A Bio-Argo pilot network in the Mediterranean Sea

Maurizio Ribera D'Alcalà, SZN Italy
Daniele Iudicone, SZN Italy
Fabrizio D'Ortenzio, LOV, France
Louis Prieur, LOV France
Vincent Taillandier, LOV France
Hervé Claustre, LOV France
Clement Fontana, LOV, France
Pierre-Yves Letraon, IFREMER, France
Laurent Mortier, ENSTA, France
Miro Gacic, OGS, Italy
Giuseppe Civitarese, OGS Italy
Pierre Marie Poulain, OGS, Italy
Carlos Duarte, IMEDEA, Spain
Susana Augusti, IMEDEA, Spain
Tommy Moore, IMEDEA, Spain
Patrizia Ziveri, UAB, Spain

Definition and goal

Bio-Argo

An oceanic observing system based on a large array of profiling floats equipped with biogeochemical sensors, sharing unique data management and representing a fully, inter-operating, sub-set of the Argo T/S network

Goal

Providing systematic biogeochemical observations that would greatly reduce the uncertainties in our estimation of elemental (C, N, O) fluxes at global scale and increase our ability to detect changes in these fluxes.

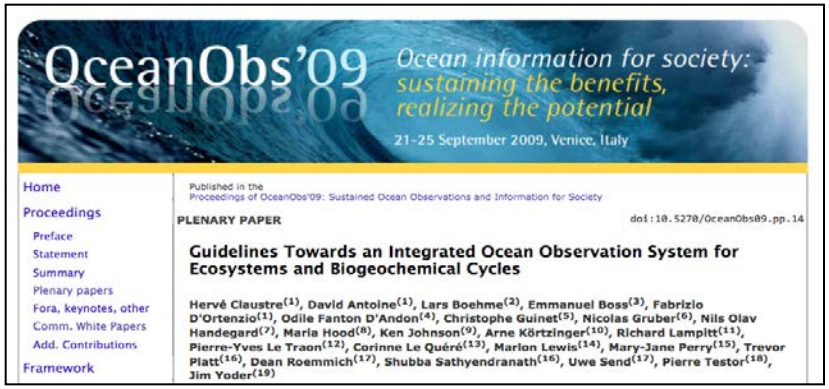
Context

The guidelines for a Bio-Argo network

Ocean Obs 09 final statement number 2/5:

«Calls on all nations and governments to commit to the implementation and international coordination of **systematic global biogeochemical and biological observations,** guided by the outcomes of OceanObs'09, and taking into account regional variations in ecosystems. »

The guidelines for a Bio-Argo network


OceanObs'09

Ocean information for society: sustaining the benefits, realizing the potential

21-25 September 2009, Venice, Italy

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Published in the Proceedings of OceanObs'09: Sustained Ocean Observations and Information for Society

PLENARY PAPER

doi:10.5270/OceanObs09.pp.14

Guidelines Towards an Integrated Ocean Observation System for Ecosystems and Biogeochemical Cycles

Hervé Claustre[1], David Antoine[1], Lars Boehme[2], Emmanuel Boss[3], Fabrizio D'Ortenzio[1], Odile Fanton D'Andon[4], Christophe Guinet[5], Nicolas Gruber[6], Nils Olav Handegard[7], Maria Hood[8], Ken Johnson[9], Arne Körtzinger[10], Richard Lampitt[11], Pierre-Yves Le Traon[12], Corinne Le Quéré[13], Marlon Lewis[14], Mary-Jane Perry[15], Trevor Platt[16], Dean Roemmich[17], Shubha Sathyendranath[16], Uwe Send[17], Pierre Testor[18], Jim Yoder[19]

Recommendations for the different components of an Integrated Ocean Observation System for ecosystems and biogeochemical cycles

1. The core variables : **NO3, O2, Chl , POC (optical)**

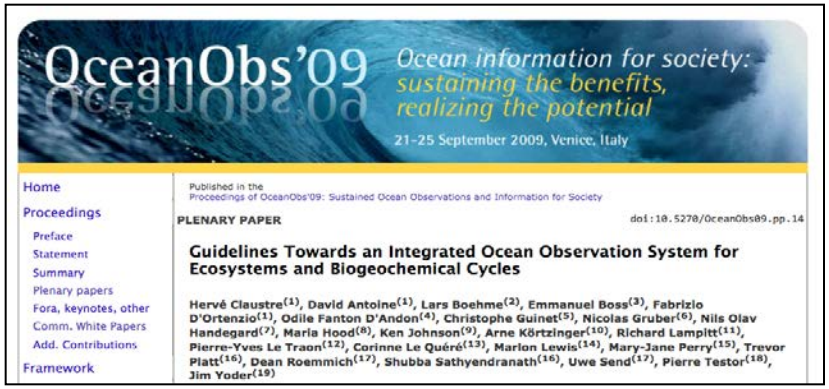
2. The sustainability of the entire system will depend on the capability of our community to implement a **dedicated data management** system.

3. The integrated system has to be clearly defined and then implemented in **close association with physical oceanographers**

4. The community should begin "**simple**" and consider the observation of "**super sites**" in key areas

5. Tight synergy with **satellite ocean color radiometry** as well as advanced **numerical models** of biogeochemical cycles.

The guidelines for a Bio-Argo network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And for Bio-Argo?

1. The core variables : **NO3, O2, Chl , POC (optical)** — Ok
2. The sustainability of the entire system will depend on the capability of our community to implement a **dedicated data management** system. — Work in progress
3. The integrated system has to be clearly defined and then implemented in **close association with physical oceanographers** — Ok
4. The community should begin "**simple**" and consider the observation of "**super sites**" in key areas — Work in Progress This talk
5. Tight synergy with **satellite ocean color radiometry** as well as advanced **numerical models** of biogeochemical cycles. — Work in Progress This talk

The NAOS project
Novel Argo Ocean observing System

A French long-term project (EQUIPEX 2009-2019) to consolidate and improve the French and European contribution to the international Argo observing system and to prepare the next decade of Argo.
(PI P.Y. Le Traon)

A whole WP dedicates to the implementation of a Bio-Argo pilot network in the Mediterranean Sea

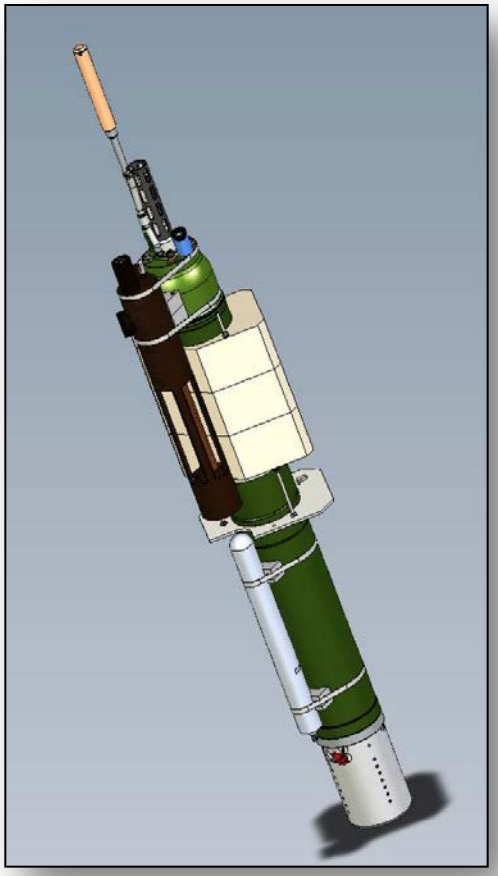
Strongly connected with FP7-ERC remOcean project (PI H. Claustre)

