UK ARGO PROGRAMME

REPORT FOR ARGO STEERING TEAM 11TH MEETING, MARCH 2010

The UK Argo programme is undertaken by a partnership between the Met Office (who manage the programme), the National Oceanography Centre Southampton (NOCS), the British Oceanographic Data Centre (BODC) and the UK Hydrographic Office (UKHO).

The most important issue for the UK programme is in securing continuing and ongoing funding for UK Argo and ensuring the long-term delivery of data from the global 3,000 float Argo array.

Floats deployed and their performance

Floats deployed. Since 2001, 288 UK floats have been deployed (including 5 floats donated to Mauritius) in support of the Argo array, as shown in Table 1 and Figure 1 below. (Argo equivalent floats are those that have been procured using research grants rather than from designated UK Argo funding.) Fewer deployments were made in 2009 due to the Druck 'microleak' problem and need to replace the sensors.

Year	UK Argo floats			Argo equivalent floats
	Apex	Provor	Mauritius	
2001	25	2		2
2002	33	1		4
2003	17	5	1	15
2004	33	12	2	
2005	27	1		
2006	24		2	
2007	27	4		2
2008	28	1		
2009	20			

Table 1. Numbers of UK floats contributing to Argo deployed by year (including floats donated to and deployed by Mauritius).

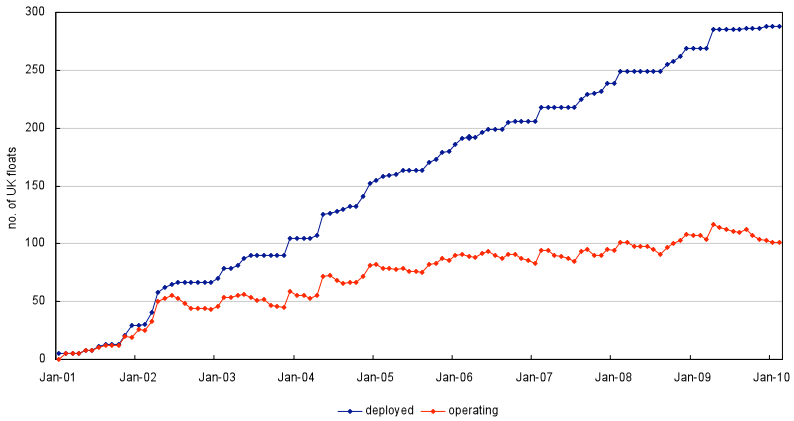


Figure 1. Number of UK floats deployed that contribute to Argo and the number operating by month.

There were 101 UK floats operating at end February 2010. There has been a distinct improvement in the survival of our Apex floats deployed since 2004 to those deployed in the earlier years in terms of cycles completed (normalised to 2,000m for floats that make

shallower profiles or only profile to 2,000m intermittently, with invalid cycles due to pressure transducer failure discounted and deployment failures omitted), as shown in Figures 2 and 3.

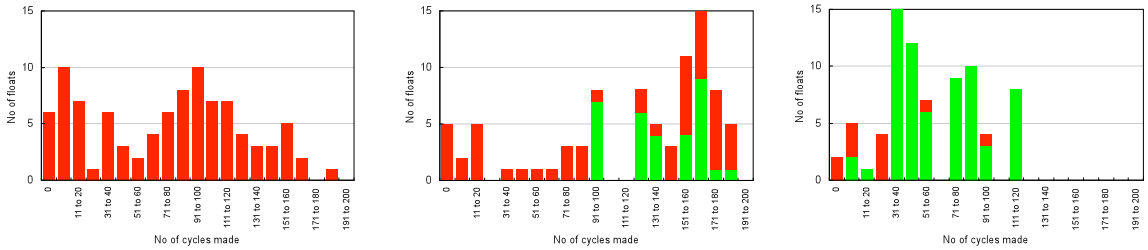


Figure 2. Number of (normalised) cycles made by UK Apex floats deployed in 2001-2003 (left), 2004-2006 (centre) and 2007-2009 (right). Operating floats are shown in green, with dead/failed floats in red.

Only 30-40% of floats deployed before 2004 made more than 100 cycles. However, for floats deployed in 2004 and 2005 around 70% and 75% exceeded the 120 cycle mark. For floats deployed in 2006 and 2007, around 75% have exceeded 80 cycles.

