

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).

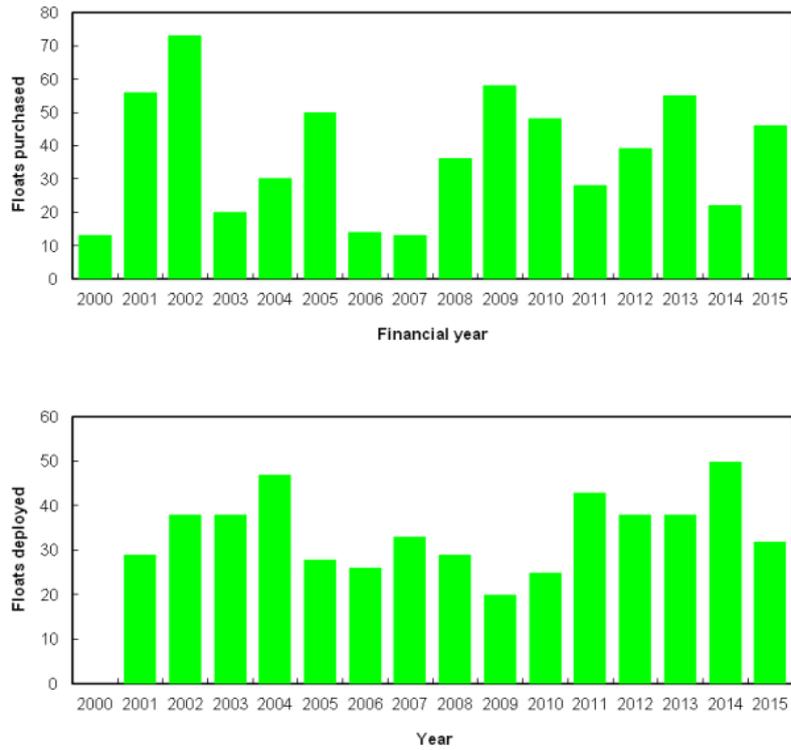


Figure 1. Showing (top) the number of floats procured each financial year (Apr-Mar) and (bottom) the number deployed in each calendar year.



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

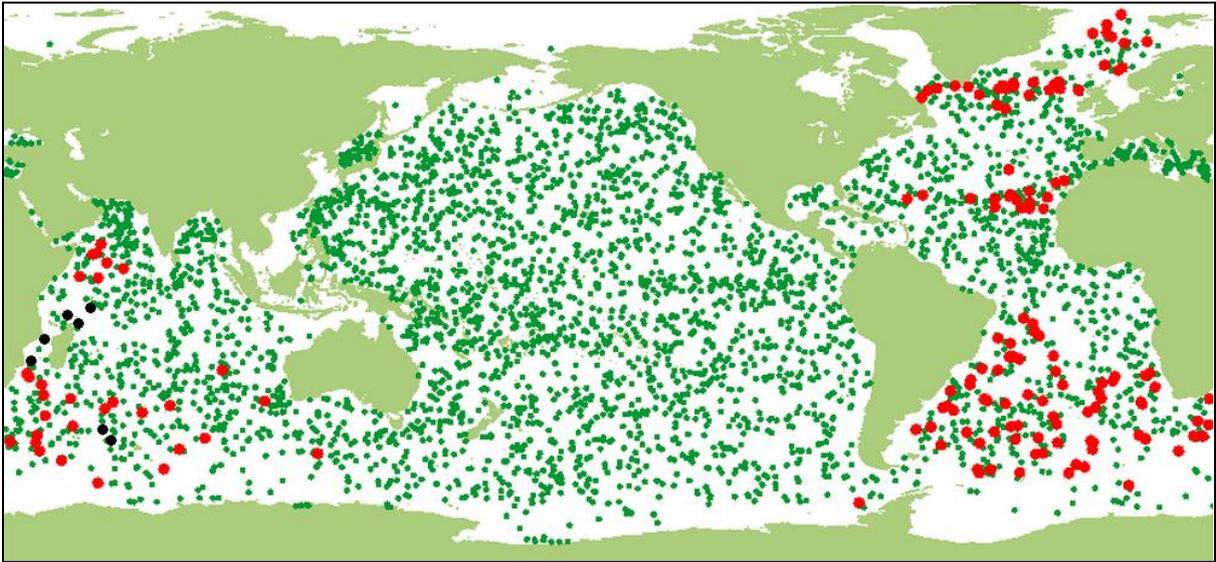


Figure 3. Showing the locations of operating UK floats (in red) and the seven Mauritius floats (black) at mid-February 2016.

