NCODA Status
NRL Coupled Ocean Data Assimilation

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HYCOM NOPP GODAE Meeting

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Outline

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

NCODA System Overview

Flexible System

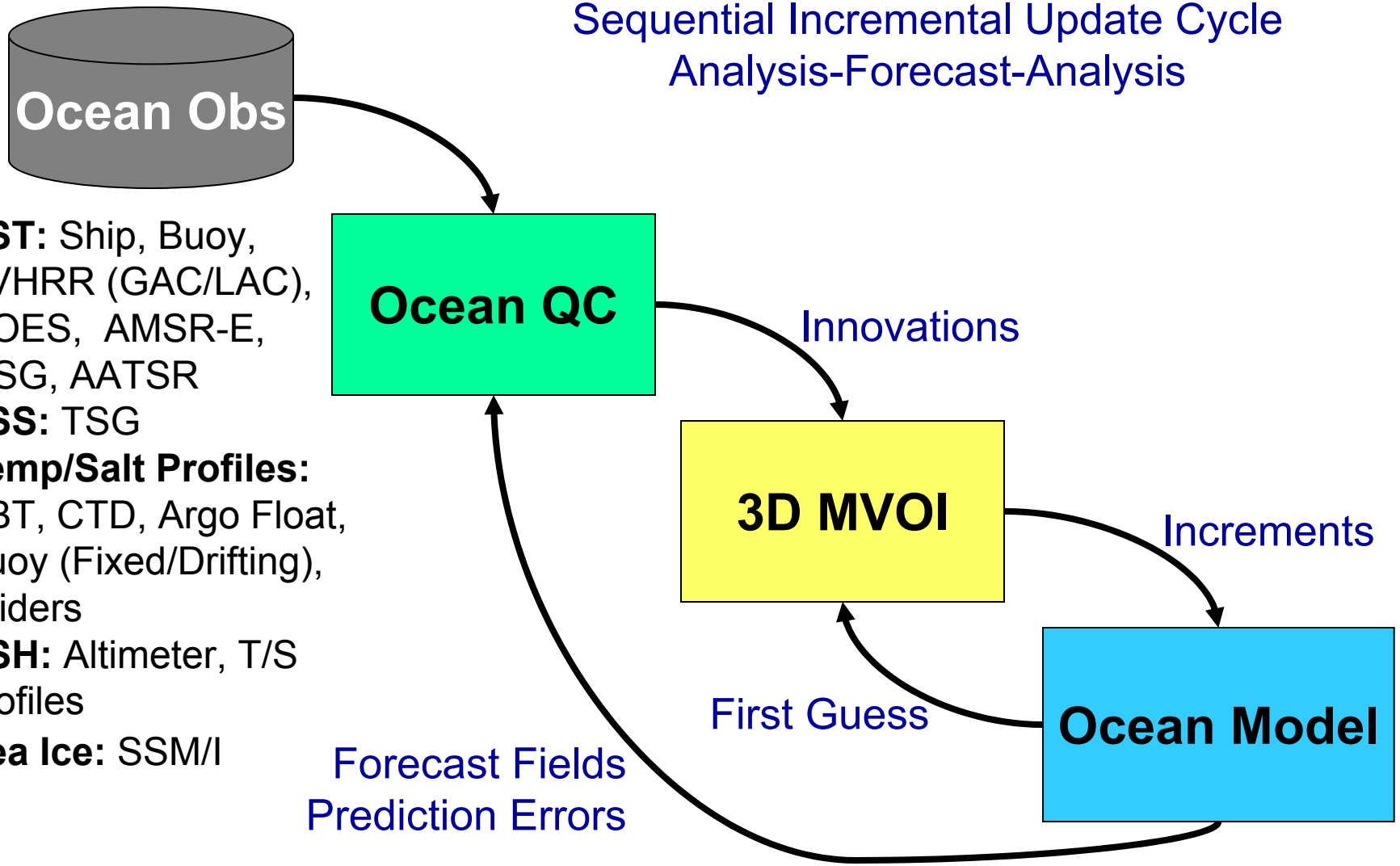
- global or regional applications
- re-locatable, multi-scale analyses on nested, successively higher resolution grids (3:1 nest ratios)
- update ocean forecast model or run stand-alone
  - 2D analyses of sea ice and SST (NWP boundary conditions)
  - 3D temperature and salinity analysis (geostrophic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



