An Overview of Nested Regions Using HYCOM

Patrick Hogan
Alan Wallcraft
Luis Zamudio
Sergio DeRada
Prasad Thoppil

Naval Research Laboratory
Stennis Space Center, MS

10th HYCOM Consortium Meeting

COAPS, Florida State University, 7-9 November 2006

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
NOV 2006		**00-00-2006 to 00-00-2006**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
An Overview of Nested Regions Using HYCOM	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Naval Research Laboratory,Stennis Space Center,MS,39529**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**27**	

Outline

- Motivation
- Open boundary nesting techniques
- Different nested regions

  East Asian Seas region – *shallow isopycnals*
  Japan/East Sea – *Intrathermocline Eddies*
  Gulf of California – *sensitivity to BC params*
  Gulf of Mexico – *cross-shelf exchange*
  California Current System – *HYCOM-NCOM coupling*
  Norwegian Coastal Current – *buoyancy driven current*
  Persian Gulf – *contaminant dispersion*

- Need generic and accurate horizontal and vertical interpolation
- Need to cover wide range of flow regimes

Navy Ocean Circulation Prediction

Expected Evolution

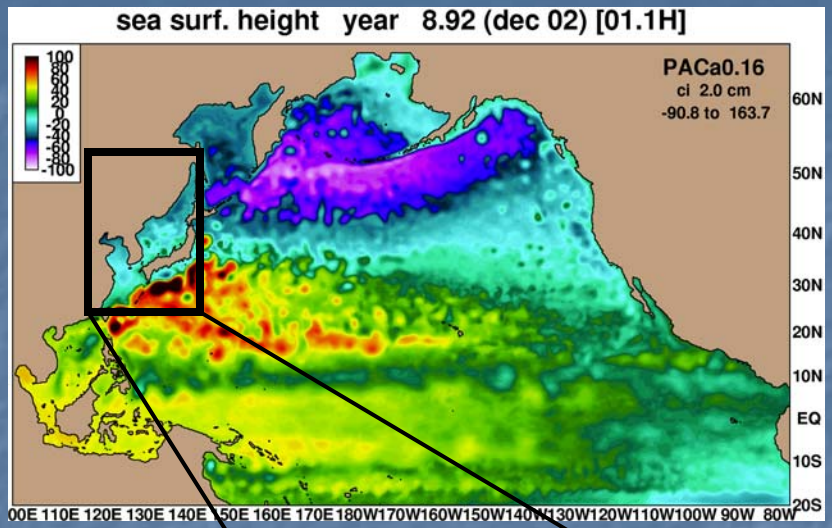
OPERATIONAL	Through FY07	FY 08 & Beyond
Naval Global Ocean Prediction	**1/32°NLOM, 1/8°NCOM**	**HYCOM (Hybrid Coordinate Ocean Model)**
Navy Coastal Ocean Prediction	**SWAFS, Relocatable NCOM, associated updates**	HYCOM ADCIRC NCOM ?

Boundary Conditions

Note: Coastal component does not include nearshore environment

Current Status of Nesting

3.5 km East Asian Seas HYCOM
Nested inside 16 km North Pacific HYCOM



HYCOM NESTING in HYCOM

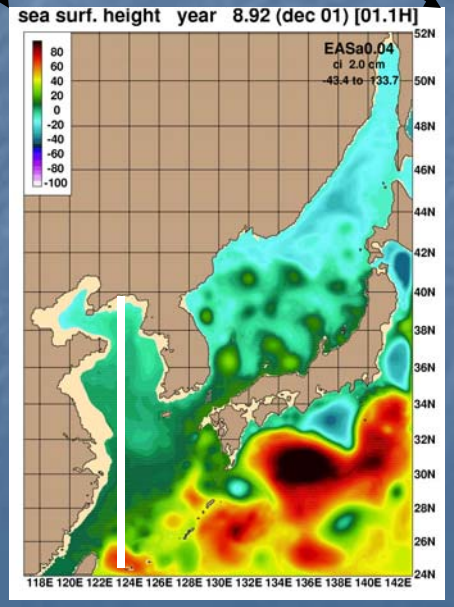
- Currently off-line
- Boundary info comes from archive files
- Exact boundary condition for depth averaged (barotropic) component
- Relaxation in buffer zone for T,S,P,u,v

Off-line:

- Boundary information comes from archive files
- Updating frequency limited by archive file frequency
- Don't need to know nest area in advance

open boundary conditions from 1/6° North Pacific HYCOM

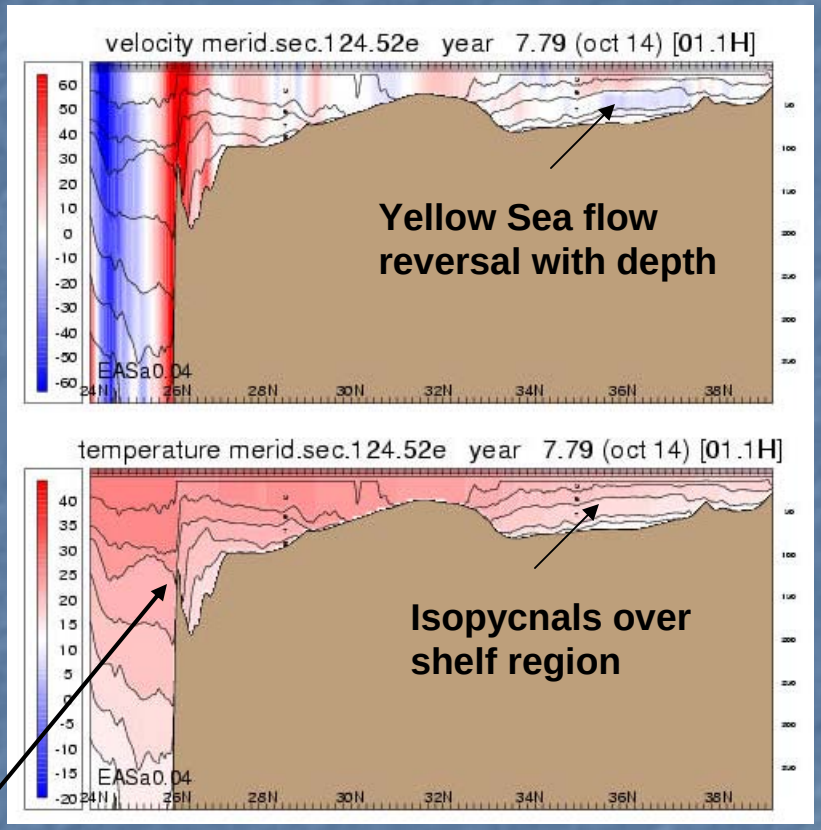
Same vertical structure as Pacific Ocean model (20 layers)



1/25° HYCOM East Asian Seas Model (nested inside 1/6° North Pacific Model

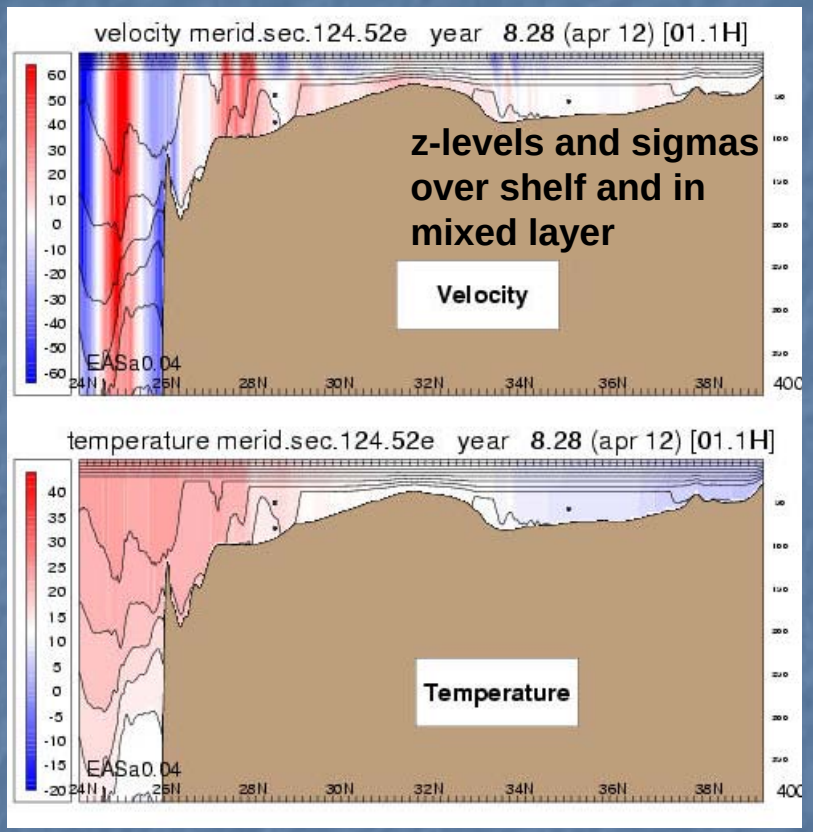
North-south cross-section along 124.5°E

blue=westward flow
red=eastward flow



density front associated with sharp topo feature (can't resolve with sigma coordinates)

