

Nesting Studies with HYCOM at NRL

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Naval Research Laboratory

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Report Documentation Page

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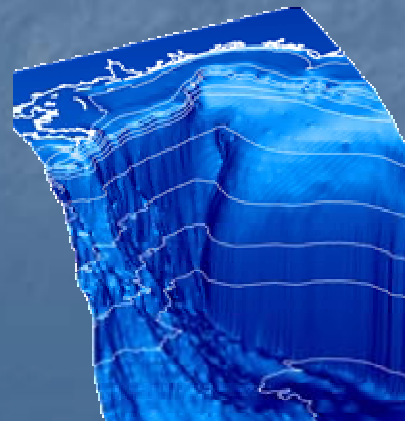
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To go with the HYCOM-based global ocean prediction system scheduled for transition to NAVOCEANO in FY06

We need accurate nesting of coastal models

- Nesting to higher resolution coastal domains using HYCOM and/or NCOM
- Implies a vertical remapping from global HYCOM to the target vertical structure of the coastal domain
- The nesting scheme must accurately represent flow regimes with widely different dynamics and time scales (e.g. in shallow water, over the continental slope and in deep water, with all three present in many cases).



Mississippi Bight

Current Status of Nesting

HYCOM NESTING in HYCOM

- Currently off-line
- Boundary info comes from archive files
- Exact boundary condition for depth averaged component
- Relaxation in buffer zone for T,S,P,u,v
- Updating frequency limited by archive file frequency
- Don't need to know nested area in advance

Off-line:

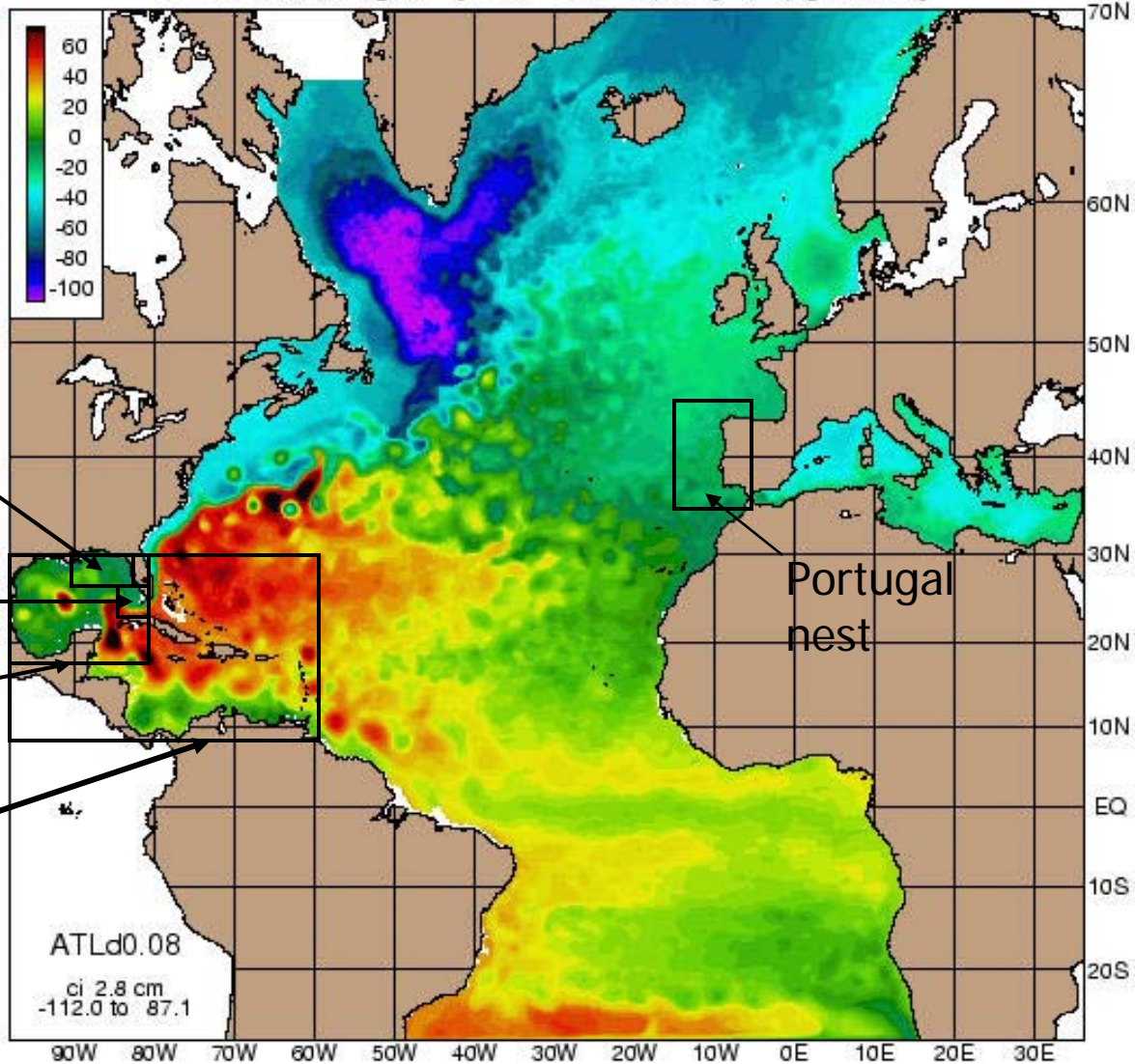
- Boundary information comes from archive files
- Updating frequency limited by archive file frequency
- Don't need to know nest area in advance

On-line (not yet implemented):

- Local model runs simultaneously with regional/basin-scale model
- Coupled via a vertical remapper
- Need to know nested area in advance

0.08° (1/12°) Atlantic HYCOM

sea surf. height year 7.38 (may 18) [02.5H]



Mississippi
Bight nest

Florida Current
nest

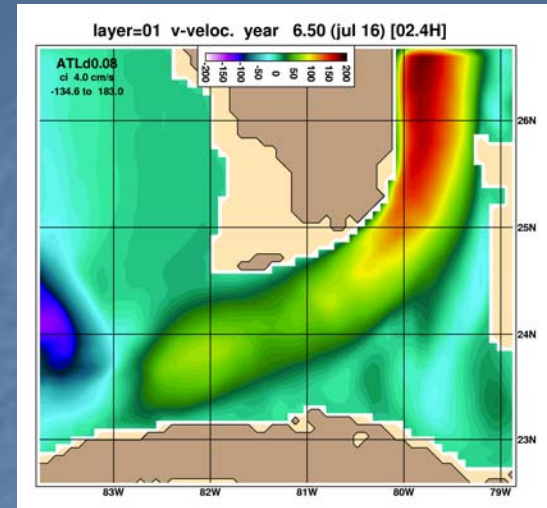
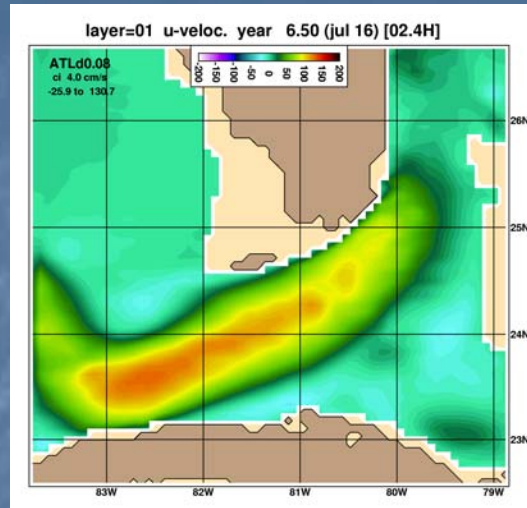
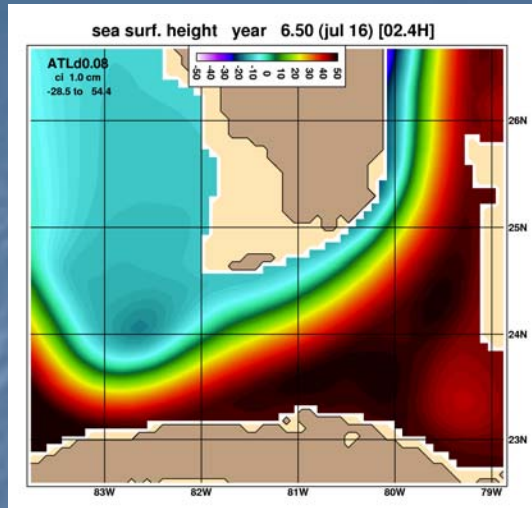
Gulf of Mexico

