Temperature assimilation on an operational coastal ocean-biogeochemical model: Assessment of weakly and strongly coupled data assimilation

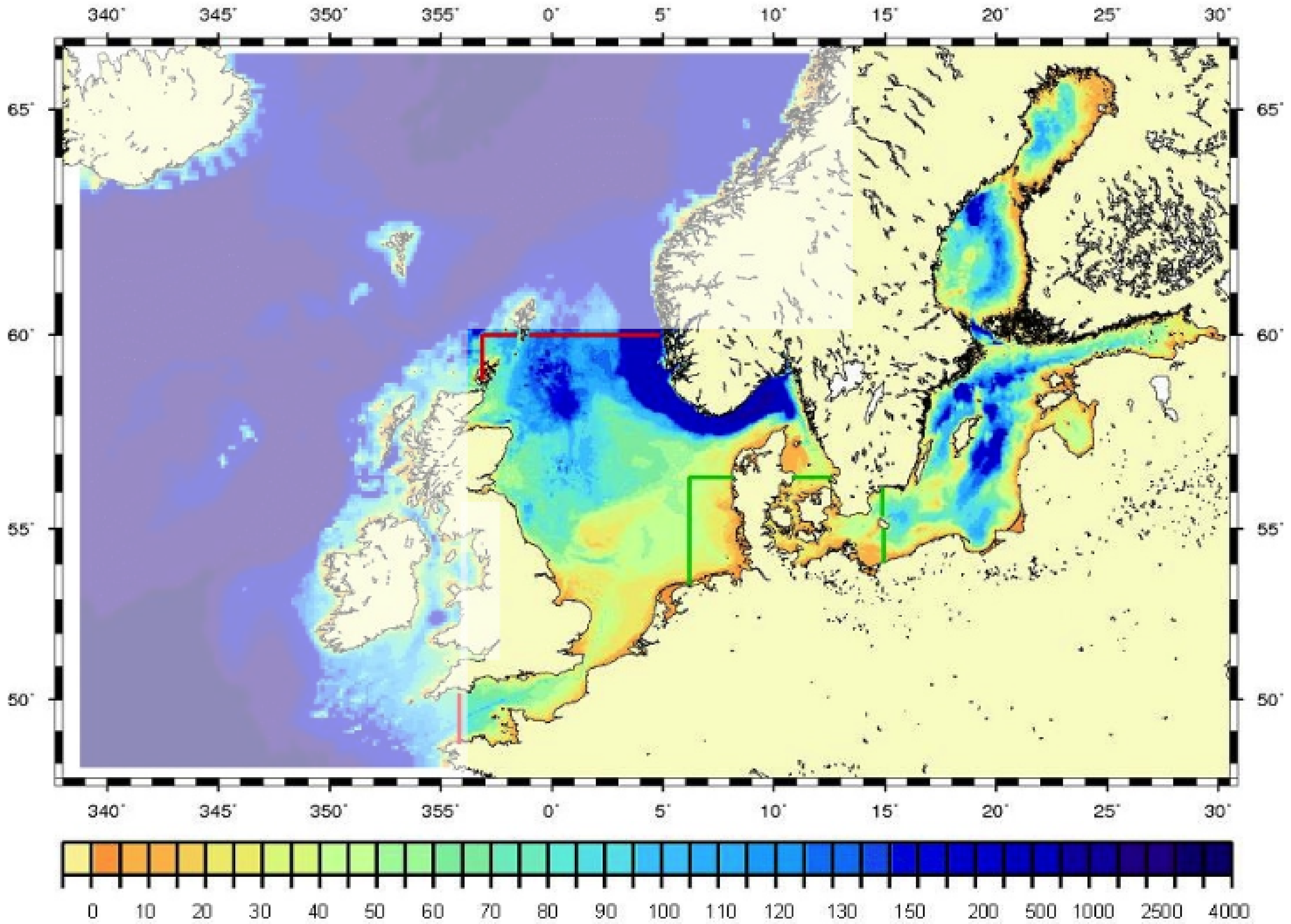
BUNDESAMT FÜR SEESCHIFFFAHRT UND HYDROGRAPHIE

