Applications of Dual Pol Data and the Latest Science in Severe Weather Warning Operations at NWS St. Louis

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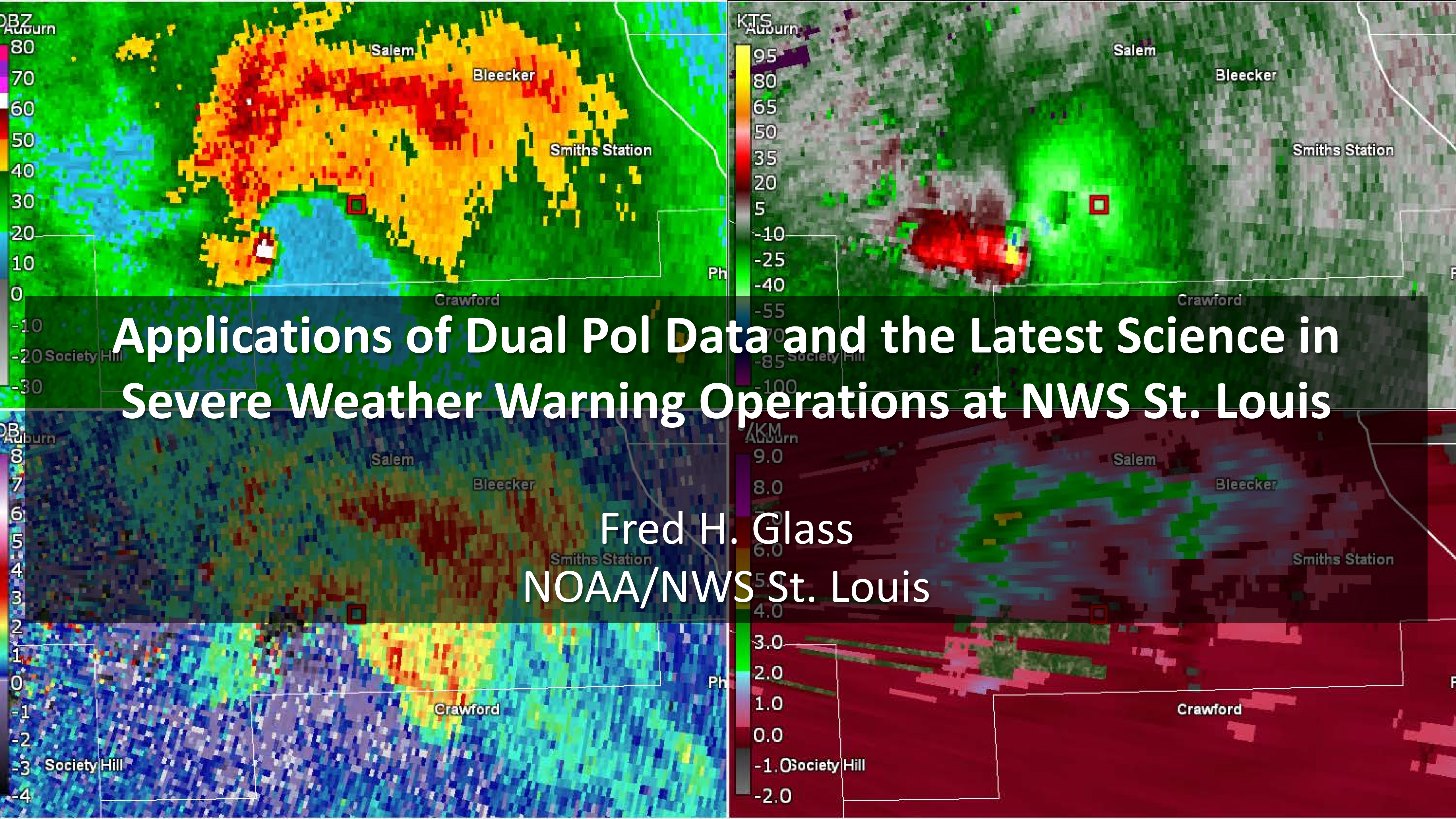
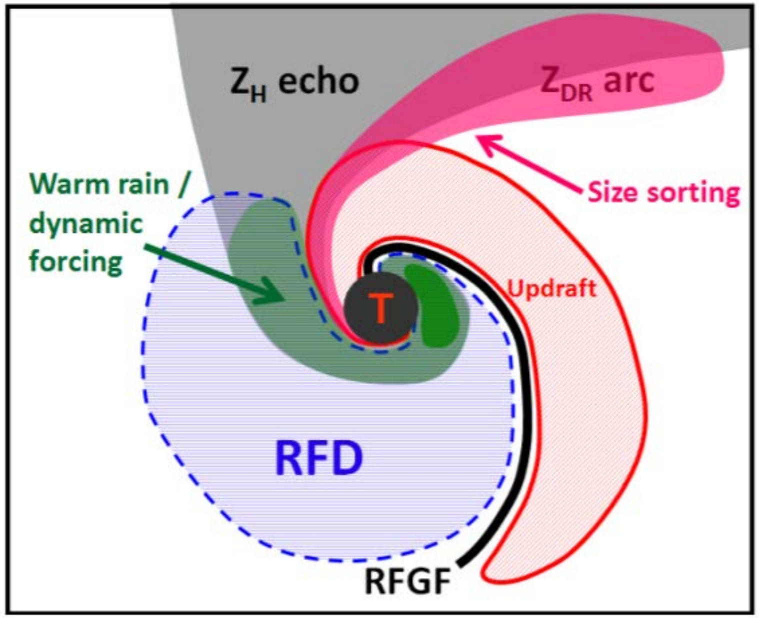
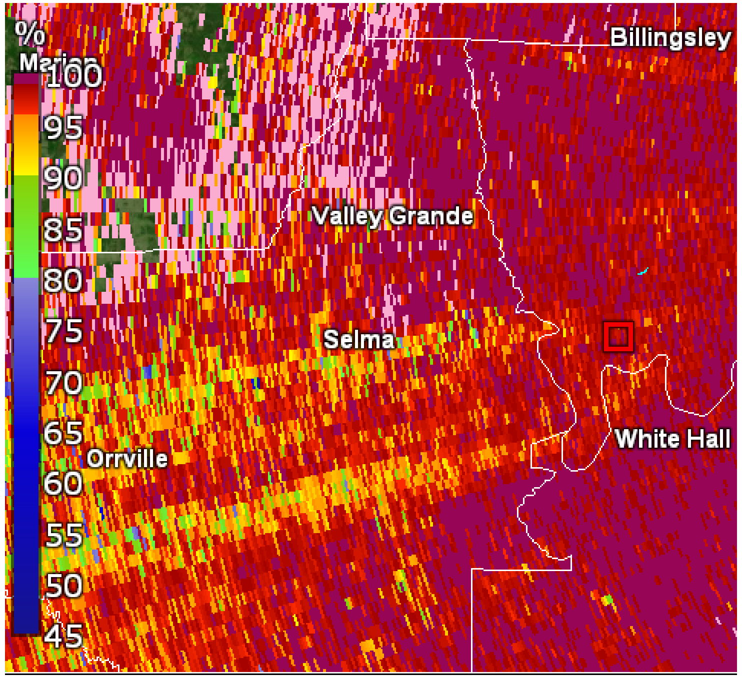
NOAA/NWS St. Louis

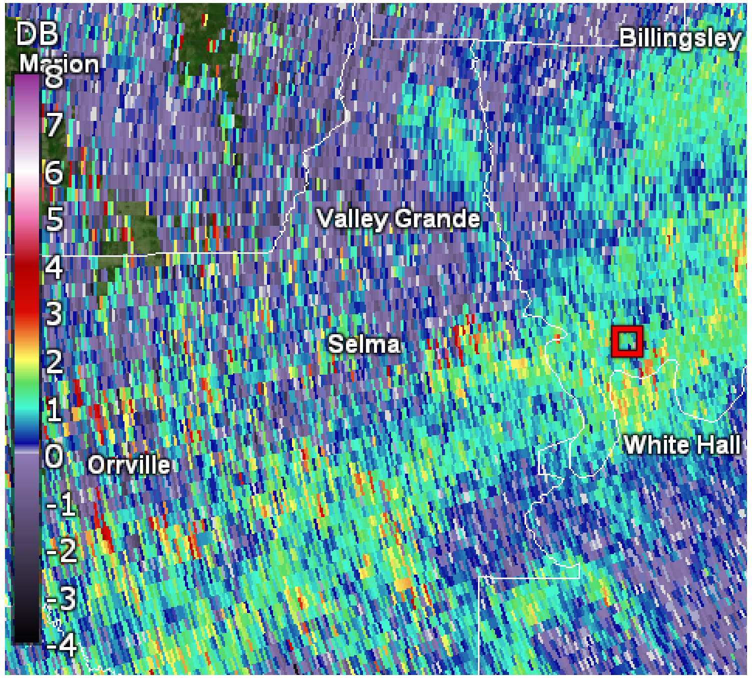


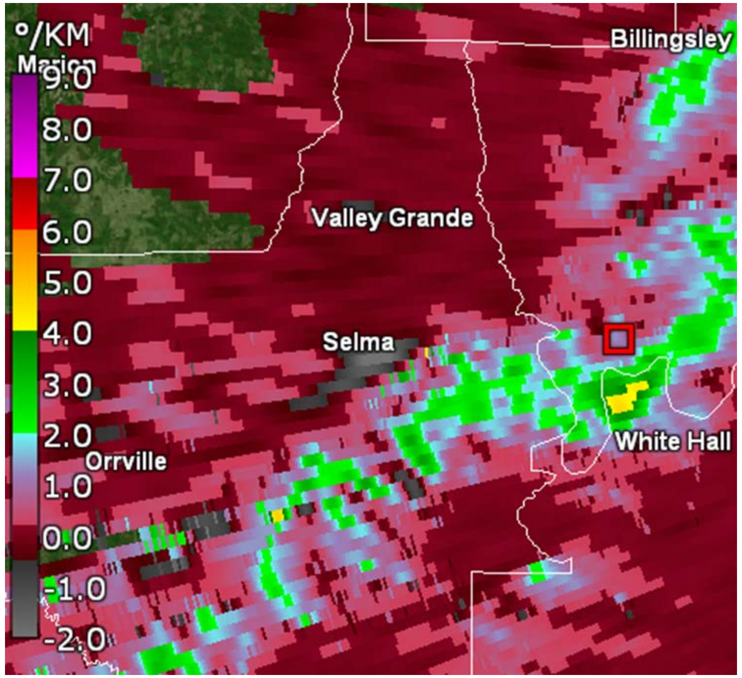


Examples of Z_{DR} Arc and K_{DP} Foot Analysis to Assess Storm-scale SRH and Potential for Low-Level Mesocyclone Intensification

Dual Pol Review 101a







Correlation Coefficient (CC): measures the consistency or variety of scatterers (type, shape, orientation)

High CC > 0.97 = high consistency, usually pure rain or pure snow

Low CC < 0.80 = low consistency, typically non-meteorological

Differential Reflectivity (Z_{DR}): measures the oblateness of a scatterer (how spherical or wide)

$Z_{DR} > 0$ = wide(r), big drops

$Z_{DR} \sim 0$ = nearly spherical, likely drizzle, small rain drops, dry hail

$Z_{DR} < 0$ = skinny, ice crystals, large hail

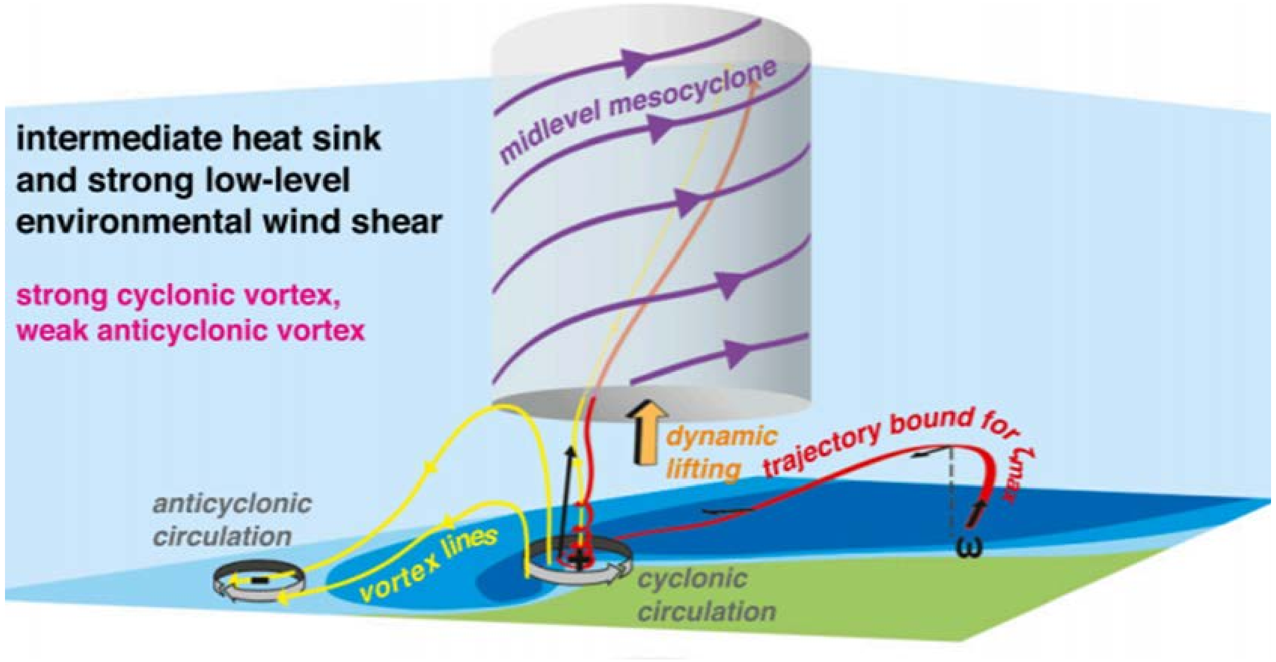
Specific Differential Phase (K_{DP}): measures how much stuff passed through the radar beam

K_{DP} - increases as the size and concentration of rain drops increases; indicates high liquid water content

$K_{DP} \sim 0$ = spherical or tumbling dry hail; <0 with very large hail

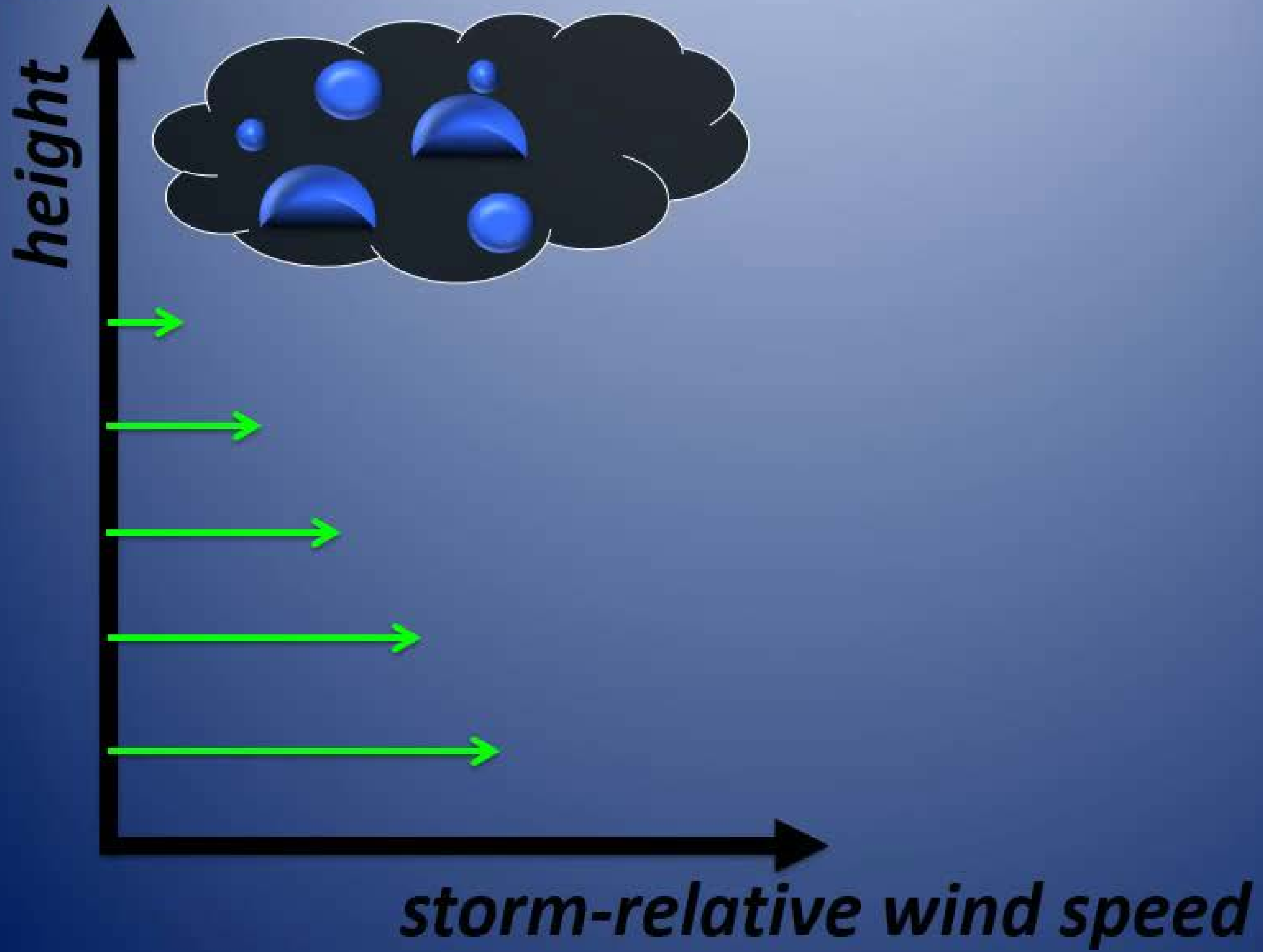
Brief Review of Key Concepts

- Strong low-level mesocyclones and high near-surface humid air are considered essential factors for tornadogenesis
- Strong environmental low-level wind shear lowers the mesocyclone base and promotes increasing VPPGF or dynamic lifting
- When dynamic lift is correctly positioned with an intermediate strength cold pool, it promotes intense stretching of near-surface baroclinically generated vorticity to tornadic strength



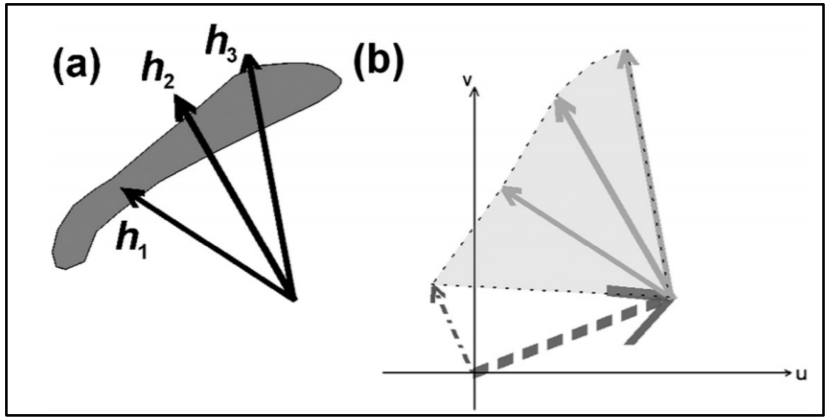
- When supercells ingest a large quantity of low-level SRH/streamwise vorticity, the low-level mesocyclone is likely to intensify

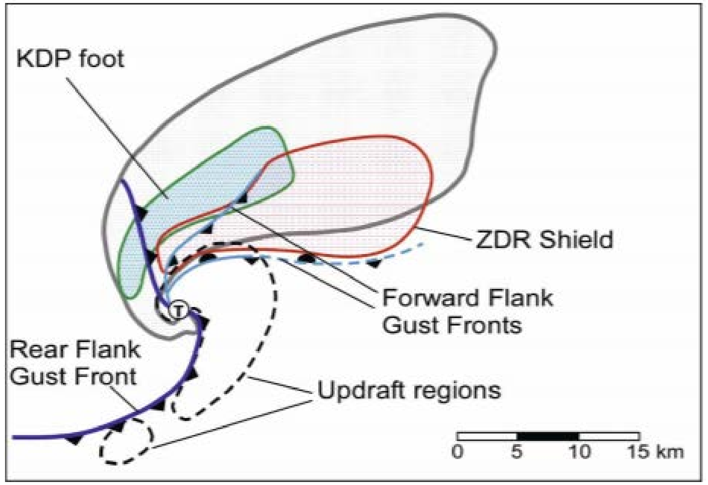
Low-level Z_{DR} and K_{DP} Signatures

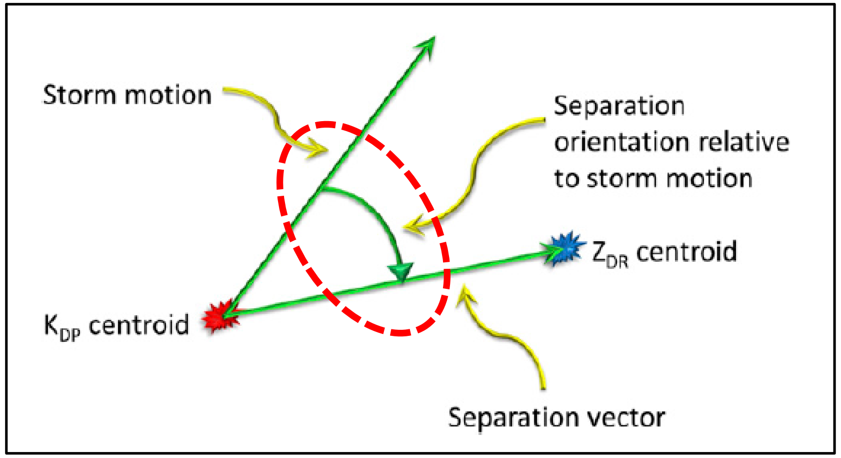


Brief Review of Key Concepts (cont.)