Mediterranean NAOS Activity

28 Bio-Argo floats in two deployment phases: 2012/2013 and 2015/2016

NKE - ProvBio II

- Provor CTS4
- IRIDIUM transmission
- T,S
- Chl, CDOM, bb, Irr, PAR
- O_2, NO_3



Fully compatible with Ocean Obs 09 requirements

see the poster and the next presentation of A. Poteau for details on the PROVBIO II and on the sensors

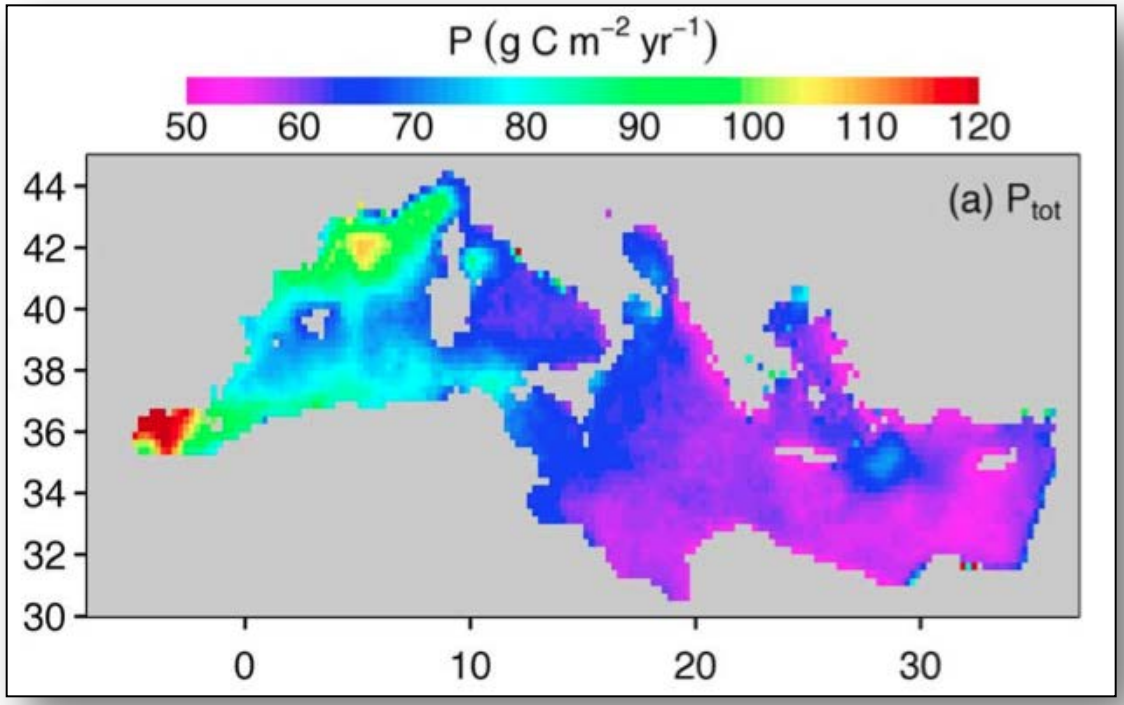
Mediterranean NAOS Activity

Several general aspects of Bio-Argo are treated in the NAOS Mediterranean activity:

- Technological issues (i.e. NO3 sensors in ultraoligotrophic environment)
- Data treatment and management (i.e. QC for Bio-Argo, sensors calibration)
- Synergy with Ocean Color
- Implementation aspects (i.e. deployment strategy, sampling protocols)

Why the Mediterranean?

- **Large spectrum of biogeochemical regimes**



Uitz et al. 2012

- Essentially oligotrophic (low PP)
- Spots of mesotrophic regimes (high PP)

Why the Mediterranean?

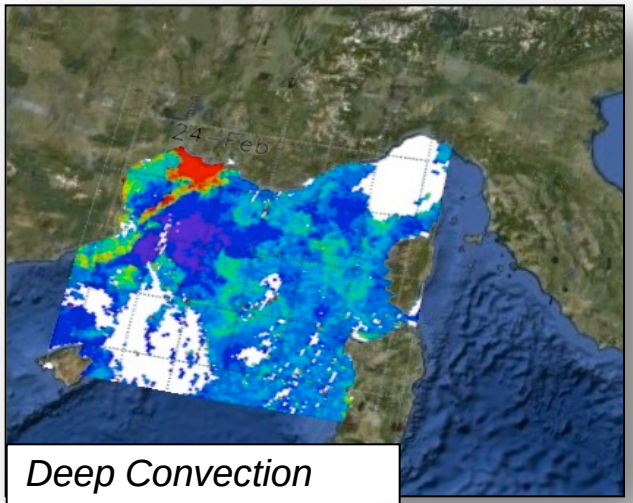
- **Good Argo coverage**

- A specific sampling strategy (MedArgo)
- Huge data base to robust statistics on float dispersions

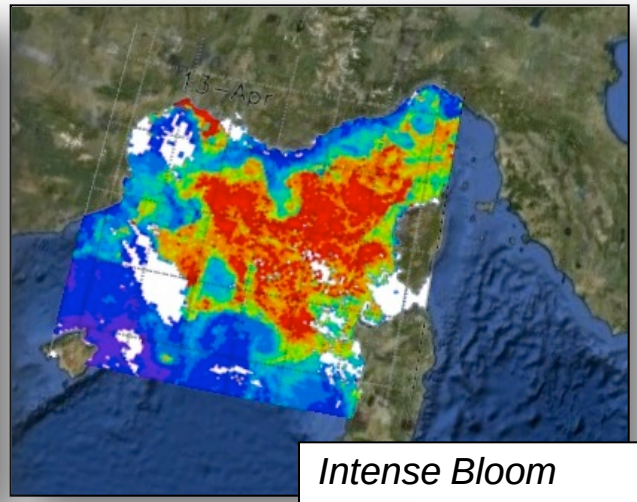
MedArgo web site

Why the Mediterranean?

- **Easy Logistics**



Deep Convection



Intense Bloom

Recover of a "problematic" Provbiol near Minorca after 1.5 year lifetime

- Important physical and biological processes close to shore
- Possibility to recover floats

The NAOS Bio-Argo Mediterranean RoadMap

The Mediterranean is then a suitable basin to implement a Bio-Argo pilot network

A dedicated working group has been created to define goals and provide recommendations for the network implementation.

The participants were selected as interested to:

- the comprehension of the Mediterranean biogeochemical functioning
- Bio-Argo (though very few have experience with floats)
- Deployment of floats, in areas where they have planned cruises

The results of the brainstorming are summarized in a "**roadmap**" available on the NAOS web site:

http://en.naos-equipex.fr/News/Roadmap-for-the-deployment-decision-of-the-NAOS-Bio-Argo-Mediterranean-floats

The NAOS Bio-Argo Mediterranean RoadMap

4th Euro-Argo Users Meeting
NOC, Southampton, UK, 18 - 20 June 2013

The Mediterranean Bio-Argo main goal

The working group recommended the reconstruction of the **seasonal cycle** of biogeochemical fluxes of C, N, and O in different Mediterranean areas, as the **main goal** of the Bio-Argo Mediterranean network

To fulfil this requirement, how the characteristics of the network should be?

