On a 3D variational assimilation scheme in hybrid coordinates

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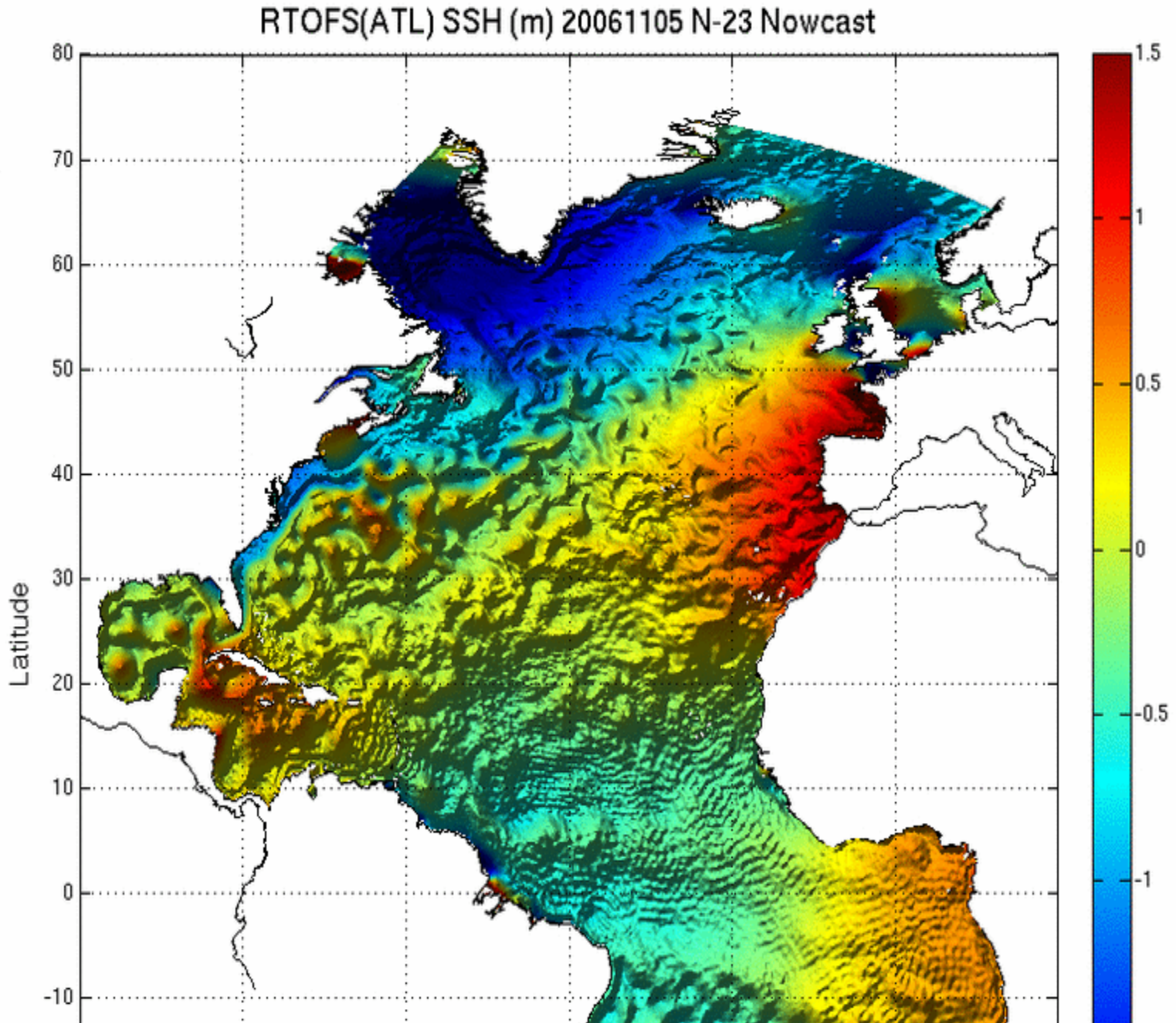
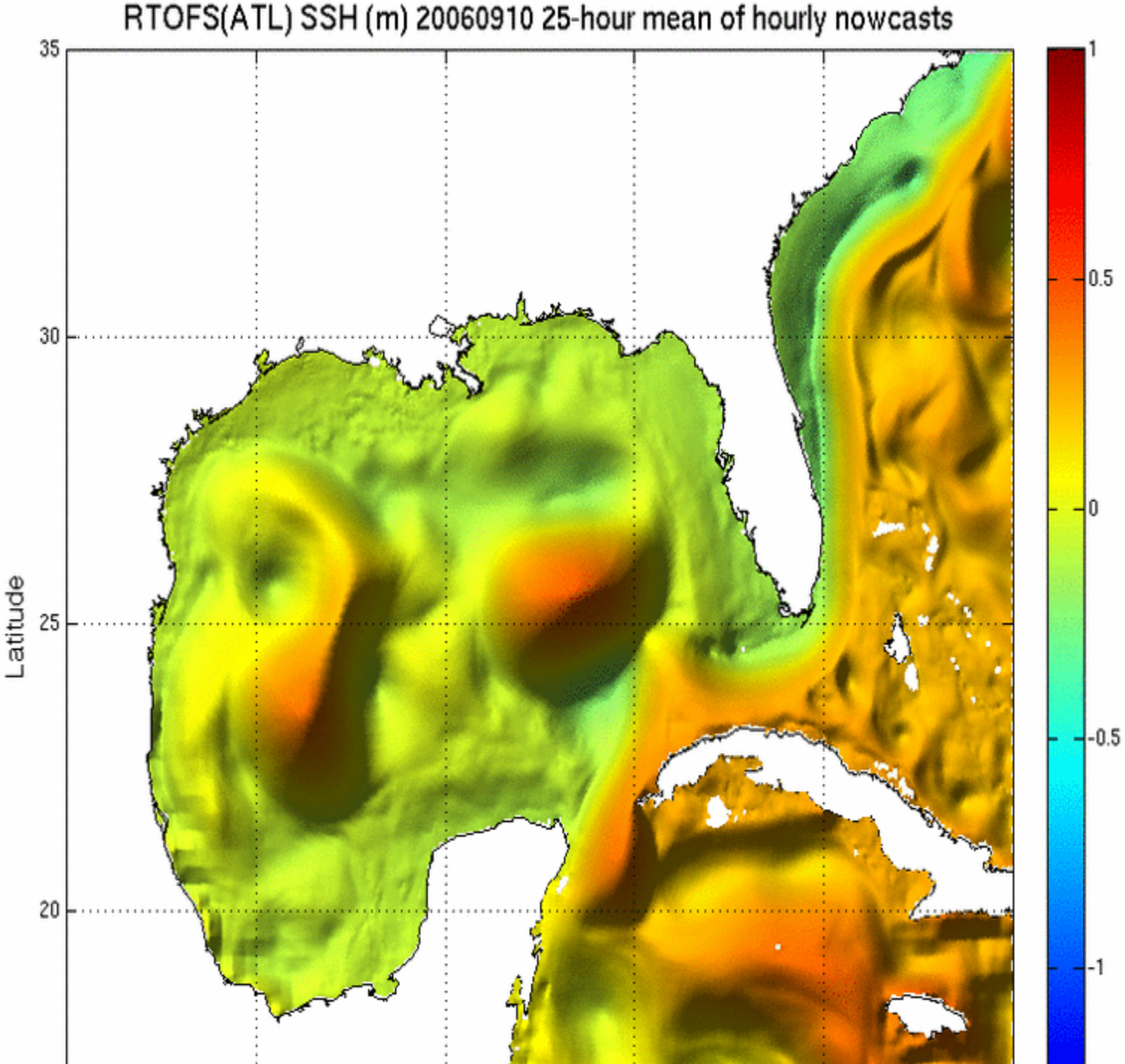
Objectives

