Data assimilation in RTOFS

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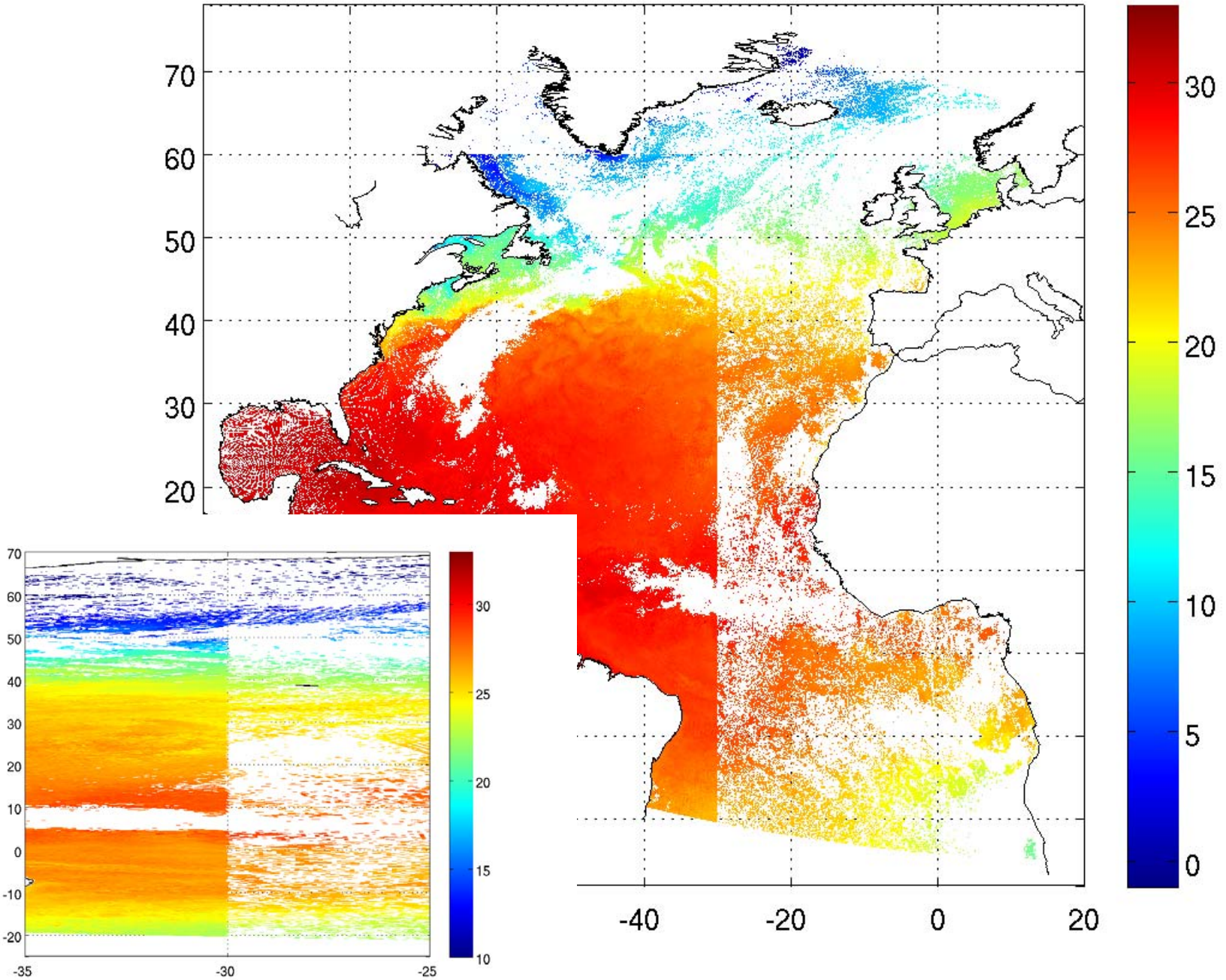
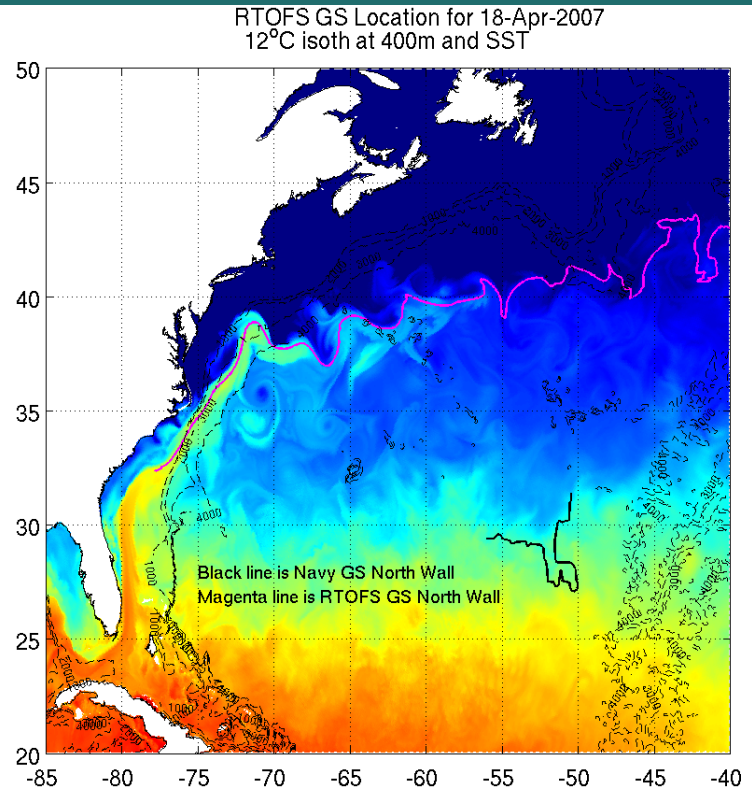
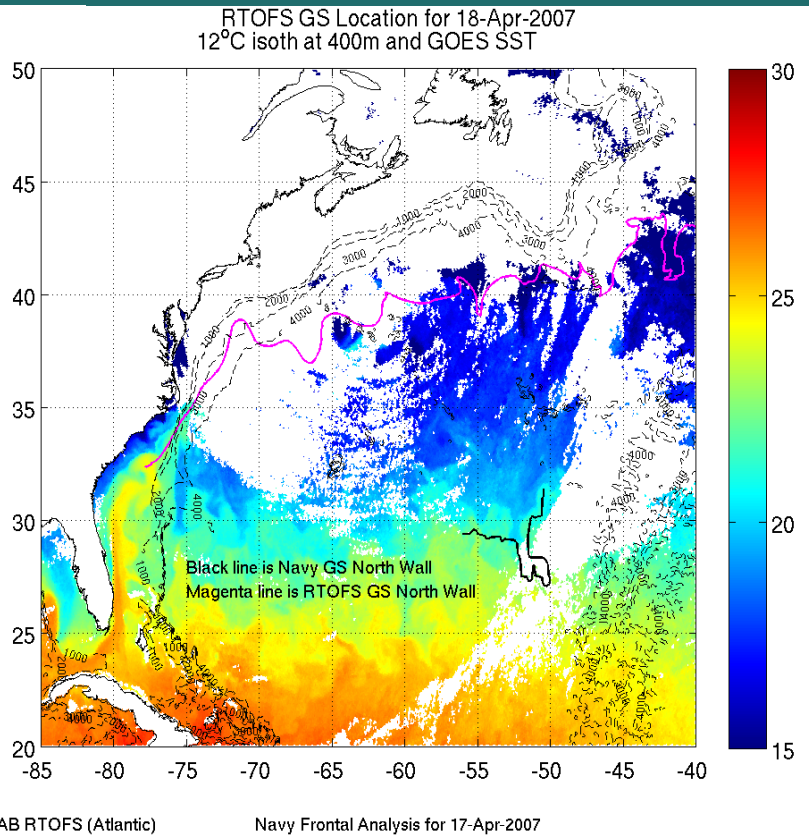
SST

