Operational Application of 0-3 km Bulk Shear Vectors in Assessing Quasi-Linear Convective System Mesovortex and Tornado Potential

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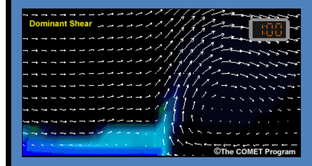
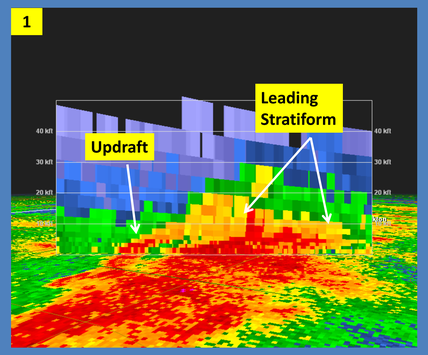
Shear/ Cold Pool Balance

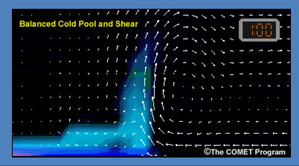
Dominant Shear



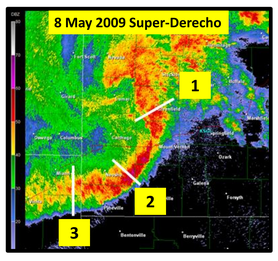


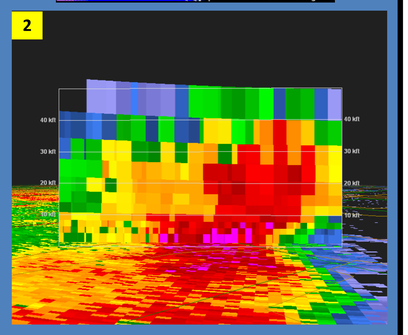
1. Near-surface updraft/downdraft convergence zone (UDCZ) is located behind developing updraft
2. Radar cross-sections or all-tilts indicates updrafts are forward leaning with less vertical development
3. Width of the updrafts can be notably thin
4. Potential leading stratiform precipitation

Balanced Cold Pool and Shear

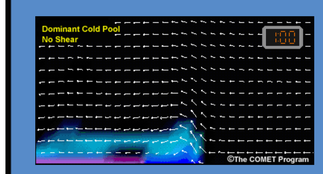


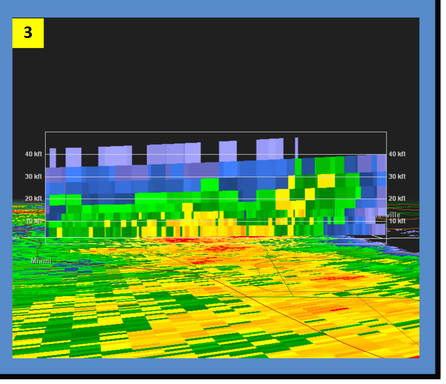
1. UDCZ located immediately downstream of vigorous convection
2. Radar cross-sections or all-tilts indicates updrafts are nearly vertical and deep in nature (perhaps compared to other convection within the QLCS)
3. A strong reflectivity gradient is noted on the forward flank of the segment
4. Echo tops are higher than surrounding convection
5. Trailing stratiform precipitation





Dominant Cold Pool



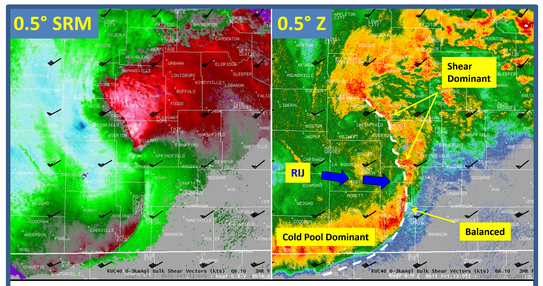


1. UDCZ or gust front is outrunning the main convection
2. Radar cross-sections or all-tilts indicates updrafts are leaning rearward with less vertical development
3. Trailing stratiform precipitation

Mesovortex Genesis Favored

1. In a portion of the QLCS in which the cold pool and ambient low-level shear are nearly balanced or slightly shear-dominant. ***AND***
2. Where 0-3 km line-normal bulk shear magnitudes are equal to or greater than 30 knots. ***AND***
3. Where a rear-inflow jet (RIJ) or enhanced outflow causes a surge or bow in the line.

Updraft/Downdraft Convergence Zone (UDCZ)



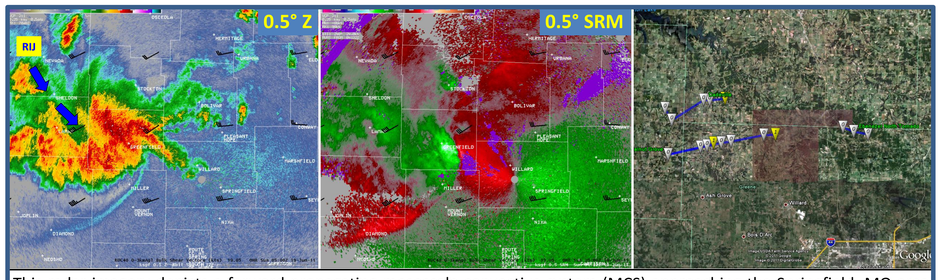
These radar images depict the 8 May 2009 super-derecho as it was moving into Springfield, MO. The UDCZ is readily apparent on the 0.5° SRM image (left). Comparison of the UDCZ to 0.5° reflectivity (dashed line in right image) effectively highlights differing shear/cold pool balance regimes. 0-3 km bulk shear vectors are overlaid in black. Despite an angle to the vectors in the balanced region, line-normal magnitudes still exceeded 30 knots. With a strong RIJ impinging on this region, all three criteria were met for mesovortex genesis. This system went on to spawn over 20 tornadoes.

