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16 *Send to prepare report outlining the benefits and energy (and other) penalties and data management implications of recording T and S data during the drift phase. Submit paper to AST members for agreement (or not) to recommend the collection of these data.* ***Send***

17 *Argo Director to collect and distribute plans for Antarctic research and supply ships for coming years* ***Gould***

18 *Argo Director to contact the International Ship Operators forum to see if advanced plans of research cruises can be made available to Argo countries**. Gould***

19 *Roemmich and Takeuchi to be contacted by volunteer lead authors to prepare a paper on issues relating to a uniform parking depth.* ***AST members*** *.*

20 *First Argo Newsletter to be issued at end of April 2003.* ***Gould, Belbéoch, Wijffels, Takeuchi, Freeland and King***

21 *Argo Director to contact PICES about Argo involvement in October 2004 Hawaii workshop**. Gould***

22 *Argo Director to start to assemble Argo bibliography and to ensure that in coming years national reports to AST include a list of Argo contributions**. Gould***

23 *Argo Director to draft appropriate text to be included in acknowledgement section of papers using Argo data* ***Gould***

24 *Proposals for changes in membership of AST and ADT to be drawn up and sent to AST members for approval**. Roemmich, Gould, Keeley, Pouliquen.***

25 *Proposals for date of AST-6 to be sent to AST members.* ***Pouliquen, Desaubies.***

1. Welcome and introductory remarks

The plenary session was started by addresses of welcome by Prof Su Jilan, (Chairman IOC and Professor in the Second Institute of Oceanography, SOA), by Dr Li Haiquen, (Head of International Affairs, SOA and Chairman of the China National Committee for Argo), by Prof Li Jinbiao, (Deputy Director of the Second Institute of Oceanography) and finally by Dr Dean Roemmich (IAST Chair).

Dean Roemmich then opened the meeting by noting the great progress since IAST-4 in terms of the change of focus from planning to implementation and commitments. He remarked that Argo in the coming year faced a number of challenges.

In general terms these centre of demonstrating during the first 5 years that Argo will succeed and the extent to which it is already a success – technologically, logistically and scientifically.

Specifically this will involve:-

- Devising strategies to get floats into the Southern Hemisphere (of 700 floats already deployed 500 are in the Northern hemisphere).
- Demonstrating that Argo float designs are rugged and reliable and establishing and maintaining a viable production base.
- Devising the means to distribute technical information and provide technical assistance
- Monitoring new sensor developments and deploying these as appropriate.
- Further developing the data system to ensure smooth data flow to users. This involves completing the final elements of the data system and targeting resources at parts of data system where they are needed.
- Meeting the challenges in project co-ordination.
    - Demonstrating the value of Argo.
    - Extending the benefits of Argo to a larger number of countries and giving them a meaningful role in the project.
    - Deployment strategy planning
    - Linking science needs and data management strategy
    - Recognising that Argo is now too large to manage on a voluntary basis and putting appropriate infrastructure in place.

He noted that 24% of the Argo array was now in place and that deployment rates would increase rapidly with a scheduled completion by 2006. While Argo would eventually become a full observing system component (rather than a pilot project) of GOOS and GCOS it seemed likely that it could not succeed without a sustained input from the research science community. Finally he commented that, while it may take a decade before the full range of benefits of Argo can be demonstrated, benefits that are already clear need to be documented and publicised.

1.1 Argo and satellite altimetry

In light of the important synergy between Argo and satellite altimetry, Dr Lee-Lueng Fu (NASA, JPL) gave a presentation on the prospects for and capabilities of a Wide-Swath Ocean Altimeter (WSOA) mission. The details can be found in NASA JPL Publication 03-002 and on the Argo web site.

The WSOA will provide global coverage at a 10 day repeat and with a planned accuracy of 5 cm. This will exceed the present coverage available from the multiple altimeter missions presently operating (T/P, ERS-2, Jason-1, Envisat, GFO) and will provide an appropriate complement to the full Argo float array. The Wide Swath Ocean Altimeter is planned to be flown on Jason-2 in 2007.

Funding for Jason-2 is not yet confirmed since the UK contribution to the Jason-2 project has still to be agreed.

Action item 1 *Argo Director and UK Argo to seek to ensure UK funding for Jason-2.* ***Gould/King/Turton***

The agenda for the meeting (Annex 1) was approved .

2 Data Issues

2.1 Status of data system elements

Bob Keeley, co-chair of the Argo data team, summarised the present status of the Argo data system. He noted that the Argo Information Centre web site has a summary of the status of all of the Argo Data Assembly Centres as follows:-

Country	Real Time Processing path and status	Delayed Mode Processing path and status
Australia	To GTS via BoM System software development at CSIRO	Under development
Canada	Fully functional	Under development
China	Provor handled via CORIOLIS Apex handled by CLS System software development at China Argo Data Centre, Tianjin	Under development
Denmark	Via GTS	
EU	Handled via CORIOLIS Fully functional	Under development
France	Handled via CORIOLIS Fully functional	Under development
Germany	Handled via CORIOLIS	Under development
India	Provor handled via CORIOLIS Apex handled by CLS	Under development
Japan	Fully functional	Under development
Korea	Via GTS	Under development
New Zealand	Via GTS	
Norway	Via GTS	
Russia	Via GTS	
UK	Provor handled via CORIOLIS Apex handled by CLS	Under development
USA	Fully functional	Under development

Within the framework noted above there were a number of common issues :-

- Some nations have decided to rely on CLS/Meteo-France to insert their profile data on the GTS in real-time rather than undertake this task themselves. At present there is no quality control if the GTS insertion is through CLS.
- Some DACs have limited processing capabilities and the complete real-time data (profiles, trajectories, metadata, technical information) are not being written to netCDF and do not get to the GDACs. Those DACs (Japan, USA, Canada and France) that do have this real-time data processing capability and submit netCDF files to the GDACs should share their expertise and experience with other DACs to ensure the complete data are being distributed in a timely way.
- Some DACs are making progress in implementing scientific delayed-mode QC procedures.
- Duplicate data are sometimes being issued to the GTS. This has a negative impact on the timeliness statistics that are calculated from the GTS.
- As yet not all real-time data is on GTS within 24hrs and worryingly this percentage has reduced fro, 65 to 50% in recent months.

Action item 2 *Investigate the recent fall in % of RT data submitted to GTS within 24 hrs and to take steps to ensure that data delivery rate is improved.* ***Pouliquen and Belbéoch****.*

The GDACS are central to the effective functioning of the Argo data system. Their status is summarised below

Function	France (Coriolis)	USA (GODAE)
Real-time metadata + profiles	From Canada, France, Japan, USA	From Canada, France, Japan, USA
Real time -Trajectories	From Canada, France, Japan, USA	From Canada, France, Japan, USA
Real time -Tech files	From Canada, USA	From Canada, USA
Delayed mode data	None	None
Synchronisation	Testing	Testing
ftp service	Operational	Operational
http graphics	Maps of all float trajectories or individual ones. Zoom feature. Displays profiles, sections, waterfall, profile overlays.	Trajectory maps by float ID. Individual float profiles and trajectories
http downloads	Profile, trajectory data in netCDF or ASCII (MEDATLAS format) for selected floats	Profiles, trajectories, technical information

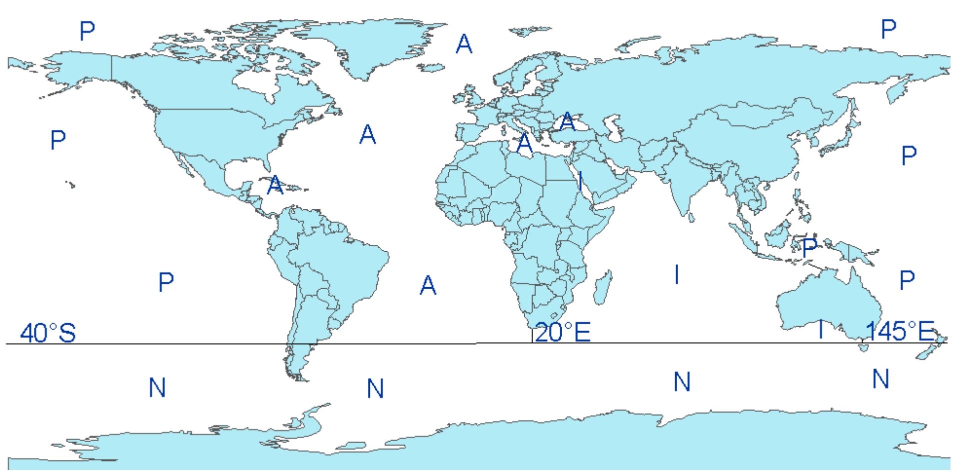
The issues relating to the GDACs were identified as

• Until recently there has no formal way for users of the GDAC's services to report problems. A prototype system is available at http://www.ifremer.fr/coriolis/cdc/argo_problem_reporting.htm
Action item 3 *A problem reporting system to be implemented at BOTH GDACs and steps to be taken to respond to users' comments.* ***Pouliquen/ Ignaszewski***

• Synchronization is not yet complete.
Action item item 4 *Steps to be taken to bring both functionality and data holdings of GDACs closer together .* ***Pouliquen/ Ignaszewski***

• About 30% of real time data comes to the GDACs from the GTS with no guarantee of the level of quality control applied.

Keeley sought approval from the AST for a clear definition of the boundaries of ocean areas. The suggestions were, 20°E between Atlantic and Indian, 145°E between Indian and Pacific. The AST recommended that on the basis of the positions of major frontal boundaries and watermasses the northern boundary of the Southern Ocean should be set at 40°S.



Action item 5 *GDACs to implement ocean boundaries as shown on the map above. Regard 20°E, 145°E, 70°W and 40°S as the ocean boundaries.* ***Carval/ Ignaszewski***

A number of regional Argo data centres have been established but there is as yet no consensus on the functions each should fulfil to merit that designation. While the functions will not need to be identical, each should have a minimum set of activities that are common to all regional data centres.

Action item 6. *Argo data team to define a core set of activities that each regional data centre must fullfill in order to be designated an Argo regional centre. These to be submitted to AST for approval.* ***Argo Data Team***

Similarly the climatological database to be used initially for salinity recalibration should be discussed and agreed by participating regional centres for each ocean. Regional adaptations and improvements to the recalibration system should be discussed and agreed by participating regional centres. Only the agencies willing to collaborate in an Indian Ocean Regional Centre appear to have started discussions. All are however waiting for funding before proceeding.

Discussion continued on the plan to issue data sets on DVD to researchers and organisations that did not have access to the internet. The data sets would effectively mimic the GDAC ftp site(s). The first issue is planned for September 2003 and will contain data starting Jan 1 1999. It will be produced by NODC. The AST agreed that the DVD should contain Java Ocean Atlas and Ocean Data View display tools but only the official Argo netCDF format to the JOA or ODV formats will be made "on the fly" It will be produced by NODC within the GADR (Global Archive Data Repository) activities. It was also suggested that the DVD could contain sample Matlab scripts to show how to read the data.

It was also agreed that the DVDs should include all the data but the graphics will only show the good data. It was not resolved as to whether the DVDs should contain corrected profiles or uncorrected profiles together with files of corrections.

It was noted that no estimate had been made of the likely customer base for the DVD data sets. It was agreed that an initial estimate would be made and that the distribution would be reassessed after the first issue.

In summarising the data discussion, the chairman highlighted three key steps that needed to be taken

1) Eliminate data entry via the GTS (Requires action by DACs)
2) Maximise Real Time data submission within 24 hr (Note 100% is not achievable due to time taken to scrutinise profiles that fail automatic QC)
3) Formats (Delayed QC is most pressing issue)

Action item 7 *Those DACs that are not yet carrying out their planned functions to be contacted to find what the problems are, how many floats they handle how are they are planning to solve the problem. Suggest partnerships with successful DACs. Keeley to get list of those DACs and Argo Director to write****. Keeley/Gould***

2.2 Delayed – mode quality control

Annie Wong summarised the status of delayed mode quality control of Argo data.

Country	Plan on implementing delayed-mode QC?	Estimate % of floats that need sensor drift correction*	Correctable by current climatology?	Corrections reached Argo data system yet?
UK	yes	50%	no[1]	no
China	yes	30%	-	no
EU/France	yes	2 out of 80	no[2]	no
Canada	yes	30%	yes[3]	no
Japan	yes	30%	yes[3]	no
USA	yes	30%	yes[3]	no

** mostly old floats that have problem of salinity sensor stability*

Footnotes

1. South Indian Ocean floats (sparse and old climatological data)
2. Subpolar North Atlantic floats (high temporal and spatial variability). Need to take into account the floats profiling in the same area
3. Open Pacific floats (relatively stable ocean, good climatological data)

The above table summarises the current status of the Argo delayed-mode data stream. While most countries have started implementing delayed-mode QC (in the form of evaluating and experimenting with methodologies to correct sensor-related drifts in Argo data), no delayed-mode data has yet reached the Argo data system.

This is due to two main reasons:

1). Currently available correction methodologies are not optimal everywhere in the world's oceans.
2). There is debate about the format in which delayed-mode corrections should appear in Argo data files.

2.2.1 Problems with correction methodologies

In the absence of deployment cruise CTD profiles, the only way to calibrate float data is by climatology. The method of Wong et al (2003) has been evaluated by the international Argo community, who reached the following conclusions:

- the appropriateness of this method is limited to regions of the world's oceans with good climatological data representation (in space and time);
- it can detect drifts and offsets in float data relative to climatology, but it cannot distinguish whether the drifts and offsets are real ocean signals or instrument related;
- this is not a simple turn-key operation; oceanographic expertise is needed to evaluate the statistical estimates;
- the linear model used for calculating drift corrections assumes that drifts are slowly-evolving, that the vertical profile itself is correct (so that only a bias correction is needed), and that pressure, temperature, and LAT, LONG are accurate;
- the system needs to incorporate data from deployment cruise CTDs (and from floats-float intercomparisons) if available.

2.2.2 Problems with correction format in the Argo data system

Because the method of correction by climatology is a statistical method, it cannot give a definitive value, but only a range. In the current Argo data file format, corrections are stored in a variable called <PARAM>_CORRECTED, the related uncertainty stored in a variable called <PARAM>_CORRECTED_ERROR, and the related quality flag stored in the variable <PARAM>_CORRECTED_QC. There is debate about whether corrections should be stored as such specific values, or whether they should be stored as calibration constants that the users can apply themselves if desired. There is also debate about whether there is sufficient warning to users that these corrections are not necessarily the best values and can potentially mask real ocean signals.

In discussion it was noted that the application of the Wong et al process is only the first step of delayed-mode quality control. Subsequently all profiles will be scrutinised by PIs as float-float intercomparisons are evaluated and scientific analysis is carried out. These later steps are essential for detecting subtle and long term changes in ocean properties and need to be seen as an integral part of delayed-mode QC. However, some definition needs to be made by AST of the entire delayed mode QC process.

Action item 8 *Argo Director to work with Wong to define the entire process of delayed mode quality control.* ***Argo Director/Wong***

Dean Roemmich summarised the discussion noting that data files contain uncorrected and "drift adjusted" salinity and that this value produced by the Wong et al process is a statistical product, not the end product. So the QC process needs to have a subjective judgement from a salinity expert in the region.

Pierre-Yves le Traon asked how the offsets derived by delayed mode QC could be fed through to the real time data.

It was noted that this issue had been considered at earlier meetings but that as yet no means of implementing this feedback had been devised and that as yet it was not high amongst the data management priorities.

2.3 Status of Argo regional data centres

2.3.1 Indian Ocean

Dr Radakrishnan reported that Dr Ravichandran has team of 3 scientists at INCOIS and that by mid-2003 the data system should be operational. Susan Wijffels added that Australia was planning to have a delayed-mode data centre for the areas around Australia. Funding had been requested and a decision was expected in about 4 months. The activity is expected to be rather labour-intensive and will involve the improvement of existing regional climatologies. Greg Johnson commented that the improved regional climatologies produced by the regional DACs need to be incorporated into global climatologies and that a mechanism needs to be devised to do this in a systematic way.

2.3.2 Southern Ocean

Brian King reported that to date the BODC effort has been on UK data not on the Southern Ocean but that work on the Southern Ocean DAC will start in mid-2003. The first step will be to contact PIs and laboratories with floats operating in the Southern Ocean. The UK interest and scientific expertise is in the Atlantic and Indian Ocean sectors and the UK could not cover the Pacific sector. Dean Roemmich commented that one possible solution to this problem would be to extend the Pacific regional centre's responsibilities southwards.

2.3.3 Atlantic Ocean

Sylvie Pouliquen gave a detailed summary of the Atlantic activities by the Coriolis/Gyroscope teams. The Wong algorithm has been run systematically at Coriolis on all Atlantic floats available at the GDAC and that this is then supplemented by local scientific expertise on the Atlantic floats starting from North Atlantic. It is possible to make a Matlab result file available on an ftp site if this is thought useful. Only two floats show clear evidence of linear drift. Several floats seem to detect change from climatology rather than a clear sign of bias. A need has been recognised to provide updates of the climatological data base so as to include more recent data and to include float-to -float intercomparisons.

Ongoing and future activities will adapt the correlation length to the geographic location, consider anisotropic correlation functions along coastlines and bathymetric features and will revise and tune the other configuration parameters. A literature review will be carried out and the most recent data sets will be used to improve understanding of water mass variability. A start will be made on float to float comparisons.

In parallel, another method has been developed using the residual error calculated with temperature and salinity fields over the Atlantic Ocean produced by objective mapping. This analysis is based on profiles collected and controlled in real time by CORIOLIS from Argo profilers, GTS or oceanographic vessels (XBT, XCTD, CTD, thermosalinographs) this weekly analysis has been run in operational mode since June 2002 on a grid with 1/3° resolution at 51 levels down to 2000 m.

Using the analysis residuals for detecting and correcting sensors drift is a way of combining three methods, usually applied separately:

- reference to a climatology,
- co-location
- history of the sensor.

A real time alert system has been set up to detect gross errors. It is based on a normalized averaged residual. A threshold has been defined over which the profile is flagged as spurious. This information can be used by the operator to flag the profile and prevent use in real time systems.

In delayed mode, the time series of normalized residuals are analysed. From the 10 profilers analysed, except for a few abrupt residual increase, it appears that :

- The temperature and salinity residuals are correlated
- Neighbouring profiles give similar residuals

This leads to the conclusion that the residuals are likely to represent oceanic signal, rejected by the analysis because of climatology deficiencies. It is worth noticing that the shape of the CORIOLIS/Ifremer residuals is very similar to the correction proposed by Wong's method.

Further development will be performed on this method for delayed mode QC at the Atlantic regional centre.

2.3.4 Pacific Ocean

Takeuchi commented that Japan was starting to implement the Wong et al software but that the task needed to be shared with the IPRC in Hawaii.

Dean Roemmich reiterated that all the regional centres had a rather different view of their role and that from an Argo standpoint we needed to define what a regional data centre is. (See action item 6)

2.4 BUFR format

Jon Turton introduced a discussion encouraging Argo to move towards the use of BUFR to disseminate real-time float data on the GTS. For National Meteorological Services (NMSs) - some of which are involved in ocean forecast modelling - GTS is, and will continue to be, used for exchange of real-time and critical data, while the Internet is likely to be used for less time-critical information. As such the preferred option of NMSs for real-time Argo data was via GTS, rather than via the GDACs in netCDF.

Use of BUFR for the real-time float data would allow the full resolution profile data (and trajectories, metadata and quality flags if required) to be disseminated on GTS. It would also be consistent with the migration towards table driven codes advocated by WMO. If the full-resolution data were available on GTS, with insertion made through a small number of centralised nodes, this would also provide a more complete real-time dataset to the GDACs; and arguably be a more efficient and robust system than relying on individual national DACs/PIs to forward the data to the GDACs.

P-Y le Traon representing GODAE and S Piotrowicz also supported the use of BUFR for GTS distribution.

After some discussion it was noted that operational ocean forecasting centres (within NMSs) primarily need the profile information, perhaps with quality flags, but not necessarily with all the metadata information; with BUFR being the format of choice. Research users preferred netCDF containing all the associated metadata. However it was recognised that BUFR, like netCDF, was a relatively complicated format and would require resources to define appropriate tables for implementation with float data.

It was agreed it would be useful to prepare a paper scoping out what information was needed by operational users and setting out what steps and effort/resources would be required to progress towards developing a suitable BUFR code. It was agreed that Jon Turton and Bob Keeley, in consultation with AIC and operational users, would prepare a paper for consideration by AST and its DMT. This would help determine the effort/resources that would be needed and allow this requirement to be judged against other priorities.

