Numerical investigation of the interaction of the Red Sea outflow with Gulf of Aden eddies

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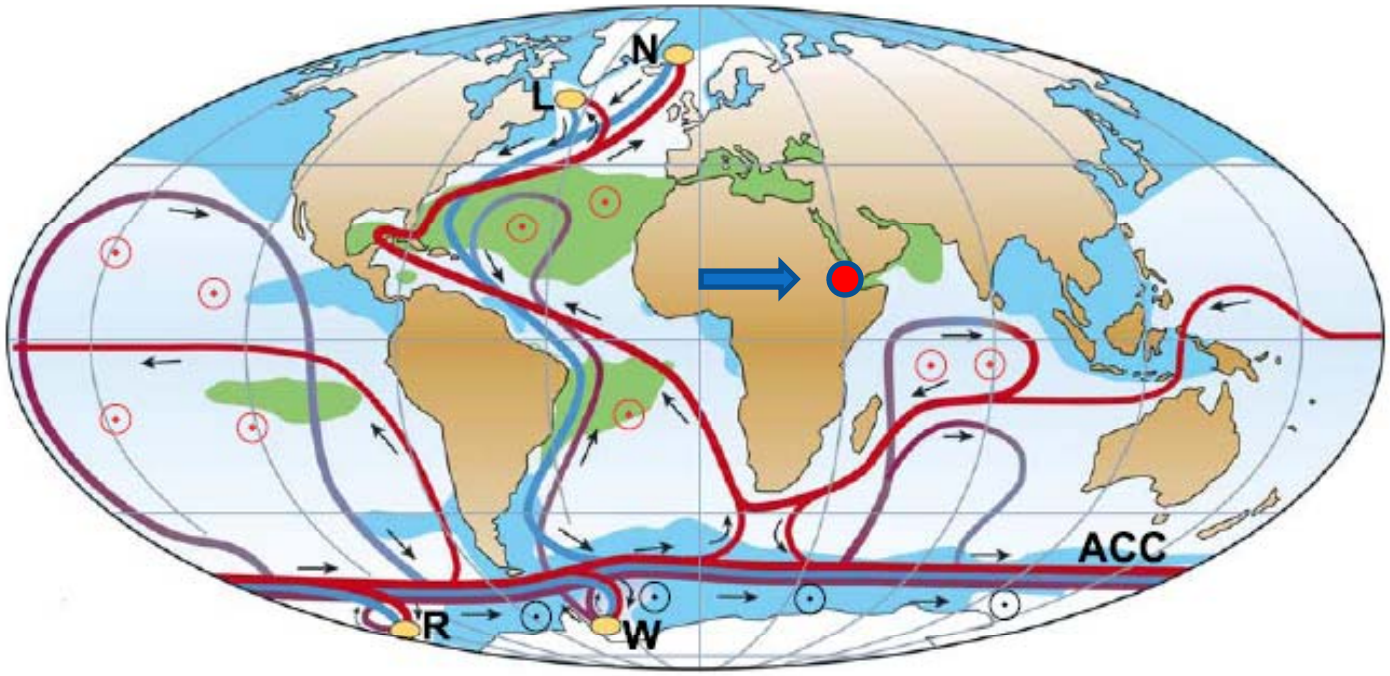
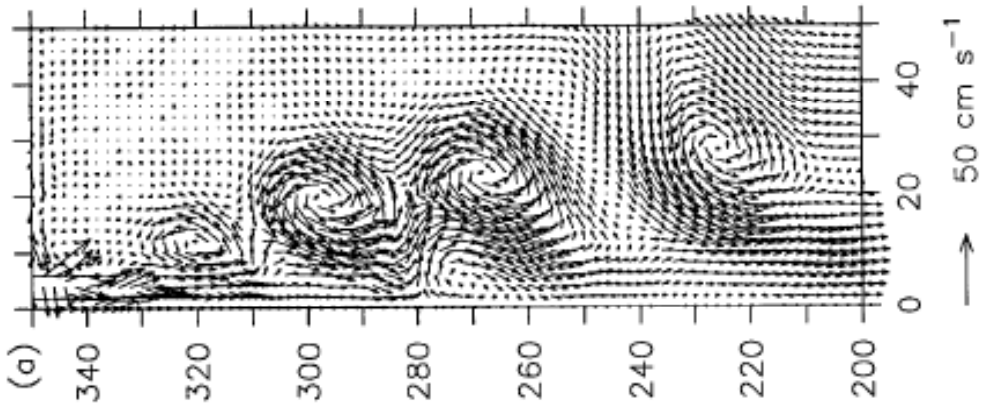
Motivation

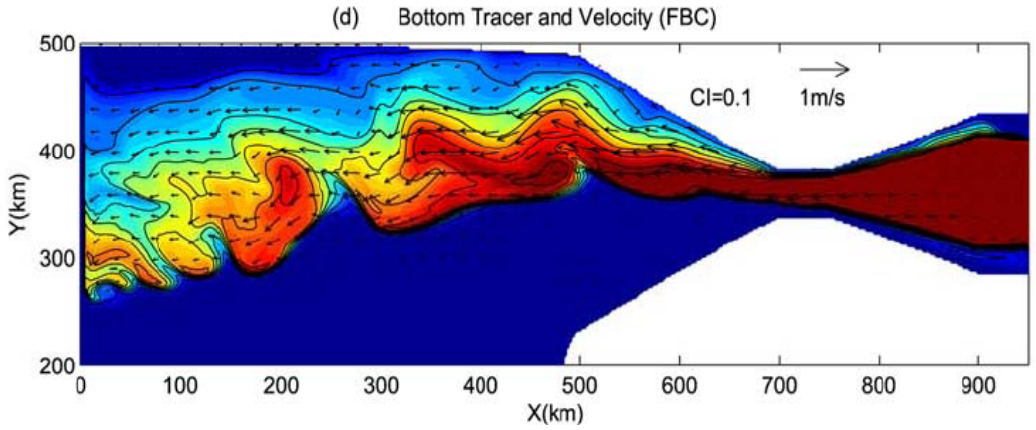
Kuhlbrodt et al. (2007).



