

# ***The Navy Coupled Ocean Data Assimilation (NCODA) system in HYCOM***

O. M. Smedstad<sup>1</sup>, J. A. Cummings<sup>2</sup>, A. J. Wallcraft<sup>2</sup>, H. E. Hurlburt<sup>2</sup>, P. J. Hogan<sup>2</sup>, E. P. Chassignet<sup>3</sup>, W. C. Thacker<sup>4</sup>, H. Kang<sup>5</sup>

*<sup>1</sup>Planning Systems Inc.*

*<sup>2</sup>Naval Research Laboratory*

*<sup>3</sup>Florida State University*

*<sup>4</sup>Atlantic Oceanographic and Meteorological Laboratory*

*<sup>5</sup>University of Miami*

**<http://www.hycom.org>**

**HYCOM NOPP/GODAE  
Tallahassee, Florida  
7-9 November 2006**

# ***Atlantic near real-time system***

- 1/12° Atlantic (28°S to 70°N)
- Running in near real-time (on Wednesday)
  - . Assimilates the satellite altimeter analysis from the MODAS operational system at the Naval Oceanographic Office (NAVOCEANO)
  - . Mean SSH from the 1/12° MICOM (ECMWF)
  - . Vertical projection via the Cooper and Haines technique (1996, JGR)
  - . FNMOC/NOGAPS atmospheric forcing
  - . Relaxation to the MODAS SST analysis
- 10 day hindcast, 14 day forecast
- Provide boundary conditions for coastal models

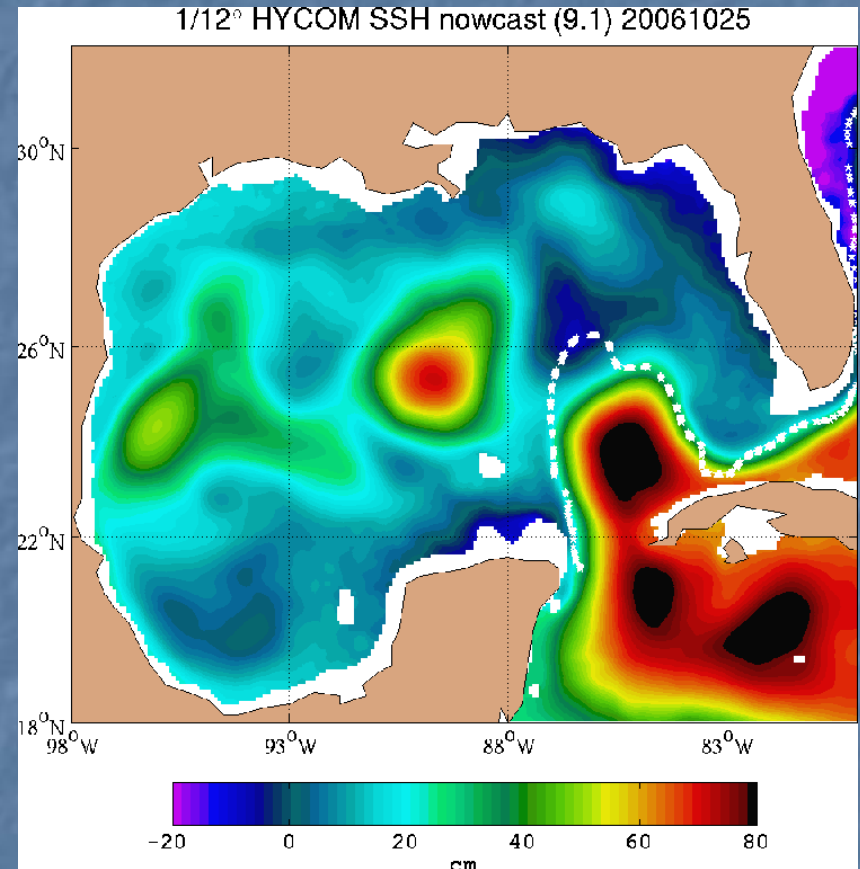
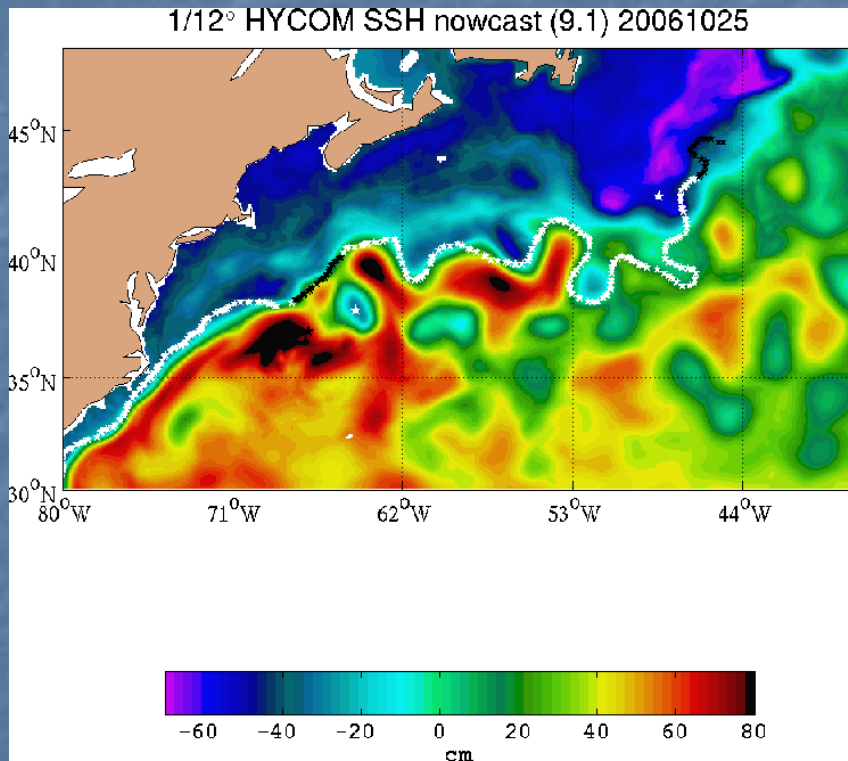
<http://www7320.nrlssc.navy.mil/ATLhycom1-12/skill.html>

<http://www.hycom.org>

# *1/12° Atlantic HYCOM*

## *SSH in Gulf Stream and Gulf of Mexico region*

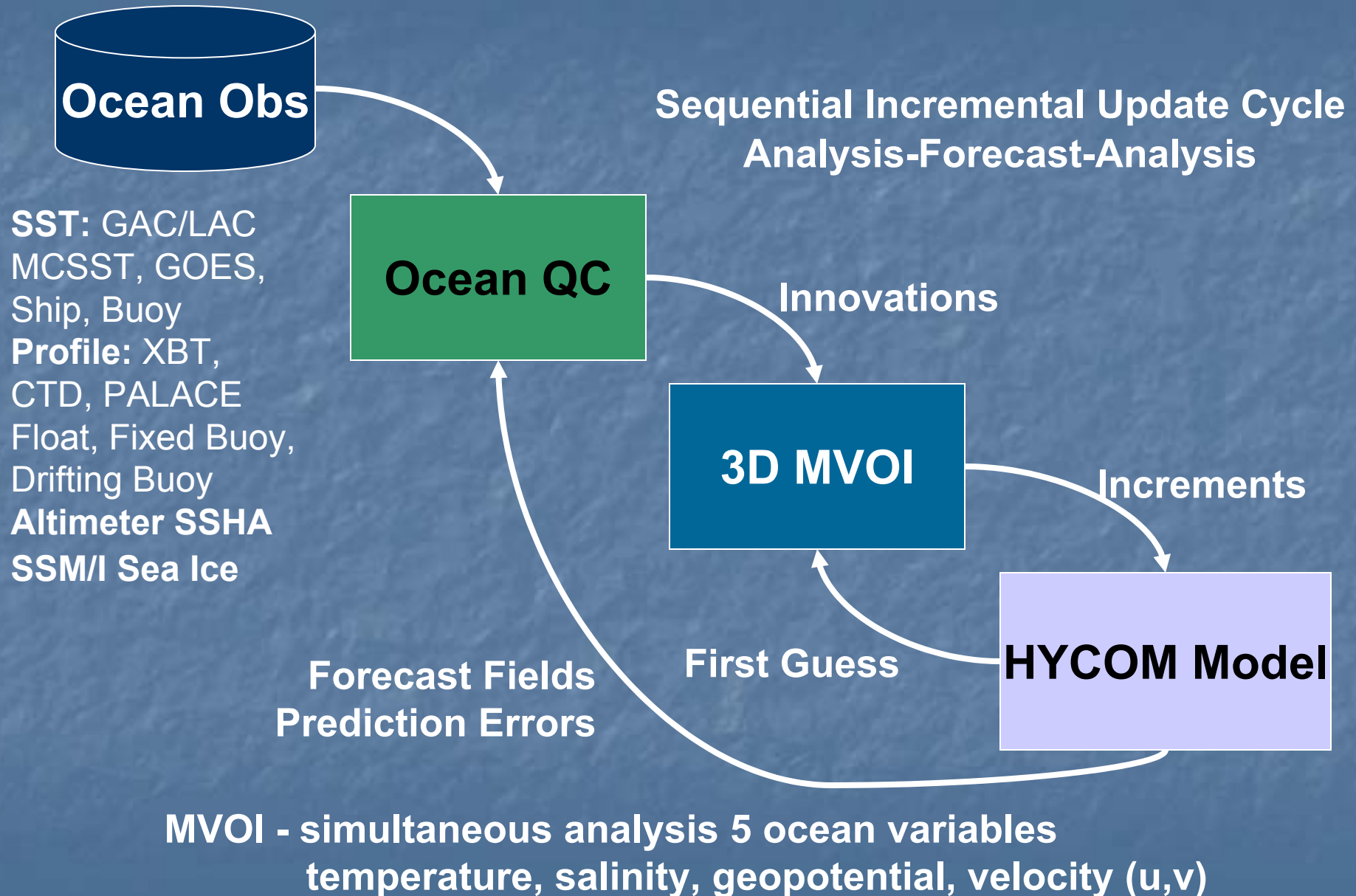
### *25 October 2006*



White/black line is the frontal analysis of MCSST observations performed at NAVOCEANO. Black line represents data more than four days old.

