UK ARGO PROGRAMME

REPORT FOR ARGO STEERING TEAM 9TH MEETING, MARCH 2008

Background and present status

The UK Argo programme is undertaken by a partnership which was developed following discussions between the NOAA Administrator and the Chief Scientific Advisor (CSA) in 1999. It has been funded by UK government through the Department for Environment, Food and Rural Affairs (Defra), the Ministry of Defence (MoD) and the Natural Environment Research Council (NERC) and is carried out in collaboration 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 UK programme was initiated in 2000, with our first Argo floats being deployed in January 2001. UK Argo has also been active within the international Argo Steering Team and the Argo Data Management Team.

Floats deployed and their performance

Since 2001, nearly 250 UK floats (including 5 donated to Mauritius) have been deployed in a number of different geographic areas, where deployments have focused on meeting specific UK requirements, while also contributing to the global array.

Year	*Floats deployed*	*Operating*
2001	*29*	*0*
2002	*38*	*0*
2003	*37 (1)*	*4*
2004	*45 (2)*	*21*
2005	*28*	*22*
2006	*24 (2)*	*20*
2007	*33*	*28*
2008	*35*	

Table 1. Numbers of UK floats contributing to Argo deployed by year, figures in brackets are floats donated to and deployed by Mauritius. An estimated figure is given for 2008, for which 10 floats have been deployed too date.

The interests of the UK are global but with particular interests in the Atlantic and Southern Ocean. However, because other countries have committed a sufficient number of floats to the North Atlantic, UK has only deployed a relatively small number of floats in that region. In particular UK Argo has taken a lead in deploying floats in sparsely populated regions (e.g. Arabian Sea, South Indian Ocean, South Atlantic and Southern Ocean) in support of establishing the global array.

Float survivability

1. Apex floats

There has been a distinct improvement in the survival of our floats deployed from 2004 to those deployed in earlier years. Only 30 to 40% of floats deployed before 2004 made more than 100 profiles, although our longest-living float (from 2002) reached 185 profiles before expiring. However for floats deployed in 2004 nearly 70% reached the 100 profile mark.

The reduction in early failures is also seen in floats deployed in 2005. For the 2006 floats we believe that 3 of the early failures (plus 2 in 2007) may have been ice-related.

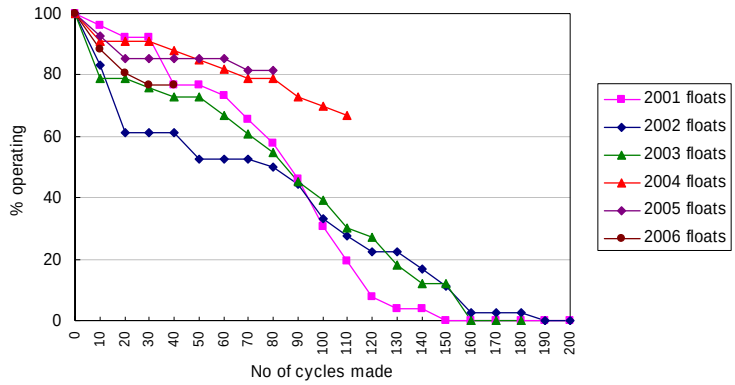

Figure 1. Showing the % numbers of Apex floats, deployed by year, operating. Statistics exclude floats where deployment failure has been confirmed and the number of cycles is adjusted for those floats that have shallower profiles or only profile deep intermittently.

2. Provor floats

Similarly the survivability of our Provor floats deployed in 2004 and 2005 (13 floats) shows a distinct improvement over those deployed in 2001 and 2002 (8 floats). However, a number of these later floats expired after making 100 profiles, leaving just 2 operating (>116 cycles). Of the 4 Provors (all upgraded by Martec) deployed in 2007, one failed after 4 cycles the others are approaching 20 cycles).

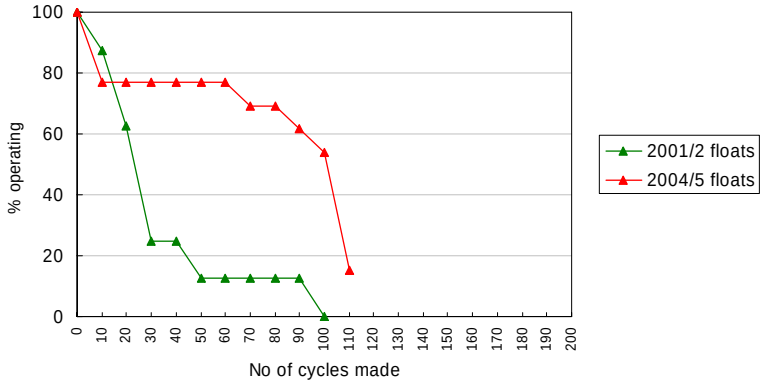

Figure 2. Showing the % numbers of Provor floats, deployed by period, operating. There were no deployment failures with all floats cycling to 2,000m depth.