IAS nest

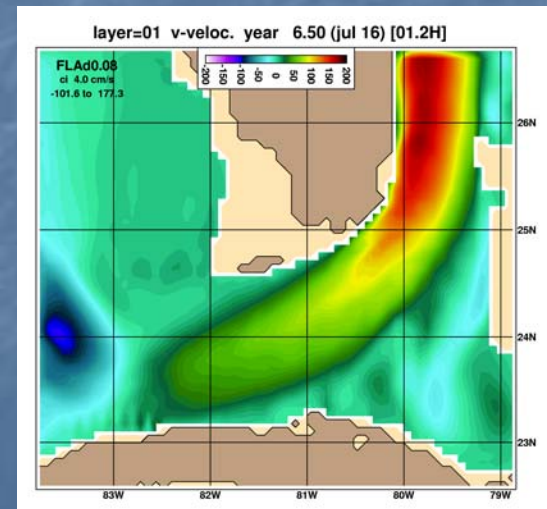
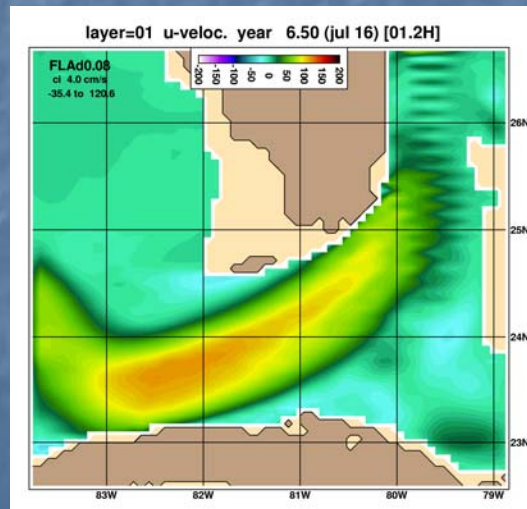
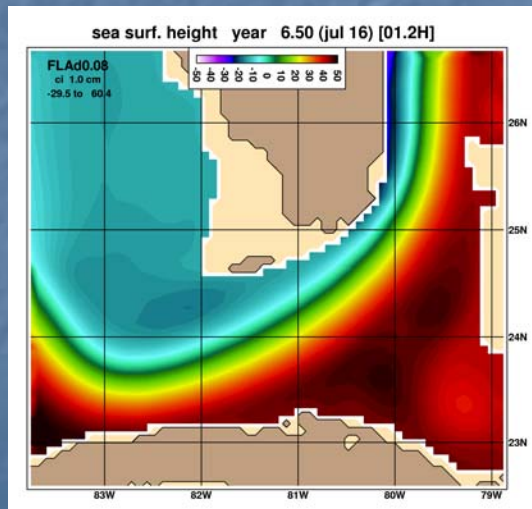
Portugal
nest

