Biogeochemical sensors on profiling floats

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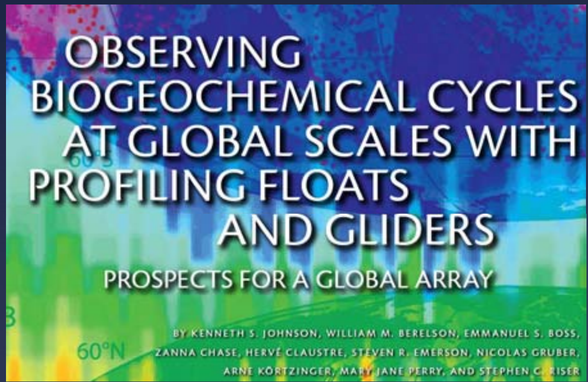
FRANCE

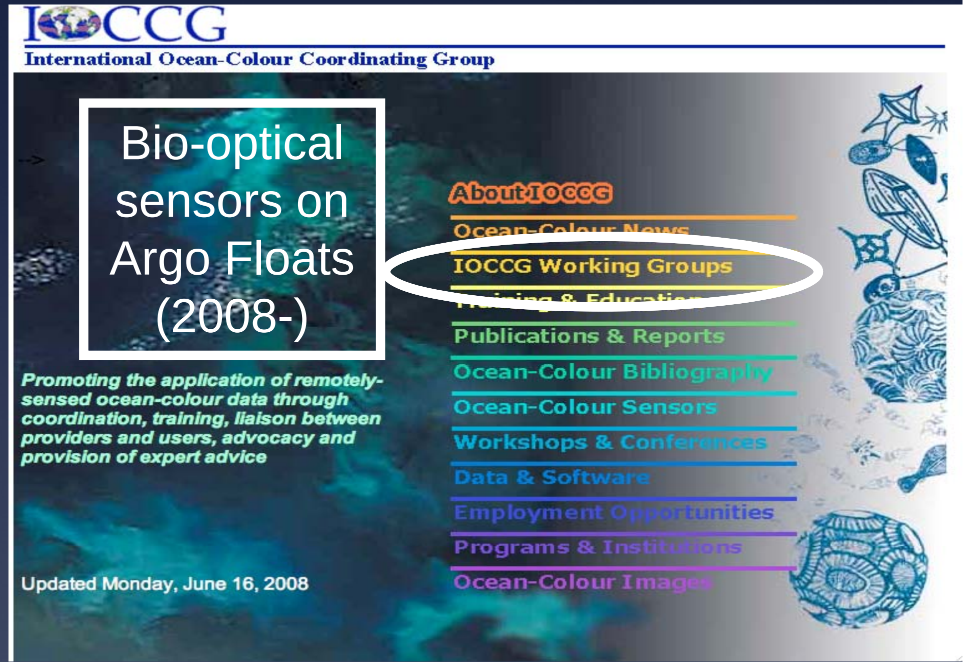
Presentation outline

- The context and the challenges
- The « bio » variables to be measured.
- Some examples of ongoing technology
  - Bio-optical floats
  - Nitrate floats
  - The advantage of iridium
- The link with satellite “ocean color” observation component.
- The issue of data flow, data management and data policy.
- Future plans

Meeting & Working Groups



Oceanography (2009), 22(3), 216-225



Claustre, H., et al. (2010). “Bio-optical profiling floats as new observational tools for biogeochemical and ecosystem studies » Community White Paper, in press.

Claustre, H.,et al. . (2010). “Guidelines towards an integrated ocean observation system for ecosystems and biogeochemical cycles”, Plenary Paper in press

The context and the challenges

- ❑ Ocean biology and biogeochemistry under increasing stress.

- ❑ Ocean biology and biogeochemistry heavily depend on physical forcing.

- ❑ Physical forcing and associated “bio” response : a continuum of spatial (sub-meso / meso / basin / global) and temporal (diurnal / seasonal / decadal) scales.

- ❑ 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 have been 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 core ecosystem and biogeochemical variables: which ones?

"*For biogeochemical time-series, the list of potential measurements is nearly endless and justifying inclusion / exclusion is difficult. Decisions as to what to measure, as well as how to measure, are never trivial.* ***The list of "essential" measurements for time-series can grow to the point that sustainability of the entire enterprise is put at risk***".

from Send CWP

❑ Observation valid for any kind of observation platform, including Argo floats.

❑ Mandatory : selection (labeling) of core variables of the future system.

- Scientific relevance (also with respect to modelers needs and OCR remote sensing products)
- Routinely and autonomously measurable by a variety of platforms (sensors) .
- The quality of data produced autonomously : agreement between established (discrete) protocols

❑ At the moment, potential core variables over the vertical dimension are: O_2, NO_3, Chl*a*, POC. Their progressive implementation in the integrated system can be envisaged.

❑ Progressive implementation / labeling of additional variables with the maturation of sensor technology.

The core ecosystem and biogeochemical variables: which ones next?

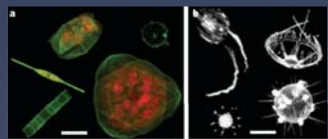
❑ Variables of the CO_2 system

- pCO_2 sensor  
- pH : Ion sensitive-field effect transistor (ISFET) (*Martz and Johnson)*

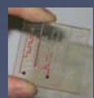
❑ Mid-trophic Automatic Acoustic Sampler (MAAS)

- missing link between plankton and fisheries

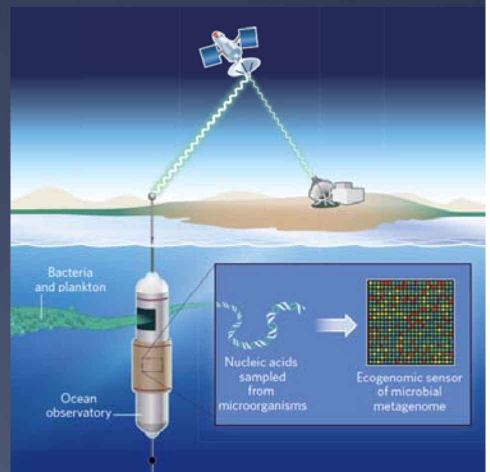
❑ Plankton functional types

- imaging systems (Jelly Fish)
- particle counting
- Hyperspectral / multispectral radiometry, spectrofluorometry

