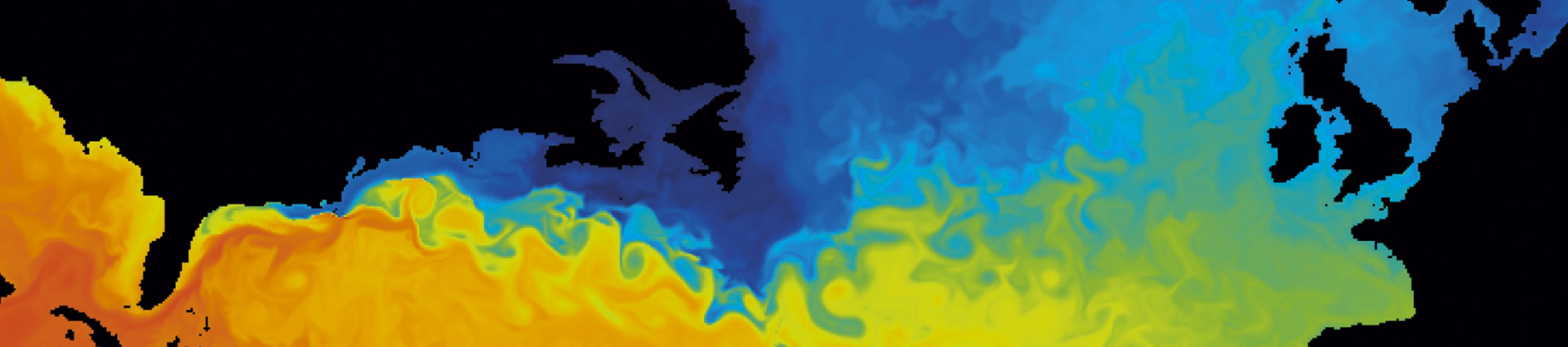


NCOF

The National Centre for Ocean Forecasting

Argo and other profile data assimilation on z and density levels in FOAM

Daniel Lea, Matt Martin, Keith Haines and Greg Smith



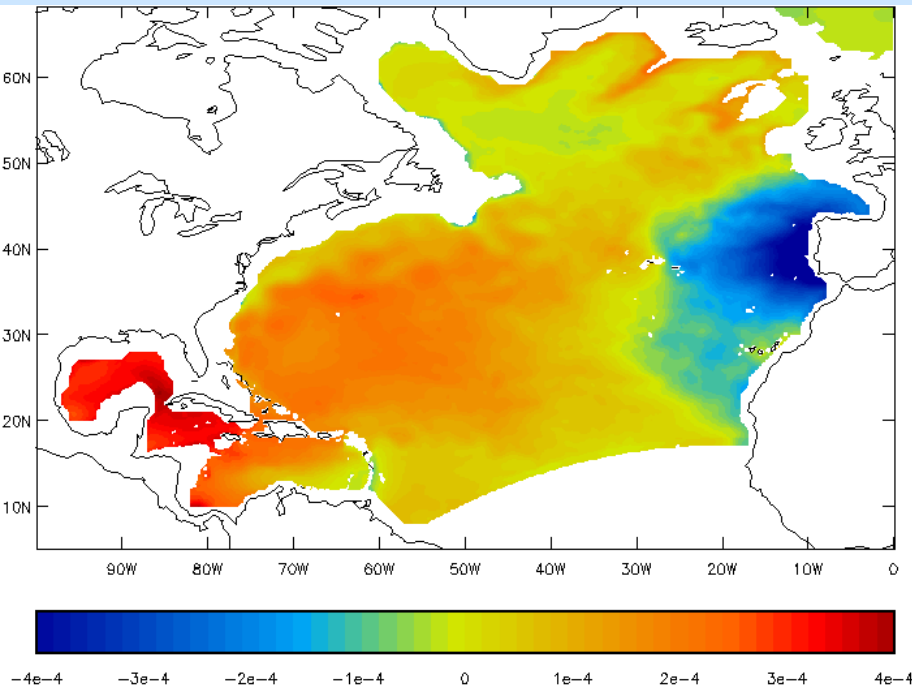
- OSE to test the effect of Argo data on assimilation in the FOAM system (on z-levels)
- Examine a different method of assim (on density-levels)
- Discussion

OSE comparing z-level assimilation with and without Argo

- Five year FOAM hindcasts (2001- 2005)
- One with T (& S) data excluding Argo
- One with all T & S data including Argo
- Assess
 - compared to Levitus
 - Increments
 - obs - bkg

