



# Study of mesoscale eddies in the Gulf of Lion and their role in the coastal-offshore exchanges.

Ziyuan HU

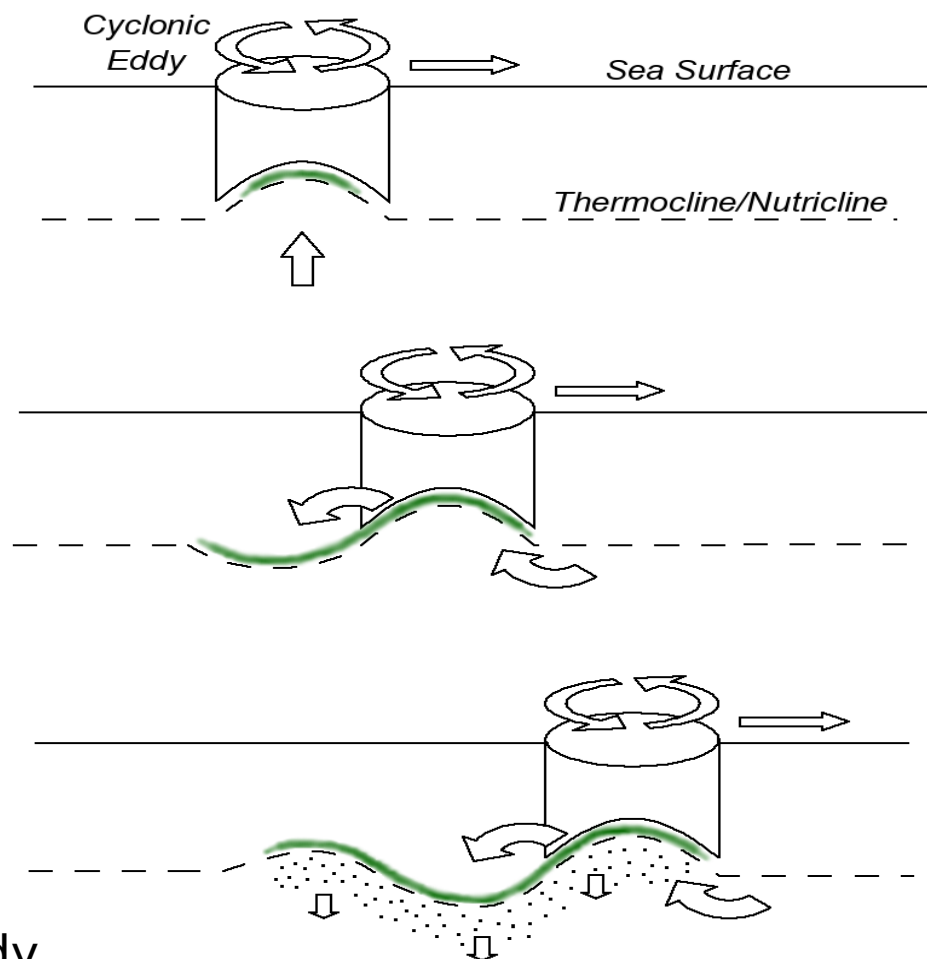
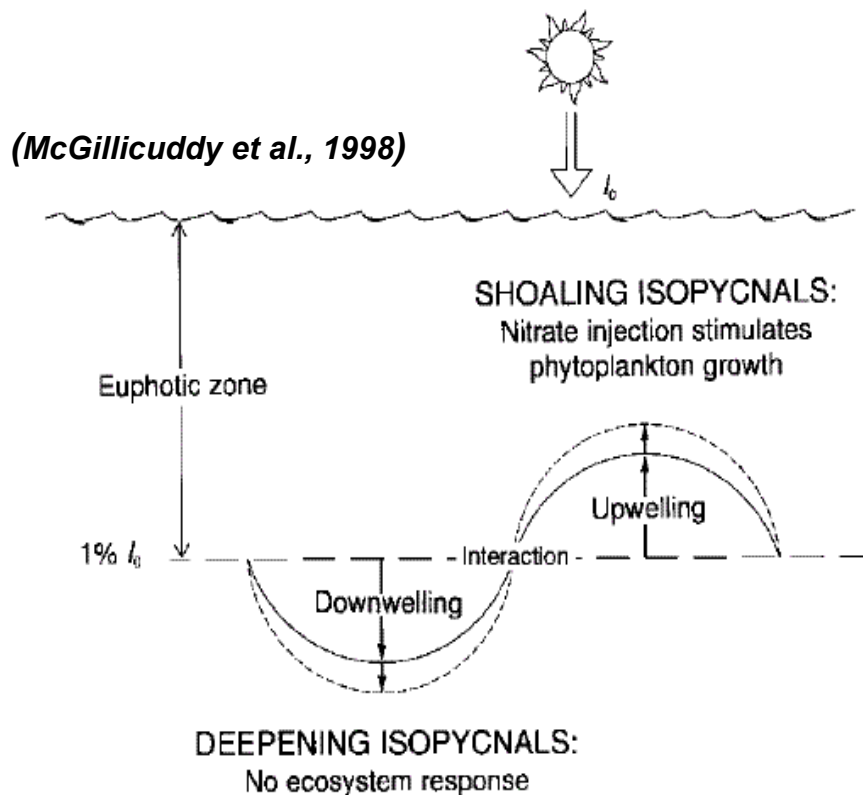
Andrea Doglioli, Anne Petrenko, R. Campbell, F. Diaz, Ivan Dekeyser

**Collaboration with: N. Grima and B. Blanke**



# Motivations – Open questions

(Sub)mesoscale processes can have an important influence on biogeochemistry (e.g. primary production budgets, nutrient availability)

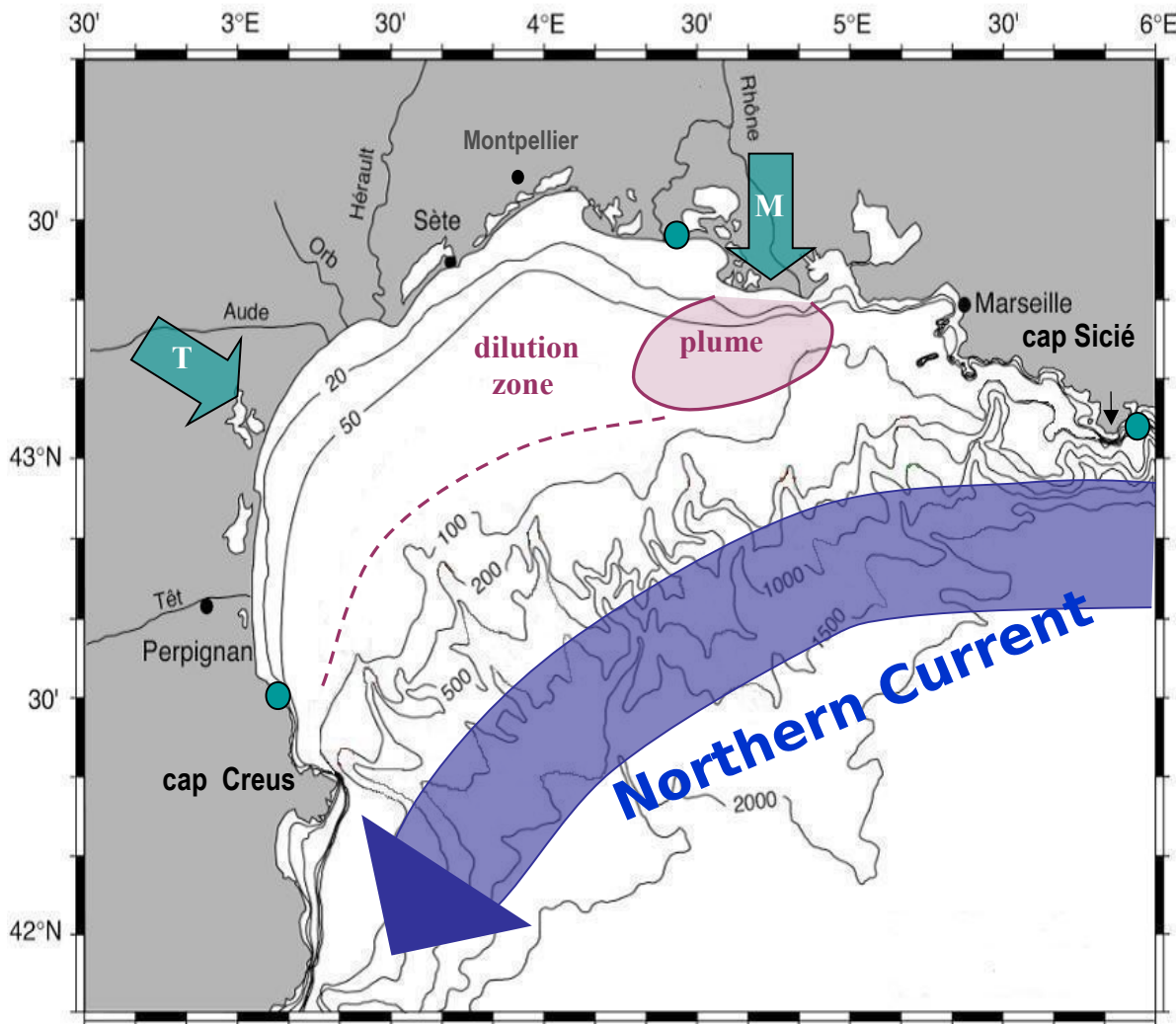


(Nencioli et al., 2008)

