1/12° Global HYCOM Evaluation and Validation

Joe Metzger[1], Harley Hurlburt[1], Alan Wallcraft[1], Ole Martin Smedstad[2], Birol Kara[1], Jay Shriver[1], Lucy Smedstad[1], Debbie Franklin[2], Bill Schmitz, Jr.[3], and Prasad Thoppil[4]

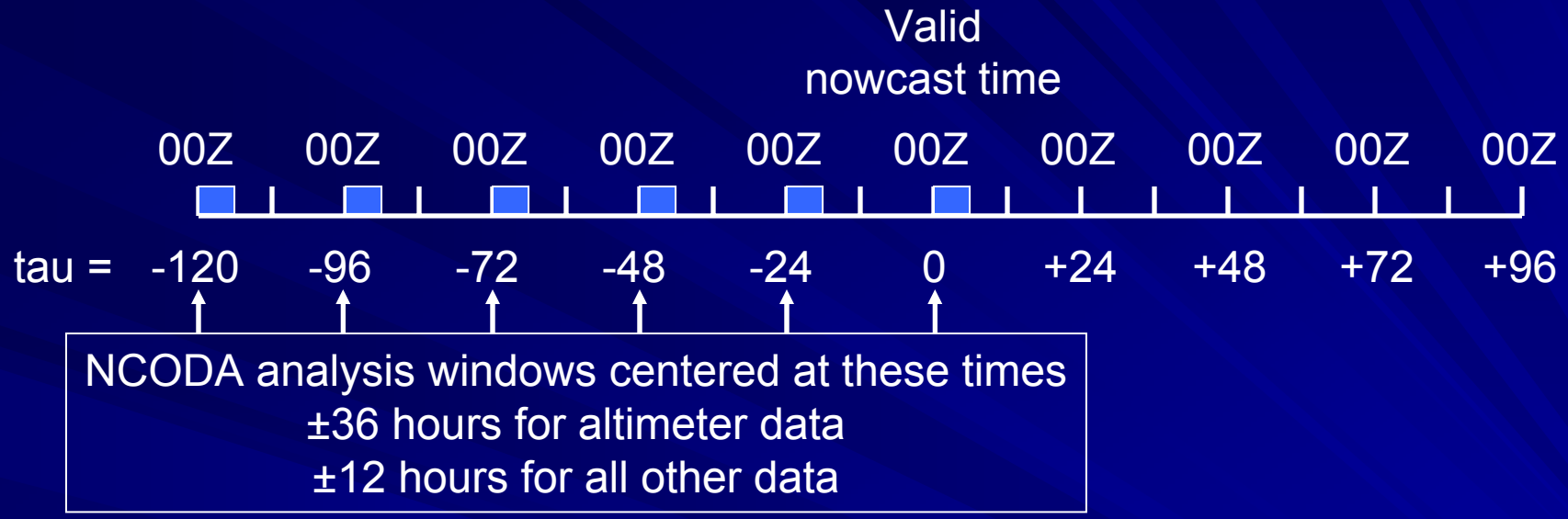
[1]Naval Research Laboratory, [2]Planning Systems, Inc.,
[3]Texas A&M-CC, [4]University of Southern Mississippi

11th HYCOM Consortium Meeting
24-26 April 2007
Stennis Space Center, MS

1/12° HYCOM/NCODA/PIPS

- **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; Validation testing has begun
- **Issues:**
  - Complete coupling of HYCOM/PIPS via ESMF (NRL)
  - Get NCODA working in curvilinear part of grid (NRL)
  - Need OcnQC running operationally (NAVOCEANO)

HYCOM/NCODA Runstream



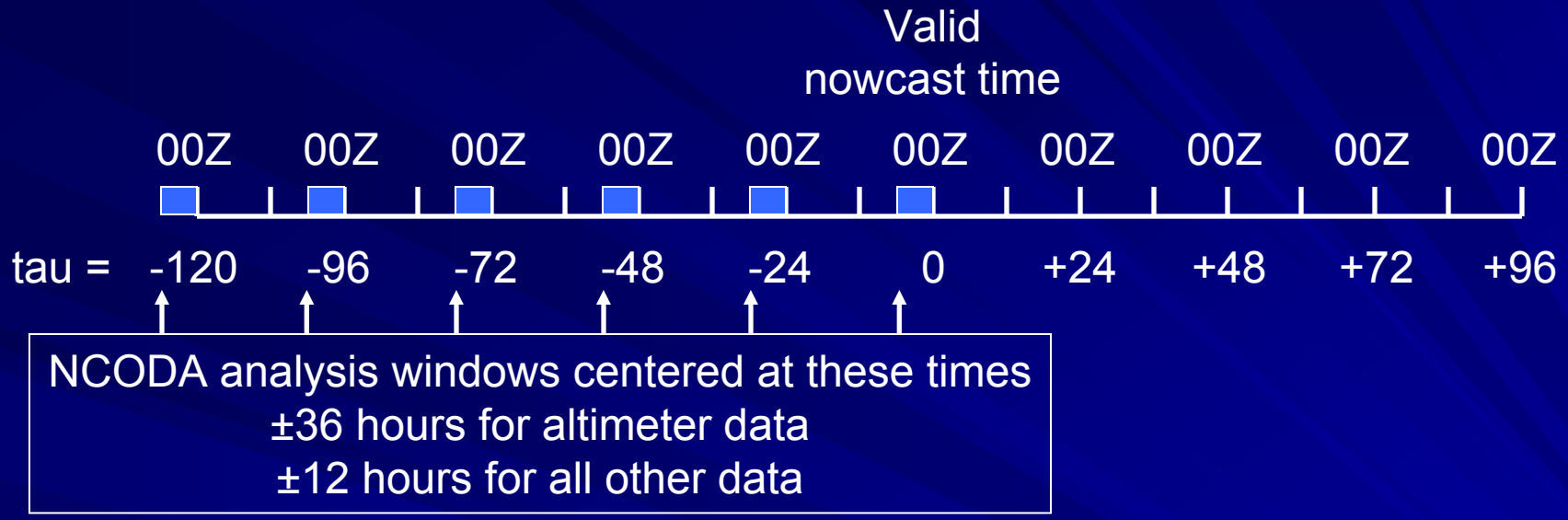
1) Perform first NCODA analysis centered on tau = -120
2) Run HYCOM for 24 hours using incremental updating ( ) over the first 6 hrs
3) Repeat steps 1) and 2) until the nowcast time
4) Run HYCOM in forecast mode out to tau = 96, eventually to tau = 120

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 Δt: 1.1 hrs/day = 5.5 hrs
3) Four HYCOM forecast days @ 150 sec Δt: 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

HYCOM/NCODA Runstream



1) Perform first NCODA analysis centered on tau = -126, i.e. 18Z
2) Run HYCOM for 24 hours using incremental updating ( ) over the first 6 hrs starting at 18Z
3) Repeat steps 1) and 2) until the nowcast time
4) Run HYCOM in forecast mode out to tau = 96, eventually to tau = 120

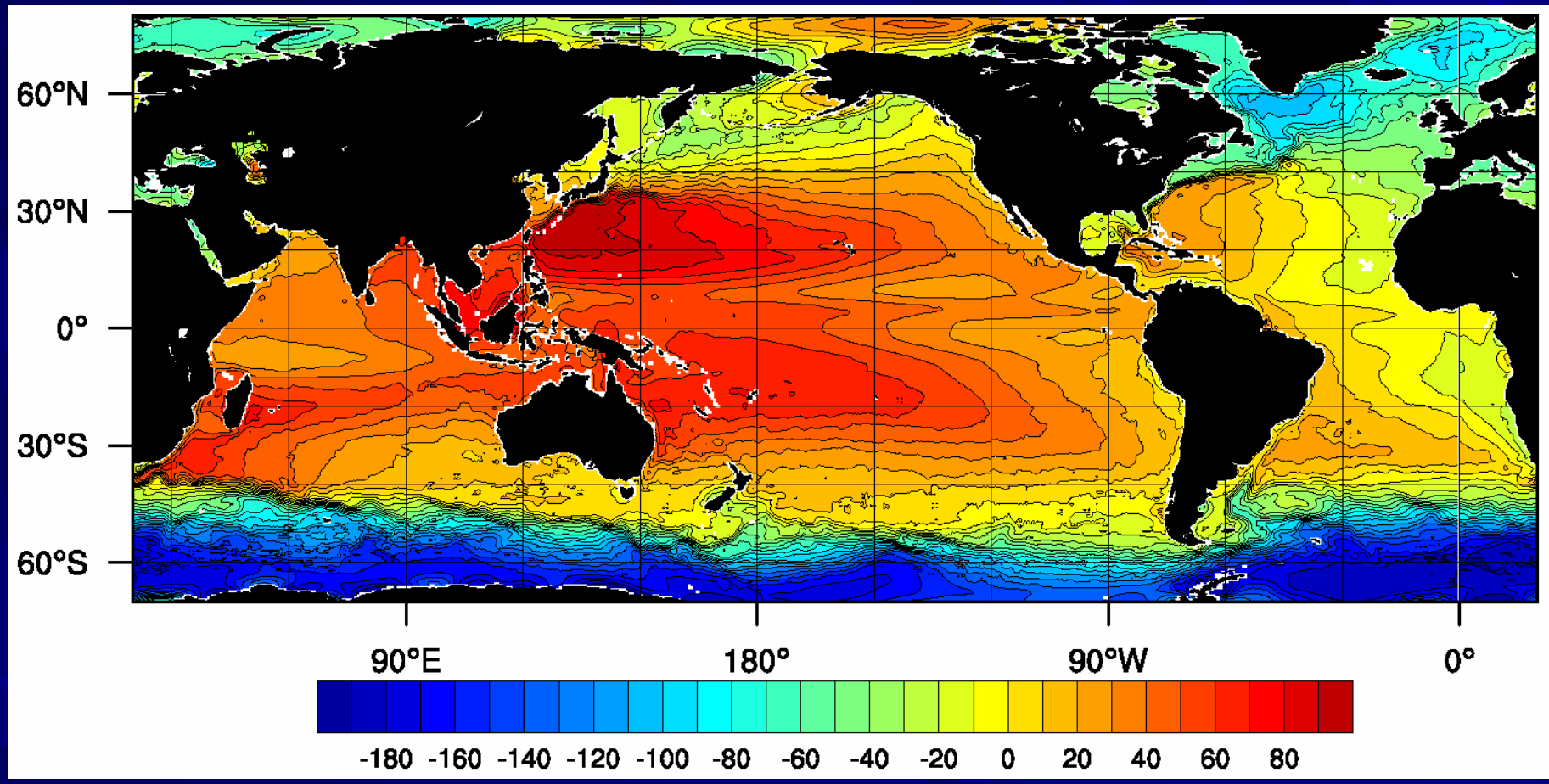
Under this scheme the incremental updating ends at the nowcast time (00Z) whereas in the previous scheme incremental updating ended at 06Z and the 00Z nowcast actually represents an 18-hour forecast from the previous day. Most results shown in this presentation are from 18-hour forecasts.

