2015 Argo Canada report of activities

(submitted by Blair Greenan, Fisheries and Oceans Canada)

17th meeting of the Argo Steering Team (AST-17)
Yokohama, Japan
22-24 March 2016

1. Status of implementation (major achievements and problems in 2015)

- *floats deployed and their performance*

From March 2015 to February 2016, Argo Canada deployed 32 MetOcean (NOVA and DOVA) floats (16 in the northeast Pacific, 13 in the northwest Atlantic, and 3 in Southern Ocean with the help of deployments from Australia DAC). Of these 32 floats, 10 died prematurely. The 22 remaining floats are still active and functioning properly. "Active" assumes that less than 4 of the last 4 profiles have been missed. Of the 32 floats, 4 were replacements. Of the 10 that died prematurely, 1 grounded, 5 were replaced under warranty, and 4 need to be replaced under warranty. Three of the latter number were replacements. One warranty replacement has yet to be deployed. The Government of Canada Standing Offer with Metocean requires that if a float fails to complete 18 profiles the manufacturer must provide a replacement float. As of 1 March 2016, Argo Canada has 57 active floats in the Argo array.

- *technical problems encountered and solved*

Oil was noted to be leaking in the packing crates for two floats prior to deployment. These were returned to the manufacturer for repair at their cost. It was determined that there was improper seating of an o-ring in some units. This resulted in a design change to prevent future oil leaks.

Four floats surfaced soon after deployment and remained at the surface transmitting to the Iridium satellite network. The Canadian Navy recovered one of the failed floats and returned it to MetOcean. It was subsequently determined there was a problem in the interface between the float and the Sea-Bird CTD; this was addressed by manufacturer and the problem has not occurred since.

In February 2016, two NOVA floats failed upon deployment in the Northeast Pacific. This was the result of a firmware change in the Sea-Bird CTD board. This appears to have resulted from a lack of communication of this change between Sea-Bird and MetOcean which resulted in a technical problem in the NOVA float.

- *Status of contributions to Argo data management (including status of conversion to V3 file formats, pressure corrections, etc)*

DFO ISDM (formerly MEDS) continues to acquire data from 65 Argo floats. Of which 8 floats seemed to be in trouble and have not reported data for at least 1 month, so that our number of active floats is actually 57. Data are issued to the GTS and GDACs hourly in TESAC, BUFR and NetCDF format. The data of all Canadian floats together with some graphics are posted on a website and updated daily: http://www.isdm.gc.ca/isdm-gdsi/argo/index-eng.html. On average 92% of data from January 2015 to January 2016 data were issued to the GTS within 24 hours of the float reporting in TESAC and BUFR format.

Since AST-16, we completed the following tasks:

- About ~18000 existing NETCDF profiles were converted to version 3.1. About roughly 5000 NETCDF profiles has been DMQC still need to convert to version 3.1 due to failure GDAC format checkers. We'll continue our conversion process based on each individual case.
- All of the meta data and technical NetCDF files were converted to version 3.1
- The new Argo BUFR template to send dissolved oxygen and surface observations on the GTS has been accepted and available for operational uses.
- We rewrote the BUFR encoder to read NetCDF profile version 3.0 and 3.1 in order to send dissolved oxygen and surface observations on the GTS. The software has been validated with AOML and is available if you would like to use it.
- Completed change the bulletin header from SOVD02 to SOFD02 for Argo TESAC messages.
- ISDM provides ADMT with quarterly reports on the performance of Argo data on the GTS in TESAC and BUFR formats.

- *Status of delayed mode quality control process*

As of February 2016, 30% of all eligible floats, active and inactive, had their profiles visually QCed and adjusted for pressure and salinity according to the latest delayed-mode procedures at least once. The salinity component of DMQC has been performed on 58% of all eligible cycles at least once. This is an improvement from March 2014 when Argo Canada reported 16% of floats were QCed.

2. Present level of and future prospects for national funding for Argo including a summary of the level of human resources devoted to Argo.

Financial resources

Canada does not have multi-year commitments of money devoted to Argo. Lobbying is necessary on an annual basis to renew the funding required to purchase new floats and other operational expenditures. Fisheries and Oceans Canada (DFO) committed $361.5k for purchases of Argo float in August 2015. National Defence Canada also commited $80k for the purchase of 5 MetOcean NOVA floats. The enabled the acquisition of a

total of 26 floats. Funding is expected to remain stable at approximately this level for the next few years with the new Federal Government committed to reinvesting in DFO Science.

The development of close links between the Argo Canada program and both the operational meteorology and operational oceanography R&D activities at the Canadian Meteorological Centre (Dorval, Québec) has been beneficial. An inter-departmental (Environment Canada, Department of National Defence, Fisheries and Oceans) Memorandum of Understanding entitled CONCEPTS (Canadian Operation Network of Coupled Environmental PredicTion Systems) has provided strong advocacy for the Argo program.

