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How to improve forecasting with bred vectors by using the geometric norm

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The choice of the norm type (Euclidean, maximum, geometric,...) has a great impact on the construction of ensembles of bred vectors. In particular, using the geometric norm obtains a set of bred vectors, the so-called logarithmic bred vectors, with interesting properties.

We have recently shown in [1] that among a spectrum of norms (including the Euclidean one) the geometric norm maximizes the statistical diversity of the ensemble while, at the same time, enhances the projection of the bred vectors on the linearly most unstable direction (the leading Lyapunov vector). Moreover, the geometric norm is also optimal in providing the least fluctuating ensemble dimension among the spectrum of norms considered.

We carry out numerical experiments in the Lorenz-96 model assimilating noisy observations with a 3D-Var scheme. We compare the performance of forecasts using ensembles of bred vectors constructed with either the Euclidean norm or the geometric one. Our results, for several lead times and observational standard deviations, indicate that the geometric norm usually outperforms the Euclidean norm, in terms of root mean square error of the ensemble mean forecast.

Finally, we give theoretical support to our results, which are expected to be generic for chaotic spatially extended systems.

[1] D. Pazó, J. M. López, and M. A. Rodríguez, Maximizing the statistical diversity of an ensemble of bred vectors by using the geometric norm, J. Atmos. Sci. 68, 1507 (2011).