Number 2
August 2003

Argonautics

Newsletter of the international Argo project

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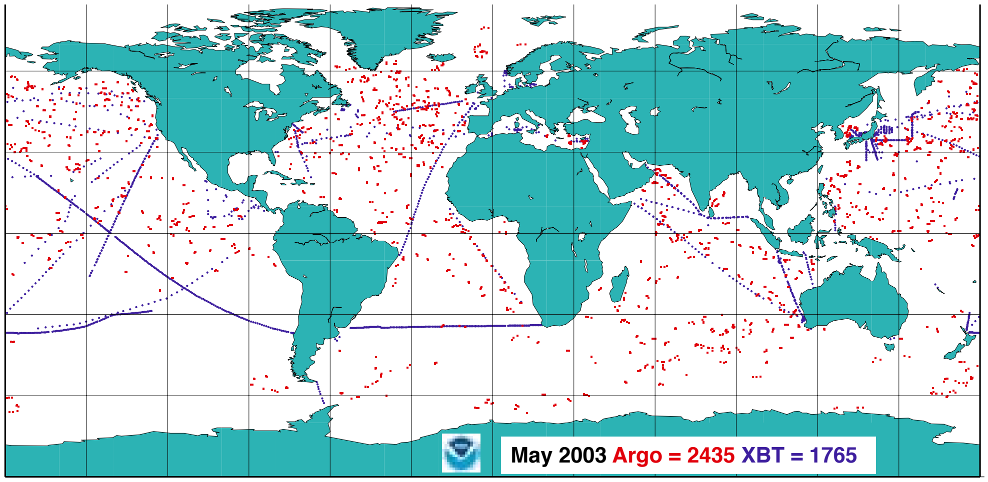

Figure courtesy of NOAA, AOML, Miami

Editorial

This month's front page picture tells an intersting story of the development of Argo. It shows for May 2003 the number and distribution of Argo profiles and of profiles from the high density XBT network. All these data were available to users within 48 hours of the observations being made either from the Argo global data assembly centres (GDACs) or via the Global Telecommunication System (GTS). Since these data are for a 1 month period and most Argo floats profile every 10 days, each red dot represents typically 2 profiles of temperature and salinity to between 1000 and 2000m. The global distribution still has many gaps but most of the three northern hemisphere oceans has good coverage. That coverage is clearly of much greater value for the calculation of global fields than are the XBTs (confined to shipping lanes, temperature only and 750m or shallower). It should be noted however that Argo is not in competition with and is not designed to replace the HD XBT network.

At the beginning of August 2003 there were 860 Argo floats operating (29% of the target array and a net increase of 97 floats since the last issue of *Argonautics* at the end of April 2003).

Argo and altimetry. The science article on page 2 gives a very nice example of the synergy between Argo profiles and satellite altimetry. Argo depends on the continued availability of high quality satellite altimetry data. At present we have an unprecedented 4 altimeters (ERS-2, Topex-Poseidon, Jason-1 and ENVISAT) and in the past month the European EUMETSAT group agreed the funding structure to allow a follow-on Jason-2 mission to be prepared.

Global observations, both *insitu* and space-based were the subject of a summit conference held in Washington DC on July 31st. This has provided a real impetus towards the commitment of resources to global observations (See *Stop Press* on page 8). An Argo "flyer" was included in the papers for the meeting and can be downloaded as a PDF file from (www.argo.ucsd.edu)

Technical discussions are a vital part of ensuring that Argo is implemented as efficiently and as effectively as possible. These discussions need to involve float and sensor manufacturers, those who build and deploy floats and those who use the data. Inevitably as the project progresses, new technical problems will be discovered and overcome.

It is often not recognised just how challenging Argo is from a technical standpoint. Each float is expected to work autonomously in a hostile environment for several years and to deliver data that scientists will want (as always) to exploit to the limit of their accuracy. It also has to be remembered that the cycle time to identify and rectify any technical problem may be of the same order as a float lifetime. Thus, continuous scrutiny of float performance and data quality and the early dignosis of problems is essential for Argo's wellbeing. Please use the technical forum on the Argo Information Web site to exchange views about these issues.

