REPORT ON
THIRD ARGO DELAYED-MODE QC WORKSHOP
(DMQC-3)

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Meeting webpage for documents and powerpoint presentations:
http://prelude.ocean.washington.edu/dmqc3/info.html

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1) Introduction, Purpose and Aims of DMQC-3

Background The agenda for the workshop had been circulated in advance of the meeting. After DMQC-2 in October 2006, it had been agreed that no date would be set for a subsequent workshop. Instead, a workshop would be convened when a requirement for one was expressed by the DMQC community. Discussion during ADMT-8 in Hobart in November 2007 made it clear that another DMQC workshop would be useful, in particular to review the extent to which DMQC operators were applying software and decision-making in a consistent manner. Also, there are a number of DMQC operators who have joined DMQC efforts since DMQC-2. There were perceived to be particular benefits in providing an opportunity for this group to exchange knowledge with more experienced operators.

In response to the expression of need, Annie Wong and Brian King agreed to convene DMQC-3. The meeting was grateful to Steve Riser, who offered to host the meeting in Seattle, and to US Argo for providing refreshments at breaks.

It was noted that all nations that host DACs were represented at the meeting, which had not been the case at DMQC-1 and DMQC-2. This represents significant and welcome progress.

Requirement The driving requirement on DMQC is to ensure a high-quality product by adopting consistently-applied procedures, and ensuring timely flow of D files from all national programs to the GDACs. Consistency must be achieved across PIs/DM decision makers, and DM operators.

Current issues The issues for discussion at DMQC-3 were defined by the Agenda. Specific topics are clustered around core issues that will remain at the heart of Argo DMQC for the indefinite future: The need to apply procedures consistently, and where necessary modify them to reflect new insights; Maintenance of the best possible reference datasets for evaluation of new float data; Understanding the evolving platform performance and modes of sensor failure (i) to avoid making invalid adjustments to data, and (ii) to enable interaction with manufacturers to stimulate hardware and software improvements to the floats.

2) Progress with Argo delayed-mode processing

2.1) Overall status of D files at the GDACs

Progress was reviewed for the program as a whole. King had prepared a list of R, A and D mode profiles at the GDAC, current at July 2008. Between October 2006 and July 2008, Argo collected approximately 167,000 new profiles. The number of D files at the GDAC increased from 70,000 to 184,000. This is a very substantial advance, but the program is still collecting new profiles faster than it is managing to complete DMQC. The balance will not change until several more DMQC groups are running at ‘full speed’ and clearing their backlogs. The table of DMQC statistics as of 13 September 2008 was prepared by Gilson.

It is expected that a further jump in the number of available D files will happen in the run up to ADMT-9 in October 2008.

Profiles are grouped by the DAC responsible for the float, and not subdivided by national efforts within that DAC. This distinction is significant for AOML (who handle floats from UW, PMEL, SIO, WHOI, …) and CORIOLIS (who handle floats from non-French efforts, notably Germany), and to a certain extent for JMA (JAMSTEC, JMA).

Table of DMQC statistics compiled from numbers provided by Gilson from a mirror updated on 13 September 2008

DAC name at GDAC	Total profiles at GDAC	Profiles < 12 months old (awaiting DMQC; not yet ready)	Profiles > 12 months old	D profiles at GDAC
aoml	237694	58123	172564	110432
bodc	19125	3728	15397	4492
coriolis	67244	11073	55214	28974
csio	2018	148	1584	1860
csiro	16688	5541	11116	8538
incois	16894	3698	13196	8720
jma	71813	13575	56412	34923
kma/kordi	7299	1637	5587	2031
meds	18978	3500	15478	12502
	0			
Total of above DACS	482588	101901	370505	212472

2.2) Report on status at each delayed-mode group

Each DMQC group was asked to summarise its status. The status of various corrections (cell thermal lag, APEX surface pressure, implementation of OW) was variable between groups. Most groups have performed at least some experimentation with OW. Some groups do not yet have the required Matlab optimisation toolbox. Some groups are still using older software (WJO, BS) for backwards compatibility with floats for which DMQC has already started. Some groups have implemented OW in trial mode, but still base decision-making on WJO. Most groups have plans to implement OW within the next 6 to 12 months.

No generic problems were identified as causing holdups in large numbers at DACs. Most DACs have manpower that is fully stretched. Implementation of remaining recommendations will be completed as manpower allows at each DAC or within each DMQC group.

Many DACs still report inadequacy of reference data as causing delays in DMQC. This is discussed further in Section 6.

3) Review of known instrument errors and sensor failure modes

3.1) APEX floats

Dana Swift presented data warts and causes in APEX floats, and how these pathologies will affect salinity, temperature, and pressure measurements. We note that even though these pathologies were diagnosed by using APEX floats, they are valid in all Seabird CTDs.

One pathology in Druck pressure sensors is known as the Druck “snowflakes”. The “snowflakes” are internal shorts caused by conductive particles suspended in oil. They cause pressure samples to become erratic or off-scale. As a consequence, all measurements become bad and unadjustable. Another pathology in Druck pressure sensors is microleaks past the glass/metal seal. This oil leak leads to an internal volume loss, which then exhibits itself as an increasing negative offset at all pressures. Unfortunately these negative pressure offsets are truncated in APEX Apf-8 floats.

Other common pathologies that affect salinity measurements include thermal mass errors, TBTO contamination, disconnection of the electrodes, and incomplete flushing of the conductivity cell at the point of deepest descent. The thermal mass error occurs when a float ascends through high temperature gradients. The thermal inertia in the flowduct alters the temperature of water entering the conductivity cell, thus inducing a conductivity error. This salinity error can be corrected if the ascent rate of the float is known. TBTO (tributyltinoxide) is used to protect the conductivity cell from biofouling. However, the cell itself can sometimes get contaminated by TBTO, thus resulting in fresh salinity offsets. Usually the TBTO contamination is flushed out after several profiles, and the salinity measurements will return to being correct. Disconnection of the electrodes will cause salinity calibration jumps that can be up to 4 PSS-78 low of correct. Even though these salinity measurements can sometimes be adjusted, they are of mediocre quality. Recently several groups have noticed “salt hooks” at the base of the profiles. These are the deepest salinity measurements that are high of correct by about 0.005 PSS-78 with respect to shallower samples, thus appearing as “hooks”. These are caused by asymmetry in Bernoulli flushing during ascent/descent. Higher salinity water in the conductivity cell carried from surface (or park level) to deep profile level is not being flushed out completely before the deepest sample is taken, thus resulting in salinity that is high-of-correct.

Lastly, it was noted that eight APEX floats from U Washington showed salinity drifts towards higher values. The cause of these salty drifts is unknown. However, it is possible that they are caused by long-term temperature drifts. The Argo community is therefore advised to put more effort into retrieving some of these floats that drift salty, so that they can be examined in the laboratory.

3.2) SOLO floats

Megan Scanderbeg presented failure modes from SIO SOLO floats. These include loss of vacuum inside float, loss of CPU voltage, oil leaks, and antenna problems.

Some SOLO floats have seen slow leaks resulting in loss of vacuum inside the floats. These are either caused by water leaking into the air bladder on the outside of the floats or from air leaking through seals. The result is that the floats will slowly sink over time until they are too deep in the water to send messages. Loss of CPU voltage was probably caused by a bad batch of batteries that failed after about 3 years, after which the floats no longer functioned. Voltage on each battery pack is now checked before deployment. About 4% of SOLO floats have been affected by an oil leak problem, where oil leaks in external bladders caused floats to shoal and not profile down to original depth. This appears to be an isolated batch of bad bladders. About 3% of SOLO floats have been affected by a bad batch of antennas. These antennas resulted in small number of messages sent during a surface interval. The goal at SIO is to reduce failure modes so that 90% of SOLO floats will survive 5 years.

