Coriolis

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3rd ARGO-France meeting

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The 3rd Argo-France meeting, organized by the Coriolis project (one of 2 GDAC of the ARGO program), occurred on 11-12 May at the Ifremer centre in Brest. The meeting was successful, with more than 25 participants and 18 presentations. The agenda and most of the talks can be found on the Coriolis web site:

http://www.ifremer.fr/coriolis/

The meeting aimed to bring together data managers from the Coriolis project and French researchers working on the ARGO floats, to review ongoing research activities and to discuss future contributions and directions within the Coriolis/Mercator research program.

The program was organized around 3 themes.

❖ Reports by the Coriolis data centre on:
- The real-time quality control applied to the data, either to vertical profiles (ARGO, XBT, XCTD, non-calibrated CTD, Moorings, Gliders, Sea furs) or "trajectory data" (Thermosalinograph, lagrangian buoys, etc.).
- The delayed-mode quality control of ARGO salinity profiles. The aim is to give to Argo PI some clues for corrections of observed conductivity drifts. The method of correction is based on the algorithm proposed by Lars and Böhme (method derived from Wong, Johnson and Owens) and the Coriolis center follows the recommendations issued from the DMQC Workshop that was held in San Diego in April 2005. Complementary tools are proposed to ARGO PI (objective analysis maps, technical parameters, etc.).
- Regional validation in the North Atlantic and coherence of the data set from 2000 to 2005.
- Products derived from objective analysis maps obtained not only from Argo floats but from all the data acquired by the Coriolis center. These maps allow a finer quality control and can be used to study the evolution of temperature and salinity at different levels of pressure.

❖ Reports by Scientists PI of Argo floats deployments, either about future deployments that will be made in the framework of research program or about scientific analysis made using Argo floats.

87 Provor floats (ARGO floats conceived by Ifremer and Maritech) have been deployed in 2005 and 74 should be deployed in 2006 by the PI funded by the GMMC (Groupe Mission Mercator Coriolis). These deployments now occur in the 4 oceans and in the Mediterranean Sea: specifically in the eastern and western Pacific Ocean, in the North Atlantic, the Canary upwelling region and in the Gulf of Guinea, and in the Antarctic ocean south of South Africa.
Scientific analysis using Argo float data are in increasing numbers and we can highlight the study of the frontal zones in the Antarctic Ocean, where Argo floats significantively increase the historical salinity profiles database in that region, or the study of zonal jets at 1000 m in the tropical Atlantic Ocean using Argo floats drift. That later study is particularly interesting as the zonal jet structures deduced from Argo floats drifts (velocity error of the order of a few 1cm s^{-1}) are very similar to the circulation inferred at 750-800 m depths from Marvor float (Rafos-like acoustic floats) known for their very good position accuracy (velocity error of the order of a few mm s^{-1})..
It has to be noted that scientists tend to develop their own criteria for validation of salinity profiles thanks to their knowledge of the region they are investigating.

❖ Reports by Scientists on the assimilation of Argo floats in OGCM. Several talks were made about the impact of the assimilation of Coriolis data in the Mercator Models. Interestingly, it was shown that

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the assimilation of the positions of 4 ARGO floats during 3 months in a high resolution model of the western Mediterranean sea improved the position and intensity of currents and eddies. The transport in the Corsica strait was also improved.

Mercator also expressed the need to get, in a near future, deep currents from Argo floats to extend their product on the surface circulation, SURCOUF, at depth, a SURCOUF-3D.

At the end of the meeting it was recommended that the links between the Coriolis project and the scientific teams be strengthened, particularly for the delayed mode quality control of Argo profiles. The Coriolis project should benefit from the regional knowledge of the hydrology and dynamics of scientists to improve the quality of the Argo database.

This improvement should also come from an increase of CTD in the data base. Scientist are now well aware that quality control necessitates that CTD profiles be transmitted in near real-time (even non-calibrated) to data center.

The final issue discussed during the meeting was the future of the Coriolis project and the Argo program.

There will be 3 phases:

1) First the merging of the Coriolis Data center, GDAC for the ARGO float program, the Navy/Shom database and the national physical oceanography database SISMER.

2) Second, discussions are in progress to make the Coriolis project a viable data center. Its main activities will be :
   - Sea-going activities (Argo program, Ship measurements, Calibration facilities)
   - Data center.
   - Data validation and Research and development activities.

3) Third, extend its activities to Europe in the framework of GMES.

At least a consolidation of the Argo float program as to be done for the near future. Discussions have been made at a European level to establish an infrastructure for the funding of 250 floats per year including regional enhancements (Nordic seas, Mediterranean).

This initiative needs the support of the scientific community involved in the ARGO program.

EURO - ARGO proposal submitted to ESFRI

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What is ESFRI?

The role of the European Strategy Forum on Research Infrastructures (ESFRI) is to support a coherent approach to policy-making on research infrastructures in Europe, and to act as an incubator for international negotiations about concrete initiatives. In particular, ESFRI is preparing a European Roadmap for new research infrastructures of pan-European interest.

This roadmap, to be officially presented in October 2006, will help the European Commission in the preparation of its FP7, and in identifying infrastructures of major interest to the European research communities. They cover all scientific areas, regardless of possible localisation.

The review criteria are based on two main criteria:

- *The Scientific Case* (needs of the scientific communities, impact on scientific developments, enhancement of the European Research Area, international context, relevance and quality).
- *The Concept case* (maturity, technological and financial feasibility).

The Roadmap is elaborated by three Working Groups (RWG), and their Expert Groups (in the present case: Expert Group on *Biodiversity and Environment*).

