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Ocean data Assimilation in the Operational models of DMI: A short Introduction

W. Fu, Z. Wan and J. She

Center for Ocean and Ice (COI), Danish Meteorological
Institute (DMI), Copenhagen, Denmark

Presented by J. She

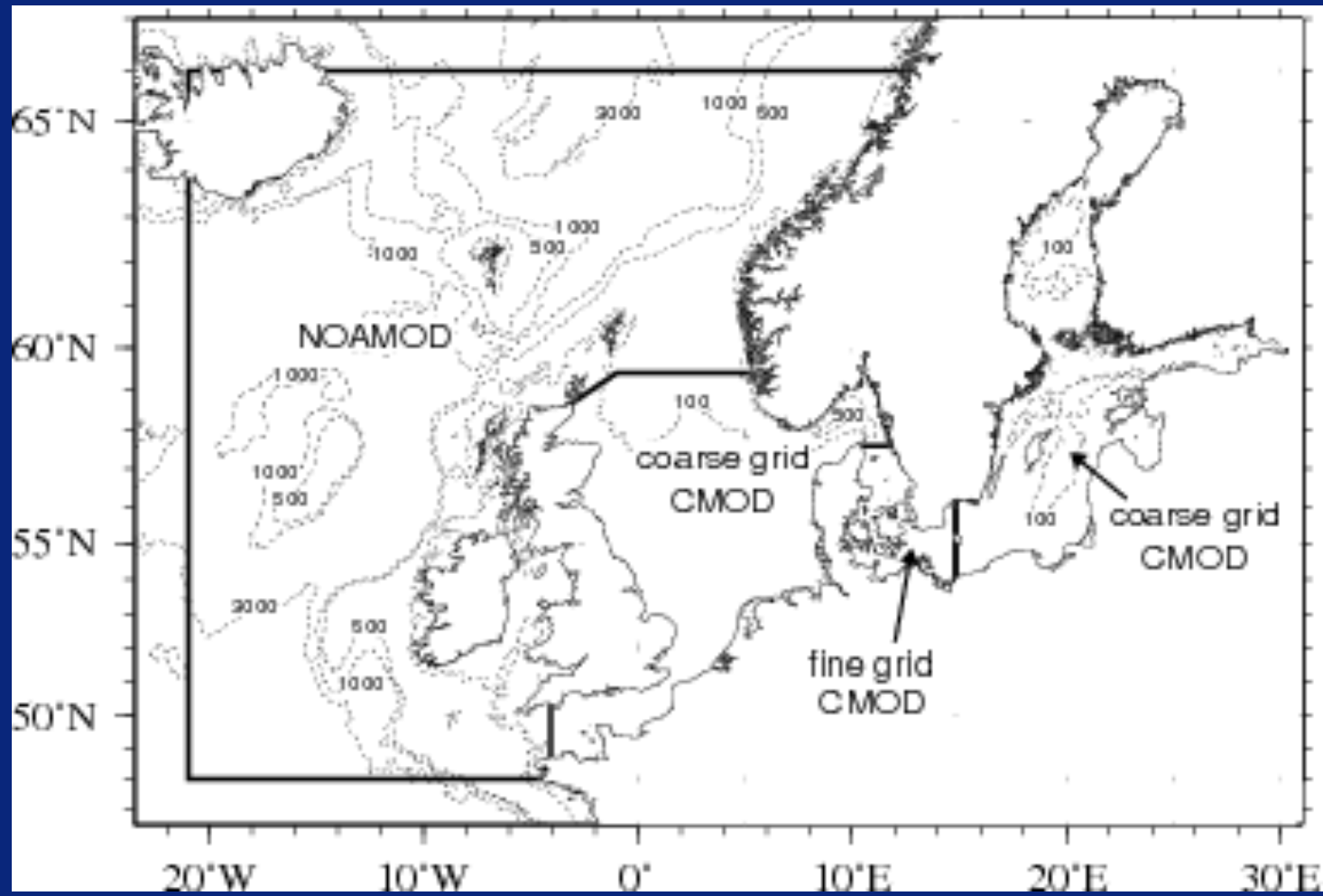


Outline

- Operational models
- Physical model assimilation
- Ecosystem model assimilation
- Summary



Physical model

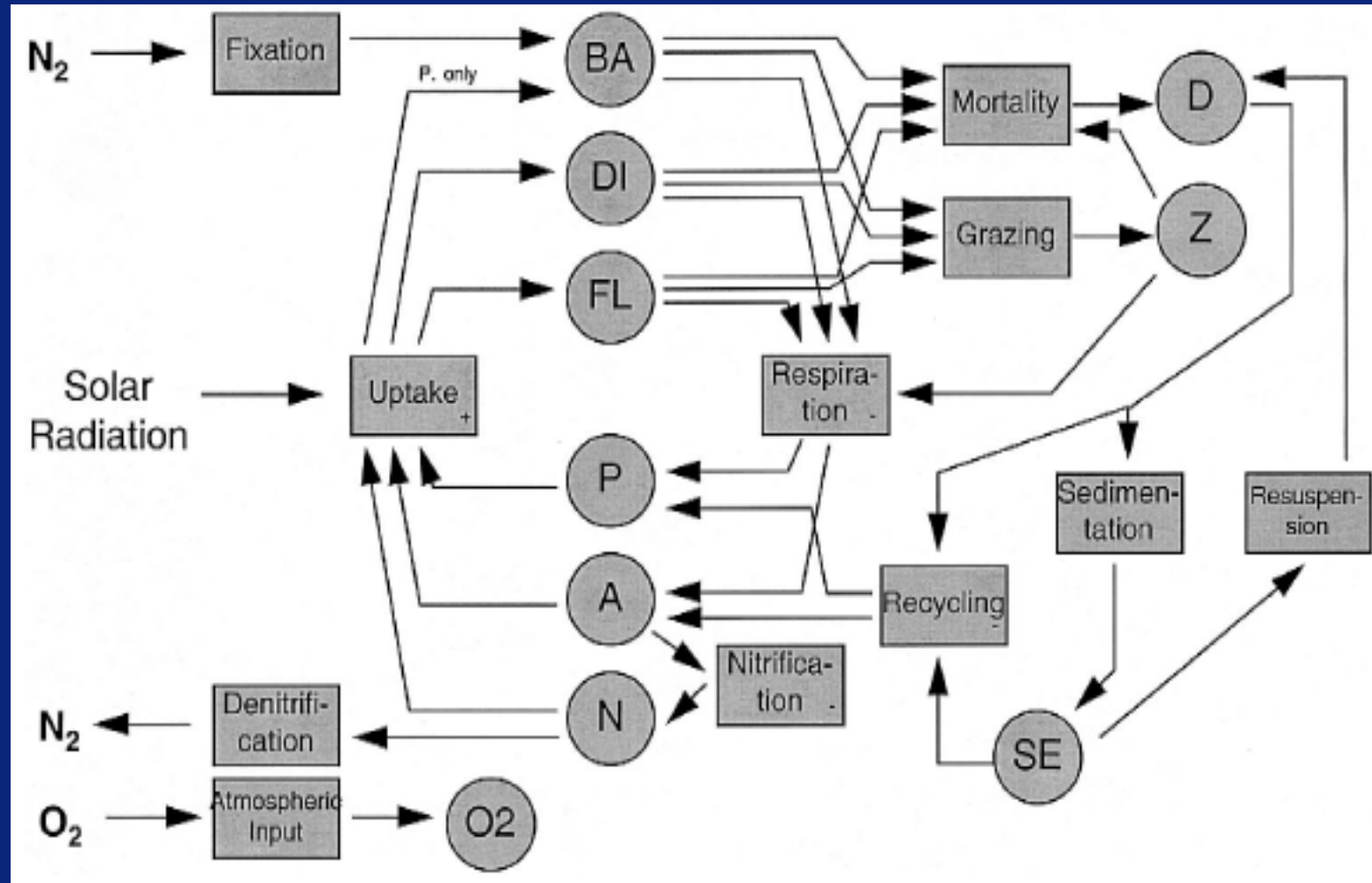




- meteorological forcing is provided by DMI's operational weather model HIRLAM. the forcing has resolution of 15km.
- River runoff is daily averaged data derived from 5 German rivers, hydrological simulations for 42 Baltic rivers and climatology values are also used.

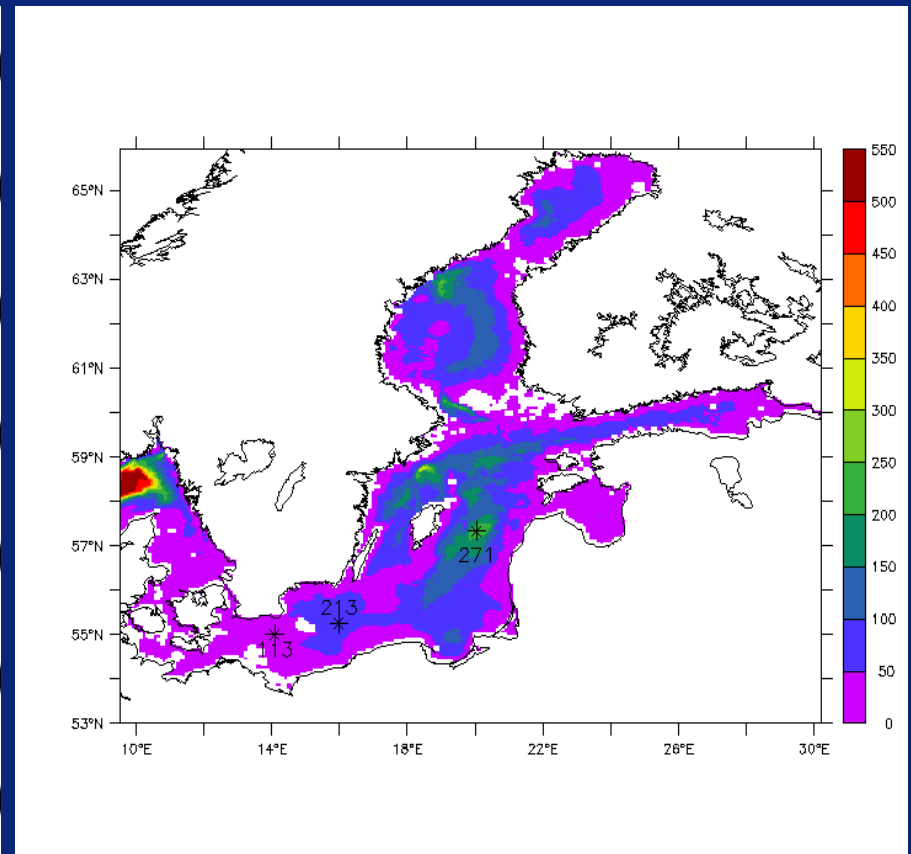
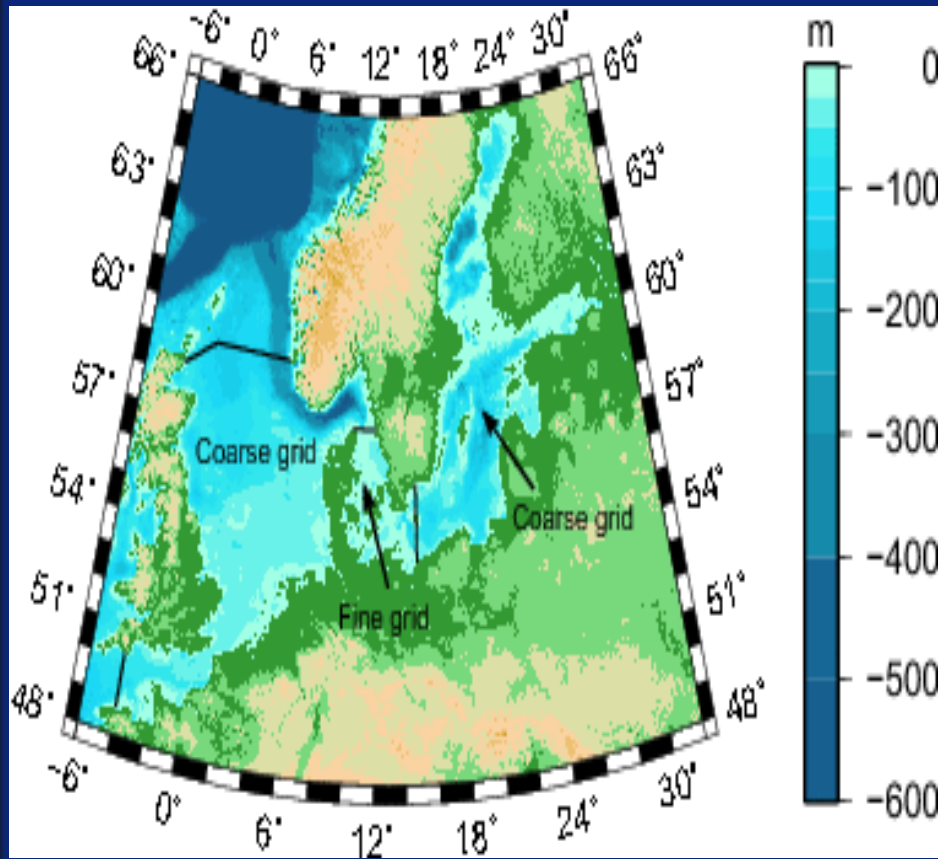