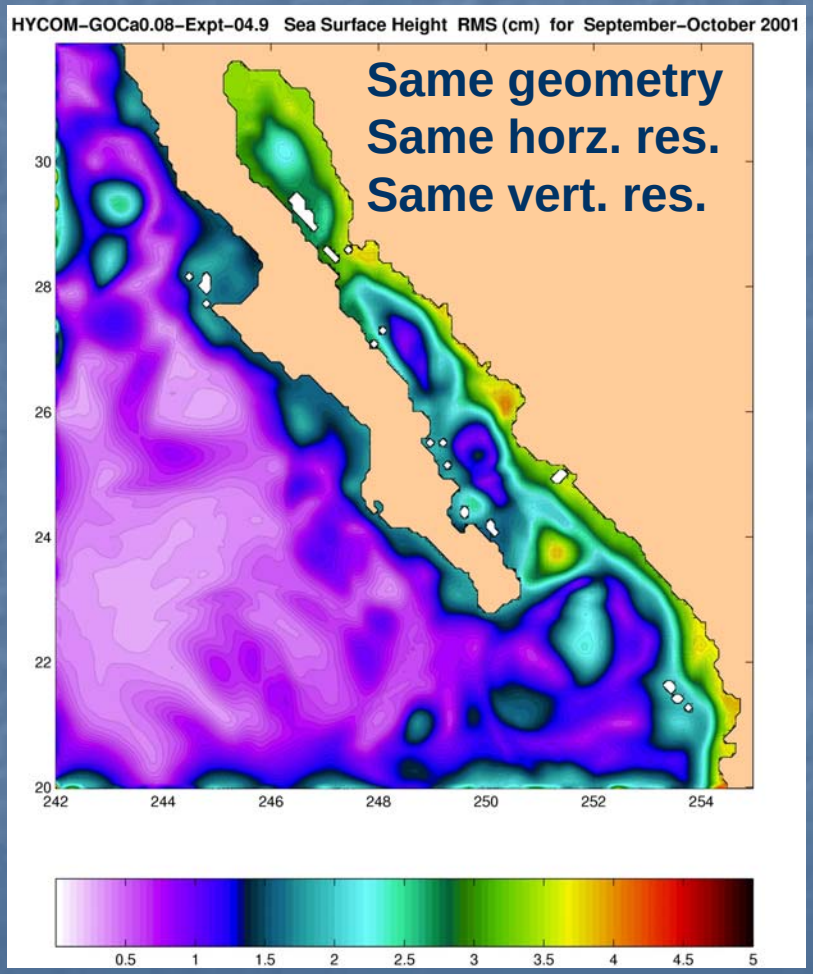
Snapshot on Oct. 14



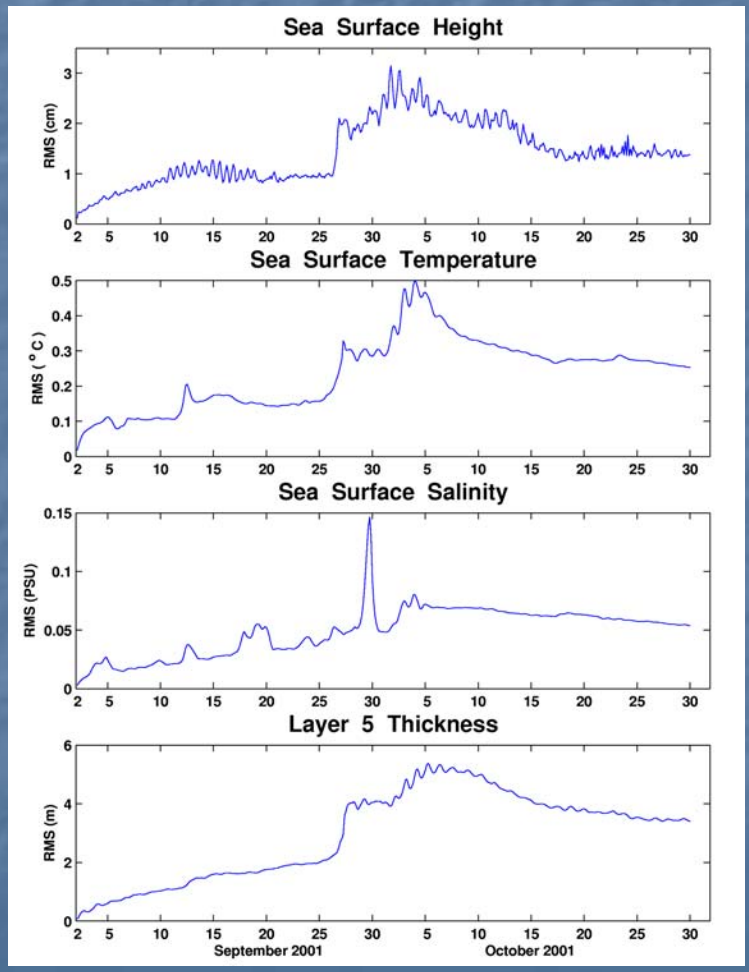
Snapshot on April 12

Starting Point

Barotropic BCS are updated every 1-day
Baroclinic BCS are updated every 6-day
10 grid-point wide relaxation zone
1-10 day relaxation e-folding time



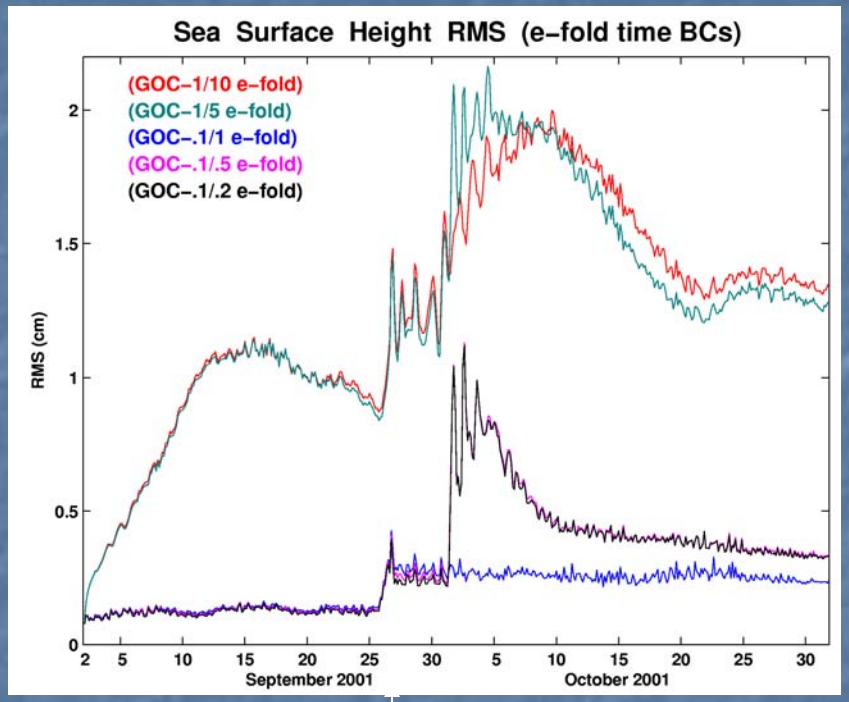
RMS error map (wrt Pacific model over GoC domain)



Time series of domain-wide RMS error

Sensitivity to:

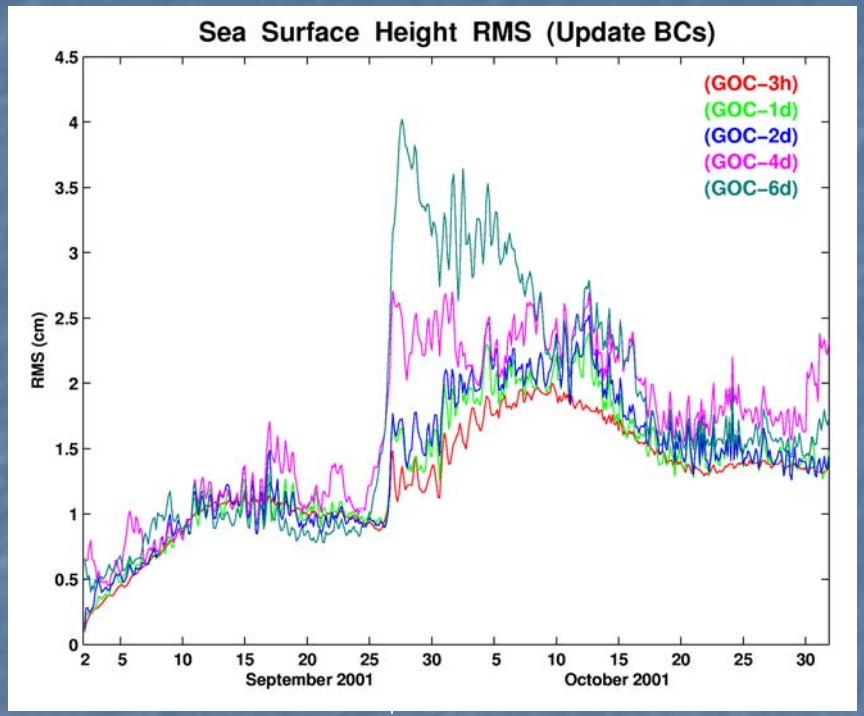
E-folding time in BZ



1-10, 1-5, .1-1, .1-.5, .1-.2

10 grid-point
3 hours
Barotropic + baroclinic

Updating frequency

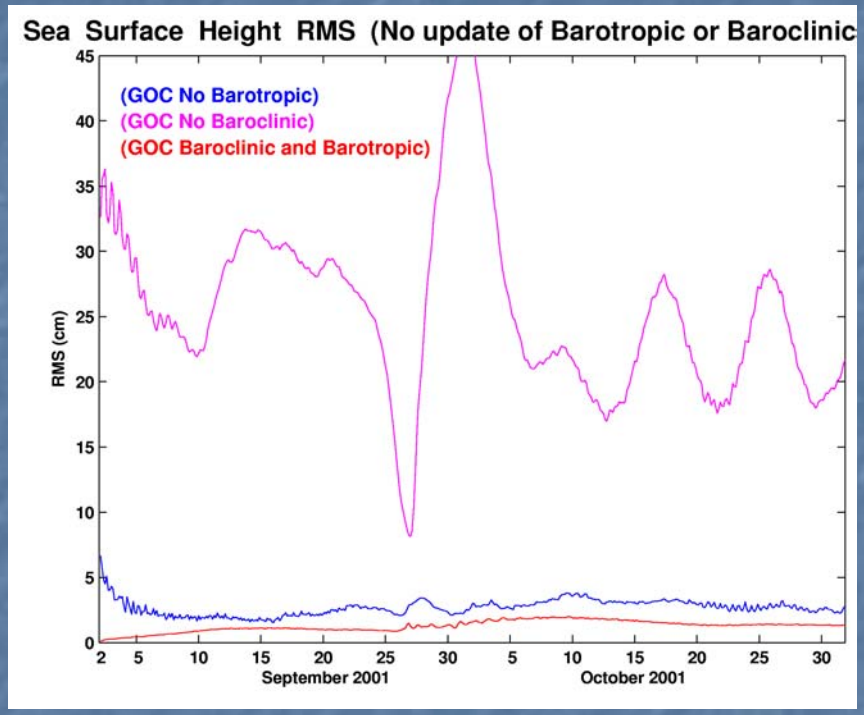


3 hours, 1, 2, 4, 6 days

10 grid-point
1-10 e-folding
Barotropic + baroclinic

Sensitivity to:

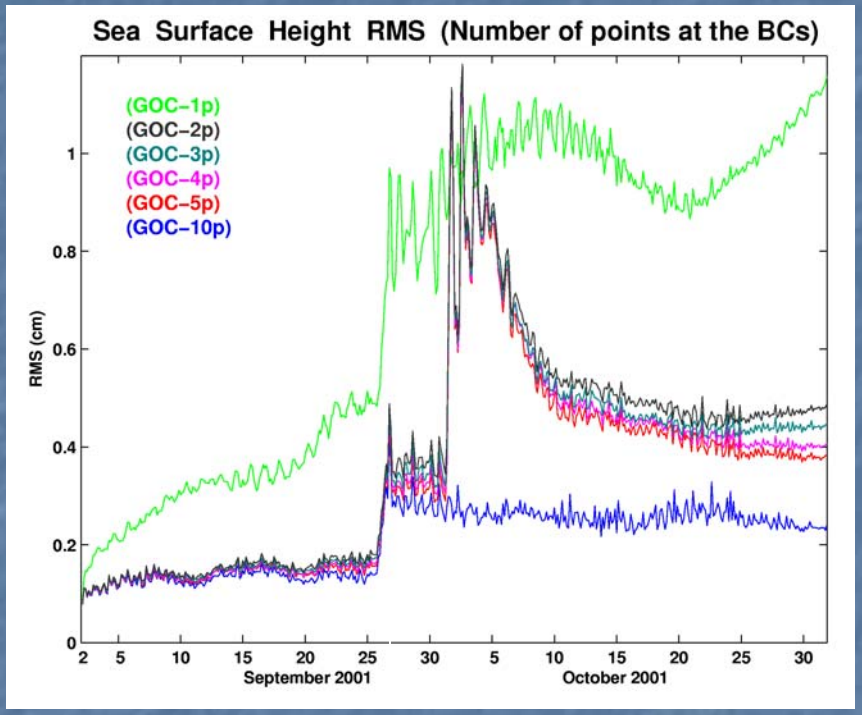
Barotropic/baroclinic mode



Barotropic or baroclinic only

10 gridpoints
0.1-1.0 e-folding
3 hourly

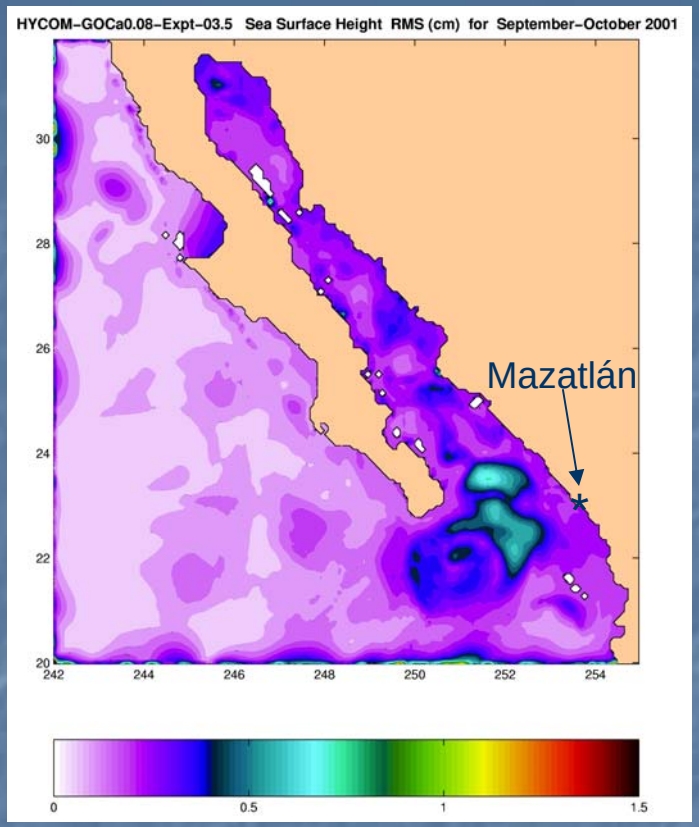
Width of buffer zone



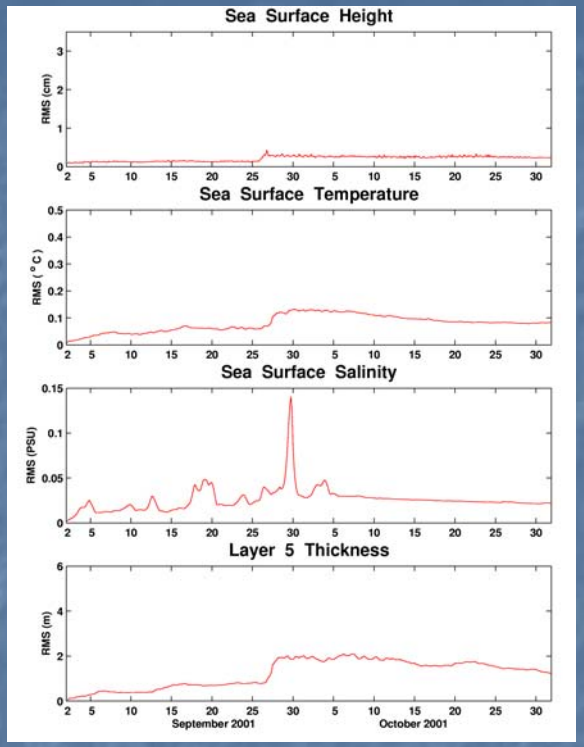
1,2,3,4,5,10 grid-point

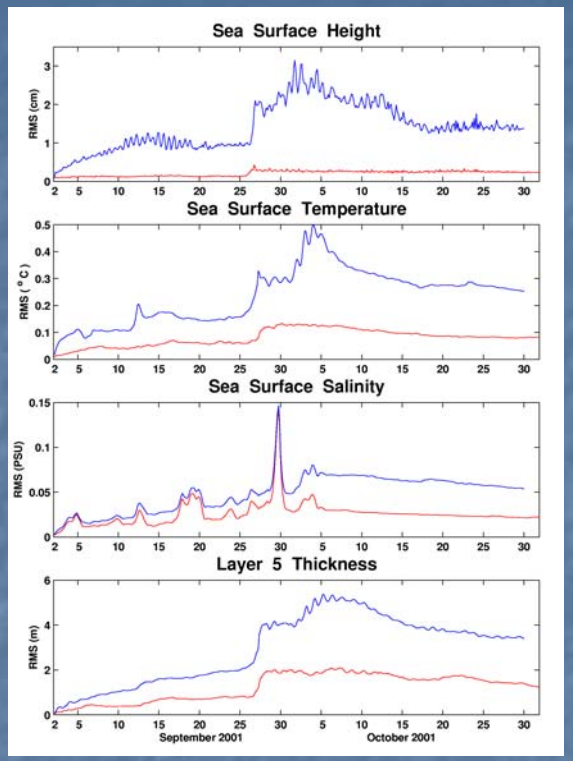
3 hourly
0.1-1.0 e-folding
Barotropic + baroclinic