1. How to optimize the monitoring of the various biogeochemical situations of the basin, with “only” 14 floats?
2. How to sample a seasonal cycle, without missing key events?

The roadmap should then:

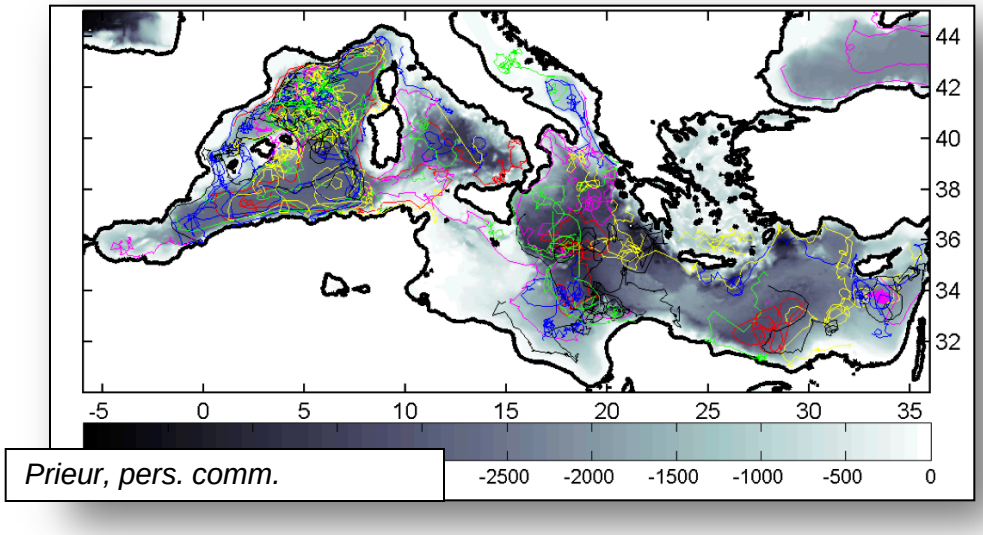
1. Define bioregions (i.e. regions sharing similar biogeochemical traits) and, consequently, the deployments areas
2. Define strategy to maintain a permanent sampling of a bioregion

1. Defining bioregions (i.e. regions sharing similar biogeochemical traits) and, consequently, the deployments areas

2. Defining strategy to maintain a permanent sampling of a bioregion

Deciding the deployments areas

Historical data base



Prieur, pers. comm.

- All the Med Argo trajectories since 2008 (350/400m parking depth)
- Statistics computed from deployment to end of float life or to the last profile

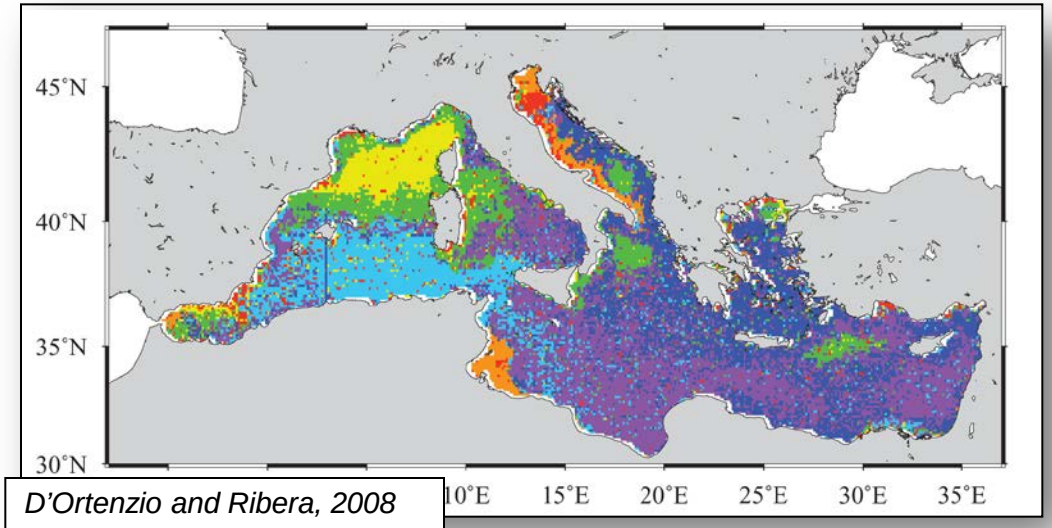
With few exceptions, **two main patterns** are observed

- Floats deployed in sub-basin belong in the same sub-basin
- Floats have tendency to move southward

ROADMAP recommendation: the BioArgo Mediterranean deployments should concentrate on northern regions

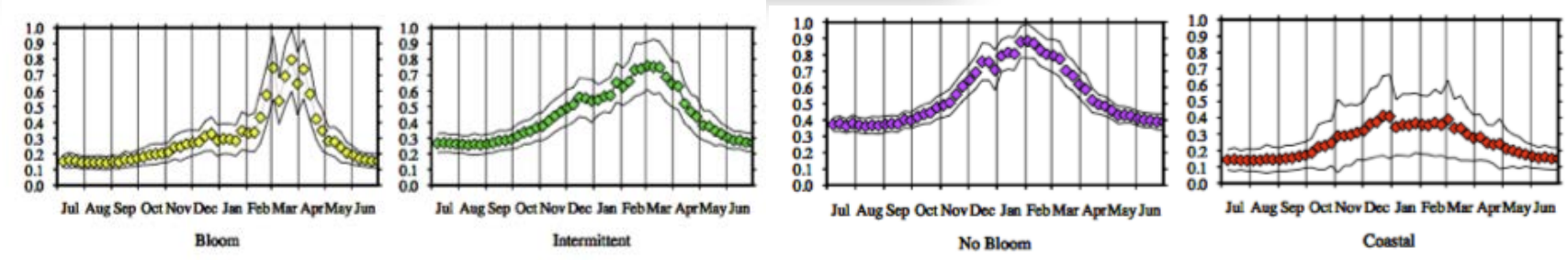
Deciding the deployments areas

The Bioregions



D'Ortenzio and Ribera, 2008

- Seawifs Surface Chl10 yrs data set
- Grouping sat time series having similar seasonal shapes
- Regions with the same color are characterized by the same seasonal shape of Surface Chl
- Bioregions reflect homogenous biogeochemical characteristics



ROADMAP recommendation: the BioArgo Mediterranean network should monitor ALL the bioregions for, at least, a whole seasonal cycle

