NCEP operational model: improvements and plans

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Model Algorithms I

Pressure gradient force (PGF)

- An alternative implementation and use of sigma star
- Surface initialized Montgomery potential
- Atmospheric surface pressure
- Torque free tidal body force

For ocean water

$$\alpha \approx \alpha_0 \quad PGF \;=\; -\alpha \nabla_z p \approx -\alpha_0 \nabla_z p = -\alpha_0 \rho \nabla_p (gz)$$

$$\nabla_p gz = -\int_0^p \nabla_p \alpha dp' \approx \alpha_0^2 \int_0^p \nabla_p \rho dp'$$

$$\rho = \tilde{\rho} + b(p)$$

$$\nabla_p gz \approx \alpha_0^2 \int_0^p \nabla_p \tilde{\rho} dp'$$

$$PGF \approx -\nabla_\xi M + gz\nabla_\xi \tilde{\rho}$$

where

$$\frac{\partial M}{\partial \tilde{\rho}} = gz$$

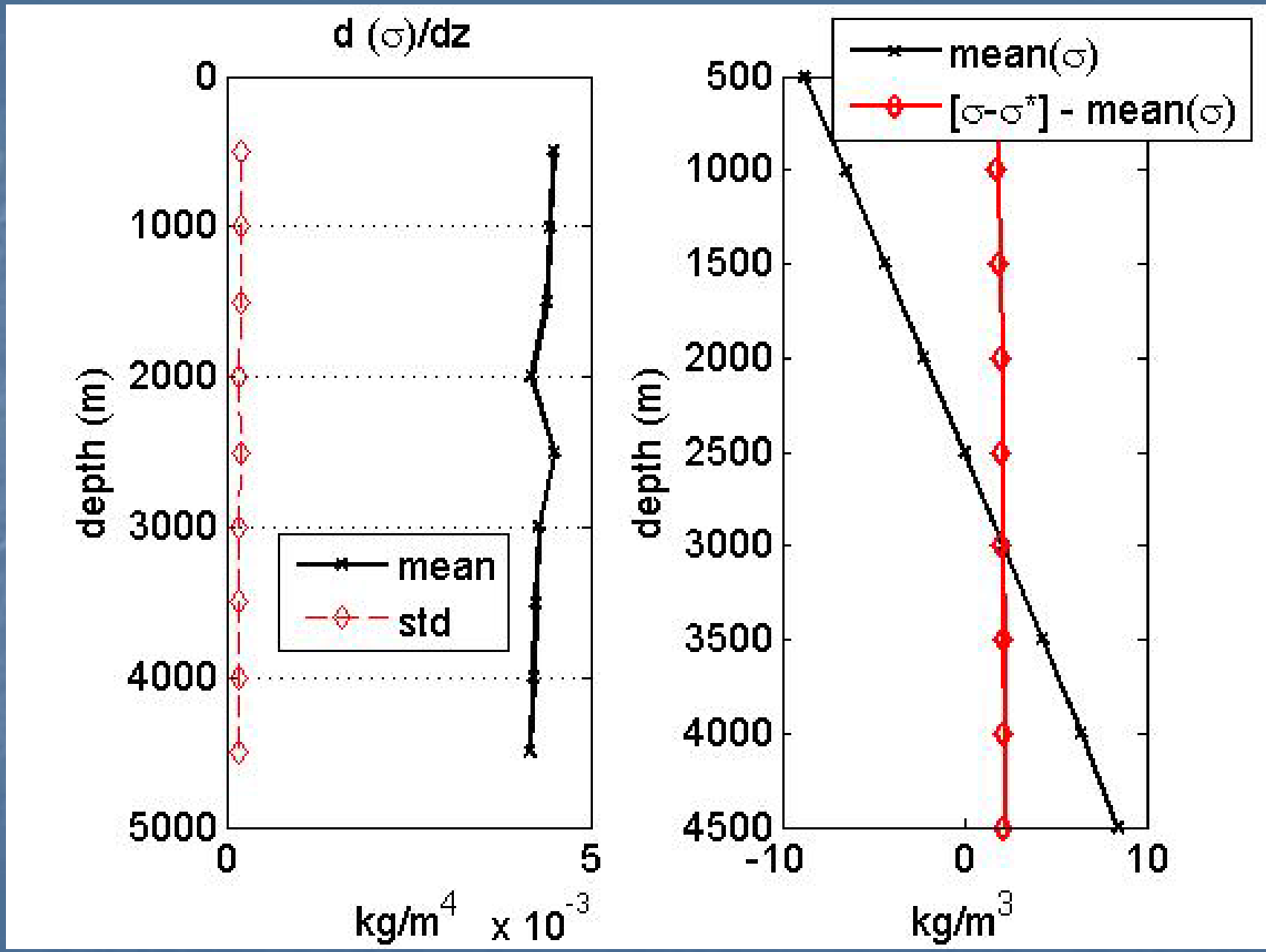
along ξ-surfaces variations $\delta\rho$ might not be small; in particular, for changes δp along ξ-surfaces

$$\frac{\partial \rho}{\partial p}\delta p$$

Part of this contribution is removable. Select

$$b(p) = \text{avg } \rho \text{ over ocean } (\theta, \text{S}) \text{and fixed p}$$

$$b(p) \approx \sigma - \sigma^*$$


d (σ)/dz
depth (m)
0
1000
2000
3000
4000
5000
mean
std
0
5
kg/m4 x 10-3
mean(σ)
[σ-σ*] - mean(σ)
500
1000
1500
2000
2500
3000
3500
4000
4500
-10
0
10
kg/m3

sigma star

- Implementation
  - Compute b(p) for the domain of interest by averaging [optimize averaging for the vertical coordinates used]
  - Construct numerical approximation to b(p)
  - Sigma star=sigma – b
- Sigma star is useful for arbitrary vertical coordinates.