1/12° Pacific HYCOM also exists

0.08° Florida Current Nested Region

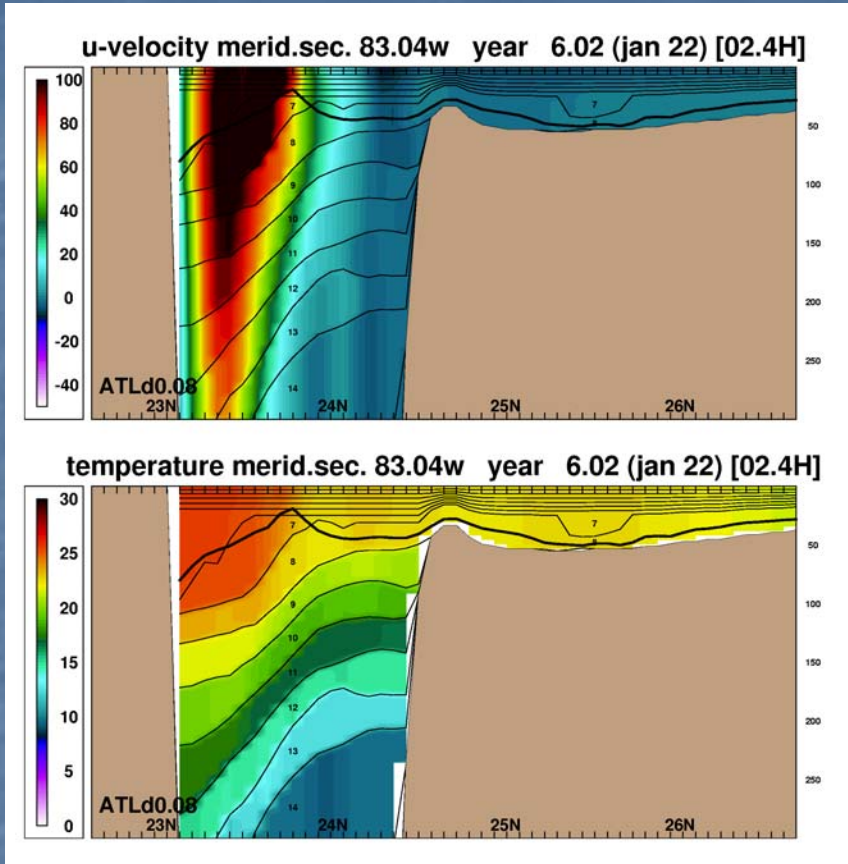


Original SSH, u,v after 180 days

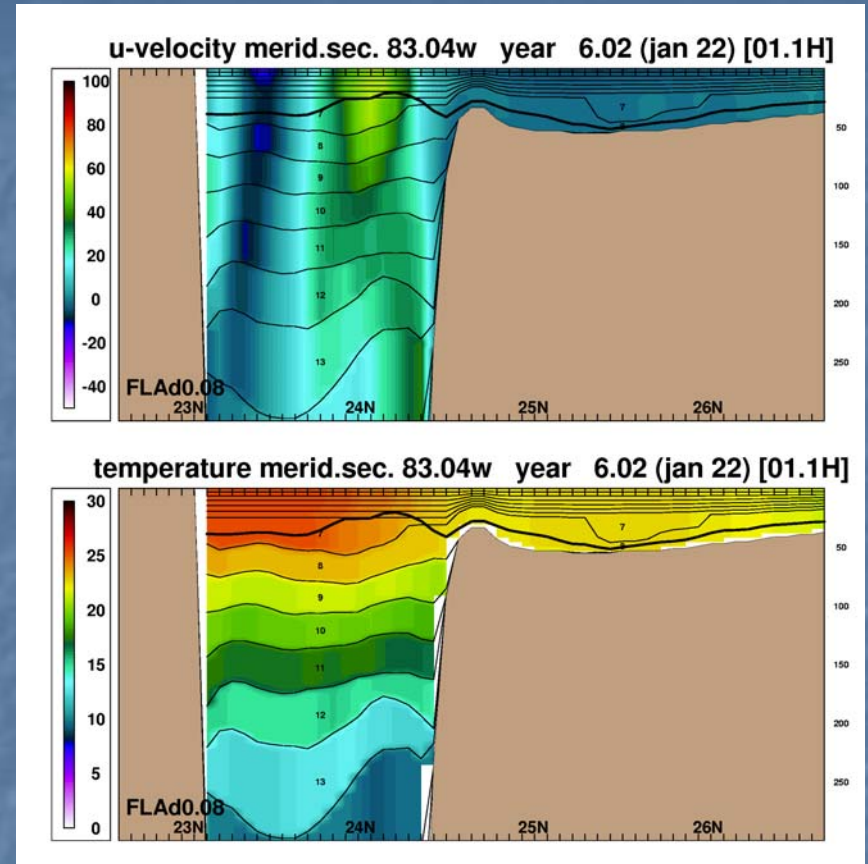


Nested SSH, u,v after 180 days (0.1-9 day e-folding; T-S-p,u,v relax)

0.08° Florida Current Nested Region

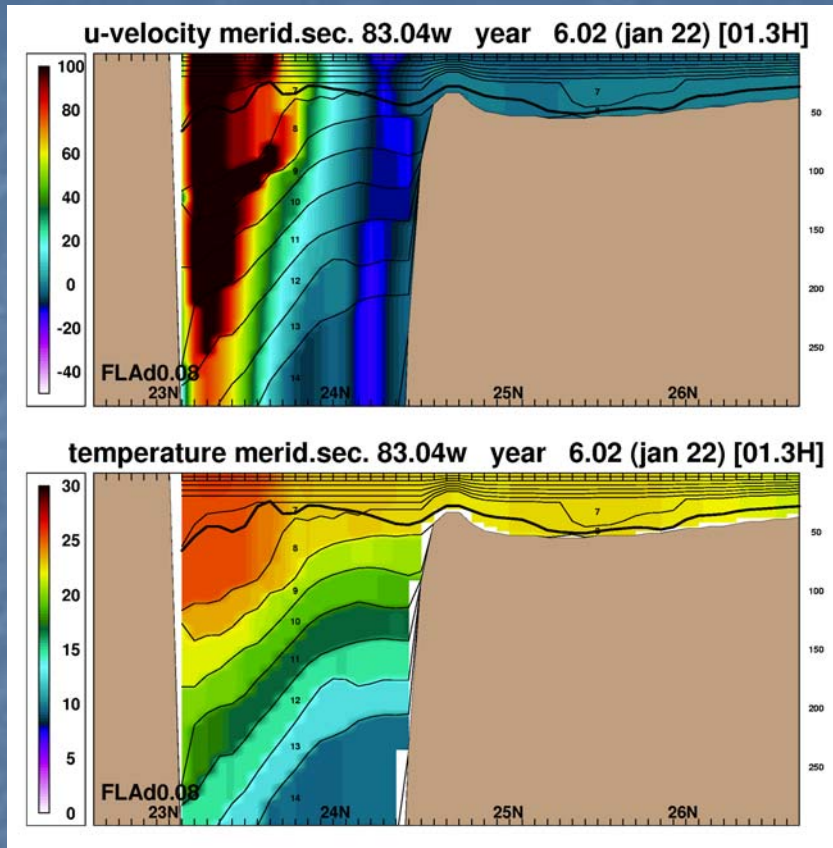


Original section after 6 days

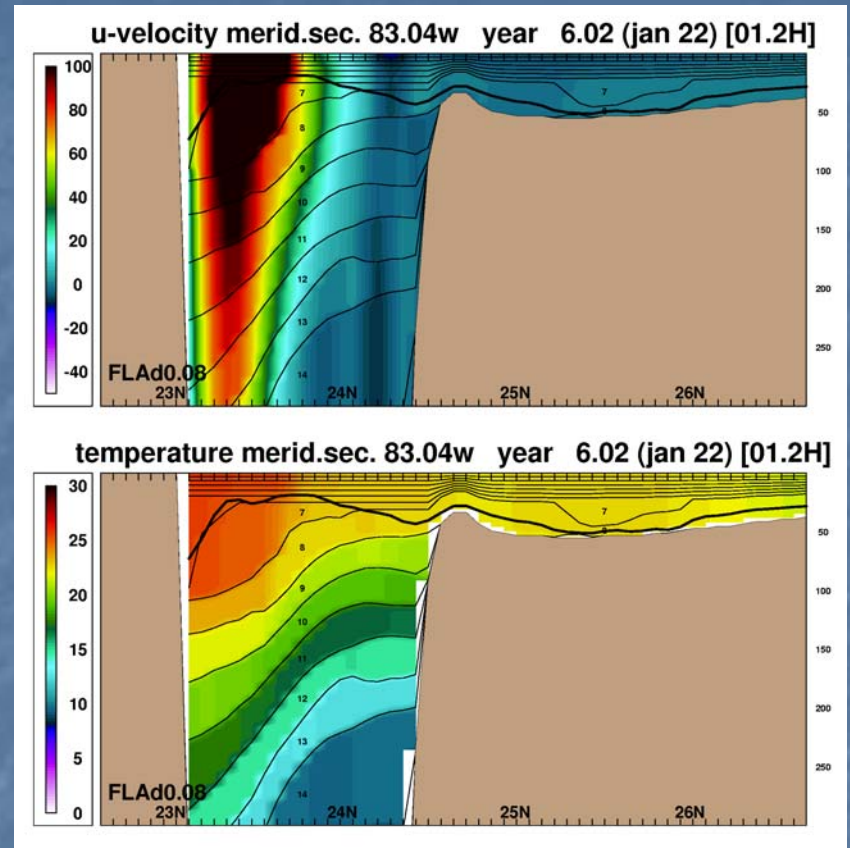


Nested section after 6 days:
1-day e-folding T-S-p relax

0.08° Florida Current Nested Region

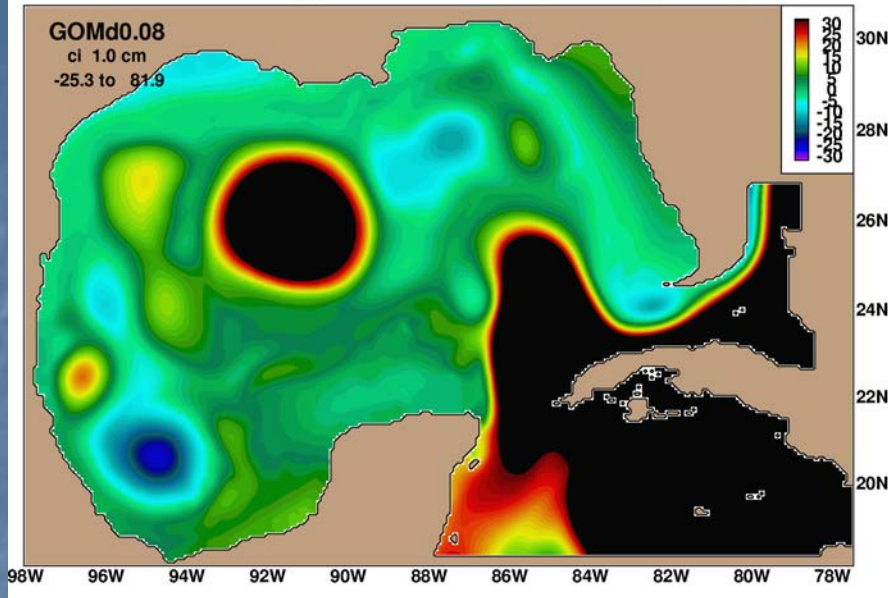


Nested section after 6 days:
0.1-day e-folding T-S-p relax



Nested section after 6 days:
0.1-day e-folding T-S-p-u-v relax

sea surf. height date: nov 02, 1999 [02.6H]