- Improve the estimate of sub-surface ocean structures based on remotely sensed observations of sea surface height, sea surface temperature, in situ temperature and salinity; and model estimates.
- Improve the joint assimilation of SSH, SST, T and S in a high resolution ocean forecast system.

04 Nov 01Z


RTOFS(ATL) SSH (m) 20061105 N-23 Nowcast
Latitude
80
70
60
50
40
30
20
10
0
-10
1.5
1
0.5
0
-0.5
-1


RTOFS(ATL) SSH (m) 20060910 25-hour mean of hourly nowcasts
35
30
25
20
Latitude
1
0.5
0
-0.5
-1

Data assimilation components (I)

- Observations:
  - SST: in situ, remotely sensed [AVHRR, GOES]
  - SSH: remotely sensed [JASON, GFO, ENVISAT]
  - T&S: ARGO, CTD, XCTD, moorings.
  - T: AXBT, moorings

Observations red notes

- ENVISAT: Final negotiations with ESSA, and NAVOCEANO completed. Data is now in the NCO pipeline
- GOES: There is a bias (~ .5 C)[using AVHRR as true]. This data is assimilated in the Northwest Atlantic only.
- T: Temperature profiles will be assimilated after salting: S(z)= F(T(z)) as a pseudo T&S profile.

  F is Carlyle Thacker's algorithm.

Data assimilation components (II)

- Quality Control: Observation accepted if
  - Anomaly from climatological mean is within h STD. h~ 2.3; and
  - Anomaly from model nowcast is within h STD. It assumes there are no model biases.
- Climatology sources
  - SST: Mean and STD from PATHFINDER version 5, Casey NODC/NOAA (global)
  - SSHA: Mean and STD from AVISO (global)
  - T&S: Mean NCEP (Atlantic), STD Levitus (global)
  - SSH: MDT Rio-5 and Maximenko-Niiler

Quality control red note

MODEL BIAS:

South Atlantic SST (cold) bias ~-6 C, was induced by noise in the Southern boundary.

- Temporary fix: remove qc based on anomalies from the nowcast.
- Semi-permanent fix: improve external mode data prescribed in the southern boundary, and re-established qc based on anomalies from the model.

Labrador mean sea surface height (tall) bias ~+0.3m

- Current fix: Mean sea level from MDT at open boundaries, in particular around Baffin Island.

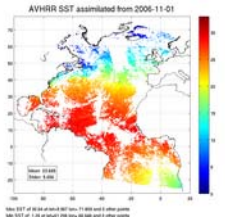
Data assimilation components (III)

- Data Assimilation Algorithm:
  - Overall employ 3Dvar = 2D(along model layers)x1D(vertical).
  - 2D assumes Gaussian isotropic, inhomogeneous covariance matrix. Jim Purser's recursive filtering.
  - 1D vertical covariance matrix.
    - Constructed from coarser resolution simulations
    - SST extended to model defined mixed layer.
    - SSH lifting/lowering main pycnocline (for comparisons)
    - S&T lifting/lowering below the last observed layer.

