# Nested Gulf of Mexico Modeling with HYCOM

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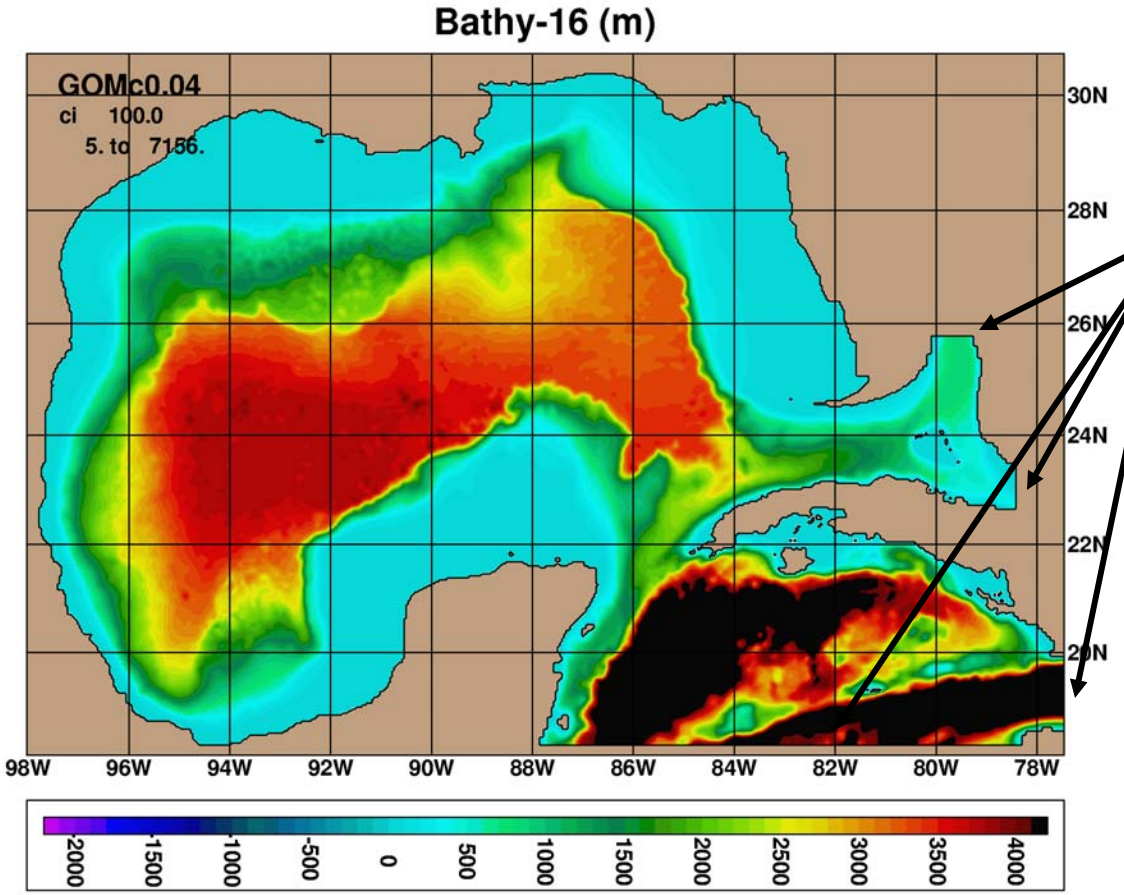
## *Brief Outline*

- 1/25° Free-Running Nested Gulf of Mexico
- 1/12° Assimilative Nested Gulf of Mexico

## *1/25° Free-Running Nested Gulf of Mexico*

- Bathymetry is from NRL DBDB2
- Surface forcing is from 6-hourly/3-hourly NOGAPS (2000/2001)
- 20 layers in the vertical (bottom 5 from Atlantic discarded)
- 16 Rivers included as salinity flux
- Relaxation to SSS
- FCT2 for scalar advection
- Initialized from January 1, 2000 interannually forced Atlantic
- Lateral boundary conditions from 1/12°Atlantic HYCOM
- Integrated over 2000-2001

# 1/25° Gulf of Mexico Model (~4 km)




Open boundary locations

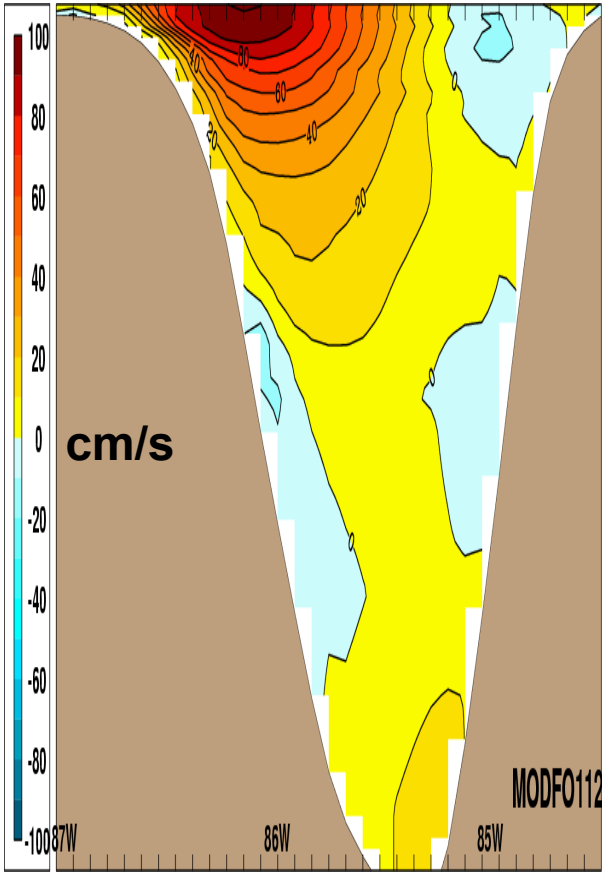
Method of Characteristics used
To update the barotropic mode

20 gridpoint buffer zone for baroclinic mode with e-folding time .1 to 10 days

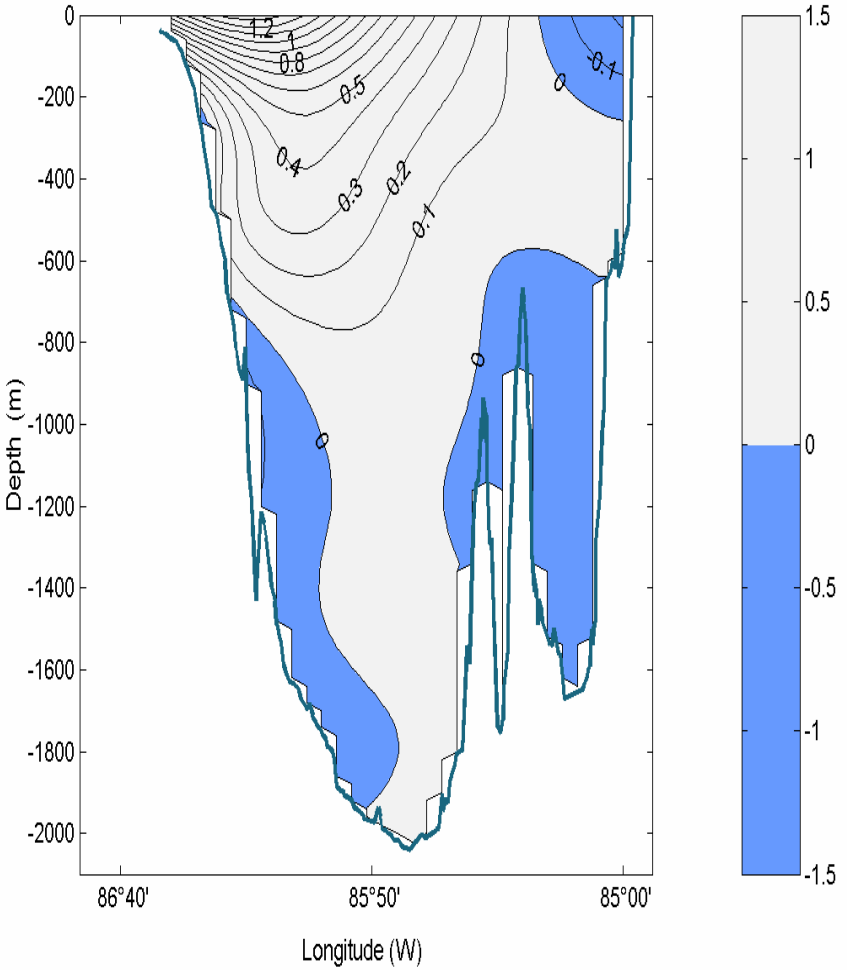
Atlantic boundary data provided daily

# Yucatan Channel Normal Velocity

1/12° Nested GOM HYCOM
September 1999 – June 2000




Observed Mean 8/1999-6/2000
(Abascal et al., JGR 2003)



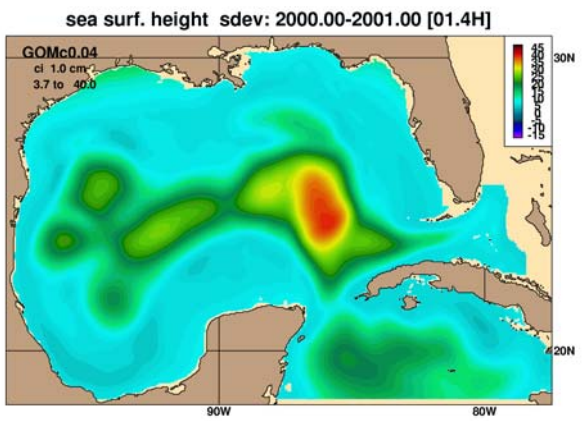

Note: boundary conditions from $\sigma_\theta$ MPDATA Atlantic simulation

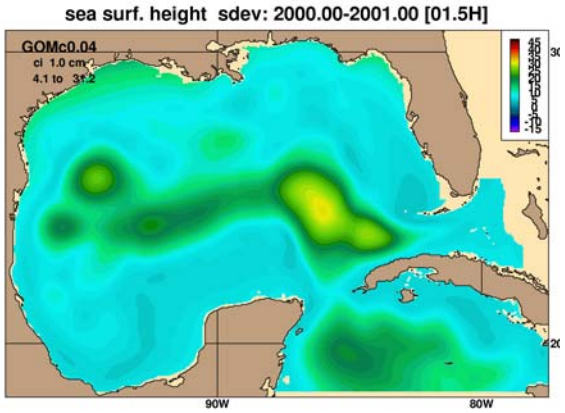
# 1/25° Free-Running Gulf of Mexico HYCOM

