Three Ingredients Method for QLCS Mesovortex and Tornado Genesis

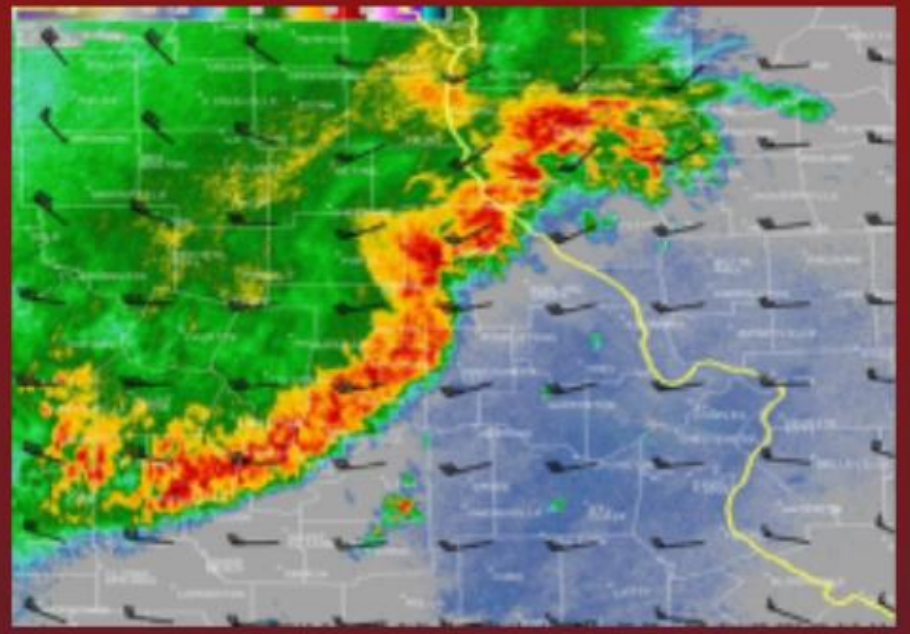
Slides taken from the Warning Operations Course on the LMS

Three Ingredients Method

Schaumann and Przybylinski 2012

QLCS mesovortex genesis and strong intensification is favored where the following three criteria are co-located:

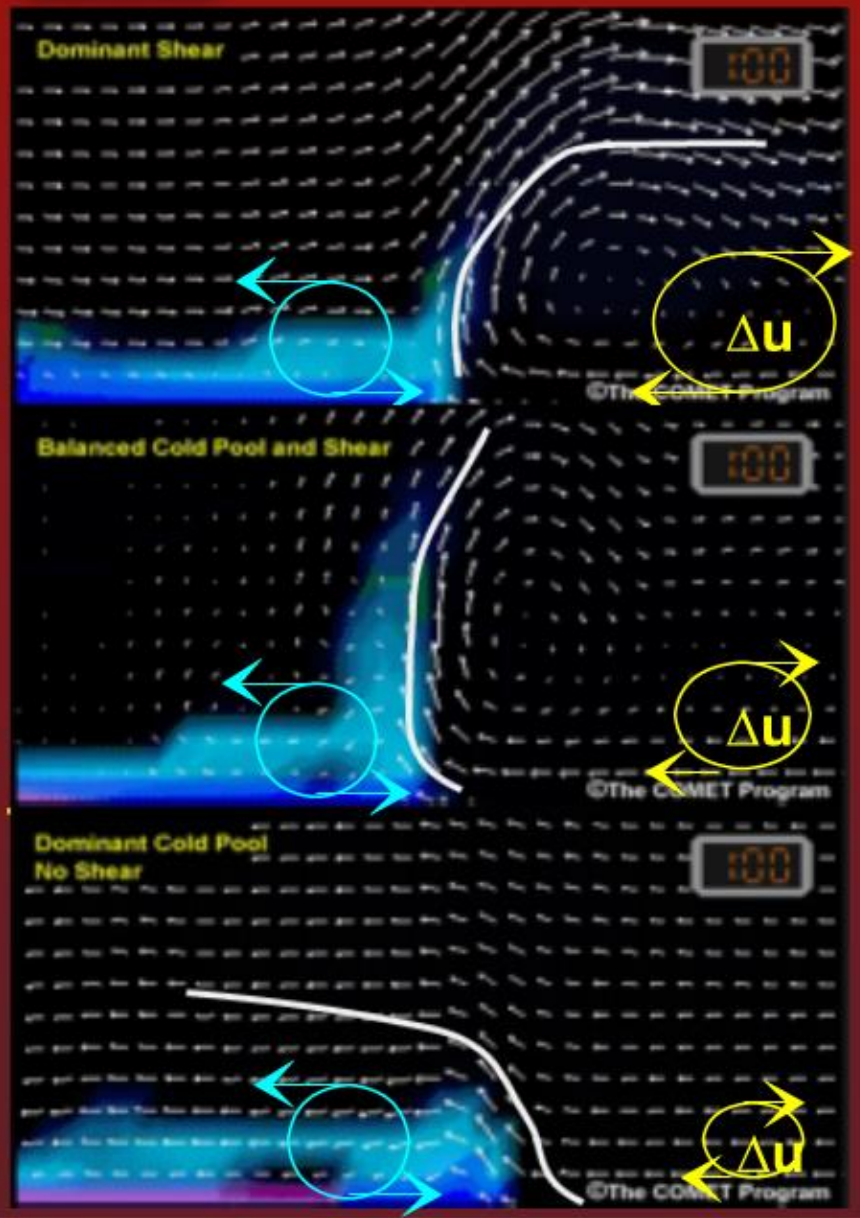
1. A portion of the QLCS in which the system cold pool and ambient low-level shear are nearly balanced or slightly shear-dominant
2. Where the 0-3 km line normal bulk shear magnitudes are ≥ 30 knots
3. Where a rear-inflow jet (RIJ) or enhanced outflow causes a surge of bow in the line



7 Jul 2014 Eastern Missouri

Remember: Mesovortex genesis and strong intensification does not necessarily mean a tornado!

