Simulated Thunderstorm Electrification Comparing Bin and Bulk Microphysics

Cloud Electrification Processes

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The vast majority of multidimensional (2D or 3D) numerical modeling studies of explicit storm electrification have used bulk microphysics to represent cloud and precipitation particles. An oft-raised question is how well the bulk schemes can simulate cloud physics compared to much more computationally expensive bin models. and even more so in the realm of electrification, which critically depends on ice interaction rates. For this study, the spectral bin microphysics scheme of Takahashi (1976) has been incorporated into the COMMAS cloud model with a new implementation of electrification within the scheme. The bin microphysics code was graciously contributed by Dr. Takahashi. The comparison 2/3 moment bulk scheme predicts total mass and number concentration for 5 hydrometeor species, and additionally predicts the sixth moment (reflectivity) for rain, graupel, and hail. The same noninductive graupel-ice collisional charge separation schemes are tested with both microphysics.

A primary task in bulk-bin comparison is to achieve a reasonable similarity in microphysical results. Some new physics were added the bin scheme (e.g., wet growth of large ice particles, incremental melting of ice particles, ice collection by graupel, and conversions of small frozen drops to graupel and large graupel to hail). The bulk scheme has also been adapted to improve the similarities in the early stages of storm development. Because ice crystals play a significant role, the same primary ice nucleation parameterization was implemented in both schemes, and the contributions of Hallett-Mossop ice multiplication process are noted.

Riming efficiency plays a large role in the bulk scheme for comparability of initial ice growth, charge separation rates, and precipitation accumulation. The bulk and bin results generally agree on dominant charging sign for a given noninductive scheme, but can have significant differences in details (e.g., complexity of charge layers) and thus also in the resulting simulated lightning. Results will be presented for simple 2-dimensional examples with wind shear, as well as for fully 3-dimensional storm simulations.