



NCODA Status

NRL Coupled Ocean Data Assimilation

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HYCOM NOPP GODAE Meeting

RSMAS, University Miami, 6-8 December 2005

Outline

- 1. NCODA System Overview***
- 2. New Analysis Capabilities***

Report Documentation Page				Form Approved OMB No. 0704-0188	
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NCODA System Overview

Flexible System

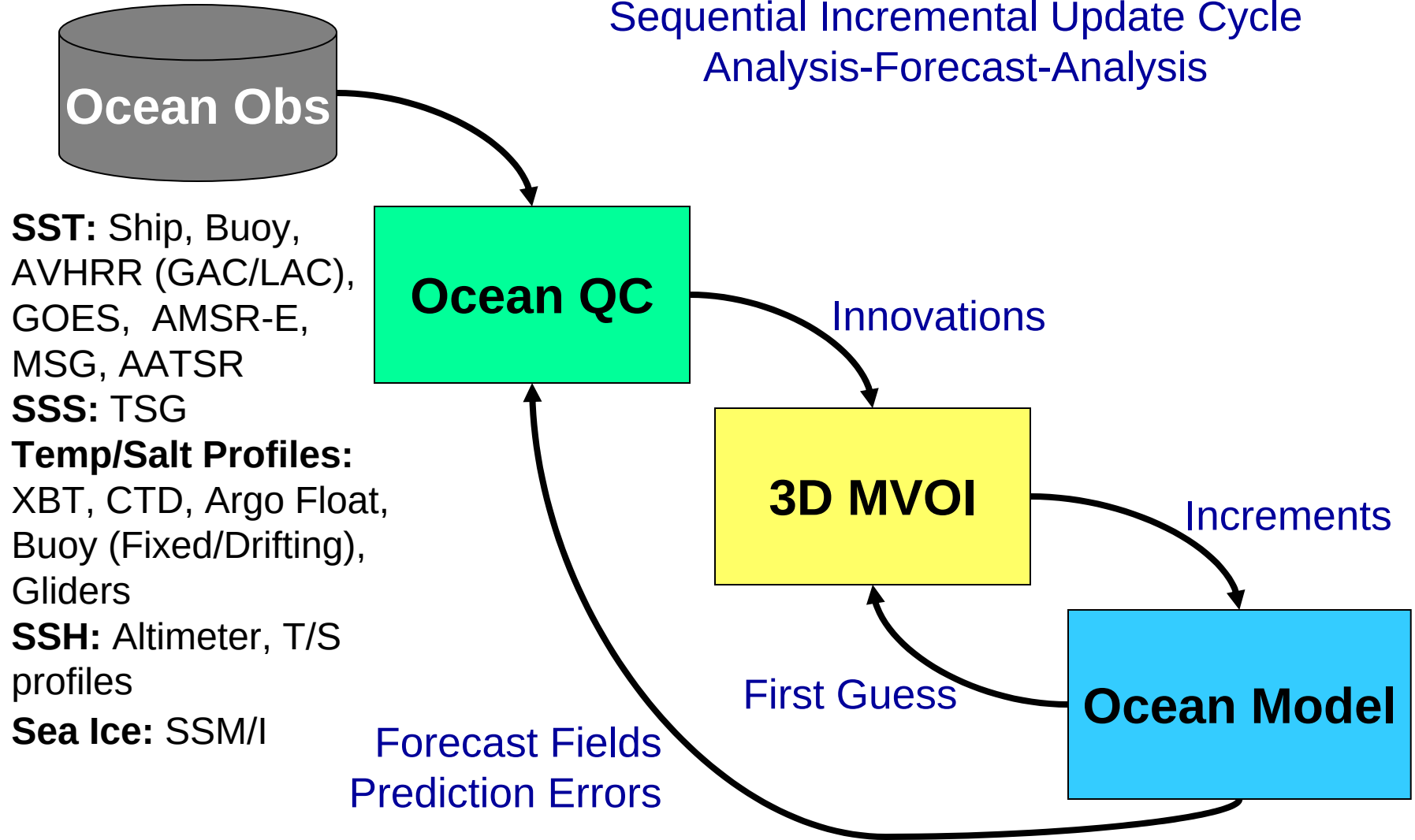
- global or regional applications
- re-locatable, multi-scale analyses on nested, successively higher resolution grids (3:1 nest ratios)
- update ocean forecast model or run stand-alone
 - 2D analyses of sea ice and SST (NWP boundary conditions)
 - 3D temperature and salinity analysis (geostrophic currents)
 - 3D MVOI sequential incremental update cycle (model-based)

