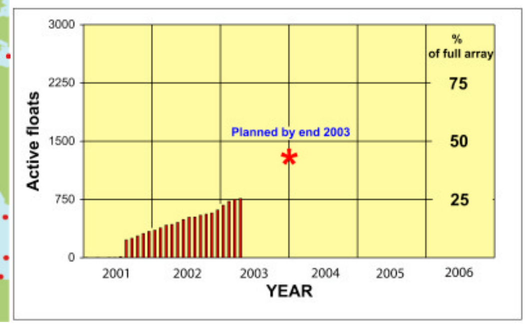
Number 1
Spring 2003

Argonautics

Newsletter of the international Argo project



Float distribution April 24 2003 *763 floats reporting*

Editorial

Welcome to the Argo newsletter. This is the first issue of a quarterly publication describing a project that is starting to revolutionise the way in which we collect ocean data. The purpose of this newsletter is to aid communication inside Argo and between Argo and others. It will be distributed electronically (as a pdf file) that you can browse online or print and post on bulletin boards and share with your colleagues.

We hope that a wide range of readers - scientists already involved in Argo, programme managers, even non-scientists - will find **Argonautics** interesting because this is really an exciting project and one in which all sorts of people can be involved.

The Newsletter will have **regular features**, the first of which will be versions of the figures you see above. They provide a regular update on the number and distribution of Argo floats. The editorial will alert you to issues of current interest. We will also have brief **articles on science** that is being done with Argo data. These will not be peer reviewed. Their purpose is to give a timely insight into the new results being achieved. The first of these notes, identifies significant changes in the Gulf of Alaska that may have serious ecosystem consequences in the coming summer season. Argo is well suited to monitoring of this kind.

We have included a list of published papers on research with profiling floats such as Argo uses. Our plan is that this will build into a comprehensive **bibliography** of the project.

A unique feature of Argo is that **data are available** to anyone who wants to use them. The data system is improving rapidly, but you can download data now.

There are as many applications of Argo data as there are of any oceanographic observations but there are many unique aspects to Argo that allow us to address a new range of oceanographic problems. In particular Argo data will be available from all deep ocean areas of the ice-free oceans and will have an enormous effect on our understanding of the oceans in the winter seasons at high latitude - where conventional observations are sparse.

Argo faces many challenges: technological, logistical, organisational, but the rapid growth of the Argo data set and progressive improvements in the ease of availability of its data are starting to have an impact on a wide range of science applications.

These challenges are being discussed by the Argo Science and Data Teams and you will see **reports of recent meetings** as well as a timetable of future Argo-related workshops and conference sessions.

This Newsletter is experimental so we would like to receive feedback on its content and layout. We look forward to hearing from you.

Editors
John Gould **La Jolla, USA**
Mathieu Belbéoch **Toulouse, France**

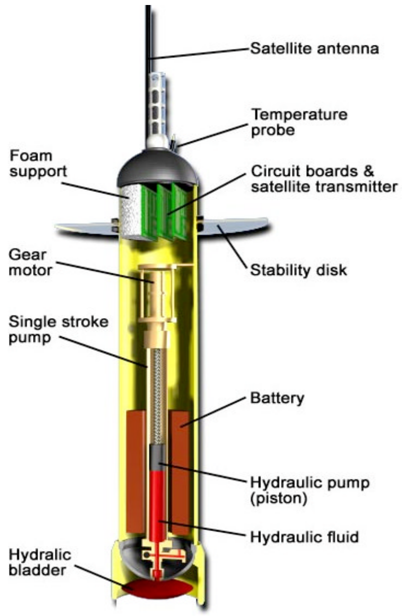
Argo Questions and Answers

What is Argo?
Argo is a project that is deploying an array of floats that drift with the currents at depth (typically between 1 and 2km down) and every 10 days come to the surface. As they rise they measure the temperature and salinity. The data and the float's position are then transmitted to a satellite (this takes up to 24 hrs) and the float dives again to start a new cycle. Argo will build to an array of 3000 floats (about one float in every 300x300km box) by 2006. They will fill the ice-free ocean areas deeper than 2km.