Overflow induced eddies



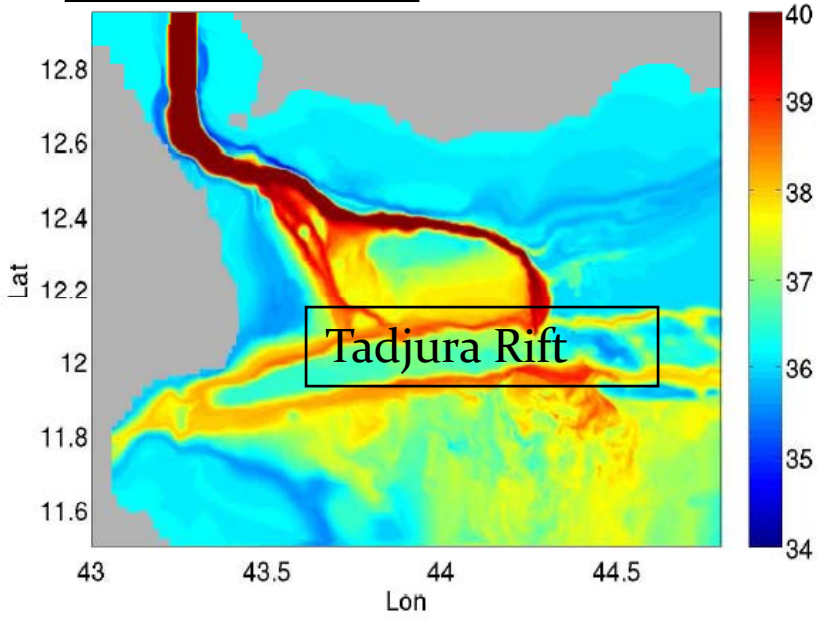
Spall and Price 1997



Ezer 2006

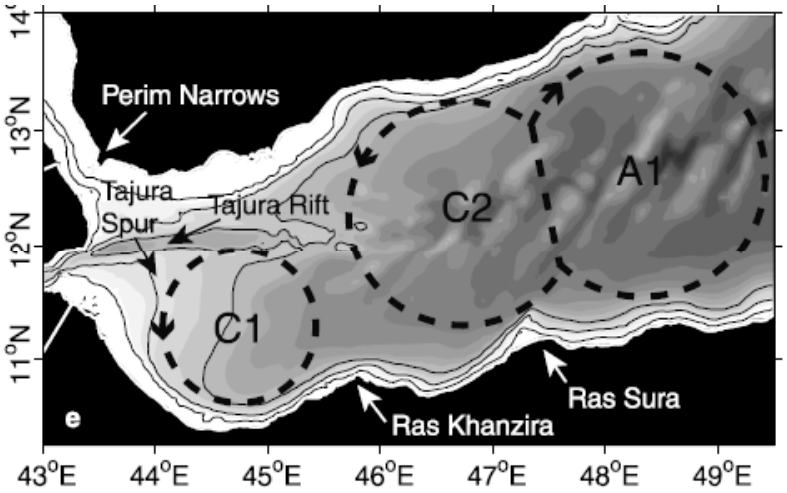
Bab el Mandeb

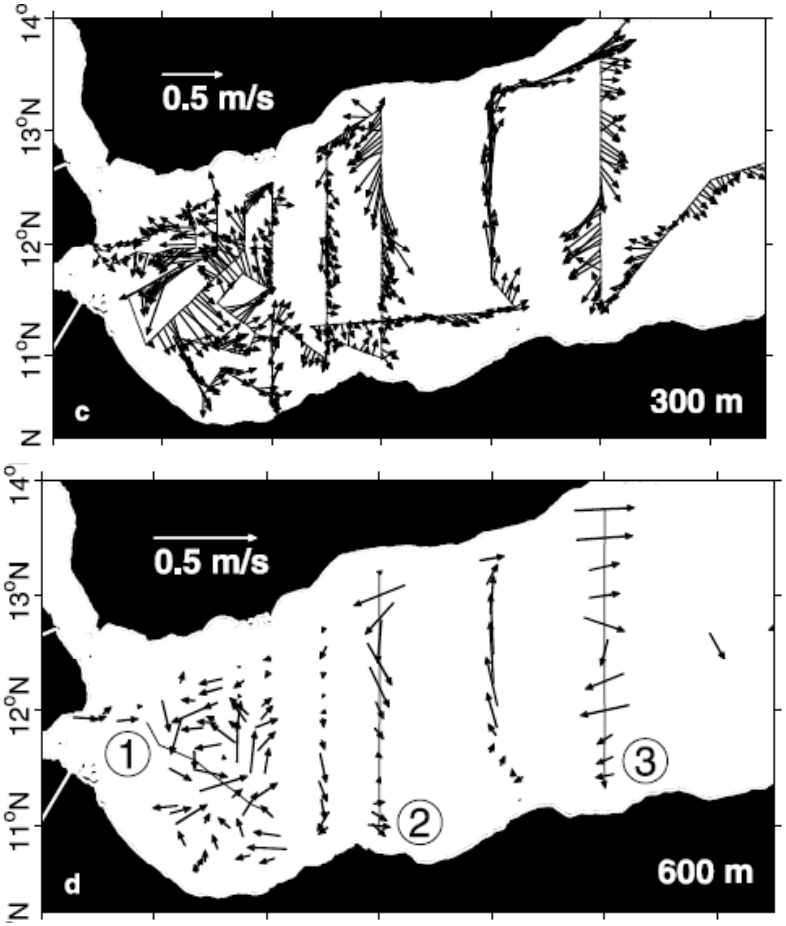
Xu et al. 2008



Ilıcak et al. 2008

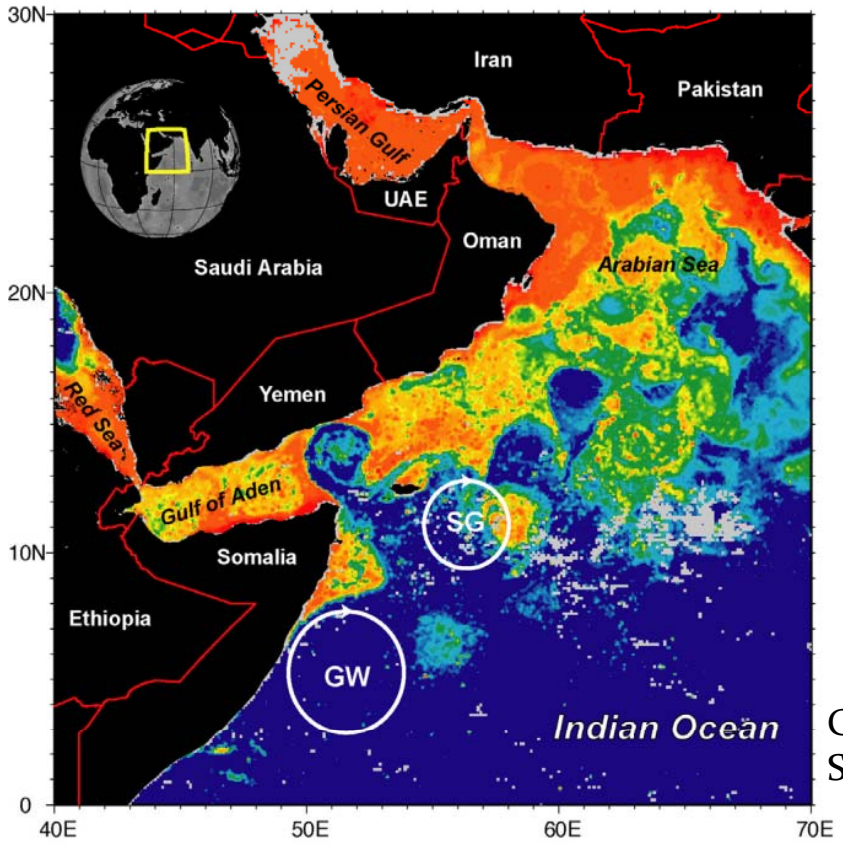
Large scale dynamics in Gulf of Aden



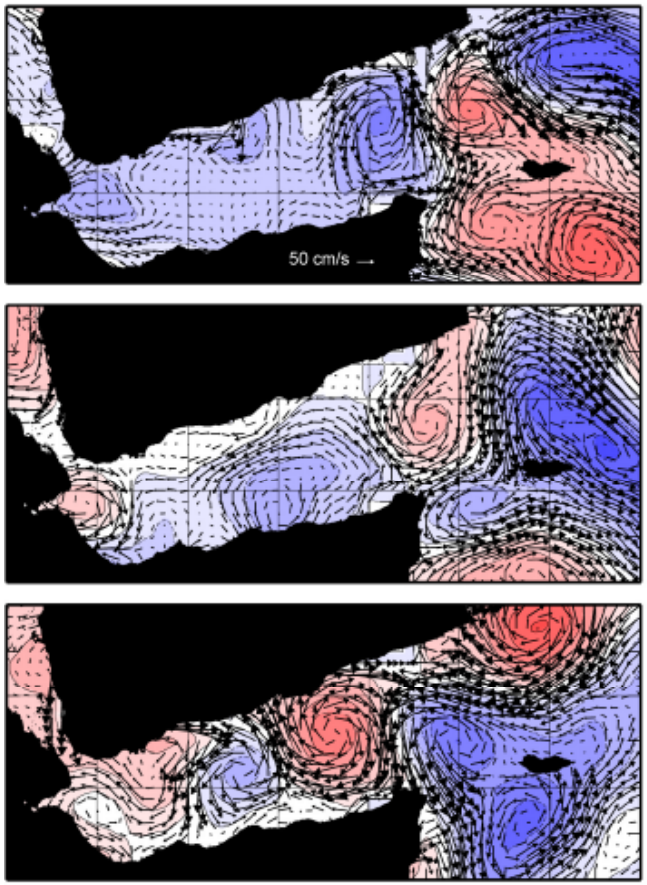


Bower et al. 2002

Possible Mechanism for Gulf of Aden Eddies



GW=Great Whirl
