO	*(also mentioned me by name)*
China	0	"No"	
France	*	**Currently producing next RefDB**	**implemented CCHDO/API**
Germany	N/A	???	"M120 by Markus Dengler"
Greece	N/A		
India	0	"none"	
Ireland	N/A	"sent to ICES"	
Italy	N/A		Actually said, "N/A"
Japan	**532 (541)**	Kanako Saito	**lots of submissions in 2016!**
Korea	N/A	no mention	
Netherlands	N/A	"CTD uploaded to CCHDO	(was "Dutch")
Norway	N/A	no mention	
Poland	0		
South Africa	**62**	5 cruises	4 have been reformatted by CCHDO
Spain	0	CTD casts with deployments	***understaffed, will remedy in 2016***
UK	N/A	no mention	
USA	*	**CCHDO**	

Version 2.0 of the CCHDO API is expected to address minor throughput issues with additional security, search and bulk download capabilities for both Coriolis and NCEI. In addition, the semi-retired oceanographer team of Howard Freeland and Jim Swift have performed their CTD data QC duties admirably and have added Breck Owens to their ranks as of ADMT-16.

6. Regional Science

6.1 Western North Pacific Integrated Physical-Biogeochemical Ocean Observation Experiment

Ryuichiro Inoue reported on the Western North Pacific Integrated Physical-Biogeochemical Ocean Observation Experiment (INBOX). An interdisciplinary project called INBOX has been conducted since 2011. In the oligotrophic subtropics south of the Kuroshio Extension near biogeochemical mooring S1 (30°N, 145°E), 18 floats, each with a dissolved oxygen sensor, have been deployed in a 150 km x 150 km square area. With the horizontal (30 km) and temporal (2 days) resolution of the data, an upper ocean structure associated with mesoscale eddies and ocean responses to atmospheric forcing were observed. The dataset obtained from the S1-INBOX study was used to elucidate the impacts of physical processes on biogeochemical phenomena. In his presentation, mesoscale variability of dissolved oxygen concentrations observed by multiple floats during S1-INBOX were presented and biogeochemical responses to eddies were discussed. All the S1-INBOX float data are available from its web site.

6.2 Deep NINJA observation

Taiyo Kobayashi reported on Deep NINJA observations. “Deep NINJA” is a deep float (profiling to 4000 dbar) developed by JAMSTEC and Tsurumi Seiki Co. Ltd. (Japan) and has been available to the public since April 2013. In 2015/16, 3 Deep NINJA floats were deployed in the Pacific and the Indian Ocean, and in total, 18 floats have been deployed as a part of Japan Argo (as of March 2016). All of the Deep NINJA measurements were distributed via GDAC in accordance with the AST consensus on the data observed by deep floats. Deep NINJA has a function to observe under (seasonal) sea ice safely, and 4 floats succeeded in surviving five Antarctic winters and transferred the deep measurements under sea ice. To evaluate the accuracy of the measurements is an important concern for deep float observation. Comparisons of 11 pairs of the first profile of Deep NINJA and the shipboard CTD at deployment (for 4 cruises of 3 ships including a GO-SHIP cruise of R/V Mirai) clarified 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 identified yet. For temperature and pressure, float measurements, the average of which was deviated negatively from shipboard reference, were not concluded statistically to be “biased” (95% confidence level). Preliminary analysis of Deep NINJA data collected off the Adélie Coast, Antarctica, clarified that seasonal change of salinity at AABW was different interannually.

6.3 Estimated State of Global Ocean for Climate Research

Shuhei Masuda reported on the Estimated State of Global Ocean for Climate Research (ESTOC). Argo data and satellite data are key observations for the recent data assimilation and state estimations since they can have reduced imbalance between observations and models in terms of degrees of freedom. In Japan, global data synthesis efforts for climate research is conducted by JAMSTEC. Their state estimation named ESTOC was introduced in the meeting to reveal that Argo data makes data-synthesis products more meaningful in science/applicable to various fields. They also showed the ESTOC system would be a good platform to integrate increasing valuable information by deep and BGC floats.

6.4 Future plan of JAMSTEC Argo

Shigeki Hosoda reported on the future plans of JAMSTEC Argo: Core Argo and Argo extensions. Research targets of JAMSTEC Argo are to clarify global/regional scale oceanic variability associated with climate and ocean environments changes, including scientific themes of deep sea warming, heat/freshwater transport, carbon cycle, ocean acidification and bio diversity in the global ocean. To achieve the targets, JAMSTEC will fill gaps in the core Argo array by deploying Argo floats mainly in the Pacific Ocean where the Pacific ARC is operated by JAMSTEC/IPRC/CSIRO, and will deploy Deep and BGC Argo floats to construct Deep/BGC Argo array as Argo extensions mainly in the Pacific and Indian Ocean. Those core/BGC/Deep Argo data will be integrated with 4D-VAR data synthesis system (ESTOC) and analyzed with regard to seasonal/long-term oceanic changes. In addition, JAMSTEC will also carry out pilot studies for core/BGC/Deep Argo for designing/implementing more appropriate arrays by synchronizing multi float missions and deploying intensively at climate hot spots, for example, identified by the ESTOC and other observational systems. G7 Ise-shima Summit and G7 Science and Technology Minister’s Meeting highlighted the need to enhance ocean observation to accumulate data and knowledge of global ocean. Following the communique, in FY2016, JAMSTEC will deploy 23 floats (iridium+CTD) for core Argo mainly in the North Pacific, 3 Deep NINJA floats and 1 Deep APEX float with Oxygen in the Southern Ocean and North Pacific Ocean, and 1 BGC float (iridium+DO, Chl-a, bb) in the North Pacific.

7. Technical issues

7.1 Performance evaluation of array

Brian King has undertaken an analysis of float survival. The statistics can be extracted by float type or by PI group. A version of the statistics was presented that excluded floats carrying Bio sensors or at that visited latitude greater than 60, so that group statistics would not be adversely influenced by ice or by extra drain on batteries. Grouping by battery types was not attempted, because this information is not available in V2 meta files. It is available in V3.1 metafiles.

Two questions were addressed: (1) is there any evidence that float performance is dropping over time? and (2) is there clear evidence that different groups have different performance?
A collection of plots of statistics, and some commentary was circulated to AST before the meeting.

Certain known failure modes showed up clearly, most strikingly the pressure micro leak. Apart from that, there was no obvious trend in performance across the fleet or across groups. All groups improved between 2000 and 2005, and have been generally steady since then, with 90, 80, 70, 60 percent of floats surviving 1,2,3 or 4 years.

However, there are clear differences between float types and between float deployment groups. The most successful sets of floats have an expectation (in the probability sense) of 180 to 190 cycles, compared with a fleet average of 145, and some groups managing significantly less than that. If all groups could match the most successful, the global array would grow simply longevity of floats.

The most successful groups included PMEL, UW and CSIRO APEX floats, SIO SOLOs. In order to really evaluate the long-term performance of floats at least 5 years of experience of 'normal' 10-day, 2000m cycling is required. Several float types have started float deployments more recently than that. SIO SOLO-II stats are very good, comparable with the best. NAVIS and ARVOR floats are about average, and MetOcean NOVA floats have performed significantly below the fleet average for floats deployed so far. It is noted that the most successful APEX groups all work hard on their floats in their own workshops, discovering or correcting faults that the manufacturer has shipped out of the factory.

BAK would be happy to develop the statistics for any grouping that AST members might find helpful. For example it would be possible to exclude by WMO number floats that had a known failure mode that has been fixed or early deaths for new float types. AST does not wish to point fingers or embarrass groups with less successful statistics. However, statistics like these should be used to bring pressure to bear on manufacturers to improve performance of their products, or for setting the standard in procurement and warranty negotiations, or for tender evaluations. BAK reported that in the most recent NERC tender for floats, survival statistics were used to evaluate the likelihood of warranty offers needing to be pay out and therefore the value of that offer in the tender price.

APEX

ARVOR
G. Maze, N. Poffa, N. Lebreton

Arvor floats appeared in 2009 and are now deployed worldwide by a number of institutes belonging to various countries, the six most important ones in terms of numbers being France, Japan, India, Germany, Italy and Korea. An Arvor-Light version that contains fewer batteries is widely used mainly outside France. However this Light version is also specified for above 150 cycles (up to 190 10-days cycles @ 2000m), we have not differentiated Arvor and Arvor-L floats. Overall 583 Arvor floats have been deployed as of March 2016. More than 100 floats are deployed year since 2012.

As still a young platform, the Arvor fleet is also quite young with: 93% of the fleet being aged less than 4 years and 70% of the floats active today.

It is important to note that the 2012 and 2013 generation of floats were plagued by a software bug that make them enter in an infinite loop between the platform and CTD electronic card connections. The so-called "Feb. 28th bug" affected 10% of the floats from each of the 2012 and 2013 years, a total of 18 floats were lost.

Without including these bugged floats: 89.4% of the floats deployed over 2008-2014 reached 40 cycles, 78.3% of the floats deployed over 2008-2012 reached 100 cycles and 73.9% of the floats deployed over 2008-2011 reached 150 cycles. These include beached floats. The main reason (50%) for identified float deaths is "natural", i.e. end of batteries or beached. About 10% of float deaths are due to technical problems (e.g. transmission, pump). The rest is unknown.

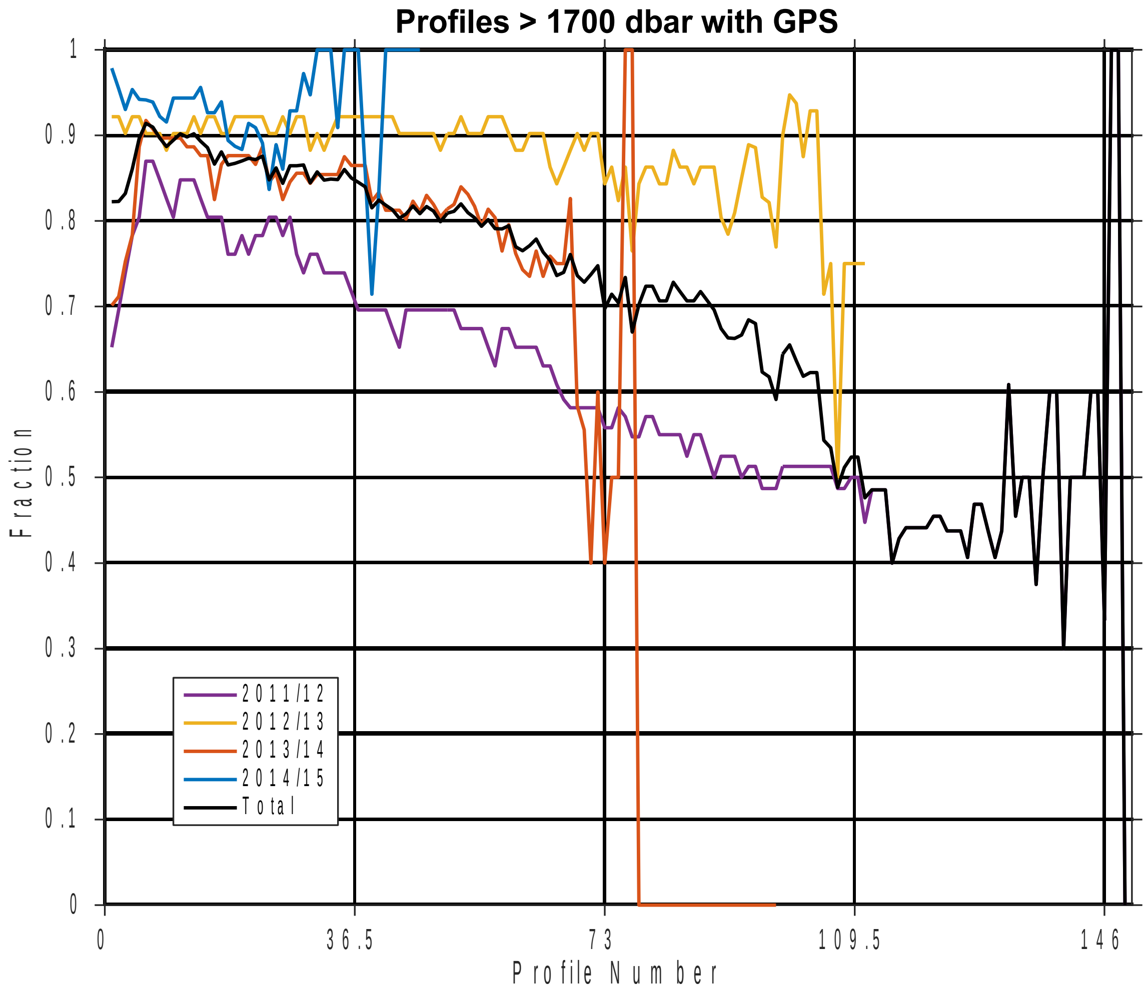
Overall, the Arvor float performance is in line with the rest of the Argo fleet.

NAVIS
G. Johnson

G. Johnson and E. Steffen prepared a report on PMEL's experience with the Navis float and M. Scanderbeg presented it at the meeting. The first PMEL Navis float (WMO 5903864) was deployed on 12 January, 2012 and it reported its 149^{th} profile on 9 February, 2016. Overall, 288 PMEL Navis floats have been deployed as of 2 February, 2016. The majority of these floats are on 10-days cycles, park at 1000db, sample from 2000db and report 2-dbar averages of 1 Hz samples. The main failure modes of the NAVIS floats, along with their impacts and fixes were presented with the caveat that the Sea-Bird warrantee replacement definitely mitigates float losses.

Four major failure modes killed 44 floats with 18 additional severely impacted. Another 14 floats are dead with 4 additional severely impacted by catastrophic leaks and miscellaneous issues. The major failure modes have been addressed, first by patches and then by a recent redesign. Leaks and some of the single failure modes have not been addressed.

Statistics on number of profiles achieved were also shown.



Here, fraction is the reported over expected number of complete profiles (sampled below 1700db and had a GPS location). The years are the delivery data periods. There was quite good performance for the 2012/2013 and 2014/2015 delivery dates implying that some of the earlier failure modes have been addressed.

NOVA
Blair Greenan

Beginning in 2012, the Argo Program has deployed a total of 134 MetOcean floats, of which 121 are NOVA floats and 13 are DOVA floats (with oxygen sensors). The DOVAs are not being included in this report.

Of the 121 floats, 89 (74%) were deployed by Canada, 22 (18%) by Germany, 7 (6%) by Greece, and 1 (1%) by each of Italy, Japan, and the United Kingdom. Of the 121 floats deployed, 77 were still active as of 8 Mar 2016.

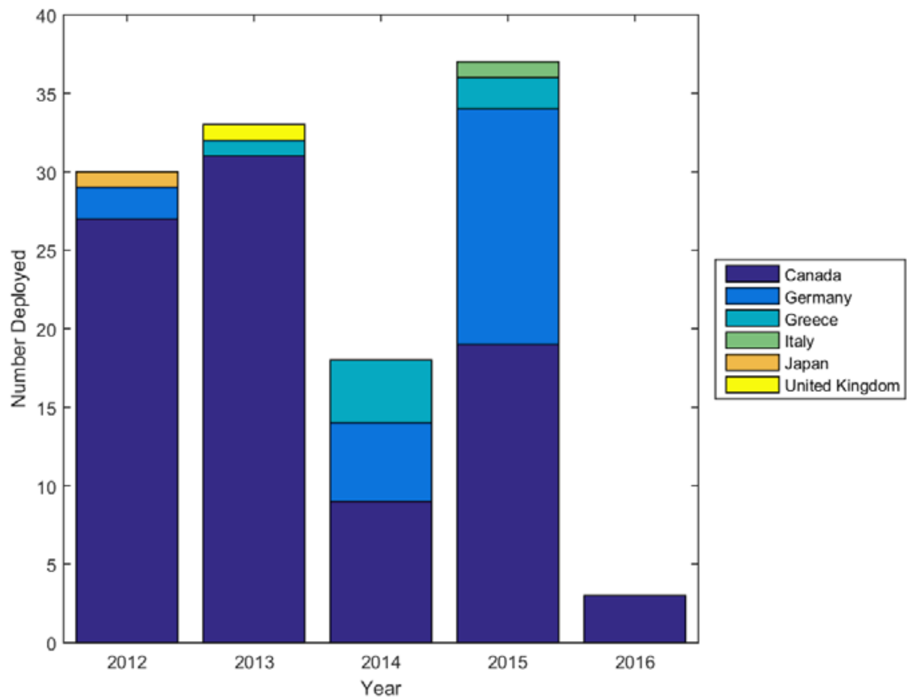


Figure 1. Number of NOVA floats deployed in each year by country.

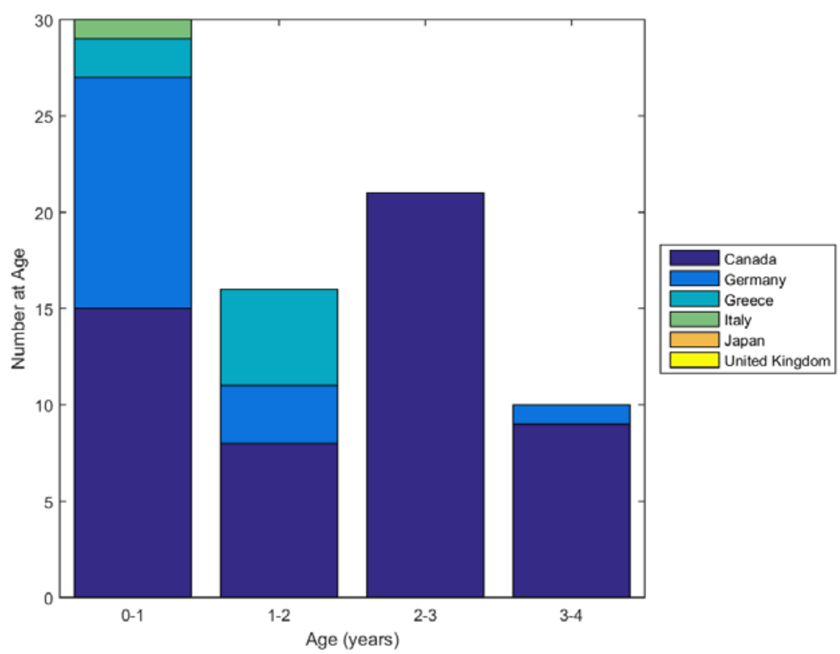


Figure 2. Number of active NOVA floats of each age by country.

The survival rate was computed as

(t)=100$*$ (Total number that survived more than time t / Total number deployed more than

time t ago)

The survival rate after 6 months was 81%, i.e. 19% were lost in the first 6 months. However the survival rate appeared to be high over the next 1.5 years (>90%), after which it decreased.

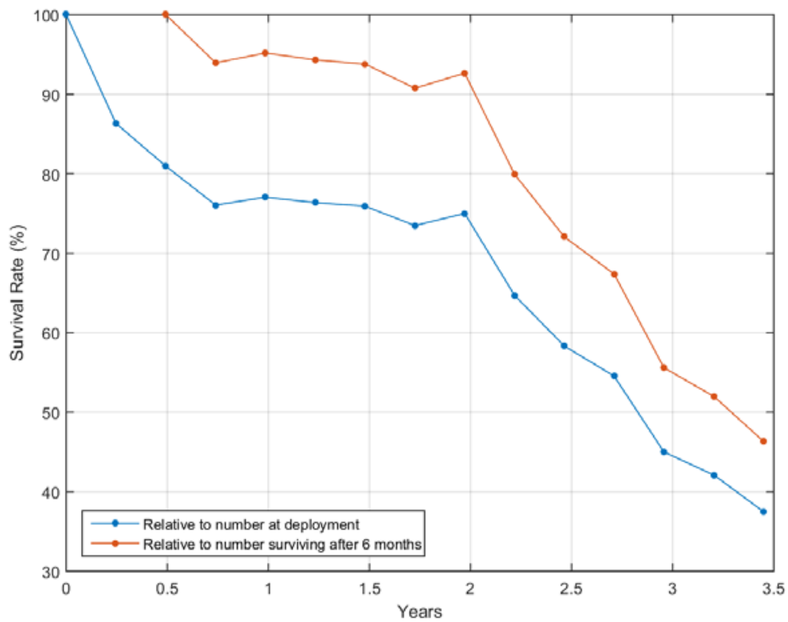


Figure 3. Survival rate of NOVA floats from all countries, relative to the total number deployed (blue), and relative to the number surviving after 6 months (red).

SOLO

S. Jayne

S. Jayne reported on the SOLO and SOLO-II float lifetimes at Scripps Institution of Oceanography and Woods Hole Oceanographic Institution. Overall, the floats are providing average to better than average float lifetimes. An issue with the SOLO-II floats is battery passivation which is decreasing some of the SOLO-II floats. When the battery has not been used for a long period (10 days), a passivation layer forms on the anode which leads to a temporary voltage delay when asked to draw high currents which damages the batteries and severely decreases their lifetime. The newest fix for this problem is the addition of a battery pack of Tadiran PulsePlus “hybrid” lithium-thioyl chloride batteries. Two floats have been deployed with this fix and it seems to be helping, but more time is needed to fully decide.

7.2 Sensor progress

RBR

S. Wijffels presented the RBR CTD with help from Greg Johnson and Clark Richards of RBR.

They reported that an RBR CTD was put onto an APEX APF11 float that was deployed in July 2015 in the Coral Sea alongside an APEX APF9 with an SBE CTD. The RBR-equipped float started on a 3-day cycle for the first 40 profiles, but has been moved to the standard 10-day cycle now. A CTD calibration was performed at deployment and both the RBR and SBE CTD has initial small offsets. So far, the RBR data look fairly good, but the stability of the sensor needs to be monitored along with improving its dynamic response. One of the advantages of the RBR sensor is that it is possible to get salinity all the way to the surface since the CTD is not pumped. RBR is working on applying the thermal lag correction onboard the CTD. The RBR CTD can be attached to APEX APF11s, ALAMO floats from MRV and NAMI floats from MetOcean.

In the discussion following, the AST agreed it would be good for Argo to have two CTDs to choose from but that Argo has greatly benefitted from the multi-year stability of the SBE CTDs. To see this stability from an RBR CTD, many of them need to be deployed for several years. The AST wants to encourage this type of testing without affecting the quality of the data stream. To that end, it was suggested that experimental CTD data be labeled with a QC flag of 3.

SBE61
USA Experience in Southwest Pacific

Nathalie Zilberman reported on the performances of the SBE61 CTDs mounted on the Deep Argo floats in the southwest Pacific pilot array. The two deep SOLO floats (6002 and 6003) deployed in June 2014, were recovered in September 2015 for post-calibration of the CTDs and assessment of wear and tear of the housing, pump, and electronics. The Deep SOLO CTDs show salinity variability within the target accuracy of the instrument after TBTO wash-off. The CTDs show small (<0.002 psu over 40 cycles) salinity drifts for 6003 (positive) and 6002 (negative) that could be instrumental or natural. The 6003 CTD mean salinity versus potential temperature at depth greater than 2000 m is 0.005-0.006 salty compared to shipboard CTD data from the Tangaroa June 2014 deployment voyage. After post-recovery recalibration, 6003 CTD salinity is meeting the accuracy goal of ±0.002 psu. The southwest Pacific pilot array counts 6 Deep Argo floats active since January-February 2016: 5 Deep SOLO floats and 1 Deep APEX float. All Deep SOLO CTDs have stable ΘS relation through 30 days of deep sampling. The Deep APEX CTD shows positive salinity drift through its early cycles, possibly due to TBTO.

UK Experience of Deep APEX

The UK deployed two deep APEX floats on the 24.5N GO-SHIP line in Dec 2015 to Jan 2016. The floats are working well mechanically, parking at 5000 dbar and diving to 5100 and 5400 on a 3-day cycle. At the time of the report the floats had completed 30 cycles. Both floats carry SBE61 CTD and Aanderaa optode oxygen. The oxygen data have not been examined in detail, but the data appear to be in good agreement with well-calibrated deployment CTDO data, and stable between cycles at the 1 percent level.

The SBE61 CTD data are disappointing. Both CTDs have drifted towards higher salinity values with a change of order 0.02 over 30 cycles. The initial drift was fast, 0.015 in the first 10 cycles, and 0.005 over the next 20 cycles. Even at 30 cycles, the sensors could not be regarded as stable. One sensor started 0.02 fresh, and is reading slightly high at 30 cycles, the other sensor started 0.007 fresh, and is 0.015 salty after 30 cycles.

Informal feedback from SBE is that these conductivity cells were built to an experimental design when originally delivered in March 2014, and that present designs are different. Therefore the floats have been deployed with a design known to be obsolete, and the sensor performance at sea gives no information about sensor performance that could be expected on future SBE61 CTDs. It is unfortunate that this was not made known so that the cells could be swapped for a current design before deployment in Dec 2015.

SBE41 under 2000db
UK Experience of Deep ARVOR

The UK deployed two deep ARVOR floats on the 24.5N GO-SHIP line in Dec 2015 to Jan 2016. Both floats carry SBE41 CTD and Aanderaa oxygen. The oxygen data have not been examined in detail, but the data appear to be in good agreement with well-calibrated deployment CTDO data.

The SBE41 CTD data have substantial offsets in salinity, reporting data too fresh by 0.07 and 0.25. NKE report that the float simply transmits whatever data the CTD sends; there is no manipulation of the data in the float controller. SBE reports that the CTDs were well calibrated when they left the SBE factory. The suggestion therefore is that the cells may have become fouled at some stage in the process of assembly, ballasting, shipping. NKE and SBE will investigate the cause of the offsets.

French Experience of Deep ARVOR
V. Thierry, S. Le Reste, C. Lagadec, C. Cabanes, H. Mercier, G. Maze, P. Velez, B. King

11 Deep-Arvor floats (0-4000dbar or 0-3500dbar) with SBE41-CP have been deployed.

- 2 of those floats have a small or non significant fresh bias
- 7 of those floats show a fresh bias ranging from 0.009 to 0.07 psu; among them the salinity experienced a jump toward an even fresher value for 2 floats; in one case the salinity recovered but the float died the next cycle
- 2 of those floats have a fresh bias of about 0.25 psu
- There is no clear dependence on pressure for the fresh salinity bias
- Some regular 0 - 2000m Argo floats are also biased toward fresher values
- Not shown here, but based on the DM procedure on our floats and on the comparison with shipboard reference data, we often sees a fresh bias (less than 0.01psu but some greater than 0.005 psu). We never see a salty bias.

Analysis of Deep-Arvor salinity data have been sent to SBE on Feb.5th 2016. We are still waiting for an answer and feedback to keep progressing and to have this issue sorted out as soon as possible.

Following the discussions of float lifetimes, failure modes and new sensors, it was thought that it might be useful to hold technical workshops again. These could be organized by float type or CTD or whatever is most needed. If an AST member feels a workshop is needed, they are urged to begin organizing one.

Action item 13: Explore technical workshops on floats and CTDs. AST members

7.3 Certification of new CTD sensors into Argo

If new CTD sensors are to be included in the Argo data stream, the AST recommends that users of a new CTD, perhaps in collaboration with the manufacturer, demonstrate the accuracy of the CTD in a peer-reviewed document. Argo cannot rely on accuracy specs alone, but requires validation of deployed CTD performance through the peer-reviewed literature. There is the further issue of stability over multi-year float lifetimes, which takes longer to establish. In the interim period, CTD data from these sensors can be included in the Argo data stream, but with qc flags of '3'.

The idea of adding a flag to the sensor list to indicate which sensors should carry qc flags of '3' was discussed. The GDAC file checker could then ensure that any experimental sensor data was flagged with a '3'.

> **Action item 14:** The AST suggests peer-reviewed publication documenting performance of experimental CTD data BEFORE SUCH DATA CAN BE INCLUDED IN ARGO. Moreover, once included these data are to be labeled with qc flags of '3' until their multi-year stability is demonstrated. Additionally, when many such floats become available, Argo should warn its users. AST, ADMT, AST website, ADMT website

7.4 Documenting pressure sensor performances

8. Completing the global mission

8.1 Report on Deep Argo Implementation Workshop

Nathalie Zilberman reported on the outcomes of the Deep Argo workshop held in Hobart in May 2015, and on other Deep Argo activities. Nathalie Zilberman and Guillaume Maze wrote a report on the Deep Argo workshop (http://www.argo.ucsd.edu/DAIW1report.pdf). A US CLIVAR Variations Newsletter on deep-ocean warming by Sarah Purkey, Damien Desbruyères, and Nathalie Zilberman was published in 2015. Two articles on Deep Argo were published in the Journal of Atmospheric and Oceanic Technology in 2015. Serge Le Reste and coauthors wrote a paper on the development and performances of the Deep Arvor floats. Greg Johnson, John Lyman, and Sarah Purkey published a study of the design of the Deep Argo array (Johnson et al., J. Atmos. Oceanic Tech, 2015). Outcomes from the Deep Argo workshop were presented at the NOAA Climate Observation Division Community Workshop in DC, and the GO-SHIP/Argo/IOCC conference in Galway, Ireland, in 2015.

8.2 Review of Deep Argo Pilot Arrays and technical updates

Southwest Pacific
Nathalie Zilberman and Dean Roemmich

The southwest Pacific Basin was chosen for the pilot Deep Argo deployment because it has a significant decadal warming signal in abyssal layers, the eddy noise is not excessive, and the bottom is relatively flat over a large area with depths between 5000 and 6000 m. Also, the region is easily accessible from New Zealand, and New Zealand Argo provides joint sponsorship of the voyages on NIWA's vessels. The southwest Pacific has been identified as having significant abyssal warming in global deep ocean heat gain studies (Purkey and Johnson, 2010). Oceanographically, the Deep Western Boundary Current flows northward along the Tonga/Kermadec Ridge just to the west of the pilot array, feeding the transport through Samoan Passage that renews the deep layers of the North Pacific.

Mission parameters for the Deep SOLO floats include profiling during descent, mixed continuous and spot sampling to the ocean bottom, parking on ascent at about 5000 m, and cycle time of 3-10 days. Deep APEX floats in the regional pilot array cycle to 5200 m every 5 days, park during descent at 3000 m, and profile continuously during float ascent. Temperature and salinity for Deep SOLO and Deep APEX floats are measured using the SBE-61 CTD developed by Sea-Bird Electronics.

The 2 prototype Deep SOLO floats that were deployed in the Southwest Pacific Basin in June 2014 were recovered during a joint U.S./New Zealand voyage on RV Kaharoa in September 2015, having completed about 110 profiles each. Recovery of the prototype Deep SOLO floats is for CTD re-calibration and possible recycling, and for assessment of wear and tear on the pump, glass ball, and electronics. A pilot Deep Argo array consisting of 7 Deep SOLO and 2 Deep APEX floats was deployed in the same basin during a joint U.S./N.Z voyage on RV Kaharoa in January 2016 (Figure 4). A GO-SHIP cruise (P15S, Australia) through the pilot array in May 2016 will provide additional high quality CTD data for comparison with the SBE-61 CTD, and an opportunity for deployment of two additional Deep SOLO floats. Deployment of 5 Deep Argo floats, including 3 Deep SOLO and 2 Deep APEX, during a joint U.S./N.Z. voyage on RV Kaharoa in July, will add to the Deep Argo fleet in the Southwest Pacific Basin.

Objectives of the Deep Argo SW Pacific regional pilot experiment are: (i) to demonstrate the feasibility and capability of Deep Argo arrays in profiling to the sea bottom, (ii) to validate the accuracy of SeaBird-61 temperature/salinity/pressure profiles, and (iii) to observe interannual variability in deep ocean properties in the SW Pacific.

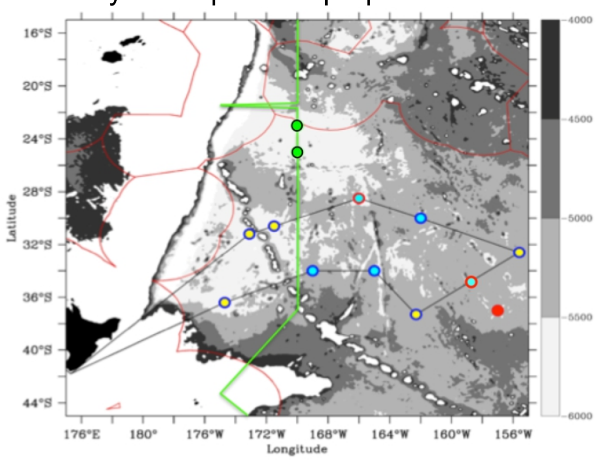


Figure 1: Present location of active Deep SOLO (yellow and dark-blue spots) and APEX (red spot) floats in the Southwest Pacific Ocean. Location of planned Deep SOLO float deployments in May 2016 (green and black spots), and July 2016 (light-blue and dark-blue spots), and Deep APEX float deployments in July 2016 (light-blue and red spots).

North Atlantic

G. Maze, V. Thierry

The North-Atlantic Ocean is a key region with regard to the ocean general circulation and role in climate. It is crucial to our understanding of global ocean variability that the interannual-to-decadal fluctuations of the formation and circulation of North Atlantic deep water-masses be observed. A North-Atlantic Deep Argo Pilot Array objective also includes an improved characterization of the heat and fresh water storage rates and their contributions to steric sea level variability in the region. Additional oxygen measurements from deep profiling floats (from A4330 optode) could also be used to complement the understanding of the deep ventilation pathways in the North-Atlantic Ocean.

9 Deep Argo floats (7 Deep-Arvor and 2 Deep-Apex) have been deployed in 2015 in the North

Atlantic during the RREX France campaign onboard the R.V. Thalassa (Jun.-Jul. 2015), the DY040/RAPID UK campaign (Dec. 2015/Jan. 2016) and the E-AIMS Spain project (Mar. 2015). Three Deep-Arvor have been deployed in the Irminger Sea, one in the West European Basin, one near the Canary Islands and two on the eastern side of the basin along the 26N line. Two Deep Apex floats have been deployed along 26N in the western side of the Atlantic basin. Among all those deep floats, three Deep-Arvor are still active and one, cycling at 2 days, reached more than 140 cycles and is left on stand-by to be recovered in 2016.

The Northeast Atlantic Ocean is chosen by Argo France for the pilot North Atlantic array because it has a large interannual signal of deep water masses variability and the bottom topography is such that sampling down to 4000 m with Deep-Arvor floats captures the vast majority of the signal targeted by the project (interannual variability of the formation and circulation pathways of deep water masses formed by deep convective events in the subpolar gyre of the North Atlantic). Our future plan is to deploy 20 Deep Arvor starting in 2016 (during the OVIDE-2016 GO-SHIP campaign and other OSNAP opportunity). Most floats will be deployed in the North-East Atlantic and the Labrador Sea.