Lowest Error Nesting Parameters



RMS error map



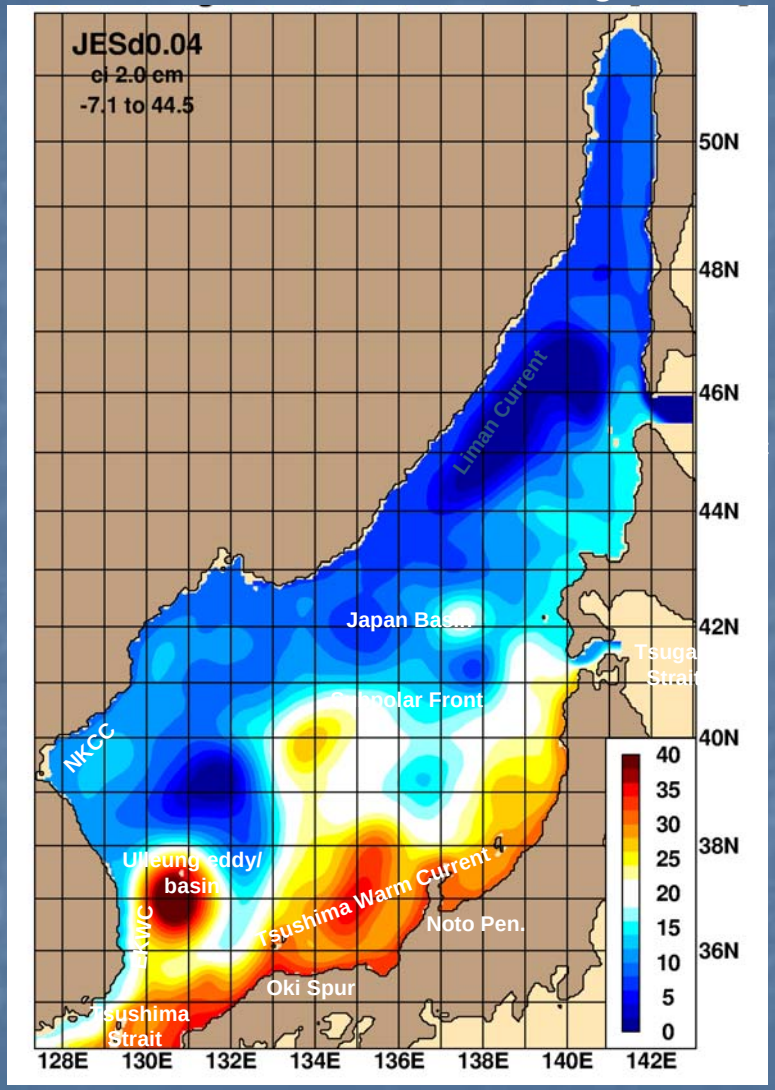


Time series of domain-wide RMS error

10 grid points
.1-1 day e-folding
3 hour updating
Baroclinic+barotropic

15 layer 1/25° Japan/East Sea HYCOM

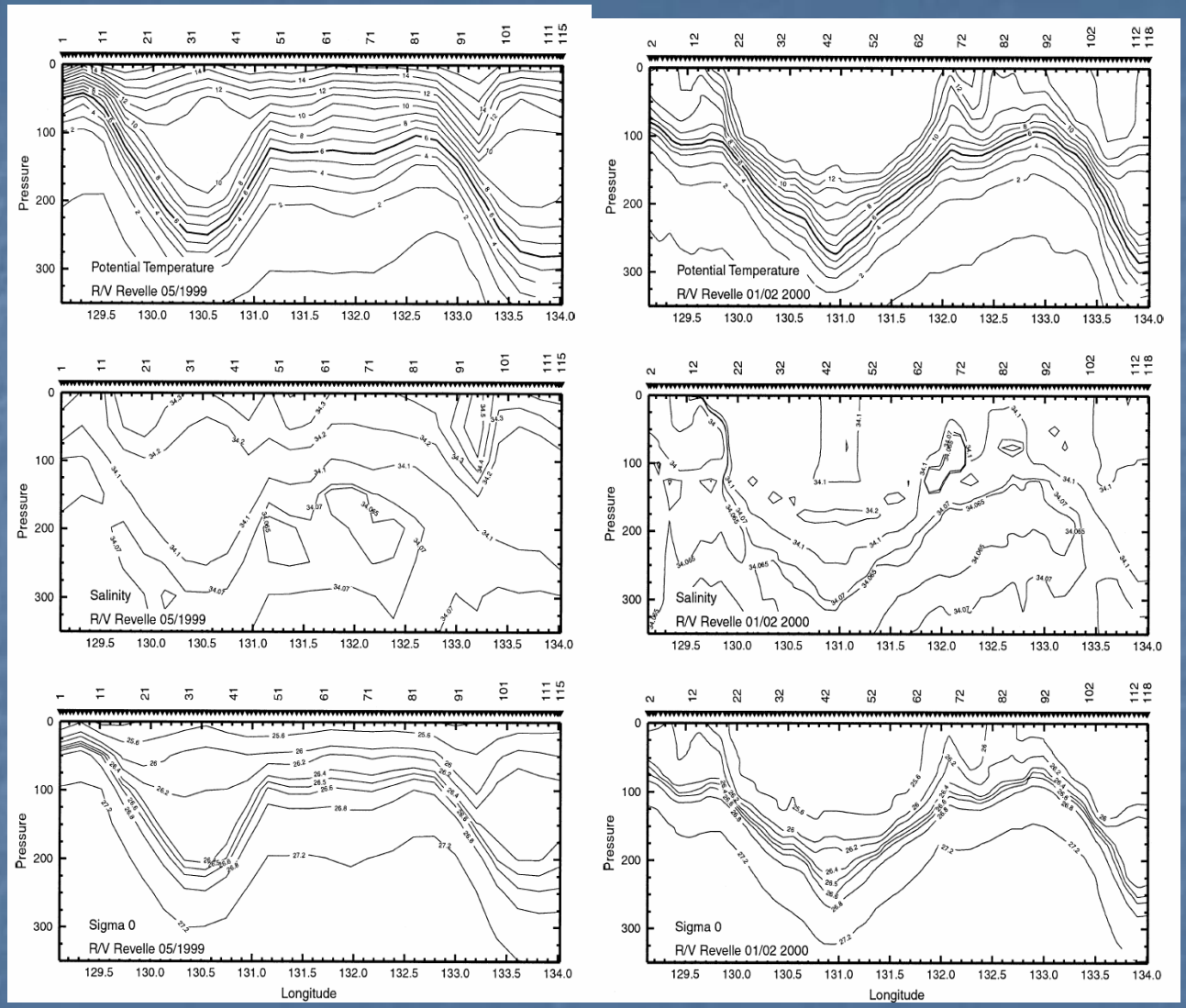
Mean Sea Surface Height



2 Sverdrup barotropic straits forcing

Relaxation to climatology for baroclinic part

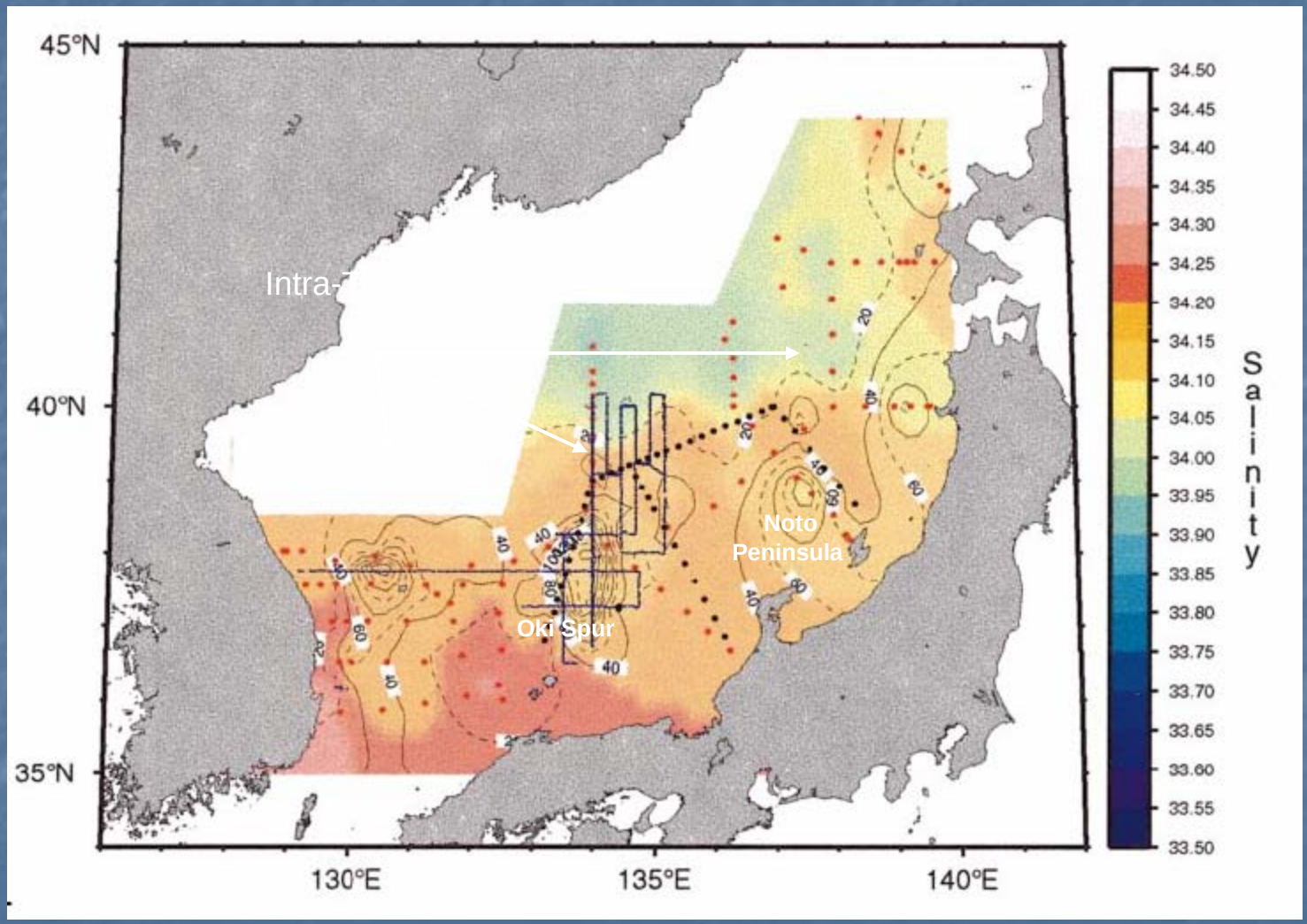
Observed JES Intrathermocline Eddies (Gordon et al., 2002)



May 1999

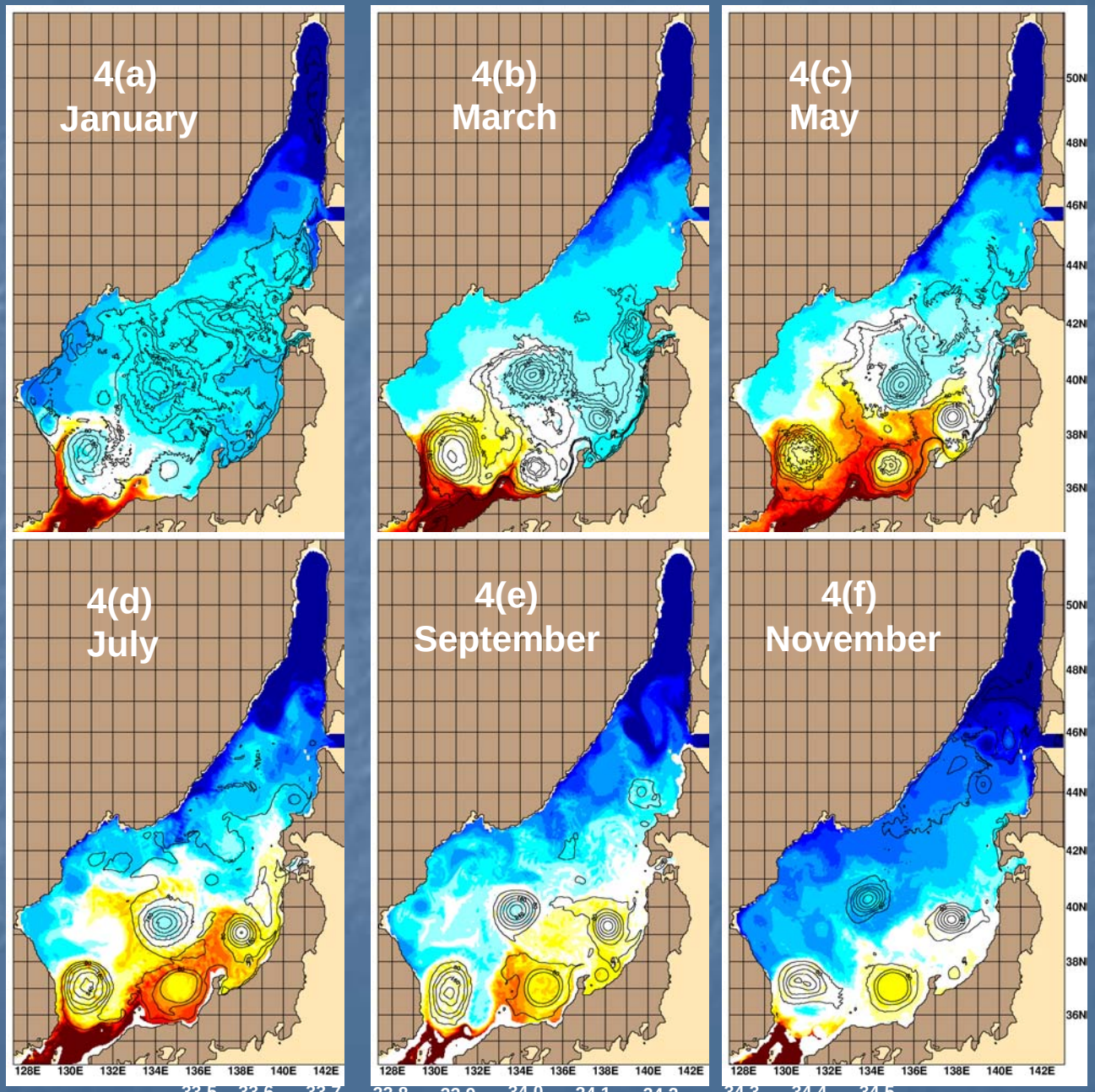
January 2000

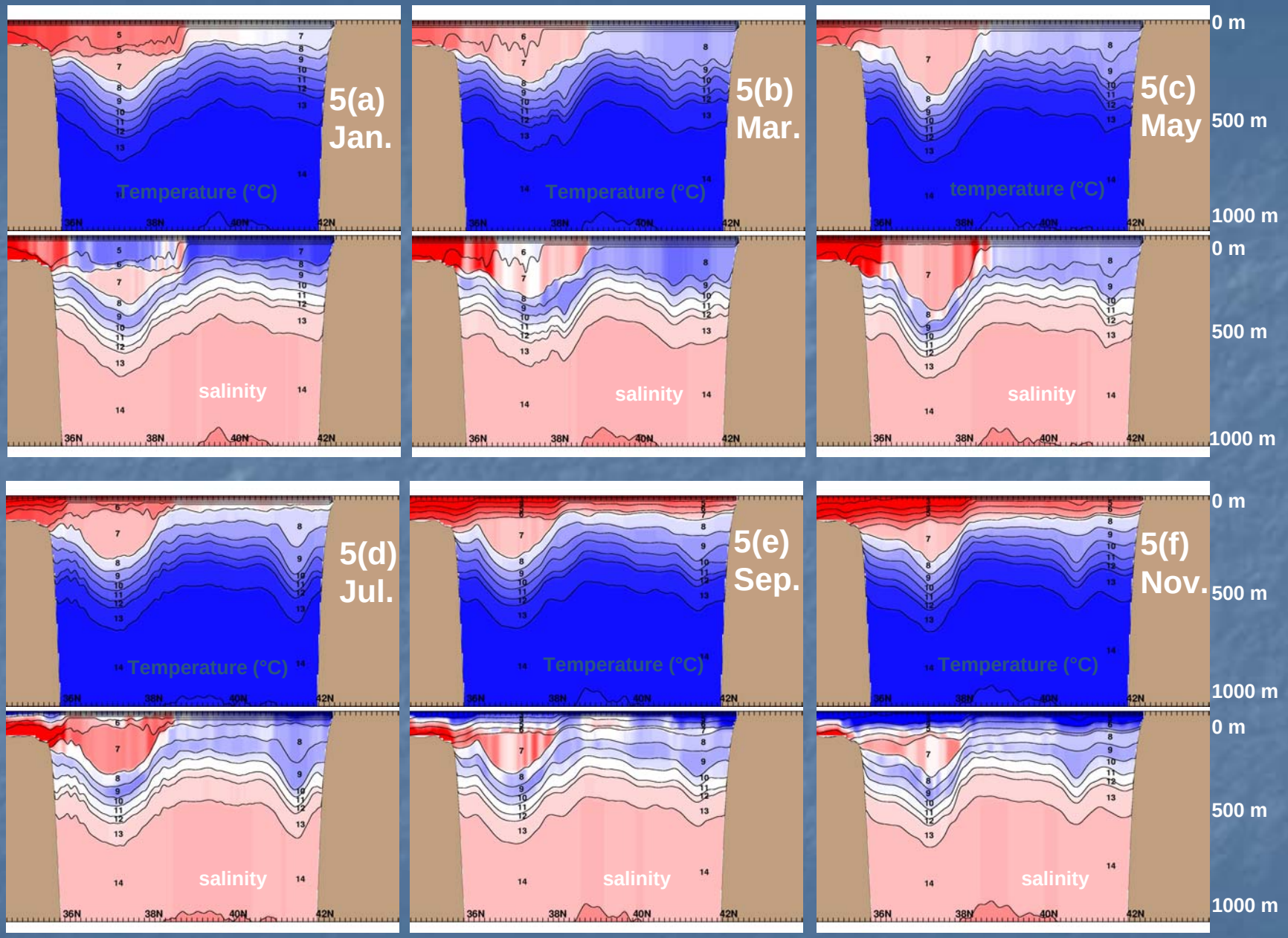
Location of JES Intrathermocline Eddies (Gordon et al., 2002)



