Linear Regime Duration: Is 24 Hours a Long Time in Synoptic Weather Forecasting?

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Abstract

Day-to-day variations in the growth of uncertainty in the current state of the atmosphere have led to operational ensemble weather predictions in which an ensemble of different initial conditions, each perturbed from the best estimate of the current state and yet still consistent with the observations, is forecast. Contrasting competing methods for the selection of ensemble members is a subject of active research; the assumption that the ensemble members represent sufficiently small perturbations so as to evolve within the ''linear regime'' is implicit to several of these methods. This regime, in which the model dynamics are well represented by a linear approximation, is commonly held to extend to 2 or 3 days for operational forecasts. It is shown that this is rarely the case. A new measure, the relative nonlinearity, which quantifies the duration of the linear regime by monitoring the evolution of ''twin'' pairs of ensemble members, is introduced. Both European and American ensemble prediction systems are examined; in the cases considered for each system (87 and 25, respectively), the duration of the linear regime is often less than a day and never extends to 2 days. The internal consistency of operational ensemble formation schemes is discussed in light of these results. By decreasing the optimization time, a modified singular vector–based formation scheme is shown to improve consistency while maintaining traditional skill and spread scores in the seven cases considered. The relevance of the linear regime to issues regarding data assimilation, adaptive observations, and model sensitivity is also noted.