3.3) PROVOR floats

Virginie Thierry presented sensor failure modes in PROVOR floats. She noted that the first generation of PROVOR floats (CTF series) used FSI conductivity sensors, which had been proven to be unreliable, giving data that contained large drifts and jumps. There was also a problem if the stability collar was fitted too close to the FSI conductivity cell so that it interfered with the measurement. A salinity offset of 0.01 PSS-78 was seen when the collar was at 10 cm of the sensor. This offset was absent when the collar was at 25 cm of the sensor. PROVOR floats no longer use the FSI CTD and have switched to using Seabird sensors (CTS series). So far no generic instrument faults have been identified on newer-generation floats with Seabird sensors, other than the SBE issues common to all SBE equipped floats and rehearsed in Section 3.1.

4) Delayed-mode QC and adjustment of PSAL

4.1) SIO Matlab GUI

Megan Scanderbeg delivered a presentation on the SIO Matlab GUI. The GUI can be used in many ways, including preparing NetCDF profiles for OW calibration, evaluation of suggested OW adjustment, and writing to NetCDF files.

The GUI can be used to prepare profiles for OW calibration because users can use the GUI to visually inspect all measurements for bad data that can skew the least squares fit. At the same time it allows users to edit the qc flags as needed, especially when bad data are missed by the real-time qc. The GUI displays data on four main panels:

T or S vs. depth for single profile and one previous
T or S vs. depth for all recent/ new profiles
Location plot of all recent/new profiles
T vs. S for all recent/new profiles of that float.

Trajectory is displayed over ocean bathymetry.

The GUI allows the users to evaluate suggested OW adjustments by providing comparison plots of nearby Argo and historical data. It has an Action Panel that allows users to accept, reject, or modify suggested OW adjustments and error bars. It saves the data with comments written into the SCIENTIFIC_CALIB section of the NetCDF files.

In conclusion, the SIO Matlab GUI is an easy-to-use tool for interacting with the Argo NetCDF files, and for evaluating float measurements and OW suggested adjustments. Delayed-mode operators are therefore encouraged to include it as part of their arsenal of dmqc tools.

4.2) JAMSTEC tool for comparison with nearby CTD/float data

Taiyo Kobayashi introduced a tool used at JAMSTEC for the evaluation of Argo float salinity calibrated by WJO by comparison with nearby CTDs and floats. The OW version is now being developed (by H. Nakajima). WJO version is available via PARC-JAMSTEC web-site, and OW version will be available soon.

4.3) Conductivity cell thermal mass inertia correction to salinity

The workshop reviewed the status of CellTM adjustment in a discussion led by Johnson and Swift. There is a paper on CellTM corrections for SBE41 and SBE41CP (Johnson, Toole, and Larsen 2007). The correction coefficients depend on the CTD type, with different coefficients for SBE41 and SBE41CP because of their different pumping strategies. The SBE41CP pumps slowly and continuously, whereas the SBE41 pumps faster but intermittently, turning on for spot samples.

Estimation of CellTM correction coefficients and their application both depend on knowledge of the ascent rate of the instrument. SIO SOLO floats pump all available buoyancy at the bottom of the profile, so the float volume is known and an ascent rate algorithm can be calculated for any measured density profile. For PROVOR floats, the meeting could not establish whether sufficient engineering data are telemetered to enable a reliable ascent rate to be determined. APEX floats calculate their ascent rate and adjust buoyancy at pre-determined intervals in an attempt to achieve a uniform ascent rate.

New data from APEX APF9s with extra engineering measurements operated by UW show that when floats reach regions of strong vertical density (and hence usually temperature) gradients, which is precisely when the CellTM correction is largest, the ascent rate is reduced to as little as half the nominal rate. After some period of reduced ascent rate, the float pumps extra buoyancy to try to restore the target ascent rate. At present, Swift said UW could not propose an ascent rate model for APEX floats. The cycle of reduced ascent rate followed by buoyancy pumping is inherently unpredictable. An example was included in Swift's presentation on this topic.

The published CellTM coefficients for the SBE-41CP were estimated from data with a known ascent rate, so that they should be accurate for application to float data to the extent that the float ascent rate is known. However, initial published estimates of CellTM coefficients for the SBE41 were made using APEX data assuming a uniform, nominal ascent rate. Since APEX-APF9 data show that the true APEX ascent rate can be significantly biased in strong pycnoclines relative to the nominal value, the use of a nominal ascent rate may have biased the initial published SBE41 CellTM coefficients. However, application of these initial SBE41 CellTM coefficients to data from APEX floats may be approximately appropriate for data in strong pycnoclines, provided the nominal ascent rate is used for the correction. (The CellTM correction using a nominal ascent rate may be overestimated deeper in the water column, where it is fortunately very small). This offsetting error may not hold on other platforms. Therefore the CellTM coefficients for the SBE41 should be reviewed using an improve float ascent rate model, and may need to be revised.

Conclusion: New APEX ascent rate data suggest that the previously recommended CellTM correction coefficients for the SBE41 are not optimal. An APEX ascent rate model must be developed, and SBE41 CellTM coefficients estimated for that model.

> ***Action 4.3.1:*** *Johnson and Swift are asked to attempt to develop an improved ascent rate model for the APEX floats using the UW data and, after that is accomplished, re-estimate the CellTM coefficients for the SBE41 using the improved ascent rate model.*
>
> ***Recommendation 4.3.2:*** *The meeting recommends that all groups continue to handle CellTM as they do at present. Groups applying CellTM can continue to do so. Groups not applying CellTM can continue to not do so, while awaiting the results of further investigation.*

4.4) WJO, BS, OW float salinity calibration tools

Annie Wong presented a summary of the evolution from WJO to BS to OW in the following table.

WJO	BS	OW
No PV constraint	Fixed PV constraint	Optional PV constraint
Fixed θ levels	Observed θ levels	Observed θ levels
Users need to eliminate undesirable θ levels.	Chooses 10 P levels.	Chooses 10 levels. Users can specify range.
Sliding window fit. Users can prescribe short windows to account for abrupt changes, or manually break up series.	Piece-wise linear fit, but users need to manually specify breakpoints.	Piece-wise linear fit. Breakpoints are chosen by statistical methods. Users can manually specify breakpoints if they prefer.

The advantage of OW is therefore in its ability to provide optimally chosen breakpoints that are reproducible. In addition, in OW the *a priori* mean and uncertainty in the mapping, as well as the error estimate in the least squares fit, have been improved.

Lastly, it was noted that when the same breakpoints are chosen, salinity data calibrated by all three methods should agree to within error bars. Therefore even though three tools are currently being used to carry out salinity drift adjustments, the Argo delayed-mode data set should still be consistent within error bars.

4.5) Review consistency of dmqc adjustments to PSAL

Annie Wong summarized the results from the Argo Delayed-Mode Data Intercomparison, which took place during 2006. The workshop then went on to discuss ways to improve consistency in values used to fill the fields PSAL_ADJUSTED, PSAL_ADJUSTED_ERROR, and PSAL_ADJUSTED_QC. All delayed-mode operators agreed that during point-wise inspection of measurements, PSAL_ADJUSTED_QC should be assigned ‘1’ or ‘4’ only. ‘2’ can be used to denote adjustments that are of poor quality. All agreed to not use ‘5’ to denote that salinity adjustment has been applied.

> ***Recommendation 4.5.1:*** *Delayed-mode operators are advised that during point-wise inspection of measurements, PSAL_ADJUSTED_QC should be assigned ‘1’ or ‘4’. ‘2’ can be used to denote adjustments that are of poor quality. Do not use ‘5’ to denote that salinity adjustment has been applied.*

Subsequent discussions on salinity adjustment errors revealed a general sentiment that the objective mapping uncertainty did not fully reflect the degree of ocean variability. In addition, the delayed-mode process involves subjective judgement that can introduce extra errors. It was then agreed that delayed-mode salinity data should be associated with more conservative error bars than were provided by statistical tools. The value of 0.01 PSS-78 was suggested as a reasonable minimum value for salinity error.

