Argo Australia – 2010 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 297 active floats distributed across the Indian and South Pacific Oceans (Figure 1)

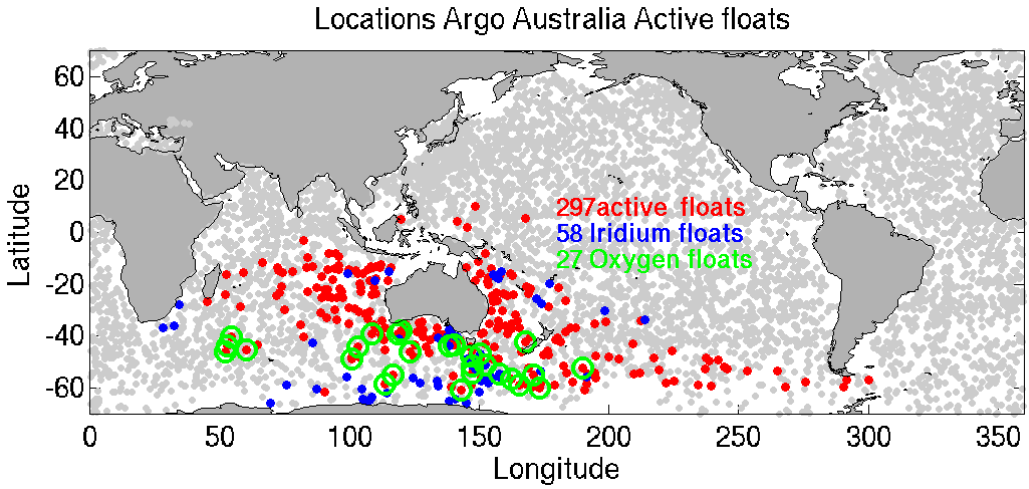

Figure 1. Locations of active Argo Australia floats (colours) with active international floats in gray. Australian floats using Iridium Communications are in blue and those equipped with oxygen sensors are in green.

In the calendar year 2010, the program deployed 78 floats in the South Pacific, Indian and Southern Oceans. Of those deployed in 2010, 46 were equipped with Iridium transmitters and the rest had standard Argos transmitters, reflecting a move towards the increased use of Iridium communications to about 50% of new acquisitions. Ice-avoidance algorithms are active on 21 of these. Oxygen sensors are on 11 floats (optodes).

We continued to partner with the US and New Zealand programs to secure deployments of both US and Australian floats into the Pacific and Indian Oceans. The program also worked with the AIC to do test deployments of a small vessel out of South Africa, *Lady Amber*. Deployments went well, and the program is proceeding with further leases of this inexpensive vessel to help overcome the float backlog caused by the 2009 deployment hiatus (see below).

Technical problems encountered and solved

Our use of Iridium communications has risen sharply as we plan on 50% of new acquisitions to use this system. Problems encountered in the second half of 2010 with our Iridium fleet have largely been solved. These included expensive and incomplete calls (solved by reducing

the log file size), unpredictable costs (solved by changing suppliers) and the need to build more redundancy into the data stream (we are solving this by moving to RUDICS). We now feel that using Iridium is extremely good value and past reliability issues are hopefully behind us. Using Iridium in the floats being piloted in the sea-ice zone in particular looks very promising, with winter profiles taken over many months below the ice returned to us in spring.

The program is also working with Seabird P/L on testing Kistler pressure sensors. These sensors may show superior stability, accuracy and the ability to be deployed on deep reaching floats. A CTD equipped with a Kistler sensor acquired data in parallel with a standard SeaBird CTD on a recent full depth repeat hydrographic cruise between Australia and the Antarctic. We are currently analyzing this data set to look for and characterize and differences between the sensors.

