2016 Argo Canada report of activities

(submitted by Blair Greenan, Fisheries and Oceans Canada)

18th meeting of the Argo Steering Team (AST-18)
Tasmania, Australia
13-17 March 2017

1. Status of implementation (major achievements and problems in 2016)

- *floats deployed and their performance*

From March 2016 to January 2017, Argo Canada deployed 26 MetOcean (NOVA and DOVA) floats (11 in the northeast Pacific, and 15 in the northwest Atlantic). Of these 26 floats, 5 died prematurely. The 21 remaining floats are still active and functioning properly. "Active" assumes that less than 3 of the last 4 profiles have been missed. Of the 26 floats, 1 was a replacement. Of the 5 that died prematurely, 3 are being replaced under warranty, and 1 needs to be replaced under warranty. One warranty replacement for a float deployed in the previous year has yet to be deployed. The Government of Canada Standing Offer with MetOcean Data Systems Ltd. (now MetOcean Telematics Ltd.) requires that if a float fails to complete 18 profiles the manufacturer must provide a replacement float. Argo Canada also deployed a MetOcean NAMI float with an RBR CTD sensor, but it was not part of the Argo array and only reported 14 profiles. As of 31 January 2016, Argo Canada has 68 active floats in the Argo array.

- *technical problems encountered and solved*

A recurring problem, caused by the communications provider not forwarding decoded data to Argo Canada when the data stream was incomplete, has been resolved in 2017.

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

MEDS, a section of DFO's Ocean Science Branch, continues to acquire data from 68 active floats and to seek potential data transmissions from 9 additional floats which have not reported data for at least one month. Data are issued to the Global Telecommunication System (GTS) and GDACs hourly in TESAC, BUFR and netCDF format. Statistics and scientific data products of Canadian floats together are posted on a daily updated website: http://www. meds-sdmm.dfo-mpo.gc.ca/isdm-gdsi/argo/index-eng.html.
On average 94% of data from January 2016 to January 2017 data were issued to the GTS within 24 hours of the float reporting in TESAC and BUFR format.

Since AST-17, we have worked on / completed the following tasks:

- netCDF profile files conversion to v3.1 (~96% complete)
- netCDF metadata and technical files conversion to v3.1 (completed)

- reprocessing Argo floats with dissolved oxygen sensors and making data available at GDACs in netCDF v3.1 (ongoing)
- implementing changes in Argo real-time quality control tests (completed)
- monitoring the distribution and timeliness of Argo data in TESAC and BUFR format on the GTS, and providing ADMT with quarterly reports on the performance of Argo data on the GTS (ongoing)

- *Status of delayed mode quality control process*

As of January 31st 2017, 33% 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 61% of cycles of eligible floats at least once.

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
During 2016 Canada transitioned to having ongoing funding for the O&M expenditures related to the Argo program. Shared Services Canada (SSC) is now responsible for the costs related to Iridium telecommunications as part of an initiative to centralize these services with the Federal government. In the Federal Budget of March 2016, a reinvestment in DFO Science was announced and this has resulted in a commitment to ongoing O&M expenditures for Argo Canada. However, ongoing capital for float purchases has not been identified and, therefore, it remains necessary to request capital resources on an annual basis to obtain the funding required to purchase new floats. Fisheries and Oceans Canada (DFO) committed $396k for purchases of 24 core Argo floats in 2016. Department of National Defence (Canada) also commited $160k for the purchase of 10 MetOcean NOVA floats (3 for core Argo, 7 supporting the Year of Polar Prediciton – YOPP). The enabled the acquisition of a total of 34 floats. Funding is expected to remain stable at approximately this level for the next few years.