Designed as Complete End-to-End Analysis System

- data quality control, analysis, performance diagnostics
- operational at Navy Centers in analysis-only mode
 - Naval Oceanographic Office
 - Fleet Numerical Meteorology and Oceanography Center

NCODA Implementation

Sequential Incremental Update Cycle
Analysis-Forecast-Analysis



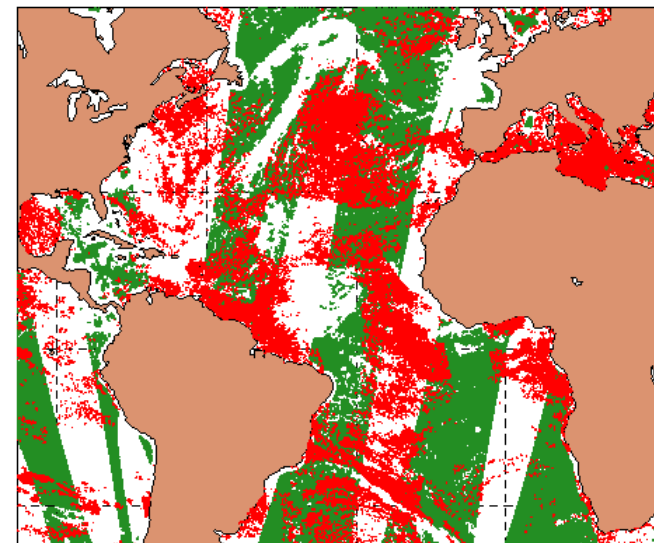
Model forecast fields and prediction errors are used in the QC of newly received ocean observations



New NCODA Capabilities

Analysis

- first guess appropriate time (FGAT)
- flow dependent correlations
- analysis error
- model climate error variance fields
- age of data on grid analysis variable
- pressure correction analysis variable
- data restriction in boundary areas



AVHRR-GAC AMSR-E

12-hrs data

Observing Systems

- MeteoSat SST (MSG) from MeteoFrance (CMS-Lannion)
- Microwave SST (AMSR-E) from Remote Sensing Systems
- Ocean Gliders (up/down profiles, position varies with depth)

Sequential Incremental Update Cycle



Data Window (+/- 12 hours)



24 Hour Forecast



Innovations

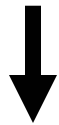
Length update cycle user defined

All observations considered synoptic regardless length update cycle

First Guess at Appropriate Time



Data Window (+/- 12 hours)



**12 Hour
Forecast**

**18 Hour
Forecast**

**24 Hour
Forecast**

**30 Hour
Forecast**

**36 Hour
Forecast**



Innovations

Length update cycle user defined

Interval of forecast periods user defined

Eliminates component of mean analysis error that occurs when comparing observations and forecasts not valid at same time

Flow Dependent Correlations

$$h_s = 0.2$$

small (large) h_s produces
strong (weak) flow
dependence

$$s_h = (x_o - x_b) / x_s$$

$$s_v = (z_o - z_b) / z_s$$

$$s_f = (h_o - h_b) / h_s$$

$$C_h = (1 + s_h) \exp(-s_h)$$

$$C_v = (1 + s_v) \exp(-s_v)$$

$$C_f = (1 + s_f) \exp(-s_f)$$

$$C_b = C_h C_v C_f$$

x_s = horizontal scale (km)

