

ARGO



REPORT ON
FIRST ARGO DELAYED-MODE QC WORKSHOP

LA JOLLA

8-13 APRIL 2005

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1. Objectives of the workshop

The First Argo Delayed-Mode QC Workshop was hosted by Scripps Institute of Oceanography at La Jolla. Co-chairs B. King and A. Wong welcomed the participants to La Jolla. The co-chairs reiterated the objective of the workshop as to standardize all aspects of the delayed-mode qc process. The workshop was divided into Phase I and II. Phase I discussions concentrated on mechanistic implementation of standard salinity qc softwares and other procedural issues. Phase II discussed in details the scientific rationale behind float salinity adjustments and related issues. Although the majority of the workshop was devoted to issues relating to salinity, delayed-mode qc procedures on pressure and temperature were also discussed. Finally, a realistic assessment was made as to the timely dissemination of Argo delayed-mode data.

This report is a summary of the discussions conducted and decisions reached at the workshop. Topics are arranged into Phase I and II, in order of discussion.

PHASE I (8-9 April 2005)

2. Subjective evaluation

The purpose of this item was to review the need to conduct subjective evaluation of the three major parameters measured by Argo: PRES, TEMP, and PSAL. It has been observed that very often erroneous data points cannot be detected by the real-time tests, or good data points are flagged wrongly by the real-time tests. These ought to be rectified in delayed-mode and is done by visual inspection of vertical profiles. Coriolis presented a scheme of using residuals from objective maps to alert the delayed-mode operator to possible erroneous data points. In future, it may be possible to make such information available to all DACs. However, subjective assessment of the residuals is still needed.

All delayed-mode operators therefore agreed that the first step in the delayed-mode qc process was to undertake visual/subjective assessment of TEMP versus PRES, PSAL versus PRES, PSAL versus TEMP, and PSAL versus density. It was recommended that this assessment be done in relation to measurements from the same float, as well as in relation to nearby floats and historical data. The assessment will aim to identify: (a) erroneous data points that cannot be detected by the real-time tests, and (b) vertical profiles that have the wrong shape.

Bad data points identified by visual inspection from delayed-mode operators are recorded with PARAM_ADJUSTED_QC = '4'.

The real-time density inversion test was then discussed. This test needs to be improved because it sometimes selects the wrong data points when vertical gradients are weak (e.g. the mixed layer). All delayed-mode operators are encouraged to pay special attention in

their visual evaluation where density inversions take place. S. Pouliquen emphasized the need for similar experience gained from the delayed-mode operation to be reported back to the real-time groups for improving the real-time qc. Some delayed-mode operators echoed the need to know the specific real-time tests that have failed or passed. As an aside, it was noted that some multi-profile files have been arranged in alphabetical order and so not necessarily in sequential order.

ACTION 1: B. King and A. Wong to ask the ADMT (i) to improve the real-time density inversion test, with input from interested scientists; (ii) to instruct DACs to include information about the real-time qc test failures in the HISTORY section of the netCDF files; and (iii) to instruct DACs to arrange the multi-profile files in sequential manner according to cycle number.

3. WJO or BS: which is appropriate in which ocean basin?

Discussions were held regarding the differences between the two softwares for salinity adjustment: WJO (Wong, Johnson, Owens, 2003) and BS (Bohme, Send, 2005). WJO estimates background salinity on a set of *fixed* theta levels, taking into account spatial and temporal scales, from a reference database that has been pre-interpolated. BS estimates background salinity on a set of *selected* depth levels, taking into account spatial and temporal scales, as well as a potential vorticity scale, from a reference database that contains the raw profiles without pre-interpolation. J. Gilson commented that in the open Pacific, the two softwares produced the same results. Z. Liu also showed an example in the western North Pacific that confirmed the identical results from the two softwares in that region.

It was agreed that for the subpolar North Atlantic, BS should be used for its better handling of topography, weak vertical stratification, and multiple water masses on common isotherms. Both WJO and BS will work in the Southern Ocean if there is sufficient historical data, but data sparsity is a problem. Either method can be used elsewhere.

The inconvenience and inefficiency for delayed-mode operators to use two sets of softwares for salinity adjustment was voiced. U. Send urged that all delayed-mode operators used the same software for the purpose of achieving a common qc standard. It was agreed that some effort will occur in US Argo to move towards a unified software.

ACTION 2: B. Owens and A. Wong to work on a unified software that combines the good features from both WJO and BS.

4. Sliding window

Coriolis presented a report on their delayed-mode salinity adjustment experience. It is suggested that when sensor drift occurs in a float series, that the series should be split so that the sensor drift segment does not contaminate the stable segment. Within each separate float series segments, an appropriate length for the sliding window should then be determined. D. Roemmich cautioned against the use of a short window, because the resulting adjustment will be subjected to effects of short-term natural variability. It was therefore confirmed that a long (+/- 6 months minimum) window should be used wherever possible. Short windows (e.g. +/- 1 profile) are to be used only when absolutely necessary.

Questions were then raised as to how to divide a float series into discrete segments. U. Send pointed out that manual division of float segments by delayed-mode operators is a subjective process, and it would be desirable to eliminate as much subjectivity as possible. B. Owens volunteered to contribute an objective method for dividing float series into discrete segments.