The Euro - ARGO proposal

A preliminary letter of interest had been sent in March 2005 by IFREMER, followed by a more complete proposal submitted in March 2006. The proposal was prepared by Y.Desaubies and P.Y.Le Traon, with input and strong support from colleagues and Agencies in France, the UK, the Netherlands, Spain, Norway, Italy, Germany, the ECMWF and NOAA. The proposal was then presented by Y. Desaubies, J. Gould and P. Vincent at a hearing held by the Expert Group on March 23.

The core of the proposal is to demonstrate the unique position of the ARGO array for ocean and climate research, as well as for ocean monitoring and applications, and the strong benefits to the European research community. The maturity of the concept is well established. It is argued that Europe must contribute on a par with major contributors. Since the international array comprises 3000 floats whose lifetime is estimated to be of the order of 4 years, the maintenance of a sustained network requires that the array be renewed by quarters every year. The USA has committed to half of that effort.

It is suggested that the European contribution should be of the order of ***a quarter of the global array***.

Specific European interest requires a somewhat increased sampling in regional seas (Nordic and Mediterranean sea): the infrastructure should comprise 800 floats in operation at any given time. The proposal is to build up to that level in four years, and thence to maintain it indefinitely. To focus the budget estimates, an extended period of eight years is envisioned, for a total of 12 years. The funding is needed for a total of the order of **250 floats per year**.

The proposal considers not only float procurement, but also field operations and logistical support, data management, and infrastructure governance.

The overall budget is estimated at 75 M€ over a 12 year period. It is expected that several sources of funding are necessary to sustain the array: national funding will continue, but specific European commitment is necessary to ensure the added global dimension. Cost-sharing between different Directorates General, several programmes and instruments (Research and Development, Industry, GMES, GEO, Infrastructure) is desirable. A possible mechanism would be to fund the Data Management activities in the wider context of GMES Marine Core Services, and share the rest of the operating costs between national and Community support.

The estimates do not include associated research programmes, nor do they include ship time. It is assumed that the deployments will take advantage of scheduled research cruises or use ships of opportunity.

Present status of the proposal

As of this writing, the proposal has cleared the first steps; it will be one of some 22 research infrastructures included in the recommendations to the ESFRI forum in Austria on June 15. Further discussions will then follow to converge on the roadmap (October 2006) and the FP7 Work Programme (it is expected that a total of 1900 M€ will be allocated for Research Infrastructures in the FP7).

Support by national delegates and agencies on the diverse European working groups and panels is essential to move forward towards a Euro - Argo research infrastructure.

Coriolis involvement in OceanSITES

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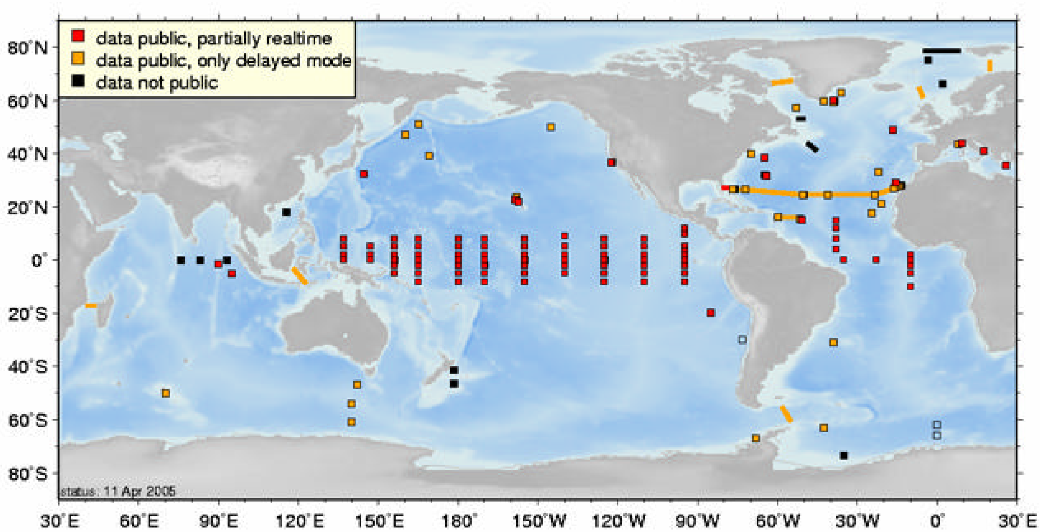
OceanSITES is a worldwide system of long-term, deepwater reference stations measuring dozens of variables and monitoring the full depth of the ocean from air-sea interactions down to 5,000 meters. Since 1999, the international OceanSITES science team has shared both data and costs in order to capitalize on the enormous potential of these moorings. The growing network now consists of about 30 surface and 30 subsurface arrays. Satellite telemetry enables near real-time access to OceanSITES data by scientists and the public. OceanSITES moorings are an integral part of the Global Ocean Observing System. They complement satellite imagery and ARGO float data by adding the dimensions of time and depth.

Last February, just before the Ocean meeting in Hawaii, members of the data management and science teams of the international program OceanSITES met for 3 days. The data management committee, lead by S Pouliquen, was formed 18 month ago but it was the first time they were meeting each other. 23 persons from 13 institutes representing most of the current OceanSITES sites attended this meeting.
The situation is that the OceanSITES data are underused, especially for operational oceanography (GODAE, JCOMM) because the data flow to users needs improvements (multiple WWW and FTP sites, multiple formats, multiple quality control methods…). It's no more a question of tools: data access has



Current and Funded Sites

improved a lot in past years within different domains that are addressing the same communities (Argo, Gosud, Carbon, Clivar…). Moreover there are national and International programs that are emerging (Orion/OOI in USA, GMES in Europe and GEO at International level…) and push OceanSites community to move forward and build for OceanSites a data management organization that is coherent with these programs without reinventing the wheel.