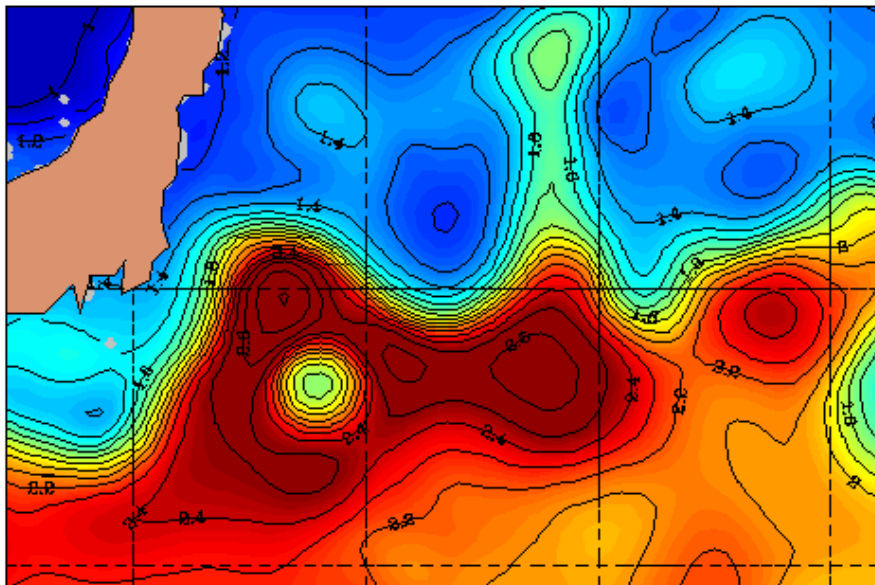
z_s = vertical scale (m)

h_s = flow scale (dyn. m)

