Diurnal Variability of the inner-shelf circulation in the lee of a cape under upwelling conditions

This poster participates in OSP

Outstanding Student Poster Contest

L. Lamas[1] A.Peliz[2] P. Marchesiello[3]

1 – Centro de Oceanografia, Fac. Ciencias, Universidade de Lisboa, Portugal
2 – Instituto Dom Luiz, Fac. Ciencias, Universidade de Lisboa, Portugal
3 – Laboratoire d'Etudes en Géophysique et Océanographie Spatiales, Toulouse, France

1. Introduction

- A recent study using observational data collected near cape Sines, Portugal, showed that not only wind and waves are important forcing mechanisms of the inner-shelf circulation, but also that the along-shore pressure gradient plays a major role on driving cross-shore exchange.
- A modeling study was conducted in order to study the diurnal variability of the inner-shelf circulation, in the presence of a cape.
- The preliminary results of the effects of these processes on the inner-shelf circulation will be presented.

2. Motivation

- Analysis from data collected lee of Cape Sines from 20 July to 04 August 2006 (Fig.1)
- Diurnal Variability of cross-shore profiles due to sea breeze with a revearsal at mid-day (Fig. 2)
- Momentum balance analysis indicate that acceleration in the depth-averaged along-shore momentum balance is important (Fig. 3)

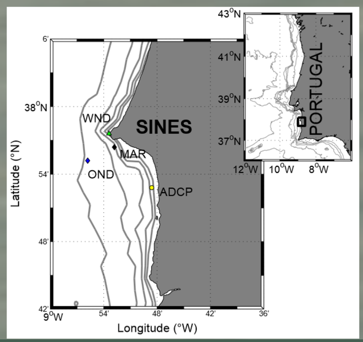

Figure 1: Cape Sines on the southwestern coast of Portugal. WND (meteorological station), OND (wave-rider buoy), ADCP and MAR (tide gauge).

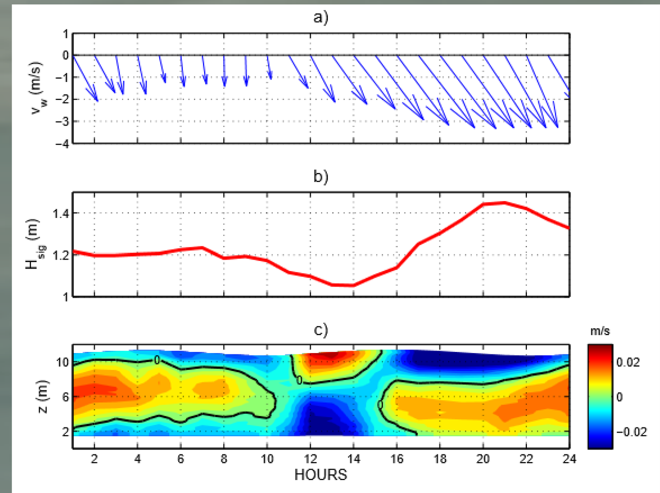

Figure 2. Clock-hour average-day of a) Wind vectors; b) Significant wave height; c) Cross-shore velocity.

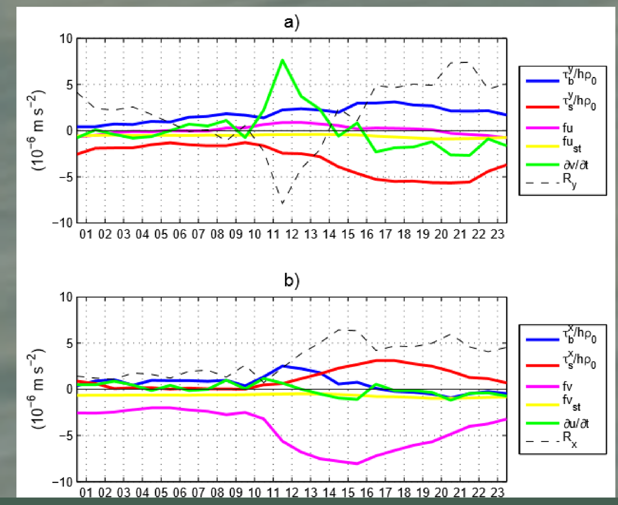

Figure 3. Momentum balance terms of Clock-hour average-day: a) Along-shore; b) Cross-shore.

