Augmenting an operational forecasting system for the North and Baltic Seas by in situ T and S data assimilation

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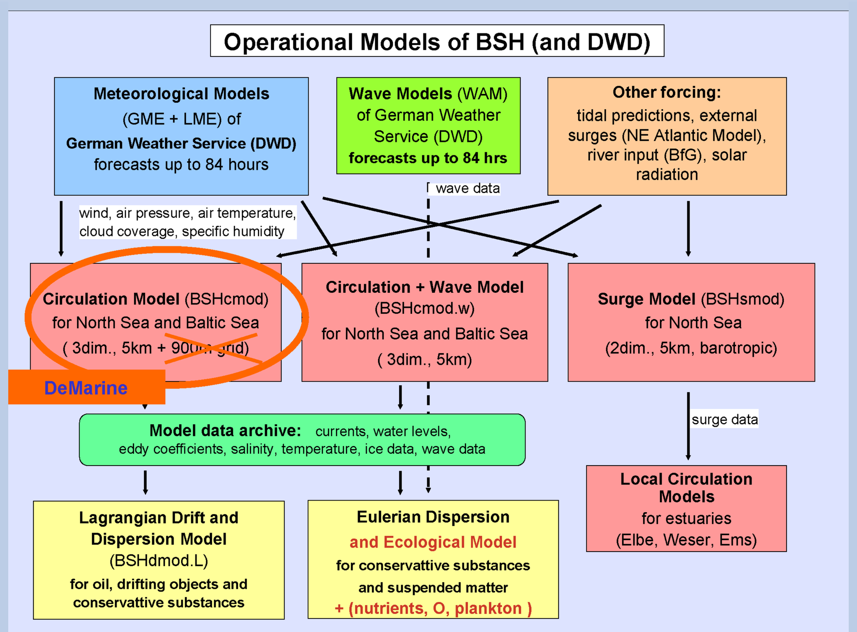
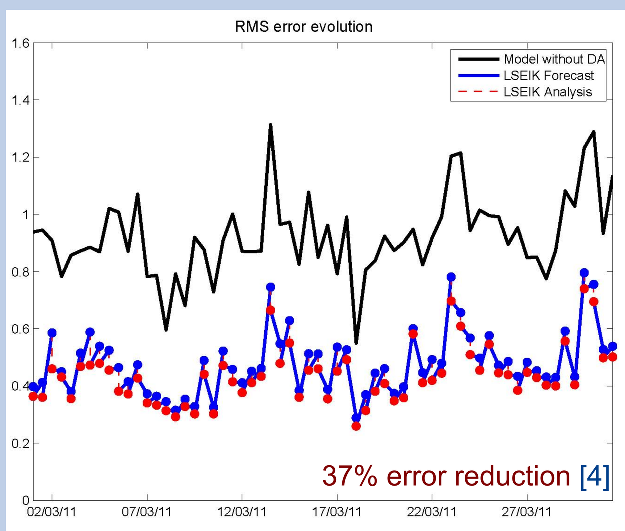
Abstract

In order to improve the hydrography forecast of the North and Baltic Seas, the operational circulation model of the German Federal Maritime and Hydrographic Agency (BSH) has been augmented by a data assimilation (DA) system. The DA system has been developed based on the Singular Evolution Interpolated Kalman (SEIK) filter algorithm (Pham, 1998) coded within the Parallel Data Assimilation Framework (Nerger et al., 2004, Nerger and Hiller, 2012). Previously the only data assimilated were sea surface temperature (SST) measurements obtained with the Advanced Very High Resolution Radiometer (AVHRR) aboard NOAA's polar orbiting satellites. While the quality of the forecast has been significantly improved by assimilating the satellite data (Losa et al., 2012, Losa et al., 2014), assimilation of in situ observational temperature (T) and salinity (S) profiles has allowed for further improvement. Assimilating MARNET time series and CTD and Scanfish measurements, however, required a careful calibration of the DA system with respect to local analysis. The study addresses the problem of the local SEIK analysis accounting for the data within a certain radius. The localisation radius is considered spatially variable and dependent on the system local dynamics. As such, we define the radius of the data influence based on the energy ratio of the baroclinic and barotropic flows.