Argo is not an acronym – it is a partner with Jason, a global satellite altimetry project. You should study Greek mythology to learn about Jason and the Argonauts.

How do the floats stay at depth?
The floats are developed from an invention made by a British scientist, John Swallow, in the 1950s. They have a "pressure case" that contains electronics and batteries. Seawater is compressible (as the pressure increases with depth, so the water density increases). The pressure cases are less compressible than seawater and are heavy enough to just sink when they are put in the ocean. As they sink they gain buoyancy so that at some depth, that can be calculated, the density of the float equals the density of the water and so they stay at that level.

How do they go up and down?
When it is time for the float to surface a pump moves oil from inside the pressure case to a bladder on the outside



Cross-section of a typical Argo float

The bladder inflates and increases the volume of the float, the float's mass remains the same so its density decreases and the float rises. When it is time for the float to dive again the oil is drawn back into the pressure case. The floats are battery powered.

Who makes the floats, How much do they cost?
Some floats are made by commercial companies (Webb Research Corporation, Martec, Metocean) and some, (the SOLO design), are manufactured by research institutions (SIO and WHOI). The SOLO plans are available to any technically-capable group that wants to build their own floats. Two new float designs from Japan (NINJA) and China (COPEX) are now being tested.

Each float costs around US$15,000 and has a design life of 3-4 years (approx. 150-200 profile cycles).

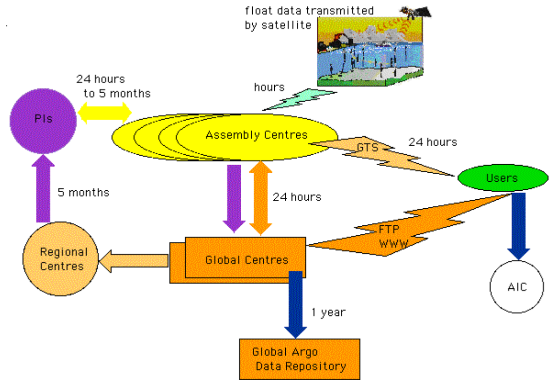
How are the floats put in the water?
Some are deployed from research ships by the scientists themselves, some are launched from merchant ships on passage from port to port and some are dropped from aircraft.

How is the Argo project run?
Argo is an international project and the floats being deployed now come from 14 countries. Scientific planning is done by the Argo Science Team (AST) that is made up of representatives of the contributing countries and other experts. Data management aspects are handled by the Argo Data Team. There is an Argo Director, John Gould, who works with the AST chairman and an Argo Technical Co-ordinator, Mathieu Belbéoch at the Argo Information Centre (AIC) in Toulouse France.

How is Argo funded?
Although Argo is planned internationally it is funded through national programmes. Each of these has its own regional priorities and organisational structure but a condition of being part of Argo is a commitment to building the global array and a willingness for a nation's floats to be deployed anywhere in the world.

What happens to the data from the floats?
The data go by satellite to national data centres and then within 48 hrs to two Argo global data centres (GDACs), one in France and one in the USA and onto the Global Telecommunication System (GTS). Some basic checks on the data quality are done within this real time process and then the data are freely available.

This free availability of data is a fundamental tenet of Argo.



Argo data flow schematic

As data accumulate a considerable effort is made by individual scientists to assess the quality of the salinity data and to identify what corrections if any need to be applied. This delayed-mode data stream is still developing. The data will finally be archived by the US NODC.

Are the velocity data important?
The start and end points of each submerged section of track indicate the currents at the depth at which the floats drift. There are some uncertainties. Floats take about 4 hours to surface and to sink and therefore the displacement between the surface positions is not an exact measure of subsurface flow. Argo floats reveal the position and strengths of the world's major mid-depth currents.