Shear/Cold Pool Balance (RKW Theory)



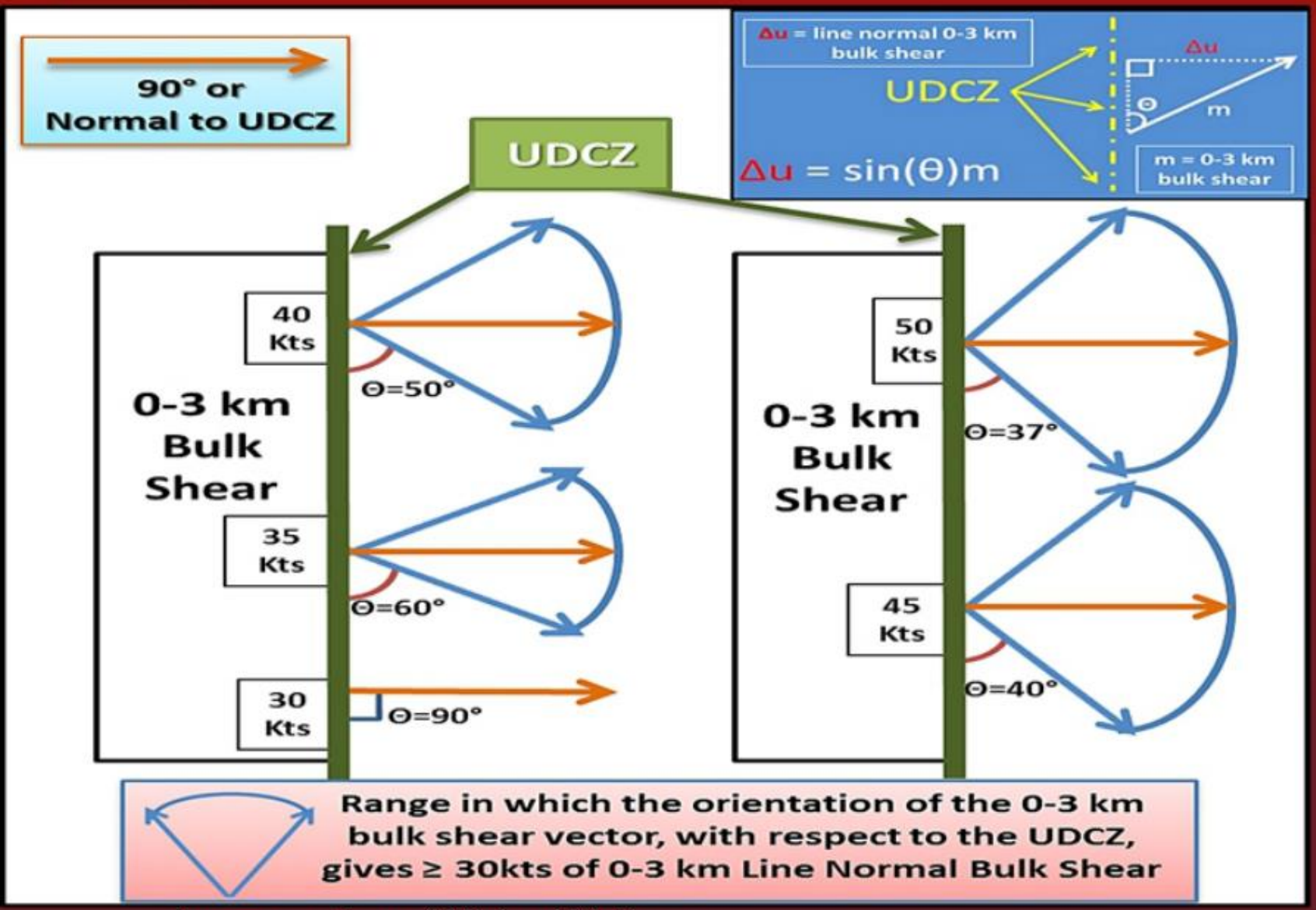
- Environmental shear (ΔU) dominates cold pool rotor
- Updraft/downdraft convergence zone (UDCZ) located within or behind convective updrafts
- Convective towers lean forward, shallower, and can be notably thin
- Leading and trailing stratiform precipitation both present
- Mesovortices and tornadoes are likely unless shear is too strong
- Damaging wind mostly restricted to mesovortices

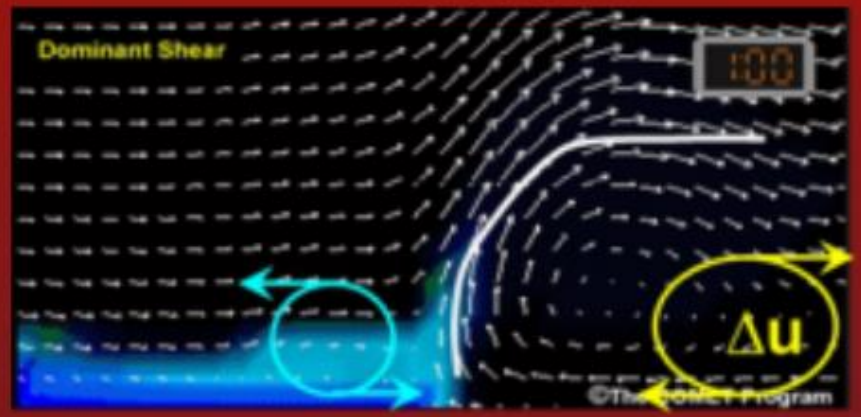
- Environmental shear (ΔU) matches cold pool rotor
- UDCZ located along immediate front edge of convective updrafts
- Convective towers nearly vertical in nature, taller, and wider
- Trailing stratiform precipitation
- Mesovortices and tornadoes are most likely
- Damaging wind more widespread, enhanced with mesovortices

- Environmental shear (ΔU) dominated by cold pool rotor
- UDCZ located out ahead of convective updrafts
- Convective towers rearward leaning and often shallower than balanced regime
- Trailing stratiform precipitation
- Mesovortices extremely rare
- Damaging wind main severe threat if cold pool is strong enough

