8th BGC-Argo Meeting October 14-15 2019

Hervé Claustre / Ken Johnson. Introduction

Hervé Claustre presents the new BGC-Argo data management task team and its terms of reference. He also highlights two papers : on the future of Argo (Roemmich et al., 2019) and on Best practices for BGC-Argo (Bittig et al., 2019). New BGC-Argo data managers are welcome (Christina Schallenberg in CSIRO, David Nicholson at WHOI and a DM operator at the LOV). A BGC-Argo project office will be created. It will be hosted at the Oceanographic Museum of Monaco and daily operated at the LOV, sponsored by Explorations of Monaco.

Ken Johnson:

BGC-Argo science is moving from analysis of one or a few floats to basin/global scale studies. Float deployments are moving to a more sustained model. For example, SOCCOM program has been refunded for an additional 4 years, starting in 2020 with 120 more floats. In addition to the 34 floats that will be deployed this year, there will be 154 new floats in the Southern Ocean.

To support this, important improvements in the data system are required. In particular, much of the data in the system remains uninspected and not properly flagged. As a result, it is difficult to use the data in the system for global analyses. Many groups are quality controlling the complete data set, but the results are not being placed back in the system. Some effort should be made to return this qc'd data to the system.

The availability of the Sprof profiles now makes it relatively easy to statistically analyze the entire system and to identify anomalous profiles. Such efforts would also allow us to identify anomalous profiles and greatly improve the status of quality control flagging. Consideration should be given to such approaches to improve the utility of the system.

Udaya Bhaskar. DAC: BGC Argo data management-India

Under Indian BGC activities of Indian Ocean, INCOIS has undertaken the following activities during the period Dec, 2018 - Oct 2019:

1. Deployed 8 BGC (Apex-BioArgo floats) in the Arabian Sea with a float equipped with a Nitrate sensor, taking the tally to 61 apart from 16 oxygen alone floats.

2. Continued to obtain ship based measurements during the BGC floats deployment and these are being used for validation of profiles from BGC floats. Also profiles are being taken during all possible cruises at available BGC floats pop-up locations.

3. Worked on generating Delayed Mode Quality Control profiles of Doxy using SAGEO2 software. ~50% of the profiles which are DMQCed are uploaded on to GDAC.

4. Utilized data of Chla, Oxygen from BGC floats for studying chlorophyll enhancement during the cyclones and published them in peer review journals.

5. The BGC data is used by modelling team for checking the model resolutions setup which will resolve the structures and reproduce the required output. Sample experiments were done with assimilation of BGC data and results are being analyzed.

6. There is a plan to procure and deploy 14 BGC floats in the next year in the Northern Indian Ocean.

Violetta Paba. DAC : UK Status Report for BGC-Argo

BODC is not yet capable of delivering BGC Argo data to the GDACs, however significant progress towards this goal was made over the past year. Thanks to a development team effort, we can now deliver core profile, technical and metadata files in v3.1 from APF9i and NAVIS N1/N2 floats, and store their raw BGC measurements in our database. Once this capability has been extended to APF11i floats, we will be able to code the remaining steps to deliver BGC profile files too. A separate development work involving Matt Cazaly (BODC) focused on creating assumptions-free Matlab scripts which derive pH, radiometry, Chlorophyll-a and backscatter variables from raw BGC sensor outputs. O2 and nitrate derivation codes are under construction. These will all be available on GitHub once the set is complete. Future work will also include a SAGE/SAGE-O2 workshop, through which we will apply adjustments to 13 PROVOR floats that Coriolis has been processing on our behalf, and up-skill in pH and O2 QC procedures. UK Argo only deployed 2 BGC floats over this past year (NAVIS with SBE63, MCOMS and OCR-504), whereas 7 more have been procured: 5 Deep APEX with an Aanderaa optode, and 2 NAVIS with SBE63, MCOMS, Seafet and SUNA sensors.

Kensaku Kobayashi. DAC: BGC Argo data management-Japan

Japan has deployed 95 BGC Argo floats since 2005. About 15,600 B-profile files have been submitted to GDACs. 11 float's B-profile files have been submitted to GDAC after last ADMT. 8 BGC floats (2 APEX, 3 Deep APEX and 3 NAVIS) is operational. JAMSTEC plans to deploy 4 BGC floats by March 2020. JMA is going to implement RTQC according to BGC QC manual and start sending oxygen data to GTS in BUFR format.