Indian Ocean

Reported to AST-17 by T. Suga and JAMSTEC Argo team with input from D. Roemmich and Nathalie Zilberman

Two Deep NINJA floats were deployed in the southwestern Indian Ocean in January 2016 by JAMSTEC as a pilot array. Scientific targets are to identify the seasonality of the deep Indian basin and to detect the long-term (interannual to pentadal) climate signal. The former will help to detect climate signal using repeat hydrography data and to constrain deep ocean state estimates. The latter may help to understand why the Indian Ocean shows bottom-water cooling, which is different from other major basins except for the North Atlantic. One more Deep NINJA is to be deployed in the southwestern Indian Ocean depending on the availability of deployment opportunity.

US Argo and New Zeeland Argo are planning to deploy 8-12 Deep SOLO floats in the southeastern Indian Ocean on the R/V Kaharoa cruise in October-December 2016. The array will cover the downstream region of the Australian-Antarctic Basin pilot array in the Southern Ocean.

Southern Ocean

Reported to AST-17 by T.Suga on behalf of S. Rintoul

The Australian-Antarctic Basin is proposed as a promising target for a Deep Argo Pilot Array for the following reasons. Since it is close to Antarctic Bottom Water (AABW) sources, the freshening/warming signal (seasonal, interannual, multi-decadal trend) is large (Figure 1). It is the best-ventilated deep basin in the Southern Ocean, supplied by the Ross Sea and Adelie Land sources (40% of total AABW). The basin is accessible and has reasonable historical coverage. Planned deep hydrography provides deployment and calibration opportunities.

A Deep Argo Pilot Array in the Australian-Antarctic Basin is proposed, targeting primarily seasonal and interannual variability, both to understand dynamics and to help interpret trends from sparse deep hydrography, with using a mix of deep float types: Deep NINJA/Arvor over the slope and Deep SOLO/APEX in the deeper basin. A few countries are interested in the proposed pilot experiment and are planning to deploy deep floats: 2 Deep NINJA by Japan, 3+ Deep Arvor by France, 5-8 Deep SOLO/APEX by Australia and possibly others. Deployment opportunities will be at SR3 (140E) in January 2018 and I9S (115E) in January 2020.

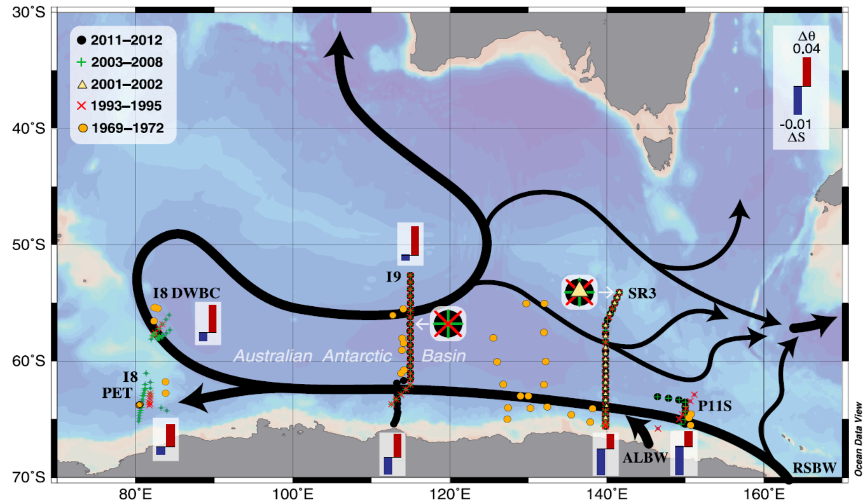


Figure 1. Colored bars indicate decadal trends in temperature (red) and salinity (blue) of the deepest 300 m of the water column (van Wijk and Rintoul, 2014).

Reference

Van Wijk, E. M, and S. Rintoul (2014): Fresening drives contraction of Antarctic Bottom Water in the Australian Antarctic Basin. Geophysical Research Review, DOI:10.1002/2013GL058921.

Deep ARVOR

A peer-reviewed article presenting the float and its technology has been published in 2016 (Deep-Arvor: A new profiling float to extend the Argo observations down to 4000m depth, Le Reste et al, JAOT Jan. 2016).

11 Deep-Arvor floats (profiling to 4000dbar or 3500dbar) equipped with the SBE41CP and an A4330 oxygen optode have been deployed in the North Atlantic since 2012. Three of these floats are active today (Two floats have achieved 26 cycles at 10-days frequency and one 77 cycles at 5-days frequency).

Three floats deployed simultaneously in the Charly-Gibbs Fracture Zone during the RREX campaign in June 2015 have reached bottom topography almost every cycle and continued to operate successfully, providing very good confidence in the grounding management system (see JAOT article for more details).

In 2016, France will attempt to recover the Deep-Arvor 6901757 deployed in the west European Basin in June 2015 during the RREX campaign. This float has achieved 146 cycles (2-days frequency). The goal is to evaluate the state of the float itself and possibly to post-calibrate the CTD sensor to help determine an origin for the fresh salinity bias.

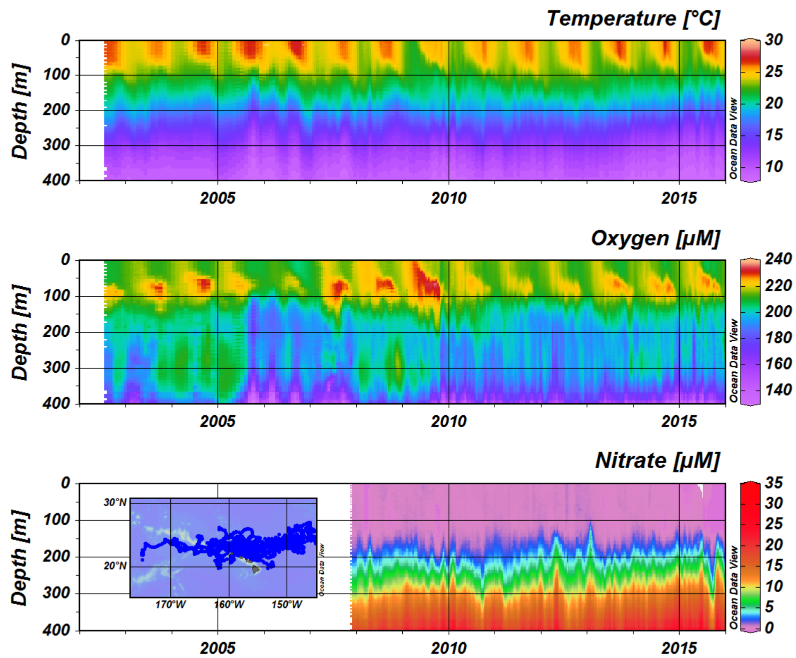
8.3 Review of Argo extensions

BGC Argo
Prepared by Ken Johnson

Biogeochemical-Argo is the extension of the Argo array of profiling floats to include floats that are equipped with biogeochemical sensors for pH, oxygen, nitrate, chlorophyll, suspended particles, and downwelling irradiance. A Biogeochemical-Argo array would enable direct observation of the seasonal, to decadal-scale variability in biological productivity, the supply of essential plant nutrients from deep-waters to the sunlit surface layer, ocean acidification, hypoxia, and ocean uptake of carbon dioxide. It would extend ocean color remote sensing observations deep into the ocean interior and throughout the year in cloud covered areas. The system would drive a transformative shift in our ability to observe and predict the impact of climate change on ocean ecology, metabolism, carbon uptake, and marine resource modeling.

Development of a global Biogeochemical-Argo array is proceeding on two tracks. First, a variety of regional-scale programs are in progress around the globe, in addition to a large number of smaller scale deployments. These regional-scale programs demonstrate the capability of biogeochemical (BGC) sensors to collect climate-quality data (i.e., “time series of measurements of sufficient length, consistency and continuity to determine climate variability and change”, NRC, 2004) and the integration of the BGC data with numerical ocean models. A second track performs the planning needed to scale the various regional projects into an integrated, global program. This effort includes a variety of analyses and Observing System Simulation Experiments (OSSE) to determine the appropriate array size.

The fraction of the Argo array that is equipped with BGC sensors is now approaching 10% (~280 oxygen, 120 bio-optical, 70 nitrate, and 40 pH sensors now operating). Many of these instruments have been deployed in regional programs with dozens of floats that are designed to produce an integrated data set that can be used to address questions related to physical-biogeochemical coupling in eddies, phytoplankton phenology, nutrient supply, and climate impacts on ocean carbon cycling. Examples include regional arrays in the Southern Ocean (SOCCOM: http://soccom.princeton.edu), the North Atlantic Sub-polar Gyre (remOcean: http://remocean.eu), the Mediterranean Sea (NAOS: http://en.naos-equipex.fr/), and the Kuroshio region of the North Pacific (INBOX; http://www.jamstec.go.jp/ARGO/inbox/index.html). Fig. 1 shows a record over 13 years of temperature, oxygen and nitrate data collected from profiling floats deployed near Hawaii that illustrates mesoscale to interannual variability not seen in conventional sampling.



These regional programs are validating sensor operation, improving sensor performance, and developing the software tools and expertise needed to operate a global network that interacts with other components of the global ocean observing system, including satellites and shipboard programs such as GO-SHIP and various time-series. For example, analysis of the oxygen data collected by 47 US and Canadian floats that made air oxygen measurements on each surfacing demonstrates that air calibration significantly improves sensor performance. It enables oxygen measurements with accuracy comparable to that obtained in the GO-SHIP program (Johnson et al., 2015). Multiyear records of pH made on profiling floats deployed at the Hawaii Ocean Time-series station (HOT) agree with the shipboard observations to 0.004±0.007 at the sea surface (Johnson et al., 2016). This exceeds requirements for climate quality pH measurements specified by the Global Ocean Acidification Observing Network (http://www.goa-on.org/docs/GOAON_plan_print.pdf). Bio-optical measurements of chlorophyll show no significant bias with satellite remote sensing products (Xing et al., 2011).

The success of these regional projects has led to preliminary planning and OSSEs in order to assess the resources required and scientific rationale for the transition to a global-scale Biogeochemical-Argo program. A meeting was held 11-13 January 2016 in Villefranche-sur-Mer, France with twenty-four persons from Australia, Canada, China, Japan, France, Germany, the United Kingdom, and the United States. Based on OSSEs and analyses of global ocean data sets presented at the meeting, an array of about 1000 BGC profiling floats would provide the needed resolution to greatly improve our understanding of biogeochemical processes on a global scale, to reduce the uncertainties of major ocean carbon fluxes, and to enable the significant improvement of marine resource models. With an endurance near four years for a Biogeochemical-Argo float, this system would require the procurement and deployment of 250 new floats per year to sustain it. The lifetime cost for a Biogeochemical-Argo float, including capital expense, calibration, data management, and data transmission, is about $100,000. A global Biogeochemical-Argo system would thus cost near $25,000,000 annually. In the present Argo paradigm, the US provides half of the profiling floats in the array, while EU and Asia share the remaining half. If this continued, the US cost for the Biogeochemical-Argo system would be ~$12,500,000 annually and ~$6,500,000 for EU and Asia. This presumes that float deployments can be carried on future research cruises of opportunity, particularly the international GO-SHIP program (http://www.go-ship.org), which provides essential validation data that is equivalent to the Argo reference database.

References

Johnson, Kenneth S., Joshua N. Plant, Stephen C. Riser and Denis Gilbert. 2015. Air oxygen calibration of oxygen optodes on a profiling float array. Journal of Atmospheric and Oceanic Technology. 32, 2160-2172.

Johnson, Kenneth S., Hans. W. Jannasch, Luke J. Coletti, Virginia A. Elrod, Todd R. Martz, Yuichiro Takeshita, Robert J. Carlson, James G. Connery. 2016. Deep-Sea DuraFET: A pressure tolerant pH sensor designed for global sensor networks. Analytical Chemistry. 88, 3249-3256, DOI: 10.1021/acs.analchem.5b04653.

NRC. 2004. Climate Data Records from Environmental Satellites. National Academies Press. 150 pp., http://www.nap.edu/catalog/10944.html

Xing, X., A. Morel, H. Claustre, D. Antoine, F. D'Ortenzio, A. Poteau, and A. Mignot. 2011. Combined processing and mutual interpretation of radiometry and fluorimetry from autonomous profiling Bio-Argo floats: Chlorophyll *a* retrieval. Journal of Geophysical Research. 116, C06020, doi:10.1029/2010JC006899.

Western Boundary Currents

Reported to AST-17 by T.Suga

Since high eddy activity in the western boundary current region drives a lower signal/noise ratio for Argo's target space/time scales, enhanced resolution is needed there. In terms of the number of profiles, double sampling has been achieved in the Kuorshio/Oyashio system since 2005 (Figure 1). This virtual pilot array has been operated due to process studies such as KESS (Kuroshio Extension System Study) to study mesoscale dynamics and sustained deployment of Argo equivalent floats with profiling cycle of 5 days by Japan Meteorological Agency (JMA) to feed into their regional data assimilation system.

According to the survey on operational use of Argo data in Japanese agencies, all major agencies see the merits of the enhanced array in the Kuroshio/Oyashio system. The agencies mentioned that the enhanced Argo array yielded improvement in the state estimation of currents/temperature, provision of better information to fishermen, etc., while it is hard to quantify those merits.

The next step towards the western boundary current region enhancement will be quantitative estimation of the impact of the enhanced sampling, taking advantage of the virtual pilot array in the Kuroshio/Oyashio system. Four-dimensional variational ocean ReAnalysis (FORA) by JMA/MRI and JAMSTEC and European data assimilation systems will provide platforms for this activity to propose an optimal array design for the western boundary current regions.

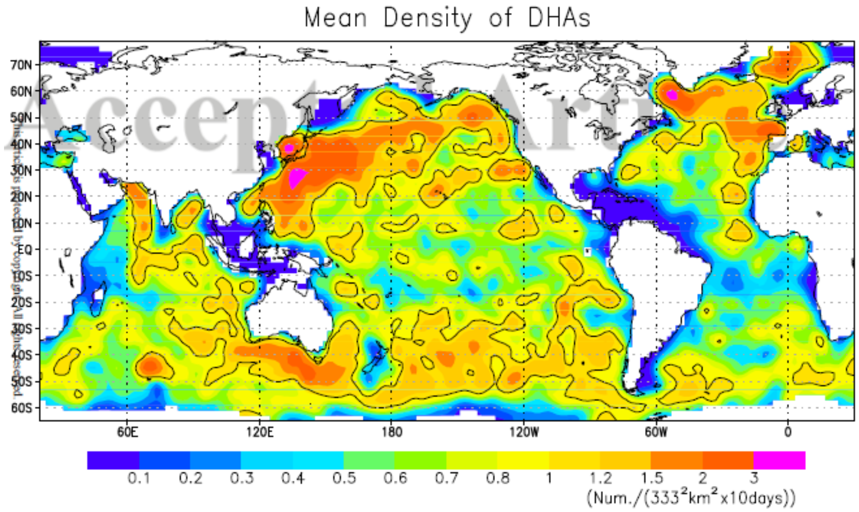


Figure 1 Number of profiles in 333^2 km^2 x 10 days as an averaged value for the period from 2007 to 2010 (Kuragano et al., 2015).

Reference

Kuragano, T., Y. Fujii and M. Kamachi (2015): Evaluation of the Argo network using statistical space-time scales derived from satellite altimetry data. Journal of Geophysical Research: Oceans, DOI: 10.1002/2015jc010730.

Action item 15: Ask ATC to fix WBC region on his maps. M. Belbeoch, T. Suga

Near-equatorial enhancements

Reported to AST-17 by D. Roemmich, F. Gasparin, and J. Gilson

In January – March 2014, 41 SOLO-II floats were deployed along the Equator between 100°W and 160°E (Figure 1). After 2 years, 38 of these remain active, having each completed about 110 seven-day cycles. This pilot array doubled the number of floats within a few degrees of the Equator, with the objective of improving the resolution of intraseasonal to interannual variability for better understanding of the onset and evolution of El Niño episodes. The SOLO-II floats use Iridium communications and have a much shorter surface time (15 minutes) than earlier floats that use Argos. As a result, the Iridium floats have remained within 1° (rms) of the Equator, compared with 3° for earlier Argos floats after the same period.

As part of this work, Gasparin *et al* (2015) developed an improved statistical model of temperature and steric height variability in the Equatorial Pacific. The accuracy of error maps of interpolated Argo data was validated using independent TAO and satellite altimetry datasets. F. Gasparin is working with the TPOS 2020 Steering Team on assessment of the impacts of Argo sampling density, including both standard and enhanced Argo coverage. The TPOS 2020 Backbone Task Team will make interim recommendations on requirements for sustained tropical Pacific Ocean observations in June 2016.

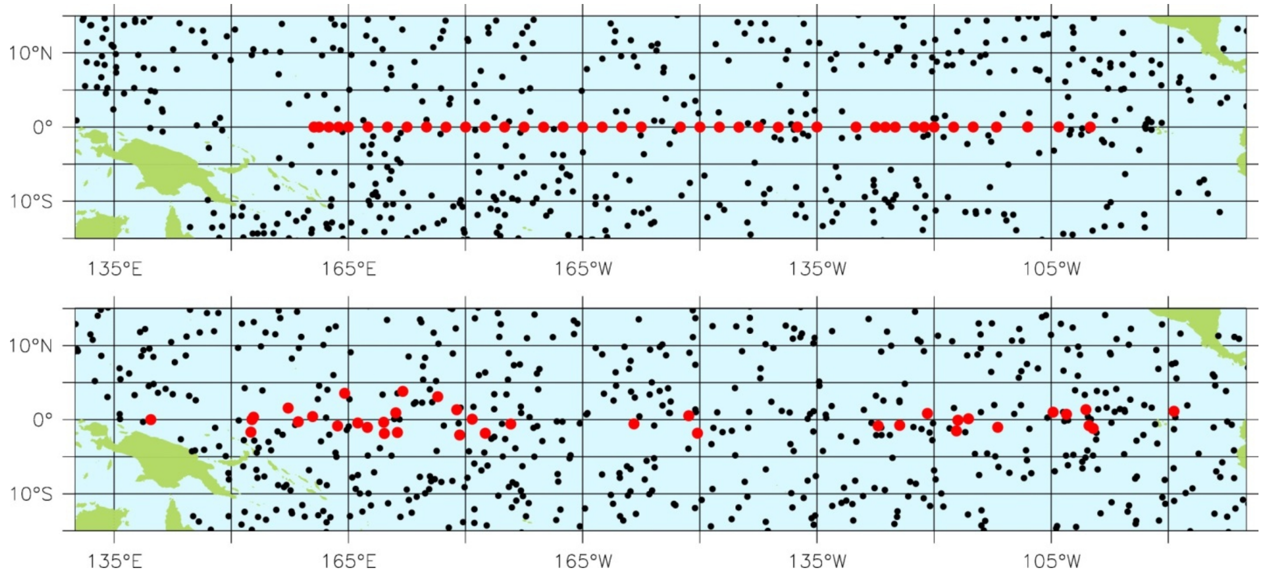


Figure 1: (upper panel) Deployment locations in early 2014 of 41 SOLO-II floats in the Equatorial Pacific pilot Argo enhancement. (lower panel) Locations in early 2016.

Reference:

Gasparin, F., D. Roemmich, J. Gilson, and B. Cornuelle (2015): Assessment of the upper-ocean observing system in the Equatorial Pacific: The role of Argo in resolving intraseasonal to interannual variability. *Journal of Atmospheric and Oceanic Technology, 32,* 1668 - 1688. doi: 10.1175/JTECH-D-14-00218.s1 .

Polar Argo

Birgit Klein and Esmee van Wijk

Capability of floats to operate under ice has been proven in areas with seasonal ice cover such as the Southern Ocean and the Nordic Seas. In recent years applications within the pilot/demonstrations projects have moved to more severe multi-year ice conditions in the Arctic proper. Target numbers for the extension of Argo into high latitudes (beyond 60°N, 60°S) have been developed in the framework of international Argo and within the European Research Infrastructure Consortium.

Nordic Seas are well sampled according to the metrics developed. In order to sample the circulation properly and resolve the seasonal cycle, a total of 39 active floats was determined, covering the four deep basins and the boundary current. More than 45 floats are active at the moment, covering the entire Nordic Seas (see Fig. 1), but still not covering the boundary current properly. The required yearly deployments are included into the Euro-Argo ERIC strategy and are managed through the national plans and EU contribution to the ERIC.

Coverage in the Southern Ocean is stalling at 45% (146 floats, including SOCCOM floats) in the latitude band south of 60° S compared to the target number of 360 active floats for that area (see Fig.2). There is very low coverage at the moment in the Weddell Gyre. European interest would primarily be in the Weddell Gyre, other groups from the US (SIO, UW) Australia (CSIRO) and Japan (JAMSTEC) are covering the other basins. Statistics show that deployment of floats south of the ACC (60-65 °S) provides a high likelihood of the floats to remain in the southern Gyre for extended periods of several years. Because of the seasonal ice coverage, floats have to be equipped with ice sensing algorithms and interim storage, which both have proven to work well extending lifetimes to 3-6 years. Only in the Weddell Gyre, a sound source network is in place which allows under ice tracking of the float positions. Investigations are underway to determine position errors in basins without RAFOS tracking based on the linear interpolation between last known positions and testing if positioning could be improved by assuming floats follow f/h contours. SOCCOM, as an NSF funded initiative, is adding the biogeochemical dimension to the sampling of the Southern ocean. At present there are 38 SOCCOM floats active in the Southern Ocean, and it is planned to deploy 35 floats per year, ramping the distribution up to 200 BGC floats in the Southern Ocean. A deployment of 21 floats with RAFOS antenna is planned for the Weddell Gyre 2016/2017. 10 additional floats are going to be deployed in the southern part of the Weddell Gyre as part of a European Research Council (ERC) funded project WAPITI in 2017-2019. Despite the success of the SOCCOM floats, there is risk of a thinning array over the next few years and deployment plans need to be coordinated at international/European level.

More severe multi-year ice-conditions in the Arctic pose a serious challenge to Argo technology. For the central part of the Arctic, pilot studies have successful tested the use of ice-tethered floats in the French initiative IAOOS (Ice Atmosphere Arctic Ocean Observing System) aiming at an array of 15 stations. Development and testing of the buoy system, consisting of atmosphere, ice and ocean sensors, has been successfully conducted from 2012 - 2015 and the first part of the array has been deployed in 2015 and it will be completed by 2018. Additional biogeochemical parameters are incorporated into the array in the framework of N-ICE (EU funded). In Baffin Bay, 19 BGC drifting floats will be tested in a pilot as part of the French program NAOS and a further 9 floats will be added from the Canadian FCI program. It will be tested if the float (PRO-ICE) can be parked at a safe depth during periods of ice coverage and continue profiling in spring. The PRO-ICE floats carry a biogeochemical payload and have ice-sensing capabilities using upward looking altimeters and an adapted ice-sensing algorithm. Addition of optical ice-detection is planned. The deployment strategy is based on the cyclonic circulation in Baffin Bay and will be optimized using model studies. Two floats have already been deployed in 2015, with the rest deployed during 2016-2017. The marginal ice zone in Beaufort Gyre is targeted within the ONR funded project SODA. WHOI is planning to deploy 20 floats in the marginal ice zone in Beaufort Gyre, with the first deployments of four floats planned for 2016. Improvements for a better Arctic float are underway with an ice strengthened antenna and more robust ice detection algorithm.

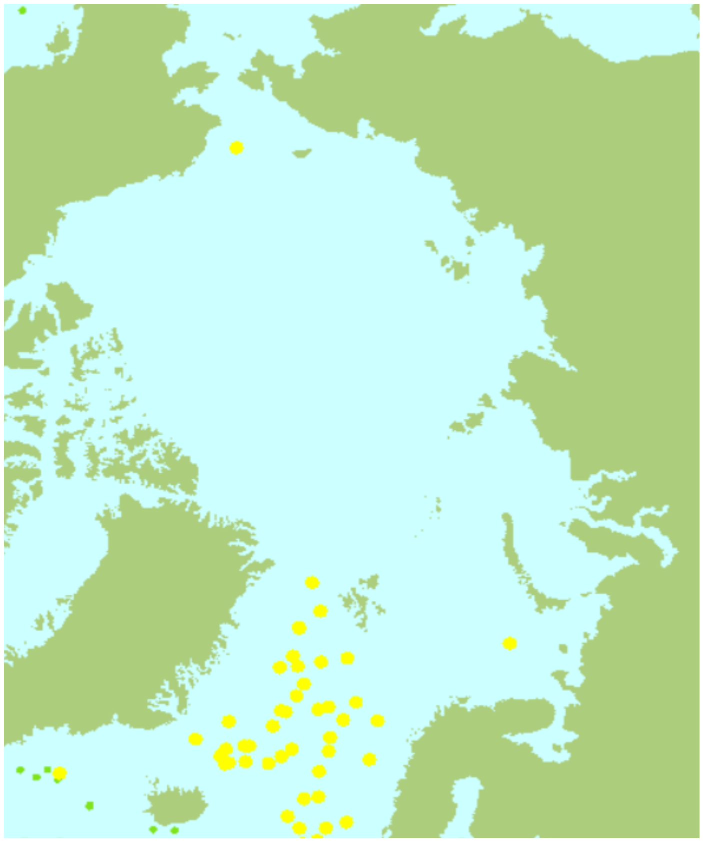


Fig. 1: position of active Argo floats in the Nordic Seas and Arctic. A total of 45 floats are listed at the Argo Information Centre.

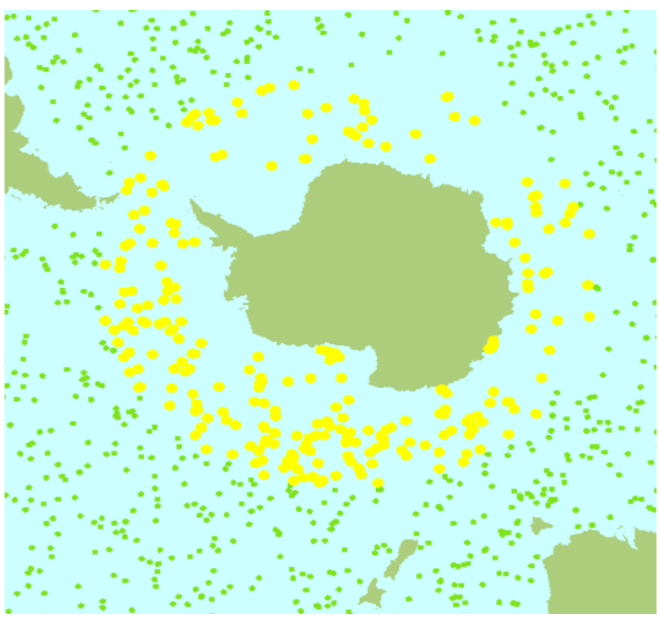


Fig. 2: Positions of active floats in the Southern Ocean (<60 °S). A total of 146 floats are active.

Action item 16: Ask ATC to make email list for Polar float task team. M. Belbeoch

Marginal Seas

Reported to AST-17 by P.-M. Poulain

The implementation of Argo in marginal seas is reviewed. In early 2016, about 255 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, Persian Gulf, Labrador Sea, Nordic Seas, 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 are still very much under-sampled (Gulf of Mexico, Caribbean, South China Sea, Indonesian Seas) whereas others like the Sea of Japan, the Nordic Sea, 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 2015, as well as the target density based on twice the Argo standard, are listed in Table 1. Excluding the Nordic, Baltic and Barents Seas, the implementation of the marginal seas has reached about 90% of 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).

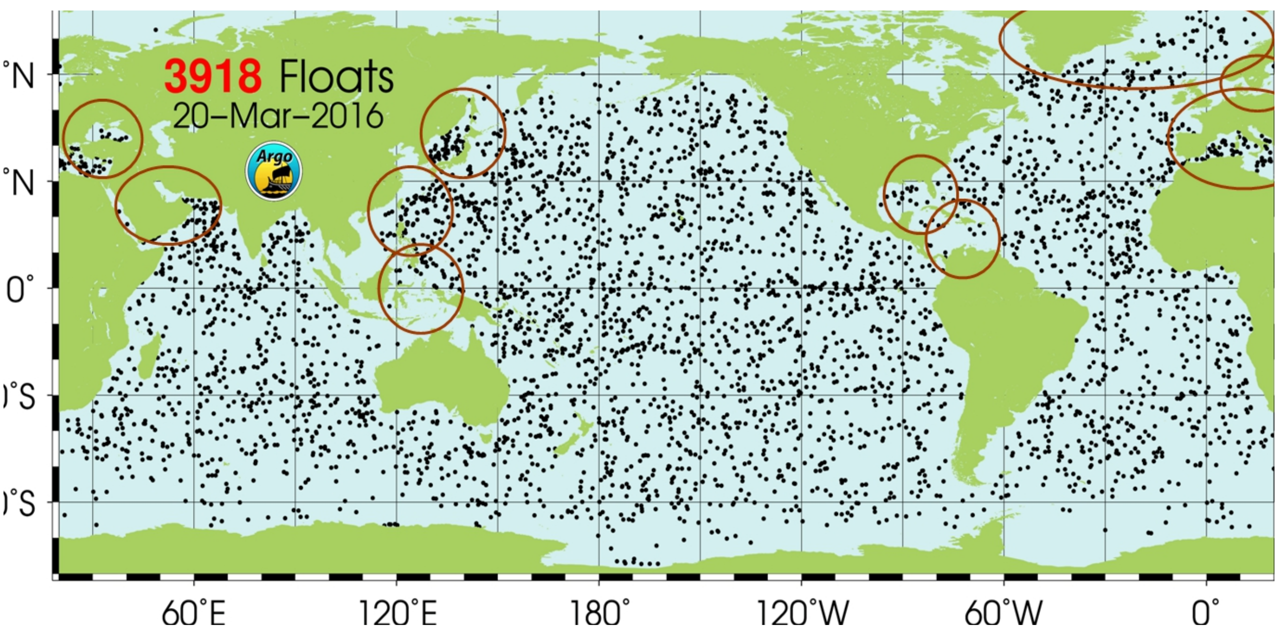


Figure 1. Argo worldwide network in March 2016 with major marginal seas highlighted.

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, eventually alternating short and long profiles.

Some marginal seas are sampled by floats with biogeochemical/optical sensors (Mediterranean, Black Sea, Nordic Sea); in particular about 22% of the Argo fleet in the Mediterranean and Black Seas, i.e., 18 floats, are equipped with such sensors. A biogeochemical float upgraded to measure simultaneously concentrations of nitrate and hydrogen sulphide has been operated 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 (decrease of the surfacing time and therefore reduction the possibility of stranding or of being stolen at surface). This has been implemented in some marginal seas. In particular, for the Mediterranean and Black Seas, about 69% of the floats are using Iridium telemetry and the downlink has been used occasionally to change the cycling and sampling parameters of some floats.

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 sensing 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**	**Target density**
Sea of Japan	40	40	40	**16**
South China Sea	8	12	8	**22**
Gulf of Mexico	8	15	15	**20**
Caribbean	8	10	12	**38**
Red Sea/Gulf of Aden	2	2	2	**8**
Persian Gulf/Gulf of Oman	8	8	5	**10**
Arctic (Nordic, Barents, Baltic, Labrador, etc.)	31	47	75	**141**
Mediterranean	60	60	74	**56**
Black Sea	10	10	9	**10**
Indonesian Seas	1	2	6	**14**
Sea of Okhotsk	0	2	2	**8**
TOTAL*	**145 (176)**	**161 (208)**	**173 (248)**	**202 (343)**

*Table 1. Implementation of Argo in Marginal Seas in early 2016 (*note that the Nordic, Baltic and Barents Seas might be considered as part of the Arctic ocean, totals between parentheses exclude these areas).*

8.4 – 8.5 Community process for approval of Argo sampling enhancements: Pathway to Argo's new design

D. Roemmich informed the meeting that Argo is being asked to articulate the community process for approval of Argo sampling enhancements. The community process in 1997-1999 for the approval of the original Argo design began with endorsement by the CLIVAR Upper Ocean Panel (UOP) and by the Global Ocean Data Assimilation Experiment (GODAE) in a joint 1998 meeting in Tokyo, Japan. This endorsement included formation of the Argo Science Team (later to become the Argo Steering Team) that subsequently wrote the Argo Design Document (http://www.argo.ucsd.edu/argo-design.pdf). Further deliberation and endorsement of Argo included that of the 1999 Upper Ocean Thermal Review (convened by the UOP and the Ocean Observations Panel for Climate (OOPC), and finally by the UOP/OOPC's OceanObs'99 Conference. Thus, the process for approval of the original Argo design was an extensive community examination and endorsement carried out jointly under the UOP, GODAE, and OOPC. Argo was approved, originally as a pilot project, of the Global Ocean Observing System.

The AST noted that the original global Argo array was limited by technical reasons in the seasonal sea-ice zones and in marginal seas. Thanks to both two-way communication and ice-sensing algorithms, these technical limitations are largely mitigated. The Argo concept is of a spatially complete global array. Inclusion of seasonal sea-ice zones and marginal seas moves the target number of Argo floats to 3800. At present, sampling of the high latitude Southern Ocean is progressing, and in some marginal seas such as the Mediterranean, Med-Argo is fully operational.

Action item 17: The highest priority for the Argo Program has always been spatially complete global sampling, wherever this is technically practical. Inclusion of seasonal sea ice zones and marginal seas moves the global array target to 3800 floats. M. Belbeoch to map the present “global domain” and show the present status in that domain.

In addition to the globalization of Argo, the additional enhancements described in 7.2 and 7.3 include Deep Argo, Bio/BGC Argo, and increased density of sampling in western boundary current regions and in equatorial regions. For each of these, one or more regional pilot arrays is already in place, and others are pending. The process for reviewing these pilots and approval as enhancements to Argo should parallel that of original Argo and should include consideration by the OOPC, GODAE Ocean View, and the CLIVAR Global Synthesis and Observations Panel (GSOP). In the case of the equatorial Pacific, the specialist panel TPOS 2020 will have an important voice. The timetable leaves several years that will be needed to study outcomes of pilot deployments, leading to OceanObs’19.

Action item 18: GCOS implementation plan needs to be updated. AST co-chairs and T. Suga

Action item 19: Ask Argo Enhancements to write a ½ page report on proposed enhancements to be endorsed by the AST and ultimately published on the Argo websites. Argo enhancement groups, AST

9. Demonstrating Argo's value

9.1 Argo bibliography

M. Scanderbeg reported 2297 papers have published since 1998 including Argo data with over a paper a day in 2015. Papers from over 30 countries, including some countries not directly involved in supporting the Argo program, are included in the bibliography, but the majority still comes from a handful of countries. The Journal of Geophysics Research, Geophysical Research Letters, and the Journal of Physical Oceanography are the top three journals that have published articles including Argo data. Combined, there are over 550 papers in those three journals. 14 articles with Argo data have been published in Science, 11 in Nature, 11 in Nature Geoscience and 11 in Nature Climate Change, including the Argo review paper lead by H. Freeland and S. Riser.