> ***Recommendation 4.5.2:*** *It was agreed that PSAL_ADJUSTED_ERROR was to be set to a minimum of 0.01 PSS-78 as follows:*
> *A=error from WJO, BS, OW*
> *B=error from cell thermal mass adjustment*
> *C=sqrt(A^2 + B^2)*
> *PSAL_ADJUSTED_ERROR = maximum(0.01, C)*
> *In cases where extra information is available, operators can refine this minimum error.*

> ***Action 4.5.3:*** *The scientific reasons for setting PSAL_ADJUSTED_ERROR to a minimum of 0.01 PSS-78 should be explained in the Argo QC Manual, so that operators can simply quote 0.01 in the NetCDF files without being too verbose in the SCIENTIFIC_CALIB section.*

5) Regional oceanography

The workshop dedicated a session to reviewing regional oceanography and discussing how ocean variability could affect assessment of float salinity data. Many delayed-mode operators made presentations on oceanographic features specific to their float regions. Many examples were shown to illustrate how ocean variability can be misinterpreted as sensor drift or offset. The major points from each presentation are summarized below.

5.1) Pacific

1) John Gilson made a presentation on the Tasman Sea. The Tasman Sea is a complex area with complicated shallow bathymetry and many currents/fronts. Fortunately there are sufficient good historical data in the area from SeHyD. Due to the spatial complexity, it is appropriate to use a set of small spatial decorrelation scales in objective mapping. For example, longitudinal scales ranging from 4° to 1°, and latitudinal scales ranging from 2° to 0.5°, are all appropriate for this area. John suggested excluding Antarctic Intermediate Water (AAIW) during calibration in the subtropical South Pacific and the Tasman Sea because AAIW was undergoing changes that were not reflected in the reference database. Brian King suggested excluding AAIW in the subtropical South Indian Ocean as well because of AAIW's high spatial variability in that region.

2) Tomoaki Nakamura presented some examples from the western North Pacific. He showed that in this area, it did not make any difference whether or not the potential vorticity (PV) constraint was used in the objective mapping. However, objective estimates are sensitive to the selection of spatial decorrelation scales here. The longitudinal scales of 8°/4° and the latitudinal scales of 4°/2° are better at producing smoother objective estimates in this area than shorter scales.

3) Mathieu Ouellet presented a detailed description of the currents, fronts and water masses in the Gulf of Alaska. He noted that temperature inversions occurred in most of the subarctic North Pacific Ocean north of 42°N. In addition, eddies in the area can create anomalous θ-S profiles. Hence for float salinity calibration in this area, only water masses below 3°C (~600 dbar) should be selected so that temperature inversions and effects of eddies are avoided. Mathieu also advised that when examining diagnostics plots, that operators should be aware of the plotting scales. Lastly, he commented that floats that sampled deep every Nth profile were not optimal for dmqc.

5.2) Atlantic

4) Paul Robbins presented a potpourri of Atlantic Argo float calibration and exploration in curve fitting. He suggested that OW users should be aware of the number of breakpoints in the OW fit. To examine whether or not the breakpoints in the OW fit are necessary, it is advised that delayed-mode operators put more emphasis in examining the float data time series on isotherms, and then compare the trend in the float data with the suggested calibration curve. This is especially important when floats are in variable ocean areas, such as near marginal seas, eddies and fronts.

5) Virginie Thierry presented results from the North Atlantic. The subpolar North Atlantic is a highly variable area with many boundary currents and frontal zones, and with interannual variability of Labrador Sea Water extending as deep as 2000 dbar. Therefore Virginie recommended that for the subpolar North Atlantic, that good Argo data should be used in the reference database to take into account the interannual and spatial variability of the water masses. In addition, extra care should be taken to compare float data with nearby CTD and good Argo data. She showed that including the PV constraint in the objective mapping was useful when the float was in a boundary current. The cross-isobath scales used are 0.5/0.1. The spatial decorrelation scales used are 3.2°/0.8° for longitude, and 2°/0.5° for latitude. The temporal decorrelation scale used is 0.7 years. Lastly, for the subpolar North Atlantic, the top 500 dbar of the water column should be excluded during calibration.

6) Birgit Klein presented examples from the Mediterranean Outflow. One of her examples showed a float whose salinity measurements underwent a calibration jump during mid-life, and then returned to normal. John Gilson commented that care should be taken to not produce 'double clouds', one centered on the present data, and another on the historical average. That is, in cases of calibration jumps, that the jumps should be adjusted back to the float data (assuming the float data are accurate) and not back to the historical average. All delayed-mode operators are reminded that it

is important to ensure continuity of the fit when breakpoints are introduced, except when there are reasons to believe that there should be discontinuity in the time series.

5.3) Indian

7) Sudheer Joseph presented examples of Argo floats in the Indian Ocean north of 10°S. The Bay of Bengal is sorely lacking in historical data, while the Arabian Sea and the equatorial Indian Ocean have slightly more historical data. Fortunately the majority of INCOIS floats are not showing signs of sensor drift, and hence there is no need for adjustment. Incorporation of good Argo data may be a practical solution for this region. Sudheer said that when floats were in areas with sparse historical data, tightness of the θ-S curve was the prime criterion for determining whether sensor drift had occurred. All delayed-mode operators are reminded that it is important to exclude the mixed layer in sensor drift adjustments, because the variability of the mixed layer tends to contaminate the least squares fit.

8) Esmee van Wijk presented a talk on the Indonesian Throughflow (ITF). The ITF is unique in that it is the only low-latitude region that connects two major ocean basins. Pathways of flow are complex and include multiple straits, sills and basins. The ITF is strongest in the upper part of the water column, from the surface to ~700m. Esmee recommended that for calibrating salinity in the ITF, that water masses below 1500 dbar should be used because they were the most homogeneous. Flow in the ITF varies seasonally in response to the monsoons and is also correlated with interannual variations associated with the El Nino/Southern Oscillation. It is therefore a complex region that requires multiple tools to distinguish salinity drift from real variability. Reviewing floats on a regional basis will help operators recognise local variability and improve consistency.

5.4) Southern Ocean

9) Esmee van Wijk presented a talk on the Southern Ocean. The Southern Ocean has three main fronts. The variability in these fronts may lead to misclassification of salinity drift when a float crosses a front. Lower Circumpolar Deep Water is a homogeneous water mass that can be used for float salinity calibration south of the Polar Frontal Zone.

10) Steve Riser warned that for ice floats, if air temperature was cold when a float came to the surface, the water in the conductivity cell might freeze and the freezing could damage the conductivity cell or the thermistor, which could then cause salinity data to shift. It was conjectured that this instrument error was less likely to occur in Iridium floats because they spent less time at the surface.

5.5) Marginal seas - Mediterranean Sea

11) Giulio Notarstefano presented delayed-mode quality control of Argo float salinity data in the Tyrrhenian Sea. Reference CTD data for the Mediterranean region were extracted from the MEDAR/MEDATLAS climatology (1975-1997). Additional data were kindly made available by Borghini and Santoleri (2004). It would seem that most floats in the Tyrrhenian Sea were stable and did not need any adjustments.

6) Reference database for PSAL

6.1) The centralised Argo reference database at Coriolis

Coatanoan explained the present status of the Argo reference databases, available on the Coriolis website. The database circulated with WJO was WOD01, subsampled and then interpolated onto potential temperature levels. The new database is based on WOD05 and retains full vertical resolution and the full depth range.

The main database has been compiled from CTD data in WOD05, with NODC flags inspected. Data have had further Coriolis QC applied (which includes automatic testing and objective analysis testing). Data have been sub-selected according to a set of criteria such as: data collected since 1990; casts must be deeper than 900 dbar (to remove coastal stations and stations shallower than the T-min layers). Salinity range 24 < S < 41. Maps of data availability are included in Coatanoan's powerpoint on the meeting web site.