- Data: AVHRR, GOES and in situ
  - GOES bias is removed
- Algorithm:
  - Two 2DVAR analyses: one for yesterday and one for today
  - Time interpolated temperature is nudge while integrating from yesterday to today
  - Nudge is a pseudo heat flux source/sink at the model top layer


70
60
50
40
30
20
-40
-20
0
20
30
25
20
15
10
5
0
70
60
50
40
30
20
10
0
-10
-20
-35
-30
-25
30
25
20
15
10


RTOFS GS Location for 18-Apr-2007
12°C isoth at 400m and SST
Black line is Navy GS North Wall
Magenta line is RTOFS GS North Wall
NCEP/EMC/MMAB RTOFS (Atlantic)
Navy Frontal Analysis for 17-Apr-2007

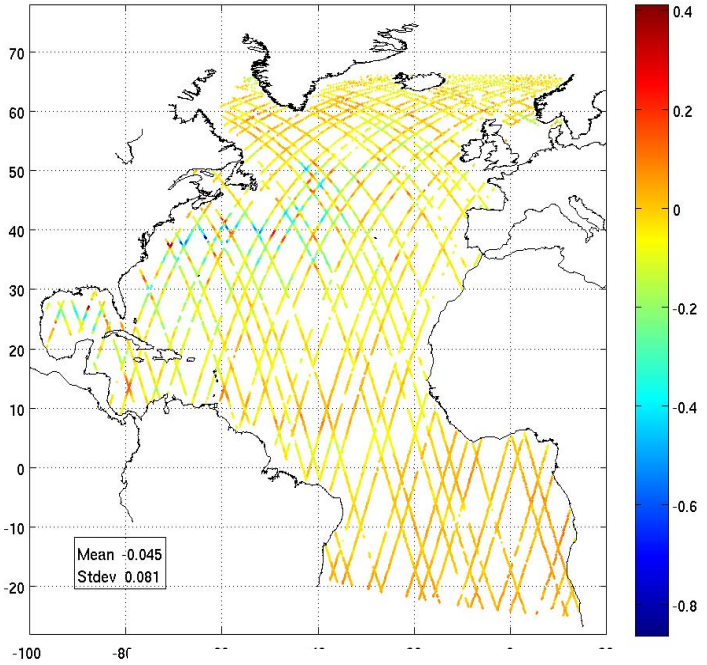

RTOFS GS Location for 18-Apr-2007
12°C isoth at 400m and GOES SST
Black line is Navy GS North Wall
Magenta line is RTOFS GS North Wall
NCEP/EMC/MMAB RTOFS (Atlantic)
Navy Frontal Analysis for 17-Apr-2007
19 Apr

SSH

- Data: JASON and GFO
  - AVISO is not operational

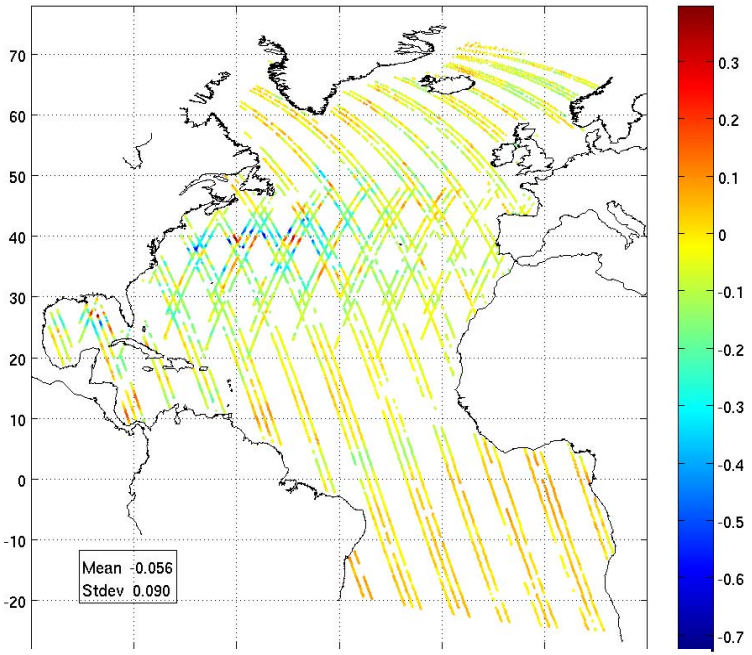
- Algorithm: 2DVAR SSH, and 1D covariance in the vertical. SSH=MDT+SSHA with MDT from Rio (2005).