ERGOM Model by T. Neumann

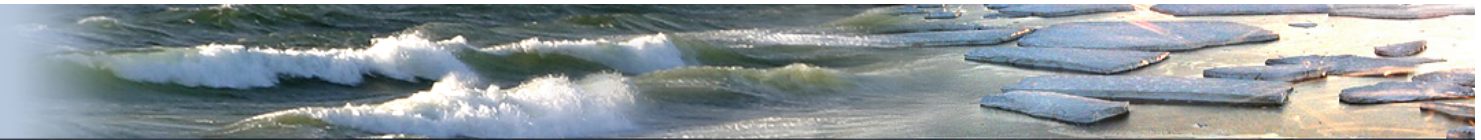




Model Domain



113 Arkona, 213 Bornholm, 271 Gotland



Ensemble Optimum Interpolation

- a simplified form of EnKF, only integrating one forecast state forward (Evensen, 2004; Oke et al., 2003).
- It is suboptimal to EnKF, but computationally efficient. The computation cost is $1/N$ that of EnKF if the size of ensemble is N .



EnOI configuration

$$w^a = w^f + K(w^o - Hw^f)$$

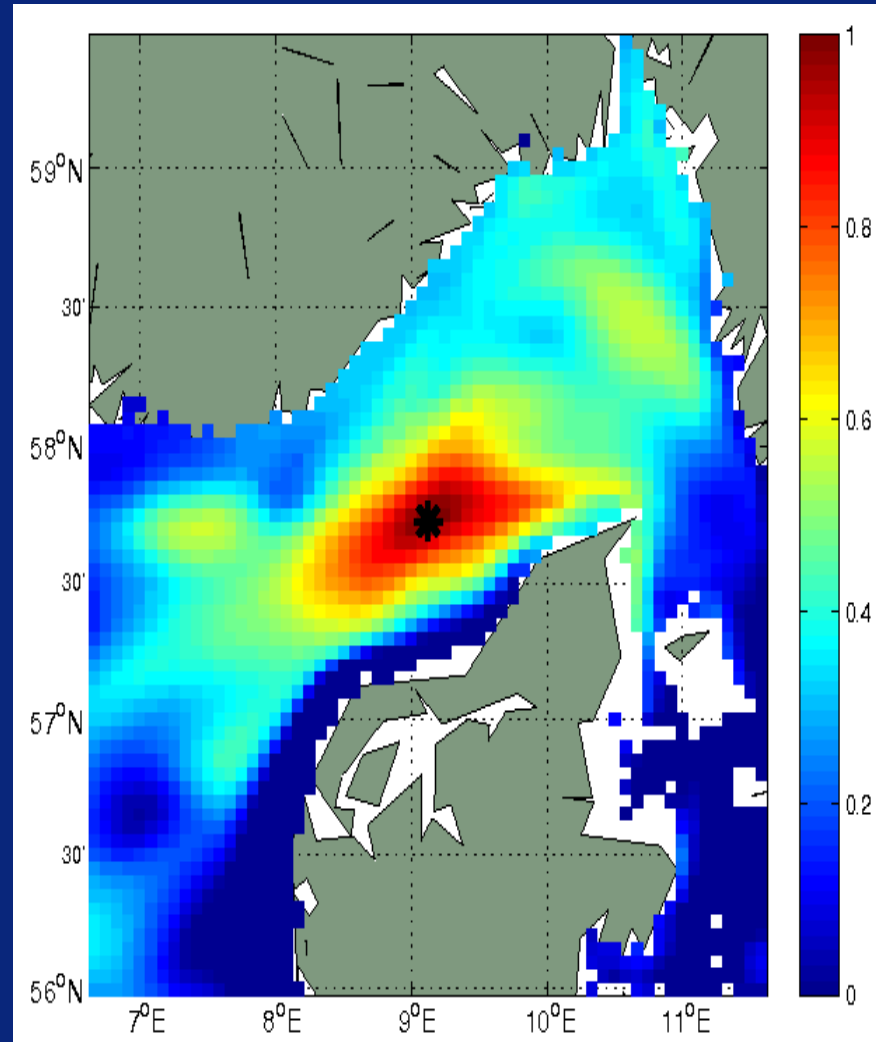
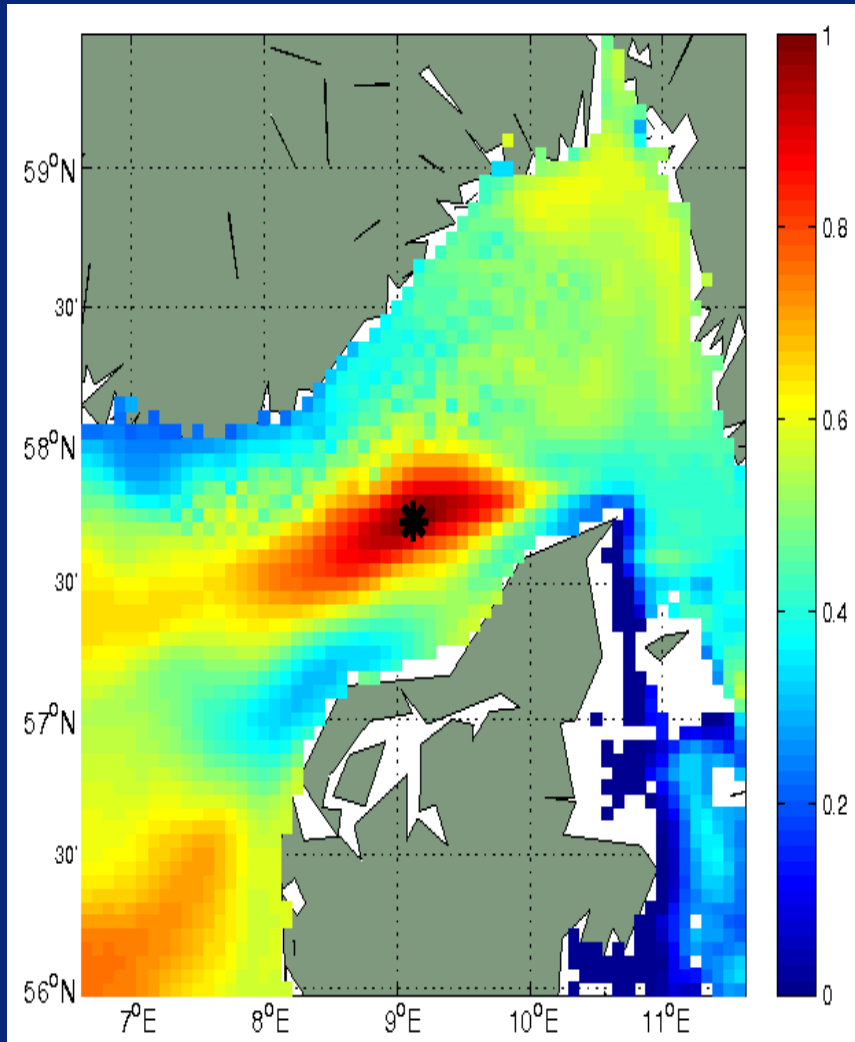
$$w = [\eta_i, t_i, s_i, u_i, v_i], i = 1, 2$$

$$K = (C \circ P^f) H^T (H(C \circ P^f) H^T + R)^{-1}$$

$$A = (w_1, w_2, \dots, w_N) \in \mathcal{R}^{n \times N}$$

$$A' = A - \bar{A}; P^f = \frac{AA'}{N-1}$$

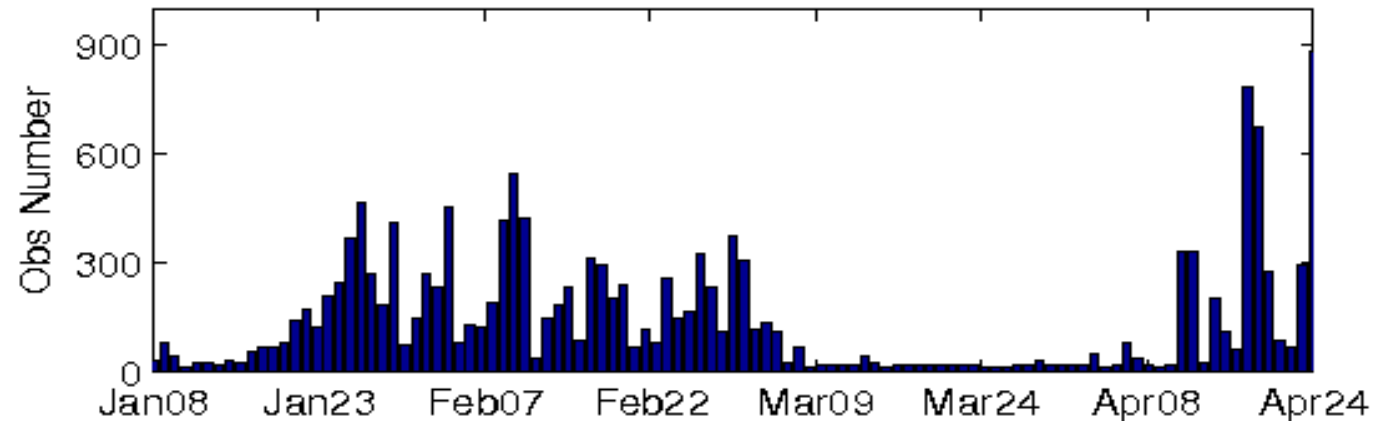
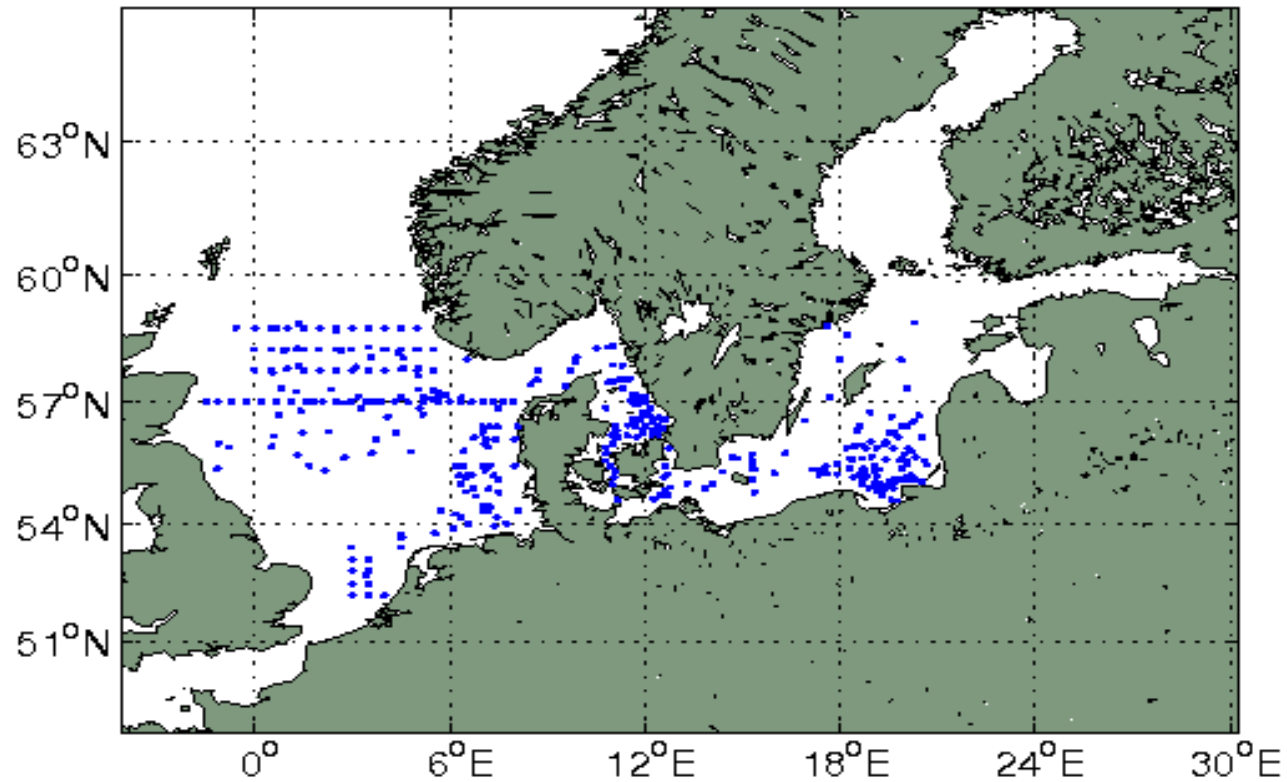
η : sea level; T: temperature; S: salinity; u: zonal current; v: meridional. Superscript a, f and o denotes analysis, forecast and observation. K: Kalman gain; C: localization; H: interpolation operator; R: measurement error covariace; P^f : background Error Covariance; circle : Schur product.