❑ Nutrients: MicroSystem Technology 

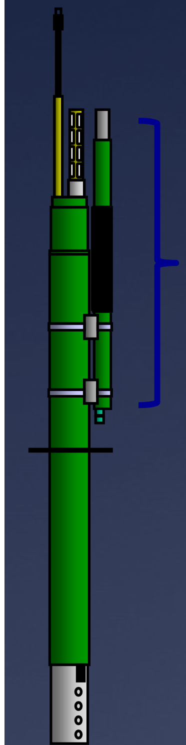
miniaturized
ecogenomic sensors

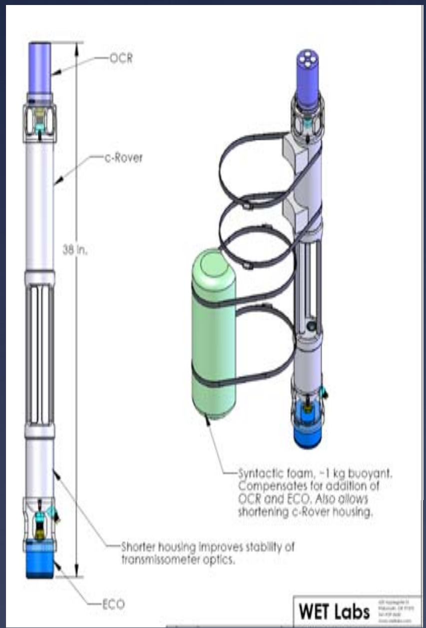


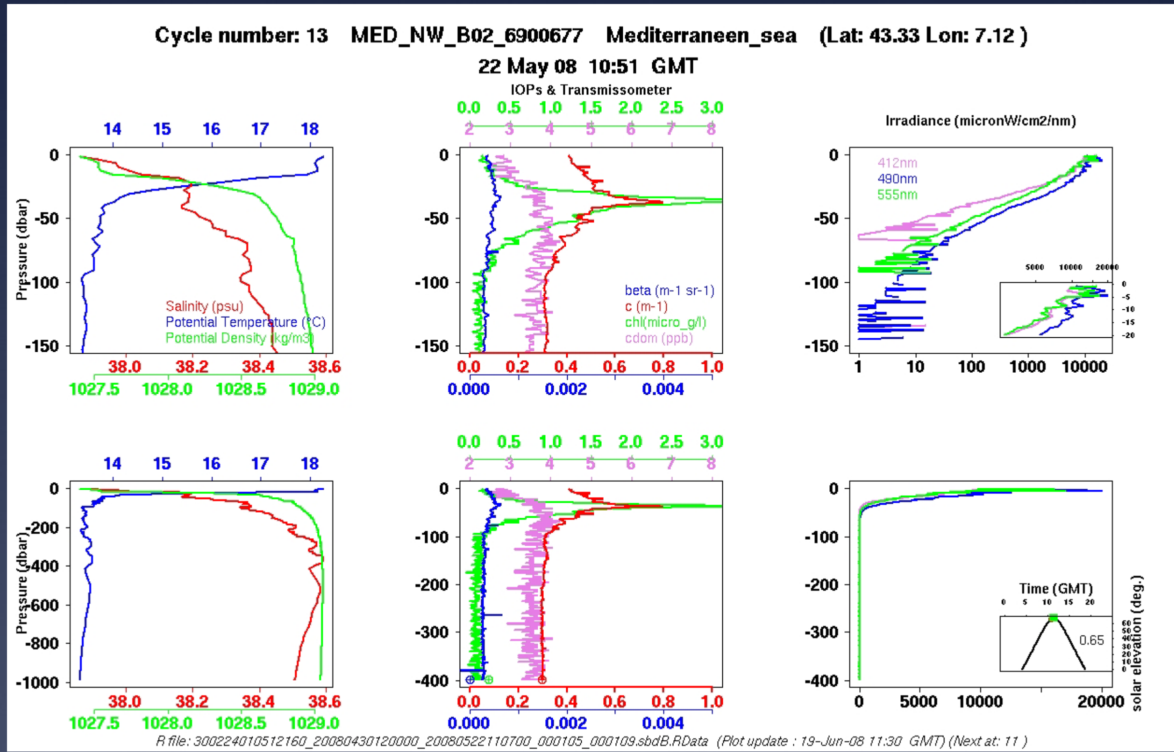
Bowler et al., 2009

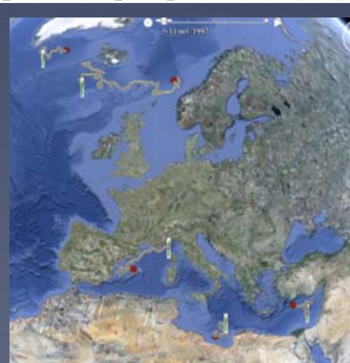
A float to investigate biogeochemical / bio-optical properties

PROVBIO : PROVOR + c(660) + b_b(555) + Chl*a* Fluo + CDOM Fluo + Ed(3λ) + iridium

