US NATIONAL DATA MANAGEMENT REPORT

24st ADMT

December 1, 2022 - October 15, 2023

1. Real Time Status

US Argo Data Assembly Center at AOML statistics

The US Argo Data Assembly Center (DAC) at AOML is responsible for processing of Argo data obtained from all US floats. During the reporting period the DAC has received real-time data from 2,537 floats and sent more than 84,200 profiles to the GDACs. In addition to this, the US Argo DAC distributed meta, technical and trajectory files in the Argo NetCDF files to the GDACs as part of the real-time processing.

The DAC distributed over 81,500 Argo profiles to GTS in the BUFR format. Both for GDACs and GTS 93% of the profiles reached the system within 24 hours. If floats with large delays are excluded (e.g. new deployments, descending profiles and floats under ice), then 97% of the profiles are available in 12 hours and 99% of the profiles are available in 24 hours.

The DAC also passes the files on to the GDACs that come from delayed-mode processing, BGC float processing and auxiliary files. For this purpose, the DAC maintains an ftp server for file exchanges, both for providing reprocessed R-mode and meta files as well as for receiving D-mode files, real-time submission of data from Iridium floats and the submission of deployment information.

Overall, the US Argo DAC has 1,508,544 core/deep profiles (at the GDACs: 210,557 R-files, 1,297,987 D-files), 102,392 BGC profiles (4,116 BR-files, 98,276 BD-files). The corresponding numbers for non-profile files are 8,614 meta, 8,451 tech, 8,444 Rtraj and 2,339 Dtraj files (total 10,783). Total number of BR files generated by AOML 48,185 (only a subset of these are sent to the GDACs - floats for which MBARI is responsible are run through BGC processing so we can add BGC data to the Rtraj files; the AOML_BR files for these are not distributed but are useful for testing).

The US Argo DAC added 382 new floats to the processing system, 68 of them were deployed in collaboration between AOML and WHOI. As part of this collaboration, the US Argo DAC is finding ships of opportunity and provides ship riders for selected cruises. Recent maps showing their positions with link to graphics of the data collected by the floats can be found at:

https://www.aoml.noaa.gov/phod/argo/opr/php_forms/deployment_maps.php

The US Argo DAC is maintaining a website that provides documentation and information about the operations: http://www.aoml.noaa.gov/phod/argo/index.php

Developments at the US Argo DAC

As in the past, changes in float technology or core Argo floats, sensor configuration on BGC floats as well as decisions by the IADMT, of which AOML is a major contributing partner, are the main reasons for changes to existing software and the development of new software.

Updating the procedure for calculating real time salinity adjustment in Argo profiles to make use of the latest calibration information provided in the scientific calibration fields of the Delayed-mode profile files. These are stored in dedicated files for use during adjustment of the salinity in R-mode profile and trajectory files. For deep Argo floats the calculation adjusted salinity was updated to include CPcor correction. Additional adaptations for salinity adjustments were added that are specific to floats with RBR CTDs. These required adding the quality control test26 for TEMP_CNDC. The main change was the need to apply a Thermal Inertia Correction for RBR floats. This development is currently undergoing testing and will be operational in October 2023.

A decoder was developed in collaboration with JPL for their float deployed near Greenlands These floats are APEX SBD that send their data in the Teledyne format. Teledyne granted permission to revise their source code to facilitate this development. Adaptations to the real time qc/netcdf software were implemented to allow for end-to-end processing of these data.

Floats found new ways to break the procedures for adding interpolated positions when a profile has no position fix. The procedures were updated to handle the unusual cases correctly. This included updates to the speed check.

Metadata improvements were implemented. One of these involved setting up a system for adding the pre-deployment calibration information to the meta.nc files. The other was related to improving how STATION_PARAMETERS and PARAMETER fields were completed for the core & BGC profile files.

