An Investigation Between Tornadic and Non-Tornadic QLCS Mesovortices using Operational and Experimental MRMS Products

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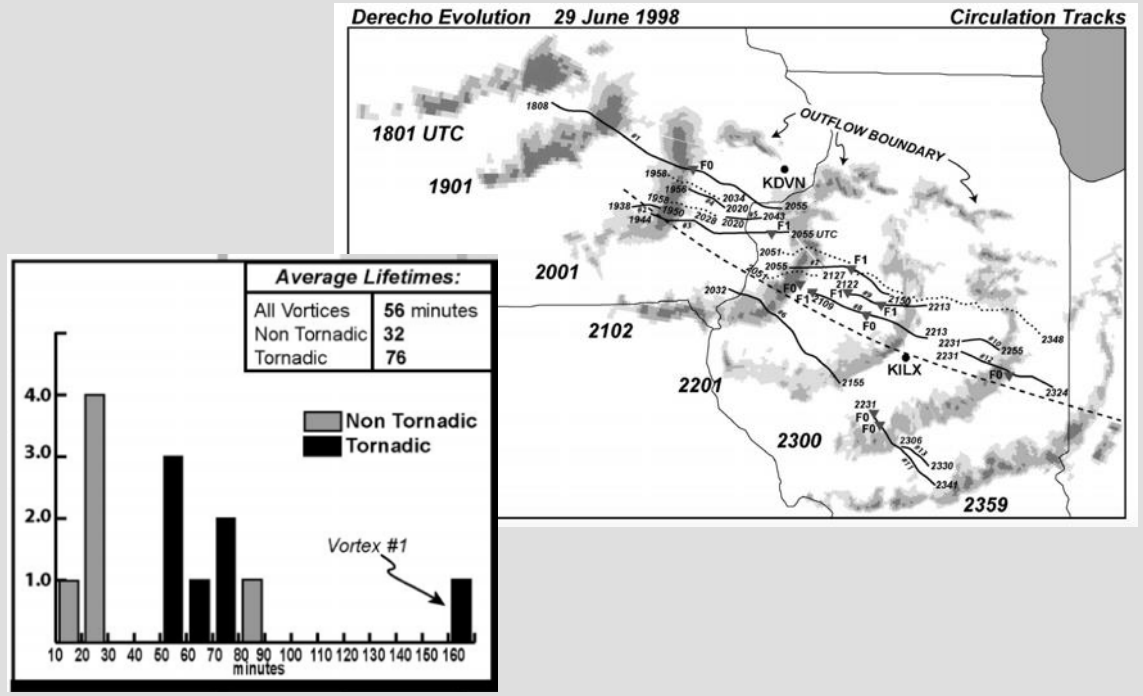
FOUNDATION STUDIES

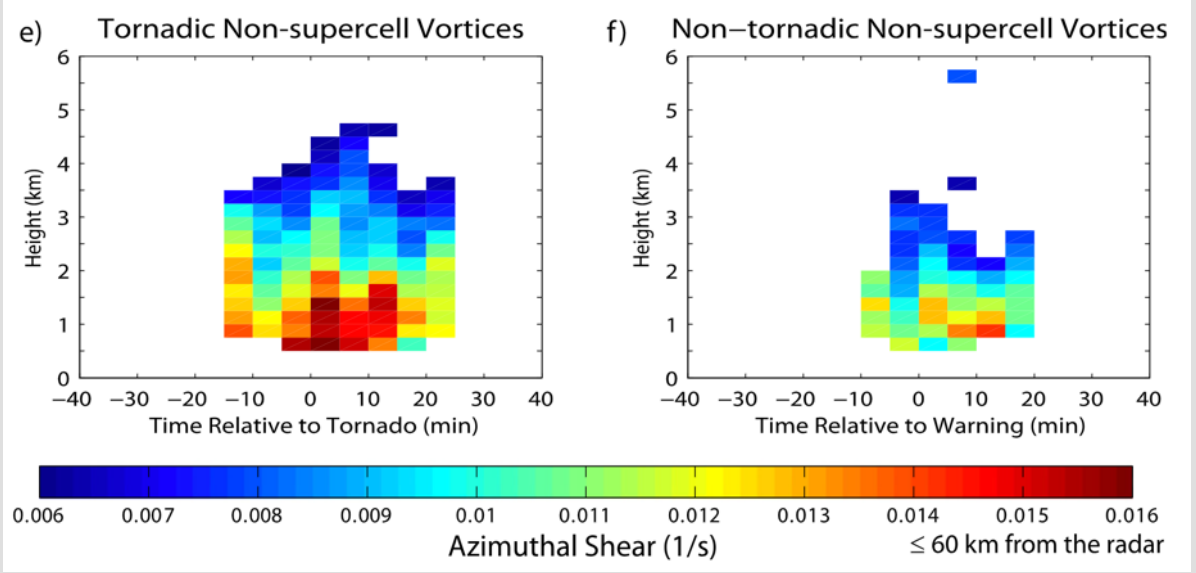
Atkins et al. (2004, 2005):