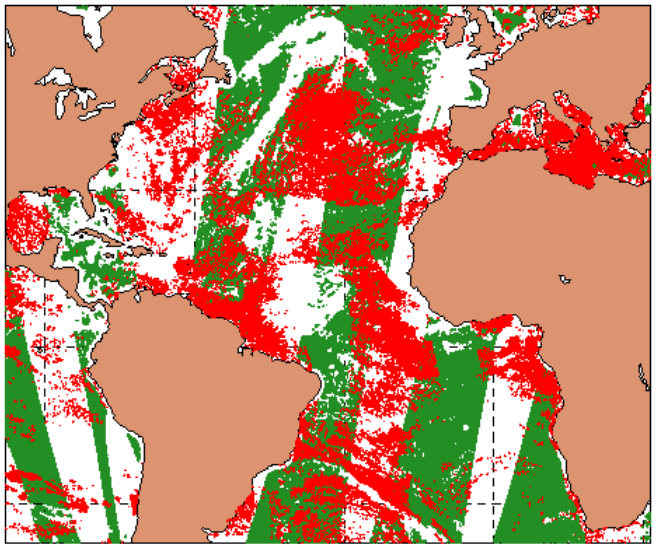
SST: Ship, Buoy, AVHRR (GAC/LAC), GOES, AMSR-E, MSG, AATSR
SSS: TSG
Temp/Salt Profiles: XBT, CTD, Argo Float, Buoy (Fixed/Drifting), Gliders
SSH: Altimeter, T/S profiles
Sea Ice: SSM/I

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



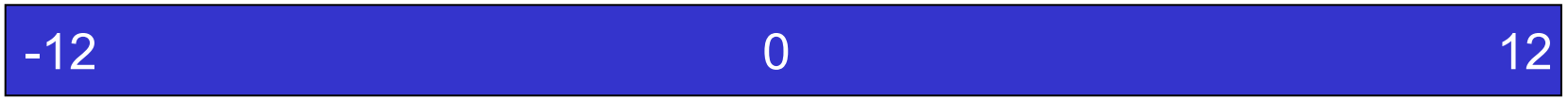
AVHRR-GAC AMSR-E

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

$$s_h = (x_o - x_b)/x_s \qquad C_h = (1+s_h)\exp(-s_h)$$

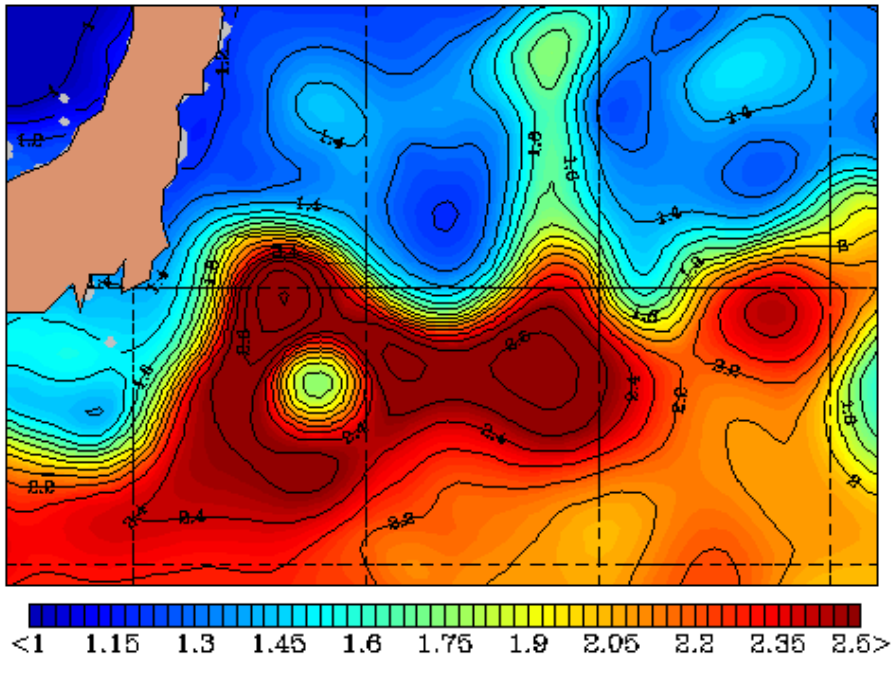
$$s_v = (z_o - z_b)/z_s \qquad C_v = (1+s_v)\exp(-s_v)$$

