UK ARGO PROGRAMME

REPORT FOR 22ND ARGO STEERING TEAM MEETING MARCH 2020

1. Status of Implementation

Floats deployed and their performance

During 2020 we were able to deploy 29 floats; 13 of these were deployed early in the year before the Covid-19 pandemic curtailed deployment opportunities, with the other 16 deployed from October when research cruises restarted.

Of these, 17 were standard core APEX, four were core APEX with RBR CTDs, seven were APEX Deep (one with RBR CTD and oxygen) and one Navis BGCi (bio-geochemical) float. Also, we deployed two APEX Deep and two core APEX in the Argentine Basin in January 2021 with four core APEX expected to be deployed in the Drake Passage before end March 2021.

At the time of writing the four APEX-RBR and four APEX DEEP floats deployed in December 2020 and January 2021 are not yet being processed, so are not shown in Figure 2 below.
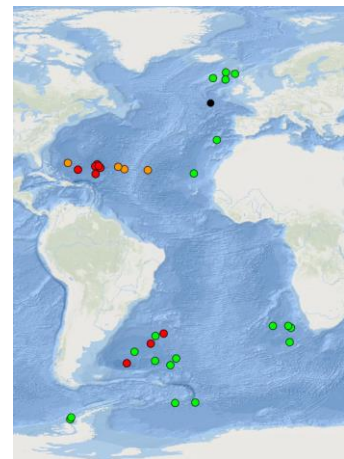

Figure 1. Showing the locations of the UK Argo floats deployed between 1st January 2020 and 31st January 2021, core APEX floats in green, APEX-RBR in orange, APEX-Deep in red and Navis BGCi in black.

As at this time the UK has 159 operational floats (i.e. for which real-time data are presently being distributed), as shown in Figure 2.
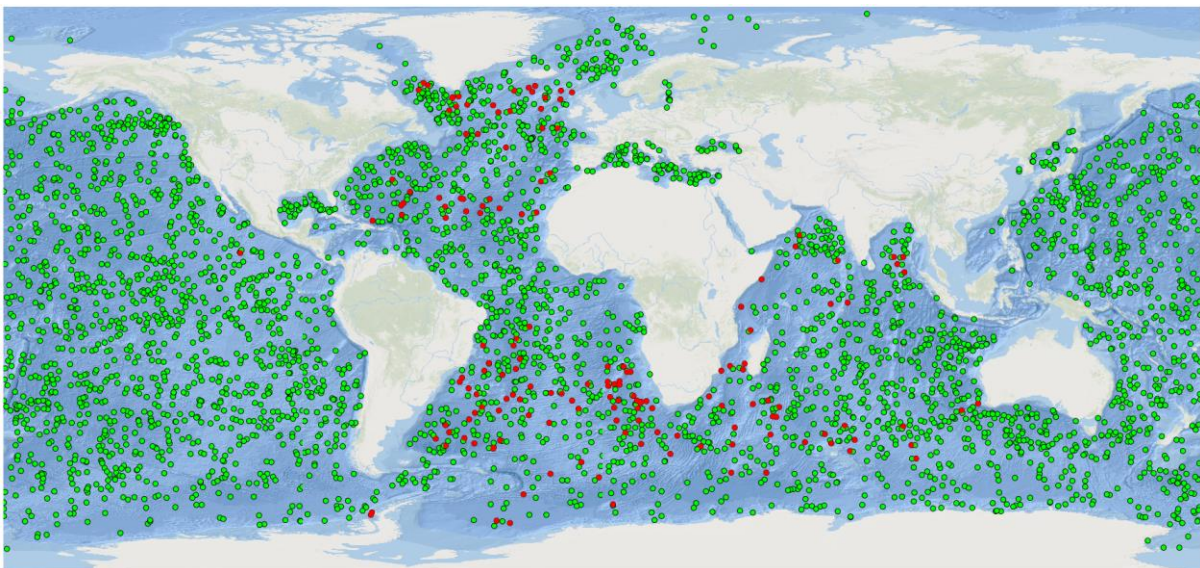

Figure 2. Showing the locations of UK floats delivering data in red with the global network of ~3,900 floats in green, as at 24th February 2021.

Technical problems encountered

APEX Core

We are experiencing issues with at least 3 core APEX floats failing to obtain GPS fixes after surfacing, but often transmitting a GPS fix at the start of the next cycle. This is causing delays in data delivery and is thought to be due to buoyancy issues after entering the surface mission.

