Verification of NCODA Assimilation in the HYCOM 1/25th degree Gulf of Mexico Domain

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Data Assimilation Intercomparison Study

Planned at December 2005 HYCOM Meeting (RSMAS)

Forecast Model: HYCOM

Domain: Gulf of Mexico, 1/25° resolution (~3.5 km)

Assimilation Time Period: 2004 – 2005

Atmospheric Forcing: 1° NOGAPS

Nesting: climatological boundary conditions (from 1/12° Atlantic)

River Inputs: monthly river flow

HYCOM Assimilation Systems

TOPAZ, ENKF (NRL), MVOI (NCODA), ROIF, SEEK, OI (NCEP)

Control Run

Free run model from 2003 – 2006 forced by 1° NOGAPS

Data Assimilation Intercomparison Study

Intercomparison Criteria – Forecasting System

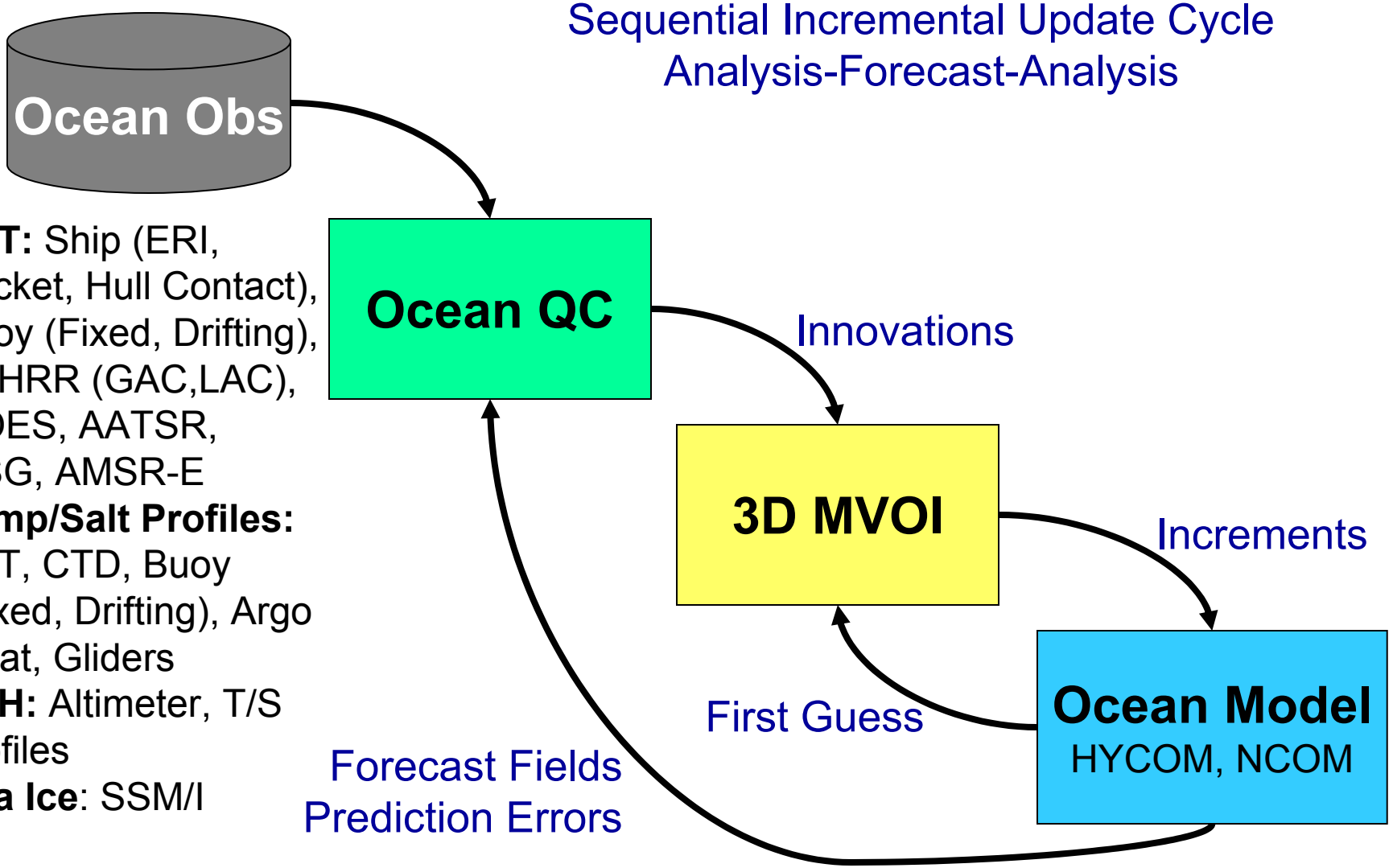
- **Skill of forecasts as compared to free run model**
- **Skill of nowcasts as compared to free run model**
- Performance measures of assimilation system
- Skill of assimilative lateral boundary conditions for downscaling
- Prediction of non-assimilated (independent) observations
- Prediction Loop Current and Loop Current eddy interactions

Intercomparison Criteria – Oceanographic Knowledge

- Water masses at all depths
- Deep circulation
- Barotropic Stream Functions
- Mass and velocity structure in Yucatan and Florida Straits

NCODA System Overview

Sequential Incremental Update Cycle
Analysis-Forecast-Analysis



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

NCODA Implementation
Data Assimilation Intercomparison Study

Observations

- SST - satellite (AVHRR GAC), ship, fixed and drifting buoy
- Profile – Argo Float, TESAC, XBT
- Altimeter – Jason, GFO, ENVISAT
- Synthetics – temperature/salinity profiles from assimilation of altimeter SSH data using Cooper-Haines vertical projection technique

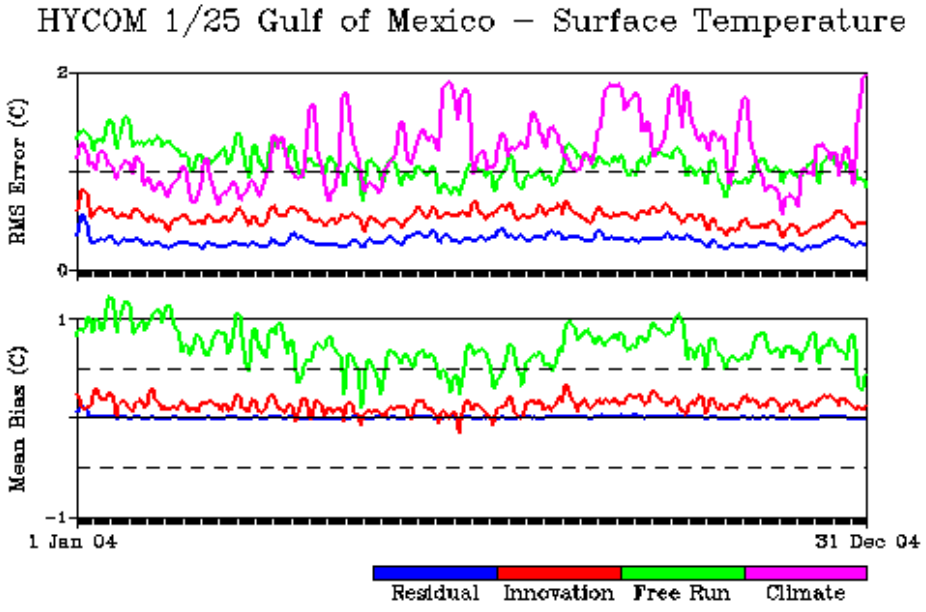
Assimilation

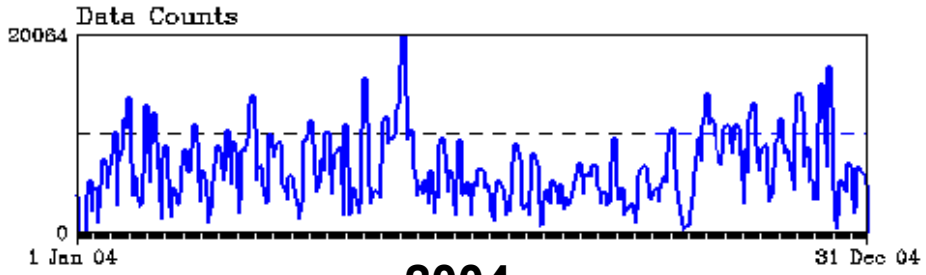
- 24-hour update cycle – 2 Sep 2003 through 1 June 2006
- No forecasts beyond update cycle interval
- Incremental Analysis Update (IAU) procedure - increments inserted over 240 model time steps (first 12 hours of forecast)

