UNITED KINGDOM CONTRIBUTION TO ARGO

REPORT FOR ARGO SCIENCE TEAM 6TH MEETING, MARCH 2004

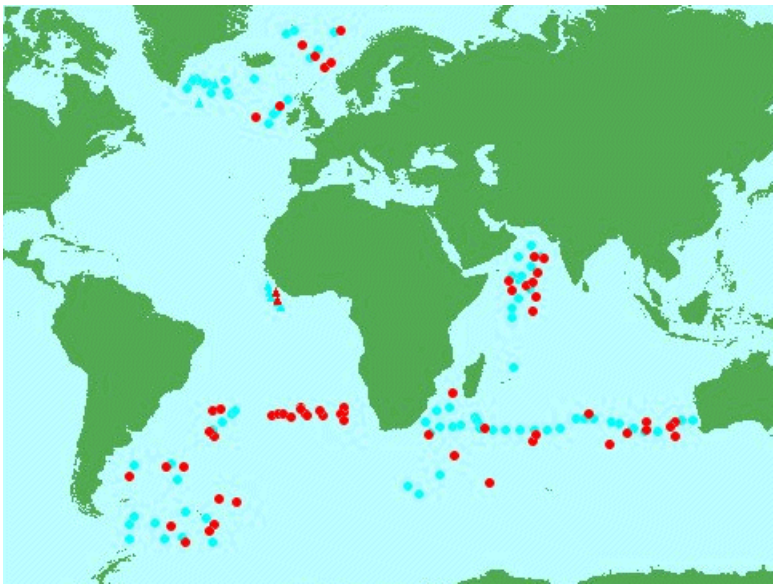
The UK's contribution to Argo is being funded by the Department of the Environment, Food and Rural Affairs (Defra), the Ministry of Defence (MoD) and the Natural Environment Research Council (NERC), and is undertaken by a partnership involving the Met Office (who also manage the project), Southampton Oceanography Centre (SOC), the British Oceanographic Data Centre (BODC) and the UK Hydrographic Office (UKHO).

UK Argo Project

The UK Argo Project was initiated in 2000 with initial funding for a 3-year period. A phase 2 project, through to 2006, is maintaining the UK contribution towards establishing the global Argo array but with an increased emphasis on demonstration of benefits, since this is essential to justify continued UK funding for Argo and its transition to sustained operation. Further information on UK Argo is at http://www.metoffice.com/research/ocean/argo and http://www.soc.soton.ac.uk/JRD/HYDRO/argo.

Floats deployed

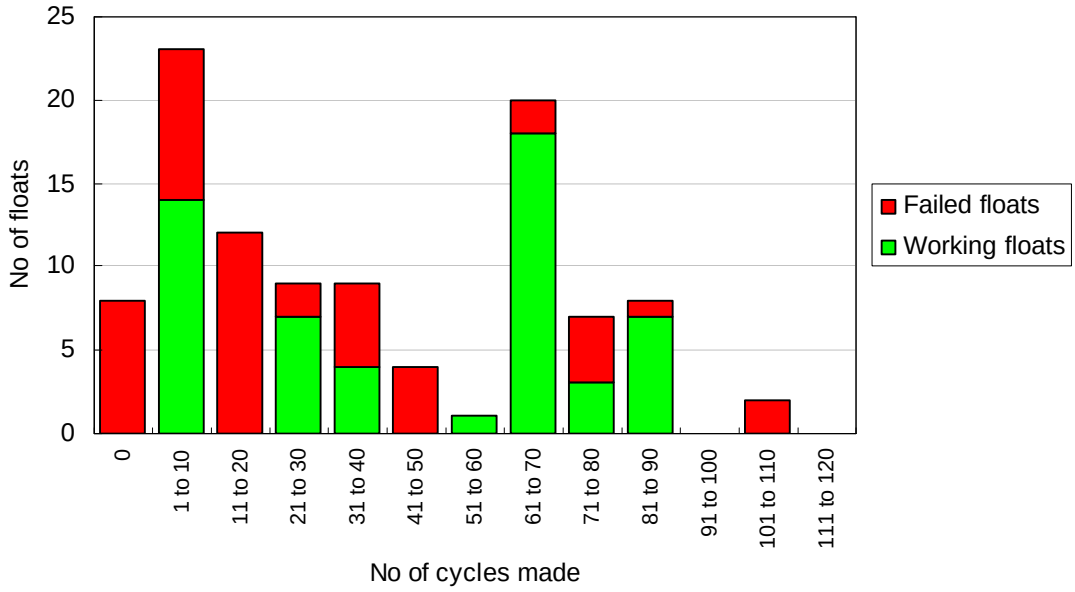
Over the last 3 years UK has deployed 104 (Argo and Argo-equivalent) floats; 29 in 2001, 38 in 2002 and 37 in 2003), across a wide range of ocean areas as shown below. A further float was donated to, and deployed by Mauritius Meteorological Service in June 2003. Following discovery of the pressure transducer problem (affecting our Apex floats with SeaBird sensors), and identification of the anti-foulant (VC-17) as the cause of failure with the salinity on our 2003 Provor floats with FSI sensors, our remaining floats were recalled by Webb and MARTEC during summer 2003 for refurbishment. Deployments restarted in November with the 15 Apex floats deployed for us by JAMSTEC in the eastern South Atlantic.