Christina Schallenberg. DAC: BGC Argo data management-Australia

Christina Schallenberg reported on the BGC Argo activities at the CSIRO DAC, with an emphasis on the status of delayed mode QC. Historically, the CSIRO focus has been on DMQC of DOXY because the CSIRO array contains more DOXY sensors than any other BGC sensor. The DMQC status of DOXY is at 86% for CSIRO, with a plan to update the DMQC software and also start RT adjustments of DOXY based on previous estimates of the gain factor and/or gain factor estimates derived from SAGEO2. The next priority for the CSIRO BGC Argo program will be the development and implementation of RT and DMQC methods for the FLBB sensors, with the other BGC sensors to follow. Christina presented some examples of biofouling on FLBB sensors from the CSIRO array, and she also showed some slides from the DOXY DMQC GUI currently in use at CSIRO.

Anh Tran / Edouard Leymarie. DAC: BGC Argo data management-Canada

As of September 2019, Argo Canada currently has the following floats with DOXY sensors: 19 Nova floats with SBE 63 sensors, of which 5 still actively report; 2 active NKE floats with Aanderaa Optode 4330 sensors, and 25 inactive Apex floats with Aanderaa Optode 3830. NAOS-Canada deployed 6 BGC floats of which 1 still actively reports whose data managed by Coriolis.

For real-time data management, DOXY floats are processed at the same time as core-Argo floats. Argo real-time quality control tests are automatically applied on the vertical profile. Data are sent to GDAC in NetCDF format version 3.1, and to the GTS in BUFR format.

For delayed-mode data management, 16 Apex floats with Aanderaa Optode 3830 have been visually QC and their DOXY data were adjusted using Bittig et al. method. Data for these floats are available in "A" mode at GDACs. 5 Apex floats with Aanderaa Optode 3830 had DOXY adjusted using Johnson et al. method. Data for these mode are available in "D" mode at GDACs. 7 out 19 Nova floats equipped with SBE63 sensors have been visually QC but have not been adjusted.

In 2019-2020, we plan to deploy about 7 NKE Argo floats equipped with Aanderaa Optode 4330 sensor. With respected to real-time adjustment on DOXY, we plan to use SageO2Argo provided by MBARI to calculate the gain coefficients for floats who don't have in-air DOXY measurements.

Thierry Carval : BGC Argo data management-France

DAC Information

The Coriolis data processing chain for Argo and BGC-Argo data and metadata is continuously being improved. It is freely available (http://doi.org/10.17882/45589) (If needed, a compiled version can be provided (java binary, no matlab license).

In september 2019, 63 634 BGC-Argo cycle files from 453 floats were available on Coriolis DAC.

Processing:

- PROVOR UVP float managed in September 2019.The UVP6 was deployed on a float in summer 2019 reporting size distribution.
- PROVOR CTS4 pH managed since june 2019.
- Apex APF11 with ECO3 and OCR managed since June 2019

RTQC and Adjustment :

- 35000 Nitrate profiles were RT-QCed in July 2019.
- Radiometry QC was applied in September 2019.
- After a general inspection of Coriolis floats, many DOXY sensors were grey listed
- DOXY real time Adjustment is managed since September 2019
- Changes in the "deepest pressure test" (https://doi.org/10.13155/49438):
    - Before "PRESSURE_THRESHOLD = CONFIG_ProfilePressure_dbar + 10% "
    - Now PRESSURE_THRESHOLD ranges linearly from CONFIG_ProfilePressure_dbar + 10% at 1000 dbar to CONFIG_ProfilePressure_dbar + 150% at 10 dbar.

DM :

- 27 318 delayed mode files for DOXY
- Tools : LOCODOX for visual inspection and DM
- ISAS (In Situ Analysis System) objective analysis configured for DOXY

GDAC Information

In October 2019, 189.142 BGC-Argo profiles from 1234 floats were available on Argo GDAC. This a fair increase over 2018: +15% more floats and +14% more profiles. 43% of BGC-Argo have delayed mode data. BGC-Argo synthetic profiles (S-prof) are now distributed on Argo GDAC ftp server. Detailed specification: Bittig Henry, Wong Annie, Plant Josh (2019). BGC-Argo synthetic profile file processing and format on Coriolis GDAC. (https://doi.org/10.13155/55637) The index of BGC-Argo synthetic profile files is available on: ftp://ftp.ifremer.fr/ifremer/argo/argo_synthetic-profile_index.txt. TheUS-GDAC is working on a synchronization of synthetic profiles from Coriolis GDAC.

Xiaogang Xing. DAC : BGC Argo data management -China

1. In this year, two (6-variable) BGC-Argo floats were deployed in the northwestern Pacific, and one was recovered. Eight floats are working.

2. In the next year, six BGC-Argo will be deployed in the northwestern Pacific and South China Sea, including two Chinese Argo floats (HM2000) equipped with Aanderra 4330 Optode.

3. 17 O_2 float (deployed in March, 2014, by Ocean University of China) data are processed and updated to D files.

