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Atmospheric Predictability Revisited

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In 1982 Edward Lorenz published a seminal paper on atmospheric predictability. Lorenz devised a method for quantifying upper and lower bounds of predictability. The lower bound was simply the forecast error (or predictive skill), determined by comparing forecast data, of varying lead times, with analysis data valid at the same time. The upper bound, or predictability, was determined by comparing consecutive pairs of forecasts, valid at the same time, but with lead times differing by some fixed time interval. As could be expected, the predictability error was smaller than the forecast error. We have repeated these experiments with a recent version of the European Centre for Medium Range Weather Forecasts (ECMWF) forecast system.

Results show significant improvement in the actual forecast skill (lower forecast error), partly due to model improvements, but also due to a significant reduction of the initial error due to better observations and to more advanced data assimilation. The estimate of predictability shows that the potential for further improvement via changes to the model is now less than in 1982. In fact the results suggest that the forecast skill is now close to its deterministic limit and that further improvements might only be achieved by a reduction of the initial error. The results indicate that deterministic prediction of the large scale atmospheric flow is limited to 2 weeks and that the ECMWF forecasts are now getting close to this limit.

Ensemble prediction provides a method of extending this intrinsic limit of a deterministic forecast. By integrating an ensemble of forecasts each started from slightly different initial conditions, an estimation of the probability density function of forecast states can be obtained. Predictability experiments have also been performed with the ECMWF ensemble forecasts, in which the predictive skill and predictability have been calculated for the ensemble mean forecasts analogous to the study of Lorenz (1982). These results will be presented and the potential for improving ensemble predictions discussed.