

Physical characteristics and dynamics of the coastal LATEX09 eddy Gulf of Lion (NW Mediterranean Sea)



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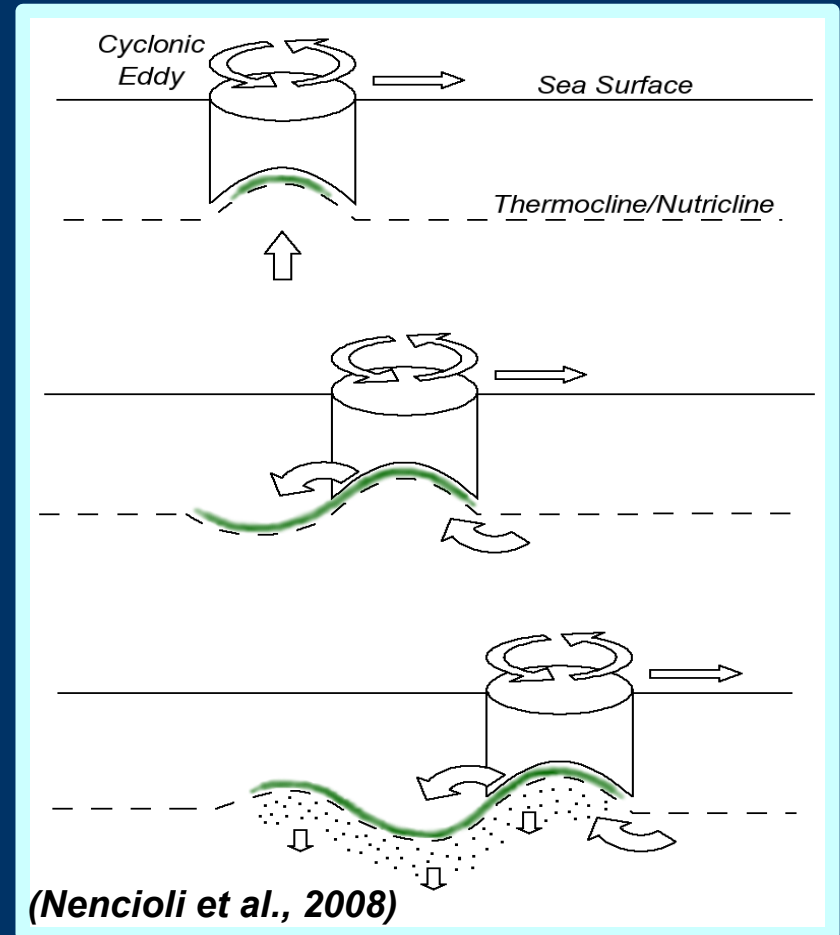
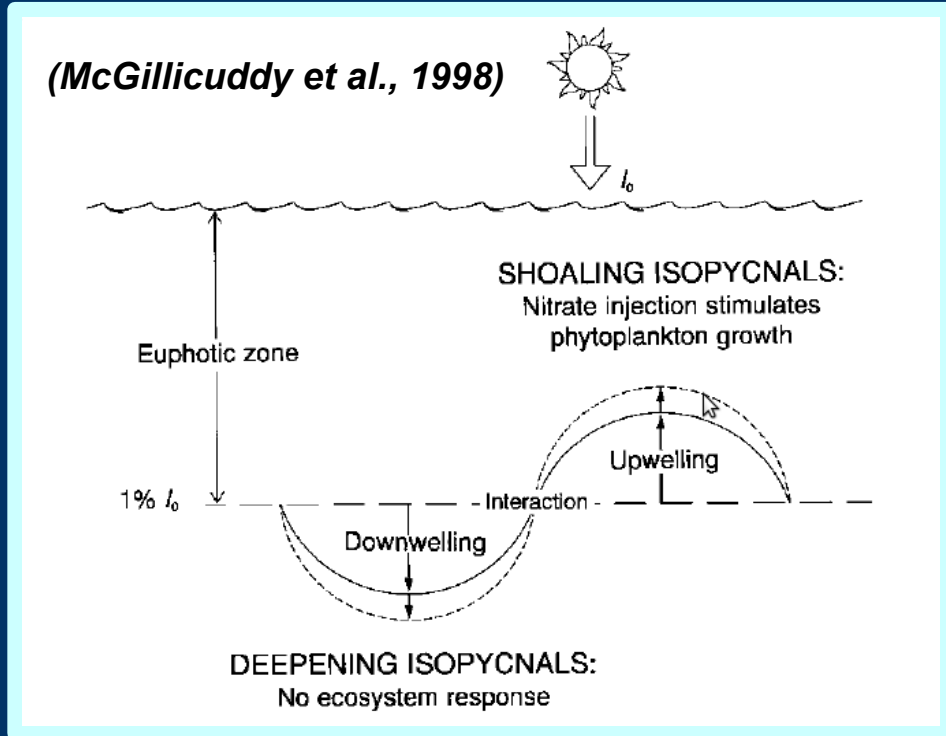
Turbintermed Workshop
April 17th, 2012
Toulon



(1) Aix-Marseille Univ., Mediterranean Institute of Oceanography, CNRS/INSU UMR 7294, IRD UMR 235, Marseille, France

Motivations - Open questions

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



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 in the coastal ocean ?

LATEX

Lagrangian Transport Experiment

Objective

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

Methodology

Multi-disciplinary project

In-situ measurements & Numerical modeling

3 Oceanographic Cruises

LATEX08 }
LATEX09 } Eddy mapping

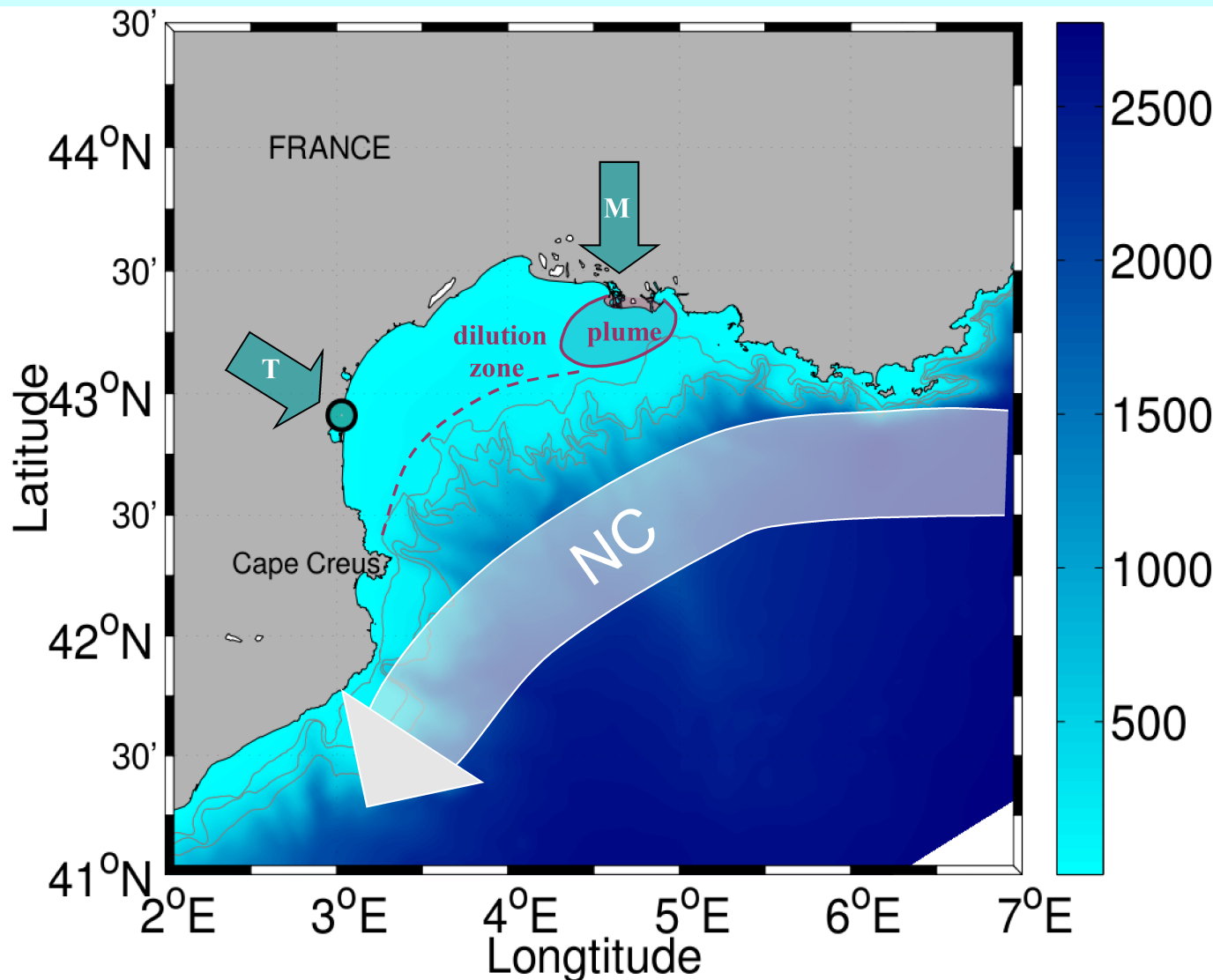
LATEX10

Numerical Time Series

2001 → 2008 [Hu et al., 2011]