Apex float monitoring

We have established a partnership with Australia's Commonwealth Scientific and Industrial Research Organisation (CSIRO) to monitor the performance of deployed UK (and Australian) Apex floats where an engineering web-site for UK and Australian Apex floats has been established (see http://www.cmar.csiro.au/argo/tech/). This work helps to identify areas where further improvements to the float technology can be made.

Deployment plans for 2008

As at mid-February 2008, we have deployed 10 floats in 2008 and anticipate at least another 25 float deployments during the year, as shown in Table 2 (over).

10 floats deployed so far in 2007	
South-east Indian Ocean	*6 Apex floats with lithium batteries deployed from CMA/GGM Lavender in January (IX-15 line)*
Arabian Sea	*4 Apex floats deployed in the Arabian Sea from RV Sagarkanya end January*

Floats available for deployment (8)
1 Apex for north-east Atlantic (Iceland Basin/Rockall Trough)
1 Apex for Arabian Sea
4 Apex for Somali Basin
1 Apex for Southern Ocean
1 Provor, region to be decided

Floats to be delivered March/April (30)
6 Apex for south-east Atlantic (plan to deploy from Agulhas in September)
8 Apex for Southern Ocean (will have lithium batteries), 4 with ice-avoidance
6 Apex for north-east Atlantic (Iceland Basin/Rockall Trough)
4 Apex for south-east Indian Ocean
6 Apex regions to be specified

Table 2. Floats deployed and available for deployment from 2008.

Data management

The UK Argo Data Centre, which is established at BODC, processes all our float data. New floats are added into the system as they are deployed and metadata compiled; a metadata netCDF file is generated for each float and forwarded to the 2 Argo Global Data Assembly Centres (GDACs) in France (Coriolis) and the US (USGODAE).

Real-time data processing. An automatic real-time processing system has been developed and is operational. This downloads, twice daily the raw (hexadecimal) data from CLS, decodes the data stream, carries out an agreed suite of automatic quality control tests (adding quality flags to the data as necessary), and generates profile and trajectory data files in the internationally agreed formats. The UK Argo Data Centre web-site is automatically updated daily with UK float status information, a map of current float positions and temperature and salinity profile plots.

The automatic real-time system generates the float data in both WMO TESAC and Argo netCDF formats. The TESAC messages are automatically emailed to the Met Office where they are then disseminated on the GTS via Exeter (EGGR). GTS (and in the future the WMO Weather Information System) will remain the primary mechanism for receipt by the Met Office (and other National Meteorological Services) of real-time data (floats, buoys and ship data etc.) needed for meteorological and ocean forecasting.

The data in netCDF format are provided (by FTP) to the two GDACs, generally within 24 hours of receipt, and 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 data processing. This is carried out by BODC with support from the UKHO. A total of 4,492 delayed-mode profiles have been submitted, this is about 40% of all floats

available for delayed mode processing (i.e. excluding floats that have been operating for less than 18 months).

Southern Ocean Argo Regional Centre (SOARC). As noted earlier, the UK has particular scientific interests in the Southern Ocean and has taken the lead in establishing the SOARC. This has been a collaborative effort between BODC and CSIRO with BODC having primary responsibility for the South Atlantic sector of the Southern Ocean and CSIRO responsibility for the eastern Indian Ocean sector and the region around Australasia. Recently the University of Washington, USA, has agreed to take responsibility for the Indian Ocean sector and JAMSTEC, Japan, for the Pacific Ocean sector. Work undertaken by BODC has concentrated on acquiring recent CTD data to improve the reference data set for the Southern Ocean needed for scientific QC of the float data.

Operational and scientific use of Argo data

A key aspect of the UK Argo programme is to develop the capabilities to fully exploit all Argo data for operational forecasting and research applications.

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). The FOAM predictions are used by the Royal Navy and also provide forcing to high resolution models of the north-west European shelf-seas that provide outputs with potential applications such as prediction of the transport and dispersion of oil-spills, ecosystem parameters, harmful algal blooms and for fisheries. Experiments have shown that Argo data has a significant positive impact; without Argo data temperature errors are up to 40% larger and salinity errors near the surface are over twice as large, even when all other in situ data sources are assimilated. Argo data have also been used to improve and validate the mixed layer model used in FOAM. Within NCOF research work continues to improve the assimilation methods used.