M. Scanderbeg began keeping track of several statistics in the past year, including how many papers are published by an Argo PI, the Argo data source and DOI citations. Over the past year, about 25% of papers were published by an Argo PI. This was based on a list from six countries (Canada, China, France Germany, South Africa, USA) and AST members from the additional countries. In terms of sources of Argo data used in papers, GDAC data and gridded fields are being used at roughly the same rate. At a lesser rate, model outputs are being used and only a very few papers are using internal databases or NCEI (formally NODC). Finally, in terms of the Argo DOI, it has only been cited a handful of times, but several papers use the official Argo acknowledgement. However, only about one out of three papers using Argo GDAC data cite a DOI or the official acknowledgement.

Finally, the thesis citation list was shown and now contains almost 190 doctorate theses using Argo data and is based on both database searches and contributions from AST members. There are databases for the US, Canada and parts of Europe, but access to the entire dissertation is not always possible and some are in languages other than English, making it harder to verify Argo data usage. For most other areas of the world, it is important for AST members to contribute thesis citations. This list can be another important way to demonstrate Argo's value, especially in education, so please send thesis citations to mscanderbeg@ucsd.edu or argo@ucsd.edu. It was noted that the decrease of papers in recent years may be due to it taking longer for theses to reach these databases and even if they reach the database, sometimes there is a hold placed on the entire document for a year to allow time for publication of data.

The AST acknowledged the usefulness of both the Argo bibliography and the thesis citation list. There was a desire to know how many papers were published outside of the Argo PI community and an action item was created to address this.

Action item 20: Ask M. Scanderbeg to start keeping track of general categories of papers. Examples: global vs. regional studies, climate change, etc. M. Scanderbeg

9.2 Argonautics

M. Scanderbeg reported that she would like to publish an Argonautics newsletter this summer and listed several possible topics including the new AIC website, float technology updates, extension updates, outreach efforts, etc. Please expect to be hearing specific requests soon. If you have suggestions for articles, please email them to mscanderbeg@ucsd.edu or argo.ucsd.edu.

9.3 Argo Steering Team Website

M. Scanderbeg reviewed usage of the AST website over the past year and stated that there were ~102,000 pageviews, up 6% from last year. In the top ten most visited pages, the Gridded Fields page and the Data viewers page replaced the Uses of Argo data page and the Argo bibliography page. In terms of questions received on the two email lists (argo@ucsd.edu & support@jcommops.org), about 50 initial emails were received in the past year. In the top ten categories of emails received, there were several new categories this year: questions on possible beached floats, how to buy an Argo float, things related to the Global Marine Atlas, and help with the trajectory files. Two categories related to float technology and float cycle did not make the top ten.

M. Scanderbeg noted that she updated the homepage to reflect the Argo extensions, but that this would need to be updated again to reflect Argo's new target. Additionally, M. Scanderbeg will work with M. Belbeoch to link to the new maps produced at the AIC. Several figures were updated on the Global Change Analysis webpage to reflect newer papers. The Atlantic section of the Research Use page was updated and M. Scanderbeg hopes to update the other ocean sectors this year.

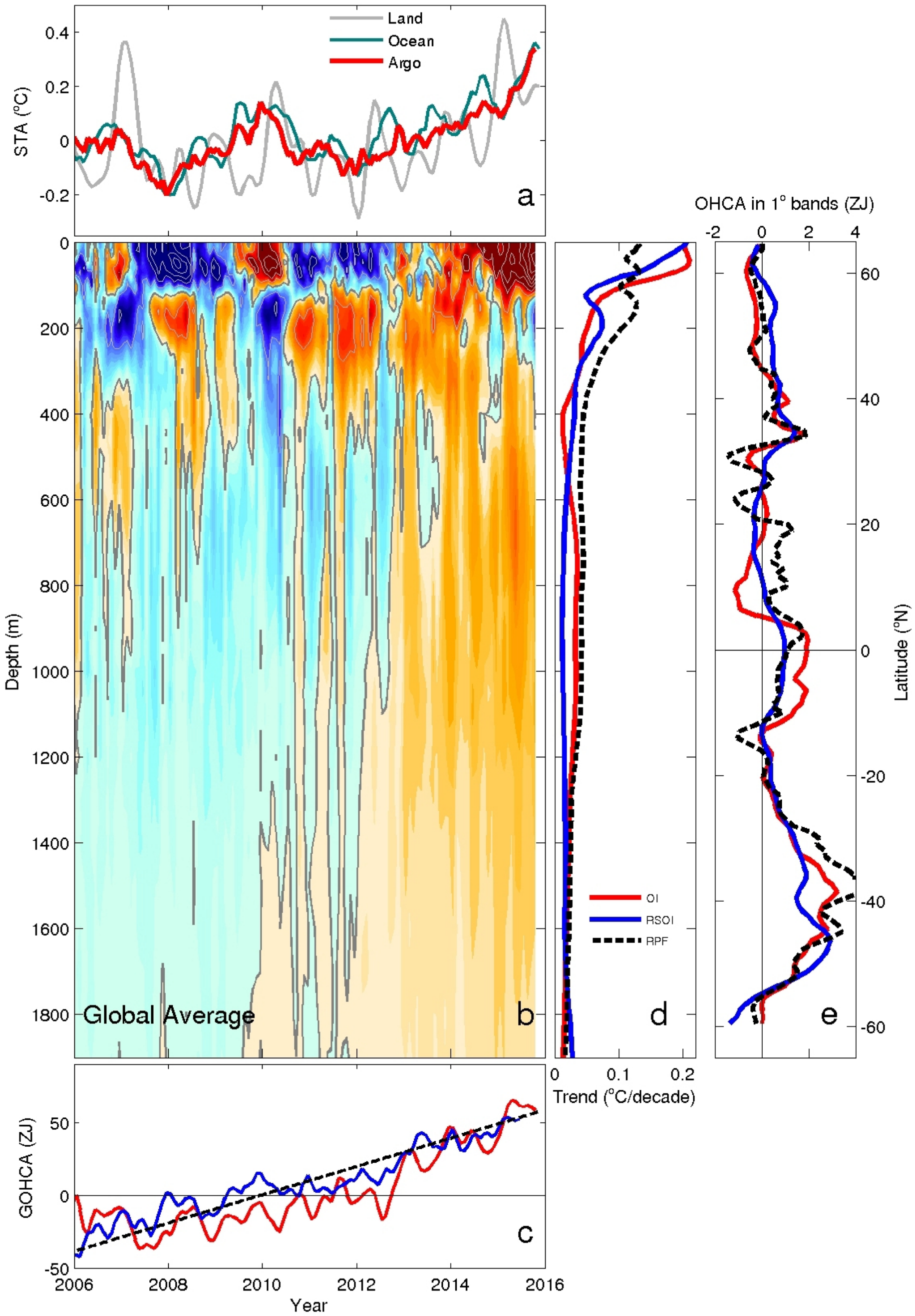
Action item 21: M. Scanderbeg and M. Belbeoch work to improve status maps on AST homepage. M. Scanderbeg, M. Belbeoch

Action item 22: M. Scanderbeg to update wording on AST website to describe new

Argo target. M. Scanderbeg

9.4 Ocean heat content plots on AST website

S. Wijffels suggested that indices on global heat content, similar to the figure from Wijffels et al, Nature Climate Change, 2016 be included on the website and updated every six months. Different gridded fields using only Argo data can be included. Please email mscanderbeg@ucsd.edu if you are interested in contributing to this figure shown below.



From Wijffels et al, Nature Climate Change, 2016.

Action item 23: These ocean heat content variability plots will be produced based on several gridded Argo datasets and update every 6 months on the AST website. Please let M. Scanderbeg know if you'd like to contribute a gridded product to this. M. Scanderbeg, grid producers.

9.5 New Argo Brochure

It is many years since John Gould produced the first Argo brochure. Howard Freeland introduced discussion on the topic and the general feeling was that a new brochure is needed and we should explore options. We have the old brochure as a starting point and it was created in InDesign, an Adobe software product. An initial committee made up of Howard Freeland, Megan Scanderbeg and Blair Greenan will explore options further and poll the AST when we see a way ahead.

Action item 24: Form a committee to create a new Argo brochure and investigate funding for printing. Work with JCOMMOPS, Argo director, M. Scanderbeg, B. Greenan. Anyone else wishing to join can contact M. Scanderbeg.

9.6 Report on ASW-5/GAIC in Galway

This took place in September 2015 in Galway, Ireland. It was well attended by both Scientists and commercial partners. The letters GAIC stood for Go-Ship/Argo/IOCCP Conference. The location was perfect, the program worked well and was received well and the finances worked smoothly.

We worked hard to integrate the commercial partners into the conference program instead of leaving them in their booths. This seemed to work well and several emails were received from our partners thanking us for the effort. We also hosted a public lecture at the University of Galway, the speaker was Dick Feely. The public lecture attracted about one third scientists, one third students and one third general public.

We received several comments from attendees asking us when the next GAIC meeting would be, we had to answer that we had no plans at the present time, but the GAIC meeting might be a good model for an ASW meeting to seek community input for a community white paper that will be needed for OceanObs-19.

9.7 Upcoming science conferences and technical workshops

9.8 Argo Education Workshop

This item was supposed to be covered by Tammy Morris, but she was unable to attend the meeting. She sent a PowerPoint presentation that was summarised by Howard Freeland. This listed the various educational opportunities available in the near future. Highlights being the upcoming meeting with educators in Sendai, Japan; a possible educators meeting in France, and Tammy Morris' desire to host an event in 2017 associated with the IAPSO conference. The PowerPoint ended with a tribute to Capt. Peter Flannagan.

Immediately following AST-17 an education workshop did take place in Sendai. This was very successful, and a longer report will be circulated separate from the AST-17 notes.

9.9 Earth.nullschool.net

9.10 Set of standard-depth Argo profiles

G. Maze

The different groups producing griddedT/S products put a lot of effort into preparing Argo in-situ data before the gridding operation (OI or 3D/4Dvar assimilation). This pre-processing is conducted with similarities among the groups: data are interpolated on standard depth levels (SDL) and filtered according to Argo QC flags. Some groups already distribute such pre-processed data (e.g. EN4, ECCOv4); some groups make them available without advertising it (e.g. ISAS) and some groups do not distribute them at all.

We believe that these sets of SDL Argo data represent an un-tapped source of information with a strong added value. For instance, it would allow or ease the evaluation & inter-comparison of gridded products when estimate/residual at the profile location is included with the profile file. It could also be used for profile-based diagnostics and facilitate possible inter-comparison or error estimates (mapping of diag. vs. diags on mapping). SDL Argo data are user-friendly (Last Argo User's manual is 134 pages vs. e.g. SSALTO/DUACS User Handbook has 72 pages). Moreover, SDL Argo data add value to the entire data workflow of the producing groups (which are often groups also working at ADMT).

Our proposition is to add a specific line on the Gridded product page of the AST Argo website that would list and point toward SDL Argo data set with gridded product descriptors and possibly more specific ones (such as the range on number of SDL).

Action item 25: Add standard depth levels Argo dataset to AST website. G. Maze, M. Scanderbeg

10. Future meetings

10.1 ADMT-17

The ADMT-17 meeting will be hosted by NMDIS in Tianjin, China the week of 26 – 30 September, 2016.

10.2 AST-16

Australia offered to host the AST-18 meeting in 2017 in Hobart, Australia.

11. AST memberships

Associate Professor Waldemar Walczowski from the Institute of Oceanology at the Polish Academy of Sciences requested to be the AST member for Poland. A motion for this was presented at the meeting and the AST agreed he will become the Polish AST member.

12. Other business

Argo Steering Team Meeting (AST-17)
Yokohama, Japan, March 22-24, 2016
Host: JAMSTEC

AST Exec meeting: 21 March

AST-17: 22 March 9h00 – 24 March 15h00

Location: Miyoshi Memorial Hall, Yokohama Institute for Earth Sciences at JAMSTEC

1. 9h00 Welcome (Naomi Harada, Deputy Director of RCGC, JAMSTEC)

2. 9h10 Local arrangements

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

4. 9h50 Status of action items from AST-16 (M. Scanderbeg)

10h20 Break

5. Implementation issues
   - 5.1 10h50 Update commitments table and a three year outlook (M. Scanderbeg)
     Can we sustain Argo coverage with current commitments?
   - 5.2 11h10 AIC Report on the Status of Argo (M. Belbéoch)
   - 5.3 11h35 JCOMM Observing Program Support Centre (M. Belbéoch)
   - 5.4 11h50 AIC Funding (H. Freeland)
   - 5.5 12h00 Japan Argo (T. Suga)

Lunch (12h45 – 14h00, L.O. 13h30)

   - 5.6 14h00 Limiting the complexity of the Argo data stream:

     Vetting the entry of new parameters (B. King discussion leader, all nations encouraged to contribute orally or in written report)
   - 5.7 14h45 Discussion items from National Reports
   - 5.8 14h55 An Argo Data Paper and advancement of Argo DOIs (S. Wijffels, J. Buck)
   - 5.9 15h10 New AIC Website (H. Freeland, M. Scanderbeg)
   - 5.10 15h25 Float deployment opportunities (M. Belbéoch)?

15h30 Break

6. Data Management and related issues
   - 6.1 Feedback from ADMT-15 (ADMT co-chair)

6.2 CTD measuring up to 1 db (D. Roemmich)

6.3 What float engineering data needs to be in Argo files? (M. Scanderbeg from working group report)

6.4 Trajectory V3.1 files (M. Scanderbeg)

6.5 Floats without a clear DMQC pathway (M. Belbéoch , S. Piotrowicz)

6.6 BUFR format for BGC floats (J. Turton)

6.7 CTD Reference data & how to describe the quality of each station (S. Diggs)

Photo session (17h30- @Miyoshi Memorial Hall)

Reception (18h00-20h00 @ Guest house in Yokohama institute)

23 March, 2016

11h00 Break

7. 11h30 Regional science, education and outreach

    7.1 Western North Pacific Integrated Physical-Biogeochemical Ocean Observation Experiment (INBOX) (Ryuichiro INOUE)

    7.2 Deep NINJA observation (Taiyo KOBAYASHI)

    7.3 Estimated State of Global Ocean for Climate Research (ESTOC) (Shuhei MASUDA)

    7.4 Future plan of JAMSTEC Argo (Shigeki Hosoda)

Lunch (12h50-14h30, L.O. 13h30)

Laboratory tour of Earth Simulator (approx. 20 minutes, 1st: 13h30-, 2nd: 14h00; each 15-20 participants)

8. Technical issues

    8.1 Float technical reports and recent performance evaluation of array (B. King)

    Arvor: G. Maze

    NAVIS: G. Johnson presented by M. Scanderbeg

    Nova: B. Greenan

    SOLO: S. Jayne

    8.2 Sensor progress:

    RBR – S. Wijffels

    SBE61 – N. Zilberman, J. Gilson on SBE61 performance in Deep SOLO and APEX floats in Southwest Pacific

    - P. Sutton and D. Roemmich: updated results from the Tangaroa SBE61 CTD validation cruise
    - B. King on SBE61 performance in Deep APEX floats in North Atlantic

    SBE41cp below 2000db – V. Thierry on pressure dependence below 2000m

    8.3 Certification of new CTD sensors into Argo (S. Wijffels)

8.4 Documenting pressure sensor performance (S. Riser)

9. Completing the global mission and exploring extensions

9.1 Report on Deep Argo Implementation Workshop – N. Zilberman/G. Maze

9.2 Review of Deep Argo Pilot Arrays and any technical updates on Deep Argo floats:

South Pacific – N. Zilberman & D. Roemmich

North Atlantic – V. Thierry & G. Maze

Indian Ocean – T. Suga

Southern Ocean – T. Suga with input from S. Rintoul et al

9.3 Status of Argo extensions (M. Belbéoch)

Bio/BGC-Argo (K. Johnson, H. Claustre)

Western Boundary Currents (T. Suga)

Near-equatorial enhancements (D. Roemmich, Ravi)

Polar Argo - Arctic/SOOS (B. Klein/E. Van Wijk)

Marginal Seas (P-M Poulain)

9.4 Community process for approval of Argo sampling enhancements

9.5 Pathway to Argo's new design (S. Wijffels)

10. Demonstrating Argo's value

10.1 Argo bibliography (M. Scanderbeg)

10.2 Argonautics (M. Scanderbeg)

10.3 Argo Steering Team Website (M. Scanderbeg)

10.4 Ocean heat content plots on AST website (M. Scanderbeg)

10.5 New Argo Brochure (JCOMMOPS, H. Freeland, M. Scanderbeg)

10.6 Report on ASW-5/GAIC in Galway (H. Freeland, B. King)

10.7 Upcoming science conferences and technical workshops –

WCRP in Qingdao China? 18-25 September, 2016

PICES November 2016

French national user workshop June 2016

APEX user workshop?

Commercial partners organize CTD technical workshops?

10.8 Argo Education Workshop (H. Freeland, M. Belbéoch, T. Morris)

10.9 Earth.nullschool.net (S. Diggs)

10.10 Set of standard-depth Argo profiles (G. Maze)

10.11 Other Argo outreach activities –

11. Future meetings

11.1 ADMT-17 in Tianjin, China 26-30 September 2016

11.2 AST-18

12. AST Membership
13. Other business
14. Review of action items

Meeting adjourns Thursday 24 March, 3 p.m.

Last Name	First name	Affiliation
Akazawa	Fumihiko	JAMSTEC
Baringer	Molly	NOAA/AOML
Belbeoch	Mathieu	JCOMMOPS
Boss	Emmanuel	University of Maine
Claustre	Herve	CNRS
Diggs	Steve	Scripps Institution of Oceanography
Dong	Mingmei	NMDIS
Freeland	Howard	Institute of Ocean Sciences
Greenan	Blair	Fisheries and Oceans Canada
Hirano	Mizue	JAMSTEC
Hosoda	Shigeki	JAMSTEC
Ito	Wataru	JMA
Jayne	Steven	Woods Hole Oceanographic Institute
Jo	Hyeongjun	Korea Meteorological Administration
Johnson	Ken	MBARI
King	Brian	National OceanographyCentre
Klein	Birgit	BSH
Kobayashi	Taiyo	JAMSTEC
Kobayashi	K	JMA
Le Traon	Pierre Yves	IFREMER
Masuda	Shuhei	JAMSTEC
Maze	Guillaume	IFREMER
Oka	Eitarou	AORI, University of Tokyo
Owens	Brechner	Woods Hole Oceanographic Institute
Park	Young-San	Korea Meteorological Administration
Piotrowicz	Stephen	NOAA
Poulain	Pierre Marie	OGS
Riser	Stephen	University of Washington
Roemmich	Dean	Scripps Institution of Oceanography
Sato	Kanako	JAMSTEC
Scanderbeg	Megan	Scripps Institution of Oceanography
Suga	Toshio	JAMSTEC/ Tohoku University
Sutton	Phil	NIWA
Tani	Masanobu	JMA
Thresher	Ann	CSIRO
Turton	Jonathan	UK Met Office
Uehara	Tomohiro	JMA
Wijffels	Susan	CSIRO
Zilberman	Nathalie	Scripps Institution of Oceanography

	Action	Responsibility	Status
1	Write letter of thanks to local host JAMSTEC	AST co-chairs	
2	Improve commitments table by breaking it out into Argo target mission, extensions, and equivalent. Ensure that equivalents are weighted by mission frequency.	M. Scanderbeg, AST co-chairs	
3	Analyze long term budget issues for the Argo Information Centre (AIC) and encourage more countries to support it.	H. Freeland M. Belbeoch	
4	B. King to describe proposals about storing data from sensors not yet approved and send them to AST and ADMT. Have a telecom with AST, ADMT, GDACs, etc. in a couple months to discuss.	AST co-chairs, ADMT co-chairs	
5	Review and publish table of requirements to be an Argo float created by B. King.	B. King, M. Scanderbeg, ADMT website, AIC website	
6	Update the list of national focal points on AIC. M. Belbeoch to send current link of focal points to AST members.	National programs M Belbeoch	
7	Ask national programs to send an author list to M. Scanderbeg. Find way to list authors appropriately.	M. Scanderbeg S. Wijffels J. Buck	
8	Ask National Programs to inform Martin Kramp who manages ships/cruises in your country	National programs	
9	For tests run regularly to monitor quality of Argo data close to real time, if files with large errors in dmode are repeatedly notified with no response, email DACs to request approval to flag the data bad. If no response, please email AST co-chairs	Test operators GDACs AST co-chairs	
10	The AST recommends that the CTD pump cutoff be set to 2 dbars in new Iridium floats.	Argo PIs	
11	Propose to ADMT that meta and tech configuration parameter tables be split into 'curated' and 'open' tables. Work with Mark Ignazewski to find a way to implement this with the GDAC file checker.	M. Scanderbeg, ADMT co-chairs, Mark	
12	UK Met Office will take the lead on providing BUFR conversion tools for BGC floats	J. Turton	
13	Explore technical workshops on floats and CTDs.	AST members	
14	The AST suggests peer-reviewed publication	AST	

	documenting performance of experimental CTD data BEFORE SUCH DATA CAN BE INCLUDED IN ARGO. Moreover, once included these data are to be labeled with qc flags of '3' until their multi-year stability is demonstrated. Additionally, when many such floats become available, Argo should warn its users.	ADMT AST website ADMT website	
15	Ask ATC to fix WBC region on his maps.	ATC T. Suga	
16	Ask ATC to make an email list for Polar float task team	ATC	
17	The highest priority for the Argo Program has always been spatially complete global sampling, wherever this is technically practical. Inclusion of seasonal sea ice zones and marginal seas moves the global array target to 3800 floats. M. Belbeoch to map the present "global domain" and show the present status in that domain.	M. Belbeoch	
18	GCOS implementation plan needs to be updated.	AST co-chairs	
19	Ask Argo Enhancements to write a ½ page report on proposed enhancements to be endorsed by the AST and ultimately published on the Argo websites	Argo enhancement groups, AST	
20	Ask M. Scanderbeg to start keeping track of general categories of papers. Examples: global vs. regional studies, climate change, etc	M. Scanderbeg	
21	M. Scanderbeg and M. Belbeoch work to improve status maps on AST homepage.	M. Scanderbeg M. Belbeoch	
22	M. Scanderbeg to update wording on AST website to describe new Argo target	M. Scanderbeg	
23	These ocean heat content variability plots will be produced based on several gridded Argo datasets and update every 6 months on the AST website. Please let M. Scanderbeg know if you'd like to contribute a gridded product to this.	M. Scanderbeg, gridded field producers	
24	Form a committee to create a new Argo brochure and investigate funds for printing. Work with JCOMMOPS, Argo director, M. Scanderbeg, B. Greenan. Anyone else wishing to join can contact M. Scanderbeg.	JCOMMOPS Argo Director M. Scanderbeg B. Greenan	
25	Add standard depth levels Argo dataset to AST	M. Scanderbeg	

	website.		

	2015 estimated	2015 Argo equiv estimated	2015 Argo deployed	2015 Argo equiv deployed 2016 estimated	2015 deployed - 2015 estimated	2015 equiv deployed - 2015 equiv estimated	% deployed vs estimated
Argentina							
Australia	45	5	49	4	4	-1	109%
Brazil	6		7		1		117%
Bulgaria			1				
Canada	29		28		-1		97%
Chile							
China	10	20	10	6	0	-14	100%
Costa Rica							
Denmark							
Ecuador							
European Union			2		2		
Finland	3		2		-1		67%
France	70	10	135	8	65	-2	193%
Gabon							
Germany	65	12	76		11	-12	117%
Greece	5		5				100%
India	40		27		-13		68%
Ireland	3		2		-1		67%
Italy	30		29		-1		97%
Japan	23	33	23	18	0	-15	100%
Kenya							
Korea (Republic o	17		15		-2		88%
Lebanon							
Mauritius	2				-2		0%
Mexico							
Netherlands	7		2		-5		29%
New Zealand	2		4		0		200%
Norway	3				-3		0%
Poland	3		3		0		100%
Russia							
Saudi Arabia							
South Africa							
Spain	3		1		-2		33%
Sri Lanka							
Turkey							
UK	40		32		-8		80%
USA	351	20	345	91	-6	71	98%
	757	100	798	127	38	27	88%
	857		925		65		
	2015 estimated	2015 Argo equiv estimated	2015 deployed	2015 equiv deployed	2015 deployed - 2015 estimated	2015 equiv deployed - 2015 equiv estimated	% deployed vs estimated

2016 estimated	2016 equiv estimated	2017 estimated	2017 equiv estimated	2018 estimated	2018 equiv estimated		Notes
						Argentina	
44	2+	38	2?	32		Australia	
						Brazil	
						Bulgaria	Argo program in Bulgaria is uncertain with no commitment decided
26		25		25		Canada	
						Chile	
15	20	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	
						Denmark	
						Ecuador	
60	7	70	6	80		European Union	7 argo equivalent in 2016 6-7 Bio in ATLANTOS project MOCCA EC to buy 130 in 2016 additionnal T&S floats in 2018 our target is still to get EU funding for 80 floats per year funed by EC but nothing is signed so far
	3		3		3	Finland	3/yr 2016-2020
65	15	65	15	65	15	France	80/yr 2016-2020
						Gabon	
50	6	50	25	50		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
	5		5		5	Greece	5/yr 2016-2020
50		40		40		India	40 floats/yr 2012-2017
3		3		3		Ireland	3/yr 2016-2020
15	20	15	20	15	20	Italy	20/yr in marginal seas; 15/yr in open ocean
23	31					Japan	
						Kenya	
						Korea (Republic of)	
						Lebanon	
						Mauritius	floats provided by UK, aim for up to 4 per year
						Mexico	
14		7		7		Netherlands	7/yr 2016-2020
2		2		2		New Zealand	
3		3		3		Norway	3/yr 2016-2020
3		3		3		Poland	3/yr 2016-2020
						Russia	
						Saudi Arabia	
						South Africa	
3	1	3		3		Spain	3/yr 2016-2020
						Sri Lanka	
						Turkey	
25	23	34	6	34	6	UK	40/yr 2016-2020
360						USA	
761	131	373	110	377	79		
2016 estimated	2016 equiv estimated	2017 estimated	2017 equiv estimated	2018 estimated	2018 equiv estimated		

Argo Australia – 2016 Activities

Report to the Argo Steering Team

Susan Wijffels, Ann Thresher, 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 379 floats actively reporting good data across the Indian, Pacific and Southern Oceans (Figure 1).

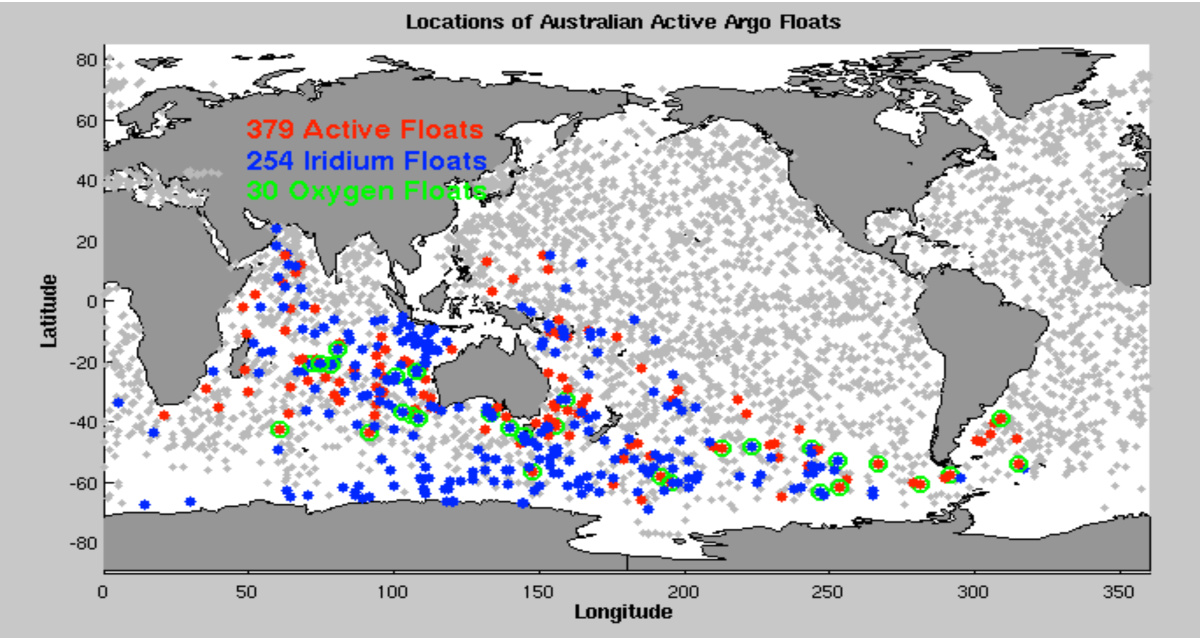


Figure 1. Locations of active Argo Australia floats (colours – defined as float reporting in the last 60 days north of 55°S, in the last year south of 55°S) as of January 2016 with active international floats in gray. Australian floats using Iridium Communications are in blue and those equipped with oxygen sensors are circled in green.

In the calendar year 2015, the program deployed 53 floats mainly spread throughout the western Pacific, Indian and in the Southern Oceans. We have deployed a further 16 already in 2016. Once again, on a joint US/Australia/New Zealand cruise, RV *Kaharoa* deployed floats for Argo Australia in the Western Pacific Ocean continuing her successful contribution to the program.

One of our focuses this year was the seeding of the area between Indonesia and northwest Australia from a GO-SHIP line carried out by Japan. 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. We also deployed 3 Argo Canada floats into the Southern Ocean.

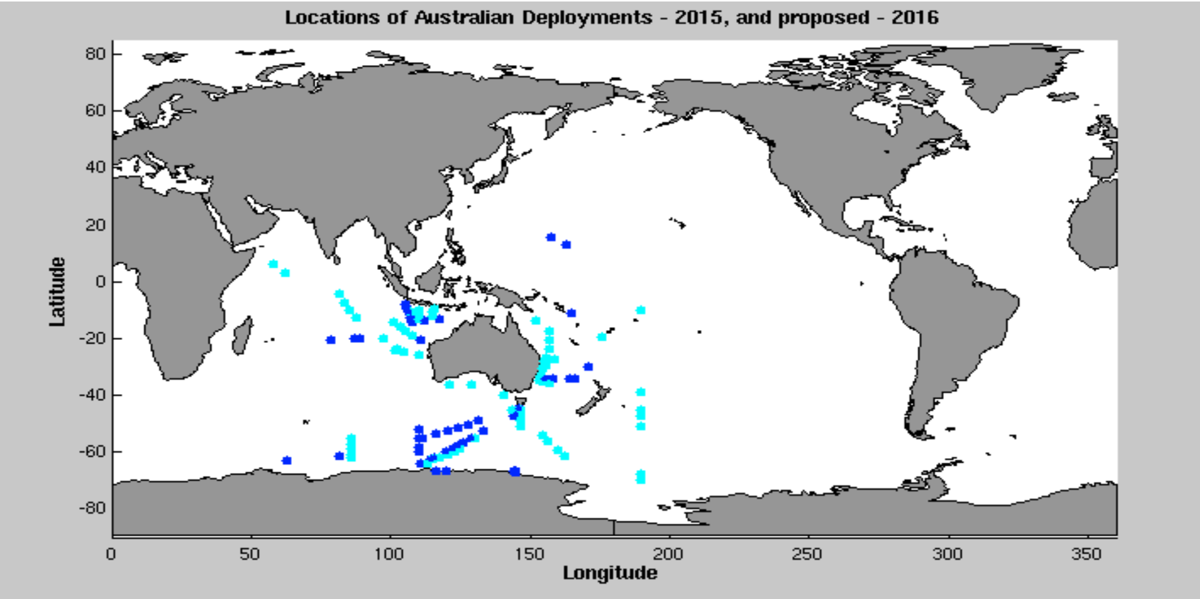


Figure 2. Locations of float deployments in 2015 (Blue), with proposed deployments for 2016 (Cyan)

We will have 63 or more floats available to deploy in 2016 but we don't expect to deploy all of them in this year.

Conversion to V3.1 formats has now been completed for all file types though work on the trajectory files continues. In addition, we have now coded to deliver BR files in version 3.1 and all have been delivered to the GDACs. We have coded Trajectory files into version 3.1 and though files from floats carrying Argos transmitters are being delivered, creation of trajectory files from Iridium equipped floats is still undergoing testing. That will complete our conversion to version 3.1.

We have also finalized production of BUFR real-time files and are delivering them to the GTS as the floats report and simultaneously with the delivery of the original TESAC data files.

This year, we were required to go to tender for further float procurements. This turned out to be a very useful process, with the establishment of a 'panel' of suppliers who meet our requirements. We can therefore purchase floats that meet our needs without further tenders. In addition, this panel arrangement applies to all Australian government agencies and universities, making it easier for our partners to contribute to the Argo program.

Technical problems encountered and solved

A big challenge this year was the outage of all data delivery via dial-up communications. We still use dial-up as a backup to our RUDICS communications. However some simm cards cannot be converted to use RUDICS. Our landline throughput was blocked by (at one point)

Telstra and (at another point) Iridium. The Telstra outage lasted for over a week while the Iridium outage affected all deliveries for over a month. This impacted on the 11 floats that cannot be converted to RUDICS, as well as all calls to the secondary backup server. As a result, we have installed an Iridium modem on our servers so the floats can now dial directly via Iridium-Iridium, bypassing all local communications infrastructure.

Changing the phone numbers for the secondary server on the floats is a long process and on-going. Once we are sure that has been totally successful, we will retire our dial-up modems. Under-ice floats will take the longest to convert because we will need to wait until all have reported before being sure they have picked up the new numbers. The only problem remaining is that our current Apex APF11 floats cannot change their phone numbers (required to switch from direct dial-up to Iridium-Iridium calls) so if we switch off our secondary dial-up server, these floats will have no backup server.

One benefit of this has been that our communication costs should again decrease since Iridium-Iridium calls are cheaper than Iridium to dial-up.

Technical problems in the core fleet have been very few this year. Our fleet is aging and we are now losing many of our floats as they reach operating ages of 7 or 8 years. Deployments have been able to fill the gaps caused by these losses. There have been a few failures on deployment and we are talking to the manufacturers about warranty replacements.