Human resources

On 1 April 2015, Blair Greenan of the Bedford Institute of Oceanography (BIO) replaced Denis Gilbert as national leader of the Argo Canada program. The logistics related to float deployments and satellite data transmission has been handled by Ingrid Peterson, also at BIO. On the west coast, Tetjana Ross has been hired by DFO at the Institute of Ocean Sciences and has taken over responsibility for Pacific deployments for Argo Canada.

In terms of FTE (Full-Time Equivalent) units, the following persons contribute to Argo Canada:

Anh Tran (ISDM, Ottawa, 0.9 FTE)
Mathieu Ouellet (ISDM, Ottawa, 0.1 FTE)
Blair Greenan (BIO, Halifax, 0.2 FTE)
Ingrid Peterson (BIO, Halifax, 0.8 FTE)
Igor Yashayaev (BIO, Halifax, 0.2 FTE)
Tetjana Ross (IOS, Sidney, 0.2 FTE)
Doug Yelland (IOS, Sidney, 0.1 FTE)
Denis Gilbert (IML, Mont-Joli, 0.1 FTE)

There is a plan to hire a co-op student in the summer 2016 to update some of the data products developed by Howard Freeland, such as surface circulation maps of the Gulf of Alaska, Argo data interpolated to station Papa and projected onto Line P.

Denis Gilbert is assisting Argo Canada with issues related to dissolved oxygen. In particular, he has been providing expert advice and support on quality control and data processing of DO data from the DOVA floats deployed in the Labrador Sea.

In addition to the above persons, we benefit from the technical support of sea-going staff that follow pre-deployment protocols and perform the float deployments.

3. Summary of deployment plans (level of commitment, areas of float Deployment, low or high resolution profiles, extra sensors, Deep Argo) and other commitments to Argo (data management) for the upcoming year and beyond where possible.

In 2016, we plan to deploy 26 new floats (firm commitment), all of which have already been purchased: 11 will be deployed in the North Pacific (NOVA), 6 in the Labrador Sea (2 NOVA, 4 DOVA), and 9 in the Gulf Stream's northern recirculation gyre and off Newfoundland (NOVA). There is also potential for up to 9 additional float deployments with replacement floats for those that failed within the warranty period.

4. Summary of national research and operational uses of Argo data as well as contributions to Argo Regional Centers. Please also include any links to national program Argo web pages to update links on the AST and AIC websites.

The Canadian CONCEPTS Global Ice Ocean Prediction System (GIOPS) assimilates Argo data on a weekly basis. The GIOPS assimilation system has been updated in 2015 to use a smoother increment update called IAU. In this process the results of the assimilation are progressively added to the model solution over a model period of 1 day. This ensures that the ocean model is more receptive to Argo data. The new version of GIOPS operational since Dec 2015, now uses the IAU update in it assimilation scheme. Inter-comparisons with observations (profiles, drifters), demonstrate increased forecast precision as a result of the updated assimilation scheme in GIOPS V2. Validations with Argo on GIOPS are also compared with four other international groups under the GODAE OceanView Intercomparison Validation Task team using class4 metrics. In addition to the operational GIOPS v2 system, CONCEPTS has implemented a Regional Ice Ocean Prediction System (RIOPS) covering the Arctic and Atlantic Oceans. This system is operational, there is no data assimilation, but RIOPS is spectrally nudged to GIOPS which assimilated Argo data. Future updates of CONCEPTS RIOPS systems will include its own assimilation scheme.

All CONCEPTS systems run operationally at Environment and Climate Change Canada's Canadian Meteorological Center (Dorval, Quebec). CONCEPTS is an MOU for a collaboration between National Defence, Environment and Climate Change Canada and Fisheries and Oceans Canada.

The Department of National Defence Navy scientists routinely use real time Argo vertical profiles of temperature into their Ocean Work Station to aid in the computation of sound velocity profiles for support of at-sea operations.

Argo floats deployed in the Labrador Sea are an important element of an NSERC Climate Change and Atmospheric Research project entitled VITALS (Ventilation, Interactions and Transports Across the Labrador Sea). This research network is attempting answer fundamental questions about how the deep ocean exchanges carbon dioxide, oxygen, and heat with the atmosphere through the Labrador Sea. New observations and modelling will determine what controls these exchanges and how they interact with varying climate, in

order to resolve the role of deep convection regions in the Carbon Cycle and Earth System. VITALs is a pan-Canadian initiative involving scientists from 11 Canadian universities as well as multiple federal government laboratories (Fisheries and Oceans Canada, as well as Environment Canada), industrial and foreign partners. http://knossos.eas.ualberta.ca/vitals/

The Argo Canada web site is maintained by Fisheries and Oceans Canada at http://www.isdm.gc.ca/isdm-gdsi/argo/index-eng.html.

