A Review of Ensemble Forecasting

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Ensembles are widely used, with demonstrated value. They are believed to sample a small subspace where error preferentially falls; with a much lower error in their mean, to contain genuinely more information about future weather; and with case-dependent variations in their distribution and cloud, to enhance probabilistic forecast performance and capture the dynamical evolution of the real atmosphere. Instead, an analysis of operational, perfect, and statistically generated ensembles reveal a different picture.

Error in initial conditions and short range forecasts is found to exhibit high independent degrees of freedom. Ensemble perturbations appear as random draws from this high dimensional domain we call the space of error. As such, perturbations have minimal projection on any single direction, including the actual realization of error. Which explains the lower level of information that is found in ensemble members, their mean, and any other derived product compared to an unperturbed control forecast, as well as the ensemble cloud's inability to encompass or bracket reality in the space of atmospheric dynamics.

Due to the odd geometry of high dimensional spaces, bracketing is missed not only by dynamically, but statistically generated samples, too. As members form a random sample in the space of error and case-dependent fluctuations have no effect on forecast performance, questions arise whether the less expensive statistical generation of samples should be reconsidered. Could statistical methods reproduce the effective noise filtering of the ensemble mean, while avoiding a loss in information suffered by dynamically generated samples through a centering of perturbations on the control?

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