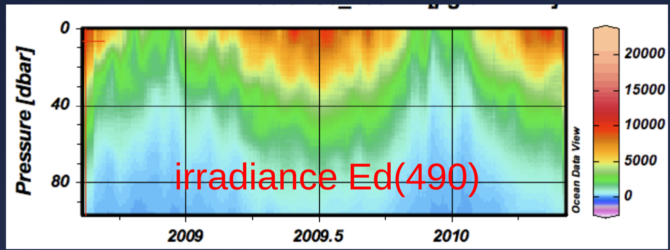


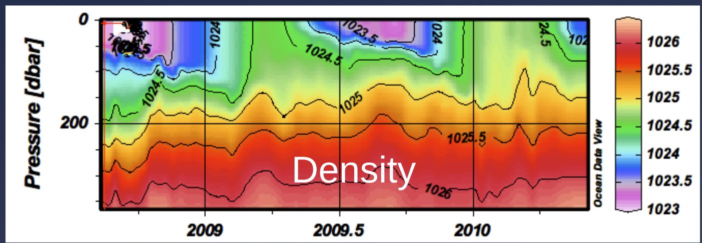


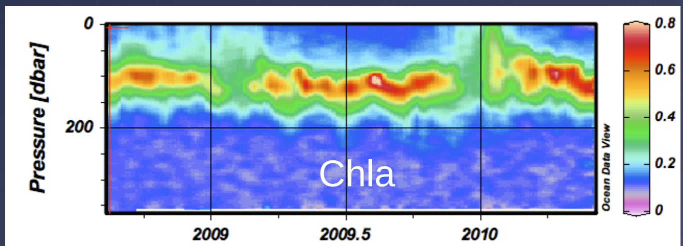


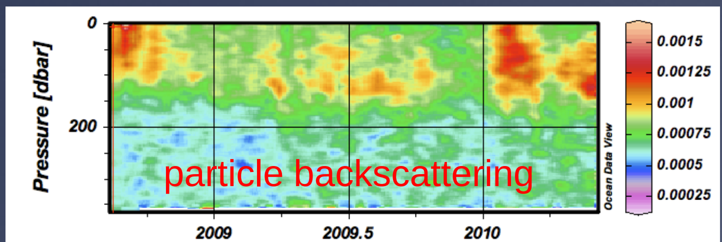


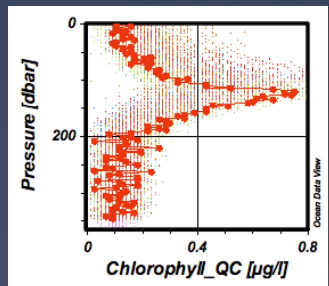
PROVBIO Float in HOT area: July, 2008 – June, 2010

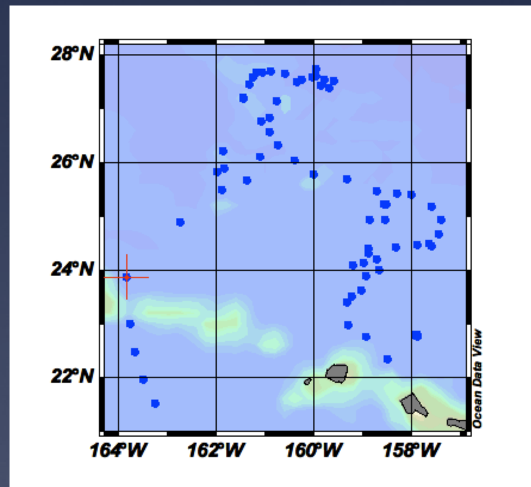












Developing a PROVOR NO3-Float

PROVOR
(PROVBIO
software)