Action Item 9 *A paper describing the needs for and the benefits and disbenefits of migrating to BUFR format for GTS distribution to be prepared after consultation with centres engaged in operational ocean analyses. Paper to be distributed to AST members by November 2003.* ***Turton/Keeley/Belbéoch***

3. Science results from Argo.

3.1 GODAE links with Argo (P-Y Le Traon)

Early results from GODAE were shown that demonstrate progress towards its objective of producing regular comprehensive descriptions of the ocean state at high temporal and spatial resolution that have included assimilation of remote and in-situ measurements under appropriate dynamical and physical constraints. Argo data are a key in-situ element.

GODAE includes the main operational and research institutions from Australia, Japan, the United States, the United Kingdom, France, Norway, and a component funded by the European Union. Its main demonstration phase is from 2003 to 2005 with a consolidation (transition to operational) phase in 2006/7.

As well as the assimilation of remote sensing and in situ data sets, GODAE has a requirement for a global high quality SST (GHRSST) product with 1day temporal and 10km spatial resolution. A pilot project (as Argo is) started two years ago and is now well established :-
(http://www.ghrsst-pp.org/).

After showing examples of global and regional data assimilation and ocean prediction projects (GODAE prototype systems), the links between Argo and GODAE were stressed noting that the best use of data is when they are integrated using effective assimilation techniques. Links between Argo and GODAE can be summarized as follows :

- Argo provides data complementary to remote sensing data to initialize and constrain ocean models
- AST provides advice on the optimum use of Argo data in models
- Argo data will be critical in the validation of analysed fields from GODAE

- GODAE will provide analysed fields to improve QC of Argo data
- GODAE will help the data interpretation
- GODAE will give feedback on Argo benefits (impact in models, consistency/ complementarity with other data sets, evaluation of the utility of Argo data in an integrated framework)

This interlinking of Argo and GODAE was highlighted with examples from Mercator and Coriolis. Argo data have been used routinely to validate Mercator model outputs for the last two years. A new multivariate data assimilation system was developed and is now ready to effectively merge altimeter data, SST and Argo data. Impact studies (contribution of Argo data with or without altimeter data) are also conduced to learn how to best use Argo data.

From the GODAE perspective, Argo progress is quite impressive. Global coverage remains a strong requirement. Salinity data are also crucial to correct model errors. Drift estimates at depth are needed to validate deep currents. Argo data have already proved useful (validation, assimilation). New assimilation schemes have been developed and are now tested or implemented. There are still challenges for effective use of Argo data in high resolution models but prospects are encouraging.

Links between Argo and GODAE must now be developed further through impact studies, feedback on GODAE analyses, QC, etc. This will be best done through collaborative studies between Argo and GODAE teams.

3.2 Ocean climate change in the S Indian Ocean (King)
Brian King showed data that demonstrate that the simple property change shift in the South Indian Ocean (Banks et al 2002) attributed to climate change does not have a simple structure. The changes differ from level to level. Float data enable us to better understand changes that had previously had been determined from temporally widely separated sections.

3.3 Mixed layer property changes (Turton)
Jon Turton discussed some early work on real-time QC and assimilation of Argo data into the Met Office's operational ocean prediction system FOAM. The previous QC rejected far too much data and a new scheme has been developed that allows most of the float data (>97%) into the model. At the same time an improved assimilation scheme, which uses new error covariance statistics, has also been developed. Assimilation studies have been made for the mixed layer, which varies on shorter time scales. Float data were used to initialise 2 mixed layer formulation (Krauss-Turner and Large et al). Both models gave best results when assimilating salinity as well as temperature. The question was raised as to over what time window the data should be assimilated. The rms error of mixed layer depth predictions from the K-T model were insensitive to the time window, while the most accurate results were from the Large et al. model with a short window (1hr). This emphasises the need for timely data for mixed layer forecasting.

3.4 Bering Sea boundary currents (Johnson)
Greg Johnson showed how float data had revealed the structure and transport of a boundary current in the Bering Sea – an area of sparse data (particularly in winter). 14 floats deployed since May 2001 yield over 15 float-years of displacement data at the 1000-dbar park pressure and 603 profiles, many of which approach 2000 dbar.

The float displacement data at the 1000-dbar park pressure allows direct estimates of velocity at that level and reveals large strong eddies.

The profile data allows relative geostrophic transport estimates and an investigation into water properties and the upper ocean seasonal cycle. Combining the absolute and geostrophic velocity data produces estimates the Bering Slope Current transport above 1700 dbar as 4.7Sv, estimates a 95% confidence interval for that current transport of 1.2Sv. and reveals that about half of the current transport is due to the 1000-dbar velocity.

3.5 Anomalous conditions in Gulf of Alaska (Freeland)
Howard Freeland showed how recent Argo data from the Gulf of Alsaka have shown a marked increase in stratification that in the past winter has not broken down in the usual way. By projecting the data onto the line P, comparisons can be made with ship-based data since the mid 1950s. This shows that the 2002/3 winter lies far outside anything within that period or that expected from the increasing stratification trend over that period. It is postulated that the lack of nutrient renewal in the past winter will have a serious adverse impact on the Gulf of Alaska ecosystem in the coming year.

3.6 Changing stratification under typhoons. (Xu)
Xu Dongfeng demonstrated changes in stratification seen in the western Pacific following the passage of two typhoons. While the changes were significant the impacts on upper ocean salinity were hard to explain.

3.7 Space/time variability and lagrangian behaviour (Send)
Uwe Send used float data from the subpolar N Atlantic to demonstrate space and time variability in particular by looking at moored T and S timeseries in the Labrador and Irminger Seas and the differences between these and float data at increasing horizontal separations. He commented on the limitations placed on the Wong et al method of DM QC by the large variations in T and S in the N Atlantic and inadequate knowledge of the spatial and temporal co-variances and scales. Without that knowledge the technique cannot be automated.

In the same area he showed intercomparisons of acoustically-tracked (RAFOS) and Argo floats (spending 18hrs on the surface) that demonstrated the rapid and significance divergence of trajectories. This illustrates the caution that should be exercised in equating Argos trajectories with water mass pathways.

Finally he showed the results of Mediterranean float comparisons and tank calibrations showing temperature offsets of up to 0.046. G..Loaec conceded that the calibration bath was not ideal and that such offsets may not be real. The temperature differences in the Mediterranean occurred between different types of floats (SOLO, ALACE with and without Seabird sensor). Caution and maybe further investigations may be required to validate the basic assumption of all current salinity calibration procedures that T is always reliable. (note that Ifremer always re-calibrates and sometimes corrects the T-sensors).

3.8 Ocean sampling experiments (Wijffels)
Susan Wijffels showed results from sampling experiments in the Indian Ocean that had been triggered by discussions at the GOOS Indian Ocean meeting and sought to address the questions :-

1) What are the required temporal and spatial sampling intervals for capturing seasonal-to-interannual variability?

2) Will Argo's ability to measure seasonal, 1000km-scale heat and freshwater anomalies be degraded due to aliasing by intraseasonal variability?

3) Where should we take these measurements?

Three models are being used to address these questions by subsampling the model output as an Argo array might, and comparing the resulting large scale fields with the fully resolved ones. The very preliminary calculations have only been completed on one model. Further work using the other models is underway. However, the model outputs suggest that the 10 degree 3x3 Argo sampling is highly effective at capturing the seasonal timescale, 1000km space scale signals, while faster sampling rates will be required to resolve the intraseasonal. However, there is great concern about the effect of higher frequency (subweekly) phenomena on the results. These frequencies are vastly underestimated in the model output compared to the real ocean. Until these effects are included, the results will not be a not a useful guide on Argo sampling. Attempts are now being made to understand how to account for this lack of high frequency energy in the models before proceeding with further sampling experiments.

3.9 Argo science workshop

In concluding this session, Takeuchi introduced the planning that had been done to date for an Argo meeting in Japan November 12-14 2003 at which Argo science results and applications would be presented. The meeting is presently sponsored by JAMSTEC and NOAA.

The AST recognised that this would be the first of many meetings and conference sessions at which Argo results would be highlighted. At this early stage in the project results from non-Argo profiling floats would have to be included.

It was seen as important to structure the meeting in such a way as to enable representatives of funding agencies to attend and be made aware of Argo's progress. Other points that were made were

- Calling it the first Argo Science Workshop would make it easier for some scientists to attend.
- The data system should be featured
- It may be hard to arrange space to hold side meetings at the conference venue.
- The links to GODAE should be highlighted
- Suggested themes were
    - Regional (especially West Pacific marginal seas)
    - Global
    - Oceanographic phenomena
    - Watermasses
    - Combination with other observations.

An attendance of between 100 and 200 was likely and the format would be a mixture of plenary presentations and poster displays. The possibility of commercial exhibits needs to be explored.

At a lunchtime session an initial organising committee was established (Roemmich, Takeuchi, Freeland, King, Phillips, Piotrowicz, Radakrishnan, Riser, Gould) and the following actions were agreed.

Action item 10 *Argo Director to establish timetable of key dates leading up to First Argo Science Workshop****. Gould***

Action item 11 *Argo Director to draft announcement for First Argo Science Workshop and design a poster.* ***Gould***

Action item 12 *Workshop committee members to seek other agency sponsorship.* ***Workshop organising committee***

Action item 13 *Explore the possibility of commercial sponsorship and displays.* ***Gould/Takeuchi.***

4. Technical issues

4.1 WRC Apex (See Annex 3)

Steve Riser described the history of development of the WRC Apex floats of which 331 had been produced. The original Apex had a 180cc displacement pump enabling profiling to 1000m, the later Apex 260 with 260cc displacement allowed profiling from 2000 in all but the fresh water capped tropical oceans. In particular he described the various technical problems that had been encountered and the design modifications that had been made to overcome these problems. The main ones were "energy flu" on floats with the APF7 controller board that caused a premature (after about 30 profiles) draining of the batteries and had been eventually diagnosed as being due to the controller board being sensitive to the build-up of moisture in the pressure case from battery outgassing. A later, motor backspin problem was caused by the external ambient pressure causing the pump motor to be driven backwards and to act as a generator the voltage from which fatally damaged the float electronics. This problem was seen on floats drifting at depth below 1600m but not on "park and profile" floats even those profiling to 2000m. These problems were first identified in mid-2002 and diagnosed by late August. The problem was solved with the introduction of the APF8c controller that is now fitted to all APEX floats.

Other failures had been due to early inexperience with air drop deployments. The initial 30% failure rate has now been markedly reduced.

The diagnosis of all such problems is a lengthy and painstaking process and it requires significant numbers of floats to approach their expected lifetime before the present design can be said to be reliable. For the floats with APF8c controllers this will not be until 2005/6.

The APEX float reliability statistics to date are:

Group	Size	Profiles Executed	Profiles Expected	Reliability (%)
APEX180	10	652	843	77.3
APEX260	130	1999	2363	84.6
APF-7	25	1460	2005	72.8
APF-8	115	1191	1201	99.2
Total	**140**	**2651**	**3206**	**82.7**

APEX Profiler Reliability Statistics
for the period from Jul 01 00:01 GMT 2000 to Mar 14 18:05 GMT 2003.

4.2 Martec/PROVOR (See Annex 4)

This was a joint presentation by GérardLoaec and Nobuo Shikama. Ifremer began to design floats at the beginning of the nineties within the framework of WOCE (about 200 Marvor multi-cycle Rafos floats were deployed in North and South Atlantic). This technology was then adapted at the end of the nineties to create the Provor profiling float. These floats are now manufactured by 2 subsidiaries of Martec: Serpe-Iesm (France) for European customers and Metocean (Canada) for the customers of the other Countries. The floats produced by these two companies are using some identical parts: (sensors, main electronic unit, Argos ptt, hydraulic system), but there are some differences : (size of the housing, battery packs, data acquisition and control software). The unique features of this range of floats are that they can profile between the surface and 2000 dbars in <u>all</u> oceans and they have great versatility of data acquisition, since measurements can be made when the float drifts at depth or during the descent and all parameters are user-defined. Buoyancy control is by the transfer of oil between an internal reservoir and an external ballast. The floats have about 2.3 litres of oil using about (according to difference of density between surface and depth) 350 cc from surface to depth and giving an emergence volume at the surface >1 litre. Depth control is ca ±30 dbars at depth. No ballasting is required before launching. Floats differ from one to another by about 500 cc.

Results of Gyroscope floats and Jamstec floats were then presented. 40 Provor and 44 Apex floats have been cycling in the North Atlantic for 1.5 year and the ratio of recovered profiles over expected profiles is more than 90% with either Provor or Apex. Jamstec initially had poor results with Provor floats provided by Metocean since many floats were deployed before the problems were recognised. Some improvements were applied, but at the date of the meeting, the floats had not yet cycled enough to provide firm conclusions.

Technical improvements about sensors and the control of the float at depth are then presented:

- the problem of the salinity offset is now solved (contaminated TBTO capsules replaced by SBE),
- FSI salinity sensors still need to be improved, even if no drift can be detected on cycling floats (without any recovered float and post-calibration). Jumps in salinity have been observed and cannot be explained.
- Provor is fitted with a grounding feature; if the float grounds, either it remains at the same location, or it tries to reach a shallower parking depth to move away (this mode is user-defined). When the gradient of density near the surface is very high, it appears that the grounding

detection level is too sensitive and the floats interpreted the thermocline as the sea floor. This detection level has been increased.
- Some software corrective actions were taken to solve the ‘emergency ascent’ problem detected on Jamstec floats.

Some further developments are in progress:
- the design of a new electronic main unit, providing more facilities to integrate new sensors and communication devices, and more memory space for program code,
- the integration of Argos downlink and Iridium,
- the improvement of the hydraulic system, to reduce the consumed power,
- the integration of new sensors : Aanderaa Dissolved Oxygen sensor and Rafos receiver.

4.3 Novel float sensors
In response to a query by King, Send replied that the oxygen senor he reported on was an optical sensor costing ca $US3000-3500 per float. He expected to deploy 3 floats (APEX and Provor) with the Aanderaa sensors in the Labrador Sea in the coming summer. Preliminary trials of the sensor appeared to be giving excellent results.

Freeland was concerned about the likely power consumption of such sensors. Riser later showed results from a SeaBird SBE-43 O_2 sensor deployed north of Hawaii. The performance claimed by the manufacturer is 2% for both stability and accuracy over a period of 1000hrs. The Hawaii results seem to be better than this but had an offset of 0.2 ml/l from Winkler determinations at the nearby HOTS site. The additional cost of the sensors is ca $US3900 per float. The data are transmitted as a frequency that is then converted to oxygen concentration. This can be coped with by the Argo data system. King made a plea for values to be reported as micro moles/kg not ml/l.

4.4 Prototype floats
Ando reported on the prototype Japanese Ninja float. He noted that it was expected that the float would not have sufficient reserve buoyancy to penetrate the fresh-capped tropical ocean. The present approximate cost of the prototype float was around $US20k .

Yu Lizhong described the prototype Chinese COPEX shallow profiling float that was on display in the meeting room. The target was for the float to be in commercial production in around March 2004.

4.5 Determination of subsurface velocities
In the final presentation in the technical session Ichikawa reported his views on issues relating to the accurate determination of subsurface float trajectories and the estimation of surfacing and submergence times. It was noted that this should be a topic to which specific attention should be devoted during the 2003 Argo science workshop.

4.6 Technical information exchange and co-ordination
There followed an extensive discussion of the issue of how the co-ordination of technical issues should be carried out in Argo. It was recognised that the rapid exchange of information between PIs and countries was an important factor in the identification and rectification of the technical problems that would inevitably appear from time to time. This exchange of information also required the collaboration of float manufacturers and it was in this areas that concerns about commercial confidentiality had the potential for hindering information flow. The existence of an Argo Director/project office raised the potential for a more vigorous exchange of information on technical issues in the future.

Roemmich summarised the discussion by noting that AST works by agreement – no agreement – no action. The technical co-ordination issue could be helped by establishing a web site on which problems could be described, technical information could be exchanged and through which technical experts could offer help.

Action Item 14 *Argo Director to establish a web site for the exchange of technical information about float performance* ***. Gould***

In continuing to discuss technical issues it was noted that countries had greatly varying success rates from their deployment methods. It was agreed that all groups deploying floats should send details of their methods and success/failure rates to the Argo Director so that some consensus on “best practice” could be reached and applied widely.

Action item 15 *Groups deploying floats to send details of their deployment instructions to Argo Director together with information on rates of early (1 cycle) failures**. All + Gould***

Send raised again (this was considered at AST-4) the issue of collection of temperature and salinity data during the drift phase of float operation. It was recognised that while the data had some value (limited due to uncertainties of position) the recording of data also had some energy budget implications.

Action item 16 *Send to prepare report outlining the benefits and energy (and other) penalties and data management implications of recording T and S data during the drift phase. Submit paper to AST members for agreement (or not) to recommend the collection of these data.* ***Send***

5. Status of Argo Implementation

Belbéoch introduced a report on the activities and status of the Argo Information Centre. In this he highlighted the need for more countries to agree to permit Argo floats to be deployed in their EEZ. It was agreed that he would work with Freeland to draft a letter that would encourage countries to agree to this step.

Action item *Belbéoch and Freeland to prepare text of letter to be sent to national contacts in countries that have not agreed to allow Argo floats to be deployed in their EEZ.* ***Belbéoch/Freeland***

It was commented that the high resolution Argo status map on the AIC web site was used by many people (particularly in giving talks) and it therefore needed to be updated much more frequently than the present one per month. It should also have a specific date rather than just a month associated with it.

*Action item. High resolution Argo status maps to be produced at least weekly and with the actual date of the map identified**. Belbéoch***

Returning to the issue of deployment strategies, it was noted that float deploying groups needed the flexibility to “exchange” floats with groups that held floats in reserve so that the best use could be made of deployment opportunities. It was agreed that this was best done by contacting the float manufacturers.

5.1 National reports

These were tabled before the meeting and can be seen in Annex 5 of this report. They were supplemented by the following table of accumulated national commitments that had been prepared by Stan Wilson and the AST members were asked to make corrections or comments.

Number of Floats by Country	Argo Funded FY99	Float Equiv's FY99	Argo Funded FY00	Float Equiv's FY00	Argo Funded FY01	Float Equiv's FY01	Argo Funded FY02	Float Equiv's FY02	Argo Funded FY03	Float Equiv's FY03	Proposed over next 3 years	Prop Float Equiv's over 3 yrs
Australia	10				19		7		50		163	
Canada	10		42		20		25		30		90	
China					10		8		12		80	
Denmark						5						
European Comm.			10		70						40	
France		8	3		50		80		90		240	
Germany				18		22		42		40	105	20
India							10		25		115	
Japan			24	4	76	8	110	3	80	3	150	9
New Zealand			2		2				2		6	
Norway							3				30	
Republic of Korea					19		25		30		90	
Russia		1		2		2	2	1	2		6	
Spain									10		20	
United Kingdom			13		50	6	40	10	38	5	95	14
U.S.A.	55		131	51	174	43	315	39	413	20	1239	75
TOTALS	75	9	225	75	490	86	625	95	782	68	2469	118
TOTALS BY YEAR	FY99 =	84	FY00 =	300	FY01 =	576	FY02 =	720	FY03 =	850	Ave/Yr =	862.3333

There was general agreement that this table represented the current state of national commitments but

Turton noted that the UK contribution was expected to be at best based on level funding. This meant that the indicated number of 50 floats per year was likely to decrease as float costs increased. Riser commented that this might be offset by decreased communication costs if and when Iridium becomes widely used.

6. Implementation planning

The deployment plans for each ocean basin were then considered.

6.1 Pacific

Roemmich reiterated the challenges of filling the Pacific south of 8°S and of addressing remaining northern hemisphere gaps. To do this people would need to be pro-active in identifying and exploiting deployment opportunities. Freeland noted that Chile may be willing to help in the SE Pacific .

Roemmich also noted that the Pacific implementation planning map was now linked from the AST web site and said that links would be made from there to the other basin plans. Gould suggested that if all maps were to be linked from a single URL it would be helpful to have some degree of uniformity and information content. It was agreed that as a first step the regional co-ordinators would compile their information tables in a common format. Wifffels suggested seeking help from the pelagic fishing fleet but Freeland noted that in his experience they were likely to unwilling to reveal their areas of activity.

The AIC offered to collect text files of deployment plans and deployment opportunities and produce similar maps that would be updated twice per year.