$$s_f = (h_o - h_b)/h_s \qquad C_f = (1+s_f)\exp(-s_f)$$

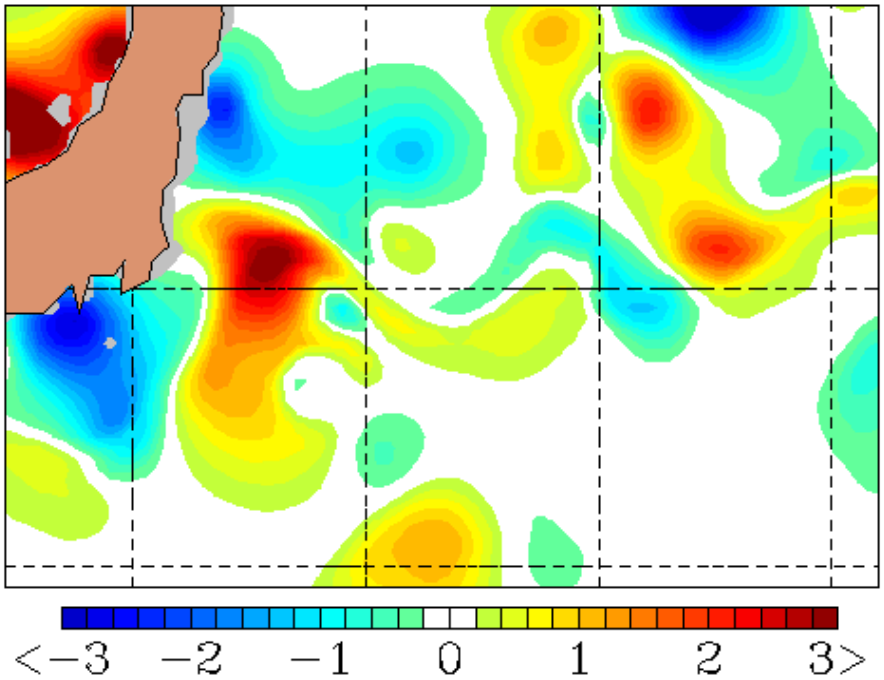
$$C_b = C_h C_v C_f$$

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



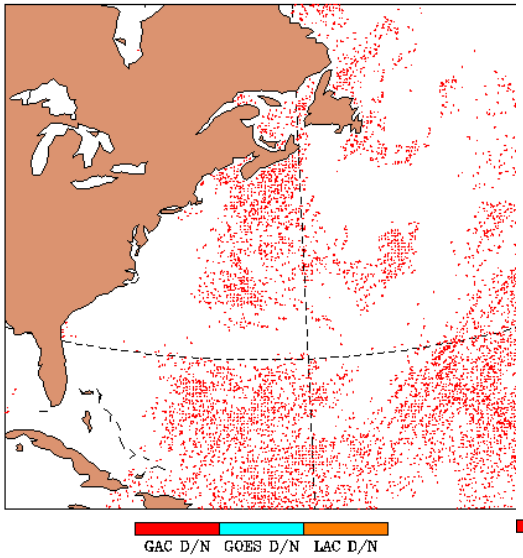
Geopotential Valid 5 August 2005 00Z
Contour Interval 0.1 dyn m