Operational System



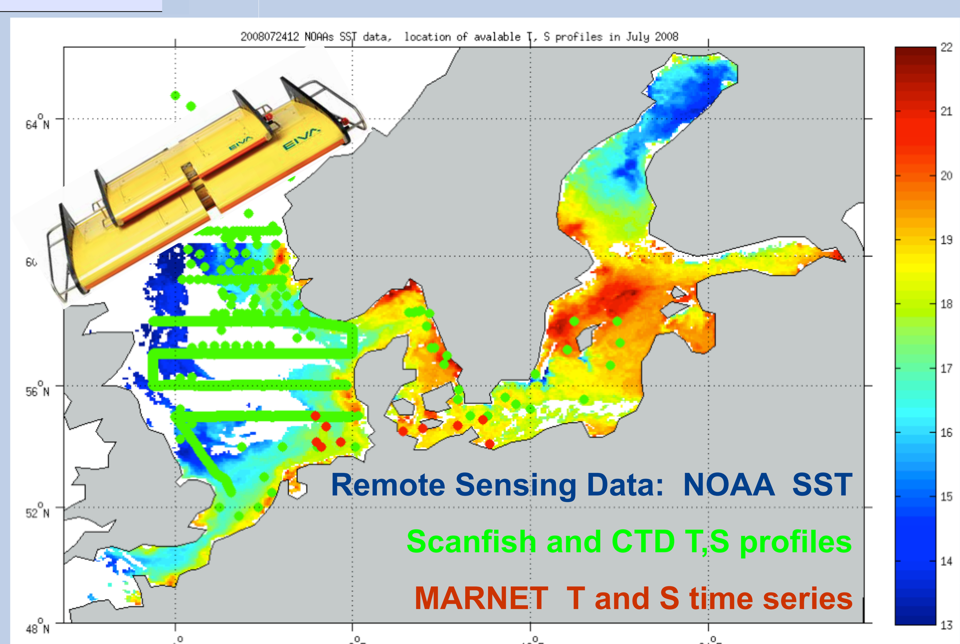
Assessing real-time SST forecast in March 2011



Observational Data:

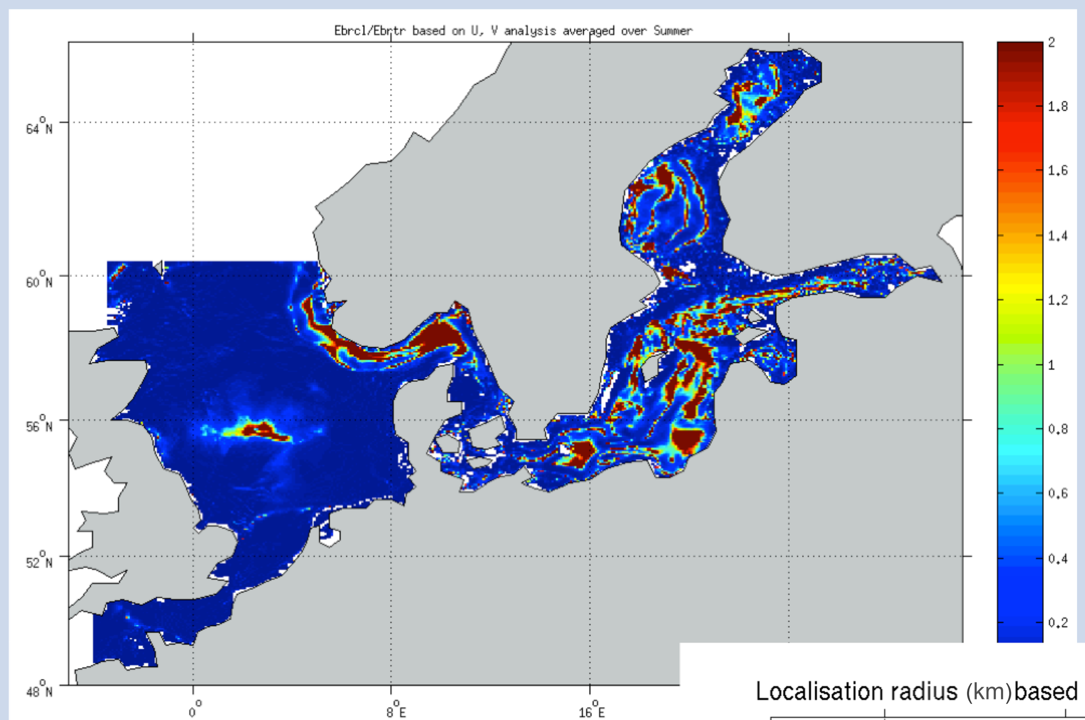
12 hourly— around 00:00 and 12:00,—composites of SST measured by the Advanced Very High Resolution Radiometer (AVHRR) aboard polar orbiting satellites;