Split mode

M=alpha_0 (p+rho gz)

M_surf=[MP_1]+{alpha_0 g rho_0 eta_1}

= alpha_0 rho_surf g eta

=[alpha_0(rho_surf-rho_mean) g eta] +

{alpha_0 rho_mean g eta}

[ ] internal mode

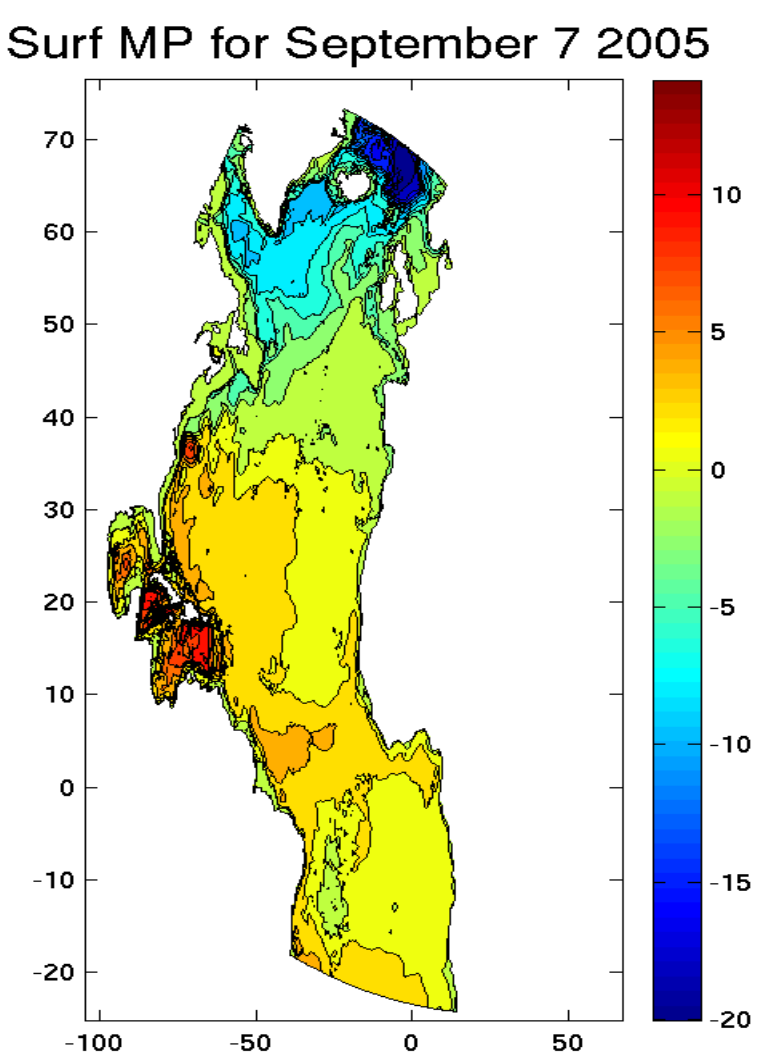
{ } external mode

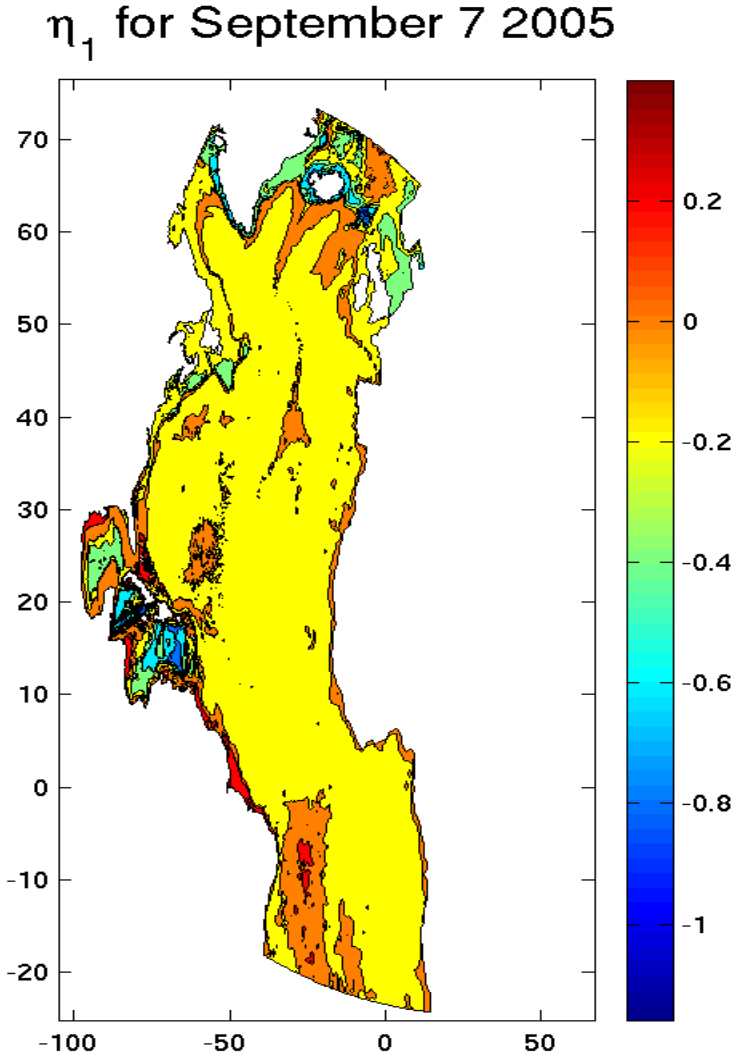
Montgomery potential

M_surface= alpha_0 g rho eta [1]

- If M is bottom initialized, in the external-internal split mode,
  - the surface elevation eta defined by [1], given M_surface, is employed in the momentum equation
  - the surface elevation eta_1 is employed in the external mode continuity equation.
- If M is surface initialized, the surface elevation