FY07 Validation Tasks

1. Mixed layer depth / sonic layer depth / deep sound channel
   - Compare simulated vs. observed for non-assimilated buoys
2. Vertical profiles of T&S
   - Quantitative comparison of simulated vs. observed for non-assimilated buoys
3. Large scale circulation features
   - Determine correct placement of large scale features
4. Eddy kinetic energy / sea surface height variability
   - Determine if the system has a realistic level and distribution of energy at depths
5. Sea surface temperature
   - Evaluate whether the models are producing acceptable nowcasts and forecasts of sea surface temperature
6. Coastal sea level
   - Assess the model's ability to represent observed sea surface heights

Mean Sea Surface Evaluation

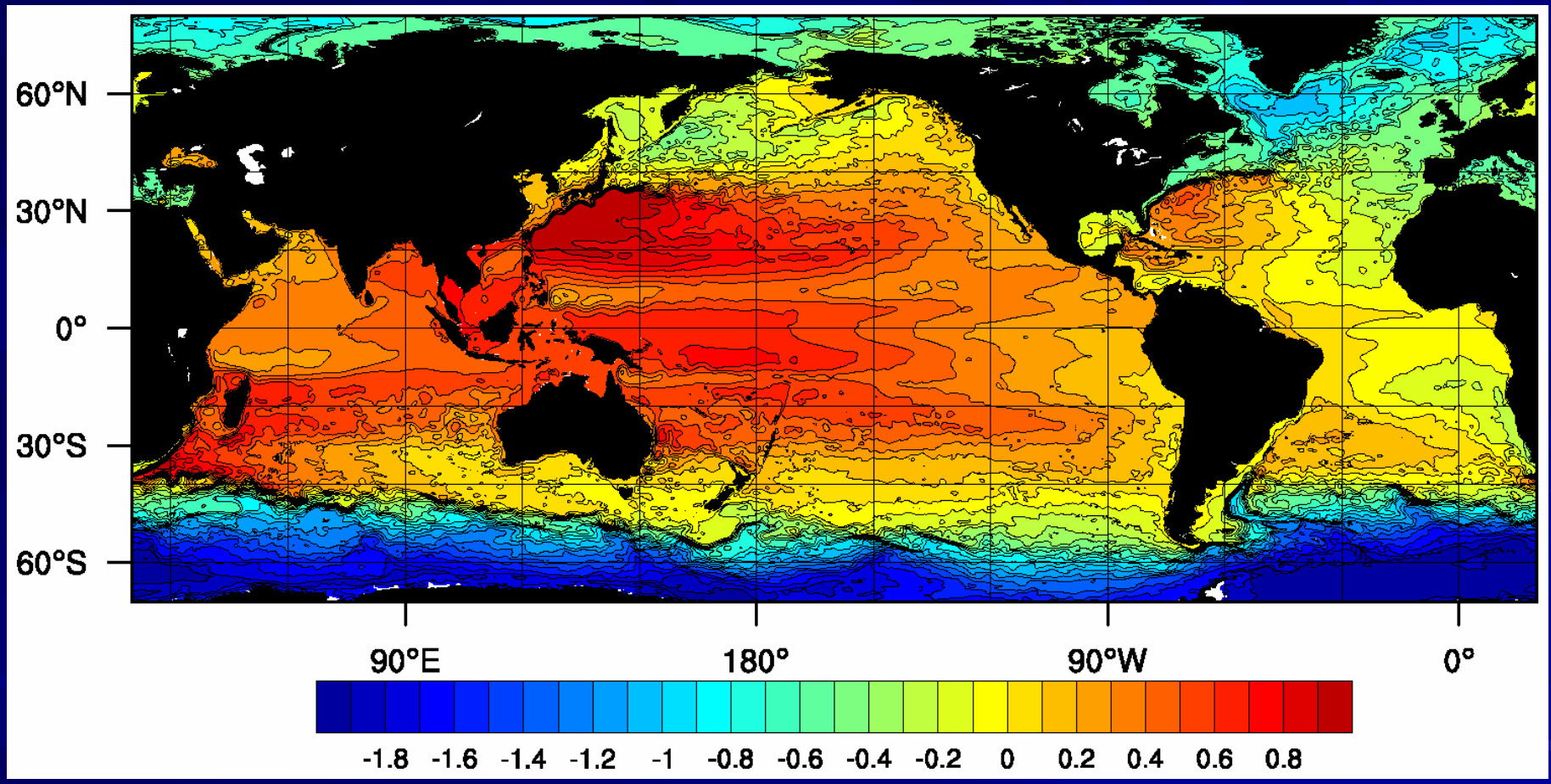
1992-2002 Mean dynamic ocean topography (0.5°)



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

Mean Sea Surface Evaluation

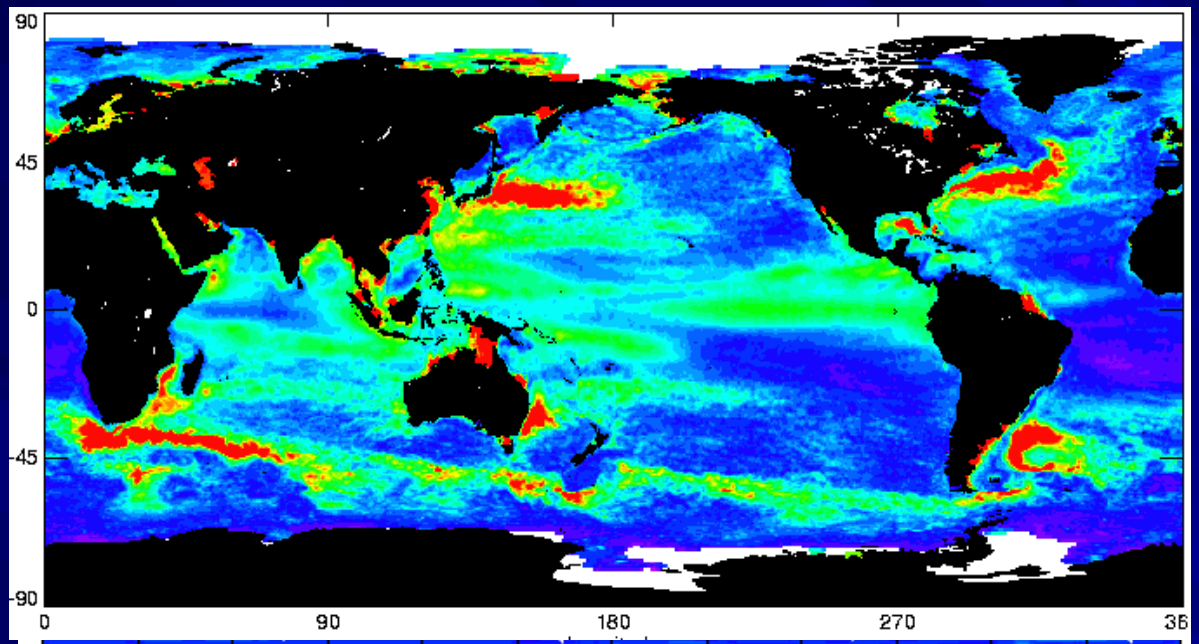
2004 Mean sea level from 1/12° global HYCOM/NCODA



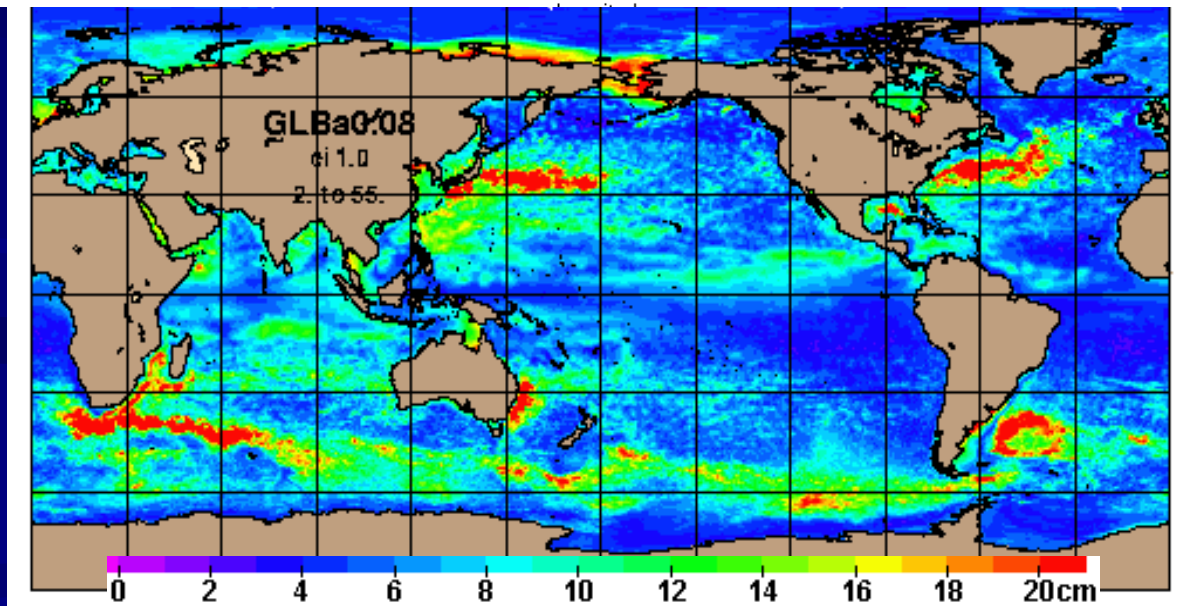
From the 1/12° global HYCOM/NCODA hindcast simulation
Mean shifted by 8.7 cm; standard deviation of difference = 9.6 cm