Schaumann and Przybylinski (2012)

0-3 km Line-Normal Shear





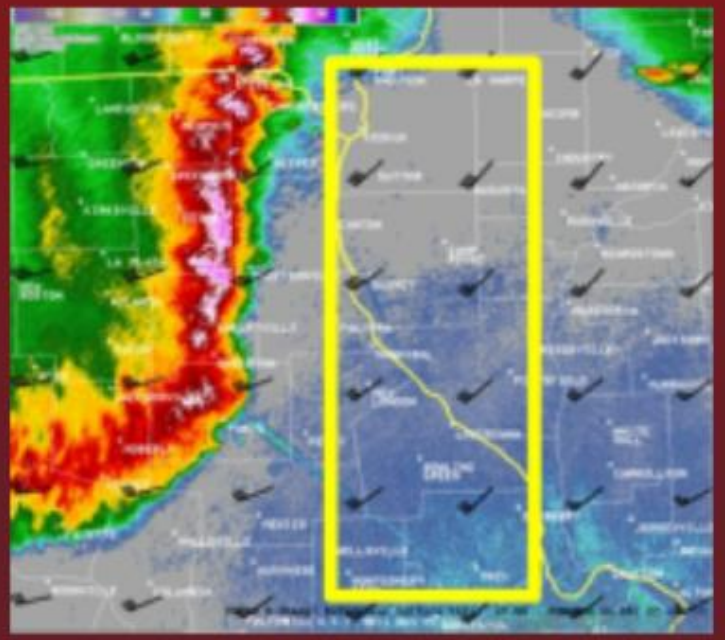
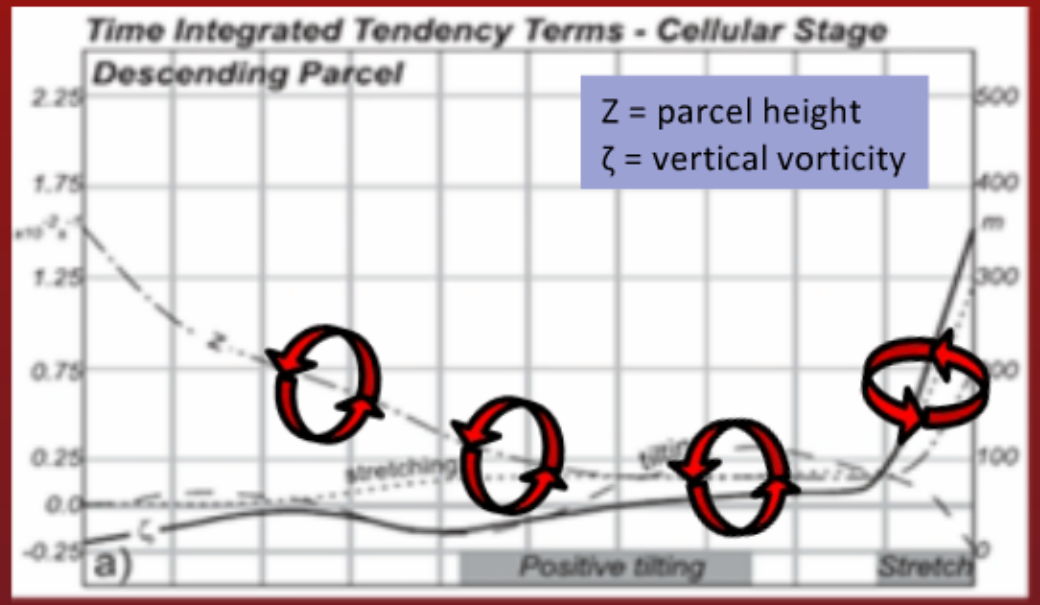
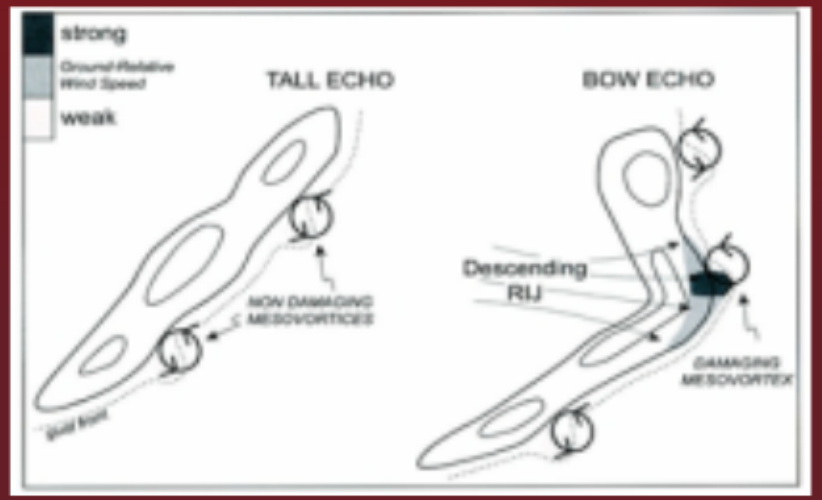


