Coriolis

n°2, February 2006 - http://www.ifremer.fr/coriolis/

Editorial

Coriolis and the GMES Marine Core Services

P.Y. Le Traon, Ifremer, Brest

The Coriolis data center is now a major European facility to provide global & regional in-situ data sets required by operational oceanography centers and their applications. Coriolis is heavily involved in MERSEA (see article by S. Pouliquen) to develop further its European activities & to consolidate interfaces and partnerships with regional in-situ systems & centers (e.g. in the Mediterranean sea). One of the major strengths of the Coriolis data center is to provide a unique portal for most of the in-situ data sets (e.g. temperature and salinity profiles, drifting buoys, sea surface temperature & sea surface salinity, moorings) required by operational oceanography systems. R&D activities & links with scientific teams (that are well illustrated in this newsletter) are also essential to improve the data quality, quality control procedures as well as to develop new data products (e.g. climatologies, indicators on the state of the ocean).

In the coming years, the Coriolis center should consolidate its operational and R&D activities as part of the GMES Marine Core Services (MCS). GMES MCS will transition MERSEA towards a sustained & operational system fully interfaced with a series of downstream & user services. An absolute pre-requisite will be to ensure the sustainability of the global & regional in situ observing systems. There is a wide consensus of the initial design that should be completed & sustained (e.g. OceanObs 99 conference, Eurogoos). Coriolis and its European partners should now be very proactive to develop its European contribution.

In this Issue

Coriolis contribution to Mersea 1st Targeted Operational Phase (Oct 2005-March 2006)

S. Pouliquen, Ifremer, Brest

Mersea (Marine EnviRonment and Security for the European Area), integrated project for operational oceanography is funded by the European Commission (http://wwww.mersea.eu.org). This project is led by Ifremer and involves contribution from 40 partners from 15 different countries from Europe but also from Canada, Turkey and Finland. Mersea IP has to demonstrate in the four coming years, that operational oceanography is a key element of the *Global Monitoring for Environment & Security* system (GMES). It has entered its 1st Targeted Operational Phase. TOP1 will be the first opportunity to run, show and assess v1 of the MERSEA Integrated System, ie the real *first version of the MERSEA Targeted System* (version 0 being a simple and light interconnection of existing systems). It will end at Mo24, ie at the mid-term milestone, when the project has to be in a position to clearly assess that all system foundations are in place. Within this project Coriolis is in charge of setting up the In-Situ ThEmatic Portal which aims to provide to the global and regional operational systems all the in-situ data they need both in real-time for forecasting activities and delayed mode for reanalysis. For TOP1 the focus is on physical parameters (Temperature, Salinity & currents) from a variety of platforms: floats, commercial and research vessels, drifters, gliders and moorings. There are three main challenges for Coriolis to set up this TEP:

1. Integrate mooring data because real-time ocean data exchange is not yet a reality for these platforms except for Tao/Triton/Pirata array. The focus has first been on defining a common data format and common data flow within the scope of the international project OceanSITES. Mediterranean & Atlantic networks, contributing to MERSEA, are now available in this format in real-time to Mersea users.

2. Finalize delayed mode processing of floats in collaboration with Argo program. The North Atlantic floats corrected from potential linear drift are now available and processing of the other floats are underway.

3. Establish links between Global and regional data exchange networks. This activity has started in collaboration with EuroGOOS Regional Alliance in order to up a sustainable schema.

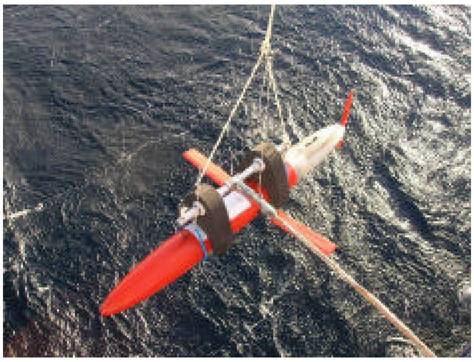
Finally Coriolis has improved the value added products they generate from Coriolis data base by extending to global the weekly temperature and salinity analysis. Reanalysis starting from 2001 will be performed in 2006. Moreover an updated mean sea state of the North Atlantic ocean for 2000-2004 is now available calculated from the Atlantic analysis.

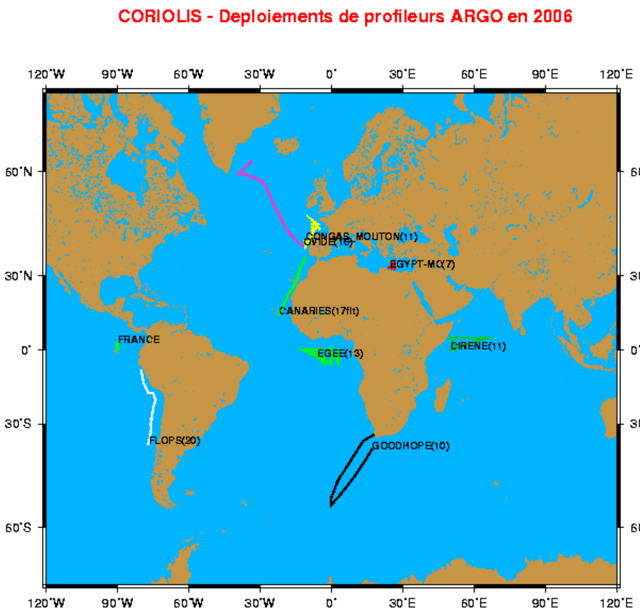
First Glider experiment in the Atlantic within Mersea Project

P. Lherminier (1), T. Terre (1), P. Testor (2), R. Link (2), U. Send (3), J. Sherman (3).

(1) Ifremer, Brest, (2) IfM-Geomar, Kiel,
(3) SIO, San Diego

On December 5, the Spray glider 004 was deployed at N47°18'W7°30' from the supply ship Argonaute, after 10 days of preparation and tests. This deployment is an example of international collaboration through the program MERSEA: institutes from Germany, the USA and France were directly implied (Ifm-Geomar, Scripps-UCSD, Ifremer, SHOM and CNRS.
The experiment objective is to add spatial information to the dataset of the biogeochemical real-time mooring called PAP, located in the Porcupine Abyssal Plain.
To this end, the Spray glider measures temperature, salinity and chlorophyll from the surface down to 1000m with a resolution of 5km, and collected data is sent in real-time to Coriolis data center and to Mercator models.
After a trip of 700km full of information on the water advected along and across the continental slope, it arrived near PAP where it is remotely controlled to sample the intense mesoscale features that advects different water masses towards the mooring. By the end of January, it will be called back and recovered hopefully near France coast."





Deployment plan for Coriolis in 2006

In 2006, Coriolis plans to deploy 91 floats during 11 cruises not only in the Atlantic Ocean but also in the Southern and Pacific Oceans. Some floats will be equipped of oxygen and carbon sensors. 16 of these floats are partially funded by the European Commission within the Mersea project.

PI	Project
Taupier-Letage	EgyptMC-2 & 3
Eldin	Flops-1& 2
S. Speich	Goodhope-5
V Thierry	Ovide
Bourles	Egée-2
Serpette	Congas-2
Peligri	Canary
Claustre	PRO-Bio
Vialard	Cirene-2

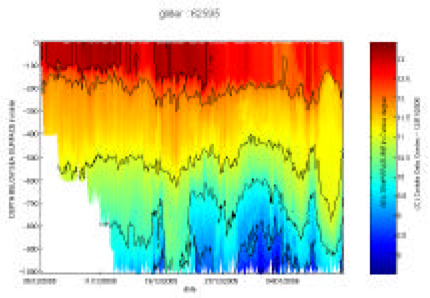
How to get ocean observations from Coriolis ?

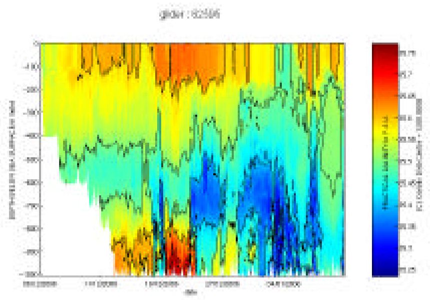
T. Carval, Ifremer, Brest

Every day, in real-time, Coriolis data centre collects, controls and distributes more than 1000 temperature & salinity profiles. A profile is a series of measurements between sea-surface and deep waters (typically 2000 meters depth). Regularly, batches of delayed mode (high quality) profiles are added to Coriolis data base.