In situ T&S data, based on measurements collected by BSH, Sweden's Meteorological and Hydrological Institute (SMHI) and the Institute of Marine Research (IMR, Norway).



Acknowledgement: The authors are grateful to Simon Jandt[2] for setting up the in situ data archive; to NOAA and BSH satellite data service for providing the SST data.

Toward spatially variable localisation (SVL)



To the left: Summer energy superposition of the baroclinic and barotropic flows (E_{brcl}/E_{brtr}) calculated for the North and Baltic Seas based on U, V velocity components averaged over June-July-August 2008. E_{brcl}/E_{brtr} represents water column mean estimates.

There is an advantage for vertical and temporal varying localisation.

Bottom: Spatial variability of lr, the localisation radius, parameterised with summer E_{brcl}/E_{brtr} and used for the local SEIK analysis.

Scaling the localisation radius based on E_{brcl}/E_{brtr}

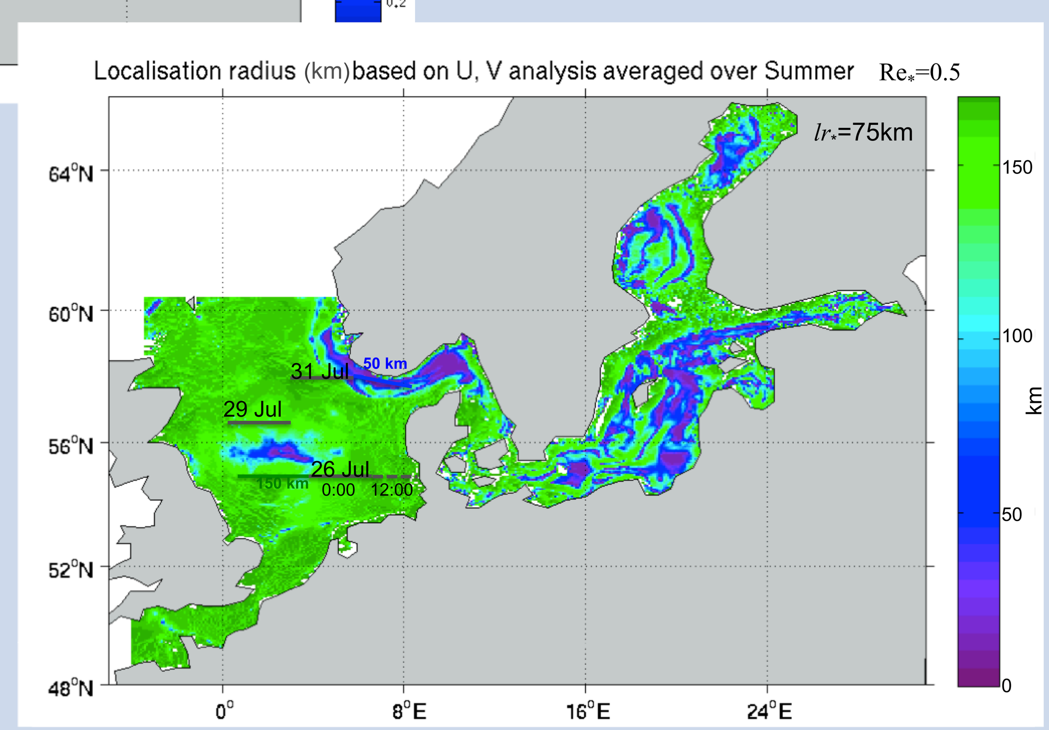
$$lr = \max\left(\frac{lr_*}{\mathrm{Re}+\mathrm{Re}_*}, 15\right)$$