Image courtesy of Michael Mathews

Mesovortex Parcel Trace

Atkins and Laurent 2009



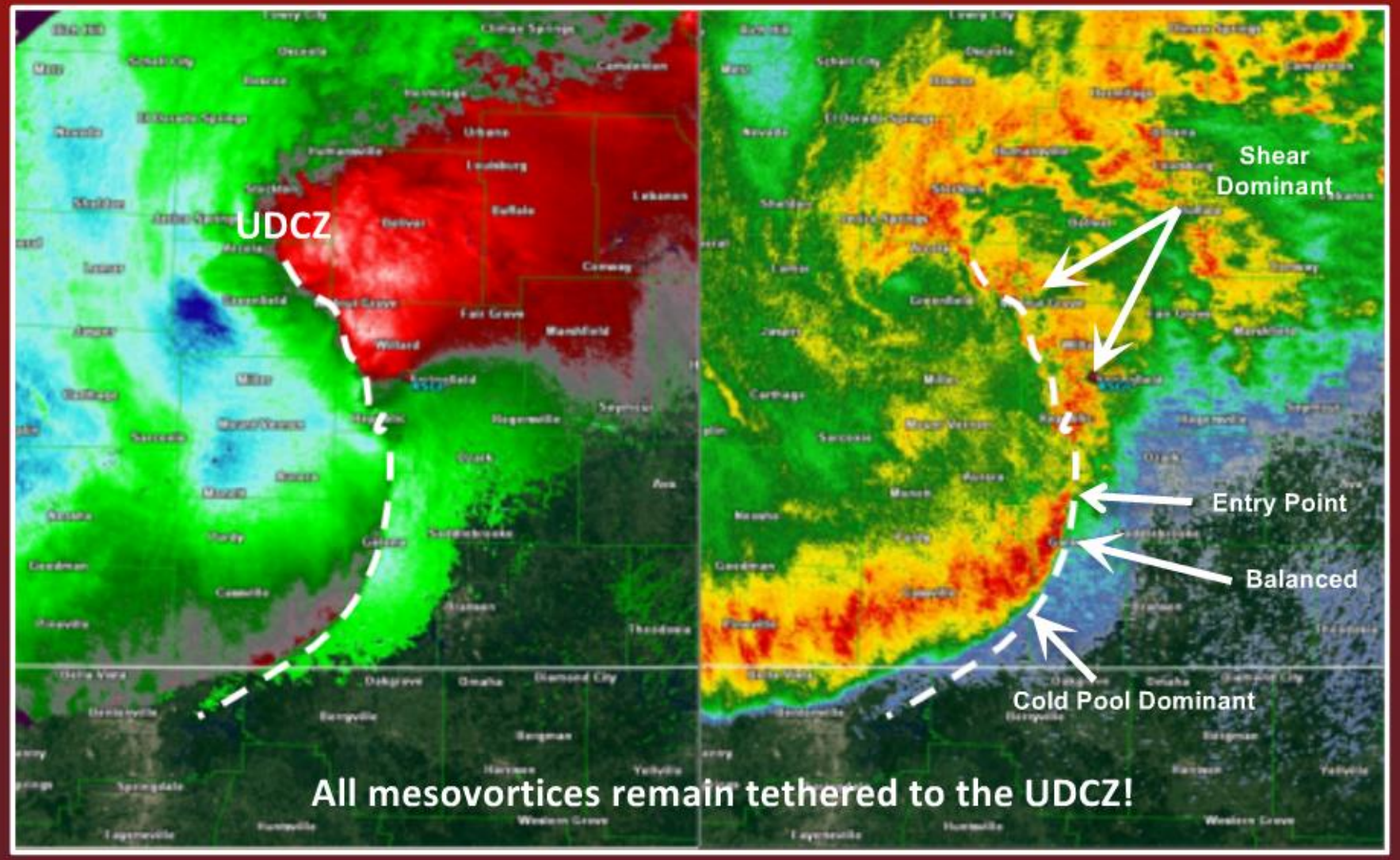


Mesovortex Genesis Process

1. Descending parcels (usually rear-inflow jet) acquire horizontal streamwise vorticity
2. Parcels are tilted and then stretched as they encounter the updraft
3. Vertical vorticity rapidly increases as parcels are stretched in the updraft

