International activities

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

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Acknowledgements: Pierre Brasseur, Fabrizio d'Ortenzio, Odile Hembise Fanton d'Andon, Arne Körtzinger, Pierre-Yves Le Traon, Antoine Mangin, Laurent Mortier, Pierre Testor, the Euro-Argo group & the IOCCG WG11.

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.

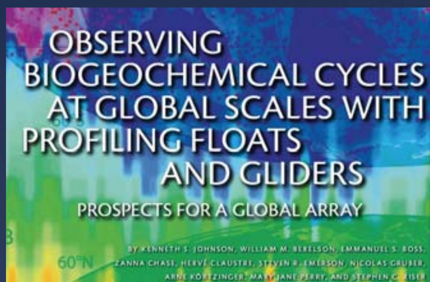
- If, from these emerging (individual, national) initiatives, we begin to coordinate in terms of networks, arrays, data sharing and management, a revolution can be expected in observation for biological and biogeochemical oceanography.

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



Oceanography (2009)

« Bio-Argo » Community White Paper, in press.
« Integrated Bio-platform» Plenary Paper, in press

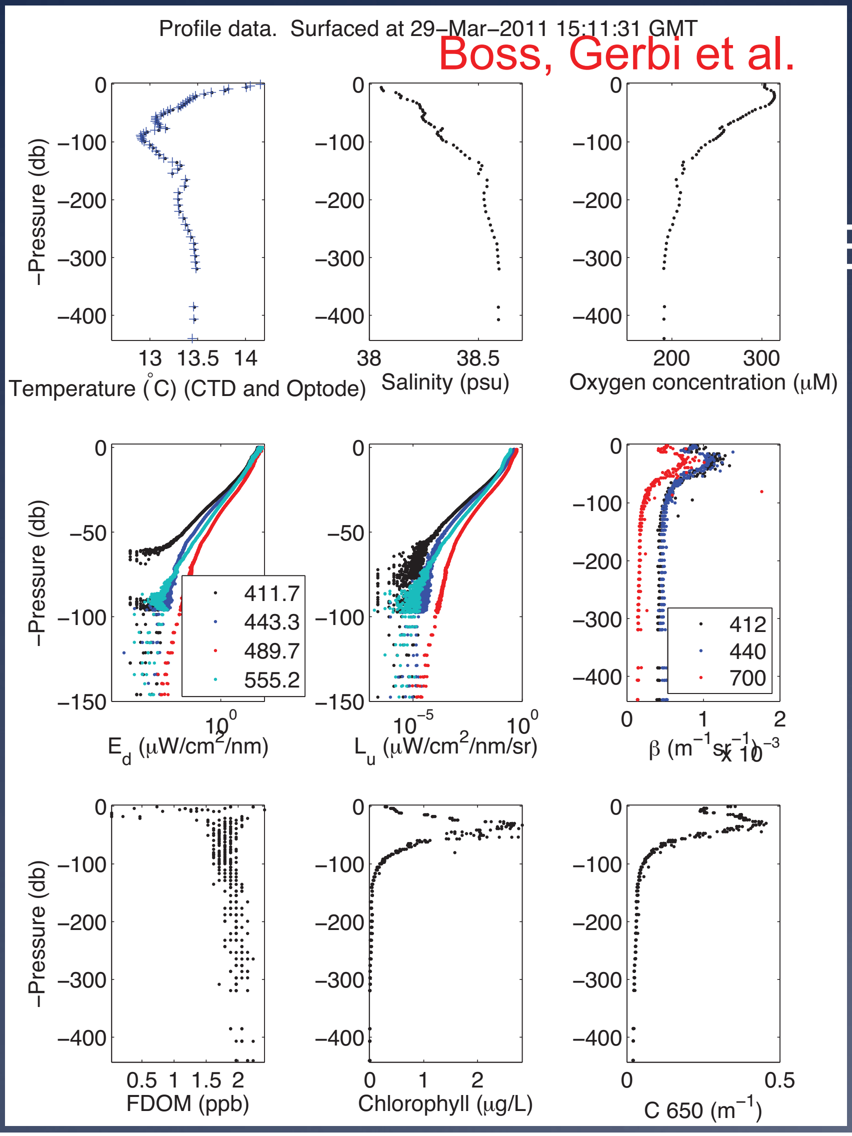
link with Argo established
AST Meeting, March 2011,
Buenos Aires

Presentation outline

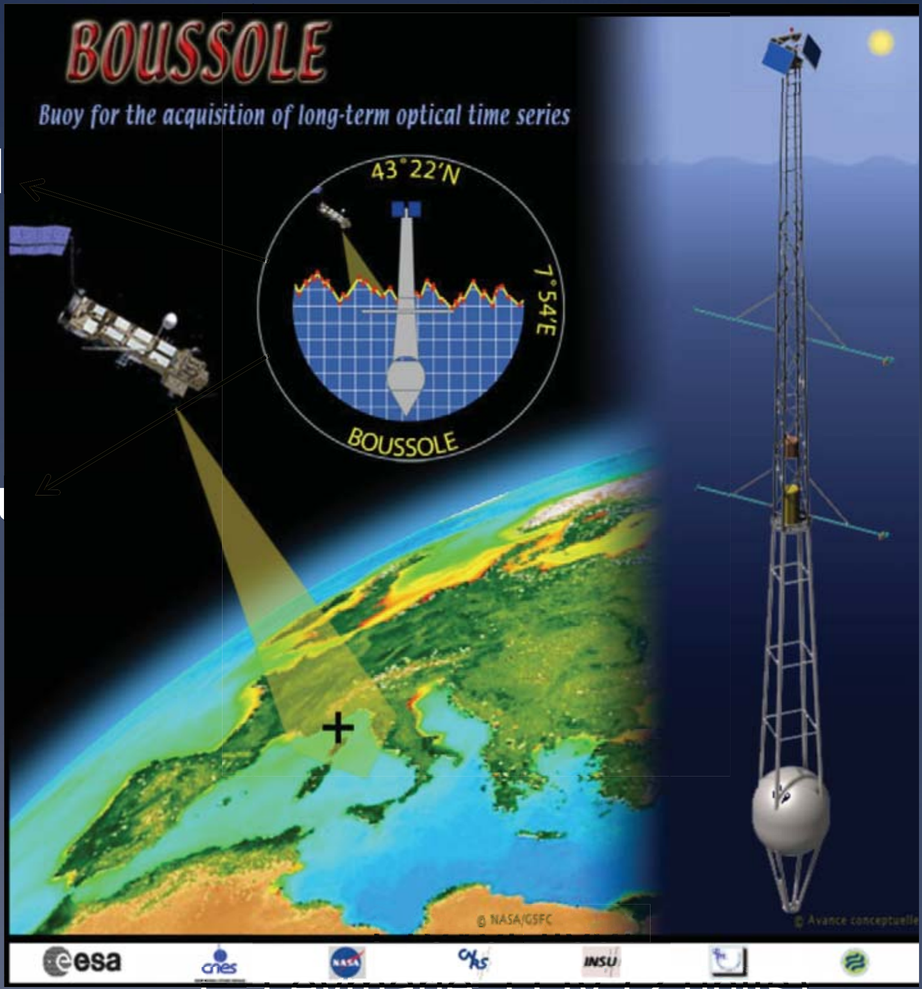
- ❑ Technologie
- ❑ Data management
- ❑ Link with satellite Ocean Color Radiometry
- ❑ European large projects and network implementation perspectives
  - Floats: Euro-Argo, remOcean, NAOS
  - Gliders: GROOM
  - Integration of floats + gliders + remote sensing + modeling + assimilation: OSS2015

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)

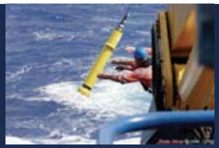
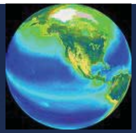
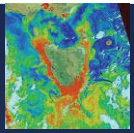
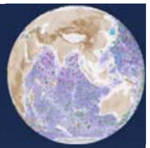