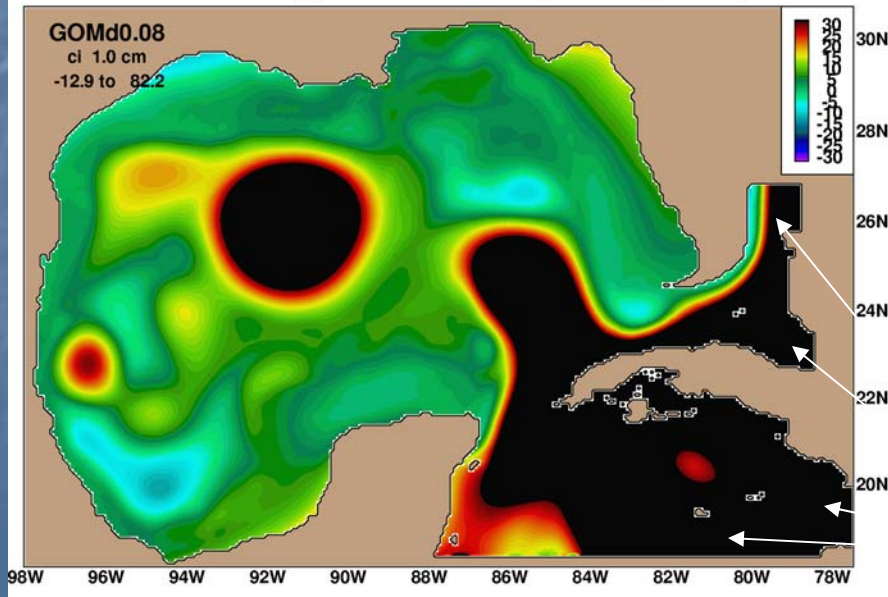


0.08° Gulf of Mexico nested inside of 0.08° North Atlantic

0.08° North Atlantic

3 months after restart
Relaxation to T,S,p
1-10 day e-folding time

sea surf. height date: nov 02, 1999 [01.2H]



