Towards Operational Data Assimilation in the North and Baltic Seas with the Parallel Data Assimilation Framework

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Introduction

Within the GMES-related project DeMarine Environment, the operational circulation model of the German Maritime and Hydrographic Agency (BSH) is extended into a data assimilation system. The aim of the data assimilation is to improve the forecasts of sea surface height, temperature, currents and salinity in the North and Baltic Seas.

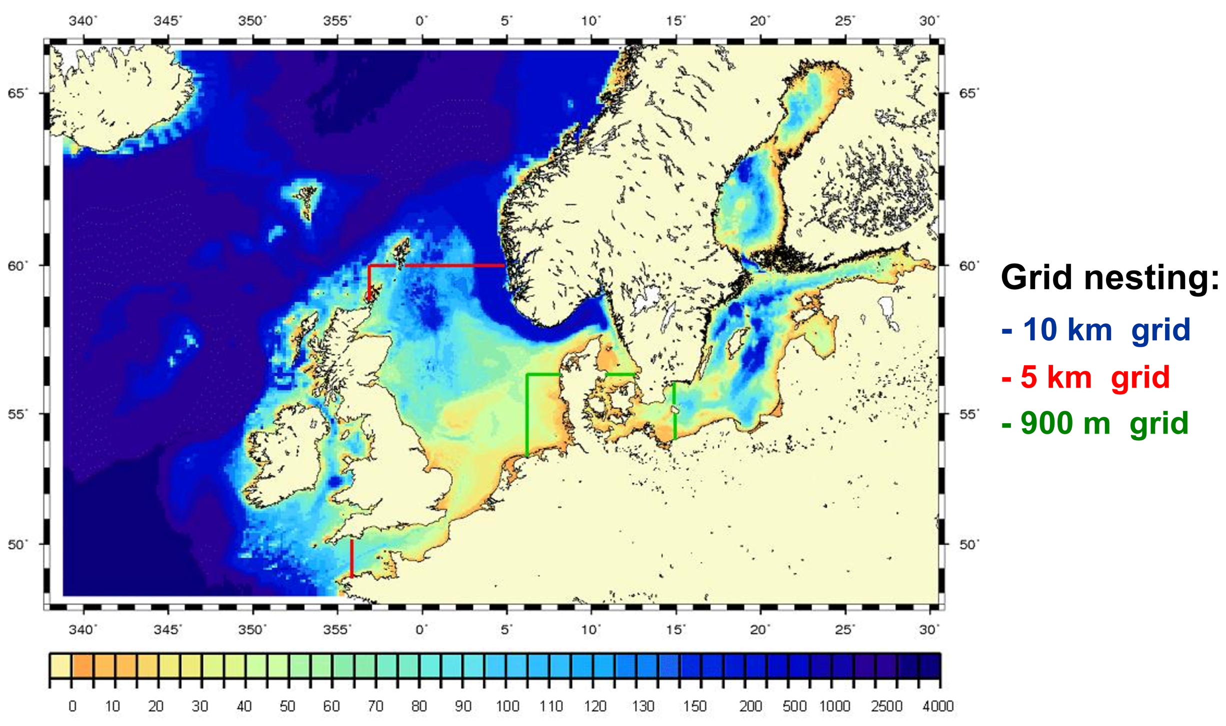
For the data assimilation component, the Parallel Data Assimilation Framework (PDAF, [1]) is coupled to the operational circulation model. PDAF provides the assimilation environment as well as fully implemented and optimized filter algorithms. We discuss technical aspects of the data assimilation system used with the BSH operational circulation model. In a companion poster by Losa et al., results obtained by assimilating satellite temperature data with the local SEIK filter are discussed.

BSH Operational Circulation Model

From the suite of operational BSH models [2], the circulation model (BSHcmod) is used. This model supports the the other operational models of BSH for predicting surges and water level. The model uses nested grids of which the current assimilation system operates on the configuration for the North and Baltic Seas with a resolution of 5 km.

The model is forced by meteorological data from the German Weather Service (DWD) and boundary data from a coarser model configuration for the North-Sea.

In the operational model configuration, a forecast is computed once per day for the following 48 hours. Currently, the pre-operational use of the assimilation system is in preparation. It will follow the operational schedule.



