The Dynamics of the Mississippi River Plume and Interactions with Coastal and Offshore Flows in the Northern Gulf of Mexico

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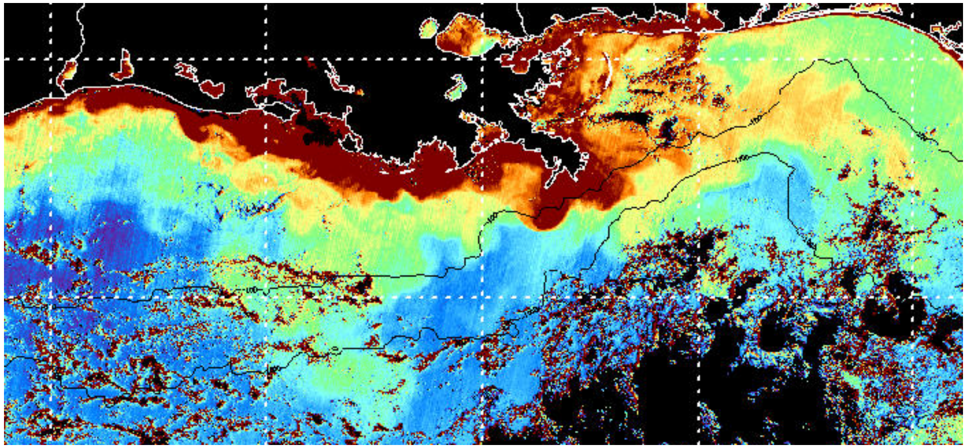
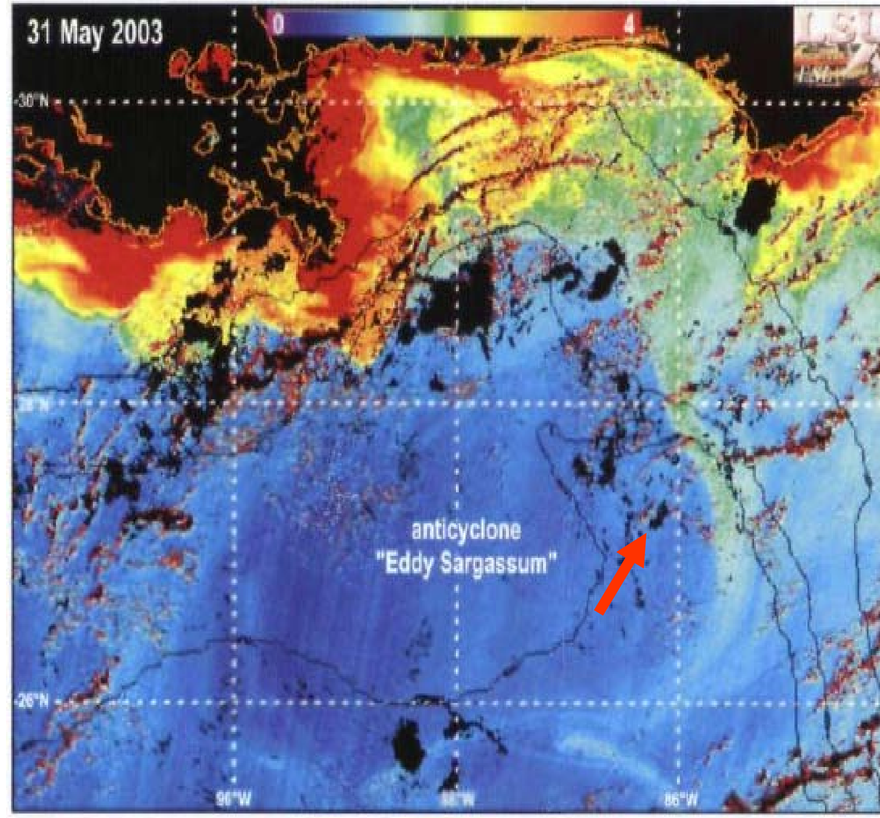
The Mississippi River plume dynamics – Northern GoM



Nan Walker, LSU-ESL



Walker et. al, 2005.

WHY CARE:

- **Drains 41% of the continental US**
- **210 * 10^6 tons/year of sediment**
- **28% of the total US catch**
- **Summer time hypoxia**
- **ecosystem management and water quality purposes**

GENERAL OBJECTIVE:

Understand the dynamics of a large river plume in a complex scenario, where STRONG BOUNDARY CURRENTS, VARIABLE WIND and TOPOGRAPHIC CONSTRAINS are present.

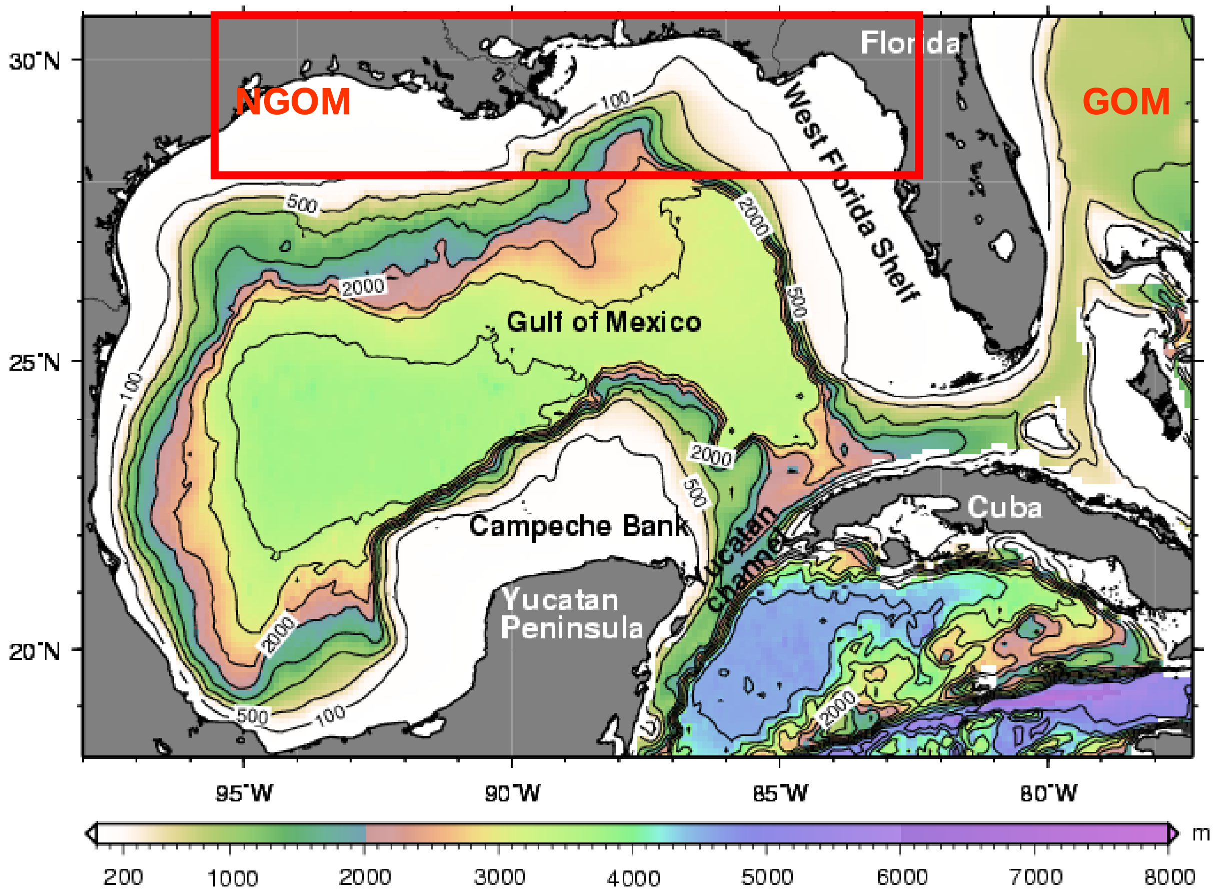
GOALS:

- *Determine the dynamic processes controlling the transport and fate of Mississippi River waters:*

    - *Coastal, wind-driven circulation*
    - *Offshore, eddy-driven circulation*
    - *Interactive processes*

- *Enhancement of coastal prediction capabilities in the Northern Gulf of Mexico.*

Methodology



- ✓ 1 year realistic simulation (2004)
- ✓ High freq. 3-hourly COAMPS 27km atm forcing
- ✓ Daily lateral boundary conditions, monthly river inflows

✓ **HYCOM**

GOM-HYCOM (nested in ATL-HYCOM)

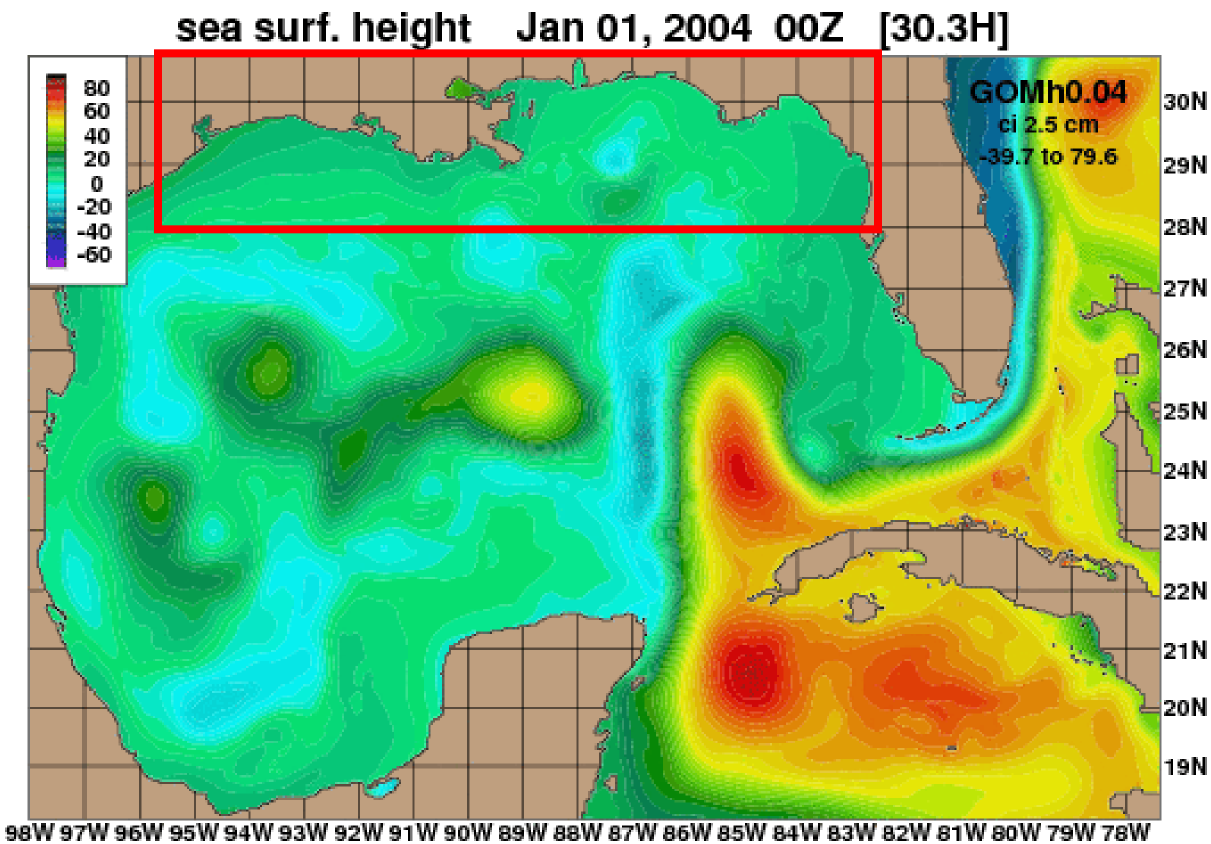
- ✓ 1/25° hor. Resolution
- ✓ 20 vertical levels
- ✓ NCODA data assimilation (Cummings, 2005)

NGOM-HYCOM (nested in GOM-HYCOM)

- ✓ 1/50° hor. Resolution
- ✓ 20 vertical levels
- ✓ No data assimilation
- ✓ 2m minimum water depth

Loop Current activity (LCE and LCFEs)

GOM simulation: lateral boundary conditions



Provided by Pat Hogan (NRL)

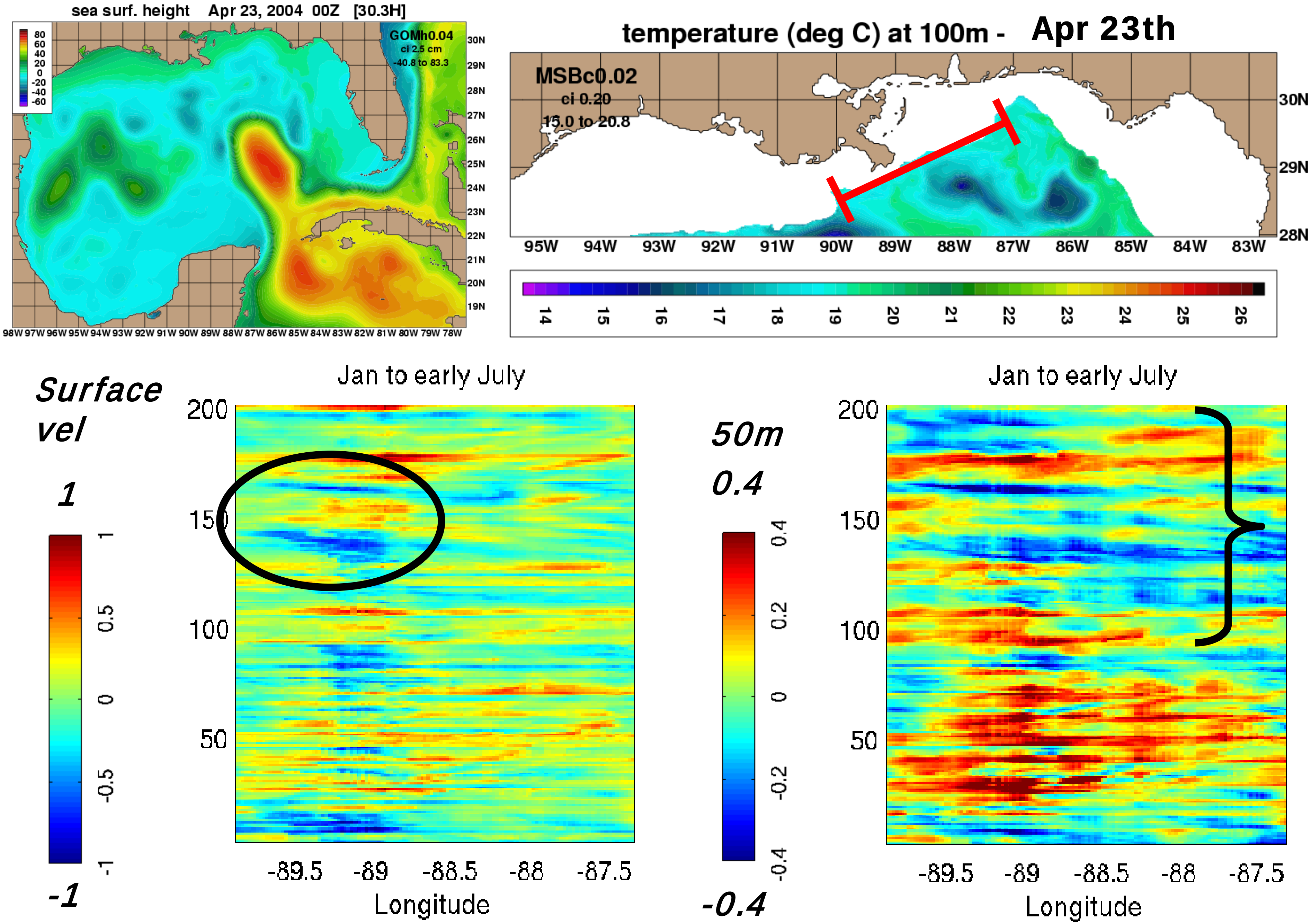
Growing stage: Jan to early July

- *No direct impact from LC system*
- *Cyclonic eddy field over the Northern Gulf*