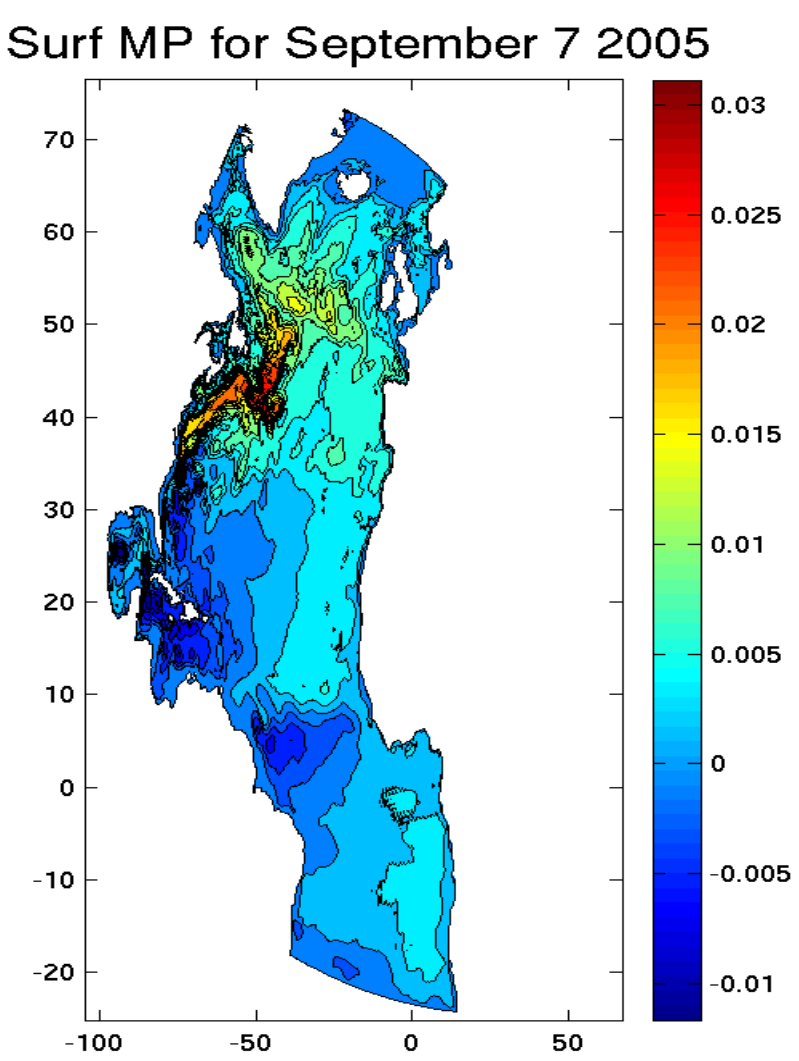
Eta= eta_1 defines M_surface.

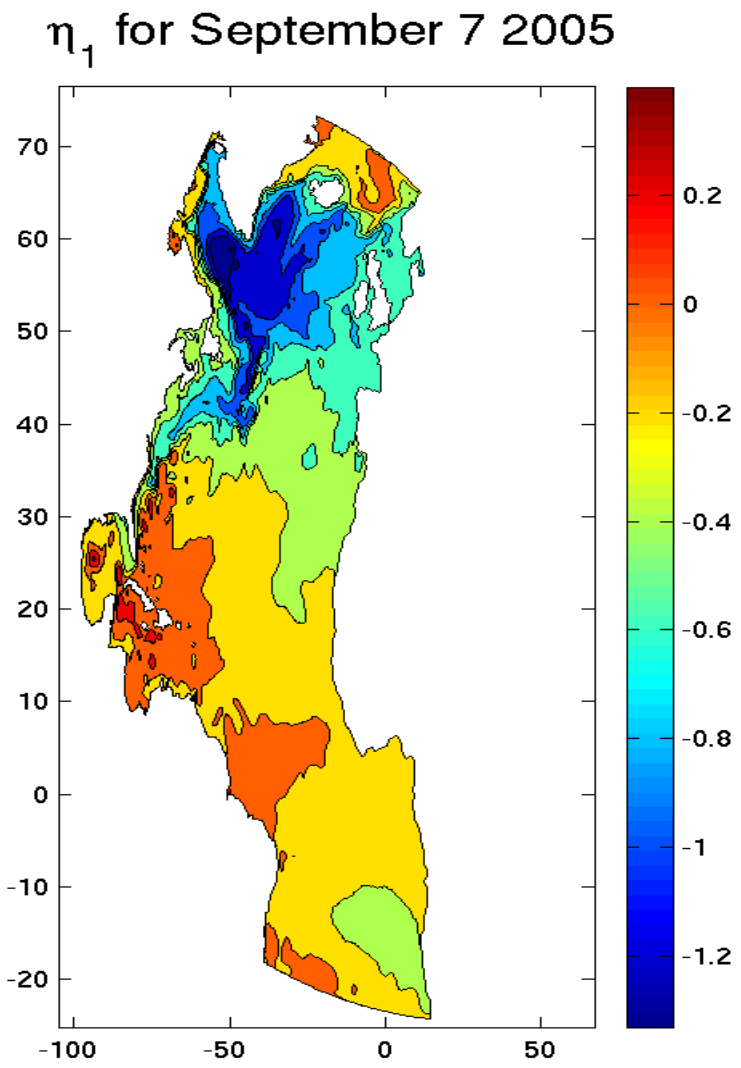




Old algorithm for integration of Montgomery Potential

correlation coefficient = - 0.2322





New Algorithm for integration of Montgomery Potential

correlation coefficient = - 0.7619

Atmospheric pressure and body tides

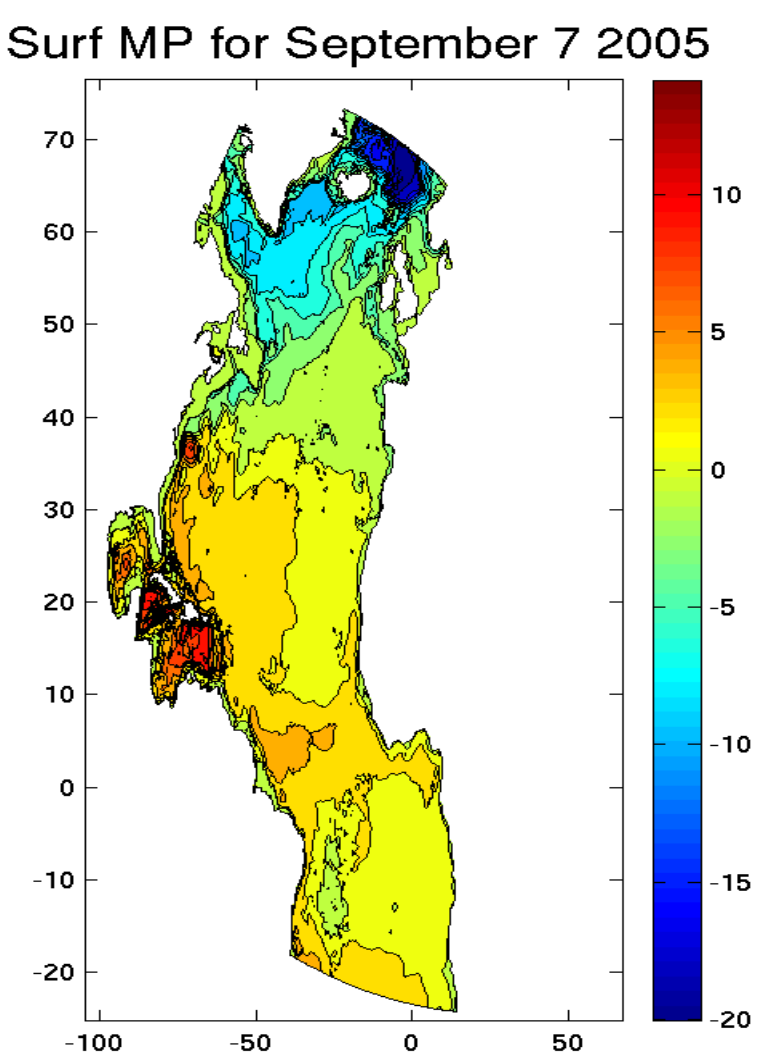
- M_surf=alpha rho_surf g eta +alpha P_atm
- At open boundaries employ inverse barometer correction for surface elevation.

