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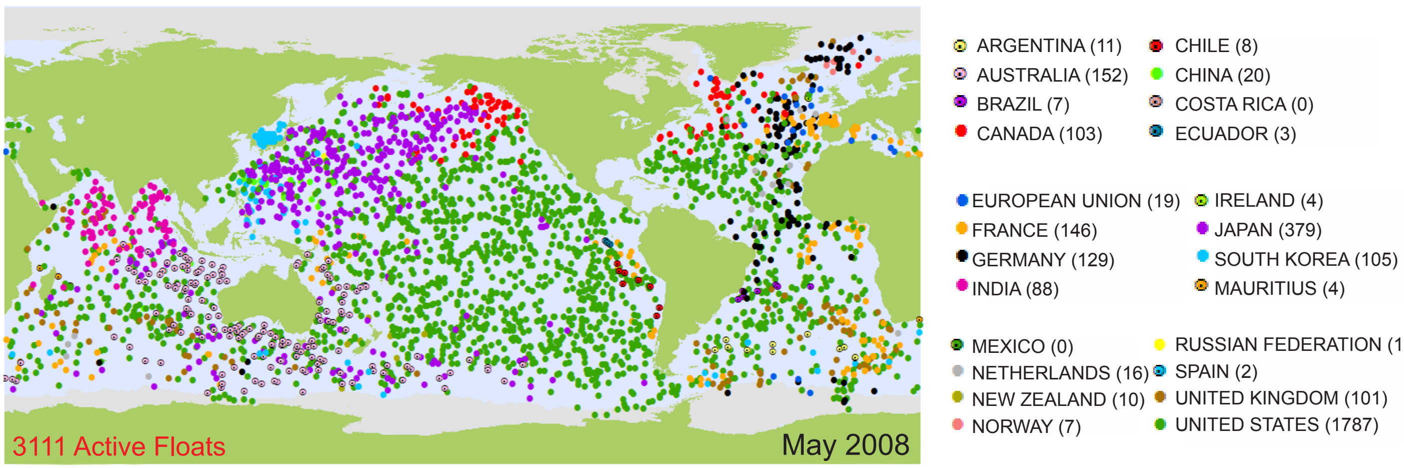
Argonautics

Newsletter of the international Argo project



Editorial

Since the December 2007 Newsletter celebrating the 3000th active float milestone, Argo has started to refocus on its core mission and to examine how well it is accomplishing the goals it originally set forth. This means looking at issues such as float density and continued coverage, data quality and availability in both real-time and delayed mode, and increasing float lifetimes. See H. Freeland's update on the Argo array status for more information.

Additionally, Argo would like to have better communication with its user community. As the data set grows larger and more complex and scientists use the data in a wider array of applications, Argo has recently set a goal to develop a more advanced data user guide.

Besides helping the user community, we realize that users can help us by providing invaluable insight into data quality. We would like to begin taking advantage of that by working to establish more direct ties with users who do routine quality control checks of the Argo dataset. See the article by S. Guinehut that explains the work she does comparing Argo data against altimeter data.

Recently there have been several advancements in float technology for all three of the major Argo float types. There is a new generation PROVOR float called the ARVOR, a prototype of which completed almost 200 cycles. APEX floats have been successfully modified by S. Riser's group to profile to 2000 m anywhere in the world. There is also a new generation SOLO float under development called SOLO-2. A test deployment will take place in the coming months. See the articles on the ARVOR and modified APEX floats in this newsletter to learn more. The next newsletter will have more information on the SOLO-2.

The UK Met Office hosted a successful Argo Steering Team meeting (AST-9) in Exeter, United Kingdom in March. In addition to discussing how to refocus Argo, the meeting participants discussed the upcoming science workshops and meetings including the third Argo Science Workshop to take place in Hangzhou, China next year and the following OceanObs'09 meeting where Argo will be represented. These workshops and meetings should give Argo an opportunity to think about where it is heading in the next ten years. At the meeting, the Argo Prize was awarded to Karen Heywood who was invited to speak. To read about her complete surprise at receiving the prize, see the article on page 5.

There are also a couple of short pieces in the Newsletter this time concerning outreach and training. There is a piece of artwork showcasing Argo done by a student and a description of photos and training for scientists from several African countries. This is an important part of the project and Argo encourages further outreach.

The list of Argo-related papers published this year is included in this newsletter, with the total number of papers published nearing 350. If you publish a paper using Argo data, please send argo@ucsd.edu an e-mail with the citation to ensure that it is included in the expanding list.

Producing delayed mode data files continues to be a high priority of the Argo Program. A third delayed mode quality control workshop is being hosted by the University of Washington this September to improve the consistency of DMQC decision making and to review experience with OW software, experimental use of Argo profiles in DMQC reference data, and regional oceanography.

To help monitor the array, the Argo TC sends out a float report each month with valuable information on both the implementation side and the data management side, including deployment planning and opportunities, various anomalies, the grey list, and altimetry QC. To download and review the most recent report, go to ftp.jcommops.org/Argo/Doc/2008-05-AIC.pdf.

Megan Scanderbeg

Update on Argo Array Status

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

Argo has realized many of the objectives first set forth in the original plan for Argo and, in fact, we have made a global array. Given these accomplishments, Argo needs to work on refining and improving some areas that still have difficulties to fully reach Argo's capability. For example, the quality control needs improvement – both the real time and the delayed mode in order for users to be able to use the data more reliably. Another remaining issue is that some parts of the array are over-sampled, while others are under-sampled. This means deployment planning and coordination needs to be improved to keep a well sampled global array over time. The density of the Argo array, produced by H. Freeland, can be seen in Figure 1.

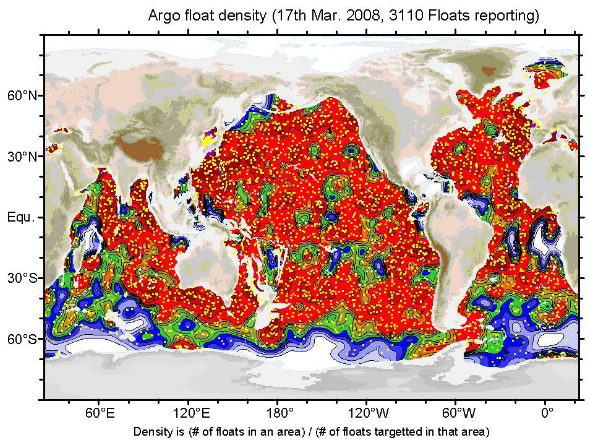


Figure 1: Argo float density

It was important to celebrate the accomplishment of a 3000-float array in November 2007, and we have achieved a tremendous amount since we started Argo, but a glance at the density map in Figure 1 shows that there are still problems in the distribution of floats. There are large areas in the southern Indian and Atlantic Oceans particularly that need more floats. The gap in the array in the Gulf of Guinea has opened up during the last few months and there is an area in the western Bering and off the east coast of the Kuril Islands and Kamchatka that is persistently short of floats. How can this be? Why do we have such large gaps when we are well over the targeted number of floats?

