UK ARGO PROGRAMME

REPORT FOR ARGO STEERING TEAM 14TH MEETING, MARCH 2013

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.

The most pressing issue for the UK programme remains on securing continuing and ongoing funding for UK Argo after March 2015, and internationally on ensuring the long-term delivery of data from the global Argo float array and agreeing the future shape of the array given the need to include high latitudes, marginal seas, bio-geochemistry and deeper profiling in Argo.

Floats deployed and their performance

Floats deployed. Since 2001, over 390 UK floats have been deployed (including 5 floats donated to Mauritius) in support of the Argo array. As can be seen from Figure 1 below, the number of floats purchased each year is very variable, as float procurement is largely reliant on the release of end-of-year under-spend funding. As a result, the number of deployments each year has also been variable, with an increase in 2011 and 2012 where 43 floats and 38 floats were deployed. At the present time (February 2013) there are 139 active floats (including 3 that were provided to and deployed by Mauritius in 2011) contributing to the global Argo array, see Figure 2.

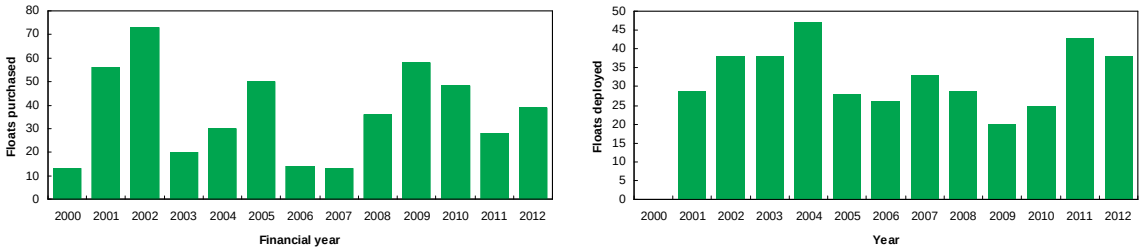

Figure 1. Showing (left) the number of floats procured each financial year (Apr-Mar) and (right) deployed in each calendar year.

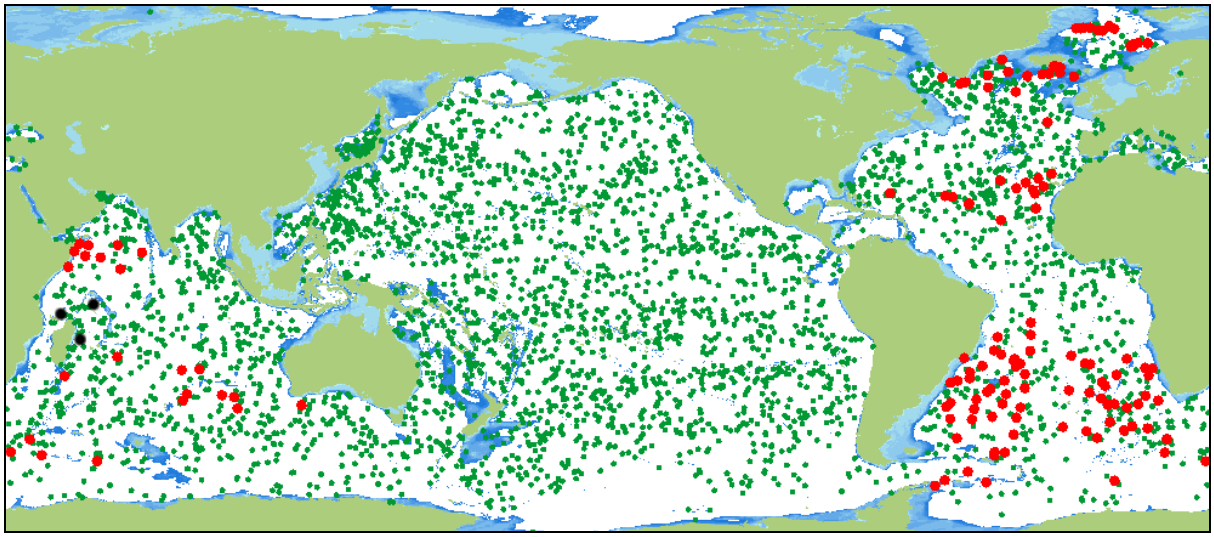

Figure 2. Showing the locations of operating UK floats (in red) and the three active Mauritian floats (in black) in mid-February 2013.

