Coriolis, a French project for operational oceanography

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Abstract

The seven French agencies concerned by ocean research are developing together a strong capability in operational oceanography based on a triad including satellite altimetry (JASON), numerical modelling with assimilation (MERCATOR), and in-situ data (CORIOLIS).

The CORIOLIS project aims to build a pre-operational structure to collect, validate and distribute ocean data (temperature/salinity profiles and currents) to the scientific community and modellers.

The four goals of CORIOLIS are:

- To build up a data management centre, part of the ARGO network for the GODAE experiment, able to provide quality-controlled data in real time and delay modes;
- To contribute to ARGO floats deployment mainly in the Atlantic with about 300 floats during the 2001-2005 period;
- To develop and improve the technology of the profiling Provor floats as a contribution to Argo;
- To integrate into CORIOLIS other data presently collected at sea by French agencies from surface drifting buoys, PIRATA deep sea moorings, oceanographic research vessels (XBT, thermosalinograph and ADCP transmitted on a daily basis).

By the end of 2005, recommendations will be done to transform the CORIOLIS activity into a permanent, routine contribution to ocean measurement, in accordance with international plans that will follow the ARGO/GODAE experiment.

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1. Introduction

The Earth's climate is determined by the atmosphere and the ocean which transport and exchange huge amounts of heat and water. Within the climate system, the interactions are numerous and complex. The atmosphere is a transient and temperamental partner. The ocean, which reacts slowly, is the memory of the system. According to annual cycles and geographical areas, it can absorb or accumulate huge amounts of heat, water and carbon, transport it over large distances, and subsequently release it in the atmosphere.

Understanding, monitoring and forecasting ocean-circulation variability require to combine theoretical studies, in-situ measurements and numerical models. Today,it becomes possible, because of scientific expertise, increase in computer capabilities, numerical modelling, observation means from space and in in-situ. It is the challenge of the operational oceanography for which France raises a research program including three complementary projects:

- JASON which will provide altimetric data following Topex/Poseidon mission,
- Ocean modelling with MERCATOR which assimilates satellite & in situ data,
- In situ measurements and data distribution with CORIOLIS.

These projects contribute to the international programs GODAE (Global Ocean Data Assimilation Experiment) for modelling aspects and to ARGO for in situ measurements Both of them will be operational during the 2004-2005 period.

2. What is Coriolis?

CORIOLIS is a pilot project, resulting from a study conducted by the seven French organizations involved in ocean research (CNES, CNRS, IFRTP, IRD, METEO-FRANCE, SHOM and IFREMER). It is setting up a complete structure for acquisition, validation and distribution, in real and delayed modes, of in-situ data over the world ocean: mainly physical parameters such temperature, salinity and currents (profiles or sections with high vertical or horizontal resolution and time series).

CORIOLIS has three phases:

- Preparation phase (2000-2002) synchronised with MERCATOR demonstration phase, which sets up the system,
- Demonstration phase (2003-2005) during which CORIOLIS will operate in an operational mode,
- Lastly, an Evaluation Phase (2004-2005), which will provide recommendations starting from this experience, on what, should be a sustainable operational structure.

The CORIOLIS project is organized in four sub-projects:

1. Development of the CORIOLIS data centre,
2. French contribution to ARGO ,
3. Development of profiling floats,
4. Integration of national activities related to in situ measurements

Plus a transversal component, which provides scientific support to the other projects.

