International activities

.....with a specific focus on the European side and on biogeochemical floats

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The context and the challenges

- The last century: a century of **undersampling**, especially for “bio”: a large part of the **variability** in oceanic biological processes missed by traditional sampling.

- Rapid technological advances in ocean observations: physical oceanographers have been the first taking benefit from it (i.e. Argo floats).

- With a certain time lag, biological and biogeochemical oceanographers are undertaking a similar technological rupture; development of “bio” sensors that fit with the requirement of the new platforms (low consumption, miniaturization, endurance).

- Biological oceanography is emerging from its data-limited foundations.

- Based on these new technologies, pilot projects are being launched.

- If, from these emerging (individual, national) initiatives, we begin to coordinate in terms of networks, arrays, data sharing and management, a revolution can be expected in observation for biological and biogeochemical oceanography.
The context and the challenges

- Two main expected outcomes from such an *in situ* observation system:
  - **Scientific outcome** are: enhanced exploration, improved understanding of change and variability in ocean biology and biogeochemistry (over a large range of spatial and temporal scales), reduction of uncertainties in biogeochemical fluxes.
  - **Operational outcome** are: ocean biogeochemistry and ecosystem predictability; provide (real time) open data to scientists, users and decision-makers.

- Both scientific and operational objectives for biology require the “in situ” part to be designed and implemented in tight synergy with two other essential bricks of an ocean observation system:
  - **Biogeochemical / Ecosystem modeling**: from NPZ models to Plankton functional Types (PFT) models.
  - **Satellite observation of Ocean Colour Radiometry (OCR)**. Global, synoptical, time-series.
The “Bio-platform” (Argo) community is getting organized

« Integrated Bio-platform» Plenary Paper, in press

link with Argo established
AST Meeting, March 2011, Buenos Aires
Presentation outline

- Technologie
- Data management
- Link with satellite Ocean Color Radiometry
- European large projects and network implementation perspectives
  - Floats: Euro-Argo, remOcean, NAOS
  - Gliders: GROOM
  - Integration of floats + gliders + remote sensing + modeling + assimilation: OSS2015
Two examples of VAL-Float => acquisition of OCR validation data set

Both floats are/will be deployed in the vicinity of the Boussole mooring (NW Med. Sea)
The first four selected « new » variables for a « BIO-Argo » float

- Oxygen
- Nitrate
- Chlorophyll a
- Particle carbon (from optical proxies)
The first four selected « new » variables
On-going developments in our lab: two examples of (more complete) Bio-Argo “like” floats

- Ed (380, 412, 490) + PAR
- Chla flou, CDOM flou, $b_b(700)$
- $c(660)$
- + $O_2$
- NO$_3$

remOcean: Remotely-Sensed Biogeochemical Cycles in the Ocean
Other “new” variables: the potential of passive acoustic

- Seismic waves: the mermaids float listen during the drift phase

- Multidisciplinary float: seismic during the drift + Bio-Argo during the ascent

- Other possible “combo applications” of acoustic during the float drift
  - ice detection => float surfacing or not; rainfall and winds (Riser et al., 2008); mammals.
Bio-data management: issues and perspectives #1

- Tremendous amounts of “bio” data will be acquired in the near future.
- An integrated observation system will be operationally useful and scientifically relevant if and only if it is supported by an efficient data management system….BUT
- The “problem” of biologists with data management
  - we are not used to the management of huge datasets.
  - we are not used to make data publicly available
  - we are not used with real time
- A “revolution” is thus required in the way we will apprehend data management
- Very efficient data management (and a good example for the “bio” community) : Ocean Color and Argo
  - Real-time delivery with real-time QC (operational data)
  - Delayed mode QC delivery after data reprocessing (scientific, climatic-trend value): real issue of climatologies for biology / biogeochemistry.
  - Generation of derived products
“Bio-data” management issues and perspectives #2

Coriolis data center has begun to implement management of “Bio-data” in real-time

Chlorophyll a

Oxygen
**“Bio-data” management issues and perspectives #3**

*Delayed mode procedure are being developed*
*(combination of sensors)*

**Chlorophyll a**

- Med Sea
- North Atlantic sub-polar gyre
- North Pacific sub-tropical gyre
- South Pacific sub-tropical gyre

**CDOM**

- surface float / MODIS


Xing, X., et al. (submitted)., *Journal of Geophysical Research, submitted*
iridium and float recovery

- « end of life command »: the float stays at the surface and send a GPS point every one hour.

- Recovery of a PROVBIIO float after 2 years and 140 cycles in the North Western Med Sea. Collaboration between spanish and french teams.

- Extremely important recovery to analysis sensor status. Some bio-fouling (essentially the bottom window of the transmissiometer)

- Implementation of Copper “protection” potentially useful
Ocean Color Radiometry remote sensing was initially developed for Chla retrieval.