6.2 Atlantic

Sylvie Pouliquen on behalf of Yves Desaubies presented the Atlantic information in three maps, (north, south and equatorial). These will be combined into a single map by Desaubies. While the North Atlantic is quite well sample, the further one goes to the south the worse it becomes. Ship opportunities are not easy to find also and cost of deployment is increases. Gould noted that opportunities might be presented in all basins by ships occupying hydro sections as part of CLIVAR. Theses plans are being assembled at (http://www.clivar.org/carbon_hydro/). For the South Atlantic he noted that the RMS St Helena (www.rms-st-helena.com) made regular trips between the UK and the S Atlantic Islands and might provide a useful deployment platform. It was also noted that the main problem in Atlantic was the exchange of deployment plans in order not to over-sample some area especially in the North Atlantic. A WWW site similar to the one for Pacific Ocean will be set up and may help in this coordination task.

6.3 Southern Ocean

Steve Riser noted that the plans for the S Ocean were not complete and did not include, Canadian, Australian and UK floats. Some German plans from AWI were not included. It was mentioned in discussions that Antarctic research vessels presented ideal deployment opportunities since they often visited the same sites year after year. Danchenkov presented a map of the cruises to be made to the S Ocean by Russian ships and suggested that the plans for other countries should be collected.

Action item 17 *Argo Director to collect and distribute plans for Antarctic research and supply ships for coming years* ***Gould***

Action item 18 *Argo Director to contact the International Ship Operators forum to see if advanced plans of research cruises can be made available to Argo countries****. Gould***

6.4 Indian Ocean

The Indian Ocean map prepared by Helen Phillips had been distributed before the meeting. The Indian Ocean faces same problems as the Pacific in Southern areas. Wijffels noted that Gani Illahuade would welcome float deployments in Indonesian interior seas. It was commented that despite the risks to floats in these populated waters, this link should be exploited and that Illahaude should be invited to participate in the Science Workshop.

In the final discussion of the implementation issues Takeuchi called for the selection of a uniform parking depth. Roemmich reminded AST that this had been recommended before but that it had proved impossible to reach agreement.

There followed an extensive discussion of various parking depth options and of their advantages (global uniformity, comparison with WOCE, ease of calibration of deep) and disadvantages (running aground, energy drain if too deep). The question was posed as to how frequently deep (2km) profiles were needed for calibration. It was agreed that GODAE also needed to have its requirements considered

It was felt that the discussion needed to be more extensive and should be carried out intersessionally so that a paper could be ready for the November Science Workshop.

Action item 19 *Roemmich and Takeuchi to be contacted by volunteer lead authors to prepare a paper on issues relating to a uniform parking depth.* ***AST members*** *.*

In bringing the discussion to a close, Roemmich re-emphasised the need to correct Argo's northern hemisphere bias. Wijffels raised the issue of air drops. Roemmich stated that drops could be made from C-130s that were widely available and at costs of around $4-5k/hr plus $5k base ground charges. Speed was ca 200kts. Riser added that for Apex floats, preparation for air dropping added ca $1400/float. Air drop survival rates were now significantly better than when first use.

7. Argo supporting infrastructure and outreach

7.1 Argo Director

Gould gave a summary of the role he saw for the Argo project Director, of its relationship with the position of the Argo Technical Co-ordinator and of the lines of communication that needed to be established and maintained both within Argo and between Argo and other bodies. All these could be helped by the existence of an Argo Director.

He noted that he was presently being supported jointly by the USA Argo project (through NOAA) and by Scripps Institution of Oceanography and that the Argo Co-ordinator position was also supported predominantly by the USA with assistance from France, Canada and the UK. He noted that the present funding mechanism that depended so heavily on the USA was neither equitable nor was it sustainable in the long term. A new funding mechanism needed to be found that would share the financial burden. This could be based for instance on the degree of commitment to the project based on numbers of floats being supplied by each country. He recognised that while this might be fair it also needed to recognise that many countries were contributing "in kind" by the provision of for instance, elements of the data system. Any funding mechanism must avoid putting the funding for float deployments and operations at risk.

He remarked that the funding of the Argo Technical Co-ordinator position was maintained by virtue of the intergovernmental mechanisms provided by IOC and JCOMM. Several AST members noted that such an intergovernmental mechanism was simpler to work within and to seek commitments for, than a more ad hoc science-based mechanism.

In concluding Gould noted that if the AST were in favour of the post of Argo Director being established in the long term he would work during the coming year to quantify the cost of maintaining the positions to suggest appropriate funding mechanisms.

The first step in seeking to establish and fund an Argo Director post would be for the AST to agree on the Director's tasks. Following that, he noted that it would be easier for some countries to provide support and difficult for others. In response to the case for funding through an intergovernmental mechanism he noted that Argo must be free to innovate while still adhering to JCOMM requirements.

The idea of an Argo newsletter was seen as being a useful one. The target would be to produce it quarterly in electronic form and to distribute it so that it can be printed locally. Wijffels, Freeland Takeuchi and King agreed to assist in identifying suitable material. Wijffels noted that CSIRO could help with layout and design.

Action item 20 *First Argo Newsletter to be issued at end of April 2003.* ***Gould, Belbéoch, Wijffels, Takeuchi, Freeland and King***

7.2 Outreach activities

Roemmich commented that the long term viability of Argo would be dependent on demonstrating its value and benefit to operational agencies and that ways should be found to ensure their involvement in Argo planning and in the programming of Argo science workshops.

Freeland noted that the PICES (www.pices.int) annual meeting in Honolulu in October 2004 would probably have a sessions devoted completely to global observations and suggested that Argo should plan to have a strong involvement.

Action item 21 *Argo Director to contact PICES about Argo involvement in October 2004 Hawaii workshop.* ***Gould***

It was suggested that Argo should start to accumulate a list of publications that describe Argo and of papers that use Argo data. The Argo Director will attempt to start this and in future countries will be asked to list such papers in their annual report to the AST.

Action item 22 *Argo Director to start to assemble Argo bibliography and to ensure that in coming years national reports to AST include a list of Argo contributions.* ***Gould***

It was also suggested that people who publish papers based on Argo data should include in the acknowledgements a form of words that highlights Argo's key role in GOOS/GCOS and its commitment to free and open exchange of data.

Action item 23 *Argo Director to draft appropriate text to be included in acknowledgement section of papers using Argo data* ***Gould***

8. AST and ADT operation and membership

Roemmich reminded the AST that the Team was made up of scientists who reperesented their country and who are therefore close to national Argo implementation. Others attended the AST meetings as representatives of bodies closely related to Argo or as individuals with particular expertise. The membership was therefore subject to change.

The Argo data team had started as an ad hoc committee that had now become permanent. Its membership was less clearly defined and perhaps needed to be formalised. This need was particularly evident at the last ADT meeting where the size of the meeting made discussion and decision making difficult.

He said that he would meet with Argo Director and the ADT co-chairs, after the meeting to start a discussion on the membership of ADT and its relationship to AST and that in due course proposals for ADT membership would be sent to the AST for approval.

Molinari suggested that operational analysis centres should be represented on the AST and Gould commented that it would also be appropriate to have Argo's sponsoring programmes (CLIVAR and GODAE) represented.

In bringing the discussions to a close Roemmich noted that Russia and Spain were now active in Argo and should be invited to join the AST as formal members. Norway should also be asked if they wished to be considered for membership. He also informed the AST that Molinari had expressed a wish to step down from the AST.

Action item 24 *Proposals for changes in membership of AST and ADT to be drawn up and sent to AST members for approval.* ***Roemmich, Gould, Keeley, Pouliquen.***

9. Date and location of next meeting

An offer had been made to hold AST-6 in Brest, France and this was accepted. The exact dates are yet to be decided.

Action item 25 *Proposals for date of AST-6 to be sent to AST members.* ***Pouliquen, Desaubies.***

In closing the meeting Roemmich thanked the hosts for their generous support and for ensuring that it ran smoothly.

<u>Annex 1.</u>

AST - 5 Agenda

Monday March 3 1400

Argo Executive* meets with local organisers and hosts.
Roemmich (Chairman IAST)
Freeland
Desaubies
Takeuchi
Radakrishnan
Wijffels
Gould (Argo Director)

Tuesday March 4 9:00 am

1.   Welcome and introductory remarks

- Welcome and local arrangements. *Local hosts*
- Introduction *Prof Su Jilan (IOC Chairman)*
- The present status of Argo and key issues for IAST-5. *Roemmich*
- Interdependence of Argo and satellites: wide swath altimetry *Lee-Lueng Fu*
- Discussion of agenda and objectives for AST-5 *All*

2. The Argo data system

- Outcome and action items from the Argo DM - 3 meeting. **Doc 2.1**
- Data Management Team report *Keeley, Pouliquen* **Doc 2.2**
- Status of delayed mode QC *Wong* **Doc 2.3**
- Consideration of the roles of regional data centres
  Status reports Indian *Ravichandran (INCOIS), Wijffels (CSIRO)*
  Johnson (PMEL), Hacker (IPRC)
  Southern *King/Turton (NERC)*
  Atlantic *Pouliquen (IFREMER), Molinari (AOML)*
  Pacific *Takeuchi (JAMSTEC), Johnson (PMEL), Hacker*
- Use of BUFR format *Turton* **Doc 2.4**

Tuesday March 4 1:30 pm
3. Science results from Argo

- Presentations from
  King Temporal TS changes in South Indian Ocean
  Turton Improved (real-time) QC and data assimilation of float data in FOAM.
  Sensitivity of mixed layer predictions to the data and model formulation.
  Johnson Bering Slope Current System
  Le Traon GODAE status and links with Argo
  Freeland Sub-arctic water in the Gulf of Alaska
  .Xu Dongfeng Typhoon of July of 2002 effects on the thermocline from Argo

- Plans for Argo Science workshop (Nov 12-14 2003) *Takeuch*i Doc 3.1

Wednesday March 5 9:00 am

4. Technical issues

- Float and sensor performance

APEX performance and status	*Riser* **Doc 4.1**
PROVOR/Metocean	*Loaec/Shikama* ***Doc 4.2***
SOLO and SOLO-II	*Roemmich*
Ninja	*Ando* **Doc 4.4**
Communication	*Riser*
Salinity sensors	*Wong/Johnson* **Doc 4.6**
Novel sensors for profiling floats	Paper by *Joos* **Doc 4.7**
Drift vel and error at parking depth	*Ishikawa* **Doc 4.8**
Salinity cal experience at LPO	*Desaubies et al* **Doc 4.9**
Float development in China	*Yu Lizhong*
Floats and in-situ CTD data	*Liu Zhenghong*

- Mechanisms of information exchange

Wednesday March 5 1:30 pm

5. Status of Argo Implementation

- National reports
- Network Status by AIC *Belbéoch*
- Projected commitments to Argo prepared by *Stan Wilson* **Doc 5.20**.

Thursday March 6, 9:00 am

6. Implementation planning

- Co-ordinators for each ocean basin report on status and issues

Pacific	*Roemmich, Takeuchi*
Atlantic	*Pouliquen for Desaubies* **Doc 6.4**
Southern	*Riser*
Indian	*Phillips on behalf of Ravichandran/Wijffels..* **Doc 6.5**

- Uniformity of parking depth selection *Takeuchi*

Thursday March 6, 1:30 pm

7. Argo supporting infrastructure and Argo outreach

- Argo infrastucture and the potential role of an Argo Director *Gould* **Doc 7.1**
- AIC Development *Belbéoch* **Doc 7.2**
- Argo's visibility and image with scientists and government agencies
- Suggestion for an Argo publication list *Takeuchi*

8. IAST and DMT operation and membership.

9. Date and location of next meeting

Annex 2.

Attendance list

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Annex 3

TECHNICAL HISTORY AND PERFORMANCE OF APEX FLOATS

Stephen C. Riser, University of Washington, USA

1. INTRODUCTION

Most of the profiling floats that have been deployed as part of Argo have been APEX-type floats, manufactured by Webb Research Corporation in the US. In most cases these floats have been purchased directly from Webb, in so-called “fantail-ready” condition, ready for deployment. One group (UW, USA) buys only the components of the floats from Webb and carries out assembly, ballasting, and final checkout themselves. As of this writing, over 400 of the more than 600 floats deployed in Argo have been of the APEX variety.

The APEX float first appeared in 1999. The design represented the evolution of the earlier PALACE float produced jointly by Russ Davis and Doug Webb, that was used extensively in WOCE. Whereas the PALACE float used a rotary pumping mechanism that pumped oil directly in and out of an external bladder, the APEX design used a single stroke pump (a piston mechanism) to force oil in and out of the bladder. The APEX design had the advantage that the pumping of oil could be more accurately controlled and that dirt and bubbles in the oil, which caused problems in many PALACE floats, did not seriously hinder the float performance. The APEX had the disadvantage that its buoyancy capability was considerably smaller than PALACE (around 180 ml initially compared to over 700 ml for PALACE). The electronics in APEX were quite similar to PALACE; while software changes were made in order to control the new pumping mechanism, the basic electronics hardware was quite similar in the two floats.

2. FLOAT HARDWARE USED

There have been 2 versions of the basic APEX float hardware in use since 1999, and 2 general versions of the controller board in the float. These include the following:

(*i*) *APEX-180*: This float was the initial APEX float and had a maximum displacement of 180 ml of fluid. This allowed the float to cycle between depths of 1000 m and the sea surface in the subarctic and subtropical regions of the world ocean. At lower latitudes, where more buoyancy is required to reach the sea surface, the APEX-180 was limited working in the range 0-700 m in many places.

(*ii*) *APEX-260*: This float was first tested in 2000 and is now the float being used in essentially all Argo applications. The displacement of the float was increased to 260 ml, allowing operation from 1000 m to the sea surface throughout the world ocean, and operation to as deep as 2000 m in about 90% of the ocean. The increase in displacement was obtained by increasing the length of the stroke of the piston and increasing the length of the basic APEX housing.

(*iii*) *APF-7 controller*: All APEX floats use a basic controller board designated with the prefix APF. Since the first APEX floats were deployed in 1999, the controller has changed from version APF-3 to APF-8 as the hardware and software evolved. Most of the earliest APEX floats that were deployed through mid-2001 had the APF-7 controller.

(*iv*) *APF-8 controller*: In mid-2001 Webb Research began supplying APEX floats equipped with the APF-8 controller. This version of the controller fixed several important problems with the APF-7 controller, as outlined below.

3. SUMMARY OF RESULTS

In what follows, a summary based on the performance of 331 APEX floats is provided, categorized according to the types of APEX floats and controllers used in Argo. This summary has been compiled using Argo data provided by IOS (Canada), FEHRHI (Russia), Second Institute of Oceanography (China), UK Met. Office (UK), KMA (Korea), and UW (USA). In addition, results from identical non-Argo floats (Argo equivalents) have been provided by NAVO (US), NDBC (US), PMEL (US), and Middle Eastern Technical University (Turkey). In all, this group of institutions deployed 19 APEX-180 floats and 312 APEX-260 floats between July, 1999 and February, 2003. All floats had SeaBird SBE-41 CTD units. All APEX-180 floats used in this performance summary had APF-7 controllers. By early 2001, Webb was no longer actively selling the APEX-180, instead replacing it with the APEX-260. A few early APEX-260 floats had a modified

APF-7 controller; all of the others had a version of the APF-8 controller. The summary given here mainly reflects the results from the APEX-260, but it should be noted that the results from the APEX-180 were similar to the early APEX-260 results.

Known problems: Several problems were seen repeatedly in the early APEX-260 floats; some of these problems were not new and had been evident going back to early APEX-180 deployments, and in some cases even back as far as PALACE floats used in WOCE.

(*i*) *Energy flu problem*. The most common problem was the often-seen "energy flu", a condition where the float battery underwent rapid discharge after 20-50 profiles. Usually in such cases the battery voltage fell to catastrophically low levels (< 8.2 volts) over about 10 profiles once the condition began. This condition was the most common APEX failure mode and caused the premature failure of a number of APEX floats through mid-2001. In April of 2001 the cause of this failure was finally identified in the UW float laboratory. It appeared that the rapid battery discharge was due to a buildup of moisture inside floats due to the normal internal chemical reactions present in alkaline batteries. In some cases this moisture caused a short-circuit on the main controller board due to faults in the manufacturing process. Once the short was initiated, it rapidly drained the energy from the batteries. While a sizable package of desiccant is put inside each float when it is built, this proved to be insufficient to absorb all of the water vapor generated by the alkaline batteries. This problem was corrected in a redesigned version of the APF-8 board by covering the board in a plastic coating, hence preventing any shorts from occurring; the new board was designated as APF-8*a*. The energy flu condition has not been observed to occur on any floats deployed after this modification was installed. Some floats with equipped with the APF-8*a* controller have now successfully completed 76 profiles.

(*ii*) *Low-high H-drive problem*. This problem was diagnosed in October 2001 and was subsequently found to be responsible for the failure of a number of APEX floats. This problem was related to the ground point on the APF-8 board. Normally both points of the motor control circuitry are tied to a common positive voltage when the motor is not in use (i.e., during drift at depth). In some floats it was found that due to faults in the manufacturing process that current could still flow in this case, leading to rapid discharge of the float batteries. The solution to this problem was to tie the motor circuitry to a negative voltage when not in use, effectively eliminating the possibility of a short. This modification was installed and the new circuit boards were designated as APF-8*b*. Several floats equipped with the APF-8*b* controller have now successfully competed 64 profiles.

(*iii*) *Motor backspin problem*. This problem was found in mid-2002 by the CSIRO (Australia) laboratory. It was noticed (in a laboratory simulation) that when descending after a profile, the motors in some floats would spin backwards due to the pressure of the ocean forcing the piston inwards. In many cases this backspin then caused a voltage to be generated that would eventually damage important components on the main controller board, causing catastrophic failure of the float after 10 profiles or less. **NOTE**: the problem appeared only on floats that were parked at a depth of about 1600 m or greater, and it did not show up on floats of the "park-and-profile" variety due to the way that the piston withdrawal is handled by the float software. This problem was fixed by adding a Schottky diode (a "Transorb") in the motor circuitry to prevent the generation of this voltage. The boards with this modification were denoted as APF-8*c*. All APEX floats presently sold by Webb have the APF-8*c* controller board. A few floats with the APF-8*c* controller have now successfully completed 63 profiles.

With each of the modifications noted above, the performance of the APEX floats improved. The success rate with various models of APEX floats is summarized in the following table, which incorporates the results from the 331 APEX floats included in this study:

GRO GROUP	NO. FLOATS	PROFILES EXECUTED	PROFILES EXPECTED	AVG. NO. PROFILES	% GOOD
APE APEX-180	19	957	1307	50.3	73.2
APE APEX-260	312	7897	9833	25.3	80.1
APF- APF-7	58	2708	3855	46.7	70.2
APF-8	273	6146	7305	22.5	84.1
APF-8 *abc* *	165	3520	3688	21.3 (maximum 64)	95.4
APF-8 *ab* †	108	2626	3617	24.3 (maximum 76)	72.6
TOTAL	**331**	**8854**	**11160**	**26.7**	**79.3**

***** Includes APF-8*a* and APF-8*b* floats that profile < 1600 m on all profiles, as well as those that park at 1000 m and profile to 2000 m, and all APF-8*c* floats at all depths.

† Includes only floats profiling > 1600 m on all profiles. Does not include park-and-profile floats.

As can be seen from the table, the reliability of the APEX has improved considerably as the controller board evolved from the original APF-7 to the present APF-8*c*. Presently half of the floats deployed (165) employ either the newest model controller (APF-8*c*), or, an older version of the APF-8 controller in conjunction with float missions that profile above 1600 m only. In these cases, the reliability of the floats exceeds 95 % (the known 5% failures were caused by ballasting errors or deployment problems). Thus, while it is probably too early to conclude that all problems with the floats have been fixed, it does appear that the overall reliability of the APF-8 generation of floats (84.1%) has greatly improved compared to the reliability of the APF-7 (70.2%) (note that the average APF-8 has executed only about 22 profiles at this time, compared to 47 profiles for the average APF-7). In about 6 months (late 2003), after the floats with APF-8 generation controllers have executed about 25 more profiles, it should be clear as to whether the problems with the APF-7 have truly been fixed. It is encouraging to note that in many cases with the APF-7 controller, problems with energy flu or motor backspin appeared after only 10 profiles. The fact that we have not seen any of these problems with the newest APF-8 generation of floats after an average of 22 profiles (with one float already executing 76 profiles) encourages us to hope that the most serious failure modes have been identified and fixed. It is suggested that a success rate of 90% or higher after 4 years should be our goal, and it appears that we can be cautiously optimistic that the reliability of Apex floats is moving in this direction.