We have greatly increased our Bio-Argo equivalent fleet this year with deployment of Seabird floats carrying a complex array of sensors. These include Radiance and Irradiance, SUNA Nitrates, various oxygen sensors, various FLBB combinations, CDOM and others. We are about to deploy another version that carries a pH sensor. This has been a complicated process and coding to deliver these files has not been easy but we can now handle a wide variety of bio sensors.

Float Failure Mode Analysis

As of the January 2016, the Australian Argo program had deployed 707 floats. From the total number of floats deployed; 306 are now dead. Of the remaining 401 floats, more than 98% are returning good data with only 8 floats producing suspect or bad data (on the grey list). This is a decrease from last year when there were 17 floats on our grey list.

Of the dead floats, most (44%) ceased to operate due to normal end of life when they ran down their battery packs. A further 12% died of unknown causes and ~6% died on deployment for various reasons. The remainder of floats ceased working mainly due to environmental reasons – see the table below. Because there were multiple causes of failure in some cases, note that these will not sum to 100%

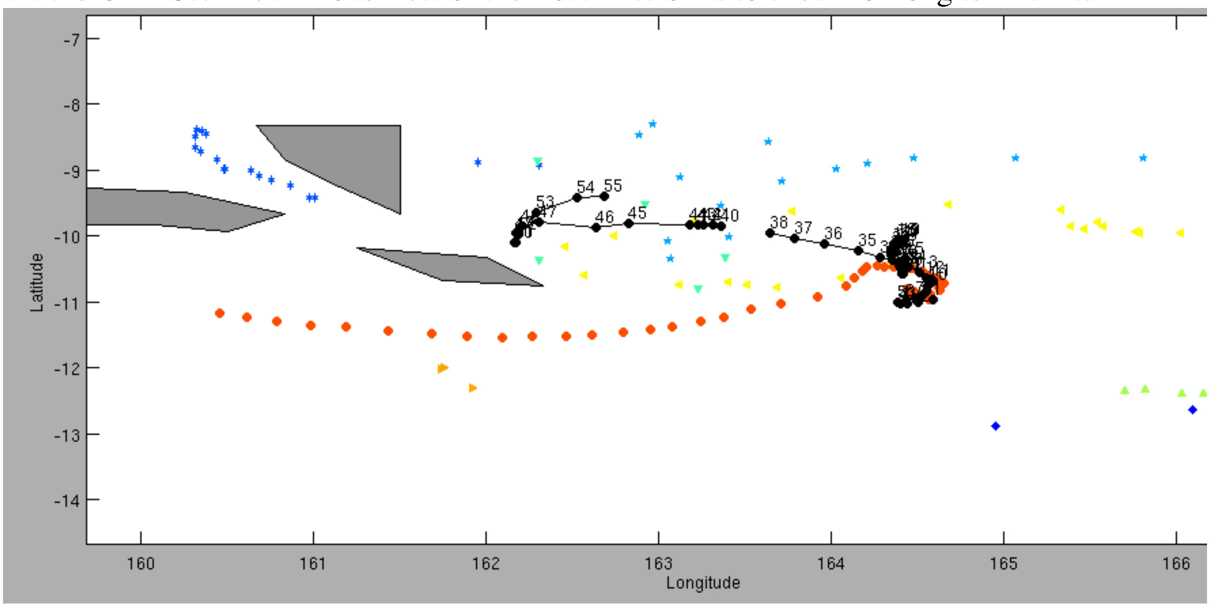
Float failure mode for dead floats	**Number of floats** (306)	**% of dead floats**
End of life	136	44.4
Grounded	34	12.7
Unknown	37	12.1
Leak	31	10.1
Died on Deployment (10 from	20	-

mechanical failure, or other mechanism, 10 unknown)		
Lost under ice	16	5.2
Mechanical or software malfunctions	32	10.4
Float preparation errors	4	0.1
Retrieved	6	2.0

<u>Summary of Technical Issues</u>

We have had a very good year with respect to technical performance. We have, however, had two more failures on deployments and will investigate to see if we can assign a cause to these disappearances.

Working with Dr. Sophie Cravatte (IRD, France) and both Teledynne Webb and RBR, the RV L'Atlante deployed an Apex float (with APF11 controller) with a new RBR CTD in the Coral Sea. This was deployed with a 'companion' Apex (APF9) SBE equiiped float for comparison. On 3 day cycles they remained close for around 35 profiles before diverging. The data are being analysed in collaboration with RBR. Subsequently the RBR was instructed to sample the upper ocean at 0.1db resolution, which it did. We then moved both floats to a 10 day cycle. The RBR data, which is still of unknown quality, has not yet been distributed via the GDACs. The aim over rest of the float mission is to check for long term drift.



Locations of test RBR (black) and SBE (orange dots) companion float profiles in the Coral Sea.

Status of contributions to Argo data management

Ann Thresher is co-chair of the Argo Data Management Team and both Susan Wijffels and Ann participated in the ADMT16, held in Bermuda.

<u>Collaboration with Argo India:</u> The program has continued to work intensively with the Indian Argo program, on coding for new data formats, Bio-Argo data and version 3.1

formats. All software has now been delivered and we are working on getting it implemented for all of their floats.

Metadata and Technical file Standardisation: Esmee van Wijk and Ann Thresher continue to work on standardization of metadata files and technical files. This is on-going as more names and variables are required for new float models and sensors.

Status of delayed mode quality control

Australian DM Statistics	core Argo	core + Bio + pilot study
D files submitted to GDAC	67866	71089
Total R files	31001	62782
R files eligible for DMQC	18093	47591
Total eligible files for DMQC	85959	118680
Total files at GDAC	98867	133871

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

The Australian Argo array continues to grow with 726 floats deployed to date since the beginning of the program and more than 130,000 Australian profiles available at the GDACs (just under 100,000 of these profiles belong to 'core' Argo floats). A total of 407 floats are operational and returning good data. A further 292 floats have reached end of life and 12 are returning suspect or bad data. As of 17/03/2016, our DMQC percentage stands at 79% of eligible profiles (those that are greater than 12 months old). Note that this percentage is for Argo floats that are designated as 'core' Argo i.e. those that measure P, T and S. Australia has deployed a number of floats that were originally notified as core Argo but are actually Argo equivalent i.e. Bio Argo floats and those deployed in pilot studies, (i.e. EM Apex floats and floats on the continental Antarctic shelf). If we include the non-core Argo profiles then we are at 59% for our DM percentage.

The conversion to the new format V3.1 has caused considerable delays to DMQC processing as has the increased data management demands of Bio Argo floats. We have made good progress in the last 12 months in bringing up our fraction of delayed mode profiles at the GDAC with an extra half time DM person. We are currently prioritising the DMQC of the core Argo profiles and hope to be caught up with DMQC by the next AST meeting if DM staffing is continued at the current level.

In addition, a second new hire spent 6 months developing a software suite to handle multi-profile data including oxygen. Unfortunately this person has moved on to another position but is still developing the software for us on a casual basis. The new software includes significant improvements and flexibility in the way we visualise our core and new bio data. We are currently in the final phases of bug testing this new software to ensure consistency of outputs compared to the old software suite. The new software enables DMQC of oxygen data from Argo floats using a modified Takeshita 2013 approach. We hired a person on a short term contract to help us start the QC of the Argo oxygen data, we are hoping to have the first dataset from 60 oxygen floats available mid year.

In total 552 floats have been assessed through the DMQC process for drift of the salinity sensor, many of these are now assessed in routine maintenance mode (i.e. at least once per year). Of these, 14 floats (3%) returned no data from deployment and 9 floats (2%) returned bad data for most of the record due to pressure sensor issues, cracked conductivity cells or other hardware problems. Of the remaining assessable floats; 84% showed no salinity drift for the life of the float, 12% showed a positive salinity drift and 2% are affected by a fresh offset, most likely to be bio-fouling. Most floats with either salty or fresh drift (and not badly bio-fouled) were able to be corrected using the OW software. A further 16 old floats (3%) suffered from TBTO fouling at the start of the record, generally only the first or second profiles but in some cases up to 7 profiles.

An analysis of pressure sensor performance reveals that most float have very stable pressure sensors over time. A small fraction (17) floats (or 3%) are affected by the Druck microleak issue, with two modes; either a very fast negative pressure drift that results in a shorting of the float electronics and death of the float after 15-20 profiles or a much slower negative pressure drift that results in a decline in pressure of up to 8db over ~250 profiles. A further 6 floats or 1% were found to have bad, non correctible pressure for the life of the float. Within the cohort of floats with well-behaved pressure sensors over time, a small proportion (around 8% of floats) showed occasional bad pressure values (non monotonic pressure values) or missing blocks of data that could be caused by problems with data telemetry as well as sensor issues. However within each float only a small percentage of the overall cycles were affected and only a small number of data points within each cycle.

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

Argo Australia has been 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, the Australian Climate Change Science Program (ACCSP), in kind assistance 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 10 deployments per year for core Argo, and some floats to be used very close to the ice-shelves and in the future, deep Argo floats (PI: Dr. Steve Rintoul). Bio-Argo floats are being deployed as part of an Australia-India Strategic Research Initiative (PI Nick Hardman Mountford).

It has been recently announced, after a national review, that IMOS has secured five years of funding at 80% of 2014/15 levels. This is excellent news. The amount to be awarded to Argo is not yet known but we anticipate this will likely be at 2015/16 levels which is a 20-30% cut on past funding rates. However, one major co-investing program, the long running Australian Climate Change Science Program, is closing down at the end of June 2016. The follow on program, the Earth Systems Science Hub of the National Environmental Science Program, does not allow support for observation networks. This results in a large funding decrease for the program. As a result, float deployment numbers for Argo Australia are on a downward slope until other sources of support can be found.

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)

Once again, we have had a successful deployment year, with very few floats remaining in the lab, though our new orders are beginning to arrive. We have ordered (so far) another 38 floats for next year, all with identified deployment opportunities. Many will go out on a reoccupation of P15S which the R/V *Investigator* will run starting in mid-April so we will be busy getting them prepared for deployments. The number of floats on order is down on our usual numbers because the Australian dollar has weakened (decreasing our buying power) and our funding has been cut. The Australian Bureau of Meteorology has, however, committed to providing between 4 and 6 floats this year which will be a help.

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. In addition, we will continue to use the French resupply vessel, *l'Astrolabe*, for deployments south of Tasmania.

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 graduate program and University of New South Wales are utilizing Argo data in their thesis studies.
- The Australian Climate Change Science 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.

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

None that are not already on the AST-17 agenda.

6. CTD cruise for Argo calibration purposes

Our new BlueWater research ship, RV *Investigator*, is now operational and currently deploying floats in the southern Indian Ocean. She will be undertaking the high resolution CTD line P15S starting in April 2016 and will be deploying floats from both the Australian Argo program and Scripps Institute of Oceanography. The Investigator web site can be found at:

http://mnf.csiro.au/~/media/Files/Voyage-plans-and-summaries/Investigator/Primary%20voyage%20schedules/2014-17%20voyage%20schedules-FINAL%2020150121.ashx

If someone would like to provide Argo floats for one of the listed voyages, let either Susan Wijffels or Ann Thresher know and we will investigate whether there will be CTDs on the trip and liaise with the Marine National Facility.

7. Argo Publications

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

2015 Argo Canada report of activities

(submitted by Blair Greenan, Fisheries and Oceans Canada)

17th meeting of the Argo Steering Team (AST-17)
Yokohama, Japan
22-24 March 2016

1. Status of implementation (major achievements and problems in 2015)

- *floats deployed and their performance*

From March 2015 to February 2016, Argo Canada deployed 32 MetOcean (NOVA and DOVA) floats (16 in the northeast Pacific, 13 in the northwest Atlantic, and 3 in Southern Ocean with the help of deployments from Australia DAC). Of these 32 floats, 10 died prematurely. The 22 remaining floats are still active and functioning properly. "Active" assumes that less than 4 of the last 4 profiles have been missed. Of the 32 floats, 4 were replacements. Of the 10 that died prematurely, 1 grounded, 5 were replaced under warranty, and 4 need to be replaced under warranty. Three of the latter number were replacements. One warranty replacement has yet to be deployed. The Government of Canada Standing Offer with Metocean requires that if a float fails to complete 18 profiles the manufacturer must provide a replacement float. As of 1 March 2016, Argo Canada has 57 active floats in the Argo array.

- *technical problems encountered and solved*

Oil was noted to be leaking in the packing crates for two floats prior to deployment. These were returned to the manufacturer for repair at their cost. It was determined that there was improper seating of an o-ring in some units. This resulted in a design change to prevent future oil leaks.

Four floats surfaced soon after deployment and remained at the surface transmitting to the Iridium satellite network. The Canadian Navy recovered one of the failed floats and returned it to MetOcean. It was subsequently determined there was a problem in the interface between the float and the Sea-Bird CTD; this was addressed by manufacturer and the problem has not occurred since.

In February 2016, two NOVA floats failed upon deployment in the Northeast Pacific. This was the result of a firmware change in the Sea-Bird CTD board. This appears to have resulted from a lack of communication of this change between Sea-Bird and MetOcean which resulted in a technical problem in the NOVA float.

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

DFO ISDM (formerly MEDS) continues to acquire data from 65 Argo floats. Of which 8 floats seemed to be in trouble and have not reported data for at least 1 month, so that our number of active floats is actually 57. Data are issued to the GTS and GDACs hourly in TESAC, BUFR and NetCDF format. The data of all Canadian floats together with some graphics are posted on a website and updated daily: http://www.isdm.gc.ca/isdm-gdsi/argo/index-eng.html. On average 92% of data from January 2015 to January 2016 data were issued to the GTS within 24 hours of the float reporting in TESAC and BUFR format.

Since AST-16, we completed the following tasks:

- About ~18000 existing NETCDF profiles were converted to version 3.1. About roughly 5000 NETCDF profiles has been DMQC still need to convert to version 3.1 due to failure GDAC format checkers. We'll continue our conversion process based on each individual case.
- All of the meta data and technical NetCDF files were converted to version 3.1
- The new Argo BUFR template to send dissolved oxygen and surface observations on the GTS has been accepted and available for operational uses.
- We rewrote the BUFR encoder to read NetCDF profile version 3.0 and 3.1 in order to send dissolved oxygen and surface observations on the GTS. The software has been validated with AOML and is available if you would like to use it.
- Completed change the bulletin header from SOVD02 to SOFD02 for Argo TESAC messages.
- ISDM provides ADMT with quarterly reports on the performance of Argo data on the GTS in TESAC and BUFR formats.

- *Status of delayed mode quality control process*

As of February 2016, 30% 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 58% of all eligible cycles at least once. This is an improvement from March 2014 when Argo Canada reported 16% of floats were QCed.

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

Canada does not have multi-year commitments of money devoted to Argo. Lobbying is necessary on an annual basis to renew the funding required to purchase new floats and other operational expenditures. Fisheries and Oceans Canada (DFO) committed $361.5k for purchases of Argo float in August 2015. National Defence Canada also commited $80k for the purchase of 5 MetOcean NOVA floats. The enabled the acquisition of a total of 26 floats. Funding is expected to remain stable at approximately this level for the next few years with the new Federal Government committed to reinvesting in DFO Science.

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 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) 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 has been hired by DFO at the Institute of Ocean Sciences and 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)

There is a plan to hire a co-op student in the summer 2016 to update some of the data products developed by Howard Freeland, such as surface circulation maps of the Gulf of Alaska, Argo data interpolated to station Papa and projected onto Line P.

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 2016, we plan to deploy 26 new floats (firm commitment), all of which have already been purchased: 11 will be deployed in the North Pacific (NOVA), 6 in the Labrador Sea (2 NOVA, 4 DOVA), and 9 in the Gulf Stream's northern recirculation gyre and off Newfoundland (NOVA). There is also potential for up to 9 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 Dec 2015, 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 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 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 ISDM and then to NODC and CCHDO. Mathieu Ouellet (DFO, Ottawa) is responsible for dissemination of Canadian CTD data. Steve Diggs sometimes obtains 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.

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The 17th Argo Steering Team Meeting, Yokohama, Japan, March 22-24, 2016

Argo Chinese National Report 2015

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

1. The status of implementation

- floats deployed and their performance

From March 2015 to February 2016 China deployed 16 profiling floats in the western Pacific and Indian oceans. These floats come from 4 PIs of 3 institutions in China, which includes 5 Iridium APEX floats deployed by Dake Chen from CSIO, 6 HM-2000 floats deployed by DongLiang Yuan from IOCAS, 4 APEX floats deployed by Jianping Xu from CSIO, and 1 PROVOR float deployed by Navigation Guarantee Department. The number of deployment decreased dramatically compared with that of 2014 owing to the status of China Argo which is supported by research programs. As of January 2016, China has deployed about 353 profiling floats in the Pacific and Indian oceans including 183 Argo equivalent floats. Now there are 170 active floats working in the seas (Figure1). In September 2015, China deployed 6 HM-2000 floats in the WBC of western Pacific ocean. It was the first deployment of floats developed by China as Argo equivalent floats. HM-2000 float uses Beidou satellite System (BDS) for data transmission and GPS for positioning. However, it can be switched between GPS and BDS for positioning. After deployment, 1 float did not transmit any data, and another float transmitted bad salinity measurements owing to the problem of its CTD sensor. Two-way communication capacity has been tested successfully when some of the floats are likely to drifted outside of the BDS coverage. As of January 2016, 2 HM-2000 floats are still active. On average, the inactive floats repeated 72 cycles from their deployment.

- contribution to international Argo

Invited by PICES, Mr. Liu Zenghong attended the 24th North Pacific Marine Science Organization (PICES) annual meeting held in Qingdao, China during October 14-25, as international Argo observer authorized by international Argo project office. He gave invited lectures entitled "Progress of global Argo" and "Progress of global Argo and float technology" at the three sessions (MONITOR、POC and IPCC AR5), and also exhibited the important achievements from the beginning of international Argo project through a poster.

On 27 January 2016, a review of "Fifteen years of ocean observations with the global Argo array" was online published by《Nature Climate Change》, which was co-authored by 27 scientists from 18 different countries. The publication of this review was reported by several China medias through which the influence of global Argo was expanded in China. It will promote the applications of Argo data and attract more attention from government.

- technical problems encountered and solved

In 2015 there were 4 floats (2 PROVOR, 1 APEX and HM-2000) added into grey list due to obvious conductivity sensor drift. The reason is still under investigation.

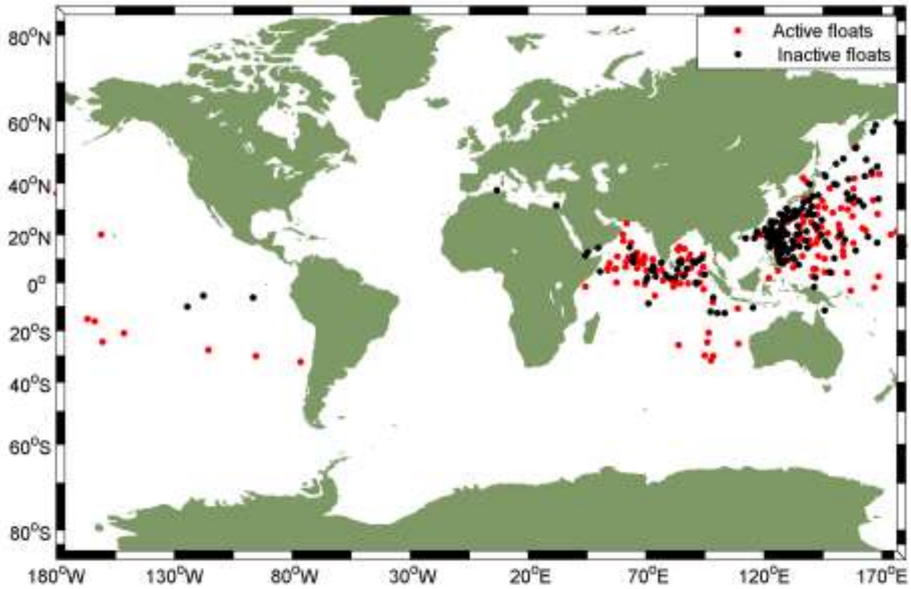

Fig.1 Launch positions of all floats (black) and latest positions of the active floats as of January 2016.

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

From the AST-16 meeting, China Argo received data from 214 active floats and submitted 7057 TS and 1000 O2 profiles to GDAC. CLS still helps us to insert all Argo profiles into GTS. However, CSIO started to insert data into GTS via Chinese Meteorological Agency (Beijing) from October 2015. All Argo profiles were converted to BUFR format through a Perl script developed by JMA. At present, profiles from Chinese floats are inserted into GTS by both CLS and CSIO. We plan to stop distributing bulletins by CLS after the AST-17 meeting. We would like to thank CLS for their helps. CSIO changed all the decoders from C language to Matlab, as well as RTQC and netcdf file generation. New decoders are very flexible due to usage of format table. We updated most of the meta files and technical files to V3.1 but not for trajectory files. We also created b-files from several bio-Argo floats except 17 PROVOR-DOI floats.

CSIO setup a BeiDou data receiving system (including a Beidou Antenna) through which the messages from HM-2000 floats can be operationally received and decoded. At present, the selected cycles from HM-2000 floats are submitted to GDAC because the PI only wants to share 10-day cycles.

- status of delayed mode quality control process

In the past year, CSIO didn't submit any D-files to GDAC due to a poor manpower. Now we are restoring submission of D-files and updating all of the old D-files to V3.1. It should be noted that the China Argo equivalent floats has been more than half of the total floats, which will lead to an increased difficulty of carrying out DMQC.

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

China Argo is a non-operational program, the number of deployment is heavily relied on Argo related research programs. Now China Argo is mainly supported by Ministry of Science and Technology (MOST).

Currently there are 5 staffs working for float deployment, data processing and data application at CSIO. A few floats will be deployed by some special programs from SOA.

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.

We estimate that about 15 floats will be deployed in 2016 (including 4 HM-2000 floats). The number of China Argo equivalent float's deployment is difficult to count because it depends on whether or not PIs want to share their Argo data with others.

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 many studies about ocean variability from basin-scale to global-scale. Besides this, Argo data has also been used into operational assimilation system or reanalysis system. CSIO maintains a monthly global Argo gridded dataset (called BOA_Argo) and updates once a year. In 2015, we added SST, SSS and MLD into this dataset based on a mixed-layer model. The dataset was carefully verified using Levitus, TAO and other Argo gridded datasets (e.g. Scripps, IPRC, JAMSTEC). The dataset has been used by some scientists from China and their papers.

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 presented. Meanwhile, GDACs, related international organizations and member's Argo websites can be accessed through these two websites. Besides this, an Argo data inquiry system has been developed by CSIO based on Hadoop technology (http://101.71.255.4:8090/flexArgo/out/argo.html).

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

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ARGO National Report 2016 – 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:
   - 69 floats have been purchased and deployed
   - 12 are working

Floats purchased between 2009 and 2012 suffered from the APEX battery leakage problem and died prematurely.
No floats have been purchased in 2015. Purchases planned for 2015 and 2016 will go through the Euro Argo ERIC to complement external funding. The corresponding floats will be delivered in 2016.

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 has approximately been reached during the past years. A semi-permanent fixed budget is available.
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).
14 (= planned amounts of 2015 and 2016 together) floats will be purchased through the Euro Argo ERIC to complement external funding. Deployment is not yet planned, but preferably in the Atlantic Ocean.

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

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

6) **CTD data uploaded to CCHDO**
Yes.

7) **Bibliography**
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Argo National Report 2015 – Finland

1. Status of implementation

The Finnish Argo program is run by the Finnish Meteorological Institute (FMI). Since 2010 FMI has deployed altogether twelve floats in the Nordic Seas. In addition of oceanic operations, seven floats (starting 2012) have also been deployed into the shallow and low salinity Baltic Sea. Three of the Baltic floats have bio-optical sensor suite.

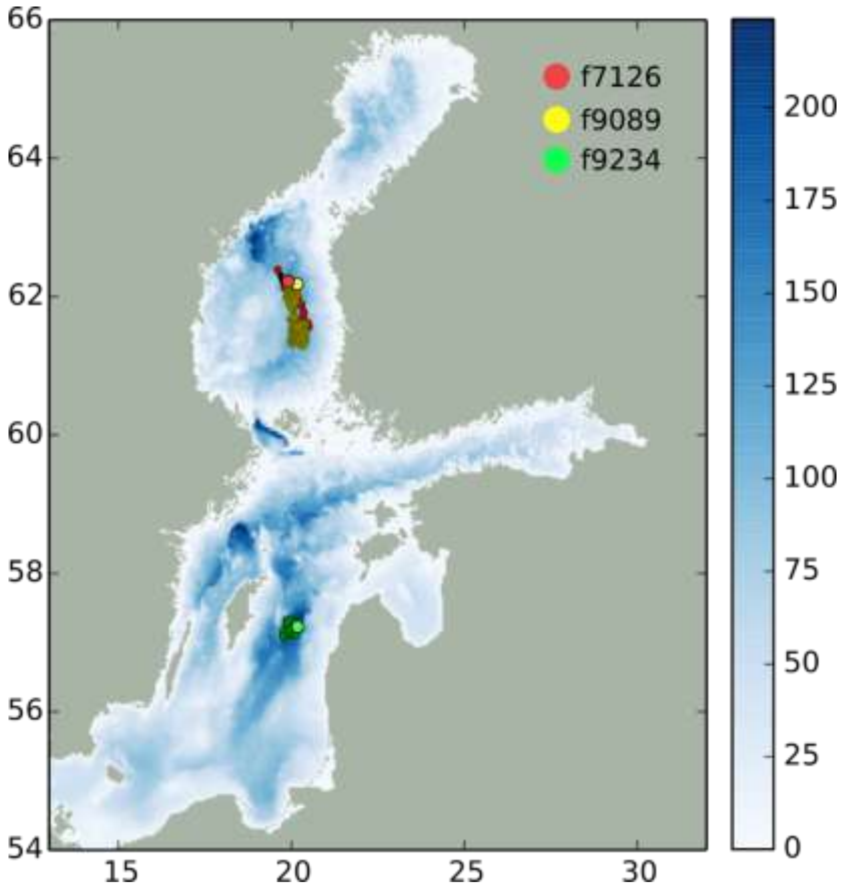

Figure 1, Routes of Argo floats which operated in the Baltic Sea in 2015. Large dots indicate the recovery point (f7126) or the position of the last profile before March 2016 (f9089 and f9234).

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

FMI has committed to purchase and deploy three floats in a year, at minimum. Our main geographical areas to operate are the Greenland Sea and the Baltic Sea. During the next years, we are looking for possibilities to further develop the Argo floats to be used in shallow ice-covered seas. First experiments with ice-avoidance on the Baltic Sea has been performed during winter 2015-1016.

3. Summary of deployment plans

This year two floats will be deployed in the Nordic Seas and two in the Baltic Sea.

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

Argo data sets gathered from Baltic Sea are used for validating the operational and research circulation models. Operational circulation models are also constantly compared on current Argo data, one of these comparison was published this year (Westerlund, Tuomi 2015). Operating Argo floats in the Baltic Sea has itself been a research on the limits of usability of Argos in shallow seas. Ongoing research is done on assimilating Argo data in the operational Baltic Sea circulation models for enhancing their forecasting skills.

In addition this year we consulted Finnish participants in Unesco's OceanApp competition, concentrating on applying Argo data.

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

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

6. CTD data uploaded to CCHDO

No data uploaded.

7. Bibliography

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French National Report on Argo - 2015

Present status and future plans

v1 - March 14th, 2016

G. Maze, C. Cabanes, T. Carval, C. Coatanoan, F. D'Ortenzio, N. Kolodziejczyk, N. Lebreton, S. Le Reste, 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[1] 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[2] 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[3] 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 pPhysique et Spatiale[4]" (LOPS, Brest, France; former LPO) and the "Laboratoire d'Océanographie de Villefranche[5]" (LOV, Villefranche, France). Coriolis and Argo France have strong links with Mercator Ocean[6] (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[7] 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 918 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, the NAOS[8] 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[9] 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
Total (2000-2015)			***918***		**993**
2016	**1400k€**	**14**	**65**		**65**

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 2016.

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).
- 2017-2021: Continuation of the core Argo mission with the addition of an extended mission.

For the upcoming phase 2017-2021, France proposes an over-fitting strategy of a 70-80 floats/year sustained fleet with:

- 10-15 deep floats
- 15-20 with oxygen sensors
- 15 with biogeochemical sensors
- 30 core T/S.

Deep floats and oxygen sensors are funded until 2021 (CPER Brittany region), biogeochemical mission is partially funded (CPER PACA region) and requires new sources of funding.

France strategy will be adjusted according to international recommendations with regard to the deep and Bio-Argo extensions. Euro-Argo has been working on 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. 2015 was the year of testing the developments at sea. More informations on technological float developments can be found in the NAOS project webpage (http://www.naos-equipex.fr/) and its last newsletter (Jan2016_English_version_v1.pdf) from which the following information are gathered:

The **Arvor** float has been improved: the deployment procedure has been simplified, the auto-test process has been extended and the monitoring of pressure during certain critical phases has been intensified. A "dual-mission" mode enables the user to split the float life into two phases. Two new floats were programmed using the "dual-mission" mode (500 dbars/ 1000 dbars every two days followed by 100 dbars/2000 dbars every ten days). Since their deployment in March 2015, those floats had completed nearly 40 cycles.

The success of Arvor's **Argos-3** transmission was confirmed by further experimentation launched in 2015. The floats transmit an Argo profile of ~110 points in just a few minutes. Compared to Argos-2, which has to transmit continuously for up to ten hours, the float uses five times less energy and has increased its autonomy by 25% with a cheaper transmission costs. A scientific article has been published on the subject of the Argos-3 transmissions: Xavier André, Bertrand Moreau, and Serge Le Reste, 2015: "Argos-3 satellite communication system: implementation on the arvor oceanographic profiling floats". *J. Atmos. Oceanic Technol.*, **32**, 1902–1914. http://dx.doi.org/10.1175/JTECH-D-14-00219.1

Four **Deep Arvor** floats, part of a first series of 12 floats, were fine-tuned during the production phase and then deployed during the Reykjanes Ridge Experiment (RREX) campaign in June 2015. Three of them were functioning as planned at the end of the year. Deep–Arvor enables an Argo profiling float to descend to 4000m, doubling its depth, and thus to explore nearly 90% of the volume of the world's oceans. One of the two indus- trially manufactured prototypes, deployed in May 2014, completed its cycles successfully before running out of battery power: 142 CTD cycles, of which 60 featured oxygen measurements at a depth of between 3500 and 4000m with successful seafloor grounding. The predicted energy balance has confirmed that there is potential to achieve 150 cycles at 4000m. NKE has been awarded a licence to manufacture and commercialize the floats until January 2019. A scientific article has been published on the subject: Le Reste, Serge and Dutreuil, Vincent and André, Xavier and Thierry, Virginie and Renaut, Corentin and Le Traon, Pierre-Yves and Maze, Guillaume: "Deep-Arvor": A new profiling float to extend the Argo observations down to 4000m depth." Journal of Atmospheric and Oceanic Technology 2016. http://dx.doi.org/10.1175/JTECH-D-15-0214.1

Another main aspect of the development concerns the bio-geochemical applications. The **Provor-CTS5 (Prov-bio)** developed in 2013 is 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.

After trials in the Mediterranean Sea, the **Provor CTS5 (Pro-Ice)** float was deployed in the Baffin Sea. The Pro-Ice profiling float targets the Arctic zone. The float deployed in the Mediterranean Sea carried out approximately one hundred profiles during two missions in the Boussole area. The tests demonstrated the float's capability to reverse its ascent speed if ice is detected. Ice detection and avoidance strategies are possible via two systems. The ISA (Ice Sensing Algorithm) compares the median temperature near the surface with a critical temperature. It has been adapted for Baffin Bay by using data from 392 CTD profiles. Furthermore, the float's distance from the surface measured by a reverse altimeter is compared to the depth (calculated from measurements of pressure). Each of the two algorithms (ISA and altimetry) provides an indicator which triggers the decision to end the ascent. Lastly, a different strategy is adopted according to the season (surfacing is prohibited or only permitted at regulated intervals). The Takuvik team tested the Pro-Ice float in intense cold conditions in a Quebec Lake and during the "Green Edge" camp at Qikiqtarjuaq. Those tests revealed certain discrepancies that were corrected accordingly.

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 (**Provor-CTS4**) in the Mediterranean Sea by teams from the French laboratories LOV, MIO and LOCEAN. The cruise provided better targeting of specific zones and also more flexibility in recovering the operational floats (i.e. after recovery of existing floats, refitting and further deployment is possible) than previous deployments by opportunity ships. Ten floats were deployed and four of the initial phase were recovered. Several methods for calibrating the BioArgo floats biogeochemical sensors were tested. Measurements of oxygen in the air were obtained and calibrations of floats was carried out between floats, in particular for nitrate concentration observations .

3 THE STATUS OF IMPLEMENTATION

3.1 Floats deployed and their performance

109 T/S floats have been deployed by France in 2015 (see map and table below). The deployment areas are chosen to meet French requirements in terms of research and

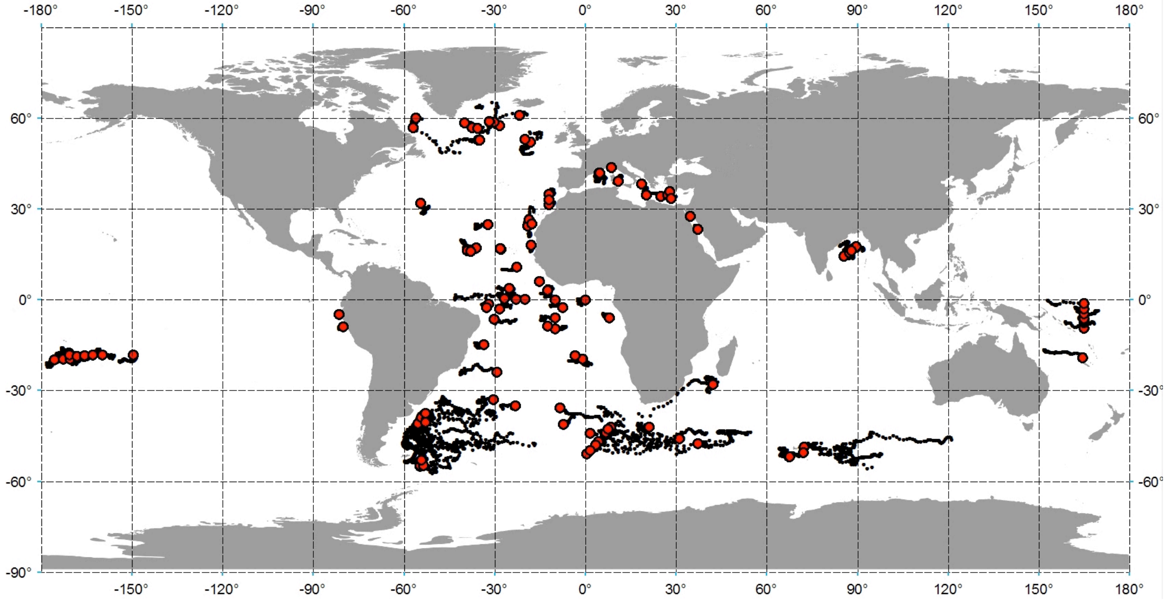


Figure 1 : Argo-France 109 deployments in 2015

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 2015.