<http://www.hycom.org>

# *Navy Coupled Ocean Data Assimilation (NCODA)*





# ***HYCOM/NCODA coupling***

- **HYCOM to 3D z-grid**
- **NCODA analysis on z-grid**
- **Use the NCODA analysis in an incremental updating of the HYCOM variables.**
- **Daily NCODA analysis**

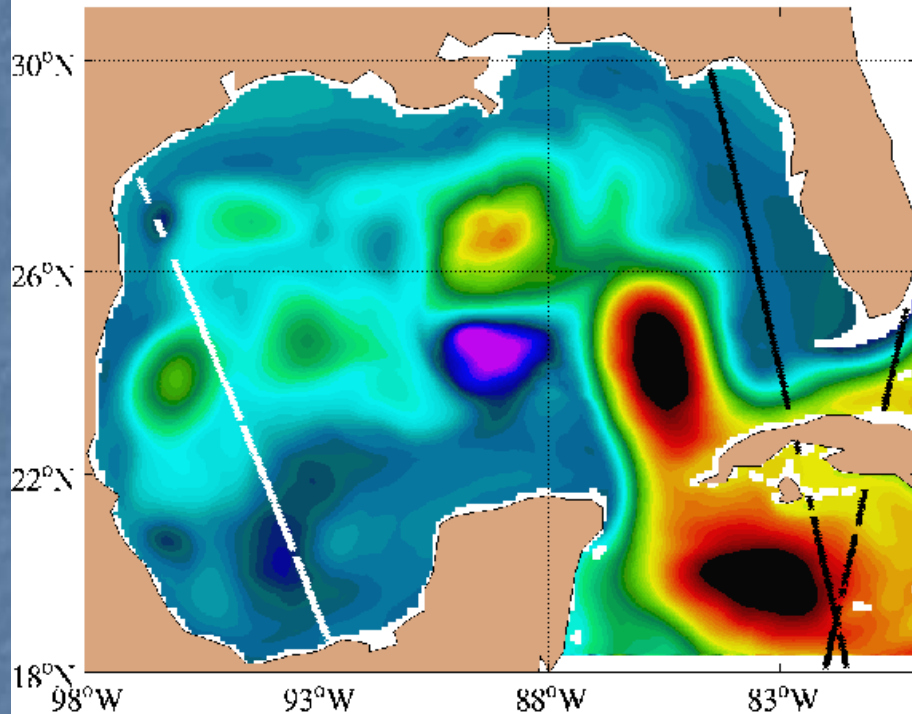
# ***1/12° GULF OF MEXICO HYCOM CONFIGURATION***

- **Horizontal grid: 1/12° (258 x 175 grid points, 6.5 km spacing on average)**
- **18°N to 31°N**
- **20 vertical coordinates**
- **Bathymetry: 5m coastline**
- **Surface forcing from FNMOC/NOGAPS**
- **Monthly river runoff**
- **Nested Boundary:**  
**relaxation to the 1/12° Atlantic HYCOM T, S, U and V along open boundary, (no assimilation in these experiments)**

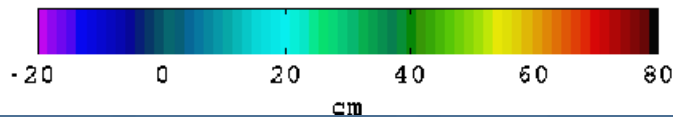
# HYCOM identical twin SSH and SST data

Ocean model sampled  
along observed tracks

1/12° HYCOM SSH noassim (0.0) 19990825

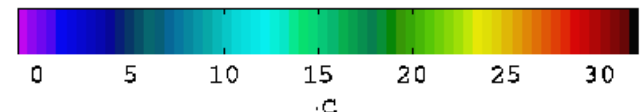
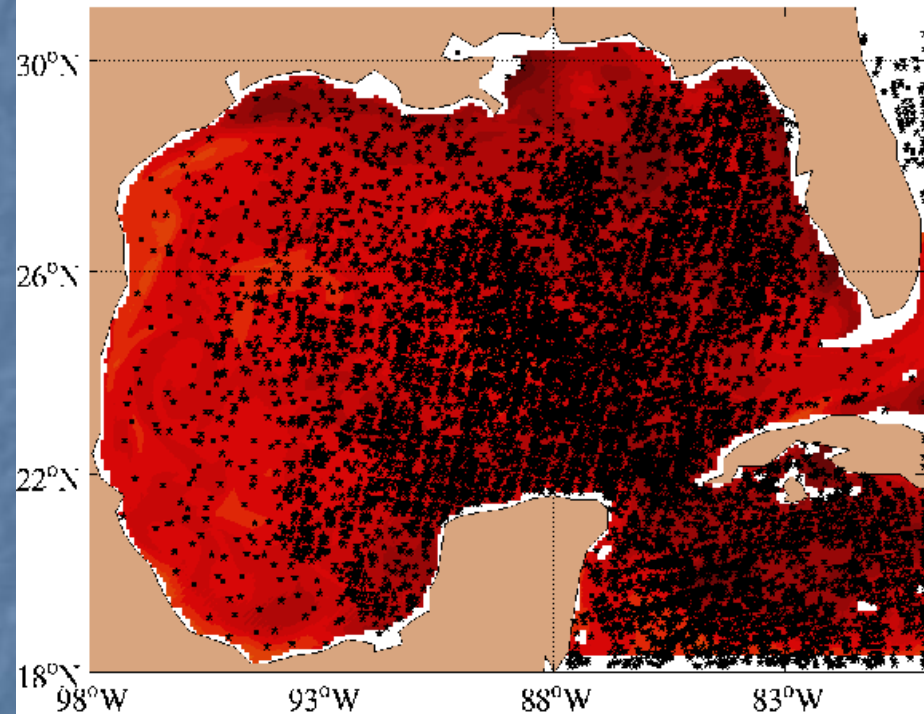


TOPEX - white ERS2 - black



Model sampled at observed  
MCSST locations

1/12° HYCOM SSH noassim (0.0) 19990825

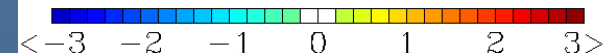
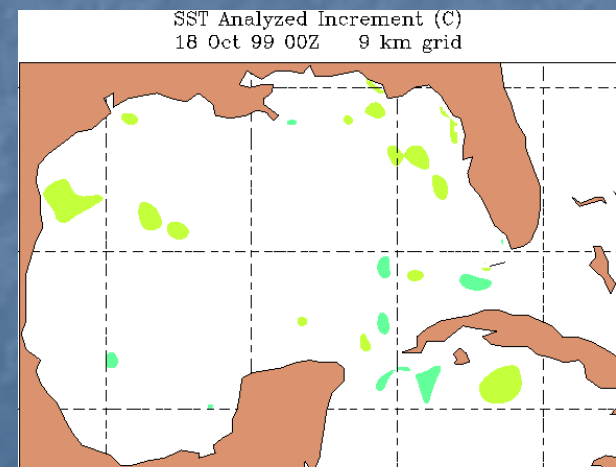
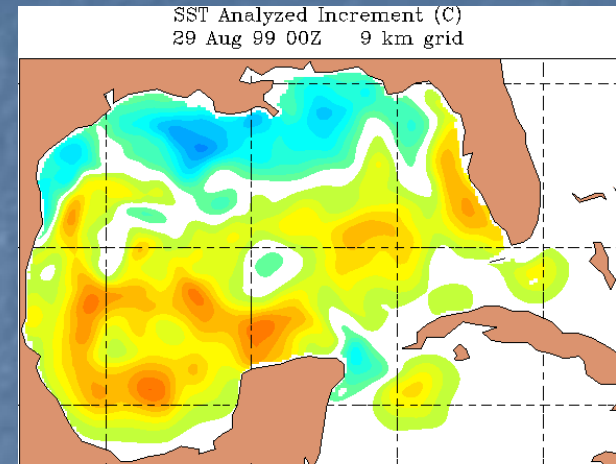
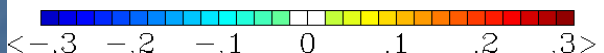
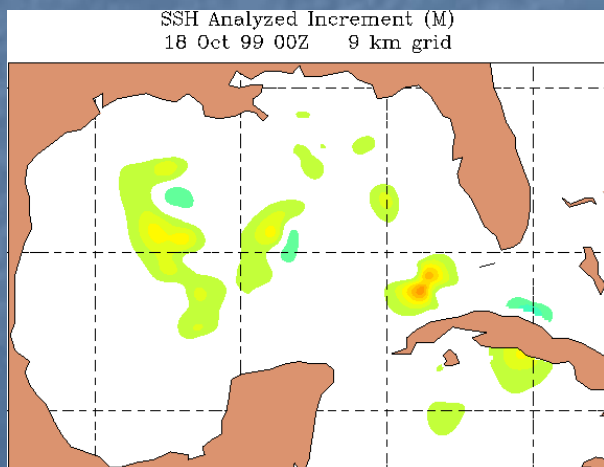
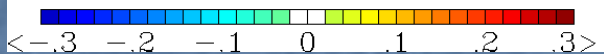
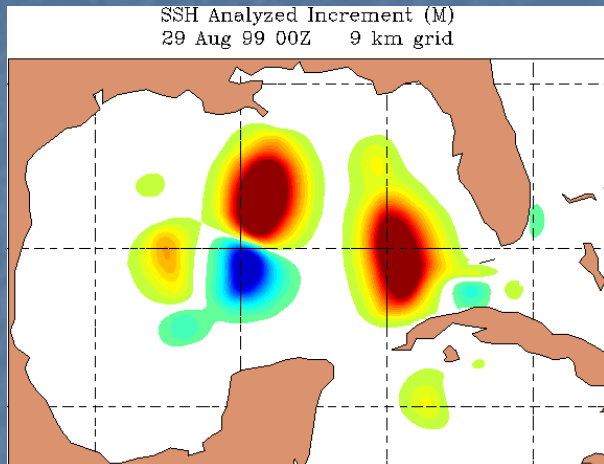


# HYCOM identical twin results

## “Observed” track and MCSST locations

SSH ← increments → SST

29 August 1999  
Day 1





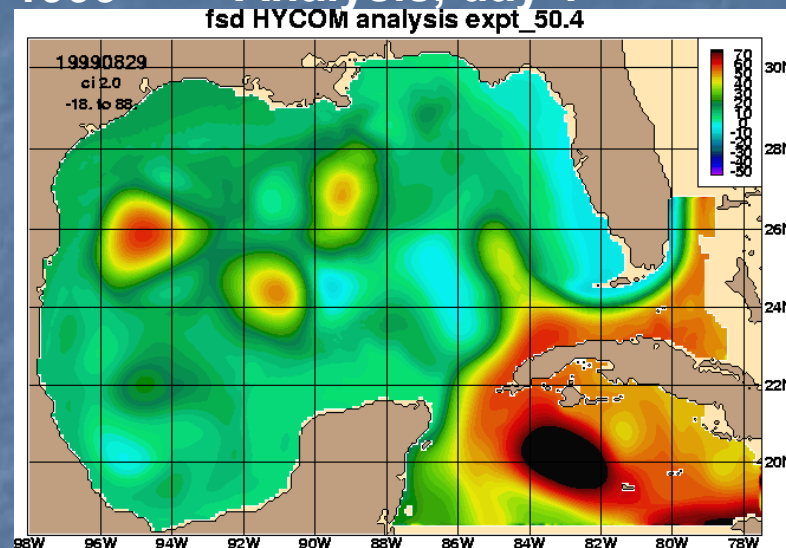
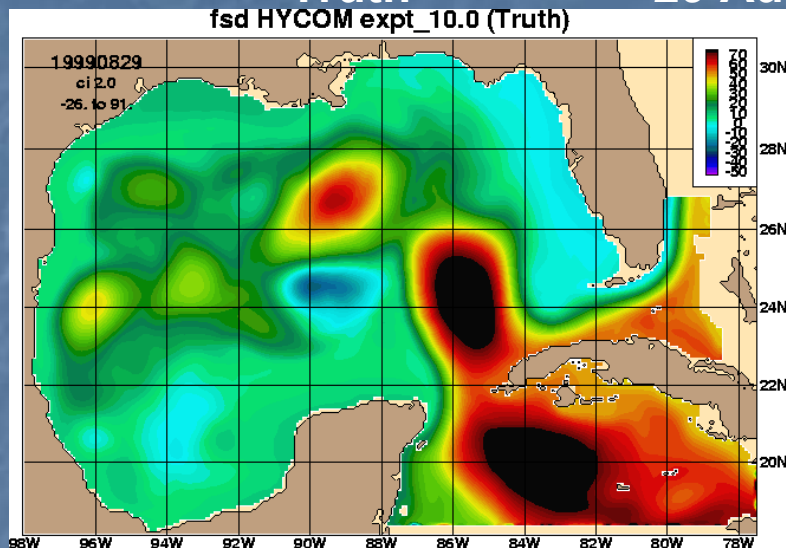
# HYCOM identical twin results

