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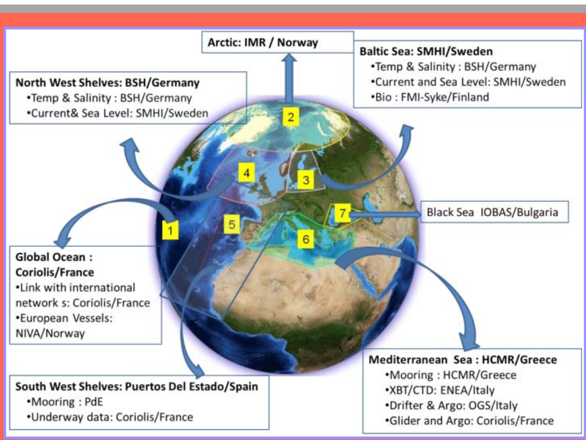
QUARTERLY Newsletter

Mercator Ocean
Ocean Forecasters
SPECIAL ISSUE with Coriolis



The in-situ TAC global and regional components: Institute responsibilities inside each component

Editorial – Apr 2013 – Special Issue jointly coordinated by *Mercator Ocean* and *Coriolis* focusing on Ocean Observations

Greetings all,

Once a year in April, the Mercator Ocean Forecasting Center in Toulouse and the Coriolis Infrastructure in Brest publish a common newsletter. Papers are dedicated to observations only.

The first paper introducing this issue is presenting the MyOcean InSitu Thematic Assembly Center (TAC) which is collecting and carrying out quality control on In Situ data in a homogeneous manner and provides access to In Situ observations of core parameters in order to characterize ocean state and its variability, thus contributing to initialization, forcing, assimilation and validation of ocean numerical models.

Next paper by Kokoszka is using the MyOcean Observation InSitu Thematic Assembly Center (TAC) Products in order to illustrate a strong wind event in the North East Atlantic in February 2013. Wind bursts over 100 km/h occurred along the French Atlantic Coast on February 6th. A possible sea surface temperature cooling is illustrated.

Next paper by Lebreton is dealing with the French Argo float deployment from opportunity vessels. In 2012, Coriolis has deployed more than 120 floats using sailing, military or educational vessels. Deploying from opportunity vessels requires developing clear deployment procedures for teams not familiar with Argo floats, training such teams to detect any anomaly in the deployment and participating to outreach activities.

Turpin et al. are then presenting MOOSE: A Mediterranean Ocean Observing System on Environment that has been set up as an interactive, distributed and integrated observatory system of the North West Mediterranean Sea in order to detect and identify long-term environmental anomalies. It will provide data for the MISTRALS project and use the MyOcean data distribution infrastructure from the InSitu Thematic Assembly Center (TAC).

Reverdin et al. follow with the presentation of SPURS, an experiment dedicated at improving our understanding of the processes controlling surface salinity in the region of maximum surface salinity of the North Atlantic subtropical region and at seeking how well remote sensing data can contribute in monitoring and unraveling those processes. This includes a research cruise, STRASSE on board the French RV Thalassa, with a variety of measurements of the upper ocean transmitted in real time, and a contribution to the overall observing arrays of 10 surface drifters, of 7 Argo floats, the use of two merchant vessels crossing the area equipped with thermosalinographs and occasionally collecting XBT profiles.

Finally, Leymarie et al. are presenting the new ProvBioII float with extended capacities among which a double board architecture as well as additional battery and connectors. Collaboration between LOV, NKE and Ifremer, and the opportunity offered by the remOcean and NAOS projects, lead to the development of this new float with extended functionalities. The extra on-board battery and the Iridium RUDICS telemetry allow longer missions and a large amount of data per cycle. Having a large panel of biogeochemical sensors on the same float also opens new opportunities to deeply understand natural cycles.

We will meet again next year in April 2014 for a new jointly coordinated Newsletter between Mercator Ocean and Coriolis.
We wish you a pleasant reading,

Laurence Crosnier and Sylvie Pouliquen, Editors.

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MyOcean In Situ TAC: A new in situ service for operational and research communities

By Sylvie Pouliquen[1], Thierry Carval[1], David Guillotin[1], Thomas Loubrieu[1], Christine Coatanoan[1], Antoine Grouazel[2], Karina Von Schuckmann[2], Henning Wedhe[3], Lid Sjur Ringheim[3], Thomas Hammarklint[4], Anders Hartman[4], Kai Soetje[5], Tobias Gies[5], Marta De Alfonso[6], Leonidas Perivoliotis[7], Dimitris Kassis[7], Antonis Chalkiopoulos[7], Veselka Marinova[8], Pierre Jaccard[9], Anna Birgitta Ledang[9], Kai Sorensen[9], Giulio Notarstefano[10], Joaquin Tintore[11], Seppo Kaitala[12], Petra Roiha[13], Lesley Rickards[14] , Giuseppe Manzella[15]

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Abstract

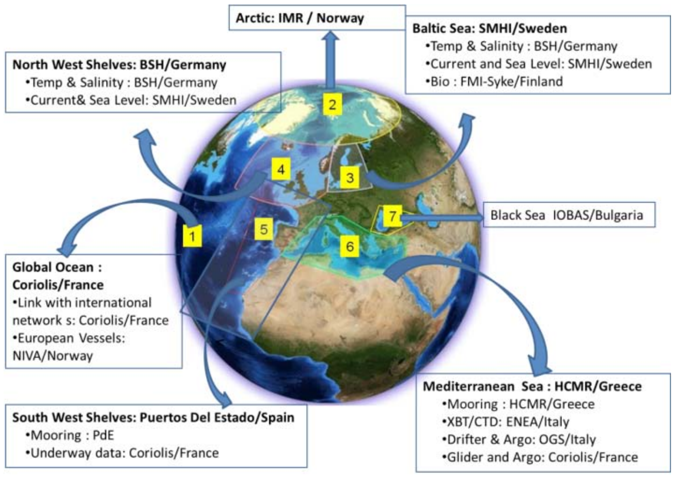
MyOcean is the implementation project of the GMES Marine Core Service to develop the first concerted and integrated pan-European capacity for Ocean Monitoring and Forecasting. Within this project, the in-situ Thematic Assembly Centre (in-situ TAC, INS-TAC) of MyOcean is a distributed service integrating data from different sources for operational oceanography needs. The MyOcean in-situ TAC is collecting and carrying out quality control in a homogeneous manner on data from outside MyOcean data providers, especially EuroGOOS partners in Europe, to fit the needs of internal and external users. It provides access to integrated datasets of core parameters to characterise ocean state and ocean variability, by this contributing to initialization, forcing, assimilation and validation of ocean numerical models. Since the primary objective of MyOcean is to forecast ocean state, the initial focus is on observations from automatic observatories at sea (e.g. floats, buoys, gliders, ferrybox, drifters, SOOP) which are transmitting to the shore in real-time. The second objective is to set up a system for reprocessing (observations) and reanalysis (models) purposes that integrate data over the past 20 years. The global and regional portals set up by the INS-TAC have been extended by the EuroGOOS ROOSes (Arctic ROOS, BOOS, NOOS, IBI-ROOS, MOON and Black Sea GOOS) to integrate additional parameters important for downstream and national applications.

The MyOcean in-situ Thematic Assembly Centre (INS-TAC)

MyOcean aims at providing a sustainable service for Ocean Monitoring and Forecasting validated and commissioned by users. The MyOcean information includes observations (Near Real Time and Reprocessings) analysis, reanalysis and forecasts describing the physical state of the ocean, its variability and the ecosystem response through primary biogeochemical parameters. It also contributes to research on climate by providing long time-series of re-analysed parameters. It started in 2009 for 3 years and will continue for 2.5 additional years through the MyOcean II project that started in April 2012.

The in-situ Thematic Assembly Centre of MyOcean is a distributed service integrating data from different sources for operational oceanography needs. The MyOcean in-situ TAC is collecting and carrying out quality control in a homogeneous manner on data from outside MyOcean data providers (national and international networks), in order to fit the needs of internal and external users. It provides access to integrated datasets of core parameters to characterise ocean state and ocean variability, by this contributing to initialization, forcing, assimilation and validation of ocean numerical models which are used for forecasting, analyses and re-analysis of ocean conditions. Since the primary objective of MyOcean and MyOcean2 is to forecast ocean state, the initial focus was on observations from automatic observatories at sea (e.g. floats, buoys, gliders, ferrybox, drifters, SOOP) which are transmitted in real-time to the shore at *global* (V0 2009) and *regional* (V1 mid 2011) scales both for physical and biogeochemical parameters (Figure 1). The second objective is to set up a system for reprocessings (observations) and reanalysis (models) purposes that requires products integrated over the past 20 years for temperature and salinity parameters. This is the main challenge of MyOcean II for the European seas. The prototype version of the regional products is available since April 2013 (MyOcean V3) for a first operation version in April 2014 (V4).

Since the elaboration of the proposal, the MyOcean in-situ TAC has been designed to rely on the EuroGOOS ROOSes with regional coordination endorsed by partners from the ROOSes and on a global component based on Coriolis data centre that acts as a GDAC (Global Data Centre) for some of the JCOMM networks.



The MyOcean in-situ TAC is focused on a limited number of parameters:

- *Temperature and salinity*: global and regional, produced in real time (all components) and delayed mode (global, as prototype in other regions
- *Currents:* global and regional, produced in real time (global, North West Shelves, Mediterranean Sea, Baltic Sea)
- *Sea level:* regional, produced in real time (South West Shelves, North West Shelves, Baltic)
- *Biogeochemical (chlorophyll, oxygen and nutrients):* global and regional, produced in real time (all components)

The in-situ TAC architecture is decentralized. However, quality of the products delivered to users must be equivalent wherever the data are processed [Pouliquen et al., 2010]. The different functions implemented by the global and regional components of the in-situ TAC are summarized in Figure 2.

Figure 1: The in-situ TAC global and regional components: Institute responsibilities inside each component

Each region has implemented 4 core functions:

- ***Acquisition***: Gather data available on international networks or though collaboration with regional partners
- ***Quality control***: apply automatic quality controls that have been agreed at the in- situ TAC level. These procedures are defined by parameter, elaborated in coherence with international agreement, in particular SeaDataNet, and documented in MyOcean catalogue
- ***Product Assessment***: Assess the consistency of the data over a period of time and an area to detect data not coherent with their neighbours but could not be detected by automatic quality control (QC). This function has a level of complexity on its implementation which is clearly different from the other three as it highly relies on scientist expertise
- ***Product distribution***: make the data available within MyOcean and to the external users

Each region has organized the activities according to the expertise and background in data management for operational oceanography.
The 4 functions are implemented in one institute per region (e.g.: Arctic, Black Sea);
The 3 functions (Acquisition, QC and Assessment) are implemented by parameter (Baltic and NWS) and only Distribution is centralized;
Acquisition and QC is done by platforms (Mediterranean Sea, SWS and Global), one institute taking care of the assessment and distribution is centralized.

In any case, the global component of the in-situ TAC (http://www.coriolis.eu.org/Data-Services-Products/MyOcean-In-Situ-TAC) collects the data from the regional components and integrates them into the global product acting as a backup of the regional centres. The main distribution channel for the INS-TAC is FTP. The *Open Geospatial Consortium* (OGC) viewing service (WMS) and Subsetting download mechanism access are under development and are gradually setup in 2012-2013 [Pouliquen et al. 2011].

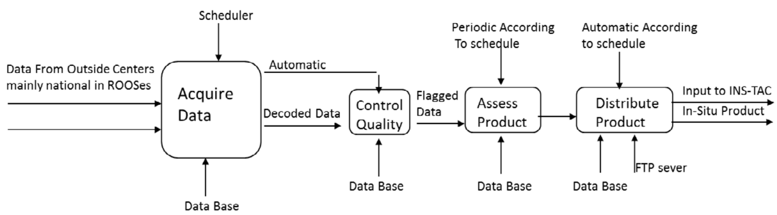


Figure 2: Functions to be implemented by an in-situ TAC component

Extension to EuroGOOS needs

As the structure of the FTP portal is based on platforms it was feasible to integrate other measured parameters and also to include platforms that measure parameters not processed by MyOcean in-situ TAC such as wind and waves. This activity has been endorsed by the ROOSes in collaboration with the regional INS-TAC partners and no additional near real time QC is performed on the new parameters. In collaboration with SeaDataNet, the appropriate vocabularies have been used to integrate the new parameters and SeaDataNet will extend these vocabularies if needed.

As a consequence, for all European seas, a unique way of distributing the data has been set up:

- Same format: The OceanSites NetCDF format has been chosen (figure3) because it is CF compliant, it relies on SeaDataNet vocabularies and it is able to handle profiles and time series data coming from floats, drifters, moorings, gliders and vessels.
- Same ftp portal organization: the data are organized in three main directories:
    - Latest: Providing access to a sliding window on the latest 30 days of observations for real-time applications.
    - Monthly: Accumulating the best copy of a dataset, organized by platform and by month.
    - History: Providing historical aggregated datasets (20 years) for reanalysis activities.

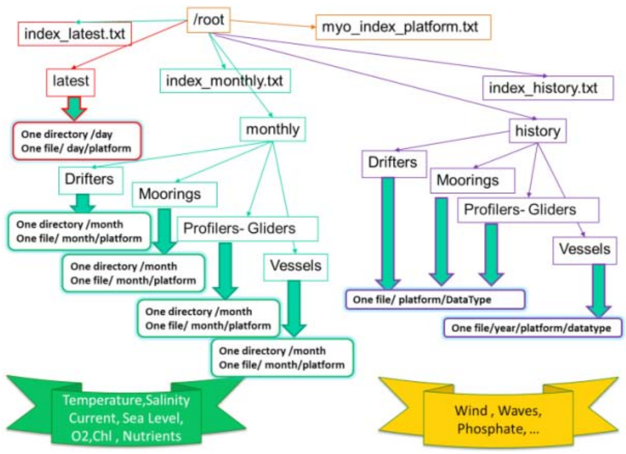


Figure3: FTP portal organisation

Which service in Near Real time?

The service provided at Global and regional scale by the MyOcean In-Situ TAC was developed in collaboration with the EuroGOOS ROOSes and set up gradually since the start of MyOcean in 2009:

- V0 : April 2009 : Near Real Time Global service operated by Coriolis
- V1 : April 2011 : Near Real Time Regional services set up and regional services connected to the Global INSTAC service
- V2 : April 2012 : Extension to the ROOSes needs of the MyOcean Service (more parameters managed). Coriolis CORA03 T&S product upgraded to integrate MyOcean new observations (1990-2010)
- V3 : April 2013: Aggregation of Historical observations in partnership with EuroGOOS ROOSes partners and SeaDataNet2 project. CORA03 T&S product upgraded to integrate ICES observations (1990-2011)
- V4 : April 2014 : T&S regional product distributed jointly with SeaDataNet2. CORA4 product updated with Regional products (1990-2012)

The In Situ Thematic Centre integrates observations from Regional EuroGOOS consortium (Arctic-ROOS, BOOS, NOOS, IBI-ROOS, MONGOOS) and Black Sea GOOS, JCOMM global systems Argo, GOSUD, OceanSITES, GTSPP, DBCP) and from the Global telecommunication system (GTS) used by the Met Offices. The accuracy of the in situ observation depends of the platforms and sensors that have been used to acquire them (see example for T&S in Table 1).

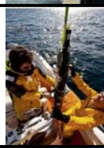
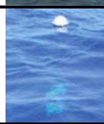
Platform-type	Instrument view	Temperature[1] [°C]	Salinity[1] []
CTD		0.005-0.001	0.02-0.003
XBT XCTD		0.1 0.02	N/A 0.003
Profiling floats (Argo)		0.01[2]	0.01[2]
Moored buoy data: TRITON/TAO PIRATA/RAMA surface Subsurface		0.002 0.01-0.3 0.01-0.09	0.003
Drifting buoy data		0.01	0.01
Marine mammals		0.005	0.01
Glider		0.005	0.02
Underway (Ferrybox, Research vessel TSG)		0.001-0.1[3]	0.003-0.2[3]

Table 1: Accuracy estimate for T&S depending of the platform

All observations are aggregated by the In Situ Thematic Centre and provided to users together with metadata information on the platforms that were used to perform the observations. In near real time (within a few hours, maximum one week from acquisition) the quality of the observation is tested using automatic procedures and flags (see Table 2) are positioned to inform the users of the level of confidence attached to the observations. Note that to be on the safe side users should only use data with flag=1 and discard data with flag=4.