Argo countries. In this issue we welcome Mauritius (see page 5) to the Argo family. By the end of the year we expect to be able to announce two more float-providing countries. Argo wishes to recognise the help it receives from countries in deploying floats from research vessels and from ships of opportunity. Substantial assistance has already been given to Argo by Iceland, Indonesia and South Africa. This list of Argo countries will surely grow and we express our thanks here for these important contributions,

Historical Footnote. In April 1989, Henry Stommel wrote a fictional article* describing how by 2020 the world's oceans would be monitored by a fleet of autonomous Slocum vehicles that could, on a monthly basis, repeat all the (10,000) hydrographic stations that were occupied during WOCE. The map at the top of this page shows that Argo is already a long way towards achieving Stommel's vision.

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* Stommel, Henry (1989): The Slocum mission, *Oceanography.* **2**,*1, April 1989.* The Oceanography Society, Washington, D.C., USA.

Combining Argo and remote-sensing data in the North Atlantic

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Despite the impressive increase in the number of temperature and salinity profiles from the Argo array, in-situ data still undersample the temporal and spatial variability of the ocean thermohaline structure. In contrast, remote-sensing measurements provide synoptic observations of sea level and sea surface temperature (SST) over the world ocean, but with no direct estimation of the ocean's vertical structure. In order to reconstruct instantaneous temperature (T) fields at high temporal and spatial resolution, a merging method is developed to combine the accurate but sparse in-situ T profiles with the high-resolution but less accurate (as synthetic T profiles) altimeter and SST measurements.

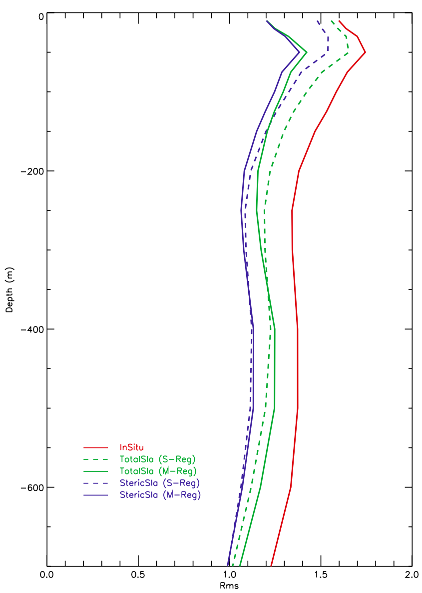


Figure 1: RMS of in-situ T anomalies (calculated from the Levitus monthly mean climatology) (red curve).
RMS of differences between in-situ T fields and synthetic profiles from total SLA (Green) and steric SLA (Blue) and from simple (SLA - dotted line) or multiple (SLA+SST - full line) regression method.

Three sources of data from the year 2002 are used. In-situ T profiles are from the Coriolis center and correspond to real-time data including Argo profiling floats and also XBT and CTD measurements. Altimeter sea level anomalies are from the SSALTO/DUACS center and are weekly combined maps of Jason-1 (Topex/POSEIDON), ERS-2 and GFO with a 1/3° Mercator horizontal resolution. SST data are from the NAVOCEANO center and correspond to maps of weekly means of MCSST AVHRR with an 18-km horizontal resolution.

[1] http://www.coriolis.eu.org/coriolis
[2] http://www.aviso.oceanobs.com/duacs
[3] http://podaac.jpl.nasa.gov/navoceano_mcsst

The first step of the method consists of deriving synthetic T profiles from the surface down to 700-meter depth from altimeter and SST data through a multiple linear regression method. Pre-processing of altimeter SLAs includes the extraction of the steric part of the SLA using regression coefficients deduced from an altimeter/in-situ comparison study (Guinehut et al., 2002). Validation of the vertical projection of SLA and SST is performed on a subset of 3,500 T profiles from the year 2002. Results indicate that extracting the steric part of the SLA greatly reduces the differences between the in-situ reference profiles and the reconstructed synthetic profiles (Figure 1). The impact of SST is also clearly visible from the surface down to 300-meter depth where SST compensates the weak correlations between SLA and temperature, which means that SST is highly complementary to SLA when deriving T profiles from remote-sensing measurements.