Recent field studies have successfully addressed this issue **in the open ocean** (e.g. Benitez-Nelson et al. 2007, McGillicuddy et al. 2007, Dickey et al 2008, Nencioli et al., 2008)

**What about the coastal ocean ?**

# Study zone: Gulf of Lion (GoL)



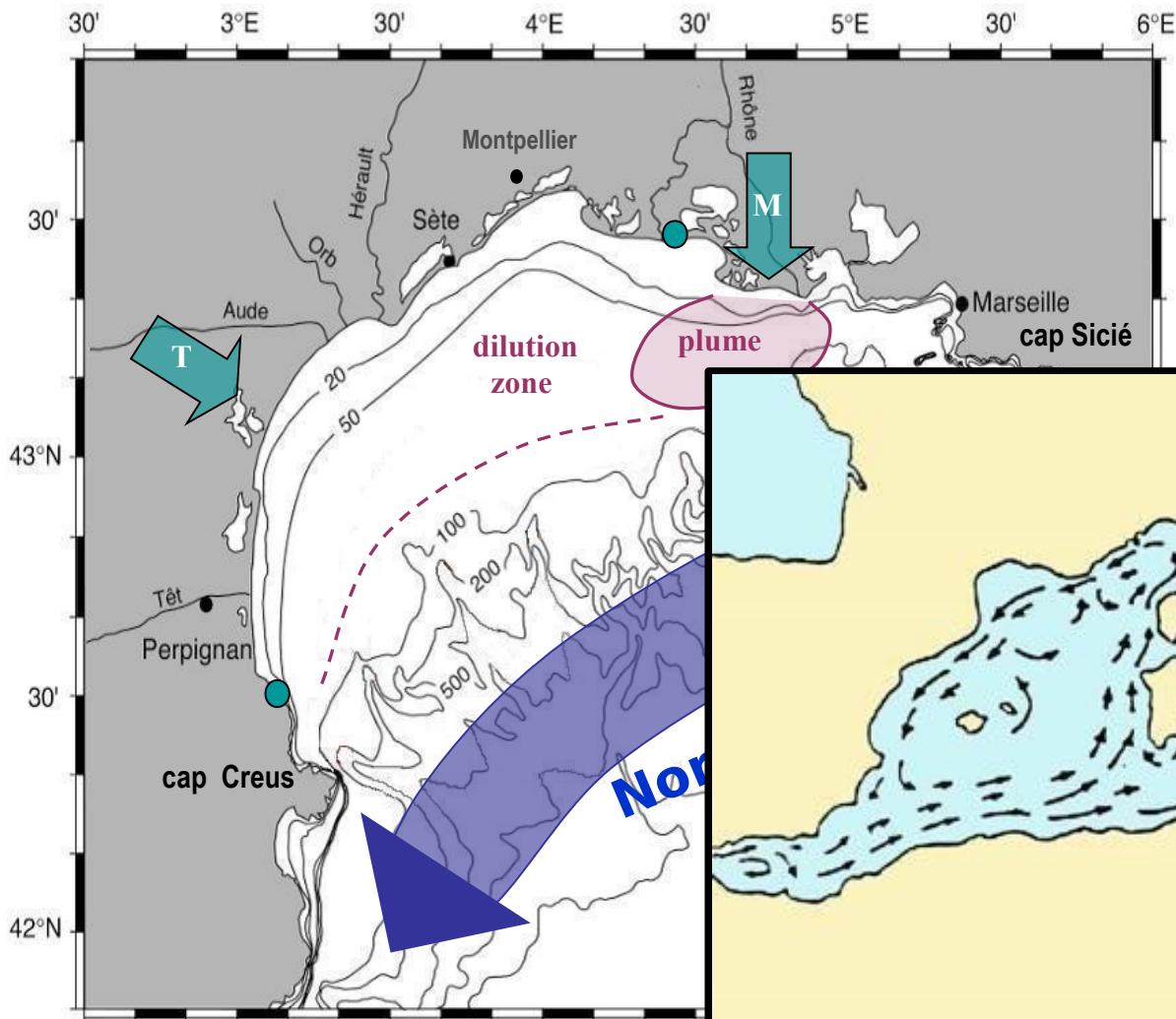
## • Description :

- surface  $\sim 11\,000\text{ km}^2$
- mean depth  $\sim 80\text{ m}$
- numerous canyons

## Main Forcings

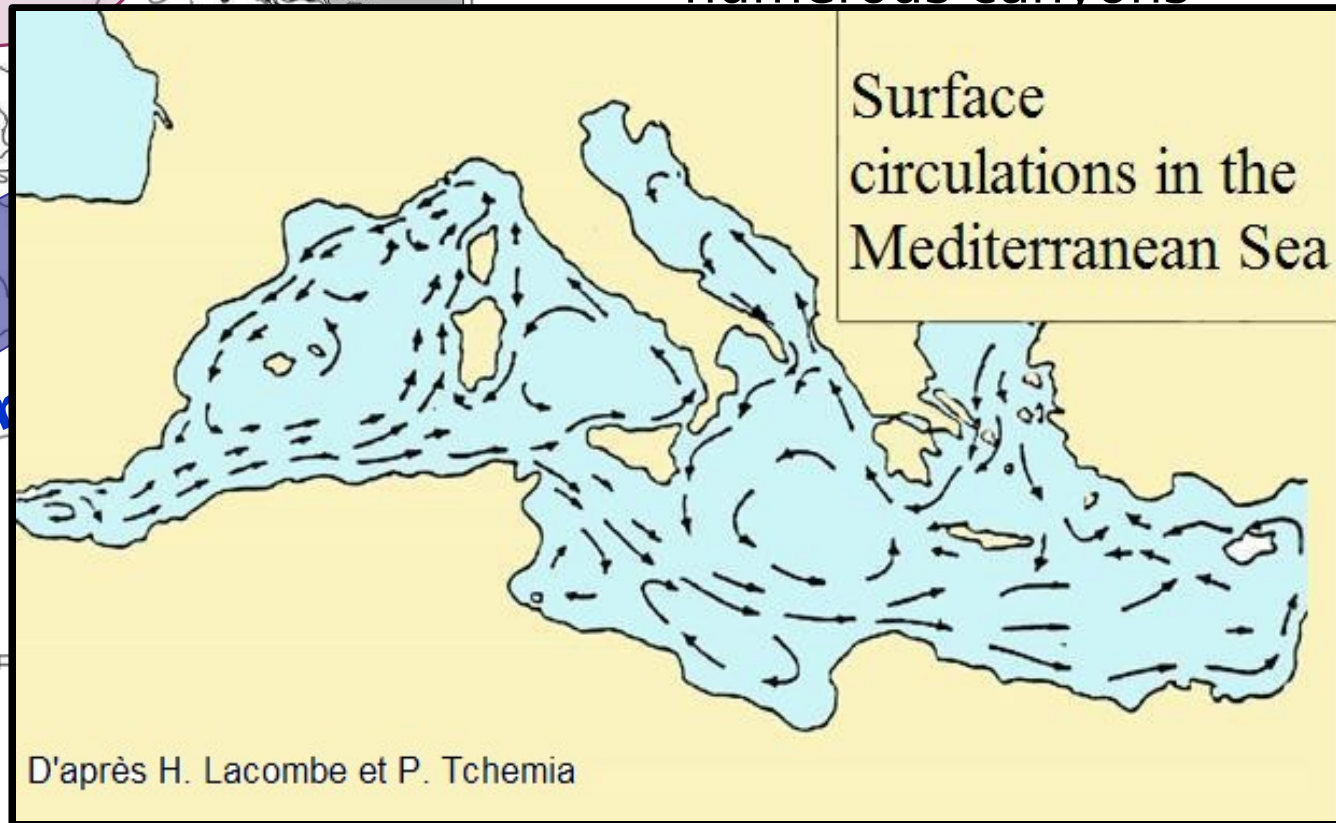
- 1-** Winds : Tramontane, Mistral.
- 2-** Rhone plume
- 3-** Liguro-Provançal-Catalan current/Northern Current (NC)

# Study zone: Gulf of Lion (GoL)



- Description :

