# Predictability of the Middle Atlantic Bight Shelf Break Front given Satellite Data

## Modeling team:

*J Zavala-Garay*

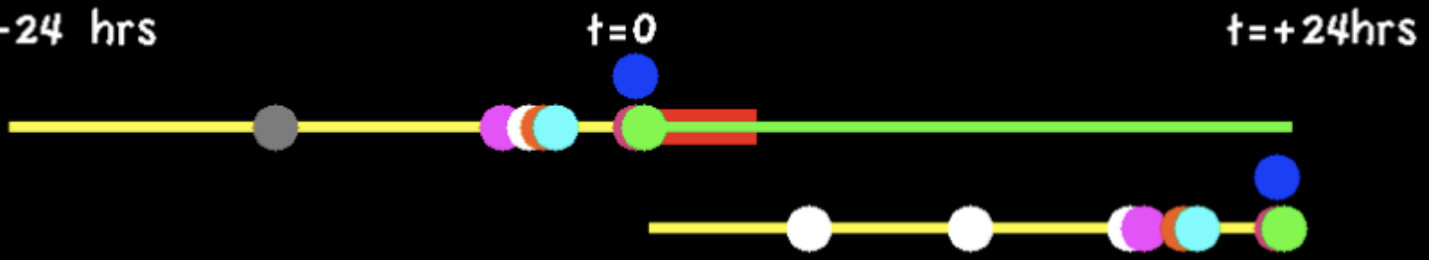
*John Wilkin, and Julia Levin*

IMCS, Rutgers, The State University of New Jersey, USA

jzavala@marine.rutgers.edu

http://marine.rutgers.edu

# A similar system to the one presented here is working operationally




@ 3:30am: Assimilation of last 3 days of observations (~4 hrs)

@ 7:30am: forecast for the next 58 hrs

@ 1:15pm and 10:15pm: UNH pushes via ftp the RADS data to RU

@ 10:00pm: get BF from HYCOM, interpolate, and correct T and S

@ 11:00am: get NAM surface forcing from NCEP

@ 11:30pm get 1-day composite RSS blended SST (B-SST) from CW

@ 12:00am get river discarge from USGS

@ 3:00am get IR SST passes, proc. errors, and combine with B-SST

@ 3:00am get and process CODAR

@ 3:10am prepare the Jason-1 along track data

# Outline

1. The Middle Atlantic Bight (MAB): overview
2. Observations
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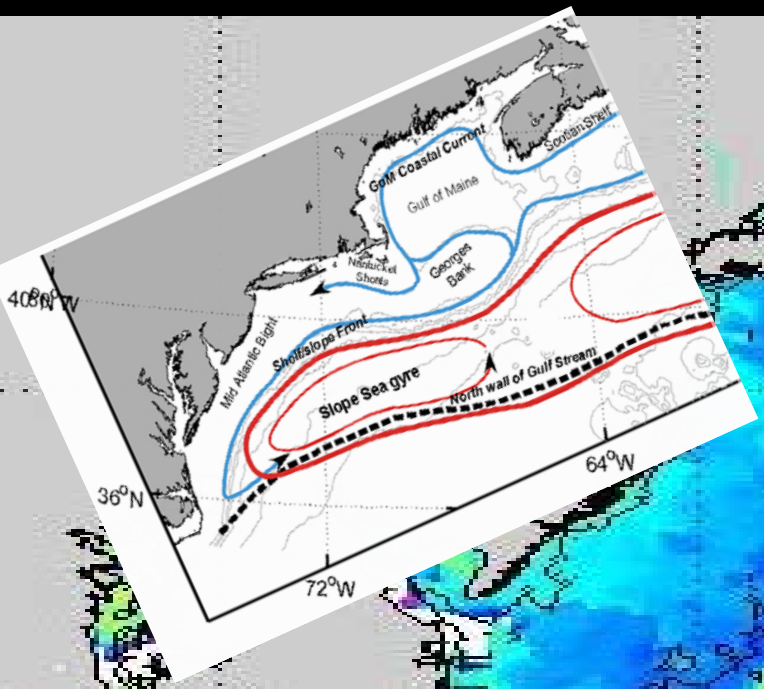
# Mid-Atlantic Bight (MAB) Shelf-slope front




- wide shallow shelf separated from Gulf Stream by the Slope Sea
- Shelf/Slope Front (~0.3 m/s) at shelf edge
- Gulf Stream rings frequently enter Slope Sea and impact shelf
- Strong tides
- Shelf variability highly affected by atmospheric forcing

Objective: nowcast and forecast 3D variability given surface information from satellites (SSH and SST).

- eddies are resolved by multi-satellite SSH and SST gridded
- MAB SSH variability is more anisotropic with shorter length scales due to flow-topography interactions

Use along-track altimetry and individual passes of AVHRR temperature:

- 4DVar uses the data at time of satellite pass
- model “grids” along-track data by simultaneously matching observations and dynamical constraints

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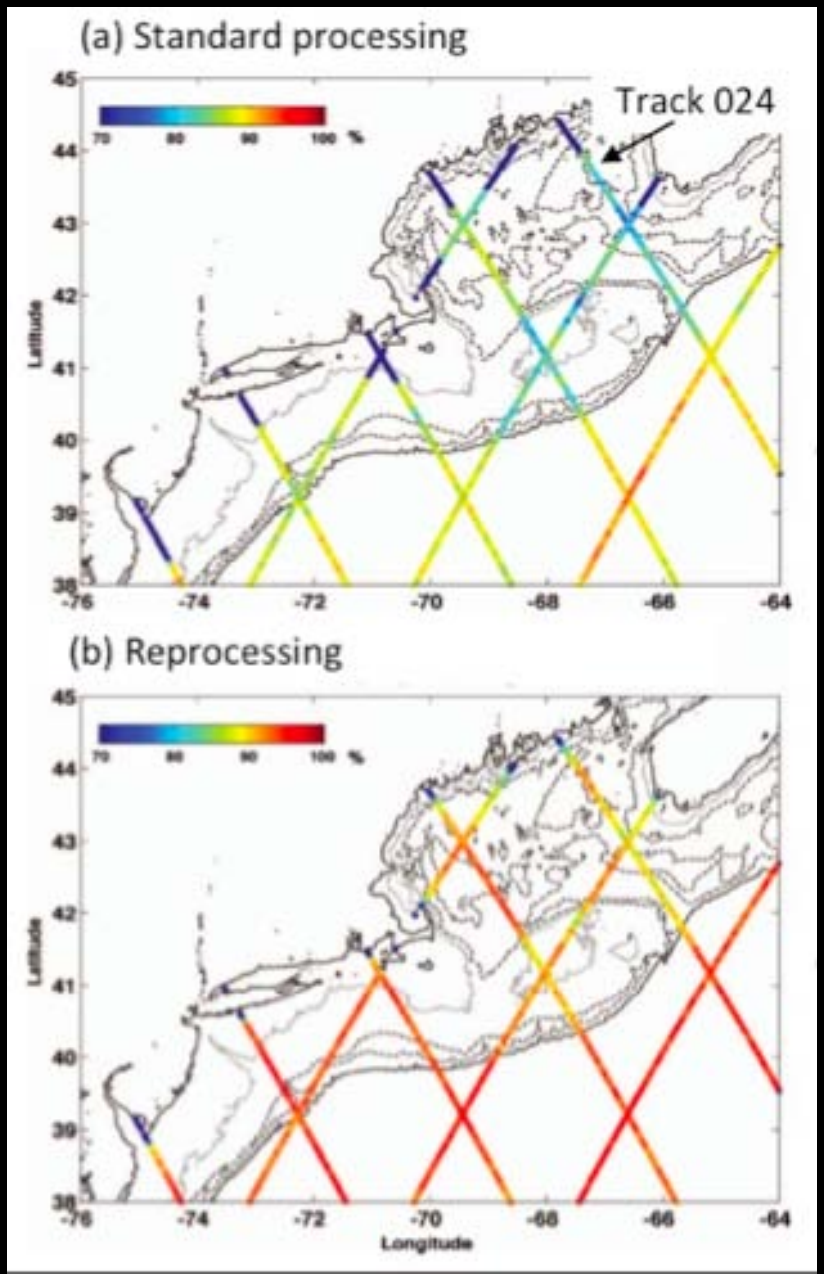
# Data Processing: SSH

re-processed along-track data in order to extend the observations of current and future altimeters as close as possible to the coast.

*Details in Feng, H. and D. Vandemark, 2011. Altimeter Data Evaluation in the Coastal Gulf of Maine and Mid-Atlantic Bight Regions (Marine Geodesy)*




*Feng and Vandemark*, 2011

# Data Processing: SSH

ROMS assimilates total SSH defined as the sum of the Mean Dynamic Topography (MDT) plus the SSH anomaly (measured by the altimeter) plus tides.