4. NO3 data in the northwestern Pacific subtropical gyre had the abnormal positive bias at sea surface, and wavelength tuning did not work to solve this problem and balance the surface and deep values. MBARI provided the new temperature correction algorithm, which worked well and thus, was suggested to be updated in the DAC documents.

Josh Plant: DAC: BGC Argo data management-US

The U.S. DAC has deployed a total of 418 floats, of which 146 are active in 2019. The float type distribution is as follows: 360 APEX, 26 NAVIS and 31 SOLO-1. 27 floats were deployed since ADMT19, 25 in the Southern Ocean as part of the Southern Ocean Carbon and Climate Observations and Modeling project (SOCCOM). 2 more SOCCOM floats were deployed near Hawaii to test new firmware for the APF11 controller. . Oxygen data for 259 legacy floats have still not been corrected yielding zero adjusted data and no quality controlled flags. Correcting the data on these floats and populating the adjusted data fields remains a priority. All SOCCOM float data is corrected in near real time, however the early pH sensors had reliability issues resulting in only about 50% of the total adjusted data being considered of good quality. The reliability of the new generation of pH sensors is greatly improved and both MBARI and SBE are working on new mechanical designs to further enhance the reliability. NOAA has recently funded 3 BGC Argo float arrays, which has resulted in float that are deployed or will be deployed in the Equatorial Pacific (Steve Riser), California Current (Greg Johnson), and the North Atlantic (Susan Wijffels). Ken Johnson has led the submission of an NSF Mid-Scale Research Infrastructure proposal for $52.9 million. It has been selected for a reverse site visit to NSF and if funded will result in the global deployment of 500 BGC Argo floats over five years.

Kim Sung-Dae. DOXY data of KIOST DAC

KIOST (KORDI) deployed 35 floats installed DOXY sensors from 2004 to 2008. The collected DOXY data were recorded in the profile files (ver 2.1) without QC flags. In 2019, KORDI DAC extracted DOXY data from old files, conducted Real-time QC including visual check, and made BR profile files (ver 3.1). Total 3,418 profile files were sent to GDAC in 'R' mode with QC flags. Delayed mode QC will be done in future.

Josh Plant. Setting up a periodic report on anomalies in BGC profiles

A prototype profile anomaly report was demonstrated which compared individual profiles to global statistics for a given test value for the entire BGC Argo float array. The newly created merged synthetic profile files have transformed our ability to look at the global data array! Data with a quality flag equal to 4 was never used in the analysis. DOXY was used as a test case and a test value was defined as the ratio of World Ocean Atlas (WOA) oxygen % saturation to the float oxygen % saturation in the top twenty meters of the water column (Gain). WOA profiles were generated by interpolating the WOA monthly climatology to every float profile position and time. Anomalies were identified using the median absolute deviation approach which resulted in a “Z” score for every profile which describes how many standard deviations the test value for a given profile is a way from the central value. Any Z score greater than five was defined as anomalous. An anomaly list was then generated and sorted by DAC and WMO and sent out to the BGC community for review. The list identified about 5000 profiles needing further review and represented about 5% of the data inspected. The idea would be that the DACs / PIs would review the list and either accept the anomaly as bad, change the quality flag and resubmit the profile to the GDAC or reject that the anomaly as bad and we would remove it from the data set for the next data scan. This is similar to what is done for core Argo. A side benefit for the DOXY analysis is that an average Gain is determined for every float which can be used to calculate DOXY_ADJUSTED values if there are no other means or resources to do so and the result compares well air calibration derived gains in the southern ocean. This same basic approach can be used for all BGC parameters

Matt Donnelly : Re-calculating derived BGC parameters: metadata that is perfect, poorly formatted or missing

BODC aims to develop a series of community toolboxes that are infrastructure agnostic (not designed with any one DAC in-mind), which can be shared, cross-tested, and developed collaboratively as deemed appropriate. Whilst beginning, progress seriously impinged by availability of metadata to re-derive variables from raw counts. Focusing on PREDEPLOYMENT_CALIB_EQUATION and PREDEPLOYMENT_CALIB_COEFFICIENT, in different DACs there is a high-level of inconsistency in formatting (creating parsing issues) and sometimes fields are completely empty.

The conclusion is that we should definetely improve the filling of the metadata while it prevents DACs from software testing on other DACs floats. It will also certainly has an impact on the recalculation/reconsideration of R,A,D data.

Henry Bittig and Annie Wong. Combining the bgc- and core- trajectory files

A working group was formed after ADMT-19 to examine the prospect of combining the bgc- and core- trajectory files. The preliminary conclusion was that the trajectory file was split following the split of the profile file, but the reasons for splitting the profile file did not all apply to the trajectory file.