It was then agreed that *in the absence of expert intervention*, that the default sliding window remains +/- 6 months. The default sliding window of +/- 6 months implies a natural delay in the production of D files. The delayed-mode operator can leave a longer delay in publishing D files for difficult floats where the behaviour is not easy to categorize. The delay may be shorter than 6 months if the float is very well behaved.

In cases where the delayed-mode operator has the capacity to produce intermediate files, he/she may choose to apply corrections and record them in PSAL_ADJUSTED right up to the most recently-available profile, and submit recent profiles as an R file with DATA_MODE = 'R'.

It was also noted that the length of the sliding window, together with other adjustment parameters, should be recorded in the netCDF files. A. Wong mentioned that there was a parameter called SCIENTIFIC_CALIB_COMMENT in the Argo netCDF files, that was a character string 256 in length, that could be used to record such information. However, this is a multi-dimensional parameter, so care should be taken when writing into this parameter.

ACTION 3: B. Owens to explore objective methods for dividing float series into discrete segments and to make code available.

ACTION 4: A. Wong to prepare code to record details of sliding window and other computational parameters (e.g. mapping scales) into SCIENTIFIC_CALIB_COMMENT.

5. Mapping scales

A. Wong presented some experimental results of using different spatial decorrelation scales in the objective estimation of climatological salinity. In the *open* low- and mid-latitude basins, at the tightest part of the θ -S curve, the values of objective mapping estimates are not sensitive to the choice of mapping scales, but the error bars are. So far the group experience has been that the default spatial scales of 8/4 and 4/2 do not seem to produce blatantly wrong error bars.

It was therefore agreed to continue to use the current default spatial scales of 8/4, 4/2 in *the open ocean*, until such time as scientifically-derived evidence is produced that other scales should be used instead. Special regions such as the subpolar North Atlantic and the Arabian Sea will require regional experts to determine a suitable set of spatial decorrelation scales.

U. Send remarked that the present use of the CFC-based time scales as the default temporal decorrelation scales was less than ideal in many regions, such as the subpolar North Atlantic. However, there is no alternative proposal on offer at present, except for the mooring-based estimates developed by BS in the subpolar North Atlantic. It was therefore agreed to continue to use the present CFC-based time scale as the default, until a more ideal set of temporal decorrelation scales became available.

6. Diagnostic plots and tools

J. Gilson demonstrated the use of the Scripps Matlab GUI for viewing and editing Argo netCDF files. The value of the Scripps GUI in conveniently showing comparison of real-time and proposed delayed-mode data with nearby Argo and historical data was emphasized. This is especially important for float measurements that are stable but show a constant average offset from climatology. Comparison with nearby Argo data often confirm that these Argo floats are measuring real ocean signals, and that historical data are old and so do not adequately reflect decadal changes.

Various people presented diagnostic plots of their ‘difficult’ floats. The value of inspecting anomaly/drift/variability at all depths and water masses, especially on ‘difficult’ floats, was emphasized. B. King demonstrated the use of salinity anomaly time series plots for distinguishing genuine ocean variability from sensor errors, and for identifying parts of the water column that should be excluded from salinity adjustment computations (e.g. the mixed layer).

7. Mechanistic process for handling generic float behaviours

Coriolis presented a report on some of the more common float behaviours that they have encountered in their delayed-mode experience. S. Joseph, T. Tchen, B. King and A. Wong attempted to lay out a point-by-point 'cookbook', in other words the mechanistic process, for handling these generic float behaviours. The following step-by-step procedure has been accepted as the agreed mechanistic process for handling generic float behaviours.

- 1) Identify different regimes in float series. These can be:
 - Stable measurements (no sensor drift), including constant offsets.
 - Sensor drift with a constant drift rate.
 - Transition phase (drift rate changing, e.g. 'elbow region' between stable measurement and constant drift; e.g. initial biocide wash-off).
 - Spikes.
- 2) Split float series into discrete segments according to these different regimes or when there are many missing cycles.
- 3) Choose length of sliding window for each segment. These can be:
 - Long window (+/- 6 months or greater) for stable regime, or highly variable regimes where a long window is required to average over oceanographic variability to detect slow sensor drift, or period of constant drift rate.
 - Short window (can be as short as +/- 10 days) for transition phase.
 - Zero length window for spikes. That is, adjust single profile.
- 4) Select temperature levels for exclusion from calibration fitting (e.g. seasonal mixed layer; highly variable water mass levels such as Mediterranean Water).
- 5) Calculate proposed correction within each segment.
- 6) Evaluate proposed correction, and submit to PI.

It was suggested that if a single profile was adjusted because of a spike in the time series, then PSAL_ADJUSTED_ERROR should be the greater of [fitting error for that profile] and [difference between the long-term adjustment and the actual adjustment for that profile].

It was also suggested that parameters from this mechanistic phase should be stored in the Argo netCDF files. These parameters can include: cycle numbers for the start and end of the calibration series for each profile adjustment; levels omitted from the fit; etc.