In January 2006, 2 million profiles (about 400 millions individual measures) from 1990 to 2006 are available on-line.
To explain how to extract data from this "mine", let's take the example of Mersea Glider.

The Mersea hydrographic glider performs continuous measurements in North Atlantic, between Brittany and Ireland. To visualize the instrument, you may have a look at the Mersea pages (link 1).





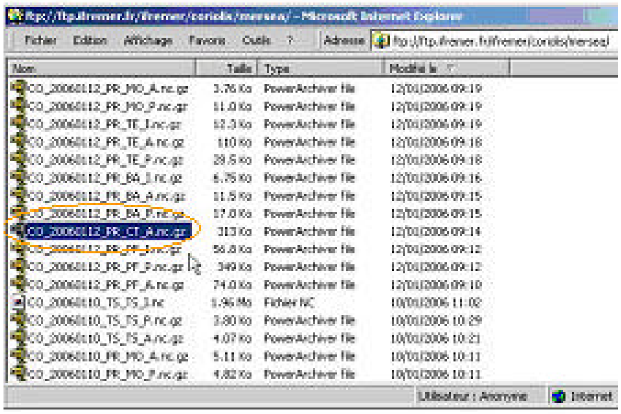
From the web interface

To visualize Mersea glider locations and all surrounding measurement, go to Coriolis data selection web page (link 2). Use button 1 to zoom on glider locations, select December 2005 to January 2006 in box 2, and the glider locations clearly appears as yellow dots on this map (→).

To get the data, simply click on "Download" button 3.

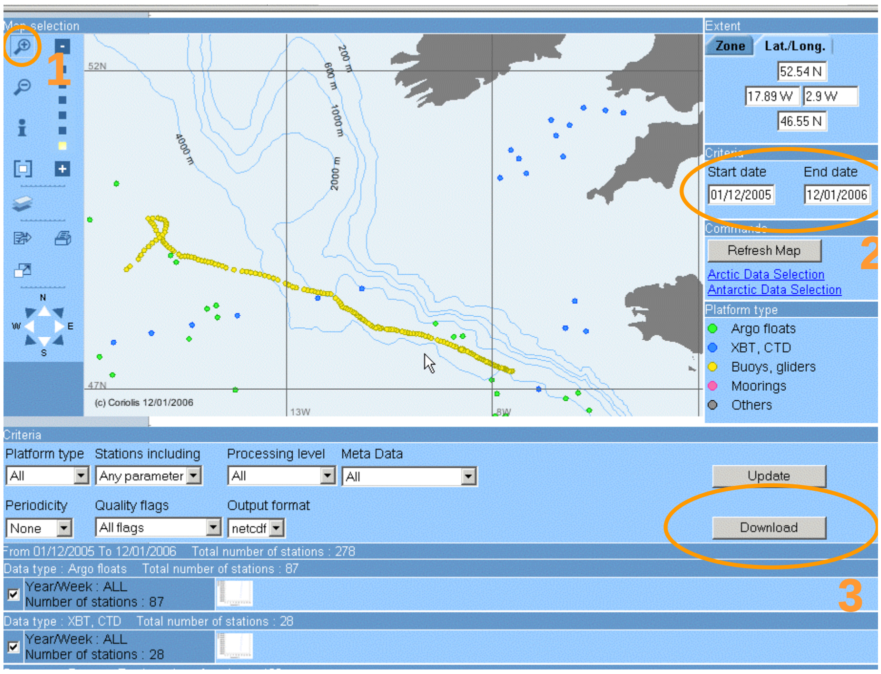
From the FTP server

As all real-time profiles, the Glider data are distributed on Mersea real-time FTP site (see link 3). The profiles of the day are packed in a NetCDF file whose file naming convention includes the day of distribution, the type of data (PR for profile, CT for CTD and A for Atlantic).
More information on the FTP organization is available at link 4.



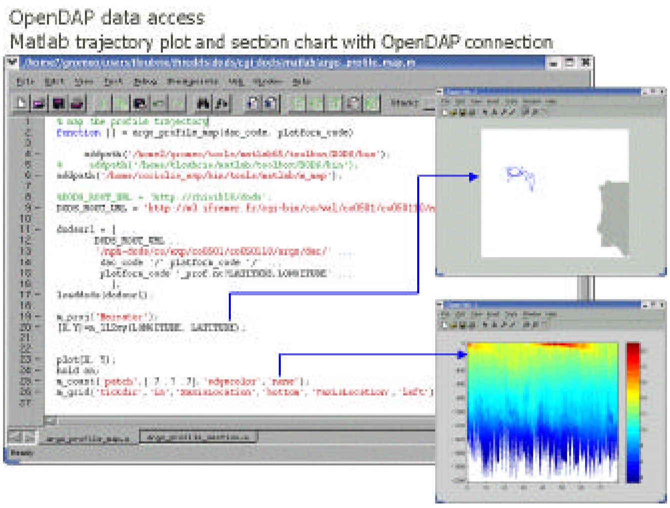
Useful links

Link 1: http://www.mersea.eu.org/Insitu-Obs/1-Insitu-Gliders.html
Link 2: http://www.coriolis.eu.org/cdc/dataSelection/cdcDataSelections.asp
Link 3: ftp://ftp.ifremer.fr/ifremer/coriolis/mersea
Link 4: http://www.coriolis.eu.org/cdc/ftp_data_distribution.htm
Link 5: http://www.coriolis.eu.org/cdc/opendap-dods_distribution.htm



From the OpenDAP interface

As all profiles, glider data are also available from Coriolis OpenDAP server (see link 5 for more information on OpenDAP server).
Using OpenDAP, data appears to you as a local file, like a network file system over the web.



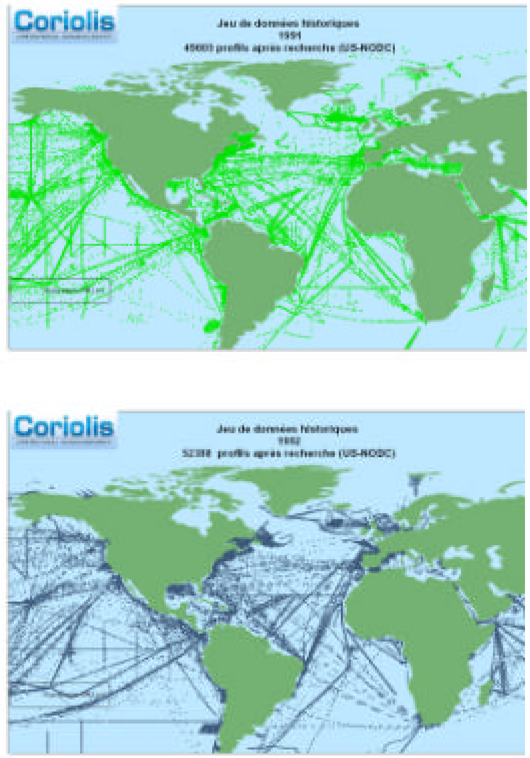
Validation data set

L. Petit de la Villéon, Ifremer, Brest

The Coriolis data centre supplies near real time datasets for assimilation in ocean models. However this is not the unique task performed by this data centre. Coriolis is also able to provide historical reanalyzed datasets for reanalysis and validation purposes.

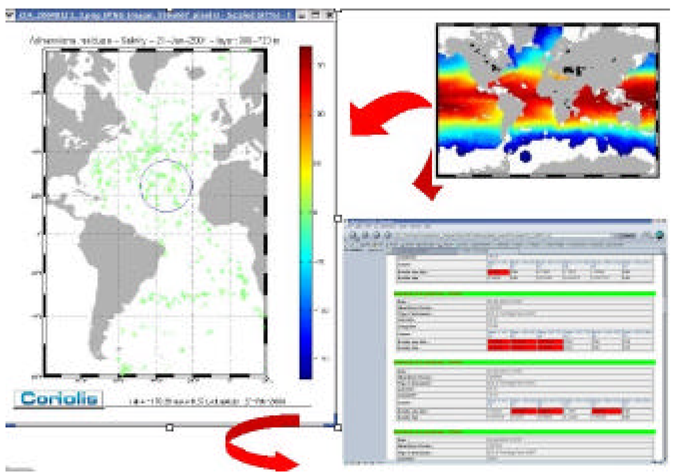
An important effort has been made during the past months in order to be able to propose most comprehensive and exhaustive Temperature and Salinity datasets. Important CTD datasets archived by US-NODC have been integrated in Coriolis database for this purpose.