Ed



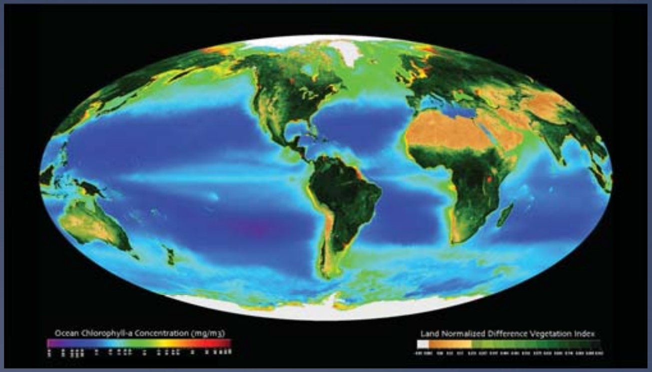
Lu

E. Leymarie, LOV (2 units)



The first four selected « new » variables for a « BIO-Argo » float

- ❑ Oxygen
- ❑ Nitrate
- ❑ Chlorophyll a
- ❑ Particle carbon (from optical proxies)



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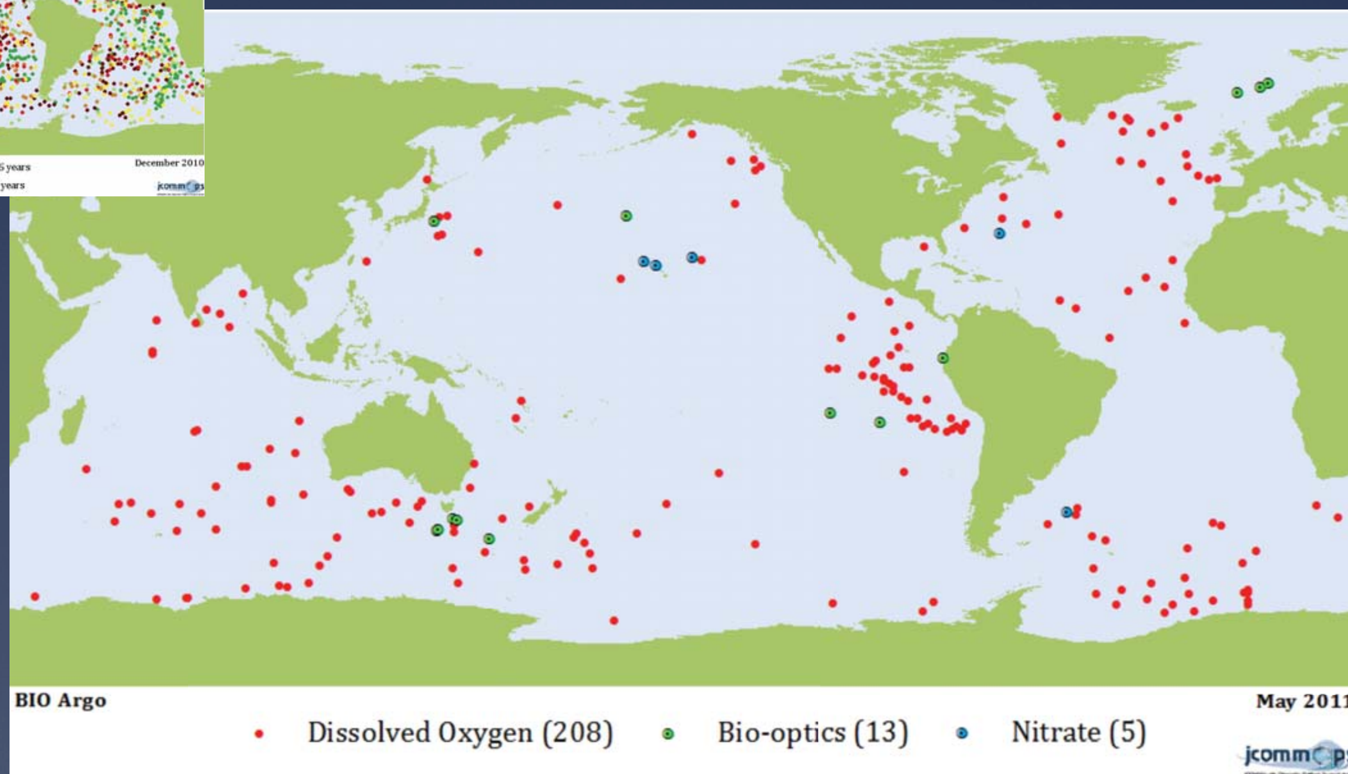
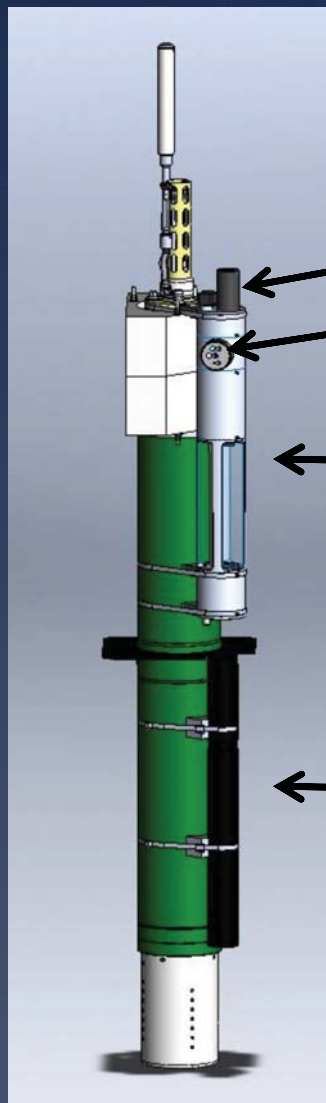


On-going developments in our lab : two examples of (more complete) Bio-Argo "like" floats



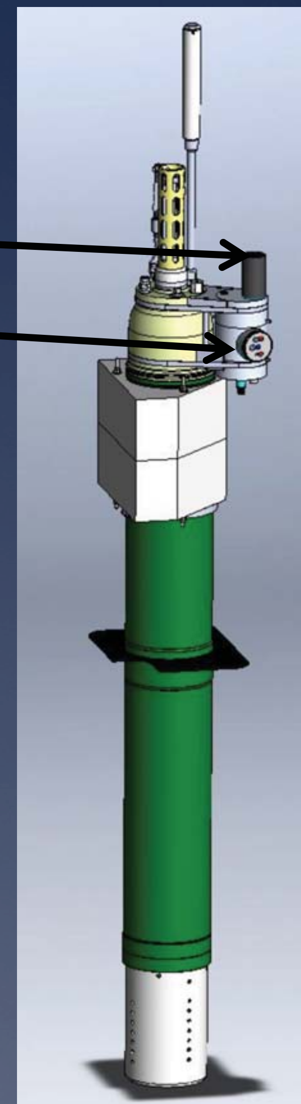
Ed (380, 412, 490) + PAR

Chla fluo, CDOM fluo, $b_b(700)$

c(660)

+ O_2

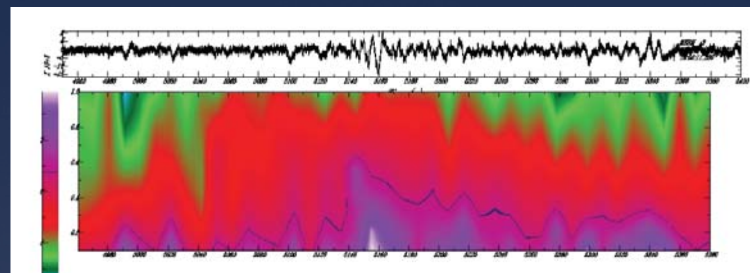
NO_3



remOcean
Remotely-Sensed Biogeochemical Cycles in the Ocean

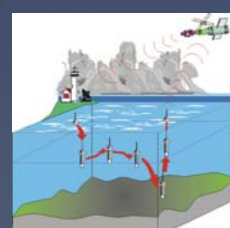
Other “new” variables: the potential of passive acoustic

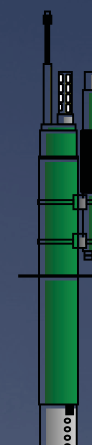
❑ Seismic waves : the mermaids float listen during the drift phase



Guust Nolet, Geoazur

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





❑ Other possible “combo applications” of acoustic during the float drift

- <u>ice detection</u> => float surfacing or not; <u>rainfall and winds</u> (Riser et al., 2008); <u>mammals</u>.