Nested Grids

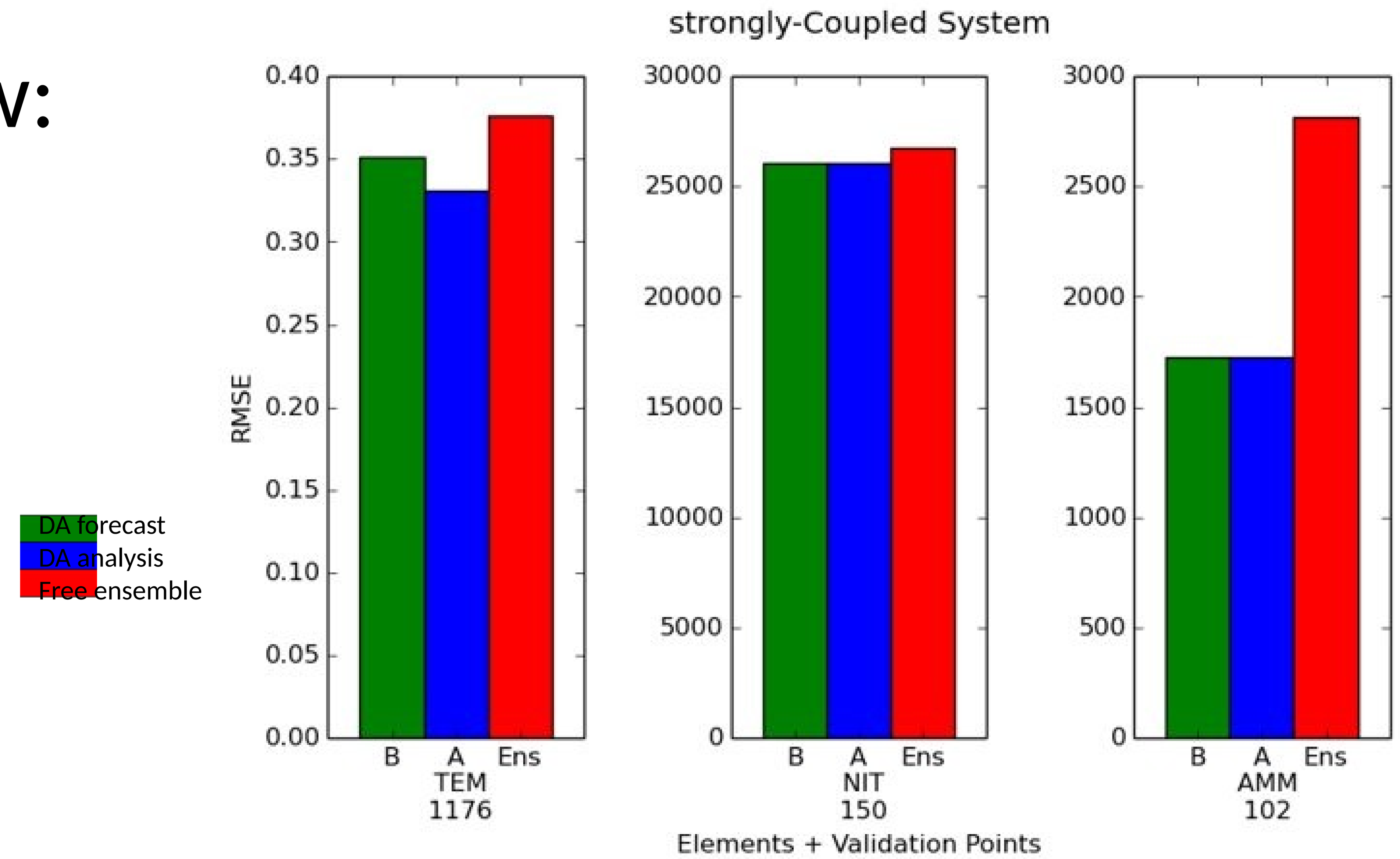
Grid nesting:

