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

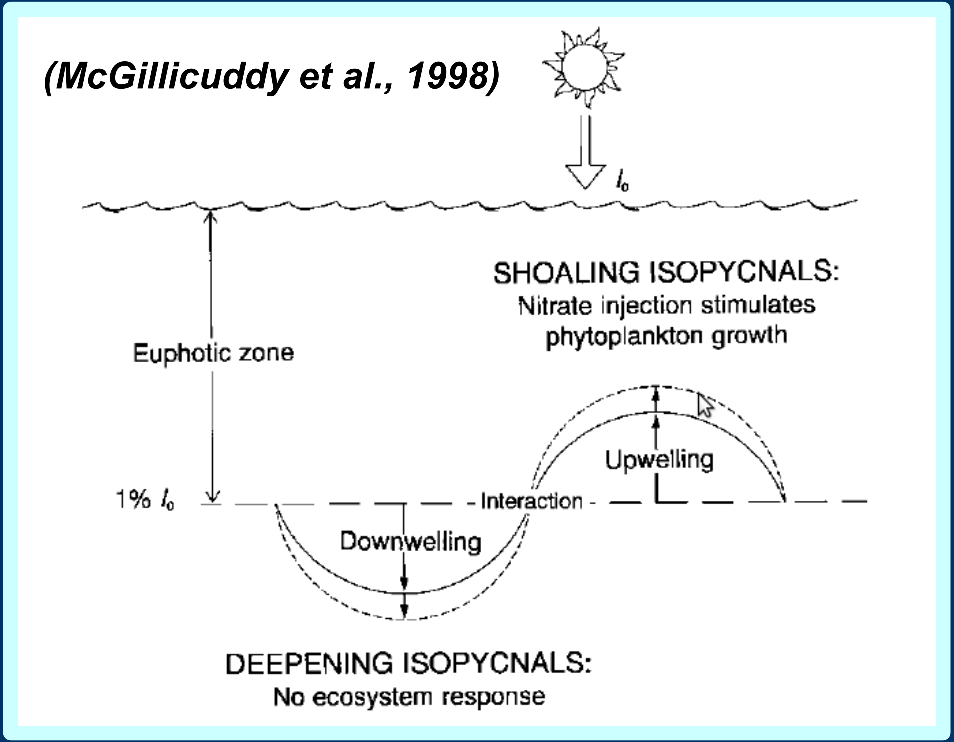
Marion Kersalé[1], Anne Petrenko[1], Andrea Doglioli[1], Francesco Nencioli[1], Jérôme Bouffard[1] and Ivan Dekeyser[1]

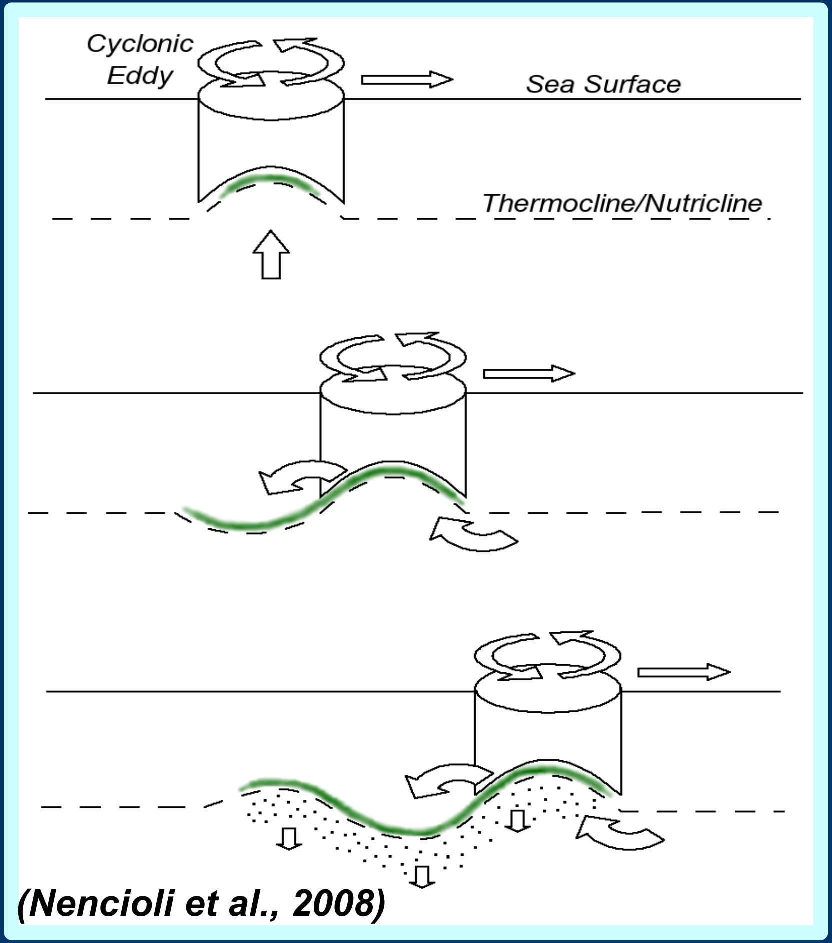
Turbintermed Workshop
April 17th, 2012
Toulon

(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

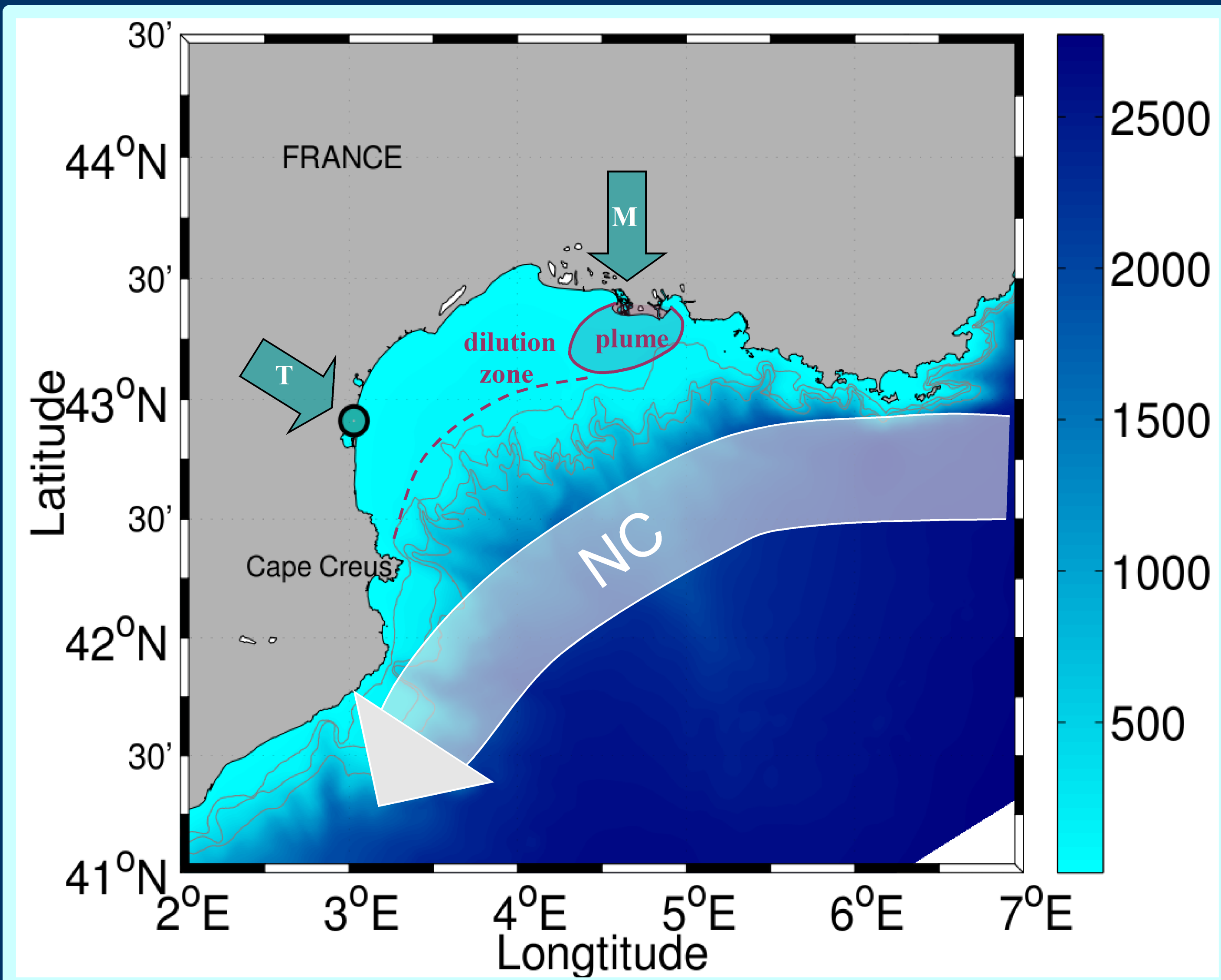
Methodology

Multi-disciplinary project

In-situ measurements & Numerical modeling

3 Oceanographic Cruises	Numerical Time Series
LATEX08, LATEX09 } Eddy mapping	2001 → 2008 [Hu et al., 2011]
LATEX10	2009

Study Zone: Gulf of Lion
NW Mediterranean Sea



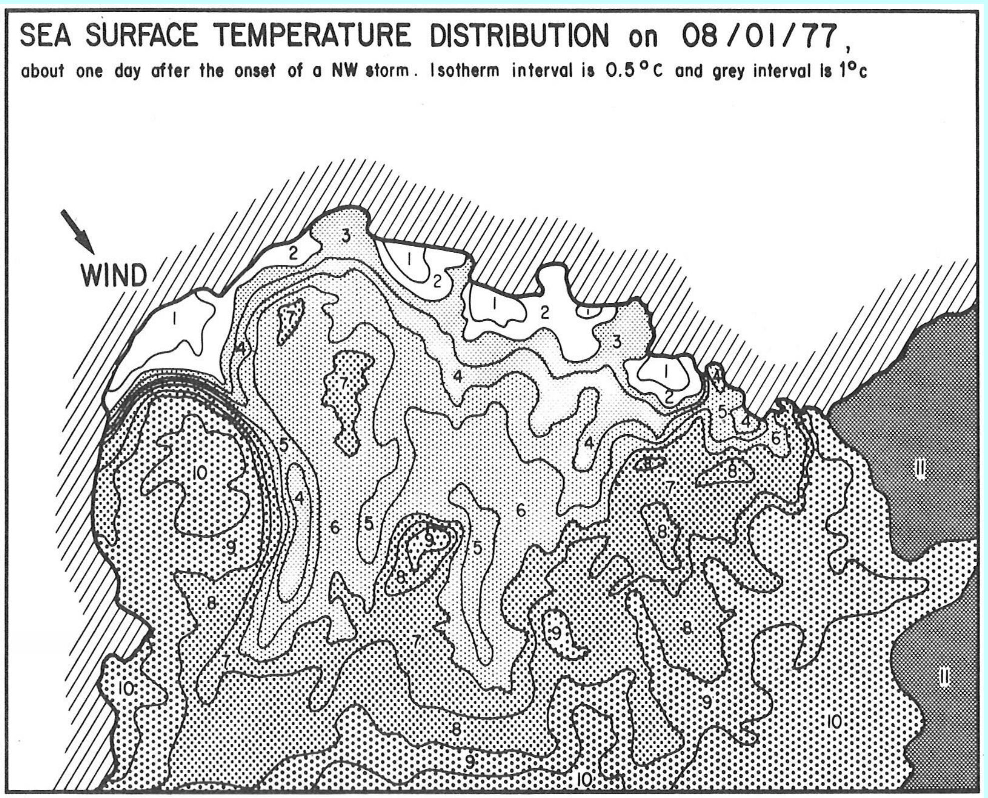
Forcings:

1- Rhone plume

2- Winds :
Tramontane
Mistral.