C_h = horizontal correlation

C_v = vertical correlation

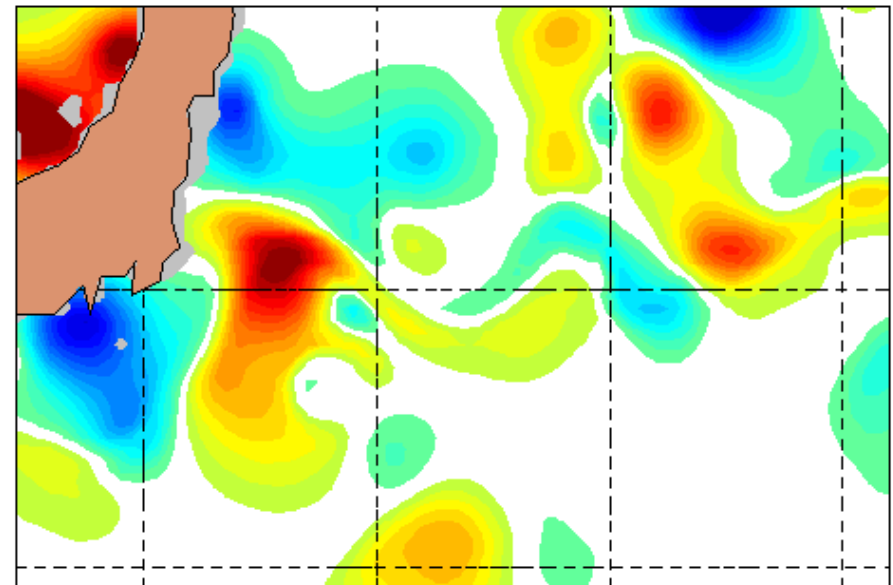
C_f = flow correlation



<1 1.15 1.3 1.45 1.6 1.75 1.9 2.05 2.2 2.35 2.5>

Geopotential Valid 5 August 2005 00Z

Contour Interval 0.1 dyn m

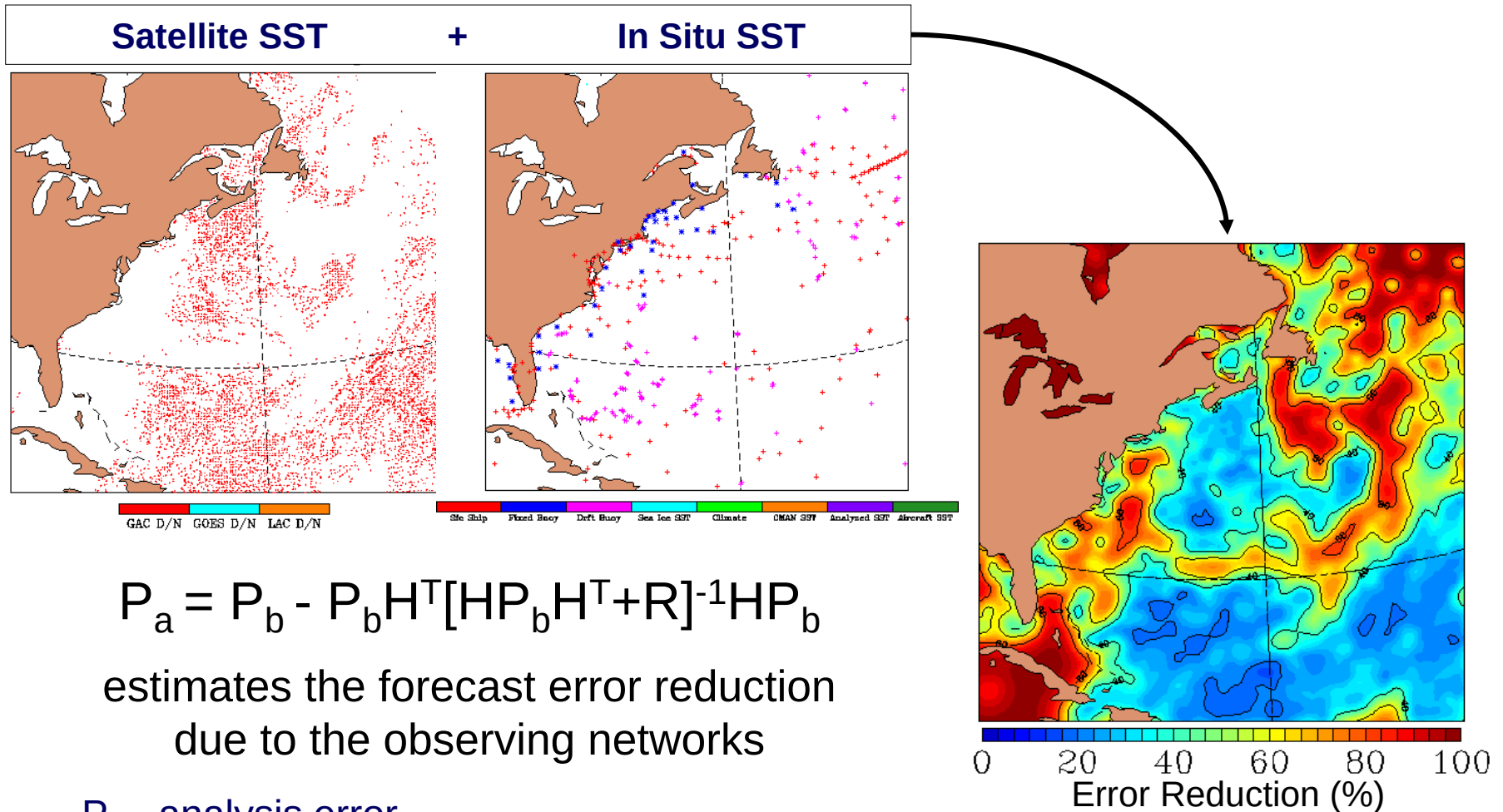


<-3 -2 -1 0 1 2 3>

100 M Temperature Increments

6 August 00Z

Analysis Error Reduction (%)