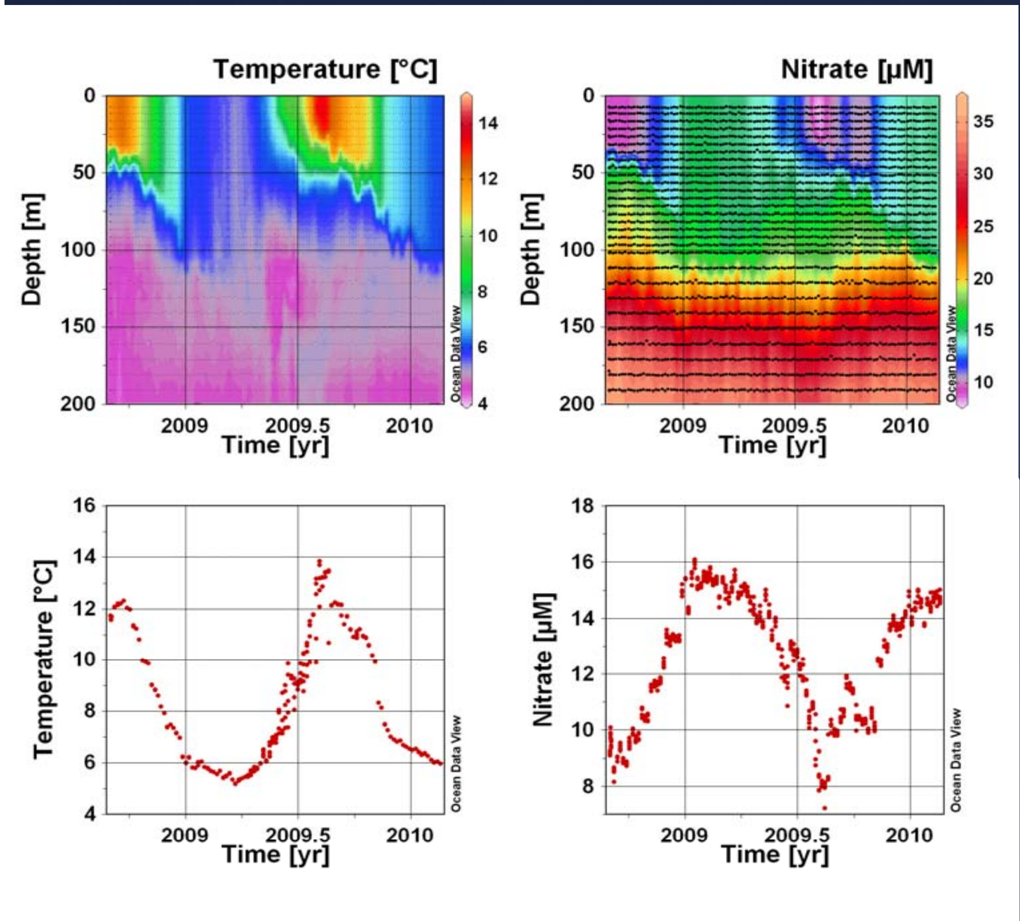
IRIDIUM
Antenna

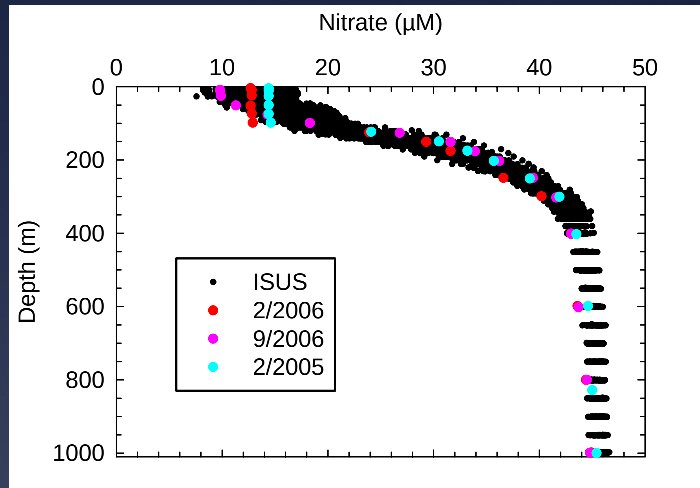
SUNA NO3

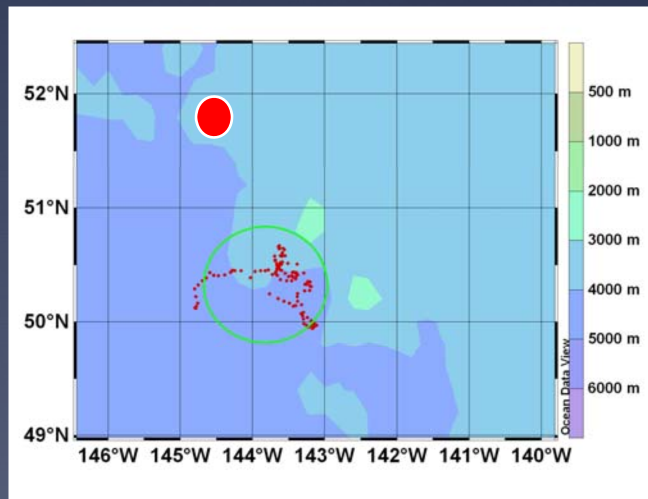
PRONUTS:

- LOV, IFREMER Brest, Roscoff Station
- First deployment tests planed for fall BOUSSOLE site

Some results of the Apex-NO3







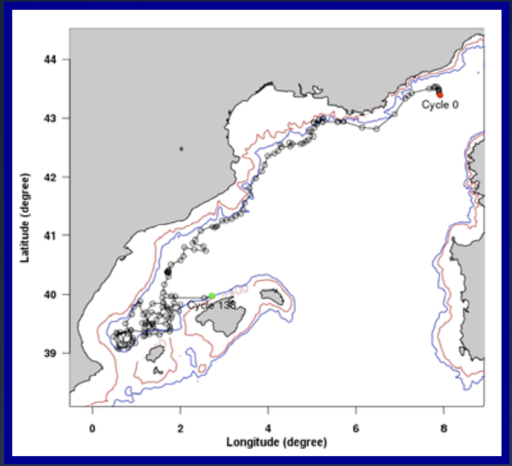
from Johnson, ASLO/AGU 2010

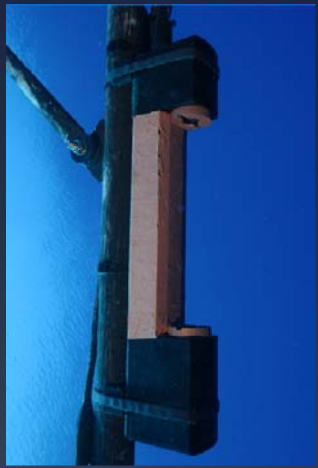
The advantage of iridium

- Cost effective high resolution (m), including for T/S…

- Adaptative sampling
    - ✓ to fit with event processes
    - ✓ take benefit of satellite ocean color and of forecasts (e.g. storms, mixed layer)
    - ✓ Diel cycle (and measurement of biological fluxes)

The advantage of iridium: float recovery





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

❑ Recovery of a PROVBIO 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)

The key to success : “Bio”-data management #1

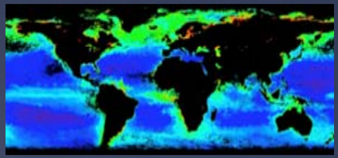
- ❑ Tremendous amounts of “bio” data will be acquired in the near future.

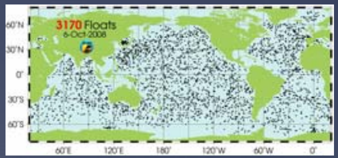
- ❑ An integrated observation system will be operationally useful and scientifically relevant if and only if it is supported by an efficient data management system….BUT

- ❑ 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





The key to success : “Bio”-data management # 2

❑ The management of “bio” data is likely a more complicated task than for physical variables because of the diversity of ways of measuring the variables

❑ For example, [Chl*a*], the “universal” proxy of phytoplankton can be measured:

- from space:
- In situ, non intrusively by sensors: (spectro)fluorescence, absorption (676 nm)
- In situ, from filtered water samples : HPLC, (spectro)fluorometry, spectrophotometry
- In fine, [Chl*a*] should represent the same “bio” product regardless of the method of acquisition. Consider modelers who visit databases…

❑ It is thus mandatory to develop a unified format and language which is essential for streamline and interfacing datasets.