- **10 km grid**
- **5 km, 36 layers**
- **900 m, 25 layers**

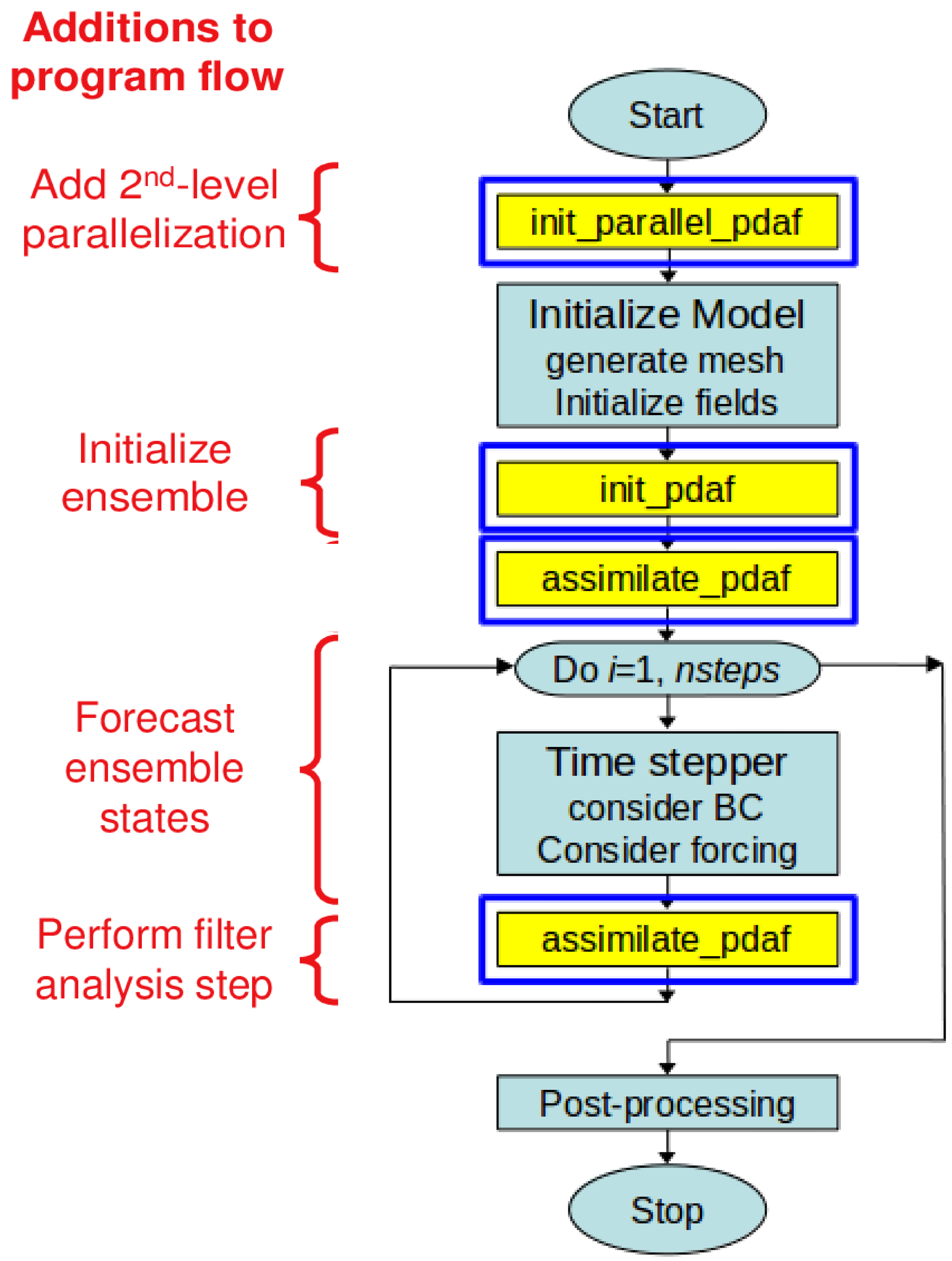
10 km grid used offline as boundary condition



