First Succes of ProvBio floats

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The anthropogenic greenhouse effect and the associated temperature rise of the planet represent the main challenging issue for the Earth sciences of the next century. Marine ecosystems are a key component of the Earth system, as they modulate the transfer of greenhouse gases (mainly CO2) to the ocean surface. Moreover, oceanic ecosystems mitigate the effects of anthropogenic carbon injection into the atmosphere, via the so-called "biological pump". Ocean biogeochemistry is hence confronted to a major challenge: the determination of the extent and efficiency of the climatic feedback of the carbon "biological pump" within the context of climate change.

However, the approaches currently utilized to assess ecosystem dynamics are inadequate for addressing climate change issues:

- manifestly, ocean biogeochemistry lacks obser-vations. The number of in situ biogeochemical observations is 2-3 orders of magnitude lower than the number of observations for the physical compartment. Moreover, large areas of the ocean are practically under-sampled, as adverse environ-mental conditions and logistics prevent the conduction of oceanographic cruises for most of the year. Ocean color satellites have greatly improved the knowledge of biomass distribution, although they are limited 1. to the biological compartment only 2. to the surface and near surface layers.
- the temporal variability of the main processes of marine ecosystems ranges from hourly to decadal scales, showing a continuum of scales, which is extremely hard to discriminate without dedicated observations; very few oceanic regions have been sufficiently explored to allow both long-trend and high-frequency analysis, thus most of the feed-backs between processes occurring at different temporal scales are very poorly characterized.
- numerical simulations, which represent an essential tool to dissect scales and provide future scenarios, begin to produce realistic results. However, models are still far from obtaining the expected accuracy, as they are inadequately constrained by observations.

Autonomous measuring platforms represent the "deux ex machina" to unblock the impasse. They could solve all the present limitations, opening novel pathways for the exploration and comprehension of oceanic ecosystems. Physical oceanography has already cumulated huge benefits from the use of autonomous measuring platforms (i.e. Argo program). It shows the way to follow for biogeochemical ocean sciences, which should evolve towards autonomous systems in order to enhance their observation capacity.

A new type of float, the "ProvBio", has been developed jointly by Ifremer and the French company KANNAD, following the scientific directives of the Oceanographic Laboratory of Villefranche (LOV). The ProvBio design has been achieved from the Provor-CTS3 float, adding miniaturized, low power consumption, and quite neutrally buoyant optical sensors for biogeochemical measurements delivered from Satlantic and Wetlabs manufacturers. Two different models have been developed: the first, ProvBioA, is fitted with a Wetlabs transmissometer (C-Rover), a 3-wavelength Satlantic radiometer (OCR-504) and the PROVOR-CTS3 CTD sensor.

The second model, ProvBioB, comprises the same ProvBioA sensors, with, in addition, an "ECO3" Wetlabs sensor, measuring chlorophyll-a fluo-rescence, coloured dissolved organic matter and particle backscattering coefficients.

The ProvBioA sampling cycle is practically the same as for a classical Argo float, with the important difference that the sampling strategy can be modified in real-time (see later). The ProvBioB has an additional characteristic: the internal software allows a sampling protocol with 3 profiles per day (the surfacing times can be programmed by the user in the mission parameters, see figure 1).

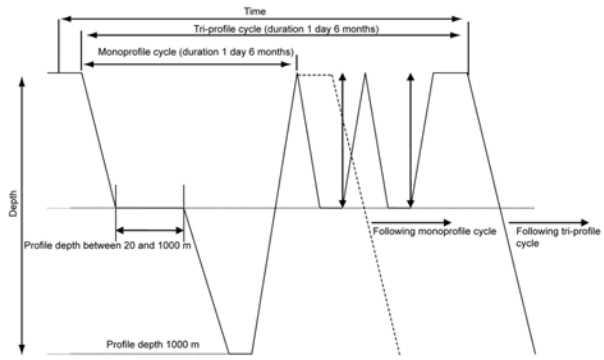

Figure 1. Diagram showing a typical ProvBioB cycle.