What happens about floats that enter or are deployed in a country's Exclusive Economic Zone?
Floats that might drift into a country's EEZ, are notified to national focal points by the AIC. A web-based monitoring system tracks the float drift within the EEZ. Deployment of a float in an IOC member state's EEZ needs the agreement of that state.

Are measurements other than temperature and salinity possible?
The Argo floats represent a very attractive array of observing platforms. Trials are being made of other sensors (particularly oxygen) on profiling floats and of communication systems with wider bandwidth and two-way capability. However, the main priority of Argo remains to implement the basic (T and S) global array.

How does Argo link to other programmes?
Argo is a pilot project of the Global Ocean Observing System (GOOS) and a major contributor to the Global Climate Observing system (GCOS). Argo is co-sponsored by CLIVAR (a global climate research programme) and by GODAE (focussing on ocean data assimilation).

How can I find more about Argo?
The following are some key URLs and the names of people who can tell you about national Argo programmes :-

Argo Science Team
www.argo.ucsd.edu
Argo Information Centre
www.jcommops.org
Float manufacturers

WRC	www.webbresearch.com
Martec	www.martec.fr
Metocean	www.metocean.com

GDAC (USA)
www.usgodae.org/argo/argo.html
GDAC (France)
www.coriolis.eu.org
CLIVAR
www.clivar.org
GODAE
www.bom.gov.au/bmrc/ocean/GODAE/
GOOS
ioc.unesco.org/goos/
GCOS
www.wmo.ch/web/gcos
History of float development
www.soc.soton.ac.uk/JRD/HYDRO/argo/
Satellite altimetry
www.jpl.nasa.gov/science/science.html

Sources of national Argo project information

Australia	Susan Wijffels Susan.Wijffels@csiro.au
Canada	Howard Freeland freelandhj@dfo-mpo.gc.ca
China	Xu Jianping sioxu@zgb.com.cn
France and EU	Yves Desaubies Yves.Desaubies@ifremer.fr
Germany	Uwe Send usend@ifm.uni-kiel.de
India	K. Radhakrishnan radhakr_incois@vsnl.in
Japan	Kensuke Takeuchi takeuchk@jamstec.go.jp
Korea	Kuh Kim kuhkim@ocean.snu.ac.kr
New Zealand	Phil Sutton p.sutton@niwa.co.nz
Norway	Einar Svendsen einar.svendsen@imr.no
Russia	Mikhail Danchenkov danchenk@vladivostok.ru
Spain	Gregorio Parrilla gregorio.parrilla@md.ieo.es
UK	Brian King bak@soc.soton.ac.uk
USA	Dean Roemmich droemmich@ucsd.edu

Unusual Conditions in the Gulf of Alaska 2002/03 revealed by Argo

Howard Freeland. Institute of Ocean Sciences, Sidney, BC, Canada

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The Gulf of Alaska developed extremely anomalous conditions during the spring and summer of 2002. These conditions persisted into 2003 and will likely have a significant impact on ecological conditions in the Gulf during 2003.

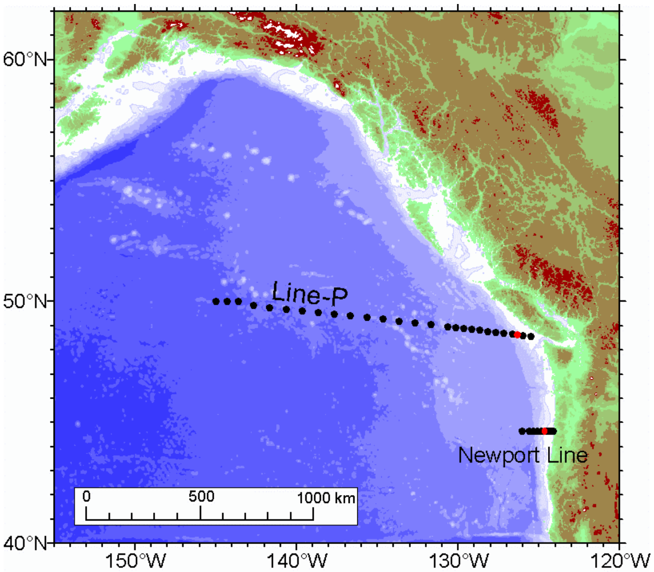


Figure 1: The locations of the Newport Line and Line-P, the red dots are stations NH-35 and MP-03 along those lines respectively.