- surface ~ 11 000 km<sup>2</sup>
- mean depth ~ 80 m
- numerous canyons



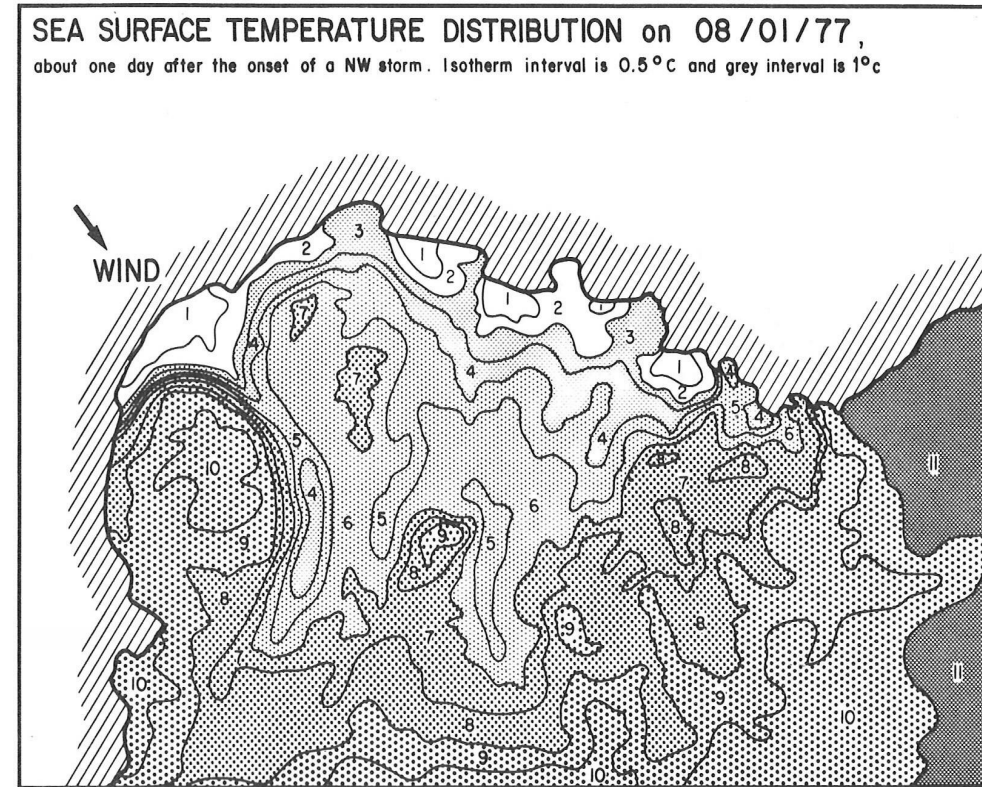
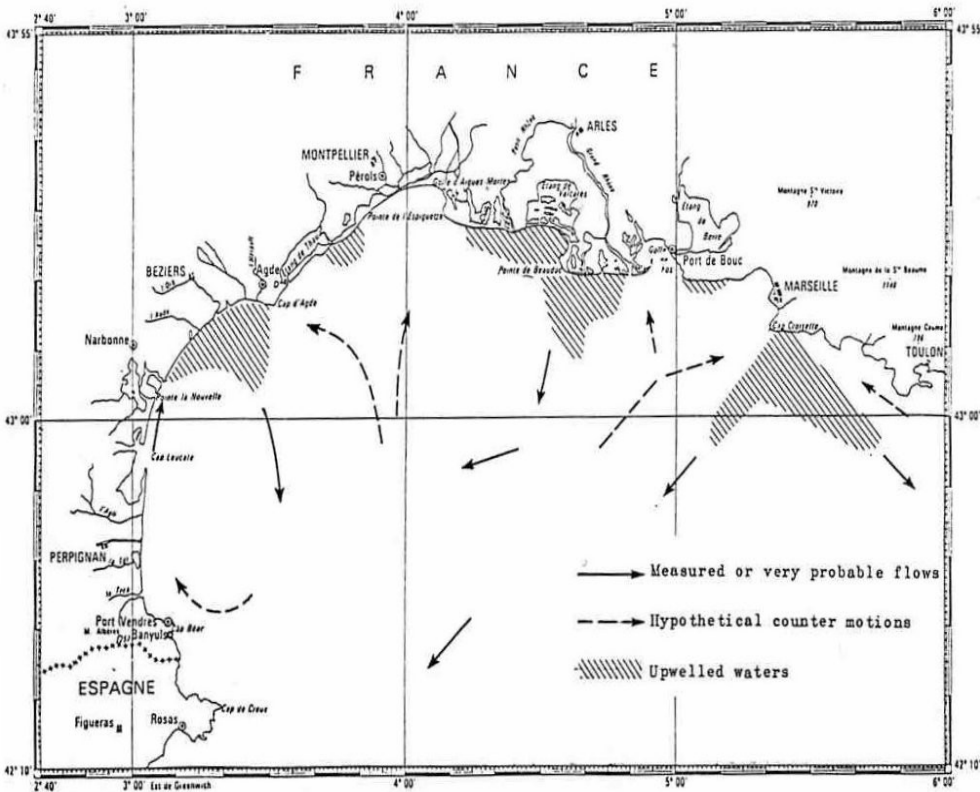


# Study zone: Gulf of Lion

*Anticyclonic circulation in the western part of the gulf of Lion.*

Millot, 1979

Millot, 1982



# **LATEX - LAgrangian Transport Experiment**

PIs: Anne Petrenko and Frédéric Diaz

*founded by LEFE/IDAO&CYBER – Région PACA*

Pilot project 2007 – Main project 2008-11

## **Objective**

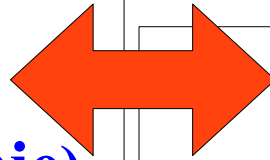
to understand the influence of submesoscale  
coupled physics – biogeochemistry  
on cross-shelf (coast-offshore) exchanges

## **Methodology**

Multi-disciplinary project + multi-«tools»:  
Lagrangian floats, SF6, hull-mounted ADCPs, Eulerian  
moorings, satellite images, gliders, radars  
& numerical modelling.

# LATEX - LAgrangian Transport Experiment

## MODELLING



## EXPERIMENTAL

### **Numerical modelling (Symphonie)**

with C.Estournel et P.Marsaleix [POC, Toulouse]

### **Wavelet analysis of relative modelled vorticity fields (WATERS)**

### **Lagrangian floats (ARIANE )**

with B.Blanke et N.Grimas [LPO, Brest]

### **Lag. times (vs OW & FSLE)**

With F. D'Ovidio [LOCEAN]

### **Coupled Physical (Symphonie)**

### **Biogeochemical (Eco-3M)**

### **Modelling**

**Sept 2007 - Tests of real-time communication with floating buoys + Lagrang. navigation**

**Sept 2008 – Eddy mapping**

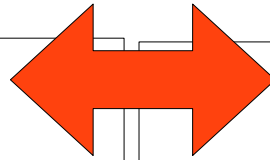
**Sept 2009 – Moorings & Eddy mapping**

**Oct 2009 – Test of SF6 device**

***Sept 2010 – CRUISE with RVs Suroît and Téthys II***

# LATEX - LAgrangian Transport Experiment

## MODELLING



## EXPERIMENTAL

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Wavelet analysis of relative modelled  
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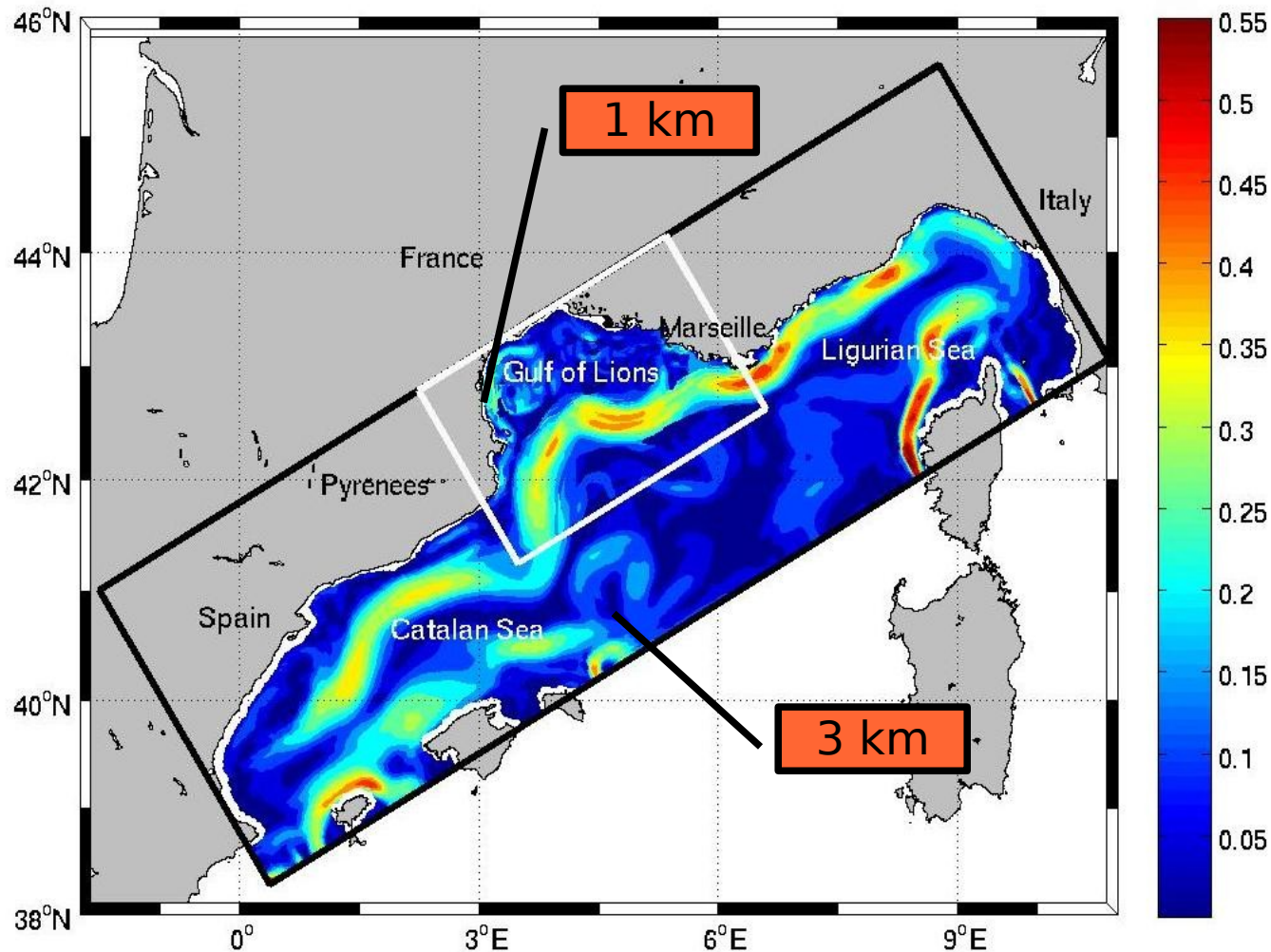
# I. NUMERICAL