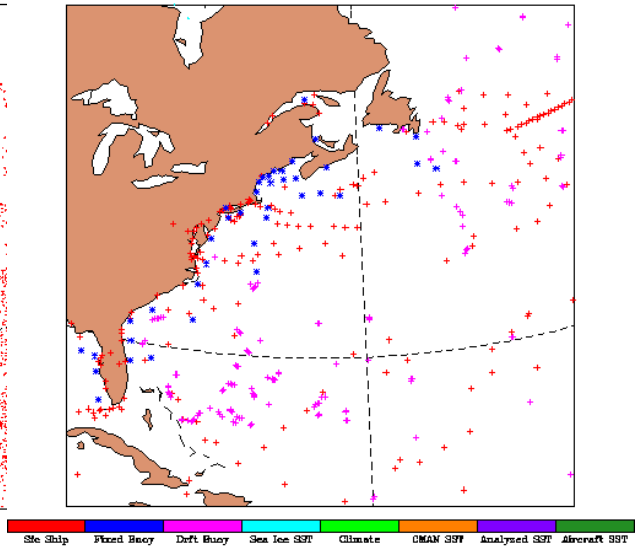


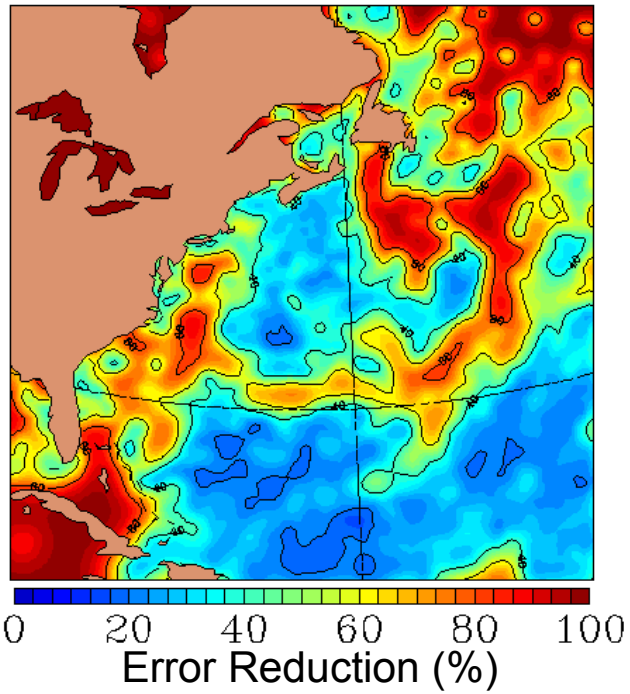
100 M Temperature Increments
6 August 00Z

Analysis Error Reduction (%)

Satellite SST + **In Situ SST**







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

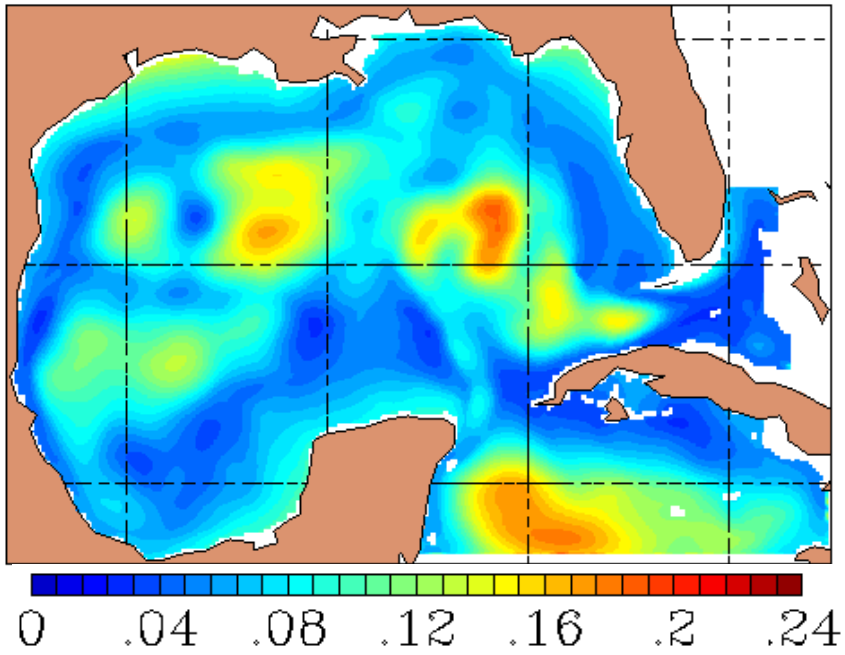
estimates the forecast error reduction due to the observing networks

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



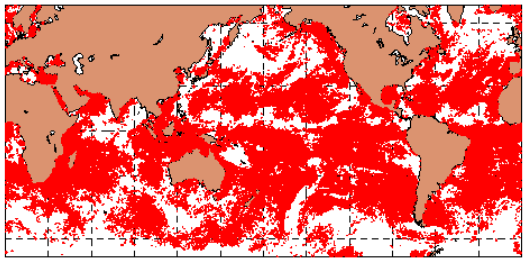
HYCOM SSH Model Climate Variability - 9 km grid Gulf Mexico

