Argo: A 2006 status report

By Howard Freeland

For the last several years, I have written a report at about this time of year on the current status of Argo and the prospects for the future. The report has, in the past, been circulated within Canada, but this year, I was asked to reproduce a version for PICES Press. This note accompanied the release of Argonautics-8, the 8th issue of the Argo newsletter (see http://www.pac.dfo-mpo.gc.ca/sci/osap/projects/argo/documents/Argonautics08.pdf).

Internationally, Argo is extremely successful. In 2001, when I was the annual tour lecturer for the Canadian Meteorological and Oceanographic Society (CMOS), Argo was just starting, but I advertised our short-term objective to have 3000 floats operating in the oceans of the world by some time in 2007. Well, 2007 is here, so we must be getting close, and **Figure 1** shows where the project is right now. I think the one message to take home from this diagram is that, perhaps we have not yet achieved the target of 3000 floats, but we have a global array of profiling floats. All floats are reporting in near real-time (with a few notable exceptions which we are endeavouring to fix), and the data from this array are available to anyone in the world who has a broadband internet connection.

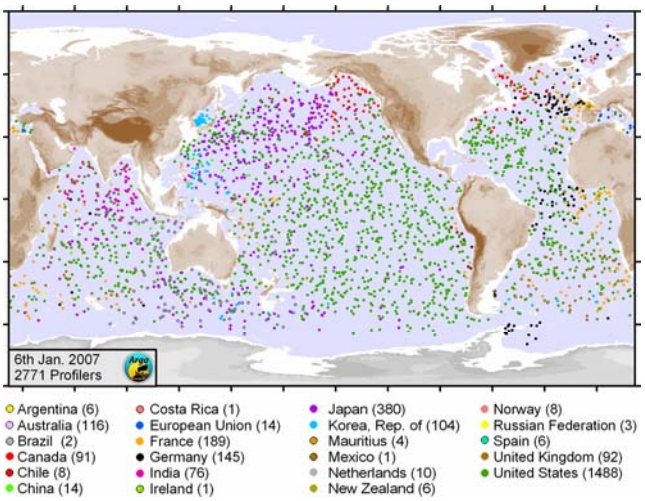

Fig. 1 A plot of the recent distribution of Argo floats, colour-coded by country that launched the float.

The Argo team aims to supply an array with even coverage everywhere. If we count the number of floats per unit area and divide it by the number there would be with a nearest-neighbour separation of 300 km, we get a density map as seen in **Figure 2**. The object then is to turn the whole map red, but we will never actually achieve this. Even in areas that are easy to reach, gaps will open up, but the large gaps now have mostly disappeared. We have a global array, and the problem now is one of maintenance until we have demonstrated the value of the array for ocean climate prediction.

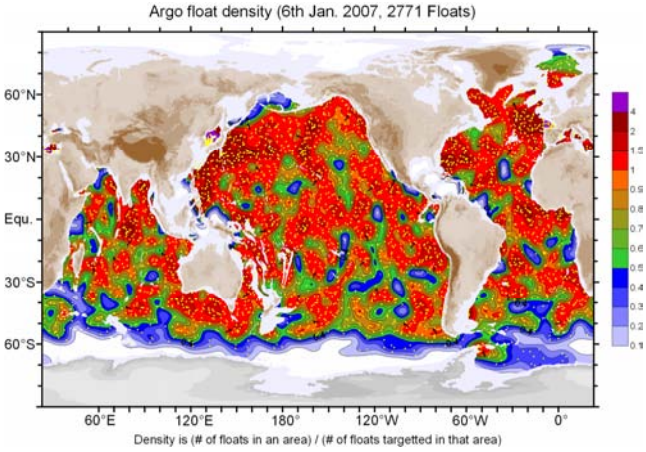

Fig. 2 A plot of the density of Argo floats (January 6, 2007, 2771 floats), normalized by the target density.

I would like to give a few examples to show how big Argo really is:

- Between 1990 and 1996, the countries of the world collaborated for a one-time survey of the climatic status of the global oceans, called World Ocean Circulation Experiment (WOCE). During that period 25 ship-years were used to gather about 20,000 CTD stations. Data were not released in real-time, rather they were protected so that the Principal Investigator had an inside-track on publications.
- In 2005, the global XBT surveys collected data from 30,000 stations. Generally, the data were made available in real-time, but these data are of limited value as the XBTs do not measure salinity, temperature is good to only ±0.1°C, and pressure is not measured, rather, it is inferred from a fall-rate equation.
- In December 2006, Argo floats gathered 8715 profiles that is equivalent to almost 103,000 profiles *per year*. Argo has a lower accuracy than the WOCE datasets had with ±0.002 in temperature or salinity, but the data are of systematically high quality, available in real-time without constraint and with a uniform quality control.