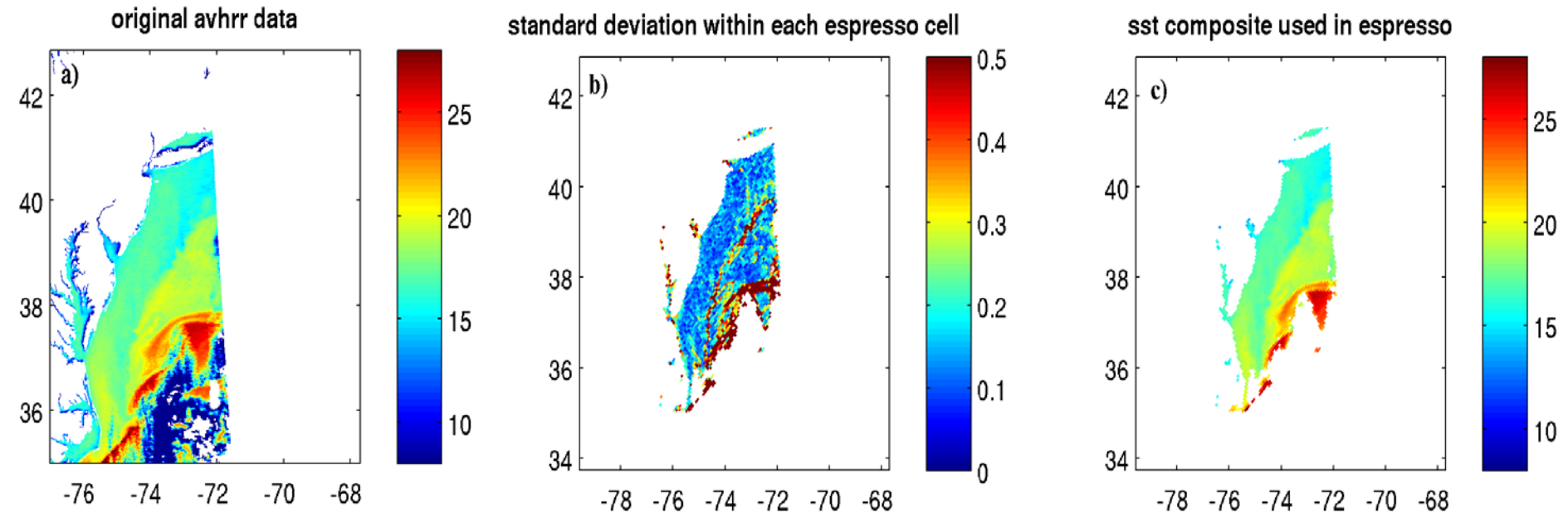
(Presented last week by J. Wilkin) Mean Dynamic Topography (MDT) is computed by 4DVAR analysis of a regional 3-D T-S climatology computed from historical hydrographic data and long-term currents. 4DVAR analysis is forced with annual mean meteorology and open boundary conditions

The SSH *observations* are *adjusted* to include model tide

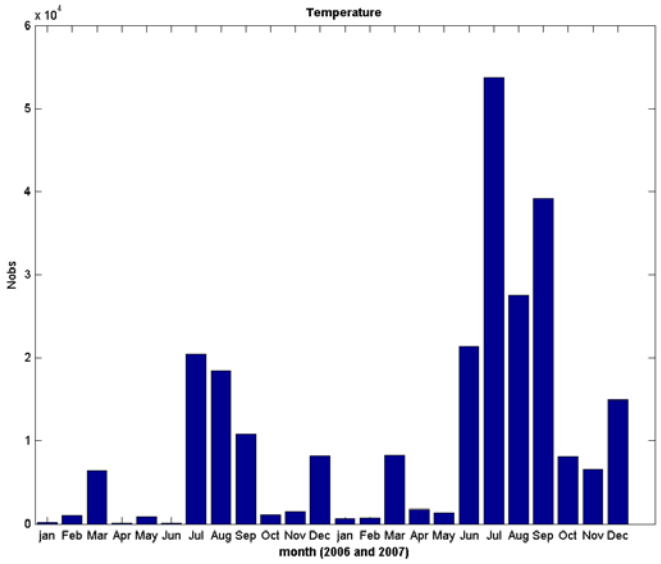
assimilate – high frequency mismatch of model and altimeter is minimized and cost function is, presumably, dominated by sub-inertial frequency dynamics.

# Data Processing: SST

SST: mean and std within each model grid-cell from individual passes of infrared data (~6 passes per day) and complemented with blended (MW + IR) where SST is not observed by the 6 passes of AVHRR



# Large set of T and S observations from CTD, gliders, XBTs for 2006 (SW06) and 2007



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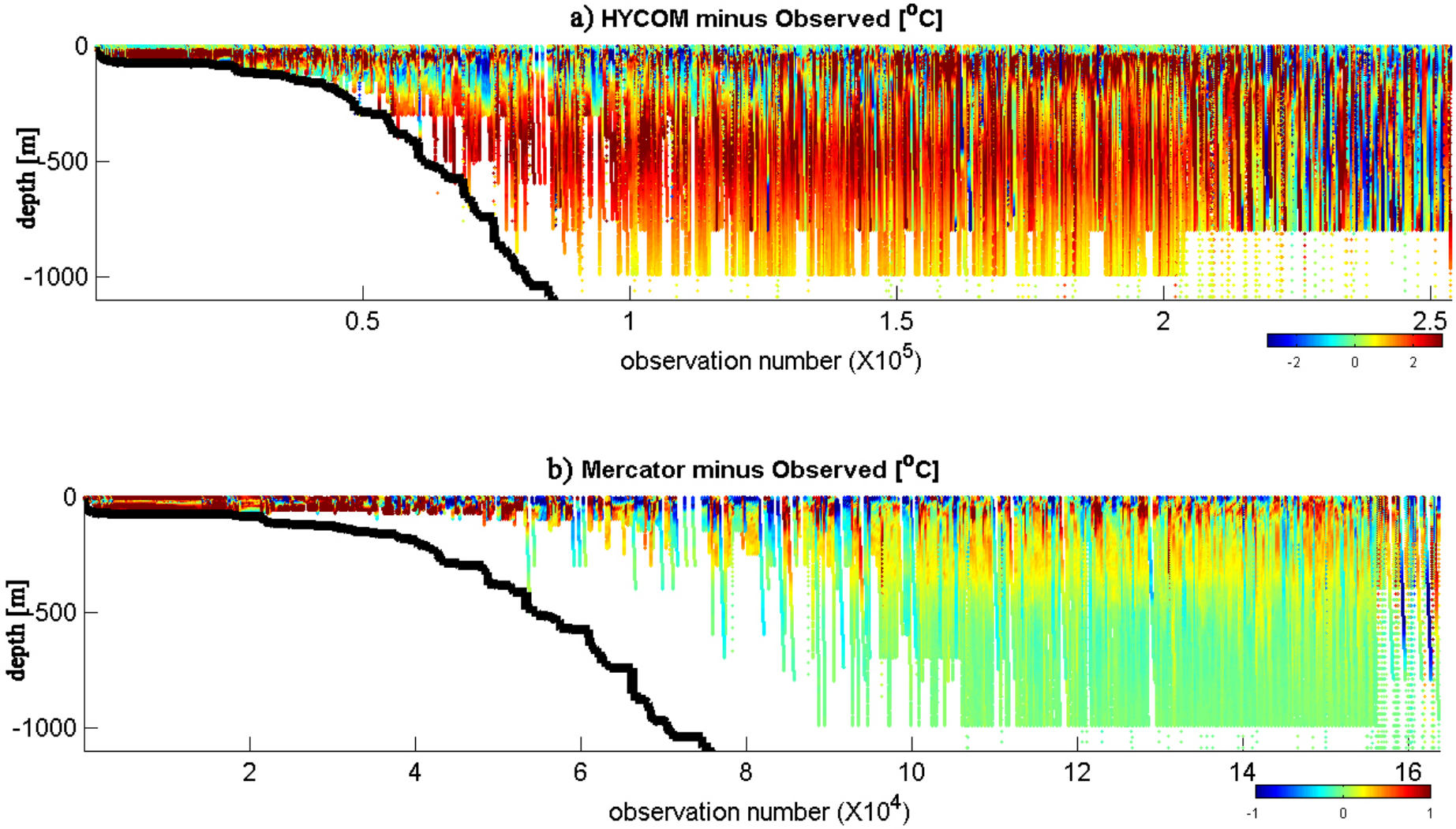
# ROMS is unique in that three variants of 4DVar data assimilation are supported as described by Moore et al 2011

- A primal formulation of incremental strong constraint 4DVar (I4DVAR)
- A dual formulation based on a physical-space statistical analysis system (4D-PSAS)
- A dual formulation representer-based variant of 4DVar (R4DVar)

- I4DVar can adjust initial, boundary, and surface forcing.
- In this work we adjust the initial conditions: IS4DVAR

Global models have have biases, which propagate to the regional model.