NCODA Background Error Variances

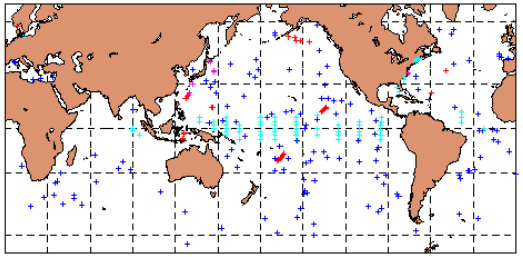
- vary by position, depth, analysis variable
- evolve with time, updated continuously using analyzed increment fields
- error growth parameterization in data void areas
  - function of age of data on grid and temporal autocorrelations
  - background errors asymptote at model (climate) variability in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

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

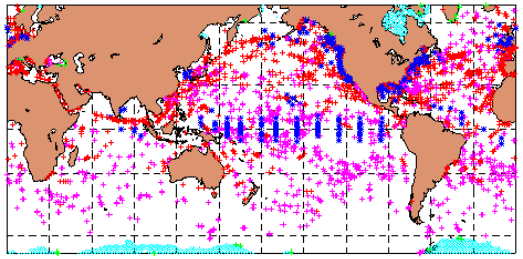
number hours since grid point influenced by an observation



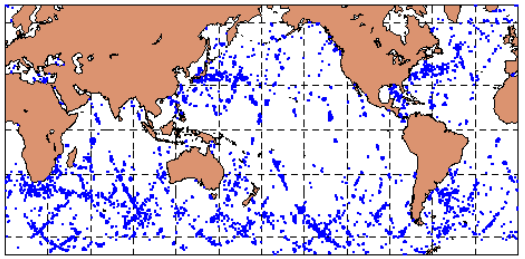
Satellite SST



Profiles

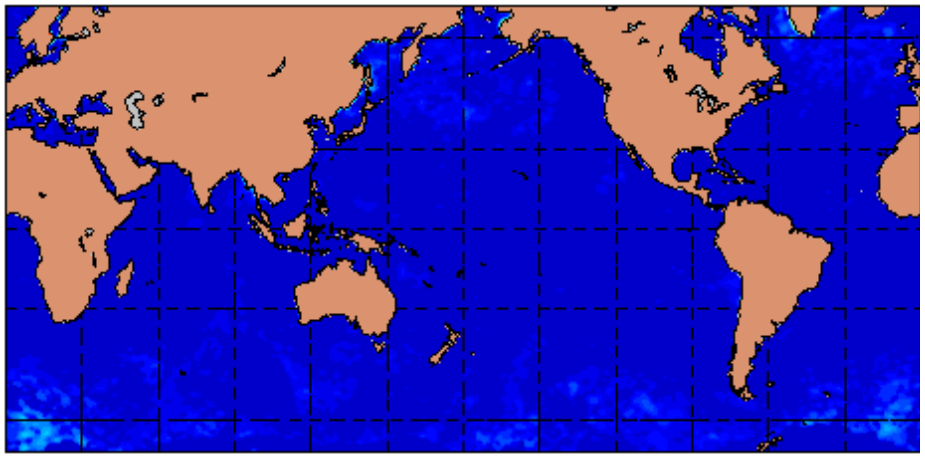


In Situ SST

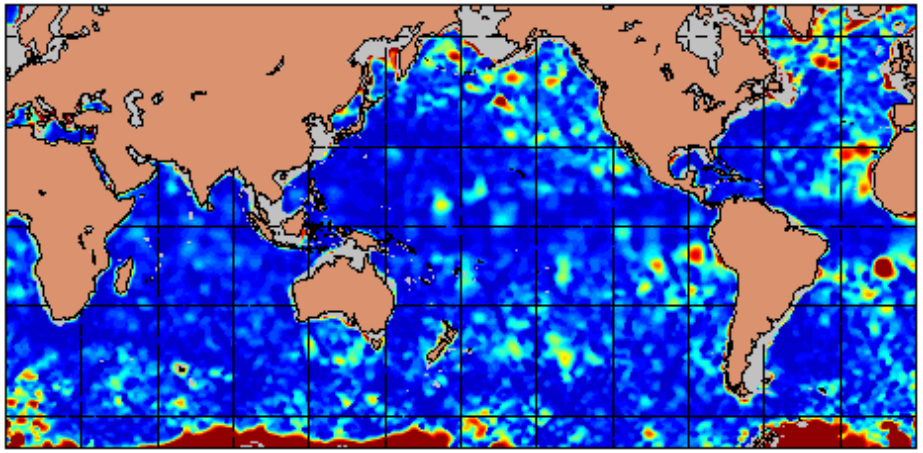


MODAS Synthetics

Age of Data at Surface

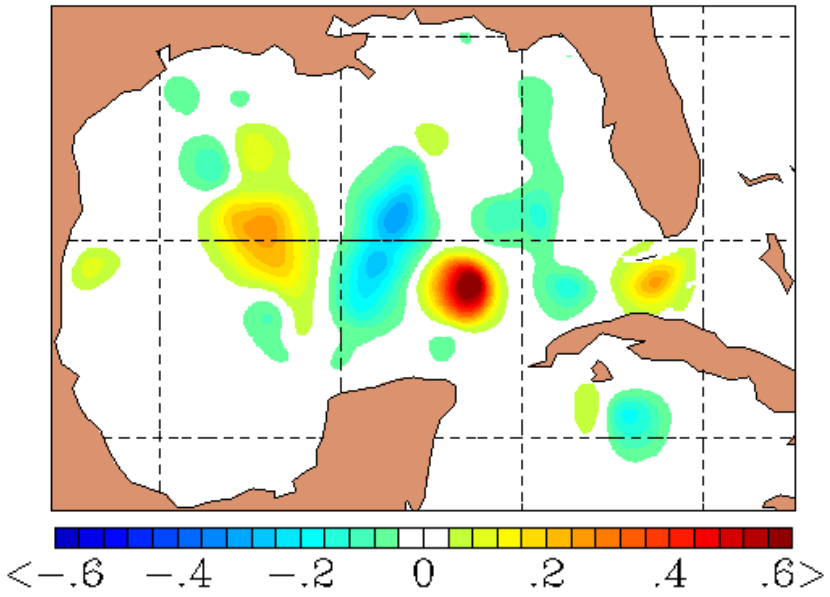


Age of Data at 400 M Depth

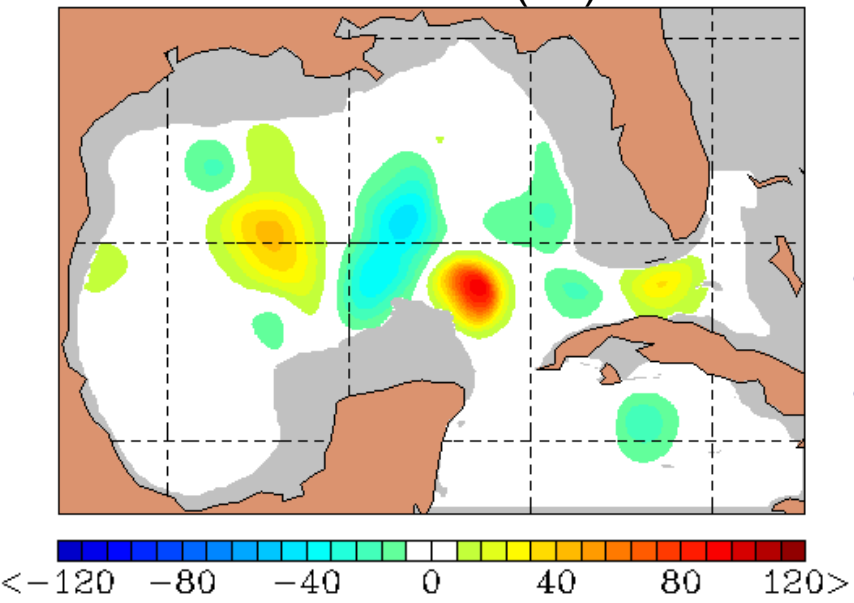


2 June 2005 00Z

SSH Increment (m)



Pressure Correction (db) at 100 M



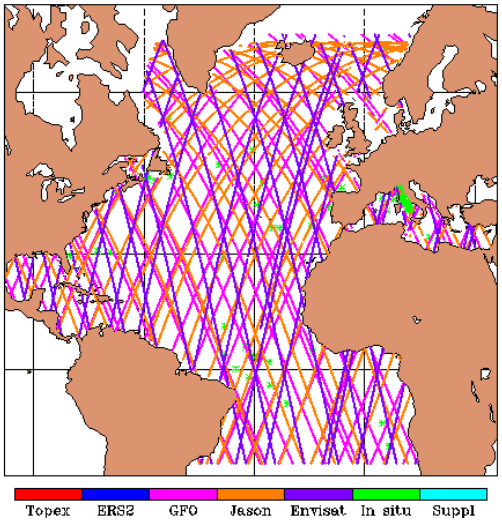
New Analysis Variable: Pressure Correction (db)