- A Z_{DR} arc confirms size sorting by the low-level storm-relative wind but is insufficient for a complete assessment of the storm-scale SRH
- Assessing **both** the Z_{DR} arc and K_{DP} foot allows a more accurate method to assess size sorting and the mean low-level storm-relative wind and assess storm-scale SRH
- From the K_{DP} foot and Z_{DR} arc centroids we can determine a separation vector

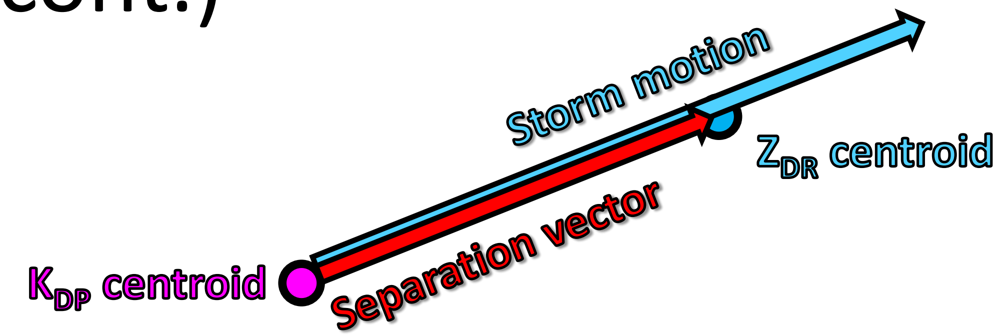




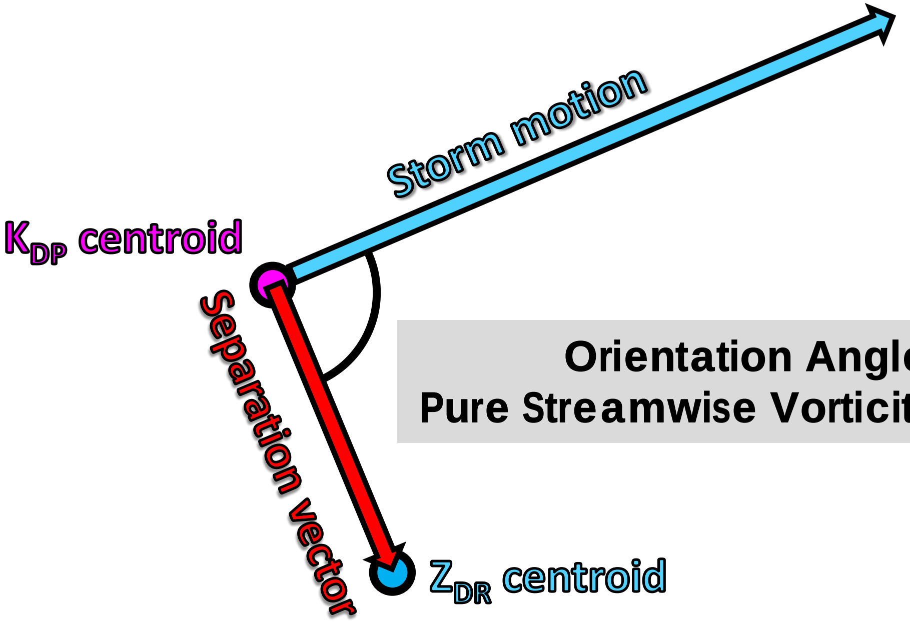


Brief Review of Key Concepts (cont.)

- The K_{DP} foot – Z_{DR} arc separation vector and orientation angle when compared with storm motion provided significant detail to assess storm-scale SRH
  - ➢ Little to no separation implies pure crosswise vorticity/zero SRH
  - ➢ Close to orthogonal separation implies pure streamwise vorticity/higher SRH
- ***In radar data*** - find raised/enhanced area of Z_{DR} along FFD/inflow region and region of offset enhanced K_{DP} not biased by small melting hail



Orientation Angle ≈ 0º
Pure Crosswise Vorticity/Zero SRH



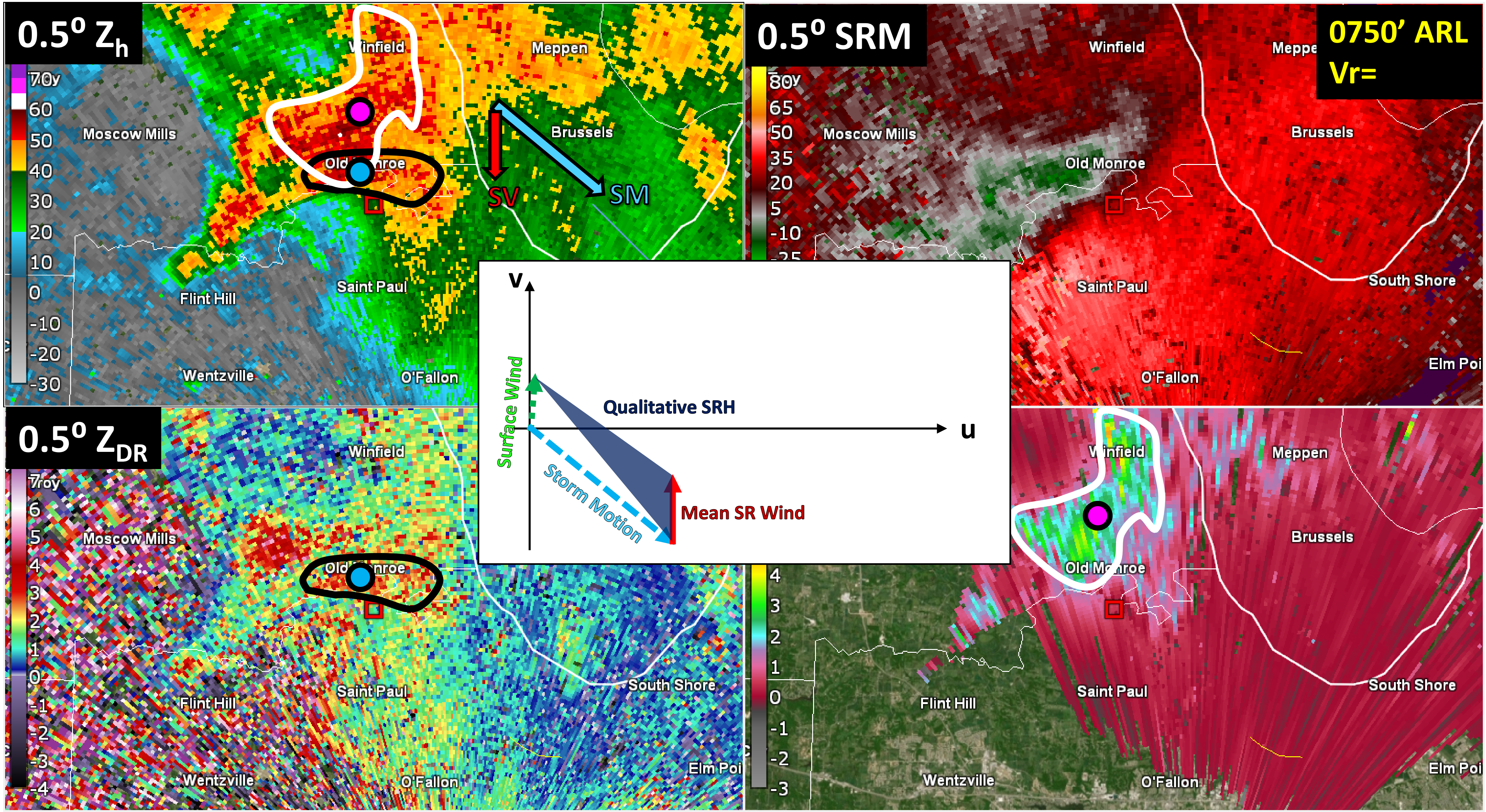
Orientation Angle ≈ 90º
Pure Streamwise Vorticity/Higher SRH