One answer lies in the distribution of floats.

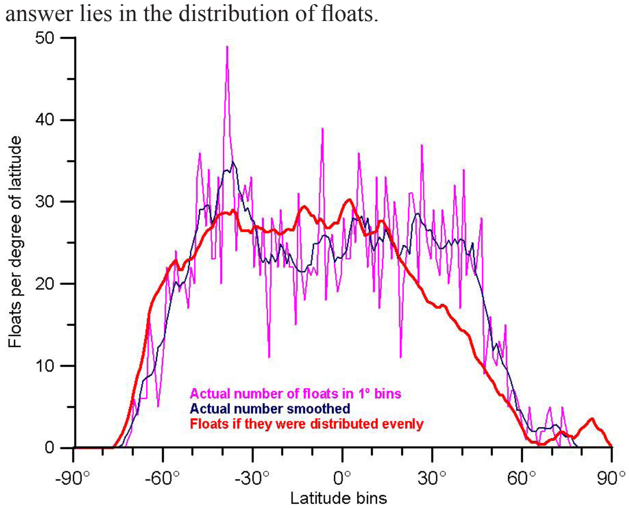


Figure 2: Floats per degree of latitude

In the plot above, H. Freeland has examined the number of floats in each 1° latitude bin which is shown by the purple line in the background. This is noisy, so a smoothed version is shown by the dark blue line. The positions are taken from M. Belbéoch's file status.txt and include 3110 floats. If we take the number of floats and redistribute them so that all regions of the oceans deeper than 2000 decibars have an equal density of floats, then the red line shows what the distribution of floats should be. Clearly there is a large excess of floats in the latitude range 20°N to 60°N due to the very large float densities in marginal seas. Had this been part of the original Argo design, then we would have needed more than 3000 floats. To achieve the Argo coverage we must deploy fewer floats in the marginal seas and more in the open oceans, particularly in the southern hemisphere.

The other concern is that in fact we have not yet really achieved the 3000-float target, notwithstanding our press releases and celebrations because even though there are 3,110 active floats less than 3,000 are delivering useful data.

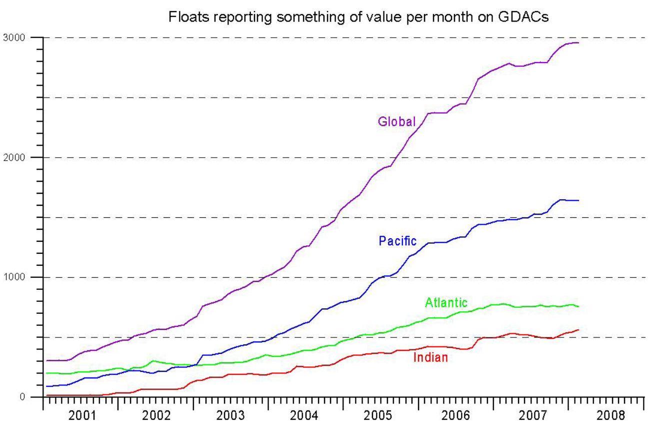


Figure 3: Floats reporting something of value each month on GDACs

The figure above is based on a scan of all CTD profiles presently available on the GDACs. A program simply searches the entire holdings and counts, how many independent WMO-IDs deliver a profile to the GDACs each month, with something, even something very small, of value in the profile submitted. This would have us very close to the 3000-float target but not quite there yet. Perhaps we should be using a different metric to measure our progress towards implementation.

DAC	Total floats > 12 mo old	Total floats > 12 mo old that have been through DMQC	%
AOML	157928	91351	57.8
BODC	14581	4492	30.8
Coriolis	52038	26365	50.7
CSIO	1498	1488	99.3
CSIRO	9942	7728	77.7
INCOIS	12339	8716	70.6
JMA	52615	27329	51.9
KMA	5176	1492	28.8
MEDS	14636	12502	85.4
GTS	23790	0	0
Total	344543	181463	52.7

Numbers as of June 18,2008

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The table shows a summary of our success to date in reducing the backlog in delayed mode QC. A lot of progress has been achieved but some centres are lagging. During February 2008, new float profiles were being acquired at the rate of 310 profiles/day = 114,000 per year. That yearly rate of acquisition is 63% of the present total number of D-Mode files, which is an alarmingly high fraction. Indeed in the last year we have acquired more profiles than we have processed. We need to start catching up and trying to process files to D-Mode faster than we are acquiring new data.

Another concern Argo needs to consider is mission creep which means that Argo could be beginning to drift from its original mission before successfully completion of some of its first goals. Argo's involvement in ice covered areas, oxygen sensors on floats, and over-sampling in marginal seas are examples of Argo moving onto areas not covered in the mission statement. At the most recent AST meeting, it was suggested that Argo create a new mission statement, in preparation for OceanObs'09 that addresses where Argo hopes to go, while reinforcing its core goals. We are also working to improve the metrics that are currently used to measure Argo's success to better reflect what Argo has accomplished and where it needs to go in order to continue and improve upon a global array that delivers high quality data in real time and delayed mode.

In summary:

- We have achieved a tremendous amount; we have an array that we can claim is global, but…
- Users need to be able to rely on our QC and that needs improvement.
- Some areas of the array are actually degrading, suggesting long term sustainability of the array is a harder problem than we initially imagined.
- We need to improve deployment planning to reduce the number of floats in over-sampled regions and improve sampling in other areas.

Hands-on training for float deployment and data acquisition in the waters off Ghana

This past March in the Gulf of Guinea, the United States Navy worked with AOML, under the U.S. Navy Africa Partnership Station initiative and the SA-ARC, to train scientists from Ghana, Cameroon and Nigeria on deployment and data acquisition techniques for Argo floats, drifting buoys and expendable bathythermographs (XBTs). The training builds on the capacity building workshop held in December 2006 in Ghana, only this time the training was held onboard the U.S.Navy vessel HSV-2 *Swift* instead to give hands-on experience. One Argo float (WMO# 1900792) was deployed as well as three drifting buoys and 12 XBTs. The participants included oceanographers, professors, military personnel, graduate students, post-docs, fisheries representatives and geologists. Now the scientists can use their understanding of how temperature, salinity and current data are taken to better understand the ocean nearby and its affects on the local economy. As a result of this training, AOML hopes to work to expand the opportunities to deploy floats, drifters and XBTs in the region.