<u>Annex 4</u> PROVOR Float development and performance

Gerard Loaec and Nobie Shikama

Ifremer began to design floats at the beginning of the nineties within the framework of Woce (about 200 Marvor multi-cycle Rafos floats deployed in North Atlantic and South Atlantic) and then adapted the available technology at the end of the nineties to design Provor profiling float. These floats are now produced by series by 2 subsidiaries of Martec: Serpe-Iesm (in France) for European customers and Metocean (in , Canada) for the customers of the other Countries. The floats produced by these two companies are using some identical parts: sensors, main electronic unit, Argos ptt, hydraulic system, but there are some differences : size of the housing, battery numbers, data acquisition and control software. The main original points of this range of floats are that this float can profile between the surface and 2000 dbars in all oceans and the great versatility of data acquisition, as measurements can be made when the float drifts at depth or during the descent and all parameters are user-defined.

Results of Gyroscope floats and Jamstec floats are then presented. 40 Provor and 44 Apex floats have been cycling in North Atlantic for 1.5 year and the ratio of recovered profiles over expected profiles is more than 90% with either Provor or Apex. Jamstec has got however quite bad results with Provor floats provided by Metocean but many floats were deployed before the problems were pointed out. Some improvements were applied, but at the date of the meeting, the floats have not cycled enough to provide conclusions.

Technical improvements about sensors and the control of the float at depth are then presented:

- the problem of the salinity offset is now solved (contaminated tbto capsules replaced by Sea Bird),
- Fsi sensors still need to be improved, even if no drift can be detected on cycling floats (without any recovered float and post-calibration). Jumps in salinity were however observed and are not explained.
- Provor is fitted with a grounding feature; if the float grounds, either it remains at the same location, or it tries to reach a lower parking depth to move away (this mode is user-defined). When the gradient of density near the surface is very high, it appears that the grounding detection level is too low. This level was increased.
- Some software corrective actions were taken to solve the ‘emergency ascent’ problem detected on Jamstec floats.

At least, some new developments are in progress:

- the design of a new electronic main unit, providing more facilities to integrate new sensors and communication devices, and more memory space for program code,
- the integration of Argos downlink and Iridium,
- the improvement of the hydraulic system, to reduce the consumed power,
- the integration of new sensors : an Aanderaa Dissolved Oxygen sensor and a Rafos acoustic receiver.

Annex 5. National reports

Australian Argo report to AST-5 (Submitted by Susan Wijffels)

Status of implementation

Floats deployed and their performance

Floats deployed in 1999-2001: of 10 Webb Research R1-PALACES deployed in an Argo pilot in 1999-2001, 6 are still operating. These 6 were opened at CSIRO, reprogrammed and had lithium batteries installed. All were instrumented with Seabird CTDs. The number of profiles to 2000m obtained by these floats is about 100, and may extend to about 120 close to 4 year record. In these floats, a quirk of the float programming meant that the CTD was turned off after the floats 'stall' in the thermocline due to a lack of buoyancy contrast with the surrounding seawater. Several of these floats were affected by the known problem of TBTO leakage into the Seabird conductivity cell, which largely disappeared after about 6 profiles. Of all 10 floats, about 4 have returned stable salinities calibrations (+/- 0.01), 4 have shown drifts to higher salinities, and one has a very serious salinity drift and what appears to be a large drift in the pressure sensor. We don't yet understand the nature of the sensor failure in this latter float.

Since March 2002, 14 Webb APEX-260 floats have been deployed in the eastern South Indian Ocean off the west coast of Australia, and one MetOcean PROVOR was deployed in the region. Commercial, naval and research vessels have been used for deployments. Three APEX floats were deployed in the Indonesian Exclusive Economic Zone through cooperation with the Indonesian Agency for Fisheries and Marine Sciences. All APEX floats were opened and lithium batteries installed. All 15 new floats have operated with out any problems, though the salinity on the Provor appears to contain an offset. Most floats have already returned over 10 profiles.

Technical problems encountered and solved

As part of our float preparations, our engineering group worked on modeling the energy budget of the APEX floats, which included bench tests and measuring current draw for various float functions. During this work, several problems were found and are reported in detail in the attached notes from Alex Papij. However, the summary is below.

1) The energy budget is likely to vary from float to float and one of the contributing factors may be the mechanical alignment of motor//gearbox, lead screw and piston. For a given battery configuration the predicted number of profiles a float will deliver will have a large uncertainty.
2) The energy budget we arrived at is less optimistic than previous budgets and that lithium batteries would be required to deliver a 4 year lifetime for APEX.
3) There was a serious issue of potential damage to the electronics due to a lack of protection against large voltages produced by the motor back EMF and motor switching spikes. After notification of this problem, a fix was implemented by Webb Research. See S. Riser's report on the APEX float performance.

Status of contributions to Argo data management:

Real time: All Australian Argo floats are subject to real time QC for both temperature and salinity. Salinity is also calibrated against high quality historical CTD data in real time. Pressure is also corrected for surface offsets. Profiles are formulated into TESAC messages at CSIRO and sent to the Bureau of Meteorology for broadcast on the GTS. Australian Argo data are currently formulated into Argo netcdf format, but we are awaiting finalisation of the data format before automating real time ftp transfer to the GDACs.
Delayed mode: No delayed mode data function is yet funded in Australia. We are proposing to host a delayed mode data center to cover the region 90-180°E, 0 – Antarctic. Two full-time data QC experts would be employed to support routine delayed mode activities as part of this proposal. Two regional climatologies would be used in float QC: CARS2000 (www.marine.csiro.au/~dunn/eez_data/atlas.html) and a new 'clean' archive of historical temperature data that is being developed for the Indian Ocean.

Contribution to Regional Coordination:

In December 2002, Helen Phillips established a website for the coordination of Argo floats in the Indian Ocean and will actively coordinate deployments for as long a necessary.

National funding

Float acquisition: Australian Argo is a joint program between the CSIRO Marine Research (CMR) and the Australian Bureau of Meteorology (BoM). A newly funded Cooperative Research Center for Antarctic Ecosystems and Climate will also acquire 45 floats to be deployed in the next several years in the subantarctic zone south of Australia.

Float acquisition is subject to yearly funding proposals in both institutions. For the FY 03/04 (upcoming year), BoM will not purchase any floats, but will ramp up to 7-11 floats per year in subsequent years. A substantial request (~35 floats/year) has been made from CSIRO, but the success of this proposal will not be known until June 2003.

Human resources: Australian Argo requires approximately 25% of a fulltime engineer for float checkout and preparation; 20% of a fulltime operations officer for float shipping coordination and deployment training; 30% of a fulltime data expert for realtime data monitoring and conversion to netcdf formats etc. Scientific analysis, coordination and oversight are supported by 1.3 fulltime equivalents.

Deployment plans

Australia will continue to maintain a float array between 100°E and its west coast. Future expansion, if funded, would likely center on float deployments off Australia's east coast in the Coral and Tasman Seas. Roughly 15 floats will be deployed next austral summer south of Australia in the subantarctic zone as part of the Antarctic CRC activity.

National research and operational uses of Argo data:

- Argo data are routinely used in the operational upper ocean analyses of Neville Smith at the Australian Bureau of Meteorology (http://www.bom.gov.au/bmrc/ocean/results/climocan.htm). These analyses are also used to initialize an experimental seasonal rainforecasting system.
- A collaborative analysis of Argo data off Sumatra and Java will begin in 2003 with the Indonesian Agency for Fisheries and Marine Research.
- Large scale interannual salinity anomalies captured by Argo in the eastern South Indian Ocean are being investigated by Helen Phillips, a postdoctoral investigator recently hired at CSIRO Marine Research. Helen.Phillips@csiro.au
- CSIRO Marine Research, in collaboration with the Bureau of Meteorology Research Center, is developing an ocean model/data assimilation system for ocean forecasting and hindcasting. Argo data will be the largest *in situ* data source for this system. Work on subsurface profile assimilation is underway. PI: Andreas.Schiller@csiro.au

Canadian Argo report to AST-5 (Submitted by Howard Freeland)

1. Status of Implementation

a) Floats deployed March 2002 onwards

	Floats Deployed	**Floats missing data**	**Howard's Score**
Atlantic Ocean	13	0	100%
Pacific Ocean	31	2	75%
Southern Ocean	6	0	100%
All Oceans	32	2	93%

All floats deployed were APEX floats made by Webb Research with SeaBird CTDs.

Atlantic deployments: These were all from research vessels and have taken place in the Labrador Sea and following the Labrador Current, around the tail of the Grand Banks and following the slope water as far south almost as Cape Hatteras. All floats appear to be functioning well and so far there have been no premature failures although one float failed its pre-launch check and was returned to shore for repair. The CTDs also appear to be giving good data.

Southern Ocean deployments: Six floats were launched from a C-130 (Hercules) aircraft in December 2002. As of writing each float has supplied the expected (5) profiles and all data appear to be of excellent quality.

Pacific deployments: Of the 13 floats listed in the table only 8 are in the water as of writing and 5 are due for deployment in February 2003. Of the 8 floats already deployed, one, 4900116, clearly has a bad CTD sensor and has supplied no useful salinity observations since its launch. We attempted recovery in September 2002 and February 2003, so far without success because of time constraints. We anticipate a successful recovery in June 2003, the float will be recovered, refurbished and redeployed. One float 4900243 (APEX S/N 516, controller board apf8a-792) failed prematurely after only 9 profiles. At the time of failure piston positions were normal and voltages were excellent.

Older floats that we are tracking have also shown some premature failures, but these were all older versions of the controller boards. Our conclusion is that there were problems associated with inexperience (Argo has led to the deployment of a lot of floats and discovered problems we didn't know existed) and with quality control (e.g. ballasting too heavy). These problems appear now to have largely been eliminated.

b) Technical problems encountered and solved:

Along with everyone else we became concerned during 2002 about the "leaky TBT" problem. We were visited by representatives from SeaBird and the floats were treated at IOS. One float that had not been treated is showing massive problems with the conductivity cell, and as mentioned above we do intend recovering that float. None of the salinities reported by 4900116 are usable and cannot be corrected using the Annie Wong routines.

The APEX float that failed its pre-launch check had a crimped tube from the air pump so that the air bladder failed to inflate. The repair was simple.

c) Status of Contributions to Argo Data Management.

MEDS is presently tracking 61 active floats of which 4 have not reported as scheduled and may well be lost. We have 38 deployed in the N. Pacific, 16 in the N. Atlantic, 1 in the Indian and 6 in the Antarctic Oceans. All data are passing through a real-time data system meeting international specifications.

Approximately 86% of the data were sent to the GTS within 24 hours of the float surfacing. One of our PIs has installed and is testing the scientific QC procedures of Wong et. al. Sample data files have been exchanged with MEDS and we are working to ensure these files are consistent with format requirements. When this is complete, we will begin sending delayed mode data to the GDACs. There is a considerable backlog of data that will need to be QC'ed and sent on to the GDACs as well.

Canada continues to post products showing samples of the data returned from the floats on MEDS web site.

A comparison between a CTD cruise along Line P in the North Pacific and float data collected at the same time and in the same area has been done and results available from our web site. To advertise the program in Canada we have prepared a Fact Sheet that describes the Canadian program. Copies are available from MEDS web site. We have published an article in the Canadian Meteorology and Oceanographic Society Bulletin describing the program and we are discussing with the editors the idea of having a periodic update of program news in the same publication.

URL: www.meds-sdmm.dfo-mpo.gc.ca follow links to the Argo program.

2. National Funding for Argo Operations (not including use of Argo)

The Canadian Argo program is relatively small but is spread across three institutions. The central management of the Canadian strategy for Argo is based at the Institute of Ocean Sciences (IOS) in Sidney, British Columbia. Deployments for the Atlantic are based out of the Bedford Institute of Oceanography (BIO), Halifax, Nova Scotia, and data management centred at the Marine Environmental Data Service (MEDS) in Ottawa.

Human resources dedicated to Argo operations add to 5. PYs Purchase of floats is conducted on an ad hoc basis but is typically C$600k/year = US$390k/year.

Operations are funded through a single grant issued specifically to support Argo operations and amounting to about C$360k (US$235/year). This supports shipping, data management, travel, computing requirements and three technical support salaries.

3) Deployment Plans

The original deployment plan for Canadian Argo floats that was formulated about 3 years ago has been followed moderately closely. In response to concerns expressed by the international Atlantic Argo Coordinator, five floats were deployed in the Labrador Sea rather than in the western North Atlantic between 35 and 50 N. The original deployment plan for year three calls for the filling of gaps within our primary North Atlantic and Pacific float arrays as well as directing Canadian floats for an increasing fraction of Canadian resources to be directed now into remote areas, such as the southern ocean. However, we are concerned about the lack of deployments in the western Atlantic south of 35 N and so presently are starting to review our plans.

The expectation as of writing is that Canada will have a total of 30 floats available for deployment during the fiscal year 2003/04 (our fiscal year operates from April 1st 2003 to March 31st 2004). These floats will be distributed roughly 60% PROVOR floats (from METOCEAN) and 40% APEX floats (from Webb Research). At the moment we do expect to be negated in some gap filling in the Gulf of Alaska, but as for the disposition of the bulk of these 30 floats, we would like an opportunity to evaluate plans for Western Atlantic deployments by, for example, US east-coast Argo groups. Following that assessment we will then determine whether Canadian floats should be directed to remote areas or towards the western Atlantic.

Beyond fiscal year 2003/04, we have no firm commitment from the Canadian Government for the acquisition of floats. However, given the interest within the Canadian Govt in seeing oceanography operationalised we anticipate that funding will be forthcoming sufficient to continue up to 30 launches/year.

4) National Research and Operational Uses of Argo Data

During August 2002 a meeting was held in Halifax, Nova Scotia, to discuss the development of ocean data assimilation and similar strategies within Canada and the use of the new real-time ocean data sets. The meeting was hosted by CMEP (Canadian Centre for Marine Environmental Prediction) which is a new agency funded partially by academic funding agencies and partially by the federal government. CMEP is based at Dalhousie University in Halifax. At that meeting a decision was announced by the Director of the Meteorological Service of Canada to develop a global coupled atmosphere/ocean data assimilation.

The following projects are ones that I am aware of within Canada that use Argo data.

1) Atlantic Ocean data assimilation - A project funded by the CFCAS (Canadian Foundation for Climate and Atmospheric Science) to develop data assimilation and hindcast tools for the N. Atlantic. The Principal Investigators are Keith Thompson (Dalhousie University) and Dan Wright (Bedford Institute).
2) Pacific Ocean data assimilation - A project funded by the CFCAS (Canadian Foundation for Climate and Atmospheric Science) to develop data assimilation and hindcast tools for the Gulf of Alaska. The Principal Investigators are Mike Stacey (Royal Military College), Mike Foreman and others at IOS.
3) Pacific Ocean data assimilation - A project funded by the Department of Fisheries and Oceans "Strategic Science Fund" to parallel and assist project 2).
4) Mixed layer mapping in the Gulf of Alaska: This project is funded at the University of Alberta (PI = Paul Myers) to hire a graduate student to study the evolution of mixed layer depths in the Gulf of Alaska focussing on the data from Argo, funds derive from the Dept of Fisheries and Oceans "Science Subvention Fund".
5) Antarctic Intermediate Water formation: This project is *sub judice* with the CFCAS, the PIs are Richard Karsten (Acadia University, Nova Scotia) and Howard Freeland (IOS) and will study the floats recently deployed in the formation area for Antarctic Intermediate water.
6) Gulf of Alaska cold pool: This project is *sub judice* with the DFO Science Subvention Fund. The PI is William Hsieh at the University of British Columbia, Vancouver. The object is to study with a combination of modelling and analysis of Argo data an unusual invasion of sub-arctic water that occurred during 2002.
7) Pacific – State of the Ocean: Howard Freeland as part of his job at IOS monitors the state of the environment in the Gulf of Alaska. Conditions have been extremely unusual during the last 8 months and upper-ocean stratification was never eliminated as has always occurred in previous winters. This threatens to reduce the supply of nutrients to the productive zone with impact on the ecosystem likely during 2003.
8) Atlantic – State of the Ocean: Profile data from the Argo floats deployed over the Continental Slope in Atlantic Canada are being examined as part of the regions annual assessment of the state of the ocean environment. This document is produced for the Fisheries Oceanography Committee of the Canadian Regional Assessment process. These documents are also presented at the annual meetings of the North Atlantic Fisheries Organization (NAFO) and the International Council for the Exploration of the Seas (ICES). Movement of cold Slope Water equatorward along the Continental Slope is an infrequent occurrence that has significant impact on the shelf fisheries from the Eastern Scotian shelf to the mid Atlantic Bight.

5) Issues that Canada would like to see addressed.

a) We are concerned about the apparent lack of deployments in the western North Atlantic. We consider it to be a high priority that this deficit be addressed. Canada is willing to contribute floats to help address this deficit but we do not have the resources to fix the problem on our own. It presently appears that floats deployed in the Irminger Sea are seeding the boundary current region of the Labrador Sea but the reseeding of the interior of the Labrador Sea (the site of deep convection) may remain and issue that Canada also might be asked to contribute to.

b) We are concerned that there is no one-to-one relationship between the availability of profiles and the availability of trajectory files. The two global data servers appear to be doing an excellent job of archiving the profiles, but just because a profile exists on one day for a float does not mean that a trajectory file exists. Also, the arrangement of profiles into geographical areas seems reasonable, but the organisation of trajectory files by national origin seems strange and counter to the sprit of Argo.

Chinese Argo report to AST-5 (Submitted by Jianping Xu)

1. Floats deployed in FY 2002

Funded by the Ministry of Science and Technology (MST), in FY 2002, China Argo project has deployed 18 floats in the areas of West Pacific (16) and Eastern Indian Ocean (2). Among them, 8 are the APEX floats and 10 PROVOR floats. After being launched, 2 floats have not sent any information, probably for troubles of communication; 3 floats receive obviously erroneous salinity data, maybe the pump of conductivity sensor has troubles. At present there are 13 floats working in normal conditions.

2. Deployment plan for FY 2003

In 2003, China plans to deploy 12 floats. The fund of 6 floats has been settled and the other remains to be settled. Except that the MST will continue to sponsor the floats, the National Natural Science Foundation of China (NSFC) has approved 2 projects, to support the research oceanographers and atmospheric experts on the application of Argo data.

China will still deploy the Argo floats in the West Pacific and Eastern Indian Ocean. In the near 3 years, we will do the best to launch at least 80 floats in the areas.

3. Issues and suggestions

(1) Data receiving and processing
For some reasons, China has not obtained Argo float profiles from the GTS up to now, but only by Internet to get the raw data from the French CLS (Collect Location Satellites). State agencies-related have noticed this issue and are now looking for ways to deal with it.

In the National Marine Data & Information Service (in Tianjing), a website, **http://www.argo-cndc.org**, "China Argo Data Center" has been set up, which is responsible for the global Argo data collecting, processing, distributing and exchanging. The Second Institute of Oceanography (in Hangzhou) presides over the floats deploying, real-time data receiving and processing, and delayed mode QC. We have imported the model of Argo data delayed mode QC developed by PMEL (Wong et. al.), and have tried the work of delayed mode QC to the Argo data of the 2 floats deployed in Oct.2002, and some experience has got. In 2003, we plan to use the model to deal with the delayed mode QC to all the floats data. The results will be published in the Web site **(/argo)http://www.sio.org.cn** and other related websites, to provide different users the application of the Argo data into the ocean and weather prediction and forecasting, and science research. Besides, Prof. Stephen C. Riser, Ocean School of University of Washington, helped China set a real-time APEX floats information homepage **(http://flux.ocean.washington.edu/sio)** in his Lab, for all Argo members to know the implementation of China Argo project.

(2) Argos receiving and communication
It is said that the Argos service has different criteria for the charges of different countries to use the Argos satellites locating and communicating. For the International Argo project, if it is possible to use the same charge criterion to all the Member countries, to support these countries to deploy more Argo floats?
At present, we have not the capability to send our Argo floats data through the GTS port in Beijing, but trust French GADC to send to GTS.

(3) Developing Argo floats
In 2002, China deployed 18 floats, but there are 4 cannot get the data. We are concerned the lifetime of the remaining floats working in the sea. This is the problem all the floats providers consider. So improving the specification and quality of the floats, and prolonging the life, is the main task and the target of the floats manufactures
China is now developing the Argo float. A floats sample with a pressure and temperature sensor has been tested in the sea, and sets of pressure and temperature data in the layer 0-1000m have been obtained. But there are some technical problems. It is hoped all the member countries can help and support. What China develop the floats is aimed at reducing the cost, having more floats to deploy and maintaining the Argo observing array long-term running.

French and European Union report to AST- 5
(Submitted by Sylvie Pouliquen and Yves Desaubies)

This includes CORIOLIS (FRANCE) and GyroScope (EU), which are partners (as well as the other EU partners).