0.08° Gulf of Mexico

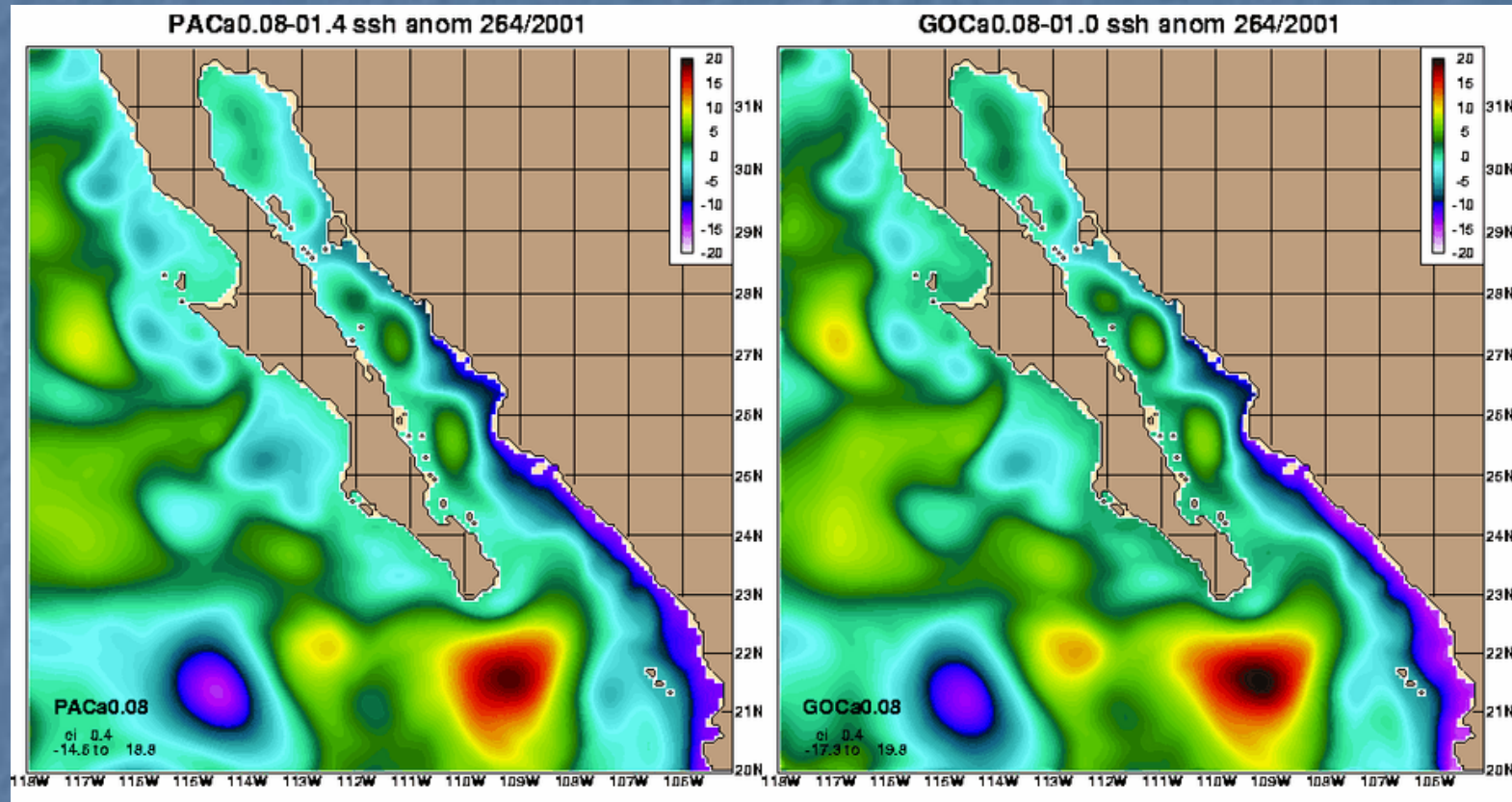
Plan to due 3x nest or ~2.7 km

Relaxation buffer zones

Gulf of California Nesting

0.08° Pacific Ocean Model

0.08° Nested Gulf of California

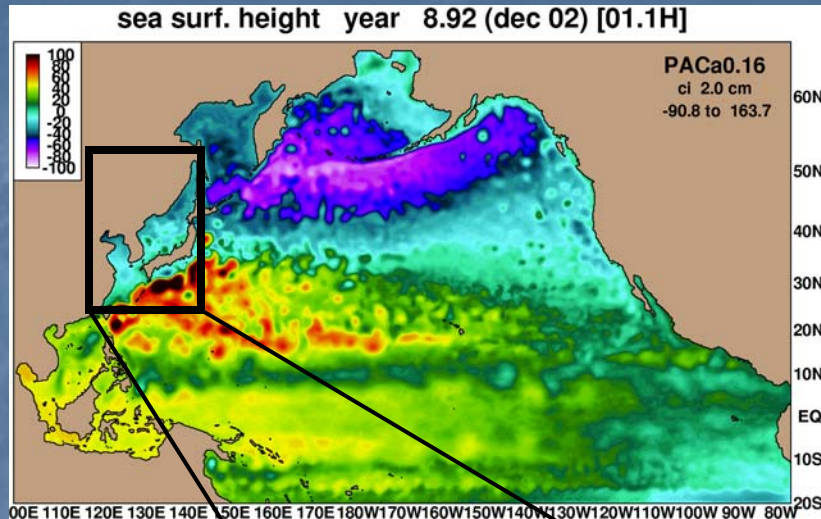


1-10 day e-folding time, relaxation to T,S,p,u,v

21 days after initialization

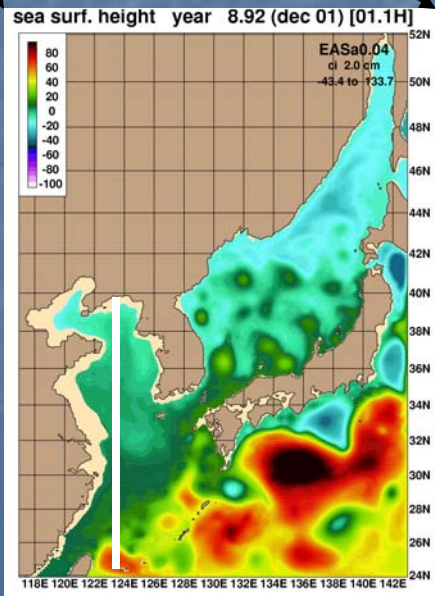
Courtesy: Joe Metzger

1/25° (3.5 km) East Asian Seas HYCOM Nested inside 1/6 ° North Pacific HYCOM



open boundary
conditions from 1/6°
North Pacific HYCOM

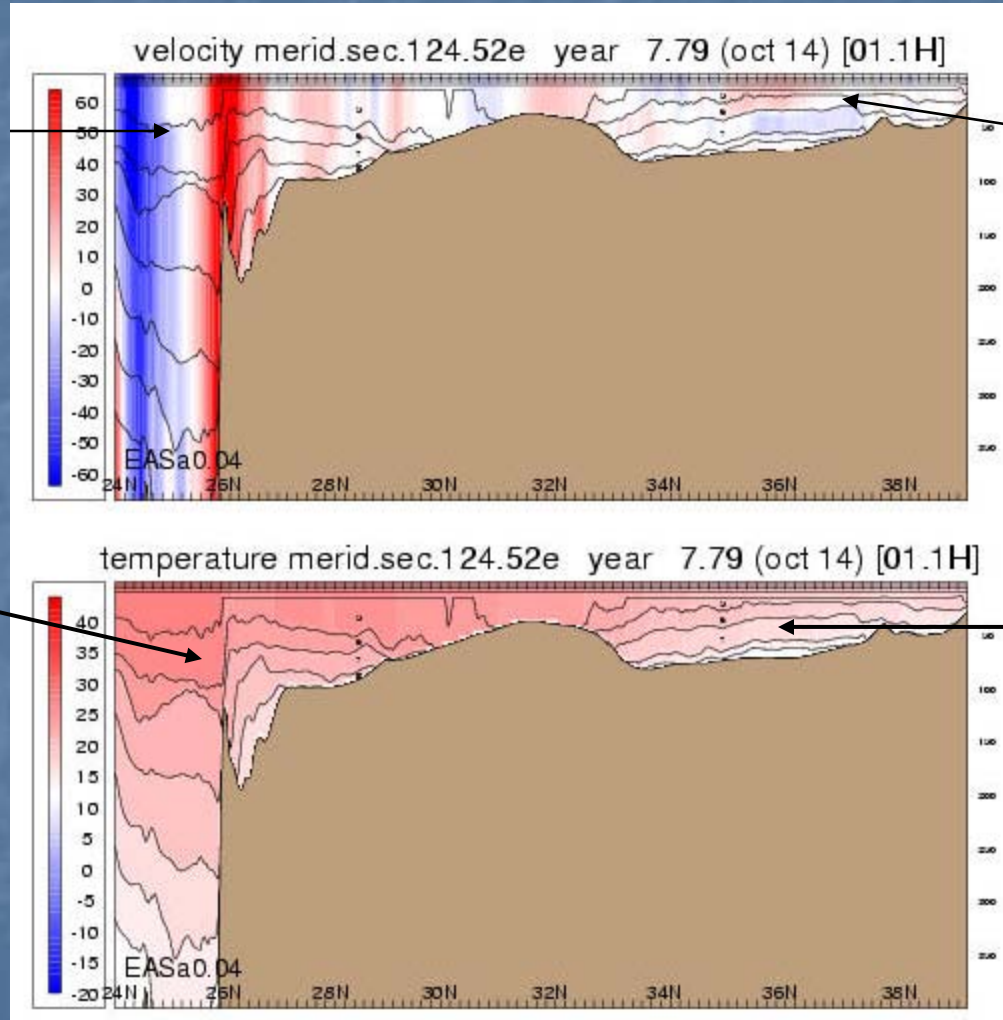
Nested model has same vertical
structure as Pacific Ocean model
(20 layers)