2009

Study Zone: Gulf of Lion NW Mediterranean Sea

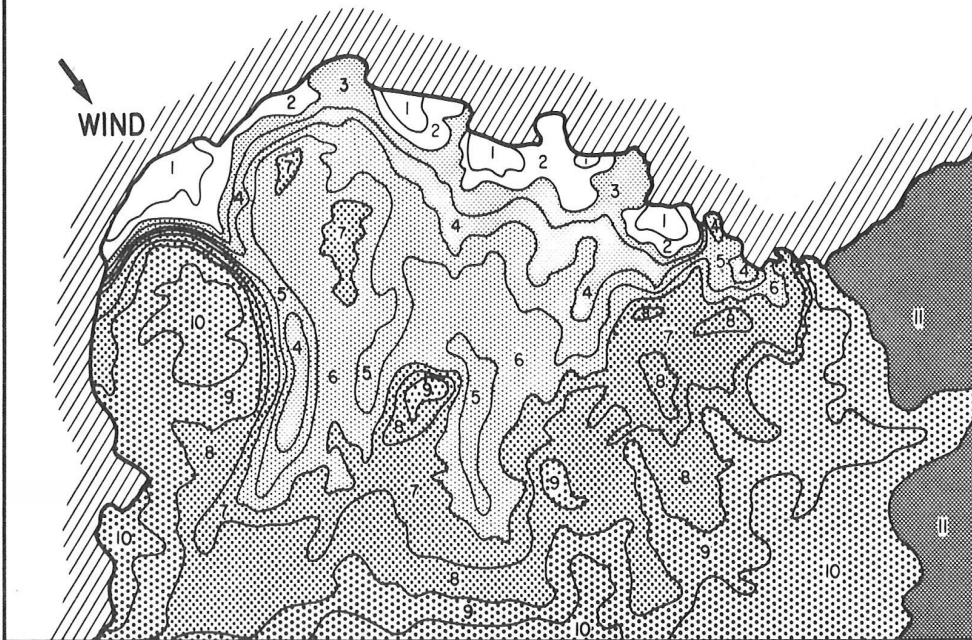


Forcings:

- 1- Rhone plume
- 2- Winds :
Tramontane
Mistral.
- 3- Northern Current
(NC)

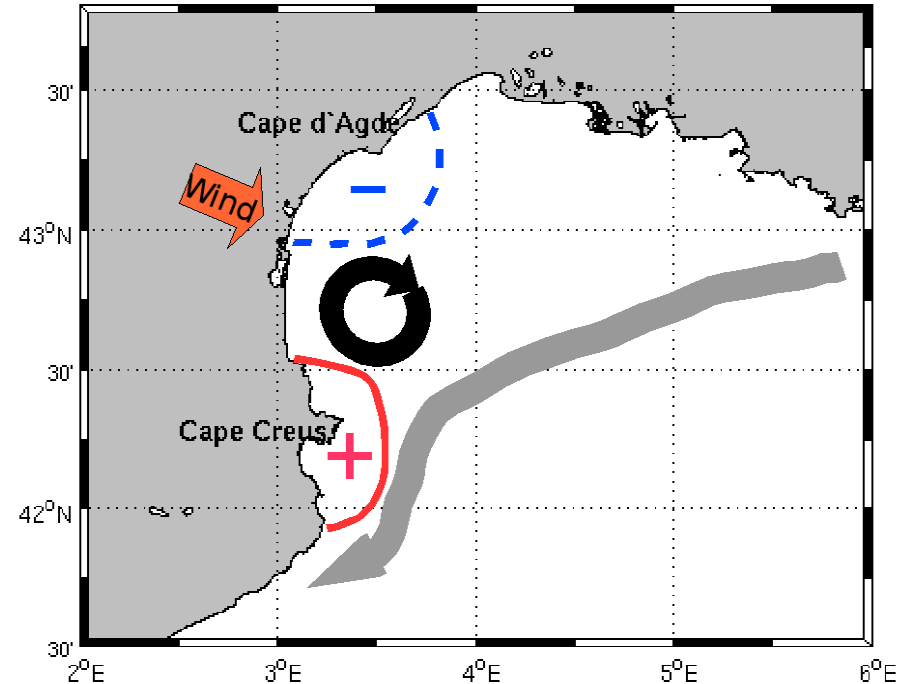
Western Anticyclonic Eddy

SEA SURFACE TEMPERATURE DISTRIBUTION on 08/01/77,
about one day after the onset of a NW storm. Isotherm interval is 0.5°C and grey interval is 1°C



First observation
[Milot, 1982]

Mesoscale anticyclonic
circulation in the western part
of the GoL



Hypothesis of generation
2001-2008
[Hu et al., 2012]

→ **Persistent & strong northwest
wind**
→ **Strong stratification**

Western Anticyclonic Eddy

SEA SURFACE TEMPERATURE DISTRIBUTION on 08/01/77,
about one day after the onset of a NW storm. Isotherm interval is 0.5°C and grey interval is 1°C

Objective:

Examine the **physical characteristics** and **behavior** of the coastal LATEX09 eddy

Method:

In-situ data & Numerical modeling

First observation
[Milot, 1982]

Mesoscale anticyclonic circulation in the western part of the GoL

Hypothesis of generation
2001-2008
[Hu et al., 2012]

→ **Persistent & strong northwest wind**
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In-situ Measurements

