Application of an Anisotropic Recursive Filter to Ocean Data Assimilation

Ye Liu[1], Jiang Zhu[1], Jun She[2]

1.*Institute of Atmospheric Physics, Chinese Academy of Sciences, Beijing, China.*
2.*Centre for Ocean and Ice, Danish Meteorological Institute, Copenhagen, Denmark.*

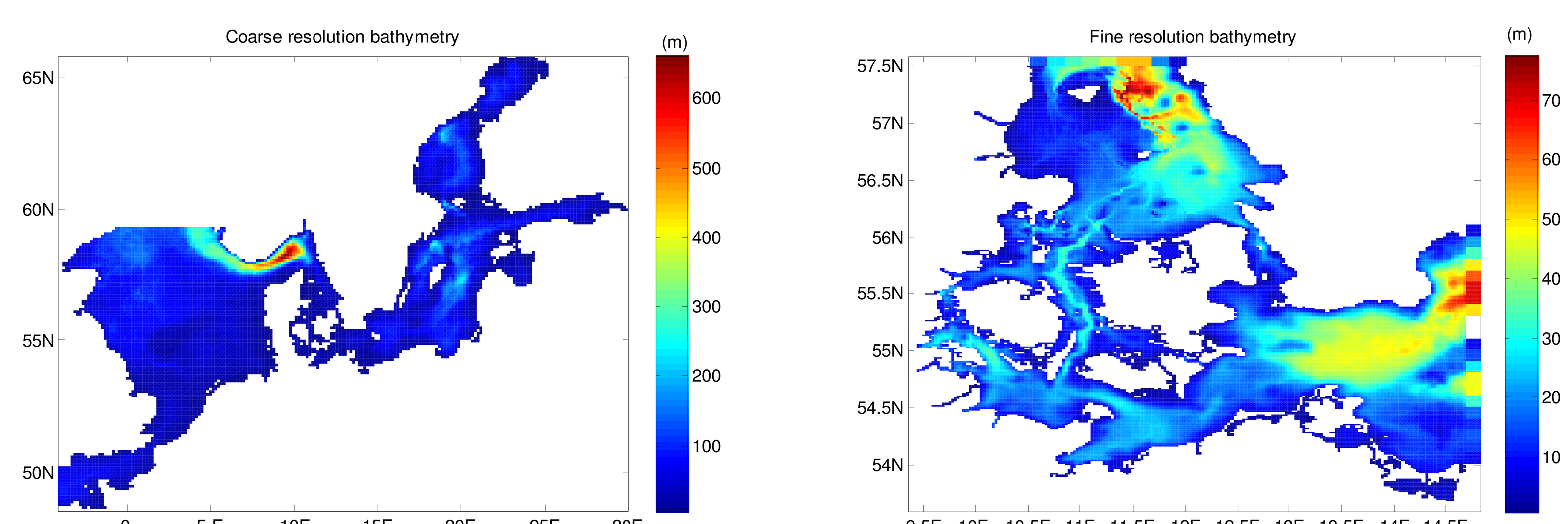
Abstract

the recursive filter (RF) is used for modeling the background error convariance matrix in the ocean data assimilation. Different from traditional algorithms of background error, the new 3DVAR scheme with RF largely reduces the memory stroage required in its implementation since the background error covariance is calculated in a implicate way. With the anisotropic recursive filter, the analysis increment fall off rapidly according to the background error field gradient. Two experiments have been conducted for verifying the assimilation scheme. It shows that the results produced by model have been largely improved by the scheme with RF.

Ocean Model

BSHcmod is a finite difference ocean model developed by the Bundesamt für Seeshiffahrt in Hamburg (BSH).The model has been operational for 3 years at the Danish Meteorological Institute and more than 10 years at BSH.

The model consists of two interactively nested grids. The coarse grid covers the entire North Sea and Baltic Sea with 6nm resolution, while the fine 1nm grid covers the seas around Denmark and north of Germany. The vertical resolution varies from a few meters in shallow model layers to several hundred meters in deep layers. The model has a total of 50 vertical levels for the coarse grid area and 52 vertical levels for the fine grid area, respectively.



