The role of nonlinear perturbation evolution in best-guess forecasts of land-falling midlatitude cyclones

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Ensemble forecasting is becoming increasingly important for numerical weather prediction, although certain characteristics of ensembles remain poorly understood. One example is the behavior of the ensemble mean once nonlinearity becomes significant. Ensemble perturbation evolution generally becomes more nonlinear as a forecast evolves, and as a result the ensemble mean can diverge from the model attractor on which ensemble members are constrained. In turn, the ensemble mean can become increasingly unrealistic, and although statistically best on average, can provide poor forecast guidance for specific high-impact events. This study uses an ensemble Kalman filter to investigate this behavior at the synoptic scale for land-falling midlatitude cyclones. This work also aims to understand the best way to select "best members" closest to the mean that both behave realistically and possess the statistically beneficial qualities of the mean.

It is found that substantial nonlinearity emerges within forecast times of a day, which roughly agrees with previous research addressing synoptic-scale nonlinearity more generally. The evolving nonlinearity results in unrealistic behavior of the ensemble mean that significantly underestimates precipitation and wind speeds associated with the cyclones. Choosing a single ensemble member closest to the ensemble mean over the entire forecast window provides forecasts that are unable to produce the relatively small errors of the ensemble mean. However, since different ensemble members are closest to the ensemble mean at different forecast times, the best forecast is composed of different ensemble members throughout the forecast window. The benefits and limitations of applying this methodology to improve forecasts of synoptic-scale high-impact weather events are discussed.