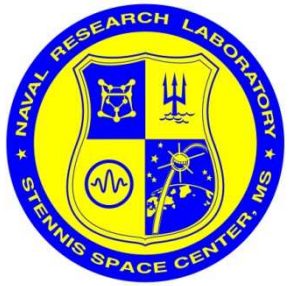


Regional and Coastal Forecasting in the Gulf of Mexico with HYCOM

Presented by

Patrick J. Hogan
Naval Research Laboratory

GODAE OceanView Coastal Oceans and Shelf Seas Task Team
(GOV COSS-TT)
International Coordination Workshop 1 (ICW-1)
Janurary 10-12, 2012
RSMAS, Miami, FL

Real Time Forecast Systems that include the GoM

- Global NCOM (oper) is a combination of
  - 1/32° global Navy Layered Ocean Model (NLOM)
  - Modular Ocean Data Assimilation System (MODAS)
  - 1/8° Global Navy Coastal Ocean Model (NCOM)

- Relo NCOM (oper) is Relocatable
  - Operational NCOM/NCODA prediction system
  - ~4 new regions/year planned over next few years

- Global HYCOM (transitioned) is 1/12° global HYCOM/NCODA
  - Passed Validation Testing Fall 2011, transitioned to NAVO
  - CICE ice, NOGAPS surface forcing, NCODA assimilation

- Major upgrade to 1/25° global HYCOM/NCODA to be transitioned ~2013
  - 3.5 km horizontal resolution globally, including Arctic
  - global tides with data assimilation, CICE

- Regional Coupled air-ocean COAMPS (4 km)
  - Based on NCOM circulation, COAMPS atmos., WaveWatch III

- Regional HYCOM 4 km (non-oper real-time)

- Regional HYCOM 1 km (non-oper real-time)

1/25°(~4 km) HYCOM Gulf of Mexico

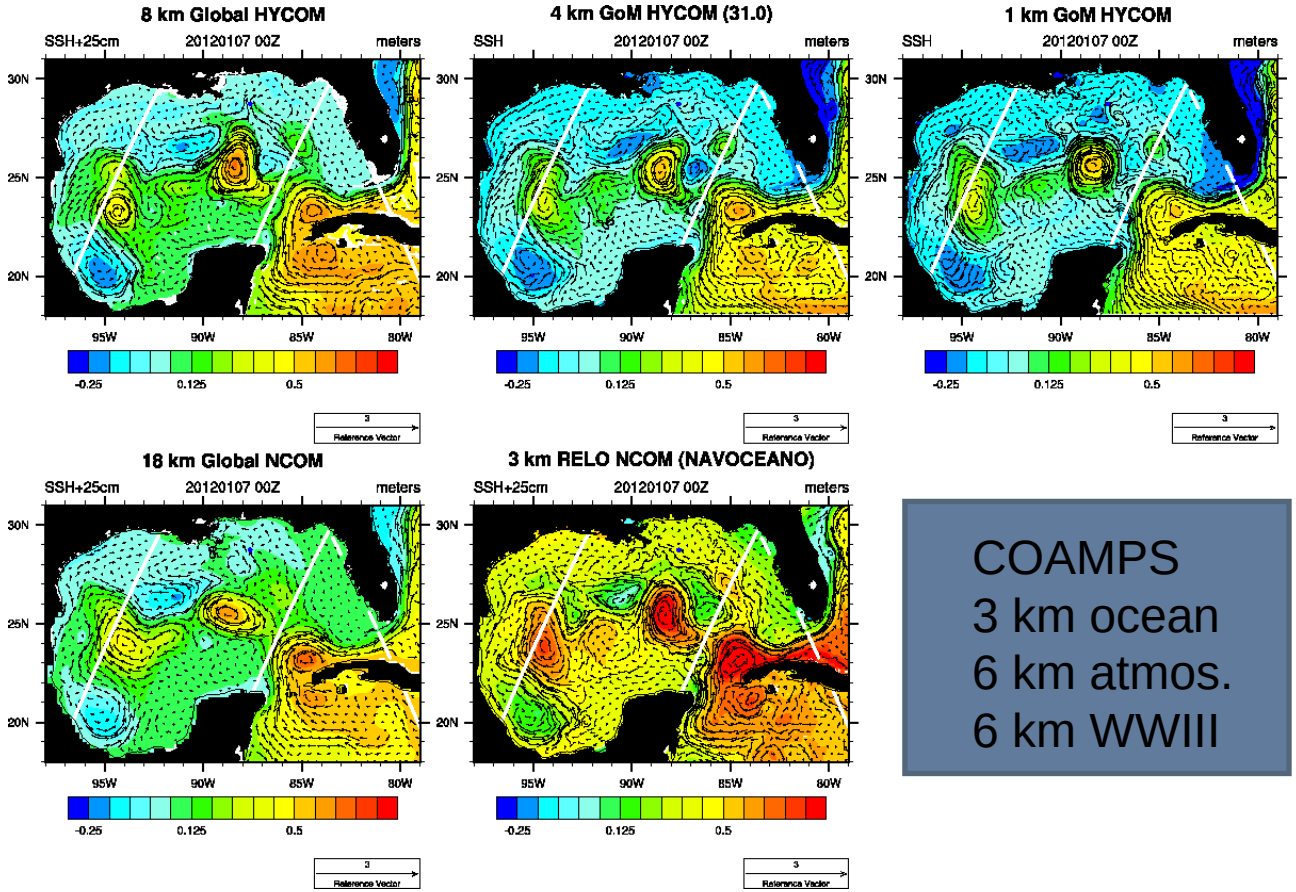
Hybrid (generalized) vertical coordinate
- Isopycnal in open, stratified ocean
- Terrain-following in shallow coastal regions
- Z-level in mixed layer and other unstratified regions

HYCOM Gulf of Mexico

- Performs a 4-day hindcast and 7-day forecast once per day
- Cyclic lateral boundary conditions from 1/12° Atlan tic HYCOM
- Surface forcing is from 6-hourly/3-hourly NOGAPS
- 20 layers in the vertical (bottom 5 from Atlantic discarded)
- 16 Rivers included as salinity flux
- GISS Mixed Layer submodel
- Bottom topography is from NRL-DBDB2
- No tides here, but recently implemented tidal boundary condition

Real-Time Forecast Systems* in the Gulf of Mexico

Sea Surface Height and currents on February 07, 2012



4 km HYCOM:
~1.5 wall (32 CPU)
for 7-day forecast

1 km HYCOM:
~9.4 wall (256 CPU)
for 7-day forecast

COAMPS
3 km ocean
6 km atmos.
6 km WWIII

* Both operational and R&D

Primary Differences:

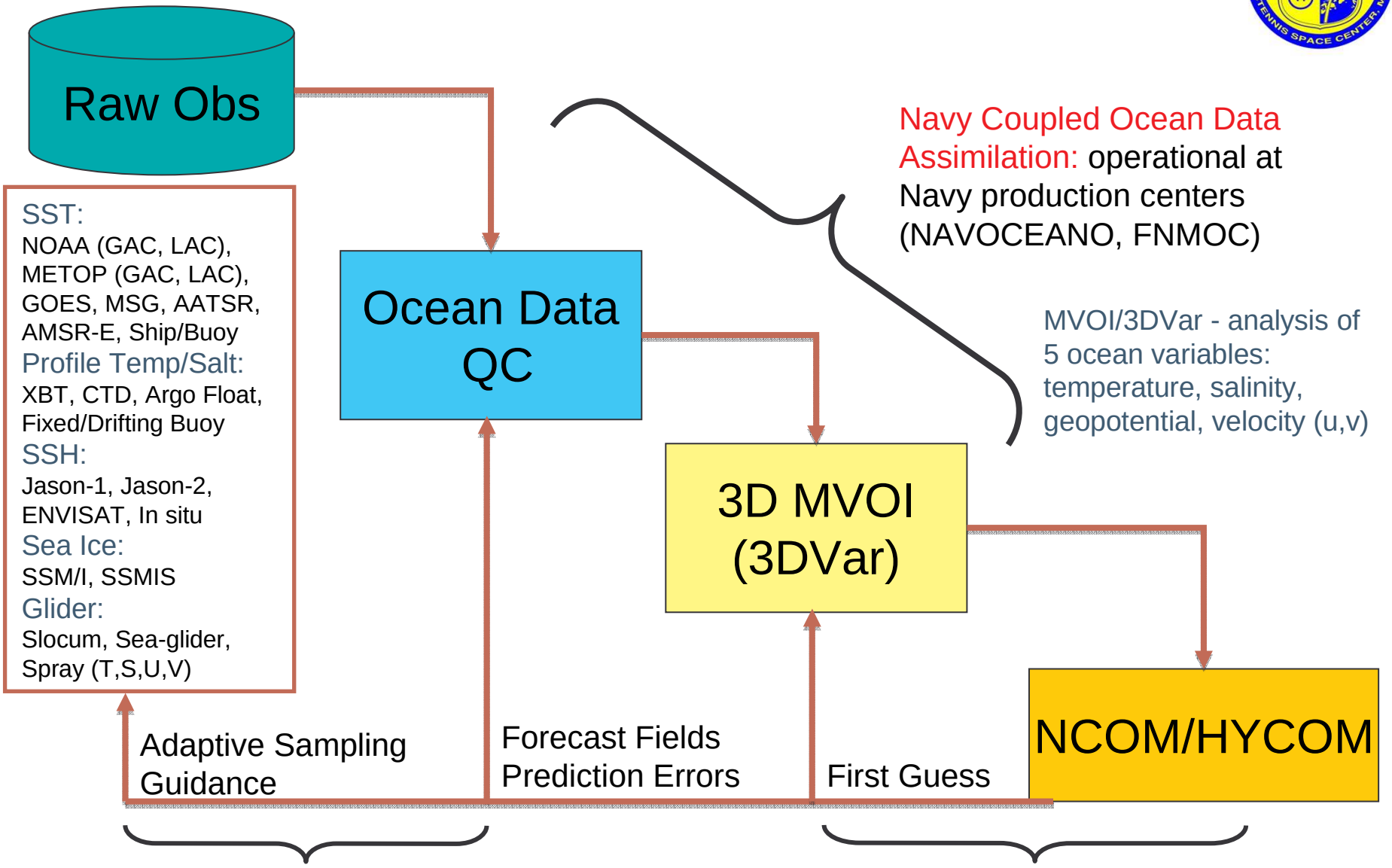
Global vs. regional – impact of lateral boundary conditions

