Hervé Claustre / Ken Johnson. Introduction/ general objectives of this meeting

2021 is the first year for which the BGC-Argo array reached more than 400 floats at sea. 870 float deployments are planned in the next 5 years, but there is still a lack of 400 floats to reach a sustained array of 1000 operational floats at sea. Available tools and audits are available through the BGC-Argo website which have been very helpful for DACs. However, routinely implementing processing updates, and performing regular DMQC data adjustments for BGC parameters remains difficult for many DACs (due to lack of resources, manpower, capacity building).

FEEDBACK FROM DACS

Udaya Bhaskar. DAC: BGC Argo data management-India

BGC-Argo progress during the last one year (Nov 2021 – Nov 2022)
1. India contributed 67 BGC-Argo floats and 16 Argo floats with O2 alone to the BGC-Argo program. The last deployment of BGC-Argo took place in 2019 and no new floats were deployed after that. As of now 29 of 67 BGC-Argo floats are actively giving the data.
2. Studies were undertaken using the BGC-Argo profiles and papers were published in JGR-Bio-geosciences and Deep-Sea Research – II. One paper was published which described a correction to the Chla profiles. This study will be extended to all 67 BGC-Argo floats and corrected profiles will be submitted to GDAC. The rest of the papers analyzed the OMZ in the Arabian Sea and Bay of Bengal.
3. Profiles from the BGC-Argo report were visually cross checked and found to have issues. Work is under progress to correct the flags and re-submit the profiles to GDAC.
4. BGC-Argo data is being utilized by the modeling team for assimilation and results will be presented to the team during the next ADMT.

Answers to Questions :
-The CHLA data published in the papers is not QCed yet, but will be soon
-The modeling team is assimilating CHLA data.
-DOXY is adjusted with gains provided by Josh Plant's audit

Violetta Paba. DAC: BGC Argo data management-UK

BODC is still developing capability to deliver BGC data from UK floats to the GDAC. The complete UK BGC fleet is made of 49 floats (16 of which are active), and are a mix of APEX, NAVIS EBR and PROVOR floats. Data from 11 UK BGC floats are on the GDAC, which were processed by Coriolis on our behalf; they are all NKE PROVOR floats with Optode, Fluorometer, BBP and PAR sensors. BODC has not yet done any DMQC on the UK BGC float parameters, though Catherine Schmechtig has kindly offered to QC oxygen and radiometer data from the UK PROVOR float data on the GDAC on our behalf in the short term. Over the past year, Giorgio dall'Olmo (PML) has developed a new BBP RTQC tests methodology, which is open and shared on GitHub. At BODC, we have reviewed 7 of the BGC DAC cookbooks and 3 RT QC manuals (BGC, O2 and Chl-a), and sent feedback to the authors. On the BGC data delivery capability side, BODC has made progress in the development of the infrastructure needed, particularly on the RTQC tests Python toolbox and the infrastructure-agnostic BGC derivation equations in Matlab, with focus on the remaining BGC parameter i.e. Oxygen. Our future plans include three development sprints in the spring, and BGC DMQC training for delivery of QCed BGC data from our floats in the near future. In terms of procurement, around 15 NKE PROVOR floats with the full BGC suite will be deployed in 2023; funding for a further ~15 floats has been secured, with procurement scheduled for the next few months.

Kentaro Tsuji DAC: BGC Argo data management-Japan

JMA started to create B-profile files of the floats with pH sensor after ADMT-21 and now decodes all the variables of active BGC-Argo floats of Japan. JMA has been developing RTQC for each parameter and plans to implement RTQC for DOXY and DOXY adjustments using WOA by March 2022.
JAMSTEC is now preparing processing programs for DOXY-DMQC, and testing whether Nitrate and pH observed by BGC floats in the North Pacific are corrected well by SAGE.
JAMSTEC is going to deploy 4 BGC floats in the next year : 2 BGC Navis equipped with SBE63, MCOM-FLBBCD and SUNA_V2, 1 BGC Navis equipped with SBE63, MCOM-FLBBCD and SEAFET and 1 BGC APEX equipped with ARO_FT.

Answers to Questions :
-NITRATE is already in the JMA Bfile but it is not QCed yet.

Christina Schallenberg DAC: BGC Argo data management-Australia

- Almost all data makes it to the GDAC in time and is correctly flagged, but not all BGC parameters that need adjusting are currently getting adjusted:
    - DOXY and NITRATE are looking good, they get adjusted in real time
    - PH and CHLA are in the works (hopefully will get it implemented for RT early in 2022)
- For NITRATE and PH we use SAGE to calculate the adjustments, then implement into the real-time system via a Python database
- Our DOXY DMQC system should be up and running again soon, but not currently set-up to use in-air oxygen (not in SAGE either)
- Results from the DOXY audit are looking good, not so good in the BBP audit, but >50% if our bad data are from 3 legacy floats that sampled only shallowly; DMQC to catch the bad data has been developed, but has not made it into the netcdfs yet
- 9 floats deployed in the past 12 months, 6 more en route to deployment/on order, to be deployed by the end of 2022