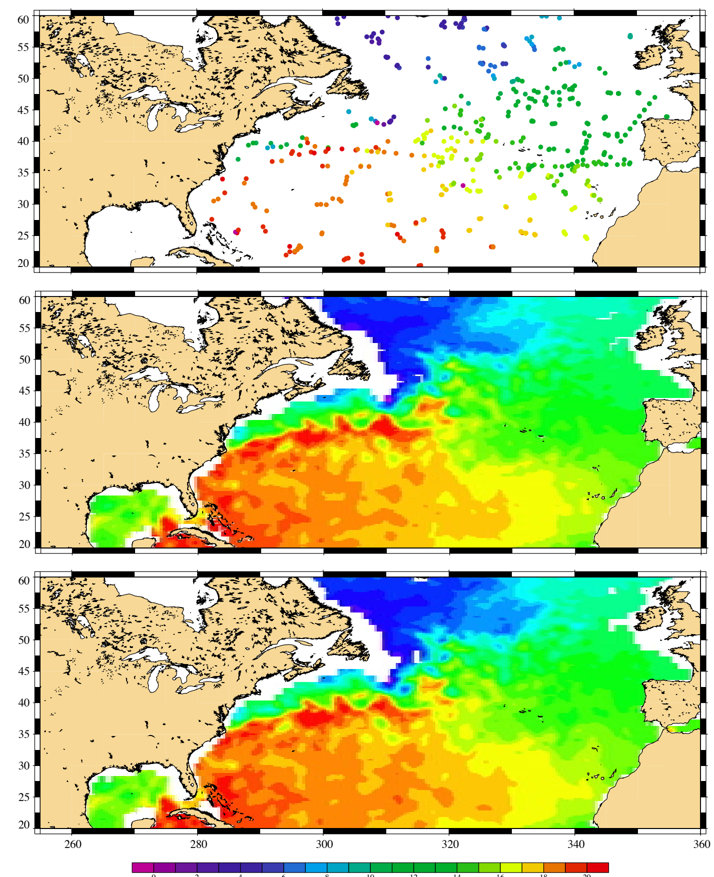


Figure 2: Instantaneous T field at 200 m (10 Feb 2002) from
Top - in-situ data selected within a ±5 day window
Middle - synthetic T and
Bottom - merged synthetic and in-situ T (in °C).

The second step of the method consists in combining the synthetic profiles with in-situ T profiles using an optimal interpolation method (Bretherton et al., 1976). Analyses are performed weekly on a 1/4° horizontal grid on each Levitus vertical level from the surface down to 700-meter depth. To gain maximum benefit from the qualities of both data sets, namely the accurate information given by in-situ T profiles and the mesoscale variability given by the T synthetic profiles, a precise statistical description of the errors of these observations must be introduced in the optimal interpolation method. For the in-situ profiles, since these observations are considered almost perfect, a very low white noise is applied. For the synthetic profiles, simulating remote-sensing (altimeter and SST) observations, since these observations are not direct measurements but are derived from the regression method, correlated errors have to be applied to correct long-wavelength errors or biases present in the synthetic fields and introduced by the regression method.

The merging method performances are analyzed by comparing merged fields with in-situ and synthetic profiles used to construct the merged fields. An example is shown in Figure 2 for an instantaneous T field at 200 meters. The merged field shows warmer T in the Azores area than those derived from remote-sensing measurements, and colder T in the Northern part of the domain, which demonstrates the ability of the merging method to take into account the information contained in the sparse in-situ measurements to correct the synthetic fields.