$$P_a = P_b - P_b H^T [H P_b H^T + R]^{-1} H P_b$$

estimates the forecast error reduction
due to the observing networks

P_a - analysis error

P_b - background error

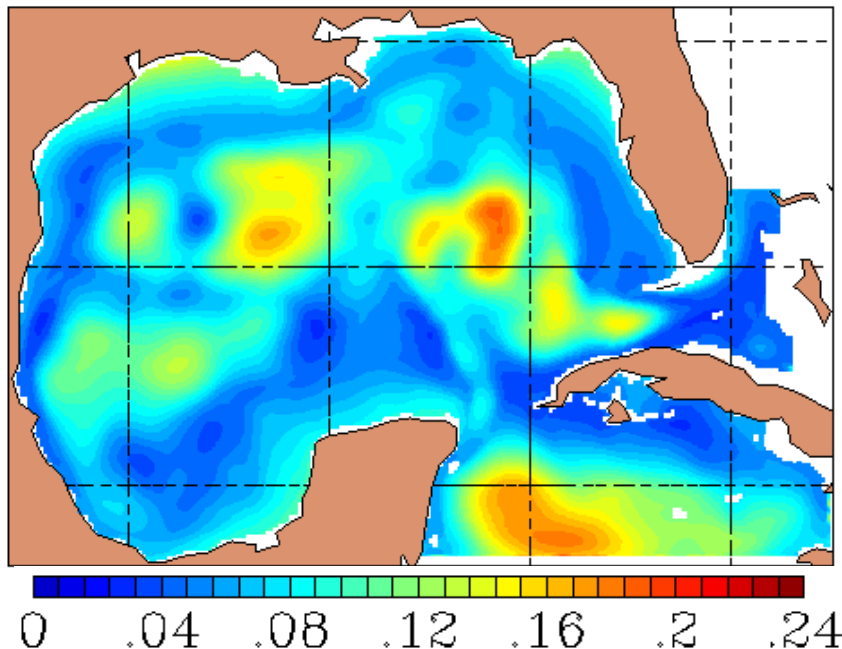
R - observation error

H - measurement functional

*Will be used in ETKF to determine
impact of glider data assimilation
(adaptive sampling RTP)*

Model Based Error Variances

- computed from differences of free running model states at analysis update cycle
- provides estimates of model error (variability) for all analysis variables (T,S,u,v,h)
- used by NCODA in time evolution of background error variances



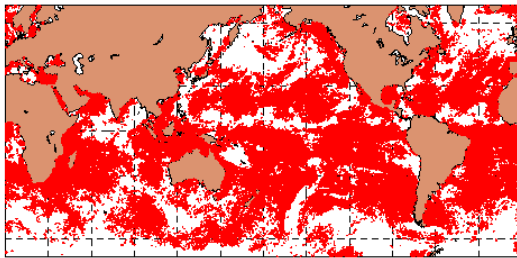
HYCOM SSH Model Climate
Variability - 9 km grid Gulf Mexico

NCODA Background Error Variances

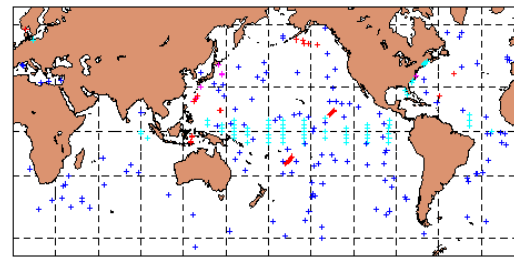
- vary by position, depth, analysis variable
- evolve with time, updated continuously using analyzed increment fields
- error growth parameterization in data void areas
 - function of age of data on grid and temporal autocorrelations
 - background errors asymptote at model (climate) variability in long term absence of observations

New Analysis Variable: Age of Data on Grid (hrs)

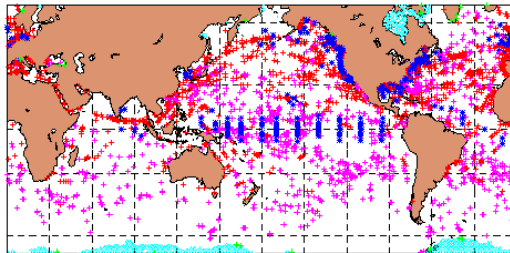
number hours since grid point influenced by an observation