## “Observed” track and MCSST locations

Truth

29 August 1999

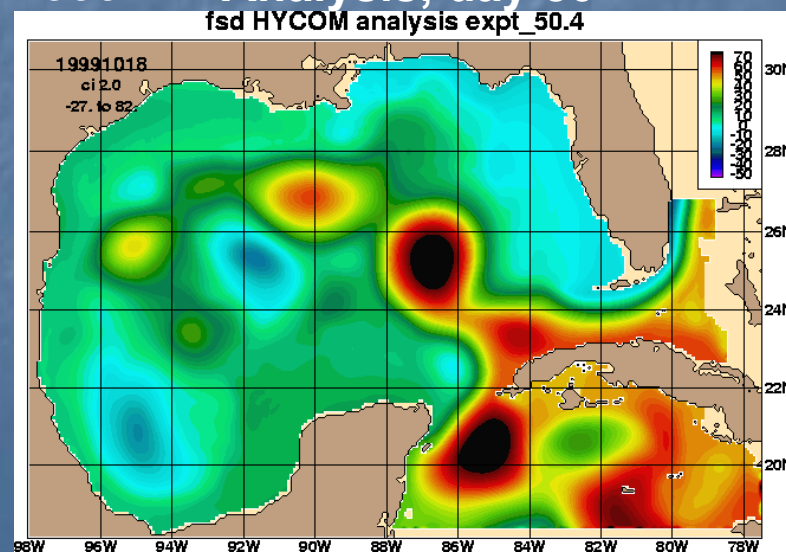
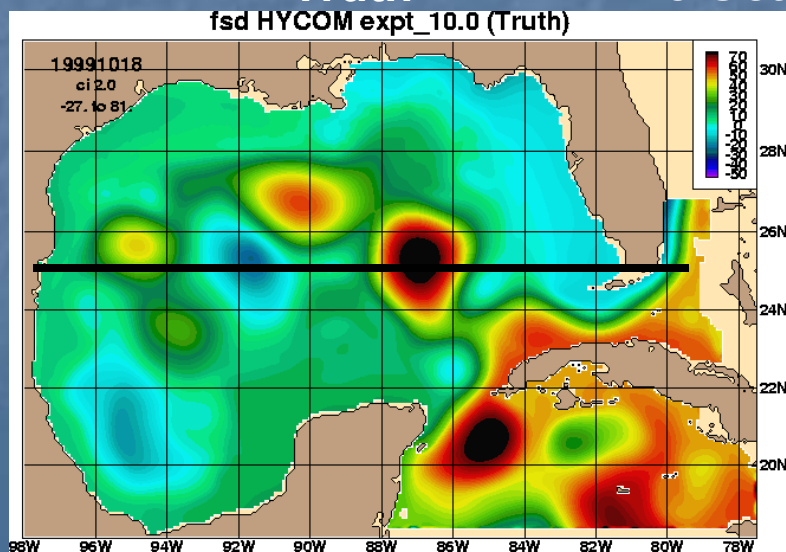
Analysis, day 1



Truth

18 October 1999

Analysis, day 50

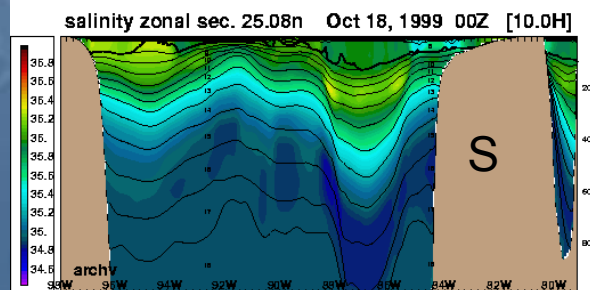
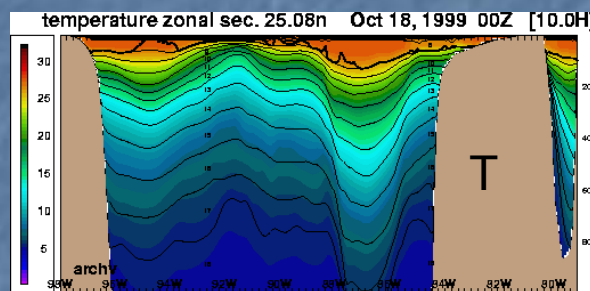
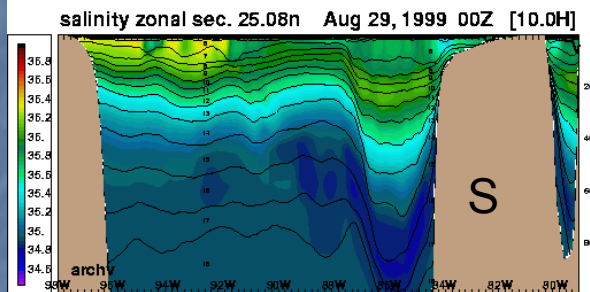
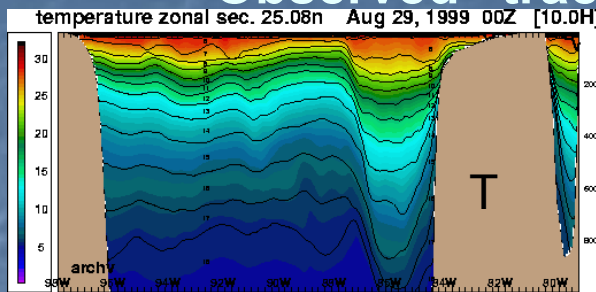


# HYCOM identical twin results

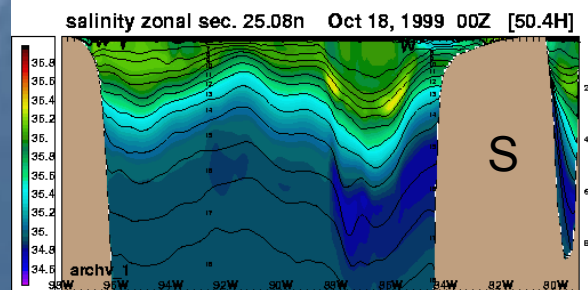
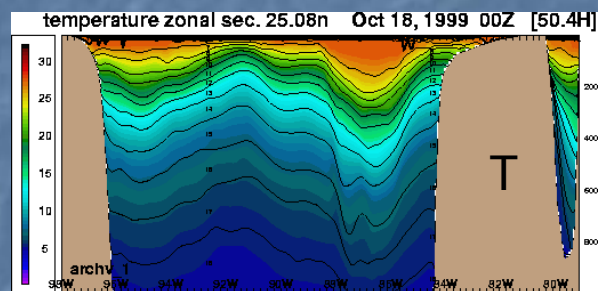
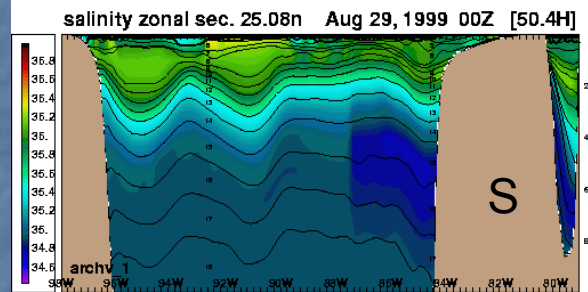
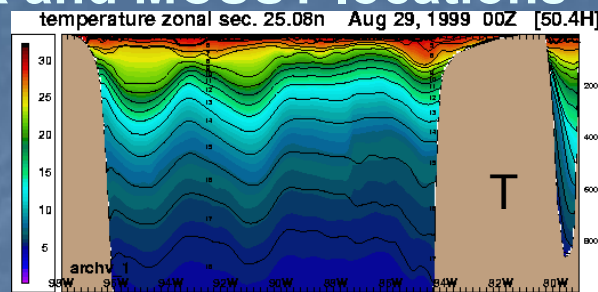
## Temperature and salinity sections along 25.08°N