Upper left photo: Cmdr. Charles Rock and Chief Quartermaster Andy Reed explain the helm to University of Ghana graduate students Rebecca Keelson, left, Rhoda Nyark and Ghana Meteorological Agency meteorological officer Francisca Martey.
Lower left photo: Participants in Gulf of Guinea deployment and training event
Right photo: Scientists examining the Argo float before deployment
Photos and information courtesy of AOML (http://www.aoml.noaa.gov/phod/sardac/education/index.php), Elizabeth Forteza (AOML), Shaun Dolk (AOML), Claudia Schmid (AOML)

When satellite altimetry is called for to help on Argo quality control issues

Stephanie Guinehut, CLS Space Oceanography Division [Stephanie.Guinehut@cls.fr]

A new method has been developed to check the quality of each Argo profiling floats time series. It compares co-located Sea Level Anomalies (SLA) from altimeter measurements and Dynamic Height Anomalies (DHA) calculated from the Argo temperature (T) and salinity (S) profiles. By exploiting the correlation that exists between the two data sets, (Guinehut et al., 2006) along with mean representative statistical differences between the two, the altimeter measurements are used to extract random or systematic errors in the Argo float time series. Different kinds of anomalies (sensor drift, bias, spikes, etc) have been identified on some real-time, but also delayed-mode, Argo floats. About 4% of the floats should probably not be used until they are carefully checked and reprocessed by the PIs.

Altimeter measurements are from the AVISO combined maps (http://www.aviso.oceanobs.com). Argo T/S profiles are from the Coriolis-GDAC database uploaded as of February 2008 (http://www.coriolis.eu.org). Dynamic height anomalies are calculating using a reference level at 900-m depth and a dedicated Argo mean dynamic height. When available, delayed-mode fields are preferred to real-time ones and only measurements with flag of '1' are used. The data and method are described in Guinehut et al., 2008.

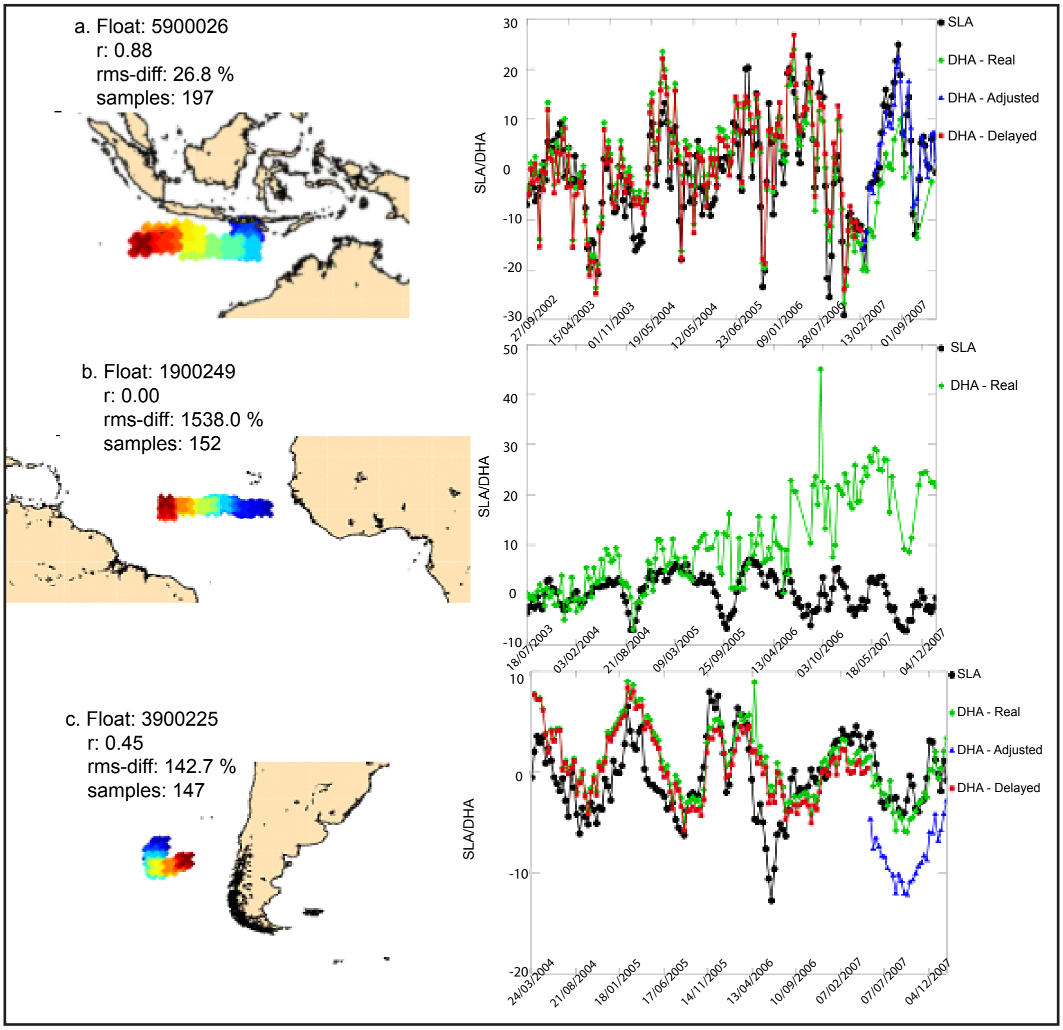

Figure 1: SLA and DHA time series for three floats (in cm). The positions of each float are also indicated, the blue cross corresponding to the deployment position and the red cross to its last reported position. The statistics correspond to r: the correlation coefficient between the two times series and rms-diff: the rms of the differences between the two times series expressed as percentage of the variance of the altimeter signal.

Some examples of SLA/DHA time series are given in Figure 1 along with the float's position and its mean statistics. The WMO 5900026 float travelling from east to west, south of Java Island from September 2002 up to the present, shows very good consistency between the two time series with a correlation of 0.88. Mesoscale structures up to 25 cm are well represented in both time series and the impact of the delayed-mode and real-time adjustments is clearly visible. The second example (WMO 1900249 float - Figure 1-b) shows a clearly progressive drift of the DHA time series compared to the SLA time series as the float moves from east to west in the tropical Atlantic Ocean. Additionally, the correlation between the two time series is null, while it is expected to be greater than 0.5 (Guinehut et al., 2006, 2008) showing a clear malfunction of one of the sensors. The last example, WMO 3900225 float in the south Pacific Ocean (Figure 1-c), shows that part of the data have been delayed-mode controlled and for that portion, the SLA and DHA time series match each other very well. At the end of the time series, when values adjusted in real time are available, they show a constant offset of about 10 cm with the altimeter data. This offset seems to be due to the salinity offset value of 0.092 applied in real-time which is over estimated and wrong compared to the 0.015 value applied for the delayed-mode.