Preview:



PDAF



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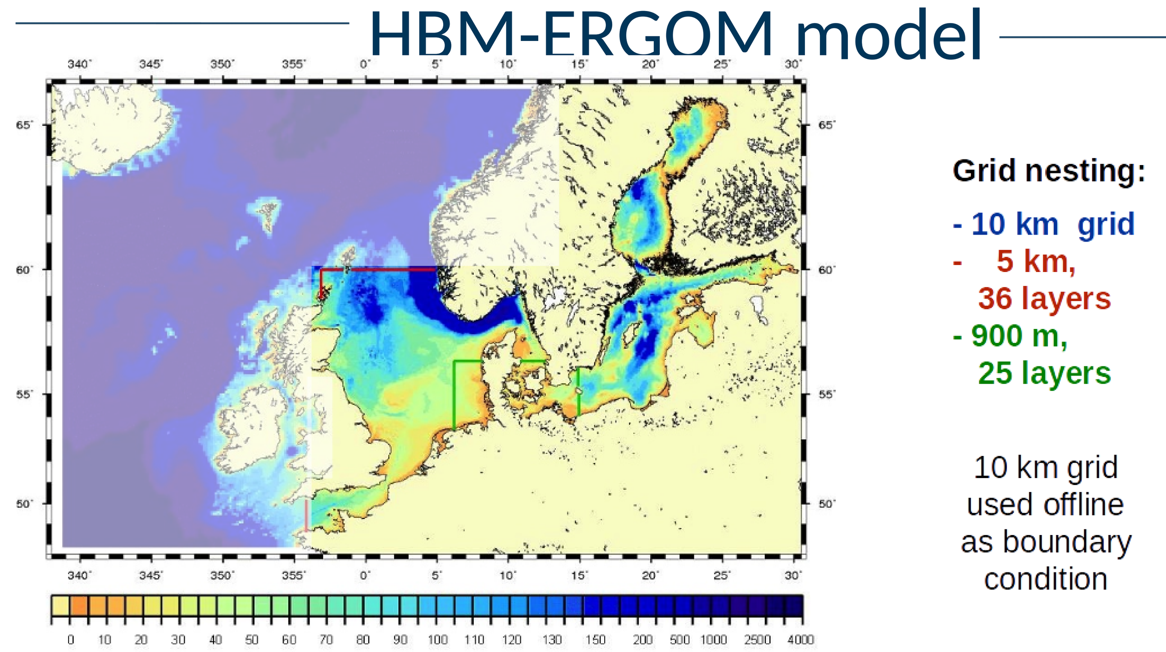
Overview

The effect of the assimilation of satellite sea surface temperature onto the forecast quality of the coastal ocean-biogeochemical model HBM-ERGOM in the North- and Baltic Seas is studied. As a first step to improve the biogeochemical forecasts the impact of assimilating satellite sea surface temperature data is assessed. This is done under two cases:

- A Weakly Coupled case: The assimilation of temperature only directly influences the physical model variables in the correction step of the assimilation while the biogeochemical fields react dynamically to the changed physical model state during the subsequent ensemble forecasts using the coupled model.
- A Strongly Coupled case: In conjunction to the physical model fields, the biogeochemical fields are also directly updated in the analysis step through the multivariate covariances estimated by the joined physical-biogeochemical ensemble of model states. Here, it is assessed whether these covariances are sufficiently well estimated to result in an improvement of the biogeochemical fields.

