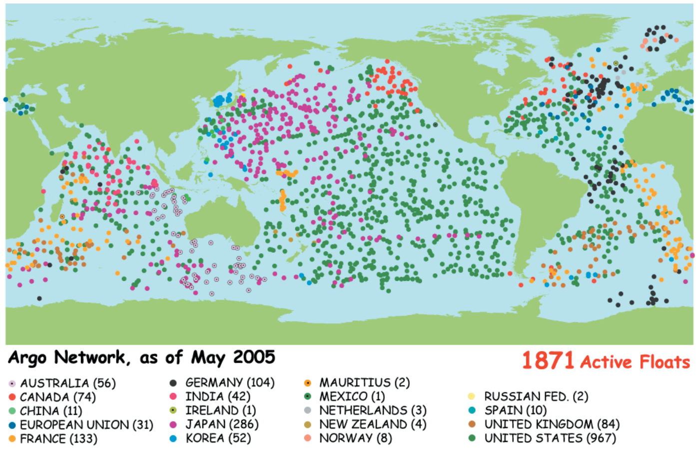
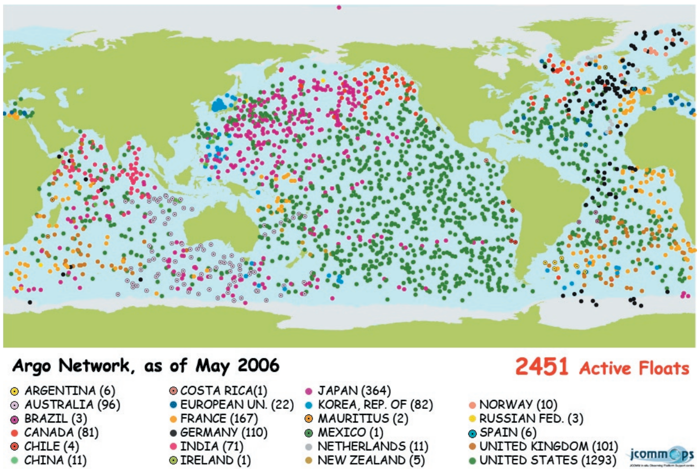
Number 7
June
2006

Argonautics

Newsletter of the international Argo project





Editorial

It is more than a year since the last Argo Newsletter was published - working only part time as Argo Director meant that some things could not be done - preparing the Newsletter was one of them. The year has been one of great progress. The maps above tell part of the story. The array has grown from 1871 to 2451 floats, an increase of 580 from 877 floats having been deployed. The other striking feature is the new countries that have joined Argo (Argentina, Brazil, Chile and Costa Rica). Welcome. News from the recent IOC Executive meeting suggests that the Dominican Republic, Ecuador and Kenya may soon join.

The little New Zealand ship Kaharoa (See Argonautics No 5) has continued its vital work in the Southern hemisphere. In the past year she deployed 171 floats and will soon be heading for the South Indian Ocean.

In September we held the Second Argo Science Workshop in Venice. Despite the short period of preparation, the meeting was great success and was attended by 200 Argo participants from 23 countries. Presentations from the workshop are highlighted in this Newsletter. Arne Koertzinger and his co-authors demonstated the quality and scientific value of oxygen measurements from Argo floats (at present 60 oxygen floats are operating) to detect climate change in the oceans. There were also a number of presentations on the use of Argo-like profilers under ice. On page 6 we report on a Japanese profiler reporting data to the Argo system from very near the North Pole. (See the dot on the May 2006 map). Under ice profilers are also operated by German and US groups. These help to bring Argo closer to being truly global.

The back page of the Newsletter gives Argo-related papers that have been published in 2006 and also lists those that we are aware of that are presently in press or being prepared. This is an impressive and rapidly growing body of results based on Argo.

Unfortunately this will be my last Newsletter since at the end of June I will be stepping down as Argo Programme Director. Despite considerable effort over the past months the Argo Steering Team have been unable to find the resources to enable the position to continue. A project as important and vibrant as Argo needs an effective oversight structure. Mathieu Belbéoch will continue as the Technical Co-ordinator in Toulouse (he has just been joined by Hester Viola who replaces Etienne Charpentier as the Technical Co-ordinator for the Data Buoy Co-ordination Panel (DBCP)). Some of my responsibilities (maintaining the Argo bibliography and the www.argo.ucsd.edu web site) will be continued by Megan Scanderbeg working alongside Dean Roemmich at Scripps. Megan will also receive any e-mails addressed to argo@ucsd.edu. Many of you met Megan at the workshop.

I wish Argo well for the future. My involvement with neutrally buoyant floats goes back 40 years to March 1966 when (as a student) I sailed with Dr John Swallow F.R.S. (the inventor of the neutrally buoyant float) on the Royal Research Ship Discovery deploying floats that lasted about a week and could be tracked for a few 10s of km. Since then floats (and my career) have developed through SOFAR, RAFOS, ALACE, P-ALACE and now to Argo. It has been an exciting period, one in which oceanography and the use of floats has developed from a tool for inquisitive scientists to a source of data and information that addresses fundamental issues that affect all of humankind.

Argo is a model of how international collaboration should work. I will watch its progress with interest .

John Gould

Oceanic oxygen – the oceanographer's canary bird of climate change

Arne Körtzinger[1], Stephen C. Riser[2] and Nicolas Gruber[3]

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The concentration of dissolved oxygen in seawater is one of the classical chemical parameters in oceanography, which is considered to have begun as a modern science with the British deep-sea expedition on board H.M.S. *Challenger* from 1873-1876. The careful analyses of 77 water samples by Dittmar (1884) during this expedition, which included measurements of dissolved oxygen, represented the most extensive seawater analysis performed at that time. Early work by Helland-Hansen and Nansen in the Norwegian Sea (1909) and most remarkably by Wüst during the German Atlantic Expedition of the R/V *Meteor* in 1925–1927 provided more detailed insight into the vertical and horizontal distribution of oxygen in the ocean. Since then and facilitated by the invention of an elegant and precise wet-chemical method by Winkler (1888), which has remained essentially unchanged until today, reliable and comparable oxygen measurements have been made during innumerable research cruises to all parts of world ocean and added to our understanding of the ventilation of the ocean as well as biological processes in the marine realm.

The most detailed and consistent picture of the oceanic oxygen distribution so far emerged from the international WOCE study (World Ocean Circulation Experiment) which yielded more than 300,000 oxygen measurements taken at nearly 17,500 stations (mostly) during the period 1990–1997. However, after the advent of reliable oceanographic oxygen sensors (e.g. Tengberg *et al.*, 2006, **Figure 1**) and with the existence of the broad-scale global Argo array of profiling floats, the next quantum leap in the observation of oceanic oxygen distributions and their variability is now possible (Körtzinger *et al.*, 2004; 2005). If only 10 % of the final array of 3000 floats were equipped with these oxygen sensors, more than 10,000 profiles with 750,000 high-quality oxygen measurements in the upper 2000m could be made in a single year. This would not only exceed the ambitious decade-long WOCE program by a factor of ten, but also provide a three-dimensional synoptic and time-dependent picture of the global oceanic oxygen distribution and hence overcome the limitations of the spatial and temporal aggregation of measurements typical for campaign-mode observations.