Nested BSH operational models

Conclusion

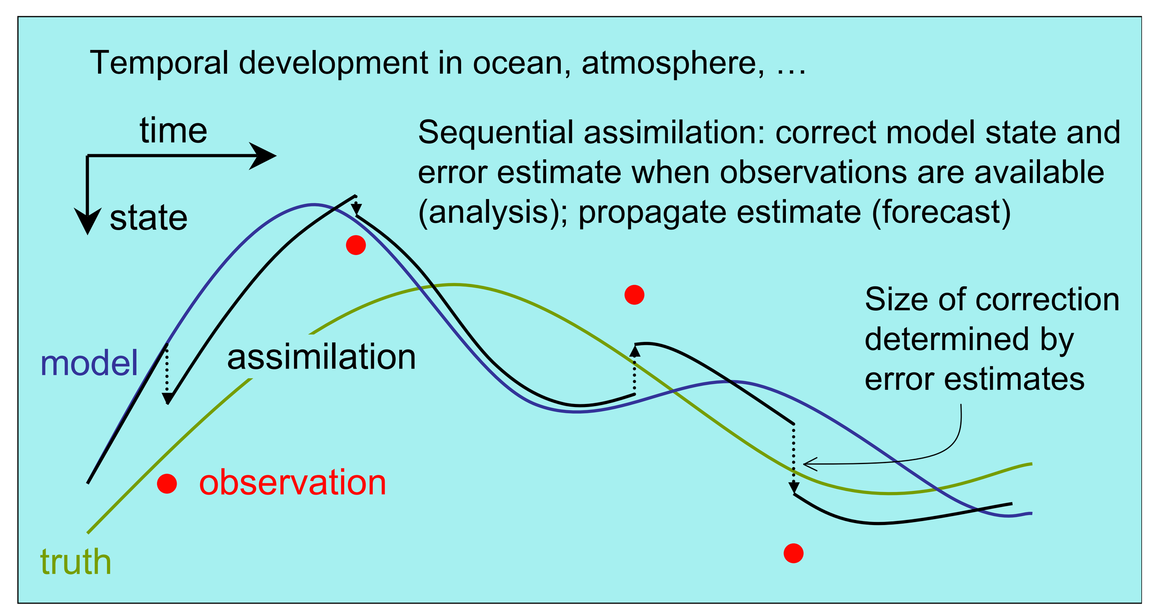
- A data assimilation system for pre-operational use has been implemented for the BSH operational circulation model BSHcmod using the parallel Data Assimilation System PDAF.
- The assimilation system is parallelized. Performing the ensemble forecast fully parallel permits to perform the assimilations with negligible overhead in wall clock time compared to the operational model without assimilation.
- PDAF is a general-purpose framework for sequential data assimilation. It provides different fully implemented and parallelized filter algorithms. In addition, parallelization support for the full assimilation system is provided. Using a defined interface that requires minimal changes in the model code, the implementation of data assimilation systems with existing models is significantly simplified.
- Results of actual assimilation experiments are discussed in the poster "Developing a data assimilation system for operational BSH circulation model of North and Baltic Seas: Local SEIK implementation for NOAA SST data assimilation" by S. Losa et al.

Data Assimilation

The data assimilation is performed using the Singular "Evolutive" Interpolated Kalman (SEIK) filter with domain localization [3]. The SEIK filter is an ensemble-based Kalman filter. An ensemble of 8 members is used to represent the state and error estimate. The ensemble is initialized by a transformation of EOF modes from a long model trajectory.

