# Evaluation and validation of the 1/12° global HYCOM system

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# 1/12° HYCOM/NCODA/PIPS

#### **Delivery:**

- Scheduled for transition to the Naval Oceanographic Office (NAVOCEANO) by the end of 2007
- Operational testing to begin in 2008

#### Capability:

- Provide accurate 3D temperature, salinity and current structure
- Depict the location of mesoscale features such as oceanic eddies and fronts

#### Progress:

- 1/12° global HYCOM/NCODA running in real-time in the NAVOCEANO operational queues since 22 Dec 2006
- Produces daily 5-day hindcast up to the nowcast time, then a 4-5 day forecast
- Graphical and digital output available through the HYCOM consortium web pages: http://www.hycom.org

#### **Issues:**

• Complete coupling (with ice edge assimilation) of HYCOM/PIPS via ESMF

# 1/12° 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: 32 for  $\sigma_2^*$
- 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
- Monthly river runoff (986 rivers)
- Initialized from January climatology (GDEM3) T and S, then SSS relaxation from PHC 3.0
  - No subsurface relaxation to climatology

# HYCOM/NCODA Verification Experiments

- Hindcast simulations:
  - 11/2003 03/2007: results from 2004-2006 used in this presentation
    - Some of this output is on the HYCOM consortium LAS
  - Second simulation was recently started in 12/2004 and will run through the end of 2005 or 2006
    - Changes to the model code (increased timestep)
    - NCODA assimilation globally
    - NCODA analysis cycle runs at 18Z

## HYCOM/NCODA Runstream



- 1) Perform first NCODA analysis centered on tau = -120
- 2) Run HYCOM for 24 hours using incremental updating (
  ) over the first 6 hrs
- 3) Repeat steps 1) and 2) until the nowcast time
- 4) Run HYCOM in forecast mode out to tau = 96, eventually to tau = 120

Approximate run times\* (using 379 IBM Power 5+ processors):

- 1) Six NCODA analyses: 0.9 hrs/analysis = 5.4 hrs
- 2) Five HYCOM hindcast days @ 150 sec  $\Delta t$ : 1.1 hrs/day = 5.5 hrs
- 3) Four HYCOM forecast days @ 150 sec  $\Delta t$ : 1.1 hrs/day = 4.4 hrs

4) Total: 15.3 hrs

\* Timings do not include PIPS coupling; assimilation in the Mercator part of grid only

# **FY07 Validation Tasks**

## A. Large scale circulation features

- Determine correct placement of large scale features
- B. Sea Surface Height (SSH) variability / Eddy Kinetic Energy (EKE)
  - Determine if the system has a realistic level and distribution of energy at depths
- C. Mixed layer depth / sonic layer depth / deep sound channel
  - Compare simulated vs. observed for non-assimilated buoys

## D. Vertical profiles of T&S

Quantitative comparison of simulated vs. observed for non-assimilated buoys

## E. Sea surface temperature

- Evaluate whether the models are producing acceptable nowcasts and forecasts of sea surface temperature
- F. Coastal sea level
  - Assess the model's ability to represent observed sea surface heights

## A. Large scale circulation features

#### 1992-2002 mean dynamic ocean topography (0.5°)



Mean ocean dynamic topography data obtained from Nikolai Maximenko (IPRC) and Peter Niiler (SIO)

## A. Large scale circulation features

#### 2004-2006 mean sea level from 1/12° global HYCOM/NCODA



From the 1/12° global HYCOM/NCODA hindcast simulation Mean shifted by 8.7 cm; standard deviation of difference = 9.6 cm

## **B. SSH Variability**



SSH variability over 1993-2006 from MODAS

SSH variability over 2004-2006 from the HYCOM/NCODA hindcast simulation

## **B. Surface EKE in the Gulf Stream**

Observations from Fratantoni (2001) based on 1990-99 surface drifters



1/8° Navy Coastal Ocean Model (NCOM) - 1/32° Navy Layered Ocean Model (NLOM) -1/8° Modular Ocean Data Assimilation System (MODAS)

## B. EKE at 700 m in the Gulf Stream



# C. Mixed Layer Depth (MLD) Evaluation

2005 MLD Median Bias (MdB): HYCOM vs. unassimilated MEDS profiles



MLD = depth where the temperature is reduced by 0.5°C from the surface value Based on 28,509 profiles

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## C. Sonic Layer Depth (SLD) Evaluation Target diagrams – Model vs. unassimilated 2005 MEDS profiles HYCOM NCOM



SLD = near surface sound speed maximum

#### Locations of TAO and PIRATA buoys used in this evaluation



Buoys are divided into two sets based on the vertical sampling and continuity of the time series over calendar year 2004

East (denoted by o's): 1, 20, 40, 60, 80, 100, 120, 140, 180, 300, 500 m. West (denoted by x's): 1, 25, 50, 75, 100, 125, 150, 200, 250, 300, 500 m.

#### 2004 subsurface temp at 140°W, 2°N

Temperature difference



Significant impact of temperature profile assimilation via NCODA

#### 2004 subsurface temp at 140°W, 2°N

Temperature difference



## RMSE – 47 TAO/PIRATA buoys 2004 Buoy vs. HYCOM Buoy vs. NCOM



Skill score – 47 TAO/PIRATA buoys 2004 Buoy vs. HYCOM Buoy vs. NCOM



Skill score based on correlation, conditional and unconditional bias.

## E. Sea Surface Temperature Mean error – HYCOM vs. MODAS



Over 2004-2006 from the HYCOM hindcast simulation

## E. Sea Surface Temperature Skill score – HYCOM vs. MODAS



Over 2004-2006 from the HYCOM hindcast simulation

## E. Sea Surface Temperature Unassimilated MEDS SST vs. HYCOM vs. NCOM



Over 2004 from the HYCOM hindcast simulation and operational NCOM

## F. Sea Level Comparison

Simulated vs. observed sea level at 148 coastal / island stations during 2004



## **FY08 Validation Tasks**

- A. Below layer depth gradient
  - Compare simulated vs. observed for non-assimilated buoys
- B. Comparison with drifting buoys
  - Evaluate the model's ability to produce ocean currents that yield drifter and ARGO float trajectories similar to observations
- C. Current cross sections
  - Evaluate model velocity cross-sections through qualitative and quantitative comparisons
- D. Provide boundary conditions to nested models
  - Nest East Asian Seas NCOM and Relocatable NCOM within HYCOM and compare inner model with the solution when forced NCOM
- E. Eddy tracking
  - Evaluate the model's ability to track mesoscale eddies
- F. Ice drift, thickness and concentration
  - Assess the model's ability to represent sea ice

## HYCOM/PIPS Coupling via ESMF

- PIPS = Polar Ice Prediction System: based on the Los Alamos CICE model
- ESMF = Earth System Modeling Framework
- Testing in a 1/12° Bering Sea (v2.2.03)
- Two-way coupling running robustly
  - HYCOM exports: SST, SSS, surface currents and available freeze/melt heat flux
  - PIPS exports: ice concentration, ice/ocean stress, actual freeze/melt, heat/salt/mass flux and solar radiation at the ice base
- No SSMI ice edge assimilation yet

## HYCOM/PIPS Coupling via ESMF Ice thickness (m) and NIC ice edge (black line)

### HYCOM/PIPS

### HYCOM/E-loan



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