Modeling the (sub-)mesoscale eddies of the Gulf of Lion

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The Lagrangian Transport Experiment (LATEX) project (2008-2011) has been initiated in order to study the impact of (sub-) mesoscale eddies interacting with the Northern Current on the evolution of conservative or biogeochemical tracers' distributions with a combined use of satellite data, numerical modeling, and Eulerian and Lagrangian in situ measurements.

Millot [1979,1982] was pioneer in observing an anticyclonic circulation in the western part of the Gulf of Lion (GoL), following upwelling phenomena and an offshore drift of surface water.

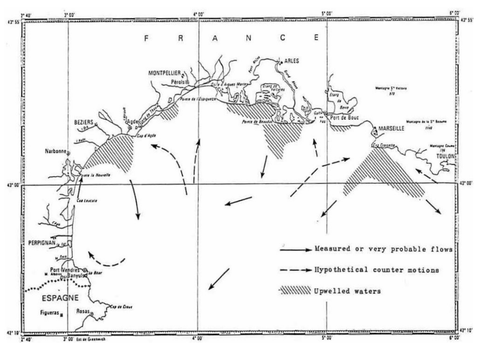


Figure 11 from Millot [1979], with a sketch of wind-induced circulation at the surface drawn coherently with infrared and in situ data.

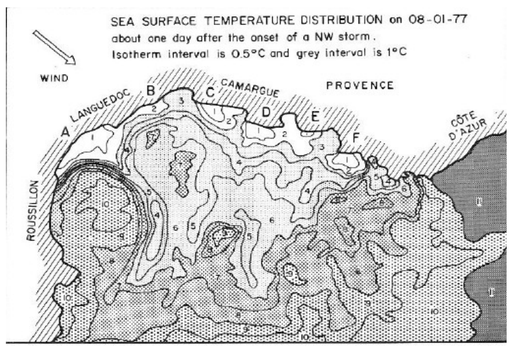
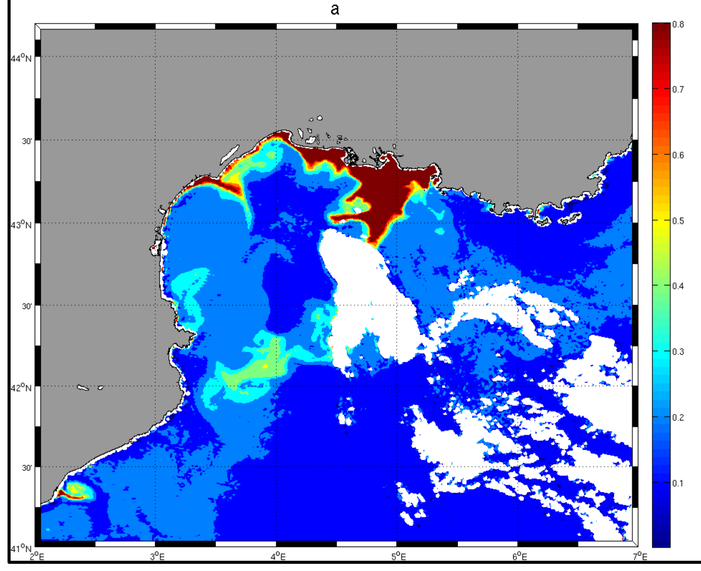


Figure 2 from Millot [1982], showing the infrared thermography obtained on the August 1, 1977 at about 09 00 TU

In this work we paid special attention to an intense anticyclonic eddy clearly observed in the Chl-a concentration derived from satellite data in 2001. These eddy-like structures could play and important role in the shelf-offshore transport of nutrients and plankton because of the presence of the Northern Current (NC) nearby.



⬅ Seawifs image of Chl-a on July 25, 2001. The used alghorithm is OC4. Data collated and provided courtesy by E. Bosc.

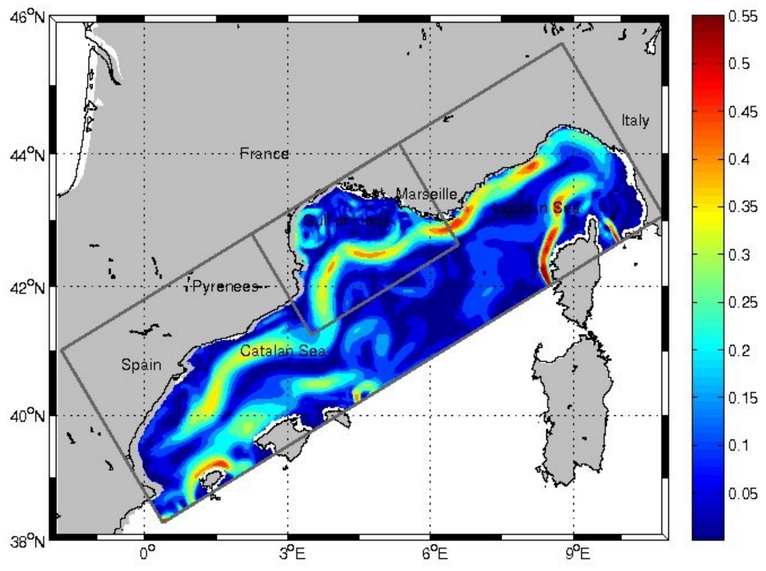
We used the SYMPHONIE numerical model [Marsaleix et al, 2008]. Starting from a regional model (Northwestern Mediterranean, 3-km resolution), we implemented a nested high resolution shelf-scale model (Gulf of Lion, 1-km resolution) and we tested the spatial grid resolution and a new diffusion scheme.

