Constraining HYCOM: Twenty years of Atlantic XBT data

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Tasks and schedule

Works completed

Prototype model development

- Preprocess module (Thacker and Esenkov, 2002)
- Assimilation scheme
- Initialization
- 20 years model run/preliminary analysis (Thacker, Lee, Halliwell, in prep.)

Future works

Model verification & improvement

- Error covariance model
- Quality of individual data (salinity estimation issue)
- Spatial/temporal distribution of data
- Model dynamics

Integration with SSH assimilation models

Global coverage

Prototype model development

1. Preprocess module

<u>Preparation of data in the form suitable for HYCOM</u>

(1) Estimate potential temperature θ (p) from XBT

(2) Estimate salinity S(p) from Levitus climatology

(3) Estimate density anomaly σ(p) from σ(p) and S(p) using equation of state

(4) Find p(k) where σ (p) = (σ_T (k)+ σ_T(k+1)) / 2

(5) Find p(k) for hybrid layers (p(k) = p_M(k) if target density cannot be achieved)

(6) Find θ(k) and σ(k) by integrating between pressure interfaces.

(7) Find salinity S(k) from equation of state

Methods for salinity estimation

(1) Estimate S(p) from climatology (Thacker and Esenkov, 2002)

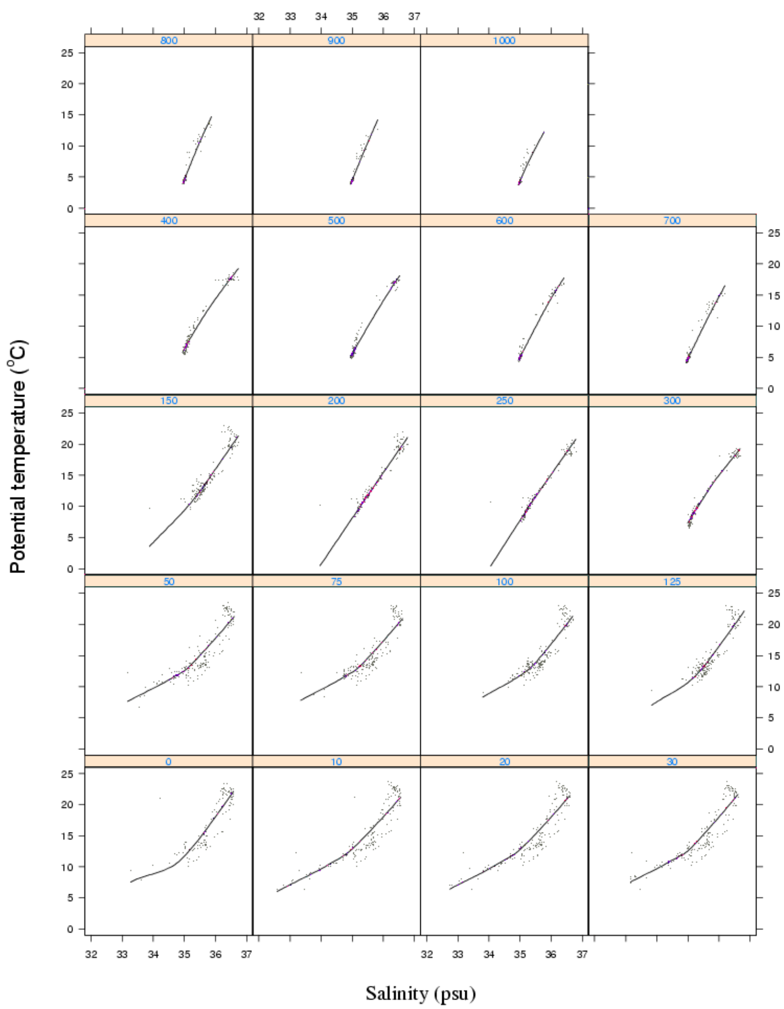
(2) Estimate S(T) from climatology (Vossepoel et. al., 1999)

(3) Estimate S(T) from CTD/bottle data (Troccoli and Haines, 1999)

(4) Estimate S(T) from model T/S relation (Troccoli and Haines, 1999)