HBM-ERGOM model



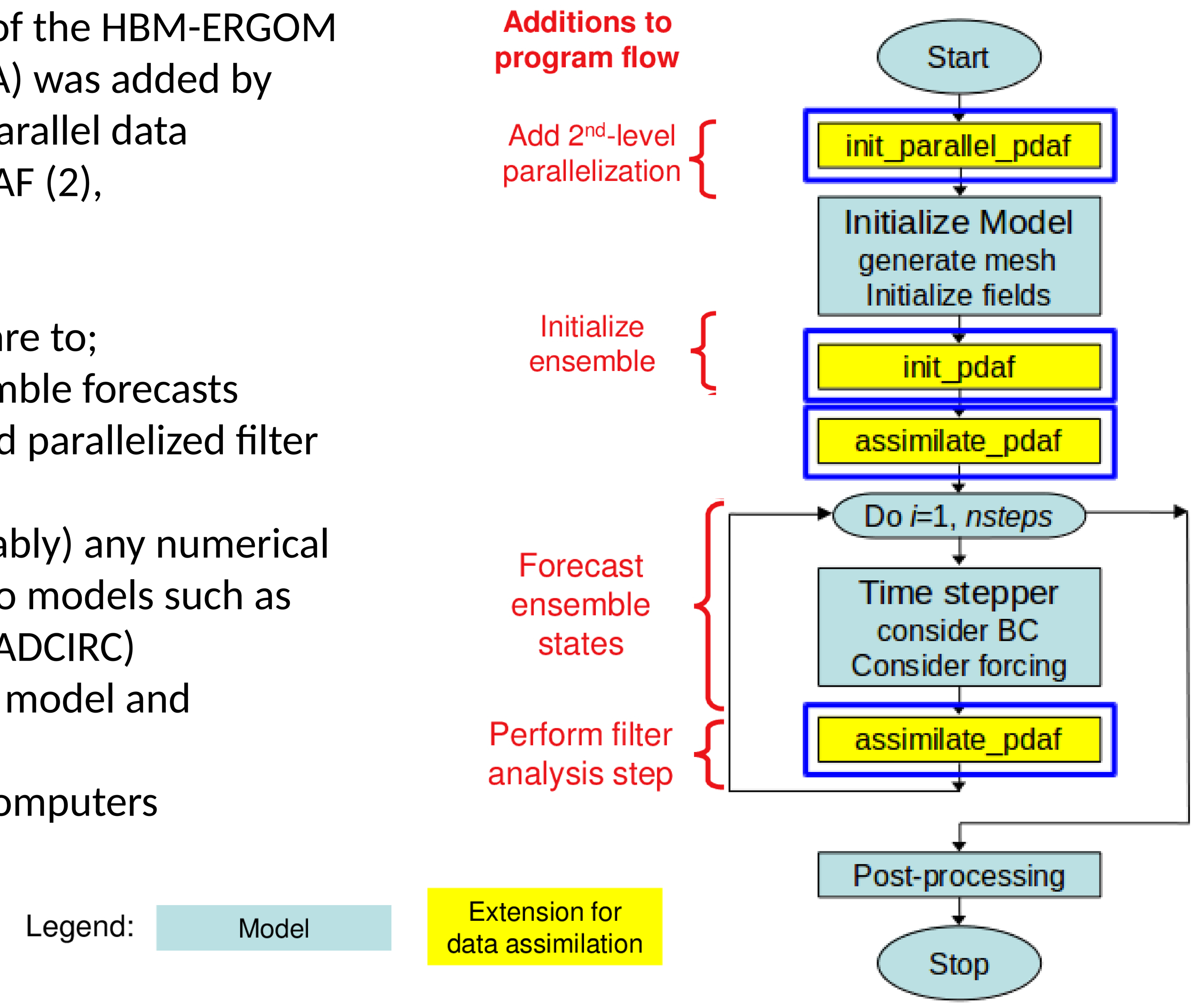
The performance of temperature assimilation is studied using the HBM-ERGOM model (1). The Model is currently in the test phase, pre-operationally, without data assimilation by the Germany Federal Maritime and Hydrographic Agency (BSH). The model is configured with nested grids with a resolution of 5km in the North and Baltic Seas and a resolution of 900m in the German coastal waters. The biogeochemical model ERGOM contains three phytoplankton groups (Cyanobacteria, Flagellates, Diatoms), two zooplankton size groups, four nutrient groups (nitrate, ammonium, phosphate and silicate), two detritus groups (N-Detritus and Si-Detritus) and oxygen to simulate the biogeochemical cycling in the coastal seas.