But why is a fully fledged observatory of oxygen in the ocean needed and how could we try to convince the Argo community that the addition of oxygen as a new "official" Argo parameter would be a smart move? As Joos *et al.* (2003) pointed out, the (mostly) decreasing trends in the concentrations of dissolved oxygen in the ocean over the last few decades (e.g. Emerson *et al.*, 2004) have important implications for our understanding of anthropogenic climate change. As sub-surface oxygen concentrations in the ocean everywhere reflect a balance between supply through circulation and ventilation and consumption by respiratory processes, the absolute amount of oxygen in a given location is therefore very sensitive to changes in either process, more sensitive perhaps as other physical and chemical parameters. Oceanic oxygen has therefore been proposed as the oceanographer's canary bird of climate change.

***Fig. 1**: Photo of the top cap of a profiling float with the two most advanced oceanographic oxygen sensors installed side by side: Seabird Inc. electrochemical sensor on the left, Aanderaa optode sensor on the right. Field results from such dual-oxygen-sensor floats are already available.*

But an enhanced oxygen observatory in the ocean can do even more for us: It will help improve the atmospheric O_2/N_2 constraint on the ocean-land-partitioning of anthropogenic CO_2, a much sought-after quantity (Keeling *et al.*, 2002). It will also allow determination of the seasonal to interannual net remineralization rates as a proxy for export production which is still a entity not well constrained. It should help interpretation of variations in water mass ventilation rates and it will provide crucial data (initial conditions, evaluation) for ocean biogeochemistry models. To end this not exhaustive list, it will aide interpretation of sparse data from repeat hydrographic surveys that are needed for example to constrain the oceanic inventory of anthropogenic CO_2. Enough reasons, as we feel, that warrant a major international attempt to determine seasonal to decadal-time changes in sub-surface oceanic oxygen storage and transport, a task that can only be achieved by a future Argo observatory augmented with oxygen sensors.

Realizing the tremendous utility of oxygen measurements in the ocean and spurred by a *Science* paper on the use of oxygen floats in the Labrador Sea (**Figure 2**) the informal "Friends of Oxygen" initiative formed to advocate the widespread use of oxygen sensors on profiling floats. From this group a writing team that includes the authors of this note and is lead by one of us (N.G.) emerged and started to write a White Paper for promotion of the addition of oxygen sensors to the international Argo float program. This document is expected to be released towards the end of the year and will form the basis for an official approach to the Argo community and steering team. Clearly a lot of homework has to be done including a careful assessment of the feasibility of high-quality long-term measurements of oxygen from floats (**Figure 3**) but we are sure that this new application

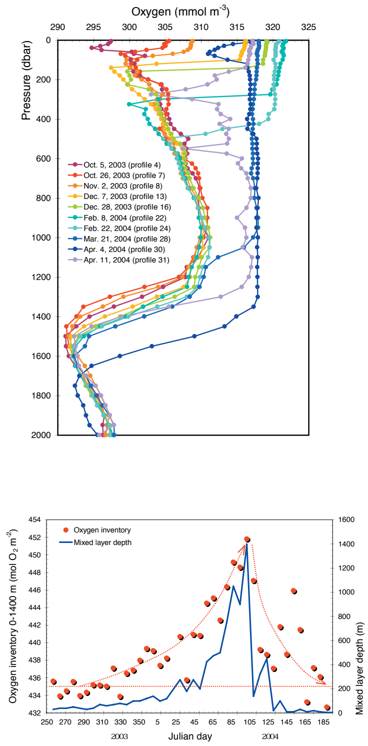

***Fig. 2:** Labrador Sea "Showcase" of oxygen on profiling floats with selected vertical oxygen profiles (top panel) and temporal development of the oxygen inventory (upper 1400 m) and mixed layer depth (bottom panel) based on 42 weeks of measurements from a profiling float re-circulating in the central Labrador Sea Gyre (from* Körtzinger *et al.*, 2004).

would strongly increase the scientific merit of Argo and also attract a whole new community. By joining forces under the Argo banner, oceanographers from various parts of the community could cause a renaissance of oxygen as a classical oceanographic parameter that will help us identify and understand global climate change.

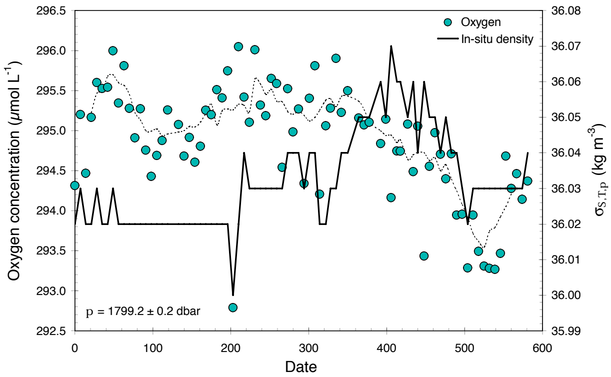

Fig. 3: *Five hundred and eighty days of oxygen readings taken at 1800 dbar by an Argo float re-circulating most of its time in the central Labrador Sea convection region. The average oxygen readings during the whole period were 295.0 ± 0.7 µmol L^{-1} (from Tengberg et al., 2006).*

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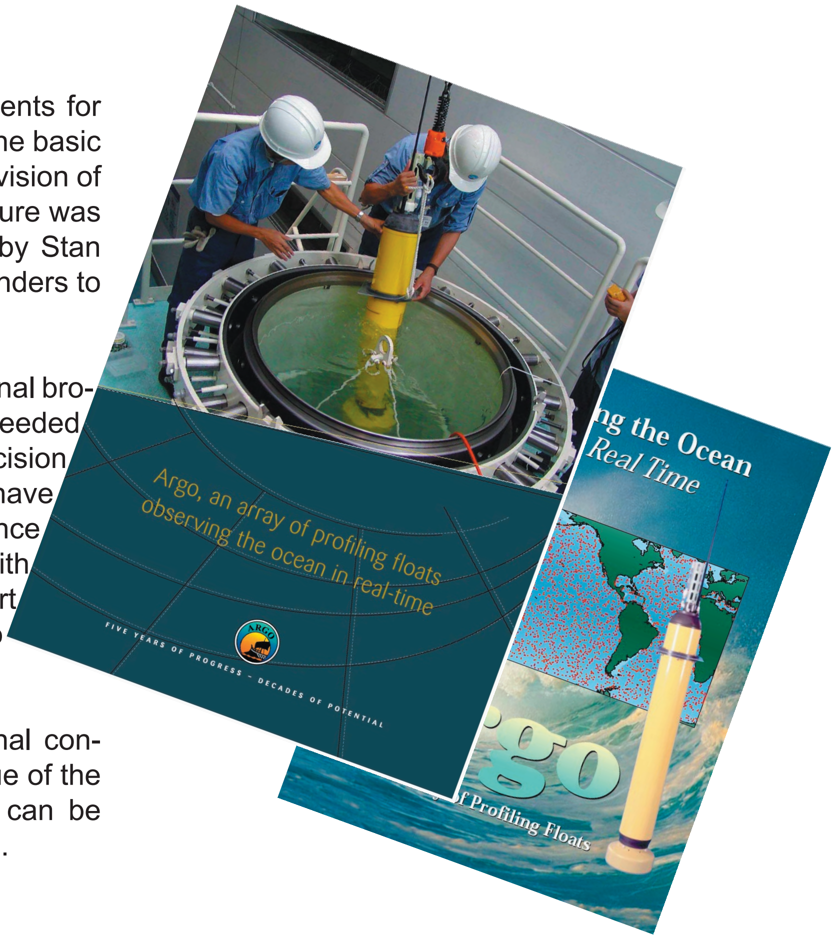
A new Argo brochure

An important step in gaining initial commitments for Argo was to have a brochure that explained the basic facts about the project and that spelled out a vision of what Argo hoped to achieve. That first brochure was produced in 2000 by NOAA and was used by Stan Wilson and Jim Baker as they approached funders to seek commitments.