11 years of data (from 1990 to 2000) have been reprocessed and are available on:
ftp://ftp.ifremer.fr/ifremer/coriolis/global_profile
(one directory per ocean). Global reanalysis from 2001 to 2005 is underway and will be available at the same address.



Representation of the 1991 & 1992 data sets

To be able to quality control such a dataset without going through visual check on each individual profile, statistical QC based on objective analysis have been passed on the global dataset (year by year) and only rejected profiles have been further submitted to visual checks.



Quality control procedure based on objective analysis

Contact: codac@ifremer.fr

Delayed Mode Quality Control on the ARGO floats

C. Coatanoan, P. Galaup, V. Thierry, Ifremer, Brest

1. Introduction

Due to the increasing amount of ARGO profiling floats in the ocean and to their moving nature (Figure 1), ARGO floats can not be recovered and their sensors can not be recalibrated at the end of their life time. The main problem concerns the conductivity sensor that may drift or show an offset due to biological fooling and other problems. A method has thus been developed by Wong et al. (2003) and Boehme and Send (2005) and implemented at the Coriolis Data Center in order to control the quality of the salinity data in an indirect way, to evaluate possible drift or offset of the conductivity sensors and to propose a correction. The aim of this delayed mode quality control is to provide a delayed-mode ARGO dataset with an accuracy of 0.01°C for temperature and 0.01 for salinity and for which conductivity sensor drifts and offsets have been taken into account and corrected whenever it is possible.
The Coriolis data center provides methods and tools to evaluate those drifts and offsets but the final correction applied (or not) to each profile is under the responsibility of the scientific team.

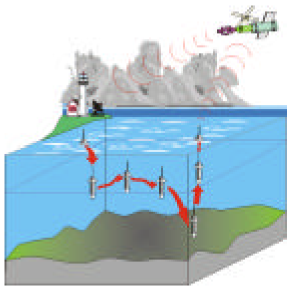


Figure 1: *Trajectory of ARGO float in the ocean.*

The delayed mode method, used at the Coriolis Data Center in an operational mode, has been developed by Wong et al. (2003) for the Pacific Ocean and adapted to the North Atlantic environment by Böhme and Send (2005). It is based on the comparison of the data with ship-board high-resolution CTDs. Those comparisons are made on deep isotherms and assume that the temperature sensor of the float is stable and that salinity on deep isotherms is steady and uniform. The calibrated historical hydrographic data are interpolated at the float profile position by an objective analysis method. The analysis takes into account the high spatial and temporal variability of the North Atlantic due to ocean processes and bathymetry. A first fit is applied to estimate an individual correction for each profile. Then, assuming that the conductivity sensor drifts slowly over time, a second fit (piece-wise linear) is applied to estimate a time-varying correction over the length of the time series. Calculations are made in potential conductivity space. The result is a set of corrected salinity data with corresponding uncertainties.

2. The Delayed Mode QC method

The method uses the two main state variables potential temperature θ and salinity S. Mean θ-S relationships can be used to estimate salinity from measurements of temperature and pressure. The calibrated hydrographic data, which we refer to in the following as historical data or reference database, are based on the World Ocean Database 2001 and on more recent CTDs data. They are interpolated on 2 dbar levels to store all information but reducing the amount of data. To provide an acceptable vertical coverage the deepest measurement of each station must be below 1000m.
To reduce the amount of historical data to be compared to the float measurements, horizontal, vertical and temporal selections are done. The temporal and horizontal selections are based on a temporal distance τ, on a spatial distance D and on a fractional distance in potential vorticity F to account for cross-isobath separation. Then, based on the float data and on the historical data, 10 depth levels (k) are selected satisfying the following conditions: maximum and minimum float pressure between 525 and 2000 dbar, minimun and maximum of float θ and S, two with tightest P-θ definition and two with highest P-S definition. Knowing that the float temperature at those depths are $\theta_{k(k=1,10)}$, the depth at which potential temperature for each historical profile equal θ_k is determined. The associated salinities are then interpolated at the float profile position. This interpolation, based on an optimal interpolation, is the sum of two stages of mapping: the first calculates the basin-wide mean; in the second, residuals are interpolated to the float profile location using a covariance function of the temporal and small spatial separation. All measurements are converted to potential conductivity to eliminate differences in pressure between historical and float data. Then the potential conductivities of the float are fitted to the interpolated historical potential conductivities.
The delayed mode QC process relies on the available historical data. If we do not have enough reference data, the DMQC method cannot work. So it is very important to collect all the CTD data from all oceanographic cruises and an effort is specially asked to the scientists to make available, for the DMQC purpose, their hydrographic dataset .

3. Analysis on ARGO float

3.1 Results of the DMQC method

Some diagnostic plots allow to follow the behavior of the float and to understand the correction computed from the DMQC method for the calibration.
Salinity anomalies on isotherms allow to detect if the detected drift/offset of the sensor is due to a physical or

technical event. The example provided on Figure 2 shows a drift at the end of the float time-series.

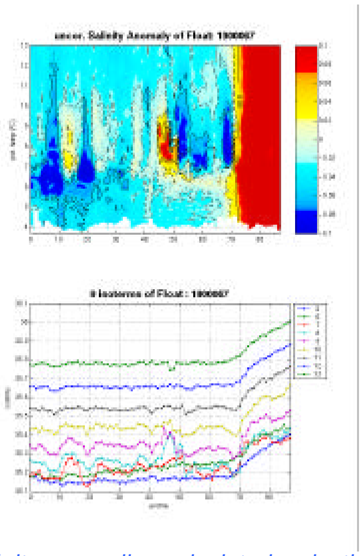


Figure 2: Salinity anomalies calculated on isotherms versus the cycle numbers of the float.

The plot of the float location (Figure 3) shows the used reference dataset; the circles are the cycles of the studied float; the diamonds are the selected data from the reference database to run the objective mapping.

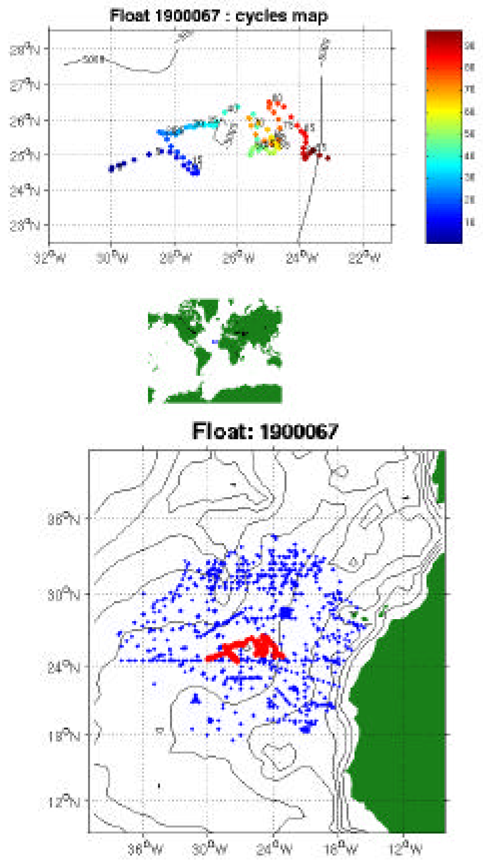


Figure 3: Trajectory of the float and reference data (blue) selected for the objective mapping.

Weighted least-squares fit is done for a time-varying slope of the correction term to smooth out outliers (Figure 4). According to the behavior of the floats, the time-series can be cut into several parts, for which different correction (no correction-individual correction-smoothed correction) can be applied.

