Satellite-based Ocean Analysis for the Mid Atlantic Bight

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RUTGERS

Extension/improvement from a previous analysis: from 2006-2007 to 2006-2012, improved boundary forcing, and more observations (all seasons and depths well represented).

A similar system to the one presented here that also assimilates CODAR surface currents is working operationally. Presented by J. Wilkin in the Near Real Time Products and Applications Splinter session.

Real-time Data Assimilative Modeling of the U.S. Mid Atlantic Bight

Outline

1. The Middle Atlantic Bight (MAB): overview
2. Variational Data Assimilation in the Regional Ocean Modeling System (ROMS)
3. Assimilated Observations
4. Fit to satellite data
5. Skill in hindcasting non-assimilated subsurface observations
6. Summary

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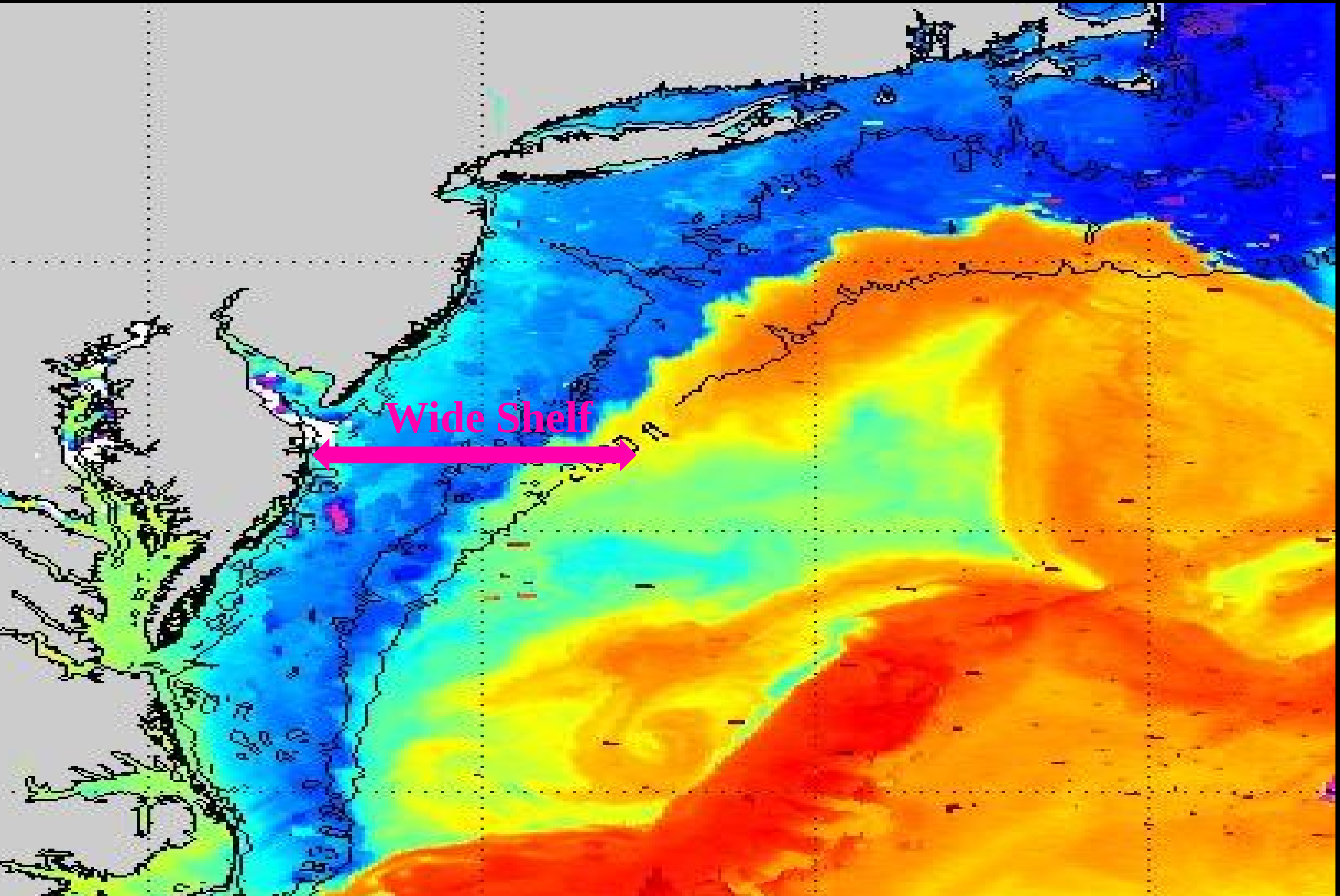
Mid-Atlantic Bight (MAB)



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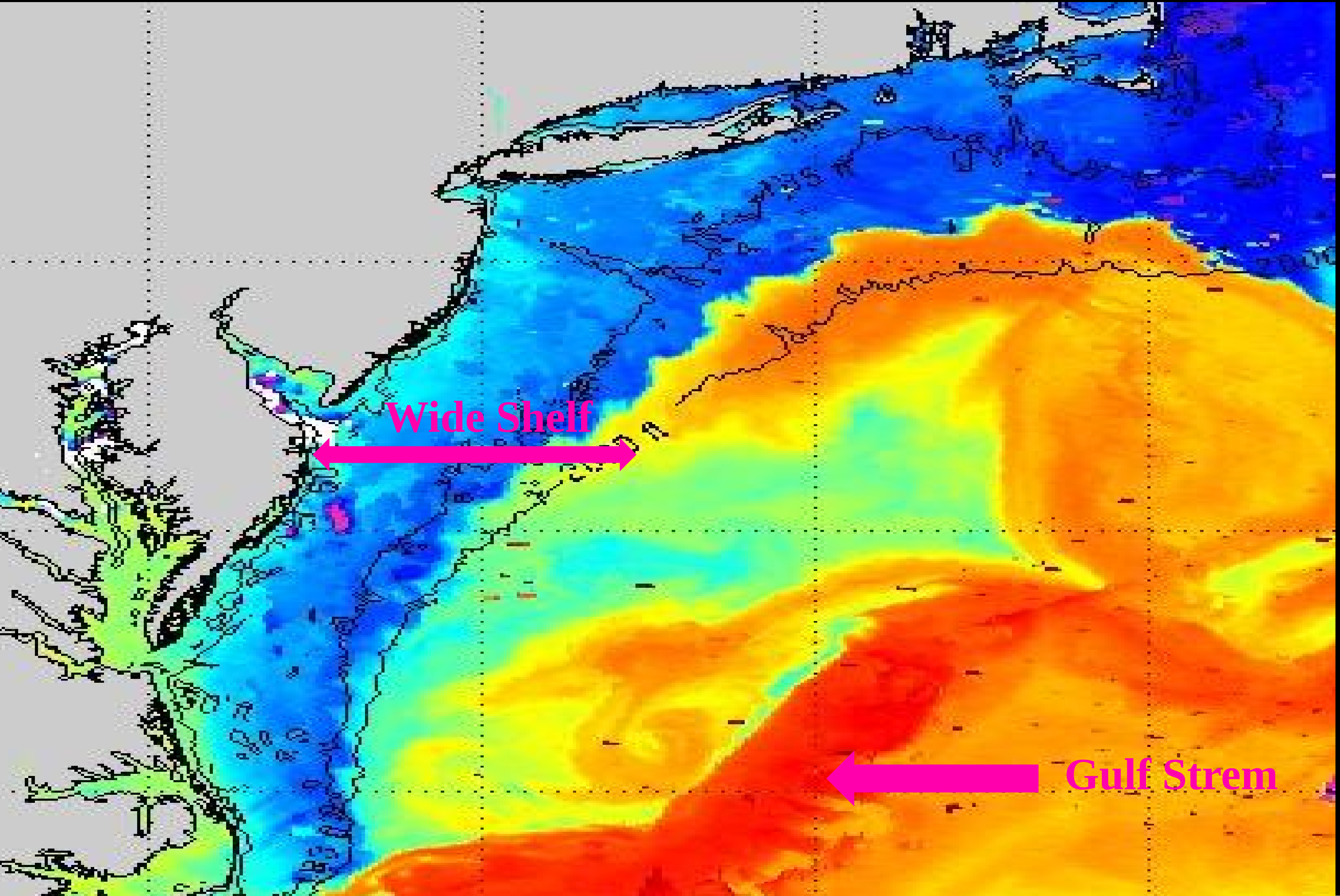

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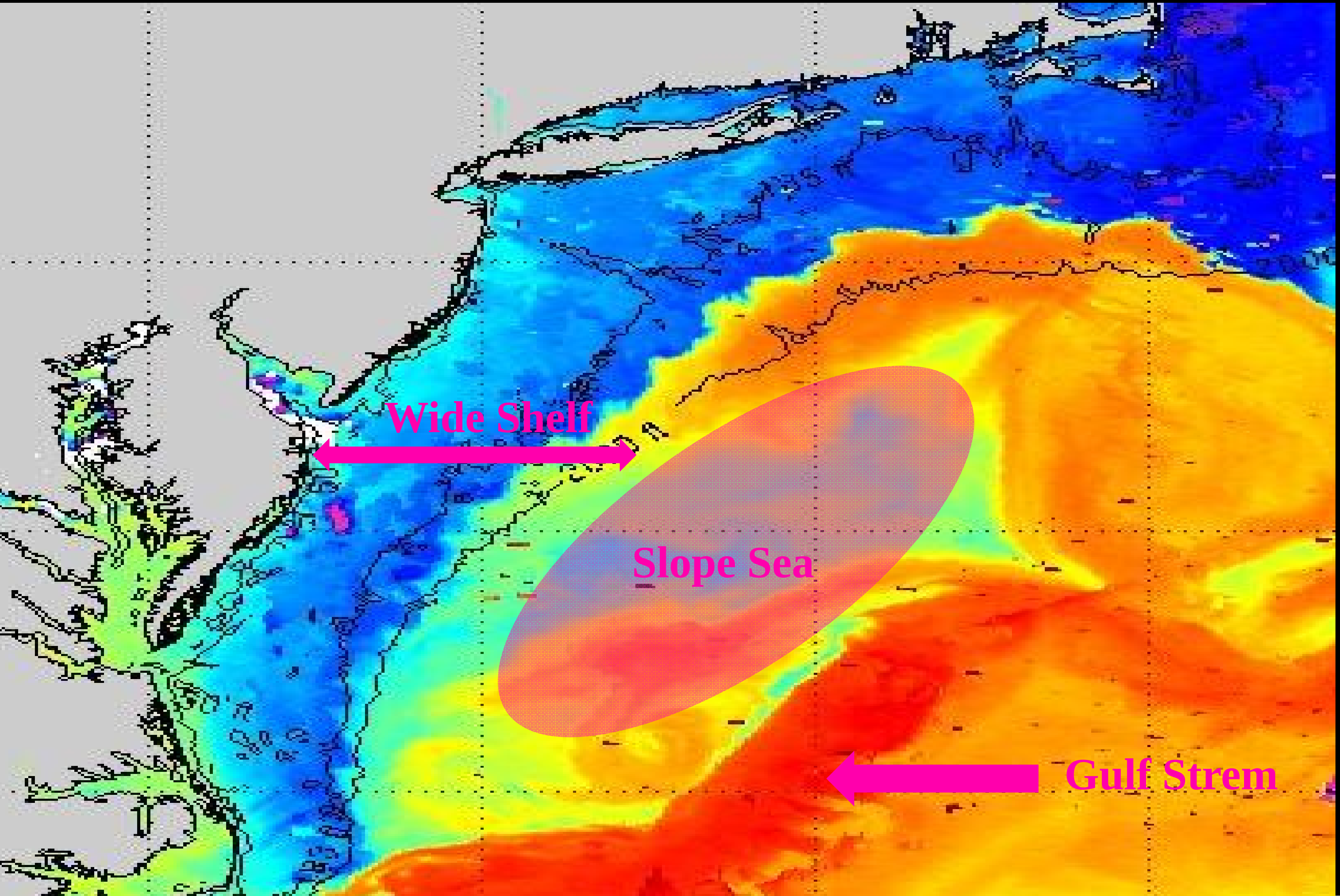

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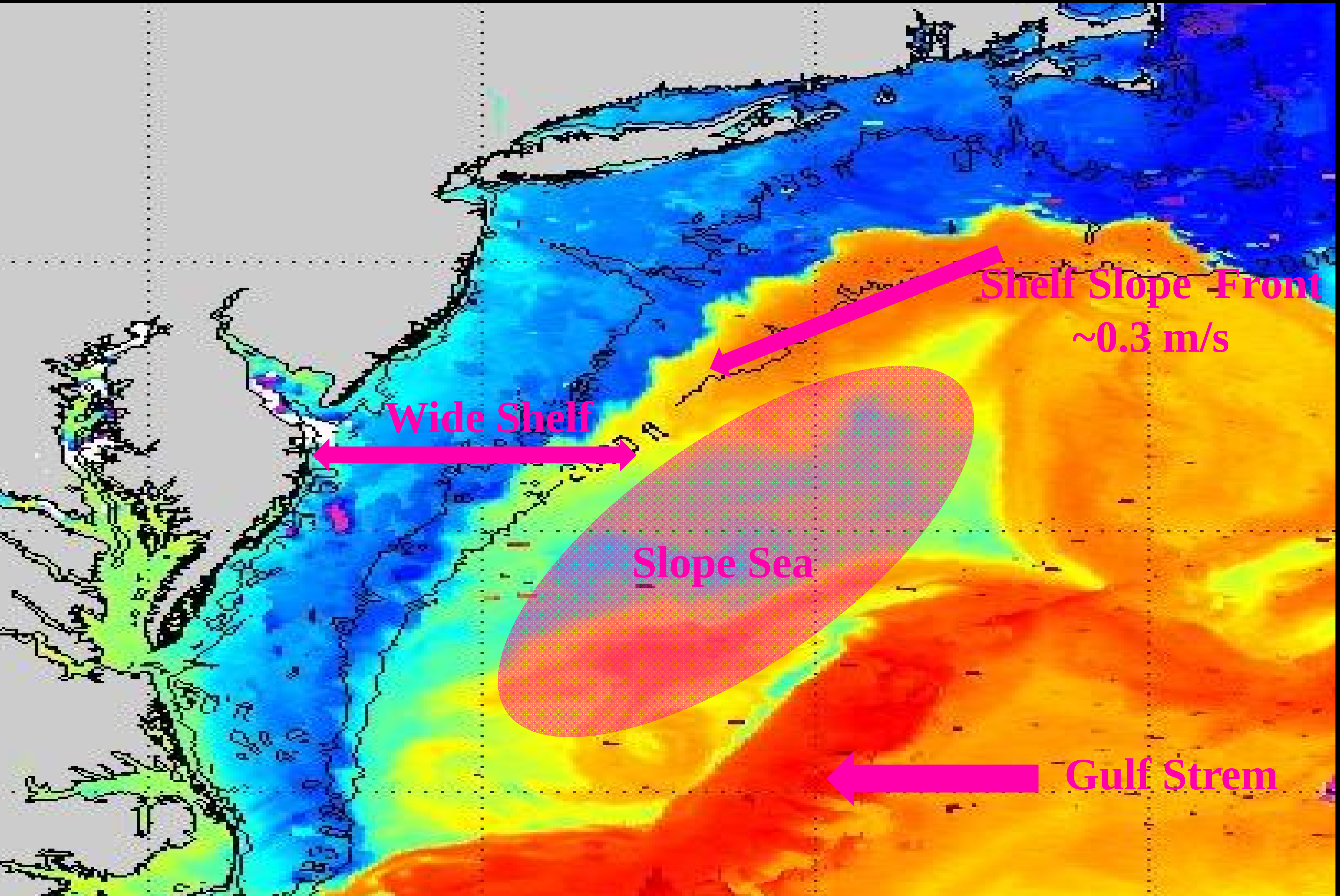