Verification Statistics – computed as daily averages by depth

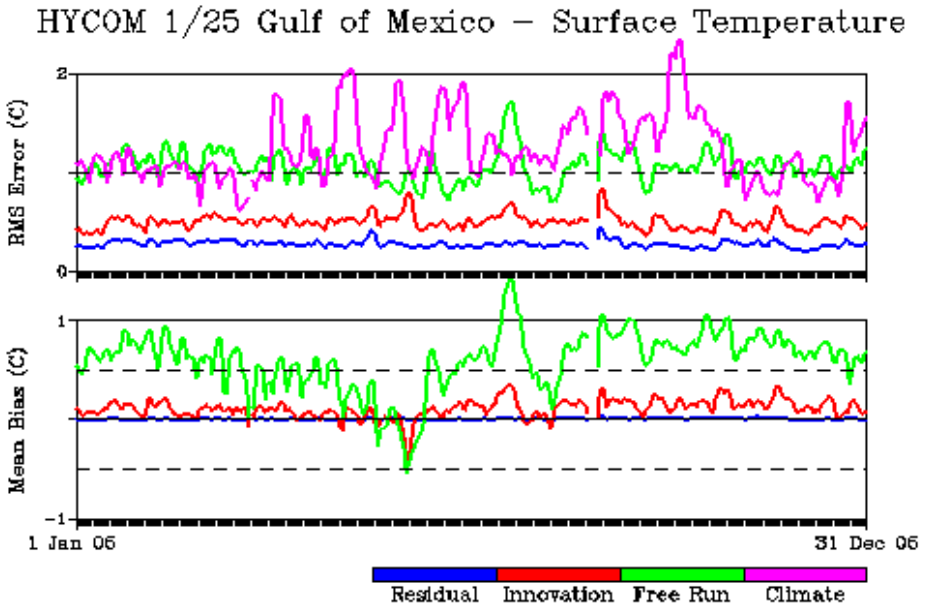
- OmA – observation minus analysis (residuals)
- OmF – observation minus 24 forecast (innovations)
- OmM – observation minus free run of model (control)
- OmC – observation minus climatology (GDEM v3.0)