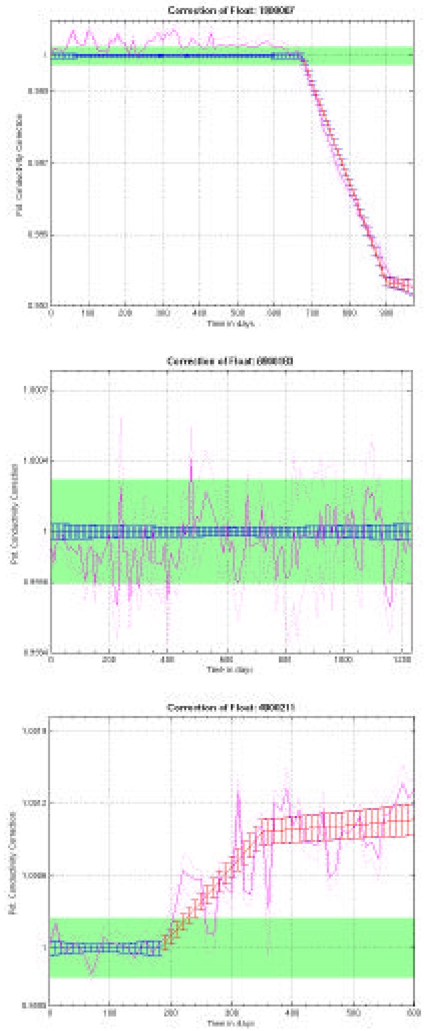


Figure 4: Examples of results of the DMQC method. The individual corrections are represented by the noised curve and the smoothed corrections are the curve associated with the error bars corresponding to two times of the standard deviation of the fit. The green box corresponds to accuracy of ± 0.01 psu.

When the correction and associated error bars intersect the green-box, the correction is not significant. When an offset is observed, it has been shown that using the tank error, this offset was reduced. A positive drift is consistent with a fooling of the conductivity cell. Specific procedures have to be applied when a drift or jump are observed, then the float series have to be split to not contaminate the stable segment.

A plot also shows θ-S diagrams before and after the correction: in this case (Figure 5), the results of the DMQC method allow to significantly correct the observed drift.

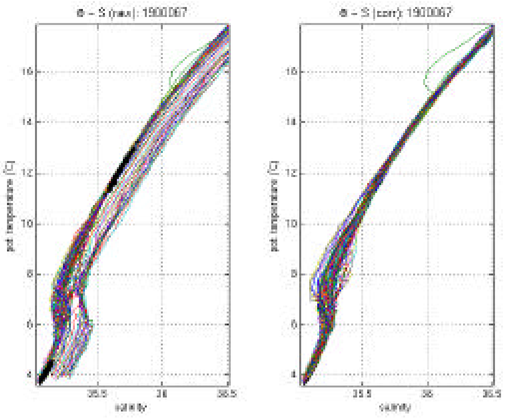


***Figure 5**: q/S diagram plot before and after the calibration correction. The drift observed in the deep water in the raw data has been corrected after application of the DMQC correction.*

3.2 Complementary tools

In parallel, a data analysis system based on an optimal estimation method has been developed and implemented at the Coriolis data center (Autret and Gaillard, 2004). This system provides in real time weekly gridded fields of temperature and salinity. The method of the differences is used to make comparison between measurement points and objective analysis fields: using the temporal closer objective analysis, getting grid points around the float, making horizontal and vertical interpolations and difference with the measurement point. Plots for some levels (Figure 6) present differences for all measurements points and mean cycle by cycle.

Residual values allow following for some levels possible drifts or offsets. The comparison with the climatology helps determine whether the detected drift or offset are real and due to a sensor problem or are due to an ocean event. Other works on pressure offset and battery voltage are also in progress to understand if the detected offset and drift are correlated with a technical problem.

4. Conclusion

Analyses of the float time series have shown that the salinity measurements can drift slowly over the time. Due to the drift and offset observed on the conductivity sensor, it is necessary to consider float data in delayed mode in order to evaluate the quality of the measurements and to propose a correction when necessary.

Offsets and drifts are detectable in the Gyroscope and other floats drifting in the North Atlantic and a corresponding correction is supplied using an objective mapping method (Wong et al. 2003, Boehme and Send 2005). The result is a set of calibrated salinity data with corresponding statistical uncertainties. Seabird sensors seem more stable than FSI sensors.

To help determine the correction, complementary tools have been developed, using the residuals and fields of an objective analysis that takes into account all type of data available in the Coriolis database (profilers, XBTs, CTDs, moorings). Argo delayed-mode procedures are mainly based on a reference database. This historical hydrographic dataset used to select the 'best' profiles to be interpolated to the float profile position need to be updated regularly with recent cruise data in order to take into account oceanic changes and because it can be too poor in some oceanic areas to run the DMQC method.

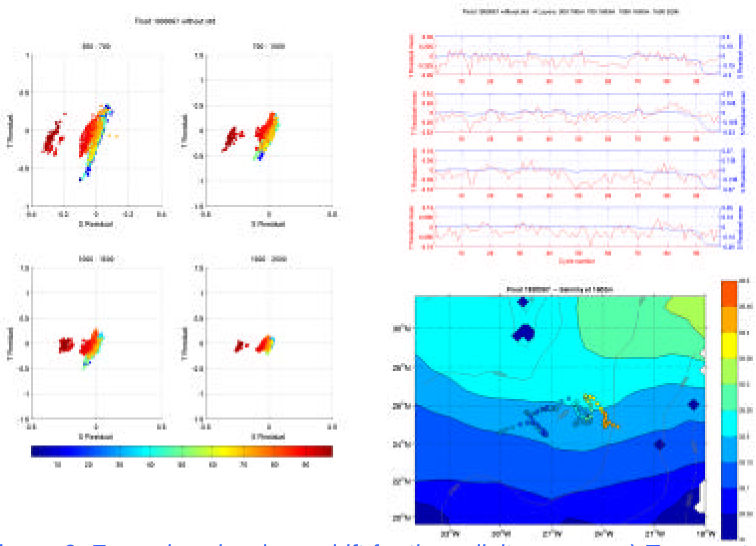


***Figure 6**: Examples showing a drift for the salinity sensor. a) Temperature residuals versus salinity residuals at different level range with colour according to the cycle number of the float, b) temperature and salinity residuals versus cycle numbers, c) comparison of the float salinity (or temperature) value with the climatology computed from the objective analysis.*

References

Autret et Gaillard, 2004: Système opérationnel d'analyse des champs de température et de salinité mis en œuvre au centre de données Coriolis. Version 3.02.

Boehme, L., and U. Send, 2005: Objective analyses of hydrographic data for referencing profiling float salinities in highly variable environments. Deep-Sea Res. II, 52, 651-664.

Wong, A.P.S., G.C. Johnson, and W.B. Owens, 2003: Delayed-Mode Calibration of Autonomous CTD profiling Float Salinity Data by θ-S Climatology. Journal of Atmospheric and Oceanic Technology, 20, 308-318.

Use of the analysis system for monitoring the ARGO sensors drifts.

E. Autret and F. Gaillard

In the previous letter, we briefly presented the analysis system operational at the Coriolis data center. This system both synthetises data sets by producing temperature and salinity gridded fields and checks for quality the data from the Coriolis database in real time. We will focus here on this latter application of the system. We will discuss of the use of the analysis tool to perform the real time and delayed mode quality control (QC), particularly of the ARGO profilers. Those two modes of QC are fundamentally different. Real time QC are meant to flag the data according to pre-defined quality levels, these tests must not slow down the data flow, they are therefore only qualitative. The delayed mode QC has to be quantitative, one wish to detect and evaluate any possible bias or drift in the sensors involved in the measurement, a particular vehicle is studied at once, and followed over its life time. Several methods based on similar techniques whose method recommended by ARGO have been proposed. Our general analysis tool is formally equivalent to this latter but also offers a wide set of possible uses.

Method

In the previous letter the objective analysis formalism used to produce estimations has been recalled:

$$x^a = x^f + C_{ao}(C_o + R)^{-1} d$$

We call «analysis residuals» the misfit between observations and analysis at measurement points:

$$d = y^0 - R(C_o + R)^{-1} d$$

Residuals are obtained at the same time as the field estimation.

