Weakly coupled assimilation of hydrographic profiles into isopycnal ocean models with ensemble data assimilation method

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Introduction

•Hydrographic profiles are crucial to initialise the vertical structure of ocean models (Oke and Schiller, 2007; Zhang et al., 2009; Karspeck et al., 2013; Brune et al., 2015)

Objective: complement NorCPM with assimilation of T&S

1. The ‘best’ implementation setting
    - Analysis scheme (innovation coordinate)
    - Localisation radius
    - Observation error estimation
2. Short-term reanalysis with this ‘best’ setting

1.1 Analysis scheme

*Is it better to assimilate observation in z-coordinate (**EnKF-z**) or to convert them in isopycnal coordinate before assimilation (**EnKF-ρ**)?*

1) **EnKF-z**:

$$\bar{x}_a = \bar{x}_f + P_f H^T (H P_f H^T + R_z)^{-1} (y - H(\bar{x}_f)),$$

where *H* is an operator from model space to observation space.

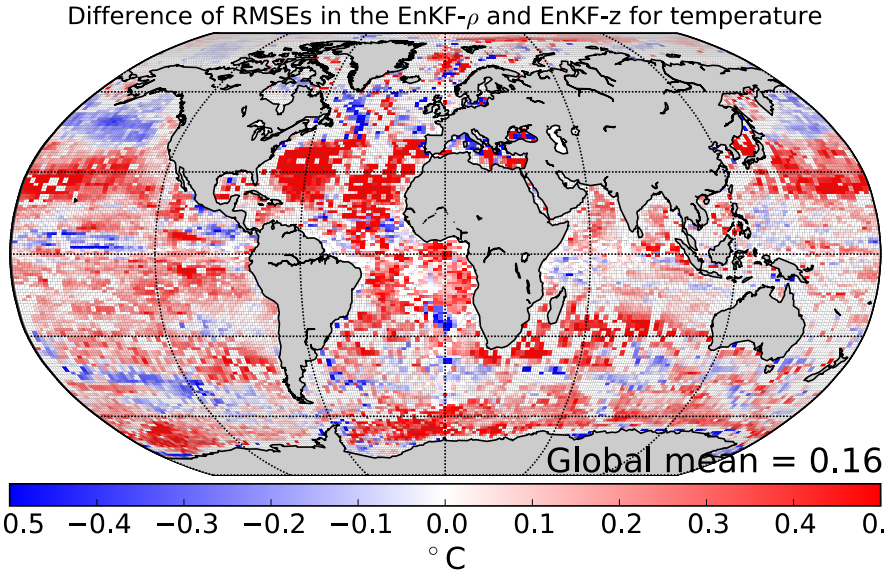
2) **EnKF-ρ** (Xie and Zhu, (2010), Thacker and Esenkov, 2002):

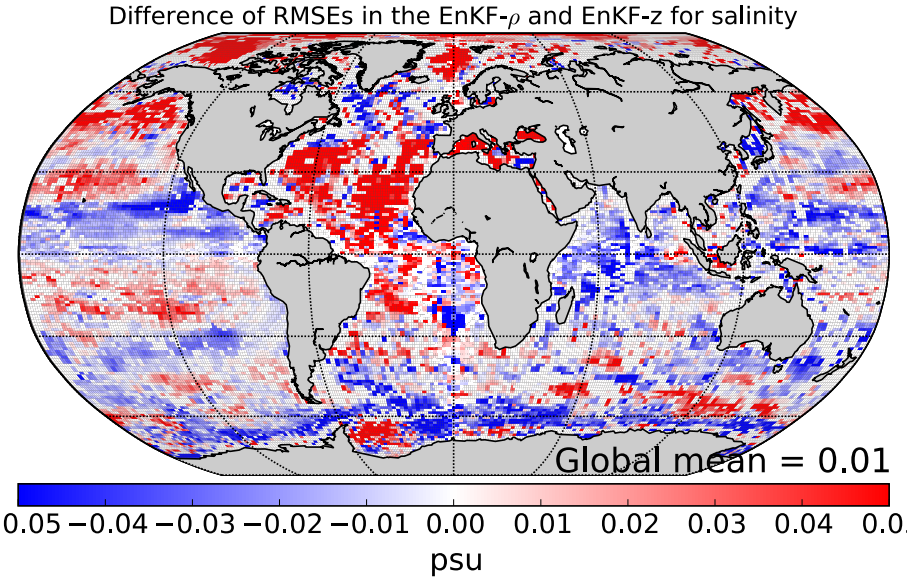
$$\bar{x}_a = \bar{x}_f + P_f (P_f + R_r)^{-1} (F(y) - \bar{x}_f),$$