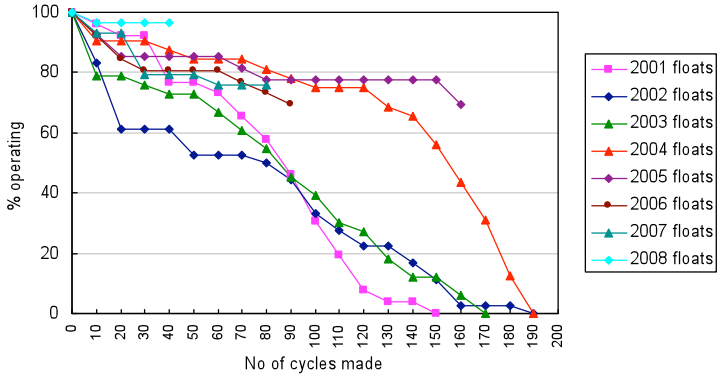


Figure 3. Float lifetime (in terms of number of normalised cycles completed) distributions for UK Apex floats deployed from 2001 to 2008.

Float enhancements. In 2007 we deployed our first Apex floats with lithium batteries and have now deployed 30 floats with such batteries. 5 of these have failed early: 1 on deployment, 1 after 3 profiles and 1 after 29 cycles (suspected due to a slow water leak). The other 2 early failures were after 21 cycles and most likely due to damage from Antarctic ice. All Southern Ocean floats considered at risk of ice are now specified with ice-avoidance capability. So far 8 floats with ice-avoidance have been deployed (in 2007 and 2008) and all except 1 (which survived for 3 years) are presently operating.

In 2008 our first 2 Apex floats with near surface temperature measurement capability (unpumped measurements) were deployed and another 4 were deployed in 2009. All are working normally at present. All new floats (apart from those with ice-avoidance) will now have this capability as standard.

Technical/engineering web-site. We have established a partnership with CSIRO, Australia to develop an engineering web-site for UK and Australian Apex floats (see http://www.cmar.csiro.au/argo/) enabling the performance of deployed UK (and Australian) Apex floats to be monitored and assisting failure cause diagnosis.

Deployment plans for 2010 and 2011

At the end of 2009 we had 26 Apex floats available for deployment, with 58 new Apex floats scheduled to be delivered by end March 2010. This will give us a stock of 84 floats for deployment in 2010 and 2011, although the actual deployments have still to be arranged. It is planned on making up to 40 float deployments in both 2010 and 2011. The floats are ballasted for the areas as shown in Table 2.

Atlantic Ocean
9 Apex for north-east Atlantic (Iceland Basin/Rockall Trough)
14 Apex for north-east Atlantic (~26N)
12 Apex for South Atlantic(~15S)
10 Apex for south-east Atlantic (~36S)
Southern Ocean
14 Apex for Atlantic sector (50-60S)
Indian Ocean
9 Apex for Arabian Sea
8 Apex for Somali Basin
4 Apex for South Indian Ocean (~30S)
4 Apex for Mauritius

Table 2. Floats available for deployment in 2010 and 2011.

Data management

The UK Argo Data Centre, established at BODC, processes all our float data (including the floats donated to Mauritius and 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 used by CSIRO Marine to populate the technical web-site.

Delayed-mode. Delayed-mode processing is carried out by BODC with support from the UKHO. Much of the work in 2009 has been working on identifying pressure sensor issues with our floats and correcting the data. A total of 4,492 delayed-mode profiles have now been submitted, this is about 22% of all our profiles eligible for delayed mode QC (i.e. excluding floats that have been operating for less than 18 months). The UKHO are now taking the lead on processing the Arabian Sea floats (~2,000 profiles). It is expected that the backlog of data needing to be submitted will be reduced during 2010 as the vacant real-time processing post at BODC has been filled.