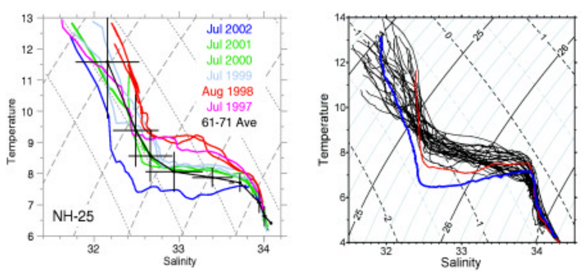


Figure 2: Observations of the temperature/salinity structure at station NH-35 along the Newport Line (left) and at station MP03 along Line-P (right)

Figure 2 shows previous observations of the TS curves along the Newport Line (left) and at an equivalent station along Line-P. In the right hand diagram the blue line shows the T/S curve observed at the end of June 2002, the red line one year earlier, and the black lines are all previous CTD curves at this station. Both diagrams are taken from Freeland et al (2003) and show that an intrusion of cold fresh water occurred during2002 that placed T/S curves outside of all previous experience. Argo provides an opportunity to map the evolution of this unusual event and describe some of the consequences.

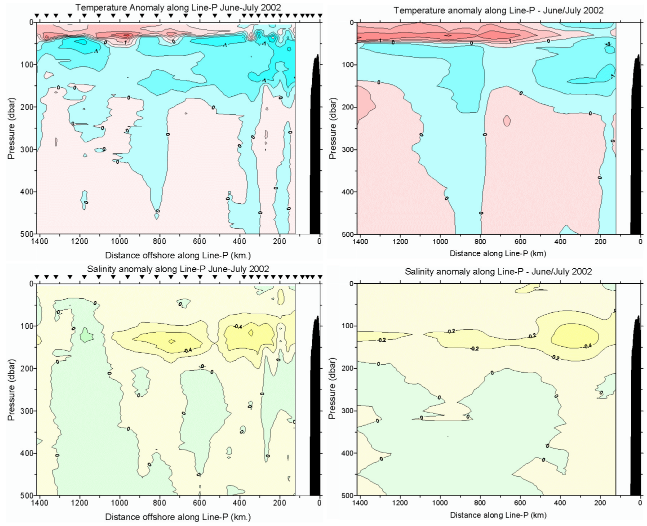


Figure 3: Temperature (top row) and salinity (bottom row) anomalies along Line-P in June-July 2002. The left column is derived from a shipboard CTD survey and the right column interpolated from nearby Argo floats.

There is now a density of Argo floats reporting in the Gulf of Alaska sufficient that we can use them to interpolate properties at all depths from the Argo array onto Line-P stations. This is shown in figure 3. In all of the panels making Figure 3 anomalies are plotted relative to a long term Line-P climatology. The white mask indicates the 2000 metre contour, in water shallower than that region we would be extrapolating from the Argo array. Apparently, the major features captured in the ship-board survey are captured in the Argo interpolation. Both show the mid-depth intrusion of cold fresh water, and an impressive warming of the surface layers of the ocean. A large collection of maps of temperature and salinity observations along Line-P, along with their anomalies, can be seen on the web at:-
http://www.pac.dfo-mpo.gc.ca/sci/osap/projects/argo/LineP_e.htm

The warm surface anomaly had the effect of creating a very stable cap on the waters of the Gulf of Alaska. In Figure 4 we show a plot of the density difference at Ocean Station Papa (50°N and 145°W, the offshore end of Line-P, see Figure 1) between 5m and 75m. In figure 1 the brown area bounded by a red line indicates the density difference expected at Ocean Station Papa, based on the long-term climatology as determined by Tabata and Peart, 1985. The blue line is the difference as observed by interpolating nearby Argo data onto Line-P at 5-day intervals and accepting data within a 10-day window. Apparently the stratification of the upper water column exceeded the climatological profile for almost all of 2002. By mid-summer the difference had become very large, and as we entered the winter stormy period in November 2002 the background stratification was almost 3 times greater than normal.