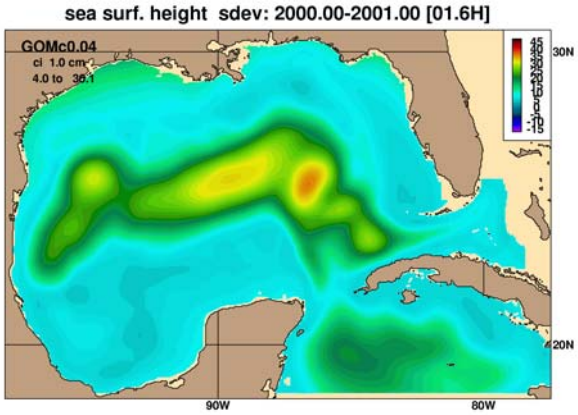
## RMS SSH Variability

KPP | MY-2.5 | GISS

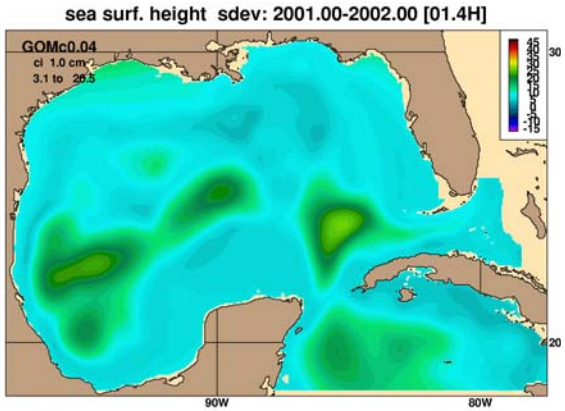
2000

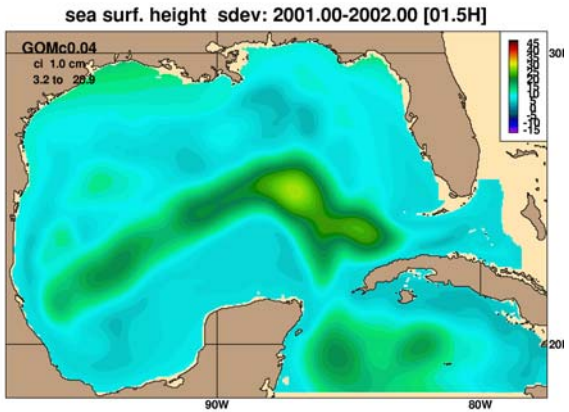


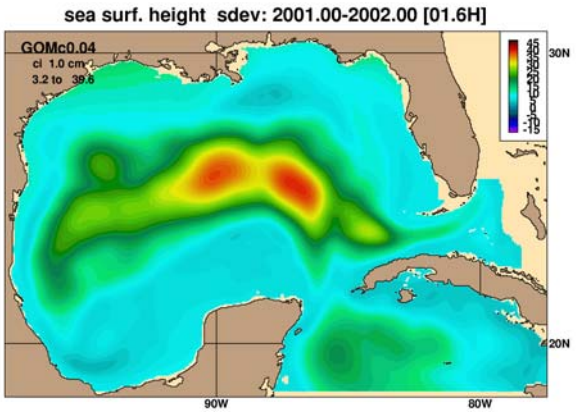




2001



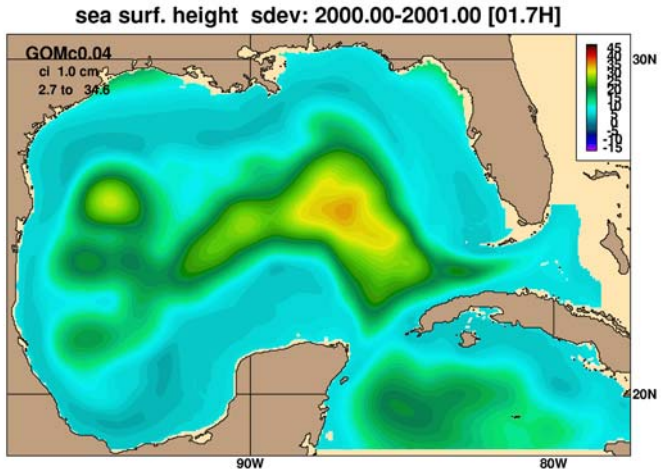
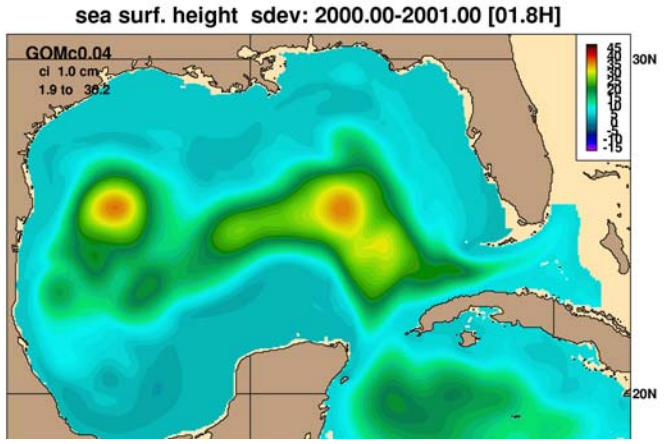
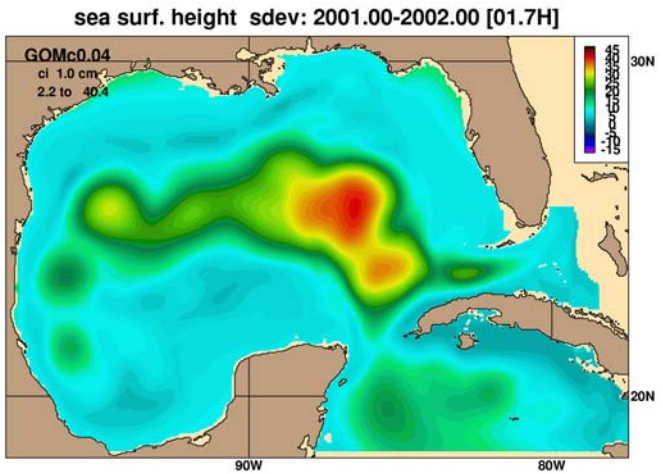
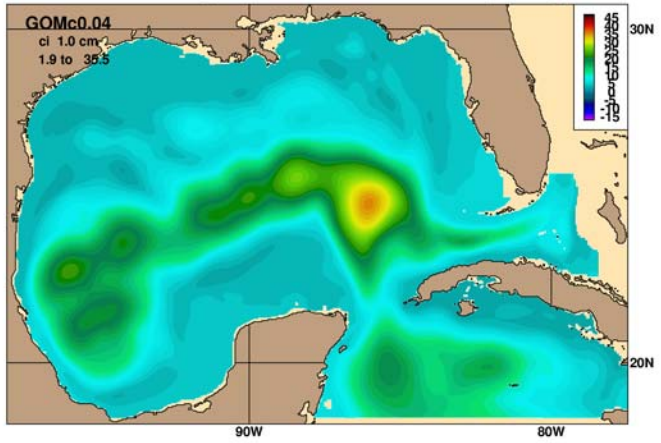




KPP variability low in 2001
MY-2.5 variability low in 2000 and 2001
Need longer time series for meaningful statistics

# 1/25° Nexted Gulf of Mexico HYCOM

## RMS Sea Surface Height Variability

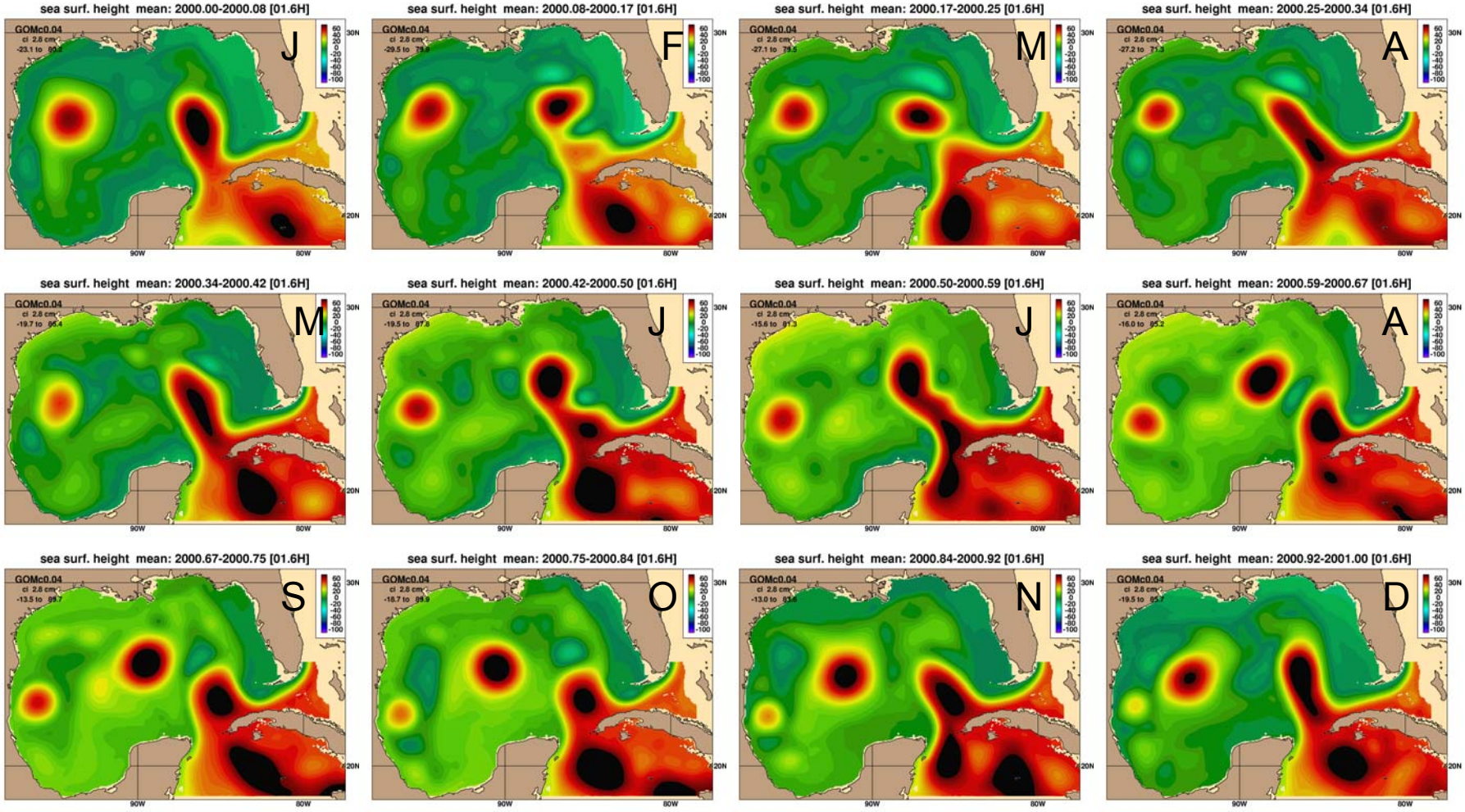
| | No Mixed Layer* | No Mixed Layer, No Winds |
|---|---|---|
| 2001 |   |   |
| 2000 |   |   |

