Master OACOS-WAPE

INTERSHIP PROPOSAL

Title : *Shelf slope variations and coastal eddy formation in the Eastern Mediterranean Sea.*

Location

Laboratoire de Météorologie Dynamique (Ecole Polytechnique, Palaiseau),
Unité de Mécanique UME, ENSTA-ParisTech, Palaiseau.

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Goals and context :

The continental slope is an important transition zone between the shallow coastal shelf (50-200m) and the open sea or ocean (1500-4000m). Several dynamical and biological processes occur in the surface layer or the intermediate layers within this transition zone above the continental slope which is often very steep (10-15%). Recent studies (Gula et al. 2010, Pennel *et al.* 2012, Poulin *et al.* 2013) have shown that a steep slope configuration may induce complex nonlinear or ageostrophic processes at meso and submeso scale on the coastal circulation. Hence, the impact of the continental slope on the cross-shelf transport and the primary production is still a complex issue for realistic coastal model.

The variation of the bottom slope may induces significant changes in the stability properties of the coastal current (Lozier and Read, 2005; Spall *et al.* 2010, Pennel *et al.* 2012 ; Poulin *et al.* 2013). Previous studies also showed strongly localized eddy variability in regions where the continental slope varies substantially in the alongshore direction (Bracco and Pedlosky, 2003; Wolf and Cenedese, 2006). Strong coastlines variations, cap or a bay, may also induce significant vortex shedding from a stable current (Perret et al., 2006, 2011). Depending on the relative slope difference the local stability of the frontal coastal current could change dramatically from one region to another.

The main questions are: *how the surface current characteristics and its stability are modified when the bottom slope varies along the shelf ? What are the typical sizes and intensity of meso or submeso scale eddies generated by the slope variation in the Mersa-Matruh area ?*

The student will perform several laboratory experiments with the LMD-UME rotating platform and contribute to the SYNBIOS (Submeso scale dYNamics and BIOlogy on steep Slopes) project which includes three research laboratories (LMD, UME-ENSTA and IUEM LPO-LEMAR). The master student will take part to the multiple discussions and meeting between the partners.

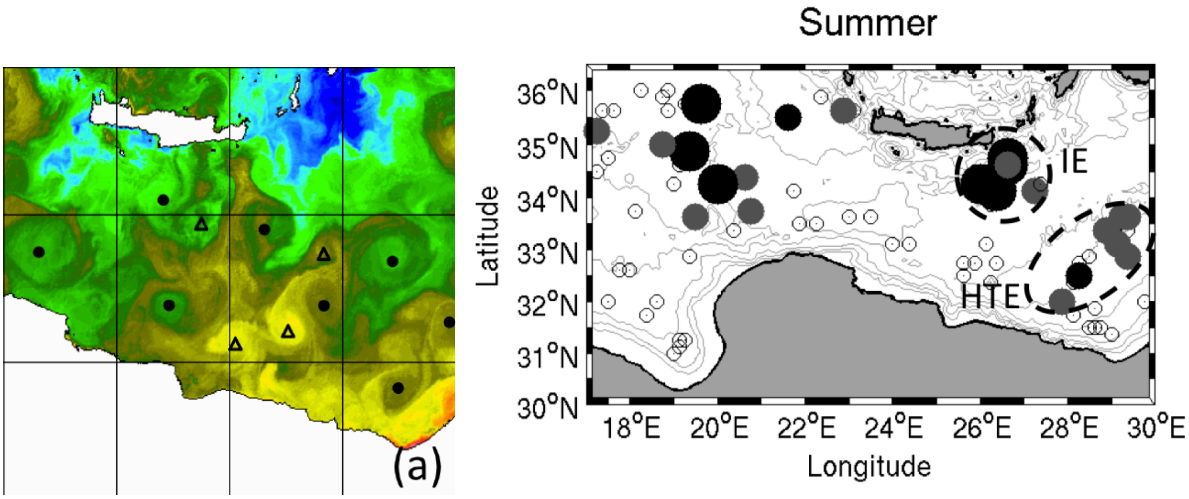

Figure 1 *Sea surface tempreature SST the 18th June 2006 (left panel) and formation points of long-lived meso scale anticyclones from Mkhinini et al. 2014 (right panel). The bottom isobaths are given by the grey lines (-200m, -500m, -1000m, -2000m, -3000m).*