In recent months it became clear that the original brochure was out of date and a new one was needed to help secure long-term Argo funding. A decision was made by the AST in January 2006 to have a new brochure ready in time for the Science Workshop in Venice. This was achieved with help from Lea Crosswell in CSIRO, Hobart who did the layout and from JAMSTEC who funded the printing of 7000 copies.

The brochure has been distributed to national contacts and will be mailed out with the next issue of the CLIVAR Newsletter in July. PDF versions can be downloaded from the AIC and Argo web sites.



Argo data and the 'cold winter' forecast for Europe for 2005/06

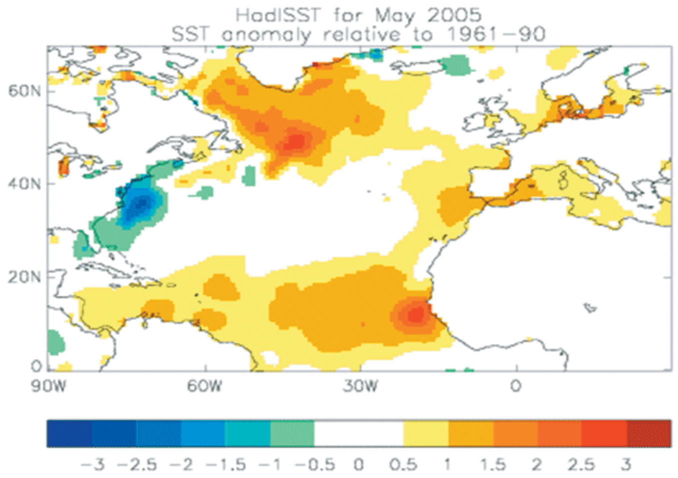
Jon Turton, Met Office, Fitzroy Road, Exeter, EX1 3PB, UK [jon.turton@metoffice.gov.uk]

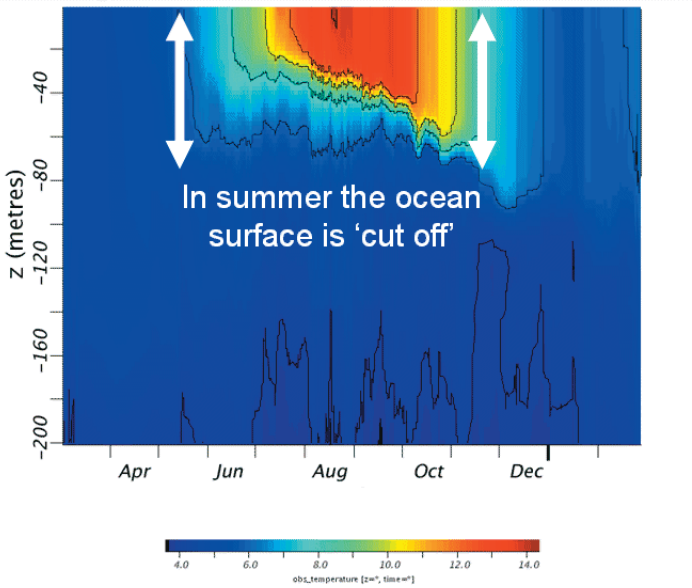
In September 2005 the Met Office issued a long-range forecast for the winter of 2005/06 of a "two in three chance of a colder-than-average winter for much of Europe, and that if Europe were to experience below-average temperatures, parts of the UK - especially southern regions - would also be affected". There was also an indication for a drier-than-average winter over much of the UK.

The forecast was produced using a combination of statistical models and complex climate models with interpretation by operational forecasters. In particular Argo and other sub-surface data were used to examine temperature anomalies in the North Atlantic during 2005 by looking for the likelihood of re-emergence in the autumn of the spring anomaly pattern which would indicate a negative North Atlantic Oscillation mode during the 2005/06 winter. (A negative NAO is often associated with a colder and drier winter across northern Europe). The sub-surface data suggested that the spring anomaly pattern was indeed still present in the sub-surface and likely to re-emerge once autumn mixing eroded the near surface warm layer (see figure), and so provided further support for the long-range forecast issued in September.

This 'cold winter' forecast attracted significant interest in the UK with briefings to key Government departments, energy companies, health authorities, road and rail authorities, the media and the public. Preparing for cold weather can take several months and groups dealing with contingencies and long-term planning were able to use the forecast to best prepare for whatever the winter was to throw at them.

Following the 2005/06 winter it can be seen that Europe did experience below-average temperatures over a wide area through the winter 2005/6. The winter was very dry across the whole of the UK, warmer-than-average in the north, colder-than-average in the south. In the original forecast there were five main issues that have been verified and in four of these five cases, the predicted most likely event happened.





Left, *SST anomaly pattern in May 2005 indicative of a positive NAO mode; right, temperature cross section for a specific location (60W, 20N) showing how the near surface warm layer develops during the summer and erodes in autumn. During the summer/early autumn the underlying temperature anomaly pattern can only be seen in the sub-surface.*

WINTER REVIEW		
	PREDICTION	**OUTCOME**
Mean temperature across Europe	Most likely colder than everage	Colder than average for many areas
UK mean temperature	Most likely colder than everage	Warmer than average
Southern UK mean temperature	Most likely colder than everage	Colder than average
UK precipitation	Most likely drier than average	Drier than average
Northy Atlantic Oscillation(NAO) for winter season	Negative	Negative

Without information from Argo on the structure of the sub-surface temperature anomalies it is unlikely that such a clear forecast could have been made on this occasion. However, it should be borne in mind that not all winters will have a strong signal one way or the other or the other, and in these cases it will always be difficult to provide definitive forecasts.

For further information about seasonal forecasting at the Met Office see http://www.metoffice.gov.uk/research/seasonal/

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Argo GODAE session at IUGG, Perugia, Italy, July 2007

2007 is the 50th anniversary of the International Geophysical Year (IGY), that started the era of systematic global scale observation of our planet. It is fitting that Argo should play an important role in the 2007 meeting of International Union of Geodesy and Geophysics. A session will be held in Perugia entitled "Argo and GODAE - regional and global partners". It will be co-convened by John Gould (Argo) and Pierre-Yves Le Traon (GODAE).

The session provides a platform *"to explore the wide range of regional and global results and new data assimilation techniques that have been made possible by the link between Argo and GODAE".*

Please mark this event in your diary and consider submitting an oral or poster presentation. The full range of science sessions at the IUGG can be found at the web site listed in the timetable below.

