Assimilation of satellite observations in BSH operational circulation model for the North Sea and Baltic Sea: recent implementation and results

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BUNDESAMT FÜR SEESCHIFFFAHRT UND HYDROGRAPHIE

Operational System of BSH with DA

The operational service at the BSH bases its model systems on the 3D baroclinic circulation model HBM (HIROMB-BOOS Model), which provides the basic information for a couple of downstream services, like e.g. the sea level prediction and storm surge warning service for the German coast, or oil spill forecasting and search-and-rescue applications.

An ensemble data assimilation (DA) system has been coupled with the HBM model and running operationally two times a day.
The DA system uses the Parallel Data Assimilation Framework PDAF (http://pdaf.awi.de)[1], which is a flexible software framework developed by the Alfred Wegener Institute (AWI).

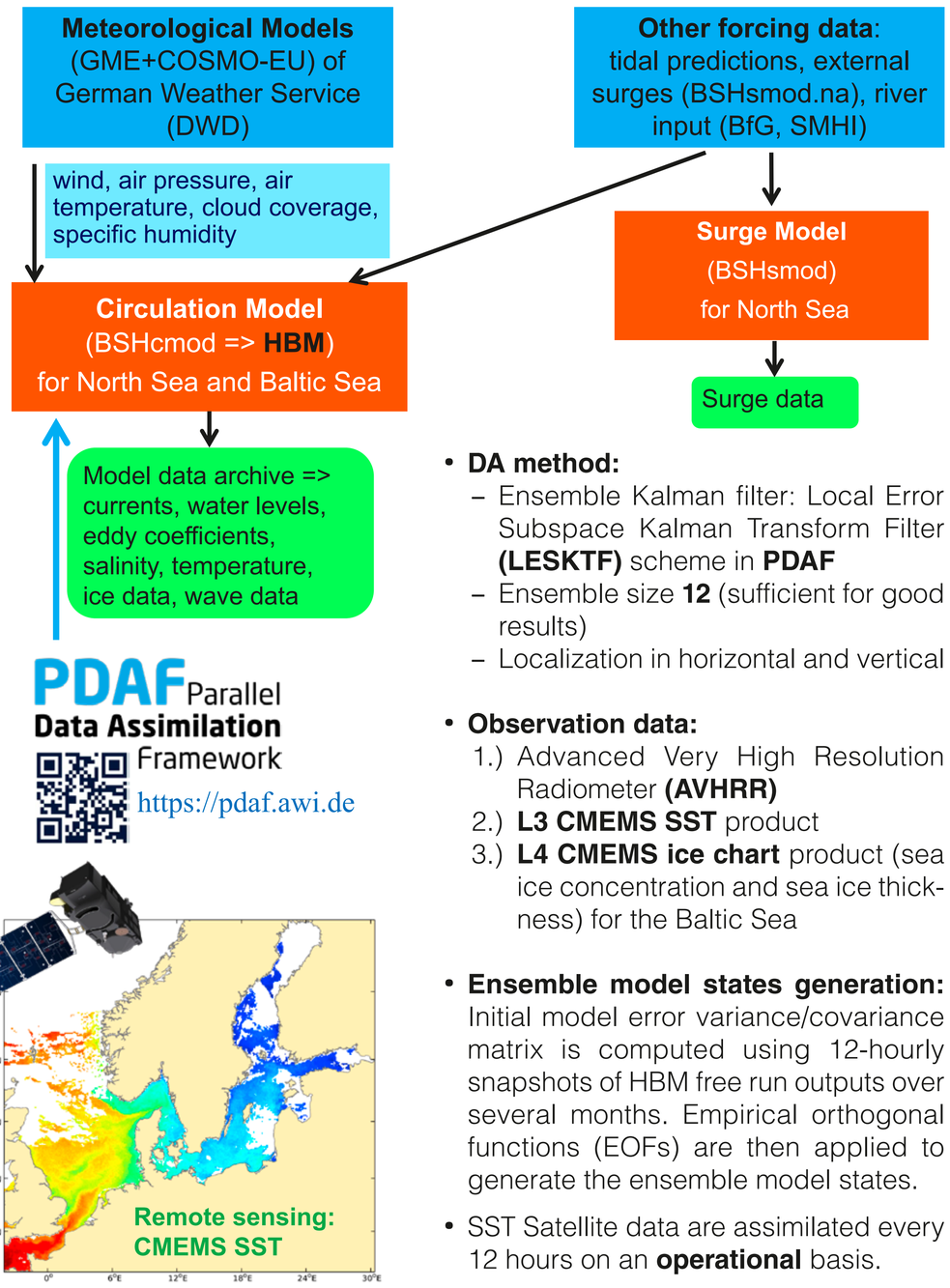

Figure 1: General structure of the coupled data assimilation system for the operational circulation model at BSH in Germany.

