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## Sensitivity of modeled microphysics to stochastically perturbed parameters

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This study investigates sensitivity of cloud and precipitation parameterized microphysics to stochastic representation of parameter uncertainty as formulated by the stochastically perturbed parameterization (SPP) scheme. SPP is applied to multiple microphysical parameters within a lagrangian column model, used in several prior published studies to characterize parameter uncertainty by means of multivariate nonlinear inversions using remote sensing observations. The 1D column microphysics model is forced with prescribed time-varying profiles of temperature, humidity and vertical velocity. 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 test case selected in this study of an idealized representation of mid-latitude squall-line convection is the same as in the prior studies. This enabled using the estimates of multi-parameter distributions from the inversions in the prior studies as the basis for setting the second-moment statistics in the SPP scheme implementation. Additionally impacts of the non-stochastic and stochastic multi-parameter representation of parameterization uncertainty on the microphysics model solution could be directly compared.

The sensitivity experiments with the SPP scheme involve ensemble simulations where each member is evolved with a different stochastic sequence of parameter perturbations, as is done in the standard practice with this scheme. The experiments explore impacts of using different decorrelation times and different estimates of second moment statistics for the parameter perturbations. These include uncorrelated perturbations between the parameters for several values of variance for each parameter and correlated perturbations based on multi-parameter empirical statistical distributions from the prior studies. The selection of physical parameters for the perturbations is based on the significance of their impacts derived from the prior studies.

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 latter include PR (Precipitation Rate), LWP (Liquid Water Path), IWP (Ice water path), TOA-LW and TOA-SW (-Long and -Short Wave, respectively). In each experiment six parameters were

perturbed.

The analyses performed so far indicate a high sensitivity of the microphysics model to the SPP scheme. The ensemble simulations with the standard uncorrelated parameter perturbations exhibit a significant bias relative to the control simulation which uses the unperturbed parameters. For the selected test case the skewness toward small parameter values in the SPP sampling based on the underlying log-normal distributions leads to less precipitating ice and more precipitating liquid and accumulated precipitation. The response is due to nonlinear relationships between the parameters and modeled microphysics output. The changes in microphysics output result in large mean changes in PR, LWP, IWP, TOA- LW and SW, suggesting a potential for using these and other microphysics sensitive satellite observations to evaluate and if needed correct properties of the underlying sampling distribution in the stochastic scheme. Further analyses will be presented at the conference.