1. Defining bioregions (i.e. regions sharing similar biogeochemical traits) and, consequently, the deployments areas

2. Defining strategy to maintain a permanent sampling of a bioregion

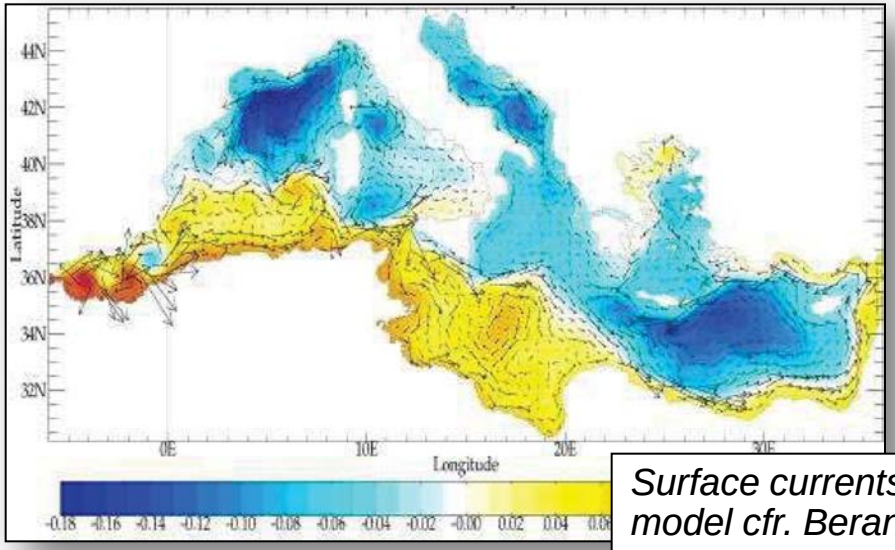
Maintaining a permanent observation of each bioregion

A numerical approach based on a realistic Mediterranean model (NEMO-WRF config MED12, C. Lebaupin, K. Béranger)

Deploying in each bioregion a large number of numerical floats, which flow/disperse following simulated currents

Computing the connectivity matrix (i.e. number of floats changing bioregions with time) on the basis of the simulated trajectories

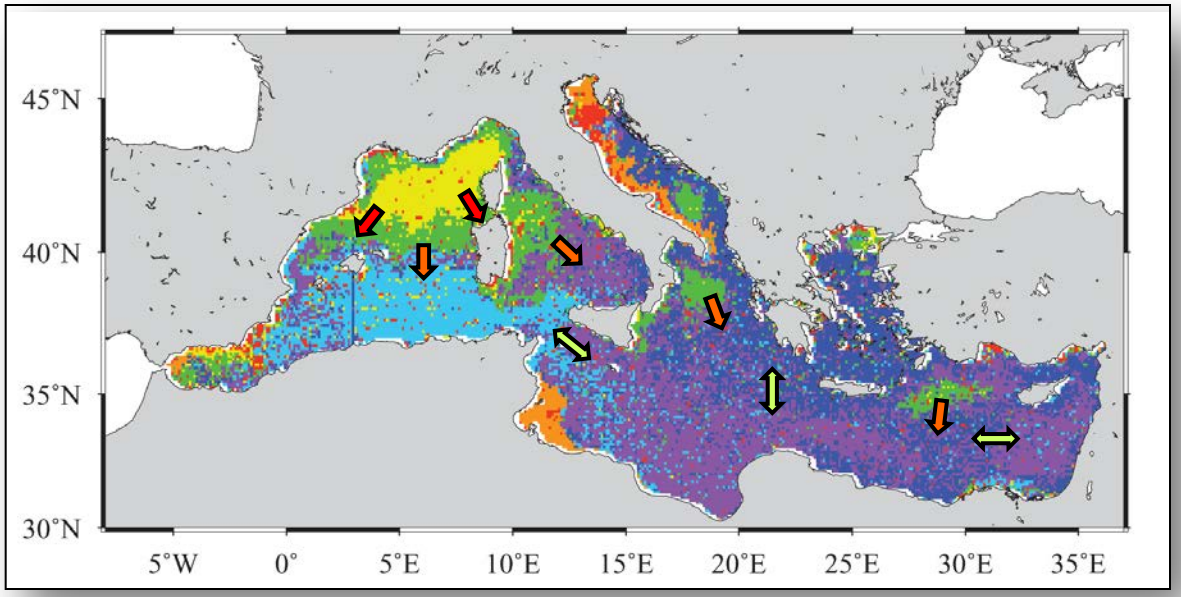
Testing different cycling frequencies (i.e. 1,2, 5, 10, 30 days) and parking depths (i.e. 10,350, 1000, 2000m)



Surface currents from MED 12 model cfr. Beranger et al. 2010

Goal: to maximise the probability that a float deployed in a bioregion continues to sample the same bioregion for at least 300 days

Maintaining a permanent observation of each bioregion



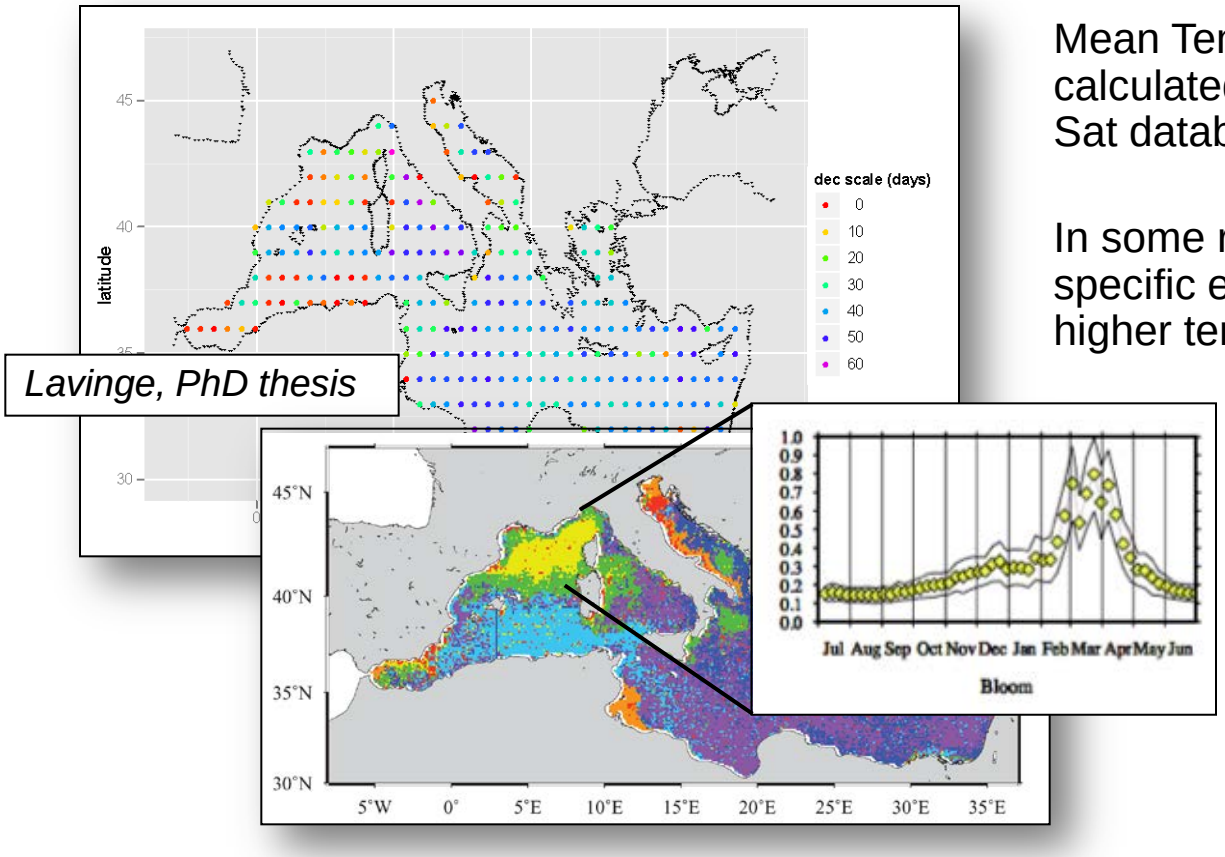
On average, dispersion from a bioregion to another are minimized using **1000m parking depth** and a cycle frequency of **5 days**

