CLIVAR-GSOP Coordinated Quality-Control of Global Subsurface Ocean Climate Observations

International Quality-Controlled Ocean Database

Inaugural meeting

June 12-14, 2013
CSIRO Marine and Atmospheric Research
Hobart, Tasmania, Australia

http://www.iquod.org

Editors

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– with great help from notetakers, chairs and presenters.

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Report:

CLIVAR-GSOP Coordinated Quality-Control of Global Subsurface Ocean Climate Observations

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Workshop overview

Motivation:

The historical archive of global ocean subsurface temperature contains a large proportion of poorly quality-controlled as well as biased data. As a result, efforts to analyze past ocean change and variability are confounded, as is the use of ocean data assimilation systems (e.g. Bluelink, SODA, etc). Currently many data centers perform automated 'quick and dirty QC' – redoing the same job poorly many times around the world. There have been no previous efforts to form a clean and definitive and very much needed historical archive. No single group has the manpower and resources to do the job properly – thus international cooperation is needed.

Final outcome:

A high-quality historical subsurface ocean temperature (salinity) global dataset, along with the most complete metadata information and formal error measurements for climate research needs.

Workshop:

To start discussions on the internationally coordinated strategy to deliver and maintain a historical subsurface ocean temperature (salinity) archive of the highest quality possible, we will be holding an initial workshop in Hobart (12-14 June), with support from CLIVAR, US CLIVAR, and CSIRO.

We will discuss:

- Recovery and inclusion of metadata information;
- Examine the inclusion of salinity observations;
- The pros and cons of each data center's quality control methods and how to streamline these methods between global data centers;
- Get agreement on both QC and instrument bias issues and how to remove these from historical data archives.
- The implementation of the best agreed methods for each data type to ensure consistent quality control of the data;
- Funding sources for the duration of the project.

Also discussed will be:

- Do we intend to provide gridded products tailored to user requirements?
- Do we need to talk about establishing global DACs to serve the data (do we need a second backup GDAC?)?
- Ongoing QC of new data – we don't want to get to the end of the project and still have a set of data that is of inferior quality.

Workshop Outcomes:

- Definition and documentation of the scope, methodologies and timeline for the project;
- Agreement on the procedures required for the quality control of such a large dataset;
- Delegation of tasks to the global data centers to begin the data clean-up;
- A science and implementation plan for submission to CLIVAR for endorsement;
- Commitments to funding or pathways for application for funding for the life of the project.

Workshop Scientific Steering Committee

Nathan Bindoff, ACE CRC/CSIRO/IMAS/University of Tasmania, Australia
Tim Boyer, NODC NOAA, USA
Antonio Caltabiano, CLIVAR, UK
Catia Domingues (GSOP), Antarctic Climate and Ecosystems CRC, Australia
Simon Good, Matt Palmer (GSOP), MetOffice Hadley Centre, UK
Viktor Gouretski, Detlef Stammer, Centre for Marine and Climate Research, KlimaCampus, Germany
Katy Hill, Ocean Observations Panel for Climate, Switzerland
Masayoshi Ishii, Meteorological Research Institute and Japan Agency for Marine-Earth Science and Technology Japan
Rebecca Cowley, Ann Thresher, Susan Wijffels, CSIRO, Australia

Introduction, Background and Objectives

Session summaries

Session summaries are a collation of notes from various note takers, highlighting the main points of talks and discussions during each session. Some summaries written by the authors are also included. As such, these sections do not follow a standard format.

Sessions 1 and 2: Overview talks.

Session Chairs: Bec Cowley, Simon Good. Notetakers: Simon Good, Ann Thresher.

The motivation for the workshop was introduced by Susan Wijffels, followed by some provisional terms of reference (Catia Domingues). Two presentations followed from Tim Boyer (Building a global ocean database) and Simon Good (Relevant lessons from the ACRE and ICOADS Projects). After a break, Instrumentation types, biases and known issues were introduced by Tim Boyer, Viktor Gouretski, Shoichi Kizu and Jim Swift. The end users' perspectives were represented with talks from Alison Macdonald, Jim Swift and Peter Oke.

Key points from these presentations and from the discussion that followed can be summarised as:

- Users don't need to know data type – they just need an error bar.
- How to sell the activity. Need to articulate clearly the need to undertake this activity.
- Metadata and documentation is critical.
- Accurate uncertainty estmates should be a major goal.
- We need to have the trust of users that the QC is good.
- We need to use the knowledge of data providers and expert data users and incorporate their QC suggestions.
- We need to identify the things that users want - for example understand why some people don`t use WOD - and add those things.
- We need to be flexible - one day the scope of the project may expand.

In more detail:

- More and more science will be done with "off the shelf" ocean reanalyses. We know that these reanalyses preserve the bias errors in the input data.
- Metadata is critical and each instrument has it's own problems.
- Metadata is often inadequate in historical records and some effort may be required to retrieve information from old logs.
- Why are there different QC systems out there? What is it that some users want that they don`t get from WOD but that they get from other sources?
- Scientists will always want to do their own QC.
- It depends on how good the QC is - it is a matter of trust.
- There are different users - some may not want to use the result of a particular QC test.
- A single user couldn`t possibly do their own QC on a large database. At the moment some groups do have to do some work e.g. reanalysis groups doing work on biases.
- QC varies with data type and ideally originators would do the QC. However, we need a sanctioned scheme to QC data that has no QC.
- If we satisfy the most demanding users we will reach the broader community as well.
- If working in a specific region people will want their own QC because of their unique expertise about that region.
- Must have back and forth communication between users and dataset team.

- Need a standard format for data providers that allows originator QC to be included within the dataset.
- The emphasis of the project is things not in WOD - bias, uncertainty etc. and will be temperature only - a derivative of WOD.
- We are focussing on temperature now but one day we may want to add in salinity, chlorophyll etc.

Other groups are just getting started. The Glider people are moving forward with DACs and aiming for format consistency and common data handling procedures. This is getting up and running now, with Derrick Snowdon taking the lead.

Jim Swift pointed out that we need a scale of data accuracy in the metadata so can subset all data of millidegree accuracy. Susan Wijffels replied that error bars do this naturally.

Viktor Gouretski would like to know what the data system will look like – a modified WOD? More like Argo? Something completely new? We don't have that answer yet.

Susan Wijffels reiterated the need for an archive that is useful for climate studies – to allow us to detect decadal to multi-decadal signals. This doesn't exist at present and is the driving force behind this gathering, even if it doesn't end up being the only reason we are here.

People who are not here are also interested in contributing so we need to keep them engaged. This will bring in more data as well. And this is not a short term project. We talked about splitting it into pre vs post woce datasets, and getting people to provide data already subjected to our standardized processing… we need to break into chewable chunks and it's not clear how this will be done.

If we focus on climate quality data only, do we need to exclude some data types such as MBTs? These will take a lot of effort so is it something we need to tackle? And can we apply corrections to MBTs? Co-located CTD/MBT studies are rare. Most data (if it exists) would be bottles/MBTs. There are some co-located XBTs and MBTs in the database - perhaps. And we can possibly find some CTDs vs Nansen casts. But numbers in all cases will be severely limited.

It sounds like we need a validation task team as well as a data/qc task team. We need to learn from our mistakes as well, moving into the future. What are we doing for real time data NOW that might be improved?

Where are we starting? And where are we going?

Instrumentation types, data and metadata (accuracy, biases and known issues)

CTD problems/metadata

J. Swift, UCSD Scripps Institution of Oceanography

"The sole fact that a given temperature or salinity profile was generated via CTD says less than some think about the quality of the data values."

There are many thousands of CTD profiles available from the oceans. Also, CTD data provide the P, T, and often S for most bottle data in the past 40 years. Temperature profiles from CTD casts are superior in quality in most respects to those from other methodologies considered at this meeting (CTD salinity profiles are often superior, too), but as with any measurement methodology there are limitations and known issues.

Early CTD data

Data quality problems may have been widespread in the early years of using CTDs. Some early CTD data were lost (perhaps intentionally discarded after problems were realized?) due to lack of attention to calibration and correction, the need for which was in some cases understood belatedly. It is not clear if some early CTD data now in archives suffered similar problems, unknown to the data originators, and hence "should have been lost".

P: Few groups had access to high-accuracy pressure sensor calibration equipment. And few groups modeled the temperature response of the strain-gage pressure sensors and applied that information in their CTD data processing. [This affects P accuracy, though perhaps it is random error?]

T: Temperature sensor drift and sudden offset was a known problem. [Random?]

S: The largest problem (in terms of relationship to density) was with conductivity/salinity, usually when the CTD values were not corrected (or corrected properly) to *in situ* water samples.

One question with respect to the focus of this meeting relates to the issue: If there is not explicit documented evidence of CTD calibration and correction, should this lower the estimated utility of those data, e.g. in terms of a lower-grade quality code and/or wider error bars?

CTD data collected for purposes other than deep-sea physical oceanography
(and maybe even some of those!)

Most CTD casts are not collected for deep-sea physical oceanography – the most demanding application and hence the use producing the highest-quality CTD data. A CTD is often used for providing a quick water property profile to complement other measurements - the mixed layer depth, or (with optical sensors) the light-depth of the euphotic zone, or other useful information for which it is not worthwhile to carry through the full range of lab calibration, data acquisition and post-cast processing procedures. Do such data arrive at the archive any differently than do "WOCE quality" CTD data? Not at present. Hence, in the database envisioned at this meeting, perhaps where calibration information is not provided in the metadata, the data should automatically get some form of "calibration unknown" flag?

There are vast numbers of CTD data collected less formally than are those for deep-sea physical oceanography. Many are coastal data or within the EEZ of the nation sponsoring the CTD work. Such data, if they are retained, are typically retained within the national data center of the sponsoring nation or possibly by the investigator or by some group at the investigator's institution. Evidence is that onward transmission to WDC-A is not carried through by some nations. But with respect to the purpose of this meeting, it should be noted that even when collected informally, CTD temperature profiles may be higher quality than temperature profiles from other methodologies. If coastal and within-EEZ temperature profile data are a priority for this exercise, a potentially vast increase in profile holdings for the intended database could be made via success in persuading coastal states to release their temperature profile holdings. Success may require international data sharing diplomacy at the very highest level. [Perhaps as the "slow war" (deleterious effects of climate change) continues to mount, nations will be compelled to cooperate?] Some progress in data release is being made at the institutional and investigator level, but direct cooperation of the national data centers would have much greater and more visible impact.

CTD Data Inherent Quality

For high-quality data, it is important that the CTD was calibrated and thoroughly checked-out before the cruise. Still, sensors used by most non-deep-sea groups are rarely freshly calibrated. The metadata should address the timing of calibration of the PTC sensors.

SeaBird claims:

P:	Digiquartz 10,000 psi	Typical stability 0.02% of full scale per year (≈1.2 dbar/year)
T:	SBE3plus	< 0.001 °C / 6 months (this is known to be overstated)
refT:	SBE35RT Reference	Temperature 0.001 °C / year
"S":	SBE4C Conductivity	0.003 mS/cm /month (≈ 0.003/month in salinity)

(Very few groups take into account the pressure effect on the T/C sensors. It's much lower than it used to be, but can cause 0.001 or more (in either T or S) at 5000 decibars for sensors used in recent years.)