Coarse and fine grids with resolution of respectively 6nm and 1nm

Recursive Filter Scheme

According to Ref. (Riishøjgaard1998; Huang 2000,Purser 2003), the effect of background error covariances matrix B can be modeling by spatial filters:

$$\mathbf{B} = \sigma_b^2 \exp\left\{-\frac{1}{2}\left[\frac{dy^T dy}{L_r^2} + \frac{(df)^2}{L_f^2}\right]\right\}$$

σ_b^2 is the variances of **B**;

$$\mathbf{B} = \sigma_b^2 \exp\left(-\frac{1}{2} dy^T \mathbf{A}^{-1} dy\right)$$

$$\mathbf{A}^{-1} = \frac{\mathbf{I}}{L_r^2} + \frac{(\nabla f)^T(\nabla f)}{L_f^2}$$

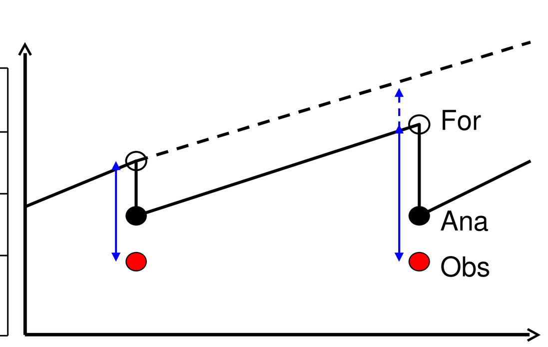
Here, dy is the distance between two grid in terms of the grid index coordinate, and *Lr* is the length scale or background error geometric correlation length scale in terms of the grid intervals and is in practice often linked to the observation density. *f* is the bathymetry of the *i*th point which represents the pattern of background error.

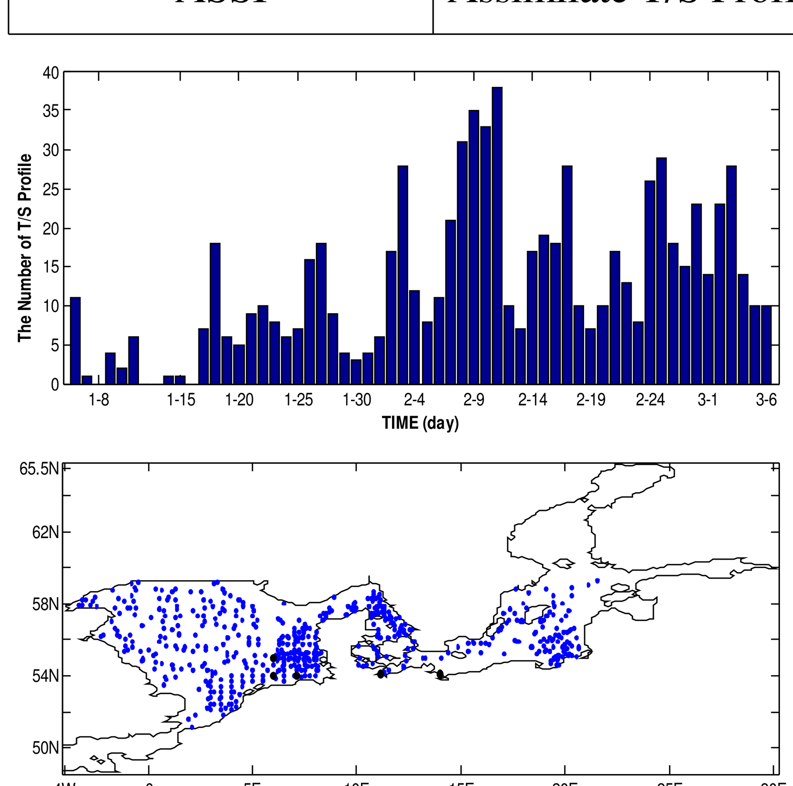
Experiments Setup

Two experiments have been conducted with the abovementioned recursive filter scheme (Table). The background error variance of temperature and salinity field are assumed to be constants, which are 1.2 degree and 0.9 psu, respectively. The correlation scale of the temperature and salinity is also assumed to be same. The assimilation setup is used at two area.