Horizontal/vertical resolution – relatively coarse vs. fine, ability to resolve eddies

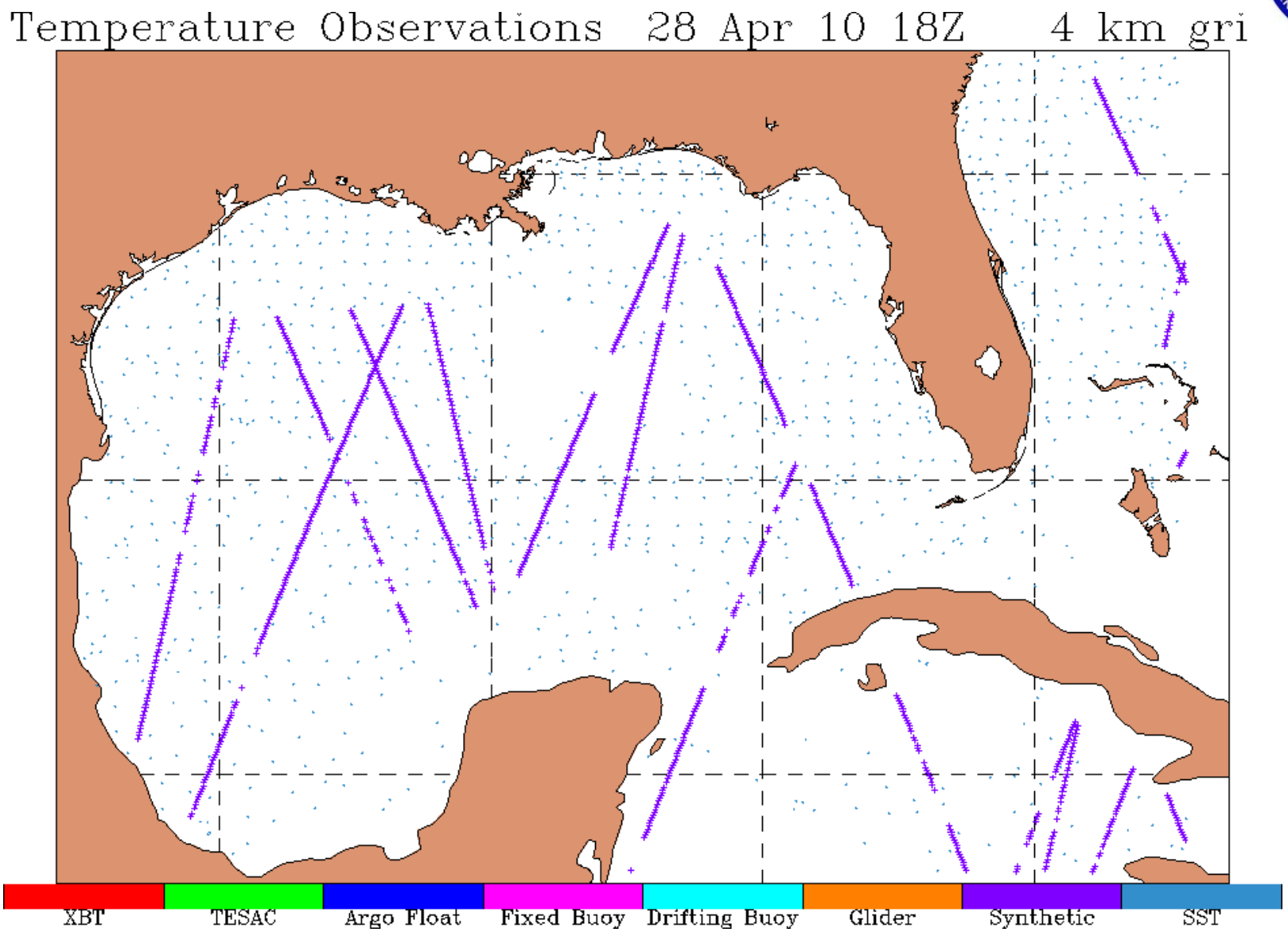
Surface forcing - impact of different winds and heat fluxes

Data assimilation – how observations are inserted into the model

U.S. Navy Prediction System Framework

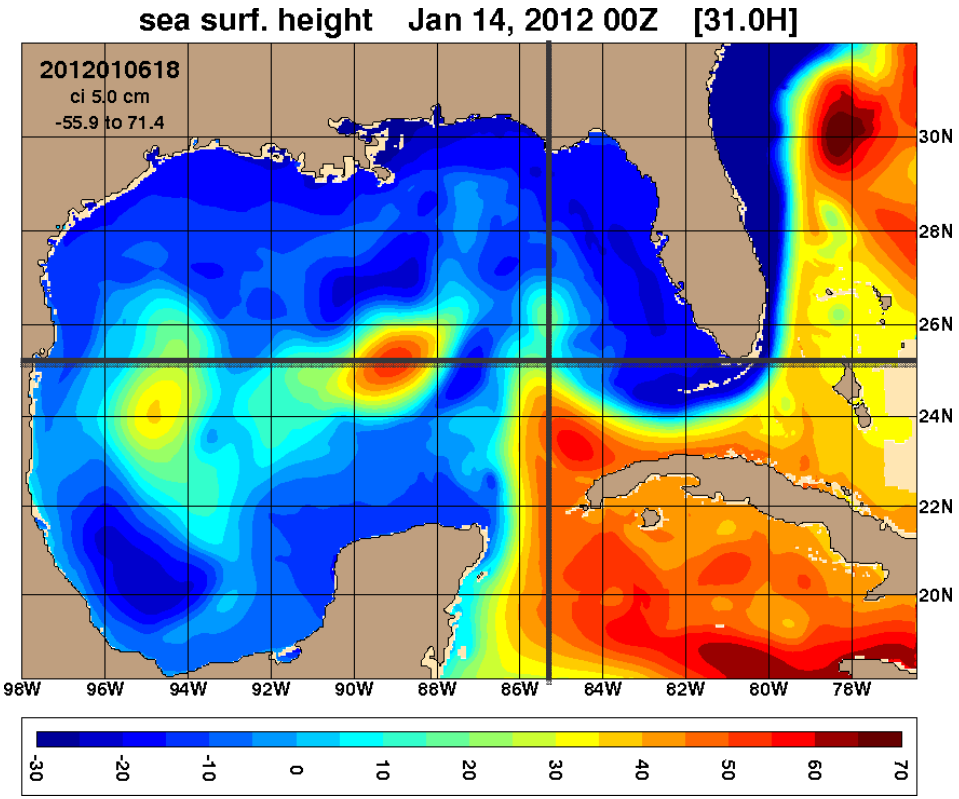


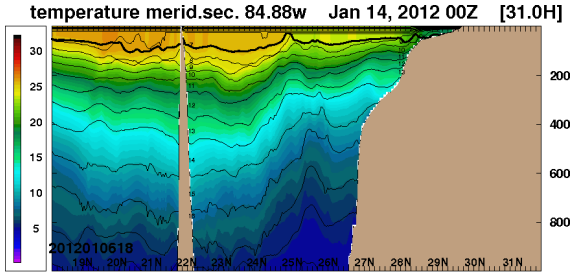
Observations used in daily analyses used to initialize forecasts
May-July 2010

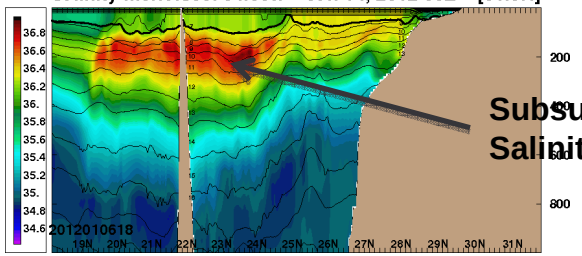


1/25° HYCOM GoM Forecast System

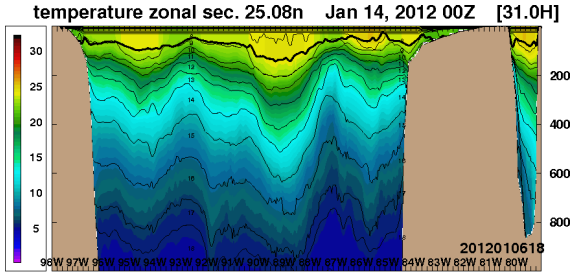
7 day forecast for Jan 14, 2010 (analysis on Jan 7)