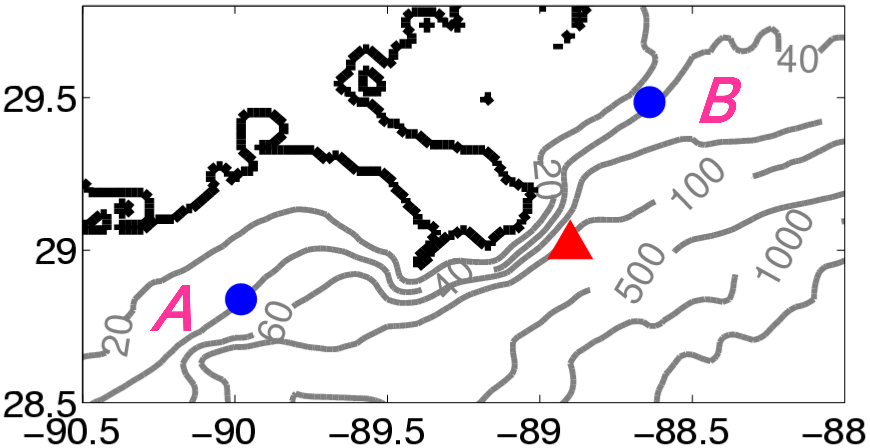
Mature stage: Mid July to early Sep

- *Shedding of LCE*
- *Impact of LCE on the Northern Gulf*

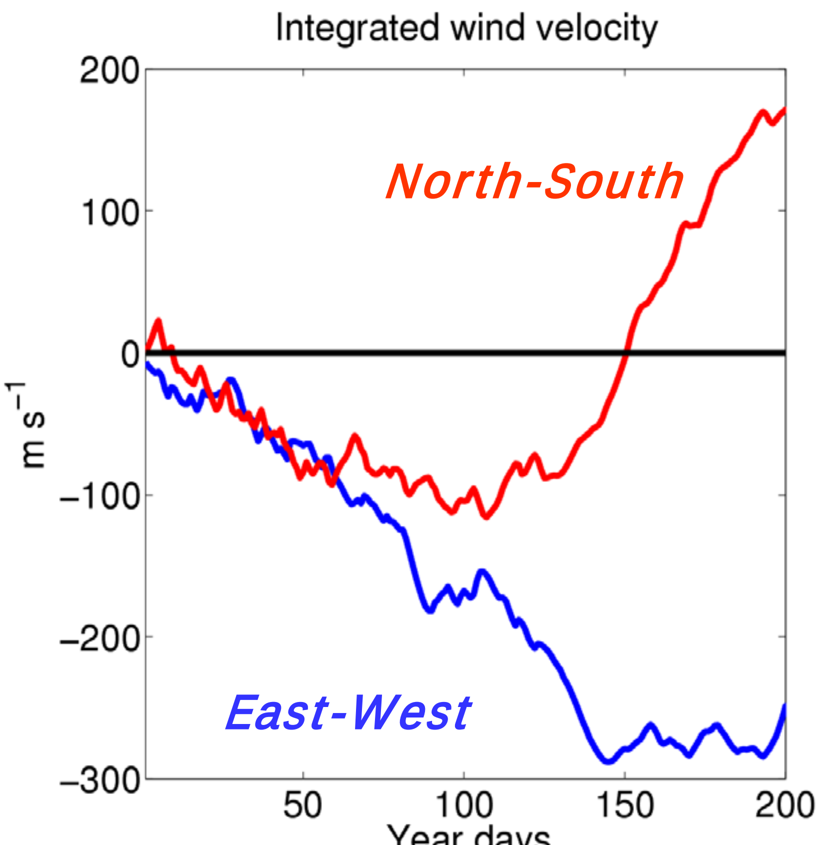
LC retreat to young stage: Sep to Dec



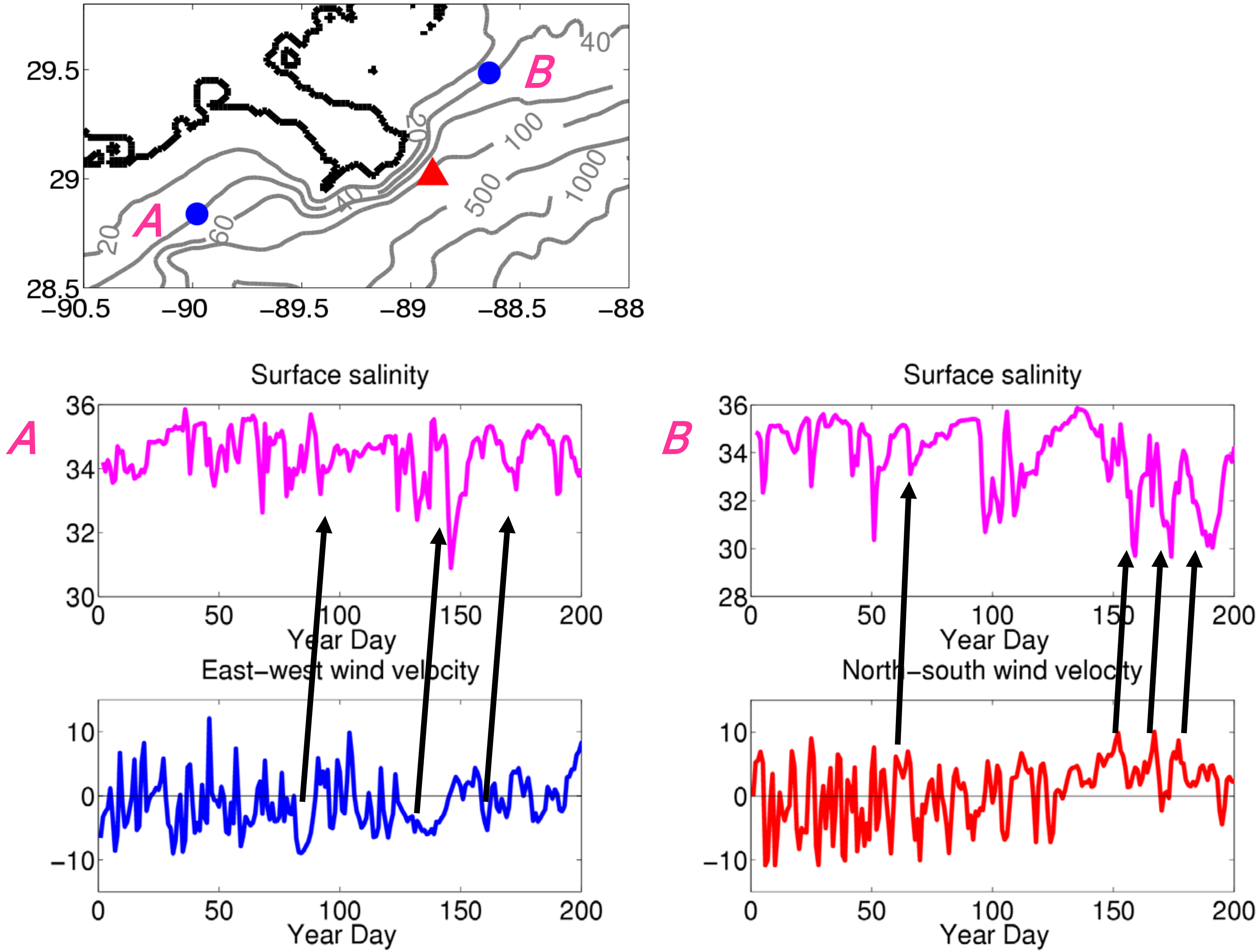
sea surf. height Apr 23, 2004 00Z [30.3H]
GOMh0.04
ci 2.5 cm
-40.8 to 83.3
temperature (deg C) at 100m - Apr 23th
MSBc0.02
ci 0.20
15.0 to 20.8
95W 94W 93W 92W 91W 90W 89W 88W 87W 86W 85W 84W 83W
28N 29N 30N
14 15 16 17 18 19 20 21 22 23 24 25 26
Surface vel
1
-1
Jan to early July
200 150 100 50
-89.5 -89 -88.5 -88 -87.5
Longitude
50m
0.4
-0.4
Jan to early July
200 150 100 50
-89.5 -89 -88.5 -88 -87.5
Longitude



