Assimilation of Dynamic Topography in a Global Ocean Model

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Introduction

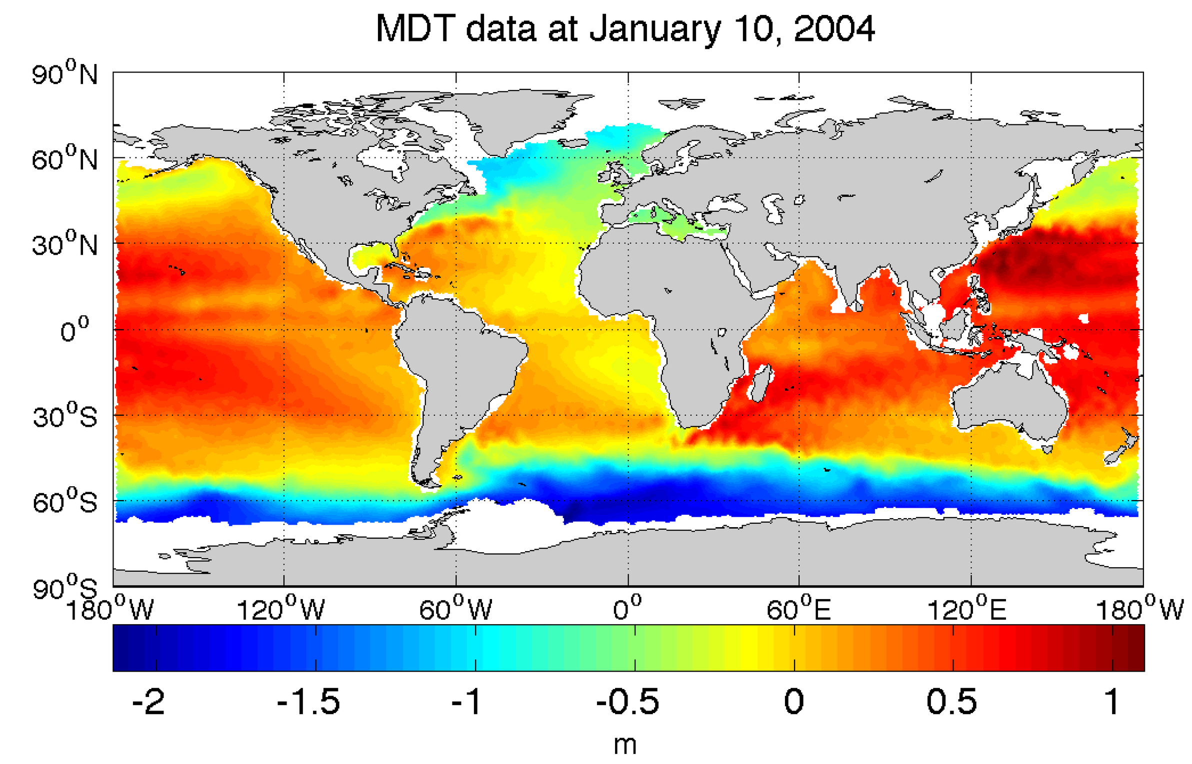
Absolute dynamic topography is assimilated in a global ocean general circulation model with a sequential ensemble-based Kalman technique.

Here, we present an update of our previous work [1, 2]. First of all, the geoid is improved over previous versions. The ocean model now includes better dynamics and full sea ice-ocean interactions and more realistic surface forcing. Finally, the filter algorithm has been updated to the "Error Subspace Transform Kalman Filter" (ESTKF) and the assimilation method is augmented by a fixed-lag smoother technique.

Mean Dynamic Ocean Topography Data

The mean dynamic topography (MDT) data is the difference of time-dependent altimetric sea surface height and geoid data.

- The sea surface height is calculated using altimeter data from ERS-1/2, ENVISAT, TOPEX/Poseidon, Jason-1, and Jason-2.
- The geoid model is based on data from the GRACE and GOCE missions.
- Both data products are spectrally filtered to degree 120 for consistency.