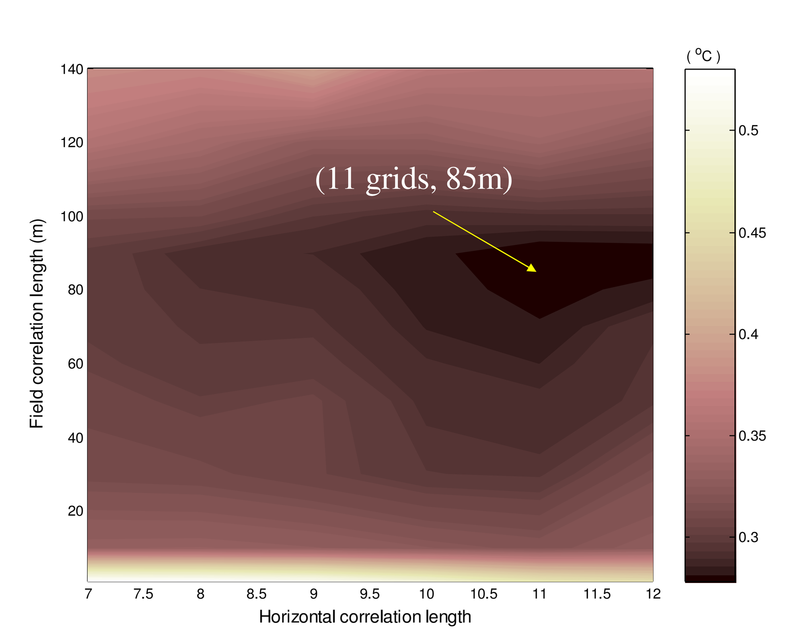
Table Experimental setup

Experiment name	Assimilation scheme	Integeration time
NON	Not Assimilation	2005.1.8-2005.3.4
ASSI	Assimilate T/S Profiles	2005.1.8-2005.3.4



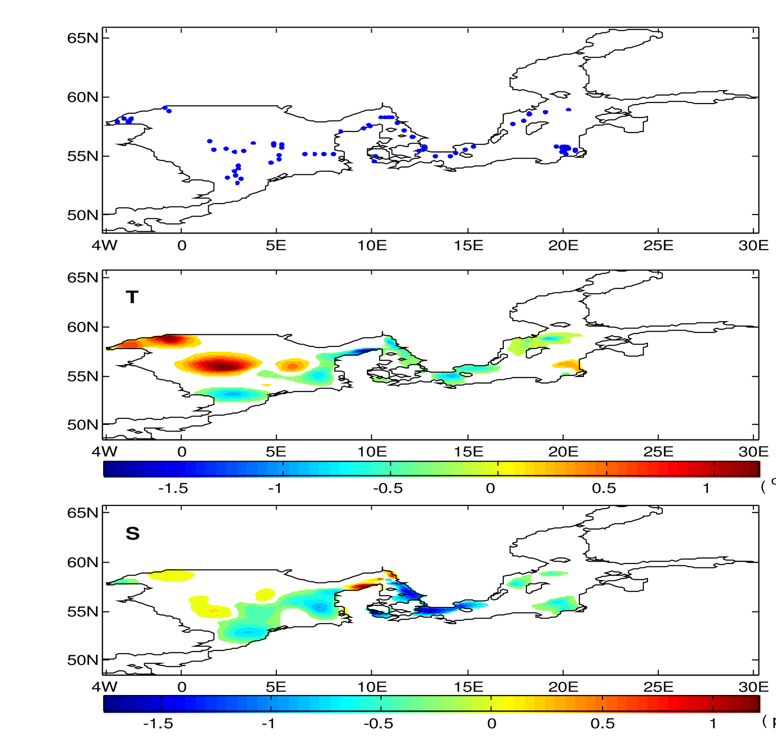


The temporal and spatial distribution of the T/S profiles in the experiment period.