JSN SSHA assimilated for 2007-04-23

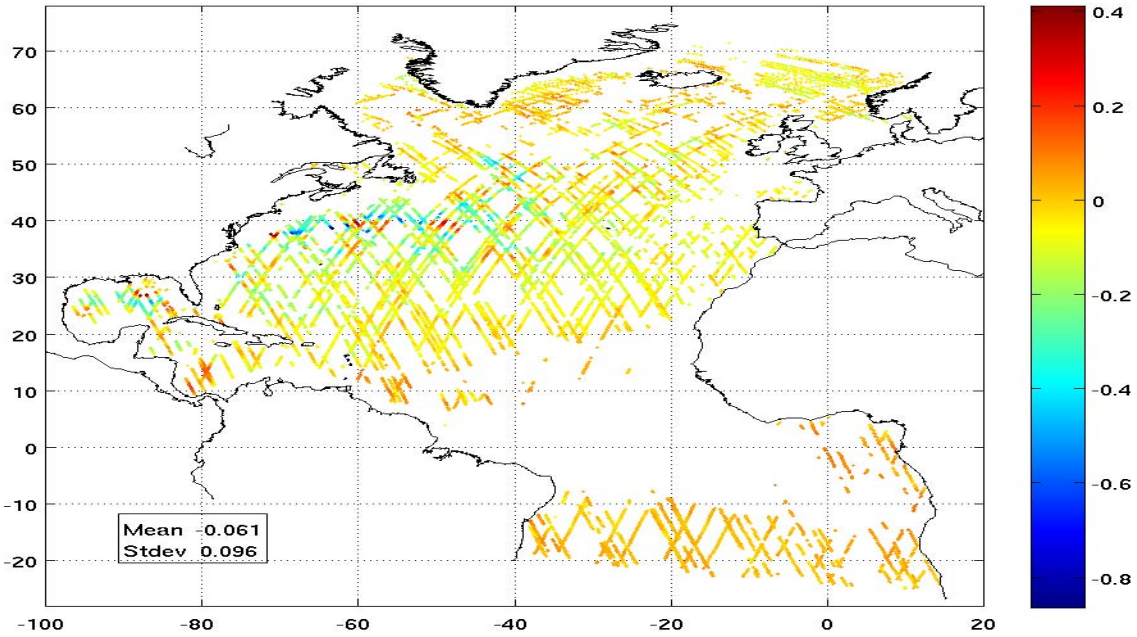


Max SHA of 0.41
Min SHA of -0.86

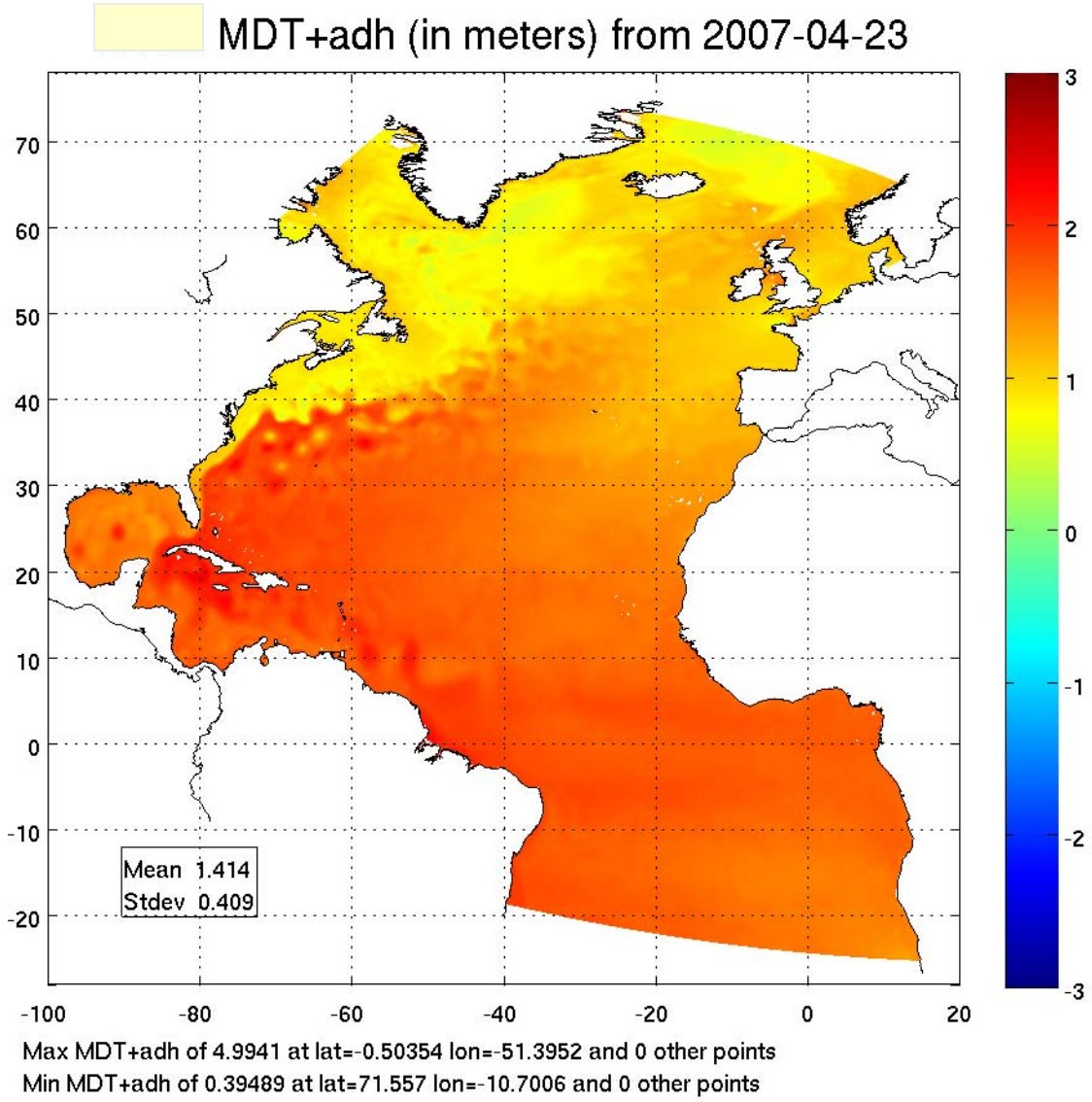
GFO SSHA assimilated for 2007-04-23

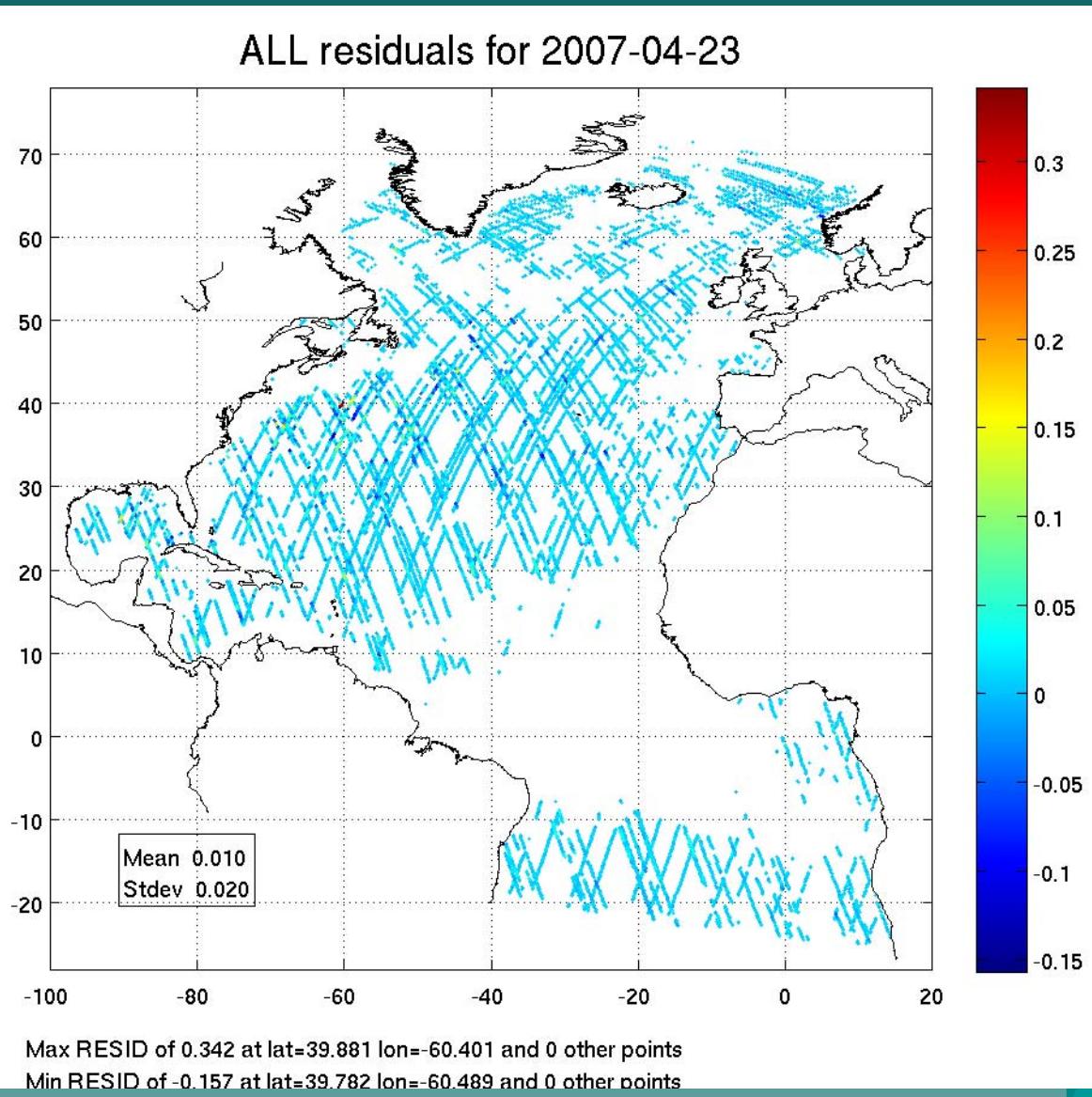


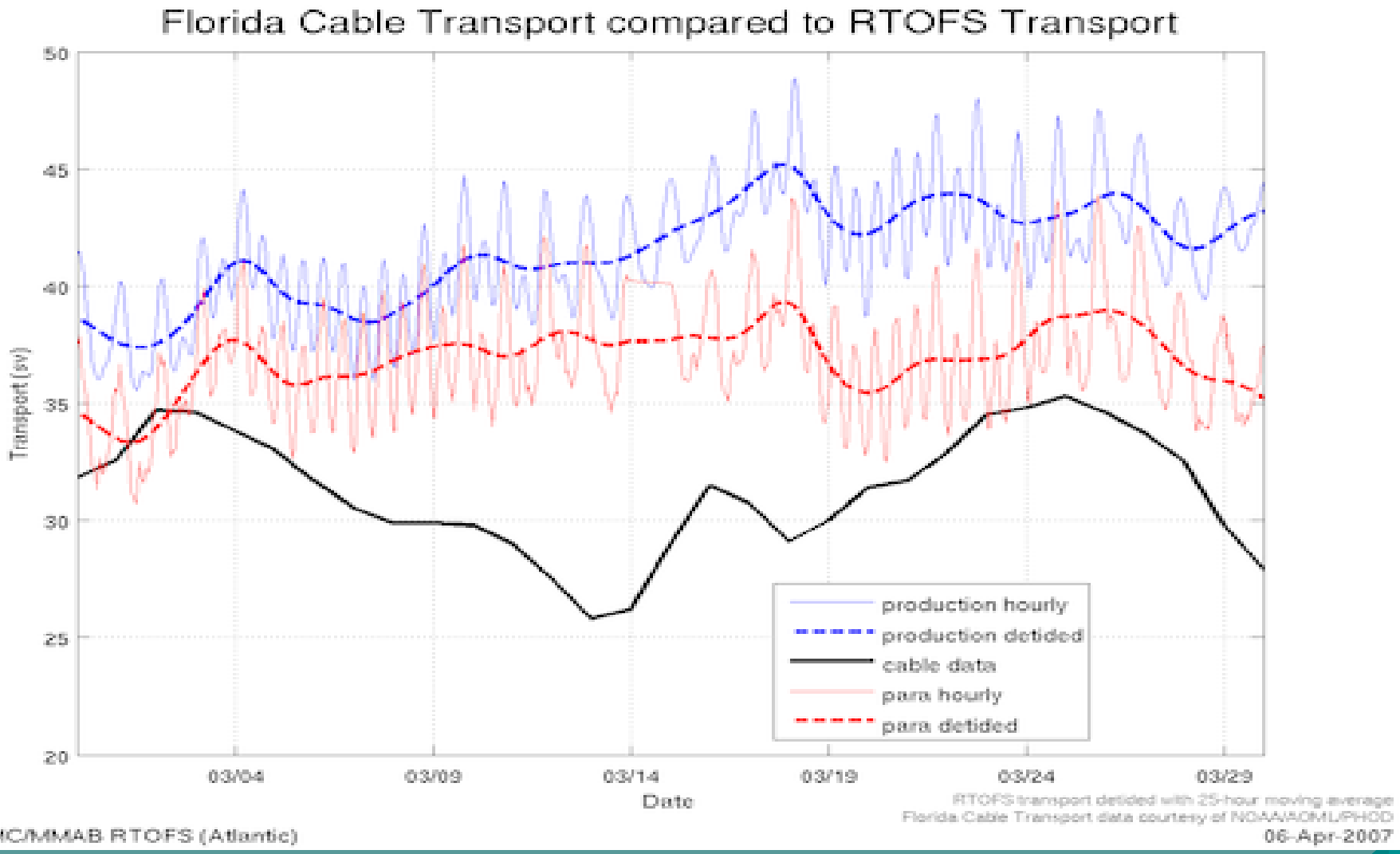
ALL SSHA assimilated for 2007-04-23



Max SHA of 0.412 at lat=37.612 lon=-71.149 and 0 other points
Min SHA of -0.864 at lat=38.591 lon=-63.3 and 0 other points


MDT+adh (in meters) from 2007-04-23
70
60
50
40
30
20
10
0
-10
-20
-100
-80
-60
-40
-20
0
20
3
2
1
0
-1
-2
-3
Mean 1.414
Stdev 0.409
Max MDT+adh of 4.9941 at lat=-0.50354 lon=-51.3952 and 0 other points
Min MDT+adh of 0.39489 at lat=71.557 lon=-10.7006 and 0 other points


ALL residuals for 2007-04-23
70
60
50
40
30
20
10
0
-10
-20
-100
-80
-60
-40
-20
0
20
0.3
0.25
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
Mean 0.010
Stdev 0.020
Max RESID of 0.342 at lat=39.881 lon=-60.401 and 0 other points
Min RESID of -0.157 at lat=39.782 lon=-60.489 and 0 other points



Results from operations as well as parallel runs give higher estimates of net transport for the section Florida to Bahamas as compared to the daily cable data. The parallel run has a similar variability to the operations but better estimates of mean transport.

Low Frequency Boundary Conditions

Internal Mode:

a) **Extrapolation of velocity fluxes for advection and momentum**

b) **Relaxation of Mass Fields T, S and P (interface thickness) in the buffer zones**

$$T^k_{t+1} = T^k_t + \Delta t \, \mu \, (\theta^k_t - T^k_t)$$

$$S^k_{t+1} = S^k_t + \Delta t \, \mu \, (\theta^k_t - S^k_t)$$

$$P^k_{t+1} = P^k_t + \Delta t \, \mu \, (\theta^k_t - P^k_t)$$

where θ represents a slowly varying estimate (here, climatology), k is the layer and μ^{-1} is the relaxation time scale.

The width of buffer zones and values of μ^{-1} are defined a priori.

Low Frequency Boundary Conditions

External Mode:

Normal transports and elevations determined from T,S climatology and Mean Dynamic Topography using:

a) Thermal wind relations

b) Absolute geostrophic velocity determined by either

i) assuming a level of no motion, or

ii) constrained by the slope of mean sea surface elevation, MDT, from Maximenko, Niiler, McWilliams (GJR,2005).

c) The mean of mean sea level is taken from MDT.