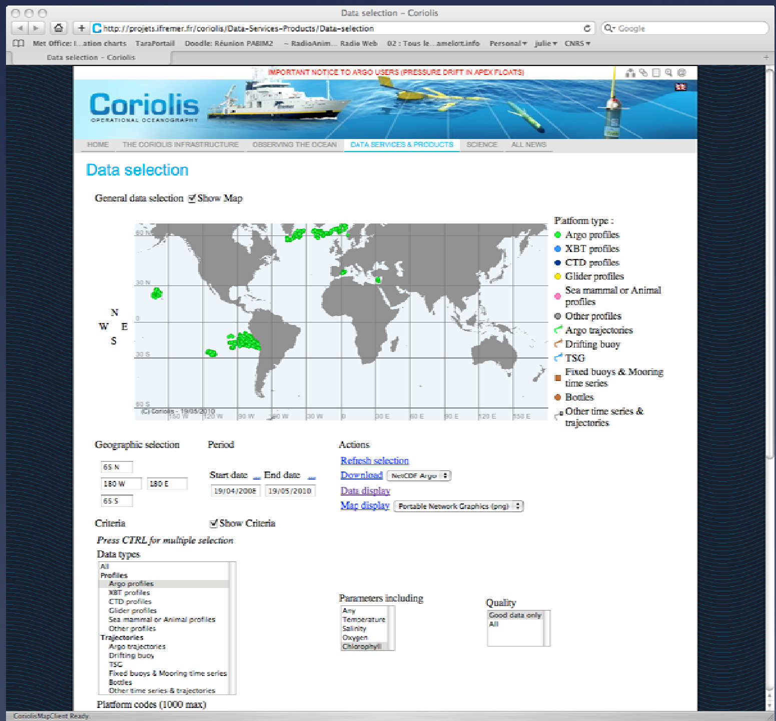
❑ Upstream of data management, QC and unified format, it will be essential to

- Establish best-practice manual / practical training / capacity building.
- Establish reference material.
- Support regular international intercomparison exercises.
- Develop internationally agreed calibration centers.

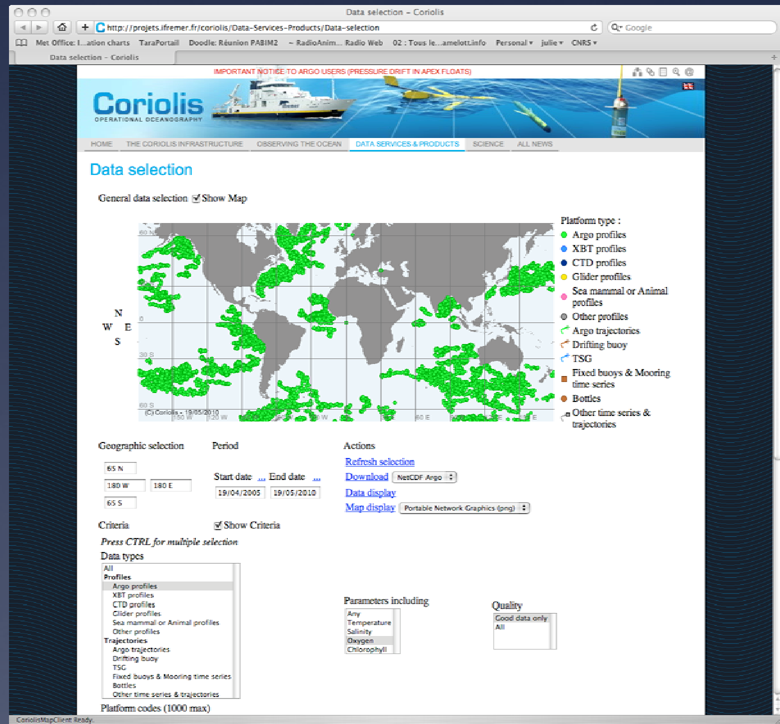
Calibration of numerous optodes for O2-Argo at Bergen

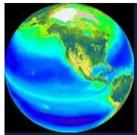
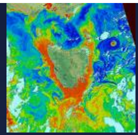
Coriolis data center has begun to implement magnagment of “Bio”-data

Chlorophylle a

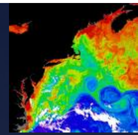
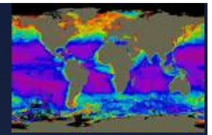