Bio-data management: issues and perspectives #1

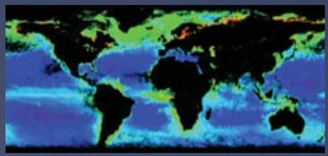
- ❑ Tremendous amounts of “bio” data will be acquired in the near future.

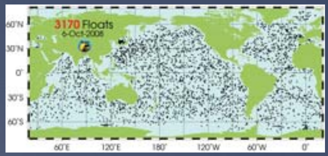
- ❑ An integrated observation system will be operationally useful and scientifically relevant if and only if it is supported by an efficient data management system….BUT

- ❑ 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 “<u>revolution</u>” 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



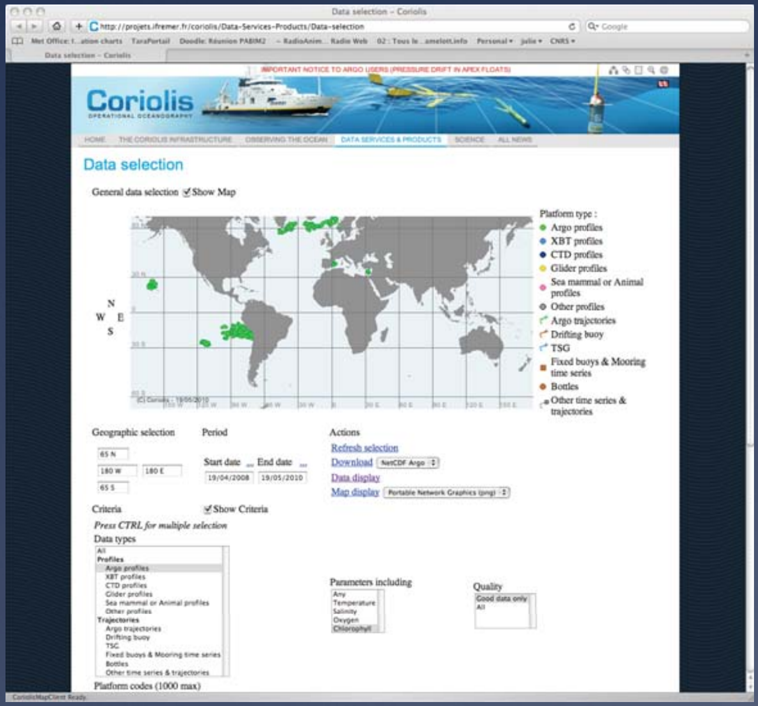


  - **<u>Real-time</u>** delivery with real-time **<u>QC</u>** (operational data)
  - **<u>Delayed mode QC</u>** delivery after data reprocessing (scientific, climatic-trend value): real issue of climatologies for biology / biogeochemistry.
  - Generation of derived products

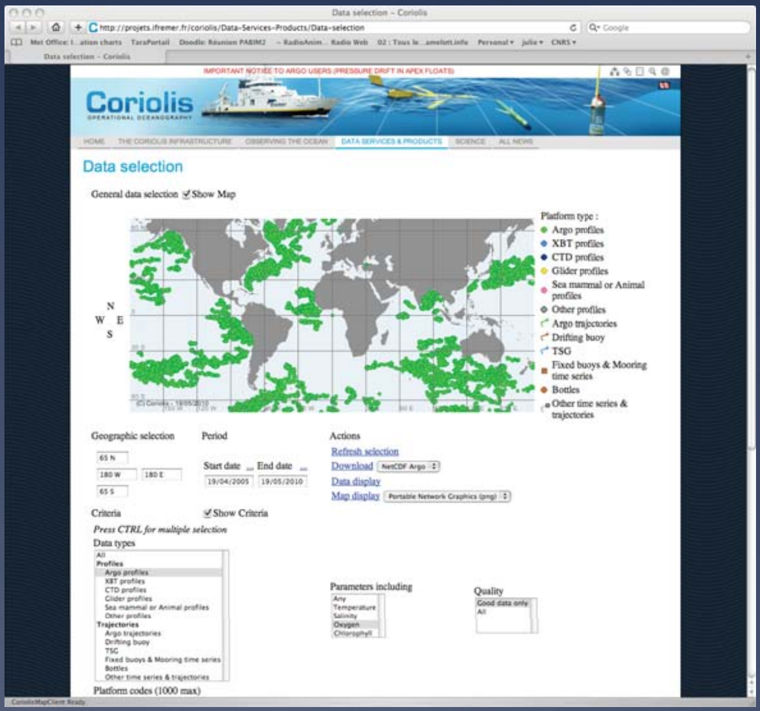
“Bio-data” management issues and perspectives #2

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

Chlorophyll a



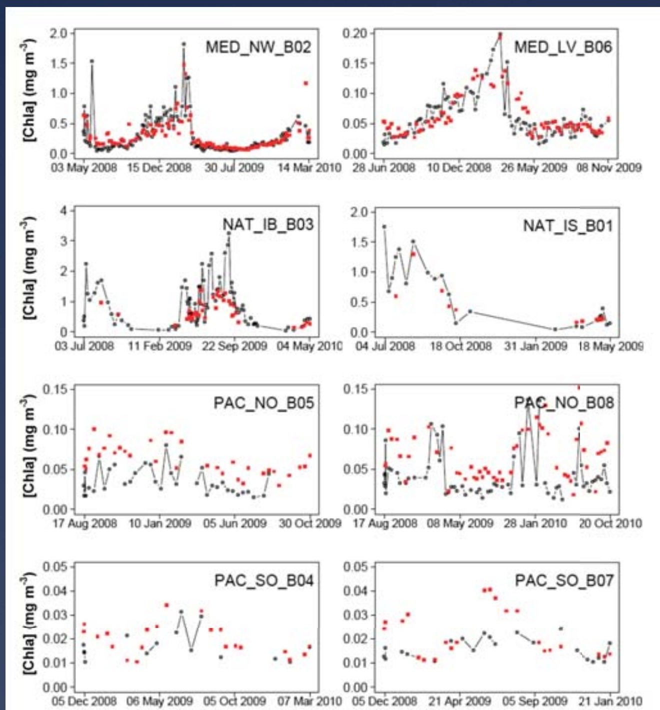
Oxygen



“Bio-data” management issues and perspectives #3

Delayed mode procedure are being developed
(combination of sensors)

Chlorophyll *a*



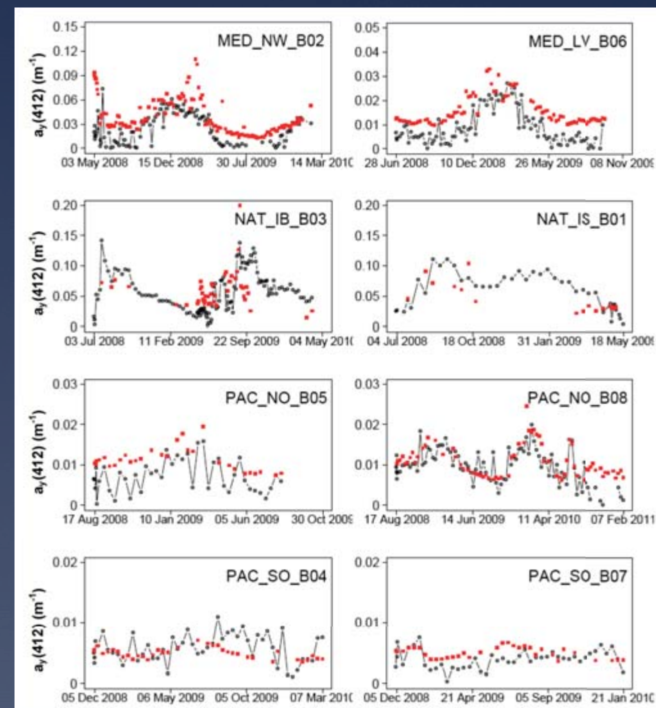
Med Sea

North Atlantic sub-polar gyre

North Pacific sub-tropical gyre

South Pacific sub-tropical gyre

CDOM

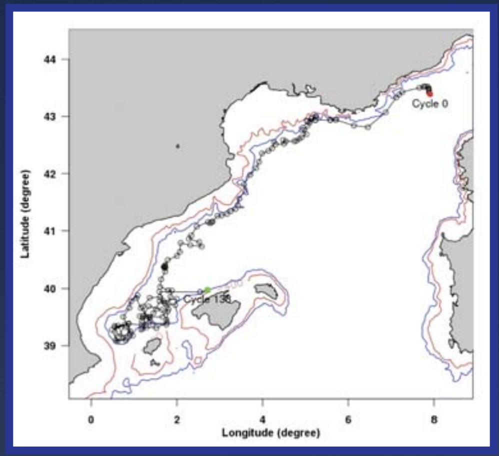


surface float / MODIS

Xing, X., et al. (2011). *Journal of Geophysical Research,* 116, C06020, doi: 10.1029/2010JC006899

Xing, X., et al. (submitted)., *Journal of Geophysical Research, submitted*

iridium and float recovery

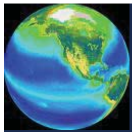


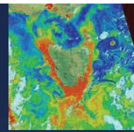
❑ « end of life command »: the float stays at the surface and send a GPS point every one hour.