### “Observed” track and MCSST locations

Truth



Truth



Analysis, day 1  
29 August 1999

Analysis, day 50  
18 October, 1999

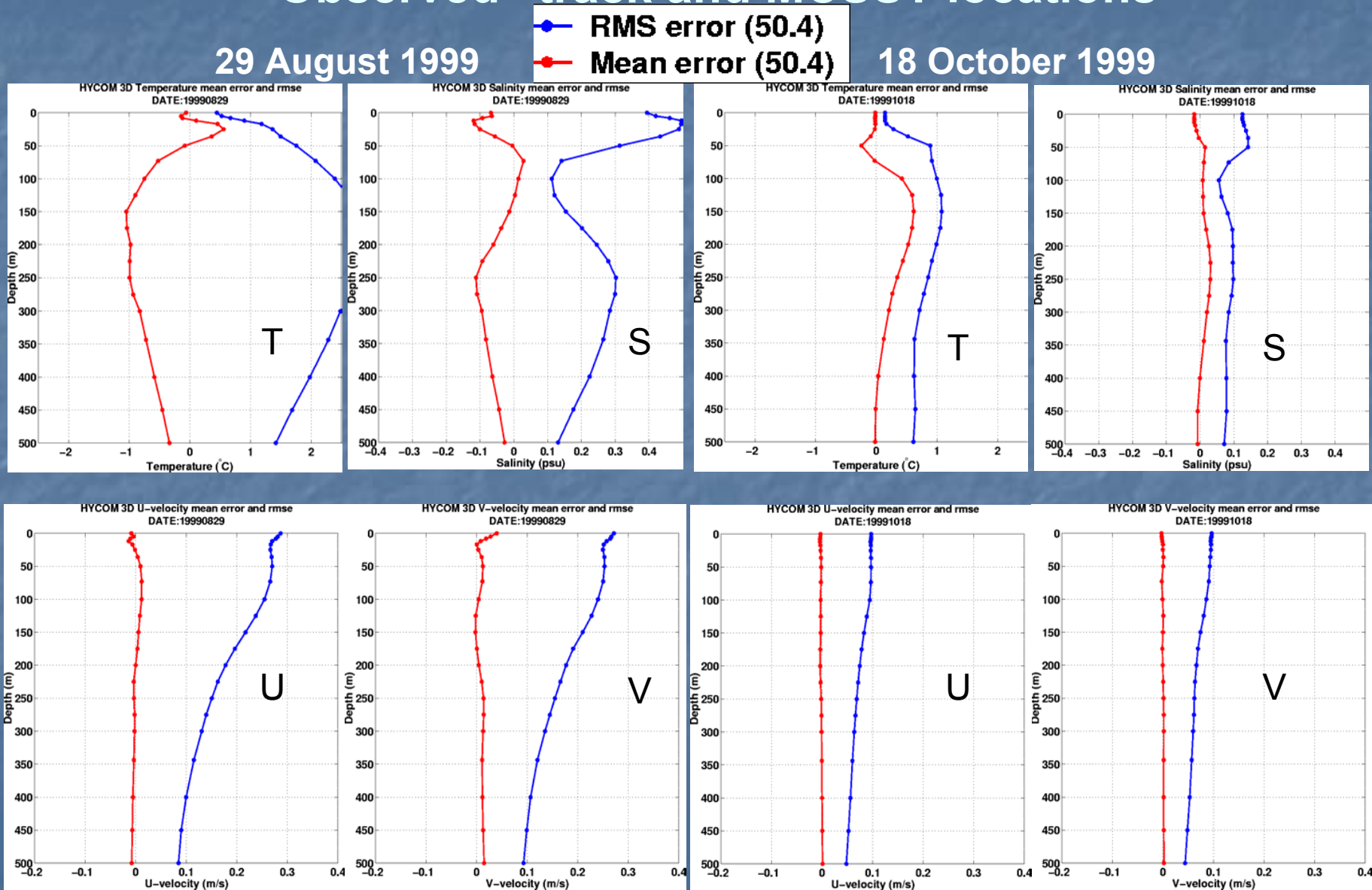
# HYCOM identical twin results

## RMSE vertical profiles (0-500m)

### “Observed” track and MCSST locations

29 August 1999

18 October 1999



# ***1/25° GULF OF MEXICO HYCOM CONFIGURATION***

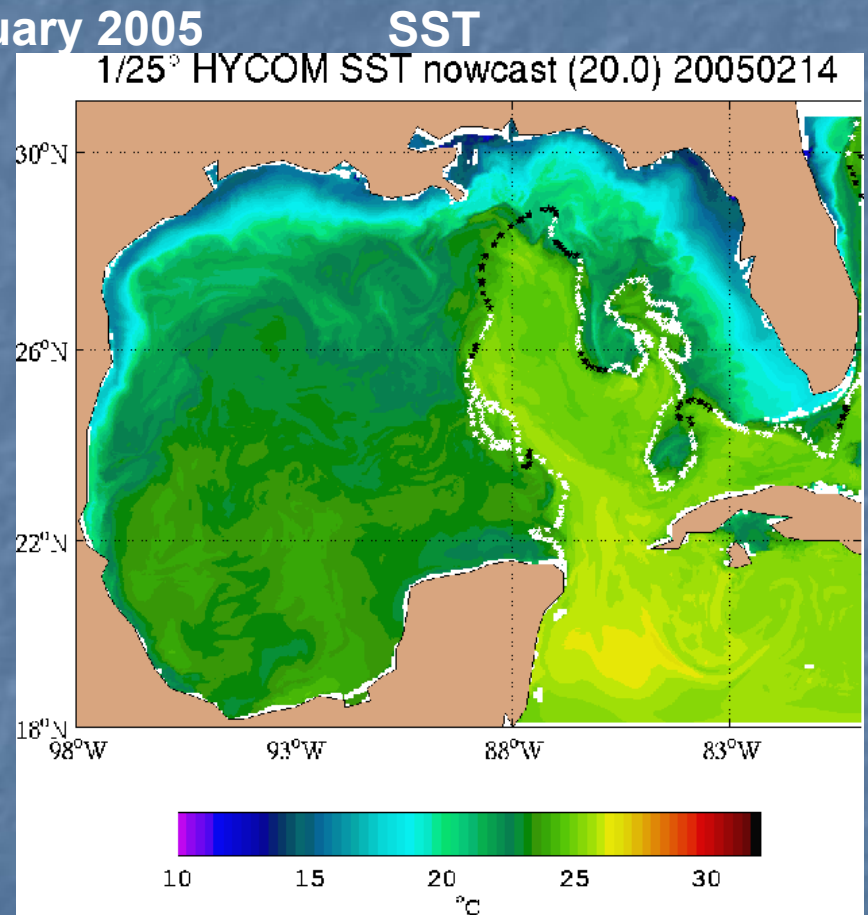
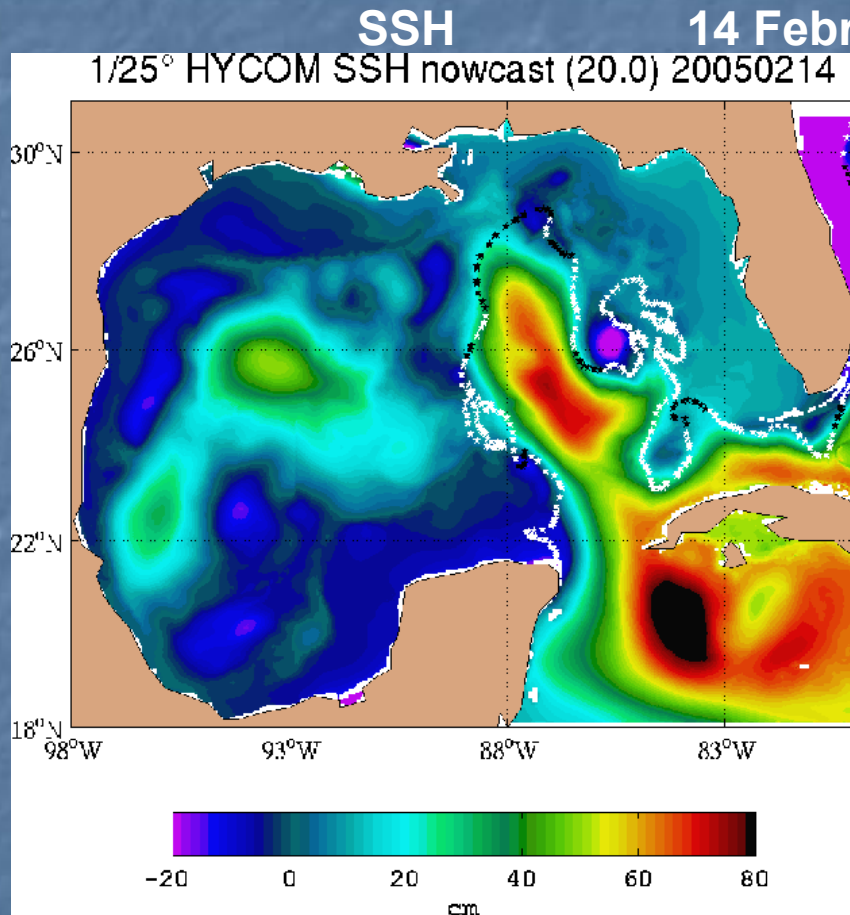
- **Horizontal grid: 1/25° (517 x 349 grid points, 3.5 km spacing on average)**
- **18°N to 31°N**
- **20 vertical coordinates**
- **Bathymetry: real coastline (minimum depth 2m)**
- **Surface forcing from FNMOC/NOGAPS**
- **Monthly river runoff**
- **Nested Boundary:**  
**relaxation to the 1/12° Atlantic HYCOM climatological T, S, U and V along open boundary**



# 1/25° Gulf of Mexico HYCOM

Hindcast started 2 September 2003

[webpage](#)



HYCOM nowcast SSH with the NAVO frontal analysis of  
MCSST observations (white/black lines, black data > 4 days old)

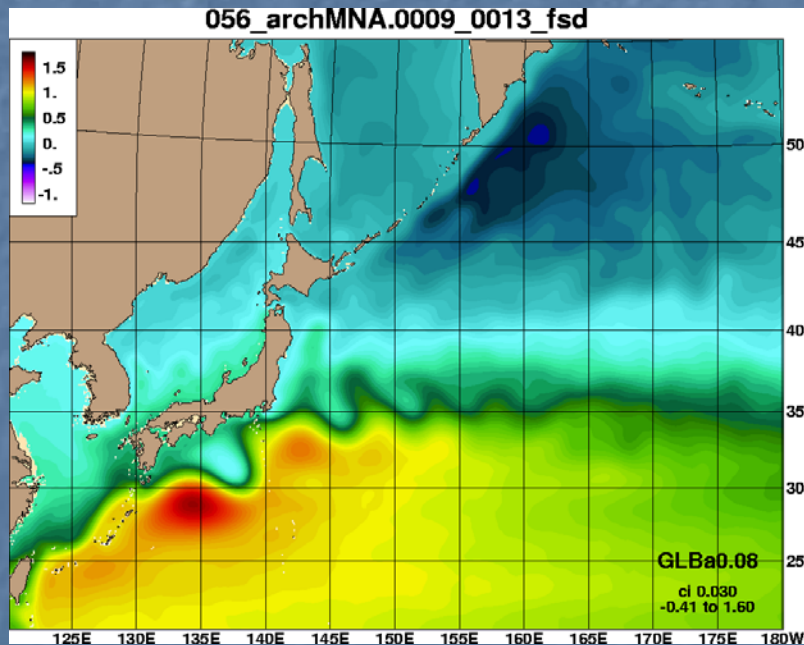


# 1/12° Global HYCOM Configuration

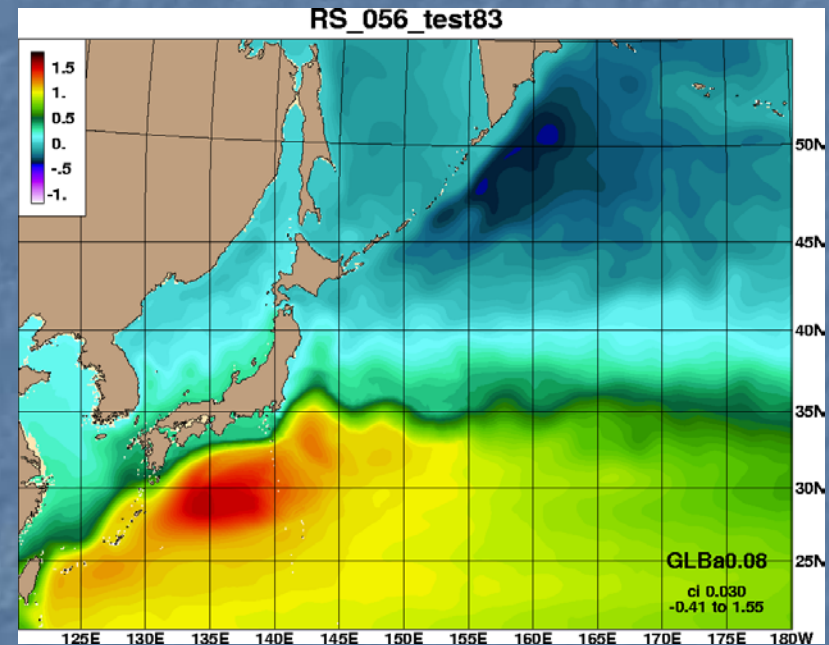
- Horizontal grid: 1/12° equatorial resolution
  - 4500 x 3298 grid points, ~6.5 km spacing on average, ~3.5 km at pole
- Mercator 79°S to 47°N, then Arctic dipole patch
- Vertical coordinate surfaces: 32 for  $\sigma_2^*$
- GISS mixed layer model
- Thermodynamic (energy loan) sea-ice model
- Surface forcing: wind stress, wind speed, thermal forcing, precipitation, relaxation to climatological SSS
- Monthly river runoff (986 rivers)
- Initialize from January climatology (GDEM3) T and S, then SSS relaxation from PHC 3.0
  - No subsurface relaxation to climatology