- Tornadic vortices tended to be stronger (< 2 km), longer-lived (76 min vs. 32 min), and deeper than their non-tornadic counterparts in a derecho simulation



Davis and Parker (2014):

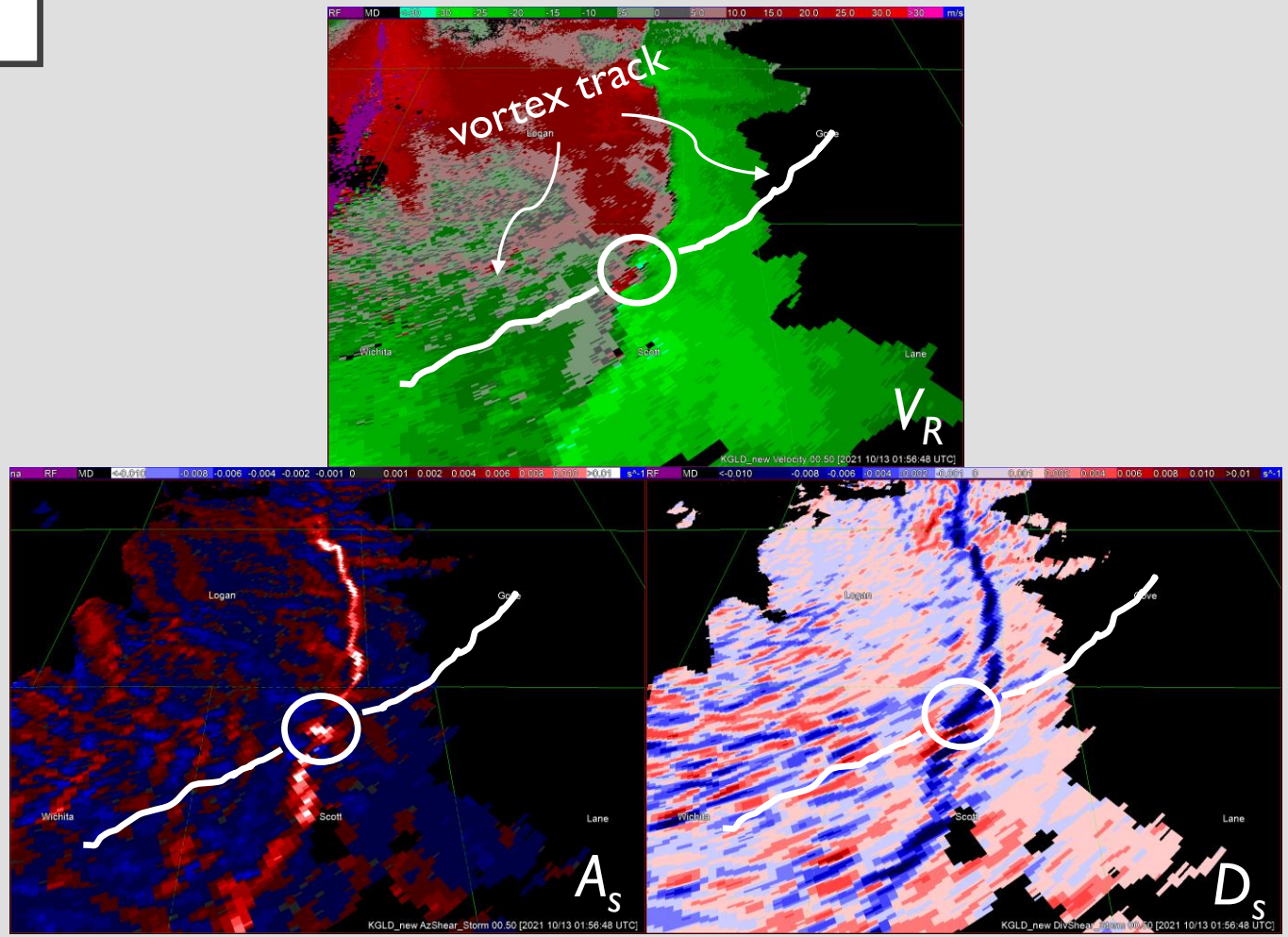
- WDSS-II processed (LLSD) single 88D obs for 225 HSLC QLCS & supercell vortices in the south-to-mid Atlantic
- Median non-supercellular vortices were stronger, longer-lived (30 min vs. 20 min), and deeper (3 km vs 2 km)