29.5
29
28.5
−90.5
−90
−89.5
−89
−88.5
−88
A
B
20
40
60
100
500
1000



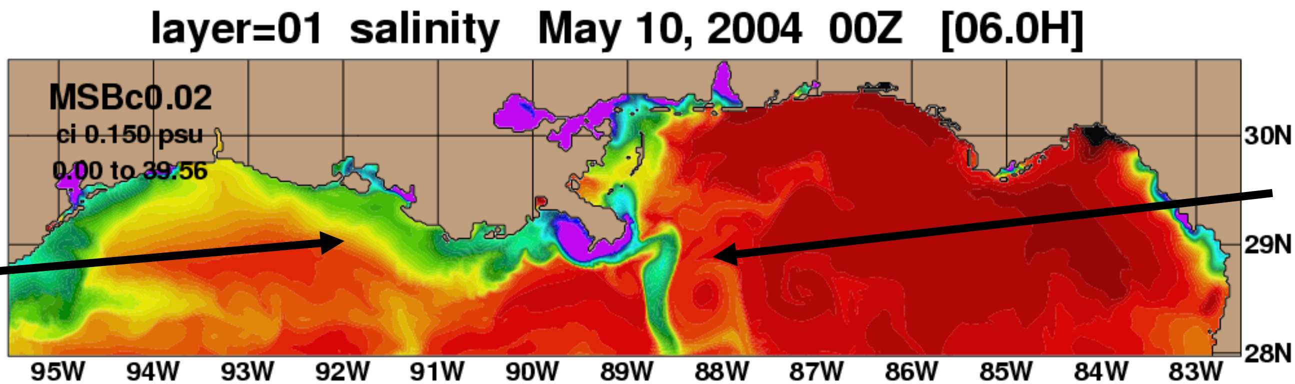
Integrated wind velocity
200
100
0
−100
−200
−300
m s^{-1}
50
100
150
200
Year days
North-South
East-West



A
B
29.5
29
28.5
−90.5
−90
−89.5
−89
−88.5
−88
20
40
60
100
500
1000
A
Surface salinity
Year Day
East−west wind velocity
Year Day
B
Surface salinity
Year Day
North−south wind velocity
Year Day