Ensemble based correlation for temperature (left) and salinity (right) between the point (9.12°E, 57.73°N) and the surrounding points.



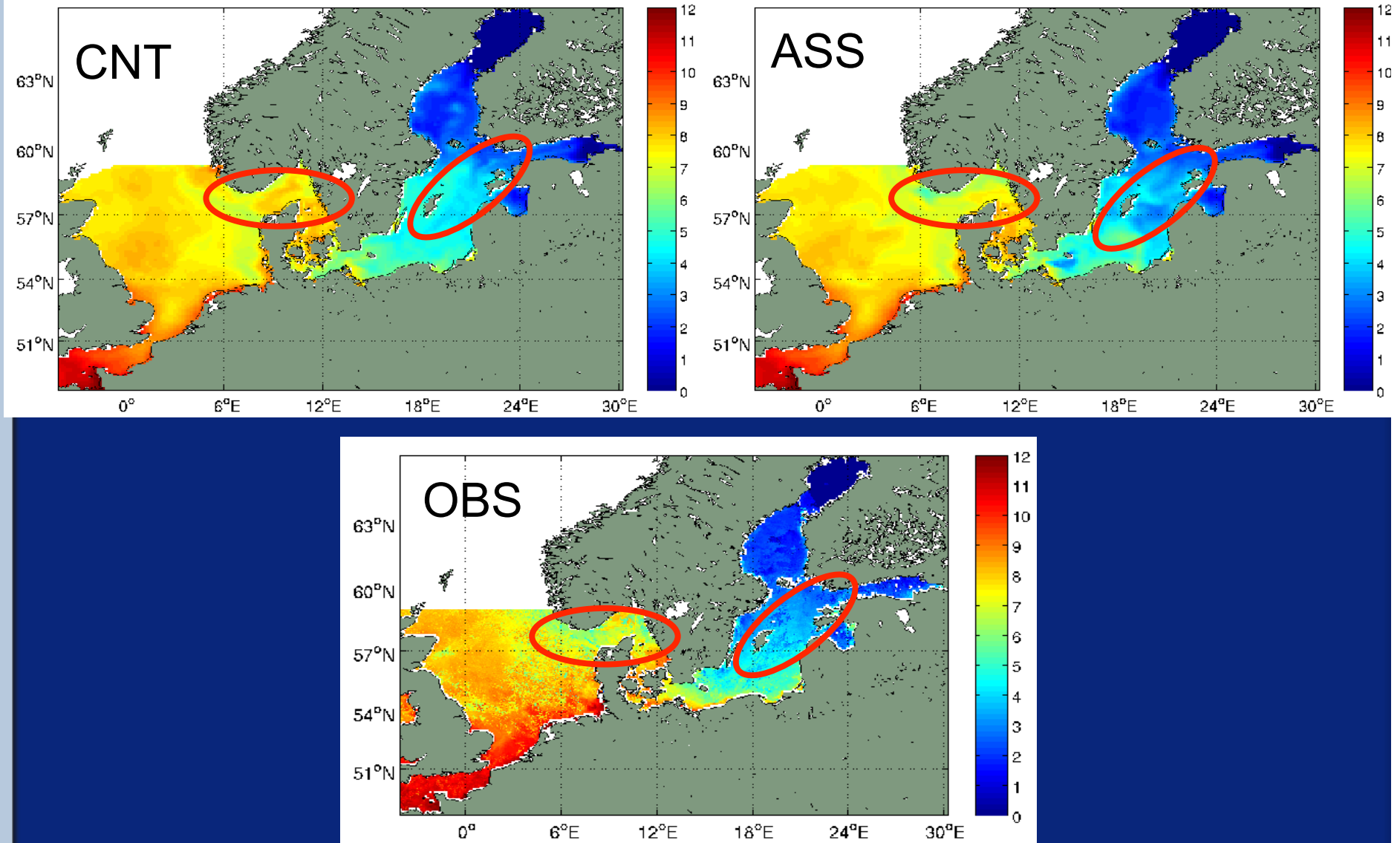
ICES Oceanographic Database and Services



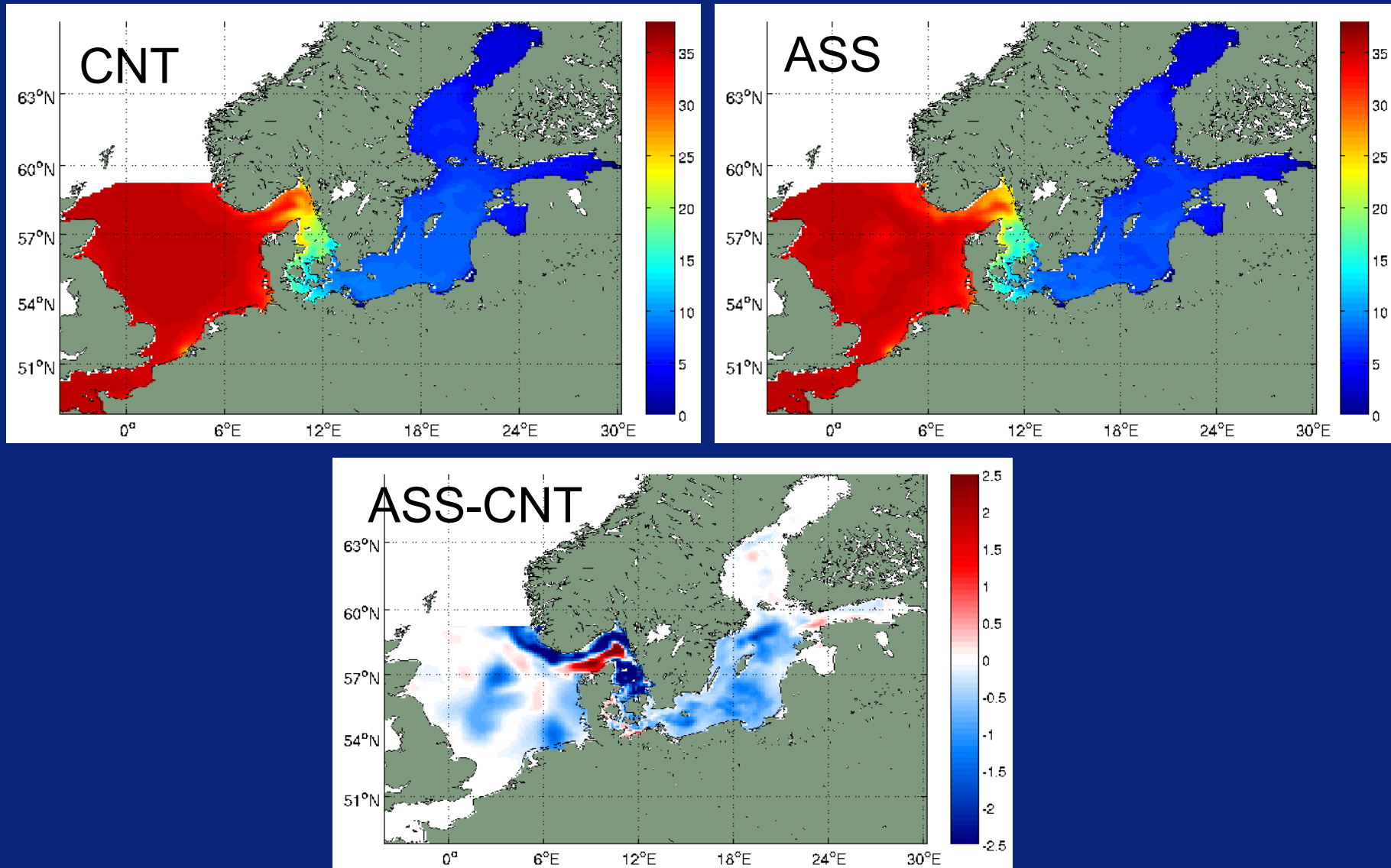
International Council for the Exploration of the Sea (ICES)



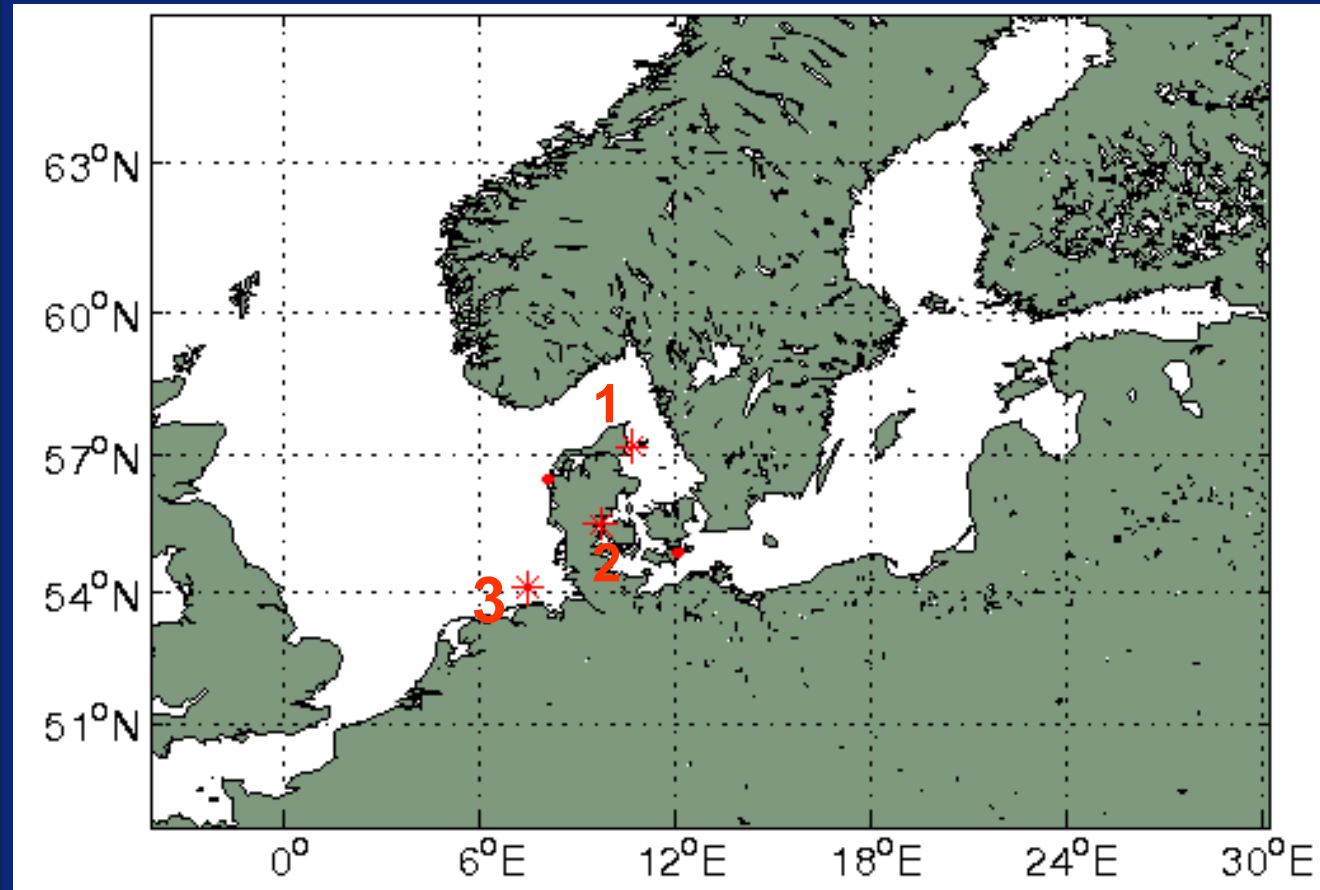
- Assimilation (Jan 8,2005-Apr 24,2005)
- Comparison with Satellite SST
- SSS increment
- Comparison with T and S (buoys)
- Root mean square error
- Comparison with sea level