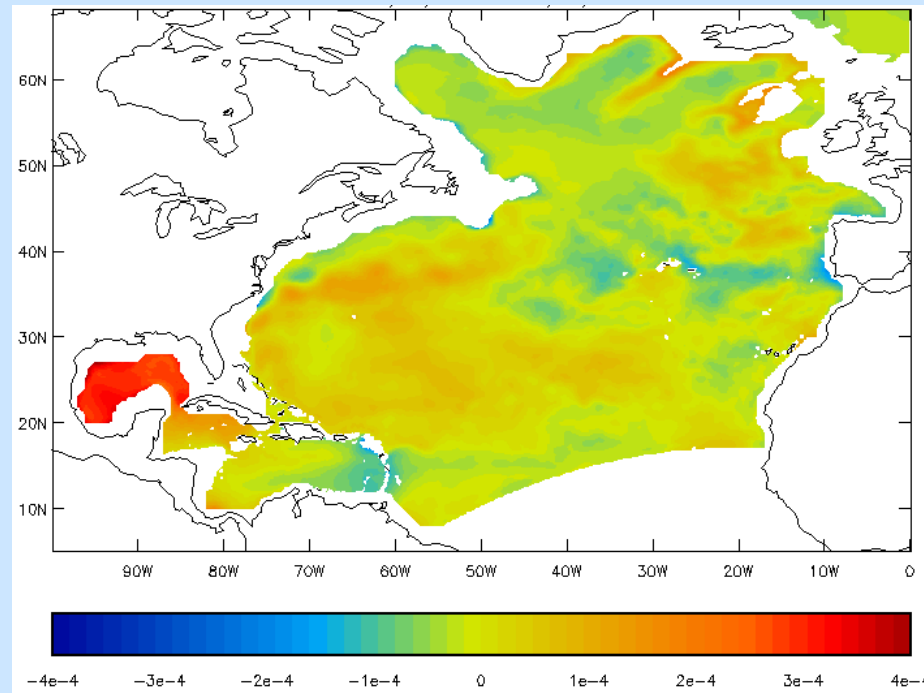
Assimilation S minus Levitus at 1000 m

No Argo



-0.4 psu 0 0.4

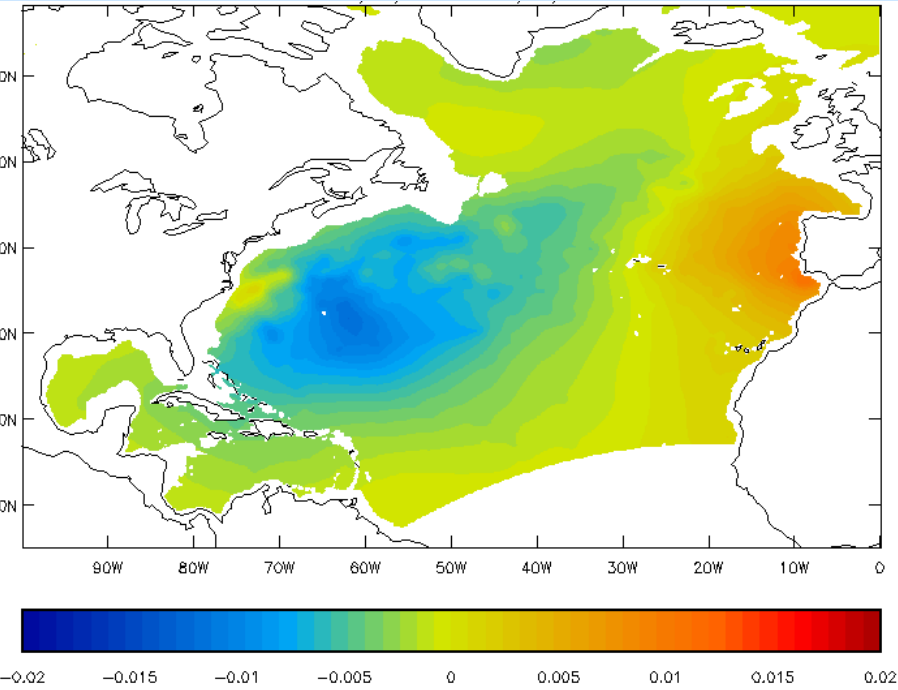
With Argo



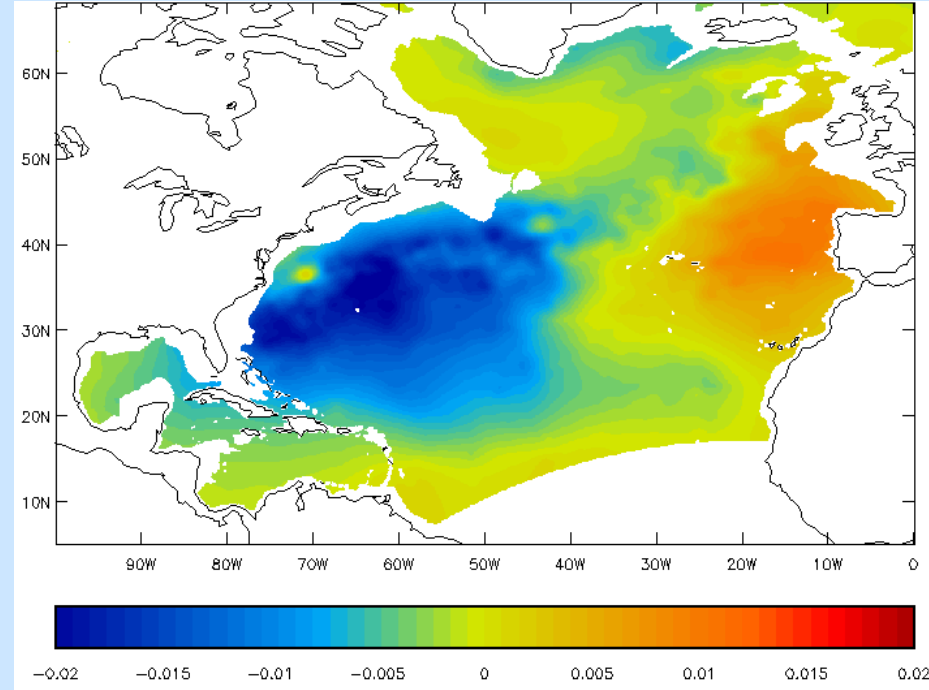
-0.4 0 0.4

Assimilation T increments at 1000 m

No Argo



With Argo



-0.02 °C

0

0.02

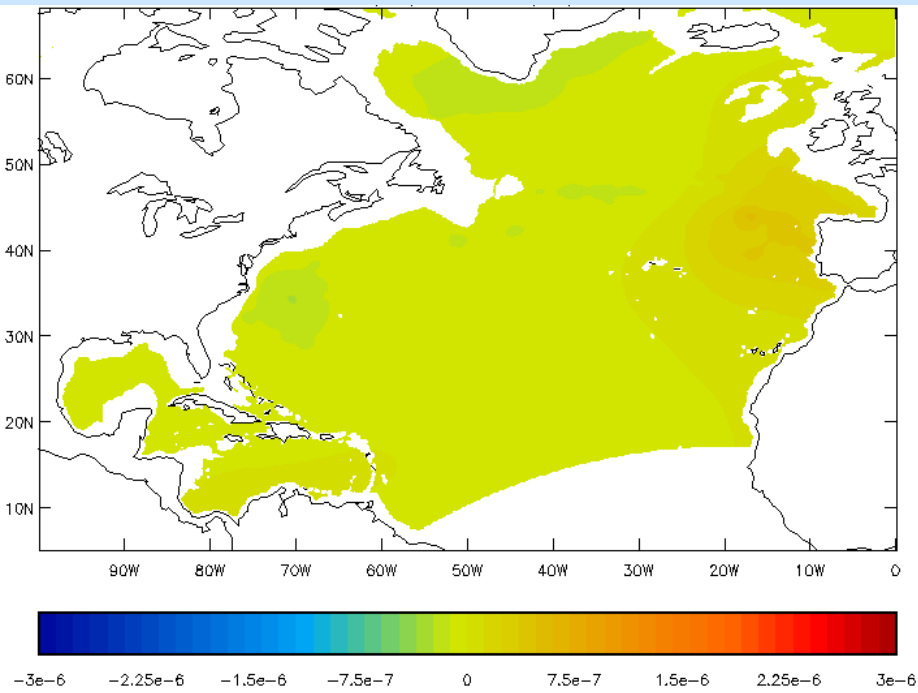
-0.02

0

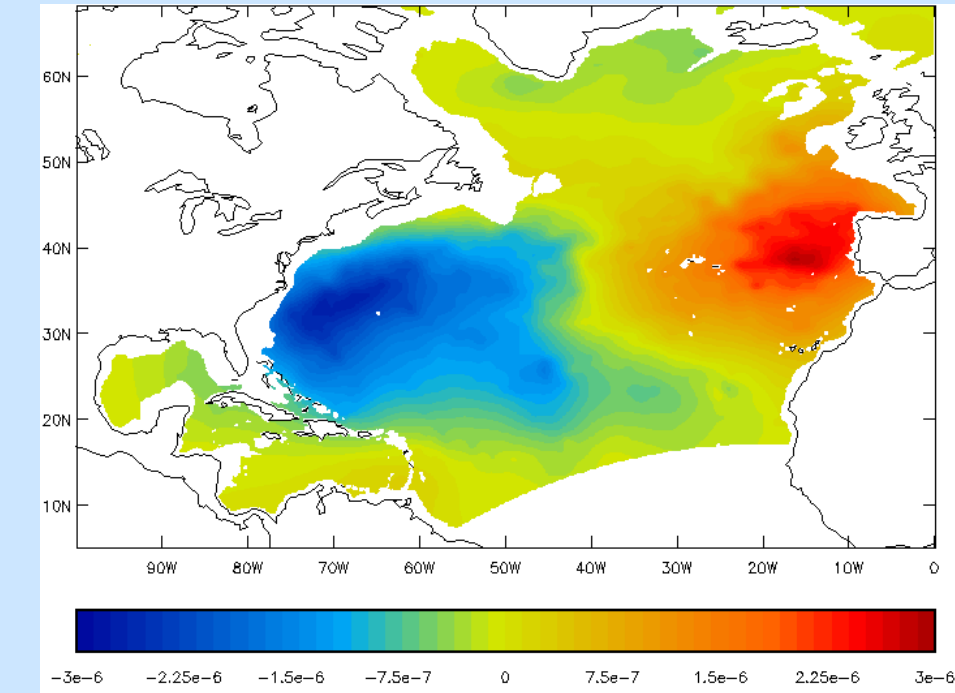
0.02

Assimilation S increments at 1000 m

No Argo



With Argo



-0.003 psu

0

0.003

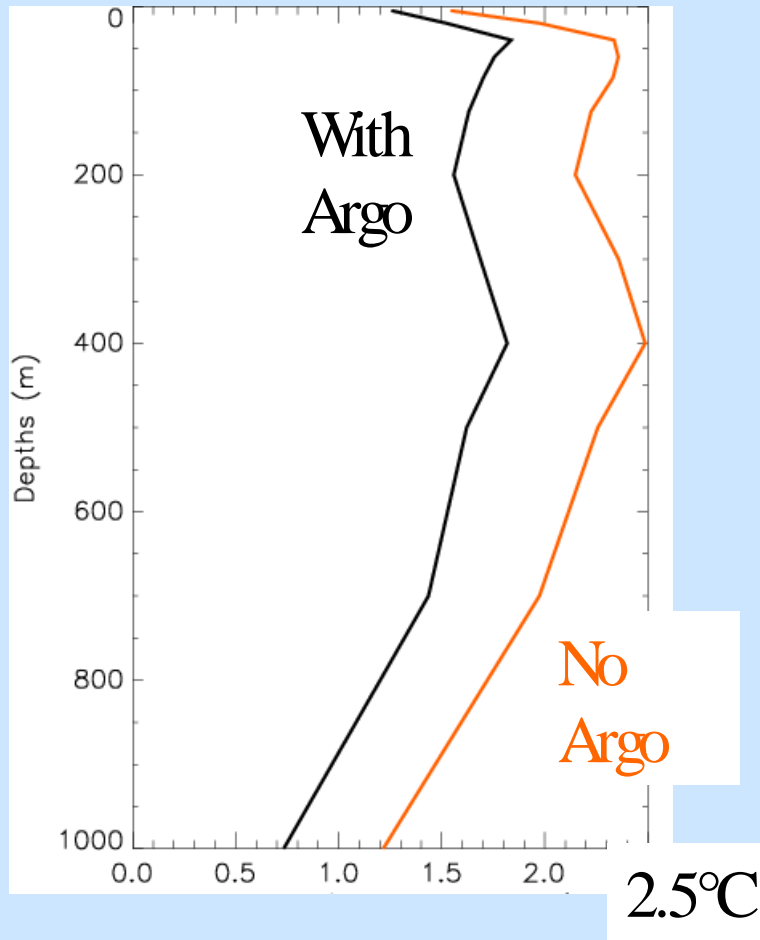
-0.003

0