- **DA method:**
  - Ensemble Kalman filter: Local Error Subspace Kalman Transform Filter **(LESKTF)** scheme in **PDAF**
  - Ensemble size **12** (sufficient for good results)
  - Localization in horizontal and vertical
- **Observation data:**
  1.) Advanced Very High Resolution Radiometer **(AVHRR)**
  2.) **L3 CMEMS SST** product
  3.) **L4 CMEMS ice chart** product (sea ice concentration and sea ice thickness) for the Baltic Sea
- **Ensemble model states generation:** Initial model error variance/covariance matrix is computed using 12-hourly snapshots of HBM free run outputs over several months. Empirical orthogonal functions (EOFs) are then applied to generate the ensemble model states.
- SST Satellite data are assimilated every 12 hours on an **operational** basis.
- Coupled SST and sea ice assimilation has been explored in experiments with different coupling methods (weakly/ strongly)

Assessment of the SST Assimilation

Our DA system can assimilate two different SST satellite data sets. The choice of the data set is based on the availability of the satellite data. However, using different observations leads to different results. It is necessary to rerun the DA, after the missing SST data are retrospectively provided by the satellite data service.

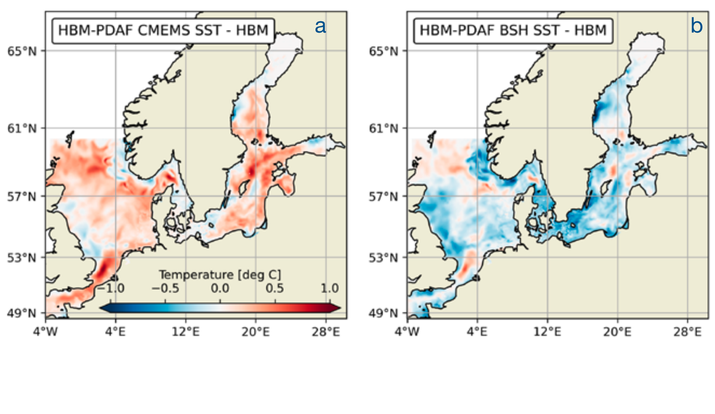

Figure 2: Comparison with using different SST: BIAS for the forecast using CMEMS SST to free run (a), BIAS for the forecast using AVHRR SST to free run (b) in April 2020.

Preliminary Results of sea ice assimilation

Based on the SST DA, sea ice assimilation (sea ice concentration and sea ice thickness) has been added into the DA system. The Weakly coupled method is firstly applied.
Fig 3. shows that ice extent from the model increases and decreases more rapidly than observation. The ice from the model covers much larger area than that of the observation.
Through the DA, the ice extent is reduced. However, it still covers much larger area than observation. The reduction from DA run using CMEMS SST is slightly larger than the reduction from DA run using AVHRR SST.
Large improvements of sea ice concentration through DA are found in the area where there are both SST and sea ice observations. Ice concentration changes can be up to 100 %.

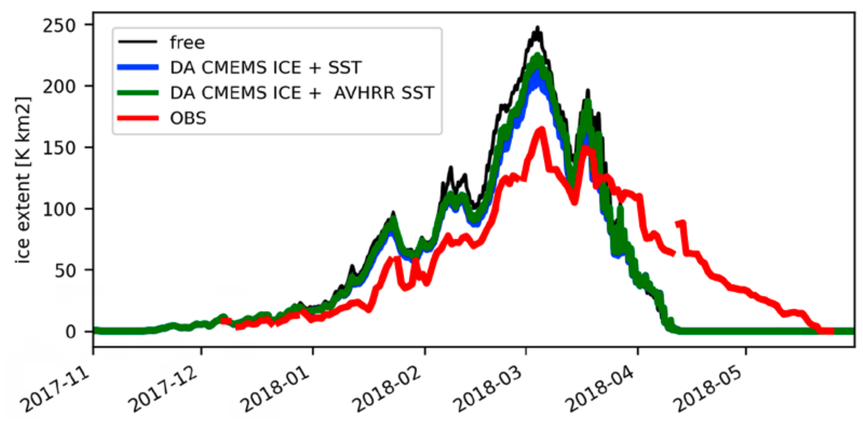

Figure 3: Baltic Sea ice extent from Nov. 2017 to May 2018

Furthermore, our DA experiments show that assimilating different SST observations leads to large differences not only on SST but also on sea ice concentration. It indicates that SST assimilation has large influences on ice model.

