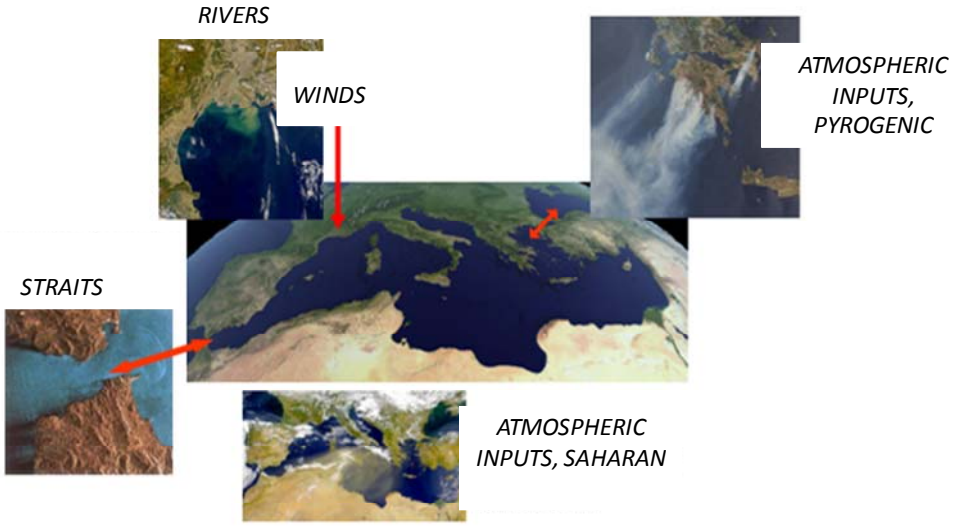
***Coordination**: Cécile Guieu (LOV, Villefranche), Xavier Durrieu de Madron (CEFREM, Perpignan) and Richard Sempéré (COM/MIO, Marseille), Ivanne Pairaud (IFREMER, La Seyne)*

Motivations

Strong anthropogenic pressure with geographical and seasonal imbalances

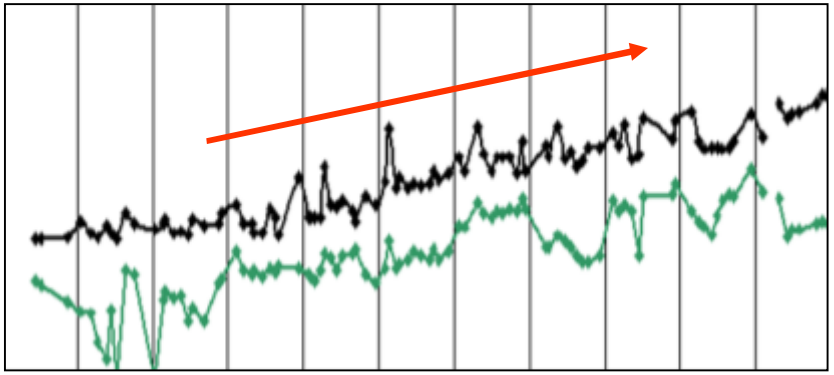
A unique coupled system (ocean/atmosphere/continent)



A changing environment : on-going increase of temperature

Surface waters : + 1.1°C in 27 years

Deep waters : + 0.05°C in 10 years

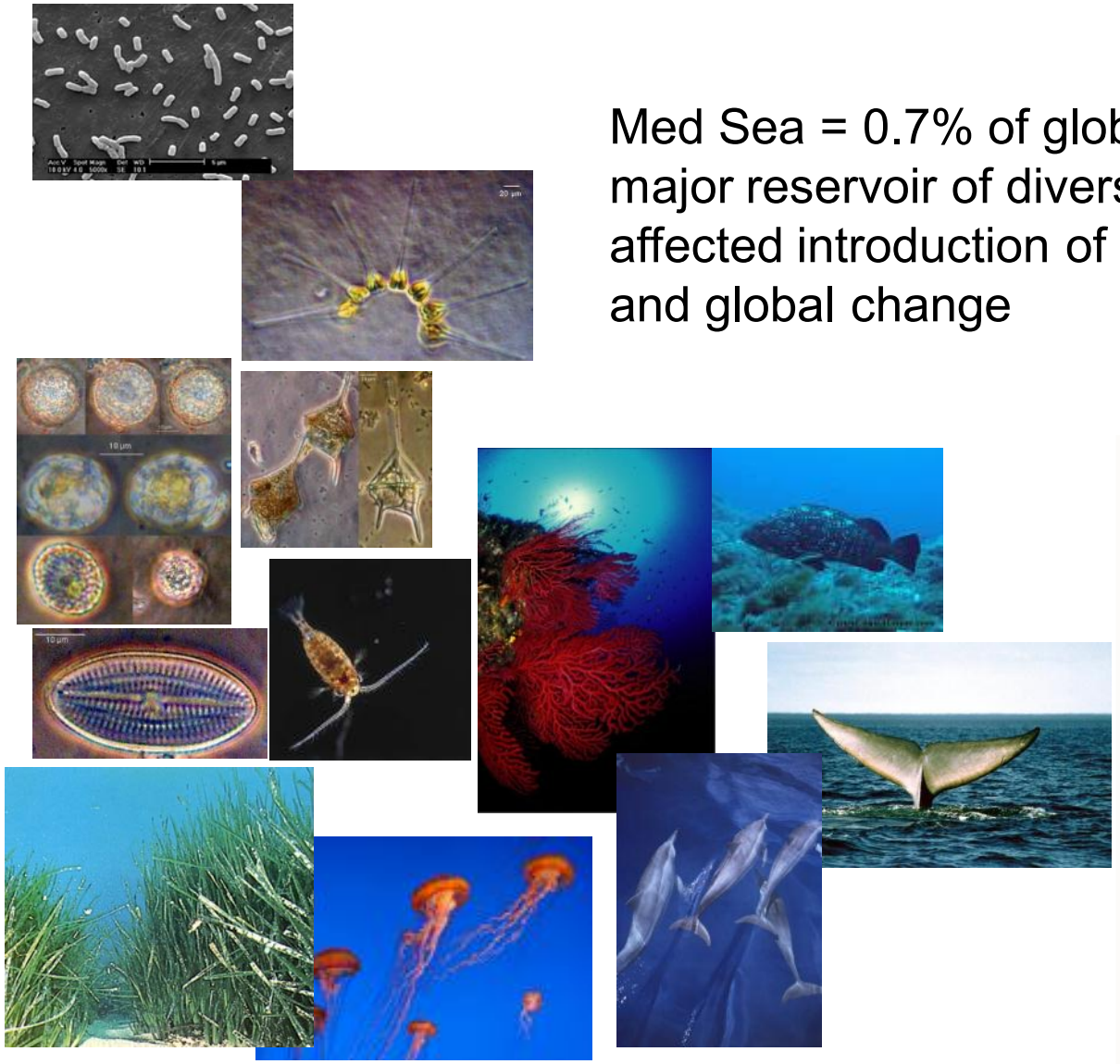


1995 *Deep water at DYFAMED* 2005

(Marty & Chiaverini, 2002)

Annual mean temperatures in the Mediterranean area are likely to increase more than the global mean (IPCC, 2007)

Motivations



Med Sea = 0.7% of global Ocean volume, but a major reservoir of diversity (18%) that might be affected introduction of many thermophilic species and global change

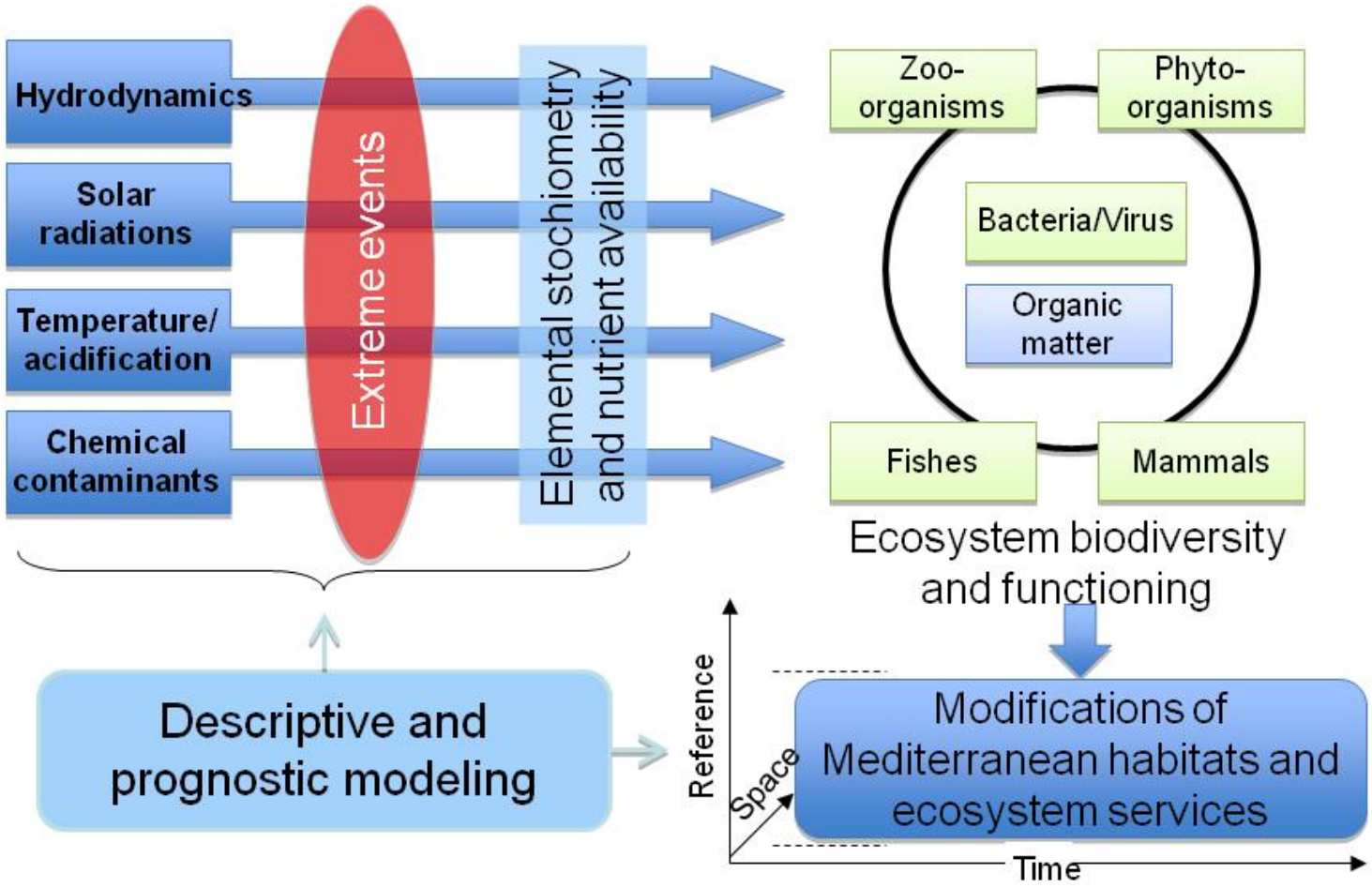
→ disturbance of ecological status, changes in the trophic chain and consequently on the resources

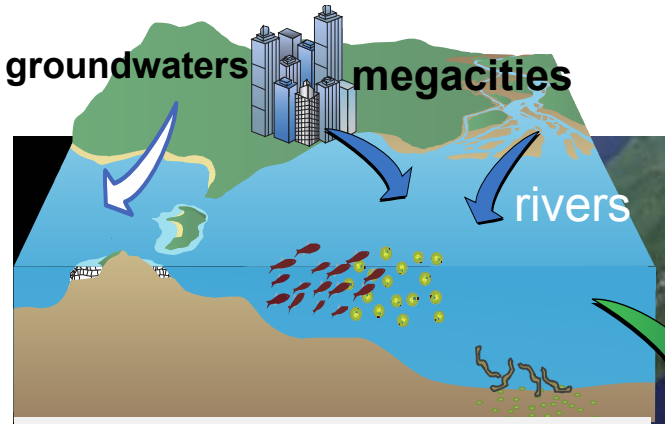
A scientific paper on current knowledge and key questions

MERMeX White Book « Marine ecosystems' responses to climatic and anthropogenic forcings in the Mediterranean » *Progress In Oceanography*, Octobre 2011

***'Mermex Group', Progress In Oceanography,* 2011**

Scientific Objectives

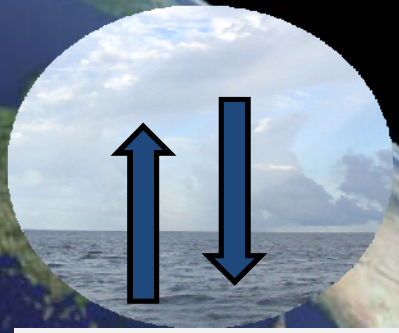




Land-Sea interactions and extreme events

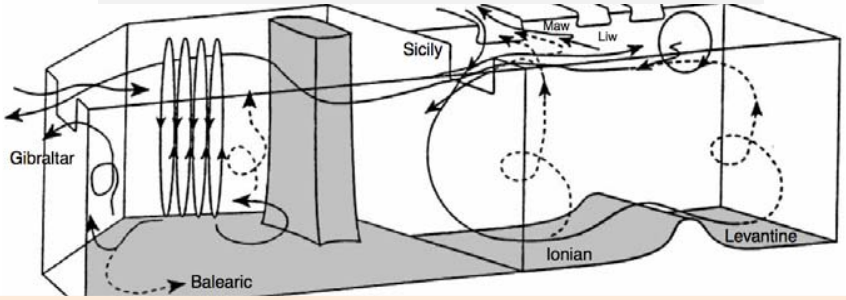
Main topic:

***RESPONSE OF MEDITERRANEAN ECOSYSTEMS* TO CLIMATE CHANGE AND ANTHROPOGENIC PRESSURE**



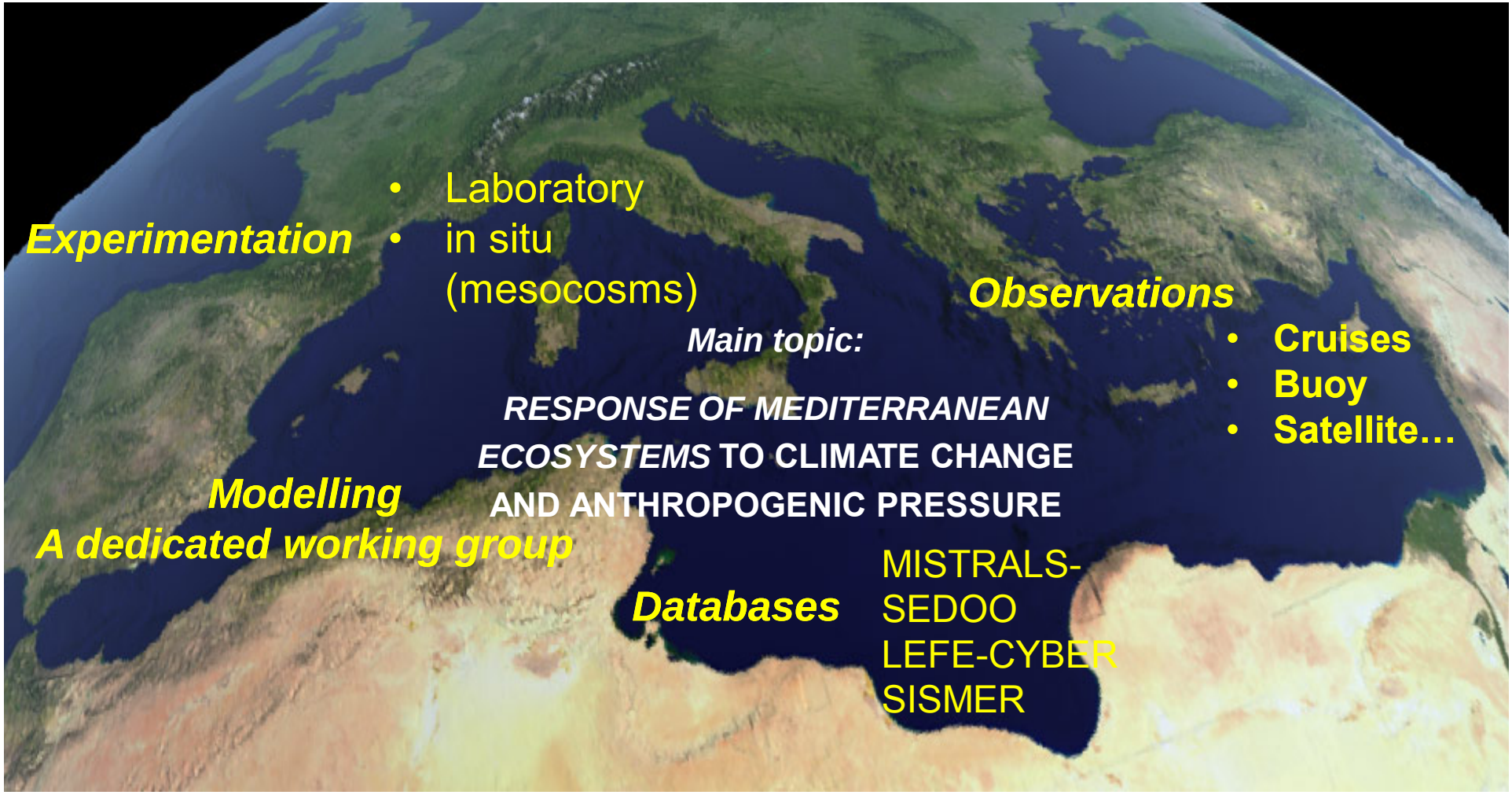
air-sea interactions

Hydrodynamics and ecological processes

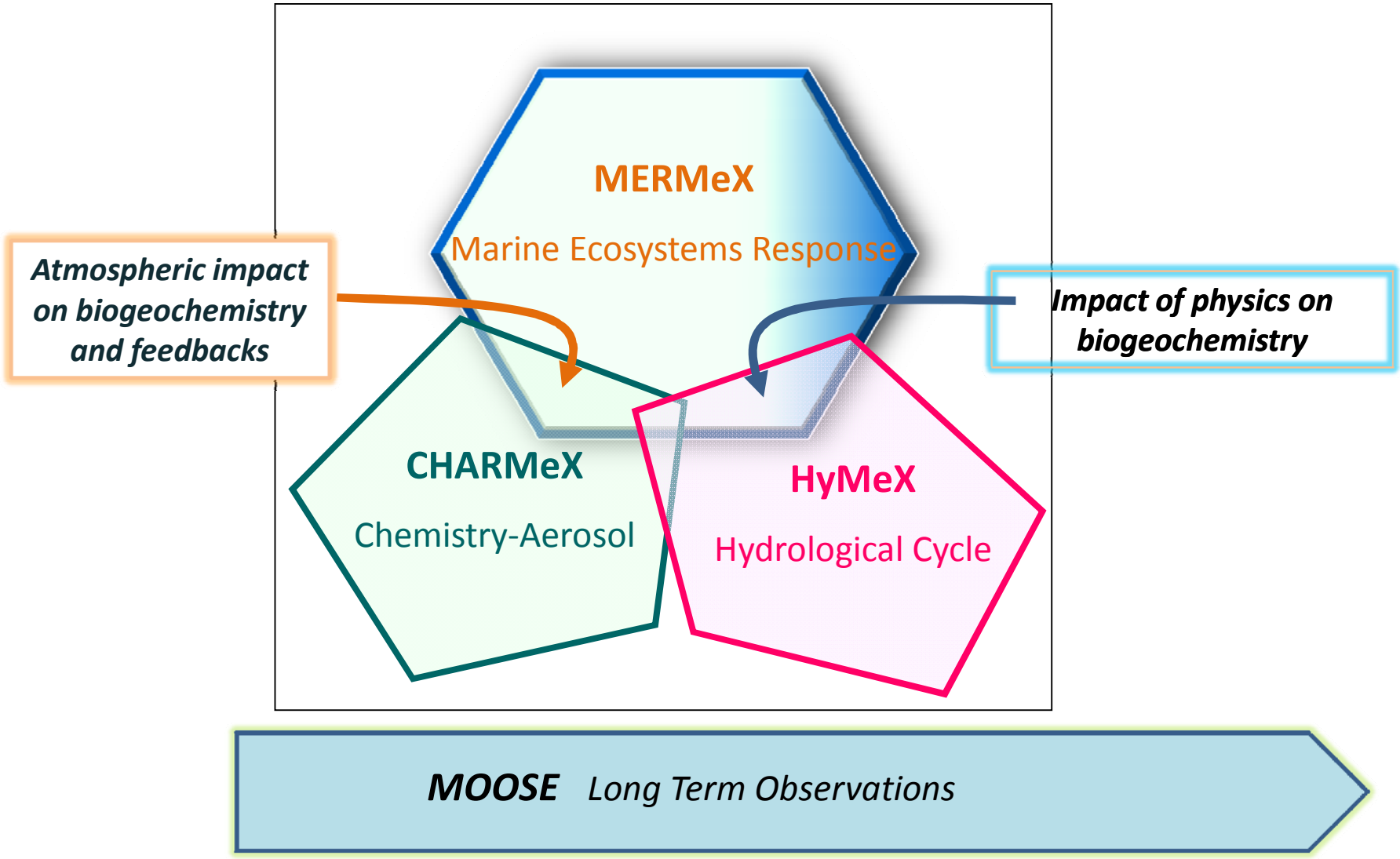


Bio- and eco-**regionalization** of the Mediterranean Sea
Mapping of **Ecosystem Services**

