The 30 June 2014 Midwestern Double Derecho Event, Part 1: Environmental Overview and Radar Analysis of the Second Derecho

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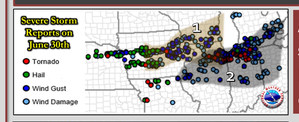
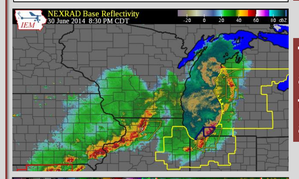
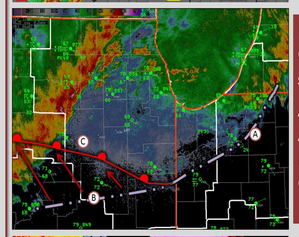
Event Overview



A pair of derecho-producing quasi-linear convective systems (QLCSs) impacted northern Illinois and northern Indiana from the evening of 30 June to the predawn hours of 1 July 2014.

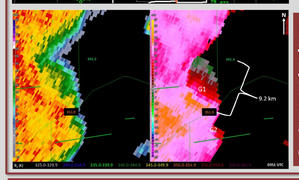


The second QLCS trailed the first one by only 250 km and approximately three hours, producing 30+ confirmed tornadoes (18 in the Kankakee River Valley) and many areas of straight-line winds estimated at 40-50 m s^{-1}.

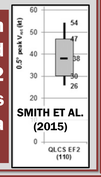


Interaction with a stalled outflow boundary from the first QLCS is believed to be critical to the evolution of the second QLCS.

At 0200 UTC on 1 July 2014 this image shows:
A—Current leading edge of cold pool from first QLCS.
B—Original southern extent of cold pool from first QLCS.
C—Current position of mesoscale warm front as the cold pool lifts back north. *From Lyza et al. 2017*

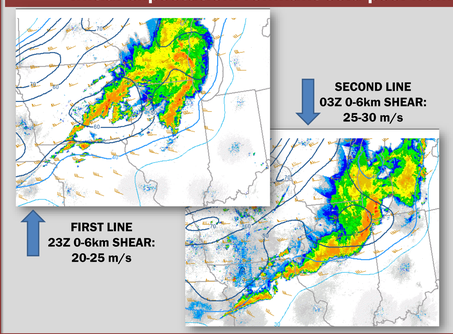


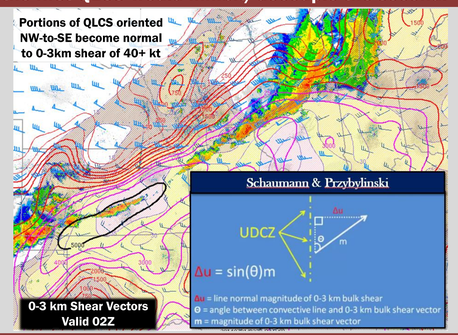
By 0341 UTC as the second QLCS moved through the Kankakee Valley, the outflow boundary had worked back north to produce a very sharp (1.2 K/km) theta-e gradient. Mesovortex G1 in this area reached a peak V_{rot} of 29 m/s (57 kt) and a depth of nearly 9 km.

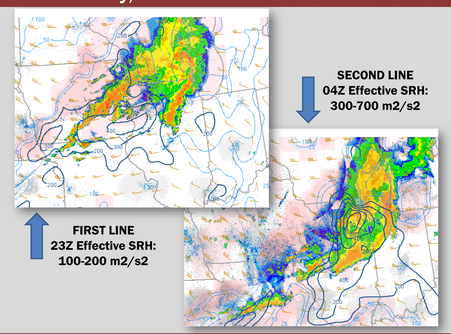


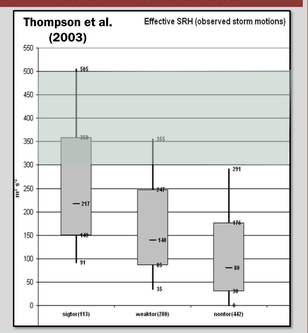
Synoptic and Mesoscale Evolution

Initial expectation: remnant cold pool from the first QLCS would inhibit/decouple the second. To the contrary, conditions evolved to become much more favorable for tornadoes.



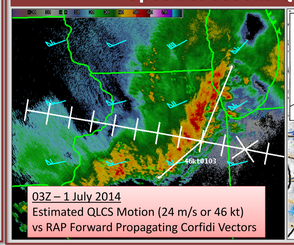


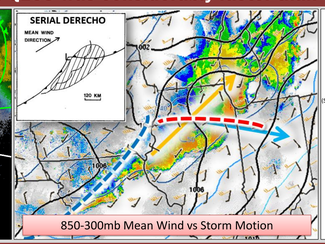


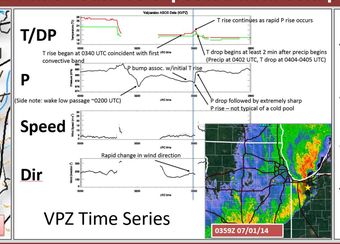


Bore Driven Motion of Second QLCS

Speed of second QLCS was considerably faster than what would be expected from cold pool propagation, especially within the remnant cold pool from the first QLCS.







