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Ice multiplication by mechanical breakup and lightning

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Laboratory studies have proven the existence of several pathways for fragmentation of ice. One of these is the rime-splintering of graupel or hail in the -3 to -8 degC region (the Hallett-Mossop process). In some clouds, however, the cloud-base is too cold for this process to be active. Instead, breakup can occur by fragmentation of ice mechanically in re-bounding collisions between crystals, snow, graupel or hail.

A new theoretical formulation of this mechanical breakup process of multiplication is presented for these types of ice. A numerical scheme is derived by simulation of published laboratory experiments.

The role of such breakup in clouds is quantified by 3D simulations with a cloud-resolving aerosol-cloud model with emulated bin microphysics, detailed treatment of ice morphology and 7 chemical species of aerosol. Graupel-graupel collisions are predicted to produce copious numbers of ice crystals in the cold-base convective cloud simulated over Kansas.

Implications for lightning from such multiplication, also simulated numerically, are discussed.