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A stochastic perturbation shceme for representing model related uncertainty in ensemble forecasting

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It has been demonstrated that ensemble forecast systems can describe forecast uncertainty associated with errors in the initial conditions. The realistic description of model-related forecast errors is a more challenging task. Despite the development and application of various related techniques, ensemble forecast systems in general are underdispersive and cannot properly account for model-related uncertainty.

To represent model-related forecast uncertainty, a stochastic perturbation scheme has been developed for and tested with the National Centers for Environmental Prediction (NCEP) Global Ensemble Forecast System (GEFS). The scheme is based on the tiem evolving perturbations in an ensemble forecast system. The stochastic perturbations are defined based on the total conventional forcing, including the grid scale processes and the sub-grid scale parameterizations. Specifically, the stochastic perturbation (i.e., an extra forcing term) for a particular ensemble member is a weighted combination of the tendencies of the ensemble perturbations, i.e the differences in tendency between the ensemble members and the control forecast. The combination coefficients are generated through a temporally correlated stochastic process using constraints that keep the perturbations quasi-orthogonal. The resulting flow dependent perturbations are applied to all model state variables.

Initial tests with the stochastic perturbation scheme showed a significant reduction in the number of outliers, and an increase in the spread of the ensemble, reaching the level of RMS error of the ensemble mean. Also, a marked decrease in systematic errors was observed, along with an improvement in probabilistic forecast performance. Interestingly, the positive effects of the stochastic perturbation scheme are complementary to the effect of statistical post-processing used for reducing systematic errors.

When statistical bias correction is applied on the stochastically perturbed ensemble, the performance significantly surpasses that of an ensemble that is either only statistically bias-corrrected or only stochastically perturbed.