The main achievements of this meeting were:

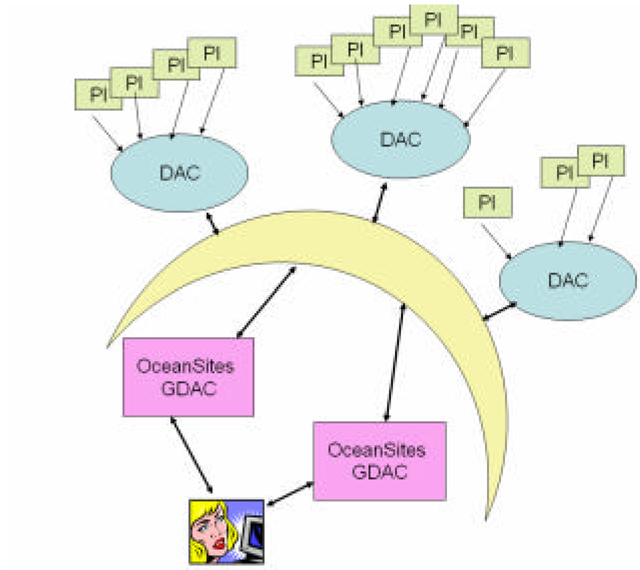
Definition of a common format for time series data able to handle both fixed mooring data and vessel occupied sites. This format is compatible with the ARGO and GOSUD formats

Definition of dataflow for OceanSITES based on a distributed data system with three different actors:

Pis: responsible of a specific Site who assure the at sea activities, and provide to the Dac the data and metadata necessary for delivery at OceanSITES project.

DACs: (Data Access Center) responsible of setting up a site server, according to the specification approved by OceanSites data management group. He guarantees the data availability, compliance to the agreed format, the quality of the data according to OceanSites agreed procedures, the organization of data processing, formatting, data transfer and update with the Pis he is working with.

Gdac (Global data access center): a Gdac is in charge of providing a virtual or centralized access to the data that are served by the Dacs, maintaining the OceanSITES catalogue, synchronizing his catalogues with the second GDAC. Coriolis will set up the European GDAC in 2006. USA plan to setup another one in 2007.



Set up a working **group to work on common quality procedures** first for real time processing

To know more on OceanSITES: http://www.oceansites.org

To access to data: ftp://ftp.ifremer.fr/ifremer/oceansites/

GOSUD: Global Ocean Surface Underway Data

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The GOSUD Project is an Intergovernmental Oceanographic Commission (IOC) programme designed as an end to end system for data collected by ships at sea.

The goal of the GOSUD Project is to develop and implement a data system for surface ocean data, to acquire and manage these data and to provide a mechanism to integrate these data with other types of data collected in the world oceans. For the purposes of this Project, the data concerned are those collected as a platform is underway and from the ocean surface down to about 15m depth. All information relative to the project is available from its web site (http://www.gosud.org).

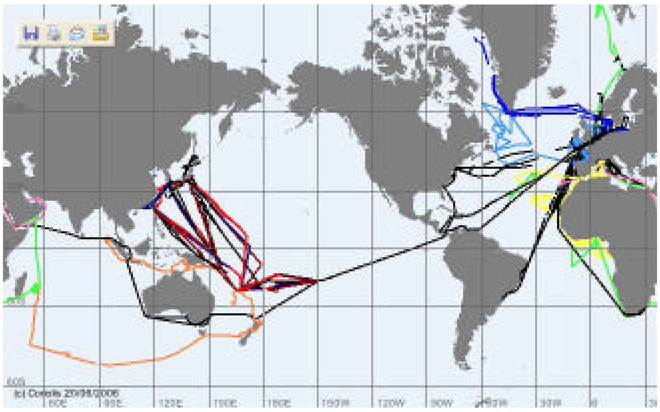
For the moment, GOSUD focused on T & S surface data. Initially, the GOSUD Global Archiving Centre was unique and hosted by the Coriolis data center. Since April 2006, a mirror site has been developed at the US-NODC. All the data are public available on ftp://ftp.ifremer.fr/ifremer/gosud/ and ftp://ftp.nodc.noaa.gov/pub/data.nodc/iode/gosud/

The GOSUD dataset is collected on board research vessels and on voluntary observing ships (VOS). IRD – France- maintain a round the world network based on merchant ships. The main interest of such a data set is obviously science. One of the new challenges will be to be able to provide validation datasets which fulfils requirements to validate the SMOS and AQUARIUS satellites data.

In parallel, the SAMOS initiative is an US project which aims to provide routine access to accurate, high-quality marine meteorological and near-surface oceanographic observations from research vessels and selected voluntary observing ships (http://samos.coaps.fsu.edu/html/).

SAMOS mainly focus on meteorological data.

The 1st joint Meeting GOSUD/SAMOS was held in Boulder in May 2006. The main objective was to identify areas of international collaboration between the 2 projects. The reflection was widened to a potential collaboration between Coriolis and SAMOS. As a first action, it was decide to exchange data from the 2 projects: Coriolis will provide the meteorological data collected by the French research vessels and SAMOS will provide the near - surface data collected by the US Research vessels.



June 2005-June 2006 12 months of T & S surface data

Correction of thermosalinograph data

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Thermosalinographs have been installed on various research vessels (R/V) and voluntary observing ships (VOS) to provide continuous records of salinity, and sometimes of temperature. Usually, they are installed on a circuit of water pumped either on the side of the bow of the vessel, somewhere below the water line. Most of the thermosalinographs currently used since the early 1990s are SBE27, which require a flow of more than 40 l/minute. The conductivity cells are fairly regularly calibrated (typically every one or two years), which indicate very commonly only minimal drifts of the cell constants. Typically, if not corrected, this results in errors on the order of 0.01 pss-78, which is satisfactory for most research studies of the variability of the surface layers (ref. GOSUD ou CLIVAR ou site ORE-SSS).