The version available on the Coriolis web site in Sep 2008 had all temperatures assumed to be ITS-90 and converted back to IPTS-68 for the centralised Argo reference database. This was for compatibility with OW, for which the current version has all internal temperature variables and external calls to the 'seawater' equation of state code scaled in IPTS-68.

The decision was taken, that the reference database and the OW code would be converted to carry ITS-90 throughout. Coriolis will need to produce a reference database with *in situ* temperature and potential temperature scaled to ITS-90. See recommendation 6.2b.2.

> ***Action 6.1.1:*** *DM operators should take care to document versions of the float data, reference data and statistical software, to keep track of the temperature scale in use.*

Database naming conventions and version control:

The database file names were thought to leave room for confusion. At present, the new centralised database prepared by Coriolis for Argo is called 'ARGO2008V01'. It includes the name Argo because it was prepared *for use in Argo*. The file name of the reference database compiled by SIO using good Argo data is called 'argo_clim' and carries the name Argo because it *includes good Argo data (but is also intended for use in Argo).* See Action 6.2.1.

It was pointed out that WOD is now being regularly updated by NODC, with latest versions including recent data available by WWW. As updates of the reference databases are generated, it is critical that operators keep careful track of the version of reference data used to estimate PSAL offsets.

> ***Action 6.1.2:*** *Coriolis to ensure that when the centralised database is updated, the latest data from NODC are included, within resource limitations. It is recognised that including NODC data within the Coriolis database requires further Coriolis QC, which requires resources.*

The centralised Argo reference database is therefore based on data already available at NODC. There is a time lag for data to be passed from PIs to NODC.

> ***Recommendation 6.1.3:*** *The system of acquiring new CTD data from PIs and adding them to the centralised Argo database by transmission through CCHDO and Coriolis does not seem to be fully effective yet. There are regions of the ocean where the ability to do good DMQC is severely restricted by insufficient reference data. This needs to remain high on the agenda at ADMT. High quality CTD data at CCHDO from critical data-sparse regions are the top priority for adding to the centralised database.*

6.2) Including "good" Argo data in the reference database

> ***Action 6.2.1:*** *A reference database with float profiles selected according to Gilson's Rules (see previous reports) has been prepared in OW format and is available at Coriolis. The workshop recommends a change of filename for future versions. See discussion in 6.1.*

The Argo-data reference database presently has 76508 profiles selected by Gilson's Rules out of 205000 D files at the GDACs. The database file is generated by Gilson at SIO using a Matlab code originated by King and a list of WMO and cycle numbers selected by Gilson.

The database version currently available used float data at GDACs, without temperature conversion and therefore contains ITS-90 temperature. This is slightly inconsistent with existing practice in which float_source.mat should have float data converted to IPTS-68 and the WJO/OW software expects an IPTS-68 database. In the near future OW and the centralised Argo reference database will be converted to ITS-90, so everything will be fully consistent.

Gilson said he would plan to regenerate the 'good_argo' reference database quarterly, to respond to the expected rate of growth of suitable D files. If this is too great a burden, six month updates might be made instead. It was recognised that easy access to recent good D files would be of increasing value in DMQC decision-making.

6.2a) Excluding good_argo data from DMQC when good CTDs are available

Gilson reviewed the rules for passing D files into the 'good_argo' database. An extra rule was considered in which D files would be excluded if they fell within a space and time window of a good CTD station. Nominal values of +/- 4° lat and lon and +/- 1 year were considered.

The point was to retain access to good_argo if nearby CTDs were many years old and might therefore represent an ocean whose properties had changed, but to ensure that in an OW run which combined centralised and good_argo databases, OW selected calibrated CTD data in preference to Argo if the CTD data were nearby and recent.

> ***Recommendation 6.2a.1:*** *The workshop suggested that the good_argo database should contain all the good profiles so that it can be used for evaluation in OW runs using only good_argo, without large 'holes' appearing where there happen to be CTD data in the centralised database. Preferential selection of CTD over good_argo can be done in software that employs the databases instead of software that generates the databases. Therefore 'Gilson's extra rule' is not recommended for generating the good_argo database.*

6.2b) Temperature scale used in databases: ITS-90 and IPTS-68

The handling of temperature scales in the WJO/OW software and in the reference databases (Coriolis central database and SIO good_argo database) is introduced in the report of 6.1 and 6.2. This section is a post-meeting note on the consequences of any operator combining databases and float data with mixed scales.

WOD01/WOD05: NODC does not 'convert' historical data in its archive when temperature scales change (t-48, t-68, t-90, …) . This is common data centre practice, in which data supplied by users are not changed. Instead, flags or metadata are used to record information such as temperature or salinity scales, if they have been supplied by the data originator. Therefore data labelled 'temperature' or 'salinity' in WOD as assembled by NODC will be recorded in a mixture of temperature scales. A careful user of all available flags and metadata should be able to distinguish the scales with sufficient care.

SeHYD/IOHB: Kobayashi said that as far as he was aware, the databases prepared by JAMSTEC (SeHyd; IOHB) were taken from WOD without temperature conversion. Therefore recent CTD data (>~1990) can be expected to be ITS-90. Older CTD data (<1990) will be in the scale as held at NODC, and are therefore probably IPTS-68.

WJO database: Wong said that the preparation of the subsampled/interpolated database distributed with WJO was done before Dec 2003; that is, before the ITS-90 version of the SEAWATER toolkit became available. Data were taken from an in-house database at PMEL that already included WOD01. Wong did not perform any further temperature conversion. Wong's best recollection is that before 2003 the PMEL database kept all data in IPTS-68, after converting post-1990 data (eg WOCE) from ITS-90 back to IPTS-68 when required. Thus to the best of our knowledge all data in the WJO release were IPTS-68.

The difference between IPTS-68 and ITS-90. A practical conversion between t68 and t90 in the oceanographic range is t90 = t68/1.00024. This means that the t68 minus t90 difference is 0 near 0°C, 0.003 near 15°C and 0.007 near 30°C.

Mixed scales? So what is the consequence if a DMQC operator has by mistake compared reference data in ITS-90 with float data in IPTS-68, or reference data in IPTS-68 with float data in ITS-90? The comparison in WJO is of salinity interpolated onto temperature levels. If an accidental mix of scales means the temperatures in one dataset differ from those in the other by ΔT, then the impact on interpolated salinity at some potential temperature level is ΔT * δS/δT, where δS/δT refers to the vertical gradient.

The DMQC statistical fits (WJO/BS/OW) are usually dominated by temperatures less than 15°C, so ΔT is less than 0.003°C. Also, the selection/exclusion of water masses in DMQC usually avoids parts of the water column where the ratio δS/δT is very large. In the SAMW in the Indian Ocean for example, which is a good water mass for DMQC but with δS/δT larger than in many other ocean regions, the ratio δS/δT is of order 0.2. **Thus almost everywhere in the ocean, the impact of any accidental mixing of temperature scales is less than 0.001 in Salinity on a temperature level. This is of no consequence to completed DMQC, but future releases of databases and software should be made internally consistent.**

> ***Action 6.2b.1:*** *Breck Owens and Annie Wong to release a new version of OW that takes ITS-90 as input.*
>
> ***Action 6.2b.2:*** *Coriolis to release new version of centralized reference database with ITS-90. See also discussion in 6.1.*
>
> ***Action 6.2b.3:*** *All operators to switch their OW input .mat files in float_source back to ITS-90 for TEMP and re-calculate PTMP. Operators who have the IPTS-68 version of the 'seawater' library on their work computers will need access to the ITS-90 version, available on the CSIRO website and easily retrievable in Google via 'csiro seawater'.*

6.3) Regional efforts

The meeting heard about regional databases being prepared for the Nordic seas by Hamburg, for the East/Japan Sea by Korea and for the Mediterranean by OGS, Italy.

7) DMQC adjustment for PRES

7.1 & 7.2) DMQC adjustments to PRES using SURFACE_PRESSURE in APEX floats, including progress report from the AST pressure working group

The state of knowledge of pressure sensor drifts was reviewed. The meeting greatly benefited from Swift and Riser, who explained many of the technical aspects of pressure sensor errors.