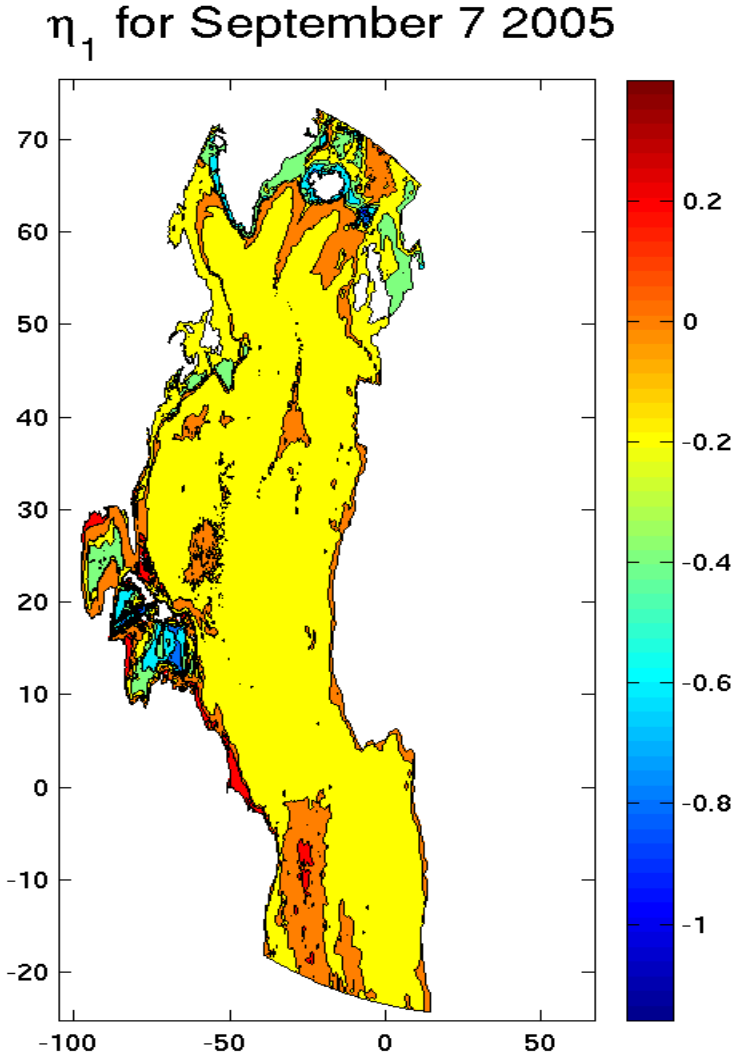
- To implement torque free GF for body tide
  - M=M+alpha rho_mean g eta_tide in momtum
  - Remove tide contribution to recover M for diagnostics.

Model Algorithms II

Open boundary conditions

- Modified two invariant and optimized one invariant
- Performance with low frequency, tidal data and one-way nesting