UDCZ and Shear/Cold Pool Balance Regimes

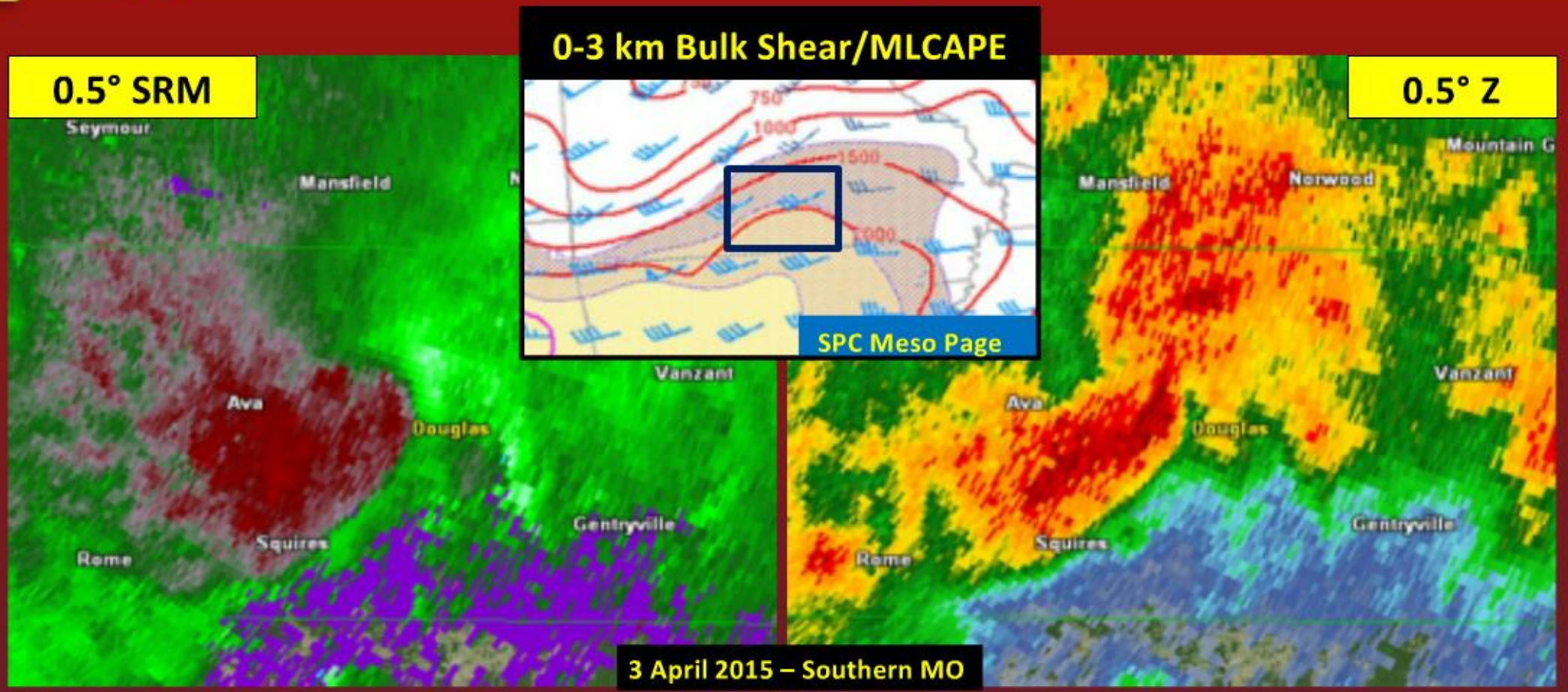
8 May 2009 Super Derecho



Applying the Ingredients' Concepts

1. Determine location of UDCZ
2. Determine where 0-3 km line normal magnitudes are ≥ 30 knots
3. Determine which areas of lines are balanced or slightly shear dominant
4. Determine where a surge or bow is present
5. Where do all three of these ingredients exist?
6. This is your area where mesovortex genesis is favored!

Application of Three Ingredients Method



- 0-3 km *line-normal* bulk shear magnitude ≥ 30 knots
- Balanced or slightly shear dominant
- RIJ or enhanced outflow causing surge or bow in the line

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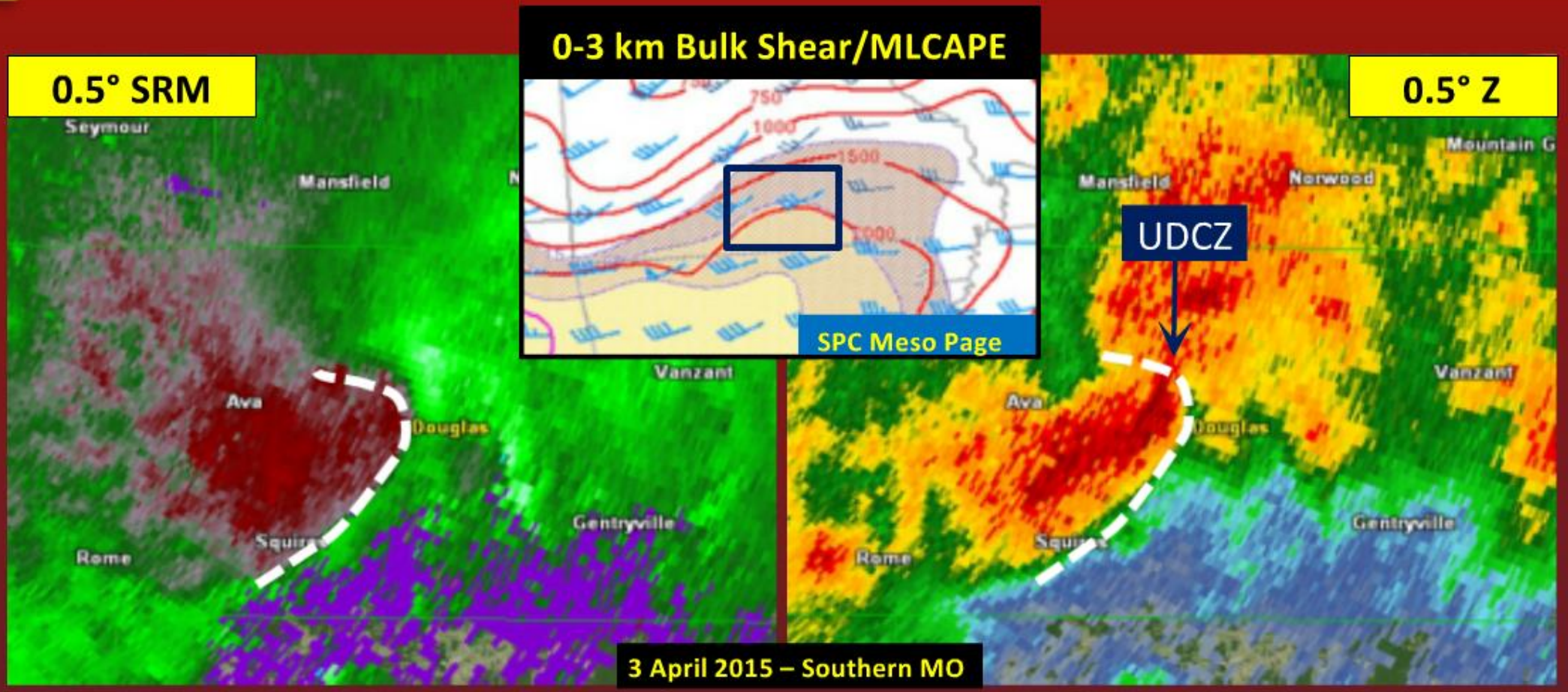

