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Building an Efficient Ensemble Data Assimilation System for Coupled Models with the Parallel Data Assimilation Framework

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We discuss how to build an ensemble data assimilation system using a direct connection between a coupled model system and the ensemble data assimilation software PDAF (Parallel Data Assimilation Framework, http://pdaf.awi.de). The direct connection results in a data assimilation program with high flexibility, efficiency, and parallel scalability. For this we augment the source code of the coupled model by data assimilation routines and hence create an online-coupled assimilative model. This first modifies the coupled model to be able to simulate an ensemble. Using a combination of in-memory access and parallel communication with the Message Passing Interface (MPI) standard we can further add the analysis step of ensemble-based filter methods, which compute the assimilation of observations, without the need to stop and restart the whole coupled model system. Instead, the analysis step is performed in between time steps and is independent of the actual model coupler that couples the different model compartments. This strategy to build the assimilation system allows us to perform both weakly coupled (in-compartment) and strongly coupled (cross-compartment) assimilation. The assimilation frequency can be kept flexible, so that the assimilation of observations from different compartments can be performed at different intervals. Further, the reading and writing of disk files is minimized. The resulting assimilative model can be run in the same way as the regular coupled model, but with additional parameters controlling the assimilation and with a higher number of processors to simulate the ensemble. Using the example of the coupled climate model AWI-CM that contains the FESOM model for the ocean and sea ice and ECHAM6 for the atmosphere, both coupled through the OASIS-MCT coupler, we discuss the features of the online assimilation coupling strategy and the performance of the resulting assimilative model.