Float Failure Mode Analysis

As of the 24th of Feb 2011, the Australian Argo program had deployed 389 floats. From the total number of floats deployed; 57 are dead. Of the remaining 332 operational floats, 319 are returning good data, a further 11 are producing suspect or bad data and are under review and a further 2 floats are confirmed as suffering from the Druck microleak issue. Of the dead floats, 19% ceased to operate due to natural causes when they ran down their battery packs. A further 16% died due to unknown reasons. The remainder of floats ceased to operate prematurely mainly due to environmental reasons such as grounding (21%) and loss or damage under sea ice (10.5%). Other contributing factors were hardware failures such as communications problem, CTD/pressure sensor damage or fault and leakage (12%); software issues such as firmware bugs (10.5%) or human error (e.g. turning on the float too early resulting in buoyancy problems and subsequent loss, picked up by fisherman or deployed in the plastic bag (10.5%),.

Float failure mode for dead floats	**Number of floats** (57)	**% of dead floats**
Unknown	9	16
Grounded	12	21
End of life	11	19
Firmware issues	6	10.5
Lost under ice	6	10.5
Turned on too early – went too deep	4	7
CTD failure/damage	2	3.5
Communications failure	1	1.75
Leak	1	1.75
Deployed in plastic bag	1	1.75
Druck snowflake	1	1.75
Potentiometer failure	1	1.75
Picked up by fisherman	1	1.75
Transmissometer leak	1	1.75

Float failure mode for floats with	**Number of**	**% of suspect**

suspect or bad data	**floats** (13)	**floats**
Unknown	3	23
Grounded and contaminated CTD	3	23
Biofouling	2	15
Druck microleak	2	15
Suspect conductivity cell	1	8
Buoyancy problems	1	8
Ice damage	1	8

Summary of Technical Issues

Faulty Solenoids

We have been having problems with the solenoid switch on the air pumps not working properly so that the valve does not shut off and does not maintain air pressure in the bladder. The problem can be identified in the lab when the bladder pressure equals the vacuum pressure. A couple of floats (2-3) have been identified with this problem in the lab during pre-deployment testing. The problem cannot be easily identified once floats are in the field as it is not possible to determine the difference between a failed air pump and a failed air pump switch.

The failure rate for solenoids from the Italian supplier went up drastically after they changed their manufacturing process to eliminate oil on the switch (previously Webb had been cleaning this off themselves). The manufacturing process has now been changed but at least 54 of our floats are potentially affected. Solenoids will be replaced where possible, depending on the amount of replacement solenoids available from the manufacturer. Priority for replacement will be given to Iridium floats and those deployed in the tropics.

Miscellaneous Float Problems:

- Two floats had faulty CPUs, the boards were returned to Webb. This seems to be a relatively rare problem.
- One oxygen calibrated float had a corroded seal; the source of corrosion was unclear.
- One float delivered with the wrong model GPS hardware that was not compatible with the version of firmware and did not work at all. This was picked up in the lab before deployment and was replaced.
- Two Iridium floats have had GPS problems – they had low signal strength and the GPS units were replaced in the lab.
- One float had a weak Iridium signal caused by an unreliable low frequency band transmitter not communicating with the CPU and resulting in poor uplink.
- Poor Iridium communications – we reduced the log file size from 60K to 5K which has helped make the communications more reliable but sometimes results in not all the diagnostics we need being transmitted if the message file doesn't arrive.
- We have also had problems with inadequate fluorometer calibrations on the Fluorometer Backscattering Meter (FLBB) sensors. Testing in the lab when the floats arrived showed the sensors were not calibrated properly. We found differences between the data readings from the sensor and those transmitted through the float. Also, there was a significant warming up period required before the readings stabilised. The problem sensors were sent back to Webb for recalibration and in some cases were sent back a second time.

- Three floats were received with incorrect CPU IDs programmed into the floats, these were detected in the lab and re-programmed here.

Status of contributions to Argo data management

Collaboration with Argo India: The program has continued to work with the Indian Argo program in the continuing bedding down of their use of the Australian realtime data processing software (http://www.marine.csiro.au/~gronell/ArgoRT/). Unresolved issues being worked on include processing some kinds of PROVOR data and encoding TESAC messages so that GTS insertion by the Indian Meteorological Service can begin. India's DM operator, Uday, also visited with us for several weeks in March for training on and to help modify our DM software and tools in order to process the Indian Argo float data.