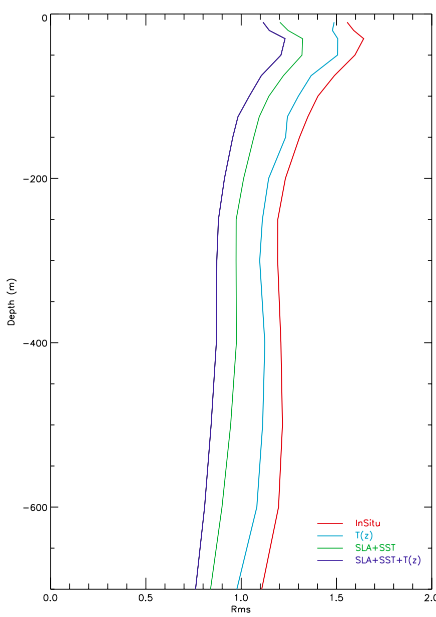


Figure 3: Rms of instantaneous T anomalies from set 2 (red) and rms error in predicting subsurface T anomalies using only in-situ profiles from set 1 (turquoise), using only synthetic profiles (green) and using in-situ combined with synthetic profiles (blue). Statistics are-calculated over the whole studied domain (in °C).

The merging method is now validated using an independent data set. The in-situ T data set of the year 2002 is divided into two sets; set 1 to be combined with synthetic profiles, and set 2 to be used to validate the merged fields. Statistics over the year 2002 (Figure 3) indicate that the rms of mapping error is greatly reduced for all depths when combining synthetic and in-situ profiles, compared to the results obtained using only in-situ (T(z)) or remote-sensing (SLA+SST) data. For example, at 200-meter depth, mapping error decreases from 1.15°C when using only in-situ data to 1°C for the synthetic profiles and to 0.9°C for the combination. Moreover, results obtained using only remote-sensing profiles are better than those obtained using only in-situ profiles. This is because it is impossible to obtain fields at high temporal and spatial resolution by any means using in-situ profiles alone, due to aliasing of mesoscale variability.

The method is now illustrated along a cross-Atlantic section between Gibraltar and Florida (Figure 4).

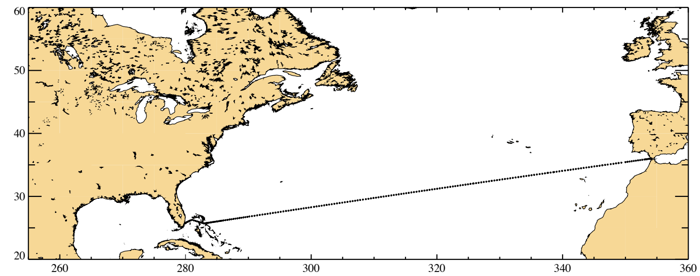


Figure 4: Hydrographic section between Gibraltar and Florida (28 February - 9 March 2002).