Maurer / Plant / Schmid DAC: BGC Argo data management-US

The US BGC DAC effort includes contributions from many US institutions (WHOI, SIO, NOAA/AOML, NOAA/PMEL, MBARI, UW) and a number of new hires have come onboard recently in support of the NSF-funded GO-BGC global float program which was launched in the spring of 2021. There is a total (as of this report) of 575 BGC floats deployed from the US DAC, many of which are older O2-only floats and the majority of which are APEX platforms. The bulk of the 5-sensor BGC floats deployed are processed and managed by MBARI. Development of the BGC SOLO II float platform and data stream has been ongoing and test deployments off San Diego are proceeding. Additionally APEX test floats with OCR (2 deployments), GDF pH sensor (1 recent deployment), and SBE83 (2 deployments) have occurred. 39 5-sensor BGC floats were deployed since last ADMT (21 GO-BGC, 11 SOCCOM, 2 WHOI EXPORTS, 4 GOM from AOML, and 2 NPac from NOAA/PMEL). 2 of these 39 floats were declared dead upon deployment. Data management development efforts have focused broadly on increasing the amount of adjusted data at the GDAC. A publication was released this year on DMQC methods for oxygen, nitrate and pH on SOCCOM floats (Maurer et al., 2021). The DOXY audit developed by Josh Plant is also ongoing. Additionally, the AOML BGC processing system continues to mature and their team is now processing BRfiles for all 3 Gulf of Mexico deployments. Exact details for future float deployments coming from the US beyond March, 2022 are not firm, but a number of cruises have been confirmed in the coming months, including a cruise later this month in the Eastern Tropical North Pacific off of the R/V Sally Ride which will deploy four 5-sensor BGC APEX floats. Additional confirmed cruises through early Spring, 2022, include 16 floats along line P02 and a number of deployments in the Southern Ocean including deployments along A10.5 and A13.5 GOSHIP lines.

Answers to Questions :

-The vertical resolution of the OCR504 (Radiometry sensor) on APEX is set to 2m.

- The US DAC processing chain was developed in MATLAB (for MBARI), as well as JAVA and fortran 90 (for AOML)

Anh Tran / Chris Gordon DAC: BGC Argo data management-Canada

In 2021, Argo Canada deployed 6 NKE floats equipped with Aanderra Optode 4330 sensor. As of 2021, Canada deployed a total of 53 floats with oxygen sensors only. Of which, 3 floats didn't transmit any profile after deployment, and 11 floats are still active reporting data. Data collected by these floats are processed, quality controlled and transmitted on the Global Telecommunication System (GTS) by MEDS DAC. Argo real-time test and BGC Argo float are being rewritten into Python language. MEDS has developed a new decoder and data processing chain to handle the new deployment of BGC floats in Spring-Summer 2022. With respect to delayed mode data management, 4 Apex floats equipped with DOXY sensors have completed the DMQC process using bgcArgoDMQC- a python package based on SAGE-02. The Python package can be found here: https://github.com/ArgoCanada/bgcArgoDMQC. All gain results are validated against SAGE. The DMQC files will be available at the GDAC after the ADMT meeting. The backlog of O2 DMQC should be completed early in the new year.

Xiaogang Xing. DAC : BGC Argo data management -China

In 2021, China deployed 5 BGC-Argo floats, including the first 2 China-made HM2000-O2 floats, and recovered 1. To date, there are 10 China BGC-Argo floats alive, 2 in the Indian

Ocean, and 8 in the Northwest Pacific. DAC CSIO updated Chla and Oxygen RTQC following the Argo documents, and checked the oxygen and bbp audit files. Most bbp profiles listed in the audit file seem good or bad but correctable, but we found some unlisted "bad" profiles which should be flagged as 3 or marked in the grey list.

Klein/Bittig. DAC: BGC Argo data management-Germany

16 BGC-Argo floats, mostly funded by research projects such as DArgo2025 (Aug 2020-Dec 2021), were deployed in 2021 by Germany in the subpolar North Atlantic as well as in the European Marginal Seas (Baltic Sea, Med Sea). They range from two BGC parameters (O2/pH) to five BGC parameters (all six but pH, or all six but nitrate). Three German BGC-Argo floats have been recovered in 2021, one in the Med Sea (7900563), one in the Baltic Sea (6904117), and one in the North Atlantic (7900561), and we would like to express a great "Thank You!" to everyone involved. The floats are going to be refurbished and reused.
Goals of current and ongoing (e.g., C-SCOPE research project, until Dec 2023) BGC activity in Germany is to link and integrate with other parts of the ocean observing system like ICOS SOOP pCO2 lines, to this way validate BGC Argo sensor performance and QC methods (e.g., for pH), to build capacity for BGC operations at BSH, and to help build a more robust and powerful BGC-Argo network by testing new sensors for sensor diversification (e.g., nitrate) or for broader impact (e.g., hyperspectral radiometry).
To this end, TriOS RAMSES ACC hyperspectral radiometers have been integrated on TWR Apex floats. A total of 5 of these have been deployed, 4 of them in pairs with buddy-floats with standard 4-channel OCR504 radiometers. So far, experience is promising and the data will open new opportunities for bio-optical long-term studies of global ocean processes (Ahlem et al., 2021, https://dx.doi.org/10.3389/fmars.2021.676537). Their data are currently stored under the GDAC aux directory according to Argo rules and can follow standard processing for radiometry.
New to Argo, a second nitrate sensor (TriOS OPUS-DS) is being evaluated for and tested on BGC-Argo floats. Besides lab studies, two dual-nitrate sensor floats have been deployed in the Baltic Sea with most challenging optical conditions (high CDOM background, small nitrate range), compared to the open ocean. For these initial tests, the commercial sensor was used without any extra modifications/optimizations for BGC-Argo floats. The results show the potential of the OPUS as an alternative to the SUNA nitrate sensor, and also identify areas for improvement (e.g., reduction of base current draw). TriOS plans to host an OPUS user meeting in spring 2022 to better understand user needs and wishes and to gauge feedback for future developments/improvements. Anyone interested is welcome to join and an expression of interest would be appreciated (can be routed through Henry Bittig, if wanted).