I am frequently asked when Argo will actually achieve the target we set back in 2001 of having 3000 floats operating at one time. I have tried fitting a simple population dynamic model to the array, and this suggests that we will have 3000 operating floats around the beginning of September 2007.

Not everything went right in 2006. During this last year, the Argo Program Director, John Gould, retired without replacement. This derives from a perennial problem that not enough countries are able to contribute funds to the Argo infrastructure. The IOC (Intergovernmental Oceanographic Commission) resolution XX-6 forces us to run an Argo Program Office with an Argo Technical Coordinator, and we (the Argo Steering Team) also feel a need to have an overall Program Director. At the moment, only five countries (Australia, Canada, France, UK and U.S.A.) contribute funds to the infrastructure, and so we were no longer able to pay the salary of the Program Director. If anyone has an innovative solution to this dilemma then please contact me, quickly.

Following a bad period in 2003, we have succeeded in improving the typical longevity of a float. There will always be floats that fail prematurely, but it should be possible for floats to complete 200 profiles with standard Argo profiling that would give a longevity of more than 5 years. Canada presently has two very old floats (known by their WMO IDs 4900073 and 4900074) that are still operating. They were launched 1 day apart in 2002, and if they continue to provide profiles, they will celebrate their 5th birthdays in February 2007. One of these (4900073) is near exhaustion and is behaving erratically, but the other (4900074) still has lots of power left in its batteries and appears likely to continue for a lot longer than 5 years. In the future, I anticipate that a large fraction of deployed floats will achieve this kind of longevity.

In March 2006, the second Argo Science workshop took place. Imagine the surprise as we were arriving in Venice for the workshop when a float was seen to emerge and deliver a profile of water properties in the Grand Canal (**Photo 1**)! This was an exciting meeting and was very well attended. However, Argo is just a global tool for the study of ocean climate, and I look forward to the day when Argo Science workshops no longer take place. Meteorologists do not have "Barometer workshops" and oceanographers do not have "CTD workshops"; these are just tools, and Argo is no more than that. It is a very new tool, and for now there is some value to the workshops still as scientists learn how to make optimal use of the data.

Currently, 80% of the floats have their data published within 24 hours of reporting. The data are subjected first to real-time quality control, and floats which have known problems are corrected in real-time. Canada now has 92 floats in the water. We are tracking 16 floats which report oxygen, and 7 floats with the capability of reporting a first profile within 24 hours after their launching. In November 2006, Anh Tran (Marine Environmental Data Services, MEDS) participated in the 7th Argo data management meeting. The meeting was very well attended. In the upcoming years, the data management group will streamline the quality control tests and will move forward in publishing Argo data in BUFR format.

Photo 1 A profiling float delivering a profile of water properties in the Grand Canal.

During the summer of 2006, Japan launched an Argo float close to the North Pole, and this can be seen just north of Spitsbergen on **Figure 1**. Since an Argo float cannot transmit data to a satellite through the Arctic sea ice, this is a modified system that has the float riding up and down a cable attached to a buoy that has been frozen into the ice. Also on the same map you will see a group of German floats in the Weddell Sea. These are designed to survive under ice and save profiles for later transmission, should they be unsuccessful in finding open water.

Denis Gilbert continued to assume his role with respect to oxygen data processing and quality checking on our now 16 Canadian Argo floats equipped with oxygen sensors. He interacted with Arne Koertzinger (Germany) at the March 2006 Argo Science workshop. In late September 2006, he welcomed Taiyo Kobayashi (Japan) for a 2-day visit at the Institut Maurice-Lamontagne, to compare the Japanese and Canadian at-sea calibration checks of oxygen floats with Winkler titrations. In October 2006, Denis also attended an Oxygen Minimum Systems workshop in Concepción, Chile. Keynote lectures focused on the physical and biogeochemical processes responsible for the establishment and maintenance of oxygen minimum zones, and how various life forms are adapted to low oxygen conditions. While in Concepción, he also visited the Chilean Argo group (Osvaldo Ulloa, Oscar Pizarro, Victor Villagran) to share experience and exchange ideas with regards to quality control of oxygen data from Argo floats. Denis and Anh Tran have continued their joint work on oxygen data from the Canadian floats. For 2007, they plan to introduce delayed mode quality-controlled oxygen data. Finally, Denis is part of a team of people writing a white paper whose aim is to promote a more intense deployment of oxygen floats within the international Argo program. This white paper will be available for public comments in early 2007.