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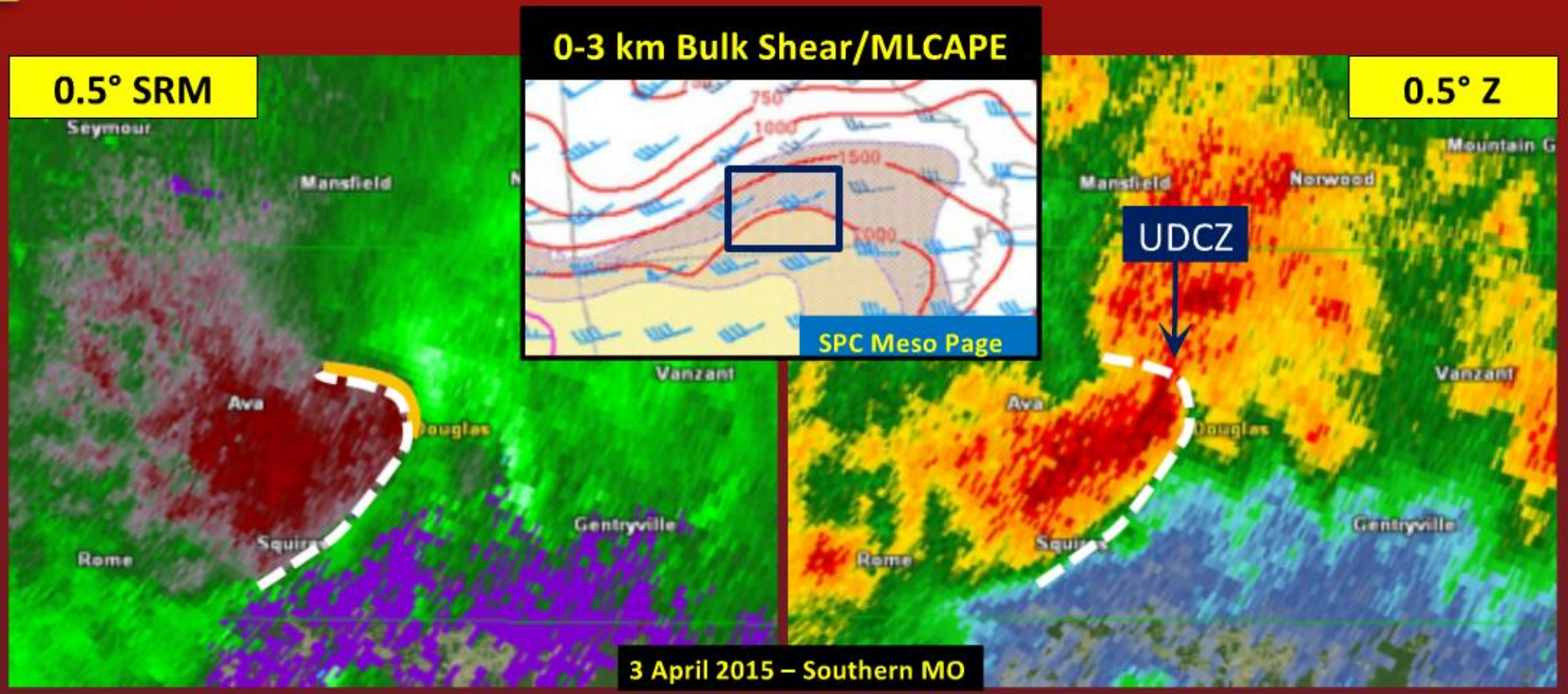

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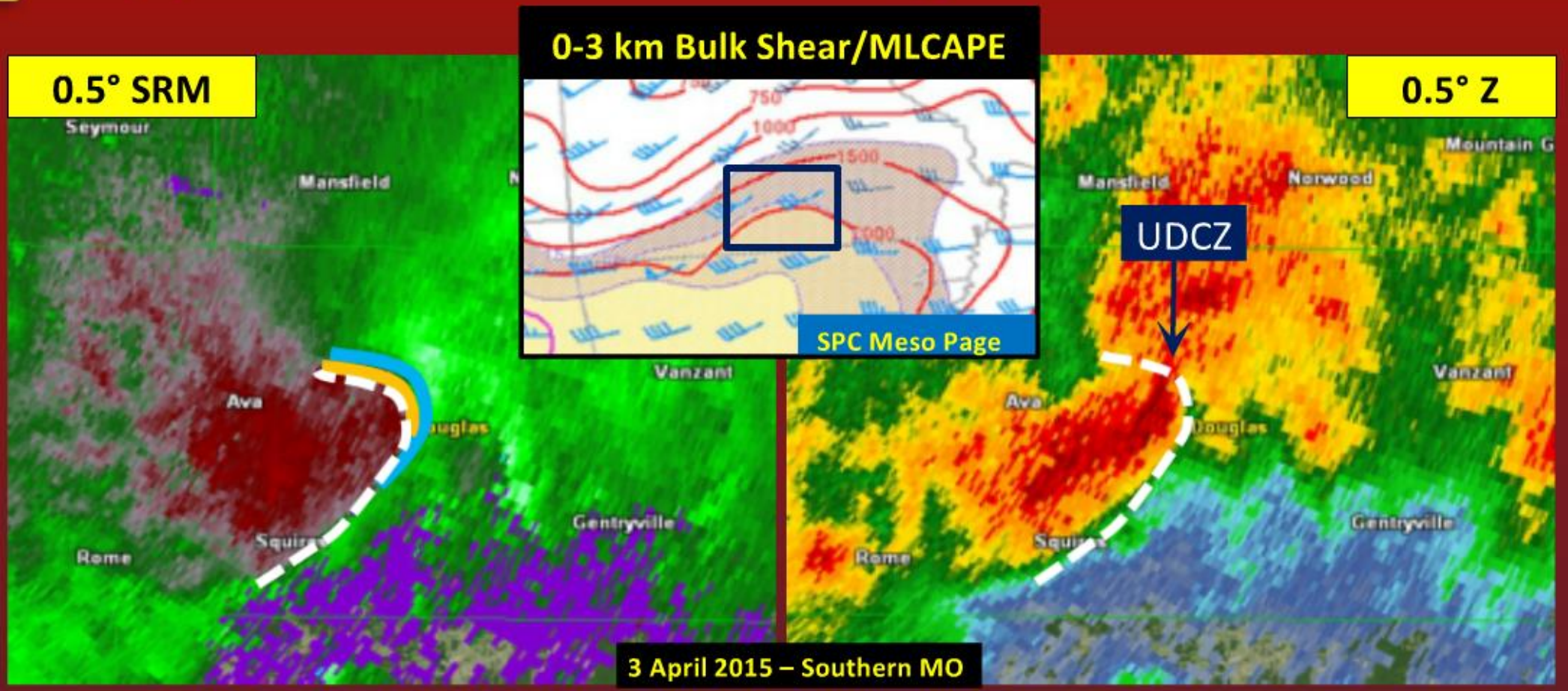

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Balanced or slightly shear dominant

