Argo Australia – 2016 Activities

Report to the Argo Steering Team

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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).
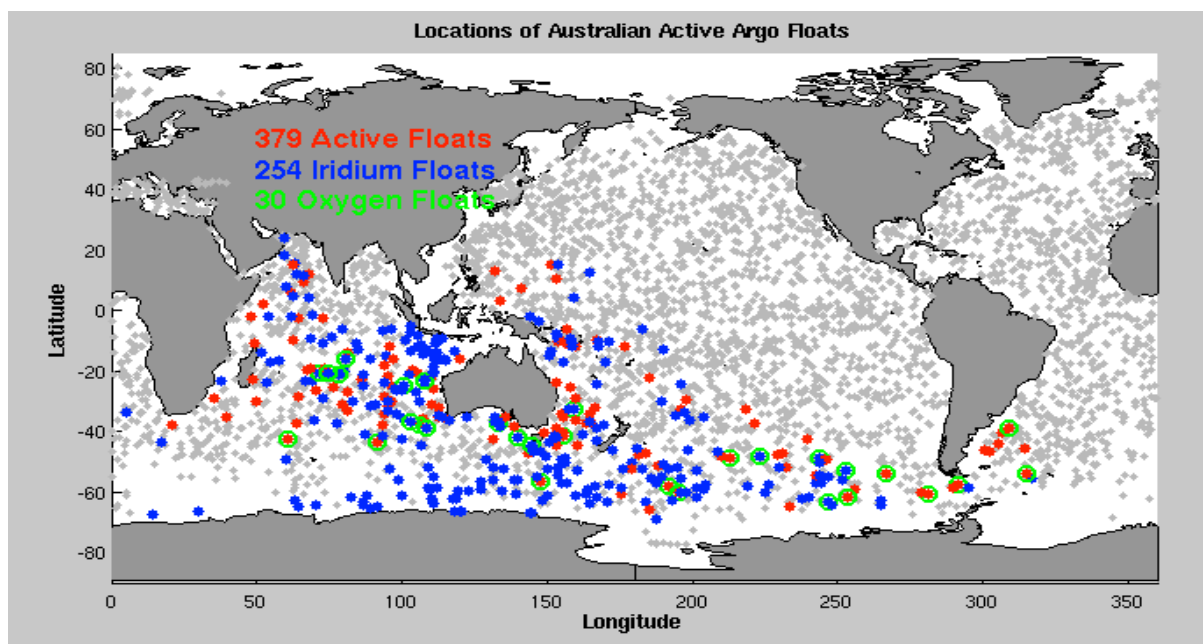

Figure 1. Locations of active Argo Australia floats (colours – defined as float reporting in the last 60 days north of 55°S, in the last year south of 55°S) as of January 2016 with active international floats in gray. Australian floats using Iridium Communications are in blue and those equipped with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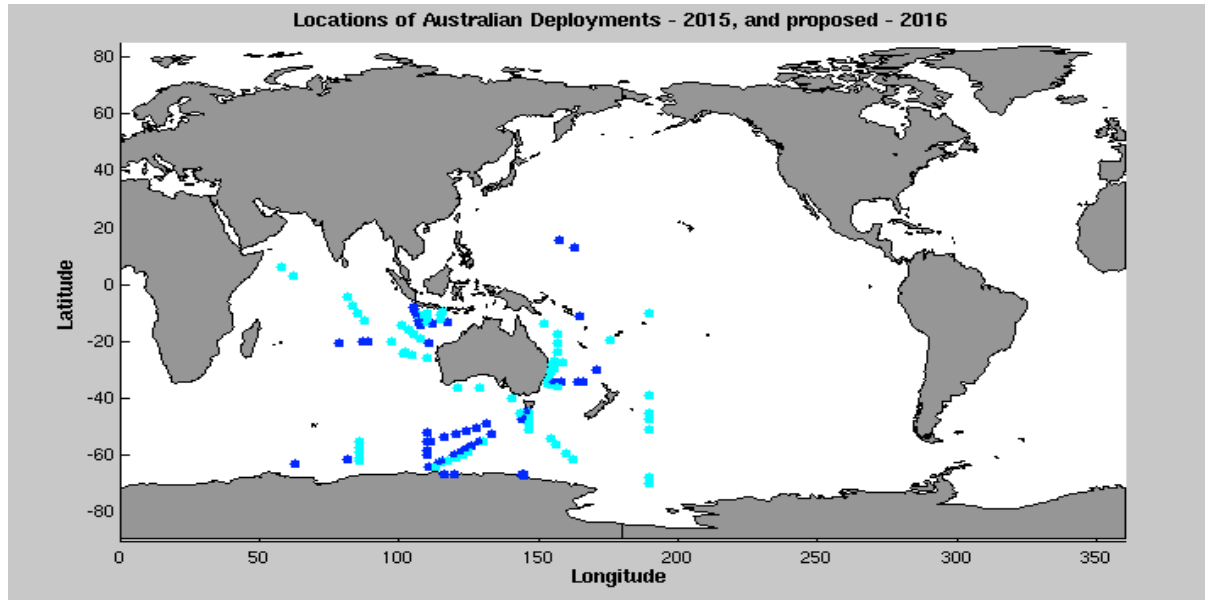

