Circulation in the GoC and the AzC

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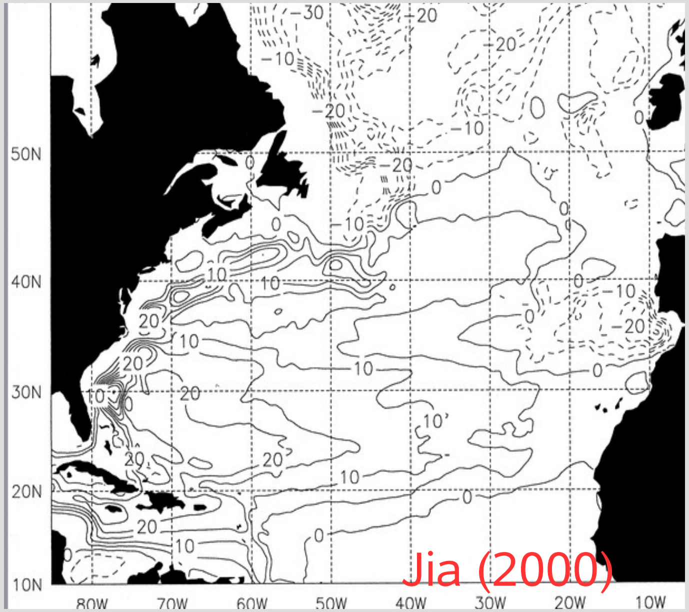
Background/Azores Current

- The Sverdrup balance explains as much as 2 Sv. (Townsend et al , 2000 checked in 11 wind climatologies)
- No clear seasonal signal
- Turbulent nature
- No explanation for its extension to the GoC longitudes
- Explanation of Counter currents Onken (1993)
- Jia (2000) Azores Current and parameterization of MW in an Atlantic model.

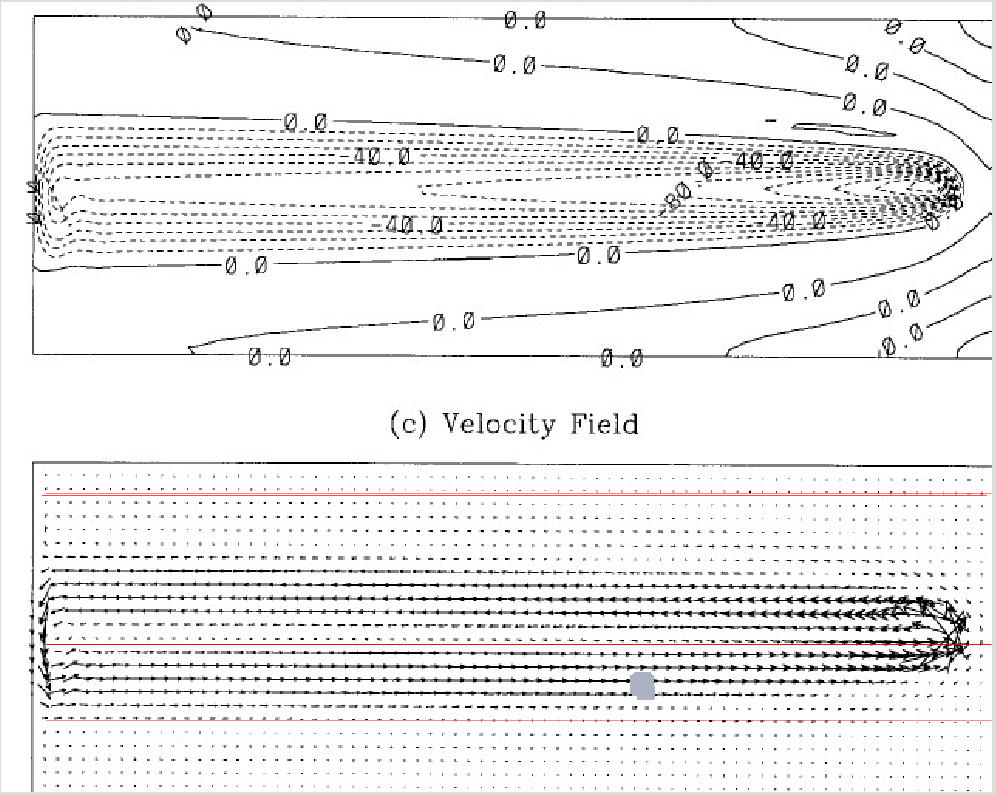


Planetary β-plume

Stommel(1982);Pedlosky(1996);Ozgokmen(2001)

$$\beta v = \frac{f_0 w^*}{h} + A_H \nabla^2 \zeta$$

$$\frac{V}{W} = \frac{f_0}{\beta L_y}$$



2Sv entrainment -> 50-100 Sv Horizontal transport for planetary β
2Sv entrainment -> 4 Sv Horizontal transport for topographic β

The topographic and eddy driven β-plume TEβ

Kida (2006)

$q = \bar{q} + q'$

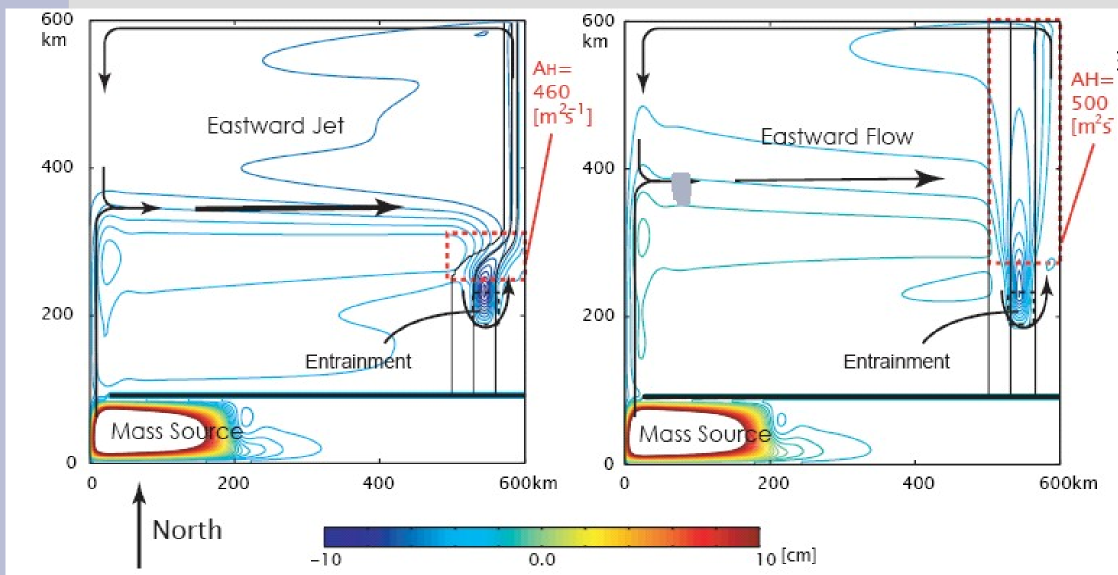
$$\bar{U}\cdot\nabla\bar{q} = \bar{q}w^{*} - \nabla\cdot\overline{(U'q')} + \widehat{k}\cdot\nabla\times\bar{\mathcal{F}}$$