Thierry Carval . DAC: BGC Argo data management-France

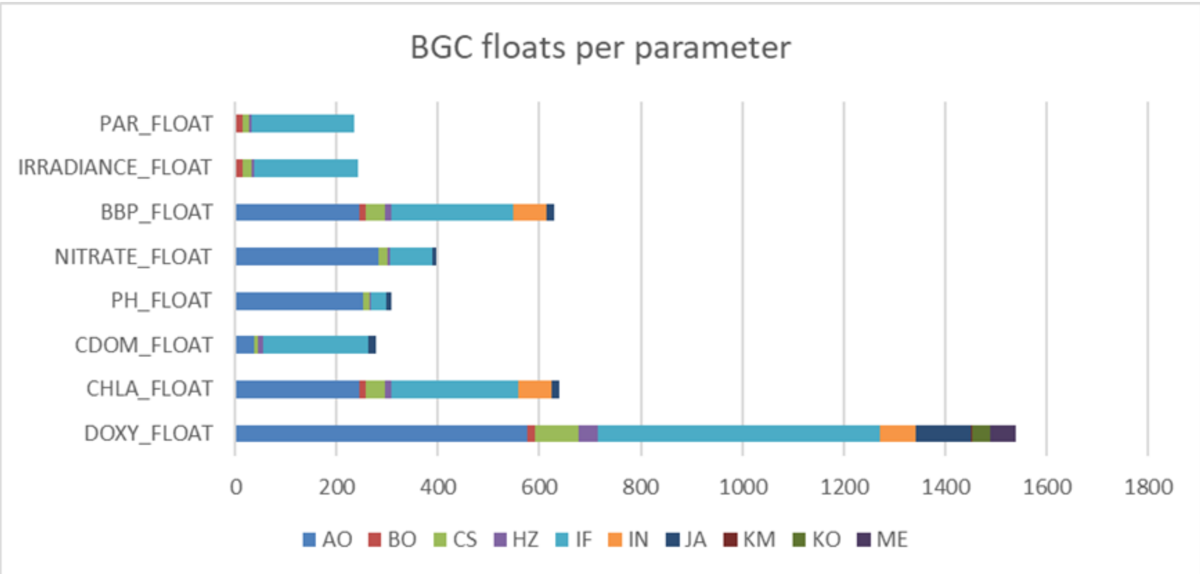
Coriolis DAC status

The Coriolis oxygen audit is now almost clear; 139 profiles added into the master list and 171 profiles waiting DM to confirm. We reported false alerts in Baltic sea, Black sea due to

specific marginal sea conditions. We also reported false alerts in Atlantic or Pacific-Peru OMZs.
The oxygen real-time adjustment is now automated, with a weekly expert check on floats having a new adjustment.
We are preparing routine oxygen QC hyper saturation and regional range alerts (a Copernicus Marine activity).
The Coriolis BGC-Argo floats data processing chain is continuously improved (a monthly release), we now manage 80 versions within 5 families (Apex, Navis, Nemo, Nova, Provor). The data processing codes are freely available: *Coriolis Argo floats data processing chain, http://doi.org/10.17882/45589*
Coriolis DAC manages 622 BGC-Argo floats (+21% yearly) from 5 families. They performed 79.192 cycles (+15% yearly).
There are 11 types of sensors mounted on Coriolis BGC floats, they observe parameters such as oxygen, chlorophyll, turbidity, CDOM, back-scattering, nitrate, bisulfide, pH, irradiance, PAR.

Coriolis GDAC status

In November 2021, 250.738 BGC-Argo profiles from 1664 floats were available on Argo GDAC. This is a strong increase compared to 2020: +35% more floats and +33% more profiles.



BGC-Argo floats distribution per parameter and DAC

PARAMETER-SPECIFIC WORKING GROUP TOPICS / RT DATA MANAGEMENT

Organelli RADIOMETRY: update from working group

The presentation by Organelli E. et al. reported on the results achieved by the WG on BGC-Argo radiometry. The WG was established after the AST meeting in March 2021, and met twice (April and November 2021). Several BGC-Argo and radiometry experts from US, Europe and Australia joined the activities that aimed to: (i) select a common set of four bands for downwelling irradiance measured by BGC-Argo, as based on shared criteria and radiative transfer simulations; and (ii) recommend the optimal vertical resolution for radiometry, as based on tests with native, 2-m and 5-m sampling resolutions and on reliability of the shape of vertical profiles of the diffuse attenuation (Kd) at 490 nm vs that of chlorophyll concentration. Preliminary results indicated that: (i) the four bands to select are: 380, 443, 490 and 555 nm. These bands will allow reconstruction of accurate PAR profiles; (ii) the optimal vertical resolution to choose is 1 dbar. This resolution allows to finely reproduce Kd profiles and better calibrate chlorophyll fluorescence measurements, and does not imply additional power consumption. An additional meeting will occur in 2022 to finalize the results.