# 1/12° Global HYCOM Mean SSH (05.6)

Original



Rubber sheeted

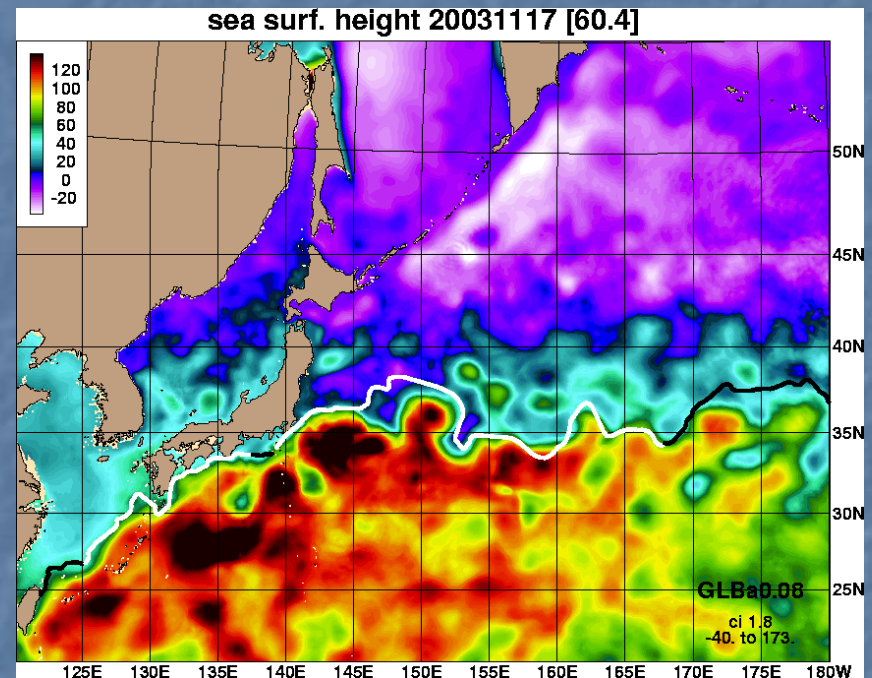
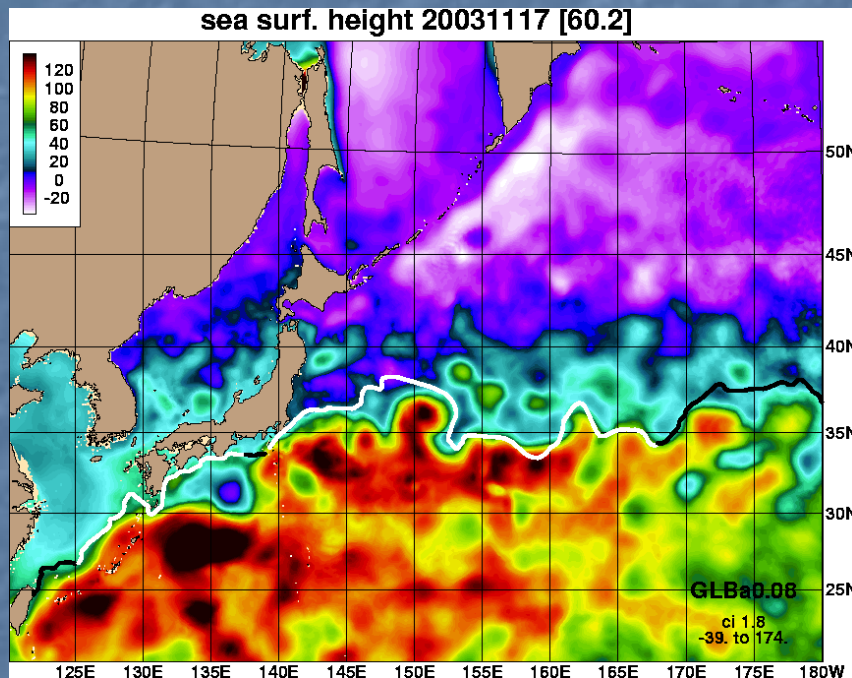


Nicolas Choplain

# 1/12° Global HYCOM

## Hindcast started 12 November 2003

SSH 17 November 2003

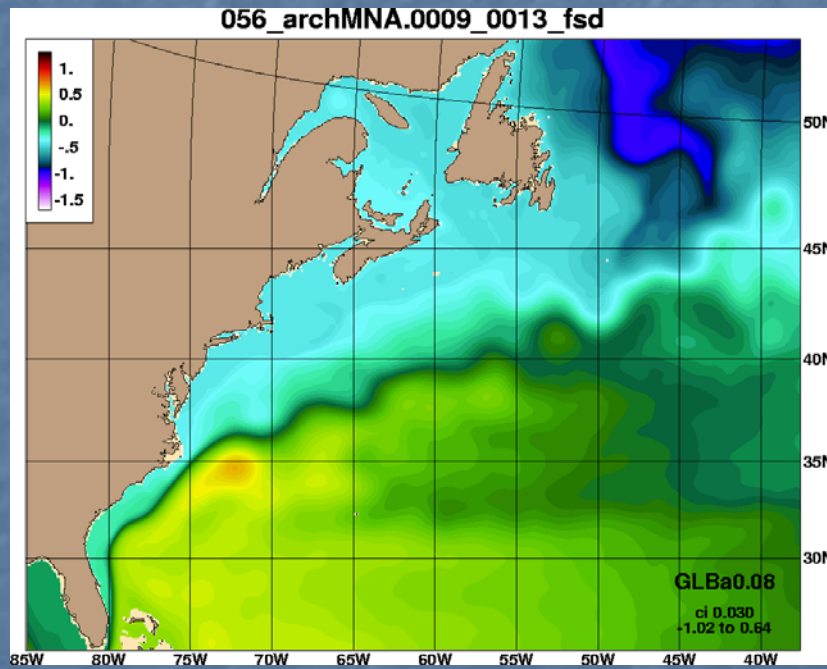


HYCOM nowcast SSH with the NAVO frontal analysis of  
MCSST observations (white/black lines, black data > 4 days old)

