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New efficient method to account for microphysical inhomogeneity in mesoscale models by using 1D variability factor

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Neglecting subgrid-scale (SGS) variability can lead to substantial bias in calculations of microphysical process rates. The solution to the SGS variability bias problem lies in representing the variability using two-dimensional joint probability distribution functions (JPDFs) for the pairs of different microphysical variables. The JPDFs have also been shown to depend on height, as a result their implementation in mesoscale models presents a challenging task.
We developed a more efficient formulation of cloud inhomogeneity by using a concept of “generic” JPDF. Using Large Eddy Simulation (LES) studies of shallow cumulus and cumulus congestus clouds we showed that JPDFs calculated based on datasets from the entire simulation time period (“generic” JPDFs) provide good approximation of microphysical process rates. . The generic JPDF, therefore, represent the cloud type in general, that is they do not depend on changing ambient conditions. The advantage of generic JPDFs is that they can be a-priory integrated and yield a one-dimensional variability factor (V-factor) specific for each cloud type. A quite accurate approximation of V-factors by an analytical function in the form of a 3rd order polynomial was obtained and can be easily implemented in mesoscale models.
How big is the effect of cloud inhomogeneity on precipitation? To answer this question we evaluated the effect of accounting for cloud inhomogeneity on precipitation in sensitivity simulations. In the shallow Cu case over the 24 h simulation the surface precipitation increased by 38% when inhomogeneity was accounted. In the congestus Cu case the increase in precipitation was even more significant: by more than 75% over only 8 hours since rain first appeared at the surface. The sensitivity experiments also revealed that most of the increase resulted from the augmented autoconversion process. The effect of modified by V-factor accretion rates was much less significant, primarily, because of the nearly linear dependence of accretion on its parameters. This shows importance of the most accurate formulation of the autoconversion process.