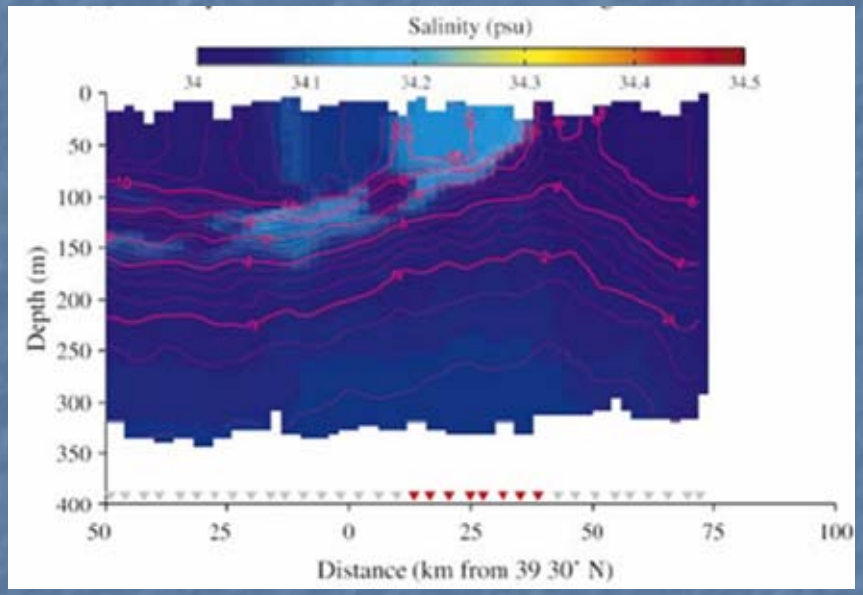
Layer thickness between the 8°-11° isotherm

Layer 6 salinity (color) and layer 7 thickness

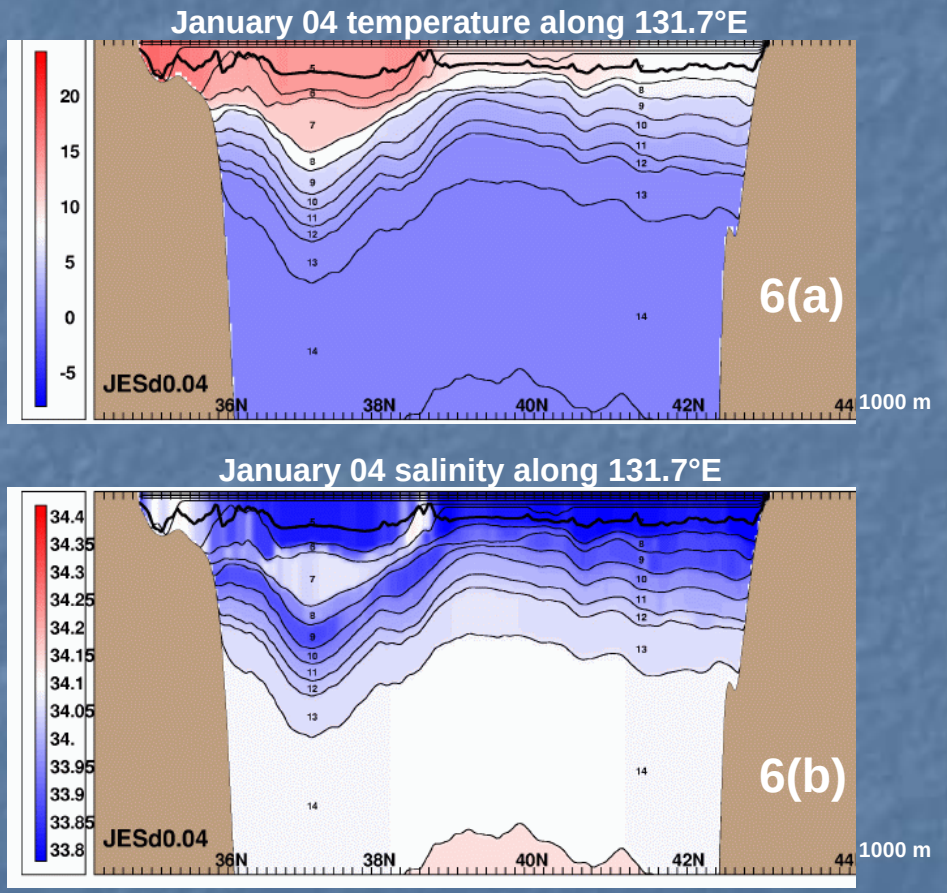



5(a) Jan.
5(b) Mar.
5(c) May
5(d) Jul.
5(e) Sep.
5(f) Nov.
Temperature (°C)
salinity
0 m
500 m
1000 m
36N
38N
40N
42N
Temperature (°C)
0 2 4 6 8 10 12 14 16 18
Salinity (PSU)
33.7 33.9 34.1 34.3

Secondary JES ITE Formation Mechanism: Frontal subduction along the subpolar front



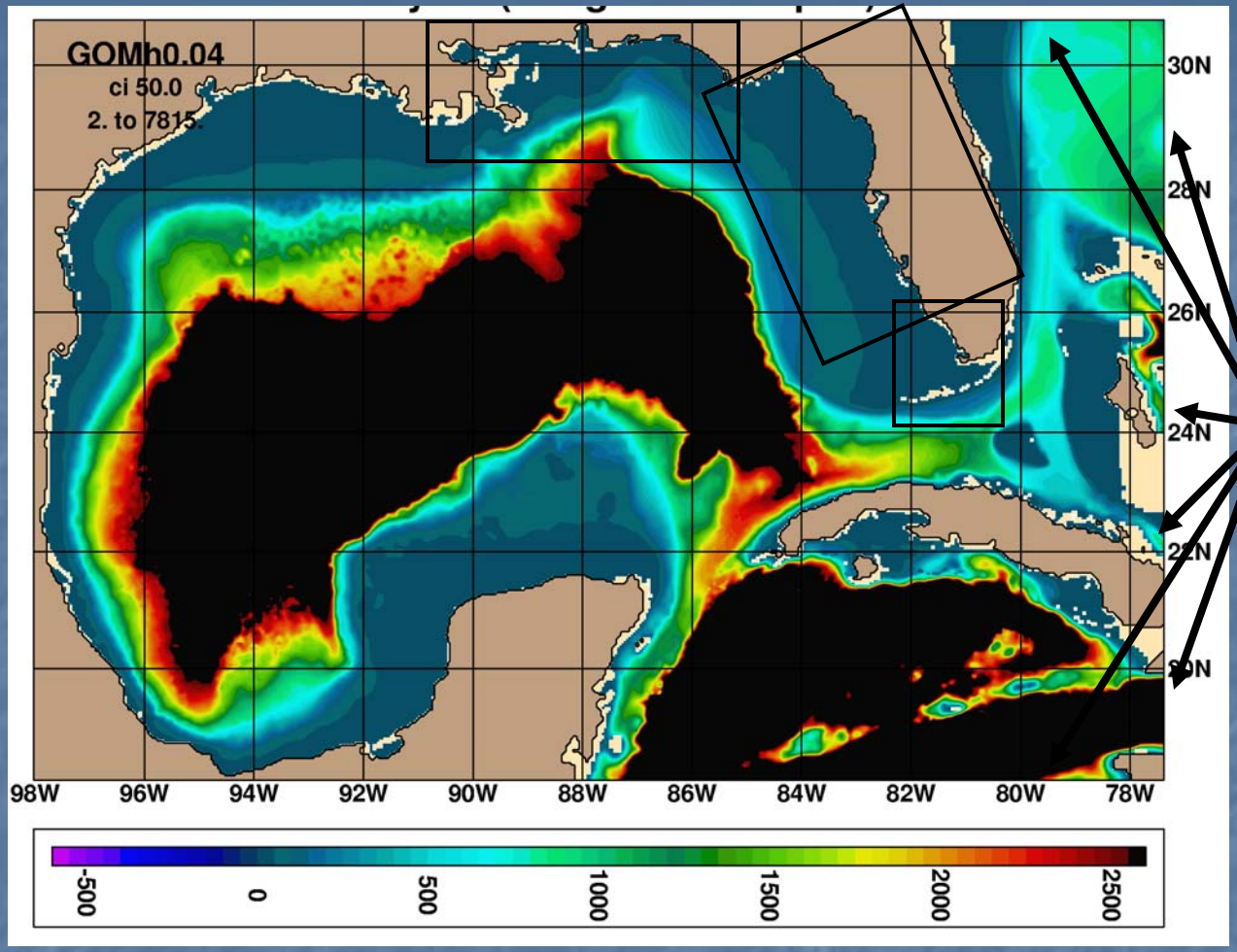
From Gordon et al. (2002)



1/25° JES HYCOM

Hogan and Hurlburt (2006)

20 layer 1/25° Gulf of Mexico Model (~4 km)