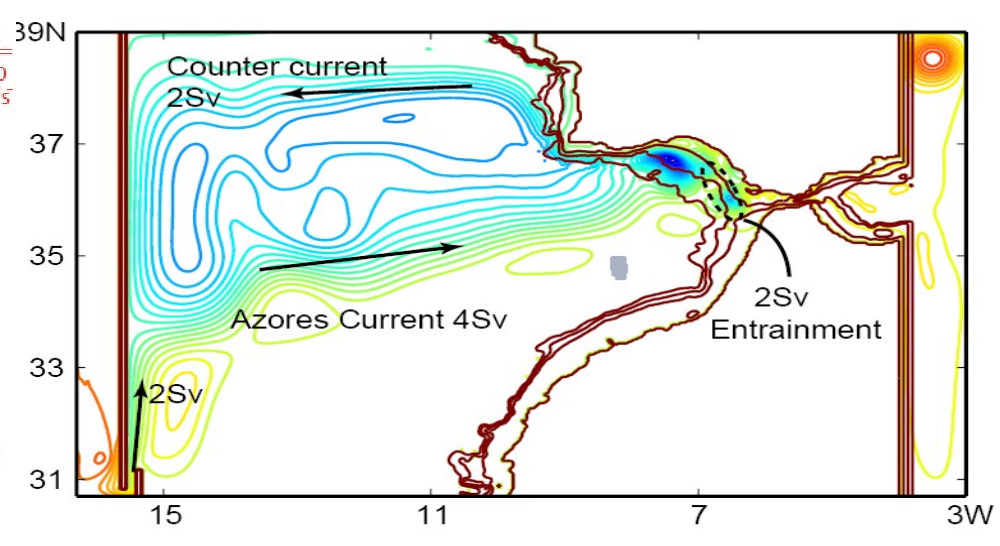
PV forcing by Entrainment

divergence of PV eddy flux

Horizontal: eddy flux of PV

vertical: form drag
(Haidvogel and Rhines, 1983)





Questions/Approach

- What is the role of the TEβ in the generation of the AzC in a realistic model?
- How does it affect the circulation in the GoC?

- Simulation of MU requires fine horizontal and vertical resolution (ideally ~2km x 2km ~80 s-layers [Serra, 2005]).
- The AzC is a cross-Atlantic current.
- Requires a domain for the mid-latitude Atlantic integrate over several years since the β-plume is expected to propagate with Rosby waves.
- Good example for a 2-way nesting application.

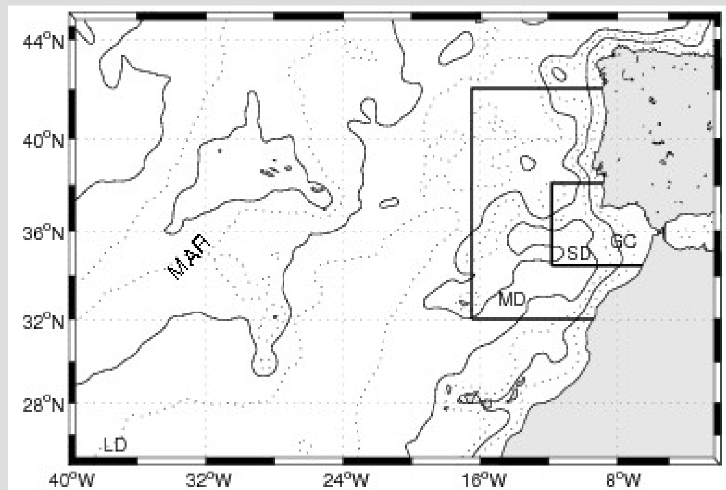
- Use nudging for reposing salinity near GoC for the spin up
- Downscale and use nesting for local configuration.

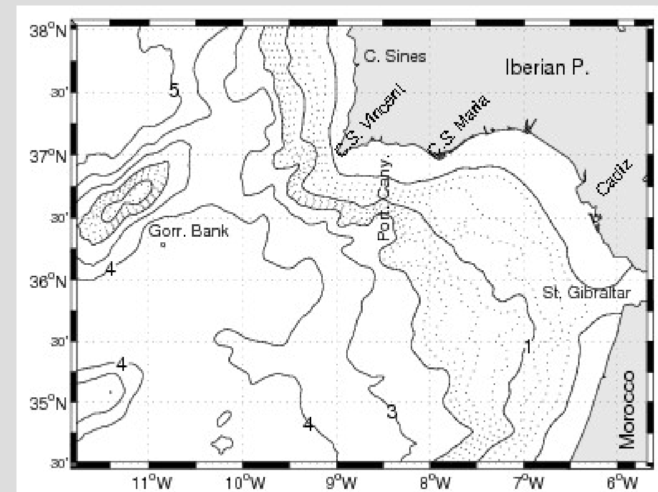
Configuration Details

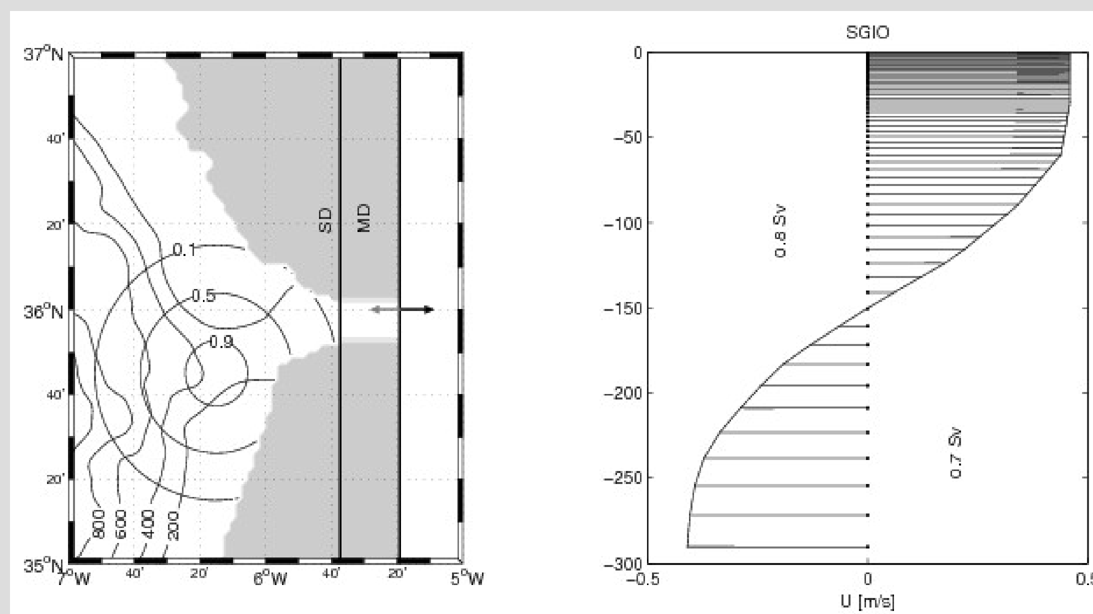
1- Levitus/COADS climatology for a 8-year spin up using interior nudging to restore salinity near GoC