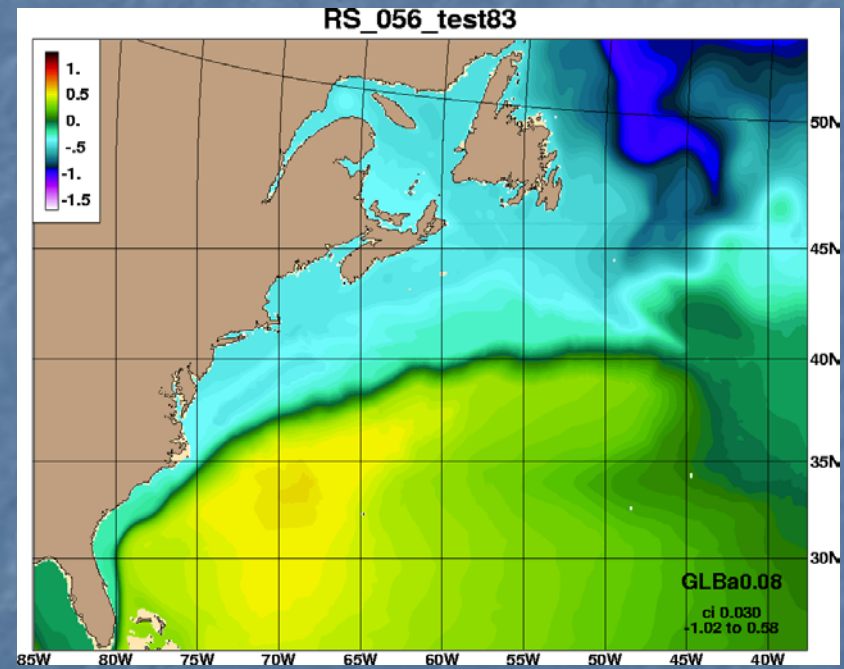
# 1/12° Global HYCOM

## Mean SSH (05.6)

Original



Rubber sheeted



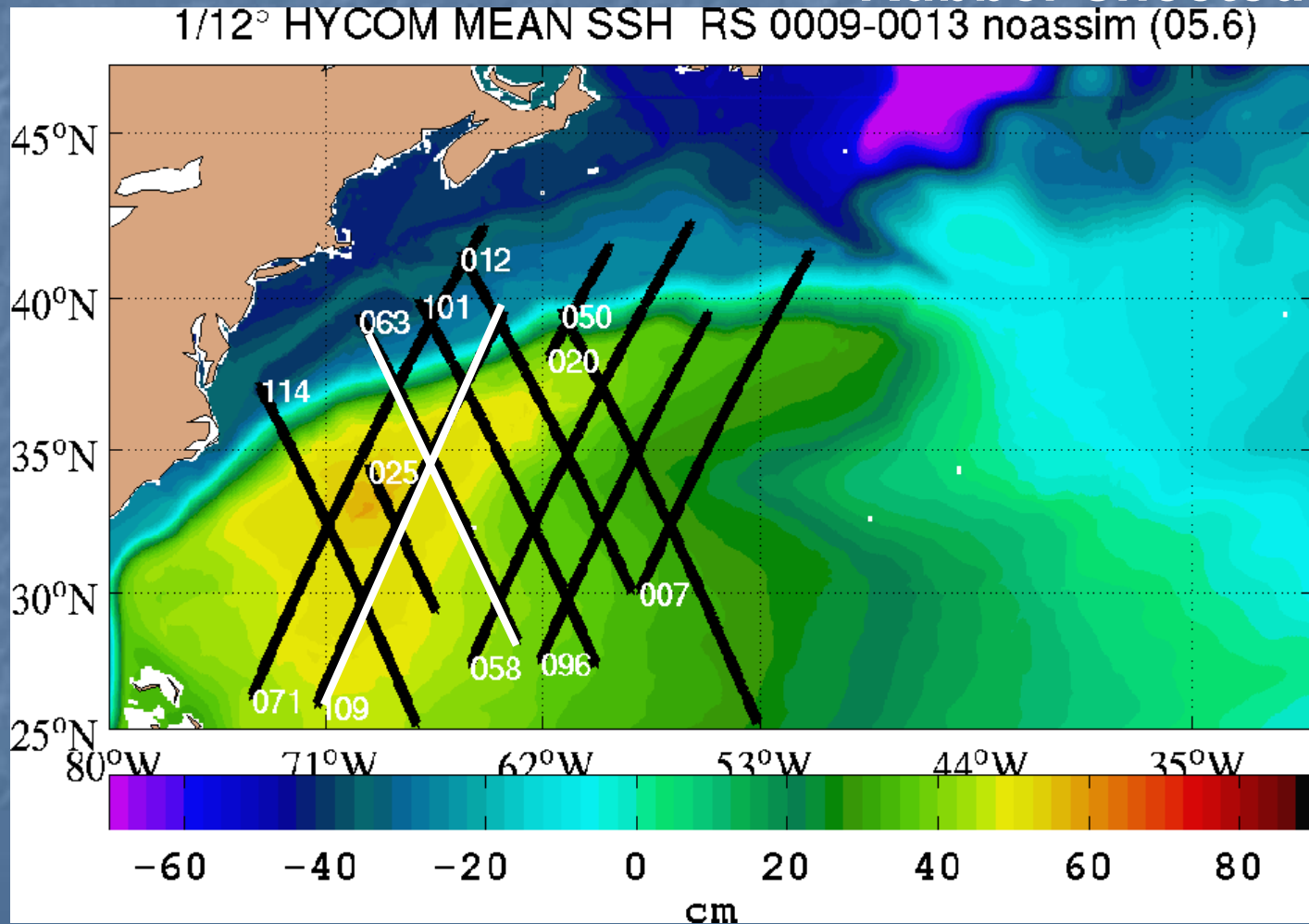
Nicolas Choplain



# 1/12° Global HYCOM

## Mean SSH (05.6)

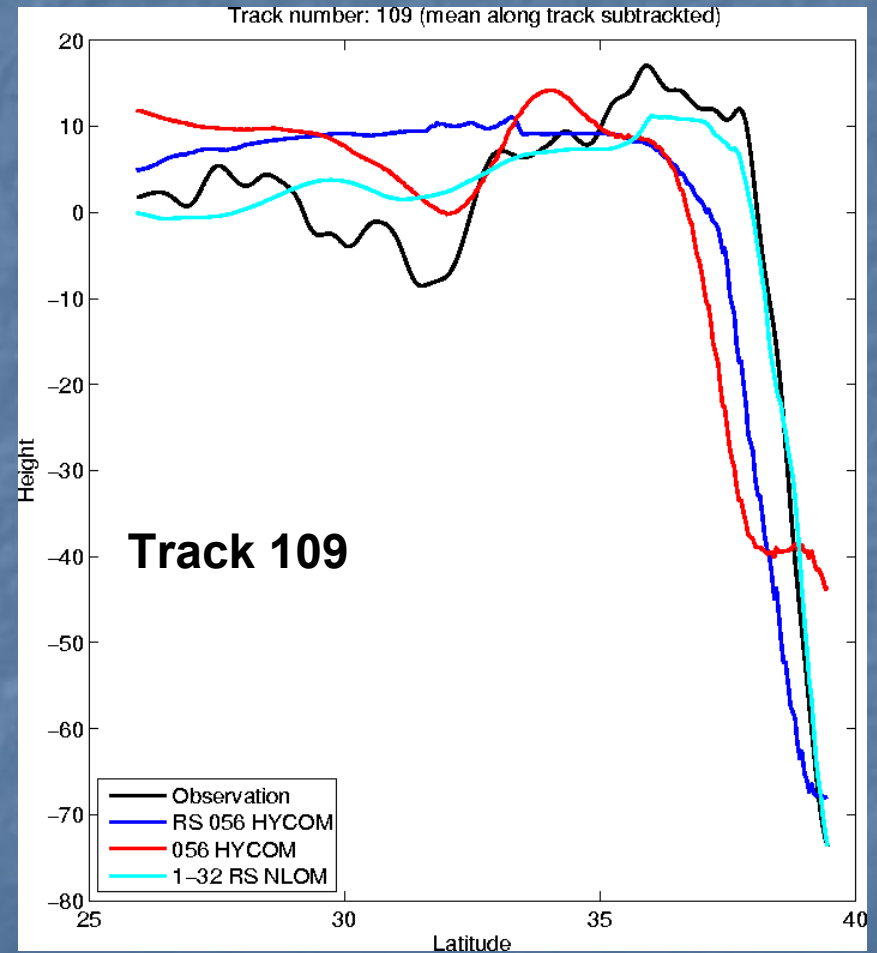
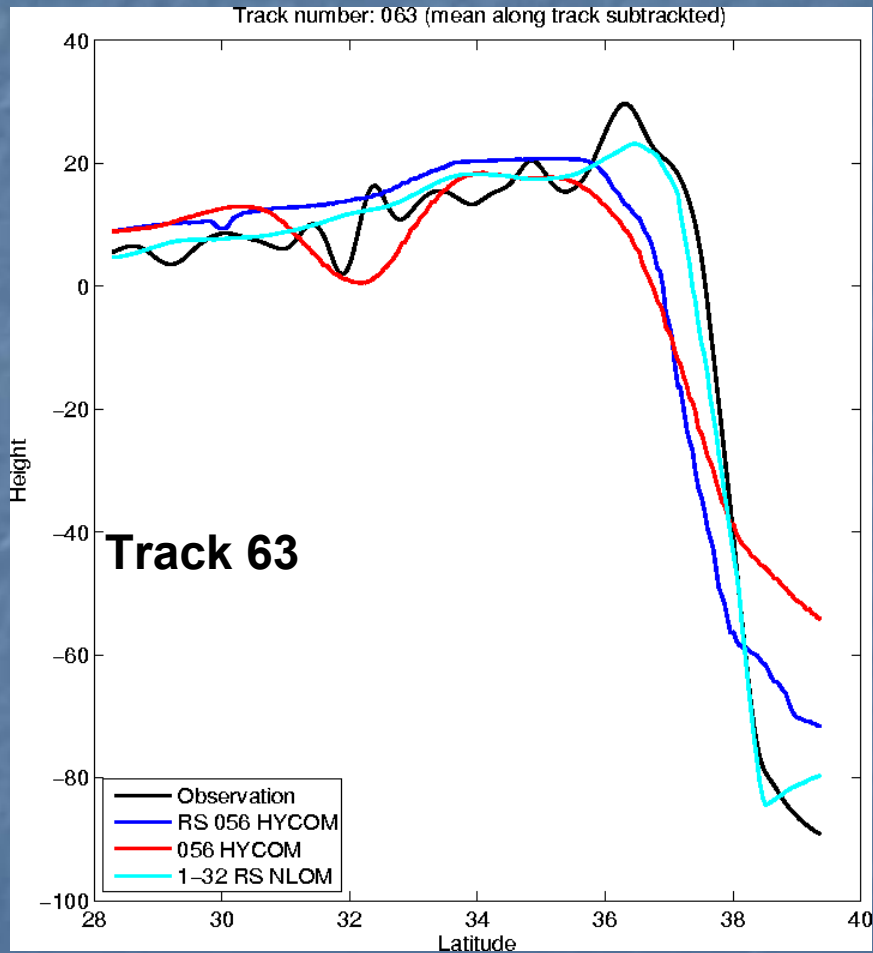
Rubber sheeted



Nicolas Choplain



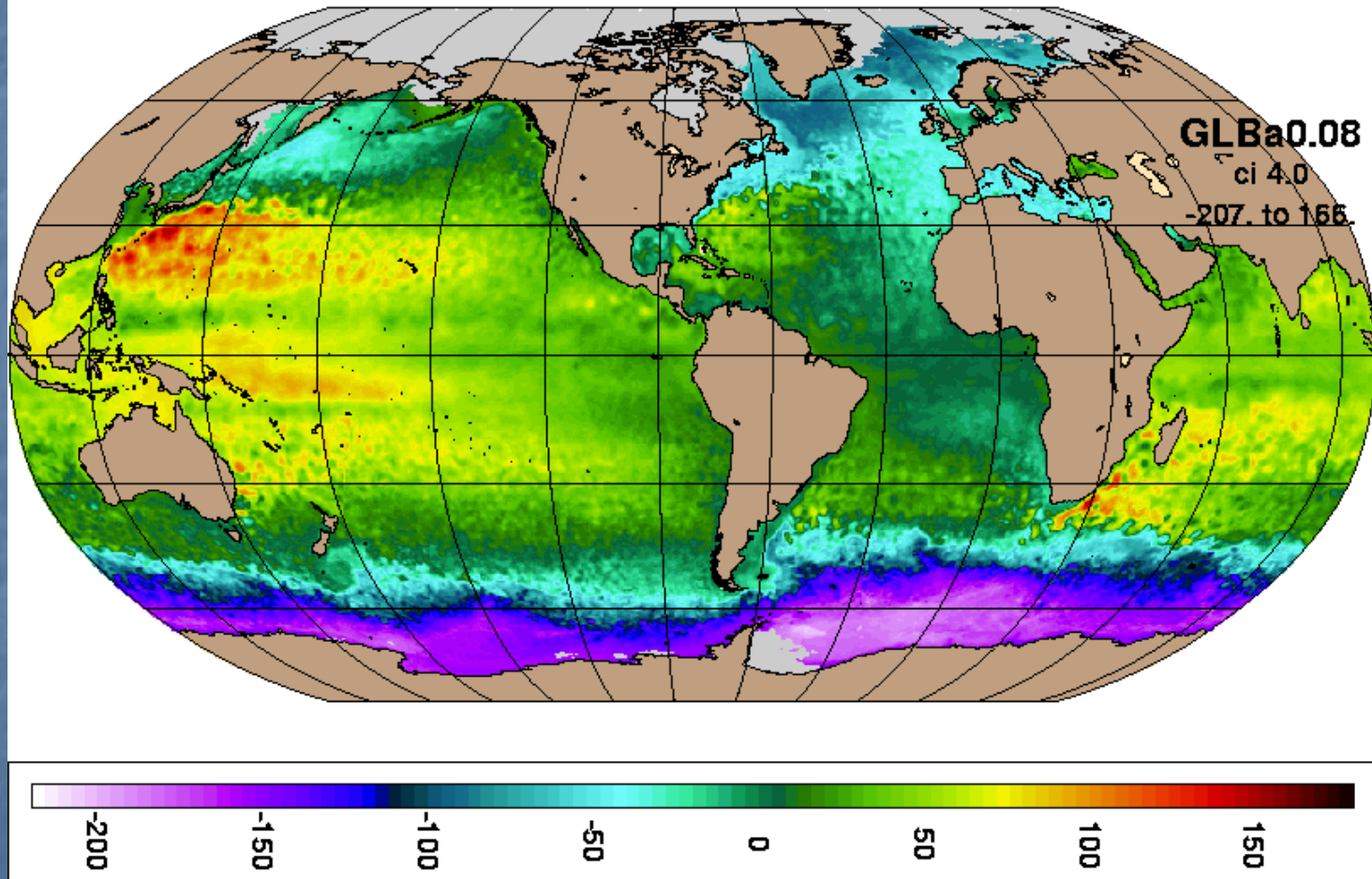
# Comparison of mean SSH to mean dynamic topography from XBTs