Ocean Model

We use the Finite-Element Sea-Ice Ocean Model (FESOM) [3]. FESOM solves the hydrostatic primitive equations on unstructured meshes of varying resolution. In addition, it includes a dynamic sea-ice model component.

The model has a horizontal resolution of 1.3° with refinement in the equatorial region. 40 vertical levels are used. The CORE-2 data set is used for the atmospheric forcing of FESOM.

Data Assimilation

The MDT data is assimilated with the Error Subspace Transform Kalman Filter (ESTKF) [4] each 10th day over the year 2004. An ensemble of 50 states is used.

The smoother operates with a lag of 50 days. The assimilation system is implemented using the Parallel Data Assimilation Framework (PDAF [5, 6], http://pdaf.awi.de).

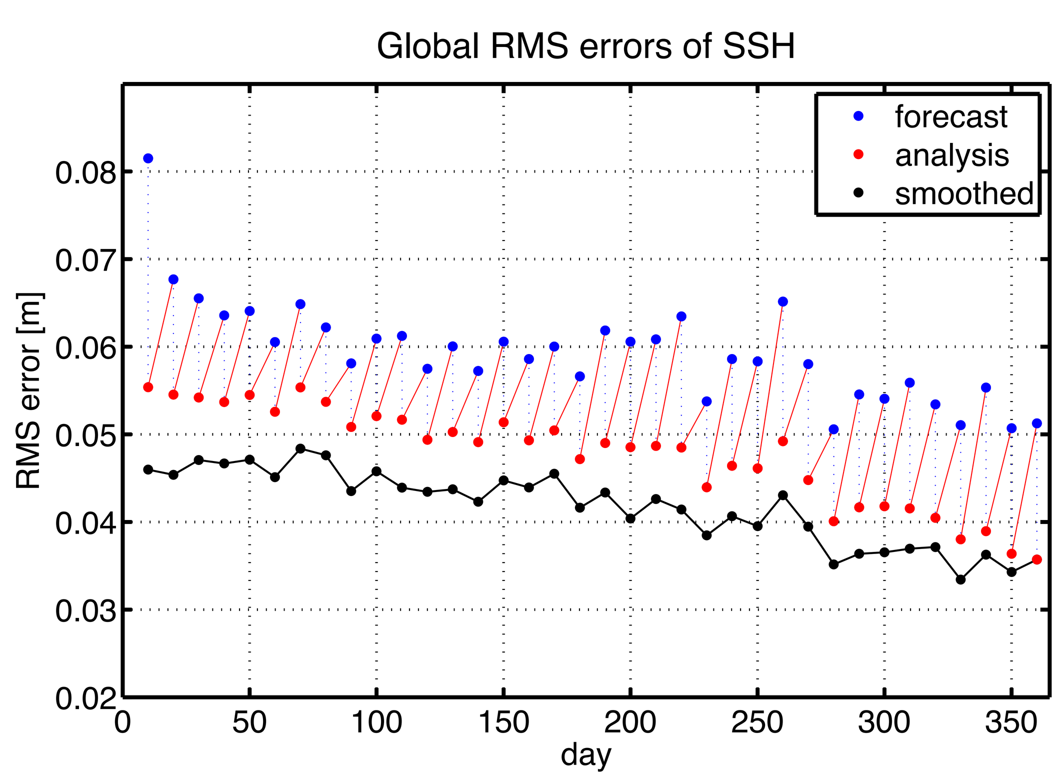
Summary

The assimilation with the ESTKF improves the sea surface height field of the model.

The smoother allows to significantly improve the model performance compared to the filter.

Larger errors are caused by model bias. This is visible from the mean assimilation increments and the deviation of the model steric height from climatology. To improve the observation impact, the bias needs to be reduced.