- File size : The addition of bgc parameters in the profile file has a big impact on the profile file size because of the N_PROF netcdf dimension in the profile file. When N_PROF > 1, lots of file size is taken up to fill the rectangular (N_PROF, N_LEVELS) netcdf structure in the profile file. Splitting the profile file into bgc- and core- reduces the file size to some degree and makes it easier for users who only want CTD data. The trajectory file does not have the N_PROF netcdf dimension. The trajectory file size can only grow along the N_MEASUREMENT netcdf dimension, which does not have a big impact on the file size. The only exception is the i-parameter UV_INTENSITY_NITRATE, which has an extra dimension N_VALUESnnn for storing spectral information. However, this netcdf dimension is only used for UV_INTENSITY_NITRATE and does not have a big impact on the size of the trajectory file.
- Stability of the parameters : When bgc parameters were first introduced, there were warnings that the bgc parameters may have to be re-processed frequently. This would have made the profile files unstable. Splitting the profile file into bgc- and core- keeps the CTD data stable, which is a requirement for the core-Argo mission. However, the bgc- parameters are now more mature and should remain stable going forward.
- Connection between the bgc- and core- traj files : In the split format, the N_MEASUREMENT array and JULD are the link between the bgc- and core- traj files. DACs who are currently only making the core- traj files will still have to add the measurement codes and JULD for the BGC events in the core- traj files.

Based on the above conclusions, the working group suggested that the trajectory file NOT be split into bgc- and core- , but keep one combined trajectory file. This will allow users to find all drift phase, surface, and timing information in one place. There will still be a Rtraj file and a Dtraj file, but two traj files is easier to manage than four traj files.

Suggestions :

- Suggest calling the proposed combined traj file Version 3.2.
- Change TRAJECTORY_PARAMETERS(N_PARAM,~~STRING16~~STRING64) (as in B-traj).
- Add TRAJECTORY_PARAMETER_DATA_MODE (N_MEASUREMENT, N_PARAM) – include P/T/S.
- Add TRAJECTORY_CALIB_* (N_PARAM, N_CALIB, STRING256).
- Add JULD_DATA_MODE(N_MEASUREMENT) to make JULD adjustments clearer. JULD is different than other params in Argo because there can be FillValue in JULD in real time, but data in JULD_ADJUSTED for the same event to indicate a time is estimated and does not come directly from the float.

If endorsed - Schedule :

- Finalize combined trajectory file format Version 3.2.
- Seek comment and approval from AST in March 2020.
- Update User Manual and begin creating combined trajectory files.
- Coordinate with GDAC file checker for traj Version 3.2.
- Begin educating users on trajectory file changes.
- There needs to be a transition period for BGC floats when both Version 3.1 (separate c- and b-traj) and 3.2 (combined traj) can exist. Floats without BGC parameters can stay in Version 3.1.
- DACs that do not have the resources to fill the BGC parameters in the combined traj file have the option of leaving them as FillValue, then let the BGC groups fill them at a later date.

Some feedback was received during the meeting regarding this proposal. DACs warned that we had to be careful when planning this trajectory file format change, as the DACs would only want to re-process the traj files once. There was concern from the delayed-mode groups about how to work on one Dtraj file with various core- and bgc- people. There was also concern from some BGC groups about whether this proposed combined traj file format will hinder their workflow.

All DACs and delayed-mode groups (core- and bgc-) were asked to think about this proposed combined traj file format and reply YES or NO by March 2020.

It was suggested that Coriolis produce a sample combined V3.2 traj file for people to test.

Independent of whether this proposal is accepted or not, DACs with BGC floats are reminded that they need to produce core- Rtraj files that include all measurement codes and JULD for all BGC events.

<u>Catherine Schmechtig for Tanya Maurer</u> : R, A, D definition for BGC

Catherine Schmechtig presents the conclusion of a discussion that began last year about a specific definition of Real Time, Adjusted and Delayed Mode for BGC parameters compared to core parameters.

Since, BGC data in its raw form is not fit for scientific use and considering that even preliminary adjustments (ie assessment after the first ~5-6 cycles) can increase data accuracy by up to 20% for some floats/variables (namely, DOXY), these preliminary adjustments can be defined as DM.

As soon as it is stated clearly in the documentation (ie Argo User Manual, website, etc) the meaning of delayed mode for BGC data with emphasizing differences in timing of initial DM assessment between core and bgc,

- DM-adjusted measurements represent the highest data quality at time of assessment
- It is accepted by BGC community that initial adjustments make BGC-data fit for scientific use
- Delayed mode data is accompanied by uncertainty estimates accessible to user
- Improvement to data accuracy between initial and subsequent DM assessments is much smaller than the accuracy gained from the initial assessment

The Argo user manual and the Quality control manual for BGC data will be updated.