Identification of sensor errors

In order to better identify a possible drift on any of P, T, C sensors, a set of simulations of errors on the measured parameters has been realized and the impact on the final data output and on the analysis residuals have been evaluated. For instance, one of the sensitivity tests studied consisted in the simulation of a constant bias in salinity (-0.04 psu) on time series of profiles from an ARGO float considered without any suspect behaviour. Analyses using the original and the perturbed float have been independently performed, and the results of this twin experiment have been looked at. We expected to retrieve in the residuals, inconsistencies with neighbouring data, due to measurement errors or small scales not resolved by the analysis, but also from oceanic structures not resolved by the data or inconsistent with the a priori statistics. The figure 1 shows the trajectory of the float used in the test and the time series of the salinity and temperature residuals (here vertically averaged on a layer 1000-1600m). Residuals oscillate around a mean value close to zero with a good agreement between T and S. Small scale structures inducing local strong residuals are obvious The results presented figure 2 show that the study of residual time series allows to retrieve a percentage (depending on the configuration) of the anomaly introduced.

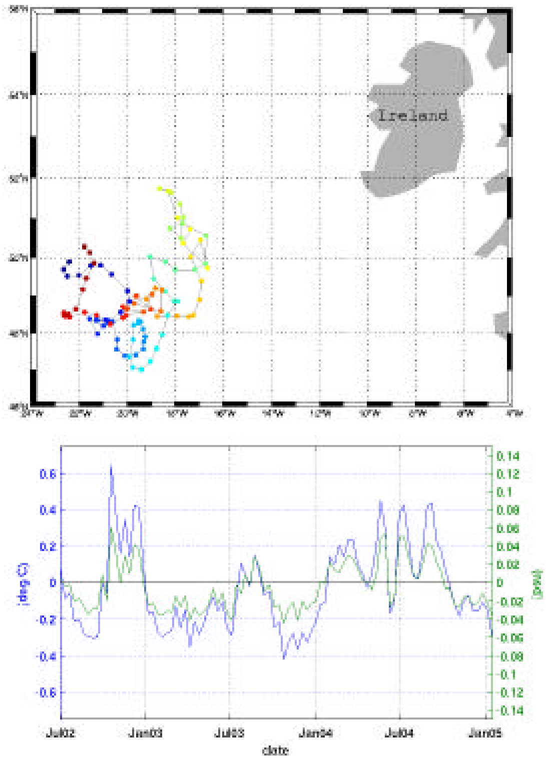


Figure 1: Top: trajectory of the ARGO profiler used in the test. Bottom: Time series of residual means (for a layer 1000-1600 m).

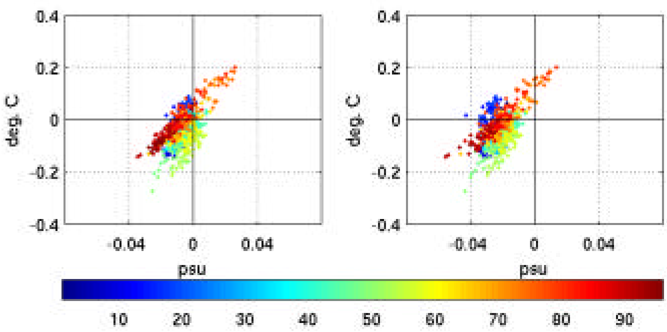


Figure 2: Sensitivity test: diagram of the temperature and salinity residuals within 1600-2000 m, left: unperturbed float, right: float perturbed with a constant -0.04 PSU offset.

The process has been iterated by introducing the correction given by the averaged residuals. In this example, the best result is obtained after 2 iterations (Figure 3).

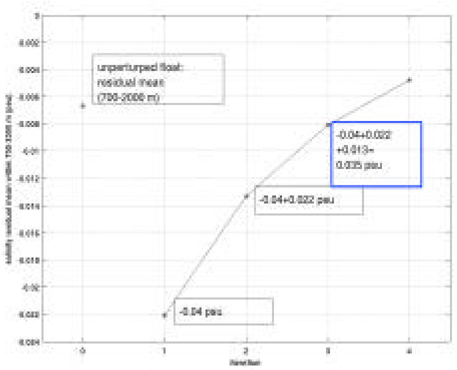


Figure 3: Error retrieved by iterations

Global diagnostic

A global diagnostic of the ARGO profilers fleet over the Atlantic has been realised from the reanalysis 2000-2004 (CORA-ATL-01). We selected the floats with QC 1 or 2 and more than 16 T and S profiles and ended with 482 floats. The space distribution of the corresponding profile is shown figure 4.

Each time series of residuals has been looked at using the graphic tools presented on figure 5. The anomalous behaviours have been sorted out in 3 categories: bias, drift and the combination bias + drift. The table 1 summarizes the result of our screening. It appears that despite the sensors problems that occurred on some floats during the early ARGO years, the fleet has behaved well with nearly 85% of good floats.

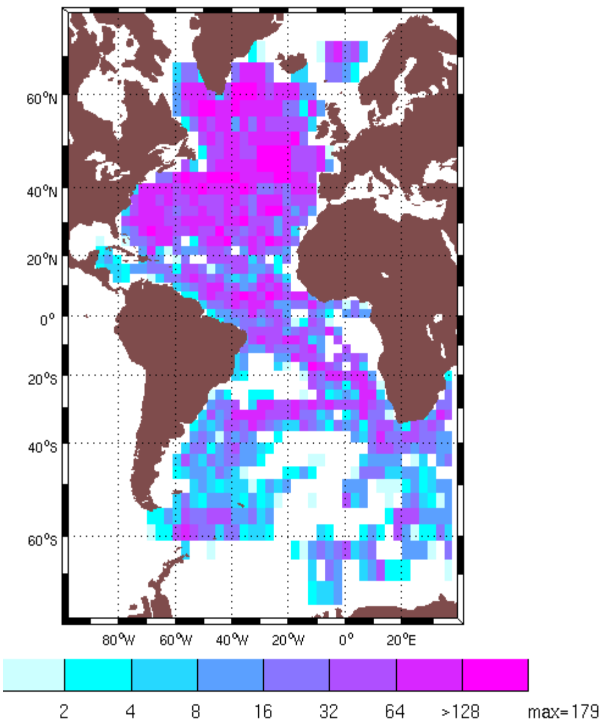


Figure 4: Number of profiles in each 3 degrees square area over the 2000-2004 period.

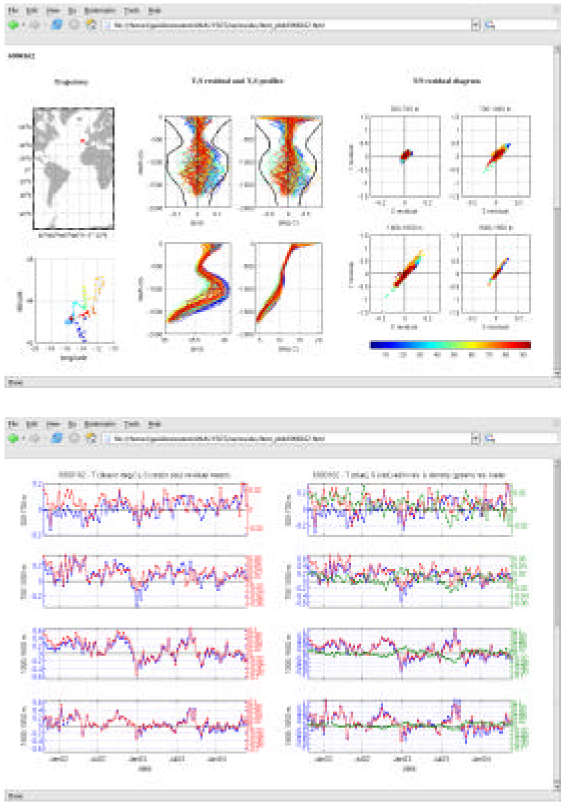


Figure 5: Graphic tools used for screening the ARGO profilers residuals over their lifetime.

	Number of Profilers	% over 482 profilers
Offset	28	5.9
Drift	29	6.1
Offset + drift	17	3.6

Table 1: Statistics of sensors offset and drift for the 482 ARGO profilers.

References

Boehme, L. and U. Send, (2005), Objective analysis of hydrographic data for referencing profiling float salinities in highly variable environments, *Deep Sea Res. II*, 52, 651-664.

Coatanoan, C., L. Petit De La Villeon, (2005), Coriolis quality control manual, www.coriolis.eu.org/cdc/quality_control.htm.

Durand, F. and G. Reverdin, (2005), A statistical method for correcting salinity observations from autonomous profiling floats: An ARGO perspective, *J. Atmos. Oceanic Technol*, 22, 292-301.