CORIOLIS: http://www.coriolis.eu.org
Gyroscope: http://www.ifremer.fr/lpo/gyroscope

Organization at French level

The French Argo Project is handled through a multi agency project named CORIOLIS and supported by 7 agencies: Cnes, Cnrs, Ifremer, Ird, Insu, Ipev, Meteo-France and Shom. It started in 1999 with the Pomme experiment for which the first prototypes of Provor floats equipped with FSI sensors were deployed.. Float deployment is handled by Ifremer, Shom and Insu. Data processing is operated by Ifremer.

Status of implementation :

All GyroScope floats have been deployed (84, including those under IFM responsability), as well as 30 French (13 Pomme, 17 CORIOLIS) all in the Atlantic ocean except 15 which were in the Indian Ocean.

Table summarizing Float Status for Gyroscope

Float Type	Start	Overall				Dead floats			Active floats	
		Number deployed	Active	Dead	Cycle recorded / possible	Max number of cycles recorded	Number less than 5 cycles	Mean number of cycles	Max number of cycles recorded	Mean number of cycles
Provor	25/07/2001	40	35	5	1101 / 1217	19	2	9.20	57	30.14
			87.5 %	12.5 %	90.5 %		40.0 %			
Apex	20/07/2001	44	40	4	1372 / 1493	51	2	16.25	58	32.67
			90.9 %	9.1 %	91.9 %		50.0 %			
Total		84	75	9	2473 / 2710					
					91.3 %					

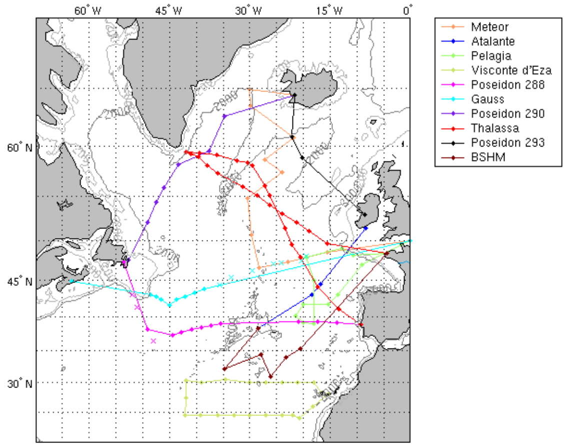
Present level of national funding for Argo including summary of human resources devoted to Argo :

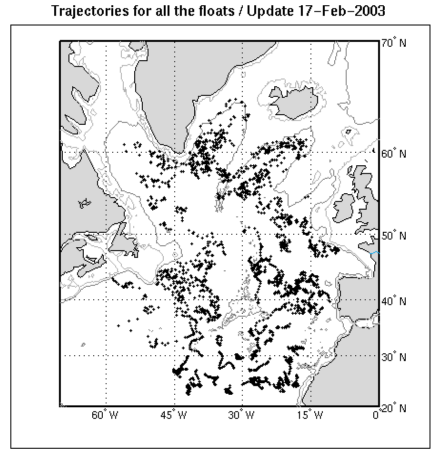
CORIOLIS is funded until 2005. It will be important in 2005 to assess the importance of Argo for operational oceanography programs in order to find "operational" fundings: or goal it to achieve buying around 80 floats per year to help sustain Atlantic network.

GyroScope is over, but a new project, MERSEA is in preparation, for which 40 floats will be requested in the period 2004-2005.

Summary of deployment plans (level of commitment, areas of float deployment) and for other commitments to Argo for the coming year (and beyond where possible)

Operations in 2002 (CORIOLIS and GyroScope)





All Gyroscope Cruises 2001-2002

59 floats have been deployed by France in 2002. 17 where deployed by Germany for Gyroscope in 2002.

CRUISE VESSEL	PERIOD	NUMBER OF PROVOR DÉPLOYÉD	NUMBER OF APEX DÉPLOYÉD (*)
Gyroscope Visconte de EZA	March	15	6
Gyroscope Poséidon	May	7	5
Gyroscope BSH 48°N Gauss	May/June	0	8
Ovide 2002 – Gyroscope Thalassa	June- July	11	5
Gyroscope IFM Poseidon	July/August	0	9
Gyroscope BSHM	September	7	1
Guinée Gulf BH2 Lapérouse	October	2	.0
TOTAL	.	42	34

(*) some of those APEX were from GyroScope / Germany, deployed by LPO/Ifremer

Operations 2003

January : 15 floats have been deployed in the Kerguelen – Crozet area (Programme Flostral)
March : *programmed* : 15 floats in a line from Dakar to CapeTown

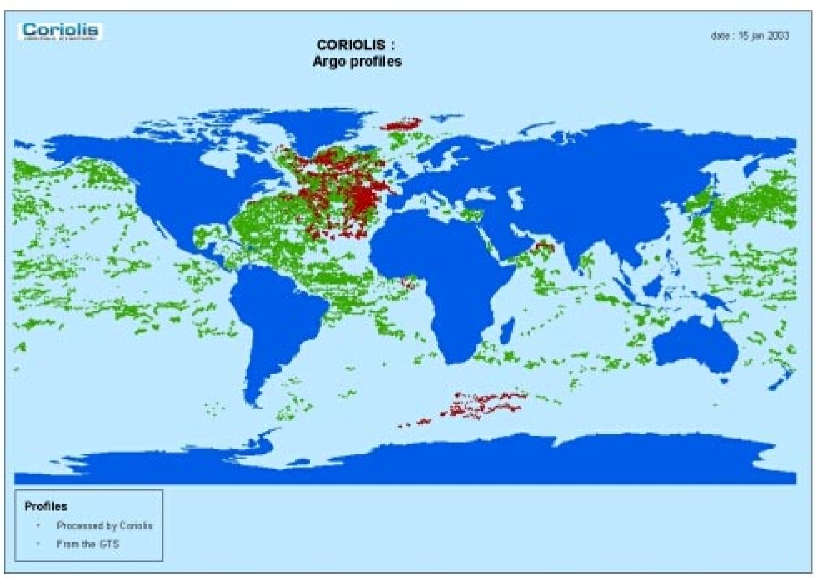
For further deployments, 113 floats are presently available. A Call for proposal has been published within France to encourage French scientists to be involved in ARGO, by deploying CORIOLIS floats in the context of their scientific programmes. The outcome will be decided in Spring, for operations to take place in the second half of 2003, through 2004. A priority has been announced for the Atlantic. Presently, groups have expressed interest in maintenance of the North Atlantic array (Ovide), the Tropical Atlantic (context of EGEE, Pirata), the South-West Atlantic (confluence region, and possibly Drake passage), a line from Capetown to Antarctica, general Kerguelen area (second batch for FLOSTRAL) and tropical Indian oceans.
The main difficulty is to find the ships, and we are soliciting collaborations.

Data Processing National Dac activity

The Coriolis Data centre processes Argo floats for the French projects, Gyroscope European project, some of the Argo European contribution, Chinese and Indian Provor floats.
Data acquired from floats Coriolis is able to process Provor (Martec and Metocean) and Apex floats in real-time. We actually process 153 floats:

- France (Shom and Coriolis): 24
- Germany: 31
- UK (Provor only): 8
- Denmark: 4
- European Union program Gyroscope: 75
- China: 6
- India: 5

The total amount of Argo profiles processed at the Coriolis data centre is 6506.Since the beginning of the activity the Coriolis data centre has processed data coming from 192 floats



Red, profiles processed at CORIOLIS Data Center,

Green profiles handled by the CORIOLIS GDAC

- Data issued to GTS: All the data processed at Coriolis are pushed on the GTS by Meteo-France
- Data issued to GDACs after real-time QC: As the Coriolis data centre is running as DAC and GDAC all the data processed at the Coriolis (DAC) are available on CORIOLIS and US-Godae GDACs.
- Data issued for delayed QC: No delayed QC has been applied to the data processed at the Coriolis data centre
- Delayed data sent to GDACs: No delayed data have been sent to the GDAC.
- Web pages: Version 2 of the Coriolis data centre has been running is test mode since November 2002. The operational Version will be installed week 9 and will include a sub-setting tools

Data Processing: Gdac Activity

Here is the summary of the GDAC functions implemented at CORIOLIS Gdac center

Function	**France**
Real-time data	• Metadata, profiles, trajectories from Canada, France, Japan, USA • Tech from Canada, USA.
Delayed mode data	None
Synchronization	First Synchronisation made on the 21st Feb
ftp service	Operational
http Selection	Can select active or all floats by ID, ocean,area, type of data…
http Graphics	• Maps of all float trajectories or individual ones. Zoom feature • Displays profiles, sections, waterfall, profile overlays
http Download	Profile, trajectory data in netCDF or ASCII (MEDATLAS format) for selected floats

Regional Dac activities over Atlantic:

Running the algorithm at CORIOLIS

The Wong algorithm has been run systematically at Coriolis on all floats available at GDAC; the results are available to users for evaluation. For the Atlantic at least, further evaluation is necessary before definite conclusions can be drawn.

Wong & al algorithm

It has been implemented systematically to all the CORIOLIS and GyroScope floats; taking the above corrections into account, it is found that in many cases the method appears to give satisfactory results, but must be interpreted with caution .

Conclusions :

- Except for 2 floats, no float shows clear evidence of linear drift.
- Several of the floats seem to detect change from climatology rather than clear sign of bias;
- Float to float comparison must be taken into account;
- Updates of the data base to include more recent data is clearly required
- It is still premature to propose definitive corrections

Some of the approaches under consideration :

- Adapt the correlation length to the geographic location, consider anisotropic correlation functions along coast lines and bathymetric features; reconsider and tune the other configuration parameters
- Review literature and consider recent data sets to improve understanding of water mass variability
- Look at float to float comparisons

Residuals from Objective Mapping

This approach is proposed by F. Gaillard and E. Autret. An objective mapping that incorporates all data available in the Coriolis database is performed weekly in real time. The underlying climatology is that of T. Reynaud.
For each level of analysis, the difference between observation and mapped field (called analysis residual) is produced by the algorithm, as part of the solution to the linear system:
$Y = H X + \varepsilon$.
The residuals represent:

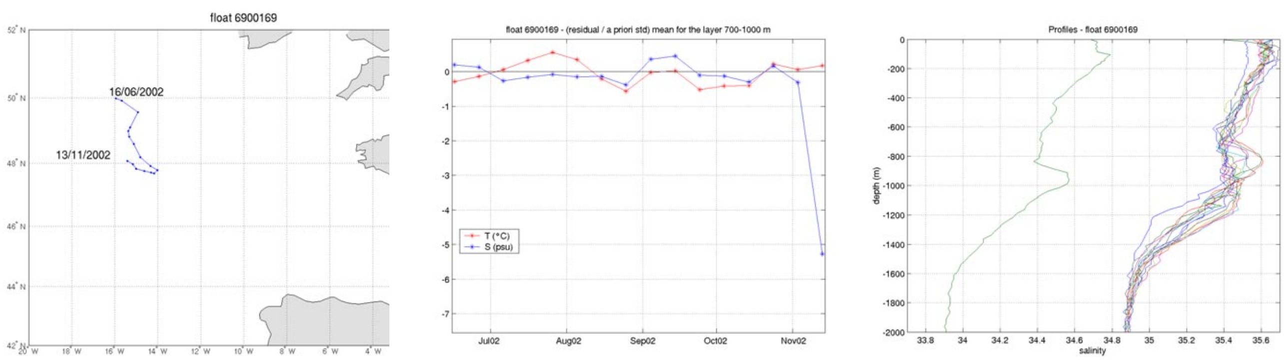
- The instrument error (nominal accuracy + drift)
- Unresolved scales
- Inconsistency between a priori statistics (climatology mean and variance)

The time and space structure of the residuals should help discriminate between the different components, this is necessary before any attempt of producing a correction.

Using the analysis residuals for detecting and correcting sensors drift is a way of combining three methods, usually applied separately:

- reference to a climatology,
- colocalisation
- history of the sensor.

A real time alert has been set up to detect gross errors, it is based on a normalized averaged residual. A threshold has been defined over which the profile is flagged as spurious. This information can be used by the operator **to flag the profile and prevent use in real time systems.**

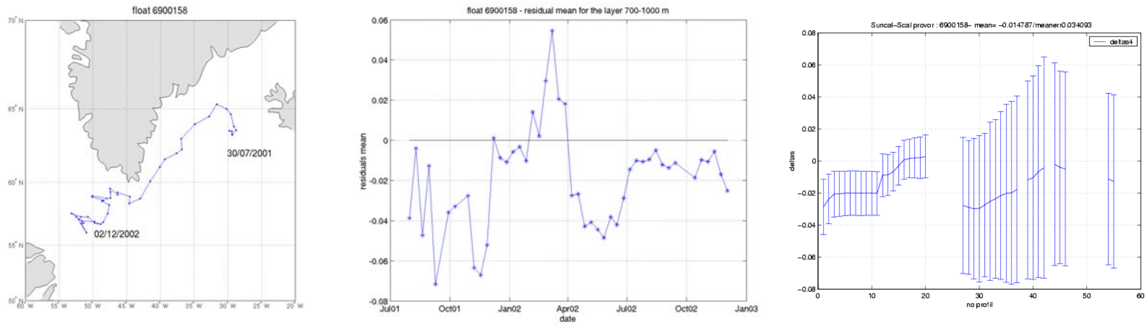


Example of profile anomaly in real time
The blue curve on the middle graph shows a gross error in salinity that is also visible on the overlayed profiles on the right graph that was not detected by the automatic QC

In delayed mode, the time series of normalized residuals are analysed. From the 10 profilers analysed, except for a few abrupt residual increase, it appears that :

- The temperature and salinity residuals are correlated
- Neighbouring profiles give similar residuals

Which leads to the conclusion that the residuals is likely to represent oceanic signal, rejected by the analysis because of climatology deficiencies. It is worth noticing that the shape of our residuals is very similar to the correction proposed by Wong's method.



In delayed mode: Wong method propose a correction (right figure) similar to the residuals (middle figure)but it is not clear if it is a sensor drift or a climatological signal.

During the next 2 months, a study of the spatial structure of the residuals will be performed in parallel with new estimates of climatology (based on three years of analysis). Then a second pass of the analysis will be done, only at that stage will the residuals be interpreted as possible sensor drifts. A linear correction over finite segments will then be proposed if necessary.

Prospects 2004

Further deployments will take place according to the decisions of the Call for proposals.

The new EU proposal, MERSEA, coordinated by Ifremer, will propose some 40 floats to be deployed in the Arctic, Southern and North Atlantic oceans, by NBIfAFG, AWI, and Ifremer.

Summary of national research and operational uses of Argo data

- Mapping of the temperature and salinity fields is done in a pre-operational mode weekly; results are displayed and details given in http://www.coriolis.eu.org . The analysis are used for QC; and validation of pre-operational assimilation models
- The French Navy Soap system assimilates the profile data in its daily bulletins
- MERCATOR, the French pre-operational ocean assimilation system, will assimilate the ARGO data during 2003
- Test of near-real time inversions of float data for the North Atlantic
- Further investigations as part of GyroScope, including water mass analysis, circulation, heat budgets, seasonal signal, etc … see the GyroScope web site (all project participants participate in those investigations, that will be reported at the end of the project (end 2003).

Issues

It has not been easy to coordinate deployments, as was seen recently for the Indian ocean. Likewise, for the Atlantic, it has been difficult to obtain information from some participants. They should be reminded of the importance to respond to the messages and to take into account the plans of their colleagues (rather than "just forge ahead"). Changes of plan are also important to know about.

The role of GDACs and GADR (Archive for Argo) have to be clearly defined by the Argo Science Team in order to avoid unnecessary overlaps.

National German ARGO Report, February 2003

1) Status of Implementation

Germany still does not have a national ARGO program but is deploying floats in a number of ocean regions via research projects or from small contributions of institutional funding. Germany also is an ongoing partner in the European efforts to contribute ARGO. Activities and plans under/for European projects are reported separately, therefore here only the national deployments are outlined.

Subpolar Atlantic/Labrador Sea: Of the 7 floats deployed by IfM Kiel near the exit of the Labrador Sea in May/June 2001, 2 failed after about 20 profiles, the others are still active. The data are processed at Coriolis and are available for ARGO.

North Atlantic: Of the floats regularly deployed by BSH Hamburg on 48N (typically 5 per year), currently 21 are active. All floats processed by Coriolis.

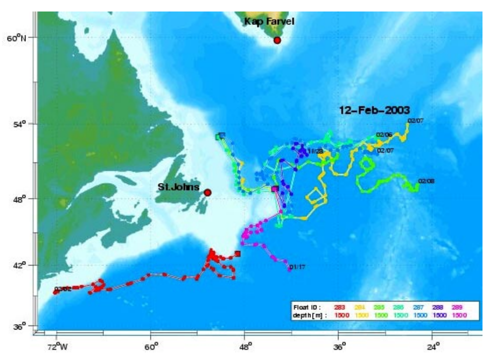


FIG. 1: Trajectories of the floats deployed in subpolar North Atlantic (IfM, SFB 460)

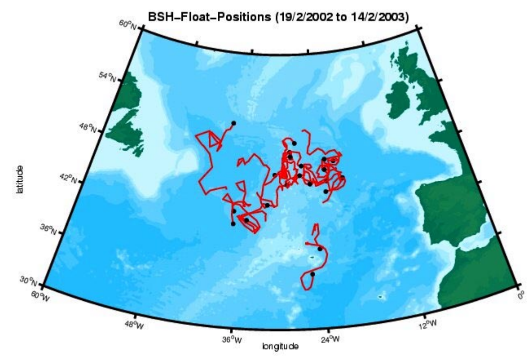


FIG. 2: Trajectories of floats alive deployed along 48N (BSH)

Tropical west Atlantic: 10 floats had been deployed in March/April 2000, 5 in Nov/Dec 2000, by IfM Kiel, all at shallow levels (200/400m). Several of these beached on the South American coast, 10 are still active. The data are processed at IfM Kiel and currently not public, but they can be made available to Coriolis.

Weddell Sea: Since 1999 a total of 49 floats has been deployed by AWI Bremerhaven, of these 25 are active at the time of writing. All floats performed well. In the last austral winter (mid 2002), 4 floats had been covered by ice, of which 3 are equipped with a new ice-recognition algorithm (if median 50m-20m temperature is below –1.79 degC, the ascent is abandoned). These 3 floats survived the ice-cover (one for 25 weeks, i.e. 25 attempts to surface), while the other one did not re-appear.
The data are available through Coriolis but processed and QC´d separately at AWI.

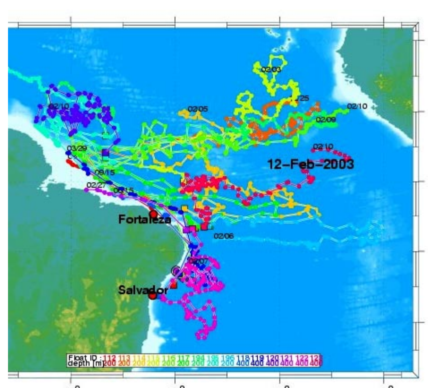


FIG. 3: Trajectories of the floats deployed in the tropical Atlantic (IfM, CLIVAR)

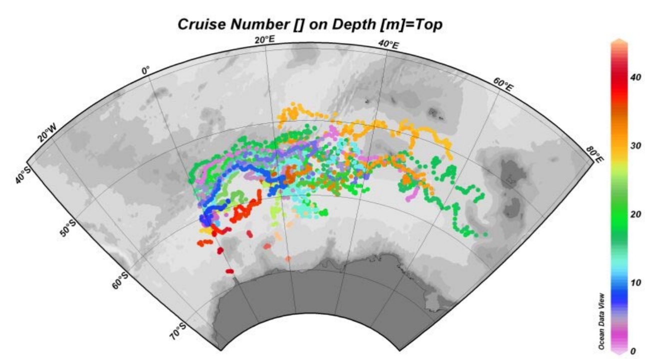


FIG. 4: Trajectories of floats deployed in western Weddell Sea (AWI)

2) Level of funding and deployment plans

2003:
For 2003, funded or already deployed are the following float equivalents.
10 floats in the subpolar N.Atlantic (Labrador Sea vicinity, IfM Kiel), 5 floats along 48N in the N.Atlantic (BSH), 10 floats in the Weddell Sea (AWI), and 15 for the Indian Ocean (IfM Kiel).

Next 3 years:
A joint proposal of three research groups at the AWI, BSH and IFM Kiel for a German ARGO component was sent to the funding agencies in 2002, for a 3-year program.
This proposal has three components, each with a requested number of 35 floats each in the Southern Ocean Atlantic Sector (AWI), in the western tropical Atlantic (IFM-Kiel) and in the subpolar North Atlantic (BSH). The funding prospects are uncertain.
In addition, BSH has proposed to continue deploying 5 floats per year a 48N in the Atlantic, and IfM Kiel has proposed 5 additional floats in the tropical W.Atlantic.
The German share of possible EU funded float projects are explained in the European report.