Improved temperature correction for UV nitrate sensors on profiling floats (Plant)

As the BGC Argo float array grows, more and more floats have been deployed in tropical waters where the surface waters tend to be warmer than the standard 20C calibration temperature and the nitrate concentration should be close to zero. In these same waters it has been noted that the adjusted nitrate concentration measured by the floats tends to be anomalously high (~1.0 – 1.5 µmol/kg) and the anomaly is correlated with temperature. This anomaly appears to result from a minor deficiency in the current temperature correction when estimating the sample bromide absorption spectrum which we propose to alleviate with a new temperature correction algorithm.

Nitrate sensors on profiling floats use the absorption spectrum of UV light (217-240) to estimate nitrate concentration. This is done by modeling the total UV absorption spectrum as the sum of three components: sea salts (bromide), nitrate & a linear baseline component which accounts for dissolved organic carbon, changes in lamp intensity and changes in light throughput. The absorption due to bromide is temperature (and pressure) dependent. The current calculation used by BGC Argo is the temperature compensated, salinity subtracted method (TCSS, Sakamoto et al., 2009, DOI:10.4319/lom.2009.7.132). This approach uses the salinity value recovered from the CTD to first estimate bromide absorbance and subtract this from the sample spectrum prior to estimating the nitrate concentration and linear baseline absorption coefficients. This reduces the degrees of freedom and greatly improves the accuracy of the multiple linear regression used to estimate nitrate.

The newly proposed temperature correction scheme relies on the fact that LN[ABS_{Br}] vs temperature is linear for a given wavelength and the slope is constant for a given wavelength. This relationship was noted by Ken Johnson during ADMT19 and was used by Nehir etal., 2021 (doi: 10.3389/fmars.2021.663800) for the temperature correction in their OPUS nitrate sensor, a sensor based on similar principles with slightly different components. The correction takes the form of:

$$E_{sample,WL} = E_{cal,WL} * \exp[f(WL) *(T_{sample} - T_{cal})]$$

where E (absorbance / salinity/pathelength) is the extinction coefficient for bromide, T is temperature, WL is wavelength -210 and f(WL) is a polynomial function of the LN[E_{Br}] vs temperature slopes vs WL. The new correction method fits the experimental data from the laboratory much better and minimizes this observed warm water bias in nitrate concentration. Our f(WL) function matches that of Nehir et al., (2021) quite well except at wavelengths < 221 nm where the MBARI slope estimates are about 10% lower. All MBARI tests and validation used ISUS sensors in the lab and on profiling floats which tend to suffer more from scattered light issues than with the optics of OPUS or SUNA sensors which have a similar optical path. The new temperature correction formulation will be validated on tropical floats equipped with SUNA sensors to check if scattered light may be the cause for this discrepancy. If it is, ISUS & SUNA floats will require different f(WL) functions. Once this question is resolved we would advocate that the new temperature correction(s) replace the current Sakamoto et al., 2009 temperature correction. This will then need to be updated in the NITRATE processing documentation.

The NITRATE QC documentation is now online DOI: http://dx.doi.org/10.13155/84370

Gordon/Maurer/O2WG DOXY:

Time response correction (C. Gordon)

All oxygen optodes suffer from a time response error, especially unpumped optodes, which make up the majority of the oxygen sensors on Argo floats. The nature of the time response error is well characterized and can be corrected for if the data are temporally resolved (i.e. there is a timestamp for each datapoint, Argo parameter `MTIME`) and the response time is known or can be estimated by float vertical velocity.

We strongly recommend that DACs begin including timing information in their files where possible. Currently there are only 131 floats reporting `MTIME` and all come from the Coriolis DAC. This is a simple and powerful inclusion that would allow end users of Argo data to perform the correction at their discretion to perform high quality science. For implementation of the correction within Argo (into the `DOXY_ADJUSTED` field), the error introduced by the correction must be well characterized. However it is my [Chris Gordon] belief that expert DMQC operators should be able to include this correction in D-mode files if proper care is taken. Chris Gordon, Tanya Mauer, and other members of the Argo O2 task team will propose guidelines for implementing the time response correction to the ADMT following the meeting.

NCEP vs ERA5 for O_2 in-air calibration (Maurer)

Optode in-air calibration is the preferred in-situ calibration method for oxygen sensors on BGC profiling floats. This method involves comparing in-air pO_2 from a float to that derived from an atmospheric reference. Historically, surface pressure from NCEP/NCAR-R1 reanalysis has been used but there are numerous other reanalysis products available, including ERA5 produced by the ECMWF that is assumed to be superior in many fields. Analysis was presented demonstrating how the switch from NCEP to ERA5 for use in optode gain computation across the BGC-Argo array has the potential to improve accuracy of certain floats in key regions (ie near the coast, for example) while not introducing any significant bias across the array. MBARI plans to implement ERA5 into DMQC software in the near-future.