Showing locations at which UK floats have been deployed • and current positions • of those reporting (February 2004). Circles show Apex floats, triangles Provor floats. Figure includes the Mauritius float and 2 Irish floats (deployed in the Rockall Trough) being processed by UK Argo.

Float performance/technical problems

As can be seen from the figure the number of operating floats is substantially less than the number of floats deployed. Of the 105 floats deployed (93 Apex floats and 8 Provor) some 54 were operating in early February. In the last 2 years we have experienced a significant number of early failures; 14 floats failed early in 2002 due to the motor backspin problem, and in 2003 a number of floats failed due to the pressure transducer problem. In both years the floats were deployed before the failure mode was discovered. Of the 8 Provor floats deployed in 2002 and 2003, only one is still providing valid (temperature only) data. Our high failure rate, compared to other nations Argo programmes, is a particular concern. Therefore, over the next 2 years we plan to improve our technical capability, through collaboration with CSIRO Marine, with the aim of improving our float performance.



Showing the performance of UK floats deployed (excluding 2 floats which were not correctly deployed) as at early February 2004.

Deployment plans

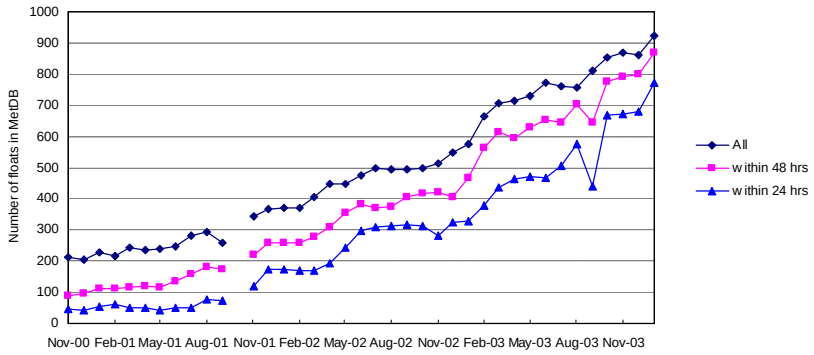
As at February 2004, we have in our inventory 62 floats (including some replacement floats provided by Webb for those that failed early in 2002) for deployment in various regions as detailed below; this includes 25 floats for which deployments have been scheduled.