Oxygen

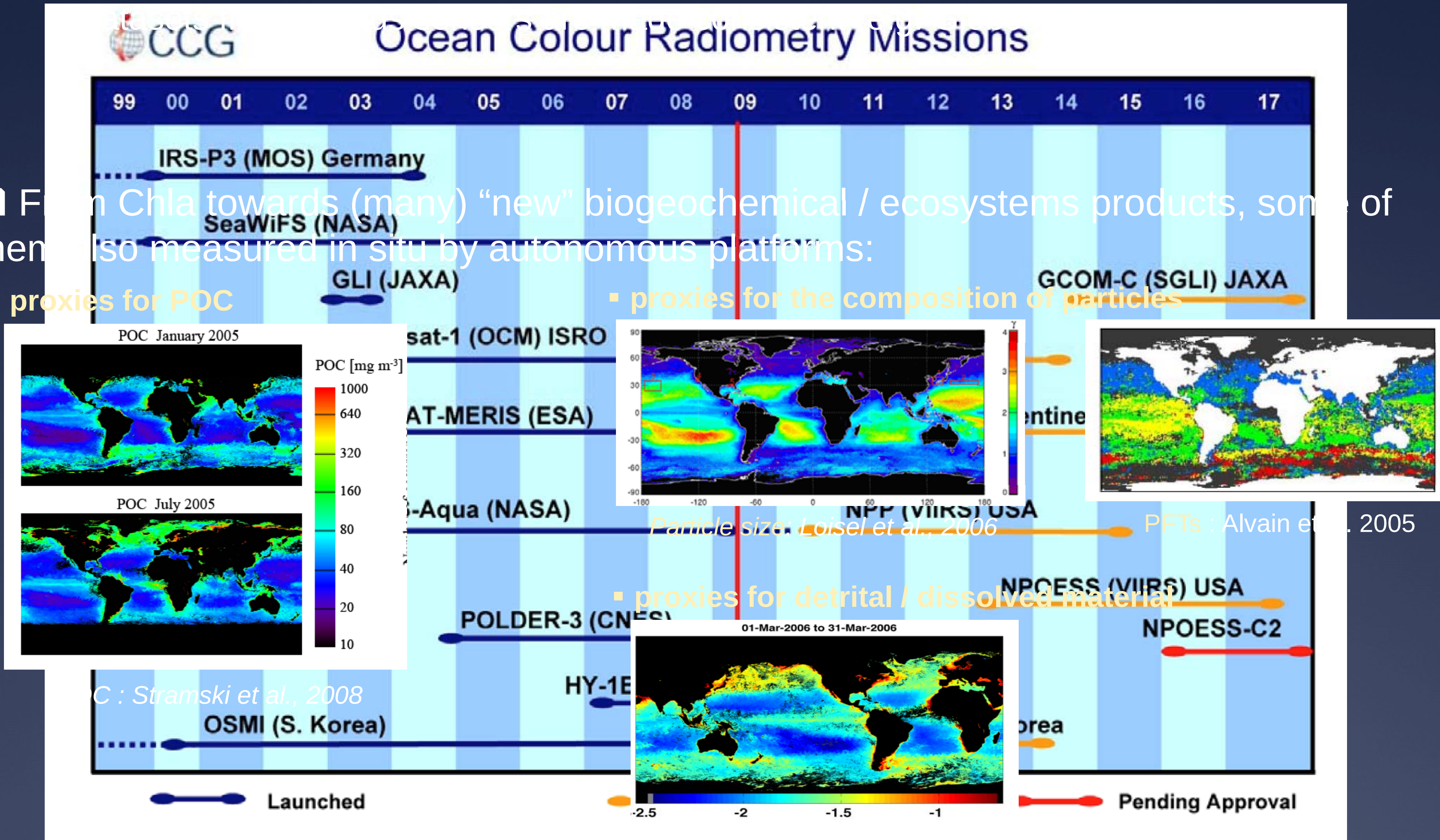


The OCR satellite component

- To produce climate – research valuable data sets, it is critical that:
  - **<u>There is no interruption in the OCR missions</u>**



- From Chla towards (many) “new” biogeochemical / ecosystems products, some of them also measured in situ by autonomous platforms:
  - **proxies for POC**
  - **proxies for the composition of particles**
  - **proxies for detrital / dissolved material**