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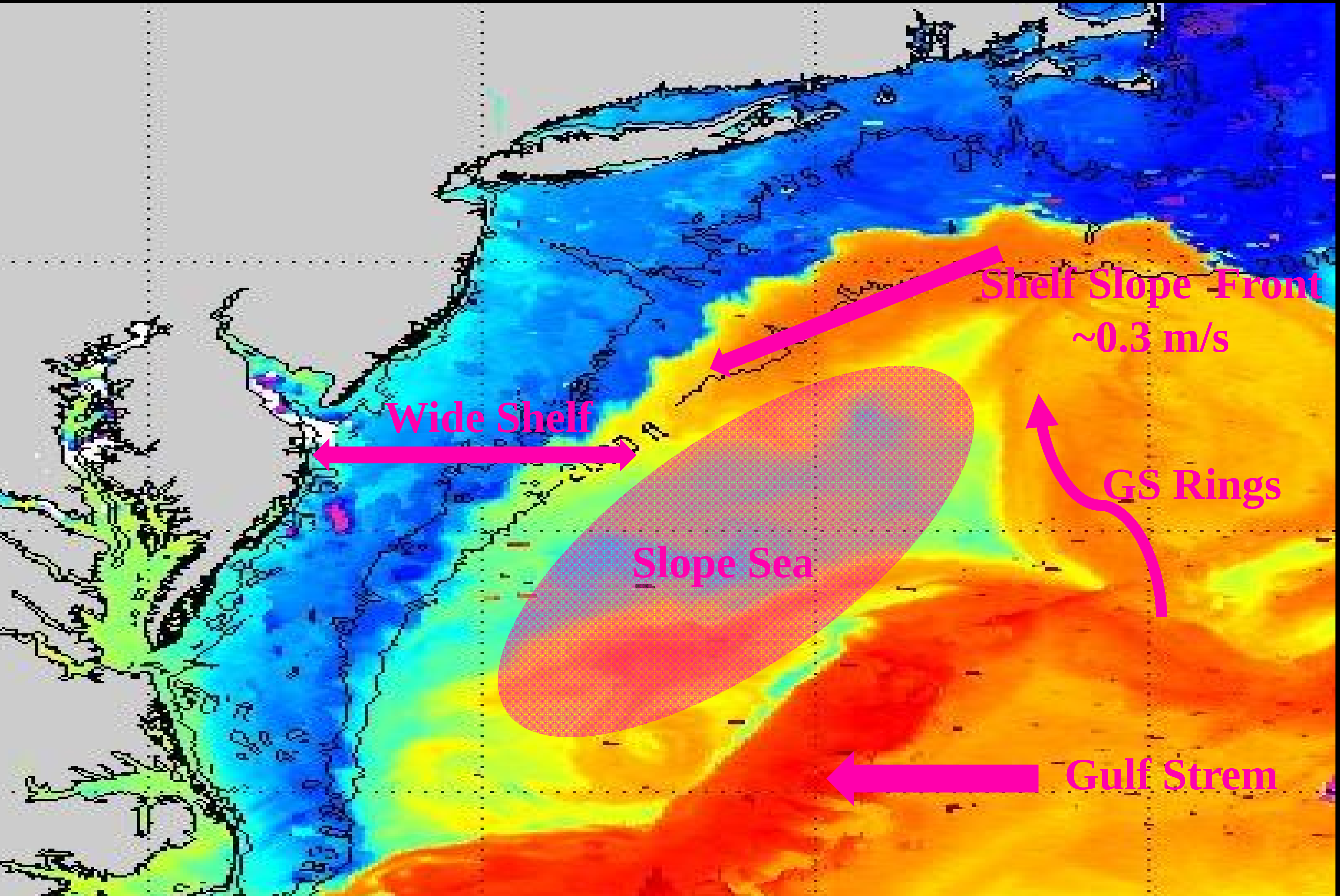

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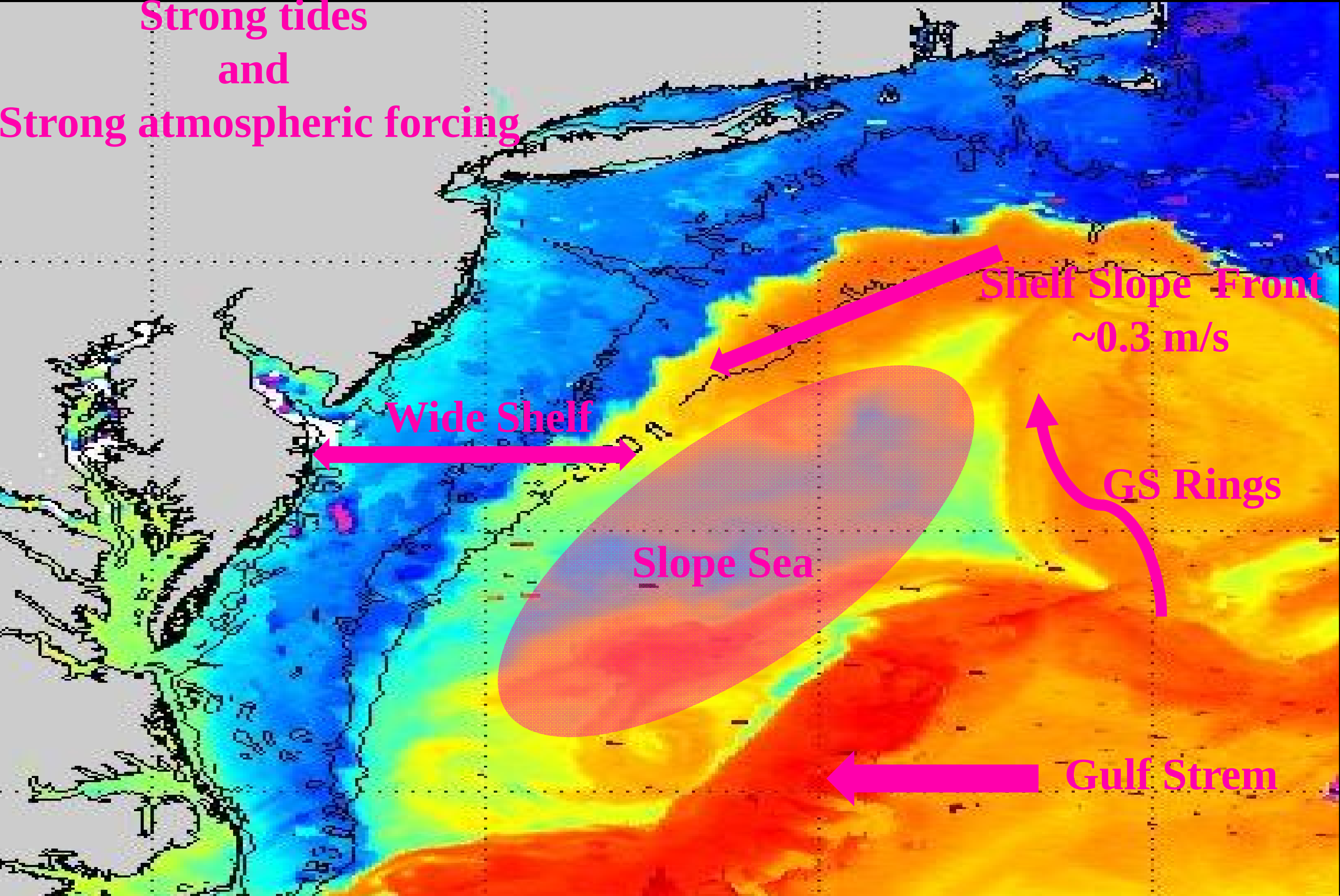

Objective: hindcast 3D variability given surface information from satellites (SSH and SST).

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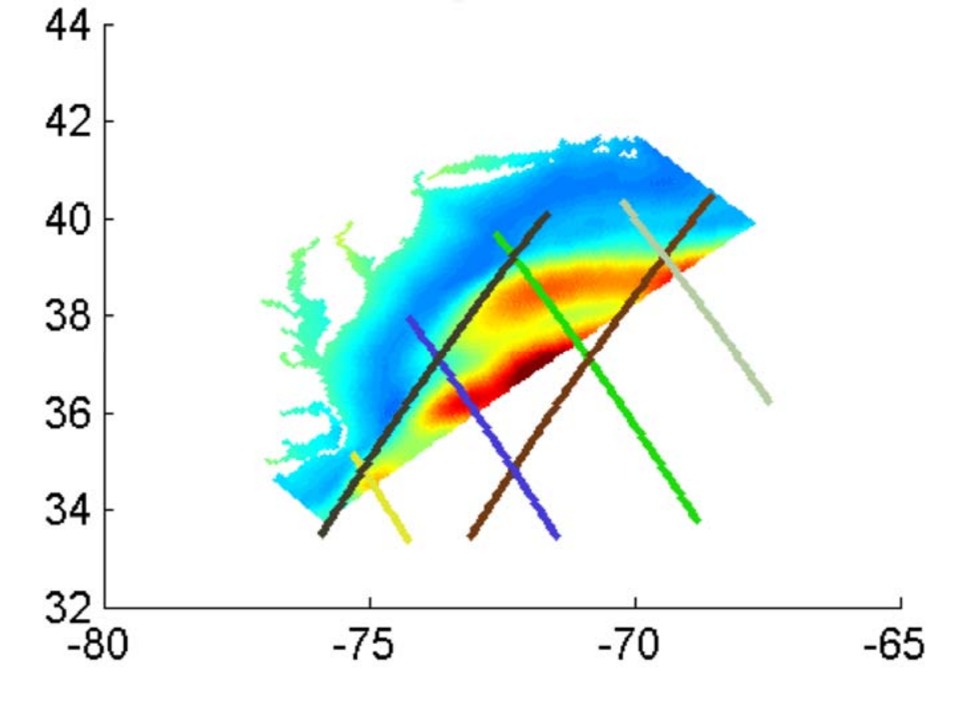
ROMS is unique in that three variants of 4DVar data assimilation are supported as described by Moore et al 2011

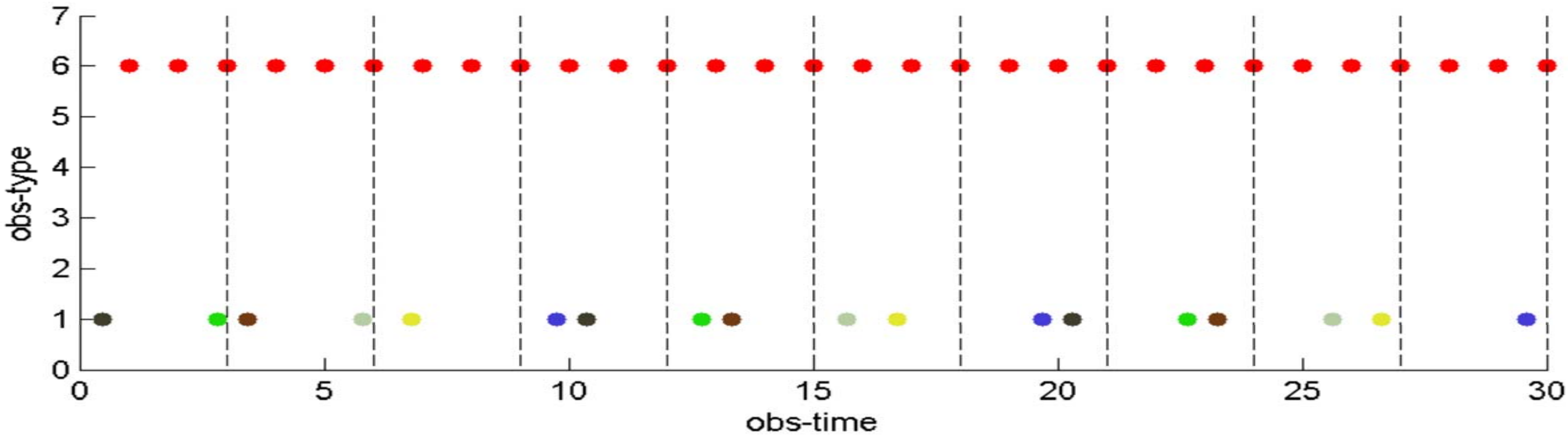
- A primal formulation of incremental strong constraint 4DVar (I4DVAR)
- A dual formulation based on a physical-space statistical analysis system (4D-PSAS)
- A dual formulation representer-based variant of 4DVar (R4DVar)