# 1/12° Global HYCOM

Hindcast started 12 November 2003

SSH date: Feb 25, 2004

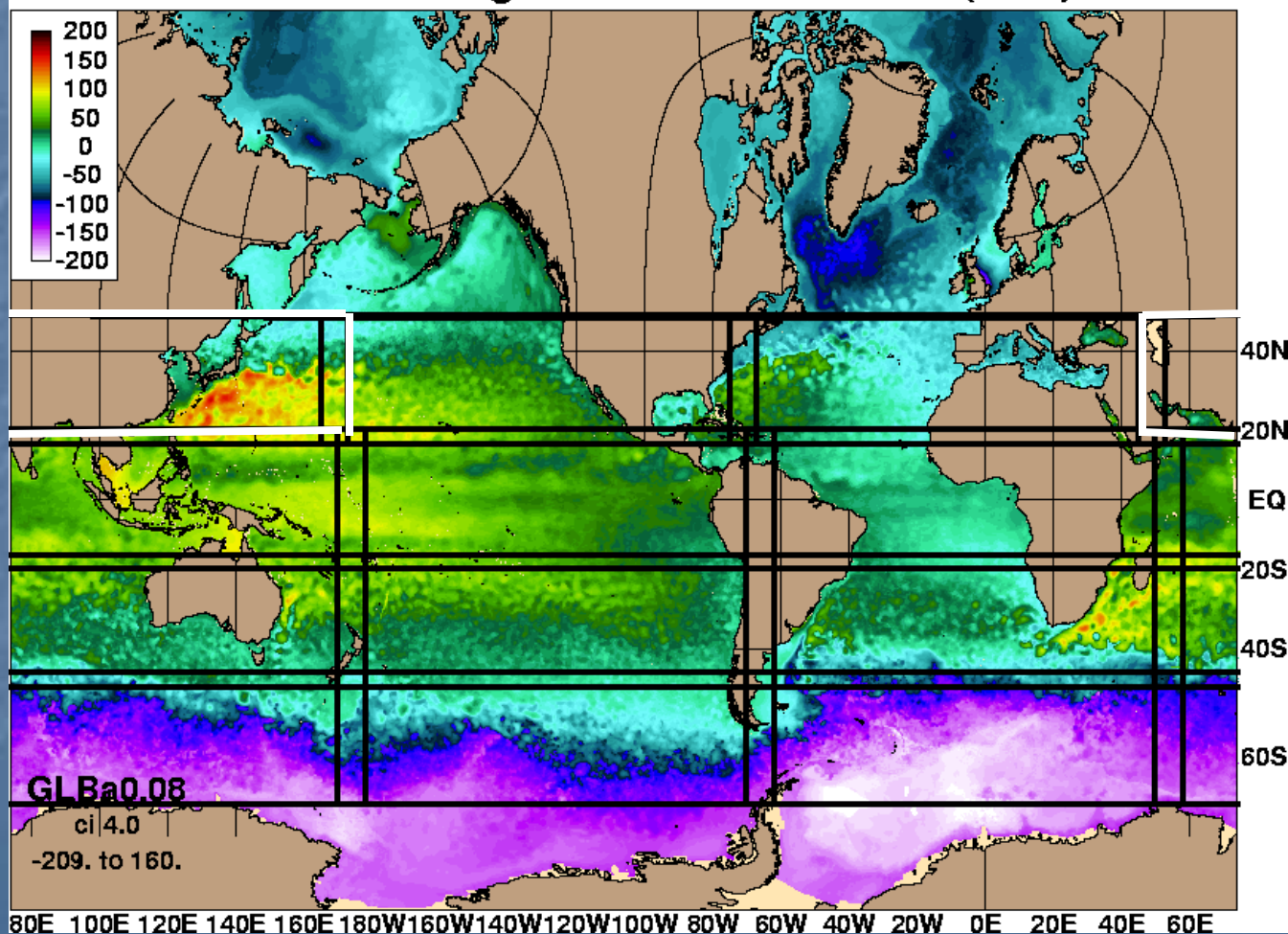


# 1/12° Global HYCOM

## Hindcast started 12 November 2003

SSH 12 November 2003

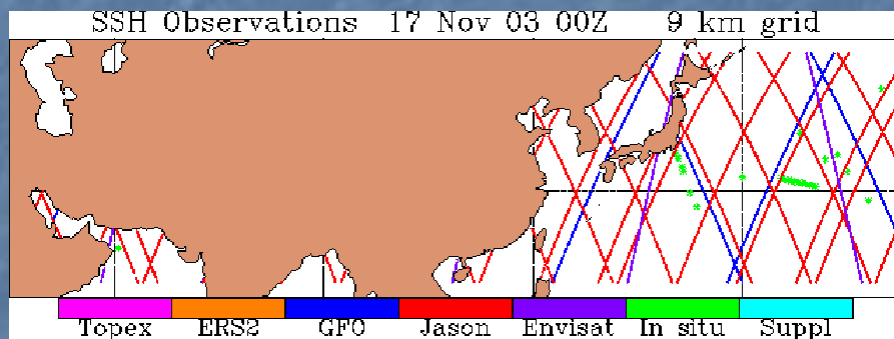
sea surface height 30 November 2003 (60.4)