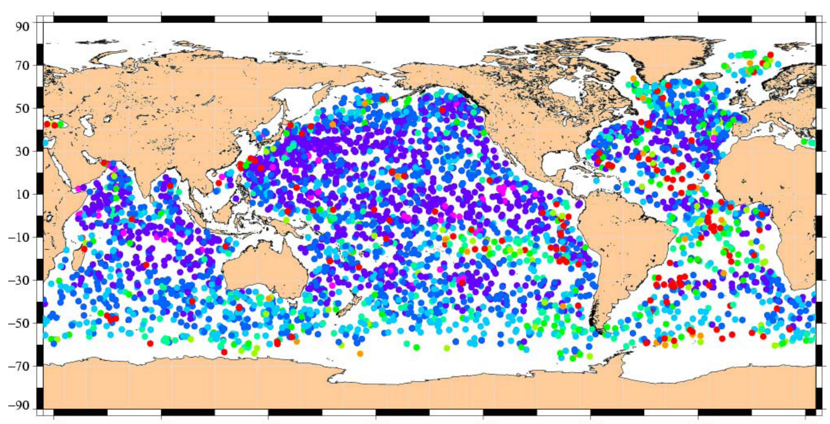

Figure 2: Rms of the differences between SLA and DHA as a percentage of the SLA variance (in %) – each point represents the value for one float time series at its mean position.

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And the Argo Prize goes to ... Karen Heywood

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

In March 2005 there was no Argo Steering Team meeting. Instead the Argo Executives met in Perth, Western Australia, to discuss urgent items. One of the items that was discussed while we sampled Australian red wines was the question of raising the scientific profile of Argo. Perhaps this was rather a rash decision, but nevertheless we decided to offer a prize for the first paper based overwhelmingly on Argo data to be published in either Nature or Science. The prize was decided on as well - it was to be a case of wines selected from Argo nations. One might be forgiven for being surprised that it took so long, but it did take until March 2008 before we were able to award the prize. A paper recently published in Science is: Matthews, A., P. Singhruck, K. Heywood, 2007: Deep ocean impact of a Madden-Julian Oscillation observed by Argo floats. Science, 318, 1765-1769.

This paper might actually have escaped my notice except that as soon as it was published the Argo Co-Chairmen received an e-mail from Karen Heywood reading "Thank you Argo." We immediately decided that we liked this woman and that this paper clearly was the winner of the Argo Prize. Subsequently we decided that we needed a science-content talk at the AST meeting in March 2008 in Southampton and Karen Heywood agreed to make a presentation. Her talk was very well received and after the seminar was over we had a surprise for her. Our security had evidently been excellent, as she had no idea this was going to happen. I do have to admit that we did not advertise the existence of the Argo Prize very aggressively.

Argo Prize Wine list

Argentina	Malbec Finca Flichman Reserve
Australia	Barramundi Shiraz Cabernet
Brazil	Cabernet Sauvignon Rio Sol
Canada	Indiscipline Gold Ice-wine
Chile	Casillero del Diablo Cabernet Sauvignon
France	La Vielle Ferme Cotes de Ventoux
Germany	Dr. Wagner Riesling Ockfener Bockstein
Italy	Frascati Le Marmorelle
New Zealand	Nobolo Five Fathoms Sauvignon Blanc
Spain	Rioja Campo Viejo Crianza
UK	Somborne Valley Hampshire Madeleine Angevin
USA	Ravenswood California Zinfandel

continued from S. Guinehut article on page 4

Results obtained for each Argo float time series are summarized in Figure 2; each point represents the value for one time series at its mean position. For most of the floats (more than 3900), rms of the differences between SLA and DHA are of the order of the referenced numbers (not shown). 160 anomalous floats with much higher values (some of the red dots on Figure 2) can be detected all over the different oceans. As illustrated by the two examples on Figure 1-b,c, these higher values are mainly the results of errors on the float time series due to a systematic offset, a punctual error or the drift of a sensor (salinity or pressure). More investigations on these particular floats are thus needed.

This study has demonstrated that SLA/DHA comparisons are very efficient in detecting spikes, systematic offsets or drift in some Argo float time series. The comparisons also give a quick idea of the behavior of the time series of the float. The main advantage of this method is the use of independent and contemporaneous altimeter measurements. It appears to be very complementary to the real-time and delayed-mode Argo quality controls (Wong et al., 2008) or the use of more classical methods based on historical data sets or climatological fields. Additionally, the comparisons can be done in near real-time in order to detect problems before the delayed-mode quality control but also as a verification tool after the delayed-mode control to validate and quantify its impact.

Finally, as part of these results have been already provided to some PIs, some floats time series might have already been corrected or separated on the GDAC database. Also, as an on-going collaborative effort, the list of the anomalous floats and the figures of the collocated SLA/DHA time series are published on the Coriolis web site (http://www.coriolis.eu.org).

References

Guinehut, S. P.-Y. Le Traon, & G. Larnicol, 2006: What can we learn from global altimetry/hydrography comparisons?, Geophys. Res. Lett., 33, L10604, doi:10.1029/2005GL025551.

Guinehut, S. C. Coatanoan, A.-L. Dhomps, P.-Y. Le Traon and G. Larnicol, 2008 : On the use of satellite altimeter data in Argo quality control, submitted to J. Atmos. Oceanic.Technol.

Wong, A. P. S., R. Keeley, T. Carval, and the Argo Data Management Team, 2008: Argo quality control manual, Version 2.31, ar-um-04-01.

Opportunities to showcase your Argo research

Float of the Month on AIC web site

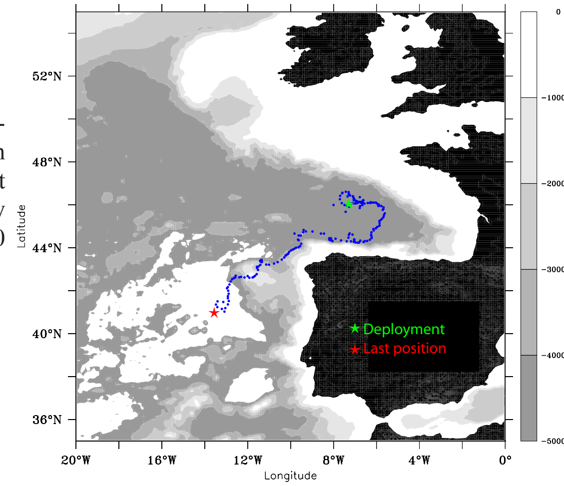
Beginning last August, each month a float of the month is featured on the AIC web site with text and graphics explaining the data. May's float, deployed by PMEL in April 2008, is featured along with its close encounter with the Malum Atoll of Papua New Guinea. March's float was deployed as part of the OVIDE project and shows the changes in mixed layer depth in the Irminger basin. This feature is a great way to learn about floats contributing to the Argo program around the globe. Their data are explained in a direct, easy to understand manner. If you would like to contribute a float to this feature, e-mail argo@ucsd.edu.