**Latex09 Oceanographic cruise
August 24 to 28 2009**



Satellite observations

ADCP
Thermosalinometer



CTD

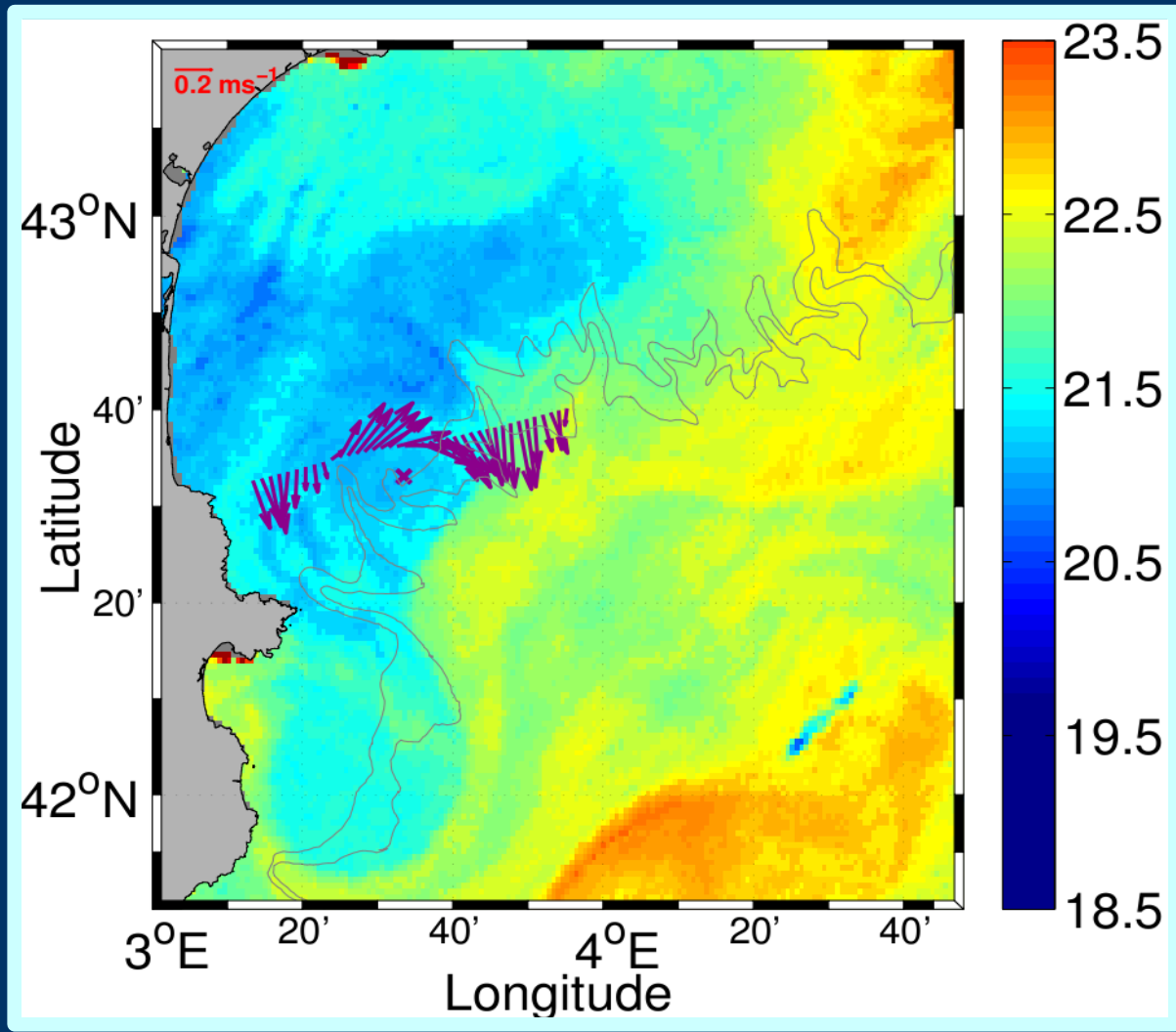


Lagrangian
floats

Horizontal Characteristics

Transect 1

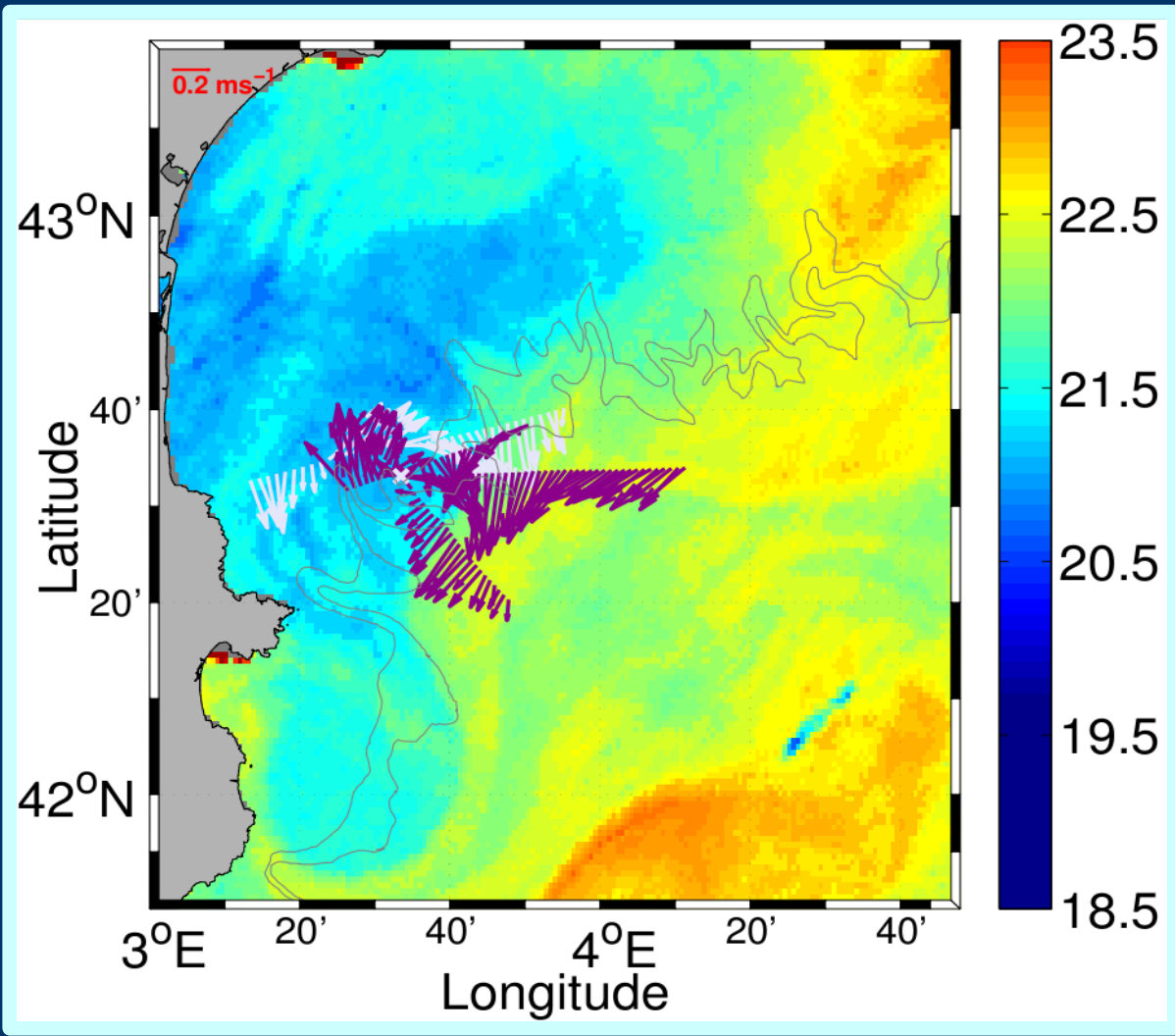
ADCP 15m depth - SST (°C) August 28



Horizontal Characteristics

Transects 1-2-3-4

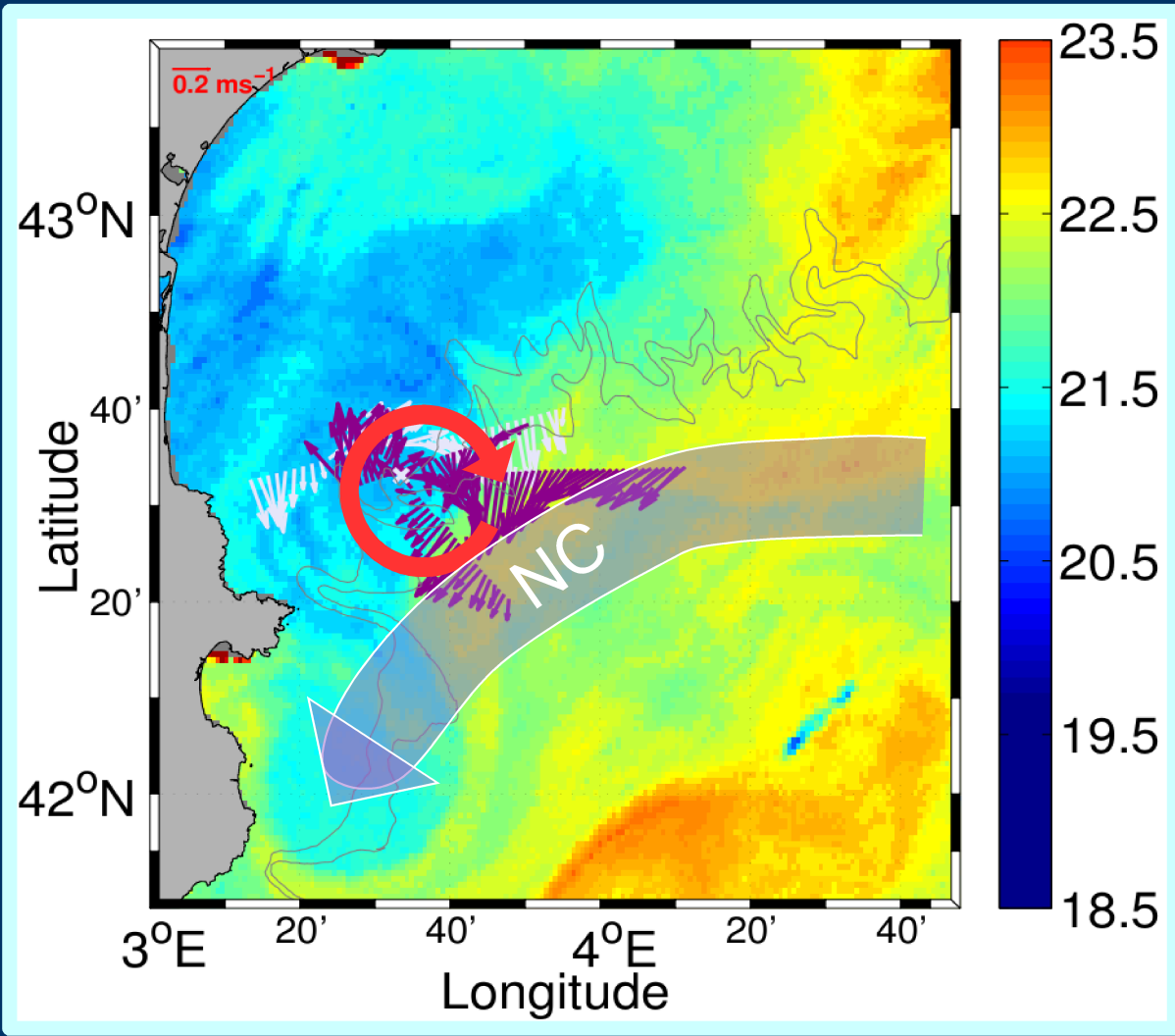
ADCP 15m depth - SST (°C) August 28



Horizontal Characteristics

Transects 1-2-3-4

ADCP 15m depth - SST (°C) August 28



Anticyclonic circulation

$V_{max} \sim 0.4 \text{ m.s}^{-1}$
 $T \sim 3 \text{ days}$

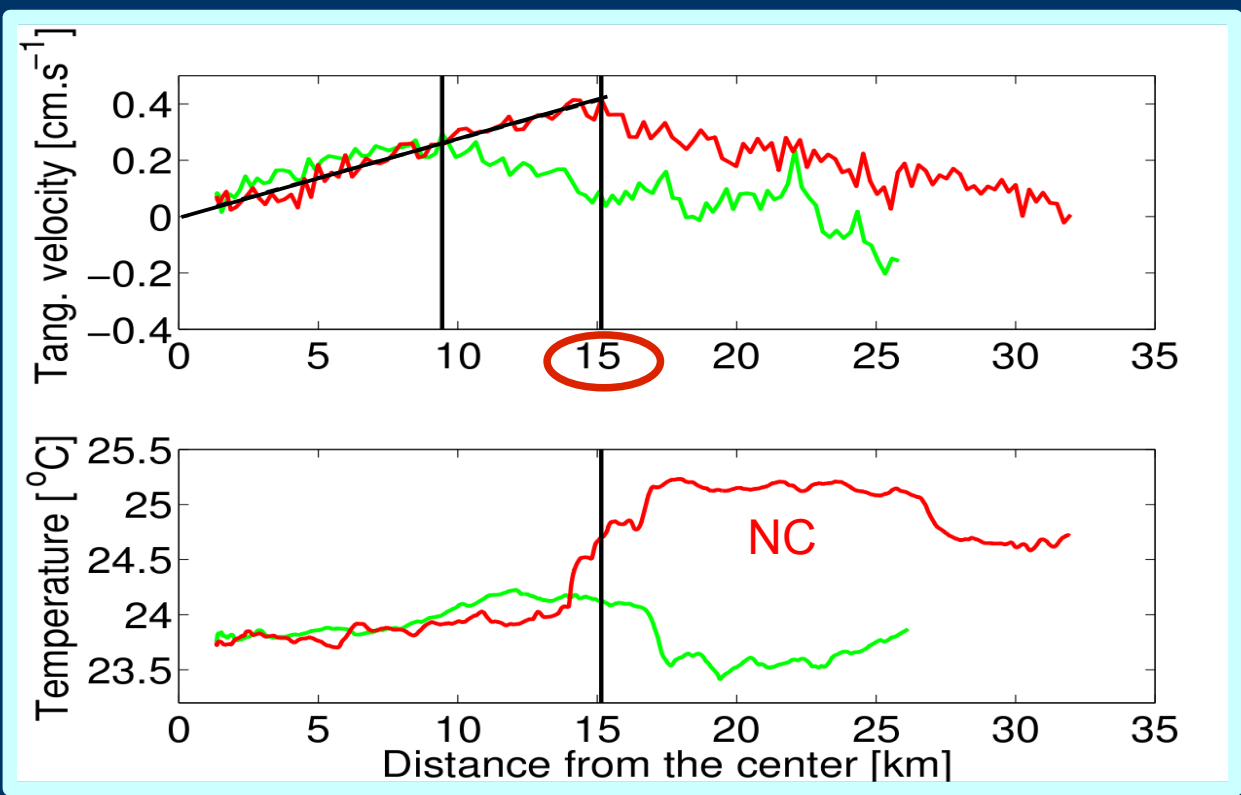
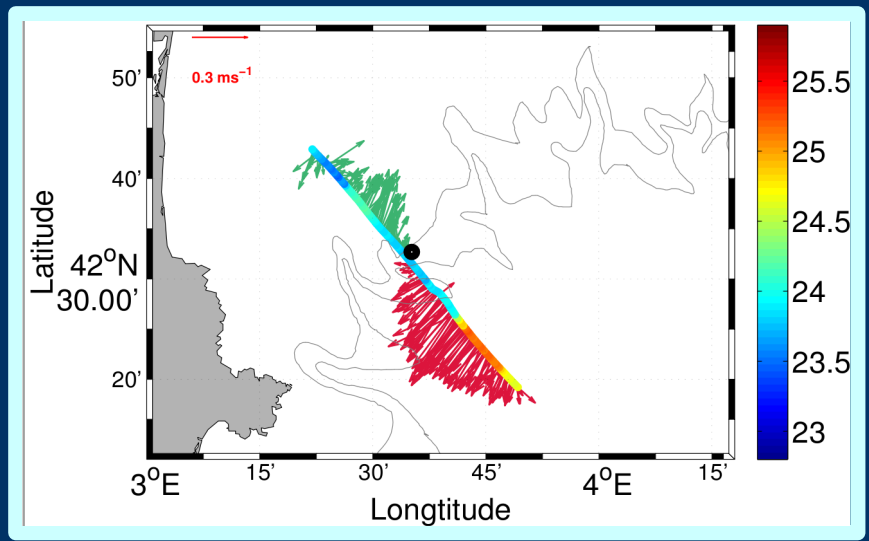
Center:
3°34'E - 42°33'N