$$\mathrm{Re} = \frac{E_{brcl}}{E_{brtr}}$$

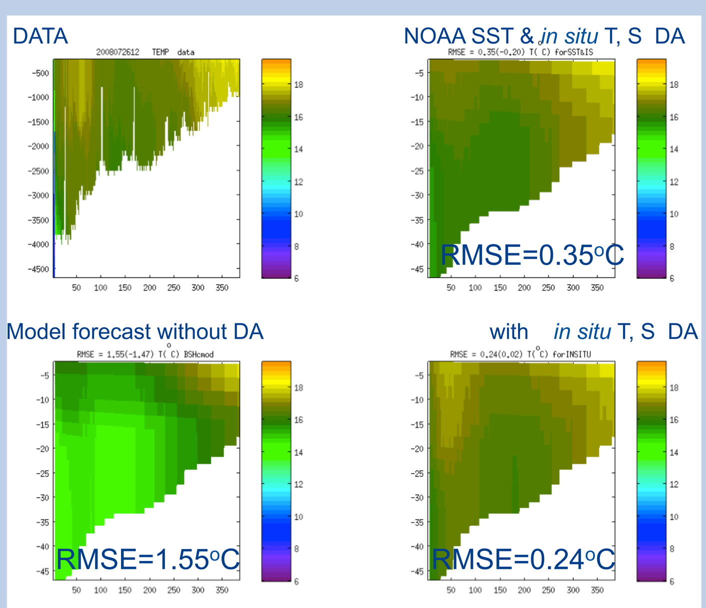
lr is the localisation radius (km);

lr_* is a reference localisation radius;

Re_* is a reference Re

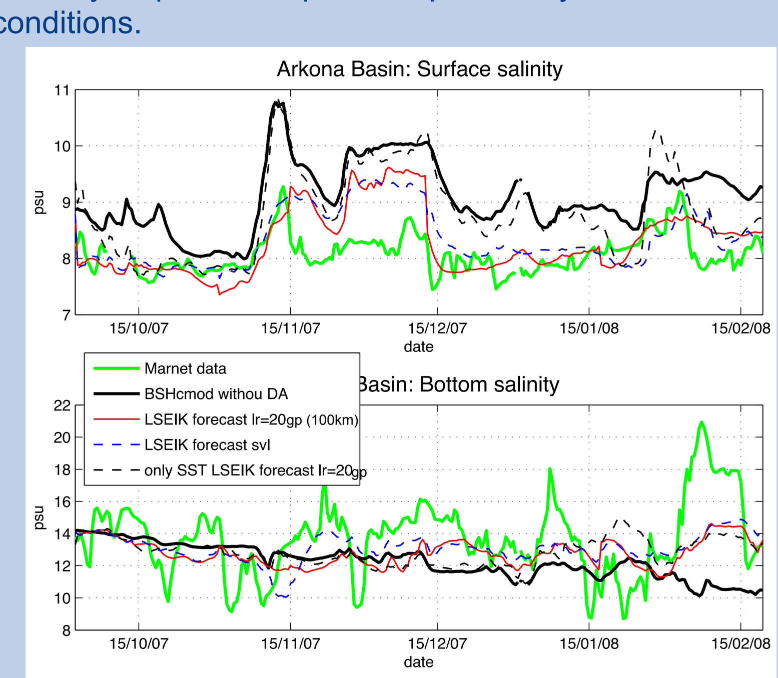


Forecast improvement with in situ T, S DA



To the left: Temperature profiles ordered and plotted along the longitudinal direction on 26 July 2008 at 12:00.

