

UK ARGO PROGRAMME

REPORT FOR ARGO STEERING TEAM 16TH MEETING, MARCH 2015

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 bio-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 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.

A second issue is ensuring that the GTS data stream, that delivers data to operational users, is successfully migrated to the BUFR format in 2015 (when the use of TESAC on GTS should cease) without degrading the timeliness of delivery. Also it will be important to ensure that the BUFR format(s) continue to evolve in parallel to the Argo NetCDF to allow for the exchange of additional profiles (e.g. near-surface and bio-geochemistry).

Floats deployed and their performance

Floats deployed. Since 2001, over 480 UK floats have been deployed (including 7 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 variable as it has often been reliant on the release of end-year under-spend funding. As a result, the number of deployments each year has also been variable, but with an increase over the last 4 years with 169 floats having been deployed, with 50 floats deployed in 2014.

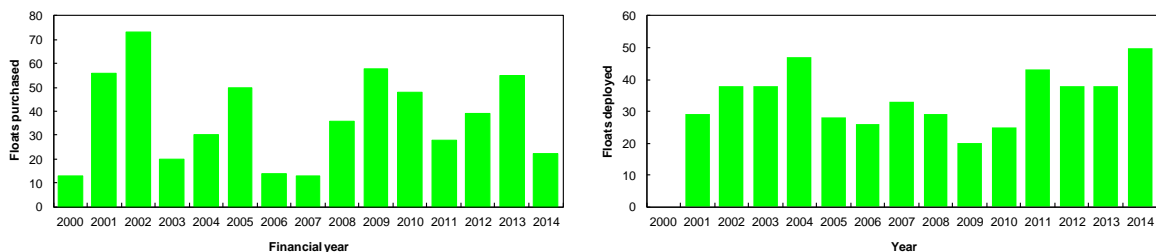


Figure 1. Showing (left) the number of floats procured each financial year (Apr-Mar) and (right) the number deployed in each calendar year.

With the increase in the number of floats deployed in the last 3 years the number of UK floats contributing to Argo (including 6 Apex that were provided to and deployed by Mauritius) has increased from around 100 to around 130, as shown in Figure 2. There are a few active floats for which data processing has not yet been set up, these are not included in Figures 2 and 3.

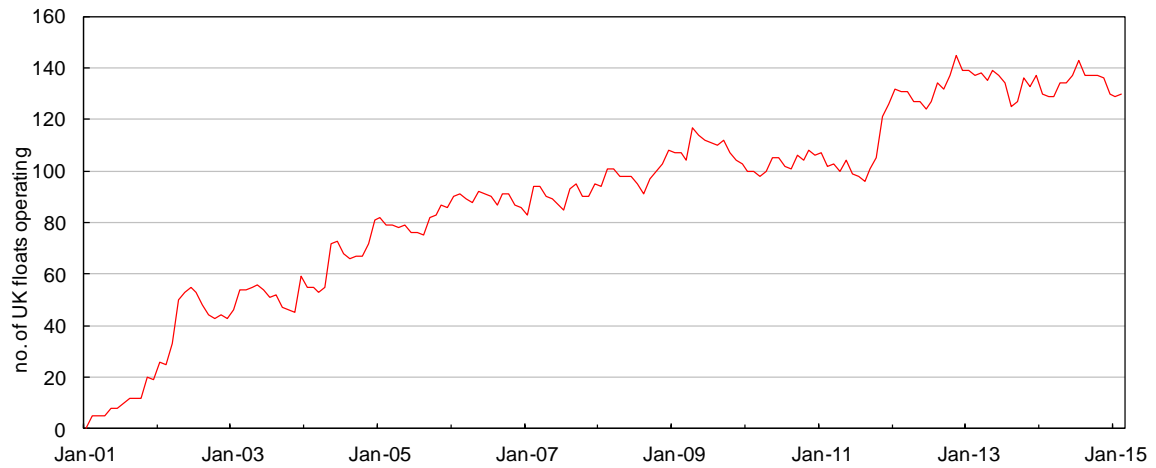


Figure 2. Number of UK (including Mauritius) floats reporting data to Argo by month.