With the increase in the number of floats deployed in the last 2 years the number of UK floats contributing to Argo has increased to around 140, as shown in Figure 3.

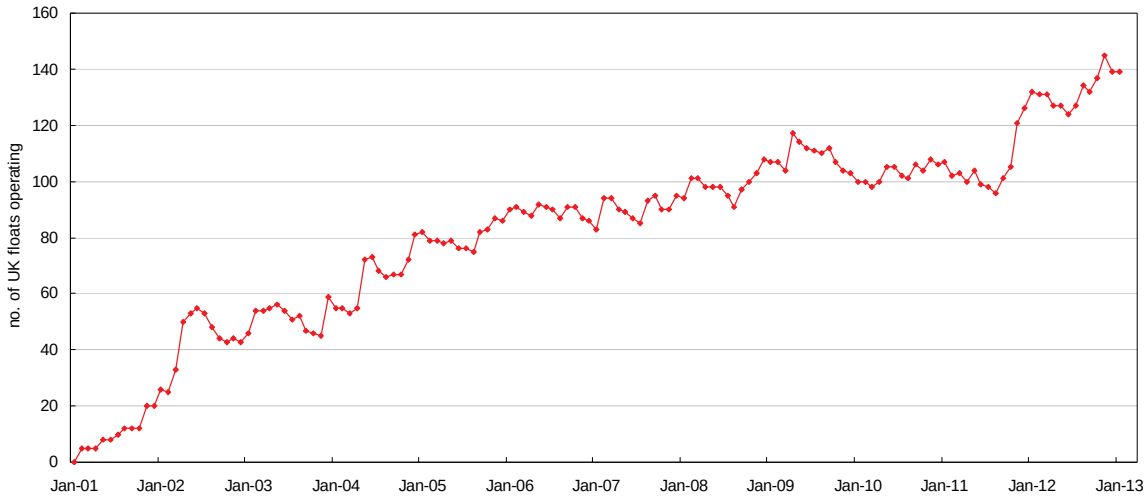

Figure 3. Number of active UK (including Mauritius) floats contributing to Argo by month.

Float performance. There has been a steady improvement in the reliability (survival) of our Apex floats deployed since 2004 in terms of cycles completed, as shown in Figure 4. (Where 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 from 2007 to 2009 over 80% of floats have exceeded 110 profiles (>3 years lifetime) with around more than 70% expected to achieve 4 years (or longer). For floats deployed in 2010 and 2011, 93% have reached the 1 year mark.

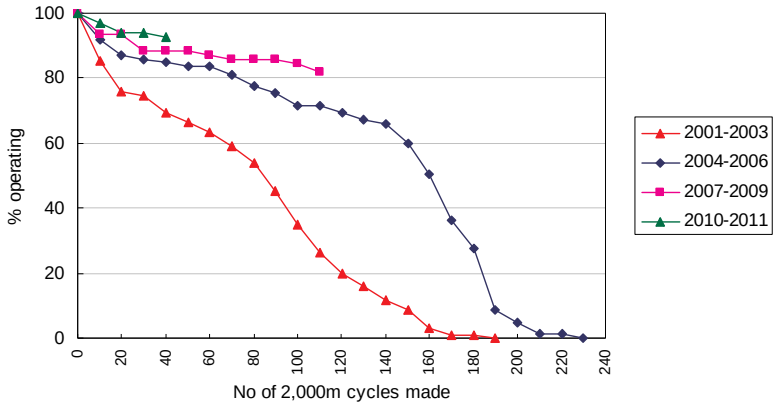

Figure 4. Number of (normalised) cycles made by UK Apex floats deployed in 2001-2003, 2004-2006, 2007-2009and 2010&2011.