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

Sequential assimilation of SSH and SST

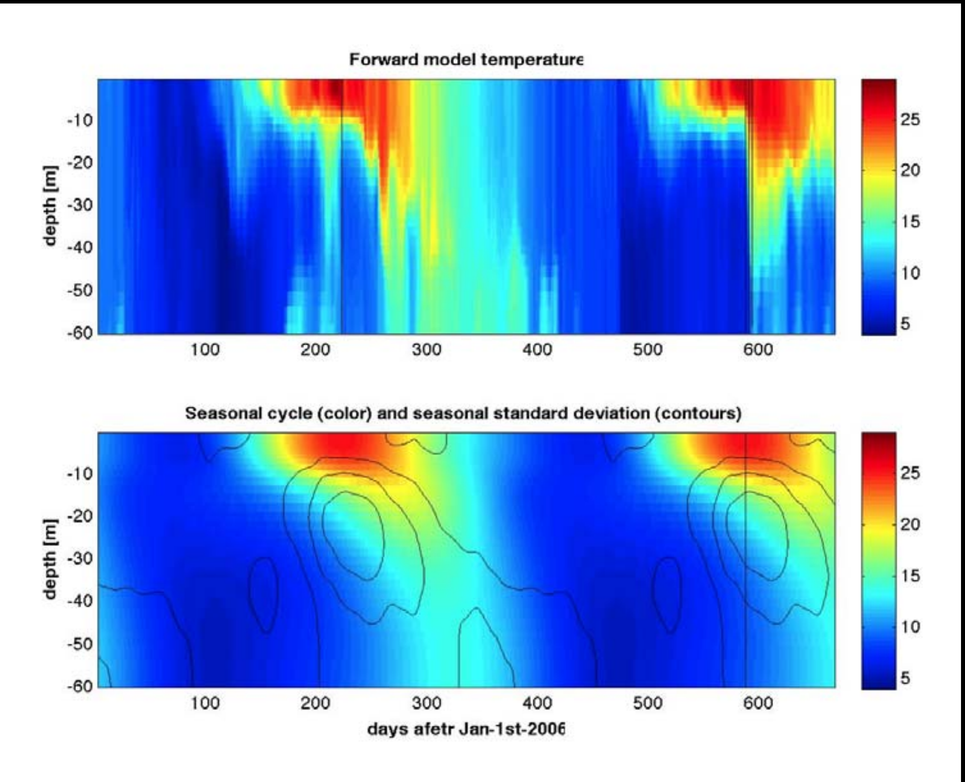
- Reference time is days after 1-1-2006
- 3-day assimilation window (AW)
- Daily IR + blended SST (available real time)
- SSH = Dynamic topography + ROMS tides + Jason-1 SLA (repeated three times)
- For the first AW we just assimilate SST to allow the tides to ramp up.





Background error covariance scaled by an standard deviation file.

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



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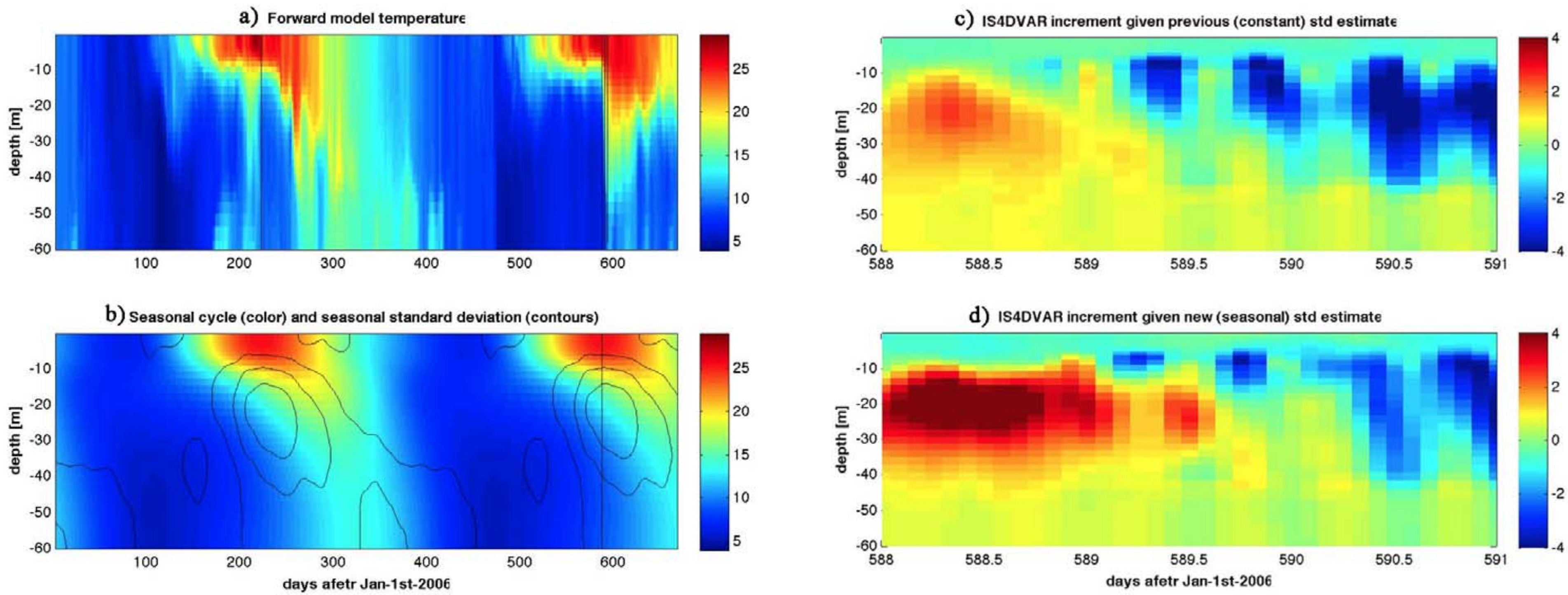
Strong seasonality in the MAB shelf background field -> Strong seasonality in the standard deviations.

Impact of seasonal std:



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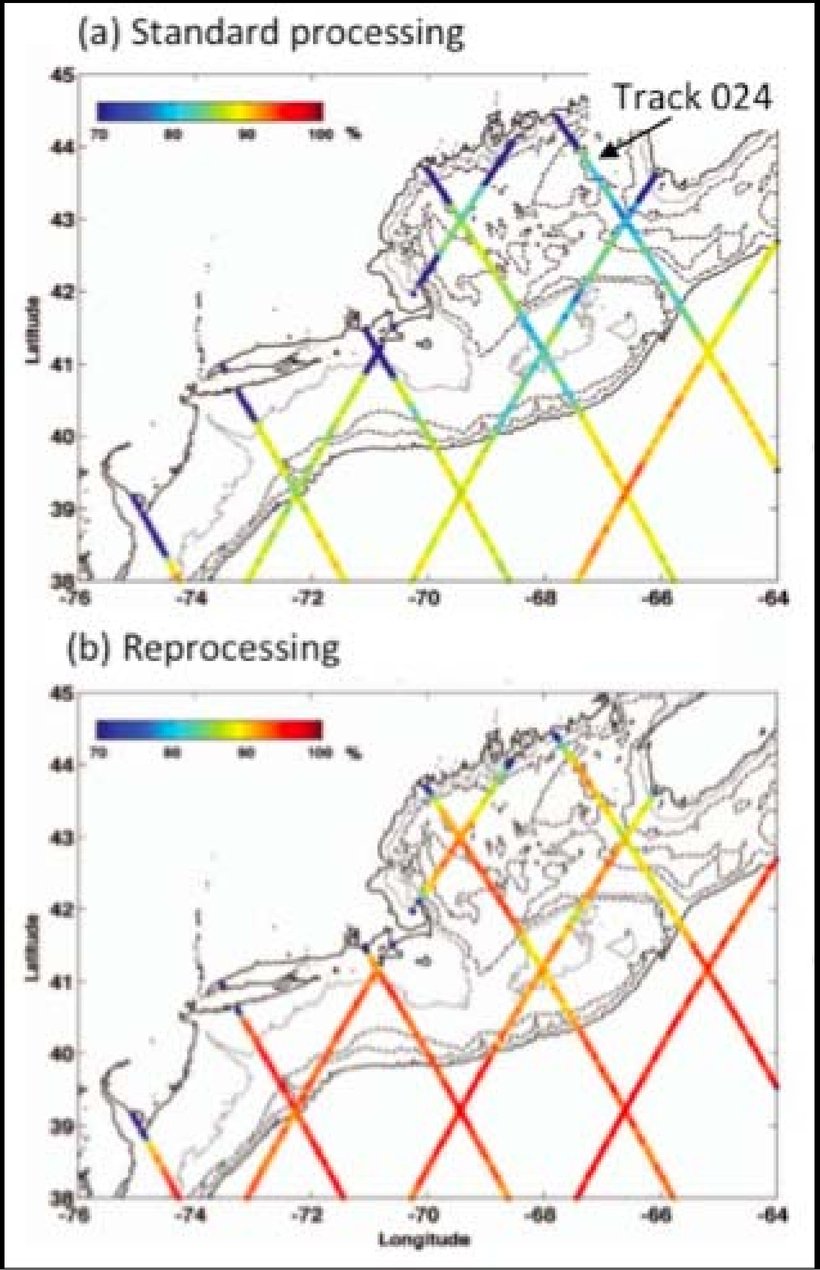
Data Processing: SSH

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)

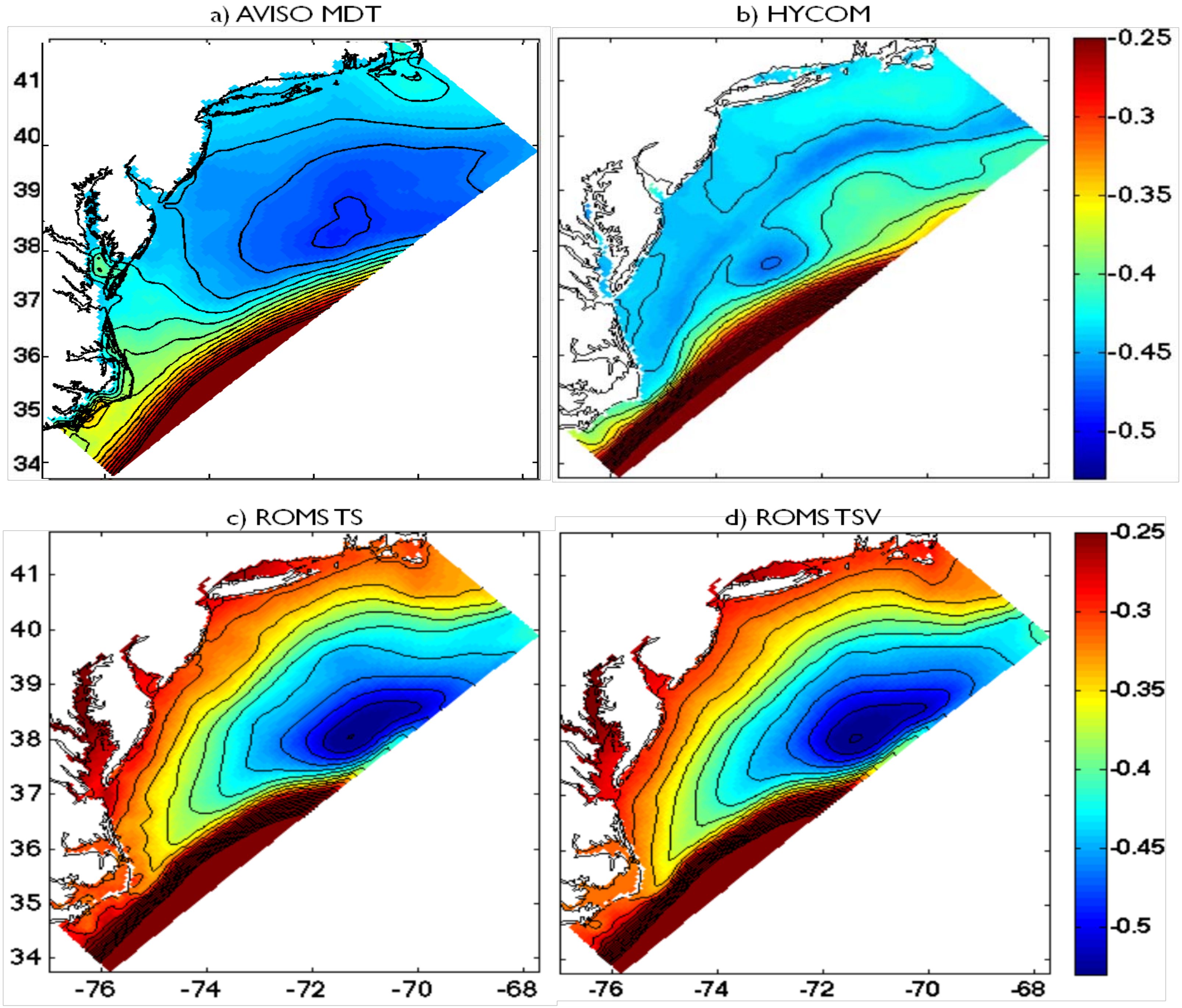


Feng and Vandemark, 2011

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.