The trajectory NetCDF file format version 3.2 has been defined in user manual 3.41 (July 2021). Adaptations for writing trajectory files in format 3.2 (in this format core and BGC data are in the same file) were completed in September 2022 and the updated code was activated in March 2023 (once the GDAC format checker had been updated to accept the files). Doing this required adaptations to our decoders, especially for adding air oxygen data from different oxygen sensors (SBE83 and Aanderaa Optode) to the trajectory files for APEX/NAVIS floats. Depending on the float type, the development was completed in the March-April time frame. Another improvement for these types of floats included decoding the number of CTD samples used during bin-averaging. All these data are already added for new floats. Reprocessing old floats with such data is ongoing.

Real time pressure adjustment and salinity adjustment were added to the code generating the traj.nc file. Revisions to this code were started to apply grey list flag th the data in traj.nc file.

BGC profile related changes include: Adding the QC Range tests for radiance, irradiance, and PAR (January 2023). In February 2023, Solar Angle checking for revised QC procedures for CHLA were written. Most of the Nitrate QC tests were added to the quality control software in the spring of 2023.

In March the DAC also adapted how CHLA_ADJUSTED fields were updated and filled based on the currently approved QC manual. The DAC developed a processing system for a new float type, NAVISIR, that required changes to the meta files that control how data are processed, the decoding system and a qc/netcdf software. A new temperature module called getTRUE_SUNAtemp, unique to SUNA nitrate sensors, was implemented to account for differences in the measurement delay of the SUNA sensor and the CTD sensor. A challenge was that the direction of profiles written to the data files depends on the data set.

Development of a decoder for SOLO BGC processing for CHLA, BBP, CDOM, pH, NO3, irradiance and PAR is close to completion in preparation for floats to be deployed by PMEL (expect first deployment in January 2024). Adaptations to the qc/netcdf software will be done as needed to accommodate the created data files.

The AOML DAC and AOML BGC D-mode operators are working together to develop a system to apply Sage and Sage-O2 determined adjustments in real-time to produce A-mode data. This system will also be used for PMEL floats and can be used for floats from other teams (if necessary with adaptations to the code).

2. Delayed Mode QC status

The US Argo DAC receives the Delay mode Argo profiles from US delayed-mode operators and verifies their contents to ensure soundness of the files if requested.

Each US Argo institution has provided information on their delayed-mode processing which was added to this report.

NOAA/AOML

AOML set up the delayed-mode processing system for core data based on OWC and a GUI from SIO. The reference database was expanded to cover the Gulf of Mexico where our floats are with the help of Christine Coatanoan from France. So far three floats (150 profiles) in the Gulf of

Mexico have been DMQC'd. All these are quite young and had good data that did not need adjustment and no flagging needed to be done during visual QC.

AOML's BGC group has implemented Sage-O2 and Sage for DOXY, nitrate, and pH corrections to their Apex and Navis BGC data. Code has been developed to use alongside Sage-O2 to utilize the in-air data collected by Apex floats to make in-air rather than WOA corrections. AOML continues to develop scripts to translate DMQC data into GDAC accepted bd files. DOXY data for AOML's floats have been submitted and accepted to the GDAC. Work is underway to write DMQC'd nitrate and pH data to these bd files. AOML has not begun deeply exploring the DMQC tools created by EuroArgo for chl-a corrections, but plans to do this over the coming year.

NOAA/PMEL

According to OceanOps, as of 28 September 2023, PMEL had 225,617 D-files at the GDAC and 50,495 profiles pending for DMQC, and so was at ~82% of the Argo target for DMQC. Last year, on 28 November 2022, PMEL had an estimated 214,525 D-files at the GDAC and 46,025 pending for DMQC, and so was also at ~82% of the Argo target for DMQC. The PMEL DMQC team's efforts since last year's report resulted in a net increase of ~11,902 DMQC profiles, which is not quite as many as the ~13,127 PMEL real-time profiles that came in during that time period, but is more than the ~7,975 DMQC profiles added during the previous reporting period. In the past year, Kristy McTaggart has been occupied by GO-SHIP work and John Lyman by a product development project, which diminished the amount of DMQC work that they could do. A focus on difficult cases identified by automated checking also slowed progress. In May 2023 Hristina Hristova was hired to work part-time on PMEL Argo DMQC. Her addition to the PMEL Argo team, in addition to the continued DMQC work by Lyman and McTaggart, should begin to clear this backlog in the next year.