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. **More details on the Coriolis activities as DAC and GDAC can be found in Coriolis annual reports**[10](French only).

The data processing chain based on Matlab to manage data and metadata from Provor-Remocean floats is now fully operational and is continuously improved. These are advanced type of floats performing bio-geo-chemical measurements. In 2015, data and metadata from these floats have been distributed on Argo GDAC. They feature version 3.1 core and bio profiles, core and bio trajectories, metadata and technical data. The other bio-Argo floats (Apex, Navis, Nemo and Nova) are distributed in V3.0 data files. Data are available in real-time from Argo GDAC when the new version of the format checker is deployed. More information at: http://www.coriolis.eu.org/Data-Products/Data-Delivery/Argo-bio-floats-from-Coriolis

3.3.1 Data Assembly Center[11]

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 2015 Coriolis DAC 7 GDAC data management report (http://doi.org/10.13155/39749).

These last 12 months (oct14-sep15), 25 568 profiles from 745 active floats were collected, controlled and distributed. Compared to 2014, the number of profiles increased by 18%, the number of floats increased by 14%. The increase in both profile and platforms number is mainly explained by new bio-Argo floats. The 745 floats managed during that period had 54 versions of data formats.

All Coriolis DAC real time files (including from Provor CTS3 bio floats) have been converted to Argo NetCDF 3.1 version. Delayed mode files are still being converted (50% done).

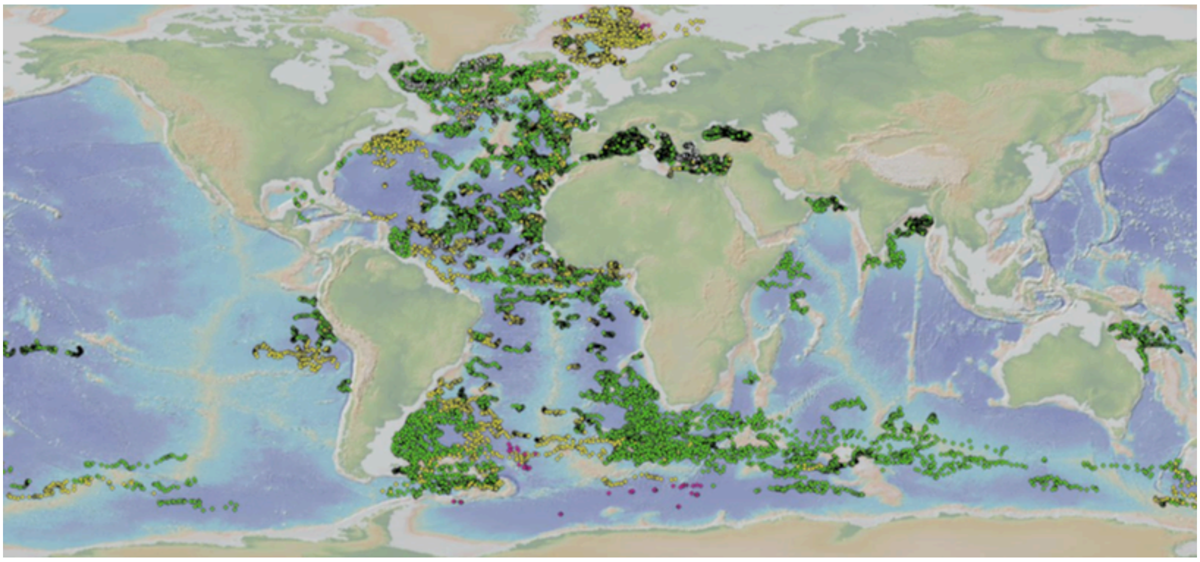


Figure: Maps of the 25 568 profiles from the 745 floats managed by Coriolis DAC in 2015.

3.3.2 Global Argo Data Centre[12]

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 2). There is a monthly average of 483 unique visitors, performing 4518 sessions and downloading 4 teraoctets of data files. On the last 12 months, the weekly average performance was 99.84%. The 0.16% of poor performances represents 15 minutes for a week. For the last 12 months, the cumulative poor performances period is of 24 hours. We faced 3 significant events these last 12 months.

- First week of January: 8 hours of Internet poor performances
- Last week of January 2015: disk storage instability: 7 hours and 35 minutes of poor performances of ftp.
- Mid-August 2015 : 4 hours of poor Internet performances

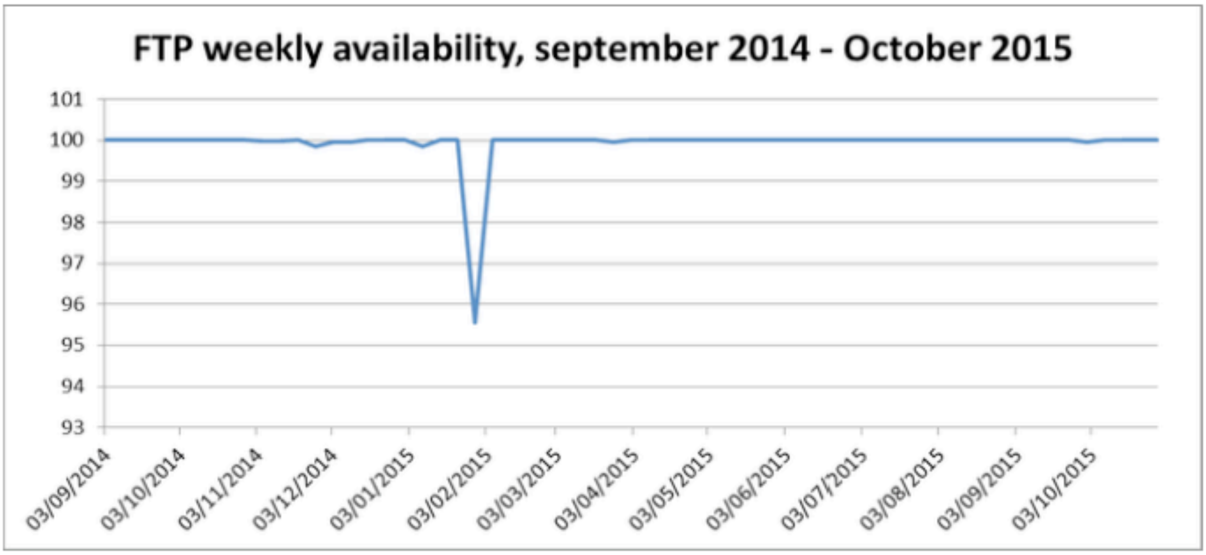


Figure 2 : Nagios monitoring: between October 2014 and September 2015.

3.3.3 North Atlantic Argo Regional Centre[13]

See section 5.4

3.4 Status of delayed mode quality control process

In 2015, a total of 8118 new delayed mode profiles (628 floats) were produced and validated by PIs. A total of 124 997 delayed mode profiles were produced and validated since 2005 (see Figure 5). In February 2016, 59% of the floats and 60% of the profiles processed by the Coriolis DAC were in delayed mode (see Figure 6). Main DM operators are Coriolis, LOPS, BSH, OGS.

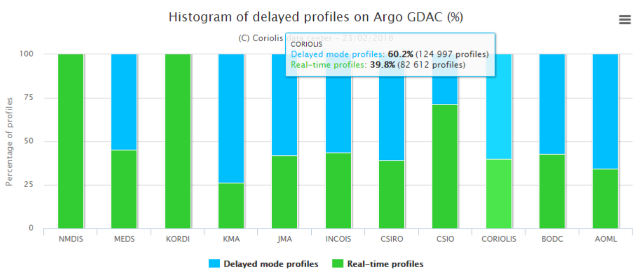


Figure 5: Evolution of the DM profiles' submission versus dates

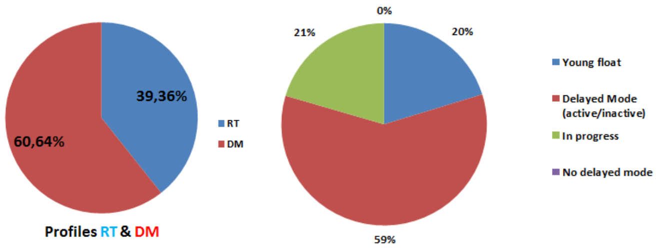
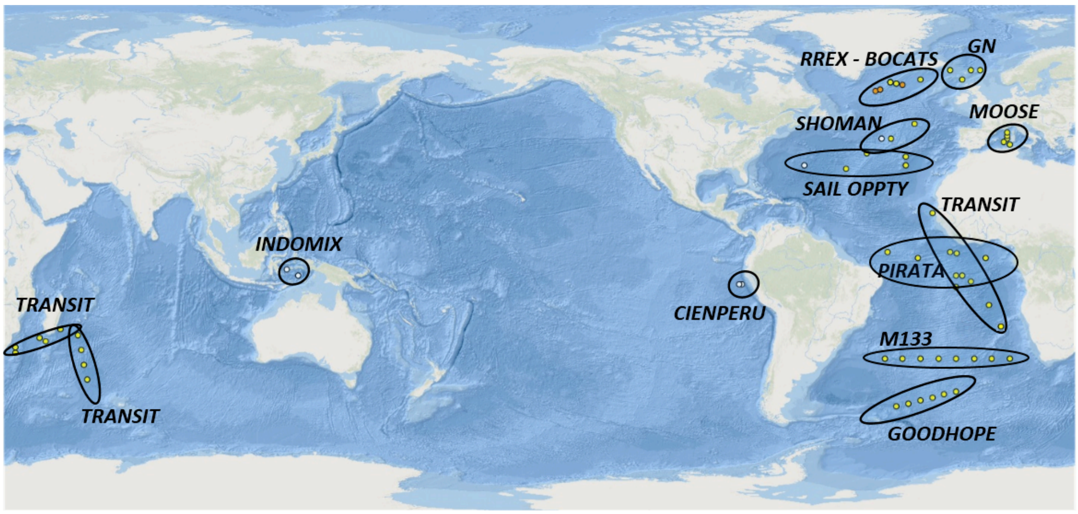


Figure 6. Status of the floats processed by Coriolis DAC. Left: in terms of float percent and right: in terms of profile percent (DM : delayed mode – RT : real time).

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

According to the current deployment plan, 65 core T/S floats will be deployed in 2016. They will be deployed in the Mediterranean Sea, in Atlantic (North and South), in the Southern Ocean and in the Indian Ocean. During the following cruises:

CRUISE	AREA	PERIOD	CTD FLOATS
CIENPERU	Peru	December	2
INDOMIX	Indonesia	May	2
MOOSE	Mediterranean Sea	May	5
OPPORTUNITY (SAIL)	North Atlantic	June	2
OPPORTUNITY (SAIL) VSF	North Atlantic	June	2
OPPORTUNITY (TRANSIT) BR-DKR-LR	South Atlantic	August	3
OPPORTUNITY (TRANSIT) BR-DUR	South Atlantic	November	7
OPPORTUNITY (TRANSIT) TAAF	South Indian Ocean	November	4
OPPORTUNITY GN	North Atlantic	August	4
OPPORTUNITY GOODHOPE	South Atlantic	December	6
OPPORTUNITY M133	South Atlantic	December	8
OPPORTUNITY SHOMAN	North Atlantic	September	4
PIRATA FR26	Gulf of Guinea	April	6
RREX-BOCATS	North Atlantic	June	10
		TOTAL :	65



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

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

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 MERCATOR-Ocean[6] structure.

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, …). In section 8 a non-exhaustive list of 2015's publications involving Argo data and a scientist from a French laboratory is reported.

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).

We have checked 627 floats processed in delayed mode (DM) in the North Atlantic, North of 30°N. Among the 627 floats, 24 floats show a significant salinity drift or bias according and have been corrected according to to the PI decision. A scientific article reporting the modified OW method have been submitted: "Improvement of bias detection in Argo float conductivity sensors and its application in the North Atlantic". C.Cabanes, V.Thierry, C.Lagadec. Submitted to Deep Sea Research part1, 2015.

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 number of CTD cruise data uploaded by PIs within France in 2015 to the CCHDO website is not known.

Since december 2014, no new version of the Argo CTD reference database has been generated. The last one is the version 2014V0, available on the ftp site (see Figure 11). In 2015, the work has been focused on the CCHDO API to get all the CTD data. In May 2015, API was made accessible to Ifremer to get the data, then after Coriolis was working on the association of platform_code and expocode available in the CCHDO dataset. In 2016, those data will be integrated in a new version.

In 2015, some corrections have also been done after checking quality on the deep water to remove bad data. This work of correction has been done for the boxes with wmo number started with 3 and in progress for the others areas.

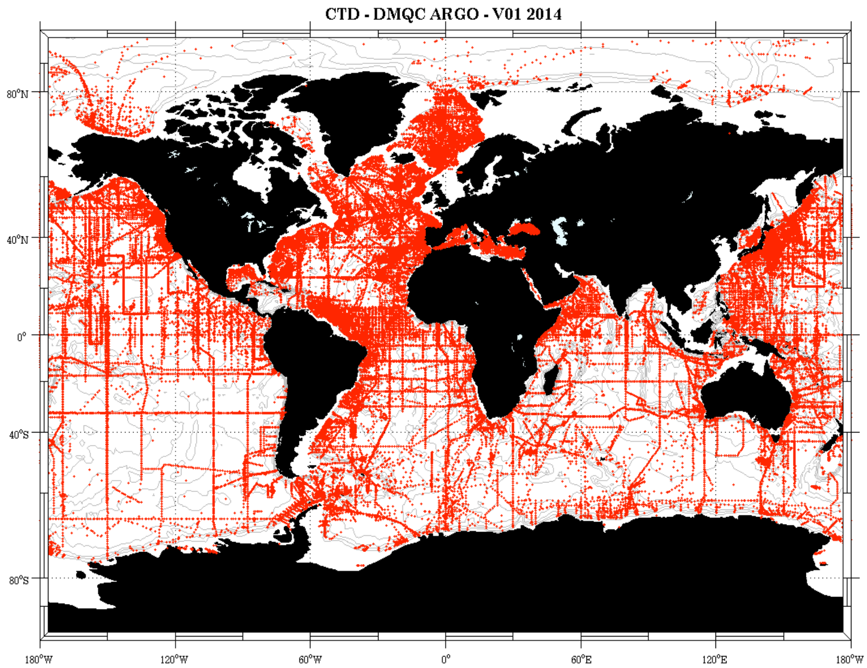

Figure 11: CTD reference database (2014V01)

8 BIBLIOGRAPHY

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

In 2015, at least 42 articles with a French scientist 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[14] and on the Argo Bibliography[15] webpage. To date, around 265 articles have been listed.

Argo-France Bibliography *(44 references):*

1 - Anne Piron, 2015: Observation de la convection profonde en mer d'Irminger avec les données Argo. PhD, Universite de Bretagne Occidentale.

2 - Damien, Pierre, 2015: Etude de la circulation océanique en Méditerranée Occidentale à l'aide d'un modèle numérique à haute résolution : influence de la submésoéchelle. PhD.

3 - Houpert, L. and Testor, P. and Durrieu de Madron, X. and Somot, S. and D'Ortenzio, F. and Estournel, C. and Lavigne, H., 2015: Seasonal cycle of the mixed layer, the seasonal thermocline and the upper-ocean heat storage rate in the Mediterranean Sea derived from observations. *Progress in Oceanography*, **132** (**0**), 333--352, doi: http://dx.doi.org/10.1016/j.pocean.2014.11.004.

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1993 to 2010. *Progress in Oceanography*, **132** (**0**), 250--261, doi: http://dx.doi.org/10.1016/j.pocean.2013.11.001.
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8 - André, Xavier and Moreau, Bertrand and Le Reste, Serge, 2015: Argos-3 Satellite Communication System: Implementation on the Arvor Oceanographic Profiling Floats. *Journal of Atmospheric and Oceanic Technology*, **32** (**10**), 1902-1914.
9 - Bashmachnikov, I. and Neves, F. and Nascimento, \^A. and Medeiros, J. and Ambar, I. and Dias, J. and Carton, X., 2015: Temperature--salinity distribution in the northeastern Atlantic from ship and Argo vertical casts. *Ocean Science*, **11** (**2**), 215--236, doi: 10.5194/os-11-215-2015.
10 - Blanke, Bruno and Speich, Sabrina and Rusciano, Emanuela, 2015: Lagrangian water mass tracing from pseudo-Argo, model-derived salinity, tracer and velocity data: An application to Antarctic Intermediate Water in the South Atlantic Ocean. *Ocean Modelling*, **85**, 56-67.
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Footnotes

[1] Argo France: http://wwz.ifremer.fr/lpo/SO-Argo
[2] Euro-Argo: http://www.euro-argo.eu
[3] Coriolis: http://www.coriolis.eu.org
[4] Laboratoire d'Océanographie Physique et Spatiale: http://www.umr-lops.fr/
[5] Laboratoire d’Océanographie de Villefranche: http://www.obs-vlfr.fr/LOV
[6] Mercator: http://www.mercator-ocean.fr
[7] IUEM OSU: http://www-iuem.univ-brest.fr/observatoire

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Argo Germany National Report 2015

February 2016

Birgit Klein, BSH

1. The status of implementation (major achievements and problems in 2015)

Data acquired from floats:

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 66 floats by the end of 2015, 6 floats purchased in 2015 are kept in store to serve deployment cruises early 2016. No floats have been deployed by GEOMAR this year. Early in 2015 AWI has deployed 15 floats, but due to technical problems none of the floats is able to deliver its data. This gives a total of 66 German float deployments until the end of 2015.

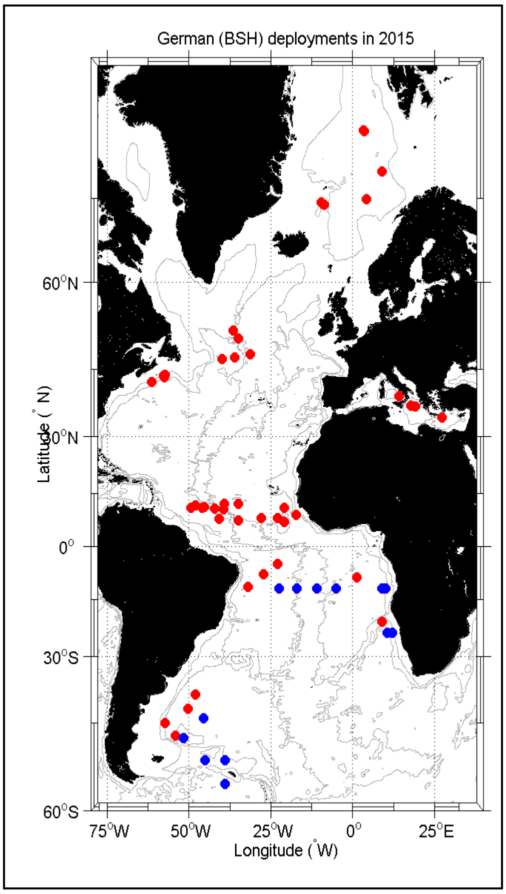
Currently (February 24th, 2016) 129 German floats are active (Fig.1) and the total number of German floats deployed within the Argo program increased to 732. Due to the increased loss rate of APEX floats with alkaline batteries the number of German floats in the network is still at a low rate, but slowly increasing. Some of the under-ice floats deployed by AWI in the previous years are assumed to be still active under the ice. It is anticipated that about 20 floats should resurface again in the next austral summer and deliver their stored data.

Fig. 1: Locations of active German floats (red) with active international floats (green) (Argo Information Centre, February 2016).

In the past most of the German floats were APEX floats purchased from Webb Research, but a smaller amount of floats were manufactured by the German company OPTIMARE. The company has been working in close collaboration with the AWI and has developed a float type suitable for partially ice covered seas. These floats are equipped with an ice sensing algorithm which prevents the float from ascending to the surface under ice conditions and prevents it from being crushed. Float profiles are stored internally until they can be transmitted during ice free conditions. In the last year three manufacturers supplied the floats purchased by BSH: ARVOR floats from NKE, NOVA floats from METOCEAN and APEX floats from TELEDYNE/WEBB. Additionally 11 APEX floats were supplied by TELEDYNE/WEBB as replacement for floats which had problems with their alkaline batteries.

We had discovered major technical problems with the alkaline batteries in our APEX floats deployed since 2010. Until September 2015 more than 60 floats 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. We had contacted TELEDYNE/WEBB about the problem and it was discovered that the floats were experiencing ‘energy flue’ because of a design change in the floats. As a possible fix against the premature fail of the entire battery pack due to failure of an individual alkaline battery a diode had been installed in the design in 2004, but was removed again in 2009/2010. WEBB/TELEDYNE had offered 14 floats in compensation for the malfunctioning floats in 2014 and 11 floats in 2015.

All of the German floats deployed in 2015 are standard TS floats. Deployment was carried out mostly on research vessels but also with the help of the German Navy in areas which are difficult to reach with research vessels such as the western Indian Ocean. The scientific research vessels comprised Canadian, German and UK ships. The deployment locations for 2015 are shown in Fig. 2a-b.



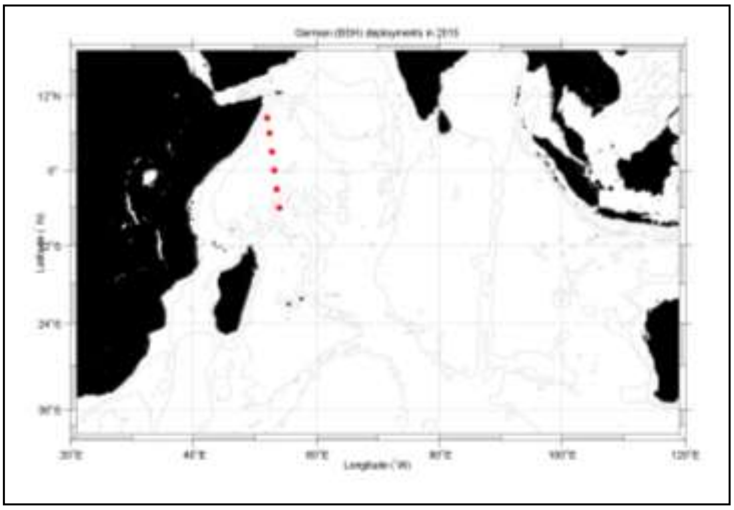


Fig. 2a-b: Deployment positions in 2015 in the Atlantic (left) and the Indian Ocean (right). At positions marked in red the deployment has already been carried out and those in blue will be achieved until the end of the year.

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). It is planned to coordinate the deployments for 2016 at the European level and this could invoke changes to the proposed plans. GEOMAR and AWI are members of the EU-funded ATLANTOS project and will deploy deep-floats and bio-Argo floats within this project.

2. Deployment plan for 2016

The deployment plans for 2016 will comprise at present about 53 floats from BSH in the Atlantic, the Nordic Seas, Indian Ocean and the Southern Ocean and consists of floats purchased already in 2015, funds from 2016 and warranty floats (Fig. 3a-e and Fig. 4a-e). The priority of our deployments is grid completion and extension of the core Argo array into the seasonally ice covered oceans in the Nordic Seas and the Southern Ocean. We have received 9 additional replacements by WEBB/TELEDYNE for floats which died of energy flue in 2015. Contacts with researchers on potential deployment cruises have been established and agreement has been reached on the possibility to deploy floats. The German Navy has been contacted again about potential deployments in the Indian Ocean during their regular survey operations. The AWI is planning to deploy about 22 floats during the Polarstern cruise PS103 in December 2016-February 2017. No deployments are planned yet for 2016 by GEOMAR. But GEOMAR is partner in the ATLANTOS consortium and will be involved in the deployment of deep floats as part of the pilot study in the Atlantic.

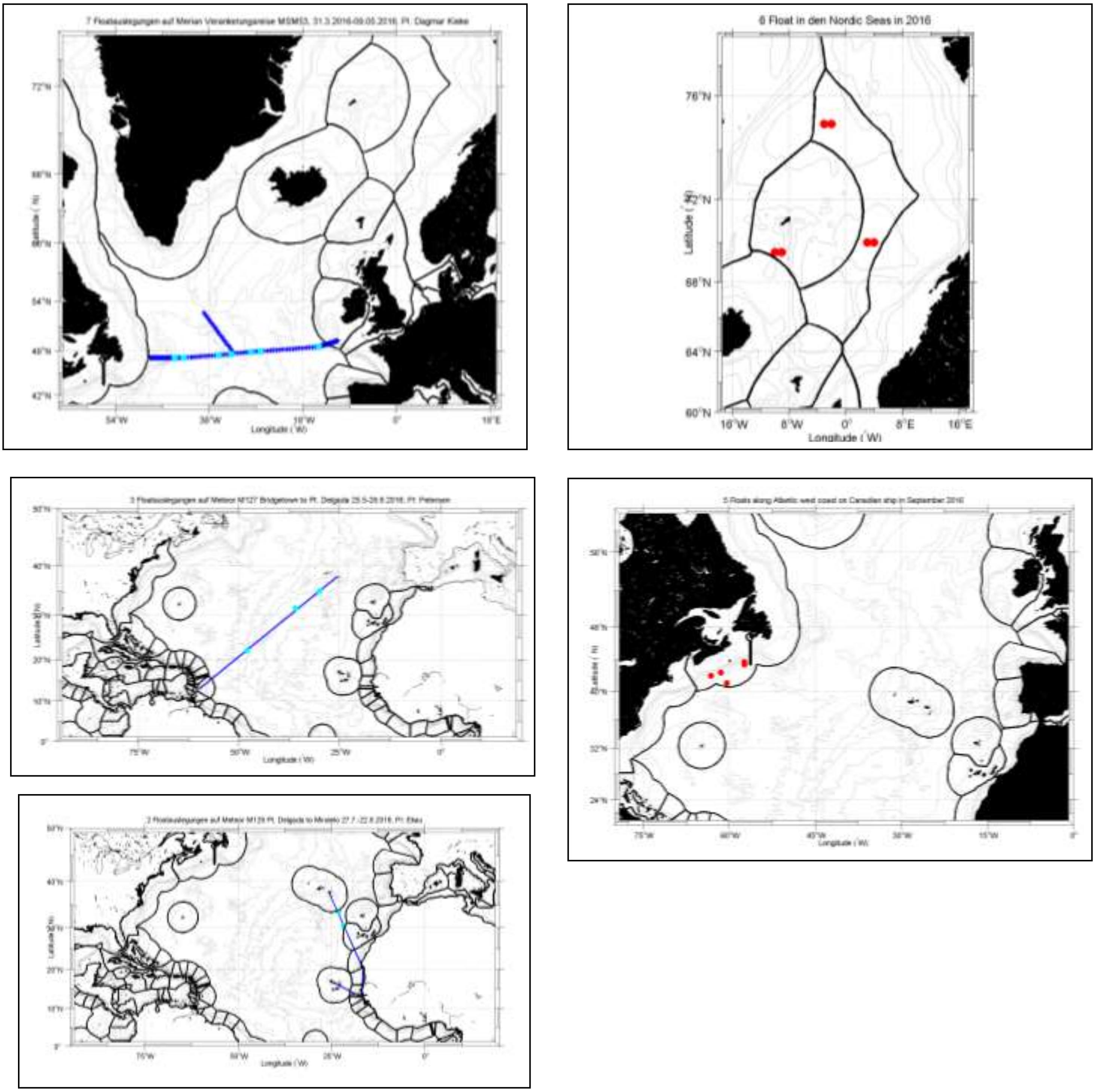


Fig. 3: a-e: Planned deployments of 24 floats in the North Atlantic

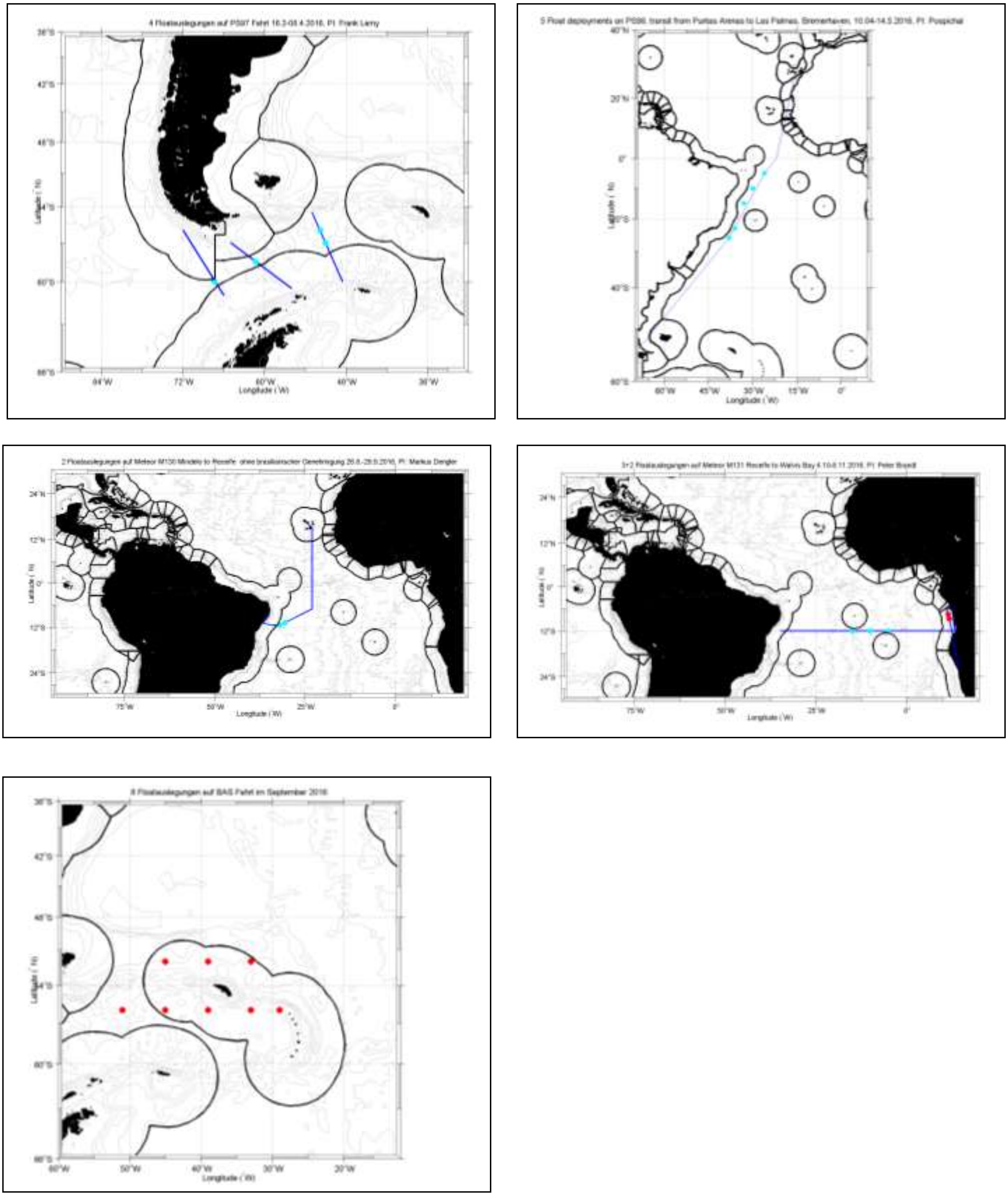


Fig. 4: a-e: Planned deployments of 22 floats in the South Atlantic

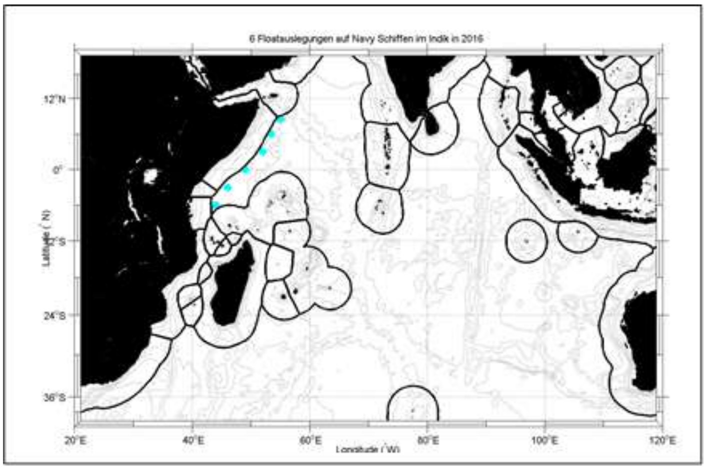


Fig. 5a: Planned deployments of 6 floats by the German Navy in the Indian Ocean.

3. Commitments to Argo data management

Data issued to GTS

The profiles for all German floats are processed by Coriolis and are distributed on the GTS by way of Meteo-France.

Data issued to GDACs after real-time QC

The real-time data processing for all German floats is performed at the Coriolis Center in France. Data processing follows the procedures set up by the Argo Data Management Team.

Data issued for delayed QC

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 the Pacific floats. 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. BSH has also adopted some European floats which did not have a DMQC operator assigned to them, such as national Argo programs from the Netherlands, Denmark, Norway, Finland and Poland. All German institutions have been working in close collaboration with Coriolis and delayed mode data have been provided on a 6 monthly basis. Delays in delayed-mode data processing have occurred occasionally due to changes in personal and delay in data transmission in the Southern Ocean due to ice coverage. The processing of the RAFOS information on the under ice floats has yet to be started, it is planned for the second half of 2016. Delayed-mode data processing follows the rules set up by the Data Management Team. The DMQC process is well underway and no major delays have been encountered.

Delayed mode data send to GDACs

All delayed mode profiles from BSH have been sent to the Coriolis GDAC node. The total number of available profiles from German floats is 54082 (February 24th, 2016), the number of DM profiles is 44236. The percentage of DM profiles with respect to the total number of profiles is about 87%. Early in 2015 the delayed mode quality control for the Dutch float has been performed by BSH and a 100% of all eligible floats are now available in delayed mode.

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

Web pages

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.

Statistics of Argo data usage

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 data for the Northwest European Shelf. Argo data are routine assimilated in the GECCO reanalysi, which is used for the initialisation the decadal prediction system MiKlip

Publications based on Argo:

Czeschel, R., Stramma, L., Weller, R. A. and Fischer, T. (2015) Circulation, eddies, oxygen and nutrient changes in the eastern tropical South Pacific Ocean, *Ocean Science*, 11, pp. 455-470. DOI 10.5194/os-11-455-2015.