# MODELLING – Appropriate Model Configuration

Numerical model: **Symphonie** (3-D primitive equation model)

Laboratoire d'Aérodologie de Toulouse, France [P. Marsaleix and C. Estournel]

modelled velocity intensity (July 25, 2001) at 20 m  
boxes: model domains



Sensitivity Study on:

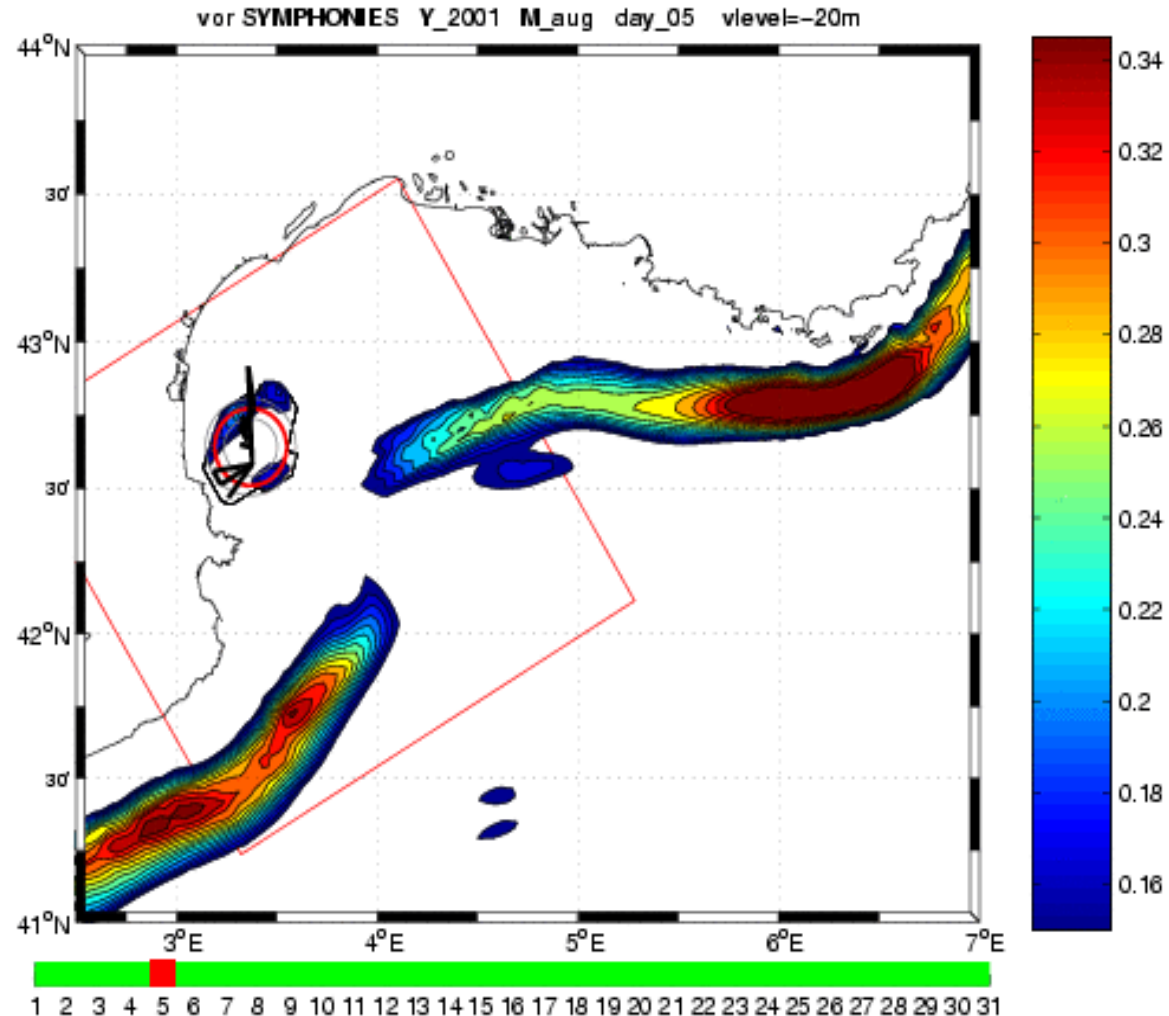
- Model resolution (One-way Nesting)
- Horizontal Diffusion

[Hu et al., 2009]

# MODELLING – Interaction with the NC

WATERS  
Wavelet Analysis offline tool  
[Doglioli et al., 2007]

August 1 – 18, 2001

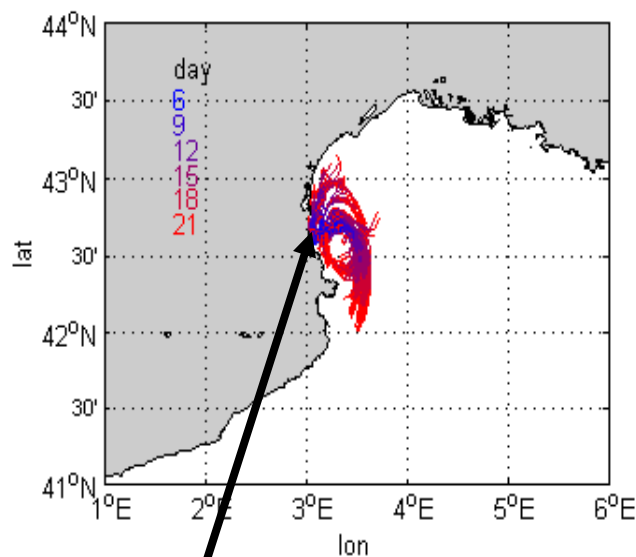


Only the currents  $> 15$  cm/s are represented in filled color contours

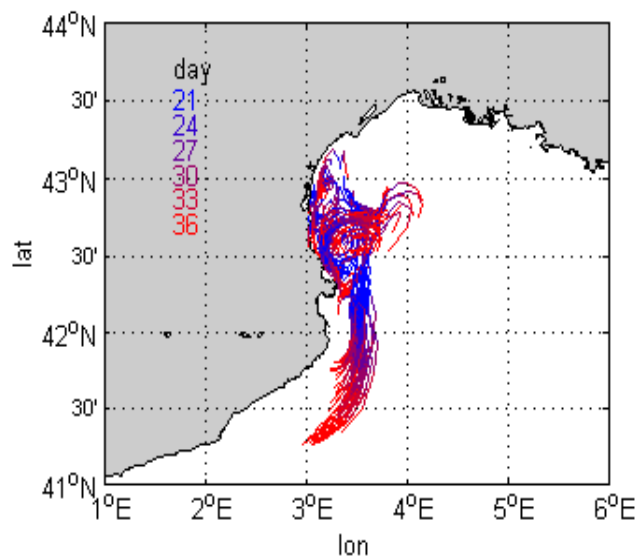
# MODELLING - Preliminary results on floats dispersion with ARIANE

ARIANE Lagrangian tool (N. Grima et B. Blanke, LPO)  
Trajectories of Numerical Lagrangian floats

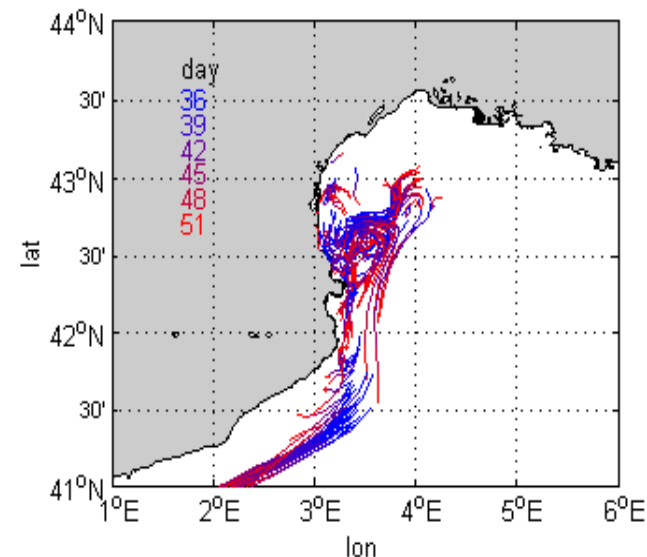
1 → 21 days



21 → 36 days



36 → 51 days



Qualitative test: 170 floats launched on August 11, 2001  
on the coastal radial transect of eddy (total water column)  
followed for 51 days