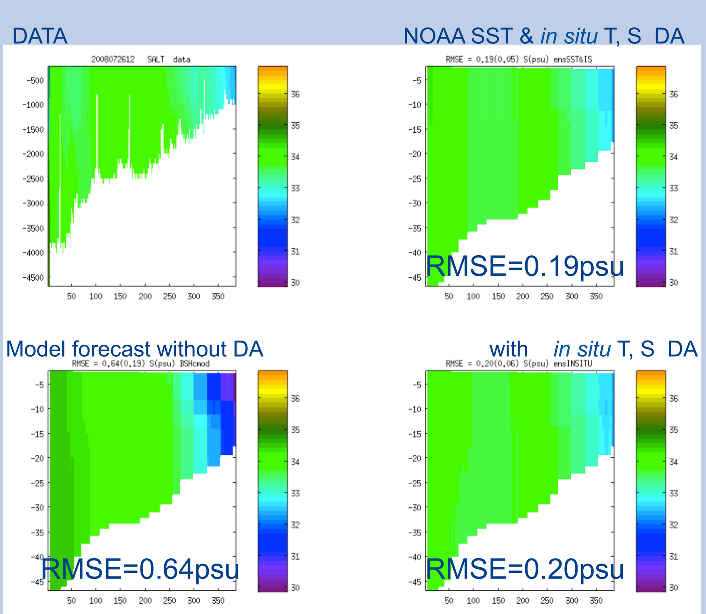
Despite of good agreement between LSEIK analysis and observations both for T and S, the forecast quality is crucially dependent upon the plausibility of the localisation conditions.



Temporal evolution of salinity at the "Arkona Basin" MARNET station (54°53' N, 13°52' E).

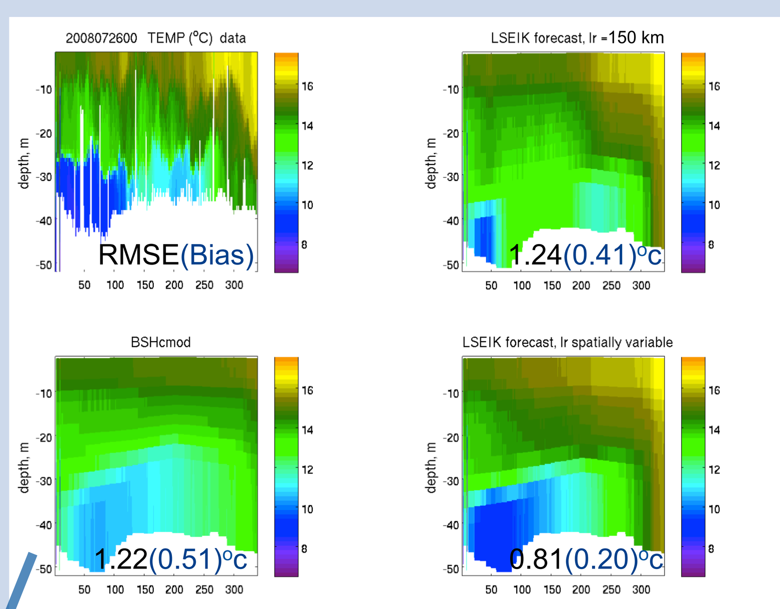
The figures (to the right) depict the forecast based on local SEIK analysis under spatially variable localisation conditions against observations, forecast without DA and the best forecast based on local SEIK filtering with a constant lr.

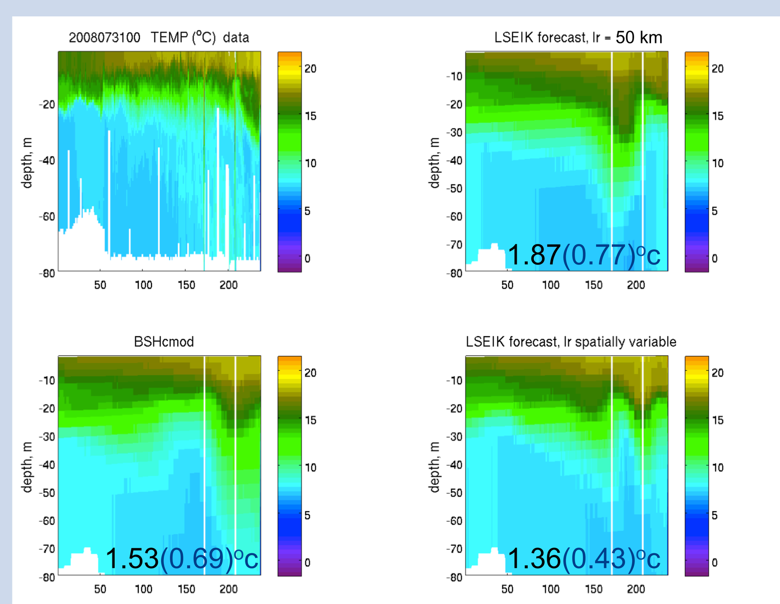
Variable radius improves DA at certain locations and generally compares well with DA exploiting fixed localisation.



