Hervé. Introduction/ general objectives of this meeting

The terms of reference for Bio-Argo task team were accepted at the AST16.

The announcement is done for a meeting to be held in Villefranche-sur-mer in early January 2016 and dedicated to discussions on the design and implementation of a Bio-Argo global network.

Uday. Bio Argo data management-India

India deployed 15 floats with oxygen sensors (Anderaa and SBE-IDO), 28 "true" bio-floats were deployed (18 provors and 10 APEX, some issues with provors), 20 will be deployed in the next two years. No QC are performed (except O2). Data are used to study productivity, DCM, MLD, Tuna fish migration and harmful algal blooms.

Justin. Bio Argo data management-UK

The UK has the following bio-Argo floats deployed:

Float type	#	Raw data archival	Data decoder	Data ingestion	V3.1 delivery	Notes
APEX – APF9i (FLBB, AADI O2 optode)	4	Yes	Yes	Yes	No	Nordic Seas
PROVOR – CTS3 (Wetlabs triple, AADI O2 optode, Satlantic OCR504)	7	Yes	Partial	No	No	1,000 dBar cycling
NAVIS – BGCi (Wetlabs triple, AADI O2 optode, Satlantic OCR504)	3	Yes	Yes	No	No	

The development for the production of Argo version 3.1 files is on-going.

With the following on order or awaiting deployment:

- NAVIS BGCi on order including 2 Durafet pH sensors
- PROVOR CTS3 (Wetlabs triple)
- Two deep ARVOR with O2 optode
- Two deep APEX with O2 optode

Basic limit real time QC and the advised DOXY RTQC tests are in place at BODC. The AtlantOS project task 3.1 will be helping with the QC of UK Bio-Argo data.

BODC are part of a couple of EU projects that are of relevance to Bio-Argo. The SenseOCEAN project is designing new sensors and introducing data standards at the sensor level. ENVRIplus will be looking at time series heterogeneity for carbon data and the utility of fluorimeter data for satellite calibration validation activities.

Kanako ;Bio Argo data management-Japan

Japan has deployed 65 Bio-Argo floats since 2005. About 50 floats of them are equipped with only oxygen sensor, and the other are equipped with Chl-a and/or BBP sensor in addition to oxygen sensor. The oxygen data have been submitted to GDAC but not put through rQC. The Chl-a and BB data have not yet submitted but will be submitted in 2016. JAMSTEC examined the data quality of oxygen data from Optode4330 mounted on 21 floats and ARO-FT (RINKO) sensor mounted on 2 floats. JAMSTEC has released ESTOC (Estimated STate of Ocean for Climate research) which provides a coherent picture of the global ocean circulation by synthesizing observations including biogeochemical parameters.

Ann. Bio Argo data management-Australia

Argo Australia manages a wide variety of Bio Geochemical floats. Sensors include Aanderaa optode 3830 (DOXY), Seabird 63 optode (DOXY) , Seabird 43F IDO (DOXY) , CROVER transmissometer (CP650) , FLBB_AP2 (CHLA, BBP700 and BBP532) , FLTNU (CHLA, CDOM, BBP700) , Eco Triplet ((BBP470, BBP532, BBP700) , SUNA (NITRATE) , Satlantic OCR-I (UP_RADIANCE412, 443, 490 and 555) and Satlantic OCR-R (DOWN_IRRADIANCE412, 443, 490 and 555). With increasingly complex combinations. The most complicated so far contains a Seabird 63 Optode, an FLTNU, an Eco Triplet, a CROVER, an OCR-R, and an OCR-I.

The biggest issues have been conversion of files from version 2. To version 3.1 and coding to process new, far more complex Bio floats with sensors we have not seen before. Now that these have been completed, all of our Bio-Data, including both raw and derived parameters, are delivered to GDACs in format version 3.1 BR files.