MRMS

Blends data from multiple 88Ds onto a 3D grid (Lakshmanan et al., 2007, Mahalik et al., 2019), grid value weighted sum of input data/derived single-radar products from multiple radars:

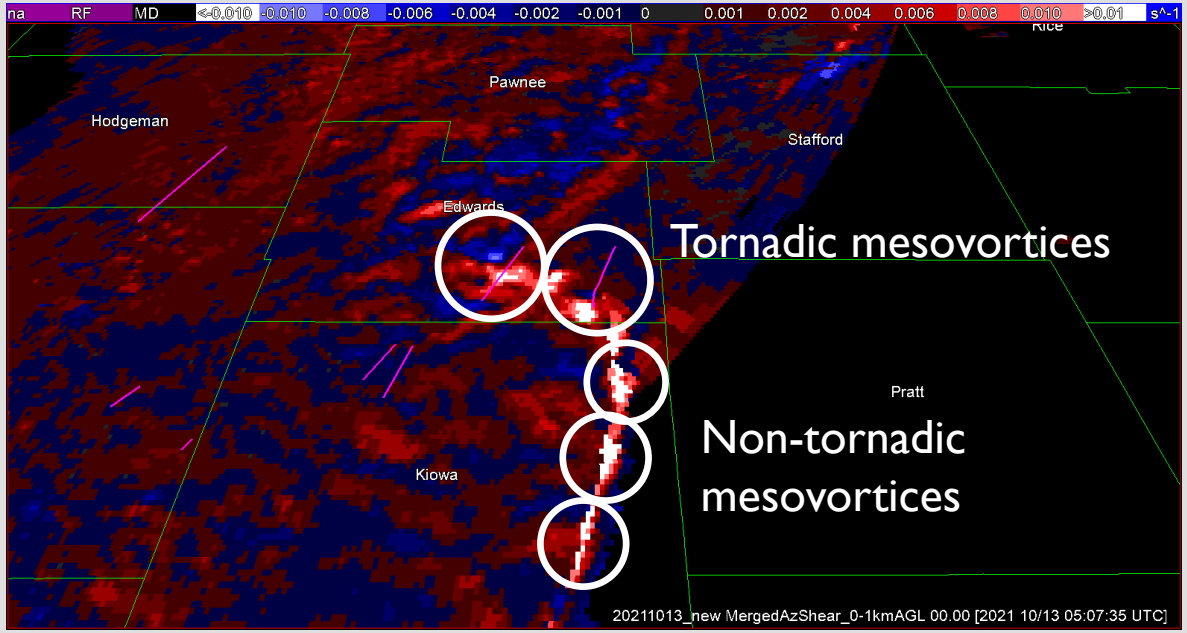
- **Azimuthal Shear** (A_s): Estimates one-half of the 2D vertical vorticity (*operational*).
- **Divergent Shear** (D_s): Estimates one-half of the 2D horizontal divergence (*experimental*).
- **Dual-pol products!** (*experimental*)
- 2-min updates,
  - Δ x ~500 m for AzShear & DivShear;
  - Δ x ~1 km for reflectivity and dual-pol products.