On the other hand, when analysing TSG records, it is common place to observe much larger biases or data of uncertain quality. Automatic checks have been implemented, which are recommended by GOSUD (http://www.coriolis.eu.org/GOSUD), and which result in removing a large part of the most dubious data transmitted in real time to Coriolis. However, this is not adequate to remove biases which don't result in anomalous behaviours of the salinity (or temperature) records. Correcting these biases requires having salinity data or products to which the TSG salinity records can be compared.

The present paper summarizes two approaches that can be implemented to correct the TSG records based on these comparisons.

1) comparison to other data collected on the same vessels, usually included in the 'calibration' process
2) comparison to other near-surface data using an objective mapping approach, this last step more relevant to the 'scientific validation'.

Calibration using samples or accurate measurements

Recently (since 2004 or earlier, for most vessels for which thermosalinograph data are collected in France), water samples are routinely collected (on a nearly-daily basis) that are later analysed either by ORE-SSS or CORIOLIS within six months of collection. Other data are provided by CTD casts, but have not been taken into account here. The method of correction of the biases is based on the paradigm that one can isolate periods during which the biases vary slowly, for example, between successive cleanings of the conductivity cells or calls in ports where the pump might be turned off. This seems often the case, although there are instances in particular for research vessels involved in near coastal cruises when the biases have been shown to evolve quite fast (Reverdin et al., 2006).

A typical example of the differences between sample and TSG salinities is shown for one merchant vessel (Fig. 1). This indicates a large variability in the differences from sample to sample, possibly resulting from uncertainties in the actual time of sampling. To estimate a bias, a first step is to select the salinity samples that can be retained for estimating biases.

This is based on a priori elimination of samples that present particularly large differences with a smoothed (one-hourly running mean) version of the TSG records, which eliminates in particular most samples collected in areas presenting very large salinity variability. The comparison to a smoothed version is required because:

- the TSG records are somewhat noisy, either because of irregularities of the flow rate or because of bubbles, even though most of these records have been already reduced through applying a median to the distribution of data over a certain time period (typically, 1 to 5 minutes).
- the exact time of sample collection is often uncertain, in particular on VOS.

Then, we proceed to estimate the bias by a running mean over a certain time window of the retained differences between sample and TSG salinities. We find that estimating the bias based on 5-day running mean of the differences is a good compromise between reducing this sample-to-sample noise and retaining enough time resolution for following potential time evolution of the biases. In this particular case (Fig. 1), the estimated bias is seen to present little time evolution. Another example is presented for the research cruise Picasso of the R/V Marion Dufresne (Fig. 2). Here, although the ship called in various ports and regularly crossed regions of low salinity and high particle content, we found that it was not necessary to separate in pieces the whole record, as the biases seemed to evolve smoothly during the cruise.

Validation/correction through objective mapping

Although samples are now often collected on a daily basis, this is not always the case: in particular on research vessels when not commissioned for research work, or on week-ends during transits. This was not the case for the earlier R.V. or VOS data, and for estimating biases, we have to rely on other comparisons. This can be done in some areas where the data are particularly numerous and where the statistics of space and time variability are favourable. Typically, a large number of the vessels involved here regularly cross the Bay of Biscaye or the western approaches of the British Channel. In this case, statistical techniques can be implemented (for example, by inverse modelling, Nadia Ayoub, personal communication) to estimate relative biases between the different data sets. This can be somewhat time consuming and the assumption that the biases do not evolve fast has to be done in order to use those locally-estimated biases for earlier or later segments of the TSG record.

We will explore the application of another technique, already implemented for the ARGO floats (Gaillard and Autret., 2005) at the CORIOLIS center. This is based on an analysis of residuals of objective mapping.

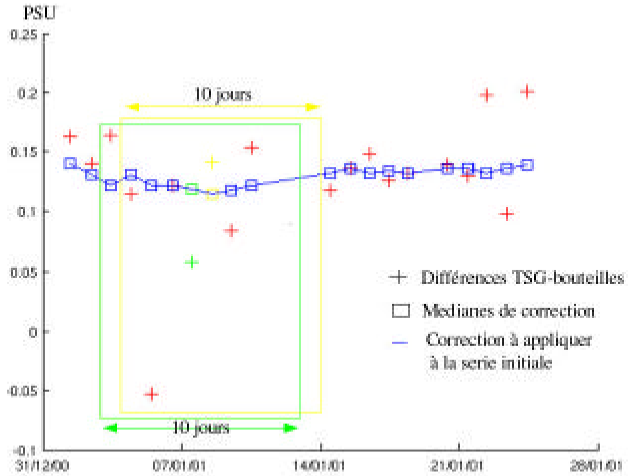

Figure 1: VOS Toucan TSG and sample data in January 2001

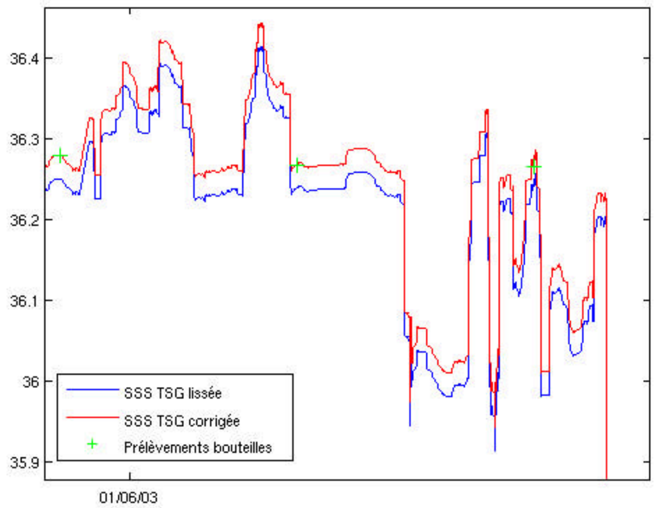

Figure 2: part of the TSG record from the PICASSO research cruise on the Marion Dufresne (June 1 2003). Samples with green crosses, and corrected record in red .

