On the Interactions between the Mississippi River Plume and the Gulf of Mexico offshore circulation

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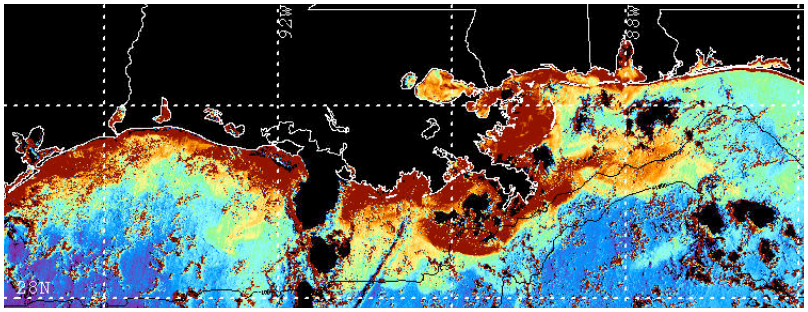
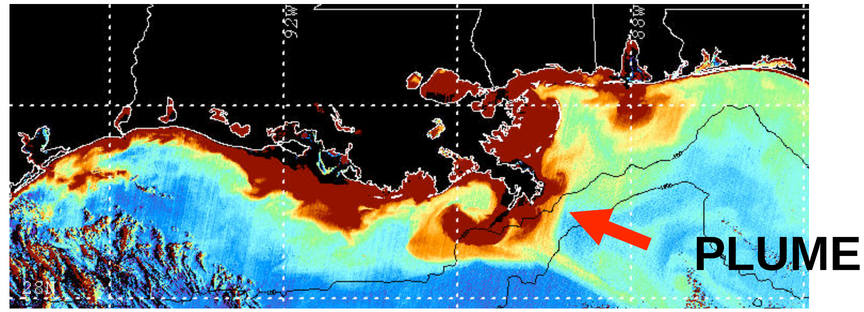
LOM 2011 meeting
Miami, FL

The Mississippi River plume

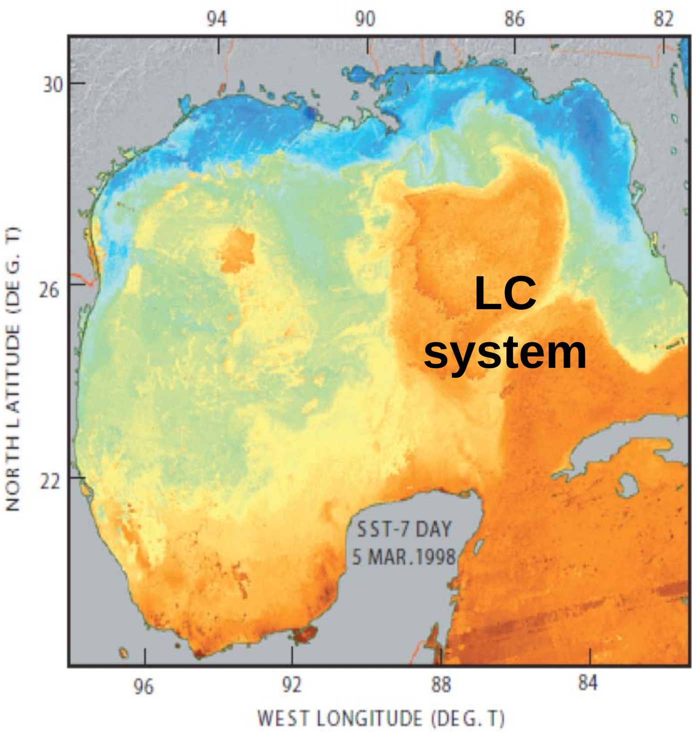
Chl-a concentration - Oceansat 1 Ocean Color Monitor – Earth Scan Laboratory, LSU