Bore Observations & Dynamics

TEMPERATURE:	Steady or rising
MIXING RATIO:	Steady or decreasing
PRESSURE:	Rapid rise

All are semi-permanent (not transient)

Destabilization of Boundary Layer

Common consequence of bores
Raise inversion height
Mix warmer, drier air to surface
Temperature rise just ahead of QLCS arrival

Speed of Density Current (shallow, with drag): $c = k\left[gh\frac{\rho 1-\rho 0}{\rho 0}\right]^{\frac{1}{2}}$

Speed of Gravity Wave: $C_{gw} = \left[g\left(\frac{\Delta\theta v}{\theta v}\right)h_0\right]^{\frac{1}{2}}$

Speed of Bore: $C_{bore} = C_{gw}\left[\frac{1}{2}\frac{h_1}{h_0}\left(1+\frac{h_1}{h_0}\right)\right]^{\frac{1}{2}}$

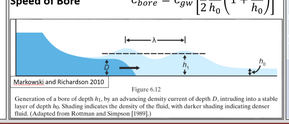


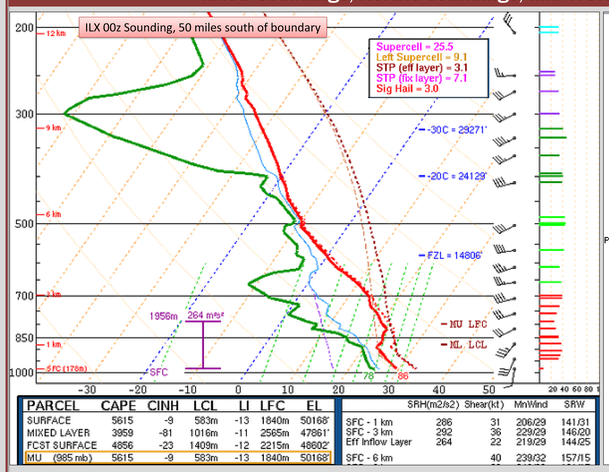
Figure 6.12
Generation of a bore of depth h_1, by an advancing density current of depth D, intruding into a stable layer of depth h_0. Shading indicates the density of the fluid, with darker shading indicating denser fluid. (Adapted from Rottman and Simpson [1989].)

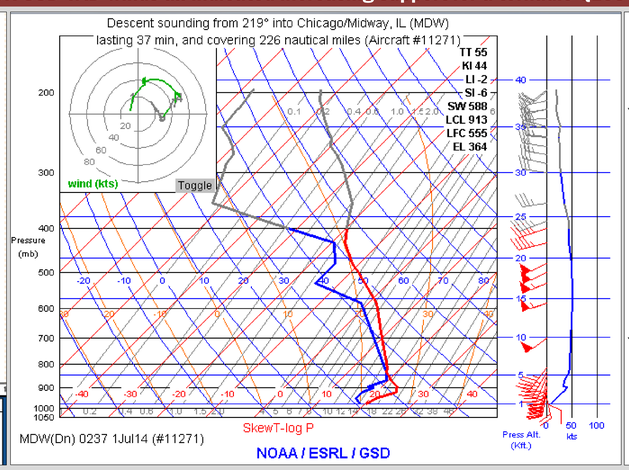
System Motions thru VPZ Area

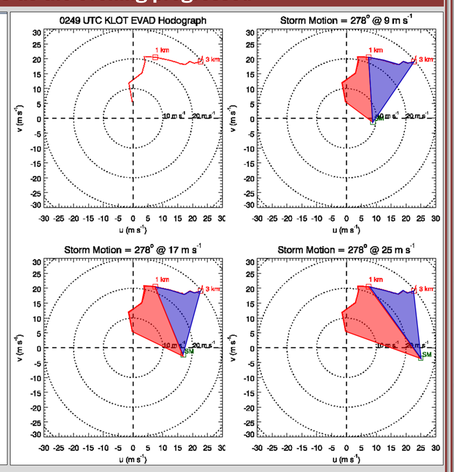
	1st QLCS	2nd QLCS
Actual Speed	17 m/s	25 m/s
Theoretical Cold Pool Speed	16-30 m/s	9-17 m/s
Theoretical Bore Speed	n/a	26 m/s

