2019 Argo Canada report of activities

(submitted by Blair Greenan, Fisheries and Oceans Canada)

21st meeting of the Argo Steering Team (AST-21)
Southampton, UK
16-20 March 2020

1. Status of implementation (major achievements and problems in 2019)

- *floats deployed and their performance*

From January 2019 to December 2019, Argo Canada deployed 2 MetOcean NOVA floats in the northeast Pacific and 36 NKE Arvor floats (18 in the northeast Pacific, and 18 in the northwest Atlantic). Of these 38 floats, 1 MetOcean NOVA float died prematurely. The 37 remaining floats are still operational and functioning properly. As of 21 January 2020, Canada has 95 operational floats in the Argo Canada program.

- *technical problems encountered and solved*

Several Arvor floats stayed at the surface immediately after deployment. However by resetting the floats remotely, the problem was solved.

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

DFO Ocean Sciences Branch, continues to acquire data from 95 Argo floats. Data are issued to the GTS and GDACs hourly in BUFR TM315003 and NetCDF formats. Data are available for delayed mode QC as soon as they are sent to the GDACs. The data of all Canadian floats together with some graphics are posted on a website and updated daily: http://www.meds-sdmm.dfo-mpo.gc.ca/isdm-gdsi/argo/index-eng.html.

From January 2019 to October 2019, 82 % of the data were issued to the GTS in BUFR format within 12 hours of the float reporting. This reporting in the month March 2019 was affected by one of the DFO servers being unavailable. Ad-hoc procedures were put in place during this period to mitigate the problems.

Since AST-20, we have worked on the following:

- Process the oxygen data which have been adjusted by Henry Bittig using the method described in "Oxygen Optode sensors: Principle, Characterization, Calibration, and application in the Ocean" by Henry Bittg et al. (2018), ORCID 0000-0002-8621-3095. These oxygen data were collected by 24 floats which equipped Aanderra Optode sensor and performed in-air oxygen measurements. These floats were

deployed between 2004 and 2010. Data for these floats are now available at the GDAC in "A" mode.

- Implement SAGEO2-Argo software developed by Monterey Bay Aquarium Research Institute to evaluate oxygen collected by Nova floats which didn't collect any in-air oxygen measurements.

  Provide ADMT with quarterly reports on the performance of Argo data on the GTS in TESAC and BUFR formats and assist DACs that have difficulty with BUFR transmission.

- *Status of delayed mode quality control process*

As of January 2020, 48% of all eligible floats, active and inactive, had their profiles QC'd visually and adjusted for pressure according to the latest delayed-mode procedures at least once. The salinity component of DMQC had been performed at least once on 65% of eligible cycles. 71% of B-files had been visually QC'd, and 14% were fully DMQC'd. In addition to DMQC of new profiles, 11 previously-processed floats received either updates to the visual QC or new adjustments in 2019 in response to feedbacks (e.g., reports of density inversions) or to address known issues (e.g., higher likelihood of salinity drift for salinity sensors in the serial number range 6100-7000).

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

Argo Canada has ongoing funding for the O&M expenditures related to the International Argo program. Shared Services Canada (SSC) is responsible for the costs related to Iridium telecommunications as part of an initiative to centralize these services with the Federal government and will cover the costs for up to 85 core Argo floats. If Argo Canada has more than 85 active Argo floats, DFO is responsible for the additional telemetry charges. 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. The Government of Canada committed $1.31M for purchases of core NKE Arvor-I Argo floats in the Fiscal Year 1 April 2019 to 31 March 2020. The funding resulted in acquisition of 53 core Argo floats in this fiscal year. The Government of Canada also procured three Arvor float equipped with RBR CTDs to contribute to the global pilot for this sensor.

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.

At the G7 meeting in Halifax in October 2018, the Government of Canada announced new funding for the International Argo Program (up to $5.6M over 4 years). The primary intention of this investment is to support the implementation of the BGC-Argo array with a strong emphasis on having ocean observations benefit Small Island Developing States. https://g7.gc.ca/en/environment-oceans-energy-ministers-ready-take-action-oceans-seas-conclude-g7-joint-meeting-healthy-oceans-seas-resilient-coastal-communities/

Human resources

Since 1 April 2015, Blair Greenan of the Bedford Institute of Oceanography (BIO) has acted 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 (DFO, Institute of Ocean Sciences) is responsible for Pacific deployments for Argo Canada.

The following DFO staff contribute to the logistics and data management for Argo Canada:

Anh Tran (MEDS, Ottawa)
Mathieu Ouellet (MEDS, Ottawa)
Isabelle Gaboury (MEDS, Ottawa)
Blair Greenan (BIO, Halifax)
Ingrid Peterson (BIO, Halifax)
Igor Yashayaev (BIO, Halifax)
Adam Hartling (BIO, Halifax)
Tetjana Ross (IOS, Sidney)
Lindsay Mazzei (IOS, Sidney)
Denis Gilbert (IML, Mont-Joli)

Denis Gilbert (DFO) and Roberta Hamme (University of Victoria) are assisting Argo Canada with issues related to dissolved oxygen. In particular, they have been providing expert advice and support on quality control and data processing of DO data from the MetOcean 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.

National Coordination

With increasing participation in the Argo program within Canada, both in core Argo and BGC-Argo, it was decided to establish a new governance structure in 2018. The Canadian Argo Steering Team (CAST) provides scientific leadership and oversees the development and implementation of the Canadian contribution to the International Argo Program. The CAST is chaired by Blair Greenan.