The TSG data are incorporated (with a low weight) in the data set to be mapped, which core is from the ARGO floats or other more reliable data. It is recommended at this stage that simple corrections of the most obvious TSG biases are applied before mapping. The residuals (with their error bars) can be combined along a ship track to estimate an average bias, which can be removed. Then, a new objective map can be produced, which accuracy can be checked by comparison of the residuals at sites near the TSG data in separate analyses done with or without incorporating the TSG data.

We have already evidence that corrected TSG data fit fairly well with the upper level (5m) salinity analysed at the Coriolis center. Fig. 3 presents a comparison in the central Irminger Sea of a reanalysis of ARGO data (E. Autret personal communication) and of the thermosalinograph data originating mostly from the VOS Nuka Arctica. Except for a few cases, when analysis errors are large, the two monthly time series extending now over almost five years present only small differences with no clear systematic biases and rms differences less than 0.03 pss-78. Both time series present a trend of increasing SSS until early 2005.

An example of the residuals from an objective mapping is presented on Fig. 4 at the time of the Picasso research cruise of the R.V. Marion Dufresne. In areas with other data and away from large near-coastal gradients, clearly the residuals of TSG data are small and are not particularly different from the residuals of nearby ARGO data. In areas of large gradients, the residual are non-zero, but so is the case of CTD data. Clearly, the method cannot be used as is in those later areas for estimating residual biases. Not too surprisingly, it is in those areas that the TSG data have most significantly modified the analysed SSS field (Fig. 4b). We also applied the method to a set of salinity data from surface drifters obtained during the Cosmos experiment in 2005 in the Bay of Biscaye (Reverdin et al., 2006). There, few other data were available, and this should provide an intercomparison of the different drifters. In this case, the small dimension of the domain and the large gradients near the shelf breaks prevented a successful estimation of the biases on the different drifters, that were estimated independently based on direct measurements. The differences between the known biases and the ones estimated from the residual method can reach 0.05 pss-78. It is clear that in such areas (shelves and near coasts), the configuration of the analysis system designed for the global ocean ARGO array needs to be adapted to the local bathymetry and hydrographic peculiarities.

Conclusions

We have now methods that can be implemented with reasonable success to correct biases in the thermosalinograph data transmitted to CORIOLIS or GOSUD. As mentioned before, this assumes that the sensor drifts, mostly due to fouling, do not evolve quickly. This is usually the case, but we found instances on cruises, in particular near shelves, where the drift evolves quite quickly, from day to day. To recover acceptable versions of those data would require much more thorough analysis. In those cases, the correction we propose is associated with a very large error estimate, and therefore the data can be discarded by the user.

Intercomparing the data or analysing biases by residuals of an analysis incorporating large sets of data (for instance, the ARGO float data) is also promising, and should allow the identification of biases, at least in areas far from large salinity gradients. As thermosalinograph data subject to fouling are becoming more common on various near-surface platforms, moorings, R.V. or VOS, drifting buoys, sea mammals, the need to provide some estimate of biases in a timely fashion will become more important. These techniques can provide a first guess, even though later corrections based on actual samples will certainly improve the estimate.

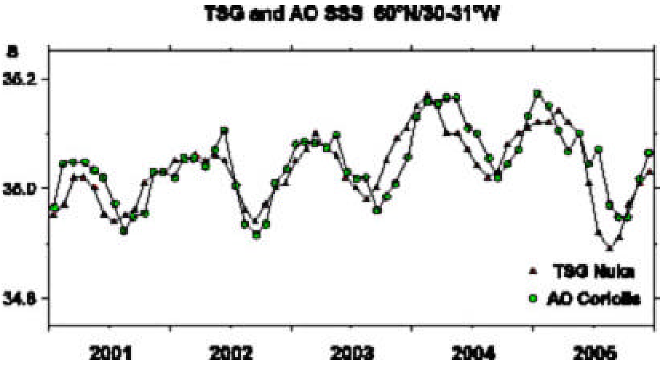

Figure 3: Time series of salinity from thermosalinographs (mostly VOS Nuka Arctica) and of the CORIOLIS 5m analysis (E. Autret, personal communication) in the eastern Irminger Sea (North Atlantic). When excluding periods with low data coverage, the average difference is 0.003 pss-78 with standard deviation of 0.035 pss-78.