Floats for which deployments are planned	
Southern Ocean	*6 Apex floats to be deployed in March by SA Agulhas on SR2 line*
Southern Ocean/South Atlantic	*8 Apex floats between 40°S and 24°S, deployment during May/June on Atlantic Meridional Transect (AMT) cruise.*
Somali Basin	*9 Apex floats to be air deployed by NAVO in May*
North Atlantic	*2 Apex floats for the north-east (Rockall Trough) region, expected to be deployed from RV Poseidon in July.*
Floats for which deployments have not yet been planned	
Mozambique Channel	*2 floats to be deployed by INAHINA (floats to be refurbished)*
Mauritius	*2 floats to be delivered in February*
Southern Ocean	*7 Apex floats*
Western Indian Ocean	*8 Apex floats*
tbd	*18 Provor floats*

In 2004 we are looking at procuring around 40 floats. Assuming that the North Atlantic is adequately populated with floats by other participants it is likely that these floats will targeted towards the South Atlantic, Southern Ocean and Indian Ocean regions.

Data management

Real-time data (GTS). Data from all working UK floats are automatically placed onto GTS in WMO TESAC format by CLS/Meteo-France or (for our PROVOR floats) by Coriolis/Meteo-France. Since November 2000 the Met Office has monitored real-time float data received by GTS and assimilated into its operational ocean prediction system FOAM (Forecasting Ocean Assimilation Model) and coupled ocean-atmosphere general circulation model for seasonal forecasting GLOSEA (Global Seasonal). At end January 2004 data from over 900 floats were being received. Typically only ~1% of these data fail real-time QC tests (spike, stability, background and buddy checks) and are rejected prior to assimilation. The UK is strongly in favour of the migration of the GTS data format from TESAC to BUFR, as has now been taken onboard by the Argo Data Management Team.

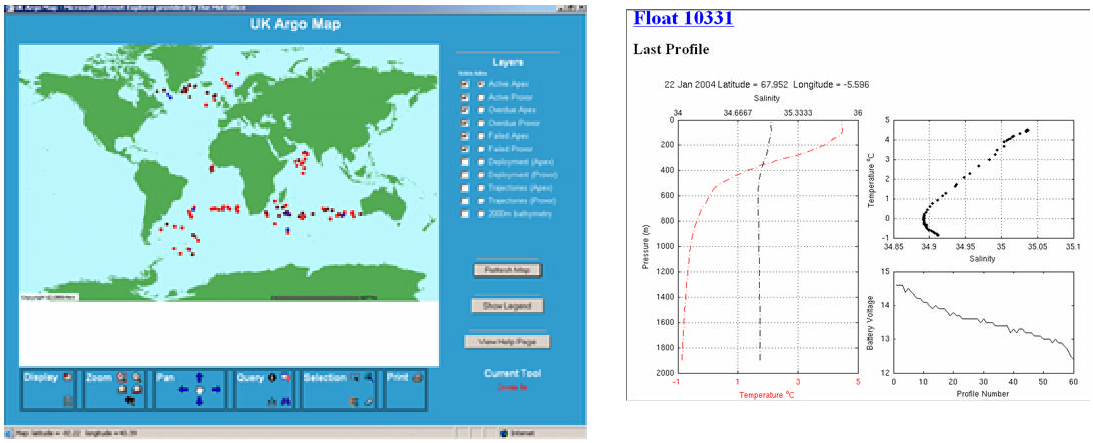


Showing the amount and timeliness of float data received at the Met Office via GTS.

UK Argo Data Centre. The UK Argo Data Centre, established at BODC, (see http://www.bodc.ac.uk/projects/argo/argo.html), processes all our full-resolution float data. An automatic processing system (decoding the Argos data which is delivered by ftp and putting the profile data on the web-site) has been set up and BODC have been routinely issuing full resolution profile data (after real-time QC) in netcdf to the GDACs since July 2003 for all data received from CLS (all profiles prior to this date have also been issued to the GDACs). However, there is a need for Argo to implement procedures for netcdf version control; when changes have been agreed the format should remain static for several months, to enable DACs to make the necessary software adjustments. Without advance scheduling of version changes it is difficult to plan the work involved.