Contribute to the next newsletter

If you are doing research on Argo floats that you think others would like to read about, let us know. We are always looking for news article submissions for Argonauts. The research can be on float technology, data assimilation, data analysis methods, or other aspects of Argo data. The next newsletter will be published in December, so please submit your article idea to argo@ucsd.edu by November 2008. We will let you know soon after if your article idea has been accepted for the upcoming newsletter.

New Arvor float prototypes ready for deployment

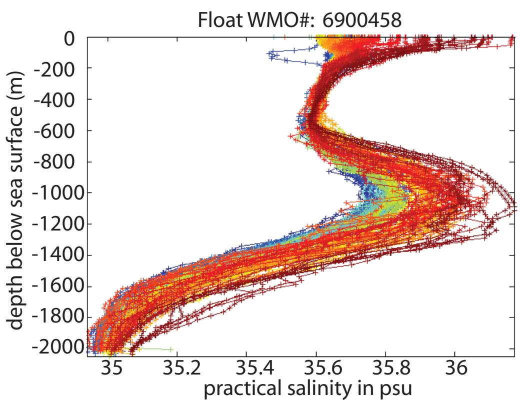
Serge Le Reste [Serge.Le.Reste@ifremer.fr]

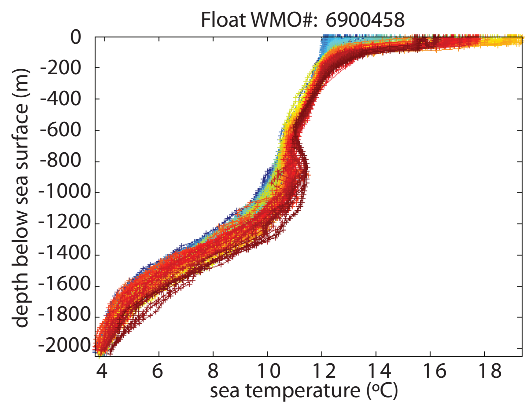


ARVOR is a new, fully Argo compatible, profiling float designed to acquire salinity and temperature profiles using the "SEA-BIRD" proven CTD metrology. The design has been performed by Ifremer, the French institute for sea research, using their important knowledge in float activities and well qualified subassemblies. Kannad is the company which is manufacturing PROVOR and has achieved the industrial design of ARVOR. 10 ARVOR will be available for deployment in 2008.

Main features :

- ARVOR float is self-ballasted, allowing operation in a wide range of density conditions and gradients. Ballasting operation is not required.
- ARVOR is fantail ready using a magnet.
- ARGOS satellites are used to collect data and localize the float when surfacing.
- Wireless connectivity using Bluetooth eases configuration and testing before deployment.
- ARVOR is light and deployable by only one person.
- ARVOR can perform up to 200 profiles every 10 days from 2000 meters depth to the surface (pump in continuous mode, 92 CTD points when profiling and 18 points when drifting). A profile is taken during the first descent for comparison with a CTD cast.





Float dimensions :

Overall length :
195 cm with antenna
Hull length : 120 cm
Hull diameter : 12 cm
Damping and floating collar : 25 * 25 cm
Weight : 19.5 kg (hard anodized aluminium casing)

First prototype :

The first prototype was deployed in December 2006. The float performed 186 cycles every 2 days with success, overshooting the expectation of life duration (a battery pack lighter than the industrial model was included for this prototype test).

Timetable of Argo-relevant meetings			
2008 - 2009			
September 10-12, 2008	Seattle, Washington, USA	DMQC-3	http://www.argo.ucsd.edu/AcDMQC3.html
October 29-31, 2008	Hawaii, USA	ADMT-9	Argo Data Management Team -9 meeting
November 12-15, 2008	Nice, France	GODAE Final Symposium	http://www.godae.org/Final-symposium.html
March, 2009	Hangzhou, China	AST-10 and ASW-3	Argo Steering Team - 10 meeting and Argo Science Workshop - 3
September 21-25, 2009	Venice, Italy	OceanObs'09	http://www.oceanobs09.net/

Profiling to 2000 m Anywhere in the World Ocean: Advances with APEX Floats

Stephen C. Riser, University of Washington [riser@compass.ocean.washington.edu]

In 1999 and 2000, the nascent Argo Science Team (later renamed the Argo Steering Team) spent considerable time debating the technical specifications that would be required for profiling floats used in Argo. As a result of these discussions it was decided that floats should be parked at a depth of 1000 m and should profile from 2000 m to the surface whenever this was technically feasible. Now, nearly a decade later, most floats being deployed in Argo are programmed to carry out these profiling specifications. Yet there are still parts of the world ocean where profiling from a depth of 2000 m to the surface is generally difficult or impossible. This is especially the case at low latitudes, within about 15º of the Equator.

This difficulty is caused by the fact that profiling floats operate by changing their density in order to ascend or descend through the water column. At a depth of 2000 m, the density is roughly the same over large expanses of the world ocean; but the surface waters near the Equator are generally very warm and thus have a relatively low density, so that the density difference between 2000 m and the sea surface is a maximum at low latitudes.

For example, the in situ density at 2000 m in much of the world ocean is about 1037 kg/m^3; at the sea surface at mid-latitudes the density is typically 1025 kg/m^3, while in the tropics the density at the sea surface can be as low as 1021 kg/m^3. Thus, to be able to ascend to the sea surface from a depth of 2000 m at mid-latitudes might require a float to change its density by about 12 kg/m^3, while near the Equator the same float would have to alter its density by 16 kg/m^3, a more difficult requirement. For this reason, until recently most APEX (and also SOLO) floats have been programmed to profile over a smaller depth range, typically 1000 meters to the sea surface, near the Equator.

Floats change their density in several ways. The most important is pumping oil from an internal reservoir into an external bladder, thus inflating the bladder and increasing the volume of the instrument. Since density is defined as mass divided by volume, inflating the bladder decreases the density of the instrument (the total mass of the float does not change) and causes the float to ascend through the water column; deflating the bladder by pumping the oil back into the internal reservoir decreases the volume of the float and thus increases the instrument density, resulting in the descent of the float back to its parking level. For APEX floats, the volume of the bladder changes by about 260 ml over one of these pumping cycles.

In addition, as a float ascends through the water column it encounters lower pressures, allowing the float housing to expand and further decrease the density (the reverse happens during descent, when the pressure increases, resulting in a decrease in the volume of the float). At mid-latitudes, the increase in volume due to hull expansion can be as much as 50% of the volume change due to the inflation of the bladder.