SBS / Johnson sensor development

Ken Johnson presented an update on the status of the Gasket DuraFET (GDF) pH sensor design upgrade at MBARI.
Original design: MBARI Deep Sea DuraFET stem
New design: MBARI GDF stem (Gasket DuraFET)
The GDF represents a significant improvement to the current pH sensor design in production at MBARI for use on BGC-Argo floats. GDF parts are much easier to machine and fabricate. No glue or epoxy are required during assembly. The assembly takes 3-4 hours, and all parts can be accessed for repair or diagnosis if during calibration there is any indication of reduced performance. The first tests performed using float and glider deployments are encouraging. Further tests are planned in the near future.

Advances in SBS BGC Sensor Development (J. Klinke)

Within the framework of a NOPP project, Sea-Bird Scientific, University of Washington, and MBARI have been collaborating to improve the performance of the ISFET pH sensor as well as enhance in situ calibration capabilities of the dissolved oxygen sensor. In the last year, the development of the new SBS 83 oxygen was focused on field testing the alpha design of this model. The SBS 83 was integrated into a Navis float together with a SBE 63 and an Aanderaa oxygen sensor model 4330. Intercomparison of the data collected since December 2020 show that the SBS 83 performs in air-calibrations at least as well as the Aanderaa optode. Integration of the SBS 83 design with the TC duct yields improved time response. Full water column data of the SBS 83 and the Aanderaa 4330 show excellent agreement against the SBE 63 as in situ reference. Currently, alpha testing is uderway for multiple float platforms, including Apex, Navis BGC and R&D Triple O2 Navis. Integration of the SBS 83 into the BGC SOLO has been completed. Upcoming field testing is aimed at evaluating the long term performance and the time response of the SBS 83. Beta release of the SBS 83 is targeted for early 2022.

Improvements to the SBS pH sensor include a pressure-compensated design that linearizes the pressure response of the ISFET sensor and greatly reduces the mechanical strain on the ISFET chip and seals. This reduction in the stress on the sensor will lead to a more reliable pH measurement for the lifetime of the float. Field testing of the design has been ongoing since 2020 on an MBARI spray glider. Initial results revealed hysteresis of the ISFET sensor that was attributed to the temperature response of the reference electrode. Additional glider deployments in 2021 of the new pH sensor design paired with a faster reference electrode show no evidence of hysteresis and drift-corrected data agree with CANYON-B estimates on the order of 5-10 mpH below 400 m water depth. Field testing of the new pH sensor design on Navis and Apex float platforms is planned for early 2022.

Schallenberg CHLA: parameter update , RT procedures updates

The new variable, CHLA_FLUORESCENCE (relative units) has been approved by the Argo community. This parameter is intended to represent the fluorescence output from the sensor, QC'ed only for sensor issues, not for issues stemming from phytoplankton physiology such as non-photochemical quenching (NPQ) and calibration issues (the Roesler factor). The raw fluorescence is scaled using the factory calibration; no other adjustment is performed. Currently no DACs have implemented this new variable into their data streams. Documentation updates are underway and will be published in the coming year. These will also include updates to the RT tests for CHLA, which include:

- Updated dark correction:
    - FLOAT_DARK will be the median of the first 5 iDARKS that could be estimated in a float's life (profiles need to be >950 m in order to estimate iDARK)
    - iDARK is the absolute minimum (no depth constraint) of a profile
    - No spike removal prior to estimation of iDARK
    - Quality of FLOAT_DARK is assessed against the factory dark
- No more flagging of spikes
- New limits of global range test reflecting the Roesler factor (which will not have been applied by the time the range check is done): -0.2 < CHLA < 100
- NPQ correction:
    - Check sun angle before proceeding: SUN_ANGLE > 0
    - Use a smoothed (running median) CHLA profile to estimate the depth from which the NPQ correction should begin
    - Do not put spikes back in on the NPQ-corrected part of the profile
    - The rest of the CHLA profile stays as it was (ie no smoothing)

Dall'Olmo BBP: Status of RTQC methodology development (WG report)

G. Dall'Olmo, C. Bellingham, H. Bittig, E. Boss, J. Brewster, N. Briggs, H. Claustre, M. Donnelly, Q. Jutard, T. Maurer, R. Nicholson, V. Paba, J. Plant, A. Poteau, R. Sauzède, C. Schallenberg, C. Schmechtig, C. Schmid, K. Walicka

A summary of the activities related to developing RTQC tests for BBP was presented with the goal to officially propose the tests at the ADMT22 so that they can be implemented at the DAC level. Key to these activities was the feedback from the interested Argo community. Two specific workshops were organised in which the tests were discussed in detail and feedback was obtained and implemented in revised versions of the tests. Additional feedback was obtained by sharing the results of applying the tests to all the data in the GDAC. The tests have been developed with the objective to deliver an automatically and consistently quality-controlled global BBP dataset to non-expert users (e.g., operational modellers). The philosophy behind the tests has been to tune the test parameters conservatively. As a consequence, the tests tend to flag more data points than they should and thus deliver a dataset that is less prone to contain anomalous values. The tests that have passed the community scrutiny (with the % of data points at the GDAC that they flagged) are the following: Missing-Data (10.8%), High-Deep-Value (4.4%), Global-Range (3.3%), Noisy-Profile (1.7%), Parking-Hook (0.3%). These are described in more detail here: https://docs.google.com/document/d/1amf58gLxhwuIM_Y3XxUmGdVyJXrm5IU48A_SnOYAu_A/edit. Significant efforts were spent to ensure that DACs can implement the new tests easily: Python code (https://github.com/euroargodev/BBP_RTQC) has been made freely available, the number and complexity of tests have been kept low, and examples of input and expected output for each test have been provided. Overall, the proposed tests currently flag about 16% of the data at the GDAC.