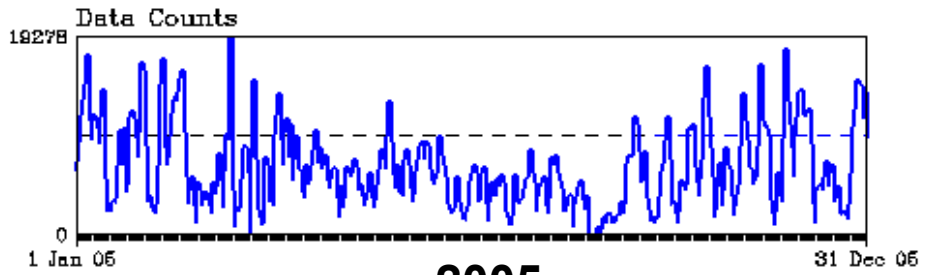
Surface Temperature Validation





2004

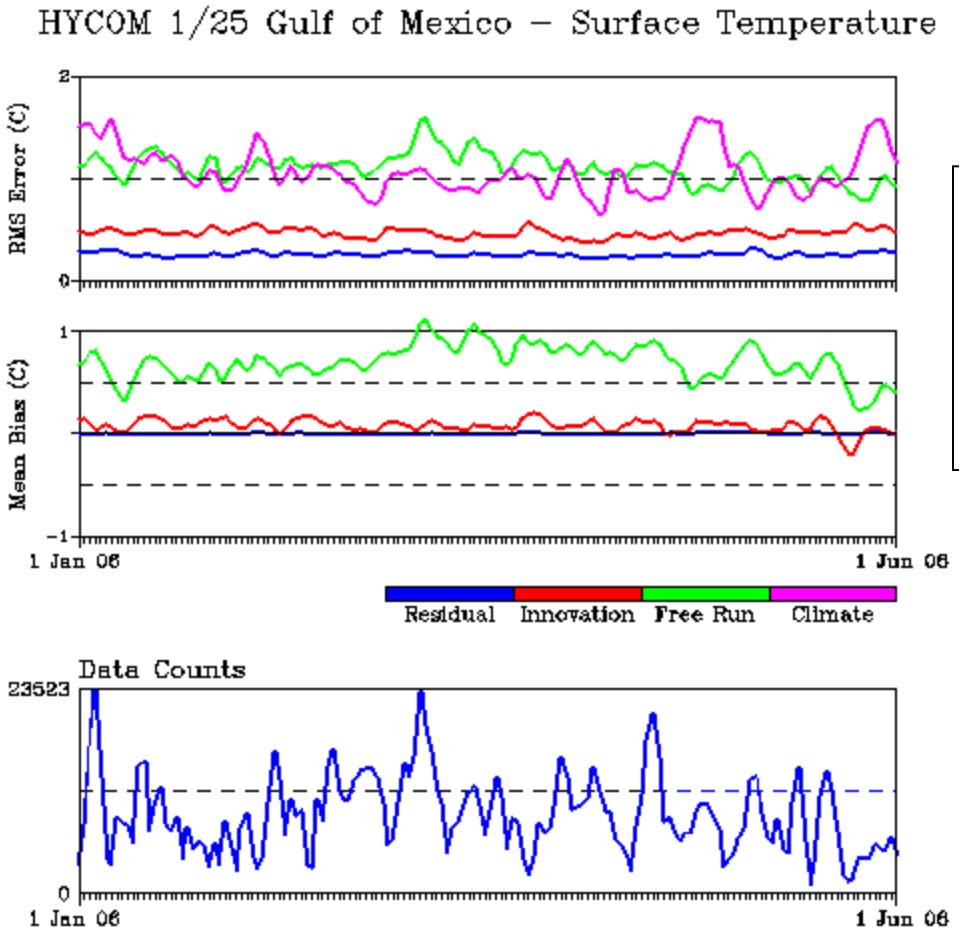




2005

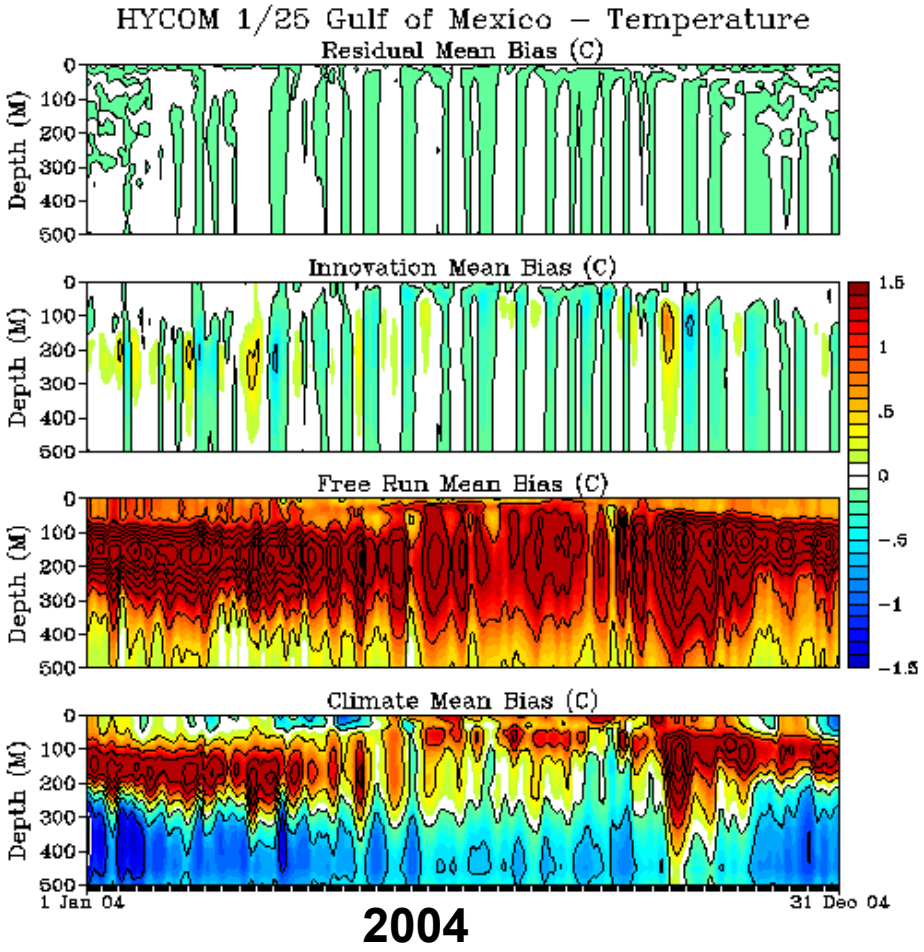
residual error	0.28	bias	0.01	ºC	residual error	0.27	bias 0.01	ºC
innovation error	0.51	bias	0.13	ºC	innovation error	0.48	bias 0.10	ºC
free run error	1.06	bias	0.71	ºC	free run error	1.06	bias 0.58	ºC
climate error	1.14			ºC	climate error	1.17		ºC

Surface Temperature Validation – Jan to Jun 2006

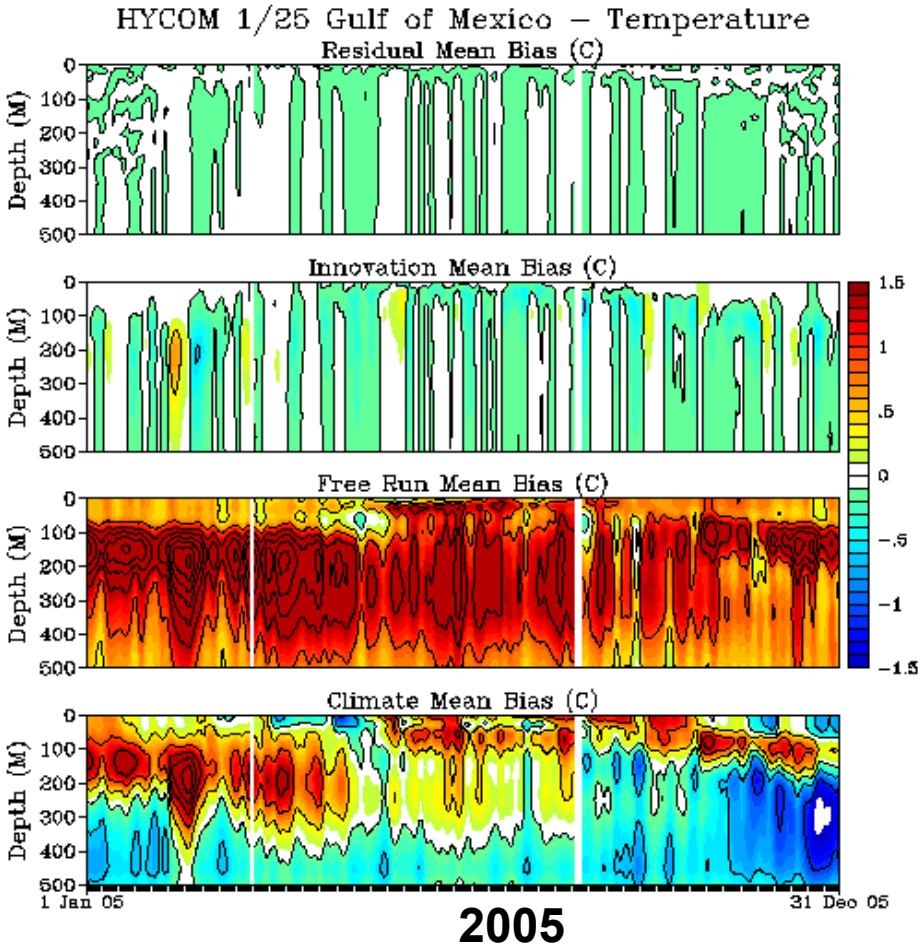


residual error	0.26	bias 0.01 ºC
innovation error	0.46	bias 0.08 ºC
free run error	1.15	bias 0.75 ºC
climate error	1.04	