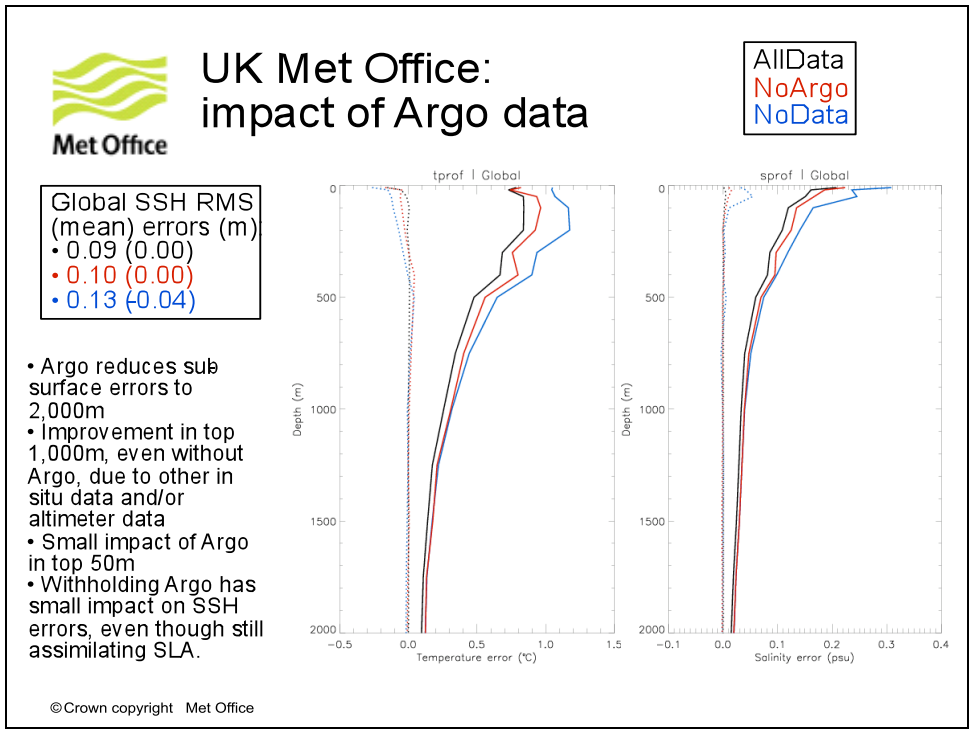
Southern Ocean. We work with 3 other organizations to operate a Southern Ocean Argo Regional Centre (SOARC) and to cover the entire Southern Ocean - BODC (Atlantic Ocean Sector), CSIRO ('Australian' sector), JAMSTEC (Pacific Ocean Sector) and the University of Washington (Indian Ocean Sector). BODC hosts the main SOARC data and information web pages. These pages contain an animation of the Met Office Forecast Ocean Assimilation Model (FOAM) outputs (potential temperature, salinity and velocity at 5m and

around 1,000m depth) and an interactive map giving information on last known positions, deployment positions and direct links to both GDACs ftp sites. Due to resource problems little progress has been made on the Regional Centre activities during the last year.

Under the EC-funded MyOcean project the level of SOARC activities at BODC should increase. Initial plans include the working up and submission of relevant CTD profiles to the NODC which will then filter through to the Argo delayed-mode QC reference data. Collaborative work with the Environmental Systems Science Centre (ESSC) at Reading is beginning that will compare the results of Argo QC to several Met Office operational assimilation QC tests. It is hoped to identify potential improvements for both the Argo QC and operational data assimilation QC systems.

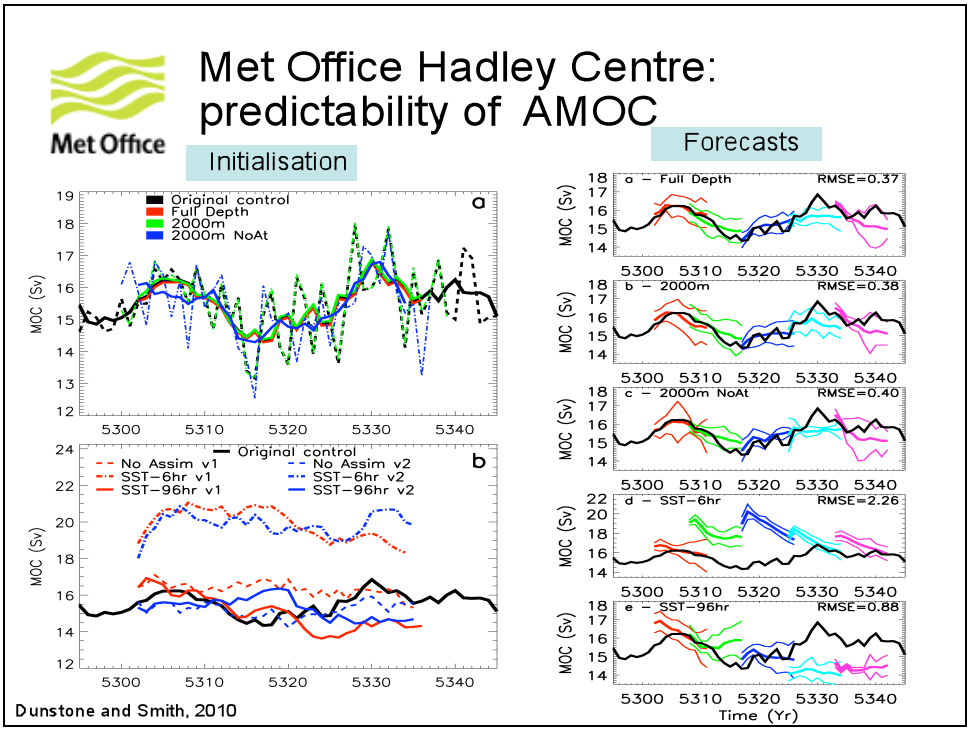
Operational and scientific use of Argo data at the Met Office