St. Charles Co. MO EF2

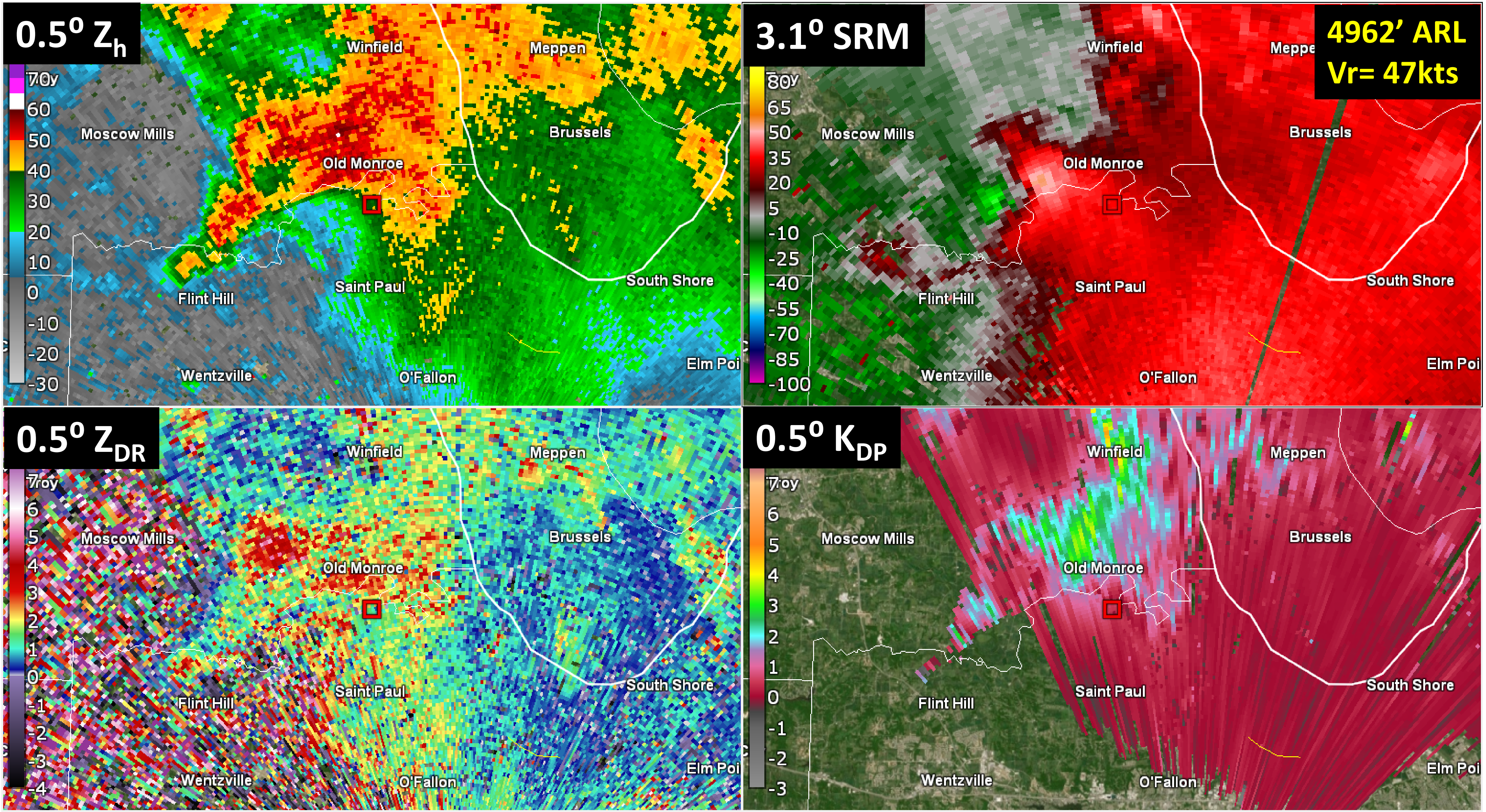
0104-0109 UTC 28 June 2015

2.26 mile path length

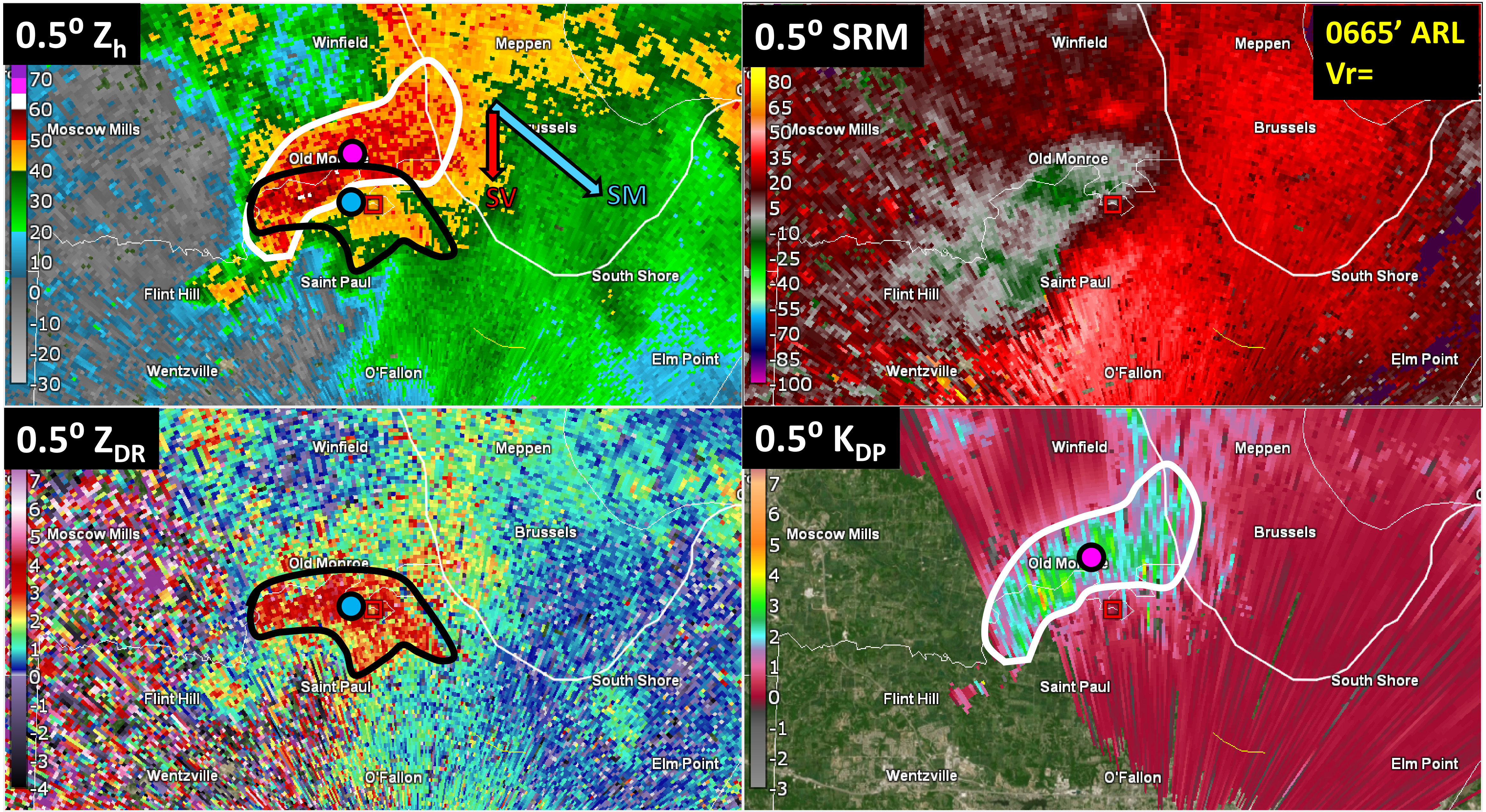
06/28/2015 EF2 Tornado 0041 UTC T-23m



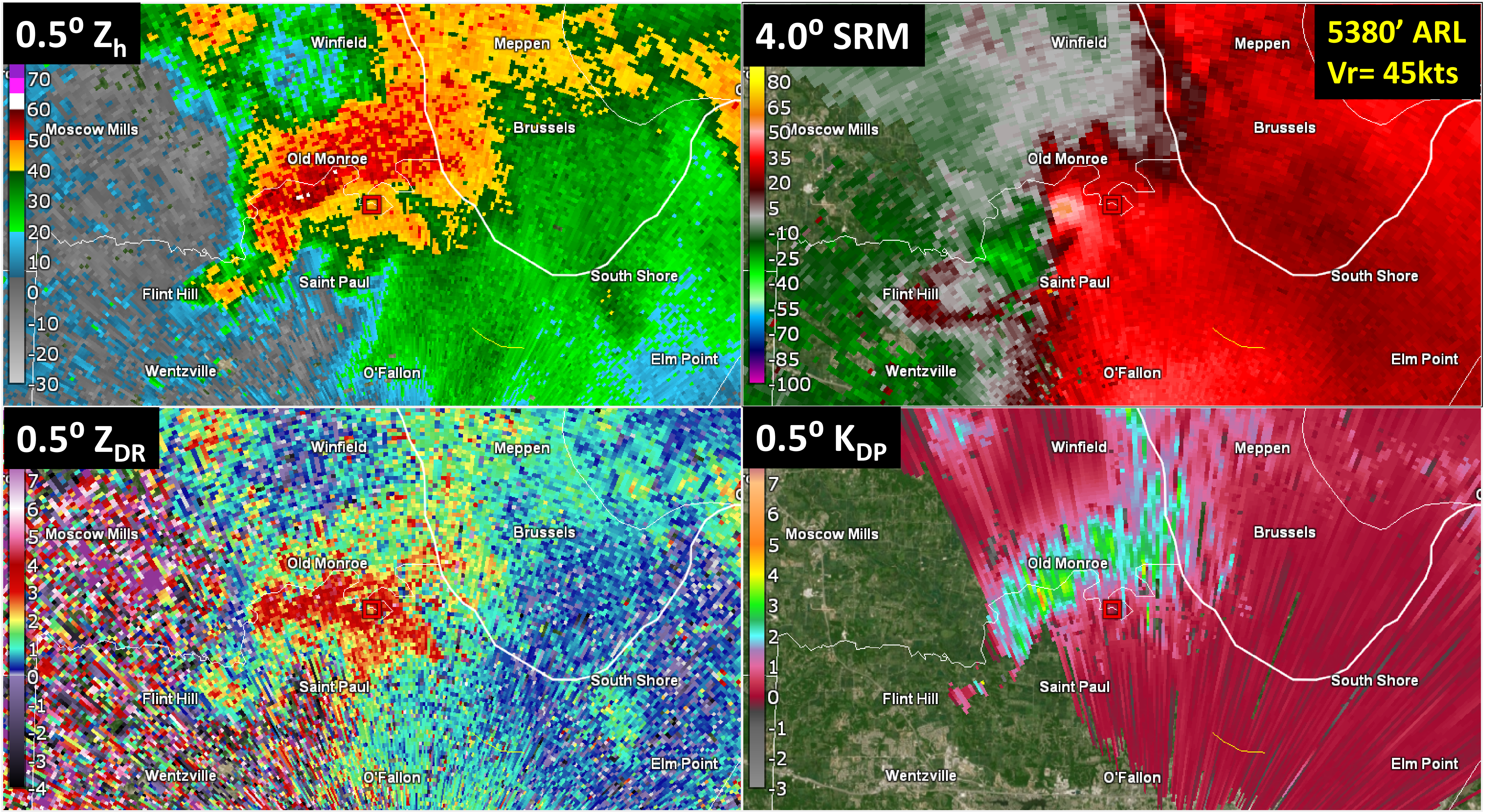
06/28/2015 EF2 Tornado 0041 UTC T-23m



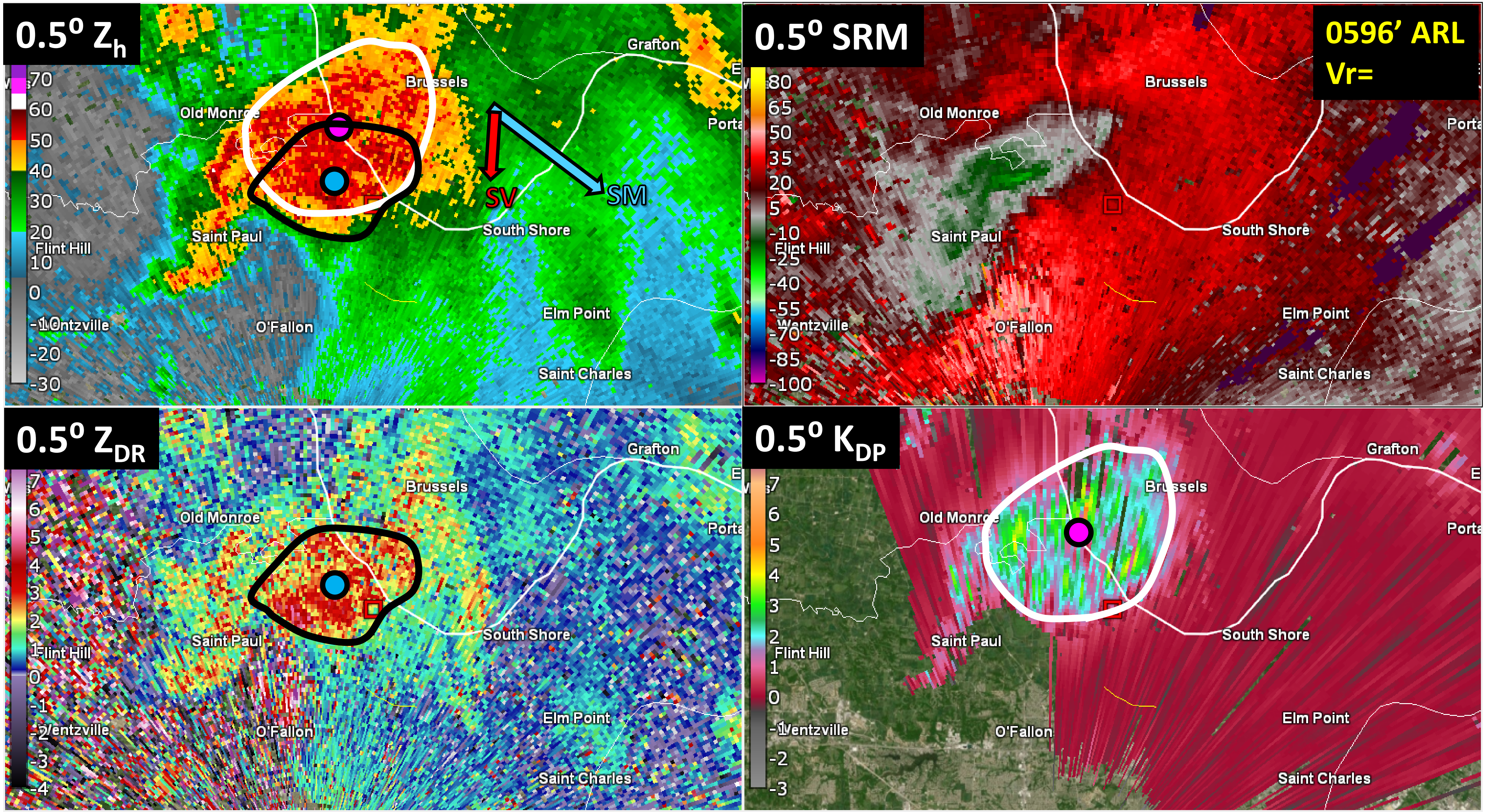
06/28/2015 EF2 Tornado 0046 UTC T-18m



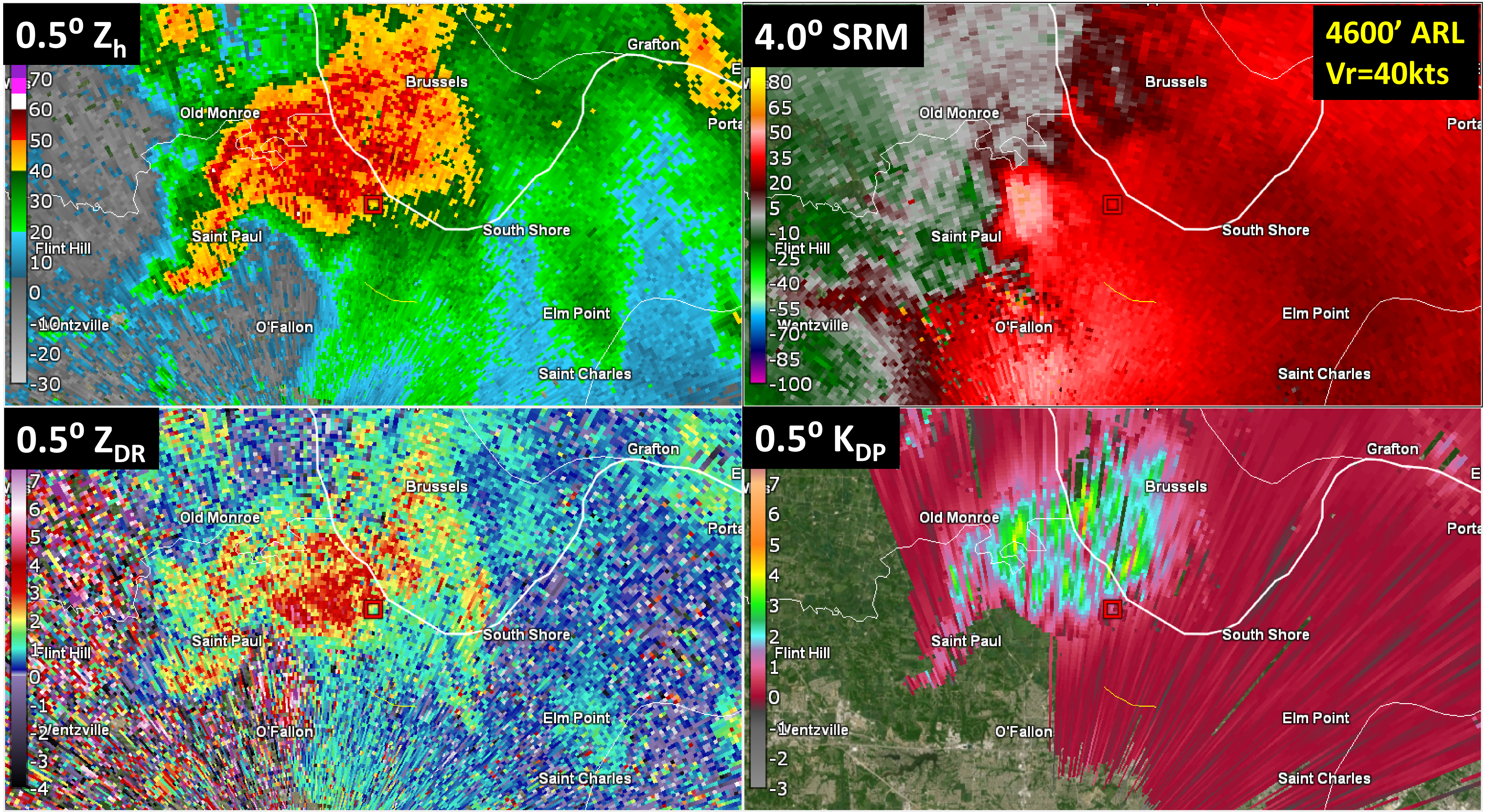
06/28/2015 EF2 Tornado 0046 UTC T-18m



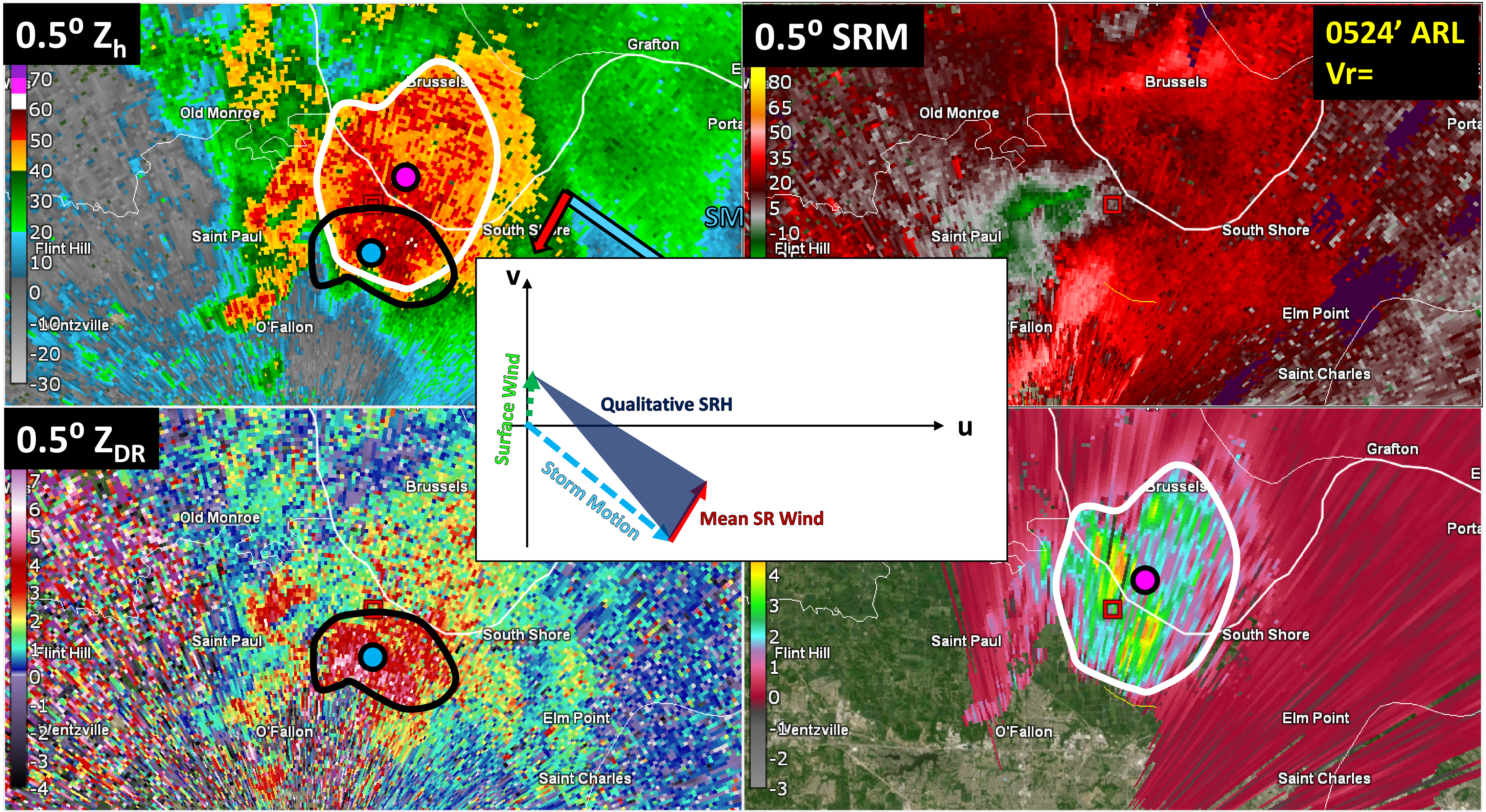
06/28/2015 EF2 Tornado 0051 UTC T-13m



06/28/2015 EF2 Tornado 0051 UTC T-13m



06/28/2015 EF2 Tornado 0056 UTC T-08m



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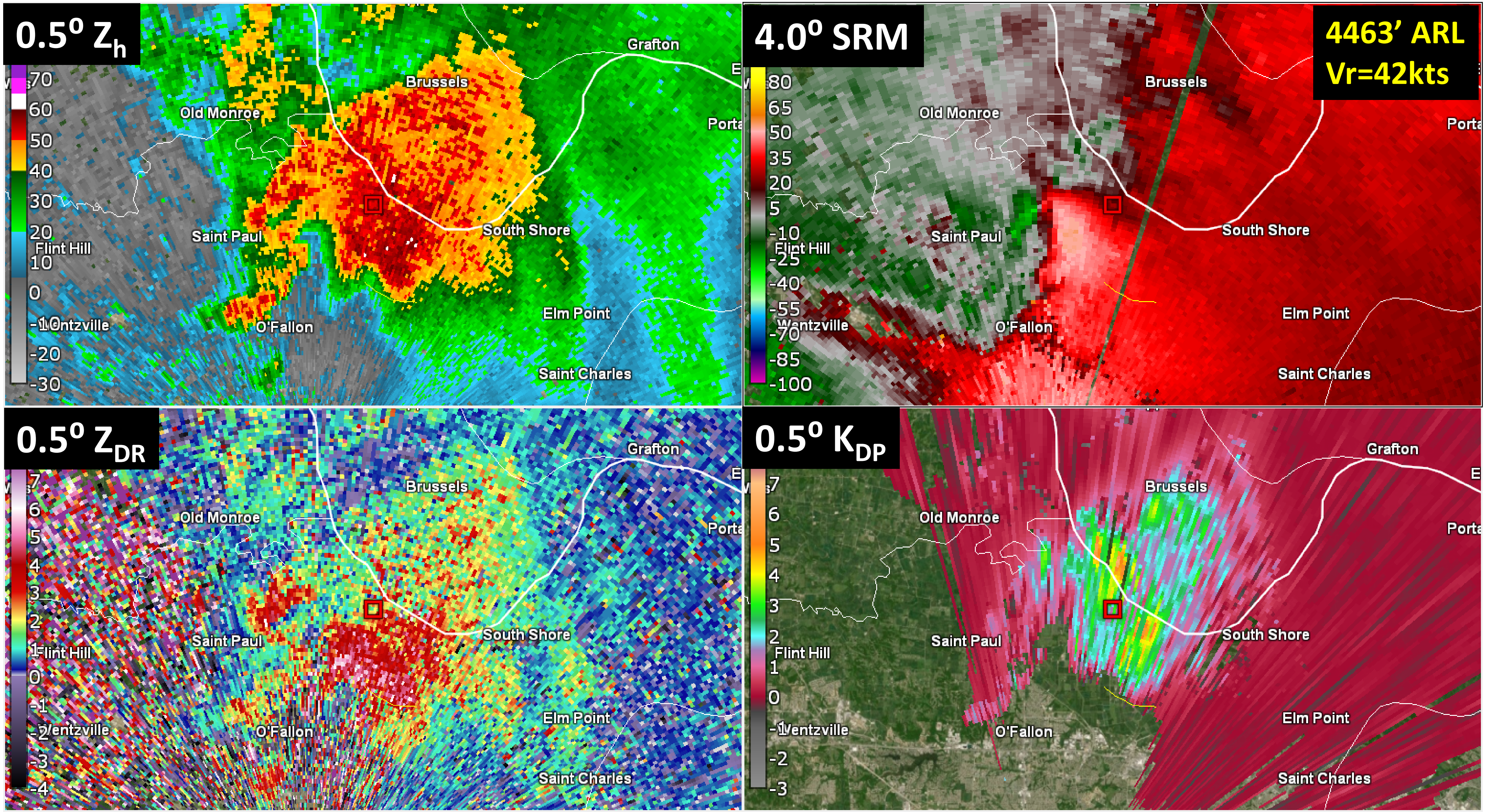
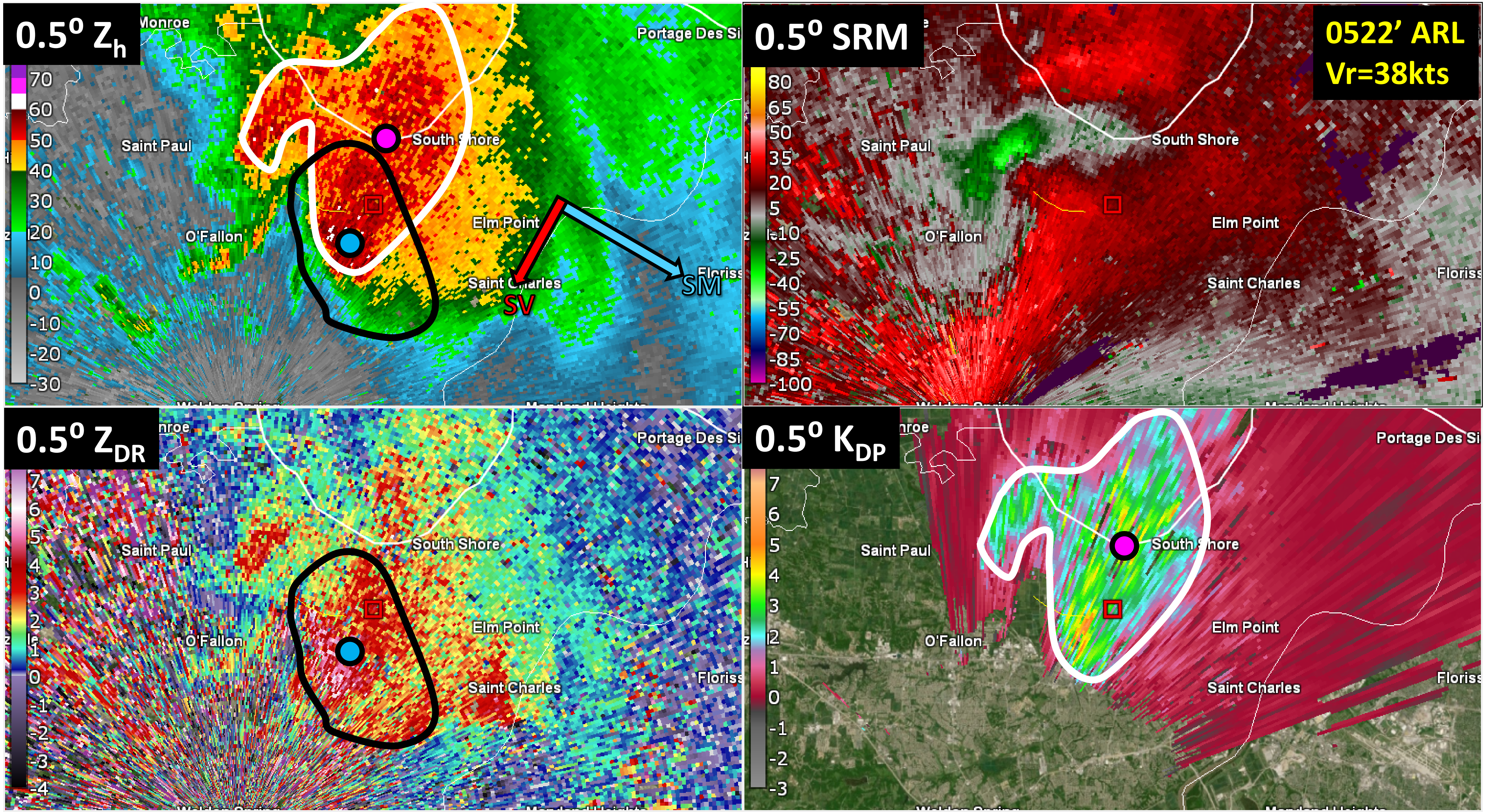
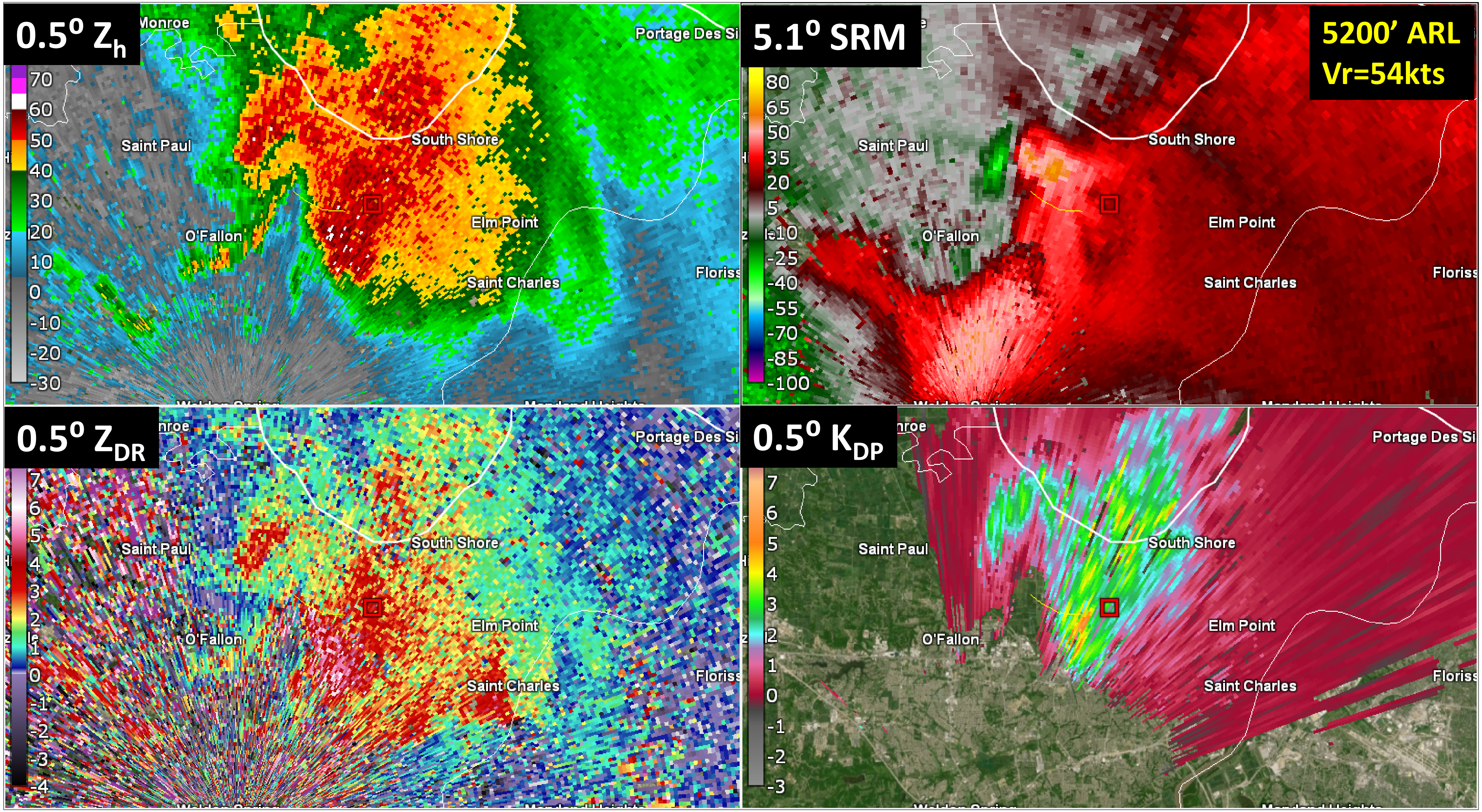