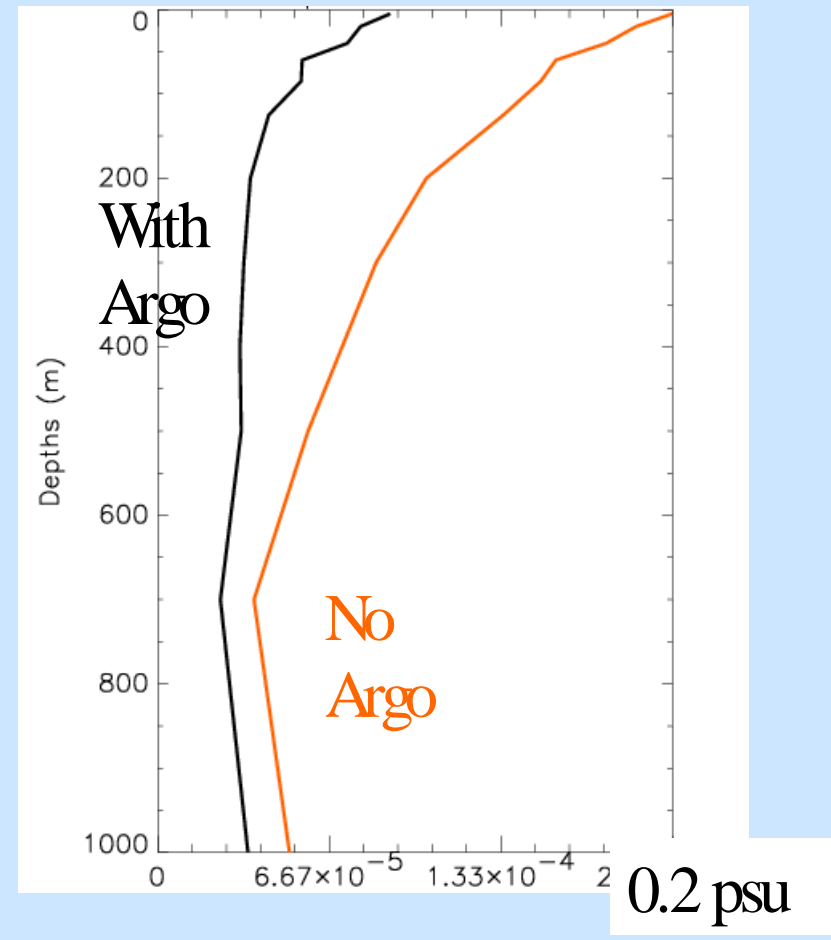
0.003

Observation (inc Argo) – Background

(a) RMS temperature error



(b) RMS salinity error



Dissusion of part 1

- Argo data improves results of model compared to Levitus
- Increments of T and particularly S are much larger with Argo data
- Bias may be due to vertical diffusion (QUICK) - may be too diffusive.
- Therefore results model dependent
- Negative S increments correlate with negative T increments (with Argo assim). Perhaps a spiciness correction required (see part 2)