## II. EXPERIMENTAL

*Cruises Latex08  
September 1 – 6, 2008*

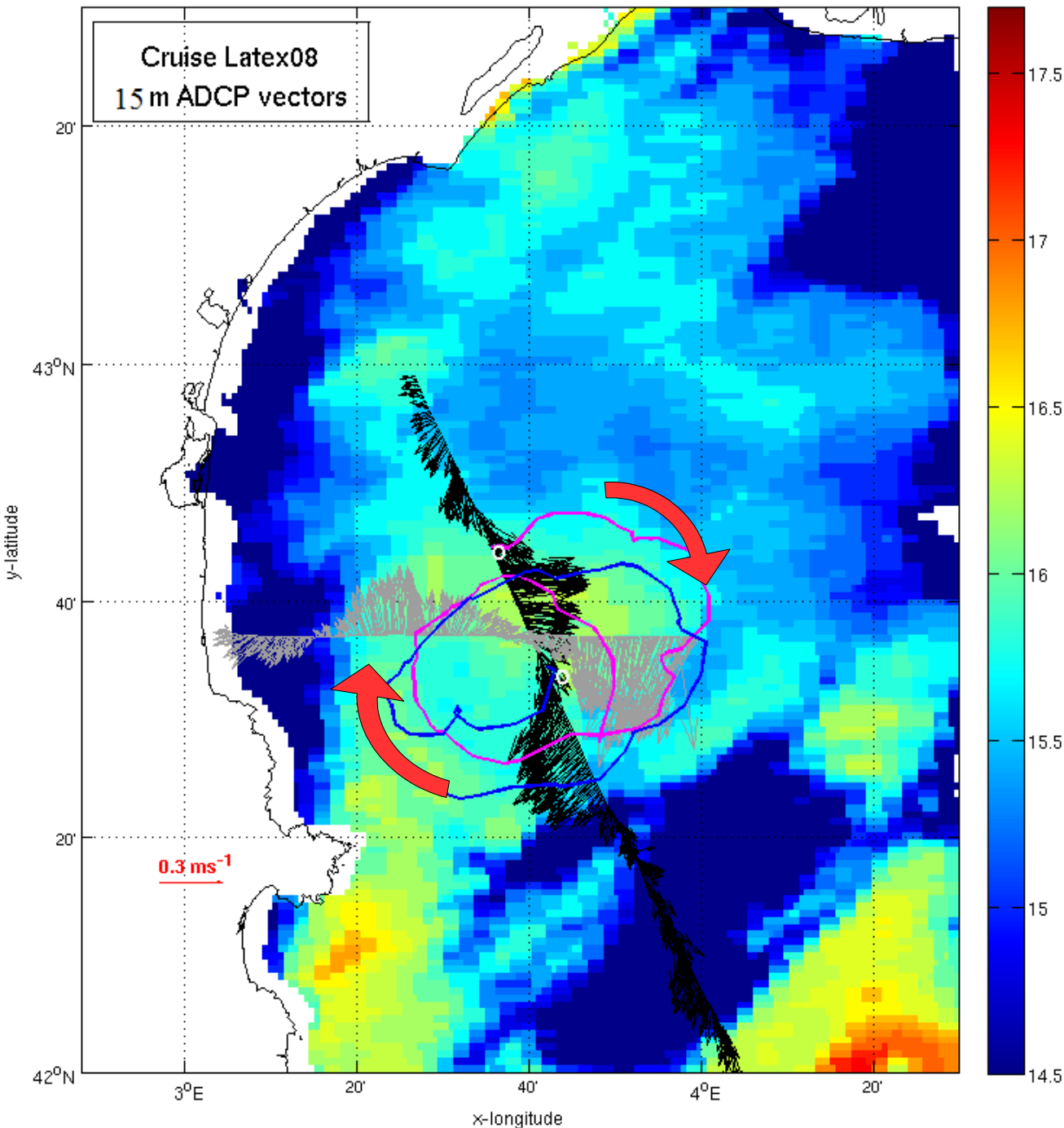


*Cruises Latex09  
August 24 – 29, 2009*





# EXPERIMENTAL - Cruise Latex08, September 1 – 6, 2008



## 2008

ADCP transects (15m)  
+ SST image  
+ Buoy trajectories

**Clockwise (anticyclonic)  
circulation**

**T ~ 5 days**

**V ~ 0.3 ms<sup>-1</sup>**

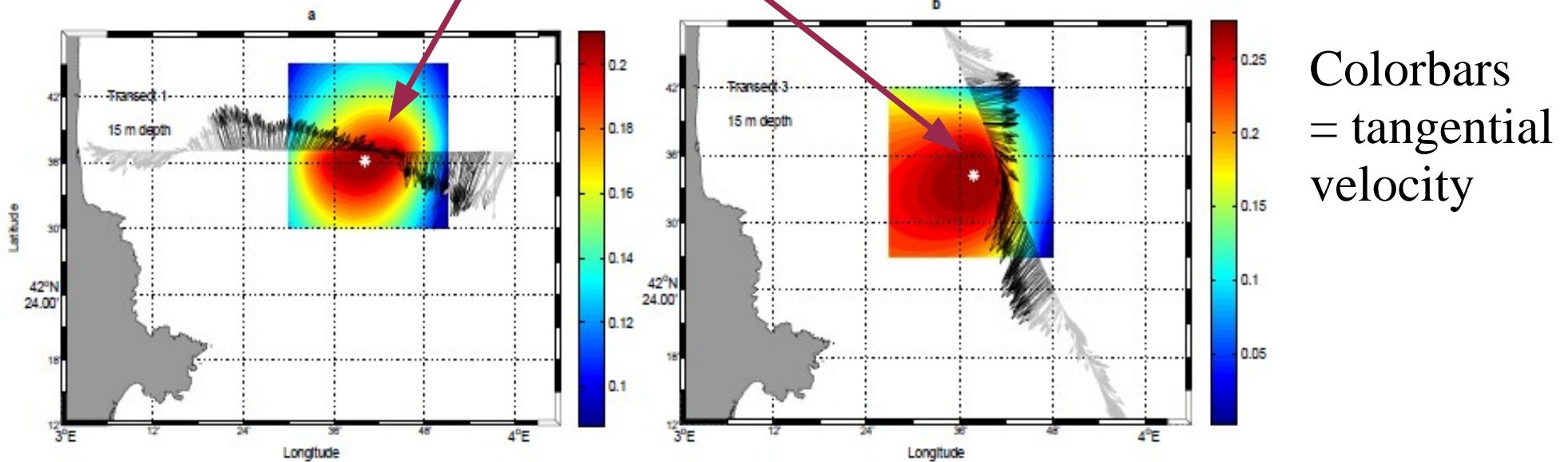
**R ~ 11.5 - 21.5 km  
(+/- 1.5 km)**

(Hu et al., in revision)

# EXPERIMENTAL: Cruise Latex08, September 1 – 6, 2008

ADCP + Eddy center location

2008



Center of the eddy:  
center of the referential in which the sum of the absolute values of tangential velocity is maximal.

*(Matlab routine developed by F. Nencioli, UCSB)*

Center moved  $\sim 5$  km in 4 days - Drift velocity 1 cm/s

(Hu et al., in revision)