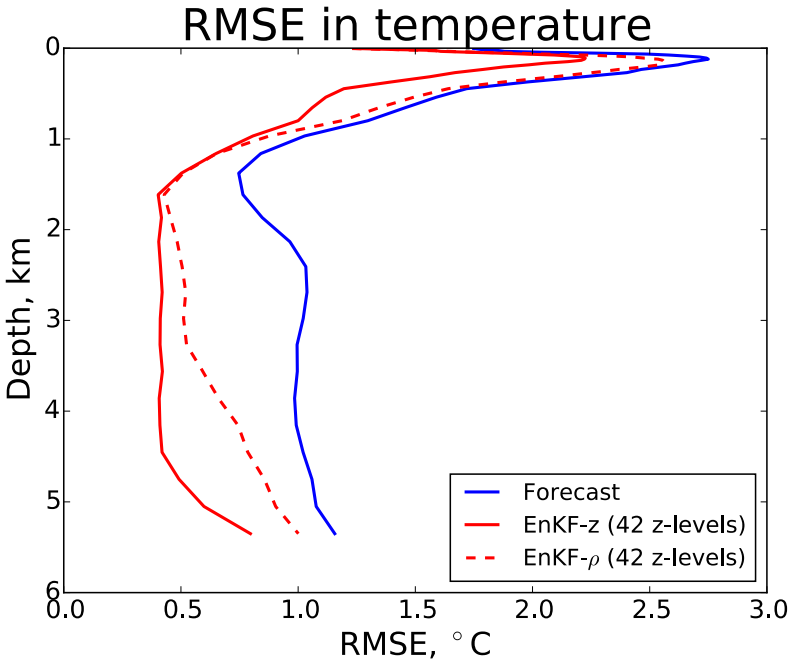
where *F* is a non-linear operator from observation space to model space.