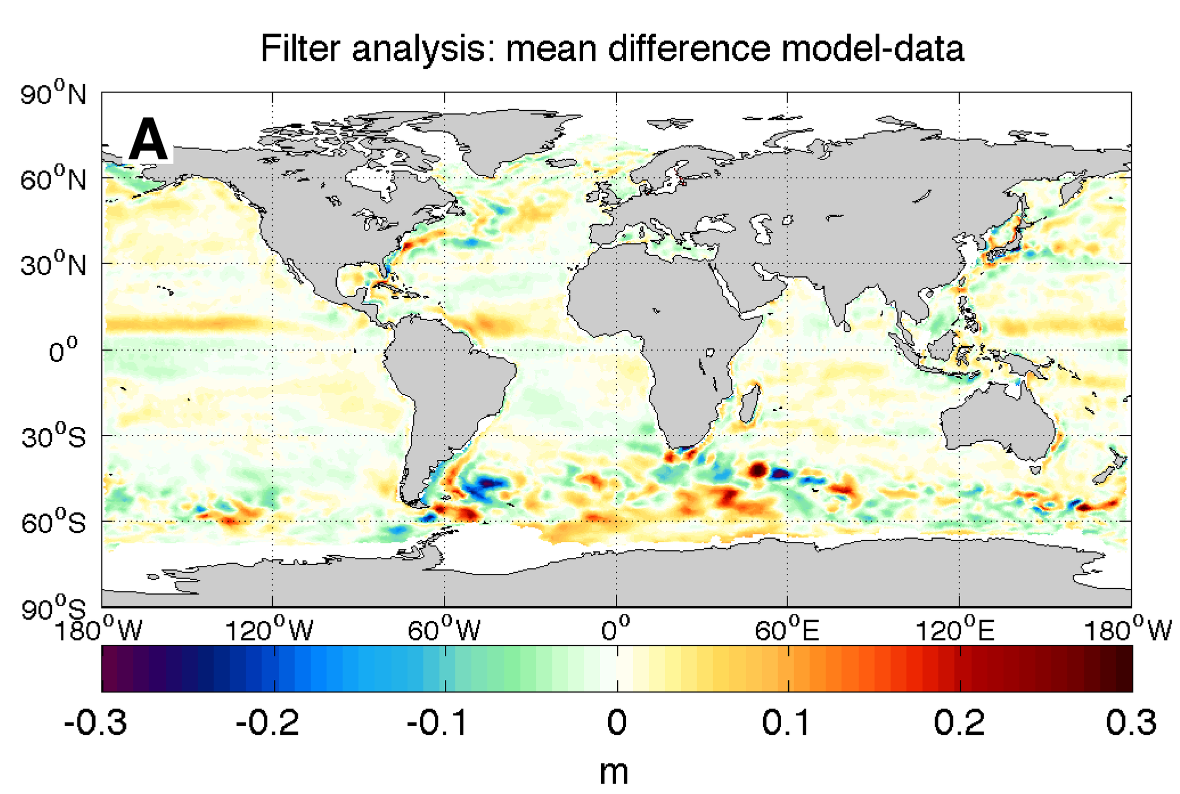
Assimilation Results

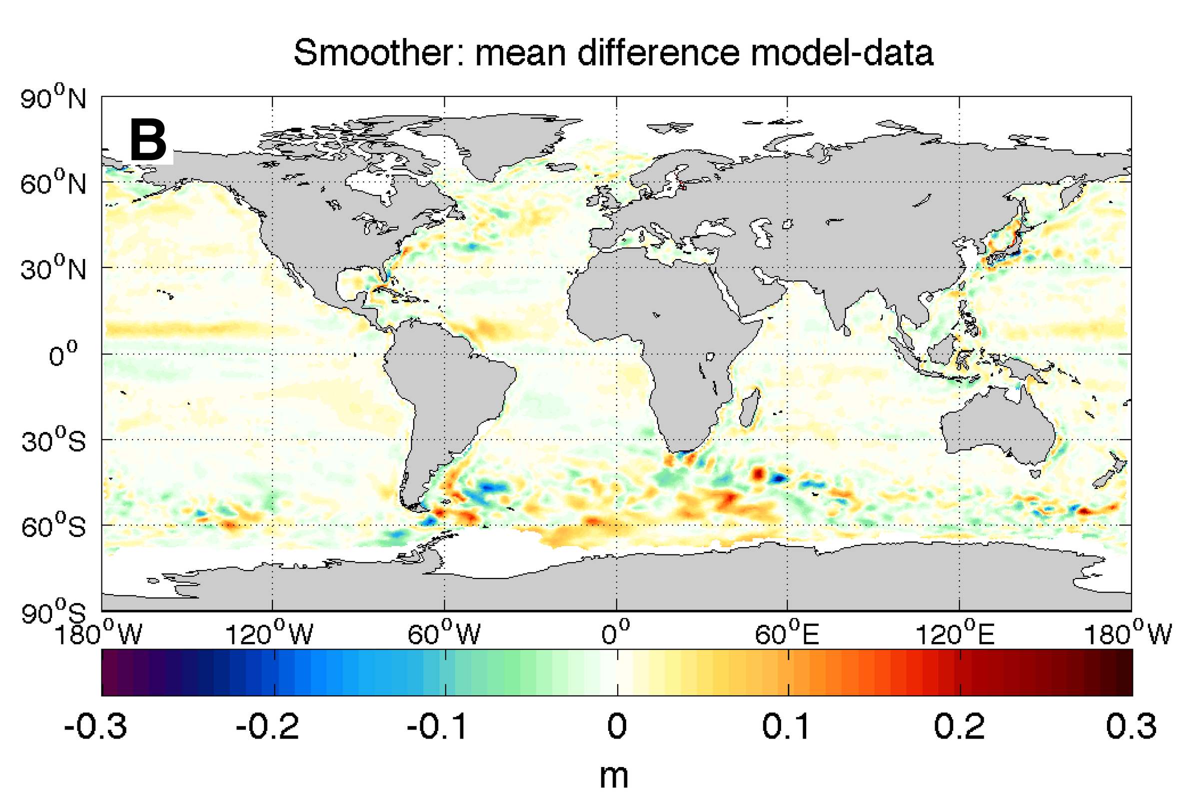


The assimilation strongly reduces the root mean square (RMS) deviation between the MDT data and the modeled