J. Plant / A. Mangin / A. Poteau / C. Schmechtig. Increasing the amount of adjusted data at the GDAC

Providing gain adjustment value for DOXY parameters (Josh Plant)

BGC Argo has produced over 118 million BGC measurements which is a phenomenal amount of data. Unfortunately only a small percentage of this data has been adjusted (A or D mode). DOXY is a good example. Only 38% of the data has been corrected and 5% of the profiles, which have not already been marked as bad, appear to be anomalous. These facts limit the utility of the data set to the user community and are a detriment to the forward progress of BGC Argo. This situation should be corrected rapidly! Many DACs are now generating adjusted oxygen data for current floats, but there is a backlog of 457 legacy floats with no adjusted oxygen data. The two main hurdles to propagating this raw data to the adjusted data field are that off-line corrected data bases are not propagated to the GDACs and some DACs do not have the resources or expertise to do this. We have generated a correction term (GAIN) for every DOXY float which can be used to calculate adjusted data (DOXY * Gain = DOXY_ADJUSTED) if resources or time do not permit a more accurate solution.

Sharing Tools to fill DM file (C. Schmechtig)

Catherine Schmechtig presents how the LOV proceeded to DM a hundred of floats in summer 2019. Once a gain, an offset and a drift is estimated with methods like SageO2, a shell script is used to write an input file containing all parameters/information needed to fill a BD files :

- PARAMETER_ADJUSTED, PARAMETER_ADJUSTED_QC, PARAMETER_ADJUSTED_ERROR
- SCIENTIFIC_CALIB_*** (DATE, COMMENT, EQUATION, COEFFICIENT)
- HISTORY_*** (INSTITUTION, STEP, DATE, SOFTWARE, SOFTWARE_RELEASE, ACTION)

  Tools available :
  - SCOOP to visualize and change QC (https://doi.org/10.17882/48531)
  - SAGE-O2, SAGE to estimate trends for DOXY, pH, NITRATE (https://github.com/SOCCOM-BGCArgo/ARGO_PROCESSING)
  - LOCODOX to estimate trends for DOXY
  - DM Filler tool, to fill BD files with adjusted fields, error and calibration https://github.com/catsch/DM_FILLER

The information about codes/tools available for the BGC community will be gather on the BGC-Argo web site.

Before beginning the session on BBP and CHLA, Hervé Claustre insists on the fact that an effort should be made by the whole scientists community that published BGC-Argo quality controlled data in peer review journal to make an effort to transfer their data in DM files in the Argo data system.

Ian Walsh / Antoine Poteau / Emmanuel Boss / Josh Plant BBP

Emmanuel Boss presents a published study (Bisson et al., 2019) that compares different satellites (OLCI, VIIRS, MODIS) derived estimates (with QAA, GSM, GIOP algorithms) of the particulate backscattering coefficient at 700 nm with in situ bbp using observations from autonomous BGC-Argo floats. The results herein support the use of autonomous floats for performing ocean color validations. Now that the quantity of in situ matchups is less of a limiting factor, more restrictive matchup criteria may be appropriate in future work.

Ian Walsh. QA/QC and Factory Calibration of Backscattering Data

The range of the instrument output collected during the calibration process under conditions of no signal load can be used as initial conditions for determining expected variance in the signal from the instrument in the field. Where multiple sensors are challenged at the same time with targets, e.g. fluorescence sensors during backscattering bead loading, the calibration data can be used to determine the expected instrument variance due to non-target signals in the field. Combining all of the calibration data variance allows for an estimation of the potential variance related to the instrument in the field compared to the target. This allows QA/QC structures to be built with standard input from each instrument rather than general guidelines.

Xiaogang Xing / Emmanuel Boss / Josh Plant / Herve Claustre. Chlorophyll-A

Xiaogang Xing presents the review of FCHLA QC. As the CHLA is estimated from fluorescence of Chlorophyll-A measured with fluorometers that excites at 470nm and received signal at 700nm the error sources are :

- Dark count
- FDOM interference (Fluorescence of dissolved organic matter)
- The Non Photochemical Quenching
- The Slope variability

For the RTQC, the dark count estimates at depth, the NPQ correction from Xing et al., 2012 and the slope correction from Roesler et al., 2017 are simple and robust and adapted for RTQC. But this can be improved in DMQC:

Dark Correction:

- Option 1: Minimum for each profile (after median filter)
- Option 2: On-Float Dark (estimated with a tape on the sensors at deployment)
- Option 3: Median of all minima (after median filter) during the whole float life

NPQ correction (Xing 2018):