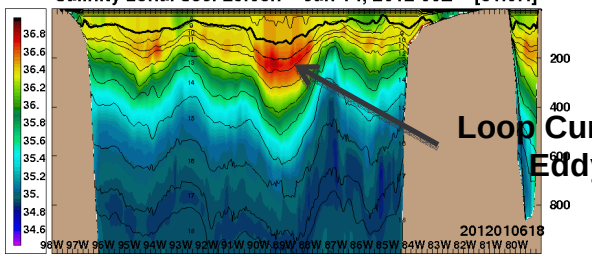






Subsurface Salinity max

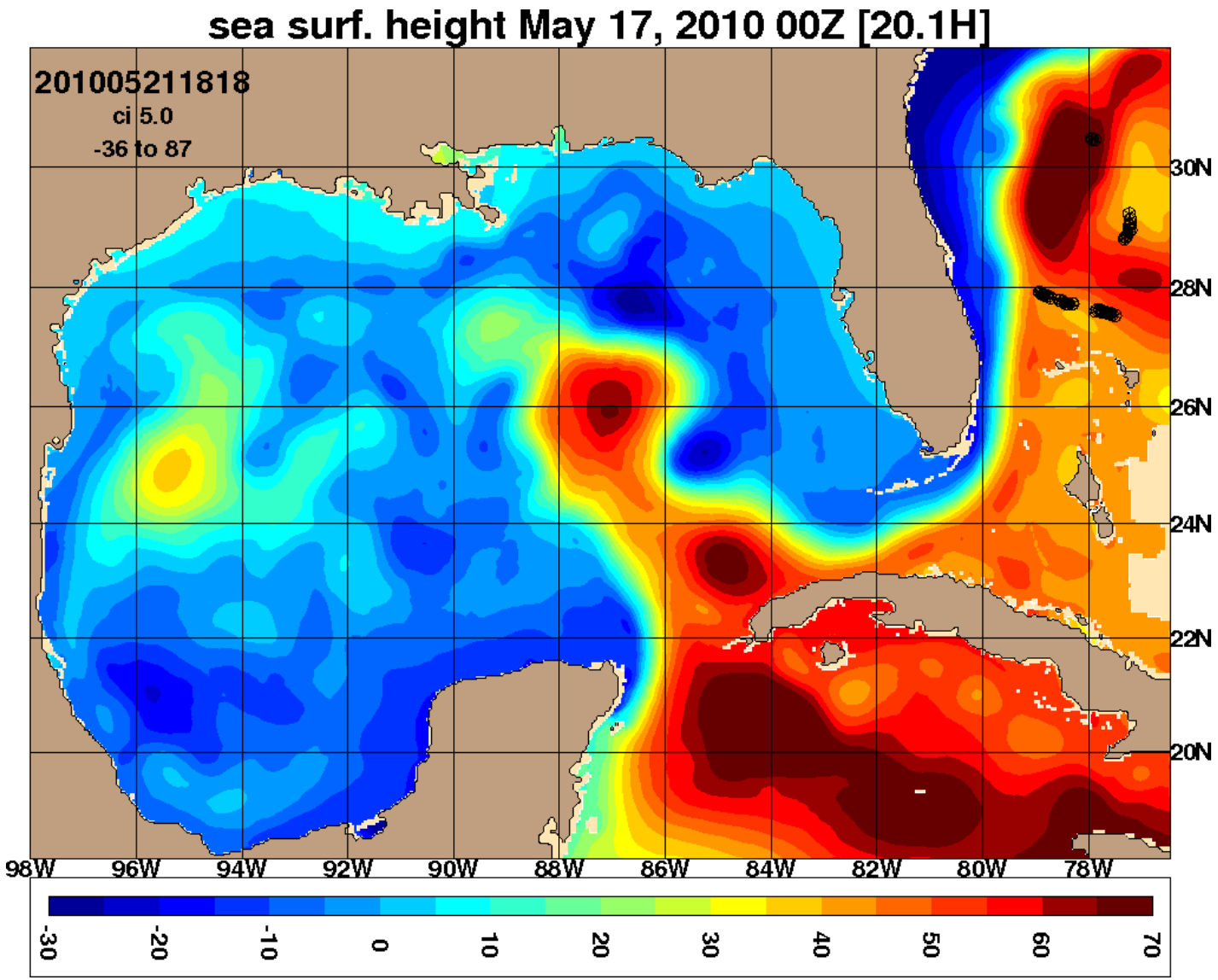




Loop Current Eddy

NOGAPS surface forcing, lateral boundary conditions from Atlantic HYCOM, NCODA assimilation

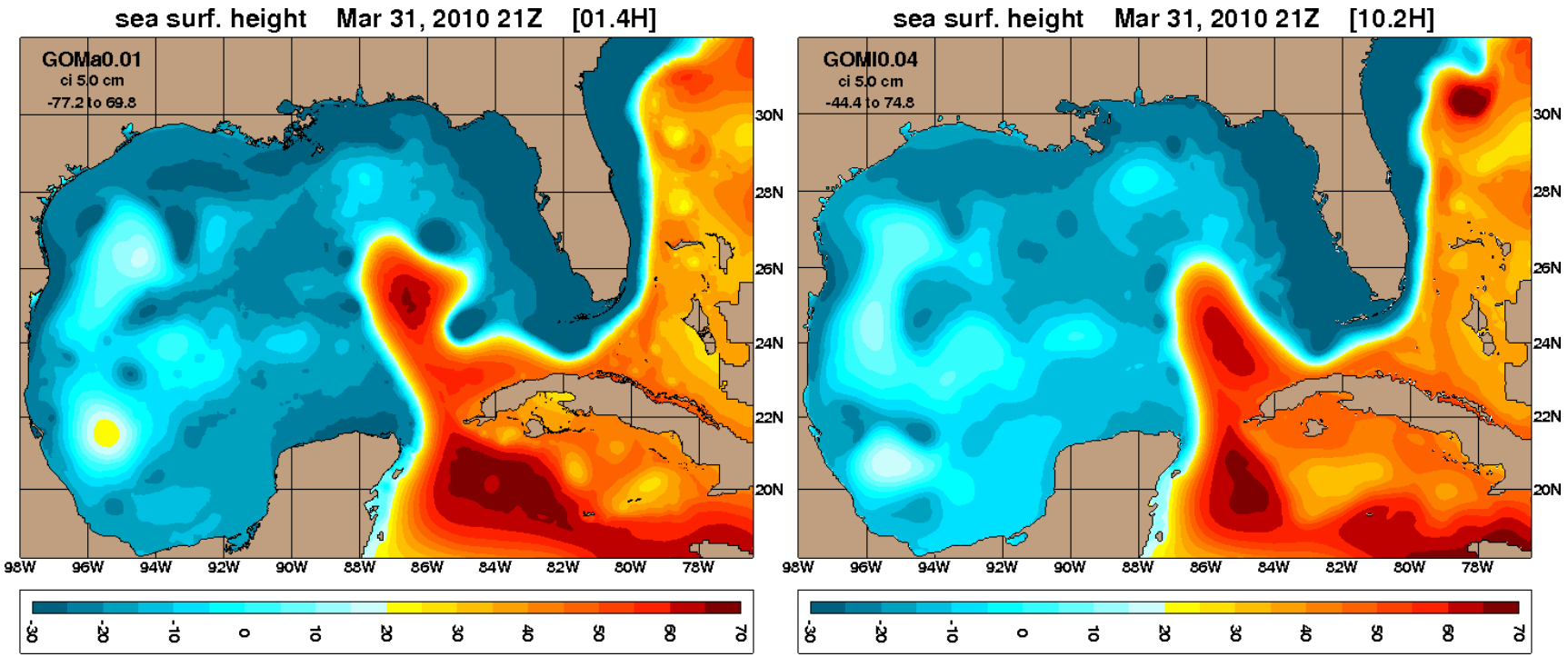
SSH from 4 km GoM simulation May 17 through August 31, 2010