Temperature Validation – Mean Bias



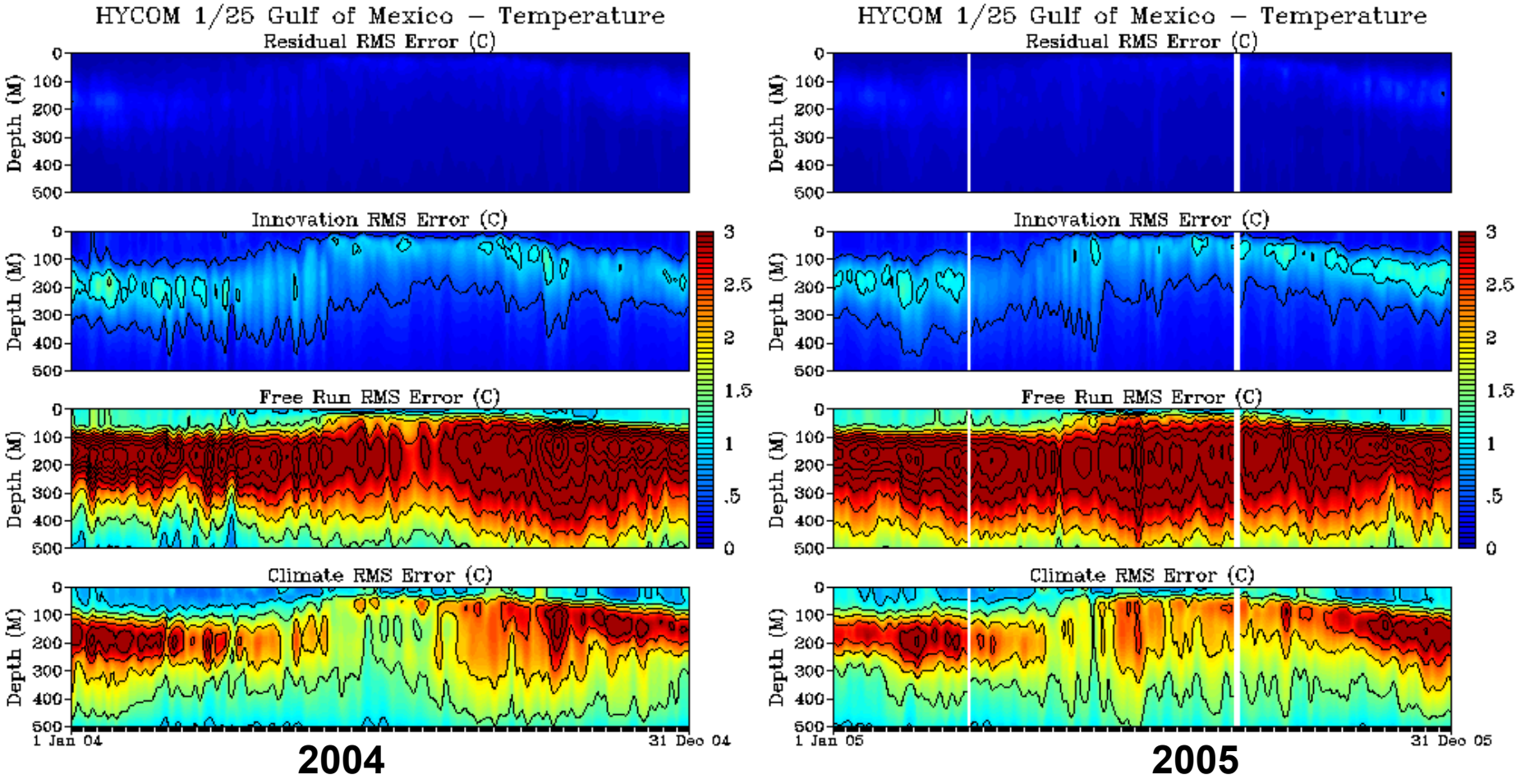
2004



2005

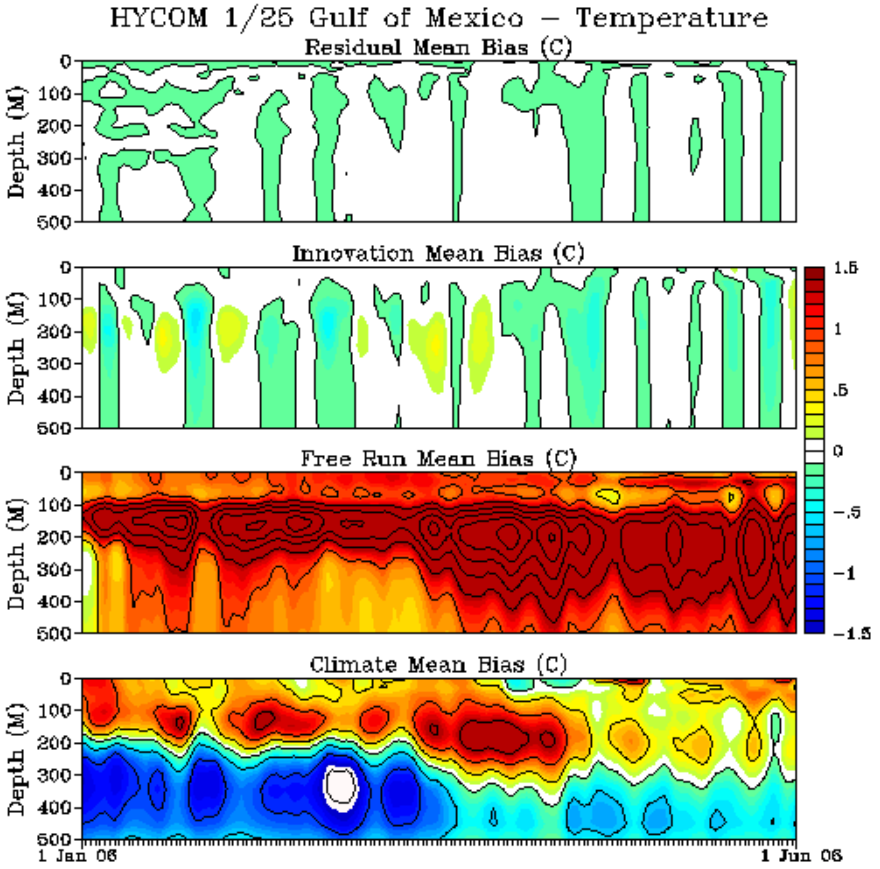
- analysis residuals biased slightly warm ~0.08 ºC
- 24-hr forecasts from assimilation run essentially unbiased ~0.1 ˚C
- free running model biased very cold ~1.0 to >3.0 ºC
- observations (synthetics) biased warm and cold relative to climatology

Temperature Validation – RMS Error

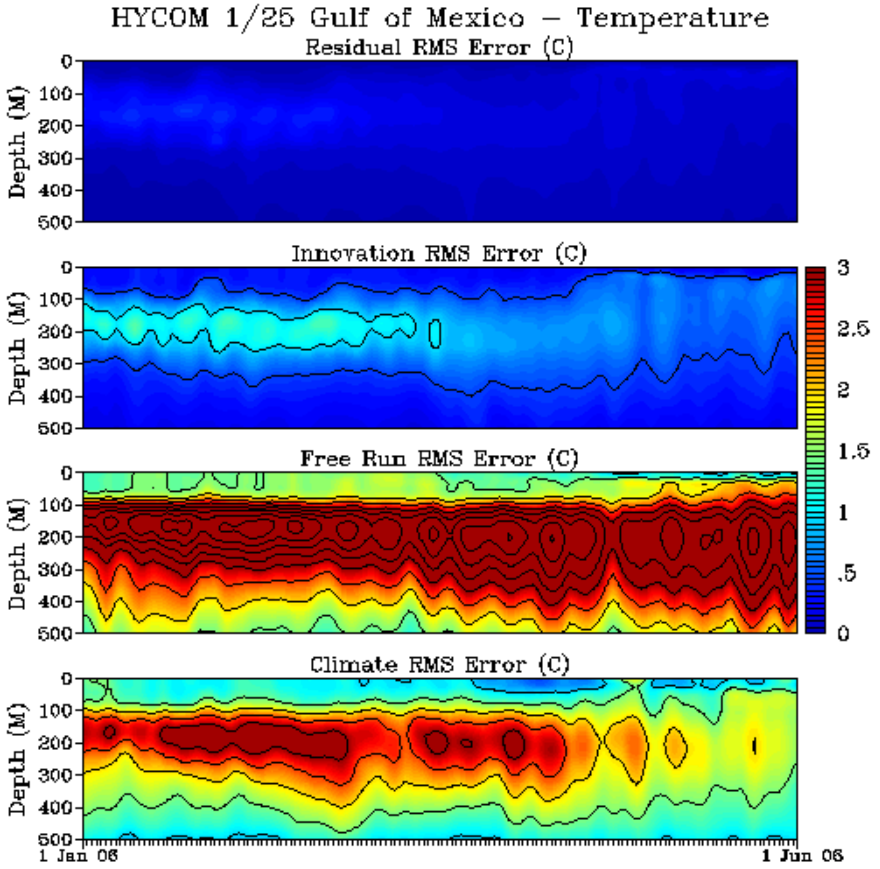


- residual errors very low ~0.3 ºC
- innovations errors concentrated in thermocline
- free running model errors very large ~1.0 to >4.0 ºC