Pressure

SBE software is consistent with respect to pressure. Data quality depends more on how well the equipment is taken care of and how frequently the sensor is calibrated. With manufacturer's calibrations +/- 0.3 db down/up consistency is expected from an acceptable sensor but roughly 1 db offset on average between down/up casts has been noted with sensors subject to some abuse. Recent CTD data from a GEOTRACES PI were 4.3 decibars low at the surface, using factory calibration coefficients that were 13 months old. (Still, that is very large for one year - there remain questions about this.)

Did the seagoing team turn the CTD on out-of-water in order to monitor on-deck pressure offsets? (Many tech groups follow the SBE standard of "turn the CTD on after it goes in the water".)

Temperature

When an SBE-35 reference thermometer is used, this sometime shows that factory calibrations of the main temperature sensor can be 0.004 °C-0.006 °C off. (Such differences tend to be dependent on equipment management and abuse of the sensor.)

Without an SBE35RT, unrecognized temperature error will contribute to salinity differences (salinity is calculated from pressure, temperature and conductivity).

Does ITS-90 versus IPTS-68 matter? How often is T scale identified? How often is T scale incorrectly identified?

Conductivity/Salinity

Were there bottle salts to verify the salinities (and what was their IAPSO standard batch?

Bottle salts are of course essential for conductivity correction and where there is no evidence of correction to bottle samples a lower quality code should be considered.

Data collected by NOAA on a CLIVAR cruise had a 0.003 deep salinity difference from the start, likely due to a bad "standard" calibration point from SBE distorting the deep corrections. This was corrected during the cruise with bottle salt data, but if there had been no bottle salts, this error would have been unrecognized.

CTD data artifacts

Common artifacts in CTD data should be recognized.

Unusual upper 10-15 decibar characteristics may appear in T, S, and density. These are related both to how the instrument is powered up and allowed to stabilize, and also to assumptions used in data processing to fill in (interpolate) T & S values for the portion of the water column shallower than the shallowest reliable CTD measurement.

Density inversions appear in many CTD data but can easily be filtered out.

Ship roll oscillates the CTD through the water, not only adding upwards vertical motion to the down cast time series, but also forcing the CTD to repeatedly pass through dragged water and wake.

Rosette wake is significant on up casts and has some effects (especially in terms of blurring smaller features) on down casts.

The bolus of water dragged with the rosette also interferes with CTD values observed during rosette stops and also in the contents of the water sample bottle (and generates a systematic error in everything except P) if sufficient time is not taken for the bolus to clear the rosette and for the water in the open bottles to more closely match the ambient water. This can potentially be a major issue with T & S for bottle data; look to documentation for information on length of waits before bottle closure.
There are also more subtle CTD errors and artifacts related to the limitations of the instrument. In temperature these are mostly at the sub-millidegree level. Some of these are not yet fully understood.

Metadata Recommendations for CTD Data Used in Ocean Circulation and Climate Studies

James H. Swift, UCSD Scripps Institution of Oceanography
version of 19 October 2018

Introduction

CTD data originate as time series data but most ocean circulation and climate data users expect or require their CTD data as a uniform pressure series in order of increasing pressure, often with a pressure resolution of 2 dbar (1 dbar pressure series are also used by some).

Although all of the processed CTD observations from a single pressure level could potentially be used as the limiting granularity of CTD data, it is customary to place the CTD data from a single cast into a single file. Such a record from a single CTD cast is thus the traditional granularity for CTD data, meaning in metadata terms that the most important metadata must be present in the headers for that profile and not stored elsewhere.

The individual CTD records from multiple casts (multiple stations) on a single cruise are customarily bundled into a zipped all-cruise CTD directory, but this is optional.

The essential parameters in a CTD data file used for ocean circulation and climate studies are pressure, temperature, and salinity, the last being calculated from conductivity, pressure, and temperature. Typically these are derived from data recorded by the CTD while it is lowered on station (a "downcast"). If the downcast data are not available or unsuitable for use, the upcast CTD data can be substituted, but should be reported in order of increasing pressure starting at the sea surface. [When upcast CTD data are reported, a note should be placed in the master documentation file explaining why the downcast data are not available at that station and that the upcast CTD data were reported for that cast.]

Supplementary measured CTD parameters (e.g., dissolved oxygen, fluorometer, transmissometer, nitrate, etc.) may accompany each pressure, temperature, salinity record. Other CTD information (e.g., number of scans averaged, elapsed time, etc.) or calculated parameters (e.g., potential temperature, density parameters, etc.) may also be present at each record.

Data quality codes may also be present for some or all of the measured parameters at each record.

Parameter	**Units**	**Scientific Units**	**Param**	**Range**	**FORTRAN format**
CTD PRS	DBAR	decibar	Pressu	0,1 1000	F8.1
CTD TMP	ITS-90	°C (ITS90)	Tempe e	-2,35	F8.4
CTD SAL	PSS-78	PSS-78	Salinity	0,42	F8.4
CTD OXY	UMOL/KG	μmol/kg	Oxyger	0,500	F8.1
XMISS	%TRANS	% light transmitted (or volts)	Transm meter	0,100	F8.2
FLUOR	MG/CUM	mg/m^3 (or volts)	Fluores ce (chloro and phaeop ents)	0,50	F8.3

Metadata Recommendations for CTD Data

Metadata embedded into each file at the header level provide essential and useful information.

Essential metadata (at the file header level) include:

cruise identifier
station identifier
cast identifier
cast date (definition: the UTC date when the cast is at its deepest level)
cast time (definition: the UTC time when the cast is at its deepest level)
cast latitude (definition: the latitude when the cast is at its deepest level)
cast longitude (definition: the longitude when the cast is at its deepest level)

Additional, useful metadata (at the file header level) include:

ship identifier (may be part of the cruise identifier)
section or location identifier (used for repeats of well-known sections or stations)
depth to bottom (corrected depth to bottom when the cast is at its deepest level)
instrument identifier (e.g., CTD serial number or equivalent)

Metadata embedded into each file at the observation level provide information essential to use the data. These are typically column headings for CTD data files containing the observations from one CTD cast.

Essential column-heading metadata include:

parameter names for each/every column

parameter units of each parameter (usually dbar, ITS-90, and PSS-78 for the three essential parameters, but the actual/correct units must be written into the file, not the suggested units)

There are additional metadata which can be embedded into each CTD data file at the observation or column heading level to improve the utility of CTD data. These include:

observation quality code for each measured parameter (including quality code scheme reference if possible, otherwise the reference is in the master documentation file)
other observation information (e.g., number of CTD scans averaged into the observation, elapsed time, etc.)

The number of scans indicates the number of observations, or cycles, used to calculate the average temperature and salinity at each pressure increment. A description of how the data are averaged, or interpolated, and how pressure measurements are derived, should be included in the master documentation file.

CTD data quality flags

CTD data should contain a quality byte for each measured value based upon the data originator's evaluation of their data quality. Quality flags are optional for non-standard parameters. Although data quality flags are not strictly required, their inclusion will add to the utility and service life of the data. There are various schemes for quality flags. The WOCE-era scheme remains in use in CLIVAR and GO-SHIP:

Quality flag definitions for CTD data.

Flag Value	Definition
1	not calibrated
2	acceptable ("good") measurement
3	questionable measurement
4	bad measurement
5	not reported
6	interpolated over >2 dbar interval (Where noise or other problems create small gaps in the data over several dbars the missing values should be interpolated and flagged with a quality flag of 6. However, interpolation should not be done over large gaps or in regions where conditions are changing rapidly with depth.)
7	despiked
(8)	(flag 8 is not yet assigned for CTD data)
9	parameter not sampled at this level

It is the responsibility of the data originator, usually working with the oceanography team on a particular cruise, to assign quality codes. Typically a "good" quality code is initially assigned to each measured value, and these are replaced with other codes when needed. It is useful to include a description of how one used the quality flags in the cruise master documentation file.

CTD Documentation

The CTD documentation should contain all the information necessary to retrace the processing and calibration steps used to calibrate the CTD sensors, and should address the following issues:

- instruments used during the cruise,
- description of problems, for example, aborted casts, sensor fouling, etc. including station/cast numbers of data affected,
- description of special procedures employed, such as cell cleaning, sensor replacements, etc., including the station numbers related to or affected by these events,

- pre- and post-cruise laboratory calibration information, together with the coefficients used to fit CTD pressure and temperature,
- conductivity and oxygen calibration coefficients and equations, and the station groups used when fitting to water sample data,
- description of or easily located reference to the standard processing procedures employed, and
- variations from standard methods, including the station numbers related to or affected.

CLIVAR GSOP Coordinated Quality-Control of Global Subsurface Ocean Climate Observations "End-user Perspective, from Measurement to Research"

Alison Macdonald (WHOI), Jim Swift (SIO) and Steve Diggs (SIO)

The ideas presented from the end-user perspective were very much in-line with the workshop discussion and thoughts on: (a) data discovery, (b) integration; (c) quality control; (d) documentation and metadata; and (e) data management. Our main points for each of these items are listed:

(a) Data discovery, finding the data of interest to the community being served which in the case is the climate community of an important step for as we have to wait for the record to stretch into the future we have a limited window in time to find and archive past data sets many of which have been and continue to be lost as the data originators retire and die.

(b) In the integration process data origins must remain identifiable due to inherent quality/use differences. The integration must include 'reconciliation' of disparate data sets and special attention must be given to resolve data center to data center differences in metadata such as the expedition/cruise designators, cruise dates. We also strongly urge the group to include techs in integration meetings as their input can be invaluable to the process.

(c) Quality Control: The need for data quality examination data is based upon the experience of compilers of global data sets who know that many data (including some well-known data) require adjustments (i.e. corrections for calibrations) and identification (preferred) or removal (acceptable if necessary) of bad and questionable values. We believe that the qc process can differ depending on data type, but the underlying definitions of qc code must be clear so that quality codes can be translated into other schemes. All quality codes should be integrated with the data and the documentation. Although it is best, when possible, for data originators to assign the quality codes (following a sanctioned scheme) for each measured parameter, the work of external 'data quality experts' on earlier data sets can and in the past have usually proceeded without guidance and information from data originators.

(d) Documentation (metdata) is key to creation of a reference-quality data set. It provides a huge added value in context, history and connection to surround (in space and time) data sets. For this reason, it is the basis for a long-term service life of the data. Because maintaining data pedigree is crucial, metadata should be embedded in the data whenever possible. These key data elements include succinct data histories and version numbers. Further details could be kept in a metadata database.

(e) Data management priorities are: to acquire, improve and secure data & metadata (documentation); to provide data access, which should include tools to allow transparent user data discovery (links to both data and originators ebsites) and access (widely used formats e.g., both ASCII & netCDF); to maintain data 'pedigree' (version control); to learn about data holdings (especially new holdings) from & for research community; to know who is using the data, what their needs are, and what features they would like to see in the dataset and how it is queried.