8. Reference datasets

A. Wong summarized the reference datasets currently used by various delayed-mode groups:

- | | |
|----------------|--|
| North Atlantic | <ul style="list-style-type: none">- Christine: WOD2001 (ctd only) + Lars addition;- Ron Perkin: WOD2001 + Labrador Sea addition (soon);- Annie: WOD2001. |
| South Atlantic | <ul style="list-style-type: none">- Christine: WOD2001 + French addition;- Annie: WOD2001. |
| Indian Ocean | <ul style="list-style-type: none">- Sudheer: WOD2001 + Bay of Bengal addition;- Rebecca: WOD2001 (ctd only) + SOC 32°S line from 2002;- Annie: WOD2001 + SOC 32°S line from 2002;- CSIRO: Indonesian Throughflow region?? |
| North Pacific | <ul style="list-style-type: none">- JAMSTEC: SeHyd;- Ron Perkin: WOD2001 + IOS addition (soon);- John Gilson: WOD2001;- Annie: WOD2001;- China, Korea: WOD2001?? |
| South Pacific | <ul style="list-style-type: none">- John Gilson: WOD2001;- Annie: WOD2001. |
| Southern Ocean | <ul style="list-style-type: none">- Rebecca: WOD2001 (ctd only);- Annie: WOD2001 |

The issue of how to achieve a uniform and up-to-date reference database was discussed. There is currently no prospect of a coordinated/common-format basin-scale reference database in the near future. ADMT and RDACs are to be asked to progress on this issue by the ADMT meeting in Nov 2005. Until then, delayed-mode operators are urged to make a good effort to share data updates and maintain contact with other operators in their region of interest.

It was again emphasized that in data sparse areas, nearby float data should be used to evaluate the reliability of the proposed WJO/BS adjustment.

It was noted by S. Joseph that INCOIS had access to a significant body of data that were not public and could not be shared at present. S. Joseph would be willing to apply WJO to floats in the Bay of Bengal using these reference data, and return the results to other delayed-mode operators for assessment and float adjustment.

Further discussion on this topic was undertaken during Phase II.

9. DMQC for PRES and TEMP

It was noted that some delayed-mode groups that had extra information on surface pressure performed delayed-mode adjustments on PRES if needed, by comparing measured surface pressure and 0.0 dbar.

Coriolis reported making a PRES adjustment on 18 out of approximately 400 PROVOR floats based on sea surface pressure measurements. Coriolis will advise other PROVOR users of a maximum threshold for making PRES adjustments that will allow most profiles to pass but will identify bad profiles in the tail of the distribution. If the threshold is exceeded, PRES_ADJUSTED_QC = '4'.

Coriolis is exploring the possibility of detecting TEMP drift by comparing TEMP profiles with objective maps.

All operators agreed to fill _ADJUSTED, _ADJUSTED_QC and _ADJUSTED_ERROR for PRES and TEMP, even when no adjustment is made.

It is emphasized that it is PRES_ADJUSTED and TEMP_ADJUSTED that are used for DMQC of PSAL.

Unless we know better, PRES_ADJUSTED_ERROR is the manufacturer's calibration uncertainty. The CALIB section is used to state the source of this error estimate. If surface PRES is reset to zero for each profile (e.g. automatically in the float so that this forms part of the raw data), it should be stated in SCIENTIFIC_CALIB_COMMENT.

TEMP_ADJUSTED_ERROR is the manufacturer's quoted accuracy at deployment of float. It was agreed that we would quote a fixed error that does not increase with time. SCIENTIFIC_CALIB_COMMENT should therefore contain such wording as: "Calibration error is manufacturer specified accuracy at time of laboratory calibration".

If PRES_ADJUSTED_QC is '4', then TEMP_ADJUSTED_QC and PSAL_ADJUSTED_QC should also be set to '4'.

There is no need to recompute PSAL when PRES is adjusted in delayed mode. Any salinity offset that may result from PRES adjustment can be reflected in PSAL_ADJUSTED.

As an aside, S. Minato presented operations within JAMSTEC to repair positions and time with post real-time data. It is these repaired LONGITUDE, LATITUDE and JULD that are used in DMQC in JAMSTEC.

ACTION 5: B. King to refer question of PRES errors in APEX floats to the APEX Workshop, to be held at the University of Washington in September 2005. Also, B. King to request that APEX floats be modified to report surface pressure, if they don't already, and reset it to surface pressure.

10. Assessment of progress in delayed-mode processing

Most delayed-mode groups expect to be up-to-date with ‘available’ profiles in areas with expertise and reference data by end of 2005.

11. Miscellaneous format issues

A. Wong proposed for writing Argo netCDF files, that:

For all float salinity that are considered unadjustable in delayed-mode

- PSAL_ADJUSTED = FillValue;
- PSAL_ADJUSTED_ERROR = FillValue;
- PSAL_ADJUSTED_QC = ‘4’.

To be consistent with PSAL_ADJUSTED, data points with TEMP_ADJUSTED_QC = ‘4’ or PRES_ADJUSTED_QC = ‘4’ should also be filled in similar fashion. That is, when PARAM_ADJUSTED_QC = ‘4’,

- PARAM_ADJUSTED = FillValue;
- PARAM_ADJUSTED_ERROR = FillValue;

The proposal was accepted.

Lastly, B. King proposed that the GDACs should carry out basic checks on the contents of the delayed-mode files, such as CALIBRATION_DATE is filled, etc., in addition to their routine netCDF file format checks.