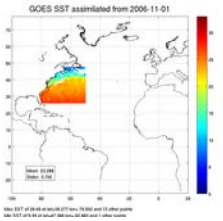
SST Assimilation

Data

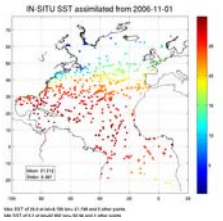
AVHRR



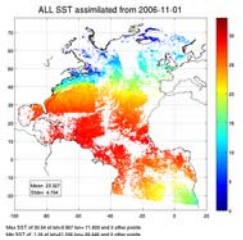
GOES



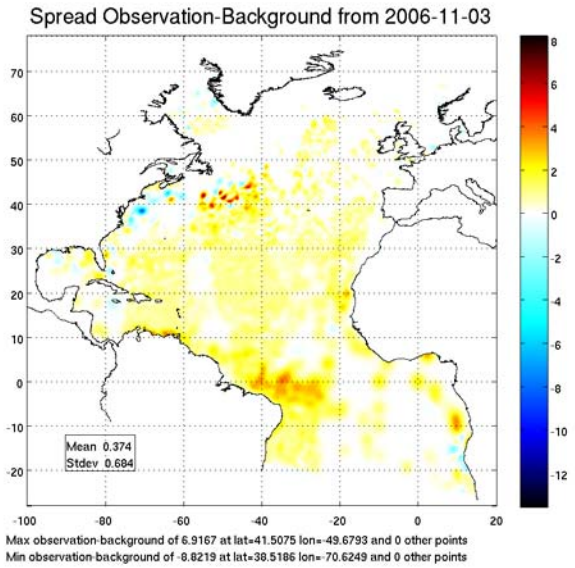
IN-SITU



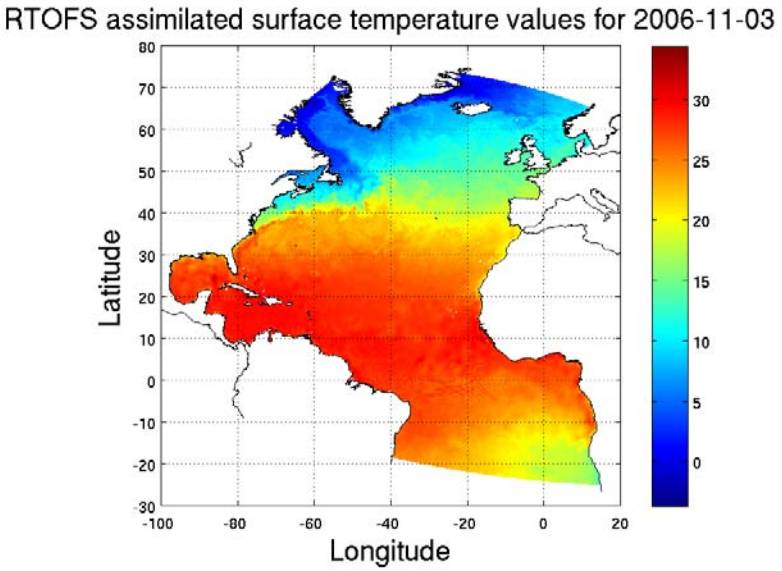
ALL



Observation - Background



Assimilated Field



Data Assimilation red notes

Analyses on layers:

PDFs are likely to be gaussian along isopycnals in the deep ocean, and along equi-potentials near the free surface. Hybrid coordinates are suitable for this purpose; except for shallow waters (hybrid is then mostly terrain following) and for very high horizontal resolution <=1km (3D covariances are not well approximated by 3D=2DX1D).

Land barriers:

The recursive filters are implemented for efficiency in domains without land barriers. Some minor extensions to this algorithm is anticipated to avoid the 'Cape Cod syndrome'.

Layer Analyses Variables

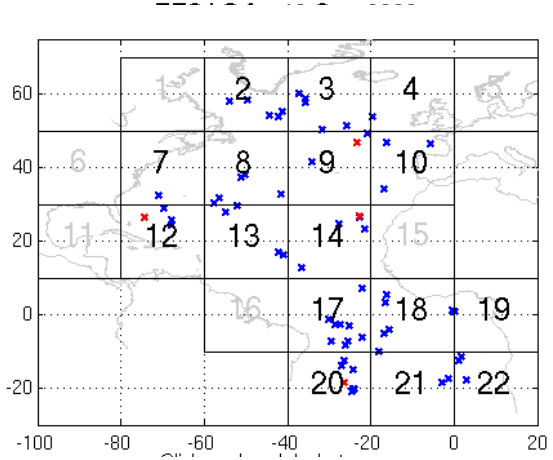
H : layer thickness

T : layer potential temperature

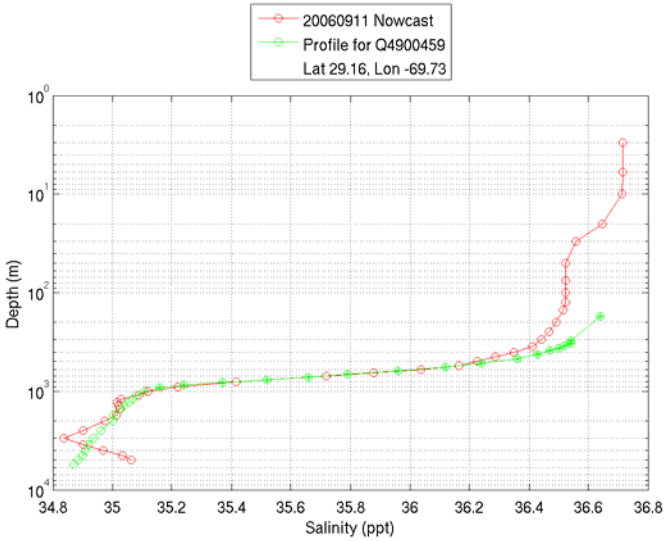
D : layer potential density (almost constant in an isopycnic layer).