The PMEL float DMQC procedure currently consists of the following steps: We perform an automated correction, with visual check, of reported pressure drifts and correction for the effect of these pressure drifts on salinity, as well as an automated correction of conductivity cell thermal lag errors following Johnson et al. (2007). For deep floats, we also make estimations of the conductivity cell compressibility coefficients, subject to availability of reference data, and use it or (in the absence of sufficient reference data) the agreed upon nominal coefficient for SBE61 CTDs. We do visual inspection and modification of quality control flags for adjusted pressure, temperature, and salinity using the SIO GUI and the Lyman GUI. We overwrite the raw Param_QC flags during this step as required. We use OWC Version1.1, currently with CTD (CTD_2021v2) and Argo (2021v03) reference databases, and adjust run parameters to get appropriate recommended salinity adjustments. Errors in OWC are computed directly from the least squares fit. We accept or reject the OWC recommendations on the basis of comparison with nearly historical profiles using a PMEL GUI written for this step.

Scripps Institution of Oceanography (SIO)

Scripps Institution of Oceanography (SIO) has evaluated, as part of delayed-mode quality control (DMQC), a total of 363,989 Argo stations (profiles). This is an increase of 28,989 stations (794 nominal float years) since the previous Argo Data Management Team (ADMT) Report (November 2022). This count represents 98.6% of the SIO DMQC-eligible stations (older than 12 months). The above numbers include SIO Core, BGC, and Deep Argo floats and all Argo New Zealand floats for which SIO does DMQC.

SIO expects to maintain a high DMQC completion percentage during the coming year and will continue with a 7-9 month revisit schedule. Annie Wong has joined the SIO DM group allowing this goal to be achievable. Over the past year, SIO has nearly returned to our historical DMQC completion level. The DMQC backlog of SIO's Deep SOLO floats is much improved from last year, with only the Southern Ocean pilot array remaining to update. The consensus standard DMQC procedures for SOLO/SOLOII/BGC/Deep profile data were continued in 2021.

Although not a DMQC metric, the timeliness of SIO real time Iridium data arrival at the GDAC is dependent on the initial parsing of the data received by the float done by the SIO PI group. Timeliness this year has been good. SIO profile data collected between 1 Jan 2023 and 02 Oct 2023 reached the GDAC within 24 hours 99.4% of the time, and 94.2% of the time within 6 hours. The month of best performance was in July with on time arrival percentages of 99.9%/97.6%. There were no hardware issues of note for Core data during the year, although a transition to a new computer at SIO has led to some delay in BGC profile netCDF file creation. The above timeliness calculation used the float surfacing time, so the temporal span includes the time of transmission, SIO SBD/directIP processing, and AOML DAC netCDF creation.

The transition to the Dtraj V3.2 netCDF has been completed for the 6-sensor BGC SOLO floats. Utilizing the new V3.2 for SIO's Core Dtraj files will continue to be considered. However, at this point in time it is not a priority.

SIO deployed in 2023 a single RBR equipped SOLOII, with an older RBR sensor (prior to new calibration done by manufacturer). The integration of the updated RBR CTD sensor onto the SOLOII remains a goal for SIO. In the previous 2 years, SIO has ordered 5 RBR sensors each year. However development of the SOLOII with RBR CTD has been slowed due to IDG (Instrument Development Group) personnel changes as well as other SIO priorities which took precedence.

University of Washington

The total number of real-time profiles (R-files) recorded by active UW floats (n = 690) during the 2023 reporting period (January 1 through September 22) was 14,980. The total number of profiles processed in delayed mode (i.e., D-files) from the UW fleet was 27,383, of which, 13,037 were either reprocessed from currently existing D-files (reprocessing is necessary when calibrations are updated or changed) or processed from R-files that were written before 2023 and were missed during previous reporting periods. A total of 14,346 "new" D-files were written in 2023; thus, 96% of R-files written in 2023 have been processed in delayed mode.

Floats associated with the SOCCOM program recorded 2,755 new profiles, of which 2,200 (~80%) have been processed in delayed mode. The total number of D-files written in 2023 was 4,729 (includes new and reprocessed D-files).

