Argo Australia – 2012 Activities

Report to the Argo Steering Team

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The Australian Centre for Atmosphere, Weather and Climate Research: a joint partnership between the Australian Bureau of Meteorology and CSIRO

1. Status of implementation

Floats deployed and their performance

Australia currently has 391 active floats distributed across the Indian and South Pacific Oceans (Figure 1)

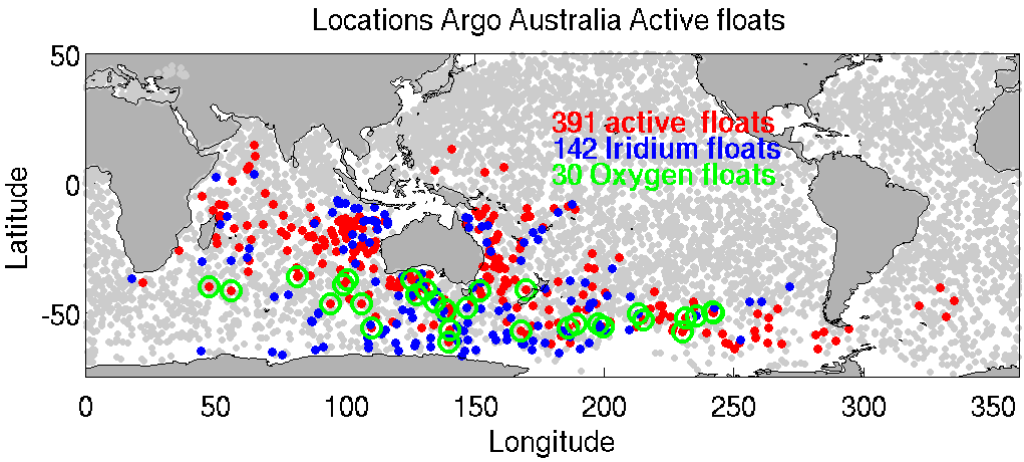
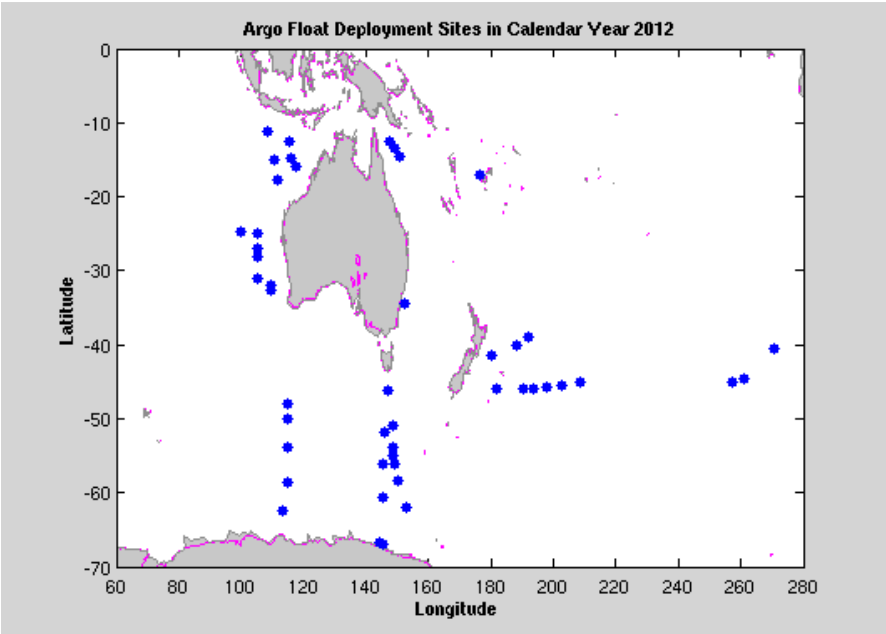


Figure 1. Locations of active Argo Australia floats (colours) as of March 2013 with active international floats in gray. Australian floats using Iridium Communications are in blue and those equipped with oxygen sensors are circled in green.