Report on the Argo Data Management Team (ADMT).

Sylvie Pouliquen and Mark Ignaszewski (Co-chairs) [Sylvie.Pouliquen@ifremer.fr, Mark.Ignaszewski@fnmoc.navy.mil]

The ADMT met in November 2006 in Tokyo. The meeting was hosted by JMA and 52 persons from 10 countries attended.

Main achievements in the data system were:

- 80% of the data are on GTS within 24h from all GTS nodes
- 100% of the Real Time data arrive at GDACs via National DACs. Replacement of the historical GTS data by DAC versions (459 Floats) is underway
- Actions are underway to improve the consistency of real time QC for spike/gradient/density inversion tests.
- Delayed mode QC activities progress in a consistent way and important steps were made since the first Delayed Mode workshop at San Diego in April 2005. In November 2005, 27% of eligible data had been processed by June 2006 this was up to 45%.
- Salinity adjustment in the real time data stream will be done by applying an offset equal to the last correction validated by the responsible PI. Each DAC will implement this correction according to their own planning by providing a "PSAL-Adjusted" parameter in the real-time files.
- In collaboration with CLIVAR the reference database needed for delayed mode quality control will be updated. Actions are also underway to integrate in this reference data base Argo floats which passed delayed mode QC and didn't need adjustment . This will aid delayed mode quality control in areas with few CTD profiles
- A format change was implemented in February2006 to handle parameters other than T & S and to decrease file size (growing rapidly because of history records in multi-profile files).
- A major problem affecting the distribution of Indian Ocean data on the GTS by CLS has been identified and corrected. Further validation and troubleshooting are being performed
- The WMO ET/DRC approved the Argo BUFR template in November 2005. The ADMT is proceeding with the experimental exchange of BUFR data and hope to receive approval from the WMO for pre-operational use in November 2006.

Some actions, raised by the Argo data management committee, were discussed at the Argo Steering Team that met last January in India. An action has been taken regarding the application of thermal inertia lag correction on data acquired by Seabiird sensor: it will first be applied in delayed mode and revisited by the science team before its routine application in real-time. Considering that delayed quality control is still an activity under development, that may need some tuning, a peer-review of the delayed mode data that have been processed by the delayed mode operators will be performed prior to the next delayed mode meeting that will be held in WHOI/USA beginning of 4-8 October. Finally AST decided to specify the best means of extracting velocity information from float data and to provide precise instructions to the Data Management Team.

The next meeting will be held in Tianjin. China , hosted by NMDIS/SOA 1-3 November 2006 .

The 6th ADMT meeting report is available at at http://www.coriolis.eu.org/cdc/meetings/ARGO-DM-report-6th.pdf

Timetable of Argo-relevant meetings

2006			
July 15	Hobart, Australia	Southern Ocean Observing System Workshop	http://www.ocean-partners.org/meetings.htm
Aug 31- Sept 1	Reading, UK	CLIVAR/GODAE Ocean synthesis	Nico Caltabiano (caetano@noc.soton.ac.uk)
October 4 - 8	Woods Hole, USA	Second Argo Delayed-Mode QC Workshop	bak@noc.soton.ac.uk
October 16 - 20	La Jolla, CA, USA	DBCP	http://www.jcommops.org
October 16 - 18	Beijing, China	GODAE symposium on Ocean Data Assimilation and Prediction in Asia-Oceania	http://ctwf.iap.ac.cn/godae2006/OtherNews_show.asp?id=1
October 27-28	Seoul, Korea	Argo Trajectory Workshop	bak@noc.soton.ac.uk
November 1 - 3	Tianjin, China	Argo Data Management Team 7th meeting	http://www.cadc.org.cn/argo-eng/meeting/ADMT-2006.htm
Nov 9 - 12	Beijing, China	ESSP Ocean Science Conference	http://www.essp.org/essp/ESSP2006/
December	Ghana	Africa Argo training workshop	belbeoch@jcommops.org
2007			
January 17 - 19	Qingdao, China	POGO - 8	http://www.ocean-partners.org/meetings.htm
July 2 - 13	Perugia, Italy	Argo/GODAE session at IUGG Ocean Sciences	http://www.iugg.org/assemblies/2007perugia/

Report of the Argo Steering Team meeting Hyderabad, India (January 16-18th, 2006)

Howard Freeland AST Co-chair [freelandhj@dfo-mpo.gc.ca]

The Argo Steering Team met in Hyderabad, India, thanks to the hospitality of our hosts at the Indian Centre for Ocean Information Services (INCOIS) which also manages the Indian Argo Program. The time and location were chosen so that we could have a joint meeting with POGO (Partnership for Observation of the Global Oceans).

The Data System The meeting began with a review of the Argo data system. Some problems that were identified a year ago remained, for example, the delivery of partial profiles on the GTS. This is a problem that needs urgent action to resolve. A decision was reported on agreement on a process to feed back delayed-mode quality control to the real-time reports and some countries are now doing this. Energetic discussion took place on the need for a "peer review" of the delayed mode QC process, the ADMT recommended that this be done and asked the steering team to implement a review. At the time of writing this report a peer review process has begun and we look forward to results being reported at the next AST meeting. Questions also arose again about the best method for extracting velocities from the trajectories of Argo floats. The AST endorsed a proposal from Brian King to establish a sub-committee charged to establish a list of recommended procedures. This turns critically on having the appropriate information stored in meta-data files. There will be a second Delayed Mode Quality Control Workshop in Woods Hole (October 4-8).

GODAE and CLIVAR. The relationship of Argo to other programs was discussed. Pierre-Yves LeTraon reported that GODAE is impressed with the progress of Argo. Though challenges remain for those trying to use Argo data in high-resolution models, the data are mandatory for the execution of GODAE. Our relationship with CLIVAR is a little different, we expressed an urgent need to receive recent high-quality CTD data for the DMQC process. We are looking for assistance in encouraging PIs worldwide to deliver CTD to the CCHDO without delay to help build reference data sets.

Technical issues.

1) Steve Riser reported on the first APEX Users Group meeting in Seattle,September 2005, which was well attended and useful. Discussion followed on the cost effectiveness of installing lithium batteries in APEX floats. A lithium battery pack weighs 900 grams and supplies 1300 kJ of energy, in comparison the standard alkaline battery pack (as installed in a standardAPEX float) weighs 1400 grams and delivers only 600 kJ. Several packs are needed, the extra cost of lithium packs might be about US$600 extra, so superficially this appears to be effective. The AST recommends that countries not using Li batteries to consider doing so, however, this is not a trivial thing to do and should only be done in close consultation with the manufacturer. Using the PnP node of operation with a parking depth less than 1500 db and a profiling interval PD > 1 significantly reduces the incidence of "energy flu" and increases float longevity.

2) Other developments will be coming soon, such as a user-programmable controller board, the APF-9, also Iridium communications, and novel sensors for rainfall and wind speed. Riser is also testing a new model of the APEX float which will carry significantly more batteries and use less energy per profile.