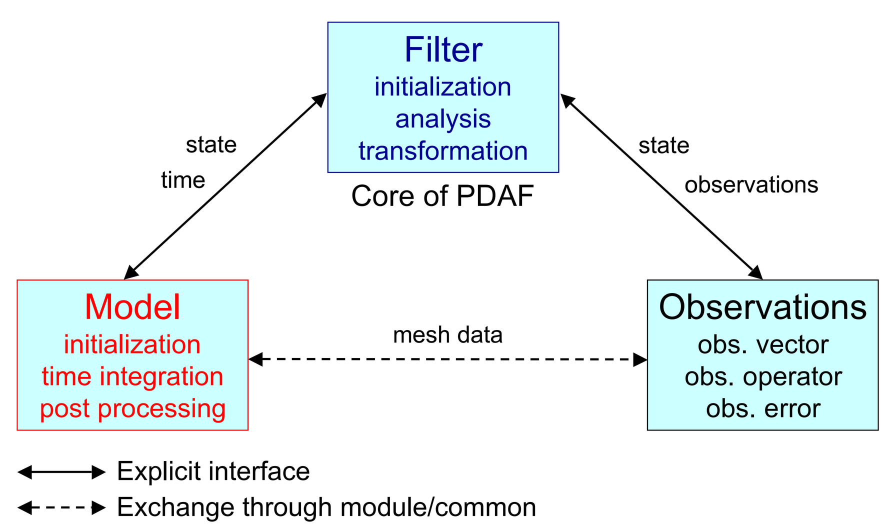
The assimilated observations are currently sea surface temperature data from NOAA satellites. At a later time, further data types including ocean color will be added. The data is used in a multivariate way to influence the temperature, salinity, and current fields of the model.

For the data assimilation, the ensemble of model states is propagated by the model for 12 hours. Then, observations are assimilated that are a composite of different satellite tracks over 12 hours. For the pre-operational application, two forecast-assimilation cycles are performed, before a new forecast over 48 hours is computed.

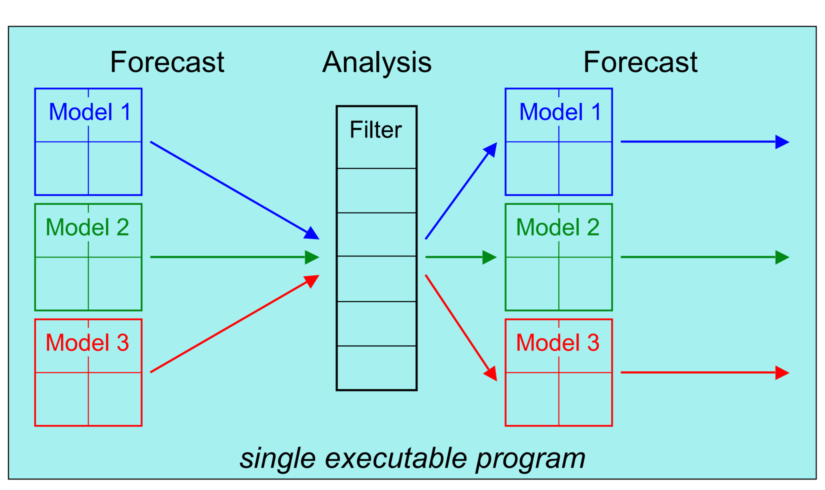


Principle of sequential data assimilation with a filter algorithm. The state estimate of the assimilation is given by the ensemble mean. The analysis estimate lies typically between the forecast estimate and the observation, hence closer to the true state.

PDAF – Parallel Data Assimilation Framework



Logical separation of the data assimilation system and interfacing between the components.