Sea surface temperature on April 24, 2005



Sea surface salinity on April 24, 2005



1* (57.2°N, 10.7°E)

2* (55.5°N, 9.7°E)

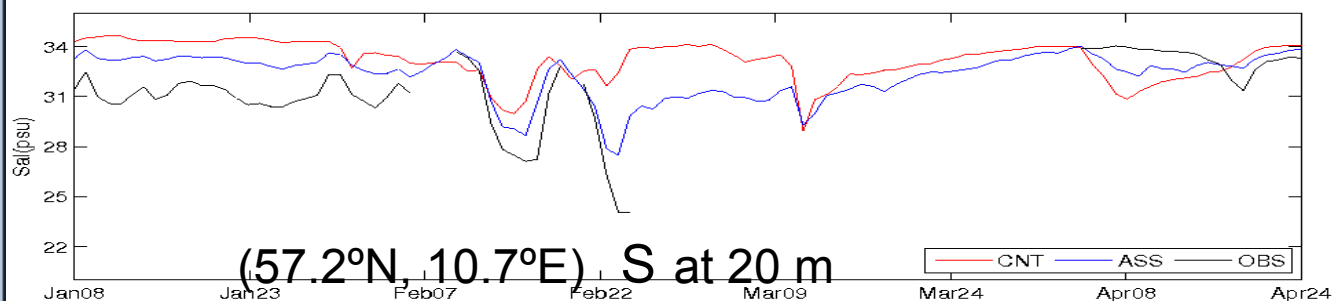
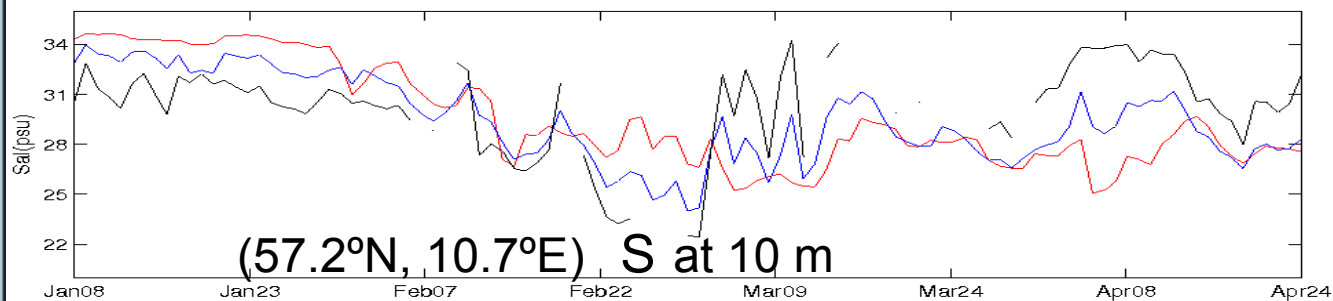
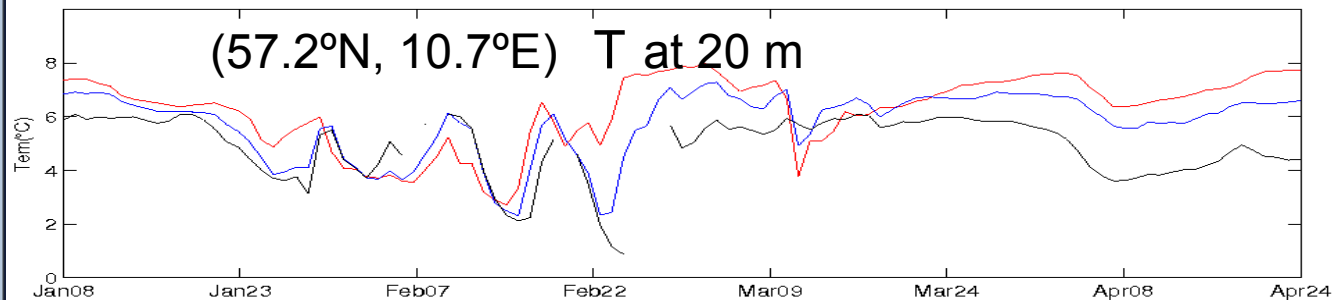
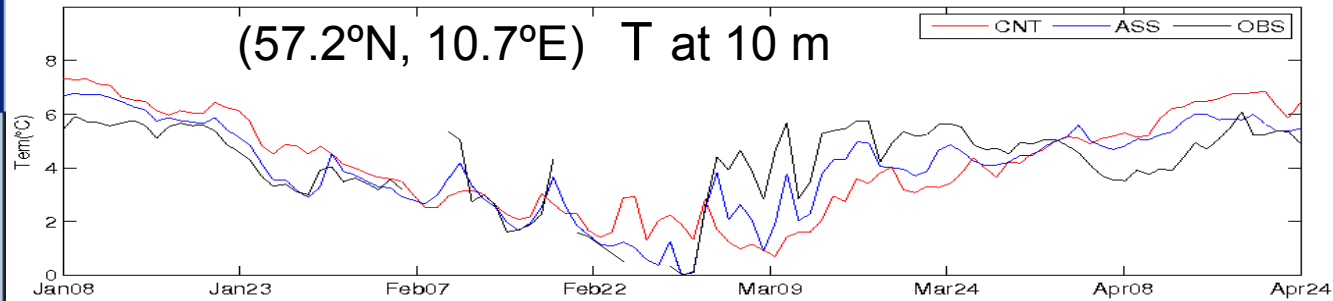
3* (54.2°N, 7.5°E)

• (56 °32'N, 08°07'E)

• (54°49'N, 12°08'E)

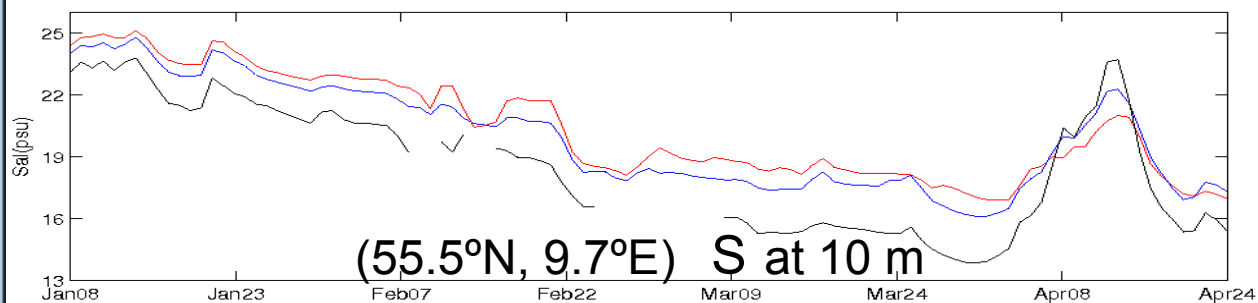
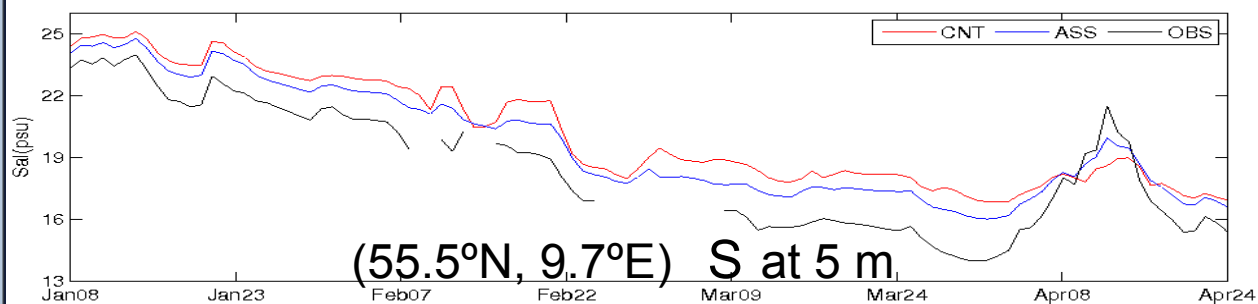
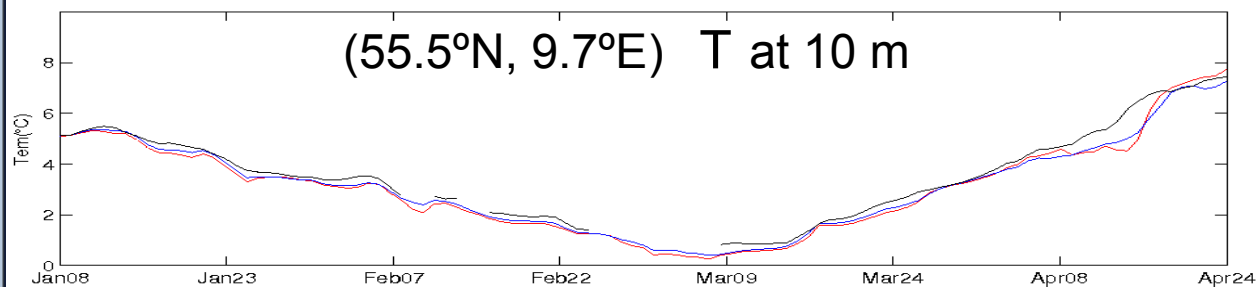
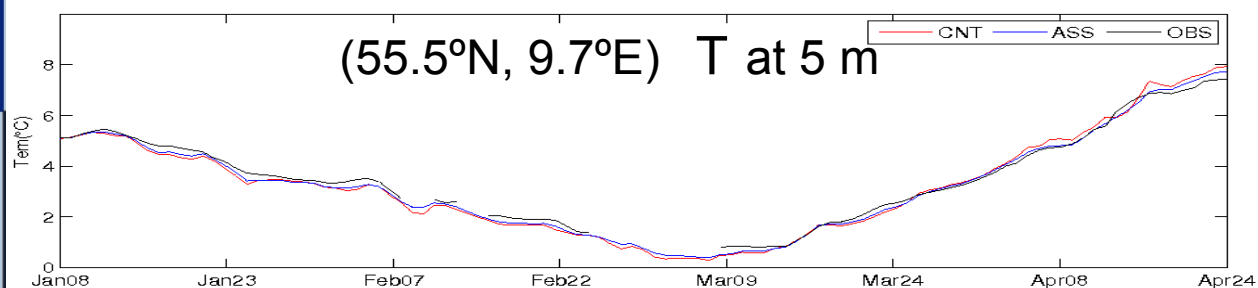
3 buoys for T and S (star) – **NOT USED IN ASSIMILATION**

2 observing stations for sea level (dot)