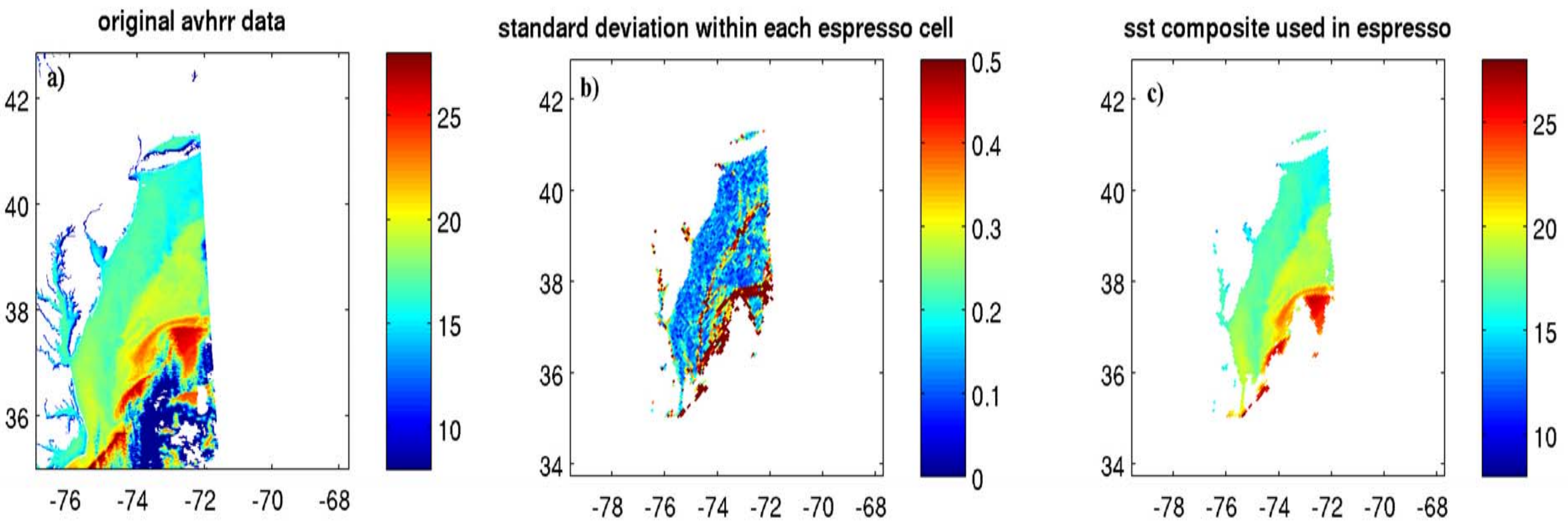
The SSH *observations* are *adjusted* to include model tide. Therefore
the high frequency mismatch of model and altimeter is minimized and cost function is, presumably, dominated by sub-inertial frequency dynamics.



a) AVISO MDT
b) HYCOM
c) ROMS TS
d) ROMS TSV
41
40
39
38
37
36
35
34
-76
-74
-72
-70
-68
-0.25
-0.3
-0.35
-0.4
-0.45
-0.5

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



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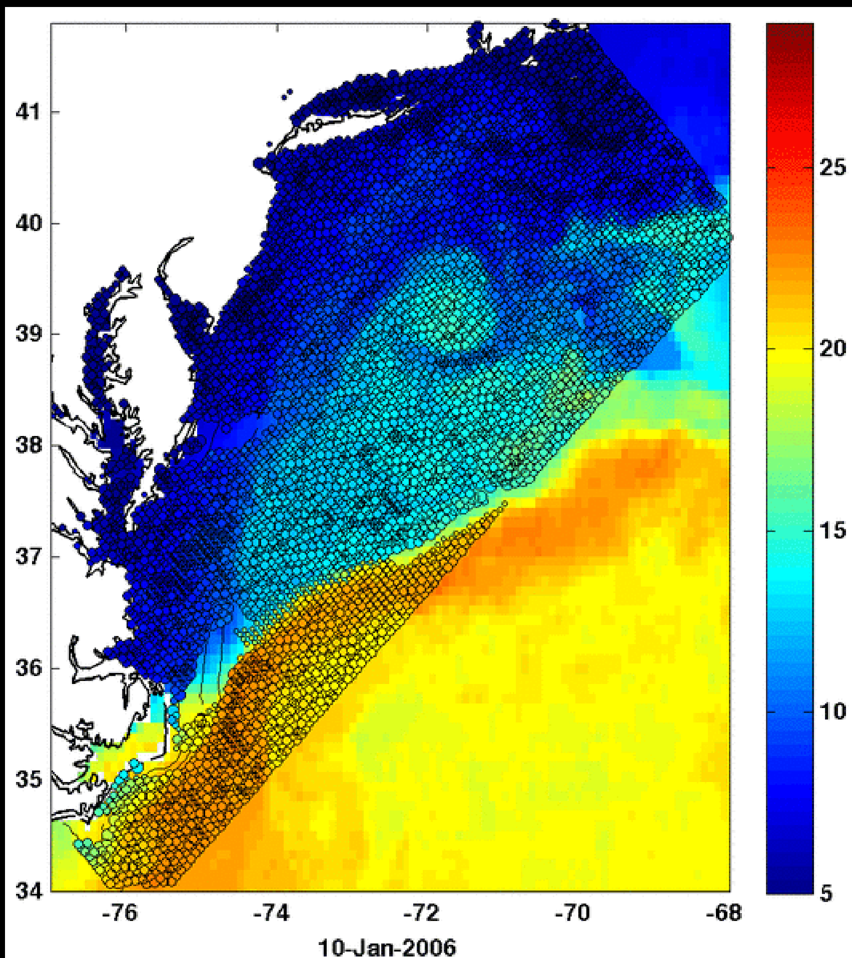

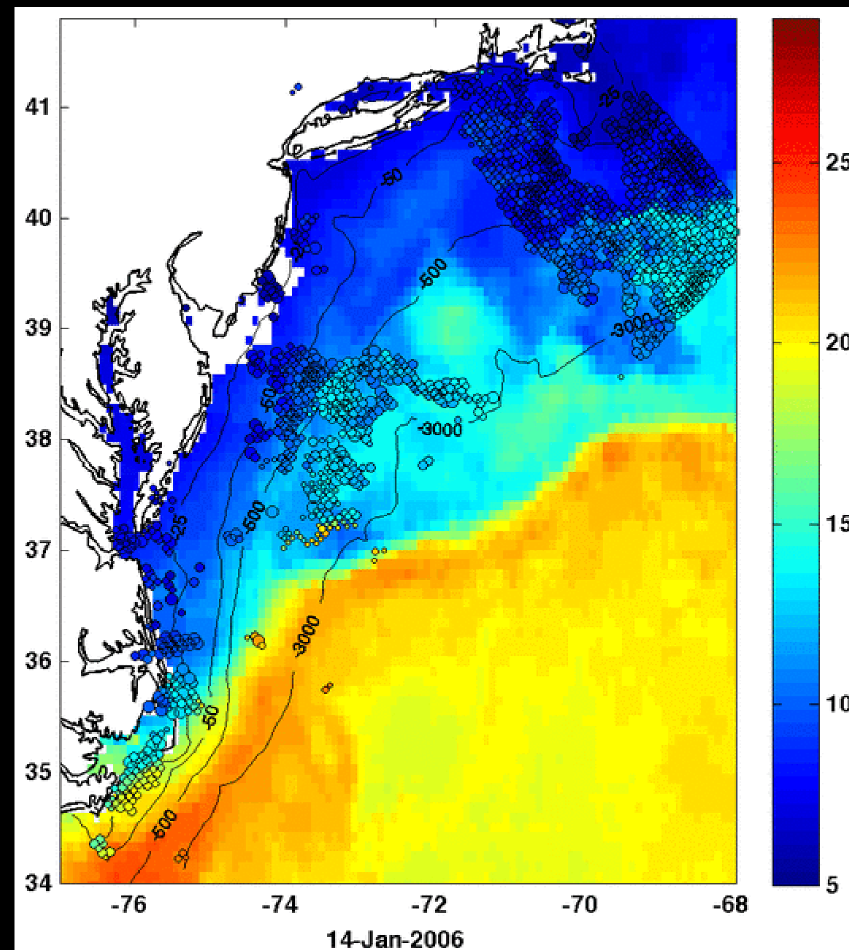

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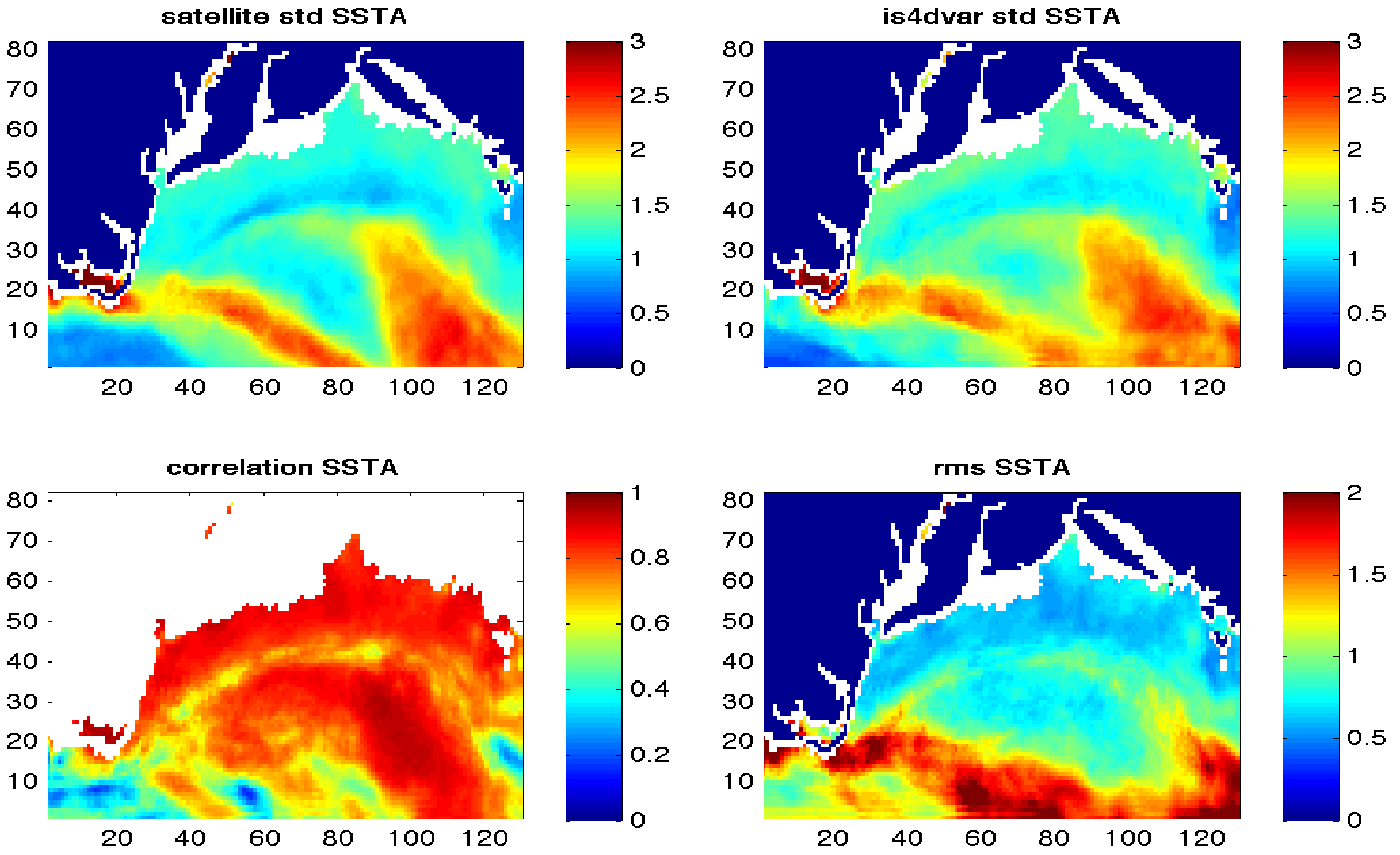
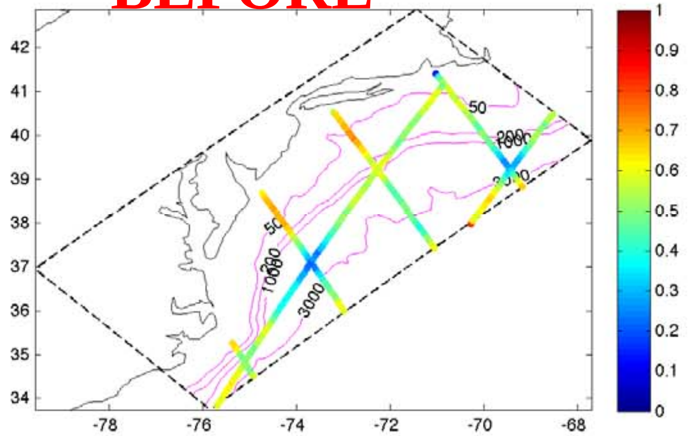
Skill in hindcasting mesoscale SST by the assimilation system



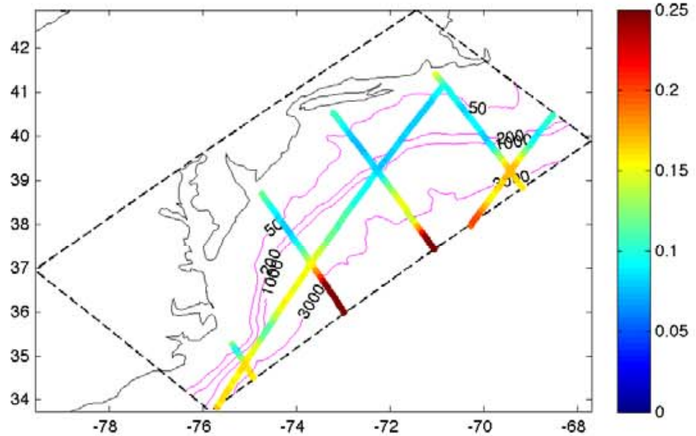
Correlation and RMS error between Jason along-track data and model SSHA before and after data assimilation

BEFORE

Corr.