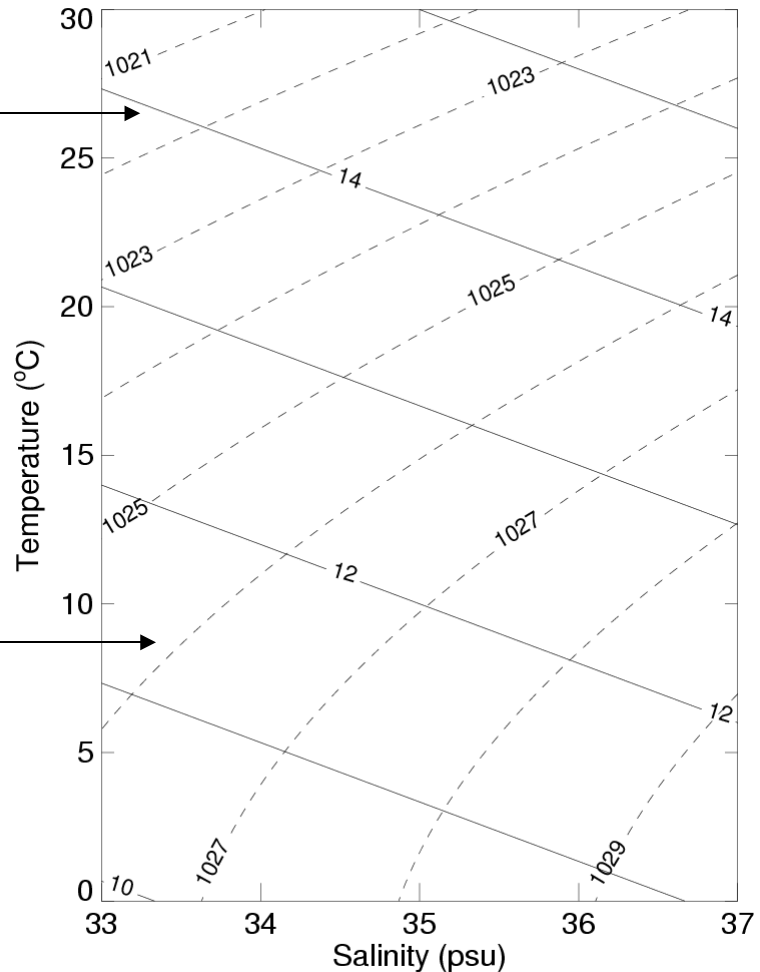
Density level assimilation

- Results may also be assimilation system dependent
- Investigate a better use of the data by spreading the information on density surfaces
- Introduce the system
- Obs-Bkg results
- Discussion

Density assim: Spiciness on TS diagram

Spiciness
(simple)
- orthogonal to
density

Density

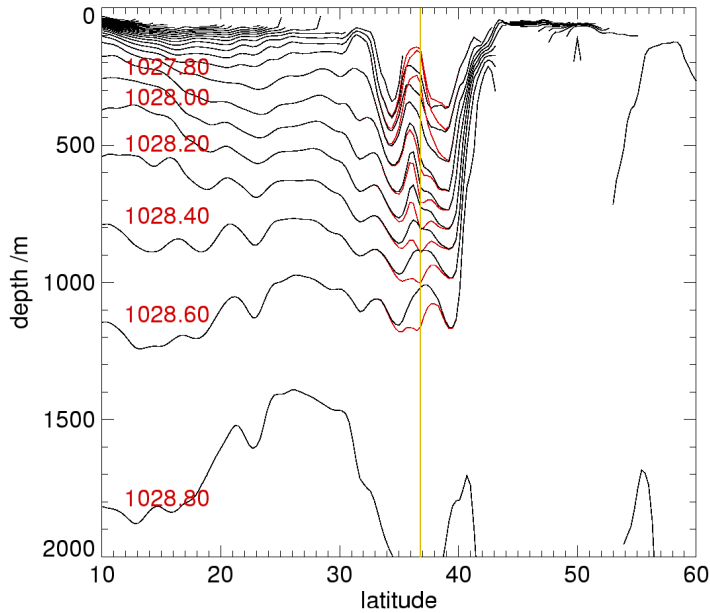


Assimilation of 1 observation

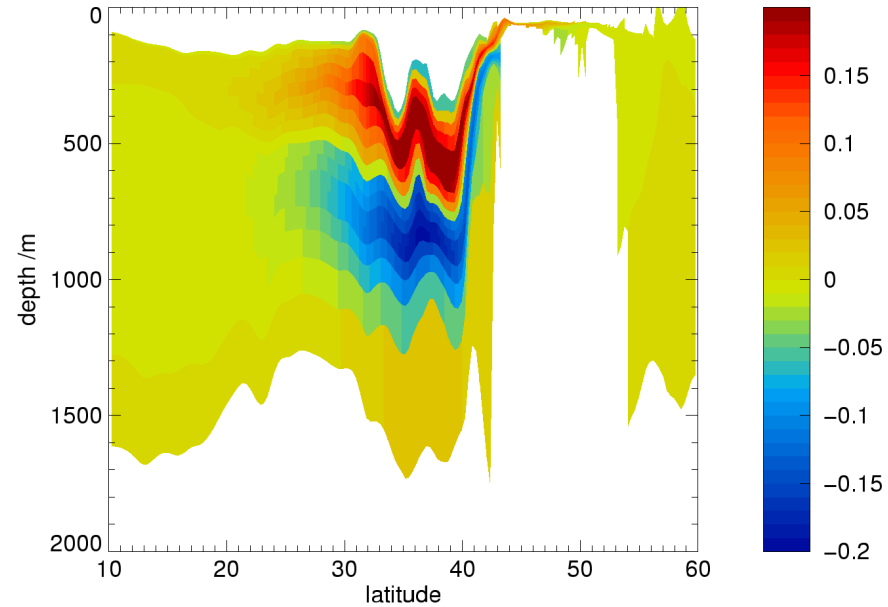
$T(z), S(z) \rightarrow z(\sigma), \quad (\sigma) \rightarrow \text{Assimilate} \rightarrow T(z), S(z)$

Density level depth $z(\sigma)$
before and **after** assimilation

Spiciness increment (σ)