Demonstrates that mixed layer, winds don't impact LCE shedding dynamics

*includes background diapycnal diffusion

# 1/25° Nested Gulf of Mexico HYCOM (GISS)

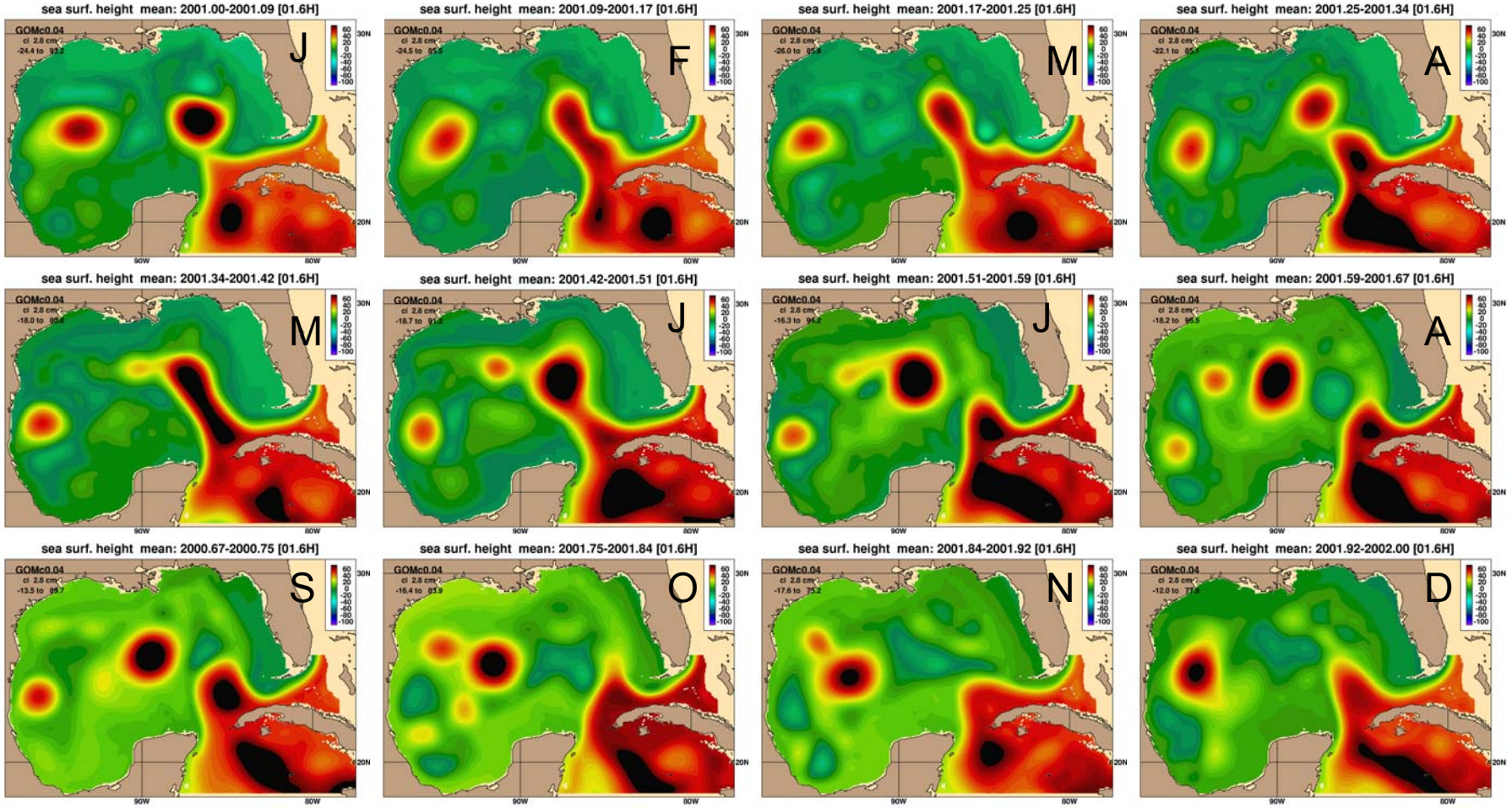
## Monthly Mean Sea Surface Height Year 2000




- Loop Current Eddy sheds in April 2000
- Role of cyclones in Loop Current Eddy shedding evident

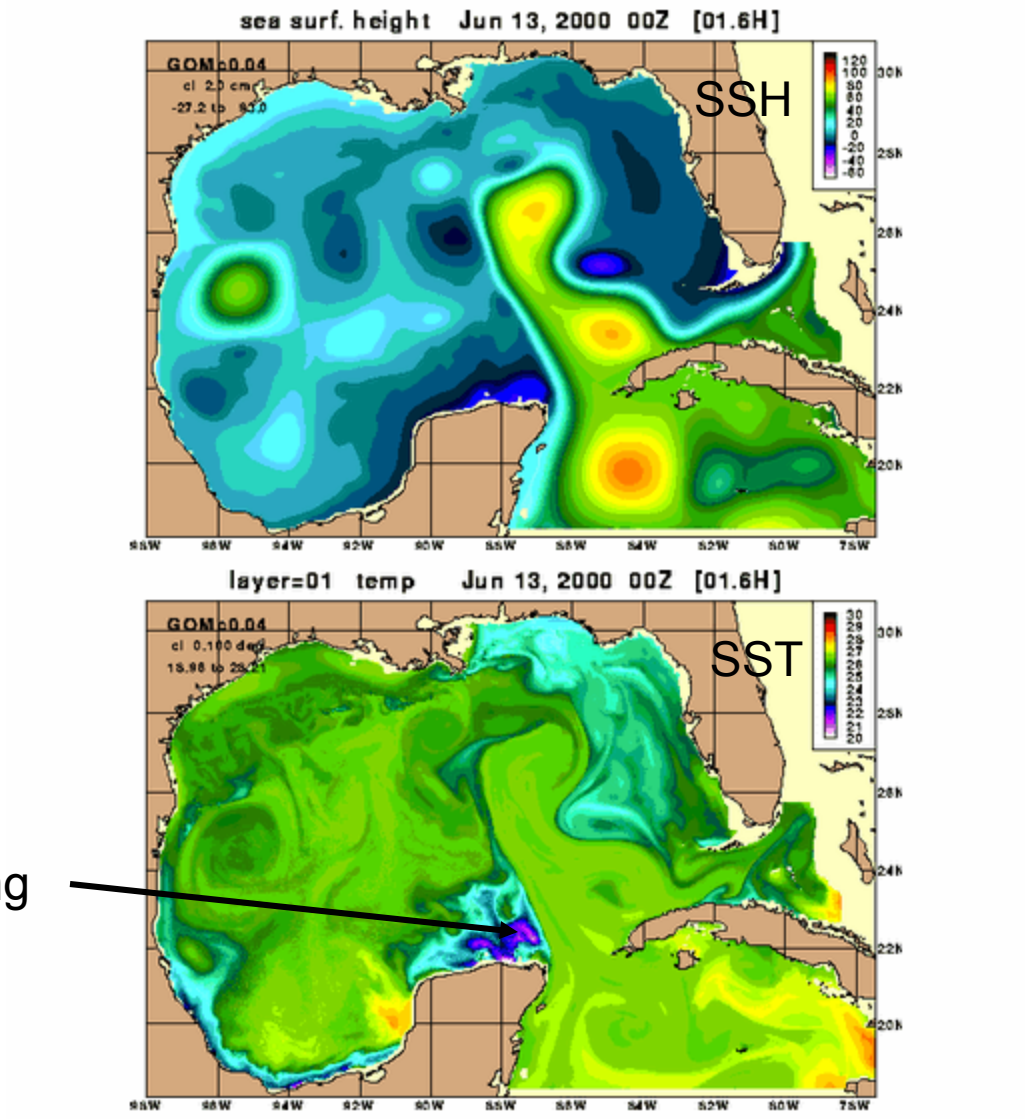
# 1/25° Nested Gulf of Mexico HYCOM (GISS)

## Monthly Mean Sea Surface Height Year 2001




Loop Current Eddy sheds 10 months later (July 2001)
Detached eddy reabsorbed in several cases