SG=Socotra Gyre



Fratantoni et al. 2006

• Due to summer monsoon winds, Somali Current changes its directions and retroflects eddies. These eddies travel west into Gulf of Aden.

Open Questions

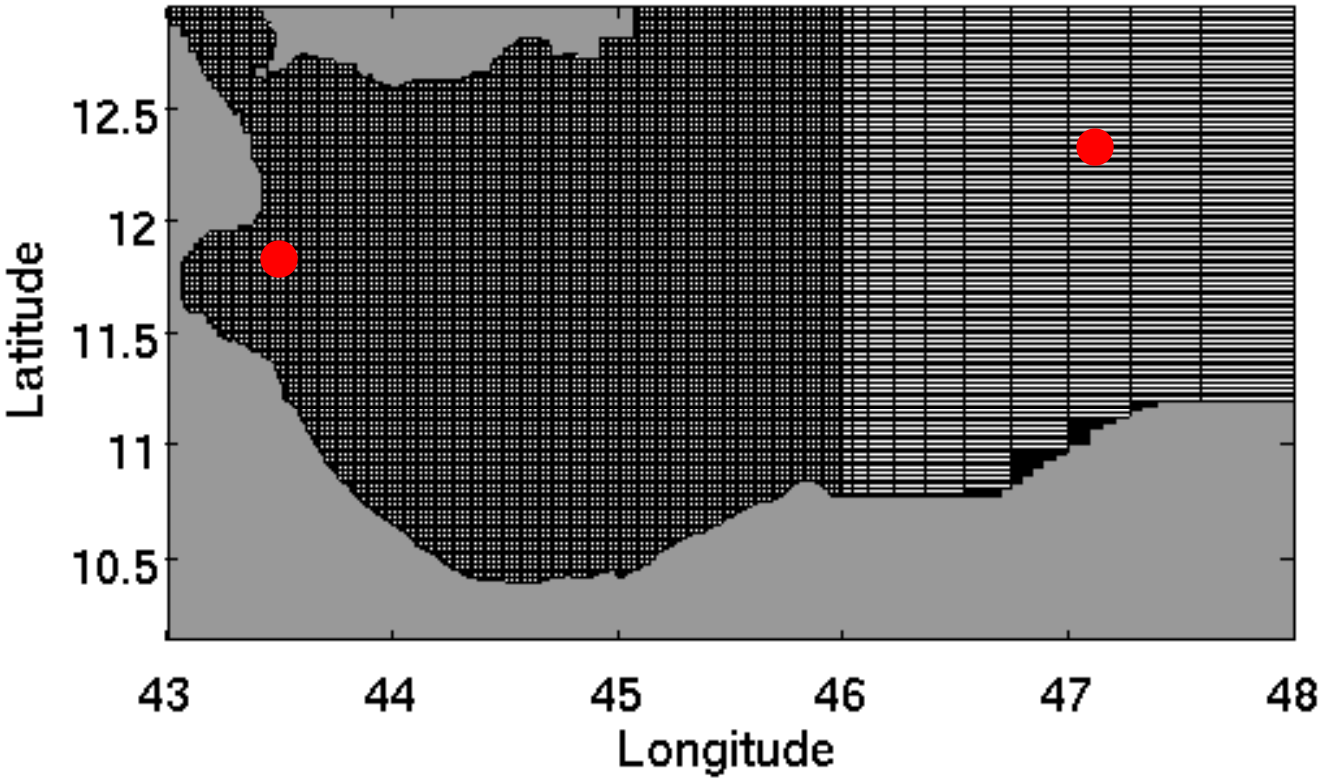
- How is the RSOW transported between the NC and SC channels and the Gulf of Aden through mesoscale eddy field in the gulf?

- Is there a preferred pathway of the Red Sea overflow out of Gulf of Aden?