Now, (many) “new” biogeochemical / ecosystems products can be retrieved from space; some of them are also measured in situ by profiling floats.

proxies for POC

- POC: Stramski et al., 2008
- Kostadinov et al., 2010
- Phytoplankton size: Uitz et al., 2006

proxies for CDOM

- Particle: Loisel et al., 2006
- Siegel et al.., 2002
- PFTs: Alvain et al. 2005
In situ data extend the satellite data into the ocean interior.

Satellite data fills the gap of loose spatio-temporal resolution of in situ data.

Essential to develop synergetic use of “bio” in situ and OCR satellite data:

- Produce 3D/4D fields of some “bio”-variables for the global ocean: Chla.
- “Initial climatologies” => required for developing delayed-mode QC procedures.
- In situ data for validation of OCR products (e.g. “VAL-floats”).
European large projects and network implementation perspectives: profiling floats

- **remOcean**: REMotely sensed biogeochemical cycles in the OCEAN
- **NAOS**: Novel Argo ocean Observation System
- **Euro-Argo**.
5-year project (2010-2014)

- **Development of profiling floats** to measure oceanic variables which are essential for the characterization of phytoplankton dynamics and related carbon fluxes.

- **Deployment of these floats in the four sub-tropical gyres** (16 floats) and in the sub-polar North Atlantic (24 floats) automated investigation of biogeochemical cycles in these areas over a continuum of temporal scales and over a period of 3-4 years.

- **Development of parameterisations** linking surface biogeochemical properties to their vertical distribution in the ocean interior, and ultimately development of **3D fields** of these properties by combining float and satellite data.

- **Estimation of carbon fluxes** by combining these fields with bio-optical modelling including retrospective analyses thanks to satellite data archives.

Pi: Hervé Claustre, collaboration with A. Körtzinger, AWI
sub-tropical gyres

- 40% of the global ocean.
- Primary production (NCP): controversial
  - Classical (incubation) methods & models: 2-3 times lower than:
    - "Non-intrusive" techniques (O2 isotopes; O2 floats budget)
- Inter-gyre variability:
  - N limitation (North & South Pacific) vs P limitation (North Atlantic)
  - Seasonal
NA sub-polar Gyre

• 1.5% surface, ~ 20% of CO2 sink

  ▪ timing and magnitude of blooms

    ✓ haline stratification (early): intense and « quick » bloom
    ✓ thermal stratification (progressive): « classical bloom »

  long term: ice melting and bloom dynamics

• small scale variability (day, week) in $Z_m$ and bloom

  ✓ intermittency in stratification/mixing during bloom period

  long term: NAO, “storm tracks” and bloom dynamics
iridium and float recovery

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Novel Argo Ocean observing System

9-year project (2011-2020), french «equipment of excellence » funding scheme

- Reinforcement of the French contribution to Argo (S. Poulquen, Ifremer).

- Technological developments (deep floats, new transmission, towards biogeochemistry and under ice) (S. LeReste, Ifremer)

- North Atlantic: Deep Oxygen floats: 24 (V. Thierry, LPO)

- Med Sea: “remOcean” floats: 30 (F. D’ortenzio, LOV)

- Arctic (Baffin bay) : “remOcean” floats: 26 (M. Babin, Univ. Laval, LOV)

Pi: Ifremer (P.-Y. LeTraon), co-Pi: UPMC (H. Claustre)
Mediterranean Sea: understanding phytoplankton dynamics (phenology) within various trophic regimes

- Intensification of observations (time / space)
- Evolution of the Argo rules (every 10 days, more float density than 300 km x 300 km)
- Deployments adapted to trophic regimes: seasonality in biomass
- 30 “remOcean” floats

F. D’ortenzio, LOV
Arctic: Ice-edge blooms

Perrette et al. (2011)

- 13 +13 « remOcean » floats with ice detection

M. Babin, Univ. Laval, Quebec
The new Euro Research Infrastructure Consortium (ERIC): Euro-Argo

Goals of ERIC: Establish a long term (> 10 years) « legal » structure for strengthening Argo activities at the European level (rather than at a national one) for being efficient with respect to:

- Organize float procurements
- Coordinate deployments
- Follow the network
- Decide for future evolutions with respect to the “core” Argo mission (new measurements, regional seas, higher latitudes)
- Facilitate data access to users, develop new products
- Facilitate scientific and operational users
- Interface and integration at the international level (Argo)
Estimation of the costs for Bio-Argo implementation at an European Level

- OceanObs 09: community agreement that 20% of the floats should be on a “Bio-Argo” mode. For the Euro-Argo (250 floats year\(^{-1}\)) this represents 50 Bio-Argo floats year\(^{-1}\)

- The sensor **additional cost** together with iridium transmission: \(~ 25 \text{ k€ float}^{-1}\)

- Data QC/ management / distribution: 4 persons full time

- BIO-Argo first phase of implementation: 1.5 M€ year\(^{-1}\)
Implementation perspectives on the European side

- While the global scale is obviously the target to set up the “final” observation system, the implementation of pilot studies on regional “hot-spot(s)” could be a first and reasonable step.

- There are indeed regional “hot-spots” that are “natural laboratories” for addressing key scientific questions of global relevance.