# 1/25° Nested Gulf of Mexico (GISS)

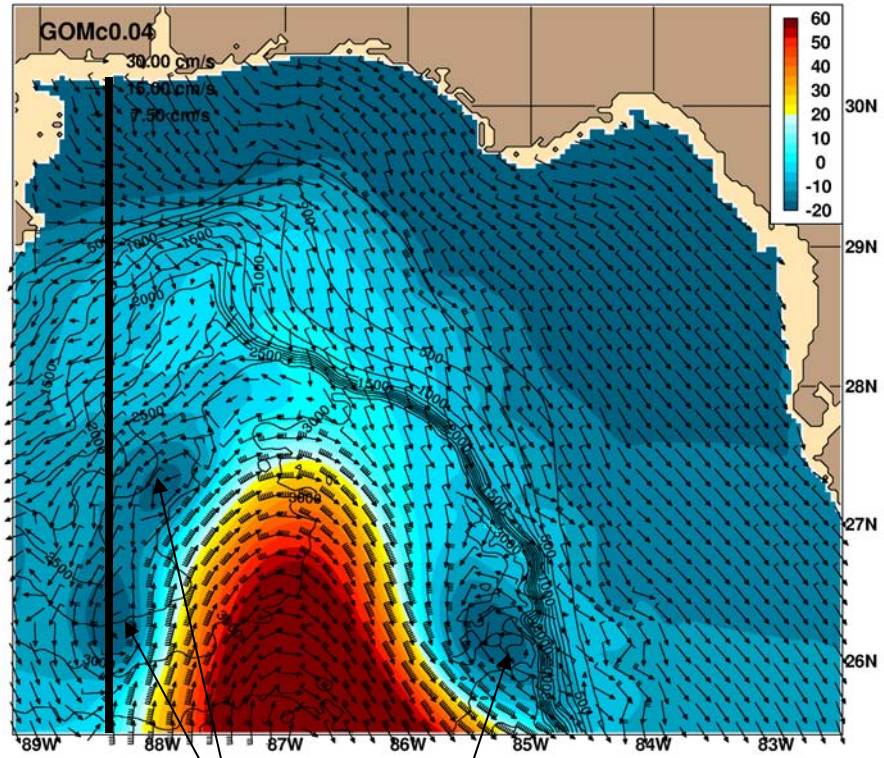



upwelling

Lots of cyclonic cold core eddies

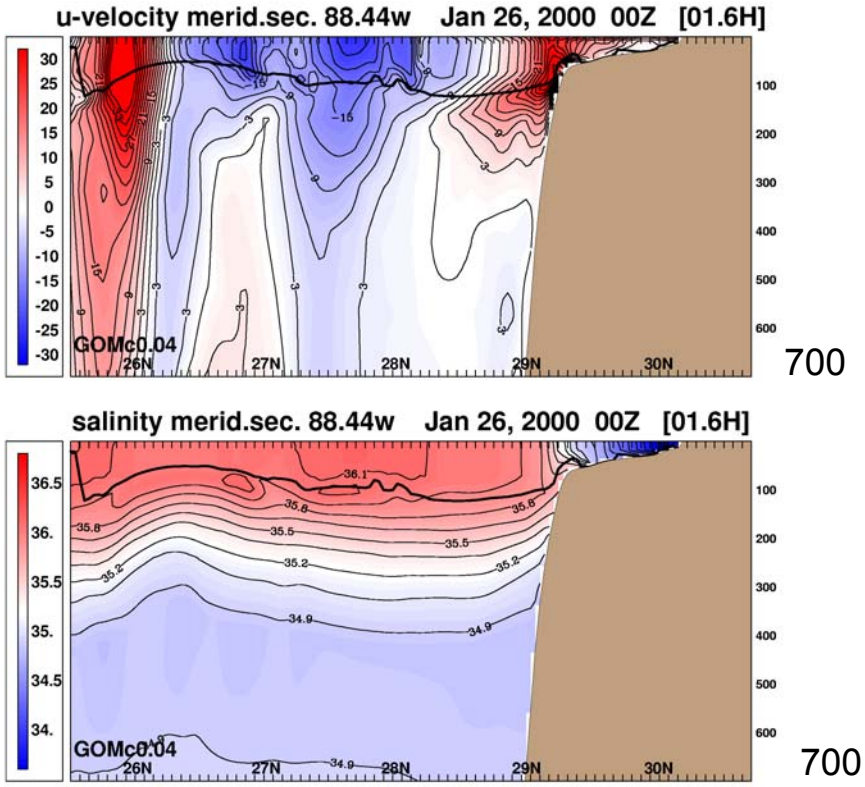
# 1/25° Nested Gulf of Mexico HYCOM (GISS)

## Jan 026 2000 SSH and Surface Currents




cyclones

## Cross-section along 88.4°W



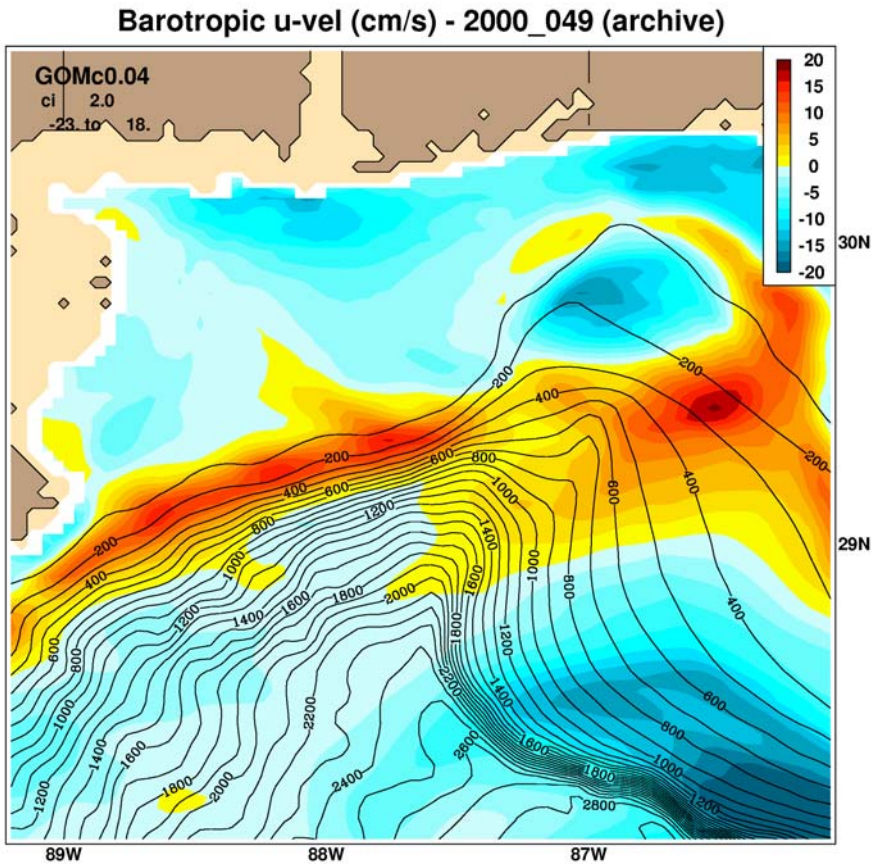

- Cyclones are fairly shallow
- Robust shelf-break current associated with strong salinity gradient
- Loop Current penetration to ~28°N