In the ProvBio series, the satellite communication device is based on an Iridium "two-ways" link[1], which replaces the Argos system of the Provor-CTS3, as required by the increased quantity of data to be transmitted. The Iridium "two-ways" system also allows for a real time modification of the mission parameters, by adapting, for example, the float's sampling strategy to specific events (i.e. phyto-plankton bloom, extreme wind forcing, mixed layer deepening etc). Moreover, a "mission end" command can be transmitted to the float, which gives the possibility to recover the instrument in cases of energy drops or instrument anomalies[2].

The housing of the optical sensors is mounted onto the main hull of the float, connected by the lower part of the housing. The optical device housing is fixed at the damping disk of the float, with 2 band clamps and contoured saddles, in order to ensure the correct alignment of the transmissometer optical path. The electrical connection with the float is assured by a cable mounted on the lower end cap (see figure 2).

A new antenna has been specifically developed for the satellite transmission system of the ProvBio series (max depth attested: 210 bar pressure).

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[1] *A "two ways" communication allows not only the transmission of the data from the float to land, but also the transmission of messages from land to the float.*

[2] *The mission end" command will force the float to rejoin the surface and to transmit the position every hour.*

Figure 2: The ProvBio and its deployment

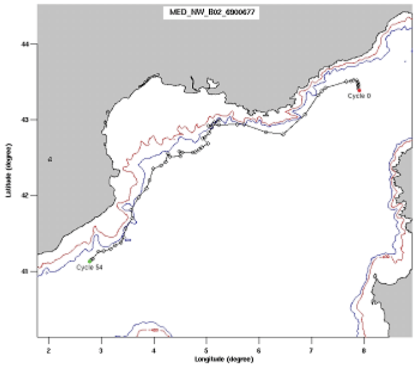

Figure 3. Geographical locations and trajectories of the of NW_B02 ProvBioB float : deployment (red dot), profiles (black dots), current position (12 December 2008, green dot). See also: www.obs-vlfr.fr/OAO.

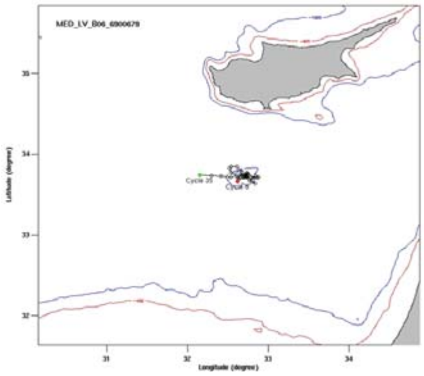

Figure 4. Geographical locations and trajectories of the LV_B06 ProvBioB float: deployment (red dot), profiles (black dots), current position (12 December 2008, green dot). See also: www.obs-vlfr.fr/OAO.

A hard coated aluminium mast maintains the antenna sufficiently distant from sea-surface (about 20 cm). The modem, from NaI research, includes a GPS receiver and an Iridium transmitter, and is located in the main hull of the float, close to the electronics pcb. The collected data are transmitted in a unique "data message" of 1960-bytes size, which comprises 14 data packets of 140 bytes each. If an error is detected, the number of packets in a message is lowered, and a new transmission is attempted. A "status message", containing technical parameters on the state of the float and of the sensors, is also separately transmitted. The transmission period at the surface doesn't exceed a few minutes, which minimizes the transmission cost and the risk of boat collisions (which depends of surface time).

A 800 cm^3 foam has been fixed on the top of the float, around the hull, in order to compensate the weak negative buoyancy of the optical sensors and then to ensure a correct surfacing, which is crucial to correctly establish the satellite communication.

The optical sensors are activated 5 minutes before the start of the profiling phase (depth data are transmitted and used as "reference" values), as, to save energy, optical sensors are switched off for most of cycle period. The collected data are vertically averaged to minimize the transmission cost, although the efficiency of the Iridium system allows a rather metric resolution (about 2 meters). This is also done for CTD derived parameters. If the "three-profile" option is selected, all the data from the 3 profiles are transmitted at the end of the third profile. The assessment of ProvBioB lifetime is of about 200 "one-profile" cycles and of about 100 "three-profile" cycles[31].