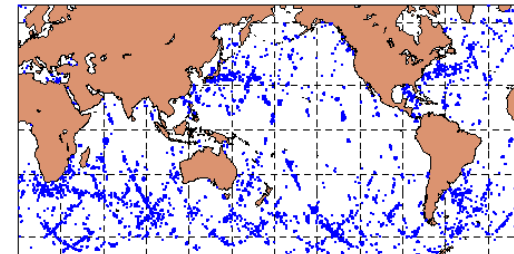
Satellite SST



Profiles

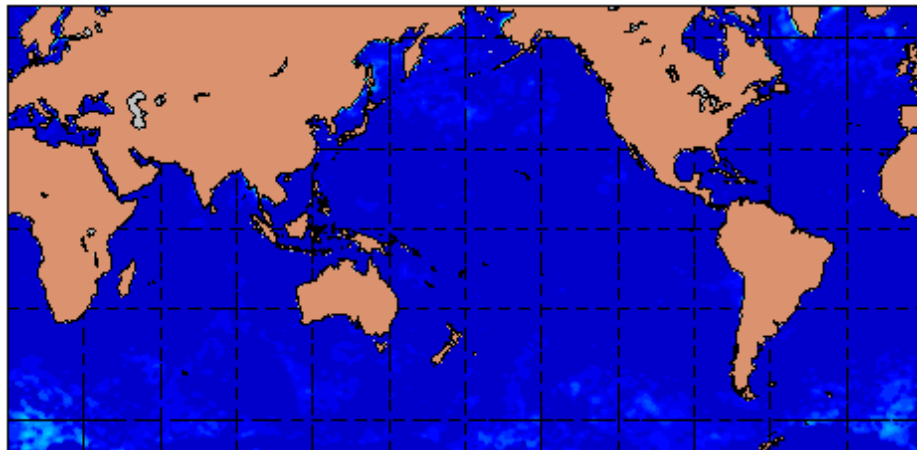


In Situ SST

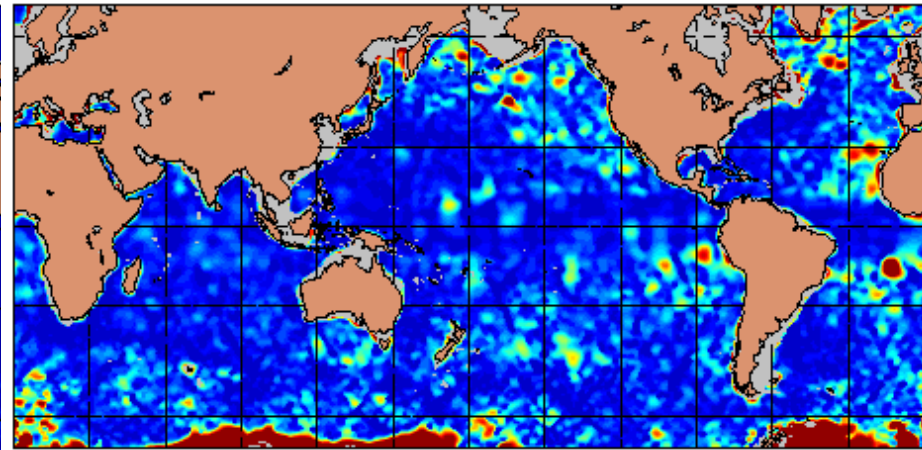


*MODAS
Synthetics*

Age of Data at Surface

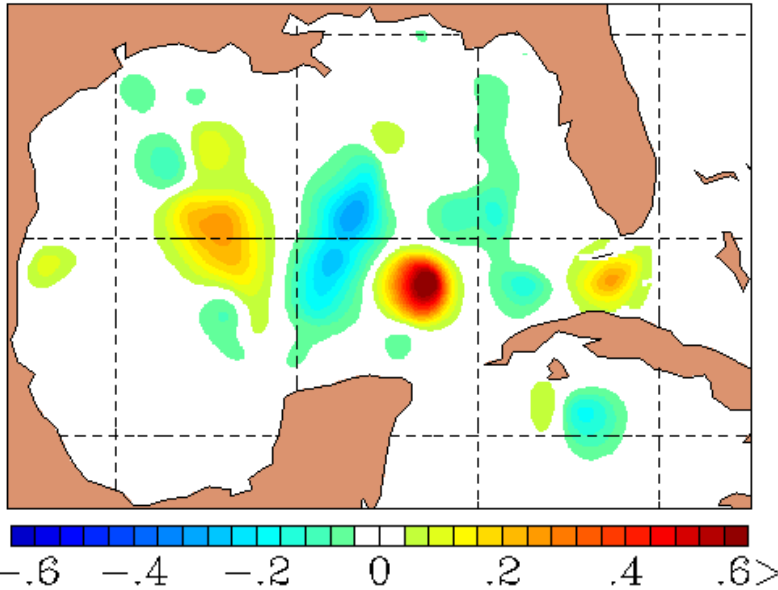