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

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

North-south cross-section along 124.5°E



East China Sea

Yellow Sea flow reversal with depth

blue=westward flow
red=eastward flow

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

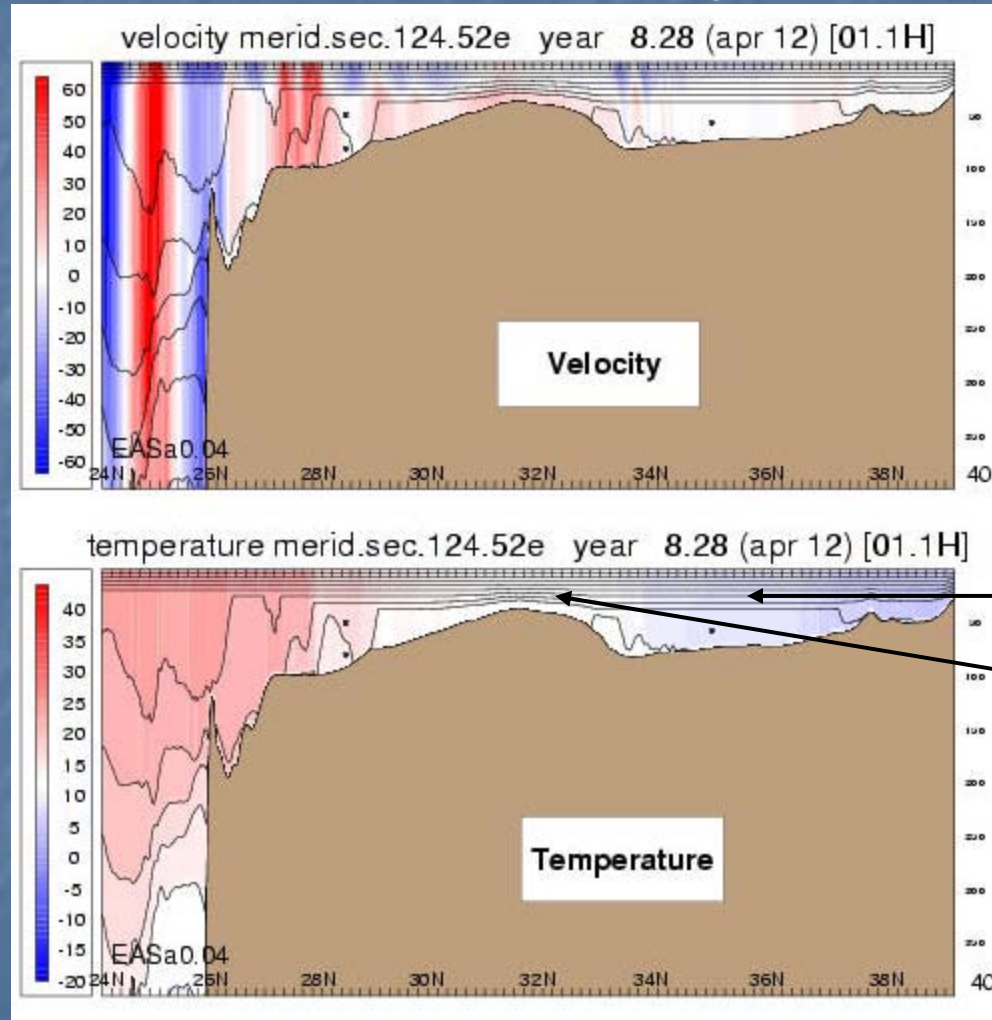
Isopycnals over shelf region

Snapshot on Oct. 14

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

North-south cross-section along 124.5°E

red=eastward flow
blue=westward flow



Snapshot on Apr. 12

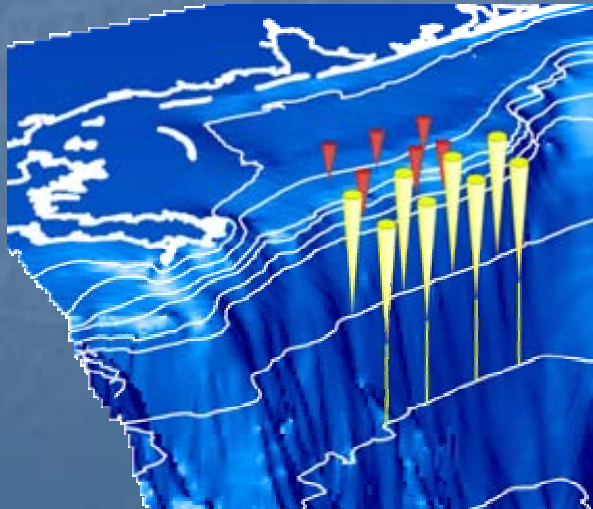


Future Plans

Slope to Shelf Energetics And Exchange Dynamics

(Jacobs, Teague, Hogan, Arnone)

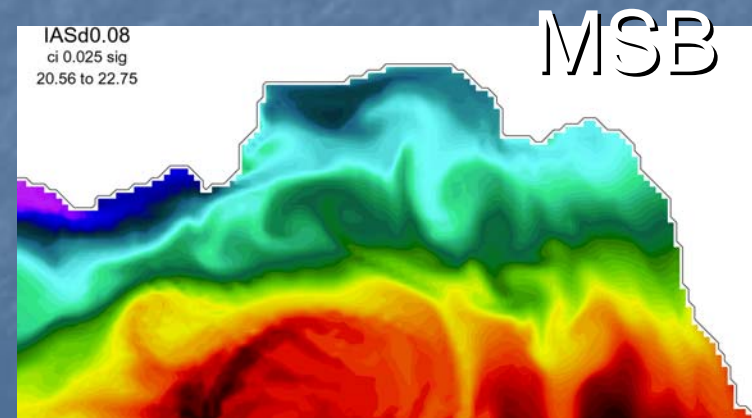
*Measuring and modeling of
processes that affect cross-
slope exchanges in the GoM*



Coastal Ocean
CO-NESTS
Nesting Studies

(Hogan, Kindle, Wallcraft)

- *Develop HYCOM coastal capabilities*
- *Evaluate coastal HYCOM and NCOM*
- *Evaluate coupling and boundary conditions*



Mississippi Bight Domain

NCOM

HYCOM

Navy Coastal Ocean Model

Hybrid Coordinate Ocean Model

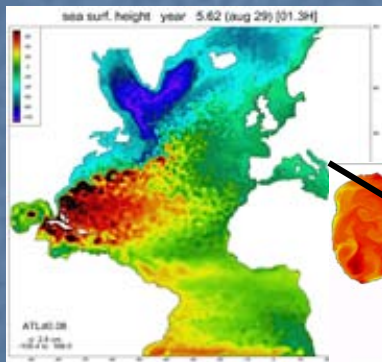
- Designed for coastal ocean Modeling
 - Hybrid sigma-Z vertical coordinate (sigma is terrain-following)
 - Transition between coordinates fixed (ideally at shelf break)
 - Limited representation of topog. (full cells in z-level mode)
 - ~ 3 times faster per layer than HYCOM
 - Developed from POM by Paul Martin (NRL)
- Designed for deep water domains and accurate deep to shallow water transition
 - Hybrid isopycnal-sigma-Z
 - Dynamic in space and time
 - More flexible design
 - Don't need as many isopycnals as Z-levels in deep water
 - Developed by NOPP HYCOM consortium

Can HYCOM do both global and coastal domains?

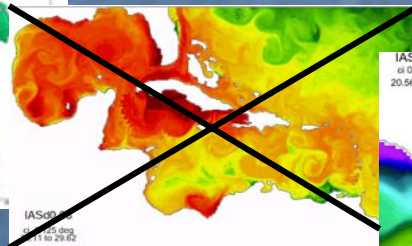
We will nest coastal HYCOM and NCOM within regional and/or global HYCOM with progressively finer horizontal and vertical resolution

- Sub-kilometer horizontal resolution is the goal
- Optimal vertical coordinate over shelf and shelf slope (isopycnals over the shelf when water is stratified?)
- Sensitivity to nesting ratios, number of nests, type of boundary condition
- Dynamical impact of increased horizontal and vertical resolution
- On-line nesting capability for multiple coastal nests

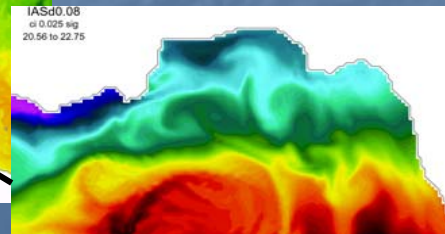
Run on massively parallel supercomputers