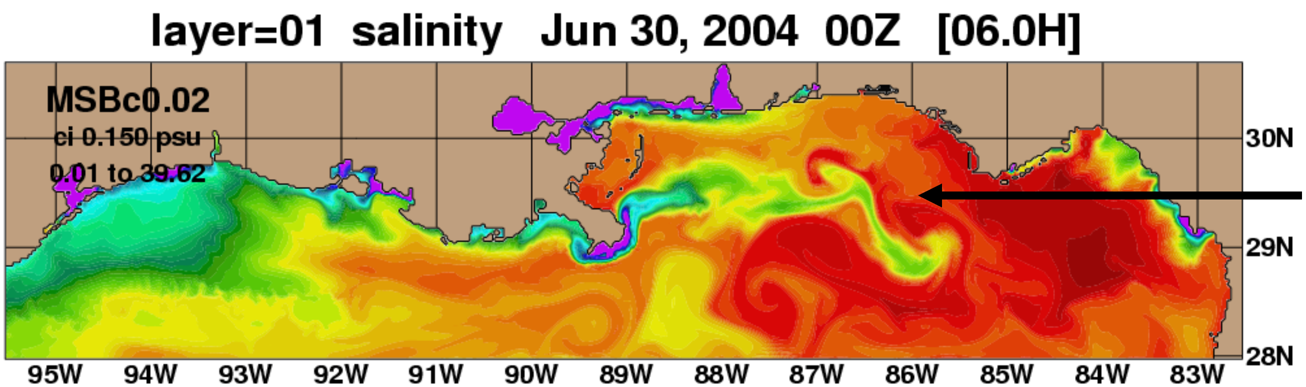
wind

Westward **wind-driven along-shelf transport**

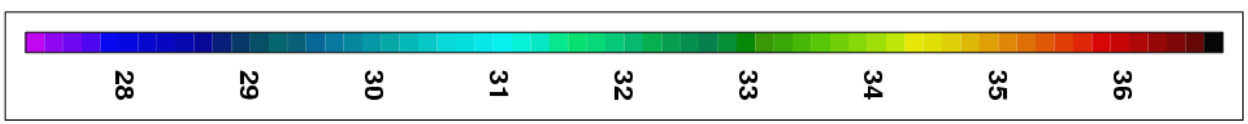


Eddy across-shelf transport

wind

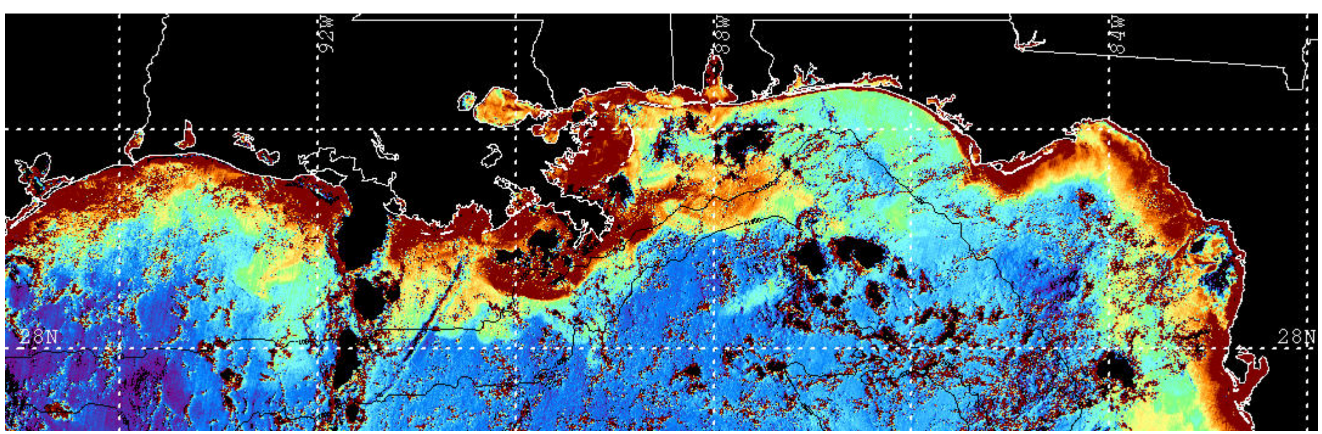


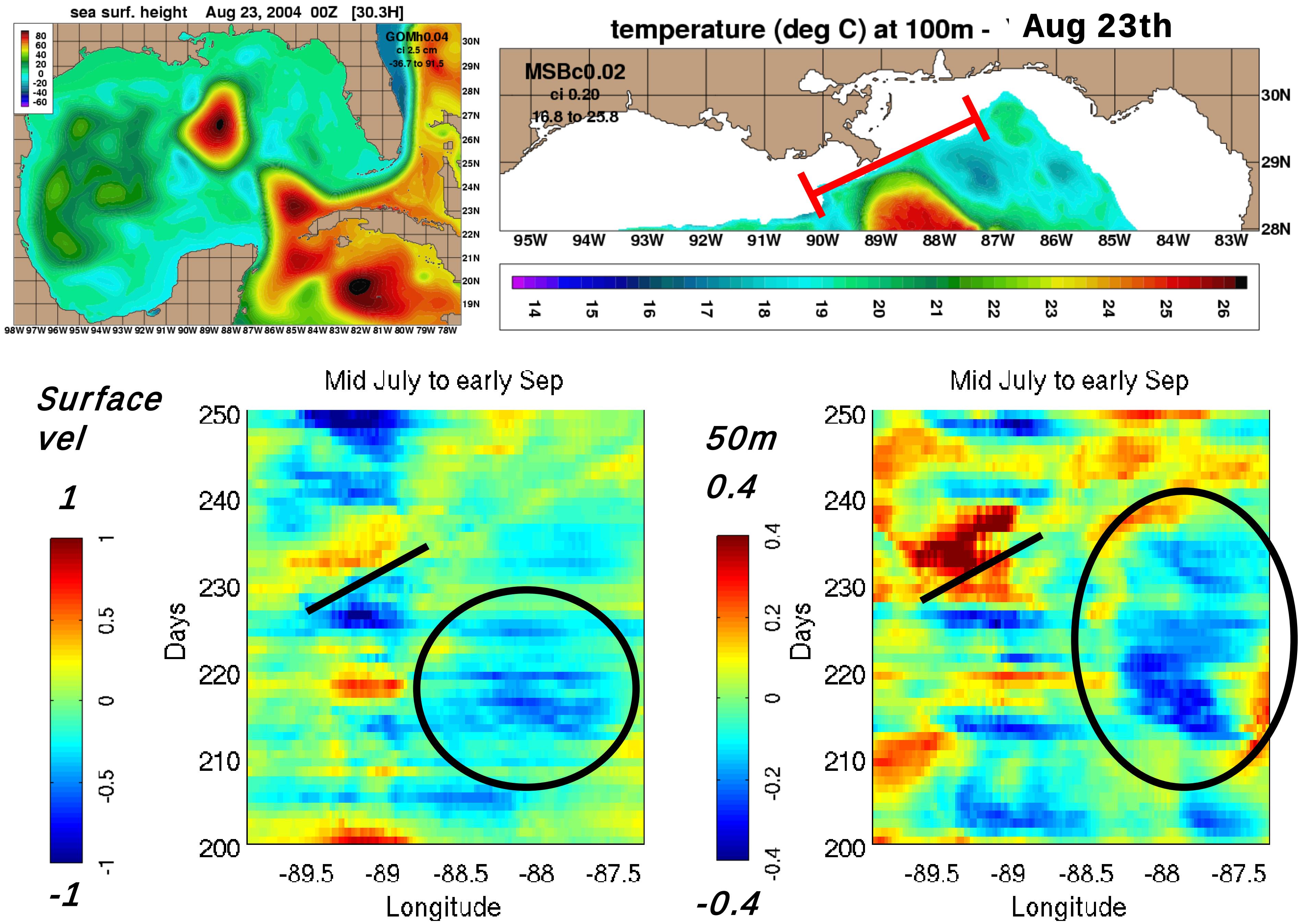
Eastward **wind-driven along-shelf transport**