Surface drifters are not assimilated and provide independent verification

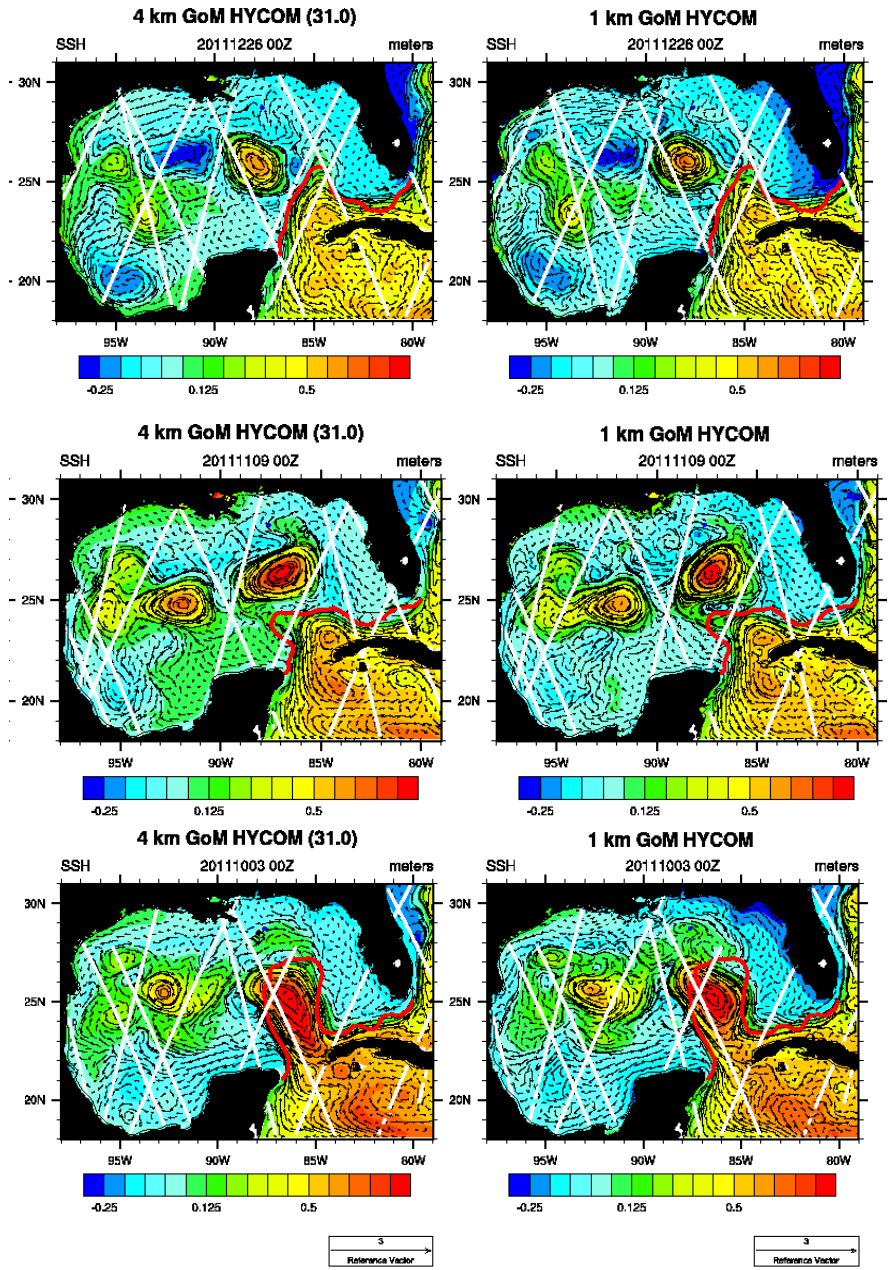
A seven-day forecast is performed once per day

4 km vs. 1 km Free Running HYCOM on March 31, 2010



1 km initialized from 4 km December 2009

4 km (1/25°) **1 km (1/100°)**



Dec. 26 2011

Comparison of SSH snapshots from assimilative 4 km vs. 1 km Gulf of Mexico HYCOM

Nov. 09 2011

Is the higher resolution worth The significant increase in Computational cost in forecast Mode?

Oct. 03 2011

Mesoscale observing systems can't necessarily constrain features on a 1 km grid

One last thought…

Will global HYCOM with 3.5 km resolution (scheduled for Transition in FY14) make regional GoM HYCOM obsolete?

Thanks!

