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The interaction between aerosols, ice multiplication and lightning: a modeling perspective

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In much of the troposphere, temperatures are subzero and clouds contain ice. In clouds with tops warmer than -36 degC, the first ice can only be initiated by solid aerosol. At temperatures colder than -36 degC in the upper troposphere, all liquid must freeze. The problem is that in clouds warmer than -36 degC, the solid aerosols cannot account for most of the ice observed and the precise identity of the implied fragmentation is often unclear, especially when the cloud base is cold, out of several types of fragmentation possible.

In the presentation it is shown that fragmentation in collisions of graupel or hail with snow produces most of the ice in such clouds. An energy-based formulation for fragmentation in ice-ice collisions is developed. It is found in numerical simulations of a continental convective storm that this type of fragmentation must be represented for ice concentrations observed by aircraft to be predicted. Break-up was predicted to generate about $10-20$ times more ice particles than solid aerosols and reduced surface precipitation by about 30%.
Moreover, we found this fragmentation has the remarkable ability to multiply the number of ice particles by a positive feedback, with a super-exponential explosion of ice number, consistent with our previous theory.

Numerical simulations with a coupled aerosol-cloud-lightning model are validated for a comprehensively observed case over the US High Plains. Sensitivity tests show how ice multiplication mediates the linkage between aerosols and the charge separation controlling lightning.