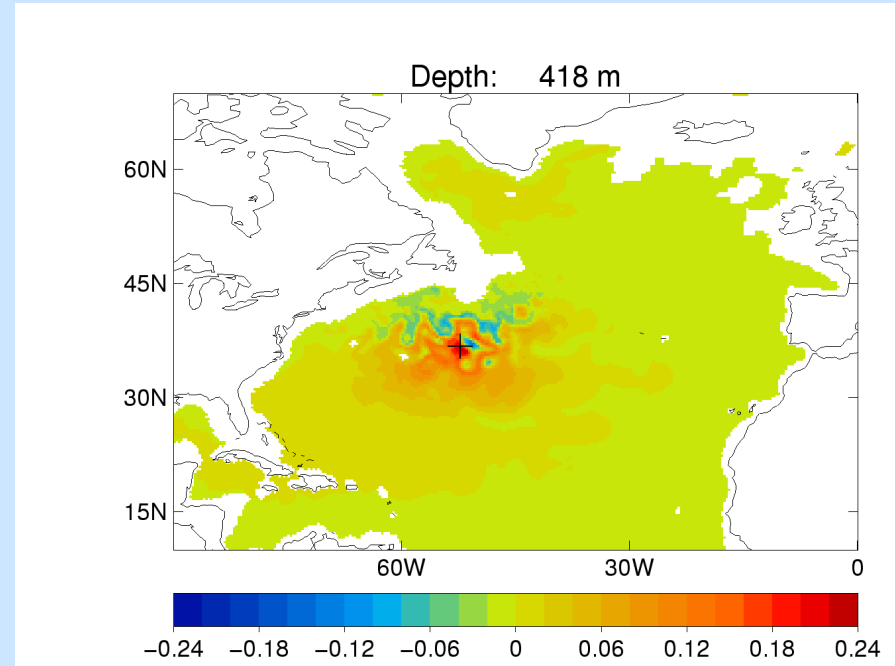
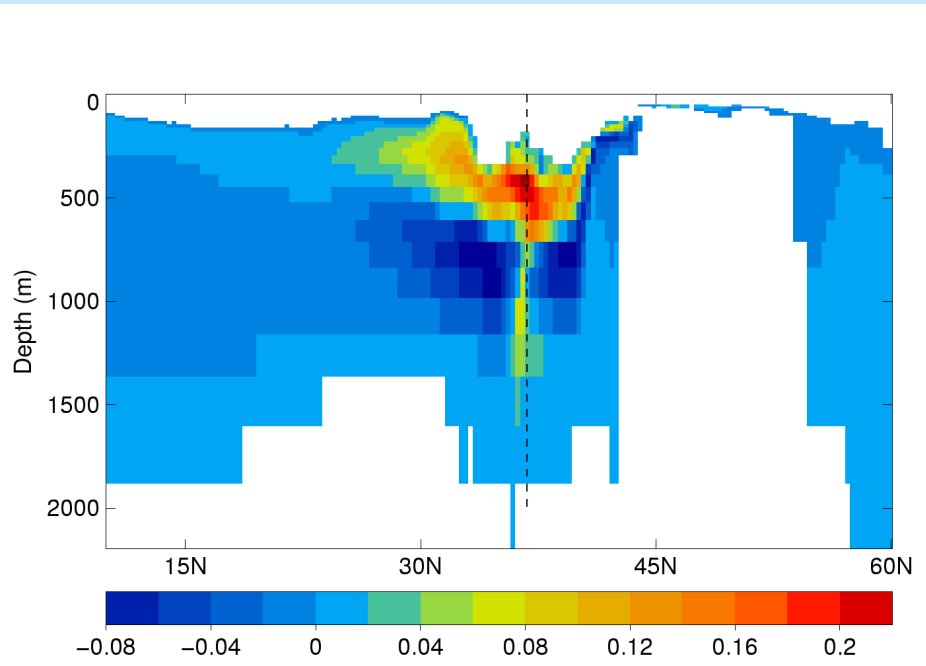
Correlation width 60 km



Correlation width 400 km

Assimilation of 1 observation

Assimilation increments interpolated back onto model z levels
 Plots of salinity increments /psu (similar results for temperature)

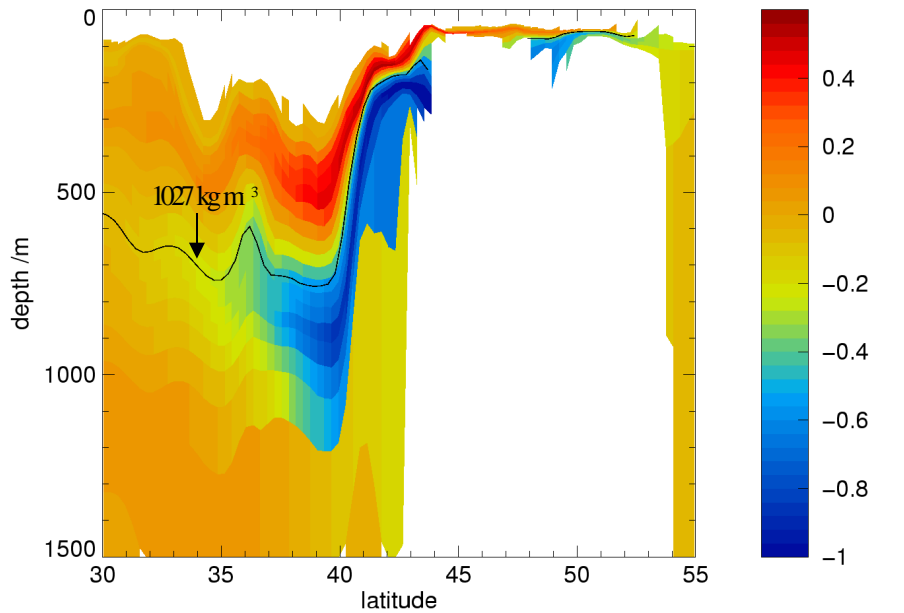


Near the observation results are from changes in density level depth –
 further away just spiciness increments produce S (and T) increments