SSH Variability Evaluation

Sea surface height variability



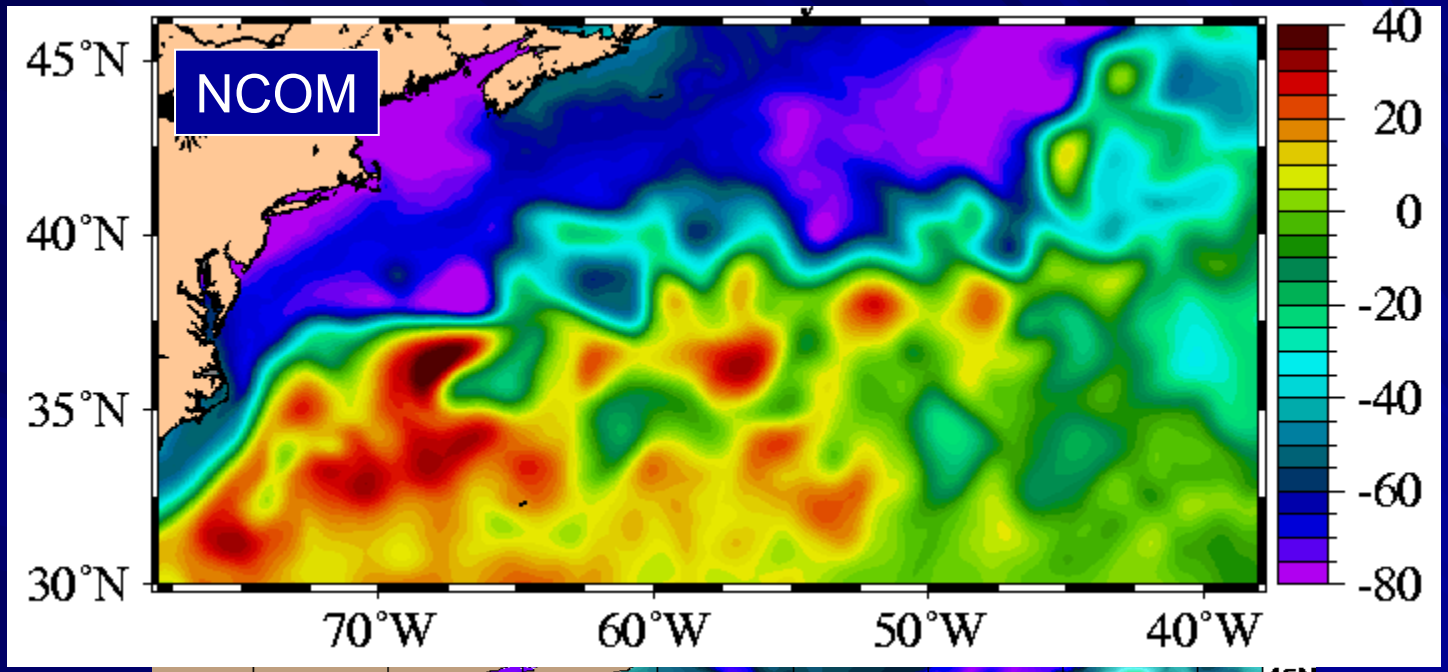
Oct 92 – Nov 98 SSH variability based on T/P, ERS-1 and ERS-2 altimeters (from Collecte, Localisation, Satellites (CLS))

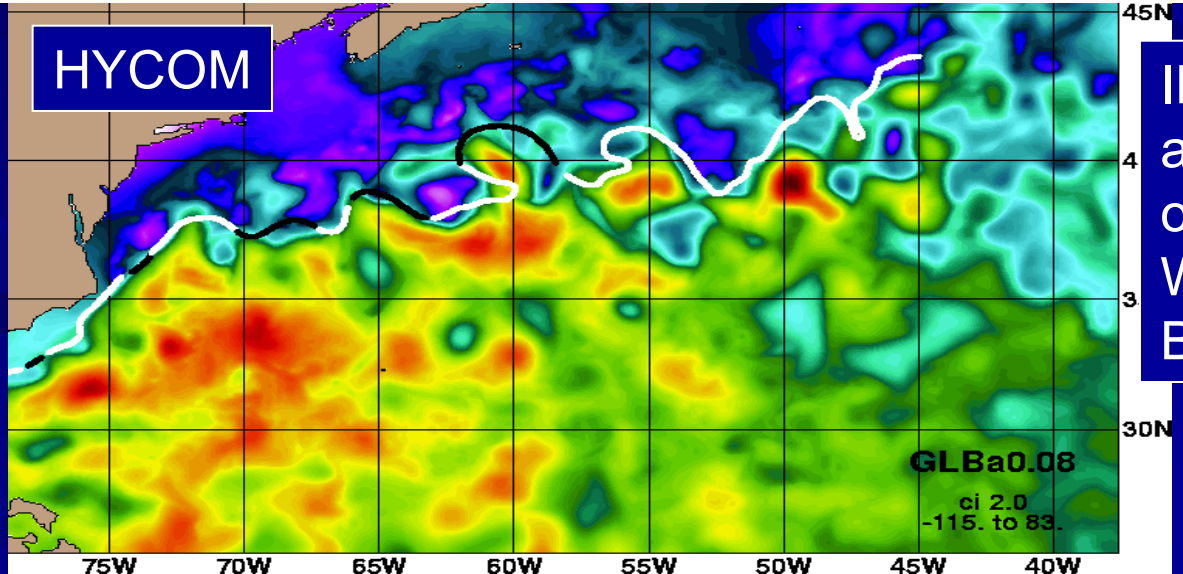


SSH variability over 2004 from the 1/12° global HYCOM/NCODA hindcast simulation

Western Boundary Current Comparison

Sea surface height – 9 March 2007



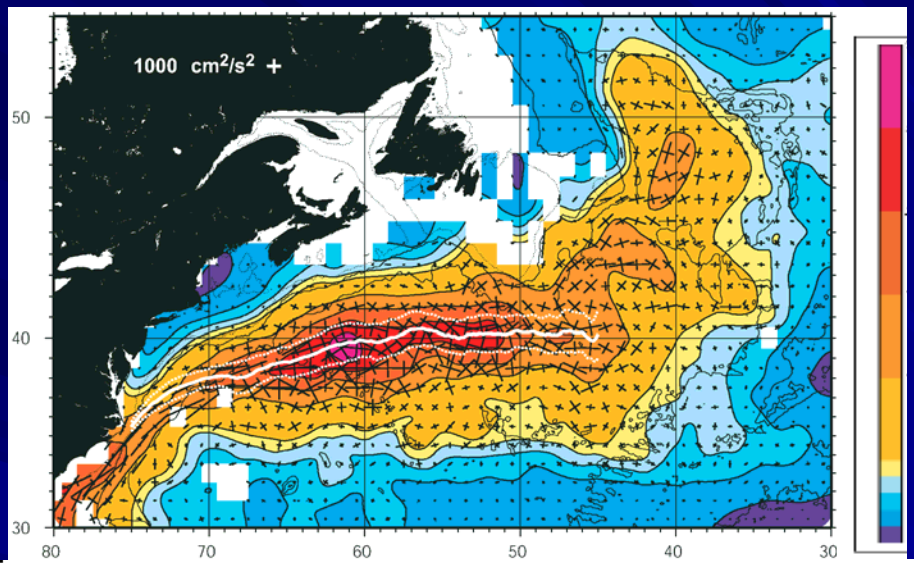


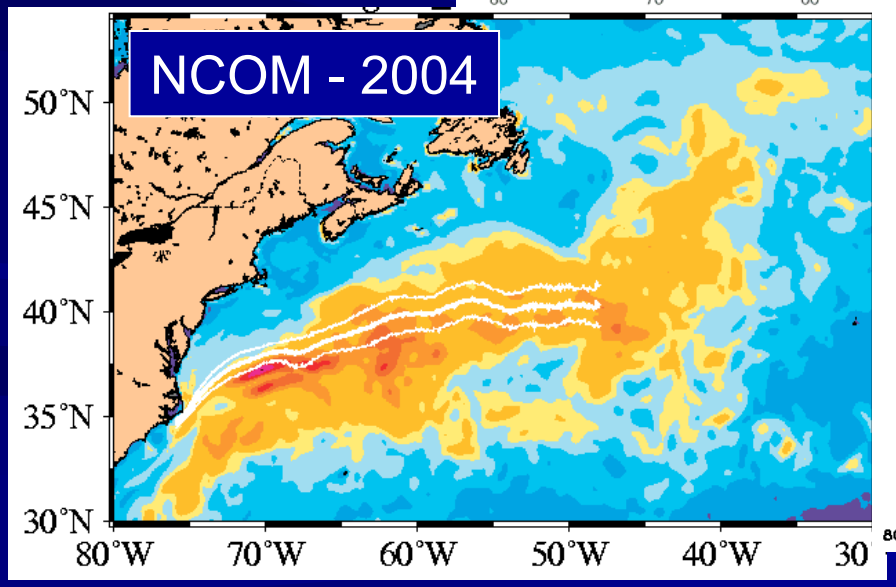
IR frontal analysis overlaid:
White ≤ 4 days
Black > 4 days