The float hull will also expand as the float ascends through higher temperatures (and contract during the descent phase as the temperature decreases), with the thermal expansion effect accounting for an additional 10-15% of the volume change due to the bladder.

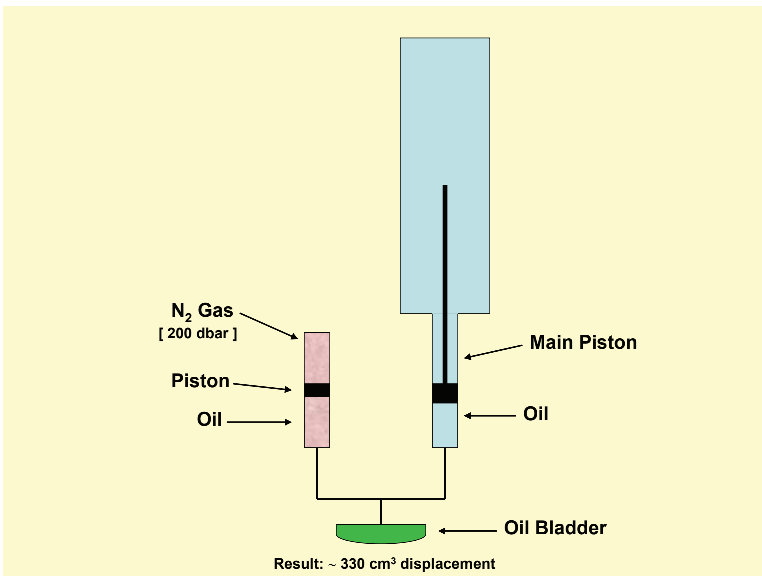


Figure 1. A schematic diagram showing the main piston and N$_2$ gas canister arrangement on a Webb N2 APEX profiling float. Normal APEX floats have only the main piston and oil reservoir. For N2 floats, the additional oil and piston connected to the gas canister provide a means to store energy as the gas is compressed during the float descent and recover this energy and use it to increase the float's buoyancy during the ascent phase.

For most of the world ocean, the density change of an APEX float due to the combined effects of bladder inflation, thermal expansion, and compressibility is more than 12 kg/m^3, thus allowing profiling from 2000 m to the sea surface. But at lower latitudes, where the near-surface waters can be extraordinarily warm and a density change of 16 kg/m^3 or more is required, floats often have insufficient excess buoyancy to reach the sea surface from at depth of 2000 m. In the case of an APEX float, this problem would be manifested by the float finishing its program cycle and sensing (via pressure) that it did not reach the sea surface in an allotted time. At this point the float would initiate its descent back to its parking depth, and the profile data would be lost. This is an undesirable situation and has been the impetus for programming shallower profiling depths for low latitude floats.

There is a strong rationale for trying to profile from 2000 m to the surface everywhere in the world ocean, as there is generally a lack of observations from the deep sea in most of the world ocean. Furthermore, the temperature/salinity relation is usually more stable in deeper water, and the use of the deeper float data in conjunction with climatology is essential for carrying out delayed-mode salinity adjustments, a fact that was recognized by the Argo Science Team a decade ago.

In order to be able to employ APEX floats to a depth of 2000 m at low latitudes in the world ocean, in 2004, engineers at Webb Research Corporation designed a prototype APEX float that carried a small canister of nitrogen gas that was plumbed into the internal buoyancy engine, as shown schematically in Figure 1. The gas in the canister is charged to a pressure of about 200 decibars (the hydrostatic pressure at a depth of 200 m). During a float mission, as the main piston is retracted, the float begins to sink. Until the float reaches a depth of 200 m, it behaves as a normal APEX float. As the float continues its descent, the pressure of the ocean exceeds the pressure in the gas canister, the canister piston is forced inwards, and the nitrogen gas is compressed, with the float eventually sinking to its parking depth (the main piston also continues to be retracted).

After 10 days or so the float begins its ascent back to the sea surface by pumping its external bladder full of oil using the main piston, with additional excess buoyancy coming from the extension of the piston in the gas canister. The gas expands as the float ascends, and when the float ascends through a depth of 200 m the canister piston is fully extended. The energy stored in the gas via compression during its descent is used to provide an additional source of buoyancy for the float during its ascent, allowing it to change its density by the 16 kg/m^3 required for 2000 m profiles at Equatorial latitudes. For APEX floats, the inclusion of the gas canister yields a buoyancy increase equivalent to an increase in oil volume from 260 ml to 330 ml, a significant

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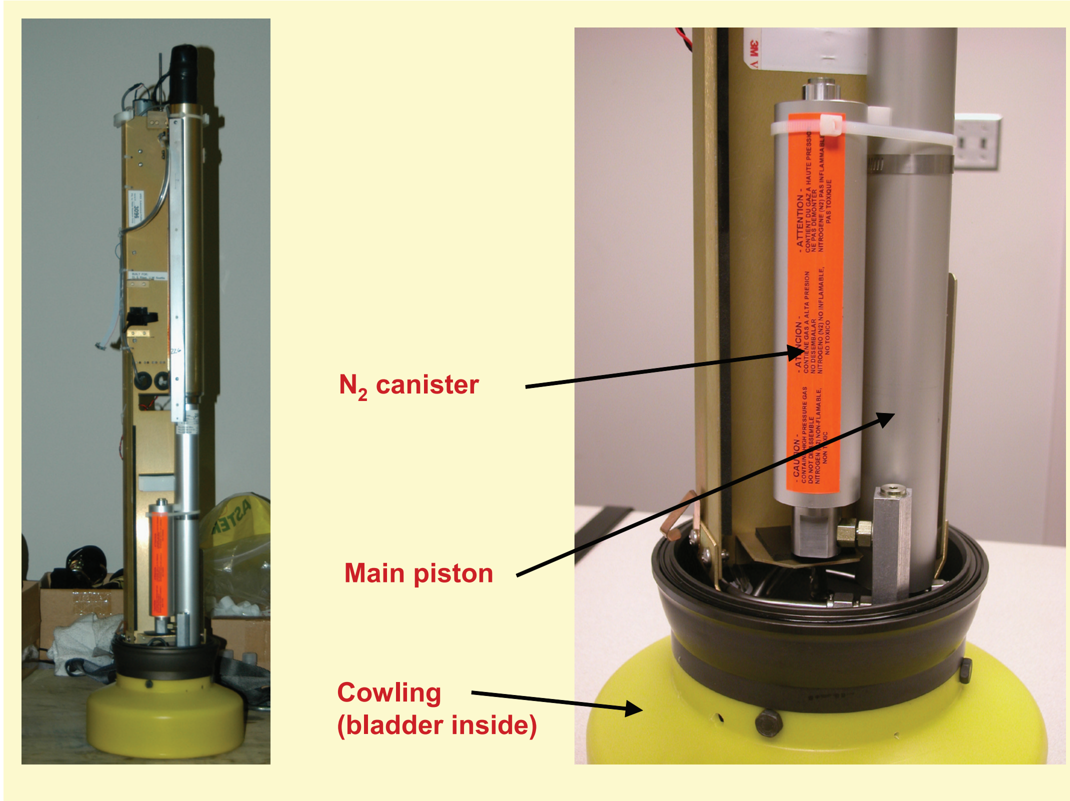


Figure 2. Photos of an APEX N2 float with the hull removed. Left panel: the entire float, showing the motor and buoyancy pump, the main piston, and the N_2 gas canister. Right panel: a close-up of the main piston, gas canister, and protective cowling.

addition.