- Results from Lentz et al., 2008 linear, unstratified, inner-shelf model forced with wave and wind parameters of the clock-hour average-day (Fig.4)
- Adding acceleration and along-shore pressure gradient to the forcing reproduces closer results to the observations.
- Acceleration was added using v from ADCP.
- Pressure gradient was the value that would best-fit model results to the observations (Fig 4a)

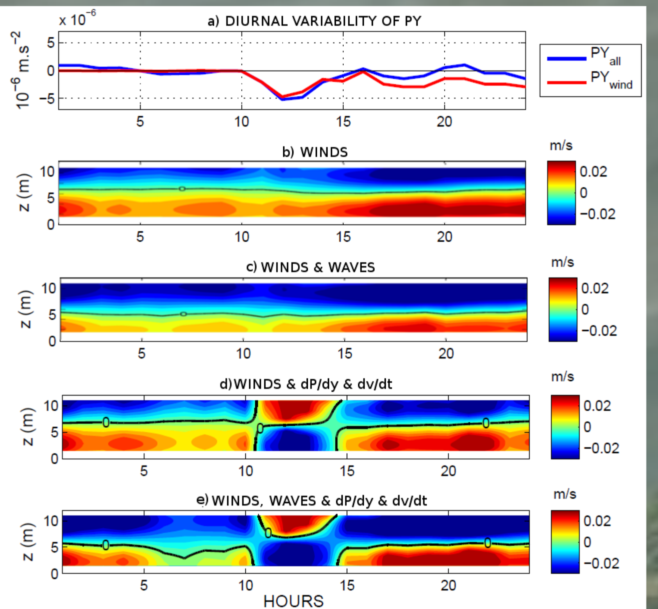

Figure 4. a) Diurnal Variability of Along-shore pressure gradient found with the model; Modeled Clock-hour average-day forced with: b) Winds; c) Winds and Waves; d) Winds, dP/dy and dv/dt; e) Winds, Waves, dv/dt and dP/dy.

3. Results

I. ROMS Model Configurations

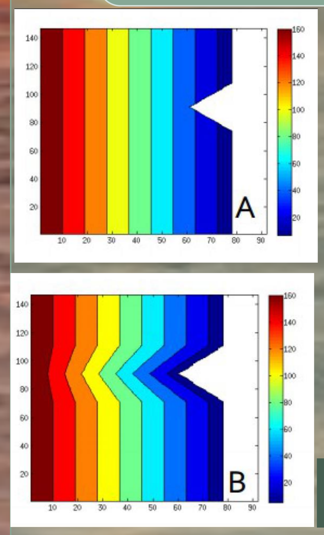

Figure 5. ROMS idealized configuration with Topography for test case A(top) and B(bottom).

Idealized configuration

- ~ 0.3km resolution
- 180m > H > 5m
- A – Topo constant slope
- B – Topo follows cape

TEST CASE: Sea Breeze

- Analytical Wind Forcing
- No Stratification
- T = 15ºC ; S=35
- No heat fluxes

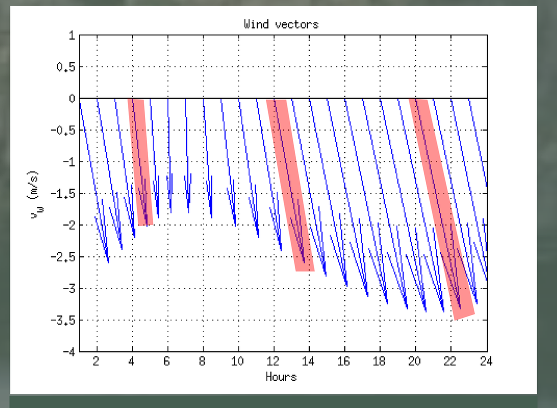

Figure 6 – Wind vectors over a period of 1 day. This analytical wind forcing was used to simulate sea breeze, repeatedly during 15 days. Red shades indicate wind vectors for plots in III.

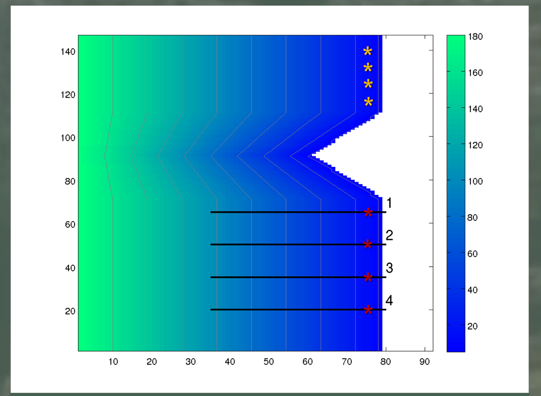

Figure 7 – Model grid with bathymetry and: yellow and red stars – locations of Diurnal Variability of Cross-shore flow for A and B (II); and black lines – sections of Cross-shore velocity plotted in Cross-shore velocity for B (III)