Wong, A. P. S., G. C. Johnson and B. W. Owens, (2003), Delayed mode calibration of autonomous CTD profiling floats salinity data by theta-S climatology, *J. Atmos. Oceanic Technol*, 20, 308-318

Surface salinity drifters during the 2005 COSMOS experiment in the Bay of Biscay

G. Reverdin[1], P. Blouch[2], W. Scuba[3], P. Niiler[3], J. Boutin[1], N. Barre[1]

[1] LOCEAN/IPSL, CNRS/UPMC, Paris, France
[2] CMM/Météo-France, Brest, France
[3] SIO, La Jolla, CA, USA

G. Reverdin, Laboratoire d'Océanographie et de Climatologie: Expérimentation et Analyse Numérique, Institut Pierre Simon Laplace, Université Pierre et Marie Curie, case 100, 4 pl. Jussieu, 75252 Paris Cedex 05, France (gilles.reverdin@lodyc.jussieu.fr ; tel : 33-1-44272342 fax ; 33-1-44273805)

Drifters have been recently developed to measure precisely temperature and salinity near the surface (typically in the top meter). An experiment took place in 2005 to validate the data from three types of drifters. Two of them are based on the SVP WOCE principle with a top sphere (41 cm diameter) attached to a drogue centred at a depth of 15 meters (Niiler et al., 1995), which will be respectively referred to as SIO and METOCEAN. The SIO drifter uses a SBE 37SI C/T system placed vertically along a cylindric hull attached to the sphere at an average depth of 36 cm. The METOCEAN drifter uses a SBE47 C/T system placed facing upward under the drifter top sphere (average depth of 66 cm) and has in addition a hull temperature placed in the lower part of the top sphere. The third drifter, referred to as SURFACT, is a surface float with no drogue with a C/T ASD system. Seventeen surface drifters (12 SIO, 3 METOCEAN, 2 SURFACT) were deployed in the Bay of Biscaye during two cruises in early April and early May 2005. Deployments were done by sets of at least three drifters, to provide intercomparison of data for the first weeks after deployment.

The Bay of Biscaye encompasses a deep ocean area between France and Spain with spatial gradients on the order of 0.1 pss away from the shelves and the shelf breaks. This is a region regularly sampled by research cruises, in particular on board French and Spanish research vessels, with ample opportunities to collect data that can be compared to the drifter data. In addition, a 5-days cruise, COSMOS2, took place in late June 2005 in order to take measurements near most drifters and examine some of them. Eight of the drifters have been brought back and examined after been at sea, one in July, and the others in October-December.

The drifters provide series of T, C and derived S at hourly or half-hourly (SIO) intervals that are transmitted by ARGOS. Few data are lost due to data transmission, and nearly complete time series of T and S could be constructed. The SURFACT drifters had a fairly short life span (less than 5 days), a failure that is been investigated. The initial METOCEAN and SURFACT salinities were within 001 pss of reference values at deployment. The SIO salinities were too low at deployment in the range -0.005 to -0.026 pss, and were somewhat harder to validate, as the salinities sometimes drifted during the first hours after deployment.

During the COSMOS cruise (June 22-27), the direct observation of the drifters indicated little sign of fouling. The comparison of the salinities suggested a slight drop of the drifter salinity (averaged increase in negative bias of -0.007 pss, with individual ranges between 0 and -0.017 pss). During the summer and autumn months, validation of the drifter salinities is based on chance encounters with research vessels (Cote de la Manche, Thalassa and Beautemps Beaupré) or with other drifters. These comparisons are still being analyzed, but they suggest that some of the drifter salinity could have been biased by more than -0.040 pss in August, and that the changes vary considerably from drifter to drifter. When redeploying in August the drifter recovered a month earlier in July, we found also a larger initial drift of -0.060. In view of the data, it is not likely that the biases have increased much further through the autumn and winter. Data during the recoveries of the drifters or from recalibration in Brest (often a month or more after recovery) are being analyzed. Visual evidence is that the drifters recovered had developed some fouling, either algal near the sensors (see fig. 1) or from shellfish, but often not too close to the sensors.

Figure 1: photograph of METOCEAN drifter 52197 in December 2005, roughly one week after its recovery during the CONGAS2 cruise. The subsurface sensor area is shown with noticeable algal fouling near the sensors.

A careful analysis of the daily cycle of nearby drifters also pointed out difficulties in interpreting the mid-day and afternoon salinities (fig. 2). A very different behaviour is found for the SIO drifters with too high SSS than for the Metocean drifters with too low SSS. In the case of the SIO drifter, it can be interpreted as T being measured lower than the conductivity cell (and

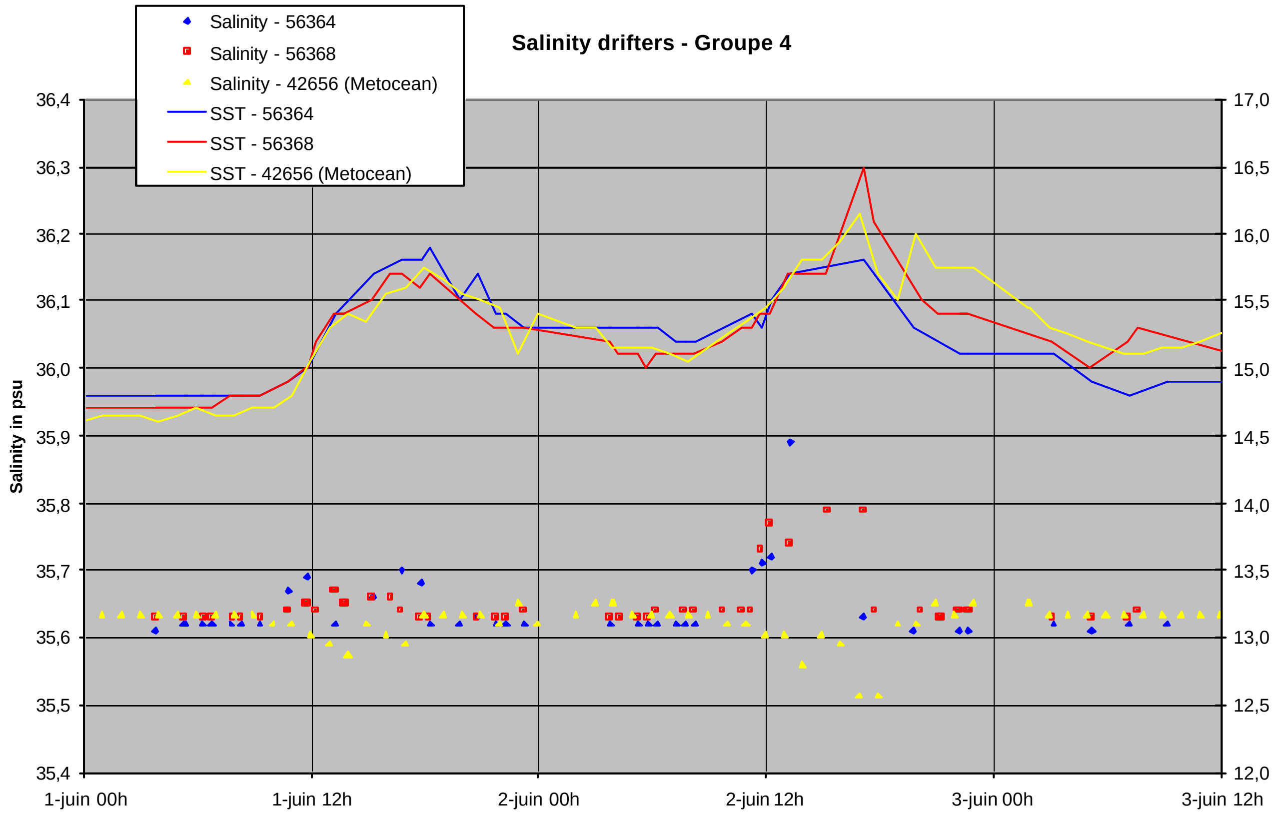


Figure 2: Two daily cycles (June 1 and June 2 2005) during a period of weak wind and low cloudiness for three close-by drifters (SIO drifters: 56364, 56368; Metocean drifter: 42656).

therefore experiencing a lower temperature), and for the METOCEAN drifter, probably as a result of a solar radiative warming of the temperature probe. These effects happen on clear days with low winds in spring or summer.