Before using IS4DVAR one should reduce as much as possible such biases in the regional model



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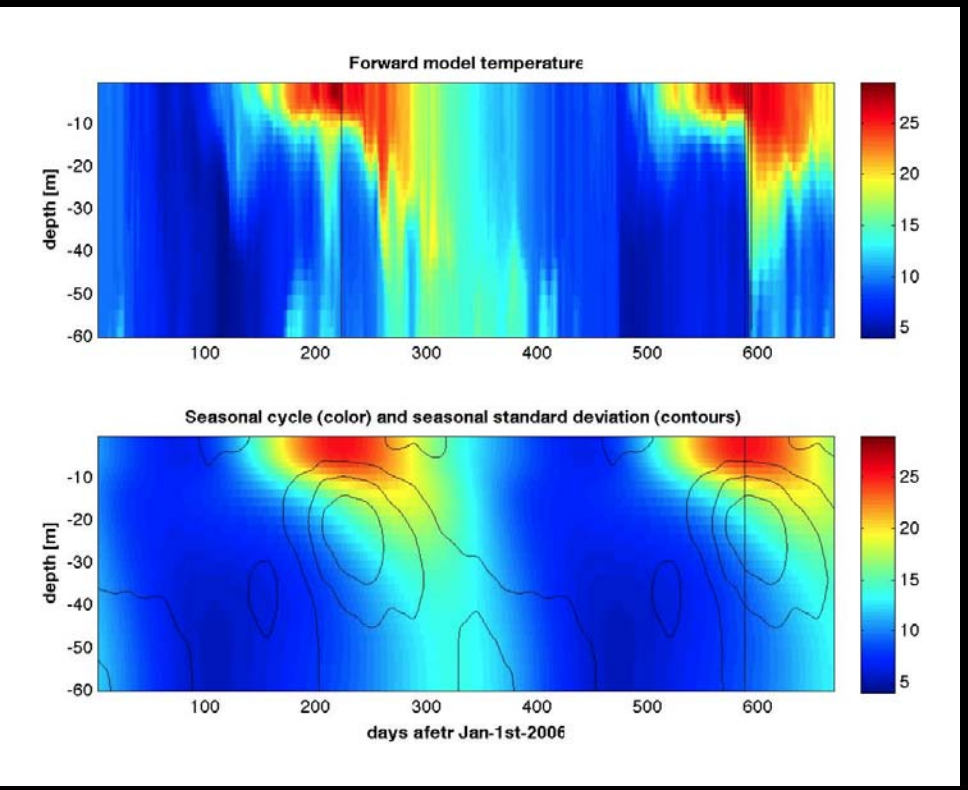
placed the seasonal climatology of temperature and salinity fro
HYCOM by that derived from observations
gh resolution climatology from historical data) before using it t
force ROMS.

Background error covariance scaled by an standard deviation file.

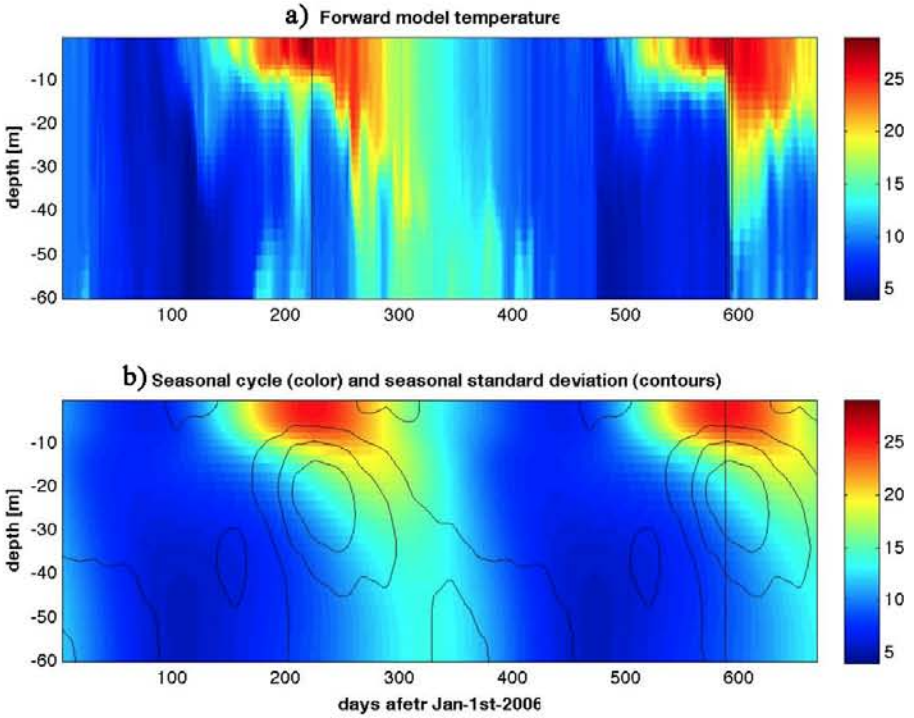
Strong seasonality in the MAB shelf background field -> Strong seasonality in the standard deviations.

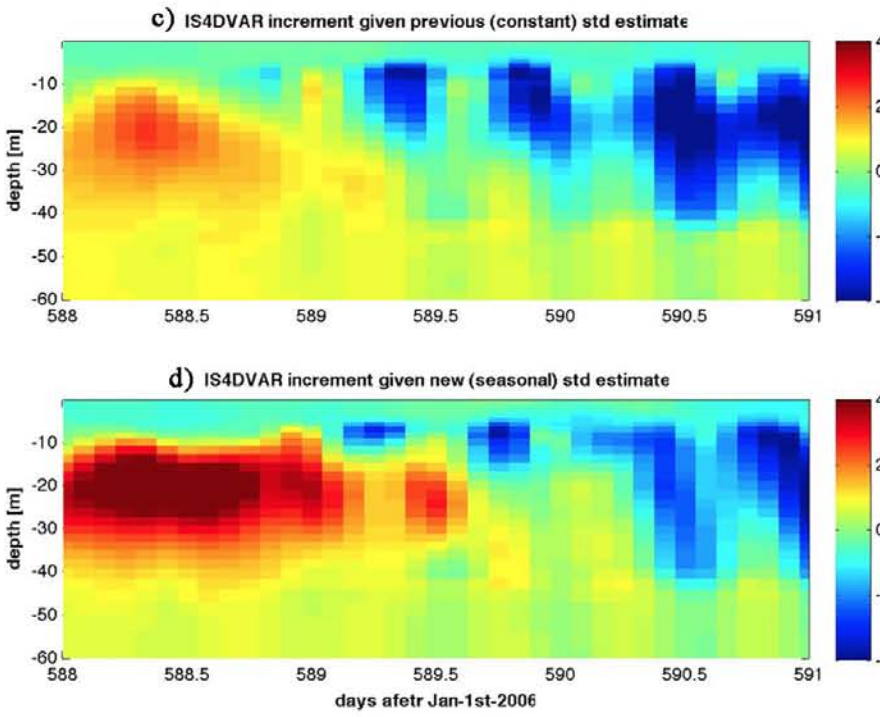


Background error covariance scaled by an standard deviation file.

Strong seasonality in the MAB shelf background field -> Strong seasonality in the standard deviations.

Impact of seasonal std:



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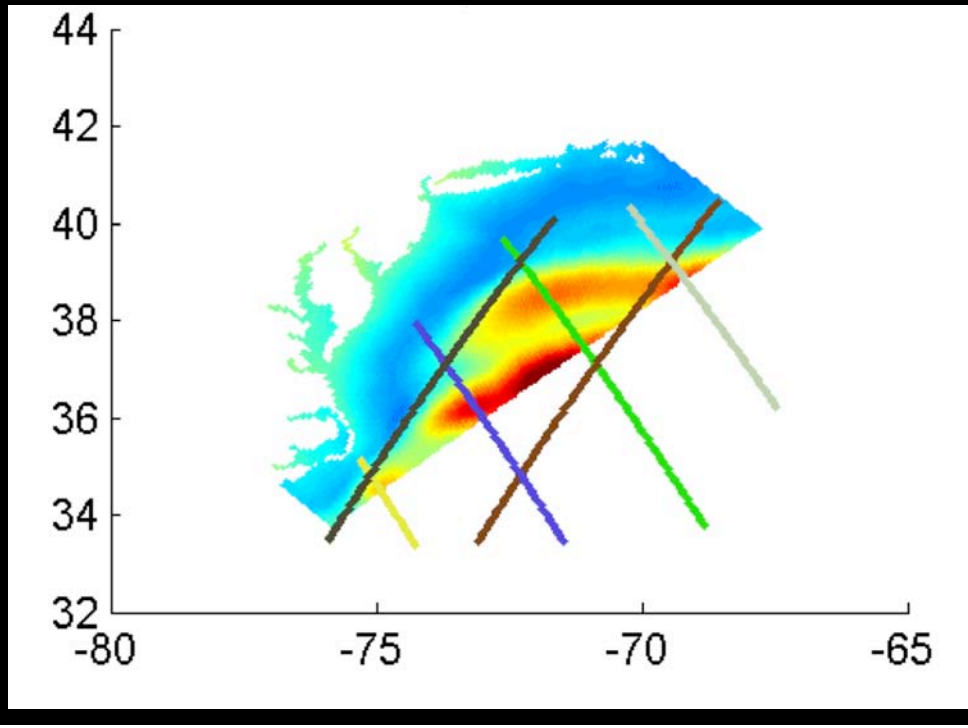
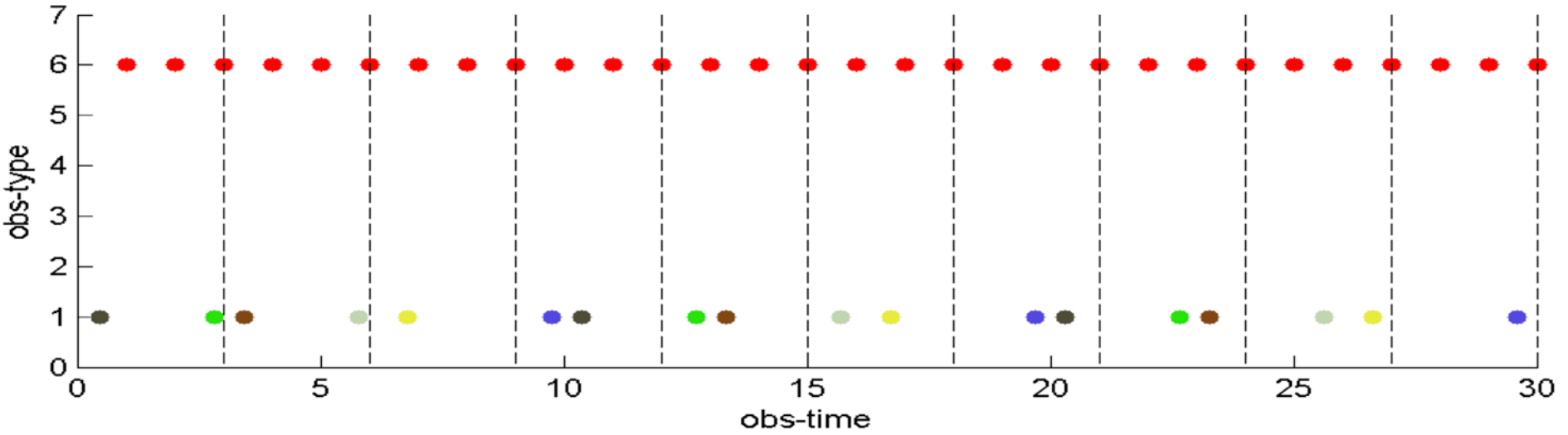
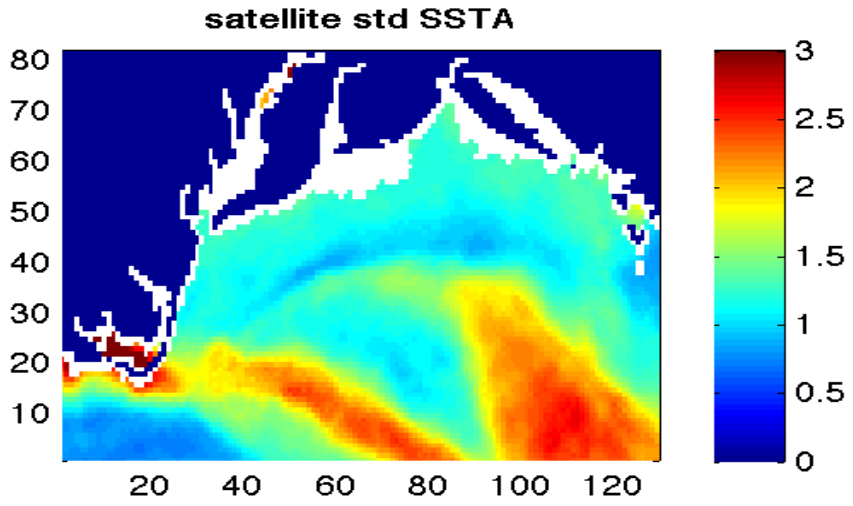
# Sequential assimilation of SSH and SST