Differences exist between bioregions:

Yellow (Bloom) toward green (Intermittent) :	positive flux of about 20%
Green (Intermittent) toward blue/violet (No Bloom):	positive flux of about 10%
Blue/violet toward blue/violet (No Bloom):	flux = 0

ROADMAP recommendation: deploying at least one float for bioregion; increasing the number of floats in the Yellow (bloom) and Green (Intermittent) bioregions

Fixing Sampling protocol



Lavinge, PhD thesis

Mean Temporal decorrelation scales calculated on the SeaWiFS 10 yrs Chl Sat database

In some regions (i.e. Ligurian Sea) specific events (i.e. bloom) require higher temporal resolution sampling

ROADMAP recommendation: increasing cycling frequency (1-3 days) at the end of winter and during spring for blooming region (Green and Yellow)

The roadmap plan: a synthesis

A homogenous spatial distribution of floats appears not appropriate to the Mediterranean biogeochemical monitoring; **deployments by bioregions seem more suitable**

Floats tend to **accumulate in the southern part of the basin**, no matter the bioregion

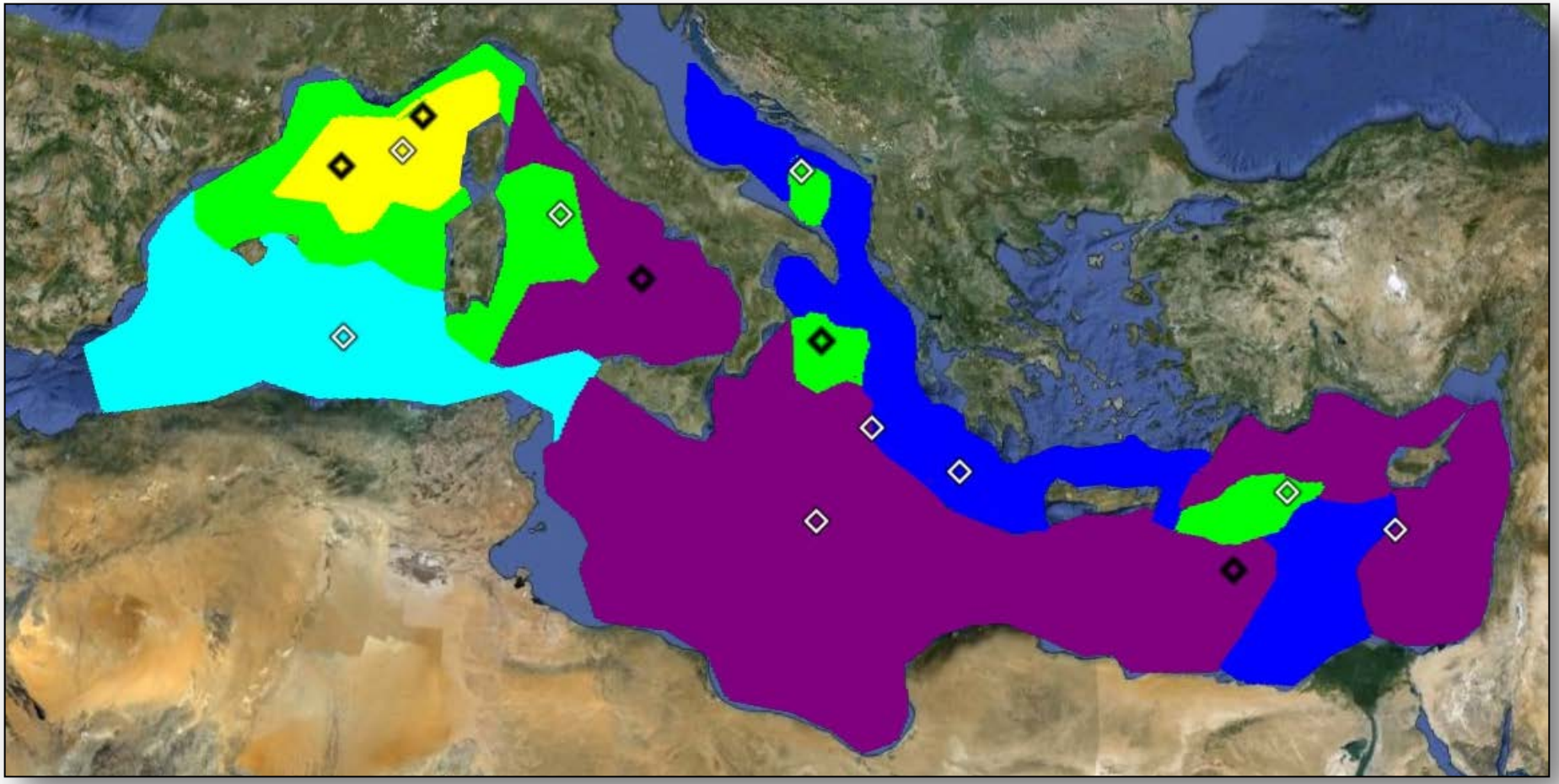
On average, a common strategy (**1 float for bioregion, 1000 m parking depth and 5 days cycling)** should allow to fit the Bio-Argo goals for Mediterranean

Some bioregions are however different (high dispersion, small decorrelation scales). **They require higher density of floats and an increased cycling frequency.**