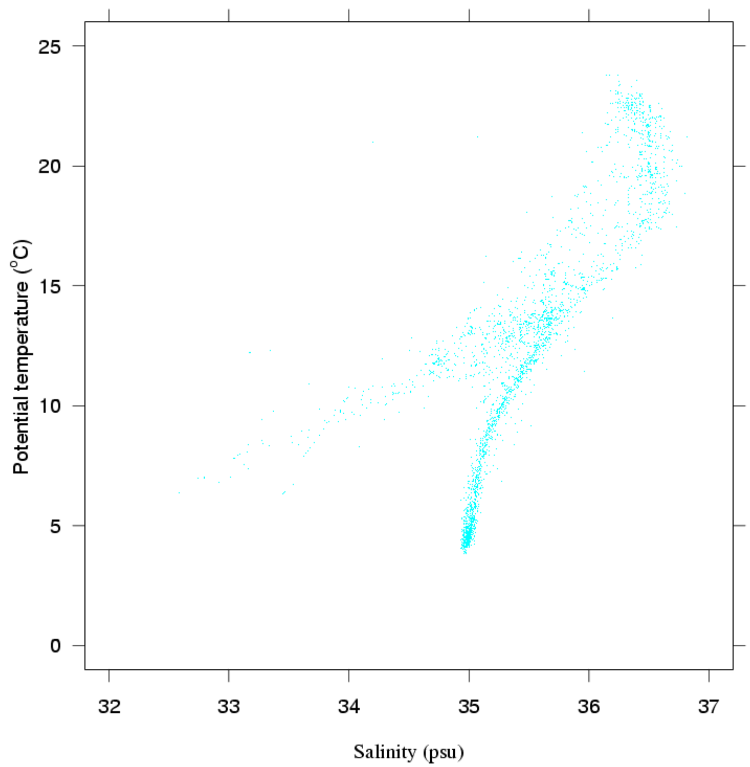
(5) Estimate S(T,z) from TSZ relation (Fox et. al., 2002)

Hydrobase T-S curve on pressure surface for 5 degree square (Jan)



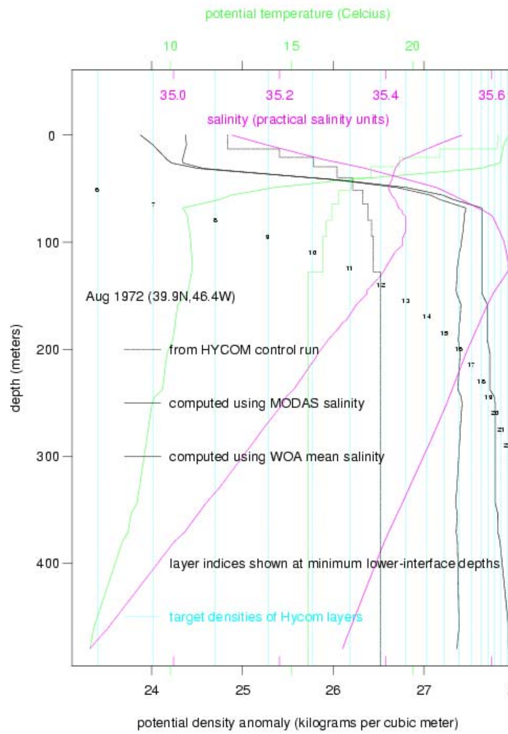
Left bottom corner of 5 degree box at 75°W,35°N

Hydrobase T-S curve for 5 degree square (Jan)



Left bottom corner of 5 degree box at 75°W,35°N

IMPORTANCE OF SALINITY ESTIMATE:



Error model

- $SD_C(T)$, $SD_C(S)$ from Levitus climatology
- $SD(\sigma) = SD_C(\sigma)\sin\psi$, $SD(p) = SD_C(\sigma)\left(\frac{\partial p}{\partial \sigma}\right)\cos\psi$

  where

$$SD_C(\sigma) = \left(\frac{\partial \sigma}{\partial \theta}\right) SD_C(\theta) + \left(\frac{\partial \sigma}{\partial S}\right) SD_C(S)$$

$$\cos\psi = \frac{(p - p_M)/p}{\sqrt{\left(\frac{p - p_M}{p}\right)^2 + \left(\frac{\sigma - \sigma_T}{\sigma}\right)^2}}, \quad \sin\psi = \frac{|\sigma - \sigma_T|/\sigma}{\sqrt{\left(\frac{p - p_M}{p}\right)^2 + \left(\frac{\sigma - \sigma_T}{\sigma}\right)^2}}$$