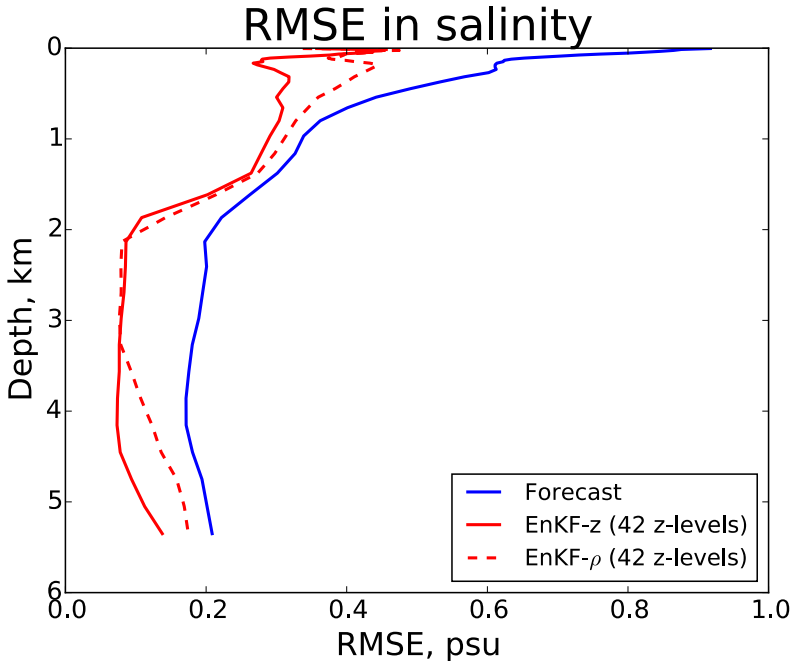
$$R_r = F R_z F^T$$

EnKF-z vs. EnKF-ρ in OSSE

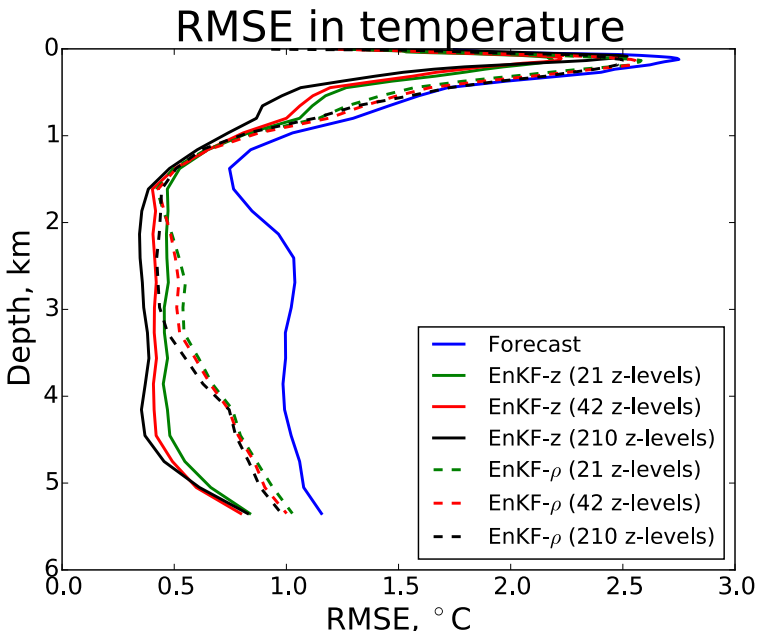


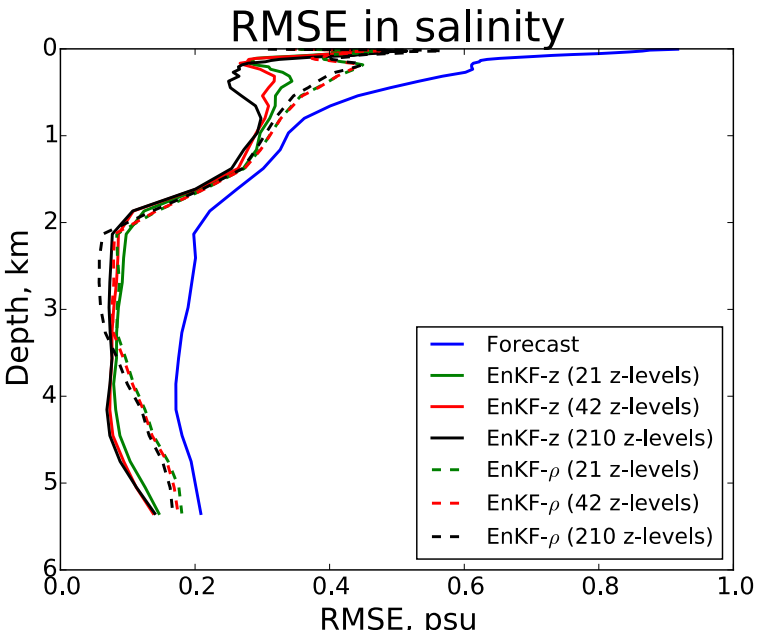


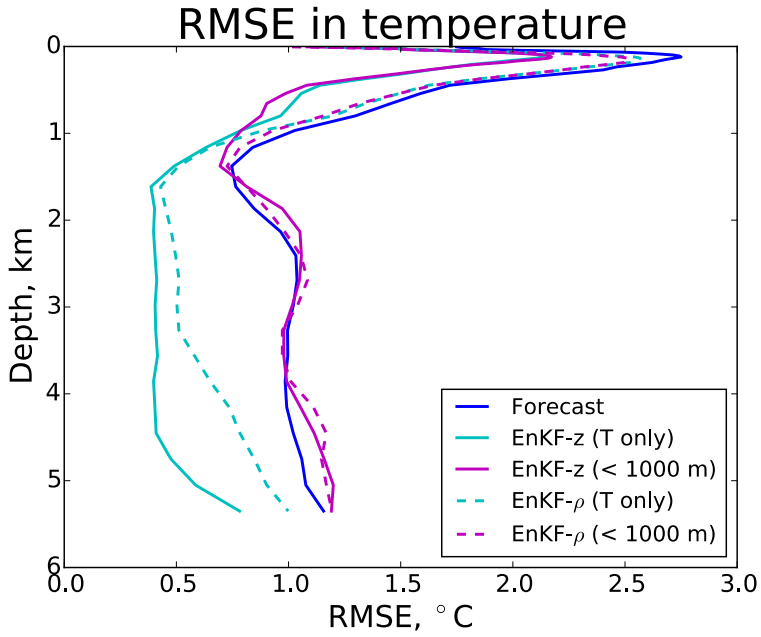


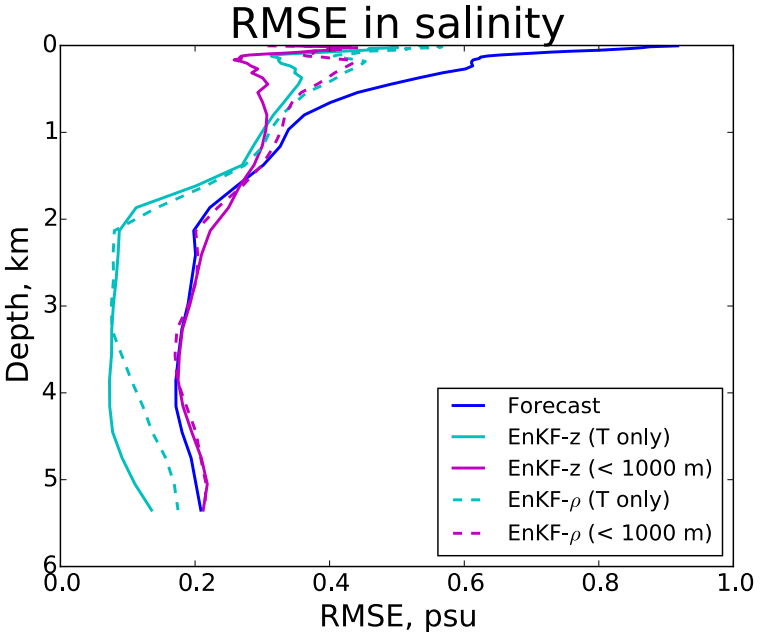


Sensitivity on other datasets



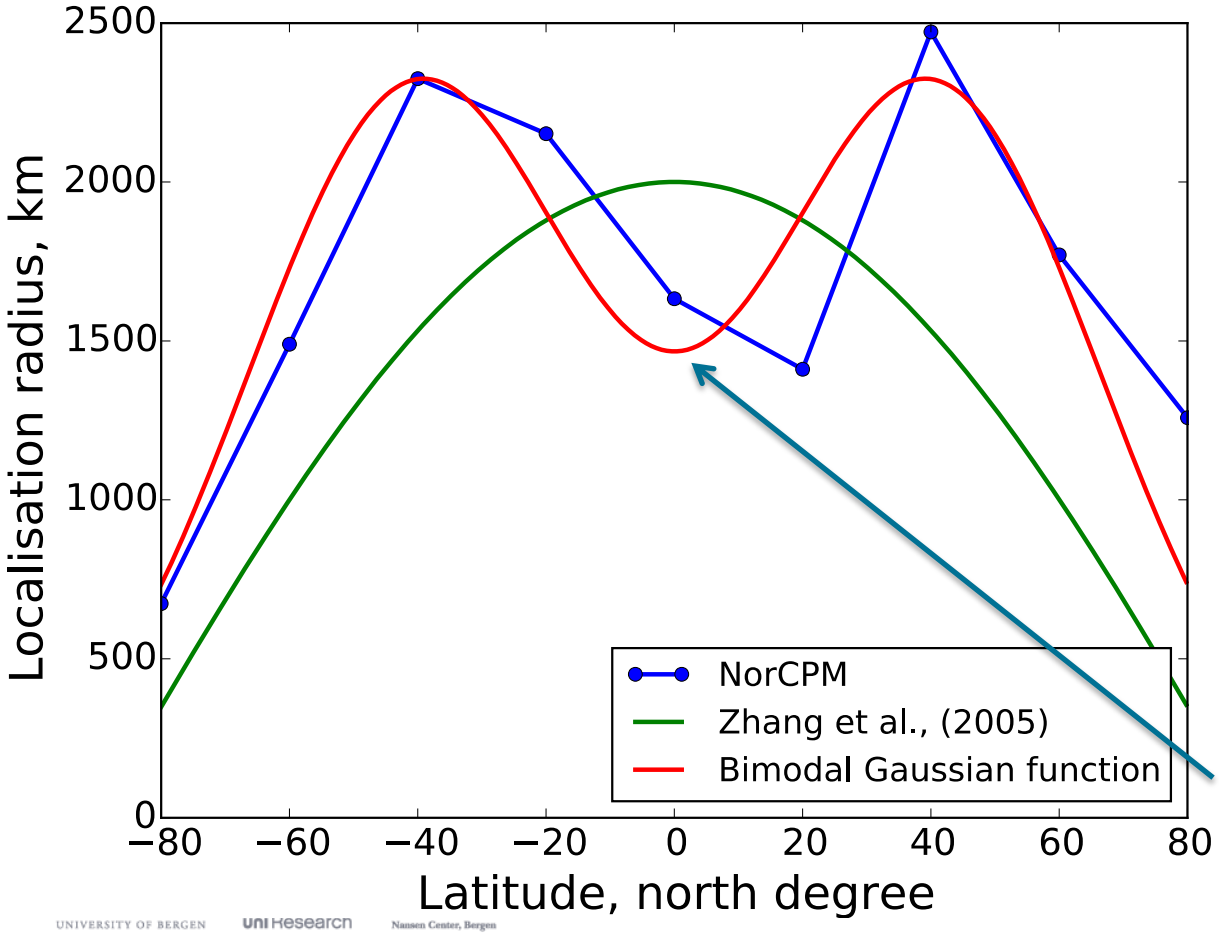