Human resources:
BSH has no human resources for ARGO, IfM Kiel currently covers most of the ARGO-equivalent work with students. AWI has devoted 50% of a scientist to ARGO, and is funding a half-time position at a company for float data processing.

3) Research and operational uses of ARGO

There no operational uses of ARGO data, but they are used and important in various research projects, like German CLIVAR, the special research initiative SFB460 in Kiel, and smaller individual projects. An important aspect to emphasize is that the intention stated in research proposals to make maximum use of existing ARGO data seems to have helped review success and leveraged better funding prospects.

4) Issues for AST-5

Most of the issues already are on the table.

One item that we will raise at AST-5 is an apparent unreliability of also the temperature calibrations. The basic assumption until now had been that the temperatures are ok.

Another issue (which is not new) is the capability/option/choice for ARGO to collec some sensor data during the deep drift phase, e.g. daily values of T. This could be valuable for
<v’T’> estimates and other applications.

Indian report to AST-5 Submitted by K Radakrisnan

Indian Argo Project

Financial sanction from the Government of India was accorded for participation in the International Argo programme, with necessary institutional mechanism. The Scope of the Indian Argo Project covers
(i) deployment of 150 Argo profiling floats in the northern Indian Ocean,
(ii) Argo Data Management and (iii) Data Analysis and Assimilation.

Deployment of floats

India deployed 10 Argo floats (5 Apex +5 Provor) in the Indian Ocean (Southern Bay of Bengal and Equatorial Indian Ocean) during the IOGOOS Cruise (October-November, 2002) onboard ORV Sagar Kanya.

a) Six floats (3 Apex +3 Provor) were deployed with 10-days cycle and parking depth of 2000 metres
b) 2 Apex floats were deployed with 5-days cycle and parking depth of 500 metres for four cycles and 1000 meter for the fifth cycle.
c) 2 Provor floats were deployed with
    (a) 5-days cycle and parking depth of 500 metres for four cycles and
    (b) 10 day cycle and parking depth of 2000 meter for fifth cycle

One of the Provor float that was deployed at Equatorial Indian Ocean [with mission profile (a) above] stopped transmitting data after two months. However, the health of the float was normal up to last reported profile.

Orders have been placed for another 21 floats to be deployed in April-May 2003 in the Bay of Bengal and Arabian Sea.

Argo data Management

Actions are underway to set up ARGOS HRPT Regional Center at INCOIS, Hyderabad (new campus) by end of 2003 to downlink data from ARGOS .Also, INCIOS plan to establish GTS link from India Meteorological Department.

Currently, data pertaining to the floats deployed by India are acquired by CLS- ARGOS. The data from Apex floats are sent by CLS ARGOS to GTS. Data from Provor floats are sent to GTS, after real-time QC by Coriolis Data Centre. Also, INCOIS receives raw data from CLS-ARGOS daily through e-mail and this data is processed by INCOIS for real-time QC and published in the INCOIS Web Site (www.incois.gov.in/argo.html). Waterfall plot of temperature, salinity and density are made available from INCOIS website. Time series plots, T/S profiles, MLD and other products are planned to be made it available from INCOIS Web site by end of April 2003.
2
Data from all floats deployed in Indian Ocean are downloaded by INCOIS from Coriolis Data Center via FTP once in a week and convert it from netcdf format to ASCII (thanks to Dr. Howard Freeland for the advice). This data is again passed through the real time QC and made available in the INCOIS Web Site. Regional Data Center.

The Regional Data Centre is functional at INCOIS. INCOIS has received PMEL software for delayed mode QC. Data from all floats deployed in the Arabian Sea floats were tested with this software and the available historical data. We could not notice any sensor drift; may be because:

a) The time of one year is too short to check / validate the sensor drifts in the Indian Ocean.
b) Not enough historical data set is available to correct the sensor drift.

INCOIS is now developing North Indian Ocean Hydrology using the data sets available from the Indian Research Cruises conducted from 1965 to present. This will enhance our capability for delayed mode quality control.

Regional Co-ordination (Indian Ocean)

INCOIS/India has been identified as the Regional Coordinator for the Indian Ocean deployment. INCOIS set up a Website for this purpose with WEB GIS facility with Java Viewer. Since most of the Users did not prefer to access this Site because of Java Viewer, INCOIS modified the design of the We site with facility for HTML Viewer also. All Countries deploying floats in the Indian Ocean are requested to register at the INCOIS Site from April 1, 2003.

In the interim period, CSIRO, Australia facilitated regional co-ordination page from the site http://www.marine.csiro.au/~phi147/Indian_ARGO.htm.

During the Indian Ocean Conference held at Mauritius during November 4-9, 2002, detailed discussions took place on the observation network for the Indian Ocean by a Working Group.

Data Analysis and Data Assimilation

The Canadian float deployed by India has provided one year good data except during March and April (summer vacation). This float has provided useful information to select the future float type, design and operation cycle.

Study Projects have been taken up in India at Institutions such as Centre for Atmospheric and Oceanic Sciences, Centre for Mathematical Modelling and Simulation, Space Applications Centre, National Institute of Oceanography, Indian Institute of Tropical Meteorology and National Centre for Medium Range Weather Forecasting already.

Capacity building on Data Assimilation and Modelling is imperative for effective utilization of Argo data in this region.

Japanese report to AST-5

1) **Status of implementation**

Floats deployed and their performance

JAMSTEC deployed 17floas (APEX 17) in FY 2000, 44 floats (APEX 5, PROVOR 39) in FY 2001 and 103 floats (APEX 66, PROVOR 31, NINJA 6) in FY 2002. Among them 118 floats are operating at the end of February 2003. Most of the floats are deployed in the North Western Pacific Ocean, but also 5 and 4 floats are deployed in Indian Ocean in FY 2001 and 2002, respectively, and 5 floats are deployed in the Southern Ocean. For these deployments, not only the research vessel of JAMSTEC, but also the ships of many agencies and universities are used. JMA deployed 6 floats in total in the last 3 years. National Polar Research Institute deployed 3 Argo Equivalent floats in the Southern Ocean in FY 2002.

Technical problems encountered and solved

Some of the PROVOR floats with SBE sensors deployed in FY 2001 showed salinity offset up to 0.05. With cooperation of the manufactures of the floats and the sensors, it is found that the pump operation at the sea surface and inferior TBTO are responsible for the salinity offset. By improvement of the float operation software and TBTO, the problem was solved, and the same type of float deployed in FY 2002 has not shown this kind of offset.

Among the 70 PROVOR floats deployed so far, 28 floats have experienced emergency pop-up. Once a floats experience the emergency pop-up, it tend to repeat the emergency pop-up, and many of them dies earlier than their expected life time. JAMSTEC are testing the new software for the floats deployed in February 2003.

Among 20 APEX floats deployed in FY 2000 and 2001, 6 floats stopped operation due to drop of battery voltage after 40 to 50 profiles. These floats use APF6 or 7 boards, known to cause so-called energy flu. The other floats with the specific board also show same kind of drop of battery voltage. The manufacture changed the design of the floats, and the new type of floats were used for the deployment in FY 2003. So far, none of them reach the profile number 40 yet.

Contributions to Argo data management

Japan Meteorological Agency established NDAC for Japan Argo. The Japan NDAC started its operation at the beginning of Argo so that all Argo data are distributed through the GTS. It started providing netCDF profile and trajectory files to GDACs in September 2002 and February 2003 respectively. The Japan Argo asked other Japanese institutes to share profiling float data so that their data are assembled into the Argo data management. Three institutes agreed and the NDAC started processing data from 23 floats of those institutes. Total number of the floats of which the data have been processed into netCDF files is 133.

JAMSTEC is preparing for the operation as the National delayed mode QC center and the Pacific Regional Center. It is now updating the data management system to implement the automatic QC procedure proposed by PMEL. It is planning to start providing quality-controlled data in net CDF in early FY 2003. Also, it is constructing a high quality climatologic data of the Pacific Ocean to be used in the QC process. It is planning to expand the area of the climatologic database to adjacent seas like Japan Sea and Bering Sea. It is also collecting CTD data for direct comparison with float data. As a product, grid data with 1-degree resolution for 22 levels are now constructed and will be provided in WWW.

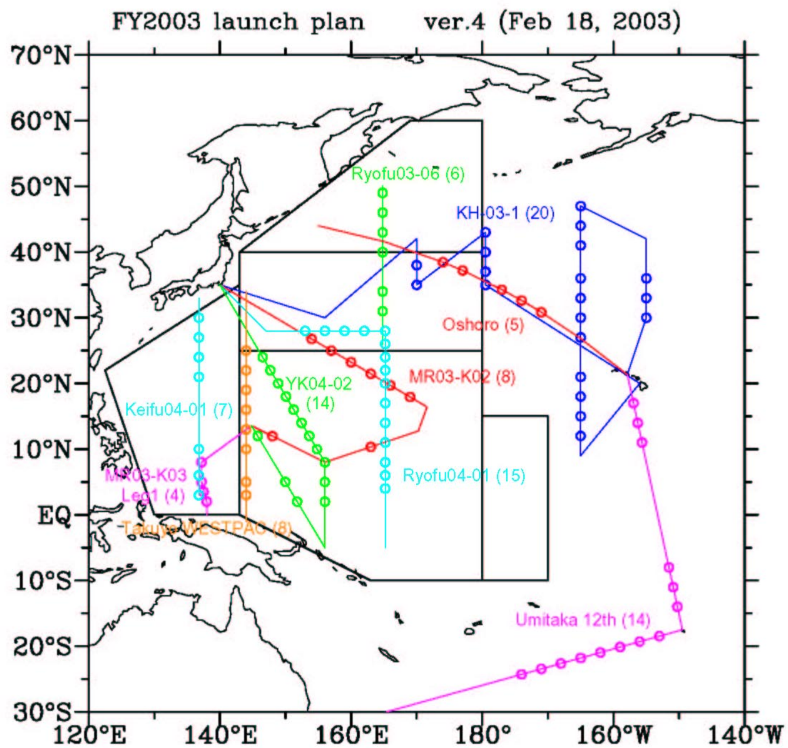
2) Level of National funding for Argo

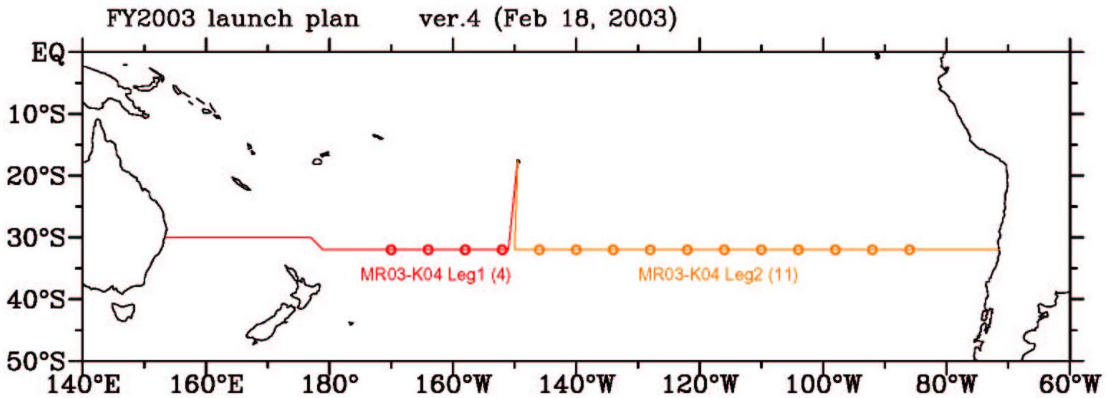
Japan Argo is a 5-year program from FY1999 to FY2004. After the program, i.e. from FY2005, no funding is guaranteed yet at the present time. The funding for FY 2002 was about 400 million Japanese Yen, which is about 3.4 million US dollar at the rate at Feb. 2003. The Ministry of Land, Infrastructure and Transport and Ministry of Education, Culture, Sports, Science and Technology are the funding agencies for the project. Three agency, Japan Marine Science and Technology Agency(JAMSTEC), Japan Metrological

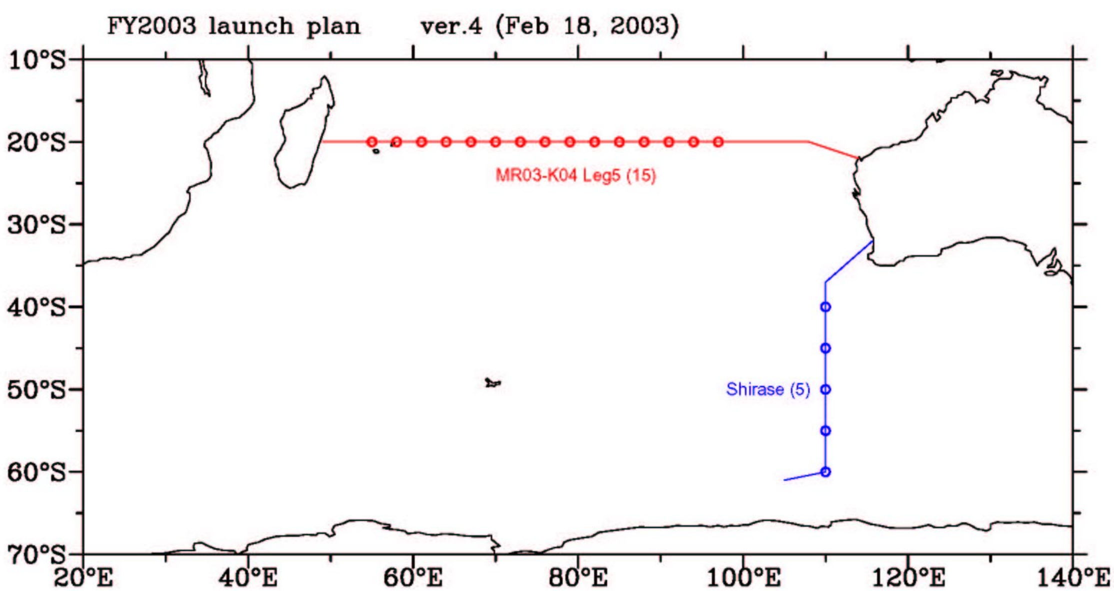
Agency (JMA) and Japan Coast Guard (JCG) are involved in the operation of the project. JAMSTEC is responsible for the float operation and delayed mode data management, while JMA is mainly responsible for the real time data management and JCG is responsible for complementally observation to Argo. In total more than 20 people are involved in the Argo project. More than 10 people of them are working full timers.

3) Deployment plans and other commitments for the coming year.

In total 100 floats are planned to be deployed in FY 2003. Main portion of the floats will be deployed in the Western North Pacific Ocean, but also 5 floats in the Southern Ocean by Shirase (NPRI), 11 floats in the Southern Pacific by Umitaka-maru (Tokyo Fisheries University) and 20-30 floats in the Indian Ocean and the Southern Pacific in the Mirai around the world cruise. The Mirai around the world cruise will also be used for deploying American floats in the Southern Pacific and the Atlantic.







4) Research and operational uses of Argo data

Global TESAC messages from Argo are used for operational ocean analyses conducted by Japan Meteorological Agency. The monthly mean sub-surface temperature charts on the Japan ARGO real time data base web site are the products based on one of the analyses. The global TESAC messages have been distributed through the NEAR-GOOS Regional Real Time Data Base operated by JMA since the beginning of JAPAN Argo. The number of FTP connection to get the TESAC messages is an average of 450 per month in the recent seven months. It implies there are users who use Argo data operationally.

In JAMSTEC, research on 4-dimensional assimilation of Argo data into an ocean global circulation model is on the way. JAMSTEC and JMA are working together to construct drift map at the parking depth. JAMSTEC is also cooperating with university researchers. These research includes analysis of structures of mesoscale eddies, analysis of distribution of mixed layer depth and its variation in the Western North Pacific Ocean, formation, spreading and modification of North Pacific Subtropical Mode Water and formation, spreading and modification of North Pacific Central Mode Water.

5) Issues to be considered by AST

Formal international agreement on the EEZ clearance of Argo observation is desirable. Without such agreement, Japanese Ministry of Foreign Affair requires Japanese researchers to get EEZ clearance from every country whose EEZ Japanese floats have possibility to drift in. In FY 2002, JAMSTEC applied for EEZ clearance to 18 countries and none of them are rejected. However, it takes long time, and tend to spoil flexibility of deployment plan.

Korean Report to AST-5 (Submitted bu Kuh Kim)

Korea deployed 25 floats in 2002 and 18 are active as of Febraury 19, 2003. Four floats deployed south of Australia stopped transmitting after a couple of cycles.

In 2003 Korea plans to purchase 30 floats; 15 funded by the Ministry of Marine Affairs and Fisheries and another 15 as a program of Korea Meteorological Administration/Meteorological Research Institute. Planned areas of deployment are the western North Pacific, Antarctic Ocean and the East/Japan Sea.

Funding Agency in Korea wants to see usefulness of the International Argo Program and further funding in future may require some results to justify the continuation of the current program.

PALACE data taken in the East/Japan Sea have been useful to understand the circulation pattern and variability of currents. Profile data are also used to detect water formation in winter. Research groups at universities and research institutes are working to develop data assimilation using Argo data.

Russian Report to AST-5 (Submitted by Mikhail Danchenkov)

Russia does not have a funded national ARGO program still now. Activity on ARGO project is carried out at the support of the Russian Hydrometeorological Agency only. Full-scale funding of Russian ARGO project will begin in 2004 only.

Status of implementation

In November of 2002 one of our floats died after 2.5- year work. Two APEX floats were bought with the support of School of Oceanography, University of Washington (SOUW). Both were deployed in October of 2002 in area close to Kamchatka peninsula (off of the Russian EEZ)- Figure 1. Their drift passes on the depth of 1000 m (2 cycles) and 2000 m (every third cycle).

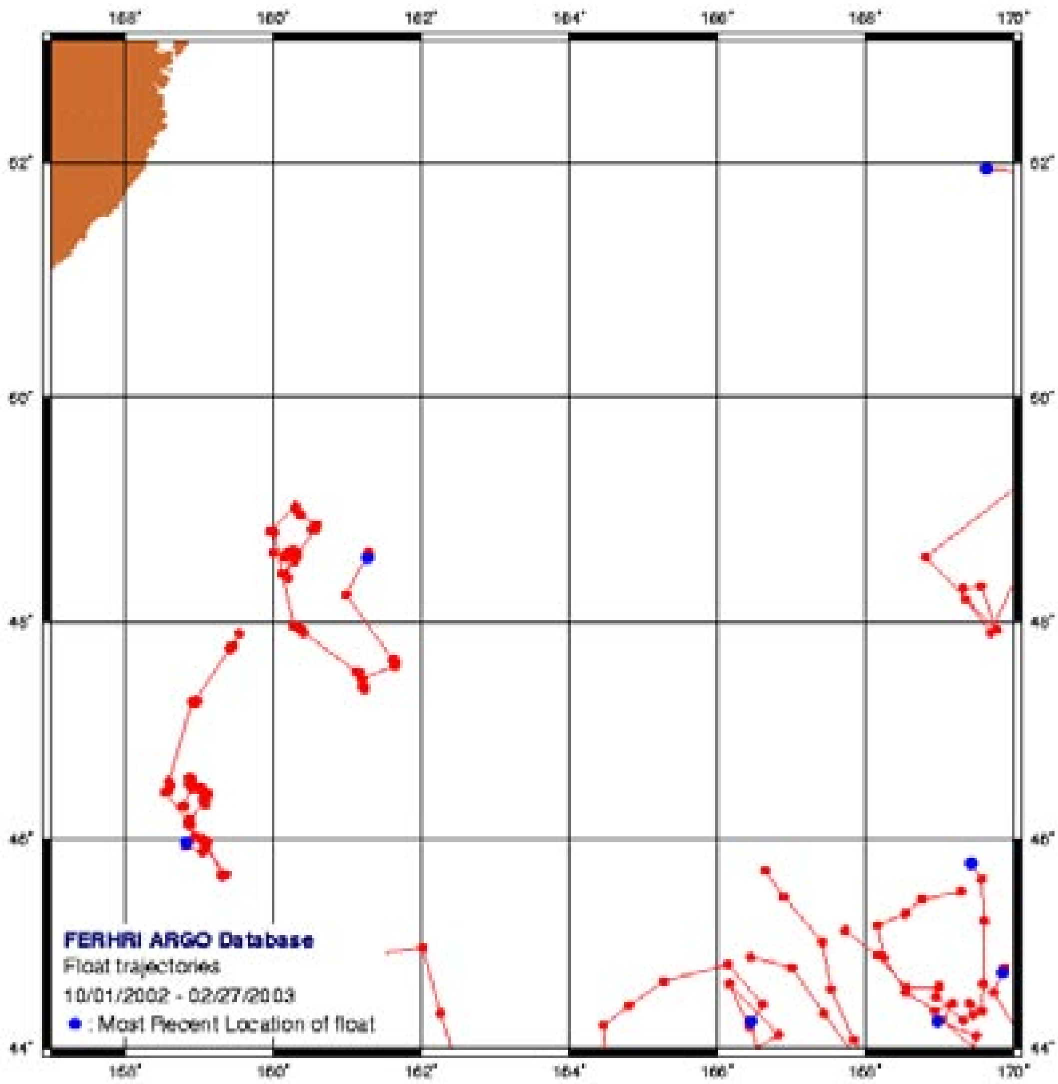


Figure 1. Drift of 2 Russian ARGO floats in 2002-2003.