The Canadian Biogeochemical-Argo Committee (henceforth the Committee) facilitates the implementation of the Canadian contribution to the Biogeochemical-Argo program by

coordinating and advising national efforts, and acting as liaison to the International Biogeochemical-Argo Steering Committee. The Committee is chaired by Katja Fennel.

Both of these committees held at least one virtual meeting in 2019.

The Canadian BGC Argo committee had two poster presentations at the OceanObs19 Meeting in Hawaii: one representing Canadian BGC Argo efforts overall (led by Blair Greenan) and one describing an effort to raise funding for a BGC Argo array in the northwest North Atlantic (led by Katja Fennel). The committee frequently interacted via e-mail and in person at conferences. A dedicated website was set up at http://bgc-argo.ocean.dal.ca/.

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

Argo Canada will procure 56 new NKE ARVOR floats by March 2020. In 2020 and early 2021, Argo Canada plans to deploy about 40 of the floats (firm commitment). Twenty will be deployed in the Northeast Pacific, and about twenty in the Northwest Atlantic. Seven of the ARVORS in the Pacific will have oxygen sensors, and three of the ARVORs in the Atlantic will have RBR CTD sensors. We are currently seeking deployment opportunities for the remaining 16 floats, some of which may be deployed in 2021.

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 Government of Canada CONCEPTS initiative (Canadian Operational Network for Coupled Environmental Prediction Systems; http://science.gc.ca/eic/site/063.nsf/eng/h_97620.html) uses observations from the Argo array for a variety of operational and research applications. These include direct assimilation into operational weather and environmental prediction systems, monitoring of forecast quality (verification), and well as detailed research to improve model physics (e.g. further development and optimization of model parameterizations) and data assimilation (e.g. Observing System Experiments). The CONCEPTS Global Ice Ocean Prediction System (GIOPS) provides daily estimates (analyses) of global ocean and sea ice properties using a multi-variate data assimilation system assimilating Argo observations together with other sources of in situ temperature and salinity, satellite altimetry, and sea surface temperature data. GIOPS analyses are used to initialize the ice-ocean components of the coupled Global Deterministic Prediction System (GDPS), responsible for providing operational medium-range weather forecasts for Canadians. GIOPS analyses are also used to initialize the operational forecasts from the Canadian Seasonal-Interannual Prediction System (CanSIPS). An update to the Regional Ice Ocean Prediction System (RIOPS) was accepted for operational implementation in December 2018 that will now include a regional data assimilation system package (including Argo), as well as extend the domain to include the North Pacific Ocean in addition to the Arctic and North Atlantic Ocean. This

system will provide a daily three-dimensional state of the ocean estimate for Canada's three coastlines.

The Department of National Defence scientists, operational oceanographers and sonar operators routinely use real time Argo vertical profiles to assess model performance and in some instances use as data to compute acoustic range predictions (both at sea and in the Meteorology and Oceanography Centres (Esquimalt and Halifax)). DND uses the web-based Ocean Navigator tool (http://navigator.oceansdata.ca/public/) to assist with these activities.

The Canadian-Pacific Robotic Ocean Observing Facility (C-PROOF, http://cproof.uvic.ca/) is funded by the Canadian Foundation for Innovation (CFI) and B.C. Knowledge Development Fund (BCKDF) to build ocean observing capacity off the British Columbia coast. C-PROOF is based at the University of Victoria. A fleet of autonomous gliders, Argo floats, and moorings will provide ocean scientists with long-term monitoring of the ocean at the small scales important to resolve upper ocean physical and biological properties. C-PROOF will add dissolved oxygen sensors to 7 of the DFO core Argo floats that will be deployed in the Northeast Pacific in 2020. This project is planning to deploy BGC-Argo floats along Line P in future years.

Argo data have proven to be invaluable to understanding marine heatwaves in the Northeast Pacific. The lingering influence of the "Blob" in the NE Pacific was revealed through Argo data. Argo data are regularly used in preparing DFO's State of the Pacific Ocean and (new in 2019) State of the Salmon reports.

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

The Canadian BGC Argo website is maintained by Katja Fennel at http://bgc-argo.ocean.dal.ca/.

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.

CTD data collected by DFO researchers are routinely transferred to MEDS and from there to NOAA NCEI on a yearly basis. CCHDO acquires data directly from scientists. In 2018, MEDS contacted CCHDO to resume exchanges for Line-P. CCHDO can acquire Line-P data up to June 2018 directly from the https://waterproperties.ca/linep website. Once the Line-P data has been ingested by CCHDO, MEDS will work to complete the AR07W (Labrador Sea) data.

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. 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.
There is also the thesis citation list (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.
Finally, if you haven't already sent me a list of Argo PIs in your country, please do so to help improve the statistics on how many papers are published including an Argo PI vs no Argo PIs.

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Yu, L., K. Fennel, B. Wang, A. Laurent, K. R. Thompson, and L. K. Shay, 2019: Evaluation of nonidentical versus identical twin approaches for observation impact assessments: an ensemble-Kalman-filter-based ocean assimilation application for the Gulf of Mexico, Ocean Science, 15, 1801–1814, https://doi.org/10.5194/os-15-1801-2019

Ph.D./M.Sc. Thesis

Garcia Quintana, Y., 2019: On the driving sources and variability of North Atlantic deep water, Ph.D. Thesis, Dept. of Earth and Atmospheric Sciences, University of Alberta.

Gordon, C., 2019: Autonomous measurement of physically and biologically driven changes in dissolved oxygen in the northern Gulf of Mexico, MSc thesis, Dalhousie University, http://hdl.handle.net/10222/76822

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Books