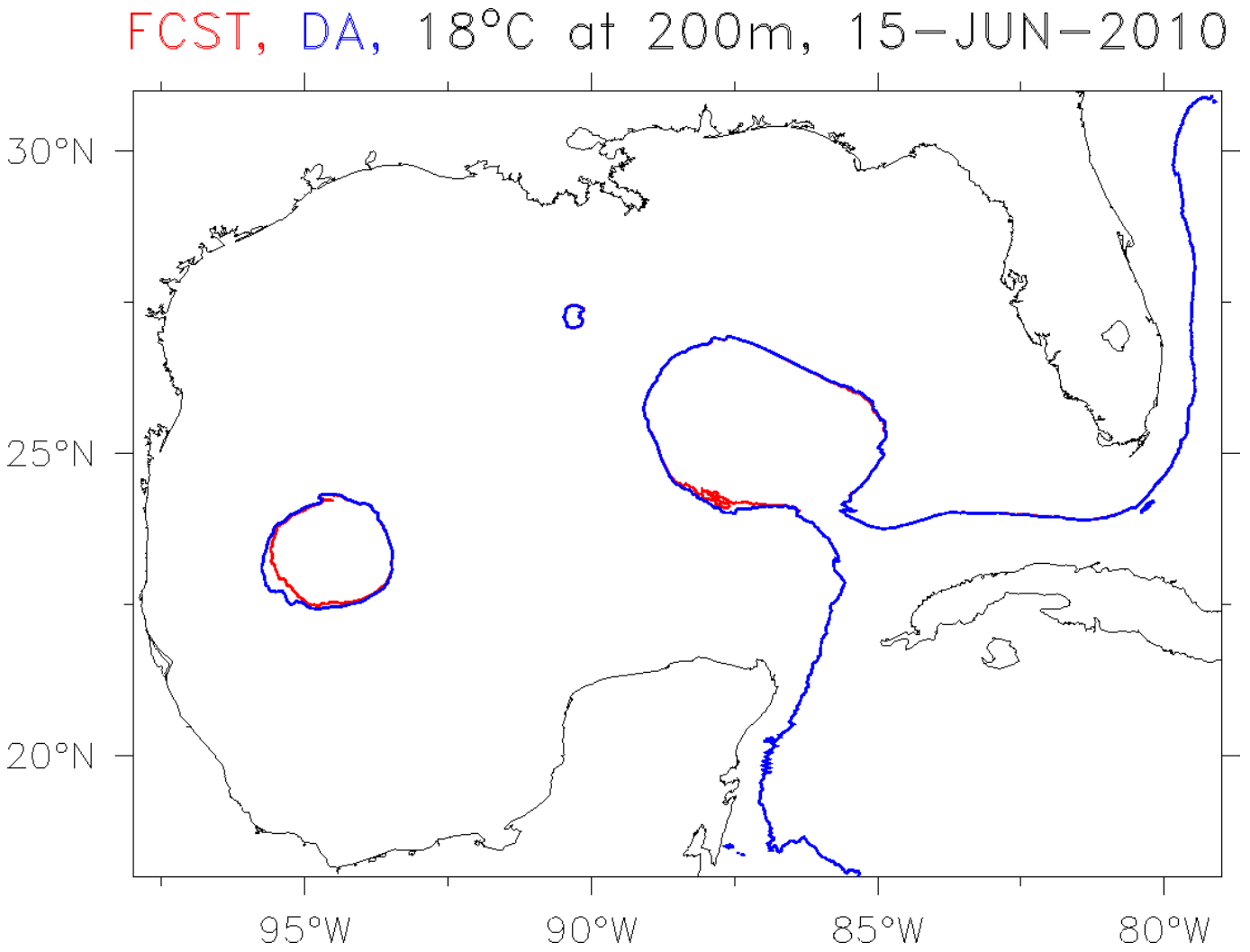
http://www7320.nrlssc.navy.mil

http://www.hycom.com

supplemental slides follow

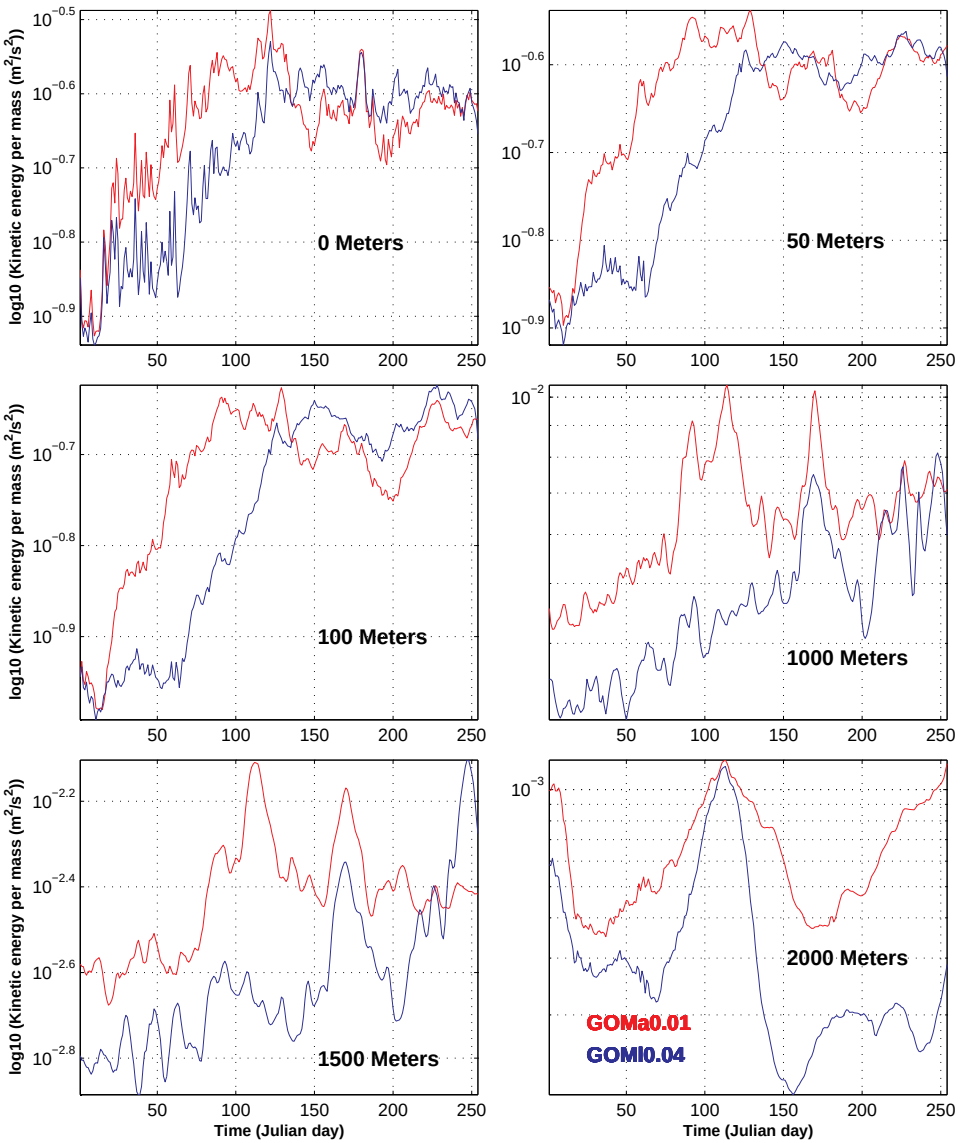
4 km Gulf of Mexico HYCOM: Long Term Predictability?

60 day forecast (June 15-Aug 15 2010)

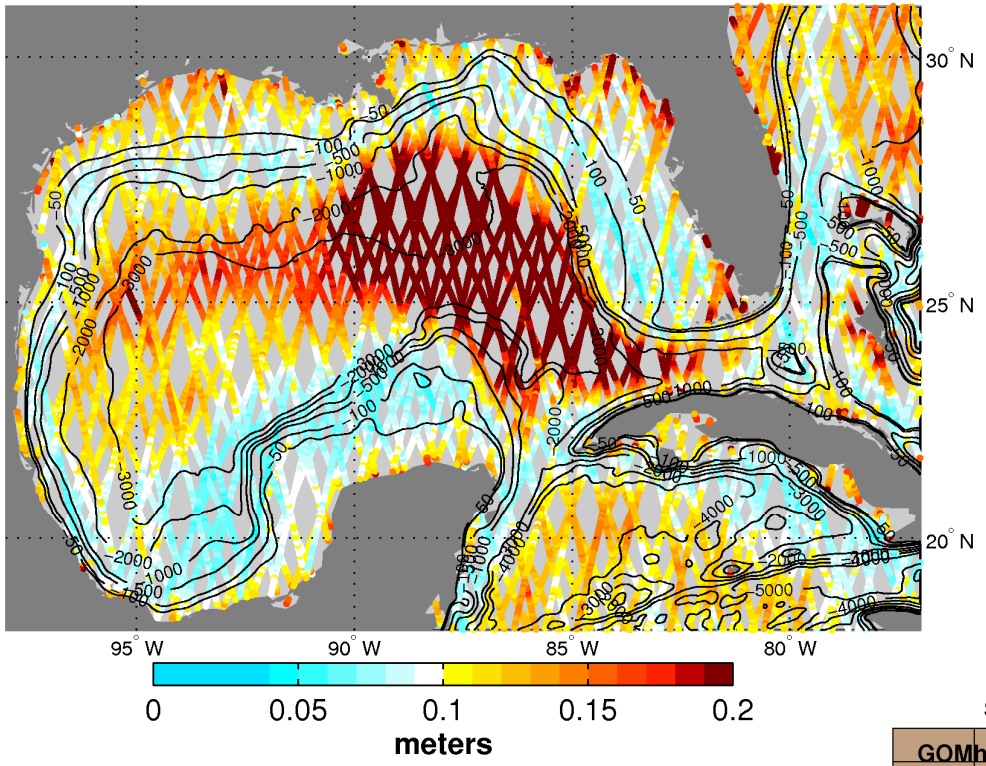


Free-Running HYCOM GoM: 4 km vs. 1 km

2010 Kinetic Energy as a function of depth (90-80W, 20-26N)

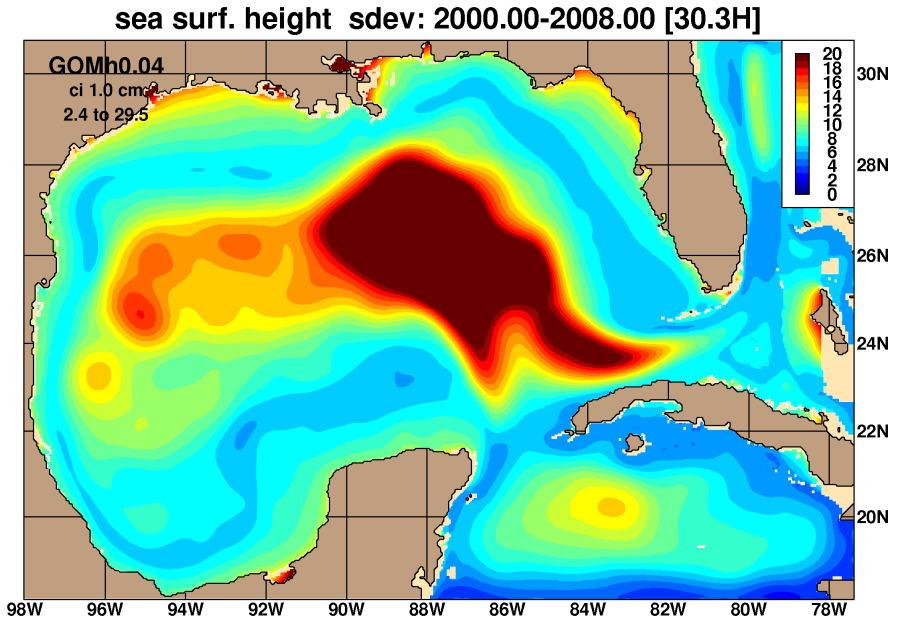


SYSTEM	Objectives	Assessment	Large Scale	Applications
HYCOM				

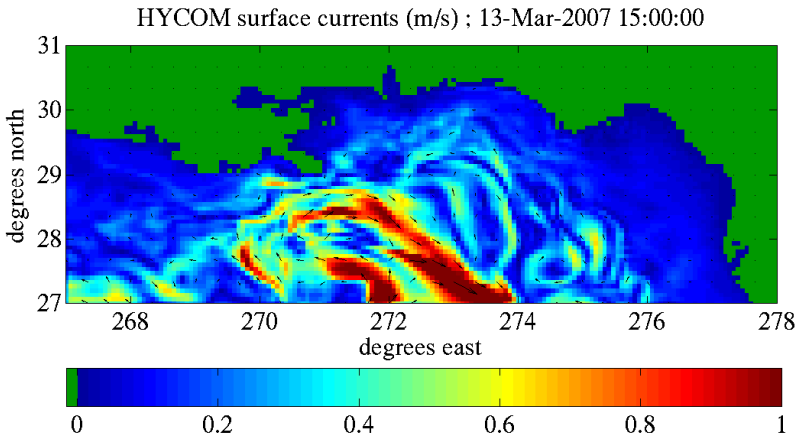


RMS SSH at ground track points from GFO, ENVISAT, Jason, and interleaved TOPEX satellite altimetry

RMS SSH from 1/25° HYCOM Over 2000-2007 with 1/2° NOGAPS surface forcing and NCODA assimilation