APEX Deep

As noted above UK has deployed nine APEX Deep in the last year or so. Five were deployed in January/February in the North Atlantic, three of these are presently working (although one has bad salinity data) having completed over 40 cycles, the other two failed in March 2020. A recovered and refurbished APEX Deep, with RBR CTD, was deployed in the North Atlantic in December and failed during its eighth cycle having lost communication with the CTD while parked at 4,000 dbar. Three other APEX Deep were deployed in December 2020/January 2021 in the South Atlantic, one of which has failed to report. Overall, five 5 APEX Deep are presently transmitting data. We presently have two APEX Deep available for deployment and one Deep SOLO on order scheduled for delivery later this year.

Bio-geochemical Argo

Both of the two Navis BGCi floats deployed in December 2018 have now failed. A third float from that batch which failed pre-deployment tests was sent back to SeaBird for repair and a firmware upgrade and has subsequently been returned and was deployed in November near the Porcupine Abyssal Plain mooring. The float is presently working normally. We presently have four other Navis BGCi floats (two of which are to be returned to SeaBird for a firmware upgrade) and one recovered PML ProvBio float that will require refurbishing.

APEX floats with RBR CTD

We procured our first six APEX-RBR floats in 2015. Five have been deployed with three having failed early, the other two are still operating, two replacements for the early failures were provided in 2020. The sixth has since been upgraded and was deployed in the North Atlantic in December 2020 alongside the two replacement floats and one new APEX-RBR. These four APEX-RBR are all presently operating normally and the profiles will shortly be assessed with a view to collecting 1 Hz data in the region of strong gradients. Three other APEX-RBR are available for deployment.

Status of contributions to Argo data management

Real-time data processing

As at 24th February the British Oceanographic Data Centre (BODC) were processing data from 158 active UK floats, 15 Irish floats and 62 Euro-Argo MOCCA floats. During the last year processing was set up for APEX APF11i floats so that temperature and salinity all our APF11i floats can now be handled. Work remains to deliver all UK BGC data to the GDACs, and this will be a main focus and high priority for the coming year. However, as noted earlier four APEX-RBR and four APEX DEEP floats deployed in December 2020 and January 2021 are not yet being processed. Real-time processing is run four times a day with NetCDF files distributed to the GDACs and the Met Office, where the BUFR files are generated and disseminated on the WMO Global Telecommunications System (GTS). The capability now exists to include supplementary profiles and oxygen into the BUFR files. However, we have not yet been able to progress the extension of the BUFR capability to include other biogeochemical variables. Within the Euro-Argo RISE project, UK Argo is also developing real-time tests for BBP, as well as a technique for producing uncertainty estimates for BBP.

As at 18 February 2021 BODC has delivered 89,044 profiles from UK floats, of which 64,746 profiles have been subjected to delayed-mode QC. This represents 73% of all profiles, and 77% of eligible profiles (i.e. all profiles from expired floats and profiles over one-year old from active floats). This is a significant improvement on last year, as an additional 19, 224 profiles across 156 floats have been through DMQC, clearing a significant backlog.

NOC, including BODC, have also played a key role in coordinating the development of deep DMQC methods as part of the Euro-Argo RISE project WP3. Progress on BGC DMQC has been limited due to temporary staffing issues, but this will become a significant focus in the coming year as part of the Euro-Argo RISE project WP4.

Southern Ocean Argo Regional Centre (SOARC)

BODC has led the development of the SOARC Partnership, which has expanded to include the Alfred Wegener Institute, Scripps and the University of Washington. This in addition to the current partners of CSIRO, BSH and MBARI. The result is that the SOARC Partnership now includes expertise across the range of ARC responsibilities.

During 2020 SOARC, in cooperation with the Atlantic ARC and Mediterranean ARC through the Euro Argo Management Board, worked to develop a proposal on 'Evolving the Argo Regional Centres'. This was presented to ADMT-21 and received support from the Pacific ARC and Indian ARC. The proposal centred around rethinking the responsibilities of Argo Regional Centres into a value cycle, starting at deployment planning, through to data quality assessments, intercomparison with models, feeding back into observing design, and future deployment planning. As part of this, SOARC has reviewed the 'Southern Ocean deployment gap' and is considering how best to work with the Argo and wider Southern Ocean community in how to address it.