3) A new version of the PROVOR float (PNG, which stands for PROVOR New Generation) is expected to be available soon. This model will be 30% cheaper, significantly lighter and will be capable of 150-180 profiles. We encourage a PROVOR Users Group meeting before the end of 2006.

4) Nobie Shikama reported on further work on the gear float. Development continues and promises a very small and light float. No float has had a field test as of Feb. 2006. Of great interest was a report on JAMSTEC experiments with floats without TBTO plugs in the sensor assemblies. Deployments so far are short term but look very promising.

5) The AST notes that many operators are deploying floats carrying dissolved oxygen sensors. While we recognise the great value of D.O. sampling, we reiterate that the primary mission of Argo is global temperature and salinity and do not wish to see that mission compromised with the displacement of resources into D.O. or other sensors. The AST also reiterates that the recommended parking depth for floats is 1000 decibars and strongly encourage rogue states to adopt this as a standard.

Beached floats. As the Argo array continues to grow it is inevitable that more floats will be found on beaches. The AST reminds operators that it is the responsibility of each PI to ensure the recovery of any float found on a beach. Assistance can be made available and indeed the AIC has been offering international coordination to effect recoveries. However, the cost of recovery belongs with the PI.

Regional Data Centres. The AST received reports from the Pacific, Indian, South Atlantic and Southern Ocean Regional Data Centres. The AST reminds the Regional Centres that data assembly belongs to national centres (whatever is needed to deliver data to the GDACs) and to the GDACs themselves. There are many things that a regional centre can do, but the single critical item is the function of comparing quality-controlled float profiles and trajectories assembled by two or more countries in areas where the national arrays overlap. We need to be assured that the same protocols are being followed by, for example, Japan, USA, China, Russia, Korea and Canada in the N. Pacific so to ensure a homogenous data set.

The new INCOIS facility

A joint meeting with POGO took place at the hotel and at the impressive new INCOIS facility in Hyderabad. POGO discussed interests that they share with Argo at some length and we emerged with three recommendations:-

1) POGO will write letters to Argo nations expressing their strong support for Argo and recommending that national programs be put on long-term sustained funding bases.

2) POGO will encourage the delivery of high quality CTD data to the CCHDO.

3) The POGO Secretariat proposes trying to maintain a global schedule of upcoming missions by research vessels. Argo expressed the opinion that this would be of enormous value to us and would be immensely grateful if this was achieved. It seems to be a task very well suited to the POGO mandate.

We thank Harsh K. Gupta, Muthalaga Ravichandran and Kopillil Radhakrishnan for their assistance in making this meeting possible.

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Arctic Ocean observation by Argo-type CTD profiler

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Institute of Observational Research for Global Change, Japan Agency for Marine-Earth Science and Technology (IORGC/JAMSTEC), Yokosuka, Japan.

The Institute of Observational Research for Global Change/ Japan Agency for Marine-Earth Science and Technology (IORGC/ JAMSTEC) successfully installed a Polar Ocean Profiling System (POPS) on the Arctic multiyear ice at 89.03°N, 165.66°E on April 17, 2006 as part of the 2006 North Pole Environmental Observatory (NPEO) operation (please refer the NPEO website; http://psc.apl.washington.edu/ northpole/index.html).

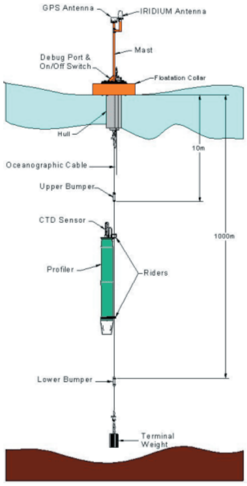
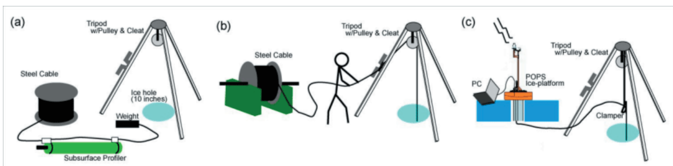
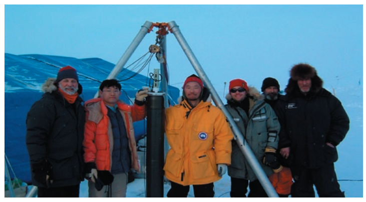


Figure 1. Schematic view of POPS

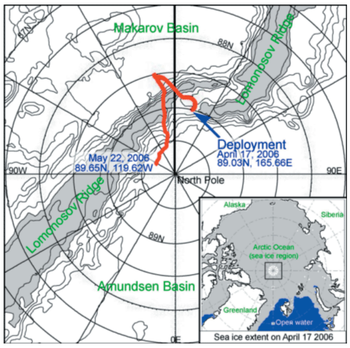
POPS is an ice-drift buoy system that tethers Argo-type CTD profilers to multiyear ice (Figure 1). JAMSTEC and METOCEAN began collaboration to develop POPS in 2004 with the aim of obtaining ocean profiling data from beneath Arctic multiyear ice (*Kikuchi and Langevin*, in preparation to *Deep Sea Res*.). POPS mainly consists of an ice platform and subsurface CTD profiler based on the PROVOR design. The ice platform contains the system controller, meteorological sensors (barometric pressure and air temperature), a global positioning system (GPS), and Iridium satellite communication system. The system controller manages all data acquisition, processing, formatting and messaging to the Iridium satellite system. The subsurface CTD profiler is based on Argo profiling float technology. The major difference in relation to a usual Argo profiling float is that a POPS profiler is mounted on an oceanographic steel cable 0.156 inches in diameter that is interfaced to a platform; the profiler moves along the cable between the bottom of the sea ice (10 m deep) and a depth of 1000 m. An inductive modem system allows data communication between the ice platform and subsurface profiler.

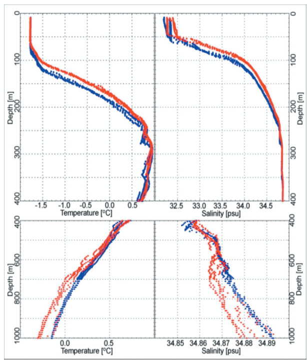


The POPS deployment for the 2006 NPEO operations was conducted on the Arctic multiyear ice near the North Pole. First, we made an ice hole 10 inches in diameter. While drilling the ice hole, we fixed a terminal-weight, lower bumper, and CTD profiler to an oceanographic steel cable and then completed preparations for seawater placement (Figure 2a). Once the ice hole broke through to water, we put the weight, profiler, and cable into the seawater in that order (Figure 2b). We temporarily stopped lowering the cable as it neared the end of its length. We connected the cable to the buoy platform so that observations could start at any time. We then connected the buoy to a computer and turned on the POPS to begin observations (Figure 2c). Once we had confirmed that data acquisition and the Iridium transmission were successfully occurring, we lowered the buoy platform into the ice hole and completed the deployment (Figure 3).