Presence of the NC

Horizontal Characteristics

Transect 3

Eddy center detection + Tangential components decomposition
[Nencioli et al., 2008]

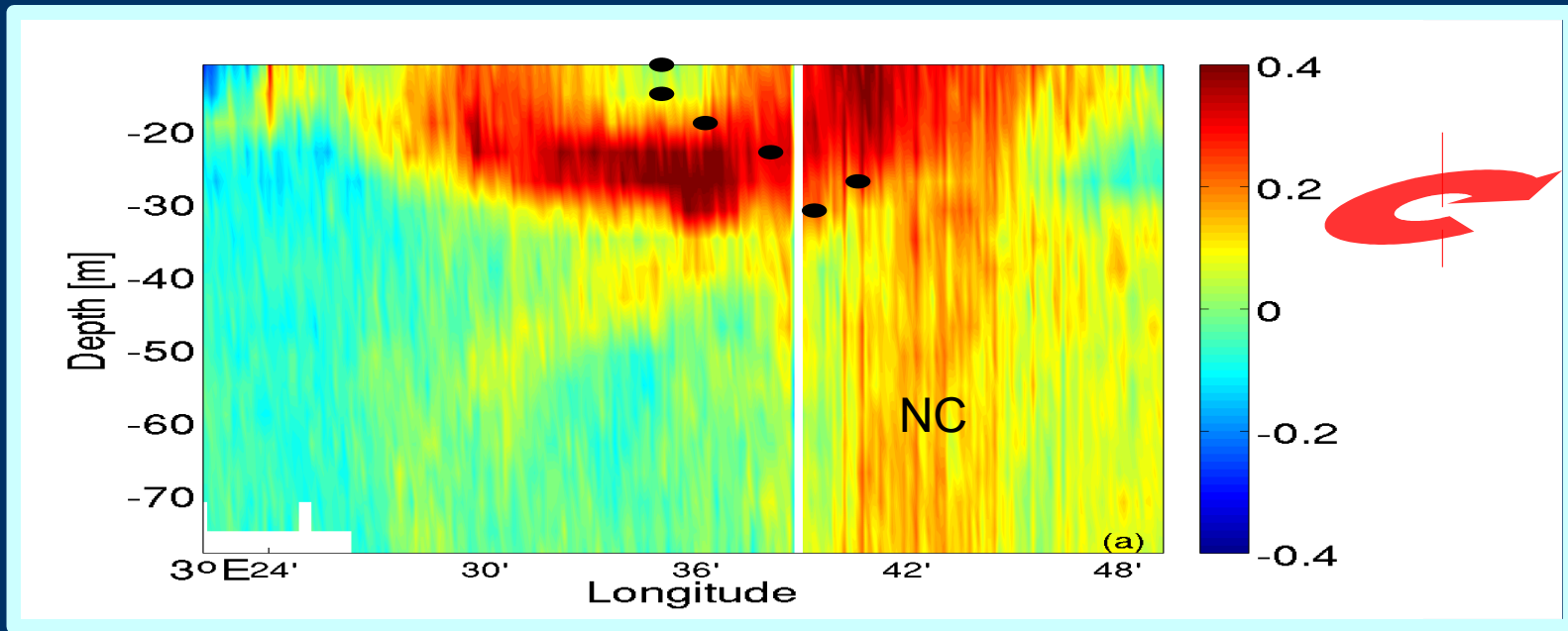


ADCP 15m depth - SST (°C)

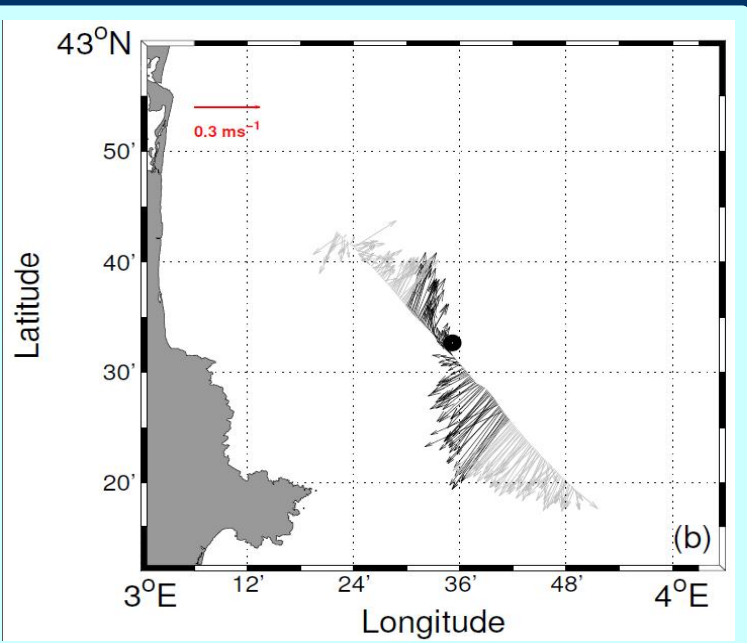
$$D_{\text{eddy}} = \bar{D} \pm \sqrt{D_{\text{var}}}$$

$$D_{\text{eddy}} = 22,7 \pm 1,2 \text{ km}$$

Vertical section

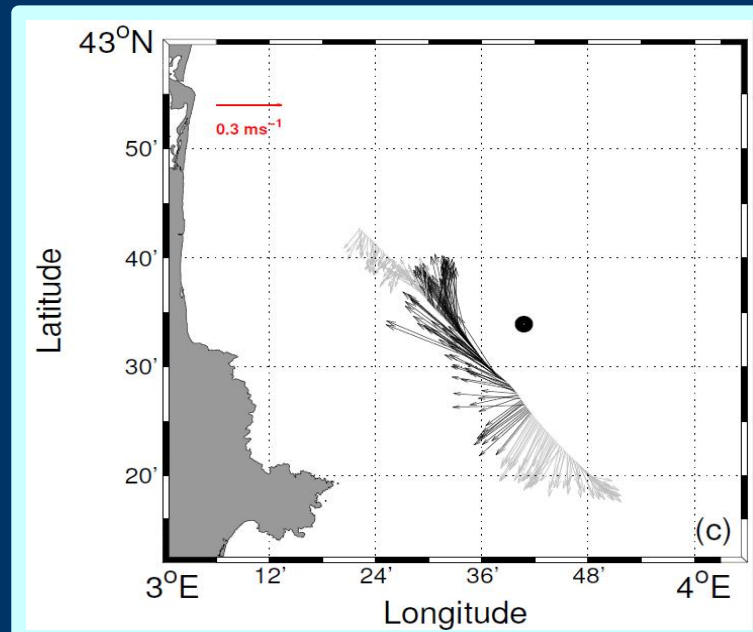


Vertical section of the tangential component of the horizontal current (m.s^{-1}) for Transect 3



ADCP current at
← 15 m depth →
27 m depth →

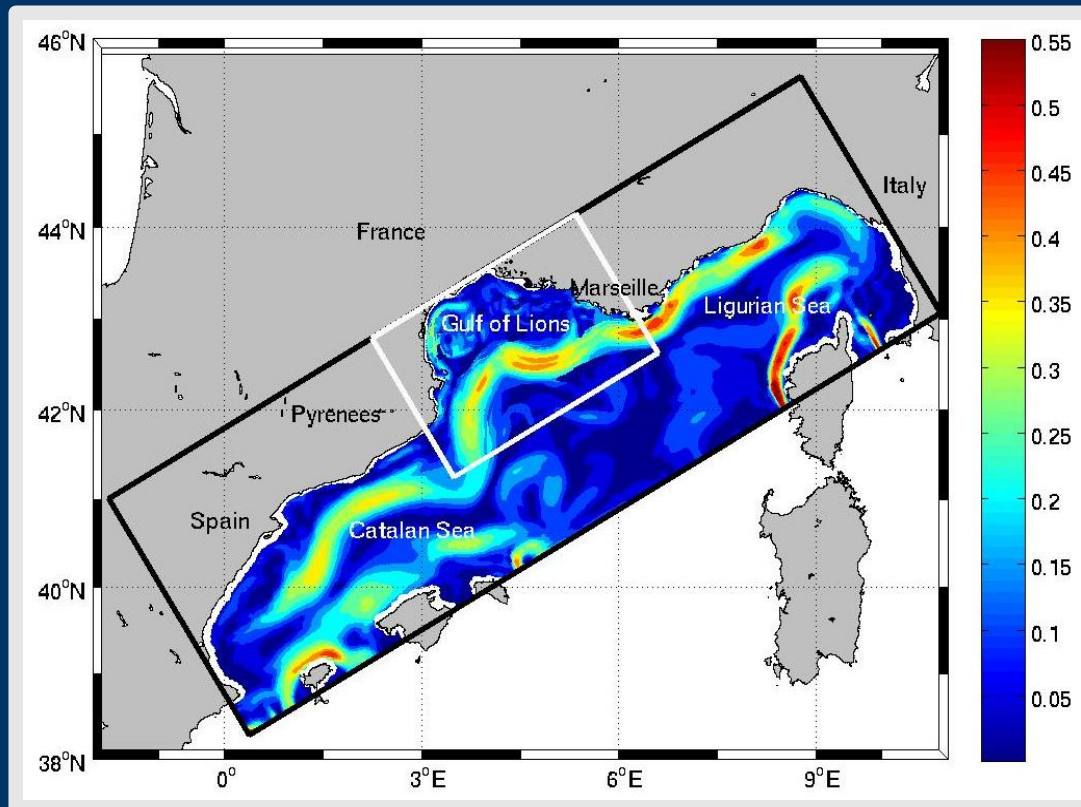
Depth_{max}
30-35 m



Numerical Modeling

Numerical model: **SYMPHONIE**

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



3D; Primitive Equations

Horizontal grid : Arakawa C

Vertical: 40 sigma-z hybrid

Closure Scheme: [Caspar et al., 1990]

