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Quasi-most unstable modes: a window to 'À la carte' ensemble diversity?

Victor Homar Santaner (1) and David J Stensrud (2)

(1) Universitat de les Illes Balears, Departament de Física, Palma de Mallorca, Spain (victor.homar@uib.es), (2) NOAA/National Severe StormsLaboratory, Norman, OK, USA

The atmospheric scientific community is nowadays facing the ambitious challenge of providing useful forecasts of atmospheric events that produce high societal impact. The low level of social resilience to false alarms creates tremendous pressure on forecasting offices to issue accurate, timely and reliable warnings.Currently, no operational numerical forecasting system is able to respond to the societal demand for high-resolution (in time and space) predictions in the 12-72h time span. The main reasons for such deficiencies are the lack of adequate observations and the high non-linearity of the numerical models that are currently used. The whole weather forecasting problem is intrinsically probabilistic and current methods aim at coping with the various sources of uncertainties and the error propagation throughout the forecasting system. This probabilistic perspective is often created by generating ensembles of deterministic predictions that are aimed at sampling the most important sources of uncertainty in the forecasting system. The ensemble generation/sampling strategy is a crucial aspect of their performance and various methods have been proposed. Although global forecasting offices have been using ensembles of perturbed initial conditions for medium-range operational forecasts since 1994, no consensus exists regarding the optimum sampling strategy for high resolution short-range ensemble forecasts. Bred vectors, however, have been hypothesized to better capture the growing modes in the highly nonlinear mesoscale dynamics of severe episodes than singular vectors or observation perturbations. Yet even this technique is not able to produce enough diversity in the ensembles to accurately and routinely predict extreme phenomena such as severe weather. Thus, we propose a new method to generate ensembles of initial conditions perturbations that is based on the breeding technique. Given a standard bred mode, a set of customized perturbations is derived with specified amplitudes and horizontal scales. This allows the ensemble to excite growing modes across a wider range of scales. Results show that this approach produces significantly more spread in the ensemble prediction than standard bred modes alone. Several examples that illustrate the benefits from this approach for severe weather forecasts will be provided.