II. Diurnal Variability of Cross-shore flow for A and B

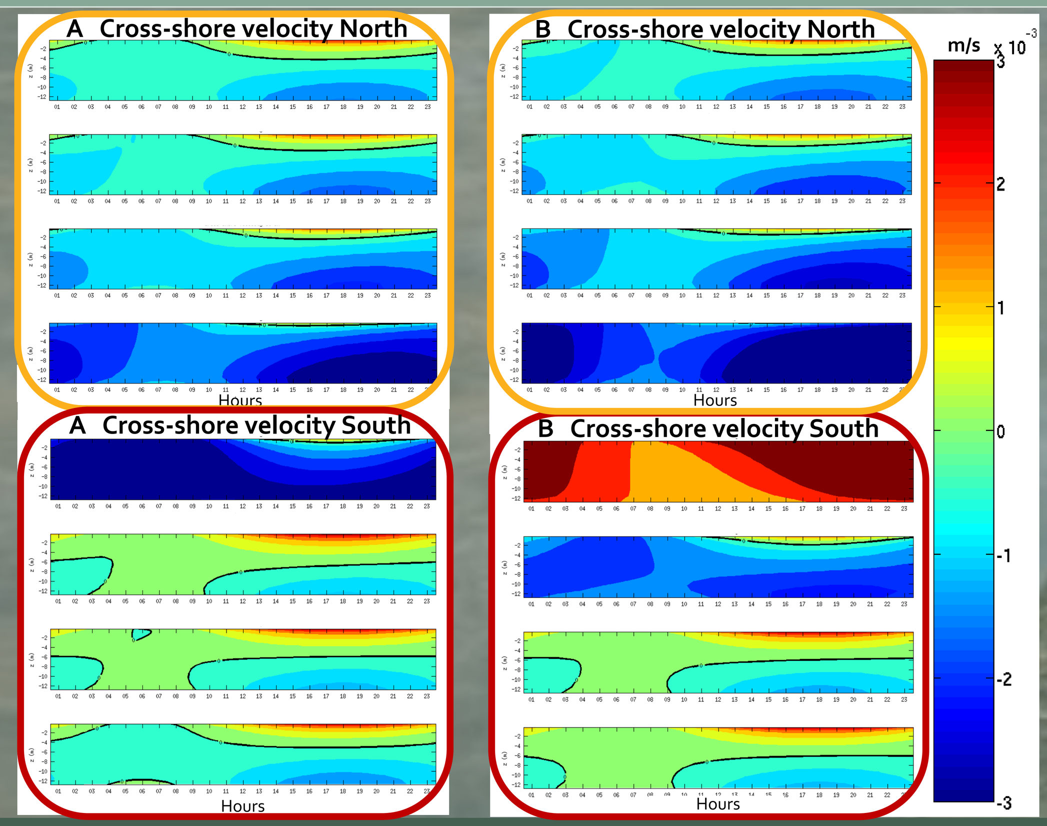

Figure 8. ROMS A(left) and B(right) Modeled Clock-hour average-day for cross-shore velocity at 4 locations North of Cape (top yellow square) and 4 locations South of Cape (bottom red square), all at 12-m depth.

III. Cross-shore velocity for B

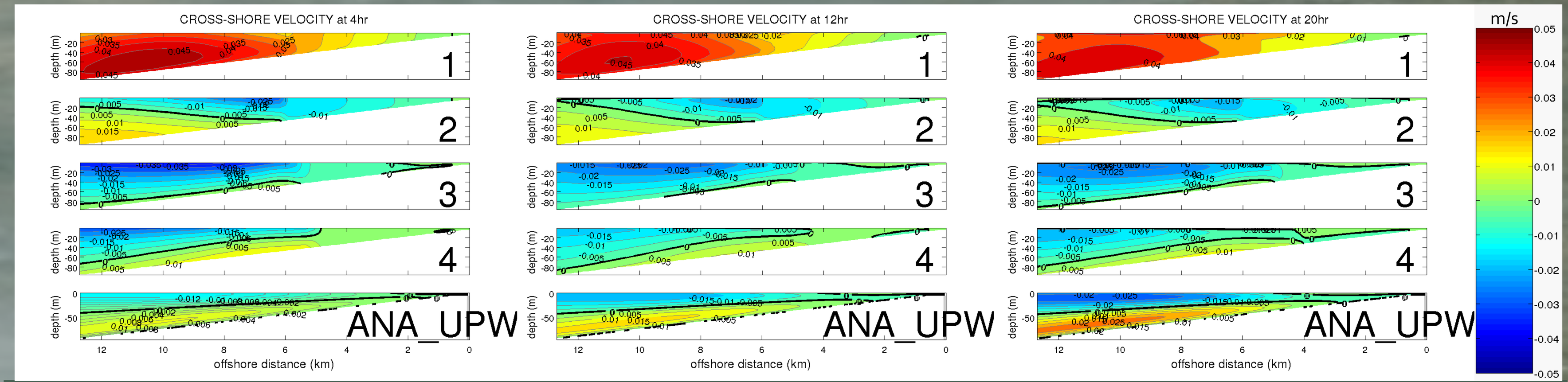

Figure 9. Cross-shore velocity at 4 sections South of Cape, for 3 different hours (4h, 12h and 20h) of the Clock-hour average-day for ROMS results (1, 2, 3 & 4) and the solution found with Marchesiello and Estrade, 2010, analytical model with equivalent topography and forced with the same wind stresses as the ROMS model.