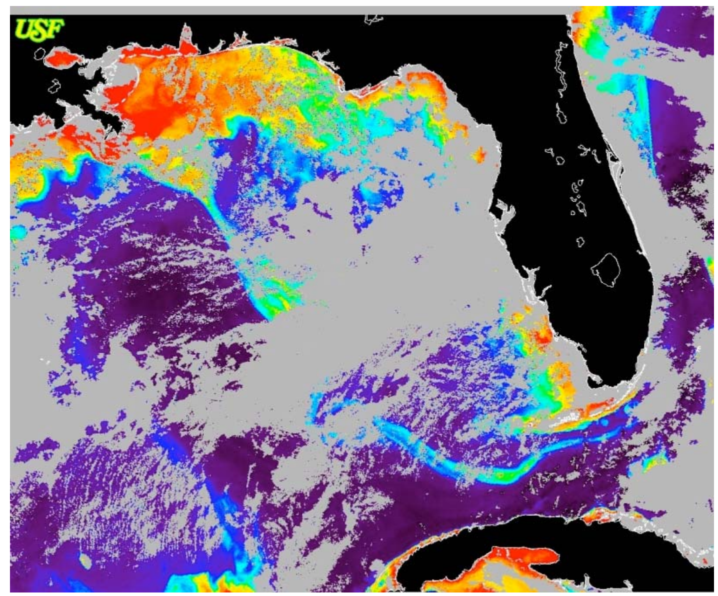
06/30/2004



04/24/2005

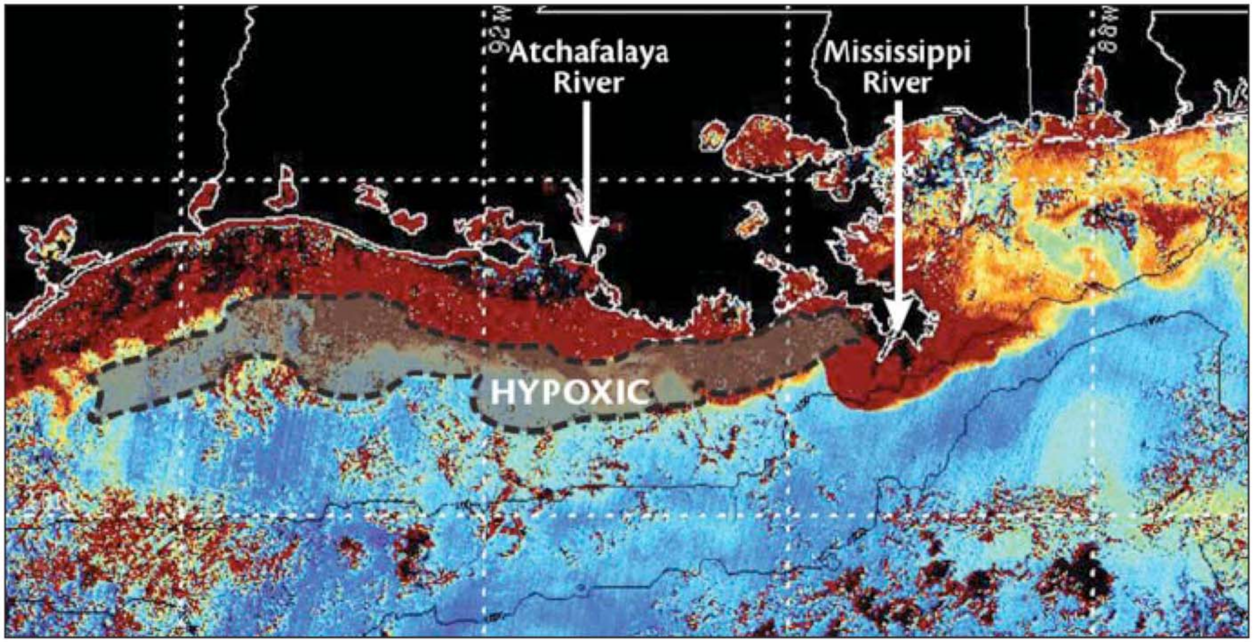


Schmitz, 2003.



Chl-a concentration – SeaWifs Monitor – USF

Why care?



Chl-a concentration - Oceansat 1 Ocean Color Monitor – 06/11/2008

Boesh et al., 2009

- ***Drains 41% of the continental US***
- ***210 * 10^6 tons/year of sediment***
- ***Fisheries***
- ***Summer time hypoxia***
- ***Remote source of freshwater for the South Florida Region***
- ***Ecosystem management and water quality purposes***

Overarching goal:

Expand river plume studies (that generally are confined on the coastal and shelf areas) to the interaction with shelfbreak and offshore flows.

Specific objective:

- **Investigate the dynamic processes controlling the fate of Mississippi River waters**

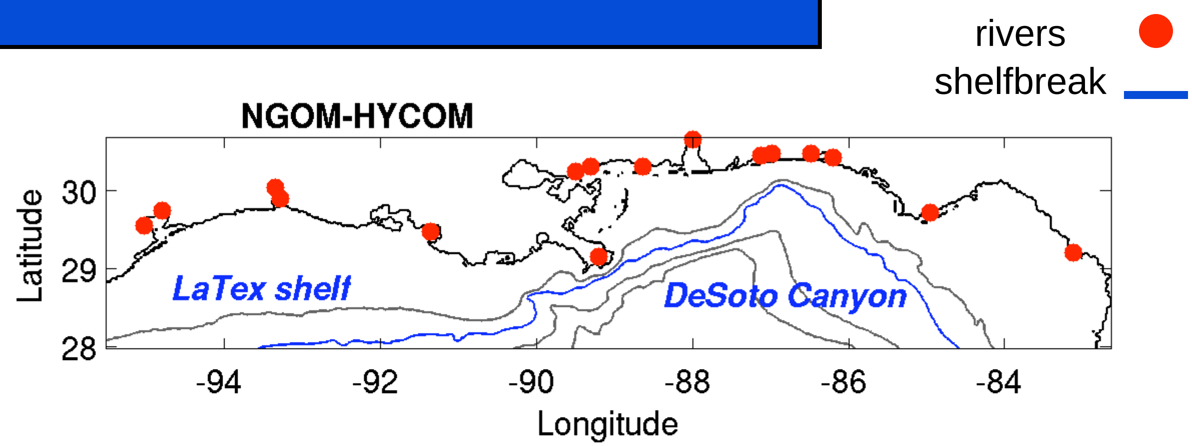
- **Focus on the conditions that favor the offshore exportation of riverine waters**

- **Synergy of mechanisms**
  - **Shelf circulation**
  - **Offshore circulation**
  - **Topography effects**

Northern Gulf of Mexico model

NGoM-HYCOM

- 1/50° hor. resolution
- 30 hybrid vertical levels
- no data assimilation
- nested in GoM-HYCOM