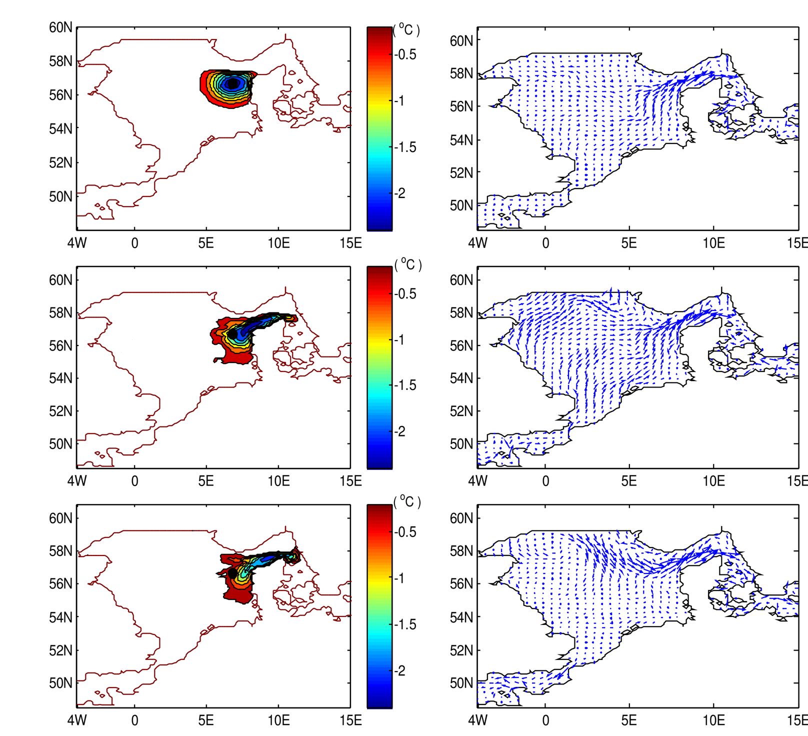


RMSE of Temperature is shown as function of the two length scales Lf and Lr using all observation at the Feb,2,2005.