Red=east
Blue=west

# 1/25° Nested Gulf of Mexico HYCOM (GISS)

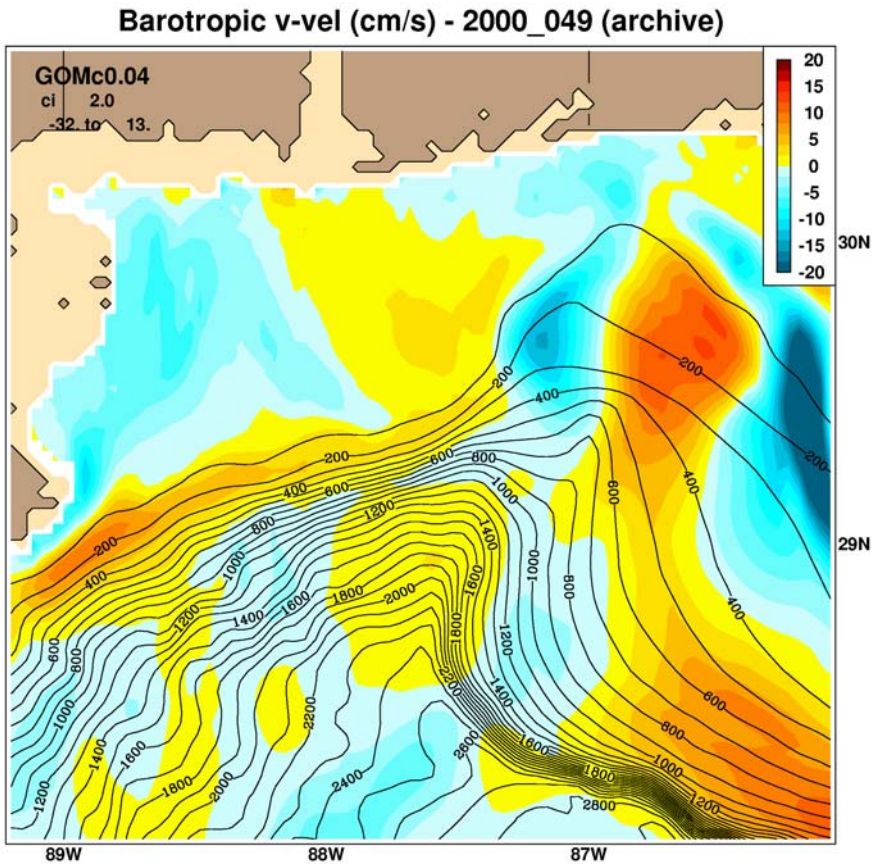
## Barotropic u-velocity

red=east blue=west




## Barotropic v-velocity

red=north blue=south

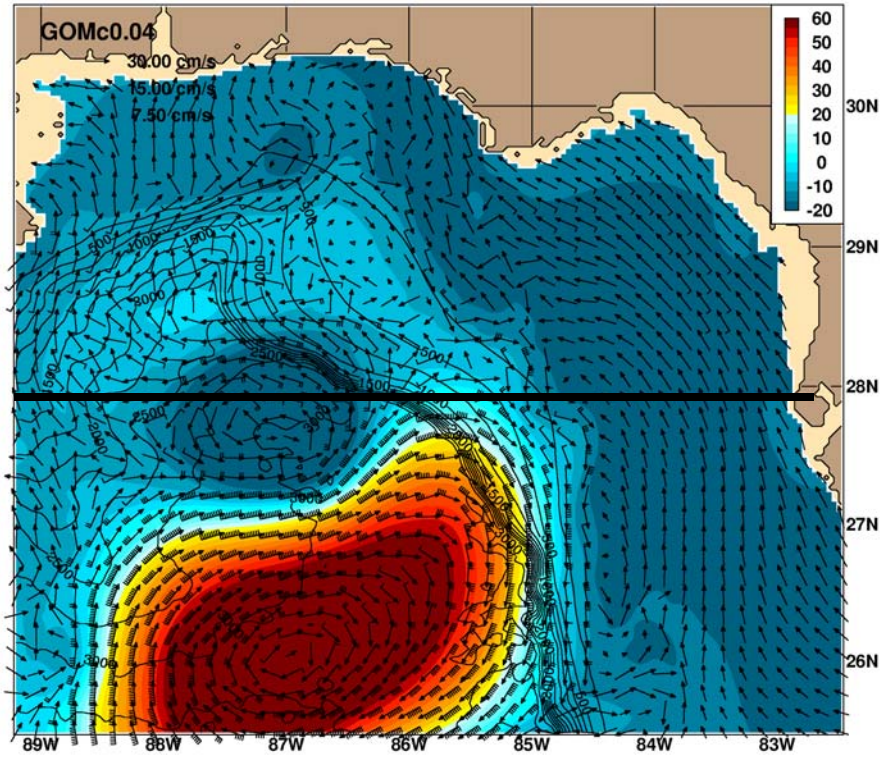



Note topo-trapped cyclone at head of DeSoto Canyon

# 1/25° Nested Gulf of Mexico HYCOM (GISS)

Red=north
Blue=south

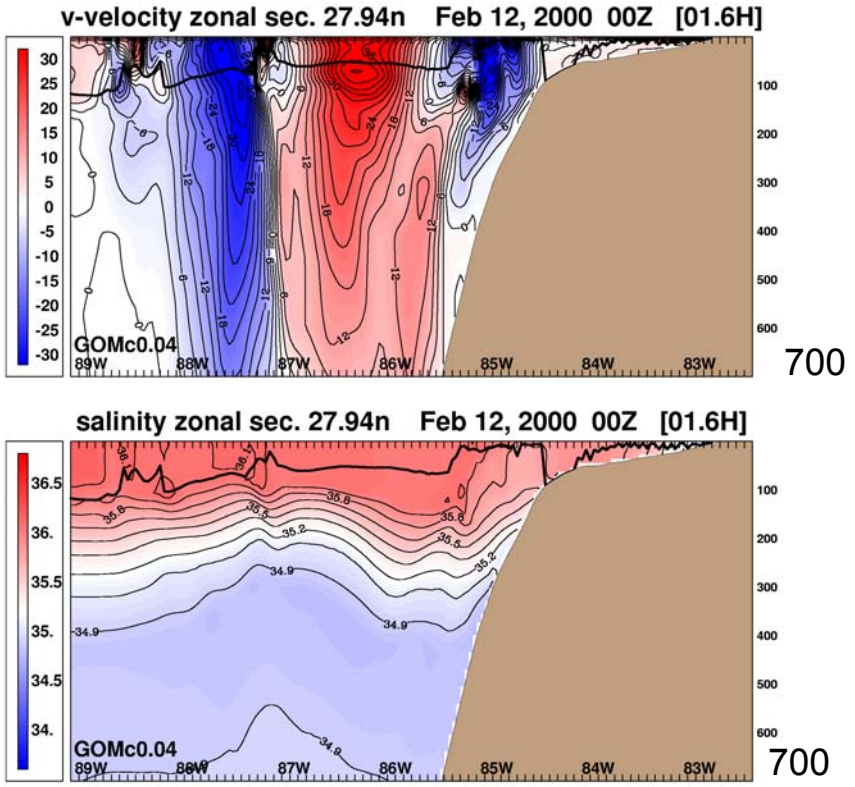
## Feb 12, 2000 SSH and Surface Currents




Loop Current has migrated to NE and is impinging on shelfbreak

Cyclone also impinging on shelfbreak

## Cross-section along 27.9°N

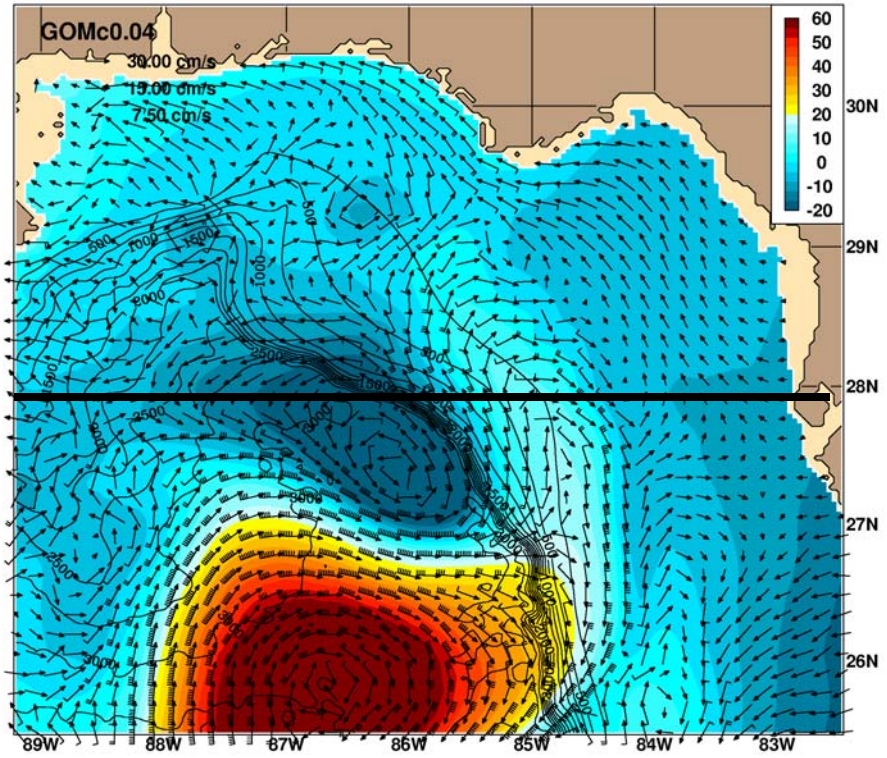


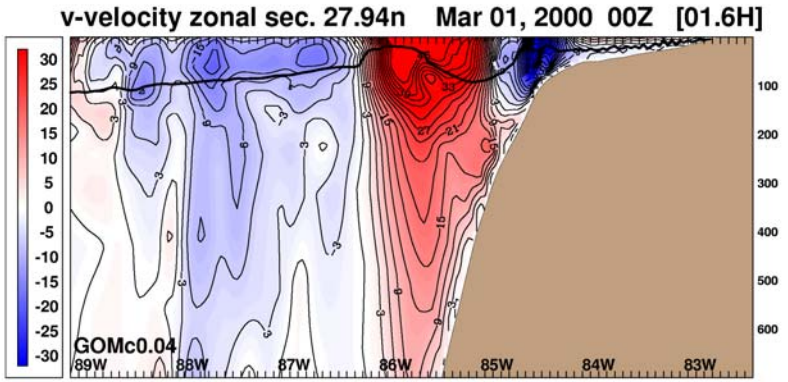

- Doming of isopycnals associated with cyclone
- Sharp shelfbreak front
- Intense northward subsurface jet

# 1/25° Nested Gulf of Mexico HYCOM (GISS)

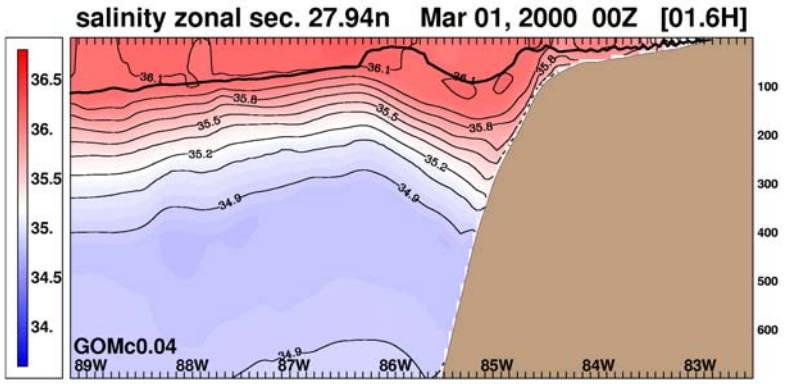
Red=north
Blue=south

March 01, 2000 SSH and Surface Currents




700




700

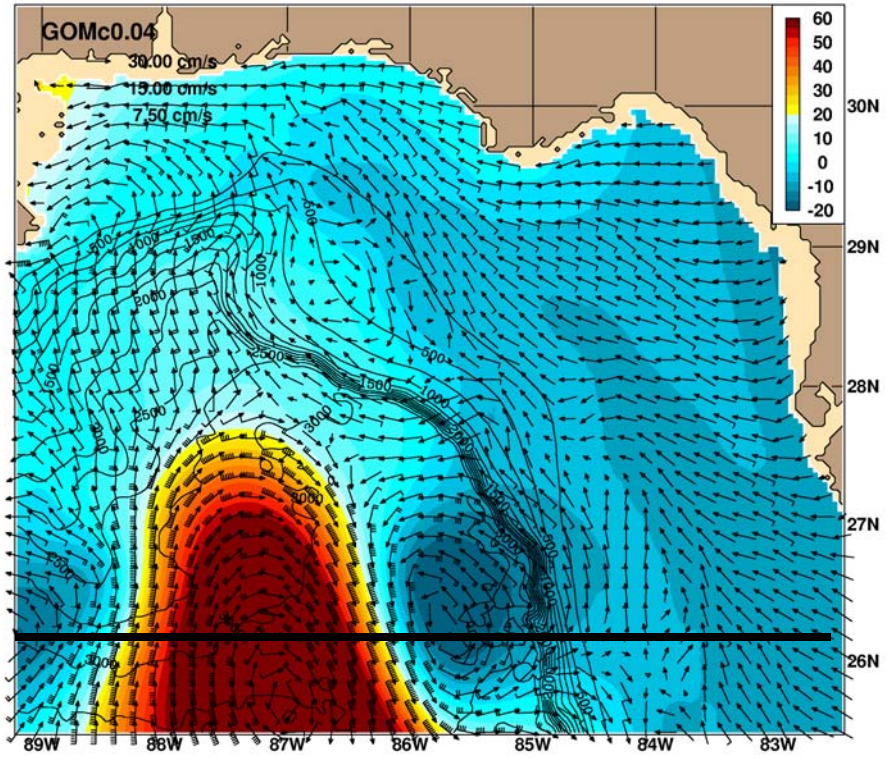
- Cyclone orbiting Loop Current Eddy,
- Loop Current Eddy breaching shelf break
- Southward flow enhanced by vortex compression?