Code	Meaning	Comment
0	**No QC was performed**	**-**
1	**Good data**	**All real-time QC tests passed.**
2	**Probably good data**	**These data should be used with caution**
3	Bad data that are potentially correctable	These data are not to be used without scientific correction.
4	**Bad data**	**Data have failed one or more of the tests.**
5	Value changed	Data may be recovered after transmission error.
6	Not used	-
7	Not used	-
8	Interpolated value	Missing data may be interpolated from neighbouring data in space or time.
9	Missing value	-

Table 2: Quality Flag meaning

Presently in near real –time about 2500 platforms for the global, between less than 10 for the Black Sea and 450 for the Iberian-Biscay-Irish seas are distributed every day on the In situ TAC portals (figure 4). Depending of the seas the platforms used are diverse from mainly fixed stations and ferrybox from the Baltic, to research vessels and Argo for the Arctic to a wider kinds of platforms for North and South West Shelves and Mediterranean Sea. The number of platforms is sparse in the Black Sea but improving since the start of the Argo program in the area.

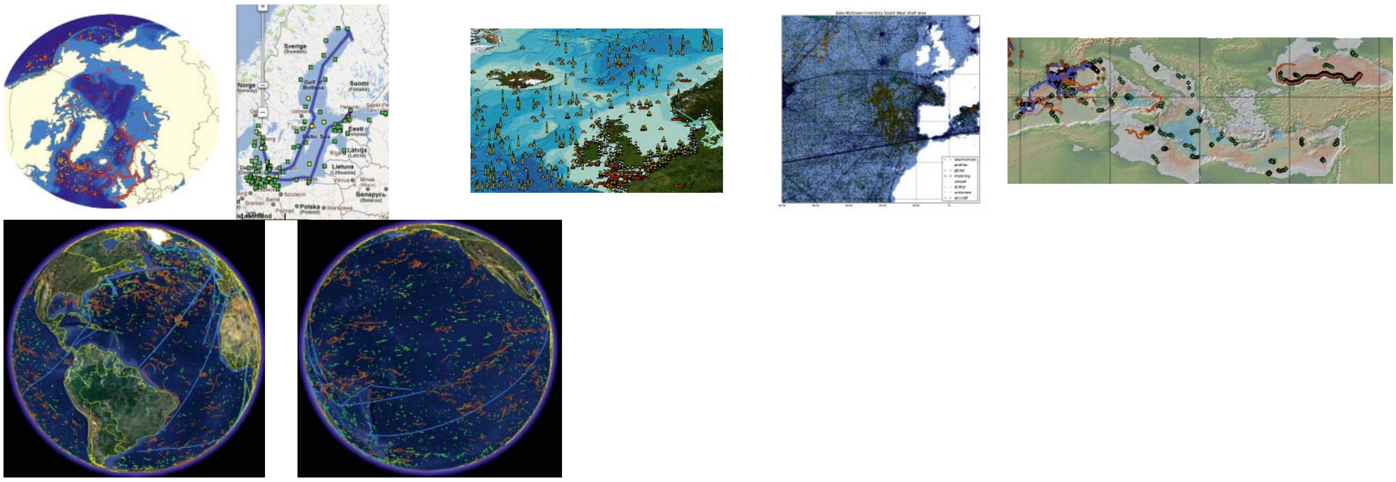
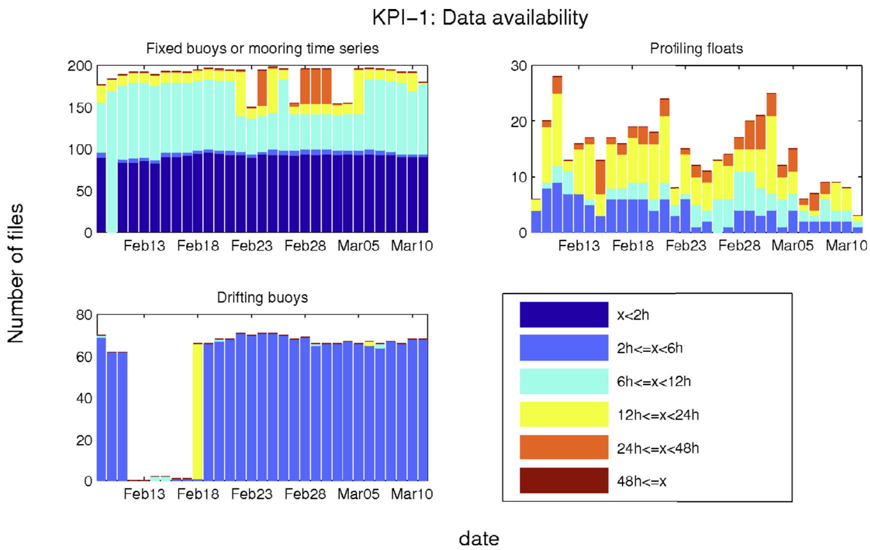


Figure 4: Latest 3 months of observations in each region

The service was also strengthened and monitoring tools where set up to survey the connections with the national data providers, the continuity of the services, the delays between acquisition and delivery, the quality of the product delivered. Based on feedback from users a continuous service improvement loop is set up that lead to the connection to new data streams, improvement of the NRT QC procedures, reduction of the delays and improvement of the product assessment through quarterly validation of the products (figure 5).



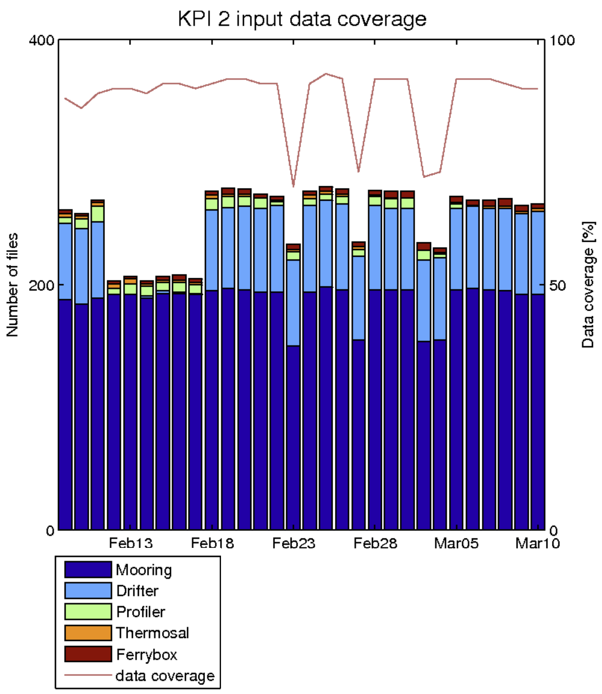
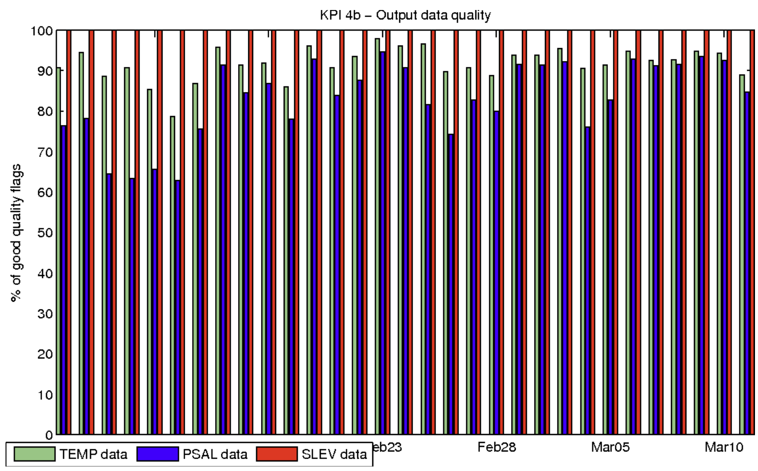


Figure 5: Monitoring the delay per platform (top) ,
the number of platform per date (left),
the quality for each parameter (right)
Example of the NWS seas



Reprocessed In Situ Products for reanalysis

An ideal in situ product for ocean re-analysis should cover the entire global ocean and be continuous in time, subject to regular quality control and calibration procedures, and encompass several spatial and temporal scales (that can be regionally different and variable depending on the dominant underlying oceanic physical processes and forcing). This goal is not an easy one to achieve in reality, especially with in situ oceanographic data such as temperature and salinity. We have shown previously that these data have as many origins as there are scientific initiatives to collect them. Efforts to produce such ideal global datasets have been made for many years, especially since Levitus (1982).

During the decade 2000–2010, the French project Coriolis, whose main aim is to supply in-situ data in real time to French and European operational oceanography programs, started to distribute a quality-controlled dataset named CORA. The first two versions were released in 2007 and 2008. In 2010, as part of the MyOcean project, the Coriolis research and development team developed a new procedure to be able to produce a quality-controlled dataset on a regular basis. Our objective is to update the CORA dataset (figure 6) every year with all the data acquired during the last full year available and to update the entire CORA dataset (full timespan) every 2 years.

The content of this Global product as well as the validation is described in Cabanes et al. (2013) and has also been advertised in previous issues of Mercator-Coriolis newsletter (Cabanes et al. 2011) . For MyOcean V3, CORAV03.4 covers 1990-2011 period and has added ICES CTD as well as the year 2011 to the previous CORA03.3 product.

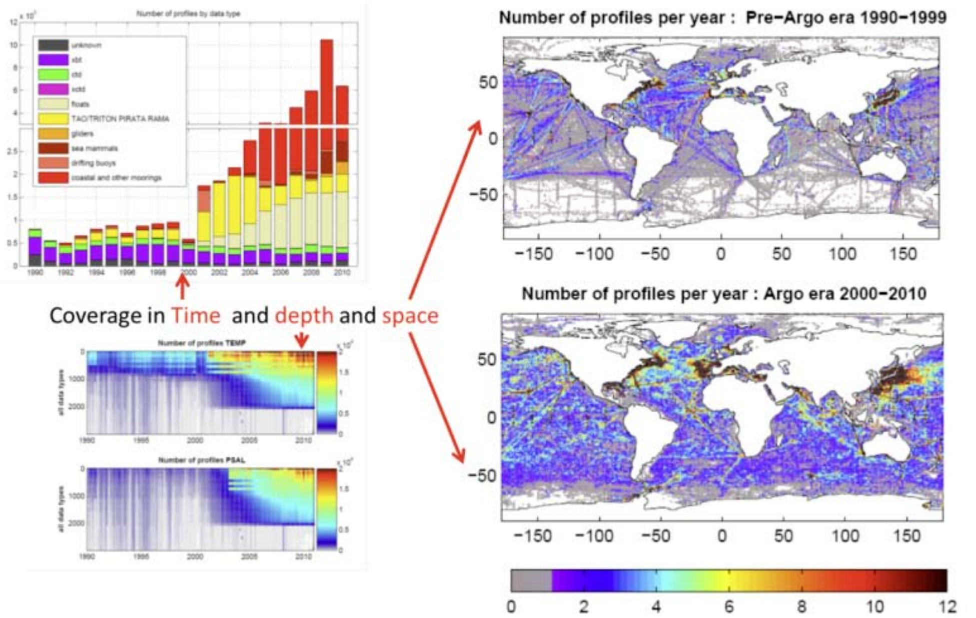


Figure 6: Temperature & Salinity Global CORA product.

Based on the Global product experience and in partnership with the SeaDataNet2 EU project (http://www.seadatanet.org/), similar Myocean2 products for the European seas are under development. A first version will be delivered in April 2013 and a fully validated one will be available for MyOcean-V4 in April 2014. These products integrates observation aggregated from Regional EuroGOOS consortium (Arctic-ROOS, BOOS, NOOS, IBI-ROOS, MONGOOS) and Black Sea GOOS, from SeaDataNet2 National Data Centres (NODCs), from World Ocean Data Base (US-NODC), JCOMM global networks (Argo, GOSUD, OceanSITES, GTSPP, DBCP) and from the Global telecommunication system (GTS) used by the Met Offices (see Figure 7).

While the NRT products were aggregating the observations available in real-time since 2010, for the reprocessed product it is important to retrieve whenever it is possible the observation qualified in delayed mode, eventually corrected from offset or drift either from ROOS national centres, SeaDataNet NODCs or JCOMM networks. In case a duplicate is detected between the new data provided and a copy that was already provided in real time, each regional in situ TAC has defined rules to handle them and a visual inspection is performed when it is not clear from the provided metadata which copy have been through scientific validation.

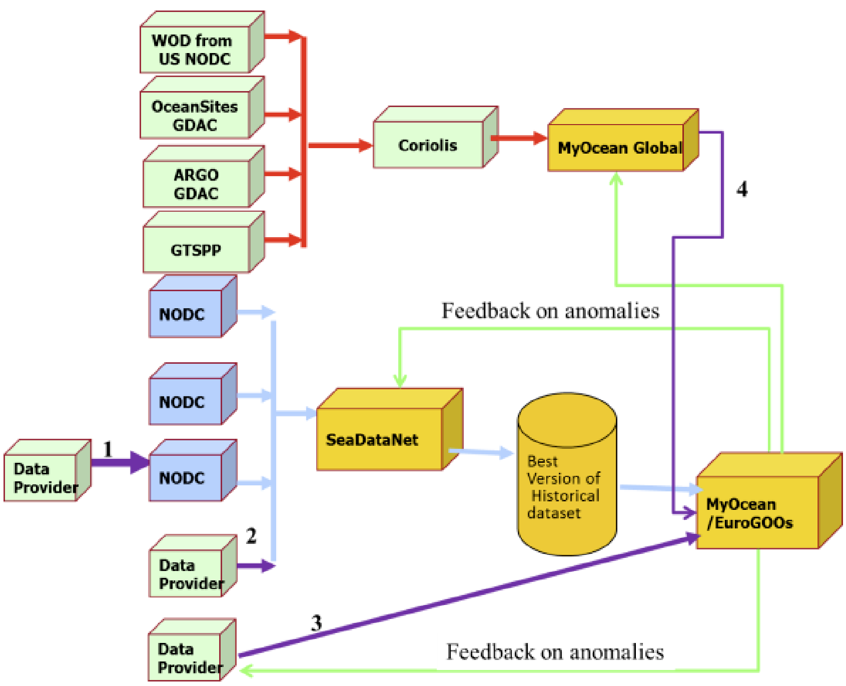


Figure 7: External and internal interfaces for Reprocessed in situ product elaboration.

The regional products are built in two steps (figure 7): first, for MyOcean V3, the focus is the aggregation of the data from the ROOS providers and the SeaDataNet National Data Centres, removing duplicates and converting all data in the same format with the same QC flags. Whenever it is possible, all the parameters measured by a platform are aggregated even if the scientific validation will only be performed of the Temperature and Salinity parameters.

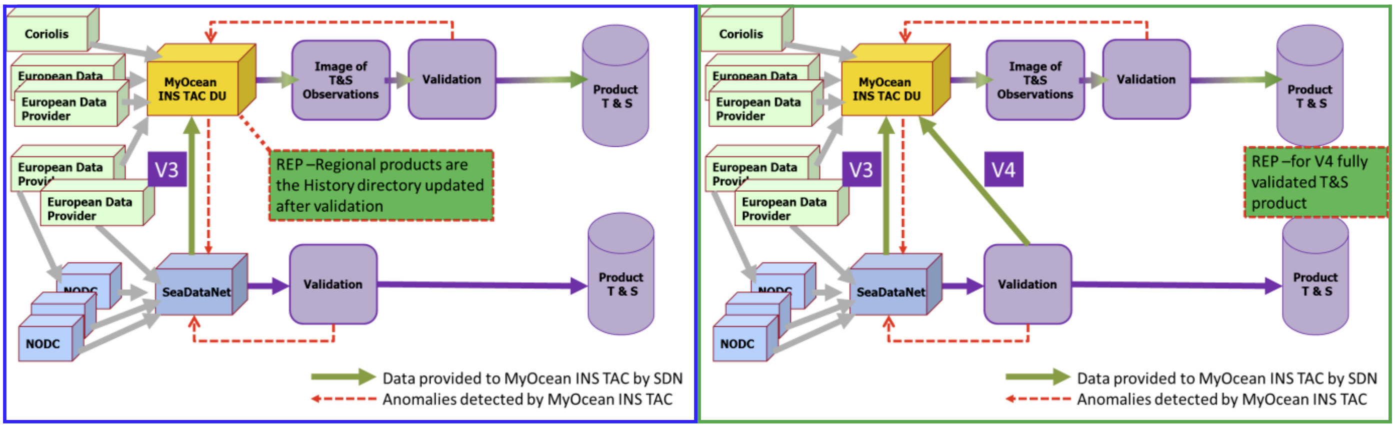


Figure 8: Building V3 and V4 Reprocessed T&S in situ products.

The scientific validation will be performed of on a fixed copy of the history directory (figure 8). It will consists on statistical tests to check the consistency of the observation with its neighbours, climatology test and the detected outliers will be examined by a scientist to avoid flagging a real phenomenon as bad data sampling. Feedback to providers (ROOS partners or SeaDataNet NODCs) on the anomalies detected will be performed so that this validation helps to enhance not only the MyOcean products but also the provider datasets. These fully validated T&S regional products will be available in MyOcean V4 and also integrated in the Global CORA04 in situ TAC product.
These regional T&S products (figure 9) will be distributed jointly by MyOcean2 and SeaDataNet2 projects. The process to create these products has been designed to allow periodic update from EuroGOOS ROOS and SeaDataNet NODC holdings in the future.