Hummels, R., P. Brandt, M. Dengler, J. Fischer, M. Araujo, D. Veleda, and J. V. Durgadoo, Interannual to decadal changes in the western boundary circulation in the Atlantic at 11°S, *Geophys. Res. Lett.*, 42, doi:10.1002/2015GL065254, 2015.

Karstensen, J., B. Fiedler, F. Schütte, P. Brandt, A. Körtzinger, G. Fischer, R. Zantopp, J. Hahn, M. Visbeck, and D. Wallace, Open ocean dead zones in the tropical North Atlantic Ocean, *Biogeosciences*, 12, 2597-2605, doi:10.5194/bg-12-2597-2015, 2015.

Meredith, M. P., Mazloff, M., Sallee, J. B., Newman, L., Wahlin, A., Williams, M. J. M., Garabato, A. C. N., Swart, S., Monteiro, P., Mata, M. M. und Schmidtko, S.

(2015) *The Southern Ocean Observing System (SOOS), Bulletin of the American Meteorological Society*, 96 (7), S157-S160

Schmidtko, S., Heywood, K. J., Thompson, A. F. und Aoki, S. (2014) *Multidecadal warming of Antarctic waters, Science*, 346 (6214). pp. 1227-1231. DOI 10.1126/science.1256117.

Schütte, F., Brandt, P. and Karstensen J. (2015) Occurrence and characteristics of mesoscale eddies in the tropical northeast Atlantic Ocean, *Ocean Science*

Stramma, L., Czeschel, R., Tanhua, T., Brandt, P., Visbeck, M. und Giese, B. S. (2015) *The flow field of the upper hypoxic Eastern Tropical North Atlantic oxygen minimum zone*, *Ocean Science Discussions*, 12 (5). pp. 2147-2187. DOI 10.5194/osd-12-2147-2015.

Burmeister, K., Tropical Atlantic SST variability with focus on the extreme events in 2009, Master thesis, Christian-Albrechts-Universität, Kiel, 71 pp., 2015.

Bittig, Henry C. (2014). Towards a Quantum Leap in Oceanic Oxygen Observation - From Oxygen Optode Characterization to Autonomous Observation of Gas Exchange and Net Community Production, Dissertation, Christian Albrecht University Kiel.

Bittig, H.C., B. Fiedler, R. Scholz, G. Krahmann, and A. Körtzinger (2014). Time response of oxygen optodes on profiling platforms: Dependence on flow speed and temperature and recommendations for field applications. Limnol. Oceanogr.: Methods 12, 617-636, doi: 10.4319/lom.2014.12.617.

Ronja Eisner, Die Entwicklung der Deckschicht im Islandbecken und ihr Beitrag zum Nordatlantischen Tiefenwasser, Batchelor Thesis, 52 pp., University of Hamburg, 2012.

Kieke, D., und I. Yashayaev (2015), Studies of Labrador Sea Water formation and variability in the subpolar North Atlantic in the light of international partnership and collaboration, *Prog. Oceanogr.*, 132, doi:10.1016/j.pocean.2014.12.010.

Katrin Latarius, Über die Wassermassentransformation im Europäischen Nordmeer - Prozess-Studien und Budgets, Dissertation, Universität Hamburg, Department Geowissenschaften, Hamburg, 176 pp, 2013. http://ediss.sub.uni-hamburg.de/volltexte/2013/6088/

Products generated from Argo data

A key aspect of the German Argo program is to develop a data base for climate analysis from Argo data, to provide operational products for interpretation of local changes and to provide data for research applications.

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 NARC and contributes recent CTD data to the Argo climatology.

CTD data submitted to Reference data base:

M120 by Markus Dengler

GREEK ARGO PROGRAMME

PRESENT STATUS AND FUTURE PLANS

G. Korres and D. Kassis
HCMR
February, 2016

1. Background and organization of GREEK ARGO activities

Greece has established a 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 the period November 2013-July 2015, 12 Argo floats were successfully deployed in the Greek Seas in the framework of the Greek Argo Project. During the second half of 2014, 4 deployments were accomplished by the Greek-Argo team. The 4 floats were purchased by the Greek Argo RI and were deployed in the North, Central, South Aegean and South Ionian accordingly. The floats integrate an Iridium satellite telemetry system which provides a dual telecommunication capability allowing modification of the configuration in real-time, while the one in Central Aegean comprises an additional Dissolved Oxygen sensor. The first Argo NOVA float (WMO number: 6901884) was deployed at the 7th of October of 2014 at the Northern Aegean, near Athos. Next day, the second NOVA float (WMO: 6901885) was deployed at the northwestern part of the Cretan Sea. About one month later, at 12 November 2014, a DOVA float (equipped with dissolved oxygen sensor) was deployed in the Myrtoan Sea, east of the Hydra Island. This one (6901886) was the second float equipped with dissolved oxygen sensor that was ever deployed in the Greek Seas, aiming to give better insight to ecosystem's dynamics of the region. One day later, at 13 November 2014, another NOVA float (6901887) was released off the coast of Pylos, in southwestern Peloponnese. During 2015, 5 additional successful deployments have been accomplished by the Greek Argo Infrastructure. The first is a DOVA float (6901888) and was deployed at the 3rd of July 2015 in the Northern Aegean, near Athos peninsula. Next day (4 July 2015) the NOVA float 6901890 was deployed in the Northern Aegean, west of Mytilene Island. Later this day the DOVA float 6903152 was released off the southwestern coast of Chios Island in the Central Aegean. At the 7th of July of 2015 the NOVA float 6901889 was deployed in the Cretan Sea, northwesterly of Heraklion port. Finally, a PROVOR CTS3-DO was re-deployed 20 km south of Central Crete. The float had initially been deployed in the center of the Cretan basin on the 30th of October of 2013. The float was purchased under PERSEUS FP7 project and deployed under the coordination of the Greek Argo National Infrastructure.
The deployments during 2015 are presented in the table 1 and in figure 1:

Table 1. Deployments performed from Greek Argo team during 2015

	FLOAT TYPE	WMO	IMEI NUMBER	SERIAL NUMBER	DEPLOYMENT DATE	DEPLOYMENT TIME	LAT	LON	STATUS
1	NOVA OXYGEN	6901888	300234062720330	169	3/7/2015	18:30	40o 02'	24o 37'	MALFUNCTION
2	NOVA	6901890	300234061667320	140	4/7/2015	1:00	39o 13'	25o 05'	ACTIVE
3	NOVA OXYGEN	6903152	300234062729330	170	4/7/2015	9:00	37o 55'	25o 38'	ACTIVE
3	NOVA	6901889	300234061663020	138	7/7/2015	18:00	35o 55'	25o 20'	ACTIVE
4	PROVOR CTS3 DO	6903153	Argos transmission	OIN12GRS3DO	17/7/2015	14:00	34o 45'	24o 45'	ACTIVE

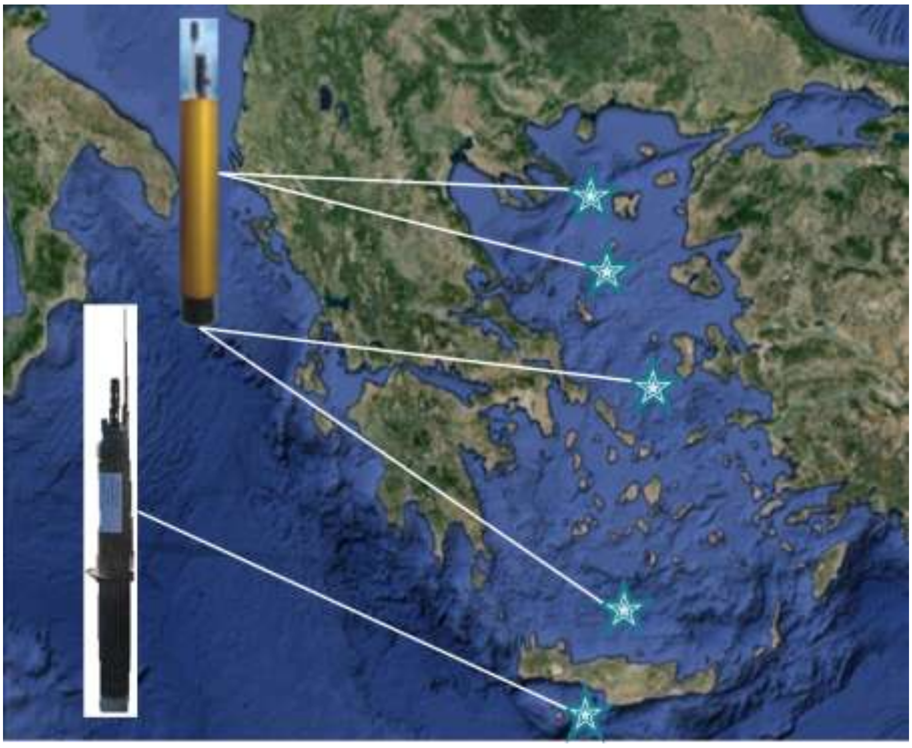


Figure 1. Greek Argo deployments sites during 2015.

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 350m, its profiling depth to 1000m 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 on 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 (2000m) 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. On January 2014 the first Greek Argo Users meeting was hosted by HCMR aiming to present the activities of the national network to coordinate present and future actions that will take place at national level. The 2nd meeting of the members of the Greek Argo infrastructure was held on January 2015. The 3rd meeting took place on December 2015 and there were 5 scientists participating from HCMR Institute of Oceanography and 7 scientists and researchers from different Universities and departments from all over Greece. 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 Ferrybox SSS data assimilation into the Aegean Sea hydrodynamical model component of the POSEIDON system running operationally at HCMR within the framework of POSEIDON system.

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

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

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

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

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

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

Ocean science

Med-Argo data are currently used by a small group of researchers in Greece for studies of water mass characteristics of the different deep basins of the Mediterranean Sea and as a continuous record of T/S characteristics providing insight in the seasonal and inter-annual variability of the Mediterranean Sea and its sub-basins. A number of publications and scientific results have been released regarding the Greek Argo acquired data during the last 3 years.

Publications in scientific journals and conferences proceedings:

[1] 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

[2] 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
[3] 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:

[1] "**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.
[2] "**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.
[3] **"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.
[4] "**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:

[1] 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/
[2] 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:

[1] 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
[2] 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.

2. Funding

2.1 Existing funding for Greek Argo

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

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 2016 generally includes:

- 2 float deployments in the Southern 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 Northern Aegean
- 1 float deployment in the Ionian Sea, since the Argo coverage in the area is good

For the Levantine Sea, although the coverage is satisfactory, the Greek Argo could contribute with 1 deployment per year, to maintain this coverage at high levels.

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

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 further upgrade took place during January 2016, 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.

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. A press release was sent after the deployment of the Greek float. The press release is permanently hosted in the HCMR's Greek webpage, http://www.hcmr.gr/listview4_el.php?id=1110.

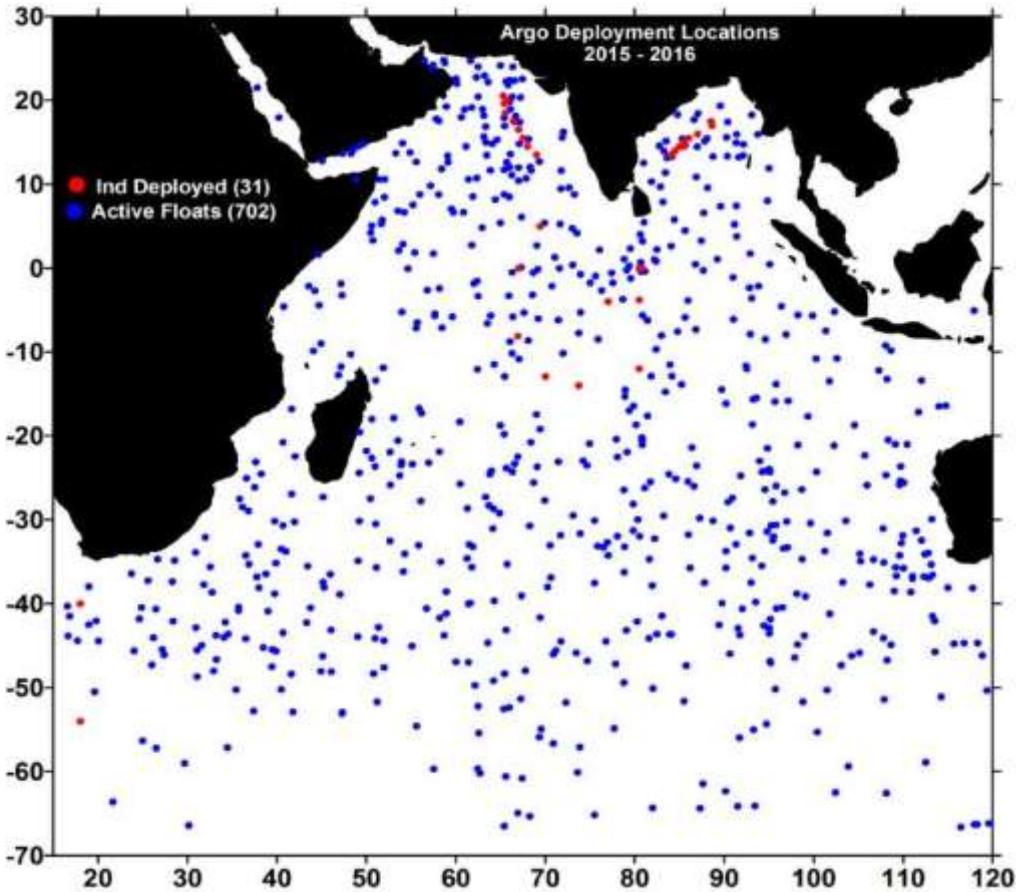
Argo Steering Team Meeting (AST-17)

National report of India

1. The status of implementation

1.1a Floats deployment

During the year 2015–16, 31 floats were deployed in the Indian Ocean, taking the total to 396. The new deployment includes 8 Bio-Argo floats with additional sensors like Doxy, FLBB, Chl-a. Due to unexpected technical issues with the ship, we could not deploy 10 floats identified for southern Ocean. However, these floats will be deployed during next southern summer.



1.1b performance Analysis of Floats deployed

Out of 396 floats deployed so far 137 floats are actively giving data. Out of these 137 active floats, 96 (67) 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 396 floats so far. Out of these 137 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 (137) 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. INCOIS Argo web page statistics (for the past one year) are as shown below

Page	Views	Visitor
Argo Web-Gis	1027	1129
Data downloads	1492	1570
Live Access Server	2,57,809	1,13,702
Argo products	1842	1097

- Argo data viewer developed at INCOIS and supplied to the users through DVDs is now also available from Argo UCSD web site. The link for viewing the same is: http://www.argo.ucsd.edu/incois_ADV.html
- User interactions were conducted to bring about awareness about the Argo data among the researchers and students from various organizations and universities respectively.
- INCOIS is also conducting University outreach program wherein scientists visit various universities to bring about awareness about the data available through INCOIS. Students are encouraged to use Argo data for their MS thesis dissertations, thereby giving wide publicity to the Argo program. The publications and dissertations arising out of the Argo program are well documented at INCOIS.
- INCOIS also started issuing projects to universities to utilize the Argo data. A visualization project using Argo data is sanctioned to IIIT, Bangalore.

1.4 Status of Delayed Mode Quality Control process

DMQC is done on all eligible floats on a routine basis.

- Around 250 floats were passed through the DMQC s/w and the following problems are tackled

- Pressure Sensor offsets.
    - Salinity drift.
    - Salinity Hooks.
    - TBTO problems.
    - TNPD problems. etc
- Around 57 % of FLOATS are DMQCed for INCOIS DAC. Migration to Ver 3.1 is hampering the progress in DMQC processing.

1.5 Trajectory files status:

A total of 394 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 need to be finished and uploaded to GDAC.

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 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 2017-2022, India plans to deploy 50 floats/per (40 tropical Indian Ocean and 10 in the Southern ocean)

Three Permanent and three 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 2017-2022, 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)

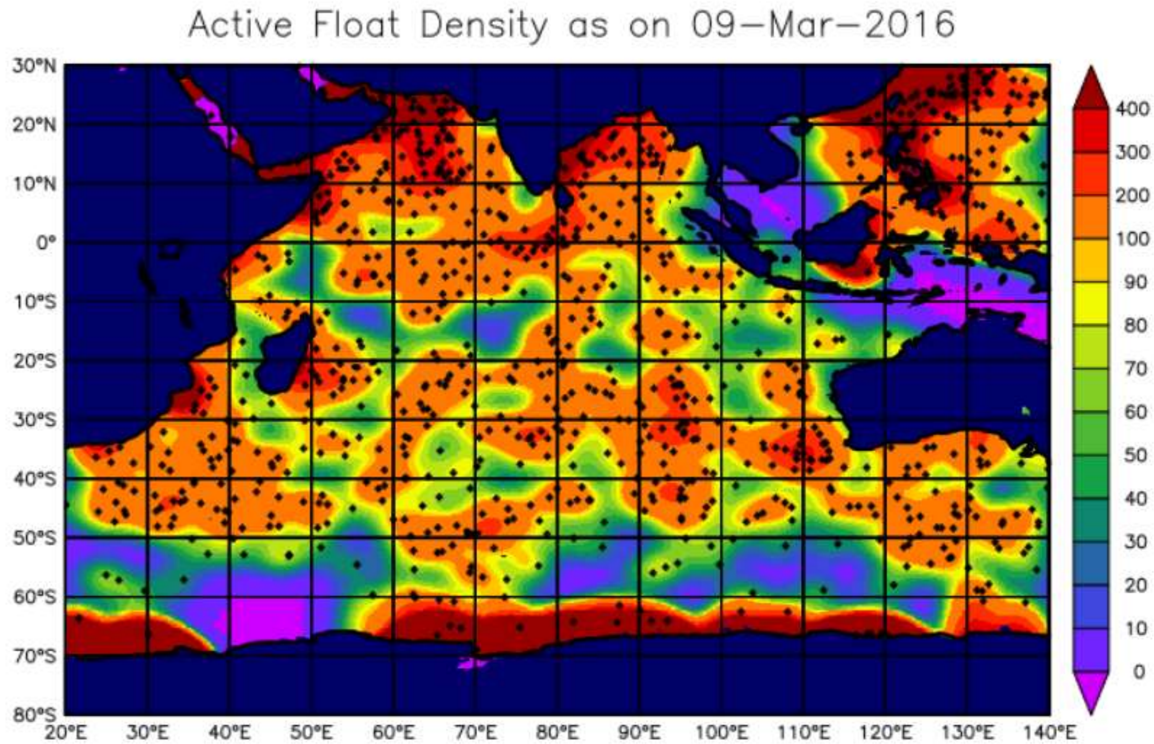
- Acquisition of Argo data from GDAC corresponding to floats other than deployed by India and made them available on INCOIS web site.
- Delayed Mode Quality Control
  (Refer 2.0 above)

- 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). Derived Argo Value added products are also made available in NetCDF format on ILAS. Users can view and download data/images in their desired format.
- Data Sets (CTD, XBT, Subsurface Moorings) are being acquired from many principle investigators. These data are being utilized for quality control of Argo profiles.
- Argo Data Viewer is constantly updated and this product is made available via FTP from INCOIS and UCSD web site.
- Value added products:

  Two types of products are currently being made available to various users from INCOIS web site. They are: (i) Time series plots corresponding to each float (only for Indian floats). This include Water fall plots, Surface pressure, Bottom most pressure, Surface temperature, Bottom most temperature, Surface salinity, Bottom most salinity, Trajectory of float, T/S plots. Also, Spatial plots using the objective analysis from all the Argo floats data deployed in the Indian Ocean. This include Temperature (at 0, 75, 100, 200, 500, 1000 meters), Salinity (at 0, 75, 100, 200, 500, 1000 meters), Geostrophic Currents (at 0, 75, 100, 200, 500, 1000 meters), Mixed Layer Depth, Isothermal Layer Depth, Heat Content up to 300 mts, Depth of 20 deg and 26 deg isotherms. These valued added products can be obtained from the above web site.

- Other statistics

- Regional Co-ordination for Argo floats deployment plan for Indian Ocean. The float density in the Indian Ocean as on 09 March 2016 is shown below.



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

None

6. As part of an action item from AST-15 aimed to improve 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.

None

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Argo National Report 2014-2015: Ireland

1) The status of implementation (major achievements and problems in 2015):
   a) floats deployed and their performance

WMO Code	Type	Deployment Date	Performance
6901919	APEX	22/04/2015	Good
6901920	APEX	22/04/2015	Good

   b) technical problems encountered and solved
   None

   c) status of contributions to Argo data management (including status of conversion to V3 file formats, pressure corrections, etc)
   Carried out by BODC for us.

   d) 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's application for membership of the Euro Argo ERIC (legal consortium) is currently being processed through the relevant national decision making bodies and is expected to be finalized in Q1 of 2016. This will commit Ireland to:
Subscription fee = €30,000
Minimum deployment of 3 Argo floats = €20,000 each per annum (under current framework agreement).
TOTAL = €30,000 + €60,000 per annum (minimum)

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 2016 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.

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. Additionally National University of Ireland Galway (NUIG) will deploy a float within an eddy feature on the 2016 transatlantic cruise to characterise the distribution of the deep scattering layer in such features over longer timescales; their data has shown there are large increases in this layer around eddy features/meanders in the North Atlantic Current. The 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 2016.

Report on the Italian Argo Program for 2015

1. The status of implementation (major achievements and problems in 2015).

- floats deployed and their performance:

In total, **26 Italian floats** were deployed in 2015 (see Tables 1 and 2 for details). These floats were 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 some have Argos telemetry (Apex).

Two floats were deployed in the Black Sea and 14 units were released in the Mediterranean (Table 1). Except for float WMO 6901844, all these instruments were still operating in early January 2016. 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 float WMO 6903174 deployed in the Malta Channel which has a diurnal cycle.

Model	WMO	Deploy date	Lat	Lon	Cycles	Last_TX date	Lat	Lon	Status*	Cycle
Provor Bio	6901862	26-Mar-2015 18:26	41.53	18.06	115	07-Jan-2016 10:35	39.58	17.96	A	5
Arvor I	6901869	22-May-2015 18:26	34.21	24.85	46	09-Jan-2016 00:20	34.64	25.55	A	5
Apex	6901867	26-May-2015 11:54	32.95	34.82	45	12-Jan-2016 09:05	35.54	35.80	A	5
Provor Bio	6901863	26-May-2015 16:18	36.69	20.10	54	07-Jan-2016 10:35	36.71	19.25	A	5
Provor Nut	6901866	27-May-2015 15:12	43.16	29.00	46	07-Jan-2016 09:44	43.45	30.92	A	5
Provor Bio	6901864	30-May-2015 14:59	39.21	10.87	50	07-Jan-2016 11:54	38.49	8.41	A	5
Arvor I	6901870	06-Aug-2015 14:53	37.28	11.50	158	12-Jan-2016 00:41	0.00	0.00	ANP	5
Apex	6903172	29-Aug-2015 06:22	42.00	10.03	27	12-Jan-2016 08:14	41.00	12.80	A	5
Apex	6903173	29-Aug-2015 23:15	39.78	11.88	27	08-Jan-2016 09:36	39.54	12.18	A	5
Nova	6903177	02-Oct-2015 23:15	40.82	1.99	20	10-Jan-2016 02:10	38.87	2.09	A	5
Dova	6903178	30-Oct-2015 14:08	41.74	17.69	21	10-Jan-2016 02:41	42.28	17.94	A	5
Apex	6903175	15-Nov-2015 15:28	33.01	30.69	12	11-Jan-2016 04:10	33.21	30.37	A	5
Apex	6903176	15-Nov-2015 20:55	32.34	31.56	12	11-Jan-2016 08:37	32.32	32.02	A	5
Arvor I	6901844	24-Nov-2015 00:19	33.61	34.02	0	24-Nov-2015 00:19	33.62	34.02	D	-
Arvor I	6901834	25-Nov-2015 06:55	43.16	28.99	9	11-Jan-2016 00:09	41.65	30.12	A	5
Nova	6903174	14-Dec-2015 10:35	36.23	14.58	29	12-Jan-2016 04:12	36.25	14.63	A	1

**Status in early January 2016: A = active, D = dead; ANP = active without positions.*

Table 1. Status information for the 16 Italian floats deployed in the Mediterranean and Black Seas (grey rows) during 2015.

Most floats were deployed from research vessels of opportunity (i.e., R/V Minerva, R/V Tethys II and R/V OGS Explora for the Mediterranean and R/V Akademik for the Black Sea) with the help of colleagues from Italy, France and Bulgaria. One float was deployed from a commercial ship of opportunity in the Levantine basin with the help of a Cypriot colleague. Three floats were deployed from boats of opportunity (M/Y Alegria and M/Y Morning Glory) with the help of the International Seakeeper Society.

Three floats equipped with biogeochemical and optical sensors (Provor Bio) were deployed in the southern Adriatic, northern Ionian and southern Tyrrhenian Sea. The Provor Bio 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 (Sea-Bird 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).

One NOVA float equipped with SBE 63 optical dissolved oxygen sensor (also called DOVA) was deployed in the southern Adriatic in late October 2015.

One Provor Nut float was deployed in the western Black Sea (WMO 6901866). The Provor Nut float is a Provor Bio float with additional sensors: an Aanderaa optode oxygen sensor and a SUNA nitrate sensor. The firmware of this float was modified to be able to measure (and also transmit to the satellite) simultaneously nitrate and hydrogen sulphide concentrations.

One Provor Nut WMO 6901865 deployed in the southern Adriatic on 18 February 2014 was recovered at sea by French collaborators during a cruise on the R/V Tethys II. The float appeared in excellent condition after 15 months at sea. This float was sent back to the manufacturer (NKE) for refurbishing and it will be re-deployed in 2016.

Ten Italian floats were deployed in the South Pacific and the Pacific sector of the Southern Ocean (Table 2) with the help of Italian colleagues onboard the South Korean R/V Araon. These floats included 5 Arvor floats from NKE and 5 Apex floats from Teledyne Webb Research. 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. Out of the ten floats deployed in the Southern Ocean, seven units were still operational in January 2016.

Model	WMO	Deploy date	Lat	Lon	Cycles	Last_TX date	Lat	Lon	Status*	Cycle
Apex	6901875	03-Jan-2015 02:27	-51.01	163.01	38	09-Jan-2016 02:01	-50.81	190.29	A	10
Arvor I	6901843	03-Jan-2015 06:50	-52.01	163.18	37	09-Jan-2016 23:59	-50.27	-162.46	A	10
Arvor I	6901841	03-Jan-2015 11:05	-53.01	163.05	37	10-Jan-2016 00:05	-52.98	-171.05	A	10
Arvor I	6901840	03-Jan-2015 20:50	-55.00	162.85	37	09-Jan-2016 23:57	-51.06	-158.03	A	10
Apex	6901871	04-Jan-2015 00:00	-56.00	162.79	0	04-Jan-2015 00:00	0.00	0.00	D	-
Apex	6901872	04-Jan-2015 09:29	-58.01	162.69	38	10-Jan-2016 12:37	-60.29	185.54	A	10
Apex	6901873	04-Jan-2015 19:47	-60.01	162.59	15	26-May-2015 05:22	-64.59	182.36	D	10
Apex	6901874	06-Jan-2015 01:14	-61.01	157.31	36	12-Jan-2016 07:58	-63.35	189.37	A	10
Arvor I	6901842	06-Jan-2015 09:42	-62.00	158.48	16	17-Jun-2015 09:36	-64.27	173.38	D	10
Arvor I	6901838	06-Jan-2015 18:16	-63.00	159.69	36	03-Jan-2016 00:09	-64.81	-173.25	A	10

**Status in early January 2016: A = active, D = dead; ANP = active without positions.*

Table 2. Status information for the 10 Italian floats deployed in the Southern Ocean during 2015.

Since 18 February 2012, a total of 81 Italian floats have been deployed. In less than 4 years, they have provided about 7000 CTD profiles. The temporal evolution of the number of active floats is shown in Fig. 1 with weekly resolution, along with the annual numbers of float deployments and float deaths for the period 2012-2015. It is seen that after the significant increase in float population in 2012-2014, the network tends to stabilize around 50 active instruments.

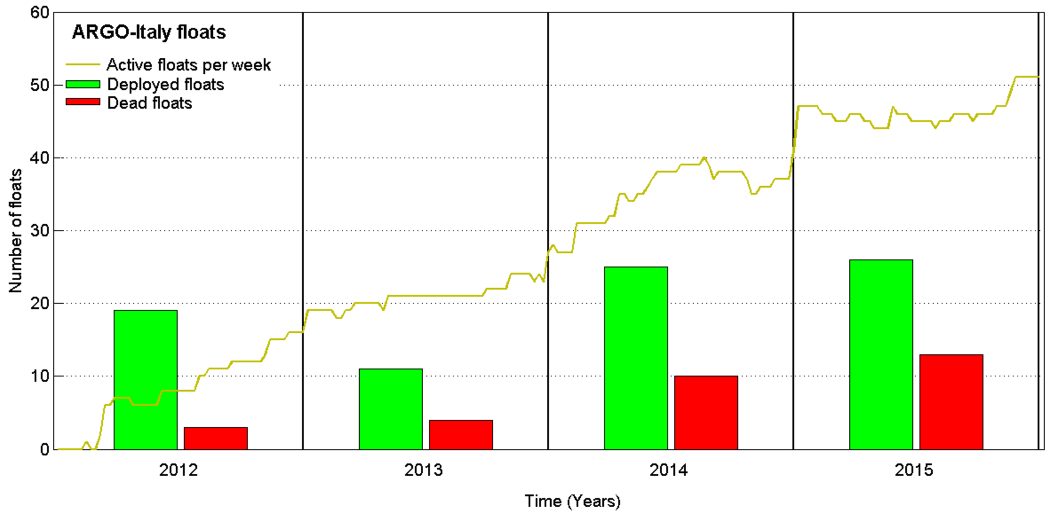

Figure 1. Temporal evolution of the number of active floats with weekly resolution and histogram of the annual float deployments and losses.

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

Float WMO 6901870 deployed in the Tyrrhenian Sea on 6 August 2015 suffered a malfunction from the beginning. It cycled, collected profile data and transmitted the data correctly but unfortunately there was a problem with the GPS and no positions for the profiles are available.

Float WMO 6901834 was deployed on 24 November 2015 from a commercial container ship transiting between Limassol in Cyprus and Haifa in Israel. Unfortunately the float stopped functioning right after deployment and no data are available from it. The cause of this failure has still to be investigated.

Float WMO 6901871 failed right after deployment for reasons still to be investigated.

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

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.

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

The delayed mode quality control (DMQC) of the Mediterranean physical data provided by the Italian floats was done for 27 floats (16 D-files sent to Coriolis, 11 D-files not yet sent). OGS will continue this activity in 2016 and beyond as part of the Copernicus CMEMS and MOCCA projects. Note that OGS is responsible for the DMQC of all the floats operated in the Mediterranean Sea. The temperature and salinity data of 178 Mediterranean floats (over a total of 282 floats; 210 dead and 72 alive floats) have been quality controlled following the standard Argo procedure, covering the period 2000-2015.

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 22 floats in 2015, including 5 instruments with dissolved oxygen sensors and 2 deep floats (4000 dbar). In addition, the Italian human resources per year devoted to Argo-Italy amounts to about 50 man-months for technical, administrative and scientific personnel involved in the project in 2015. It is expected that the same level will be maintained in 2016, including the procurement of 12 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 2016 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 are detailed in Table 3. The main areas of interest are the Mediterranean and Black seas and the Southern Ocean.

Year	Floats with T/S		Floats with biogeochemical sensors		Total
	Quantity	Area	Quantity	Area	
2016	15 2 15	Mediterranean Black Sea Southern Ocean	2 1	Mediterranean Black Sea	**35**
2017	15 2 15	Mediterranean Black Sea Southern Ocean	2 1	Mediterranean Black Sea	**35**

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

OGS is committed to carry out the DMQC on all the Argo floats of the Mediterranean Sea as part of the Copernicus 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 (alongside 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). 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), climate monitoring and on how they are applied in ocean models, with particular focus to the Mediterranean Sea.

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 2014.

N/A

7. Italian contribution to Argo bibliography in 2015.

Kovacevic V., Ursella L., Gacic M., Notarstefano G., Menna M., Bensi M. and P.-M. Poulain (2015). On the Ionian thermohaline properties and circulation in 2010-2013 as measured by Argo floats, Acta Adriat., 56(1): 97 - 114, 2015.

Dobricic, S., C. K. Wikle, R. F. Milliff, N. Pinardi, and L. M. Berliner (2015) Assimilation of oceanographic observations with estimates of vertical background-error covariances by a Bayesian hierarchical model, Q. J. R. Meteorol. Soc., 141(686), 182-194, http://dx.doi.org/10.1002/qj.2348

Lavigne, H., D'Ortenzio, F., Ribera D'Alcalà, M., Claustre, H., Sauzède, R., and Gacic, M. (2015) On the vertical distribution of the chlorophyll a concentration in the Mediterranean Sea: a basin-scale and seasonal approach, Biogeosciences, 12, 5021-5039, doi:10.5194/bg-12-5021-2015.

Pinardi, N., et al. (2015) Mediterranean Sea large-scale low-frequency ocean variability and water mass formation rates from 1987 to 2007: A retrospective analysis, Prog. Oceanogr., 132, 318-332, http://dx.doi.org/10.1016/j.pocean.2013.11.003

Tonani, M., et al. (2015) Status and future of global and regional ocean prediction systems, J. Oper. Oceanogr., 8(sup2), s201-s220, http://dx.doi.org/10.1080/1755876X.2015.1049892

Japan National Report

(Submitted by Toshio Suga)

1. The Status of implementation (major achievements and problems in 2015)

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 27 Argo and Argo equivalent floats from January to December 2015: 8 ARVOR and 19 Navis floats. All the floats except one described below were deployed with the aid of R/Vs of 10 domestic organizations.

