Progress of the 1/12° Global HYCOM Effort

E. Joseph Metzger and Alan J. Wallcraft

HYCOM Consortium Meeting
6-8 December 2005
RSMAS, Miami FL
1/12° Global HYCOM: Initial Development and Evaluation


Ocean Sciences Meeting
20-24 February 2006
Honolulu, HI
HYCOM Long-term Goals for Operational Ocean Prediction

- 1/12° fully global ocean prediction system transitioned to NAVO in 2007
  - Include shallow water, minimum depth 5 m
  - Coupled sea-ice model (LANL CICE)

- Increase to 1/25° resolution globally by the end of the decade
  - Optimal resolution for basin-scale
  - Boundary conditions for coastal models
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: 26-28 for $\sigma_0$, 32 for $\sigma_2^*$

- KPP and GISS mixed layer models

- 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 snapshot: SSH and ice (gray)

- Running at NAVO under DoD Challenge
- 190K CPU hrs/model year on 784 CPUs
- 7.2 TB/model year for daily 3-D output

6 Dec 2005
1/12° Global HYCOM Experiments

- ECMWF Reanalysis (ERA15) climatological wind and thermal forcing
  - Annual bias corrections to air temperature (ERA40), radiative fluxes (ISCCP) and precipitation (GPCP)
- $\sigma_0$ simulations:
  - 26-layers with KPP for 6 model years
  - 28-layers with GISS for 3 model years
- $\sigma_2^*$ simulations:
  - 32-layers with GISS for 9 model years
Initial 1/12° Global HYCOM $\sigma_0$ Simulation

- Major shortcomings:
  - Poor simulation of both Gulf Stream and Kuroshio
  - Poor representation of tropical current systems
  - Unrealistic transport at key locations:
    - Florida Straits (23 Sv vs. $\sim$32 Sv) [simulated vs. observed]
    - Drake Passage (91 Sv vs. $\sim$134 Sv)
    - Pacific to Indian Ocean Throughflow (22 Sv vs. $\sim$10 Sv)
Improved 1/12° Global HYCOM $\sigma_0$ Simulation

- ** Modifications
  - Added two layers (26 $\rightarrow$ 28) and changed layer structure
  - Increased eddy viscosity: $A = 30 \text{ m}^2/\text{s}$ constant everywhere
  - Increased Smagorinsky diffusion: $.05 \rightarrow .1$
  - KPP $\rightarrow$ GISS

![Map of sea surface height with contour lines representing the mean values of 2.00-3.00 [03.0H].]
Improvements in Tropical Pacific Current Structure

Observations

Original 26-layer $\sigma_0$

Modified 28-layer $\sigma_0$

Zonal velocity along the equator

Zonal velocity at 140°W

m/s

-0.8 -0.6 -0.4 -0.2 0 0.2 0.4 0.6 0.8
1/12° Global HYCOM Mean Gulf Stream And Kuroshio Pathways

Mean over four model years

ERA15 climatological wind & thermal forcing

Latest $\sigma_2^*$ simulation

6 Dec 2005
1/12° Global HYCOM $\sigma_2^*$ Simulation

The Atlantic subpolar gyre generally looks good

From Schott et al. (2004, JPO)
Global SSH Variability

Oct 92 – Nov 98 SSH variability based on T/P, ERS-1 and ERS-2 altimeters (from Collecte, Localisation, Satellites (CLS))

SSH variability from 1/12° global HYCOM $\sigma_2^*$ with climatological wind and thermal forcing
Atlantic Meridional Overturning Circulation

$\sigma_0$ vs. $\sigma_2^*$

Maximum of Atlantic Zonal Overturning Streamfunction
Atlantic Meridional Overturning Circulation
Velocity Cross-section Along Luzon Strait

Sb-ADCP data (top) vs. 1/12° global HYCOM (bottom) in the upper 300 m
Section along 21°N between 118.5°E and 124.0°E

Sb-ADCP data from Liang et al. (2003, DSR Pt. II)
Mean from HYCOM with ERA15 wind and thermal forcing
No ocean data assimilation in HYCOM
Vertical Structure in the Equatorial Pacific

Zonal velocity along the equator

- Observations
- 32-layer $\sigma_2^*$
- Modified 28-layer $\sigma_0$

Zonal temperature along the equator

- Color bars for velocity in m/s
- Color bars for temperature in °C
Deep Flow Through Samoan Passage

Observed mean northward transport below 4000 m = 6.0 Sv
Rudnick (1997, JGR)

HYCOM $\sigma_2^*$ in layers 27-32 = 9.3 Sv
## Transport Comparisons at Key Locations

<table>
<thead>
<tr>
<th>Section</th>
<th>Obs.</th>
<th>Orig. $\sigma_0$</th>
<th>Mod. $\sigma_0$</th>
<th>Orig. $\sigma_2^*$</th>
<th>Mod. $\sigma_2^*$</th>
</tr>
</thead>
<tbody>
<tr>
<td>PCM-1</td>
<td>23</td>
<td>24.8</td>
<td>24.7</td>
<td>25.5</td>
<td>26.4</td>
</tr>
<tr>
<td>Bering Strait</td>
<td>1</td>
<td>1.1</td>
<td>1.1</td>
<td>1.1</td>
<td>1.1</td>
</tr>
<tr>
<td>PACIO TF</td>
<td>-10</td>
<td>-21.8</td>
<td>-24.1</td>
<td>-18.2</td>
<td>-17.0</td>
</tr>
<tr>
<td>STACS</td>
<td>30-34</td>
<td>23.2</td>
<td>23.1</td>
<td>22.9</td>
<td>24.0</td>
</tr>
<tr>
<td>Yucatan Channel</td>
<td>23-27</td>
<td>23.3</td>
<td>21.6</td>
<td>21.8</td>
<td>22.0</td>
</tr>
<tr>
<td>Denmark Strait</td>
<td>-2.9</td>
<td>-2.9</td>
<td>-2.3</td>
<td>-2.3</td>
<td>-2.9</td>
</tr>
<tr>
<td>Drake Passage</td>
<td>134</td>
<td>91.3</td>
<td>96.2</td>
<td>152.4</td>
<td>146.4</td>
</tr>
</tbody>
</table>

Modified $\sigma_2^*$ experiment uses a new topography with sill depth refinements in the IAS, Indonesian Seas, etc.
Future Work (FY06)

- Ten May 2001 – June 2002 assimilative runs in FY06
  - Time period with three satellite altimeters
  - Five with bi-weekly 30-day forecasts

- Near real-time nowcast/forecast starting in mid-FY06

- Interannual non-assimilative case:
  - 1995-present using NOGAPS

- Coupling with LANL CICE via ESMF