Implementation started in 2011



MISTRALS Interconnected Research Projects supported by Long Term Observations



MERMEX endorsed by 3 international programs:

IMBER: Integrated Marine Biogeochemistry & Ecosystem Research

SOLAS: Surface Ocean - Lower Atmosphere Study

LOICZ: Land-Ocean Interactions in the Coastal Zone

Budget and activity

MERMEX today =

- ***15 projects funded or co-funded by MISTRALS***
- ***~630 man-month***
- ***35 PhD***
- ***10 post-doc***

YEAR	MISTRALS
2011-12	*200 K€*
2012-13	*213 K€*
2013-14	*314 K€*
2014-15	*331 K€*

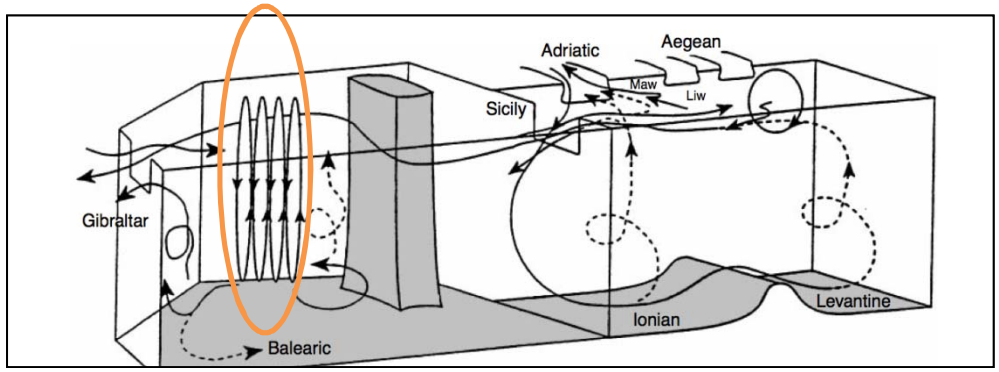
On going projects, few examples

TOTAL BUDGET MERMEX in 2014 = 1321 K€
Other funding* = 865 K€

- *Europe (Hermione, Perseus, Medsea, Groom)*
- *french ANR (Costas, Sam, Ecogely, Risco)*
- *Other National projects (EC2CO, Equipex NAOS)*
- *Regional (PACA)*
- *Foundation (BNP-Paribas, FRB)*
- *Ministry foreign affairs (Envi-Med)*

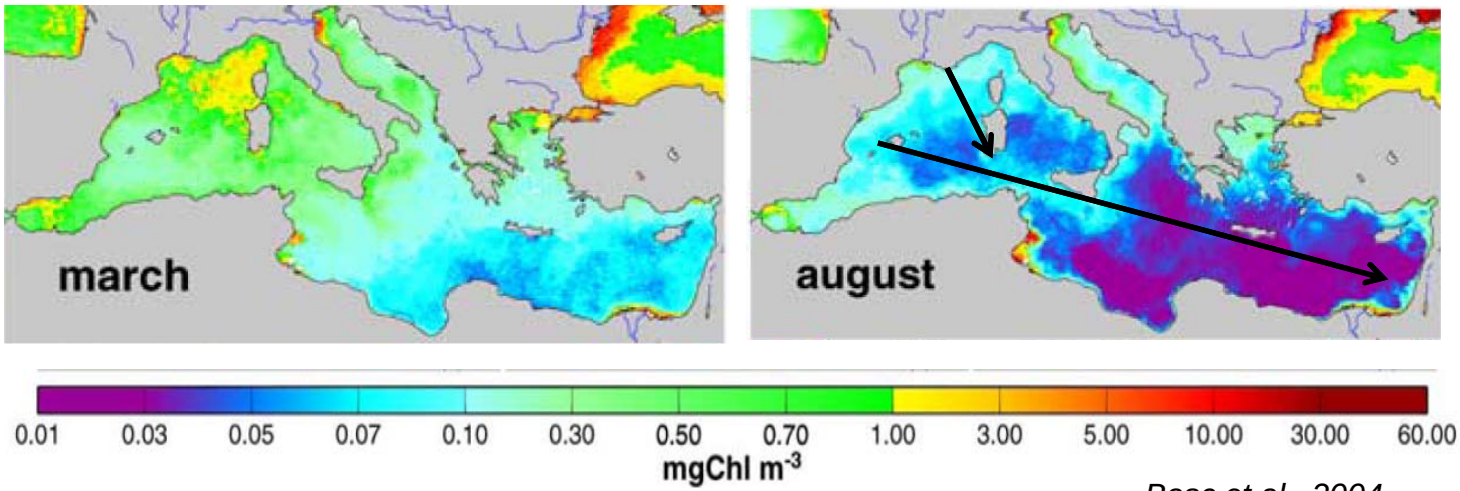
DEWEX DEep Water formation EXperiment

- ***Strong dynamic in specific area → determine the distribution of nutrients at large scale***



- ***Nutrient stœchiometry is not constant over the bassin (East–West gradient and surface-deep waters gradients***

- **Strong trophic gradients; very poor waters in the Eastern Bassin; strong seasonal variability**



Bosc et al., 2004

DEWEX DEep Water formation EXperiment

The main objective: to reconstruct the physics and biogeochemical history of the water masses of the NW Med S

→ a full year observation cycle (2012-2013)

- 6 cruises covering key moments
- Large number of Autonomous platforms with biogeochemical sensors during and in between the cruises comprising:
  - ✓ Gliders for high frequency acquisition
  - ✓ Floats for the law frequency acquisition
- Satellite, in particular Ocean Color

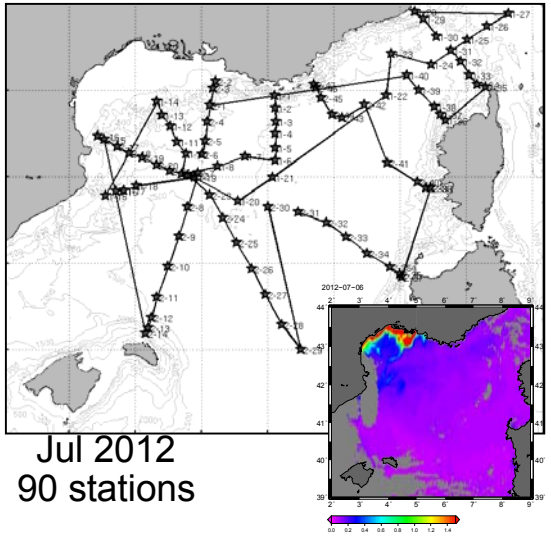
- *MerMeX*
- *HyMeX*
- *SOERE MOOSE*
- *ANR ASICS-MED*
- *EQUIPEX NAOS*
- *GMMC MESOLAB*

Coll. ES, IT
- *FP7 GROOM*
- *FP7 PERSEUS,*
- *FP7 JERICO*
- *FP7 E-Aims*
- *FP7 OSS-2015*

DEWEX DEep Water formation EXperiment

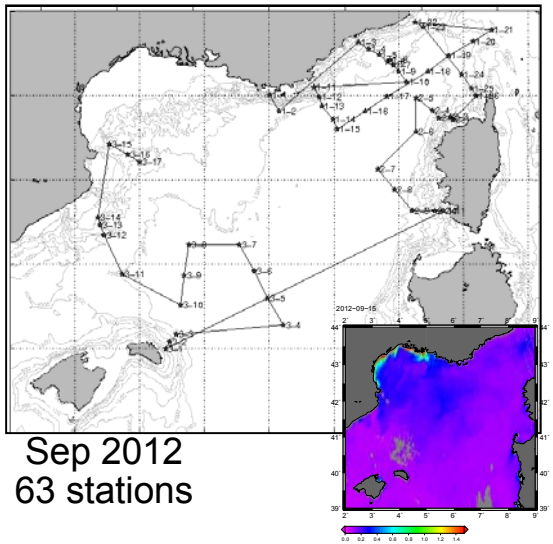
6 cruises = **119 days at sea = 499** stations CTD profiles

MOOSE-GE2012



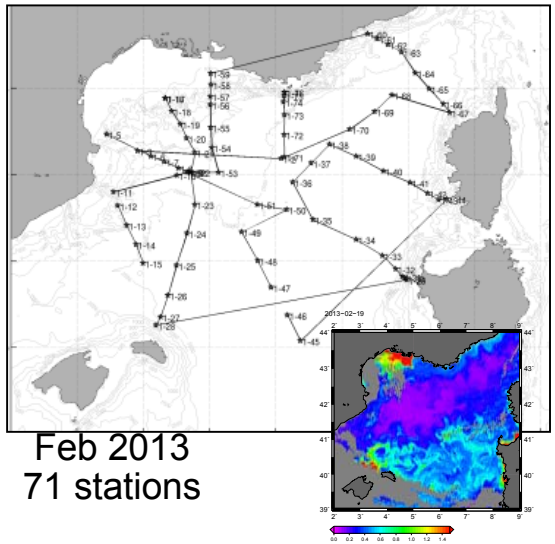
Jul 2012
90 stations

DOWEX2012



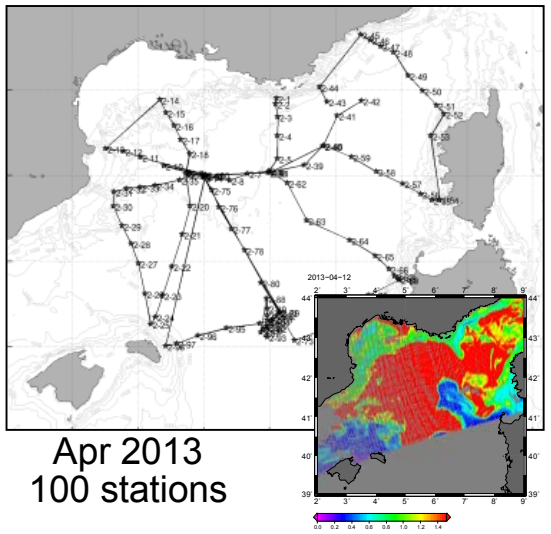
Sep 2012
63 stations

DEWEX2013-1



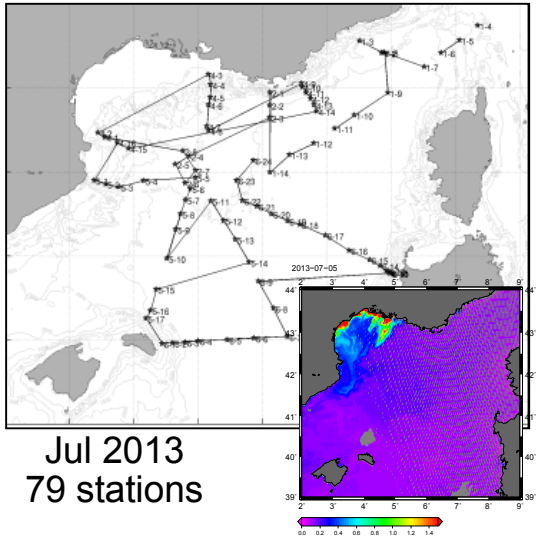
Feb 2013
71 stations

DEWEX2013-2



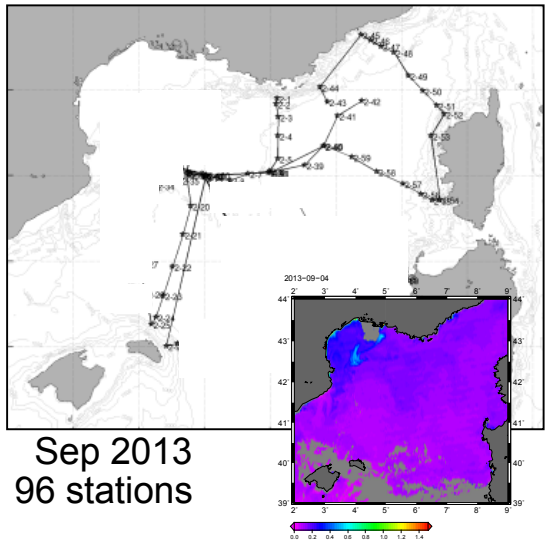
Apr 2013
100 stations

MOOSE-GE2013



Jul 2013
79 stations

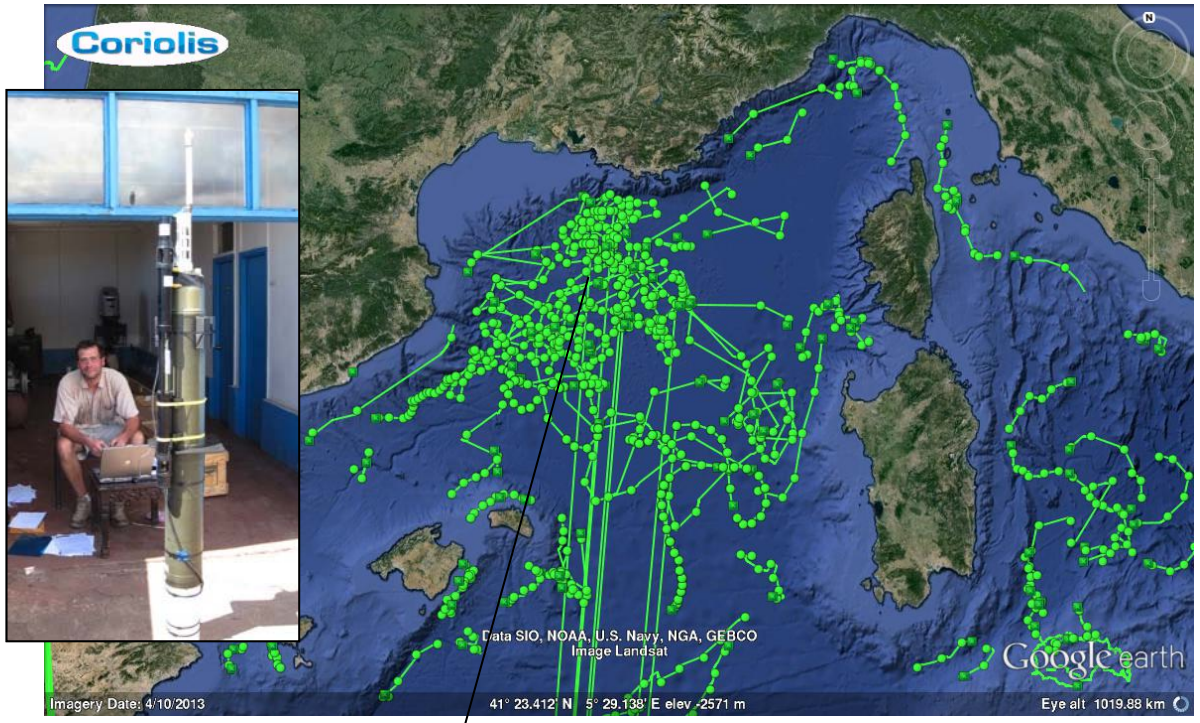
DOWEX2013



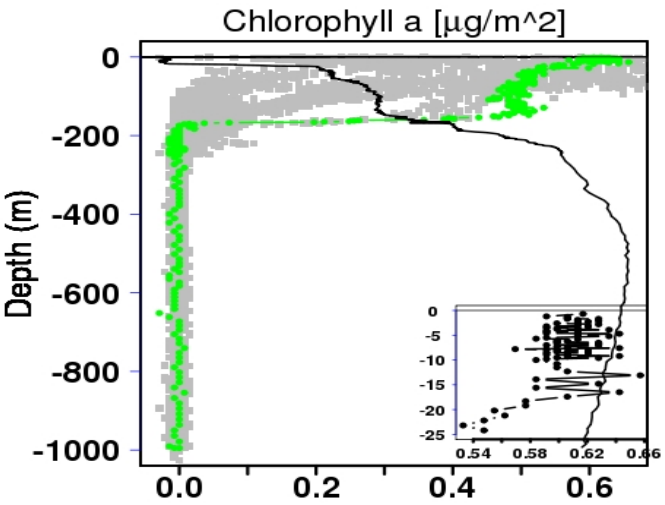
Sep 2013
96 stations

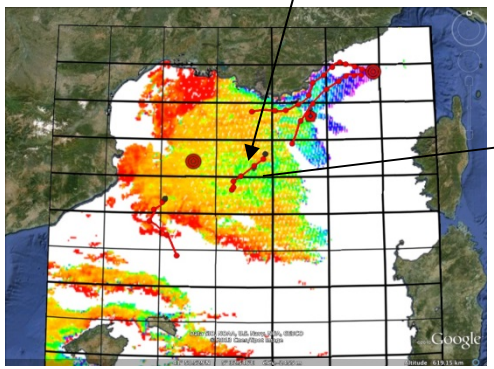
Floats = ~1500 profils Argo (0-1000, **520** Bio/02)