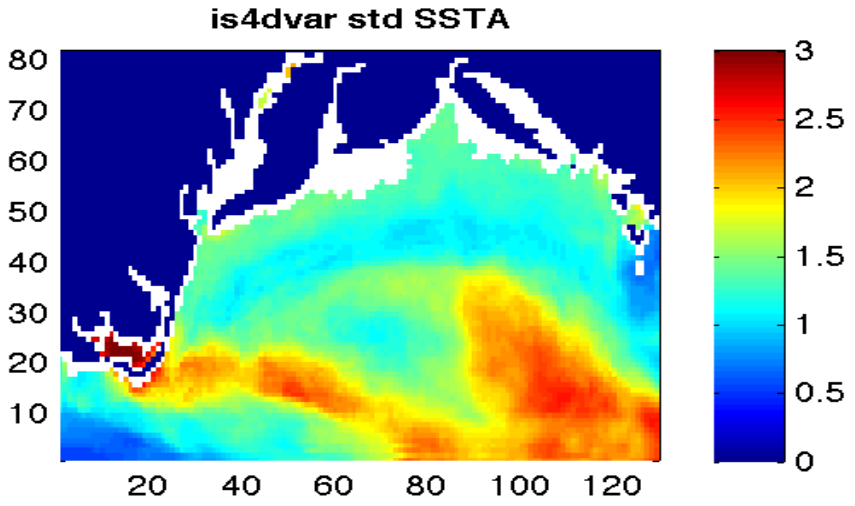
- Reference time is days after 1-1-2006
- 3-day assimilation window (AW)
- Daily IR + blended SST (available real time)
- SSH = Dynamic topography + ROMS tides + Jason-1 SLA (repeated three times)
- For the first AW we just assimilate SST to allow the tides to ramp up.