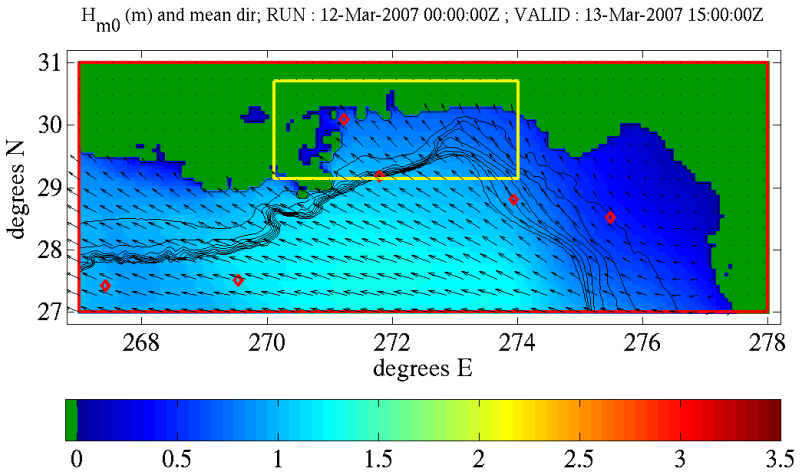
1/25º GOM HYCOM currents



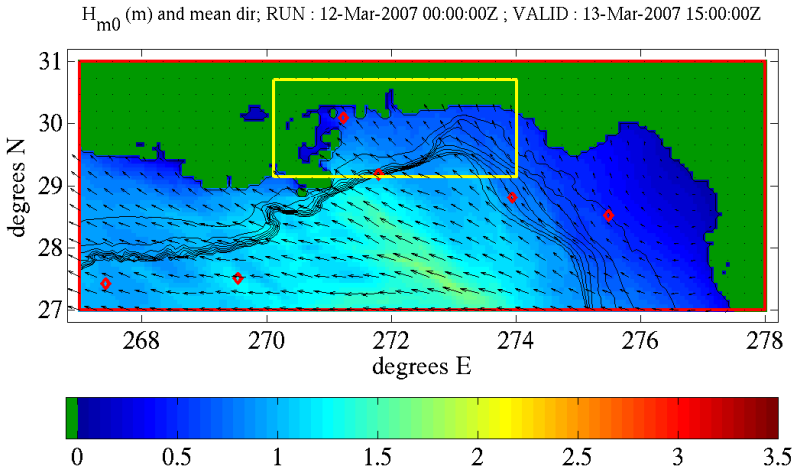
13 March 2007 15:00Z

From Erick Rogers
Naval Research Lab

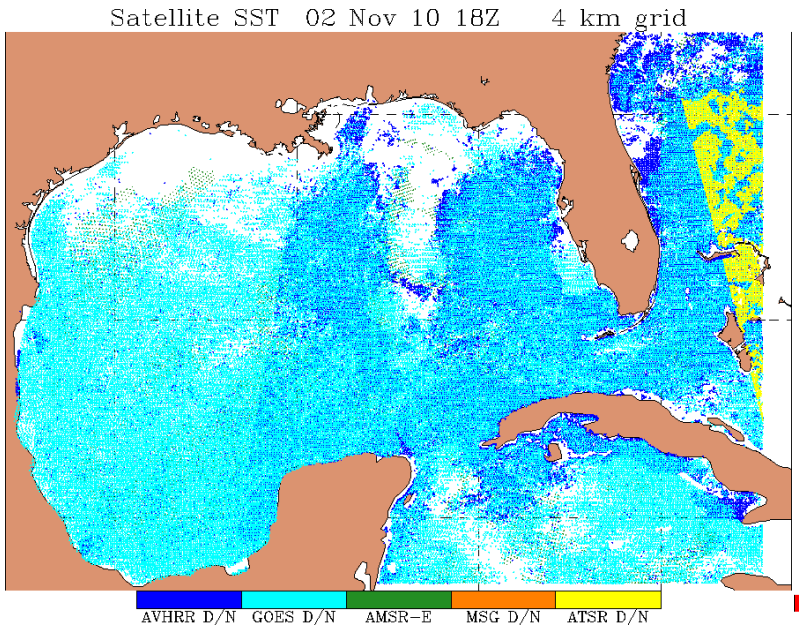
Wave prediction without accounting for currents

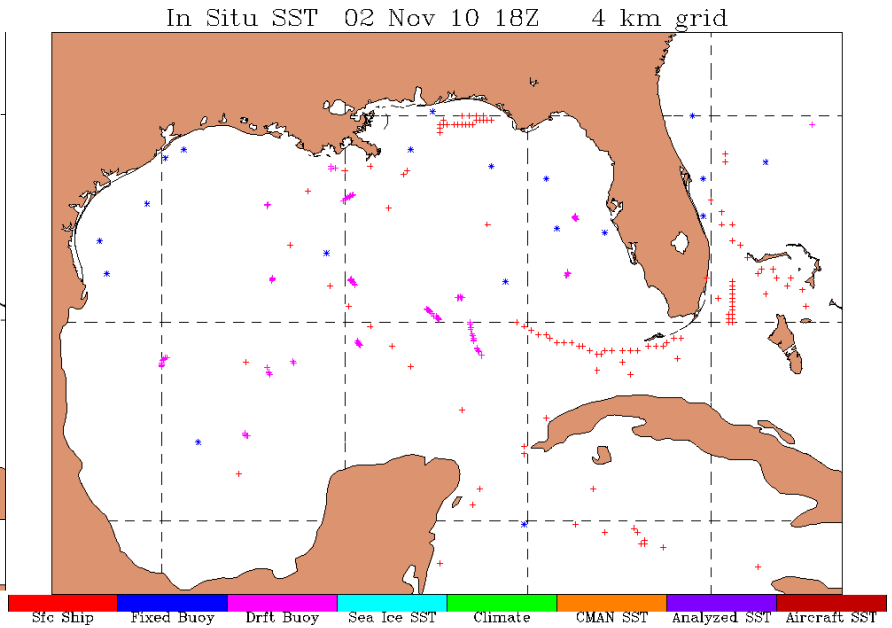


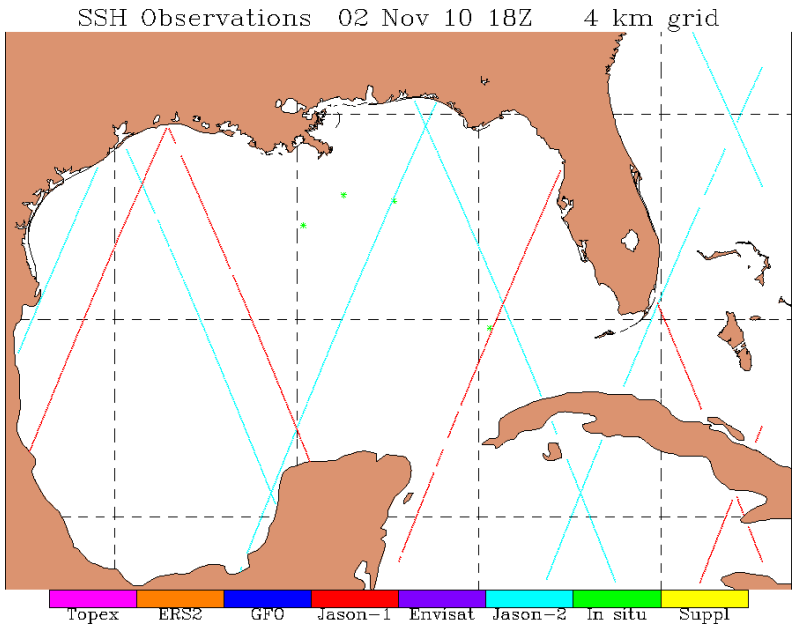
Wave prediction with accounting for currents