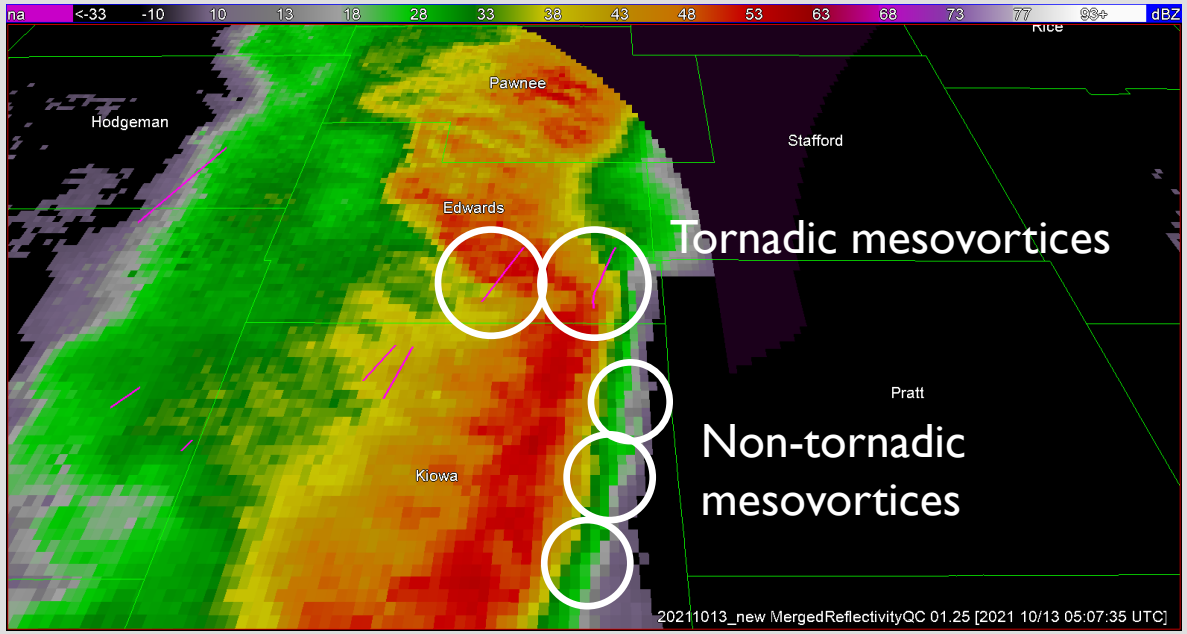


VORTEX IDENTIFICATION

- Tornadic vortices identified when 0-1-km AzShear max becomes collocated with tor damage path and tracked forward and backward in time relative to the time of collocation (t_0).