Low Frequency Boundary Conditions

Data assimilation modulates directly the low frequency mass field and sea surface height:

a) SST: mixed layer
b) SSH: water column and SSH
c) CTD: water column and SSH

But; there is no feedback…

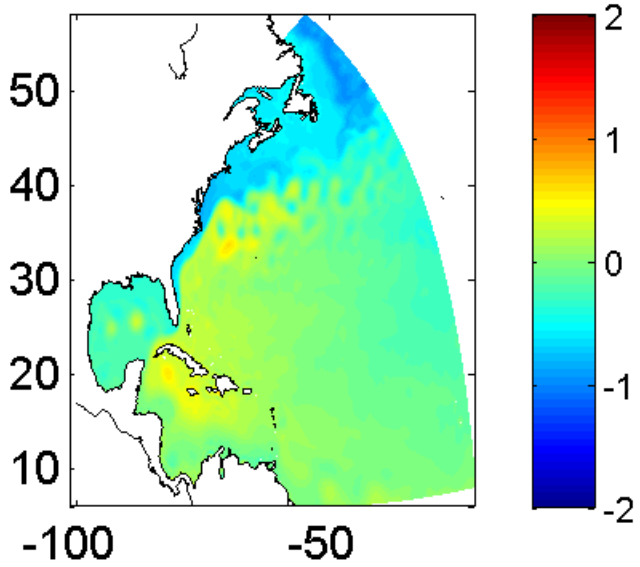
Large scale

- Large scales O(>500km) are well resolved by observations
- Internal dynamics at the mesoscale is influenced/modulated by the ambient potential vorticity
- Are we introducing the large scales correctly in the assimilation?

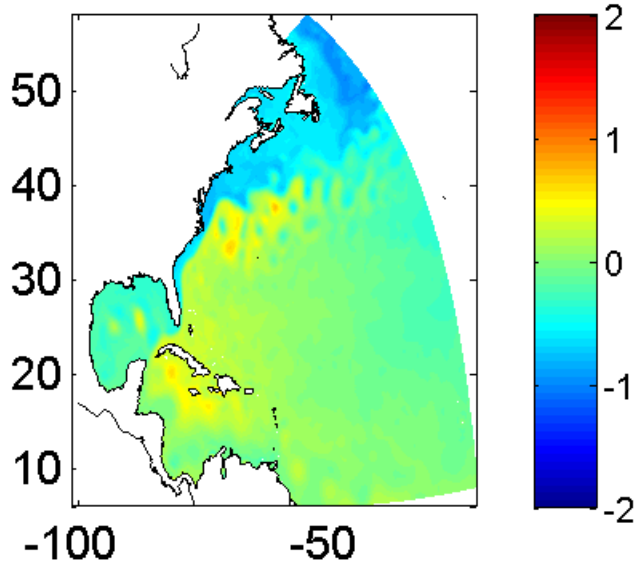
Experiment

- Three simulations (from Jan 1 to March 31 2007)
  - Central: No assimilation (*)
  - With SST assimilation
  - With SST & SSH assimilation
- Model parameters and forcing nearly identical to those used in operations

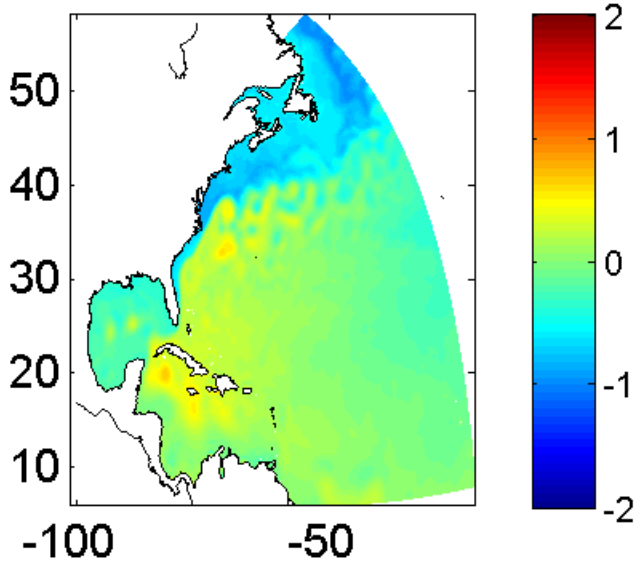
Central Jan 03-Mar 03 2007



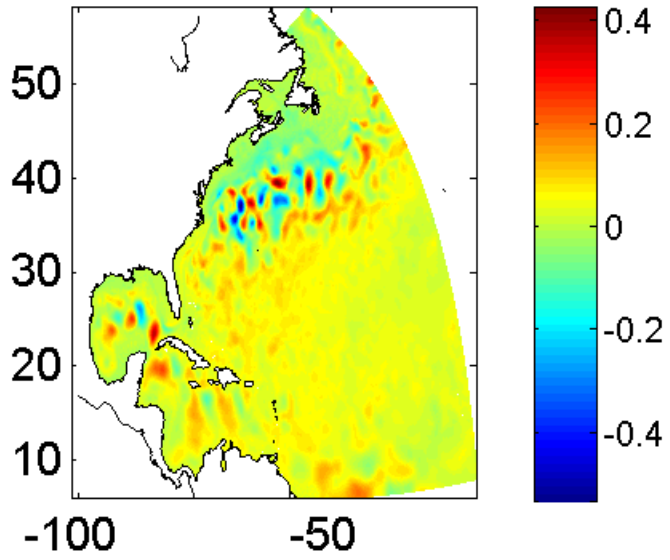
Mean:η (m)