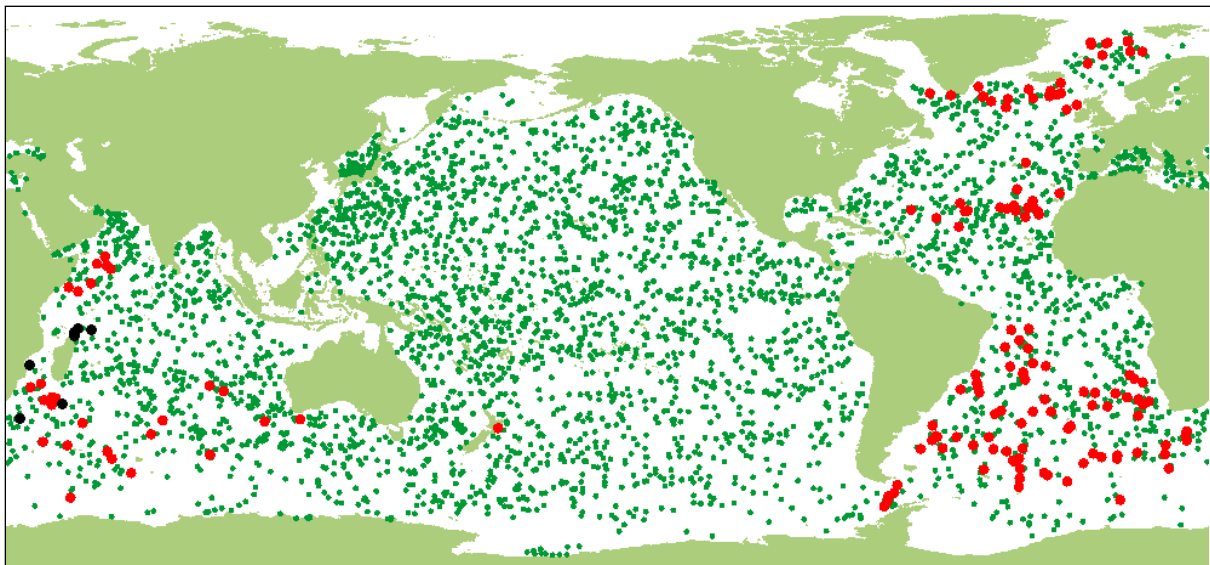


Figure 3. Showing the locations of operating UK floats (in red) and the six Mauritius floats (black) at mid-February 2015.

Float lifetime. The majority of UK floats deployed have been Webb Apex floats, which have seen a steady improvement in reliability (survival) since 2004 in terms of cycles completed, 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 have been discounted and deployment failures omitted.)

For floats deployed 2004-2006 only 66% of floats reached the target 4 year lifetime (140 profiles), whereas for 2007-2009 floats 69% reached this mark, with 14 floats (27%) having passed the 200 profiles mark with 3 still operating having made over 290 profiles. For floats deployed in 2010-2012, 88% have reached the 2 year (70 profile) mark.