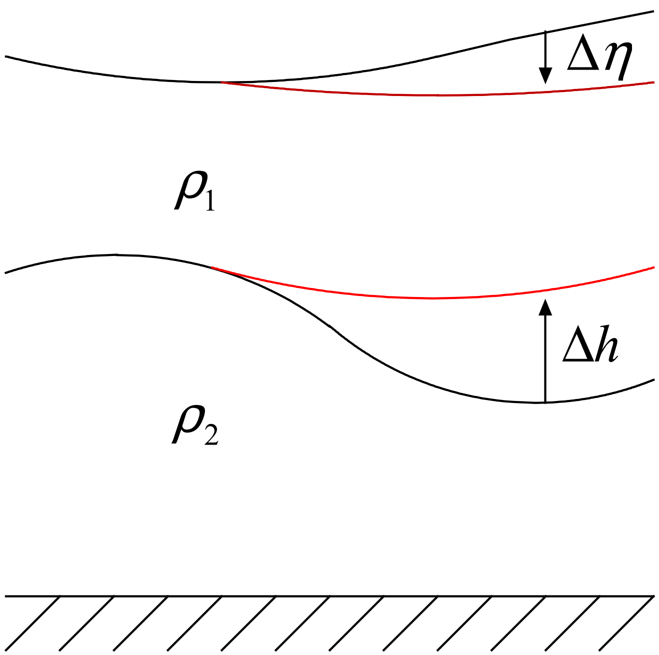
- Background error covariances, which are constant for each layer, are set to the third quartile value of observational error covariances

- Gaussian function used for covariances between errors of the model state in different grid cells. The radius of influence is constant (=2 $\times$ model grid size)

2. Assimilation scheme

- Optimal interpolation

- Barotropic correction
  - Conserve bottom pressure (Cooper and Haines, 1996)



$$\Delta p_b = 0,$$

$$\Delta\eta = \sum_{k=1}^{N-1}\left(\frac{\rho_{k+1}-\rho_k}{\rho_o}\right)\Delta h_k$$

3. Initialization

- Geostrophic correction
- Incremental Analysis Update (Bloom et. al., 1996; Cartons et. al., 2000)

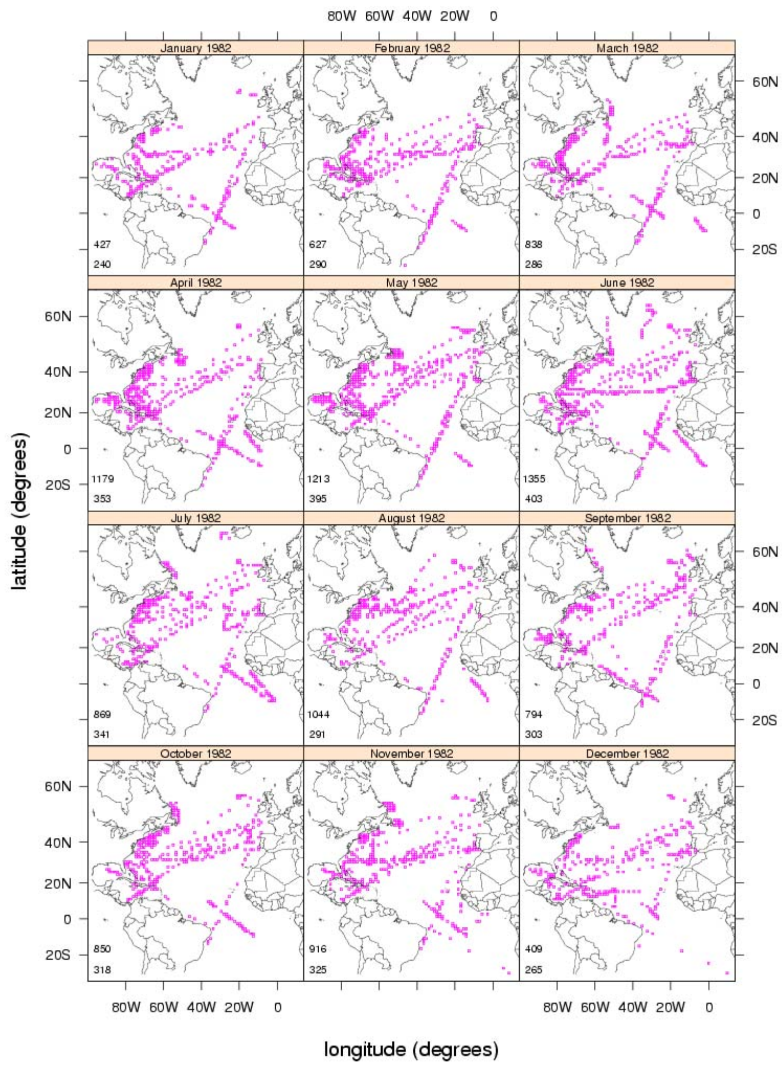
  - About two times more expensive than the geostrophic initialization.