The ongoing effort required to process the data in real-time has meant there has been less time for (manual) data screening and delayed-mode QC (which is carried out with the UKHO) than originally envisaged. The first delayed-mode QC efforts have been focused on our South Indian Ocean floats and Southern Ocean floats. Delayed-mode QC work has concentrated on working with the Wong software on 2 long time-series floats in the Drake Passage. This work has highlighted specific difficulties in the QC of Southern Ocean data due to the existence of a subsurface temperature maximum south of the Polar Front and highlighted the need to improve present techniques. It has been seen that by working up from the bottom of the profiles to the 1st inversion and truncating the profile there improves the results considerably. Annie Wong is now working on further improving her software south of the Polar Front.

Towards the end of 2003 the UK Argo Data Centre's web-site was upgraded to include an interactive map with links to plots of the last temperature and salinity profiles and battery voltage time-series for each of our floats (see below).



Example of web interface for UK float data on the UK Argo Data centre web-site.

Southern Ocean Regional Centre. BODC has begun operation of a Regional Argo Data Centre for the Southern Ocean (which will be operated in conjunction with Australia) and will handle data from the Atlantic and Indian Ocean sections of the Southern Ocean (but not the Pacific sector) and have started to collate data from south of 30° S to improve the historical dataset used in any checks against float data. This has involved removing some points from the supplied dataset which are of suspect quality.

Operational and scientific use of Argo data

Operational ocean forecasting. As noted earlier all Argo data (alongside other in-situ and remotely sensed ocean data) are assimilated into the FOAM operational ocean forecasting system (see http://www.metoffice.com/research/ocean/operational/foam/index.html). During 2003 an assessment of the benefits from Argo was made and the results demonstrated the positive impact of Argo data on predictions from FOAM. Temperature and salinity errors are reduced at almost all depths when both temperature and salinity data are assimilated. Assimilating only temperature degrades the model salinity and assimilating only salinity degrades the model temperature – this demonstrates the value of Argo in providing collocated temperature and salinity data. Prior to Argo it was not worthwhile assimilating deep (>1,000 m) ocean data since little deep data were available – as a result the model tended to drift away from climatology. Assimilating Argo data has largely eliminated these accumulated deep ocean biases. Experiments with the 1/9° North Atlantic FOAM have also shown that, with Argo data, it is possible to spin-up the model more rapidly. The impact of the data on mixed layer prediction has also been demonstrated. These results were presented at the Argo Science Workshop in November and a report on the results provided (http://www.ifremer.fr/lpo/gyroscope/documents/Gyroscope_report_Sep03.doc) as a contribution to Gyroscope.

Seasonal forecasting. From January 2002 experimental seasonal forecasts have been made by the Met Office using its new GLOSEA coupled ocean-atmosphere general circulation model, these together with a description of the system are described at http://www.metoffice.com/research/seasonal/monthly_public/index.html. All Argo data are assimilated in runs of the GLOSEA system, although no work has yet been done to demonstrate the impact.

Climate studies. In spring 2002 UK Argo deployed 25 Apex floats along the 32° S section in the Southern Indian Ocean – a region in which previous hydrographic sections had shown a freshening in the intermediate waters. Furthermore, Hadley Centre climate model (HadCM3) simulations suggested these changes are a fingerprint of anthropogenic change. Analysis of the float data and comparison with CTD profiles by SOC has shown the accuracy of the salinity data should be sufficient to observe subsurface salinity changes as small as 0.04 with a high degree of confidence and without needing long time-series. The float data have also confirmed that the mode water properties are stable over large horizontal scales (meridional and zonal) and over a 12-month timescale. This suggests the changes are due to a slower trend and not down to seasonal or inter-annual variability. These results, presented to the Argo Science Workshop in November, highlight the great potential of Argo data, with careful selection and calibration, to interpolate between research cruises and to provide unprecedented descriptions of subsurface property variability and trends.