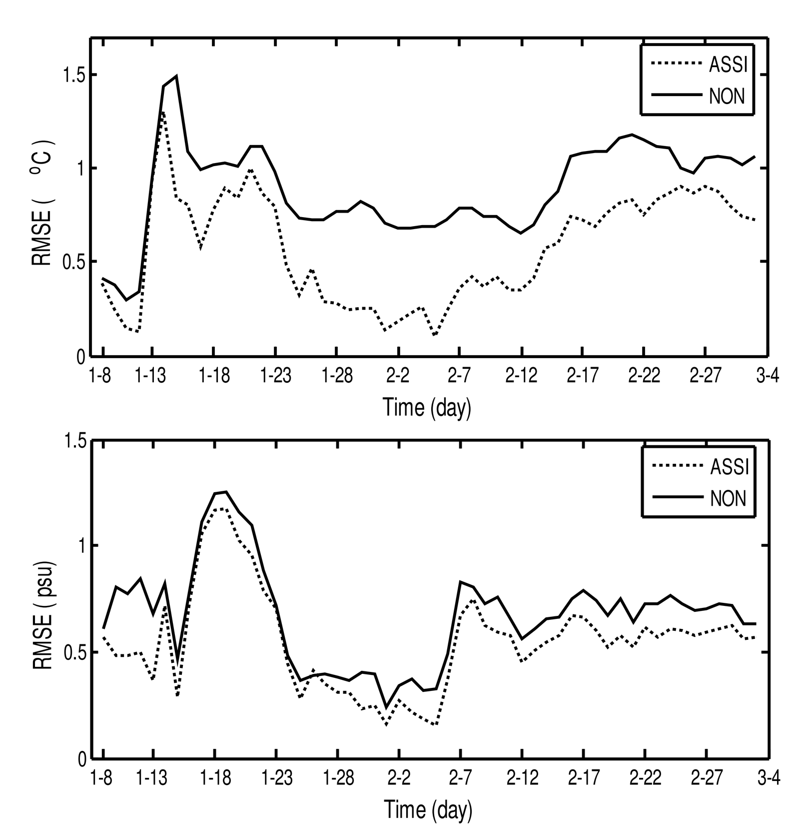
Experiments Results



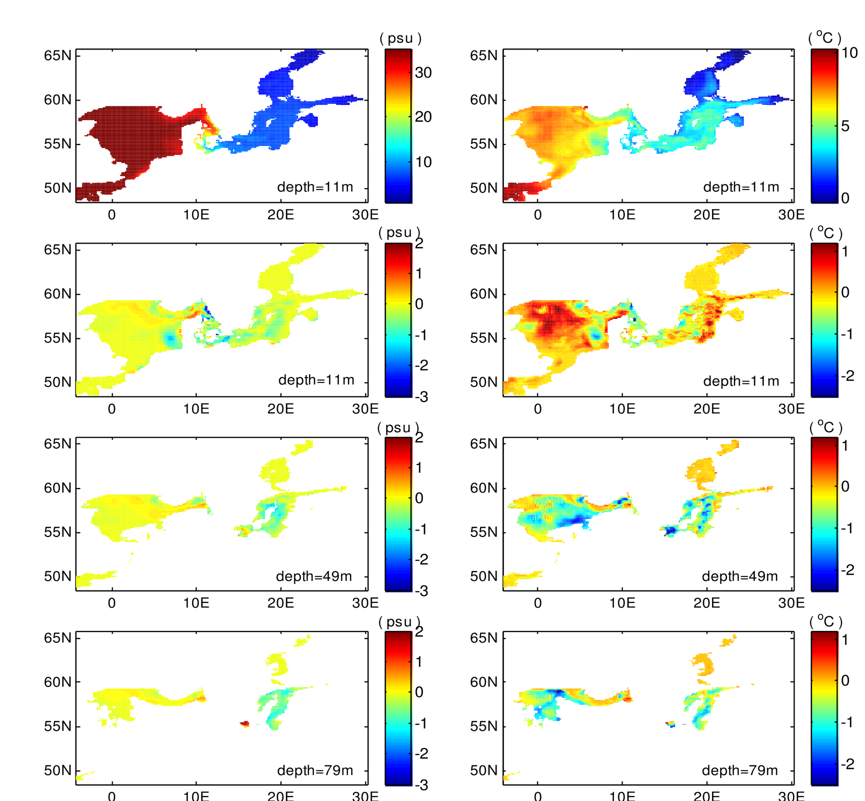
The spatial distribution of observation (top) and the analysis increment of temperature (middle) and salinity (bottom) at the Feb 22,2005, respectively.