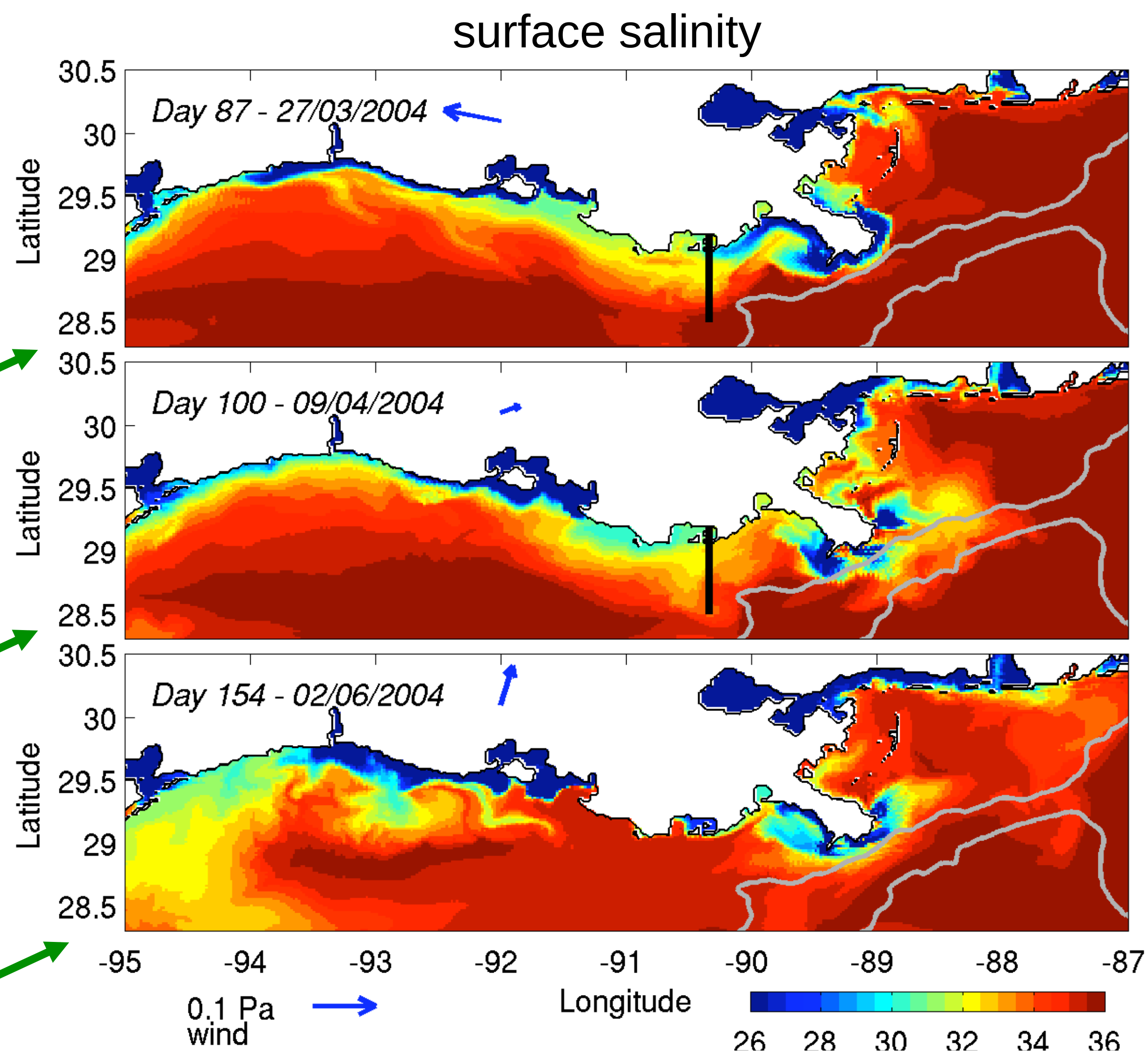


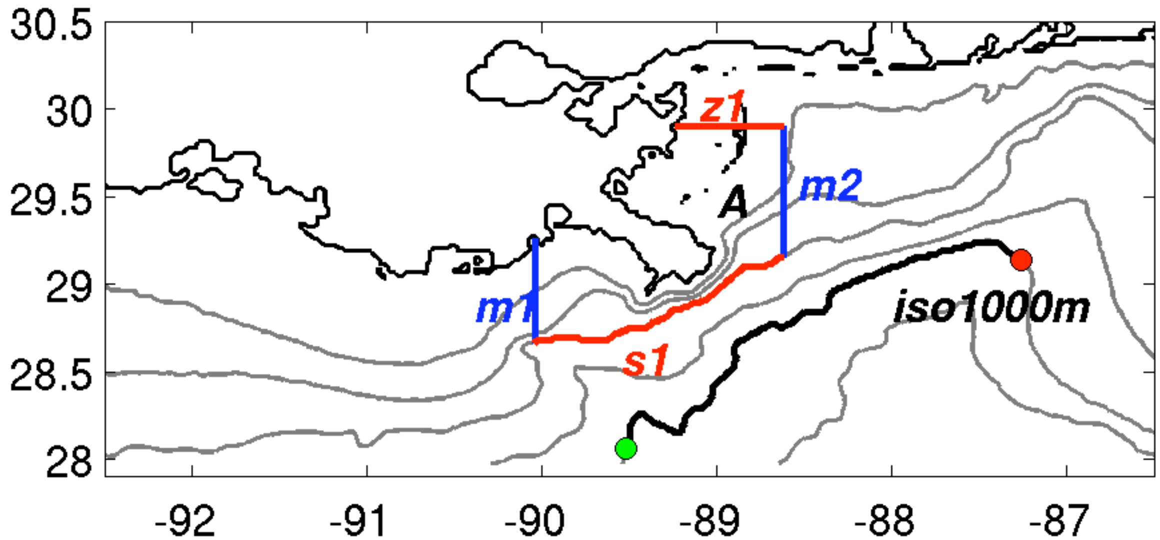
Plume wind-driven dispersion

Easterly (downwelling-favorable)

Westerly (upwelling-favorable)

Southerly





$$Q_{fw} = \iint_{-h}^{\eta} fw_f V \, dz\, dx \qquad fw_f = \frac{S_b - S}{S_b}$$

Q_{fw} = freshwater flux ($m^3\ s^{-1}$)