North Atlantic (NATL) Domain



Intra-Americas Sea (IAS) Domain



Mississippi Bight domain

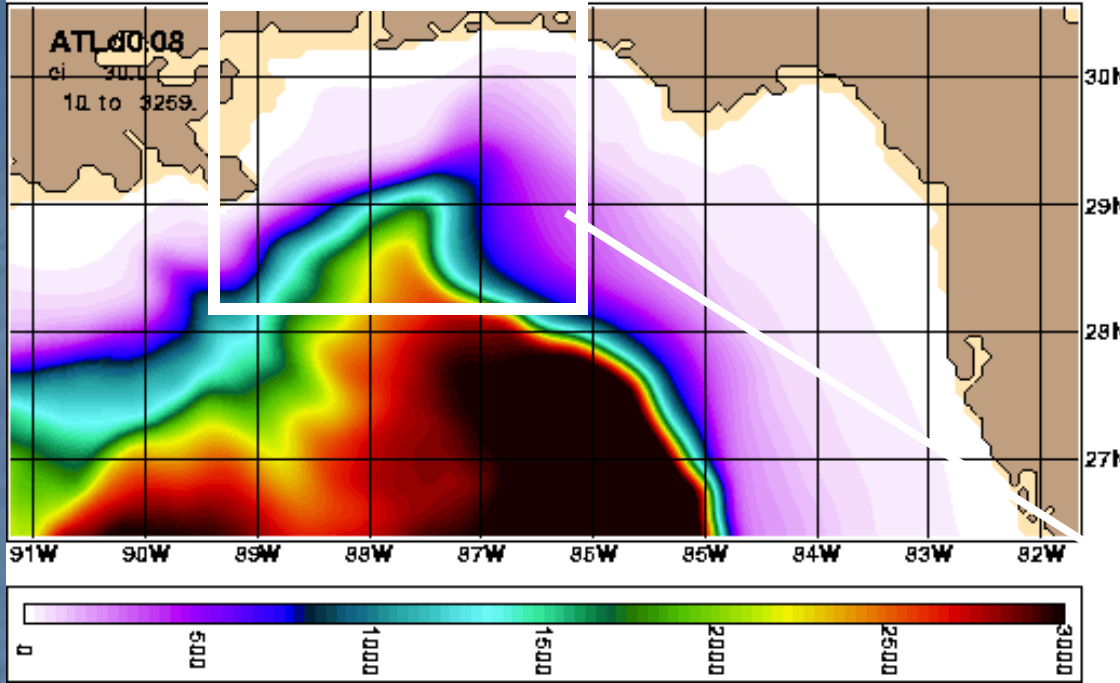
Eliminate need for regional models by end of decade

Run on Workstations or low-cost clusters

Mississippi Bight

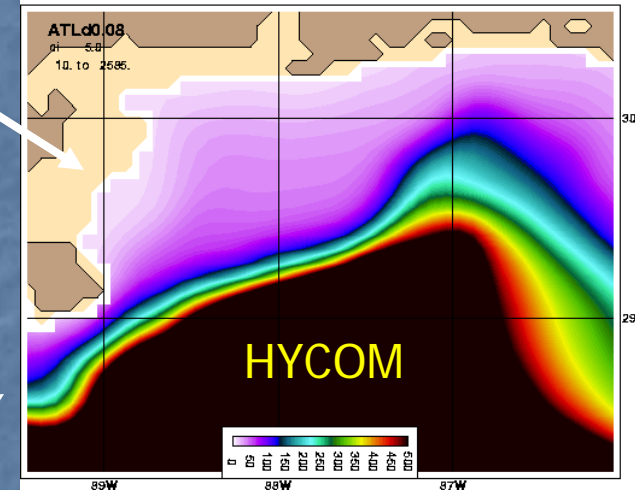
- Test cases are for the Mississippi Bight
 - Primary focus area for two NRL projects using NCOM and HYCOM (CO-NESTS) and HYCOM and ADCIRC (SEED)
- Large Mississippi Bight domain using HYCOM
 - Nested inside an Atlantic domain using HYCOM, both at 0.08 degree resolution
 - Using off-line, file-based, nesting
 - Makes the HYCOM domain practical (3 processors instead of 200+)
- Smaller Mississippi Bight domain using NCOM
 - Always has 40 fixed levels in the vertical
 - Nested inside HYCOM using archive files for boundary exchange
- Two test cases already performed as part of CHSSI project (Wallcraft)
 - 0.08 degree 40-level HYCOM, 0.08 degree 40-level NCOM
 - 0.08 degree 26-layer HYCOM, 0.08 degree 40-level NCOM

HYCOM Bathymetry

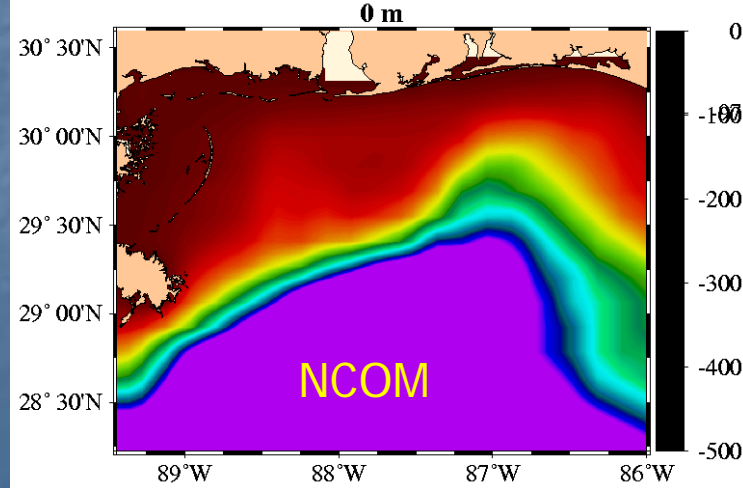


Initially a HYCOM subregion will be set up

HYCOM Bathymetry



Topography (m)