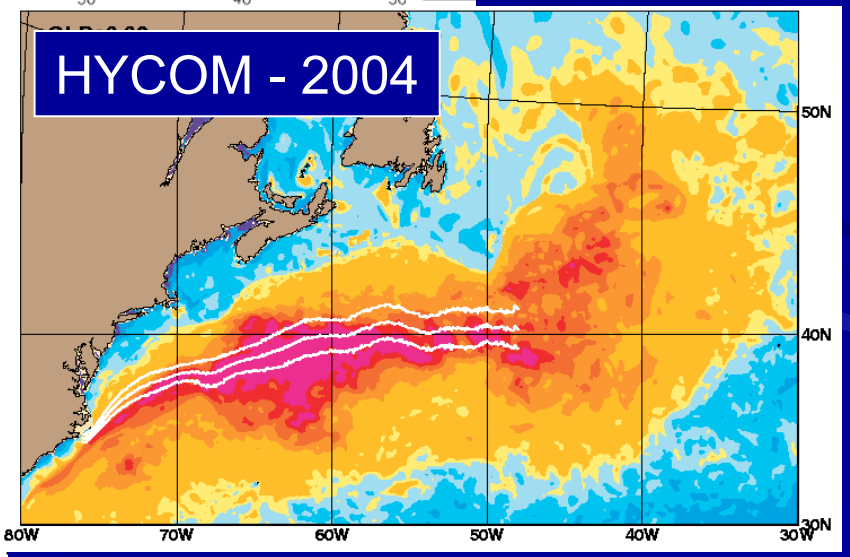
Eddy Kinetic Energy Comparison

Surface EKE in the Gulf Stream

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



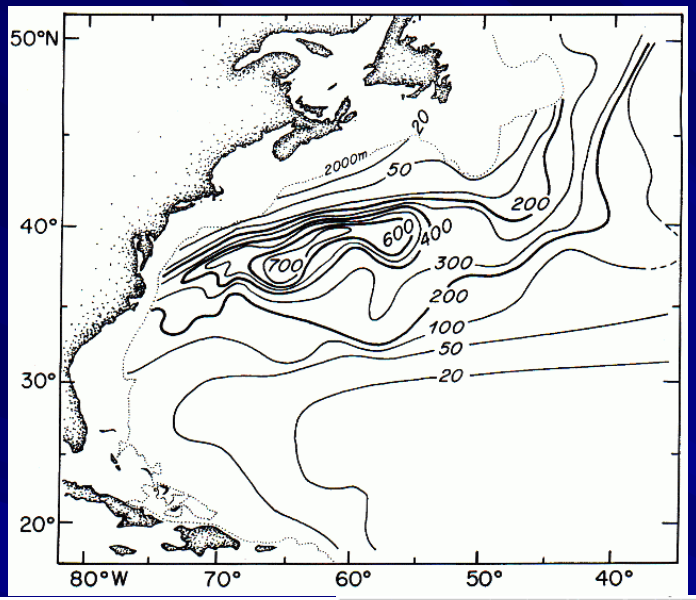


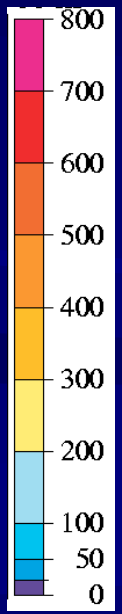


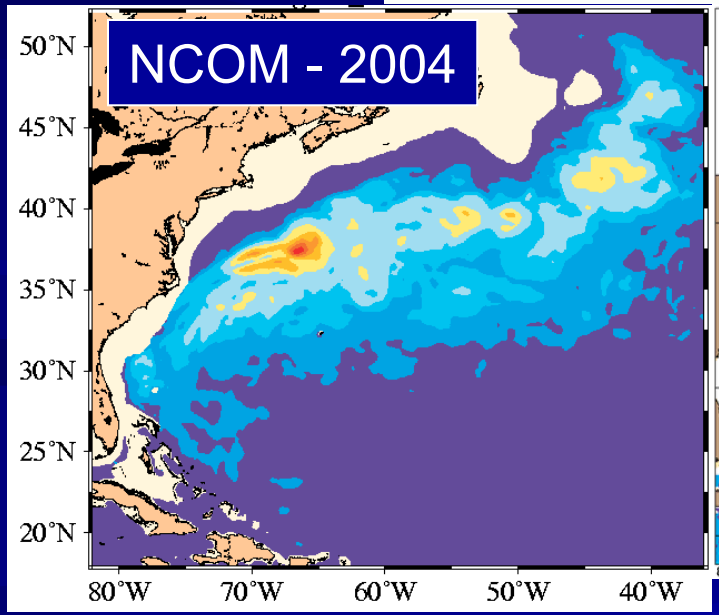
Eddy Kinetic Energy Comparison

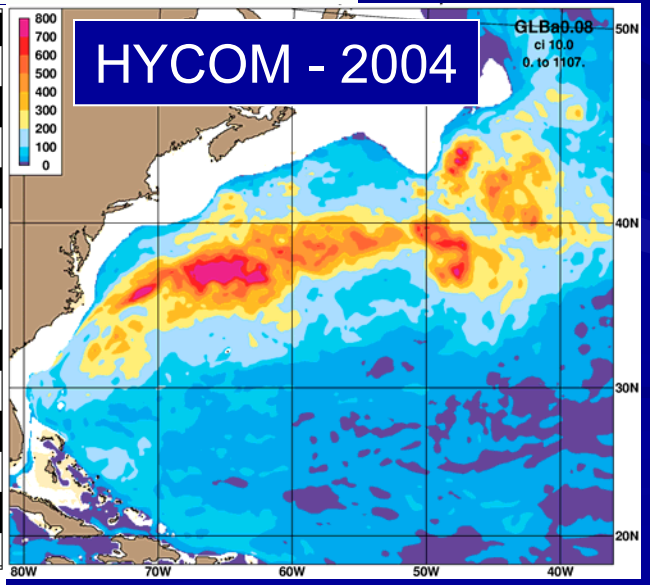
EKE at ~700 m in the Gulf Stream

Observations from Schmitz (1996)



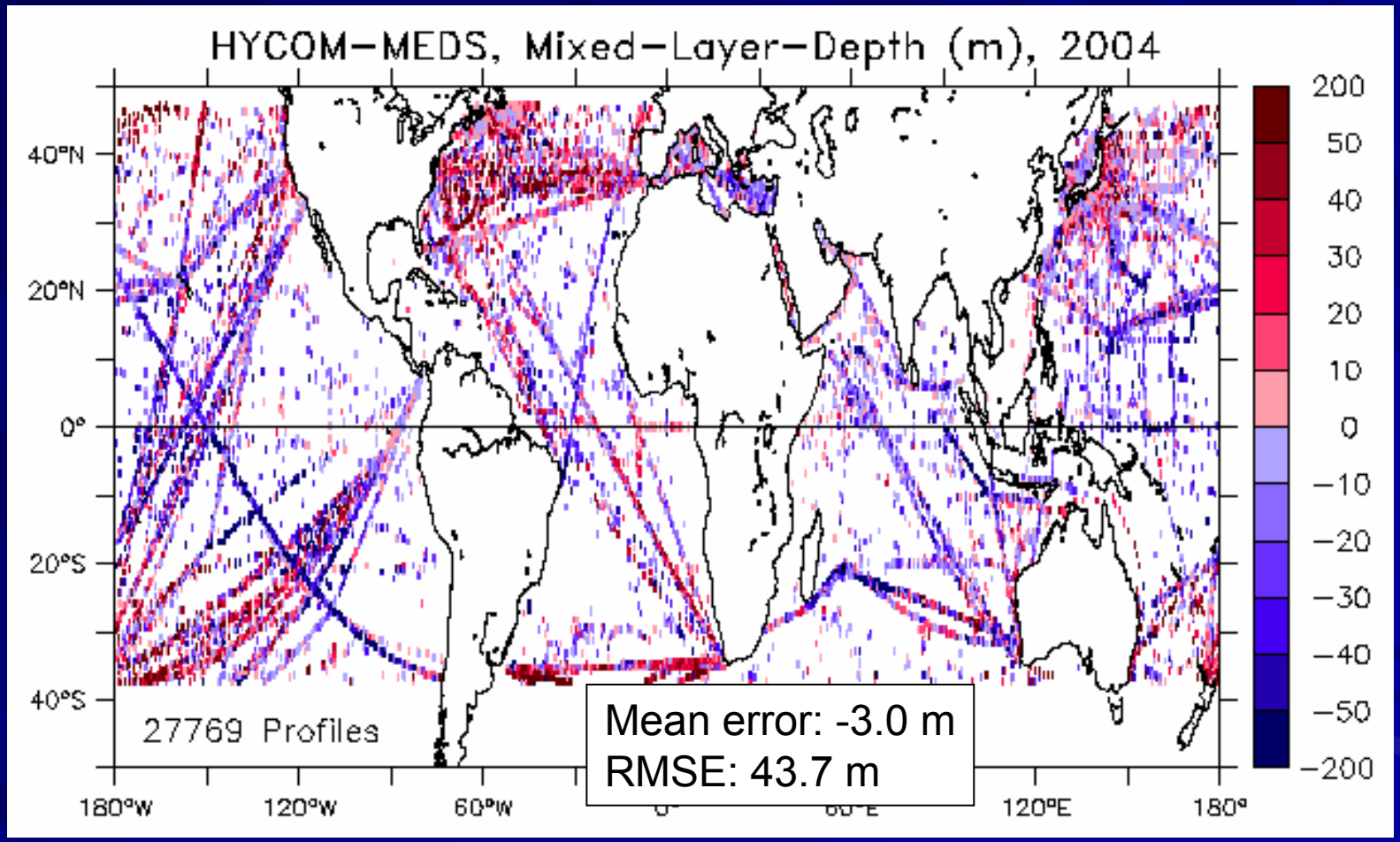






Mixed Layer Depth Comparison

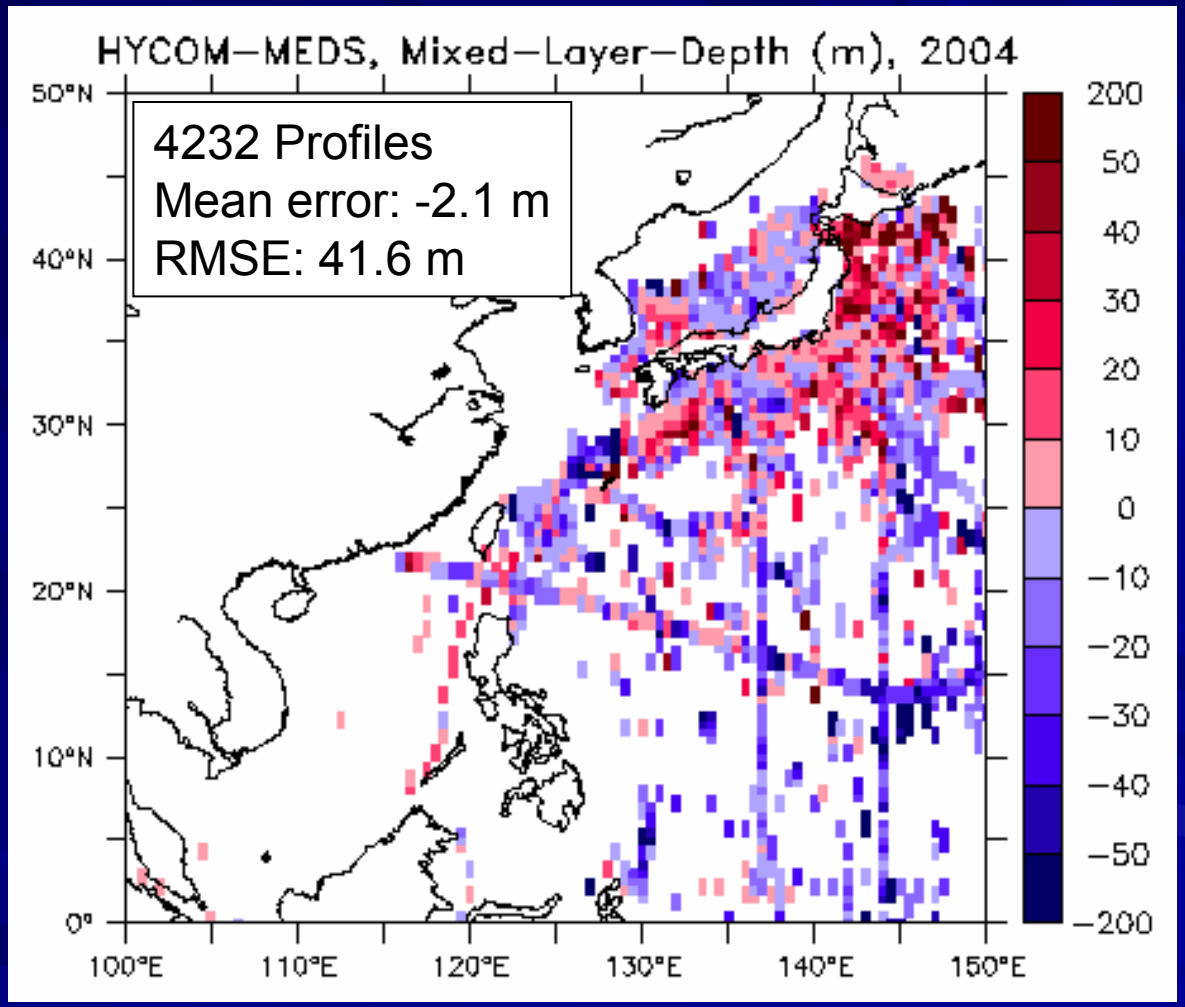
2004 MLD difference: HYCOM minus unassimilated MEDS profiles