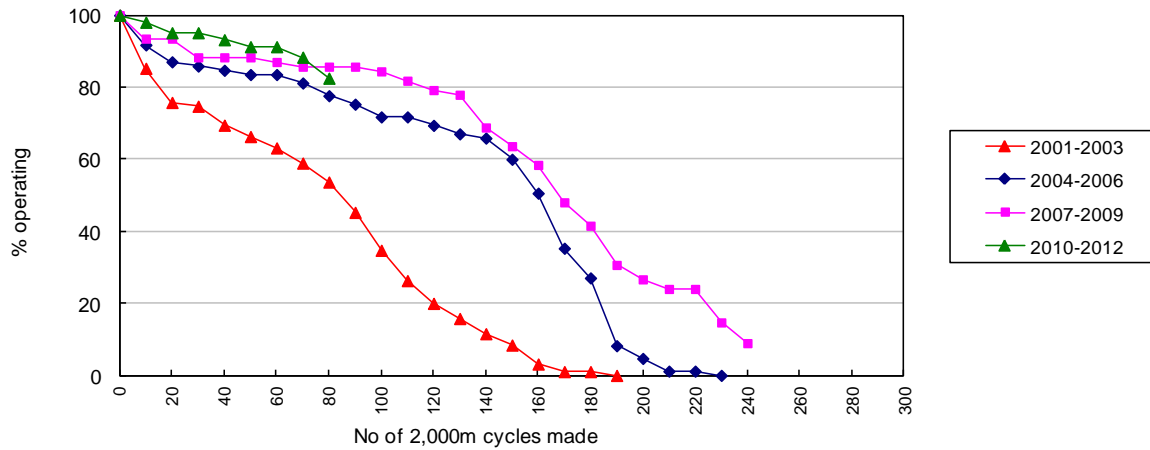


Figure 4. Number of (normalised) cycles made by UK Apex floats deployed in 2001-2003, 2004-2006, 2007-2009 and 2010-2012.

The extended (beyond the nominal 4 years) lifetime of our floats is also a result of fitting lithium batteries. From 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 clearly shows with alkaline batteries the longest living floats expire after 110 – 200 cycles (apart from one that has made 235 cycles), while with lithium batteries a significant number of floats are operating beyond 180 cycles.

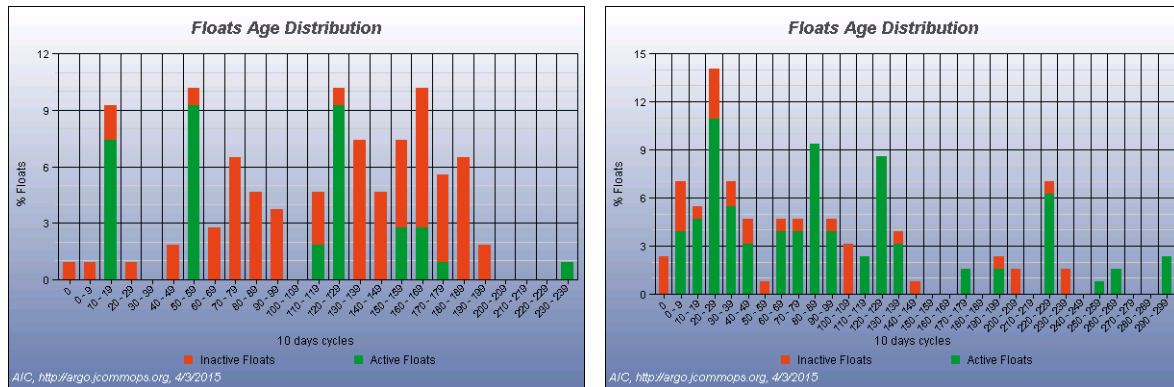


Figure 5. Number of cycles made by UK Apex floats deployed since 2007 with (left) alkaline and (right) lithium batteries. Note the horizontal scales are different.

Float enhancements. 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 near surface temperature measurement capability (un-pumped measurements) were deployed and all our 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, 10 SeaBird Navis, 3 SeaBird Navis BGCi, 1 MetOcean Nova (provided free-of-charge by MetOcean) and 7 NKE E-AIMS BGC floats (including 5 funded by PML) and floats.

Outline deployment plans for 2015

So far in 2015 we have deployed 6 floats (shown in Figure 3) in the Drake Passage and (at end Feb 2015) have around 45 Apex floats available for deployment, with a further 11 floats expected to be delivered before March. The available floats include 2 deep Apex (6,000m depth capability) equipped with SBE61 and oxygen sensors and 2 deep ARVOR (expected depth capability 3,500 – 4,000m) equipped with ruggedized SBE41 and oxygen sensors expected to be deployed later in 2015. In addition there are a further (PML-funded) 6 NKE bio-geochemical floats available to be deployed in 2015.

At present, outline deployments in 2015 are likely to include:

- 6 floats South Atlantic/Argentine Basin (Apr/May)
- 4-8 floats Rockall Trough/Iceland basin (May/Jun)
- 4-6 floats SE Atlantic (SA Agulhas, Sep)
- 4-10 floats S Atlantic (AMT cruise, Oct/Nov)
- 4-10 floats 26N (RAPID cruise) Nov/Dec
- 2-4 floats for Mauritius

Other deployments will be arranged as opportunities arise. The aim is to deploy around 40 floats during the year, including floats provided to Mauritius.