Floats associated with the GO-BGC program recorded 2,236 new profiles, of which 2,003 (~90%) have been processed in delayed mode. The total number of D-files written in 2023 was 2,957 (includes new and reprocessed D-files).

In addition, a total of 529 dissolved oxygen profiles were acquired from 16 floats during the reporting period. These profiles were recorded by floats equipped with Aanderaa 4330 optodes and are not processed by the Monterey Bay Aquarium Research Institute. These floats are separate from the SOCCOM and GO-BGC programs. All of these newly-recorded profiles have been processed in delayed mode and an additional 2,653 files were reprocessed after associated calibration coefficients (i.e., gain values) were updated. It is common practice to update all existing, delayed-mode files with newly calculated gain values.

In addition to the UW floats, 2,436 profiles recorded by 24 “orphan” floats that are not officially assigned to any specific institution for processing, were processed in delayed mode.

MBARI (Monterey Bay Aquarium Research Institute)

Biogeochemical data from 303 operational five- or six-sensor BGC-Argo floats are currently being processed and subjected to real-time and delayed-mode quality control by the Monterey Bay Aquarium Research Institute (MBARI). This includes 138 active SOCCOM floats in the Southern Ocean, 125 active floats deployed as part of the Global Ocean Biogeochemistry (GO-BGC) array, and 40 active “SOCCOM-equivalent” partner floats in various locations. The majority of these are five-sensor BGC floats, although six-sensor BGC deployments are increasing, with seven deployed thus far under MBARI management throughout the Pacific and Indian Ocean. The MBARI data management team includes Tanya Maurer, Josh Plant, Emily Clark, and recently hired, Nicola Guisewhite.

A total of 78 BGC-floats managed at MBARI have been deployed throughout 2023. 43 of these were GO-BGC floats deployed across 13 different cruises, and 35 were SOCCOM floats deployed across six cruises. These deployments included 46 APEX and 32 Navis. MBARI has also been involved in the processing and management of data from various test-floats within the past year, including two five-sensor APEX floats with SBS83 oxygen optode (a new SBS design capable of in-air sampling), three six-sensor APEX with OCR504, and two five-sensor APEX with FLBBFL (a three-channel bio-optical unit that includes BBP at 700nm, as well as CHLA at both 435nm and 470nm excitation). Additionally, in collaboration with other US institutions, MBARI has assisted with the monitoring of two recent test-deployments of the SBS Nautilus. Assessment of sensor and data performance on this new BGC- profiling float platform is ongoing.

BR- files are being generated and transferred to the Argo GDACs for all 5- and 6- sensor operational floats managed by MBARI at a frequency of four times per day. Since January, 2023, over 6,000 B-files have been submitted to the GDAC, including over 4,700 BD-files. Delayed-mode (DM) quality control assessment of oxygen, pH and nitrate data is performed multiple times per year. BD-designated files generated at MBARI signify that at least a preliminary DM assessment has been performed, although BD* files are subject to updates periodically throughout a float's life. MBARI-developed MATLAB software used to perform BGC DM assessment is publically available through the SOCCOM Github at https://github.com/SOCCOM-BGCArgo/ARGO_PROCESSING and methods are described in Maurer et al (2021), https://doi.org/10.3389/fmars.2021.683207.

MBARI continues to generate a semi-annual audit on DOXY profiles to assist DACs with furthering the amount of adjusted DOXY data at the GDAC. Work is ongoing and international response to this audit has been positive thus far (information on the audit can be found on the MBARI ftp: https://ftp.mbari.org/pub/BGC_argo_audits/DOXY/).

An updated temperature correction for NITRATE was recently developed at MBARI which improves the accuracy of processed nitrate, particularly in surface waters in regions where temperatures are well beyond the sensor calibration temperature. A manuscript describing this method was recently published in to L&O methods (Plant et al, 2023; https://doi.org/10.1002/lom3.10566) and the method was subsequently added to the Argo processing document for nitrate (https://doi.org/10.13155/46121) as a replacement to the earlier Sakamoto et al (2009) correction. Additionally, documentation outlining processing methods for PH_IN_SITU_TOTAL was enhanced this year by the MBARI team and this document is also now publicly available (https://doi.org/10.13155/57195).