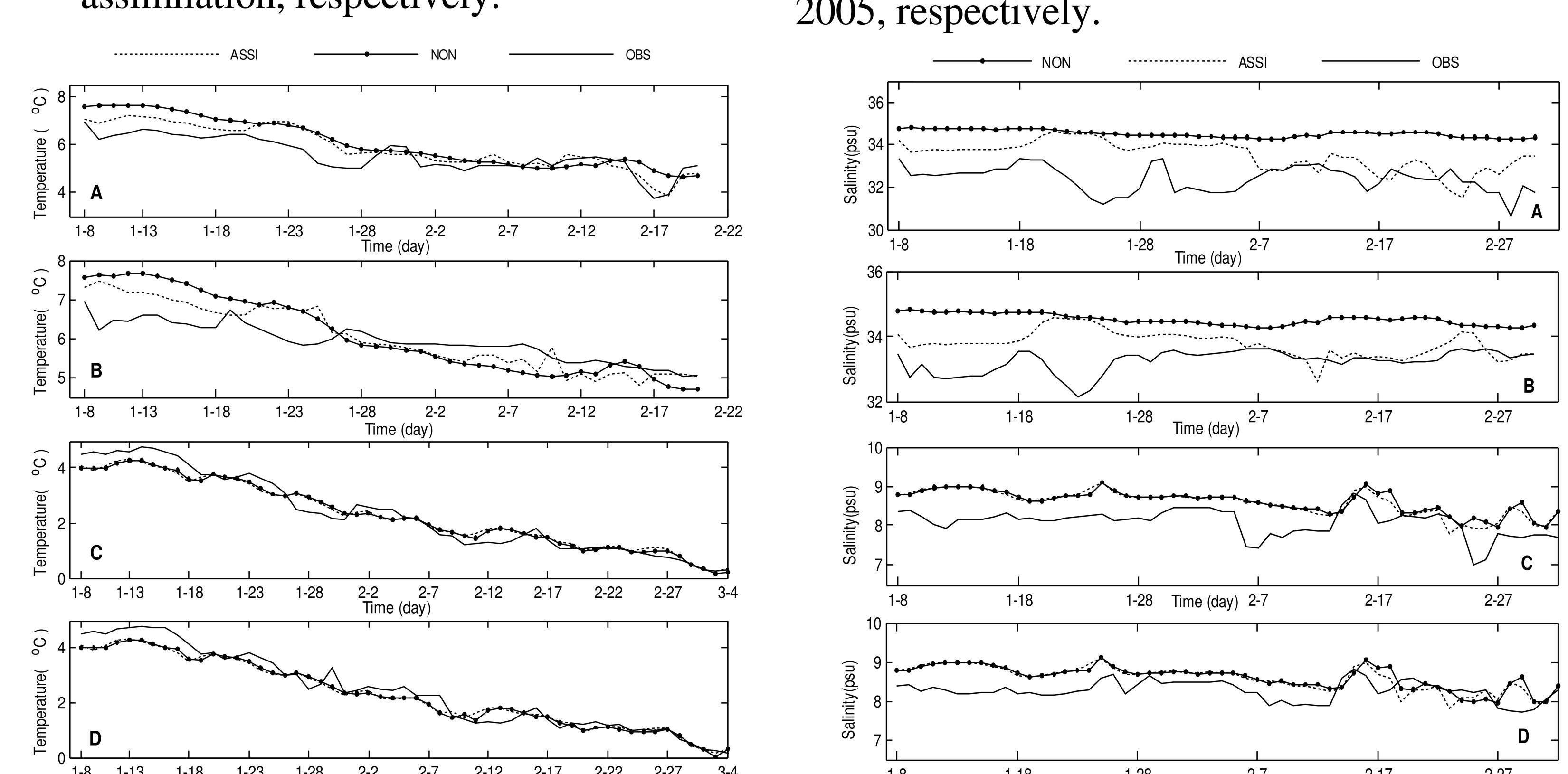
The temperature analysis increments and the corresponding mean current at (top) 10 Jan 2005, (middle) 12 Jan 2005 and (bottom) 14 Jan 2005, respectively.



The overall RMSEs for temperature and salinity verified daily just before the assimilation, respectively.



The ASSI results at 11m depth and the differences between ASSI results and NON results at 11m, 49m and 79m for the Temperature and salinity at Jan 30 2005, respectively.



The Salinity and temperature VS the time series at the point (54.0N, 7.1167E), the water depth are (A) 6m depth, (B) 30m depth and at the point(54.083N, 14.0E), the water depth are (C) 3m depth and (D) 12m depth, respectively.

※ The memory used in the assimilation experiments is about 361M bytes with the RF assimilation scheme. However, the traditional 3DVAR without RF will use about 1334Mbyte computer memory .

References

1.Riishøjgaard, L. P. 1998: A direct way of specifying flow-dependent background error correlations formeteorological analysis systems, *Tellus*, 50A, 42–57.
2.Huang X. Y., 2000: Variational Analysis Using Spatial Filters. *Mon. Wea. Rev.*, **128**, 2588 — 2600.
3.Purser, R. J., W. S. Wu, D. F. Parrish, and N. M. Roberts, 2003a: Numerical aspects of the application of recursive filters to variational statistical analysis. Part I: Spatially homogeneous and isotropic Gaussian covariances. *Mon. Wea. Rev.*, **131**, 1524 — 1535
4.Purser, R. J., W. S. Wu, and D. F. Parrish, 2003b: Numerical aspects of the application of recursive filters to variational statistical analysis. Part II: Spatially inhomogeneous and anisotropic general covariances. *Mon. Wea. Rev.*, **131**, 1536 — 1548.

Contact :liuye@mail.iap.ac.cn