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

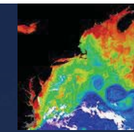
❑ Extremely important recovery to analysis sensor status. Some bio-fouling (essentially the bottom window of the transmissiometer)

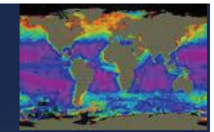
❑ implementation of Copper “protection” potentially useful





Scientific perspectives: the link with OCR satellite products

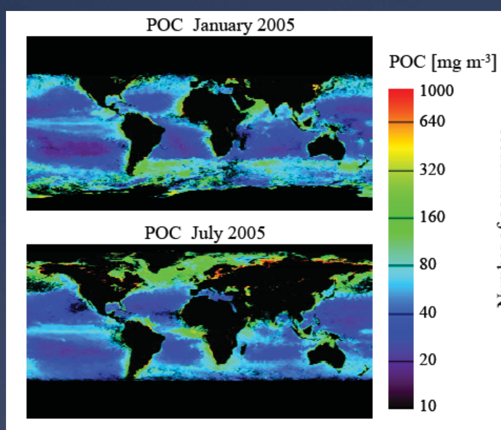




- ❑ Ocean Color Radiometry remote sensing was initially developed for Chla retrieval.

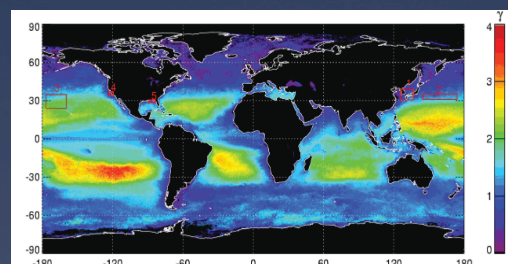
- ❑ Now, (many) “new” biogeochemical / ecosystems products can be retrieved from space; some of them are also measured in situ by profiling floats.

proxies for POC



POC : Stramski et al., 2008

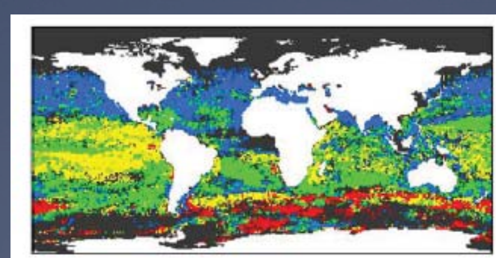
proxies for the composition of particles



Particle size: Loisel et al., 2006

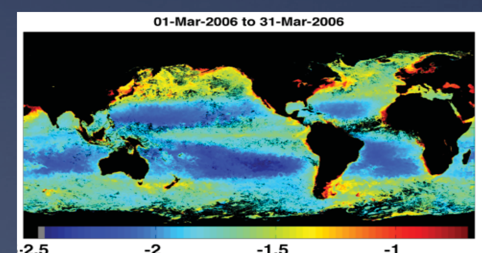
Kostadinov et al., 2010

Phytoplankton size: Uitz et al., 2006

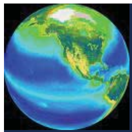


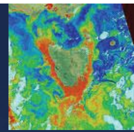
PFTs : Alvain et al. 2005

proxies for CDOM

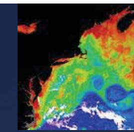


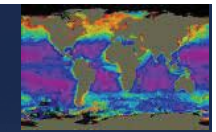
Siegel et al et al., 2002





Scientific perspectives: the link with OCR satellite products #2





❑ *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.

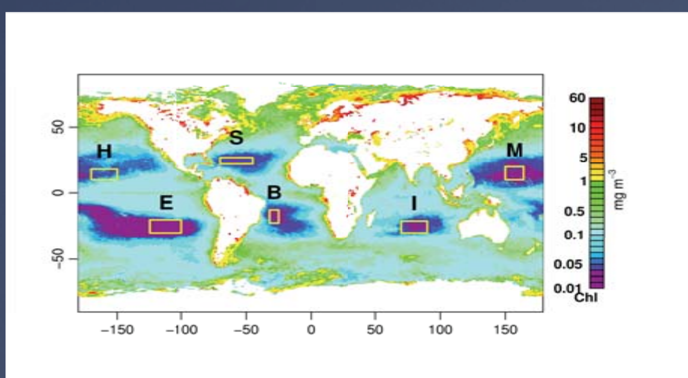
Pi: Hervé Claustre, collaboration with A. Körtzinger, AWI

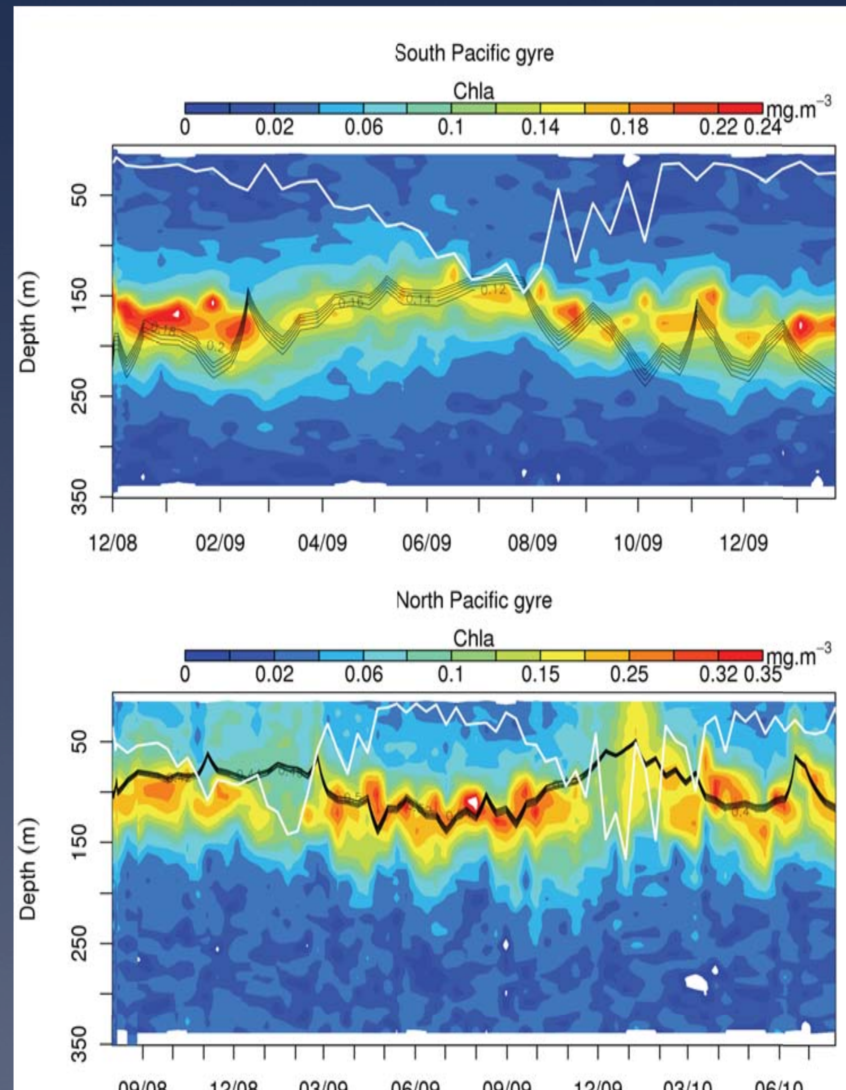
sub-tropical gyres

Remotely-Sensed Biogeochemical Cycles in the Ocean

- 40% of the global ocean.
- <u>primary production (NCP)</u>: controversial
  - ✓ classical (incubation) methods & models: 2-3 times lower than:
  - ✓ «non-intrusive» techniques (O2 isotopes; O2 floats budget)