Temperature Validation – Jan to Jun 2006



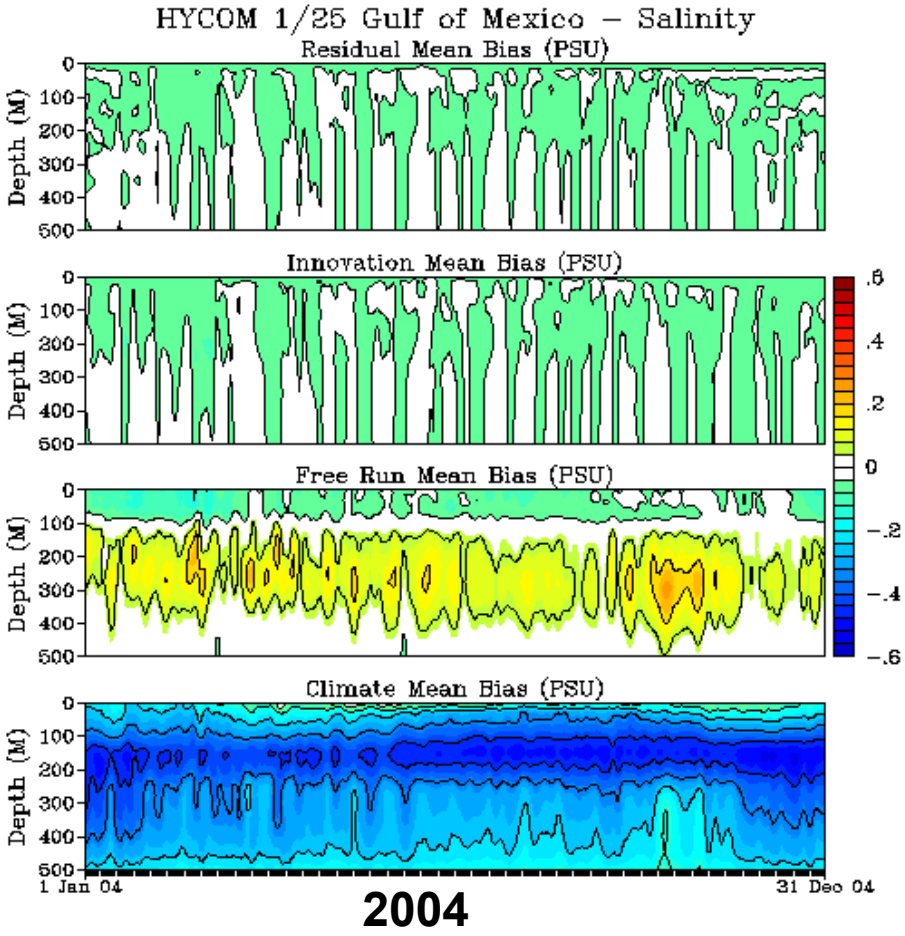
Mean Bias



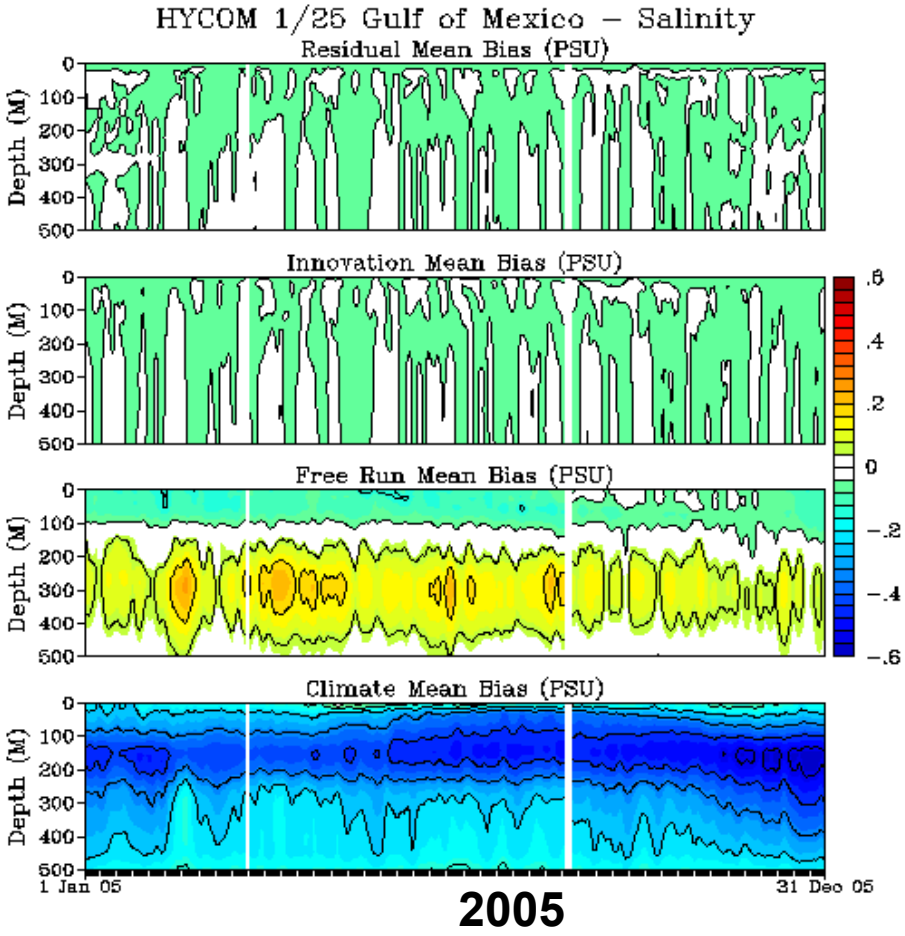
RMS Error

similar error patterns as 2004 and 2005

Salinity Validation – Mean Bias



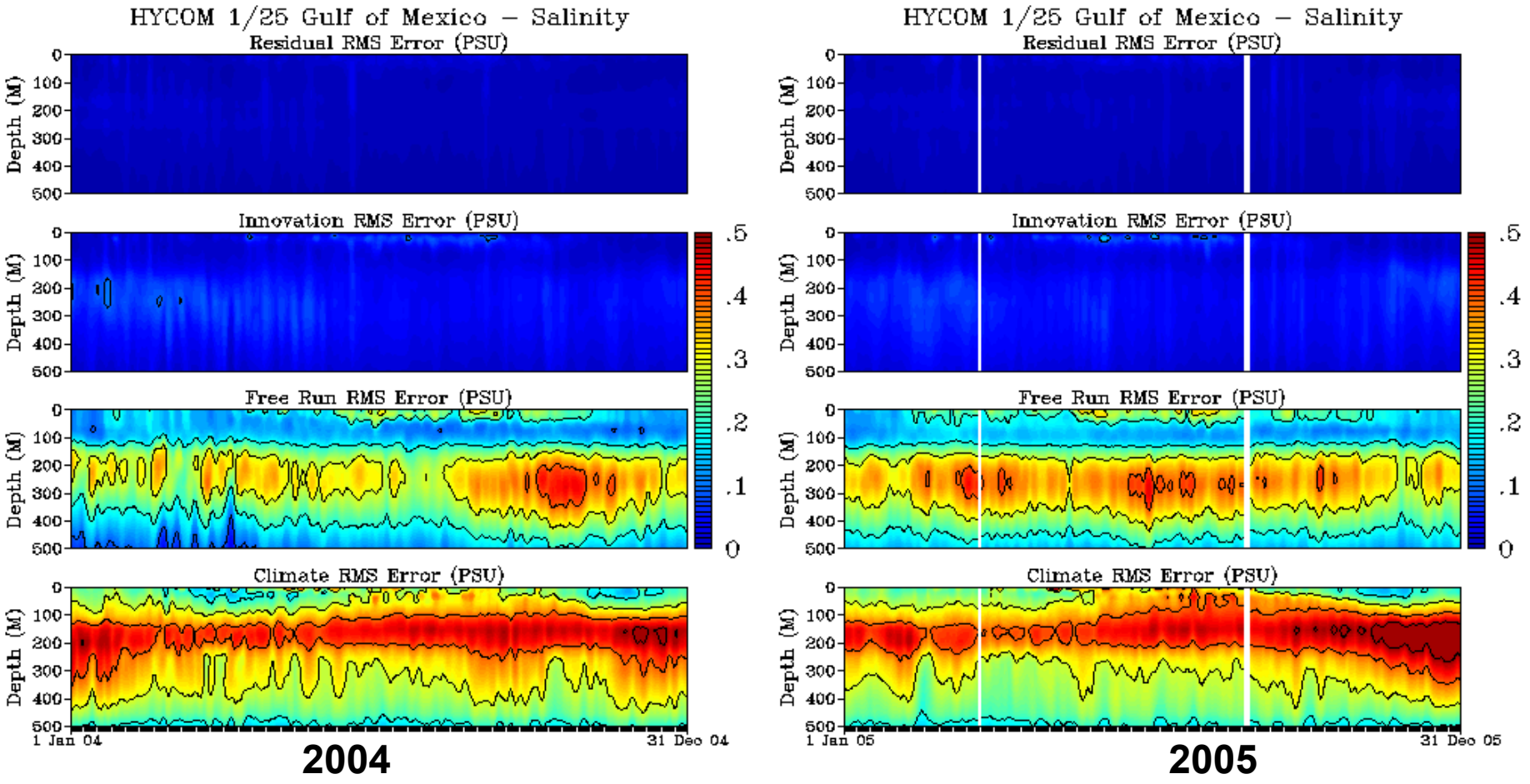
2004



2005

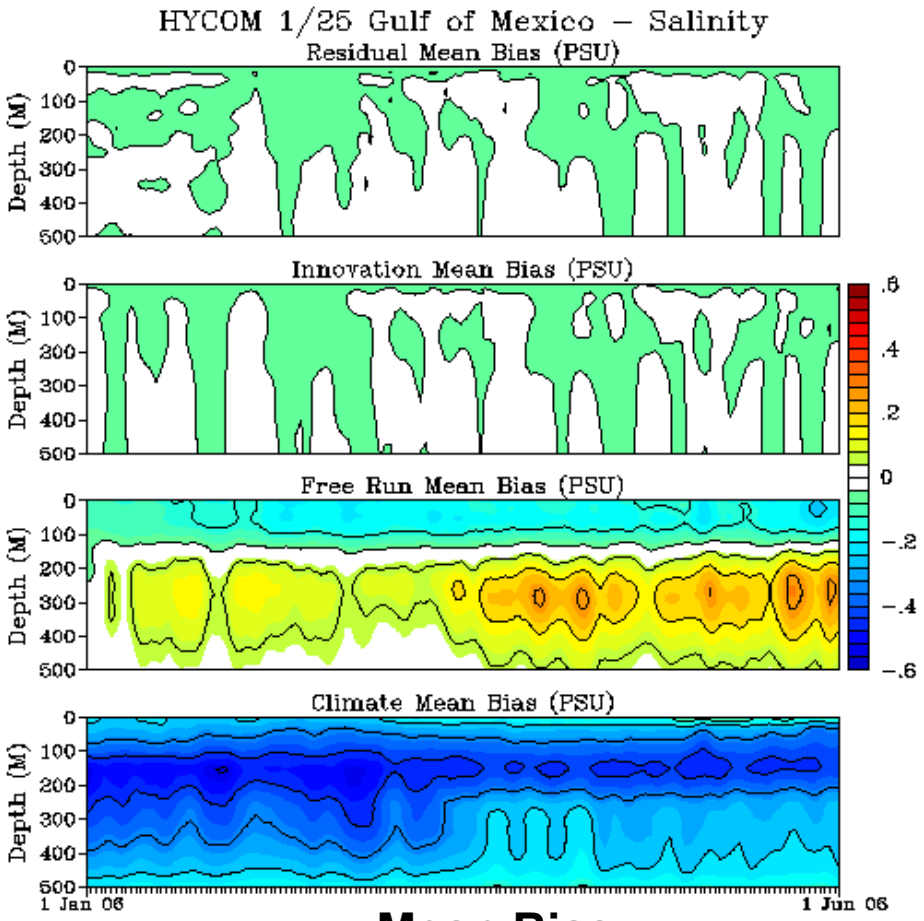
- residual and innovation salinities biased salty ~0.05 PSU