ACTION 6: B. King to talk to Mark Ignaszewski to include some kind of basic content check for delayed-mode netCDF files in FNMOC’s format check routines.

PHASE II (11-13 April 2005)

12. Reference database and RDACs

The question on how to achieve a uniform reference database for float salinity adjustment was again discussed during Phase II. It was reiterated that there was currently no central guardian and exchange mechanism for reference datasets. In the short term we will continue the present situation of delayed-mode operators using ad hoc addition of recent CTD data in data sparse areas. Exchange will be based on personal communication.

In the longer term, RDAC efforts to update basin-scale datasets need to be better coordinated. Discussions were held as to what guidelines the DMQC Workshop could provide to the RDACs on the collection of data for use in salinity delayed-mode qc. The workshop participants concluded that the following would be proposed to the RDACs:

- 1). That the most recent version of World Ocean Database (WOD) published by NODC be used as the primary reference database for salinity delayed-mode qc.
- 2). For recent CTD data from cruises that occur in between new releases of WOD, that the PIs should take the initiative to notify the relevant RDACs of data they have collected. If PIs are aware of data collected on other cruises, they should notify the relevant RDACs, who will then liaise with AIC to obtain the data.
- 3). For old data that are not submitted to NODC, if RDACs are aware of historical data in data sparse regions, these should be added to reference datasets. The data will need to be subjected to quality control. RDACs are not required to submit these data to NODC themselves; they can notify NODC of their existence and availability.
- 4). For data already in WOD, RDACs are asked to keep track of data which are considered unsuitable for Argo salinity delayed-mode qc and which have been removed from reference datasets, so that they can be quickly removed from future releases of WOD.

ACTION 7: Coriolis (i) to have ready by the next ADMT a proposal for managing and formatting reference datasets to include a unique data ID and metadata; and (ii) to host a central location to provide access of latest copies of reference datasets, such as SeHyd.

ACTION 8: A. Wong and/or B. King to communicate DMQC Workshop proposals to the RDACs at the next convenient venue.

13. Adjustment of salinity in real-time

We acknowledged that there was a lot of user demand for real-time salinity adjustment. We therefore proposed that salinity be adjusted in real time, both for GTS messages and for real-time netCDF files. The adjusted value will go in PSAL_ADJUSTED. Data mode and file name will remain as 'R'. However, it was also noted that the method for applying salinity adjustment in real-time could not be finalized until further studies were conducted.

ACTION 9: Coriolis and Meds to undertake hindcast studies to investigate the best and most practical way of applying salinity adjustment in real-time. These can be extrapolation using offset and drift rate from the last delayed-mode assessment. They will also conduct investigation of a threshold above which a float should go on the grey list. A proposal will be put forward in the next ADMT meeting to be discussed with real-time operators.

ACTION 10: ADMT co-chairs to write to DACs to ask them to consider how to implement salinity adjustment in real-time, so that it can be implemented soon after the next ADMT meeting if approved.

14. More diagnostic tools

The following diagnostic tools were presented and discussed.

- 1). Residuals from objective mapping (V. Thierry).
- 2). Salinity anomaly time series contour plot (B. King).
- 3). Visual check of float trajectory with reference to oceanographic features such as eddies and rings (B. Klein).
- 4). Use of gridded products such as the online plots at NODC (A. Wong).

There was a request to include overlay of trajectory on background gridded salinity fields in the Scripps GUI.

15. Sensor behaviour/failure modes

The following sensor failure modes and the related sensor behaviours were described.

- 1). TBTO leakage: this will result in fresh offsets in float series that usually gets washed off. Delayed-mode operators should pay special attention to the shape of the salinity profiles at the beginning of the float series if TBTO leakage is suspected.

2). Pollution events: these will result in fresh measurements. When pollution washes off, reversal of drift trend can occur. Delayed-mode operators need to be careful in splitting float series.

3). Cell geometry change causing electrodes to change distance: this will cause either an increase or decrease in salinity measurements.

4). Low voltage at end of float life or Energy Flu: both of these will cause spiky erratic measurements, which will make it difficult to determine where to split the series and how to fit a slope. Towards the end of float life, low voltage will result in large drift, followed by death, and Energy Flu will cause spikes that get worse and more frequent, also followed by death.

5). Be careful not to confuse water mass change during float path with sensor problem.

V. Thierry voiced the need for better communication with Seabird so that delayed-mode operators could be better informed of what sensor failure modes to expect as floats age.

16. Generic salinity adjustment

The workshop then discussed methods for adjusting generic salinity trends that were due to sensor errors. For the mechanistic procedures to calculate a proposed adjustment, participants were asked to refer to Phase I summary (see Item 7).

PIs should first determine whether a proposed statistical adjustment is due to sensor error or ocean variability. They should refer to all available independent information, and should inspect as long a float series as possible. If the PI is confident that the sensor is in error, the threshold for making an adjustment is 2 times whatever is reported in PSAL_ADJUSTED_ERROR. By default this will be the error from the statistical method, but PIs can provide an alternative estimate of uncertainty if they have a basis for doing so. There is a further lower bound on the size of an adjustment which is the instrument accuracy.

Adjustments should be continuous and piecewise linear within error bars, except where the PI believes there is a genuine discontinuity. If necessary, the salinity adjustment from two data segments should be extrapolated to the point of intersection.