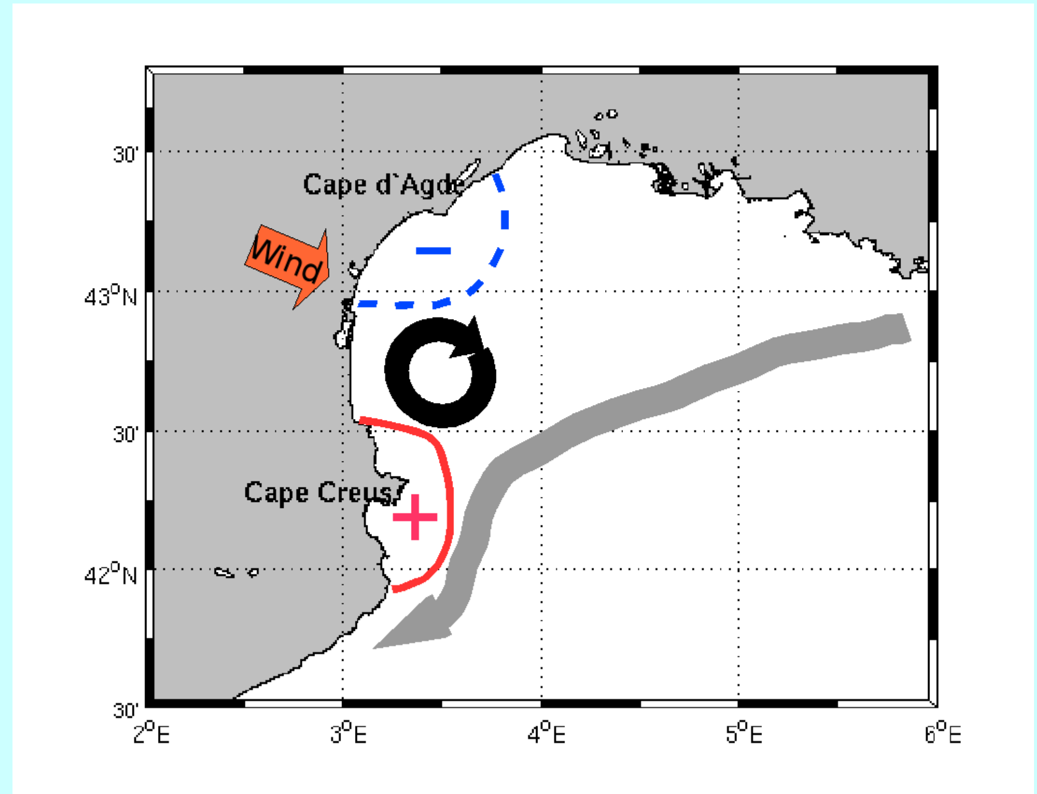
3- Northern Current
(NC)

Western Anticylonic Eddy



First observation
[Millot, 1982]

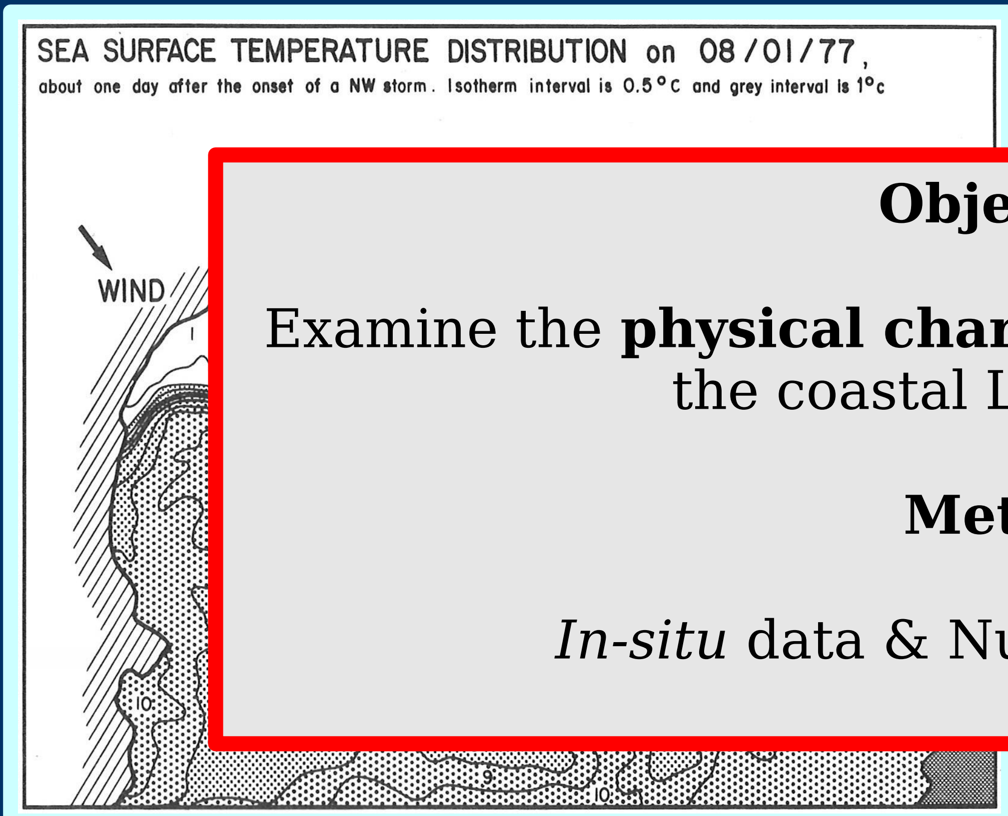
Mesoscale anticyclonic circulation in the western part of the GoL

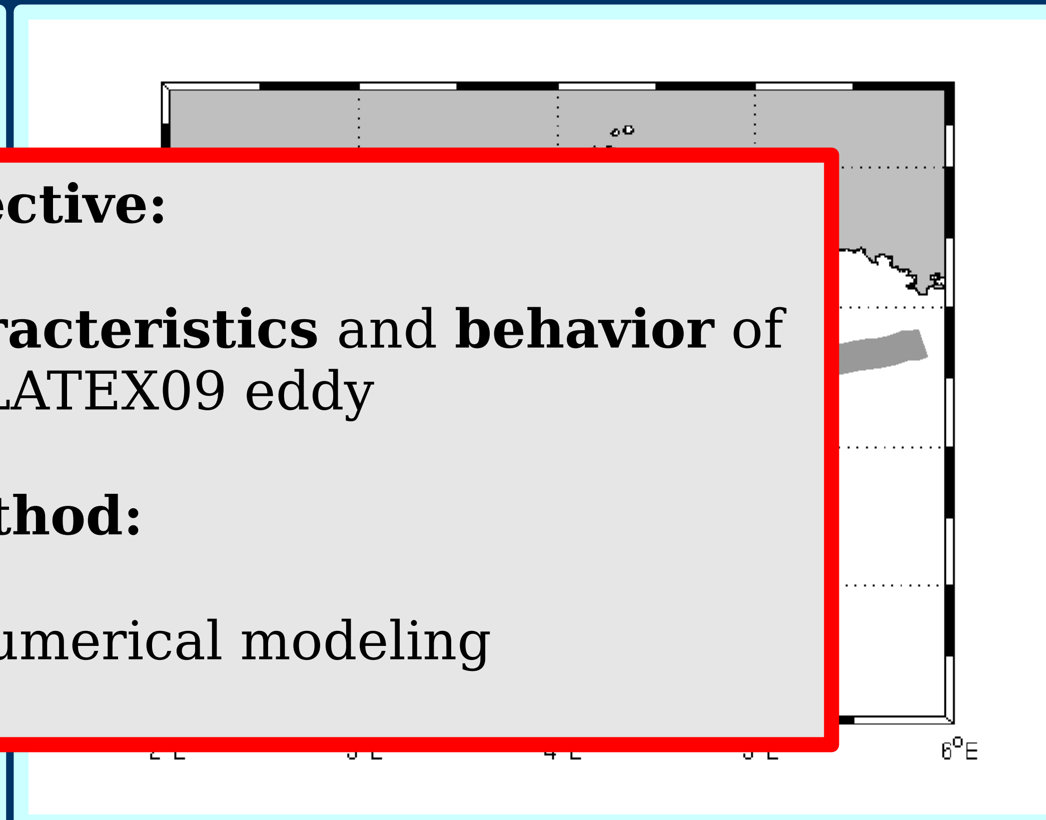


Hypothesis of generation 2001-2008
[Hu et al., 2012]

→ Persistent & strong northwest wind
→ Strong stratification

Western Anticylonic Eddy





Objective:

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

Method:

In-situ data & Numerical modeling

First observation
[Millot, 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**