The first prototype “N2” float (WMO ID 2900106; named because of the canister of nitrogen gas; see Figure 2) was prepared at the University of Washington and deployed in the Bay of Bengal by Indian scientists from the National Institute of Ocean Technology in Chennai in the autumn of 2004. The Bay of Bengal was chosen as the deployment site because of its exceedingly strong near-surface stratification, with a density difference of nearly 18 kg/m^3 between 2000 m and the sea surface; this is one of the most highly stratified sites in the entire world ocean. The prototype float performed flawlessly from the first profile and continues today to provide excellent data between 2000 m and the surface, more than 136 cycles after deployment. The temperature, salinity, and trajectory data for this float can be viewed at http://flux.ocean.washington.edu/argo/homographs/index/1795.html.

There is one potential complication with the use of the nitrogen gas canister. The overall compressibility of N2 floats is greater than for normal APEX floats because the gas in the canister is much more compressible than seawater. As a result, over part of the water column the float can actually become slightly more compressible than the surrounding seawater, rendering it buoyantly unstable. Because of this instability, early prototypes of N2 floats could not be parked between about 300 and 1100 meters in the water column, an undesirable feature given the target specifications for Argo floats of parking at 1000 m and profiling between 2000 m and the sea surface. This limitation has been removed on more recent versions of N2 floats through software modifications developed at the University of Washington. These modifications involve the float monitoring its pressure and descent rate every 30 seconds as it approaches the parking depth of 1000 m instead of waiting until the float descent is completed as happens in other Argo floats. As a result of these changes to the controller software, N2 floats can now be parked at 1000 m and profile to 2000 m, indistinguishable from other Argo floats.

N2 floats are available commercially through Webb Research Corporation. Nearly 80 N2 Webb/APEX floats have now been built and deployed by the University of Washington in low latitude regions of the Pacific and Indian Oceans, and both PMEL in the United States and CSIRO in Australia have also successfully deployed a number of N2 floats. The additional cost of the N2 feature is only about $US400, a seemingly reasonable price to pay for the increased profiling capability at low latitudes.

A second method that has been used to increase the buoyancy capacity of APEX floats is to substitute a hull made of carbon fiber composite material for the usual aluminum hull. These composite hulls are the same length and inside diameter as aluminum APEX hulls (so that the same end caps can be used), but their mass is nearly 4 kg less than the usual aluminum hull. The composite hulls have strength comparable to aluminum and have been produced with a range of compressibilities ranging from 70% to 90% of that of seawater (the compressibility of aluminum hulls is about 65% of the compressibility of seawater). Since an APEX float with a composite hull has an oil bladder and pump identical to those used with aluminum hulls (with a pumping capacity of 260 ml) but is generally more compressible, it is easier to change the density of a float with a composite hull by the 16 kg/m^3 necessary to reach the sea surface in the tropics.

Outside of the tropics, floats with composite hulls can also be used in special applications where additional buoyancy capacity is required, since the composite hulls have significantly lower mass than aluminum hulls. The use of composite hulls has proven to be useful on prototype Argo-equivalent floats that carry arrays of biogeochemical and acoustic sensors. Given their greater mass, aluminum-hulled floats with these sensors would not be able to profile between 2000 m and the sea surface over much of the tropical and mid-latitude ocean. By using composite hulls instead, it has been possible to test such sensor arrays on floats in the tropics and elsewhere. The University of Washington float group, in conjunction with Webb Research Corporation, has since 2002 deployed more than 10 Argo-type floats with composite hulls in various parts of the world ocean; these floats have generally performed without problems, and some have already carried out over 200 profiles to a depth of 2000 m. The composite hulls cost about $US500 more than regular APEX floats with aluminum hulls, but, as with N2 floats, this seems not an unreasonable price to pay for the added profiling capabilities in applications where such additions are required.

Thus, for APEX floats there are now two options available that can be used to allow profiling from 2000 m to the sea surface anywhere in the world ocean. Both of these options are commercially available at a relatively small incremental cost and can be used whenever warranted scientifically. The target of profiling to 2000 m over the entire world ocean that was outlined in the initial Argo Science Team reports nearly a decade ago can now be met.

Report on the Ninth Argo Steering Team Meeting

Megan Scanderberg [mscanderbeg@ucsd.edu]

The 9th meeting of the international Argo Steering Team was held in Exeter, United Kingdom on March 18-20 2008, hosted by the UK Met Office. IAST-9 focused on Argo re-examining its core mission and working to fulfill its original goals as well as looking to the future and where Argo will be in another 10 years. H. Freeland opened the meeting with a discussion of the array status including what has been achieved so far and where Argo wants to improve (see the article on page 2 of the Newsletter). Similar to last year, a few speakers were invited to give science talks. The first talk, given by Dan Lea, was a follow-up talk to the one given last year on the use of Argo data in the UK Met Office's operational FOAM model. A second talk was given by Doug Smith of the UK Met Office on using Argo data in decadal predictions. The last talk was given by Karen Heywood on using Argo data to investigate the Madden-Julian Oscillation. Many other topics were discussed and highlights from the meeting included:

Data quality issues

Data quality is one area where Argo is choosing to refocus on its core mission of providing quality real time data within 24 hours as well as quality delayed mode data within the 6 months to one year time frame. To this end, several actions were endorsed at the AST meeting including developing an updated data user manual, working with the user community to implement more quality control of Argo data, forming a working group to address several different pressure issues, and holding a third delayed mode quality control workshop in September 2008. A presentation was given at the meeting detailing a method that uses satellite altimeter data to compare altimeter sea level anomalies with dynamic height anomalies from Argo T/S profiles. See S. Guinehut's article in this Newsletter.

Reference data

For delayed mode quality control, Argo requires a global database of reference quality CTD data with an emphasis on recent data. To this end, a partnership has been formed between CCHDO, Coriolis and US-NODC to make a "virtual data center". Argo encourages PIs to submit their CTD cruise data to this secure web site for Argo delayed mode quality control purposes only. Additionally, a presentation was made to show results from a study designed to compare Argo data to Levitus WOD05 and to a seasonal Argo climatology as well as to objective analysis maps made by Coriolis in delayed mode. Preliminary results indicate that this will be helpful in detecting bad profiles. Other studies are evaluating the use of Argo data as part of a reference database for delayed mode quality control purposes. This topic will be discussed at the upcoming DMQC meeting.