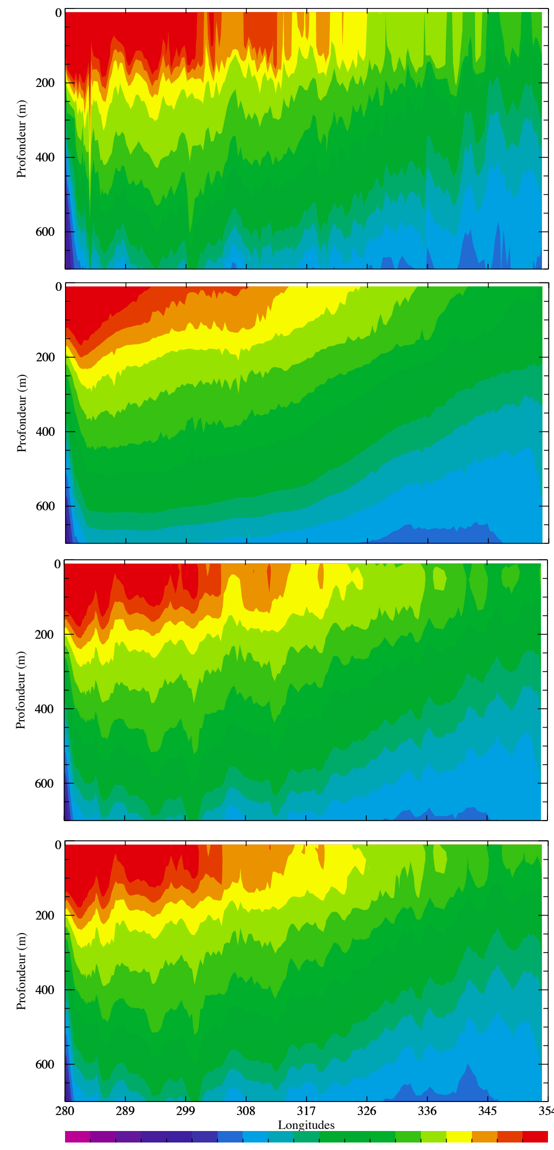


Figure 5: T field (in °C) from
Top the Gibraltar/Florida section,
Next Levitus monthly mean climatology,
Next the vertical projection of SLA and SST, and
Bottom combination of synthetic and in-situ profiles.

Temperature sections from the in-situ measurements, the Levitus monthly mean climatology, the vertical projection of satellite SLA and SST, and from the combination (SLA, SST, in-situ profiles, except those from the Gibraltar/Florida section) are compared in Figure 5. The large-scale structure of T is relatively well represented by Levitus monthly mean climatology. Temperatures are nevertheless too cold in the surface layers for all longitudes. In addition to the large-scale structure, the vertical projection of SLA and SST restores the mesoscale variability present along the section as well as T much closer to the in-situ data. Further constraints added by a few near in-situ profiles correct the synthetic field appreciably to produce a combined field closer to the in-situ reference field. Statistics calculated over the 180 profiles of the section indicate that the combination induces an rms error of 0.5°C. This is half the rms difference between the section and the monthly Levitus climatology. Additionally, even if the merging method is performed individually on each vertical level, the combined field shows very good vertical coherence.

This study confirms that it is possible to combine accurate but sparse in-situ data with high-resolution satellite altimeter and SST measurements. The merging method developed makes it possible to estimate the North Atlantic T field with a mean precision of 1°C over the first 700 meters. Considering the precision of such analyses, the combined T fields can be used to study the ocean heat content variability (heat transport, variability along specific hydrographic sections, etc.). Furthermore, more than 50% of the in-situ data come from profiling floats in our studied area where Argo is already close to its nominal resolution (particularly thanks to the European Gyroscope project, which deployed more than 80 instruments during the last three years). This underlines the major role of the Argo data set in studying the variability of the vertical structure of the ocean at high temporal and spatial resolution.

References

Bretherton, F. P., R. E. Davis, and C. B. Fandry, 1976: A technique for objective analysis and design of oceanographic experiments applied to MODE-73, Deep-Sea Res., 23, 559-582.

Guinehut, S., P.-Y. Le Traon, and G. Larnicol, 2002: A comparison between altimeter data and in-situ temperature and salinity profile measurements over the global ocean during 1993-2001, WOCE and Beyond international conference, San Antonio, Texas

Acknowledgements

This study was carried out as part of the French Mercator project activities. It was partly funded by CNES and the European Commission as part of the Gyroscope project.

Argo Technical discussions - how to get involved

John Gould, Argo Director,
Mathieu Belbéoch, Argo Technical Co-ordinator

Argo is using profiling float technologies that have been evolving since the first such floats were deployed in the early 1990s (Ref). We now have two commercially manufactured designs the APEX (Webb Research Corporation) and the PROVOR (SERPE-France and Metocean - Canada) as well as the SOLO float built by Scripps Institution of Oceanography. New designs from Japan and China are in the development phase.

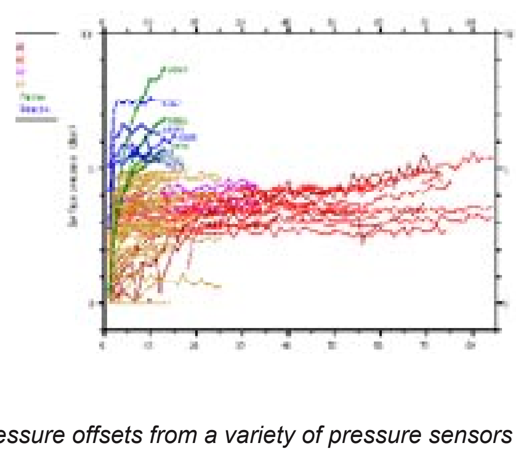
The project neeeds to keep the performance of the floats and their sensors under constant review so that we can maximise data return and quality. This, in a project that involves laboratories and research groups from 16 countries and with the multiplicity of float types, sensors and deployment methods, is a daunting task. Since the Argo Information Center was established there has been a web-based Technical Discussion forum where technical notes can be posted. Alerts are sent out to subscribers when a new note is posted.