We are also undertaking a rewrite of all of our DMQC software to include bio data and this is nearly complete. DOXY will be the first parameter put through this new system. Other Bio parameters will be added later.

Preliminary results of the new DOXY DMQC is validated by comparing corrected float data to calibrated oxygen profiles taken on deployment of several floats.

On average the calibrated profiles and the climatology agree well at the surface (within ~3 %Sat) and in the deep (within ~1 %Sat).Before calibration, the average agreement at the surface and in the deep is 8 and 6 %Sat, respectively.

Annie. Bio Argo data management-US

Annie Wong presented an overview of biogeochemical (BGC) data management in the US. Within the US, efforts to deploy BGC floats have mainly come from the University of Washington (UW) float group and its partners. Processing of BGC float data and the production of Argo B- files is divided between:

- MBARI and UW, who process all BGC float data from floats deployed after 2014, including all BGC data from the SOCCOM project; and

- AOML and UW, who process historical oxygen data from floats deployed before 2014.

Some progress has been made towards the Argo V3.1 format B- files. Annie has converted historical V2.2 D-files with DOXY to V3.1 D- and B- profile files. Production of Argo B- files with SOCCOM BGC data will begin in 2016.

Anh Tran, Bio-Argo data management Canada

Canada deployed the first float with oxygen sensor in May 2004 as part of the Argo Canada program. Currently, we deployed a total of 33 floats with oxygen sensors. Out of 33 floats deployed, only 7 floats currently actively report data within the last six months. Twenty-six out of thirty three floats deployed equipped with Aanderaa Optode 3830 and reported surface measurements. The other eight floats equipped with SBE63 optical dissolved oxygen sensor. The manufacture for floats deployed between 2004 and 2010 is Web Research, and the recent ones are from MetOcean.

The real-time data management for oxygen floats are handling by MEDS. The doxy data are subjected to real-time QC tests listed in Argo quality user manual version 2.9. The meta, profile (core and BR), trajectory and technical NetCDF files in format version 3.1 are generated and sent to GDAC for the floats deployed in 2014. The DOXY data are also on the GTS in BUFR format.

For delayed-mode data management for DOXY floats with Aanderaa Optode sensor 3830, we plan to apply corrections based on in-air measurements as it described in article

"Air oxygen calibration of oxygen optodes on a profiling float array" by Kenneth Johnson et al 2015.

Thierry,. Bio Argo data management-France

The Matlab data processing chain for Provor floats is continuously improved. These data were distributed in V3.1. 83 parameters are managed : core-argo, b-argo, i-argo parameters These parameter include chlorophyll, turbidity, CDOM, back-scattering, UV, nitrate, bisulfide, pH, radiance, irradiance, PAR

Real Time QC for DOXY and Chlorophyll-A are applied. Transition from V3.0 to V3.1 for other floats (Apex, Navis, Nemo and Nova) is underway.

Bio-Argo floats, Coriolis DAC				
Familly	**nb versions**	**nb floats**	**nb profiles**	**nb cycles**
APEX	20	85	9542	9326
NAVIS	1	2	233	233
NEMO	1	2	297	297
NOVA	1	3	28	27
PROVOR	20	202	54542	21820
Total	**43**	**294**	**64642**	**31703**

Antoine. Hardware and software : good practices for good data

Antoine explained how important it is to fully qualify the sensors before deployment especially for BGC sensors. Organising a workshop around the BGC float activity will be useful to make sure that sensors are qualified and procedures for complementary measurements are followed. Complementary measurements (CTD at deployment, Bottle files for Nitrate…) should be stored (CCHDO?) and there should be official documentation available to describe the procedures.

Antoine also presented how to use CDOM drift data to anticipate the Biofouling contamination, these data could also be used to detect sensor failure. Drift data can also be used to study export of aggregates.