SOLO and PROVOR floats make profile-by-profile adjustments for surface pressure measurements, by resetting the pressure offset in each profile. APEX floats do not. The problem is APF8 floats that truncate and discard negative offsets. (Note: there is now a version of APF8 that records and transmits negative offsets, but users do not get this option unless they specifically ask WRC for it.)

Previous advice to adjust all APEX floats equipped with Paine or Ametek sensors is endorsed. The overwhelming majority of drifts of those sensors is towards positive errors.

APF-8 APEX floats with Druck sensors remain undecided. The WG on pressure offsets established by AST, chaired by Wijffels has not yet made a definitive recommendation, although a progress report from Wijffels was available to the meeting.

The meeting was shown new and detailed analysis of behaviour of Druck sensors by UW, using about 200 APF-9 floats that report the surface pressure properly.

The majority of Druck sensors (> 95%) have surface_pressure drifts with magnitude less than 1 dbar over the float lifetime. One failure mode, quite rare, involving microleaks, results in strong negative offsets that would be hidden by APF-8.

Of the small (< 1 dbar) offsets, Swift showed there was a small bias to positive values, with a mean and standard deviation both of order 0.2 dbar. Two possible strategies were discussed:

(1) Correct all Druck offsets. This has been the inclination of the Kobayashi and Johnson paper, with agreement in the Wijffels progress report. However, it could introduce a bias because small positive offsets are adjusted but an almost equal number of small negative offsets are not.

(2) Do not adjust offsets with magnitude less than 1 dbar. This could introduce a bias because the mean of the small offsets that would not be applied is in fact positive.

> ***Action 7.2.1:*** *Swift was asked to calculate and notify the AST pressure WG (Wijffels et al.) the magnitude of the bias introduced by either the 'adjust all' or 'adjust none' strategy for small Druck offsets. Zero-mean RMS errors of less than 1 dbar would not be important. The issue is to try to avoid bias.*
>
> ***Action 7.2.2:*** *After receiving Swift's analysis of small Druck offsets, the pressure WG can review their conclusions and notify argo_dm_dm of the recommended strategy.*
>
> ***Action 7.2.3:*** *Delayed Mode operators can wait for a recommendation from the AST pressure working group before applying small Druck offsets.*
>
> ***Recommendation 7.2.4:*** *The delayed-mode group recommends the ADMT to record surface pressure offsets from Apf-8 APEX floats as transmitted (ie. with +5 dbar) in the tech files, but advises that there should be different parameter names for surface pressures that include the +5 dbar and surface pressures that do not.*

Note after the meeting from King/Wong: The present version of the tech file parameter naming convention offers two choices of names.

PRES_SurfaceOffsetTruncated_dBAR for the old APEX APF8s that have negative offsets truncated to zero. The artificial +5dbar is not recorded under this parameter name.

PRES_SurfaceOffsetNotTruncated_dBAR for all other APEX floats. These include APF9s and the new APF8s that telemeter SURFACE PRESSURE as measured (whether positive or negative), and without the artificial +5dbar.

Hence the present choices of parameter names are sufficient for recording surface offsets telemetered by APEX floats of all configurations. Whether the artificial +5dbar from the old APEX APF8s should be retained in the tech file or not is still an issue under discussion.

7.3) Preliminary results of laboratory test on Druck pressure sensor drift/hysteresis

JAMSTEC is undertaking laboratory investigation of drift/hysteresis in Druck sensors, but the investigation is still underway; no results were available for the meeting.

8) DMQC adjustment for TEMP

Riser showed examples of floats where PSAL drifts towards higher salinity compared with reference. Almost all DMQC operators confirmed that they had seen examples of floats with similar drifts to higher salinity. If the error is believed to be in conductivity, which can be corrected by adjusting PSAL, there is no physical explanation of why conductivity cells would drift to higher conductivity. All the known conductivity error modes involve drifts to lower salinity.

The concern is that floats drifting to higher PSAL may in fact be showing error in TEMP. If the TEMP reads low with PRES and CNDC good, then PSAL will be calculated and reported high. The order of magnitude scaling is that if TEMP is 0.01 low, PSAL is 0.01 high, but the ratio of TEMP/PSAL errors varies by a factor of two over S, T, P parameter space.

Thus there is a suspicion, pending further understanding of the sensors, that some floats may have TEMP errors, which are presently undetected. If TEMP has a problem, this could be a sensor problem or an electronics problem.

> ***Recommendation 8.0.1:*** *In the absence of further information, we continue to report TEMP_ADJUSTED_ERROR as 0.002, being the manufacturer uncertainty.*
>
> ***Recommendation 8.0.2:*** *There would be enormous benefit in recovering one or more floats with a significant drift to higher PSAL, so that the cause can be investigated. Any float provider who has opportunity to recover such a float is urged to do so.*

9) Interaction with real-time QC, regional QC & the GDACs

9.1) Using satellite altimetry data in Argo qc

Stephanie Guinehut presented a scheme to search for offsets in Argo data using satellite altimetry measurements. The main idea is to compare co-located (in time and space) Sea Level Anomalies (SLA) from altimeter measurements and Dynamic Height Anomalies (DHA) calculated from in-situ T and S profiles to detect systematic errors in the Argo data set. Altimeter measurements are from the AVISO combined maps. Argo T/S profiles are from the Coriolis-GDAC. Dynamic height is calculated using a reference level at 900-m. The mean dynamic height used to calculate DHA is from a combination of WOA annual mean climatology and a contemporaneous Argo climatology. Systematic diagnosis is then carried out for each float time series. Comparison with mean statistics allows anomalous floats to be extracted. Anomalies can be due to sensor drift, calibration offset, measurement spikes, or other strange float behaviour. So far errors are detected mainly in the real-time data set. Stephanie cautioned that for now, the method was not able to extract small errors in high variability regions and very small bias (~2-3 cm) in lower variability regions.

Anomalous floats detected by the altimetry qc are shown in the AIC Monthly Report. The list is also posted on a CORIOLIS ftp site together with a figure for each float at ftp://ftp.ifremer.fr/ifremer/argo/etc/argo-ast9-item13-AltimeterComparison. DACs should check these anomalous floats together with their delayed-mode operators and PIs and provide appropriate adjustment if needed. All delayed-mode operators are urged to read the AIC Monthly Report to check for floats that are flagged by the altimetry qc and provide feedback to Stephanie Guinehut. Stephanie is advised to not remove the anomalous floats that are active from her list because operators may want to check them again at a later date as the time series grows. The altimetry qc has successfully detected a number of anomalies in real-time data. Stephanie's results should be presented at the next ADMT meeting so that the real-time DACs can be informed of these anomalies. All delayed-mode operators are reminded that they should communicate with their DACs to put bad floats on the grey list.

> ***Action 9.1.1:*** *All delayed-mode operators to read the AIC Monthly Report to check for floats that are flagged by the altimetry SLA/DHA qc, and provide feedback to Stephanie Guinehut. If a dead float is flagged by Stephanie and then investigated by an operator who confirms its PSAL_ADJUSTED is good, it can be taken off Stephanie's list for future flagging. Active floats that have new data that trip Stephanie's test should continue to be notified to DM operators, so the floats get further review.*
>
> ***Action 9.1.2:*** *The altimetry qc has successfully detected a number of anomalies in real-time data. Stephanie's results should be presented at the next ADMT meeting so that the real-time DACs can be informed of these anomalies.*
>
> ***Action 9.1.3:*** *All delayed-mode operators are reminded that they should communicate with their DACs to put bad floats on the grey list.*

Post-meeting comment by King: If possible, the sensitivity of the SLA/DHA test should be set so that approximately 50% of floats flagged as anomalous are agreed by DM operators to require further adjustment. If 95% of flagged floats are investigated but then confirmed by DM operators to be good, the test is too sensitive and DM operators will be discouraged from investigating future notifications. If 95% of floats are agreed to require further adjustment, then the test is not sensitive enough and there will be a significant number of floats that should have further adjustment but which do not get flagged.