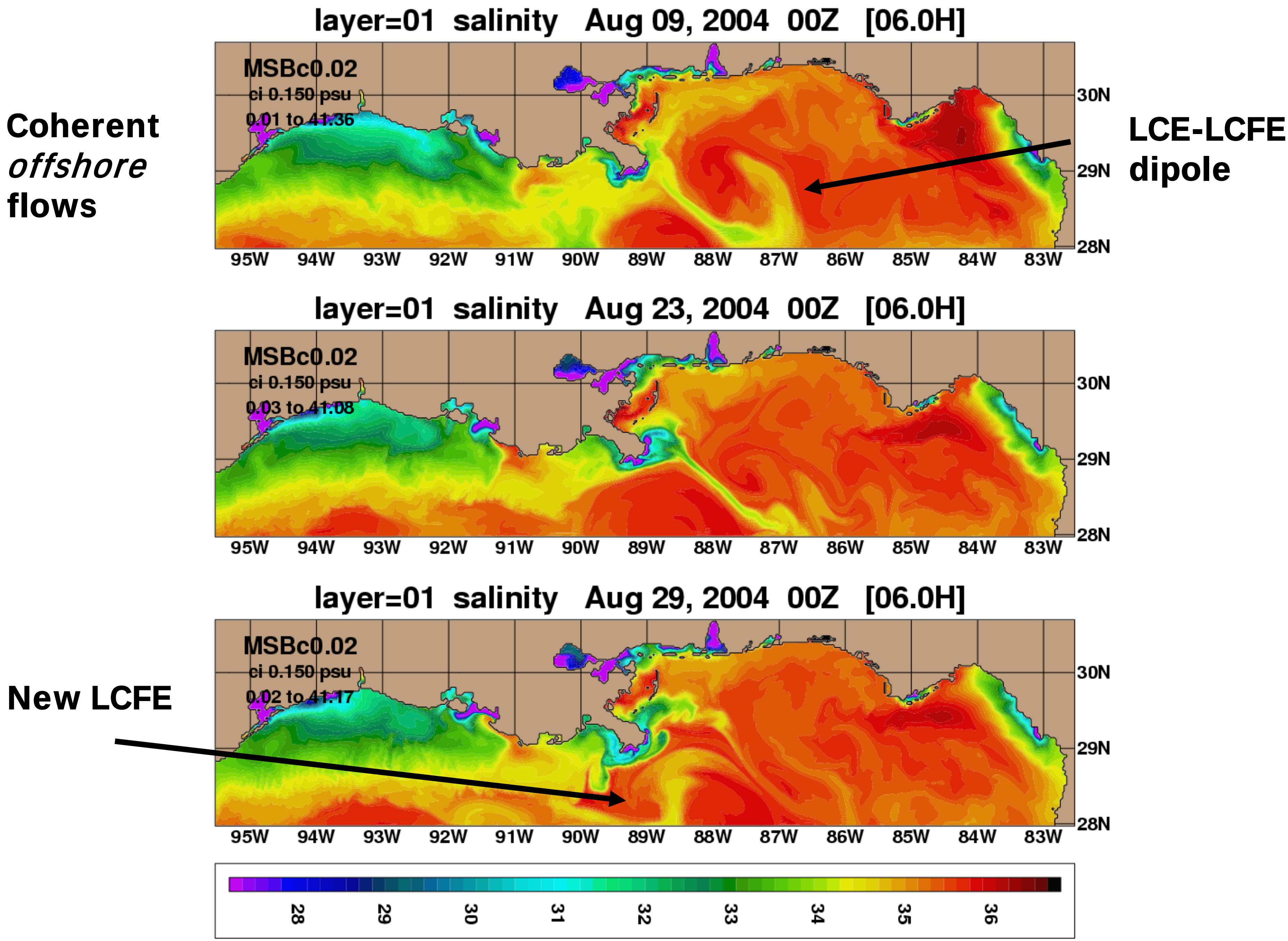
Jun 30th

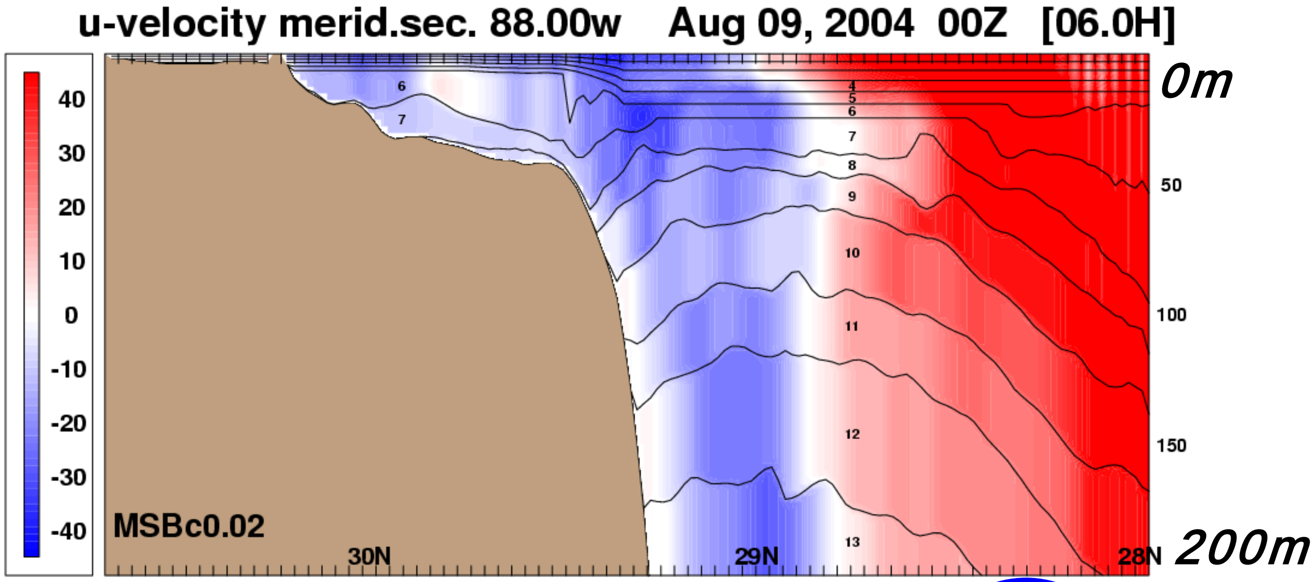
LSU-ESL



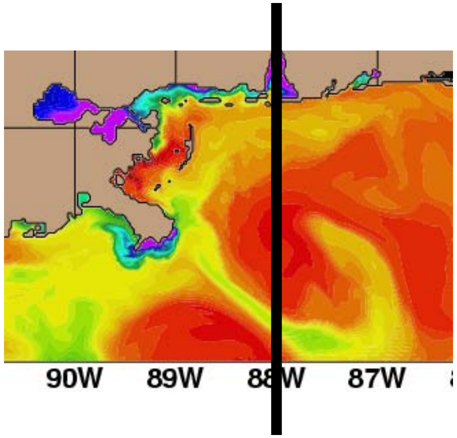


sea surf. height Aug 23, 2004 00Z [30.3H]
GOMh0.04
ci 2.5 cm
-36.7 to 91.5
80
60
40
20
0
-20
-40
-60
30N 29N 28N 27N 26N 25N 24N 23N 22N 21N 20N 19N
98W 97W 96W 95W 94W 93W 92W 91W 90W 89W 88W 87W 86W 85W 84W 83W 82W 81W 80W 79W 78W
temperature (deg C) at 100m - Aug 23th
MSBc0.02
ci 0.20
16.8 to 25.8
30N 29N 28N
95W 94W 93W 92W 91W 90W 89W 88W 87W 86W 85W 84W 83W
14 15 16 17 18 19 20 21 22 23 24 25 26
Surface vel
1
-1
1 0.5 0 -0.5 -1
Mid July to early Sep
Days
250 240 230 220 210 200
-89.5 -89 -88.5 -88 -87.5
Longitude
50m
0.4
-0.4
0.4 0.2 0 -0.2 -0.4
Mid July to early Sep
Days
250 240 230 220 210 200
-89.5 -89 -88.5 -88 -87.5
Longitude

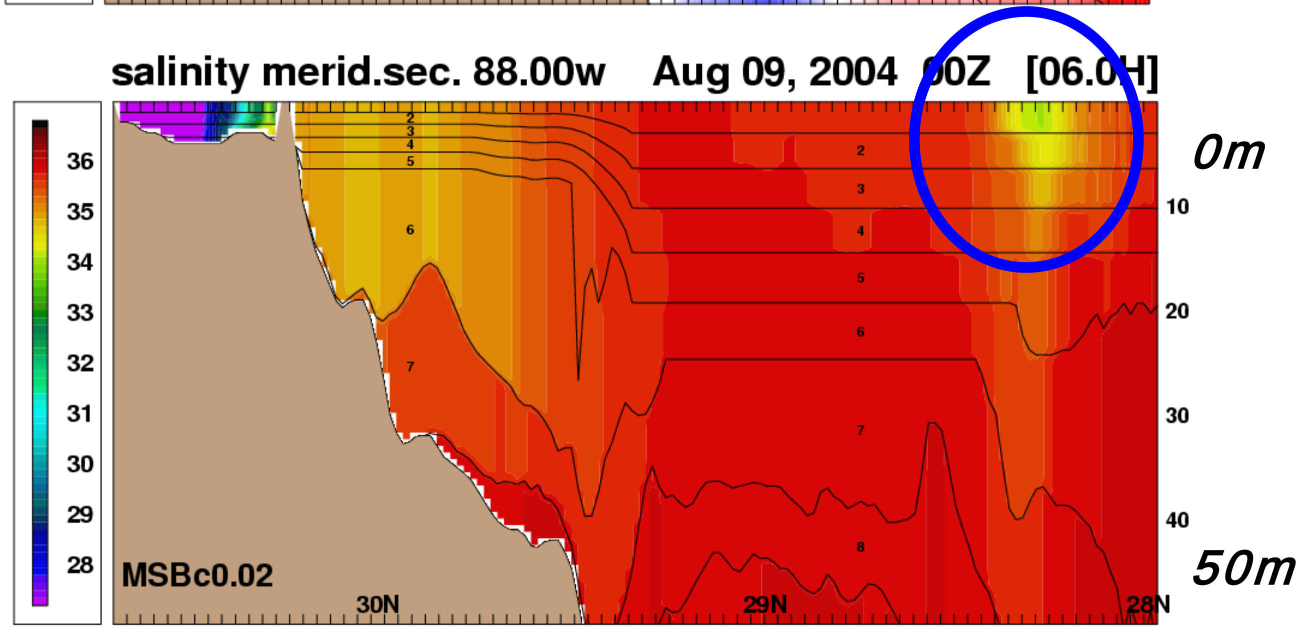

Coherent *offshore* flows
LCE-LCFE dipole
New LCFE
layer=01 salinity Aug 09, 2004 00Z [06.0H]
MSBc0.02
ci 0.150 psu
0.01 to 41.36
layer=01 salinity Aug 23, 2004 00Z [06.0H]
MSBc0.02
ci 0.150 psu
0.03 to 41.08
layer=01 salinity Aug 29, 2004 00Z [06.0H]
MSBc0.02
ci 0.150 psu
0.02 to 41.17
95W 94W 93W 92W 91W 90W 89W 88W 87W 86W 85W 84W 83W
30N 29N 28N
28 29 30 31 32 33 34 35 36



u-velocity merid.sec. 88.00w Aug 09, 2004 00Z [06.0H]
40
30
20
10
0
-10
-20
-30
-40
MSBc0.02
30N
29N
28N
0m
50
100
150
200m

