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Including Cloud Microphysics Uncertainty in Convective Data Assimilation: Stochastic vs Static Parameter Perturbations

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It has long been known that model physics uncertainty can contribute as much or more to errors in forecasting and data assimilation as errors in initial conditions. Many studies have attempted to include the effects of model physics uncertainty in data assimilation by introducing static perturbations to model parameters. In such studies, parameter values are modified at the beginning of a simulation and remain unchanged throughout the duration of the forecast. Uncertainty is spanned by generating an ensemble of forecasts, each member having a different set of parameter values. Other studies have implemented dynamic perturbations to parameters, introducing methods that modify parameter values online in a stochastic fashion.

We present here the results of a study that investigates the sensitivity of convective cloud structures to static and stochastic cloud microphysical parameter perturbations. Static parameter values are drawn from a database produced by a Markov chain Monte Carlo algorithm, while stochastic perturbations are applied via a stochastically perturbed parameterization (SPP) scheme. Both static parameter perturbations and SPP are applied to multiple microphysical parameters within a Lagrangian column model, used in several prior published studies. The 1D column microphysics model is forced with prescribed time-varying profiles of temperature, humidity and vertical velocity in such a way as to emulate the environment inside of a convective storm. This modeling framework allows for investigation of the effect of changes in model physics parameters on the model output in isolation from any feedback to the cloud-scale dynamics.

The results are evaluated in terms of changes to the ensemble mean and variance of time evolving profiles of hydrometeor mass quantities, the microphysics processes within the model as well as in terms of the simulated column integral microphysics-sensitive satellite-based observables. The outcomes of our experiments indicate a high degree of sensitivity of the to the way in which the SPP scheme is implemented. In particular, the distributions from which parameters are drawn, as well as the decorrelation time scale, have a large effect on the simulation outcomes. We discuss the results of SPP, compare with our static perturbation experiments, and note the implications

for convective scale data assimilation.