Atmos. Forcing: Météo-France Aladin

Boundaries: OPA outputs (MFSTEP)

Initialization: [Estournel et al., 2003]

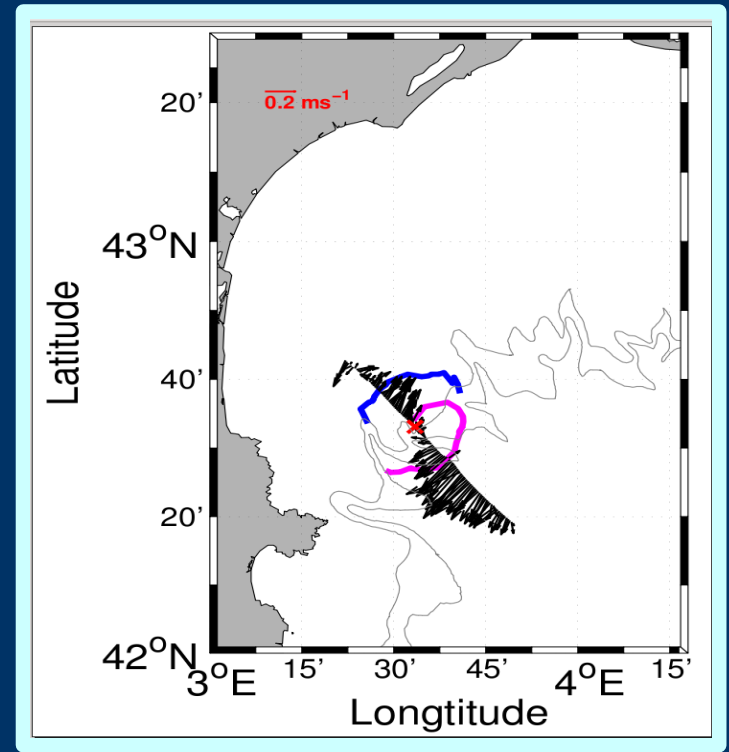
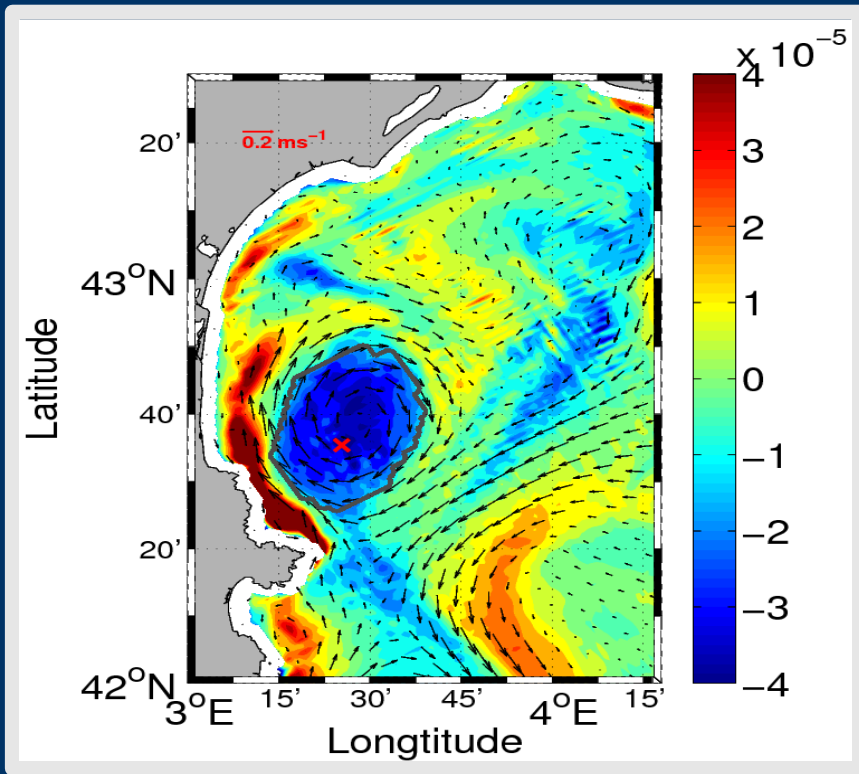
Zoom on the Gulf of Lions

One - Way nesting [Spall et Holland, 1991]

Resolution: 3km → 1km

[Hu et al., 2009]

Numerical eddy



Eddy detected by wavelet analysis [Doglioli et al., 2007]
 Relative vorticity [s^{-1}] 15m depth **August 27**

Latex09 ADCP data **August 27**
 +Buoys from August 26-29

Center: 3°26'E - 42°36'N
 $D_{\text{eddy}} = 28,6 \pm 1,4 \text{ km}$
 $\text{Depth}_{\text{max}} = 37 \text{ m}$

Center: 3°34'E - 42°33'N
 $D_{\text{eddy}} = 22,7 \pm 1,2 \text{ km}$
 $\text{Depth}_{\text{max}} = 35 \text{ m}$