rms



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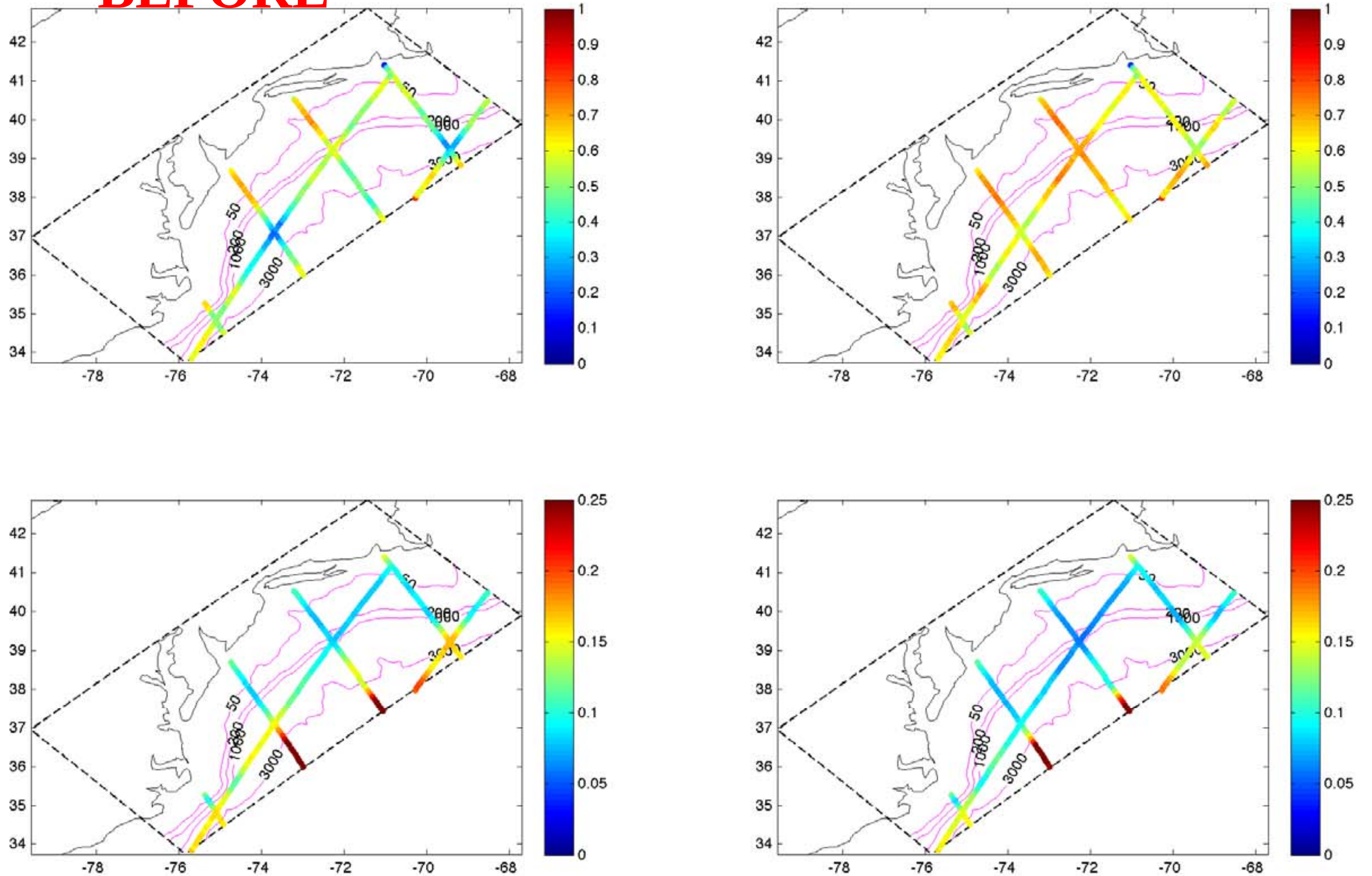
rms



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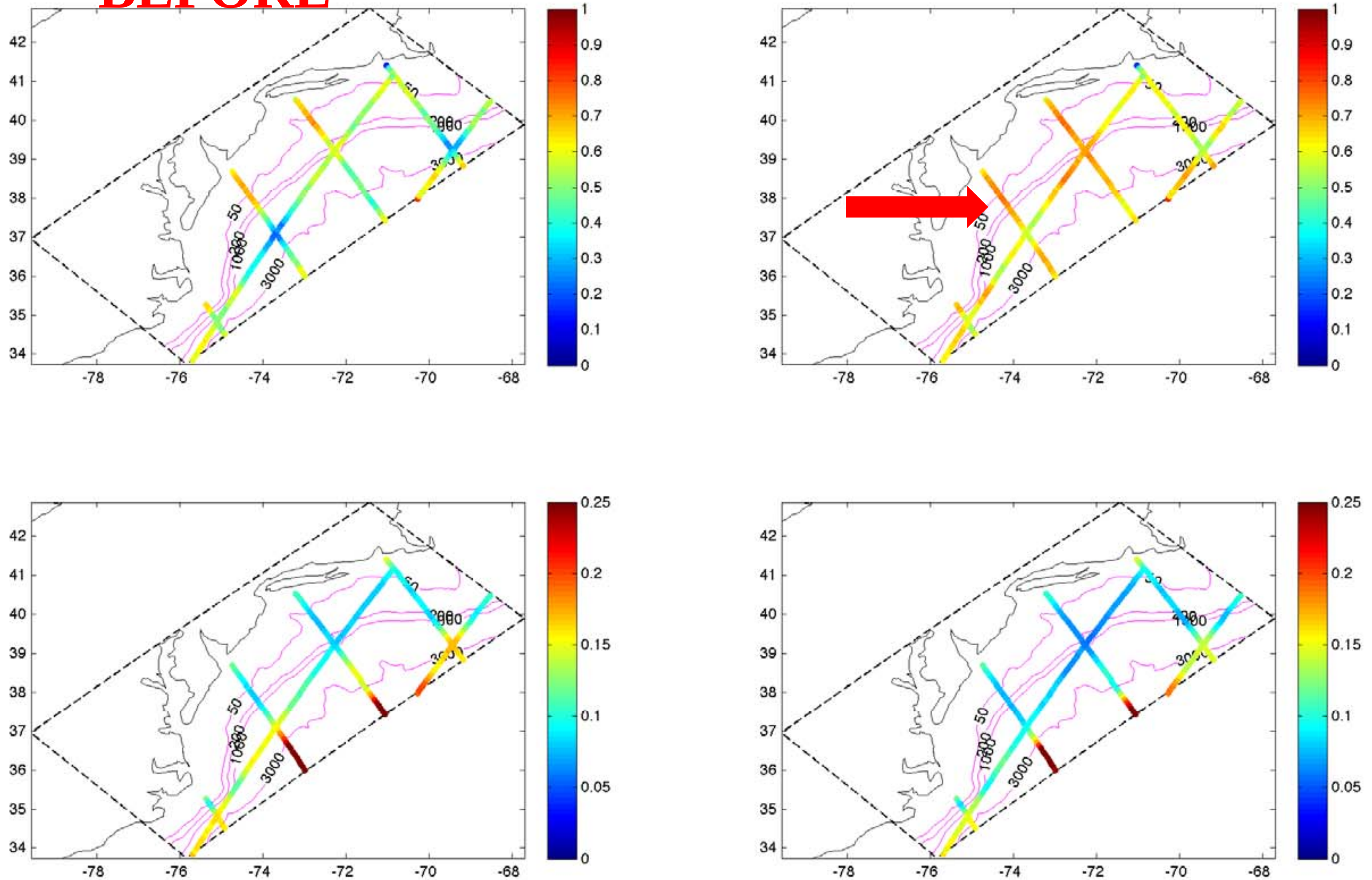
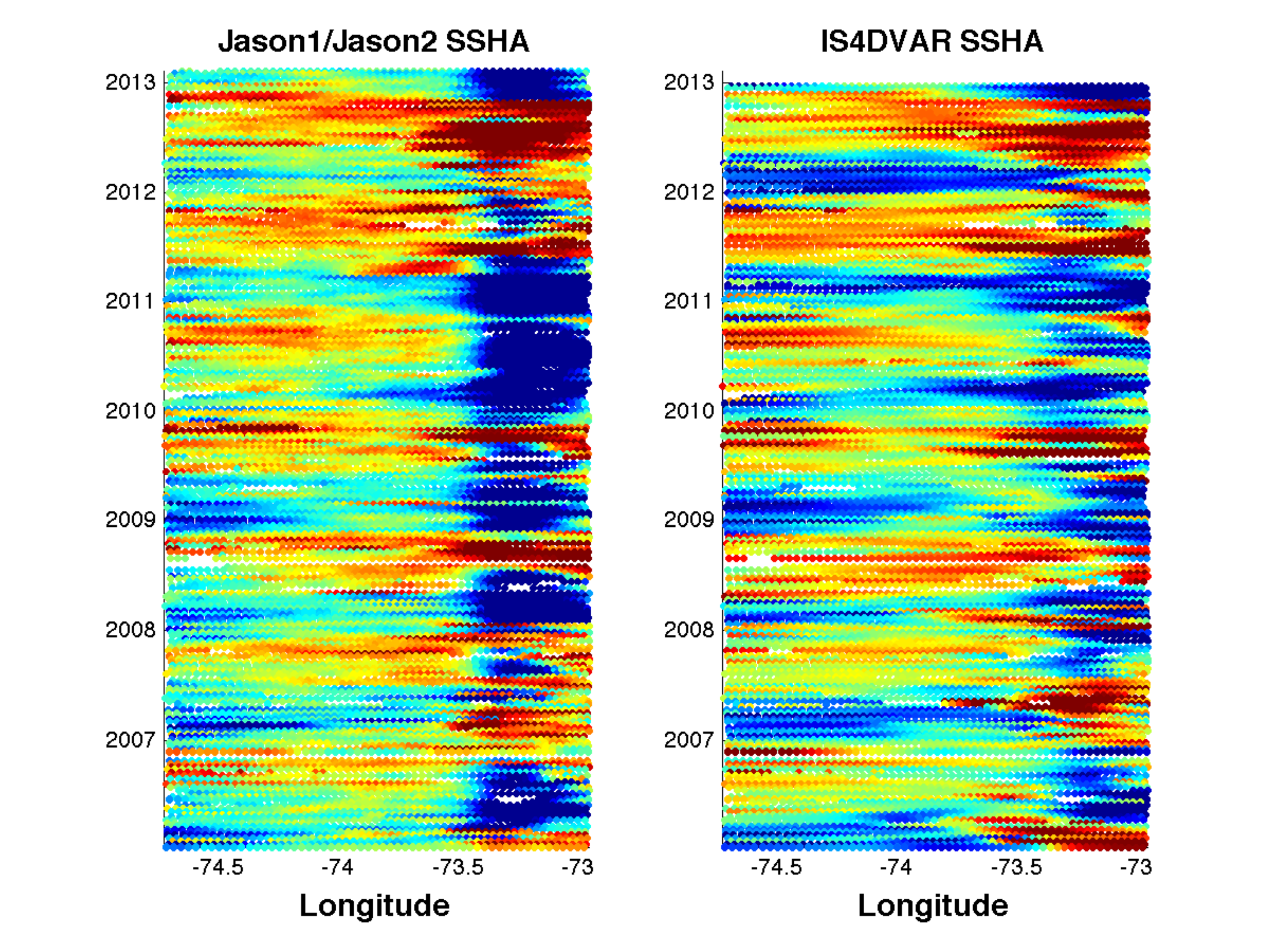
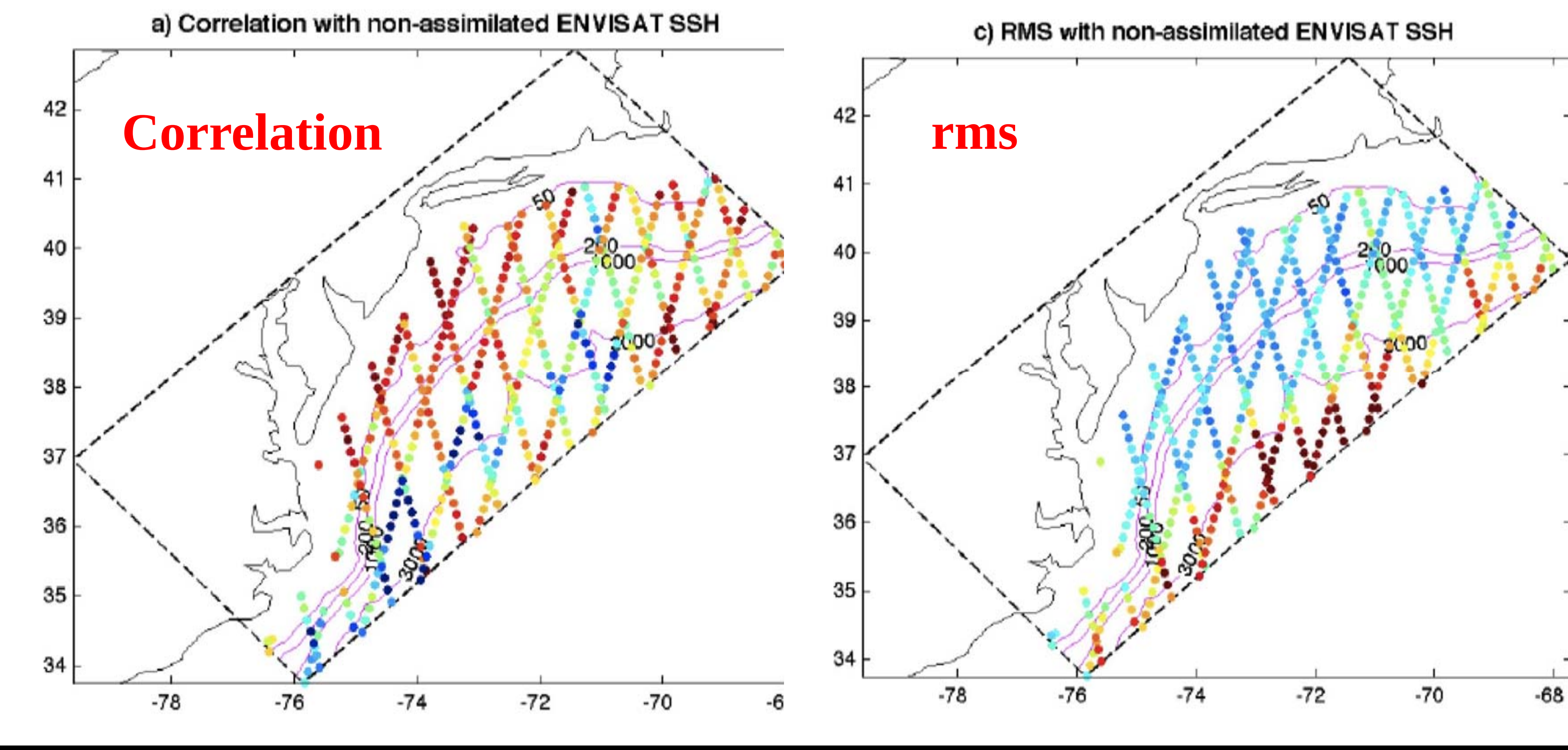