# EXPERIMENTAL - Cruise Latex09, August 24 – 29, 2009

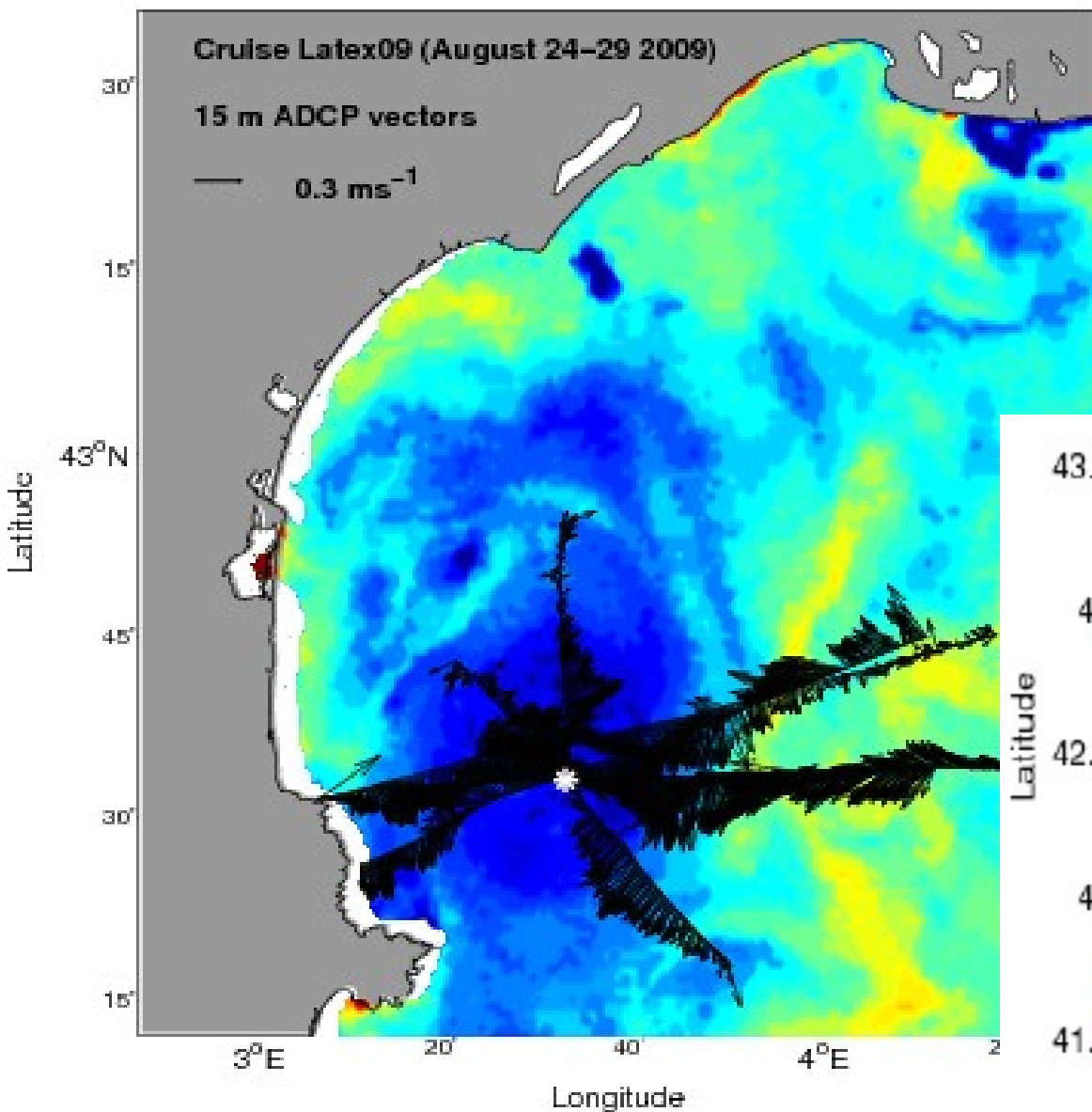
## 2009

LATEX09 ADCP bin2 + SST 081920

Cruise Latex09 (August 24–29 2009)

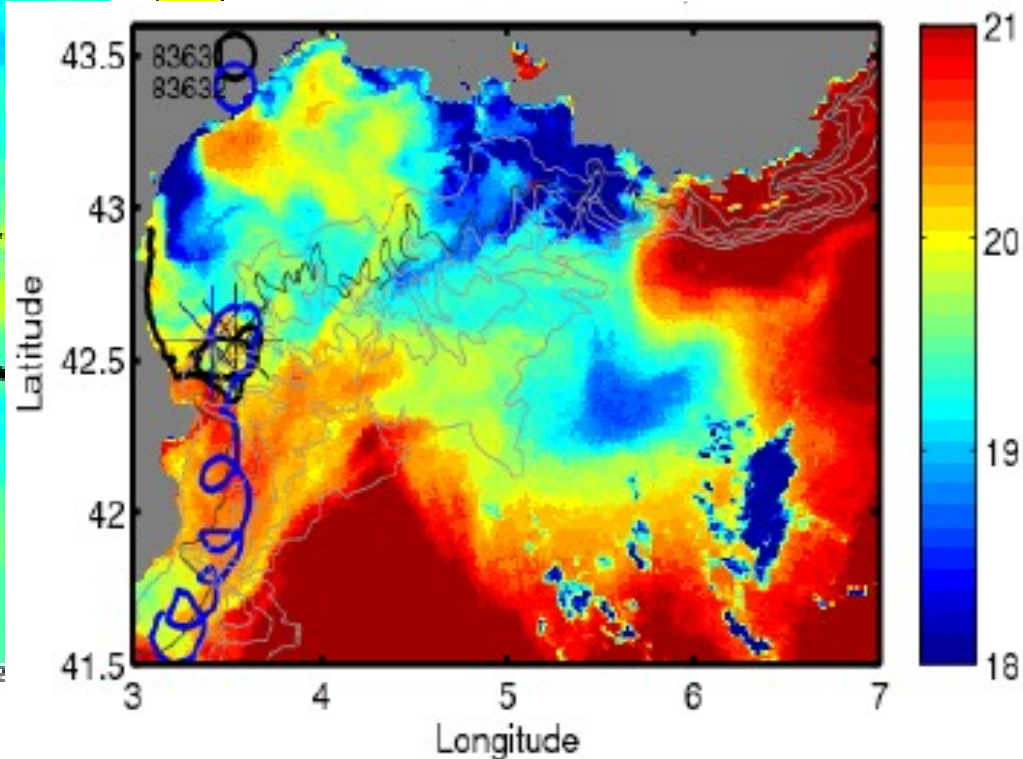
15 m ADCP vectors

— 0.3 ms<sup>-1</sup>



ADCP transects (15m)  
+ SST image

Buoy trajectories



## II. EXPERIMENTAL

*Cruises Latex2010, September 1 – 27, 2010*  
*SF6 tracer experiment*

# LAGRANGIAN (theory for biogeochemical budgets)

Mass budget for a Lagrangian control volume = THE EDDY

$\psi = O_2, C, SF_6$

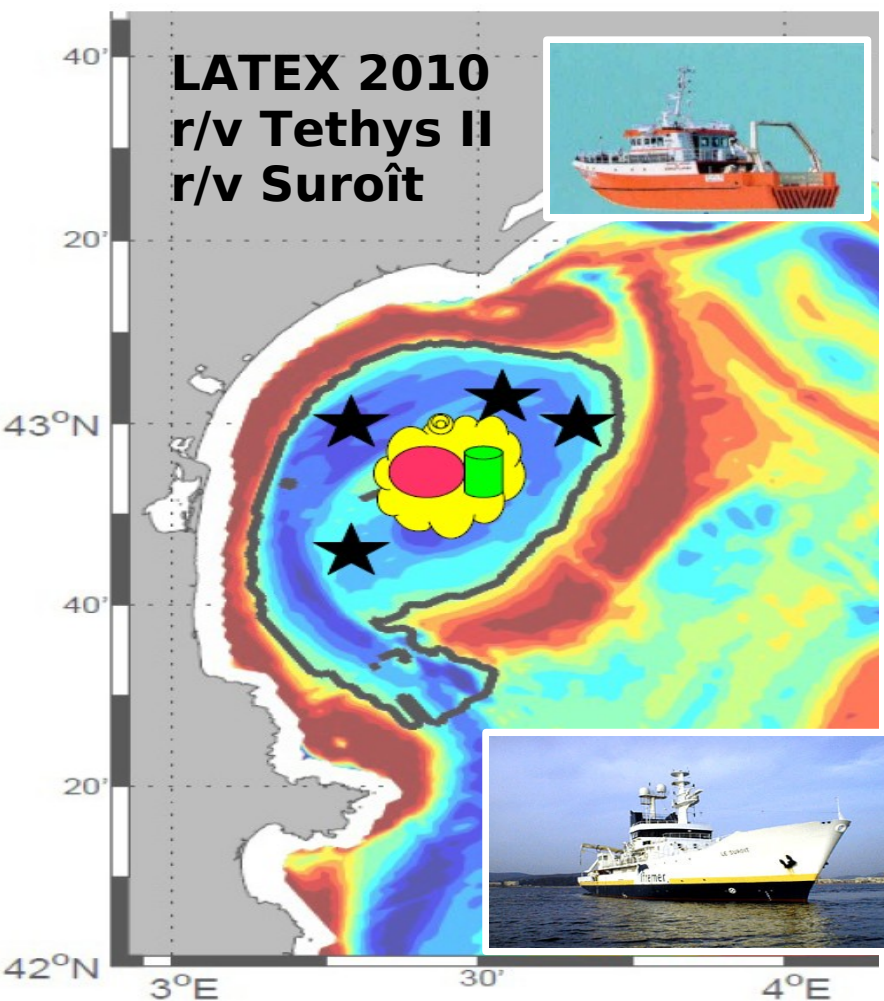
Temporal variation





$$\frac{d}{dt} \int_V \psi dV + \oint_S \psi \mathbf{u} \cdot d\mathbf{S} + \oint_S \chi \cdot d\mathbf{S} = \int_V \xi dV.$$

Advection

Exchanges at horiz+vert boundaries

Sources & sinks



-  Iridium Buoy  
*Real-time communication anchored 12 m*
-  Carioca Buoy  
*Measures pCO<sub>2</sub> (J. Boutin, LOCEAN)*
-  15 Argos buoys
-  SF6 tracer injected at 10 m  
*(LOPB et S. Blain, Banyuls) deformation and mixing*