There are, however, a slew of age-old problems working that face those working with the data both before and after it reaches data management such as: lack of time, lack of commitment, 'My data are not ready', lack of memory ('my cruise was *years* ago'); lack of personal contacts or trust (which often leads to redundant effort); lack of definition for metadata; lack of data management expertise in originator's lab; support staff too busy at PI or national data center; gaining & maintaining cooperation of national agencies & data version control problems by PI or national data center; lack of definition for metadata);lack of expertise; and lack of support staff.

To help mitigate these issues data management and its oversight should involve both active scientists and technical teams. A data committee, a DAC system, and team focused on data discovery are a strong trio. We should recognize issues that include lack of history & limitations in funding and available time, which result in a shortage of data quality experts who are too often busy doing their 'day job'. Technical staff have to deal with competing assignments and are sometimes limited by their cultural and technical origins. Successful data management avoids only providing pages of requirements as the issuance of requirements on its own cannot change human nature. To overcome some of these limitations, data management should work closely with individual data providers as many can & do perform credible internal data quality control. Data management should also ask what can be offered to a data originator or quality examiner in return for data or scarce time? Community data examination can also work when well-defined.

Important questions to the group at the workshop are: 1) is it possible to agree upon the design of a system which satisfies all/most users? 2) can we quantify the cost of this not-yet-conceived data system in adequate detail? Can the funds to construct and maintain this not-yet-conceived data system be found?

Tasks and considerations for the workshop should include: 1) to agree on a firm, written definition of the project; 2) to assign a value to the project in terms of priority and $$; 3) to design a low-cost system comprised of existing semi-permanent data sites aggregated through a single well-designed portal; 4) to group data intelligently and keep synthesis efforts in mind; 5) to include deadlines and milestones, and 6) to design the system should so that it's *never* "finished"

Finally, it is important not to worry about non-inclusiveness or partial failure, as it is inevitable. The group should focus on improving the usability of the data that forms the product, not in making a product. Improved data information and searchability are useful first outcomes. Providing seamless updating and flexible access to the resulting data set in both space and time, and in terms of quality and suitability are useful final goals.

Additional materials, not part of presentation

Embedded metadata must include measurement type, source (expedition code or other ID), station/cast/etc. ID, xyzt. [What about profile quality code?] Units must be unambiguously identified.

Should the database contain no interpolated values and no gridded/averaged values - only quality coded observations? Or should interpolated data be included with a special flag?

Preferred to have a data quality code attached to each measured value. For pressure, where pressure is estimated (a function of the type of measurement device in use for that profile), the pressure quality code and/or header should identify this.

What should be the granularity of the data in the database? Three obvious choices are the individual observation, the profile, and the cruise or collection or source. There are users who would prefer each of these. It could be argued that if the granularity were the individual observation, and if the metadata were properly designed (each observation would need a complete metadata tag), the user could easily reassemble the profile or the cruise/collection if needed. This would lead to very large total file volume (no problem?) but excellent versatility.

Commitments to funding or pathways for application for funding for the life of the project.

A project needs to be officially sanctioned at the international level, and adequately publicized.

- Once the project, procedures, and software are in place, can invite individual proposals to national agencies to carry out a specific piece of the DQE?

- If the value of the product were clear and was accepted by the community at large, could this be done the way some astronomical projects are done, with (qualified) individuals/teams chipping away at it bit by bit? If 100 people world-wide DQE'd 10 "suspect" [as identified by the master software] profiles per day for 100 days each year, that would be 100,000 profiles per year.

SCALES – spatial and temporal. **One investigator's noise is another's signal.**

Automatic qc can wipe out signals because they are not recognized by the software, or because of software error. But manual qc is subject to scale bias as well as operator experience bias/error, is likely overly time-consuming., and is often not reproducible, or has logic associated with it that is lost.

No one particular database product will be as useful as a system which is designed to take in data from multiple (not necessarily pre-defined) platforms, has a system of quality control that is both flexible and reproducible, allows the user to define the resolution (spatial and temporal - and data reliability?) of the final product and where feasible also produces some useful statistics - variance or uncertainty based on data availability for example.

SOFTWARE – The goal should be **a system** that includes

A base dataset

Software for qc'ing data or a group that is funded to accept and qc data

Software that will work on multiple platforms to read the dataset, as well as software to write new data into the same format

Software that makes conversion to generally used platforms for using and viewing data transparent

There needs to be mechanism to maintain the all software so that it can be used by the majority of users [alternative is to code data for quality]

This upkeep of the system cannot fall to one person or even one funded group.

TIME/FUNDING/MANPOWER – To be successful, all three must be available a continuous fashion otherwise to maintain a useful product.

ACCESS: It should not simply be available, but advertised across disciplines.

The project dataset should basically be cleaned/proven but otherwise unaltered data, brought to as high a standard of reliability as feasible and to a very high standard of usability.

[One key to the success of past/existing efforts has been the persons involved in the project. There is no effective substitute for hands-on expertise. Another important point has to do with the exact goals underlying creation of the dataset. Perhaps rather than create datasets, the project might aim for some sort of "wiki-DQ", where data sets are labeled with some sort of escalating coding for quality and reliability (accuracy & precision)]

How will the dataset be kept up to date? The dataset will be an ongoing community creation.

How will proprietary data be sought after and included? [Applies mostly to more recent data, which are maybe not the main focus?]

Session 3: Sharing PROS and CONS experiences: QC and data management

Session Chair: Masayoshi Ishii, Notetaker: Bec Cowley.

Presentations on quality control of data from each data centre represented at the workshop were given: US (NODC), US (AOML), US (Scripps), US (GTSPP), UK (Met Office), Japan, Germany, Australia (CSIRO), India (INCOIS). A discussion followed the presentations.

The main points from this session:

- It is essential to have the best possible automatic tests. Should choose the best tests from all those being used already, and impove tests by taking advantage of new data such as from Argo.
- We must minimise the number of profiles quality controlled by hand as this is very expensive to do.
- We need to have a good idea of how many profiles will be manually quality controlled in order to cost the project.
- We need to be able to demonstrate that the extra quality control is worth it.
- Additional costs will come from needing to gain expertise about different areas of the ocean, and some areas will always be difficult to quality control.
- Modern data tend to have active groups working on the data. We should concentrate on older data.

More details of the discussion during this session:

- Everyone is doing similar tests but which version is best?
- Need to look at the difference it makes with different choices of tests - is it regionally/instrument dependent?
- Manual inspection is expensive. We need the best automated methods.
- It will be a continual process. We will always need to go back if problems are noticed with the data.
- With semi-automated methods in CSIRO's QuOTA, the tests pick up 30% of data to get approx. 10% of data that are bad.
- Manual QC is expensive so need to train tests to be as close as possible to the manual result so that we are not QCing too much manually.
- With Argo we will be able to develop more effective automatic tests.
- How big a cost is it to start looking at new areas (learn about the region etc.)?
- Some areas will be particularly difficult to QC.
- We need to know this type of thing when costing the project (how many profiles we need to hand QC etc.)
- We need to test how much better our automated tests will be with the new Argo data available now.
- Is it time to move to a reference that is more consistent with other variables such as from satellite altimetry? This would be no good when looking back before about 1993 but is relevant for the recent period.
- Should we have a discussion about joining together information from different variables?
- Modern data streams have active groups already working on the data. We are thinking about focussing on older data.
- If we are going to start on higher quality data, they will probably also have salinity.
- A lot of this work has been done by Argo delayed mode quality control, i.e. anything well QCed already could go straight in, and we shouldn't only include older data.

US NODC, Tim Boyer.

Tim noted that standard deviation checks are done on standard level data. No flags are applied to observed data. Flags are only applied to standard level data. The advantage of the automatic QC scheme at NODC is that the pass/fail flag scheme is statistical, not objective like a good/bad flag scheme. The disadvantage of the automated QC scheme is that throwing out data that fails the statistical test can bias the heat content calculations, particularly in regions like the Southern Ocean.

US AOML, Gustavo Goni.

AOML data is discarded during the DM QC procedure, not flagged. Profiles are corrected (eg. Spikes are interpolated and premature launch surface data is removed). For realtime QC, the data is not discarded.

US SCRIPPS, Dean Roemmich (presented by Ann Thresher).

The SIO XBT lines have ship riders. They also use autolaunchers. A few transects are done without riders. 2m averaged data is sent to NODC. The raw data is not kept. How long have these XBT data been QCd for? At CSIRO, since the early 1980s (the start of the program). At AOML, since 1993(?). We should use these scientifically QC'd data as a starting point for building the QCd global database.

US GTSPP, Charles Sun (presented by Ann Thresher).

A question was asked: are GTSPP doing QC on data they are generating? Ann replied that these are QC tests that are run on delayed mode data that is sent to GTSPP, regardless of if QC is already done. Tim and Ann had some discussion on this and Tim was unsure of who in GTSPP is doing this QC. More than one person has mentioned climatology tests. Which climatology was used for QC? This information should possibly be recorded in the metadata information. History groups in meds-ascii format do record this sort of information, but the detail of what these mean might be recorded elsewhere.

It is important to keep 'raw' and 'adjusted' values, and document the changes that lead to the adjusted values. It will make everything bigger, but this information is very important.

Global Temperature and Salinity Profile Programme (GTSPP) Data Quality Tests

Prepared by

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What is GTSPP?

The GTSPP is a joint program of the Intergovernmental Oceanographic Commission (IOC) Committee on International Oceanographic Data and Information Exchange and the Joint IOC/WMO Committee on the Integrated Global Ocean Services System. The primary objective of the GTSPP is to develop and maintain a global ocean T-S resource with data that are as up-to-date and of the highest quality as possible. The primary goal of the GTSPP is to make these data quickly and easily accessible to users.

Development of the GTSPP began in 1989. The GTSPP went into operation in November 1990. Countries contributing to the project are Australia, Canada, France, Germany, Japan, Russia, and the United States. Canada's Marine Environmental Data Service (MEDS) leads the project and has the operational responsibility to gather and process the real-time data. MEDS accumulates real-time data from several sources via the Global Telecommunications System (GTS). They check the data for several types of errors, and remove duplicate copies of the same observation before passing the data on to the NODC. Both real-time data transmitted over the GTS and delayed mode data received by the NODC are acquired and incorporated into a relational database, also known as the Continuously Managed Database (CMD).

GTSPP Data Quality Control Tests

Quality control of the data in the GTSPP system is handled at a number of centres. The Integrated Scientific Data Management (ISDM) in Canada handles real-time, low resolution data and applies quality control processing on these data before forwarding them to the U.S. NODC. NODC handles the delayed mode, high resolution data. The procedures NODC uses are the same as those employed by ISDM. The procedures of MEDS are described below.

The three delayed mode data assembly centres also have quality control procedures. Each has slightly different ways of handling the data. A brief description of their respective procedures follows as well.

Data Centre Quality Control Procedures for Ocean Profile Data

Data quality control (QC) is a procedure of verification and validation. To validate the data, the data are reformatted to the GTSPP internal processing format. In so doing, the data are checked to be readable and that they can be interpreted. Data which have format errors in the original source form, or which have invalid values (such as characters where numbers should be, or irrational contents of a parameters such as date/time, or profile depth order, are reviewed and corrected by programmers, by adjusting the reformat procedures to handle these inconsistencies.