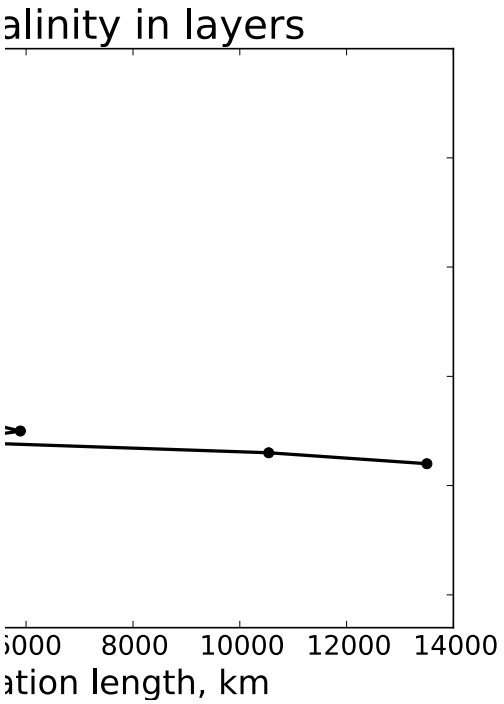




1.2 Localization in ensemble DA

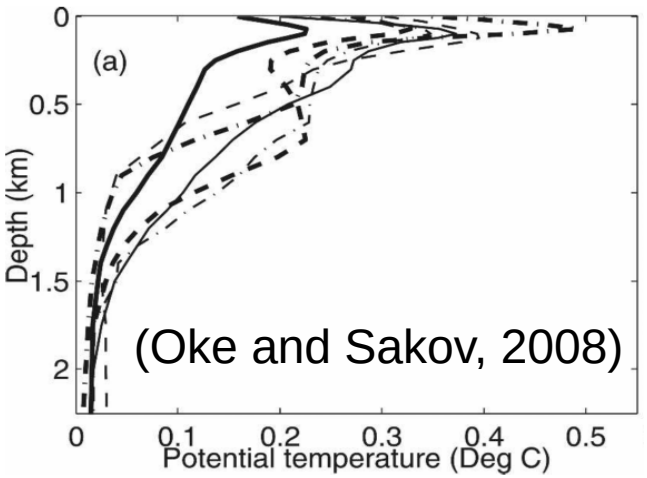
- Ensemble size is too small to span the whole model space (spurious correlations).
- We approximate here the horizontal localisation radius by the auto-correlation length scale that best fits the Gaspari and Cohn function.