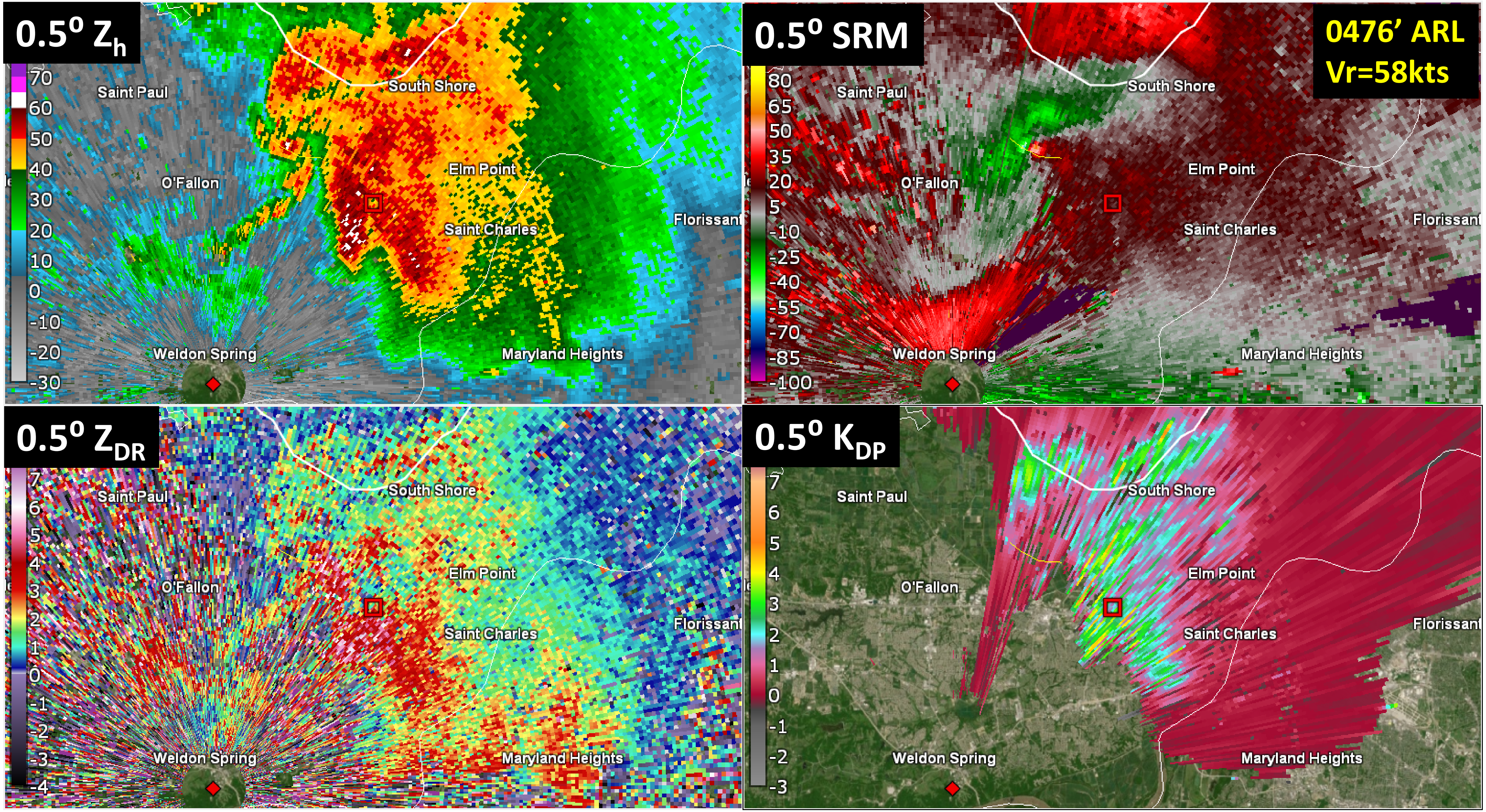
06/28/2015 EF2 Tornado 0101 UTC T-03m



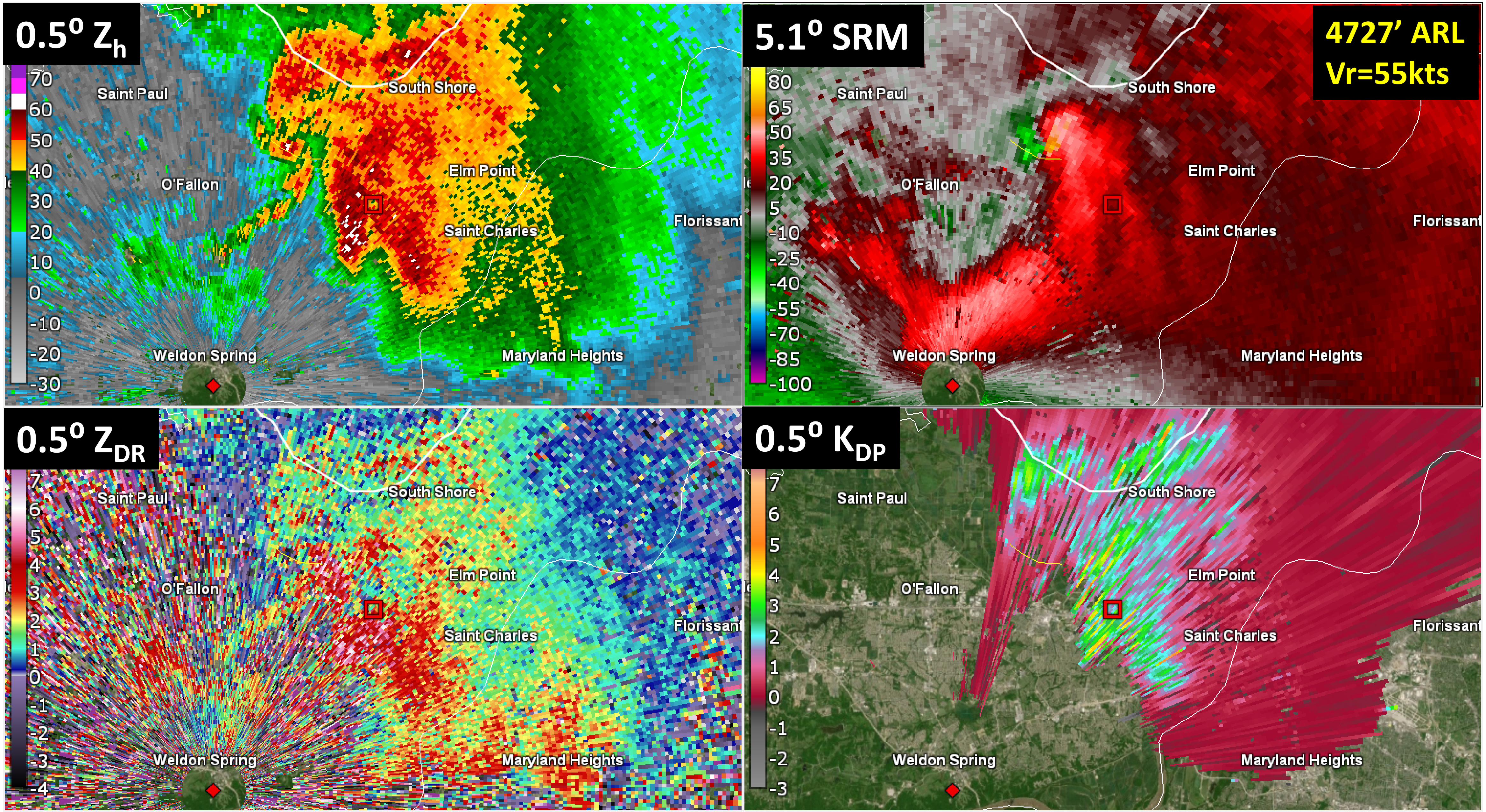
06/28/2015 EF2 Tornado 0101 UTC T-03m



06/28/2015 EF2 Tornado 0106 UTC T+02m



06/28/2015 EF2 Tornado 0106 UTC T+02m

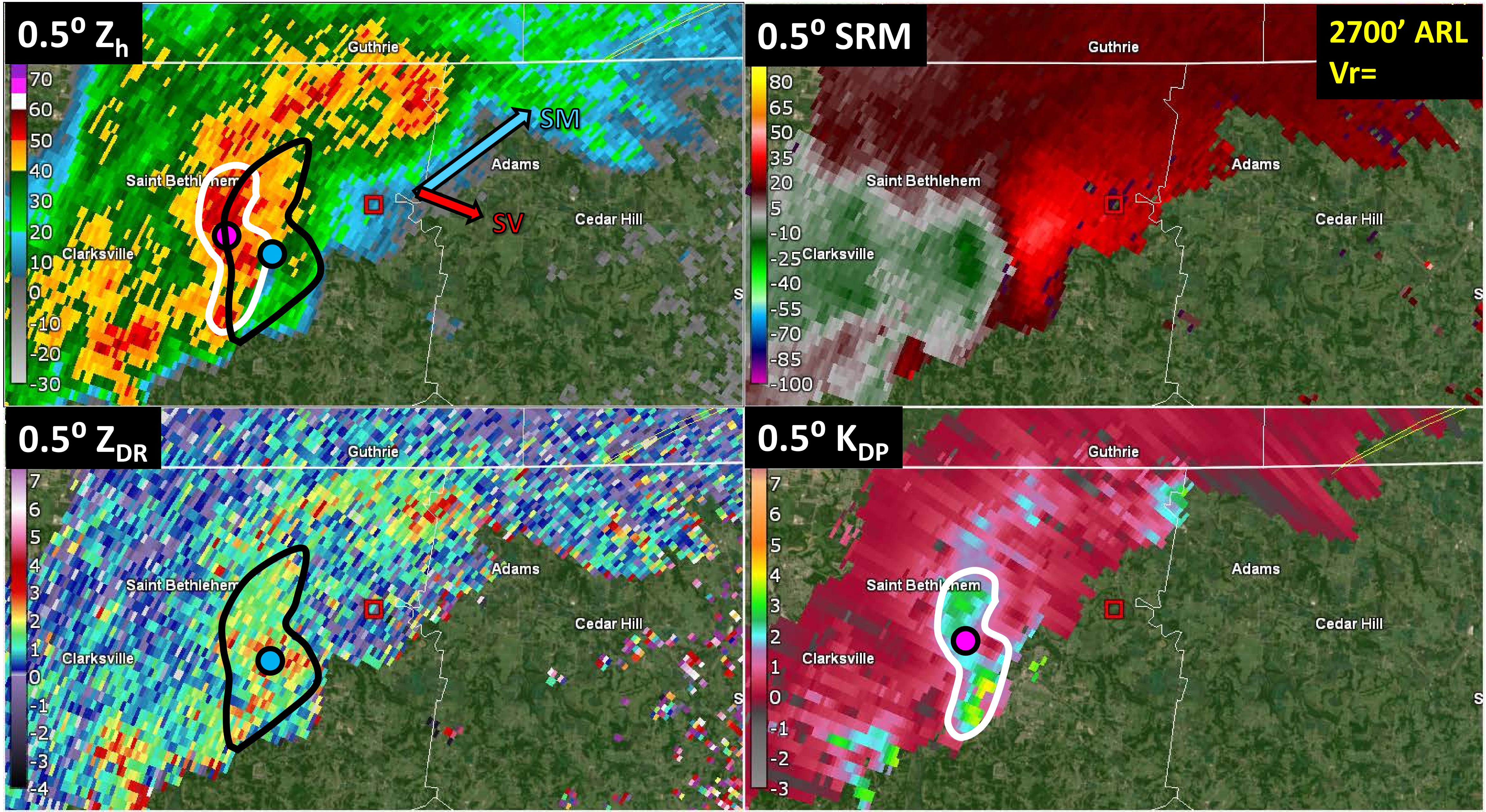


Robertson Co. TN/Logan Co. Kentucky EF2

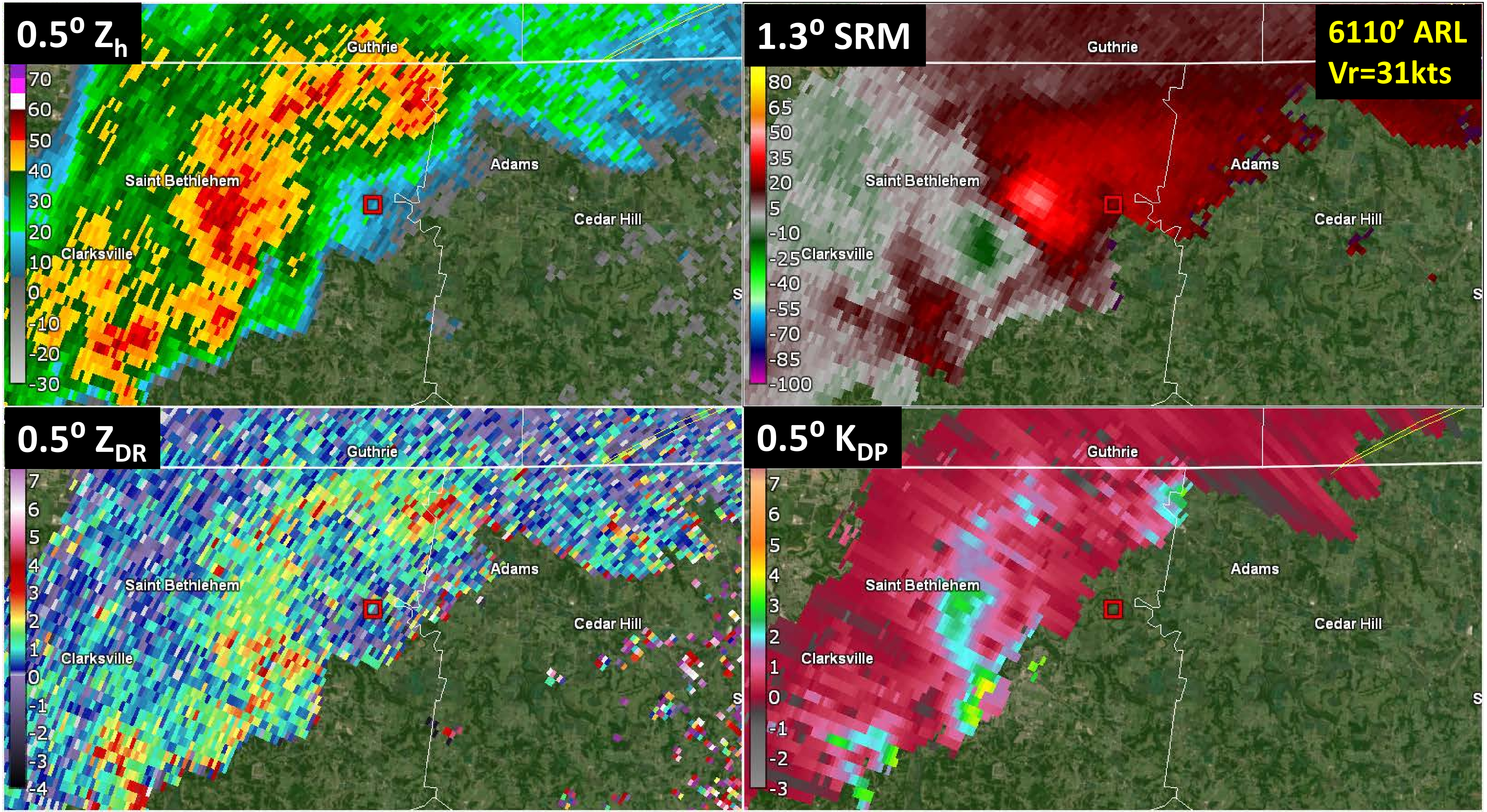
2153-2212 UTC 24 February 2018

12.18 mile path length

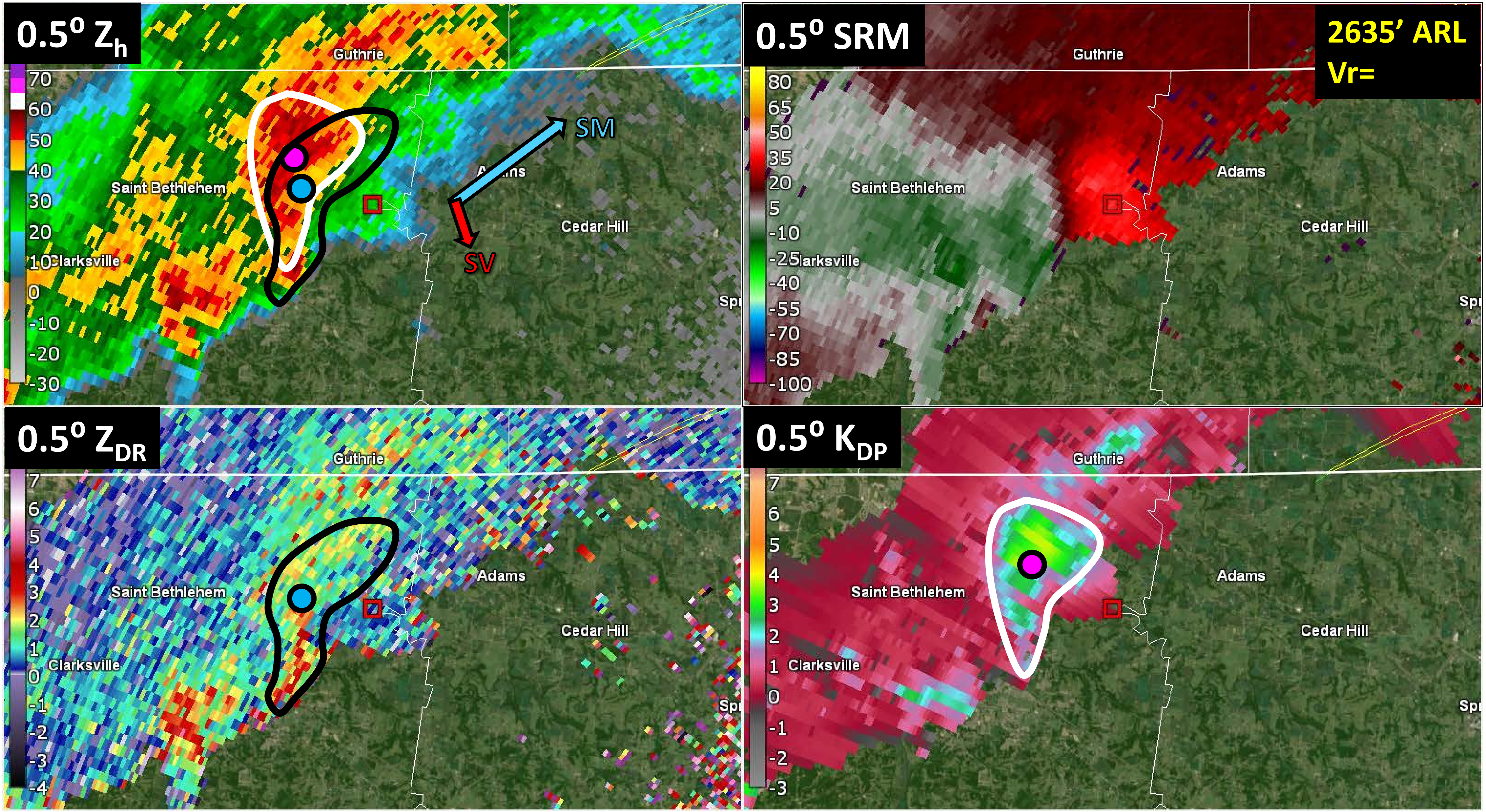
02/24/2018 EF2 Tornado 2131 UTC T-22m



02/24/2018 EF2 Tornado 2131 UTC T-22m



02/24/2018 EF2 Tornado 2136 UTC T-17m



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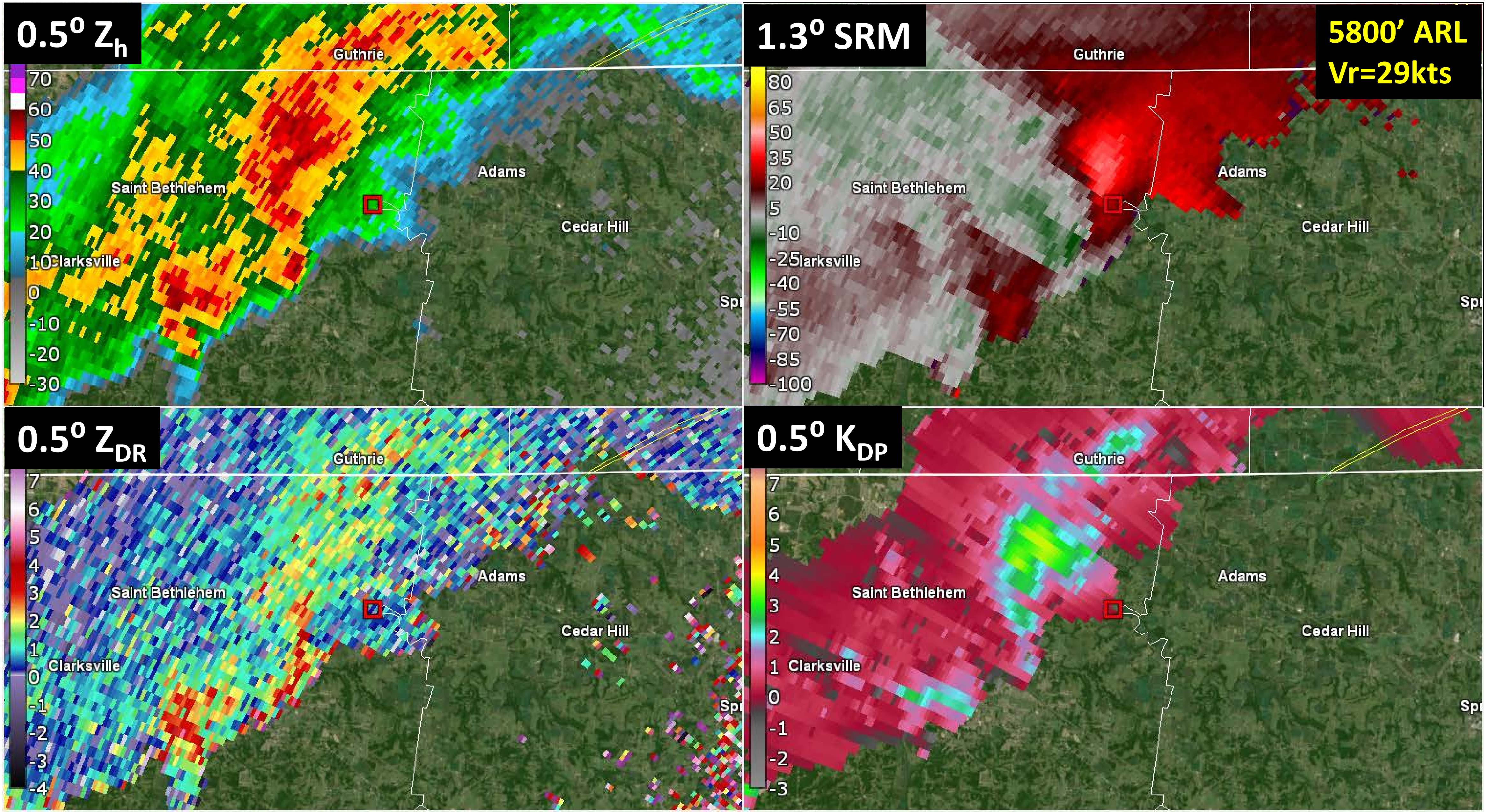
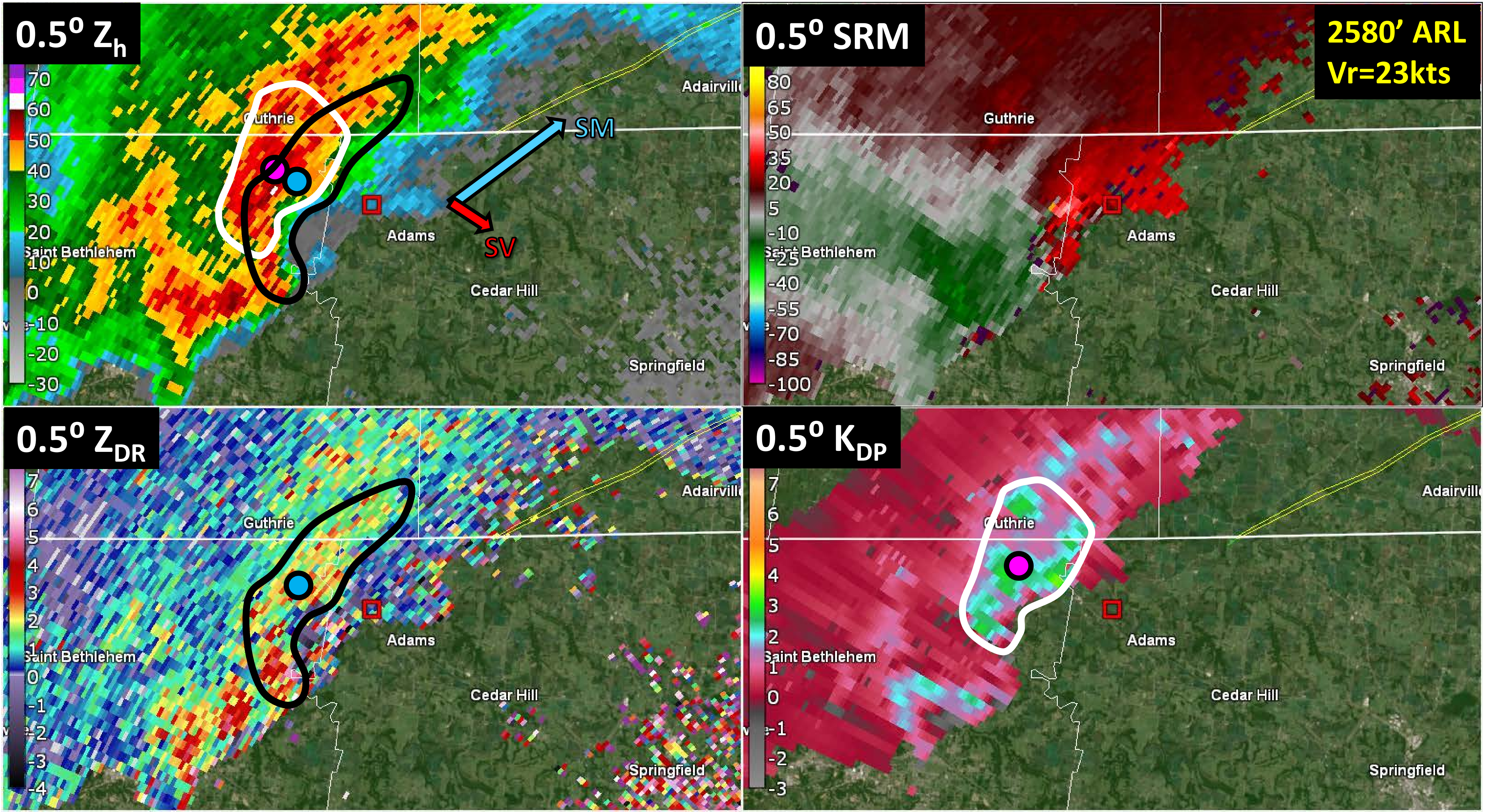