MLD = negative temperature difference of 0.5°C between the surface and depth; data averaged in 0.5° bins

Mixed Layer Depth Comparison

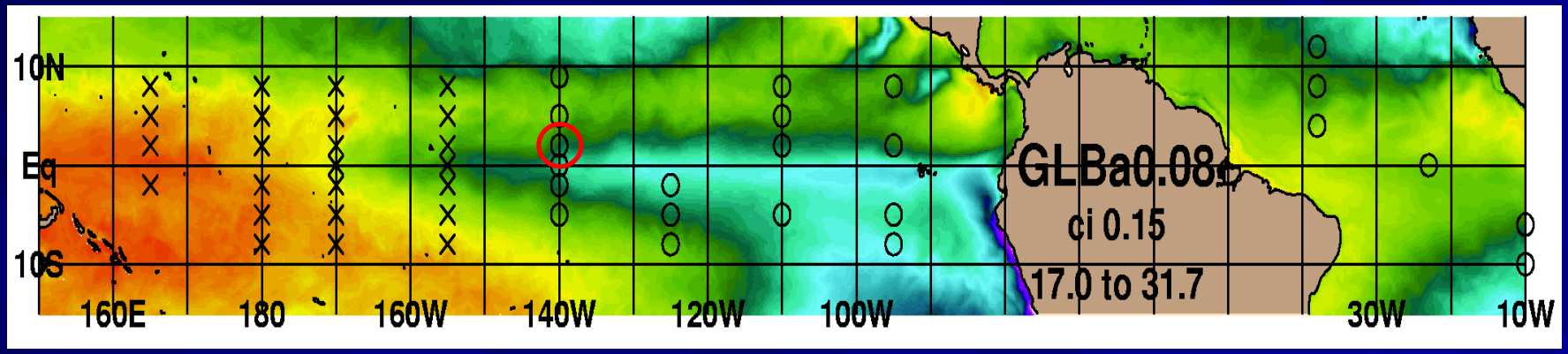
2004 MLD difference: HYCOM minus unassimilated MEDS profiles



MLD = negative temperature difference of 0.5°C between the surface and depth; data averaged in 0.5° bins

Temperature Structure Comparison

Locations of TAO and PIRATA buoys used in this evaluation



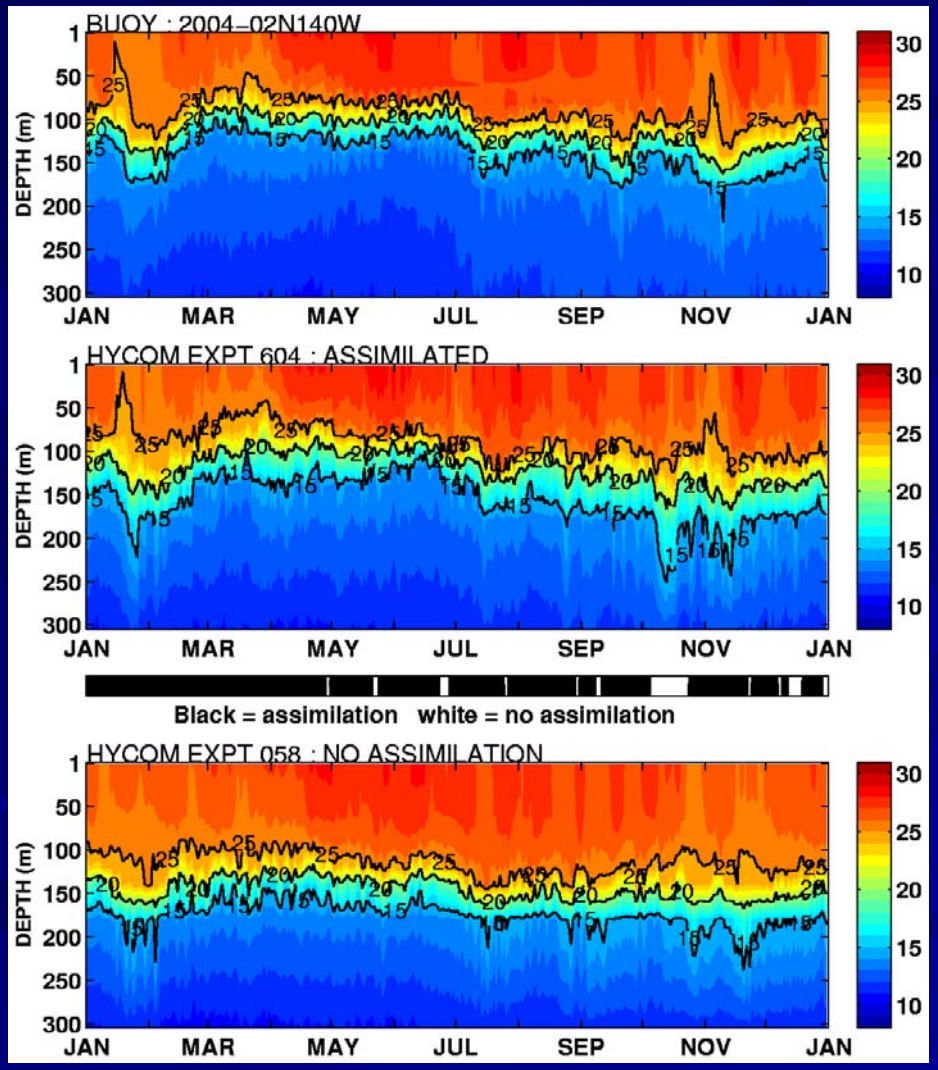
Buoys are divided into two sets based on the vertical sampling and continuity of the time series over calendar year 2004

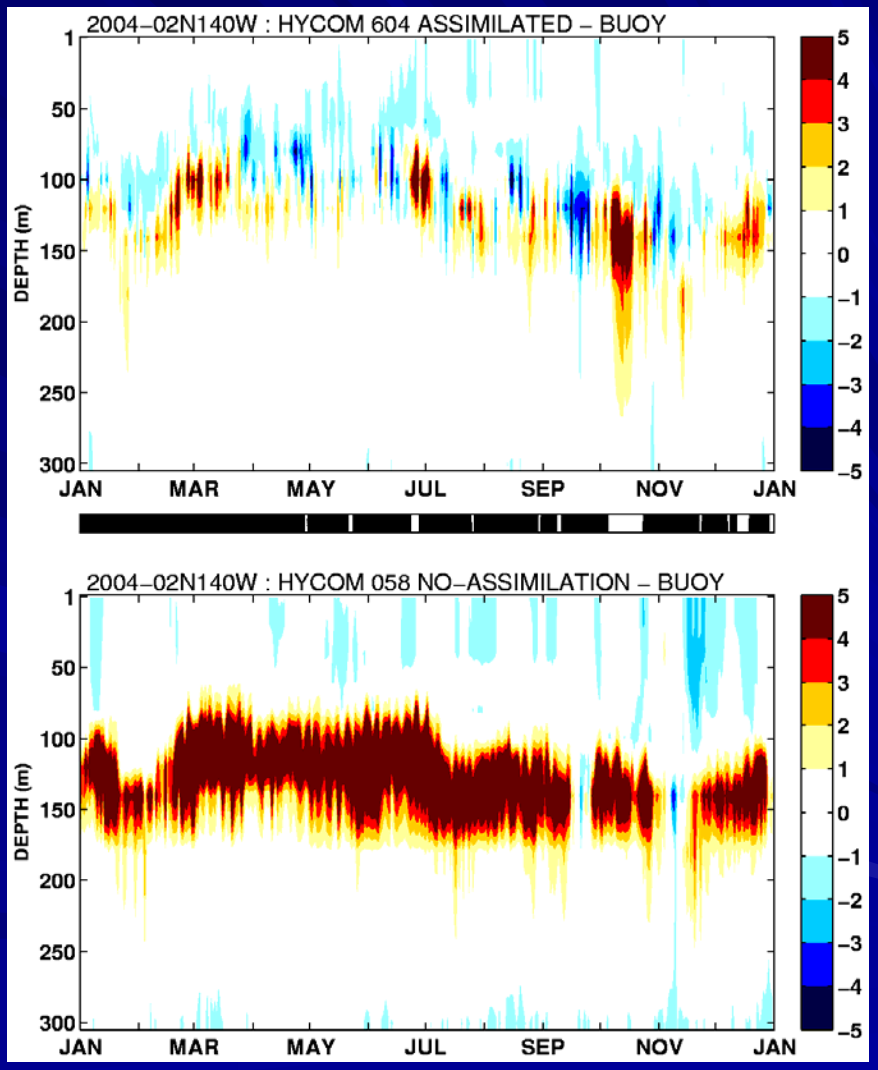
Set 1 (denoted by o's): 1, 20, 40, 60, 80, 100, 120, 140, 180, 300, 500 m.
Set 2 (denoted by x's): 1, 25, 50, 75, 100, 125, 150, 200, 250, 300, 500 m.