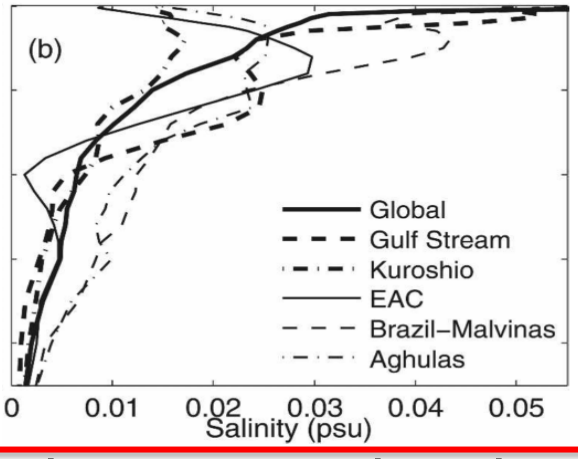


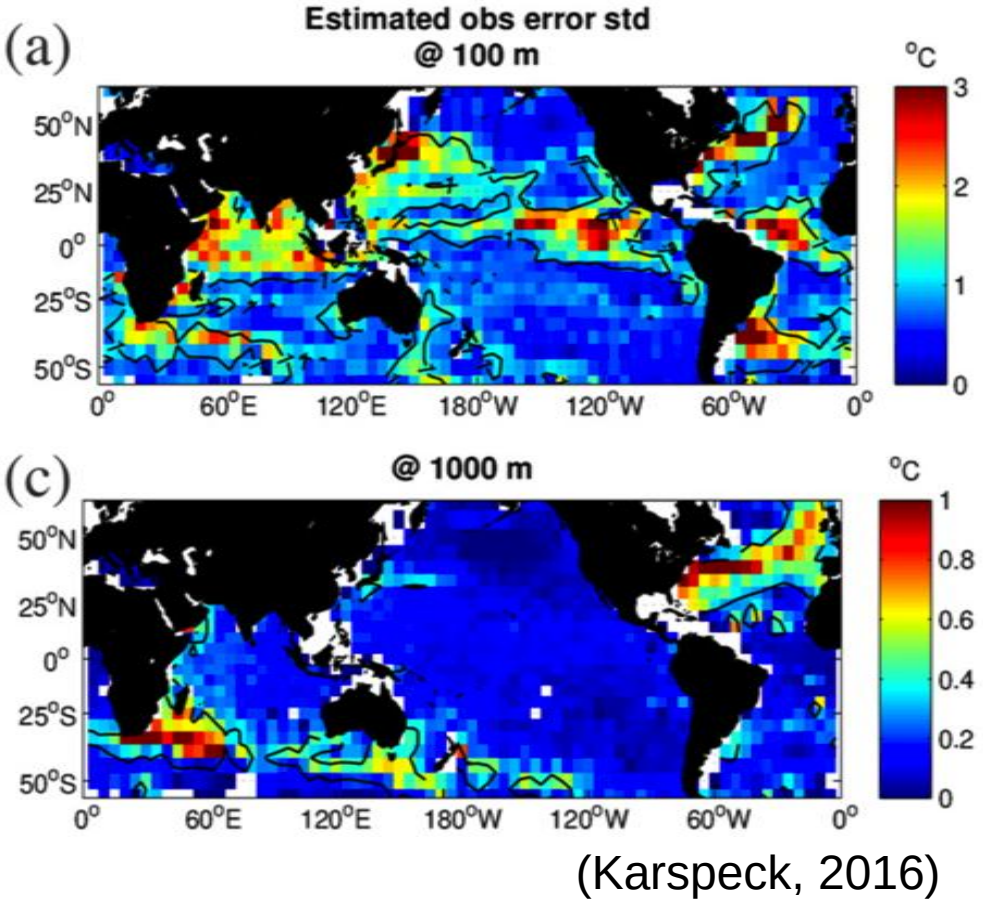
Auto-correlation is anisotropic at Equator due to the influence of Coriolis force.