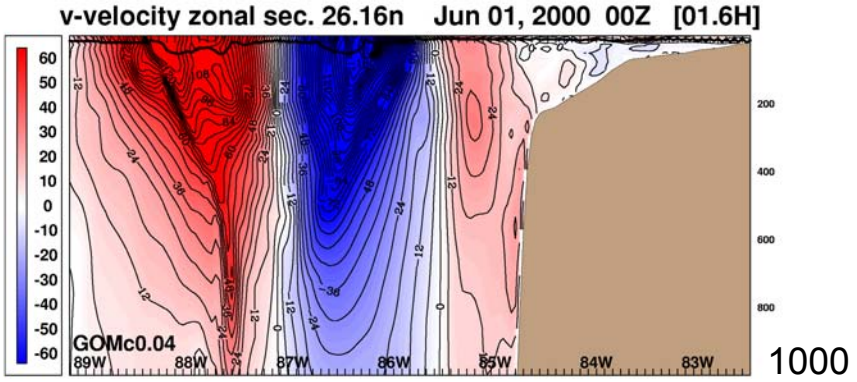
Southward subsurface velocity maximum

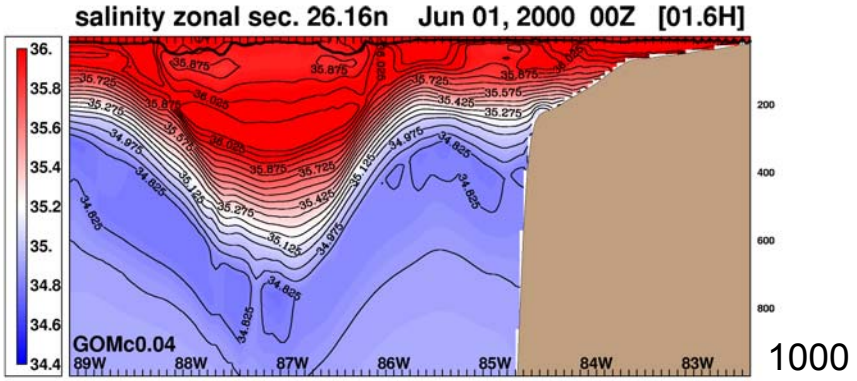
# 1/25° Nested Gulf of Mexico HYCOM (GISS)

Red=north
Blue=south

June 02, 2000 SSH and Surface Currents



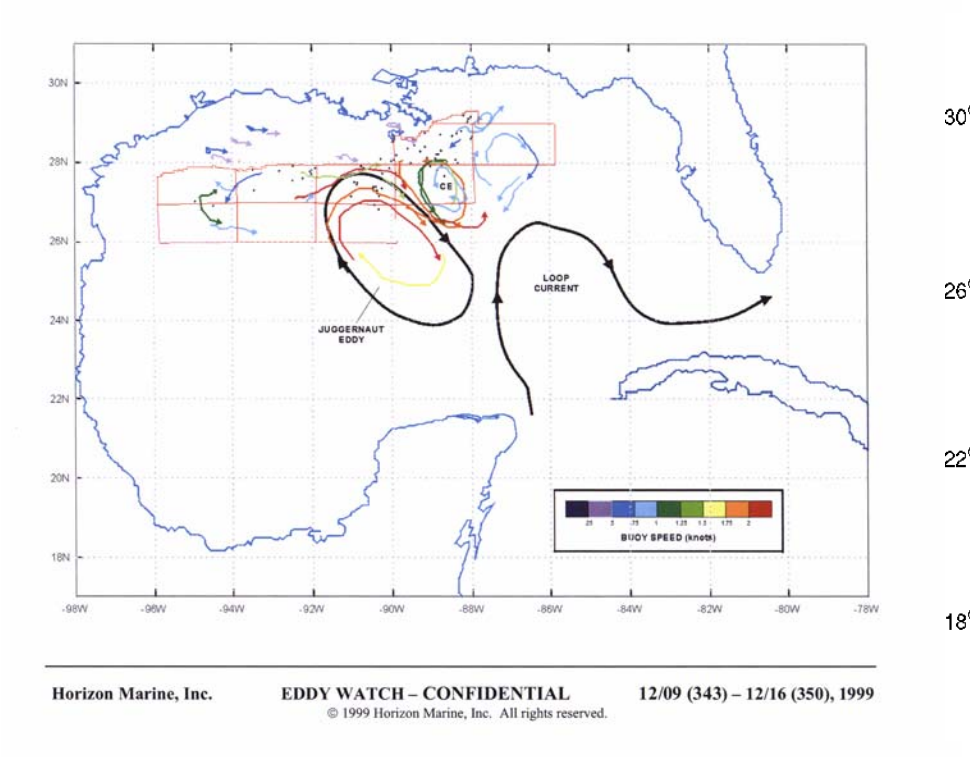

3 months later cyclone hasn't migrated very far but is being steered by the shelf break

- Strange symmetry of LCE especially on western side
- Subsurface salinity max beneath LCE

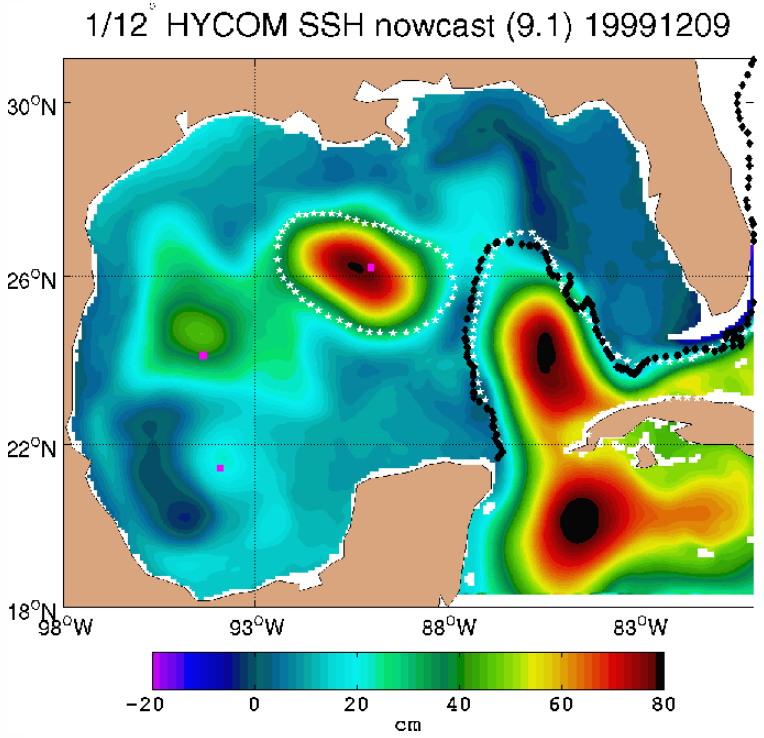
# 1/12° Assimilative Gulf of Mexico Model

- Participation in DeepStar (Oil Co. Consortium) forecast study
- Hindcast run 1999-2000 (Eddy Juggernaut period)
- Assimilates MODAS analysis of SSH
- SST is relaxed toward MCSST
- 6 hourly NOGAPS winds used for entire forecast period
- 14 4-week forecast periods
- Validation via distance to 18°C isotherm at 200m for both Eddy Juggernaut and the Loop Current