→ Similar eddy found in the numerical results

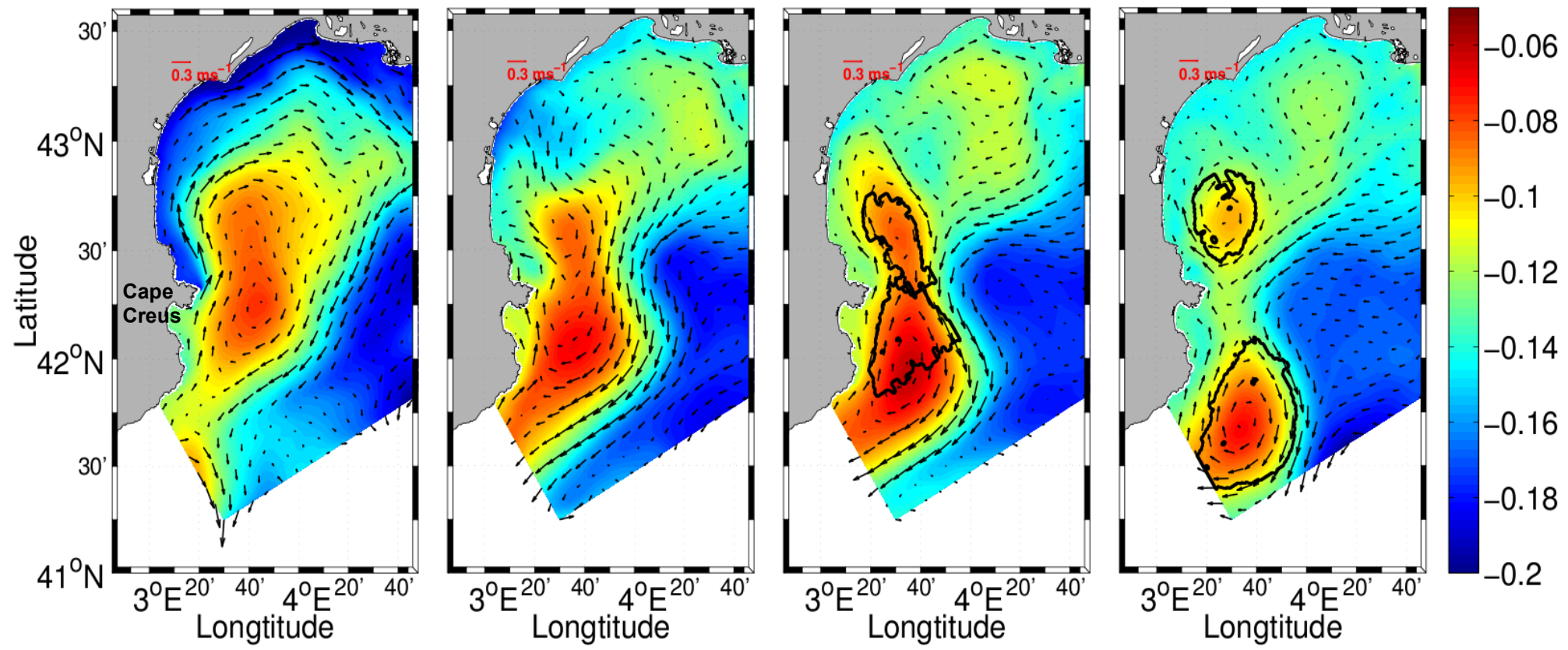
Eddy Generation Process

July 20

August 8

August 16

August 27

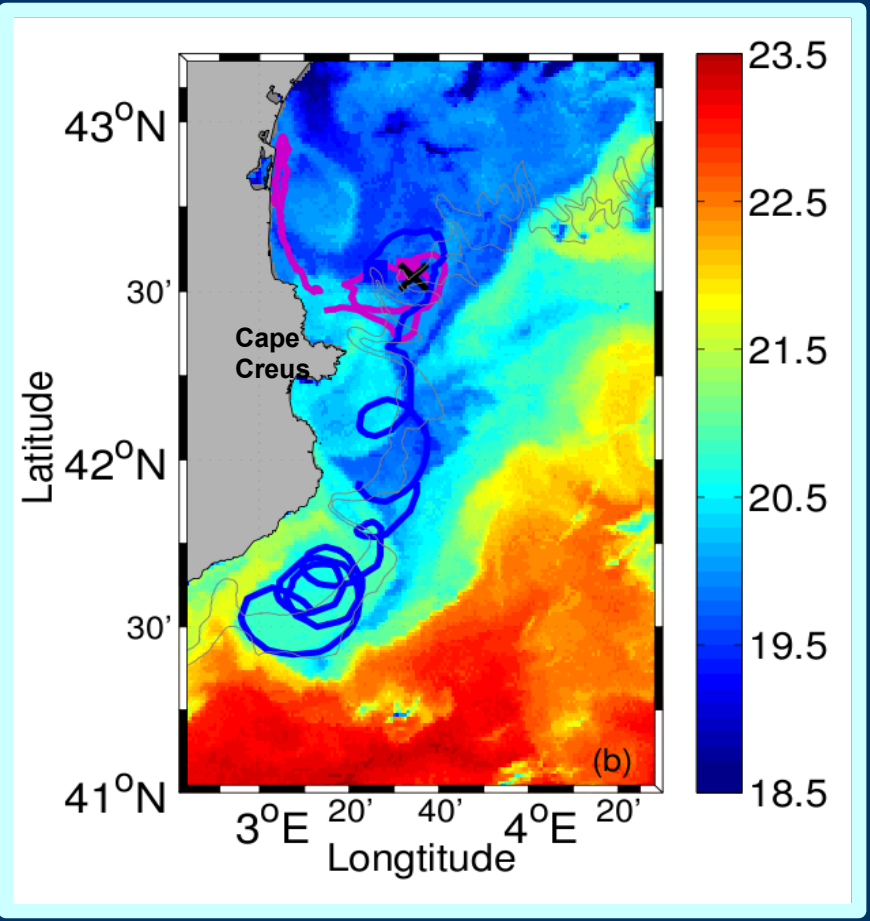


Eddies detected by wavelet analysis
Sea Surface Height [m]

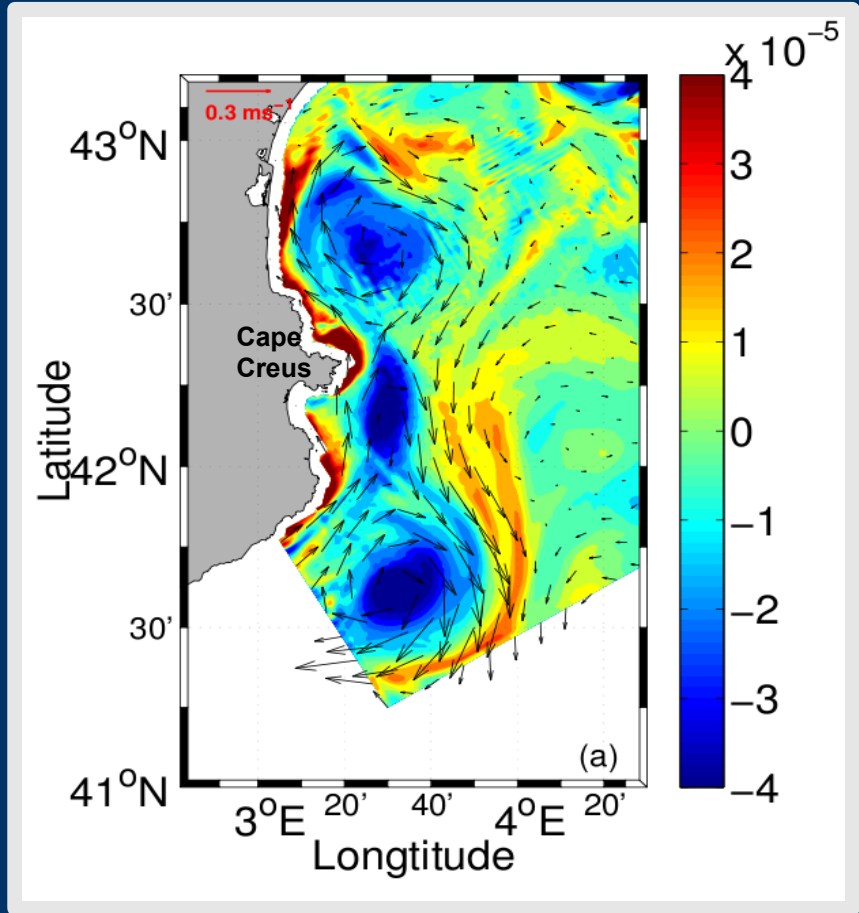
New Generation Process

- Pushing and squeezing of an anticyclonic circulation between a meander of the NC and the coast
- Separation in two structures

Latex09 feeds the Catalan eddy



SST (°C) September 12
+Buoys from August 26- September 12



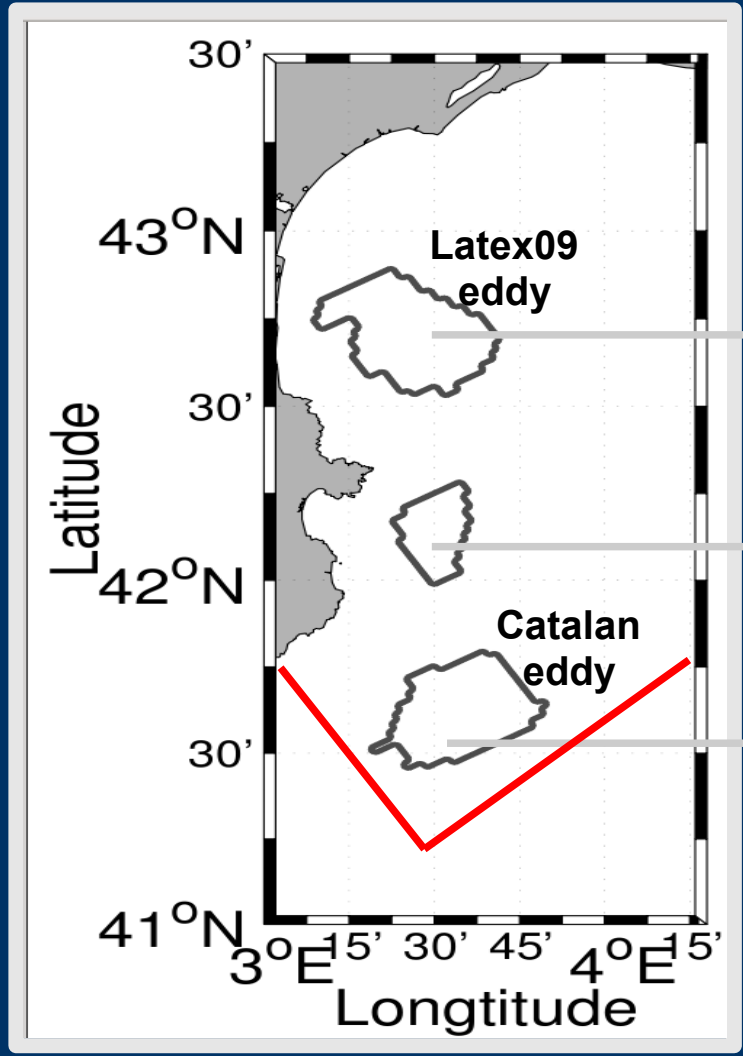
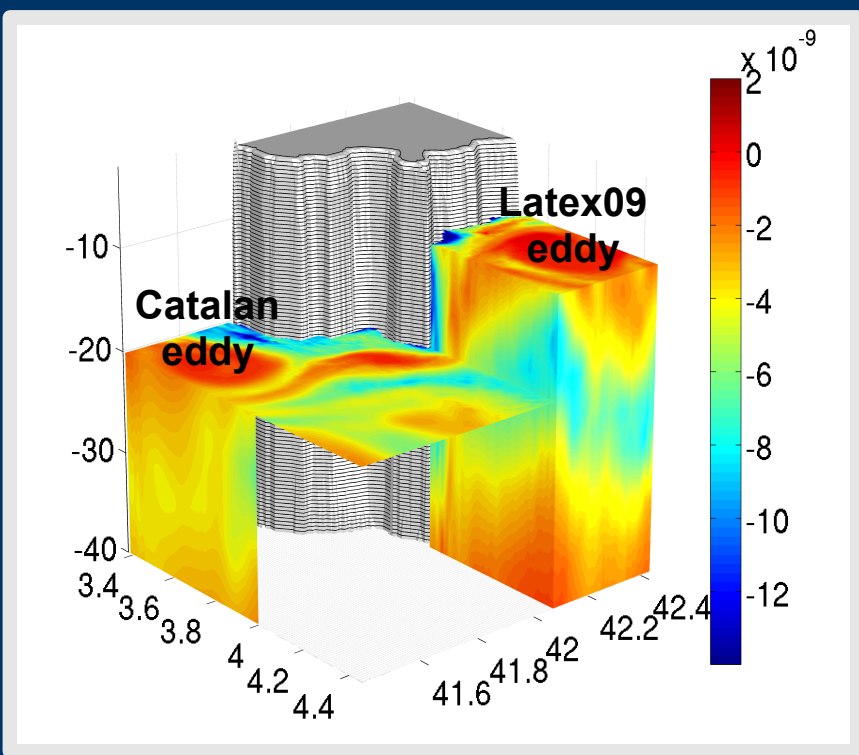
Relative vorticity [s^{-1}]
20m depth September 3

➔ The trajectories of the drifters explained by the model results :
Generation of a transient structure

Latex09 - Loss of mass

Eddies detected by wavelet analysis

Potential vorticity [$\text{kg}\cdot\text{m}^{-4}\cdot\text{s}^{-1}$] in 3D on September 3



Loss of mass 41%

33% of the GoL eddy's mass

Gain of mass?