Entrance of Kattegate

Error reduced by
T: 0.6C
S: 0.8

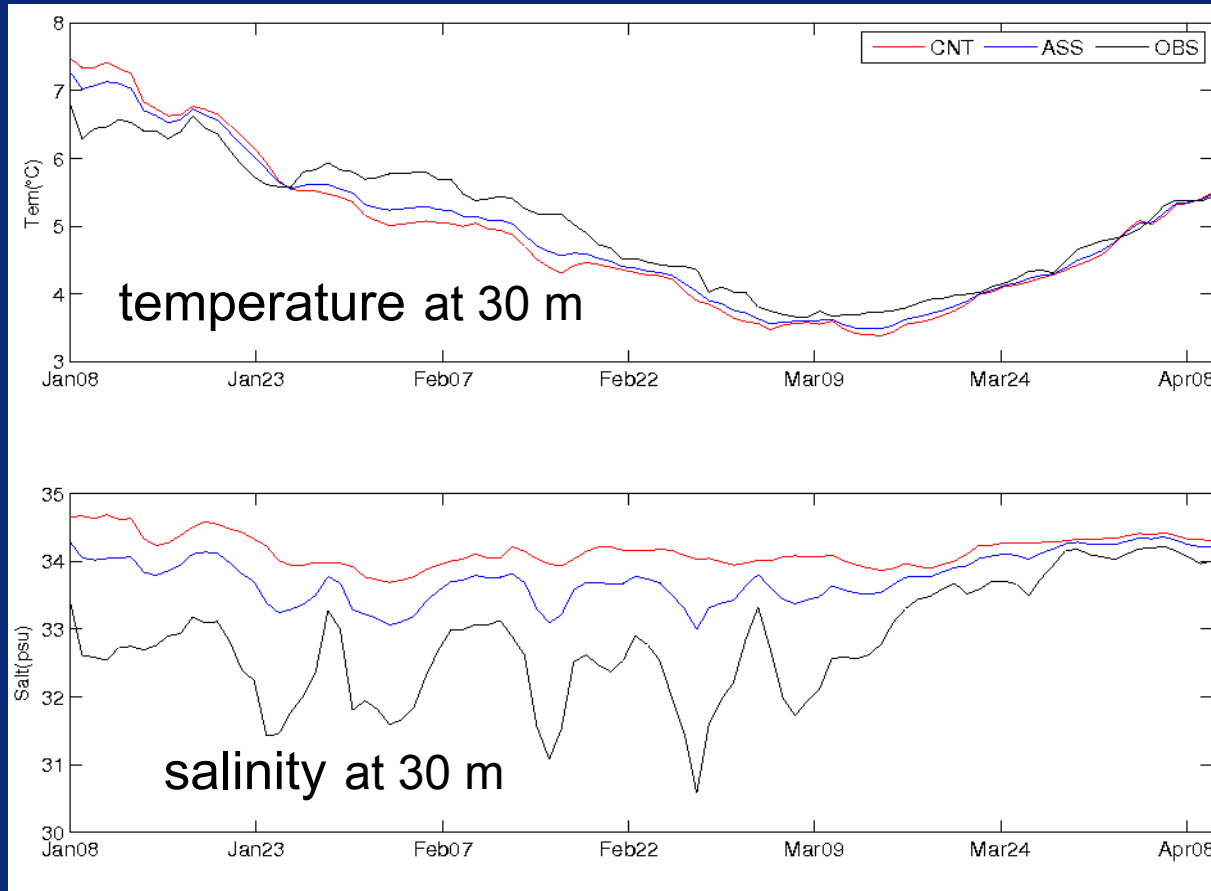


Buoy at Lille Belt

Error reduced by

T: 0.2C

S: 0.6



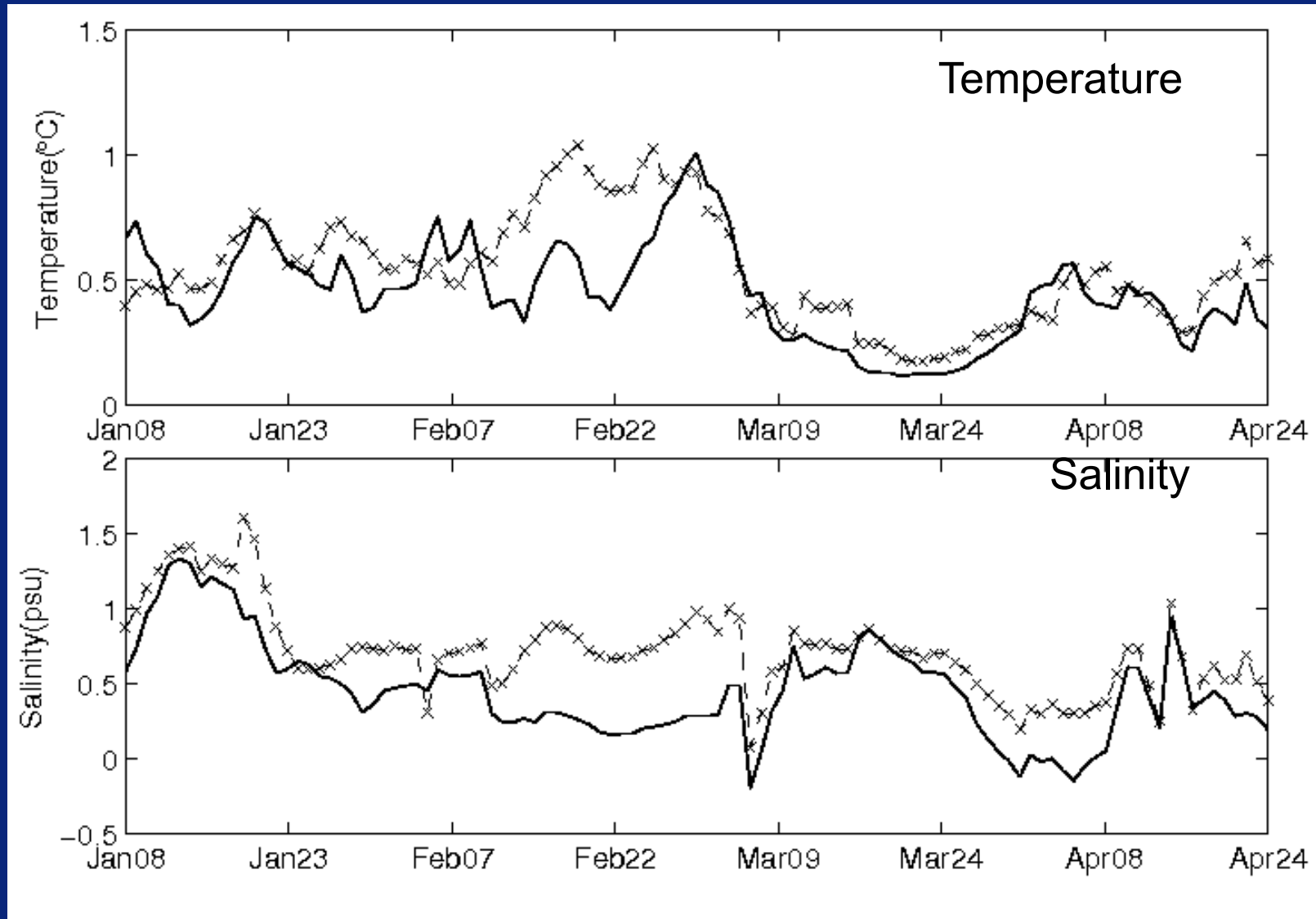
Buoy at German Bight

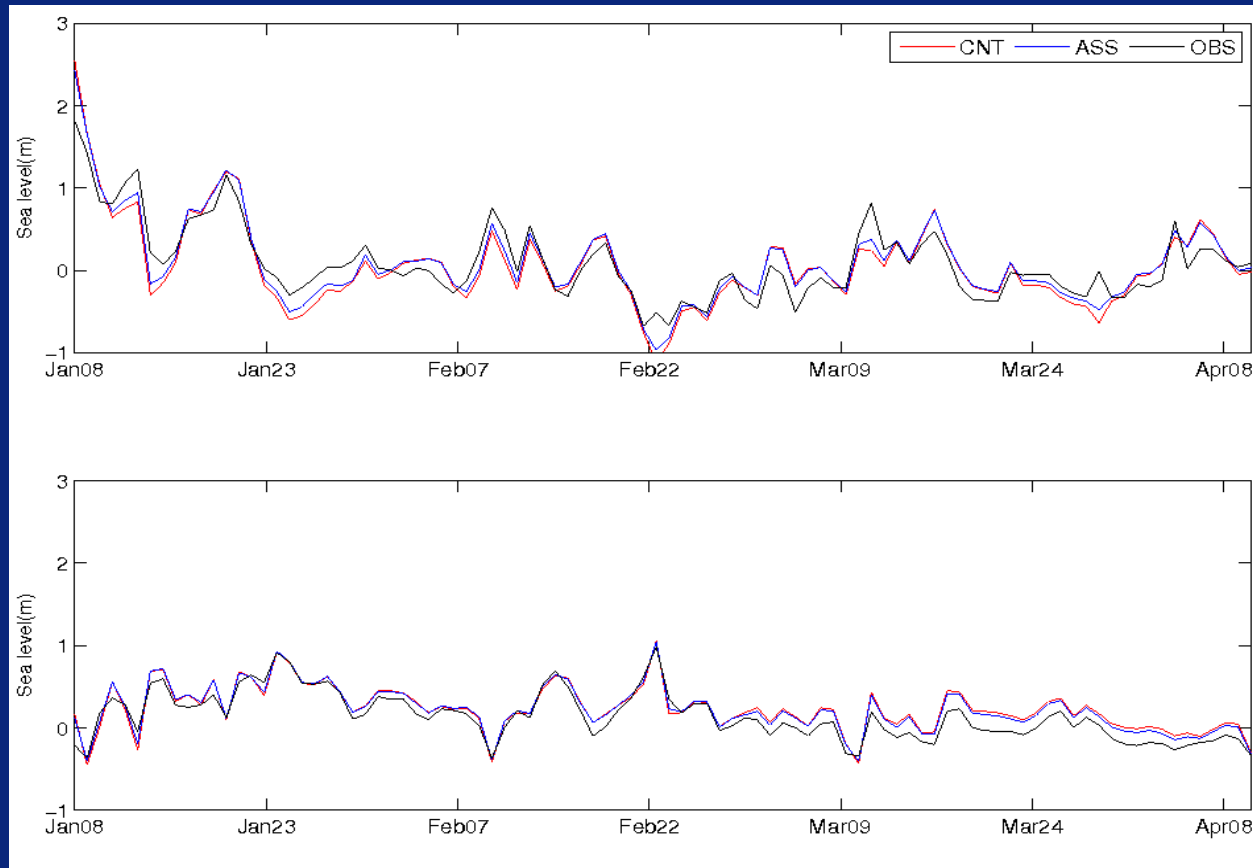
Error reduced by
T: 0.5C
S: 0.6

temperature and salinity evolution at (54°10', 07°27") at the depth of 30 m.