Jason along-track data SSHA vs Model SSHA after data assimilation

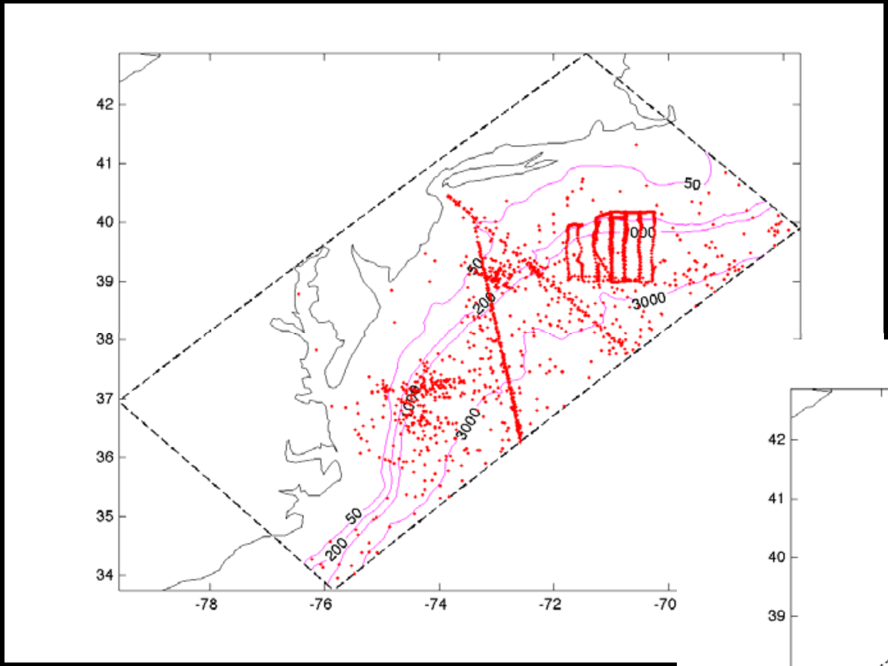


Correlation and RMS error between NOT ASSIMILATED ENVISAT along-track data and model SSHA and vertical skill in temperature

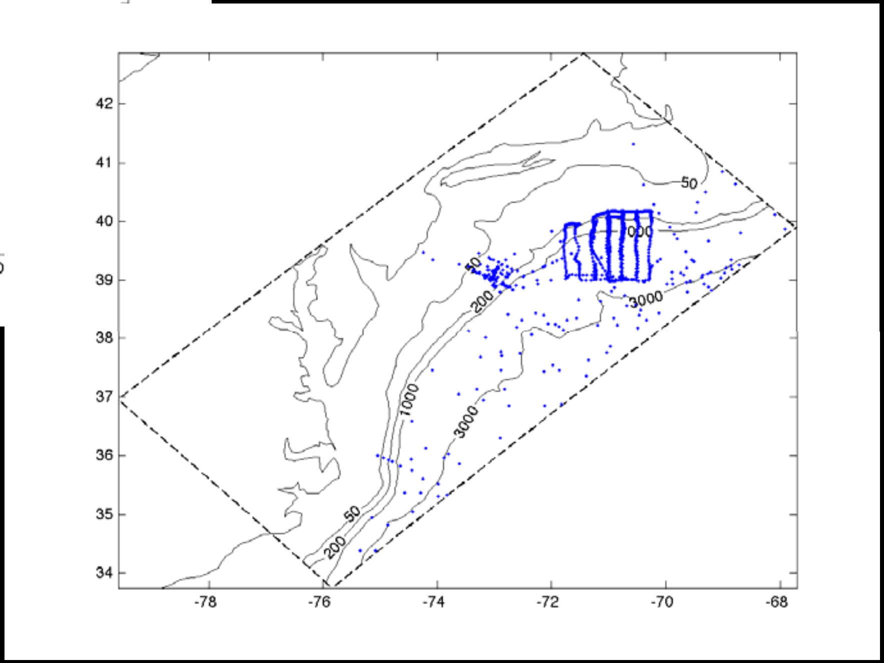


T and S observations from: CTD and gliders from SWO6 (2006), Pioneer array (2007) and XBTs for 2006 - 2007

TEMPERATURE



SALINITY



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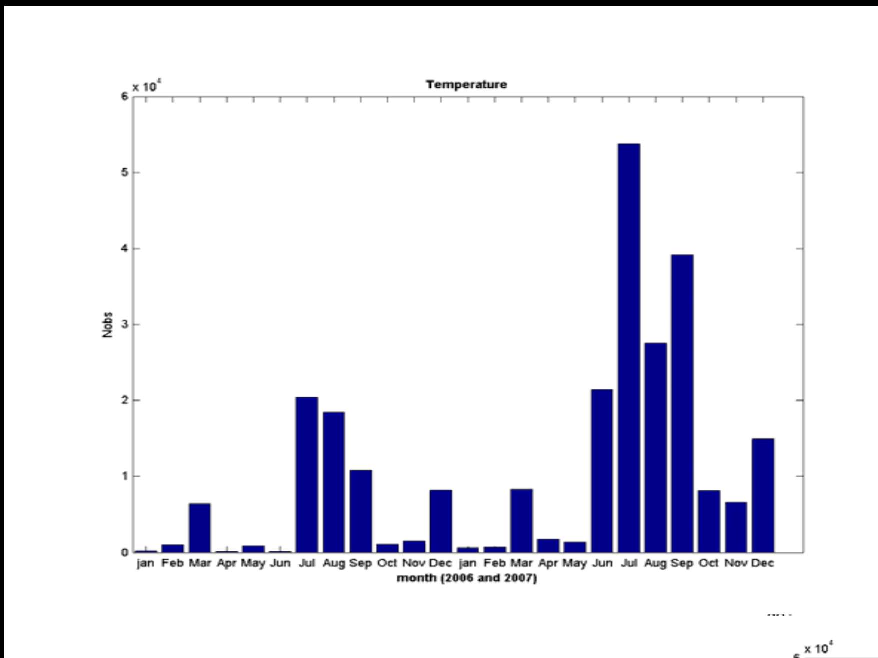

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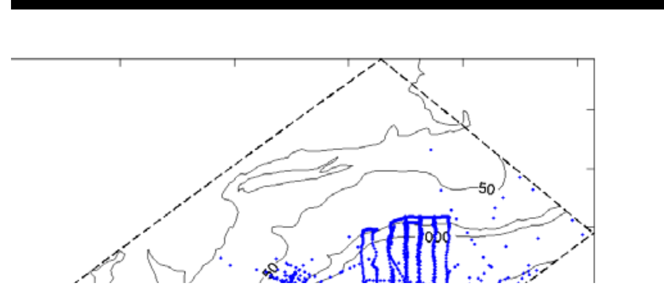

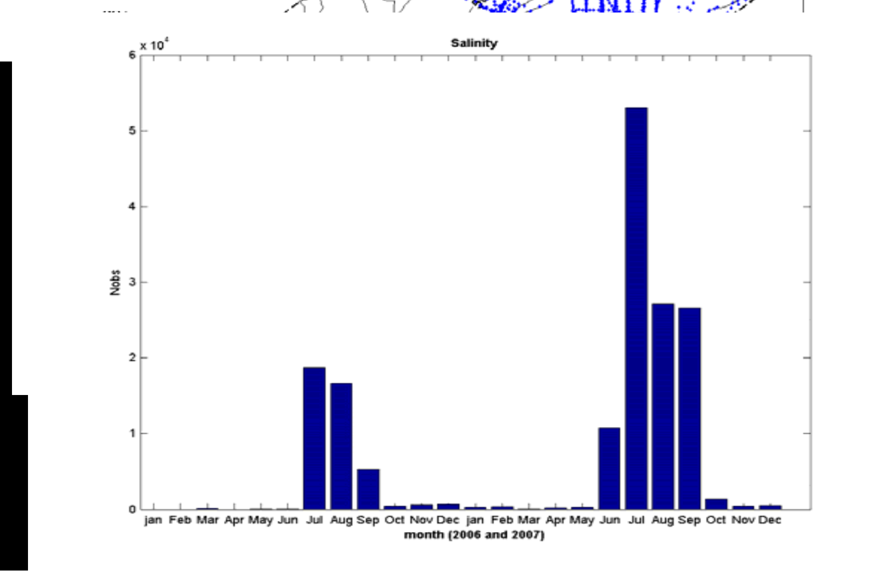

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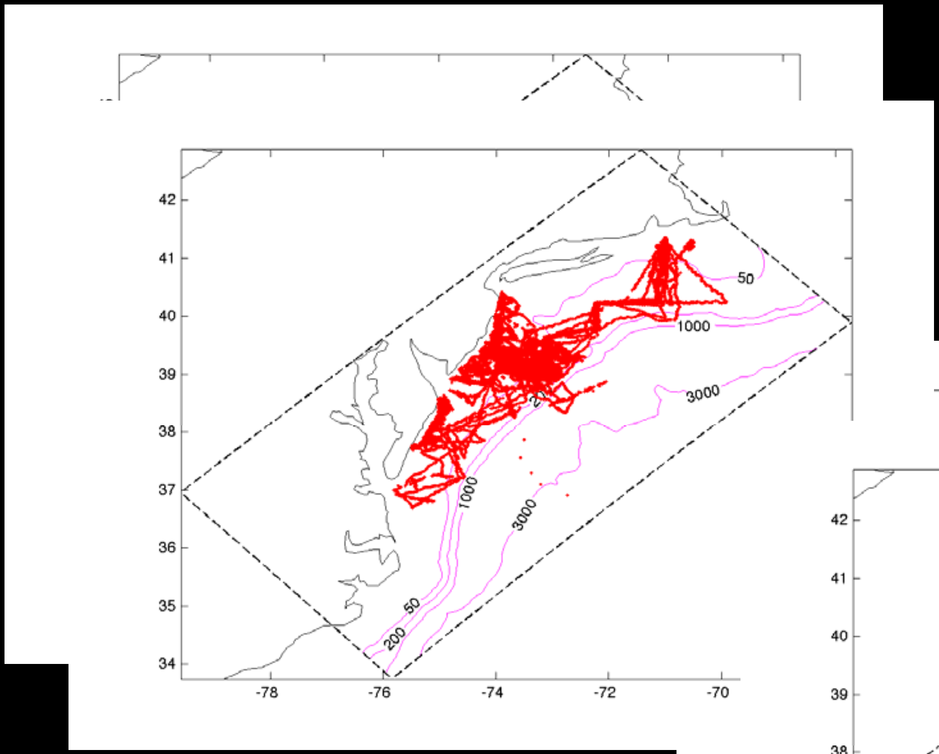

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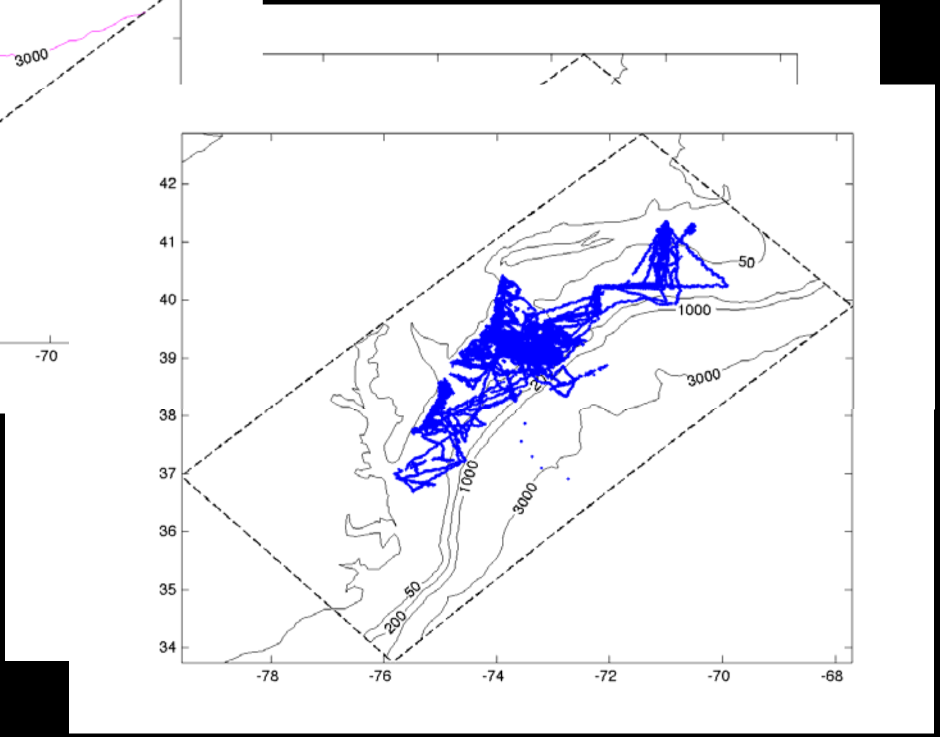