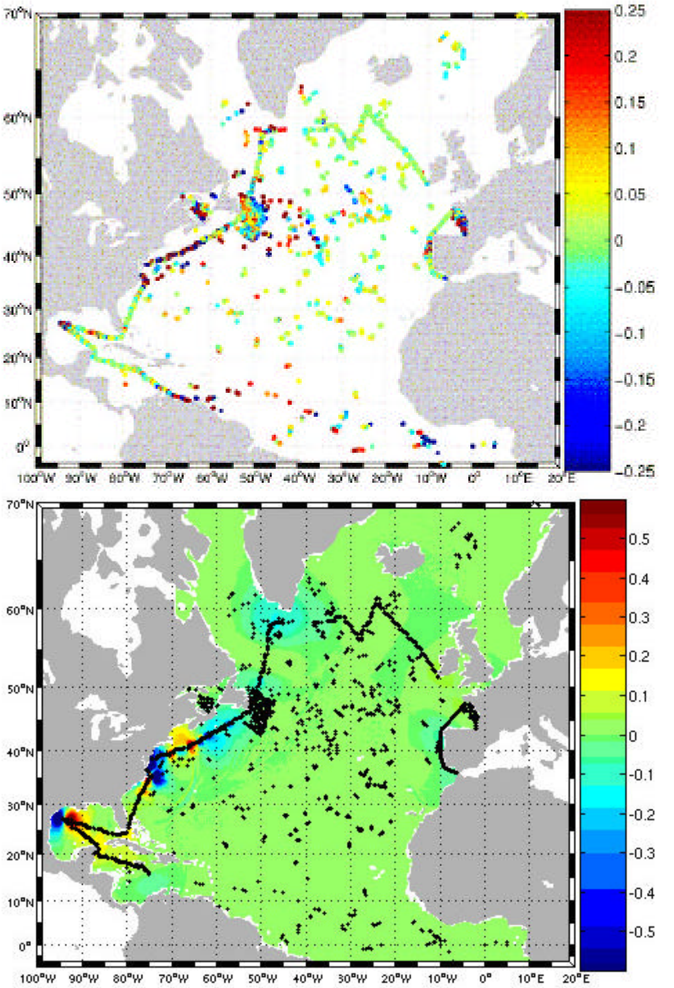

Figure 4 : Top panel: residuals from the objective map centered on June 1 2003; lower panel, difference between the analysis incorporating the TSG data and the one which did not. The analysis includes TSG data from the PICASSO cruise (R.V. Marion Dufresne), as well as some data in the Bay of Biscaye and near Spain (from R.V. Suroit and Thalassa).

Acknowledgments

This project was supported by CORIOLIS and SHOM. Data were acquired on the different French research vessels as well as by the Observatoire de recherches en environnement (ORE) SSS.

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Salinity Calibration for Southern Ocean ARGO data

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Salinity measurements of Argo floats are subject to sensor drift and offset due to biofouling and other technical problems. Several calibration methods have been developed to solve this problem and correct the data. The most recent algorithms are based on comparing the ARGO salinity profiles with historical CTD casts, and under certain conditions these algorithms are now approaching the Argo salinity accuracy target of 0.01. However, when these algorithms are applied to floats drifting in regions with very sparse historical CTD data such as the Southern Ocean, the existing methods give either large errors or no estimated correction. Errors are also increased when float data are close to strong hydrological fronts such as the Subantarctic Front (SAF) in the Southern Ocean. The SAF is associated with strong changes in hydrological characteristics and water mass structure. Since the salinity algorithms are compared to historical in-situ data within a certain radius (the basic influence bulb) it can choose historic profiles from each side of the SAF and mix them in the objective analysis, resulting in large salinity correction errors (see Fig. 1).

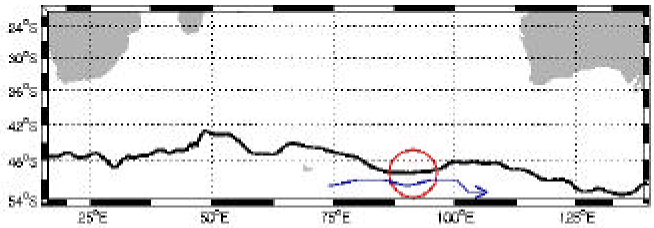

Fig. 1: Mean position of SAF in the Southern Indian Ocean (black line) from Sallée et al. (2006). The basic influence bulb (red circle) for a drifting ARGO float (blue line) which is close to the SAF can include historic profiles from either side of the front.

Since lagrangian floats can also converge towards hydrological fronts, this is a real issue for correcting Southern Ocean ARGO data.

Due to the specific problems in the Southern Ocean, we propose to improve the existing calibration method. We start by using the Argo Data Management Tool developed and made freely available by Owens and Wong (2006). It provides a calibration of float conductivity sensors that merges the objective mapping scheme of Wong et al. (2003) and Bohme and Send (2005), plus an optimal linear piecewise fitting scheme based on Dey and Jones (1995). This method based on a two step mapping procedure is applied with a generalized distance technique introduced by Bohme and Send (2005), which takes into account the strong barotropic and topographically constrained flow of the Southern Ocean. For the Southern Ocean we chose to set the large spatial scales to 4 degrees of longitude, 2 degrees of latitude, and the cross-isobath large scale to 0.5. The small scales are 2 degrees of longitude, 1 of latitude and 0.1 for the cross-isobath scale. The more recent historic observations are considered to be more appropriate for the region, hence we define a temporal decorrelation scale of one year.

Our technique to improve the salinity correction in the Southern Ocean is based on a better choice of historical data profiles. The improvement are made in two ways: 1) by improving the number of historical data profiles available, and 2) by improving the choice of profiles close to the main polar fronts.

Historical data density

The calibration technique developed by B.Owens and A.Wong uses theWOCE Ocean Database 2001 (WOD2001) for their historical data base, which includes 6646 profiles South of 25_ S after processing. Our technique uses the WOCE Southern Ocean Data Base (SODB), which has been quality checked and made freely available by Orsi and Whitworth III (2005). This dataset consists of about 93,000 hydrographic (bottle and ctd) stations south of 25S. After we have applied the same processing steps defined by B.Owens and A.Wong for the WOD2001 data, we have a final total of 31582 historical profiles South of 25 _S. In addition to increasing the total number of profiles by more than 475 %, we note that the SODB also provides a broader spatial coverage of the Southern Ocean (see Fig. 2).