- 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

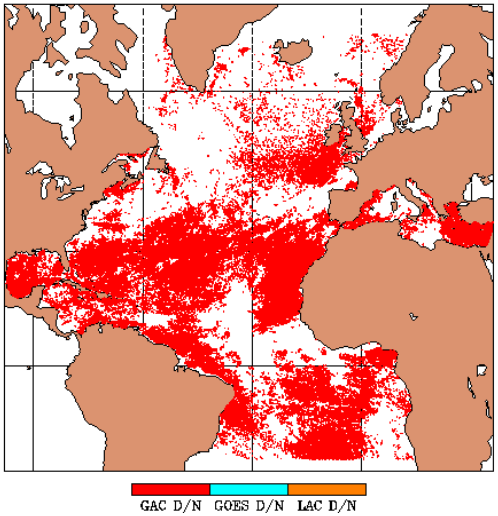
$$e_p = (e_\theta \cdot \partial\rho/\partial\theta + e_S \cdot \partial\rho/\partial S) \,/\, (\partial\rho/\partial p)$$

- 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 positve
  - no bottom pressure change

Data Restriction in Lateral Boundary Areas

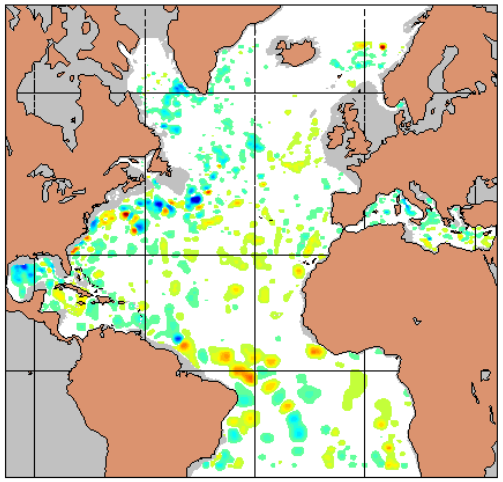


Altimeter

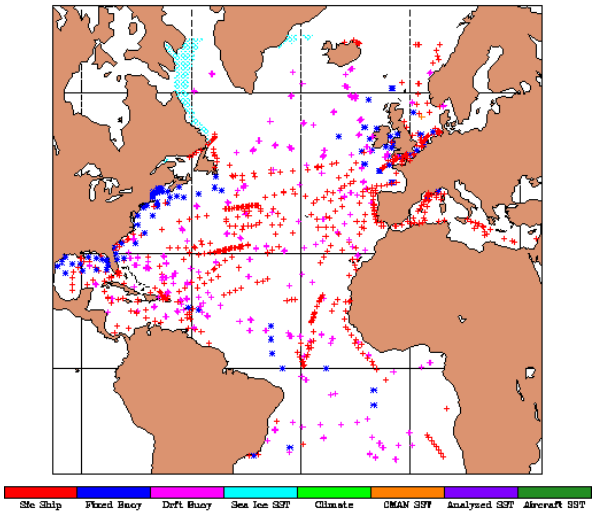


Satellite SST

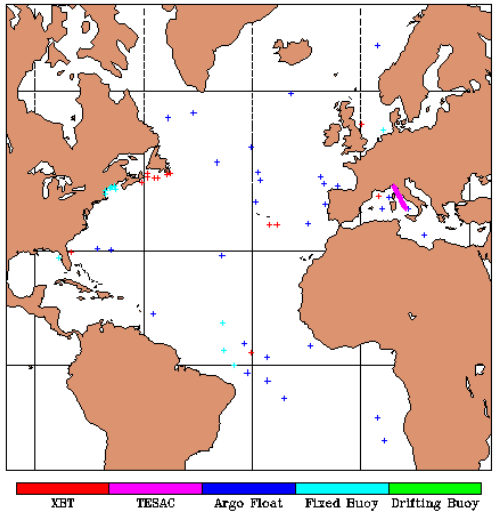
- model forecast not accurate in lateral boundary areas
- innovations (OmF) can be large in boundary areas
- analyzed increments from boundary areas can degrade forecast in active regions



Temperature Increments
200 M



In situ SST



Profiles

END