with SST Jan 03-Mar 03 2007

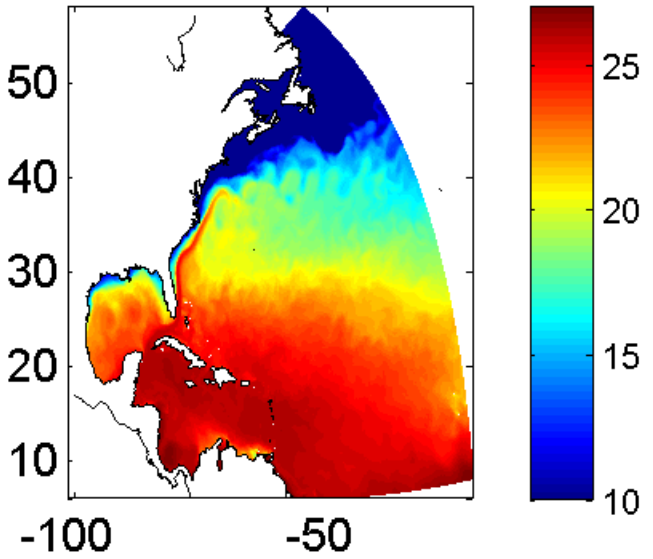


with SST & SSH Jan 03-Mar 03 2007

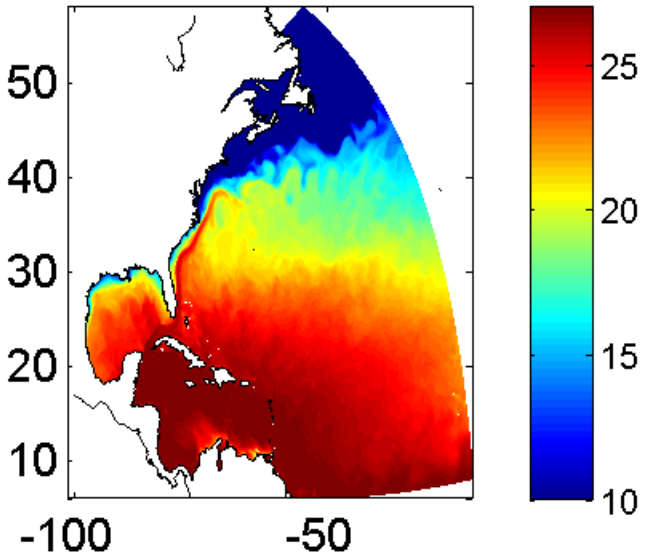


Diff [SST & SSH] - Central

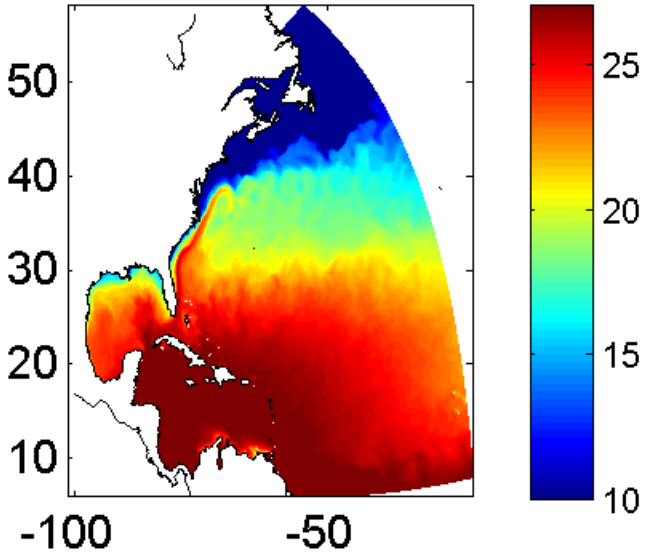
Central Jan 03-Mar 03 2007



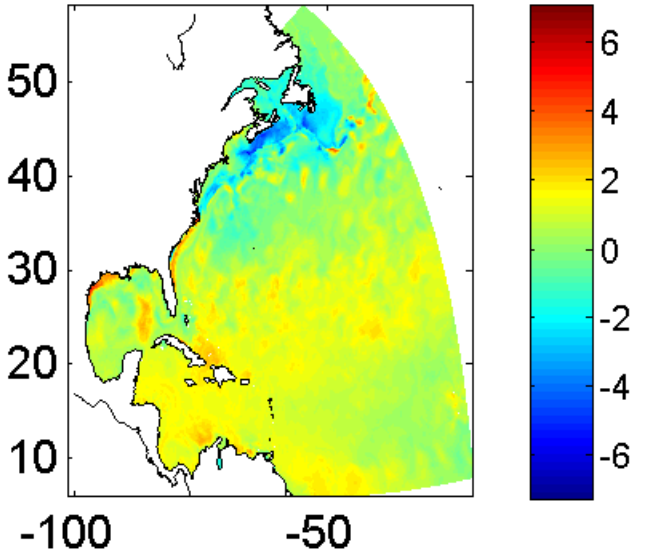
Mean:Temperature (°C)



with SST Jan 03-Mar 03 2007



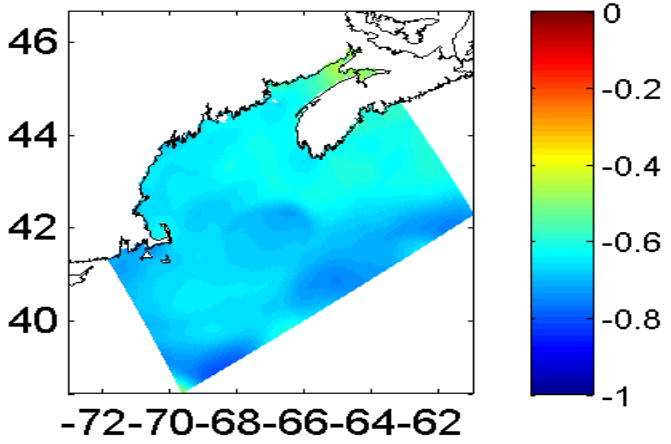
with SST & SSH Jan 03-Mar 03 2007



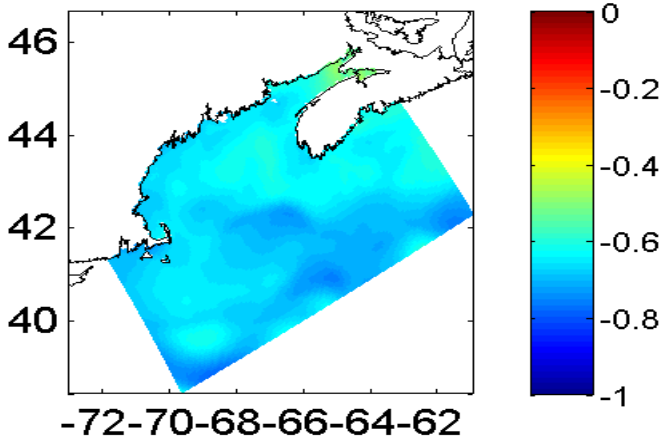
Diff [SST & SSH] - Central

Gulf of Maine

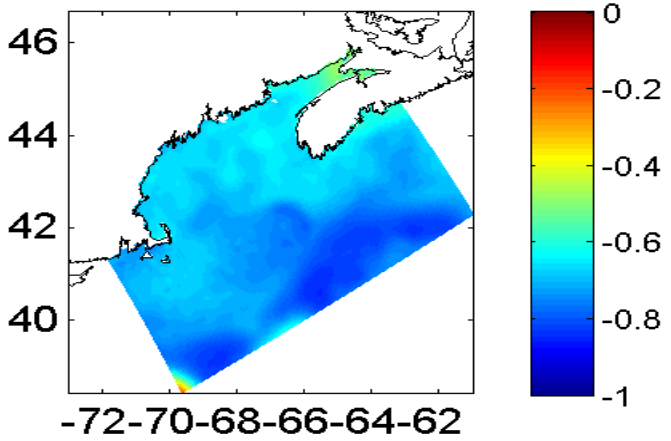
Central Jan 03-Mar 03 2007



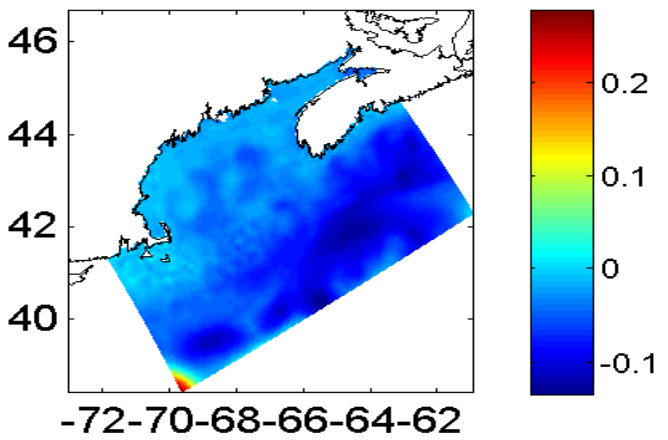
Mean:η (m)