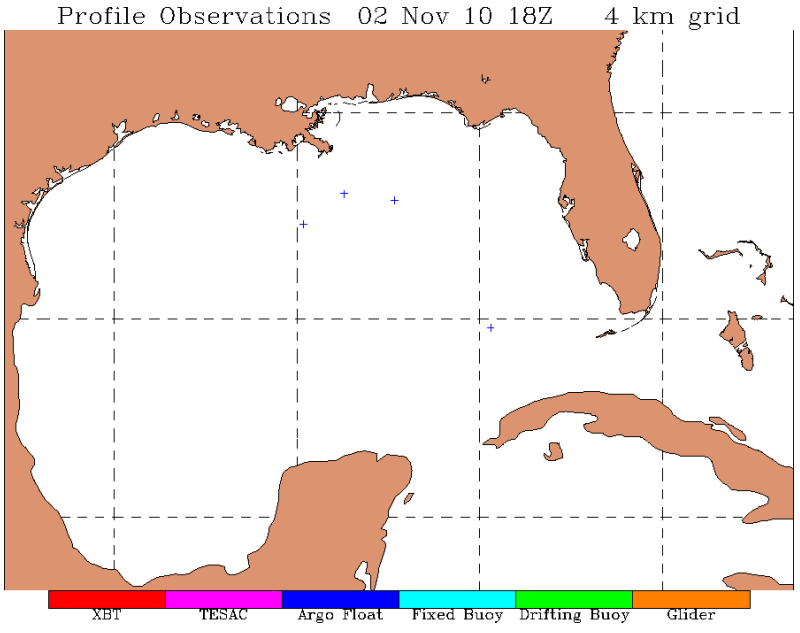


Observations going into NCODA 03 Nov. 2010 – 02 Dec. 2010

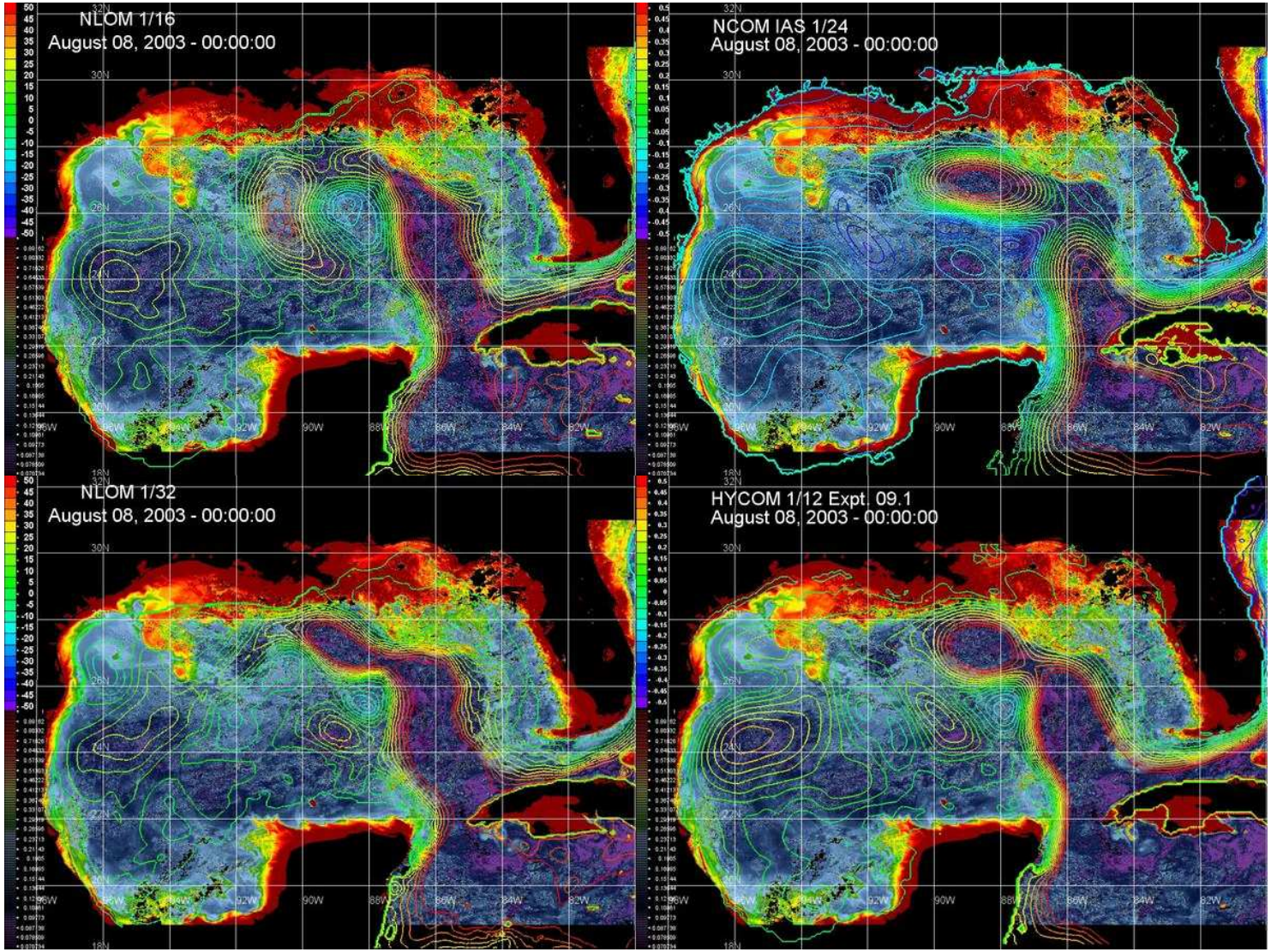






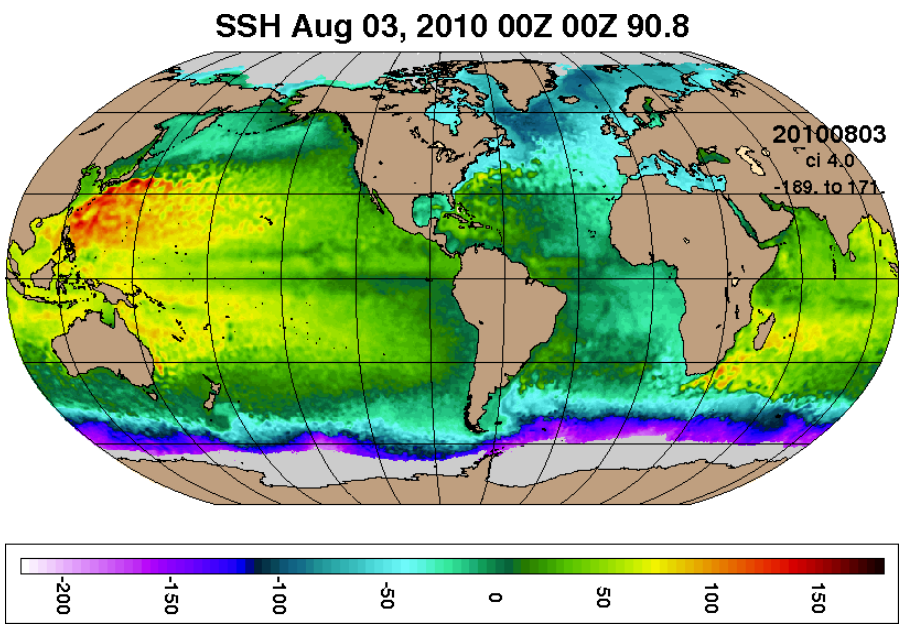


4 Nowcast/Forecast Systems Compared with SeaWiFS Ocean Color



Sea Surface Height overlain on SeaWIFS ocean color In Gulf of Mexico. SST and satellite SSH from GFO and JASON-1 were assimilated. Surface forcing from NOGAPS

