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

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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?
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

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
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

CTD

ADCP
Thermosalinometer

Lagrangian floats
Horizontal Characteristics

Transect 1

ADCP 15m depth - SST (°C) August 28

Eddy center detection [Nencioli et al., 2008]
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

\[ V_{\text{max}} \sim 0.4 \ \text{m.s}^{-1} \]

\[ T \sim 3 \ \text{days} \]

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]

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

\[ D_{\text{eddy}} = 22.7 \pm 1.2 \text{ km} \]
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’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]
Numerical eddy

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

Center: 3°26' E - 42°36' N

\[ D_{\text{eddy}} = 28.6 \pm 1.4 \text{ km} \]

\[ \text{Depth}_{\text{max}} = 37 \text{ m} \]

Similar eddy found in the numerical results

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

Center: 3°34' E - 42°33' N

\[ D_{\text{eddy}} = 22.7 \pm 1.2 \text{ km} \]

\[ \text{Depth}_{\text{max}} = 35 \text{ m} \]
Eddy 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

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

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?
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

![Graph showing eddy center detection with tangential and radial components.](image-url)
Wavelet analysis method

\[ C_{t,z} \in C_{t-\Delta t,z} \]

\[ C_{t,z} \in C_{t+\Delta t,z} \]
Wavelet analysis method

Criterion:

\[ C_{t,z} \in C_{t-\Delta t,z} \]  (Forward)

\[ C_{t,z} \in C_{t+\Delta t,z} \]  (Backward)

C3(01)
26 September – 9 October
Eddy Tracking Backward
Start & end dates of the transects

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<th>Transect</th>
<th>Start</th>
<th>End</th>
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<td>18h27</td>
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# Characteristics of the eddy

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<th>Diameter (km)</th>
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CTD Profiles

(a) Depth vs. Potential Temperature [°C]
(b) Depth vs. Fluorescence [µg/l]