Figure 9: Building regional T&S product for re-analysis in European seas.

Future developments

This infrastructure developed jointly by MyOcean and EuroGOOS ROOSes has set up a useful service both for operational oceanography in Europe but also for the research community and the development of downstream services. It relies on open and free data policy and the EUROGOOS ROOSes should encourage such data policy.

Within MyOcean2, the focus is on enhancing the assessment of the products and developing temperature and salinity time series for re-analysis activities in partnership with SeaDataNet2. It is also extended to coastal data within the JERICO project (www.jerico-fp7.eu/) as well as in Mediterranean Sea within Perseus (http://www.perseus-fp7.eu/). At global scale a better integration of the European glider data is developed in partnership with the GROOM project (http://www.groom-fp7.eu/).

Finally this infrastructure is used by the EMODNET-PP project (http://www.emodnet-physics.eu/) to provide discovery and viewing service for fixed point stations and ferrybox data managed by MyOcean/EuroGOOS for real time and SeaDataNet for historical data. This portal will be extended to other type of platforms within the Emodnet-PP2 in 2013-2014.

The infrastructure described in this article has been set up to fulfil the Operational Oceanography and EuroGOOS partners needs and will show its benefit to the community if it is sustained on the long term jointly by the regions and the European Commission and not only through national funds complemented by FP project as presently. It can be the foundations of a reliable data exchange system for operational oceanography applications both for core and downstream applications as well as research activities to improve the services at European scale.

Acknowledgements

This work is part of the MyOcean project. Additional observations are acquired outside MyOcean and especially by EuroGOOS ROOS institutes at European Scale and through SeaDataNet2 EU projects for historical data.

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Using In Situ TAC products to view the early February 2013 Storm over the Iberian Biscay Irish (IBI) area.

By Florian Kokoszka (R&D Coriolis, DT-INSU, Brest, Ifremer, France)

Abstract

Using MyOcean2 Observation InSitu TAC Products, we present here a quick overview of a multi-parameters study over the MyOcean2's Iberian Biscay Irish (IBI) area. A strong wind event occurred over the North and Celtic's Seas in the eastern North Atlantic from the 5th to 10th of February 2013. Wind bursts over 100 km/h occurred along the French Atlantic Coast on February 6th. We illustrate here a possible sea surface temperature cooling using the in situ data available in the MyOcean2 data distribution unit.

Sea Surface temperature

First, in order to get a synoptic view of the area, we used satellite datasets produced at *Center for Satellite Exploitation and Research* (CERSAT): wind speed and sea surface temperature (SST) daily products on a 1/10° grid (Figure 1). Then we extracted from the MyOcean2 real time product in situ measurements with higher time and spatial resolutions into the area between the 1st and 10th of February : this includes the K5, K4 and North Cormorant buoy stations, three drifters, data of one vessel and six Argo profiles (Figure 2).

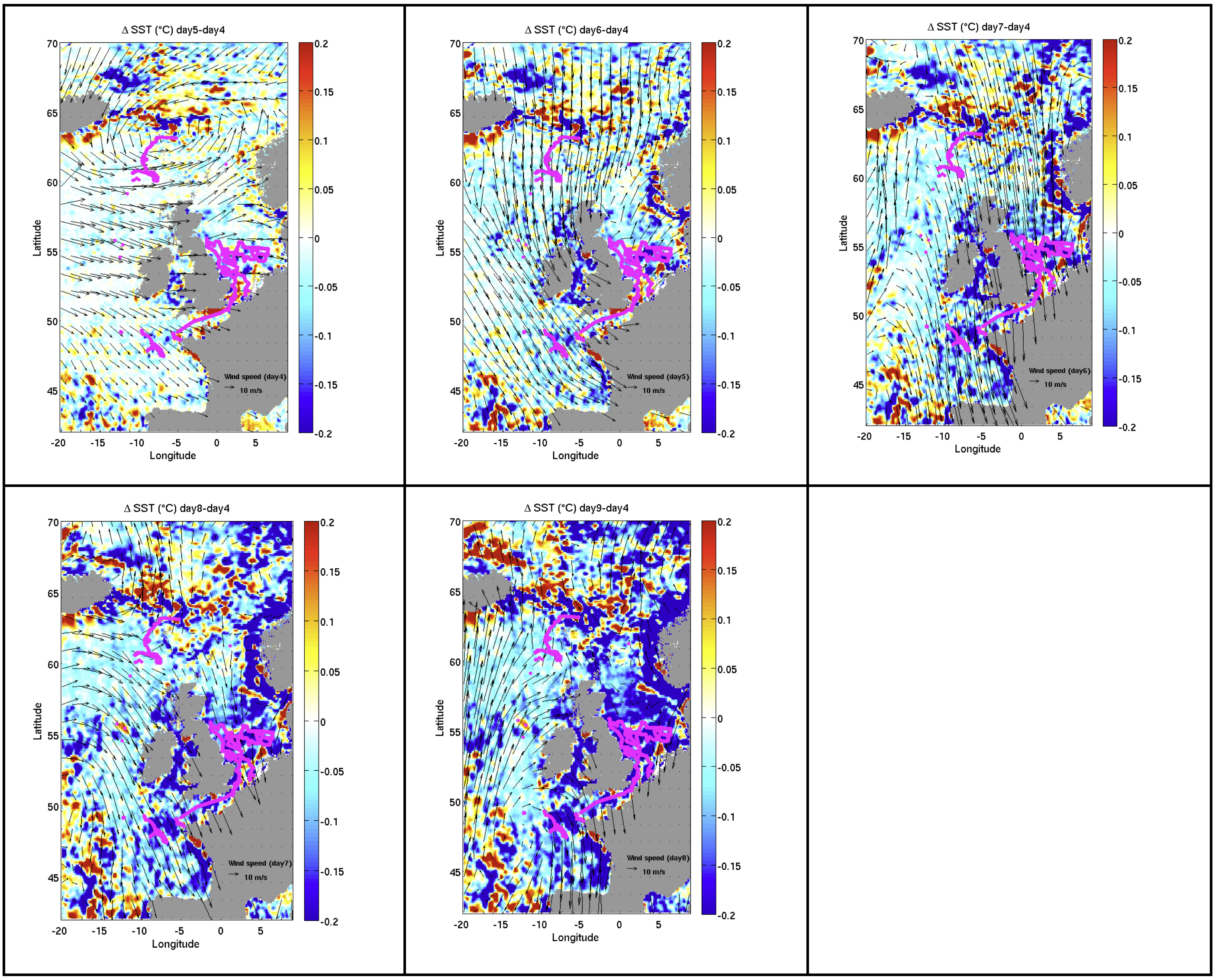

Figure 1: February 2013. Satellite Sea Surface Temperature (SST [°C]) differences between successive days and a reference day (day 1 is February 1st. Here the reference is day 4). Wind speed [m/s] at day -1 is shown with black quivers. In situ data positions are shown in magenta (See Figure 2 for data's types).

The 4th of February (here day 4) is taken as the reference day for sea surface temperature before the wind event. In order to take into account the ocean's response time to the wind forcing, we make the following coarse hypothesis: We expect that wind bursts over the period lead to a surface cooling over the area with a 24h inertia. We chose a day J, from the 5th to 9th, and we calculate SST differences between this day and day 4 (reference) and thus we associate it with the wind speed at J-1 (24h inertia).

We show on Figure 1 a progressive cooling that occurs over the area where wind is blowing on J-1. Between February 4 and 9, a decrease of nearly 0.5°C is seen on the Bay of Biscay's shelf and over the North Sea. The Celtic Sea from Scotland to Iceland shows a mean cooling of 0.3°C. We note that regional and local warmed or cooled patches appear over the area with a strong spatial inhomogeneity. This could be partially due to interleaving water parcels deeper into the water column, isolated from the surface that could be entrained in the surface layer along wind bursts.

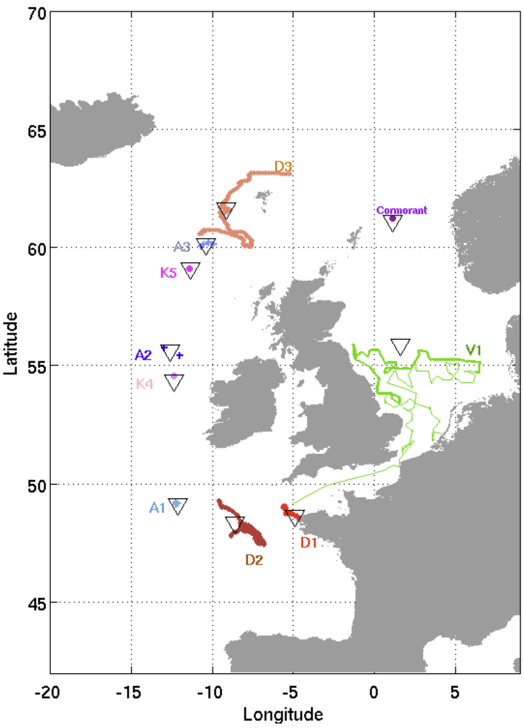

Figure 2: Part of in situ data found in the area between 1st and 10th of February 2013. Time series are plotted on Figure 3b-c. Vertical profiles are plotted on Figure 4. Black triangles indicate satellite wind speed checkpoints plotted on Figure 3a. A1, A2 and A3 refer to Argo profiles. D1, D2 and D3 refer to surface drifters. V1 refers to vessel pathway (here Thalassa from Ifremer). K4, K5 and Cormorant refer to buoy's stations.

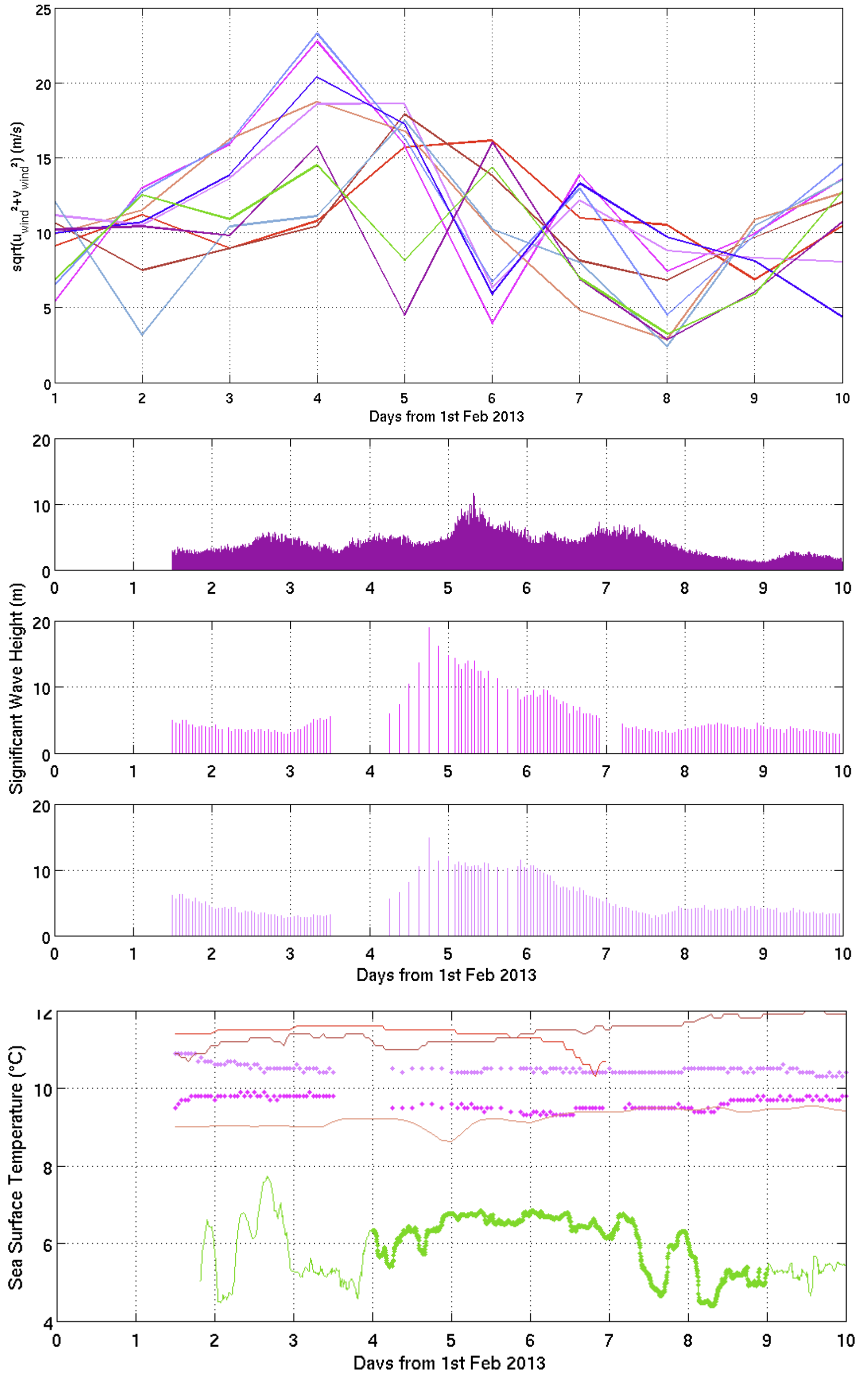

Figure 3: (a) Satellite wind speed's time series at checkpoints chosen among data's positions. (b) Significant wave height [m] recorded at buoy's stations (North Cormorant, K5 and K4). (c) Sea Surface Temperature [°C] in situ time series found in the area. Colors refer to data's types (See Figure 2).

Wind Speed

Then we used the satellite wind speed's product to check time series at geographical points among in situ data (Figure 3a).

For example, the surface drifter D3 trajectory (Figure 2) shows a maximum of wind speed of 18 m/s on the 4th of February (Figure 3a). Here the temperature's time series show a 0.6°C cooling between the 4th and 5th. Interestingly, this signal doesn't appear clearly on satellite SST maps (day5-day4 on Figure 1).

At the K5 buoy station (Figure 2), wind speed peaks at 23 m/s on the 4th of February. A remarkable peak of significant wave height appears later, on the 4th in the evening, with a maximum at 19 m (Figure 3b). A cooling of 0.4°C appears afterwards. This cooling is visible on SST difference maps (Figure 1) but signal is weaker with a mean cooling of 0.1°C. The same case appears for the K4 buoy in a moderate way compared to K5. At North Cormorant buoy station, satellite winds show peaks at 4th and 6th (Figure 3a), and a maximum of wave height of 12m happens on the 5th.

Looking closer to the western French coast, surface drifter D1 (Figure 2) shows a quasi-constant temperature along the trajectory from the 2nd to 5th, then a 0.8°C cooling between the 5th and 7th (Figure 3c), one day after the wind maximum (18 m/s) that occurred on the 6th (Figure 3a). SST difference maps show this signal, with weaker amplitude of 0.5°C (Figure 1). Near the shelf break in the Bay of Biscay area drifter D2's temperature follow the D1's tendency but does not show a cooling as important as for D1. Maximum of wind occurs on the 5th (Figure 3a) with 18 m/s peak, followed by a nearly 0.1°C cooling (Figure 3c). Nevertheless Satellite's SST shows a decrease of nearly 0.5°C over this area (but with high heterogeneity due to shelf break front and vertical mixing) between February 4 and 9.

West of the British Isles, in the southern North Sea, NO Thalassa (Ifremer research vessel, here V1) recorded surface temperature and salinity along its path. The trajectory is shown in green on Figure 2. The bold line indicates the ship's path between the 4th and 9th of February. Two 14 m/s wind peaks happened on the 4th and 6th (Figure 3a), followed by a cooling of 0.8°C. A strong cooling of nearly 2°C then appears between 7th and 8th (Figure 3c), but which could also be associated to spatial variability along the ship track. The satellite monitoring shows that this area is strongly impacted by the wind event, with a mean cooling over 0.5°C (Figure 1).

Mixed Layer Depth

The wind event should also induce a deepening of the mixed layer depth. We identified 3 Argo floats (A1, A2 and A3) shown on Figure 2, with profiles on different days. From the temperature and salinity profiles we computed the potential density. Using the density profiles we inferred mixed layer depths with the method given in de Boyer Montegut et al. (2004) (figure 4). Here mixed layer is also defined where density difference between surface and depth stays inferior or equal to 0.03 kg/m³.