The NAOS Bio-Argo Mediterranean RoadMap

4th Euro-Argo Users Meeting
NOC, Southampton, UK, 18 - 20 June 2013

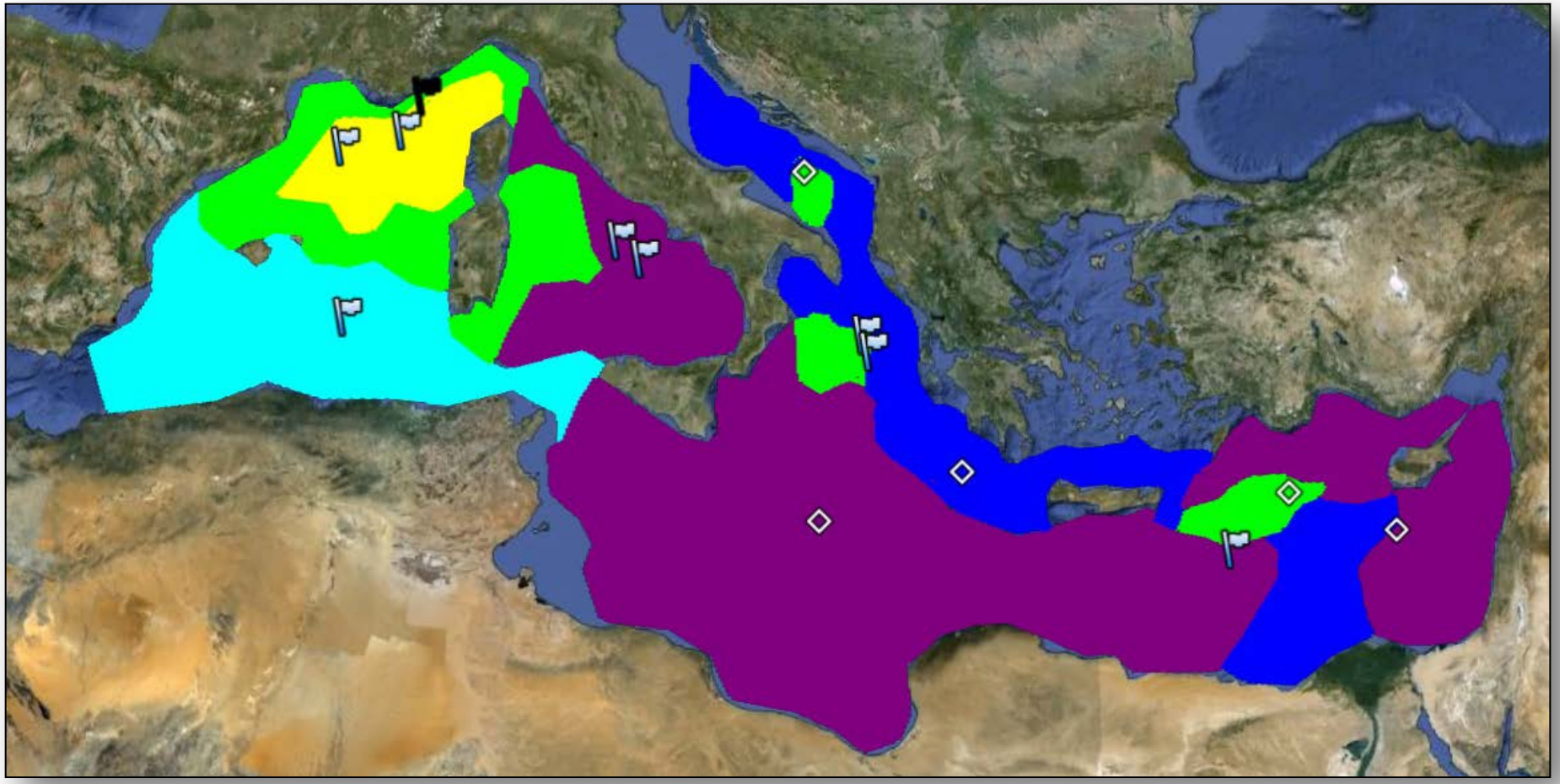
The roadmap plan



The NAOS Bio-Argo Mediterranean RoadMap

4th Euro-Argo Users Meeting
NOC, Southampton, UK, 18 - 20 June 2013

The roadmap plan *vs* reality (juin 2013)



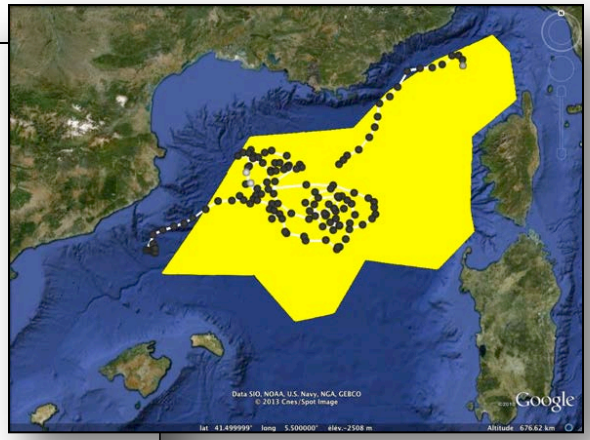
- **9 floats deployed**
- **1 float lost**

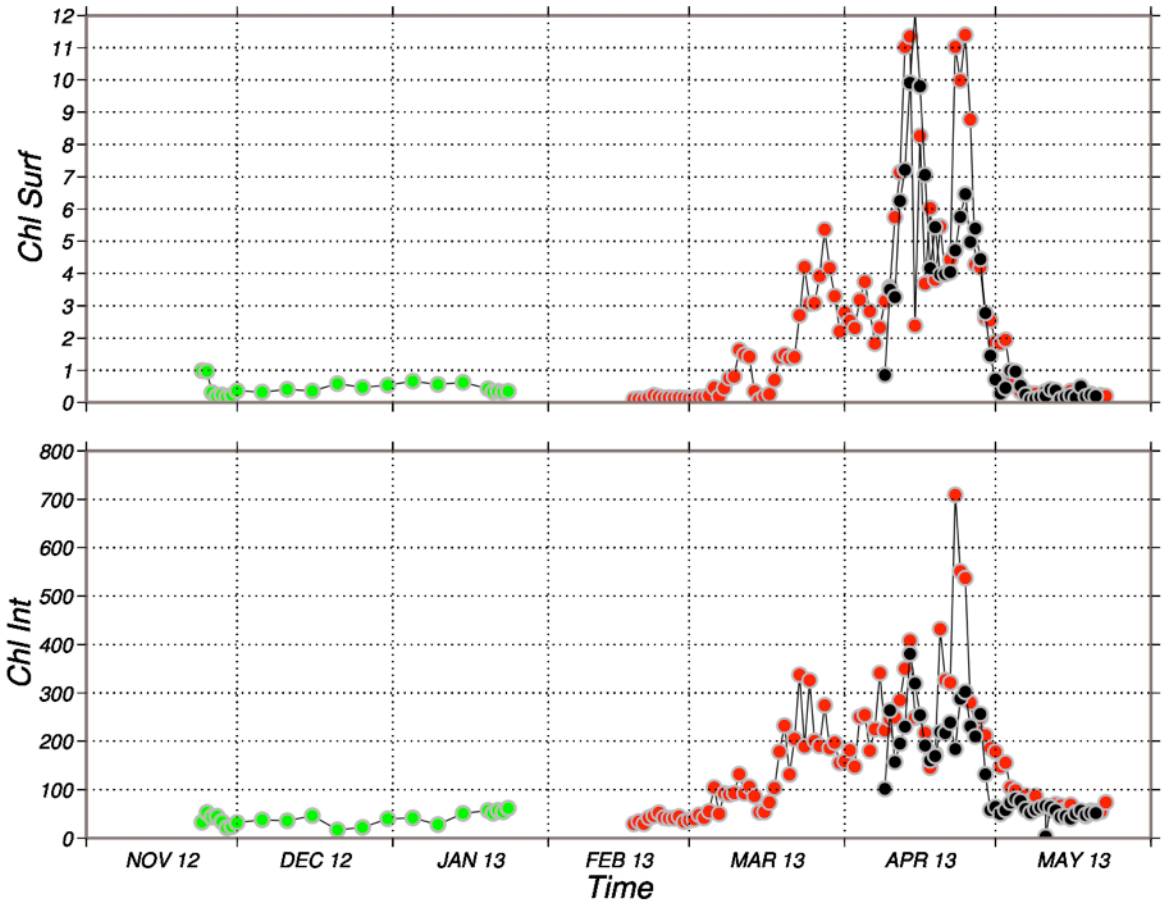
Vary few modifications respect to the roadmap

Some preliminary data….