Seasonal forecasting. Seasonal forecasts provide long-range warning of weather conditions, both for the UK and for developing countries (e.g. forecasts for drought conditions in the Sahel, East African rainfall). They are largely determined by statistical methods in which the forecast is based on precursor sea surface temperature patterns as these change slowly and influence patterns in the weather. An example of where Argo data had a direct impact on the UK forecast was in the North Atlantic in summer 2005 where monitoring of sub-surface temperature anomalies provided clear observational support for the statistical forecast of the forthcoming 2005/06 cold winter.

Numerical models are also run to make seasonal forecasts. Although initialising numerical seasonal forecasting models with Argo data improves the accuracy of their predictions of surface temperature, the models are not presently any more accurate than the statistical techniques as they are still experimental and not yet capable of exploiting the full benefits from the Argo data; this is an area of continuing research and development.

Climate monitoring and prediction. Modelling studies at the Met Office Hadley Centre have shown that the traditional approach of occasional (and generally haphazard) observation of the sub-surface ocean through research cruises does not produce sufficiently close sampling of the ocean (in space or time) to allow rapid detection of the effects of climate change. Argo is the only observing system that provides the global coverage and frequency of sampling required. Climate model simulations by the Met Office Hadley Centre have indicated that 3,000 floats is probably near optimal. The results suggested that with $3^{\circ} \times 3^{\circ}$ spacing Argo should capture the variability and signal in ocean heat content, as the

temperature variability (noise) in the model decreased most rapidly when sampling up to 3° resolution, but the decrease was less (diminishing return) when sampled at higher resolution.

The Hadley Centre have developed the HadGOA dataset, a new ocean analysis of historical temperature and salinity suitable for climate model validation, evaluation of historical ocean heat content variability and more general climate monitoring, based on observed data (mainly Argo). HadGOA will provide an important addition to the key global climate datasets maintained by the Hadley Centre for the climate research community.

It has been demonstrated that initialisation of ocean heat content is a key element adding skill to decadal predictions of regional climate; use of Argo data significantly influences predictions of the Atlantic thermohaline circulation (THC) which is responsible for the relatively mild climate of western Europe (and expected to weaken as a result of global warming).

Ocean science. Argo data are being used by many researchers in UK on improving understanding of ocean properties (e.g. circulation, heat storage and budget, and mixing) and on how they are applied in ocean models (e.g. improved salinity assimilation, mixed layer forecasting and seasonal forecasting). This includes many scientists from outside of the UK Argo community. The UK Argo Users' Group has provided a forum for engagement between these scientists and the UK Argo programme.

Funding

As noted earlier the UK Argo Project has been funded by Defra and MoD (through the Met Office, but provided from departmental research lines) and by NERC (through NOCS and BODC). Presently part of the funding support is agreed to 2011 with other parts being agreed on an annual basis. In addition MoD also funds UKHO support for data processing.

Our aspiration for UK Argo is to contribute to the global programme to at least a GNP level based share (~5%), i.e. to deploy 40 – 50 floats each year. However, present funding levels are insufficient to deliver that level of contribution. We are currently working through the UK government's Marine Monitoring and Assessment Strategy (UKMMAS) with the aim to secure agreements on longer-term funding for UK ocean observations, with Argo as a pressing example for action. (The UKMMAS remit includes monitoring activities in both UK waters and the open oceans and covers ocean monitoring, such as Argo, carried out in support of internationally agreed programmes that are commitments to the GOOS, GCOS and the GEOSS.) This is proving to be very difficult as there is presently no mechanism within UK Government to transition systems from research funding to operational funding lines. Hence it is likely that funding for Argo for the next few years will continue to be requested from existing research budgets.

Euro-Argo

Euro-Argo is a 30-month programme (which started January 2008) to develop and recommend a European infrastructure to enhance the collective ability of the European nations to contribute to Argo, and by working together to be able to do so more efficiently in the future. For the UK the organisations involved are NERC (through the National Oceanography Centre, Southampton and the British Oceanographic Data Centre) and the Met Office. The aim is to develop the infrastructure to the level where the European partners have the capacity to procure and deploy ~250 floats per year, the ability to monitor these floats, ensure all float data can be processed (both in real-time and delayed-mode) and to

clear the present backlogs in the data processing system. With a mean float lifetime of 3¾ years such a European contribution would support approximately 1/4 of the global array and provide an additional 50 floats per year for enhanced coverage in the European and marginal seas.

By entraining more European countries into Argo, and seeking EU GMES funding for floats, it is expected that the European-wide contribution to Argo will be increased and put onto a more secure basis. This will help secure the longer-term operation of the Argo 3,000 float array, and its continued ability to deliver valuable data to operational and research users. Securing a long-term UK funding commitment to Argo and the Euro-Argo infrastructure is critical to both Euro-Argo and to the international Argo array.