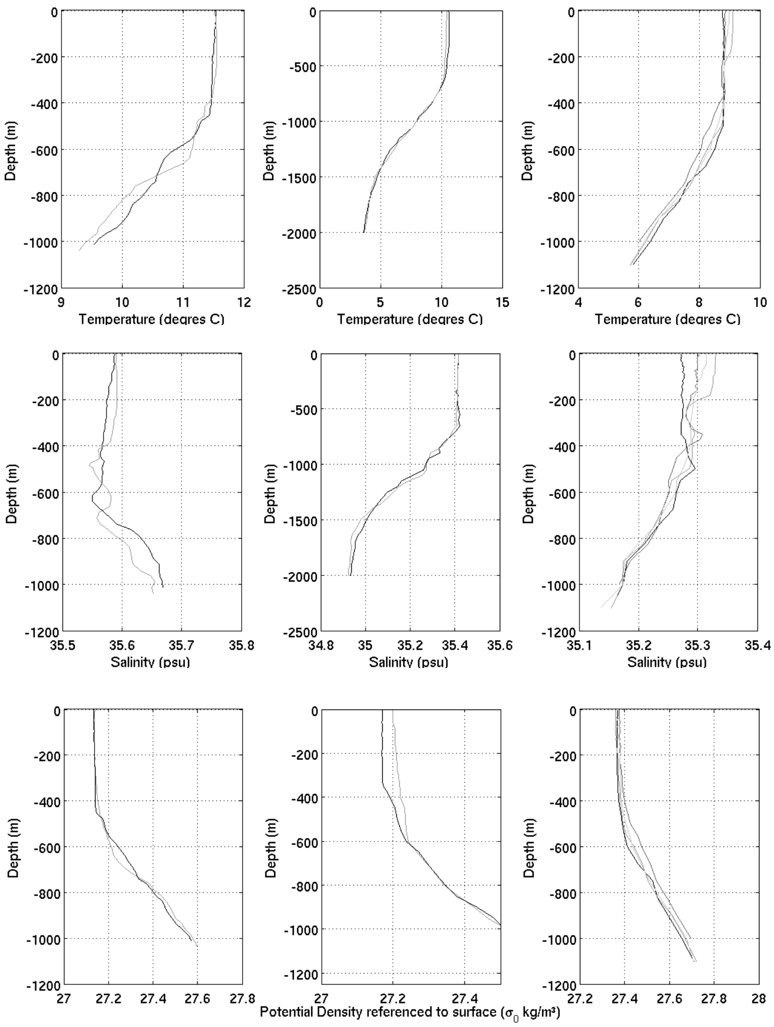

Figure 4: Argo profiles found at sites A1, A2 and A3 (See Figure 2). Profiles are plotted from black to light gray, respectively from the older to the more recent. We give here the profile dates: A1 (5th and 15th), A2 (6th and 16th), then A3 (3rd, 7th, 11th and 15th). Potential density is calculated with the Seawater Algorithms from temperature and salinity profiles.

Site/Date	A1 5th	A1 15th	A2 6th	A2 16th	A3 3rd	A3 7th	A3 11th	A3 15th
MLD(m)	476m	513m	450m	550m	550m	450m	500m	550m

Table 1: Mixed layer depth (MLD [m]) inferred from density profiles, calculated for each Argo profile with the method given by Boyer Montegut et al. (2004).

Results are reported in Table 1. A1 cast shows a 37m deepening of the mixed layer between February 5 and 15, then 100m deepening at A2 between February 6 and 16, and a 50m deepening at A3 between February 7 and 11.

Conclusion

This quick overview provides an example of an extreme event that can be tracked into the MyOcean2 Real Time In Situ TAC, over a large area and into the water column depth, complemented here by the CERSAT satellite's products. This illustrates the complementarity between datasets, from the synoptic view of the satellite to the high resolution in situ measurements, but also remaining differences that can be ascribed to spatio-temporal variability, but also errors in satellite data.

French Argo float deployment from opportunity vessels in 2012

By Nathanaële Lebreton, Ifremer, Brest, France

Abstract

Since 2000, the Argo Program has grown rapidly and become a functioning global observing system for the subsurface ocean. More than 3000 Argo floats now cover the world's ocean. With these instruments operating on 10-day cycles from surface to 2000m, the array provides 9000 temperature/salinity/depth profiles every month that are quickly available via the Global Telecommunications System and the Internet. Maintaining such a network requires international collaboration as about 800 new floats need to be deployed to fill the gaps created by the death of old floats and the fact that Argo floats are moving according to ocean currents.

France contributes to the Argo effort through Coriolis that coordinates the contribution of the French institutes involved in Argo (CNES, CNRS, IFREMER, IRD, IPEV, Météo-France and SHOM). About 80 floats are deployed each year mainly in Atlantic Ocean and Mediterranean Sea. Most of the deployments are performed from research vessels in collaboration with scientific teams involved in Argo. But in some areas, other platforms such as opportunity vessels that have the capabilities to deploy a few floats during their transit are needed.

In 2012 Coriolis deployed more than 120 floats as France had some backlog to resume after the Seabird pressure sensor failure that led to stopping most of the deployments in 2010. Therefore we have used either sailing vessels, military vessels or educational vessels. Deploying from opportunity vessels requires

- to develop clear deployment procedures that can be understood by teams that are not familiar with the Argo floats,
- to train the teams so that they can easily detect if an anomaly occurs that should prevent the deployment to be done
- to participate to outreach activities in order to explain to non specialist the Argo deployment program and the scientific goals it aims at achieving.

Voiles Sans Frontières

The French Non-Governmental Organization "Voiles sans Frontières" (figure 1) (VSF, Sailors without borders) operates in isolated areas of the Atlantic with the open sea or rivers being the only way to access.

With the support of ocean-going sailing vessels, VSF accomplishes in priority sanitary or medical missions and educational programs. In 2012, JCOMMOPS established a partnership with VSF for the deployment of floats and funded the test campaign and Coriolis collaborated with VSF to perform the first deployment. Five VSF yachts (figure 2) (LILADHOC, SODRIC, CHANIC, DREAMWEAVER and YOBALEMA) took on-board one or two floats, which later were released at an indicated position according to the procedure they were trained to. A special thanks to Michel Huchet (NGO president) and Laurent Gouy who took care of the logistic of this adventure (float transport, documentation and training) and to the yacht crews that performed the deployments. We plan to renew this experience in coming years.

Nathanaële Lebreton, responsible of the Deployment team for Coriolis, met the NGO members and presented the Argo project during a seminar attended by interested persons from medical and paramedical sector. She got a lot of questions about the oceans, the profilers, etc… (figure3).

Figure 1: Voiles Sans Frontières (VSF)

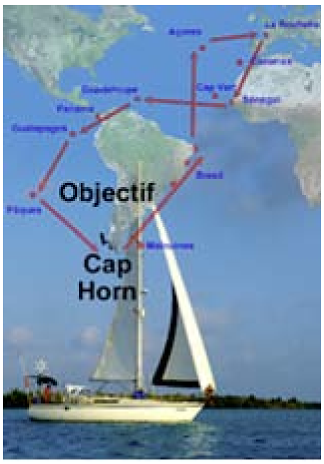

Figure 2: Example of 3 VSF Yachts: The Liladhoc (left), The Chanic (middle), The Dreamweaver (right).

Figure3 : Example of seminars given by Nathanaële Lebreton.

The Military vessel Commandant L'Herminier

The Military vessel Commandant L'Herminier (Figure 4) has deployed 10 floats during summer 2012 by Gilbraltar strait and to the gulf of Guinea. An article was published in the newspaper "Cols Bleus" n°2999 in September (Cols-Bleus-2999). This cruise was also followed by an elementary class and it was the occasion to teach children how an ARVOR float operates, what it measures and for which purpose. The children visited the vessel before its departure and followed the activities during the campaign.

Figure 4: Float deployment on board the Military vessel Commandant L'Herminier.

From Sailing boats before and even during a race

Stève Ravussin (Multi-one attitude, Race for Water) and Michel Desjoyeaux (Foncia) skippers accepted to deploy floats on their way to the KRYS OCEAN RACE departure (New York -Brest) where there were gaps in the Argo network. The arrival was during the "Tonnerres de BREST" festival in July and outreach activities have been performed by N. Lebreton and L. Petit de La Villéon on the race stand to explain how floats operate, how they are deployed using video made by the skippers, how the data are processed and can be viewed by general public.

The **SOJANA** and the **FOFTEIN of RYE (Figure 5) are** the first sailing vessels that deployed 4 ARVORS floats (2 each) in June 2012 during the Maxitransat 2012 race from Antigua to Europe. In order to know more, please refer to Alexia Barrier narrative at http://www.coriolis.eu.org/Observing-the-ocean/Observing-system-networks/Argo/French-Contribution-to-Argo/Navires-d-opportunite-2012/Yachts-2012.

Goélette Rara Avis

The RARA AVIS schooner is own by the AJD association created by father Jaouen in 1951in order to help young people with difficulties in their life. It left Brest port on the 15th December 2012 for Antigua with 4 ARVOR floats on board that will be deployed between Canary Islands and Antigua is areas poorly sampled by Argo.

Figure 5: Example of sailing vessels participating in the deployment of floats (© Yvan Zedda, © Sojana, Rara Avis © AJD)

Conclusion

As a summary, 30 floats were deployed using these opportunity vessels in 2012. These new partnerships were rich in term of human exchanges with people interested in oceanography sciences. A great experience that will be renewed in the future!

MOOSE: Mediterranean data management link with Coriolis

By: Victor Turpin[3 then 1], Patrick Raimbault[2], Loïc Petit de la Villéon[3], Magali Krieger[3] and Armel Bonnat[3]

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Abstract

A Mediterranean Ocean Observing System on Environment (MOOSE) has been set up as an interactive, distributed and integrated observatory system of the North West Mediterranean Sea in order to detect and identify long-term environmental anomalies. It will provide data for the MISTRALS project and use the MyOcean data distribution infrastructure. It will be based on a multisite system of continental-shelf and deep-sea fixed stations as well as Lagrangian platform network to observe the spatio-temporal variability of processes interacting between the coastal-open ocean and the ocean-atmosphere components.

The MOOSE concept is based on eulerian observatories and autonomous mobile platforms to enlarge and enhance the Mediterranean observation (Figure 1). The strategy is mainly based on:

- 2 glider endurance lines and several floats for characterizing the large scale circulation.
- Long-term time-series from coastal and offshore moorings.
- Radar measurements for synoptic view of surface circulation and variability.
- Monthly sampling at 3 offshore stations.
- High frequency monitoring of river input (Rhône and Têt) and atmospheric deposition (cap Ferrat, Frioul Island and Cap Bear).

Figure 1: MOOSE implementation strategy

Coriolis is a multi-organism project sustained by Ifremer, Shom, CNRS, IRD, Meteo France and IPEV. Initially designed for operational oceanography purposes, the Coriolis data centre has been adapted to also fulfil the needs of science oriented projects. MOOSE data management needs the service proposed by Coriolis.

In this paper, we will detail the technical aspects of the data management processes behind the collaboration between Coriolis and MOOSE head office. We will also discuss the reasons that led us to choose various options to manage the data.

Aims

In terms of data management the MOOSE requirements are:

- Archiving data produced by the ocean measurement platform grid,
- Giving MISTRALS project access to all of the MOOSE data sets.

As the French National Ocean Data Centres (NODC), Sismer together with the Coriolis data center are able to provide an operational service for

- Archiving the ocean data produced by the national oceanographic fleet and many other platforms and data sources;
- With quality control of the datasets,
- Fuelling the global data distribution programs (in real time and delayed mode)

Specific features of the project

The main features of the MOOSE project are a high diversity of platforms, data types and qualification and collecting processes (see Appendix1). Data produced by MOOSE is in real time or delayed mode, and contains physical or chemical data, vertical profiles or time series. It will be distributed through two different channels (Coriolis data base and Marine Physics and Chemistry Data Base- MPCDB). The Coriolis database is built to handle physical ocean data in real time, whereas the MPCDB deals with physical and chemical data in delayed mode. In addition, a dedicated ftp site has been set up in order to distribute to Mistrals the data that can not be loaded in the Coriolis database.

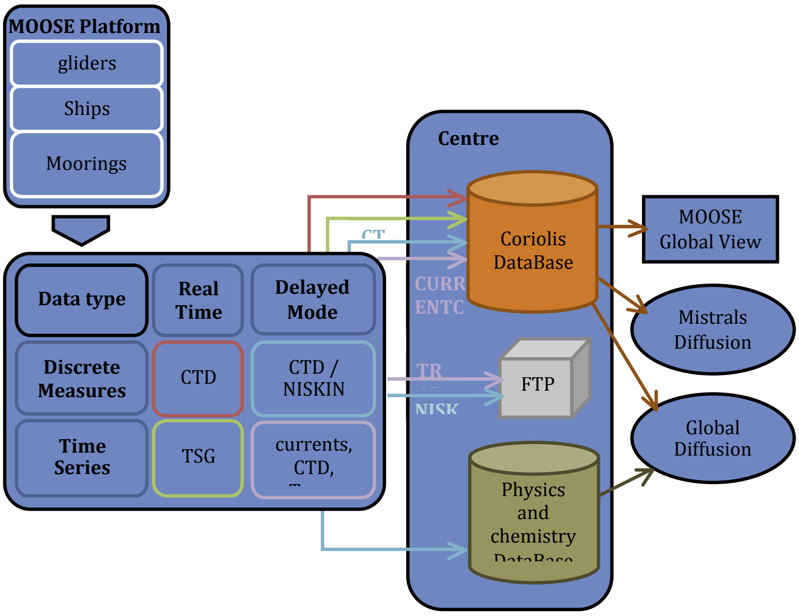

Figure 2: Production, archiving, distribution: the MOOSE data flow

Measuring platform types	How often?	Data Types	Realtime / delayed mode	QC done by	Archiving	Distribution channels
Glider : 2 Transects 6-10 months/year	A few cruises every year	CTD (T°, S, P, O_2, Fluorescence)	Real time	Coriolis	BDD Coriolis	GTS, MyOcean, Mistrals
Research vessels	Monthly cruises on dedicated sites and a large scale cruise every year	CTD (T°, S, P, O_2, Fluorescence)	Real time	Coriolis	BDD Coriolis	GTS, MyOcean, Mistrals
		CTD (T°, S, P, O_2, Fluorescence)	delayed mode	PI	BDD Coriolis BDD Sismer FTP Mistrals	MyOcean, Seadatanet, Mistrals
		Bottles NISKIN (P, T, S, O_2, NO3, NO2, PO4, SIOH4, AT, CT, others)	delayed mode	PI	BDD Sismer FTP Mistrals	Seadatanet, Mistrals
Open Ocean Moorings	Every year or every 6 months	CTD (ST – T, S,P)	delayed mode	PI	BDD Coriolis	MyOcean, Mistrals
		Current meters (ST)			BDD Coriolis	MyOcean, Mistrals
		Particles traps, mass, carbon and nitrogen fluxes			FTP Mistrals	Mistrals

Table1: Characteristics of the MOOSE datasets

Figure 2 and Table 1 show that all the data produced by MOOSE are not loaded into the same data bases. For example, real time data will be loaded into the Coriolis data base whereas data from NISKIN bottles or particle traps will be loaded into the MPCDB.
The data from a single project has to be spread over different databases based on their characteristics. Hence, the main difficulty of MOOSE data management is to organize the different data management processes around the main constraints of the MOOSE project and reach the goals of each stakeholder (National Centre of Ocean data, MOOSE head office, data providers).

How to track MOOSE data? The MOOSE label.

On the one hand, the data not loaded into the Coriolis database is stored on the ftp site for the MISTRALS distribution. There is no problem to retrieve the part of the dataset stored on the ftp site. On the other hand, the MOOSE data stored in the Coriolis database is mixed in with the rest of the data. The question then becomes how to identify and get the MOOSE data back from Coriolis database.
We decided to add to MOOSE data loaded in the Coriolis database a specific “project name” metadata. This metadata will allow us to recover all of the data set from the database. This is the “project label” principle.
From the technical point of view, platforms that produce data for the MOOSE project are identified as MOOSE platforms for a specific period of time. As moorings are dedicated to MOOSE from the beginning to the end of the project, the MOOSE flag will be done only once. It is a bit more complicated when we deal with gliders or ships that produce MOOSE data during specific deployments. For these platforms the MOOSE label is only set for that period of time.

Sharing constraints between data provider, data manager and project manager.

As the data comes from different providers, rules have been decided by the stakeholders in order to optimize their management.

Rule 1: Catching up in real time

Real time data from MOOSE has to follow the existing format and collection process used by Coriolis. The data does not have to be controlled by the providers before it is sent to Coriolis. The data QC will be made in the data centre automatically before being loaded onto the data base. Figure 3 explains this procedure.