- Do the eddies act to homogenize RSOW ? If not how do they influence the fate of this overflow?

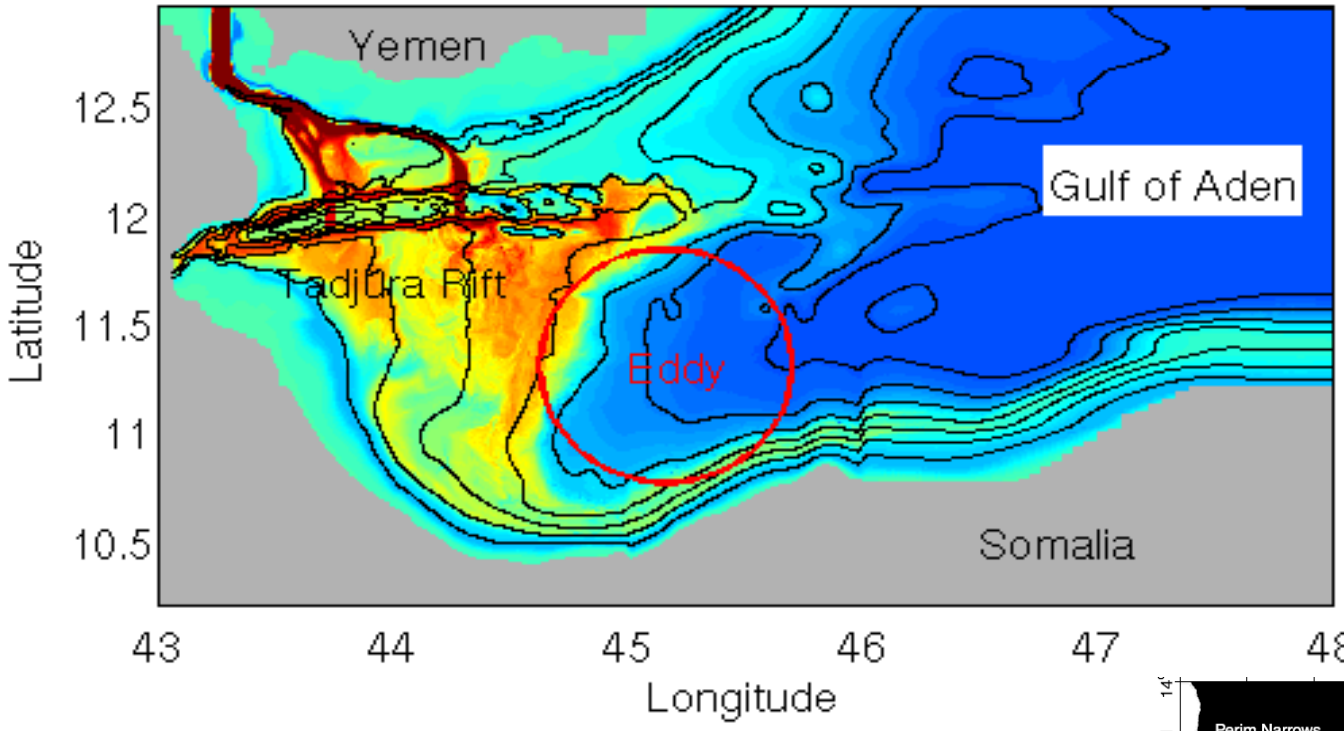
Setup

Grid points at every 5

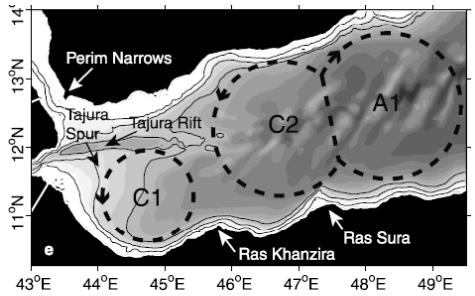


- N_{grid}= 800x700x30
  = 16.8 million points
- Δx ≈ 250 m to 10km
- Run on 64 procs.
- WCT = 120 hours
- Integrated for 120 days.
- k-ε turbulence closure
- Initial conditions from

Red Sea Overflow and Eddy Interaction

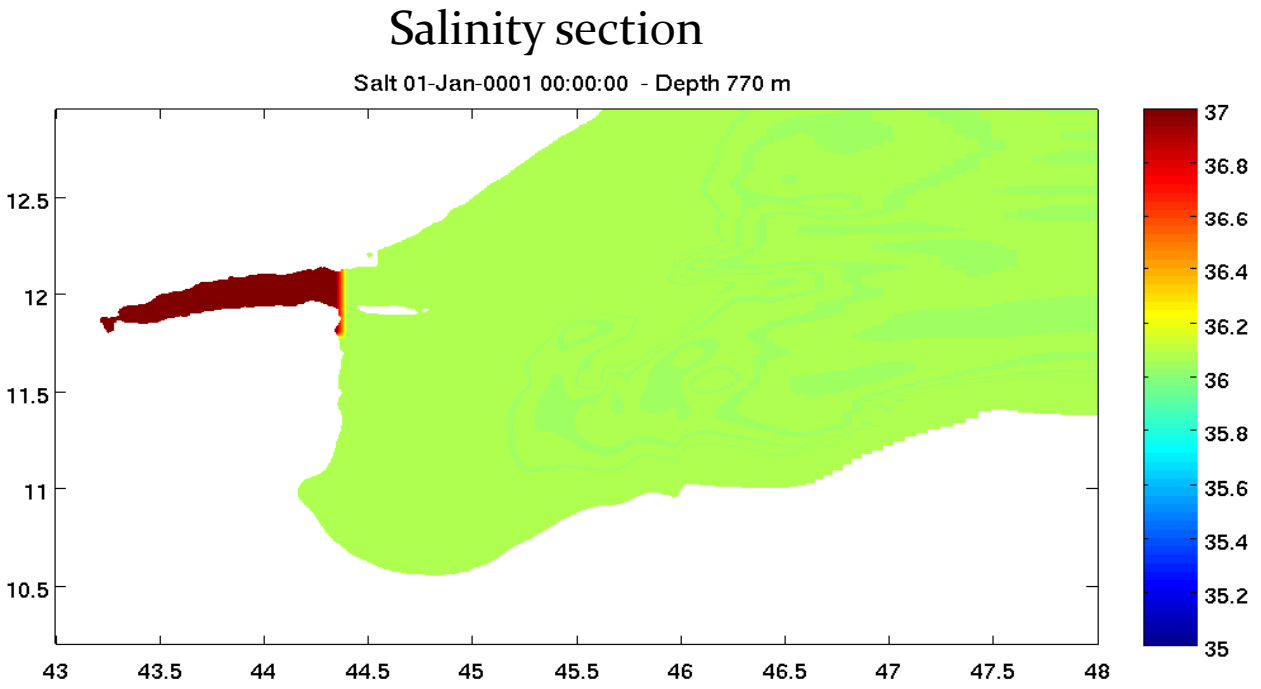


$$\left.\begin{aligned} \iint \zeta \, dxdy = 0 \\ \zeta = \partial_x v - \partial_y u \end{aligned}\right\} \quad v_\theta = A_0 \left(\frac{r}{R}\right) e^{-\left(\frac{r}{R}\right)^2}$$