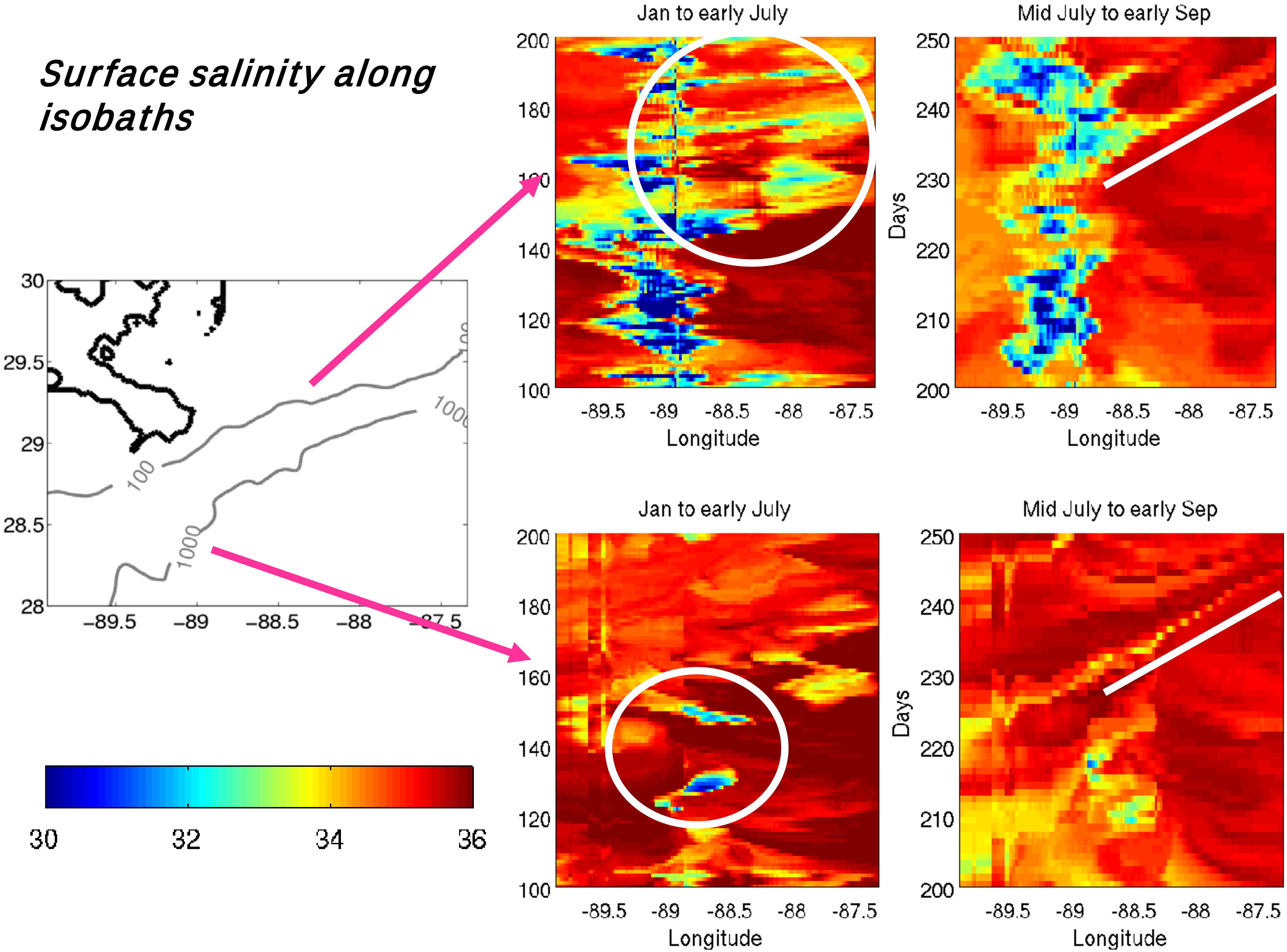


90W
89W
88W
87W



salinity merid.sec. 88.00w Aug 09, 2004 00Z [06.0H]
36
35
34
33
32
31
30
29
28
MSBc0.02
30N
29N
28N
0m
10
20
30
40
50m