Real time transmission of the data to CORIOLIS

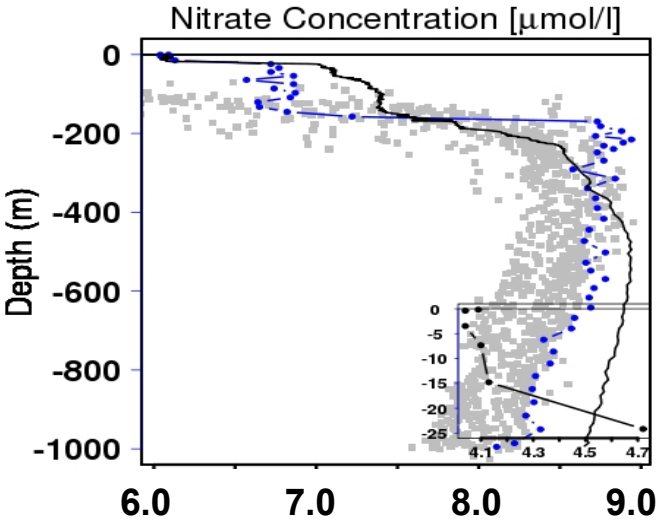


Flotteur NAOS



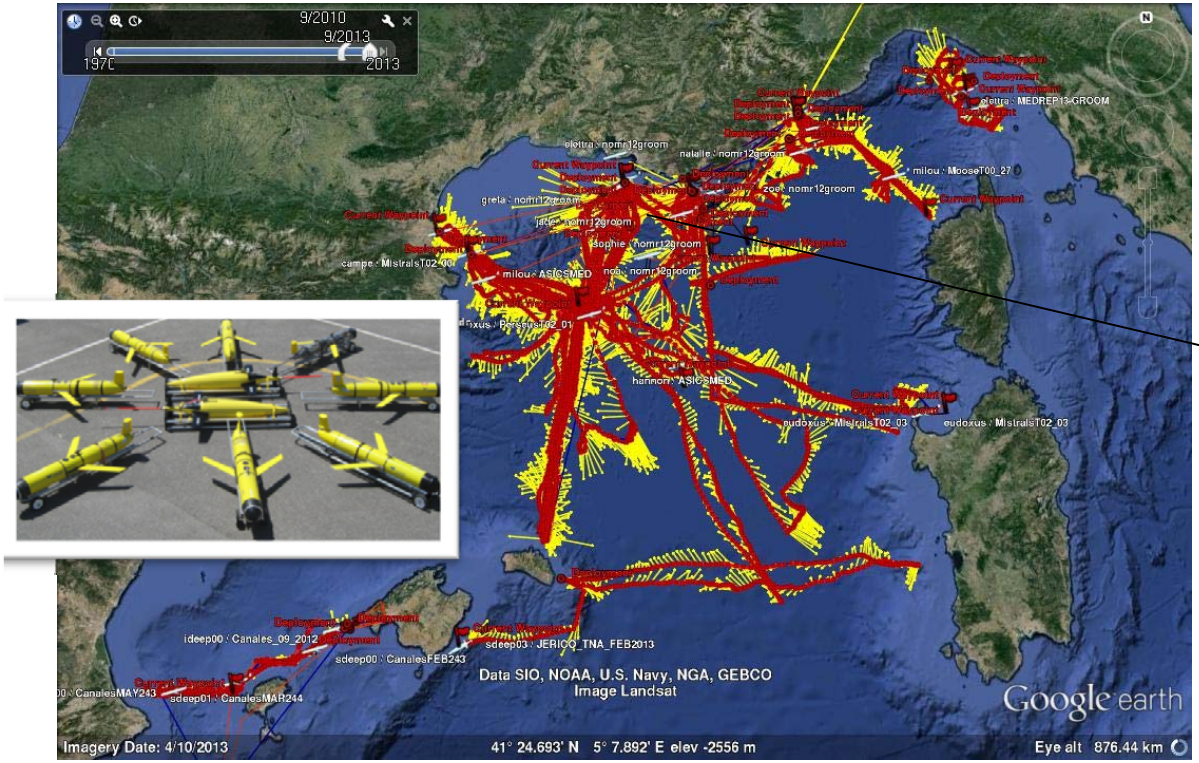


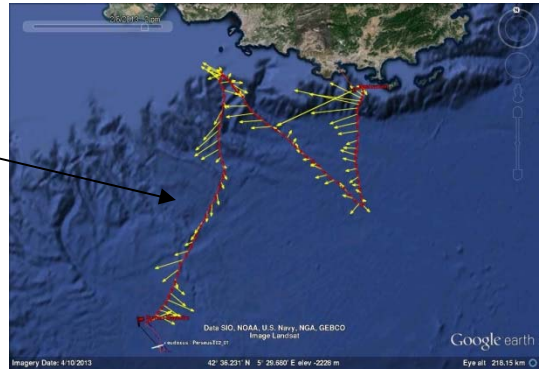
Modis du 10 Janvier



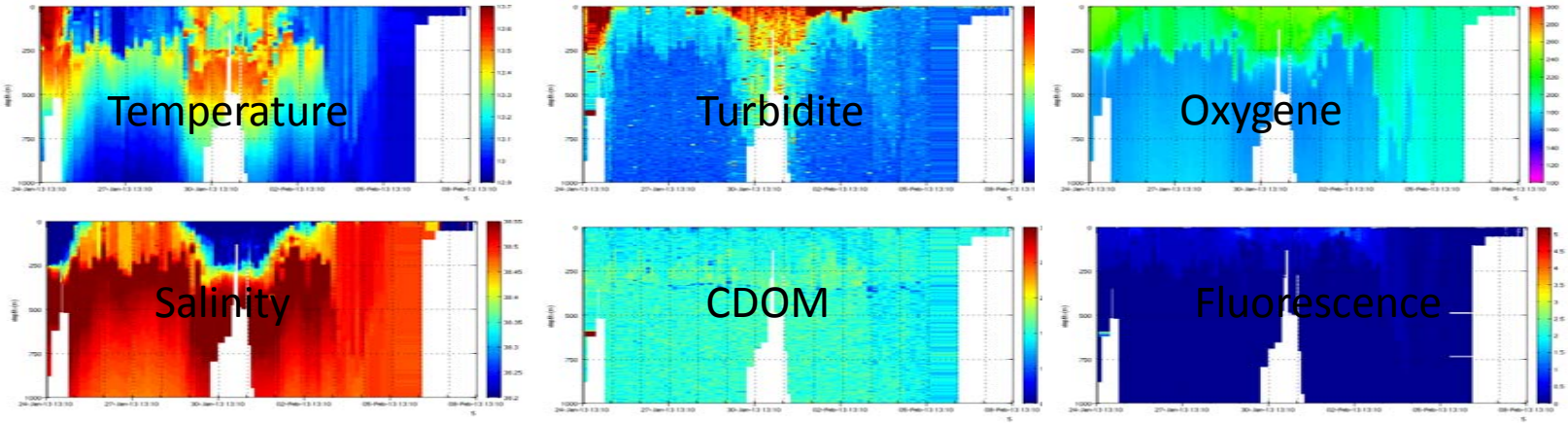
Gliders: a total of 30 Missions = **~13000** profiles (0-1000m)