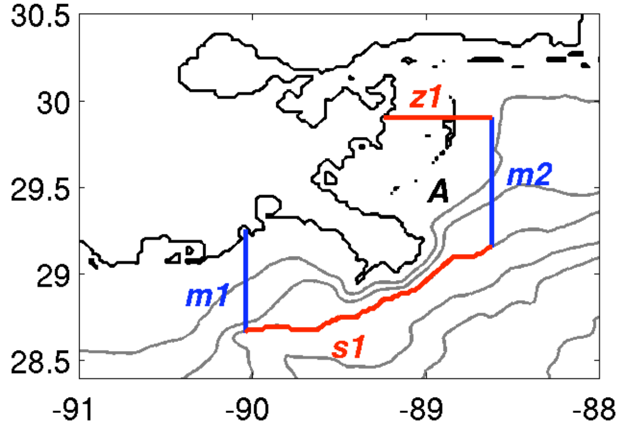
fw_f = freshwater fraction

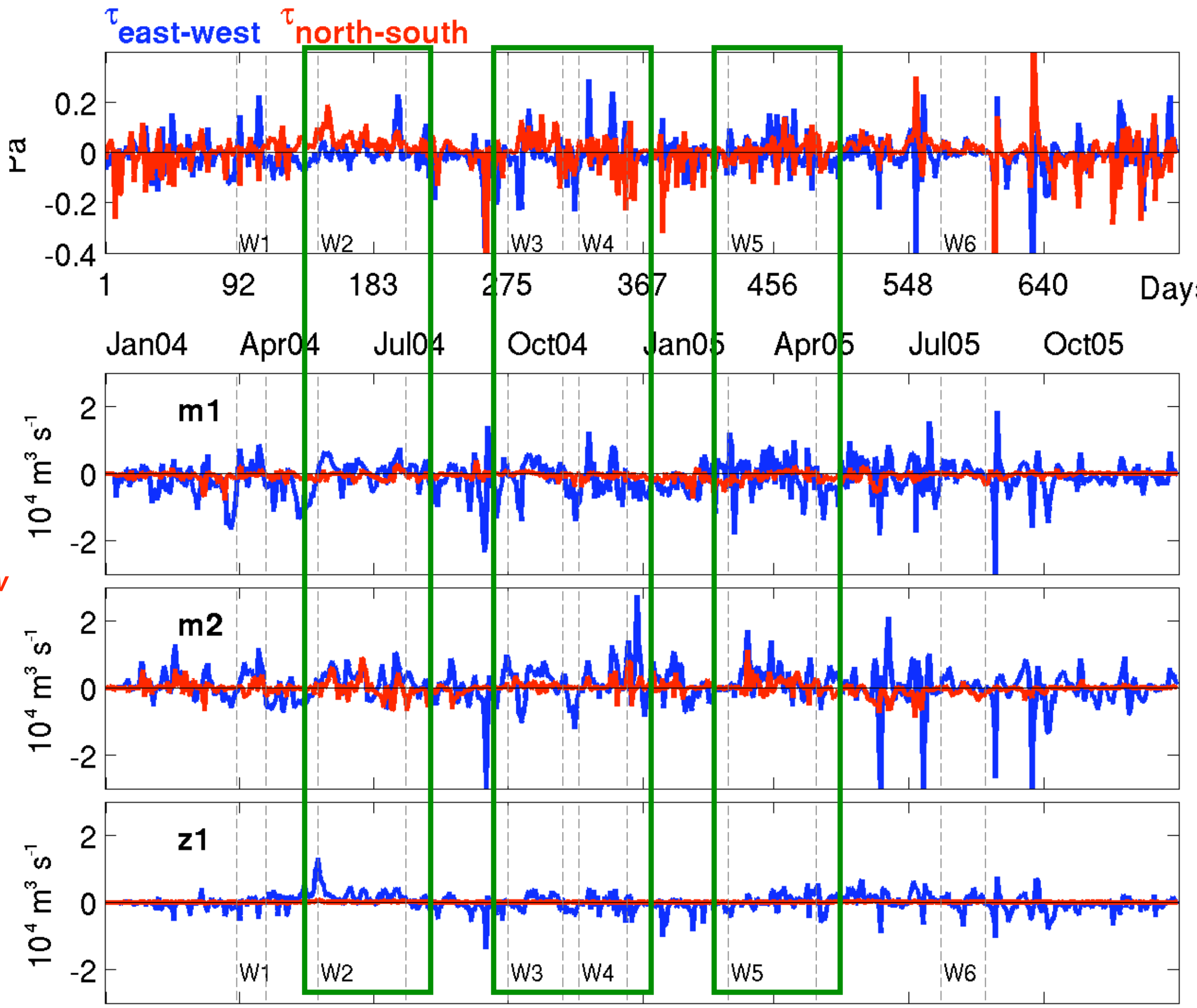
V = across-section velocity

S = salinity

S_b = undiluted salinity

$$Q_{fw}total = Q_{fw}barotropic + Q_{fw}baroclinic = \iint_{-h}^{\eta} fw_f V_{btrop} \, dz\, dx + \iint_{-h}^{\eta} fw_f V_{bclin} \, dz\, dx$$