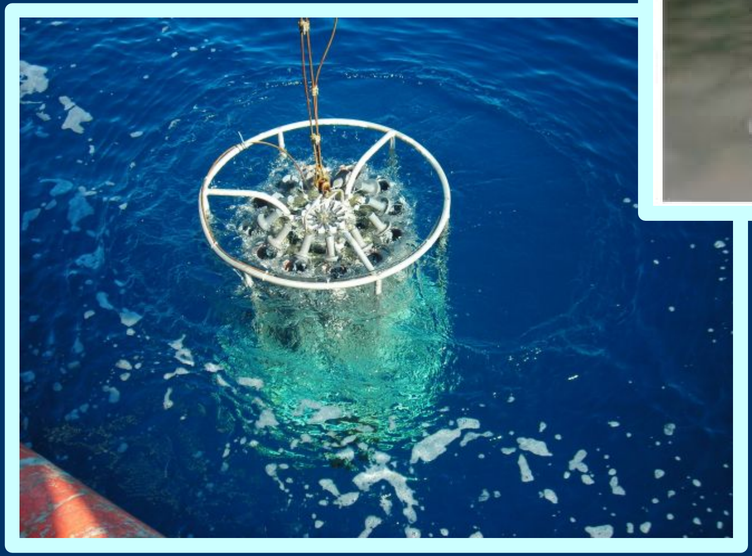
In-situ Measurements

Latex09 Oceanographic cruise
August 24 to 28 2009

Satellite observations

ADCP
Thermosalinometer

CTD

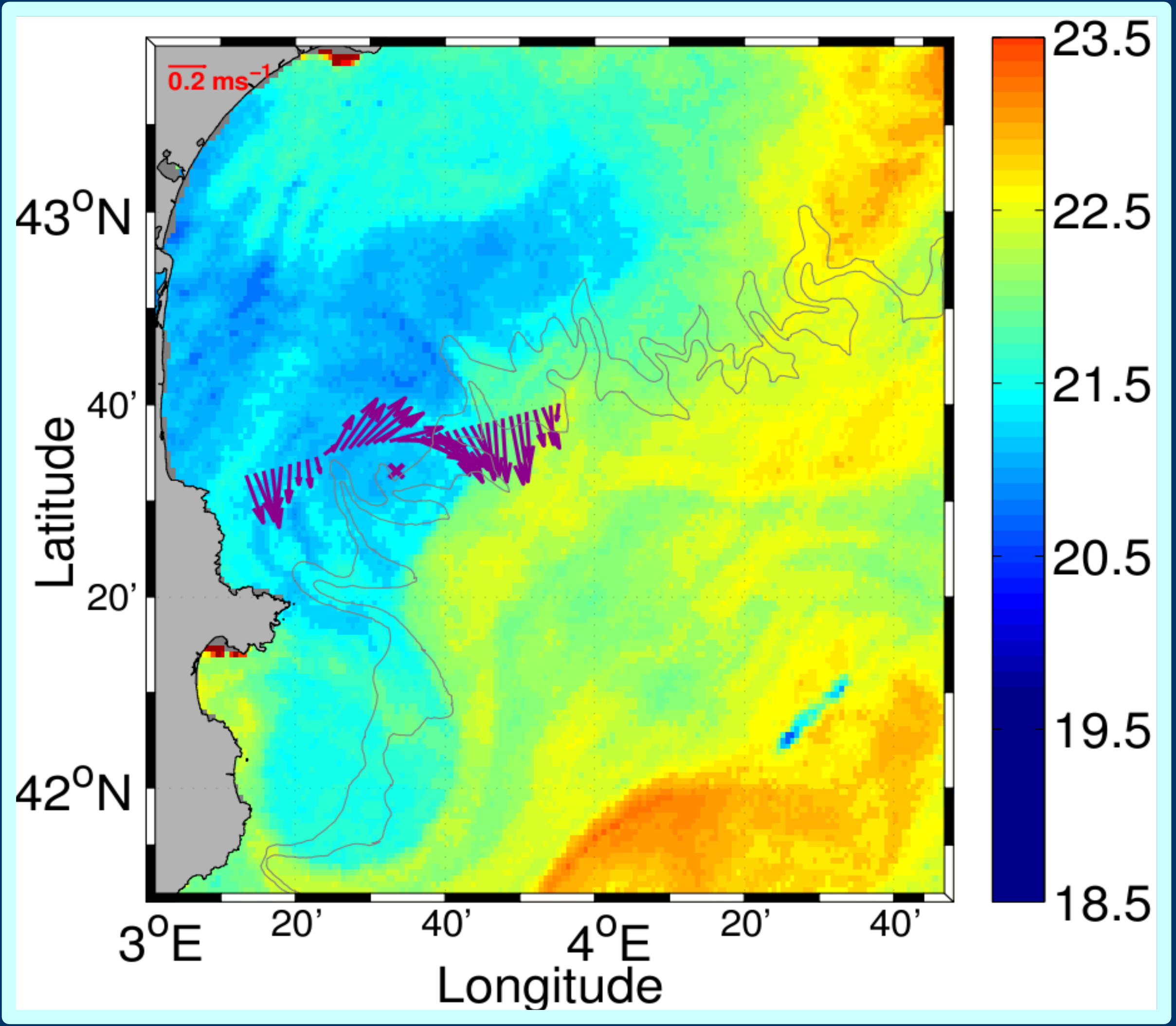


Lagrangian
floats

Horizontal Characteristics

Transect 1

ADCP 15m depth - SST (°C) August 28



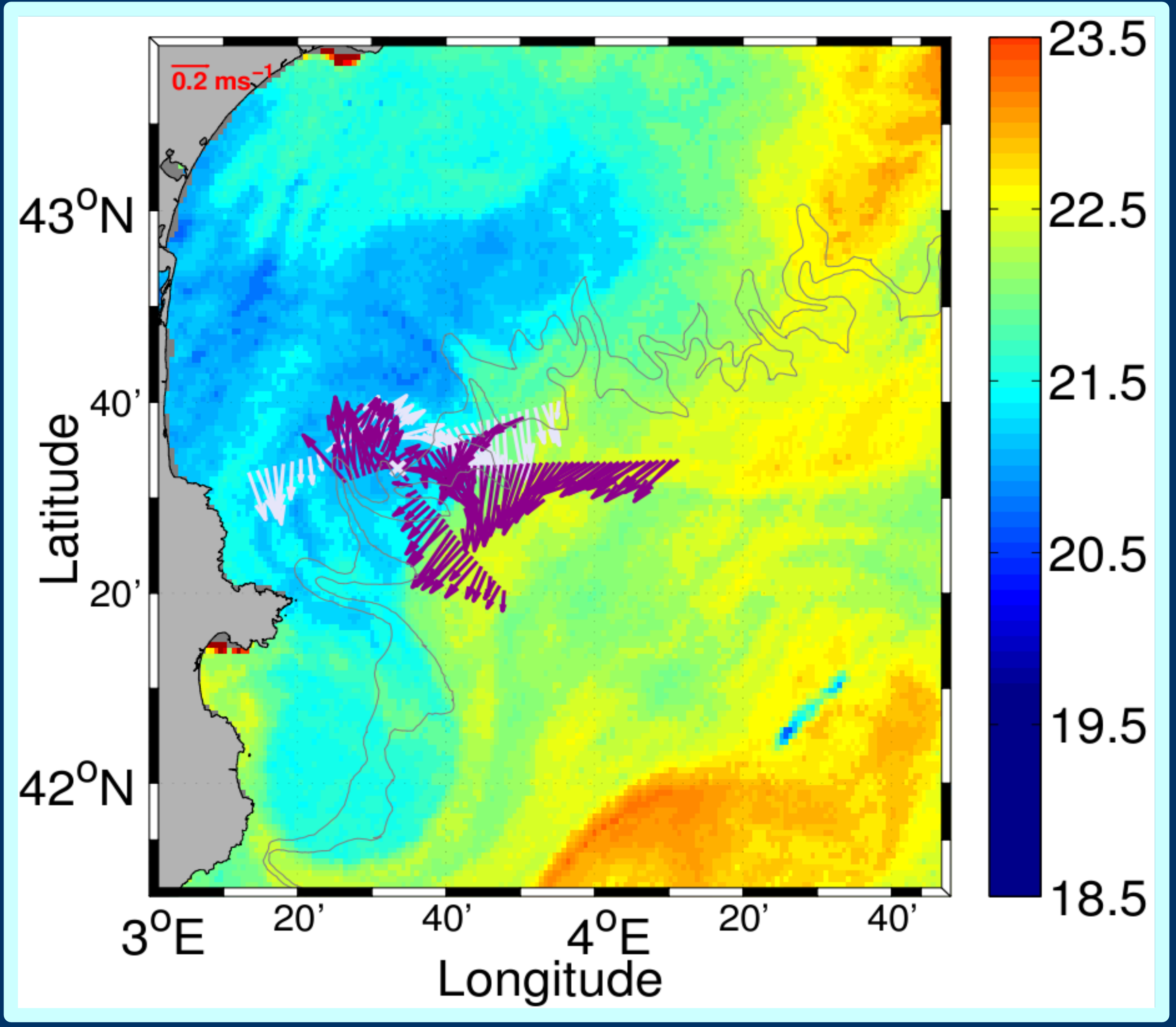
Eddy center detection [Nencioli et al., 2008]