02/24/2018 EF2 Tornado 2141 UTC T-12m



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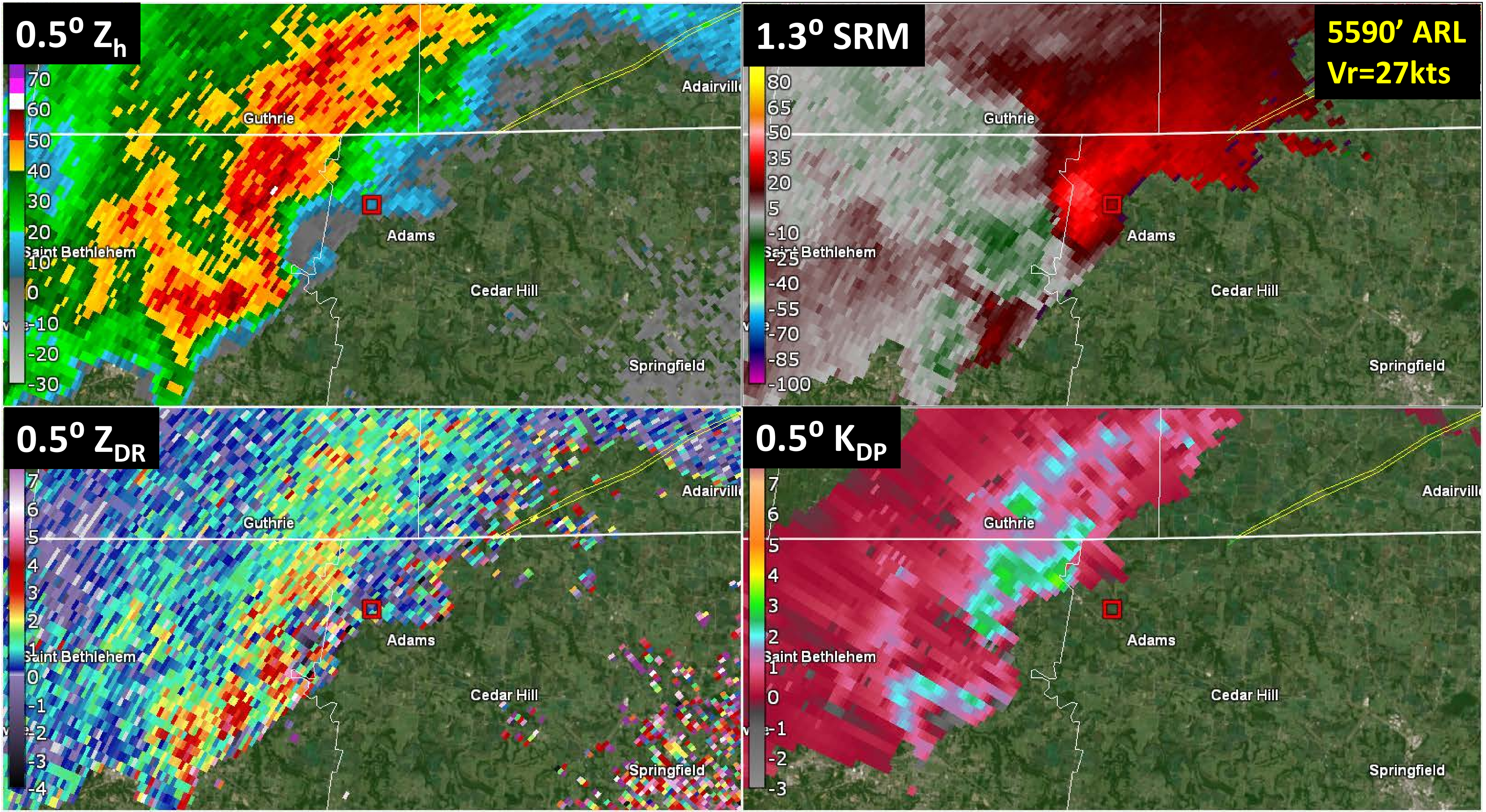
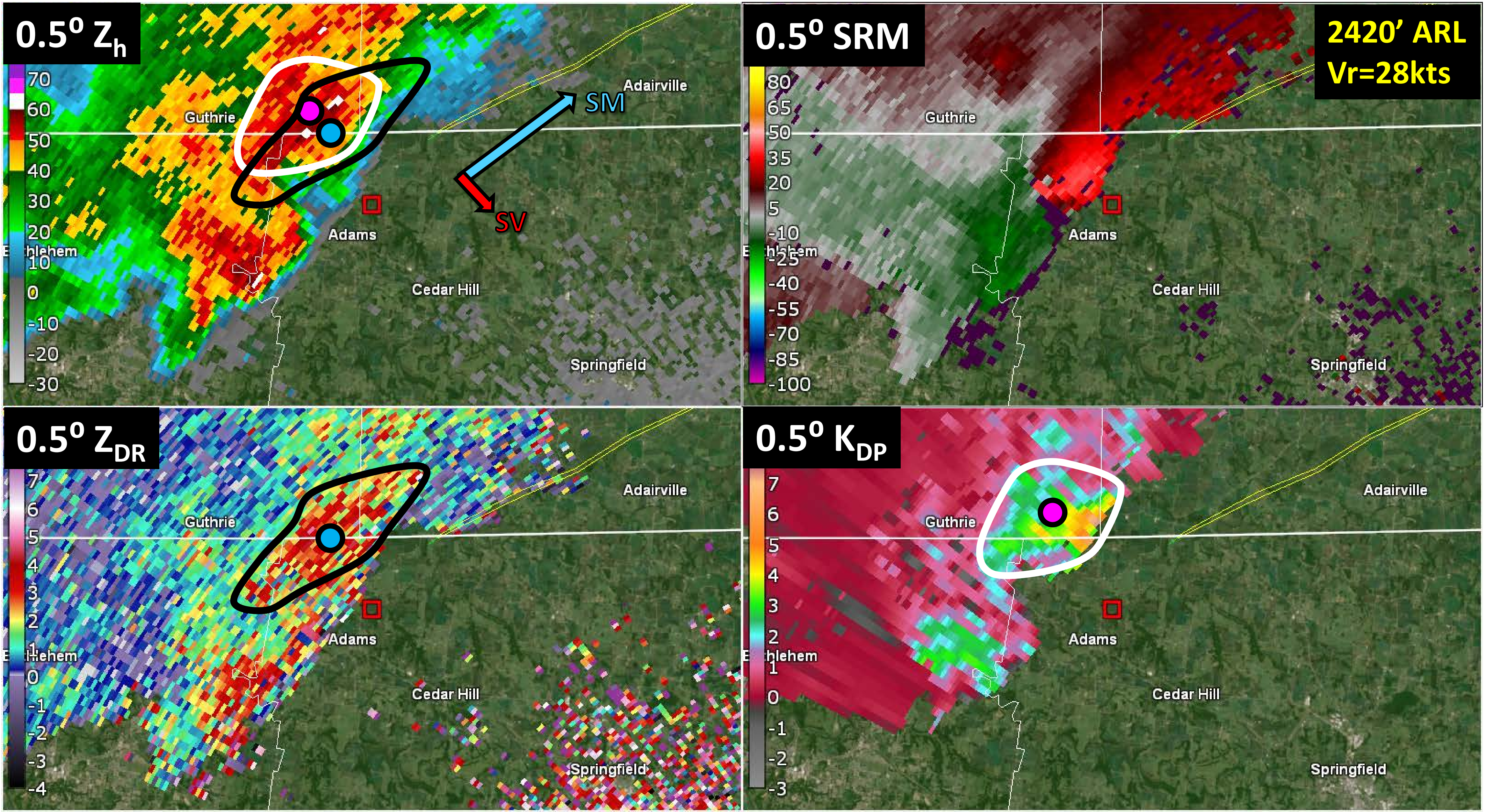
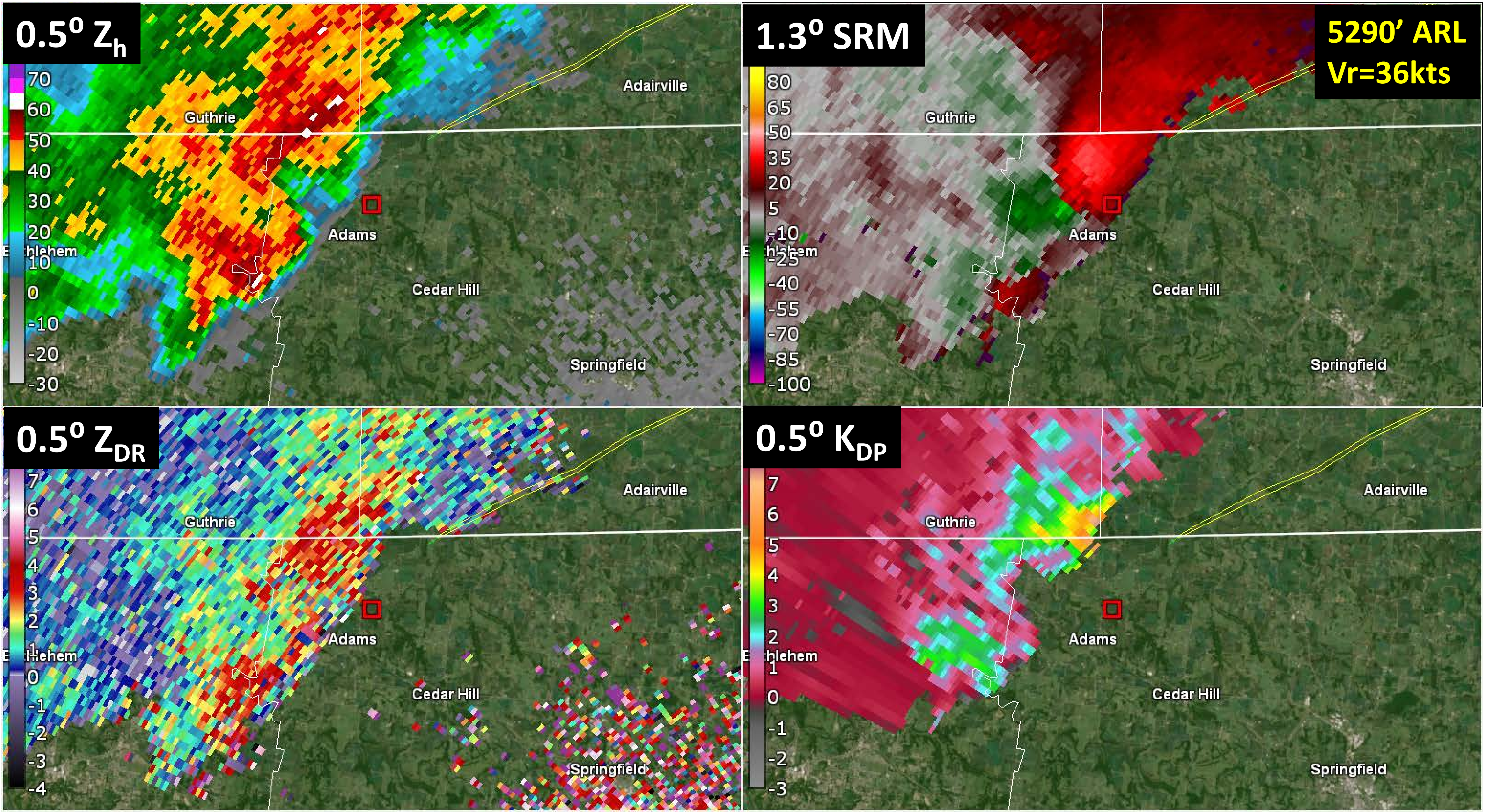


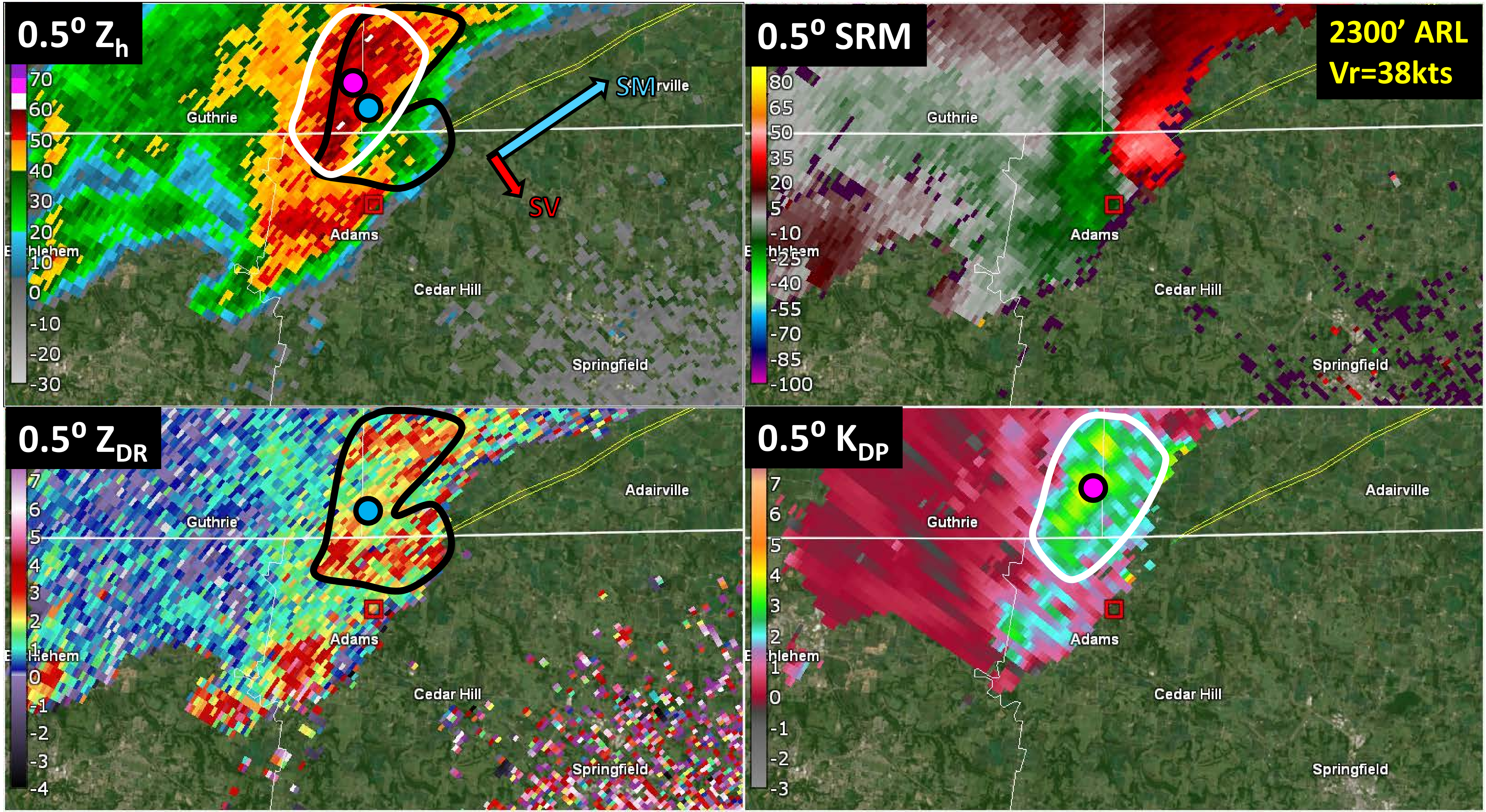
02/24/2018 EF2 Tornado   2146 UTC   T-07m