sea surface height (SSH) field.

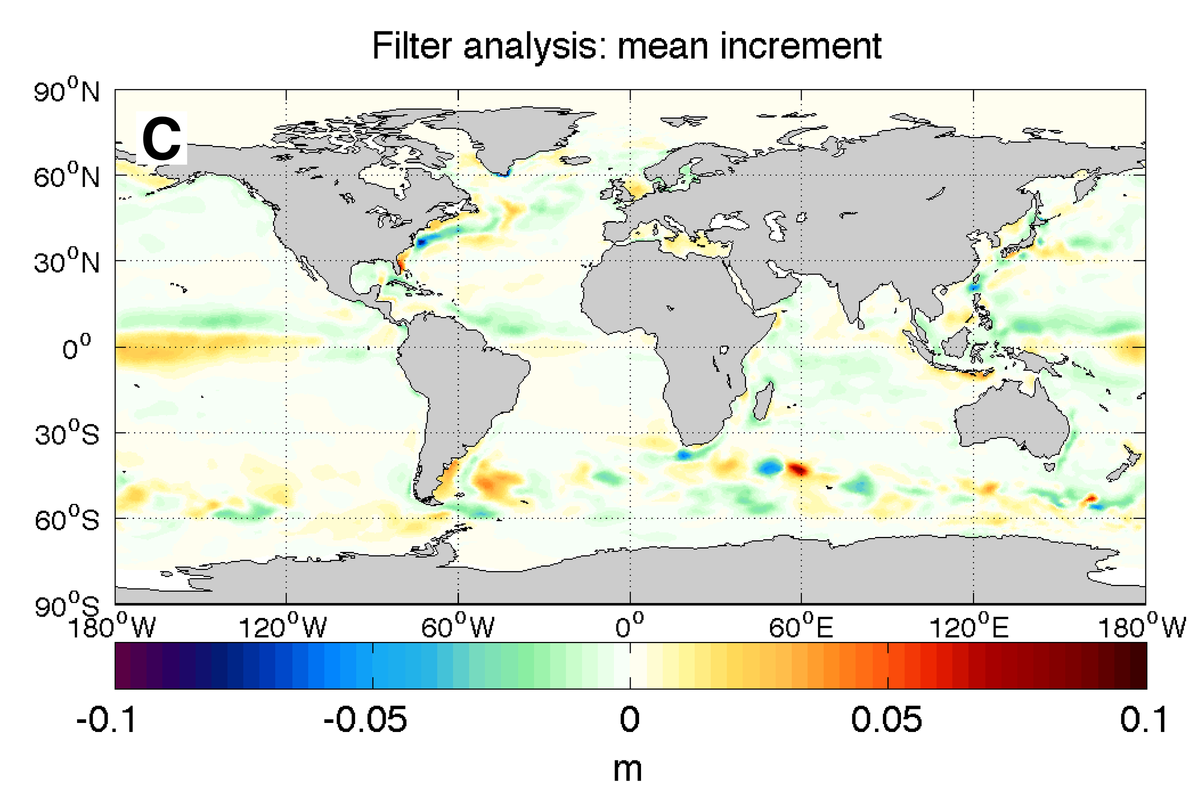
The smoother results in a further reduction of the error. The impact of the smoother is largest at the beginning of the experiment.