in-situ

Horizontal Characteristics

Transects 1-2-3-4

ADCP 15m depth - SST (°C) August 28

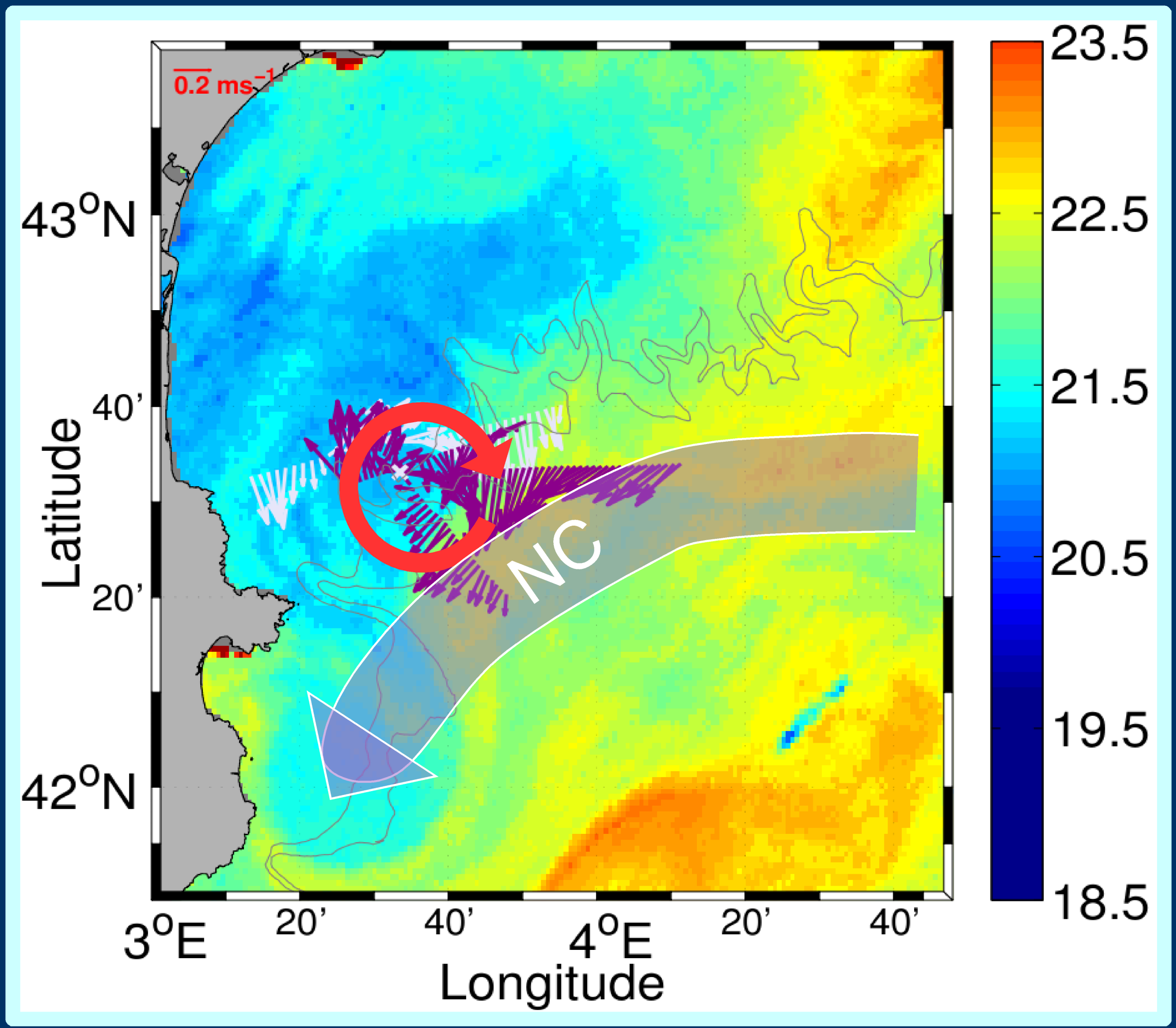


in-situ

Horizontal Characteristics

Transects 1-2-3-4

ADCP 15m depth - SST (°C) August 28



Anticyclonic circulation

$V_{max} \sim 0.4\ m.s^{-1}$

T ~ 3 days

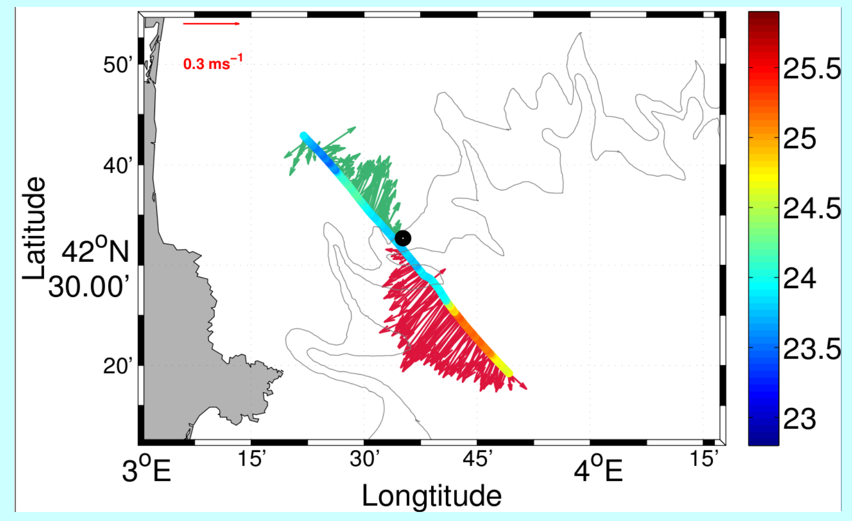
Center:
3°34'E – 42°33'N

Presence of the NC

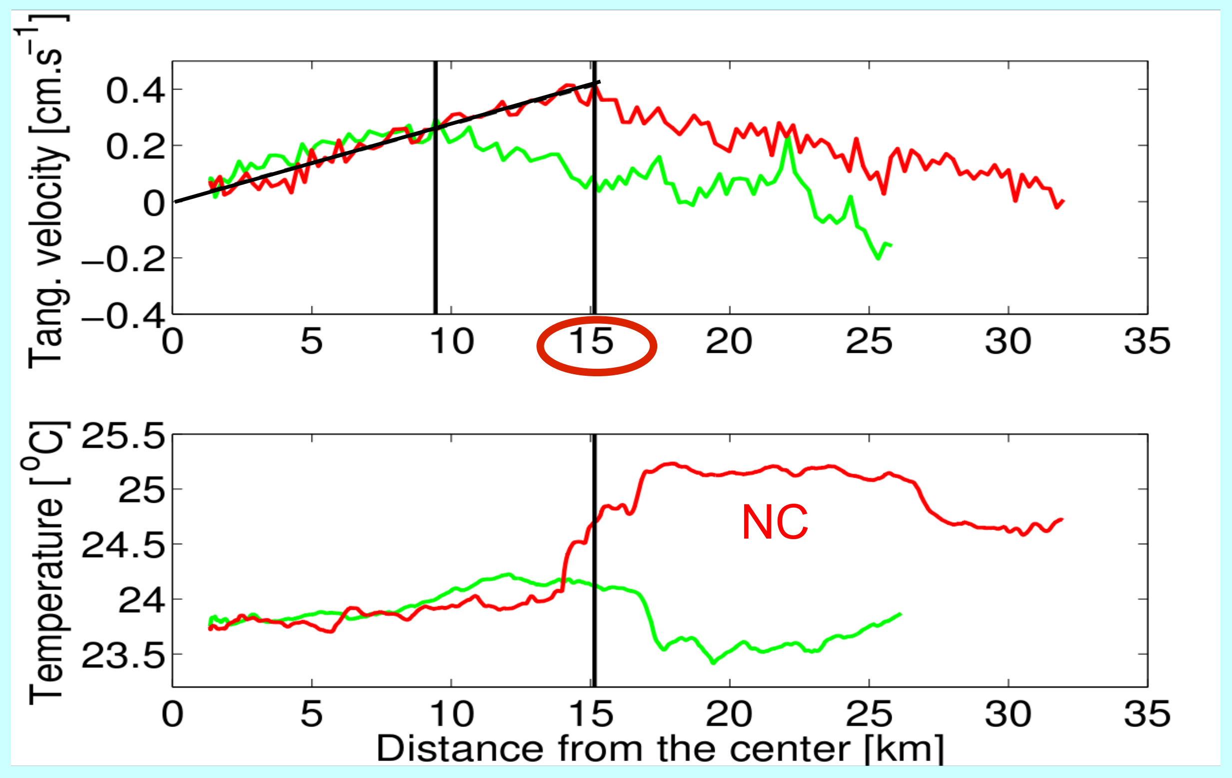
Horizontal Characteristics

Transect 3

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



ADCP 15m depth - SST (°C)

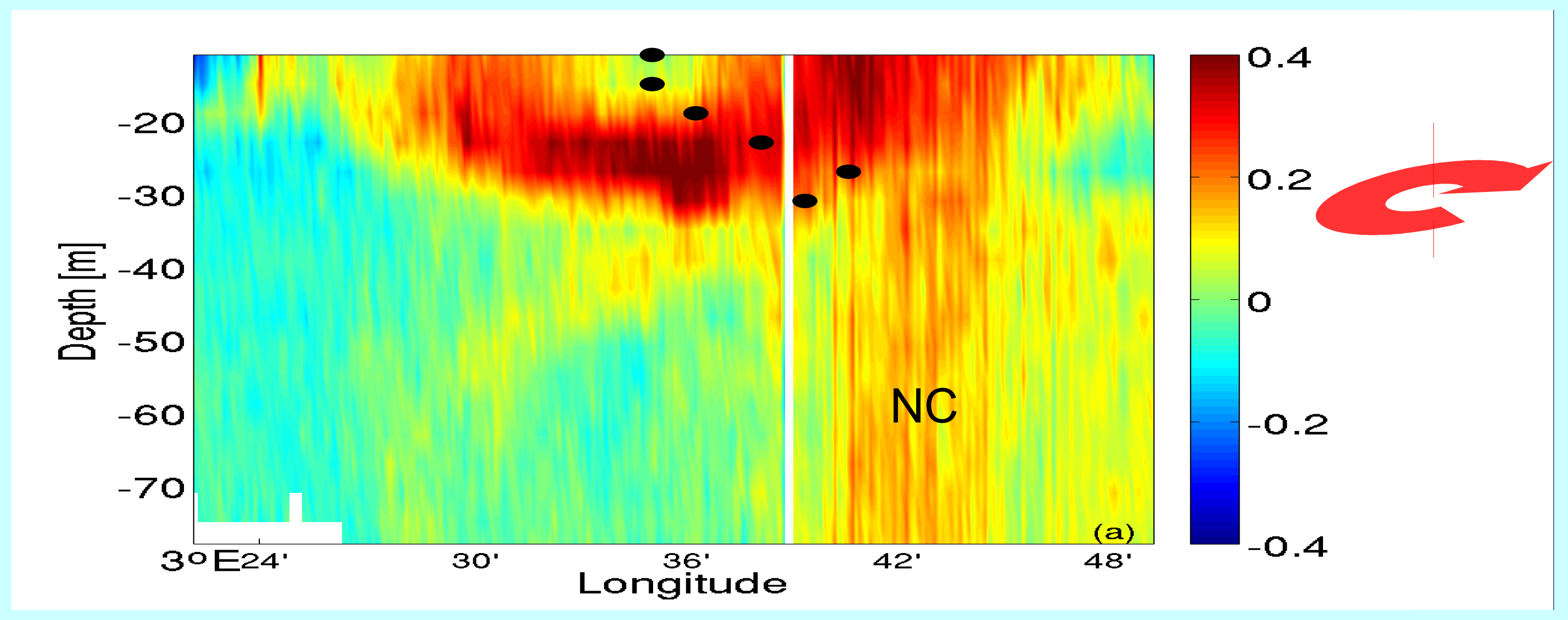


$$D_{eddy} = \bar{D} \pm \sqrt{D_{var}}$$

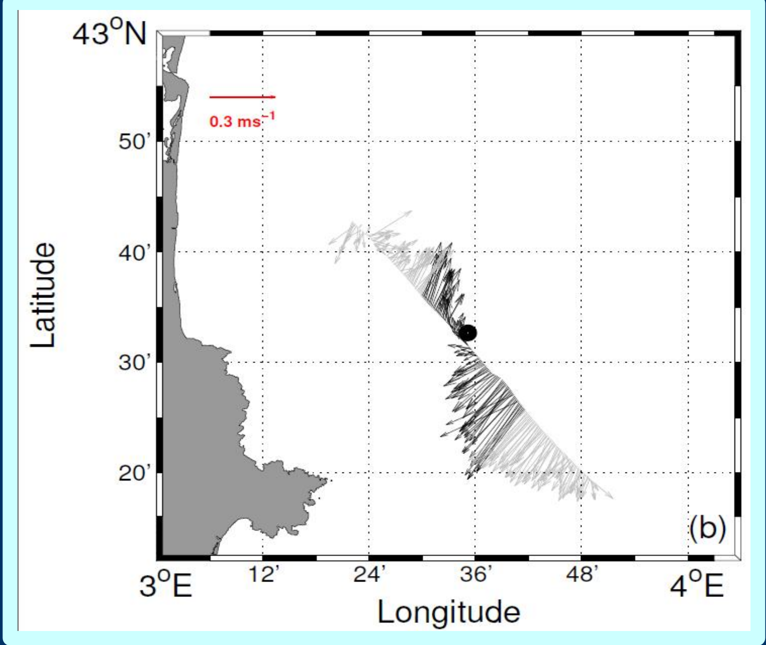
$$D_{eddy} = 22{,}7 \pm 1{,}2 \text{ km}$$

in-situ

Vertical section

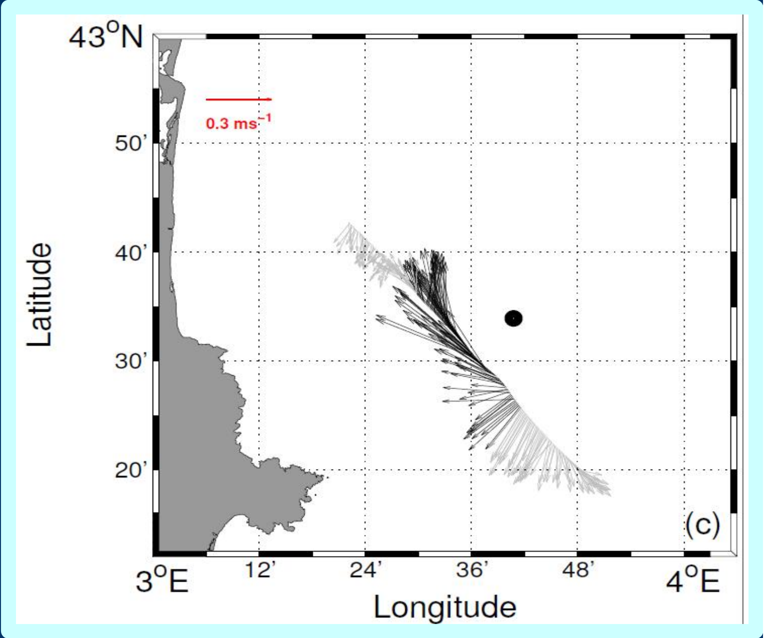


Vertical section of the tangential component of the horizontal current (m.s[-1]) for Transect 3