2- Use 10-day-averaged fields of year 4 to build initial fields and climatologies for the intermediate grid

3- Run intermediate and small grids in 1-way nesting with explicit representation of MU

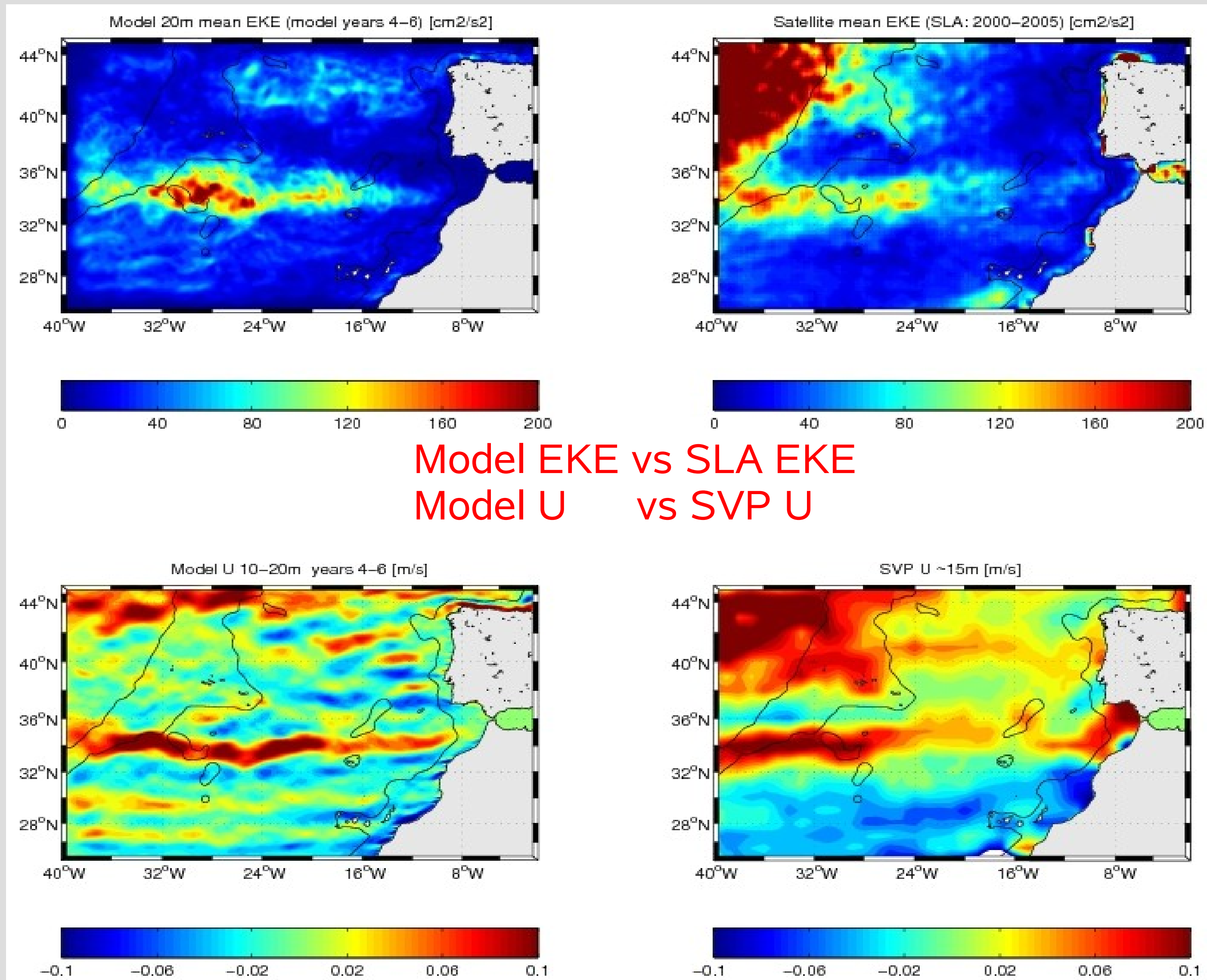






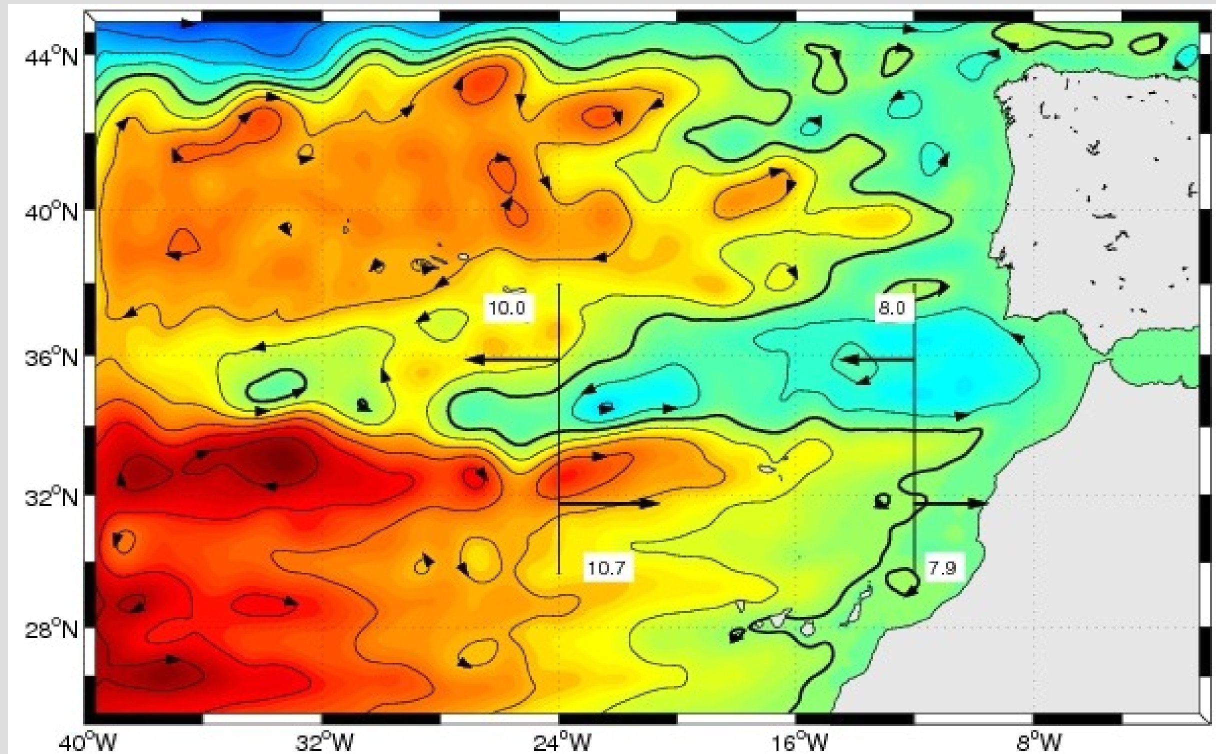
large scale solution

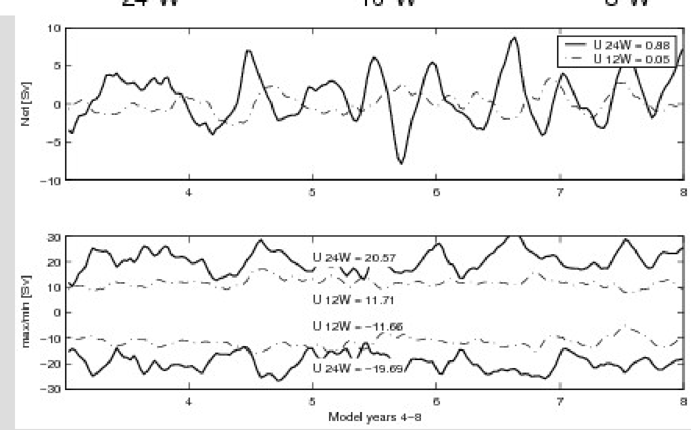
large scale solution represents the AzC in great detail despite the climatological western boundary



large scale solution

- ~10 Sv in mean 0-1500m on the western side