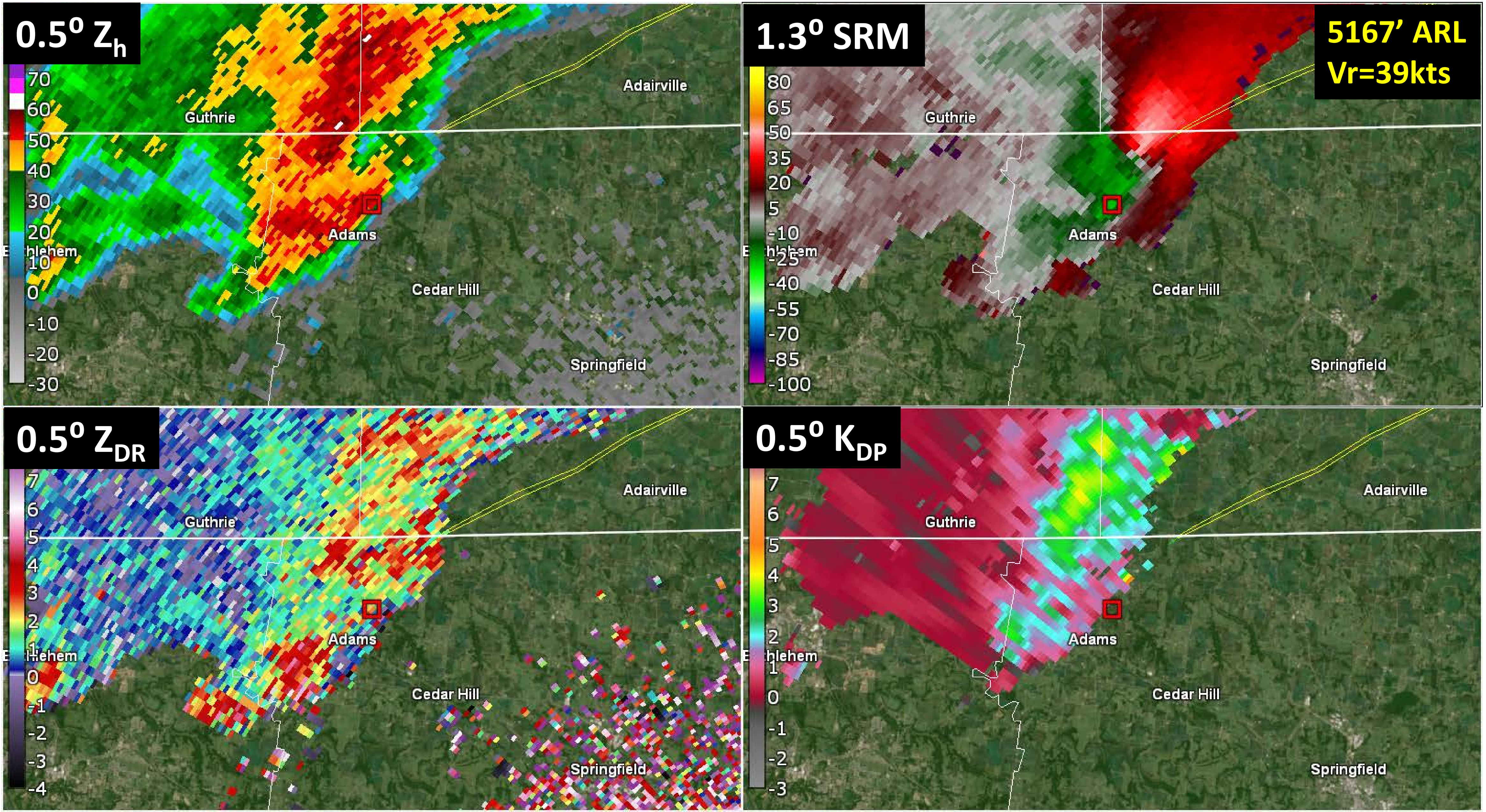
02/24/2018 EF2 Tornado 2146 UTC T-07m



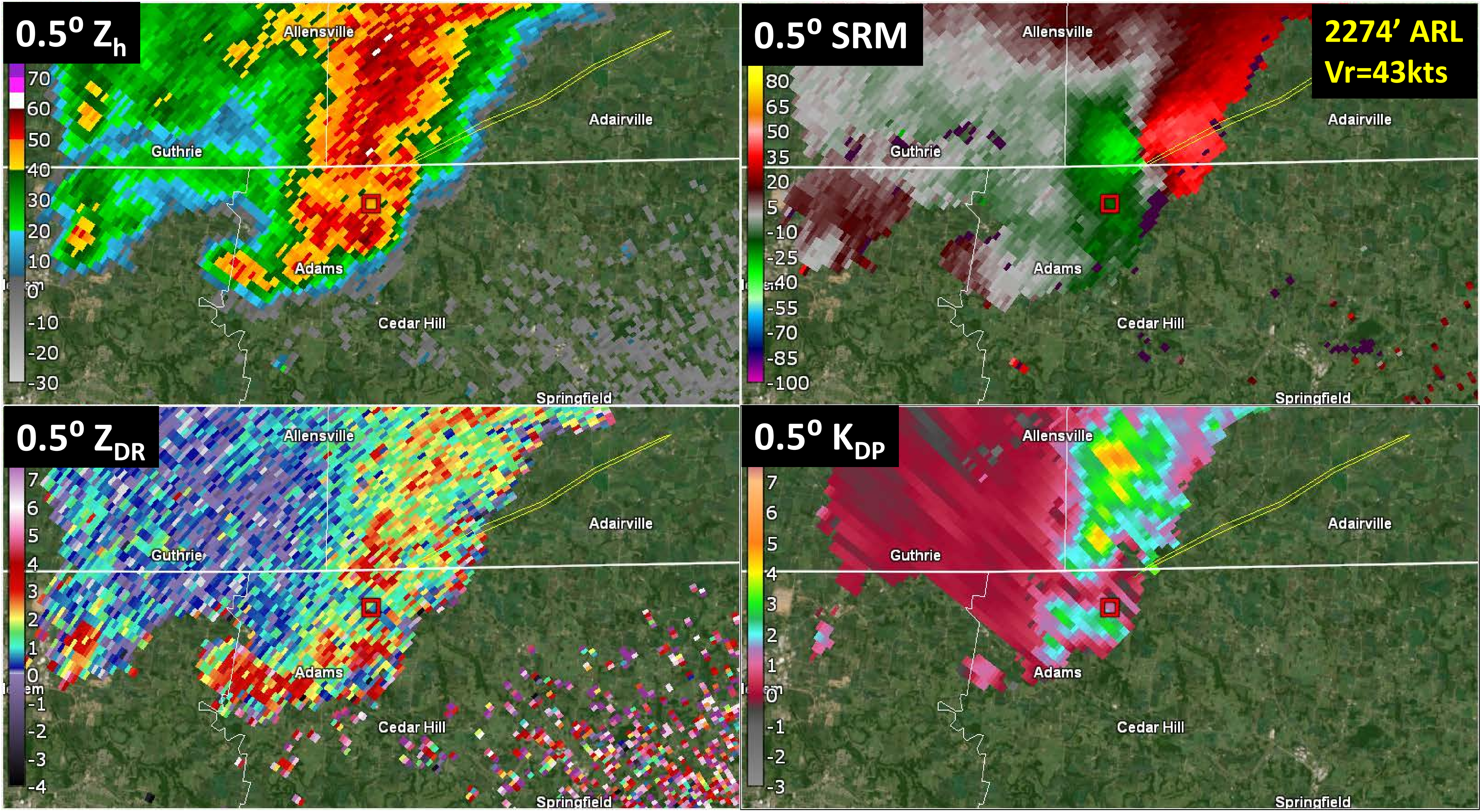
02/24/2018 EF2 Tornado 2151 UTC T-02m



02/24/2018 EF2 Tornado 2151 UTC T-02m

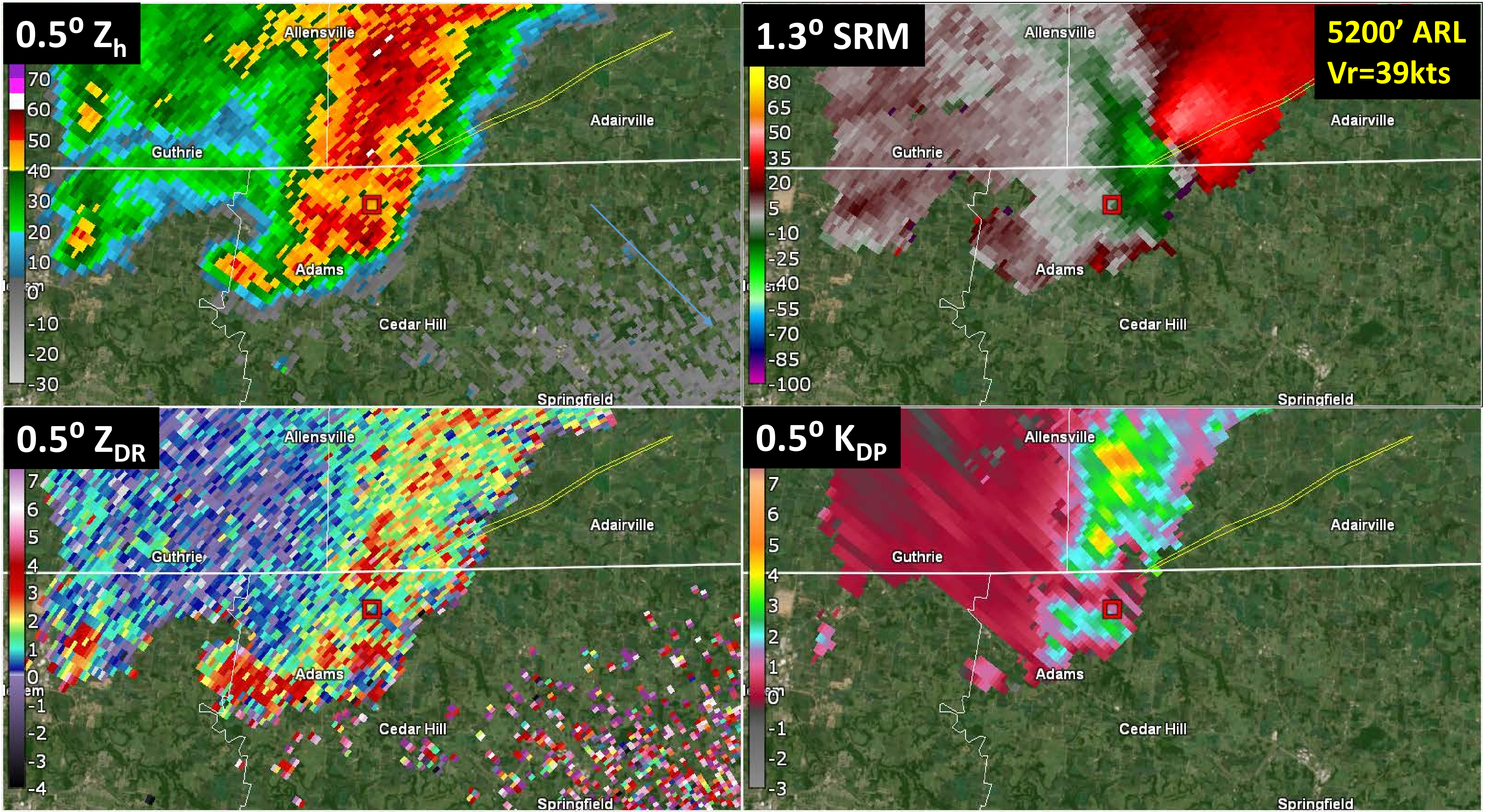


02/24/2018 EF2 Tornado 2155 UTC T+02m



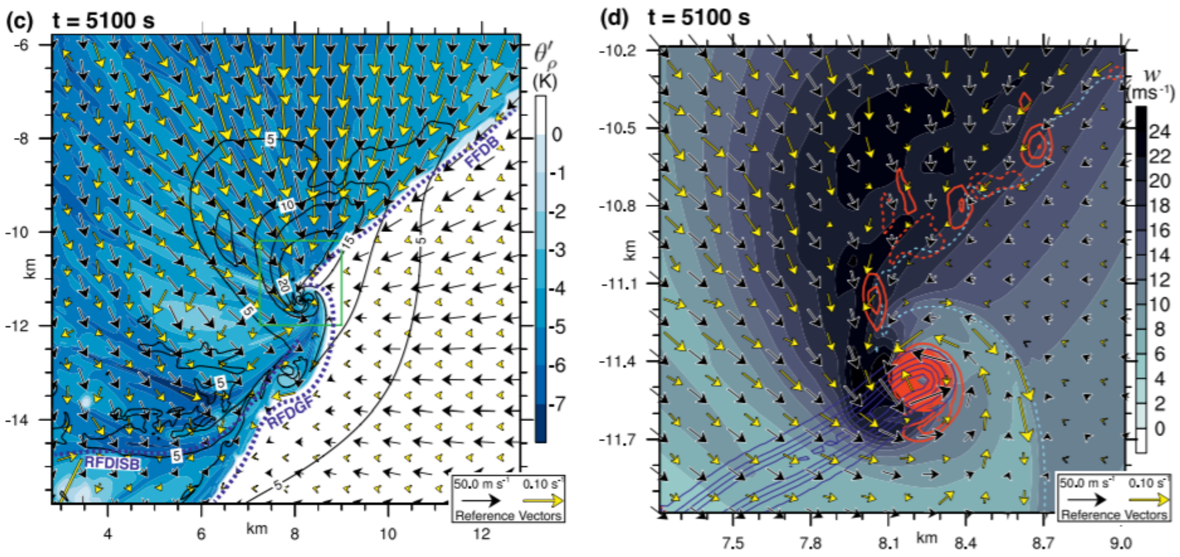
02/24/2018 EF2 Tornado

2155 UTC T+02m



Some Comments

- Supercells which also track along the spine of the Z_{DR} arc/FFD are noteworthy
- Identifying the centroids of the Z_{DR} arc and K_{DP} foot is subjective
- GR2Analyst is the best tool to use (panel center and marker options)
- Monitor Vr trends in the lowest 1.5-2.0 km (low-level meso)
- One of the duties of the LSX Warning Assistant
- This is a new radar/science application and we are just getting started applying it in WDM (a learning & comfort curve)



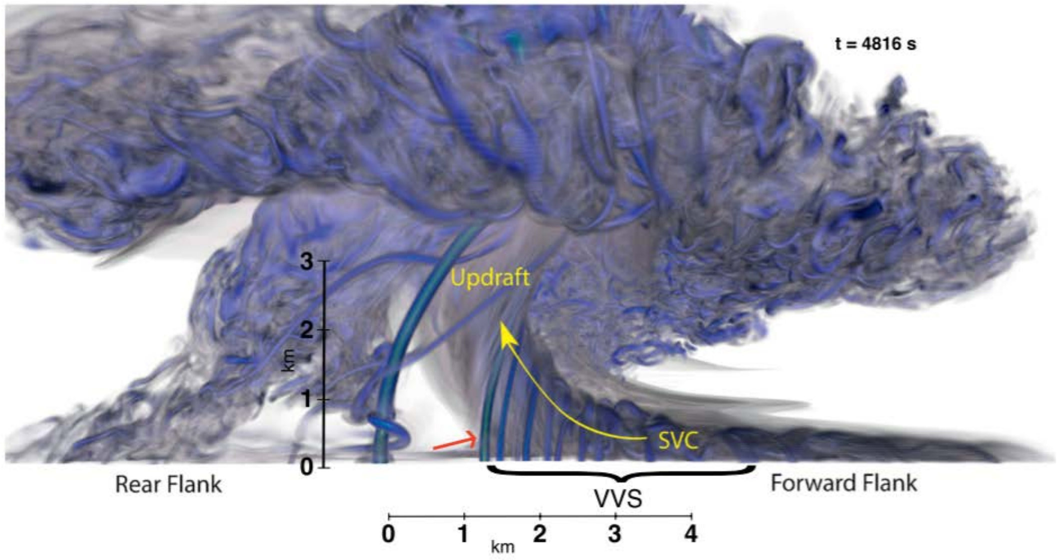
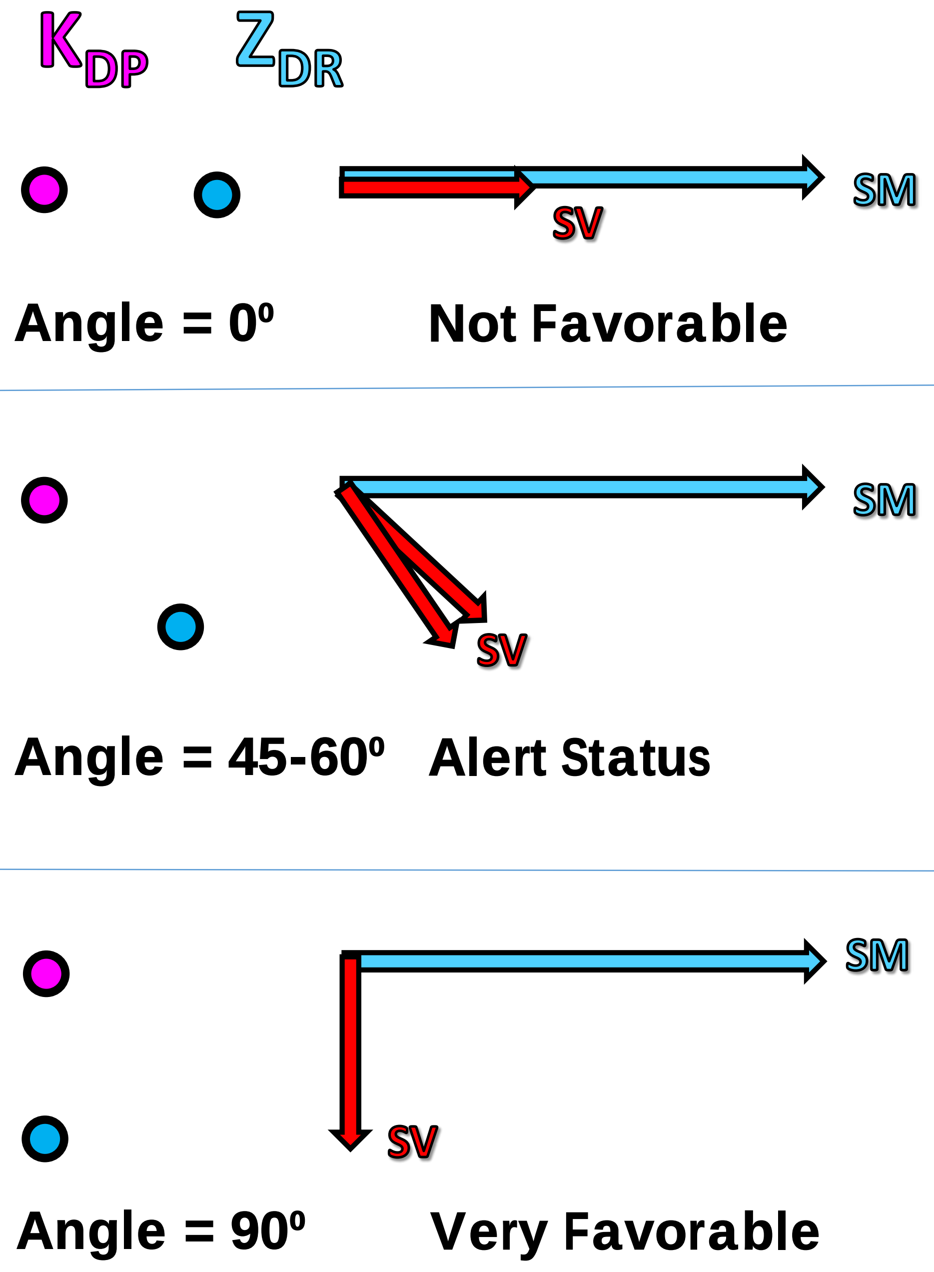


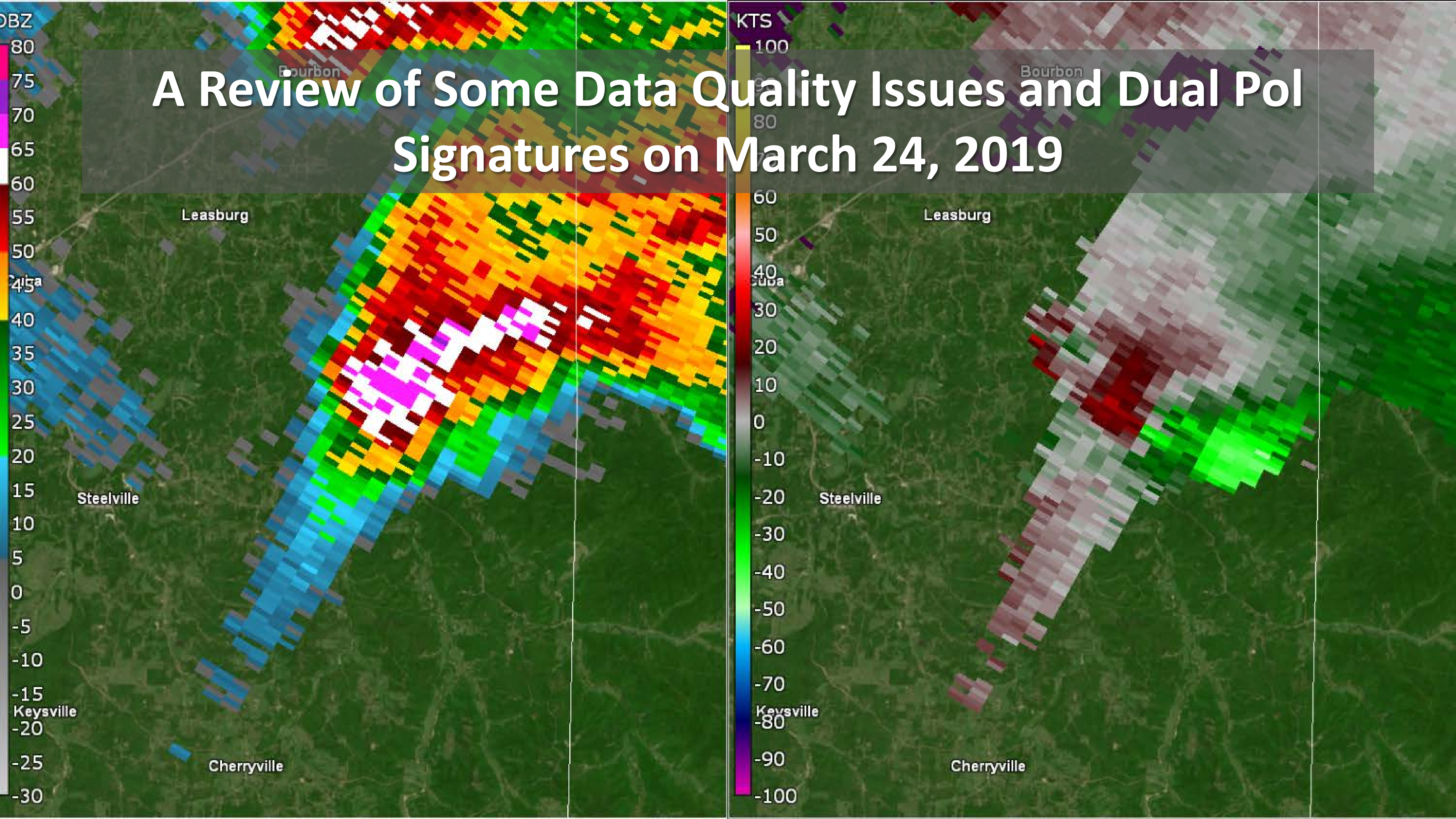
Fig. 7. Volume-rendered vorticity magnitude with a lower threshold of 0.025 s^{-1} at t = 4,816 s, prior to tornado formation. View is looking north. SVC marks the feature we call the streamwise vorticity current, and VVS marks the location of the vertical vorticity sheet. The red arrow points to the vortex that becomes the tornado. The yellow arrow indicates the storm-relative path of the air within the streamwise vorticity current as it is drawn into the updraft.

Some Comments

- Another radar tool in your arsenal
- Used to infer potential for LL mesocyclone intensification and thus increased tornado potential
- ***Orientation angle is key*** on inferring *storm-scale* vorticity component and SRH to assess potential for LL meso intensification
- Can be used to discriminate supercells with better tornado potential



A Review of Some Data Quality Issues and Dual Pol Signatures on March 24, 2019

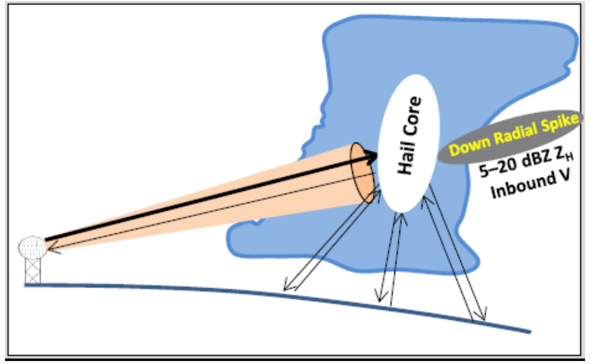


Side Lobe Contamination

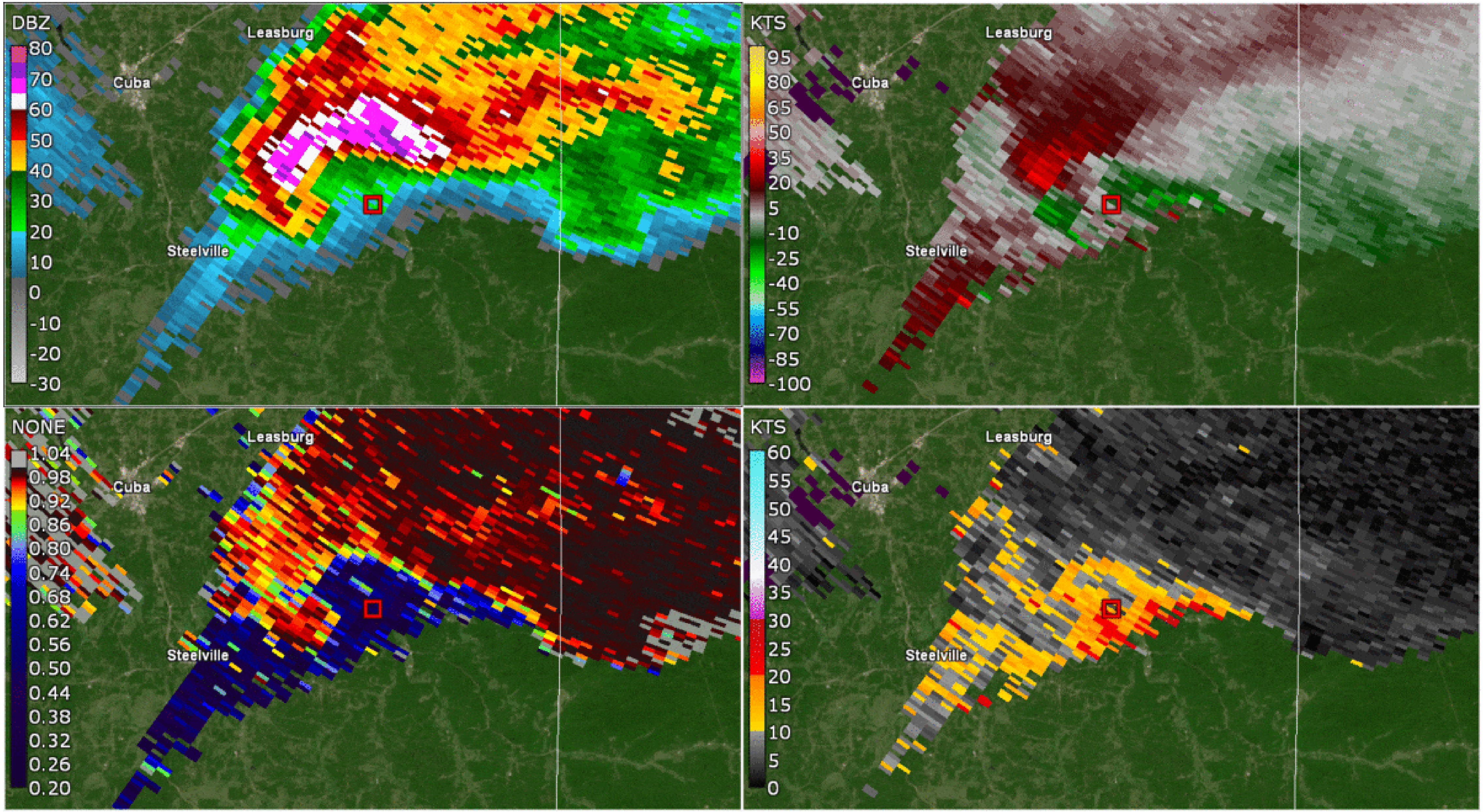
- Radar beam is imperfect due to engineering (strut and radome design) and energy around the main lobe results in side lobes
- Occurs when first side lobe returns dominate the signal
- Typically occurs in supercell inflow region
- Low reflectivity downwind of high Z_h cores
- Anomalously high velocity/strong gradients
  - Check CC (low) and check SW (high)
  - Check Z_h/V aloft and check Z_{DR} (noisy)
  - Look for data consistency with space & time to rule out side lobe contamination

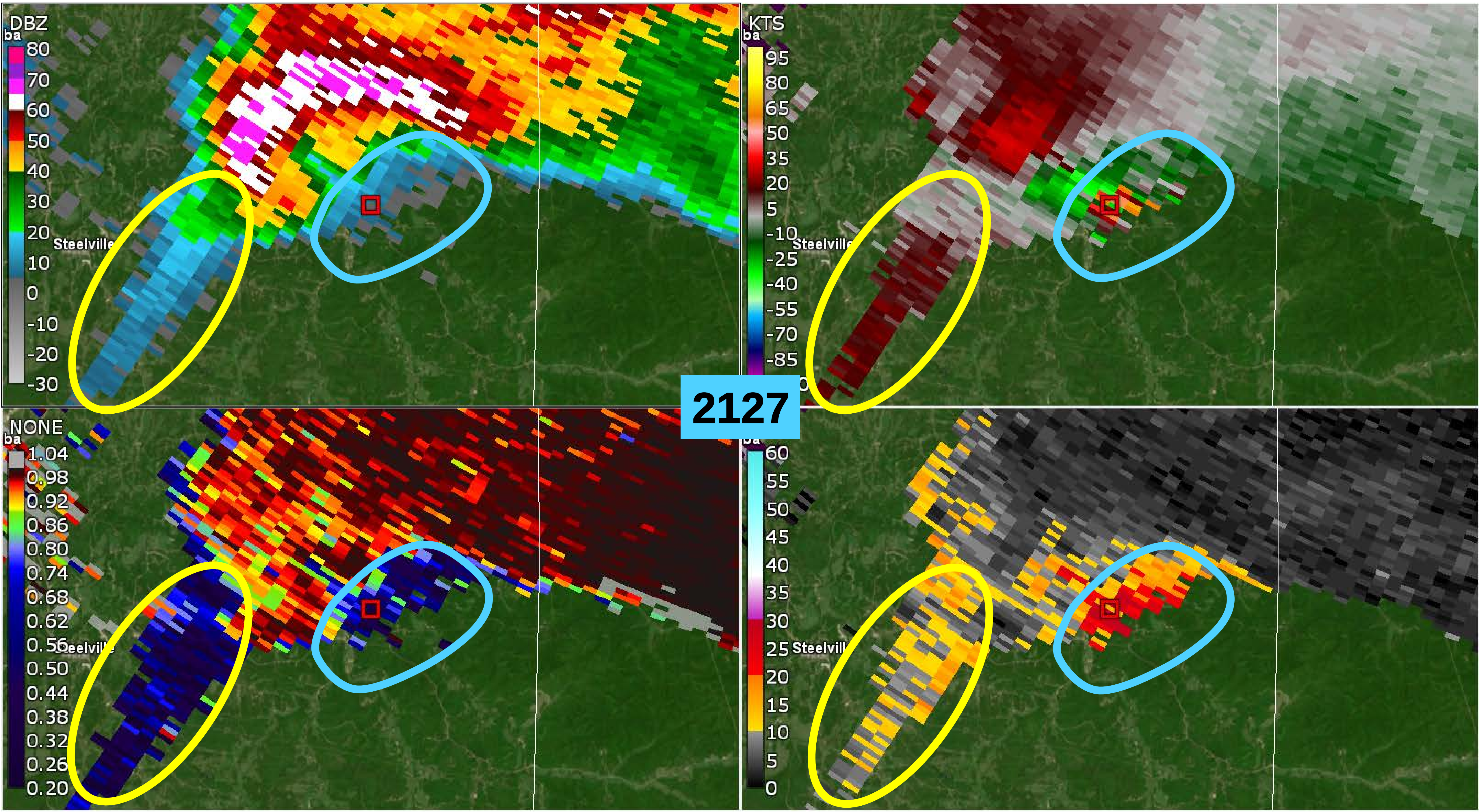
Three Body Scatter Spike (TBSS)

