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Influences from soluble and insoluble aerosols on precipitation and lightning in deep convection

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Observations reported in past studies in the literature have revealed correlations between measures of aerosol loading and lightning occurrence. Recent advances in simulating cloud-microphysical processes have highlighted their control by aerosol conditions. New hypotheses about aerosol-precipitation-lightning interactions have emerged.

Most deep convective clouds globally have warm bases with precipitation controlled by coalescence and by loadings of soluble aerosols, which form droplets. However, those over mountainous continental regions often have cooler bases and can generate much hail that reaches the ground. Cold-base convective clouds were observed to produce lightning over the High Plains of the USA during the Severe Thunderstorms Electrification and Precipitation Study (STEPS) in the summer of 2000.

Cold-base thunderstorms can be without an active coalescence process, due to the low adiabatic liquid water content limiting droplet sizes. There is then the potential for a greater influence from ice-nucleating insoluble aerosols on ice-precipitation production, charge separation and lightning, relative to soluble aerosols.

In the presentation, an aerosol-cloud model (hybrid bin/2-moment bulk microphysics, prognostic aerosol component with 6 aerosol species) with a new electrification component is described. The model treats non-inductive charge separation and has a lightning discharge scheme. A simulation of a STEPS case of a cold-base thunderstorm is validated against aircraft, radar and electrical observations.

Sensitivity tests are presented to show the roles of ice multiplication and ice-nucleating aerosols, such as dust and soot from biomass-burning plumes, in controlling ice-precipitation production and lightning frequencies for the cold-base thunderstorm. Their influence is compared with that from soluble aerosol loadings. The roles of cloud-base temperature and wet growth of hail and graupel are discussed.