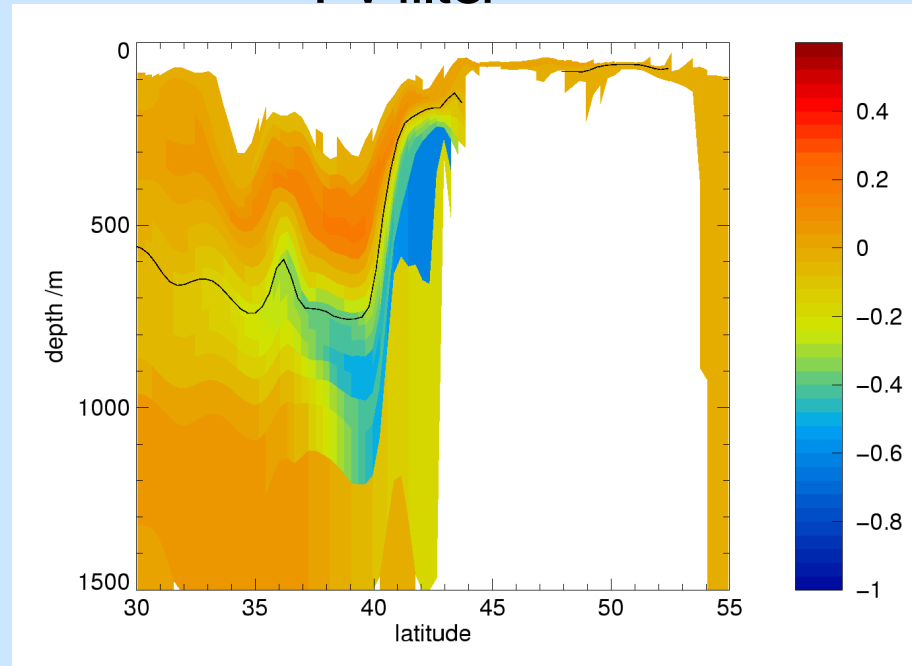
PV filtering

Problem with increments spreading across strong PV gradients.
 Adjust filter (which spreads increments) to reduce correlation width
 where PV gradient high (and where layers outcrop).

No PV filter

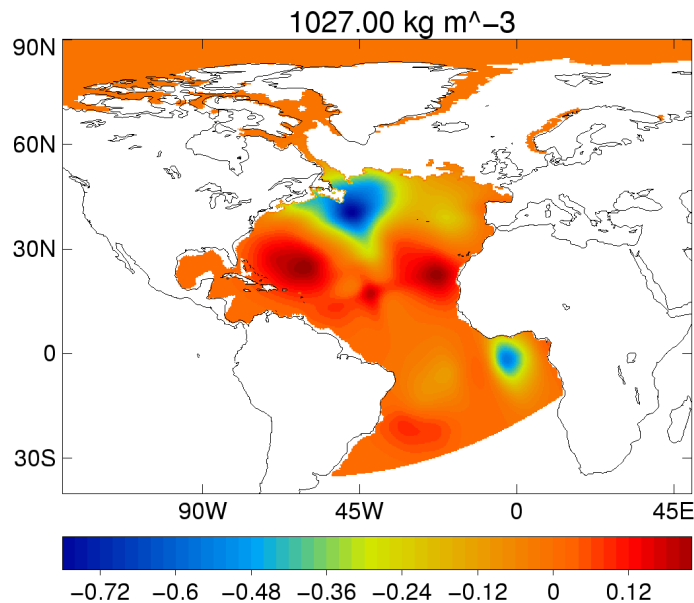


PV filter

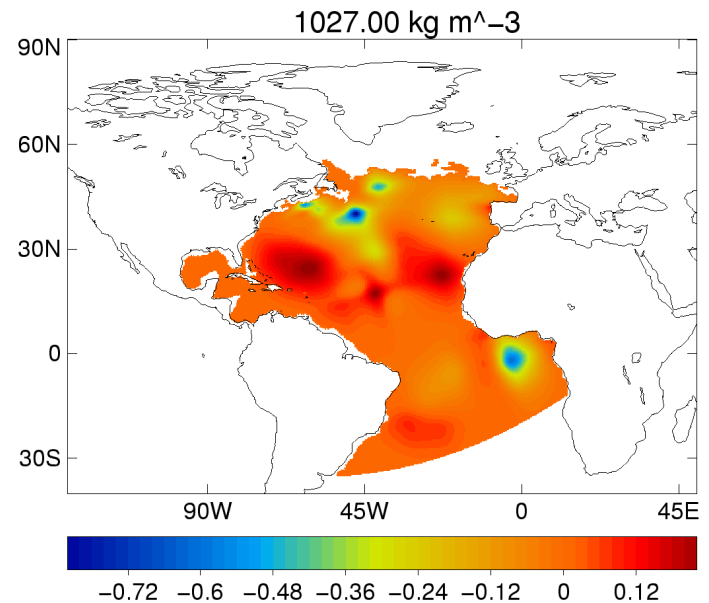


Note now assimilating more than one observation.

No PV filter

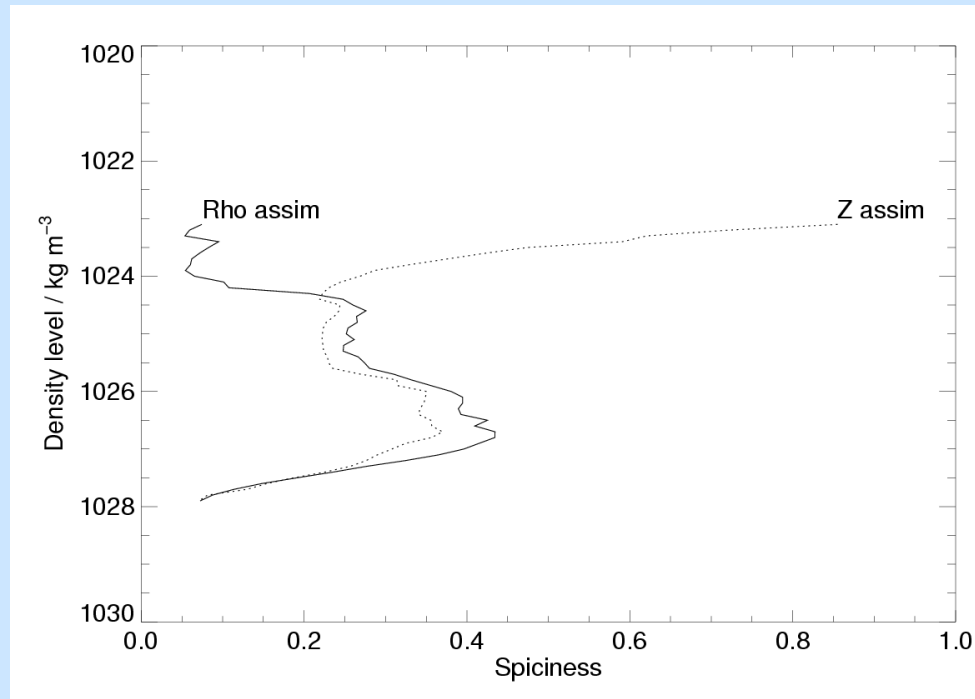


PV filter



Results at obs locations unaffected but spreading in NE Atlantic, where PV gradient is high, is markedly reduced