Catherine/Hervé. Chlorophyll a: real-time QC, delayed mode QC

Documents related to processing and RT-QC procedure are available on the Argo data management web site. The RTQC procedure includes a range test, a spike test, a sensor failure test. The chlorophyll-A concentration is adjusted to be 0 at depth and to account for the Non Photochemical Quenching. Some issues about the calibration of the Chlorophyll-A sensor have been presented. A meeting will be hold in Villefranche in December with the manufacturer and possible actions will be discussed. The deep fluorescence signal (especially obvious in the black sea but also in sub-tropical gyres) will also be taken into account either in RT or in DM.

Regarding DM, building a reference database is an ongoing work, nevertheless the limited number of profiles of CHLA fluorescence is critical for a database at the global scale. Regional scales database (biogeochemical provinces) is a better candidate to evaluate the shape and the range of the profile. Beside the overestimation factor linked to the calibration, there is also a regional bias in the relationships (float vs HPLC or float vs radiometric Chla) that should be considered in development of DM procedures.

Catherine / Hervé. bb: real-time QC, delayed mode QC

Document related to processing of particle backscattering are available on the Argo data management web site (Xiaodong Zhang (author of the matlab code to compute the contribution of the pure sea water) was contacted and agreed to copy his code on the ADMT web site). The document on RT QC procedure is almost done, this procedure includes a range test and a Bad Offset test.

Regarding DM, the reference database still needs to be developed. A paper by sauzede et al., is submitted to JGR, based on a neural network approach to extend to depth the surface bio optical properties. The comparison between BBP on floats and BBP from satellite data is underway.

Dissolved Oxygen Processing, Quality Control and Organisation

(Henry Bittig, Annie Wong, Virginie Thierry)

Oxygen Quantity Conversions

The SCOR WG 142 "*Recommendations on the conversion between oxygen quantities for Bio-Argo floats and other autonomous sensor platforms*" were presented.

The oxygen content of a water parcel can be stated in three different quantities: as O_2 concentration (amount of O_2 per unit volume or mass of the water sample), as O_2 partial pressure (hypothetical pressure of O_2 in the gas phase when in equilibrium with the water parcel), and as O_2 saturation (ratio of the oxygen amount present in the water parcel and the calculated amount at atmospheric equilibrium). The SCOR WG 142 defined a best set of equations to be used for the conversion between these three quantities and the recommendations document summarizes equations relevant to Argo: the conversion between different concentration units (e.g. $mL_{STP}\ L^{-1}$ to $\mu mol\ L^{-1}$, $\mu mol\ L^{-1}$ to $\mu mol\ kg^{-1}$), the salinity-correction of optode raw O_2 data, and the conversion between O_2 partial pressure and concentration (relevant for in-air measurements, see below).

The SCOR WG 142 recommendations are to replace the (varying) manufacturer's equations of O_2 quantity conversion to reach a physically consistent data treatment (since the conversion of O_2 quantities does not depend on the manufacturer of a sensor but solely on physical principles).
The DAC O_2 cookbook will be updated accordingly and O_2 sensor manufacturers are encouraged to follow the SCOR WG 142 guidelines.

The conversion to units of $\mu mol\ kg^{-1}$ is currently the only place in the Argo data system where the seawater density is computed and the equation of state was discussed quickly. Brian King noted that any advice should ideally point to the most recent, i.e., TEOS-10, unless there is some intrinsic reason to the conversions to stick to the superseded Fofonoff and Millard (1983) and Millero et al. (1980) equations. This will be checked by Henry Bittig and Virginie Thierry.

Use of timing information for the interpretation of Bio-Argo data

An example for the different time response of an unpumped (Aanderaa 4330) and a pumped (Sea-Bird SBE63) optode was given from float 6900890. Pumping does improve data quality, though the difference is generally smaller than expected since strong density gradients (where the float's ascent is slowed down) tend to coincide with strong O_2 gradients. The important part to assess the lag (i.e., the time needed for the sensing membrane to equilibrate) is the temporal gradient, not the spatial (depth) gradient. Argo floats as buoyancy-driven platforms move at the same time in space (depth) and time. The first is stored in the profile, the second (currently) not. If it is available, it can help in the interpretation of sensor behaviour (and a potential correction of the O_2 data).

