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Environmental factors controlling lightning in a cold-based continental storm

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No physical process in a cloud occurs in isolation. Lightning is no exception. Only a few laboratory experiments have ever been performed to measure charge separation in ice-ice collisions. Yet they are sufficient to permit the study of dependencies of lightning on diverse environmental factors by simulating observed storms with numerical models. These factors include the loadings of solid and solute aerosols and vertical profiles of humidity and temperature in the environment.

In the presentation, an electrification component of a cloud model is described and its validation against coincident observations of lightning in a cold-based continental storm is shown (19/20 June 2000 UTC, Colorado/Kansas, USA). This storm case is interesting as the cloud base (near 0 degC) is too cold either for coalescence or for the usual Hallett-Mossop process of rime-splintering. Instead the precipitation arises from the ice crystal process, while high ice concentrations arise from breakup in ice-ice collisions. The electrification component involves the tracing of two leader channels, one positive and the other negative, from each trigger-point where the field exceeds the dielectric breakdown threshold. Branching is then added in a parameterized manner, using an empirical branching law. Charge is separated in ice-ice collisions, as represented with lab observations.

Secondly, the relations between such environmental factors, the thunderstorm microphysics and lightning are quantified by means of budget analyses of the validated simulation and sensitivity tests. Lightning is shown to arise mostly from charging collisions involving fragments from previous ice-ice collisions. The reversal of charging polarity at warm subzero temperatures contributes to the normal tripole structure of charge density where lightning is triggered. The graupel is produced by riming of snow near the downshear edge of the convective updraft, where graupel-snow collisions separate charge, and the lightning occurs where the charged graupel falls out.

To conclude, possible directions for future laboratory experimentation on charge separation are delineated.