Russian ARGO Data Center

The data are processed (the decoding and 10-steps primary control) at Russian ARGO Data Center (FERHRI, Vladivostok) and separately at SOUW. Delayed-mode QC is conducting with the use of all available data of our Regional Data Center. An example of temporal temperature section is presented at figure 2.

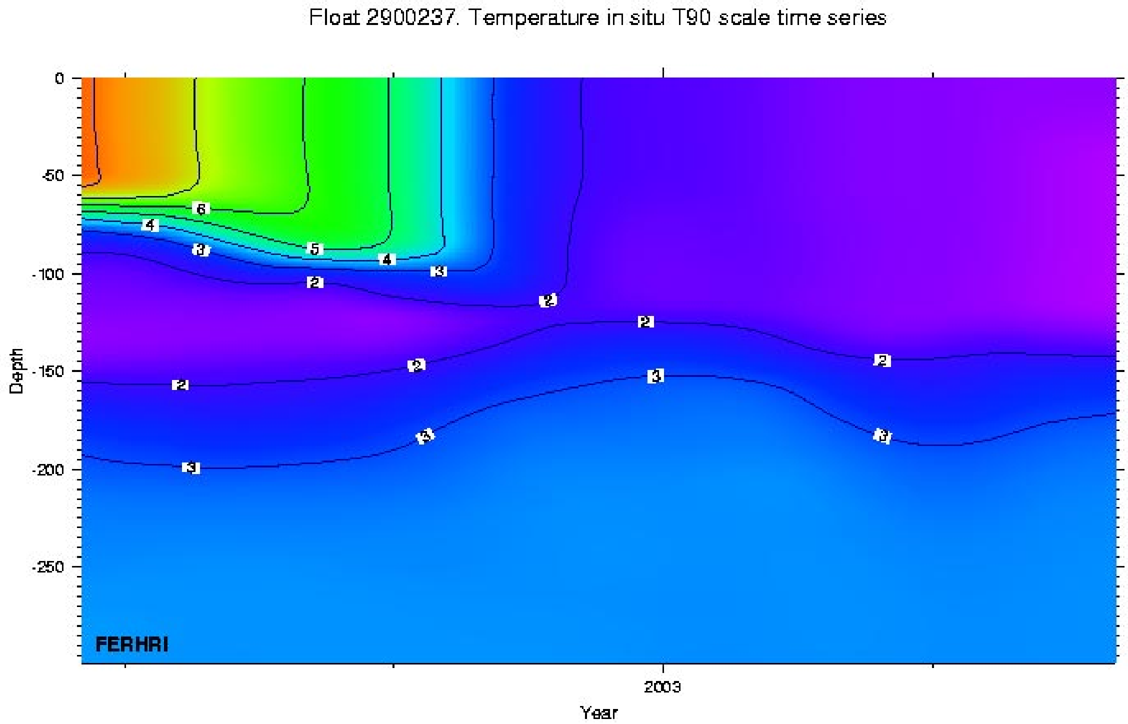


Fig.2. Temperature /time section of one float from October of 2002 till February of 2003.

On site profiles and their overlays, maps of float trajectories with zoom feature are presented.

Logistic Issue for 2002
Our R/V was used for SOUW floats deployment in the Indian ocean southern part as well.

This year deployment
This year Russia plans to deploy two floats in the same area (close to Kamchatka peninsula).

Logistic issue in 2003
Russia gives the opportunity to deploy the floats during the cruises of 4 research vessels on cross-ocean section (in the northern and south Atlantic ocean) and in circumantarctic cruises too. We are looking for collaborators in those areas.

Data
There no operational uses of ARGO data now. All Russian data are accessible to the users as from a site ***http: // rus.hydromet.com / ~ argo/*** on request. Next site version (both in English and in Russian) will be presented to May 1, 2003.

Proposal
It is obviously necessary to carry out the training of our expert in one of Global Data Center for the mastering of the delayed data QC methods.

Spanish report for AST-5 (Prepared by Gregorion Parrilla)

Floats deployed and their performance.
Until now Spanish floats have deployed within Gyroscope with no major problems. (See EU report Doc 5.5/6)

Technical problems encountered and solved
The problems of sensor drift in the delayed mode have not been solved. This has already been mentioned and discussed in the Ottawa meeting and by e- mails in recent months.

Present level of national funding for Argo.
10 floats funded by Spanish agency for this year.

Deployment plans
Areas of floats: Atlantic Ocean, (under discussion) distributed among the area between Cape Vert and Canary I. and SW Cape S. Vincent.
Deployment date: around September 2003.

Future funding
We are thinking about submitting another funding proposal this year for 10 more floats.

Research and operational uses of Argo data
1) To study the time evolution of temperature salinity and geostrophic transport through the 24.5°N section where there are 9 profilers. This study will focus on the different time scales that the project period can resolve, that is short time scale (several days-weeks), associated to mesoscale variability, and seasonal cycles at those depths where they do exist.

2) Tracing the Mediterranean Water Mass

Issues to be considered by AST-5
We have been offered before to become a member of the AST. We declined until we received the funding. We will gladly accept now the offer.

UK Report to AST-5 Submitted by Jon Turton.

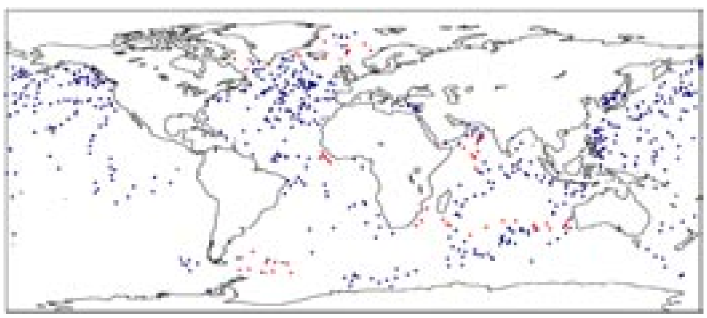
The UK's contribution to Argo is being funded by the Department of the Environment, Food and Rural Affairs (DEFRA), the Ministry of Defence (MoD) and the Natural Environment Research Council (NERC), and is co-ordinated by the Met Office with support from Southampton Oceanography Centre (SOC), the British Oceanographic Data Centre (BODC) and the UK Hydrographic Office (UKHO).

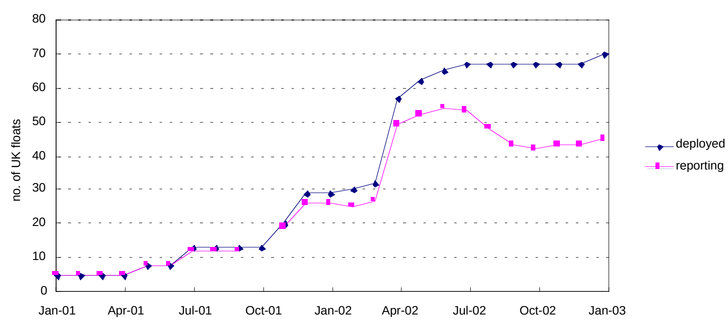
UK Argo Project

The UK Argo Project was initiated in 2000 with the aim of establishing the capacity to procure and deploy about 50 floats each year, to apply all real-time float data in operational ocean forecasting, and to process UK float data in delayed mode for climatological and hydrographic purposes. These aims have largely been met. Funding for the Argo Project was originally agreed to end March 2003. A phase 2 project, through to 2006, will sustain the UK contribution towards establishing the global Argo array and have an increased emphasis on demonstration of benefits. This is essential in order to justify continued UK funding for Argo as it transitions to "operational" status (i.e. undertaken to agreed standards on a routine and on-going basis with plans in place for continuity and homogeneity). Further information on UK Argo is at http://www.metoffice.com/research/ocean/argo and http://www.soc.soton.ac.uk/JRD/HYDRO/argo.

Float deployments during the last year

Over the last 2 years UK has deployed 67 floats (29 in 2001, 38 in 2002), including 6 Argoequivalent floats (one of which was provided and deployed by the Scott Polar Research Institute). A further 12 floats have been deployed in January and early February 2003. The floats have been deployed in a range of ocean areas as shown below.





Top: *showing the locations of UK floats (in red) contributing to Argo in mid February, 2003.* ***Bottom****: showing the numbers of UK floats deployed and those reporting to end January 2003.*

Of these floats we have experienced: 2 failed (air) deployments, 5 floats which failed to report a single profile, 11 early failures (between 8 and 16 cycles), 5 other failures (between 28 and 39 cycles) with 2 floats currently overdue. The number of early failures was particularly marked during summer 2002.

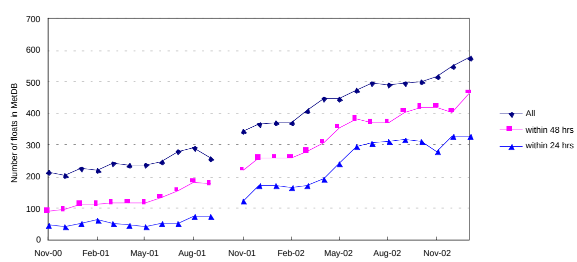
The major deployment in 2002 was of 25 floats along the 30°S section across the South Indian Ocean. It was particularly disappointing that, of the 25 floats, 10 have failed, especially as this is an area not frequently revisited by deployment opportunities. The experience has highlighted a shortcoming in the exchange of technical information within the Argo community. *Issue to be raised at AST#5.*

In spring 2003, we will have in our inventory 54 floats for deployment in a number of regions as detailed below. This figure includes a number of replacement floats provided by WRC for those that failed early.

North Atlantic	*2 Apex floats for the North-east (Rockall Trough) region.*
South Atlantic	*5 Apex floats around 30 °S, 27 °W, deployment planned during May/June on Atlantic Meridional Transect (AMT) cruise.* *16 (10 Apex, 6 PROVOR) to be deployed along eastern part of 30 °S section, tba.*
Southern Ocean	*4 Apex floats in Indian sector, deployment planned from SA Agulhas in March.* *3 Apex floats in Atlantic sector, deployment planned in May on AMT cruise.* *6 PROVOR floats deployment tba.*
Indian Ocean	*9 Apex floats for Somali Basin, deployment (tba).* *2 Apex floats for Mozambique Channel, to be deployed by INAHINA, Mozambique.* *1 Apex float for western Indian Ocean (near Mauritius) to be deployed by Mauritius Met Service.*
Others	*6 PROVOR floats, region(s) to be decided.*

In 2003 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 processing
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 have monitored real-time float data received over GTS. The number of floats received has increased from 214 (52 with salinity) in November 2000 to 575 (523 with salinity) by January 2003, with over 460 floats returning data within 2 days. This demonstrates that the Argo real-time GTS system is working well - this is essential for application of the data in operational ocean prediction as discussed later.



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

UK Argo Data Centre. The UK Argo Data Centre (see http://www.bodc.ac.uk/projects/argo/argo.html), established at BODC, processes all our fullresolution float data. A new automatic processing system (decoding the Argos data stream and putting the profile data on the web-site) has been set up. One problem is, for our Apex floats, the Argos data formats are frequently changed (e.g. to provide more engineering data) and the software to read the data has to be updated on a regular basis. It would be more efficient if WRC provided appropriate software with each batch of floats. *Issue to be raised at AST#5.*

At present the UK Argo Data Centre has not contributed any full-resolution data in real-time to the GDACs as this is not seen as a highest priority. Our position is, it would be much more efficient if our float data could be placed on GTS in BUFR instead of TESAC, this would allow the full-resolution data to be picked up by the GDACs. We consider BUFR distribution of GTS data should be encouraged by Argo as it would provide a substantially more complete real-time dataset to the GDACs and to operational forecasting centres, it would also free-up resources at individual Data Centres or PIs for delayed-mode QC. *Issue to be raised at AST#5.*

The ongoing effort required to process the data in real-time has meant there has been little time for (manual) data screening and delayed-mode QC, although some has been carried out. We have identified the need for additional resources to run the UK Argo Data Centre (and Southern Ocean Regional Argo Data Centre), without these it is likely to be a year before any QC'd data will be ready to be passed to the GDACs. As a consequence little progress has been made towards establishing the Southern Ocean Regional Argo Data Centre at BODC, although some preliminary web pages have been established.

Quality of salinity data
Of the floats deployed to end 2002, all but 3 have been Apex floats fitted with SeaBird salinity sensors. In a careful study of data from Apex/SeaBird floats deployed in the southern Indian Ocean in mid 2001 and early 2002, 21 out of 23 floats were accurate to better than 0.01 over their first 10 profiles using only the factory calibration. These floats were selected for evaluation as they were deployed from a research vessel. High quality CTD profiles were collected at each deployment location and showed that the upper thermocline water has uniform properties over large spatial scales (many 100s of kilometres). Any sensor drifts were of the same magnitude as the ocean variability – and could not be distinguished from ocean variability.

The 3 MARTEC PROVOR floats deployed in the North Atlantic have all shown large offsets towards fresher values. MARTEC/FSI have concluded that the most likely cause of the salinity shifts was a proximity error associated with the dampening collar attached to the base of the CTD head. With the design of the collar it would be relatively easy for material to become trapped on the outer edge of the collar cut-out, or for the collar to rotate if not properly tightened (where the cut-out is replaced with the solid portion of the collar). A design modification has been implemented.

Scientific exploitation
Operational Ocean Prediction. All float data that are available on the GTS are routinely assimilated into the FOAM (Forecasting Ocean Assimilation Model) run at the Met Office, (see http://www.metoffice.com/research/ocean/operational/foam). FOAM produces global and regional analyses and forecasts of the temperature, salinity and currents of the deep ocean to 5 days ahead. FOAM is run operationally in a variety of configurations: 1° global, 1/3° Atlantic/Arctic Ocean, 1/3° Indian Ocean and 1/9° Arabian Sea. A 1/9° North Atlantic FOAM is also being run daily as part of GODAE and a 1/9° Mediterranean/Black Sea FOAM is also run daily. A 6 km Intra Americas (Gulf of Mexico and Caribbean) Seas FOAM is currently being spun-up to evaluate the potential application of current profile forecasts for the offshore industry.

Improved QC procedures have been developed for accepting/rejecting data float prior to assimilation into FOAM. As part of the Gyroscope (http://www.ifremer.fr/lpo/gyroscope/) project work has been done on determining the optimum covariances, at synoptic and mesoscales, for assimilation of Argo and satellite altimeter data. Routine assimilation of salinity data has been in place since autumn 2002. There are early indications that Argo data gives a significant improvement in the accuracy of the deep (1,000 m) ocean temperature predicted by FOAM.

In conjunction with work on FOAM assessment through participation in GODAE (http://www.bom.gov.au/bmrc/ocean/GODAE/), studies will be made to quantify the impact that Argo data have on the accuracy of ocean forecasts, with particular emphasis on
(i) mixed layer predictions and (ii) predictions from relocatable regional high resolution FOAM configurations.

Seasonal prediction and climate studies. Building on from work carried out under the EC funded ENACT (Enhanced Ocean Data Assimilation and Climate Prediction) project (see http://www.lodyc.jussieu.fr/equipes_lodyc/ecume/CONTRIBUTION/ENACT) to produce a 40-year QC'd global ocean dataset and development of improved QC and assimilation of float data, an assessment will be made to quantify the impact that Argo data have on seasonal climate predictions.

Scientific work to exploit float data in the North Atlantic and Southern Indian Ocean for ocean climate studies (e.g. ocean heat content) will be carried out by SOC and the Hadley Centre. Float profiles from the Southern Indian Ocean have been compared with historical data, and show that a trend towards a fresher T-S relation in the upper thermocline up to 1987 has been reversed over large spatial scales. Investigation of this result continues.

From February to July of 2003 a PhD student from Prof. Kuh Kim's group at Seoul will visit SOC and continue his work on estimating subsurface displacement from surface positions.

Resources and future commitments

At present funding levels for UK Argo Phase 2 have not been confirmed and plans for the next 3 years are based on continuation at the current funding level. The planned figures are summarised below.

	To end 02/03	*2003/04*	*2004/05*	*2005/06*
Met Office *Staff* *Floats funded*	*4.02 m-y* *95*	*1.7 m-y* *38*	*2.05 m-y* *33*	*2.05 m-y* *31*
NERC *Staff* *Floats funded*	*5.52 m-y* *8 + 15eq.*	*2.5 m-y* *0 + 5eq.*	*2.5 m-y* *0 + 7eq.*	*1.75 m-y* *0 + 7eq.*
UKHO *Staff*	*0.9*	*0.3*	*0.3*	*0.3*

During the last 2 years UK Argo has managed to procure around the planned number (~50 per year) of UK Argo floats, plus additional Argo-equivalent floats funded through bids by SOC to various NERC thematic programmes, e.g. Marine Productivity (http://www.nerc.ac.uk/funding/thematics/marprod/) and COAPEC (Coupled Ocean Atmosphere Processes on European Climate, http://www.soc.soton.ac.uk/coapec/coapec.php).

Over the coming years we are looking at, at best, level funding; but with a strong possibility of gradual reductions. This, taken with the gradually increasing price of floats, will make it difficult to sustain the UK contribution at ~50 floats per year as shown by the declining numbers in the table above. If the cost of floats continues to rise, this may make maintaining a long-term global 3,000 float array unaffordable. *Issue to be raised at AST#5.*

UK funding for Argo beyond 2005/06 will be contingent on demonstrable progress being made towards a mechanism for operational funding (i.e. providing sustained funding for long-term ocean monitoring). Establishing the Argo array is only a start, the real challenge will be to sustain the Argo array as a long term global ocean monitoring system. This is an issue not just for the UK, but for the international Argo community. In the longer term research funding may supplement Argo but cannot be relied upon to sustain Argo. The Argo Science Team, and WMO/IOC (through JCOMM), must strongly encourage nations to prepare for a transition to sustained operational funding. *Issue to be raised at AST#5.*

USA Report to AST-5 (Presented by Dean Roemmich)

Organization:

The U.S. Argo Project is supported through the multi-agency National Ocean Partnership Program (NOPP). The project is carried out by a U.S. Float Consortium that includes principal investigators from six institutions (SIO, WHOI, UW, NOAA/AOML, NOAA/PMEL, LDEO). Float production, deployment, and data system functions are distributed among these institutions on a collaborative basis. Following 2 years of pilot activity supported by ONR and NOAA (FY99, FY00), U.S. Argo is now in the second year of a 5-year full implementation phase funded by NOAA.

In addition to U.S. Argo floats, Argo-equivalent floats are provided by a number of U.S. organizations, including PMEL, AOML, NAVOCEANO, and NDBC. Status and plans of those programs is not included in this report. The U.S. also sponsors the Argo Global Data Assembly Center (GDAC) located at FNMOC, whose activities are reported separately.

Support level:

The present level of funding is sufficient for U.S. Argo to build and maintain 1/3 of the global Argo array (1000 active floats, based on a deployment rate of 275 floats per year). At present, due to relatively low communications costs in early years, a somewhat higher deployment rate is supported - 315 floats in FY02, an increase from 174 floats in FY01.

It is proposed that the level of U.S. Argo be further increased to provide up to half of the global array.

The U.S. Argo effort includes float production and deployment, technology improvement, communications, and data system development and implementation for real-time and delayed-mode data streams.

Status:

There are presently (20 Feb 2003) 238 active U.S. Argo floats. Following an interrupted deployment schedule in 2002, U.S. Argo is now deploying floats at an accelerated pace, as described below. As noted in the U.S. report at AST-4, the failure rate of early U.S. Argo floats was unacceptably high. Float production was suspended from early 2002 until late in the year.

Diagnosis of problems was especially difficult because systematic failures occurred after many cycles. Failure modes were identified in pumping and control systems in both APEX and SOLO floats. In the former case, S. Riser worked with the manufacturer, Webb Research, to successfully identify and correct problems, and the corrections were subsequently applied to APEX instruments provided to all APEX users.

