HYCOM and GODAE in Relation to Navy Ocean Prediction

An Overview Presented by

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Naval Research Laboratory
Stennis Space Center, MS
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NRL Effort Related to HYCOM

**Modeling**
- Harley Hurlburt
- Birol Kara
- Joe Metzger
- Jay Shriver
- Alan Wallcraft
- Xiabiao Xu (Postdoc at USM)

**Data Assimilation**
- Jim Cummings
- Ole Martin Smedstad (PSI)

**Regional Modeling and HYCOM Boundary Conditions for Regional/Coastal Models, Including COAMPS**

<table>
<thead>
<tr>
<th>Nested Model</th>
<th>Nested Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pat Hogan</td>
<td>HYCOM</td>
</tr>
<tr>
<td>Luis Zamudio (FSU)</td>
<td>HYCOM</td>
</tr>
<tr>
<td>Prasad Thoppil  (Postdoc at USM)</td>
<td>HYCOM</td>
</tr>
<tr>
<td>Kyung-Hoon Hyun  (Postdoc at USM)</td>
<td>-</td>
</tr>
<tr>
<td>Cheryl Ann Blain</td>
<td>finite element</td>
</tr>
</tbody>
</table>
Collaborative Effort on HYCOM for Ocean Prediction

Coordinated 6.1-6.4 effort with university, NOAA and international collaboration

- 6.1 Global Remote Littoral Forcing via Deep Water Pathways
- 6.1 Indonesian Throughflow
- 6.1 ONR Philippine Straits DRI
- Navy/NOAA/Univ./Internat. HYCOM NOPP GODAE
  - development of a next generation global ocean prediction system, including boundary conditions for multiple coastal models and COAMPS
- Participating in multinational Global Ocean Data Assimilation Experiment (GODAE)
- 6.4 Large-Scale Prediction and Ocean Data Assimilation
  - For transition to NAVOCEANO
- 6.1 SEED ARI, 6.2 CO-NESTS and NOPP CODAE
  - boundary conditions for a variety of coastal models
- DoD HPC challenge and non-challenge computer time
  - Largest Navy user of DoD HPC
## U.S. Navy Present and Planned Global Ocean Prediction Systems

<table>
<thead>
<tr>
<th>Global Product</th>
<th>Mid-Lat Resolution</th>
<th>Vert. Coord.</th>
<th>Inputs</th>
<th>Run By</th>
<th>Actual or Target Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/16° NLOM</td>
<td>7 km</td>
<td>Layered</td>
<td>SSH, SST, hydro, FNMOC NOGAPS Atmospheric Forcing</td>
<td>NAVO</td>
<td>OP 9/01-3/06</td>
</tr>
<tr>
<td>1/8° NCOM ¹</td>
<td>15 km</td>
<td>$\sigma/z$</td>
<td></td>
<td>NAVO</td>
<td>OP 2/06</td>
</tr>
<tr>
<td>1/32° NLOM ²</td>
<td>3.5 km</td>
<td>Layered</td>
<td></td>
<td>NAVO</td>
<td>OP 3/06</td>
</tr>
<tr>
<td>1/12° HYCOM ³,⁵</td>
<td>7 km</td>
<td>$\rho/\sigma/z$</td>
<td></td>
<td>NAVO</td>
<td>2007</td>
</tr>
<tr>
<td>1/25° HYCOM</td>
<td>3.5 km</td>
<td>$\rho/\sigma/z$</td>
<td></td>
<td>NAVO</td>
<td>2011</td>
</tr>
<tr>
<td><strong>Near Real-time demonstration</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>NRL</strong></td>
<td>2002</td>
</tr>
<tr>
<td>1/12° Atl. HYCOM ⁴,⁵</td>
<td>7 km</td>
<td>$\rho/\sigma/z$</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**OP = operational**


³ Running in real time at NAVO.

⁴ Under the National Ocean Partnership Program (NOPP), 1/12° Atlantic HYCOM demo is running in near real-time. Includes the Mediterranean Sea.

