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The Impact of Vertical Wind Shear on Hail Growth in Simulated Supercell Storms

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Severe hailstorms produce billions of dollars in insured losses annually in the United States and Europe, yet the details of a given storm's hail threats (maximum hailstone size, total hailfall, etc.) remain challenging to forecast. Previous research suggests that storm-relative airflow patterns could be equally as important as maximum updraft speed for hail formation and growth, but this has yet to be explored systematically across a wide parameter space. The storm-relative airflow and storm structure is governed in part by environmental factors such as vertical wind shear. This talk describes our first step toward determining how changes in environmental wind shear and subsequent changes in simulated supercell storm structure affect hail production.

Twenty idealized supercell simulations are performed in which the thermodynamic profile remained fixed, but the environmental hodograph was systematically altered. Hail growth is quantified using composites of storms over the last hour of simulation time. Hailstone growth "pseudotrajectories" are computed from these storm composites to determine favorable embryo source regions. Our results indicate that increased deep-layer, zonal shear elongates the storm's updraft in that direction, providing (1) increased volumes over which relevant hail microphysical processes can act, (2) increased hailstone residence times within the updraft, and (3) a larger potential embryo source region; together, these lead to increased hail production. Increased low-level, meridional shear (which results in hodographs with increased 0-3-km storm-relative helicity and a greater tornado potential) similarly elongates the updraft in the north-south direction. However, hail mass is reduced owing to a separation of favorable embryo source regions (which shift southward) and available hydrometeors to serve as embryos (which shift northward). Operational implications and outstanding questions will be discussed.