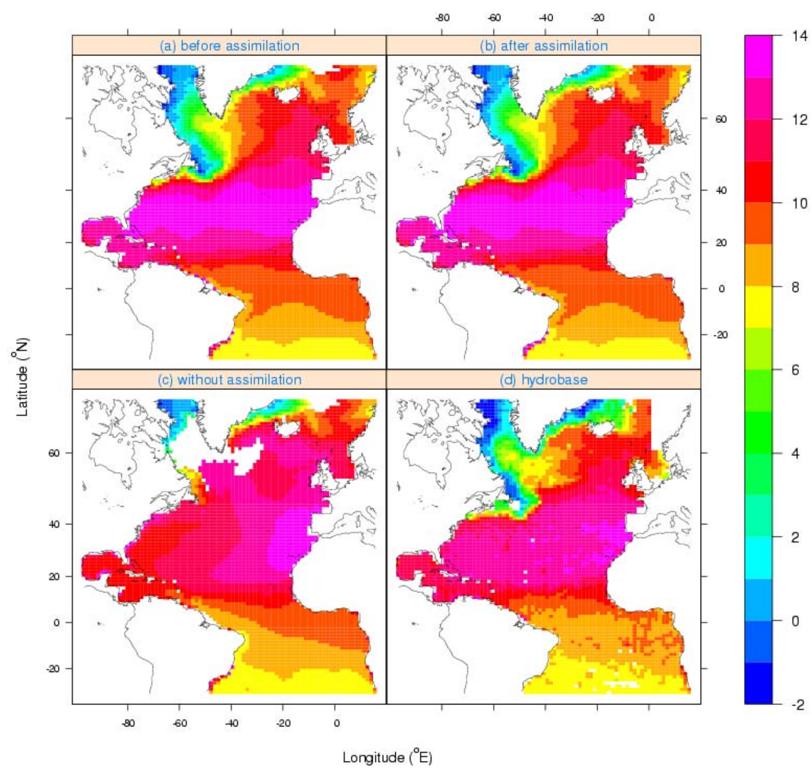
  - Geostrophic assumption not required

  - Performs well near the equator

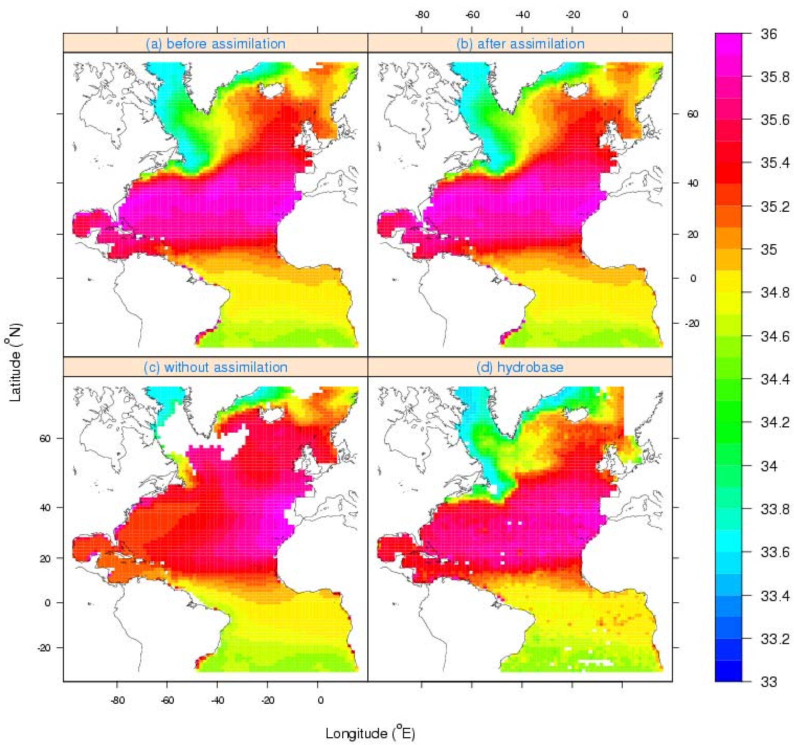
4. Twenty years model run/Preliminary analysis