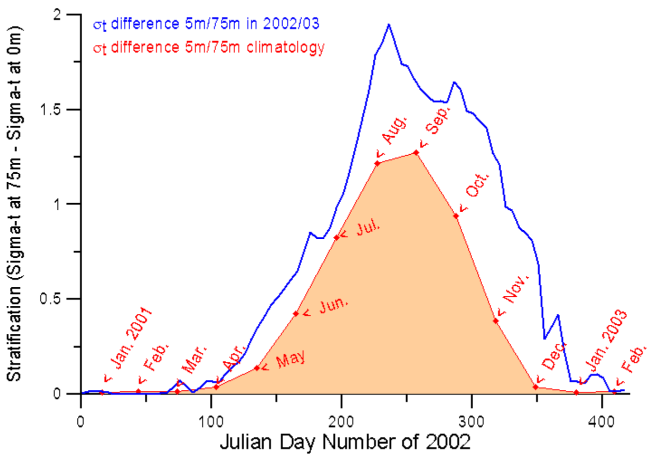


Figure 4: Upper ocean stratification from January 2002 to February 2003 at Station Papa, interpolated from Argo observations.

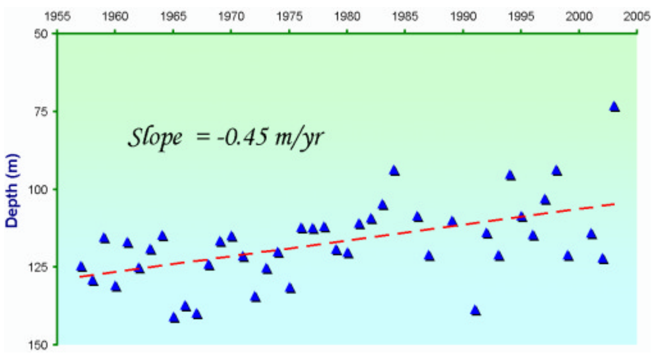


Figure 5: Winter mixed layer depth at Ocean Station Papa. In the early years this is an average over observations in Dec-Mar, in the later years (after about 1983) it is the single observation on the February survey.

We have previously reported (Freeland et al, 1997) on a steady shallowing of the mid-winter mixed layer in the Gulf of Alaska. Figure 5 shows the maximum depth of mixing averaged over each successive winter. In the early points each observation represents an average over observations in Nov, Dec, Jan and February, but after 1981 each observation is from a single month, usually February. It is clear that the mixing depth observed in February 2003 is entirely different from anything previously observed. Further, maps of the depth of the mixed layer in March 2002 compared with March 2003 demonstrate that the anomalous shallow mixed layer extends over most of the Gulf of Alaska.

Certainly, part of the reason for the anomalous mixing conditions in the Gulf of Alaska during 2002/03 is the very strong density difference presented at the start of fall 2002. However, that imposes a potential energy barrier that can be broken down given sufficient energy input. In fact during the winter for 2002/03 there were no major storms in the Gulf and so we conclude that the energy input was also low.

Why is this important? The supply of nutrients to the upper water column is determined by how deep winter mixing penetrates. At Ocean Station Papa itself nitrates are never limiting to primary production, but nitrate can be limiting closer to the coast. Over all of the Gulf of Alaska iron is limiting, as a micro-nutrient, and iron is also primarily supplied from the deep ocean reservoir. Unfortunately, we have no observations of dissolved iron concentrations during this interesting period. On the February 2003 Line-P survey silicate was observed to be extremely low (Whitney, private communication).