Age of Data at 400 M Depth

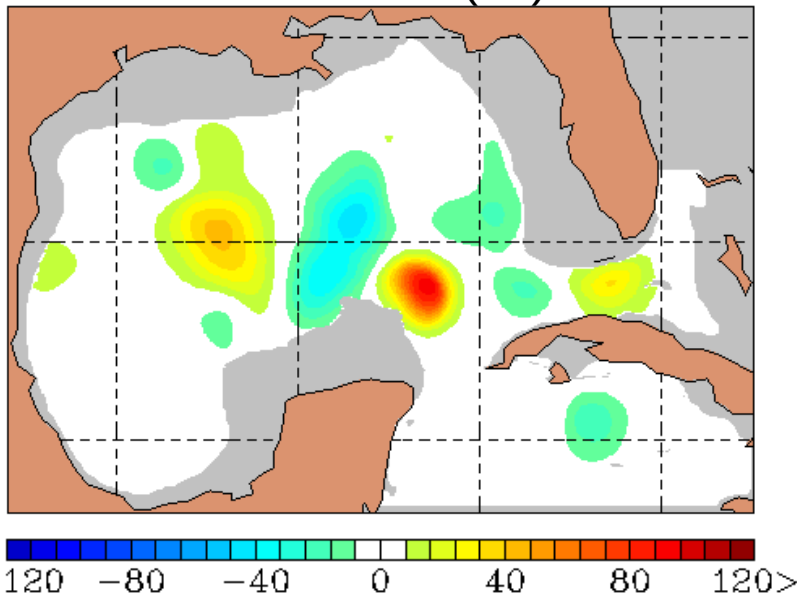


2 June 2005 00Z

SSH Increment (m)



Pressure Correction (db) at 100 M

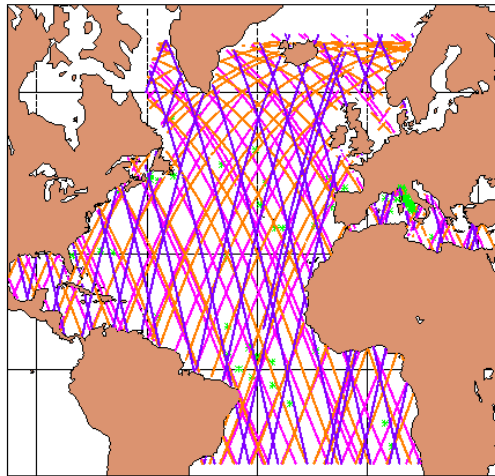


New Analysis Variable: Pressure Correction (db)