with SST Jan 03-Mar 03 2007

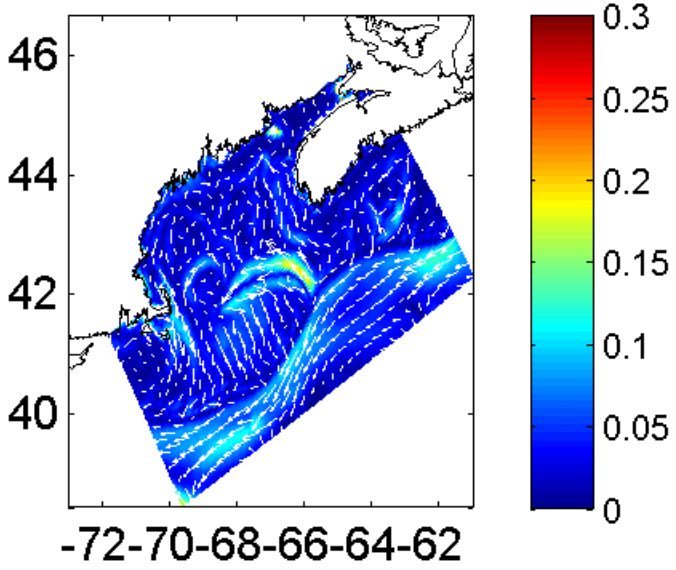


with SST & SSH Jan 03-Mar 03 2007

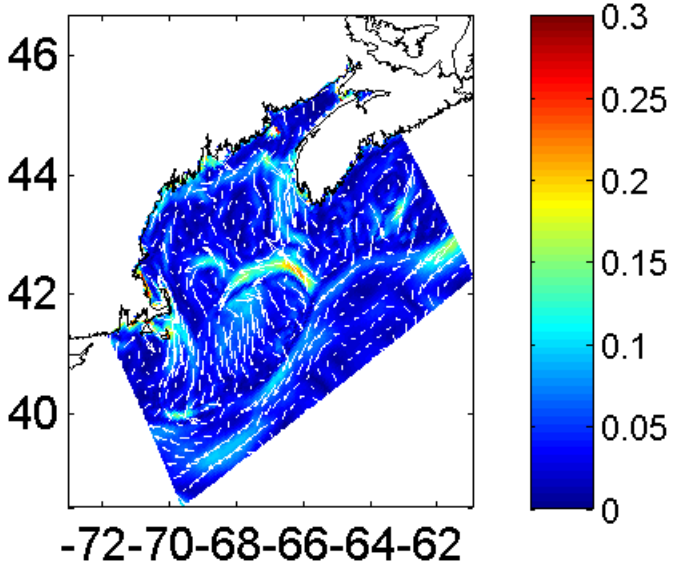


Diff [SST & SSH] - Central

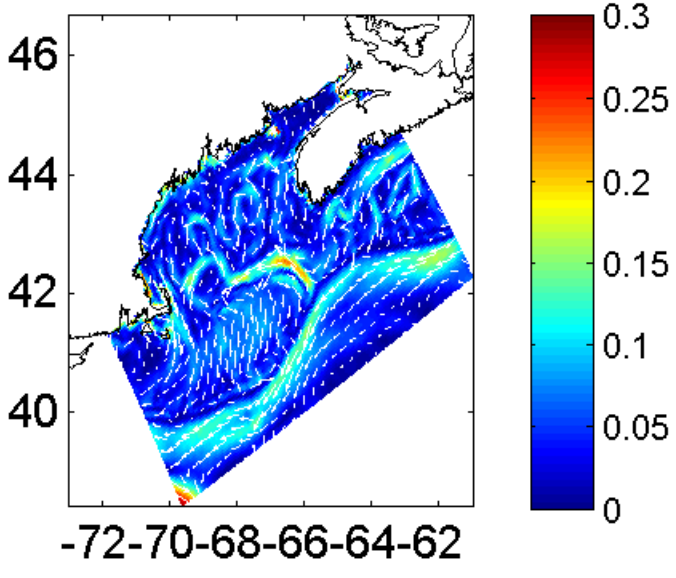
Central Jan 03-Mar 03 2007



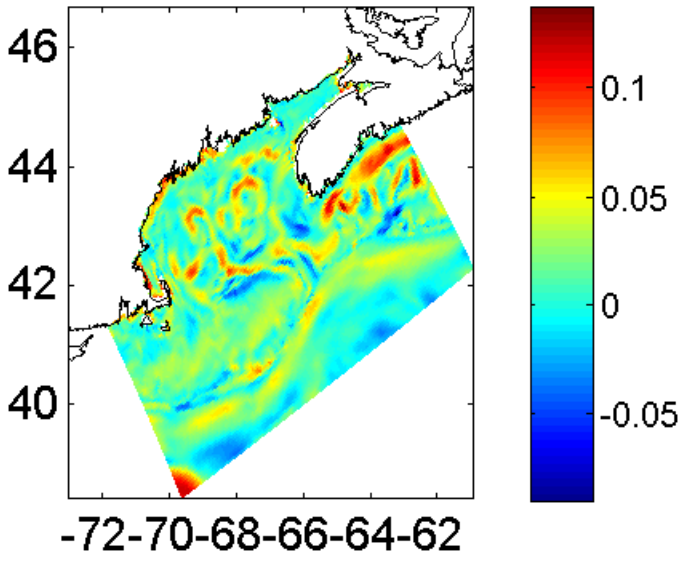
Mean:Barotropic velocity (m/s)