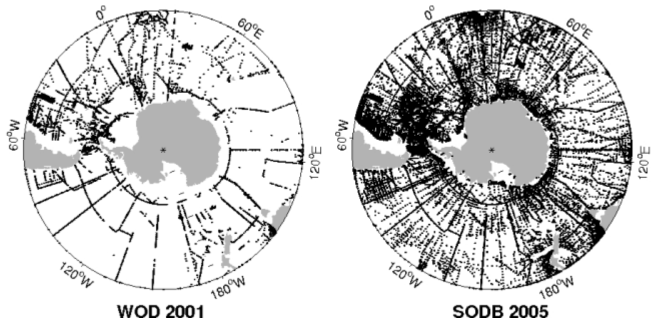

Fig. 2: Spatial distribution of historical data from WOD2001 (left) and SODB2005 (right) after the same database treatment is applied following Wong et al (2006)

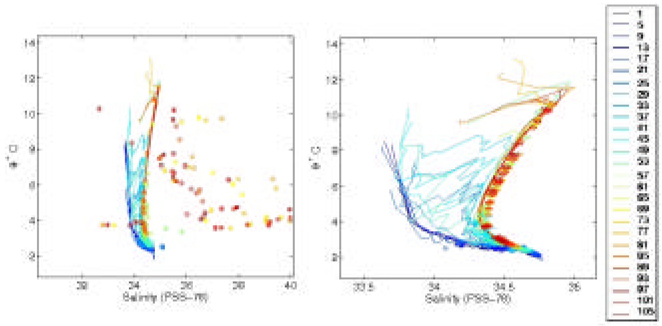

Fig. 3: Uncalibrated ?/S profiles for float n°1900042 (solid lines) compared with the estimated salinity correction from the objective analysis along theta levels for each profile (circles). Left panel: correction based on WOD2001 historical database ; right panel: SODB2005 historical database. The colours show the time evolution from cycle 1 (blue) to cycle 108 (red) three years later. The float starts south of the SAF (cold fresh profiles) and moves north of the front (warm, salty profiles) passing through the frontal region with strong interleaving.

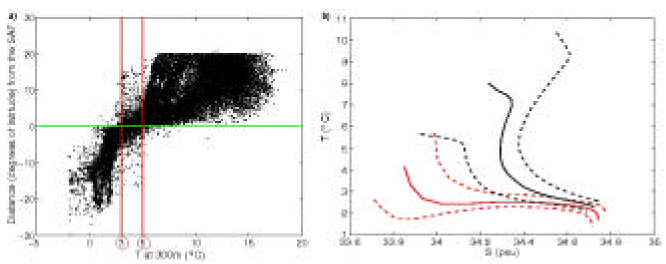

Fig. 4: (a) Temperature at 300m depth versus the distance from the SAF. Temperature data are from all of the SODB2005 and ARGO profiles available during the altimetric years (1992-2005). The SAF location is found following the Sallée et al. (2006)'s altimetric method. A positive (negative) distance means the profile is north (south) of the SAF.
(b) Mean T/S profile from south of the SAF (solid red line) with its standard deviation (dashed red line) ; mean T/S profile from north of the SAF (solid black line) plus standard deviation (dashed black line), derived from all SODB2005 profiles available during the altimetric years. The SAF location is found following the Sallée et al. (2006) altimetric method.

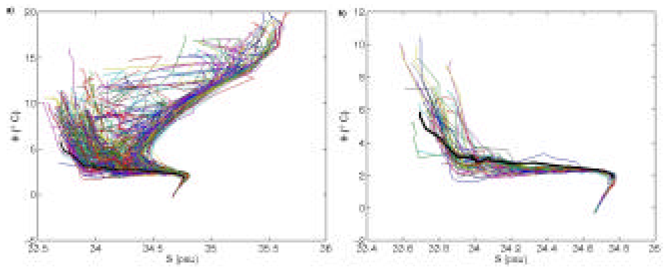

Fig. 5: Choice of historical profiles used to calibrate cycle 21 of float 1900042. The 21th _-U profile sampled by the argo float 1900042 is superimposed (bold black). (a) SODB2005 historic profiles selected without using the front criterion method. (b) SODB2005 historic profiles selected using the front criterion method

Figure 3 shows the differences in the corrected salinity when either WOD or SODB is used in the objective analysis. The salinity corrected with the WOD dataset are completely unrealistic and so no correction would be performed. Applying the same correction method but using the SODB historical data provides more acceptable corrected salinity.

Hydrological front issue

Improving the data density is not enough. Consider one profile from cycle 21 of the previous ARGO float (1900042) when it passes through the frontal interleaving region. Even when using the improved SODB database, we see that the automatic choice of selecting historical profiles within the influence bulb around the ARGO profile mixes data from very different water masses (see Figure 5a).

In fact we recognize two different groups of profiles: warm, salty profiles typical from north of the SAF and fresh, cold profiles from south of the front. Since the ARGO profile (cycle 21) is typically from south of the SAF we choose to only select historic profiles from south of the SAF to improve the salinity correction.

How do we detect whether the historic profiles are north or south of a given front ? Sallée et al. (2006) have developed an automatic method to detect time evolution of the SAF positions, using contours of altimetric SSH. This allows us to calculate the distance of the ARGO float position with respect to the SAF localized by their method. This distance is then compared to the temperature at 300m depth from historic profiles (SODB and Argo) sampled during the altimetric years. The two parameters provide a tight relation (see Figure 4a) and allow us to define a robust criterion to detect whether a profile is north or south of the SAF. This criterion is consistent around the circumpolar path. Hence we divided the Southern Ocean in three areas: (i) North of the SAF where T300m > 5°C; (ii) South of SAF where T300m < 3°C; and (iii) the "frontal zone" where 3 °C = T300m = 5°C.

The frontal zone still needs particular processing, and we have added a second criterion for profiles localized in the “frontal zone” region. Again, we use all of the WOCE historic data available during the altimetric years and localize these data with respect to the SAF, and then calculate a typical T/S profile envelope from south of the SAF, and a typical T/S profile envelope from north of the front (see Figure 4b). Hence all of the profiles which fall into the “frontal zone” in the first phase are then tested to see whether they lie inside the Southern or the Northern envelope (the envelope is defined by the mean T/S profile plus or minus the standard deviation). If the ARGO profile can’t be localized after these two steps we use all of the historic profiles, as in the basic method.

Figure 5b shows the selection of historic profiles when we use the two step front criterion method. Clearly for profiles close to the SAF the two-step method provides a better representation of the water mass structure observed by ARGO.