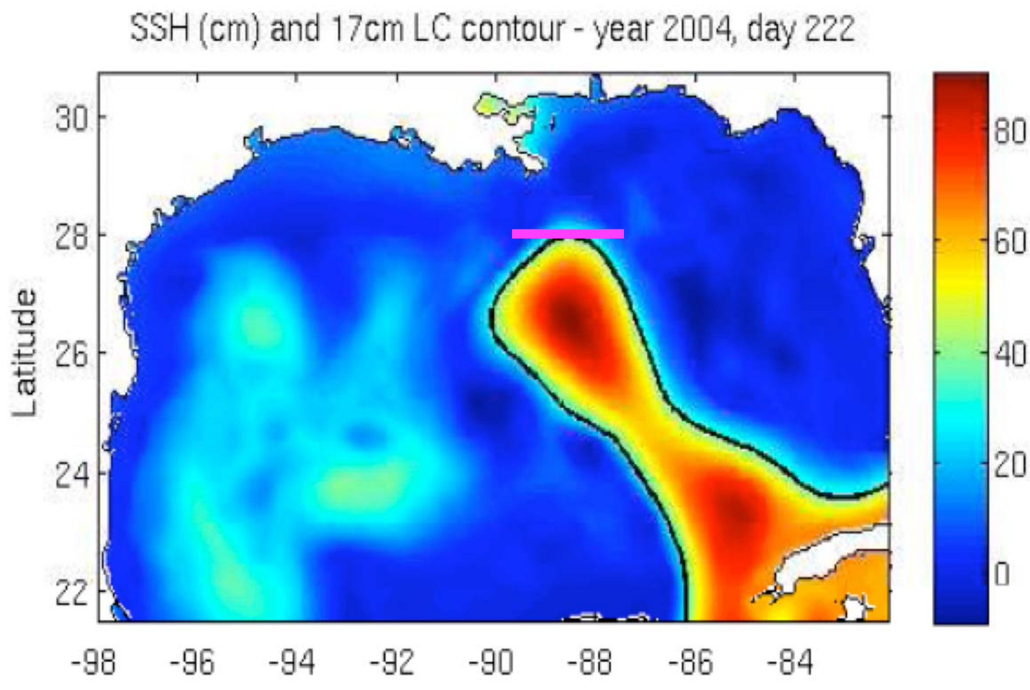


Barotropic Q_{fw} ***Baroclinic Q_{fw}***

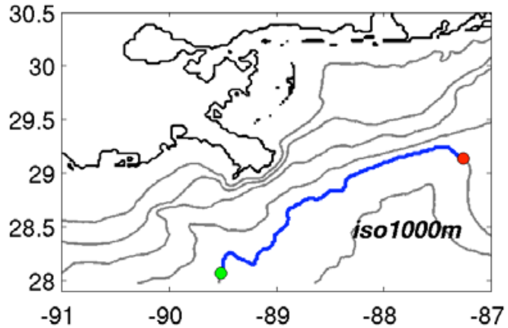
m1,m2	***>0 eastward*** ***<0 westward***
z1	***>0 northward*** ***<0 southward***
s1	***>0 onshore*** ***<0 offshore***

Loop Current impact

- Tracking the 17cm ssh contour
- Indicative of the location of the upper core of the LC (Leben, 2005)
- Years 2004-2005

