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Sensitivity and out–of–sample error in data assimilation

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Abstract

Data assimilation refers to the problem of finding trajectories of a prescribed dynamical model in such a way that the output of the model (usually some function of the model states) is, in some sense, coherent with a given time series of observations. Hence data assimilation comprises two objectives—tracking the observations as well as adhering to the proposed model equations; In a practical situation, meeting both objectives at the same time is usually impossible. Thus, some sort of balance or trade–off has to be found between them. In (weakly constrained) variational data assimilation, for example, this trade–off is controlled by the relative weighting of observational and dynamical perturbations in the error functional. (These weights are usually interpreted as the observational and dynamical error covariances, although this statistical interpretation is problematic.) In any event, choosing the appropriate balance in this trade–off will clearly have a fundamental effect on the performance of the data assimilation. In this contribution, a generalisation of the out–of–sample error concept from statistics is discussed. The out–of–sample error provides a useful measure of performance of data assimilation, whereby the trade–off can be analysed and settled. A relation between the out–of–sample error and the sensitivity (of the data assimilation algorithm with respect to the observations) is established which allows, at least in principle, to calculate the out–of–sample error under operational conditions. Numerical examples involving two approaches to data assimilation demonstrate the feasibility of the approach.