In the calendar year 2012, the program deployed 48 floats mainly spread throughout the South Pacific and in the Southern Ocean. The sailing vessel *Lady Amber* deployed another 11 floats for Argo Australia bringing her total deployments for us to 65. RV *Kaharoa* also deployed floats for Argo Australia, continuing her successful contribution to the program.

For the first time, we have deployed MRV and Seabird manufactured floats as part of a 'Proof of Concept' trial and analysis of new float technologies. We also have 4 Teledyne Webb APF11 floats which will be deployed shortly.



Technical problems encountered and solved

We have switched almost our entire Iridium fleet to RUDICS communications which has decreased our costs significantly, making the program more sustainable into the future. Technical problems have been very few this year. The biggest challenge has been running the tender process for float purchases (a new requirement with the availability of new float models) and then preparing the floats we purchased as a result of our Proof of Concept trial. We have had to deal with new data formats and different preparation methods, as well as new communications methods (Z modem instead of X modem). Hopefully now that these problems are all solved, we can go forward more easily.

Float Failure Mode Analysis

As of the 15^{h} of March 2013, the Australian Argo program had deployed 558 floats. From the total number of floats deployed; 156 are dead. Of the remaining 402 operational floats, more than 90% are returning good data, 18 floats are producing suspect or bad data and are under review including 4 floats that are confirmed as suffering from the Druck microleak issue. Of the dead floats, 34% 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% were dead on deployment. The remainder of floats died mainly due to environmental reasons such as grounding (19%), leakage (10%) or were lost in the ice (6%). Other contributing factors are summarized in the table below.

Float failure mode for dead floats	**Number of floats** (156)	**% of dead floats**
End of life	53	34
Grounded	29	19
Unknown	19	12
Leak	16	10
Died on Deployment	10	6

Lost under ice	9	6
Firmware issues	5	3
Turned on too early/went too deep	5	3
Software issues	4	3
CTD failure/damage	2	1
Communications failure	2	1
Druck snowflake	1	1
Redeployed	1	1

Summary of Technical Issues

As for last year, we have had problems with faulty solenoids on some of our floats. These faults mean that the air pump doesn't close, and so the air bladder doesn't inflate. This loss of buoyancy at the surface potentially leads to problem with the satellite communications, particularly for our Iridium floats. We have killed one iridium float with a faulty solenoid because it was incurring excessive communications costs and another two might be suffering from this. One Argos float with a faulty solenoid is still communicating reliably however.

To control telecommunications costs, we have reduced the size of the log file sent by Iridium floats from 60K to 5K. In most cases we still receive sufficient diagnostic information and can increase the log file size when necessary to diagnose failure modes.

Many faults are detected before we deploy the floats during our extensive lab testing. These include faulty transmitters, unreliable solenoid connections which required soldering by our technicians, calibration issues and erroneous metadata programmed into the floats. Some are more serious than others. We have the ability to reprogram the floats in-house which simplifies correction of most metadata errors (wrong serial numbers or iridium dial-up strings – a relatively common problem). Other problems have required return of the float or sensors to the manufacturer.

Status of contributions to Argo data management

Ann Thresher is now co-chairing the Argo Data Management Team.

Collaboration with Argo India: The program has continued to work with the Indian Argo program, helping them code for new data formats and install DMQC processes. Esmee van Wijk worked with Uday at INCOIS in the DMQC procedures and he is now working through their backlog. They have now begun encoding BUFR messages as well.

Collaboration with KORDI: We have completed installation of both the Australian ArgoRT system and DMQC software at KORDI. They are now using ArgoRT operationally and beginning the process of DMQC, after Esmee van Wijk trained Moon-Sik during his visit at CSIRO.

Pressure Bias Audit: Jeff Dunn continues to check compliance with ADMT recommendations around the treatment of Truncating Negative Drifting Pressure (TNDP) floats and pressure corrections. This audit has been carried out roughly 6 monthly. Most DACs are now compliant through a few small remaining issues are being chased up.