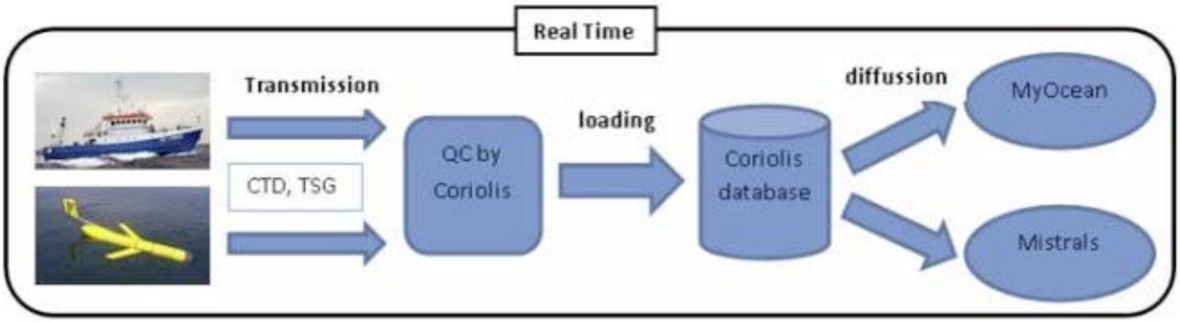

Figure 3: Real time data process

An easy email data transmission process has been implemented to collect CTD from ships in order to allow the distribution of the MOOSE data in real time to MISTRALS and global distribution programs such as MyOcean. As Coriolis is the main data centre for the gliders, they have been set up to fit the existing processes.

Rule 2: Centralizing the delayed mode process

Delayed mode data is collected, controlled and analysed by the principal investigator (PI). The aim is to simplify the delayed mode process, homogenize the QC and monitor data production. In order to achieve this, the MOOSE head office will gather data from the different delayed mode platforms from the various PI's all year round. Once a year, the Moose head office will deliver the global data set to Coriolis. Hence, the Coriolis operator communicates with only one location. The MOOSE head office can then more easily discuss data delivery and format with the PI's. Figure 4 explains the delayed mode procedure (PI: Principal Investigator, PM: Project Manager, CO: Coriolis Operator).

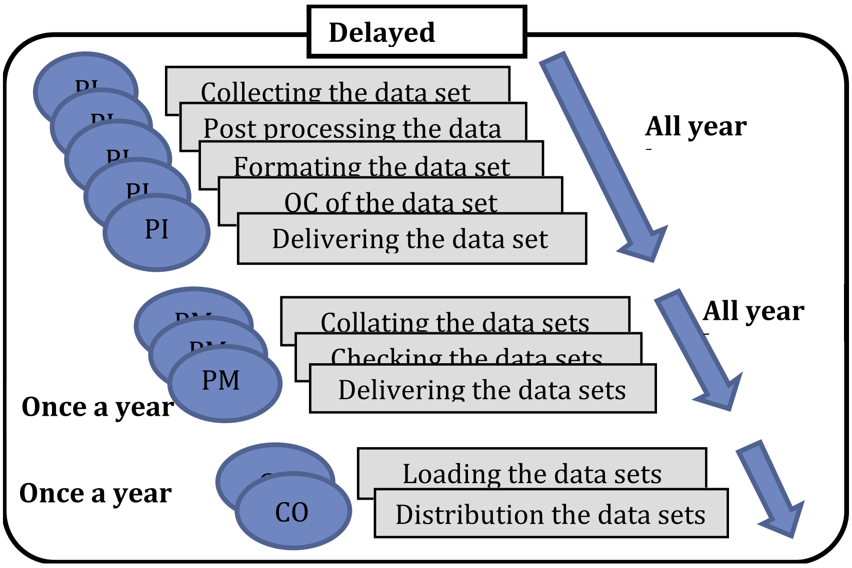

Figure 4: Delayed mode data management procedure

Rule 3: Homogenization of the formats

Real time or delayed mode data delivery format of each data type must be homogeneous. The formatting rules have been discussed between the MOOSE project manager, the data providers and Coriolis operator.

The six moorings that constitute the MOOSE grid are a good example for the importance of format homogenization. Each mooring has its own configuration of instruments. The number of sensors and the types of parameters measured is based on the PI strategy. Without a common format, the work would become too expensive for the Coriolis operator. Homogenizing the data delivery format and developing specific processes for each data type is a good option as it allows the data management to be simplified.

Each mooring can deliver 3 types of time series; CTD, currents and particles traps (Figure 5). It was decided to fix a format for each type of time series independent of the mooring. We focus on a format that is easy to produce by the PI. On the Coriolis side, we developed 3 functions to convert these time series into an OceanSites time series format that can be quickly loaded in the database.

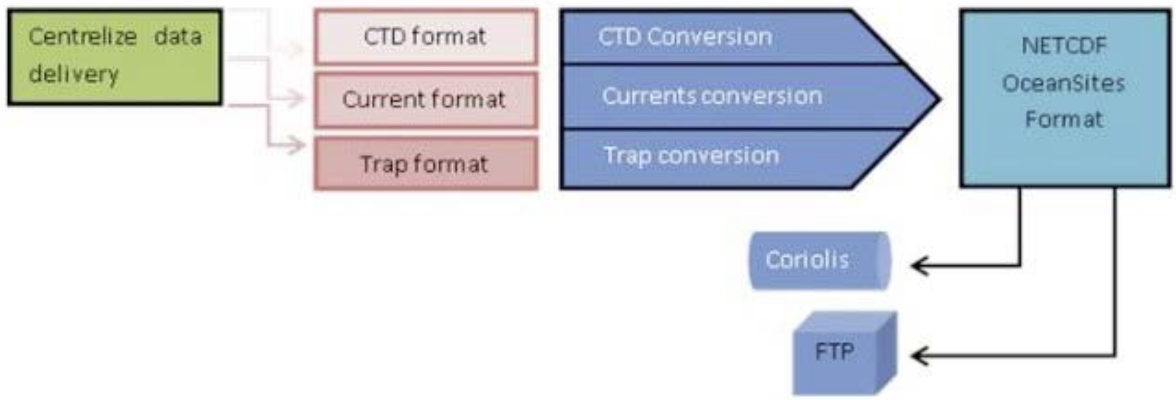

Figure 5: Mooring data management

Rule 4: Deployment planning

From the Coriolis point of view, the deployment plan for the cruises of the ships and gliders is absolutely necessary for two reasons. First, it allows the Coriolis operator to follow the different deployments and check the collection of real time data. Secondly, it also allows the labelling of the platform before the deployment. In this way, as soon as the Coriolis centre collects the data from MOOSE, it will be flagged as MOOSE data and made available for MISTRALS.
From the project manager's point of view, it is obvious that good planning is necessary for good management of the MOOSE observation activity.

Data distribution: How to access? Two level of distribution.

In order to provide MISTRALS with a unique and easy access to MOOSE data, we use existing MyOcean distribution process (Figure 6).

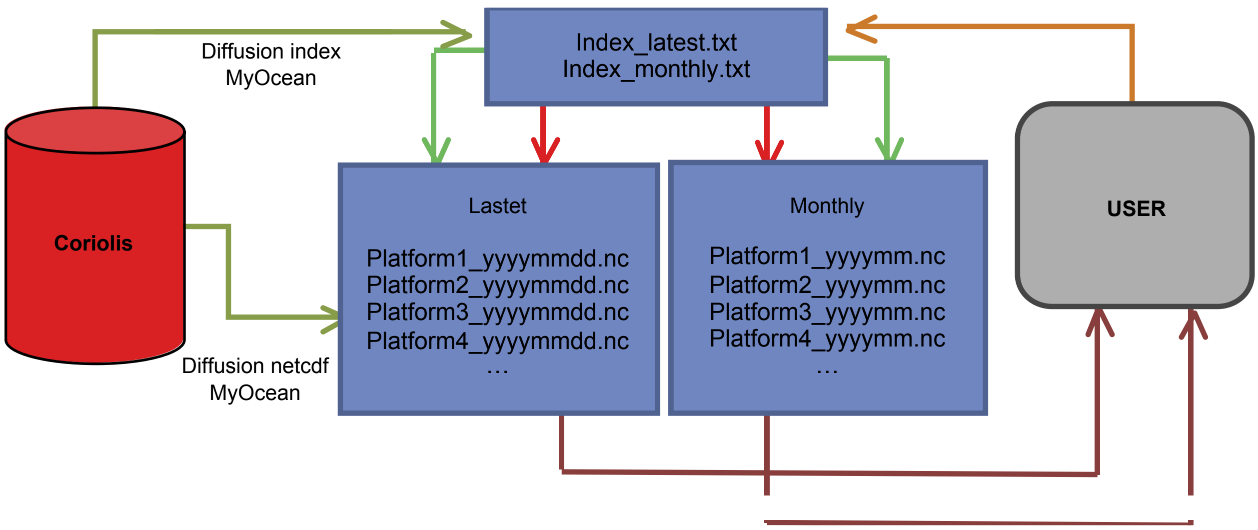

Figure 6: MyOcean FTP portal organisation

The only potential problem was to extract the MOOSE data from the MyOcean data.

For MyOcean, an index file is generated and contains the directory of the daily or monthly data available for each platform as well as Information on the latitude, longitude and data type.
A specific MOOSE index file is also generated in the same format for MISTRALS allowing an easy gathering of all the MOOSE data files in the user-friendly and well referenced MyOcean format. Figure 8 explains that process. Also, an interactive web data access has hence been developed in order to visualize and download either Mediterranean observation data or only Moose data (Figure 7).

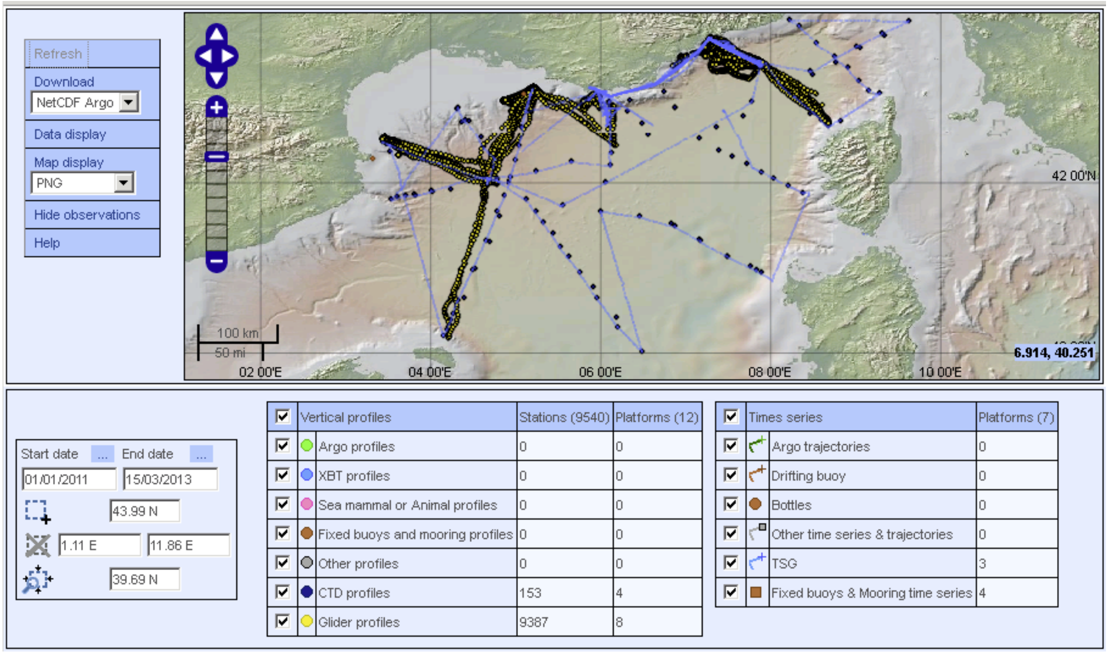

Figure 7: Moose observing system at Coriolis Data Center since 2011

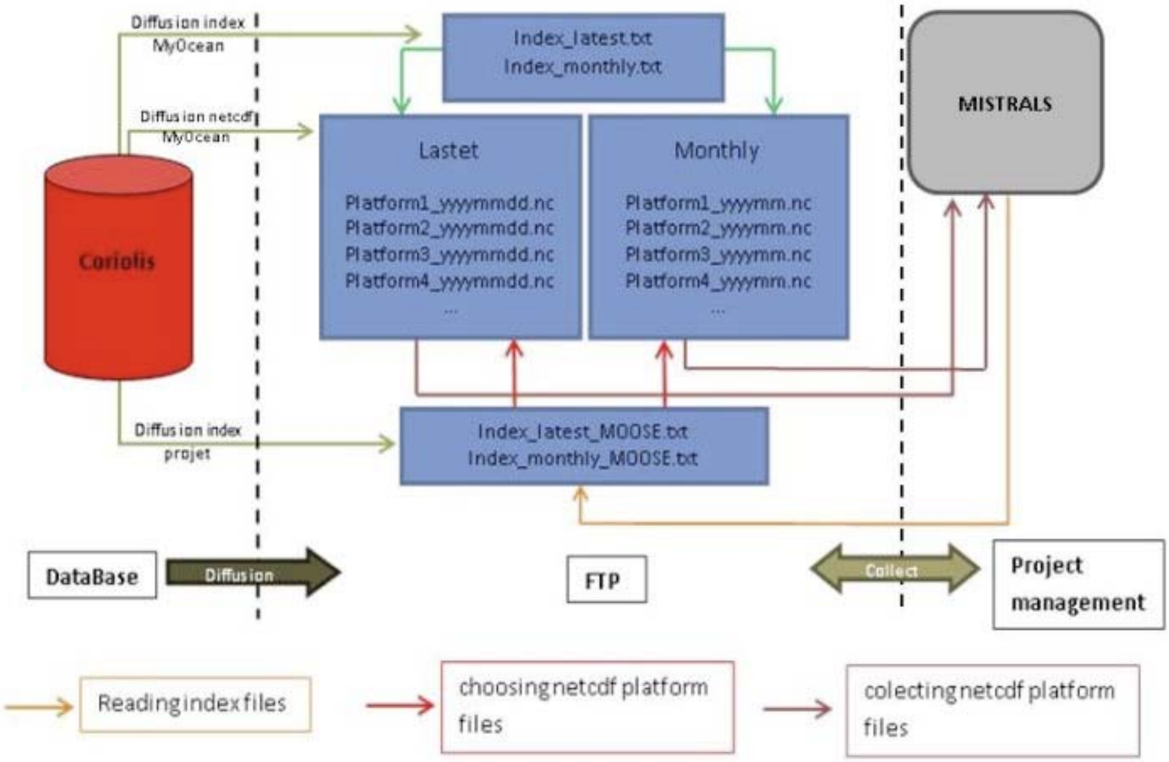

Figure 8: Customization for Moose purposes

Conclusion

A Mediterranean Ocean Observing System on Environment (MOOSE) has been set up as an interactive, distributed and integrated observatory system of the North West Mediterranean Sea in order to detect and identify long-term environmental anomalies. It provides data for the MISTRALS project and uses the MyOcean insitu data distribution infrastructure. An interactive web data access has been developed in order to visualize and download Moose data.

For any science oriented project, data management is a crucial issue. The synergy between Coriolis and MOOSE head office, the good comprehension of aims and constrains of each stakeholders led the MOOSE data management structure to a real success in term of cost and efficiency as the data set produced by MOOSE reaches this two goals: giving to MISTRALS a restricted access to a specific regional ocean data set and contributing to the global ocean data diffusion systems.

European contributions to SPURS (Salinity Processes in the Upper Ocean regional Study): Research cruise STRASSE, Argo and Provbio floats, surface drifters, ships of opportunity

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1. Introduction

Surface salinity is set by the hydrological cycle, as well as by oceanographic circulation and vertical mixing processes (Schmitt, 2008). Near-surface salinity has been monitored for a long time in the North Atlantic, for example to detect signatures associated with known modes of climate variability (Dessier and Donguy, 1994; Gordon and Giulevi, 2008; Reverdin et al., or more recently with anthropogenetically induced climate change (Terray et al., 2012; Durack and Wijffels, 2010. These observations in particular illustrated a large increase of the maximum surface salinity in the North Atlantic subtropical gyre from the 1960s to the early 2000s (Gordon and Giulivi, 2008). This region is where the highest surface salinity of the world ocean is found outside of semi-enclosed seas. One issue is to find to which extent this salinity increase is associated with increased evaporation (Yu, 2007) or with changes of circulation or other oceanic processes (vertical or horizontal mixing, subduction...) controlling its distribution.

