Assimilation component in BSH operational circulation model for the North Sea and Baltic Sea

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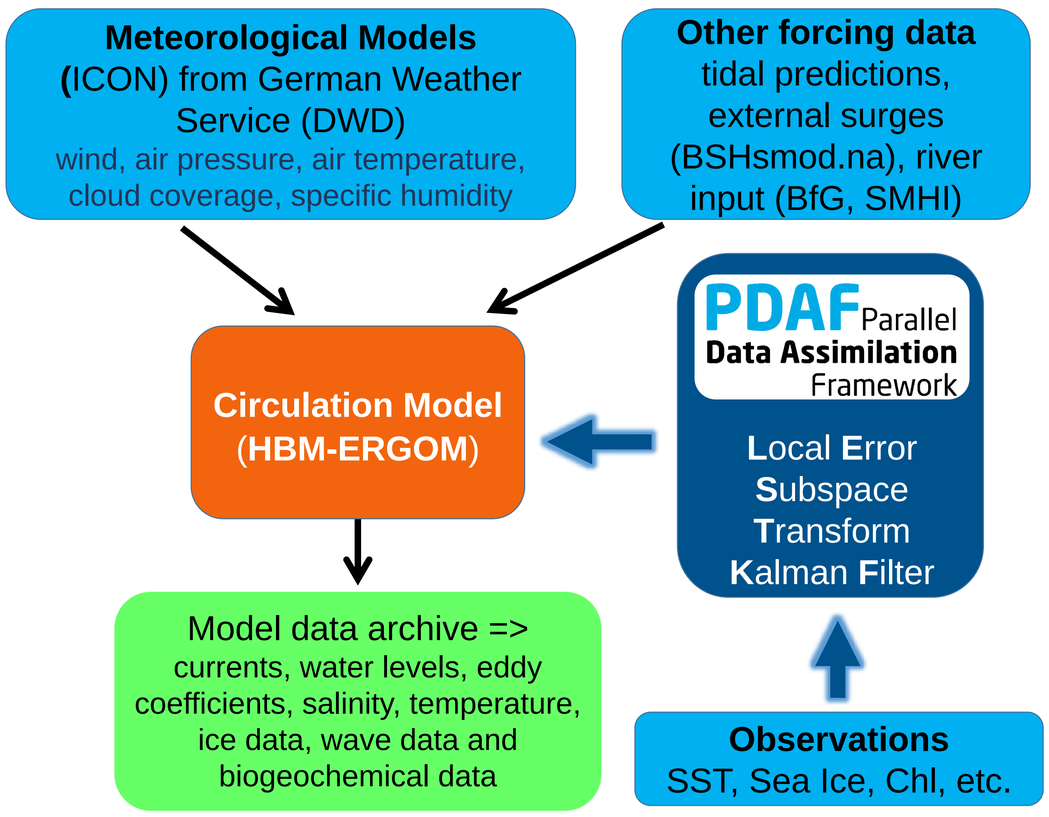
BUNDESAMT FÜR SEESCHIFFFAHRT UND HYDROGRAPHIE

BSH's operational modelling system

For over 30 years, the German Federal Maritime and Hydrographic Agency (BSH) has provided operational forecasts of water levels, currents, temperature, salinity, sea ice and biogeochemical parameters in the North and Baltic Seas, with a focus on German coastal waters. These forecasts are based on the ocean-biogeochemical model HBM-ERGOM (Brüning et al. 2021; Neumann 2000).



To enhance forecast accuracy, an ensemble data assimilation (DA) system has been integrated into the operational model. This system employs the Local Error Subspace Kalman Transform Filter (LESKTF) within the open-source Parallel Data Assimilation Framework (PDAF) (https://pdaf.awi.de), developed by the Data Assimilation Team at the Alfred Wegener Institute (AWI). The LESTKF is an efficient formulation that allows the model simulation to be optimally linked to measurements without disturbing the dynamics of the model (Nerger et al. 2012). All ensemble members are dynamically generated through a second-order exact sampling method (Pham et al. 2001) using the trajectories from the HBM-ERGOM model.