Data management

The UK Argo Data Centre, established at BODC, processes all our float data (including the floats donated to Mauritius) and also Irish and Portuguese floats, 168 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 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 year to date, the challenge has been to sustain the core Argo mission processing while setting up the data system to handle the newer bio-geochemical floats, where the setup of data distribution from the Navis and Provor bio-geochemical floats is ongoing and expected to be complete by spring 2015. There has also been a complete rewrite of the processing software in readiness to the transition to the new V3 Argo NetCDF (Network Common Data Form) file format, which in turn should resolve some issues with the WMO BUFR (Binary Universal Form for the Representation of [meteorological] data) formatted data exchanged on the GTS.

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. 70.0% 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 the transition to Argo V3.0 formats.

BODC works with three other organizations to operate the Southern Ocean Argo Regional Centre (SOARC) covering the entire Southern Ocean. Responsibilities are: BODC - Atlantic Ocean Sector, CSIRO - 'Australian' sector, JAMSTEC - Pacific Ocean Sector and the University of Washington - Indian Ocean Sector. BODC hosts the main SOARC data and information web pages (http://www.bodc.ac.uk/projects/international/argo/southern_ocean/).

Scientific and operational use of Argo data

At the Met Office Argo data are assimilated into FOAM-NEMO (Forecasting Ocean Assimilation Model - Nucleus for European Modelling of the Ocean), see <http://www.metoffice.gov.uk/research/weather/ocean-forecasting>, which is the Met Office deep ocean forecasting system Blockley et. al. (2014)¹, Lea et.al. (2014)².

Argo data are also used in the GloSea (Global Seasonal) coupled model run by the Met Office to make seasonal forecasts for several months ahead. Seasonal forecasting is still an area in which the science is being developed. On longer timescales the Hadley Centre DePreSys (Decadal Prediction System) is being developed for climate predictions on decadal timescales, where the impact of Argo data on decadal climate forecasts has been demonstrated through idealised experiments. See <http://www.metoffice.gov.uk/research/climate/seasonal-to-decadal>.

The Hadley Centre also maintains the HadGOA (sub-surface global analysis) dataset of historical temperature and salinity. 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. For further information see <http://www.metoffice.gov.uk/research/climate/climate-monitoring/oceans-and-sea-ice>.

As part of the FP7 E-AIMS project work has been carried out to assess the impact of Argo data on coupled analyses and short-range forecasts and for validation of SST analyses.

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 open calls for proposals). The matched funding agreement collapsed after MoD withdrew its funding in April 2010. Regular annual funding from DECC (ex Defra) to the Met Office has also reduced, although it has been supplemented in most years with year-end 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 funds 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 it is expected that a MoU for the coming year's funding will soon be agreed with DECC. This will only be for one year due to the impending government Comprehensive Spending Review in 2016. However the level of funding is not yet confirmed, so it is not known how much will be available for floats.

It is expected that NERC will continue to fund its Argo support activities at NOCS and BODC. The funding outlook for data management is good: on-going national capability support from NERC has been sustained and the European E-AIMS project is supporting the

¹ Blockley, E. W., Martin, M. J., McLaren, A. J., Ryan, A. G., Waters, J., Lea, D. J., Mirouze, I., Peterson, K. A., Sellar, A., and Storkey, D.: Recent development of the Met Office operational ocean forecasting system: an overview and assessment of the new Global FOAM forecasts, *Geosci. Model Dev.*, 7, 2613-2638, doi:10.5194/gmd-7-2613-2014.

² Lea, D.J., M.J. Martin, and P.R. Oke. Demonstrating complementarity of observations in an operational ocean forecasting system. *Q. J. R. Meteorol. Soc.* 140: 2037–2049, July 2014 B DOI:10.1002/qj.2281.

development needed for Bio-Argo. In addition further resources are anticipated through funding provided under the EU AtlantOS proposal and DG-MARE funding (through Euro-Argo).

Euro-Argo

Euro-Argo was formally established as an ERIC (European Research Infrastructure Consortium) 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).