These first results give confidence that such salinity drifters can be used to monitor surface salinity in addition to other data required for cross-validation. Indeed, it can work both ways, as the drifters suggest that in April 2005 PROVOR float 04SP-S2 (4900557) presented a negative salinity bias between -0.007 and -0.010 pss (this float was deployed in September 2004). The drifters also suggested corrections in the TSG salinities of the research vessels of from other ships-of-opportunity TSGs. The drifters can provide a high time resolution and are relatively easy to deploy and use. They have a simpler system than other drifters equipped with a pump and a cell inside the buoy's hull that can be poisoned and is not exposed to light. Such drifters, as the CARIOCA drifters (Copin-Montégut et al., 2004), might however develop much smaller salinity biases over time.

Acknowledgments

We are grateful to the opportunity to use R.V. Thalassa and Cote de la Manche for the deployment and tracking of the drifters. The recoveries of the drifters at sea were done by the R.V. Nereis (Roscoff, France) and during the CONGAS-2 cruise, as well as by various fishermen and personnel of the IEO institutes in Vigo, Gijon and Santander, and the tourist office of Courtis-Plage (Landes), to which we are very indebted.

References

Niiler, P.P., A.L. Sybrandy, K. Bi, P. Poulain, and D. Bitterman, 1995: Measurements of the water-following capability of holey-sock and TRISTAR drifters. Deep-Sea Res., 42, 1951-1964.

Copin-Montégut, C. M. Bégovic, and L. Merlivat, 2004. Variability of the partial pressure of CO2 on diel to annual time scales in the northwestern Mediterranean Sea. Marine Chemistry, 85, 169-189.

Impact of the assimilation of Argo data in the Atlantic Mercator Operational Ocean Forecasting System

M. Benkiran, S. Guinehut, CLS / Mercator-Océan, Ramonville, France
(mounir.benkiran@mercator-ocean.fr)

Mercator-Océan operates every week two regional (Atlantic and Mediterranean basins) and one global ocean forecasting systems which deliver analyses and forecasts up to 14 days. The Atlantic forecasting system is used here to analyze the impact of the Argo profiling floats observing system.

The Atlantic forecasting system

The Atlantic forecasting system is based on the OPA primitive equation OGCM (Madec et al., 1998) with 43 levels on the vertical and a 1/3° horizontal resolution. It covers the Tropical and North Atlantic from 20°S to 70°N. Daily surface atmospheric conditions are from ECMWF. The system assimilates simultaneously altimeter sea level anomalies (Jason-1, Envisat, GFO) from the SSALTO/DUACS data center, daily Sea Surface Temperature RTG_SST analysis (Thiébaux et al., 2003), Sea Surface Salinity (SSS) from the Reynaud climatology (Reynaud et al., 1998) and in-situ temperature and salinity profiles (Argo, XBT, CTD, moorings …) provided by the CORIOLIS data center. The assimilation method is based on the reduced order optimal interpolation scheme (ROOI) developed by De Mey and Benkiran (2002). It uses 1D vertical multivariate EOFs to extract statistically coherent information from the observations and to perform the simultaneous control of the temperature, salinity and sea surface height state variables.

The Atlantic forecasting system is operated every week since January 2001 and we present below some results of the validation of the system for the year 2003. During the year 2003, around 250 temperature profiles have entered the system in the top 500-m depth layer (Fig. 1).

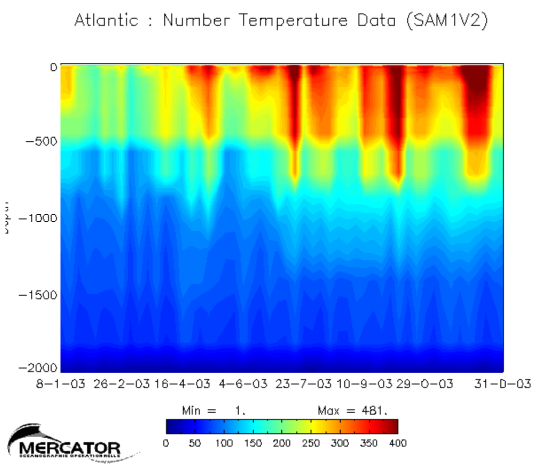


Figure 1: Number of in-situ temperature profile, as a function of depth, entering the system every week.

This number decreases with depth but increases at the end of the year thanks to the deployment of new Argo floats. Assimilation diagnostics for the temperature field show that the rms of the misfit (i.e. the differences between the observations and the model 7-days forecast) is much smaller than the rms differences between the observations and the Reynaud climatology (Fig. 2). Values are lower than 1°C for most of the depths, except in the thermocline and close to the surface where they can reach 1.5°C. Additionally, the mean value of the misfist (not showed) is remarkably weak during all year showing that the system has no bias.

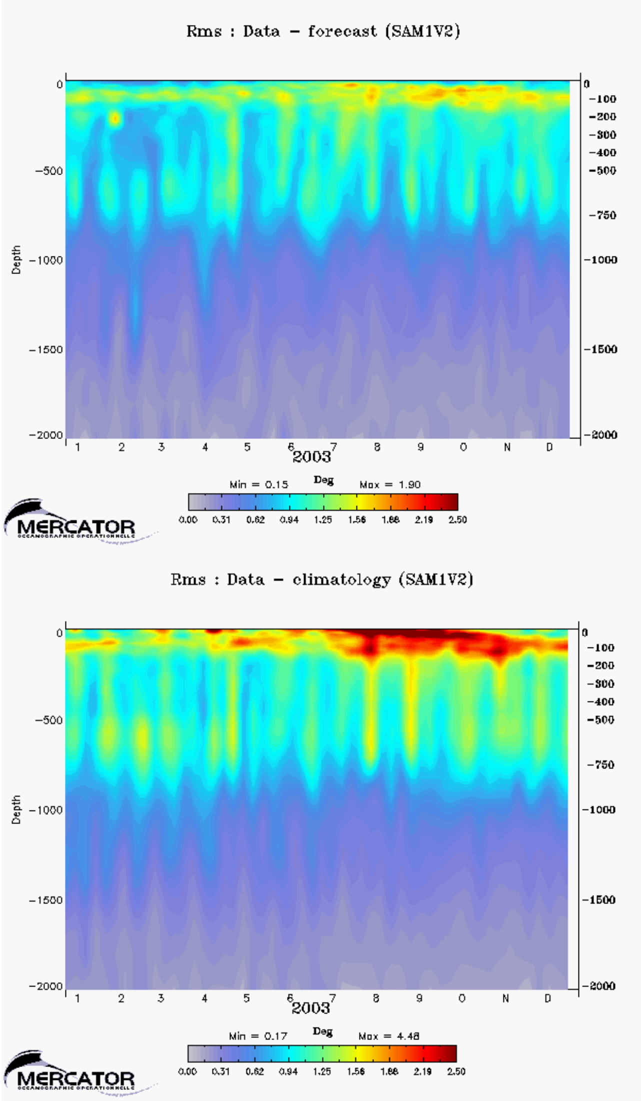


Figure 2: Rms of the differences between the in-situ temperature profiles and (upper) the model 7-days forecast and (lower) the climatology as a function of depth and of time (Unit: [0-2.5] °C).

Contribution of Argo data

Two experiments have been performed in order to quantify the impact of the Argo profiling floats observations on the Mercator-Océan Atlantic forecasting system. The first one assimilates all observations (satellites and in-situ) as the second one assimilates the same data set apart from the Argo profiles (Fig. 3).

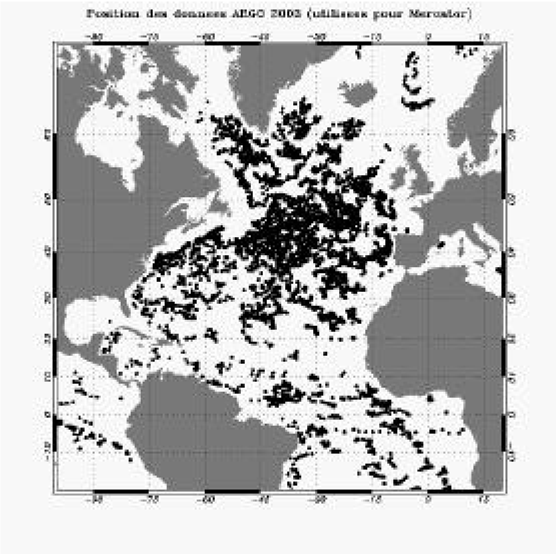


Figure 3: Spatial distribution of the Argo profiling floats data for the year 2003.