Open boundary locations

Method of Characteristics used To update the barotropic mode

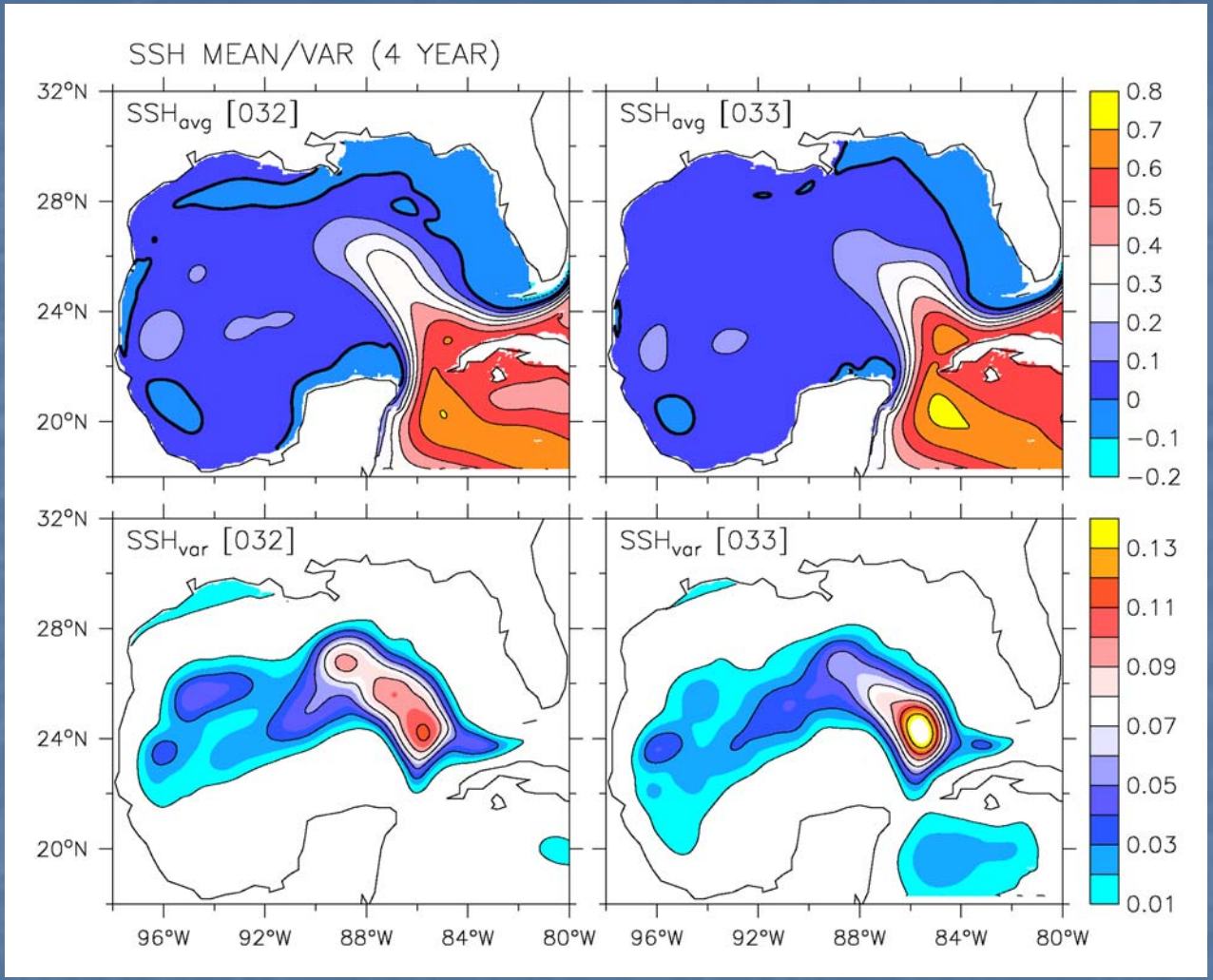
Bathy from NRL-DBDB2

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

Atlantic boundary data provided daily

Sensitivity of boundary forcing updating

Allows for long-term integrations over any timeframe

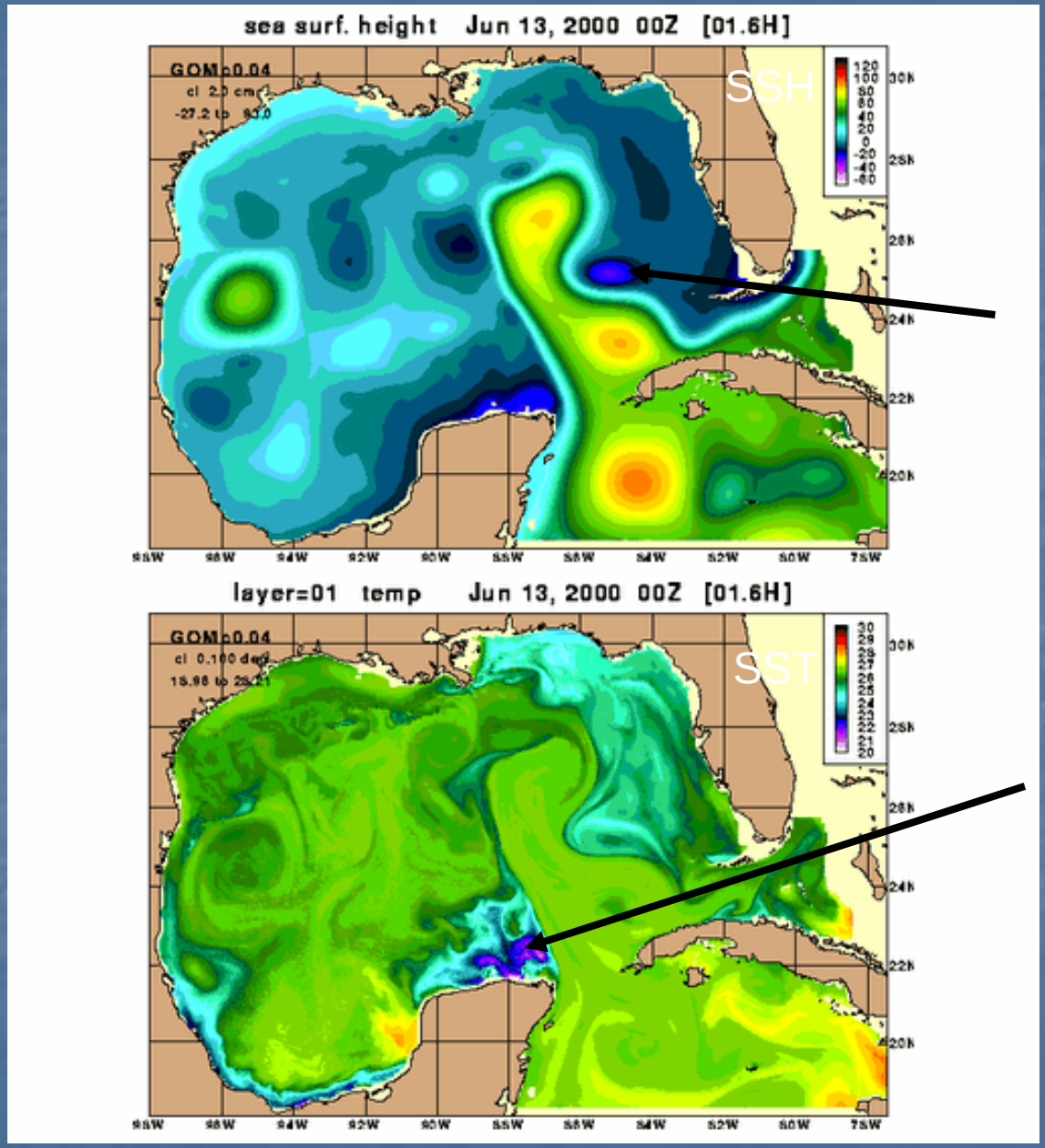


1-day forcing

Climatological forcing

Monthly climatology formed from 1-day archives

1/25° (~4 km) Nested Gulf of Mexico

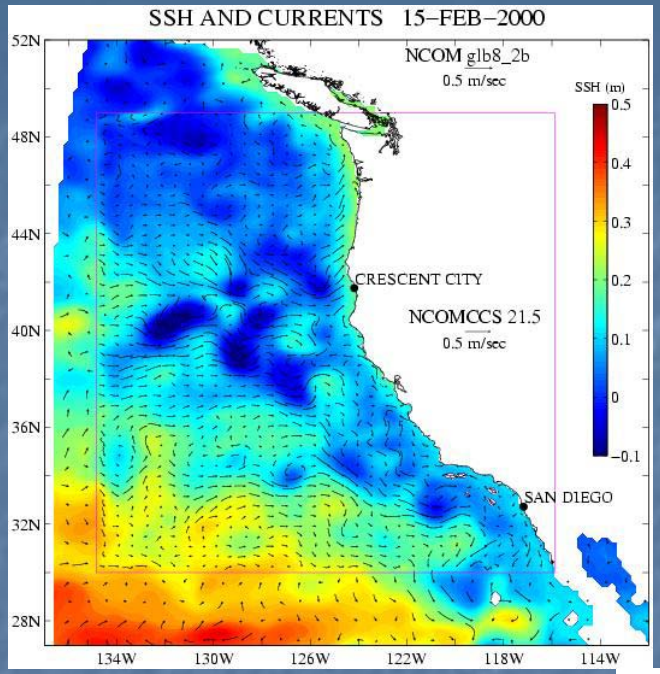


Snapshot of SSH and SST on June, 13 2000

Lots of cyclonic cold core eddies (impact of 2x res.)

Local upwelling

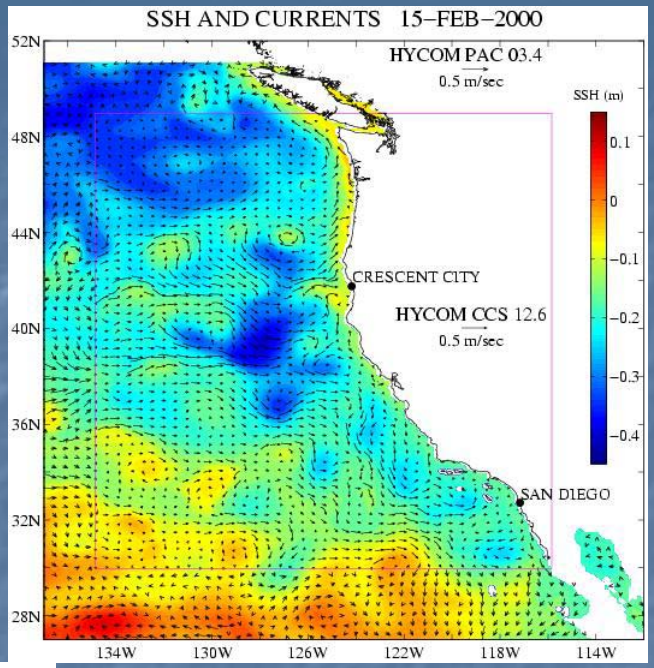
Vertical Remapping and Nesting Different Ocean Models



PAC HYCOM to CCS NCOM

(σ-z-ρ) to (σ-z)

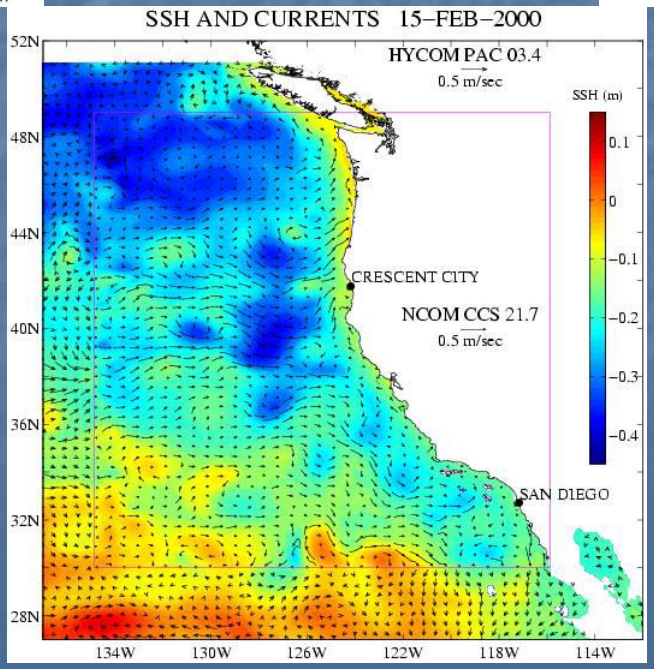
1/12°-1/12°



Global NCOM to CCS NCOM

(σ-z) to (σ-z)