➔ Interactions between the two eddies lead to a transfer of mass and vorticity from the GoL to the Catalan shelf

Conclusion

- Investigation of the dynamics and characteristics of a coastal anticyclonic eddy from a combination of *in-situ* measurement and modeled
- Numerical results : New Generation mechanism
- Transient structure => Transfer of mass and vorticity from the GoL to the Catalan shelf

Perspectives

- Role of mesoscale structures on cross-shelf exchanges

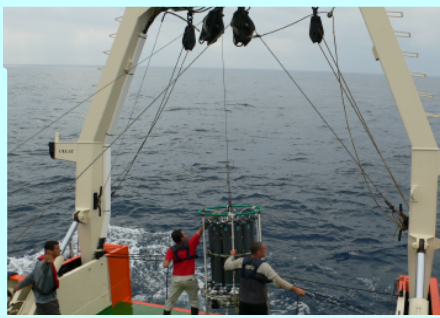
Thank you for your attention

LATEX web site

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





14/08/2007



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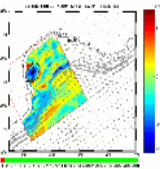
Sur le Web du CNRS

Langues du site

français

Lagrangian Transport Experiment

PIs : Frédéric Diaz and Anne Petrenko (LOPB - COM)
Project fouded by CNRS LEFE/IDAO/CYBER and Région PACA



Objective : influence of submesoscale coupled physics – biogeochemistry on cross-shelf (coast-offshore) exchanges

Methodology : lagrangian strategy to follow a submesoscale eddy using lagrangian floats and an inert chemical tracer (SF6)
Multi-disciplinary project & multi-« tools » : Lagrangian floats, SF6, hull-mounted ADCP, moorings, satellite images, numerical modelling, gliders and, radars.

Site of study : Gulf of Lion, north-western Mediterranean sea

Anticyclonic eddy A1, here on August 1st, 2001, detected with wavelet analysis of numerical relative vorticity (click image to enlarge)

General description of the project in English and in French

!!! What's New !!! [Participants](#) [Tools, Software & Miscellaneous](#) [Publications](#)

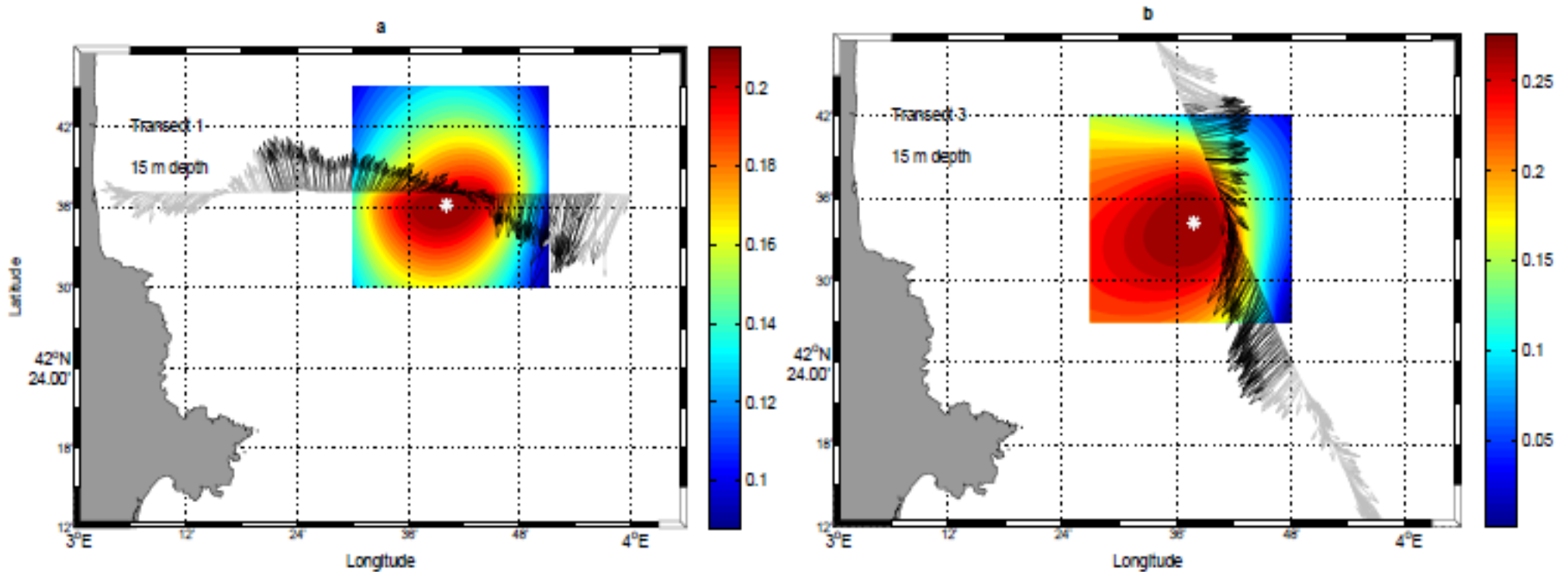
Rechercher : Occurrence suivante Occurrence précédente Surligner tout Resp.

Extra slides

Eddy's center detection

Center of the eddy

The point grid for which the mean tangential velocity is maximal [Nencioli et al., 2008]

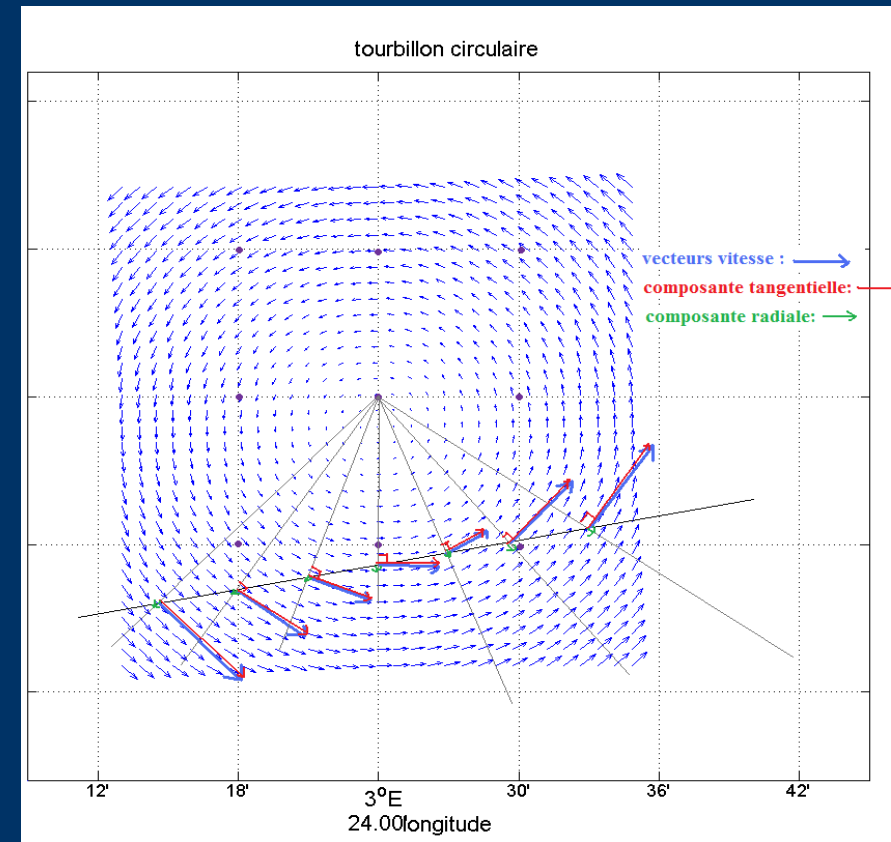
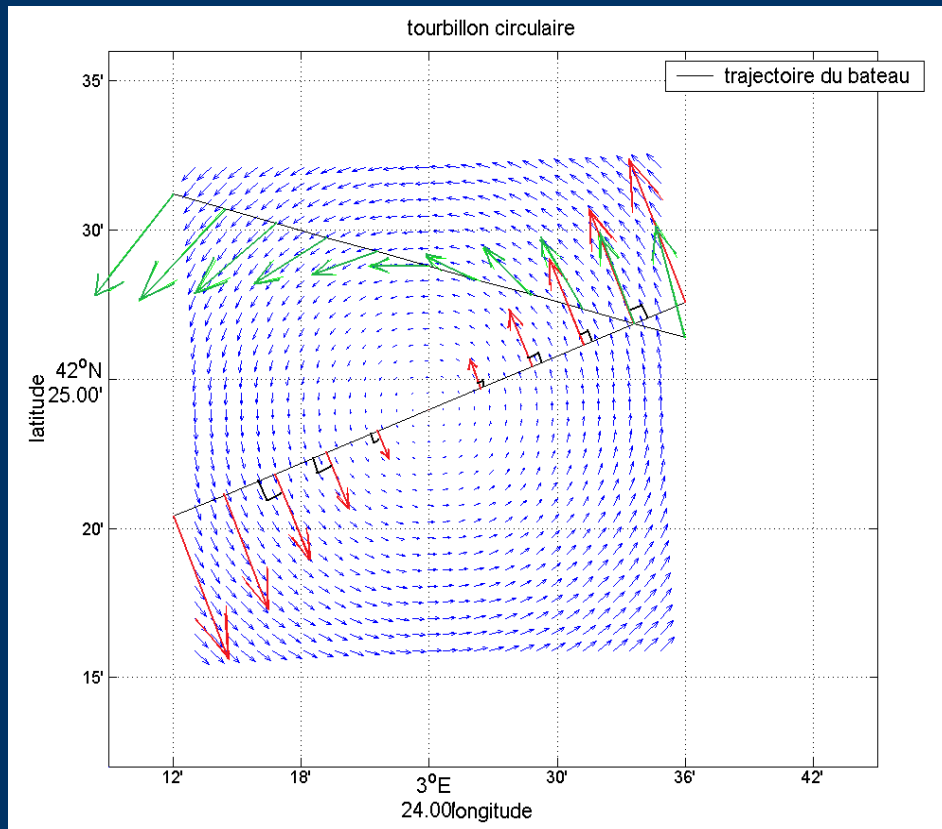