Routine O_2 optode in air measurements

The SCOR WG 142 "*Recommendation for Oxygen Measurements from Argo Floats: Implementation of In-Air-Measurement Routine to Assure Highest Long-term Accuracy*" and the rationale behind and its details were presented.

O_2 optodes on floats are typically out of calibration (up to order of 10 %) on deployment compared to a previous (factory) calibration, which impairs the utility of the Argo-O_2 network. The drift behaviour has been documented and characterized by several studies and follows coherent trends, i.e., it is dominantly an O_2 sensitivity loss (linear with O_2 content) and the loss rate decreases with time. With a single, well-defined reference, this dominant drift effect can be quantified and corrected. Atmospheric air oxygen is such a well-defined, globally available reference (based on atmospheric reanalysis models) and all optical oxygen sensors (optodes) are capable of both measuring in water and air. Field studies have demonstrated the feasibility of such in-air measurements from Argo floats and reached accuracies similar to Winkler-based hydrocast calibrations (1 %). Moreover, initial studies with routine in-air measurements over the course of the floats lifetime suggest the presence of a small in-situ drift on some floats.

The SCOR WG 142 recommendations for routine in air measurements were adopted by the Bio-Argo team. O_2 optodes are thus required to be mounted in an elevated position, so that they are exposed to the air during surfacing and to make 5-10 measurements in air at every float surfacing. Further details of the requirements and recommended practices are found in the SCOR WG 142 document.

For the data treatment, optode raw data (temperature and phase; existing <PARAM>s from the parameter list) of each in-air measurement cycle need to be stored. These data are converted to O_2 partial pressure (new <PARAM> in the parameter list: PPOX). Optional float data are pressure and the measurement time during the in-air sequence. For each cycle, the location and time of the surfacing as well as the shallowest profile temperature, salinity, and oxygen are used for the interpretation.

It was agreed that in-water data before the end of the profile (begin of the telemetry cycle) is stored in the profile files, either in the "Primary sampling" profile, N_PROF=1, or in the "Near-surface sampling", N_PROF=2, when the CTD pump is switched off. All data after the end of the profile is stored in the trajectory files. To better distinguish surface measurements in air from other events in the trajectory files, Megan Scanderbeg suggested the definition of a new measurement code MC=1100 (with relative measurement codes 1099, 1089, …) for this kind of data.

Finally, the storage of measurement times in relation to in-air measurements was discussed. The part stored in the trajectory files will have a JULD time stamp for each event, while no such information is associated with the profile file part. It was later agreed on ADMT that "if there is sparse timing information (times not sent with every CTD level), those time stamps would go into the trajectory file. If timing information is sent with every CTD level, it would go into the core Argo profile file under a new <PARAM>. The exact details of this <PARAM> are still to be determined and it will be optional."

<u>How to fill DM DOXY fields</u>

It was agreed that in the SCIENTIFIC_CALIB section of the b-files, PARAMETER will list all parameters from STATION_PARAMETER, even though not all parameters have delayed-mode QC.

Suggestions on how to fill the associated SCIENTIFIC_CALIB fields (EQUATION, COEFFICIENT, COMMENT) for oxygen have been compiled by Virginie Thierry, Henry Bittig, and Ann Thresher and are included in the "Argo Quality Control Manual for Biogeochemical Data". Given the still evolving nature of oxygen adjustment methods, this list is not exhaustive and should be seen as phrasing suggestions. PIs are free to use other wording and methods, as long as they are well documented/referenced.

It is now understood that biogeochemical parameters will have many delayed-mode methods (more than for PSAL, for example). In order to keep track of all calibration methods, people are encouraged to include a reference in the _COMMENT field, and the Bio-Argo team should keep a comprehensive record of these references.