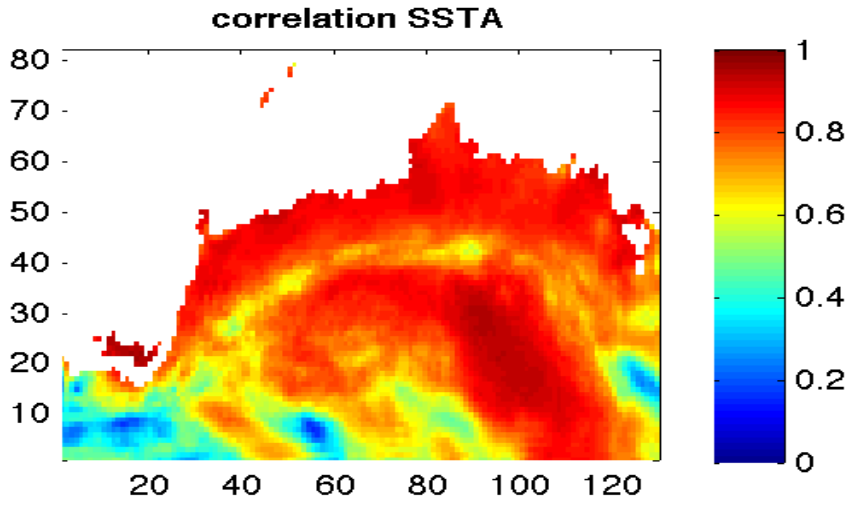


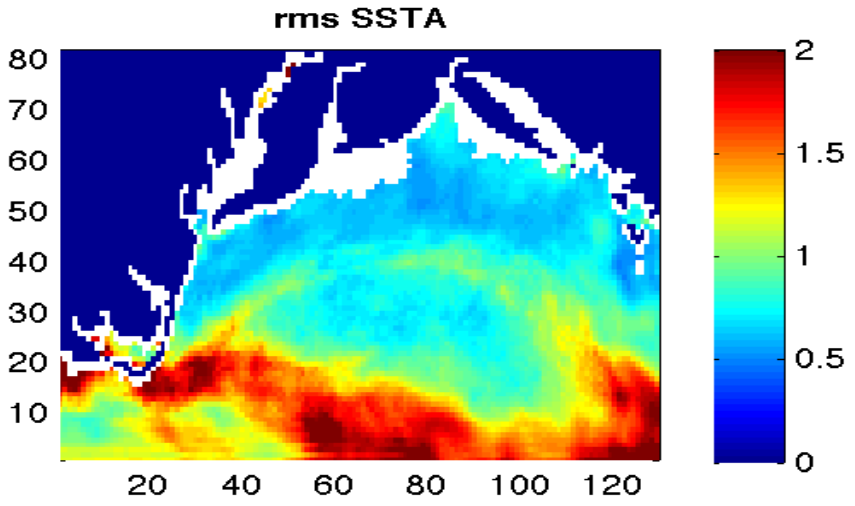



# Skill in hindcasting mesoscale SST by the assimilation system

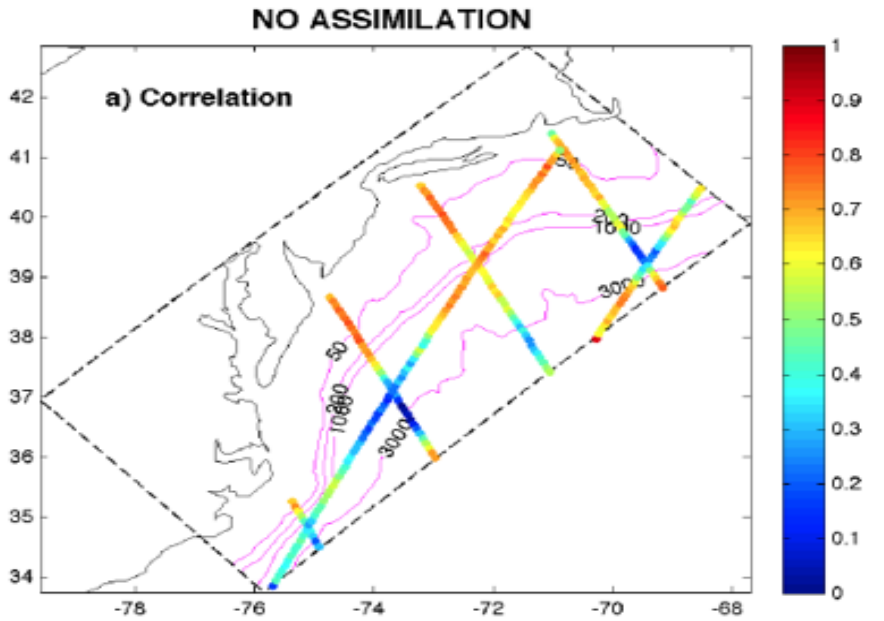


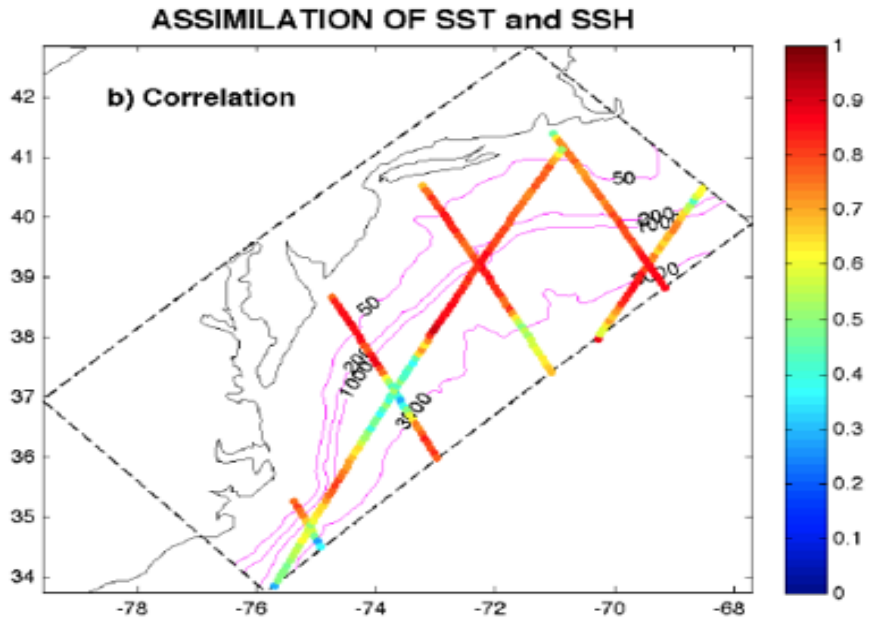



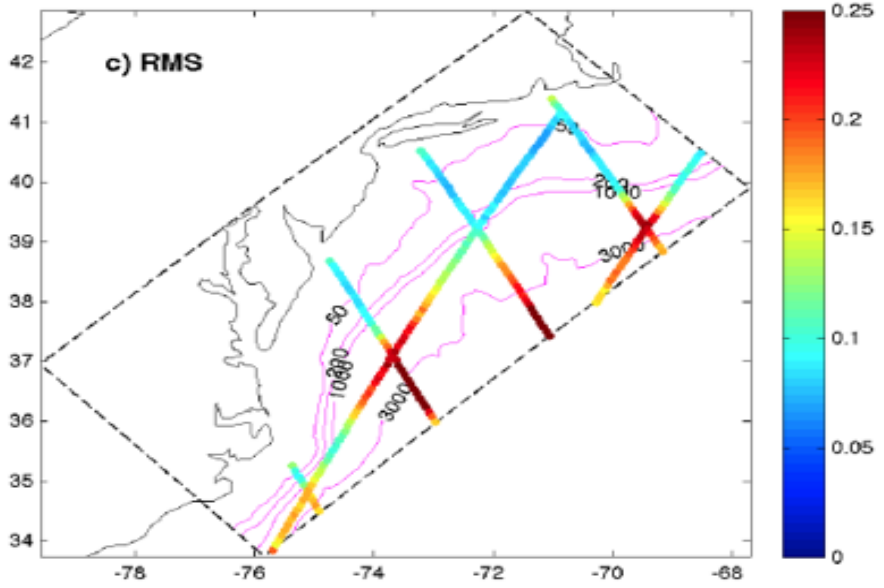



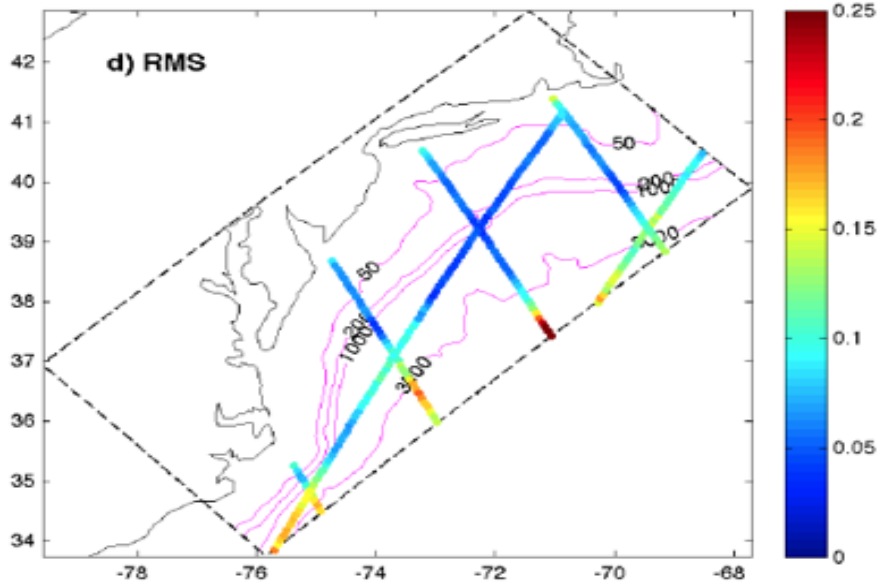



# Correlation and RMS error between Jason along-track data and model SSHA before and after data assimilation

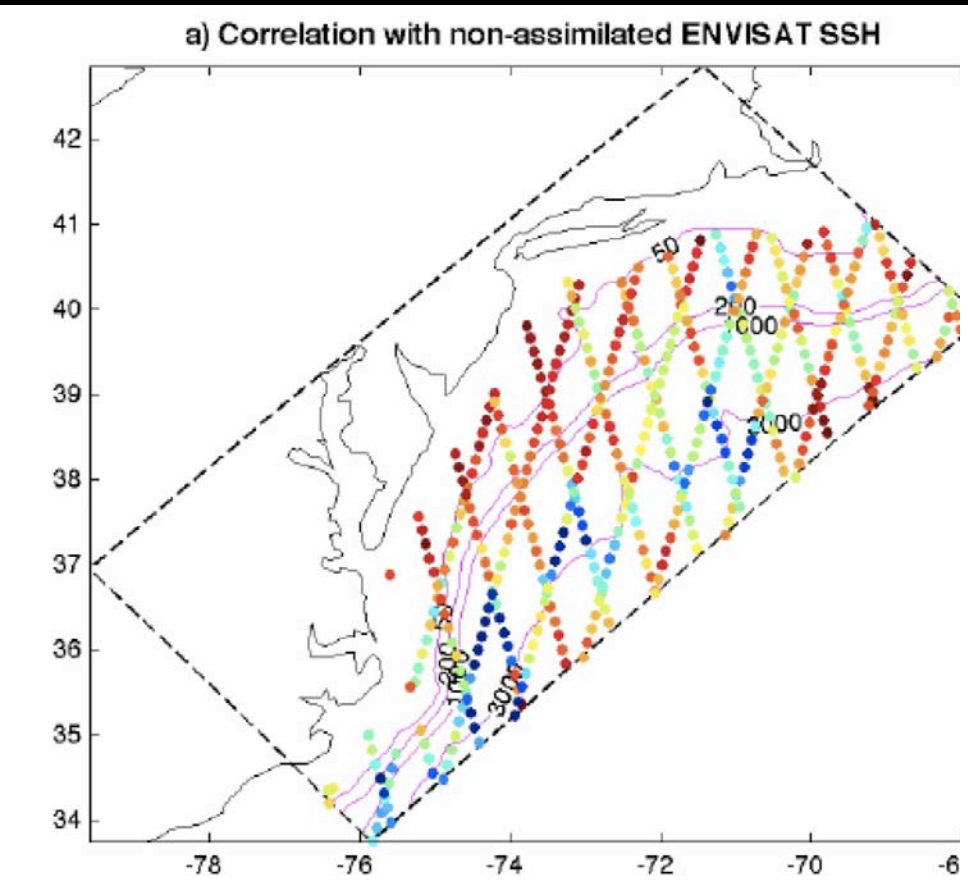


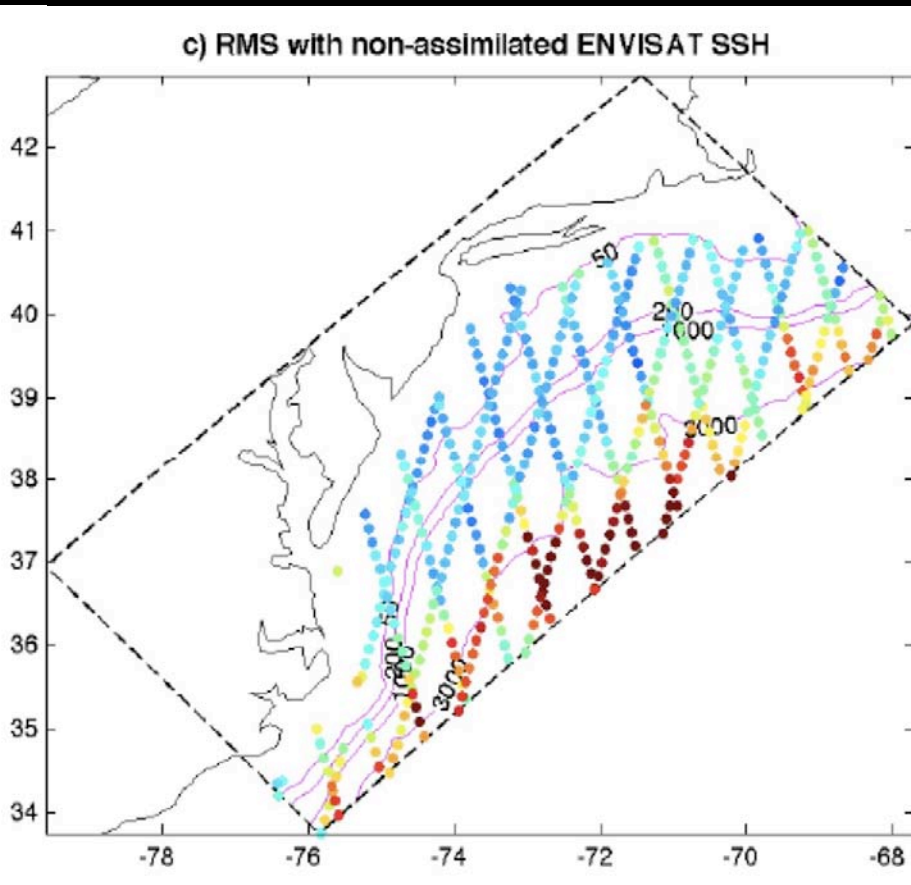



# Correlation and RMS error between NOT ASSIMILATED ENVISAT along-track data and model SSHA and vertical skill in temperature