At present, 4 ProvBioA and 8 ProvBioB have been manufactured and 2 other similar floats, named ProvCarbon (with transmittance and oxygen sensors) are also being produced. Concerning the ProvBioB, all 8 floats have been delivered to the LOV for science operations. They have been successfully deployed and all are presently operational: 2 in the North Atlantic (from June 2008), 2 in the North Pacific near Hawaii (from august 2008), 2 in the South Pacific (from December 2008) and 2 in two ecological contrasting regions of the Mediterranean Sea.

The first Mediterranean float (NW_B02) was initially deployed the 1st May 2008, in the Ligurian Sea, close to the French long term in situ optical mooring BOUSSOLE (P.I. D. Antoine, approximately 8°E, 43.5°N, see figure 3). The float was programmed with a cycle frequency of 1 day. After 15 days, the cycling frequency was changed to 5 days, and it was kept constant until now.

The second float (LW_B06) was deployed in the Levantine Basin (approximately 32.5°E, 33.7°N, see figure 4), during the French cruise "BOUM" (P.I. Thierry Moutin). The LV_B06 float was programmed similarly to the NW_B02: after an initial phase at 1 day cycling frequency (from 27/06/08 to 30/06/08), the float strategy was modified to perform 5-day cycling.

Figure 5 shows the temporal evolution of the potential density and of the chlorophyll concentration fields obtained from the NW_B02 ProvBioB float. The summer stratification of the water column affected the vertical distribution of the chlorophyll concentration, which was then characterized by a Deep Chlorophyll Maximum (DCM) at about 50-70 meters depth. The beginning of the fall in September, with the associated atmospheric cooling and the more intense wind mixing, induced a progressive deepening of the mixed layer depth, with a consequent de-stratification of the water column. As winter advanced, the DCM was progressively destroyed, and the chlorophyll concentration was redistributed uniformly in the mixed layer by the intense mixing.

Dynamical conditions of the LW_06 float are relevantly different (see figure 6). The float, as initially expected, remained trapped in the cyclonic structure related to the Eratosthenes seamount, and it profiled the same area for most of the summer and fall. The summer stratification was more important than in the Western Mediterranean basin, and, although winter conditions were observed, the mixed layer depth was never greater than 50 meters. Consequently, a DCM was permanently observed at about 100 meters depth, although the characteristics of the vertical profiles of the chlorophyll concentration varied between summer and winter. The absolute values of chlorophyll-a concentrations, ways observed in the DCM, tended to decrease with time, ranging from 1-2 mg/m^{-3} in the summer to 0.5-0.7 mg/m^{-3} in the fall.

The two Mediterranean ProvBioB's are still operational (December 2008), and their evolution can be followed in real-time on the LOV web site (www.obs-vlfr.fr/OAO), as

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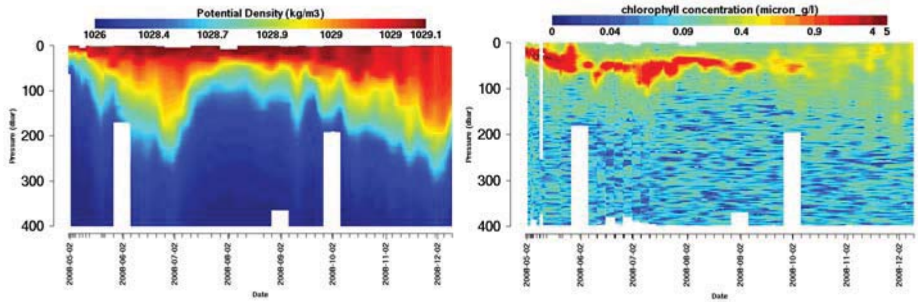
[3] *With the following assumptions: 1000 meter profiling depth, 52 CTD samples and 150 optical samples (e.g. 1 point every 2 m between 300m depth and surface).*

transmitted data are processed and plotted on the web site with a temporal delay of less than an hour. A Group Mission Mercator Coriolis project (PABIM, P.I. Fabrizio D'Ortenzio) is presently dedicated to the definition of an automatic quality control processing for the ProvBio observations, which will be in the future integrated in the Coriolis data system. Technical monitoring of the floats indicates that the energy level is still high, therefore a complete annual cycle of measurements remains possible.