1.3 Observation error



(Oke and Sakov, 2008)





(Karspeck, 2016)

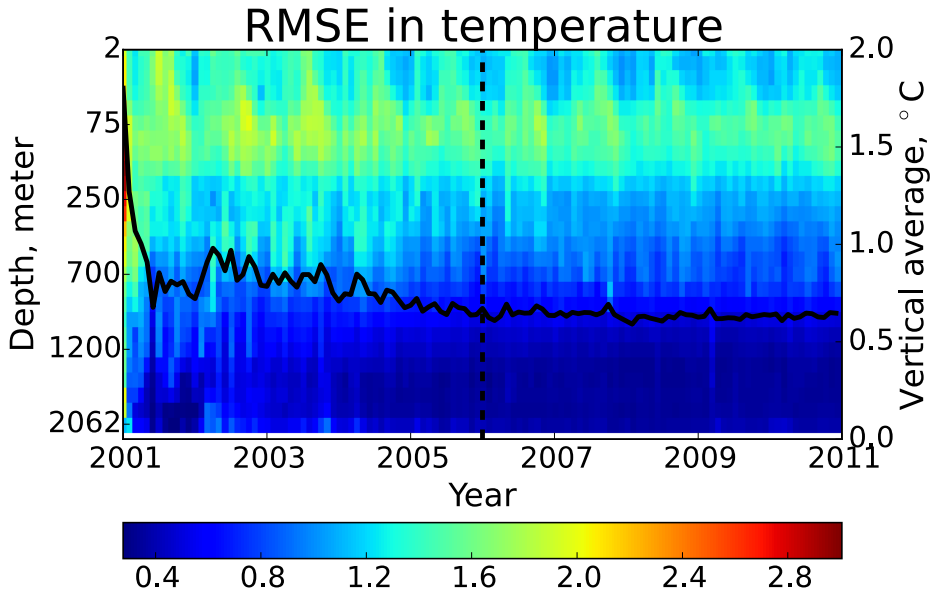
The error estimation of Karspeck (2016):

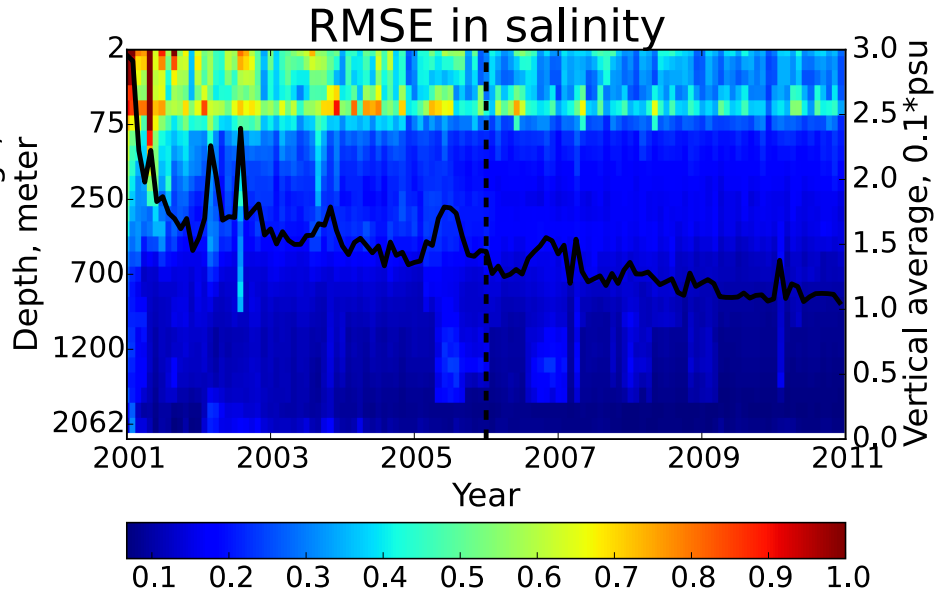
$$\mathrm{ObsVar} = \mathrm{RMSE}^2 - \mathrm{BIAS}^2 - \mathrm{EnsVar}$$

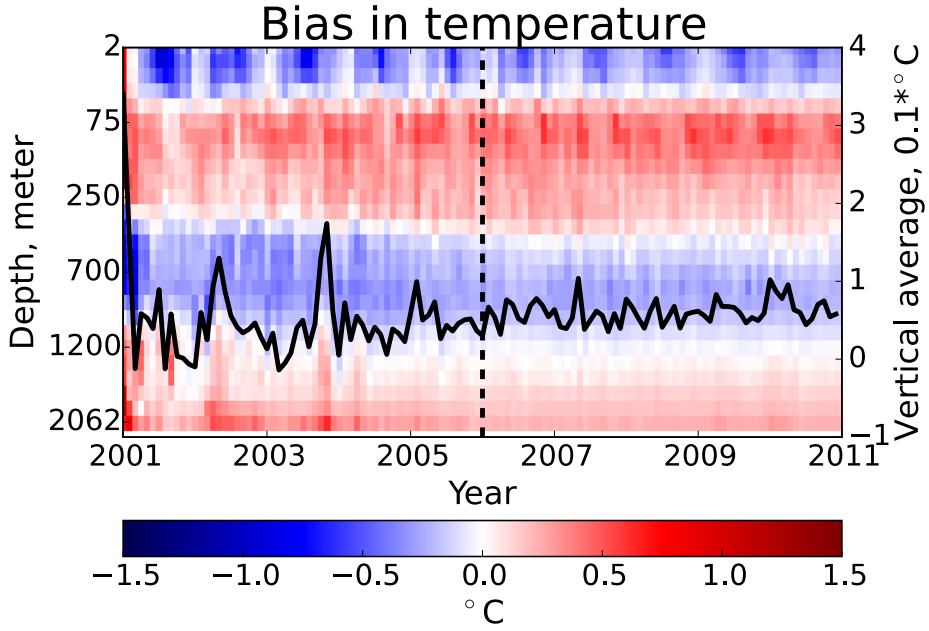
2. Verification of the stability of the system