Operational ocean forecasting. All Argo data (alongside other in-situ and remotely sensed ocean data) are routinely assimilated into the FOAM operational ocean forecasting system run by the National Centre for Ocean Forecasting (NCOF). A new series of experiments were carried out using the 1/4 degree resolution global FOAM-NEMO system, forced by 6-hourly surface fluxes produced by the Met Office's NWP system, with results (observation minus background statistics) as shown below.



Seasonal to decadal prediction. Argo data are also assimilated by the GloSea (Global Seasonal) coupled model run to make seasonal forecasts for several months ahead. These are more reliable for tropical regions than for temperate climates. Seasonal forecasting is still an area in which the science is being developed and it has been decided that the UK seasonal forecasts will not be made publicly available. On longer timescales the Hadley Centre DePreSys (Decadal Prediction System) is being developed for climate predictions on decadal timescales. The impact of Argo data on decadal climate forecasts has been assessed in idealised experiments (Dunstone and Smith, 2010). These studies attempt to predict the evolution of a control integration of a coupled climate model using pseudo-

observations taken from the model integration. Results show that decadal variability of the Atlantic Meridional Overturning Circulation (AMOC) is potentially predictable given the information that would be available from Argo floats. However, assimilating only sea surface temperatures does not initialise the AMOC correctly, resulting in much less skilful forecasts. Skill is slightly improved, especially in the Southern Ocean, with observations below 2000m. Including atmospheric observations does not significantly improve the skill apart from during the first year.



Climate monitoring and prediction. The Hadley Centre maintain the HadGOA (sub-surface global analysis) dataset of historical temperature and salinity. Variables are on a 2-degree grid and computed on number of fixed isotherms and fixed depths at monthly resolution. 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.

Research using Argo data at NOC

Argo data are also used extensively in a wide range of research projects in UK Universities and research laboratories and are a central component of several PhD and MSc projects. A survey carried about John Gould has indicated there are almost 50 projects/researchers (excluding the Met Office) that are using Argo data. The UK Argo Users' Group has provided a forum for engagement between these scientists and the UK Argo programme. Although this activity has to some extent been taken forward in the context of a European Argo Users Group under the Euro-Argo project, there remains a need to improve the interaction with UK users of Argo data and a Users Workshop was held at Exeter on 16th March 2010.

Research using Argo data at NOC is carried forward mainly, though not exclusively, through graduate students. Current projects include:

Alex Brearley is reconstructing circulation at 36N in the Atlantic using Argo profiles and trajectories. The western boundary is being handled with the addition of repeat ship-based measurements, including shipboard and lowered ADCP, at Line W. The drivers of variability

are being studied, for example the extent to which variation in the basin-scale circulation is a response to changes in the wind-driven Sverdrup transport.

Sally Close is studying seasonal to decadal variations in water mass properties (SAMW, AAIW, NADW, UCDW) in the SE Pacific/Drake Passage/Atlantic sector of the Southern Ocean. All available data are being used, including repeat hydrography, Argo profiles and animal-borne sensors.

Gerard McCarthy is studying decadal changes in intermediate and thermocline water properties in the subtropical South Atlantic, from CLIVAR/GO-SHIP repeat hydrography lines. Argo profile data are being used in support of this study to determine the magnitude of interannual variability and hence to clarify the timescale of observed changes.

Lorna McLean is studying decorrelation scales (from Argo data) in the Pacific and Atlantic basins, their geographic (mainly latitude) and depth variations. Originally motivated for use in data assimilation, the final conclusions will be applicable to the Argo DMQC task.