- free running model salinities biased salty at surface (~0.05 PSU), fresh at depth (~0.2 to 0.3 PSU)
- observations (synthetics) biased fresh relative to climatology

Salinity Validation – RMS Error

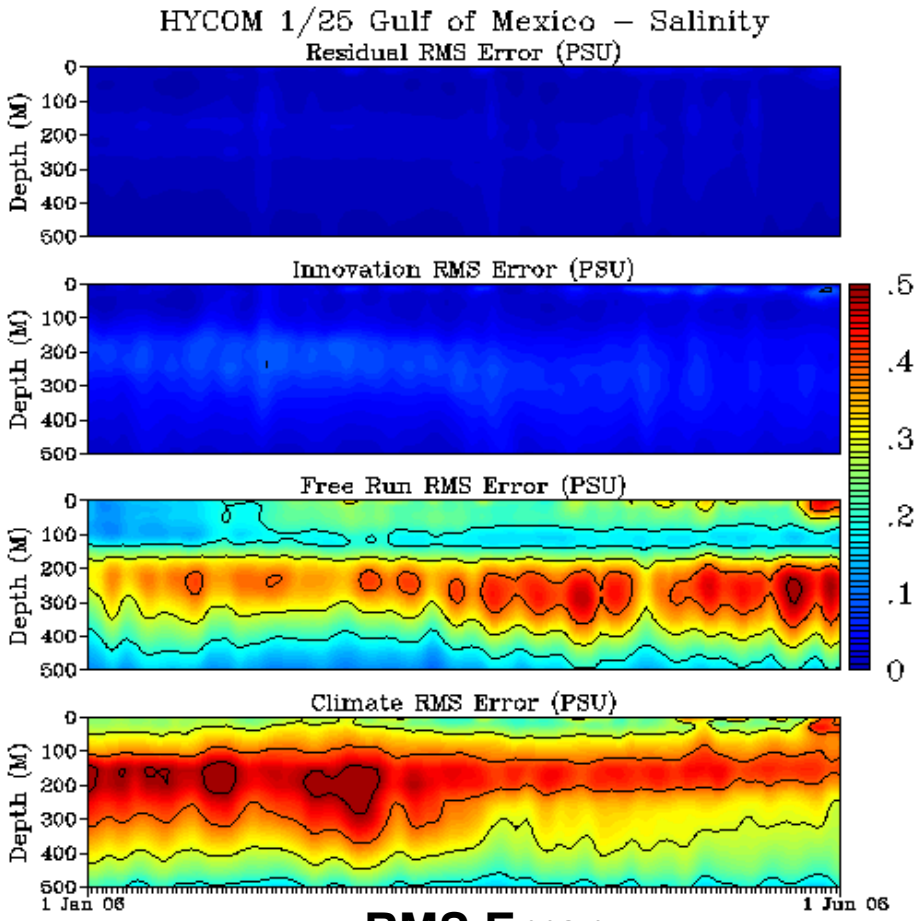


- 24-hr forecast RMS errors very low (~0.1 PSU)
- free running model RMS errors ~0.2 to 0.4 PSU