ALL BGC Day 1 closing discussion

ADDITIONAL WORKING GROUP TOPICS / DM DATA MANAGEMENT

Status update and feedback on parameter audits / getting more adjusted data to the GDAC

Status update on parameter audit - DOXY (Plant)

The DOXY audit was first implemented and brought to the attention of the BGC Argo community during ADMT20 in Villefranche sur mer in 2019. The intent of the audit report files was as a tool to help DAC's check & if need be adjust the quality flags of their data as well as to speed the propagation of DOXY_ADJUSTED to the GDAC. The audit provides DAC specific lists of identified anomalous profiles, a global list of World Ocean Atlas (WOA) based DOXY gain corrections, and documentation on when and how to use these lists. It should be noted that an identified anomalous profile does not necessarily mean the profile is bad, only that it stands out in a statistical sense. The audit compares surface float oxygen percent saturation to estimates from space and time interpolated WOA monthly climatology. This climatology does less well in upwelling regions, shallow seas (i.e. Mediterranean, Baltic & Black Seas), upwelling zones and in the high latitude Southern Ocean, and is active area of audit improvement. The list of oxygen correction factors is intended as a way to adjust oxygen data for floats which do not measure in-air oxygen and have no other means of corrections such as bottle data comparison, or as an initial correction if an air-gain correction cannot be implemented at the current time.

At the time of the initial audit 3.7% of the 146,000 inspected profiles on the GDAC were deemed anomalous and only 40% of the DOXY data had been adjusted. At the time of this meeting (ADMT22, December, 2021) the improvement in the DOXY dataset is dramatic! Only 1.5% of the 188,000 profiles inspected were flagged as anomalous and 80% of the DOXY data are now adjusted. This a phenomenal improvement in a short period of time which has made the data set much more valuable to the scientific community so thank you for all the hard work by the delayed mode data managers! While this improvement is wonderful, 80% means 1 in 5 DOXY profiles remain unadjusted and many of the unadjusted profiles are greater than a year old. Additionally there are a handful of floats that appear obviously in error and would benefit from further inspection and need to be flagged as bad or possibly there may be an error in the calculation. So in short please use that audits as an aid to continually improve the data set & if there is any way we at MBARI can help speed up these processes please let us know. Lastly I think it should be noted that the DOXY data set residing at the GDAC is a very impressive data set containing over 44 million measurements!

Status update on parameter audit - BBP (Sauzède)

R. Sauzède, C. Schmechtig, A. Poteau and H. Claustre
The status of the BBP variable and an update of the BBP audit have been presented. 96,391 BBP700 profiles are available from the BGC-Argo database. 17 % are in delayed mode and 25% are in adjusted mode. 64,093 of these profiles have been inspected from the BBP audit (first release in June 2021 from MBARI ftp). From the inspected profiles 1,851 profiles (3%) were flagged as anomalous and would benefit from further inspection. aoml and coriolis have inspected these profiles and have sent their rejection list. This work is ongoing for incois, csiro and csio, just waiting for the exclusion list. Bodc will have a look in the next few months. jma prefers to wait for the implementation of the RTQC test presented by G. Dall'Olmo before the inspection of anomalous profiles flagged.
A second release of the BBP700 audit is planned just after ADMT and then we will update the audit together with the DOXY audit (~twice a year). The same audit is under development for CHLA and will be available next year. There is a possibility to develop in the near future an audit for radiometry.
We proposed to provide an offset computed from the SOCA-based product in the audit in the same way as it is done with the slope for DOXY to help with the DM process in case of possible correction of bad profiles. During the discussion Tanya Maurer raised the point that the SOCA-based BBP700 estimation is not always available (e.g. high persistent cloud coverage) so maybe it won't be so adequate to provide such an information.

Nitrate and pH QC for floats with failed optodes (Maurer)

Methods for the quality control of nitrate and pH data on BGC-Argo profiling floats currently rely on having concurrent high-quality oxygen data. These data are used as inputs to the various reference model algorithms applied in the quality control process (ie, Carter et al., 2018; https://doi.org/10.1002/lom3.10232). Due to the number of failed optodes within the BGC array processed at MBARI, an additional reference algorithm formulation has been explored for use in nitrate and pH QC. This formulation (LI(N/PH)R equation 8 from Carter et al. (2018)) does not require oxygen data as an input parameter. Analysis is presented that suggests that the use of LIR equation 8 in the QC process on MBARI floats adds only a small (<0.5umol/kg) level of additional uncertainty in QC'd nitrate data at specific locations of interest. The impact to the accuracy of pH data is more prevalent, although impacts (in terms of added uncertainty) are also considerably more spatially variable. It was presented that this QC option has been implemented into SAGE software for use on floats with failed optodes (although code is not yet available on the github). If using this algorithm, it must be reflected in the SCIENTIFIC_CALIB_* fields, and *_ADJUSTED_ERROR should be inflated. QC flags for adjusted nitrate data treated in this way can be set to '1'; for pH data adjusted in this way, it is suggested that QC flags be set with more care, and flags of '2' are recommended.