Once the data are reformatted, the contents are quality controlled in order to verify that the numbers and codes actually represent physical quantities and that these are reasonable given the location and time of the observation. ISDM has adopted an approach which combines specialized computer code to organize, and test data values according to common rules with displays of the data as plots of ship tracks and data profiles with selection and editing capabilities to allow trained personnel to review and flag the data, or correct values where obvious. Typically, results of the QC procedure are the setting of flags or making corrections where data illustrate instrument failures and human errors.

The subtler inaccuracies (such as those caused by instrument noise, or signal processing algorithms), and whether or not the observation is representative of the ambient conditions (by considering errors due to small scale variability, or inherent randomness in convective water flow) are apparent in the ISDM system. Automated tests have tolerances which allow for these inaccuracies. The QC technician quite often spots these problems and flags these where values go beyond reasonable bounds.

The QC system at ISDM is a fully automated pipeline of applications and executables capable of handling both real-time and delayed mode data. The real-time system is used to handle data received primarily through the Global Telecommunications System (GTS), and process through to the BATHY and TESAC archive files.

The delayed mode system, which has differences to allow an operator to select an arbitrary file of formatted data, is used for the higher resolution data received well after data collection.

There are three main components to the quality control of ocean profile data. The first component examines the characteristics of the platforms track looking to identify errors in either position or time. The second component examines the various profiles of observations to identify values which appear to be in error. The third component is software to identify duplications of profiles either by having received the data more than once, or because data of lower resolution (such as a BATHY message) will arrive, followed later by the XBT cast on which the BATHY message was based.

QC Test Component I: The Procedure for Checking a Platform's Track

The track QC procedure examines the position and date/time and, in the case of real-time messages, the call sign of the observations. To carry out these checks, the data are ordered by call sign (treated as the cruise number) and within each cruise, by date and time. Each cruise is passed through tests which check that the date is valid (including future and too far in the past), the latitude and longitude are valid, that the station location is not positioned over land (using a bathymetry file with values every 5 minutes of latitude and longitude and an algorithm that accounts for the resolution of the file), and that the inferred speed between stations is reasonable. Each cruise is plotted to show the cruise number, the track (with scales and land for reference), and the platform speed from station to station (calculated from the time and space differences between stations).

At the same time as these displays are shown, the software tests for possible errors and presents the results directly to the screen. If a test fails, an appropriate error message and a scrollable and editable table of date/time, latitude/longitude, and their flags is shown. A QC technician then examines the plot (and error messages) and undertakes to assign flags or correct values. The interface allows the technician to select stations, edit values, and see the results of their changes, in order to experiment with solutions to find the logical reason (and fix) for the data. With real-time data, stations with different call signs may be merged into a single cruise if this is appropriate due to an erroneous call sign being reported.

QC Test Component II: The QC Procedure for Profile Checking

The profile checking software automatically tests each station profile, sets flags accordingly, and displays a plot of the profile and error messages for review and flagging by the QC technician. This is carried out in the following stages. First, a file of stations is opened by the software, and the technician uses a menu to move through this file, station by station. A station is read, and the profiles are identified and tested.

Tests include a group to examine global ranges, bathymetry, single valued profiles and monotonically increasing depths for all known parameter types (e.g. temperature and salinity). Next follow a set of statistical tests including regional range, global profile envelops and a test against the “Levitus” Climatology. Other tests look for spikes, for gradients that are too pronounced, for density inversions (when temperature and salinity are present) and for temperature inversions (when only temperature is present).

Flags are set according to the severity of the test failure, based solely on the type of test. The profile is always plotted for examination by the technician. Where both temperature and salinity are present, both are plotted, and accompanied by a plot of calculated density. Flags are shown by graphical indicators. The QC technician examines the plot and sets flags by selecting points and menu items using a mouse. This interface provides a wide range of functionality, which allows the QC technician to list the station as a text file, to list flags and other specific information such as the climatology, to adjust scales and zoom, or to plot by arbitrary parameters (e.g. T/S Plot), and to show the cruise track, and location of the station in question.

QC Test Component III: The QC Procedure for Duplicates Checking

Duplicates’ checking is necessary to identify data which are versions of the same observation. Exact matches mean that one of the versions has no additional information, is redundant, and is usually deleted. Two or more data records are often found to be the same observation, but differ in their method of analysis or reporting. In this case both records are kept, and all but the best one is flagged as a duplicate. For example, TESAC messages reported in real-time also arrive at ISDM in a much higher resolution form as delayed mode data, and bottle data used to calibrate a particular CTD profile, and the CTD profile itself.

Where data are collected within the above defined space and time window but are not exact matches, the subsurface data is compared using an algorithm which selects from each station, a common profile type (e.g. temperature), without distinguishing the instrument type (CTD, XBT...), sets allowable tolerances for comparing the profiles, using the a table of accuracies for instrument type, compares the profiles, depth by depth, using linear interpolated values from the profile with the lower vertical resolution, to the exact depth value of the profile with the higher vertical resolution and returns a ratio of trials to failures for interpretation by the main program rules. Where duplication is proven, the duplicate checker uses program rules to select the best of the exact or inexact duplicate profiles, based on criteria evaluated in the previous steps.

Sometimes the automatic check cannot determine if stations and profiles are duplicates, or if they are, which profile is the most desirable one. This often happens when data are very close in time and space, but actually different casts of the same instrument. It also may occur when a data originator delivers a "correction" or updated version of a station after their revised analysis. These cases are isolated and reported (or displayed in the delayed mode system), for the QC technician to review and flag through an interactive session.

Optical Spectrum Decomposition – Charles Sun, presented by Ann Thresher.

Optimal Spectral Decomposition (OSD): An Advanced Approach for Optimal Estimation of Ocean States and Data QC Tests

Prepared by

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1. Background: Problem Statement

The classical objective analysis (OA) scheme (Gadian, 1965) requires the background field and autocorrelation function of the variables should be given. The estimation of the variables' de-correlation scales in time and space was often too subjective to produce meaningful ocean structures. OA might yield unrealistic current speeds in the vicinity of coastlines or velocities are far from the historical range. These problems are usually caused by sparse boundary data; and for instance, most importantly, OA never fulfills the physical boundary condition such as the normal component of current velocity should be zero at the coast.

2. The Method of Optimal Spectral Decomposition

The Optimal Spectral Decomposition (OSD) method developed by the Naval Postgraduate School (Chu, et. al, 2003 a, b) overcomes the deficiencies of the classical OA method and can process sparse and noisy ocean data without knowing the background field and de-correlation scale. Any field (temperature, salinity, or velocity) can be decomposed into generalized Fourier series using the OSD method. The three dimensional field is then represented by linear combination of the products of basis functions (or called modes) and corresponding Fourier coefficients. If a rectangular closed ocean basin is considered, the basis functions are sinusoidal functions. If a realistic ocean basin is considered, the basis functions are the Eigen-values of the three-dimensional Laplace operator (∇^2) with real topography. After the decomposition, the three-dimensional field is represented by a set of Fourier coefficients. This method has three components: (1) determination of the basis functions, (2) optimal mode truncation, and (3) determination of the Fourier coefficients.

Determination of basis functions is to solve the Eigen-value problem. Chu et al. (2003a, b) also developed a theory to obtain the basis functions with physical boundary conditions such as the **zero normal velocity at the coast**. The basis functions are only dependent on the geometry of the ocean basin and boundary condition at the coasts. This is to say, the basis functions are the same, and can be pre-determined before the data analysis. Therefore, the OSD method does not have three weaknesses in the classical OA method.

For data without error, the more the modes, the more the accuracy of the processed field. For data with error, this rule of the thumb is no longer true. Inclusion of high-order modes leads to increasing error. The Vapnik variational principal (Vapnik, 1982) is used to determine the optimal mode truncation.

After the mode truncation, optimal field estimation is to solve a set of a linear algebraic equation of the Fourier coefficients. This algebraic equation is usually ill-posed. The rotation method (Chu et al., 2004) is developed to change the matrix of the algebraic equation from ill-posed to well-posed such that a realistic set of the Fourier coefficients are obtained.

3. Applications

The OSD method has been demonstrated to be a powerful tool for reconstructing the velocity field in the Texas-Louisiana continental shelf from the near surface drifting buoy (Chu et al. 2005a) and current meter data and the chlorophyll-*a* concentration field in the Black Sea (Chu *et al*. 2005 b.)

Using the temperature and salinity profiles from the GTSPP (Global Temperature and Salinity Profile Programme) and Argo data as shown in Figure 1, NPS demonstrated the ability of using the method of OSD to identify (see Figure 2) and eliminate high noisy data (see Figure 3).

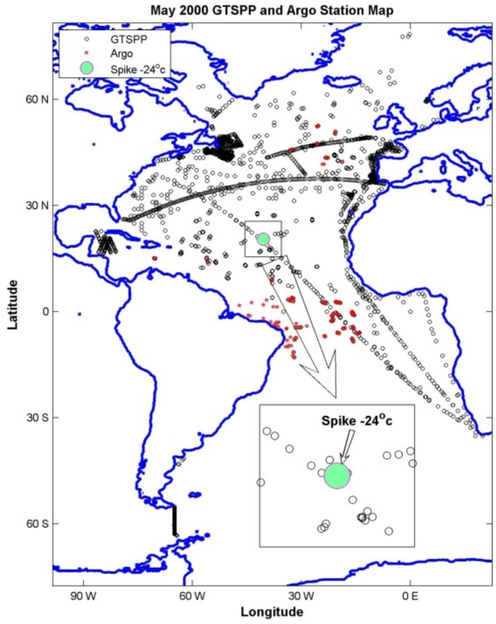

Figure 1 Ocean temperature profile data from GTSPP and Argo. The green dot indicates the location of a fake profile by subtracting 24 C from its original one from top to bottom artificially,

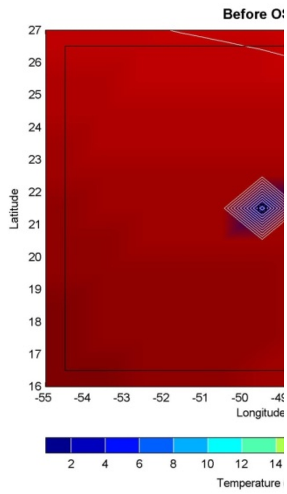

Figure 2. A close up of the fake noise data point (green dot in Figure 1)

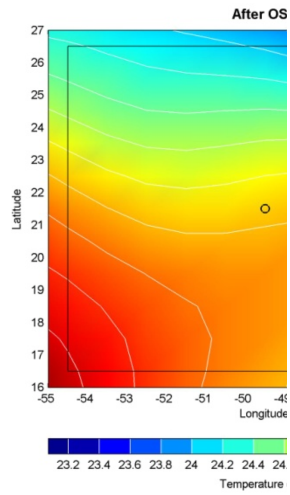

Figure 3. The fake noise data point was eliminated after the OSD.