Soundings and Hodographs

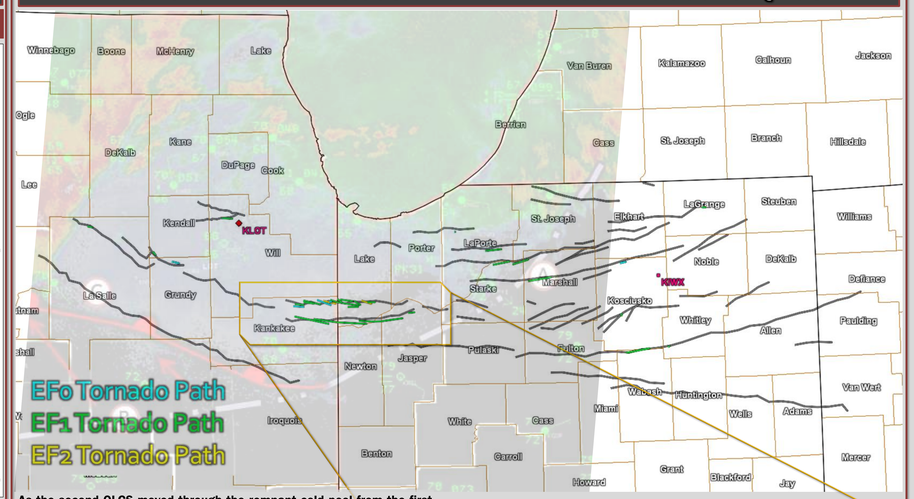
RAOB soundings, ACARS soundings, and WSR-88D VAD winds all indicated increasing support for a tornadic QLCS as the evening progressed





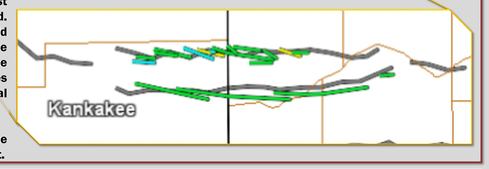


Tracks of Mesovortices and Tornadoes in Second QLCS

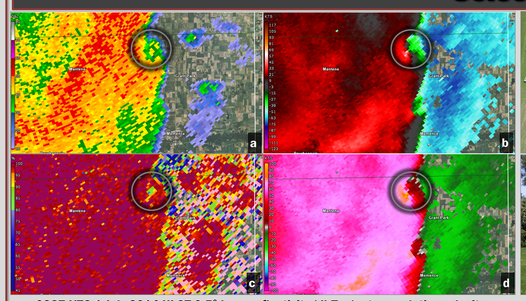


As the second QLCS moved through the remnant cold pool from the first QLCS, only isolated mesovortices (gray tracks) and tornadoes developed. The second QLCS became prolifically tornadic near the edge of the cold pool while intersecting the remnant outflow boundary in the Kankakee Valley. As it moved into the less stable air in Indiana and away from the outflow boundary, mesovortices became more numerous but tornadoes less concentrated, though it should also be noted that additional undocumented tornadoes may have occurred in Indiana.

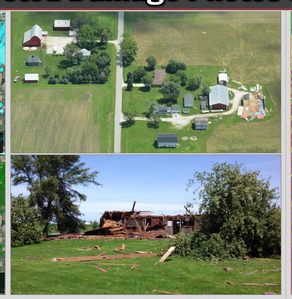
The overlay of radar and surface station plots is valid 0200 UTC as the first QLCS was exiting and the second was entering the region of interest.



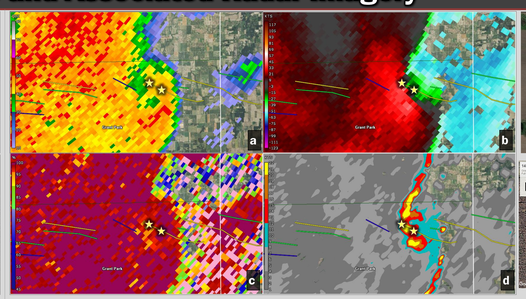
Selected Damage Photos and Associated Radar Imagery



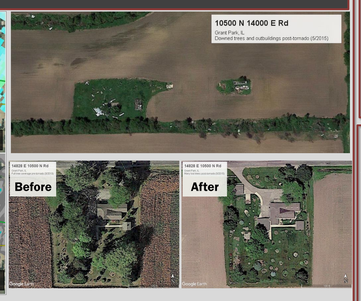
0327 UTC 1 July 2014 KLOT 0.5° base reflectivity (dbZ, a), storm relative velocity (kt, b), correlation coefficient (% ρ_{hv}, c), and base velocity (kt, d). TDS is circled.



Damage northwest of Grant Park, IL, near location of TDS annotated in radar imagery.



Left: 0330 UTC 1 July 2014 KLOT 0.5° base reflectivity (dbZ, a), storm relative velocity (kt, b), correlation coefficient (% ρ_{hv}, c), and spectrum width (kt, d). Left and right stars correspond to the upper and lower photos. A TDS also is visible in this radar image.



For More Information

- Lyza, A. W., A. W. Clayton, K. R. Knupp, E. Lenning, M. T. Friedlein, R. Castro, and E. S. Bentley, 2017: Analysis of Mesovortex Characteristics, Behavior, and Interactions during the Second 30 June - 1 July 2014 Midwestern Derecho Event. *Electronic J. Severe Storms Meteor.*, **12** (2), 1–33.
- Lyza, A. W., R. Castro, E. Lenning, M. T. Friedlein, B. S. Borchardt, A. W. Clayton, and K. R. Knupp, 2019: A Multi-Platform Reanalysis of the Kankakee Valley Tornado Cluster on 30 June 2014. *Electronic J. Severe Storms Meteor.*, **14** (3), 1–64.

Also see Part 2 of this poster presentation:

The 30 June 2014 Midwestern Double Derecho Event, Part 2: Analysis of a Complex Tornado Cluster during the Second Derecho