Real time transmission of the data to CORIOLIS





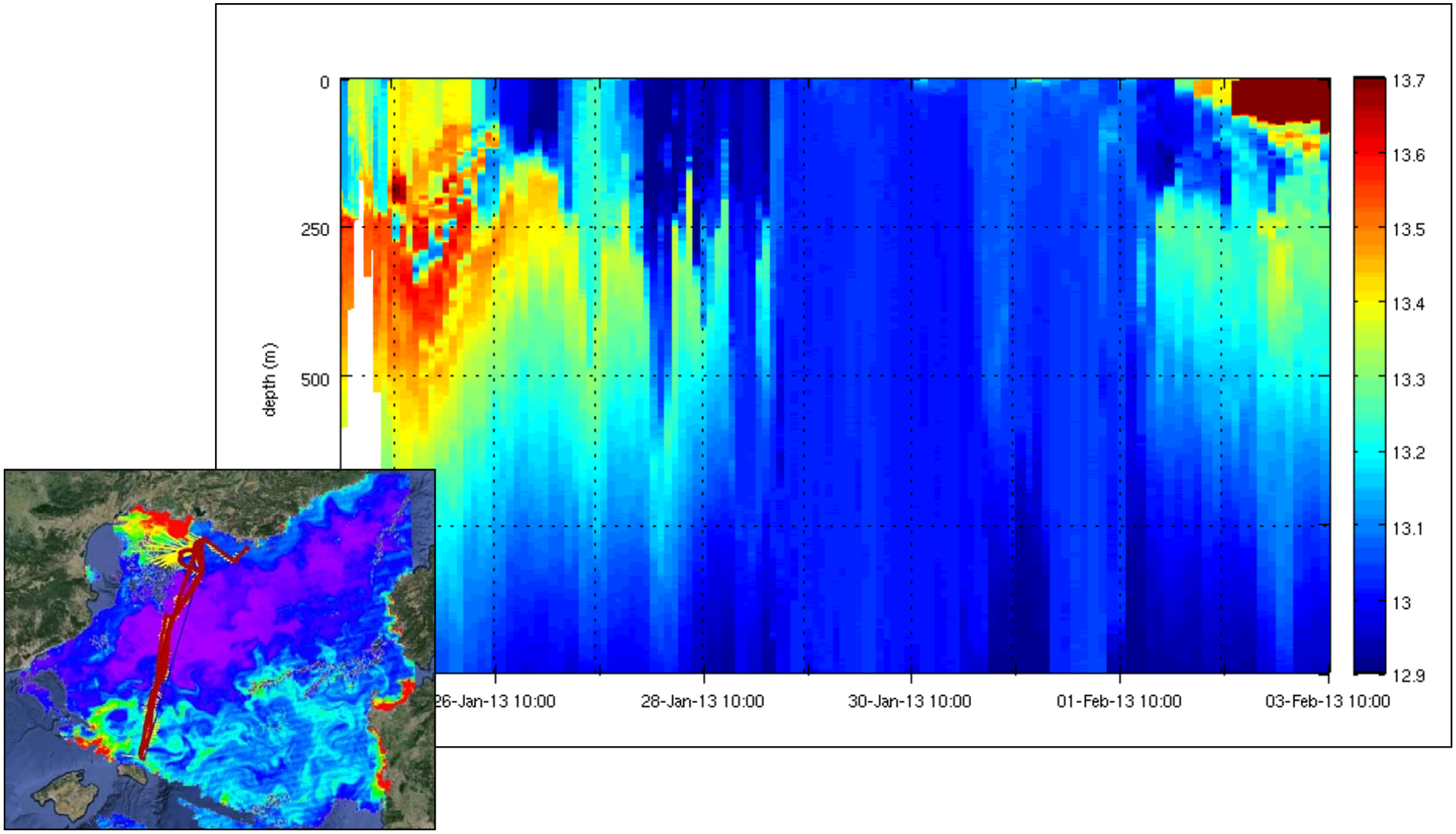
Courants 0-1000m



DEWEX DEep Water formation EXperiment

Gliders transects

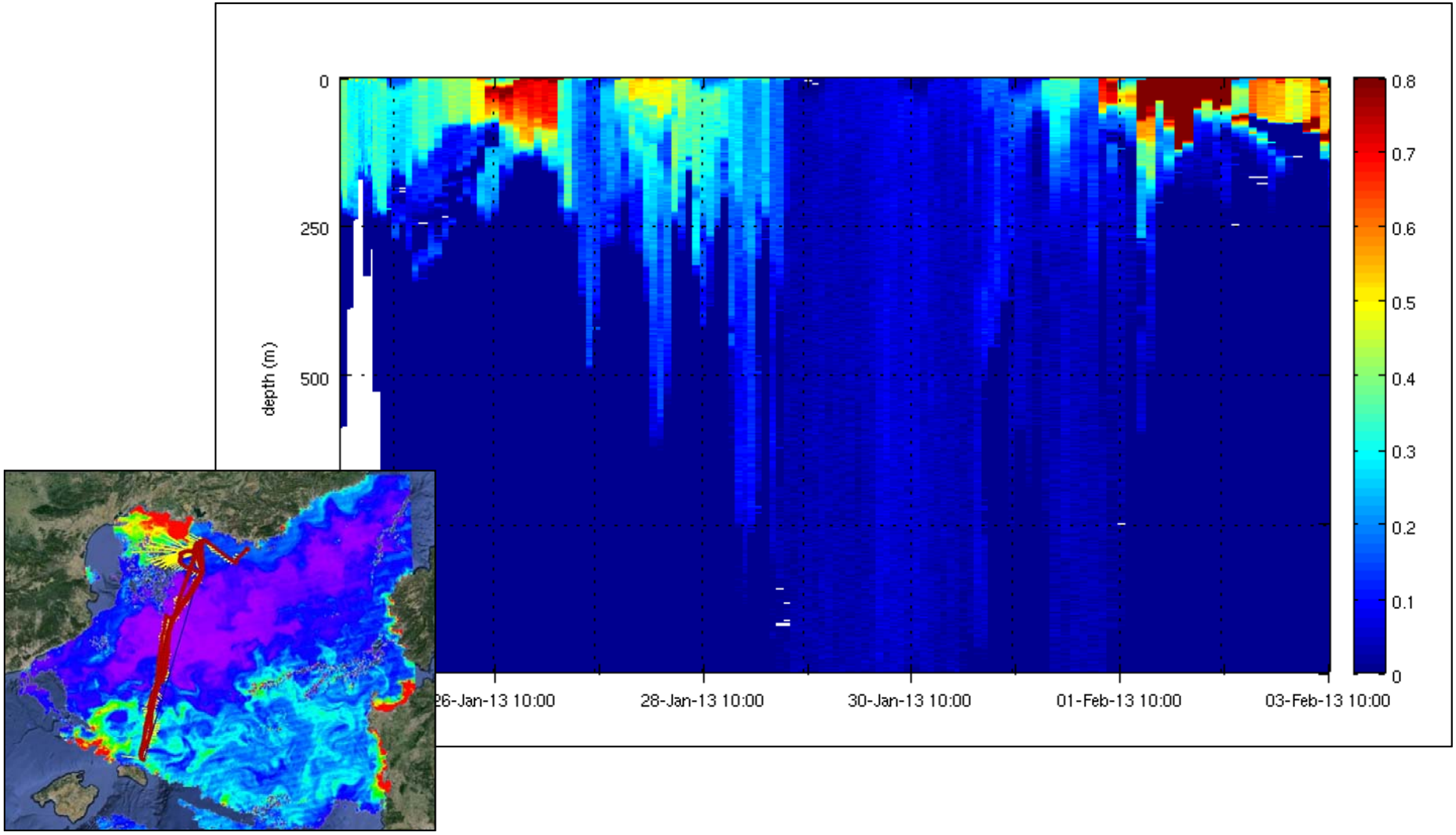
temperature



DEWEX DEep Water formation EXperiment

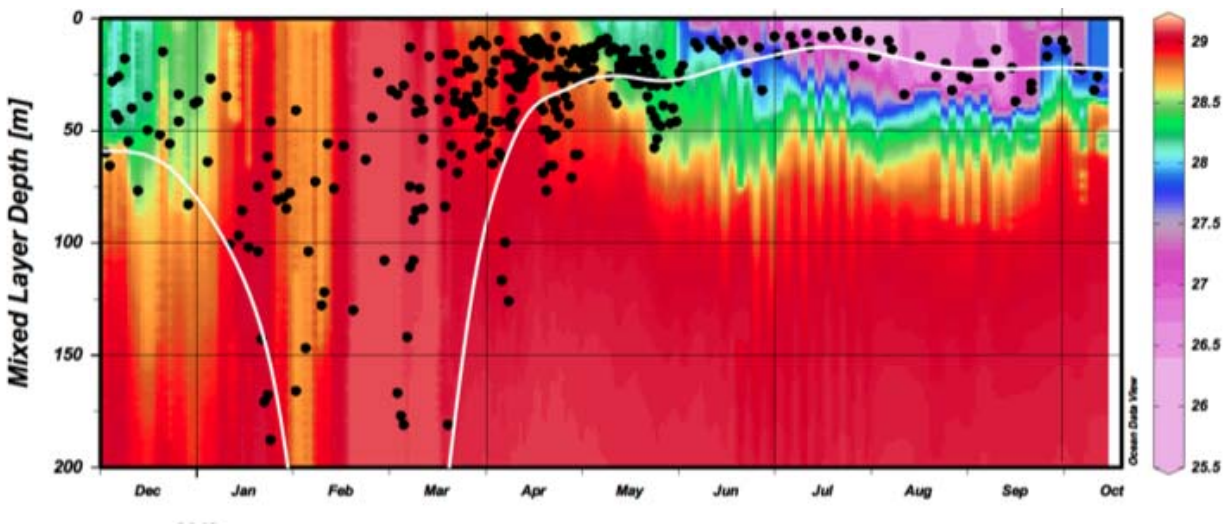
Gliders transects

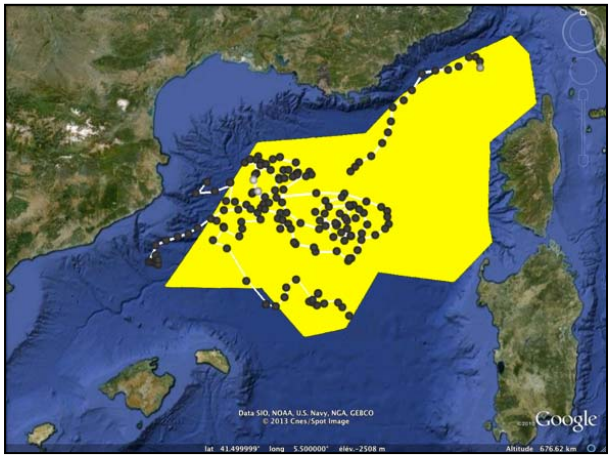
Chlorophyll



DEWEX DEep Water formation EXperiment

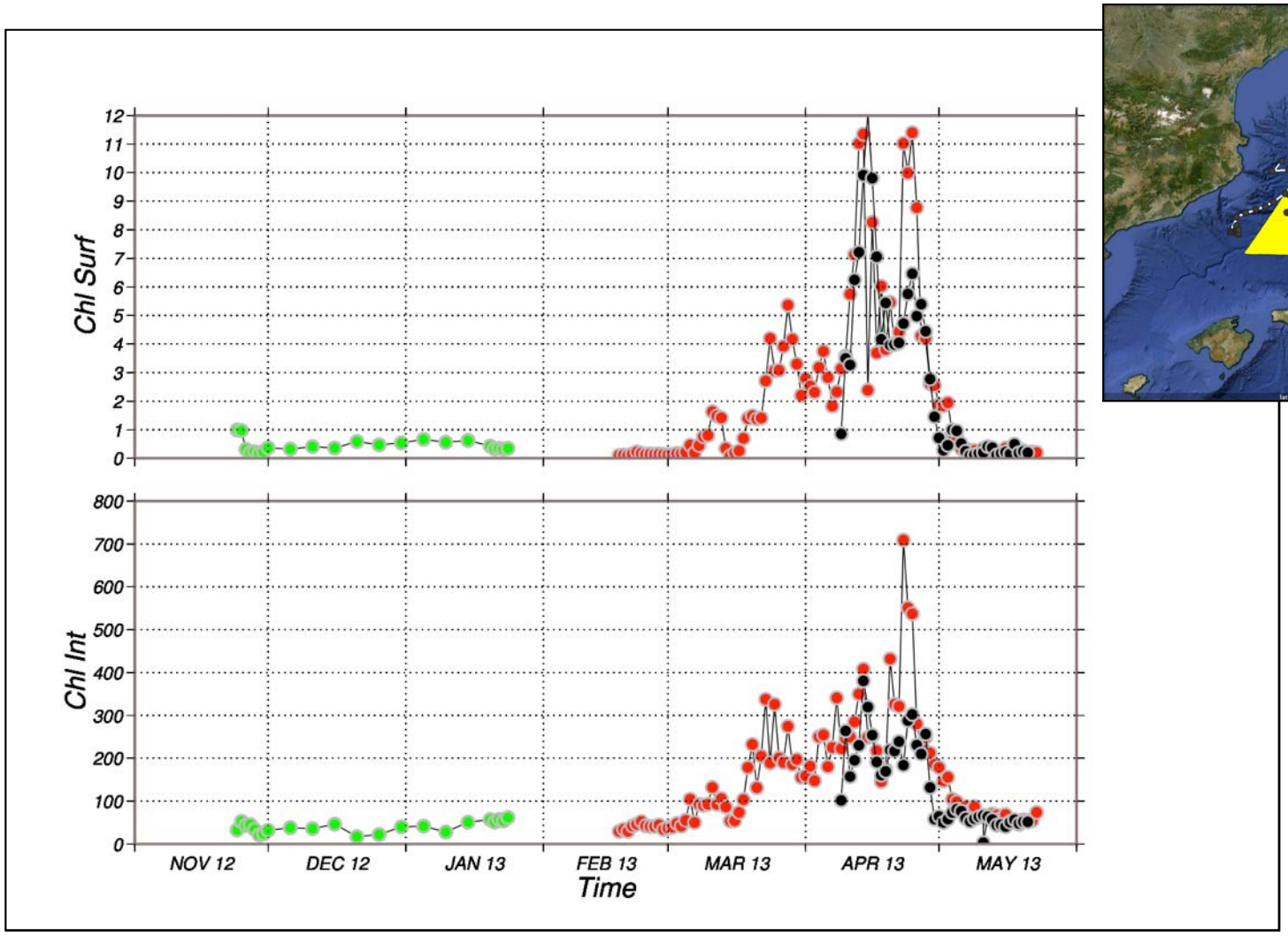
Bio-Argo floats

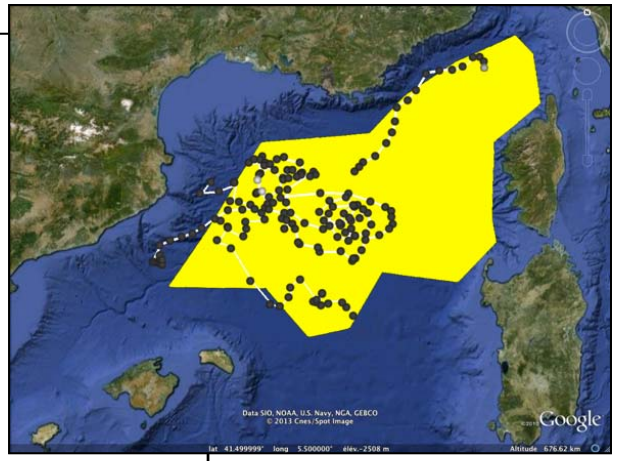




DEWEX DEep Water formation EXperiment

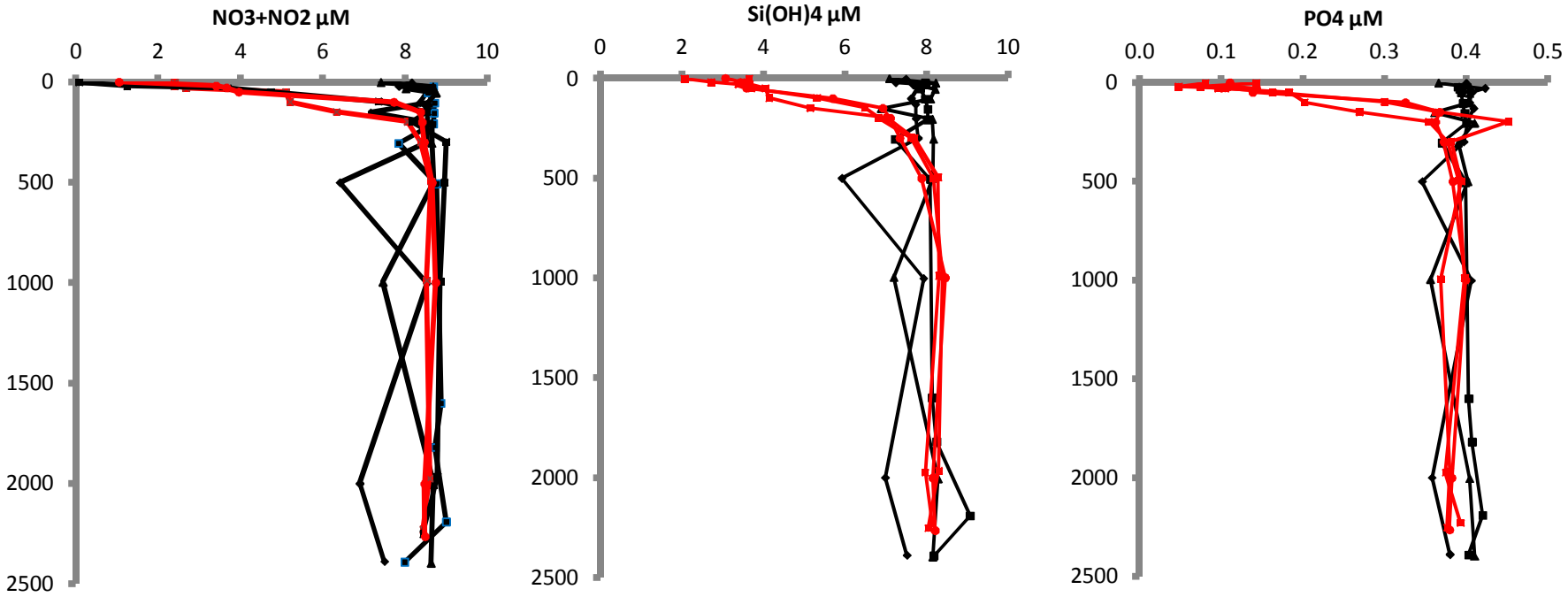
Bio-Argo floats

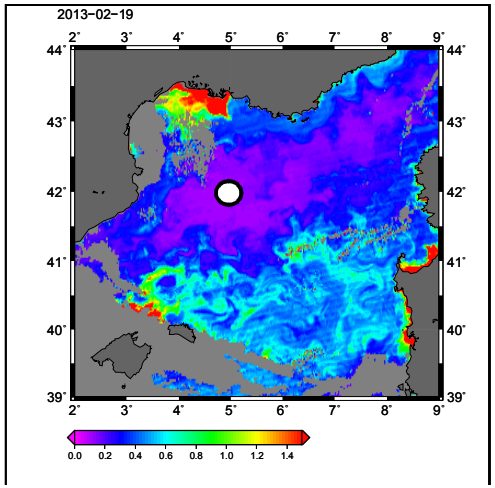


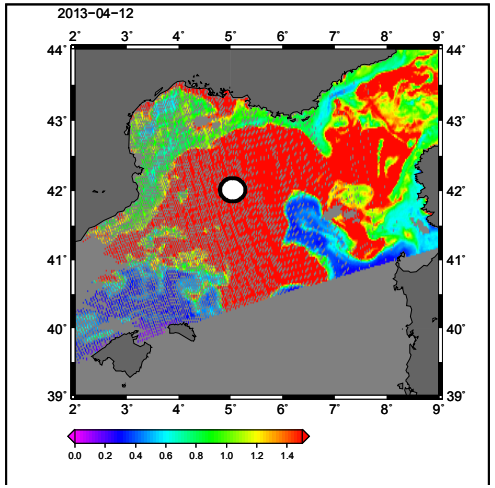


DEWEX DEep Water formation EXperiment

Data on board





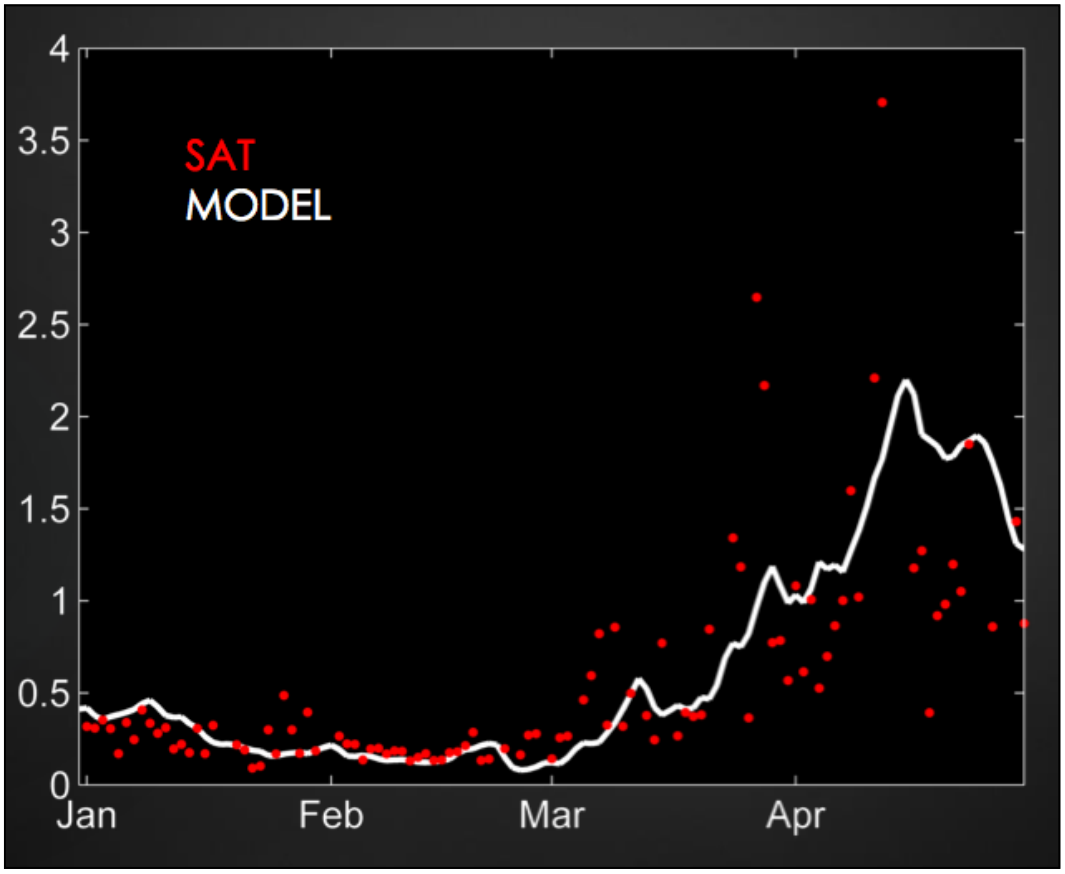


Février

April

DEWEX DEep Water formation EXperiment

Modelling



Model (LA Toulouse):

- Symphonie/ECO3m
- 1km résolution
- Aux frontières: Mercator PSY24v4r2
- Forcé en surface: ECMWF (« bulk »)
- Réajustement de l' état initiale avec les données (Juillet-Aout 2012)

DEWEX → an original and huge data set; development of data is underway and a special issue is being prepared

Land-Sea interactions and extreme events

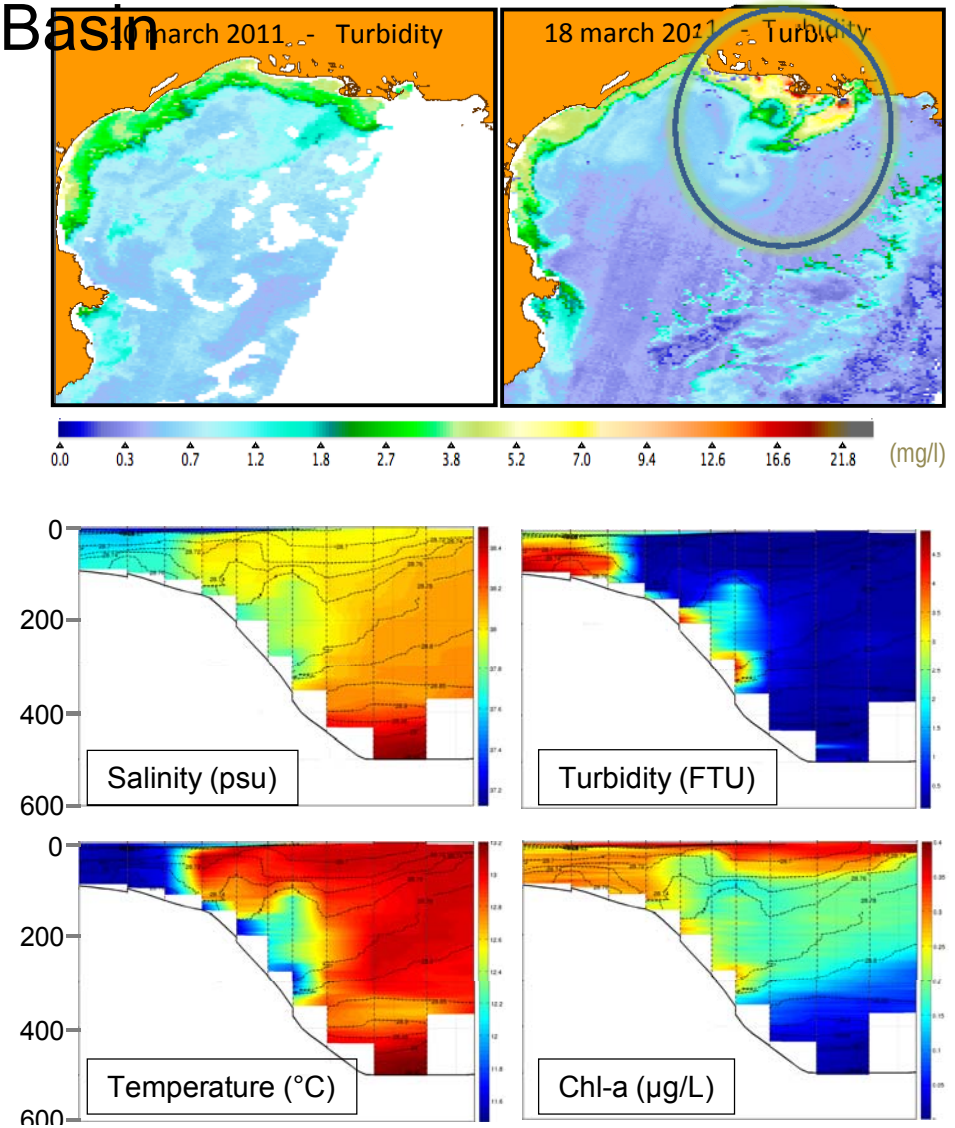
Transfers and transformations of carbon, nutrients and contaminants from rivers to the open sea, including the impact of extreme events (storms, floods,…).

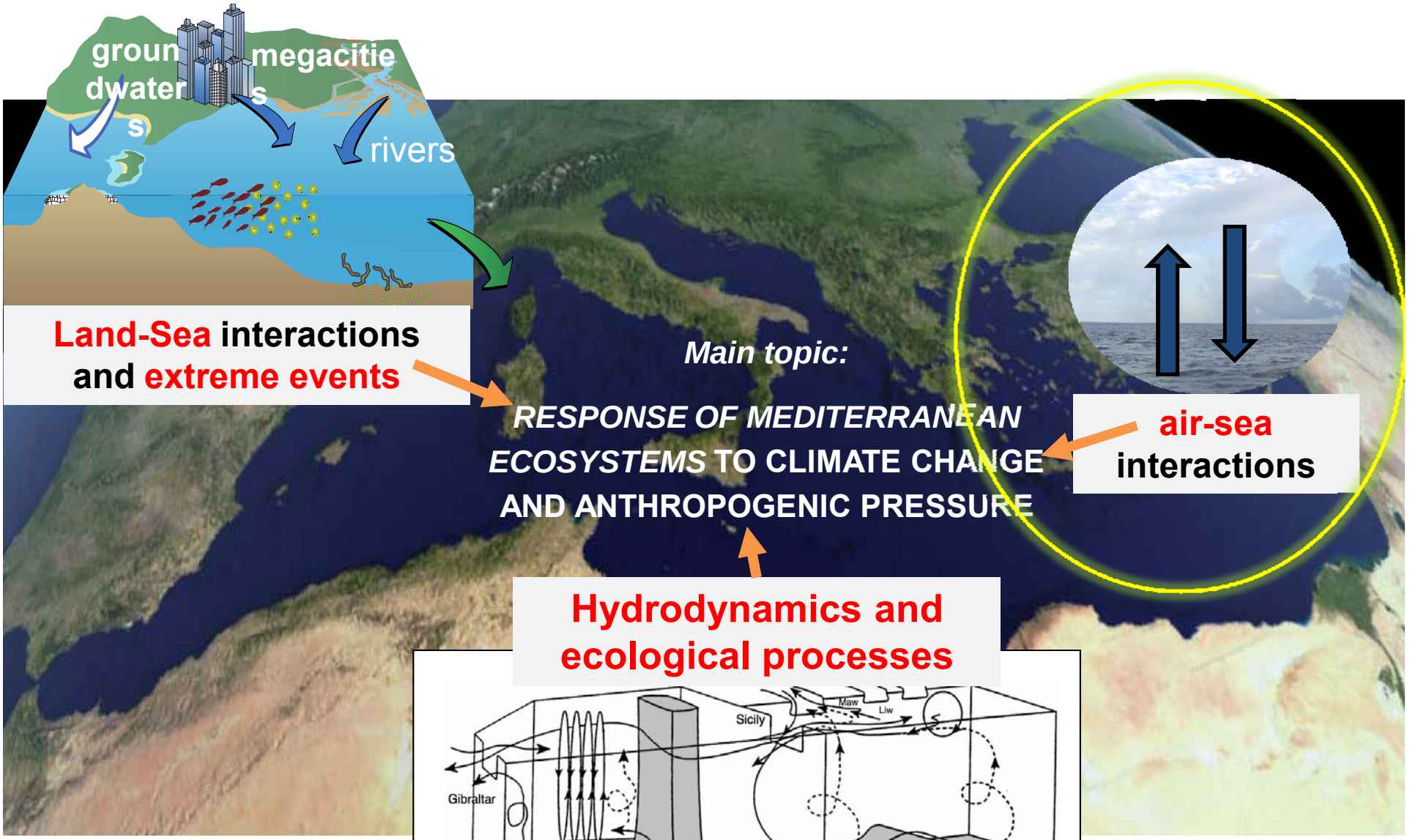
Ex. Storm-Induced Export to the Basin

Storm induced plume on the Gulf of Lion's shelf

⟶ Along-shore propagation of a turbid plume of buoyant (**cold but fresh**) coastal water during a strong eastern storm

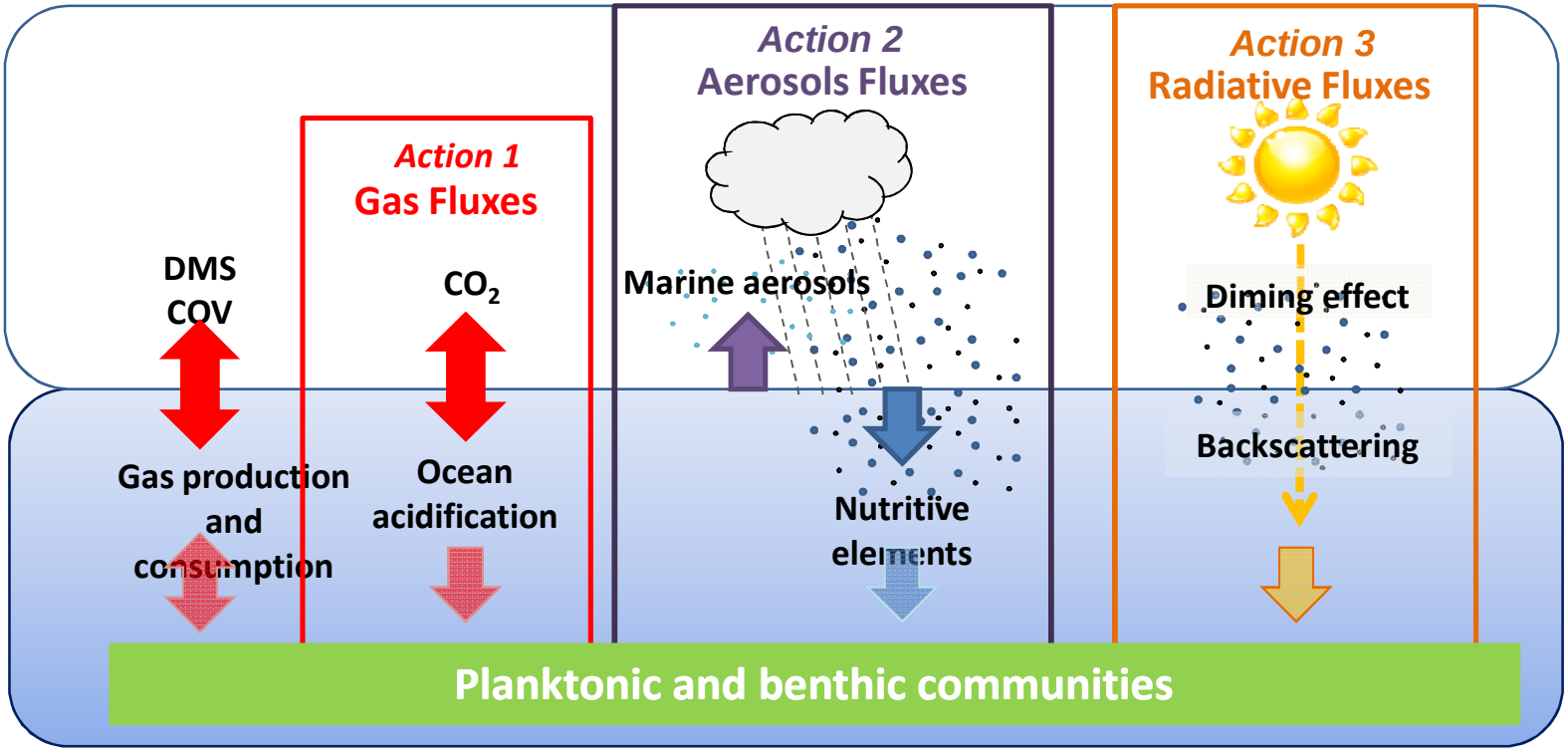
⟶ Storm-induced **downwelling in a canyon**, with the intrusion of **turbid and chlorophyll rich coastal water down to 400 m** depth in the canyon head





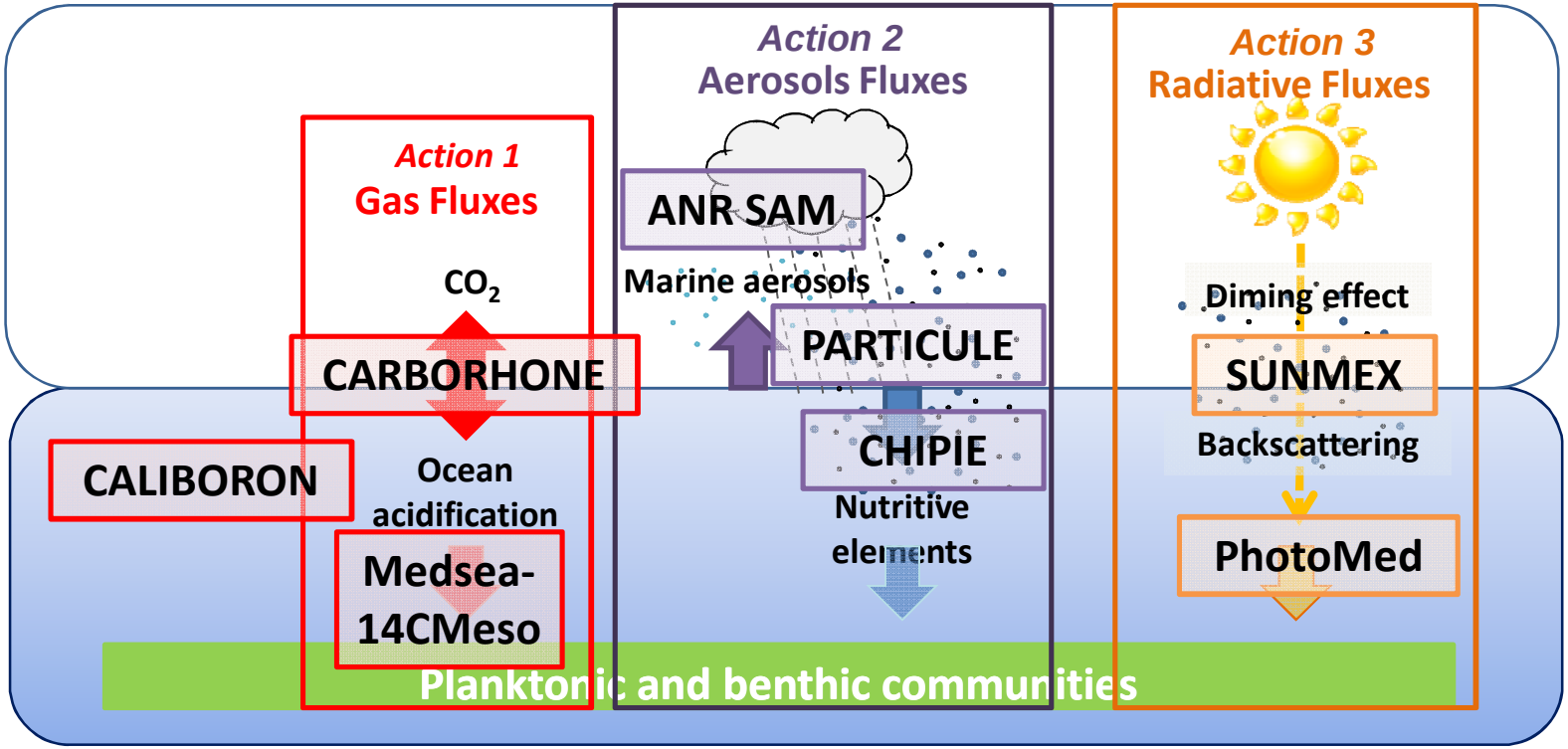
Bio- and eco-**regionalization** of the Mediterranean Sea
Mapping of **Ecosystem Services**

Natural and anthropogenic air-sea interactions
→ Impact on ecosystem functionning



Natural and anthropogenic air-sea interactions
→ Impact on ecosystem functionning

8 on going projects!