Metadata Standardisation: Esmee van Wijk, Ann Thresher and Matthieu Belbeoch (with the help of the broader Argo community and manufacturers) have been working on making the content of the global metadata files consistent. A table of fixed configuration parameter names exists on the ADMT website so that file content is standardised. Any new names required for new floats etc. must be added to this table and vetted for consistency before being used in the files. Work on unifying the labelling of data formats is continuing. The manufacturers have been asked to provide a unique data format label with all new floats and manuals. The task to identify old float formats is ongoing but will take some time.

Status of delayed mode quality control process

Australian DM Statistics (as at 15/03/2013)	
D files submitted to GDAC	35796
Total R files	35586
R files eligible for DMQC	20150
Total eligible files for DMQC	55946
Total files at GDAC	71382

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

The Australian Argo array continues to grow rapidly with a 30% increase in the total number of profiles delivered to the GDAC compared to the previous year. A total of 558 floats have been deployed to date since the beginning of the Argo program and 402 floats are still operational. As at 15/03/2013, 64% of eligible profiles (those that are greater than 12 months old) have been processed through delayed mode quality control.

The next 12 months will focus on the incorporation of new float types, data formats and metadata variables, multi-profile files, trajectory files, oxygen data and delivery of Argo products. We have 2 new float types (the Solo S2A and Navis floats) that will require tweaks to the RT and DM software to deal with the new formats.

In total 435 floats have been assessed through the DMQC process for drift of the salinity sensor, many of these are now assessed in routine maintenance mode. Of these, 10 floats (2 %) returned no data from deployment and 8 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 417 assessable floats, 375 (90%) show no salinity drift for the life of the float. A further 34 (or 10%) of floats show a positive salinity drift. Eight floats (2 %) are affected by a fresh offset or biofouling. Most floats with either a salty or fresh drift were able to be corrected using the OW software. A further 16 floats (4 %) 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.

Detailed descriptions of the quality control process, including the data and plots for each float are available at the following CSIRO website:
http://www.cmar.csiro.au/argo/dmqc/index.html

For those working with trajectory data or whom are interested in float data formats, electronic copies of the CSIRO APEX float manuals are now available online: http://www.cmar.csiro.au/argo/dmqc/html/Australian_float_manuals.html

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). Argo Australia also gets direct funding from CSIRO's Division of Marine Research, the Australian Climate Change Science Program, in kind assistance from the Bureau of Meteorology and also logistical assistance from the Royal Australian Navy who will deploy floats for us again this year.

EIF funding for Argo Australia ends in June 2013 and while the Australian government has provided bridging funds for July 2013-Dec 2014 under the CRIS program, these funds are very limited - essentially aimed at 'keeping the lights on' - and comprise a 70% cut for most facilities. As a result, many parts of the IMOS network are seeing large quantities of equipment recovered and warehoused. Due to the recognized high value of the program, cuts to Argo were not as severe as initially thought. However, there will be the loss of our full time engineer and a limited float purchase of 20 floats (10 not yet confirmed), less than half of our normal target deployment of 50 floats for the core array per year. In addition, we expect to see delays in DMQC processing as the cuts have meant we cannot grow our data processing team as planned. We are hoping a follow-on program for the IMOS will be forthcoming but to date no announcement has been made.

Despite impact of purchasing fewer floats, due to longer float life times and floats already purchased and prepared for deployment we believe we can maintain an array of around 350 active floats over this period. Due to the lag imposed by our lab-testing processes, the impacts of next years' lower acquisition will only be felt in the out years.

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

We have just over 60 floats the lab with identified deployment opportunities for most of these in 2012/13, most in the Indian and Southern Oceans, and some in the Western Pacific Ocean (Figure 3). The RAN will deploy floats along IX12 in the Indian Ocean.

In the Pacific, floats will be deployed from ships of opportunity but also the RV *Kaharoa,* in partnership with US Argo and New Zealand's NIWA.