5. Issues that your country wishes to be considered and resolved by the Argo Steering Team regarding the international operation of Argo. These might include tasks performed by the AIC, the coordination of activities at an international level and the performance of the Argo data system. If you have specific comments, please include them in your national report.

Nothing to report this year.

6. To continue improving the quality and quantity of CTD cruise data being added to the reference database by Argo PIs, it is requested that you include any CTD station data that was taken at the time of float deployments this year. Additionally, please list CTD data (calibrated with bottle data) taken by your country in the past year that may be added to the reference database. These cruises could be ones designated for Argo calibration purposes only or could be cruises that are open to the public. To help CCHDO track down this data, please list the dates of the cruise and the PI to contact about the data.

Most of the recent CTD data collected by DFO researchers are transferred to ISDM and then to NODC and CCHDO. Mathieu Ouellet (DFO, Ottawa) is responsible for dissemination of Canadian CTD data. Steve Diggs sometimes obtains data directly from Canadian PI's at DFO labs.

7. Keeping the Argo bibliography (http://www.argo.ucsd.edu/Bibliography.html) up to date and accurate is an important part of the Argo website. This document helps demonstrate the value of Argo and can possibly help countries when applying for continued Argo funding. We reached more than 2000 papers published using Argo data! To help me with this effort, please include a list of all papers published by scientists within your country in the past year using Argo data, including non-English publications.
I've added a thesis citation list too (http://www.argo.ucsd.edu/argo_thesis.html). If you know of any doctorate theses published in your country that are missing from the list, please let me know.

1. Hauser, T., Demirov, E., Zhu, J. and Yashayaev, I., 2015 North Atlantic atmospheric and ocean inter-annual variability over the past fifty years – Dominant patterns and decadal shifts. Prog. Oceanogr. http://dx.doi.org/10.1016/j.pocean.2014.10.008
2. Kieke, D. and Yashayaev, I. 2015 Studies of Labrador Sea Water formation and variability in the subpolar North Atlantic in the light of international partnership and collaboration. Prog. Oceanogr. http://dx.doi.org/10.1016/j.pocean.2014.12.010
3. Yashayaev, I., Seidov, D., Demirov, E., 2015. A new collective view of oceanography of the Arctic and North Atlantic basins. Prog. Oceanogr., http://dx.doi.org/10.1016/j.pocean.2014.12.012
4. Dupont, F., Higginson, S., Bourdallé-Badie, R., Lu, Y., Roy, F., Smith, G., Lemieux, J.-F., Garric, G., and Davidson, F.A. 2015. A high-resolution ocean and sea-ice modelling system for the Arctic and North Atlantic Oceans - *Geosci. Model Dev.*, 8, 1577-1594, doi:10.5194/gmd-8-1577-2015. http://www.geosci-model-dev.net/8/1577/2015/gmd-8-1577-2015.html
5. Holdsworth, A.M. and Myers, P.G. 2015. The Influence of High Frequency Atmospheric Forcing on the Circulation and Deep Convection of the Labrador Sea. Journal of Climate, 28 (12), 4980-4996.
6. Legler, D.M., Freeland, H.J., Lumpkin, R. , Ball, G., McPhaden, M.J., North, S., Crowley, R., Goni, G.J., Send U. and Merrifield, M.A. 2015. The current status of the real-time in situ Global Ocean Observing System for operational oceanography, Journal of Operational Oceanography, 8:sup2, 189-200, DOI:10.1080/1755876X.2015.1049883.
7. Bond, N.A., Cronin, M.F. and Freeland, H. 2015. The Blob: An extreme warm anomaly in the northeast Pacific—2015. BAMS State of the Climate in 2014. Chapter 3: Global Oceans.
8. Bond, N. A., Cronin, M.F., Freeland, H. and Mantua, N. 2015. Causes and impacts of the 2014 warm anomaly in the NE Pacific, Geophys. Res. Lett., 42, doi:10.1002/2015GL063306.
9. Riser, S. C., Freeland, H. J., Roemmich, D., Wijffels, S., Troisi, A., Belbeoch, M., Gilbert, D., Xu, J., Pouliquen, S., Thresher, A., Le Traon, P.-Y., Maze, G., Klein, B., Ravichandran, M., Grant, F., Poulain, P.-M., Suga, T., Lim, B., Sterl, A., Sutton, P., Mork, K.-A., Velez-Belchi, P. J., Ansorge, I., King, B., Turton, J., Baringer, M. & Jayne, S. R., Fifteen years of ocean observations with the global Argo array Nature Clim. Change, **6**, 145-153, doi: 10.1038/nclimate2872
10. Johnson, K.S., Plant, J.N., Riser, S.C. and Gilbert, D. 2015. Air oxygen calibration of oxygen optodes on a profiling float array. J. Atmospheric and Oceanic Technology, 32, 2160-2172, doi: 10.1175/JTECH-D-15-0101.1