$$\frac{\phi_i^{t+\Delta t} - \phi_i^{t-\Delta t}}{2\Delta t} = -\frac{c_{i+1/2}}{\Delta x}\frac{\phi_i^t + \phi_{i+1}^t}{2} + \frac{c_{i-1/2}}{\Delta x}\frac{\phi_i^t + \phi_{i-1}^t}{2} + \frac{A_{i+1/2}}{\Delta x}\frac{\phi_{i+1}^{t-\Delta t} - \phi_i^{t-\Delta t}}{\Delta x} - \frac{A_{i-1/2}}{\Delta x}\frac{\phi_i^{t-\Delta t} - \phi_{i-1}^{t-\Delta t}}{\Delta x}$$

$$A = |u|\frac{\Delta x}{2} \dashrightarrow \tilde{A} = \delta \cdot |u|\frac{\Delta x}{2}$$

⬆ The adopted advection scheme (in the *Ox* direction, same for *Oy*) is an upwind scheme [James, 1996] which has been combined with a Leapfrog time-stepping scheme.

The non-dimensional coefficient δ varies between 0 and 1. When δ = 0, the dissipative effect is canceled; and when δ = 1, the dissipation is totally taken into account.

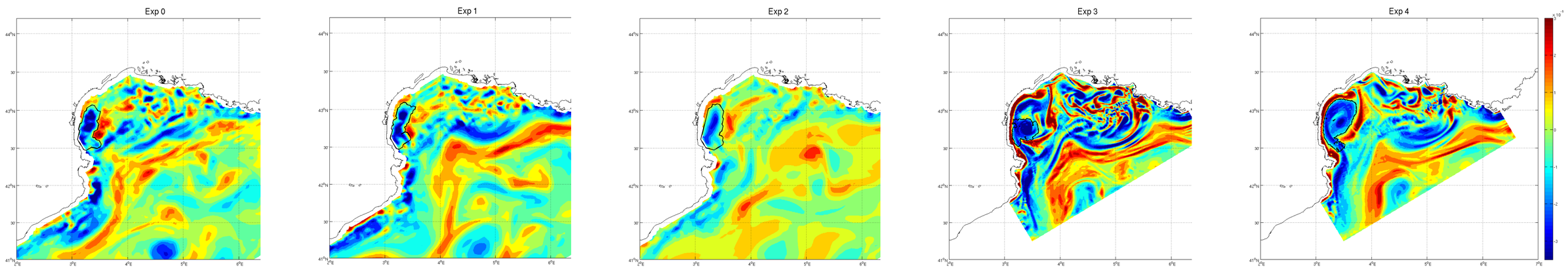


	resolution [km]	δ [adims]	eddy area mean ± std [km²]	tracking duration [days]
exp0	3	$\tilde{A}$ = 15 [m²s⁻¹]	1112 ± 298	46
exp1	3	0.2	963 ± 424	39
exp2	3	0.8	2223 ± 1882	43
exp3	1	0.2	967 ± 328	68
exp4	1	0.8	1206 ± 504	69

⬆ Summary of the numerical experiments on resolution and and their results

⬅ Horizontal slice of the modeled speed intensity on July 25, 2001 at 20-m depth for *exp1* (3 km) and *exp4* (1 km, in the GoL). The simulations reproduce the major features in the GoL: the NC, eddies and filaments.

We use the technique developed by Doglioli et al.[2007], based on wavelet analysis of horizontal slices of relative vorticity to identify, follow the eddy structure and measure its area.



Simulated relative vorticity [s−1] on July 25, 2001 at 20-m depth.

Exp-0,-1,-2,-3,-4 represent the relative vorticity issued from the numerical experiments (see table above). All fields are calculated at depth -20 m. The identified eddy is contoured in black.

- *The model resolution affects the accuracy in reproducing the eddy structures in both position and size.*
- *The variation of the coefficient δ plays a role in the coherence of the eddy, with diminishing importance as the resolution increases.*
- *Satellite imagery suggests that, to obtain a comparable size and position of the eddy, we have to use the 1-km resolution and δ = 0.8.*

Acknowledgments

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