Following some early float losses to ice damage in 2007, since 2008 all new Southern Ocean floats considered at risk of ice have been specified with ice-avoidance capability. So far 19 floats with ice-avoidance have been deployed in the Southern Ocean and 13 in the Nordic Seas (one of which has recently gone under ice). In 2007 we deployed our first Apex floats with lithium batteries and have since deployed over 80 floats with lithiums. Figure 5 shows lifetime figures from AIC for our floats deployed since 2007. This suggests with lithium batteries there have been fewer mid-life failures.

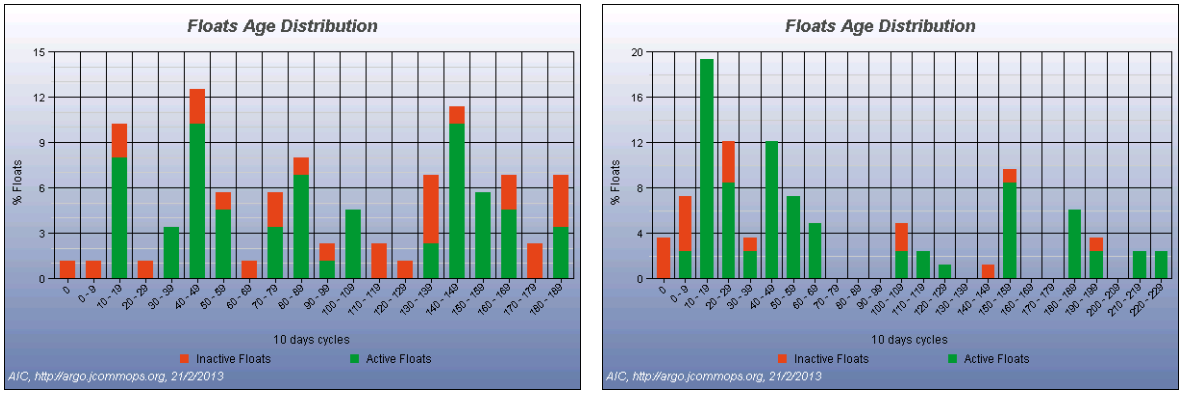

Figure 5. Number of cycles made by UK Apex floats deployed since 2007 with (left) alkaline and (right) lithium batteries.

In 2008 our first 2 Apex floats with near surface temperature measurement capability (un-pumped measurements) were deployed, with 74 SST-capable floats having now been deployed.

In 2012 we deployed 13 floats with Iridium communications in the Nordic Seas, 4 of these also carried sensors for dissolved oxygen and chlorophyll fluorescence.

Deployment plans for 2012

At the end of Feb 2013 we have around 45 Apex floats available for deployment, with a further 39 floats expected to be delivered by end March 2012. This includes 27 Apex floats (16 Argos, 11 Iridium) and 12 SeaBird Navis floats.

Anticipated deployments in 2013 include:

8 floats Southern Ocean/Drake Passage (March)
4 floats Rockall Trough/Iceland basin (Extended Ellett Line, May)
4 floats Western Indian Ocean (ACEP cruise, July)
2-4 floats Nordic Seas
4 floats SE Atlantic (SA Agulhas, Sept)
6-10 floats S Atlantic (AMT cruise, autumn)
2-4 floats for Mauritius

The expectation 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 floats for the Irish Argo programme).

Real-time

An automatic system processes the data in real-time and generates the profile data in WMO TESAC and BUFR and Argo netCDF formats. The TESAC/BUFR messages are relayed to GTS via the Met Office (EGRR). Almost 100% of GTS messages are available within 24h. Occasional disruptions happen due to email server failures and server problems. Data in netCDF format are also sent (by FTP) to the two GDACs. The real-time processing system operates every 12 hours and delivers data twice daily. The data are also available from the UK Argo Data Centre web-site via an interactive map interface. In addition the technical files are updated once a week and these files are provided to CSIRO Marine to populate the technical web-site.