# Comparison of Nowcast to Observations




Eddy Watch Analysis 12/09 – 12/16/99

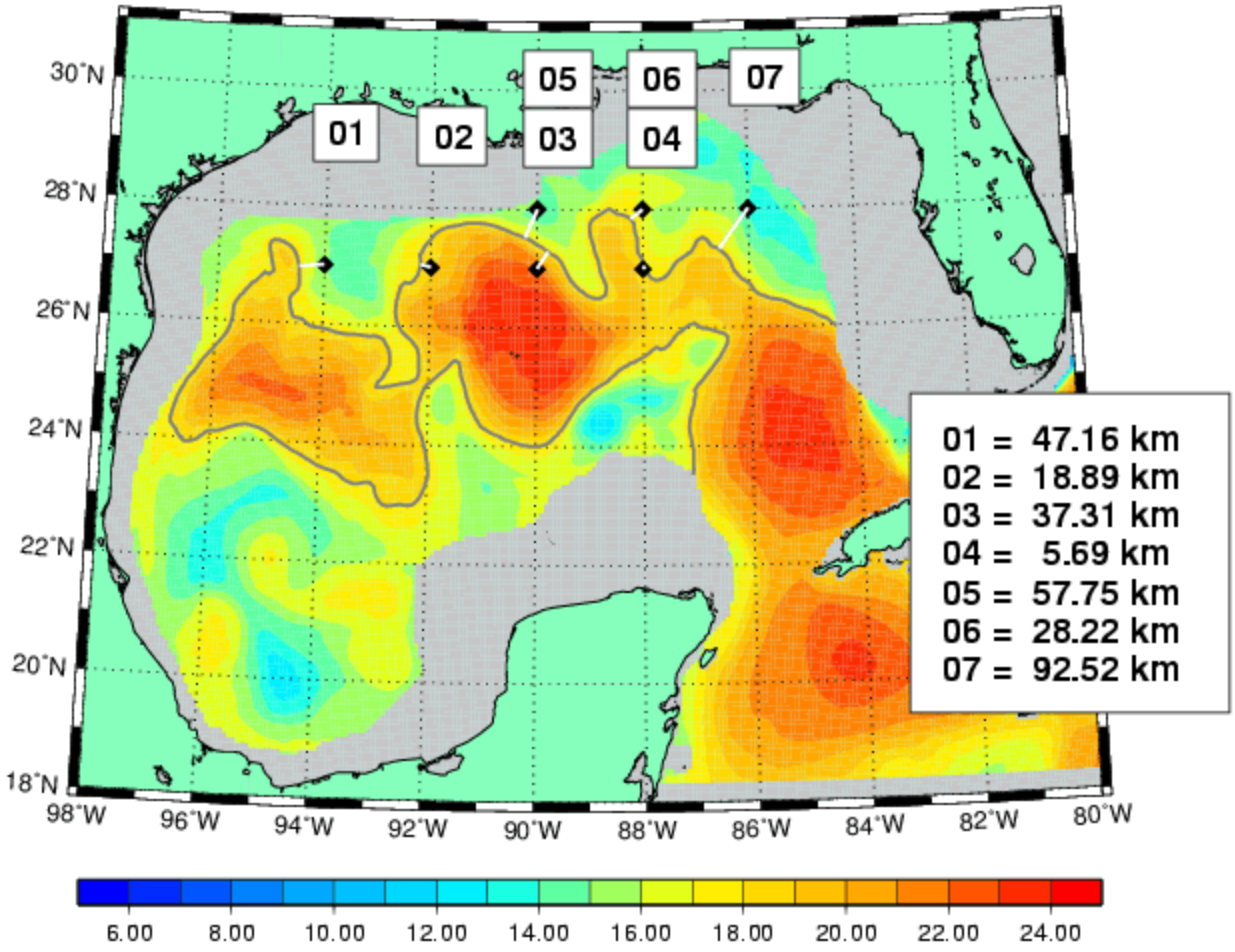



1/12° HYCOM Nowcast 12/09/99

White=Eddy Watch frontal analysis
Black=NAVO MCSST analysis

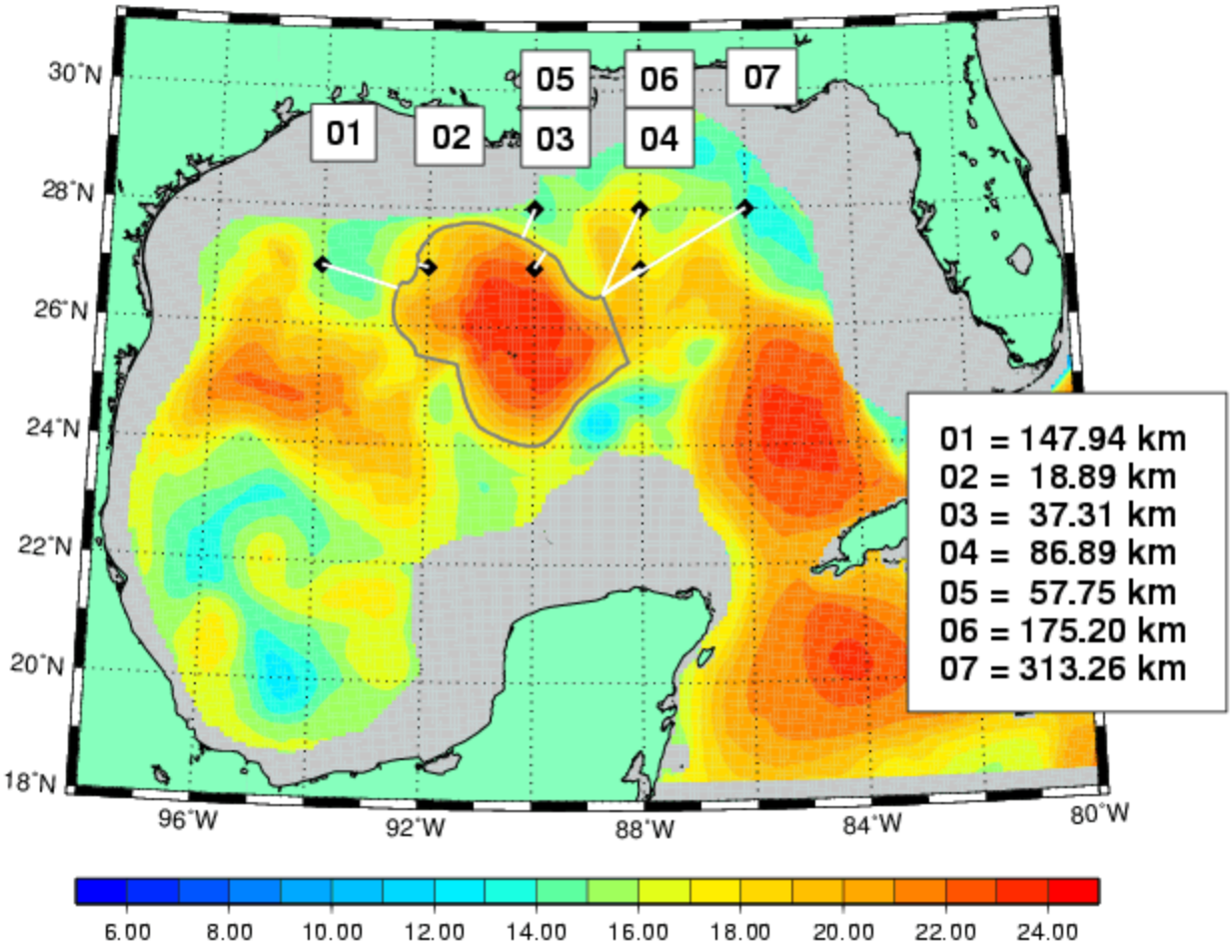
# 2-week forecast on 12-22-1999

(14 forecast periods)(4 1-week forecasts)(7 distances) = 392 distance measurements



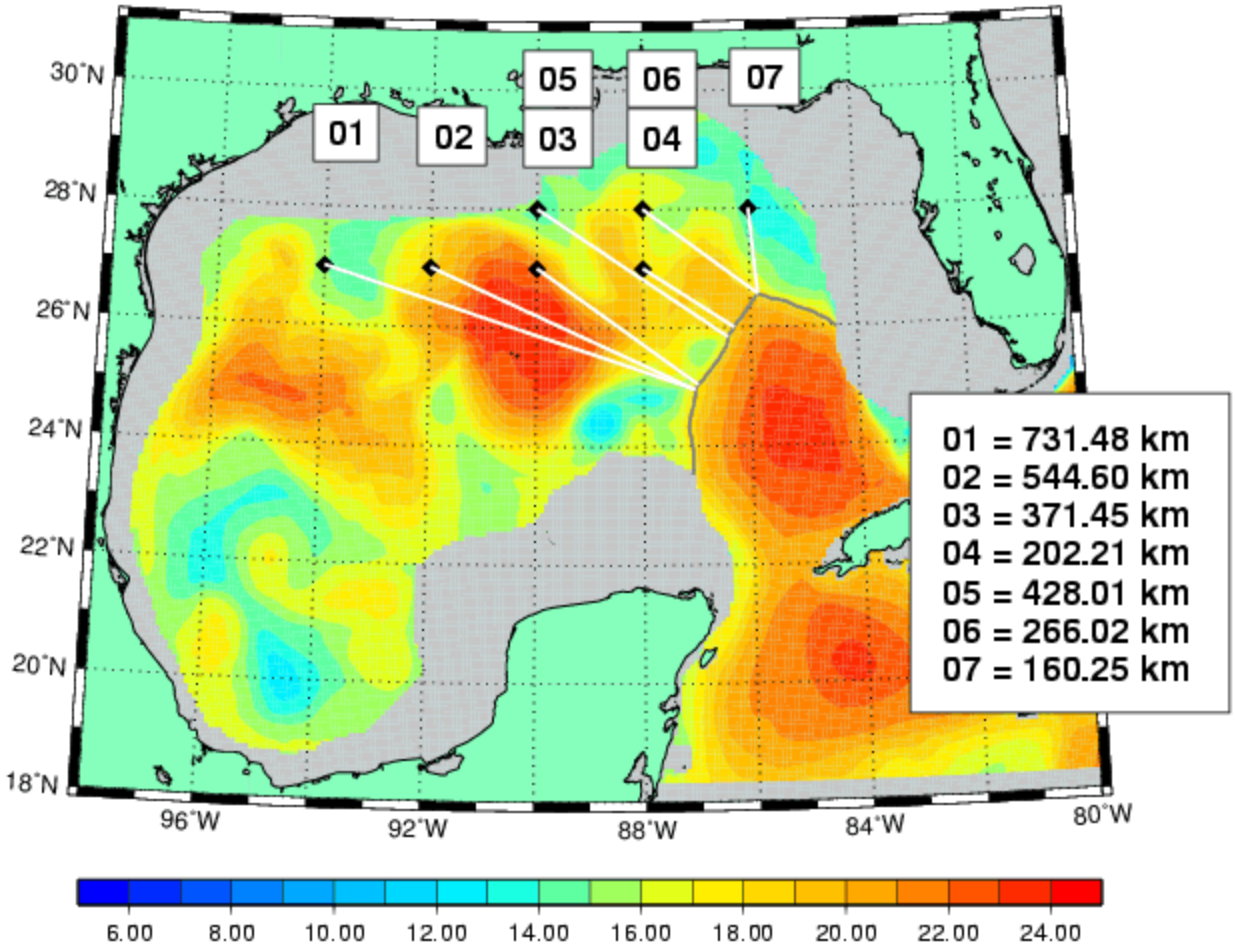

Grey = 18°C isotherm at 200m (automated alogrithm)

# 2-week forecast on 12-22-1999




Manually edited to highlight Eddy Juggernaut

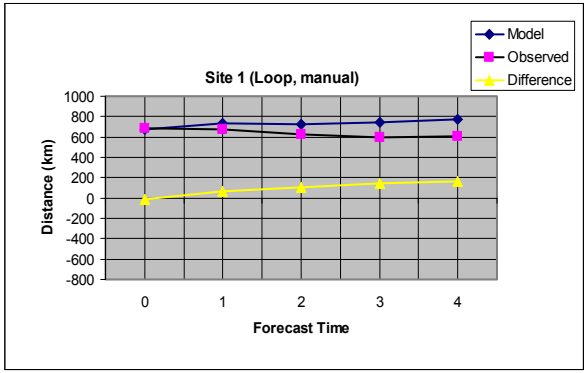
2-week forecast on 12-22-1999
based on 18°C at 200m

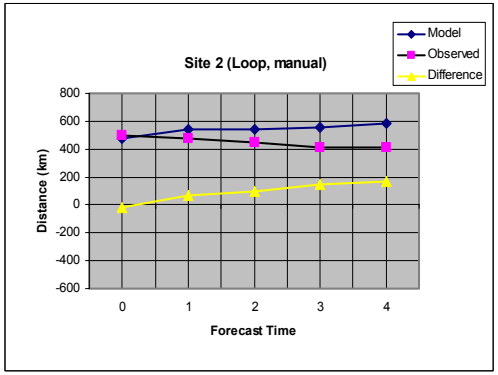


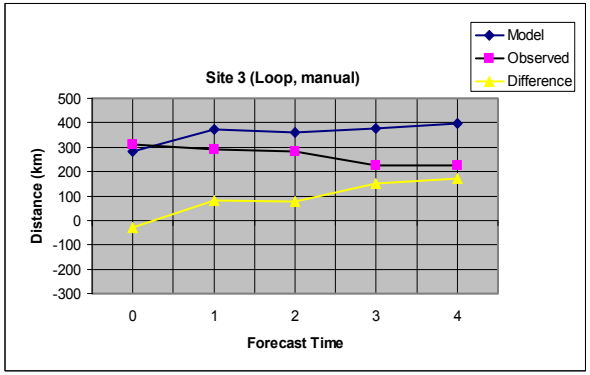

Manually edited to highlight Loop Current

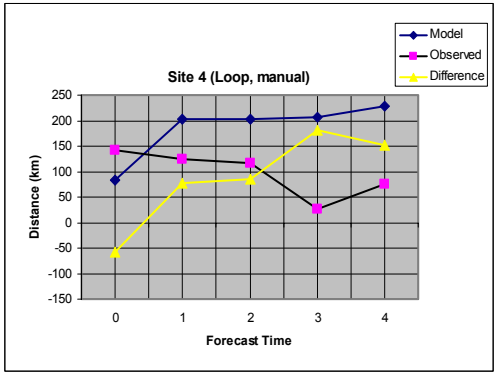
# Distance to the Loop Current* vs. Forecast Length: Model vs. Observations