1/8°-1/12°

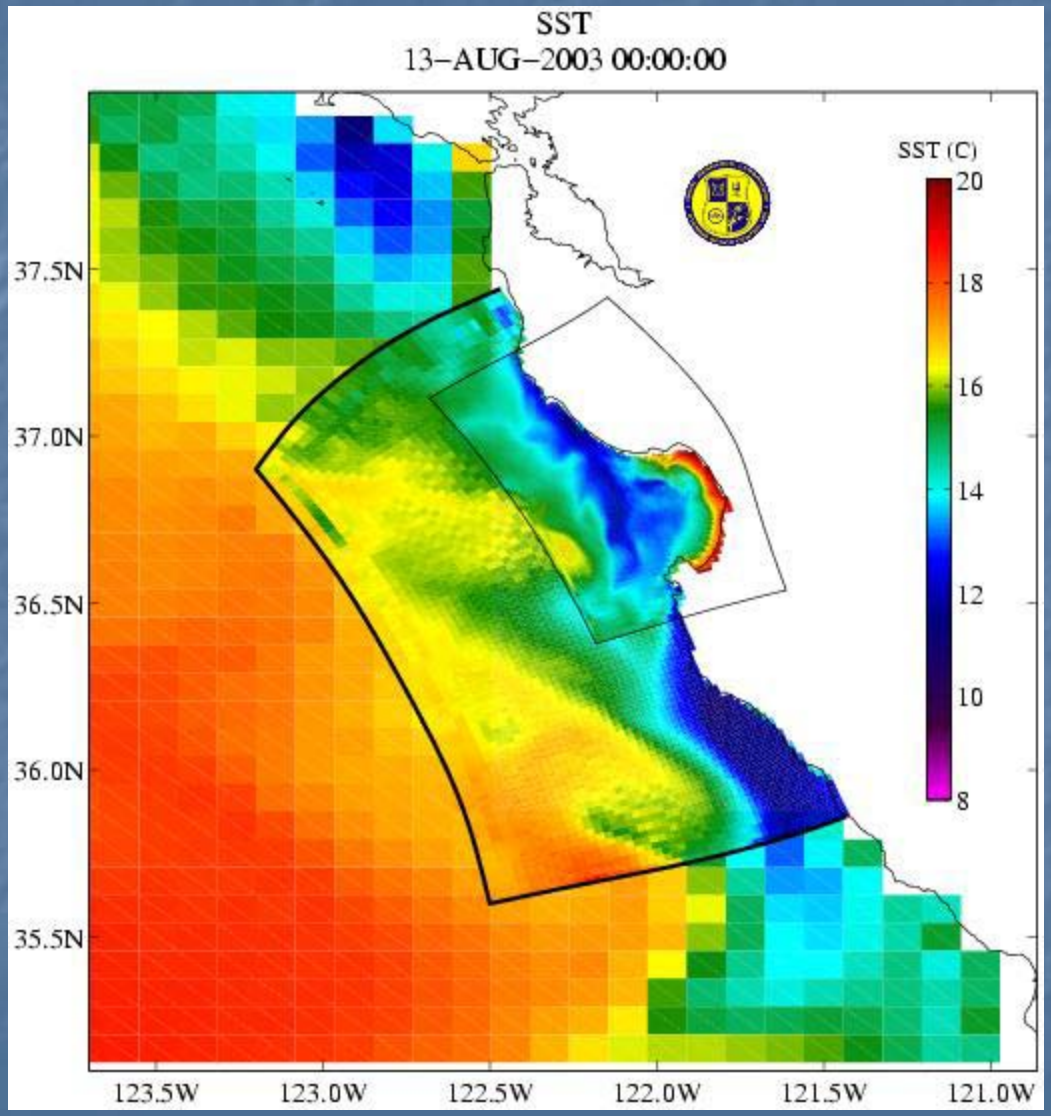


PAC HYCOM to CCS HYCOM

(σ-z-ρ) to (σ-z-ρ)

1/12°-1/12°

Triple nesting in the California Current System

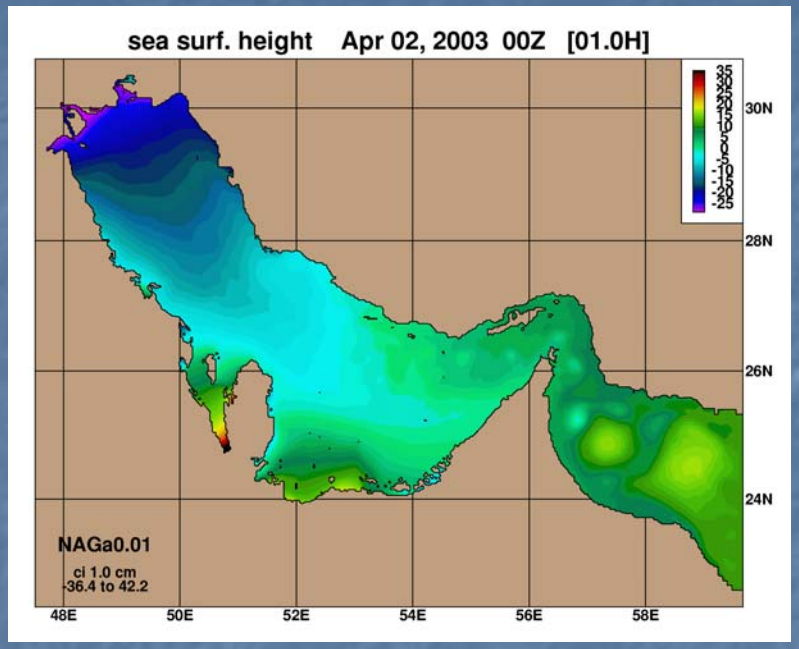


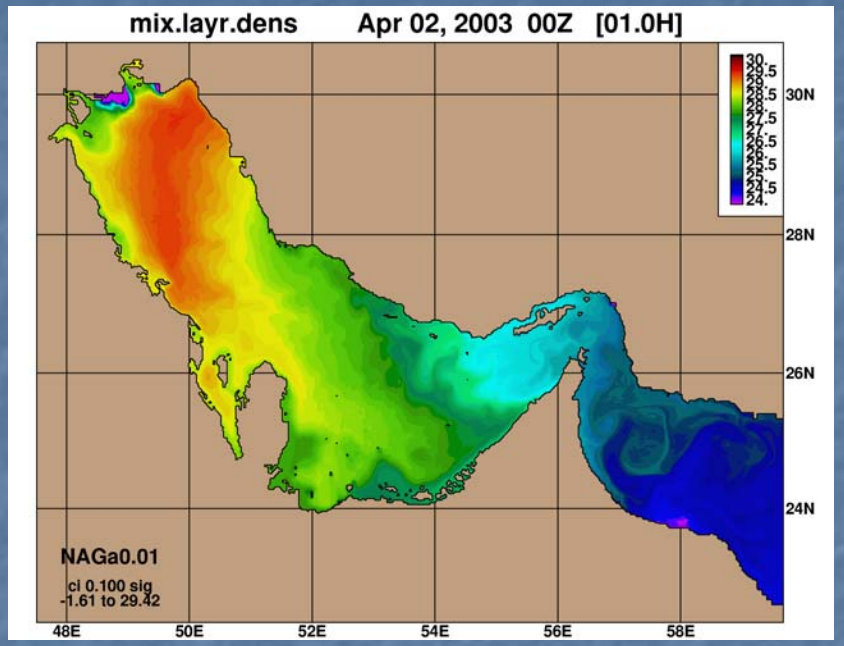
NCOM CCS 9 km

NCOM-NCOM 1-4 km

NCOM-NCOM 0.5-1.5 km

1 km Persian Gulf HYCOM



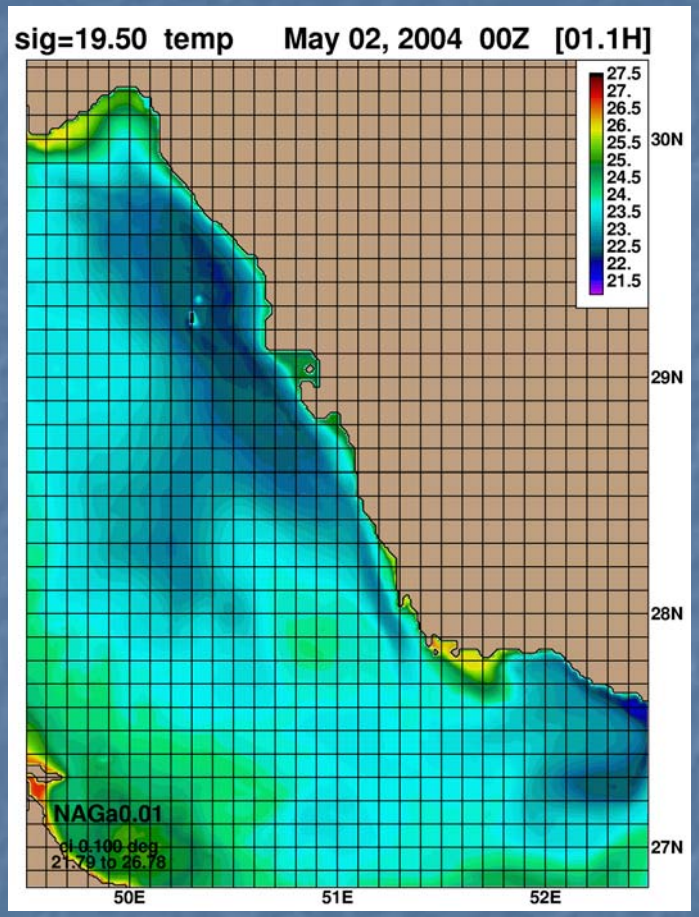


- Boundary conditions from 1/12° Global HYCOM
- Includes rivers, bottom boundary layer
- Requires remapping from σ_{2000} to σ_{θ}

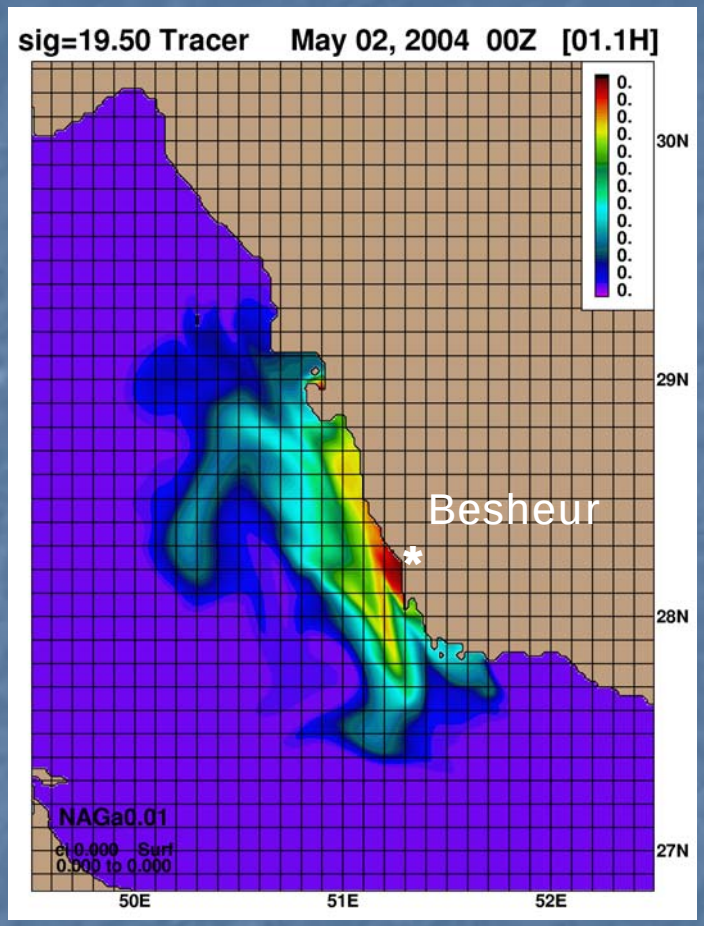
unclassified

1 km Persian Gulf HYCOM

Surface Temperature



Surface Tracer



Forced with 0.5° NOGAPS and lateral boundary conditions from 1/12° Global HYCOM

unclassified

Summary and Future Plans

- A Robust capability exists for nesting HYCOM within HYCOM and HYCOM within NCOM
- Sensitivity studies reveal the most accurate nesting params
- HYCOM successfully simulates JES Intrathermocline eddies
- HYCOM successfully simulates Loop Current eddy shedding