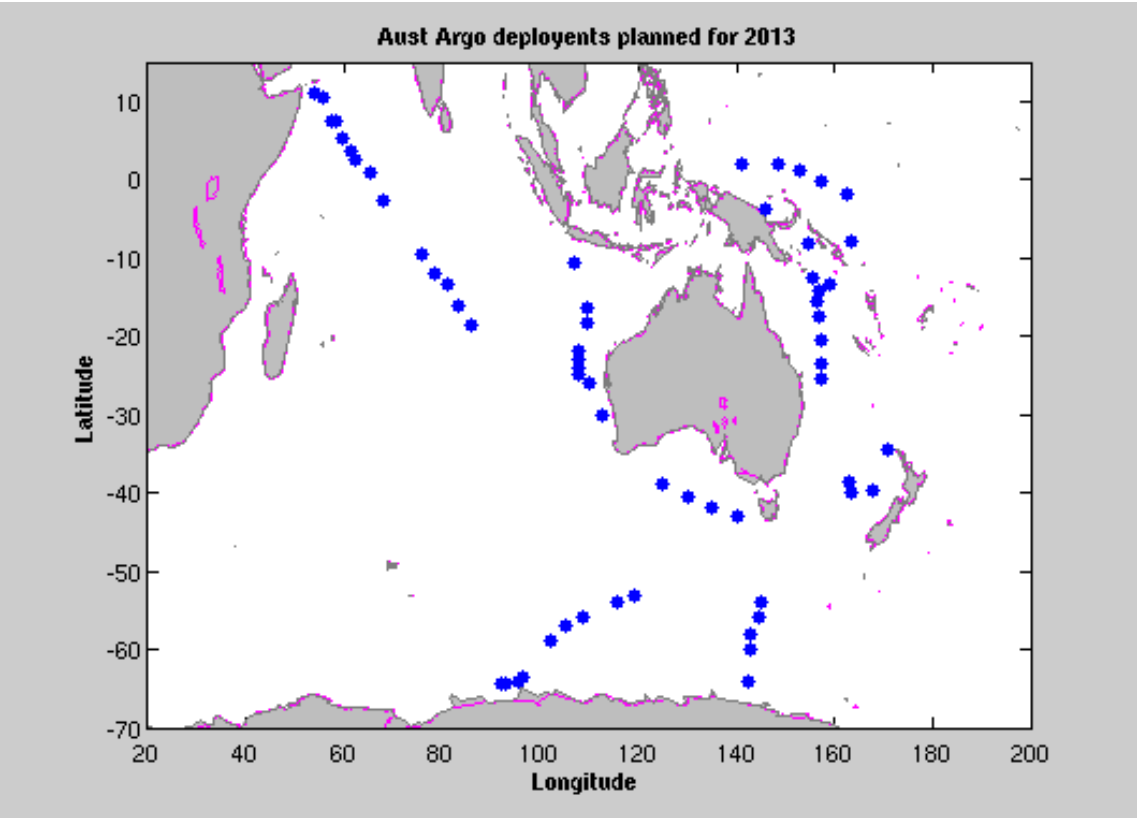


Figure 3. Proposed Locations of planned float deployments over the next year

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 Marine and Atmospheric Research, 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://www.cmar.csiro.au/staff/oke/BRAN.htm. The Ocean 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.
- Jeff Dunn is refining a global ocean climatology based on Argo data - http://www.marine.csiro.au/~dunn/cars2009/

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/

Delayed Mode data documentation: http://www.cmar.csiro.au/argo/dmqc/index.html

5. Issues to be raised with the Argo Steering Team

Definition of "core Argo" versus "Bio Argo" Ice Argo" etc. Do we want to create categories of extensions to the argo array in the metadata or will this cause more problems than it's worth? The idea was to create a simple way of searching through the global database so that floats could easily be grouped into different categories. There was however vigorous debate at ADMT as to whether a float can belong to multiple categories, i.e. core Argo and Bio Argo and the wording of these definitions.