4. Summary

The method of Optimal Spectral Decomposition has been proven to be a very powerful tool for optimal estimation of ocean states, not only scalar variables such as ocean temperature and salinity fields but also vector variables such as u and v components of ocean currents. a useful tool for processing real-time velocity data with short duration and sparse sampling area such as Argo and GTSPP data. OSD can handle highly noisy data and can be used for velocity data assimilation and automated QC tests and doesn't need first guess field and autocorrelation functions: a significant improvement over classical OA.

5. References

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Gandin, L. S., 1965: Objective Analysis of Metrological Fields. Israel Program for Scientific Translation, 242 pp.

Vapnik, V.N. Estimation of Dependencies Based on Empirical Data. Springer-Verlag, New York, 1982.

UK, Simon Good. Met Office.

The Argo real time data is added to EN dataset every month. When the EN version is updated, the entire Argo dataset is re-added. Met Office have well developed and sophistocated automated tests with good traceability. EN use the WOD09 without the flags. They use the observational data. A month of data is condensed into a single netcdf file, this is proving to be a good way to access the data. The disadvantage of the automated QC only technique is the lack of a manual QC step means you miss subtleties. However, different users want different things. Data assimilation users are more interested in getting rid of bad data.

Is pattern matching a possibility? Uday is doing something like pattern matching, but not the same. He will talk about this later.

The EN auto QC does do some duplicate checking, exact and near duplicates. They also QC salinity if available. Most of the checks are independent. Vertical stability is one that uses salinity & temperature & rejects both if failed.

The EN dataset and quality control system

Simon Good. Met Office, Hadley Centre, UK.

Introduction

The EN dataset is a climate dataset of temperature and salinity profiles. Both temperature and salinity data are quality controlled using a suite of (mainly) automatic tests. Monthly objective analyses are made from the quality controlled data.

The current version of the dataset is EN3 v2a, but there is new version in preparation called EN4 and that is the version that is discussed here. The current version is available from http://www.metoffice.gov.uk/hadobs/en3.

Data sources

The main source of data is the World Ocean Database 2009 (WOD09). Data from the Global Temperature-Salinity Profile Project (GTSPP), Argo and data collated by the Arctic Synoptic Basinwide Observations (ASBO) project are added to this. The dataset covers the period 1900 - present. Monthly updates are performed using data from GTSPP and Argo, which add a month to the end of the dataset with approximately half a month lag. Updates to older data are not made - these are only picked up periodically when a new version of the dataset is made.

Data processing and quality control

Processing is performed on a month of data at a time. The data are quality controlled and the results are output to a NetCDF file. The quality controlled data are used to make an objective analysis. This is used to estimate the ocean estimate in the next month by assuming that anomalies largely persist from month to month. This persistence forecast is used in the quality control of the next month of data and is also the background to the next objective analysis.

The profiles are first checked for duplicates using an automated method based on the one described in Gronell and Wijffels (2008). This looks for profiles with the exact same temperatures (and salinity if available), close matches (e.g. find matches where one profile has missing levels) and profiles in the same location.

Quality control of the data is mostly automatic. The exceptions are manual reject lists such as the Argo grey list. Automatic checks for temperature are a track check, check against bathymetry (both reject entire profiles), profile checks (look for spikes, constant values in profiles), stablity check (increasing density through the profile), range check, check for increasing depth in the profile, backround check (on observed and standard levels) and a buddy check. Then, profiles with 50% or more levels rejected are fully rejected. Experience has shown that some tests are well suited to automation, some not.

The quality control code is written in Fortran and takes between a few seconds to approximately 25 minutes to run on a month of data, depending on the quantity of data. Owing to the origins of the dataset as an input to an assimilation system, and the fact that memory requirements are large when processing very high resolution profiles, profiles with >400 levels are subsampled.

Data use

The data are freely available for research and personal use from http://www.metoffice.gov.uk/hadobs/en3. Uses are varied and include ocean monitoring, ocean heat content change estimation, initialisation of decadal forecasts and as an input to reanalyses.

Performance of the system

A study has started into the performance of the EN quality control system, as benchmarked against the QuOTA dataset. Initial results have shown differences in the quality control results from the two systems. The differences can be seen in the objective analyses formed from the data (particularly in regions with high variability), but differences in time series of temperature averaged over the Indian Ocean and south-west Pacific seem small. The method used to select data to compare needs to be refined, and it is also planned to compare the results of the NODC quality control system.

The Australian temperature data QC experience

Rebecca Cowley (CSIRO), Ann Thresher (CSIRO) and Lisa Krummel (BOM)

The CSIRO and Bureau of Meterology (BOM) both operate several high density XBT lines around Australia. They quality control (QC) data from these lines regularly, using a scientific QC technique and specialised software (MQuEST). The QC techniques are all manual (ie, done by hand). Data from these XBT archives is submitted to GTSPP and WOD amongst others.

The CSIRO has also constructed a sub-surface temperature dataset for the Indian and South-West Pacific Oceans from the 1870's to 2000. This dataset is known as 'QuOTA' and contains temperature data sourced from WOD01, CSIRO/BOM, NODC/GTSPP, Far Seas Fisheries and IRD. It contains all types of temperature data including CTD, XBT, MBT, Bottle, UOR, XCTD, Bathy, moored and drifting buoy data.

The QC procedures for the QuOTA dataset included an automated step, followed by a manual QC step on the profiles that failed any of the 12 automated tests applied. The automated step is based on a climatology built from profiles that were high quality and QC'd. As the database expanded (as new data was added and QCd) the statistics used for the automated QC became 'tighter'.

The data is available for download as 5m and 2m gridded files in netCDF format from: http://www.marine.csiro.au/~cow074/quota/quota.htm. Full resolution profiles are available from Rebecca Cowley or Ann Thresher.

Quality control of the QuOTA dataset resulted in a reduced warm bias in XBT data when compared with non-QCd data.

References:

Gronell, A., and S.E. Wijffels. 2008. A Semiautomated Approach for Quality Controlling Large Historical Ocean Temperature Archives. *Journal Atmospheric and Oceanic Technology*. **25**, 990-1003.

Session 4: Establishing a QC system and data management protocols for subsurface ocean temperature data

Session Chairs: Ann Thresher, Viktor Gouretski, Susan Wijffels, Nathan Bindoff. Notetakers: Matt Palmer and Marty Hidas.

This session focussed on reviewing QC methods and the pathway to a unified QC system approach. Data management and a discussion on the possible route to the IQuOD dataset was discussed. Following are notes and summaries from this session.

What level/type of quality control/metadata does the creator of analysis tools and gridded products need and want? - Jeff Dunn & Ken Ridway

CARS-CSIRO Atlas of Regional Seas

Data assembly was tailored to the purpose: generation of a climatology, and specifically a climatology for model initialisation: eg want a value everywhere. Decided would not use XBT and MBT because of bias suspicions (in mid 1990s) and lengthscales determined by salinity anyway.

Summary:

T, S, nutrients

Mean, seasonal harmonics, and variability fields on 79 depth levels

Isobaric loess mapping

Derived fields: mixed-layer depth, dynamic height

Also salinity mapped on temperature, and related QC system

Property local extrema atlas

synTS – daily inferred 3D T and S gridded fields – 90-180E 10N-60S only

BOA - Clean science-ready ocean profile archive

Some steps in building CARS

- Acquire trusted major international and local datasets. Some datasets (NIWA, AIMS, GBRMPA) traded for access to the climatology, but often data is then restricted so only for use in the climatology.
- Apply originator's screening and check metadata
- Range check
- S(T) screening
- Interpolated to standard depth levels
- Lenient outlier screening against existing CARS, if available. Limits based on mapped variability measures, data referenced to seasonal values. Better if can also allow for longer timescale signals.
- Evaluate whether rejected data is more correct than our screening
- Use data in new version of CARS (and possibly iterate the screen/map steps)

CARS 2009 used "BAR" to make allowance for topographic barriers.

We now have "DLU": **D**istance **L**ook**U**p. It can be used for mapping or modeling, or separating domains for selecting buddies or generating property range fields.

The software is available to generate your own tables (~2 weeks per depth level on a modern desktop), or you can download ours.

3Gb in 600 files for each depth level – 50 levels presently. We don't have download set up yet but if interested please get in touch: jeff.dunn@csiro.au

{ Example of distances at 24 dbar at one ¼ degree grid location. }

For every ¼ grid point, topography–corrected distance is pre-computed to every other gridpoint up to a max distance of 2300km.

{ Example of preventing contamination across topo barrier at north end of Capes Basin at 3750m. }

S(T) climatology

Salinity mean, seasonal cycle, and RMS of residuals mapped on potential temperature levels can be a powerful QC tool. T inversions occur naturally – a work-around is to map S(T) for deep, middle and upper ocean separately.

Range Limits

3D gridded fields (5 degree, 25 depth bands) derived from all available data. (I need to check, but I think I expanded to 2nd and 98th percentiles by a fraction of the range between, and maybe iterated that, then did a smoothing over cells which was designed to generally relax limits). The idea is just to exclude impossible data, so expect this to be a fairly inactive filter, but in regions of strongly skewed variability this can be a better outlier test than a system that uses a mean and symmetric variance limit.

Could use known ocean variability indications (eg of eddy or non-stationary frontal regions, or regions of significant longer timescale variability) to expand limits, especially where existing sampling is temporally limited.

Also need to have ***tools to continually evaluate*** the screening effect and to ***allow continual refinement*** of limits.

Screening philosophy

- screen leniently in many different dimensions
- scrutinize screening effect, and aggregate results in different ways, to detect bad screening or biases/calibration errors in particular datasets

Metadata

Like information which allows assessment by groupings: eg extra metadata together with non-unique cruise id allowed determination of discrete cruises, so I could look at profiles-deeper-than-bathymetry rates to detect longitude or latitude sign errors.

Preserve originator QC flags and original data (eg I use 3 digit code with WOD data: 1st=originator, 2nd=WOD, 3rd=my own QC). At times we choose to ignore original screening and reprocess raw data.

Need to maintain codified records (machine readable) of all prior screening and calibration!

Making a cast statically stable

Paul Barker, Trevor J McDougall, Jeff Dunn

Making vertical casts statically stable

There are three different aspects to this work and software

- Stabilizing a cast of observed data (*in situ* temperature)

- When stabilizing observed data, the *in situ* temperature is left unchanged and only the Absolute Salinity is changed.
- [Jackett and McDougall (1995) stabilized vertical casts by altering both temperature and salinity.]

Organization	Scheme	Pros	Cons

- Example shows salinity adjustments to achieve N^2 marginally > zero.

- - Stabilizing a cast of model or atlas data (Conservative Temperature)
- - Making the vertical stability greater than some positive limit

44% of casts (the black dots) of the mean Levitus-1982 atlas have a vertical instability somewhere on the water column.

This is the vertical distribution of the instabilities in the mean Levitus-1982 atlas.

62% of casts (the red dots) of the mean CARS-2009 atlas have a vertical instability somewhere on the water column.

All three pieces of code will be made available as part of the TEOS-10 GSW Oceanographic Toolbox.