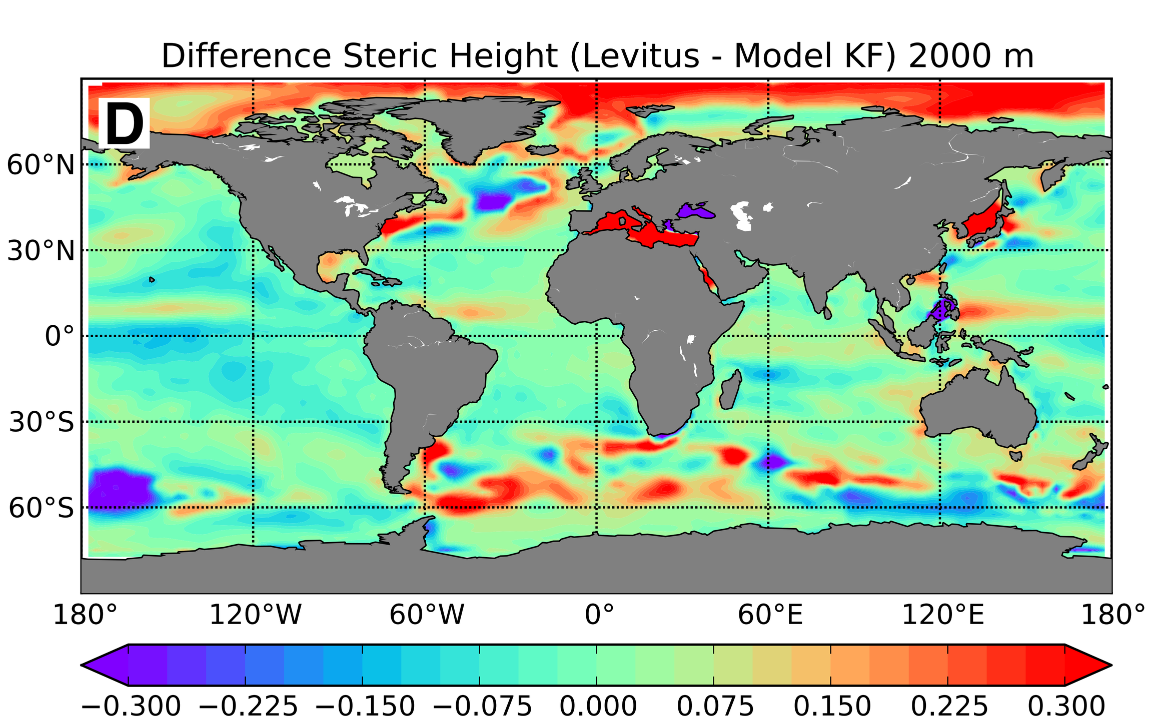
The annual mean difference between the assimilation and observation (**A**) shows several localized spots with larger deviations. These are significantly reduced by the smoother (**B**).





The mean increments (**C**) show that the largest deviations are caused by model biases. The bias is also visible in the difference between the steric heights of the model and climatology (**D**).





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