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A test of an alternative approach for uncertainty representation in weather forecasting

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Quantification of evolving uncertainties is required for both probabilistic forecasting and data assimilation in weather prediction. In current practice, the ensemble of model simulations is often used as primary tool to describe the required uncertainties. In this work, we explore an alternative approach, so called stochastic Galerkin method which integrates uncertainties forward in time using a spectral approximation in the stochastic space.

In an idealized two-dimensional model that couples compressible non-hydrostatic Navier-Stokes equations to cloud dynamics, we investigate the propagation of initial uncertainty. The propagation of initial perturbations is followed through time for all model variables during two types of forecasts: the ensemble forecast and stochastic Galerkin forecast. Since model simulations are very expensive in weather forecasting, our hypothesis is that the stochastic Galerkin would provide more accurate and cheaper forecast statistics than the ensemble simulations. Results indicate that uncertainty as represented with mean, standard deviation and evolution of trace through time provides almost identical results if a 10000-member ensemble is used and truncation of stochastic Galerkin is made at ten spectral modes. However, for coarser approximations, for example if 50 ensemble members are used or the stochastic Galerkin is truncated at two modes, differences in standard deviations become significant in both approaches. A series of experiments indicates that differences in performance of the two methods depend on the system state. For example, for stable flows, the stochastic Galerkin outperforms the ensemble of simulations for every truncation and every variable. In very unstable, turbulent flows the estimate of the mean between the two methods still remains similar. However, the ensemble of simulations needs more than 100 members (depending on the model variable) and the stochastic Galerkin a truncation with more than five spectral modes, to produce accurate results.