ADCP current at
← 15 m depth
27 m depth →

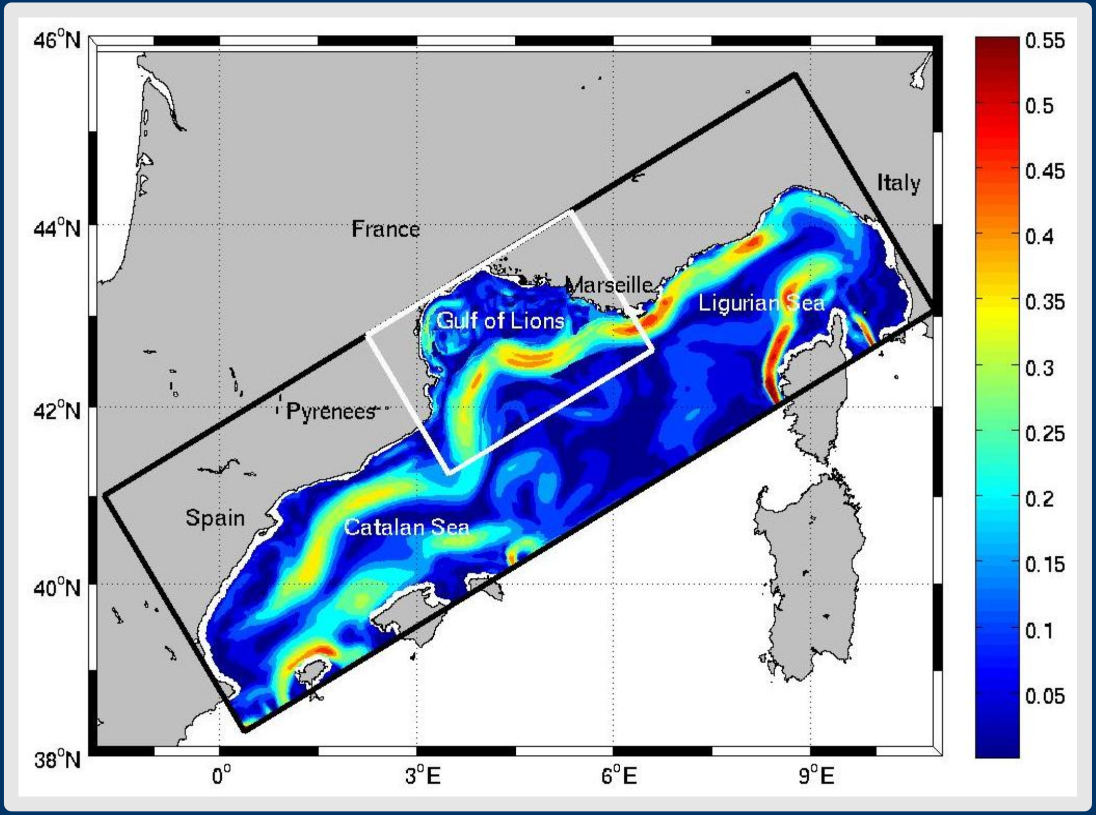
Depth $_{max}$
30-35 m



Numerical Modeling

Numerical model: **SYMPHONIE**

Laboratoire d'Aérologie 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]

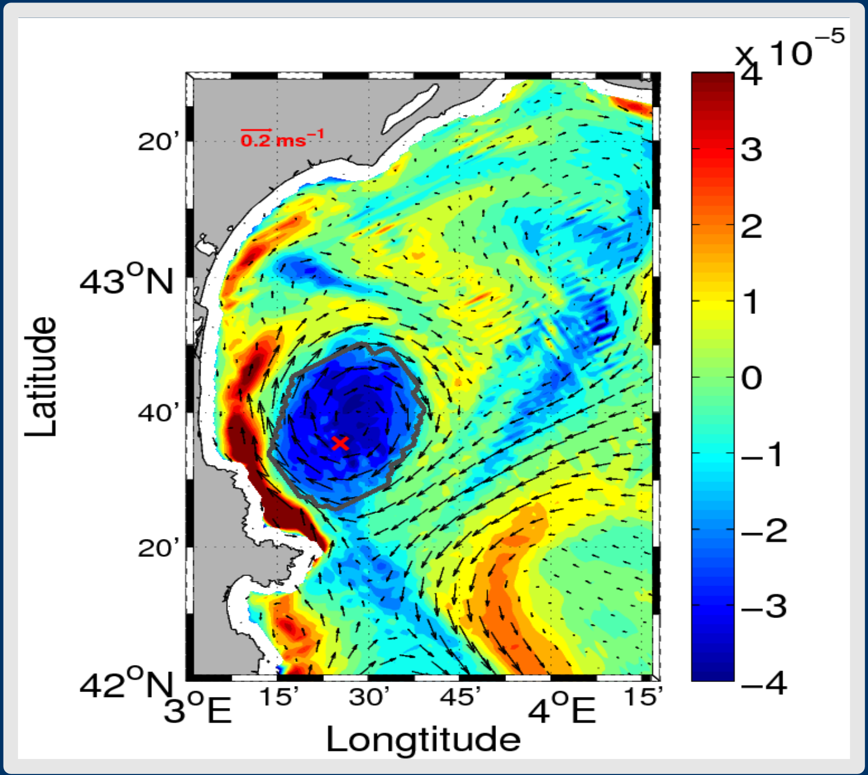
Atmos. Forcing: Météo-France Aladin
Boundaries: OPA outputs (MFSTEP)
Initialization: [Estournel et al., 2003]

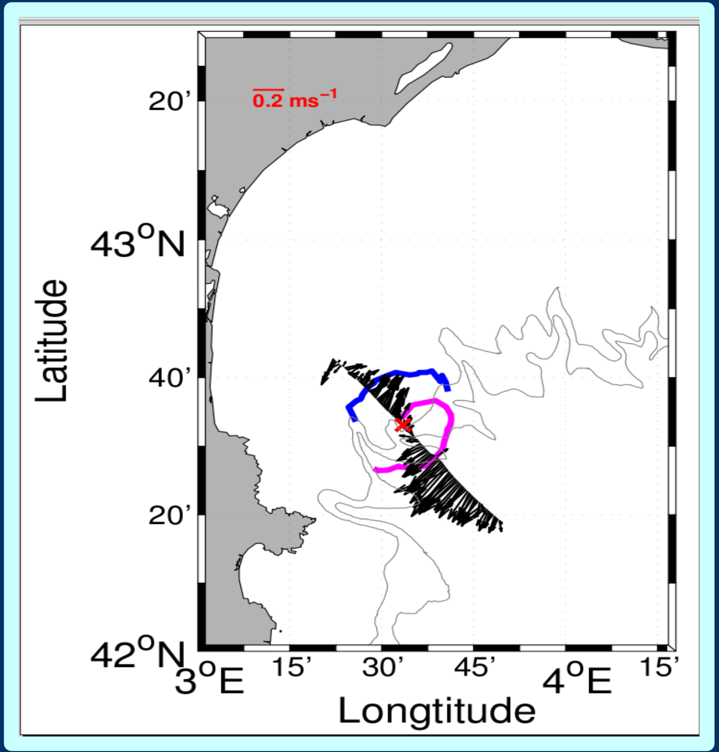
Zoom on the Gulf of Lions
One – Way nesting [Spall et Holland, 1991]
Resolution: 3km → 1km

[Hu et al., 2009]

model

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_{eddy} = 28,6 ± 1,4 km

$Depth_{max}$ = 37 m

Center: 3°34'E – 42°33'N

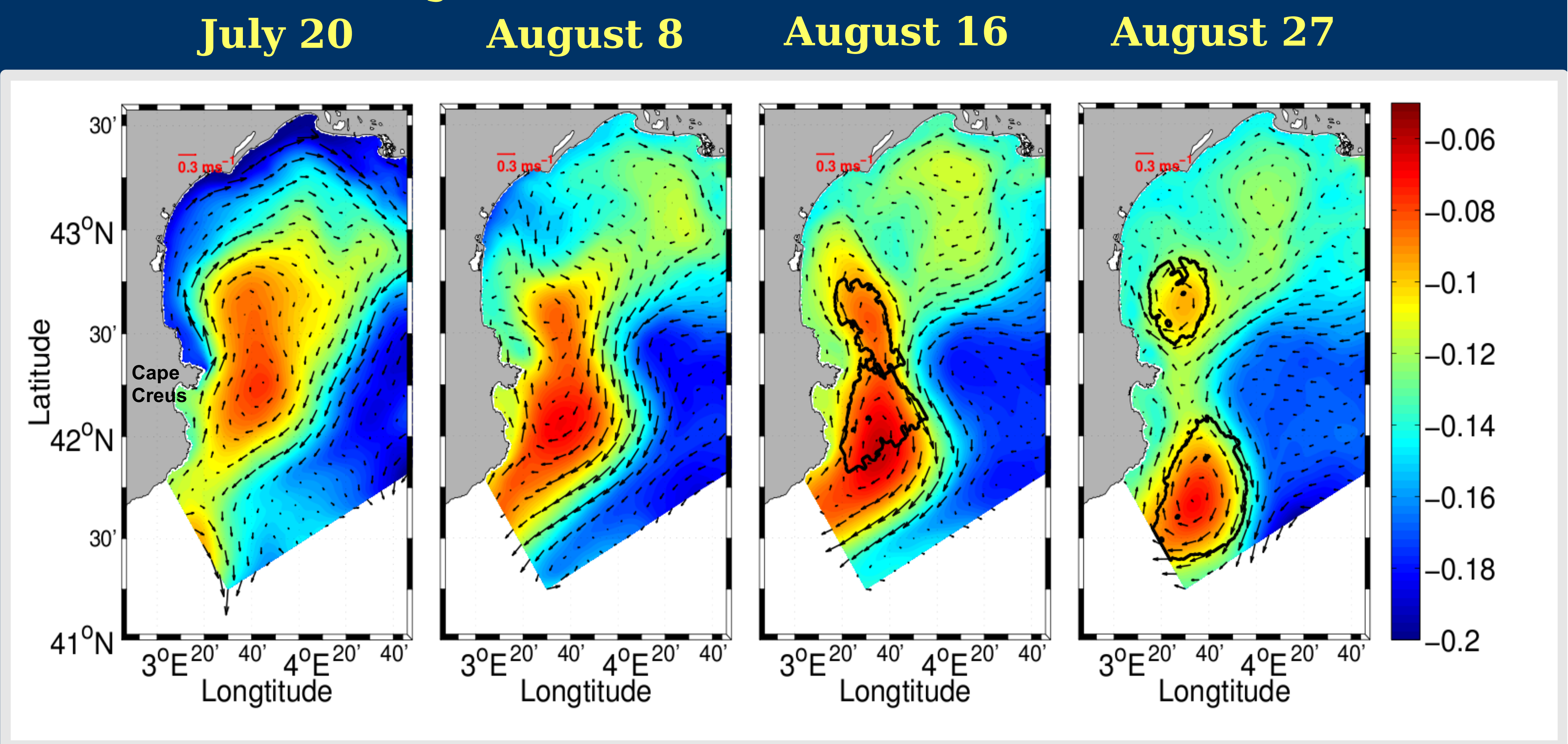
D_{eddy} = 22,7 ± 1,2 km

$Depth_{max}$ = 35 m

➔ Similar eddy found in the numerical results

model

Eddy Generation Process



Eddies detected by wavelet analysis
Sea Surface Height [m]