Temperature Structure Comparison

2004 subsurface temp at 140°W, 2°N
Buoy / HYCOM / nonassim HYCOM

Temperature difference
Buoy - HYCOM / Buoy - nonassim HYCOM

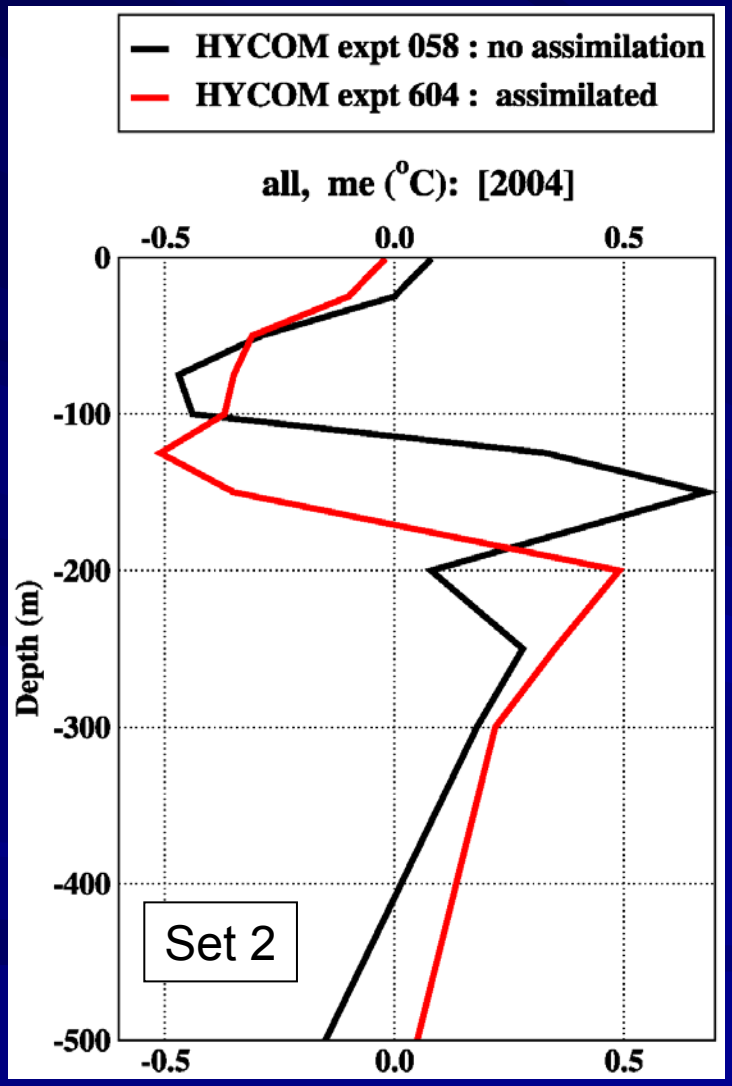


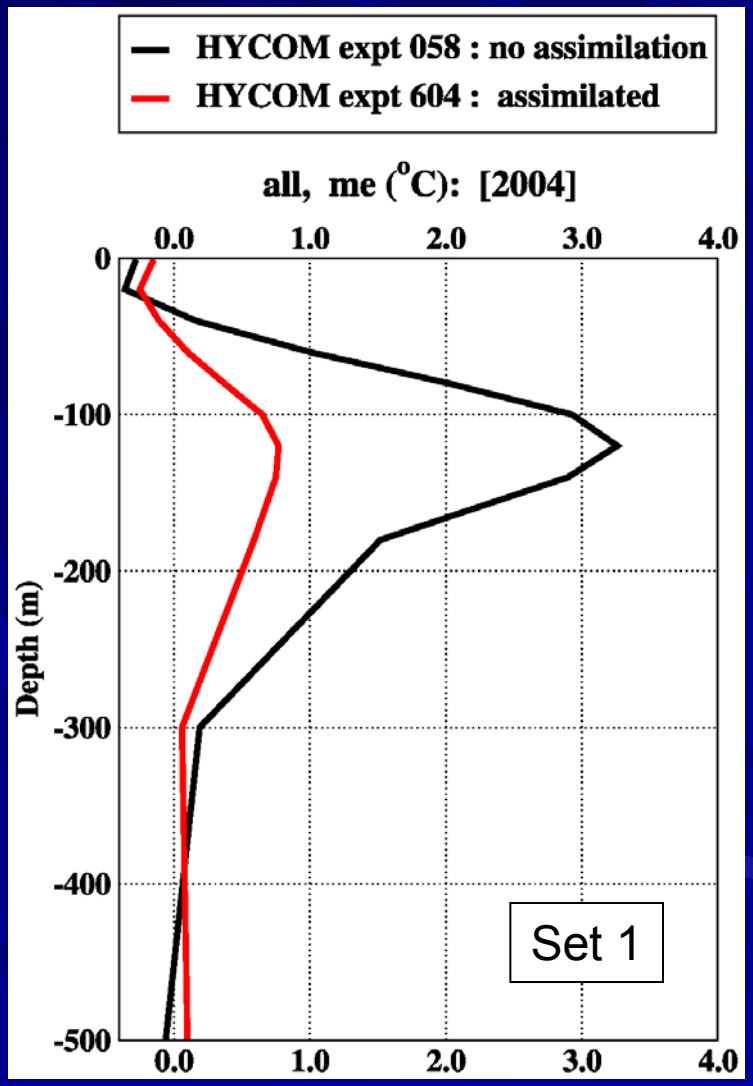


Significant impact of temperature profile assimilation via NCODA

Temperature Structure Comparison

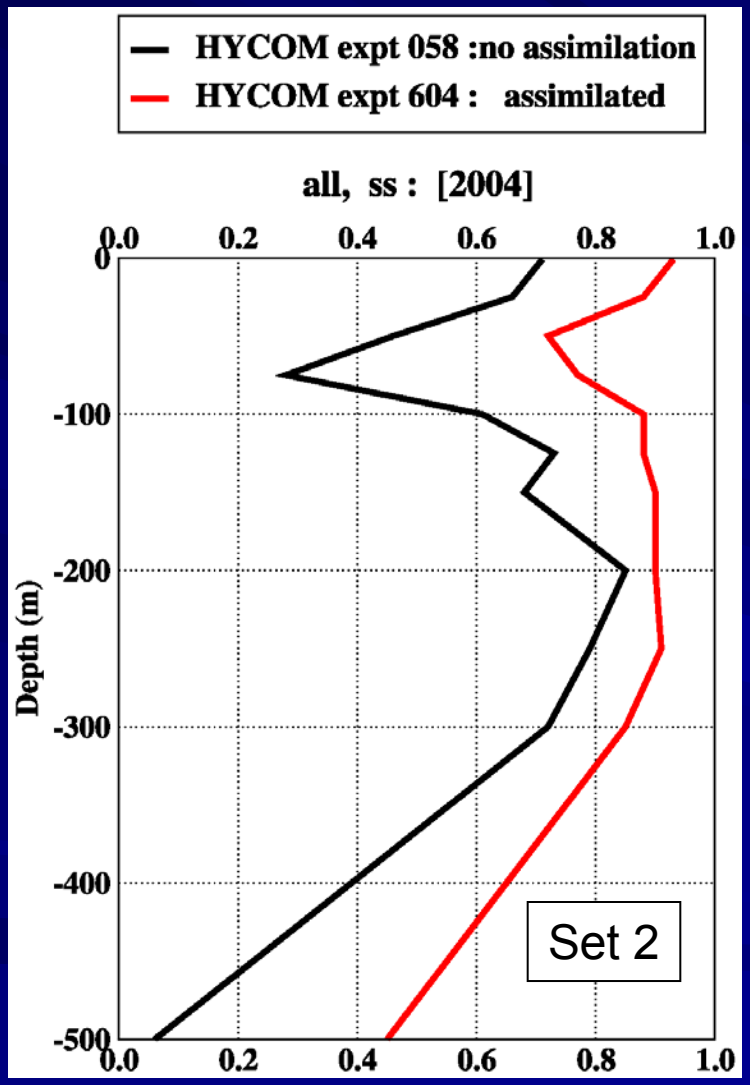
HYCOM vs. non-assim HYCOM – Mean error – 47 TAO/PIRATA buoys 2004