  - **The eastern boundary currents**: upwelling and OMZ areas; biogeochemical cycles (C, N,..); fisheries; coastal / open ocean interface.

  - **The North Atlantic**: variability in MOC; decrease/variability in the CO2 sink over inter-annual, decadal time scales.

- These pilot studies would be also useful for demonstrating / developing progressively the community capability for:
  - manage the operational aspect of a fleet of floats (sensor calibration/intercalibration and interoperability)
  - real-time and delayed mode QC data distribution
The coming playgrounds
Sub-polar NA gyre and higher latitudes

26 floats: 2013-2016
bio-optics, $O_2$, $NO_3$ (some)
under-ice capability
+ gliders
(ice edge-bloom)

12 deep $O_2$: 2014
12 deep $O_2$: 2016

10 floats: 2014
bio-optics, $O_2$, $NO_3$ (some)
proposal

24 floats: 2012-2013
bio-optics, $O_2$, $NO_3$ (some)
European large project
Gliders
The European Activity with Gliders

- The “European Gliders Observatory” network active since 2006
- Several leading institutions having developed glider facilities
- First focus: sustained lines in “observatories” for climate, multidisciplinary coastal obs.
- Second focus: processes studies in convection areas, mesoscales, eastern boundaries, upwellings, polynias, … physics and coupled with “bio”

Status of the European fleets (2011)

Existing and planned “observatories”
GROOM : Gliders for Research, Ocean Observation and Management

- Design study for an European Research Infrastructure for gliders, supported by European Commission. Start 1st Oct. 2011, duration 3 years
- Objective 1: design a distributed architecture of a networks of “gliderports” around the European seas and overseas to operate glider fleets in combination with existing observing systems. Link with IOOS and IMOS
- Objective 2: assess organization, costs, … of the infrastructure suitable to operate fleets of gliders continuously for monitoring and research. Focus on “new sensors” (color, acoustics, …).
- Close cooperation with EuroARGO, EuroSITES, JERICO (coastal obs.)

Artistic view of the functional organization of the network of “gliderports”
European large project:

integration
floats + glider + satellite + model & assimilation

The OSS 2015 project
Ocean Strategic Services beyond 2015
funded by the EU Seventh Framework Programme (FP7) – Space 2011. Project duration: 3 years

Objectives:

- Promote the *assimilation of ocean colour* and *in situ observation* data into biogeochemical models
- Contribute to a better characterisation of Chl-a *vertical distribution vs surface information*
- Define and test methodology for *optimisation of observation network* and of complementarity between in situ and EO measurements
- Provide research support to the *European Marine Core Service* (MyOcean)
- Develop new products relevant for the biogeochemistry status analysis of the oceans

Space and time scales of oceanic processes and domains covered by satellite remote sensing, *in situ* autonomous platforms and models addressed by the OSS2015 activities (adapted from Prof. T. Dickey)
Partnership / pilot sites

North Atlantic
Assimilation of bio-profilers, (gliders) and ocean colour (2013-2014)

Ligurian
Assimilation of floats, gliders optical data and ocean colour (2013-2014)
Scientific Perspective: model + satellite + in situ integration

Physical model
NEMO
NATL025
ECMWF forcings
U,V :10 m
T,H :2 m
Precipitations \( \downarrow \) month
Radiations \( \downarrow \) 24h

Biogeochemical model
LOBSTER
Nitrogen cycle

DOM → ZOO → PHYTO → CHL
DOM → DET → NH4 → NO3

Assimilated variable using SeaWiFS data
Reanalysis product: April-May 2006 snapshot
Positive impact of OCR assimilation on nitrate in the upper 30 m

SeaWiFS assim
Free simulation
SeaWiFS

Vertical section (35°W)

RMS log misfit with independent (unassimilated) in situ nitrate profiles: no impact detected below 50 m depth
Conclusions / final recommendations

MESSAGE 1: The development of a Bio-Argo program represents a fantastic opportunity to address new scientific questions and to explore ocean biology & biogeochemistry over a broad range of scales (diurnal to interannual), some of them up to now unexplored.

MESSAGE 2: The implementation and the sustainability of the Bio-Argo system rely on the critical choice of the “Bio” variables and of their progressive implementation in the system.

MESSAGE 3: The sustainability of the entire system will depend on the availability of QC data and hence on the rigor in setting the data management system.

MESSAGE 4: Consider to study “super sites” in key areas of global relevance (e.g. North Atlantic) as a first step towards integration and before thinking “global”.

Overall this is a collaborative effort with a broad international participation!
**Activities**

- website for scientific and non-scientific public
- creating a community
- school children - “adopt a float” concept: real-time data at school
- training of early career scientists
- training of teachers (including retired) and science mediators

**Themes**

- NW Mediterranean: “Ocean model” and oasis linked to currents
- North Atlantic: sub-polar Ocean and CO$_2$ sink
- Subtropical gyres: oceanic deserts
- Arctic: Ocean under ice and its changes linked to climate change

Thank you