IV. Along-shore Momentum balances for B

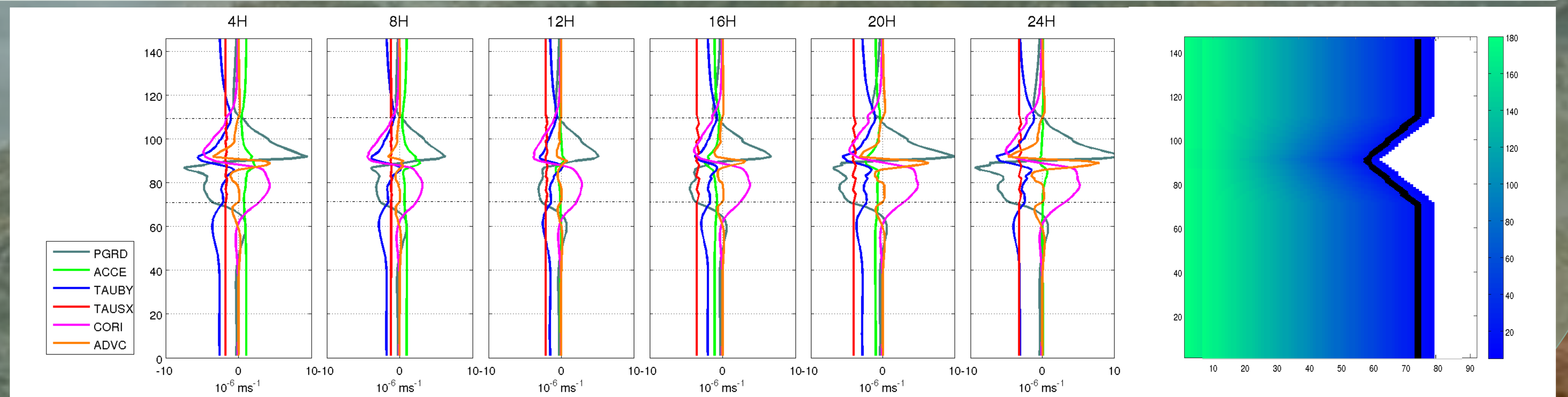

Figure 10. Average along-shore momentum balance terms, between 15m and 20m depth, for 6 different hours (4h, 8h, 12h, 16h, 20h and 24h) of the Clock-hour average -day for ROMS results.

4. Summary

- ✓ The circulation is deeply affected by the presence of a cape and along-shore topography variations. (Fig.8, 9, 10)
- ✓ The reversal at mid-day seen in data is probably not only due to winds. In every modeled profile the return flow is at bottom and not at mid-depth as seen in data (Fig 8).
- ✓ Away from the cape the cross-shore circulation is closer to the analytical Ekman solution from Marchesiello and Estrade, 2010. (Fig. 9)
- ✓ The presence of a cape and the along-shore variations of topography affects the circulation, adding small scale pressure gradient and other terms not important on straight coastline topography. (Fig. 10)

5. Future work

- Adding Stratification
- Tidal forcing
- Wave forcing
- Realistic Configuration

6. References

- ✓ Lamas, L. A. J. Peliz, J. Dias, P. B. Oliveira, M. M. Angélico, J. J. Castro, T. Cruz and J. N. Fernandes - Diurnal variability of inner-shelf circulation in the lee of a cape under upwelling conditions (*in prep. 2013*)
- ✓ Lentz, S. J., M. Fewings, P. Howd, J. Fredericks, and K. Hathaway (2008). Observations and a model of undertow over the inner continental shelf. *J. Phys. Oceanogr.*, **38**, 2341– 2357.
- ✓ Marchesiello, P., and P. Estrade (2010). Upwelling limitation by geostrophic onshore flow. *J. Mar. Res.*, **68**, 37–62.

7. Acknowledgements

Financial support was provided by FCT (POCI/MAR/57630/2004; PTDC/BIA-BEC/103734/2008 and PEst-OE/MAR/UI0199/2011). Luísa Lamas was funded by the FCT under a PhD grant (SFRH/BD/69533/2010).

Fundação para a Ciência e a Tecnologia