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 and Climate Change 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, DFO) 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 at the Institute of Ocean Sciences (DFO) 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)

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 2017, we plan to deploy 30 new floats (firm commitment), all of which have already been purchased (21) or will be received as replacements (9): 12 will be deployed in the North Pacific (11 NOVA, 1 DOVA), 10 in the Labrador Sea (7 NOVA, 3 DOVA), and 8 in the Gulf Stream's northern recirculation gyre and off Newfoundland (7 NOVA, 1 DOVA). There is also potential for several 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 Jun 2016, 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 the Department of 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 and Climate Change 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 MEDS and then to NOAA NCEI and CCHDO. MEDS (Ottawa) is responsible for dissemination of Canadian CTD data. CCHDO sometimes obtain 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.

Journal Publications

1. Gerbi, G.P., E. Boss, J. Werdell, C. Proctor. N. Haentjens, M. Lewis, K. Brown, D. Sorrentino, J. R. Zaneveld, A. Barnard, J. Koegler, H. Fargher, M. DeDonato, W. Wallace, 2016. Validation of Ocean Color Remote Sensing Reflectance Using Autonomous Floats. *J. Atmos. and Oceanic Tech.* 33: 2331-2352. doi: 10.1175/JSTECH-D-16-0067.1
2. 2016 Palter, J. B.; Caron, C.-A.; Law, K. L.; Willis, J. K.; Trossman, D. S.; Yashayaev, I. M. & Gilbert, D. Variability of the directly observed, middepth subpolar North Atlantic circulation. Geophys. Res. Lett., 43: 2700-2708. doi: 10.1002/2015GL067235
3. 2016 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.
4. The Influence of High Frequency Atmospheric Forcing on the Circulation and Deep Convection of the Labrador Sea, 2015, AM Holdsworth and PG Myers, Journal of Climate, 28 (12), 4980-4996
5. Donohue, S. M. and M. W. Stacey (2016) Simulation of the 2014 Anomalous Warming in the Northeast Pacific. Atmos.-Ocean., 54, 457-468.

6. Cummins, P.F., D. Masson, and O.A. Saenko (2016) Vertical heat flux in the ocean: Estimates from observations and from a coupled general circulation model, J. Geophys. Res. Oceans, 121, doi:10.1002/2016JC011657.
7. Dukhovskoy, D. S., et al. (2016), Greenland freshwater pathways in the sub-Arctic Seas from model experiments with passive tracers, J. Geophys. Res. Oceans, 121, 877–907, doi:10.1002/2015JC011290
8. Smith, G. C., Roy, F., Reszka, M., Surcel Colan, D., He, Z., Deacu, D., Belanger, J.-M., Skachko, S., Liu, Y., Dupont, F., Lemieux, J.-F., Beaudoin, C., Tranchant, B., Drévillon, M., Garric, G., Testut, C.-E., Lellouche, J.-M., Pellerin, P., Ritchie, H., Lu, Y., Davidson, F., Buehner, M., Caya, A. and Lajoie, M. (2016), Sea ice forecast verification in the Canadian Global Ice Ocean Prediction System. Q.J.R. Meteorol. Soc., 142: 659–671. doi:10.1002/qj.2555
9. Igor Yashayaev and John Loder, 2016. Further Intensification of Deep Convection in the Labrador Sea in 2016, Geophysical Research Letters, doi: 10.1002/2016GL071668.
10. Igor Yashayaev and John Loder, 2016. Recurrent replenishment of Labrador Sea Water and associated decadal-scale variability, Journal of Geophysical Research: Oceans, doi: 10.1002/2016JC012046.
11. Friederike Fröb, Are Olsen, Kjetil Våge, Kent Moore, Igor Yashayaev, Emil Jeansson, Balamuralli Rajasakaren, 2016. Irminger Sea deep convection injects oxygen and anthorpogenic carbon to the ocean interior, Nature Comm., 13244, doi: 10.1038/ncomms13244.
12. Zeliang Wang, David Brickman, Blair J.W. Greenan and Igor Yashayaev, 2016. An abrupt shift in the Labrador Current system in relation to winter NAO events, Journal of Geophysical Research: Oceans, May 2016, doi: 10.1002/2016JC011721.
13. Ellen Kenchington, Igor Yashayaev, Ole Secher Tendal and Helle Jørgensbye, 2016. Water mass characteristics and associated fauna of a newly discovered Lophelia pertusa (Scleractinia: Anthozoa) reef in Greenlandic waters, Polar Biology, doi: 10.1007/s00300-016-1957-3.
14. Jaime Palter, Charles-Andre Caron, Kara Law, Joshua Willis, David Trossman, Igor Yashayaev, Denis Gilbert, 2016. Variability of the directly-observed, mid-depth subpolar North Atlantic circulation, Geophys. Res. Lett., doi: 10.1002/2015GL067235.
15. Danabasoglu, G., S. G. Yeager, W. M. Kim, E. Behrens, M. Bentsen, D. Bi, A. Biastoch, R. Bleck, C. Boning, A. Bozec, V. M. Canuto, C. Cassou, E. Chassignet, A. C. Coward, S. Danilov, N. Diansky, H. Drange, R. Farneti, E. Fernandez, P. G. Fogli, G. Forget, Y. Fujii, S. M. Griffies, A. Gusev, P. Heimbach, A. Howard, T. Jung, M. Kelley, W. G. Large, A. Leboissetier, J. Lu, G. Madec, S. J. Marsland, S. Masina, A. Navarra, A. J. G. Nurser, A. Pirani, A. Romanou, D. Salas y Melia, B. L. Samuels, M. Scheinert, D. Sidorenko, S. Sun, A.-M. Treguier, H. Tsujino, P. Uotila, S. Valcke, A. Voldoire, Q. Wang, I. Yashayaev, 2016. North Atlantic Simulations in Coordinated Ocean-ice Reference Experiments phase II (CORE-II). Part II: Inter-Annual to Decadal Variability, Ocean Modelling, Volume 73, January 2016, Pages 76–107. doi:10.1016/j.ocemod.2013.10.005.