3. Development of Coriolis data center

3.1 Real Time

Built on the experience acquired during twenty years the Ifremer oceanographical data centre SISMER the CORIOLIS data centre has been set up progressively to collect, control, distribute physical oceanography in-situ data, initially temperature and salinity profiles. The core of this centre is located in Brest. It handles in-situ data available in near real time coming from the GTS (Global Transmission System of meteorological data whose French partner is METEO-FRANCE) and also from other sources including French floats, buoys, and research vessels (figure 1). 6500 profiles are now provided to MERCATOR on a weekly basis. These data are assimilated by MERCATOR and are also used in real-time by other customers, such as the Hydrographic Service of the French navy (SHOM), METEO-FRANCE and other GODAE modellers.
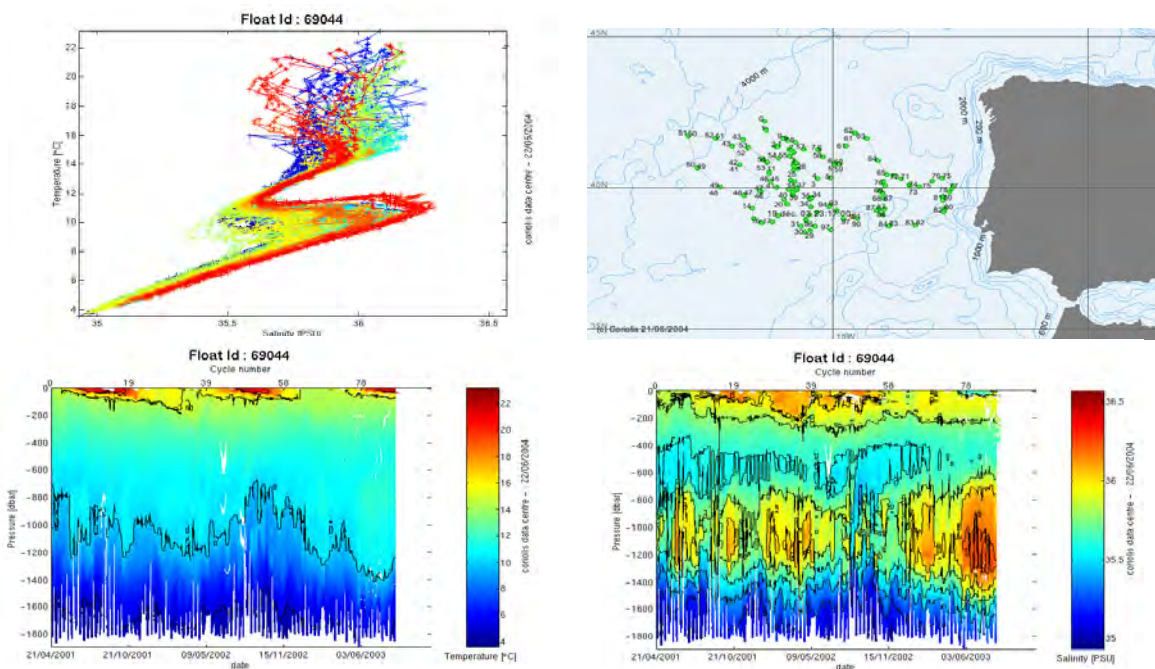

Figure 1: T/S diagram, T and S sections for a nearly 3 year lifetime of a Provor float offshore Spain (http://www.coriolis.eu.org)

The CORIOLIS data centre also operates in **delayed mode** for:
- Instruments and sensors monitoring to estimate sensor drifts,
- Re-analysis and data synthesis: gridded fields in different areas.

For more see in this volume *T Carval " Coriolis : A data center for operational oceanography"*
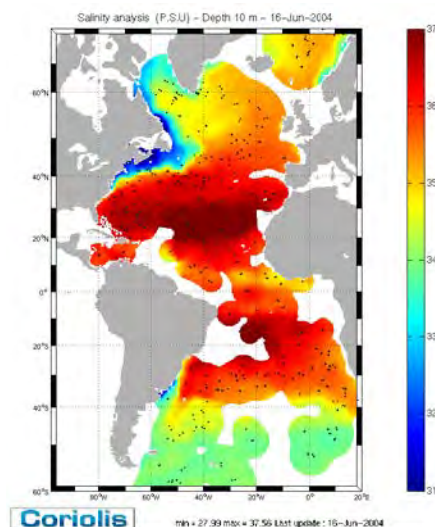
3.2 Weekly analysis

Coriolis has developed an analysis system able to serve both the validation needs and the production of weekly gridded fields. This system based on an objective analysis (Bretherton & al., 1975) is operated by the data center in real time. It allows to detect outliers and provides weekly T and S fields. It is used for sensor drifts monitoring within a time scale of 6-12 months. Finally, multi-year analysis are produced for climatological studies (figure 2).