The use of Argo for climate forecasting and evaluating the changing state of the ocean is rapidly expanding. I recently participated in an Argo Capacity Building workshop at the University of Ghana (**Photo 2**). This was attended by about 40 scientists from countries along the Atlantic coast of Africa.

Photo 2 Attendees at the Argo Capacity Building workshop at the University of Ghana, in East Legon, a suburb of Accra (photo by Howard Freeland).

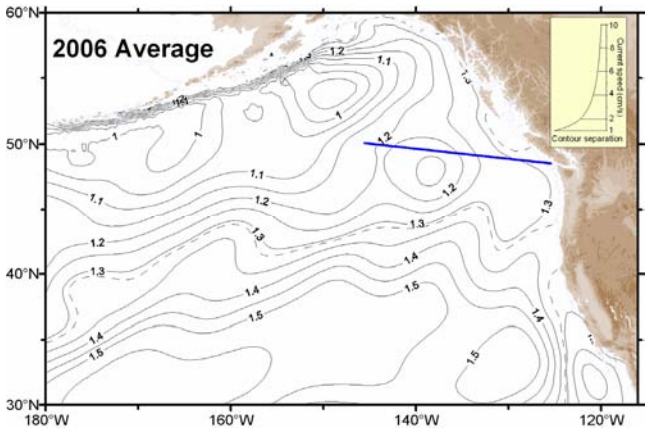

Fig. 3 The average surface circulation in the N.E. Pacific in 2006. The blue line shows Line-P and the dashed line shows the line separating water that ultimately flows north from that eventually heading south.

The workshop was very successful, and participants were convinced that the data are truly available free of charge for the benefit of everyone.

Argo is a new tool, and we are trying to learn how to use it. It does allow a real-time look at the behaviour of the ocean, and I am preparing real-time assessments of changing conditions in the Gulf of Alaska. Maps of ocean properties, mixed layer properties, evolving circulation maps, conditions in the biologically-active areas of the Gulf of Alaska, and some derived quantities are available on my website devoted to Argo (http://www.pac.dfo-mpo.gc.ca/sci/osap/projects/ argo/Gak_e.htm). **Figure 3** shows, for illustrative purposes, the surface circulation pattern averaged over all of the year 2006. The website also includes indicators of the changing circulation field, for example, one plot shows that in December 2006, the surface flow in the North Pacific Current was the largest it has been since 2002. The computations that produce those maps can now be done anywhere at all from the Southern Ocean to the Gulf of Guinea or Spitsbergen.

In 2007, I expect we will see an increase in the number of float-supplying nations. I note that Kenya, in December 2006, has 5 floats awaiting deployment in the Indian Ocean. It is also likely that South Africa will deploy floats during 2007, and there are rumours that other nations may be joining the Argo club in 2007.

The technology in an Argo float is also likely to change in 2007. At long last, the manufacturers are ready to supply floats broadcasting on the Iridium global cell-phone system rather than the old Service Argos system. That will give Argo floats a large increase in flexibility. Webb Research may also be supplying floats with carbon-fibre hulls, instead of aluminium hulls. This change offers several advantages. First, the float will be lighter and so will be able to carry more batteries, thus increasing the potential lifetime of a float. Second, the hull will be slightly compressible, about 50% of the compressibility of water. This will allow the floats to make the vertical excursions between 2000 decibars and the surface with less power drain, again enhancing the potential float lifetimes.

Acknowledgements: Many thanks to Anh Tran (Marine Environmental Data Services, Fisheries and Oceans Canada, trana@dfo-mpo.gc.ca) and Denis Gilbert (Maurice-Lamontagne Institute, Fisheries and Oceans Canada, gilbertd@dfo-mpo.gc.ca) who helped create this report.

P.S. Download the Argo icosahedral net from http://www.pac.dfo-mpo.gc.ca/sci/osap/projects/argo/images/icosa.jpg, print it on a good colour printer, score it for easy folding, cut it out, fold it and stick it together (in that order) to make an unusual decoration.

Dr. Howard Freeland (FreelandHJ@pac.dfo-mpo.gc.ca) is a physical oceanographer conducting research on the circulation and dynamics of the N.E. Pacific and works for Fisheries and Oceans Canada at the Institute of Ocean Sciences. He was launching profiling floats before the Argo concept emerged. Since then Howard has been involved in every meeting of the International Argo Steering Team and Executive Committee and presently he co-chairs the International Argo Steering Team. Howard received his B.A. at the University of Essex (England) and his Ph.D. at Dalhousie University, in Halifax, Nova Scotia.