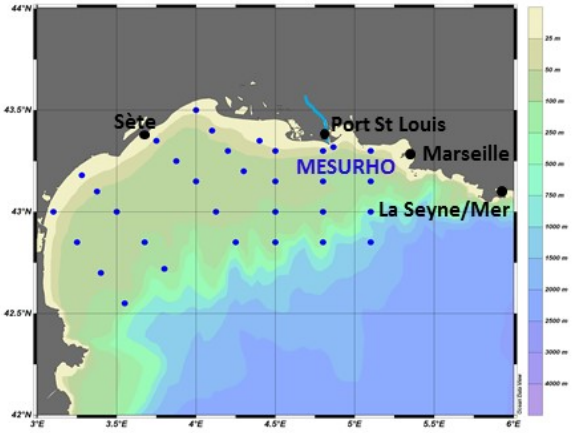


Gaz fluxes

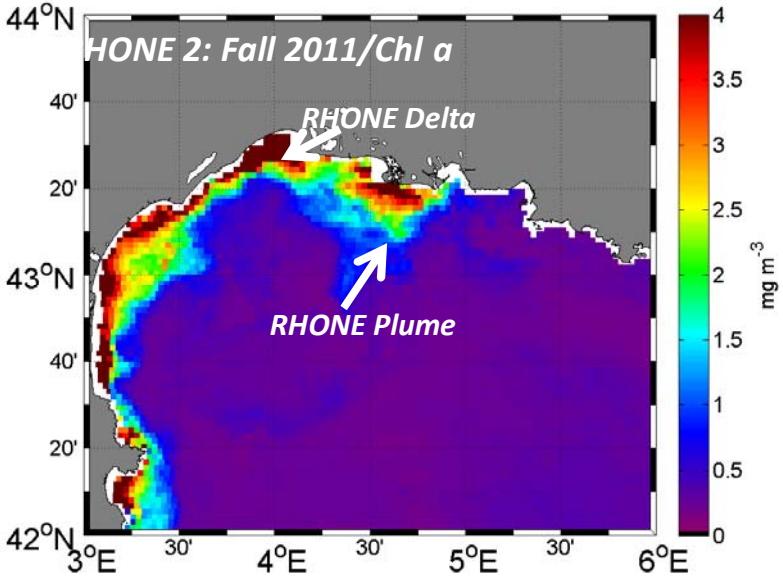
CARBORHONE: Air-sea CO_2 fluxes in the Gulf of Lion (GoL)

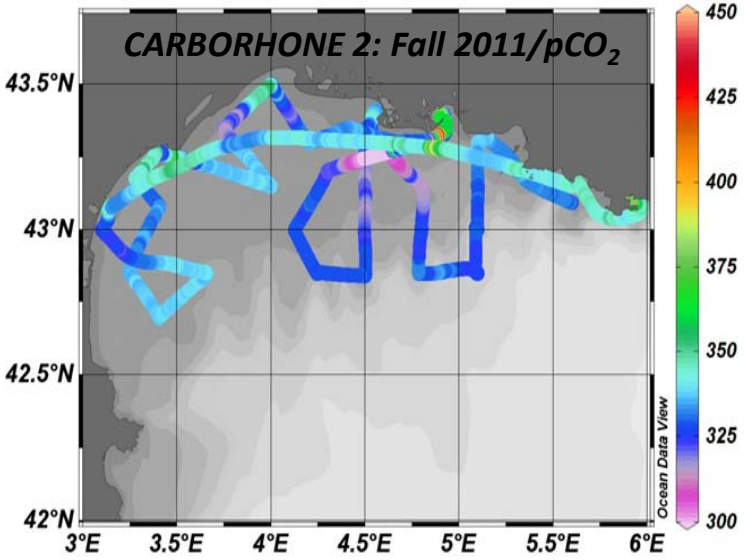
⇨ **What are the biogeochemical processes driving air-sea CO_2 fluxes in the GoL?**

⇨ **Does the Rhone plume influence air-sea CO_2 fluxes at regional scale?**



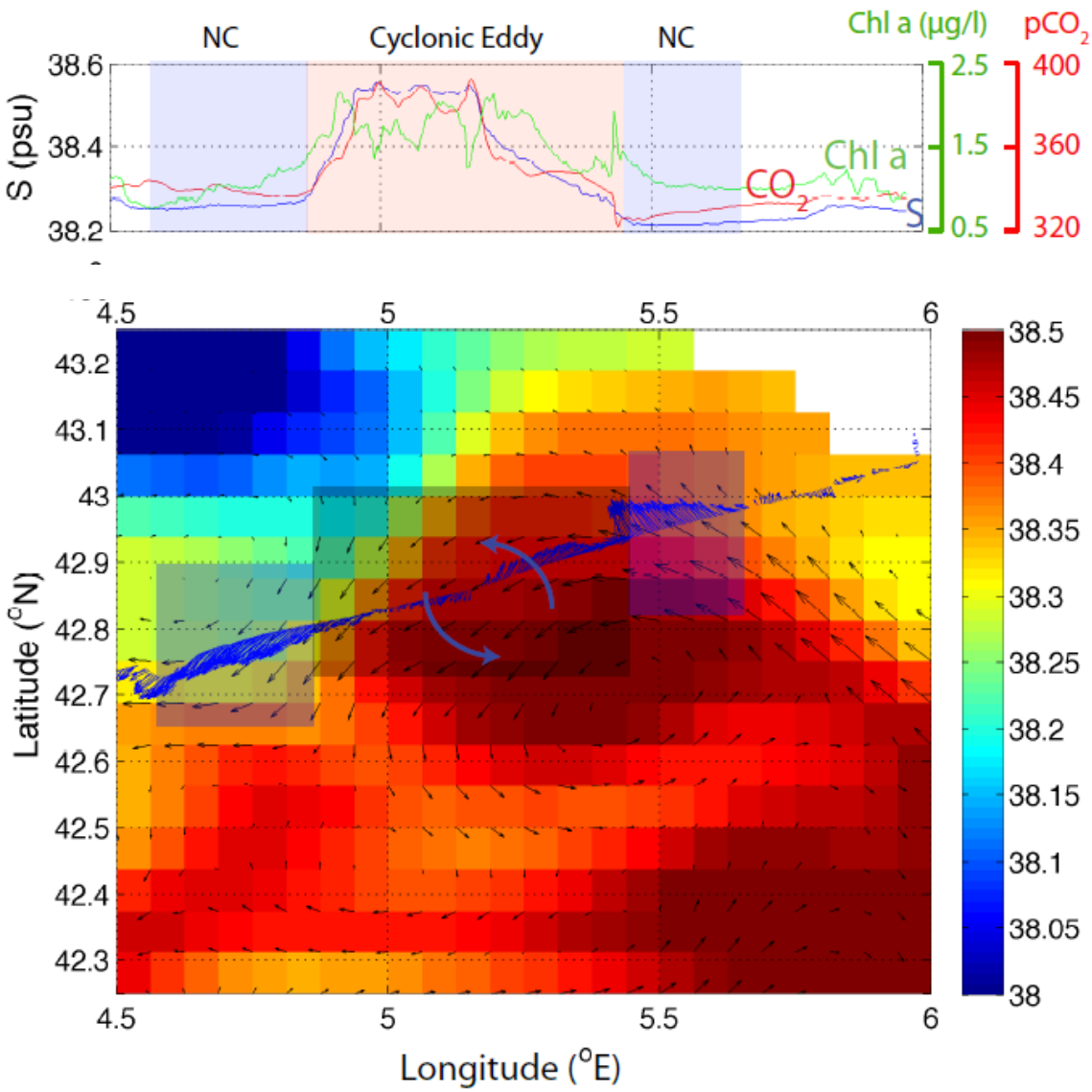
- 4 seasonal cruises in 2011/2012.
- Grid of 31 stations / CTD profiles.
- Surface measurements: T, S, Fluo, pCO_2, DO.
- Test of the SAMI pCO_2 sensor for MESURHO buoy.





(Bozec et al., IMBER OC, Bergen, June 2014)

Gaz fluxes **CARBORHONE: Cyclonic eddies and pCO_2 in the Gulf of Lion**



Winter 2012 observations:

- **Cyclonic eddy located in the Northern Current (NC).**

- **Upwelling of CO_2-riched subsurface waters.**

- **pCO_2 increase of +40 µatm in the eddy.**

(Bozec et al., IMBER OC, Bergen, June 2014)

All pCO2 data → submitted to SOCAT DB, under validation

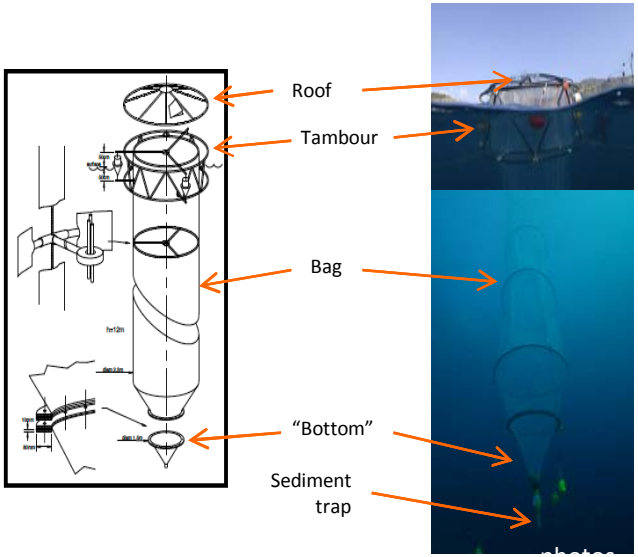
⇨ **Cyclonic eddies decrease the CO_2 sink in the GoI during winter**

Gaz fluxes/acidification

Mermex – MedSeA (EU project 2011-2014)

Two mesocosm experiments to test for ocean acidification impact in the Mediterranean Sea

Mesocosm
Height 12 m, volume 52 m^3

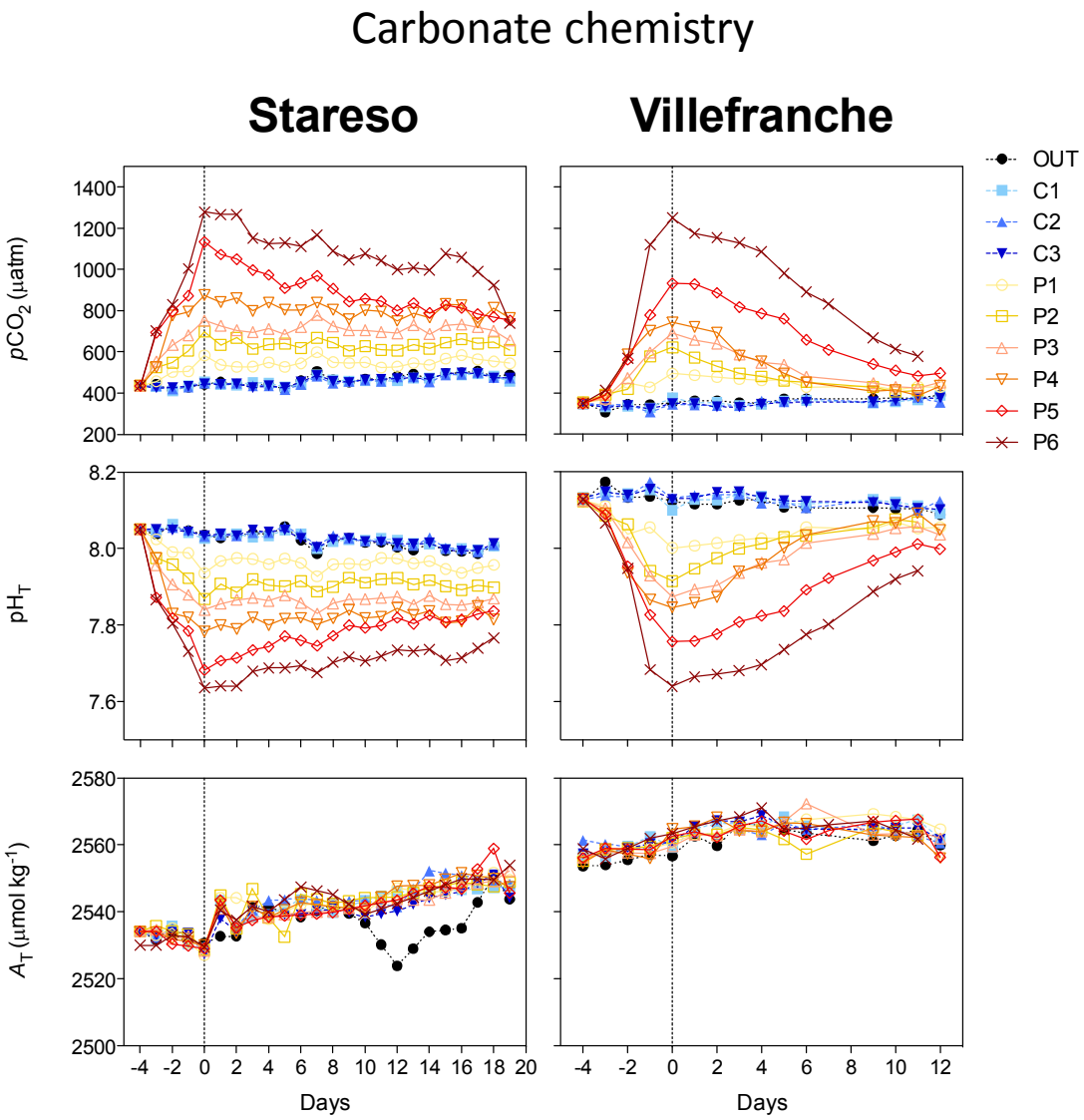


Stareso, summer 2012

Villefranche, winter 2013

Gaz fluxes/acidification

Mermex – MedSeA (EU project 2011-2014)



- 9 mesocosms
- 6 acidified mesocosms
- Daily sampling with integrative bottles
- 20 days experiment in Stareso
- 12 in Villefranche (bad weather)

- Successful experiments overall
- **No important impacts of ocean acidification in these nutrient-limited ecosystems**

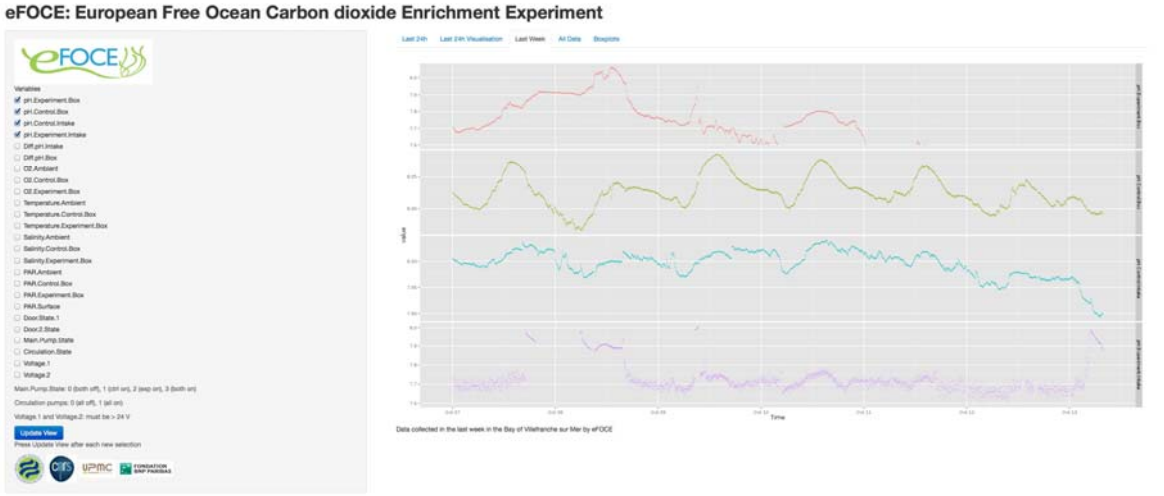
- In the vast majority of the ocean (oligotrophic regions), ocean acidification will not have the fertilizing effect that we anticipated

Gaz fluxes/acidification

Mermex – eFOCE (French project 2011-2014)

Development of experimental systems to study the effects of ocean acidification on benthic organisms, directly in the natural environment

- 1 control chamber vs. 1 « acidified » chamber
- Experiment started in June 2014, will end in January 2015
- Continuous pH regulation at -0.3 (projected for 2100)
- Focus on key species (*Posidonia oceanica*: seagrass)



MERMEX-CHIPIE

Dust deposition + acidification : What impact on marine biogeochemistry ?

Small version of mesocosms (300 L), in abiotic conditions

CHIPIE project

Dust deposition + acidification : What impacts on marine biogeochemistry ?

