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A design of the optimal setup for a coupled data assimilation for decadal climate predictions

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The need for reliable climate predictions is growing in demand for various socio-economic sectors. The predictability studies though show that Earth System Models (ESMs) can predict important climate variables, the predictions suffer from model errors and initialization shocks that limit predictability. The magnitude of this effect is difficult to quantify unless one could perform experiments in dynamically- and model-consistent settings to contrast against each other various sources of initialization shocks. This is the idea of our study, which concerns quantifying and understanding the impact of deriving dynamically balanced initial conditions on the decadal prediction skill.

Among a variety of coupled data assimilation (CDA) methods, the adjoint method is one of the promising because its result is dynamically consistent with the ESM equations; however, the method might also be one of the most demanding to design and maintain. Here, we use the coupled adjoint model developed for the ESM of intermediate complexity CESAM (Centrum für Erdsystemforschung und Nachhaltigkeit Erdsystem Assimilations-Modell) to produce a coupled ocean-atmosphere reanalysis. So far, we prepared and tested the forward and adjoint CESAM for upcoming decadal climate prediction experiments. We present the performance of the forward CESAM in terms of the 20th-century historical simulations, which are typically used as the benchmark for comparing initialized versus uninitiated climate simulations. We also present the setup for the adjoint CESAM as well as the initial CDA experiments. In the following, these CDA experiments will serve as a source of initial conditions for ensembles of retrospective decadal predictions. In a model-consistent approach, the study will compare initialization based on the coupled ocean-atmosphere reanalysis and based on the widespread strategy in decadal prediction studies of nudging toward ocean and atmosphere reanalyses, which are usually external to a prediction system as well as they are un-coupled. Results of this study aim to guideline future initialization developments for comprehensive ESMs.