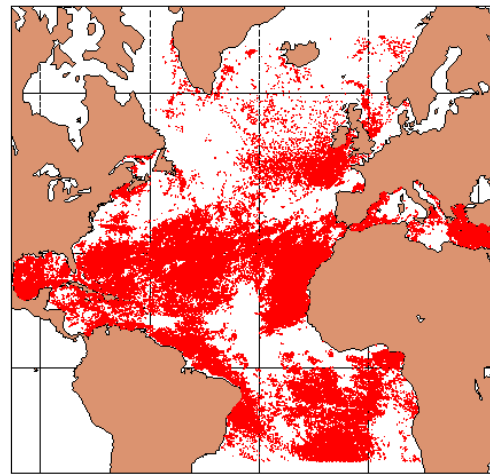
- compute pressure innovation (**OmF**) of forecast density in observed density profile
- compute pressure innovation error from T,S, ρ errors scaled by observed potential density pressure gradient

$$e_p = (e_\theta \cdot \partial\rho/\partial\theta + e_S \cdot \partial\rho/\partial S) / (\partial\rho/\partial p)$$
- assimilate pressure innovations using T/S covariances in **T,S, ϕ ,u,v,p** analysis
- correct HYCOM forecast interface pressures when layers are at target density
 - positive: move the layer down, forecast density shallower than observed
 - negative: move the layer up, forecast density deeper than observed
- correct HYCOM forecast T,S, ρ when layers are not at target density
- apply constraints before initializing model
 - layer thickness is always positive
 - no bottom pressure change

Data Restriction in Lateral Boundary Areas

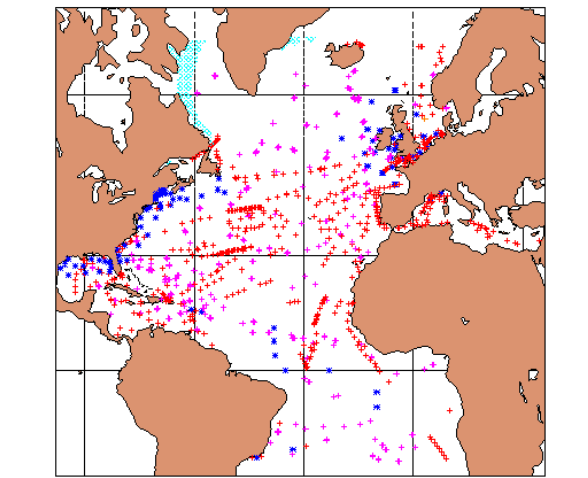


Altimeter

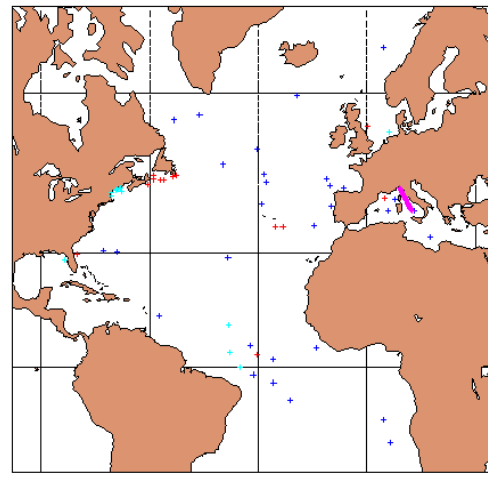


Satellite SST

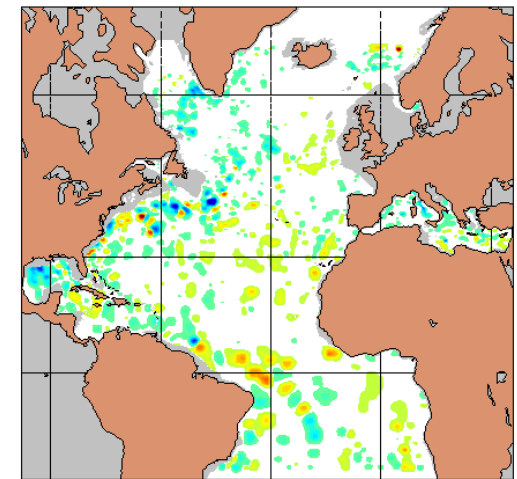
- model forecast not accurate in lateral boundary areas
- innovations (OmF) can be large in boundary areas
- analyzed increments from boundary areas can degrade forecast in active regions



In situ SST



Profiles



Temperature Increments
200 M

END