L-band frequency radiometric remote satellite monitoring can be used to estimate salinity in a layer on the order of 1 centimeter (Swift and McIntosh, 1983). This observation is now provided using the SMOS (European Space Agency/Soil Moisture and Ocean Salinity) and Aquarius/SAC-D (Lagerloef et al., 2012) satellite missions. After correcting SMOS brightness temperatures from systematic biases, SMOS sea surface salinity (SSS) reproduces expected SSS variations at large scales (Font et al., 2010) as well as rainfall-related signals (Boutin et al., 2012), but its accuracy as well as the accuracy of Aquarius retrievals are still subject to large uncertainties that require sets of validation data. The L-band penetration layer is much larger than the salinity skin-depth layer (Zhang and Zhang, 2012), and the issue of validating/interpreting these satellite data is probably more an issue of sub-surface stratification between a few meters and 1-cm depth than a skin-layer effect. Thus, the data of instrumented drifters and surface buoys could contribute to this goal, as well as data of instrumented profilers reaching the sea surface or near-surface data on moorings, gliders or from research cruises.

A dedicated experiment, SPURS, has thus been organized in order to improve our understanding of the processes controlling surface salinity in the region of maximum surface salinity of the North Atlantic subtropical region and to seek how well remote sensing data can contribute in monitoring and unraveling those processes. This experiment lasts from August 2012 to September 2013 with lead from US investigators, and a European contribution that includes mostly French, Spanish and Irish efforts. Here, we will summarize the EU contribution to the in situ oceanographic sampling in 2012. This includes a research cruise, STRASSE on board the French RV Thalassa, with a variety of measurements of the upper ocean transmitted in real time, and a contribution by EU PIs to the overall observing arrays of 10 surface drifters, of 7 Argo floats, including 5 with order(1m) vertical resolution in the upper ocean layer, the use of two merchant vessels crossing the area equipped with thermosalinographs and occasionally collecting XBT profiles. During the cruise a real-time web site was created where in situ data could be visualized and accessed, and where some satellite (from CSM (at Météo-France in Lannion), and Aviso (at CLS in Toulouse)) or model (Mercator Ocean) products could be accessed as well as diagnostics to estimate where the cruise should take place (www.locean.ipsl.upmc.fr/smos/spurs).

The first research cruise, STRASSE, was done on the French RV Thalassa from August 16 to September 14 2012. The physical oceanography objectives were to contribute to the deployment of a drifter array in the core of the North Atlantic subtropical gyre, and estimate during a very stratified season how horizontal variance in the salinity field is dissipated. Thus this involved first identifying a propitious region, then realizing meso-scale surveys, and finally following some submeso scale features for which the horizontal variance is large, as well as regions with no horizontal gradients to better understand vertical gradients and mixing. The identification of a key region was helped with a real-time analysis of ocean circulation and how it could stir the large scale field to generate meso-scale structures/filaments. We were particularly keen to place the survey in a region of large spatial contrast in salinity, possibly through the penetration of higher northern latitude water. In order to include the effects of the mesoscale dynamics on the spatial distribution of SSS, we have merged large scale satellite SSS with surface geostrophic velocities derived from AVISO real-time altimetry. This was done using Lagrangian back-trajectory tools with the moving eddy field resulting in the horizontal stirring in the large scale gradients into meso-scale filaments. Based on this analysis, we identified a possible area of study near (35-36° W, 25.5-26.5° N) for the STRASSE field cruise.

The structures identified (and which did not depend too much on the large scale SSS field considered) were found in situ, although with O(50 km) shifts. Such structures are prone to increased frontal gradients and thus horizontal mixing. The mesoscale survey was carried with the ship towing an undulating CTD (scanfish) and occasional CTD casts, as well as by two gliders (all transmitted in real time), and surface drifters that were released during the survey or just before. An autonomous sailing vessel (Vaimos) was also deployed to perform a surface survey. Only one of the gliders could stay through the cruise which was later recovered by US RV Knorr in mid-September, and the sailing vessel could not be redeployed successfully, which resulted in a scarcity of meso-scale data after the end of the first survey.

ADCP and drifter data indicated a very contrasting dynamical situation between the northeastern half of the domain with weak currents and the southwestern half with stronger currents; the two regions being separated by a very salty filament of 10 km width, contrasting by more than 0.2 psu with the surrounding areas (Figure 1). We then decided to carry sampling on different contrasting submeso-scale situations during site surveys. For each site (duration on the order of 3 days each), an array of instrumented drifters, vehicles and an autonomous profiler (ASIP) was deployed over a patch of a few kms, which was followed during day time by the RV Thalassa (with alternating CTDs and turbulence profiles in the upper ocean), and during night time by undulating CTD surveys over a 10km-size box, usually around the drifters. The first site was located north of the filament. Then, a second site was located in a filament (probably branching southward from the first filament) (Figure 2), and the third site, on the western rim of that filament. We expected the filament to be on the rim of an anti-cyclonic eddy, but this was not so clearly confirmed by the drifters, and that might have been an artifact (in Aviso maps and Mercator Ocean analyses) of the altimetric data distribution. These surveys were quite successful, and show rather strong gradients of properties and velocity over scales shorter than 10 km. The fourth site was chosen away from gradients, to investigate in particular day-time stratification and air-sea flux forcing/vertical mixing effects on surface salinity. It illustrated in particular a small measurable daily cycle in surface salinity with moderate winds and evaporation.

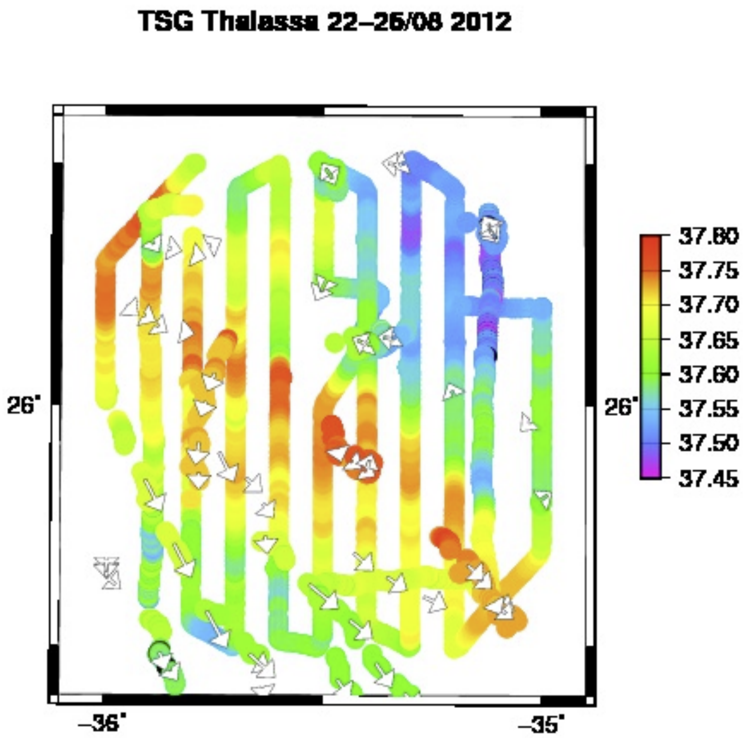

Figure 1: meso-scale survey of surface salinity during the Strasse cruise. We include in this plot the data from RV Thalassa, two gliders and salinity drifters on August 23-26 2012. The arrows represent 25 hours-averaged velocities from the drifters drogued at 15m depth (largest velocities are 20 cm/s). Notice the salty filament across the domain (from Northwest to Southeast) .

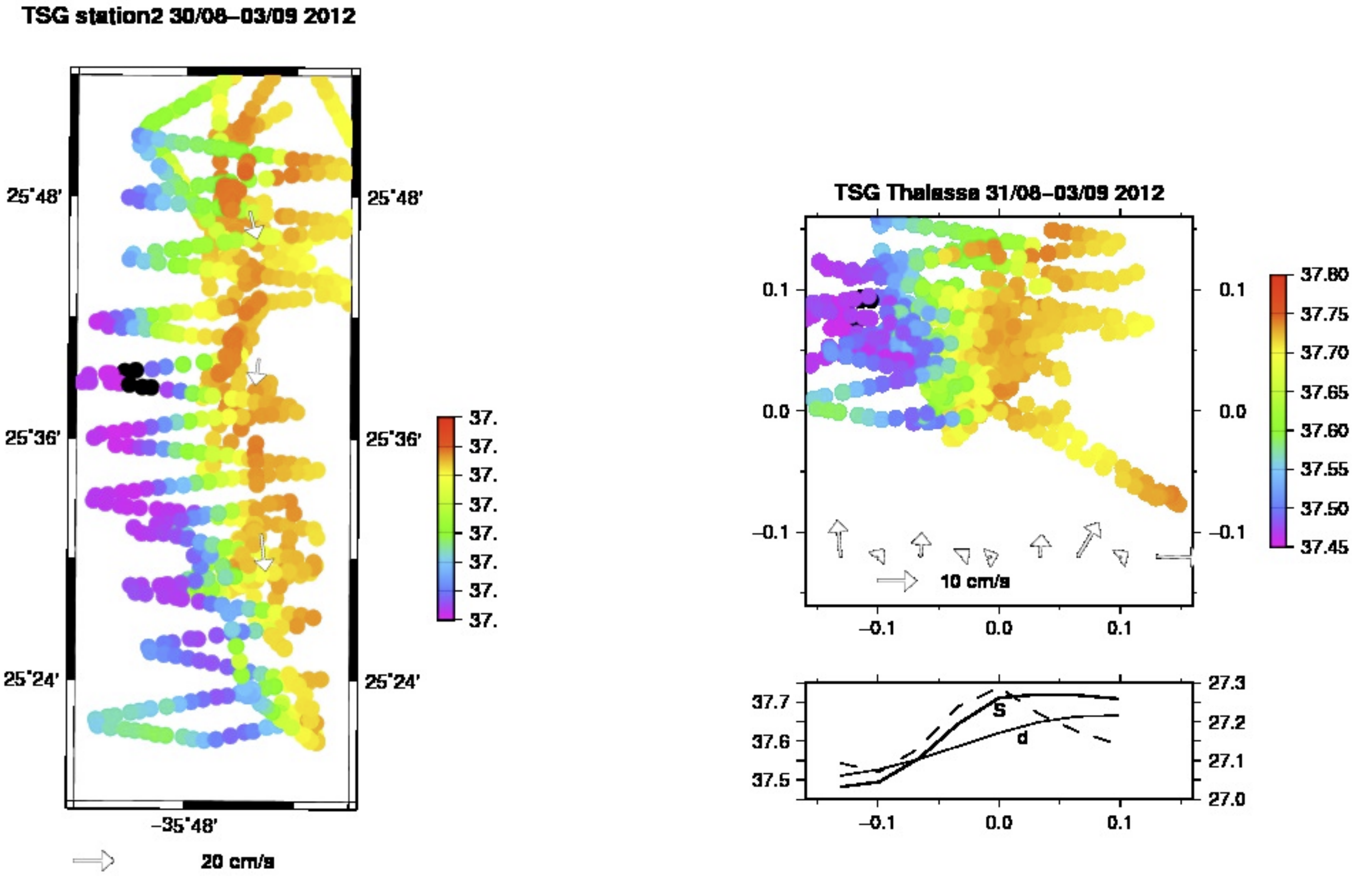

Figure 2: One of the long station surveys centered on the deployment of 5 drifters drogued at 15 m depth. Left panel, the salinity survey during the over-three days of station following the drifters. Right top panel, salinity survey (RV Thalassa TSG) in the position framework relative to the barycenter of the drifters (0.1 is 10 km). It illustrates a mostly North-South oriented filament centered at the barycenter longitude. Velocity is 15m ship-ADCP velocity relative to the barycenter motion (it shows that the filament core coincides with a maximum southward velocity). Lower panel, average night-time profiles of SST, SSS and surface density across the salinity filament.

Argo floats

During the STRASSE cruise, three Argo floats were deployed. Two of these floats were classical Provor floats provided by Ireland Marine Research Institute transmitting a profile to 2000 db every 10 days via Argos. The third one was a prototype of a new iridium-transmitting, deep-diving Deep-Arvor float.

“Deep Arvor”: a new profiling float for Argo

Ifremer-RDT (Research & Technical Development unit) has designed and developed this float within the “NAOS” project framework. This extension of the standard Arvor addresses the climate change studies requirement of monitoring the deep water masses.
The Deep-Arvor is rated to 4000 dbar pressure and has an operational profiling depth of 3500m. Its improved Seabird41CP offers full scale accuracy for salinity and temperature over this range. The sensor end cap is also fitted with an oxygen sensor (Aanderaa 4330 optode), which delivers raw data (phases) and temperature to satellite transmission, allowing post-calculation of concentration. During the cast, the samples collected every meter (with continuous pumping of the CTD) are averaged into slices (with specified thickness) and three sampling layers can be chosen (deep, middle and surface layers).
An Iridium modem is used to transmit high resolution profiles (over 1000 CTDO points), while maintaining a short stay at surface and offering remote control capability over the whole parameters set. A GPS receiver localizes the float at surface.
The battery pack has been sized to achieve 150 CTDO cycles, at 3500m depth, with CTD pumping continuously. Saving energy is possible by intertwining deep casts with standard Argo casts to 2000m. Deep-Arvor maintains the self-ballasting feature of Provor & Arvor and the easy deployment of Arvor thanks to its light weight.

Results

During the STRASSE cruise, the new deep Arvor was tested for the first time. It was launched at the end of August 2012 (near 24.5°N– 35.7°W). This float performed profiles down to 3500 db, and transmitted 60 profiles of temperature, salinity and oxygen until January 20 2013 often from 3500 to 3 db (Figure 3). Vertical resolution was nearly 1 db in the upper layer, and some profiles were collected every 3 days, providing a good resolution of the time variability in the upper layer north-east of the SPURS core site (near 24.5°N/38°W). During the 6 months lifetime of the float, the float remained in a 1° in longitude x 2° in latitude box which allows verifying the stability of the conductivity sensor and oxygen sensor. While the conductivity sensor is very stable (the salinity variations at 3500db are less than 0.01), the oxygen sensor exhibits an apparent drift of about 5 µmol/kg towards lower value during the 6 month of measurements. The comparison with the CTD data acquired at the float deployment suggests a fresh bias of the float data of order 0.01 and an oxygen bias (underestimation) of about 40 µmol/kg. Finally, as previously observed on oxygen profiles from classical PROVOR-DO floats, an unrealistic hook is observed at the base of the profiles. Further analyses are required to validate those first results and to provide a corrected data set. To conclude, those results confirm that deployment of deep Arvor floats in area where the water masses are stable will help us understand the behaviour of the sensors in deep (greater than 2000 db) layers and define the sampling strategy and target for a deep float array.