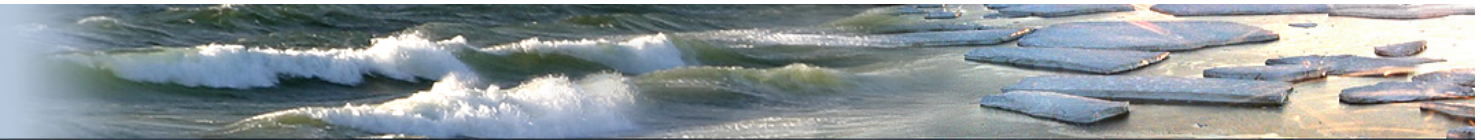
Root mean square error



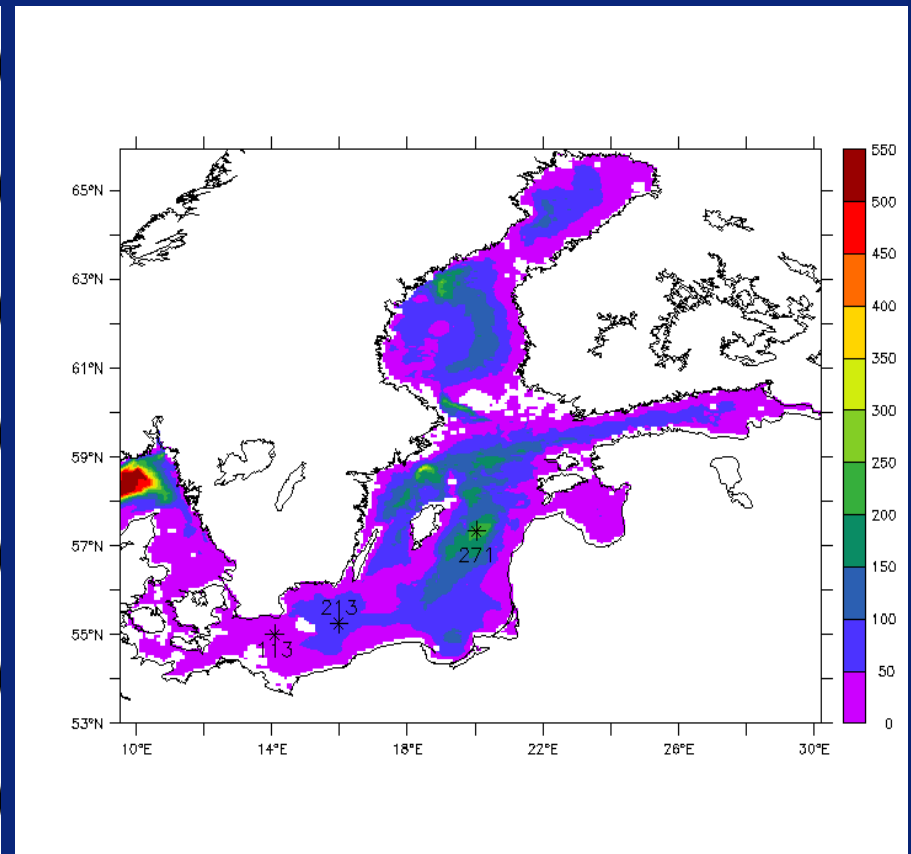
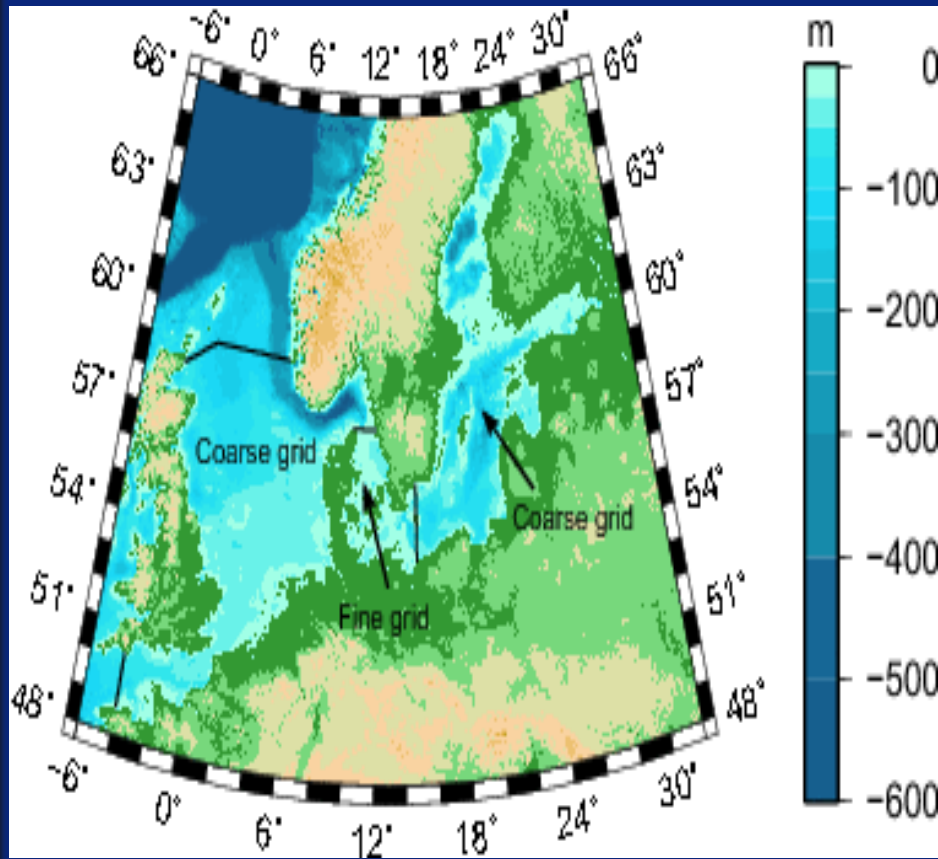


Error reduced by
5-10cm

Comparisons of sea level at Ferring (Nr. 24018) station ($56^{\circ}32', 08^{\circ}07'$) and Hesnaes (Nr. 31493) station ($54^{\circ}49', 12^{\circ}08'$).



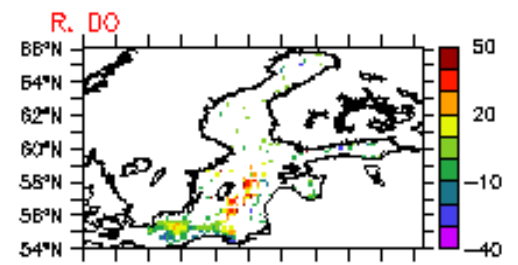
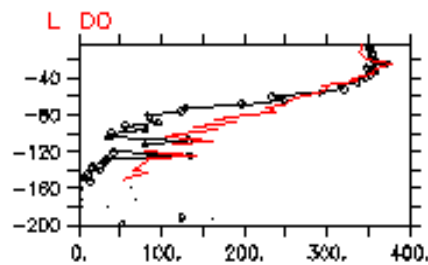
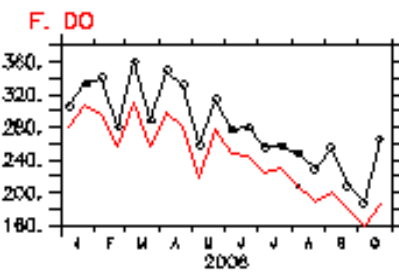
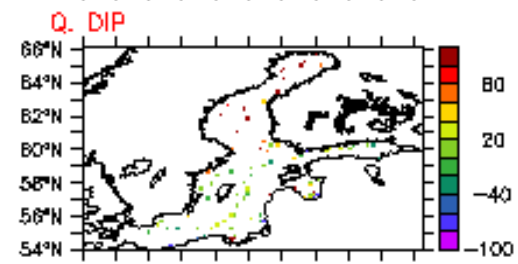
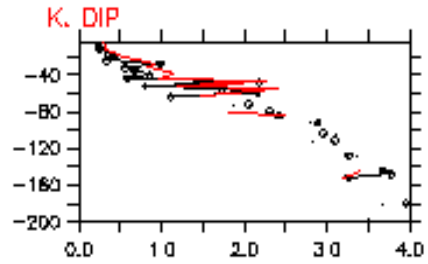
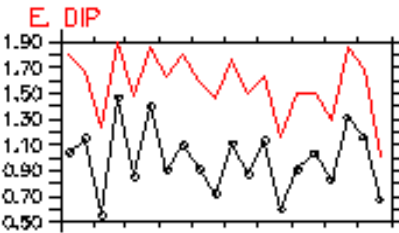
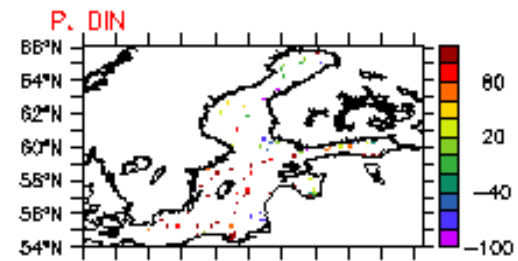
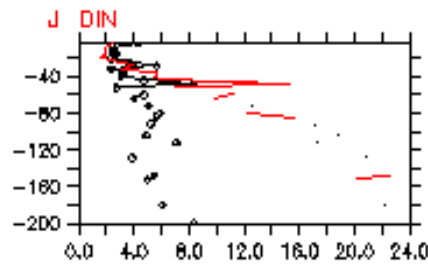
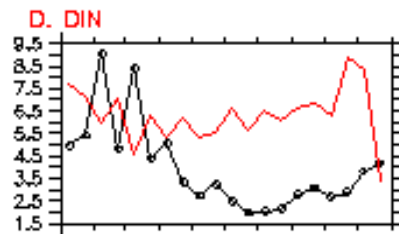
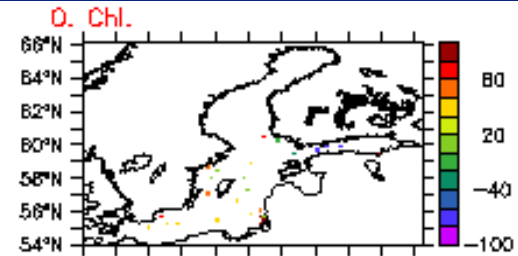
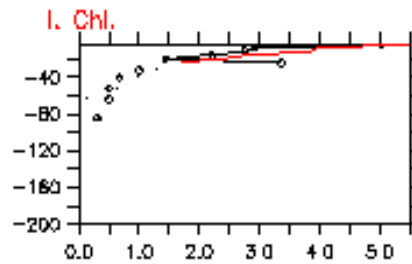
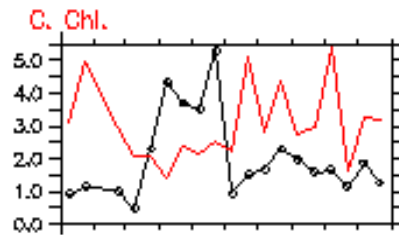
Model Domain



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Model Validation





Ecosystem assimilation

- Sequential methods (Allen et al., 2002; Evensen, 2003; Natvik and Evensen, 2003; Lenartz et al., 2007, etc)
- Variation methods (Natvik et al 2001; Fennel et al., 2001; Schartau and Oschlies, 2003; Hemmings et al, 2003; Losa et al., 2003, 2004; Friedrichs et al., 2002, 2007, etc).



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- Biogeochemical model is a non-conservative system. There are problems (fundamental, a priori) in the definition of the biological continuum, the definition of biological state variables, the formulation of the basic biological dynamical model equations.
- compatibility (e.g. Anderson et al., 2000) is required between the biophysical data sets and the biophysical models into which the data are to be assimilated.



The state vector w includes :DIN (Nitrate); DIP (phosphate), DO (oxygen), CHL (chlorophyll).

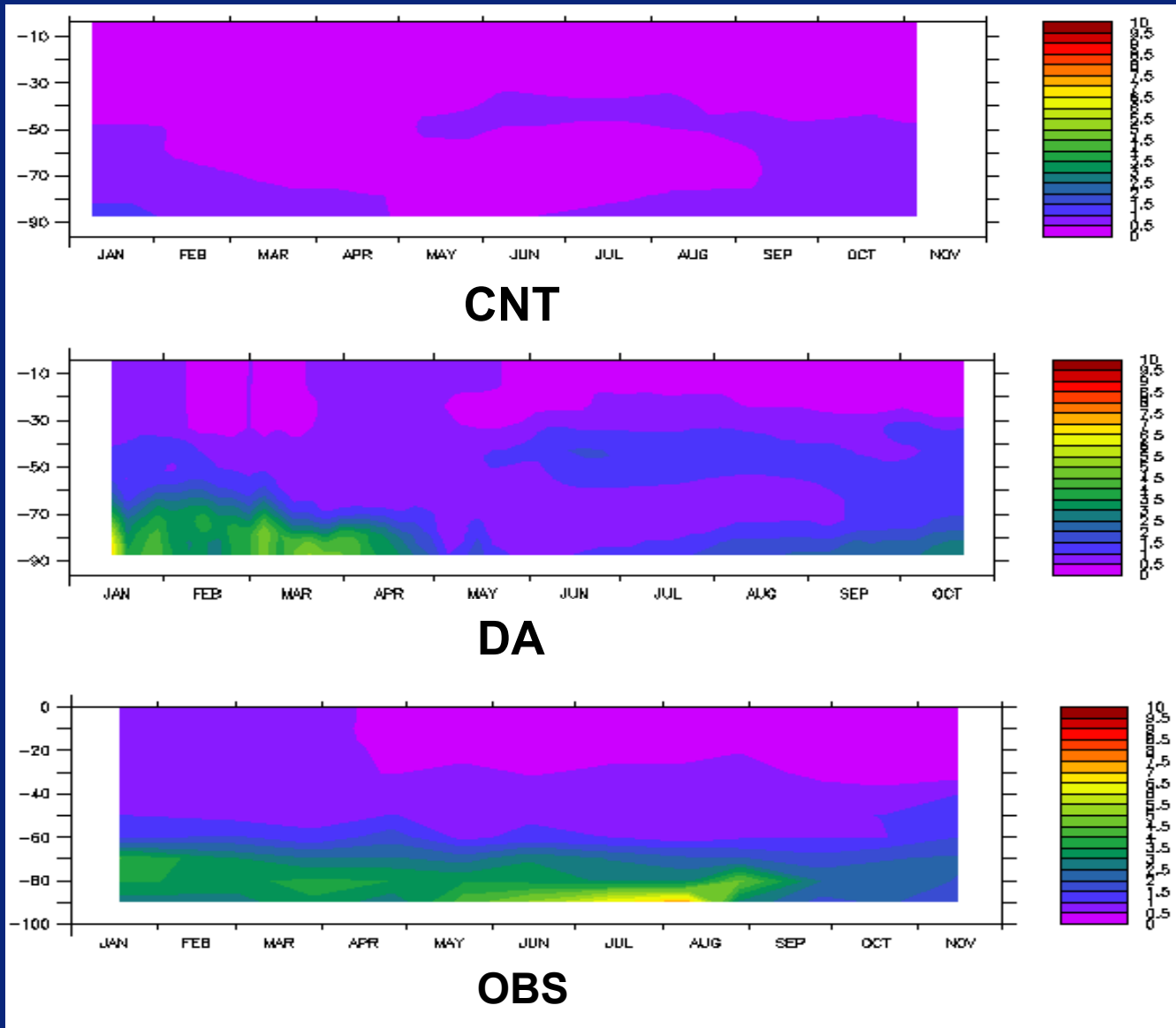
$$w = [DIN, DIP, DO, CHL]$$

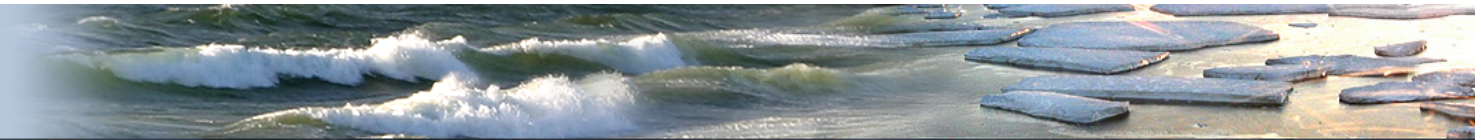
$$w^a = w^f + K(w^0 - Hw^f)$$

- The assimilation of DIP is run for 2 year (2004-2005), observations are from ICES.
- Assimilation is done every 7 days.
- At the assimilation time, the observations 3 days before and after are included.

