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Allowing for model error in strong constraint 4D-Var

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Four dimensional variational data assimilation (4D-Var) can be used to obtain the best estimate of the initial conditions of an environmental forecasting model, namely the analysis. In practice, when the forecasting model contains errors, the analysis from the 4D-Var algorithm will be degraded to allow for errors later in the forecast window. This work focusses on improving the analysis at the initial time by allowing for the fact that the model contains error, within the context of strong constraint 4D-Var.

The 4D-Var method developed acknowledges the presence of random error in the model at each time step by replacing the observation error covariance matrix with an error covariance matrix that includes both observation error and model error statistics. It is shown that this new matrix represents the correct error statistics of the innovations in the presence of model error. A method for estimating this matrix using innovation statistics, without requiring prior knowledge of the model error statistics, is presented.

The method is demonstrated numerically using a non-linear chaotic system with erroneous parameter values. We show that that the new method works to reduce the analysis error covariance when compared with a standard strong constraint 4D-Var scheme. We discuss the fact that an improved analysis will not necessarily provide a better forecast.