For more see this volume *F Gaillard, E Autret "Climatology and interannual variability of the North Atlantic from Coriolis re-analysis", T Loubrieu, E Autret: "Real time objective analysis for validation of CORIOLIS in-situ dataset"t*

Figure 2: Weekly salinity analysis at 10m depth for the Atlantic Ocean available through a LAS server
http://www.coriolis.eu.org/cdc/ObjectivesAnalysis/global_atlantic.htm

3.3 Delayed mode quality control

Since 2 years, the Argo Science team is working on defining salinity delayed-mode procedures designed to specifically check artificial drifts and offsets.

The free-moving nature of profiling floats means that most float salinity measurements are without accompanying in-situ "ground truth" values for absolute calibration (such as those afforded by shipboard CTD measurements). Therefore Argo delayed-mode procedures for salinity rely on reference databases and statistical methods for detecting artificial drifts and offsets. However, since the ocean has inherent spatial and temporal variabilities, these drift and offset adjustments are subject to statistical uncertainties. That is why corrections are provided together with an estimation of the error to users.

For more see this volume *C Coatanoan "Delayed Mode Quality Control on ARGO floats at the Coriolis Data Center", E Autret "Delayed mode qualification of ARGO floats: CORIOLIS analysis system"*

4 French contribution to ARGO

CORIOLIS contributes to the ARGO program (A global array of profiling floats). By 2007, the Argo program should have deployed 3000 profiling floats according to a regular grid in the world ocean.. The float displacement gives information on the fields speed. Such a network will provide a low-resolution sampling, at a 10-day frequency. ARGO is placed in the context of international programs on the ocean monitoring (GODAE) and on climatic variability studies (CLIVAR), and under the auspices of several agencies, such as the World Organization of the Meteorology (WMO) and the Intergovernmental Oceanographical Commission (IOC) of UNESCO. *(http://www.argo.ucsd.edu)*

France has first focussed its deployments in the Atlantic Ocean, gradually from North to the South. It will supply 300 profiling floats (2001-2005); this contribution includes 55 floats funded by the European Commission for the demonstration project "Gyroscope" and the Integrated project MERSEA co-ordinated by IFREMER.

The CORIOLIS data centre (http://www.coriolis.eu.org) has also volunteered to be one of the two Argo Global Data Centres together with the US GODAE centre, providing a unique access to all the ARGO data acquired over the entire globe. These centres are fed by various national data centres which validate the data provided by the floats they deployed, using the same quality control procedures as defined by the "ARGO data management team".

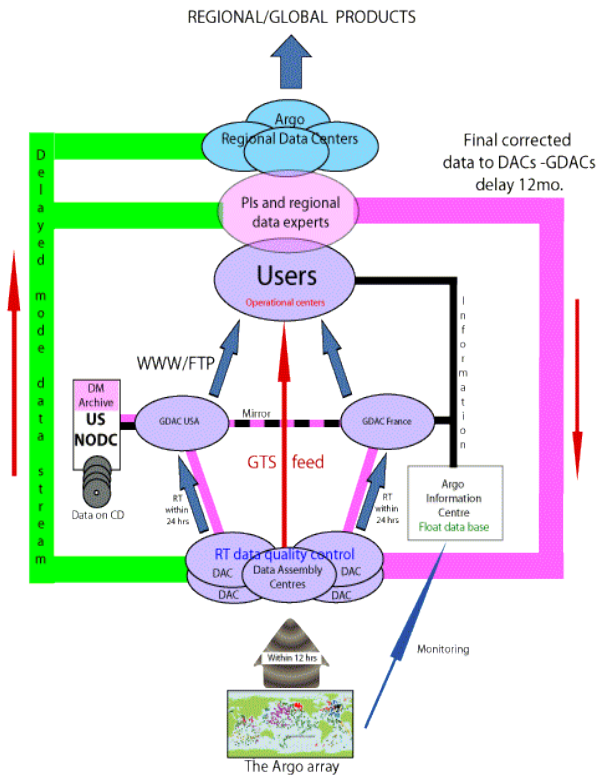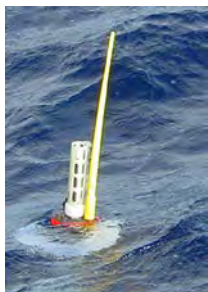For more see this volume *M Belbeoch, "The Argo Project: 21st century ocean observing system"*