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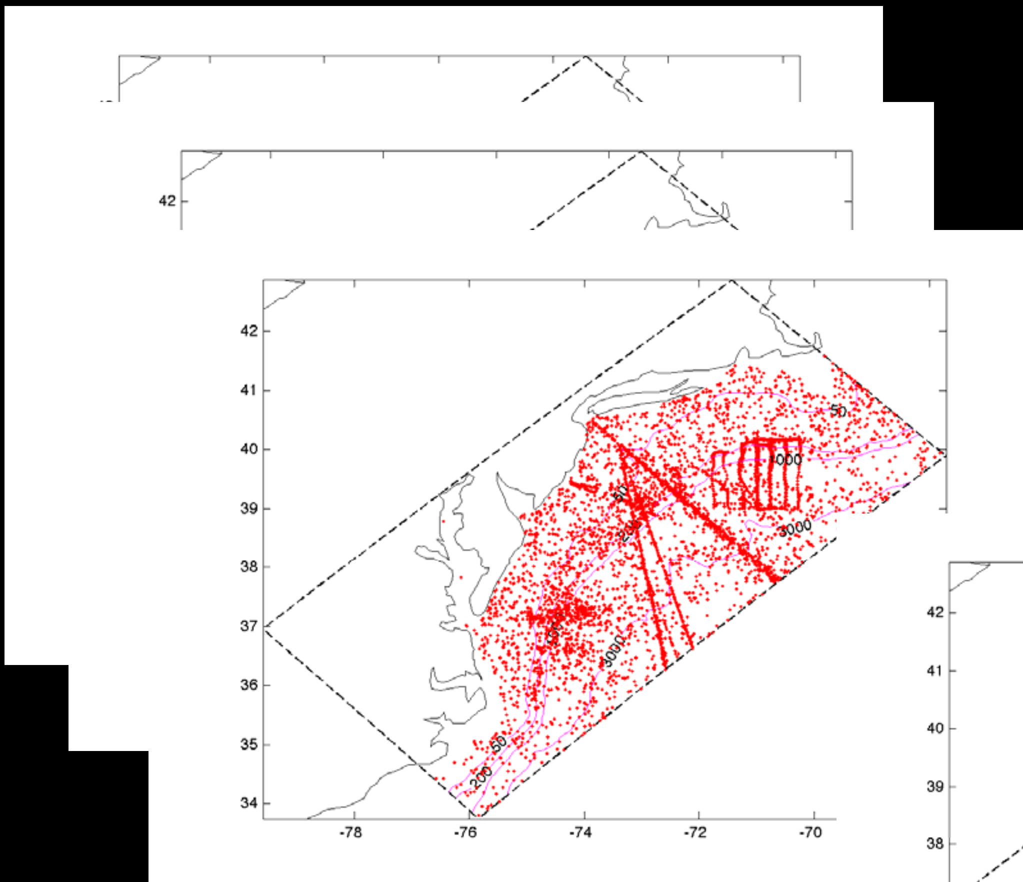

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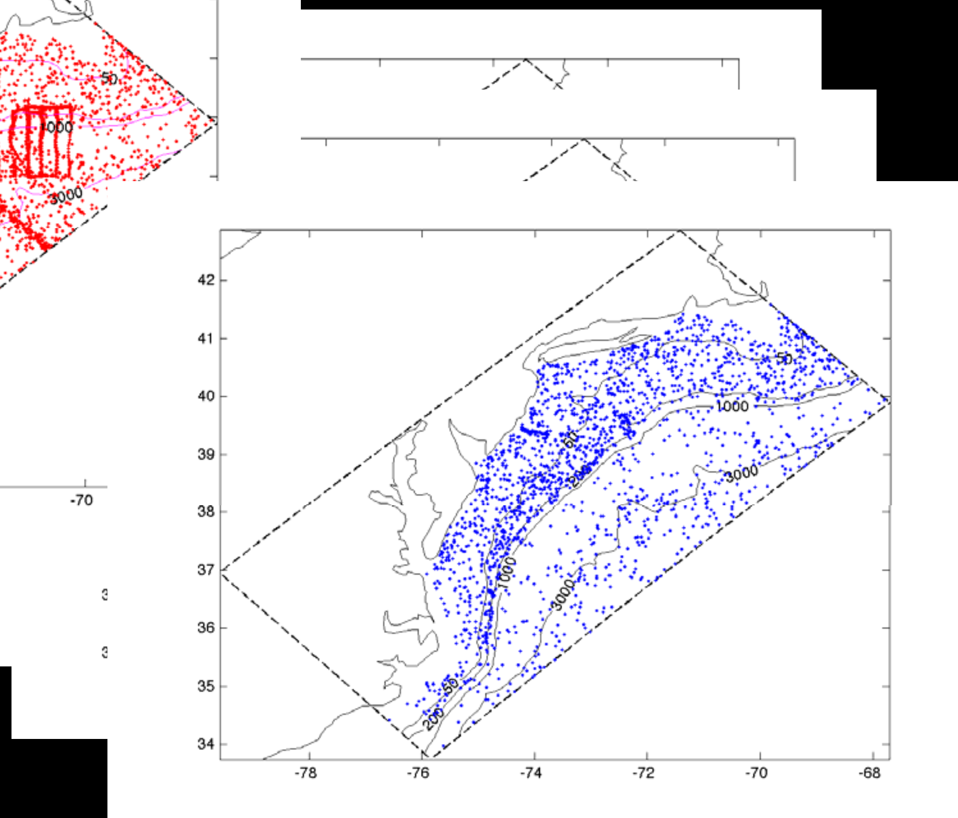

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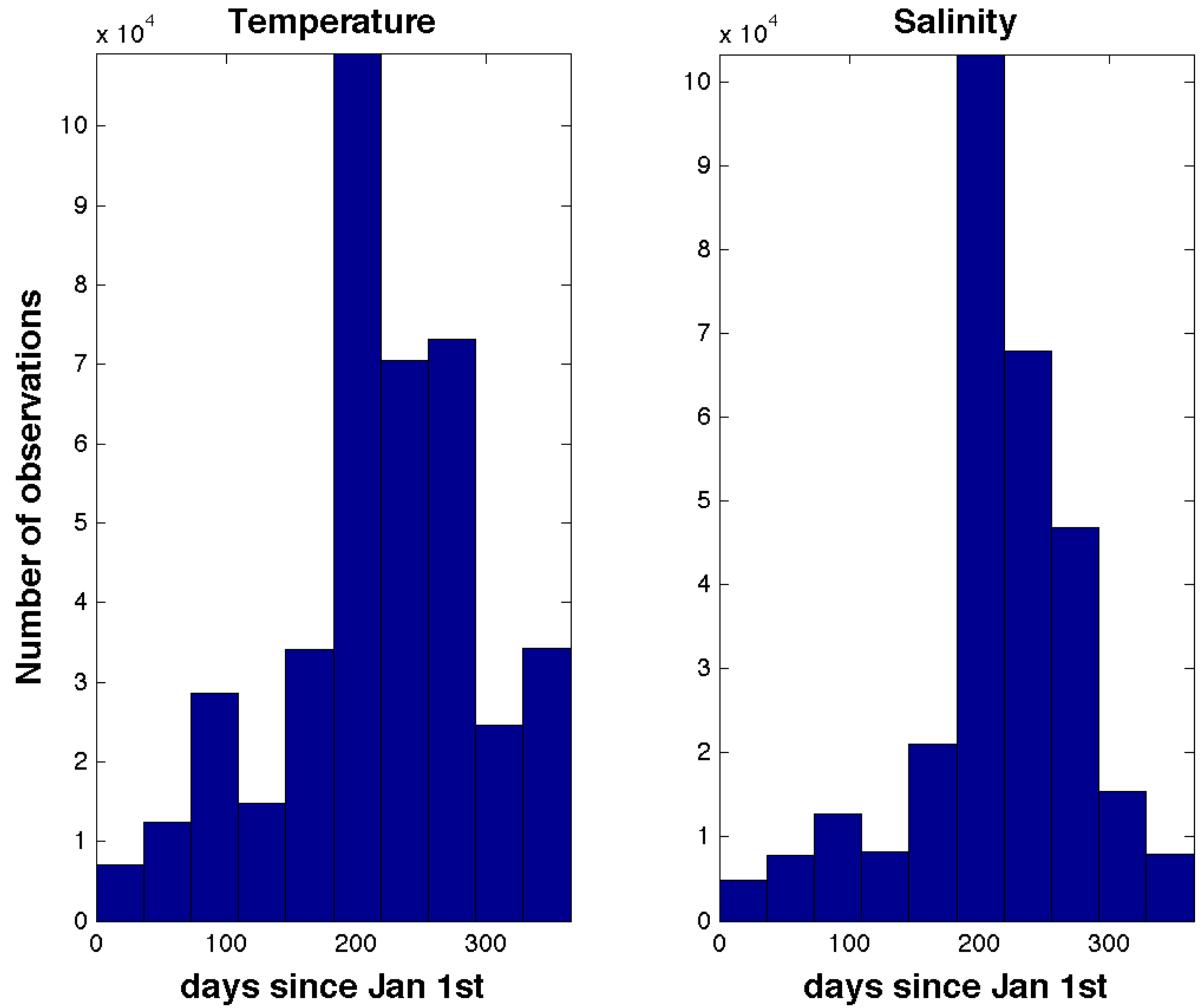
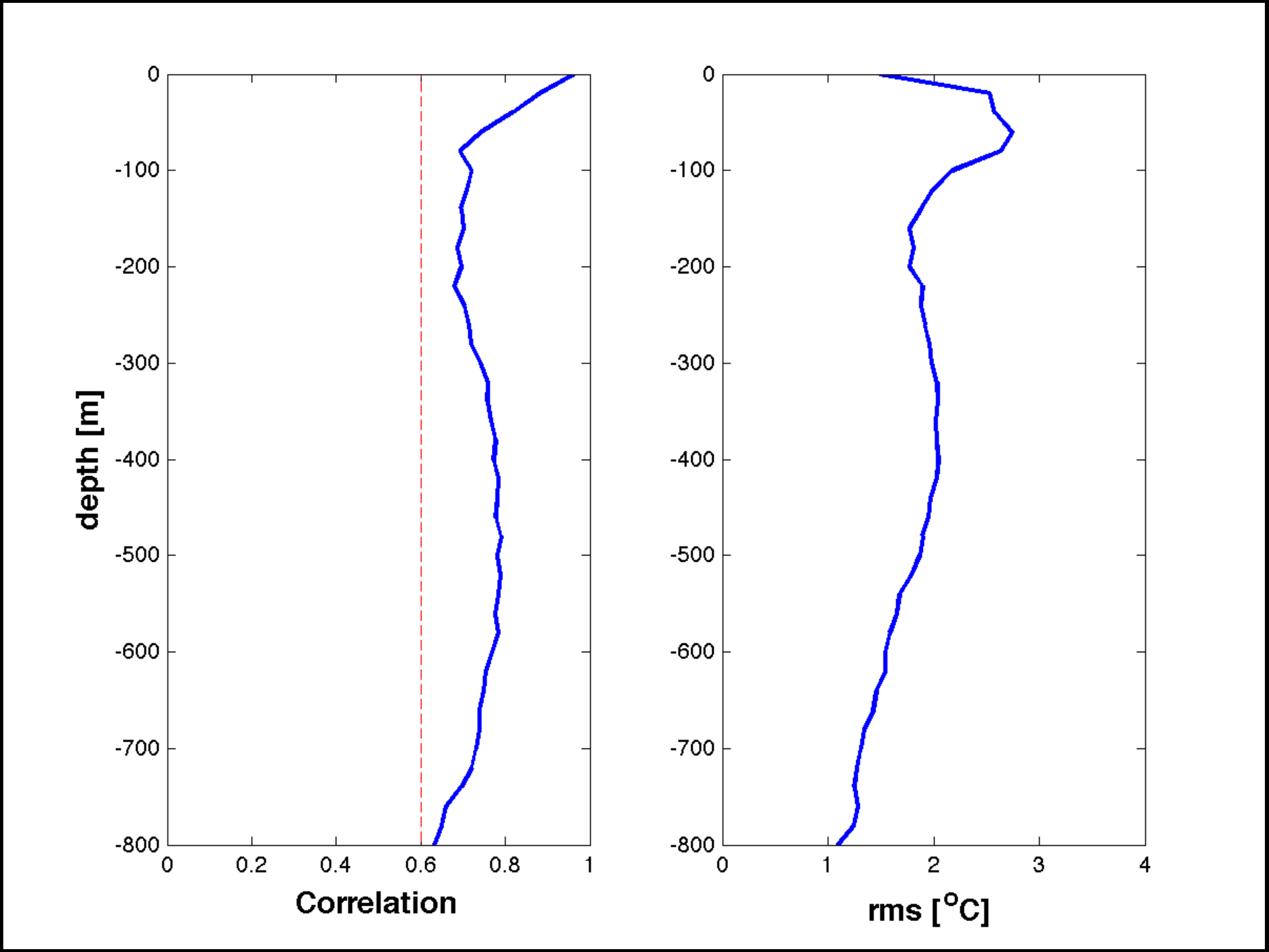