Surface salinity along isobaths



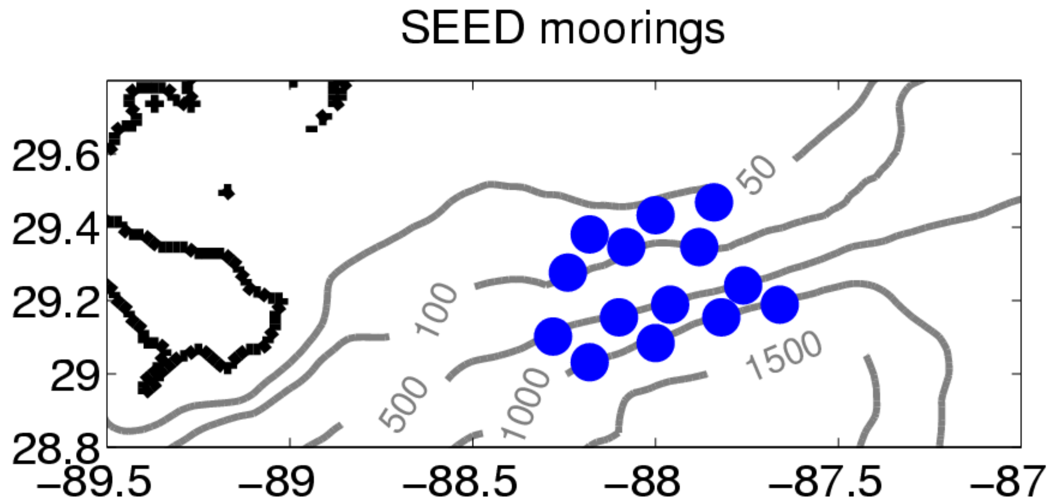
Comparison to observations – SEED array

✓ **Slope to Shelf Energetics and Exchange Dynamics Project (NRL)**

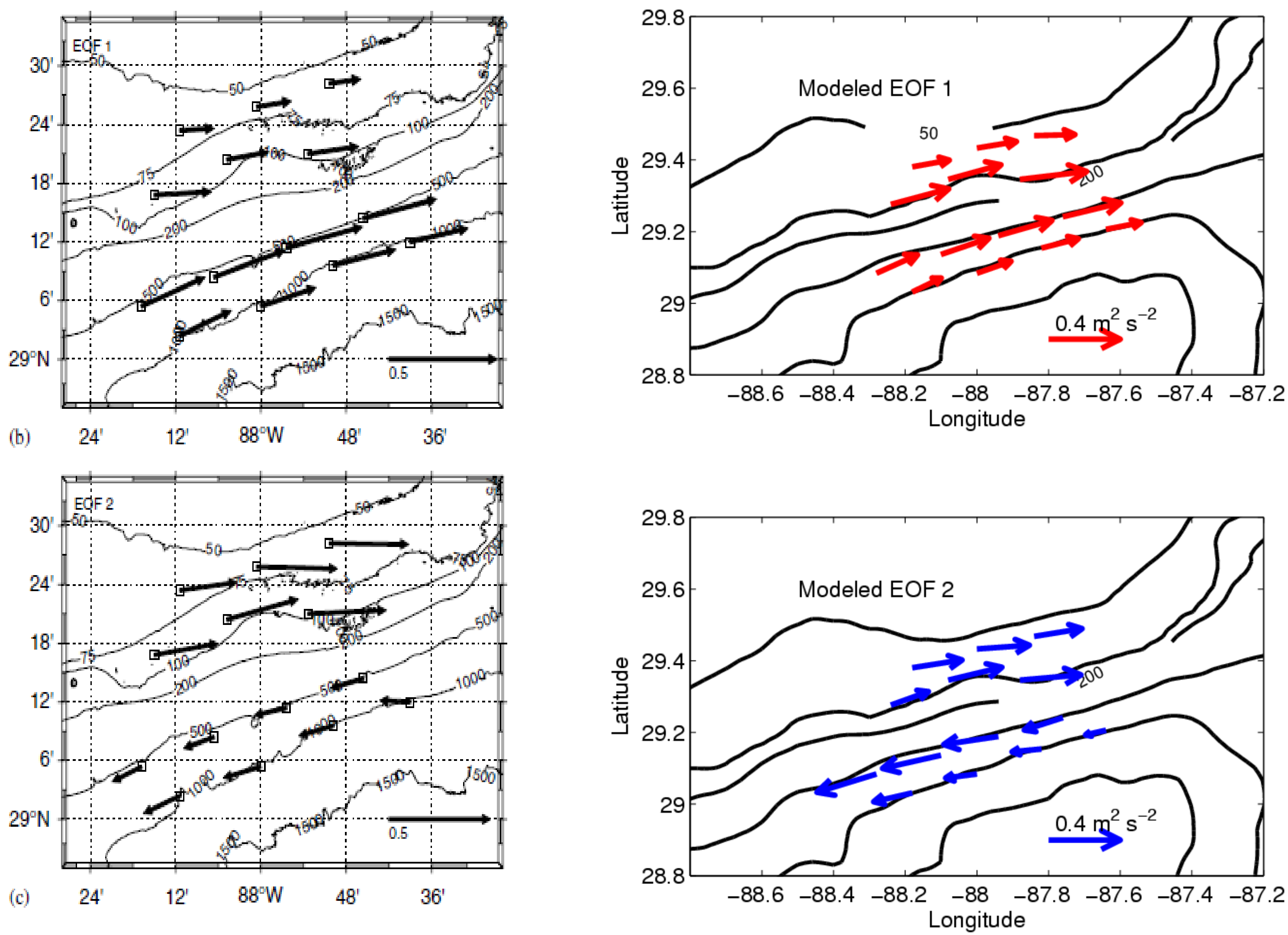
✓**14 moorings – ADCP deployments**

✓ **May 2004 – May 2005**

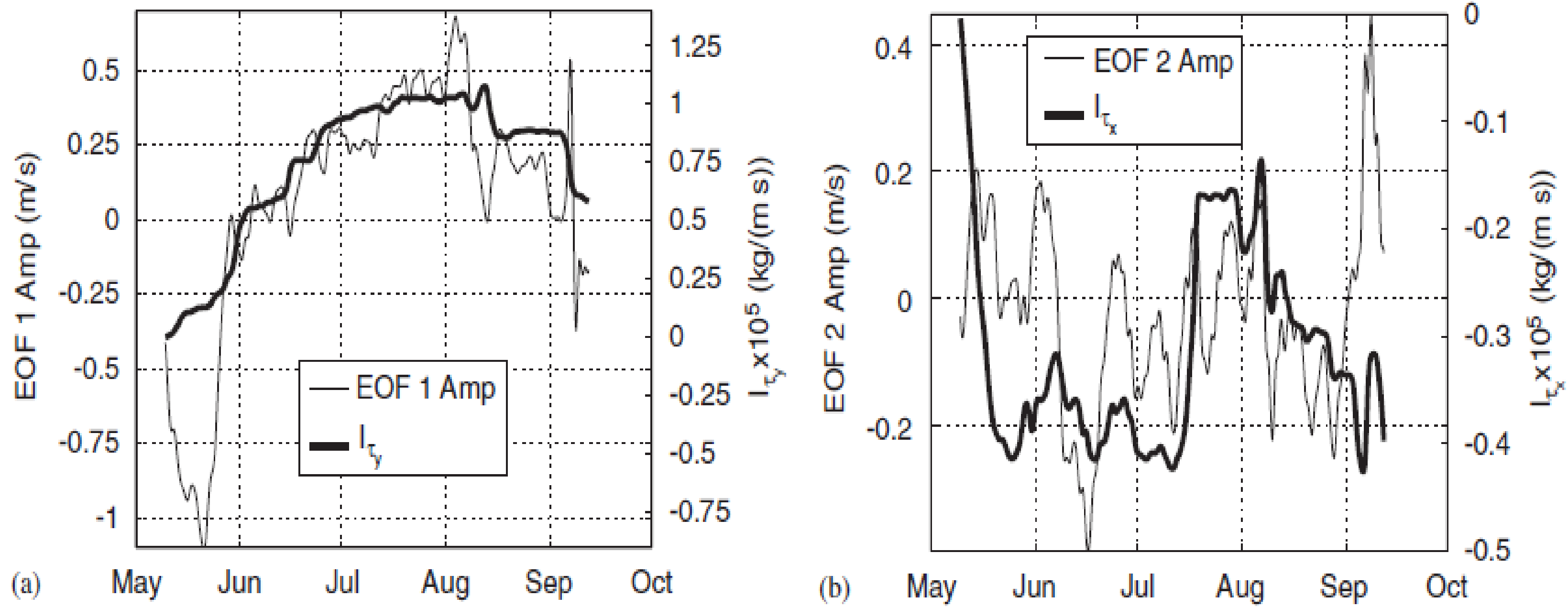
✓ **Teague et al. (2006), Carnes et al. (2007), among others**

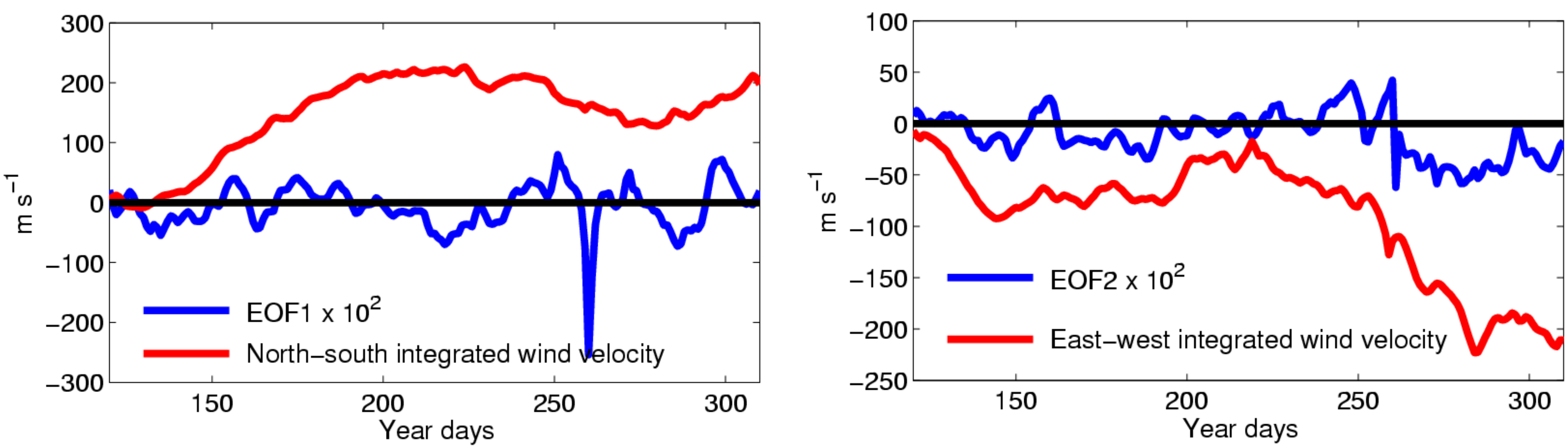


EOF analysis: Depth-averaged currents (May – Oct 2004)



EOF 1: 68.4% EOF 2: 14.5% EOF 1: 60% EOF 2: 21%


EOF 1 Amp (m/s)
0.5
0.25
0
-0.25
-0.5
-0.75
-1
1.25
1
0.75
0.5
0.25
0
-0.25
-0.5
-0.75
I_{τ_y}x10^5 (kg/(m s))
EOF 1 Amp
I_{τ_y}
(a)
May
Jun
Jul
Aug
Sep
Oct
EOF 2 Amp (m/s)
0.4
0.2
0
-0.2
0
-0.1
-0.2
-0.3
-0.4
-0.5
I_{τ_x}x10^5 (kg/(m s))
EOF 2 Amp
I_{τ_x}
(b)
May
Jun
Jul
Aug
Sep
Oct


m s^{-1}
300
200
100
0
−100
−200
−300
EOF1 x 10^2
North−south integrated wind velocity
150
200
250
300
Year days
m s^{-1}
100
50
0
−50
−100
−150
−200
−250
EOF2 x 10^2
East−west integrated wind velocity
150
200
250
300
Year days

Summary

- **Complex interactions determine the fate of MR waters in the northern Gulf**

- **Persistent wind periods are essential**
- **Wind-driven transport is important in the vicinity of the Delta**
- **North/eastward winds enhance offshore removal by eddies**

- **Eddies effectively entrain MR waters even in during unfavorable wind events.**
- **“Correct” positioning of eddies is essential to offshore removal processes**

- **Downscaling from larger scale models to high resolution coastal models is essential to effectively resolve such interactions.**