- <u>inter-gyre variability :</u>
  - ✓ N limitation (North & South Pacific) vs P limitation (North Atlantic)
  - ✓ seasonal





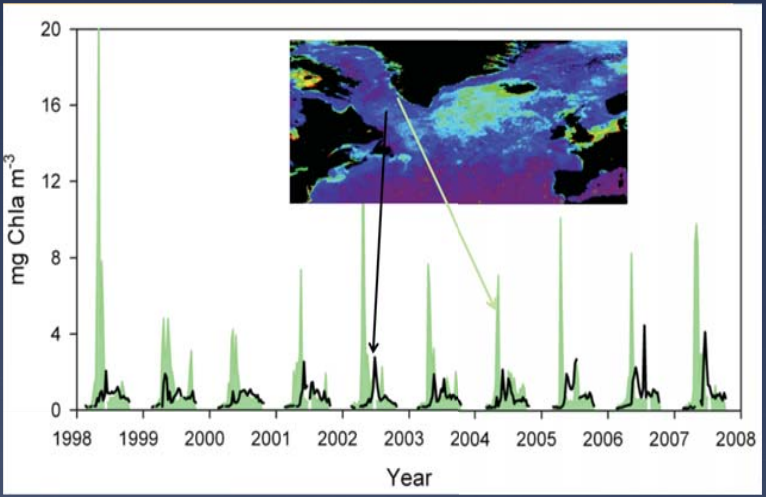
NA sub-polar Gyre

• 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

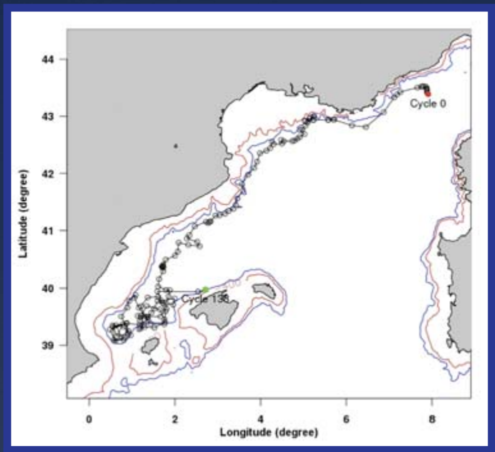


• small scale variability (day, week) in Zm and bloom

  ✓ 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

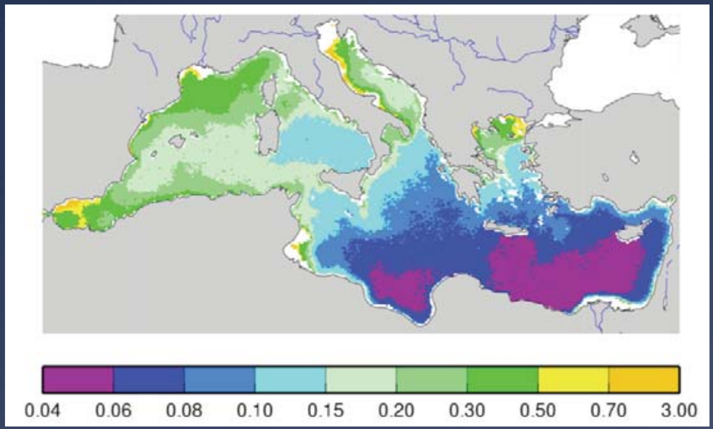
9-year project (2011-2020), french «equipment of excellence » funding scheme

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

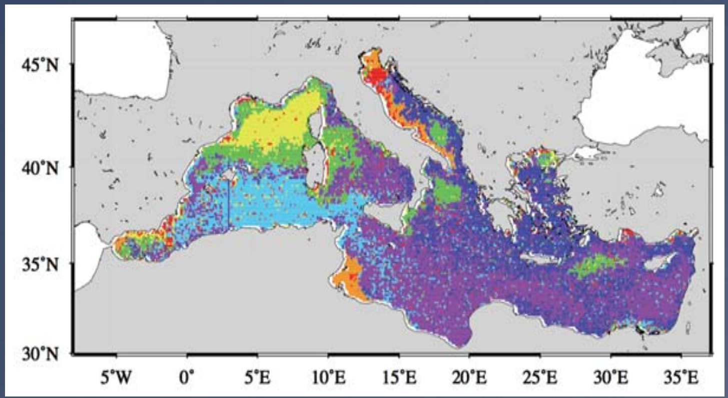
Pi: Ifremer (P.-Y. LeTraon), co-Pi: UPMC (H. Claustre)

Mediterranean Sea: understanding phytoplankton dynamics (phenology) within various trophic regimes

chlorophyll a



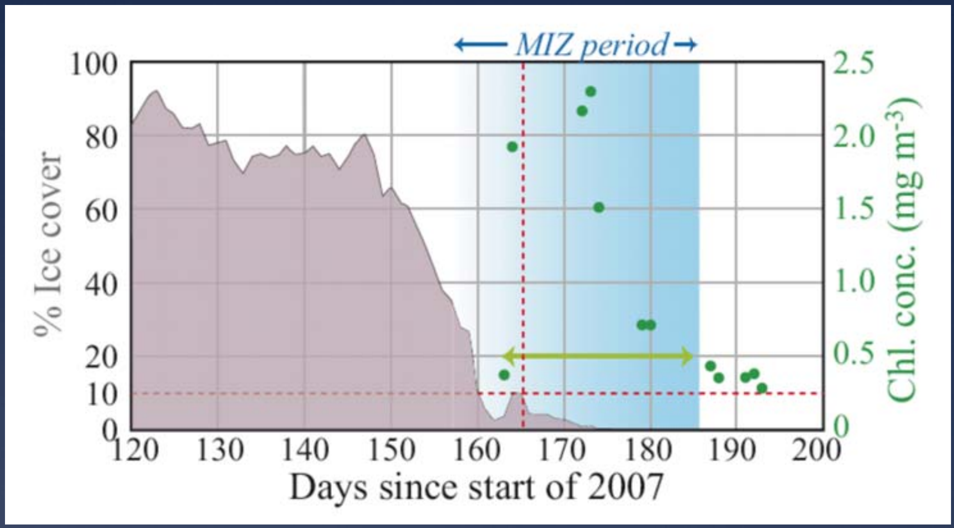
5 open-ocean trophic regimes



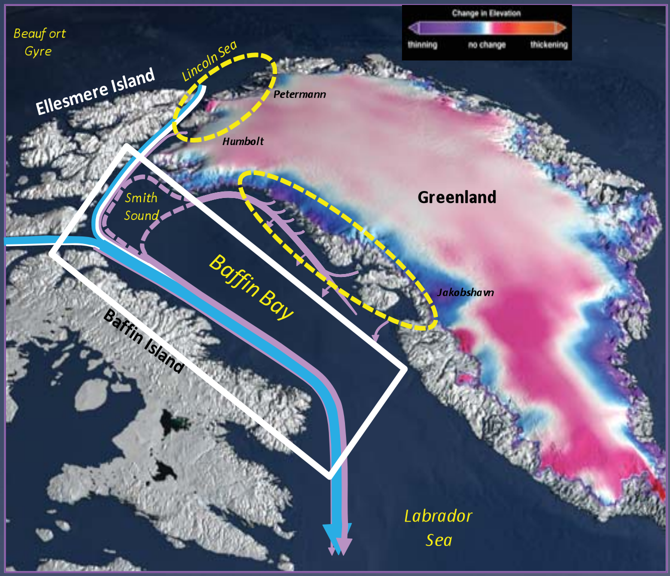
- deployments adapted to trophic regimes : seasonality in biomass
- Evolution of the Argo rules (every 10 days, more float density than 300 km x 300 km)
- intensification of observations (time / space)
- 30 "remOcean" floats

F. D'ortenzio, LOV

Arctic: Ice-edge blooms



Perrette et al. (2011)



- 13 +13 « remOcean » floats with ice detection

TAKUVIK

NAOS Novel Argo Ocean observing System

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 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.