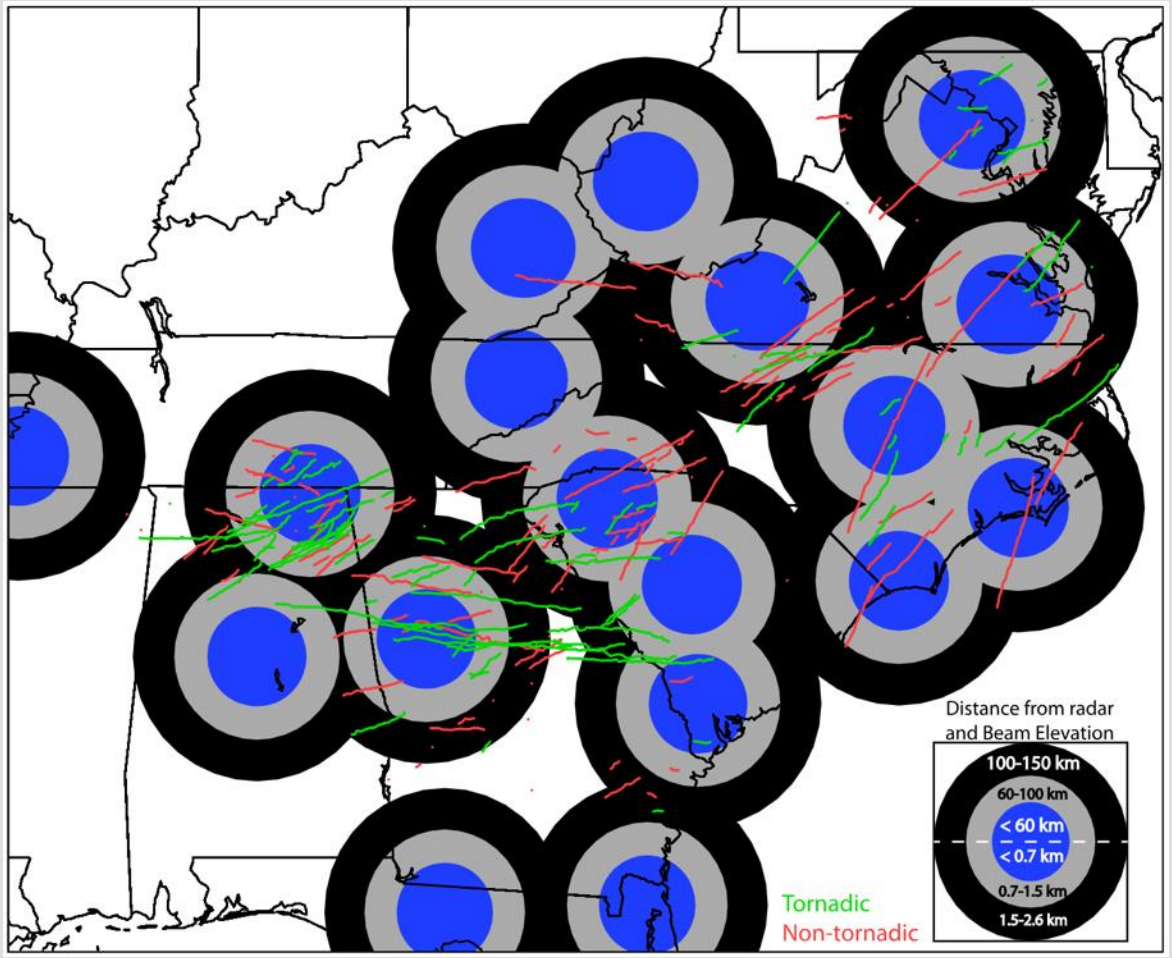
- Non-tornadic (null) **vortex defined as AzShear01 in excess of 0.01 s^{-1} and resides farther than 50 km away from any damage path (Davis & Parker 2014)**.





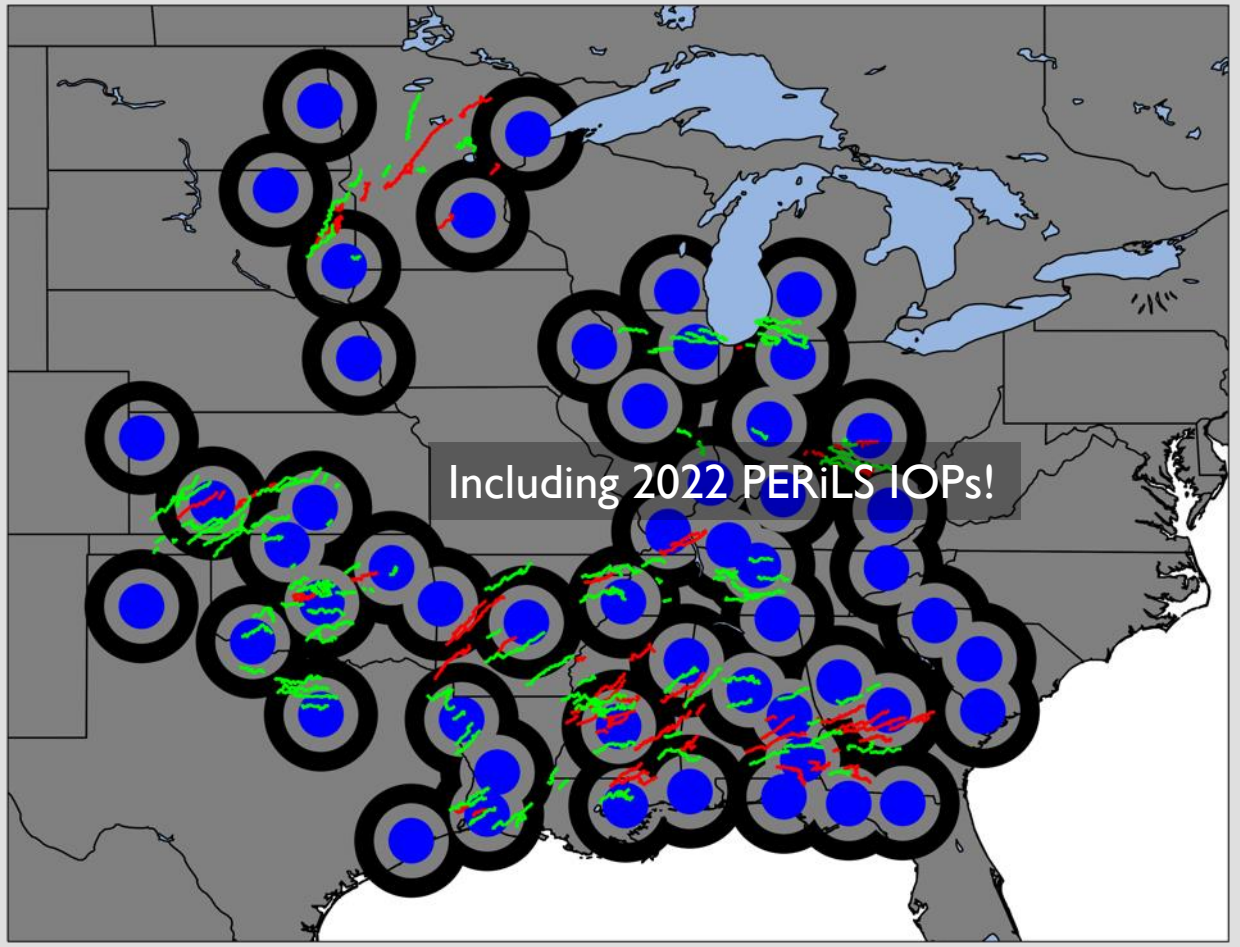
Davis and Parker (2014)