1 forcing :
- **dust addition**

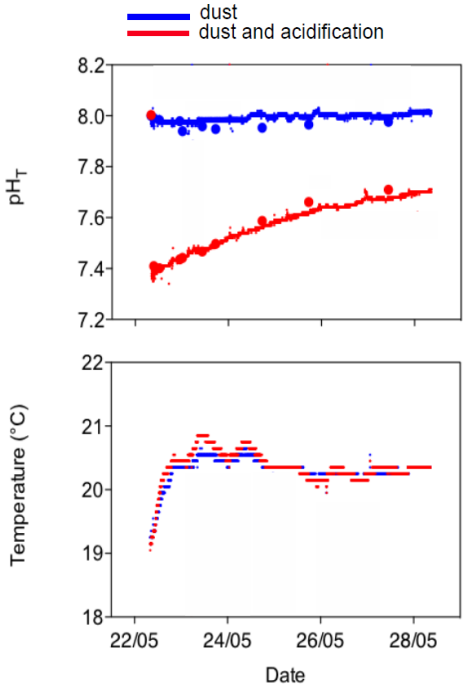
2 forcings :
- **dust addition**
- **acidification**

Minicosm of 300 L
Abiotic condition

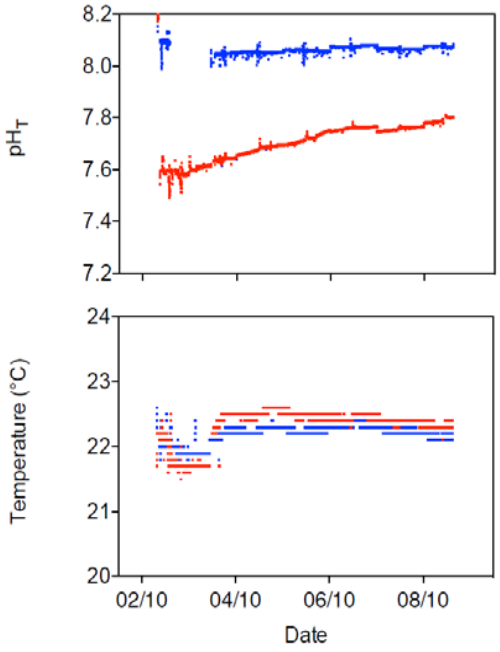
Seawater saturated with pCO_2 : 1250 ppm

Follow up pH and temperature

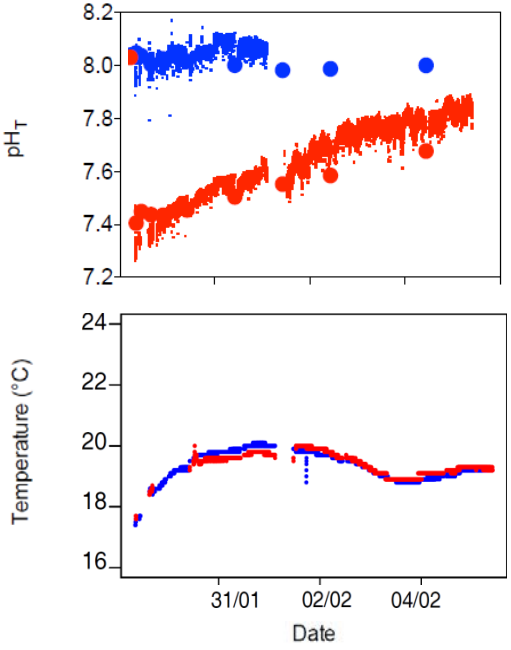
May : post-bloom



October : end of stratification



February : winter mixing layer



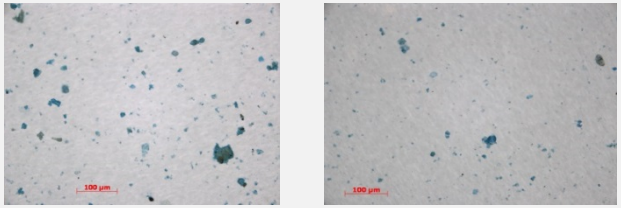
CHIPIE= Some (very recent) results

Organic matter – fraction > 0.2 µm
Example of October exp.

No acid. **Acid.**

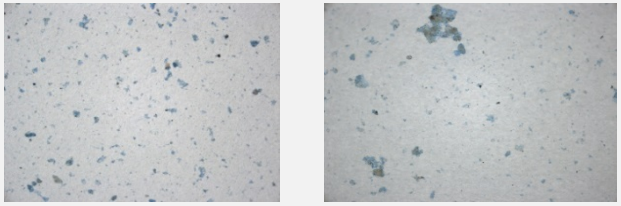
Before seeding - Vol. filtered : 50mL

1 hour after seeding - Vol. filtered : 15mL



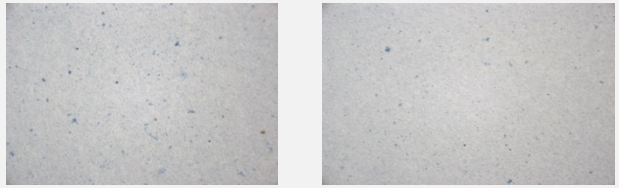
aggregation

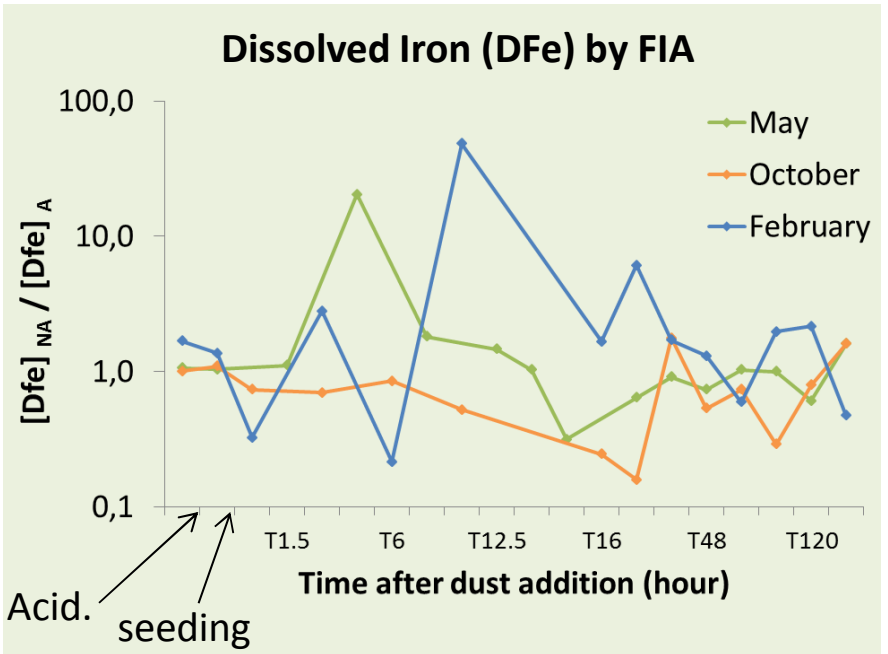
1 day after seeding - Vol. filtered : 40mL

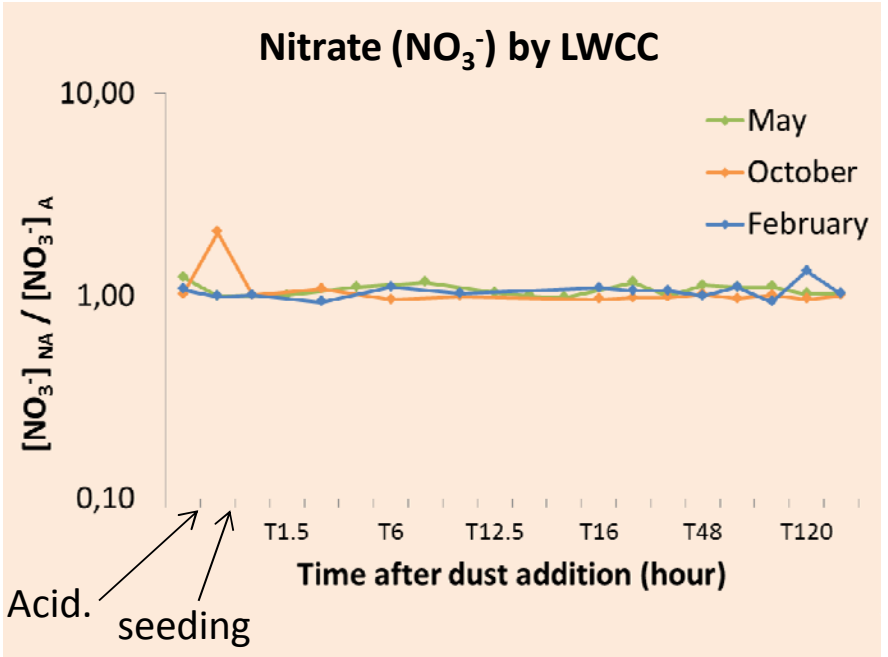


sinking

6 day after seeding - Vol. filtered : 50mL



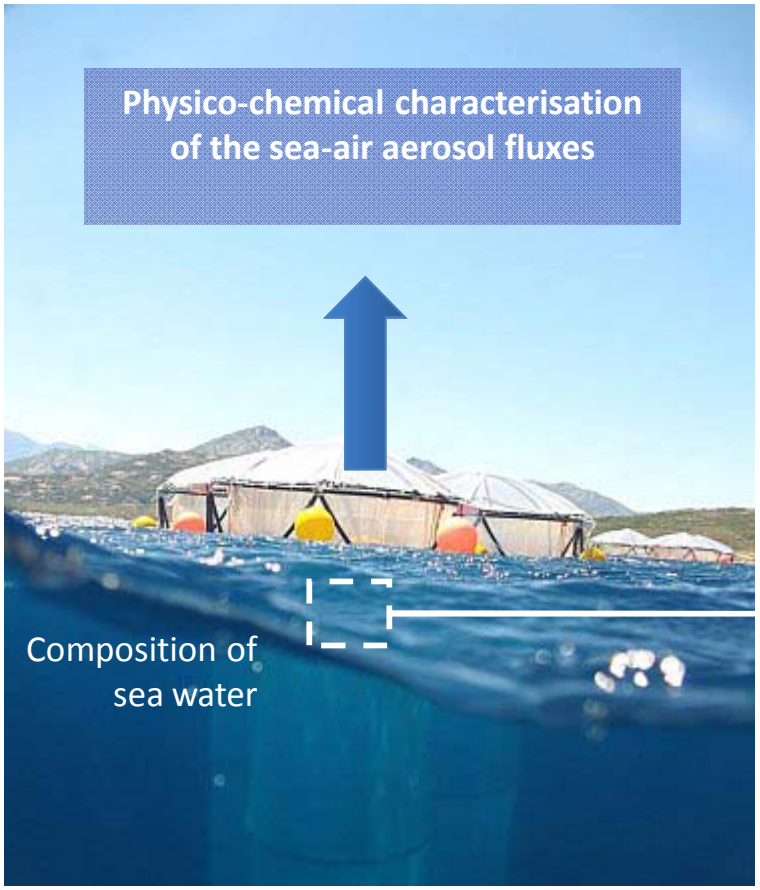


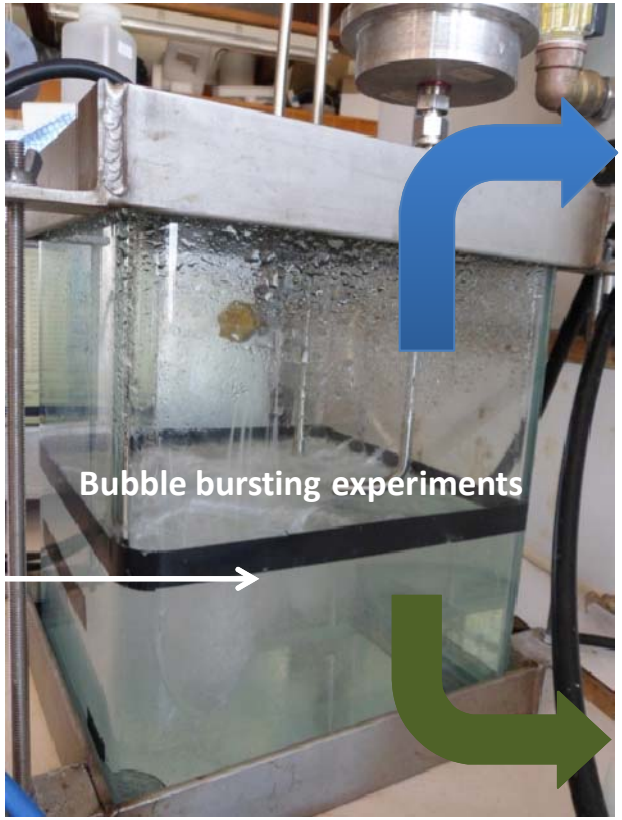


SAM and MedSea-emissions : Mesocosms studies

How are marine emissions related to the biogeochemical composition of the Sea water?

Objective 1: Characterize and quantify the primary marine aerosol fluxes

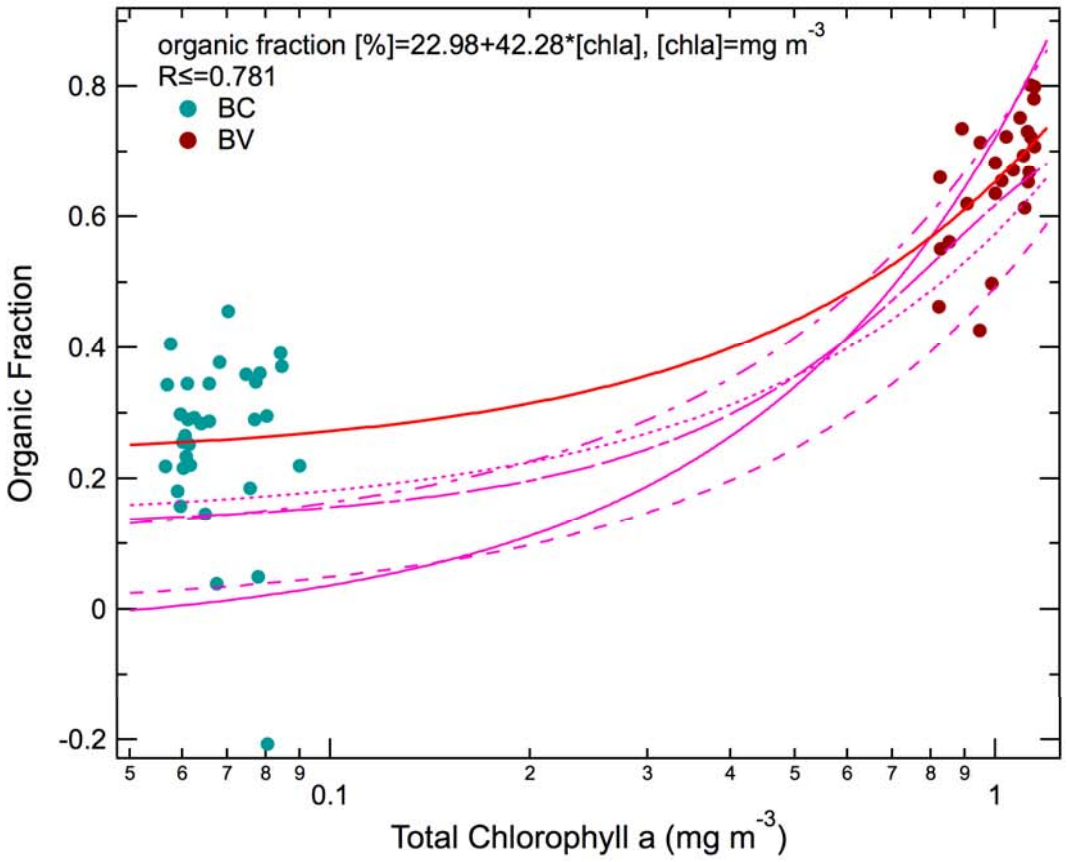




- Chemical composition
- Size distribution
- Cloud Cond. Nuclei
- Biological charac.

- Chl-a
- DOC-POC
- Biological charac

New parametrizations of marine aerosol emissions



Rinaldi et al. [2013]: North Atlantic Ocean
Gannt et al. [2011]: Mace Head, Ire.
Vignati et al. [2010]: Mace Head, Ire.
Langmann et al. [2008]: revised O'Dowd et al. [2008]
O'Dowd et al. [2008]: Northeast Atlantic Ocean
This work

A higher organic content from the Mediterranean waters?

Schwier et al. ACPD 2014

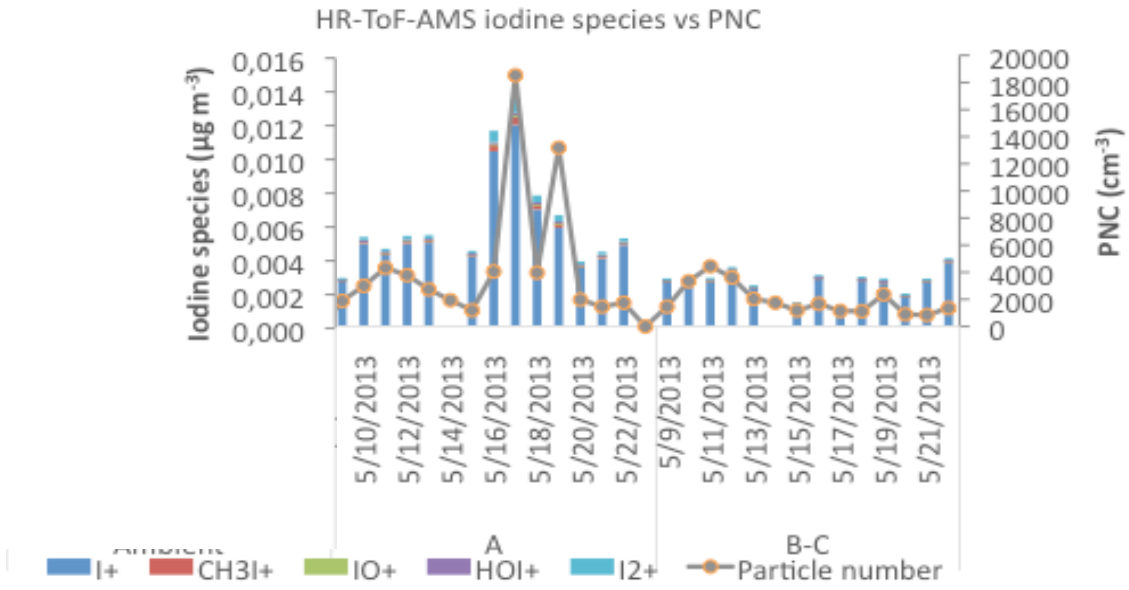
Objective 2: Characterize the VOC emissions and understand the secondary aerosol formation

Directly from the emerged part of the mesocosm:

-VOC measurements from PTRMS

-Ultrafine particle size distribution

-trace species on HR-AMS



➔New particle formation observed for the first time w/o presence macroalgea

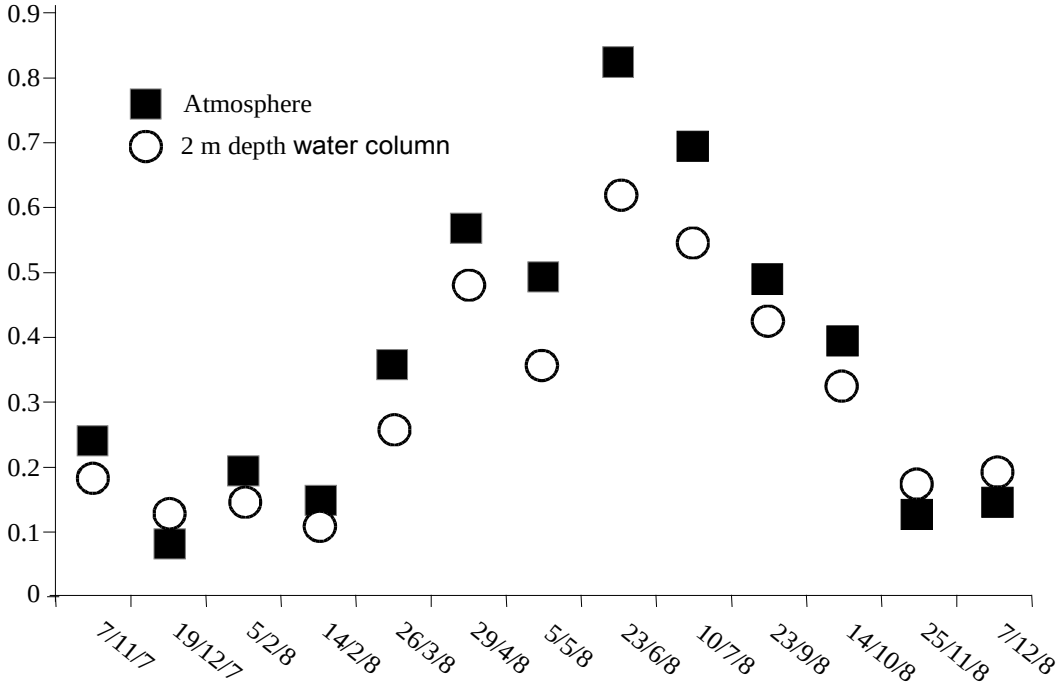
Radiative fluxes

Sunmex, Marseille Bay

Potential effect of aerosol and tropospheric ozone attenuation on marine ecosystems and seagrass rarefaction