BGC data recovery for floats with bad salinity (Maurer)

The calculation of concentration of the chemical parameters on a BGC profiling float is in part dependent on the salinity of sampled waters. Within the Argo array, this presents an issue if the salinity sensor onboard a float has failed (or is rapidly drifting beyond viable correction) and the BGC sensors are still in full health. In order to prevent widespread loss of BGC data, an option was explored for incorporating the use of a proxy PSAL value into BGC calculations. This presentation focused on recovery of DOXY data, although other BGC parameters are similarly affected (i.e. Nitrate, pH, backscatter) as well as reference estimates used in DMQC (i.e., LIR's, CANYON-B, & ESPER). The product of interest for use as a PSAL proxy is the ARMOR3D salinity product (although additional viable products may be available). Details can be found here: https://catalogue.marine.copernicus.eu/documents/QUID/CMEMS-MOB-QUID-015-012.pdf. Matchups of the ARMOR3D product to BGC float locations suggest minimal bias (-0.0007 psu over 800 floats). Two case studies were presented to further investigate the use of this method in recovery of DOXY data: US float 5905988 in the North Pacific, and Coriolis float 6902736 in the Southern Ocean. Results shown were very promising and suggest that the uncertainty in DOXY imposed from using ARMOR3D PSAL matchup is small (bias < 0.005 µmol/kg bias overall, with larger uncertainties in the upper layers near the halocline that remain within +/- 1µmol/kg for the two cases presented). The BGC community would like to move forward with incorporation of a PSAL proxy (ARMOR3D) for use in calculation of DOXY_ADJUSTED. The recommendation would be to only apply this recovery method in delayed mode on a case-by-case basis, and the method must be tracked appropriately through the SCIENTIFIC_CALIB_* fields. Additionally, the *_ADJUSTED_ERROR should be inflated. The working group will move forward with developing documentation and specification of this method, including example recommendations on how to trace the PSAL proxy matchup profile that was used in the analysis (storing this data in the GDAC aux directory was suggested, but this has not been confirmed and may not be approved).

Addendum from the discussion in ADMT Plenary session

The BGC community would like to move forward with incorporation of a salinity substitute (formerly termed "PSAL proxy") (ARMOR3D as a first guess) for use in recovering BGC parameter with bad salinity. The recommendation would be to only apply this recovery method in delayed mode on a case-by-case basis, and the method must be tracked appropriately through the SCIENTIFIC_CALIB_* fields. A general consensus is reached to say that it should be done. The working group is working on finalizing details of the recommendation which will be circulated soon (and integrated into the Argo User Manual).

Schmechtig/Sauzède. DMQC for CHLA (WG update)

DM for CHLA (Schmechtig)

As presented by Xiaogang Xing in San Diego in 2018, the Delayed Mode procedure for CHLA can't be split in three steps.
STEP1 - The Dark estimation
STEP2 - The quenching correction

STEP3 - The Slope estimation

For STEP1, the dark estimation is the same for all floats no matter the suite of sensors on board.
Both STEP 2 and 3 can take advantage of radiometric information :

- STEP2 - Radiometric information allows to determine sharply the limit of the quenching correction with ipar_15 (depth where the downwelling PAR reaches 15 micromolquanta/m2, value under which no quenching should occur).
- STEP3 - Combining the irradiance profile at 490nm and the fluorescence profile, one can determine the ratio between fluorescence and chlorophyll-A (The so-called “Slope estimation”).

The SOCA-Radiometry is a neural network approach which was developed to infer radiometric information for floats profiles (without radiometry on board), from matchups satellite data and core profiles.

Using SOCA-Radiometry, the complete DM procedures can be applied regardless of the series of sensors present on the float.
The method was applied on more than 300 floats (with and without radiometers) and encouraging results are presented. In the near-future, the complete DM procedure will be applied at the Coriolis DAC for floats deployed in the Mediterranean Basin and Catherine offers to perform a first guess of DM for chlorophyll-A for other DACS to test the CHLA_ADJUSTED products against their reference data.

R. Sauzède, P.R. Renosh, C. Schmechtig and H. Claustre
This presentation dealt with the use of the SOCA-Chl method to determine the accuracy of BGC-Argo CHLA_ADJUSTED. SOCA-Chl (Satellite Ocean Color merged with Argo data to infer Chl to depth is a neural network-based method trained using the BGC-Argo CHLA_ADJUSTED data as reference. This method is validated using an independent HPLC database of reference (~1600 stations). The idea is to use this framework of HPLC-based independent validation to choose the best CHLA-ADJUSTED for the training. This framework offers the capability to extrapolate BGC-Argo measurements at the same time/location of HPLC measurements to use a global database of validation. An example was presented for a training using CHLA (raw Chl) vs. CHLA-ADJUSTED.
The validation can be looked at by “regions” to highlight the potential effect of the slope correction on the DM of CHLA. Note that we need to correct CHLA at “global scale” to train the SOCA-Chl method. This framework could be run to determine the best methods of adjustment (either in RT or in DM)

Jutard DMQC for radiometry

Quentin presented a Delayed Mode Quality Control (DMQC) method to correct radiometry profiles for sensor temperature and drift effects that has been published in Jutard et al., 2021 (https://dx.doi.org/10.3390/s21186217). The method focuses on potential sensor issues, especially in the dark part of profiles. The latter is now implemented in operational DM and was used to correct around half of the profiles in the coriolis DAC. Quentin develops RADM;

it makes the computations and creates the DM plots for the operator, who then makes the decisions through a simple text menu system. RADM then creates corrected files populated with error estimations, flags, and metadata. It is available on line https://github.com/qjutard/radiometry_QC.