16. Yashayaev, I., Seidov, D. and Demirov, E., 2015. A new collective view of oceanography of the Arctic and North Atlantic basins, Progress in Oceanography, doi:10.1016/j.pocean.2014.12.012.
17. 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, Progress in Oceanography, doi:10.1016/j.pocean.2014.12.010.
18. John W. Loder, Augustine van der Baaren, Igor Yashayaev, 2015. Climate Comparisons and Change Projections for the Northwest Atlantic from Six CMIP5 Models, Atmosphere-Ocean, 09/2015; 53. DOI:10.1080/07055900.2015.1087836.
19. Linn Schneider, Dagmar Kieke, Kerstin Jochumsen, Eugene Colbourne, Igor Yashayaev, Reiner Steinfeldt, Eirini Varotsou, Nuno Serra and Monika Rhein, 2015. Variability of Labrador Sea Water transported through Flemish Pass during 1993-2013, Journal of Geophysical Research: Oceans 07/2015; 120(8). Pages 5514-5533. DOI:10.1002/2015JC010939.
20. Josey, S., J. Grist, D. Kieke, I. Yashayaev, and L. Yu, 2015. Sidebar: Extraordinary ocean cooling and new dense water formation in the North Atlantic [in "State of the Climate in 2014"], Special supplement to the Bulletin of American Meteorological Society, 96(7), S67-S68.
21. Beazley, L., Kenchington, E., Yashayaev, I. and Murillo F.J., 2015. Drivers of epibenthic megafaunal composition in the sponge grounds of the Sackville spur, northwest Atlantic, Deep Sea Research Part I: Oceanographic Research Papers, doi:10.1016/j.dsr.2014.11.016.
22. 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, Progress in Oceanography, doi:10.1016/j.pocean.2014.10.008.

Ph.D./M.Sc. Thesis

McAlister, J. Biogeochemistry of dissolved gallium and lead isotopes in the northeast Pacific and western Arctic Oceans. Ph.D. Thesis, Oceanography, UBC (April 2015)