Collaboration with KORDI: We are working with KORDI on installing Australia RT software. While still not operational due to software bugs, much progress has been made. It was realized that some older hex data (from around 10 floats over a period of a few years) was distributed with the wrong number of bytes by CLS Argos. CLS has reprocessed this data and now we expect that we can decode and deliver a fuller error and gap-free data set.

Pressure Biases in the Global Argo data set: An analysis and correction of pressure drift errors in the global data set as available at the end of 2008 has now been accepted by the Journal of Atmospheric and Ocean Technology (soon available as an online early release at http://journals.ametsoc.org/loi/atot)

Jeff Dunn has applied the methods described in the above paper in building software that checks pressure corrections carried out by DACs and also compliance with ADMT recommendations around the treatment of Truncating Negative Drifting Pressure floats. This audit can be carried out monthly, and its latest results will be reported on at AST-12. The latest audit can be accessed at

http://www.marine.csiro.au/argo/dmqc/audits_2011_02_22/tnpd_report.html

Technical Naming Table: Ann Thresher has been working with the DACs to build and maintain a fixed table of technical parameter names for use in Argo data files. A common approach to naming these parameters is vital if these files are to be machine parseable. Previously each DAC had an almost non-overlapping set of names for parameters.

Status of delayed mode quality control process

Comprehensive documentation of float data and quality control decisions is available at:
http://www.cmar.csiro.au/argo/dmqc/index.html

Australian DM Statistics (as at 31/12/2010)

D files submitted to GDAC	27552
Total R files	12641
R files eligible for DMQC	5486
Total eligible files for DMQC	33038
Total files at GDAC	40193

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

The Australian Argo array continues to grow rapidly with an 18% increase in the total number of profiles delivered to the GDAC in the past quarter. A total of 399 floats have been deployed to date since the beginning of the Argo program and of these, 332 floats are still operational. As at 31/12/2010, 82% of eligible profiles (those that are greater than 6 months old) have been processed in delayed mode quality control.

The re-write of the DMQC processing software is now largely complete and the integration of the SIO GIO and OW software is fully implemented. The next 12 months will see effort focusing on incorporating new formats, variables and multi-profile files into the DM process as well as trajectory files, oxygen data and delivery of Argo products.

A total of 285 floats have been assessed through the DMQC process for drift of the salinity sensor. Of these, 6 floats (2 %) returned no data from deployment and 8 floats (3 %) returned bad data for the entire record due to pressure sensor issues or other hardware problems. Of the remaining 271 assessable floats, 235 (87 %) show no salinity drift for the life of the float. A further 33 or 12% of floats show a positive salinity drift. These floats can be subdivided into those floats that drift gradually towards the end of life (18 floats or 7 %) and those that are salt offset from the start of the record (15 floats or 5 %). A small number of floats (3 instruments or 1 %) are affected by a fresh offset or biofouling. Of the floats that are either salt or fresh offset, most were corrected using the OW salinity drift correction. 15 floats (5 %) 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.

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 National Collaborative Research Infrastructure Initiative (NCRIS) and now the Education Infrastructure Fund (EIF). EIF funding for Argo Australia is now secured through June 2013 and work is beginning on the follow-on.

Through IMOS, and if levels of support from our partners remains steady, Argo Australia will sustain deployments of 50-60 floats per year and maintain an array of around 220-240 active floats. However, longer float lifetimes may mean the standing array size could grow much larger. If this is the case, increased communication costs may require a slight reduction in the numbers of floats deployed in future years.

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

We aim to deploy over 90 floats in 2011, most in the Indian and Southern Oceans, and some in the Pacific Ocean (Figure 2). We plan to lease the *Lady Amber* for many deployments in the Indian Ocean. However, we have had to modify plans to deploy in the northwestern sector due to the expanding activities of pirates in the region. Navy and very large container ships may be the only means of deploying floats into this dangerous region at present. On completion of her tour out of Fremantle, the *Lady Amber* may be available for follow-on leases by other Argo programs.