For large offsets or drifts and extreme behaviour: If the relative vertical T-S shape does not match good data, then PSAL_ADJUSTED_QC = '4' and PSAL_ADJUSTED and PSAL_ADJUSTED_ERROR = FillValue. If the relative vertical T-S shape is close to good data, then the best estimate of the adjustment is made. If the PI is not confident that PSAL_ADJUSTED is good, then PSAL_ADJUSTED_QC can be set to '3'. The PI can assign a large value to PSAL_ADJUSTED_ERROR.

At present, there is no maximum threshold for the magnitude of salinity adjustment.

17. Non-generic behaviour of proposed salinity adjustment

If the proposed salinity adjustment has non-generic behaviour (e.g. oscillations in and out of agreement with climatology), this will often be caused by the float sampling oceanographic features (eddies, fronts, seasonal anomalies, etc) that are not described in the reference database. Delayed-mode operators should look carefully at the choice of levels included or excluded from the statistical fit, and use long sliding windows to average over oceanographic noise. If there is doubt about whether the proposed adjustment is appropriate, the submission of a D file should be delayed. The best available guess can be included in PSAL_ADJUSTED and submitted as an R file with DATA_MODE = 'R'.

Delayed-mode operators should exchange experience of non-generic proposed salinity adjustments.

ACTION 11: Delayed-mode operators and PIs agreed to review the salinity adjustments submitted so far, and prepare and submit new D files where necessary. Revised D files submitted before 1 January 2006 can be written with a single new HISTORY entry. After that date, HISTORY must be accumulated. The latest revision date will be recorded in CALIBRATION_DATE and DATE_UPDATE.

ACTION 12: A. Wong to revise the User Manual, the QC Manual and the Gould simple users guide to reflect latest agreed delayed-mode practice as well as to warn users that delayed-mode data are regularly updated. A section on float behaviour/failure modes is to be included in the QC Manual.

ACTION 13: B. King to ask GDACs to consider the issue of version control of data.

ACTION 14: A. Wong and B. King to prepare a short article for the next Argonautics about the conclusions of the workshop. They will draft a short statement to appear on the GDAC sites concerning the need for users to be alert to the version control issue.

18. Use of recent data in DMQC of salinity

Discussions were held as to how best to use recent data in salinity adjustments. There are two categories of recent data: recent shipboard CTD data, and nearby Argo data.

We will continue to use shipboard CTD data calibrated to an absolute standard as the primary source of reference data. See discussions in Item 12.

We will use nearby Argo data in two ways:

- 1). Visual comparison as a diagnostic (e.g. within the Scripps GUI).
- 2). Use in statistical methods, but identified as a separate source which can be switched on and off.

The following guidance was noted:

- a). There should be at least one pass of WJO/BS for which the reference database contains CTD only.
- b). When float data are included, we should use only profiles which have a zero salinity adjustment, i.e. with no known sensor problems.

ACTION 15: Experiments of inclusion of Argo data in delayed-mode salinity adjustment to be undertaken and reported to next ADMT and AST by S. Joseph and A. Wong for Arabian Sea; B. King for Southern Ocean; B. Klein for the Weddell Sea; V. Thierry for the North Atlantic.

ACTION 16: AST co-chairs to discuss/clarify with NODC which Argo profiles should be included in the next release of WOD.

19. Quality assurance of the Argo DMQC process

B. King noted that there needed to be an assessment across the Argo program of the consistency of application of DMQC procedures and adjustments. It was agreed that delayed-mode operators would make the diagnostic plots used in the salinity adjustment process available to other operators via email or FTP. As experience grows, the need for a central repository will be assessed.

ACTION 17: D. Roemmich to ask the AIC to compile statistics on the percentage of eligible profiles that have been submitted with DATA_MODE = 'D'. Profiles older than 15 months are considered 'overdue'.

20. Thermal inertia lag

G. Johnson presented a conductivity sensor error termed "thermal inertia lag". Salinity reported immediately after a float has crossed a strong thermal gradient can be in error as a result of conductivity cell thermal mass. This error arises because of heat exchange between the conductivity cell and the water within it. Float transit from cold to warm water can result in fresh errors, and from warm to cold in salty errors. These errors can exceed Argo salinity accuracy specifications (error > 0.01 PSS-78) for strong thermal gradients, and sometimes result in unstable fresh spikes at the base of the mixed layer.

While there is at present no general algorithm for correction of these artifacts, delayed-mode operators should be aware of the nature of the problem.

21. Other items

1). The issue of sampling depth for Argo floats was raised because for the purpose of delayed-mode salinity qc, it was desirable to have the sampling depth be as deep as possible. The study by Kobayashi et al. on the impact of variable-depth profiling (PnP4 sampling) on DMQC of salinity in the North Pacific was noted. The workshop welcomed comparable studies in other basins. The Kobayashi et al. study was considered a good model of how to analyze and report the data. Coriolis may undertake such a study in the North Atlantic.

ACTION 18: AST to include the topic of variable-depth profiling on the agenda of the next AST meeting.

ACTION 19: B. King to ask AIC if they can easily produce a map showing distribution of floats with a variable-depth profiling strategy.