Figure 2. Locations of float deployments in 2015 (Blue), with proposed deployments for 2016 (Cyan)

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

Summary of Technical Issues

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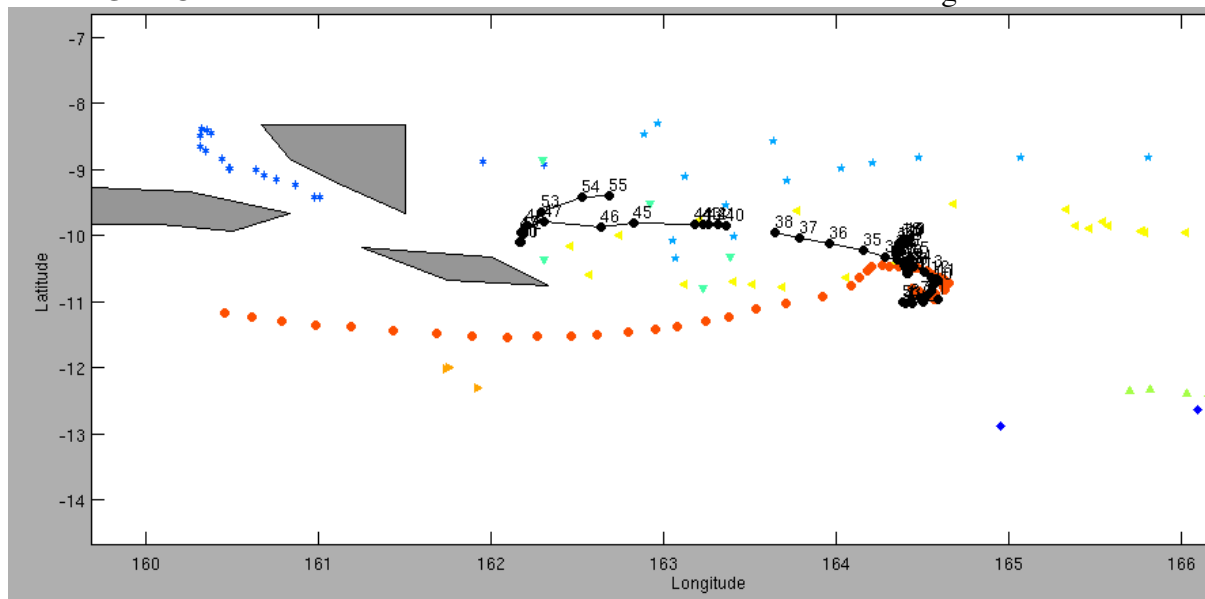
Locations of test RBR (black) and SBE (orange dots) companion float profiles in the Coral Sea.

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.

Collaboration with Argo India: 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.