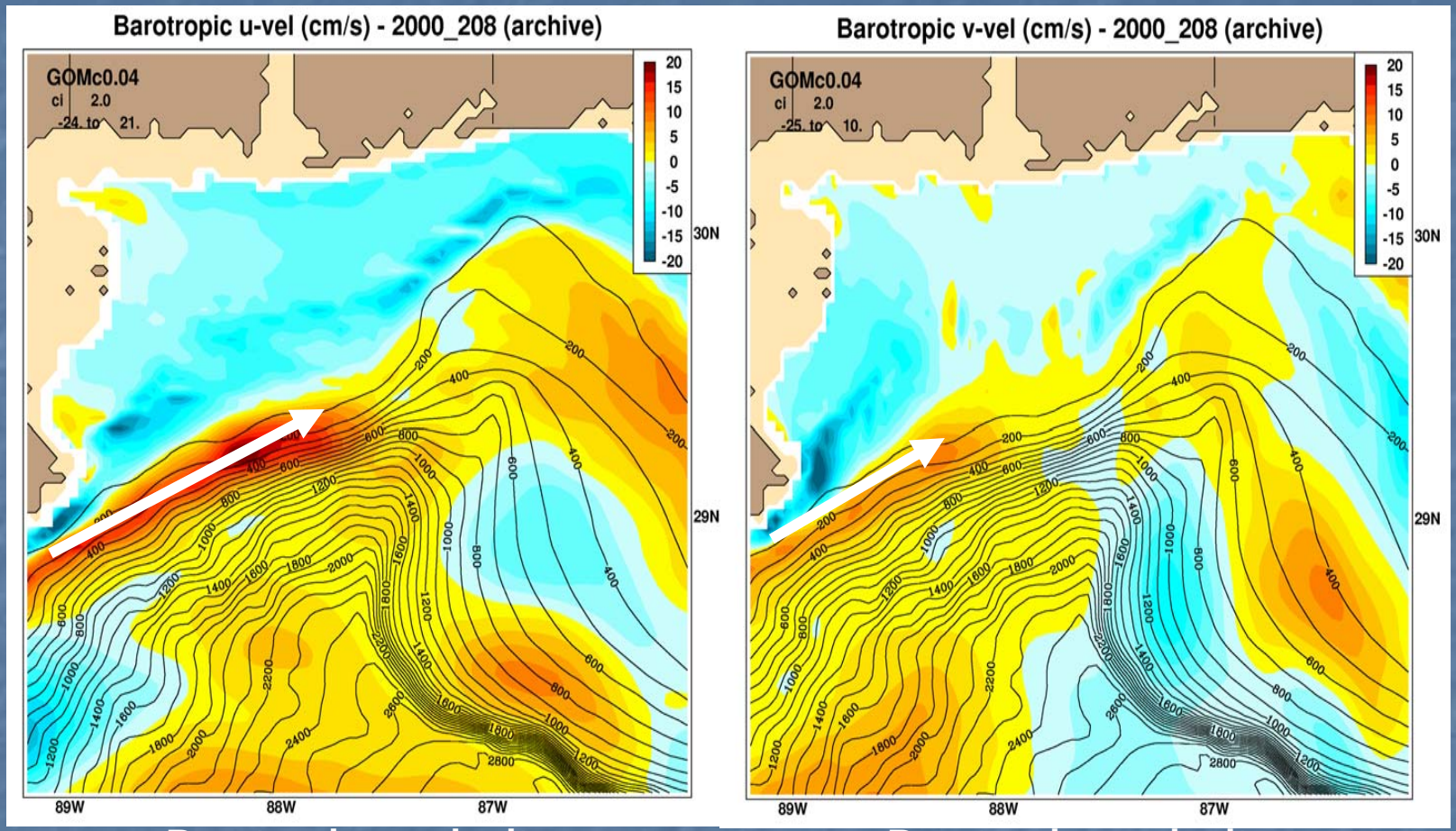
Future Plans

- Add wetting and drying (inudation) capability to HYCOM
- Add tidal forcing to standard version
- Improve river plume dynamics
- More quantitative HYCOM-NCOM-Observations comparisons
- Evaluation of nested boundary placement (on or off-shelf)
- Implementation and evaluation of other boundary conditions
- Additional evaluation of coastal HYCOM

Supplemental Slides Follow

1/25° Nested Gulf of Mexico HYCOM

red=east blue=west **July 27, 2000** red=north blue=south



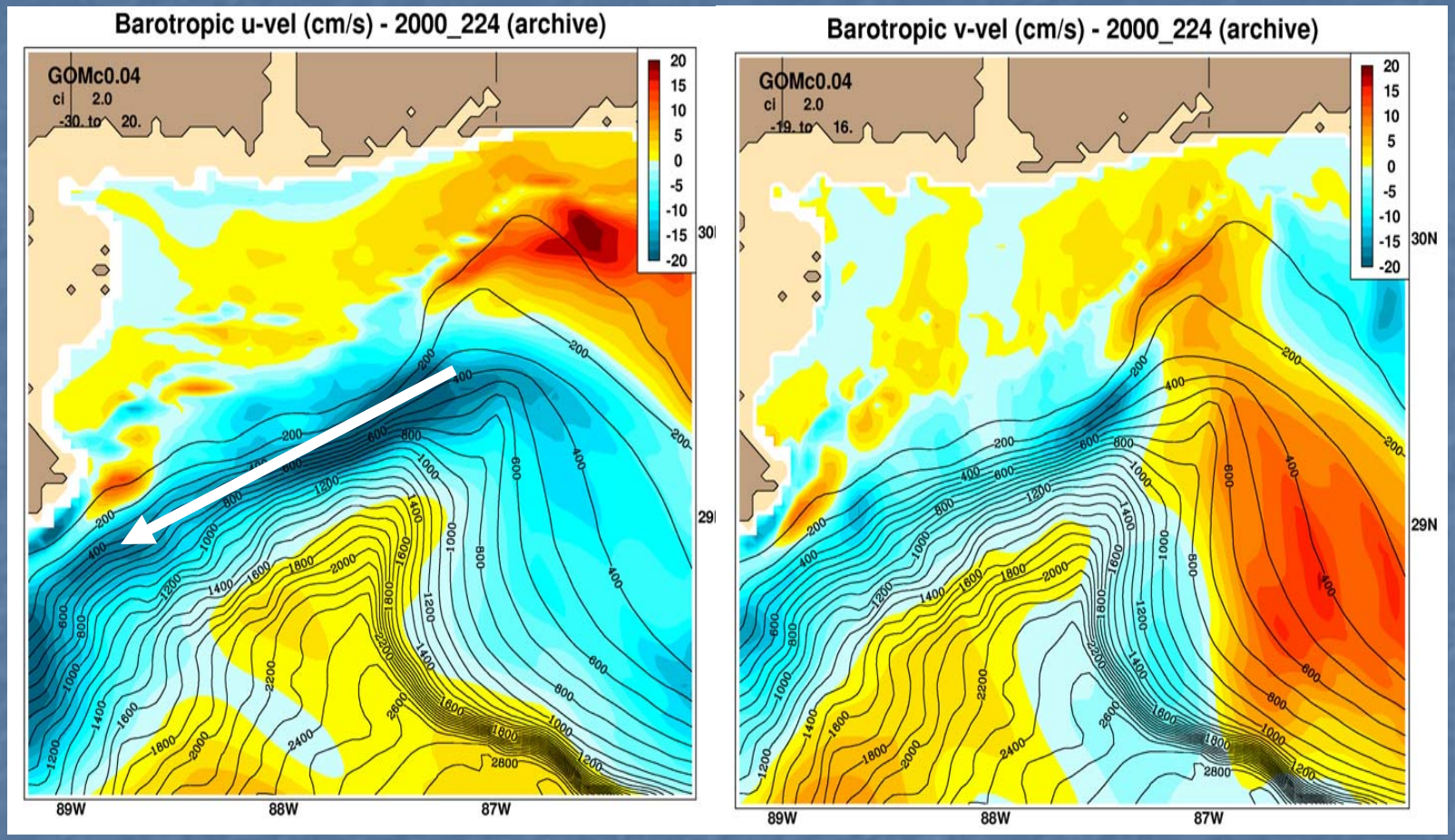
Barotropic u-velocity

Barotropic v-velocity

Initial eastward along-shelf break current in geostrophic balance

1/25° Nested Gulf of Mexico HYCOM

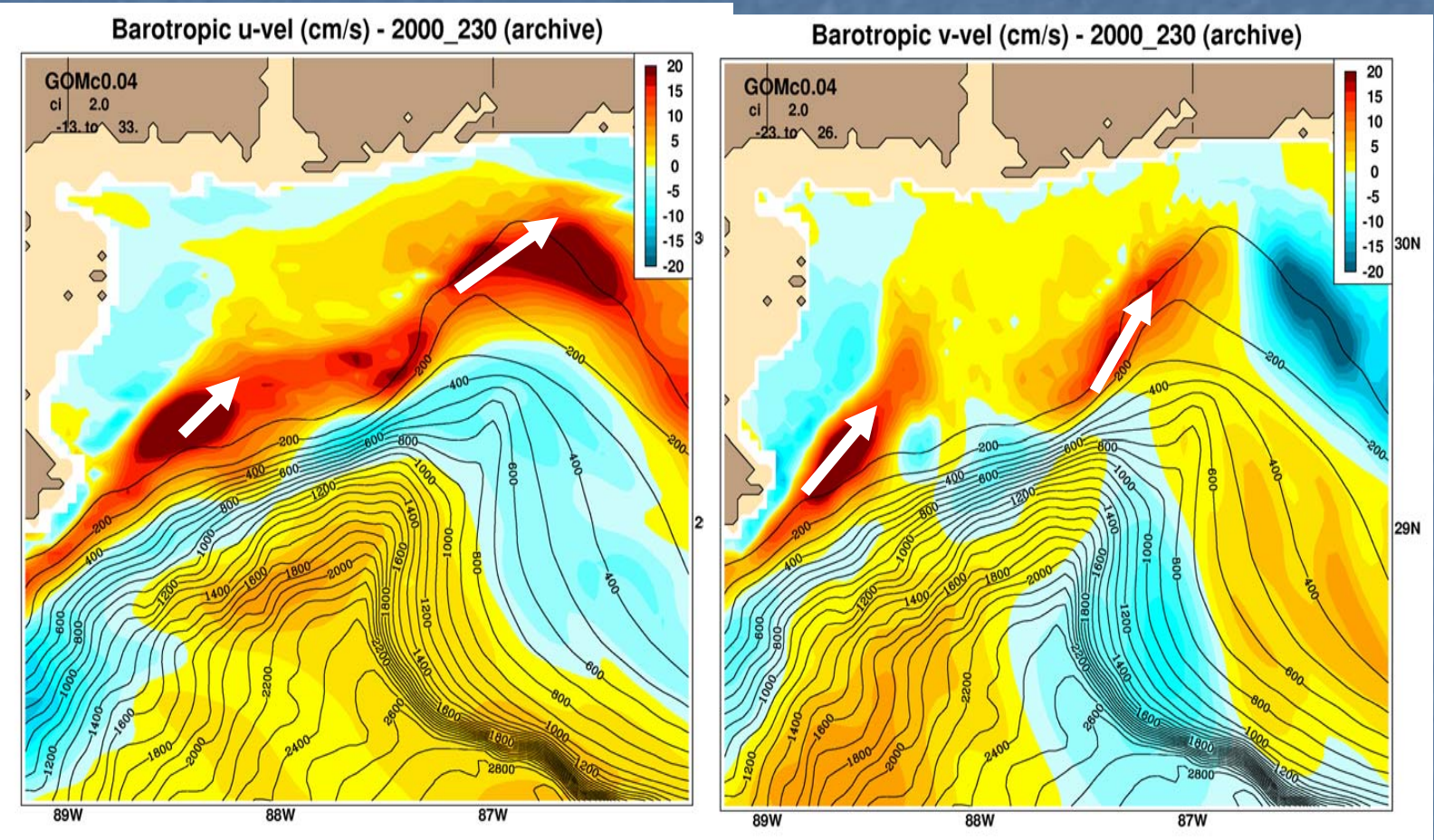
red=east blue=west **August 12, 2000 (+ ~2 weeks)** red=north blue=south



A reversal in the barotropic currents triggers a transition of the along-shelf break currents to flow onto the shelf

1/25° Nested Gulf of Mexico HYCOM

August 18, 2004 (+ ~1 week)



red=east blue=west

red=north blue=south

Significant cross-shelf flow exists after the reversal