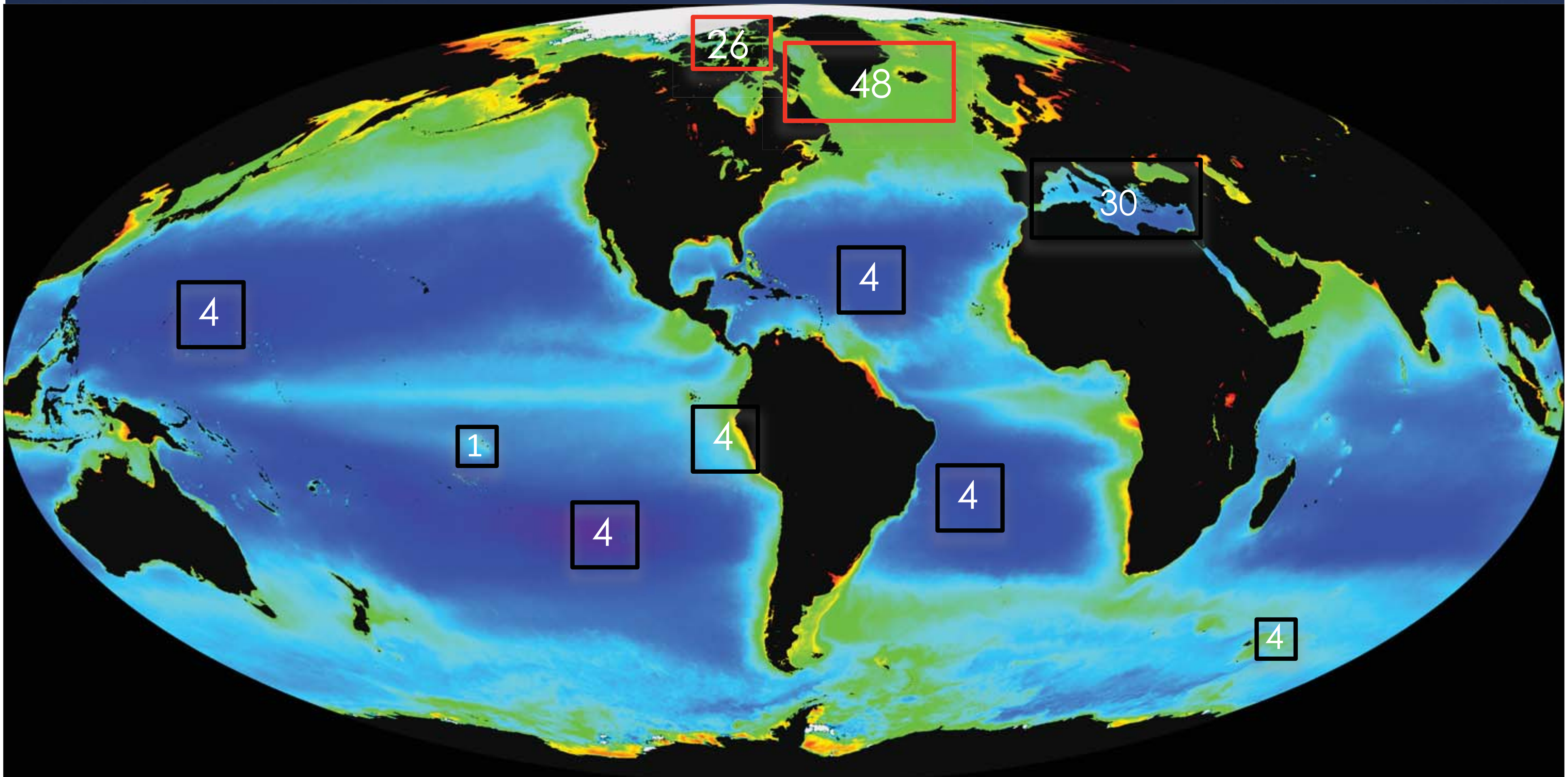
- There are indeed regional "hot-spots" " that are "natural laboratories" for addressing key scientific questions of global relevance.

  - **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 CO_2 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



Remotely-Sensed Biogeochemical Cycles in the Ocean

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)

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

Remotely-Sensed Biogeochemical Cycles in the Ocean

12 deep O_2: 2014
12 deep O_2: 2016

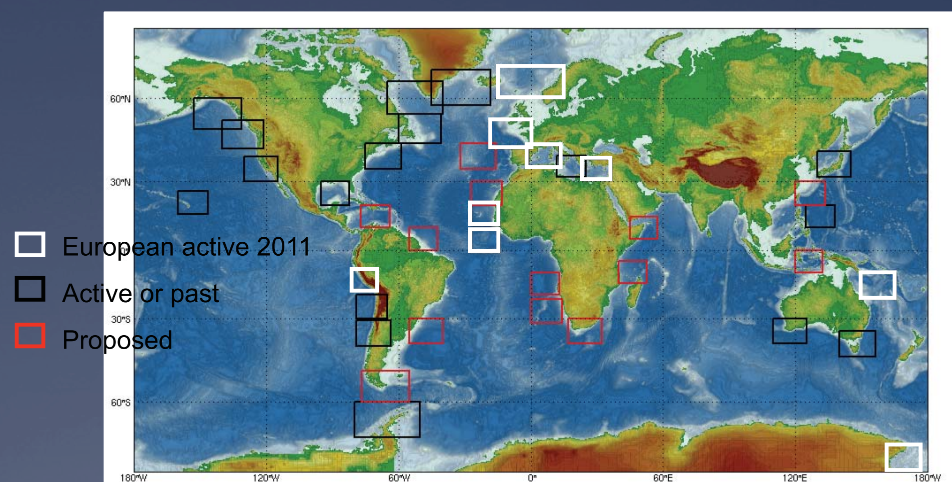
24 floats: 2012-2013
bio-optics, O_2, NO_3 (some)

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"

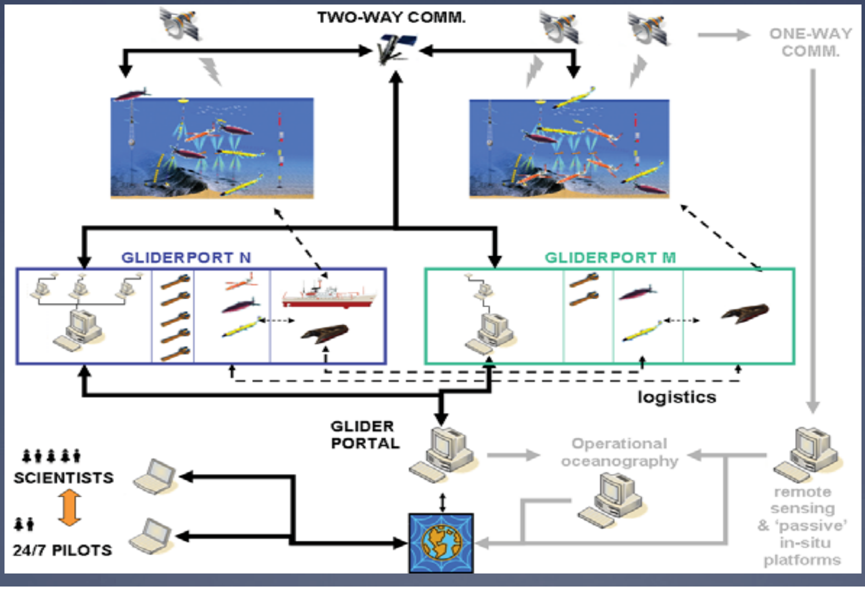
Status of the European fleets (2011)



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:

<u>integration</u>

floats + glider + satellite + model & assimilation

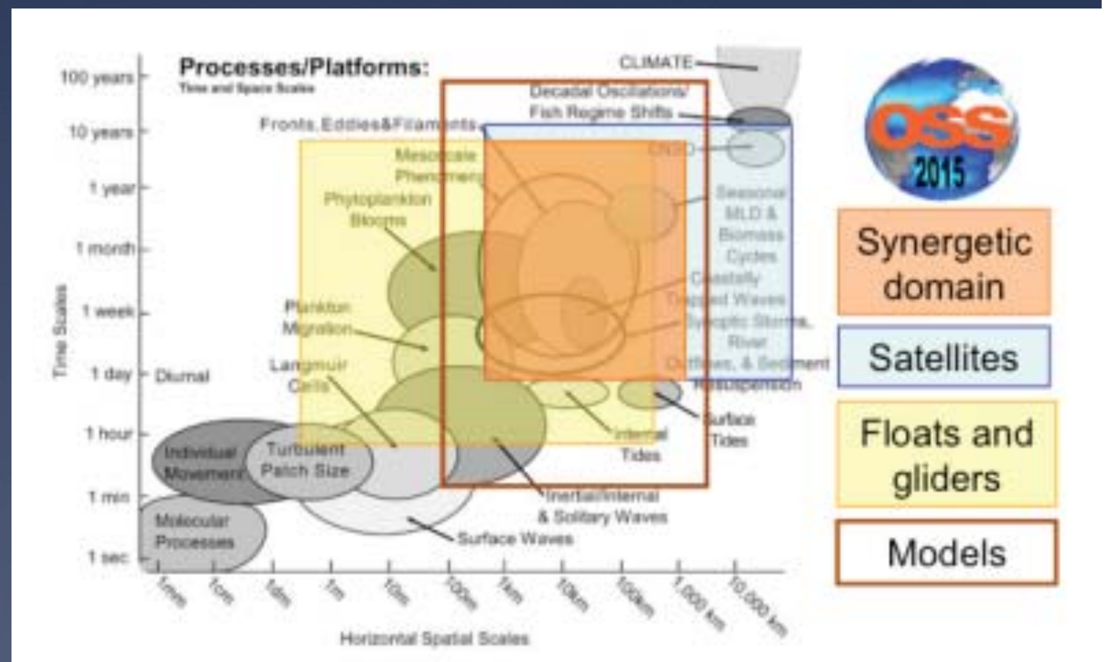
The OSS 2015 project

Ocean Strategic Services beyond 2015

funded by the EU Seventh Framework Programme (FP7) – Space 2011. Project duration : 3 years

Objectives:

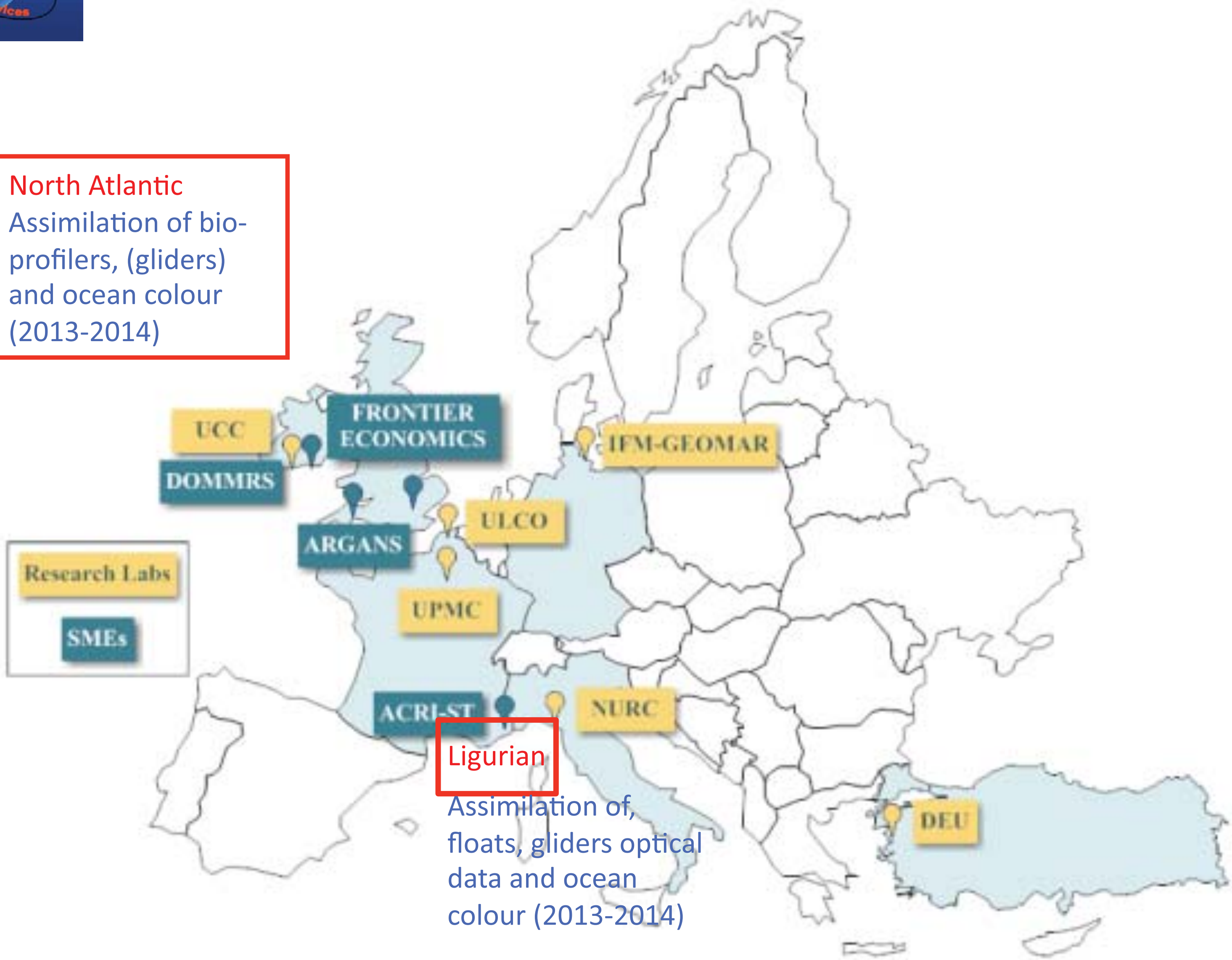
- Promote the assimilation of ocean colour and in situ observation data into biogeochemical models
- Contribute to a better characterisation of Chl-a vertical distribution vs surface information
- Define and test methodology for optimisation of observation network and of complementarity between in situ 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)