R. Sempéré, B. Charriere, M. Mallet, J. Para

UVR-B/UVR-A x 10

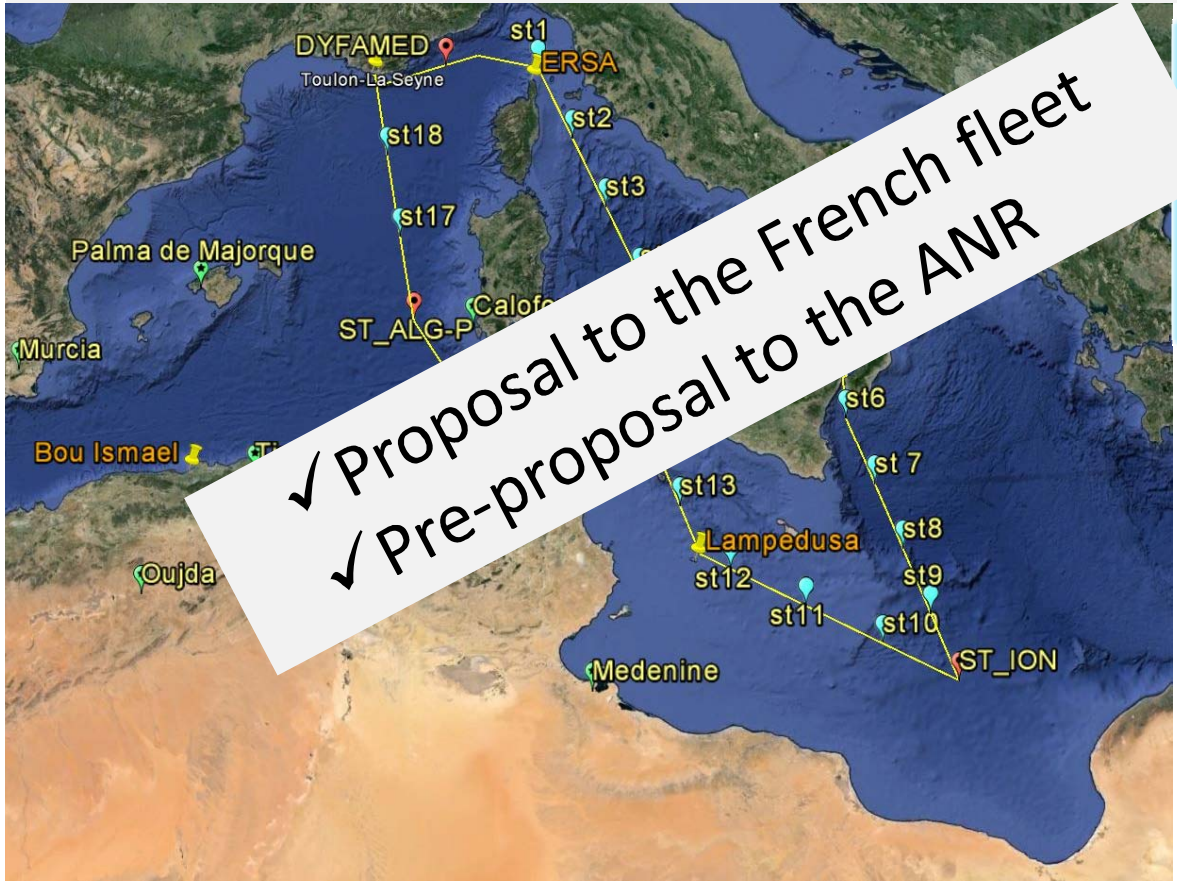


- These UVR values are the first ever reported on an annual basis in Mediterranean Sea.
- Examination of the ratios of UVR-B/UVR-A shows that **UVR-B increased 7 to 8 fold more than its UVR-A** during the summer.

In project PEAcEtIME : ProcEss studies at the Air-sEa Interface after dust deposition in the MEditerranean sea (2015-2018)

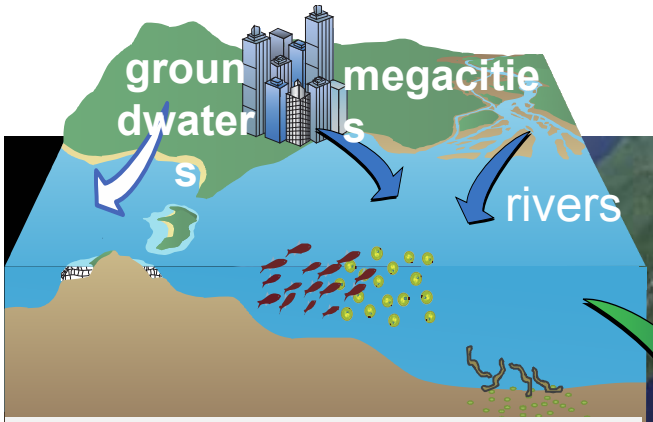
Cécile Guieu and Karine Desboeufs: PI of PEACETIME

To characterize the fundamental processes and their interactions at the ocean-atmosphere interface in the Mediterranean Sea, and **how these processes impact, and will impact, the functioning of the pelagic ecosystem** and the feedback to the atmosphere, today and in the future.
Experimentalists and modelers from atmospheric and marine sciences,



- Target: A 33-days cruise planned in MAY 2016 R/V Pourquoi Pas? (40 scientists embarked).
- 14 lab in France
- 9 research laboratories abroad

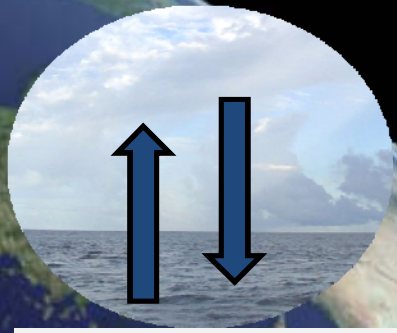
- **National Frame**: part of the **MISTRALS** programme (Mediterranean Integrated STudies at Regional And Local Scales) and a joint project between **ChArMEx** (the Chemistry-Aerosol Mediterranean Experiment) and **MERMEx** (Marine Ecosystems Response in the Mediterranean Experiment).
- **International Frame**: SOLAS, GEOTRACES, IMBER (supports)



Land-Sea interactions and extreme events

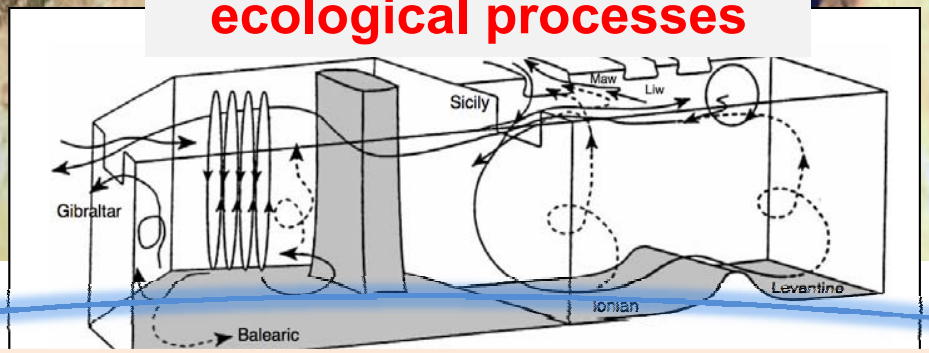
Main topic:

***RESPONSE OF MEDITERRANEAN ECOSYSTEMS* TO CLIMATE CHANGE AND ANTHROPOGENIC PRESSURE**



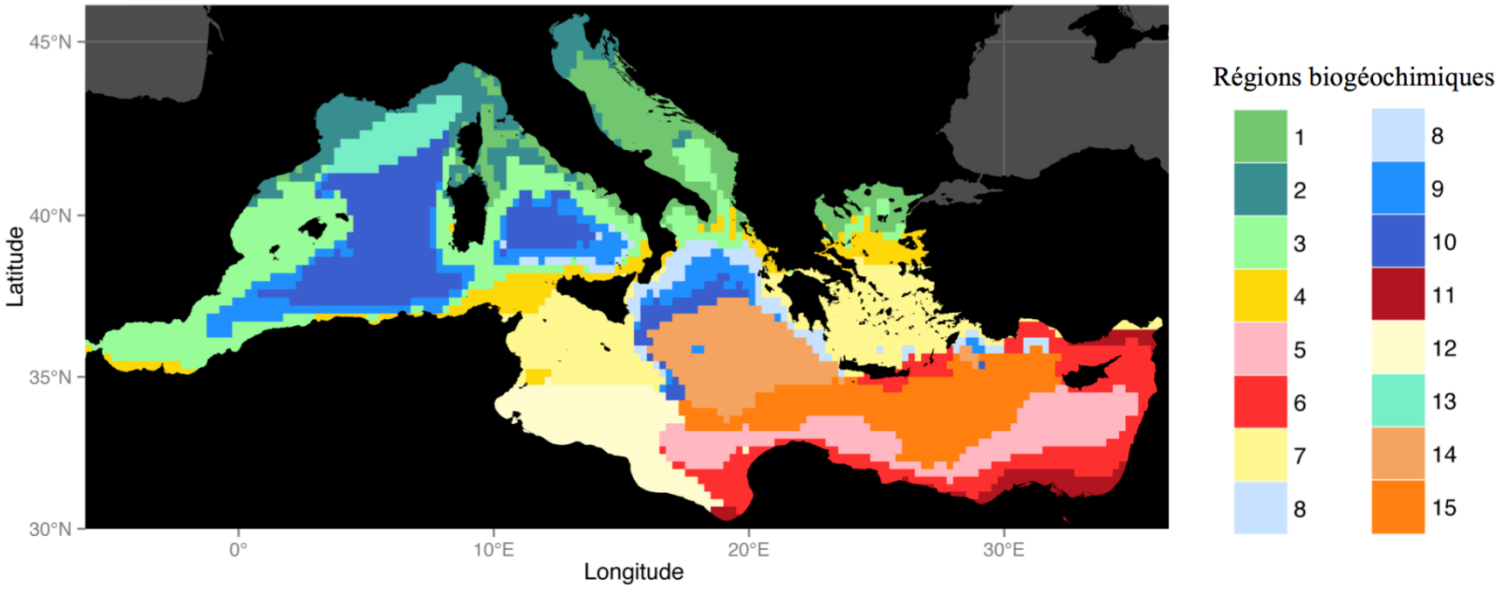
air-sea interactions

Hydrodynamics and ecological processes



Bio- and eco-**regionalization** of the Mediterranean Sea
Mapping of **Ecosystem Services**

REGIONALISATION: Bio- and eco-regionalization of the Mediterranean Sea from data analysis in international databases + data collected by MERMEX



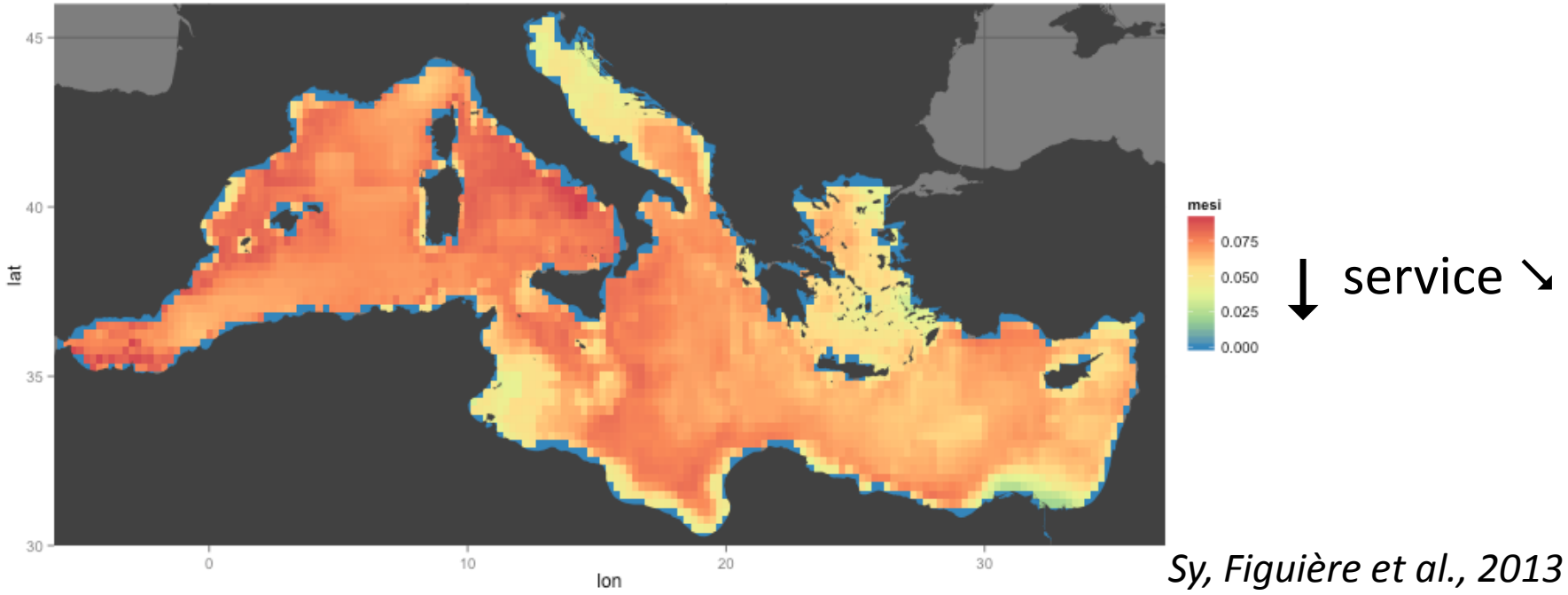
Reygondeau et al., 2013

Post-doc funded by PERSEUS

- Mediterranean bio-region:
- Acquisition of the distribution of 14 environmental variables… → clustering
- A map composed of homogeneous regions: « bio-region »
- On going: seasonal pattern of the bio-regions and 3D pattern;

Mapping of ecosystem services

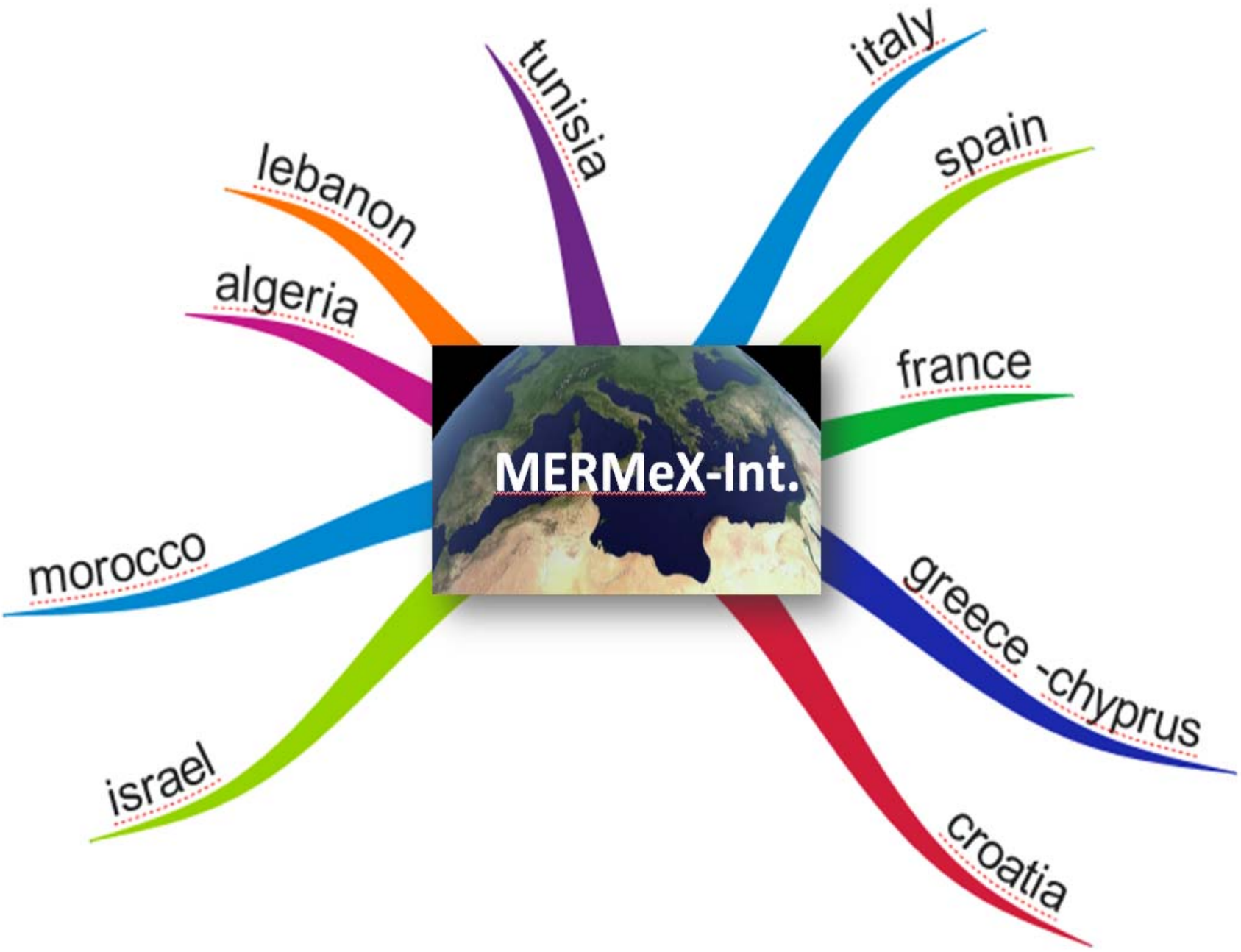
MESI index



Sy, Figuière et al., 2013

MESI index → mapping of ecosystem services

- Nord-ouest more rich in term of ecosystem services compared to the south and north-east
- MESI is higher in some area where there are no MPAs!

