Spatio-temporal evolution of perturbations in ensembles initialized by bred, Lyapunov and singular vectors

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We study the evolution of finite perturbations in the Lorenz '96 model, a meteorological toy model of the atmosphere. The initial perturbations are chosen to be aligned along different dynamic vectors: bred, Lyapunov, and singular vectors. Using a particular vector determines not only the amplification rate of the perturbation but also the spatial structure of the perturbation and its stability under the evolution of the flow. The evolution of perturbations is systematically studied by means of the so-called mean-variance of logarithms diagram that provides in a very compact way the basic information to analyse the spatial structure. We discuss the corresponding advantages of using those different vectors for preparing initial perturbations to be used in ensemble prediction systems, focusing on key properties: dynamic adaptation to the flow, robustness, equivalence between members of the ensemble, etc. Among all the vectors considered here, the so-called characteristic Lyapunov vectors are possibly optimal, in the sense that they are both perfectly adapted to the flow and extremely robust.