Observations

The data assimilation component is now able to assimilate various satellite-derived products and in situ observations:

- Satellite-Derived Products
  - Sea Surface Temperature (AVHRR or CMEMS)
  - Sea Ice Concentration & Thickness (L4 CMEMS products of BAL MFC)
  - Chlorophyll (CMEMS)
  - Phytoplankton: e.g. Cryptophytes, Cyanobacteria, Diatoms (Brockmann Consult)
- In Situ Observations
  - Temperature & Salinity profiles (CMEMS)

T. Brüning, X. Li, F. Schwichtenberg, & I. Lorkowski, An operational, assimilative model system for hydrodynamic and biogeochemical applications for German coastal waters. Hydrographische Nachrichten 118, 6–15, (2021)

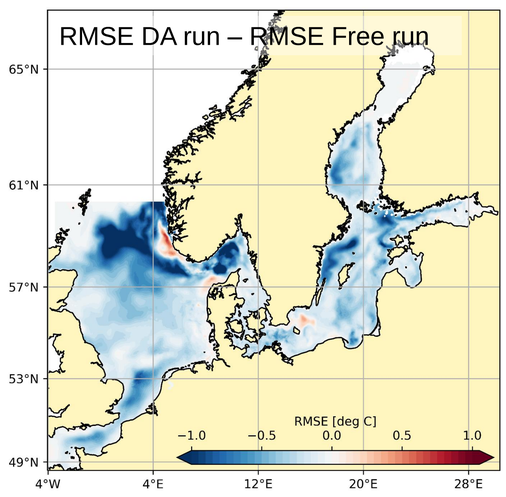
Nerger, L., T. Janjić, J. Schröter, and W. Hiller, A Unification of Ensemble Square Root Kalman Filters. Mon. Wea. Rev., 140, 2335–2345, (2012)

Neumann, T., Towards a 3D-ecosystem model of the Baltic Sea. J. Mar. Syst. 25,(3–4), 405–419, (2000)

Pham D.T. Stochastic methods for sequential data assimilation in strongly nonlinear systems. Monthly Weather Review 129 (2001)

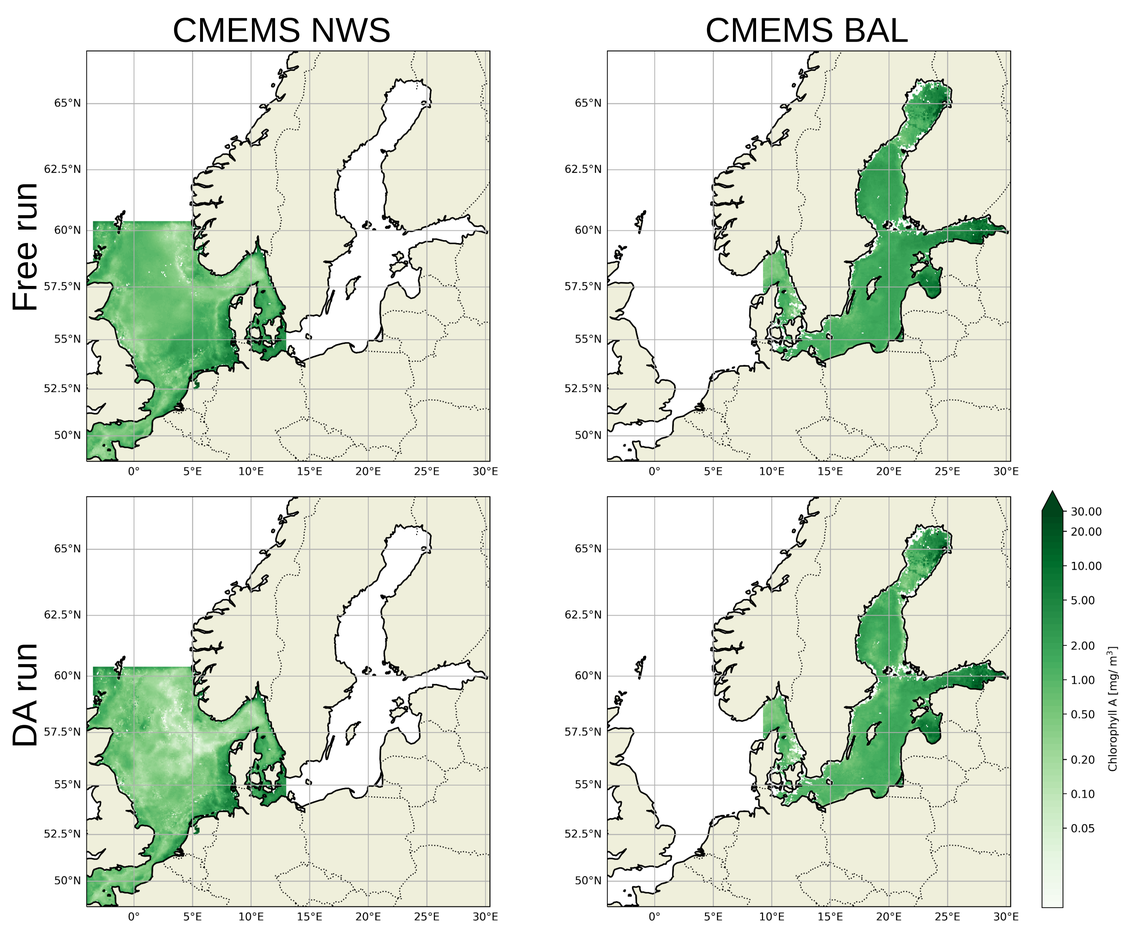
Assimilation Impacts on Forecast Performance