PDAF

To improve the predictions of the HBM-ERGOM model, data assimilation (DA) was added by coupling the model to the parallel data assimilation framework (PDAF (2), http://pdaf.awi.de).

The main features of PDAF are to;

- Provide support for ensemble forecasts
- Provide fully-implemented parallelized filter algorithms
- Easily useable with (probably) any numerical model (Already coupled to models such as NEMO, MITgcm, FESOM, ADCIRC)
- Separate development of model and assimilation algorithms
- Make good use of supercomputers



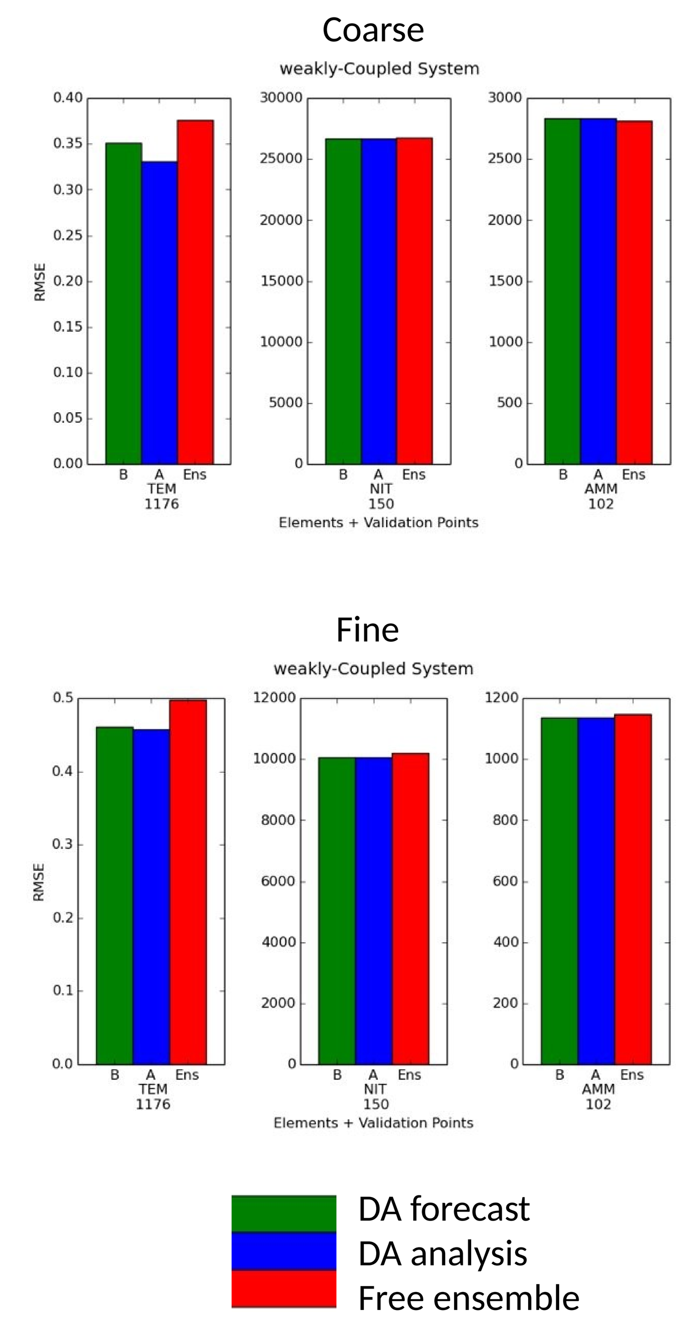
Experimentation

The ensemble-based error-subspace transform Kalman filter (ESTKF) is applied for the data assimilation. The ESTKF was developed to give identical transforms to the ensemble transform Kalman filter (ETKF), whilst being computationally less expensive.