2). The role of RDACs in DMQC was briefly discussed. Since all national programs are now undertaking the responsibility of doing their own DMQC, it was suggested that RDACs could aid in the DMQC process by taking on orphan floats or brokerage them to other national programs.

3). The delayed-mode comment for qc flag '3' was modified.

ANNEXES

Annex 1 – List of workshop participants

Phase-1 (8-9 April 2005): total of 16 people

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Phase-2 (11-13 April 2005): total of 19 people

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Annex 2 – Agenda for Phase-I, First Argo DMQC Workshop, Friday 8 – Saturday 9 April 2005, Scripps Institute of Oceanography, NTC 330

The timings on this agenda are flexible, but suggest the approximate amount of time we can afford to spend on each topic if we are going to cover all the items in the total time available.

Please come prepared to show examples of problems found and solutions that you have developed. *Problems require proposed solutions* that can be adopted and applied consistently across the array.

The overall objective of the workshop is to ensure that DMQC operators and PIs have agreed procedures that will enable them to process and release the majority of float profiles (>90%) in a routine manner, with agreed strategies in place for handling the remaining profiles.

Key objectives/questions during Phase-I

- Standardize tools used for dmqc of PSAL: implementation of WJO and Boehme-Send (BS) software; review of extensions/modifications introduced by operators; discuss the sliding window issue and adopt uniform mapping scales in regions; interpretation of diagnostic plots. Use of Scripps' Matlab GUI.
- Identification of generic float behaviours; agreement on how to handle them.
- Reference datasets; protocols for updating and sharing them.
- DMQC of PRES and TEMP. Agree to issue PRES_ADJUSTED and TEMP_ADJUSTED, with QC and ERROR for all profiles. As with PSAL, these fields should be filled even when the dmqc process suggests no correction is required.
- Review of timescale for operators to complete dmqc of 'majority of floats'; feedback to real-time.

Friday, 8 April

Fri 0830 - 0845 Introduction

Review of agenda; identification of other issues requiring discussion during Phase-I.

DMQC for PSAL

Fri 0845 - 1000 1. PSAL Methods

- 1.1 Subjective evaluation by operators to identify bad PSAL.
- 1.2 WJO or BS: which is appropriate in which ocean basin?
- 1.3 Review extensions/modifications to WJO/BS introduced by operators.

Fri 1000 - 1030 2. Sliding window and mapping scales

- 2.1 Review of options on sliding window; discussion of operators experience and experiments; formulation of recommendation for discussion/agreement at Phase II.
- 2.2 What mapping scales do operators find to be effective in which regions ? Low-, mid-, high- latitudes ? Special regions ? The objective is to ensure that scales are used consistently by different operators applying dmqc in the same region.

Fri 1030 - 1100 Morning Break

Fri 1100 - 1230 2. Sliding window and mapping scales (continued)

Fri 1230 - 1330 Lunch

Fri 1330 - 1530 3. Interpretation of diagnostic plots

- 3.1 Review of diagnostic information used. Operators to report on local tools used alongside WJO and BS. Illustration using real-time work on laptops or using screenshots. Scripps Matlab GUI.
- 3.2 How to judge whether floats are good, have single calibration offset or have sensor drift. Operators to show examples of generic or difficult behaviours, where care was needed to avoid a wrong conclusion.
- 3.3 Discuss how to adjust generic float behaviours.

Fri 1530 - 1600 Afternoon Break

Fri 1600 – end 3. Interpretation of diagnostic plots (continued)

Saturday, 9 April

Sat 0830 - 1030 4. Reference datasets

Review of enhanced regional datasets in use;
DMQC operators should be prepared to explain or demonstrate what they have done to create enhanced/cleaned up datasets

- 4.1 Pacific
- 4.2 Indian
- 4.3 Atlantic
- 4.4 Southern
- 4.5 Protocol for documenting reference datasets used
- 4.6 Protocol for sharing enhanced datasets
- 4.7 Inclusion of recent CTD data

Sat 1030 - 1100 Morning Break

Sat 1100 - 1230 5. Assignment of PSAL ADJUSTED QC and PSAL ADJUSTED ERROR

- 5.1 Review of what to do when WJO/BS fails and adjustment/QC/ERROR are assigned subjectively or using other methods.

Sat 1230 - 1330 Lunch

Sat 1330 - 1430 6. DMOC for PRES

- 6.1 Which groups attempt dmqc for PRES and on which platforms ?
6.2 Which platforms send extra engineering data and/or surface pressure that can be used ?
6.3 What data are available to operators for adjusting pressure ?
6.4 What indications of bad PRES are available if the operator has to rely only on subjective evaluation ?
6.5 What is the PRES_ADJUSTED_ERROR if we have no other information ?
6.6 How should the CALIB section be filled ?
6.7 What percentage of floats require this correction ?

Sat 1430 - 1530 7. DMOC for TEMP

- 7.1 Which groups attempt dmqc for TEMP and on which platforms ?
7.2 Which platforms send extra engineering data that can be used ?
7.3 What data are available to operators for adjusting temperature ?
7.4 What indications of bad TEMP are available if the operator has to rely only on subjective evaluation ?
7.5 What is the TEMP_ADJUSTED_ERROR if we have no other information ?
7.6 How should the CALIB section be filled ?
7.7 What percentage of floats require this correction ?