New float technology

Both the PROVOR and SOLO floats have new versions in different stages of testing. An ARVOR prototype, the PROVOR successor, profiled successfully from December 2006 to December 2007, sending back profiles from 2000m every 2 days. Ten more ARVOR prototypes will be deployed this year by Coriolis. The SOLO-2 prototype, considerably smaller and more efficient than the SOLO, is scheduled for deployment in July 2008. APEX floats have been successfully modified by S. Riser to profile to 2000m anywhere in the world and to park at the desired parking level of 1000db. Articles on the ARVOR and APEX new float technologies can be found in this Newsletter.

Argo products

As Argo reaches more complete global coverage for several years running, products based on only Argo data can be produced and distributed to the scientific community and more groups are beginning to do this on a regular basis. M. Scanderbeg presented a Global Marine Atlas under development that provides a way for users to view gridded Argo data sets made by D. Roemmich and J. Gilson. As these products progress, they will be added to the Argo web site to help demonstrate Argo's value and the need for the data.

Demonstrating Argo's value

Since Argo has moved into the sustained maintenance phase, demonstrating its value has become even more important as Argo works to maintain funding. One way to do this is to involve Argo in relevant science meetings around the globe. H. Freeland reported on the GEO Ministerial Meeting for which much work was done to create an effective Argo-Jason display. Despite a disappointing turn out by ministers, an impressive display was made that can be used by others in the future.

Argo has several opportunities in the coming year and a half to showcase what it has accomplished and what it hopes to do in the next 10 years. The GODAE Final Symposium in November invited Argo to give a multi- author paper and a round table discussion. It is also hoped there will be a strong Argo representation in the poster session. The decision was made to hold the 3rd Argo Science Workshop in early 2009 in Hangzhou, China to help prepare for the OceanObs'09 meeting later in 2009. The Workshop will include invited papers on Argo and will request that speakers address the effectiveness of the Argo array. After participating in the workshop, a small group will draft a paper for OceanObs'09.

Argo Information Centre

In addition to providing a mechanism for satisfying IOC Resolution XX-6 on float deployment notification, the AIC's Argo Technical Coordinator has developed a Support Centre to address problems users may have with Argo data. Users can request help online, track their request as it is forwarded to the appropriate person to answer the question, or browse the FAQs section. For the upcoming year, the TC will work on refining his metrics that monitor the array status to better understand the status of the array and to help with issues like deployment planning. It was noted that the monthly reports compiled by the TC are very appreciated and useful to scientists deploying Argo floats.

As global observing systems grow, the structure of JCOMMOPS is growing and changing as well. Several institutions have responded to a WMO/IOC circular letter to host the future JCOMM-OPSC office. Argo looks forward to following the process of selecting a new site and determining a new structure for JCOMM-OPSC.

New sensors on Argo floats

Argo floats provide potential platforms for accommodating additional sensors that may increase the scientific value of the Argo array. Any additions must be carefully considered and cannot impact the core capabilities of Argo, including float lifetime. A follow-up talk was given on the Oxygen White Paper which was presented at last year's AST meeting. More than 100 floats are now deployed with dissolved oxygen sensors and this number is growing rapidly. Progress has been made to improve the long-term drift of the SBE-IDO sensor, but some sensors still have large drifts over a few years. Aanderaa is working to address slow response times and poor initial calibrations on its sensors. The OXY-WATCH project has been created as a response to a European call for monitoring oxygen and is the pilot phase proposed by the Oxygen White Paper. Argo welcomes these two pilot programs and hopes they will continue developing. It was noted that Argo needs to be very careful in determining what type of data, such as oxygen or other data from new sensors, can be included in the Argo data stream. We need to ensure that data acquired within the EEZs of coastal states and released in real-time is compliant with the law of the Sea. This issue will be clarified for us by ABE-LOS.

The full report of the AST-9 meeting and the supporting documents are available on the AST web site at
http://www.argo.ucsd.edu/ FrMeeting_reports.html.

Thank you UK Met Office for hosting the meeting.

Argo in Schools

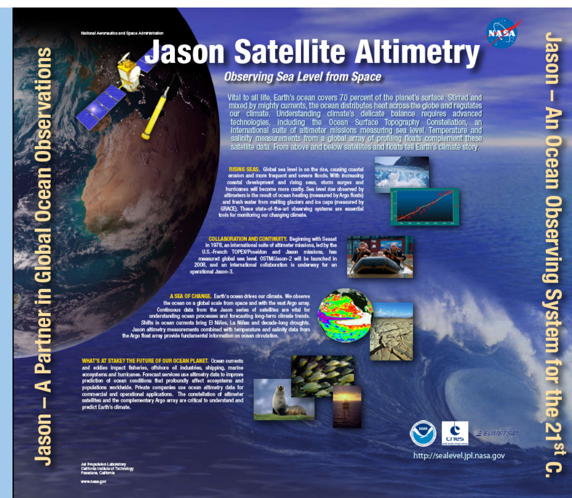
Argo has begun a new feature on the web site to showcase work done by students after learning about Argo in school. The firs submission is a piece of artwork Howard Freeland received from a student after he had the opportunity to talk to a group of home-school children in Canada during an event called Tech Week organized by a home-school parent. Howard has worked with these children before, many of whom live in remote areas without access to schools.

Eliana Snell is 12 years old and loved the Argo robots in the ocean, however, she was also worried about the floats being attacked by Orca whales. She sent the picture to the left to illustrate her concerns.

To submit a piece of work from a student and a description of the outreach, contact Megan Scanderbeg at argo@ucsd.edu

GEO Ministerial Exhibition Display

The Argo and Jason posters prepared for the GEO Ministerial Exhibition shown to the right look are available for display. It is possible to obtain the entire "Oceans United Display" which works on a PLEX system and would require a substantial shipping cost. Contact Chris Reid if you are interested. If you would prefer pdfs of the posters, go to http://www.pac.dfo-mpo/gc.ca/sci/osap/people/Argo_Final_crop.pdf and http://www.pac.dfo-mpo.gc.ca/sci/osap/people/Jason_Final_Crop.pdf. Contact Howard Freeland if you have questions about the pdf versions of the posters.



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Update the Argo in press bibliography

Please send argo@ucsd.edu citations for Argo articles submitted or in press to keep this part of the bibliography updated.

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 programs that contribute to it. (www.argo.ucsd.edu, argo.jcommops.org). Argo is a pilot program 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.

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