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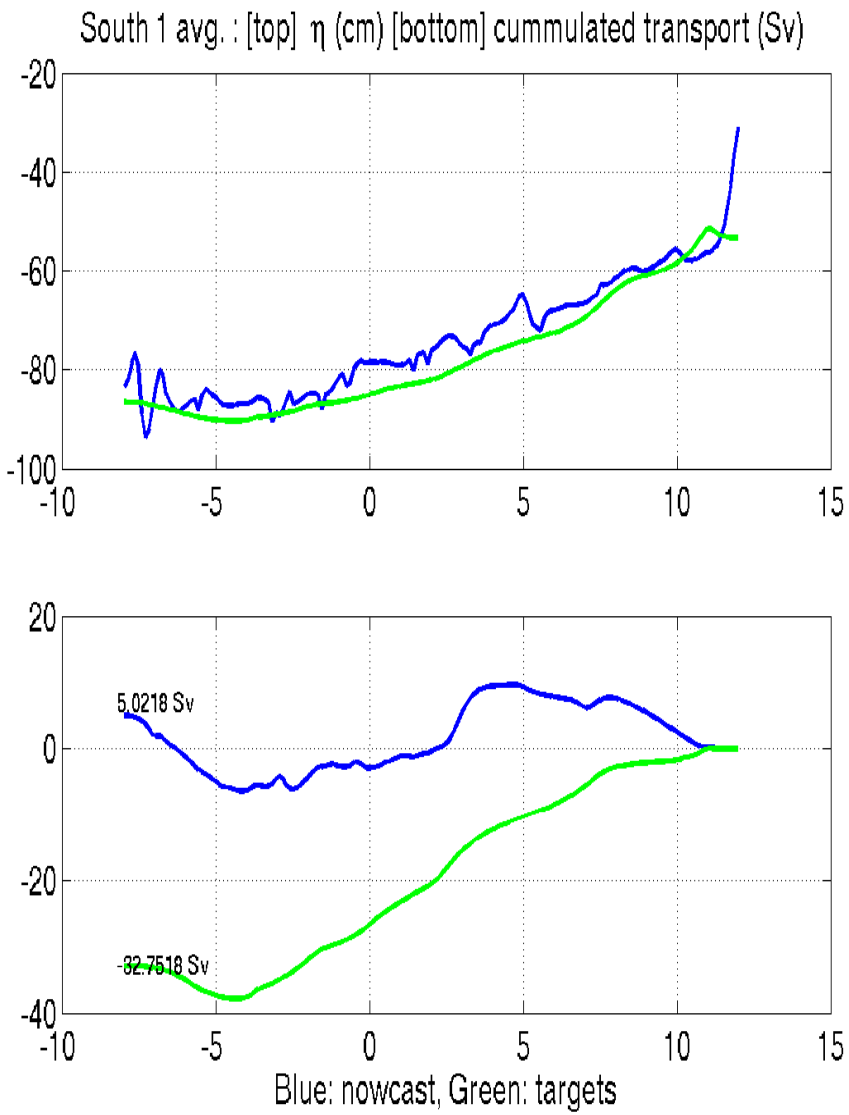