Preliminary results

Bioregion “Bloom” Ligurian Sea





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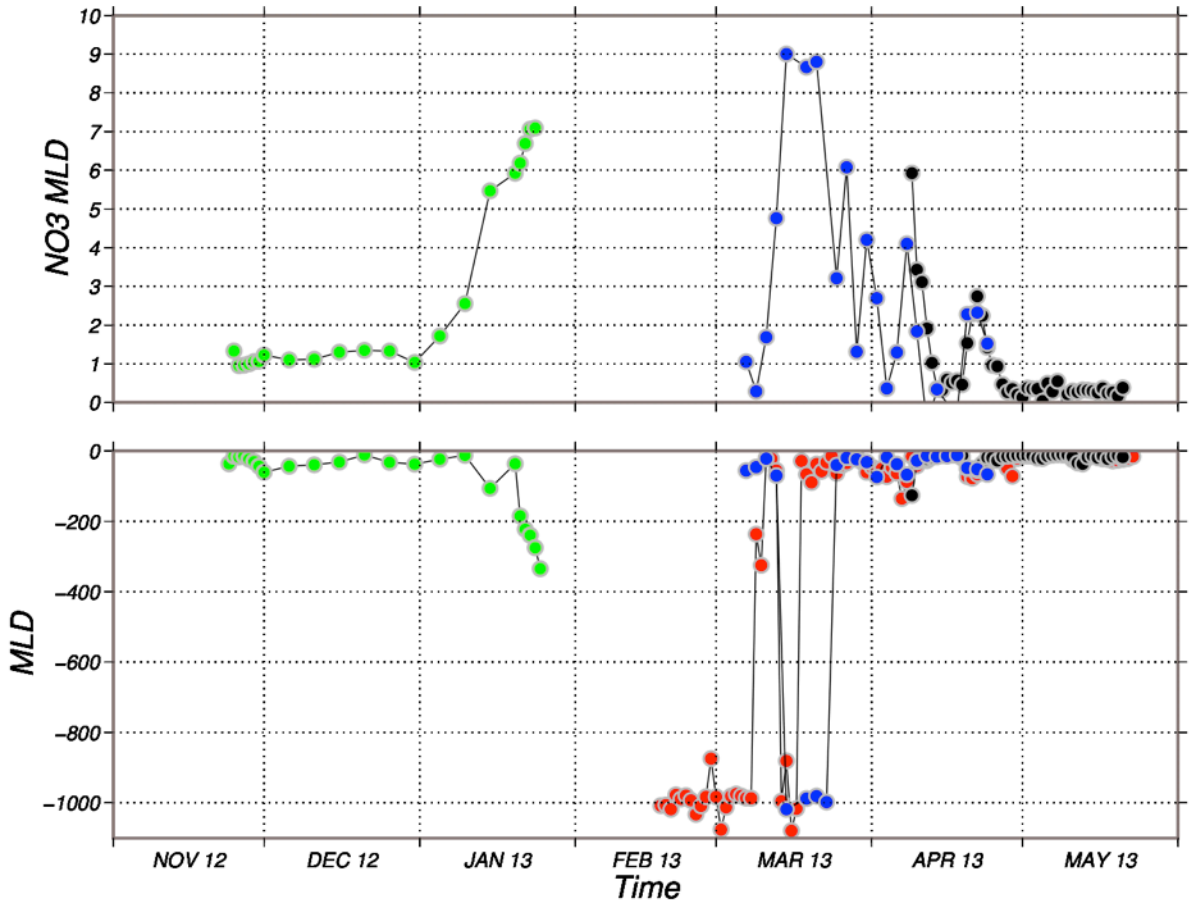
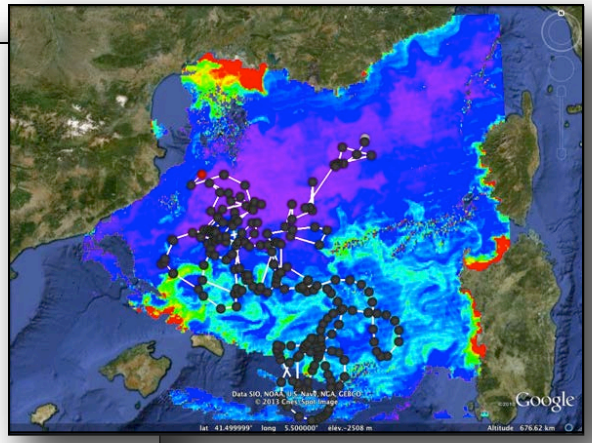




Prototype « Pronuts »
PROVOR with NO3 sensor
Deployed July 2011

Conclusions

A **preliminary reflexion** on a Bio-Argo pilot network in the Mediterranean has been initiated

Roadmap is just a roadmap.

The “real-life” deployments are strongly constrained by **logistic** (i.e. ship time availability, sea state).

Results should differ from expected (i.e. erratic or not linear behaviours of floats). Metrics to verify the agreement between plans and expected results have to be implemented (i.e. method of C. Fontana).

Anyway, preliminary results seem confirming that the **selected strategy, as indicated in the roadmap, is not too bad for the expected results.**

In the framework of French project NAOS:

The 14 floats of the first wave will be deployed following the roadmap (last float planned for march 2014)

The 14 floats of the second wave (2015/2016) will be deployed **to sustain the pilot network**

Ocean color remote sensing appears **as invaluable tool to design Bio-Argo networks** (as altimetry for Argo?)

Bio-Argo and Argo networks should not necessarily share the same characteristics. However the **interoperability characteristics have to be respected** (i.e. data format).

Conclusions

Principles of Bio-Argo data Management (last ADMT India)

1. **The Bio-Argo data must contribute to Argo (i.e. the protocols and the T&S data must match Argo requirements)**

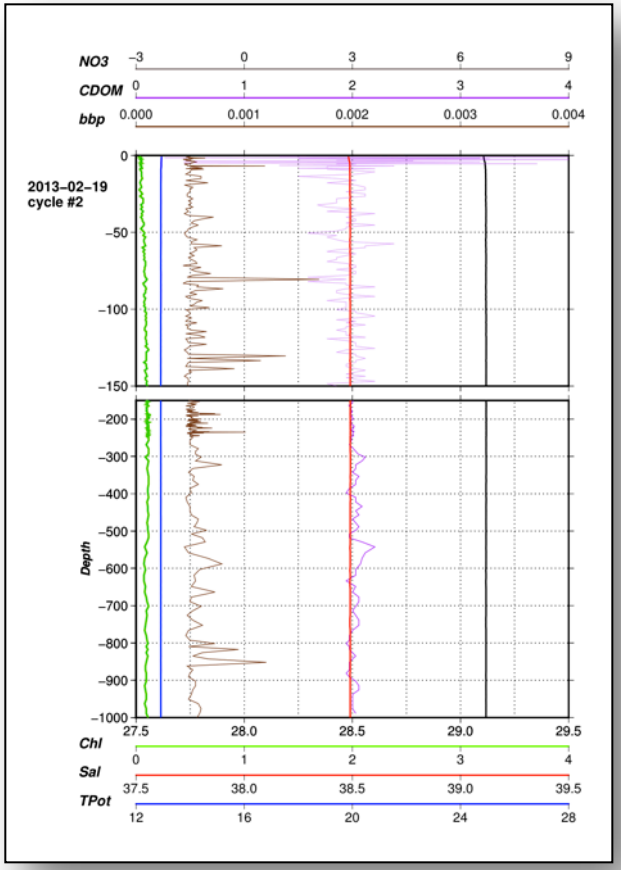
2. **The Bio-Argo data must be organized and processed with the same structure of the Argo for T&S.**