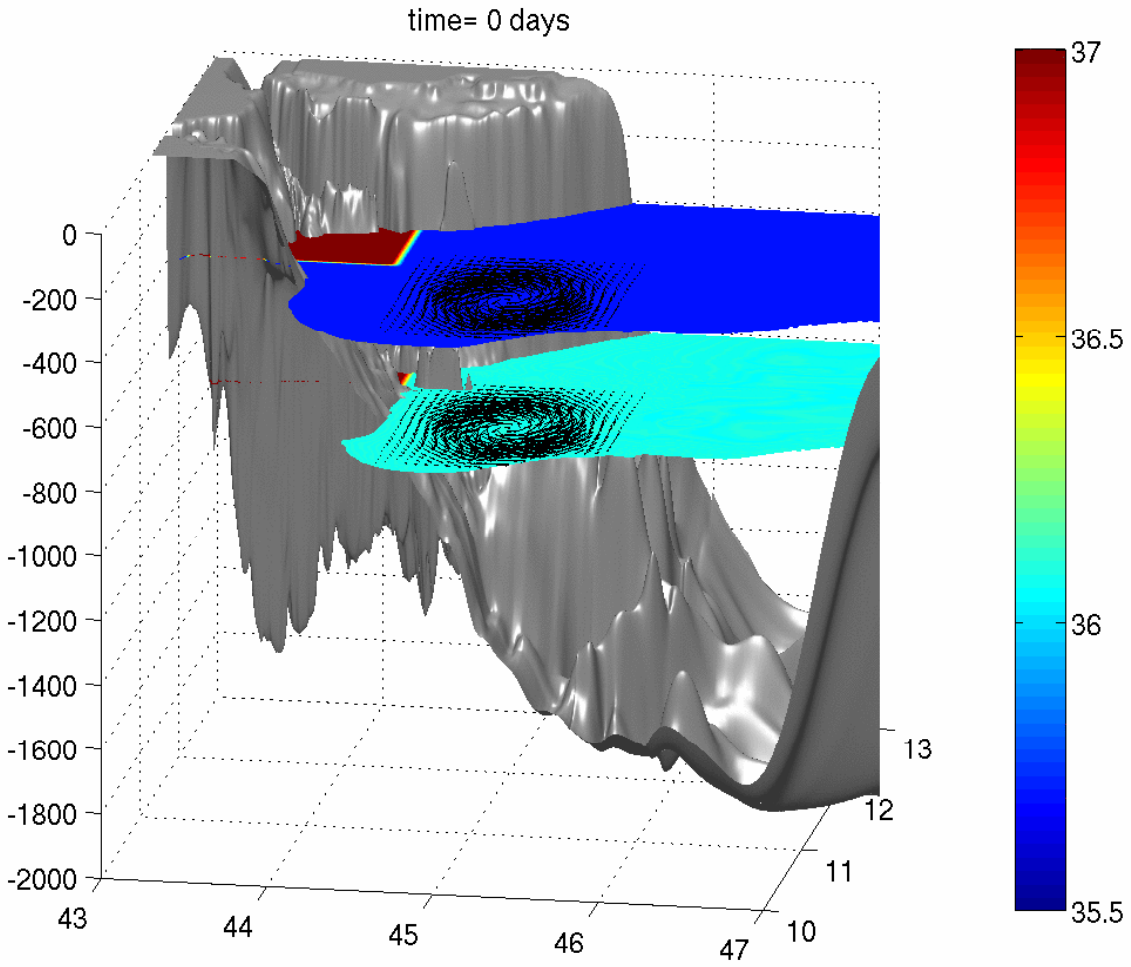


Morel and McWilliams 1997

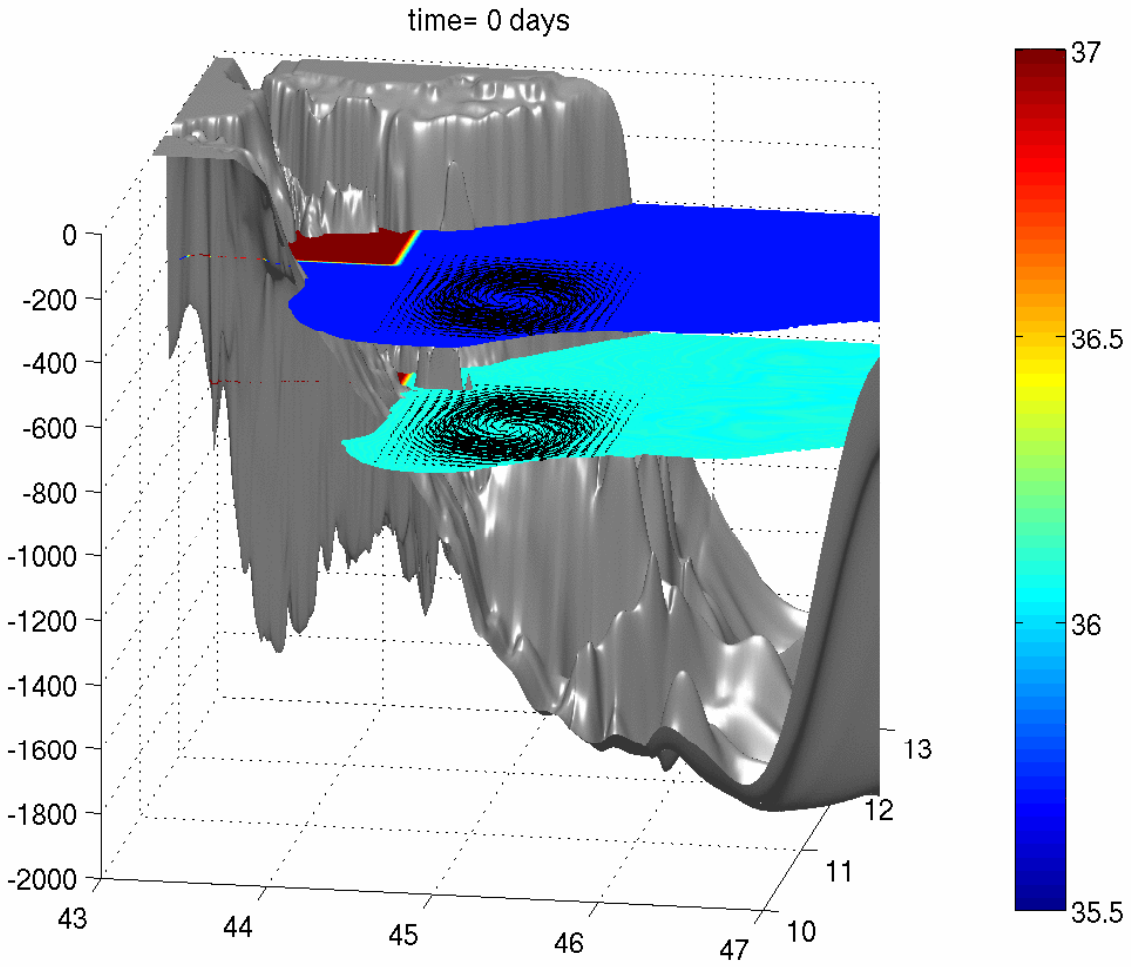
Overflow at z = 770m



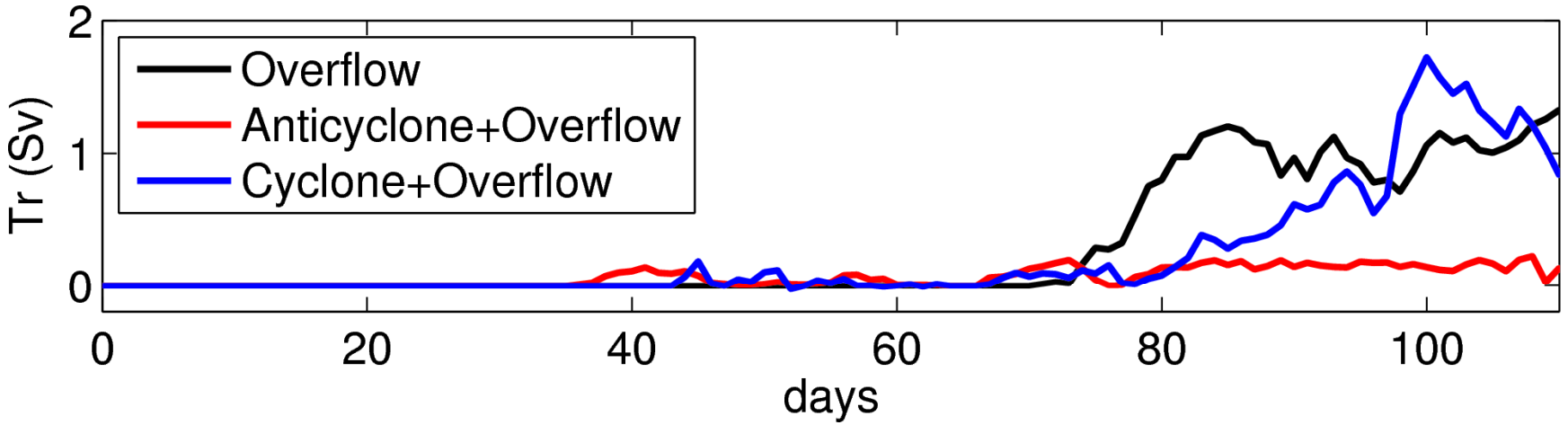
Overflow + Cyclone



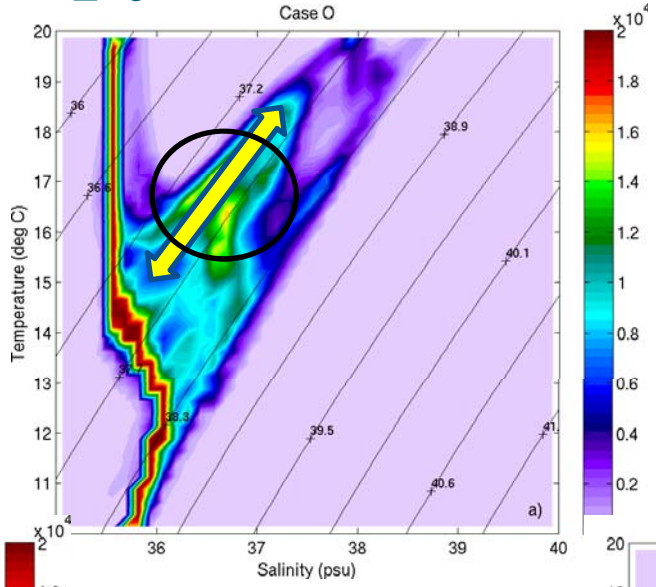
Overflow + Anticyclone



Transport at Lon = 46°N

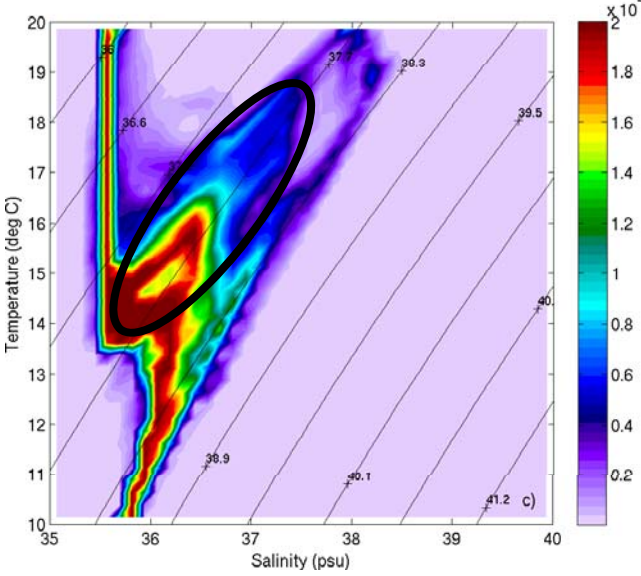


Isopycnal mixing