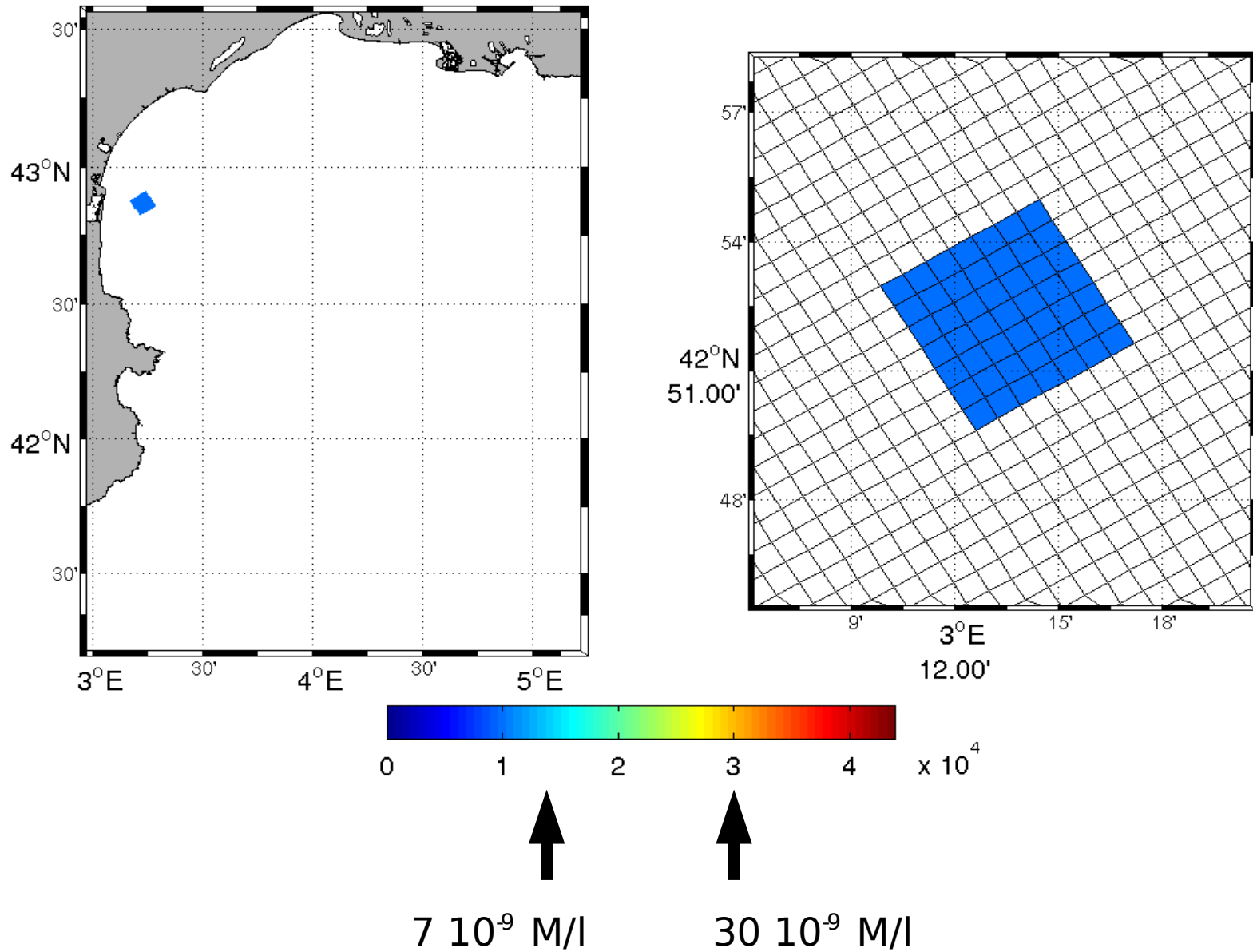




# EXPERIMENTAL – SF6 modelling with ARIANE (N. Grima, LPO)

With 2001 eddy simulated by SYMPHONIE

Number of particles in 1x1 km square

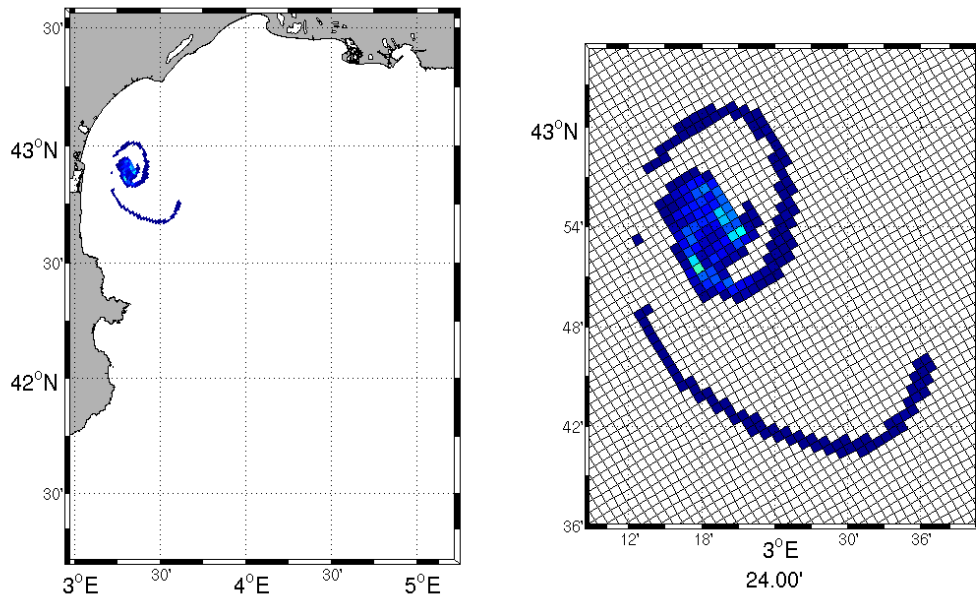


# EXPERIMENTAL – SF6 modelling with ARIANE (N. Grima, LPO)

4 days of simulations with different day of beginning

Number of particles in 1x1 km square

time step = 206 h:12 m:0 s:0

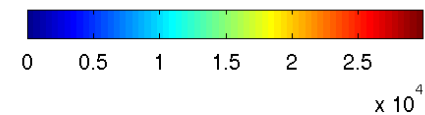
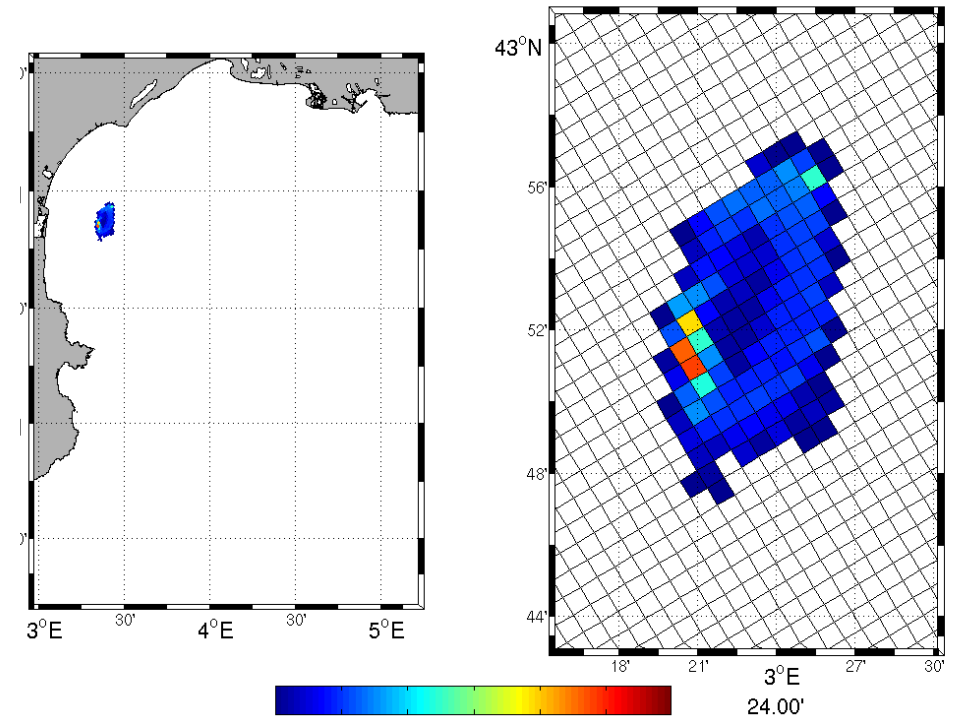