- The TBSS is a result of non-Rayleigh scattering or Mie scattering when the radar beam impacts hail cores of strong convection
- Portions of the radar beam are forward-scattered to the ground, then backscatter from the ground into the storm, and finally back to the radar
- Can result in down radial spike of low Z_h that is seen in CC and SW values as well but also contaminates velocity with anomalous inbound values
  - Check CC (low) and check SW (high)



2127-2145 UTC





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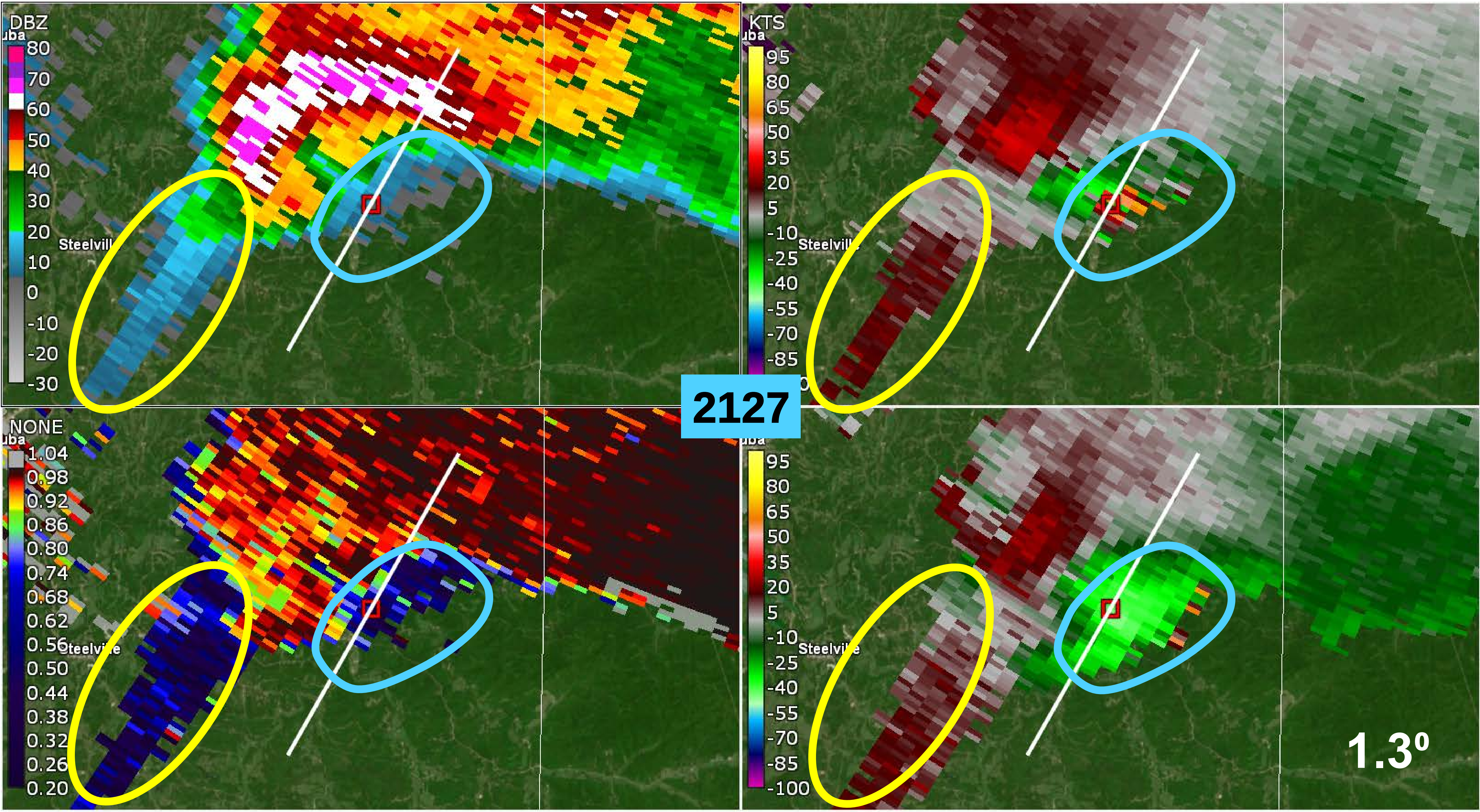
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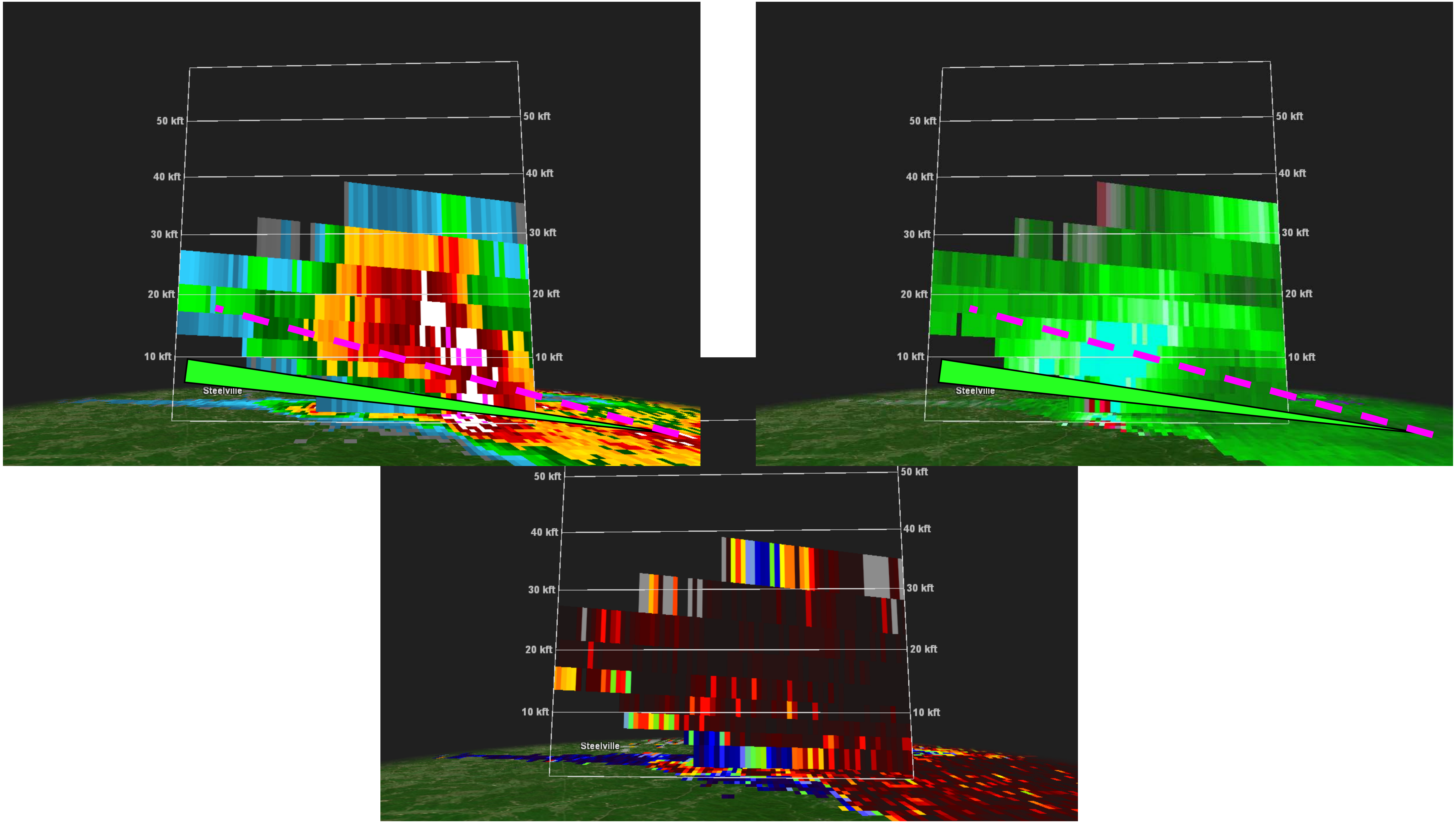
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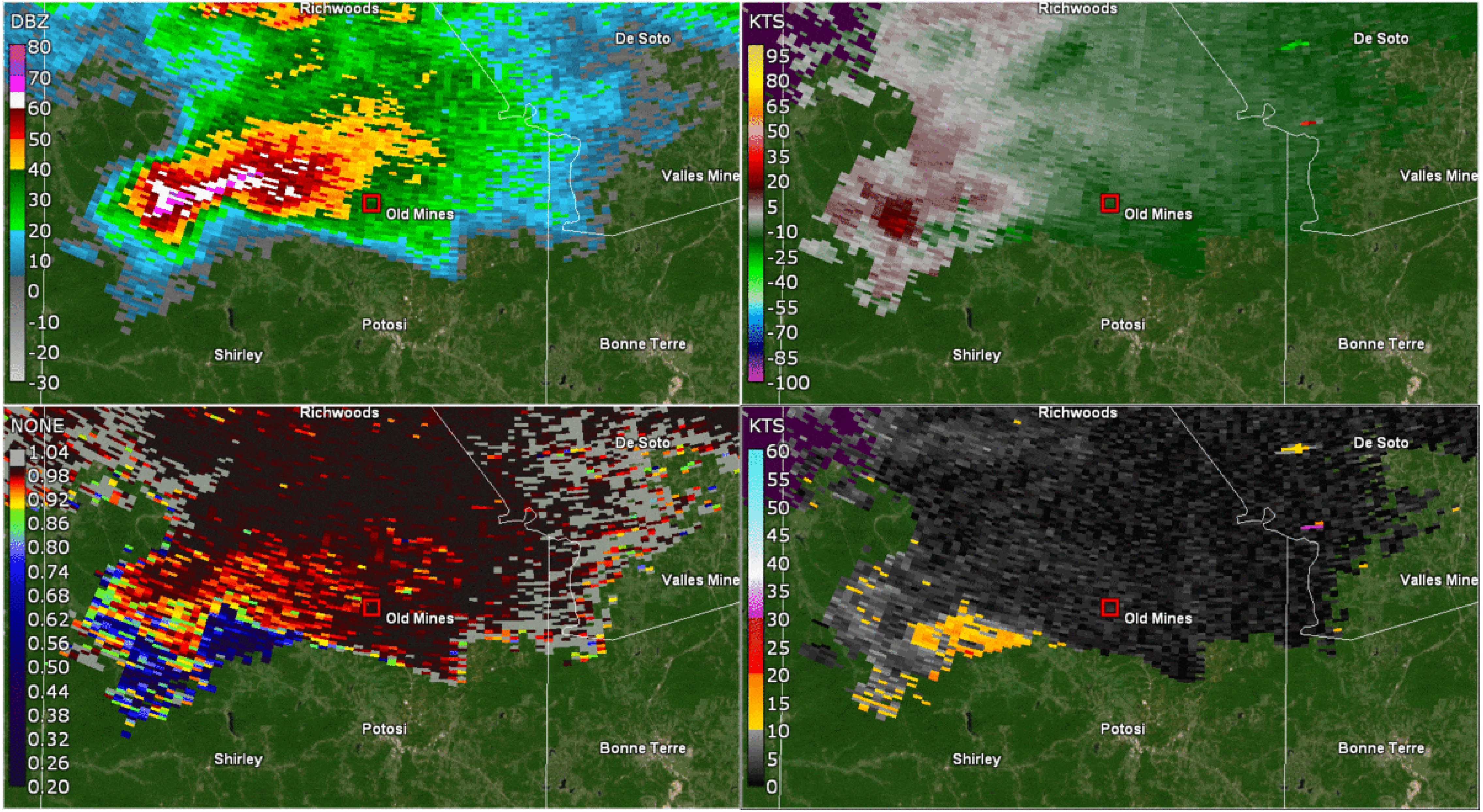
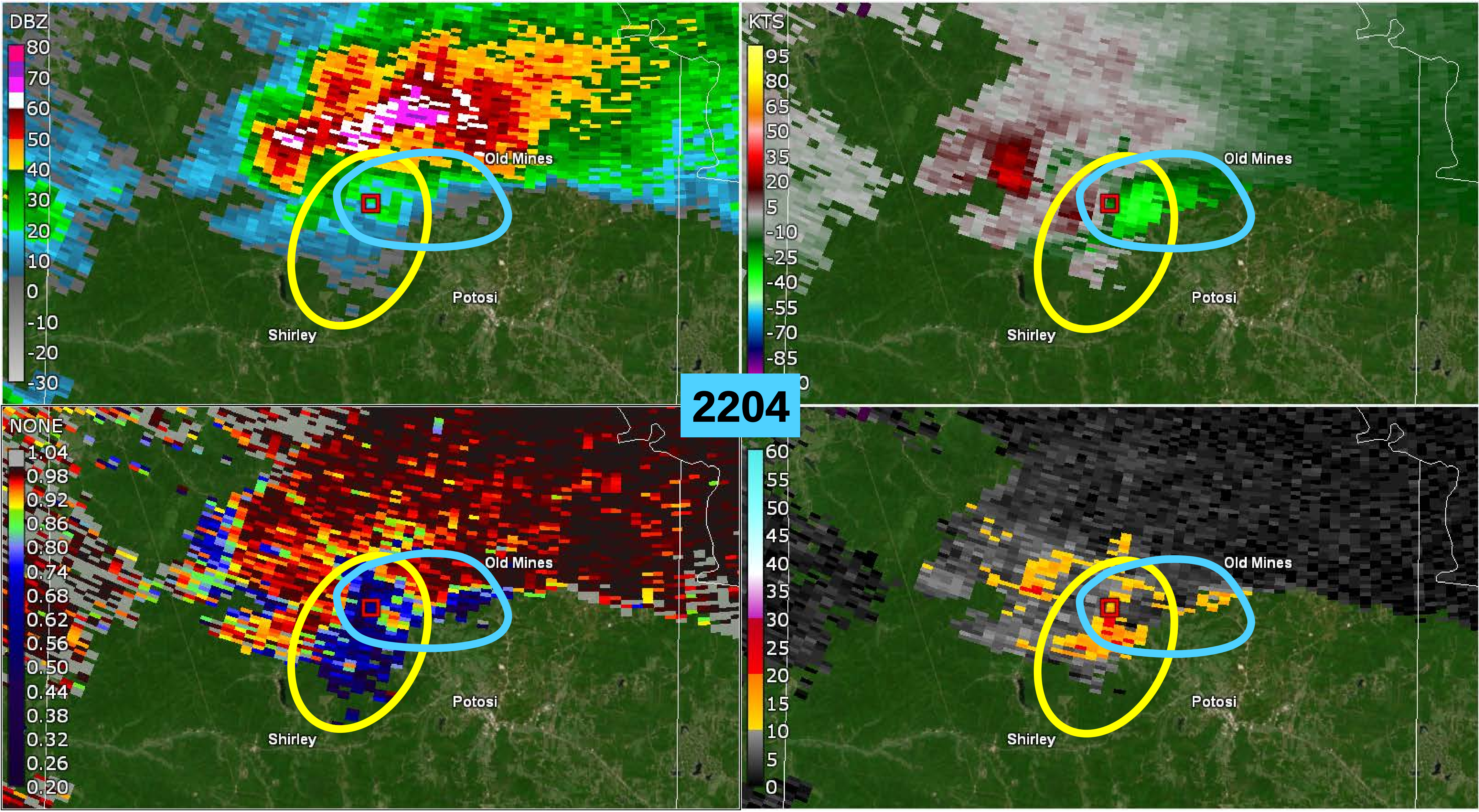
2156-2230 UTC

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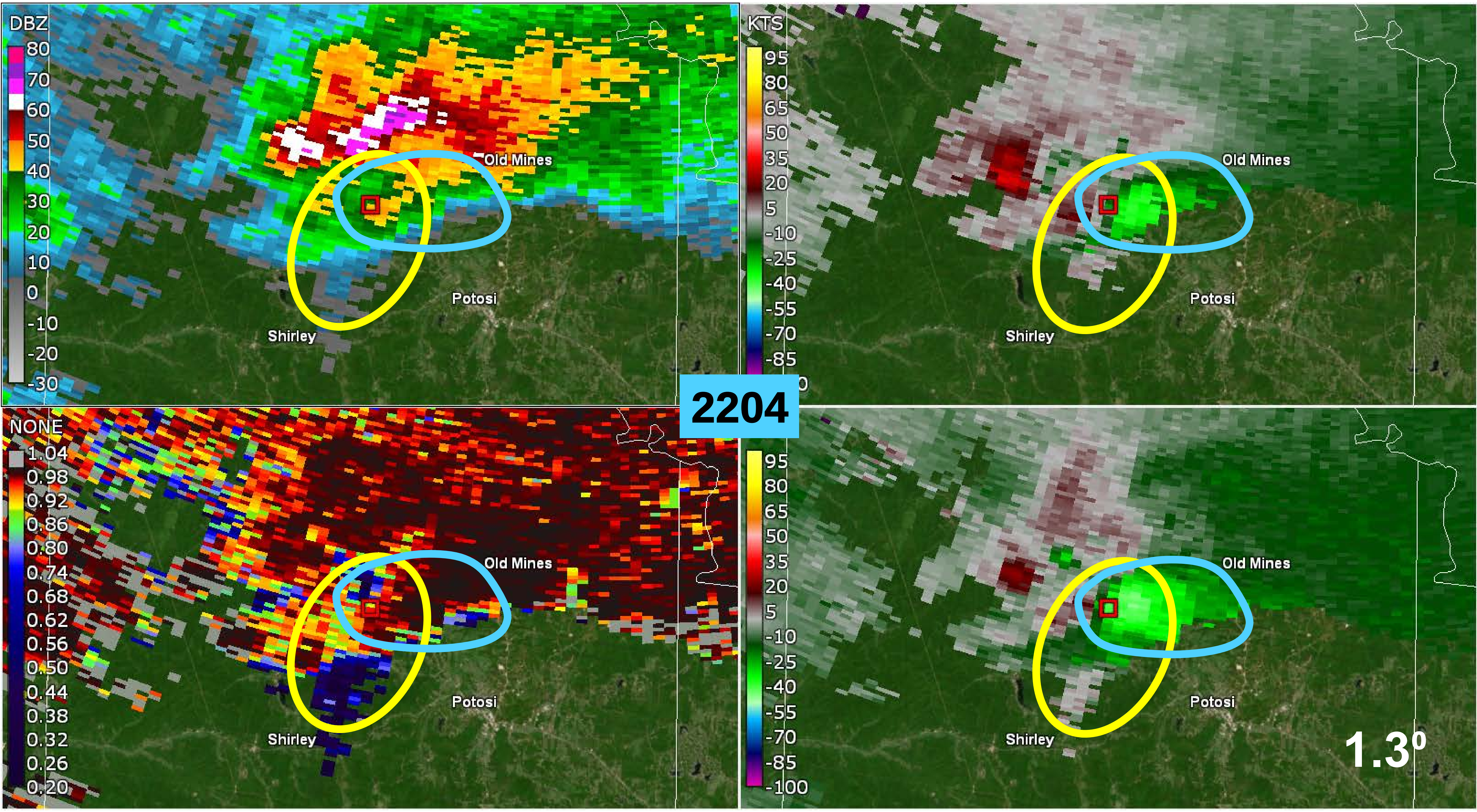

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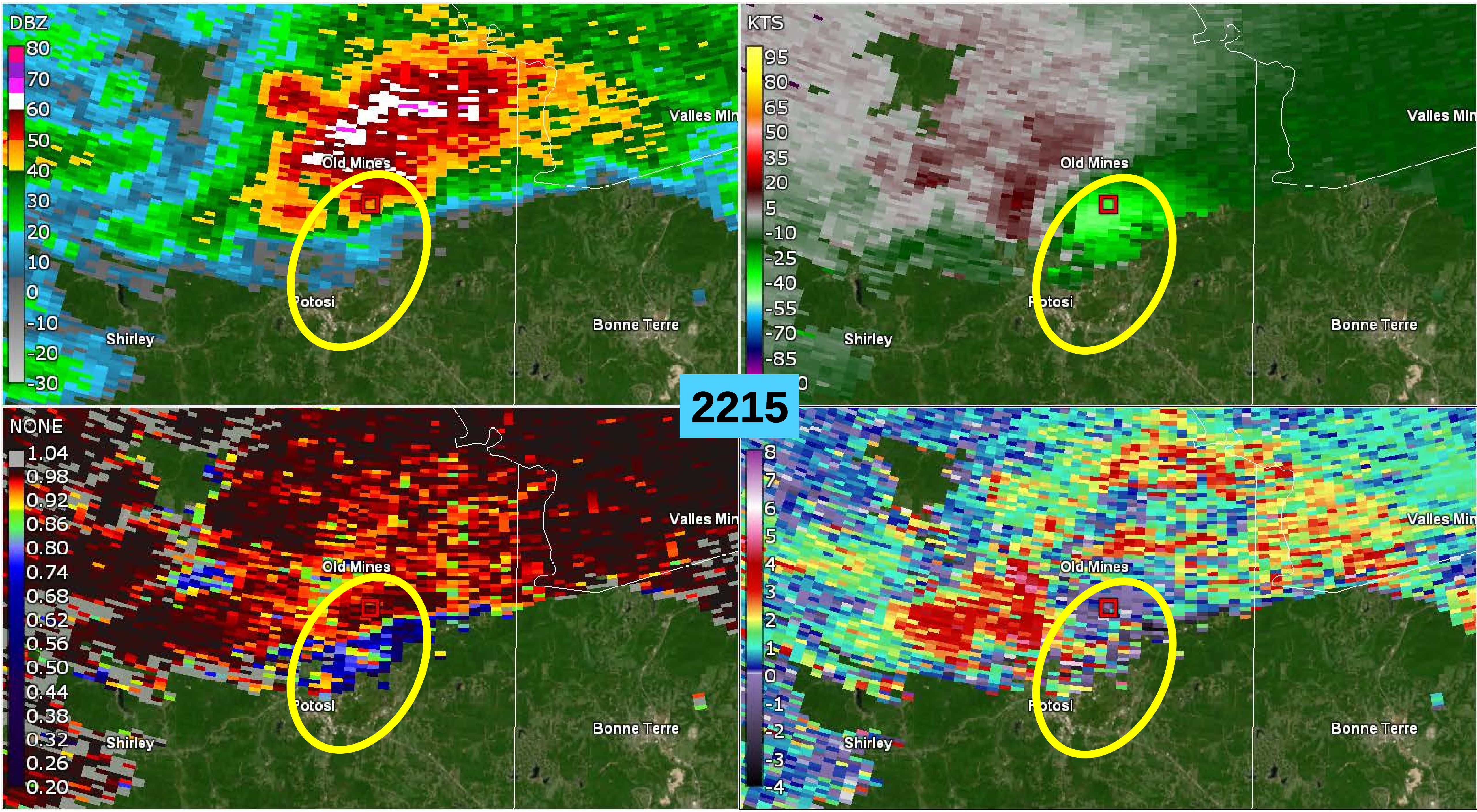