Salinity Validation – Jan to Jun 2006



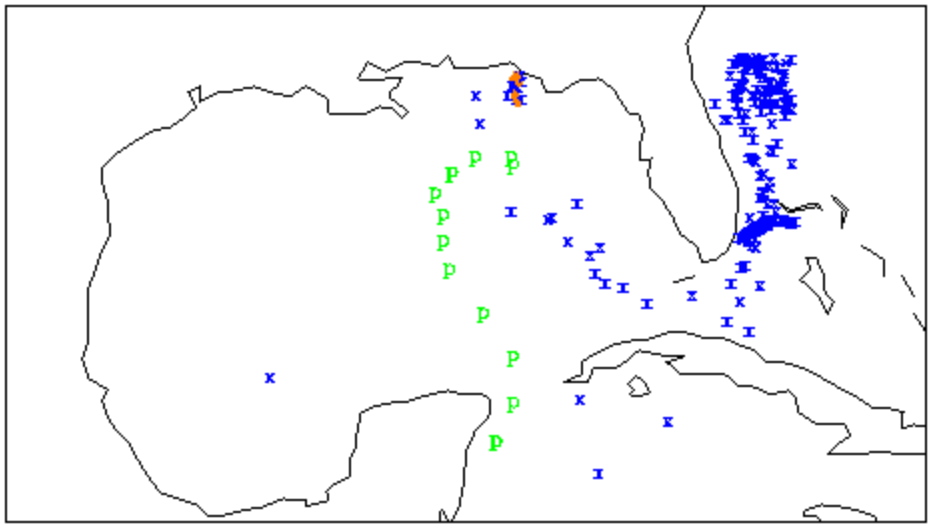
Mean Bias



RMS Error

similar error patterns as 2004 and 2005

In Situ Profile Locations
January 2004 through June 2006



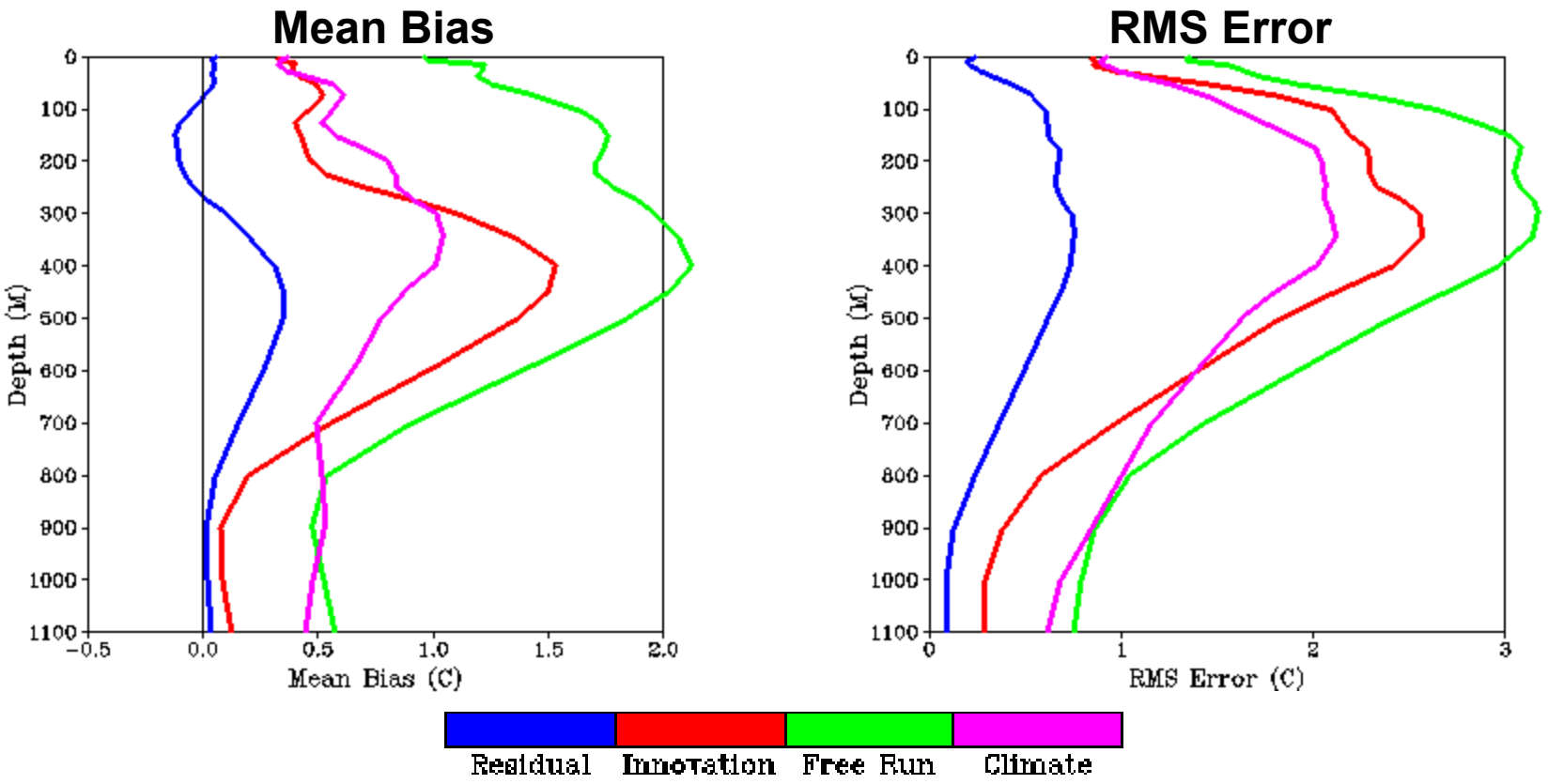
P – Argo profiling float (13)

T – TESAC salinity-temperature-depth profile (15)

X – eXpendable BathyThermograph (222)