Research cruise CTD data

When the UK notifies float deployments with OceanOPS, we include any information about nearby or simultaneous CTD casts if the scientists on board the deploying ship provide this. It is written in the Description free text box in the notification form.

2. Funding and human resources

The UK Argo programme is undertaken by a partnership between the Met Office, the National Oceanography Centre (NOC, which includes BODC) and Plymouth Marine Laboratory (PML). The Met Office are responsible for programme management and coordination, procurement of floats, organizing float deployments, preparation of floats for deployment, telecommunications (costs) and international funding contributions (OceanOPS and Euro-Argo). NOC and BODC have responsibility for Argo science and data management respectively. PML play a leading role in the recent expansion of the UK programme into BGC-Argo.

Funding

UK funding for Argo comes through various channels – the Met Office, NOCS and PML. Both the Met Office and NERC (Natural Environment Research Council) funding originates from BEIS (Department for Business, Energy and Industrial Strategy). At this time UK Government has not set out departmental budgets beyond April 2022.

Argo funding to the Met Office is presently provided directly from BEIS mainly through the Hadley Centre Climate Programme (HCCP), but with an additional contribution through the Public Weather Service Programme. The HCCP workplan and funding for 2021 to 2024 is presently awaiting approval by BEIS and Defra (Department for Environment, Food and Rural Affairs) and includes UK Argo for the period April 2021 to March 2024. In September 2020 a seminar was given to BEIS staff which

provided an opportunity to highlight the benefits that will arise from a multi-disciplinary global 'Argo2020' array.

NERC funding for Argo is primarily directed through NOC under its National Capability (NC) funding line. On 1st November 2019 NOC became an independent self-governing organisation – a charitable company limited by guarantee. With this independence NOC has discretion on the allocation of NC funds from NERC, which covers Argo data management at BODC and Argo science at NOC. Non NC funding is also provided participation in through EU-funded Argo-related projects. During the last year a successful bid for capital funding was made for the procurement of 14 six-parameter biogeochemical floats, and a further bid is in the system that could cover a further 12 six-parameter biogeochemical floats if successful.

Our aspirations are to contribute 10% of each of the BGC and Deep Argo arrays, and continue to provide 5% of the Core floats deployed. This could be achieved by deploying 25 BGC floats per year, with a projected lifetime of four years this would lead to a sustained fleet of 100 BGC floats. Deployment of 25 each of Deep and Core floats per year, with a five-year lifetime would ramp up to a sustained fleet of 125 of each float type. The UK would then maintain a fleet of 350 floats (100 BGC, 125 each Core and Deep), about 8% of the total anticipated global fleet. However, funding for this, at around five times the present level, is not in place and would require significant additional investment primarily from BEIS.

Human resources

Staff members working on UK Argo, their institution and estimates of effort on Argo during 2020 are given below; this will have been reduced below previous years effort due to Covid-99 lockdowns and associated home-schooling demands.

Met Office – 0.65 FTE
Jon Turton, Fiona Carse, John Hankins

NOC, Southampton – 0.25 FTE (estimated)
Brian King

NOC, BODC – 4.3 FTE
Primarily Matt Donnelly, Kamila Walicka, Clare Bellingham and Violetta Paba, with others providing additional support

PML – 0.1 FTE
Giorgio Dall'Olmo

3. Summary of deployment and data management plans

Deployment plans

As noted earlier, as at 24th February, so far in 2021 UK Argo has deployed two core APEX and two APEX-Deep floats, with a further four APEX floats on the James Cook expected to be deployed shortly in the Drake Passage, three floats on the Discovery to be deployed as she transits back to the UK from the Falklands, four APEX in Cape Town for deployment from SA Agulhas II and two APEX in Mauritius.

At the time of writing we also have 40 core APEX, three APEX-RBR, four Navis BGCi floats and two APEX-Deep floats in NOC stores. PML also have one ProvBio float that was recovered in 2018.

Deployments presently anticipated are:

Four APEX: Drake Passage (by March 2021)
Two APEX: South Atlantic (March/April 2021)
One APEX: North Atlantic (April 2021)

One Navis BGCi: North Atlantic (PAP cruise, March/April 2021)
Four APEX: South-west Indian Ocean (Marion Island cruise Apr/May 2021)
Two APEX: Indian Ocean (to be deployed by Mauritius Met Service 2021)

Other deployment opportunities later in the year will be investigated. A reasonable estimate for the year 2021 would be twenty core floats, four deep floats and two biogeochemical floats.