Topics that have been discussed in recent weeks are

- the benefits (improved data transmission in high sea states) and problems (impact on energy budget, effect on salinity sensors) of having damper plates on floats
- the technical difficulty of trying to measure atmospheric pressure from floats,
- do floats pick up sediment when they run aground?

Most recently Ken Ando (JAMSTEC) posted a note about the time history of zero pressure offsets in APEX floats. The full note can be accessed by subscribers to the Technology forum.

We encourage all who are using floats in Argo to use the forum so as to alert your colleagues to problems you have encountered or solutions you have found and so to improve the performance of the Argo array..



Pressure offsets from a variety of pressure sensors on APEX floats (K. Ando, JAMSTEC)

Mauritius becomes a contributor to the Argo programme

Jon Turton, UK Met Office
(E-mail jon.turton@metoffice.com)

Since the initial Indian Ocean Argo Implementation meeting in June 2001, Argo has developed rapidly in the Indian Ocean with over 150 floats now operating in the region. In November 2002 the Indian Ocean GOOS (IOGOOS) alliance was established during its First Conference held in Grand Bay, Mauritius. During this conference a number of collaborations were established, in particular one between UK and Mauritius on Argo. Following the IOGOOS Conference an Apex float, funded through UK Argo, was delivered directly from Webb Research Corporation to the Mauritius Meteorological Services, to be deployed in a location of particular interest to Mauritius.

The float was delivered to Mauritius in March 2003 and on 19th June was formally handed over, on behalf of the UK Met Office, by the British High Commissioner, His Excellency Mr David Snoxell. The Permanent Secretary of the Prime Ministers Office, Mrs K. Beegun, received the float on behalf of the Mauritius Meteorological Services. The handing-over ceremony was held on the deck of the National Coast Guard Vessel "The Guardian" moored in Port Louis Harbour, and was attended by a number of eminent personalities including the High Commissioner of Australia. The ceremony was covered in peak time news on national television, radio and by the leading newspaper of Mauritius.

Mr. K. Issuree, Principal Electronic Technician of the Mauritius Meteorological Services and the officers of the National Coast Guard a few minutes prior to launching the float near the St. Brandon Islands.

During the afternoon the ship left Port Louis and sailed to the St. Brandon Islands where the float was launched by several technicians from the Meteorological Services. The float (WMO number 1900177, Argos ID 9412) has since reported its first profile and the data are being provided in real-time by the UK Argo Data Centre to the Mauritius Meteorological Services.

It is hoped to build on this collaboration over the coming years with UK Argo providing further floats to the Mauritius Meteorological Services for deployment in Indian Ocean waters around Mauritius.

For further information contact:
Mohomudally Beebeejaun, Argo Project Officer in Mauritius
Jon Turton, UK Argo Programme Manager

Stop Press
Earth Observations Summit

As a step toward building an international, comprehensive, integrated and sustained Earth observation system, the United States hosted the Earth Observation Summit on July 31, 2003 in Washington, D.C. The Summit was attended by ministerial level representatives of 34 countries and by 30 international agencies.

