Charge Structure and Lightning Patterns in Simulated Mesoscale Convective Systems
Cloud Electrification Processes

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Observations of charge structure within the stratiform region of a mesoscale convective system (MCS) repeatedly reveal quasi-steady, horizontal charge layers at and above the melting level. The uppermost layers purportedly result from a charge advection process as charged ice particles are ejected from the convective line into the weaker downdrafts of the transition zone. These sloping layers persist beyond the transition zone to the weak, broad mesoscale updrafts in the stratiform region. The horizontal extent of the upper charge regions has also been corroborated by lightning mapping arrays, which indicate the layers serve as a conduit for lightning initiated in upper portions of the convective line, yet reach ground toward the rear of the stratiform region where a lower positive charge layer is diminished or nonexistent. Near the melting level, in particular the layer below -10°C, significant charge densities are consistently evident. This charge is apparently independent of the convective line, thus it is reasonable to hypothesize that some *in situ* charging process is actively creating and maintaining these charge layers.

Other two-dimensional kinematic models have shown melting and evaporation processes were insignificant compared to charge advection or non-inductive charging, although charge advection was highly parameterized. This study reexamines the contribution of charge separation by melting graupel, or possibly melting snow aggregates, to the generation and maintenance of charge layers near the melting level. In doing so, we employ a high-resolution, three-dimensional model using full dynamics with two-moment microphysics. The model microphysics include prediction of liquid water fractions on graupel and snow to better parameterize these alternate charge separation mechanisms. The model solutions exhibit similar structure to the standard conceptual model of a leading-line, trailing stratiform MCS with respect to observed kinematics, microphysics, and charge structure. Negative cloud-to-ground (-CG) flashes are primarily produced in the leading-line cells, whereas positive CG flashes are more likely in the transition zone behind the leading line. A comparison of charge separation mechanisms specific to the melting layer is also examined.