RIJ or enhanced outflow causing surge or bow in the line

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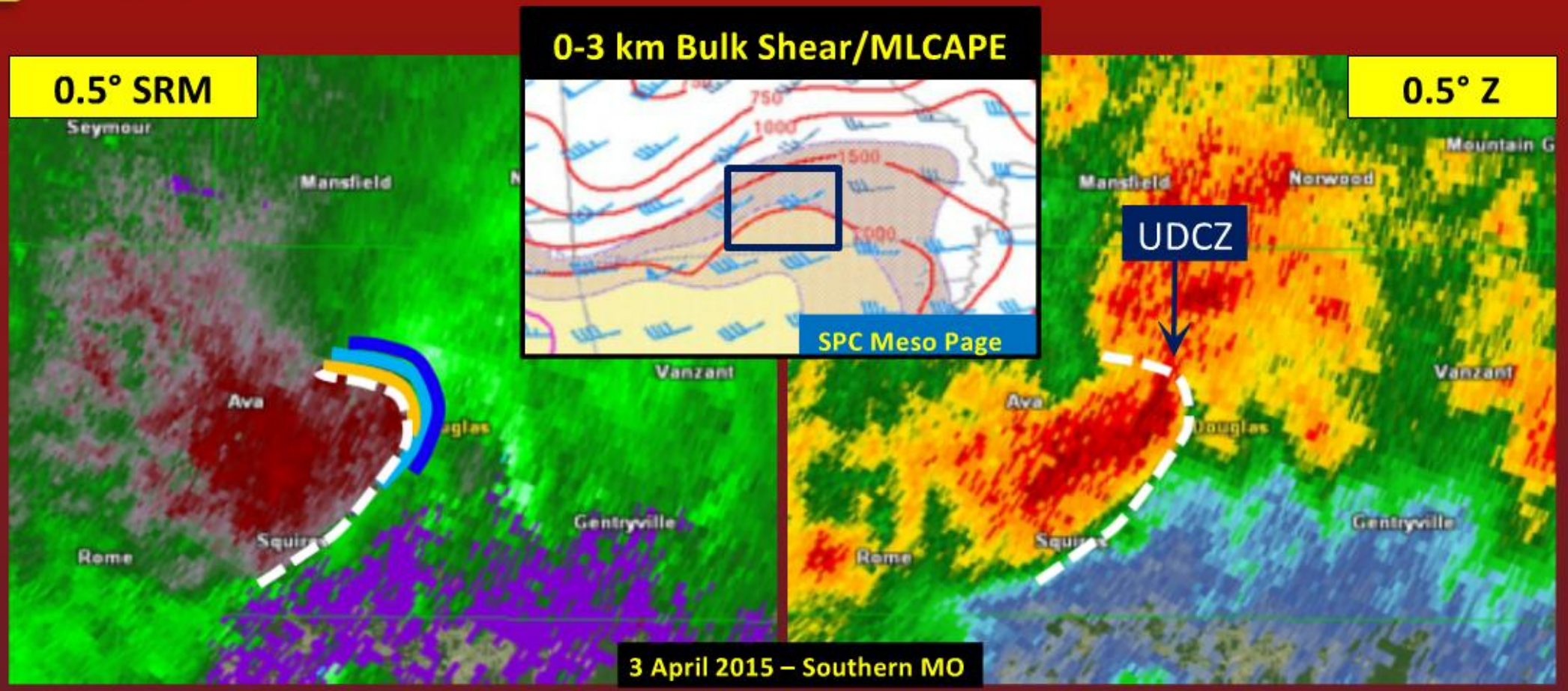

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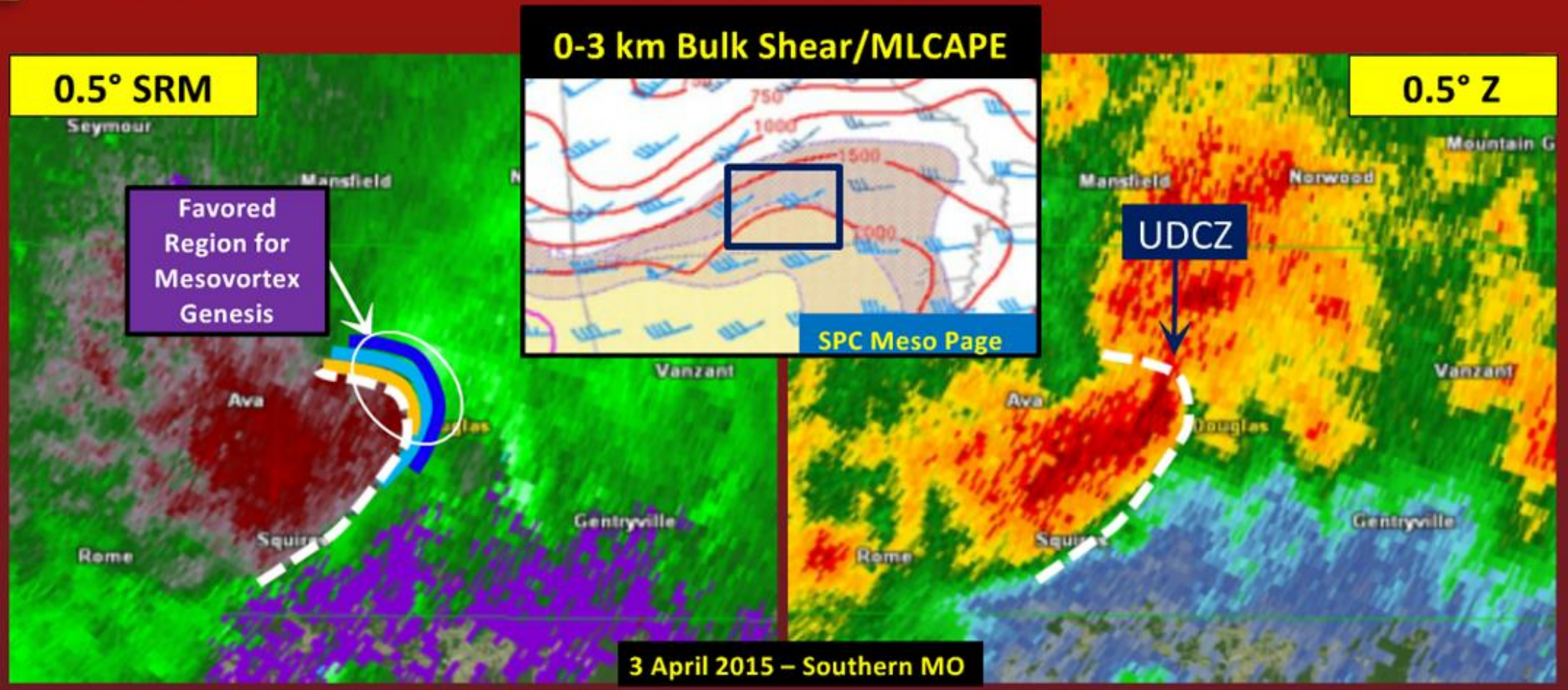