2 Jul. → 6 Jul.

Experiment I

Number of particles in 1x1 km square

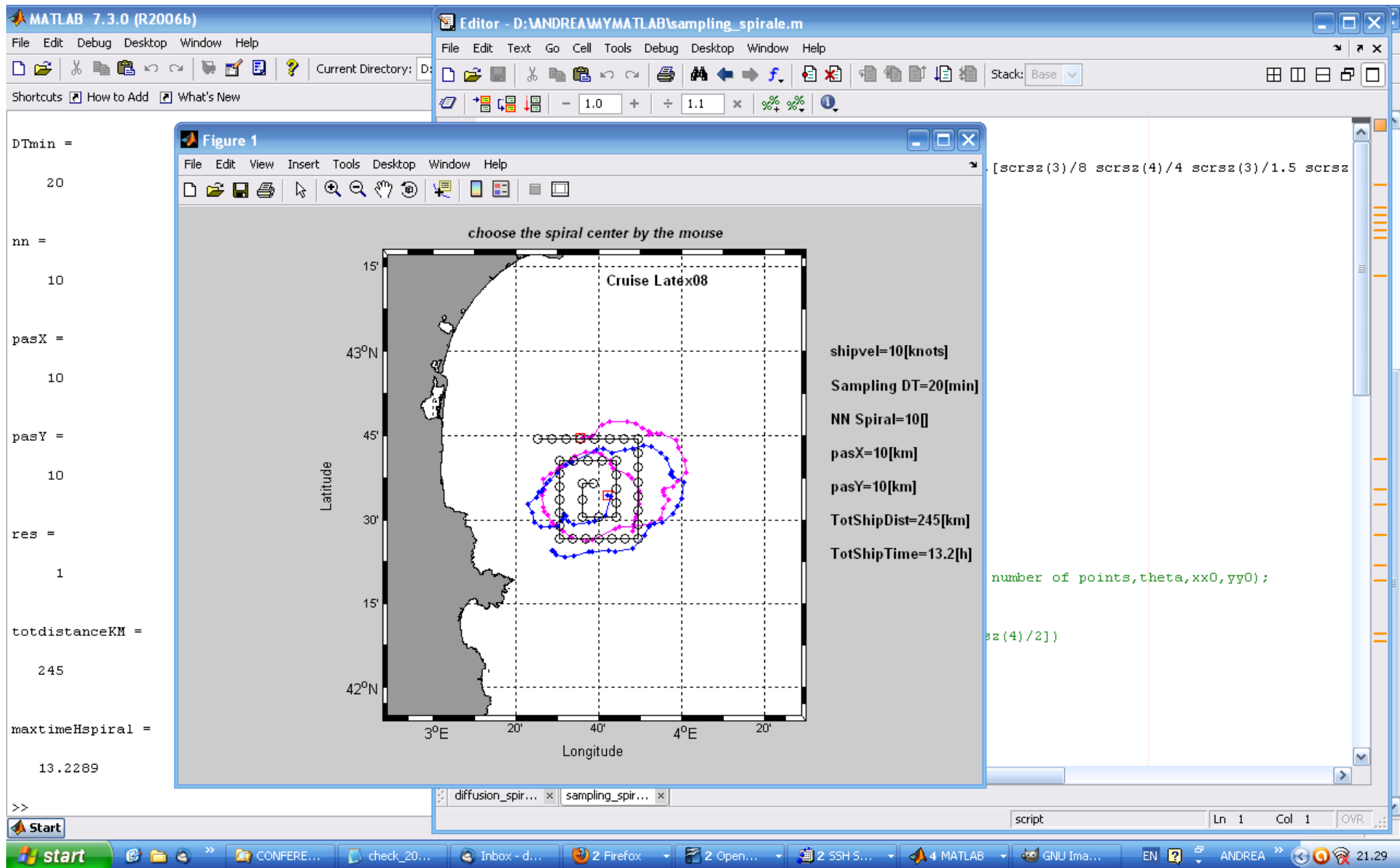
time step = 210 h:12 m:0 s:0



6 Jul. → 10 Jul.

Experiment II

# Matlab utility for design sampling spiral



## Conclusions:

- The sensitivity study on model resolution and horizontal diffusion allows us to find the best model setup to reproduce (sub)mesoscale eddies in the GoL,
- the cruise Latex08 Latex09 confirmed the presence of an anticyclonic eddy,
- increase our knowledge on these coastal eddies.

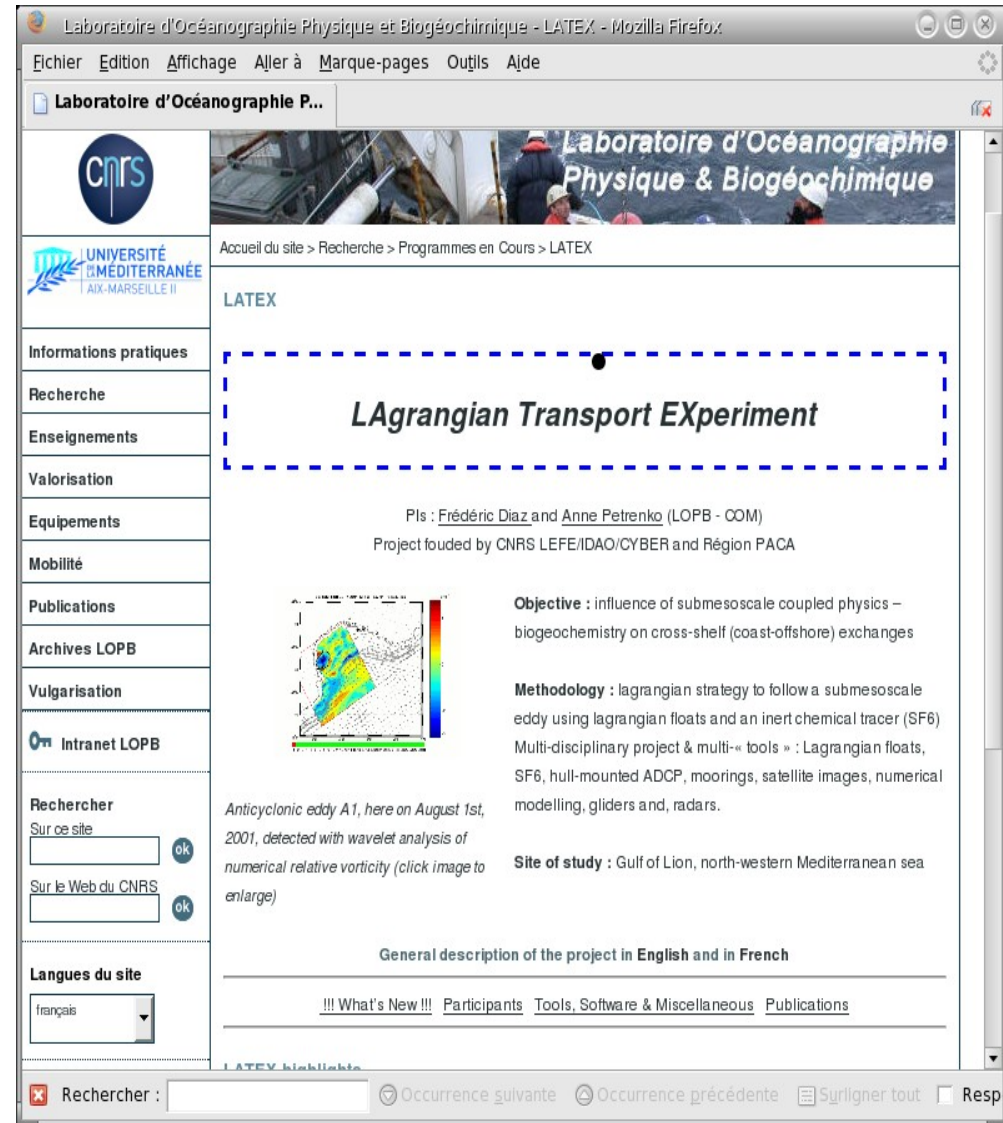
## Future Work:

- run simulations for a long period (2001 – 2010) to obtain interannual variability and statistics on coastal eddies, to study the generation process of the anticyclonic eddy,
- more ARIANE experiments,
- quantify the role of these (sub)mesoscale eddies on the shelf-offshore exchanges in the GoL, using the data from coupled physical and biological modelling and the next cruise (Latex2010/moorings, SF6 and radar, etc.).

All documents can be found on:

# LATEX web site

http://www.com.univ-mrs.fr/LOPB/LATEX



The screenshot shows a Mozilla Firefox browser window displaying the LATEX website. The browser's address bar shows the URL 'Laboratoire d'Océanographie Physique et Biogéochimique - LATEX - Mozilla Firefox'. The website's header includes the CNRS logo and the text 'Laboratoire d'Océanographie Physique & Biogéochimique'. The main content area features a large blue dashed box with the title 'Lagrangian Transport EXperiment'. Below the title, it lists the project leaders 'Pls : Frédéric Diaz and Anne Petrenko (LOPB - COM)' and the funding sources 'Project funded by CNRS LEFE/IDAO/CYBER and Région PACA'. A small map shows the location of the study site in the Gulf of Lion. The website also includes a navigation menu on the left with categories like 'Informations pratiques', 'Recherche', 'Enseignements', 'Valorisation', 'Equipements', 'Mobilité', 'Publications', 'Archives LOPB', 'Vulgarisation', and 'Intranet LOPB'. At the bottom, there is a search bar and a language selection dropdown set to 'français'.