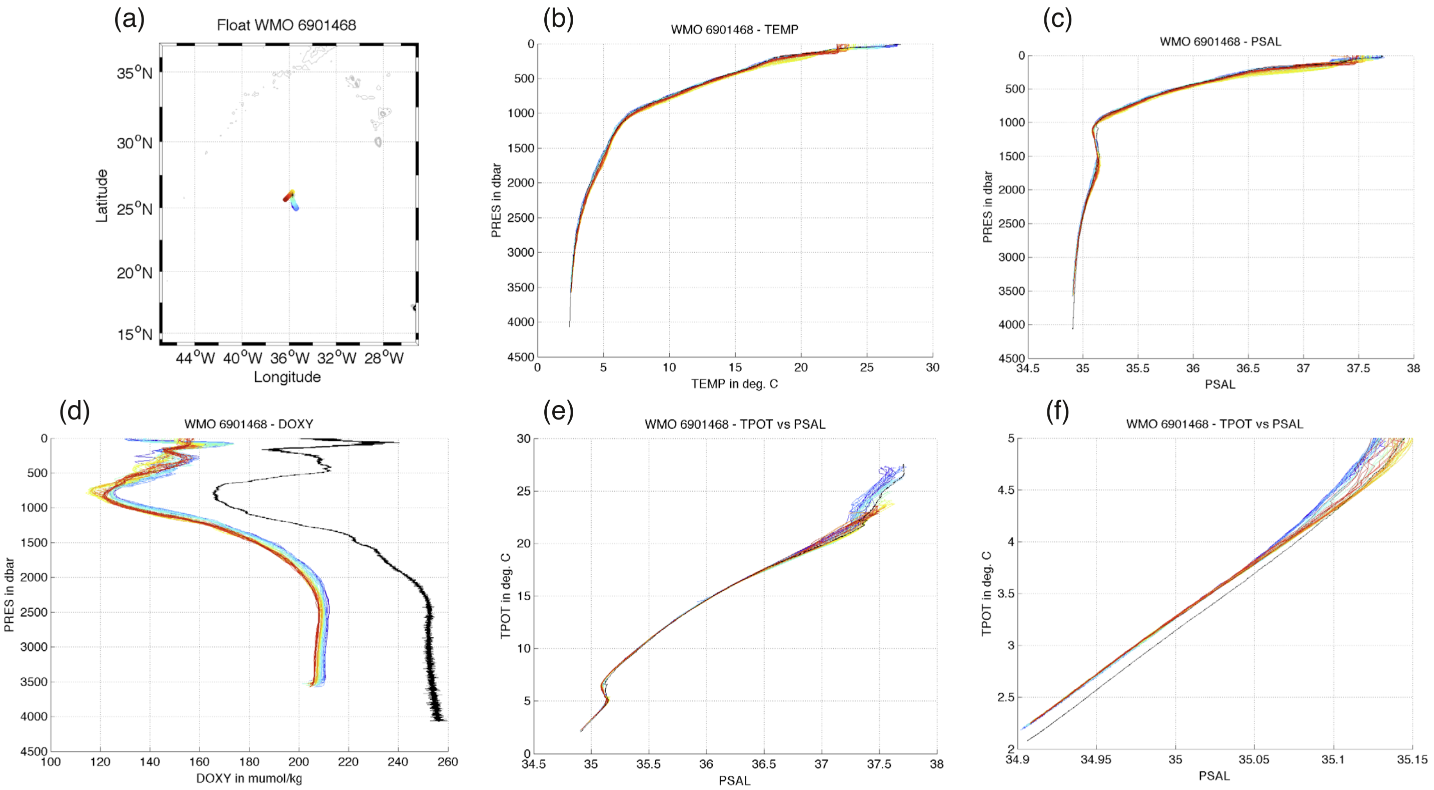

Figure 3: (a) Profiles position of the deep Arvor deployed during the Strasse cruise. (b, c, d) Temperature, salinity and oxygen profiles (in µmol/kg), respectively. (e, f) θ/S diagram. On the figures, the colored curves, from blue to red, are relative to time since deployment. The black curves are the calibrated CTD data acquired at the float deployment

ProvbioII floats

In late October, during the AMT-22 cruise on the RV James Clark Ross, four ProvbioII floats with different sets of instruments were deployed near 22°N/40°W, a little to the south-west of SPURS. These floats are designed for bio-geochemical investigations and are equipped with different sets of sensors (see Leymarie et al., 2013 in the same issue). The vertical resolution in the upper layer is 0.3 db for the biogeochemical measurements up to 1 db for T and S. The sampling strategy differs between the different floats from the classical 10-day cycle of the Argo program, to one profile every day or to 4 profiles per 24 hours every 10 days. The sets of instruments equipping these floats are also different but they all measure T and S as well as chlorophyll and CDOM fluorescence, irradiance at three wavelengths, the Photo synthetically Available Radiation as well as the back-scattering coefficient. Some of them measure dissolved oxygen, one nitrate, and one beam transmission (Figure 4). Their trajectories have quickly diverged due to large differences in profiling cycles. Three of those are still close to 22°N/40°W, and provide complementary data to the bulk of the floats that were deployed by US investigators close to 24.5°N/38°W.The last one has ended its life prematurely.

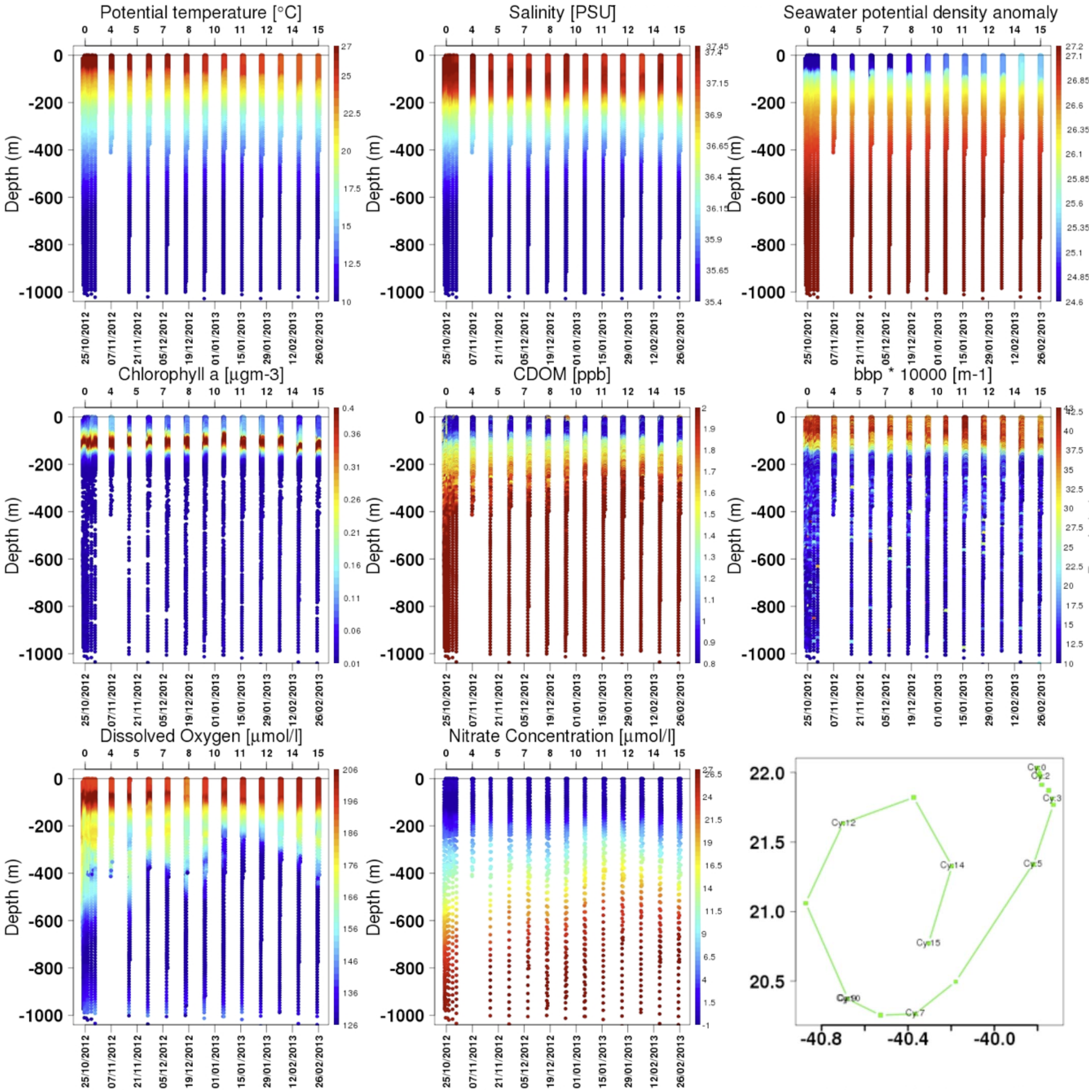

Figure 4: Data from a ProvbioII float deployed near 22°N/40°W on October 22 2012 as part of the AMT cruise. The float was programmed to acquire 4 profiles per day every 10 days. The biogeochemical payload of this float is the most complete to date and also includes transmissiometry and radiometry measurements (data not shown). Data can be seen in real time at: http://www.oao.obs-vlfr.fr/carto/

Surface drifters

European participants to SPURS contributed five SVP-BS drifters, two SVP-S drifters, and three SVP drifters in the subtropical North Atlantic in 2012. We also used prototype Surpact drifters designed to estimate simultaneously T and S 4-5 cm from the surface, wave spectra and wind for a period up to 5 months (Reverdin et al., 2013). Eleven more drifters from ICM/CSIC will be deployed in March 2013 during the Spanish Midas cruise on board the Sarmiento de Gamboa.

In addition, we contribute to the deployment of drifters provided by the Global Drifter Program (AOML/NOAA, SIO) with 15 SVP-SB and 10 SVP drifters deployed in 2012. 6 more SVP-BS and up to 50 more SVP drifters will be deployed in 2013.

Ships of opportunity

French 'service d'observation' for SSS has installed thermosalinographs on the MN Colibri and Toucan which regularly connect Northern European ports with Cayenne (French Guyana). The thermosalinographs provide thus regular transects in the North Atlantic subtropical gyre. Recently (October 2012 and March 2013), XBTs were also deployed from MN Colibri at fairly high resolution (every 25 km along the track). We expect four repeats of this XBT section during one year.

Perspectives:

The cruise STRASSE was an opportunity to test transmitting in near-real time some reduced data sets from the collected data (ADCP data as well as the scanfish data). This is possible, but requires extra-staff on board, and would be difficult to implement on a regular basis. The large number of drifters deployed by us, as well as by US colleagues implies that there is a large data set of 15m current data that could be used to validate/improve regionally the different products based on satellite altimetry. This could contribute to improve the mapped currents from altimetry (correcting the average sea surface relative to the geoid), or the assimilated products as done by Mercator. The experiment took place in a region of relatively low eddy energy, and thus the real-time mapped current products have a fairly low signal to noise ratio. It will be interesting to see whether this could be improved in delayed mode, and what is the complementarity of the different data sets collected on the meso-scales investigated. The cruise STRASSE, together with the two US SPURS cruises and the Spanish Midas cruise on the RV Sarmiento de Gamboa (March 15-April 13 2013) also provide unique opportunities to investigate the sub-meso scales over a fairly large domain and in different seasons in the North Atlantic subtropical gyre, and will contribute to deciphering the processes controlling the high salinities of the surface North Atlantic subtropical gyre.
The new floats that were tested were prototypes, and thus were only deployed to demonstrate their potential for later experiments. Although the Deep-Arvor float and two of the ProvbioII floats were short-lived, these floats have produced interesting data that will also contribute to the overall objectives of the program.

Acknowledgments

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Development and validation of the new ProvBioII float

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Abstract

In the last ten years, a productive collaboration has grown between the Laboratoire d'Océanographie de Villefranche (LOV), NKE and IFREMER to implement biogeochemical sensors on profiling floats. A first project (2003) was dedicated to the design of the so-called ProvBio floats (models A and B) that consisted of a PROVOR-CTS3 float instrumented with three new optical sensors: a Wetlabs transmissometer (C-Rover), a 3-wavelength Satlantic radiometer (OCR-503) and an "ECO3" Wetlabs sensor, measuring chlorophyll-a fluorescence, colored dissolved organic matter and particle backscattering coefficients (see *First Success of ProvBio floats*, Coriolis Letter n°5). Then, the integration of biogeochemical sensors continued in the framework of ProNuts project (2009, *autonomously profiling the nitrate concentrations in the ocean: the pronuts project*, Coriolis Letter n°8), by equipping a PROVOR with a nitrate concentration sensor. In parallel within the framework of the Carbocean EU project, the ProvCarbon and ProvDo floats were developed as in 2006 by fitting on a PROVOR a C-Rover and a 3830 Aanderaa optode, respectively. They were used to investigate new tools to assess marine carbon sources and sinks. These initial developments have led to a first invaluable dataset and to subsequent papers (Xing et al. 2012, Xing et al. 2011) and report (IOCCG 2011).
Nevertheless, the above projects have grown partially dissociated, as related to specific and project-related needs, while a more integrated solution may have a lot of advantages. Undoubtedly, the scientific exploitation of data would be strongly improved if a unique multidisciplinary float, able to measure all accessible parameters, was available. Such a multidisciplinary float would also strongly reduce costs, by sharing the float itself, and by reducing deployment, validation and communication costs. The idea to merge all these sensors on the same profiling float was thus at the origin of the ProvBioII float project, which was developed in the framework of the remOcean and NAOS programs.

A new float with extended capacities

The main general objective of the ProvBioII float was to build the capability to easily and safely implement new sensors on a PROVOR platform and to use them with the maximum of flexibility. This capability was initially required for the commercial sensors chosen for the remOcean program, but it will be also useful for future integration of new sensors. In order to reach these main objective, successive new developments were required, which represented the different steps of the ProvBioII acquirement, realized in the last years. They will be presented hereafter.

Double board architecture

The ProvBioII float electronics is based on a double board architecture, which physically separates the float navigation from the sensors driving. While previous floats used one electronic board to manage float mission and sensors, the new ProvBioII float uses two dedicated boards. The master one, the so-called "navigation board", is used to drive the navigation (hydraulics), the positioning (GPS) and the communications (Bluetooth and Iridium). The navigation board is actually the I535, which is already implemented on the PROVOR CTS3.1. The navigation board controls and exchanges data with a second electronic board, the so-called "acquisition board", used to manage the acquisition of sensors (including the CTD probe). The double board architecture was selected, instead of a unique powerful board, for two main reasons.

- First, the double architecture allows dissociating the "vital" functions (i.e. navigation and communication) from the "non-vital" (i.e. data acquisition and sensors management). Considering science functions as "non-vital" could be considered not pertinent, as a float still moving and communicating without providing data could be considered as useless. However, in the case of a malfunction of the acquisition board or sensor, vital task separation would allow to maintain the link with the float, which could be a crucial step to identify problems and to possibly fix them.
- The second reason to introduce double board architecture is to secure the integration of new sensors. With a unique board, the integration of a new sensor requires to modify the unique software which also drives the float. This makes possible unwanted side effects on vital functions. The two board architecture is therefore a way to increase system capacities, to protect float vital functions and allows easier and safer implementation of new sensors.

The Science Board architecture was designed by IFREMER and the board was developed by the ASICA Company, thanks to funding from IFREMER, to be implemented on both PROVOR and ARVOR-CM (Coastal Multisensors) floats. The Science Board uses the same 8 bit low-power micro-controller as the I535, with 128/256 Kbytes of code memory, 64Kbytes of RAM, 8Mbytes of data memory, six extended serial ports and a 12 bit height channels analog to digital converter. One major improvement is the implementation of switchable supply regulators, which allows various sensor connections with a dedicated switchable power supply. A communication protocol between the two boards ensures the separation of tasks: the acquisition board samples the sensors, computes the data and sends packets of data to the navigation board. The navigation board ensures the link with satellite network (see hereafter) to send data packets onshore without knowledge of their content. The acquisition board is now industrialized and directly provided by NKE, which also developed the embedded software.

In order to manage the new double board architecture, two new software programs were developed by NKE according to IFREMER and LOV specifications. The first one embedded on the navigation board provides enhanced functionalities and flexibilities to manage navigation cycles of the ProvBioII. For example, on a previous version (ProvBioB floats), only mono or a tri-profiles cycles were available (i.e. one or three profiles per cycle). On the ProvBioII, up to ten profiles per cycle can be realized to study diurnal cycles or other time-dependent processes. Additionally, for each profile, different starting depths, schedules for surfacing and communication options could be indicated (figure 1). Moreover, any configuration could be modified through the Iridium downward link, and a "mission end" command could be sent to allow float recovery.

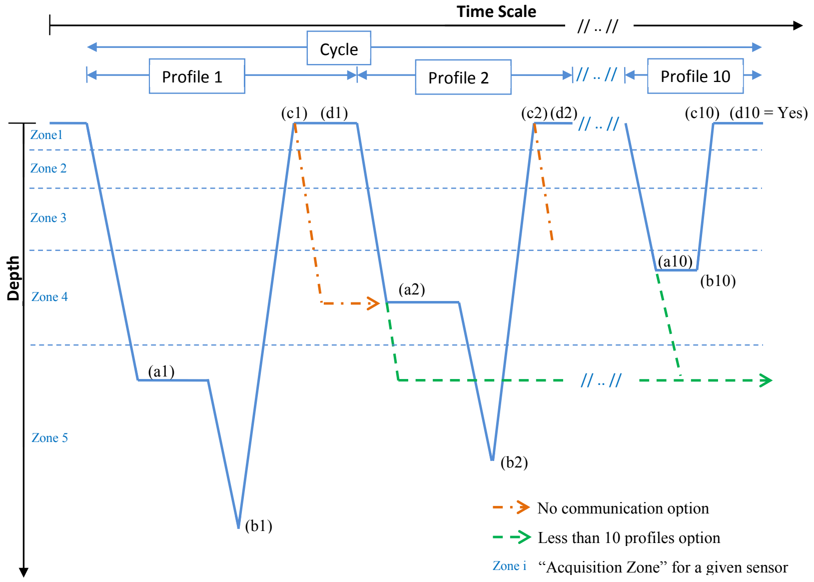

Figure 1: Navigation options of ProvBioII float: from 1 to 10 profiles could be programmed per cycle. For each profile, it is possible to define: (a) parking depth, (b) starting profile depth, (c) time schedule for surface (over several days), (d) Positioning and communication option (Yes or No). Five "Acquisition Zones" could be defined for each sensor within which acquisition parameters could be personalized.

The second new software, installed on the acquisition board, allows a very precise definition of sensors sampling strategy during profiling phases. For each sensor, five depth intervals (i.e. zones) could be created within which it will be possible to personalize the acquisition mode and the depth resolution. For each zone, a given sensor could be off, in pulse mode (i.e. powered on and off for each acquisition) or in continuous mode (Figure 2). Pulse mode, which is primarily used to save energy, could automatically switch to continuous mode (and vice versa) depending on the requested depth resolution and the warm-up time of the sensor. For each zone, raw data are generally averaged to obtain the required resolution by subsampling data within defined depth slices (down to 1m width). In each depth slice, data could be averaged, but median and standard deviation could be also optionally calculated within the slices. Standard deviation can be useful to characterize the quality of the data but also provides valuable information like the presence of aggregates, which can be associated to pulses on backscattering data for example. However, raw data (raw mode) could be optionally stored, and then transmitted to shore, providing resolution up to 0.2m (this very high resolution is currently limited by the CTD sampling rate).