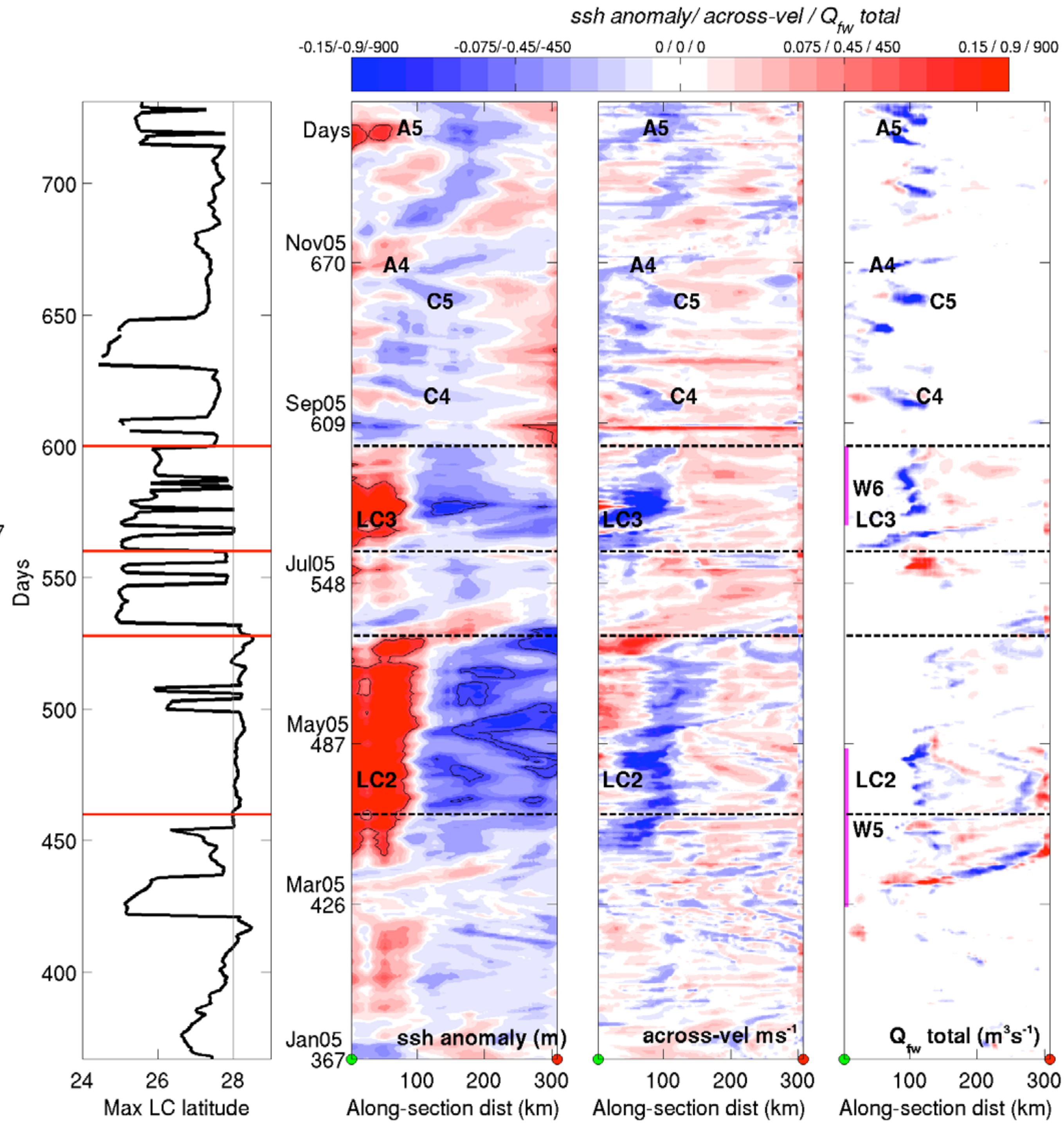


Offshore freshwater fluxes - Year 2005

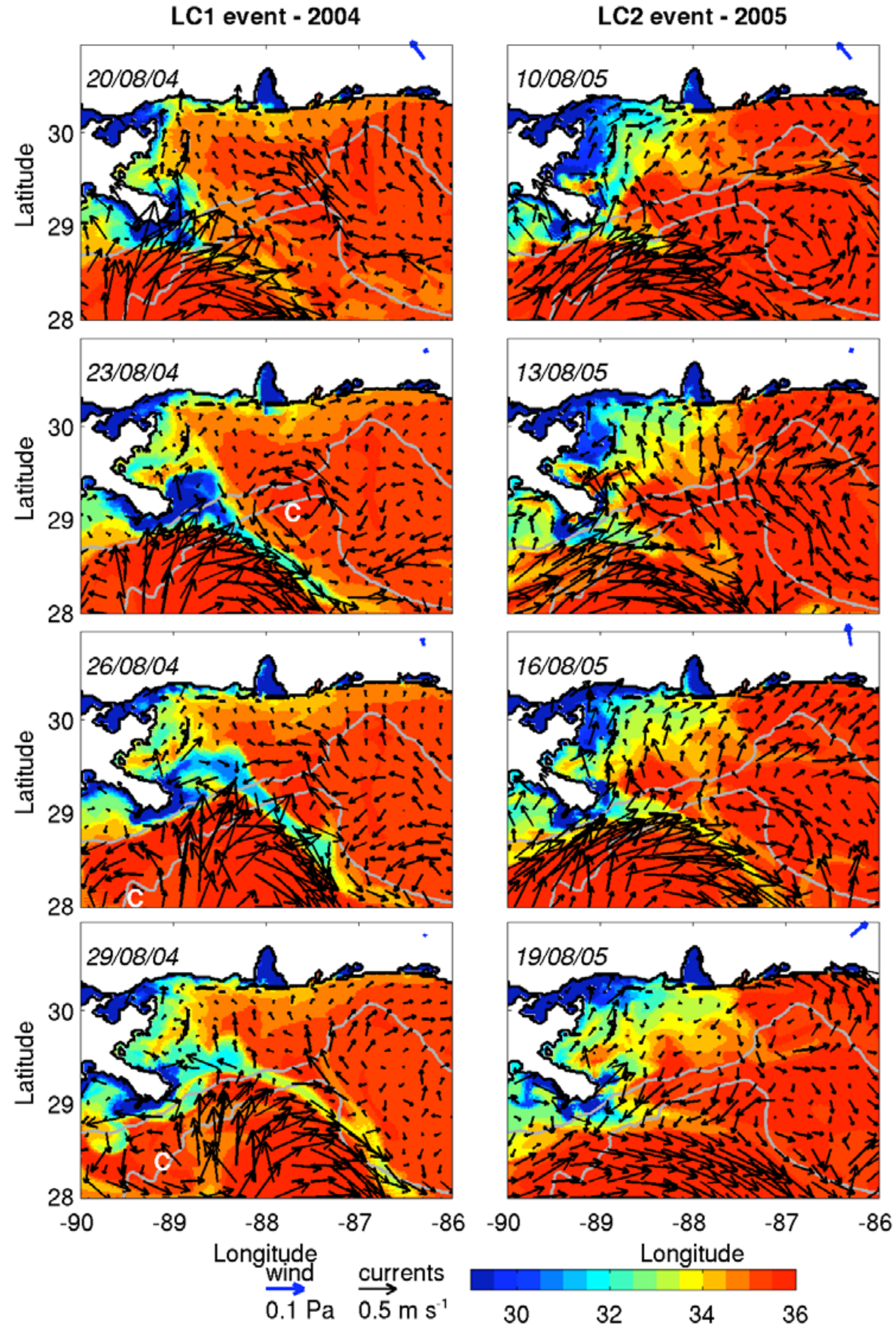