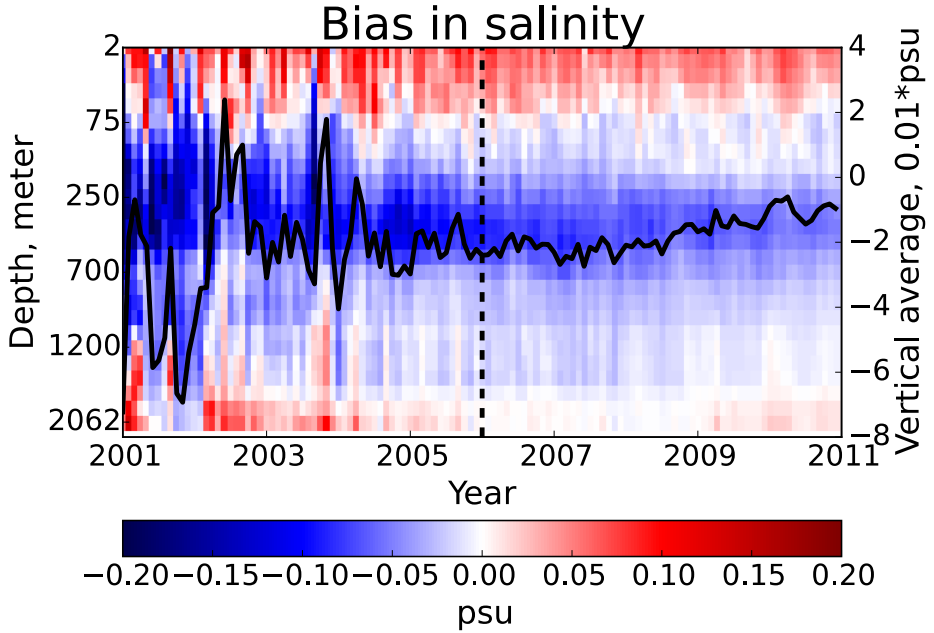
- Carry out a 10-year reanalysis (2001-2010)
  - Observations: EN4 dataset
  - Model: NorCPM-L (2° atmosphere, ocean, sea ice)
  - 30 ensemble members
  - Monthly assimilation