POPS is now sending ocean temperature and salinity profile data every 3 days, as well as 3-hourly GPS position, atmospheric temperature and barometric pressure data. Figure 4 shows the trajectory of the POPS from deployment (April 17) up until May 22, 2006. The POPS was deployed over the Lomonosov Ridge, moved toward the Alaskan side, and is now drifting toward the Greenland Sea. Drift velocity of sea ice in the central Arctic Ocean is generally less than 10 cm/sec. However, GPS position data





from the POPS show that mean drift velocity between 0900Z and 1200Z on April 29, when acquisition of ocean profile data started, was almost 30 cm/sec. Even under conditions of such fast sea-ice drift, the POPS successfully obtained temperature and salinity profiles. Figure 5 shows the first eight profiles measured by the POPS. Interestingly, there are differences in the temperature and salinity profiles over the Lomonosov Ridge and Makarov Basin. The POPS will allow us to accumulate more data and to investigate conditions in the Arctic Ocean.

After confirming whether the POPS had worked well for a month, we began distributing POPS data to Global Telecommunication System (GTS). These data are the first Argo profiling data sent from the Arctic Ocean. Because the expected lifetime of the equipment is more than 2 years, the POPS will be able to send data until it moves out from the sea ice area (or until a polar bear eats the buoy...).

The POPS may also be able to monitor oceanographic conditions under the "Fast ice" (i.e., coastal stable ice) in the Antarctic coastal region. As we are approaching the International Polar Year (March 2007 to February 2009), we hope that many POPS will be deployed in the polar oceans and that their data will be used not only by the polar oceanographers but also by global climate change researches.

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NEWS In BRIEF

ARGO or Argo?

A frequent question that is asked is whether the name of our project should be ARGO or Argo and whether ARGO is an acronym.

Here is the definitive answer :-

- ARGO was originally an acronym "Array for Realtime Geostrophic Oceanography" - a proposal prepared by Dean Roemmich before OceanObs'99.
- Following the amalgamation of this proposal with that prepared by Ray Schmitt for GOSAMOR (Global Ocean SAlinity MonitOR-ing) the name ceased to be an acronym and became Argo (named after Jason's ship in Greek mythology.

The Argo Steering Team strongly encourages you to refer to the project as Argo. We will very soon have modified logos and all our web site material will be made consistent with this policy.

Velocity data - a progress report

Velocity data from Argo provide a valuable supplement to the profiles but, in order to produce the best possible data set, care needs to be taken to estimate the exact times at which each float starts and ends its profiling.

Brian King (UK) and JJ Park (Korea) have been leading work on this problem for some while and an informal meeting was held in Venice to make progress on developing and implementing a consistent treatment of velocity data across all float types. A workshop is planned for October in Korea. (See calendar on page 5).

The Venice meeting included Nickolai Maximenko who, with colleagues from the IPRC in Hawaii, had just issued an Argo-based set of surface and subsurface velocity fields. (YoMaHa'05)

http://apdrc.soest.hawaii.edu/projects/yomaha05/index.html

The IPRC product will eventually be refined to take into account the agreed methodology.

Did you see this float in Venice?

Constructing an Argo user database.

Many people are now downloading data from the two Argo Global Data Assembly Centres. In order to help the Steering Team to know who are our "customers" and for what purpose the data are being downloaded, Mathieu Belbéoch our Argo Technichal Co-ordinator in Toulouse has prepared an online questionnaire asking:-

- The user's job
- Their location
- What kind of an organisation they work in
- What is their main means of getting information about Argo
- Whether they are satisfied with the information sources
- How they plan to use Argo data and for what area(s)
- How and from where they access Argo data
- How satisfied are they with data access.

We already have over 50 replies. Please complete it next time you download data.

Argo certificates

In the past year we have issued Argo certificates to the Kaimimoana (Second Certificate - 40 floats), to the TAO project (second certificate - 44 floats), to RV Knorr (21 floats) and to Gopillil Radhakrishnan for his services as the Indian representative on the Argo Steering Team.

Please address any further requests for certificates to argo@ucsd.edu.

More ice profilers

In addition to the Japanese work reported on Page 7 there are other groups working on under ice profilers. Notable among these are a group led by John Toole at Woods Hole who have an ice-tethered profiler (ITP) that is powered up and down the mooring line. A description of this instrument will soon appear in EoS. See http://www.whoi.edu/itp.

Researchers at the Alfred Wegener Institute (AWI) in Germany gave an update on their Hybrid Antarctic Float Observing System (HAFOS) at the Venice workshop. Unlike the US and Japanese systems HAFOS is a true under ice float capable of producing trajectories using acoustic tracking. The floats detect if they are under ice using an algorithm to estimate if they are encountering freezing conditions. The presentation on HAFOS by Olaf Klatt and collaborators can be viewed on the Argo web site link to the Venice workshop.

It is hoped that these systems will play a significant role in the coming International Polar Year.

How ocean forecasting benefits from Argo

Jean-Michel Lellouche,Marie Drévillon, Sophie Baudel, Mercator Océan, 8/10 rue Hermès, Parc Technologique du Canal, 31520 Ramonville Saint Agne, France.[jlellouche@mercator-ocean.fr]

The Mercator Océan Monitoring and Forecasting System is routinely operated in real-time in Toulouse by the Mercator Project since early 2001. It has been regularly upgraded through three prototypes of increasing complexity (PSY1, PSY2 and PSY3), expanding the geographical coverage from regional to global, improving models and assimilation schemes.

We focus here on the North Atlantic and Mediterranean High Resolution Prototype PSY2 and ocean forecasting benefits from the use of Argo data. The ocean model is based on OPA-8.1, a general circulation model developed at LODYC (IPSL Paris), and is designed to simulate the Atlantic and Mediterranean oceans with a very high horizontal resolution (5 to 7 km). The assimilation system is based on the Reduced-Order Optimal Interpolation algorithm and uses 1D vertical multivariate EOFs to extract statistically-coherent information from the observations. The multivariate PSY2v2 system assimilates conjointly altimeter data from the SSALTO/DUACS database, RTG-SST Sea Surface Temperatures from NCEP and in situ observations from the CORIOLIS database, including Argo temperature and salinity profiles. The previous version of the system (PSY2v1) only took into account the satellite Sea Level Anomalies (SLA) in the data assimilation process. Therefore, the impact of the use of the Argo floats measurements by the forecasting system can be assessed in a quantitative way by comparing the results of the two versions of the system. One example is that of the Bay of Biscay, along a vertical section extending from southern Brittany to La Coruña, in north-western Spain (Fig 1)

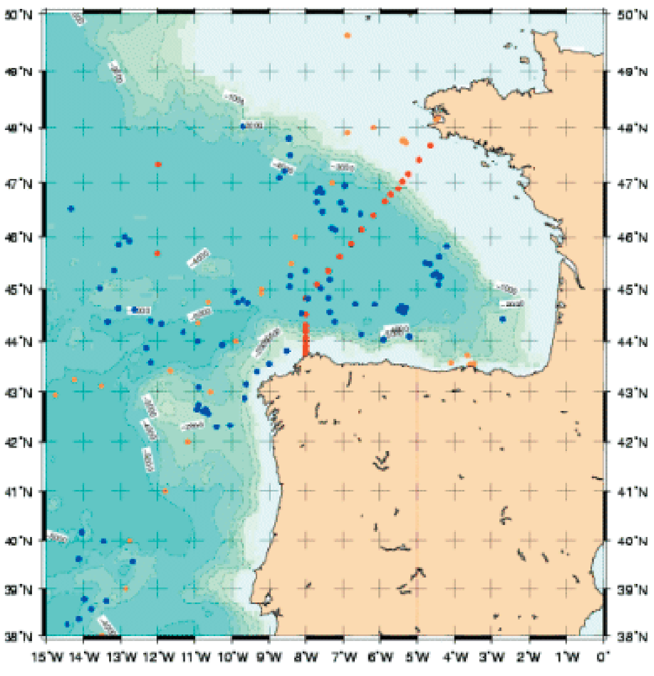

Figure 1 : Positions of the Argo floats (blue dots) and also of CTD measurements (red dots) and XBT measurements (orange dots) obtained by the Thalassa research ship on a cruise funded by the Spanish Institute of Oceanography (IEO). These measurements are assimilated into the PSY2v2 prototype.