Line Normal 0-3 km Bulk Shear Magnitude

Δu = sin(θ)m

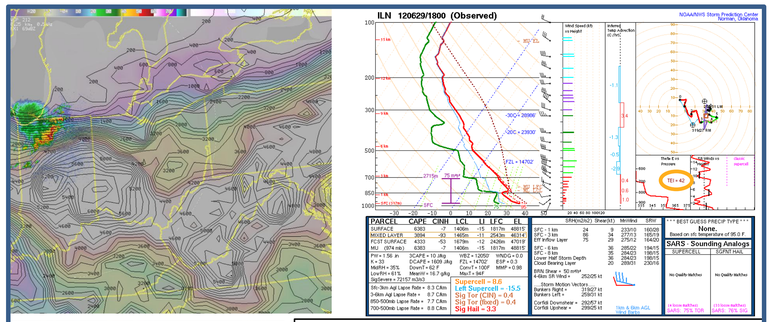
Δu = line normal magnitude of 0-3 km bulk shear
Θ = angle between convective line and 0-3 km bulk shear vector
m = magnitude of 0-3 km bulk shear vector

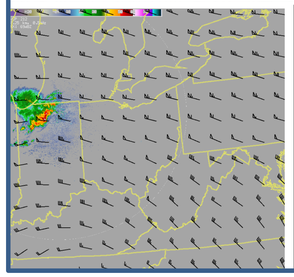
18 June 2011 Southern Missouri



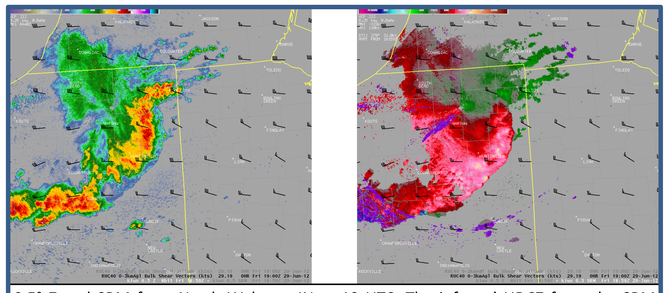
This radar imagery depicts a forward propagating mesoscale convective system (MCS) approaching the Springfield, MO area during the late evening of 18 June 2011. 0-3 km bulk shear vectors are overlaid in black. The line appears to be in balance just to the east of Greenfield, MO as the UDCZ is located on the front edge of vigorous updrafts. 0-3 km bulk shear vectors were orientated nearly perpendicular to the UDCZ resulting in line-normal magnitudes of 30-35 knots. A RIJ also impinged on the UDCZ in this same area with a notable bowing structure. This system went on to spawn 3 tornadoes just to the north and northwest of Springfield, MO, and would spawn 2 additional tornadoes in eastern MO.

29 June 2012 Ohio Valley/Mid-Atlantic Derecho

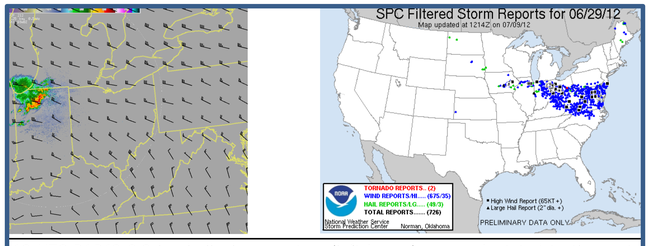




The environment during the afternoon of the 29th featured extreme amounts of instability from the Ohio Valley into the Mid-Atlantic region. The 18 UTC RAP40 depicted MUCAPE values in the 3500-5500 J/kg range (upper-left). An 18 UTC sounding out of Wilmington, OH (upper–right) also indicated a delta theta-e value of 42 degrees Kelvin when comparing parcels between the surface and 700 mb. This thermodynamic environment favored very strong cold pool potential and was a prime candidate for a forward propagating MCS. Radar imagery with 18 UTC RAP40 forward propagating Corfidi vectors overlaid (lower-left) indicated the potential for forward MCS speeds of around 50 knots.



0.5° Z and SRM from North Webster, IN at 19 UTC. The inferred UDCZ from the SRM product appears to be slightly ahead of the main convection. Thus, this forward propagating MCS appears to be cold pool dominant. The RAP40 0-3 km bulk shear vectors (black overlay) were aligned nearly normal to northern portions of the line with magnitudes between 25 and 30 knots. While very brief and weak mesovortex genesis was noted at times along the advancing gust front, 0-3 km line-normal bulk shear magnitudes were too weak to balance the strong cold pool.



18 UTC RAP40 0-3 km bulk shear vectors (left image) were orientated to the east-southeast as the developing derecho was moving out of northwestern Indiana. With magnitudes generally less than 30 knots and conditions conducive for a strong system cold pool, the derecho would likely remain cold pool dominant as it advanced into the Mid-Atlantic region. Preliminary storm reports from the Storm Prediction Center (right image) indicated expansive wind damage with several reports of straight-line winds exceeding 65 knots. Despite the two preliminary reports of tornadoes in eastern Ohio, storm surveys revealed that the damage was caused by straight-line winds.