HadCM3 simulations have also investigated the potential of Argo data for detection and attribution of climate change on the 10 to 15 year time-scale. In addition to looking at changes in water mass properties (e.g. the South Indian Ocean) to identify trends and variability, the results suggest that the full Argo array of 3,000 floats (~3° spacing) will be sufficient to resolve global heat content variations on inter-annual and longer timescales. (A coarser array (5° spacing or poorer) would not be sufficient and would lead to spurious variability.) A further set of studies looked at the Atlantic THC and what observations could supplement the proposed deep ocean mooring at 24° N. The results suggest Argo will be able to detect signals related to anthropogenic changes in the THC, which were spread throughout the Atlantic. In particular, the model suggested, a strong signal would occur in the south-east Atlantic, a region in which 15 Argo-equivalent floats funded through the NERC COAPEC (Coupled Ocean Atmosphere Processes on European Climate) programme were deployed in November 2003.

Resources and future funding

At present the Met Office is funded by Defra and MoD (£600K pa) for UK Argo; this covers project management, technical support, procurement and deployment of floats, communications, together with work on operational and scientific use of the Argo data (as described above). NERC provides staff resources for scientific support and data processing at SOC and BODC, plus deployment from its research vessels. Additional (Argo-equivalent) floats and work on scientific exploitation is funded through bids to NERC science programmes. Support on data processing is also provided by the UK Hydrographic Office. Overall, human resources dedicated to UK Argo (not including additional work funded through science bids) total about 4 person-years.

An evaluation of the resources required to sustain operation of the UK Argo Data Centre at BODC and to spin up the Southern Ocean Regional Data Centre has been made. This indicates that the resource required is for 3 people (2 for the UK Argo Data Centre plus 1 for the Southern Ocean Centre). At present support is available for 1 person through BODC and SOC funding, plus Met Office support for another ½ years development work to June 2004. Because of this shortfall the scientific delayed-mode QC will be prioritized to process those floats in regions of greatest interest. Without additional resources it is unlikely that all UK floats will be subjected to scientific QC (over and above any automated procedures).

Agreed funding from Defra and MoD extends to 2005/6, and the NERC contribution will continue until at least 2004/5; beyond these dates funding has not been assured. Currently Defra and MoD funding is from research budgets and these will not provide sustained funding for UK Argo in the longer term, both Defra and MoD have stated that continued funding for UK Argo must come from operational budgets. Over the coming years there is a need to identify such longer-term UK funding in order to help sustain the Argo array and

demonstrate its full value, and discussions are ongoing with Defra, MoD and other appropriate inter-agency bodies. It is likely that a scientific case for continued NERC funding can be made, but this would only be sufficient to supplement, rather than sustain, the UK contribution to Argo.

Longer-term UK funding will likely be contingent on demonstrable progress being made by Argo towards becoming 'operational'. (In the context of Argo the definition of operational in the 2nd GCOS Adequacy Report for UNFCCC is relevant: "Operational … means observational activities that are undertaken according to agreed standards on a routine and on-going basis with plans for continuity and homogeneity. It also implies compliance with the GCOS Climate Monitoring Principles".)

International coordination

Even though it is recognised that Argo is still some way from being operational in the above sense, it is necessary for the international Argo community to begin preparing, through JCOMM, for this transition earlier rather than later. At the same time Argo will need to become properly integrated within the international (JCOMM) operational observing capability. Although the baseline Argo array should be based on well-established technology, there will remain an important role for the research community in improvement of the technology, development of new sensors and implementation of higher resolution regional arrays for scientific research.

Over the coming years UK Argo agrees the need for an Argo Project Office Director, but this Office should not be independent of JCOMM (perhaps reporting to the JCOMM Management Committee or through the Observations Programme area), and working closely with the Argo Technical Coordinator. At some time it may be timely to review the remit of the Argo Science Team, as what may be needed in the future is an Argo Implementation Team, perhaps with a science sub-team in the same way there is a data management team at present. Either way, the Argo Science Team (or Implementation Team) will need to become fully integrated into the JCOMM structure.