7. Argo Publications by Australian Authors 2012

Rintoul, S, Meredith, MP, Schofield, O, Newman, L 2012, The Southern Ocean Observing System, Oceanography, vol. 25, no. 3, pp. 68-69, doi:10.5670/oceanog.2012.76

Durack, P, Wijffels, S, Matear, R 2012, Ocean Salinities Reveal Strong Global Water Cycle Intensification During 1950 to 2000, Science, vol. 336, no. 6080, pp. 455-458, doi:10.1126/science.1212222

Wu, L, Cai, W, Zhang, L, Nakamura, H, Timmermann, A, Joyce, T, McPhaden, M, Alexander, MA, Qiu, B, Visbeck, M, Chang, P, Giese, B 2012, Enhanced warming over the global subtropical western boundary currents, Nature Climate Change, no. 2,pp. 161-166, doi:DOI: 10.1038/NCLIMATE1353

Rousseaux, C, Lowe, R, Feng, M, Waite, A, Thompson, P 2012, The role of the Leeuwin Current and mixed layer depth on the autumn phytoplankton bloom off Ningaloo Reef, Western Australia, Continental Shelf Research, vol. 32, no. 1, pp. 22- 35, doi:10.1016/j.csr.2011.10.010

Zavala-Garay, J, Wilkin, JL, Arango, HG 2012, Predictability of mesoscale variability in the East Australian Current given strong-constraint data assimilation, Journal of Physical Oceanography, doi:10.1175/JPO-D-11-0668.1

Rayson, MD, Jones, N, Ivey, GN 2012, Temporal variability of the standing internal tide in the Browse Basin, Western Australia, Journal of Geophysical Research - Oceans, vol. 117, doi:10.1029/2011JC007523

Sallee, J-B, Matear, R, Rintoul, S, Lenton, A 2012, Localized subduction of anthropogenic carbon dioxide in the Southern Hemisphere oceans, Nature Geoscience, vol. 5, pp. 579-584, doi:10.1038/ngeo1523

Qiu, Y, Cai, W, Li, L, Guo, X 2012, Argo profiles variability of barrier layer in the tropical Indian Ocean and its relationship with the Indian Ocean Dipole, Geophysical Research Letters, vol. 39, doi:10.1029/2012GL051441

Holte, J, Talley, LD, Chereskin, TK, Sloyan, B 2012, The role of air-sea fluxes in Subantarctic Mode Water formation, Journal of Geophysical Research - Oceans, vol. 117, doi:10.1029/2011JC007798

Durack, P, Wijffels, S, Matear, R 2012, Ocean Salinities Confirm an Intensifying Hydrological Cycle, Science, vol. 336, no.6080, pp. 455-458, doi:10.1126/science.1212222

Drushka, K, Sprintall, J, Gille, ST, Wijffels, S 2012, In Situ Observations of madden-Julian Oscillation Mixed Layer Dynamics in the Ondian and Western Pacific Oceans, Journal of Climate, vol. 25, pp. 2306-2328, doi:10.1175/JCLI-D-11-00203.1

Baird, ME, Ridgway, K 2012, The southward transport of sub-mesoscale lenses of Bass Strait Water in the centre of anticyclonic mesoscale eddies, Geophysical Research Letters, vol. 39, doi:10.1029/2011GL050643

Oke, P.R, P. Sakov, M. L. Cahill, J.D. Dunn, R. F. Feidler, D.A. Griffin, J. V. Mansbridge, K. R. Ridgway and A. Schiller, 2013: Towards a dynamically balanced eddy-resolving ocean reanalysis: BRAN3. Ocean Modelling, in review.

Feng, M., M. J. McPhaden, S-P. Xie3, J. Hafner, 2013: La Niña forces unprecedented Leeuwin Current warming in 2011. Nature Scientific Reports, 3, (1277) doi:10.1038/srep01277