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Bayesianity of Ensemble Variational Assimilation

Mohamed Jardak and Olivier Talagrand
Laboratoire de Meteorologie Dynamique, Paris, France (mjardak@lmd.ens.fr)

Ensemble assimilation methods (EnKF, Particle Filters, Ensemble Variational Assimilation) are basically meant to produce a sample of the Bayesian probability distribution of the state of the observed system, conditional to the available data. We present a comparative evaluation of those methods, and in particular of Ensemble Variational Assimilation (Ens/4D-Var), considered as Bayesian estimators. Ensemble Variational Assimilation achieves bayesianity in the linear and gaussian case. It is implemented here on small dimensional chaotic systems (Lorenz '96, Kuramoto–Sivashinsky) in nonlinear and/non-gaussian situations. The bayesian character of a probability distribution cannot be in general objectively verified, and the weaker property of reliability (statistical consistency between predicted probabilities and observed frequencies of occurrence) is used instead.

The general conclusions are, first, that non-gaussianity has no significant impact. Second, that Ens/4D-Var produces reliable and accurate ensembles. These conclusions remain valid for long assimilation periods, either through the use of Quasi-Static Variational Assimilation, in which the length of the assimilation window is progressively increased (in the case of a perfect model), or through weak-constraint assimilation (in the case of an imperfect model). Comparison with EnKF and Particle Filters shows that Ens/4D-Var is at least as good a bayesian estimator, although at a higher cost. The pros and cons of Ens/4D-Var are further discussed.