with SST Jan 03-Mar 03 2007

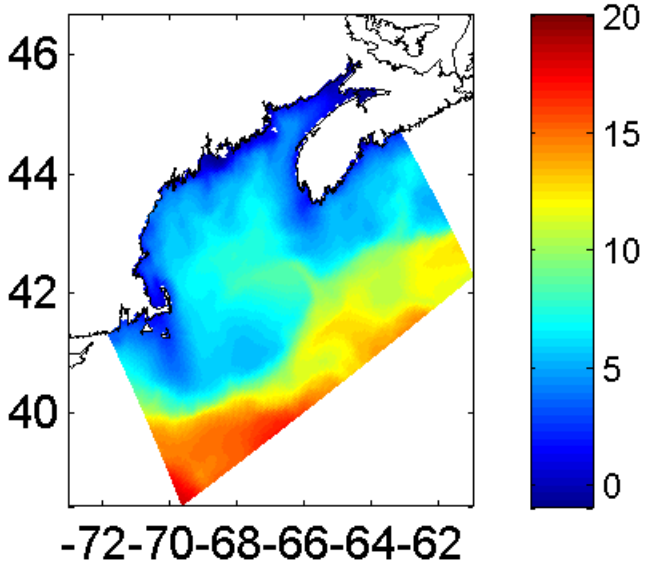


with SST & SSH Jan 03-Mar 03 2007

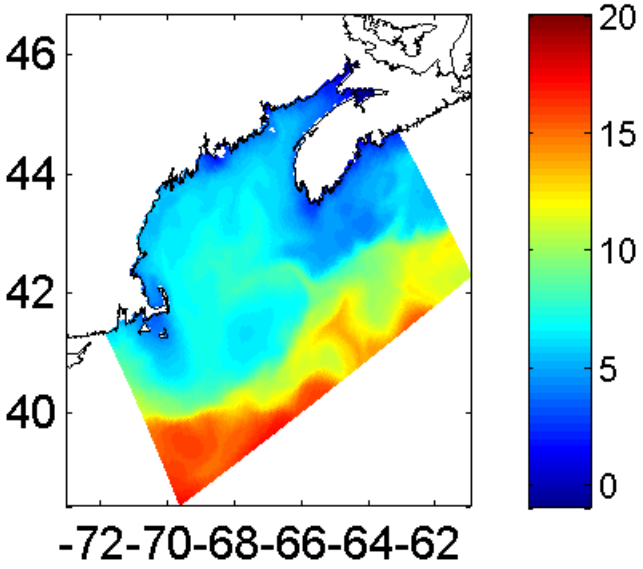


Diff [SST & SSH] - Central

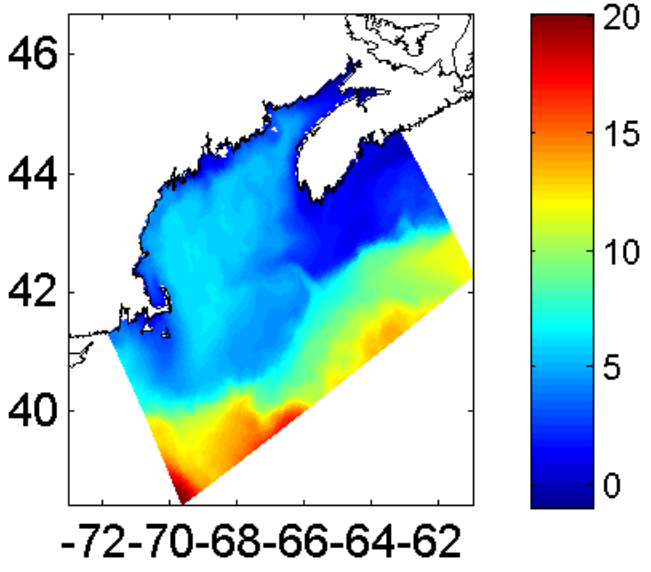
Central Jan 03-Mar 03 2007



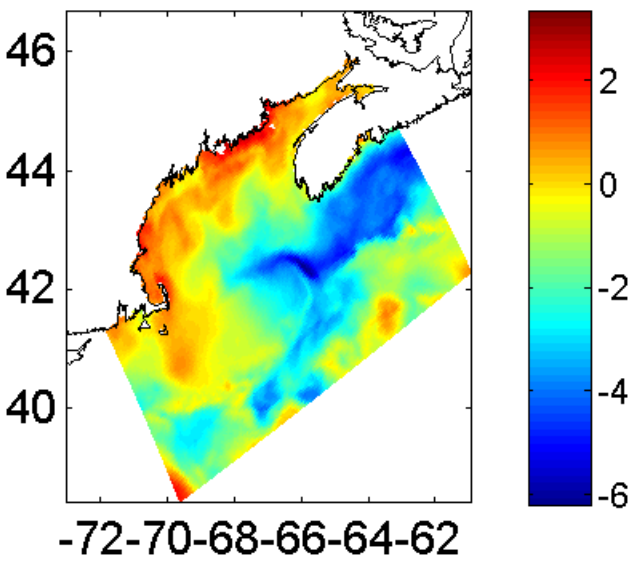
Mean:Temperature (°C)



with SST Jan 03-Mar 03 2007

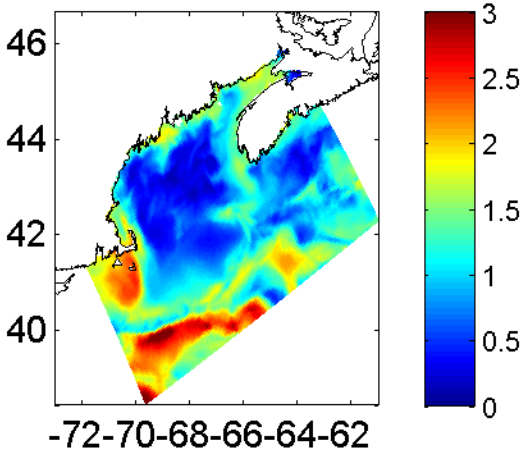


with SST & SSH Jan 03-Mar 03 2007

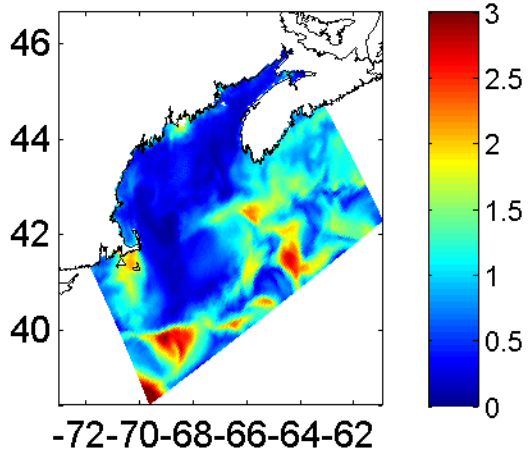


Diff [SST & SSH] - Central

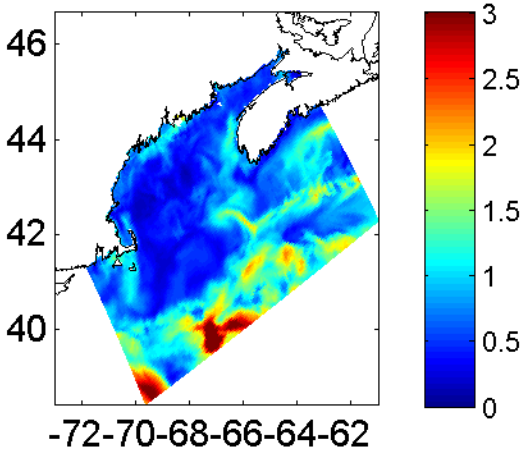
Central Jan 03-Mar 03 2007



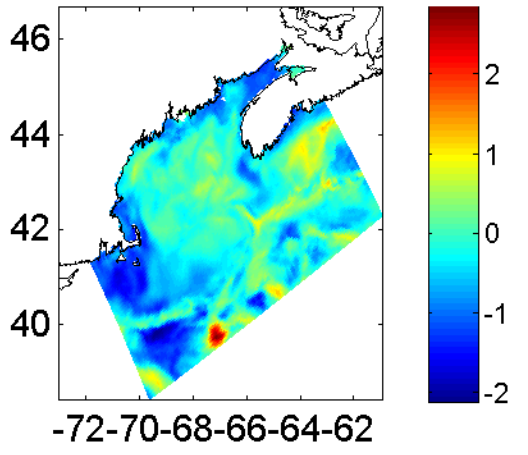
Std:Temperature (°C)



with SST Jan 03-Mar 03 2007



with SST & SSH Jan 03-Mar 03 2007



Diff [SST & SSH] - Central

Remark

- The large scale estimates derived from the model and from the combination of model and data assimilation require improvements in some geographical areas (of practical interest).
  - Model
  - Data
  - Data assimilation