- Strong variability in instantaneous transports.
- Almost null net flow in the all system (30-38 N) is integrated
- A β-plume type cyclonic recirculation is observed
- < 2Sv recirculate in the in the GoC / 1 order less than Jia (2000)

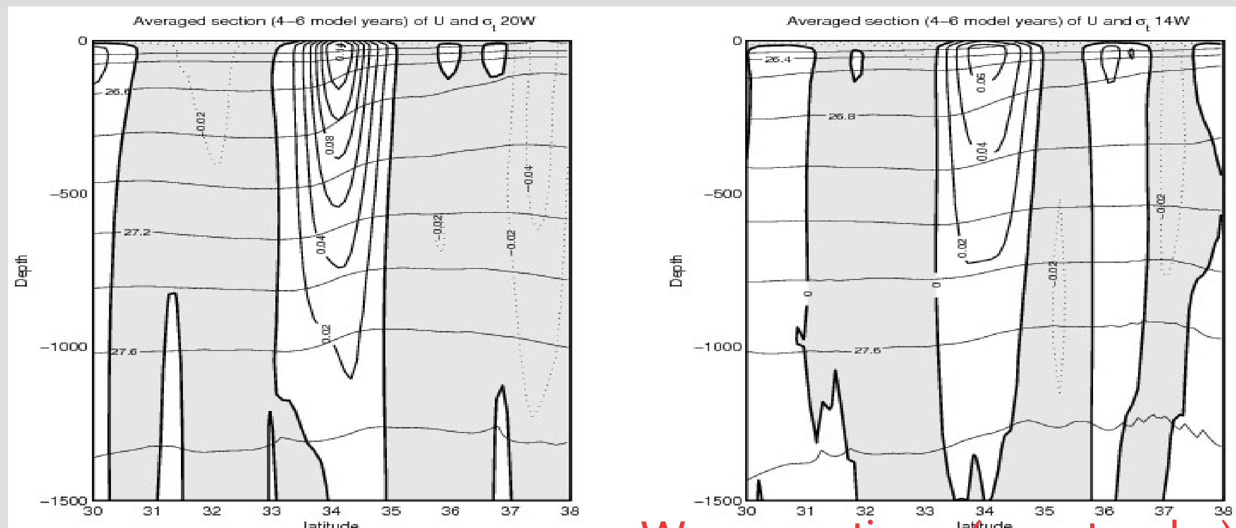




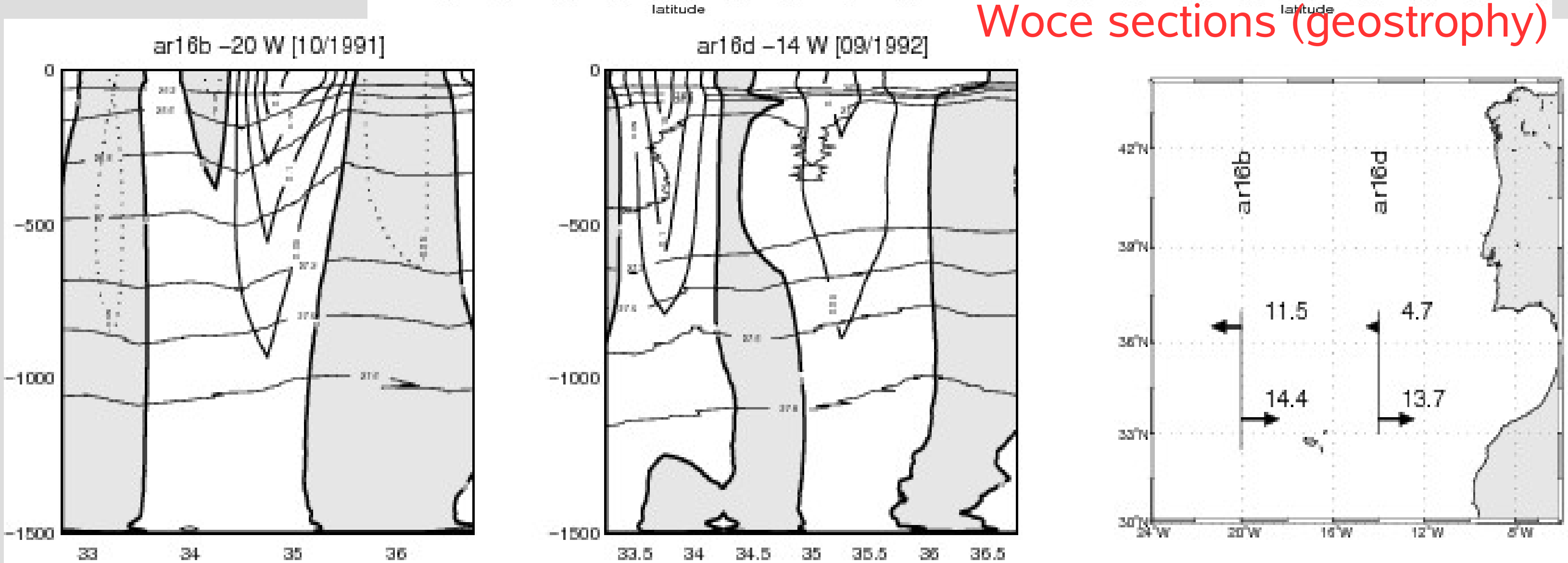
large scale solution

- Correct velocities transports and depths near the Madeira longitude
- Contercurrents on both sides
- weak evidence of undercurrents (Alves and Colin de Verdier 1999)