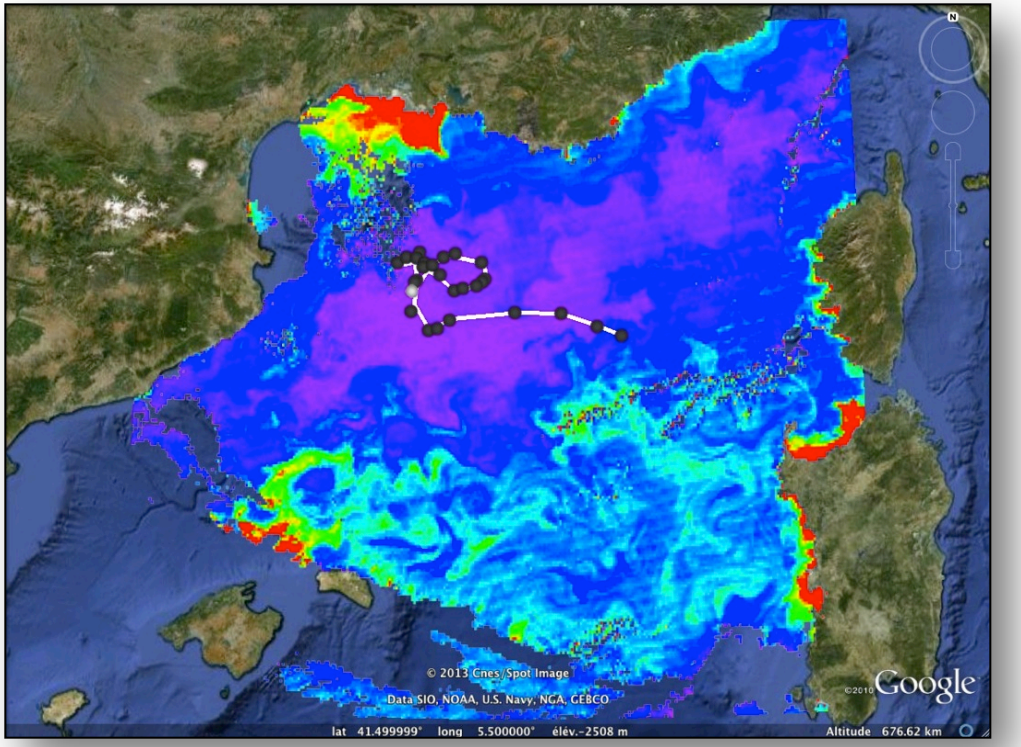
3. **The Bio-Argo data must be stored in the same format of the Argo for T&S.**

4. **The Bio-Argo data must have the same distribution policy of the Argo for T&S.**

5. **The Bio-Argo data processing protocols have to be based on established (i.e. published) methods, and implemented on operational level in strong coordination between scientists and data centers.**

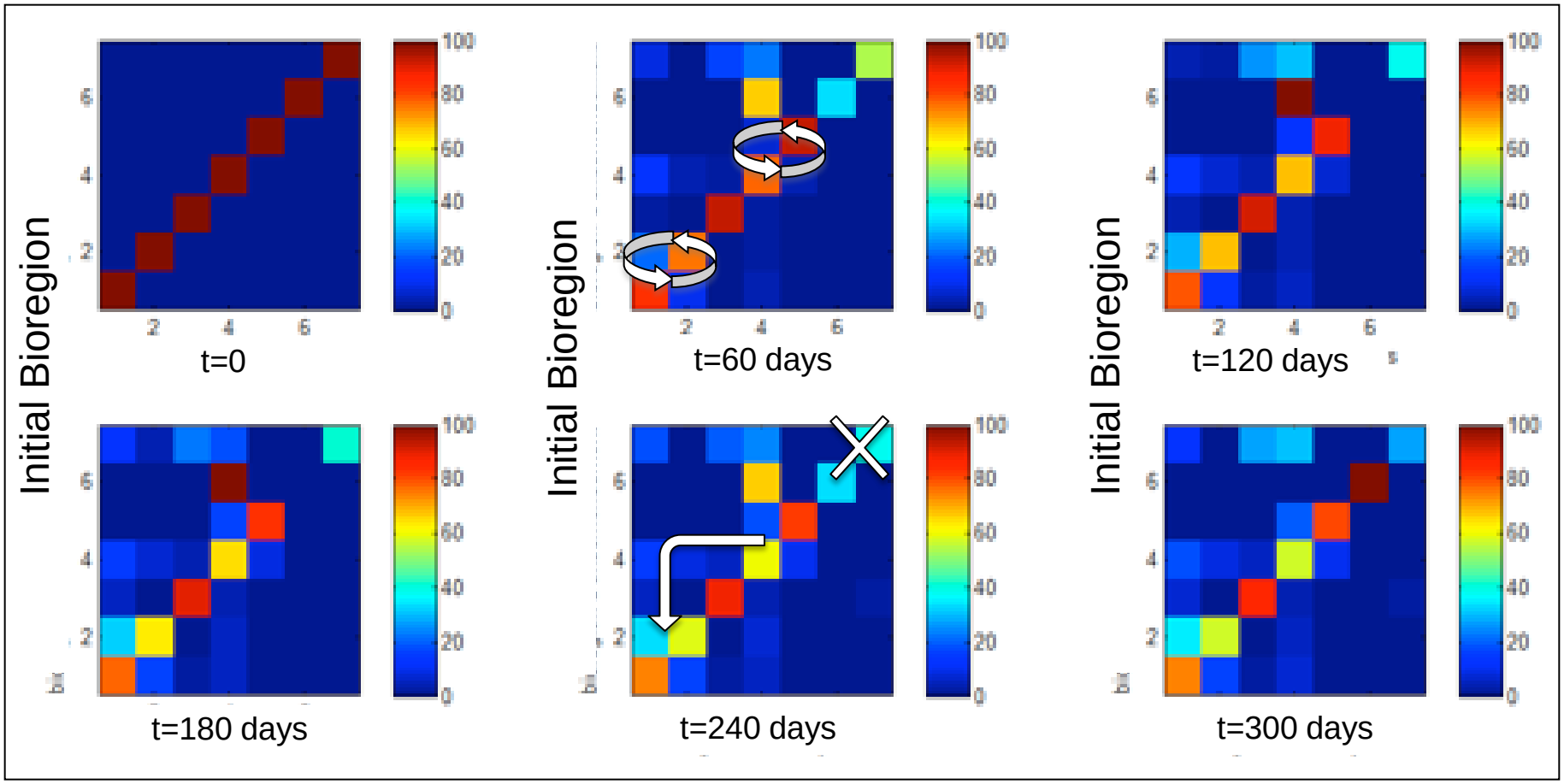
Thank you


NO3
CDOM
bbp
2013-02-19
cycle #2
Depth
Chl
Sal
TPot


© 2013 Cnes/Spot Image
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Google
lat 41.499999° long 5.500000° élév.-2508 m
Altitude 676.62 km

Maintaining a permanent observation of each bioregion

Connectivity matrix



The Mediterranean Bio-Argo main goal

The working group recommended the reconstruction of the **seasonal cycle** of biogeochemical fluxes of C, N, and O in different Mediterranean areas, as the **main goal** of the Bio-Argo Mediterranean network

The reconstruction of a water column seasonal cycle will provide:

1. A better characterization of the **main events** of Mediterranean biogeochemical cycles (i.e. bloom, summer oligotrophy).
2. A more detailed description of the **physical/biological** interactions
3. A more accurate evaluation of the **biogeochemical fluxes** of the basin (i.e. primary production, nutrients uptake, oxygen dynamic) , as recommended by OceanObs09