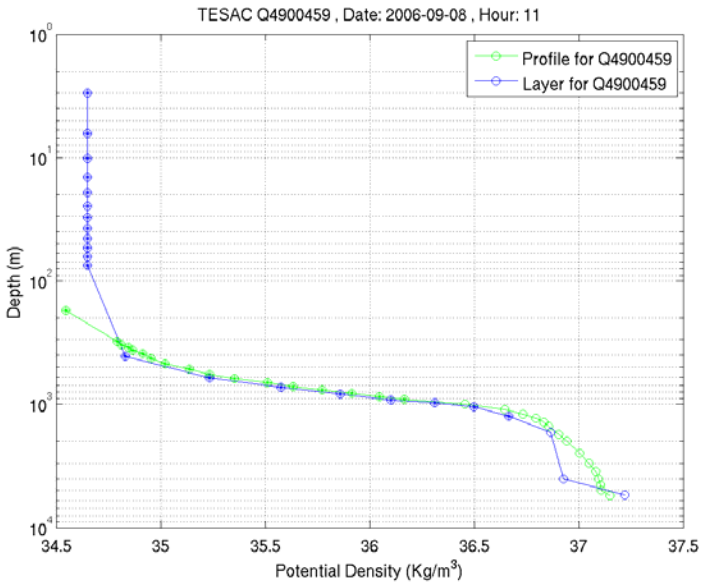
[G(S:salinity,T,D)=0 is defined implicitly through the equation of state]