The previous smallest ever winter mixing depth occurred during the winter of 1997/98. Following that event nutrients were consumed rapidly in the early spring and the result was seriously negative for the ecosystems of the Gulf of Alaska. It is dangerous to make a prediction when we are faced with conditions never seen before, but one must imagine that the implications of the very shallow mixed layer in winter 2002/03 does not bode well for the productivity of the Gulf of Alaska in 2003.

References

Freeland, H.J. K.L. Denman, C.S. Wong, F. Whitney and R. Jacques. 1997. Evidence of change in the N.E. Pacific Ocean. *Deep-Sea Res.* **44**(12), 2117-2129.

Freeland, H.J., G. Gatien A. Huyer and R.L. Smith. A cold halocline in the northern California Current: an invasion of subarctic water. Geophys. Res. Let. 30(3), 1141, doi:10.1029/2002GL016663, 2003.

Tabata, S. and J. L. Peart. 1985. Statistics of Oceanographic Data Based on Hydrographic/STD Casts made at Ocean Station P during August 1956 through June 1981. Canadian Data Report of Hydrography and Ocean Sciences, No. 31.

Meetings past……

The Argo Science Team held its 5th meeting March 4-6, 2003 in Hangzhou, China (previous meetings have been in the USA, UK, Canada and Australia). A full report of the AST-5 meeting can be found on the Argo web site but here we highlight some key issues that arose and decisions that were taken.

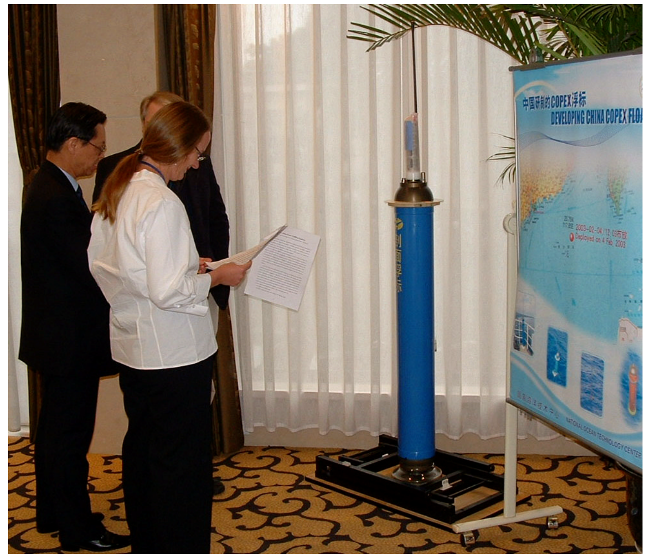
Discussions at AST-5

Northern hemisphere bias. A high priority for the coming year will be to start to redress the present northern-hemisphere bias of the Argo array. This will involve some logistical challenges for remote areas of the Pacific Ocean and an inventory is being compiled of the schedules of Southern Ocean research vessel tracks that might be used. For some areas, deployment from C-130 aircraft may be the most cost-effective method.

Co-ordination of deployments in each ocean basin is undertaken by a designated scientist. The plans for the coming year are available on the Argo home page.

Technical information. The speedy sharing of technical information about float performance is needed between countries and with manufacturers to ensure that the array will perform as well as possible. There are plans to improve these communication paths during the coming year.

Salinity correction. The long-term performance of salinity sensors is a key factor in the usefulness of Argo data. A method described in Wong Johnson and Owens (2003) (see Argo bibliography) that compares Argo profiles with regional climatological data has now been evaluated by several groups. The value of the method depends on the stability of the θ-S relationship and on how recently the climatology has been updated. AST-5 recognised that incorporating recent high quality ship-based CTD data into the climatologies and studying float-float intercomparisons will be vital in detecting long term salinity changes in some areas.