Post-meeting comment: Annie Wong has asked Mathieu Belbeoch to include subscribers in the argo-dm-dm list in his distribution of the AIC Monthly Report.

9.2) Open discussion

The workshop reviewed how the delayed-mode data stream interacted with the other branches of the Argo data system, namely, the GDACs, the real-time DACs, and the regional ARCs.

a) Interaction with the GDACs

The discussion started with a presentation made available to the workshop by Mark Ignaszewski on the enhanced format checker that was projected to come into effect at the US-GDAC in October 2008. Under the enhanced format checker, all the highly desirable parameters will be checked for valid values. All the _DATE_ parameters will be checked for sequential validity. For 'D' files, all the _ADJUSTED_ parameters will be checked that they are filled. The SCIENTIFIC_CALIB_ section will be checked that all parameters are filled.

Failure of any of these checks will result in either a warning or outright rejection of the bad files by the GDAC, depending on which checks are failed. The enhanced format checker will also check if there are R-file cycles embedded within the D-file sequences.

A question was raised regarding the action for files that were already at the GDAC. Will they be removed from the GDAC if they fail the enhanced format checks? Annie Wong will ask Mark Ignaszewski to clarify this when the enhanced format checker comes into effect.

The delayed-mode group welcomes the enhanced format checker and suggests that the GDAC should consider the following question and recommendations:

> ***Recommendation 9.2.1:*** *Check that the HISTORY section is filled;*
>
> ***Recommendation 9.2.2:*** *Check that character strings do not contain ASCII null characters. Strings should be padded with 'space'.*
>
> ***Question 9.2.3:*** *When the enhanced format checker comes into effect, what action will be taken on already-existing D files? What happens if a new/replacement D file fails a test and is rejected, when there is already an existing D file which is now out of date?*

b) Interaction with the real-time DACs

Workshop participants are reminded that real-time DACs carry out salinity adjustments in real-time by extracting the latest delayed-mode salinity adjustment and propagating it through the more recent profiles. This is an automatic procedure done in real-time and the R files have DATA_MODE = 'A'.

> ***Recommendation 9.2.4:*** *The delayed-mode group recommends that when real-time adjustments are applied (ie. DATA_MODE = 'A'), that the PARAM_ADJUSTED_QC fields should be filled with values from PARAM_QC.*

It was suggested that the Argo QC Manual should emphasize the fact that these R files with DATA_MODE = 'A' were not checked by delayed-mode operators, even though the _ADJUSTED_ fields were filled. Annie Wong will update the QC Manual to reflect this.

> ***Action 9.2.5:*** *Annie Wong to update the Argo QC Manual to ensure there is sufficient emphasis that data mode 'A' applies to real-time data which may not have had any further checking (Discussion reported under 9.2b).*

Discussion then proceeded to the topic of how the real-time DACs should record SURFACE PRESSURE values from APEX floats. This is an issue for APEX floats equipped with Apf-8 controllers because the SURFACE PRESSURE values from these floats have an artificial 5 dbar added to them. The delayed-mode group feels that the data files should record what are transmitted, and so recommends the ADMT to record surface pressure offsets from Apf-8 APEX floats as transmitted (ie. with the artificial +5 dbar) in the tech files, but advises that there should be a parameter name that reflects that the artificial +5 dbar is retained. (See recommendation 7.2.4.)

A discussion was carried out on whether delayed-mode operators should adjust real-time qc flags. After the 2006 Delayed-Mode Data Intercomparison, AST-8 passed an action item (Item 13) stating that when qc flags were examined and edited in delayed-mode, these edits should be made to the real-time qc fields (ie. PARAM_QC). Opinion from workshop participants on this AST action item was mixed, with several operators supportive of this resolution, several operators strongly against it, and the majority of the operators feeling neutral or uncertain. The reasons that some operators are against this resolution include the fact that editing real-time qc flags by subjective judgement can lead to inconsistency and can potentially make the real-time qc flags worse. Also results from the real-time qc tests will be lost. Overall the workshop participants felt that more open discussions on the ramification of this action item were needed between the AST, the real-time DACs, and the delayed-mode operators. Annie Wong will compose a letter to the AST summarising the concerns of delayed-mode operators on editing real-time qc flags, so that this topic can be discussed further at the next AST meeting.

> ***Action 9.2.6:*** *Annie Wong to compose a letter to the AST summarising the concerns of delayed-mode operators on editing real-time qc flags, so that this topic can be discussed further at the next AST meeting.*

c) Interaction with regional qc

Annie Wong described to workshop participants that several Argo Regional Centres (ARCs) were spinning up their efforts to do basin-wide qc on Argo data. This third level of Argo qc is different from the delayed-mode qc because dmqc inspects individual float time series, whereas regional qc inspects all profiles within an ocean basin. Any suggestions from the delayed-mode group on how to review basin-wide data quality will be appreciated. The group agrees that basic analysis such as objective analysis anomaly checks will be useful for basin-wide qc of Argo data.

The delayed-mode group feels that one way the ARCs can help with the dm process is to include a list of published scientific papers on the respective ARC webpages describing climate change of water masses in their ocean basins. Delayed-mode operators can then peruse the literature and be wary of local variability when carrying out sensor drift assessment.

> ***Recommendation 9.2.7:*** *The delayed-mode group suggests that it will be useful if the ARCs can compile a list of published papers describing climate change of water masses in their respective basins and make this list available on their webpages. Operators can then peruse the literature and be wary of local variability when carrying out sensor drift assessment.*

10) Miscellaneous issues

10.1) Recording delayed-mode information in the Argo NetCDF files

a) Format of SCIENTIFIC_CALIB and HISTORY

All delayed-mode operators are currently filling the SCIENTIFIC_CALIB and HISTORY sections of the Argo netcdf files. Discussions were carried out as to whether it was possible to use standardised codes in describing sensor behaviour and calibration coefficients. The purpose would be to enable the character string variables to be parsed automatically. At the end it was concluded that because sensor behaviour was so variable, that it was best to carry on the current practice of filling in as much detailed information as the operator deemed appropriate.

b) Profiles without LATITUDE, LONGITUDE or JULD

A pre-workshop email exchange with Claudia Schmid alerted the group of a problem with profiles without LATITUDE, LONGITUDE or JULD. Currently the Argo QC Manual recommends that for these profiles, that PSAL_ADJUSTED_ERROR = FillValue, PSAL_ADJUSTED = FillValue, and PSAL_ADJUSTED_QC = FillValue. This practice poses a problem for users who are only interested in time series data regardless of whether there are positions or not. For these users, they would like to be able to extract data from the _ADJUSTED_ fields, even if the data have no positions. Moreover, there are currently many ice floats deployed that do not report positions when under ice. It is not ideal to leave all the _ADJUSTED_ fields blank for these under-ice profiles.

All delayed-mode operators therefore agree that for profiles without LATITUDE, LONGITUDE or JULD, that they will fill the netcdf files with interpolated x, y, t, then record position qc = ’8’. The profiles can then be put through WJO, BS or OW to obtain a drift adjustment. The _ADJUSTED_ fields in the netcdf files can then be filled. Wong will update the Argo QC Manual accordingly.

> ***Recommendation 10.1.1:*** *For profiles without LATITUDE, LONGITUDE or JULD, operators are advised to fill the NetCDF files with interpolated x, y, t, then record position qc = '8'. The profiles can then be put through WJO, BS or OW to obtain a drift adjustment. The _ADJUSTED_ fields in the NetCDF files can then be filled.*

10.2) Argo QC Manual; Argo Data User's Manual

It would appear that apart from the new recommendations from this workshop, that there is no need to change either the Argo QC Manual or the Argo Data User's Manual.