Jeff's summary:

> When the group turns to salinity, I recommend consulting McDougall and Barker.

Review the QC methods and discuss the PROS and CONS

Ann Thresher produced a summary table from the previous sessions talks.

Organization	Scheme	Pros	Cons
US AOML XBT	Mixed (RT) Hand QC (DM)	Can handle a lot of RT qc and deliver it within 24 hours (automated QC) Visual QC is added to those which fail the autoQC (RT) Visual QC of every profile (DM)	Not consistent with what others do, flagging is different from other groups. May miss bad data and catch good data (RT).
US Scripps XBT	Hand qc system (DM)	Uses buddy checks to improve decisions and has scientific expertise when Qcing profiles.	QCs 2m data and does not retain the full resolution data (.7m).
US GTSPP	RT – mixed at ISDM No QC currently of DM data submissions	Tests are identifiable and results are documented	
JAPAN (JODC) XBT	Similar to WOD method (DM), mixed on observed as well as standard levels.	Consistency with other groups (WOD)	
Germany Everything	Observed level data (DM), statistical/automated only	Decision to reject is automated and these are regionally adjusted	Needs development and comparison with other procedures.
India INCOIS Argo XBT	Mixed, DM Plus clustering analysis mixed	Clustering identifies outliers reliably Can handle a lot of data in a single run	Relies on climatology and this can be of variable quality
Australia QUOTA Everything	Mixed DM	Catches high percentage of bad data	Need to screen a lot of good data as well. Expensive and time

			consuming.
CCHDO Hydrographic	Manual QC	Scientific, local expertise used to make decisions	Need scientific expertise, focusses on major problems, not subtle errors
Hydrobase T, S	Mixed DM Group check	Carries all data along, keeps raw data and also has qc'd data available All statistics are done on isopycnals. Good history information but not available with the data	XBTs need regional salinity. Data is rejected, not flagged. Needs to be updated.
UK Met office Everything	Fully automated	Evolving background, tests quite well developed Keep record of which tests failed. Fully objective	Balance between missing bad data and catching good data. Could improve rejection processes for different instrument types. Limitations of the automated system.

Important to know whether a QC system works on observed levels and standard level checks?

Susan Wijffels: Training data sets with a model baseline. Basically look at how much data will be rejected (what is the size of the task for manual QC?).

Test data set allows us to demonstrate that we can run part of the automated system and get identical results (?). Has to be an iterative process. Need to write some tests down that are very instrument/platform specific.

XBT data: Type of XBT should match the profile depth. Type of XBT should match the types of XBT used by the country code. Lots of potential metadata checks for XBTs. Acquisition system is also important. We need a list of dates that the acquisition system came online.

What do do with Salinity values apparent in MBT (and XBT?) profiles.

Need to come up with an intelligent system to guess the metadata. There are about 50% of the profiles don't have the metadata.

Note: potential to make use of SST measurements/interpolated fields, to track movement of fronts etc? Something to be explored in development of the QC system (?).

Data management (acquisition/delivery) – Steve Diggs

Data Management Zeigeist – Looking Forward, Looking Back

Getting the right data to the right people as quickly as possible.

"Human nature is not changed by issuance of requirements". Scientists build portals that they don't use.

Is there a case for less data overall and more GOOD data?

Crowd-Sourcing Quality Control. "Community data examination works when well-defined".

We are designing a system for the next generation.

1. Scientists, Data Managers and governments will lose control over data distribution.
2. "Mom, what's a data format?"
3. Data products will be used much more than "raw" data (who will make these products?)
4. One answer, not multiple results
5. Data pedigree and QC will be crucial (too many copies of the same data in the wild)
6. The divide between the responsibilities of ocean experts and data distributors will be very obvious.
7. FORTRAN will still be in use.

Consumers won't know the difference between the right answer and the wrong answer.

We need metrics for successful outcomes.

Whatever we do, it will be better than nothing.

Insert some **signal** before the noise comes. Many copies of your data will exist on the internet.

Q. How do we get what we do out there, to replace what is out there currently?

Most people go to Wikipedia for their answers. Only people who are interested in things takes the time to document things.

There has to be a way of putting a "gold stamp" on the files, to say that it was validated by this group.

Issue of keeping all data with QC flags vs the Joe Reid approach? Is this something that the present group should consider.

Steve's opinion is that you should do BOTH. Give what in your opinion is the "best" data, but also give people the option of going back. The two data sets should definitely be linked.

Two classes of people: those who want to go back and mine the data, and those that don't have time/inclination to do so.

Would rather wean people off flagging and onto an uncertainty estimate.

When the procedure is done – an analysis of the outliers can follow. Has to be an iterative process.

1. Aggregation of the complete set of profiles.
2. The system - agreed set of QC checks.
3. Then the products themselves.

Ann Thresher - "The nature of the problem" + Discussion

Agreed that we will tackle this. There will be an automated part to the QC process. There will also be a manual QC step.

Do we want a working group on bringing more data into the archives? Is this activity outside the remit of this group?

What are the data we should include? Suggest that Argo data is fine. What about TAO data? Do we just accept their QC? Data that are already scientifically Qced?

The very early data deserve special attention. V. Gouretski. Do that separately.

Looking at pre-WOCE, post-WOCE.

Coastal vs non-Coastal areas.

Not QC Argo, but still need to assign error bars to that data.

Discussion on how to break up the problem into bite size chunks. Subset by geographic region, time period, instrument type etc etc.

Important to establish the scope of the task at hand. How much already Qced data can we simply ingest? (and assign error bars for?).

What is the science driver?

Bec suggests just tackling those data types that we already know something about – XBT, MBT, CTD, Bottle data etc. Ocean feature expertise are more important than instrument XBT. Argues for processing more than one data type at the same time – more information for helping with manual QC.

Need specific groups who are experts on instrument type pathologies and that can support each other. It can take a while for people to converge on the manual QC methods. So much of the QC is regionally based, and requires regional expertise.

The nature of how the task is broken down may be determined by the resources available.

Want to achieve the best data set for climate estimation. Issue of providing data for data assimilation.

IPCC AR5 science drivers: Extending the period, and shrinking the systematic errors.

Probably not cover Argo, Moored arrays, drifting buoys.

Use aggregated data quality control.

Discussion on crowd-sourcing. Lots of advantages. With 100s of people looking at it. The work is really on responding to the questions and managing and maintaining the engagement. Use it to sell other messages. The economics needs to be worked out.

Data interoperability (Seb Mancini)

Data management issues relevant to the QC process we're discussing

- raw data input: metadata, data discovery,
- QC methods/flags, uncertainties,
- outputs: metadata, data format/storage/discovery/delivery/visualisation

New distributed marine data management structures

- SeaDataNet (SDN) - network of data centres (35 European countries)
- Australia Ocean Data Network (AODN) = Commonwealth agencies + IMOS + Universities + state govt. agencies + fisheries ...

Ocean Data Interoperability Platform (ODIP)

- barriers to re-use of marine data (formats, standards, best practice...)
- create prototype solutions
- several topics relevant to our CLIVAR project
- QA/QC to be discussed at next meeting (San Diego, Dec 2013)
- **need interaction between our group here and ODIP**

Data discovery - metadata catalogue(s)

- standard for metadata
- examples: SeaDataNet and AODN

Common vocabularies

- important pre-requisites for interoperability (reduce ambiguities in metadata)
- For our QC project, important to have vocabularies for platforms, instruments, collection methods, processing levels, QC flags/tests, etc...

Data formats: netCDF & CF

- NODC and SeaDataNet developing common templates for data types (profile, timeseries, etc...)
- some of these templates already being adopted in IMOS
- templates being developed for glider data

Data delivery/access - compare metadata/data access & tools between SeaDataNet & AODN

Q&A

- compare SDN & IMOS netCDF conventions (new for SDN, IMOS convention has existed for a few years)
- where do SDN & AODN fit in to our QC project? A: Both as input source and to disseminate results
- if we set up QC procedures in this group, can we disseminate that via e.g. AODN? A: yes, we can adopt it within IMOS to start with, then communicate it further...
- can we approach SDN to get access to all data? A: yes, we already have contact with

them -> **ACTION**

Discussion (data management / metadata standards)

Strawman structure (Susan/Nathan) - streams of activities

1. Data and metadata recovery & assembly/aggregation

- Key data sets to target to add into WOD?
    - any low-hanging fruit? Steve: worth trying, if there's none it will be a short project; Tim: maybe, but is it essential?
    - For data that are currently available, just not in WOD, task is to communicate the request to get them in to WOD (aggregate)
- build a data assembly/recovery team? (big task! do we have the resources? Susan: could be a big distraction)
- tap into existing recovery projects?
- Susan: **invite countries to participate in this project, with condition that they contribute to the recovery & assembly work** (and the QC?)
- Nathan: through invitation, facilitate QC process & transfer of technology - i.e. it's an "outreach project"
- (these points were debated for some time ...)

- **can we fill the major metadata gaps?** (e.g.unknown XBTs; MBTs; Nansens-depth by wire out or thermometric?)
    - need to create a list of missing metadata

- **Which datasets have already been QC'd to our satisfaction that we can "trust" & adopt (add error estimates)?**
    - e.g. Hydrobase - can't get the QC info - bad data have been removed! (keeping raw data sets) It's a significant fraction of all available data; large effort has already gone into the QC, used TS space). We can still use them, just label anything still in there as "good" and give it error estimate - BUT, need to deal with duplicates!
    - WOCE UOT ?
    - CCHDO?
- **Conclusion: where we have known QC results, will find a way to incorporate them into our process (details TBD by task team)**
- What about when they have adjusted parameters?

- **Produce a detailed paper describing the aggregated data sets**

2. Auto screening of data & assigning error bars

- Improving and converging existing procedures

Task: agree on approach

- observer levels or gridded?
- agree on flag scheme, algorithms and approaches to assigning errors (by variable, platform, instr. etc..)
- do we adjust the data? (e.g filling in gaps & spikes) when do we do it? (before other checks are applied?)
    - option: fix data at point where issues are identified (in automated checks)
    - Matt: allow wider stddev range rather than apply correction before check
- What is the goal of doing auto QC? Just pick out suspect data to be reviewed

manually, or as a stand-alone QC process?

  - Susan: it's both - an interim product that can be used as is - **but it's better than existing procedures because we've agreed on the procedures together as a group of experts** - and also starting point for manual QC.