The prototype Chinese COPEX float at AST-5

Satellite altimetry. The AST were given a glimpse into future satellite altimeter missions by Lee-Leurg Fu, NASA JPL. He compared the present unprecedented abundance of satellite altimeter coverage (Topex-Poseidon, ERS-2, Jason-1, ENVISAT, GFO) with further improvements that would be expected from a plan to launch a Wide Swath Ocean Altimeter in 2007. The data (swath width is 200km) would provide two dimensional instead of the present along track coverage and hence improve both the temporal and spatial coverage.

More information can be found in JPL publication 03-002.
ftp-oceans.jpl.nasa.gov/pub/llf/WSOAreportFinal2.pdf

Argo management infrastructure John Gould assumed the position of the Argo project Director in January 2003 (located at Scripps Institute of Oceanography). The AST agreed that as Argo grew, it would need to have an appropriate level of infrastructure support that would include the functions of a project office and the Argo Information Centre.

Thanks. The meeting was hosted by the Chinese State Oceanographic Administration's Second Institute of Oceanography, in the Zhehiang Xizi Hotel on Hangzhou's beautiful West Lake. The AST is very grateful for the hospitality extended to them by their Chinese hosts. The meeting was truly memorable.

……..and future.

First Argo Science workshop

This will be held in Tokyo, Japan, November 12-14, 2003. It will be the first of a number of dedicated meetings and conference sessions in the coming years that will focus on the findings made by using profiling floats.

The workshop is jointly sponsored by the Japanese Marine Science and Technology agency JAMSTEC and the US National Oceanographic and Atmospheric Administration (NOAA).

The workshop will be aimed at both Argo scientists and the programme managers and funding agencies that support the project.

The objectives of the meeting are to :-

- ***Exchange information on the early results obtained using Argo and other profiling floats***
- ***Demonstrate the present and likely future value of Argo for a wide range of applications***
- ***Identify ways in which Argo can best meet the needs of scientists and ocean applications and operational programmes.***

An initial announcement will be issued at the end of April 2003. Please mark the dates in your diary and consider whether you will attend and present your results

Calendar of Argo - related meetings

Date 2003	Venue	Event	More info
May 13-15	Silver Spring, MD,USA	US Climate Obs Wkshop	(US Argo PIs attending)
Jun 30–Jul 11	Sapporo, Japan	IUGG-23	http://www.jamstec.go.jp/jamstec-e/iugg/
Oct 10 - 18	Seoul, Korea	PICES-XII	http://pices.ios.bc.ca
Nov 5 - 7	Monterey, CA,USA	Argo Data Team - 4	http://www.usgodae.org/argodm/
Nov 12-14	Tokyo, Japan	1st Argo Science workshop	http://www.argo.ucsd.edu/
Nov 18-20	Tokyo, Japan	POGO-5	http://ocean-partners.org

Argo Bibligraphy

(Peer-reviewed articles about Argo or that use profile (and/or) velocity data from profiling floats)

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

Iwasaka N., T. Suga, K. Takeuchi, K. Mizuno, Y. Takatsuki, K. Ando, T. Kobayashi, E. Oka, Y. Ichikawa, M. Miyazaki, H. Matsuura, K. Izawa, C.-S. Yang, N. Shikama, and M. Aoshima, 2003: Pre-Japan-ARGO: Experimental observation of upper and middle layers south of the Kuroshio Extension region by using profiling floats. *J. Oceanography*, **59**, 119-127.

If you know of other relevant papers please send details to argo@ucsd.edu. Thank you. Eds.

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Lavender, K.L., R.E. Davis and W.B. Owens, 2002: Observations of open-ocean deep convection in the Labrador Sea from subsurface floats. *J. Phys. Oceanogr.*, 32(2), 511-526.

Roemmich,D et al, 2001: Argo: The global array of profiling floats. Chapter 3.2 (Pp 248-258). In *Observing the Oceans in the 21st century*. C.J. Koblinsky and N.R Smith, (Eds.) Bureau of Meteorology, Melbourne, Australia, 604pp.

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