Results from Real-Time Global 1/12° HYCOM with NCODA Data Assimilation

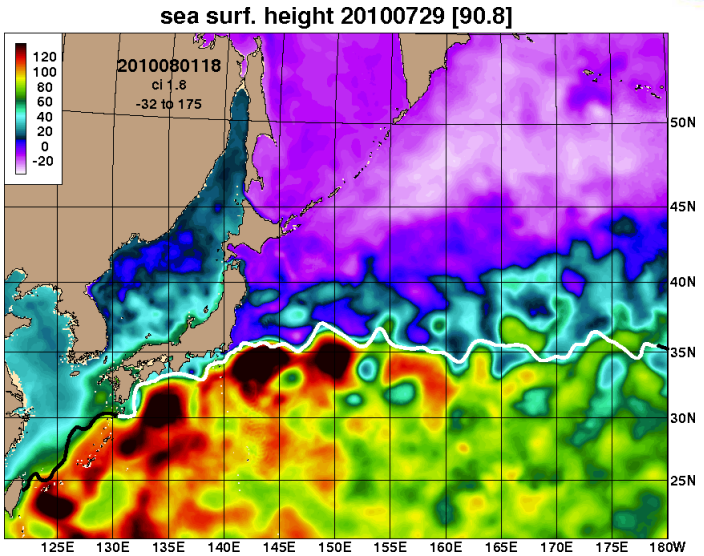


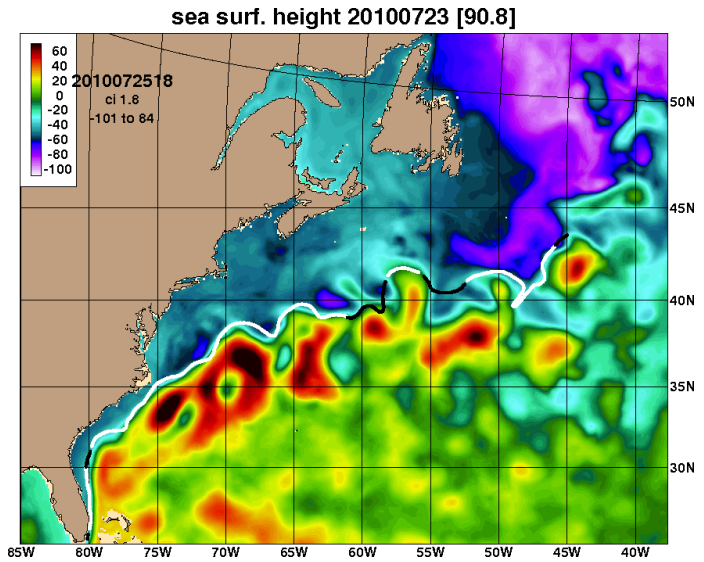
Global SSH on 3 August 2010

Gray areas are ice covered

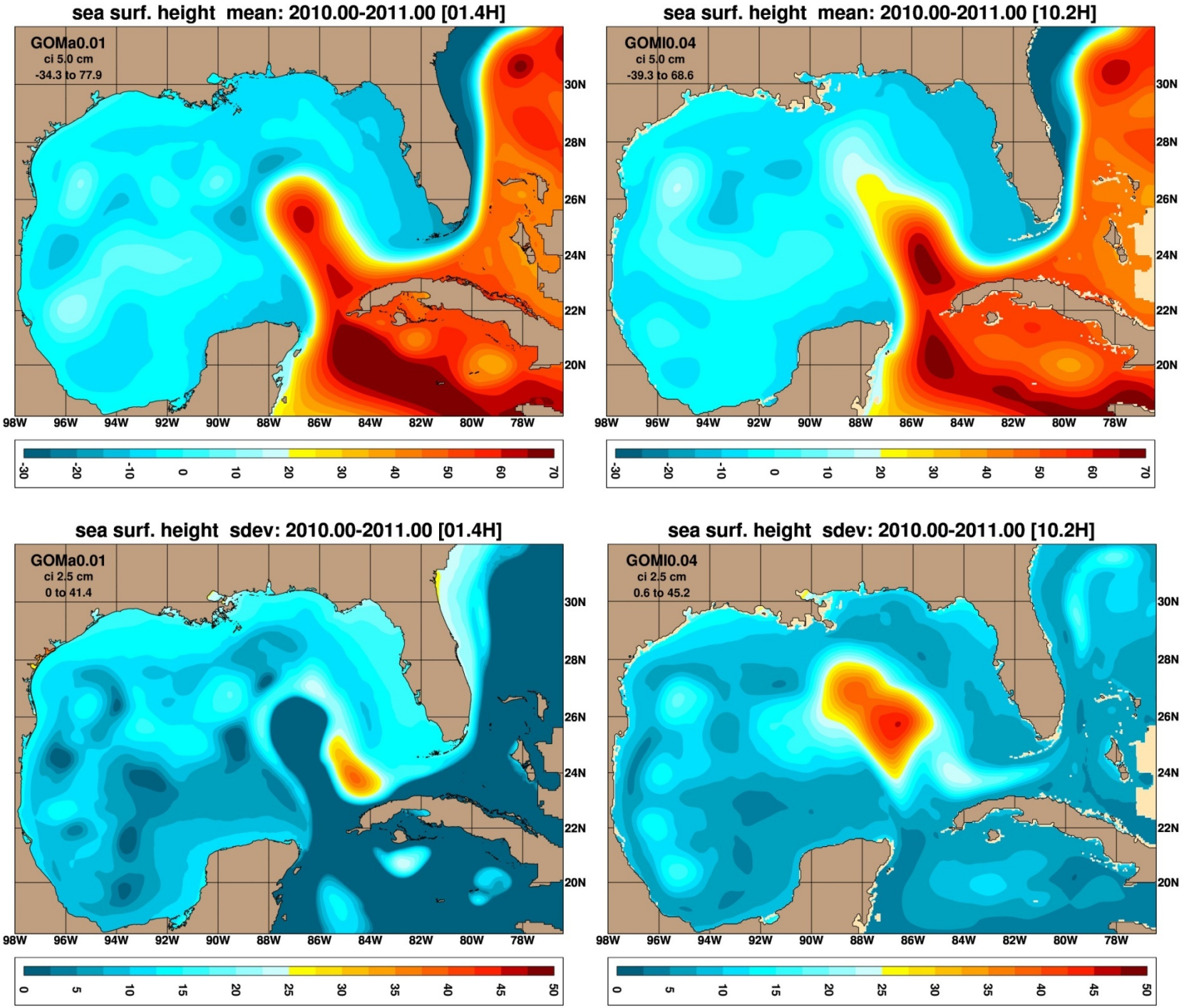
- **Horizontal grid: 1/12° equatorial resolution**
  - **4500 x 3298 grid points, ~6.5 km spacing on average, ~3.5 km at pole**
- **Vertical coordinate surfaces: 32 for σ_2***
- **KPP mixed layer model**
- **Thermodynamic (energy loan) sea-ice model**
- **Surface forcing: FNMOC NOGAPS 0.5° wind stress, wind speed, thermal forcing, and NOGAPS 1.0° precipitation**
- **~2 wallclock hours/model day on 624 Cray XT5 processors**

SSH and independent IR frontal analysis: July 2010





Frontal analysis < 4 days old = white, analysis ≥ 4 days old = black


sea surf. height mean: 2010.00-2011.00 [01.4H]
GOMa0.01
ci 5.0 cm
-34.3 to 77.9
sea surf. height mean: 2010.00-2011.00 [10.2H]
GOMI0.04
ci 5.0 cm
-39.3 to 68.6
sea surf. height sdev: 2010.00-2011.00 [01.4H]
GOMa0.01
ci 2.5 cm
0 to 41.4
sea surf. height sdev: 2010.00-2011.00 [10.2H]
GOMI0.04
ci 2.5 cm
0.6 to 45.2
30N
28N
26N
24N
22N
20N
98W
96W
94W
92W
90W
88W
86W
84W
82W
80W
78W
-30
-20
-10
0
10
20
30
40
50
60
70
0
5
10
15
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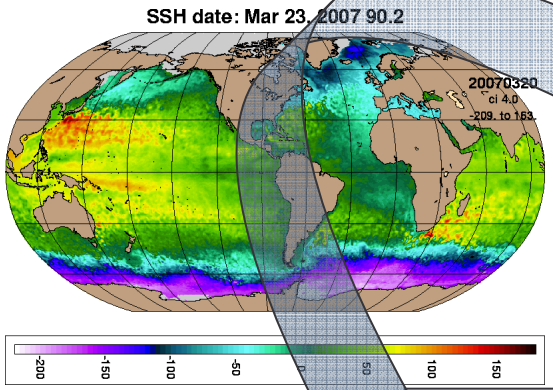
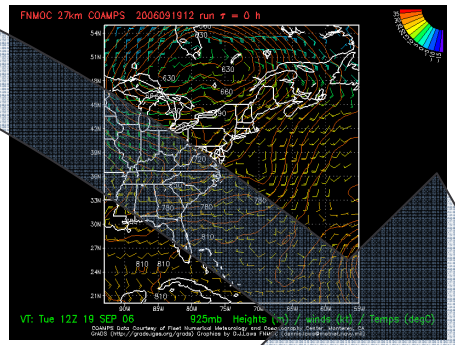
25
30
35
40
45
50

Environmental Modeling at NRL covers a wide variety of disciplines

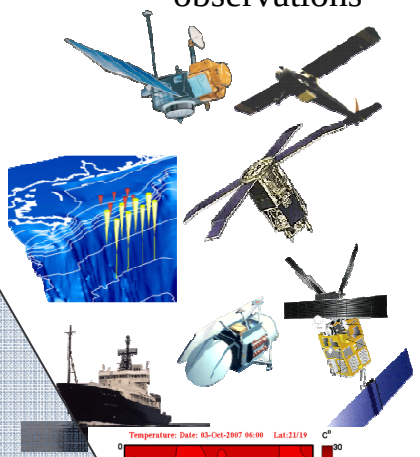
Global Ocean Models



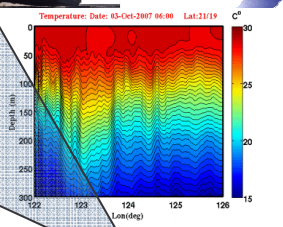
Meteorological models

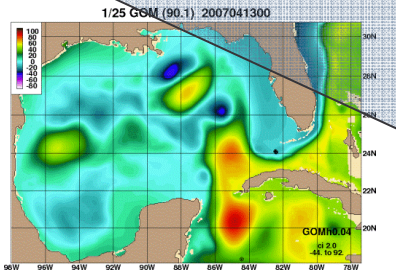


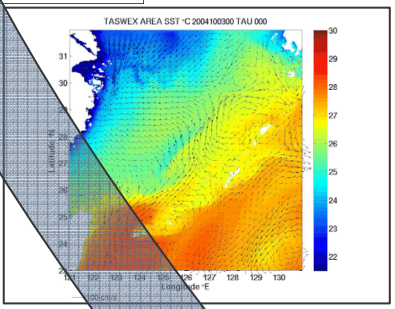
observations



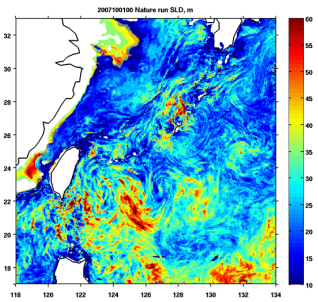
Processes and Dynamics



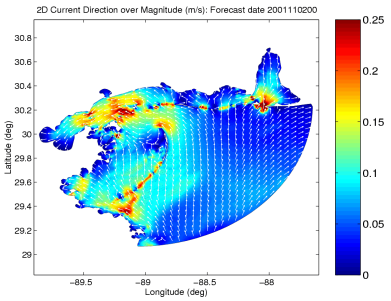


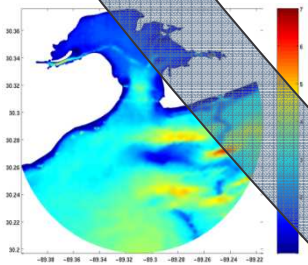


Regional applications

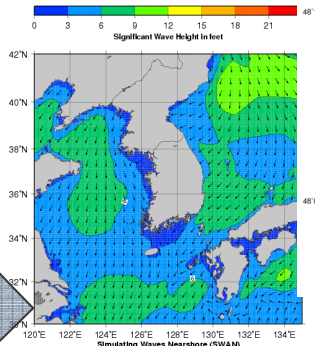


Acoustic performance surfaces

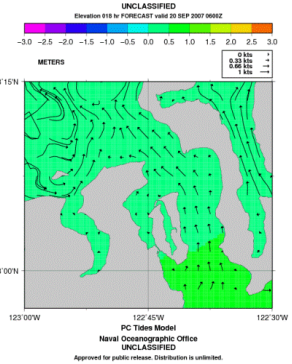




Unstructured grid models



Wave Modeling



Tidal Modeling