- Using PAR profile to determine a NPQ threshold depth (ziPAR15), the extrapolation of Xing12 is applied from surface to min(ziPAR15, MLD) for well-mixing waters

$$z_{X12+} = z\left(FChla = max\left(FChla\left(z \leq \min\left(MLD, z_{iPAR15}\right)\right)\right)\right).$$

$$X12+(z) = \begin{cases} FChla(z_{X12+}) & (z \leq z_{X12+}) \\ FChla(z) & (z > z_{X12+}) \end{cases}.$$

- Using PAR profile and empirical relationship (XB18) to correct NPQ for shallow-mixing waters (DCM>MLD)

$$XB18(z) = \begin{cases} FChla(z)/\left(0.092 + 0.908/\left(1+\left(iPAR(z)/261\right)^{2.2}\right)\right) & (z \geq 10\text{m}) \\ XB18(z = 10\text{m}) & (z < 10\text{m}) \end{cases}.$$

- Option 1: Onboard-based correction (haentjens et al., 2017)
  - Water-sampling at deployment place
  - 2. [Chla] is determined by HPLC or fluorometry
  - 3. A linear (or exponential) regression on [Chla] vs. FChla (after Dark and NPQ correction) without intercept to acquire SLOPE
- Option 2: Satellite-based correction (Lavigne et al., 2012)
- Option 3: Irradiance-based correction (Xing et al., 2011)

Hervé Claustre presents potential reasons why there is so much variability in the CHLA , vs FCHLA relationship. The in-vivo pigment-specific absorption of main pigments is presented. This figure highlights the fact that the absorption for the chlorophyll-A pigment is maximum at an excitation wavelength of 440nm and close to 0 at an excitation wavelength of 470nm. Chelsea florometers are equipped with an excitation wavelength of 440nm, while Seabird/Wetlabs fluorometers are equipped with excitation wavelength at 470nm. The Seabird/Wetlabs fluorometers don't excite Chlorophyll-A pigments. In low latitudes environment (Subtropical gyres), they excite non photosynthetic accessory pigments at surface and and photosynthetic pigments at depth. In high latitudes environment (North Atlantic, Southern Ocean), they excite photosynthetic accessory pigments.

As most of the floats are equipped with Seabird/Wetlabs fluorometers, in order to be able to characterize correctly chlorophyll-A pigments, a transfer function should be studied and evaluated. In order to achieve this goal, multiple sensors (Chelsea + Wetlabs) are deployed together on ships with HPLC casts acquisitions and floats will be tested with double excitation (440, 470nm) fluorometers.

<u>**Xiaogang Xing / Antoine Poteau**</u>. Radiometry

The document for the control quality of the radiometry is presented. A range test has to be apply for all the values, if the test fails, the QC should be set to QC=4.

Suggestions are made to study the variability of the radiometry per area, per type of float… (cf Poteau et al., 2017 for BBP). This would be presented at the next ADMT.

<u>**Virginie Thierry / Kenneth Johnson / Henry Bittig**</u>**.** Doxy

Henry Bittig presented the current state of BGC-Argo O_2 observations: **Argo has acquired ca. 180,000 oxygen profiles, of which ca. 80,000 have been DMQCed – more than double the amount from**

ADMT19. This is a great, positive effort by DACs and operators, which hopefully continues in order to diminish the number of un-DMQCed (inactive) floats.

O_2 processing following the cookbook (version 2.3.1, June 13 2018) is implemented at all DACs. No changes to the processing have been necessary since the last ADMT or are anticipated. In contrast, while the O_2 QC manual (version 2.0, October 23 2018) contains most essentials (simple QC tests, how to adjust data and how to fill the adjusted error), future refinements are to be expected and done during ADMT20 (new surface saturation test, refinement of adjusted error filling; see below).

(1) **PhaseCoef0 issue:** Preceding ADMT19, Aanderaa optode multipoint calibration sheets between ~April 2017 and ~September 2018 (Optode 4330 SN range ~2400 – ~3000) were found to lack information on the PhaseCoef settings (with a potential non-zero PhaseCoef0). This information is retrievable from the calibration sheet data or from the sensor's internal storage. DACs were made aware by e-mail to argo-bio on June 14 2018. **As of ADMT20, all DACs fixed** potentially missing PhaseCoef0 values and reprocessed **data for all floats within the calibration dates / SN range (209 floats)**. **New deployments with 4330 optodes in the ~2400 – ~3000 SN range need scrutiny.**

(2) Recognizing that **optode O_2 sensors typically are biased** (low), **DACs are encouraged to implement methods to produce real-time adjusted ('A' mode) DOXY_ADJUSTED data and with filled DOXY_ADJUSTED_ERROR fields (Action 01; DACs),** following a quick initial DMQC by an operator or an otherwise estimated gain factor (e.g., Josh Plant / MBARI DOXY audit).