MBARI continually supports the ADMT. Tanya Maurer serves as co-chair of the BGC-ADMT task team and the MBARI data team members remain active in various ADMT working groups focused on various BGC parameter topics. MBARI played a key role in organizing the first BGC DMQC workshop in January, 2023 in Villefranche Sur Mer, France. Along with other international DAC representatives, the MBARI Argo data management team continues to strive toward the common goal of improving the standardization, usability and utility of BGC-Argo data.

Wood Hole Oceanographic Institution (WHOI)

WHOI Argo data management report covering the time period Oct 1, 2022 thru Sep 30, 2023. During this time, the WHOI Argo group deployed 94 floats. Of these there were 71 MRV S2A, 19 Navis-BGC, 3 MRV Deep Solo (for Deep Madagascar Basin Experiment) and 1 MRV-RBR Alto.

The size of the standing fleet averaged about 450 platforms. There are currently 273693 profiles reported to the GDAC, of which 255999 are eligible for DMQC. Of the eligible profiles, 94.5% have completed DMQC. WHOI maintains two instances of our real-time telemetry decoder. The first operates on a server in Woods Hole while the second backup server operates in the cloud.

Both of these servers are configured to submit data to the primary AOML DAC as well as the DAC's backup server. This system provides redundancy which has been exercised several times in the past year with good success as we have managed to maintain data flow despite numerous downtime events of the primary servers at WHOI and AOML.

Deb West-Mack continues significant progress in development of protocols and software for performing DMQC on trajectory files. Other contributions to Argo data management include Global audits of salinity drift of each individual CTD (https//argo.whoi.edu/argo/sbedrift_wmo/) and global maps of fleet coverage (https://argo.whoi.edu/argo/maps/sparse)

3. Value Added items

University of Washington

A manuscript summarizing physical and biogeochemical data recorded from floats deployed in the Argentine Basin was recently published in JGR Oceans:

Alkire, M.B. and S. Riser (2023). Net community production in the Argentine Basin estimated from nitrate drawdown using biogeochemical Argo floats, *J. Geophys. Res. Oceans,* **128**: https://doi.org/10.1029/2023JC019858.

Scripps Institution of Oceanography

SIO continues to maintain the Argo Program website (https://argo.ucsd.edu) as well as the local Scripps float webpage which contains info/engineering/DM status of the Scripps float fleet (https://sio-argo.ucsd.edu).

SIO has actively participated in expanding the scientific application of Argo data. One example of this is the work of Nathalie Zilberman and Megan Scanderbeg who have been exploring the feasibility of adding Argo float bottom hits to the data incorporated into the creation bathymetric maps.

Value added efforts at Scripps have been crucial for incrementally improving the Argo data set. John Gilson updates on a yearly basis the Argo Climatology Dataset (ARGO_IN_OWC) used for OWC salinity calibration. Annie Wong updated and distributed her DMQC salinity audit of the global Argo salinity dataset. Annie Wong has also been very active in updating the Argo QC manuals to the latest best practice.

Float and sensor improvements are critical to the Argo Program. Nathalie Zilberman, Dean Roemmich, and IDG have continued to assess the quality of the Keller pressure sensor for eventual use in Deep Argo. Over this year, Sarah Purkey has assisted the transition of the IDG

developed BGC SOLO to commercial release by MRV Systems. This will crucially diversify the available choice of BGC Argo floats.

John Gilson has continued to release monthly updates to the RG Climatology Argo product that is openly available to aid scientists in their research. Nathalie Zilberman and Megan Scanderbeg led the development of an Argo level-of- known-motion research product based on Argo data (Scripps Argo Trajectory-Based Velocity Product). Both of the above are available through the official Argo 'products' website (https://argo.ucsd.edu/data/argo-data-products).

4. GDAC Functions

US GDAC is up and running. Details will presented during ADMT24

5. Regional Centre Functions

Not applicable

6. Other Issues

Nothing to report