Development and validation of a diagonal ensemble transform Kalman filter

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Abstract

A variant of the ensemble transform Kalman filter (ETKF) has been developed with the following property: analysis perturbations run independently from each other. The independence of each perturbation helps to maintain physical structures of perturbations associated with large-scale systems like tropical cyclones or fronts in a consistent and coherent manner through multi assimilation cycles. This property dictates a special form for the ensemble transform matrix (ETM) in ETKF: that is a scalar multiple of the identity $\mathbf{I}$. Therefore, this variant of ETKF is called the diagonal ETKF.

In this study, we show that the diagonal ETKF can be derived from the two very different approaches: (1) the diagonally predominant property of the unique positive symmetric ETM $\mathbf{T}^s$, i.e. the diagonal elements are at least an order of magnitude larger than the off-diagonal elements; and (2) constant inflation functions, i.e. the spectrum of $\mathbf{T}^s$ is replaced by a constant function. Experiments using real observations show that the diagonal ETM produces forecasts better than the ones obtained from the conventional ETM $\mathbf{T}^s$.