(3) **After order ~200 of noon profiles, the optode sensing foil can become significantly deteriorated** (biofouling and/or foil damage)**, rendering all subsequent data as bad.** Repeated surfacing during noon in subtropical areas can adversely affects O_2 sensing by Aanderaa optodes. The phenomenon shows itself as extraordinarily high O_2 saturations > 150 % under light exposure (e.g., 2901554, 6901439, 6901474, 6901472). By switching between day/night time, the accumulated number of noon profiles can be shifted to a later deployment date.

(4) A **new RTQC test "Surface Saturation Test"** is proposed and accepted by the BGC-ADMT:

a) Convert DOXY into "O2 saturation" (SCOR WG142 O_2 conversions as for O_2 processing).
b) Calculate the "mean(O2 saturation)" within 0 – 10 dbar (without "DOXY_QC = 4" set, e.g., by the range test).
c) If "mean(O2 saturation) >= 150 %", then set "DOXY_QC = 3" for the entire profile.
d) If the "Surface Saturation Test" is triggered for 10 consecutive profiles, then put the float on the greylist with "DOXY_QC = 3" and notify float operator.

This test applies both to DOXY ('R' and 'A' mode) as well as to DOXY_ADJUSTED ('A' mode).

(5) For **DOXY adjustments**, there are **two independent elements: (a) the source / kind of reference data, and (b) the way to adjust the sensor data**.

a) Aims to give the highest quality reference data with the following priority:
    i. Direct in-air measurements on the float (SCOR WG142 recommendation).
    ii. An estimate of surface O_2 saturation (which is close to 100 %) based on historical data = Surface O_2 saturation from WOA or other climatology.
    iii. Winkler-calibrated CTD-O_2 deployment profile, or a climatology-based DOXY estimate on a deep, stable layer (as for PSAL).

b) Follows the sensing principle, i.e.,

i. A gain factor in PPOX_DOXY for O_2 optodes (Aanderaa, Sea-Bird SBE63, JAC, …). For older (Aanderaa) optodes with batch calibration, a small offset on PPOX_DOXY (order 5 hPa) may be applied if warranted.

ii. A gain factor and offset on the voltage for O_2 electrodes (Sea-Bird SBE43)

(6) The **DOXY_ADJUSTED_ERROR estimate primarily depends on the reference data accuracy and character**:

i. Constant with time but increasing with depth / distance from the surface for direct in-air measurements.

ii. Constant with time but increasing with depth and larger than (i.) for surface O2 saturation for a climatology

iii. Increasing with time from the reference profile time but constant with depth for a deployment profile, or constant with time but increasing with distance from the reference depth (i.e., towards the surface) for a deep DOXY climatology

Depending on the sensor factory calibration's accuracy, the error estimate from the reference data must be increased (e.g., for batch calibrated O_2 optodes). **For O_2 optodes,** which are sensitive to PPOX_DOXY, **the adjusted error should be expressed as absolute value of partial pressure, PPOX_DOXY_ERROR, not as a percentage of the O_2 value.** PPOX_DOXY_ERROR is then converted to DOXY_ADJUSTED_ERROR using the SCOR WG142 conversions. A complete error budget for DOXY is work in progress.

(7) **O_2 optode time response corrections require measurement times**. Those can (a) be transmitted by the float firmware and stored alongside the profile data (optional MTIME i-parameter). Currently, this is only done by the Coriolis decoder for 41 floats. **DACs are encouraged to check their recent decoders whether float information is available that should be stored in "MTIME" (Action 02; DACs)**. (b) Measurement times can be estimated. During the ADMT20 discussions, the number of samples per bin for continuously pumped data was discussed as a promising proxy of ascent speed. With a known, constant sampling frequency, the number of samples per bin gives the time spent per bin. **A subgroup will re-evaluate the "NB_SAMPLE" parameter definition and its potential use for time response correction (Action 03; Josh, Annie, Henry, Matt)**. More on time response corrections on the SOCCOM fleet, see below.

Josh Plant (SOCCOM Fleet) :

The two biggest factors affecting oxygen accuracy for optodes are the storage drift and the time response of the optode. While storage drift is now easily corrected the time response has been largely ignored in data processing. When an ascending optode passes through a strong oxygen gradient the response time is not fast enough to capture the observed variability. If the gradient goes from low to high this results in an underestimate of the actual concentration. Henry Bittig has published two papers which describe the problem and a correction solution. Tanya Maurer applied this solution to the entire SOCCOM array to test the effectiveness of this approach which works quite well, removing much of the time response bias in the high gradient regions of the profile. This approach require a time value for each sample in order to calculate a float velocity. For floats with no explicit time value, bin counts from the cp mode ctd might be a way to back out time. If time data is available this procedure could run in real time but that leads to operation questions about data flagging and whether it is appropriate for real time?