> ***Action 10.2.1:*** *Annie Wong to update the Argo QC Manual with results from this workshop.*

10.3) argo-dm-dm@jcommops.org email list

Workshop participants are reminded that all currently active delayed-mode operators are on the argo-dm-dm@jcommops.org email list, and that this email forum is the most effective way to get messages out to all delayed-mode operators. This email forum has the advantage that all email threads are archived, so that when new operators come onboard, they can browse through the archive to search for discussion topics that are of interest. All Argo email forum archives can be found on http://list.jcommops.org. All delayed-mode operators are encouraged to be more active in sharing technical information on the argo-dm-dm email forum.

Post-meeting comment by Wong: The argo-dm-dm list has been updated as of 26 September 2008 to include all the new delayed-mode operators.

10.4) Communication between AST and delayed-mode operators

Annie Wong raised the issue that in the past couple of years, several AST resolutions that affected the delayed-mode data stream were passed, but these resolutions were either not discussed with the delayed-mode operators or not communicated clearly to the delayed-mode group. This breakdown in communication comes from the fact that hardly any delayed-mode operators attend AST meetings, and national representatives who attend AST meetings are not always diligent in passing on the information. A more effective way of communication is sorely needed. Megan Scanderbeg therefore graciously accepted the request to act as the coordinator between the AST and the delayed-mode group by sending summaries to the argo-dm-dm email forum when resolutions that affect the delayed-mode data stream are passed at AST meetings.

> ***Action 10.4.1****: Megan Scanderbeg to act as the coordinator between the AST and the delayed-mode group by sending summaries to the argo-dm-dm email list when resolutions are passed at AST meetings that affect the delayed-mode data stream.*

11) Summary discussion

11.1) Sharing of DMQC experience

It was suggested that there should be a web-based table that summarised software configurations used by operators on batches of floats. The table would be filled/updated by an operator when they completed a batch of floats. The headings that might be useful might include:

Operator; date; region (free text or lat/lon limits); software (WJO/OW/BS); ref db (eg central ARGO db version, locally enhanced db, etc); mapping scales chosen; PV on/off; parts of water column included/excluded; web link to diagnostic plots; other comments (eg AAIW fresher in recent Argo data than in ref db); etc.

The purpose of the table is not to formally document the procedure, which is done elsewhere. Rather it is to enable operators to see who else is doing DMQC in their area and what sort of general configurations they employ. This is especially useful when using configurations that are not the 'defaults'. The 'other comments' would be particularly useful for operators who need to do DMQC in a region of ocean somewhat outside their area of familiarity/expertise.

The filling procedure must be made very simple, so that it is not a burden. It will need to be password controlled and to allow easy table-filling by operators.

Virginie Thierry places the diagnostics plots from her DMQC, together with a collection of other information, at http://www.ifremer.fr/lpo/ovide/data/argo_profiling_floats.htm. This is the complete record of DMQC decision making that she keeps for her own use, but is available to anyone who is interested.

> ***Action 11.1.1:*** *Van Wijk and Scanderbeg agreed to investigate how a web-based table could be done and to try to get a draft procedure up and running.*

11.2) Sharing of code

It was agreed there should be a method for sharing code developed by operators that they find helpful in their DMQC. This can be anything from major tools that have reached a mature state of development/documentation (eg. a tool like the SIO Matlab GUI) through intermediate codes (tools for displaying nearby Argo data under development at JAMSTEC and CSIRO) to useful but immature codes with no support from the originator but which may nevertheless be worth making available.

> ***Action 11.2.1:*** *Robbins to investigate hosting a code share site. All delayed-mode operators are encouraged to be more active in sharing technical information via the argo-dm-dm email forum.*

11.3) Meeting documents

> ***Action 11.3.1:*** *Wong to assemble all powerpoint presentations and related documents and lodge them on the meeting webpage http://prelude.ocean.washington.edu/dmqc3/info.html.*

Appendix – 1 Resolutions, recommendations and action items from DMQC-3

Action 4.3.1: *Johnson and Swift are asked to attempt to develop an improved ascent rate model for the APEX floats using the UW data and, after that is accomplished, re-estimate the CellTM coefficients for the SBE41 using the improved ascent rate model.*

Recommendation 4.3.2: *The meeting recommends that all groups continue to handle CellTM as they do at present. Groups applying CellTM can continue to do so. Groups not applying CellTM can continue to not do so, while awaiting the results of further investigation.*

Recommendation 4.5.1: *Delayed-mode operators are advised that during point-wise inspection of measurements, PSAL_ADJUSTED_QC should be assigned '1' or '4'. '2' can be used to denote adjustments that are of poor quality. Do not use '5' to denote that salinity adjustment has been applied.*

Recommendation 4.5.2: *It was agreed that PSAL_ADJUSTED_ERROR was to be set to a minimum of 0.01 PSS-78 as follows:*
  A=error from WJO, BS, OW
  B=error from cell thermal mass adjustment
  C=sqrt(A^2 + B^2)
  PSAL_ADJUSTED_ERROR = maximum(0.01, C)
In cases where extra information is available, operators can refine this minimum error.

Action 4.5.3: *The scientific reasons for setting PSAL_ADJUSTED_ERROR to a minimum of 0.01 PSS-78 should be explained in the Argo QC Manual, so that operators can simply quote 0.01 in the NetCDF files without being too verbose in the SCIENTIFIC_CALIB section.*

Action 6.1.1: *DM operators should take care to document versions of the float data, reference data and statistical software, to keep track of the temperature scale in use.*

Action 6.1.2: *Coriolis to ensure that when the centralised database is updated, the latest data from NODC are included, within resource limitations. It is recognised that including NODC data within the Coriolis database requires further Coriolis QC, which requires resources.*

Recommendation 6.1.3: *The system of acquiring new CTD data from PIs and adding them to the centralised Argo database by transmission through CCHDO and Coriolis does not seem to be fully effective yet. There are regions of the ocean where the ability to do good DMQC is severely restricted by insufficient reference data. This needs to remain high on the agenda at ADMT. High quality CTD data at CCHDO from critical data-sparse regions are the top priority for adding to the centralised database.*

Action 6.2.1: *A reference database with float profiles selected according to Gilson's Rules (see previous reports) has been prepared in OW format and is available at Coriolis. The workshop recommends a change of filename for future versions. See discussion in 6.1.*

Recommendation 6.2a.1: *The workshop suggested that the good_argo database should contain all the good profiles so that it can be used for evaluation in OW runs using only good_argo, without large 'holes' appearing where there happen to be CTD data in the centralised database. Preferential selection of CTD over good_argo can be done in software that employs the databases instead of software that generates the databases. Therefore 'Gilson's extra rule' is not recommended for generating the good_argo database.*

Action 6.2b.1: *Breck Owens and Annie Wong to release a new version of OW that takes ITS-90 as input.*

Action 6.2b.2: *Coriolis to release new version of centralized reference database with ITS-90. See also discussion in 6.1.*

Action 6.2b.3: *All operators to switch their OW input .mat files in float_source back to ITS-90 for TEMP and re-calculate PTMP. Operators who have the IPTS-68 version of the 'seawater' library on their work computers will need access to the ITS-90 version, available on the CSIRO website and easily retrievable in Google via 'csiro seawater'.*

Action 7.2.1: *Swift was asked to calculate and notify the AST pressure WG (Wijffels et al.) the magnitude of the bias introduced by either the 'adjust all' or 'adjust none' strategy for small Druck offsets. Zero-mean RMS errors of less than 1 dbar would not be important. The issue is to try to avoid bias.*

Action 7.2.2: *After receiving Swift's analysis of small Druck offsets, the pressure WG can review their conclusions and notify argo_dm_dm of the recommended strategy.*

Action 7.2.3: *Delayed Mode operators can wait for a recommendation from the AST pressure working group before applying small Druck offsets.*

Recommendation 7.2.4: *The delayed-mode group recommends the ADMT to record surface pressure offsets from Apf-8 APEX floats as transmitted (ie. with +5 dbar) in the tech files, but advises that there should be different parameter names for surface pressures that include the +5 dbar and surface pressures that do not.*