Delayed-mode

Delayed-mode processing is carried out by BODC using the OW software and the most recent CTD climatology and Argo climatology reference datasets. These are updated when new versions are made available. However, the additional time needed to train new staff combined with setting up real-time systems for biogeochemical floats meant delayed-mode processing at BODC was paused in 2012 and will resume in summer 2013. Clare Davis is to be trained as a delayed-mode operator in addition to her real-time operator duties. This will mean BODC have 2 delayed-mode operators which is important with the additional load caused by bio-geochemical sensors and trajectory file improvements.

As of March 2013 the percentage of eligible (greater than one year old) profiles on the GDACs in delayed mode is 89%.

Southern Ocean

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/).

On-going development activity

In addition to maintaining progress of previous years on-going development at BODC is focusing on the following:

- Improving the quality of trajectory data distributed by BODC. This is based on the actions decided by the ADMT and output from the ANDRO Atlas.

- Development of real-time quality control procedures for un-pumped near surface temperature data from Apex.
- Real time processing and distribution of data from floats with bio-geochemical sensors.
- Investigation into how persistent identifiers can be assigned to Argo data.

Reference CTD data

At the Argo Data Management Team meeting in 2012 the link between BODC and CCHDO was restored. This included an initial submission of ~3,500 CTD profiles in BODC holdings for use in the Argo delayed mode reference climatology. The aim is an eventual move towards automated submission of data to CCDHO (plus NODC and ICES) when data are banked at BODC.

The delayed mode cookbook information produced by BODC in previous years has also been supplied to Steve Diggs who is using this information to identify areas where the current reference data/climatology is in need of enhancement so these areas can be prioritised when seeking new data for inclusion in the climatology. This approach has already been fruitful in the Northwest Atlantic. Under Euro-Argo SIDERI the cookbook is to become part of the documentation available on the Argo data management pages and will consist of short summaries of ocean regions where complex oceanography can impact on delayed mode results. The summaries will primarily be produced by Euro-Argo partners.

Scientific and operational use of Argo data

At the Met Office Argo data are assimilated into FOAM (Forecasting Ocean Assimilation Model), see http://www.metoffice.gov.uk/research/weather/ocean-forecasting, which is the Met Office deep ocean forecasting system. It comprises a global ¼ degree model (ORCA025) and nested $^{1}/_{12}$ degree North Atlantic, Mediterranean and Indian Ocean limited area models. The system is run operationally at around 0500 UTC every day.

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.

Research results

Work has continued on examining the near-surface temperature measurements from Argo floats, in particular to detect near surface stratification (diurnal warming) which is of interest to the GHRSST (Group for High Resolution Sea Surface Temperature) community. A detailed analysis of data (15,916 profiles) from 329 near-surface capable floats was carried out and results presented at the 4th Argo Science Workshop (Venice, September 2012). 345

profiles showed significant temperature gradients in the upper 10 m, many of which would have been missed by normal Argo floats. These profiles were compared to the Met Office OSTIA (Operational Sea Surface Temperature and Sea Ice Analysis) 'foundation' SST and the results suggest an 'equivalence depth' between Argo near-surface temperature and OSTIA foundation SST of approximately 4 dbar, which supports the use of the normal (pumped) Argo temperature data from approximately 4 m depth to verify GHRSST foundation SST products. *Near-surface temperature profiles from pumped and un-pumped Argo measurements. Poster for Argo Science Workshop, Venice, Sept 2012. Fiona Carse, Justin Buck and Jon Turton.*