POC : Stramski et al., 2008

Particle size: Loisel et al., 2006

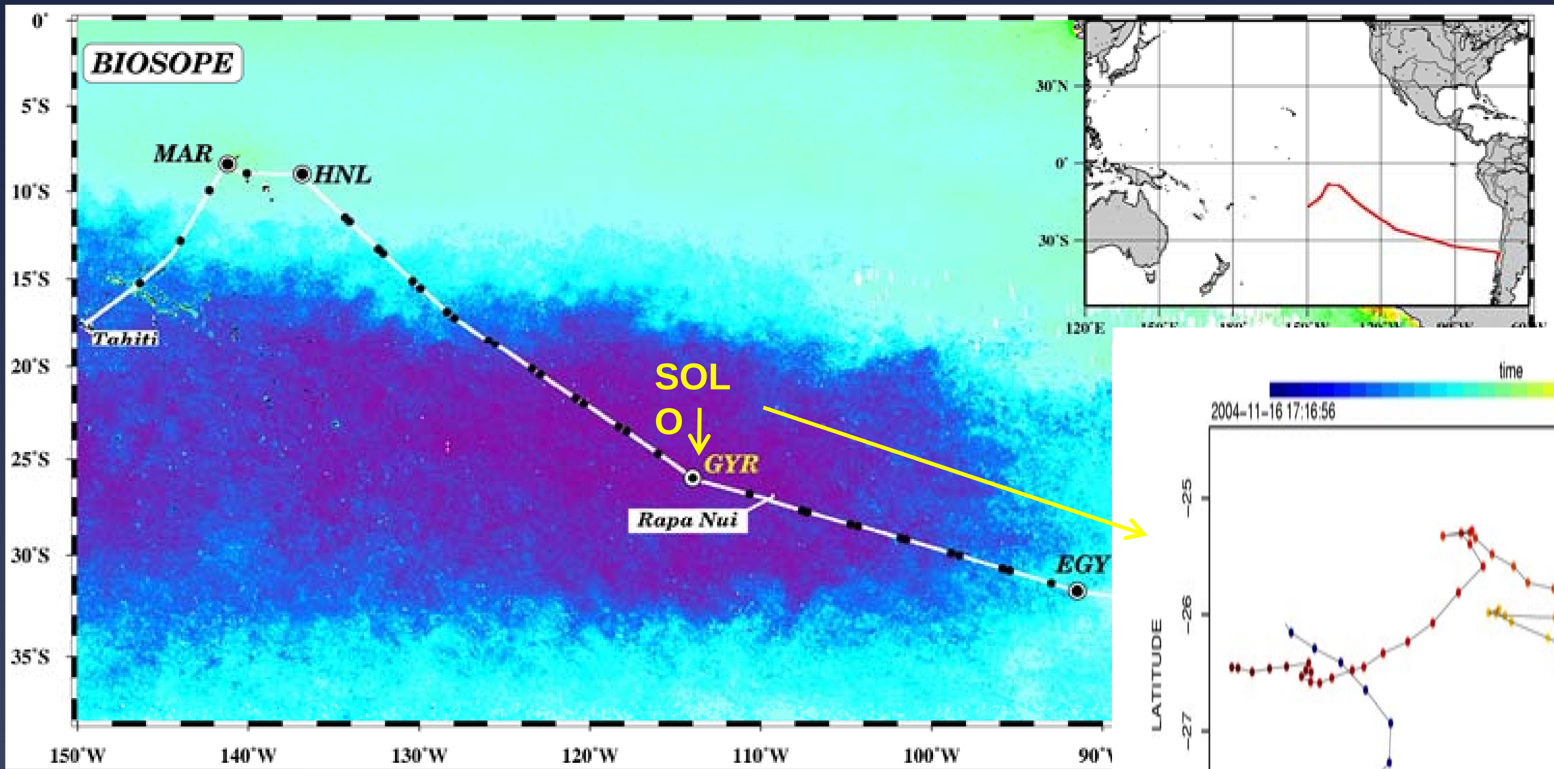
PFTs : Alvain et al. 2005

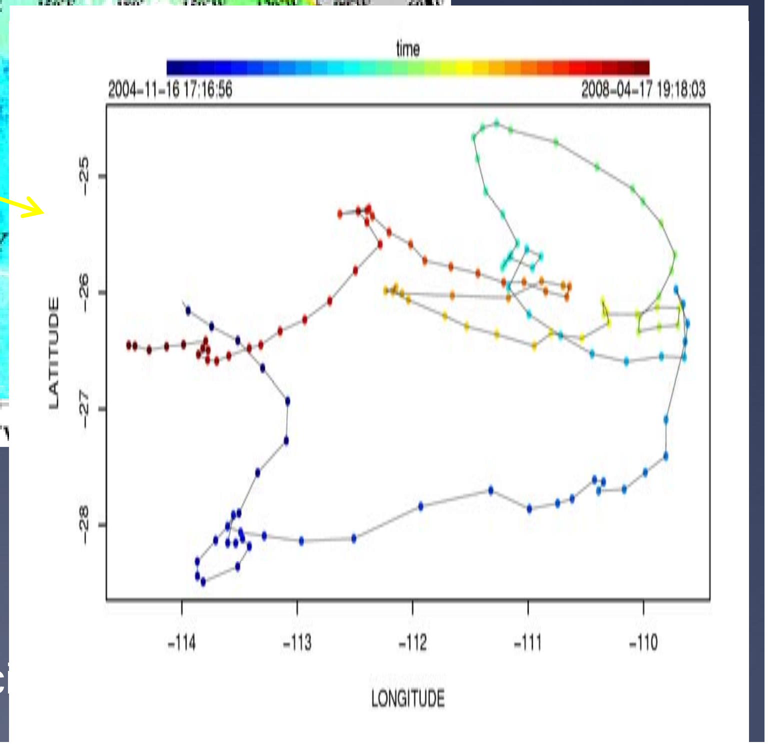
CDM: Brown et al., 2008

CWPs: Sathyendranath, Yoder, Lequéré

Satellite (OCR) - in situ data integration (synergy)