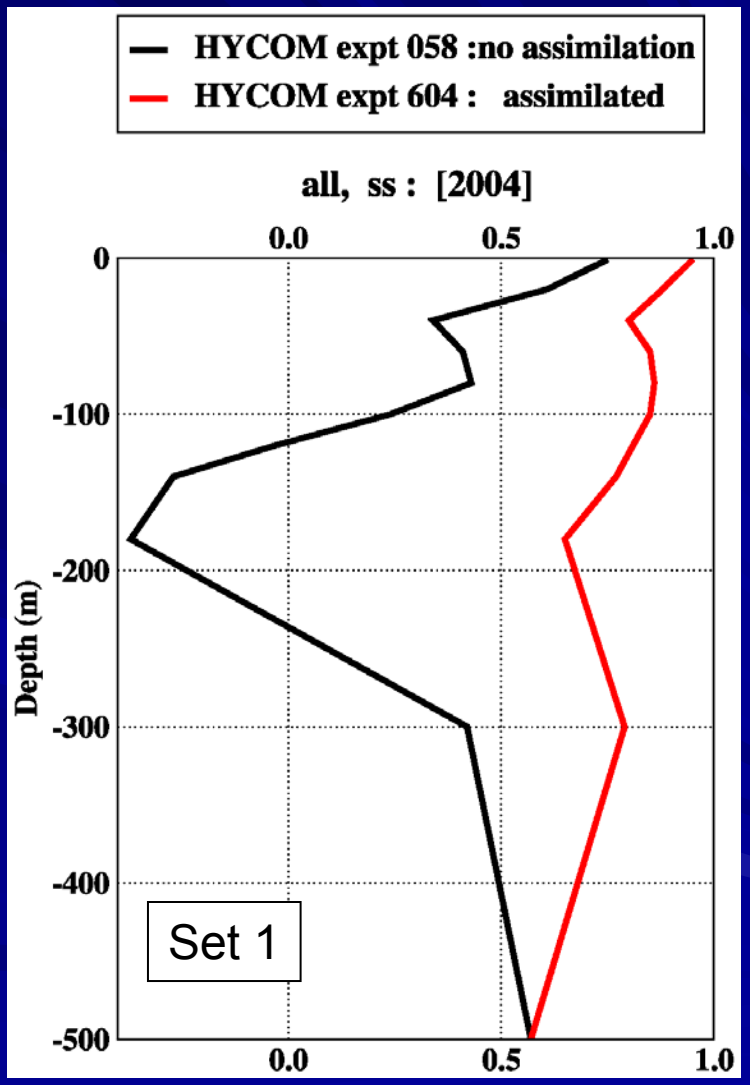




Temperature Structure Comparison

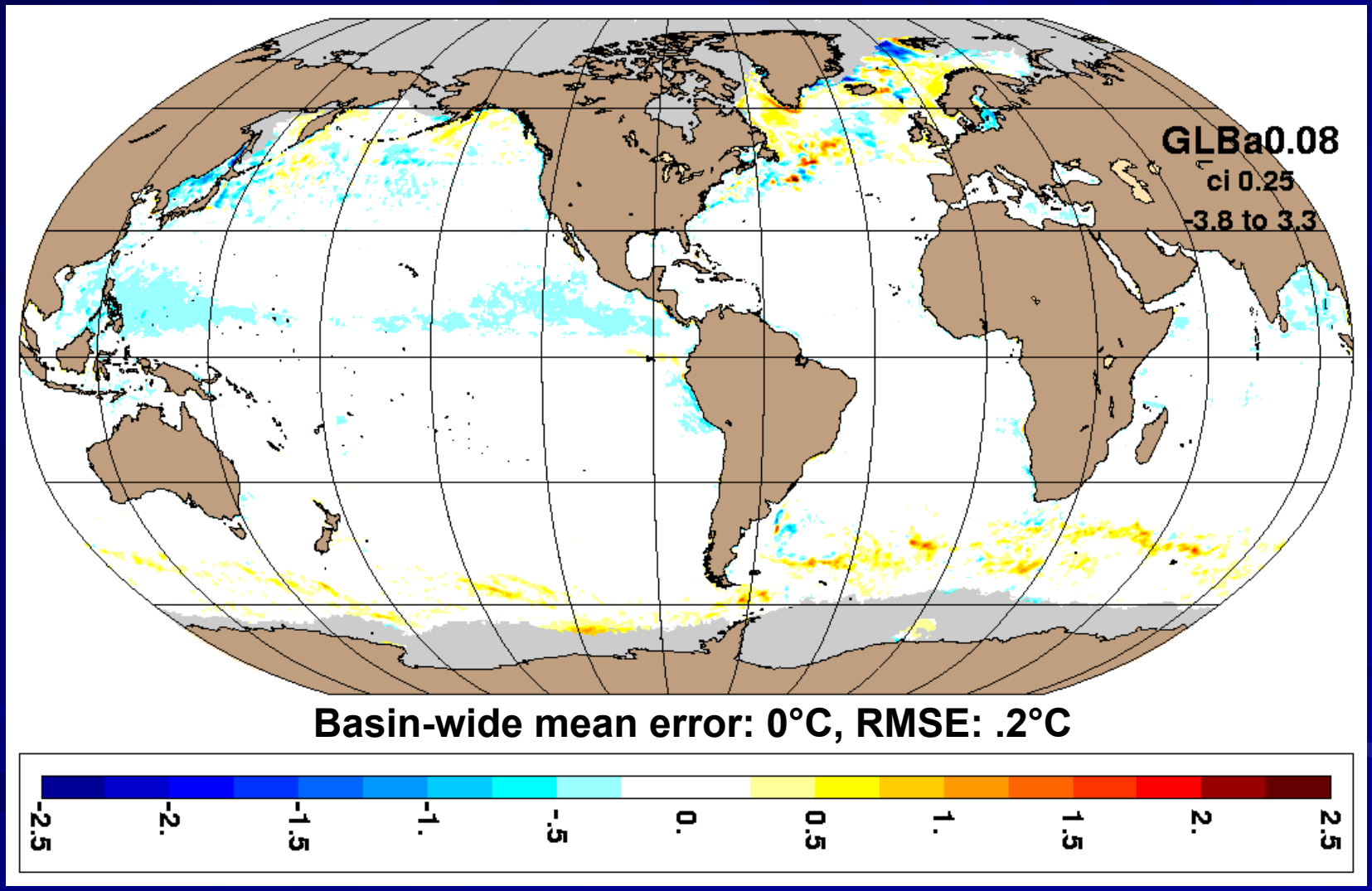
HYCOM vs. non-assim HYCOM – Skill score – 47 TAO/PIRATA buoys 2004





Sea Surface Temperature Comparison

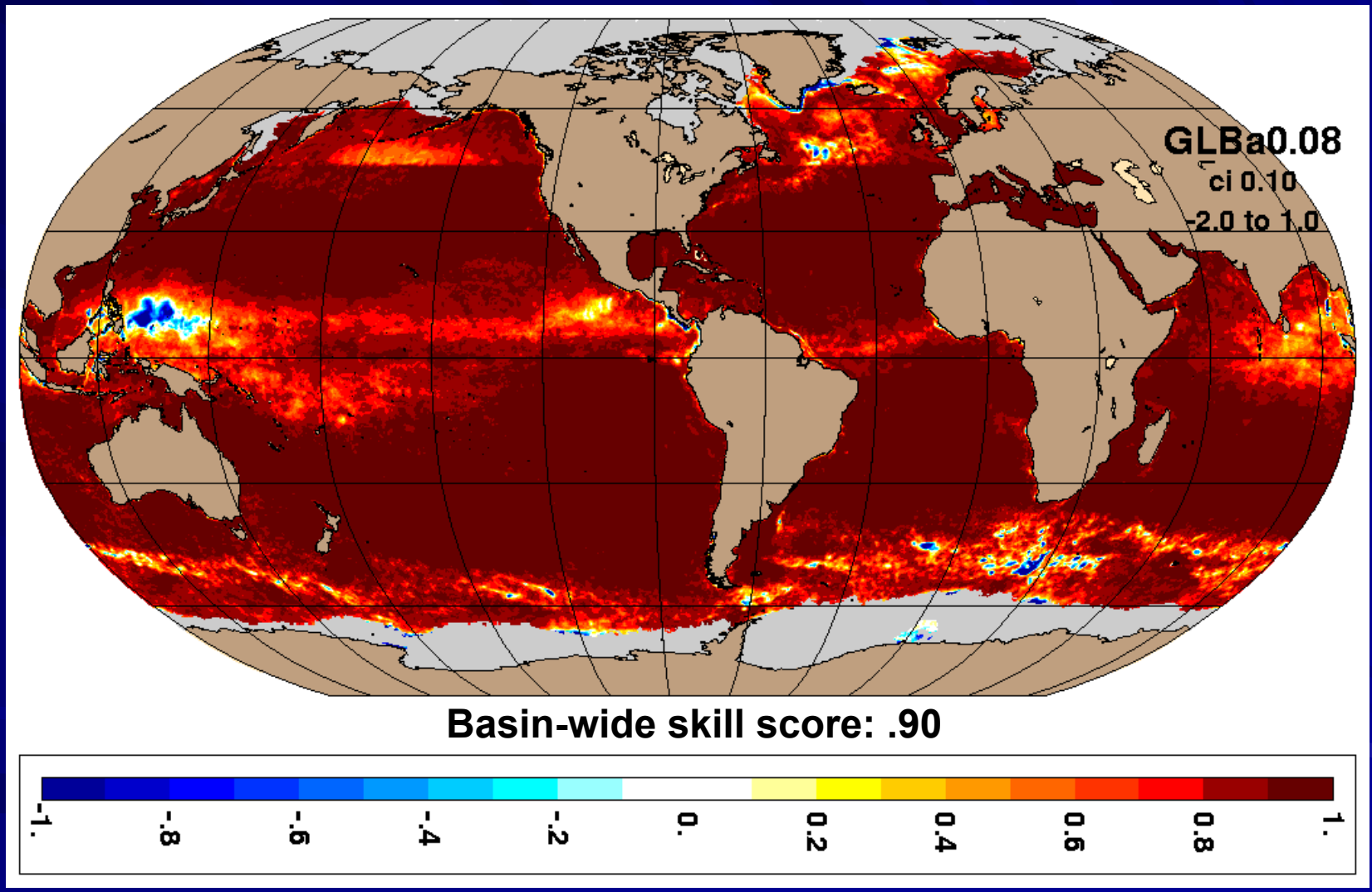
HYCOM vs. MODAS – Mean error – white area = ± .25°C



