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Estimation of 4D-var Data Assimilation Error for Coupled Climate Models

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Four dimensional variational data assimilation (4D-var DA) is aimed to adjust model's parameters by fitting estimates to observed data. Due to a number of reasons, such as constant persistence of numerical and observational noise, interpolation errors etc., 4D-var DA produces unavoidable inaccuracies in the model's initial state vector. For reducing the impact of these inaccuracies the 4D-var DA is in principle equipped with an inverse error covariance matrix (IECM). The computation of the error covariance however, requires considerable computational resources. Moreover, the computation of inverse of such matrix is not possible, if the error covariance matrix is singular. Two novel concepts for computing DA error and estimation error weight matrix (EWM), an analog of IECM, are suggested in this paper. The first concept aimed on estimating DA error is similar to 4Dvar DA, with the only exception that special error equations and observational errors are used instead of model equations and observations. Although requirement of prior knowledge of observational error seriously restricts its applicability to real cases, this concept forms a theoretical basis for the second concept for estimation of EWM. The estimation of EMW does not require any prior knowledge on observational error, and the matrix can be computed directly from the model. Moreover, the computation of EWM is easier than computation of IECM since EWM can be computed with the first order derivatives and does not require inversion. The methods and EWM are tested in a framework of coupled ocean-atmosphere model in a set of twin experiments. These experiments reveal that the suggested methods produce reliable estimates of DA error and equipping the 4D-var DA with EWM improves the results of assimilation up to 10%.