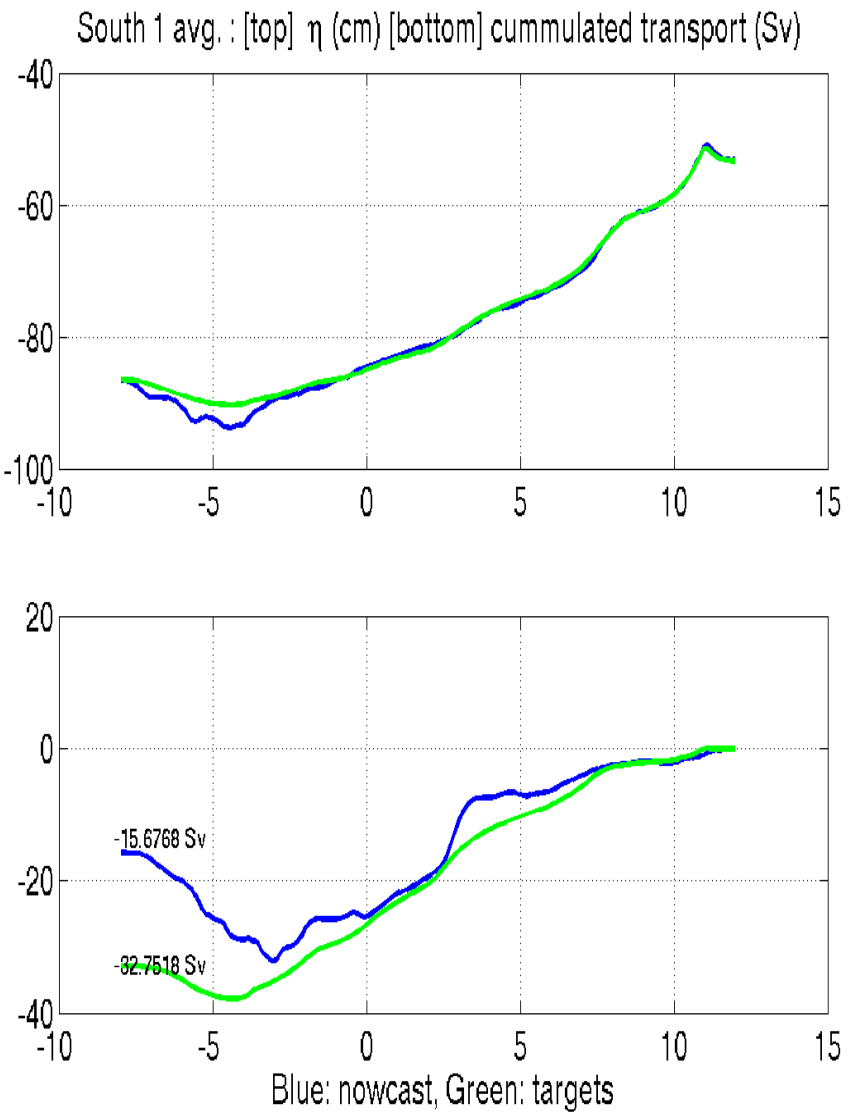
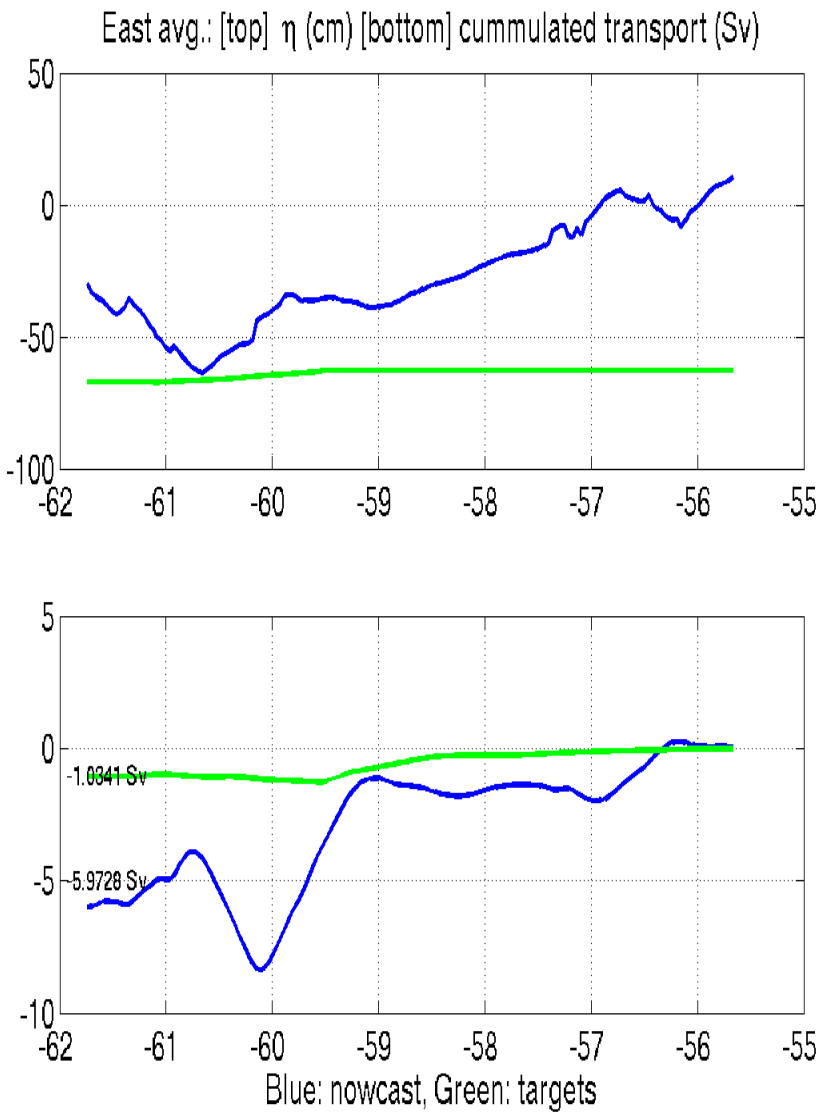
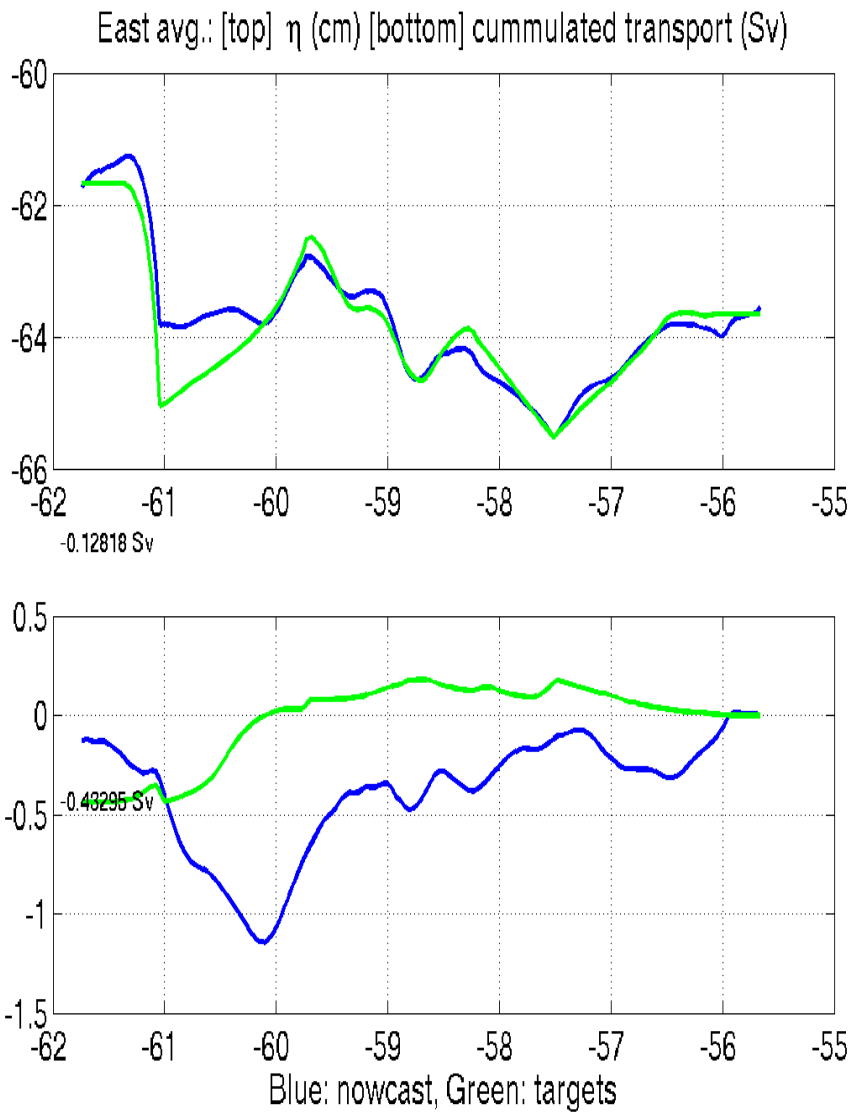