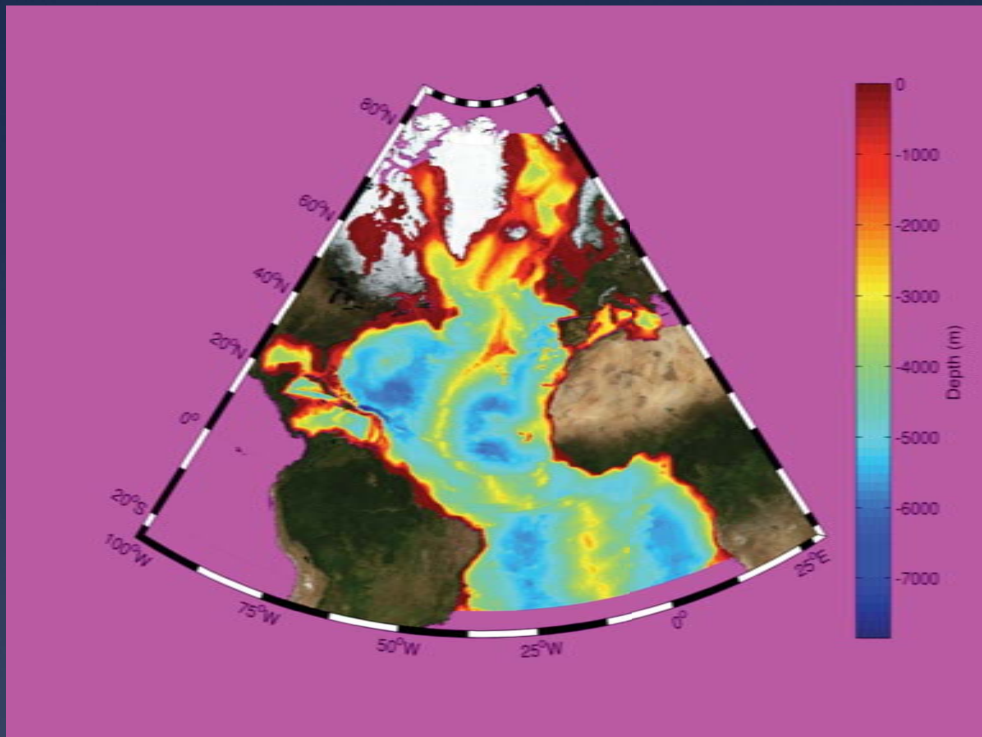
Partnership / pilot sites

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



<u>Physical model</u>

NEMO

NATL025

ECMWF forcings

U,V :10 m } 6h

T,H :2 m

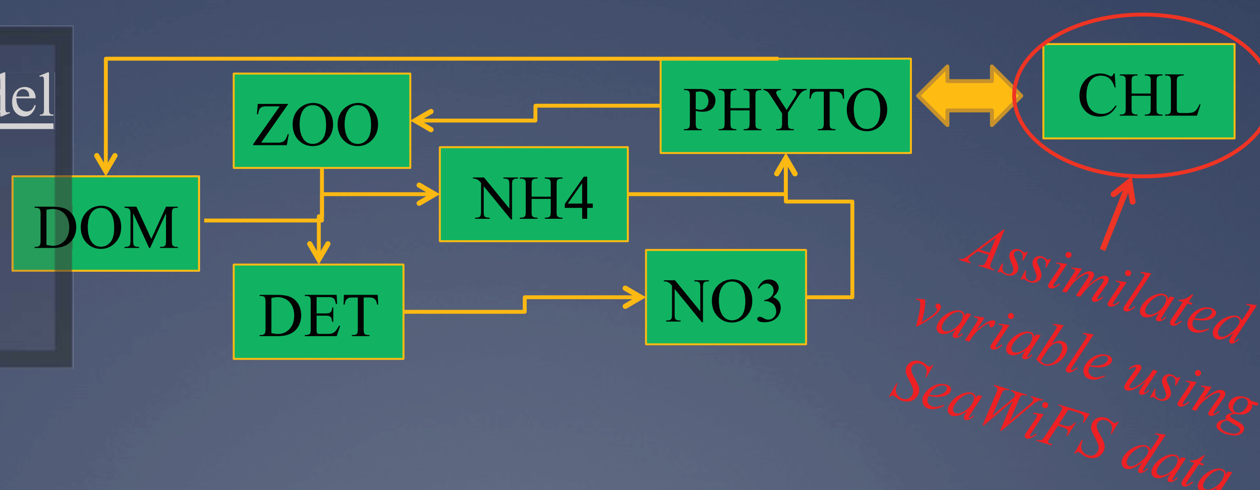
Precipitations } month

Radiations } 24h

<u>Biogeochemical model</u>

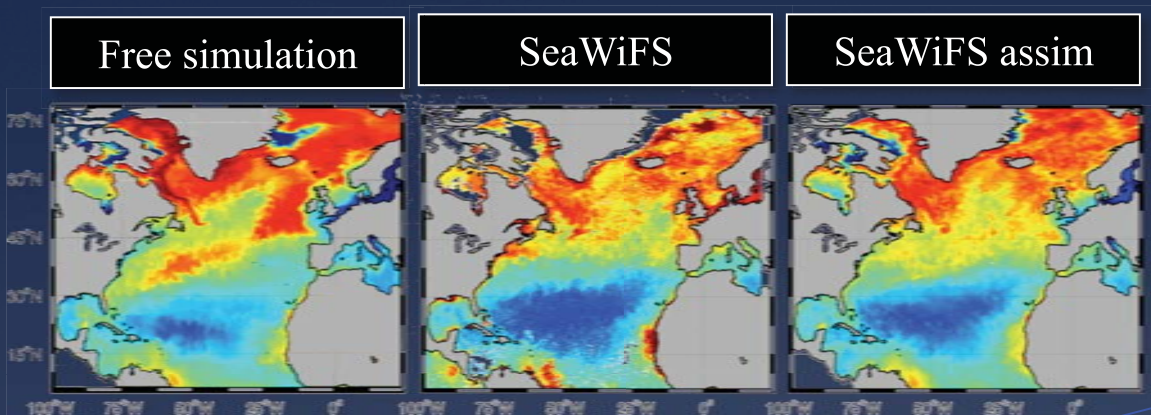
LOBSTER

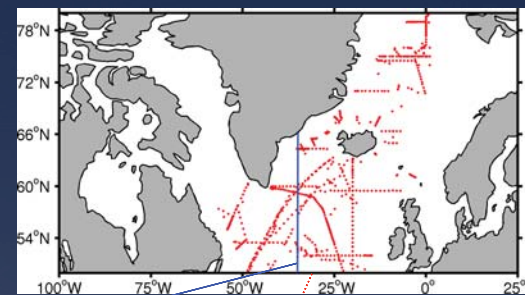
Nitrogen cycle



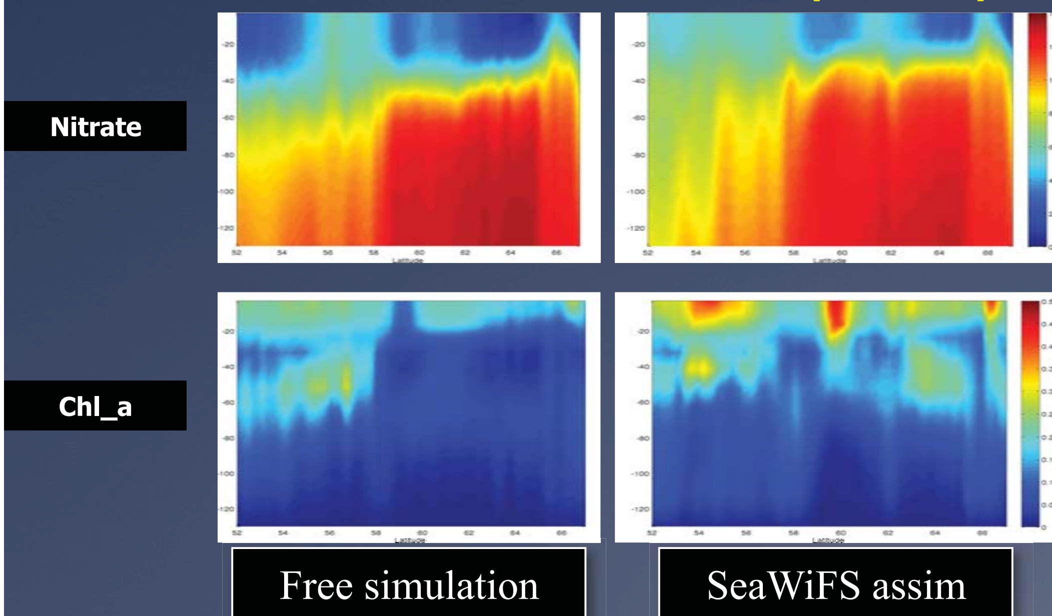
Reanalysis product: April-May 2006 snapshot

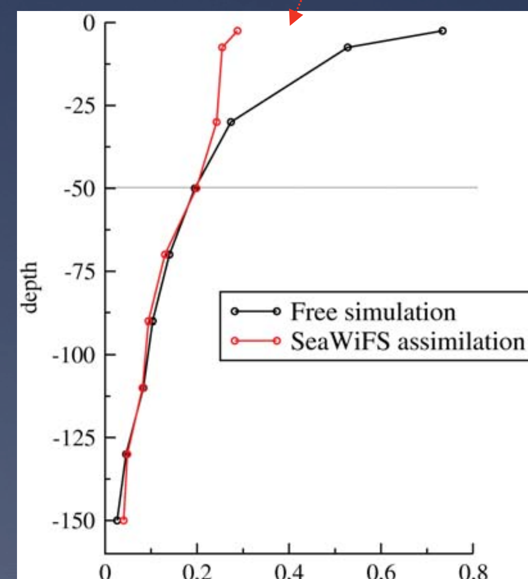
Positive impact of OCR assimilation on nitrate in the upper 30 m





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 <u>explore</u> 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 <u>progressive implementation</u> 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!

Bio-Argo & outreach activities

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

➤ *Integrating profiling floats with extended capabilities in future education and outreach activities. COSEE Vision paper - Scheurle, C., Claustre, H., Antoine, D., Boss, E., Johnson, K., Körtzinger, A., Mangin, A., Nolet, G., Perry, M.-J., Schofield, O. and J. McDonnell (2010).*

Thank you