Z to LAYER

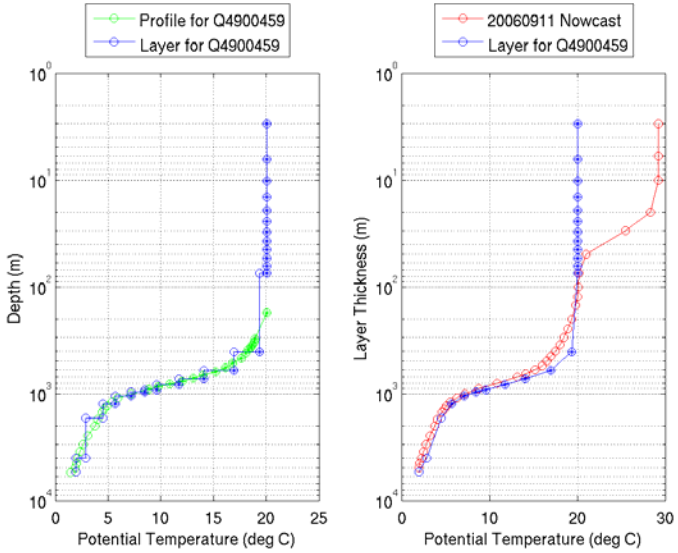


Data





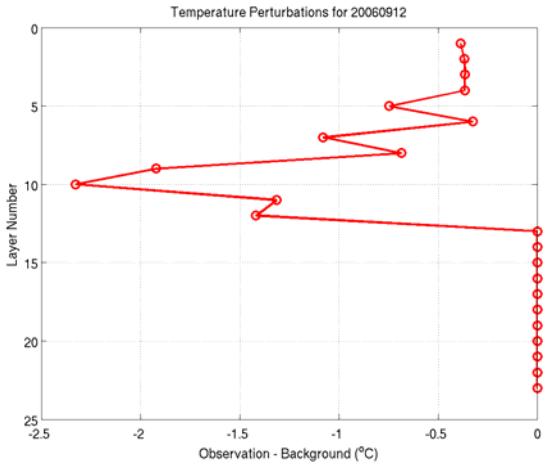
Profile To Layers

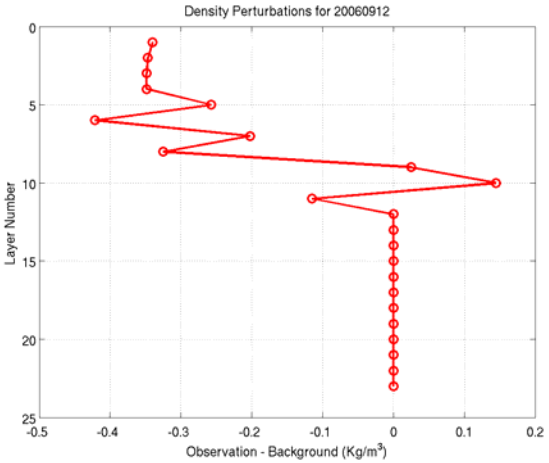


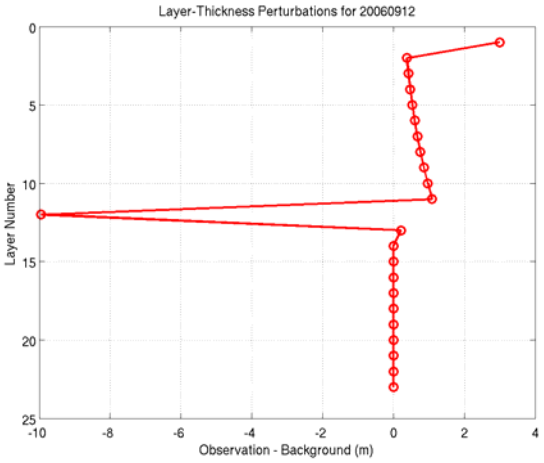
Layer representation rules

- Z to layer map: Use model vertical grid parameters (from RELAX)
- Evaluation of perturbations: relax layerization rules (limited to geometry dh>0 and sum of dh= depth)
- Remap from analyses layers to model layers: employed mass preserving advection scheme (from HYBGEN)

CTD Assimilation (per layer)