Task: team of groups who do this now

- Task 1. compare and converge on tests, critical values, levels
  - how do we do this? specify software to use? offer common code-base as free software?
  - existing software has been developed over many years - easier to adjust than to adopt completely new software.
  - -> **Agree on algorithm independent of implementation**
- Task 2. run and check over some test data sets - consistency and efficacy
  - Viktor: should use a range of data sets covering wide range of oceanographic conditions
- (iterate over 1 & 2 to fine-tune)
- Task 3. run over aggregated archive - v1
- Task 4. write peer-reviewed paper documenting method
  - It's important to document how we get the results, to build trust. They will be used as input to ocean heat content calculations. Goal is to eliminate one of the uncertainties.
  - Ccapture knowledge about instrument behaviour, e.g. from XBT comparison experiments
  - Also need to document the data sets we've assembled & gathered knowledge about

3. Expert (manual) QC

- Revisit suspect data from previous step - change flags & error estimates, adjust data where necessary, record in history
- Need machine parsable table of history and QC decisions (and human-readable, English)
- Need convergence on how this is done
- Could manual QC be crowd-sourced?
- Software: shouldn't need to be prescribe what to use, but would be good to have one piece of open-source software that anyone can use (this will be necessary if crown-sourcing)
- Should we have platform/instrument or regional specialists?
  - Alison: need to be careful that we don't do QC on a particular data set in isolation (compare to the full archive for buddies)
  - Viktor: having an expert in the instrument would make the process faster
- Need to work on creating a standard way to look at all profile data (independent of collection method)
  - Susan: this will be addressed by assigning error estimates
- What volume of data will we need to look at? Answer from tasks 1-4 above (under auto QC)

4. GDAC role

- Assemble results into a database

- Enforce/check QC flagging schemes & error assignment (format checker, etc...)
- Merge in scientific QC from previous efforts & add history as appropriate
- Provide user FAQs to guide filtering the archive for different applications, respond to questions
- Host documentation, manuals, etc...
- Produce products
    - and tools? NO - don't have resources to support
    - link to products others have produced
- metrics for success?
- Track metrics on progress:
    - global coverage,
    - % years covered,
    - % manual vs. auto screened,
    - data usage (can be done at low level, without user login or action needed)
- Timeframe? Needed from the beginning as GDAC has a coordinating role (mainly communicate via website)

Interim outputs

OCDA:

- **V1: machine flagged observer data archive w/ documentation** VX (with high-quality core data such as CCHDO, Hydrobase, ...)
    - the main product is the QC information
    - need unique profile id (have these in WOD)
- **V2: start to include some manual QC, more data**, etc...
- Put DOI on each release
- Versions fixed or continually updated?
- Annual releases? V2.1, 2.2, etc... (For WOD, quarterly releases, archived so you can get earlier ones)
- **Traceability is essential!**
- Suggestion to call V1 "A" and V2 "M" (instead of using numbers)

GOCDA: vertically gridded version?

5. how to organise ourselves?

- Science steering team: experts and users
- 4 technical task teams?
    - rescue/aggregation experts
    - automated QC experts
    - manual QC experts
    - GDAC role
- + group to define what products/outputs to produce??
- Close interaction between auto/manual QC groups

Organised break-out groups for the 4 technical task teams, names on board.

Session 5: Implementation plan: An agreed outline

Session Chairs: Matt Palmer, Gary Meyers. Notetaker: Bec Cowley.

The first part of this session was devoted to breakout groups and deriving agreed goals for each task group. A summary of the discussions are listed below, and following are the agreed tasks from these breakout groups.

AGGREGATION GROUP

- Compiling the list of what we don`t have is an essential first step.
- Will need to get support from CLIVAR and other agencies to get people to release their data.
- Need to be able to demonstrate the difference that releasing data will make.
- Acquiring readily available data will have a 2-3 month timeline.
- Engaging parties will take 3-6 months.
- For the provision of intelligent metadata, the important thing is to define the algorithm, the application of this may be part of the auto QC effort.
- Should be able to show that additional metadata has improved metrics such as comparisons between XBT and CTD profiles for the profiles with guessed metadata.

AUTO QC GROUP

- Assigning uncertainty is mostly instrument based, and this will be OK for a first attempt at this.
- We can then do a better job by looking at the details of e.g. type of recorder, who collected the data.
- We haven`t addressed the influence of people using different climatologies in their tests.
- Different climatologies may be better in different regions.
- Time line is 1st Aug - Get data sets; 31st Oct - run screening tests; 31st Dec - complete assessment (i.e. convergence on algorithms comes afterwards). A subset of the data will then need to go to the manual QC group.

MANUAL QC GROUP

- There was a discussion about data formats. Questions included whether we need a working group on this or should we use translation tools (data can be reformatted to the WOD input format, and can create particular formats from the output)? We should use existing formats rather than creating our own, but we need to decide on what we need in the files (such as history information) and tell our requirements to the people creating the data.
- Should we modify the data (e.g. interpolate spikes)? There was disagreement over this. Some people thought yes, others thought it should be up to users to choose to do this if they wish. There is also a question about how to store any adjustments. The raw data could be kept with information about how to do the adjustments, or multiple copies of the data could be stored (adjusted and non-adjusted). The former could be difficult to store if the adjustments are complex, so the option of keeping two copies is probably preferred.

GDAC GROUP

- The GDAC role is numbers 3 and 4, and maybe 5 (from the list of tasks from this group).
- Would need 3-4 months to define the GDAC role (Tim).
- Alison, Susan and Steve will work on defining metrics (with Susan coordinating).
- Simon and Matt to coordinate item 5.

GDAC task group

Members:

Catia Domingues (group leader), Tim Boyer, Nathan Bindoff, Steve Diggs, Jim Sift, Simon Good, Susan Wijffels, Matt Palmer.

Others to be invited to join: ?

Goals, tasks, timelines

The GDAC task group will:

1. Coordinate all task teams
2. Establish a steering group (Director, Co-chairs: provide clear directions)
   - Steering group role: ensuring delivery of what we promised (quality/consistency) and managing the integrity of the workflow
3. Investigate possibilities for GDAC locations and define GDAC roles and resources needed (NODC, Coriolis, ?)
4. Define & track metrics (over different steps workflow/final product)
5. Establish documentation/products to meet end user requirements (FAQs, flags/errors/data products/ documentation/traceability/manuals)

Task	Date completed by	Who
Coordinate all task teams		
Establish a steering group		
Investigate possibilities for GDAC locations and define GDAC roles and resources needed.		Tim
Define & track metrics		Alison, Susan, Steve
Establish documentation/products to meet end user requirements		Simon, Matt

Aggregation task group

Members:

Catia Domingues (group leader), Tim Boyer, Gustavo Goni, Viktor Gouretski, Nathan Bindoff, Steve Diggs, Jim Swift, Marty Hidas, Sebastien Mancini, Guy Williams, Uday Bhaskar, Toru Suzuki, Sergey Gladyshev.

Others to be invited to join: ?

Goals, tasks, timelines

The Aggregation task group will:

1. Provide an inventory of the details of the problems for available historical data/metadata

2. Provide a list what we don't have / high level pressure
3. Begin acquisition of readily available sources of QCed/flagged data into WOD.
4. Begin engaging parties in acquisition
5. Begin provision of intelligent metadata

Task	Date completed by	Who
Provide background information for an inventory of the details of the problems for available historical data/metadata		Tim, Viktor, Toru/Ishii
Make a list what we don't have / high level pressure		Nathan, ??
Begin acquisition of readily available sources of QCed/flagged data into WOD.		Potential sources: • ENACT (Simon) • Hydrobase (Curry), Southern Ocean DB (Orsi) (Tim) • BSH (Viktor) • Japan (Toru/Ishii group) • Australia (Marty/Guy/Seb) • Any other? (Catia)
Begin engaging parties in acquisition		• Norway (Catia) • China (Bec) • Mexico (Tim/Catia) • South America (Alberto Piola/Catia) • Brazil (Clemente/Catia/Gustavo) • Russia (Sergey/Catia) • European Union (Roger Proctor/Catia)
Begin provision of intelligent metadata		Tim, Viktor, Gustavo, Steve, Jim

Auto QC task group

Members:

Rebecca Cowley (group leader), Ann Thresher, Tim Boyer, Jeff Dunn, Shoichi Kizu, Gustavo Goni, Viktor Gouretski, Guy Williams, Matt Palmer, Simon Good.

Others to be invited to join: Giles Reverdin, Mathieu Ouellet, Igor Yashayeev, Ruth Curry, Loic Petit de la Villeon.

Goals, tasks, timelines

Short term/immediate goals:

The Auto QC working group will:

- Work towards a consensus on auto screening tests
- Do this by testing different auto screening methods on two datasets that have been fully QCd
- Get one person (student?) to assess the performance of each auto qc screening
- Re-grouping to discuss the results

Long term goals:

- Gather together a group of experts in individual instrument types to develop a scheme for assigning error estimates (Bec to begin coordinating, but might be better to engage someone else for this job)
- Provide a clear statement of what the AutoQC group would like to achieve
- Document a standard list of tests

Task	**Date completed by**	**Who**
Construct test datasets	1st August, 2013	Ann, Bec, Viktor
Run screening tests on datasets	31st October, 2013	Vkitor, Tim, Simon, Ishii, Gustavo, Bec/Ann. Giles? Loic?
Develop an assessment plan for the screening tests	End of 2013	Ann, Viktor, Simon.
Pass on a sub-set of the screened data to the manual QC group.	Start of 2013	?

Manual/Expert QC task group

Members:

Ann Thresher (group leader), Shoichi Kizu, Matt Palmer, Gustavo Goni, Simon Good, Uday Bhaskar, Ping Robinson, Alison Macdonald, Rebecca Cowley, Molly Barrenger, Lisa Lehman, Giles Reverdin, Alexandro Orsi, Guy Williams

Others to be invited to join: ODF group at Scripps?

Goals, tasks, timelines

The Expert QC task group will:

1. Define codes and flags and tests to be applied. Some of these will be instrument specific, others will be general.
2. Establish rules for quality code use (e.g., you cannot apply a wire break to a bottle, XBT data cannot have good data below bad except in very specific circumstances), decide whether we can change data (interpolate spikes? Move data subject to premature launch failure?)
3. Document codes and procedures and provide detailed instructions for QC.
4. Establish a group of experts to advise on regional issues or issues specific to a particular instrument type
5. Provide an estimate of costs of doing manual QC for funding applications.

Long term goal: Set up a group to monitor and assess the global manual QC as it is returned to the master database.

Task	Date completed by	Who
Define codes and flags and tests to be applied.	1st August, 2013	
Establish rules for quality code use		
Document codes and procedures and provide detailed instructions for QC.		
Establish a group of experts to advise on regional issues or issues specific to a particular instrument type		
Provide an estimate of costs of doing manual QC for funding applications		
Set up a group to monitor and assess the global manual QC.		
Investigate crowd sourcing	End 2013	Matt Palmer

Planning funding strategies and wrap-up discussions

Do we nominate that we are only doing temperature? Do we open the door to salinity and other variables? Remember that the QC is not of 'salinity', but of 'density'. We all agree that we should concentrate on temperature, but in the future we may apply the methods developed to other variables. Ultimately we want a 'climate' dataset.

Do we adopt an XBT fallrate correction? For QC, we should adopt the Cowley et al corrections at this stage.

We need a chair and a project support officer to be included in any funding requests. The Science Steering team might get very big, so we will need an executive committee consisting of hands-on members.

Any one who would like to be involved in the write up of the scientific implementation plan was invited to let Catia or Matt know. The Leaders of each task group will be involved in the write up. The Steering Team members need to be entrained in the writing.

Is it possible to get sustained funding sources? The idea of sustained funding is still out there. Not a bad environment to push this idea forward.