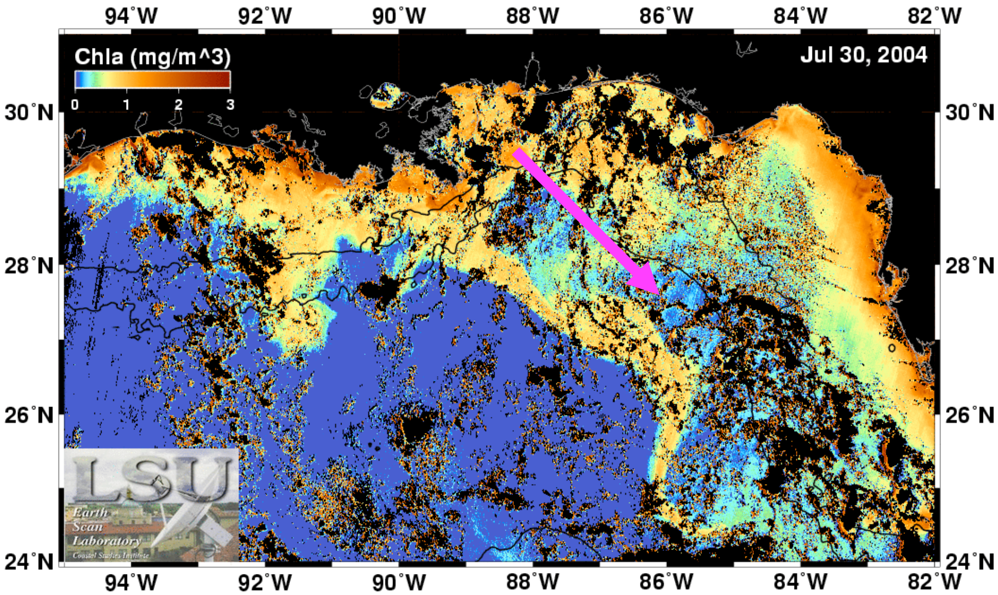
ssh anomaly: Negative / positive

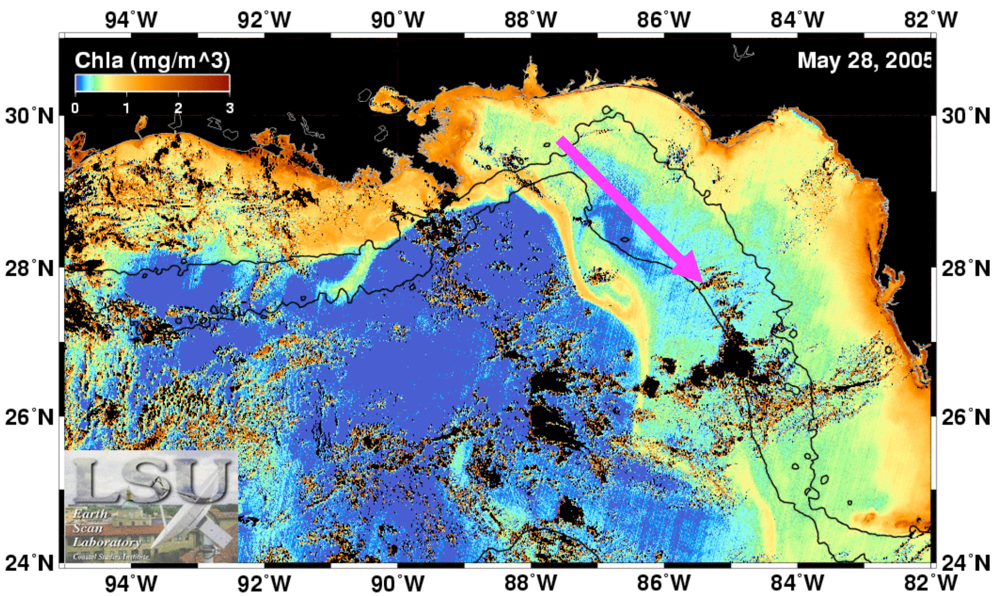
across-vel and Q_{fw}: Offshore / onshore