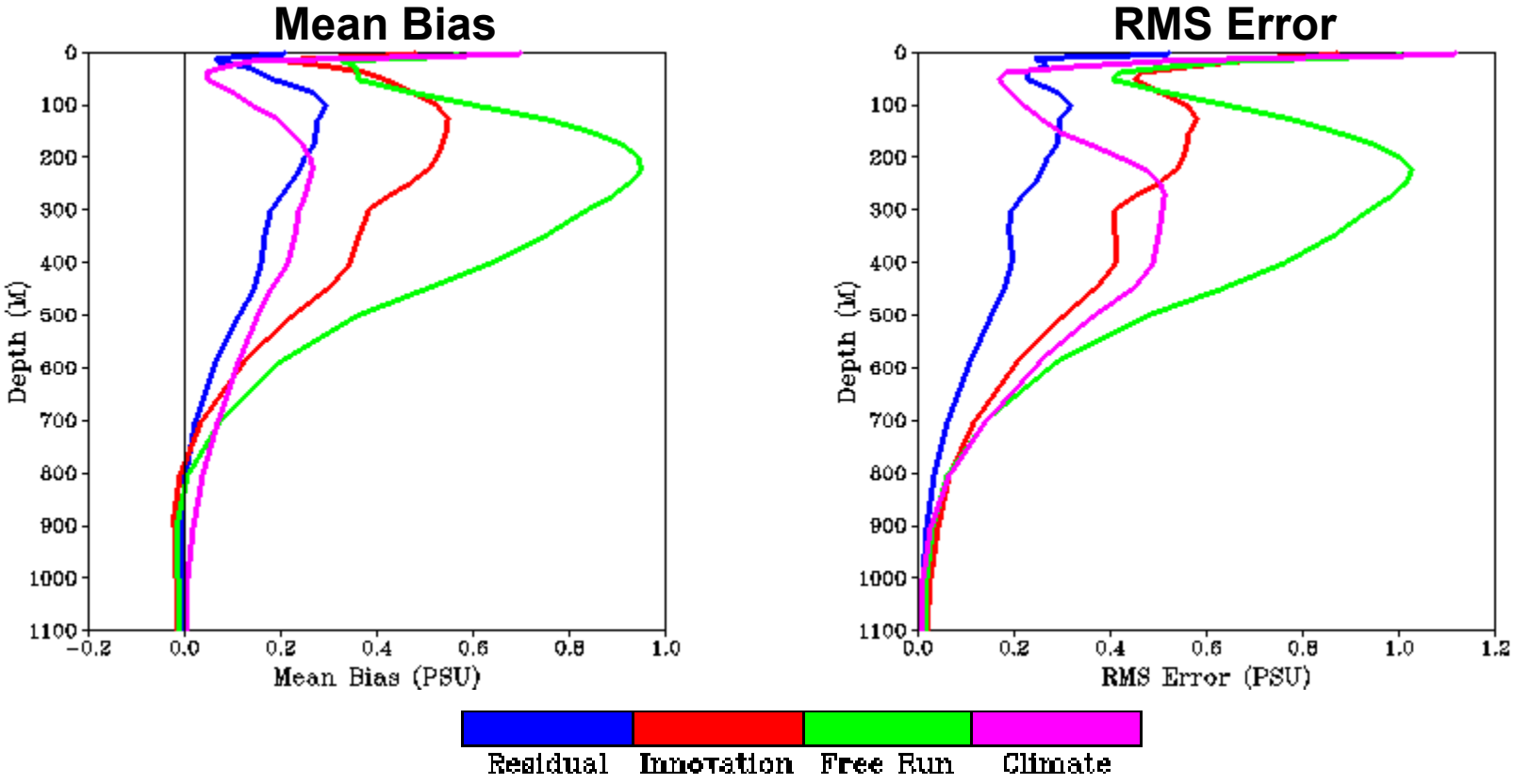
250 Total ! **28 measured salinity !**

In Situ Profile Temperature Verification



- residuals unbiased, magnitude residual RMS errors similar to obs errors
- 24-hr forecast innovations biased cold, maximum errors in thermocline
- model free run biased very cold at all depths (0.5 to 2.2 ˚C)

In Situ Profile Salinity Verification



- residuals biased fresh, magnitude residual RMS errors similar to obs errors
- 24-hr forecast innovations biased fresh, large errors near surface
- model free run biased fresh in upper 700 m water column, low errors at depth

Conclusions and Future Plans

Conclusions

- successive reduction in error from assimilation

  model free run >> 24-hr assimilative forecast > analysis nowcast

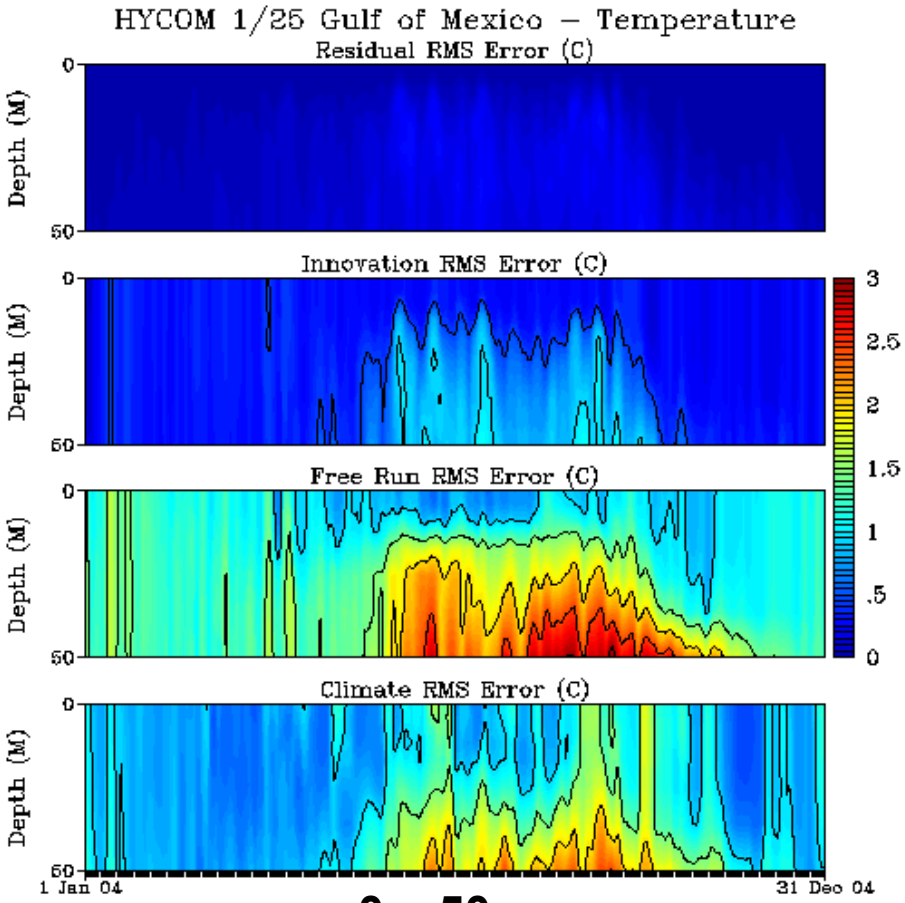
- no spurious time dependent model adjustments to data corrections
- model appears to be biased cold (all depths) and fresh (at depth)
  - difficult for assimilation to correct systematic model errors
  - conclusion based primarily on synthetic profiles at depth
  - need more *in situ* observations, better sampling in space and time

Plans

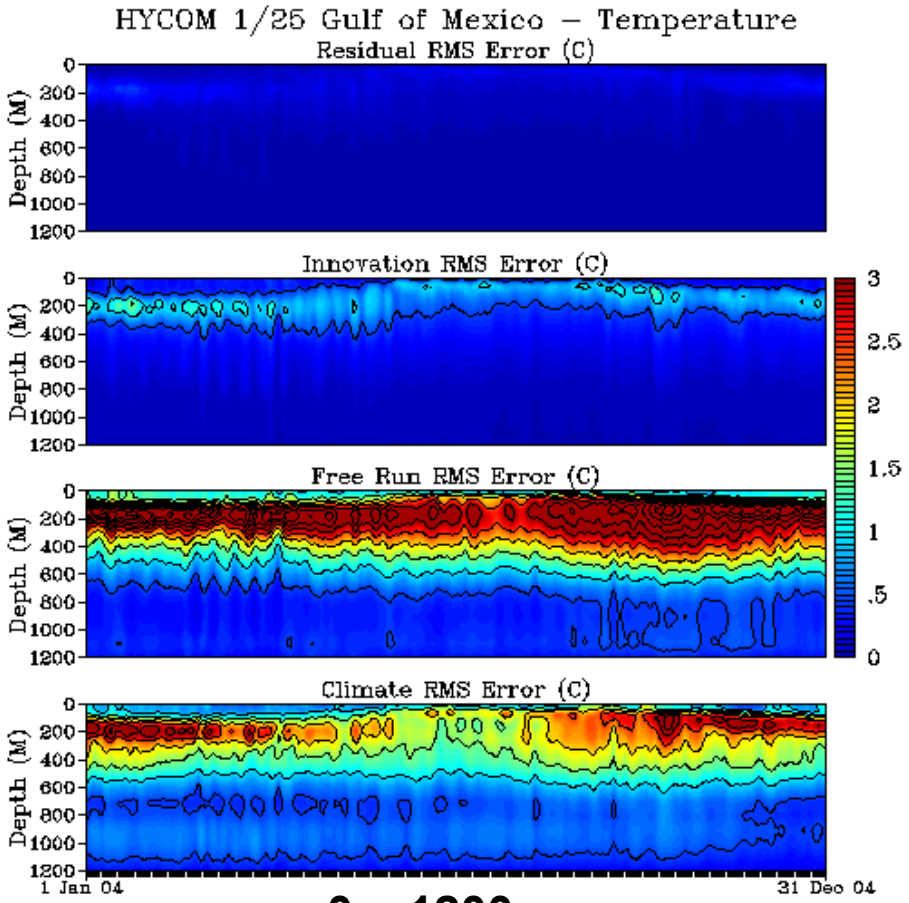
- compute analysis performance measures from innovation and residual time series
- prediction of independent data – MEDS, oil platform observations, etc
- examine oceanographic aspects of assimilative and model free runs

Temperature Validation – RMS Error

Expanded Depth Ranges



0 – 50 m



0 – 1200 m

- innovation errors in upper 50 m show small corrections in mixed layer
- innovation and forecast error corrections in upper 1200 m are restricted to depths shallower than ~600 m

END