Funding sources.

Gustavo: the NSF might be a viable source of funding. Endorsement from CLIVAR might help.

Viktor: There is good support from the European community and large funds available for environmental studies. Viktor will talk with Detlef about this.

Catia: What about the European Union? They have funding if you have a project with infrastructure already. These funders are very keen to fund something like this project.

Matt: Cost action (?) will fund small projects.

Alison: What about private foundation funding? Woods Hole donors?

Steve: Earth Cube are looking for this sort of project. They are looking for cyber infrastructure to fund. How do we approach them? Steve Diggs is working with them. They are having a meeting in Tuscon in August and he will present our project to them (we need to have some slides ready for this).

Presentations to International panels and committees.

GODAE group: Tim and Susan

Ocean coordination group for GOOS: Susan, Gustavo

Ocean Sciences meeting Febrary AGU (Maybe a Town Hall meeting?): Bec

Earth Cube: August, Steve

IAPSO: informal meeting? Alison, Bec (too late?)

EGU: April, Matt, Simon, Detlef?

We need a set of powerpoints ready by September to give to presenters. We will circulate a list of these meetings and see who is going.

Next meeting.

Gustavo volunteered AOML, Miami – June 2014.

APPENDIX A – WORKSHOP AGENDA

Day 1	**Wed 12th June (8.00 – 18.10 h)**		
8.00 – 8.15	**Registration and Tea/Coffee**		**15 min**
Morning	**Overview talks**		
Chair:	***Bec Cowley (Rapporteur: Good)***		
8.15 – 8.20	**Welcome and logistics**	Domingues	5 min
8.20 – 8.30	**Motivation and workshop goals** (defined by org. committee, including report for CLIVAR)	Wijffels	10 min
8.30 – 8.40	**Introduction to provisional Terms of Reference** (project scope developed by org. committee, reviewed and finalised at the end of the meeting)	Domingues	10 min
8.40 – 9.20	**The historical subsurface ocean T/S data: what takes to assemble a global data set & metadata recovery: what has been achieved and what lies ahead.**	Boyer, Levitus, Gilles, Gouretski, Kizu	30 min + 10 min
9.20 – 9.45	**Relevant lessons from ACRE & ICOADS Projects**	Good/Allan, Palmer/ Woodruff	20 min + 5 min
9.45 – 10.00	**Break**		**15 min**
Chair:	***Simon Good (Rapporteur: Thresher)***		
10.00 – 11.40	**Instrumentation types, data and metadata (accuracy, biases and known issues)**		80 min + 20 min
	1. Introduction	Boyer	5 min
	2. General Nansen cast problems/metadata	Gouretski	10 min
	2a. 19th/early 20th century data	Gouretski	5 min
	2b. Specific Nansen cast example	Kizu	5 min
	3. MBT problems/metadata	Gouretski	10 min
	4. XBT problems	Kizu	10 min
	4a. General XBT metadata	Kizu	5 min
	5. CTD problems/metadata	Swift	15 min
	6. Other instruments problems/metadata	Boyer	10 min
	7. Wrap up	Boyer	5 min
11.40 – 12.05	**The end users perspective – from measurement to research**	Macdonald, Swift	20 min + 5 min
12.05 – 12.30	**The end users perspective – who are we doing this for?** (e.g., climate science and data assimilation efforts)	Cowley (coordinated by Oke)	15 min + 5 min

12.30 – 12.50	**Overall discussion (lead: Cowley, Good)**	All participants	20 min
12.50 – 14.00	**Lunch**		**70 min**
Afternoon	**Sharing PROS and CONS experiences: QC and data management**		
Chair:	***Masayoshi Ishii (Rapporteur: Cowley)***		
14.00 – 14.20	**US NODC**	Boyer	15 min + 5 min
14.20 – 14.40	**US AOML**	Goni	15 min + 5 min
14.40 – 15.00	**US Scripps**	Thresher, Roemmich	15 min + 5 min
15.00 – 15.30	**US GTSPP (+ Optimal Spectrum Decomposition)**	Thresher, Sun	25 min + 5 min
15.30 – 16.10	**UK**	Good, Palmer	15 min + 5 min
16.10 – 16.30	**Break**		**20 min**
Chair:	***Tim Boyer (Rapporteur: Good)***		
16.30 – 16.50	**Japan**	Ishii (brief), Suzuki	15 min + 5 min
16.50 – 17.10	**Germany**	Gouretski	15 min + 5 min
17:10 – 17:20	**India INCOIS**	Bhaskar	15 min + 5 min
17.20 – 17.40	**Australia (QuOTA)**	Cowley, Thresher	15 min + 5 min
17.40 – 18.10	**Overall discussion & Summary QC methods: PROS and CONS (lead: Ishii and Boyer)**	All participants	30 min
18.30 – 21.00	**BBQ with UTAS-ACE CRC-CSIRO PhD students & Postdocs (CSIRO canteen)**		**150 min**

Day 2	**Thurs 13th June (8.00 – 17.30 h)**		
8.00 – 8.20	Tea/Coffee		**20 min**
Morning	**Establishing QC system and data management protocols for subsurface ocean temperature data**		
Chair:	***Ann Thresher, Viktor Gouretski (Rapporteur: Palmer)***		
8.20 – 8.45	**What level/type of quality control/metadata does the creator of analysis tools and gridded products need and want?** (e.g., Data quality and CARS;	Dunn, Ridgway, Barker,	20 min + 5 min

	Making a cast statically stable)	McDougall	
8.45 – 9.00	**Reviewing QC methods** (summary table: pros/cons)	Thresher, Gouretski	15 min
9.00 – 10.30	**Discussion of a unified QC system approach** (producing a flow chart of the QC steps) **(lead: Thresher and Gouretski)**	All participants	80 min
10.30 – 11.20	**Group photo (with Craig Macaulay) + Break**		**50 min**
Chair:	***Ann Thresher, Viktor Gouretski (Rapporteur: Palmer)***		
11.20 – 11.40	**Data management (acquisition/delivery) – Title TBA**	Diggs	15 min + 5 min
11.40 – 12.30	**Discussion of QC data engagement priorities** (e.g., straw man approach with list of possible subsets – recent data, XBT data, full resolution data, ocean basis approach (WOCE, DAC approach, only profiles with adequate metadata, attack only data that has not been scientifically QCed or gone through high quality QC processes?) **(lead: Thresher and Gouretski)**	All participants	50 min
12.30 – 12.50	**Summary discussions**	Thresher, Gouretski	20 min
12.50 – 14.00	**Lunch**		**70 min**
Afternoon	**Continued: Establishing QC system and data management protocols for subsurface ocean temperature data**		
Chair:	***Nathan Bindoff (Rapporteur: Hidas)***		
14.00 – 14.30	**Data interoperability for 21st century science** (e.g., overview of SeaDataNet, Ocean Data Interoperability Platform (ODIP), Australian Ocean Data Network (AODN); data format, metadata protocols, modes of data delivery)	Mancini, Proctor	20 min + 10 min
14.30 – 15.30	**Discussion of data management / metadata standards** Software development? Storing/serving/webhosting the data? Do we need a GDAC? More than one GDAC? Will the GDAC do basic checking before adding data? Obvious errors? Formats OK, content check? Who sends out the	All participants	60 min

	datasets that need to be QCed? What checks are done before they are sent? (Duplicates? Basic stat/metadata checks?) Data preservation? **(lead: Bindoff and Wijffels)**		
15.30 – 16.00	**Break**		**30 min**
Chair:	***Susan Wijffels (Rapporteur: Hidas)***		
16.00 – 17.00	**Way forward: what working groups do we need?** Sharing the workload. Seek commitments from groups for personnel and funding. Division of the workload based on expertise or locality? Attach members to each group. i. QC methods ii. Steering group for scientific implementation plan (CLIVAR requirement) iii. Data assembly iv. Metadata harvesting v. Quantifying uncertainties (uncertainty in the data from instrument errors; uncertainty in how to correct for bias; uncertainty in the QC decisions (one system or operator might make a different choice on what data to reject). It is also important to assess correlation scales for errors e.g. an error in an XBT bias correction factor would affect XBT data globally, while assigning the wrong correction to an XBT due to lack of metadata is a more localised error.) vi. Data delivery/final formats/storage **(lead: Bindoff and Wijffels)**	All participants	60 min
17.00 – 17.30	**Summary discussions & agreed points**	Bindoff, Wijffels	30 min
18.30 – 21.00	**Dinner function (The Mill, Morrison st, Hobart)**		**150 min**
Day 3	**Fri 14th June (8.40 – 17.00 h)**		
8.40 – 9.00	**Tea/Coffee**		**20 min**
Morning	**Implementation plan: an agreed outline**		
9.00 – 9.10	**Introduction** (room locations, what outcomes we want from the breakout sessions)	Domingues	10 min
9.10 – 9.40	Aggregation break out group in Freycinet Room	Breakout sessions Part 1	30 min
9.40 – 9.50	**Mini-Break**		**10 min**

9.50 – 10.20	Auto QC break out group in Freycinet Room	Breakout sessions Part 2	30 min
10.20 – 10.30	**Mini-Break**		**10 min**
10.30 – 11.00	Manual QC break out group in Freycinet Room	Breakout sessions Part 3	30 min
11.00 – 11.20	**Break**		**20 min**
11.20 – 12.10	GDAC Role break out group in Freycinet Room	Breakout sessions Part 4	30 min
Chair:	***Matt Palmer (Rapporteur: Cowley)***		
12.10 – 13.00	• Decide on Science Steering Team members • Meet and review each group's outline for implementation plan. • Decide on sharing/writing/editing tasks – report of meeting and proposals for further funding/participation. • Agree on drafts/final copy timelines. **(lead: Palmer and Domingues)**	All participants	50 min
13.00 – 14.30	**Lunch**		**90 min**
13.45 – 14.30	**CSIRO Marine Lab tour (with Mark Underwood & Craig Macaulay)**		**Max. 45 min**
Afternoon	**Planning funding strategies & Wrapping-up**		
Chair:	***Gary Meyers (Rapporteur: Cowley)***		
14.30 – 15.00	**Lessons from XBT & Argo projects** (relevant to our project, from coordination, citizenship projects, protocols to funding, etc.)	Meyers, Wijffels	20 min + 10 min
15.00 – 17.00	• Identify main funding agencies/sources • Project lifetime? Are there any ways to try to guarantee long-term sustainability of this project? • Agree on and finalise the Terms of Reference • Review action items (ensure names & deadlines are associated with action items) • Next meeting – How often? in conjunction with other communities (SOT, GTSPP) **(lead: Meyers, Palmer and Domingues)**	All participants	120 min
17.00	**Adjourn**		

APPENDIX B – List of Participants

Organising Committee	Email	Affilliation	Country
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Katy Hill	khill@wmo.int	GCOS/GOOS/WCRP/WMO	Switzerland

Attendees

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*CLIVAR Global Synthesis and Observations Panel (GSOP) panel/**Project Officer

http://www.clivar.org/organization/gsop/activities/clivar-gsop-coordinated-quality-control-global-subsurface-ocean-climate