The summit adopted a *DECLARATION OF THE EARTH OBSERVATION SUMMIT* that :-

Affirm the need for timely, quality, long-term, global information as a basis for sound decision making. In order to monitor continuously the state of the Earth, to increase understanding of dynamic Earth processes, to enhance prediction of the Earth system, and to further implement our environmental treaty obligations, we recognize the need to support:
(1) Improved coordination of strategies and systems for observations of the Earth and identification of measures to minimize data gaps, with a view to moving toward a comprehensive, coordinated, and sustained Earth observation system or systems;
(2) A coordinated effort to involve and assist developing countries in improving and sustaining their contributions to observing systems, as well as their access to and effective utilization of observations, data and products, and the related technologies by addressing capacity-building needs related to Earth observations;
(3) The exchange of observations recorded from in situ, aircraft, and satellite networks, dedicated to the purposes of this Declaration, in a full and open manner with minimum time delay and minimum cost, recognizing relevant international instruments and national policies and legislation; and
(4) Preparation of a 10-year Implementation Plan, building on existing systems and initiatives, with the Framework being available by the Tokyo ministerial conference on Earth observations to be held during the second quarter of 2004, and the Plan being available by the ministerial conference to be hosted by the European Union during the fourth quarter of 2004.
To effect these objectives, we establish an ad hoc Group on Earth Observations and commission the group to proceed, taking into account the existing activities aimed at developing a global observing strategy in addressing the above. We invite other governments to join us in this initiative. We also invite the governing bodies of international and regional organizations sponsoring existing Earth observing systems to endorse and support our action, and to facilitate participation of their experts in implementing this Declaration.

The summit established an *ad hoc* Group on Earth Observations (GEO) that will prepare a framework document before the next ministerial level meeting in early 2004. The GEO will prepare a 10 year implementation plan for a sustainable Earth Observation System(s) (EOS) building on existing systems and focusing on data integration and user requirements.

Further information can be found at
http://www.earthobservationsummit.gov/

Argo will be a centrepiece of the ocean component of this activity.

First Argo Science Workshop
Tokyo, Japan
November 12-14 2003

Planning for the workshop is now advancing rapidly, all invited speakers have accepted their invitations and submissions of science presentations are building steadily.

The meeting will be held at the Yakult Hall in the Ginza district of central Tokyo. This is a modern conference room with excellent facilities and will be an ideal venue for the plenary talks, poster sessions, and exhibits by float and sensor manufacturers. Blocks of rooms have been held at 5 nearly hotels and can be booked via a link from the Argo web site (www.argo.ucsd.edu).

Deadlines

15 September	Final date for submission of abstracts
22 September	Confirmation of acceptance of abstract and allocation of travel funds (if requested)
12 October	Final date to book accommodation at Conference rates
12 November	Workshop starts

Why should you attend? If you are already involved in analysing Argo data this is a chance to see what others are doing, to exchange ideas and to form partnerships. The science presented will range through the impact of extreme events (hurricanes, typhoons) on the ocean, studies of processes in the high latitiude winter oceans, data assimilation, ocean state estimation and ocean forecasting, detecting anthopogenic climate change ,...... etc. etc. All ocean scientists should see this as an opportunity to learn more about a new data source that is already making a significant impact in ocean science. The workshop is also an opportunity for science managers to gain an insight into the potential of Argo.

We look forward to seeing you in Tokyo.

The workshop is co-sponsored by NOAA and JAMSTEC and will also be supported by PICES the Pacific Marine Science Organisation.

Workshop provisional timetable

Wednesday Nov 12

Opening of Workshop

0930 - 1000
- Opening remarks
- Welcome by local hosts
- Welcome from senior NOAA person
- Dean Roemmich (AST Chair)
- KensukeTakeuchi and/or senior JAMSTEC person

Setting the scene – Argo and its sponsors

1000 - 1015 • Argo, background, status and challenges
• John Gould (Argo Director)
• Mathieu Belbéoch (Argo T.C.)

1015 - 1040 • Argo's role in climate science (CLIVAR talk)
• Kimio Hanawa

1040 - 1105 • Argo and GODAE
• P-Y Le Traon

Coffee break

Argo float technology achievements and challenges

1125 - 1150 • Invited talk • Steve Riser

1150 - 1250 • 4 x 15 minute submitted talks

Lunch

1400 - 1600 • Poster session with coffee break

Delivering Argo data to users

1600 – 1625 The Argo data system, its design, achievements and challenges
•Bob Keeley/SylviePouliquen