Temperature measurements obtained by the Thalassa, are compared on Figure 2 with results from the Mercator system, both from its previous version PSY2v1 (without assimilation of in situ data) and its current version PSY2v2 (which does assimilate in situ data, in particular that from the Argo floats).

In situ measurements improve the performance of the system, as expected. This is particularly true for the ocean surface: the temperature

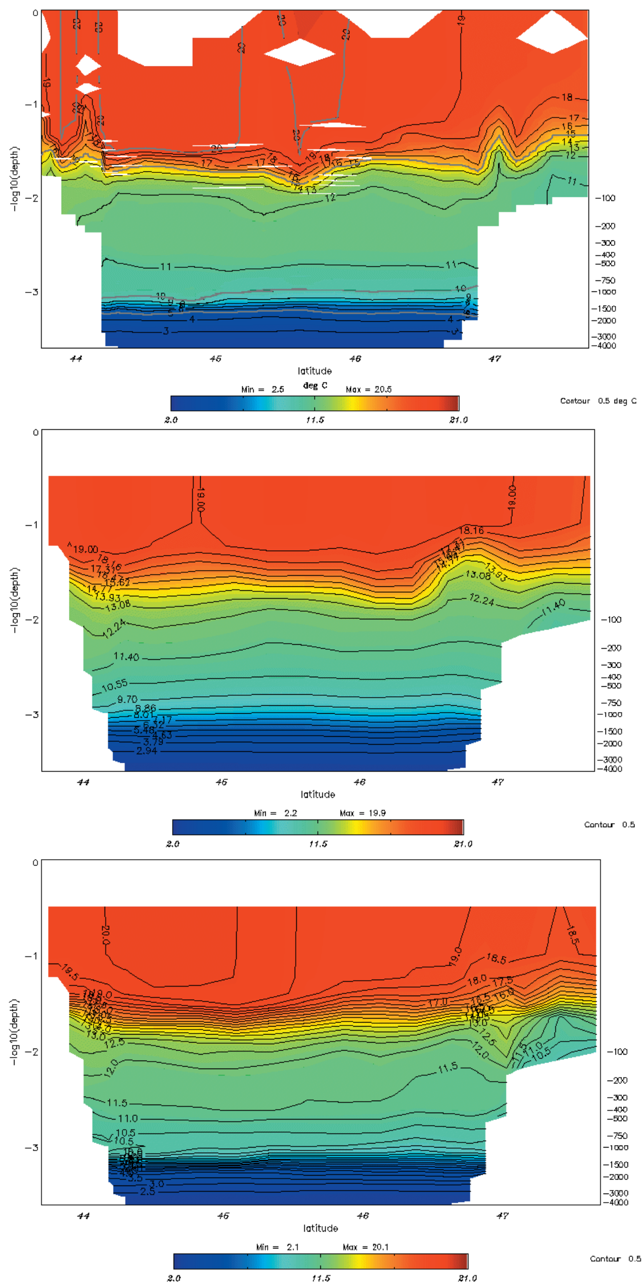

Figure 2 :

- *Measured temperature section (top panel)*
- *PSY2v1 temperature section without assimilation of in situ data (middle panel),*
- *PSY2v2 temperature section with assimilation of in situ data (bottom panel).*

of the mixed layer and the gradient of the thermocline are both more accurately characterised (the temperature is warmer and the gradient steeper). This is also true at deeper levels, particularly with large-scale phenomena which are better simulated as more than a year's worth of in situ data has been assimilated.

This improvement is even more apparent in the salinity sections (Figure 3). One of the characteristics of the waters in the Bay of Biscay is the presence of Mediterranean Water, which is saltier than Atlantic

Continued on page 10

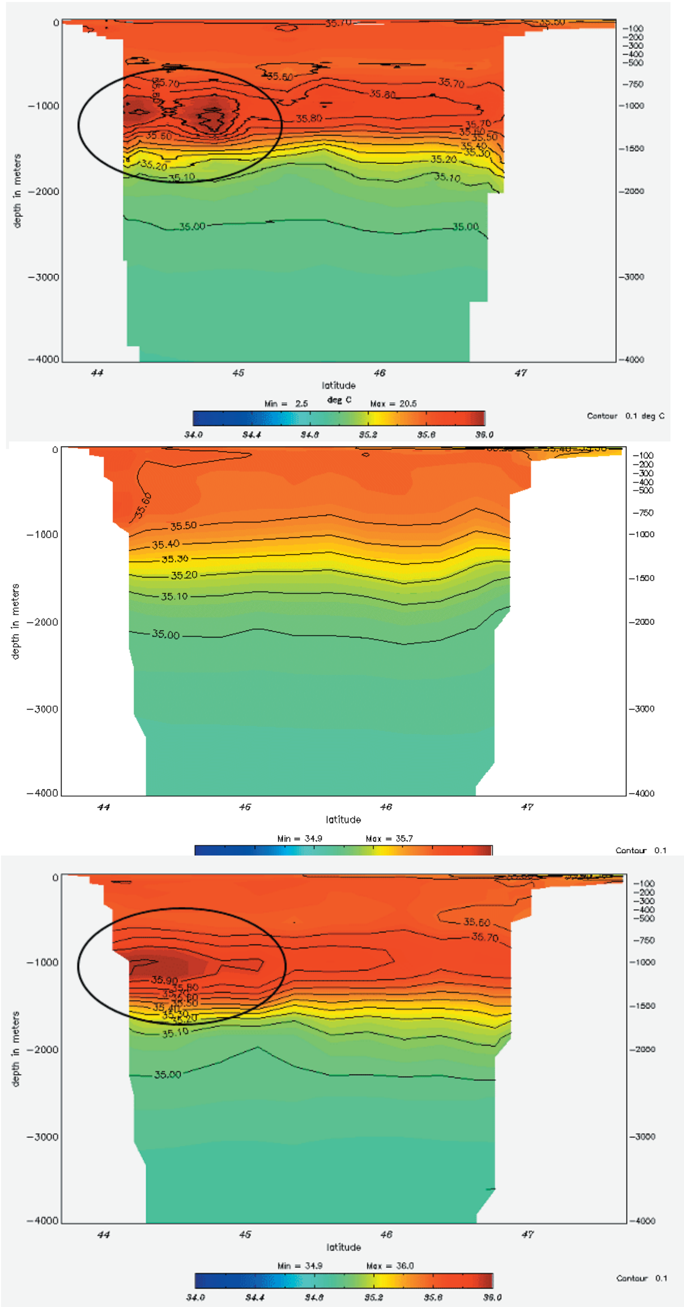

Figure 3 :
•Measured salinity section in psu (top panel),
• PSY2v1 salinity section without assimilation of in situ data (middle panel),
• PSY2v2 salinity section with assimilation of in situ data (bottom panel). The black circle corresponds to the presence of Mediterranean Water.

water and is found at depths of around 800 m to 1200 m. This water comes from the Mediterranean Sea and flows deep down through the Straits of Gibraltar.