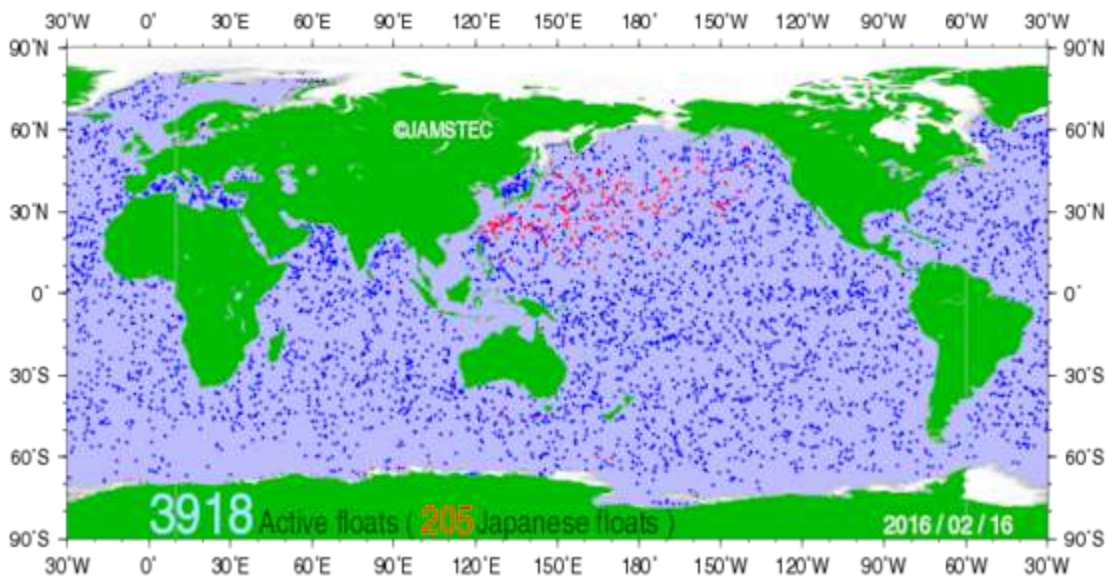

Figure 1: The distribution of active Argo floats. The red dots represent active Japanese floats.

One of JAMSTEC Navis floats were deployed by a voluntary cargo ship owned by a Japanese merchant ship company, NYK Line, in May 2015. 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. NYK Line has a lot of cargo shipping routes covering the global ocean, which is very useful to deploy Argo floats in the area of sparse float density. This is also part of environment conservation efforts of NYK Line through optimal routing owing to improvement of ocean current prediction that is benefitted from Argo.

From 1999 to the end of December 2015, JAMSTEC deployed 1105 (1130) 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: 739 (764) APEX, 141 (143) PROVOR, 112 (112) ARVOR, 33 (39) NEMO, 49 (49) Navis, 11 (11) NINJA, 12 (12) Deep NINJA, 6 (6) POPS and 2 (2) SOLO floats. As of the end of December 2015, 145 (158) floats [5 (16) APEX, 1(3) PROVOR, 92 (92) ARVOR, 42 (42) Navis, 4 (4) Deep NINJA, and 1 (1) SOLO floats] are in normal operation. The other 961 (973) floats terminated their missions, including 9 floats transmitting on the beaches after stranding or being captured by ships, 12 floats drifting at the sea surface and 10 floats recovered. JAMSTEC deployed 10 floats [5 ARVOR, 3 Navis, and 2 DeepNINJA floats) in January and February 2016.

The Japan Meteorological Agency (JMA) deployed 14 Argo equivalent floats (14 APEXs) in the seas around Japan from January to December 2015. All the floats get 2,000 dbar T/S profiles every 5 days for operational ocean analysis and forecast.

Among 206 floats (16 PROVORs, 163 APEXs and 27 ARVORs) which JMA has deployed from 2005 to 2015, 52 floats (52 APEXs) are active as of the end of December 2015, while 7 floats (7 APEXs) terminated the transmission in 2015. JMA deployed 3 APEX floats in February 2016.

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. Out of five Deep NINJA floats in operation at the beginning of 2015, three off the Budd Coast, the Antarctica lost contact from the end of June 2015, due to sea ice extension there and two survived Antarctic winter and resumed data transfer in December 2015 and January 2016. We confirmed that they have observed the Antarctic deep layer under sea ice throughout the winter. In March 2015, the data measured by these Deep NINJA floats began to be 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. 6floats (6NEMOs) are active as of end of December 2015.

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 its contribution on decadal heat content change. In 2015, we further deployed 4 Navis floats for the array as Argo floats, especially focusing on the temporal variation of surface and subsurface vertical mixing process forced by wind and surface cooling. In addition, we changed the observation frequency from normal Argo cycle (10 days) to every day for two Navis floats which were observing around the array area as normal Argo floats. The Navis floats measure temperature and salinity with fine vertical resolution (2 meters) every 1-10 days synchronizing sampling interval.

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

Four Navis floats were deployed as Argo equivalent floats in the northwestern Pacific during 2015 summer to 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, enhancing air-sea interactions. Although high resolution numerical simulation suggested that they strongly work as a trigger of changes in vertical velocity and primary production associated with phytoplankton blooming in spring, there have been no observational evidences because of a lack of detailed observation with temporally and vertically frequent measurements. The four floats were deployed diffusely to capture changeable path and location of the bomb cyclone. Their mission is to be switched to 6-hour cycle when approaching bomb cyclones are predicted in the weather forecast. Thus far the floats succeeded to capture oceanic changes during bomb cyclone passing, although some of Navis floats stopped to send correct data. The obtained data are opened and processed in real time, being available from GDACs and 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).

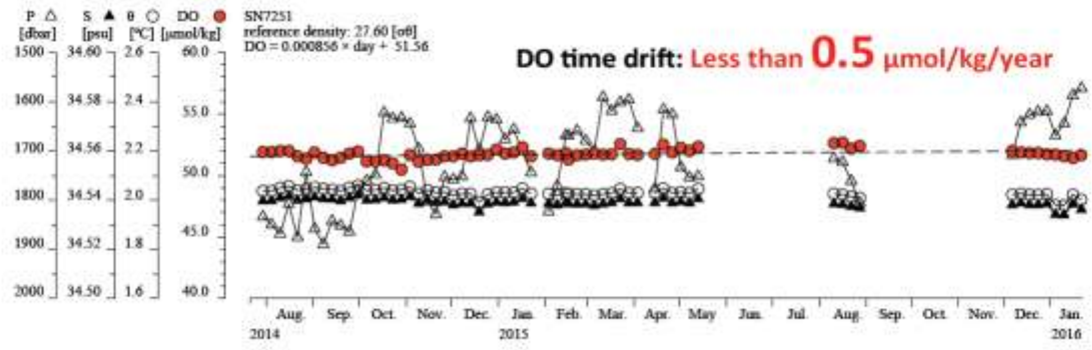

Figure 2. Time series of pressure (open triangle), salinity (filled triangle), potential temperature (open circle), and DO (red circle) recorded bu float SN7251 (WMO_ID:2902530) at a potential density of 27.6 σ_θ. The broken line represents the linear regression fitted to the DO data. Data missing period indicates that the float was drifting in shallow regions near the Hokkaido/Tohoku coast.

1.2 Technical problems encountered and solved

1.2.1 Float hardware troubles

JAMSTEC deployed 31 and 20 Navis floats as Argo floats which had been purchased in FY2013 and 2014 respectively. Eighteen of them suffered some hardware troubles, which were possible caused by pump, bulb or bladder system failure, according to the technical messages. The Navis floats with the troubles were drifting at the sea surface or not able to control their drifting or profiling depth. SBE diagnosed the troubles and judged that they were caused by manufacturer error. Following their warranty policy, SBE will deliver 7 Navis floats to JAMSTEC in 2016, and the others are now under monitoring.

1.2.2 Deep Ninja and RINKO sensor on S3A

One of two S3A floats equipped with RINKO sensor has been measuring 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 (Figure 2). We are now analyzing its DO data in detail.

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 205 active floats as of February 12, 2016. 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 been converting the meta-, prof-, tech-, and traj-files of Japanese floats, including APEX, PROVOR, ARVOR, NEMO, NOVA, Navis, NINJA, DeepNINJA and S2A, since the 15th ADMT meeting. JMA and JAMSTEC have converted almost all Japanese meta- and tech-files from v2 to v3.1 and submitted them to GDAC. JMA has converted the Rprof-files of Japanese ARGOS floats, except floats with NST sampling scheme and Iridium floats equipped with only CTD sensor. JAMSTEC has converted all v2 Dprof-files of Japanese floats to v3.1 and submitted them to GDAC.

JMA is working on coding conversion programs for traj-files. No Japanese v3.1 traj-files were sent to GDAC.

1.4 Status of delayed mode quality control process

JAMSTEC has submitted the delayed-mode QCed data of 95,423 profiles to GDACs as of December 2015. JAMSTEC could not submit new delayed-mode QCed profile file of Japanese floats during 2015, because JAMSTEC spent a lot of time converting meta- and Dprof-files from v2 to v3.1.

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 operation but in the scale somewhat lower than ever before (less than 50 floats to be deployed every year with delayed-mode data management) under its new mid-term program FY2014-2018. In FY2015, since their fund for research activity including Argo is cut >20% based on the fund in FY2014, the number of deployment/purchase of Argo floats should decrease. Due to this budgetary situation, the number of technical staff devoting for delayed mode QC and PARC will decrease from 5 to 4 after FY 2015. Additional research fund for enhancement of Argo, including competitive research funding, should be sought. JMA allocates operational budget for 27 floats in FY2016.

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.

In FY 2016, JAMSTEC will deploy about 23 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. Two to four Deep Argo floats will be deployed as Argo equivalent floats in FY2015 mainly in the Pacific. To investigate response of physical/biogeochemical oceanic processes to explosive cyclones, two Navis floats with CTD sensor (SBE Inc.) will be deployed as Argo equivalent floats along winter-time storm track in the western North Pacific, based on competitive research funding. Since several Japanese scientists are applying for competitive research funding to purchase Argo floats, deep floats and bio Argo floats, the number of floats to be deployed in FY2015 may be increased.

JMA plans to deploy 27 Argo equivalent floats around Japan in FY2016 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://ds.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. Users can select profiles even if they have bad flags of our checks. The dataset is provided not only netCDF but also ascii formats for users who are unfamiliar with netCDF format. 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 23 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 532 CTD casts conducted by JMA in the western North Pacific from November 2014 to July 2015 were uploaded to the CCHDO website.

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National Report on Argo-2015

by Republic of Korea

Deployment in 2015 and Future Plan

Korea Meteorological Administration (KMA) and Korea Institute of Ocean Science & Technology (KIOST) are involved in the International Argo Program since 2001. In 2015, KMA deployed additional 17 floats in the East Sea.(14 floats in May, 3 floats in July)

KMA has a plan to deploy 16 floats in the East/Japan Sea in August 2016. One float equipped with DO sensor will be deployed. It is expected that KMA is able to continue the float deployment.

KIOST’s strategy regarding the Argo program is under revised in terms of contribution toward the global ocean observation.

Status of Argo data management

During Jan. - Dec. 2015, 2,944 R-files of KMA were sent to GDAC. It is improvement 22% than last year.

National Fisheries Research and Development Institute (NFRDI)/Korea Oceanographic Data Center (KODC) is responsible for DMQC. NFRDI/KODC executed DMQC for 15,083 profiles (~87.8% of total profiles).

Research and operational uses of Argo data

KMA used Argo data for Impacts of Argo temperature in East Sea Regional Ocean Model with a 3D-Var Data Assimilation

Impacts of Argo temperature assimilation on the analysis fields in the East Sea is investigated by using DA-ESROM, the East Sea Regional Ocean Model with a 3-dimensional variational assimilation module. Namely, we produced analysis fields in 2009, in which temperature profiles, sea surface temperature and sea surface height anomaly were assimilated and carried out additional experiment by withdrawing Argo temperature data. When comparing both experimental results using assimilated temperature profiles, RMSE of the Exp. AllDa is generally lower than the Exp. NoArgo. In particular, the Argo impacts are large in the subsurface layer, showing the RMSE difference of about 0.5℃. Based on the observations of 14 surface drifters, Argo impacts on the currents along the drifter positions are improved fields in the surface layer are investigated. In general, surface currents along the drifter positions are improved in the Exp. AllDa, and large RMSE differences between both experiments are found in drifters which observed longer period in the southern region where Argo density was high. On the other hand, Argo impacts on the SST fields are negligible, and it is considered that SST assimilation with 1-day interval has dominant effects. Similar to the difference of surface current fields between both experiments, SSH field also reveal significant difference in the southern East Sea, for example the southwestern Yamato Basin where anti cyclonic circulation develops. The comparison of SSH fields implies that SSH assimilation does not correct the SSH difference caused by withdrawing Argo data. Thus Argo assimilation has an important role to reproduce meso-scale circulation features in the East Sea.

Web pages

KMA is operating the Argo Korea Web site. The URL is:
http://argo.nimr.go.kr/

Status of Argo Norway, March 2016

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. Three floats were deployed in 2002, six floats in 2003, two floats in 2006 that included oxygen and fluorescence sensors, and four floats in 2010 that also included oxygen and fluorescence sensors. In 2013 two floats were deployed in the Norwegian Sea that included oxygen and fluorescence sensors, in 2014 six floats were deployed, two in the Irminger Sea that include oxygen and four in the Norwegian Sea that included oxygen and fluorescence sensors. In 2016 two floats have already been 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. At present Argo Norway have seven active floats. Figure 1 shows the number of Argo floats deployed in the Nordic Seas for the different years and number of profiles taken each year. Numbers of deployed floats each year have been irregular, ranging from 2 to nearly 30. Numbers of profiles taken each year have been steady around 1600-1800 the last years.

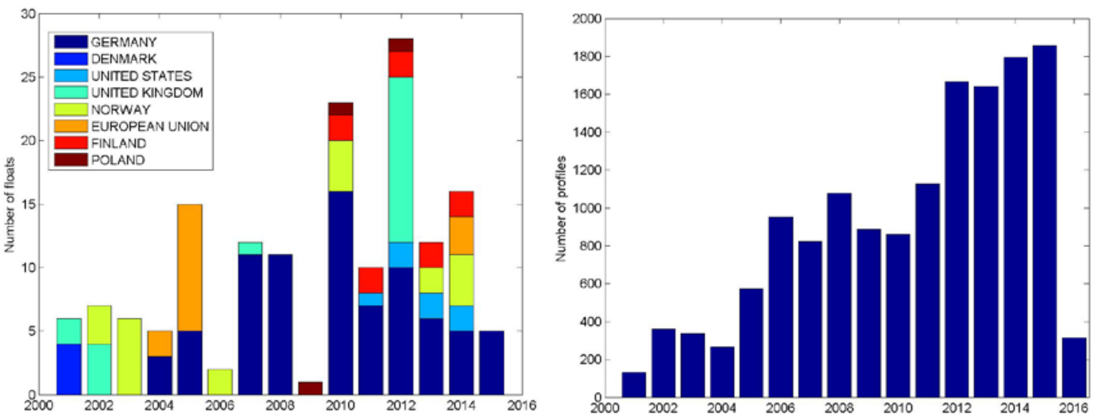

Figure 1. Left: Number of Argo floats deployed in the Nordic Seas. Right: Number of taken profiles in the Nordic Seas (updated 1. March 2016).

Delayed mode quality control

Regarding the “Delayed mode” Argo Germany do 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 was 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 Argo Norway will in 2016 submit a new proposal to the Norwegian Research Council for long-term funding of Argo floats.

3. Summary of deployment plans

In 2016 we have deployed two Argo (APEX) floats in the Norwegian Sea; one standard and one including dissolved oxygen and fluorescence+backscatter sensors. Additional one APEX Electro Magnetic (EM) float will be deployed summer 2016 in the Norwegian Sea. Estimates of future deployments (from 2017) are three floats per year in the Nordic Seas. Some of these floats might include additional sensors (e.g., oxygen and fluorescence sensors) dependent on the funding.

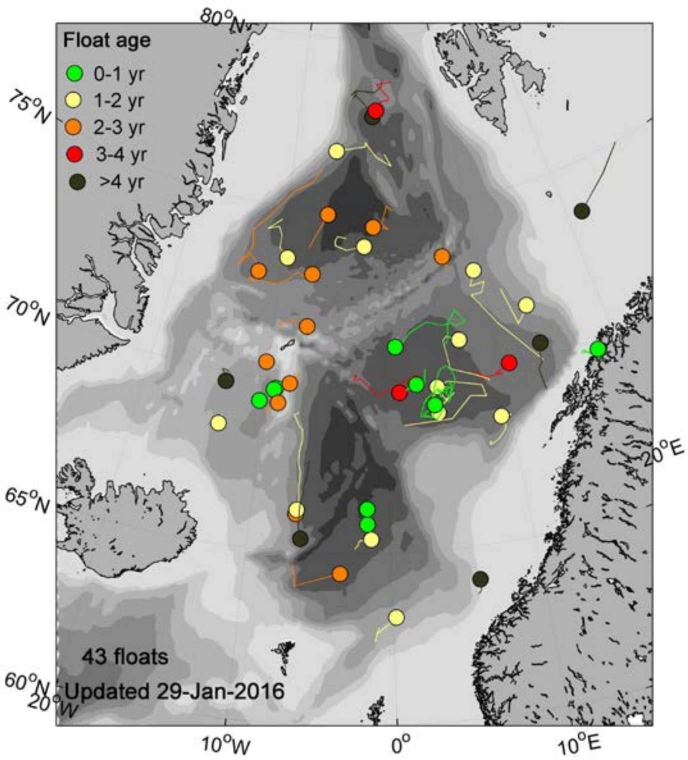

Figure 2. Active Argo floats within the Nordic Seas, updated 29th January 2016. The colours indicate age in years while the thin lines (for some floats) are the drift over the last 2 months.

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 2015

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 ten Argo floats in the Nordic Seas: two in June 2009 and 2010, one in July 2012, two in July 2014.

Three Argo floats (WMO 6902038, 6902039, 6902040) were deployed in the Norwegian Sea from the board of r/v Horyzont II in September 2015. All instruments are the APEX floats with Argos transmission system. The floats are still operating at the middle of February 2016. The parking depth is set at 1000 dbars and profiling depth at 2000 dbars. They all have cycles of 5 days. Fortunately, there were no technical problems with the three instruments. Every float has sent 28 complete sets of hydrographic data by February.

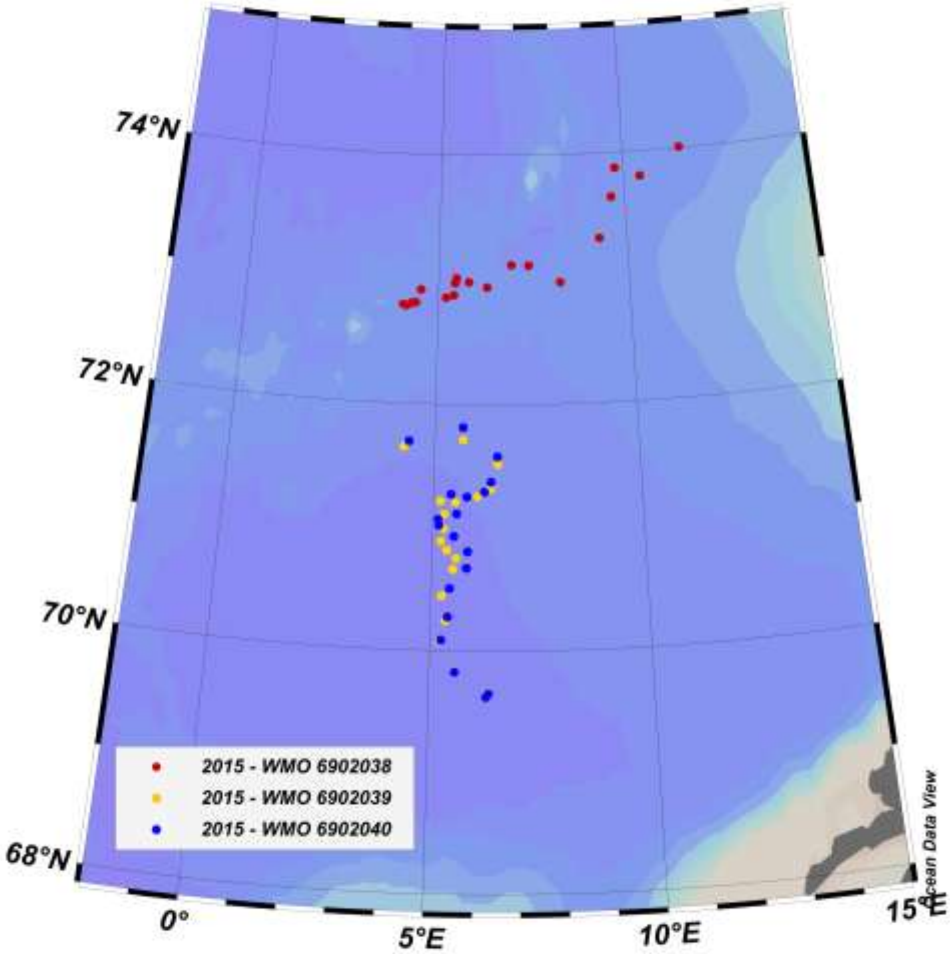

Figure 1. Surface position of three Argo floats deployed in the Norwegian Sea in September 2015.

The float deployed in May 2014 (WMO 6902042) was also active during the whole 2015 year. Unfortunately, the instrument stopped transmission of data on the 03th January 2016, probably due to drifting under the sea ice. During its whole operating time, the float has been sent 121 complete sets of hydrographic data from the Fram Strait region.

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

Poland is an observer in the EuroArgo ERIC consortium. Polish government (Ministry of Science and Higher Education) pays yearly fee for the E-A ERIC. In 2015 Institute of Oceanology PAS received a grant that enabled purchase of 7 Argo floats. Three of them were deployed in 2015, three will be deployed in 2016. Currently we do not get money for data transmission and processing, travel costs etc. Negotiations with ministry are in progress, we hope to develop a system allowing for wider activities. Our ambition is to be a full member of the Euro-Argo ERIC and work in international ARGO structures more actively. We also plan to introduce (basic on Finland experiences) Argo floats at the Baltic Sea. The development works in cooperation with other entities are planned.

3. Summary of deployment plans

Poland committed to launching three Argo floats per year. In 2015 we deployed 3 floats at the Norwegian Sea. In 2016 we plan to deploy 3 floats: two in the Nordic Seas region and one at the Baltic Sea. Plans for 2017 and later will be known after finalizing negotiations with the founding institution (Ministry of Science and Higher Education).

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

For 20 years IOPAS carries the scientific program aimed at investigation of the Atlantic Water inflow into the Arctic Ocean and climatic aspect of this process. 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 supports this research, in particular those concerning the advection of the warm Atlantic Water through the Nordic Seas. The Argo results are compared with data from standard *in situ* measurements, used in calculation of the signal propagation velocities, current pathways.
All the data are transmitted to the CORIOLIS center.
In the future we are going to use Argo floats at the Baltic Sea to investigate hydrography of the Polish zone and currents pattern.

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. 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.

In 2015 Polish floats were deployed from the Maritime Academy training ship and CTD was not made. IOPAS can provide the 2015 CTD data from the Nordic Seas after placed in the IOPAS database and publication.

7. The Argo bibliography

There were no published scientific articles in the past year. There were also no PhD theses using the Argo data completed neither.

Argo National Report – South Africa

Report to Argo Steering Team Meeting: March 2016

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, Bayworld Centre for Research and Education (BCRE), 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), the Research Schooner *Lady Amber* and the Nansen-Tutu Centre for Marine Environmental Research.

1. **Status of implementation (major achievements and problems in 2015):**

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

   Southern Ocean and South Atlantic Ocean:

   SAMBA Mooring Cruise – December 2015

   4 APEX floats: UK Met Office with DEA and SAEON

   (serial #'s: 7345, 7346, 7347, 7348)

   SANAE Cruise (RV SA *Agulhas II*) – November 2015-February 2016

   4 NOVA and 1 DOVA floats from the Argo-Italy program.

   WMO numbers: 3002340 - 063609390/ 063606400/ 62787180/ 62785180/ 62788170

   Indian Ocean:

   None

   Technical issues encountered and solved:

   No updates on the issues reported on in AST-16 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:**

<u>Southern Ocean:</u>

Marion Island Cruise (RV SA *Agulhas II*) – April/May 2016.

This cruise follows the CrossRoads Transect on Figure 1.

available for deployment assistance

Gough Island Cruise (RV SA *Agulhas II*) – September 2016. .

This cruise follows the SAMBA Transect on Figure 1.

available for deployment assistance

SANAE Cruise (RV SA *Agulhas II*) – December 2016 / January 2017.

This cruise follows the GoodHope Transect on Figure 1.

available for deployment assistance

<u>Indian Ocean:</u>

Agulhas System Climate Array (ASCA) deployment cruise – April 2016.

Refer to Figure 1 for positions.

4 APEX floats deployed on behalf of UK Met Office in to the Agulhas Current

ACEP Deep Secrets Cruise (RV *Algoa*) – September - October 2016.

This cruise will take place on the south coast of South Africa between Cape Town and Port Elizabeth.

available for deployment assistance

ACEP Transkei Coast Cruise (RV *Algoa*) – January – February 2017

This cruise will take place between Port Elizabeth and Durban in the Agulhas Current.

available for deployment assistance

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. The Research Schooner *Lady Amber* will also be taking part in these expeditions and her contact details are found below.

Atlantic Ocean:

SAMBA Mooring Array (RV *Algoa*) – September 2015.

Refer to Figure 1 for positions.

available for deployment assistance

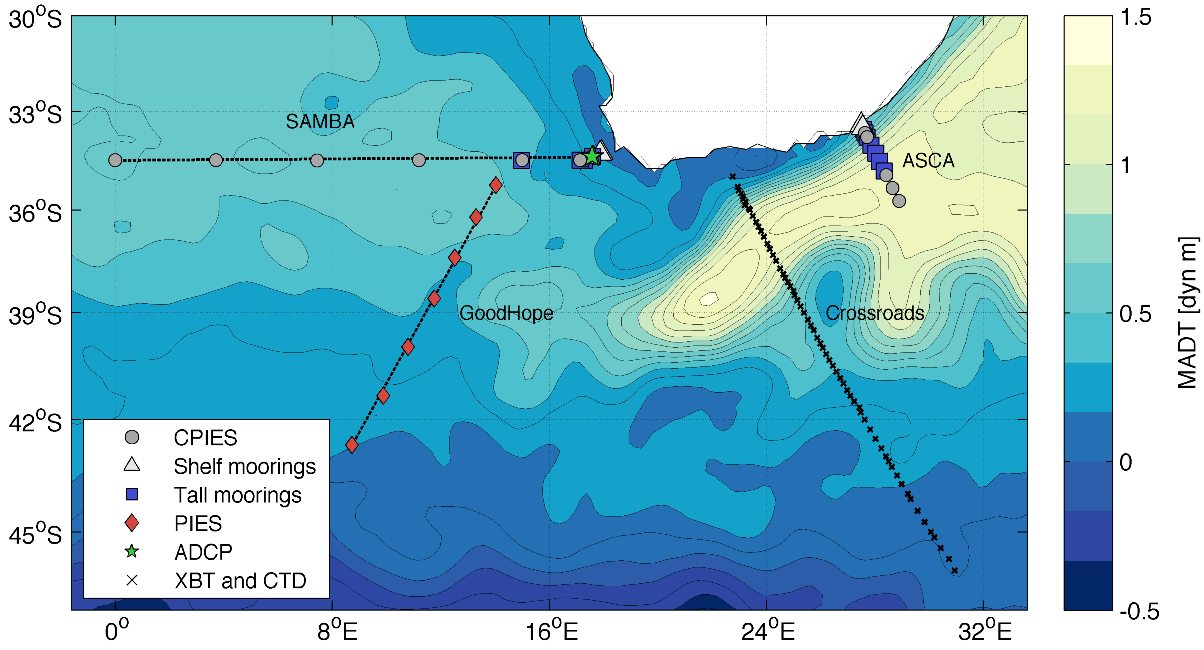

Figure 1: Large mooring array and CroosRoads transects around South Africa where floats could be deployed if available.

Pacific Ocean: 2016-2017 (future plans):

The Research Schooner *Lady Amber* will be working with NASA from April 2016 to August 2017 on the Salinity Processes Upper-ocean Regional Study (SPURS-2) Experiment around 10° N and 125° W. There could be opportunities here to deploy Argo floats within the Pacific Ocean but also en route to and from the study region.

Contact: Capt. Peter Flanagan on explorerstrust_uk@yahoo.co.uk

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) SOSCEx III:

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

SOSCEX III 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. To this end we will be publishing the more detailed SOSCEX III White Paper and focusing on linking up with the US based SOCOM initiative (using floats as central platforms) as well as inviting graduate student participation from Mozambique, Namibia and Zimbabwe.

Please refer to Appendix 1 for further information.

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) 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.

In 2015 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

The four floats arriving for the ASCA cruise in April 2016 will also be "adopted" by the schools themselves to monitor in near-real time as ongoing school projects this year. Each school will get 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 April will be documented for the schools and they will be notified by email so they can begin their projects and monitor how the floats behave in particular within the Agulhas Current.

e) Educational Outreach – The Research Schooner *Lady Amber*:

Capt Peter Flanagan

Continued effort is being made by Capt. Flanagan and his crew from the Research Schooner *Lady Amber* to bring awareness of the Argo program to secondary schools. Most notably in collaboration with the GLOBE project out of Mossel Bay.

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.

The following cruises were loaded onto the CLIVAR + Carbon Hydrographic Data Office (CCHDO) website for Argo data validation (please refer to Figure 1 above for transect placements):

- ASCA Mooring cruise – April 2015 data
- SAMBA Mooring cruise – December 2015 data
- CrossRoads Transect – April / May 2013
- CrossRoads Transect – April / May 2014
- CrossRoads Transect – April / May 2015

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.

APPENDIX 1:

The 3rd Southern Ocean Seasonal Cycle Experiment (SOSCEx III)

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

Ocean Systems & Climate – CSIR, 15 Lower Hope Street, Rosebank 7700, South Africa

Email: pmonteir@csir.co.za

Introduction

Strategic Context

SOSCEX III 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. To this end we will be publishing the more detailed SOSCEX III White Paper and focusing on linking up with the US based SOCOM initiative (using floats as central platforms) as well as inviting graduate student participation from Mozambique, Namibia and Zimbabwe.

Science Context

The Southern Ocean is a key component of the earth system, being responsible for 50% of ocean uptake of atmospheric CO_2 and 30% of carbon export flux to the deep ocean (Schlitzer et al., 2002, Majkut et al., 2014). Climate models and decadal data sets predict changes in the Earth's climate that will influence the effectiveness of the Southern Ocean CO_2 sink through adjustments to sea surface temperature, stratification and mixing (Boyd 2002), all of which affect the nutrient and light supply necessary for phytoplankton production (and associated carbon export). The challenge in predicting long term trends in the Southern Ocean carbon cycle lies in our ability to resolve interannual variability and the link between seasonal and intraseasonal dynamics in physical drivers and biogeochemical responses. Despite their importance, surface ocean processes at these scales are poorly understood and quantified due to operational limitations of ships and moorings. This has necessitated the use of autonomous, remotely sensed and modeling platforms that are able to address the temporal and spatial scale gaps in our knowledge of a hitherto under sampled ocean.

Aims

- **Understanding through seasonal scale observations, the role of fine scale upper ocean physical dynamics on CO_2 fluxes and primary production in the Southern Ocean and its impact on large-scale carbon-climate sensitivities.**
- **To make a significant contribution to improving the way global climate models reflect CO_2 and primary productivity climate sensitivities in the Southern Ocean.**

Approach

A novel aspect of SOSCEx III is the integrated multi-platform approach, which aims to explore new questions about the climate sensitivity of carbon and ecosystem dynamics and how these processes are parameterized in models.

1. **Observational**
   The observational approach employs the research ship together with robotics-based continuous year-round, high-resolution observations of the upper ocean. The primary objective is to understand how meso- to sub-mesoscale features (eddies and fronts) interact with seasonal to subseasonal scales (heating & transient storms) to characterize the seasonal cycle of upper ocean mixed layer depth, CO_2 fluxes Fe and light availability, primary production and associated carbon export.
2. **Modelling**
   A hierarchy of medium to ultra-high resolution forced ocean model domains (NEMO-PISCES) will be used to test our understanding of the links between surface boundary layer physical drivers and the biogeochemical response scales, especially in terms of air-sea CO_2 fluxes, ocean productivity and associated carbon export.

Cruise Plan

The observation plans are centered on three seasonal ship-based cruises of the Atlantic Sub-Antarctic Southern Ocean in winter 2015, summer 2015 and autumn 2016 spanned by continuous high resolution robotics-based observations. The primary aims of each cruise and required ship time are summarized below:

1. **Winter**

- Description: Date: July – August 2015; Cape Town to 55°S along GoodHope Line; Ship time: 21 Days; Berth requirements: 20
- Aim 1. Two process stations in the SAZ with twinned glider deployments - surface wave glider and sub-surface buoyancy glider.
- Aim 2. CTD deployments at each process station to provide a) winter Fe profile, b) biogeochemical measurements to characterize the plankton community and rates of production and c) necessary calibrations for the gliders.

2. **Summer**
   Leg 1

- Description: Date: November - December 2015; Cape Town to Antarctica along GoodHope Line on SANAE 55; Ship stopping time: 4 Days; Berth requirements: 10
- Aim 1. Swap out buoyancy gliders and retrieve wave gliders (for overhaul and refurbishment) at both process stations in the SAZ
- Aim 2. CTD deployments at each process station to provide a) early summer Fe profile, b) necessary calibrations for the gliders.

Leg 2

- Description: Date: December 2015 - January 2016; Cape Town to 55°S along GoodHope Line; Ship time: 35 Days; Berth requirements: 25
- Aim 1. Redeployment of wave gliders at two process stations in SAZ to continue twinned sampling above of the buoyancy gliders.
- Aim 2: Ship alternates sampling between two process stations for 21 days (sampling each every alternate day) to measure meso and sub mesoscale evolution of physical, chemical and biological response to sub seasonal storm event.
- Aim 3. Deployment of Lagrangian bio-optics floats at each process station that continue sampling the SAZ till autumn 2016 completing a full seasonal cycle.

- Aim 3. CTD deployments at each process station to provide a) summer Fe profiles, b) time evolution of biogeochemical parameters, c) necessary calibrations for the gliders and floats.

Leg 3

- Description: Date: January - February 2015; Antarctica to Cape Town along GoodHope Line on SANAE 55 return voyage; Ship stopping time: 4 Days; Berth requirements: 10
- Aim 1. CTD deployments at each process station to provide a) late summer Fe profile, b) necessary calibrations for the gliders and floats.
- Aim 2. Retrieval of all buoyancy and wave-gliders at both process stations (floats continue sampling)

3. Autumn

- Description: Date: April – May 2016; Cape Town to Marion Island to 55^{o}S to bio-optics float locations; Ship time: 10 Days; Berth requirements: 10
- Aim 1. CTD deployments at both Lagrangian bio-optics float locations to calibrate float sensors.
- Aim 2. Retrieval of both bio-optics floats.