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.

UK Argo Science Report

During 2009 a report was prepared for the UK Argo funders detailing the latest results from the application and scientific use of Argo data. The report stresses that Argo is an essential element of our climate observation system and that data from Argo has already led to improvements in understanding climate-relevant ocean processes and for predictive models. It concluded that '*the long-term funding of the Argo array of profiling floats is of highest priority for UK climate science and to ensure that the best climate science is used to inform government policies on climate change mitigation and adaptation'*. The report is available at www.metoffice.gov.uk/weather/marine/observations/gathering_data/Science_case_for_Argo.pdf.

Funding

It was initially agreed that MoD and DETR (then Defra, Dept of Environment, Fisheries and Rural Affairs and now DECC, Dept of Energy and Climate Change) would provide matching funding (through the Met Office) for UK Argo, and that NERC would also provide funding and support through NOCS and BODC. However, the funding from MoD has declined since 2005 and funding from DECC (ex Defra) has also reduced and with large year-to-year variations as it has often included year-end underspend monies. From April 2010 all MoD funding will cease as the MoD has decided to withdraw its support for climate research. At the time of writing it is expected that MoD support for data processing at the UKHO will continue. NERC funding has also been relatively variable due to funding for floats relying largely on bids to thematic programmes, although funding for support activities (e.g. data processing, science leadership) has been relatively stable. NERC funding for these support activities has been allocated to March 2012 through the Oceans2025 settlement, with the expectation it will continue after the 5 year Oceans2025 period.

Securing adequate regular funding for UK Argo continues to be a problem, particularly with the cessation of MoD funding. However, the additional 'underspend' funding committed by DECC and NERC in early 2010 has enabled additional floats to be purchased so that UK Argo will be able to deploy around 40 floats in each of 2010 and 2011. Regular funding for personnel (programme management, technical support and data management) remains at a minimum level.

Considerable time and effort has been (and continues to be) expended in trying to secure longer-term funding for UK ocean observations that have been committed to international programmes such as the GOOS, GCOS and the GEOSS; with Argo as a pressing example for the need for a solution. This has so far been unsuccessful as there is currently no mechanism within UK Government to transition funding from research to operational funding lines. However long-term (9 years) funding for Jason-3 has now been agreed, after the issue was elevated to senior ministers.

During 2009, as a response to the 'Investigating the Oceans' report a new high-level cross departmental Marine Science Coordination Committee (MSCC) has been established, reporting to a Ministerial Marine Science Group. The initial task of the Committee was to develop a UK Marine Science Strategy, this has now been signed off by the Ministerial Marine Science Group, where a priority task is to "*develop a transparent prioritisation tool to help inform decisions on the funding of observation systems (for both starting and stopping observation systems*" and to "*also develop practical proposals to provide cross-cutting, longer-term funding for priority long term monitoring systems*". Hence sustained funding for long-term observations, such as Argo, will be one of the strategic issues the committee will be addressing in 2010.

Euro-Argo

Both the Met Office and NERC are involved in the Euro-Argo project (January 2008 to December 2010) to develop and recommend a European infrastructure to enhance the collective ability of the European nations to contribute to Argo, to the level where 'Europe' has the capacity to deploy ~250 floats per year, and to process the resulting data. Such a European contribution would support approximately 25% of the global array and provide an additional 50 floats per year for enhanced coverage in the European and marginal seas. This will require long-term funding commitments from the European partners and from the EU (via GMES). The Met Office and NERC are leading on several Euro-Argo work packages (WP3. Financial Work and WP6. Strengthening the User Community respectively) and the Met Office also lead on the WP5.3 Impact Studies and Demonstration Cases task. One outcome of WP6 is an educational outreach site focussed on Argo (see http://www.noc.soton.ac.uk/o4s/euroargo/).

DECC have advised that UK should go for full membership of the Euro-Argo ERIC (European Research Infrastructure Consortium) and sign off is expected to be via a DECC minister), but at present their longer-term commitment is only at a minimum level (and well below the level at which the UK ought to contribute). However, NERC have 'earmarked' longer-term funding for Euro-Argo but this is not, as yet, a commitment. In parallel with the work through the cross-government MSCC this should ensure the issue of UK Argo funding is raised to the Ministerial Marine Science Group for a decision on longer-term funding.