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Experimental Simulation of Downburst lines: A Particle Image Velocimetry Study of Downburst Collisions

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ABSTRACT

The near-surface velocity vector fields in the collision region of experimentally simulated thunderstorm downburst line events were resolved in two plane orientations, vertical and horizontal, using a dense fluid release system and Particle Image Velocimetry. The interaction between two release events was varied temporally as a time delay between event releases and spatially as a centre-to-centre separation distance to simulate a stationary downburst line in a quiescent ambient environment. Scaled separation distances of 3.2 km and 4 km were simulated at scaled time delays of 0, 30, and 120 seconds. Near-surface radial velocities of up to 1.5 times that of a single downburst release event were found in the lateral outflow plane of the collision region at a scaled separation distance of 3.2 km and a scaled event release time delay of 30 seconds. Velocities in the vertical plane were found to remain unaffected with radial velocity magnitudes close to that a single release event. No significant increases in velocities were found at time delays less than or greater than 30 seconds for both scaled separation distances used in this study. Scaled separation distances of 4 km were found to produce weak outflow interactions in general with no increase in near-surface radial velocities beyond those of a single event. A vortex trajectory analysis using the lambda criterion was used to characterize the interaction of the horizontal vortex rolls in the collision region. The trajectory analysis indicated that, at the scaled time delay between event releases of 30 seconds at a scaled distance of 3.2 km, the horizontal vortex roll of the first event was forced close to the ground by the weight of the collision of the second event. This interaction between the two events horizontal vortex rolls provided experimental support of previous numerical works into how the collision of downburst events can cause greater near-surface velocities.