Accuracy: RMSE and bias



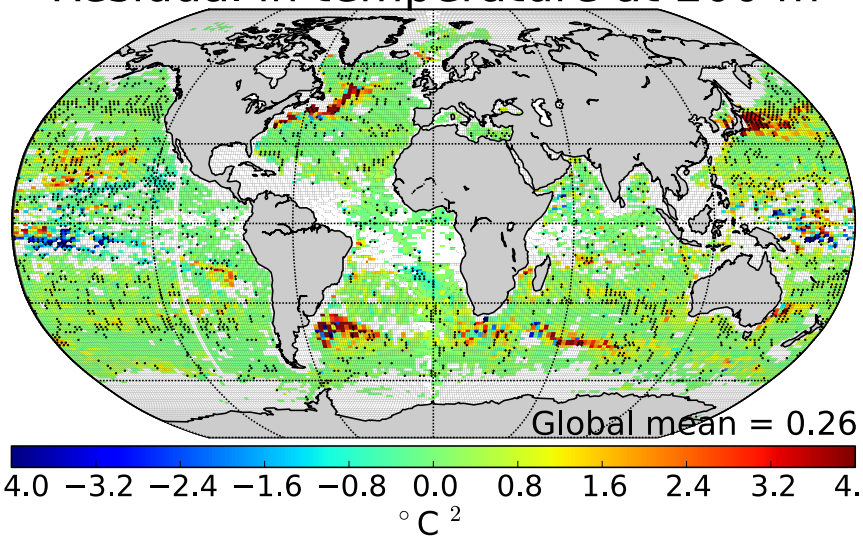




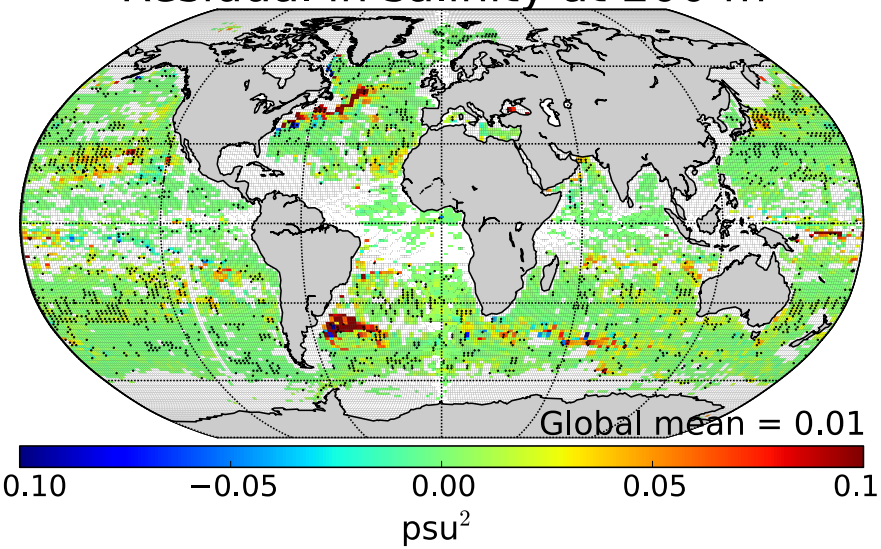


Reliability budget (Rodwell et al. 2016)

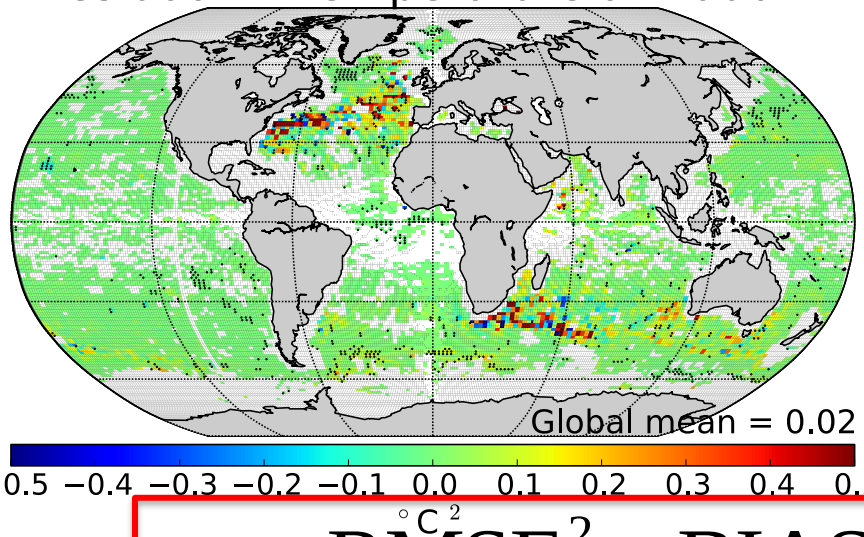
Residual in temperature at 200 m



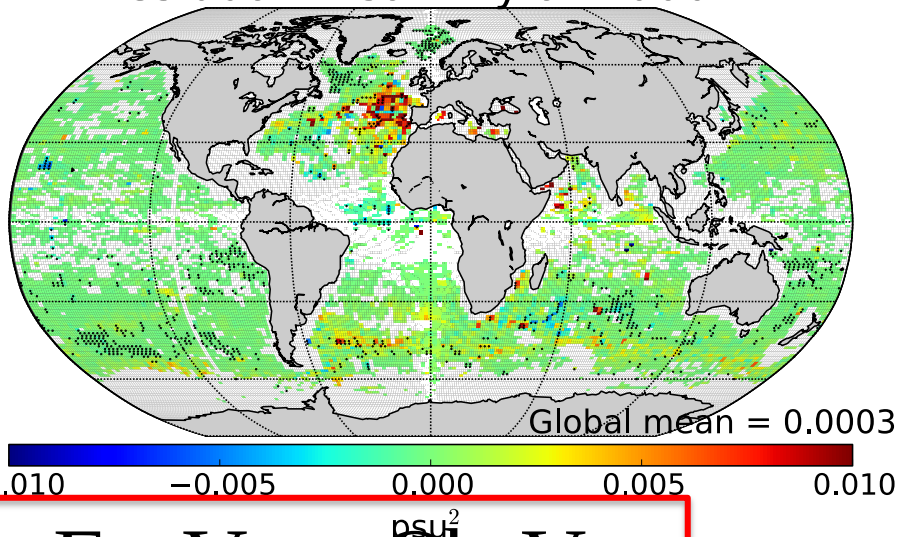
Residual in salinity at 200 m



Residual in temperature at 1000 m



Residual in salinity at 1000 m



$$r = \mathrm{RMSE}^2 - \mathrm{BIAS}^2 - \mathrm{EnsVar} - \mathrm{ObsVar}$$

Conclusions

› **Implementation setting of assimilation of T-S profiles:**

- It is preferable to assimilate observations in their original coordinate (z-coordinate).
- The localization radius varies with latitude (a bimodal Gaussian).
- Observation errors are estimated in regions.

› **Short-term reanalysis**

- DA reduces efficiently RMSE and bias.
- The system requires 5-year spin-up assim to converge to a stable performance.
- The system is statistically reliable in most regions.

Wang et al.: optimising assimilation of hydrographic profiles into isopycnal ocean models with ensemble data assimilation, in preparation.

Bjerknes Centre
for Climate Research

Thanks

Questions?

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HAVFORSKNINGSINSTITUTTET
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