<u>Review of the DAC O_2 cookbook and future challenges to the DOXY processing</u>

Henry Bittig gave a brief summary about the scope and extent of the Processing Argo Oxygen Data at the DAC Level document. It summarizes processing steps from sensor raw data through the sensor's O_2 response and O_2 conversion steps to the final DOXY for 5 sensors from 3 manufacturers in 32 separate, individual cases. The cases depend on the sensor model, input parameters, and O_2 response equation. They may be significantly different or close-to-identical from each other. Apart from the "bottom-up" view of cases (what sensor → input parameter →

individual case), an alternative "top-down" view (what sensor → O_2 response model → individual case) was presented and will be included in the cookbook as further guidance.

The recommendations on O_2 quantity conversions will reduce some of the complexity of the cases by harmonization (on average >half the equations of each case are on the O_2 conversions). However, ever more manufacturers, sensor models, O_2 response equations, and more diverse ways to treat the sensor data (e.g., a revised pressure correction?) will challenge the individual case approach (i.e., the cookbook's extent and manageability) in the future.

Catherine / Hervé Radiometry: real-time QC, delayed mode QC

A paper by Organelli et al., was submitted to Journal of Ocean and Atmosphere Technology to describe the Real Time QC procedure for the radiometry. This procedure allows to identify clouds, wave focusing and other noises, as well as “dark” pixels. Anyway there is a recommendation to avoid to set up a QC of 4 (bad data) for those values. These values should be identified and removed for optical applications requiring “clean” monotonously decreasing profile with depth. For biological / photosynthesis studies, for example, these data are valuable.

Catherine. NO3: real-time QC on PROVOR CTS4

Results of computation and Real Time QC procedures on PROVOR CTS4 floats equipped with SUNA sensor are presented.

There is a clear need to transmit the whole absorption spectrum of the spectrophotometer (and not only the concentration computed on-board) as several problems occurred with floats deployed these last months: wrong calibration file on-board, saturation of the spectrophotometer. The only way to get correct nitrate concentration is to recompute it from the spectrum.

Accounting for the vertical offset between CTD and SUNA removes some spikes in the computed nitrate concentration A pressure effect on the sensor is also illustrated. The computed nitrate concentration accounting for both effects should be stored in NITRATE_ADJUSTED.

The WOA reference at depth should be further investigated for both range test and adjustment.

Spike (Argo) tests, RMS tests on the multilinear regression and test on absorption at 240nm, previously presented by Ken Johnson are applied and are efficient to discriminate bad data.

Ken. pH/NO3/O2: real-time QC, delayed mode QC

This presentation focused on the real time processing, QC, and adjustment of data from oxygen, nitrate and pH sensors on floats deployed by the SOCCOM program. All of our oxygen sensors now make air oxygen measurements as described in Johnson et al. (J. Atm. Oceanic Technol., 2015, 32, 2160-2172). With a single gain correction, the oxygen sensors now appear to have accuracies on the order of 1% and further improvement may be possible.

Controlling nitrate and pH sensors for drift or offsets in the SOCCOM program is now based on using Multiple Linear Regression equations fitted to high quality hydrographic data from the GO-SHIP program as described in Juranek et al. (Geophys. Res. Lett., 2011, 38, L17603, doi:10.1029/2011GL048580). These fitted equations provide an efficient way to interpolate the high quality GO-SHIP data throughout the ocean. Such equations have limited geographic ranges and we are utilizing an efficient numerical framework to grid the ocean and provide such equations regionally.

Catherine/Hervé. How to implement DM ?

A general discussion with core argo DM operators occurred. For Bio-Argo, different experts for each variable might be required while a single contact point to set the DMQC in the Netcdf file would be the best configuration. At present it appears that it is required to clearly define what is relevant for RTQC and for DMQC.