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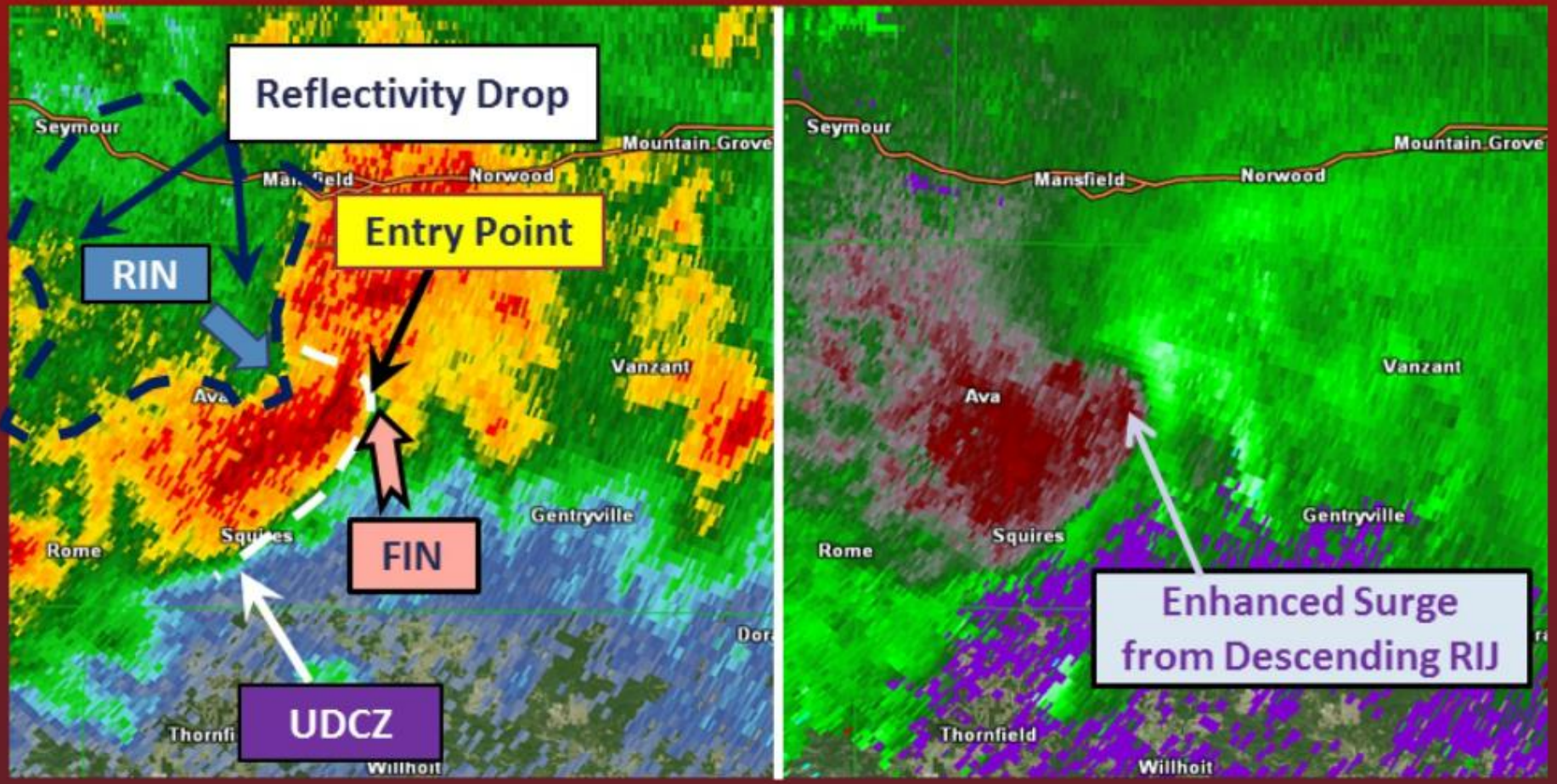
Tornado Warning Decision
Confidence Builders & Nudgers

Descending RIJ/Reflectivity Drop
Enhanced Surge
Line Break
UDCZ Entry/Inflection Point
Paired front/Rear Inflow Notch
Boundary Ingestion
Front Reflectivity Nub
Contracting Bookend Vortex with Vr ≥ 25 kt
Tight/Strong Mesovortex (Vr ≥ 25 kt)
Confirmed Tornado/Tornadic Debris Signature (TDS)
Reflectivity Tag Intersecting a Surge
0-3 km MLCAPE ≥ 40 J/kg
Cell Merger/Reflectivity Spiking Near Surge
History of Tornadoes (Includes Prior TDSs)

Warning Decision Guidance

Scenarios for Considering Tornado Warning



Tornado Warning Decision Confidence Builders & Nudgers	
Descending RIJ/Reflectivity Drop	✓
Enhanced Surge	✓
Line Break	
UDCZ Entry/Inflection Point	✓
Paired front/Rear Inflow Notch	✓
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