SSH (cm) and cumulative transports (Sv) near GIN Sea (eastern half)

left (operations), right (new initialization): for 09/01/06

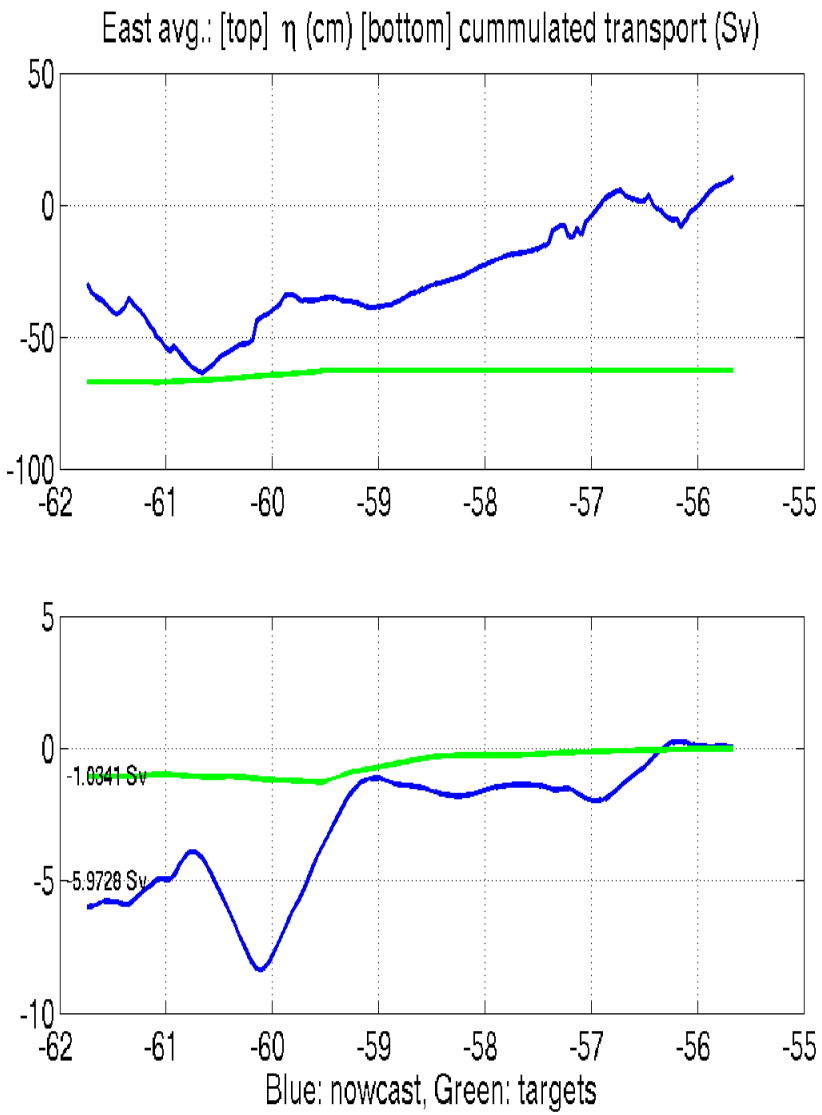


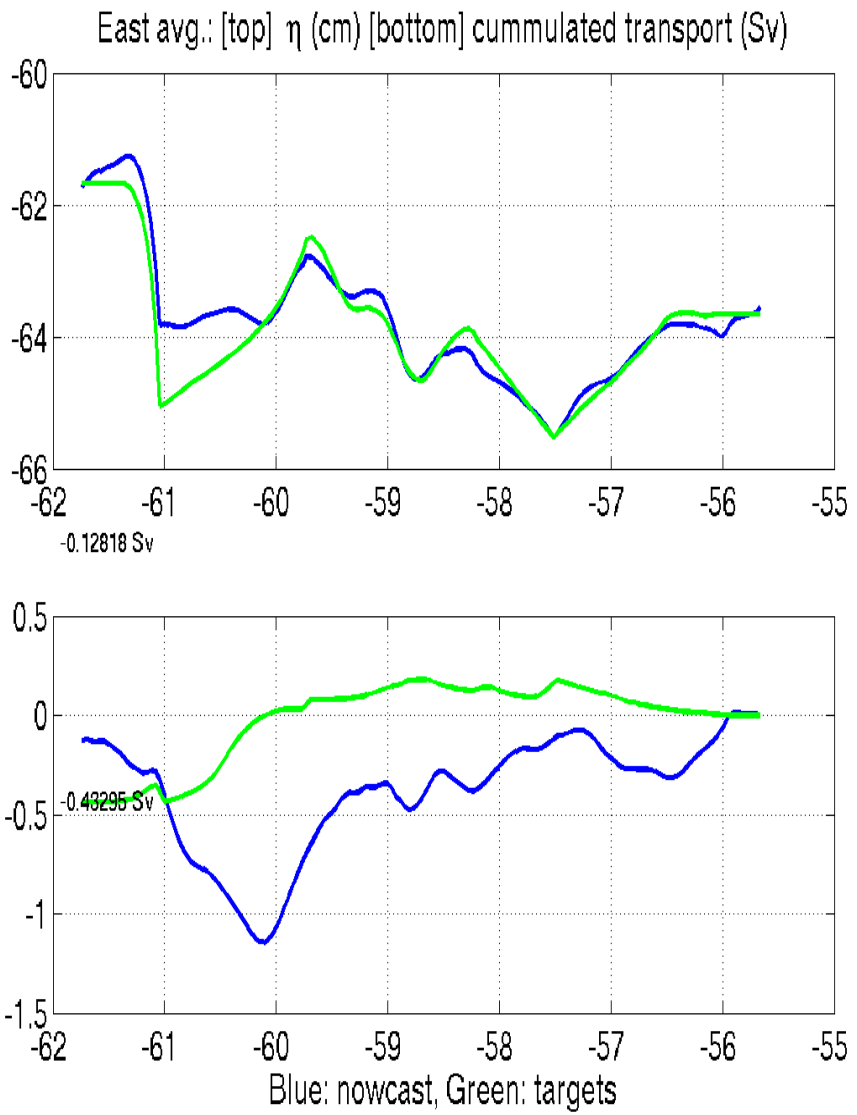


SSH (cm) and cumulative transports (Sv) near Davis Strait
left (operations), right (new initialization): for 09/01/06

New Initialization

- Updated Climatology
- Updated vertical grid parameters
- Surface initialized Montgomery Potential
- Open Boundaries with modified two invariants
- Improvements
  - External mode noise
  - Circulation elements
  - Large scale pressure gradient