exemple from « simple » Argo float in sub-tropical SPG

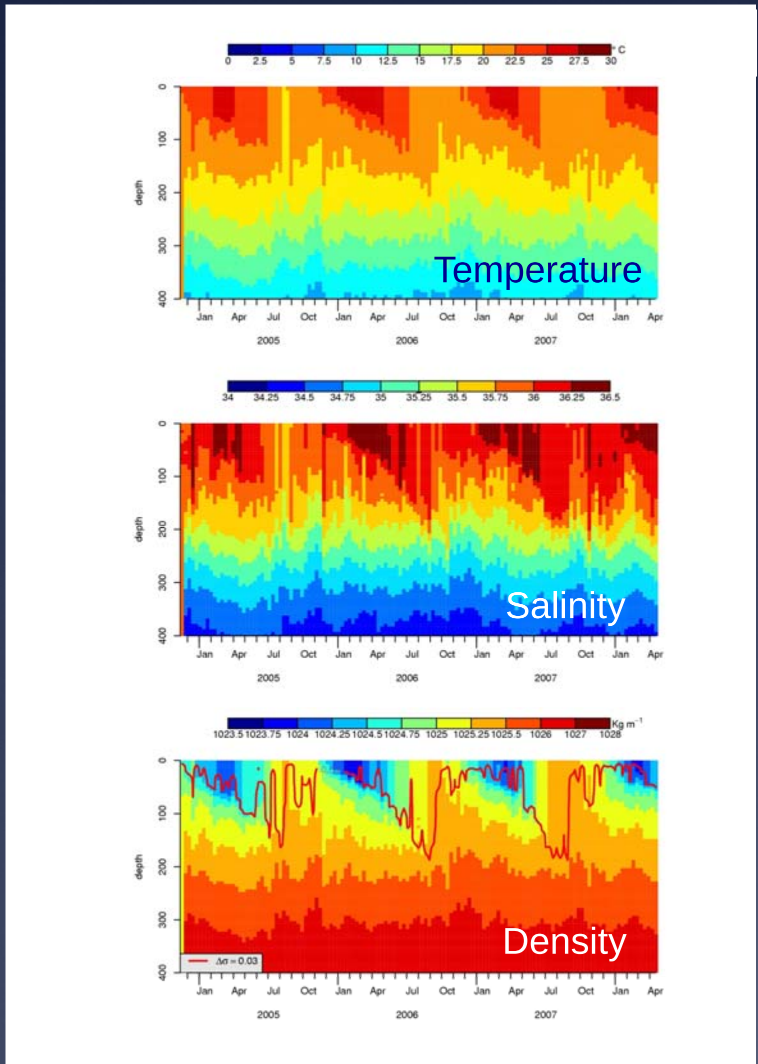


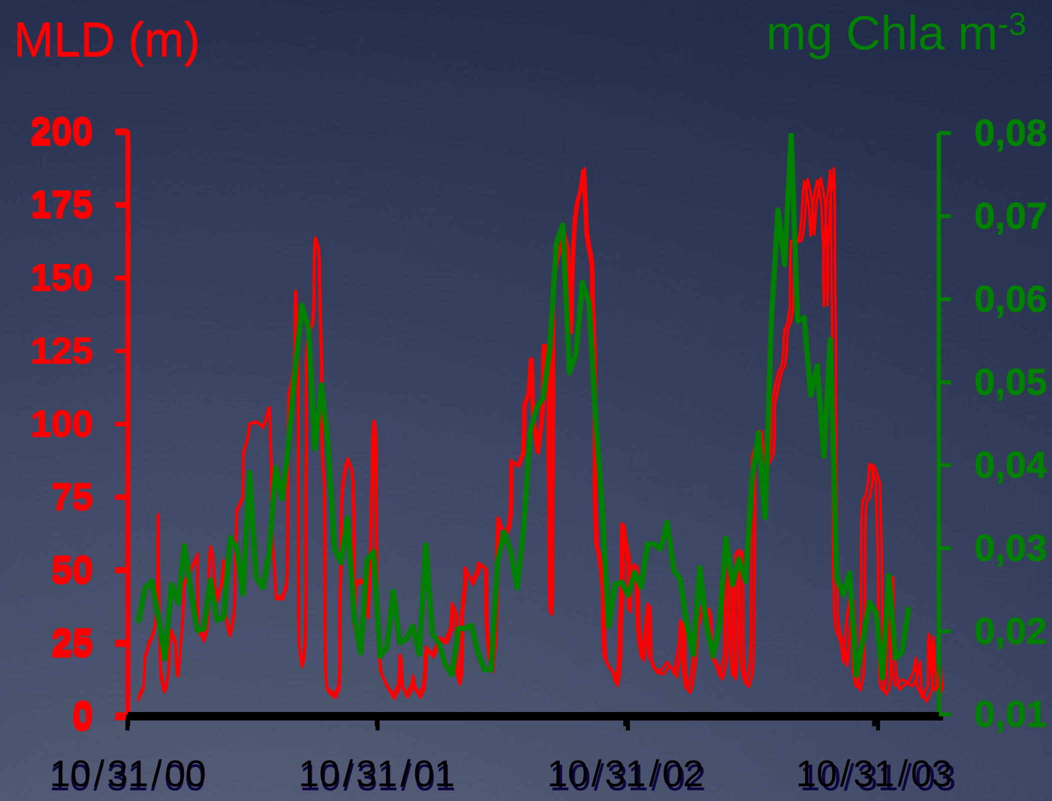


BIOSOPE cruise: see special issue published in Biogeosci

Satellite (OCR) - in situ data integration (synergy)

exemple from « simple » Argo float in sub-tropical SPG



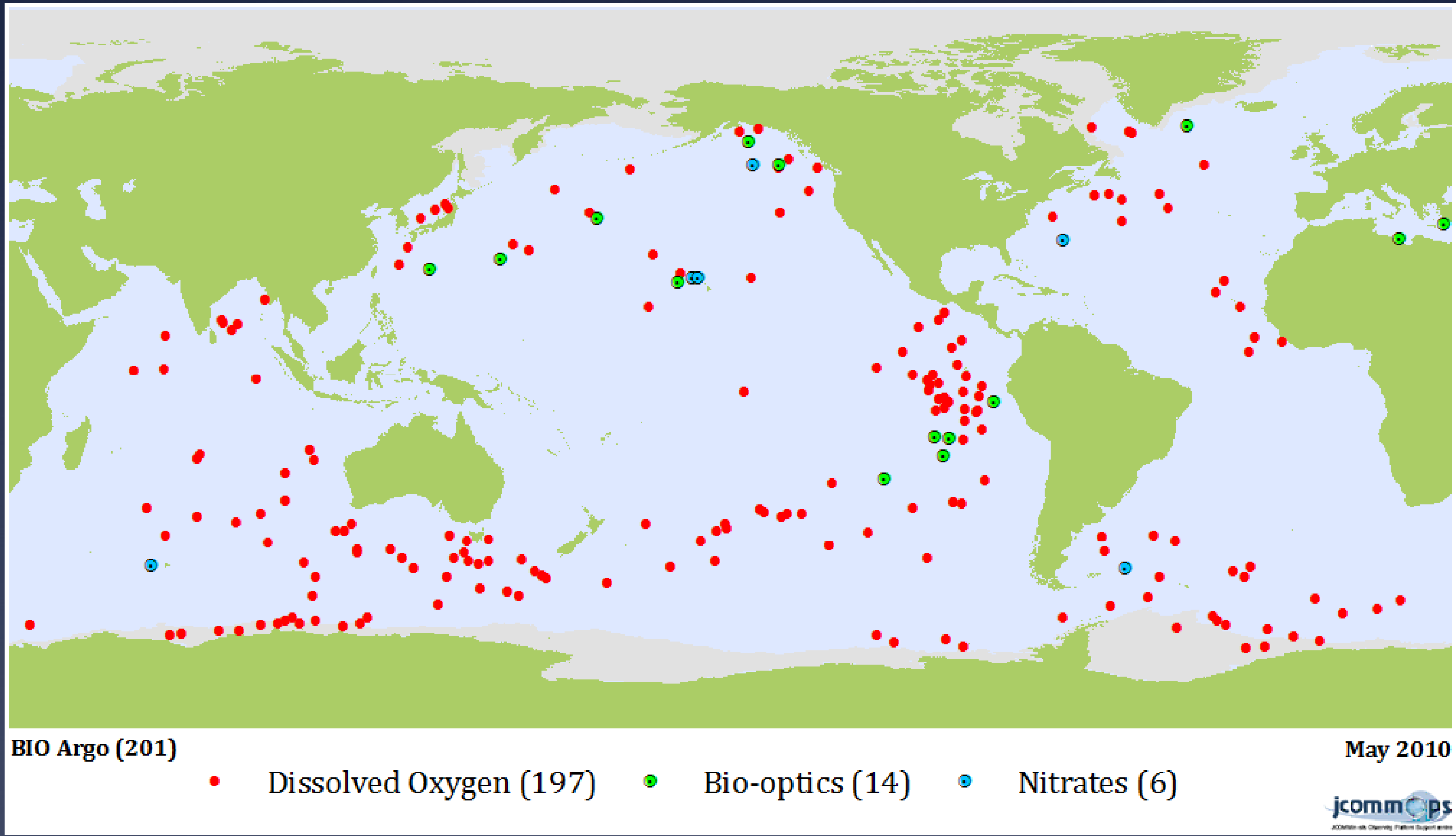


Claustre et al., 2010, in press

Satellite (OCR) - in situ data integration (synergy)

- *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”).

The status of the « bio » Argo network



What are the (known) «Bio-floats » plans at the European scale?

- 30-50 bio-optical (some +NO3) floats (LOV Villefranche).
  - A. Körtzinger (IFM Geomar): + O2
  - Floats deployed in North Atlantic (Labrador, Irminger, Island) and sub-tropical gyres
  - Cruises of opportunity welcome…
- 7-8 bio-optical payload (+ iridium) for Coriolis floats.
  - LOV will set up calibration facilities of sensors.
  - Open to the French community through the regular calls.
- Bio-optical CAL / VAL APEXs: Emmanuel BOSS (PI NASA / NOPP) tested in the Ligurian Sea (October). (D. Antoine & H. Claustre co-Pi)
- Canadian (University of Laval) – French (LOV) collaboration for (~ 30-50) bio-optical floats in the Arctic sub-Arctic (with under-ice capabilities)
- Other pending proposals

We should collect such information as part of Euro-Argo to begin some coordination for the « bio » activities

Merci de votre attention!

…..and special thanks to Serge Le Reste