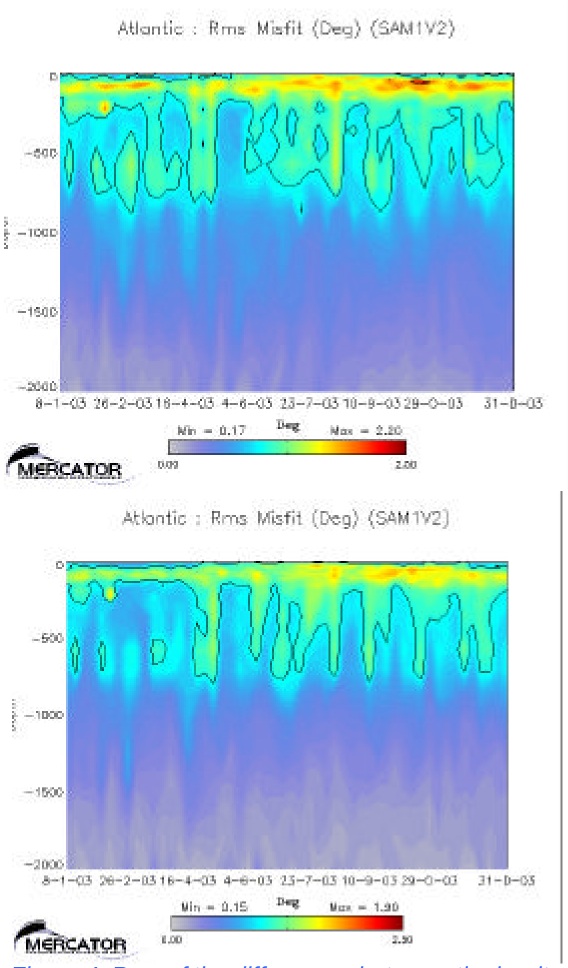


Figure 4: Rms of the differences between the in-situ temperature profiles and the model 7-days forecast for the run with no Argo data (upper) and for the run with Argo data (lower) (Unit: [0-2.5] °C).

The impact of assimilating Argo profiles on the quality of the Mercator temperature analysis is illustrated on Figures 4 & 5. The rms of the differences between the observations and the model 7-days forecast is much smaller for the run with Argo data than for the run with no Argo data at all depth (Fig. 4). Without the Argo profiles assimilation, the model tends to drift away from the climatology and over time, large bias developed. This is particularly clear between 1000 and 1500 m depth where there are very few data except the Argo profiling floats observations and where large bias developed in the run without the Argo data assimilation. Similarly, the contribution of the Argo data is also clearly visible on the mean meridional temperature structure (Fig. 5). Moreover, even if the number of floats is very low in the equatorial region, the impact on the mean meridional structure is very important. The mean differences from the Reynaud climatology reduces from 2°C to less than 0.5°C between 20°S and 20°N.

Conclusion

Argo profiling floats observations has become one of the key components of the ocean in-situ observing system as a complement to the VOS-XBT lines and to the moored buoys. As the number of floats grows, the 2000 floats target has been achieved in September last year, the impact of this observing system will increase. The results presented here have particularly showed the importance of assimilating Argo data in operational ocean forecasting system since the Argo data particularly control the drift and significantly reduces the biases in the analyses, up to 1.5°C for the temperature field in the equatorial region as showed above.

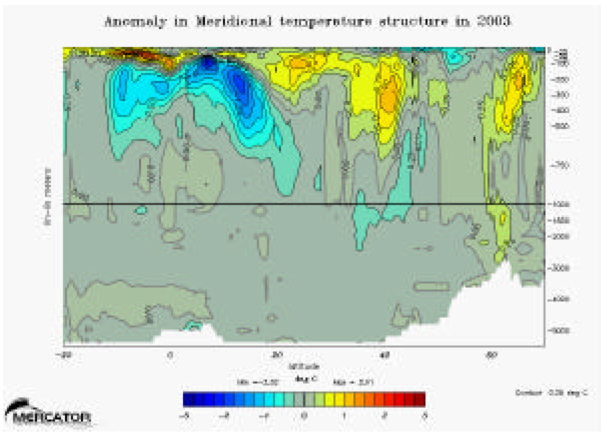


Figure 5.1: 2003 annual mean meridional temperature differences from Reynaud climatology for the run with no Argo data (Fig 5.1) and for the run with Argo data (Fig 5.2) (Unit: [-3, 3] °C).

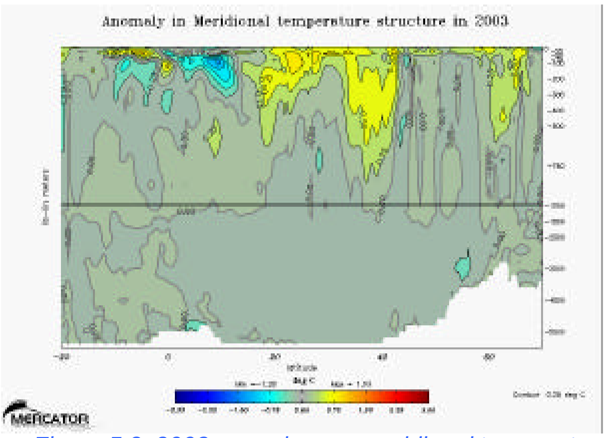


Figure 5.2: 2003 annual mean meridional temperature differences from Reynaud climatology for the run with no Argo data (Fig 5.1) and for the run with Argo data (Fig 5.2) (Unit: [-3, 3] °C).

References

De Mey, P. and M. Benkiran, 2002: A multivariate reduced-order optimal interpolation method and its application to the Mediterranean basin-scale circulation, Ocean Forecasting: Conceptual basis and applications, N. Pinardi, Springer-Verlag, Berlin, Heidelberg, New York, 281-306.

Madec G., P Delecluse, M Imbard, and C Levy, 1998 : OPA 8.1 general circulation model reference manual, Notes de l'Institut Pierre-Simon Laplace (IPSL), 91p.

Reynaud, T., P. Legrand, H. Mercier, and B. Barnier, 1998: A new analysis of hydrographic data in the Atlantic and its application to an inverse modeling study, Int. WOCE. Newsl., 32, 29-31.

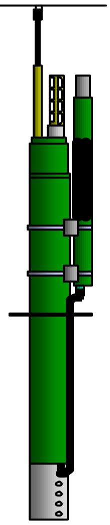
Thiébaux J., E Rogers, W Wang, and B Katz, 2003: A new high resolution blended real time global sea surface temperature analysis, Bulletin of the American Meteorological Society, 84, 645-656.

ProvBio

G. Loaec(1), H. Claustre(2), S. Le Reste(1), P. Brault (3)

(1) Ifremer, Brest ; (2) Observatoire Océanologique, Villefranche/Mer ; (3) Martec-Serpe-Iesm, Guidel

Within the range of Provor floats, ProvBio will be available soon. This float is based on the Provor-CTS3, deployed by series in Argo and Coriolis programs, to provide profiles of sea water temperature and salinity.
In addition to the Sea Bird CTD, ProvBio is fitted with optical sensors provided by Satlantic and Wet Labs (a 3 wavelength irradiance sensor & a transmissiometer).
As the volume of transmitted data increases, the Iridium Satellite System is used, on the basis of Short Burst Messages that will be send through Iridium gateway to Coriolis Data Center, decoded and made available to end-users. The typical cycle of this float is modified so that the ascent is made around local noon, taking into account the time and the location provided by the Gps receiver. The first sea trials will be made in next spring.



Next meetings

- **1st OceanSITES data management meeting**, Hawaii (USA), 16-17 February, 2006
- **Mersea - 3rd Annual Plenary Meeting**, London (UK): March 6 & 7, 2006
- **World Maritime Technology Conference** (WMTC) organised by (IMAREST), London (UK): March 6-10, 2006
- **15 Years of Progress in Radar Altimetry & ARGO science symposia**, Venice (I): March 13-18, 2006
- **1st Joint GOSUD/SAMOS Workshop**, UCAR Boulder, Colorado (USA): 2-4 May, 2006
- **7th Argo data management meeting**, China, Fall 2006

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