Large-scale float deployments by UW resumed in the fourth quarter of 2002. In the case of SOLO, floats were failing after about 1 year of operation. A new instrument controller was introduced and design changes were made in the pumping system. The principal failure mode was confirmed through diagnosis of 2 failed instruments that were grounded and recovered. Deployment of SOLO floats was resumed late in 2002.

Due to the suspension of float deployment in 2002, a large number of U.S. Argo floats is scheduled for deployment in 2003 - more than 400. A continuing focus of U.S. Argo is technology improvement: for increased ruggedness, reliability, and improved performance.

The U.S. Argo Data Center is based at NOAA/AOML. Real-time data from all U.S. Argo floats are presently being transmitted via the GTS. GTS transmission uses computers housed at Service ARGOS (U.S.) and operating round-the-clock, running software developed at AOML to implement internationally-agreed quality control tests. The AOML data center serves as the national focus for data management by passing data to PIs and to the delayed-mode QC center at NOAA/PMEL. PMEL has developed a statistical system for salinity recalibration, which has been shared with the international community, and has been implemented on a trial basis with respect to U.S. floats.

Further work on improving the system, including the underlying salinity database, is ongoing. The U.S.

Data Center has adopted the standard NetCDF Argo formats, and is exchanging NetCDF data with the GDACs.

Deployment Priorities:

Regional priorities for deployment of floats are set by the U.S. Argo Advisory Panel (C. Koblinsky and B. Owens, co-chairs). The panel is composed of float providers and representatives of the Argo user community, and its criteria are to:

- Build a global Argo array with international partners.
- Rapidly implement regional arrays that are high priority to users (e.g. the tropics and western subtropics)
- Build on existing (early Argo) float arrays.

Priorities established for the 489 total Argo floats funded in FY01 and FY02 are as follows. Approximately 100 of these have already been deployed.

Atlantic Ocean (tropics and subtropics)	- 142
Pacific Ocean (tropics, southern subtropics, northeast)	- 215
Indian Ocean (tropics)	- 54
Southern Ocean	- 80

Research Applications of Argo Data:

The Argo dataset is still very sparse, and not yet of sufficiently high or uniform quality in general for scientific research. A number of regional scientific investigations using subsets of Argo data have begun, including the Wong and Johnson (2003) work on southeast Pacific Subtropical Mode Water, the Schmid *et al.* (2003) study of the intermediate depth flow in the tropical South Atlantic, and a recent investigation of Bering Sea circulation and water properties by Johnson *et al.* (2003). Willis *et al.* (2003) provides a new technique for combining profile data, including Argo, with satellite altimetry for estimation of subsurface fields. The technology of floats and float sensors is also an active research area (Davis *et al.*, 2001, Riser and Swift, 2001).

A major research focus for use of Argo data is ocean data assimilation. There are two U.S. consortia (HYCOM and ECCO) funded under NOPP for experimental ODA studies. In addition, there are experimental data assimilation activities within NOAA and NASA. There is presently a funding opportunity under NOPP for the Global Ocean Data Assimilation Experiment (GODAE).

Issues for AST-5:

Argo is in a phase of rapid growth, with substantial float arrays in all oceans. For a program of Argo's size, there is an increasing need for scientific coordination of all aspects of the Argo Project - to maximize Argo's value and to avoid problems. It is suggested that the AST consider making the position of Argo Director permanent.

Potential problem areas identified for more attention or better coordination include deployment planning, technical performance, data system issues, and Argo's interactions with other programs (GOOS, CLIVAR, GODAE etc.)

References/Publications:

Davis, R.E., J.T. Sherman and J. Dufour, 2001. Profiling ALACEs and other advances in autonomous subsurface floats. *Journal of Atmospheric and Oceanic Technology*, 18, 982-993.

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Riser S. and D. Swift, 2001. Long-term measurements of salinity from profiling floats. Submitted to *Journal of Atmospheric and Oceanic Technology*.

Schmid, C., Z. Garaffo, E. Johns and S. Garozli, 2003. Pathways and variability at intermediate depths in the Tropical Atlantic. Accepted: *Elsevier Oceanographic Series.*

Willis, J., D. Roemmich and B. Cornuelle 2003. Combining altimetric height with broadscale profile data to estimate steric height, heat storage, subsurface temperature and SST variability. Submitted to *Journal of Geophysical Research*.

Wong, A. and G.C. Johnson, 2003. South Pacific Eastern Subtropical Mode Water. Accepted by *Journal of Physical Oceanography.*

Annex 6

. **Supporting infrastructure for the international Argo project**

A discussion document for consideration at IAST-5, March 2003.

1. Preamble

Argo is a pilot project of the Global Ocean and Global Climate Observing Systems (GOOS and GCOS) and is a contributor to the World Climate Research Programme's CLIVAR project on Climate Variability and Predictability and an essential elemnt of the Global Ocean Data Assimilation Experiment (GODAE). Argo collects and distributes data from the upper 2km of the water column using profiling, free-drifting floats.

Argo has, at the start of 2003, reached over 20% of its projected final array of 3000 floats. In reaching this stage, Argo has relied on the commitment of research scientists to design the program, develop sufficiently reliable floats, design and implement an appropriate data system and carry out the necessary dialogue between contributing countries and the agencies within them that support global ocean observations and between Argo and other research and operational programs. A continuing commitment of these scientists will be required throughout Argo's life.

Argo must now develop an international infrastructure that supports both research and operational activities and in so doing allows researchers to be freed from many of the organisational responsibilities that they have assumed in the initial phase. This infrastructure must be effective, responsive and supportive and must be neither a significant financial nor bureaucratic burden.

This document is an attempt to define the responsibilities and modes of operation of that infrastructure. It also addresses the issue of how such an infrastructure might be funded.

2. Requirements of the project

Argo's overall aim is to deliver to both the research community and to appropriate operational agencies throughout the world, global, *in situ* data of useful quality and within an appropriate time frame and to be responsive to the changing needs of these two client communities. Argo is, and is planned to continue to be, based on the pooled contributions of many nations, both large and small.

This structure requires a dialogue between a large number of elements. (Numbers given in parenthesis reflect an estimate of the present number of bodies within each category. In every case the number is likely to increase as Argo develops)

These elements are :-

- Float manufacturers (~5)
- Sensor manufacturers (~2)
- Data communications providers (~3)
- National projects (15) and their funding agencies (~ 50)
- Agencies and organisations engaged in float deployment (~50-100)
- Agencies and laboratories responsible for satellite missions (esp. Jason-1) (~20)
- Organisations providing data quality control and management
    - in real time (~6)
    - in delayed mode (~10)
    - as a final archive (1?)
- Users of Argo data
    - research scientists (~500)
    - agencies engaged in operational weather, climate and ocean forecasting (~ 50)
- International bodies with the responsibility for oversight and co-ordination of climate observations and research (~10).

The large number (>700) of "interested parties" highlights the need to establish streamlined, effective but unobtrusive communication and co-ordination channels and mechanisms and to put in place the infrastructure elements that are needed to facilitate them.

3. Present infrastructure elements

Some infrastructure elements already exist both within and external to Argo. Consideration must be given to whether those infrastructure elements within Argo's control and the communication pathways within the project and between Argo and the wider community are effective and appropriate.

Argo Science Team (AST)

International planning for Argo, including sampling and technical issues, is coordinated by the Argo Science Team (AST). Scientists from nations presently having Argo plans that include float procurement and/or production, are members of the AST. The AST meets once per year and is chaired by Dr Dean Roemmich, SIO, USA. Its terms of reference are given in Annex A to this document.

Argo data team (ADT)

Oversight of the development and implementation of the Argo data system is in the hands of an *ad hoc* International Argo Data Management Team. This was formed as a standing working group of the AST. While it has no formal terms of reference it should receive explicit guidance from the AST on a year-by-year basis. The AST should at each meeting generate a list of issues for the DM team to consider, and the DM team should report on progress and recommendations relative to its specific instructions. The Argo Data Team is made up of researchers and representatives of labs and organisations that are involved in the management of Argo data. It is co-chaired by Sylvie Pouliquen (IFREMER, France) and Bob Keeley (MEDS, Canada).

Argo data centers

The delivery of Argo data (ranging from the real-time measurements made by floats to the best available calibrated and quality assured data) is a task that presently involves many national data centers and two global data centers . The quality control process for delayed-mode data requires substantial efforts by Principal Investigators.

The **two global centres** are located in IFREMER France (part of the Coriolis project) and the US file server for the Global Ocean Data Assimilation project (GODAE) in Monterey California.

There are also a number of data centres that have a remit (national and international) for the collection and dissemination of Argo data from particular regions as follows.

Southern Ocean	UK British Oceanographic Data Centre (BODC)
Atlantic Ocean	US - NOAA, AOML France - IFREMER, Brest,
Indian	India - INCOIS, Australia -CSIRO, Hobart, USA -NOAA, PMEL, USA – IPRC, Hawaii. .
Pacific	USA - NOAA, PMEL, USA – IPRC, Hawaii, Japan – JAMSTEC.

The specific functions of the regional data centers and the manner in which the component partners will collaborate to fulfill those functions are still under development.

Argo Information Centre (AIC) and JCOMM

The deployment of floats throughout the global ocean raised the issue of observations being made within nations' Exclusive Economic Zones (EEZs). This required there to be a formal mechanism to notify the international community of floats deployment plans and of the possibility of floats entering waters under a country's jurisdiction (IOC Resolution XX-6). The Argo Information Centre exists as a part of the Joint Commission on Oceanography and Marine Meteorology's In Situ Observing Platform Support Center (JCOMMOPS).

The JCOMM Observations Coordination Group (OCG) reviews the progress of the Argo project and is charged with developing and overseeing the implementation of procedures for the full integration of Argo into the Global Climate Observing System when it reaches an appropriate stage of maturity.

The Argo co-ordinator performs the following tasks as specified in an Annex to the report of the 2nd meeting of the Argo Science Team (March 2000):

- Develop and maintain a web site for float monitoring (e.g. EEZ issue).
- Develop and maintain a scheme to alert member states on the status of floats entering their EEZ.

- Informing member states of the interest to keep them operational.
- Acting as a clearing house for information on all aspects of float use (e.g. how to access data). Web site to be updated regularly as required.
- Providing information regarding the status of the Argo buoy network.
- Advertising Argo through direct contacts, encouraging participation of new partners.
- Promoting flow of float data to designated archives.
- Promoting an improved international dialogue between oceanographers and meteorologists, and between research and operational communities.

When requested by the Argo Science Team, the Coordinator may also work on issues such as:

- Assisting with the development of co-operative arrangements for float deployments.
- Assisting in the implementation of a global system, and in particular with regard to real time exchange of the data (contacts with float operators, data telecommunication, data assimilation centres).
- Assisting in the implementation of real time and delayed-mode QC procedures.
- Acting to resolve issues arising between float operators, manufacturers, data telecommunication providers, data assimilation centres, quality control andarchiving agencies, WMO and IOC.

The AIC Co-ordinator (Mathieu Belbéoch) reports to meetings of the AST and the ADT. He is employed by the Intergovernmental Oceanographic Commission (IOC) and his position is supported by financial contributions from USA with smaller contributions from Canada, France and UK.

<u>Argo regional co-ordinators</u>
In order to keep track of evolving national plans to deploy floats, the AST identified co-ordinators for each ocean basin whose task it would be to accumulate and disseminate information between countries and groups planning float deployments so as to ensure that the pooled international resources were used in the most effective manner.

4. Suggested Argo Infrastructure and communication structure.
The description of the project given in the previous paragraphs, highlights the present dual nature of Argo infrastructure with the AIC operating under JCOMM and the remainder directly related to the AST but with any full time support.
The following is a model for a more robust and effective structure. It envisages the establishment of the post of Argo Executive Director with the following remit.

- To oversee on a day-to-day basis, all aspects of the international Argo project
- To provide administrative support for, and advice to, the Argo Science Team via its (co-Chair(s) and to the Argo Data Team via its (co-)Chair(s)
- On behalf of the AST to work with, and to monitor and direct the activities of, the AIC co-ordinator to ensure that all aspects of communication within Argo and between Argo and other bodies are handled effectively.
- To work with contributing nations to provide effective publicity for Argo
- To encourage and provide administrative support for international contacts between agency representatives of national programs.
- To share with the AST chair and the ADT (co-) chairs the representation of Argo at meetings of relevant bodies.
- To ensure that all elements of Argo have easy and timely access to the information they require on Argo.

Lines of communication and responsibilities between Argo and other bodies and within Argo might be as follows :-

External communication See Annex B

- Chairman AST.   Provides information to
  - I-GOOS
  - JCOMM OCG
  - CLIVAR SSG (via its Ocean Observations Panel)
  - International GODAE Steering Team (IGST)

(Note these tasks may be shared with/devolved to Argo Director).

Within Argo

• Argo Director	Reports to	- Chairman AST
• AIC manager	Reports to	- Chairman AST and to Argo Director
• Chair ADT	Provides information to	- Chairman AST and to Argo Director
• Argo Director	Communicates with	- National programmes
		- Argo regional co-ordinators

5. Remit, funding, location and financial support of Argo Director and AIC manager

As the two potential "permanent" elements of Argo infrastructure, the remits of the Argo Director and of the AIC manager need to be complementary.

The physical location of the Argo Director is less critical than the Director's ability to communicate well with the AST Chair, ADT chair(s), the AIC Manager, elements of the data system, representatives of national Argo projects and with the regional implementation co-ordinators.

The location of the AIC Manager is in Toulouse alongside Etienne Charpentier, (DBCP and SOOP Coordinator).

The following tasks have been carried out in the past year and are planned for the coming year by the AIC's Argo Technical Coordinator :-

	Task	% 2001/2	% Est 2002/3
a)	Formally inform member states about deployment of floats which might drift into their EEZ according to IOC resolution XX-6.	5	5
b)	Develop and maintain a web based float monitoring system that will particularly permit to alert in real time member states on the status of floats entering their Exclusive Economic Zones (EEZ) and to inform them of the interest for them to keep them operational. Application will also be used for deployment strategy.	55	15
c)	Through direct contacts with potential users in member states, advertise the Argo programme, encourage use of float data by them, and active participation of new member states in the programme.	5	10
d)	Assist when requested with the development of cooperative arrangements for float deployment	5	10
e)	Through contacts with float deployers, data telecommunication providers, and data assimilation centres, assist as appropriate in the implementation of a global system, including standardization, for the distribution in real time of float data for assimilation by oceanographic and coupled oceanographic/meteorological models.	5	10
f)	In the same context, assist in the implementation of real-time and deferred time quality control procedures for those float data distributed in real time.	5	10
g)	Promote the flow of float data to the designated archives.	5	5
h)	Act to resolve any issues arising between float operators, manufacturers, data telecommunication providers, data assimilation centres, quality control and archiving agencies, WMO and IOC.	5	20
i)	Act as a clearinghouse for information on all aspects of float use.	5	10
j)	Promote an improved international dialogue between oceanographers and meteorologists, and between research and operational communities.	5	5

The AIC-TC , as part of the intergovernmental structure has a primary responsibility for tasks a), and b). Other tasks could be either the primary responsibility of, or a shared responsibility with, the Argo Director.

While the remit of an Argo Director has formally to be considered and approved by the AST the possible responsibilities outlined above in section 4 might be summarised as:-

1) To support the AST and its Chairman in developing and maintaining Argo as an effective element of GOOS and GCOS and a valuable contributor to CLIVAR and GODAE.

2) Provide day-to-day oversight of all aspects of the international Argo project and to work with the Chair of AST and Chair(s) ADT to take appropriate action.

3) To ensure that there is effective communication between all elements of the international Argo project

The difficulty in finding the financial support needed to provide Argo project infrastructure should not be underestimated. However, it is clear that as Argo develops, the need for this infrastructure support will increase and that funding must be found to sustain an appropriate Argo infrastructure.

For CY 2003 funding provided by NOAA and by Scripps Institution of Oceanography has enabled John Gould to be employed as the Argo project Director located at SIO. The AIC-TC (Mathieu Belbéoch) is located in Toulouse, France and is funded jointly by the USA and smaller contributions from Canada, France and UK..

A model like this (arbitrary national donations to cover salary, benefits and travel) might be workable or could be put on a more formal basis of a levy proportional to the number of floats deployed by each contributing country. However this number would vary from year to year and thus make budgeting difficult. A mechanism would be needed to collect and account for the expenditure of these “dues” through a host institution.

An Argo Director will need a physical base within an institution, most likely one closely associated with Argo, and that would be willing to provide the administrative infrastructure and communications support required for the Director to work effectively.

6. Argo’s immediate requirements (CY2003)

With an interim Argo Director in post at the start of 2003, the potential exists to resolve a number of outstanding issues in addition to making progress towards the overall responsibilities of the Argo Director.

Among these initial targets (more may be identified by AST-5) are :-

1..With AST and ADT, finalise the delayed mode QC process and ensure that DM data start to be made available
2) Identify uses being made of Argo data in preparation for Argo science results workshop in November 2003.
3) Assist AST members, SOPAC and Stan Wilson, in following up the 2002 Argo-endorsed workshop Potential Applications of Ocean Observations in the Pacific.
4) Streamline and improve the regional co-ordination of float deployments.
5) Work with AST to encouarge the exchange of technical information on float performance is widely distributed and its consequences acted upon. (there are some barriers here; maybe encourage rather than ensure)
6) Ensure that AIC activities and in particular the AIC web site meet user needs.
7) Produce new publicity material for use by all contributing Argo nations.
8) Rationalise and simplify the access to Argo documents on the www.

Annex A Argo Science Team - Terms of reference

1. Develop an Implementation Plan for a global network of profiling (temperature and salinity) floats, using the GODAE/UOP Prospectus and Workshop Report as representative of the CLIVAR and GODAE requirements.

2. Provide scientific guidance to, and receive advice from, the Upper Ocean Panel of CLIVAR and the International GODAE Steering Team on the scientific and technical issues associated with the implementation of the profiling float contribution to the sustained (ocean) observing system of CLIVAR and the global ocean climate observing system of GODAE and GOOS/GCOS.

3. Develop an international consortium, to undertake the implementation and maintenance of the global network, and provide advice to the consortium as necessary.

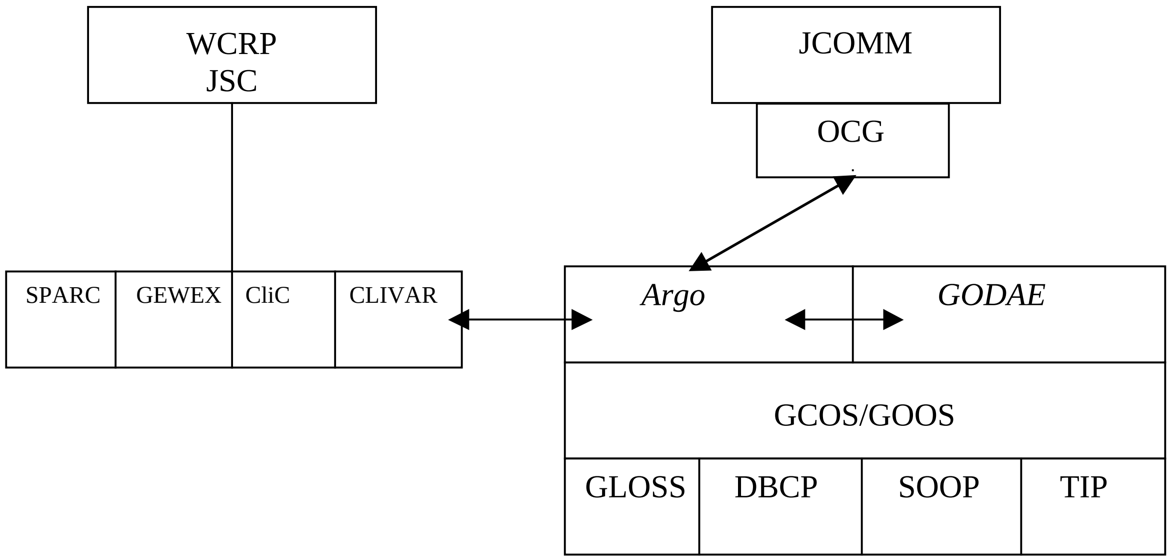
4. Promote and evaluate observing system studies to guide the initial Argo sampling design and to guide the long-term development and evolution.

5. Provide advice and guidance technical innovations relevant to the float array.

6. Liaise as appropriate with other groups associated with the (sustained) global ocean observing system, including the ship-of-opportunity program, the tropical atmosphere-ocean array, and remote sensing program such as Topex/Poseidon and Jason.

7. Provide regular reports on progress to the GODAE and CLIVAR International Project Offices.

Annex B Argo external links



Annex B

Internal Argo Communications