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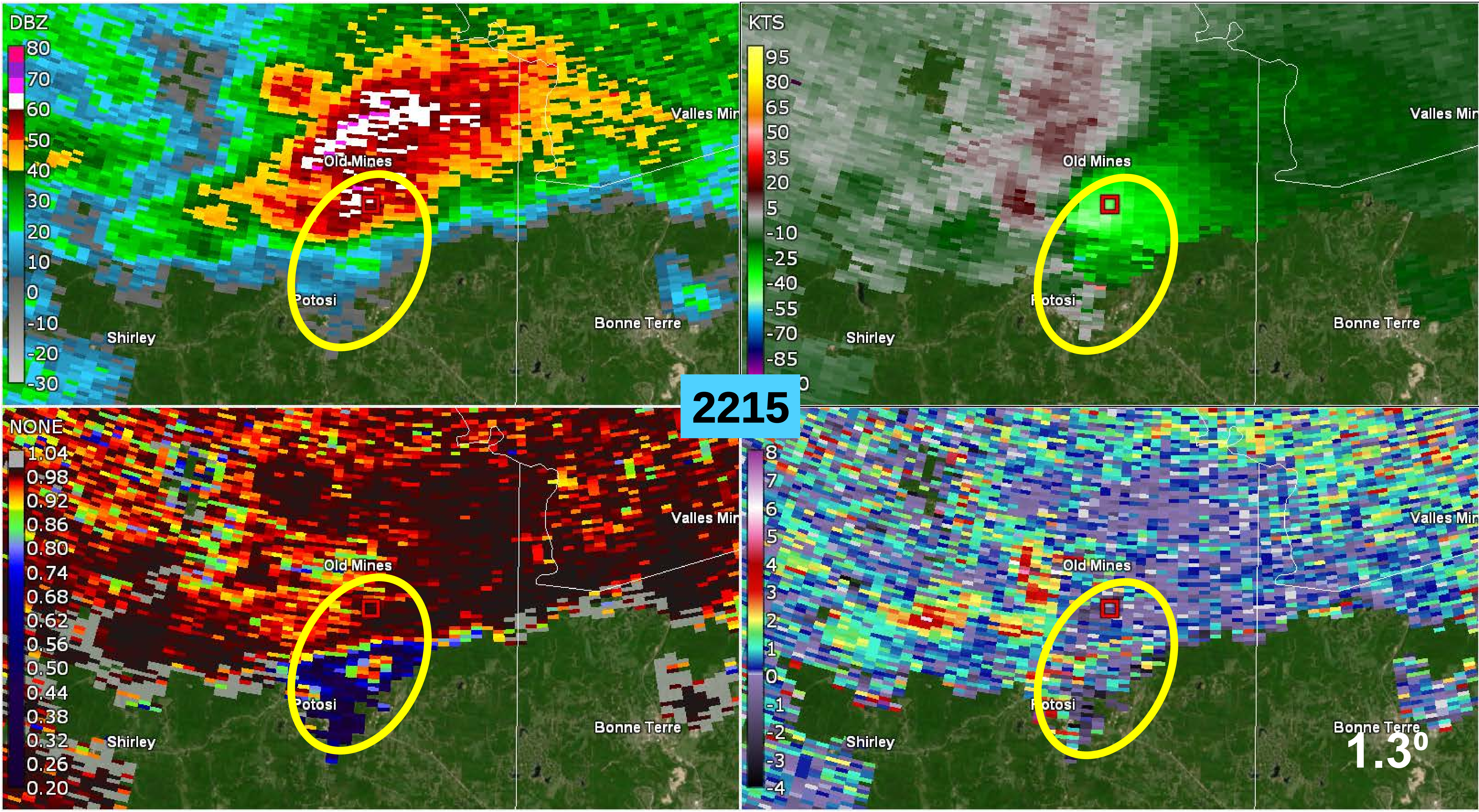

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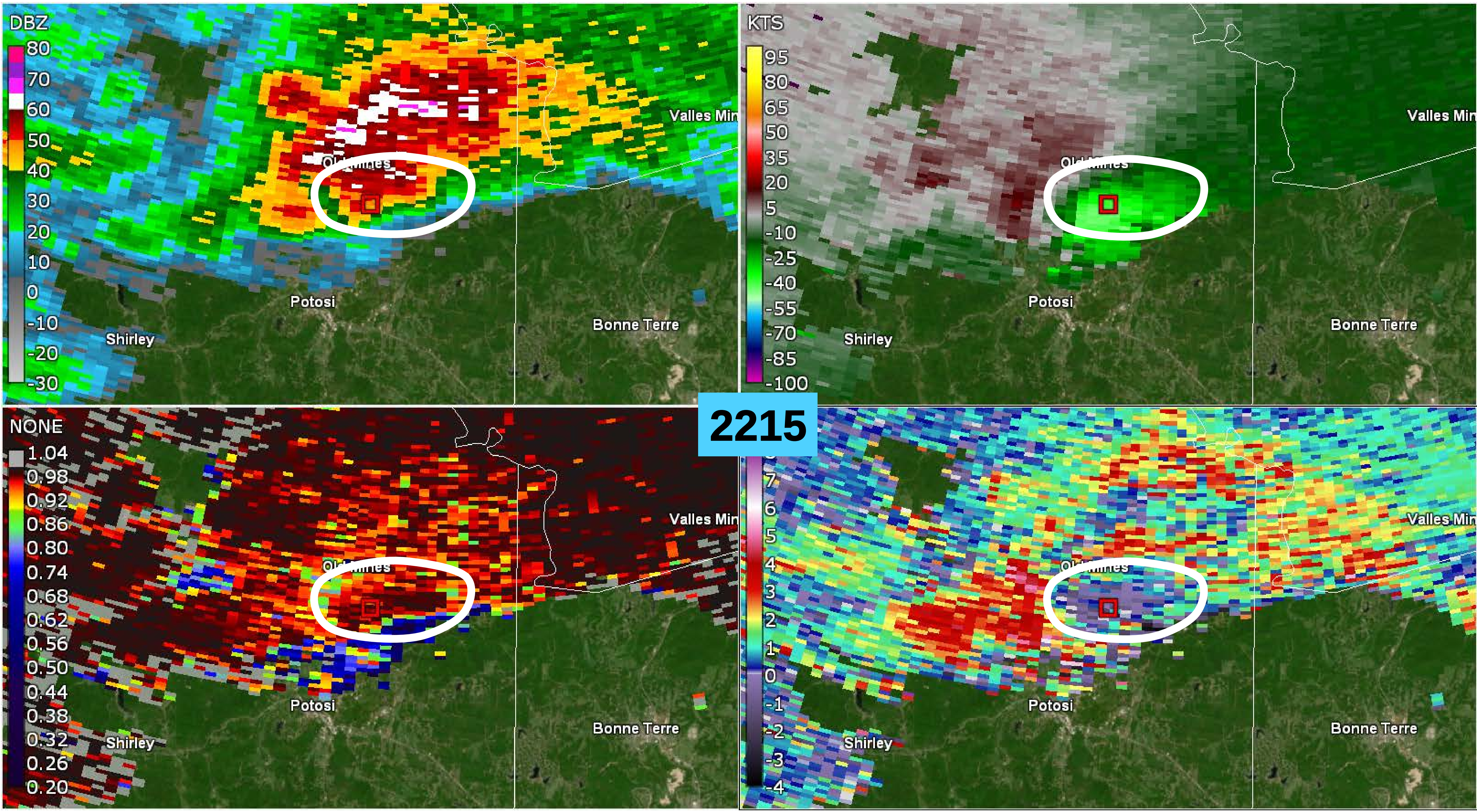
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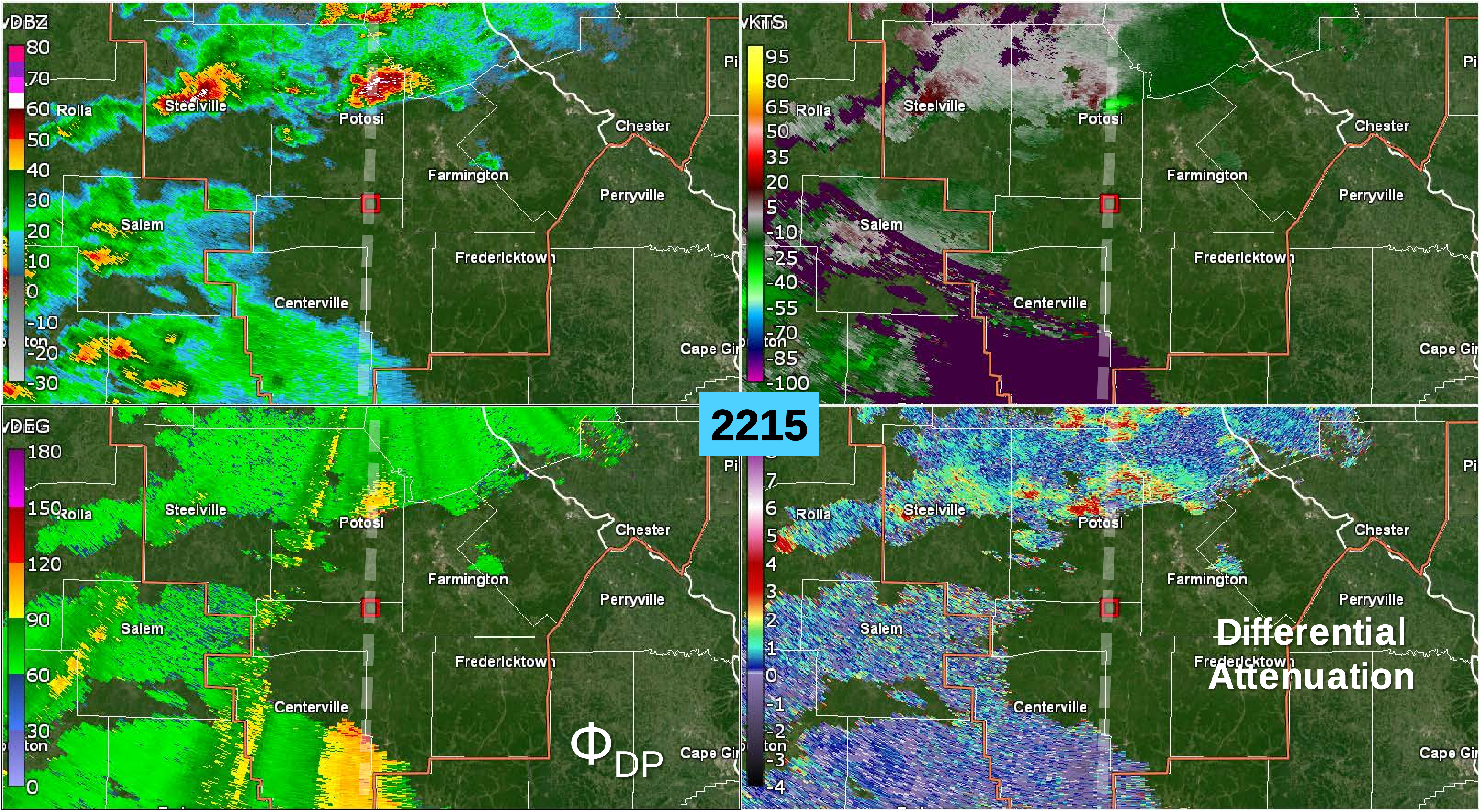
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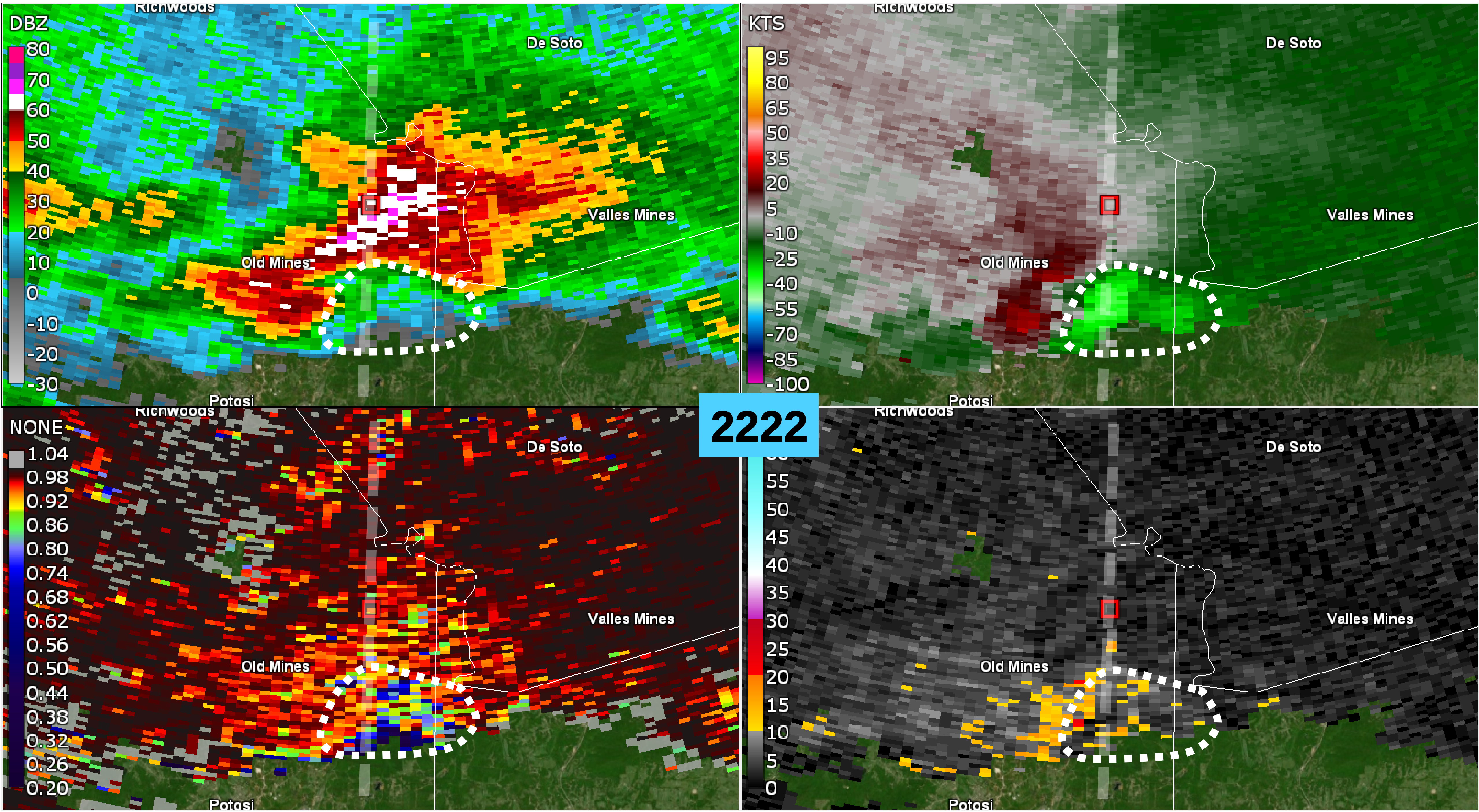
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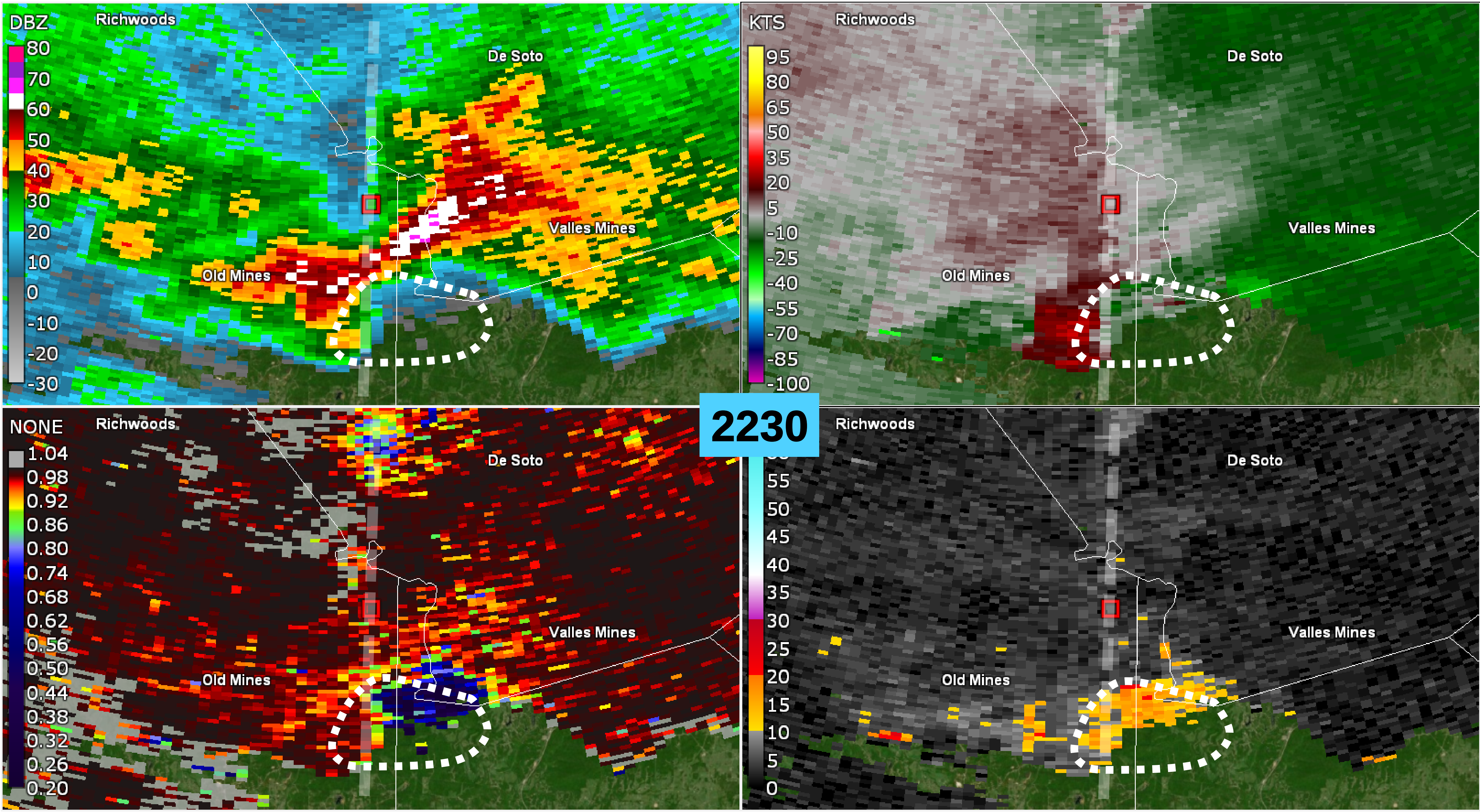
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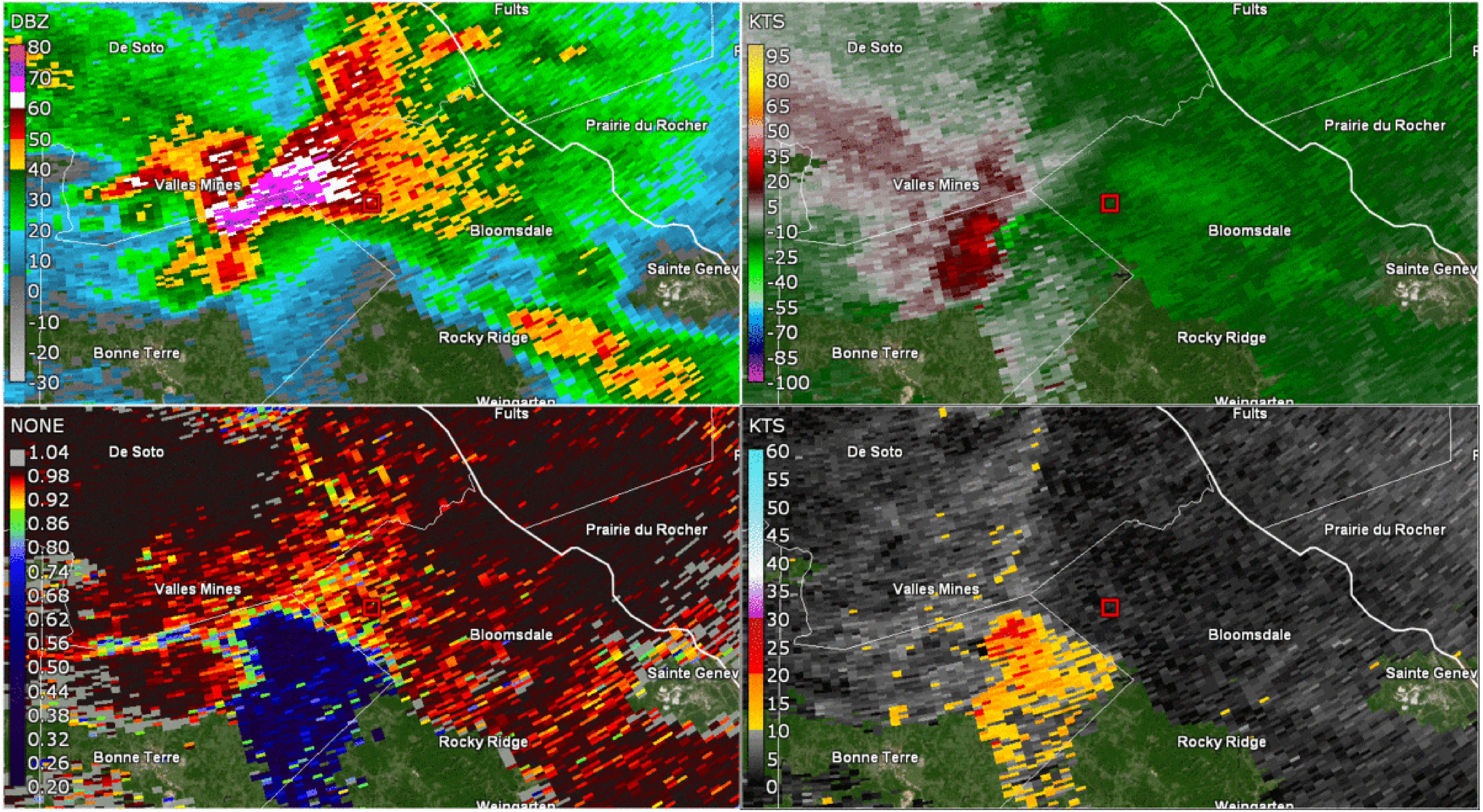

Resources For Additional Information

NWS Central Region Tornado Warning Improvement Project (TWIP) Supercell Curriculum Videos:

1) Low-Level Mesocyclone Intensification - Part I: ZDR Arc Theory
2) Low-Level Mesocyclone Intensification - Part II: Application
3) Assessing storm motion to maximize SRH - Part I: Relationship between the KDP Foot/ZDR Arc separation vector and low-level SRH
4) Assessing storm motion to maximize SRH - Part II: Case examples of using the separation vector orientation to qualitatively estimate SRH

NWS Storm Prediction Center Severe Thunderstorm Forecasting Video Lecture Series

NWS Warning Decision Training Division Dual Pol Training & Resources