Model mean sections

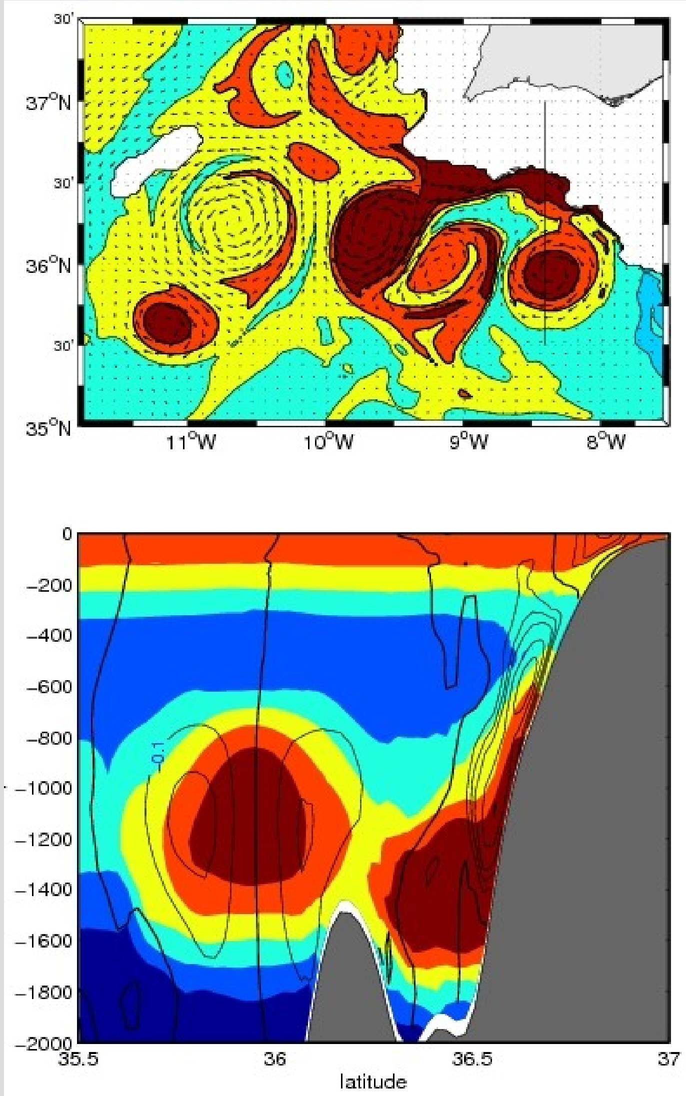


Woce sections (geostrophy)



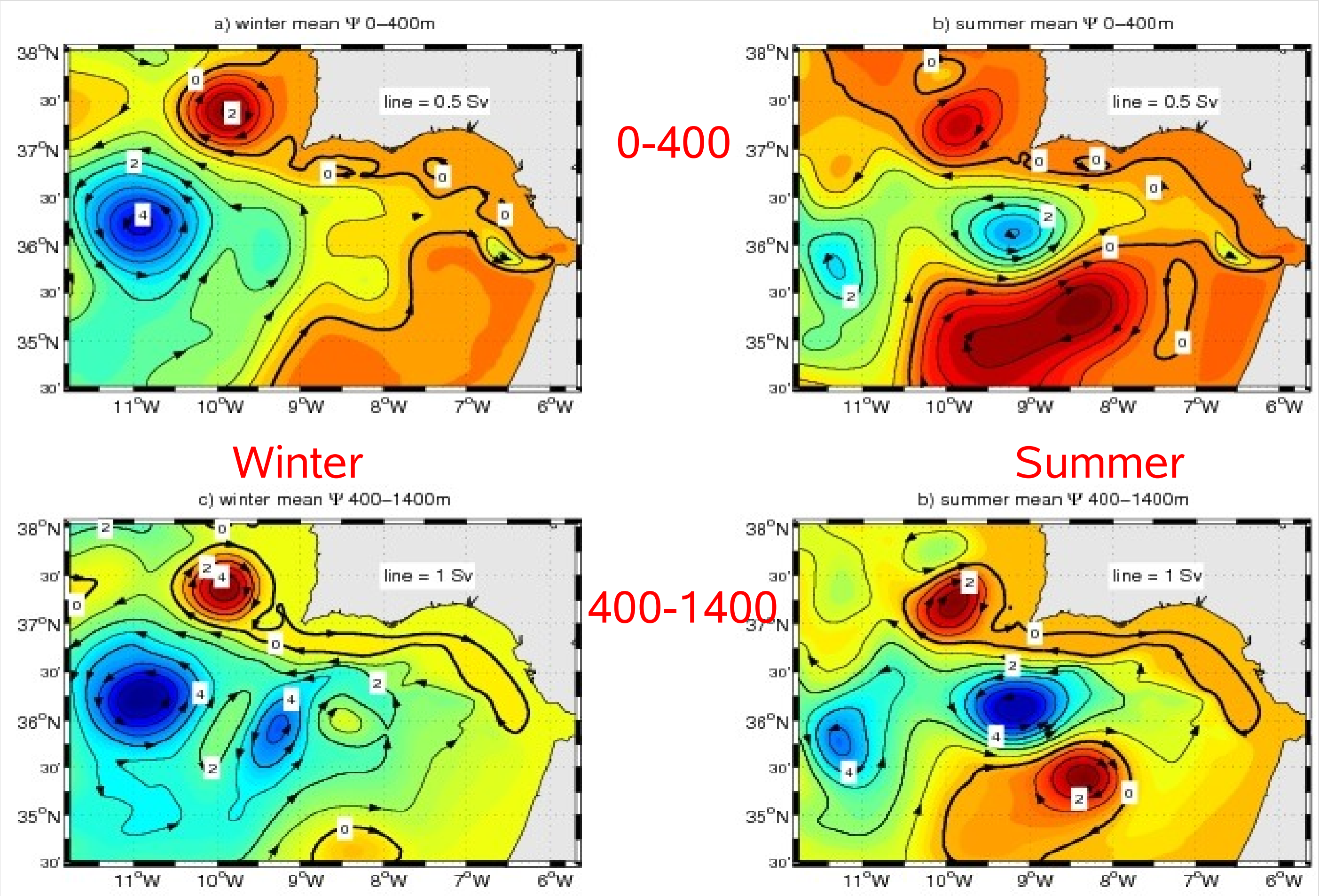
MU and Meddies

- A key point is a correct representation of MU and Meddies in the simulations
- The MU is highly sensitive to the details of BBL dynamics and mixing
- The model MU is saltier than observed and in some cases penetrates deeper than observed
- Meddies generate at proper depths and the Meddies characteristics are very similar to the ones observed [Robinson et al, 2000; Carton et al, 2002]