Recommandations :
-Irradiance data in drift should be acquired once per day.
-Night profiles of irradiance should be acquired at least once per year (ideally during the season with the largest temperature gradient at the same depth and with the same frequency as day profiles.)

Using MTIME to reconstruct the sensor temperature will be feasible (in version 1.04 of RADM) as soon as sufficient MTIME data are available (only around 10% of irradiance profiles have an MTIME axis but this number is expected to increase on newer deployments).

FORMAT, VALUE ADDED TOOLS

V3.2 Combined trajectory files for BGC floats (Maurer)

The description of the Argo trajectory format version 3.2 for combined core and BGC trajectory information can be found in section 2.3 of the Argo User's Manual (http://dx.doi.org/10.13155/29825). All DACs with BGC floats that sample park/surface BGC data are instructed to produce v3.2 traj files and include appropriate measurement codes (MCs) for each BGC event. The format change from V3.1 includes the addition of the fields TRAJECTORY_PARAMETER_DATA_MODE, JULD_DATA_MODE, and SCIENTIFIC_CALIB_COMMENT. Examples of MCs for various BGC events, and filling of SCIENTIFIC_CALIB_COMMENT fields are discussed. An action item was given for the BGC community to assist with incorporating more BGC examples into the V3.2 documentation.

Plans for the first BGC DMQC workshop (Maurer)

It was presented that plans are currently underway for designing a framework for the first BGC DMQC workshop. Initial feedback from the BGC community on this idea was received at the last BGC ADMT task team meeting (July, 2021). The primary objective of a DMQC workshop for the BGC community is to continue to forward the progress of getting more adjusted BGC data to the GDAC. This will be done through: (a) focusing on specific DMQC methodology and hands-on training of participants; (b) focused discussion on DAC DMQC plans and workflow with attempts to identify avenues of collaboration between DACs for DMQC efforts. The first workshop is tentatively scheduled to be held in late 2022, ideally leading to ADMT23. Planning will continue in the coming months.

Diggs BGC validation database - synergy with CCHDO

The Reference database for CTD is maintained by Coriolis (IFREMER) with periodic additions and updates from CCHDO (GO-SHIP), NCEI (WOD), ICES, as well as data directly from individual PIs. Currently, 11% come from CCHDO sources. In the near Future CCHDO will move from COARDS "Cooperative Ocean/Atmosphere Research Data Service" convention to CF (Climate and Forecasts) convention for NetCDF. This will allow to get "aligned" for ERDDAP, ODV, OceanSites, PANOPLY, IPCC, … A colocation tool was built and is available on the CCHDO website to allow colocation between argo profiles and cruises.

Code sharing/New community tools/Web resources & FAQ

Code sharing/New community tools (Frenzel)

We have developed a toolbox that facilitates the access and visualization of BGC Argo data for both data managers and scientists. Several tasks can be accomplished with one or two function calls, e.g., the selection of floats and profiles by geographical region, ocean basin, time period, sensor availability, and/or data mode (R/A/D). The downloading of the relevant Sprof files is performed by the toolbox. Three types of plots can be made (trajectories/locations, profiles, and sections). The toolbox is available in MATLAB, R, and Python.

Github repository for MATLAB:

https://github.com/NOAA-PMEL/BGC_Argo_Mat_Toolbox

Github repository for R:

https://github.com/euroargodev/BGC-ARGO_R_WORKSHOP

Github repository for Python:

https://github.com/go-bgc/workshop-python

Web resources & FAQ (Schmechtig)

Catherine presents the new features decided at the previous ADMT in the BGC-Argo website https://biogeochemical-argo.org/data-tools.php (all the tools for data and metadata, some new inputs to come)

A FAQ for BGC-Argo will be written.

BGC-Argo Gridded Products (Fassbender)

Andrea Fassbender (PMEL), with numerous talk contributors, presented on the current status and future potential for BGC Argo gridded data products. The talk focused on what could be learned from the experience of Core Argo and how best to coordinate efforts internationally to avoid redundancy and to speed up progress. BGC Argo presently includes 6 measured parameters, 9 derived parameters, and numerous estimated quantities that could be (or are already being) incorporated into gridded products. Community consensus on best practices (e.g., the computation of pCO2 from pH observations, representation of uncertainties, data product file types, etc.) is required to ensure that reliable data products are provided to the broader community. The talk covered four primary gridded product types, including examples of such product types that already exist and BGC Argo efforts underway to develop these product types. Interest was expressed in collating a list of ongoing efforts to assist with product development coordination and collaboration.

The main group discussion centered on key questions and concerns related to the development of gridded products at this relatively early stage in implementing the BGC Argo array. Expressed concerns included how best to: handle variables for which QC practices are still being developed; assign appropriate uncertainties in data products; make preliminary data sets used in product development available to ensure reproducibility; and address different DMQC timelines of the various DACs. Finally, there was consensus that a BGC Argo MIP (model intercomparison project) could be valuable as the community works to identify the best techniques for gap-filling data sets of different variables. Such an effort would require a leader. A survey was sent out to BGC ADMT participants to capture current community perspectives.