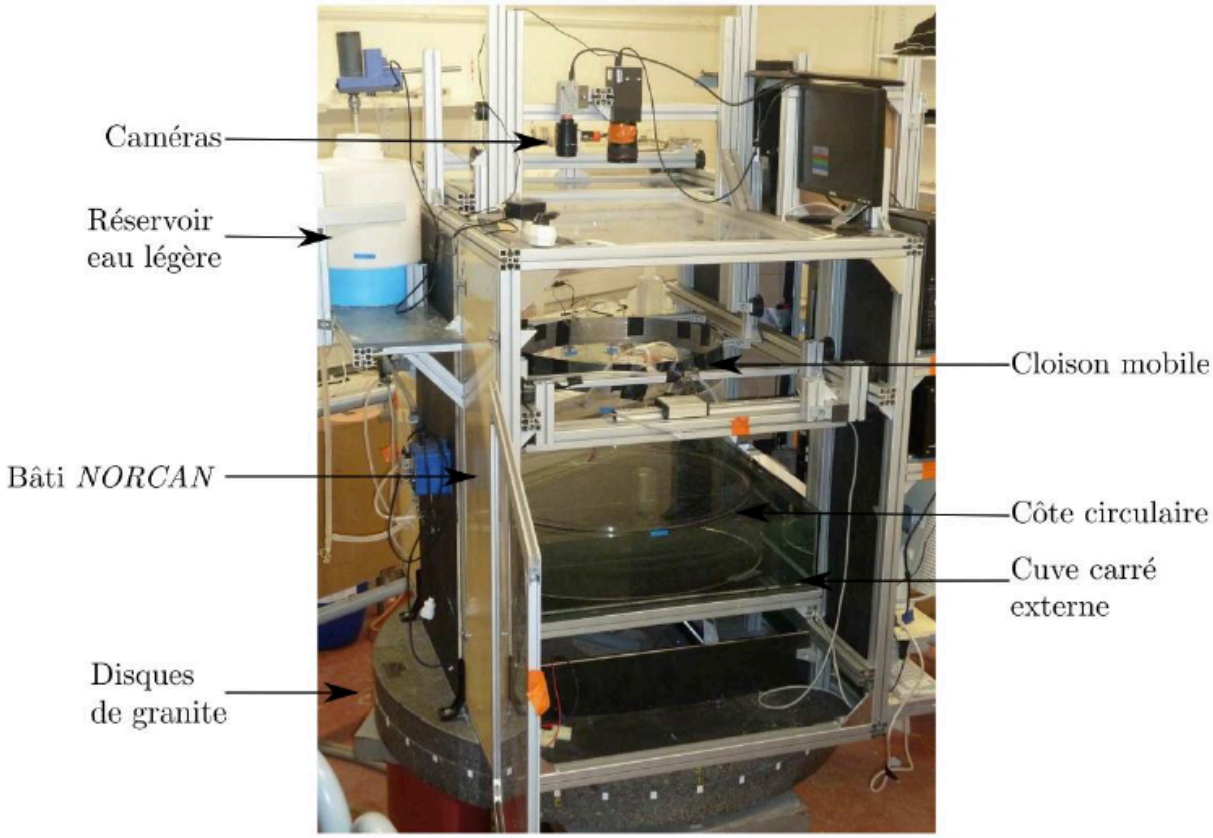

Figure 2 *The LMD-UME rotating platform at ENSTA ParisTech .*

Tools and methodology :

The candidate will use the LMD-UME rotating plateform to conduct several laboratory experiments of coastal current flowing over an irregular shelf slope. The idealized experimental configuration reproduces the shelf slope variations along the Lybio-Egyptian coast (HTE area in figure 2(b)). The candidate will use modern data acquisition techniques in order to provide datasets having spatio-temporal characteristics similar to those generated by numerical models. We will use the new generation of high-resolution 16 Mo CCD camera (4872x3248 pixels) in order to perform a particle image velocimetry (PIV) in the whole tank. Such high-resolution images will allow to derive a 600x400 vectors field in each horizontal layer. Besides, according to the LIF density measurement technique developed previously (Stegner *et al*. 2004, 2007) a third laser will be used to measure the density field in one horizontal plane. Hence, we will be able to make direct measurements of the potential vorticity (PV) in both layers and quantify accurately the deviation from the geostrophic balance in a two-layer experiment.
A comparison between theses high-resolution measurements in the lab and the geostrophic surface velocity (AVISO data set) in the Mersa Martuh area will be done.

Candidate Skills :

This project would suit a student who wants to gain experience in laboratory modeling, and analysis of coastal processes in a Research environment. The student should have strong abilities in geophysical fluid dynamics, physical oceanography, problem solving and feal at ease with laboratory experiments.
While initial training and guidance throughout the project will be available the student will be encouraged to work independently and show initiative in analysis methods and interpretation of results.

References :

- Bracco, A. and J. Pedlosky, 2003: Vortex generation by topography in locally unstable baroclinic ows. J. Phys. Oceanogr., 33, 207-219.
- Gula J., Zeitlin V. Bouchut F., 2010: Instabilities of buoyancy driven coastal currents and their nonlinear evolution in the two-layer rotating shallow water model. Part II. Active lower layer. J. Fluid Mech. 665, 209-237.
- Lozier, M. S., and M. S. C. Reed, 2005: The influence of topography on the stability of shelfbreak fronts. J. Phys. Oceanogr., 35, 1023–1036.
- N.Mkhinini, A.L. Santi-Coimbra, A.Stegner, T. Arsouze, I. Taupier-Letage and K. Béranger « Long-lived meso-scale eddies in the Eastern Mediterranean Sea: analysis of 20 years of AVISO geostrophic velocities » *J. Geophys. Res.* in press (2014).-
- F.G. Poulin, A. Stegner, M. Hernandez-Arencibia, A. Marrero-Diaz, and P. Sangra « Steep shelf stabilisation of the Bransfield coastal current: linear stability analysis. » *J. Phys. Oceanography* v.44 n° 2, 714-732 (2014).
- R. Pennel, A. Stegner and K. Beranger « Shelf impact on coastal current instabilities » *Journal of Physical Oceanography,* v. 42, No. 1 : pp. 39-61 (2012).
- Wolfe, C. L., and C. Cenedese, 2006: Laboratory experiments on eddy generation by a buoyant coastal current flowing over variable bathymetry. J. Phys. Oceanogr., 36, 395–411.
- Spall, M. A., 2010: Non-local topographic influences on deep convection: An idealized model for the Nordic Seas. Ocean Modell., 32, 72–85.
- G.G. Sutyrin, A. Stegner, I. Taupier-Letage and S. Teinturier « Amplification of a surface-intensified eddy drift along steep shelf in the eastern Mediterranean sea » *Journal of Physical Oceanography,* v.39, 1729-1741 (2009).