In our experiments, we compare the forecast, analysis supplied by the ESTKF and a free ensemble run over March 2012 for Temperature (TEM), Nitrate (NIT) and Ammonium (AMM). This is done with 20 ensemble members with observations every 12 hours. This is done on both the fine and coarse grid points. Here, we apply a forgetting factor of 0.95 and a localisation radius of 30,000 in the coarse grid and 5,000 in the fine grid. Using RMSE as a metric, the data assimilation is compared to a free run to test for improvements over both weakly and strongly coupled tests.

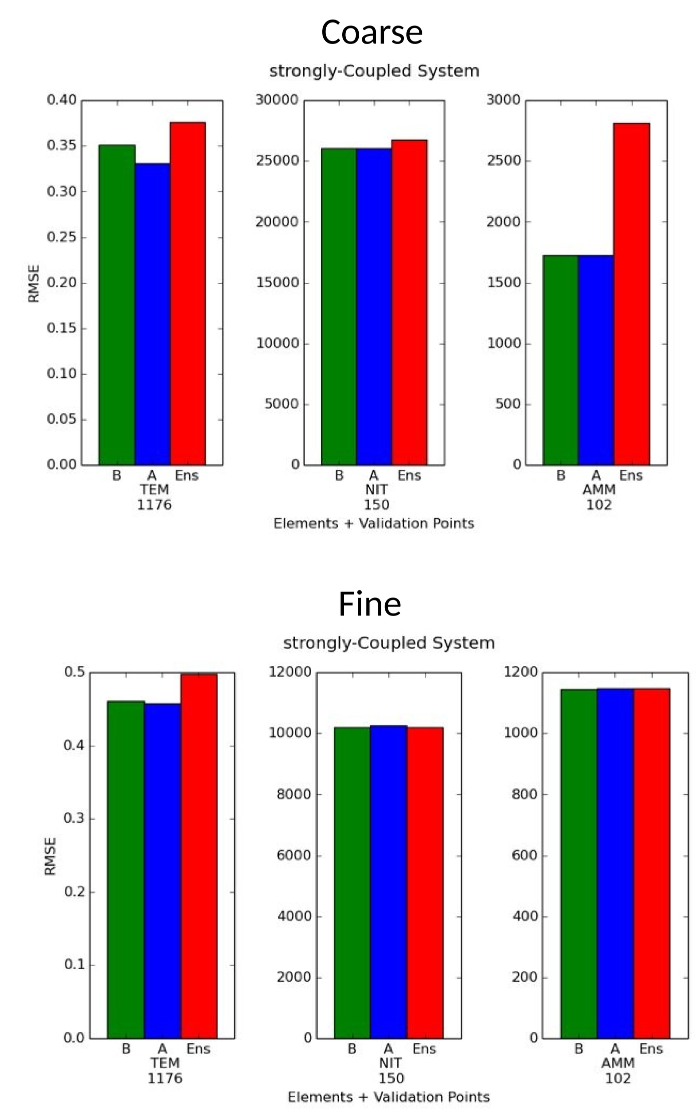
Weakly Coupled

Results show DA improving the TEM predictions over the free ensemble on both fine and coarse grid. AMM and NIT do not see a big change on the coarse grid, however, on the fine grid, AMM and NIT do show slight improvements. This could be due to the number of observations over March 2012 and the location of these observations in regards to validation data. Our results show how well the DA works where we have both validation data and observations.



Strongly Coupled

On the Strong Coupled system, we also see an improvement with TEM prediction over both grids. On the coarse grid, we see an improvement with both NIT and AMM, where AMM is shows a large improvement. On the fine grid, we see no improvement in NIT or AMM. Here, a strongly coupled system does not perform as well as the weak system, but this is over a short run and may improve with a longer run under different conditions (such as a better covariance matrix, more observations, more/less localisation, a better forgetting factor etc) which need to be considered.



References:

[1] Neumann, T. Towards a 3D-ecosystem model of the Baltic Sea Journal of Marine Systems, 1999

[2] Nerger, L., Hiller, W. (2013). Comp. & Geosci., 55, 110-118

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