Figure 3:   Argo Data Management Network

5 Profiling floats development: The French Provor float

Within the Coriolis framework, IFREMER has developed, through an industrial partnership with the MARTEC company, a free-drifting hydrographical profiler named PROVOR based on MARVOR technology (As for the MARVOR, it doesn't need any ballasting operation before launch.

Temperature and salinity measurements are performed during the ascent and/or the descent, and at drift; the sampling strategy is set before launching and parameterised at least for two user-defined layers. A coastal version of Provor, named Pagode, is under development. Also studies to add new sensors such as oxygen, carbon… are conducted by IFREMER.

For more see this volume: *P Marchand, G Loaec "In situ monitoring of the ocean: present and future technologies available for operational oceanography"*

Figure 4:   Profiling float PROVOR equipped with Seabird sensor (left) and FSI (right)

6. Integration of national activities related to in situ measurements

Many in situ measurements necessary for operational oceanography are made regularly by the French agencies involved in CORIOLIS: SHOM (XBT, hydrographic cruises), IFREMER (4 large research vessels), IPEV (one large research vessel cruising in Indian and Antarctic oceans), IRD (WOCE lines) XBT lines and thermosalinometers), METEO-FRANCE (drifters and several moorings), CNRS (floats). But, unfortunately, data are not always transmitted in real time to data centres.

Figure 5: Left: Sea Surface Salinity data acquired from French research vessels and transmitted in real time to theCORIOLIS data center in 2005. Right: Sea-Surface Salinity acquired since 2000 on VOS within the French Observatory ORE-SSS. Both of them represent the French contribution to GOSUD (Global Ocean Surface Underway Data) under IOC umbrella.

CORIOLIS aims to organize the systematic collection in real time of such in-situ measurements made either in routine or within the framework of specific research activities, in order to meet the operational oceanography needs. It harmonises reduction, control and calibration processes to cope with operational constraints.

For more see this volume: *L Petit de la Villéon: "GOSUD : Global Ocean Surface Underway Data Project"*

7 Prospectives

The CORIOLIS project implementation by the French agencies in charge of oceanography, will contribute to the ocean observing system, providing world coverage of the oceans in real time. CORIOLIS a multi-disciplinary pilot project is involved in new autonomous instruments development with up-to-date transmission capability, in float deployment in the Atlantic Ocean then world and in data collection, processing and distribution to users (public authorities, scientific community, industry sector). Within the Mersea Integrated Project, CORIOLIS data center will be extended to serve the European ocean forecasting systems: for this it will integrate data coming from other European research vessels, start distributing biochemical data coming from mooring and gliders as well as improving climatology over the Atlantic ocean.

It aims to be sustained when the world programs, to which it refer to, will have drawn their assessment for the coming years. One will then witness an evolution similar to the one observed in meteorology field twenty years ago: the deep-sea oceanography will go from science to operational for the benefit of the world population on a sustainable base. Nevertheless it will then be necessary to assume the recurring cost of such a program