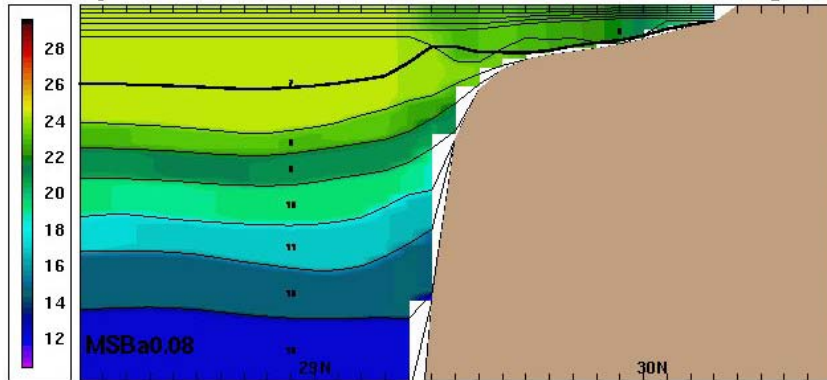


HYCOM and NCOM initial and subregions will match

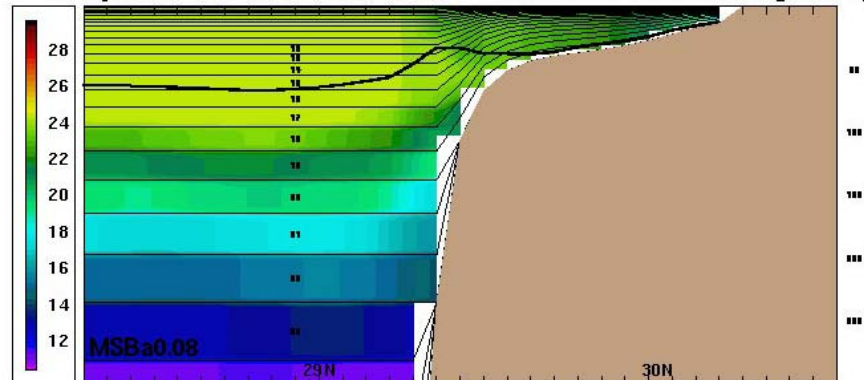
26-layer HYCOM

Remapped to 40 levels

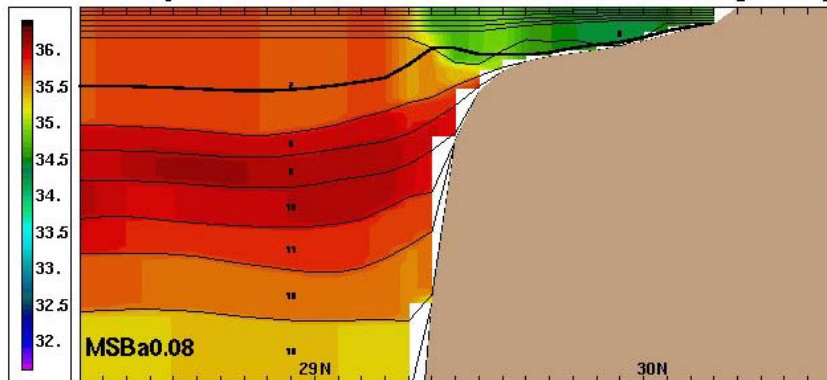
temperature merid.sec. 87.68w date: nov 30, 2002 [03.2H]



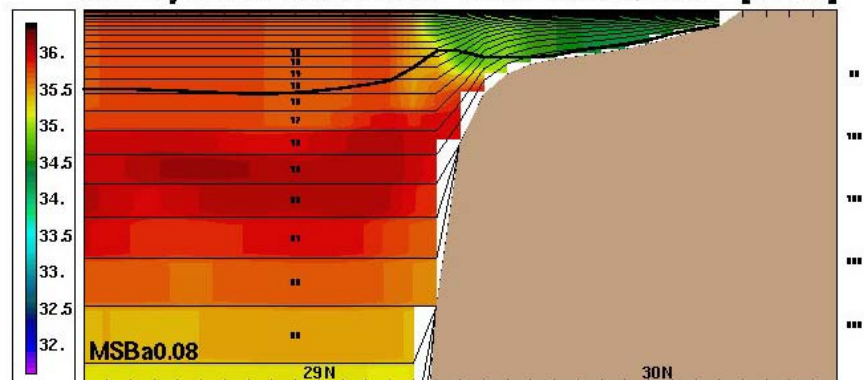
temperature merid.sec. 87.68w date: nov 30, 2002 [03.2H]



salinity merid.sec. 87.68w date: nov 30, 2002 [03.2H]



salinity merid.sec. 87.68w date: nov 30, 2002 [03.2H]



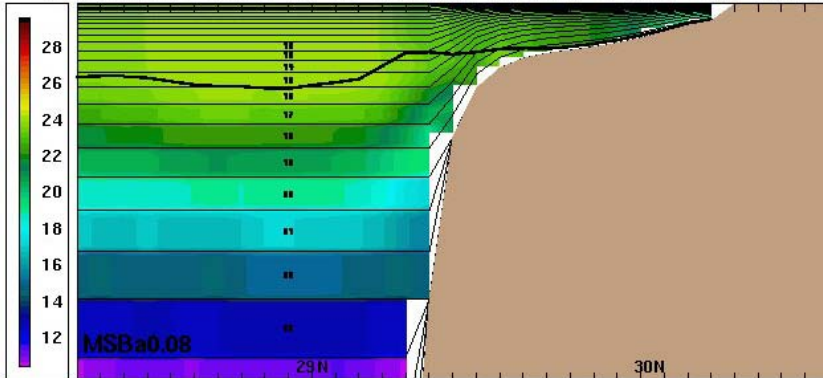
PLM remapping from 26 layer HYCOM to 40 level sigma-z

Nest of 40 level HYCOM to 40 level NCOM

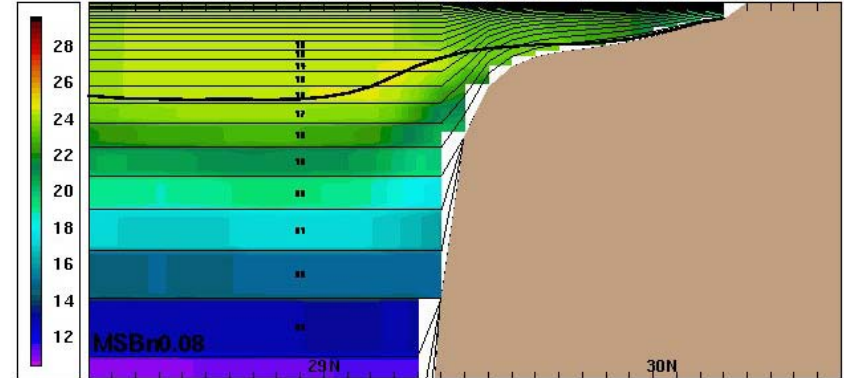
40-level HYCOM

40-level NCOM

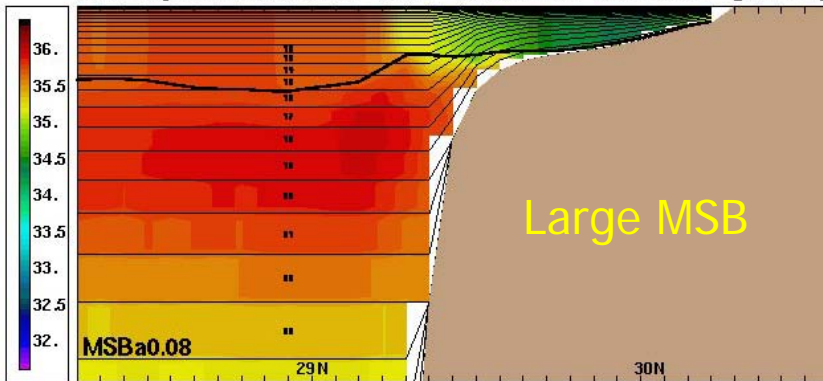
temperature merid.sec. 87.68w date: nov 30, 2002 [04.3H]



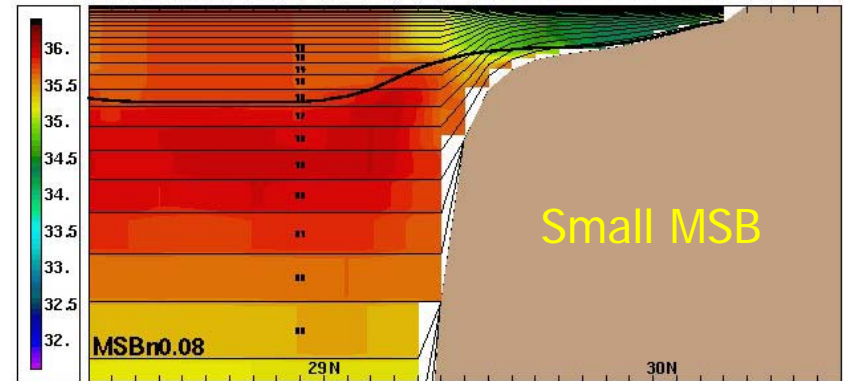
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salinity merid.sec. 87.68w date: nov 30, 2002 [04.3H]



salinity merid.sec. 87.68w date: nov 30, 2002 [94.3H]



6 days after restart

Generalized vertical remapping is the goal

THE END

SSH 40-level HYCOM

SSH 40-level NCOM