⁵ Results at [http://www.hycom.org](http://www.hycom.org) (100Tb LAS server at FSU)
**Nesting Strategy for Ocean Prediction**

<table>
<thead>
<tr>
<th>Global</th>
<th>→</th>
<th>Regional</th>
<th>→</th>
<th>Littoral</th>
<th>→</th>
<th>Nearshore</th>
</tr>
</thead>
</table>

**Near-term: present-FY04 in R&D, FY04-FY08 operational, including transition**

<table>
<thead>
<tr>
<th>1/8° NCOM</th>
<th>→</th>
<th>NCOM or SWAFS</th>
<th>→</th>
<th>NCOM or SWAFS</th>
<th>→</th>
<th>ADCIRC</th>
</tr>
</thead>
<tbody>
<tr>
<td>15-16 km mid-lat resolution</td>
<td>→</td>
<td>4 - 8 km, larger regions</td>
<td>→</td>
<td>&lt; 1 to 2 km res</td>
<td>→</td>
<td>&lt; 2 km resolution finite element</td>
</tr>
</tbody>
</table>

**Mid-term: FY04 - FY08 in R&D, FY07 – FY12 operational, including transition**

<table>
<thead>
<tr>
<th>1/12° HYCOM</th>
<th>→</th>
<th>HYCOM</th>
<th>→</th>
<th>*NCOM or HYCOM</th>
<th>→</th>
<th>ADCIRC</th>
</tr>
</thead>
<tbody>
<tr>
<td>7 km mid-lat resolution</td>
<td>→</td>
<td>2 - 4 km, smaller regions</td>
<td>→</td>
<td>.5-1.5 km res</td>
<td>→</td>
<td>&lt; 1.5 km res</td>
</tr>
</tbody>
</table>

**Long-term: FY07-FY12 in R&D, FY11 and beyond operational, including transition**

<table>
<thead>
<tr>
<th>*1/25° HYCOM</th>
<th>→</th>
<th>Regional generally not needed</th>
<th>→</th>
<th>*NCOM or HYCOM</th>
<th>→</th>
<th>ADCIRC</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 - 4 km mid-lat resolution</td>
<td>→</td>
<td>Not used</td>
<td>→</td>
<td>≤ 1km res</td>
<td>→</td>
<td>≤ 1 km res</td>
</tr>
</tbody>
</table>

*Hogan and Kindle CO-NESTS project will provide research results needed to make the appropriate choice. An alternative model such as ROMS may also be considered. *1/25° HYCOM gives useful littoral resolution globally
HYCOM Helps Explain the Formation of Intra-Thermocline Eddies (ITEs) in the Japan/East Sea

Observed ITE
May 1999 Observed density cross-section from Gordon et al. (2002, JPO) along 37.75°N

Observed frontal subduction
Jan 2000 Observed cross-section of temperature (contours) and salinity (color) along 134.4°E. From Gordon et al., 2002, JPO

Simulated frontal subduction into an ITE
January HYCOM cross-section along 131.7°E. Salinity on model layers, isopycnal with z-levels near the surface

Plumes of salinity wrap around ITE caps in HYCOM

ITEs marked by ×

From Hogan and Hurlburt (2006, Oceanography)
ONR JES DRI follow-up
**Ongoing Work on Atmospheric Forcing**

- New schemes for shortwave radiation penetration with turbidity
  - Kara et al. (2005, JPO), Lee et al. (2005, JGR-O)

- Creeping Sea Fill (Kara et al., 2007, JPO)
  - For removal of land contamination of sea grid points from any scalar atmospheric forcing field
  - Or filling data gaps, e.g. near land

- Satellite-based corrections to short and longwave radiation, wind speed, and precipitation monthly mean climatologies
  - Approach can be used for any sub-daily inter-annual or real-time atmospheric forcing product of choice, e.g. NOGAPS
  - Short and long wave radiation corrected using ISCCP climatology
  - Wind speed corrected using scatterometer or SSM/I climatology
    - Product wind direction retained
  - Precipitation is corrected using GPCP climatology

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**NOGAPS Land/Sea Mask over the Eastern Mediterranean Sea Region**

- Color bar is fractional land contamination after interpolation to the .08° global HYCOM grid
1/16° Global Linear Sverdrup Flow Circulation

ECMWF era40

Above corrected with QuikSCAT wind speed

(Sv)
Results from Real-Time .08° Global HYCOM with NCODA Data Assimilation

Sea Surface Height (SSH) in cm

Global SSH on 23 Mar 2007
Gray areas are ice covered

NW Pacific SSH zoom on 12 Mar 2006
NAVOCEANO operational analysis of the Kuroshio front based on satellite AVHRR imagery is overlaid
black segments are based on imagery > 4 days old
Forecast Verification Statistics from .08° Global HYCOM

4 Forecasts included in statistics