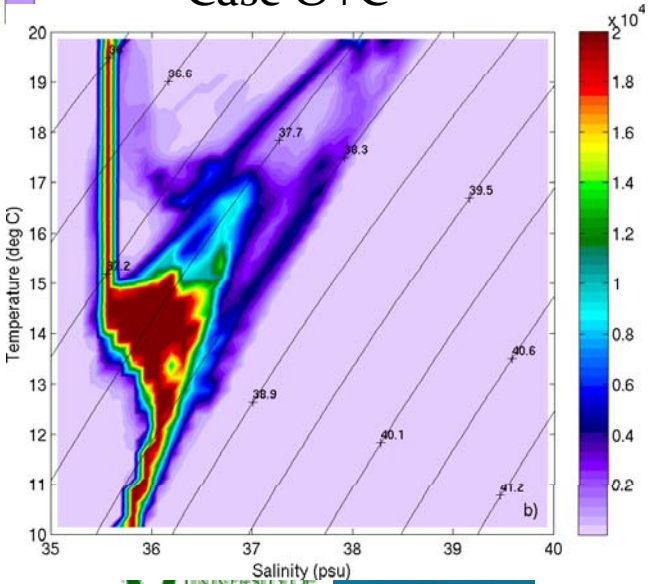


Case O

Case O+A

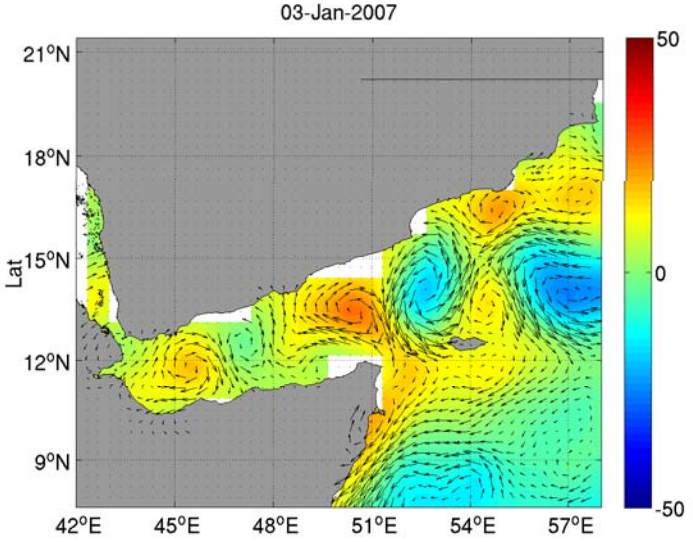


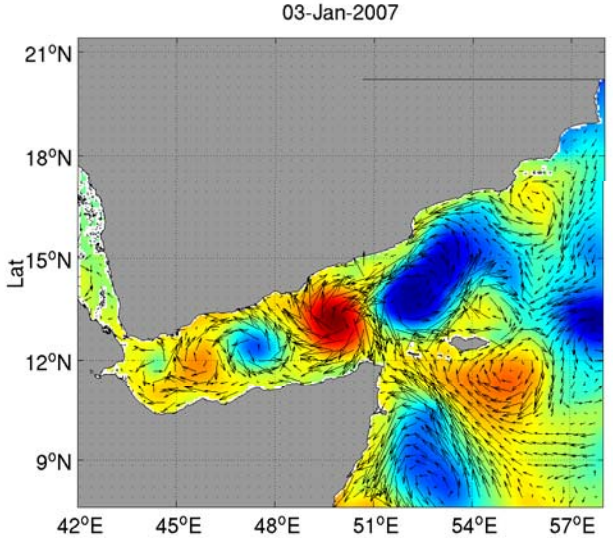
Case O+C

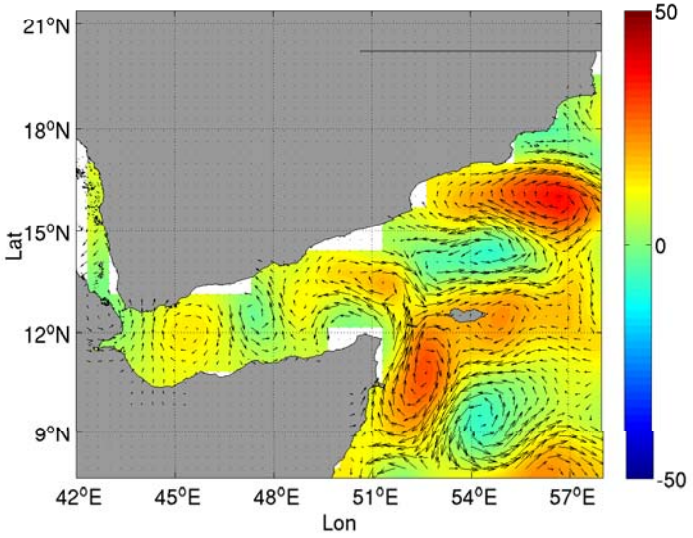


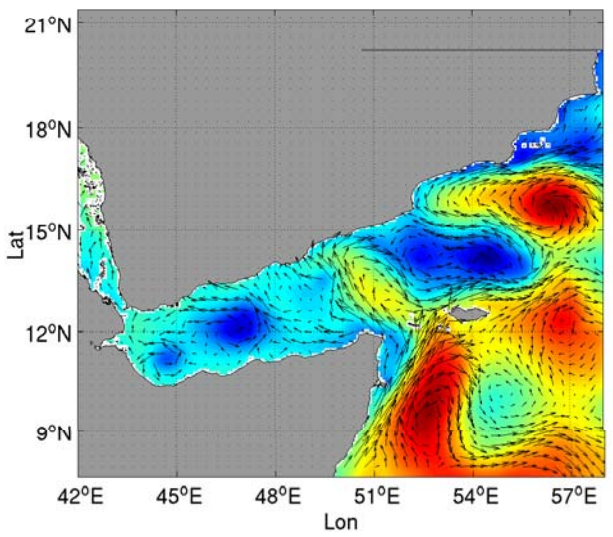
Global HYCOM using NCODA

Satellite SSH anomaly



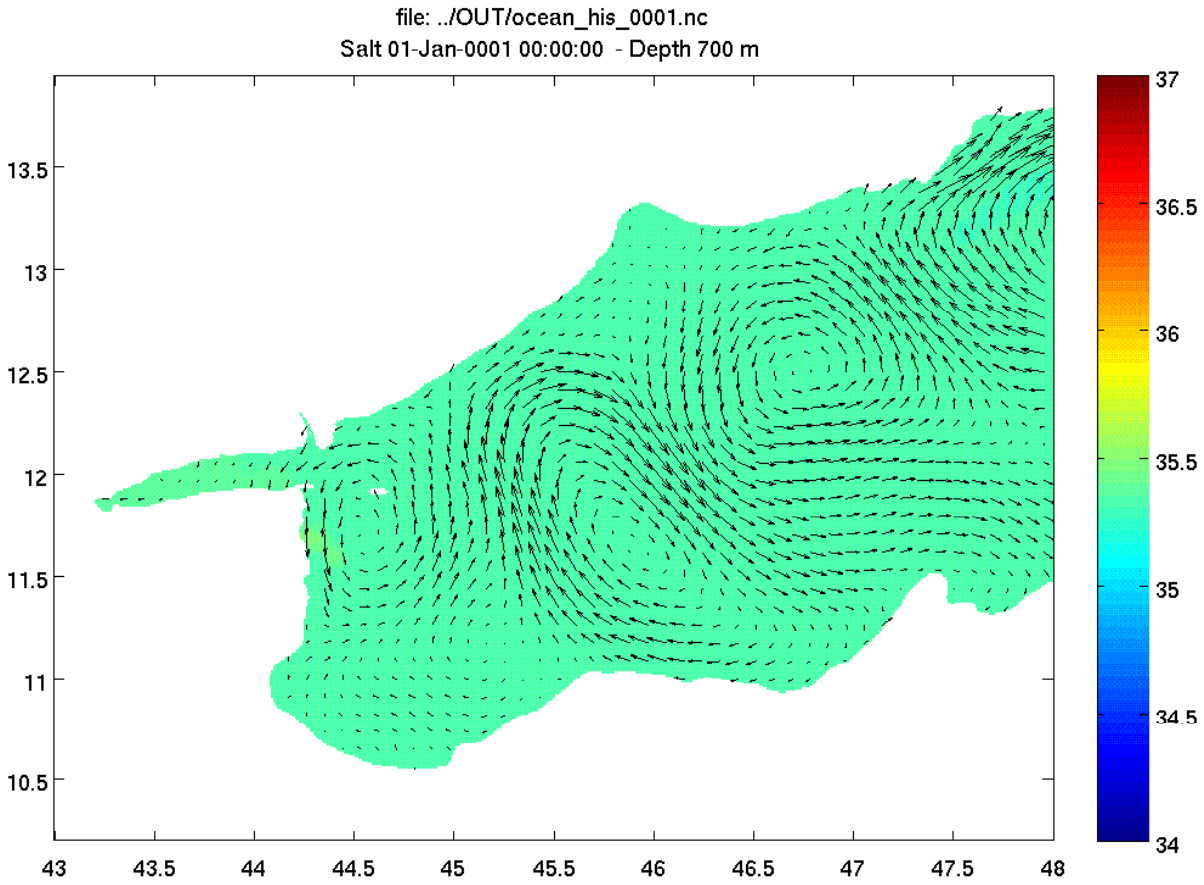




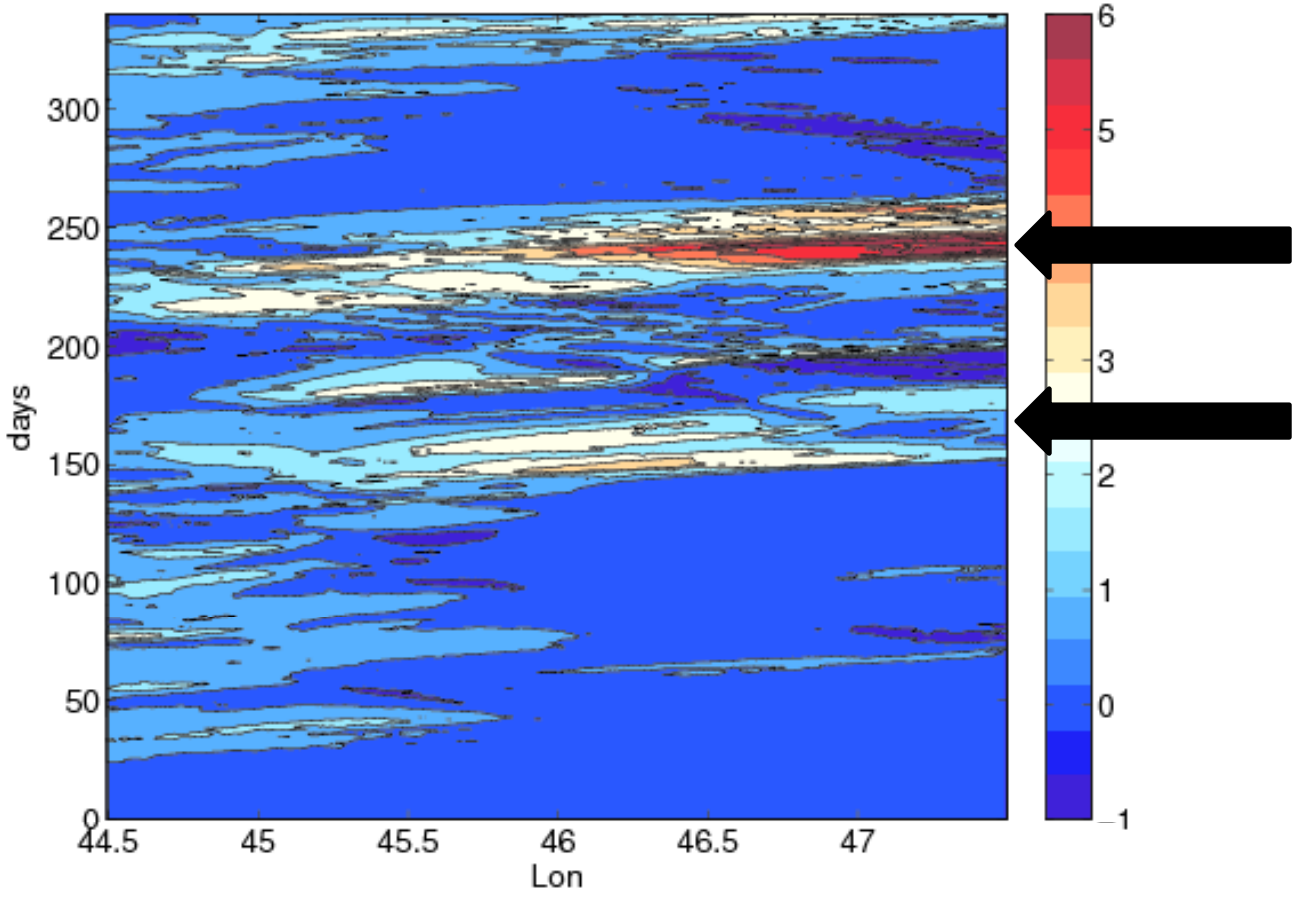


1/12° HYCOM SSH

ROMS forced by HYCOM eddies



What is the net effect of realistic eddies on the overflow transport out of GOA?



Summary

- In idealized simulations, both cyclonic eddy and absence of an eddy lead to coastal undercurrent, while the anticyclonic eddy tends to block the RSOW.

- Nevertheless, results from idealized eddy simulations are not directly applicable to the case with a sequence of realistic eddies.

- The overflow (0.6 Sv in winter) accumulates in the interior part of the Gulf of Aden. Then, it exits the gulf in a surprisingly burst (up to 7-8 Sv in 30-45 days).

- The transport and fate of the overflow depend significantly on the eddy field in the GOA.