List of critical requirements

- The redesign of the intake system of the scientific sea water supply to prevent blockage and subsequent pump damage when the pump enters the ice (or kelp beds surrounding subantarctic islands), such that oceanographic research can take place in the marginal ice zone (which dominates the time and spatial coverage of the SA Agulhas II on all SANAE voyages).
- Sufficient band width for efficient internet access particularly during glider and float deployment and retrievals.
- The use of the rubber duck (Zodiac) may be needed for float/glider retrievals, weather permitting.

Argo Spain 2015 report

Pedro Vélez-Belchí, Instituto Español de Oceanografía
Alberto González Santana, Instituto Español de Oceanografía

1. The status of implementation

The Argo Spain program began in 2003 and is currently coordinated by the *Instituto Español de Oceanografía* (IEO). Since then, 62 floats have been deployed, of which 18 were active at the end of 2015.

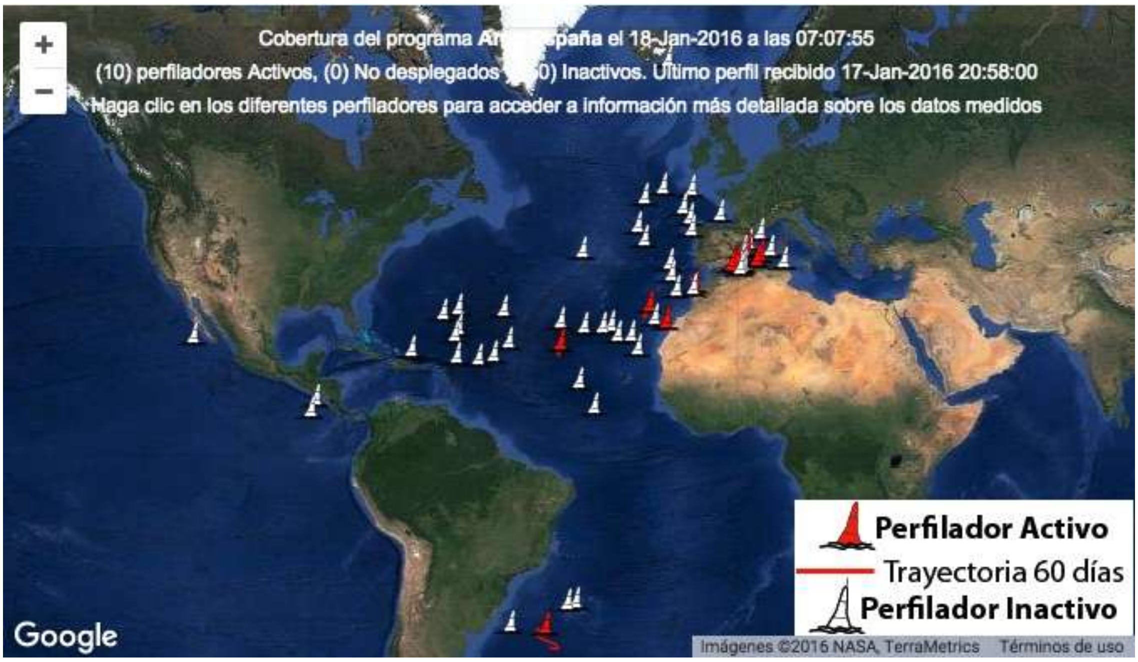

Figure 1. Status of the Argo Spain program on January 18th 2016. Altogether, 62 floats have been deployed .

- **Floats deployed and their performance**

During 2015, a total of 4 Argo floats were deployed by Spain:

- 1 Deep Arvor float (E-AIMS project) and 1 Apex float were deployed in the Eastern Atlantic by the R/V Angeles Alvariño.
- 1 Apex float was deployed in the Mediterranean Sea by SOCIB, the Coastal Ocean Observing and Forecasting System located in the Balearic Islands.

Although the funding for the purchase of the floats may come from different sources, all Argo floats deployed by Spain are managed by the Argo-Spain program, which gives support to the different contributions.

- **Technical problems encountered and solved**

No major technical problems were encountered in 2015.

- **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.

Some of the earlier floats deployed by Spain were affected by TNPD. These floats have not been yet corrected, but the corrected files will be submitted during 2016.

- **Status of delayed mode quality control process**

The delayed quality control process is underway, however it has not been submitted yet. The submission will be done during 2016 according to the information provided in the paragraph 2.

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

The Argo Spain program is actually not funded. Spain remains committed to the European contribution to Argo (Euro-Argo), however the final decision for becoming a member of Euro-Argo has not yet been taken. This decision, that will means a long-term contribution (5-10 years) to Argo, should be taken during 2016 by the Spanish Ministry of Economy.

The funding covers (and will cover) float procurement, transmission costs and part-time (1.5 man month per year) personnel support. The *Instituto Español de Oceanografía* funds the scientific coordination and the remaining personnel support of the Argo-Spain program. 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 2016.

Besides the long-term support from the Spanish Ministry of Economy, the Coastal Ocean Observing and Forecasting System located in the Balearic Islands (SOCIB) will deploy 3/4 Argo floats in the Western Mediterranean for 2016, although this funding could be extended until 2021. The Argo-Spain program also coordinates this contribution.

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

During 2016, a total of 4 floats will be deployed. Supporting the global array in the Atlantic Ocean and Mediterranean Sea is the main goal. The deployment plan has been submitted to the IAC.

Although the ultimate deployments may change following feedback from the Spanish research community, the current plan is:

- 3 floats to be deployed in the Mediterranean Sean.
- 1 Deep Float in the Eastern Atlantic

Funds are only secured for Argo deployments beyond 2016 in the Western Mediterranean Sea, with 3 floats scheduled to be deployed every year until 2021.

4. 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

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

None.

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. 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 2015. This task will be undertaken throughout 2016.

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

- Peña-Izquierdo J., Van Sebille E., Pelegrí J.L., Sprintall J., Mason E., Llanillo P., Machín F., 2015. Water mass pathways to the North Atlantic Oxygen Minimum Zone. *Journal of Geophysical Research: Oceans*, 120, 3350-3372,
- Castellanos P., Pelegrí J.L., Campos E.D., Rosell-Fieschi M., Gasser M., 2015. Response of the surface tropical Atlantic Ocean to wind forcing. *Progress in Oceanography*, 134, 271-292,
- Rosell-Fieschi M., Pelegrí J.L., Gourrion J., 2015. Zonal jets in the equatorial Atlantic Ocean. Progress in Oceanography, 130, 1-18.
- García – Lafuente J., Naranjo C., Sánchez – Leal R., Sammartino S., Bellanco M.J., Sánchez – Garrido J.C., Soto – Navarro J. On the origin of the seasonal and interanual T – S variability of the inflow through the Strait of Gibraltar, 2015. *Deep – Sea Research I*, 101, 38 – 53.

UK ARGO PROGRAMME

REPORT FOR 17TH ARGO STEERING TEAM MEETING, MARCH 2016

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

The most pressing issue for the UK programme remains on securing ongoing funding for UK Argo and, internationally, on ensuring continued delivery of data from the core Argo array. It is important 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.

A further issue is ensuring that the real-time GTS data stream, that delivers data to operational users, is successfully migrated to the BUFR format (as the use of TESAC on GTS will cease) without degrading the timeliness of delivery. Also it will be important to ensure that the BUFR format(s) continue to evolve alongside the Argo NetCDF to allow for the exchange of additional profiles (e.g. bio-geochemical variables).

Floats deployed and their performance

Floats deployed. Since 2001, over 500 UK floats have been deployed (including floats donated to Mauritius) in support of the Argo array. As can be seen from Figure 1, the number of floats purchased each year has been very 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 32 floats deployed in 2015.

With the floats deployed the number of UK floats contributing to Argo (including those provided to and deployed by Mauritius) has increased to around 135, as shown in Figure 2. However, there are a number of active floats (bio-geochemical and deep) for which data processing has not yet been set up (these are not included in Figures 2 or 3).

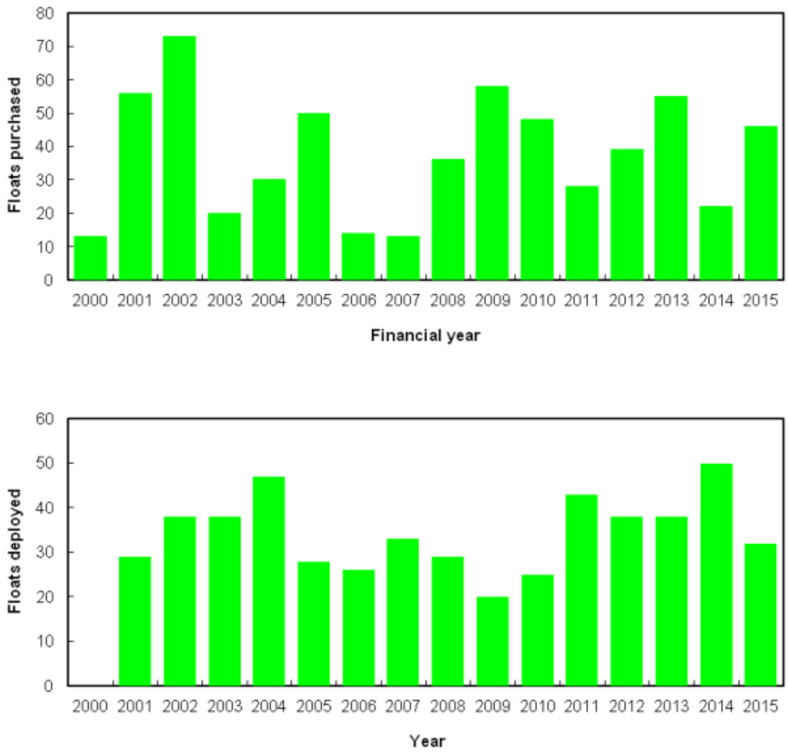

Figure 1. Showing (top) the number of floats procured each financial year (Apr-Mar) and (bottom) the number deployed in each calendar year.

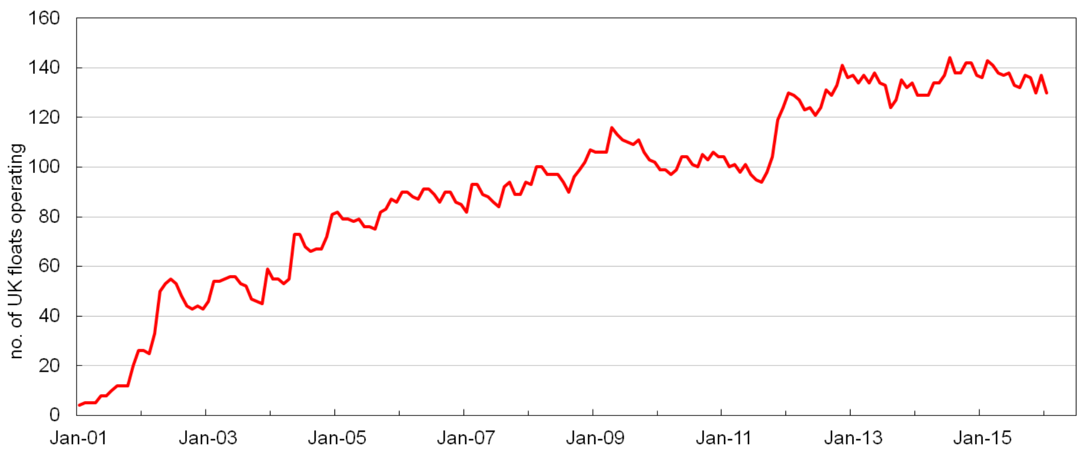

Figure 2. Number of UK (including Mauritius) floats reporting data to Argo by month.

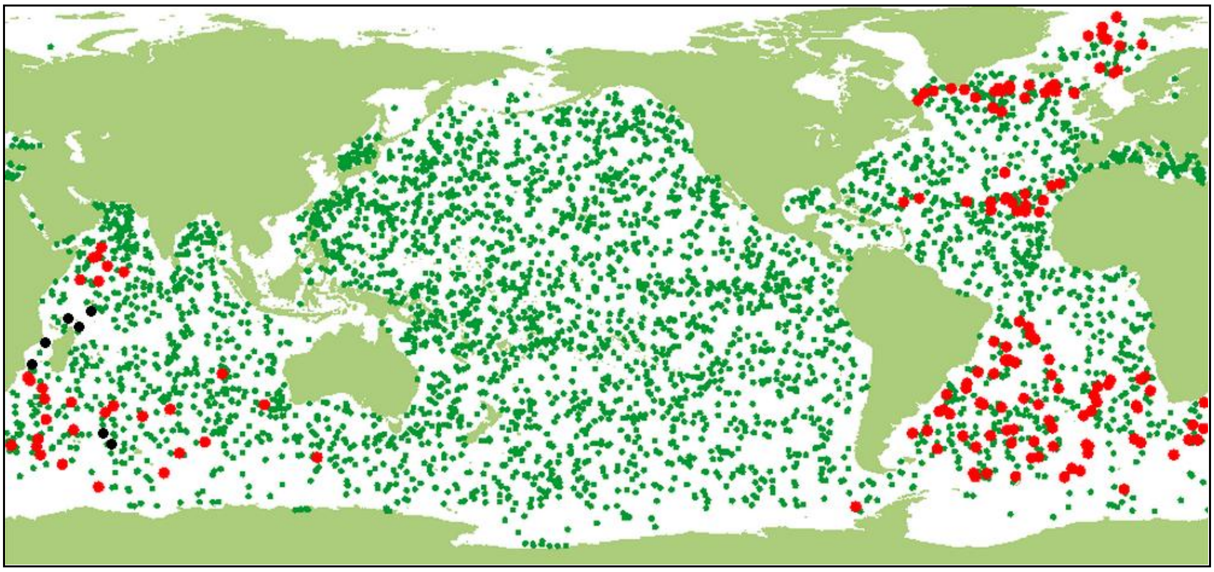

Figure 3. Showing the locations of operating UK floats (in red) and the sevenMauritius floats (black) at mid-February 2016.

<u>Float lifetime</u>. At last year's Argo Steering Team meeting it was reported that, over the past 5 years, float reliability/longevity has started to degrade in nearly all national programs (with 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. (Here the number of cycles has been normalised to 2,000m for floats that make shallower profiles, or only make intermittent deep profiles to 2,000m, where invalid profiles due to pressure transducer failure on pre-2004 floats were discounted and deployment failures omitted.) For floats deployed 2004-2006 50% of floats exceeded 160 cycles, for 2007-2009 floats 50% reached 170 cycles but for floats deployed 2010-2012 it looks (by extrapolation) as though only 50% will reach 150 cycles.

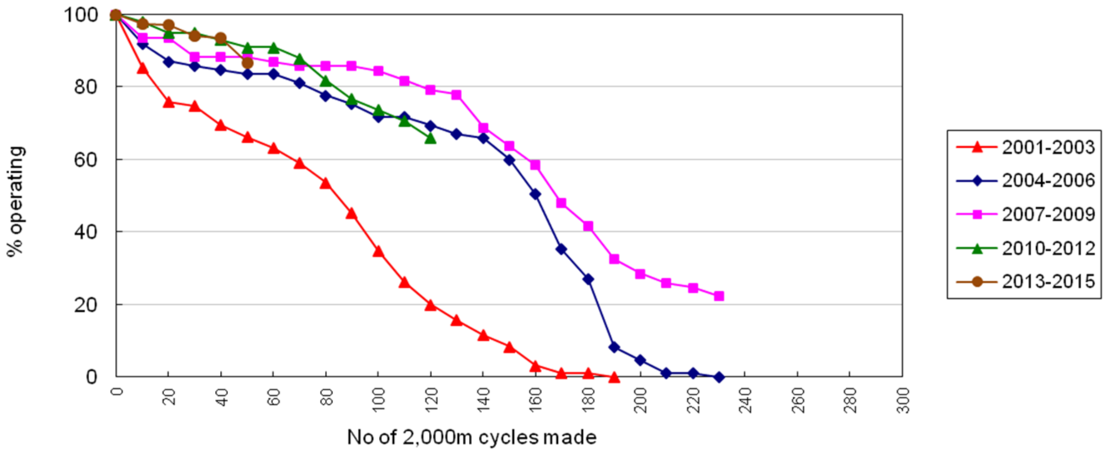

Figure 4. Number of (normalised) cycles made by UK Apex floats deployed in 2001-2003, 2004-2006, 2007-2009 and 2010-2012.

The extended lifetimes (beyond the nominal 4 years/140 cycles) of many of our floats is a result of fitting lithium batteries. Since 2007 we have fitted lithium batteries in over 50% of Apex floats deployed. Figure 5 shows lifetime figures from AIC for our floats deployed since

2007. This shows with alkaline batteries 40% of floats make 180 cycles, while with lithium batteries a significant number of floats (80%) are operating beyond 180 cycles.

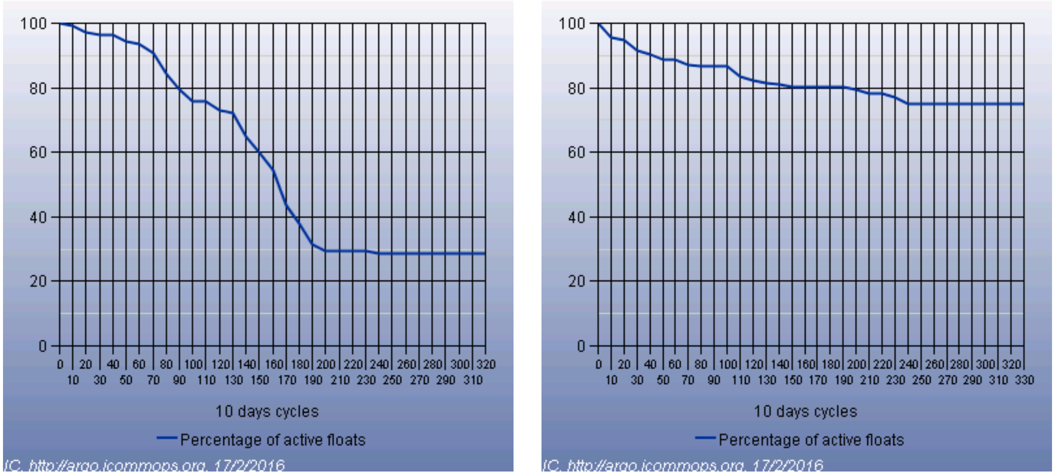

Figure 5. Number of cycles made by UK Apex floats deployed since 2007 with (left) alkaline and (right) lithium batteries.

<u>Float enhancements</u>. Following some early float losses in 2007 to ice damage, since 2008 all Southern Ocean floats have been specified with *ice-avoidance capability*. In 2008 our first Apex Argos floats with *unpumped near surface temperature measurement capability* were deployed and all our standard Apex Argos floats (other than those with ice-avoidance) now have near surface temperature capability.

Although the majority of our deployed floats use Argos for communications, we have deployed a number of Iridium floats: 17 Webb Apex, 4 Webb Apex BGC, 12 SeaBird Navis, 4 SeaBird Navis BGCi, 1 MetOcean Nova (provided free-of-charge by MetOcean), 11 NKE ProvBio floats (including 9 funded by PML), 2 Apex deep and (in early 2016) 2 deep Arvor.

As can be seen from the above we have deployed 19 bio-geochemical floats and 4 deep floats contributing to the Argo extensions (although not all of these are yet set up for processing and data delivery).

The 46 floats purchased in FY2015 includes 21 standard (Argos) Apex, 4 Apex STS, 8 SeaBird Navis with dissolved oxygen, 3 SeaBird Navis with radiometers, 4 Apex deep and 6 Apex floats with experimental RBR CTD sensors.

Outline deployment plans for 2016

So far in 2016 we have deployed 2 deep Arvor in the North Atlantic. At present planned deployments in 2016 include:

5 floats Southern Ocean (A23 line, March)
4 floats Agulhas current (ASCA cruise, April)
2 floats Somali Basin (VOS March/April)
6 floats Rockall Trough/Iceland basin (Jun) (including 2 RBR)
9 floats Bay of Bengal (BoBBLE project, Jun) (4 STS, 2 RBR and 3 SeaBird with radiometers)
2 floats North Atlantic (OSNAP cruise, July)
4-6 floats SE Atlantic (SA Agulhas, Sep)

4-10 floats S Atlantic (AMT cruise, Oct/Nov) (including 2 RBR)
2-4 floats for Mauritius

Other deployments will be arranged as opportunities arise. The aim is to deploy a minimum of 25 floats (but ideally as many as 40) during the year, including those provided to Mauritius.

Data management

The UK Argo Data Centre, which is operated by BODC and funded by NERC, processes all of our float data. BODC also handles data from Irish, Mauritian and Portuguese floats, 173 active floats in total including various Apex, Navis and Provor float models. Data from all UK floats are received at BODC by automatic download from the CLS database, JouBeh or Oberservatoire Oceanologique de Villefranche sur Mer every 12 hours and BODC endeavours to set up floats for distribution of data to the WMO GTS (Global Telecommunications System) and the Argo GDACS (Global Data Assembly Centres) within a week of notification of deployment.

During the financial year 2015-16 the focus in BODC has been on training new staff and efficiency improvements in the near-real-time data processing. This is expected to result in significant time savings for the coming year.

The UK Argo team met in February 2016 and priorities for data management for the 2016-17 financial year 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)

There is insufficient resource to complete all the tasks so available resource is to target the high priority tasks. The delayed mode quality control of bio-geochemical data is not included in the list for the coming financial year. The AtlantOS project is providing resource to begin this work in future years. Before the work can commence expertise needs identifying and international community approved guidance and tools are required.

The introduction of Argo version 3 files, although originally to handle the reconfiguration of floats that use Iridium communications, significantly increased the scope of work required to deliver BGC Argo data to the GDACs. The work necessitated a complete rewrite of the Argo file writing software. Consequently, work to do this is on-going with version 3 Argo metafiles under testing. Further to this, once version 3 files are ready the production for the GTS BUFR format will be carried out by the UK Met Office.

All delayed-mode QC on BODC hosted floats is done within BODC, who use the OW (Owens-Wong) software with latest reference data available from Coriolis (CTD climatology and Argo profile climatology) for guidance. 62.0% of UK floats profiles eligible for delayed mode QC have been processed and submitted to the GDACs in D-mode. Addressing the backlog of delayed-mode QC is the priority after real time activity in the coming financial year. This includes the training of 2 new delayed mode operators.

BODC is working to reinvigorate the activity of the Southern Ocean Argo Regional Centre (SOARC) covering the entire Southern Ocean, prioritising activities that can be supported with low-levels of resource alongside partners. The focus for SOARC is on: improving discoverability of existing resources of use to delayed-mode operators; progressing with under-ice positioning techniques; identifying additional SOARC partners and establishing an independent SOARC website. The current SOARC web presence is located at: http://www.ukargo.net/southern_ocean_argo_regional_centre/.

Scientific and operational use of Argo data

Operational oceanography. With over 85% of Argo profiles being available within 24 hours of the floats surfacing, the near real-time data are used in ocean forecasting models (see http://www.metoffice.gov.uk/research/weather/ocean-forecasting) such as the FOAM (Forecasting Ocean Assimilation Model) system run by the Met Office (Blockley et al., 2013), where Argo now provides the dominant source of in situ profiles assimilated into FOAM. Experiments have shown the impact of Argo data, as errors in the models temperature and salinity fields increase significantly when Argo data are withheld (Lea et. al., 2014). Argo data also has an impact on the Met Office's GloSea (MacLachlan et. al., 2015) seasonal forecasts (see http://www.metoffice.gov.uk/research/climate/seasonal-to-decadal) since these use FOAM to initialize the ocean part of the seasonal forecasting system. As part of the FP7 E-AIMS project work has also been carried out to assess the impact of Argo data on coupled analyses and short-range forecasts and for validation of SST analyses.

Climate monitoring. The Hadley Centre also maintains the HadGOA (sub-surface global analysis) dataset of historical temperature and salinity (see http://www.metoffice.gov.uk/research/climate/climate-monitoring/oceans-and-sea-ice). The dataset includes available Argo data and will include near real-time updates using Argo data. The dataset is used for global ocean heat content analyses.

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."

Funding

It was initially agreed in 1999 that MoD and DETR (then Defra and now DECC) would provide matching funding (through the Met Office) for UK Argo, and that NERC would also provide regular funding for support activities (e.g. data processing, science leadership) with additional capital funding for floats being provided on an opportunistic basis (e.g. via calls for proposals). The matched funding agreement collapsed in April 2010after MoD withdrew its funding. Regular funding from DECC (ex Defra) to the Met Office has also reduced, although it has been supplemented in most years with additional funding for floats. NERC has maintained regular, stable funding for support activities at NOCS and BODC, whilst funding for floats has remained variable relying largely on bids for NERC capital and year-end funds. Hence, the funding profile for UK Argo has exhibited large year-to-year variations.

For the period April 2012 to March 2015 the Met Office (Public Weather Service Programme) agreed to co-fund UK Argo with DECC and this arrangement is continuing up to the end of March 2016 (and likely to continue until at least the end March 2017). However, following the government's Comprehensive Spending Review in autumn 2015 (under which departmental spending will be reduced over the next 5 years) the level of DECC funding for Argo from April 2016 has not yet been confirmed.

It is expected that NERC will continue to fund its Argo support activities at NOCS and BODC. Previously, this was sufficient to fund real time and delayed mode activity (but no significant SOARC work). The growth in floats hosted by BODC and enhancements of Argo has increasingly put this resource under strain. For the coming financial year BODC has identified additional software developer time to begin to address the backlog of work starting with the highest priority needs.

The European funded MOCCA (hosting of real time processing of 75 Euro-Argo ERIC floats and delayed mode quality control for 38 floats for 4 years) and AtlantOS (delayed-mode QC of a subset of parameters for bio-geochemical Argo data) projects will provide funding to undertake additional data management activities for these projects but no additional funding for existing activities.

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.

USA Report to AST-17, March 2016. (Submitted by D. Roemmich)

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 deployed over 50 floats equipped with biogeochemical sensors in the Southern Ocean, and plans to increase the size of its array to 200 floats in the coming 5 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 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.

Support level:

The support level for U.S. Argo is determined on a year-to-year basis. Support levels for Core U.S. Argo have remained approximately 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 of about 1800 floats achieved since 2008. However, the present number of yearly deployments is not sufficient to maintain U.S. Argo (Fig 1). A possible augmentation by about 46 floats in 2016 (Yellow triangle in Fig 1) is under consideration to begin to mitigate this shortfall.

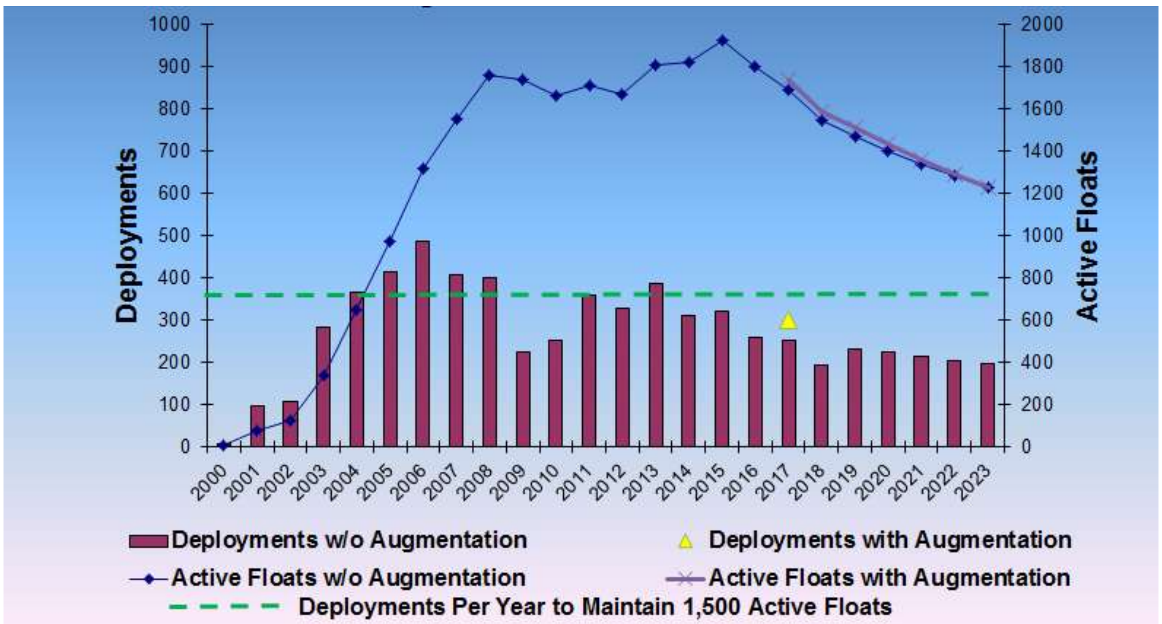

Fig. 1: *Yearly deployments by the United States Argo Program through December 2015 with and without a possible one-time, 46-float augmention in 2016. The figure also includes a projection of the number of active U.S. Argo Program floats, and of deployments based on 3.5% inflation. The number of active U.S. Argo Program floats in the Core array is projected to drop below 1,500 in 2018-19 without the augmentation and 2019-20 with the augmentation. The number of deployments necessary to maintain 1,500 active floats is 357 annually.*

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.

Since 2011, U.S. Argo has been supported for 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, including 2 Deep SOLO instruments that were deployed in June 2014 by RV Tangaroa, completing about 110 profiles each, to depths of about 5700 m, before being recovered in September 2015. Deployment of regional pilot arrays began in the SW Pacific Basin in late 2015, and is continuing in 2016 (Fig. 2). U.S. Argo was a sponsor of the international Deep Argo Implementation Workshop in May 2015.

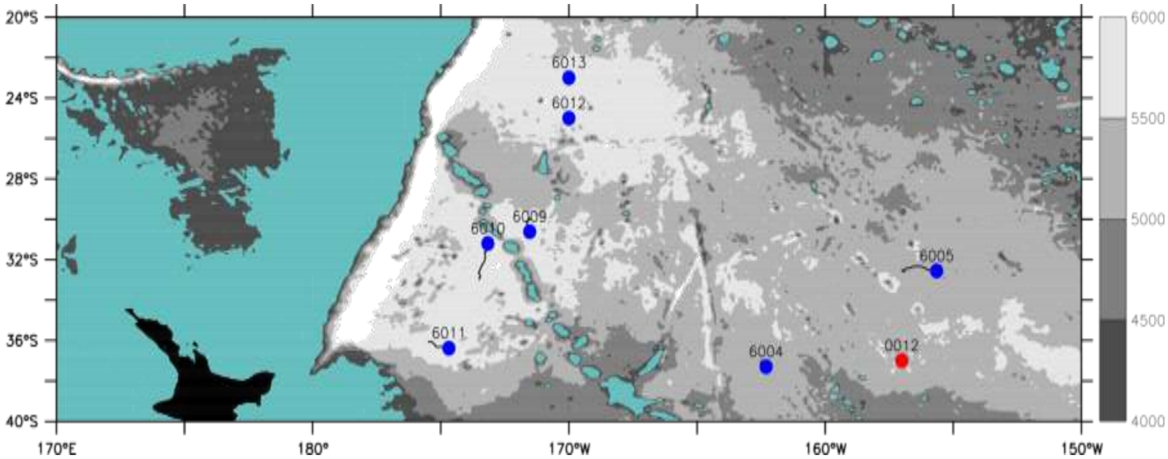

Fig 2 The SW Pacific regional Deep Argo array including Deep SOLO (blue) and Deep APEX (red) floats. Floats 6012 and 6013 will be deployed in May 2016; all others are presently active. Additional Deep Argo floats may be added to this array. See http://sio-argo.ucsd.edu/deep.html .

Status:

As of March, 2016, there are 2142 active U.S. Floats (source AIC) and these have completed an average of 152 cycles. Of the active floats (Fig 3), 1921 are provided by the U.S. Argo Program and 221 by partnering Argo-equivalent programs.

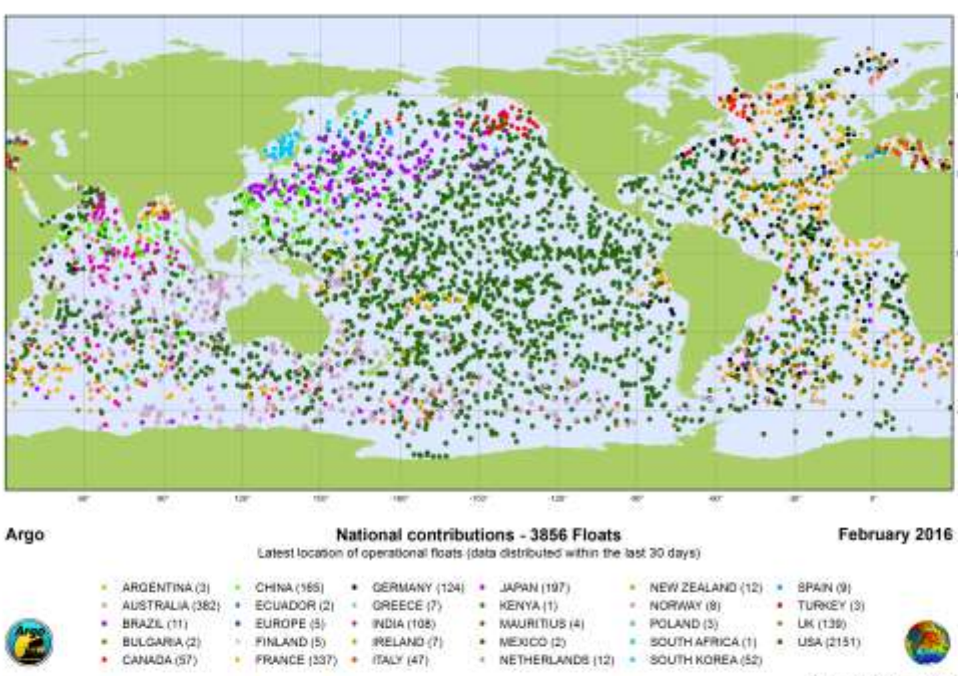

Fig 3 Positions of 2151 active U.S. floats (green dots) as of February 2016.

The highest priority for U.S. Argo is to sustain the Core Argo array. Specific plans for float deployments in 2016, as they evolve, are posted on the AIC deployment planning links. A major U.S./New Zealand deployment cruise from New Zealand to Tahiti and back on RV Kaharoa was carried out in late 2015. This voyage deployed 105 Core Argo floats in the South Pacific Ocean and 9 Deep Argo floats in the SW Pacific Basin. A Kaharoa cruise to the Indian Ocean is planned in October 2016 to deploy Core Argo and Deep Argo floats.

The U.S. Argo Data Assembly Center 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.