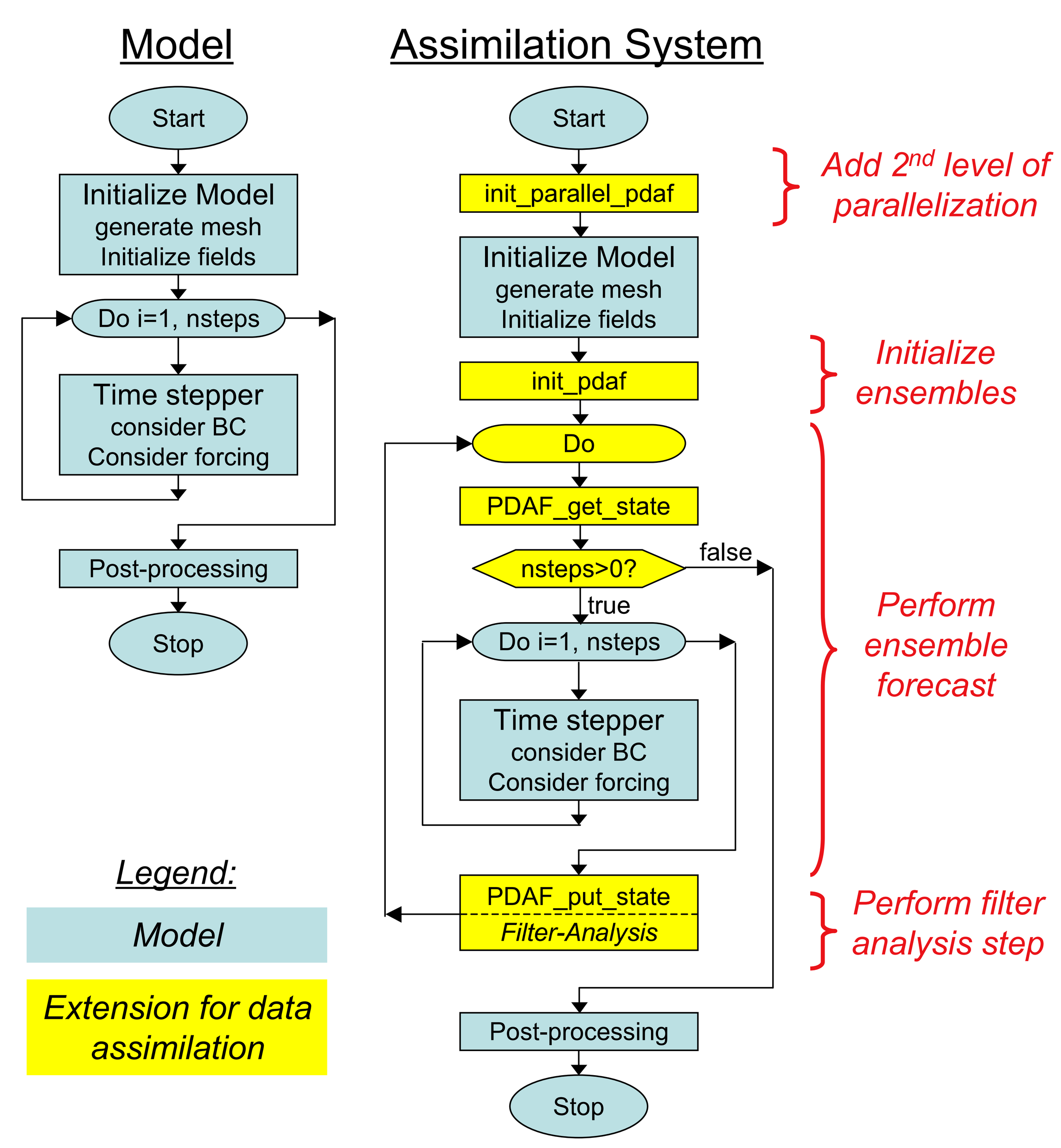
2-level parallelization of the data assimilation system: 1. Each model task can be parallelized. 2. Several model tasks are executed concurrently. In addition, the filter analysis step uses parallelization. In the online-mode of PDAF, all components are included in a single executable program.

The data assimilation system has been implemented using PDAF. PDAF provides fully implemented and parallelized ensemble filter algorithms, like LSEIK [3] and LETKF [4]. In addition, parallelization support is provided for the assimilation system to perform the ensemble integrations in parallel using a single executable.

PDAF is based on a consistent separation of the components of the data assimilation system: model, filter algorithm, and observations (see left). The filter algorithms are in the core part of PDAF, while the model routines and routines to handle observations are provided by the user. The interfacing between the three parts is through the standard interface of PDAF. Mesh data needed for the observations can be provided through, e.g., Fortran common blocks or modules.

The figure on the right hand side shows the required extensions of the model code, when the assimilation system is implemented with PDAF in online mode. In general, four calls to sub-routines have to be added. In addition, an external loop enclosing the time stepping part of the model is required to allow the data assimilation system to perform ensemble integrations. Further information and access to source code is available on the web site of PDAF:

http://pdaf.awi.de



Extension of a model source code to implement a data assimilation system using PDAF. The forecast phase is controlled by user-supplied routines that are called by PDAF_get_state. Implementations following this strategy have been performed for different models like FEOM, MIPOM, NOBM, and ADCIRC.

References

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