Skill in hindcasting NOT ASSIMILATED subsurface TEMPERATURE



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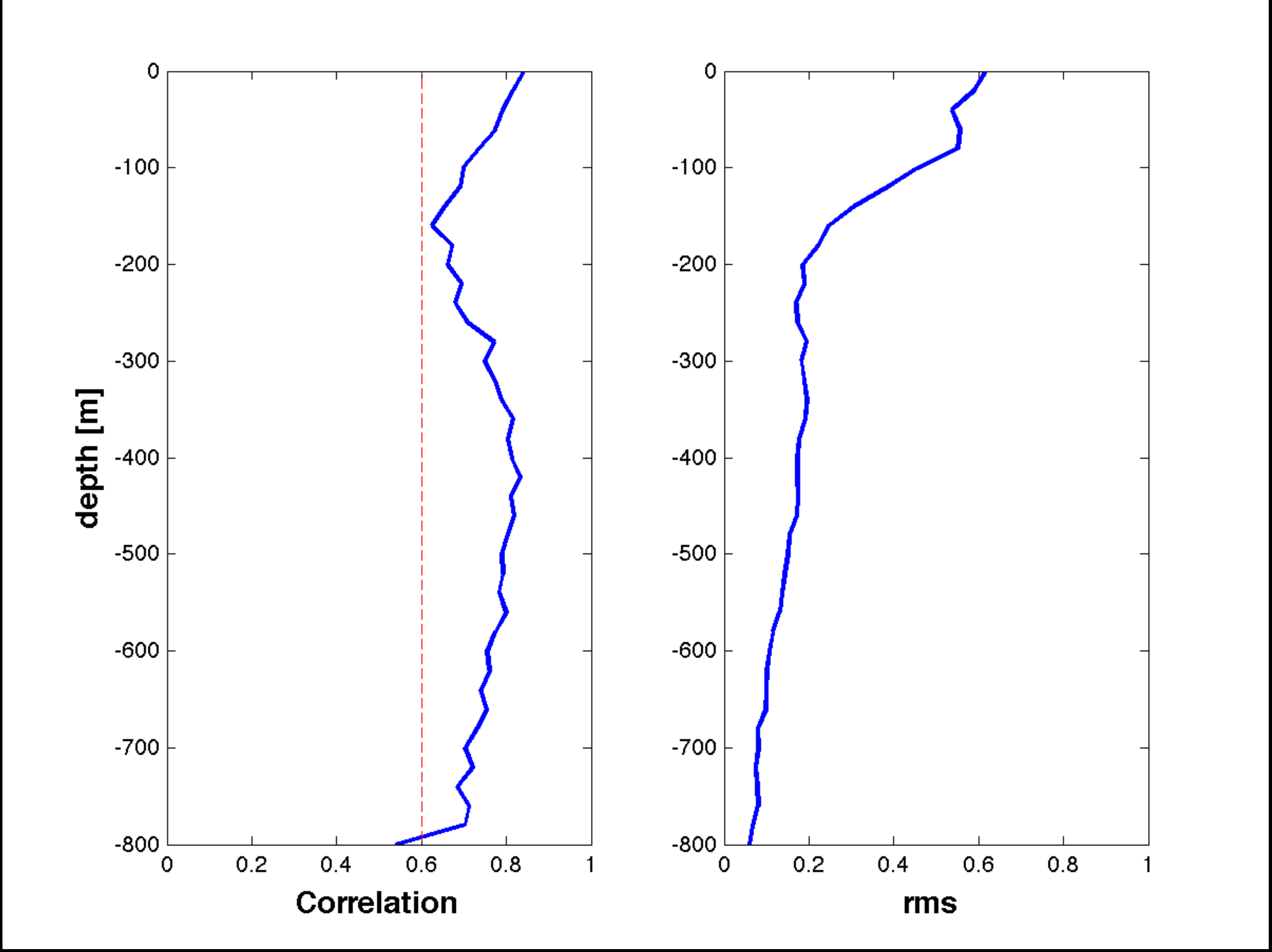
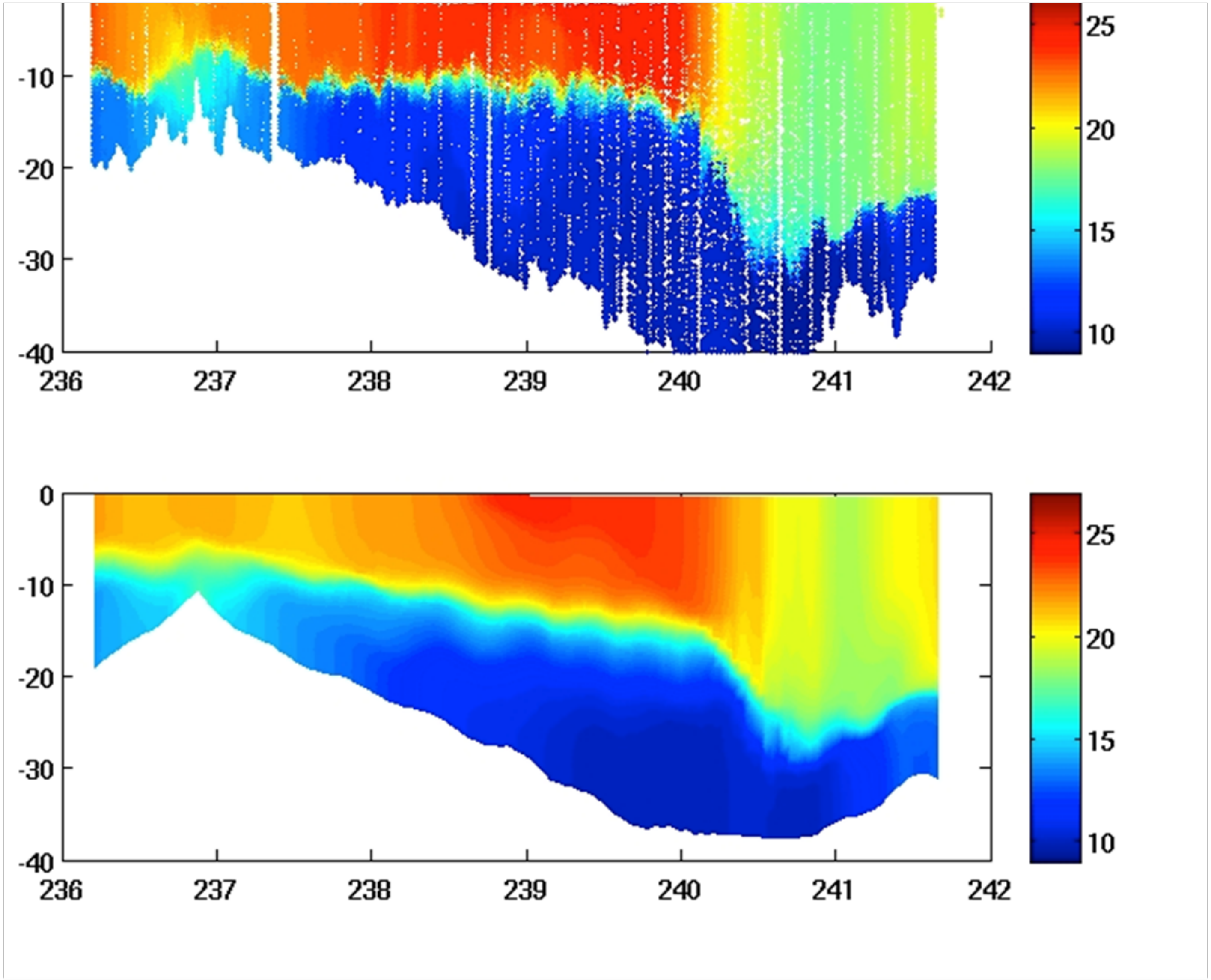
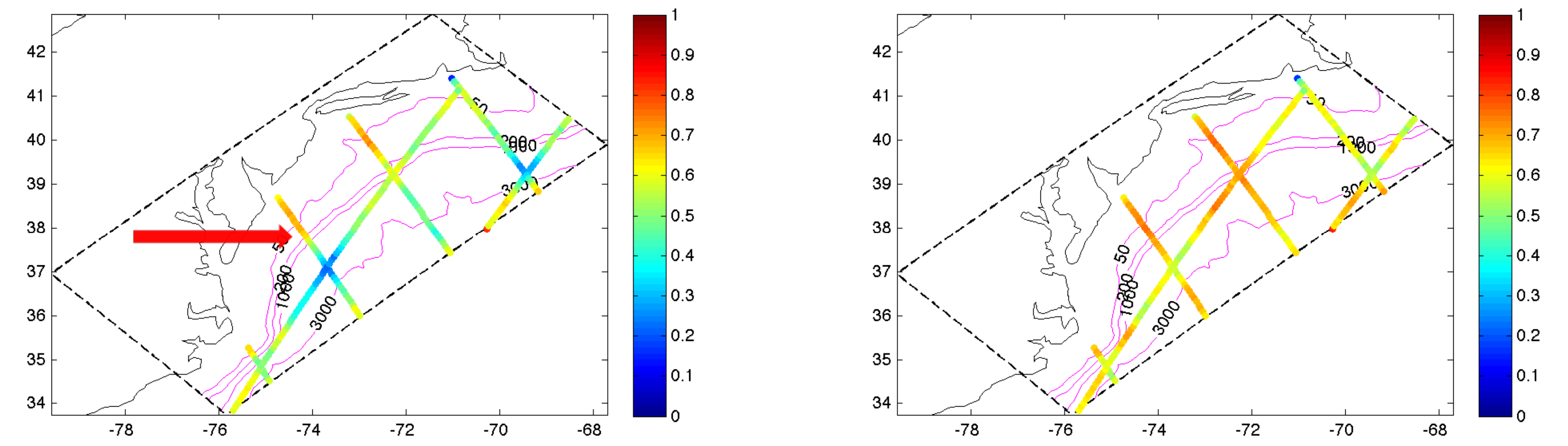


Hindcast in TEMPERATURE for Hurricane Irene

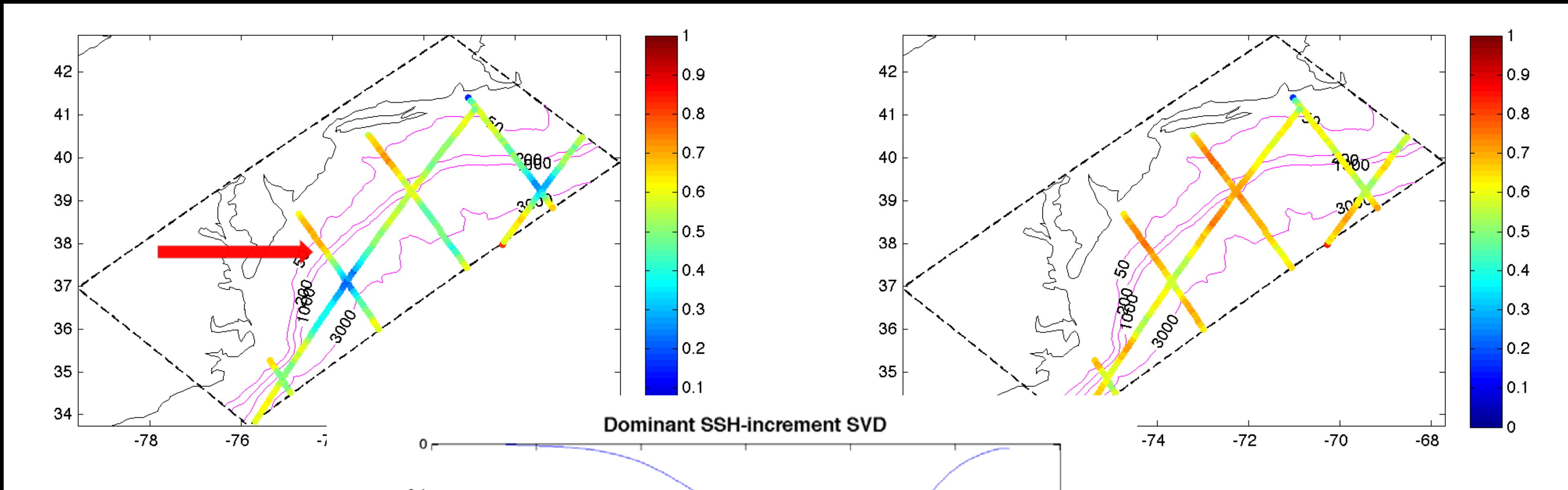


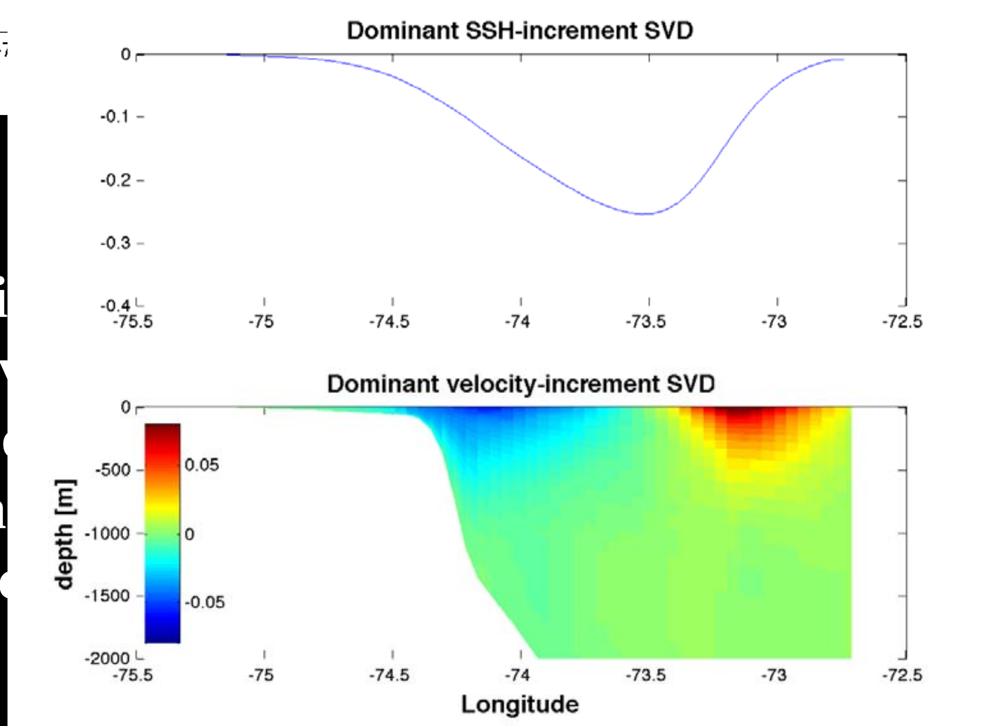
How the IS4DVAR corrections look like?



- Compute difference between forward and data assimilative model
- Compute covariance between SSH difference and subsurface velocity difference
- SVD of the covariance between the two fields
- One dominant pattern of covariability between SSH-increment and subsurface current increment.

How the IS4DVAR corrections look like?





- Compute di … milative model
- Compite co … bsurface velocity
- SVD of the c
- One domin … H-increment and subsurface c

Summary and final remaks

- Seven years of satellite-based analysis (2006-2012)
- Good fit to SSHA and mesoscale SST
- Good fit to not assimilated ENVISAT observations: The model re-grids the data imposing model physics.
- Validated against a large collection of subsurface observations (all seasons well represented down to 800 m). Correlations larger than 0.6 down to 800 m both in temperature and salinity.
- Analysis available at www.myroms.org/espresso
- Coming soon (Julia Levin): New analysis product assimilating along-track SSHA, SST, CODAR surface currents and all the available hydrographic data

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