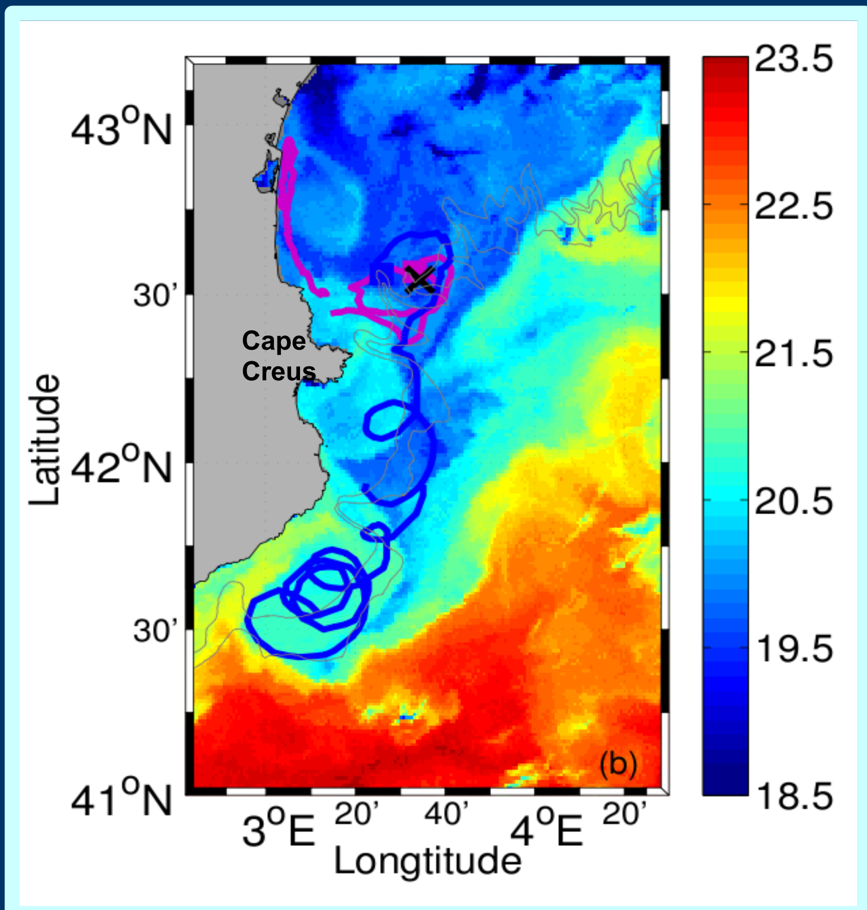
New Generation Process

➔Pushing and squeezing of an anticyclonic circulation between a meander of the NC and the coast

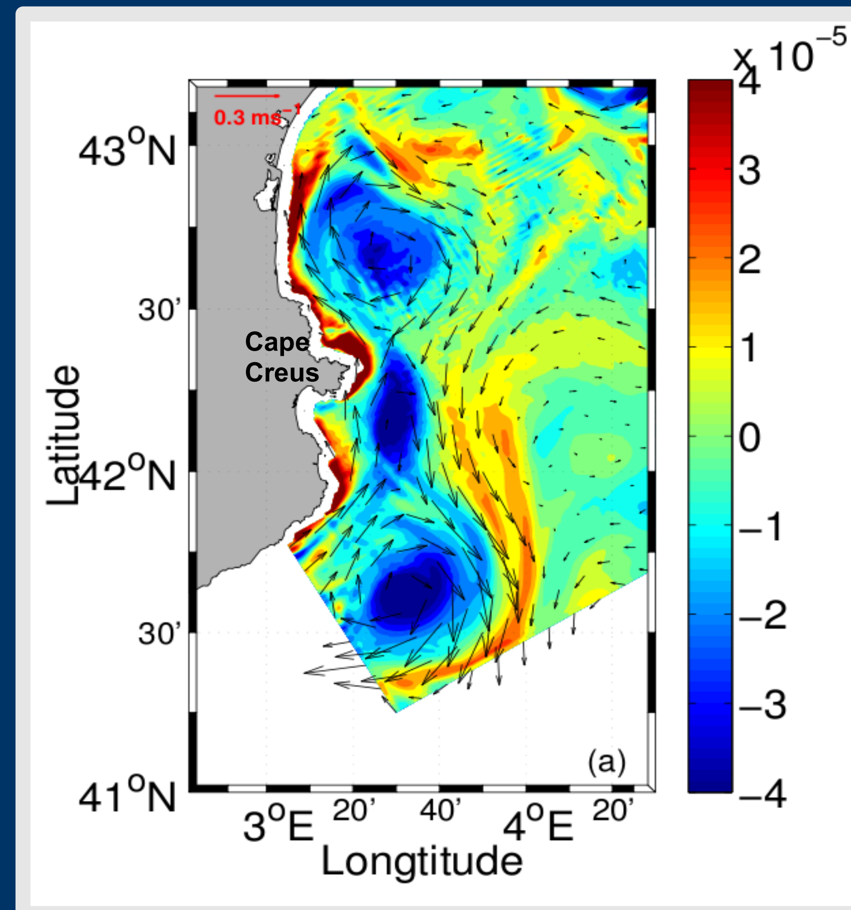
➔ Separation in two structures

model

Latex09 feeds the Catalan eddy



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



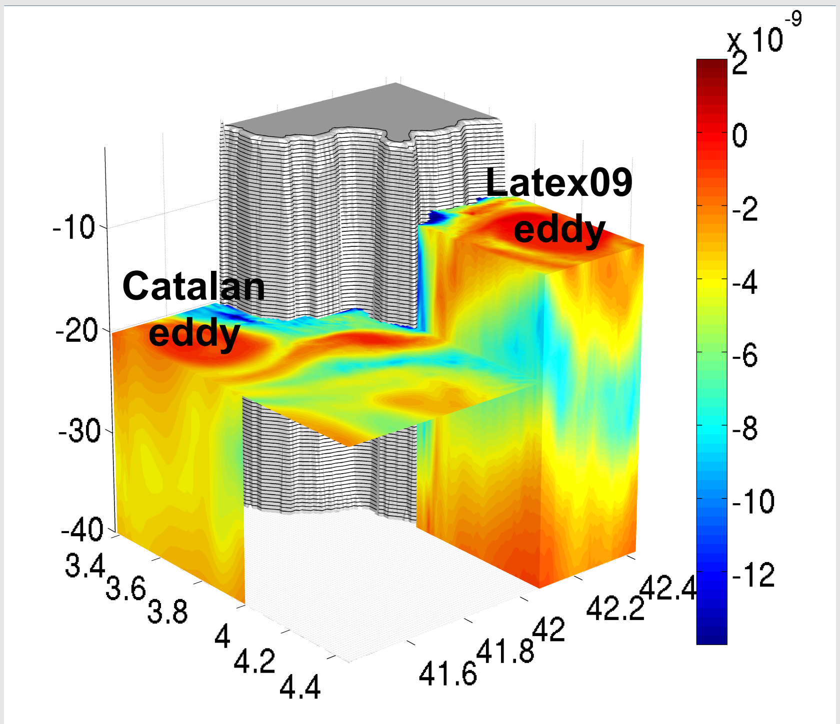
Relative vorticity [s^{-1}]
20m depth September 3

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

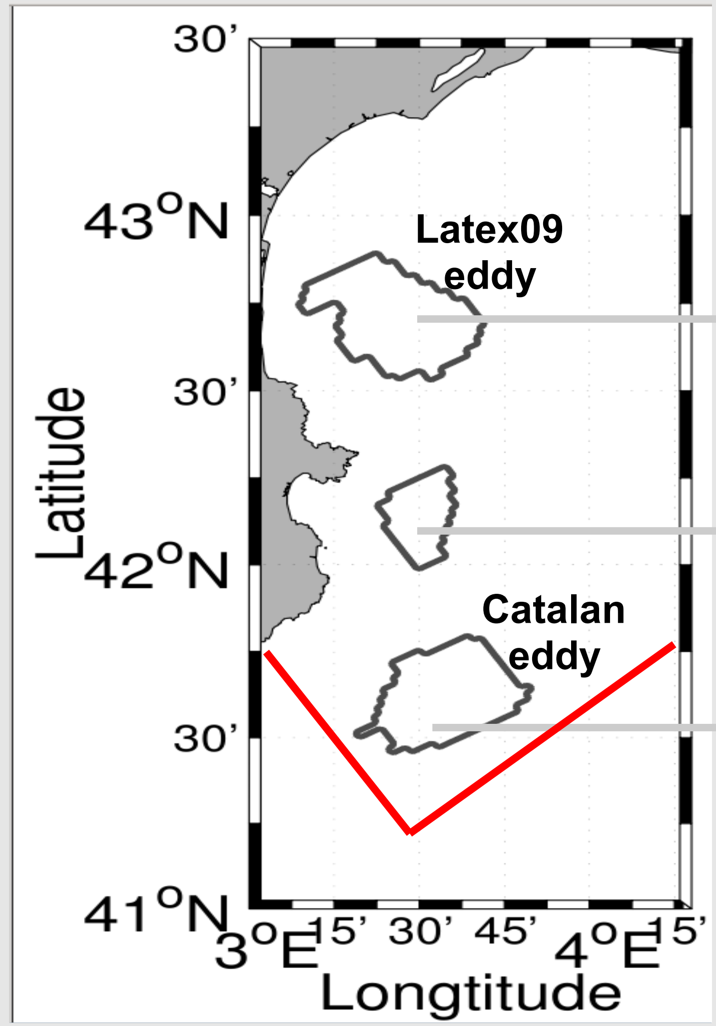
model

Latex09 - Loss of mass

Potential vorticity [kg.m^{-4}.s^{-1}] in 3D on September 3



Eddies detected by wavelet analysis



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 modelized

- Numerical results : New Generation mechanism

- Transient structure => Transfer of mass and vorticity from the GoL to the Catalan shelf