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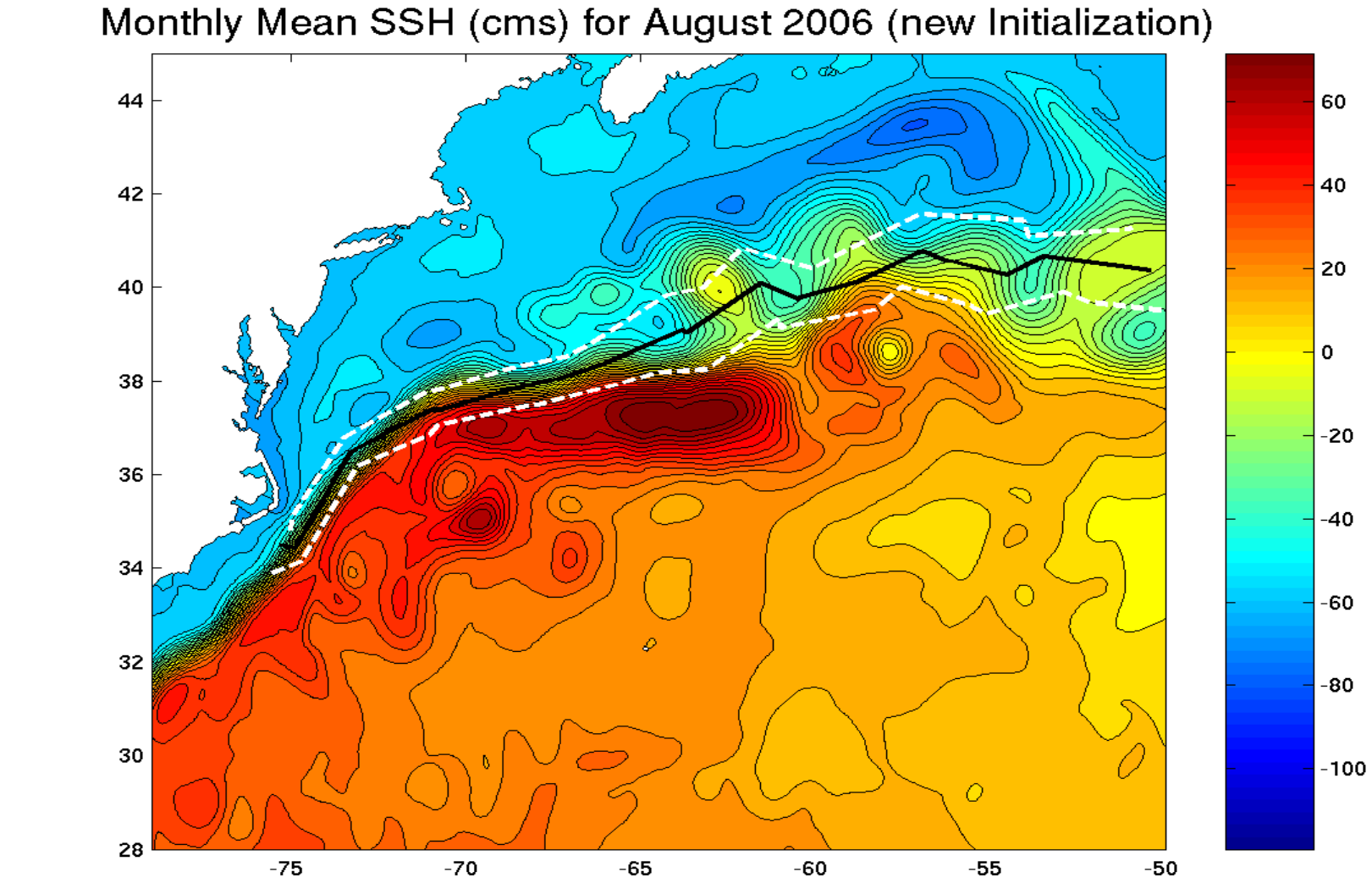
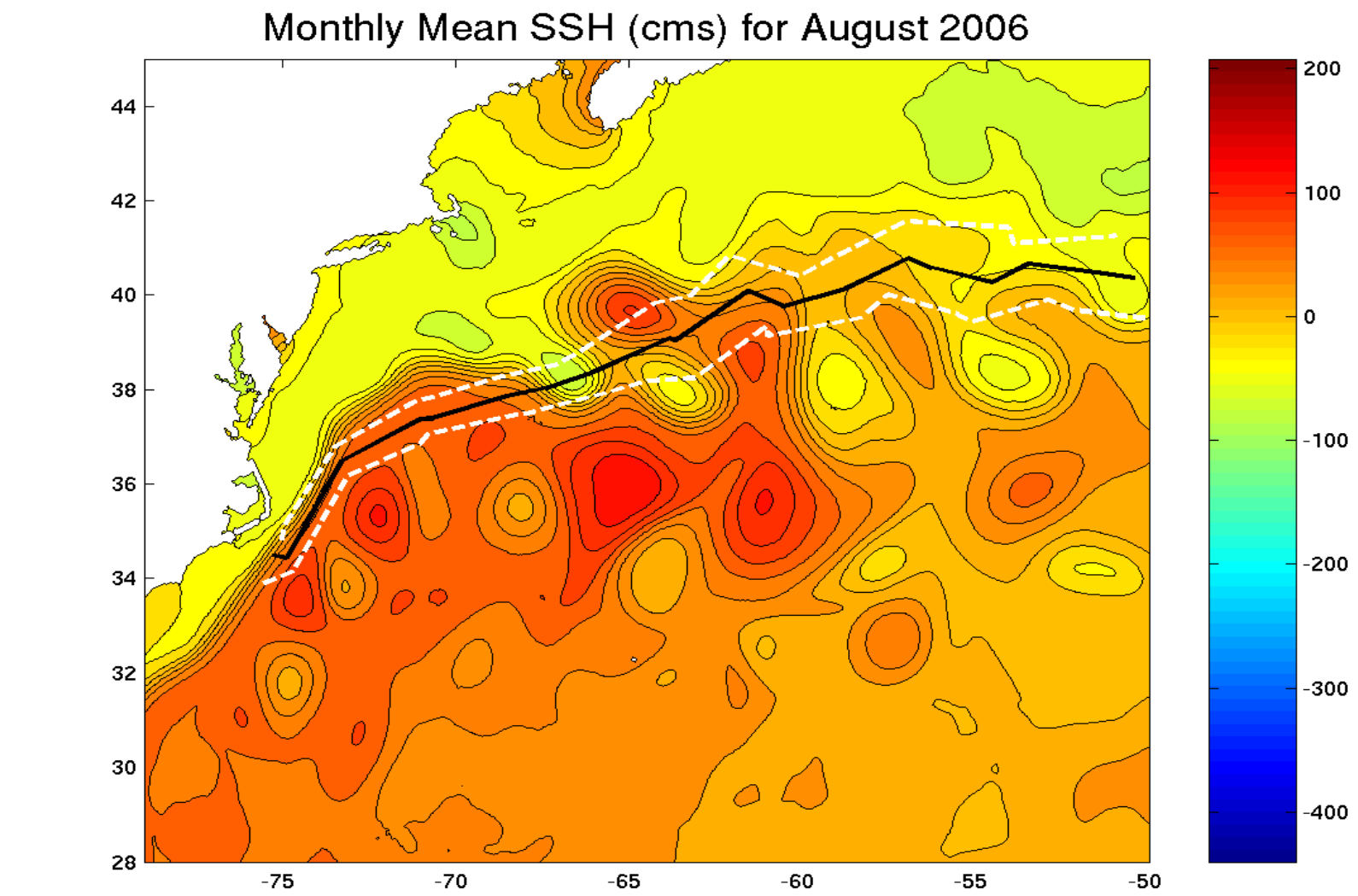


New Initialization GS location agrees with annual mean location derived from altimetry data near separation



Mean GS path from operations tends to overshoot near 63 and 72° W

NCEP COUPLED HURRICANE PREDICTION MODEL

- ATMOS: WRF coarse (Δx~27 km), fine moving grids (Δx~9 km)
- OCEAN: HYCOM with jumping grids (Δx~4.5-10 km)
- COUPLER: NCEP Interpolates fields between overlapping domains, data exchanged every 5 mi (1 designated processor, fast)
- WAVES: WAVEWATCHIII (to be added)

In other talks

- Long term plans DB
- Evaluations Bob Daniels
- Data Assimilation Carlos
- Sensitivity to layering Chandra Narayanan