4. Uses of Argo data in the UK

Argo data are used widely within NOC, where the science applications include:
- measurement of evolution and drivers of mixed layer processes in the (Indian Ocean);
- inventory and evolution of heat and freshwater establishing controls on budgets (both regional and global);
- deep heat content (N Atlantic).

PML have the lead for BGC Argo in the UK, where the data are used for:
- investigating different aspects of the biological carbon pump (e.g., mixed-layer pump, fragmentation, respiration of both dissolved and particulate organic matter);
- investigating export fluxes and efficiency in hypoxic ocean regions;
- providing a description of the physical environment in the framework of biological (e.g. mapping eel migration routes) and biogeochemical studies;
- developing techniques to generate 3D fields of biogeochemical variables by merging ocean-colour and in-situ data;
- investigating mesoscale structures by combining altimetry and in-situ profiles with a special focus on Agulhas rings.

At the Met Office Argo data are used operationally:
- they are routinely assimilated into its FOAM (Forecasting Ocean Assimilation Model) suite which is run daily and produces 2 analysis days and a 7-day forecast;
- fields from global FOAM are also used to initialise the ocean component of coupled monthly-to-seasonal forecasts;
- Argo data are also used in the initialization of ocean conditions in climate models run to make decadal predictions;
- a coupled ocean/atmosphere prediction system has been developed for weather forecasting timescales, and is now being run operationally, delivering ocean forecast information to the Copernicus Marine Environment Monitoring Service (CMEMS);
- near-surface Argo data are used to validate the output from the Met Office's OSTIA (Operational Sea Surface Temperature and Sea Ice Analysis), where the OSTIA fields are used as a lower boundary condition in numerical weather prediction models run by both the Met Office and ECMWF.

Recent Met Office research & development applications (non-operational) which have made significant use of Argo data:
- David Ford has done some OSSEs looking at the impact of the planned BGC-Argo array of floats in a global physical-biogeochemical model where he assimilates synthetic versions of the BGC Argo profiles in conjunction with satellite ocean colour data. A paper based on that work has recently been published.
- One other project where we made good use of Argo data was in the assimilation of satellite sea surface salinity data from SMOS, Aquarius and SMAP. The near-surface salinity data from Argo was used to bias correct the satellite salinity data and was crucial for the performance of the assimilation of SSS data. That work is written up in Martin et al., 2019.
- A study on the impact on FOAM of expanding the Argo array was published (Mao et al., 2020). For example, this looked at the effect on ocean heat content estimates from additional deep Argo floats.

Argo data are also used in the following Hadley Centre datasets that are freely available for scientific research uses:

- EN4 that consists of two products (i) observed subsurface ocean temperature and salinity profiles with data quality information, and (ii) objective analyses formed from the profile data with uncertainty estimates. Data are available from 1900 to the present and there are separate files for each month. See https://www.metoffice.gov.uk/hadobs/en4/).
- HadIOD (Hadley Centre Integrated Ocean Database) is a database of in situ surface and subsurface ocean temperature and salinity observations supplemented with additional metadata including bias corrections, uncertainties and quality flags. The dataset is global from 1850-present with monthly updates. See https://www.metoffice.gov.uk/hadobs/hadiod/.

References

Mao C, King RR, Reid R, Martin MJ and Good SA (2020) Assessing the Potential Impact of Changes to the Argo and Moored Buoy Arrays in an Operational Ocean Analysis System. *Front. Mar. Sci.* 7:588267. doi: 10.3389/fmars.2020.588267.

Martin MJ, King RR, While J, Aguiar AB. Assimilating satellite sea-surface salinity data from SMOS, Aquarius and SMAP into a global ocean forecasting system. Q J R Meteorol Soc, 2019;145:705–726. https://doi.org/10.1002/qj.3461.

Ford, D.: Assimilating synthetic Biogeochemical-Argo and ocean colour observations into a global ocean model to inform observing system design, Biogeosciences, 18, 509–534, https://doi.org/10.5194/bg-18-509-2021, 2021.

5. Issues from UK to be considered by AST

Performance of APEX APF11i floats.

Southern Ocean deployment planning

Also, it would be helpful to promote the deployment on ships the same BGC sensors that are installed on floats. These ship-based deployments would make the BGC-Argo data more familiar to the oceanographic community and would allow us to further test and validate the sensors.