Perspectives

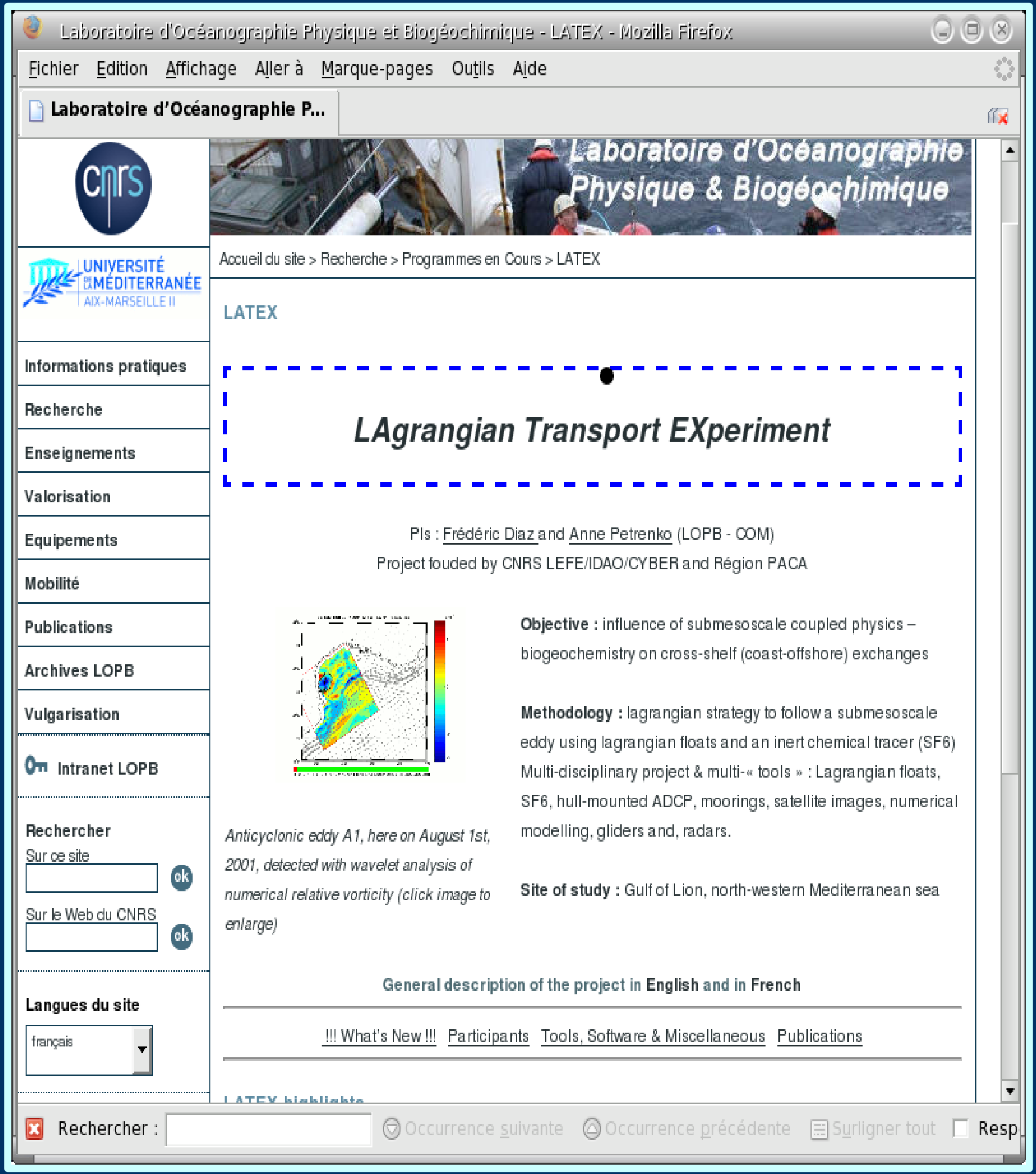
- Role of mesoscale structures on cross-shelf exchanges

[Kersalé et al., to be submitted]

Thank you for your attention

LATEX web site

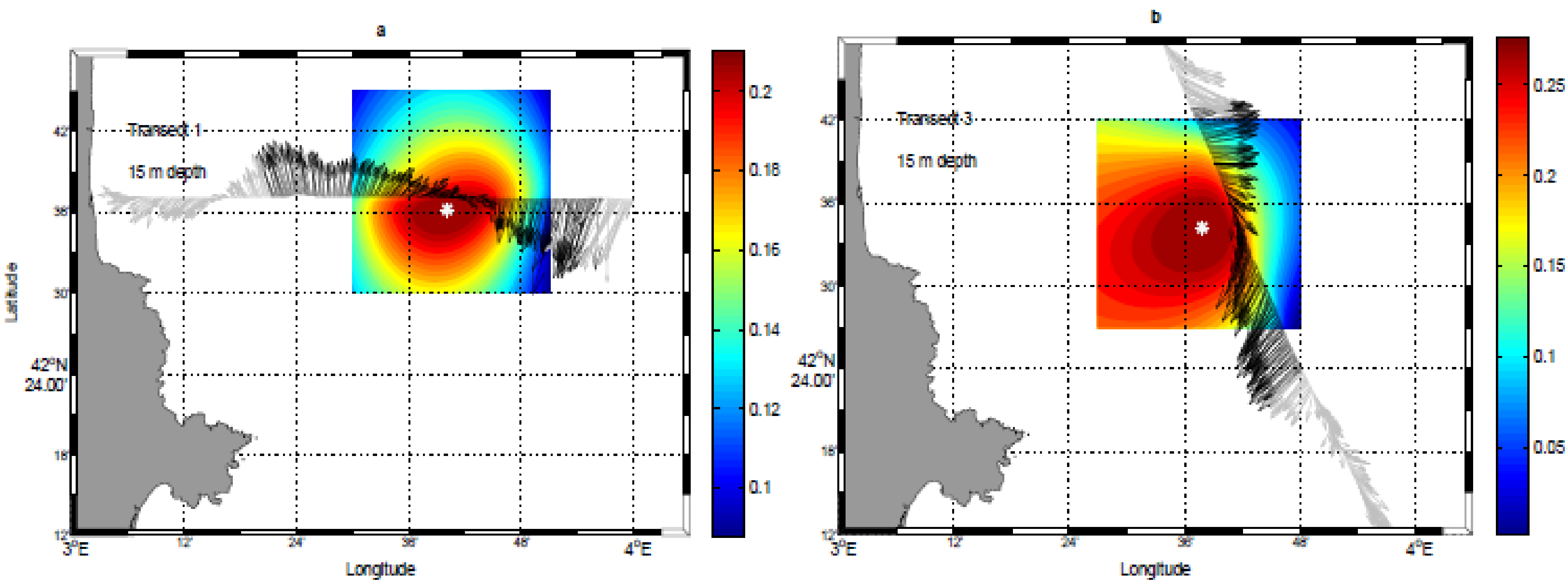
http://www.com.univ-mrs.fr/
LOPB/LATEX



Extra slides

Eddy's center detection

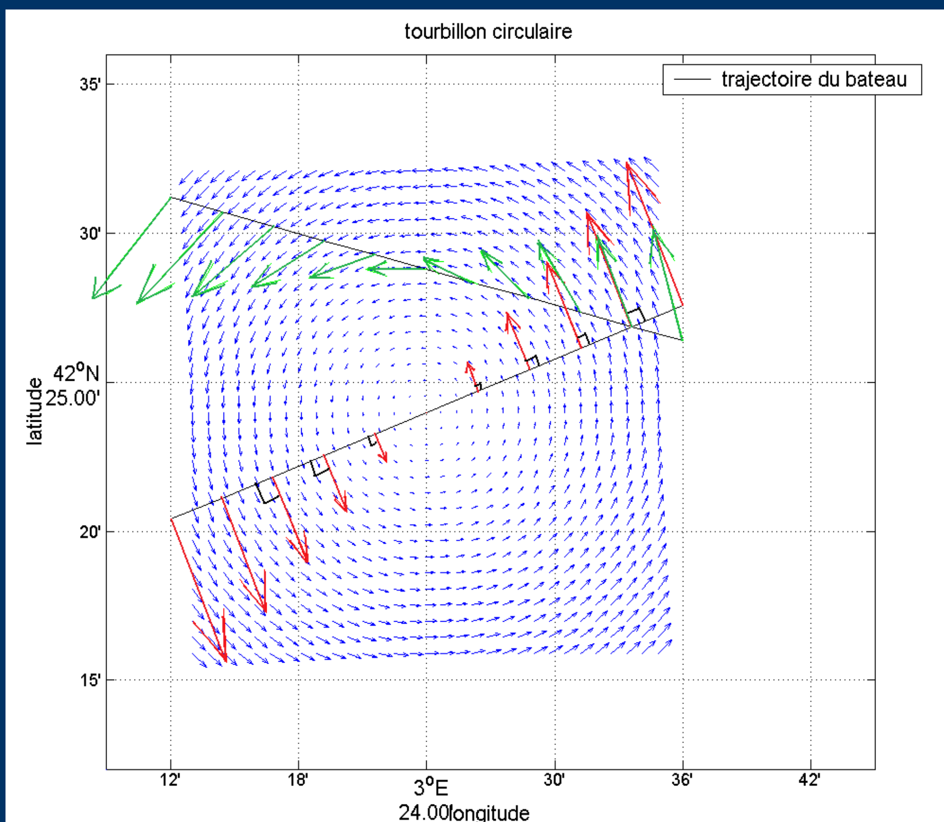
Center of the eddy
The point grid for which the mean tangential velocity is maximal [Nencioli et al., 2008]