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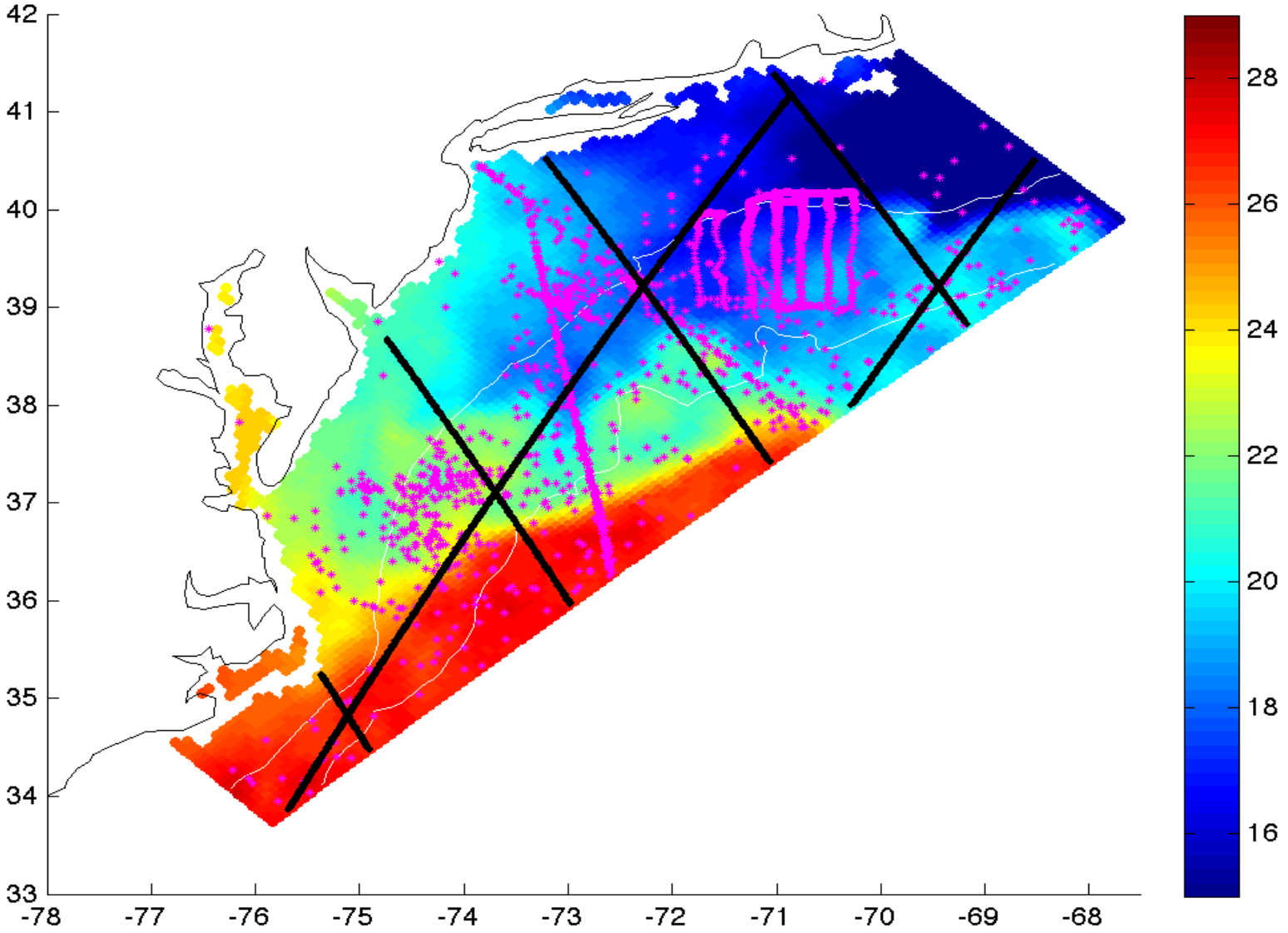
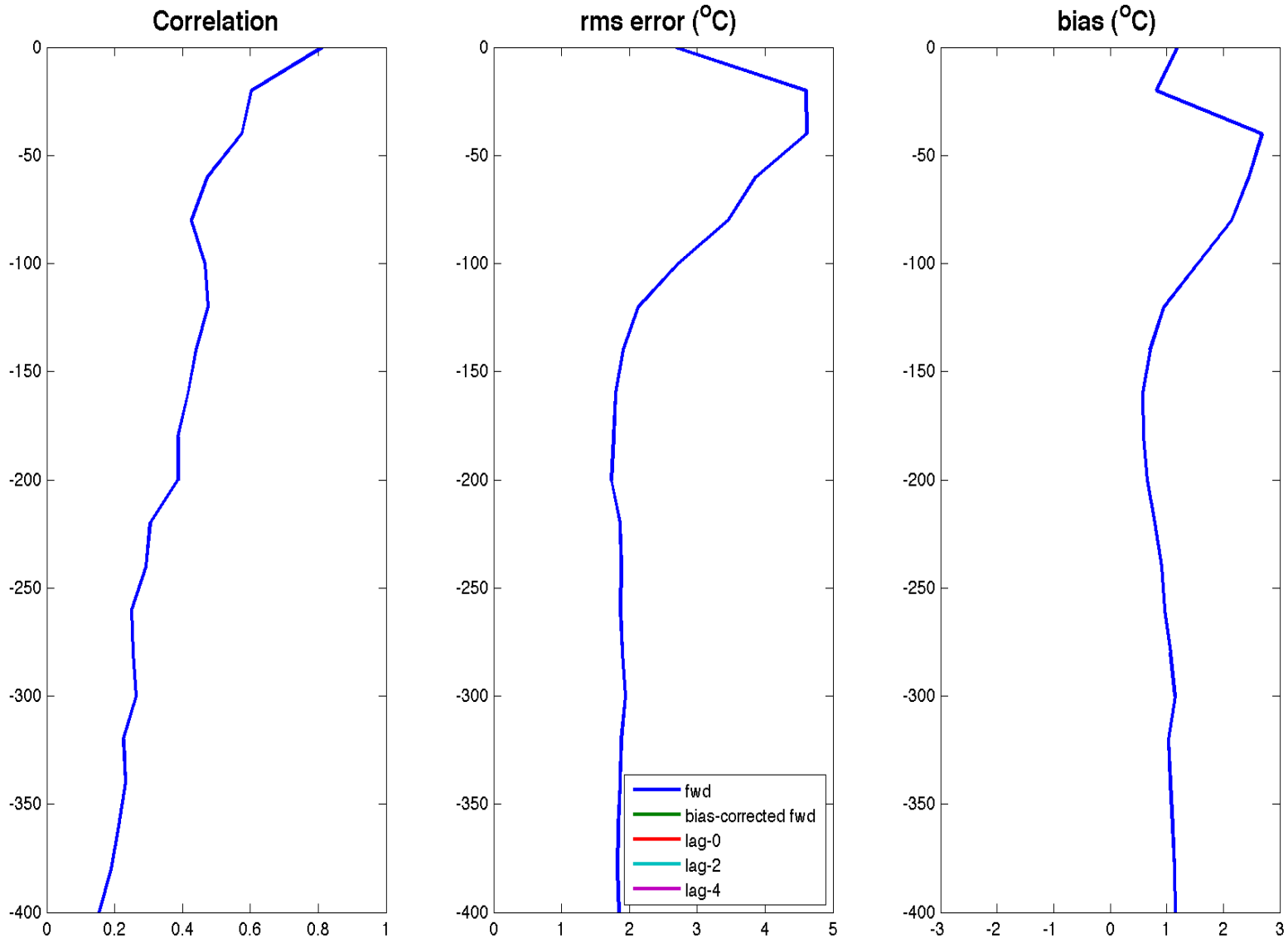
# Hydrographic data (magenta) and along-track data positions (SST is a day of July 2007)