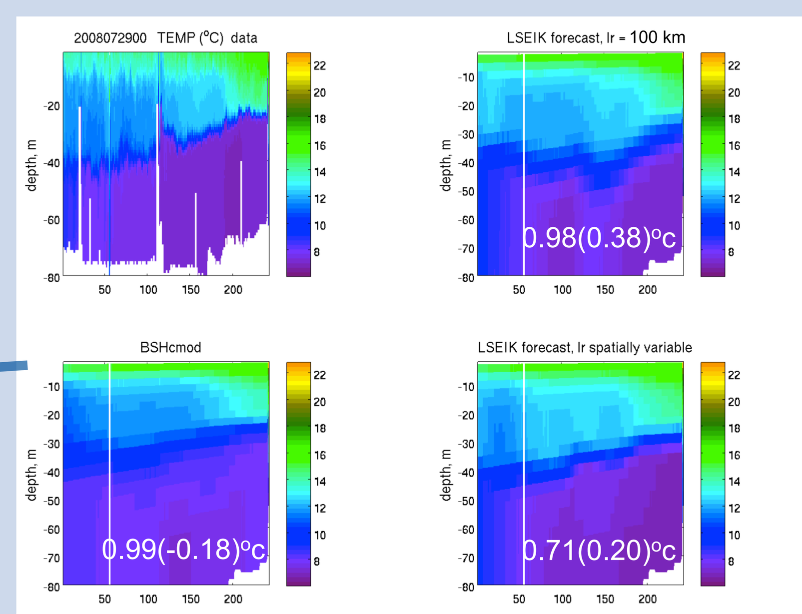
Salinity profiles ordered and plotted along the longitudinal direction on 26 July 2008 at 12:00.

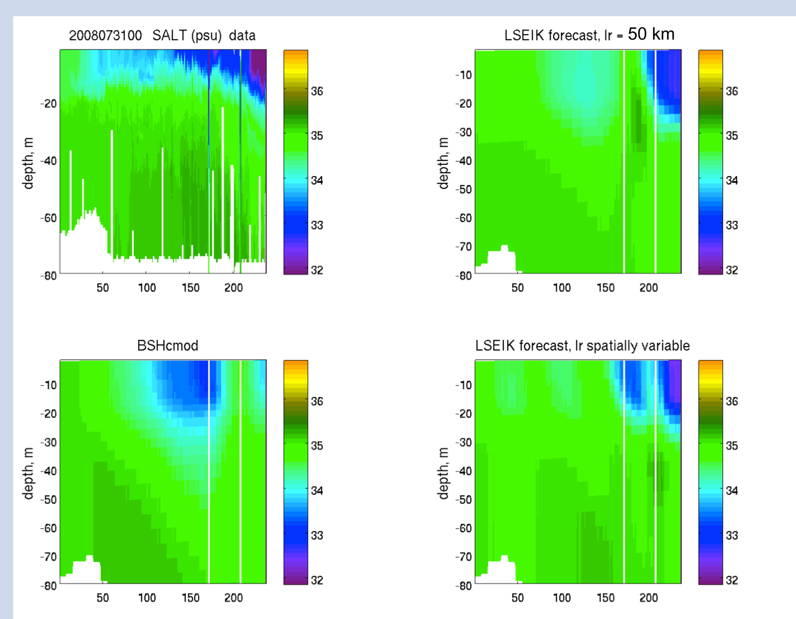
SVL validation with Scanfish T, S profiles





Temperature profiles ordered and plotted along the longitudinal direction on 26, 29 and 31 July 2008 at 00:00.





Salinity profiles ordered and plotted along the longitudinal direction on 31 July 2008 at 00:00.

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