Ken Johnson presents its Recommendation on Oxygen Flagging

1. Flag profiles with Z statistic > 5 as questionable. Z<=5 as good in real time. Reprocess existing profiles with this test.
2. Deliver quarterly audit of array with Z statistics for profiles > 6 months in age (i.e., not real time).
    1. If a DAC does not have the resources to implement Recommendation 1, a DAC can use the audit to flag existing profiles.
    2. If a profile remains on the audit list for 1 year, it should be grey listed.
3. A DM operator may change a flag of 3 to 1 or 4 following inspection of the profile.

Recommendation on Oxygen Adjustments

1. For floats with more than one year of data, if a gain correction has not been applied, data should be adjusted with a gain factor of mean[(WOA O2% saturation in upper 20 m)/(Float O2% saturation inupper 20 m)]
2. Deliver quarterly audit of array with gain term for profiles > 6 months in age (i.e., not real time).
    1. If a DAC does not have the resources to implement Recommendation 1, a DAC can use the gain reported in the audit to adjust existing profiles.
    2. If a profile remains on the audit list for 1 year, it should be grey listed.

Ken Johnson / Catherine Schmechtig. Nitrate

Ken Johnson presents a temperature correction that should be applied on the processing of the NITRATE contration. The temperature correction equation used in nitrate processing has been updated with new laboratory work and a modified analysis method. This appears to eliminate the minimum seen in nitrate concentration near the surface in warm (>20C) waters. The Nitrate Processing at the DAC Level manual will be updated as follows:

Original Algorithm in Processing Bio-Argo nitrate concentration at the DAC Level Version 1.1

Calculate the spectrum due to Bromide and other sea salt components, with a correction of the in situ temperature :

E_SWA_INSITU(R) = *E_SWA_NITRATE*(R) * F(R, TEMP) / F(R, *TEMP_CAL_NITRATE*)

(Eq. 2)

With two calculations of F, for TEMP (temperature sampled by the CTD (cf 3.1)) and for *TEMP_CAL_NITRATE* following:

F(R, T) = (A + B*T) *exp[(C + D*T)*(*OPTICAL_WAVELENGTH_UV*(R) – *OPTICAL_WAVELENGTH_OFFSET*)]

(Eq. 3)

A = 1.1500276, B = 0.02840, C = -0.3101349, D = 0.001222

OPTICAL_WAVELENGTH_OFFSET = 210 nm (*)

<u>New Algorithm</u>

Calculate the spectrum due to Bromide and other sea salt components, with a correction of the in situ temperature :

E_SWA_INSITU(R) = E_SWA_NITRATE(R) * exp[G(R) * (TEMP – TEMP_CAL_NITRATE)]   (Eq. 2)

where

G(R) = (0.00000551649 * WL(R) ^ 3 - 0.000343511 * WL(R) ^ 2 + 0.00531286 * WL(R) + 0.0021161)   (Eq. 3)

WL(R) = (*OPTICAL_WAVELENGTH_UV*(R) – *OPTICAL_WAVELENGTH_OFFSET*)

OPTICAL_WAVELENGTH_OFFSET = 210 nm

Note that you then need to apply the pressure correction in Eq. 7.

Catherine Schmechtig presents the status of the NITRATE parameter at the Coriolis DAC. She presents a preliminary version of the quality control procedure for NITRATE concentration that circulates between teams and close to an official release. This document reports :

- A range test
- A spike test
- A absorption at 240nm test
- A saturation test
- A Fit error test

This procedure has been applied to the whole Coriolis NITRATE fleet and it allows to mark as bad dubious points. Ken Johnson mentions that there is still some edition to do on the documentation before make it official.

Following Ken Johnson's presentation of the temperature correction. The whole set of NITRATE concentration at Coriolis should be reprocessed before this quality control procedure is applied.

Once, the datasets is reprocessed and RT quality control applied, as there is a regional release of the CANYON tool for the Mediterranean Sea (plus DM applied on ~100 DOXY floats at Coriolis). Coriolis is ready to DM NITRATE.

<u>Ken Johnson / Henry Bittig.</u> pH

Henry Bittig presents pH data of 7 floats at the Coriolis DAC. pH is one of the parameters that is studied in the framework of the European E-ARISE project, with a focus on improving RTQC procedures and DM procedures.

As there are strong differences between each sensor revision, one recommendation of the presentation is that we should collect these sensors revisions expand the table 27 to track the different versions in the metadata.