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Chaotic dynamics of a two-scale Lorenz'96 model: Multiple evolution regimes and large-scale spatial patterns.

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In the last years modern forecasting techniques have included some kind of uncertainty in the deterministic models allowing a probabilistic forecast that improves the deterministic results. The Ensemble Prediction System (EPS) is the most used method to achieve this probabilistic forecast. The EPS consist on considering the evolution of an ensemble of prepared initial conditions with one or more models. Differences between the members of the ensemble evolved with the same model and considered at the same time are, in general, finite fluctuations that reflect the amplification of small initial errors in chaotic models. The study of these fluctuations is important, not only to analyze the chaotic behavior of the system, which can be of academic interest, but also to prepare the optimal initial conditions of the ensemble, which has practical implications.

In this work we consider the two-scale Lorenz'96 model to analyze the spatio-temporal dynamics of their fluctuations and to define the proper Liapunov vector basis to build the optimal initial conditions of the ensemble. It is shown that when the coupling between slow and fast variables is weak the slow variables dominate the evolution of fluctuations whereas in the case of strong coupling the fast variables impose a non-trivial complex error growth pattern on the slow variables with two different regimes, before and after saturation of fast variables. This complex behavior is analyzed using both a Liapunov-like approach and the recently introduced Mean-Variance Logarithmic (MVL) diagram.

Another effect of the strong coupling is the enhancement of the wave behavior which was latent in the one-scale model. Now wave patterns interfere with chaotic fluctuations giving rise to unexpected phenomena that are important for the initial ensemble preparation: Liapunov vectors (LVs) exhibit a spatial localization highly correlated to the wavy pattern. When the vector basis is orthogonal (backward and forward LV's) the localization site of each LV is determined by the selected metric instead of being determined by the true dynamics. This artificial disposition of the LVs (spurious effects of orthogonalization) can be avoided using the so-called characteristic LVs, an unambiguous basis that should be highly appreciated for assessing or constructing initial ensembles.