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

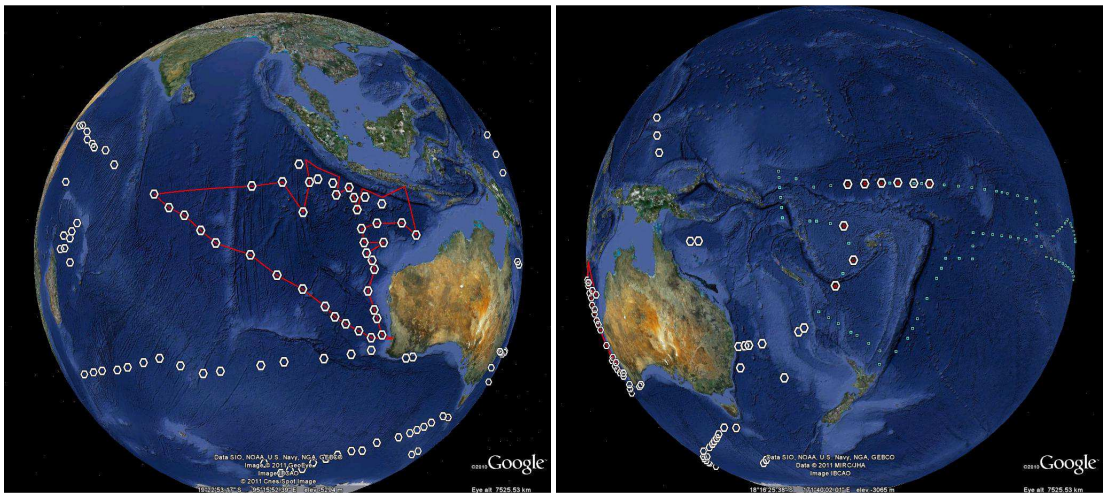

Figure 2. Locations of planned float deployments over the next year – white open pentagons. Red marks the proposed track for the deployment vessel *Lady Amber*. Blue squares indicate US Argo deployments on the RV *Kaharoa.*

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 of Neville Smith at the Australian Bureau of Meteorology (http://www.bom.gov.au/bmrc/ocean/results/climocan.htm). These analyses are also used to initialize an experimental seasonal rain forecasting system.
- The dynamical seasonal forecasting system POAMMA heavily uses Argo data – 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. Ocean forecasts and reanalysis products are now routinely published and are available via the Bureau of Meteorology website or the PI (www.marine.csiro.au\~griffin): David.Griffin@csiro.au
- Many students in the CSIRO/University of Tasmania graduate program are utilizing Argo data in their thesis studies. It's use is becoming widespread for studies of subduction in the Southern Ocean (Sallee, Sloyan, Rintoul), generation of modern era climatologies (Ridgway, Dunn, Barker, McDougall), ocean warming and its role in sea level rise (Church, Domingues, Wijffels, Barker), in ocean observing system studies (Oke and Schiller), Ocean salinity changes (Durack/Wijffels)
- Developing model-based gridding techniques to produce an Argo-gridded data set (Dunn, Monselan, Wijffels,Church)

5. Issues to be raised with the Argo Steering Team

Pressure Bias Corrections: The national DACs have made tremendous progress in removing the pressure errors in float data, improving their technical files and their identification and treatment of TNDP floats. Many were also very helpful in improving the pressure bias auditing system. We urge them to complete this task as soon as possible so that Argo may be confidently be used to track the evolution of the global ocean heat content.

6. CTD Data Delivered to CCHDO

Data from one Tasman Sea hydrographic cruise (ss2010_v01) was tracked down and permission gained from the PI for its release to Argo. These data were then delivered to CCHDO.

Data from the recently completed Tasmania to Antarctic repeat hydrographic line will also be sent to CCHDO soon.

7. Argo Publications by Australian Authors

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