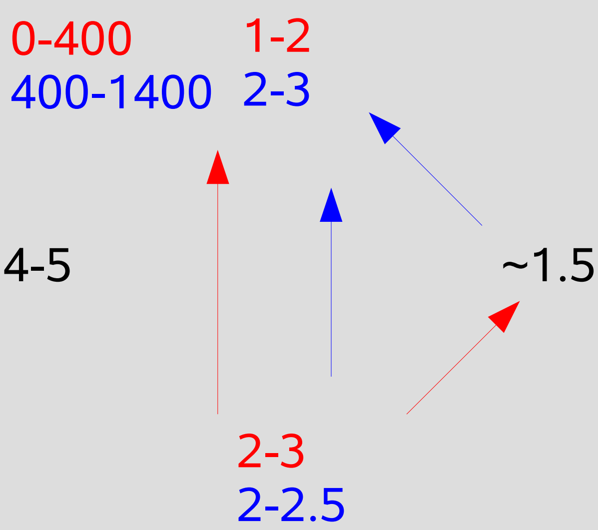
Time-mean layer circulation

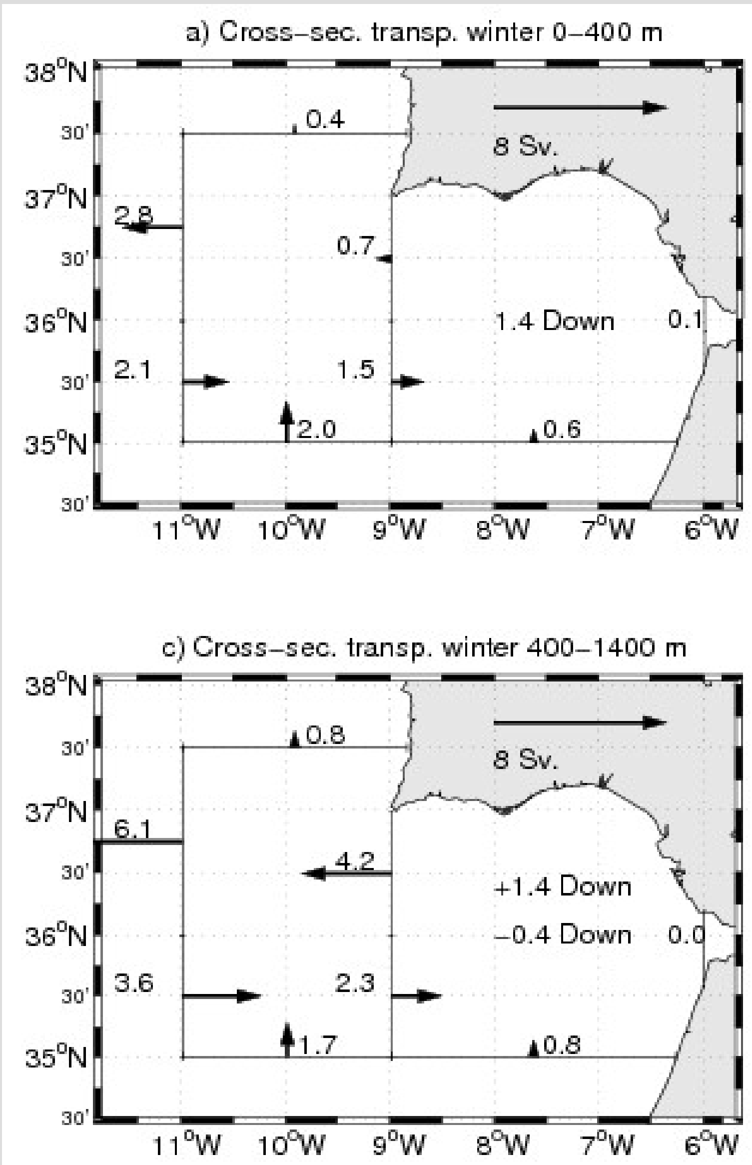
- Ψ is indicative
- Cyclonic cells that confirm TEβ- plume models
- Transport ~4-5 Sv in the 2 layers
- No clear difference between summer and winter
- The cells are not stalled and variability is also associated with meddy activity



Budget near GoC

- 4-5 Sv circulate near Goc in accordance to TEβ models
- ~1.5 Sv is entrained

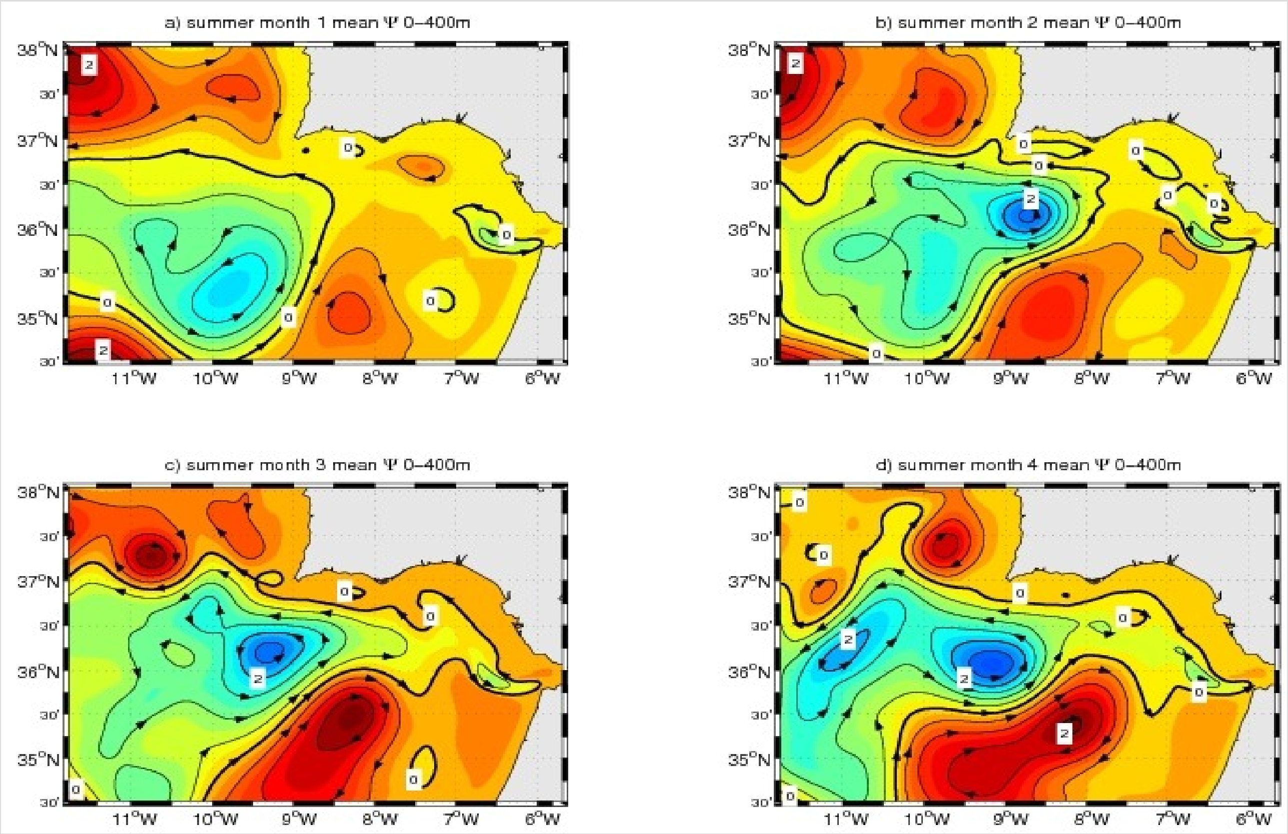




Cell evolution

- about 3 month to develop an almost steady recirculation cell
- There is an apparent intermittent behavior but it is hard to decouple from Meddies