As part of the ERA-CLIM project, a high quality subset of Sea Surface Temperature (SST) observations from drifting buoys and ships (1996-2010) was produced through assessment against the Met Office OSTIA. QC procedures were developed to flag commonly observed gross errors in drifting buoy observations and to blacklist ships whose observations were deemed unreliable. The QC outcomes were partly validated using Argo observations, which are not assimilated by OSTIA and provide a useful independent validation of the results. *Assessing the quality of sea surface temperature observations from drifting buoys and ships on a platform-by-platform basis. C.P.Atkinson, N.A.Rayner, J.Roberts-Jones, R.O.Smith. Submitted to JGR-Oceans.*

GODAE OceanView have been developing methods of assessing the impact of observations on ocean data assimilation systems. The Met Office have performed a series of experiments to assess the impact of different observing systems on its FOAM forecasting system. This included testing the impact of excluding all Argo temperature and salinity data for 1 month (July 2011). One method to assess the model is the fit to observations before they are assimilated, where the fit to both temperature and salinity profiles is 5% worse without Argo. It should be noted that one month may not be long enough to see the full impact of removing Argo data as experience in FOAM suggests the subsurface can take a year or more to spin-up (or spin-down). The results were presented at the Venice workshop and being prepared for submission in the literature. *Lea, D.J., Martin, M.J. Demonstrating complementarity of observations in an operational ocean forecasting system. In preparation for submission to Q. J. R. Meteorol. Soc.*

Research using Argo data at NOC is carried forward mainly, though not exclusively, through graduate students. Projects include: upper ocean circulation and variability in the North Atlantic, ocean correlation scales in the Pacific and Atlantic oceans, seasonal to decadal variations in water mass properties in the SE Pacific/Drake Passage/Atlantic sector of the Southern Ocean, decadal changes in intermediate and thermocline water properties in the subtropical South Atlantic. Also, the NOC satellite oceanography group is involved in ground truth for SMOS and is evaluating ways in which Argo near-surface data can be used for SMOS evaluation.

The data are used extensively in a wide range of research projects in UK Universities and research laboratories and is a central component of several PhD and MSc projects covering a broad range of topics including water mass properties and formation, air-sea interaction, ocean circulation, mesoscale eddies, ocean dynamics and seasonal-to-decadal variability.

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 Apr 2012 to Mar 2015 the Met Office (Public Weather Service Programme) has agreed to co-fund UK Argo with DECC and a MoU has been signed off. NERC will continue to fund its Argo support activities at NOCS and BODC. However the committed funding will only be sufficient to pay for support activities and does not include any provision for procuring floats, hence maintaining an annual contribution of 30 to 50 floats beyond 2013 will be dependent on the continued availability of additional funding (e.g. from year-end under-spends).

Consideration will be given to a new funding model, including an option to transfer funding, at a level to be agreed, from DECC to BIS (as the Met Office is now a BIS Agency) after the end of the 3 year DECC/Met Office agreement. While the current agreement provides some stability for the 3 years, there is still a risk that by April 2015 we are no further ahead.

Euro-Argo

During the period, the Euro-Argo ERIC statutes were modified following review by the EC and circulated for final review among prospective members. It has been agreed with BIS that John Hirst (Met Office CE) will sign the statutes on behalf of BIS; however, signature and setting up of the ERIC is not expected until summer/autumn 2013.

Work for the Euro-Argo FP7 SIDERI project started in the following areas: legal and policy (e.g. UNCLOS, EEZ) issues, how Argo should relate to (or interface with) the emerging WIGOS (WMO Integrated Global Observing System) and on near-surface measurements from floats (as noted above). Also the Euro-Argo E-AIMS FP7 project started in January 2013. This will provide (50%) funding for 2 floats with bio-geochemical sensors and 2 floats with new (Iridium) communications, developing the data processing capability at BODC for these floats and evaluation of the data. E-AIMS will also support work on assessing the impact of Argo data on short-range forecasts using a coupled ocean-atmosphere model and on validation of satellite SST products and diurnal skin SST analyses.

The Euro-Argo FP7 projects have also supplemented NERC funding at BODC to bring the resources to a level where real progress can be made, as noted earlier, and new developments are possible.