Recommendation 8.0.1: *In the absence of further information, we continue to report TEMP_ADJUSTED_ERROR as 0.002, being the manufacturer uncertainty.*

Recommendation 8.0.2: *There would be enormous benefit in recovering one or more floats with a significant drift to higher PSAL, so that the cause can be investigated. Any float provider who has opportunity to recover such a float is urged to do so.*

Action 9.1.1: *All delayed-mode operators to read the AIC Monthly Report to check for floats that are flagged by the altimetry SLA/DHA qc, and provide feedback to Stephanie Guinehut. If a dead float is flagged by Stephanie and then investigated by an operator who confirms its PSAL_ADJUSTED is good, it can be taken off Stephanie's list for future flagging. Active floats that have new data that trip Stephanie's test should continue to be notified to DM operators, so the floats get further review.*

Action 9.1.2: *The altimetry qc has successfully detected a number of anomalies in real-time data. Stephanie's results should be presented at the next ADMT meeting so that the real-time DACs can be informed of these anomalies.*

Action 9.1.3: *All delayed-mode operators are reminded that they should communicate with their DACs to put bad floats on the grey list.*

Recommendation 9.2.1: *The meeting suggests that the GDAC should check that the HISTORY section is filled.*

Recommendation 9.2.2: *The meeting suggests that the GDAC should check that character strings do not contain ASCII null characters. Strings should be padded with 'space'.*

Question 9.2.3: *When the enhanced format checker comes into effect, what action will be taken on already-existing D files? What happens if a new/replacement D file fails a test and is rejected, when there is already an existing D file which is now out of date?*

Recommendation 9.2.4: *The delayed-mode group recommends that when real-time adjustments are applied (ie. DATA_MODE = 'A'), that the PARAM_ADJUSTED_QC fields should be filled with values from PARAM_QC.*

Action 9.2.5: *Annie Wong to update the Argo QC Manual to ensure there is sufficient emphasis that data mode 'A' applies to real-time data which may not have had any further checking (Discussion reported under 9.2b).*

Action 9.2.6: *Annie Wong to compose a letter to the AST summarising the concerns of delayed-mode operators on editing real-time qc flags, so that this topic can be discussed further at the next AST meeting.*

Recommendation 9.2.7: *The delayed-mode group suggests that it will be useful if the ARCs can compile a list of published papers describing climate change of water masses in their respective basins and make this list available on their webpages. Operators can then peruse the literature and be wary of local variability when carrying out sensor drift assessment.*

Recommendation 10.1.1: *For profiles without LATITUDE, LONGITUDE or JULD, operators are advised to fill the NetCDF files with interpolated x, y, t, then record position qc='8'. The profiles can then be put through WJO, BS, or OW to obtain a drift adjustment. The adjusted fields can then be filled.*

Action 10.2.1: *Annie Wong to update the Argo QC Manual with results from this workshop.*

Action 10.4.1*: Megan Scanderbeg to act as the coordinator between the AST and the delayed-mode group by sending summaries to the argo-dm-dm email list when resolutions are passed at AST meetings that affect the delayed-mode data stream.*

Action 11.1.1: *Van Wijk and Scanderbeg agreed to investigate how a web-based table could be done and to try to get a draft procedure up and running.*

Action 11.2.1: *Robbins to investigate hosting a code share site. All delayed-mode operators are encouraged to be more active in sharing technical information via the argo-dm-dm email forum.*

Action 11.3.1: *Wong to assemble all powerpoint presentations and related documents and lodge them on the meeting webpage http://prelude.ocean.washington.edu/dmqc3/info.html.*

Appendix – 2 List of workshop participants

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Appendix – 3 Final adopted Agenda

Third Argo Delayed-Mode Quality Control Workshop (DMQC-3)
University of Washington
Wednesday 10 September to Friday 12 September 2008
Convenors

Annie Wong, UW, Seattle, USA
Brian King, NOC, Southampton, UK

Convene at 0900 on Day 1. Detailed timing to be agreed at the workshop. Names in brackets indicate the persons who will contribute to the topic.

1) Introduction

1.1) Welcome and local arrangements (Riser)
1.2) Review history from DMQC-1 and DMQC-2 (Wong)
1.3) Define goals of DMQC-3 (King/Wong)

2) Progress with Argo delayed-mode processing

2.1) Overall status of D files at the GDACs (King)
2.2) Report on status at each delayed-mode group, to include identification of any major reasons for hold-ups and problems that need to be addressed during the workshop if not already on the agenda. (all dmqc operators)

3) Review known instrument errors and sensor failure modes

3.1) APEX floats (Swift)
3.2) SOLO floats (Scanderbeg)
3.3) PROVOR floats (Thierry)

4) Delayed-mode qc and adjustment for PSAL

4.1) SIO Matlab GUI (Scanderbeg)
4.2) JAMSTEC tool for comparison with nearby CTD/float data (Kobayashi)
4.3) Conductivity cell thermal mass inertia correction to salinity (Johnson)
4.4) WJO, BS, OW float salinity calibration tools (Wong)
4.5) Review consistency of dmqc adjustments to PSAL (King)
Application of cell thermal mass adjustment.
Choice of PSAL offset. Choice of PSAL_ADJUSTED_QC.
Choice of PSAL_ADJUSTED_ERROR (from manufacturer & lab calibration, instrument accuracy, statistical method).

5) Regional oceanography for PSAL dmqc – towards consistency in setting calibration parameters and recognising oceanographic features

What theta/pressure range to use? What mapping scales? PV or no PV?
What are some of the frontal features that can be confused as instrument error?
What difficulties have encountered? Examples of comparison between WJO, BS, OW.

5.1) Pacific
- results from JAMSTEC (Nakamura)
- Gulf of Alaska (Ouellet)
- Tasman Sea surrounds (Gilson)

5.2) Atlantic
- equatorial, subtropical N, subtropical S Atlantic (Robbins)
- results from North Atlantic (Thierry)
- Med Outflow (Klein)

5.3) Indian - equatorial Indian, Bay of Bengal, Arabian Sea (Joseph)
- Indonesian Throughflow region (van Wijk)
5.4) Southern Ocean (van Wijk, Klein)
5.5) Marginal seas - Mediterranean Sea (Notarstefano)

6) Reference database for PSAL dmqc

6.1) The centralised Argo reference database at Coriolis (Coatanoan)
6.2) Including "good" Argo data in the reference database
Results from SIO (Gilson)
Results from JAMSTEC (JAMSTEC)
6.3) Other regional efforts (?) Marginal seas (?)

7) Delayed-mode qc and adjustment for PRES

7.1) Review consistency of dmqc adjustments to PRES (King/Wong)
SURFACE PRESSURE in APEX floats (Swift)
7.2) Recommendation from the AST pressure working group (Wijffels)
7.3) Preliminary results of laboratory test on Druck pressure sensor drift/hysteresis (JAMSTEC)

8) Delayed-mode qc and adjustment for TEMP

9) Interaction with real-time qc, regional qc, and the GDACs

9.1) Using satellite altimetry data in Argo qc (Guinehut)
9.2) Open discussion (all dmqc operators)
- interaction with real-time qc: real-time PSAL adjustment;
reviewing & editing real-time qc flags
- interaction with regional qc: how to review the quality of dmqc data
- interaction with the GDACs: format checker (Ignaszewski)

10) Miscellaneous issues

10.1) Recording delayed-mode information in the Argo NetCDF files
Profiles without lat, long, juld; SCIENTIFIC_CALIB section; HISTORY section
10.2) Argo QC Manual; Argo Data User's Manual
10.3) argo-dm-dm@jcommops.org email list
10.4) Others

11) Summary and Discussion

Open discussion (all)
"Strategies for future monitoring and assurance of consistency"
Workshop summary (Wong/King)

We *hope* to conclude the workshop by lunch time on Friday, so that people can use Friday afternoon for one-on-one discussions and demos.