- Assimilation period: 1972 ~ 1991
- Assimilation frequency: one month

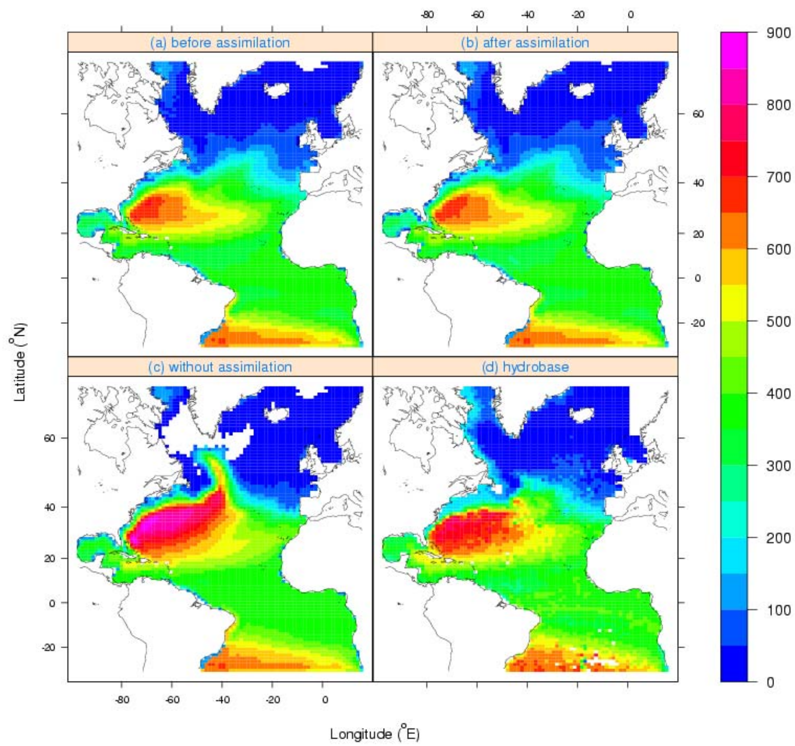

January 1982
February 1982
March 1982
April 1982
May 1982
June 1982
July 1982
August 1982
September 1982
October 1982
November 1982
December 1982
427
240
627
290
838
286
1179
353
1213
395
1355
403
869
341
1044
291
794
303
850
318
916
325
409
265
80W 60W 40W 20W 0
60N
40N
20N
0
20S
latitude (degrees)
longitude (degrees)



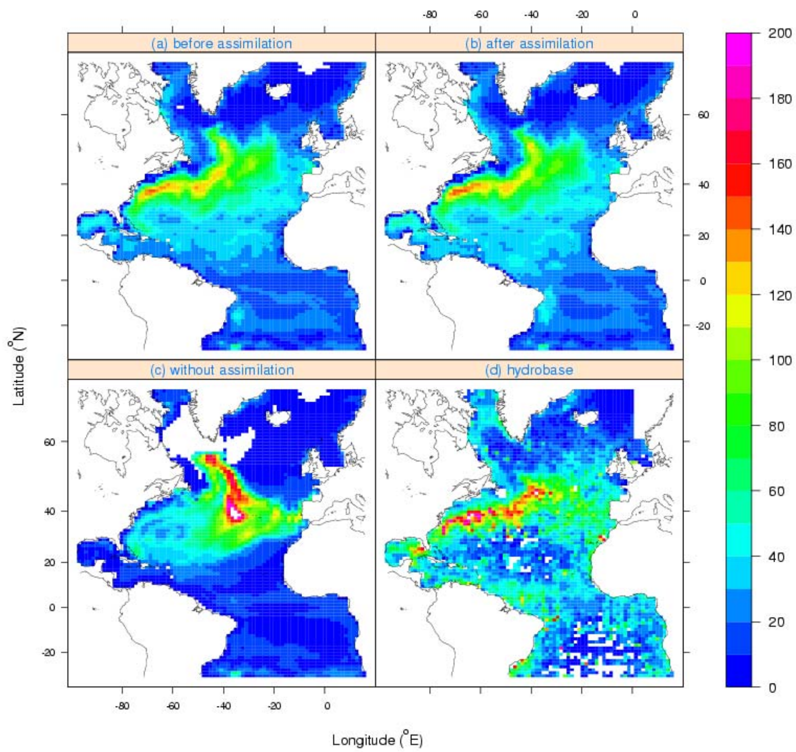
potential temperature (degree celcius) on sigma = 27 surface



salnity (psu) on sigma = 27 surface



pressure (dbar) on sigma = 27 surface



SD (pressure) (dbar) on sigma = 27 surface

Future works

1. Model verification & improvement (Jan/2003 ~ July/2003)

- **Improve quality of individual data**
  - Salinity estimation using MODAS (or TSZ curves from WOD98)
  - Surface salinity issue (SSS)
  - Recognize data within eddies
- **Revise error covariance model**
  - Observational errors from Hydrobase
  - Geographical variation of correlation function (Kurogano et. al., 2000)
  - Limit influence of data to same side of front
- **Spatial/temporal distribution of data (if time permit)**
- **Model dynamics (if time permit)**
  - Boundary conditions/forcing/resolution/mixing scheme

2. Integration with SSH assimilation models (Jan/2003 ~ Dec/2003)

3. Global coverage (Aug/2003 ~ Dec/2003)