# Skill in hindcasting/forecasting NOT ASSIMILATED subsurface temperature



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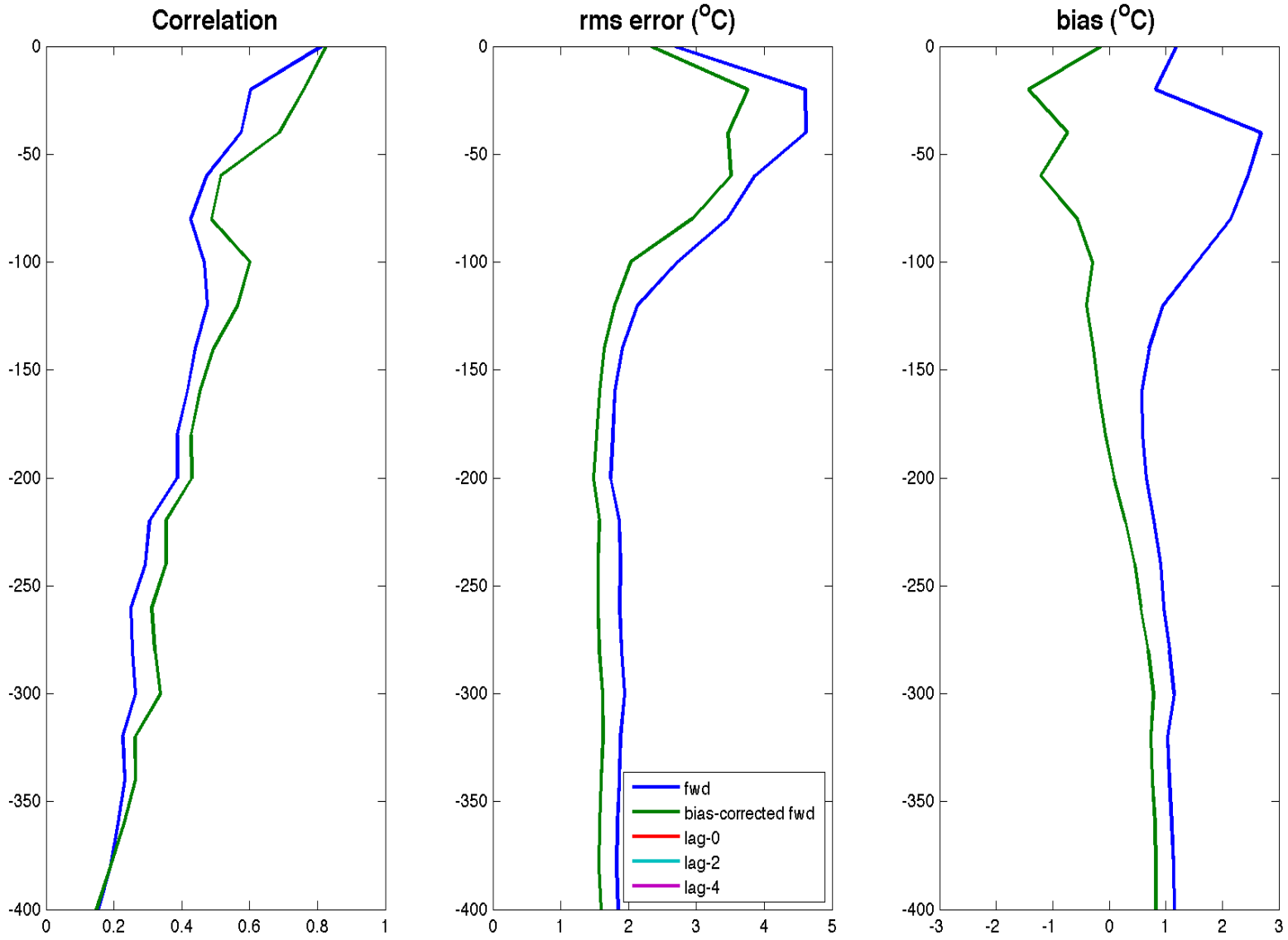

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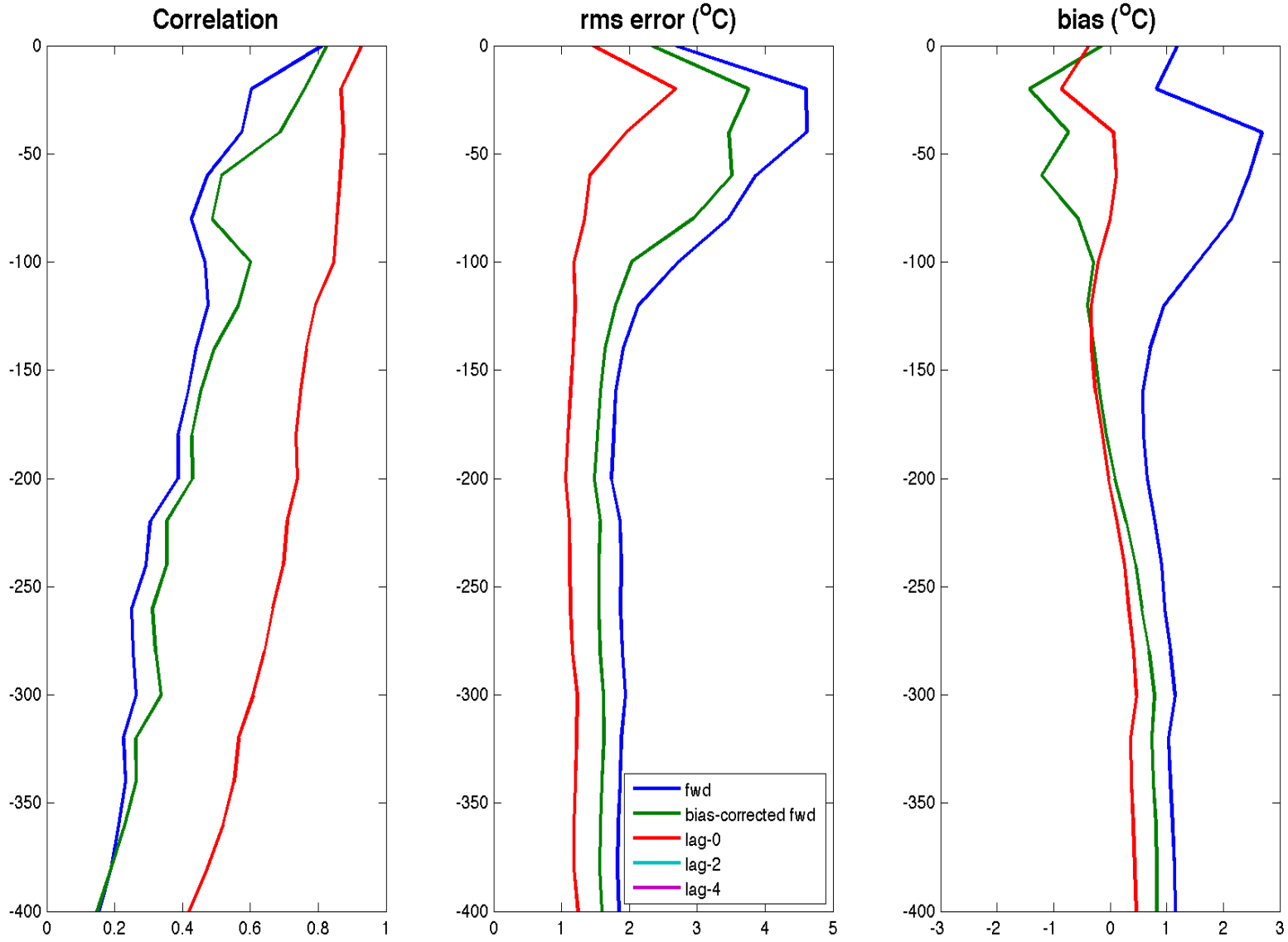

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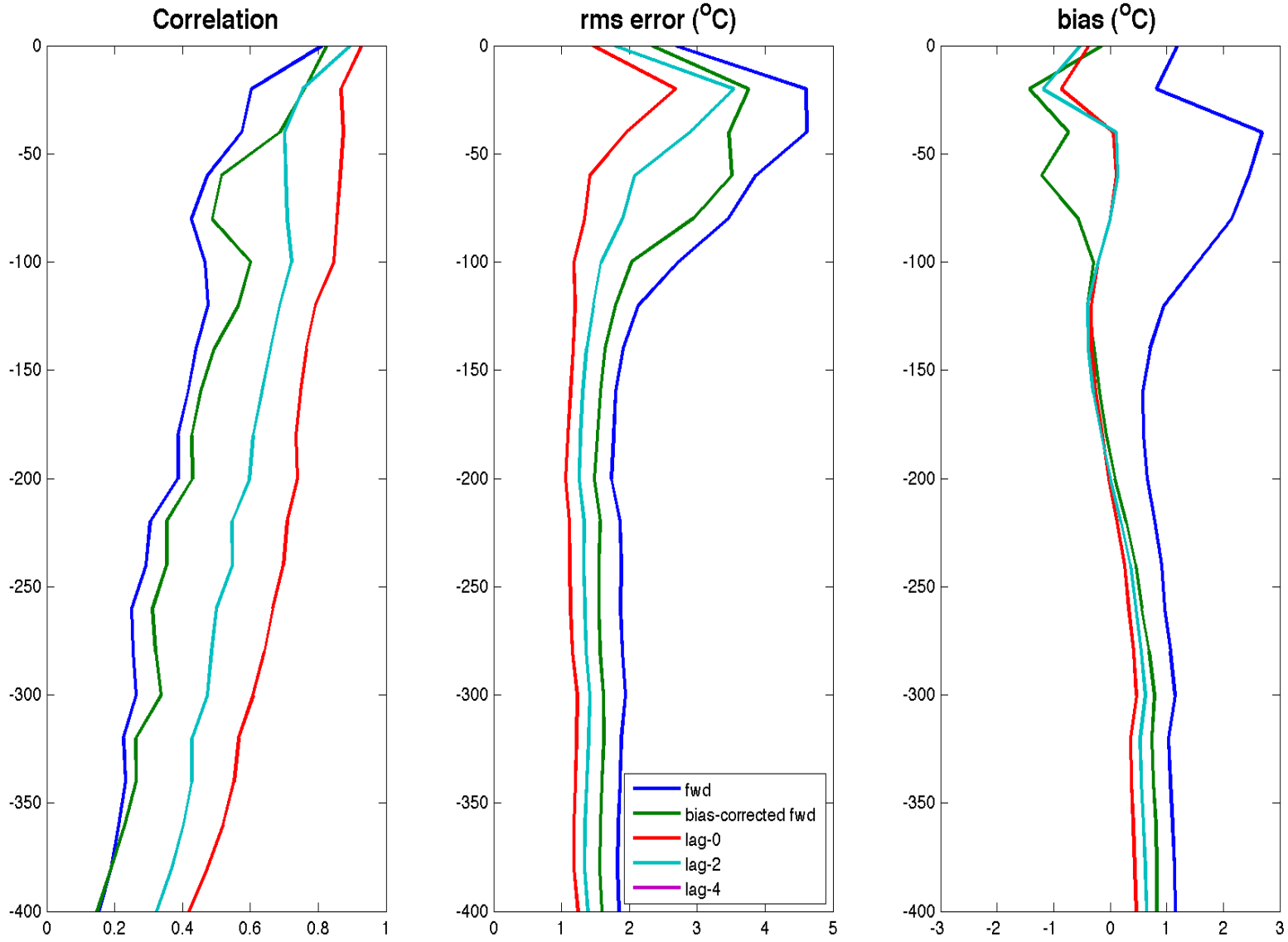