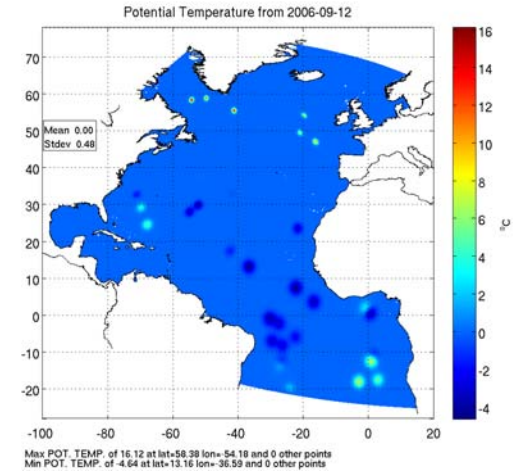


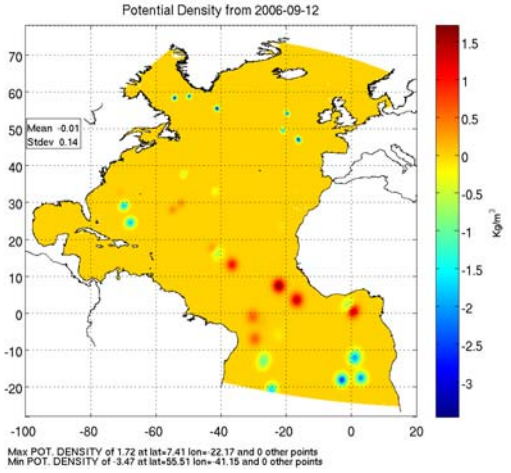


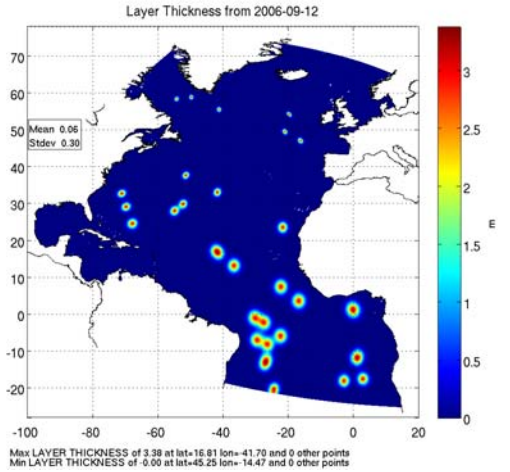
Potential Temperature

Potential Density

Layer Thickness

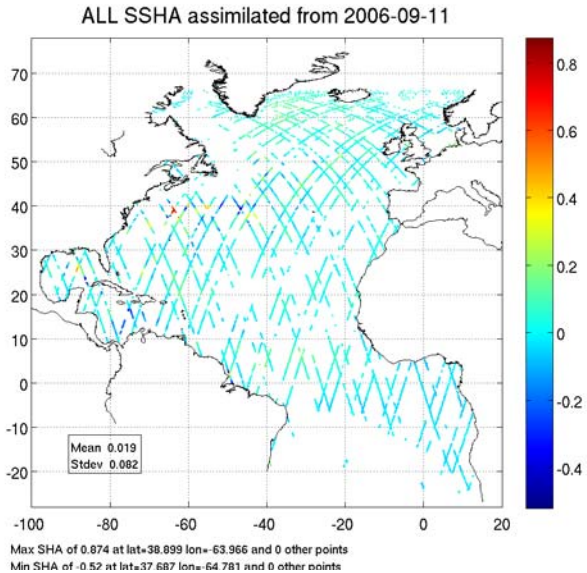




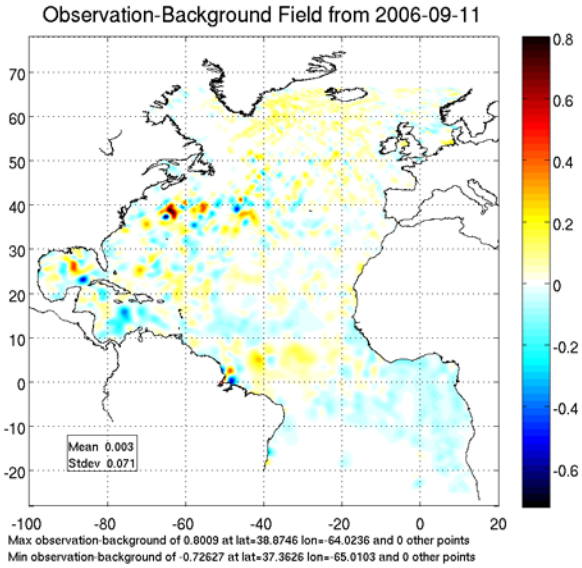


SSH Assimilation

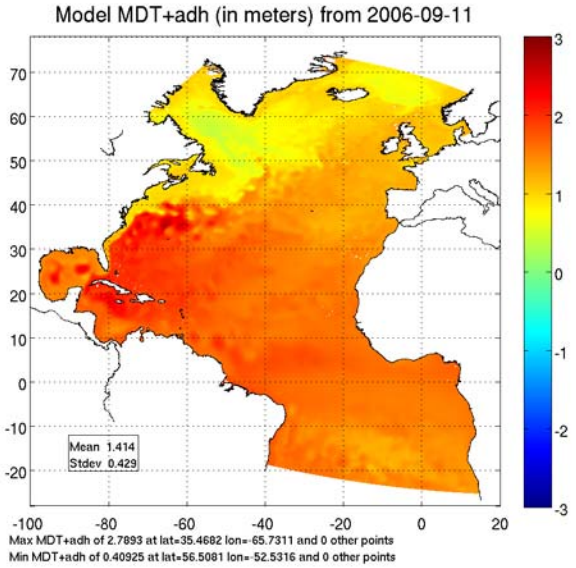
Data

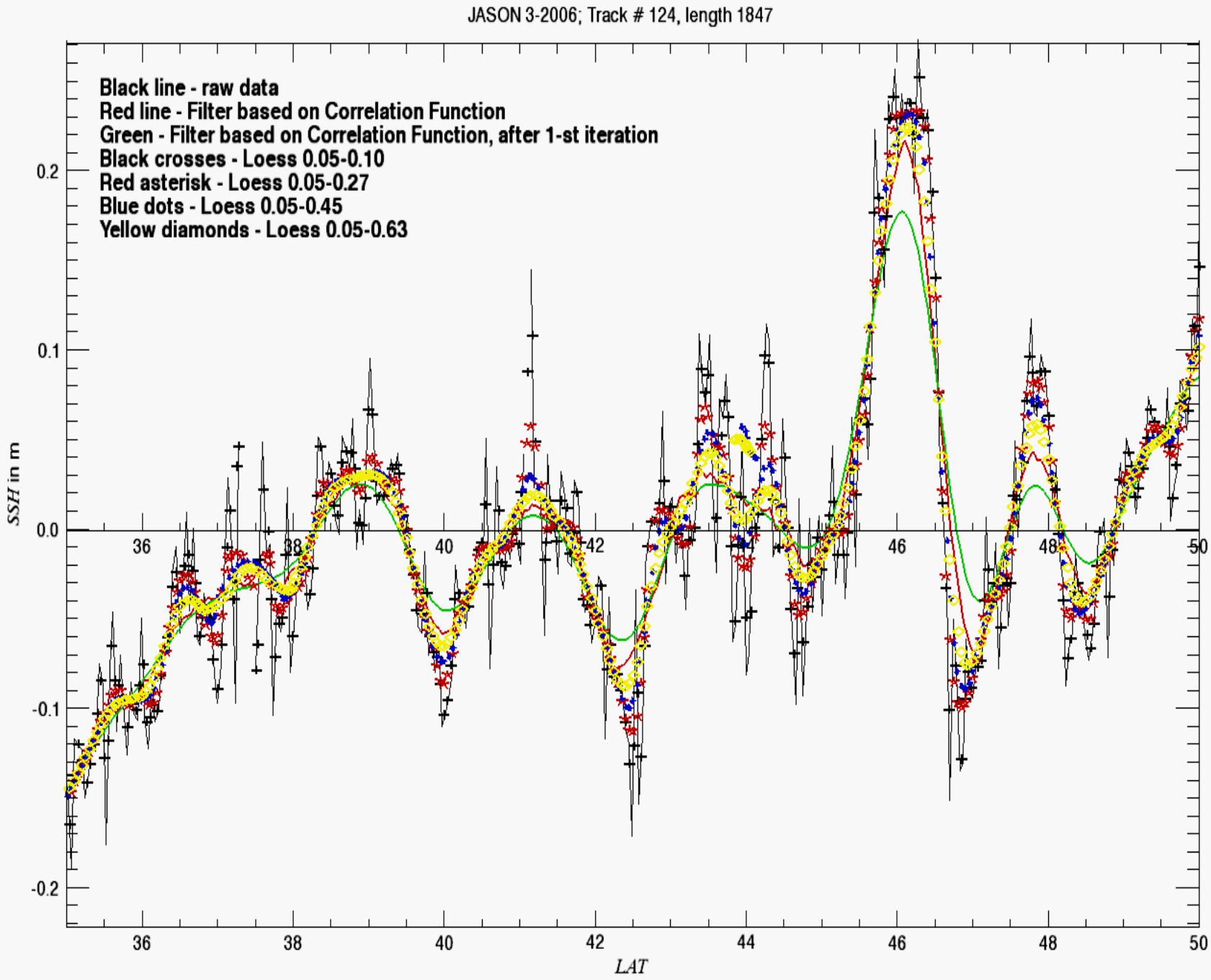


Observation - Background



Assimilated Field




JASON 3-2006; Track # 124, length 1847
Black line - raw data
Red line - Filter based on Correlation Function
Green - Filter based on Correlation Function, after 1-st iteration
Black crosses - Loess 0.05-0.10
Red asterisk - Loess 0.05-0.27
Blue dots - Loess 0.05-0.45
Yellow diamonds - Loess 0.05-0.63
SSH in m
0.2
0.1
0.0
-0.1
-0.2
36
38
40
42
44
46
48
50
LAT

Sea surface height assimilation

- SSH=SSHA + MDT
- Filtering/corrections:
  - High wave-number noise
  - Tide [de-tide model with model tide estimates]
  - Atmospheric pressure [remove inverse barometer estimation]
- 1D covariance
  - Computed from simulations function of horizontal location (and implicitly vertical layer parameters)