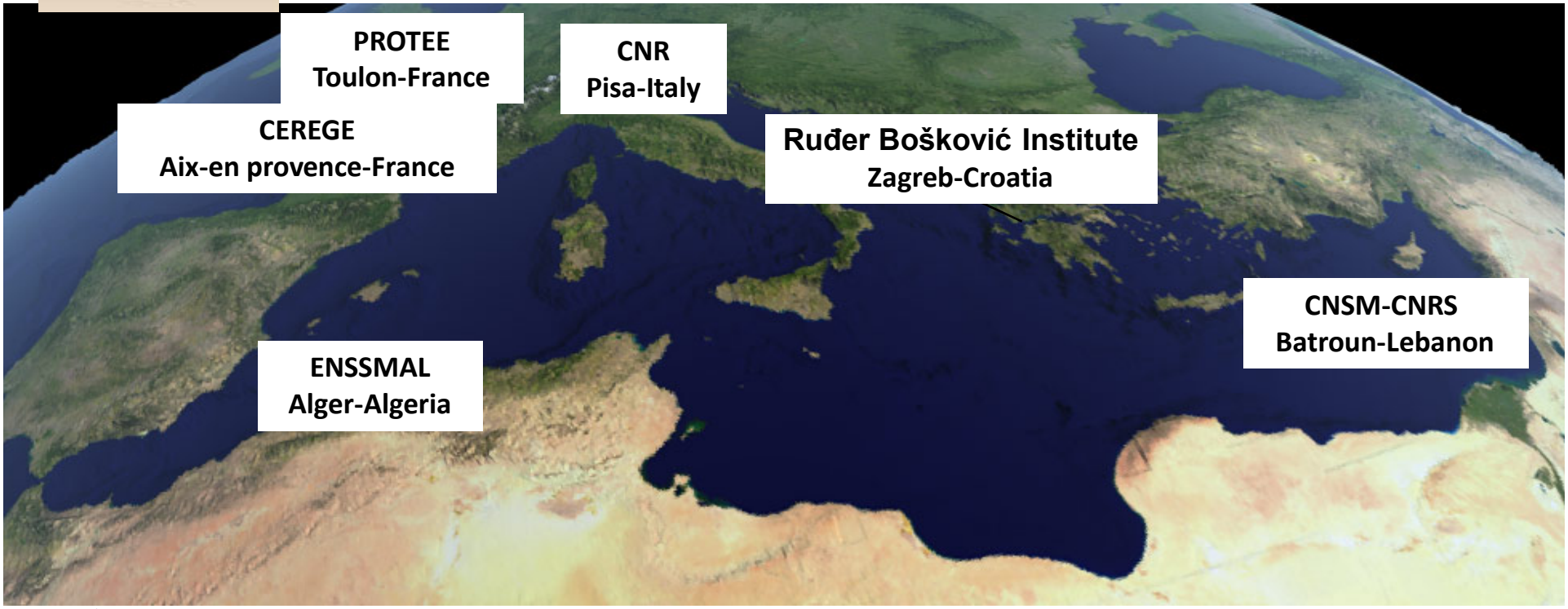

tunisia
italy
lebanon
spain
algeria
MERMeX-Int.
france
morocco
greece -chyprus
israel
croatia

Envimed project: cycles of trace metal contaminants – WP3 (on going project)

COntaminants Métalliques dans l'Environnement COtier Méditerranéen

COMECOM-MERMEX

2nd call



➢ **P.I. Olivier Radavovitch (CEREGE-Aix en Provence-France)**

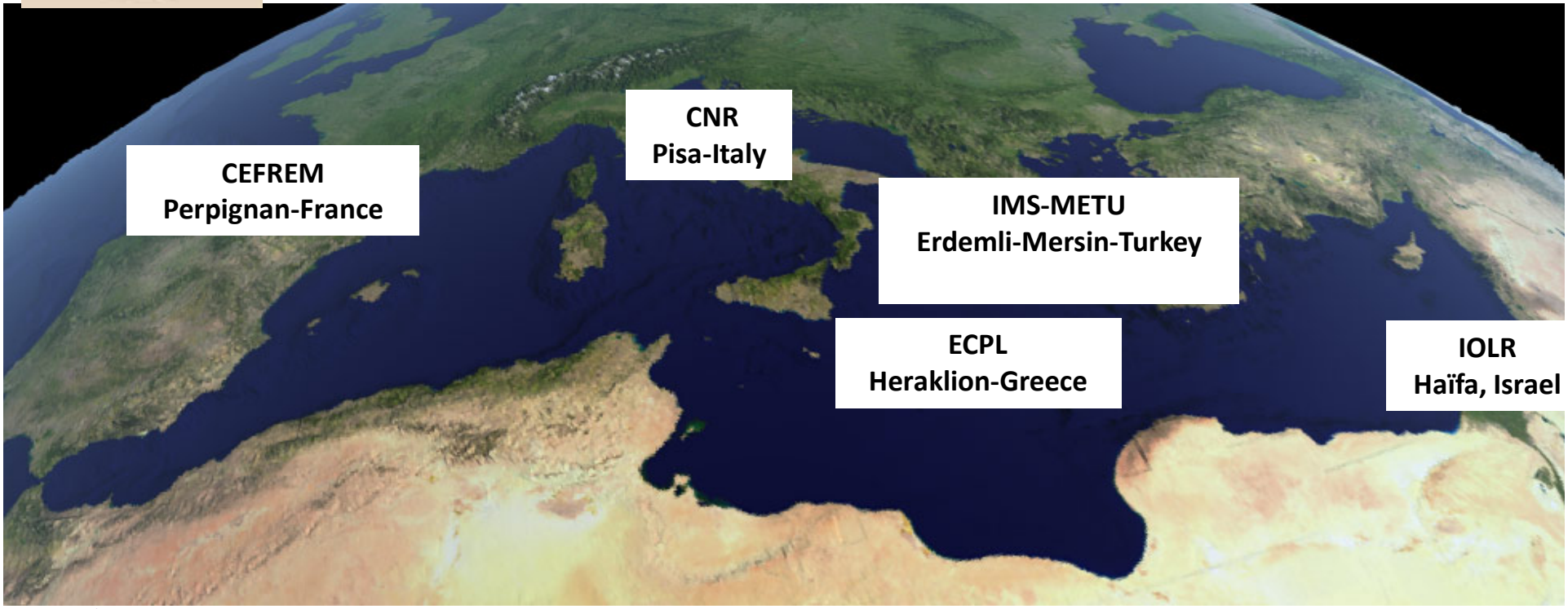
Knowledge and the sharing of expertise concerning the cycles of trace metal contaminants in the Mediterranean coastal area and their impacts on the marine ecosystem

Envimed project: Atmospheric inputs to coastal Med Sea –WP4 (on going project)

TRansfer of Atmospheric COntaminants to the MEDiterranean Sea

TRACOMED- MERMEX

2ND CALL



➢**P.I. Dominique Aubert (CEFREM-Perpignan-France)**

Knowledge and the sharing of expertise concerning the atmospheric input of trace metal and nutrients

Envimed project: SOMBA–WP1

Système d'observation de la mer dans le bassin algérien

SOMBA-MERMEX

2nd call

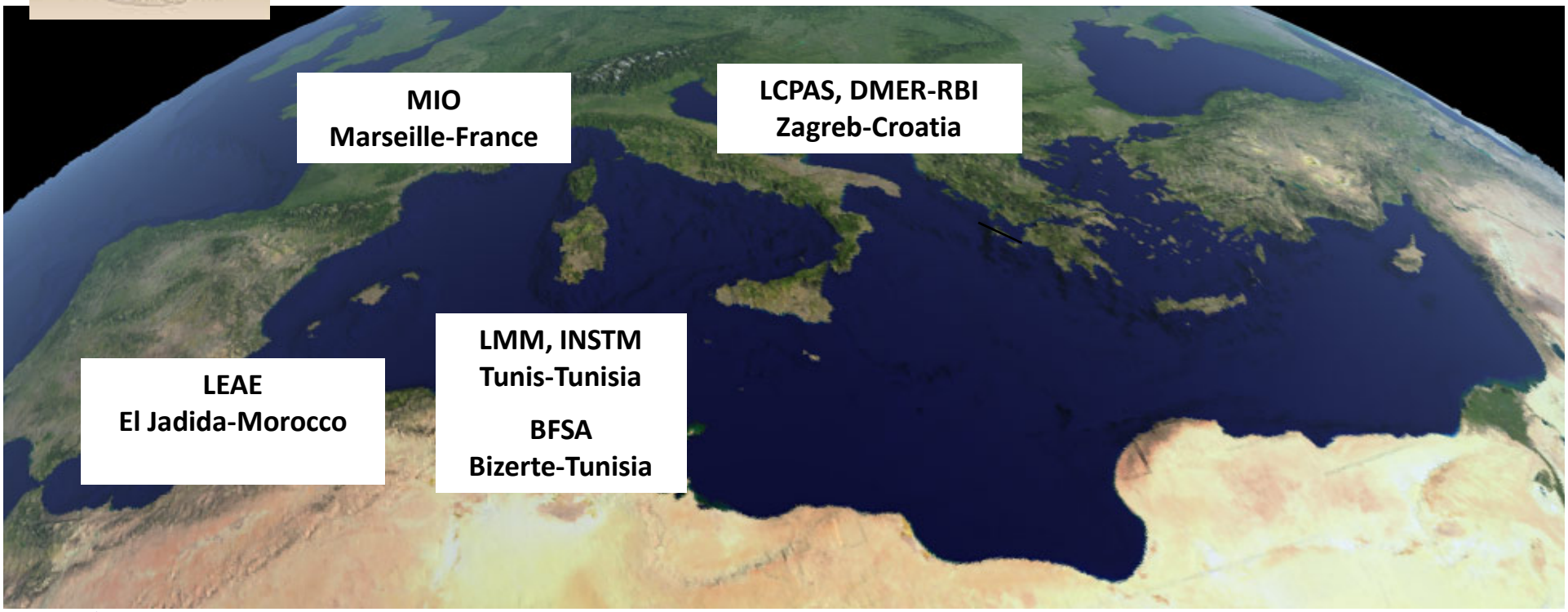
LOCEAN-Paris, MIO Marseille-France

ENSSMAL Alger-France

- **P.I. Laurent Mortier, (LOCEAN, UPMC)**

Envimed project: Effets of physical forcing on COastal ZOoplankton community structure-WP2

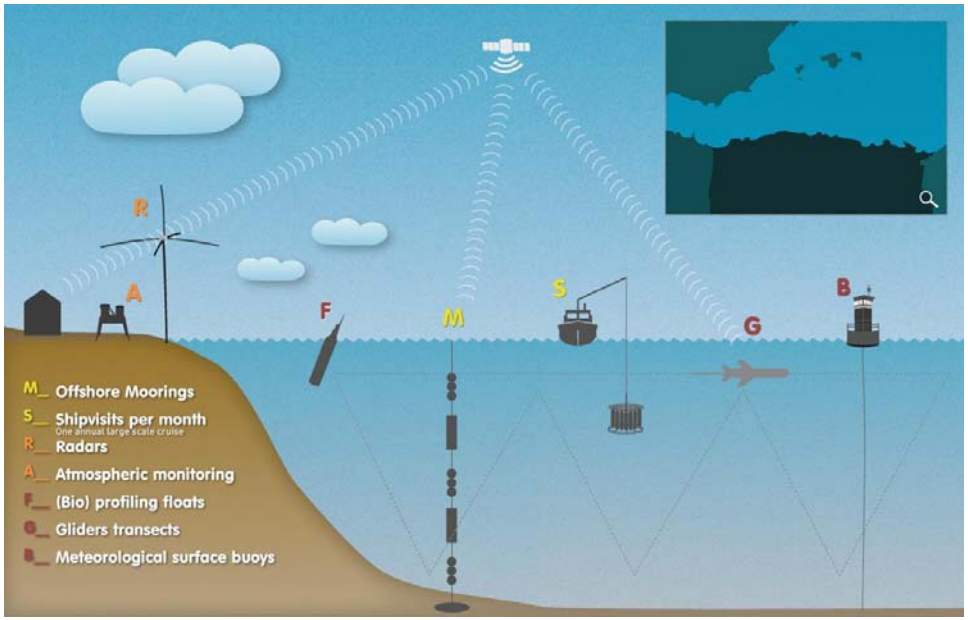
COZOMED-MERMEX
3rd call



➢ **P.I. Marc Pagano (MIO-Marseille-France)**

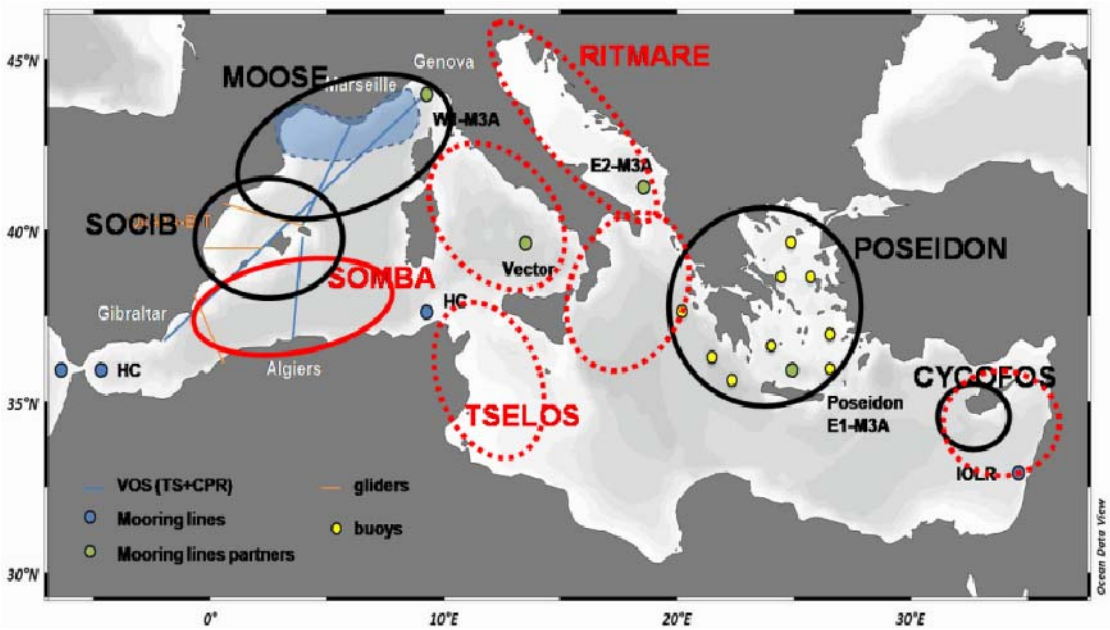
Knowledge and the sharing of expertise concerning the role of hydrodynamic and trophic forcing on the variability in time and space of Mediterranean coastal and lagoon zooplankton communities under contrasted tidal influence

SOMBA
« Système d'Observation à la Mer du Bassin Algérien »



Laurent Mortier, LOCEAN, mortier@locean-ipsl.upmc.fr
Ferial Louanchi, ENSSMAL, ferlou18@gmail.com

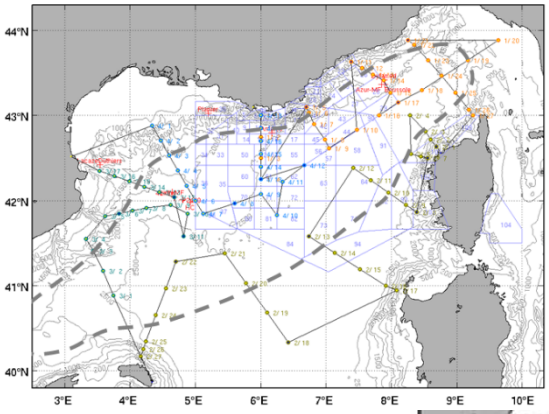
SOMBA: OBJECTIVES



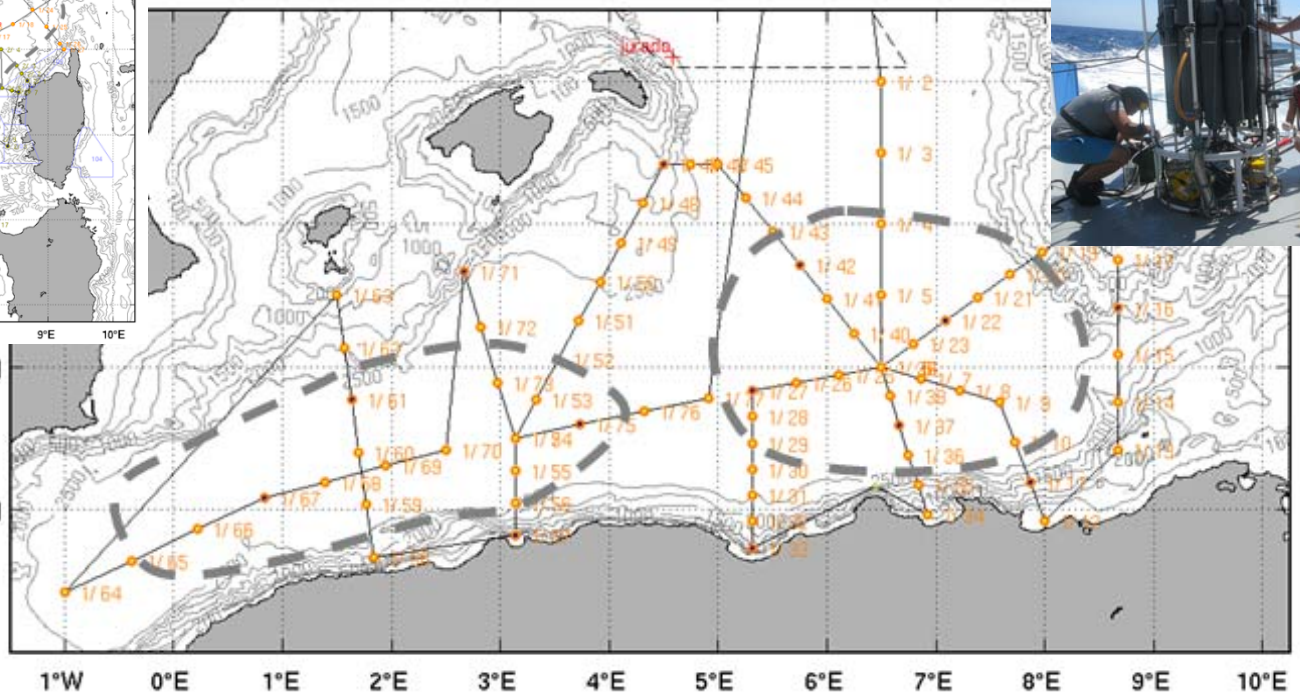
- To develop open-sea observation of the Algerian Basin
- To integrate those observation to International-MOOSE
- To support MERMEX-Algeria and national authorities (fisheries…)

➢ A mooring	✓ summer 2014
➢ ARGO float	→ autumn 2014
➢ Yearly Oceanographic campaign	✓ summer 2014
➢ Implement a glider Palma-Alger	✓ on-going
➢ Workshop ‘instruments’	✓ spring 2014
➢ MOOSE methological standards (O2, DIC, Nut.)	✓ on going

Bassin Algerian ➔ 2 Gyres ➔ Campagnes SOMBA-GE



Campagnes MOOSE-GE



- Pilot campaign SOMBA-GE2014: 15/08-10/09 sur **le R/V TethysII**
- PIs: ENSSMAL (Alger) et LOCEAN (Paris)
- Idem MOOSE-GE parameters, same protocols
- Next in september 2015
- Algerian boat from ENSSMAL « Benyahia »

Modelling activities

WP1
Impact of hydrodynamic changes on Mediterranean biogeochemical budgets

Dense water formation influence on ecosystem,
Biogeochemistry of the Mediterranean

Models:
Process studies
Data interpolation
Impact of climate change

WP3
Land-ocean interactions including extreme events

Cascading,
Influence of extreme events on the sediment budget over the goL,
Impact of coastal cities on ecosystems and fate of contaminants

WP 4
Natural and anthropogenic **air-sea interactions**

Ocean acidification,
Carbon fluxes

WP2
Ecological processes: biogeochemistry and food web interactions

HTL models: ecological models, end-to-end models,
Impact of climate change on ecosystems

WP5
Ecosystem Based **Management**

Ecological niche models
Statistical models

Links with other programs: Hymex, Charmex, Simed, COMODO, AMICO, PERSEUS,…MOOSE
Mistrals workshop in January 2015 : climate integrated modelling studies in the Mediterranean

Modelling activities

-13 configurations of models/ coupling including HTL and contaminant/ hindcasts, forecasts and scenarios

Configuration Name	Sub-models (name + type)	Coupling type	Ongoing Developments	Area	Horizontal resolution	Contact
NEMOMED12-ECO3M-Med	NEMOMED12 (0) ECO3M-Med (1)	HydroBio		Med	1/12°	F. Diaz
NEMOMED12-PISCES	NEMOMED12 (0) PISCES(1)	HydroBio		Med	1/12°	J-C. Dutay
MENOR	MARS3D (0)			NW Med	1.2 km	P. Garreau
MENOR-ECO3M-Med	MARS3D (0) ECO3M-Med (1)	HydroBio		NW Med	1.2 km	M. Baklouti
Cascade	S-model (0) ECO3M-S (1) Sedim (9) ICHTHYOP+DEB (3)	HydroBio		W Med	Polar grid: 700m (pole)	C. Estournel
NWMed111	S-model (0) ECO3M-S (1)	HydroBio		NW Med	1/111°	C. Ulses/C.Estournel
E2A	S-model ECO3M-S	HydroBio		NW Med	2.5 km	C. Ulses
GOL	MARS3D (0) MARS,(WW3) (9)			Rhone-Marseille	400m	R. Verney
GULI	MARS3D (0) ECO3M-Massilia (1)	HydroBio		GoL	1.2km	C. Pinazo
Golfe du Lion	SYMPHONIE (0) ECO3M (1) OSMOSE (3)	E2E	Coupling with Symphonie-Eco3M	GoL	3km to 1km Osmose: 12 km	D. Banaru
Golfe du Lion(plateau)	OPATM (0) BFM (1) Ecopath(Ecosim) (3)	E2E	Forced by OPATM - BFM	GoL		D. Banaru
RHOMA	MARS3D (0) MARS,(WW3) (9) Met&Or (5,6)		Forced by ECO3M-Massilia (1) (BioConta)	Rhone-Marseille	200m and 400m	I. Pairaud
MARS3D_RHOMA-ECO3M_MASSILIA	MARS3D (0) ECO3M-Massilia (1)	HydroBio		Rhone-Marseille	400m	C. Pinazo

SiMED, workshop in January

http://mermex.pytheas.univ-amu.fr/