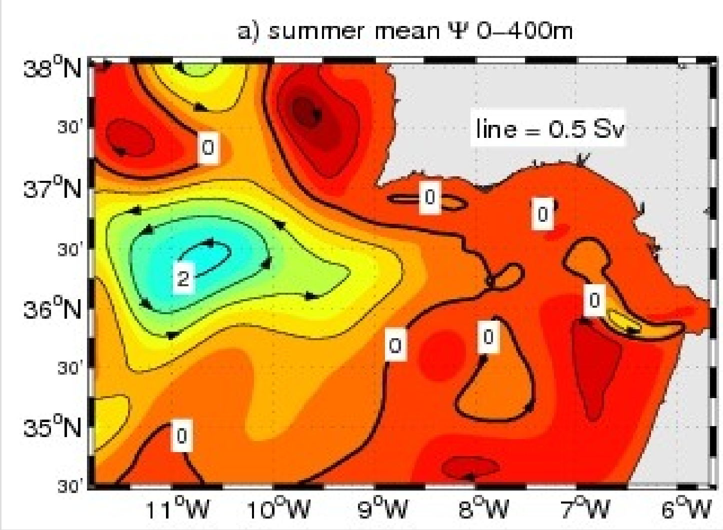
0-400m 4 month in summer



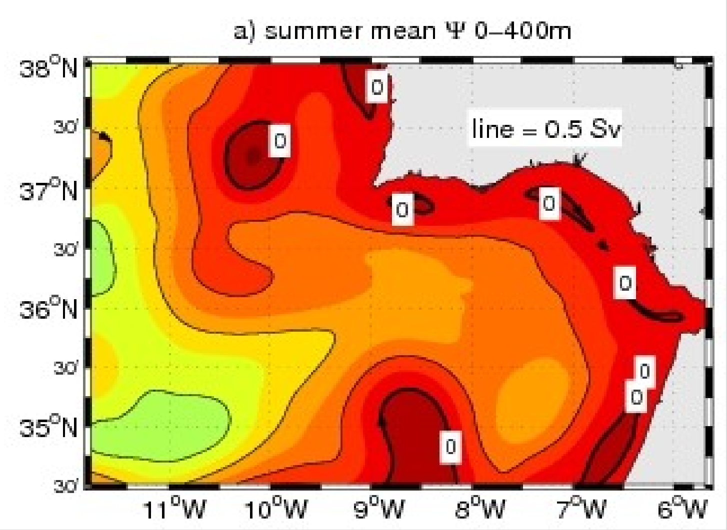
Homoge. and no MU cases

- The case with no external forcing develops the cyclonic cell.
- The no MU case shows a weak recirculation

Initially homogeneous case
(not forced along boundaries by the
large scale solution)



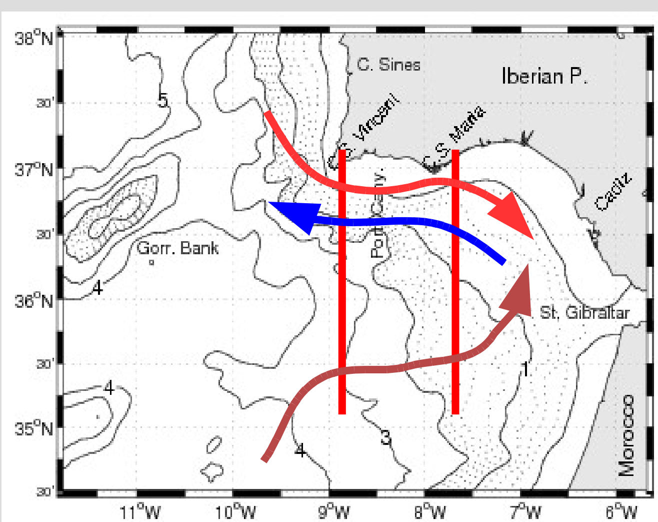
No MU (downscaling of
the large scale
solution)

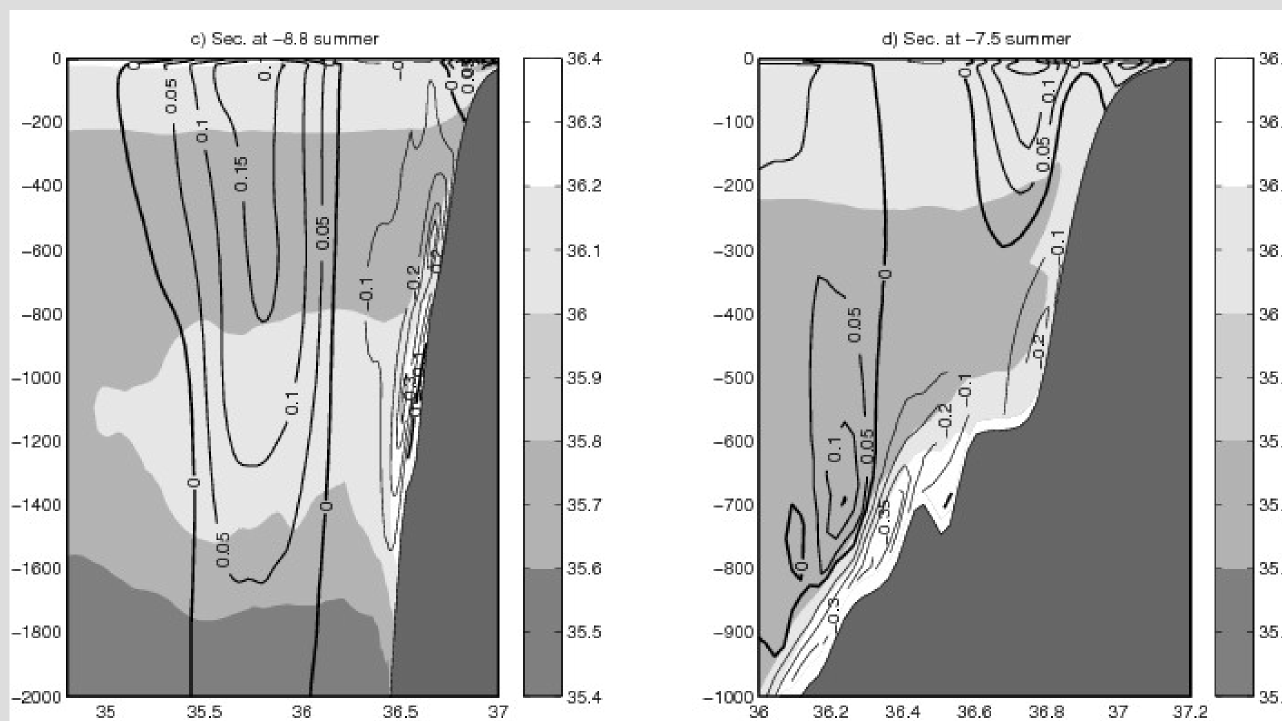


Vertical structure

- Although the 0-400 m integrated circulation is cyclonic the surface slope circulation is anticyclonic.
- A persistent slope current is present along all the GoC