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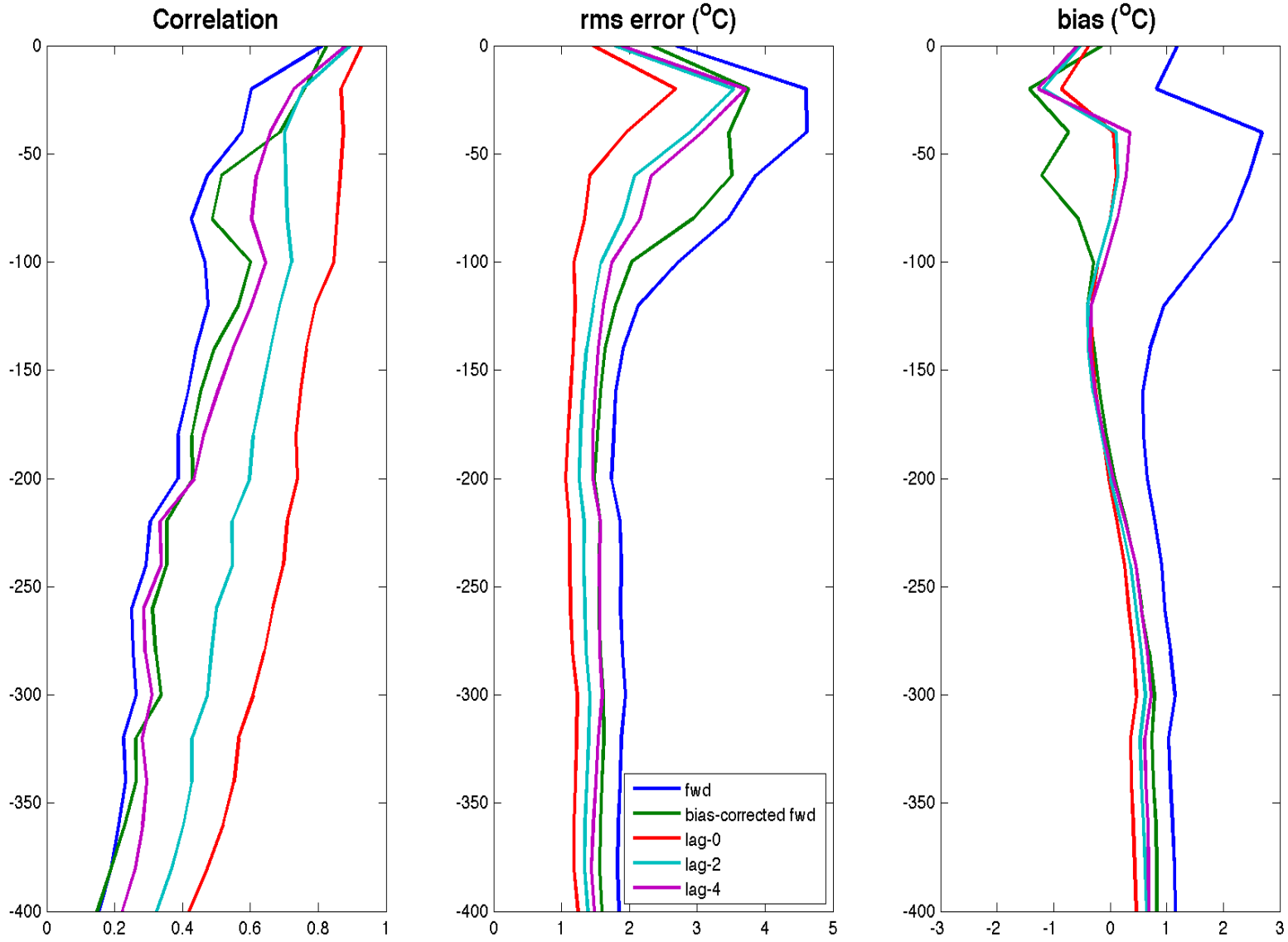

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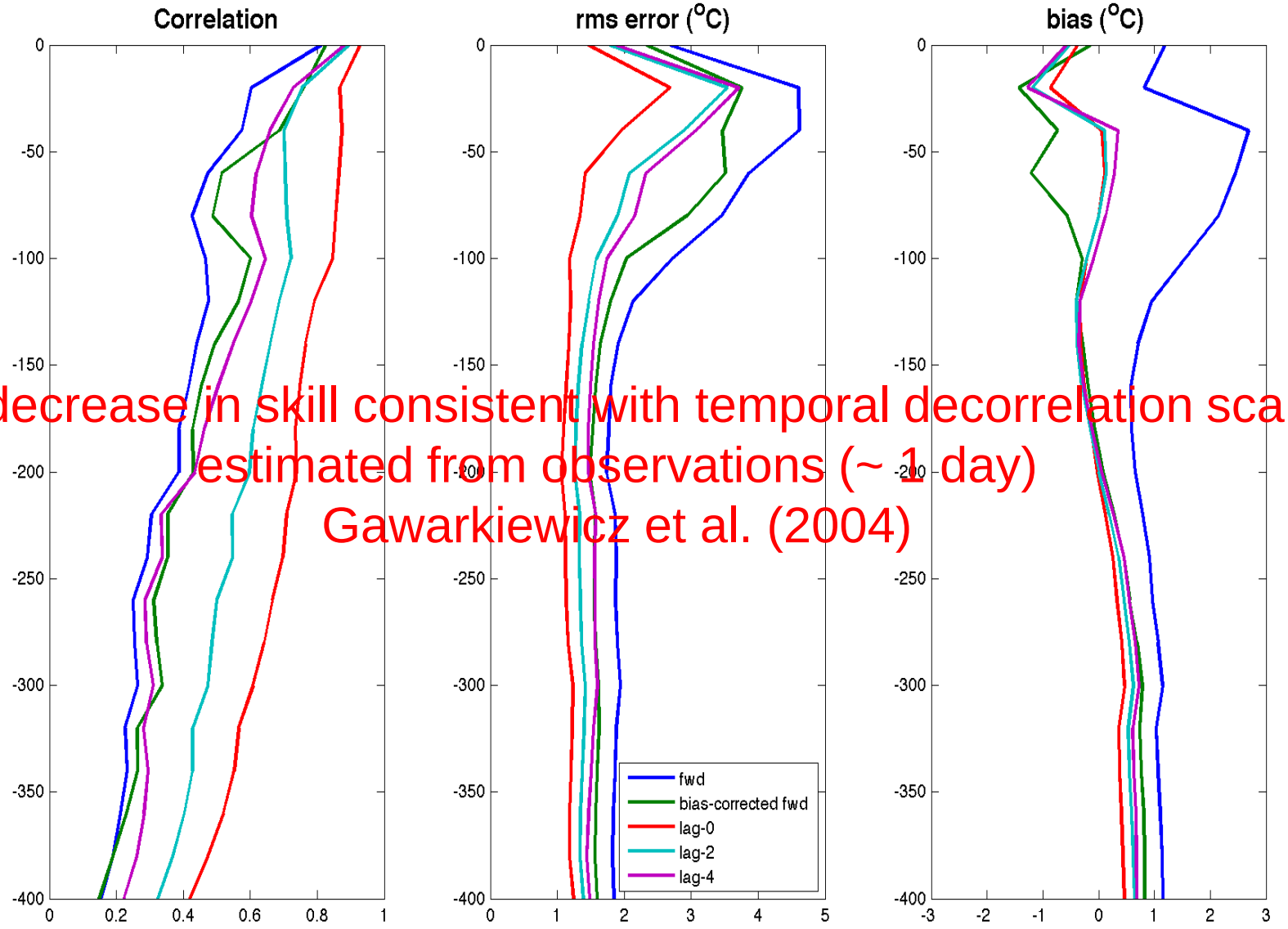


Fast decrease in skill consistent with temporal decorrelation scales estimated from observations (~ 1 day)

Gawarkiewicz et al. (2004)

# Summary

Variational methods are a very useful tool to combine model physics with coastal observations from different instruments including satellite data (SSH and SST).

We have demonstrated its applicability in a very complex coastal region (the MAB shelf-break front): strong tides, strong spatial gradients of temperature and salinity, wide shelf interacting with deep ocean eddies, etc.

Useful tool to provide gridded maps of SSH, … and 3D state of the ocean

Prediction skill is degraded very quickly in the shelf-break, consistent with decorrelation time scales estimated from observations and our own model.

The system is working operational assimilating also CODAR surface currents


jzavala@rmarine.utgers.edu