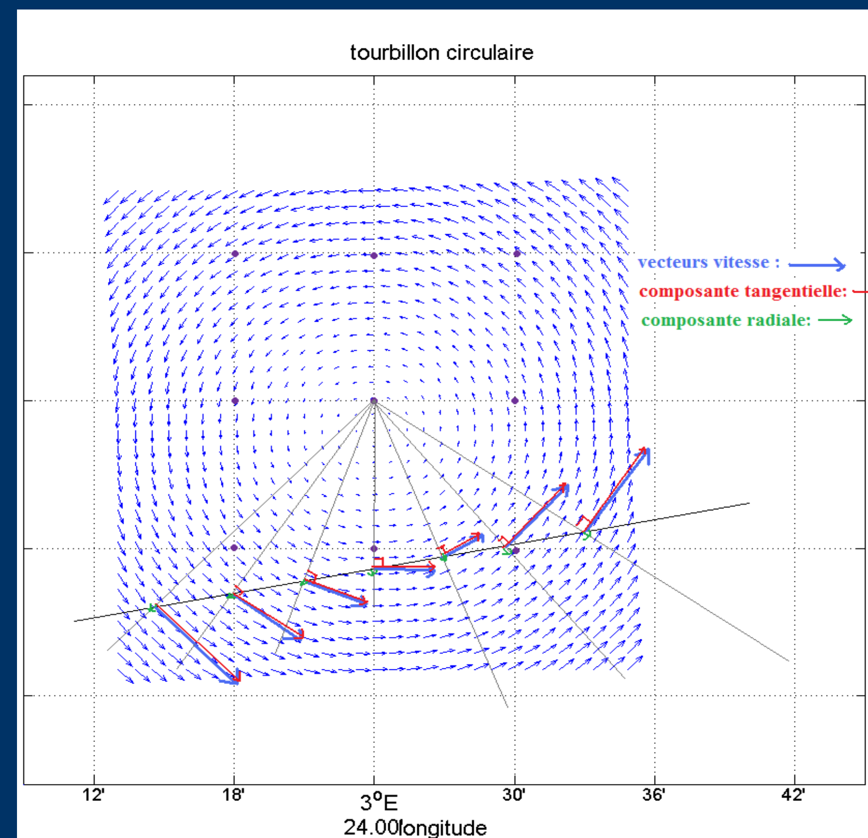


Colorbars - vitesse tangentielle

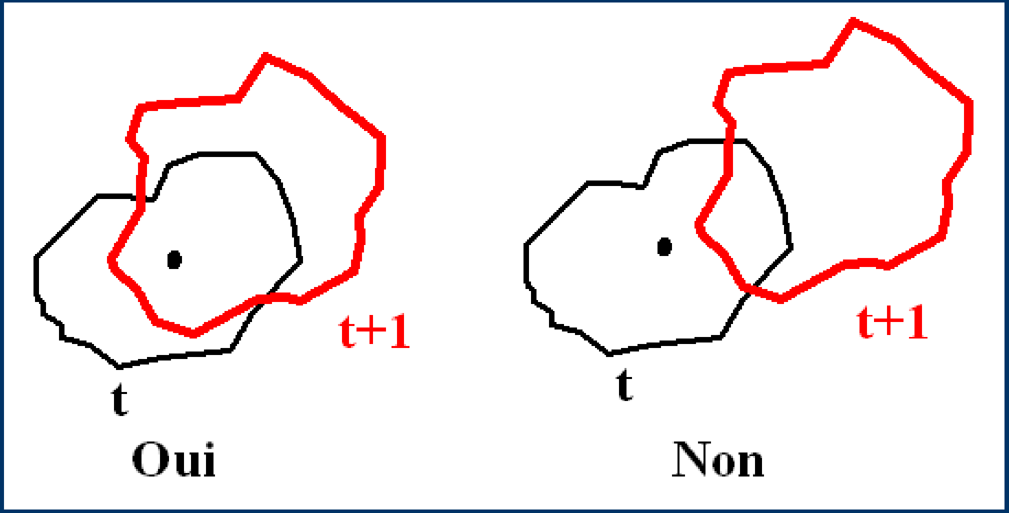
Carré: 30 x 30 pixels

Eddy's center detection Decomposition : Tangential & radial components



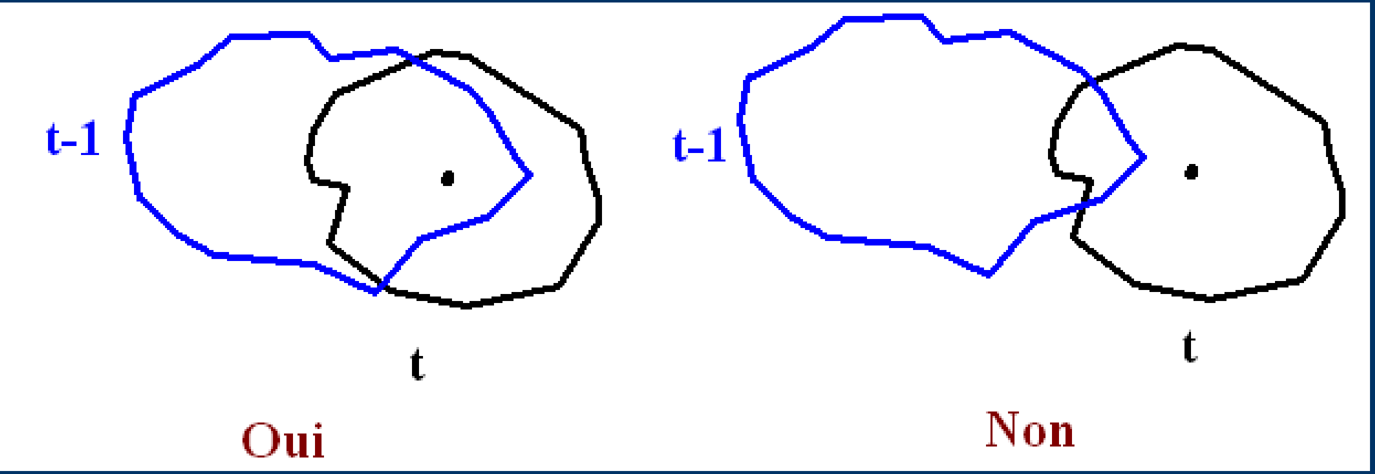


Wavelet analysis method

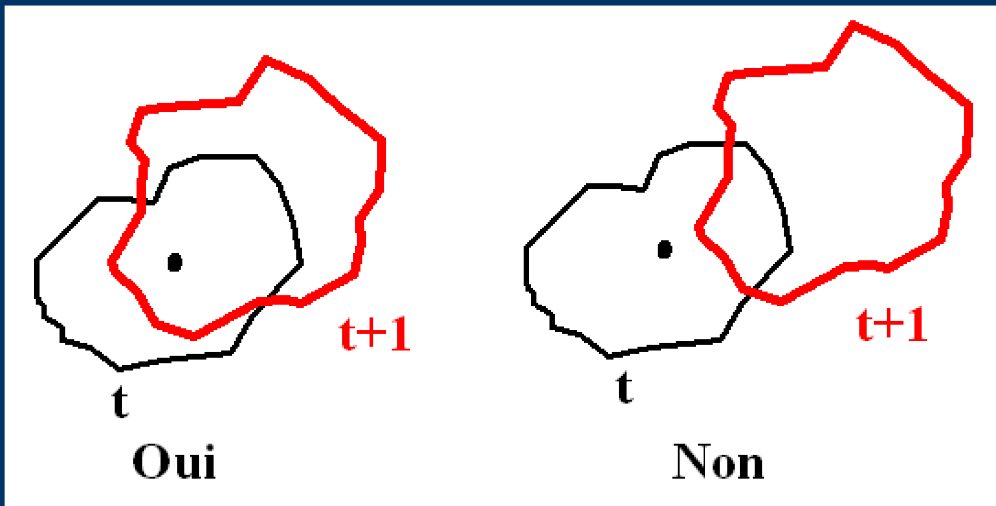


$$C_{t,z} \in \mathbb{C}_{t-\Delta t,z}$$

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



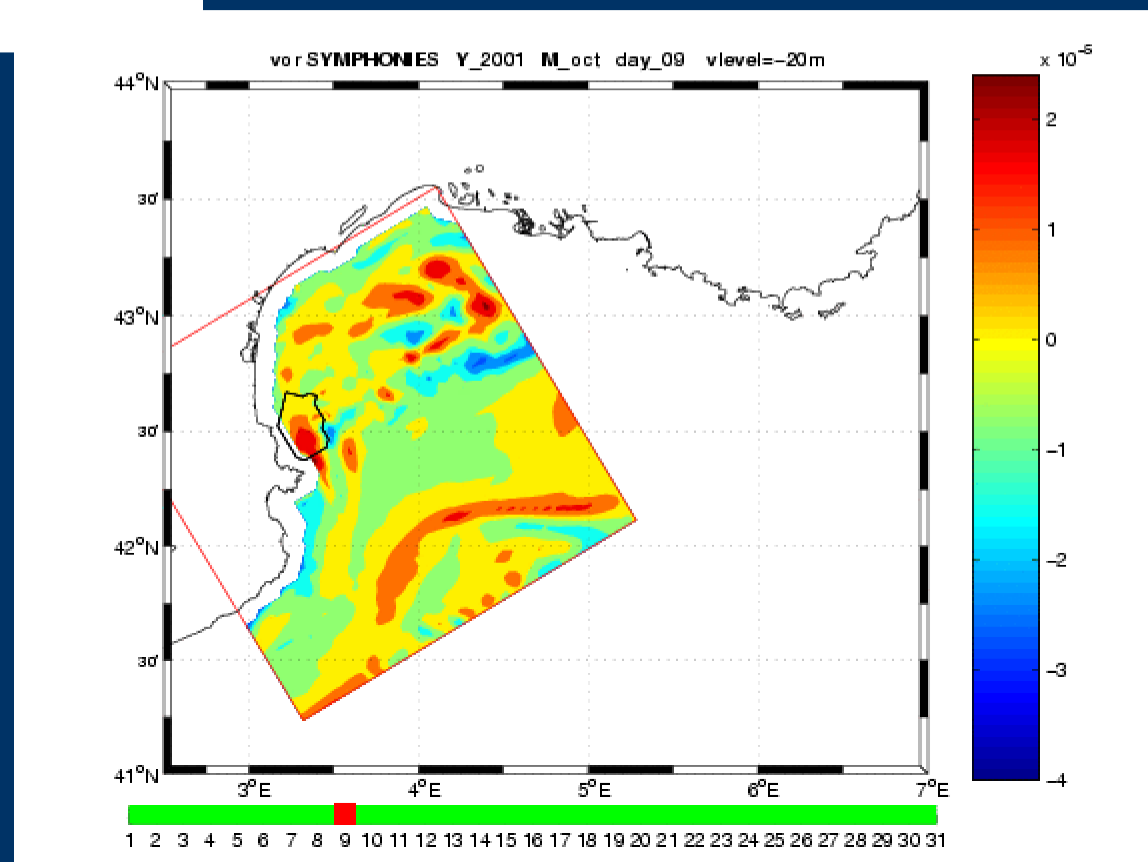
Wavelet analysis method



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	C 3°34'E - 42°33'N
	-15	33	3°33'E - 42°33'N		
	-19	35	3°35'E - 42°33'N		
2	-11	30	3°35'E - 42°30'N	C2 3°34'E - 42°31'N	
	-15	29	3°33'E - 42°31'N		
	-19	28	3°33'E - 42°32'N		
3	-11	24	3°35'E - 42°30'N	C3 3°36'E - 42°32'N	
	-15	24	3°35'E - 42°33'N		
	-19	26	3°36'E - 42°34'N		
4	-11	24	3°33'E - 42°33'N	C4 3°35'E - 42°34'N	
	-15	22	3°34'E - 42°34'N		
	-19	16	3°37'E - 42°34'N		

CTD Profiles