1625 - 1650 .Delayed-mode Argo data. How good are they?
•Annie Wong

1700 - 1800 • 4 x 15 minute submitted talks

Thursday Nov 13

The operational use of the Argo data

0930 - 0955 • The impact of Argo data on ocean and climate forecasting
•Mike Bell

0955 - 1055 • 4 x 15 minute submitted talks

Coffee break

Long term ocean change

1115 - 1140 • Detecting subsurface theta/S changes
• Brian King

1140 - 1245 • 4 x 15 minute submitted talks

Lunch

1400 - 1600 • Poster session including coffee break

Heat (and freshwater) budgets

1600 - 1625 • Closing the heat and freshwater budgets
• Dean Roemmich

1625 - 1730 • 4 x 15 minute submitted talks

Friday Nov 14

Basin and global scale ocean circulation

0930 - 0955 • Deriving ocean circulation from float data
• Breck Owens

0955 - 1020 • Argo as a complement to other global observations
• Uwe Send (To be confirmed)

1020 - 1120 • 4x 15 minute submitted talks

Coffee Break

Observations in marginal seas

1140 - 1300 • 5 x 15 minute talks

Lunch

Seasonal/interannual variability and short-lived events

1400 - 1425 • Invited talk
•Howard Freeland

1425 - 1530 • 4 x 15 minute submitted talks

Coffee break

1550 - 1640 **Closing session**
• Argo making a difference throughout the world
• K. Radhakrishnan

• Closing remarks and summary Roemmich, Takeuchi

The back page

Bibliography

Recent refereed papers of relevance to Argo

Gille, Sarah T., 2003: Float Observations of the Southern Ocean. Part I: Estimating Mean Fields, Bottom Velocities, and Topographic Steering. *J. Phys. Ocean.* **33**, 1167-1181

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Le Traon, P. Y., Faugère, Y., Hernandez, F., Dorandeu, J., Mertz, F., Ablain, M., 2002: Velocity Mapping Capabilities of Present and Future Altimeter Missions: The Role of High-Frequency Signals. *J. Atmos. Oceanic Tech.* **19**, 2077-2088

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Straneo, F., R.S. Pickart and K. Lavender, 2003: Spreading of Labrador sea water: an advective-diffusive study based on Lagrangian data. Deep-Sea Res., I, **50**, 701-719.

Wong, Annie P. S. and G. C. Johnson, 2003: South Pacific Eastern Subtropical Mode Water , *J. Phys. Ocean.*, **33,** 1493-1509.

Please inform us of any papers not yet listed in *Argonatics*.

Timetable of Argo-relevant meetings

Dates	Venue	Event	More information
2003			
October 10 - 18	Seoul, Korea	PICES-XII	pices.ios.bc.ca
November 5 - 7	Monterey, CA,USA	Argo Data Team - 4	www.usgodae.org/argodm/
November 14 -16	Tokyo, Japan	Argo Science workshop	www.argo.ucsd.edu/
November 18 - 20	Tokyo, Japan	POGO-5	ocean-partners.org
November 18 - 21	Arles, France	Jason SWT	www-aviso.cls.fr/html/swt
2004			
January 26 - 30	Portland, ORE, USA	AGU Ocean Sciences	www.agu.org/meetings/os04/
March 9 - 11	Brest, France	Argo Science Team - 6	www.argo.ucsd.edu/
March 16 - 19	London, UK	Oceanology International	www.oceanologyinternational.com/
April 26 - 30	Nice, France	EGS	www.copernicus.org/EGS/EGS.html
June 21 - 25	Baltimore, MD, USA	CLIVAR Conference	www.clivar2004.org/
2005			
April 25 - 29	Nice, France	EGS	www.copernicus.org/EGS/EGS.html
August 22 - 26	Darwin, Australia	IAPSO - IAG	

Argonautics is the Newsletter of the international Argo project.
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Please send articles for inclusion in *Argonautics* to the above address or to Mathieu Beléoch, Argo technical co-ordinator, (belbeoch@jcommops.org).

Information about Argo can be found at www.argo.ucsd.edu and from the Argo Information Center (argo.jcommops.org). The AIC site includes information about the present (and past) distribution of Argo floats.