In conclusion, the firsts two Mediterranean ProvBioB have produced, in less than a year, an invaluable data set on physical-biological interaction in two contrasting ecological regions of the basin. Considering the quality of the data, the cost/benefits ratio for this first ProvBio experiment is extremely favourable.



5. Potential density and Chlorophyll concentration from the NW_B02 ProvBioB float.

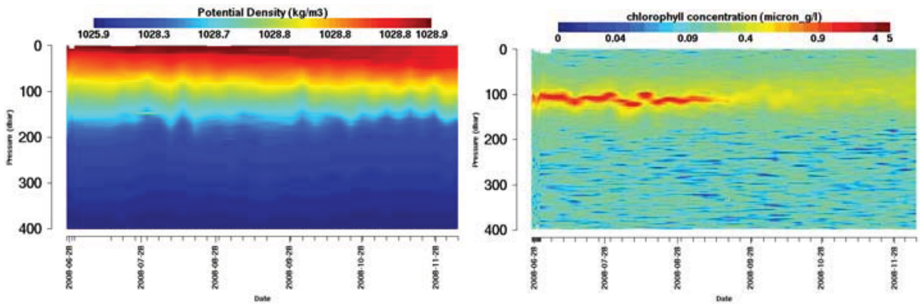


Figure 6. Potential density and Chlorophyll concentration from the LV_B06 ProvBioB float

A scientific team for the Coriolis Project

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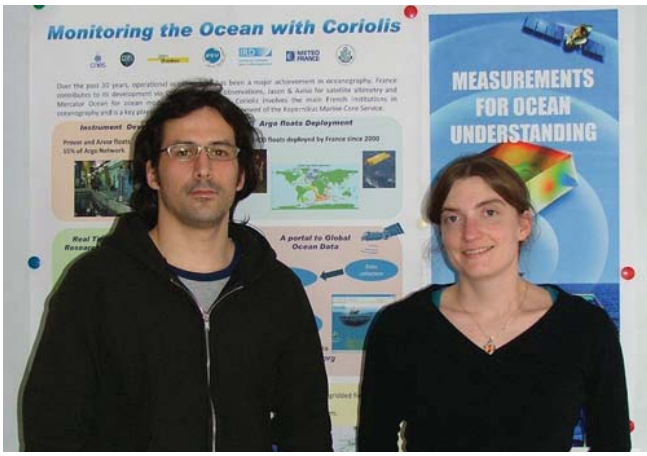
As operational oceanography grew up at the end of the 90's, the need for a strong support concerning its observational part became more important. The Coriolis project was launched in order to contribute to the ocean in situ measurements part of the French operational system. The success of Coriolis in developing continuous, automatic, and permanent observation networks and providing high quality observation data for forecast models, especially for Mercator, has been demonstrated since then.



Clément de Boyer Montégut & Cécile Cabanes

The ocean model needs the highest quality data possible as the constraints of those data in the assimilation system can be quite influential for the final results. The data may especially take the model away from a realistic state by introducing artefacts like, for example, drift or biases in a temperature or salinity profile. Direct use of in-situ observation data for research purposes also requires some preliminary advanced qualification tests. Some recent examples of the problems encountered in in-situ data accuracy are the cold bias of a group of SOLO Argo floats in the Atlantic (Willis et al., 2007), or the deep warm bias of XBT measurements (e.g., Wijffels et al., 2008). Those problems could be evidenced while trying to evaluate oceanic temperature climatic trends. An efficient way to know about