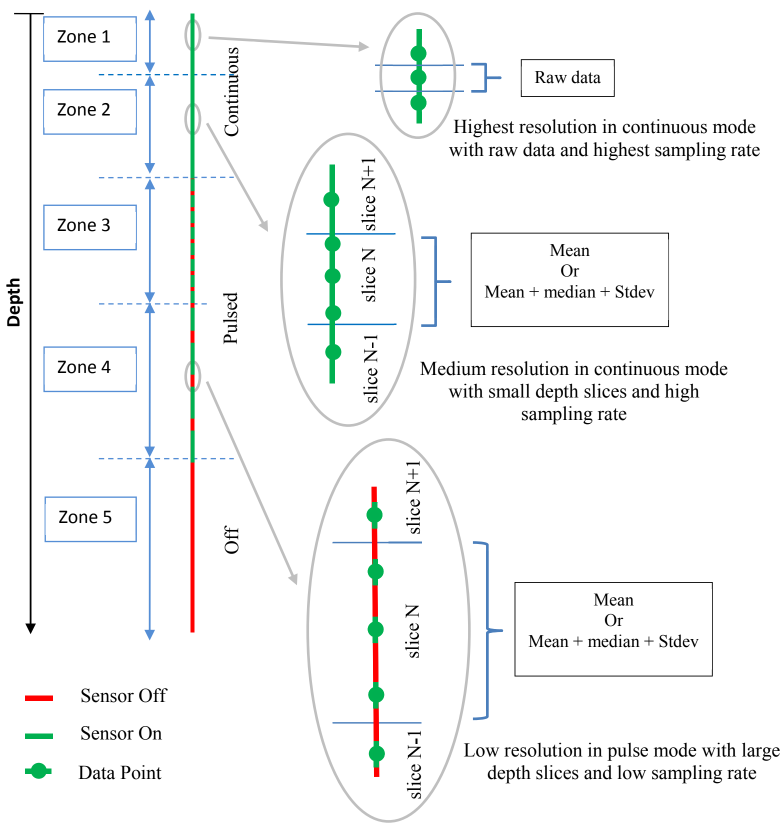

Figure 2: Sensor powering and data acquisition options along a profile. The ProvBioII float allows balancing power consumption and data resolution by controlling the sensor power supply, the sampling rate and the thickness of slices within which data will be processed. These parameters could be defined independently for each sensor for five depth intervals (Zones). In addition, within each zone, different sampling rates for descent, parking or ascent phases could be defined. This allows to have for example no (or low resolution) acquisition during the descent and the requested acquisition during the ascent of the float.

The large amount of data generated by the ProvBioII float required an enhancement of the data telemetry. The previous version (i.e. ProvBio float) used Iridium Short Burst Data (SBD) packets, which was easy to use and well-adapted to small amounts of data. SBD is however too expensive, when data amount increases. The ProvBioII float was then equipped with an Iridium Router based Unrestricted Digital Interworking Connectivity Solution (RUDICS) system, although SBD telemetry is still available. Less expensive than SDB for large amounts of data, the RUDICS system allows a direct connection of a large number of floats on a given server. The RUDICS configuration of the ProvBioII float allows transmitting typically between 50 kBytes to 150 kBytes of data per cycle at an average speed of around 3 kBytes/min. This speed is currently mostly determined by the capacity of the navigation board in charge of the communication. In this configuration, the RUDICS telemetry is six times less expensive than the cost per kBytes obtained by using SBD on ProvBioB floats. The RUDICS application on the ProvBioII float was developed by NKE, while the server application was directly based on the initial development of Dana Swift (Univ. Washington). The server was set up by the LOV in a secured data center to minimize the risk of a failure. However, if the float is not able to join the server, a redial procedure could be used to wait the re-establishment of the link.

Additional battery and connectors

The last point regarding the new ProvBioII float concerns energy. An additional 60% of battery has been added to the float, to meet the requirement of 250 cycles with the full sensor configuration of the remOcean project (see below). In order to compensate for the negative buoyancy of sensors and the weight of the extra battery, three 4.3 dm3 syntactic foams have been added to the float. In order to connect all the sensors, the ProvBioII float has on the upper end cap, close to the CTD sensor, one hole to connect an Aanderra oxygen optode and one hole to receive a Subconn 8 pin connector. This connector is sufficient to separately power and receive data from 3 sensors through a one-way serial communication. An optional second Subconn 8 pins connector can be added on the lower end cap to connect a nitrate sensor (SUNA) for example.

Examples of sensor configurations: remOcean and NAOS projects

In addition to the effort on development of the ProvBioII float, remOcean and NAOS projects also include developments and integration of new sensors. These integrations could be seen as an example of the capacity of the ProvBioII float to integrate new sensors.

In the framework of the remOcean project, two new optical packages were developed by Satlantic to be specifically implemented on profiling floats: the remA and remB combo sensors. The remA sensor is composed by one downwelling irradiance sensor (OCR 504: 380, 410 and 490nm + PAR) and one ECO3 sensor (Chlorophyll-a fluorescence, Colored Dissolved Organic Matter and particle backscattering coefficients at 700nm). Compared to the ProvBioB configuration, the remA sensor includes a downwelling Photosynthetic Active Radiation (PAR) sensor. However, the main difference with ProvBioB version is that the two sensors (Irradiance and ECO3) can be powered separately, allowing different sampling strategies (i.e. ECO3 all along the profile, irradiance sensors only close to the surface, typically above 250m, where signal is detectable). The remB sensor is the remA sensor plus a Wetlabs transmissiometer (C-Rover) at 650nm, which could also be used independently of the irradiance and ECO3 sensors. Both remA and remB systems were implemented on ProvBioII float.

Significant effort was also performed to improve the measurement of nitrates, mainly based on the know-how acquired during the ProNuts project. Compared to the ProNuts float, a new version of the SUNA nutrient concentration sensor was successfully implemented on ProvBioII: the Deep SUNA. This sensor, still from the Satlantic Company, has the same optical scheme as the SUNA used on the ProNuts float (i.e. measurement of UV absorption spectrum and derivation of nitrate concentrations by optical fitting, Johnson et al. 2002). Differences between the two SUNA versions are on the way to sample and process data. While the first SUNA works on a continuous scheme, like all other sensors, the deep SUNA takes a sample only on a direct request from the float. This sampling mode, which saves energy and provides a more repeatable warm-up for the lamp, requires a two-way link with the float. The latter then drives the acquisition of the sensor by sending a specific command. The float sends also to the deep SUNA temperature and salinity data, which are used for a real-time correction of the temperature and bromide effects on the nitrate concentration estimates (Sakamoto et al. 2009). This option, which was not available on the ProNuts floats, is considered crucial to obtain accurate nitrate concentration data. The ProvBioII float allows two options to transmit SUNA data, which can be remotely selected after deployment. In a first option, for each sample, a reduced spectrum (up to 45 wavelengths) of the measured UV absorption spectrum is transmitted. From this transmitted spectrum, nitrate concentrations could be reprocessed on land by using the current algorithm (i.e. Sakamoto et al. 2009) or reprocessed in the future by using new algorithm. In a second option, only the nitrate concentrations computed internally in real-time by the SUNA are transmitted. With this second option, the amount of data transmitted, and then the cost, is reduced, although only a basic reprocessing of data is allowed. The first option is presently selected on the deployed remOcean and NAOS floats (see below), specifically to optimize and verify the algorithms to estimate the nitrate concentration. In addition to the integration by LOV of these sensors (OCR, ECO3, C-Rover and Deep SUNA), Wetlabs FLNTU (Chla fluorescence and turbidity) and Aanderaa optode were also interfaced with the ProvBioII float.

Consequently, the ProvBioII float is presently the only float able to carry together: the SeaBird CTD, a Satlantic OCR504, a WetLabs ECO3, FLNTU, C-rover, an Aanderaa oxygen optode and a SUNA nitrate concentration sensor. Any combinations including one or several of these sensors are also possible without any modification of the software (Figure 3). The only requirements are the adaptation of the float buoyancy as well as the change of the parameter file of the float.

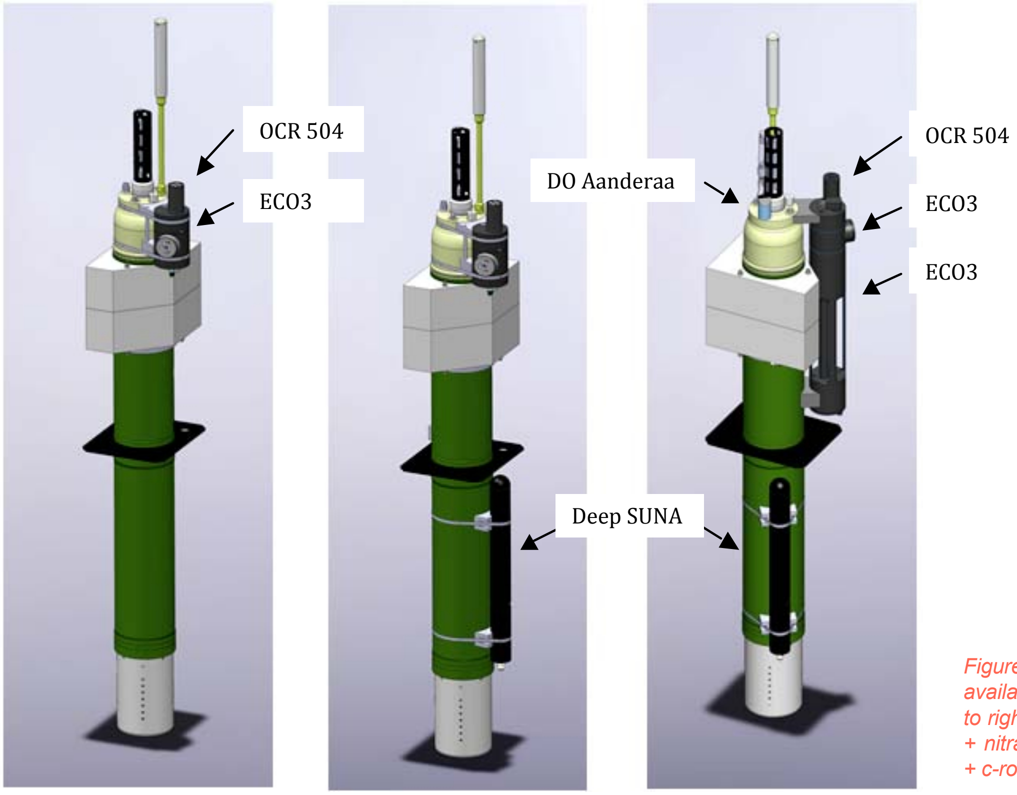

Figure 3 : Examples of sensor configuration available on the new ProvBioII float. From left to right: 1) RemA (OCR504 + Eco3), 2) RemA + nitrate (SUNA), 3) RemB (OCR504 + Eco3 + c-rover) + nitrate (SUNA) + DO (Aanderaa).

First deployments

After a validation phase (by NKE in a submerged quarry near Lorient and by the LOV off the coast of Villefranche), more than twenty ProvBioII floats have been deployed in the framework of the remOcean project in both north and south Atlantic subtropical gyres, Island and Labrador seas. Seven ProvBioII floats have been also deployed in the Mediterranean Sea, in the framework of the NAOS project. Other international groups (Sandy Thomalla from the Southern Ocean Carbon and Climate Observatory) have also purchased and deployed three floats. After these deployments, some technical problems on sensors and on RUDICS telemetry were identified and fixed.

Overall, the first results from new ProvBioII floats are very encouraging. High quality data are daily collected and delivered in real-time through a web interface. All sensor configurations were tested: from the simple RemA configuration to the complete RemB + Optode + SUNA. A large number of missions were already tested, including mono-profile missions (i.e. one profile per cycle) with various time intervals (from one to 10 days), as well as quadri-profile mission. Data are already available at www.oao.obs-vlfr.fr/carto/index.html.

Regarding depth resolution of data acquisition, radiometric and fluorescence data were acquired at a resolution of 0.2m in the upper layer (above 10m) to increase the data quality. Real improvement was also achieved for the nitrate concentration measurement. While this acquisition was subject to a drift within the ProNuts project, data from the new deep SUNA are much more stable in time (Figure 4).

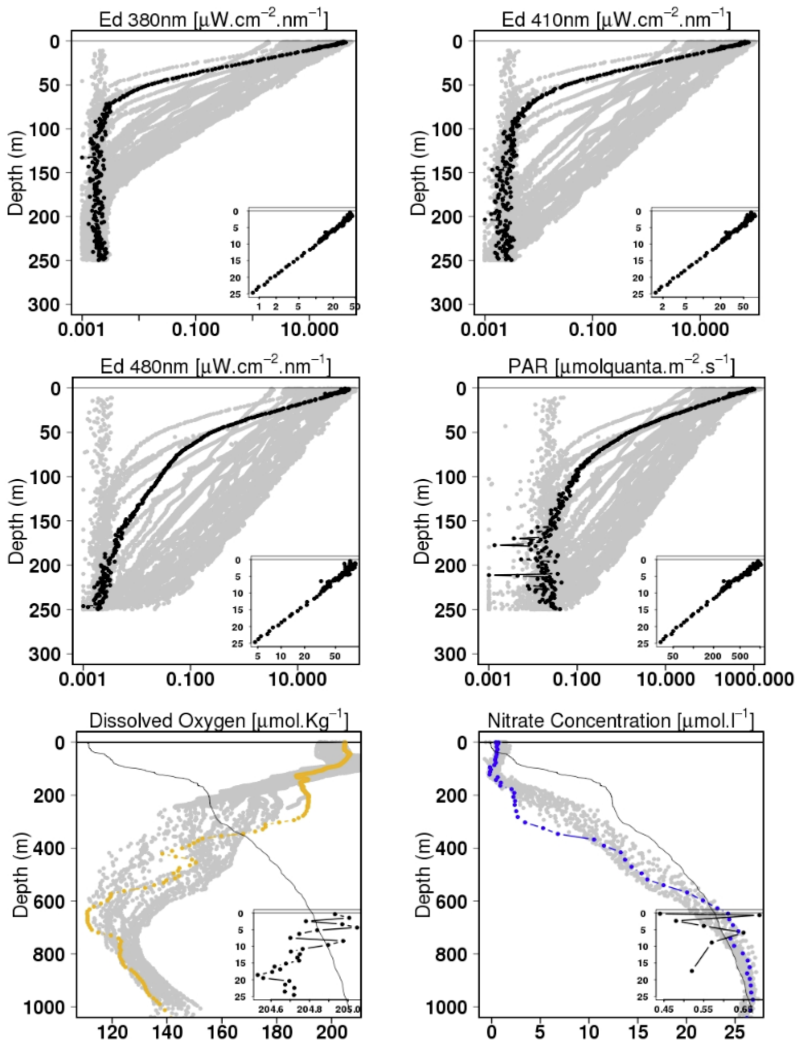

Figure 4: Examples of collected data. All data are visible through the link www.oao.obs-vlfr.fr/carto/index.html. High depth resolution (0.2m) is used for radiometric data. Very good stability of nitrate measurements is also achieved. Radiometric data from lovbio035b (wmo6901511), oxygen and nitrate from lovbio009b (wmo6901472).

Conclusion

The collaboration between LOV, NKE and Ifremer, and the opportunity offered by the remOcean and NAOS projects, lead to the development of a new float with extended functionalities. The new ProvBioII is currently the only available float offering the maximum of capacity and flexibility on the mission scheme as well as on the sensor configuration. The extra on-board battery and the Iridium RUDICS telemetry allow long term missions, even with the full sensor configuration and a large amount of data per cycle. Having a large panel of biogeochemical sensors on the same float opens new opportunities to deeply understand natural cycles and cost reduction could be also expected by sharing expenses like the float itself. After first deployments, this float is already planned to be used within French and European programs like remOcean, NAOS, E-AIMS and Euro-Argo, as well as in non-European projects. We are confident that the ProvBioII float will be an invaluable tool to increase our knowledge of oceans.
The same collaboration is already preparing the next step through a new float which will provide new functionalities for demanding sensors like imaging or acoustic and new mission flexibilities for challenging areas like arctic. This float is already in validation process and will be launched at sea for 2014.

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Programs:

NAOS: Novel Argo Ocean observing System (www.naos-equipex.fr).
remOcean: remotely-sensed biogeochemical cycles in the Ocean (www.oao.obs-vlfr.fr).
CARBOOCEAN: Marine carbon sources and sinks assessment (www.carboocean.org)

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