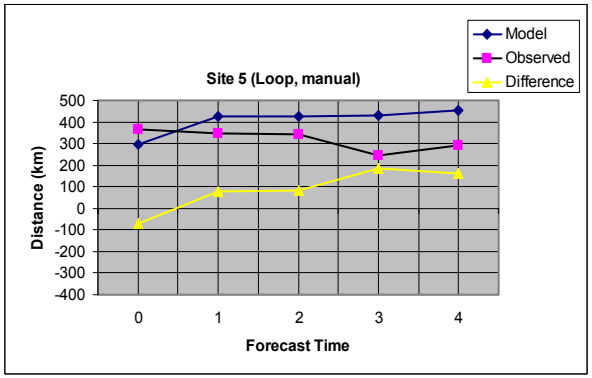
*With manual intervention

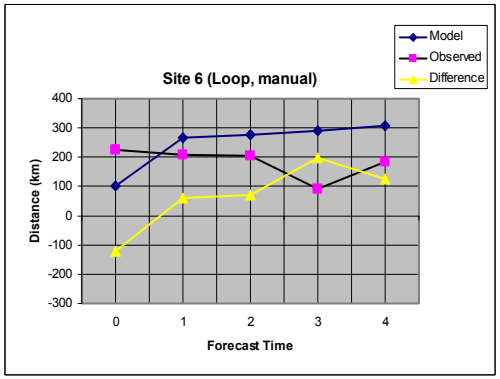


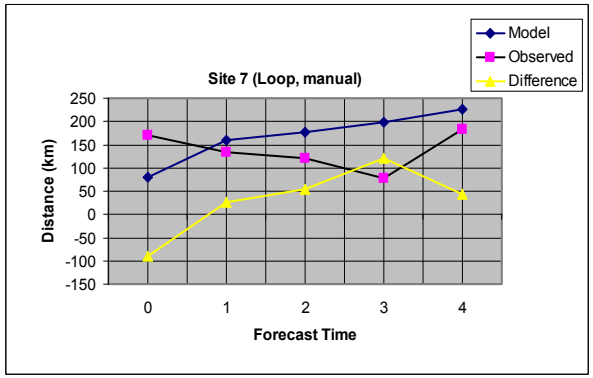



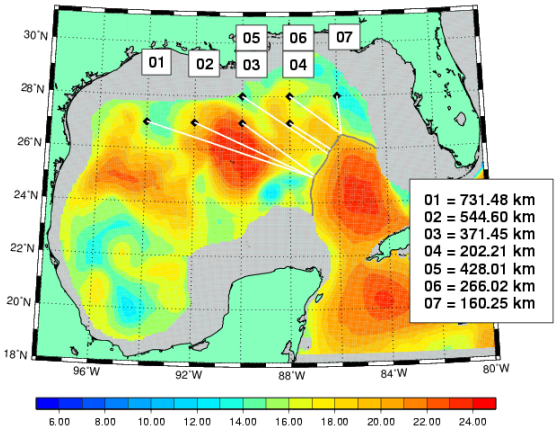



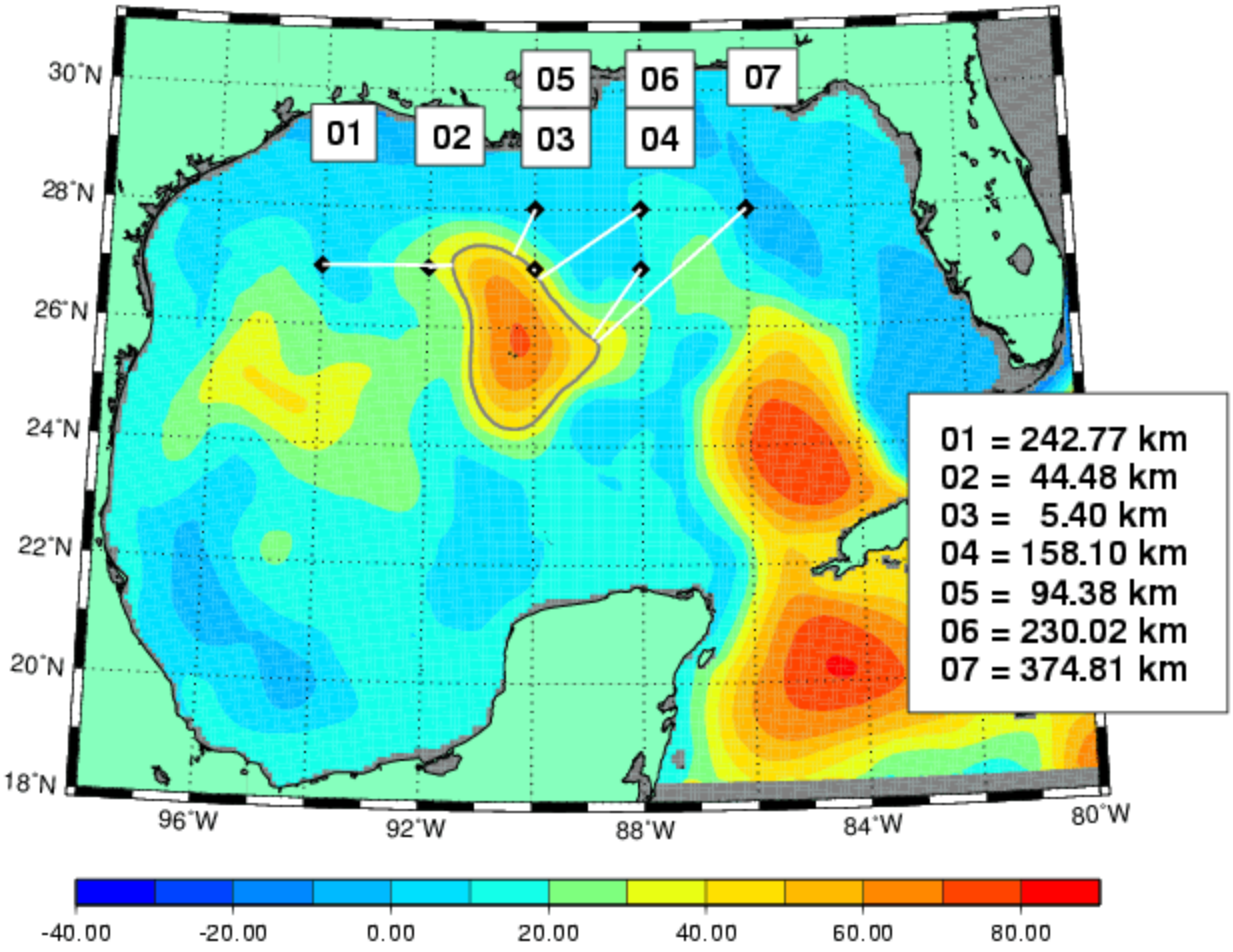



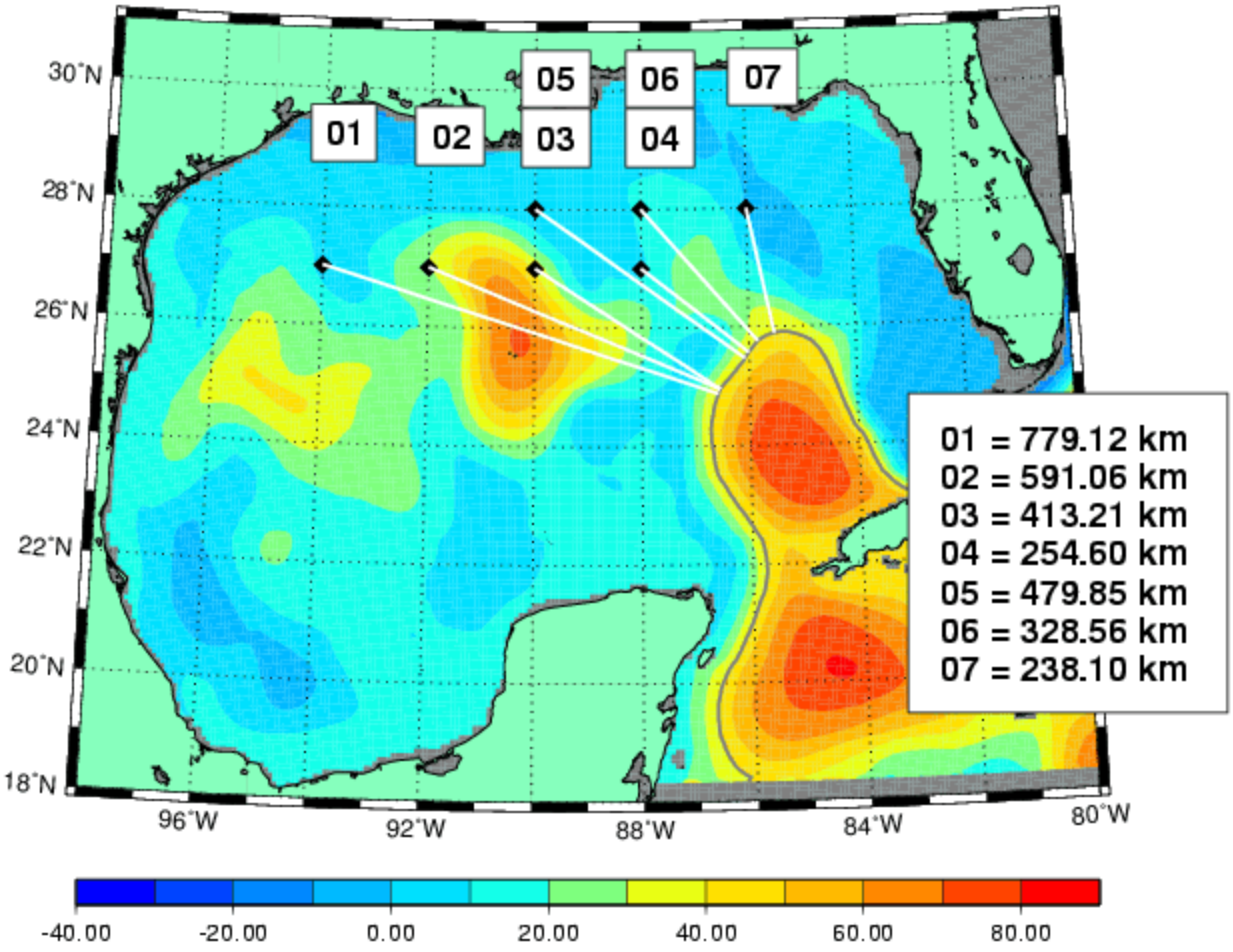

Nowcast is 12/15/99

2-week forecast on 12-22-1999
based on 40cm SSH anomaly




Distance from each station to Eddy Juggernaut

# 2-week forecast on 12-22-1999
# based on 40cm SSH anomaly




Distance from each station to the Loop Current

# Future Plans

- Nested NE GoM inside nested GoM (3x, ~1.3 km)
- Improved boundary conditions from Atlantic (sigma-2*)
- 9 km COAMPS surface forcing
- MVOI based assimilation