Sat 1530 - 1600 Afternoon Break

Sat 1600 - 1630 8. Timescale for operators to process majority of floats for which they are responsible; feedback to real-time

- 8.1 Operators to be prepared to provide estimate of rate of future progress in their national program.
8.2 Feedback to real-time.

Sat 1630 – end 9. Miscellaneous format issues
10. Any other items
Summary/review

Annex 3 – Agenda for Phase-II, First Argo DMQC Workshop, Monday 11 – Wednesday 13 April 2005, Scripps Institute of Oceanography, T-29

The timings on this agenda are flexible, but suggest the approximate amount of time we can afford to spend on each topic if we are going to cover all the items in the total time available. Agenda numbering continues from Phase-I agenda.

Please come prepared to show examples of problems found and solutions that you have developed. Problems require proposed solutions that can be adopted and applied consistently across the array.

The overall objective of the workshop is to ensure that DMQC operators and PIs have agreed procedures that will enable them to process and release the majority of float profiles (>90%) in a routine manner, with agreed strategies in place for handling the remaining profiles.

Key objectives/questions during Phase-II

- Review and endorse agreed procedures from Phase-I, so that the most straightforward 90% of data can be processed and released in the near future.
- Review/revision of accept/reject criteria when evaluating diagnostics from statistical methods (1sd, 2sd, minimum thresholds). Agree on how to adjust generic float behaviours.
- Achieve uniform standards for PI evaluation and decision-making for the remaining 10% of Argo data.
- What do we do when dmqc of recent profiles suggests the dmqc of earlier profiles has not done the best job possible ? Do we revise previous dmqc files ?

Monday, 11 April

Mon 0830 - 0845 Introduction

Review of agenda; identification of other issues requiring discussion during Phase-II.

Mon 0845 - 1030 11. Summary/review of agreements from Phase-I; discussions, especially on reference datasets and sliding window

Mon 1030 - 1100 Morning Break

Mon 1100 - 1230 12. Criteria for decision to accept as good or apply adjustment

Need an agreed standard for judging what profiles are good and need no adjustment. This sets the tolerance for errors for Argo, and is what all operators rely on to make decisions. The current criterion of not adjusting values that are within 2 x uncertainty has proven to be inadequate.

12.1 'Routine' floats

12.2 'Unusual' floats. Discussion of these floats will inevitably be combined with the next agenda item.

Mon 1230 - 1330 Lunch

Mon 1330 - 1530 13. Discussion of tools and diagnostics that PIs use for decision making

PIs to be prepared to illustrate extra diagnostics they use or any other considerations in support of decision making that they regard as additional to steps performed by dmqc operators.

Mon 1530 - 1600 Afternoon Break

Mon 1600 - end 14. Generic float behaviours and their adjustments

Review of generic float behaviours identified during Phase-I. Agreement on how to handle drifts and jumps. Specific questions include:

- 14.1 Do these behaviours match what we know about sensor performance (eg. what known effects cause increase or decrease in salinity ? Under what circumstances should trends reverse ? Do we expect trends to be linear, exponential, etc over time)? PIs and dmqc operators be prepared to show examples.
- 14.2 Discuss how to adjust generic float behaviours. Agreement on what to do when a float previously thought to have a zero or stable offset is now shown to have had a uniform drift from a much earlier time. The need to avoid 'jumps' in PSAL_ADJUSTED when a float offset moves outside a threshold.
- 14.3 Is there a maximum error/drift rate beyond which we should not attempt to make an adjustment ?

Tuesday, 12 April

Tue 0830 - 1030 14. Generic float behaviours and their adjustments (continued from Monday)

Tue 1030 - 1100 Morning Break

Tue 1100 - 1230 15. Use of recent data

- 15.1 Action to be taken when very recent CTD data are available (eg. deployment cruise CTDs).
- 15.2 What do we do when the suggestion from statistical methods disagrees with a small amount of recent data, especially in data-sparse areas ? (eg. offsets)
- 15.3 Need to agree on procedures for using nearby Argo data to assist with salinity adjustment decision-making. In many ocean regions, the quantity of nearby Argo data is now greater than the number of nearby approved reference stations.

Tue 1230 - 1330 Lunch

Tue 1330 - 1430 15. Use of recent data (continued)

Tue 1430 - 1530 16. Problem (non-generic) float behaviours

PIs and operators to be prepared to show examples and their proposed solutions.

- 16.1 How do we distinguish a real ocean event from an artifact due to sensor error ?
We have little knowledge of ocean events that occur on the time and spatial scales

sampled by Argo. Do we know enough about how sensors behave over time (see (14.1) above)?