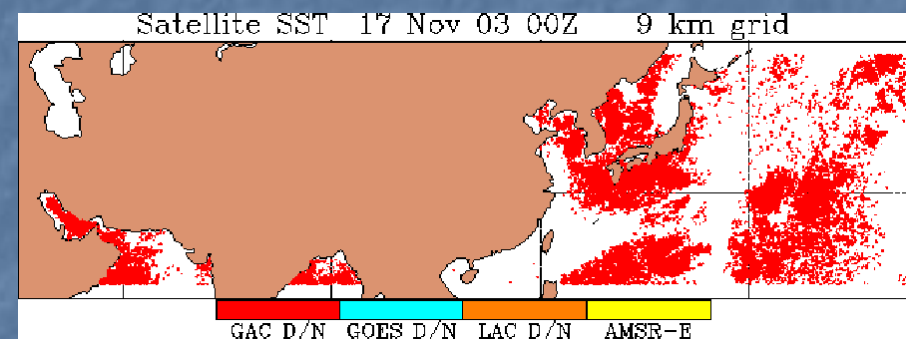
# 1/12° Global HYCOM

## NCODA observations 17 November 2003

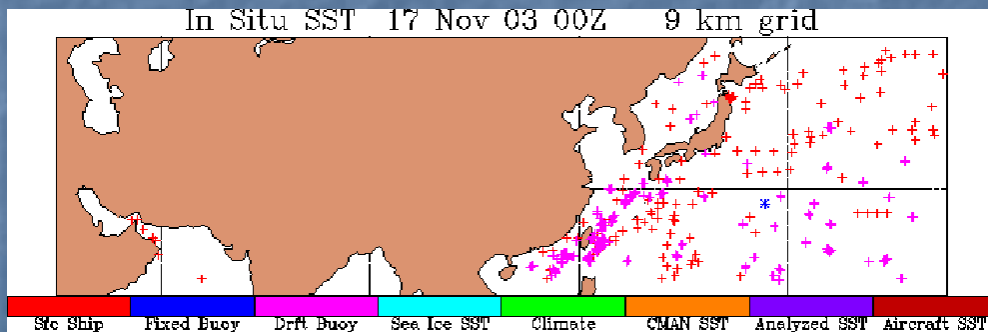
### SSH



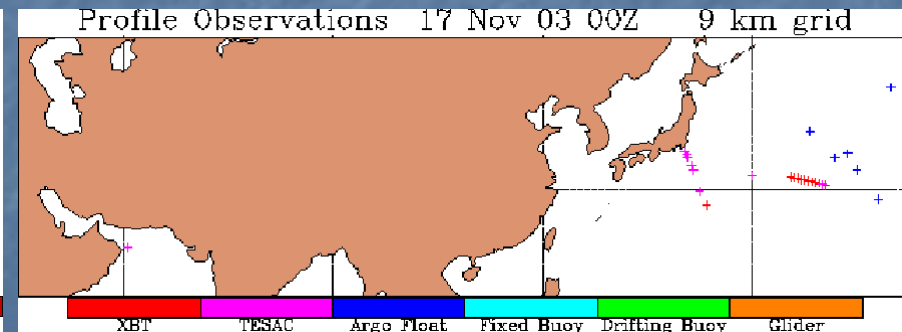
### SST



### In situ SST



### Profiles



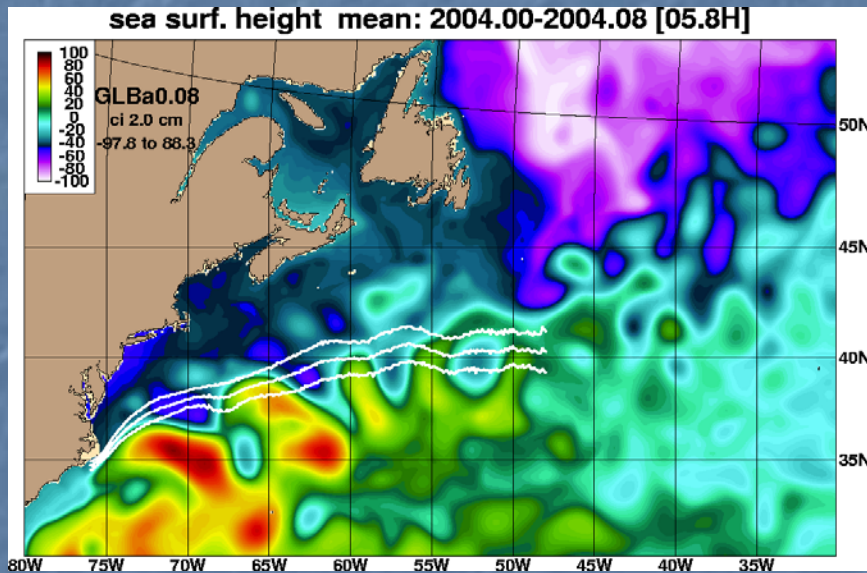


# 1/12° Global HYCOM

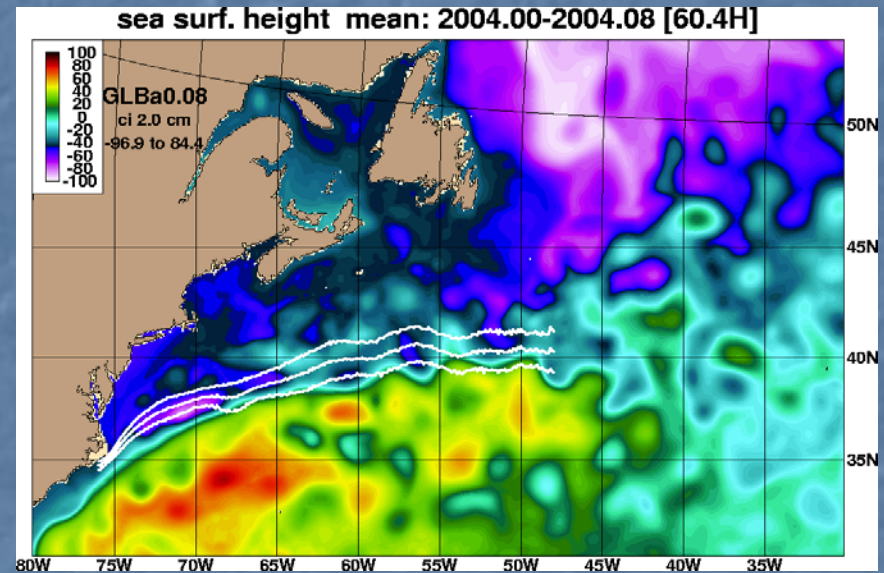
## Hindcast started 12 November 2003

### Mean SSH January 2004

No assimilation



Assimilation



HYCOM mean SSH with the mean pathway of the Gulf Stream  $\pm 1$  stdv

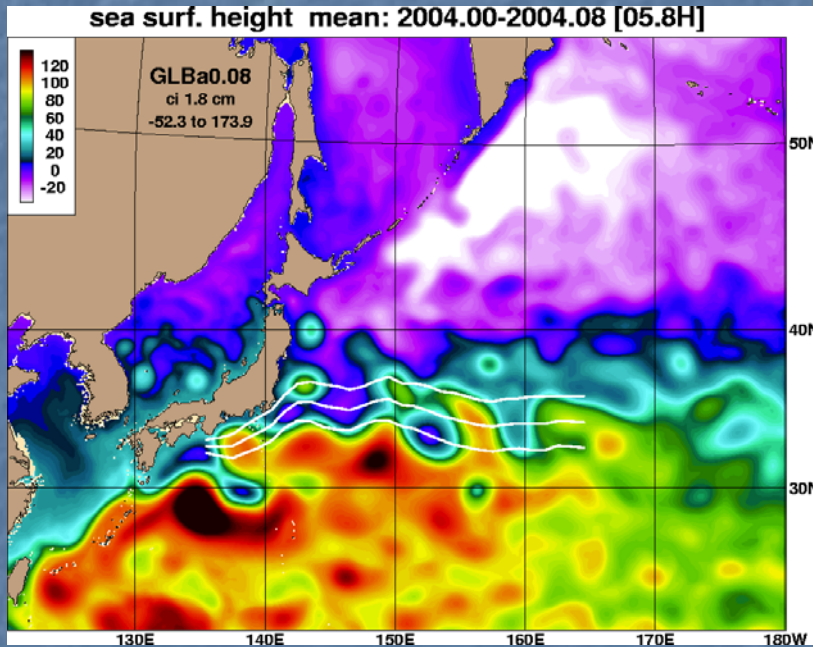


# 1/12° Global HYCOM

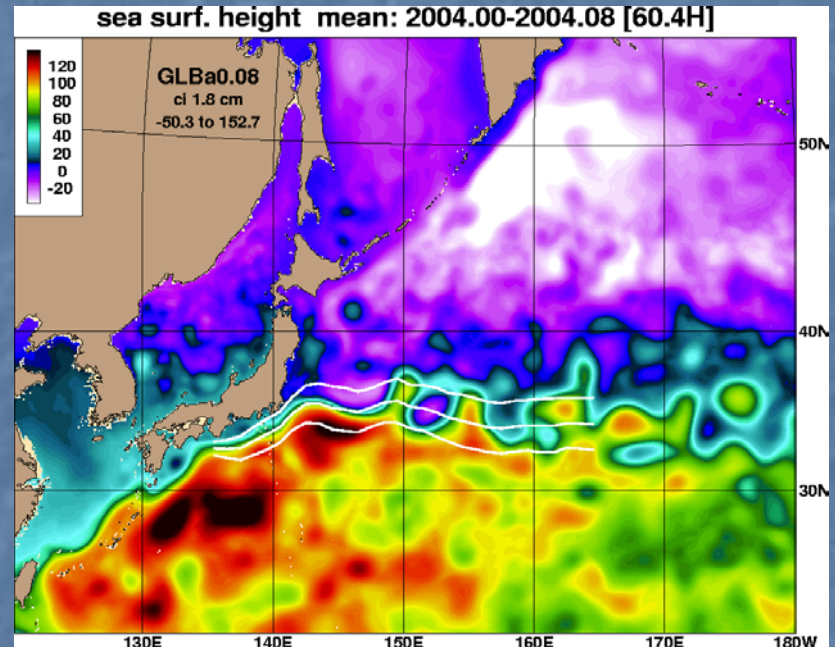
## Hindcast started 12 November 2003

### Mean SSH January 2004

No assimilation



Assimilation

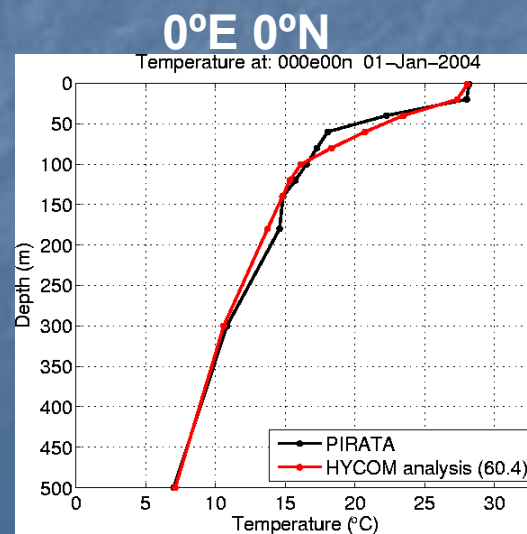
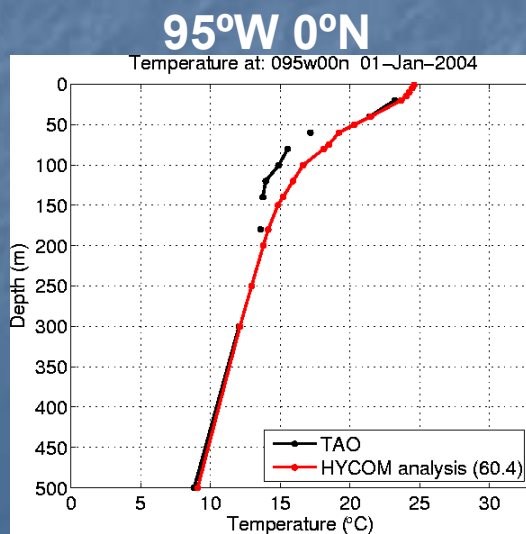
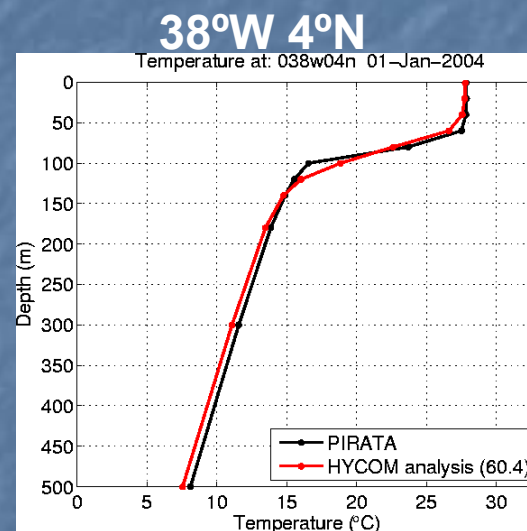
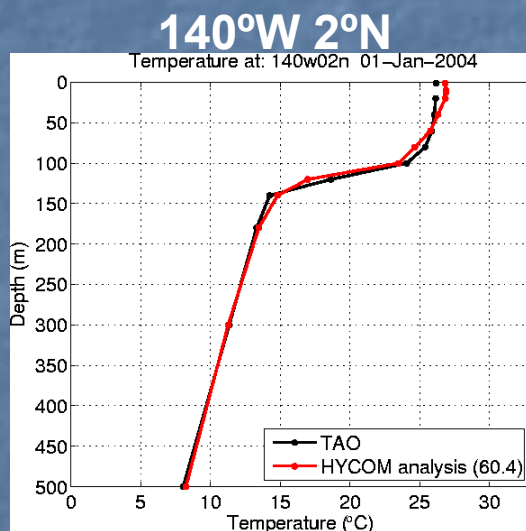


HYCOM mean SSH with the mean pathway of the Kuroshio  $\pm 1$  stdv

# 1/12° Global HYCOM

## Hindcast started 12 November 2003

January 2004



# ***Future***

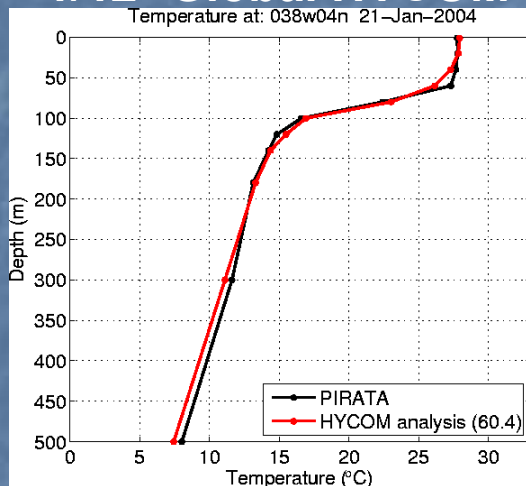
- **Update rubber sheeted mean SSH (in the Gulf Stream region)**
- **Continue present run (to real time)**
- **Include rest of domain in assimilation**
- **Test assimilation of ice concentration in the Bering Sea**

# 1/12° Global/Atlantic HYCOM

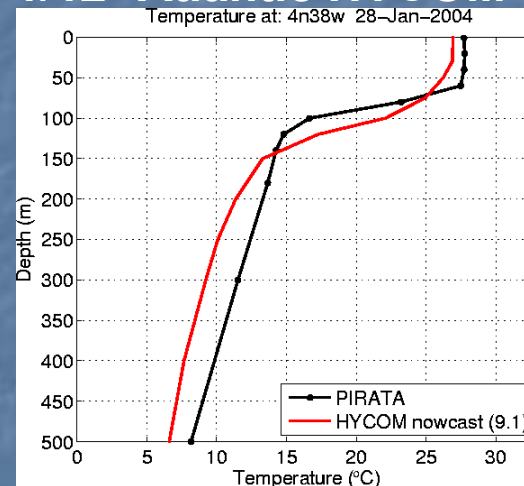
February 2004

38°W 4°N

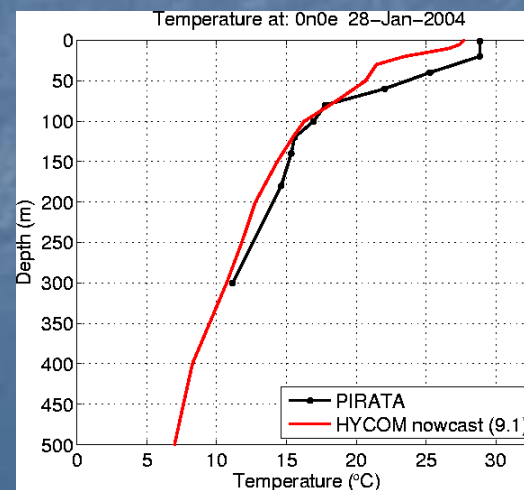
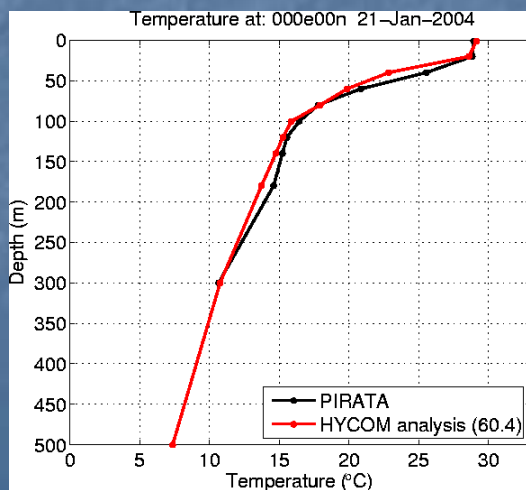
## 1/12° Global HYCOM



## 1/12° Atlantic HYCOM



0°E 0°N



**END**