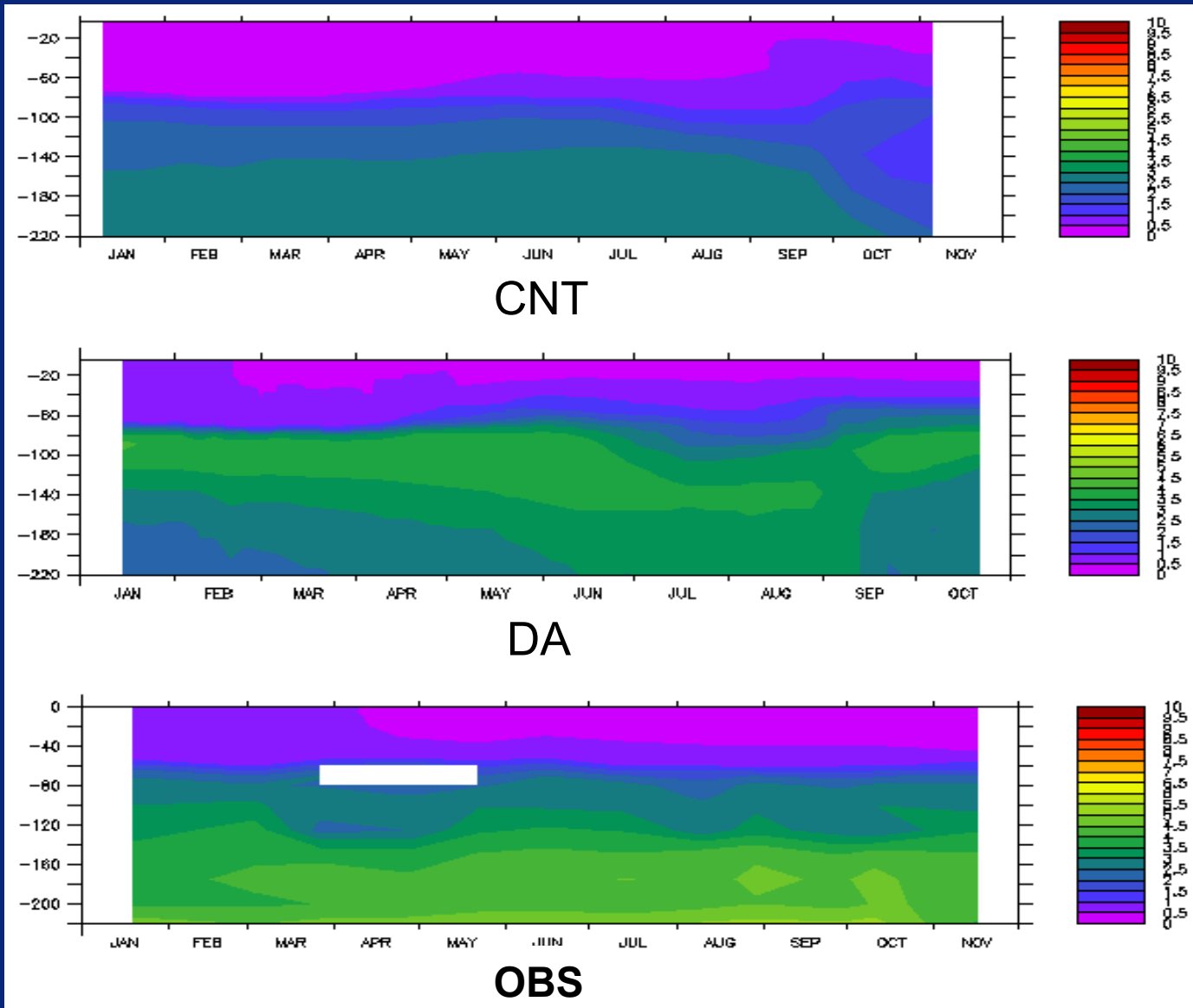


Po4 @ Arkona



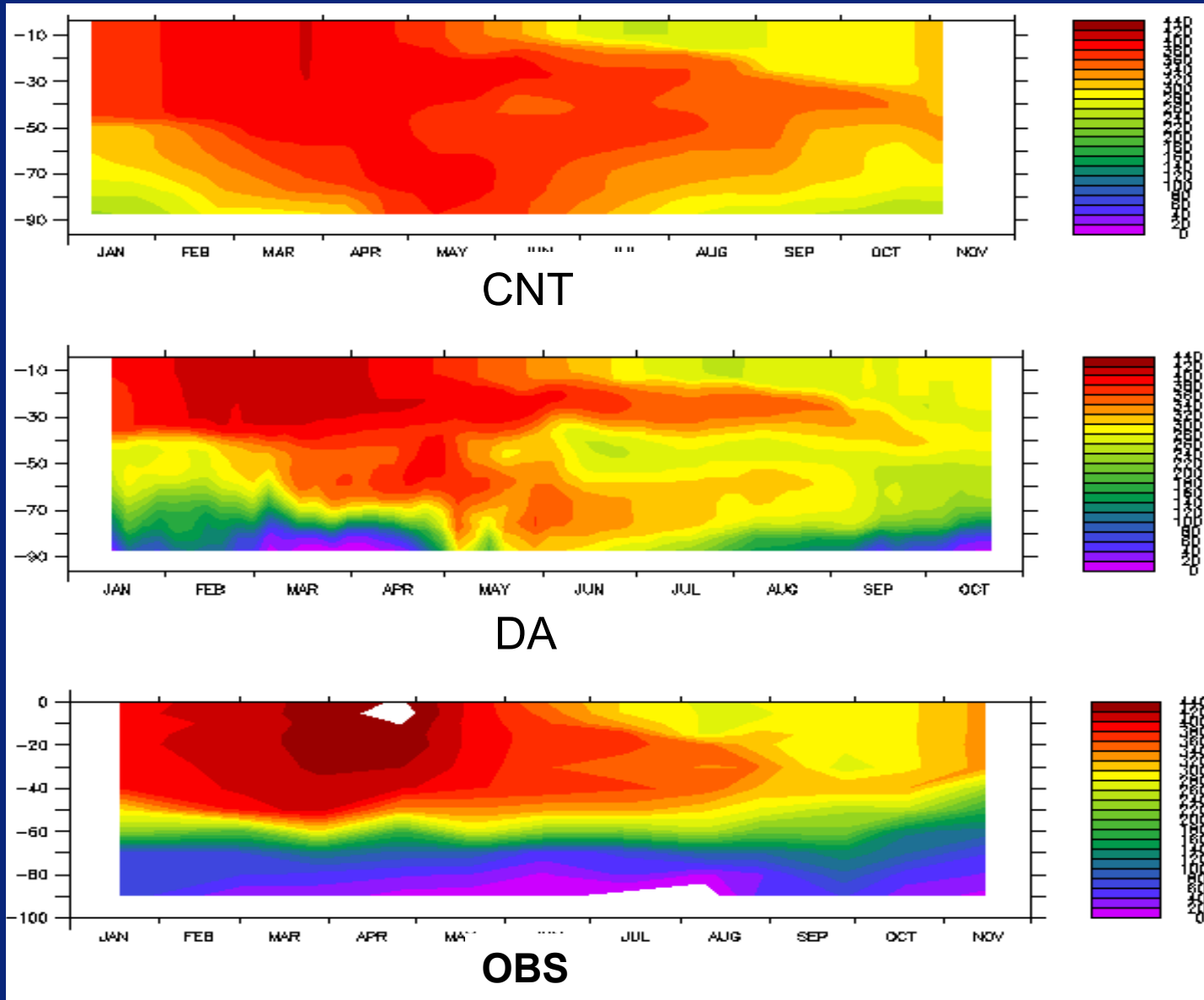


Po4 @ Bornholm



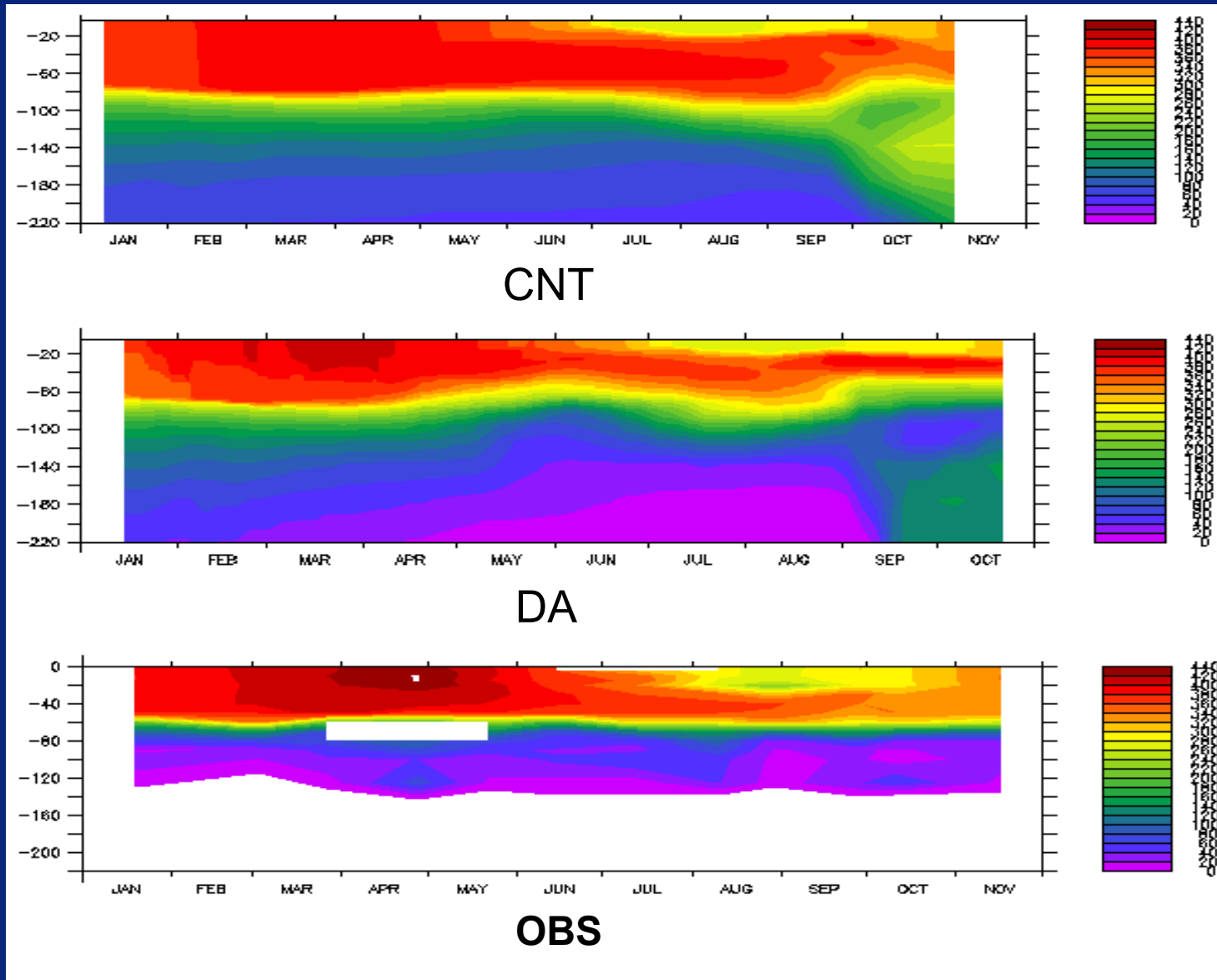


O₂ @ Arkona



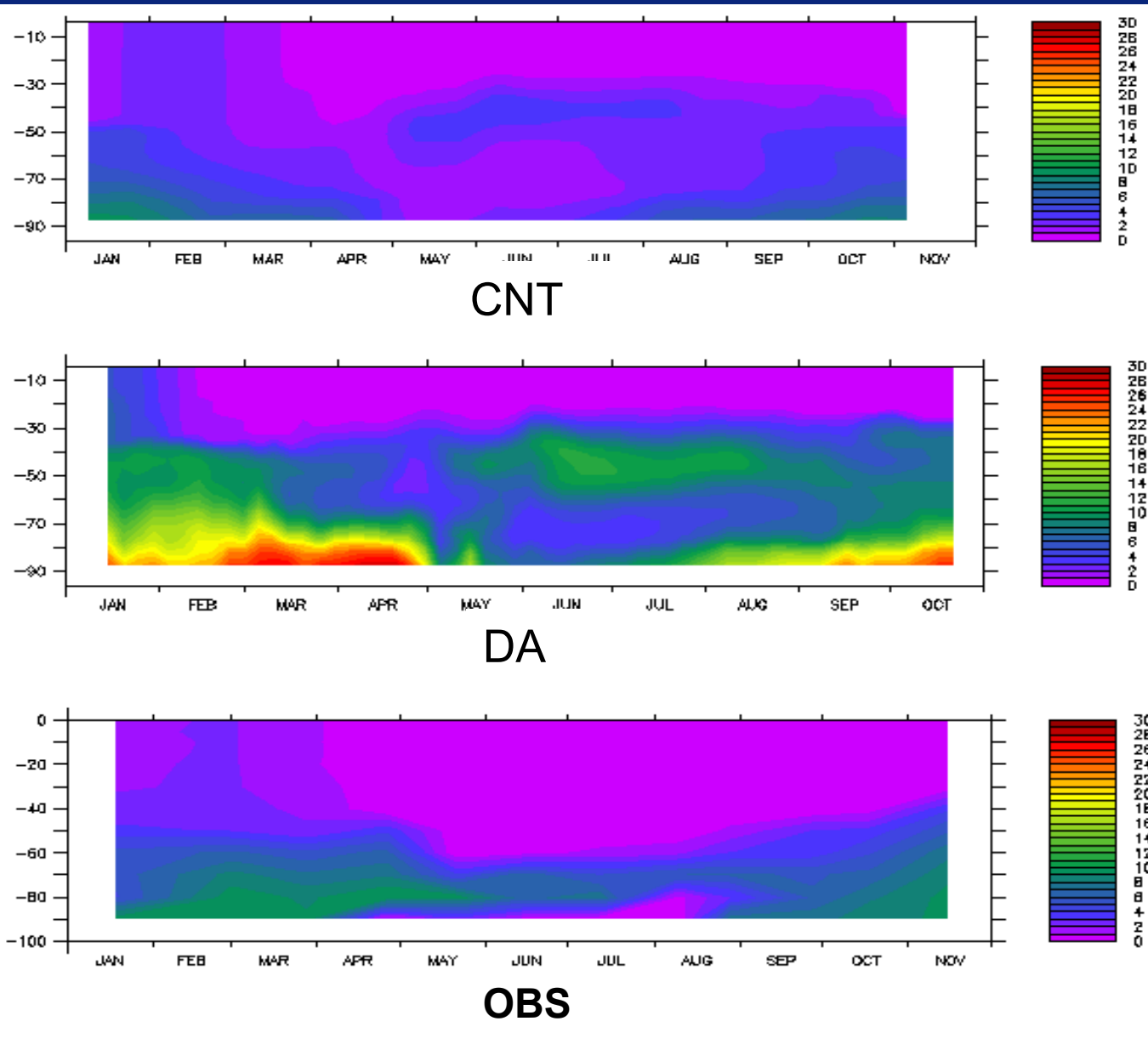


O2 @ Bornholm



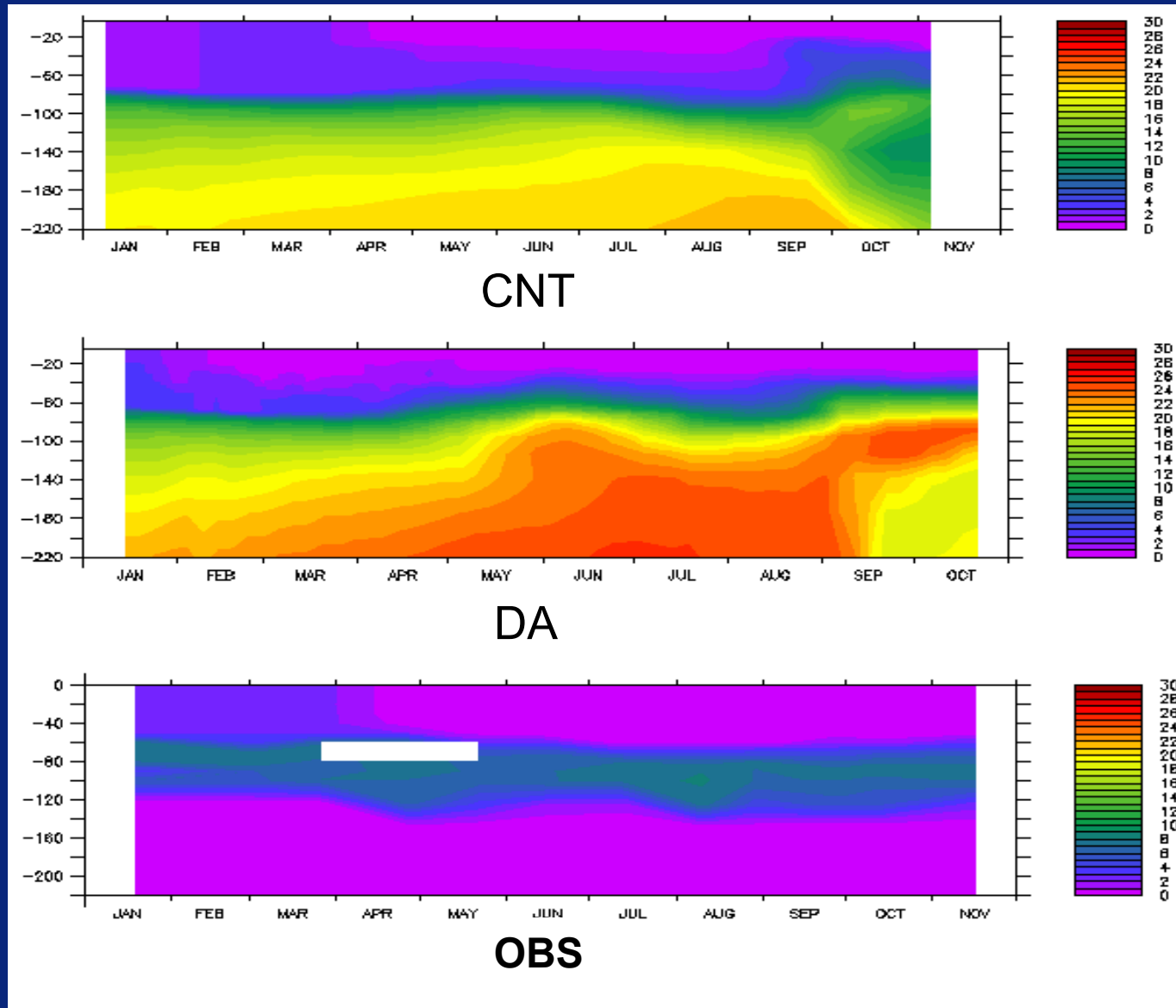


No3 @ Arkona



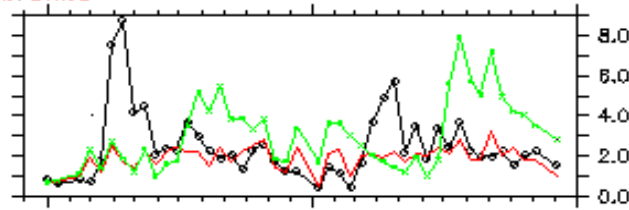


No3 @ Bornholm

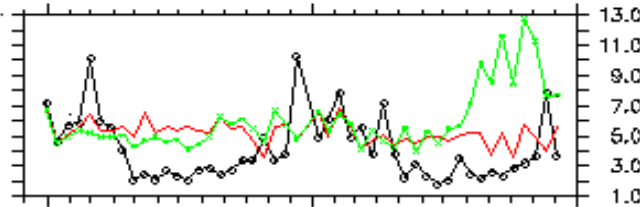




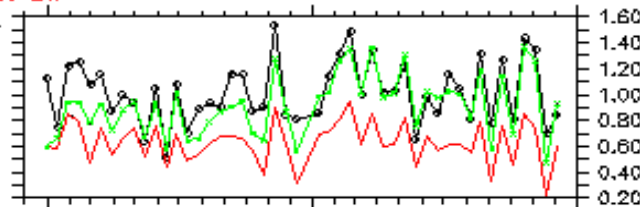
A. Chl.a



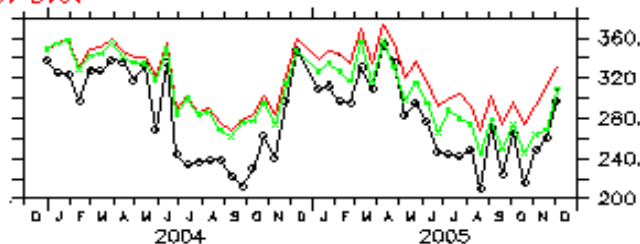
B. DIN



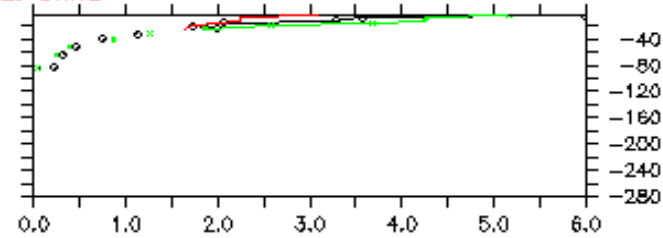
C. DIP



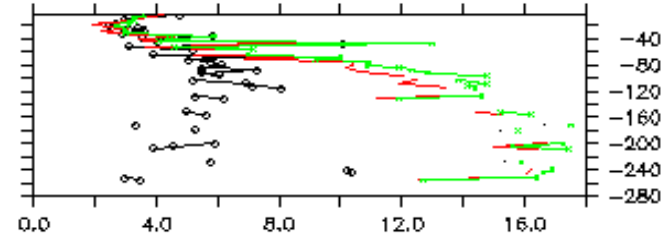
D. D.O.



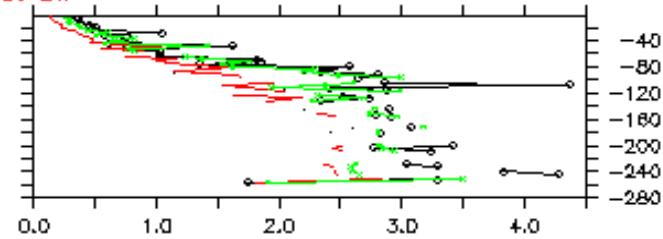
E. Chl.a



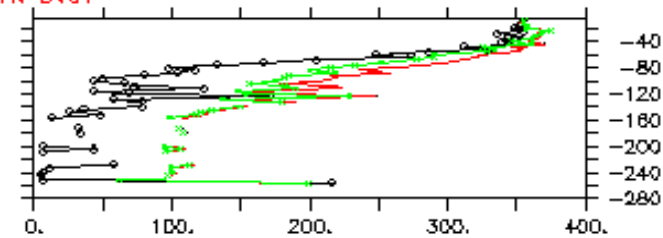
F. DIN



G. DIP



H. D.O.



Comparison with all available observations Black for observations, red for the model results, green for assimilation. Panels a-d for temporal evolution of the mean value, panels e-g for vertical profiles.



Summary

- Assimilation of T/S profiles with EnOI is effective in improving the simulations of physical model.
- The model-observation misfits are reduced for T, S and sea level from some comparisons.
- DIP assimilation produces some improvements on DIP and DO, but leads to spuriously high DIN.



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Thank You !