This water mass, which was not simulated by the old version (middle panel) is shown in the new simulation (bottom panel) at the correct depth, with correct salinity values. The salinity of surface waters is also better simulated: saltier than without assimilation of in situ measurements. Lastly, other specific salinity structures, caused by the continental shelf, are also better simulated with the assimilation of in situ measurements. The PSY2v2 high resolution forecasting system prepares the future MERSEA global multivariate system at 1/12° horizontal resolution, planned for 2008. Comparisons with the PSY3v1 global ¼° forecasting system (currently running operationally and assimilating only satellite SLA) and with in situ measurements (Figure 4) also illustrate the improvements that we can expect from the additional assimilation of in situ profiles in the global system.

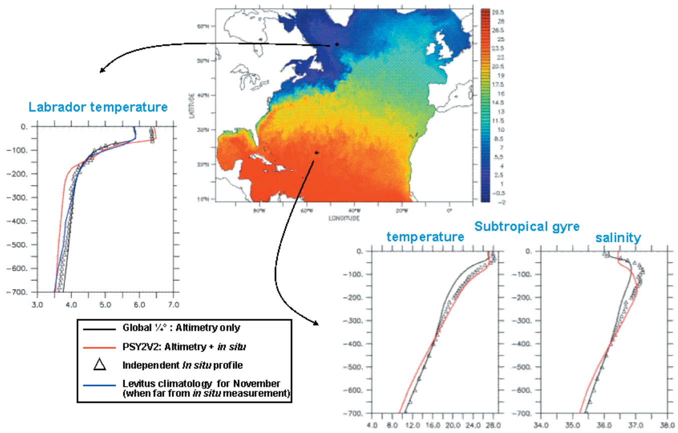

Figure 4 : The global ¼° PSY3v1 and PSY2v2 results are compared with in situ measurements located in the Labrador Sea and in the subtropical gyre on the 8th of November.

The PSY3v1 Labrador sea temperature (in black) is close to the Levitus climatology (in blue), whereas the high resolution multivariate system PSY2v2 temperature (in red) is closer to the in situ profile (triangles), even before this particular profile is assimilated by the system (which is the case here).

In the subtropical gyre, the global ¼° temperature and salinity is fresher and colder than the *in situ* observations (which in this case are close to the climatology). This is a well known drawback of the density correction that is applied when only altimetry data is assimilated. This bias does not appear in the high resolution multivariate system PSY2*v2*(in red).

Early evaluations of the contribution made to the Mercator simulations by *in situ* measurements in general and the Argo floats in particular thus suggest that the qualitative leap is comparable to that experienced in meteorological forecasting when balloon probes were first launched into the atmosphere across the world. Further improvements will come not only from an increase in the number of these profiling floats, but also, to a great extent, from an improvement in the methods used to assimilate these data into the ocean models.

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Report of Second Argo Science Workshop
Venice, Italy, March 15 -18, 2006

Argo's Second Science Workshop (ASW-2) was held in conjunction with a week-long symposium celebrating 15 Years of Progress in Satellite Radar Altimetry arranged by ESA. It had been over 2 years since Argo's first workshop in Tokyo, Japan in November 2003 and in that time the Argo array had grown from one that was only 50% complete and had major gaps to an array that was close to the global objective of 3000 floats. It was natural therefore that in that time a great deal of progress would be made and many new results would be available.

The Symposium and workshop were held in the grand surroundings of the Palazzo del Casino in Venice Lido.

As has become the norm, the meeting was a mix of poster and oral presentations and despite the late decision to hold ASW-2 in Venice (the first announcement was made at the end of July) there was an excellent response.

ASW-2 consisted of a full day of oral presentations on Wednesday March 15 as part of an "Intergrated Approach" session for the Altimetry Workshop that highlighted particularly the close interdependence of Argo and altimetry.The main Argo days were Friday and Saturday. These were attended by as many as 200 scientists and fostered lively discussions. The themes of the oral sessions were

- Heat and salt
- Watermass properties
- Ocean circulation
- Climate applications and operational use
- The upper ocean
- New technologies and future prospects.

The posters were on display for both days. ASW-2 concluded with a question and answer session.

On Tuesday and Thursday the opportunity was taken to hold an informal workshop on the production of velocity fields from Argo. (See page 8)

The Argo workshop included 92 submitted posters, 43 Argo-related oral presentations and involved authors and co-authors from 26 countries. It is hard to single out highlights from the many excellent posters and presentations but among the general themes were :-

- The increasing use of Argo data by operational centres and their growing dependence on this data source (See the articles on pages 4 and 9 of this Newsletter.
- The start of availablity of Argo based products (There is now an Argo products page available at (http://www-argo.ucsd.edu/AcProduct_page.html)
- The global nature of Argo now means that it can start to play a major role in monitoring changes in global heat content.
- There are many new sensors being added to profiling floats. Oxygen measurements hold great promise (See Page 2)
- Great progress is being made with both real-time and delayed-mode data quality control.
- There is real concern that the excellent altimetry coverage that we have relied on since the early 1990s seems increasingly uncertain as one looks to the future.

Thanks are due to Jerome Benveniste and Yves Menard (ESA) for their help in accomodating Argo at such short notice, to IOC for providing funding for 6 scientists and to NOAA for their funding of the ASW-2 share of the infrastructure costs and to Webb Research Corporation and the UK Met Office for funding and printing the ASW-2 programme.


Waiting for the bus


A grand entrance


Posters


Discussion session Saturday evening - still 150 attendees

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The complete Argo bibliographies can be found at

http://www.argo.ucsd.edu/FrUses_of_Argo_data.html

How to acknowledge Argo data

The Argo Steering Team encourages the use of a standard acknowledgement in publications that use Argo data :- *" These data were collected and made freely available by the International Argo Project and the national programmes that contribute to it. (www.argo.ucsd.edu, argo.jcommops.org). Argo is a pilot programme of the Global Ocean Observing System"*. People using Argo float data should, as a courtesy, contact the person responsible for the floats used and outline the type of research or analysis that they intend to carry out.

Argonautics is the Newsletter of the international Argo project.

Please send articles for *Argonautics* to argo@ucsd.edu or to Mathieu Belbéoch, Argo Technical Co-ordinator (belbeoch@jcommops.org)

Permission to quote an article from *Argonautics* should be obtained from the author.

Information about Argo can be found at www.argo.ucsd.edu and from the Argo Information Centre argo.jcommops.org. The AIC site includes informtion about the present (and past) distribution of Argo floats. Argo data may be downloaded from the Global Data Centres www.usgodae.org/argo/argo.html and www.ifremer.fr/coriolis/cdc/argo.htm