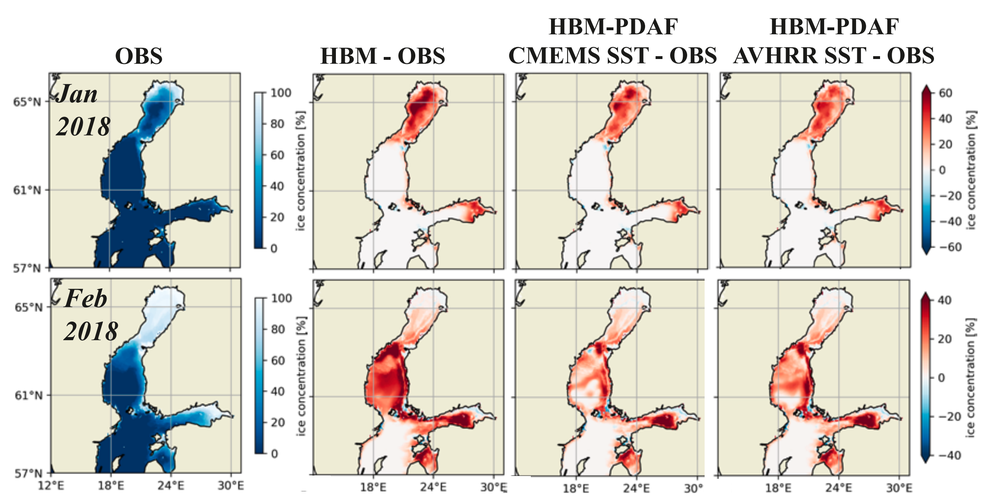

Figure 4: Averaged sea ice concentration and bias from the HBM free run, the HBM-PDAF run using CMEMS SST and the HBM-PDAF run using AVHRR SST in Jan and Feb of 2018

Effect of coupling methods

The L3 CMEMS SST and L4 CMEMS chart are assimilated with different methods. Weakly and strongly coupled methods have been evaluated.
The comparison shows that the sea ice DA can cause erroneous increments on SST, if the weakly method applied. However, the erroneous increments can be reduced through the cross-covariance of strongly coupled DA.

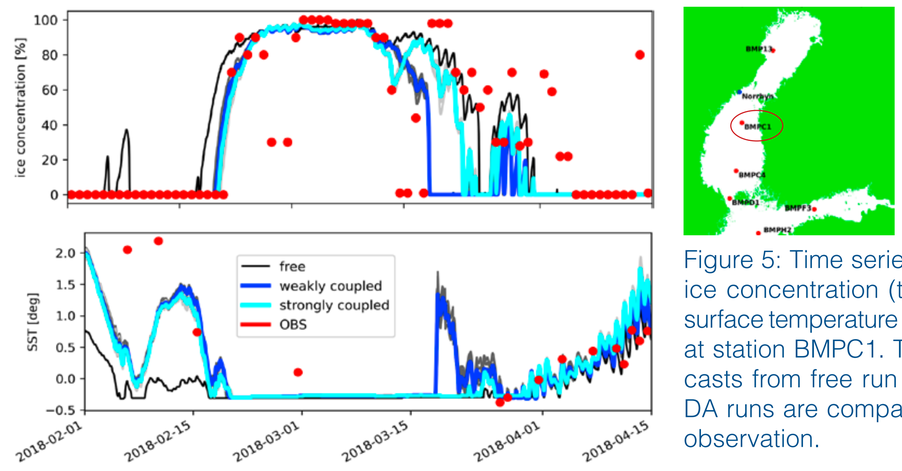

Figure 5: Time series of sea ice concentration (top) and surface temperature (bottom) at station BMPC1. The forecasts from free run and the DA runs are compared with observation.

Reference: [1] Nerger, L., Hiller, W., Schröter, J.(2005). PDAF – The Parallel Data Assimilation Framework: Experiences with Kalman Filtering, Use of high performance computing in meteorology: proceedings of the Eleventh ECMWF Workshop on the Use of High Performance Computing in Meteorology, Reading, UK, 25–29 October 2004/Eds.: Walter Zwieflhofer; George Mozdzynski, Singapore: World Scientific, 63–83.