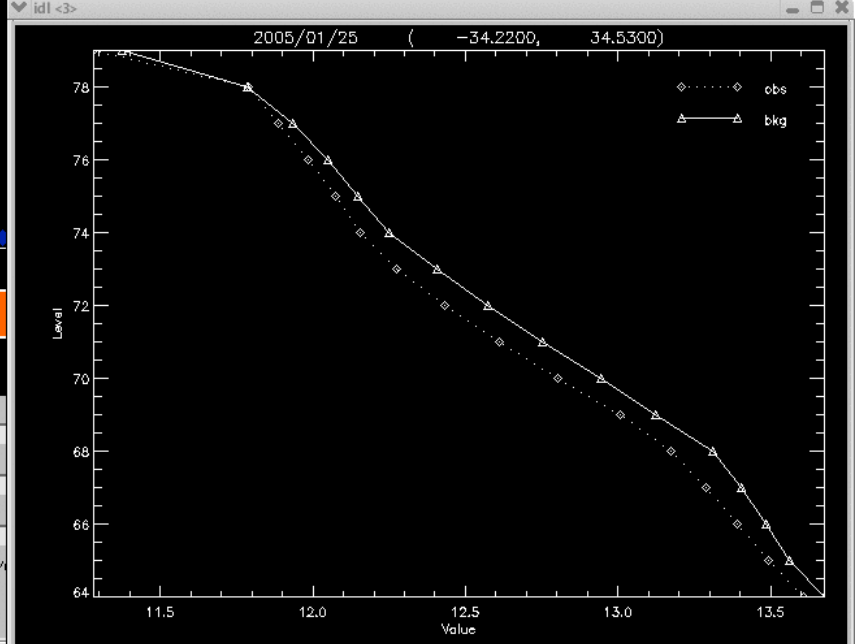
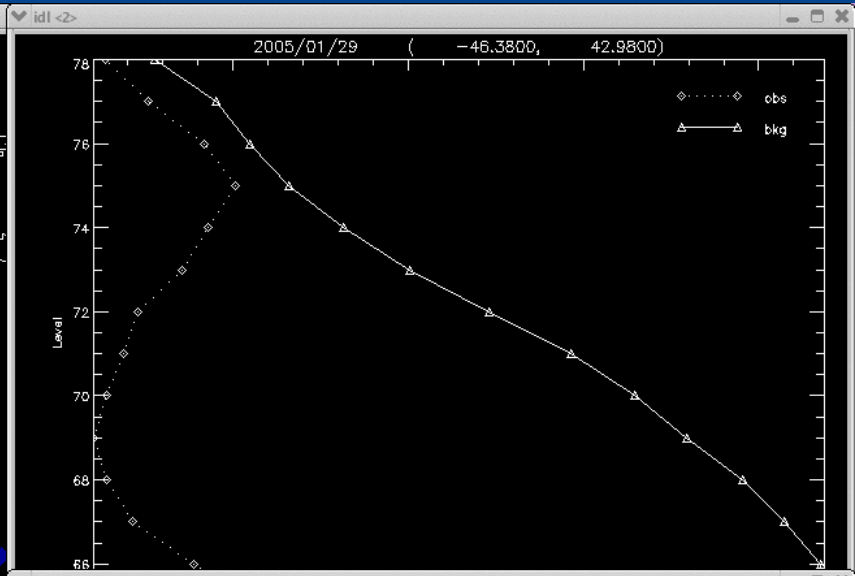
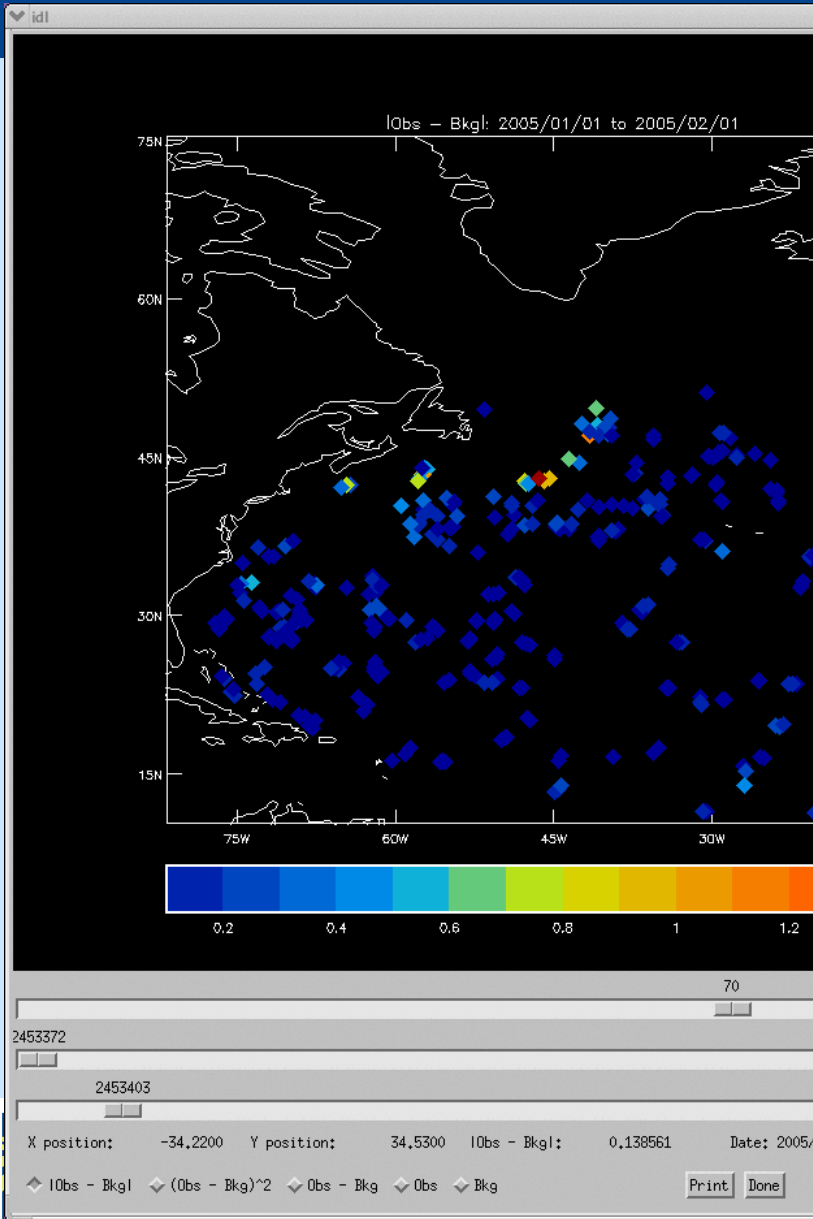
Comparison of a 1 year z-level and ρ -level assimilation



- Overall z level assimilation superior
- Need to work on covariances (+ other things?)