Over 2004 from the 1/12° global HYCOM/NCODA hindcast simulation

Sea Surface Temperature Comparison

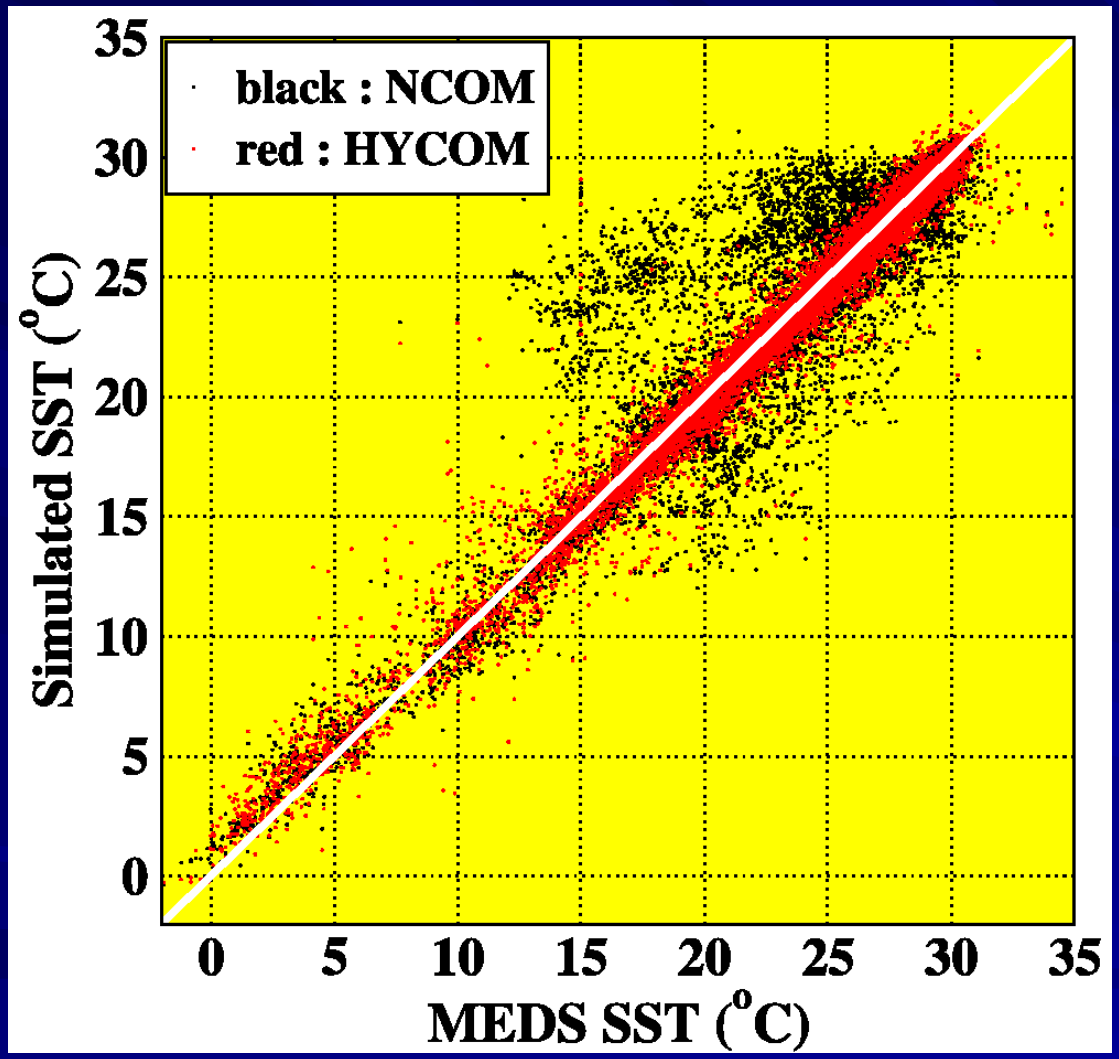
HYCOM vs. MODAS – Skill score



Over 2004 from the 1/12° global HYCOM/NCODA hindcast simulation

Sea Surface Temperature Comparison

Unassimilated MEDS SST vs. HYCOM vs. NCOM

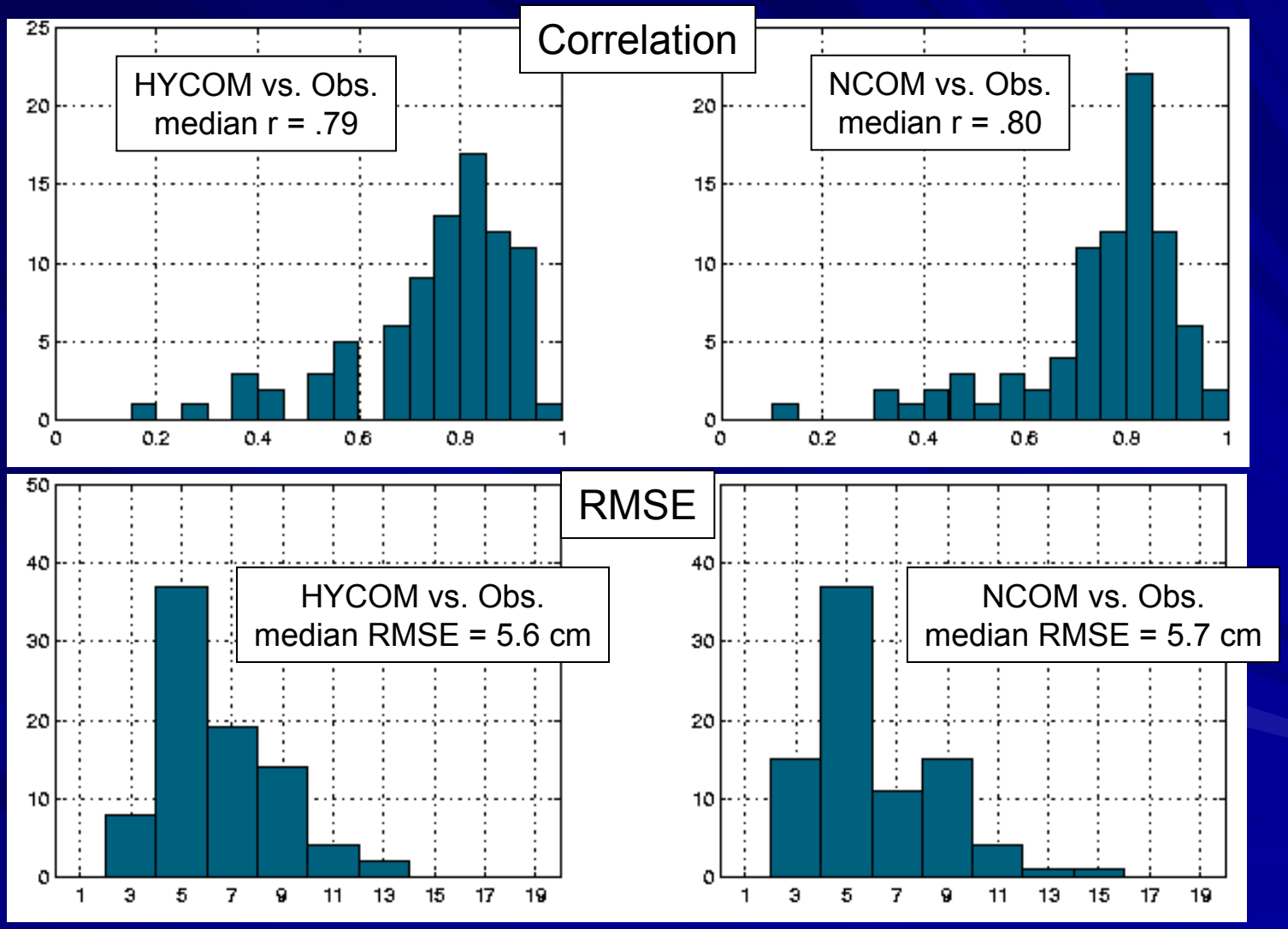


	HYCOM	NCOM
ME	-.1°C	.2°C
RMSE	.9°C	2.2°C
R	.99	.93
SS	.98	.86

Over 2004 from the 1/12° global HYCOM/NCODA hindcast simulation and operational 1/8° global NCOM; MEDS = Marine Environmental Data Services

Coastal/Island Sea Level Comparison

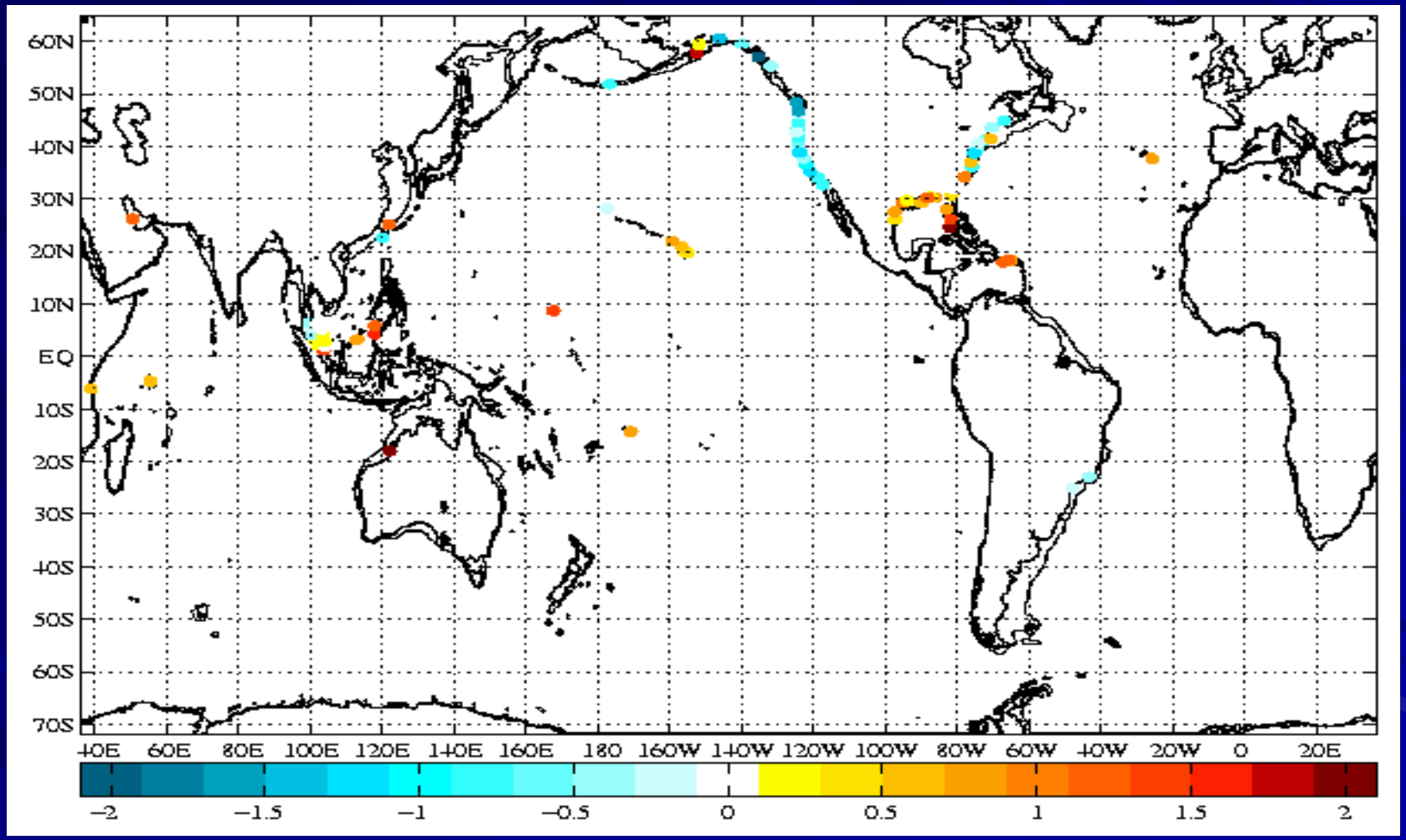
Simulated vs. observed sea level at 84 coastal / island stations during 2004



Coastal/Island Sea Level Comparison

RMSE improvement

(HYCOM – observed) – (NCOM – observed)



Simulated vs. observed sea level at 84 coastal / island stations during 2004

FY08 Validation Tasks

1. Below layer depth gradient
   - Compare simulated vs. observed for non-assimilated buoys
2. Comparison with drifting buoys
   - Evaluate the model's ability to produce ocean currents that yield drifter and ARGO float trajectories similar to observations
3. Current cross sections
   - Evaluate model velocity cross-sections through qualitative and quantitative comparisons
4. 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
5. Eddy tracking
   - Evaluate the model's ability to track mesoscale eddies
6. Ice drift, thickness and concentration
   - Assess the model's ability to represent sea ice