Float lifetime. 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.

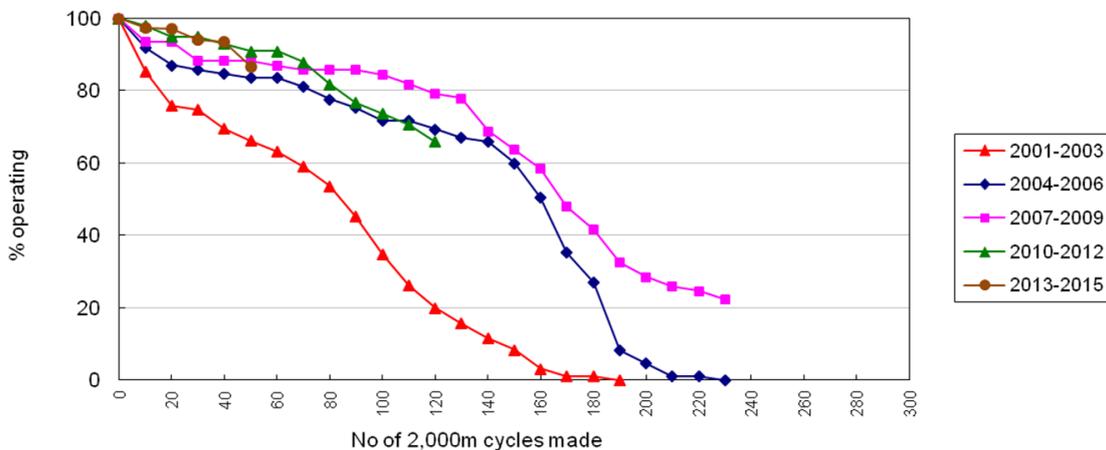


Figure 4. Number of (normalised) cycles made by UK Apex floats deployed in 2001-2003, 2004-2006, 2007-2009 and 2010-2012.

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.

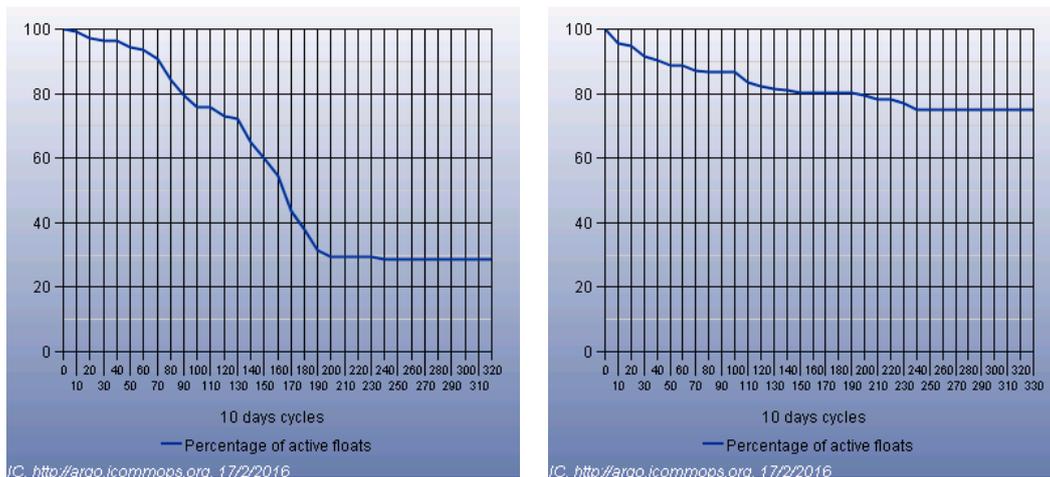


Figure 5. Number of cycles made by UK Apex floats deployed since 2007 with (left) alkaline and (right) lithium batteries.

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 *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 Observatoire 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 2010 after 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.