Colorbars - vitesse tangentielle

Carré: 30 x 30 pixels

Eddy's center detection

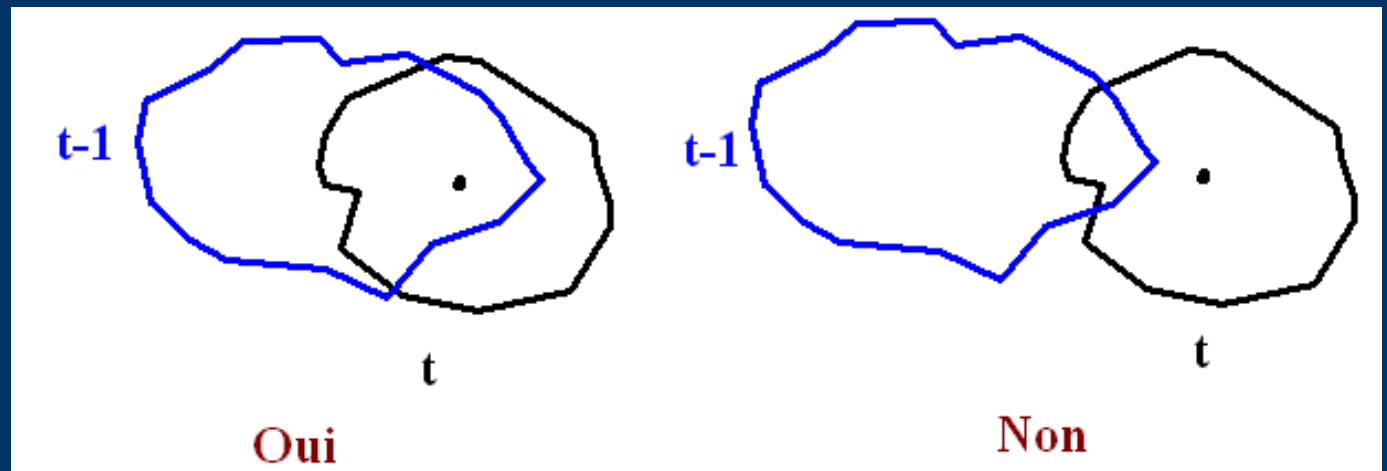
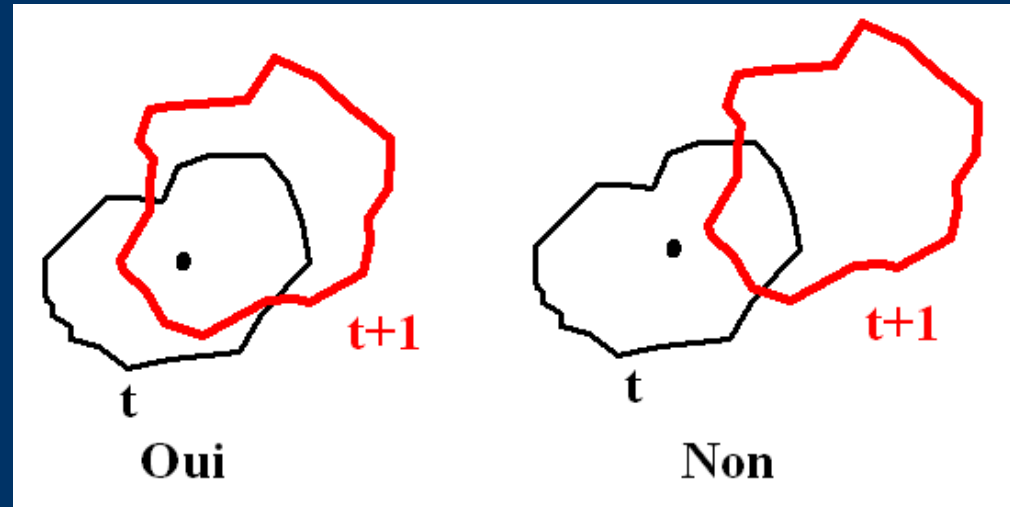
Decomposition : Tangential & radial components



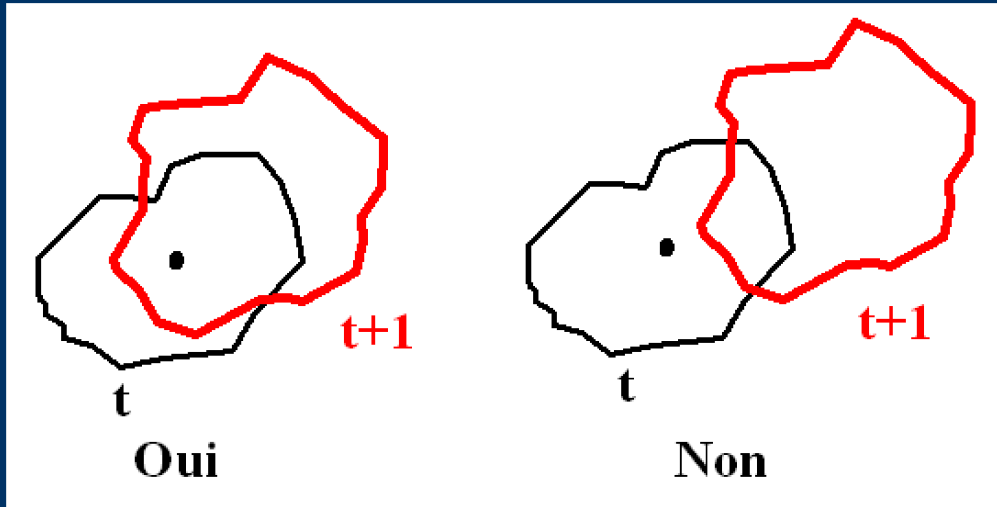
Wavelet analysis method

$$C_{t,z} \in \mathbb{C}_{t-\Delta t,z}$$

$$C_{t,z} \in \mathbb{C}_{t+\Delta t,z}$$



Wavelet analysis method



Criterion:

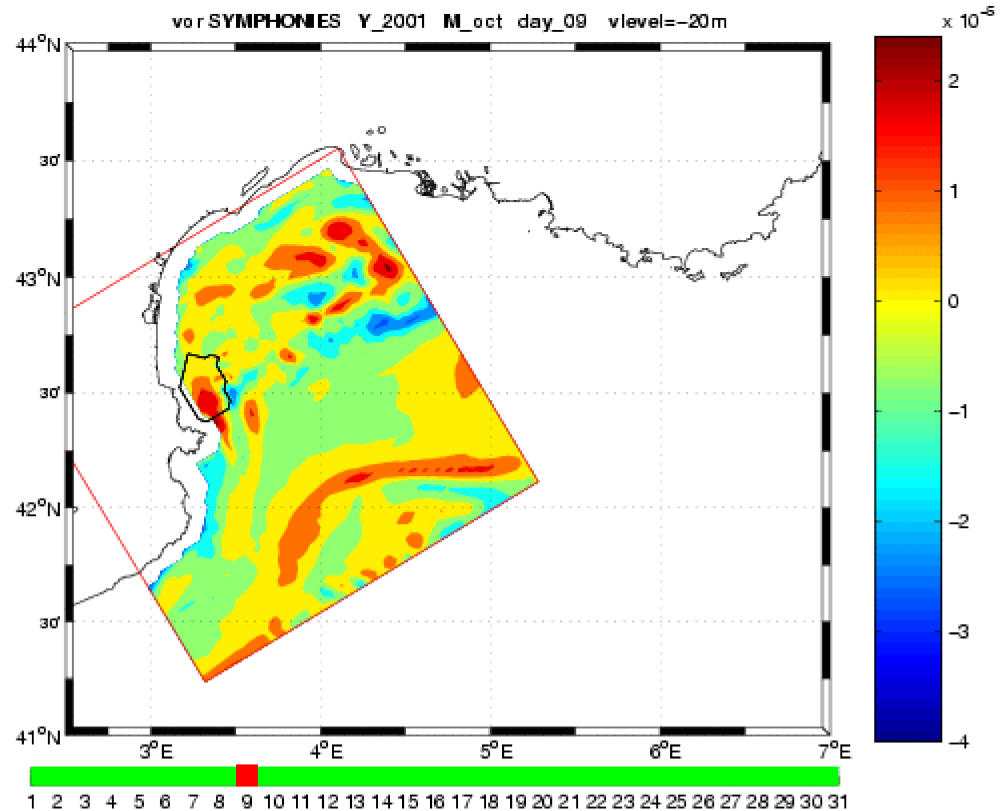
$$C_{t,z} \in \mathbb{C}_{t-\Delta t,z}$$

(Forward)

$$C_{t,z} \in \mathbb{C}_{t+\Delta t,z}$$

(Backward)

C3(01)
26 September – 9 October
Eddy Tracking Backward



Start & end dates of the transects

	Start		End	
	Day	Hour	Day	Hour
Transect 1	Aug. 25	01h38	Aug. 25	04h48
Transect 2	Aug. 25	18h27	Aug. 25	23h39
Transect 3	Aug. 26	21h24	Aug. 27	01h16
Transect 4	Aug. 27	21h31	Aug. 28	03h54

Characteristics of the eddy

Transect	Depth (m)	Diameter (km)	Center	Transect's Center	Eddy's Center
1	-11	30	3°33'E - 42°33'N	C1	3°34'E - 42°33'N
	-15	33	3°33'E - 42°33'N	3°34'E - 42°33'N	
	-19	35	3°35'E - 42°33'N		
2	-11	30	3°35'E - 42°30'N	C2	
	-15	29	3°33'E - 42°31'N	3°34'E - 42°31'N	
	-19	28	3°33'E - 42°32'N		
3	-11	24	3°35'E - 42°30'N	C3	
	-15	24	3°35'E - 42°33'N	3°36'E - 42°32'N	
	-19	26	3°36'E - 42°34'N		
4	-11	24	3°33'E - 42°33'N	C4	
	-15	22	3°34'E - 42°34'N	3°35'E - 42°34'N	
	-19	16	3°37'E - 42°34'N		

CTD Profiles