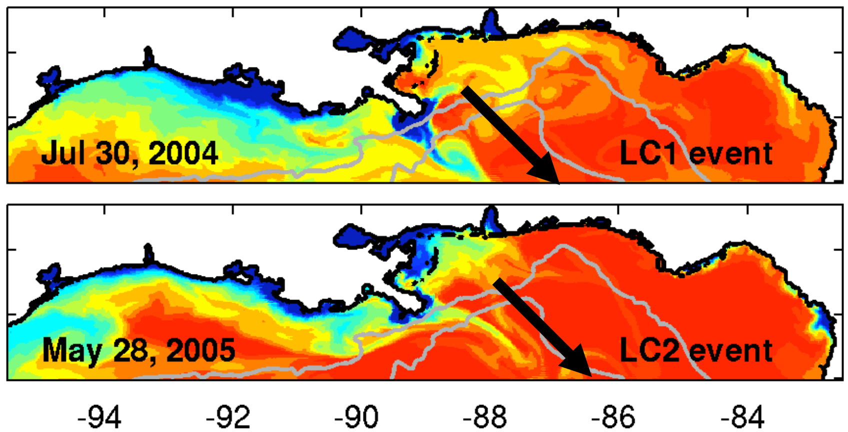
Entrainment by the LC system



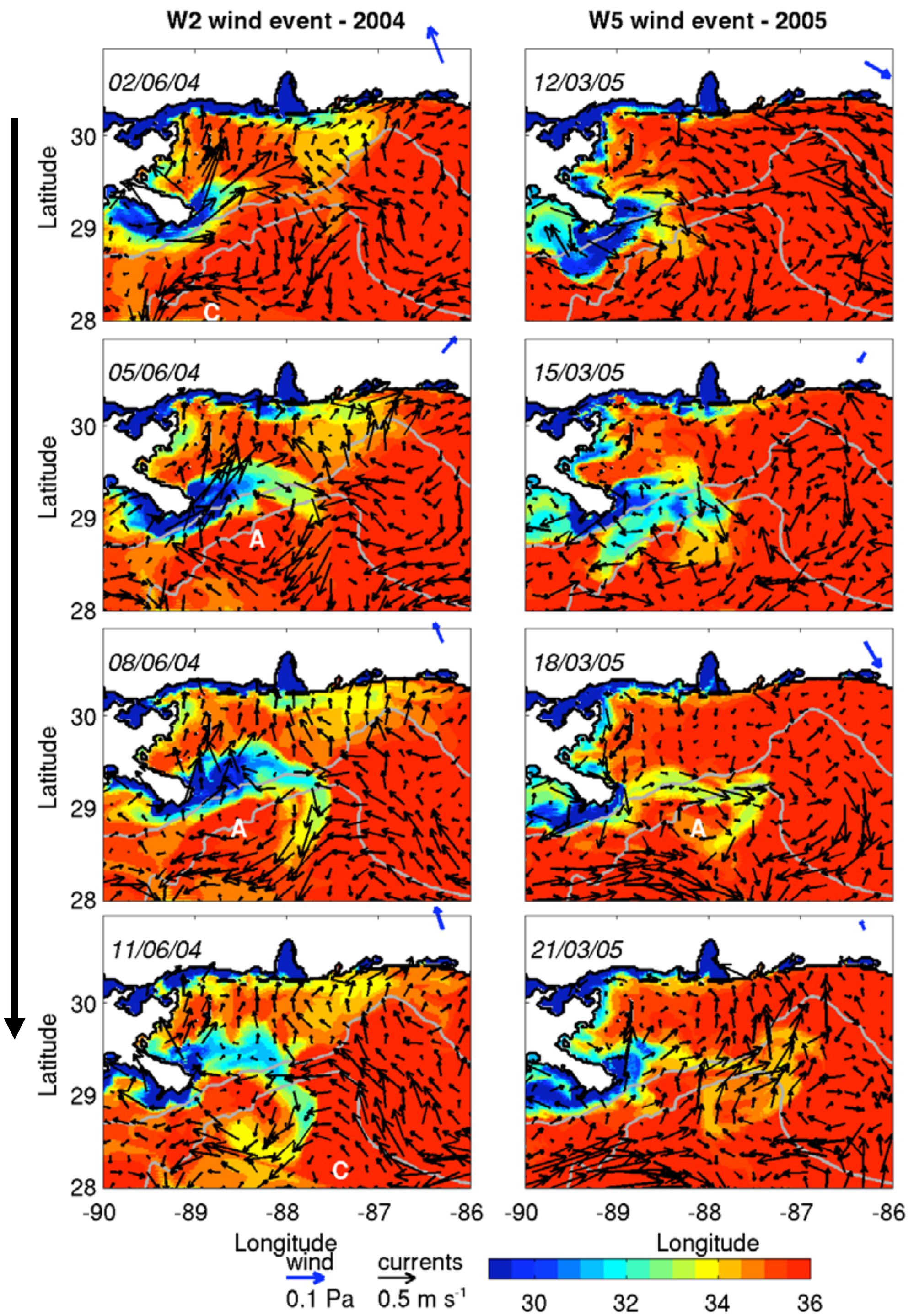


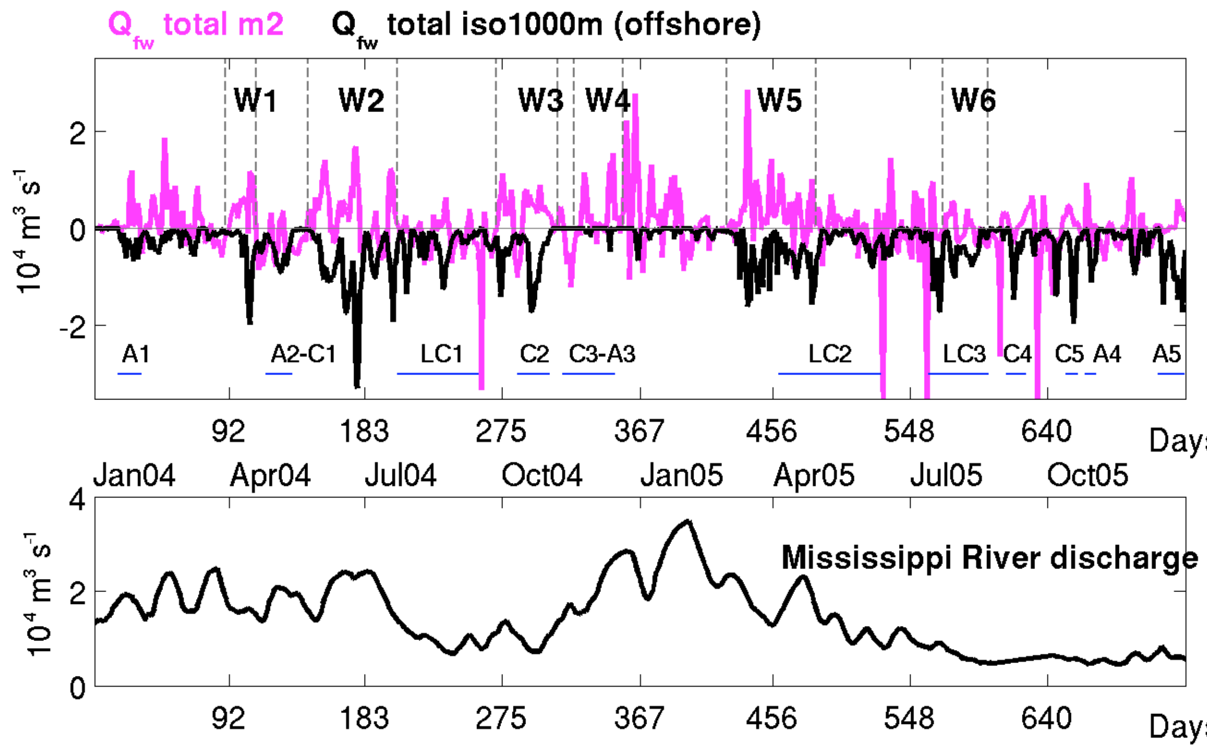


Model surface salinity



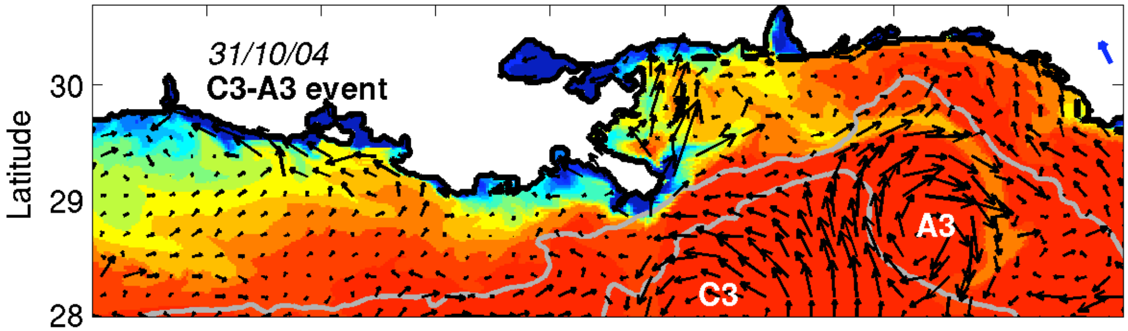
Offshore removal in the presence of S-SW winds





Q fw total m2
Q fw total iso1000m (offshore)
W1
W2
W3
W4
W5
W6
A1
A2-C1
LC1
C2
C3-A3
LC2
LC3
C4
C5
A4
A5
10^4 m^3 s^-1
2
0
-2
92
183
275
367
456
548
640
Days
Jan04
Apr04
Jul04
Oct04
Jan05
Apr05
Jul05
Oct05
Mississippi River discharge
4

Eddy dipoles and variability of pathways



Cyclone-Anticyclone and transport towards the head of the DeSoto Canyon

Summary

Complex interactions determine the fate of Mississippi River waters in the Northern Gulf of Mexico (Schiller et al., 2011, JGR, accepted).

- Offshore removal is a frequent plume pathway;
- Eastward freshwater transport by wind-driven currents towards the DeSoto Canyon facilitate the offshore removal and eddy entrainment process;
- The steep topography near the delta makes the proximity of eddies to the shelfbreak is a sufficient condition for the offshore transport;
- Offshore pathways depend on the position of the eddies, their life span and formation of eddy pairs;
- Downscaling of a larger scale coarser model, and nesting to a data-assimilative model, is a desirable approach to reproduce complex coastal-to-offshore interactions.

Current steps: Put things into perspective >> investigate the effect of the eddy entrainment on a multi-year NGoM freshwater budget.

Acknowledgements

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