16.2 Should we adjust float behaviours that are unexplainable?

16.3 How do we assign the ERROR parameters when statistical methods have failed?

Tue 1530 – 1600 Afternoon Break

Tue 1600 - end 16. Problem (non-generic) float behaviours (continued)

Wednesday, 13 April

Wed 0830 - 1030 17. Other issues

17.1 Thermal inertia lag

17.2 How much level-by-level qc and/or adjustment can we realistically do with the available manpower?

17.3 How to propagate errors using adjusted data in succession?

17.4 Adjustment of salinity in real time

17.5 Including Argo data in reference datasets

17.6 Role of RDACs in DMQC

Wed 1030 - 1100 Morning Break

Wed 1100 – 1230 17. Other issues (continued)

Wed 1230 - 1330 Lunch

Wed 1330 – 1430 17. Other issues (continued)

Wed 1430 - 1530 18. Summary

18.1 Make a realistic assessment of the time and human power needed to clear the backlog of delayed-mode data.

18.2 Agree timescale for dissemination of delayed-mode data.

18.3 Summarize agreements.

Wed 1530 - 1600 Afternoon Break and end of workshop

Annex 4 – First Argo DMQC Workshop action list

ACTION 1: B. King and A. Wong to ask the ADMT (i) to improve the real-time density inversion test, with input from interested scientists; (ii) to instruct DACs to include information about the real-time qc test failures in the HISTORY section of the netCDF files; and (iii) to instruct DACs to arrange the multi-profile files in sequential manner according to cycle number.

ACTION 2: B. Owens and A. Wong to work on a unified software that combines the good features from both WJO and BS.

ACTION 3: B. Owens to explore objective methods for dividing float series into discrete segments and to make code available.

ACTION 4: A. Wong to prepare code to record details of sliding window and other computational parameters (e.g. mapping scales) into SCIENTIFIC_CALIB_COMMENT.

ACTION 5: B. King to refer question of PRES errors in APEX floats to the APEX Workshop, to be held at the University of Washington in September 2005. Also, B. King to request that APEX floats be modified to report surface pressure, if they don't already, and reset it to surface pressure.

ACTION 6: B. King to talk to Mark Ignaszewski to include some kind of basic content check for delayed-mode netCDF files in FNMOC's format check routines.

ACTION 7: Coriolis (i) to have ready by the next ADMT a proposal for managing and formatting reference datasets to include a unique data ID and metadata; and (ii) to host a central location to provide access of latest copies of reference datasets, such as SeHyd.

ACTION 8: A. Wong and/or B. King to communicate DMQC Workshop proposals to the RDACs at the next convenient venue.

ACTION 9: Coriolis and Meds to undertake hindcast studies to investigate the best and most practical way of applying salinity adjustment in real-time. These can be extrapolation using offset and drift rate from the last delayed-mode assessment. They will also conduct investigation of a threshold above which a float should go on the grey list. A proposal will be put forward in the next ADMT meeting to be discussed with real-time operators.

ACTION 10: ADMT co-chairs to write to DACs to ask them to consider how to implement salinity adjustment in real-time, so that it can be implemented soon after the next ADMT meeting if approved.

ACTION 11: Delayed-mode operators and PIs agreed to review the salinity adjustments submitted so far, and prepare and submit new D files where necessary. Revised D files submitted before 1 January 2006 can be written with a single new HISTORY entry. After that date, HISTORY must be accumulated. The latest revision date will be recorded in CALIBRATION_DATE and DATE_UPDATE.

ACTION 12: A. Wong to revise the User Manual, the QC Manual and the Gould simple users guide to reflect latest agreed delayed-mode practice as well as to warn users that delayed-mode data are regularly updated. A section on float behaviour/failure modes is to be included in the QC Manual.

ACTION 13: B. King to ask GDACs to consider the issue of version control of data.

ACTION 14: A. Wong and B. King to prepare a short article for the next Argonautics about the conclusions of the workshop. They will draft a short statement to appear on the GDAC sites concerning the need for users to be alert to the version control issue.

ACTION 15: Experiments of inclusion of Argo data in delayed-mode salinity adjustment to be undertaken and reported to next ADMT and AST by S. Joseph and A. Wong for Arabian Sea; B. King for Southern Ocean; B. Klein for the Weddell Sea; V. Thierry for the North Atlantic.

ACTION 16: AST co-chairs to discuss/clarify with NODC which Argo profiles should be included in the next release of WOD.

ACTION 17: D. Roemmich to ask the AIC to compile statistics on the percentage of eligible profiles that have been submitted with DATA_MODE = 'D'. Profiles older than 15 months are considered 'overdue'.

ACTION 18: AST to include the topic of variable-depth profiling on the agenda of the next AST meeting.

ACTION 19: B. King to ask AIC if they can easily produce a map showing distribution of floats with a variable-depth profiling strategy.

Annex 5 – Revised qc flag table as of 13 April 2005

n	Meaning	Real-time comment	Delayed-mode comment
0	No QC was performed	No QC was performed	No QC was performed
1	Good data	All Argo real-time QC tests passed.	The adjusted value is statistically consistent and a statistical error estimate is supplied.
2	Probably good data	Probably good data	Probably good data
3	Probably bad data that are potentially correctable	Test 15 or Test 16 failed and all other real-time QC tests passed. These data are not to be used without scientific correction.	An adjustment has been applied, but the value may still be bad.
4	Bad data	Data have failed one or more of the real-time QC tests, excluding Test 15 and Test 16.	Bad data. Not adjustable.
5	Value changed	Value changed	Value changed
6	Not used	Not used	Not used
7	Not used	Not used	Not used
8	Interpolated value	Interpolated value	Interpolated value
9	Missing value	Missing value	Missing value

Annex 6 – Revised summary flowchart for salinity drift and offset qc procedures, as of 13 April 2005

Argo salinity sensor drift & offset QC procedures