Conclusion

These new salinity correction techniques are giving promising results for correcting Southern Ocean ARGO profiles. Work is underway to continue validating the technique in different circumpolar regions, with the aim of making the algorithms available for the international community.

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Consistency of the ARGO data set in the North-Atlantic

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During their lifetime, some ARGO profiling floats may face drift or offset problems with their conductivity sensors. But as floats are not recovered, their sensors can not be recalibrated. Therefore a method had to be developed to control the quality of their data in an indirect way and to propose a salinity correction if necessary. This was done by Wong et al. (2003) and Böhme & Send (2005) and implemented at the Coriolis data center (see Coriolis Newsletter #2).

The procedure is based on a statistical tool that compares ARGO data to hydrographic reference database. Complementary tools are used to help discriminate between real ocean events and sensor drifts and offsets.

Although the proposed correction is based on an objective method, the final correction may be subjective as choices have to be made by the delayed-mode operators and the PI responsible of the float. Here weinvestigate ways to verify the consistency of the delayed-mode ARGO dataset.

For this specific study, we chose 77 ARGO floats (with delayed-mode data) and focused on the North Atlantic during the 2001 - 2005 period. The validation of the ARGO correction is fulfilled applying the objective analysis method including delayed-mode data. From the objective analysis results, we specially worked on salinity fields and residuals values.

The comparison between analysis including delayed-mode data and real-time data showed an evolution in salinity fields. These salinity differences (due to the addition of delayed-mode values) take place in some specific regions and evolve with time. They occur near profiles that were corrected but not systematically. As shown in Figure 1 (see after), some profiles do not have any influence on salinity fields while some have a great impact specially in regions with salinity fronts.

Concerning numerical values of theses differences, they can reach 0.2 psu in places but do not exceed 0.06 psu on an annual mean and 0.02 psu over the 2001-2005 period. Besides, they decrease with depth and tend towards zero in bottom layers.

However, the observed difference in salinity fields does not mean that the applied correction is wrong. If we look at the residuals values of the floats, we note that they are rather low. This implies that delayed-mode values are consistent with close historical values. Delayed-mode data must therefore be considered as new information in the area.

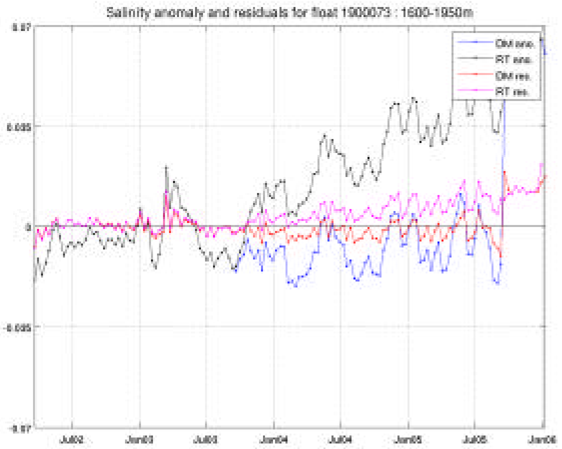

Figure 1: Difference in salinity fields at 600m - July 6th, 2005. Small and large blacks dots represent the position of real-time and delayed mode profiles, respectively.

Talking about residuals values, we can observe that all visible drifts have been properly corrected. As shown on Fig. 2 for float 1900073, the drift observed from September 2003 in real-time (pink plot) has been corrected in delayed-mode (red plot). The observation is identical concerning anomaly values (difference with reference climatology). For more details, see:

Galaup et al, Validation des corrections ARGO : application au jeu de données Atlantique Nord 2000-2005, OPS / LPO 06-03

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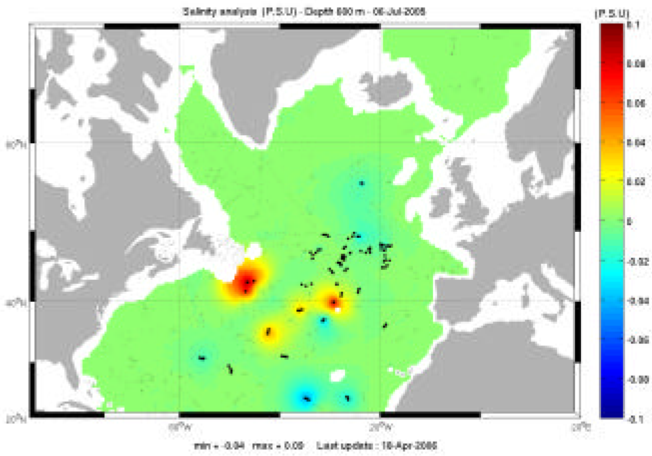

Figure 2: Residual values and salinity anomaly for float 1900073 at bottom layer (1600-1950m). Red and pink lines represent residual values in delayed-mode and real-time, respectively. Blue and black lines represent salinity anomaly in delayed-mode and real-time, respectively

Perspectives

The first study we made on dataset consistency was based on all the delayed-mode floats available in February 2006 at CORIOLIS data centre (these 77 floats were analyzed and corrected by different DMQC operators and Pis). Since that time many floats have been corrected and validated by Pis. Thus, we will restart the analysis in taken into account all the floats present in North Atlantic Ocean (179 floats, ~11500 profiles).

Next meetings

- **2nd Argo Delayed-Mode QC workshop**, Woods Hole (USA), Oct 4-8, 2006
- **GODAE symposium on Ocean Data assimilation & prediction in Asia-Oceania**, Beijing (C), Oct 16-18, 2006
- **Argo Trajectory workshop,** Seoul (K), Oct 27-28, 2006
- **Argo Data Management Team 7th meeting**, Tianjin (C), Nov 1-3, 2006
- **Argo/GODAE session at IUGG Ocean Sciences**, Perugia (I): July 2-13, 2007

We would be interested in reading about the results of your work in a future Coriolis News Letter.

We welcome your contributions!