U (west-east) / Salinity

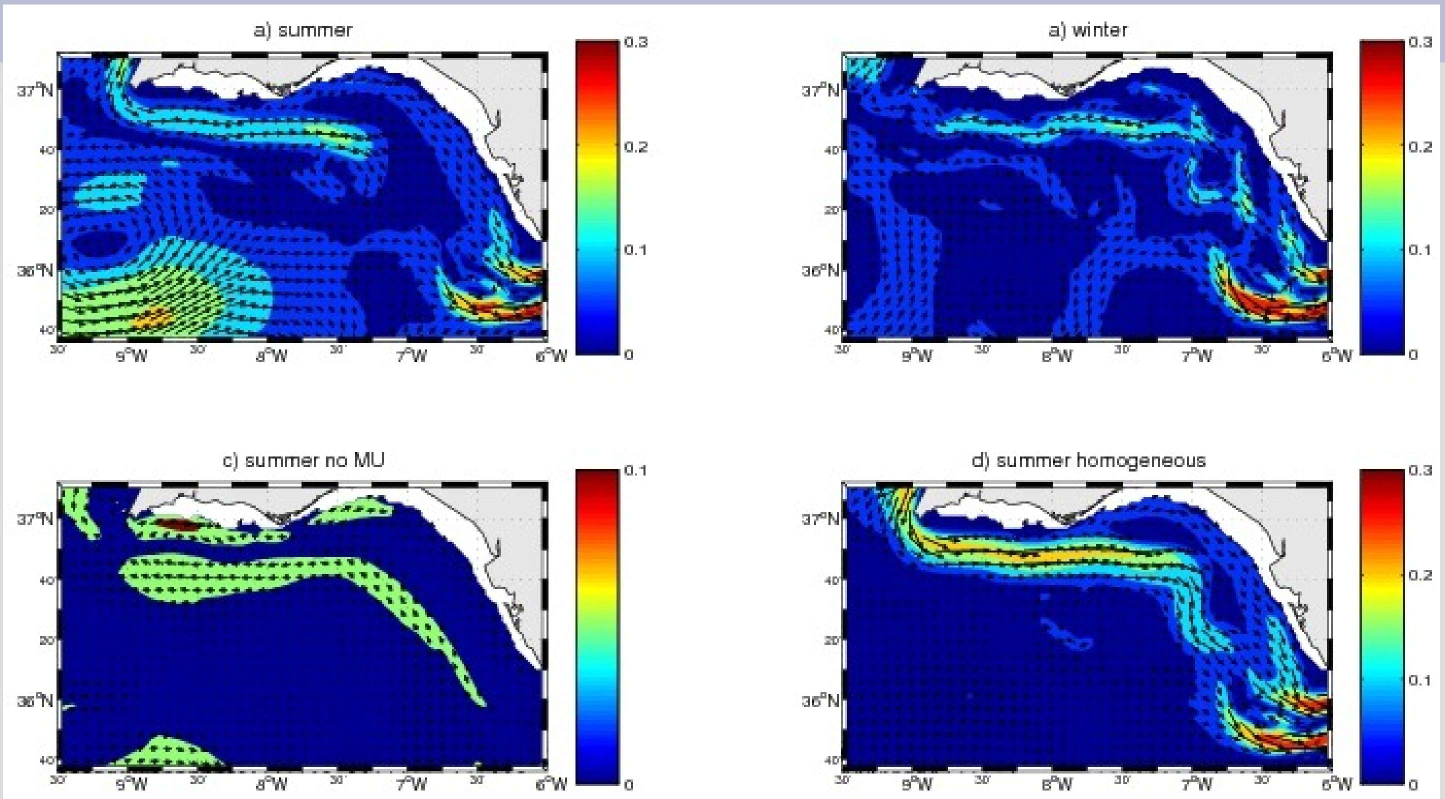


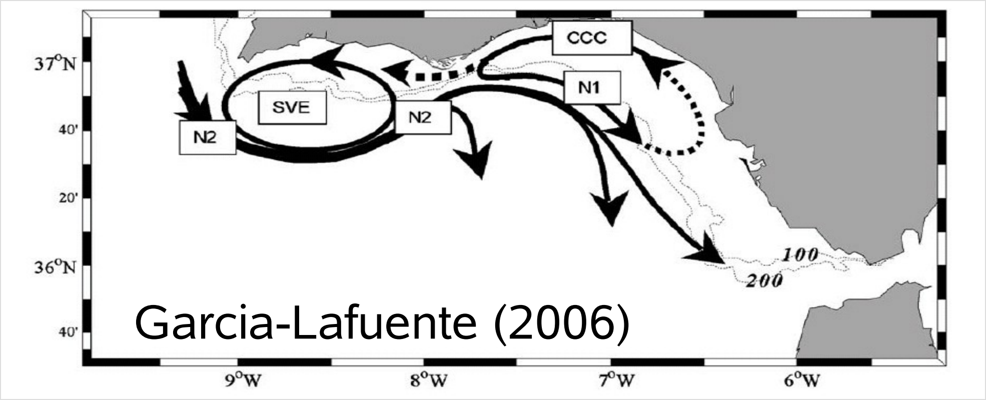


Slope Currents

A slope current connecting the Southwest Iberia and eastern GoC is present in all simulations with explicit MU.

This current helps explaining slope-shelf features described in a number of papers.





Garcia-Lafuente (2006)

Conclusion

- Large scale experiments shows that the bulk of the AzC is reproduced despite the western OBC is climatological (not critically dependent on the eastward advection).
- A β-plume type cyclonic circulation is obtained but weak transports near the GoC.
- Nested experiments confirms the TEβ models.
- 4-5 Sv circulate in (or near) the GoC for ~ 1.5 Sv of entrainment.
- The cyclonic cells show considerable variability and interaction with meddies is hard to decouple.
- The ~5 Sv associated with the TEβ + the ~2 Sv associated with the wind-driven transport possibly explain the Azores Current (and countercurrent) in the eastern side.
- However, the westward increase of both transport (> 10 Sv) and EKE is still calling for an additional explanation.
- A correct implementation of the SGIO exchange condition is critical not only for the representation of the MU but for the simulation of the surface slope-shelf currents.