Detecting problems using Obs – Bkg (spiciness) data (at $\rho = 1027 \text{ kg m}^{-3}$)

NCOF



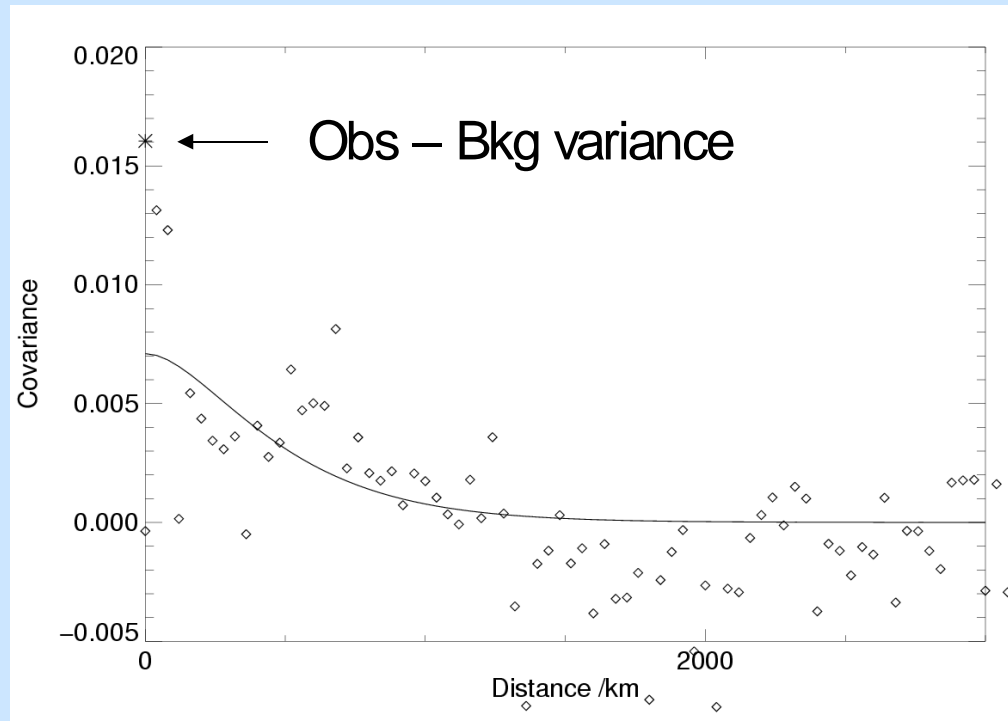
→ Increasing depth

K

Hollingsworth and Lönnberg (1986) (HL) method

Estimated observation variance

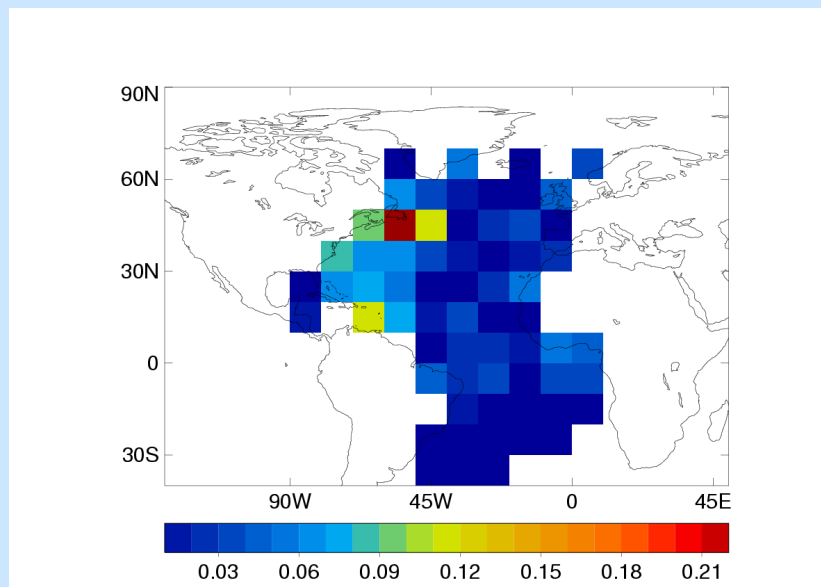
Estimated background variance



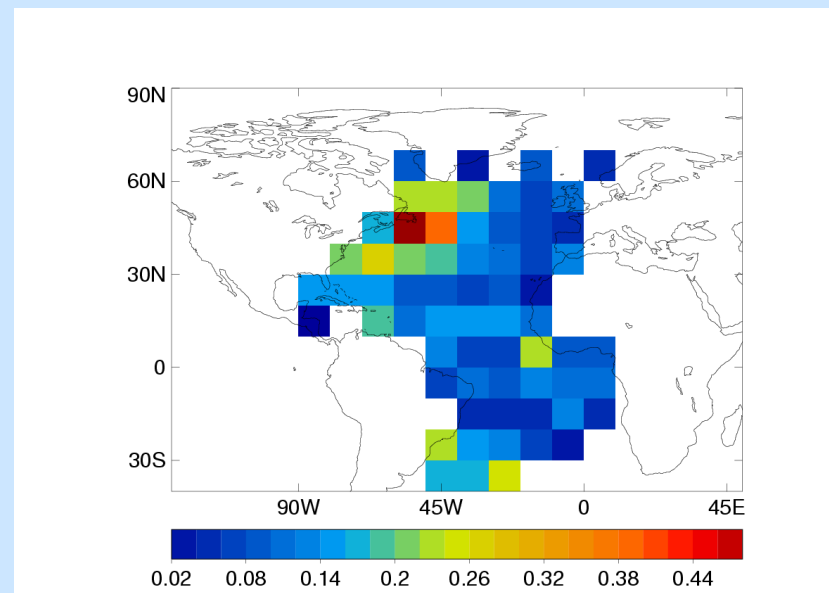
Fitted SOAR function
300km
Correlation
scale

Covariance of Obs - Bkg between different obs.
40km bins, all domain

HL method cont...



Estimated background variance



Estimated observation variance

- Correlation width of 400km fixed to give stable stats
- Background variance lower than previously estimated (1)

Density assimilation discussion

- PV filter necessary for the method to work
- 1 year integration density level assimilation of all T and S profiles complete.
- Compared to equivalent z-level assimilation – results not yet as good
- Improved covariances maybe found using obs - bkg stats in Hollingsworth and Lonnerberg 1986 method). Or another method?

Future work:

- Find out why the error is increased at depth in density level assim compared to z-level and fix it!

Ideas for future OSSE/OSE work

- Test different observation densities with z-level and density-level assimilation – OSE/OSSEs, perhaps by withholding or by twin expts
- Show whether the density level assim is better able to effectively use limited data
- Different optimal array size?