Data assimilation significantly enhances predictive skill across spatial and temporal scales, reducing errors and biases in key parameters such as sea surface temperature and chlorophyll.



← RMSE difference in sea surface temperature (SST) prediction between the DA run and the free run for February 2025, against CMEMS SST observations

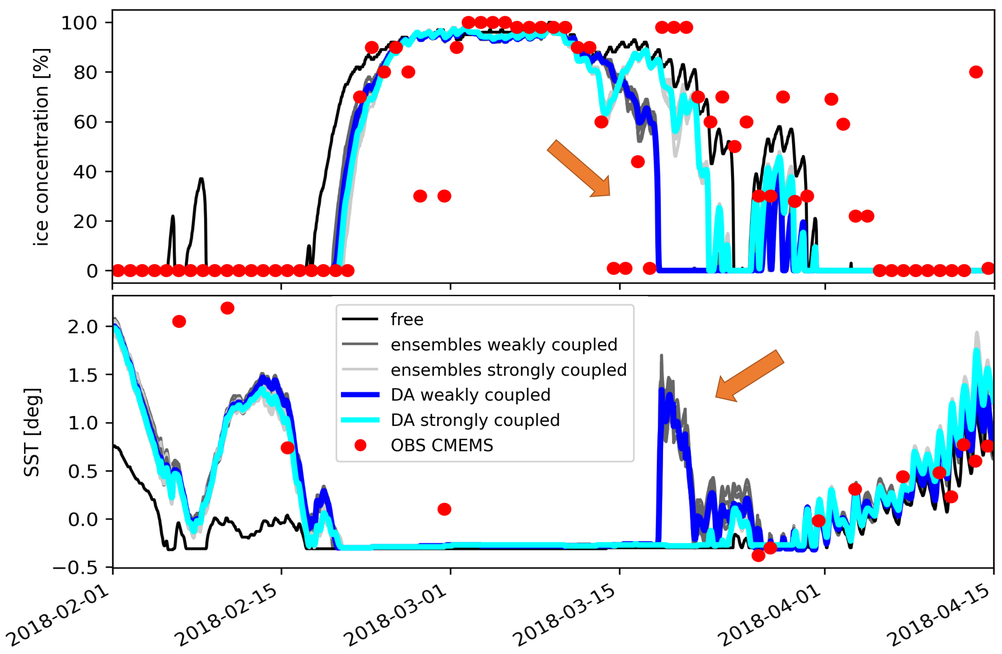
↓ RMSE of surface chlorophyll for July 2020



Effect of Coupling Methods

Different coupling approaches, weakly and strongly coupled DA, have been applied and evaluated. For example, L3 CMEMS SST and L4 CMEMS sea ice charts are assimilated using these methods.

Comparisons show that different coupling methods yield varying results. At certain validation stations, large increments in SST are observed, if the weakly coupled DA is applied. However, these increments are not observed in strongly coupled DA, possibly due to the influence of cross-covariance between SST and ice parameters.



Time series of sea ice concentration and surface temperature at station BMPC1. The forecasts from free run and the DA runs are compared with observations.