95 tornadic 135 non-tornadic
HSLC supercell + QLCS vortices



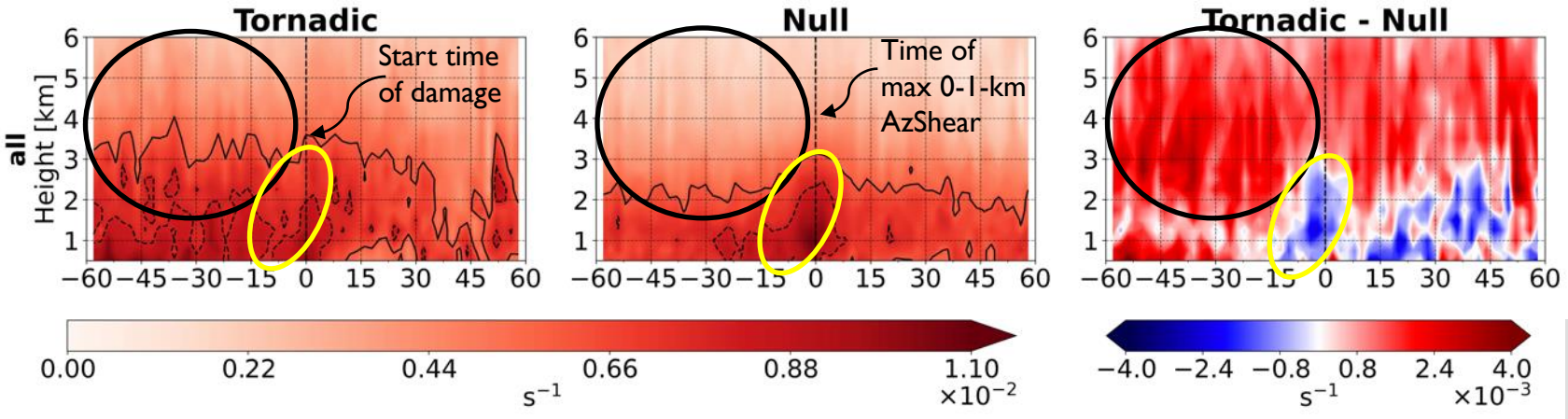
This study:

121 tornadic 171 non-tornadic
QLCS vortices (Smith et al. 2012 criteria)



AZSHEAR TIME-HEIGHT CROSS SECTIONS

ALL



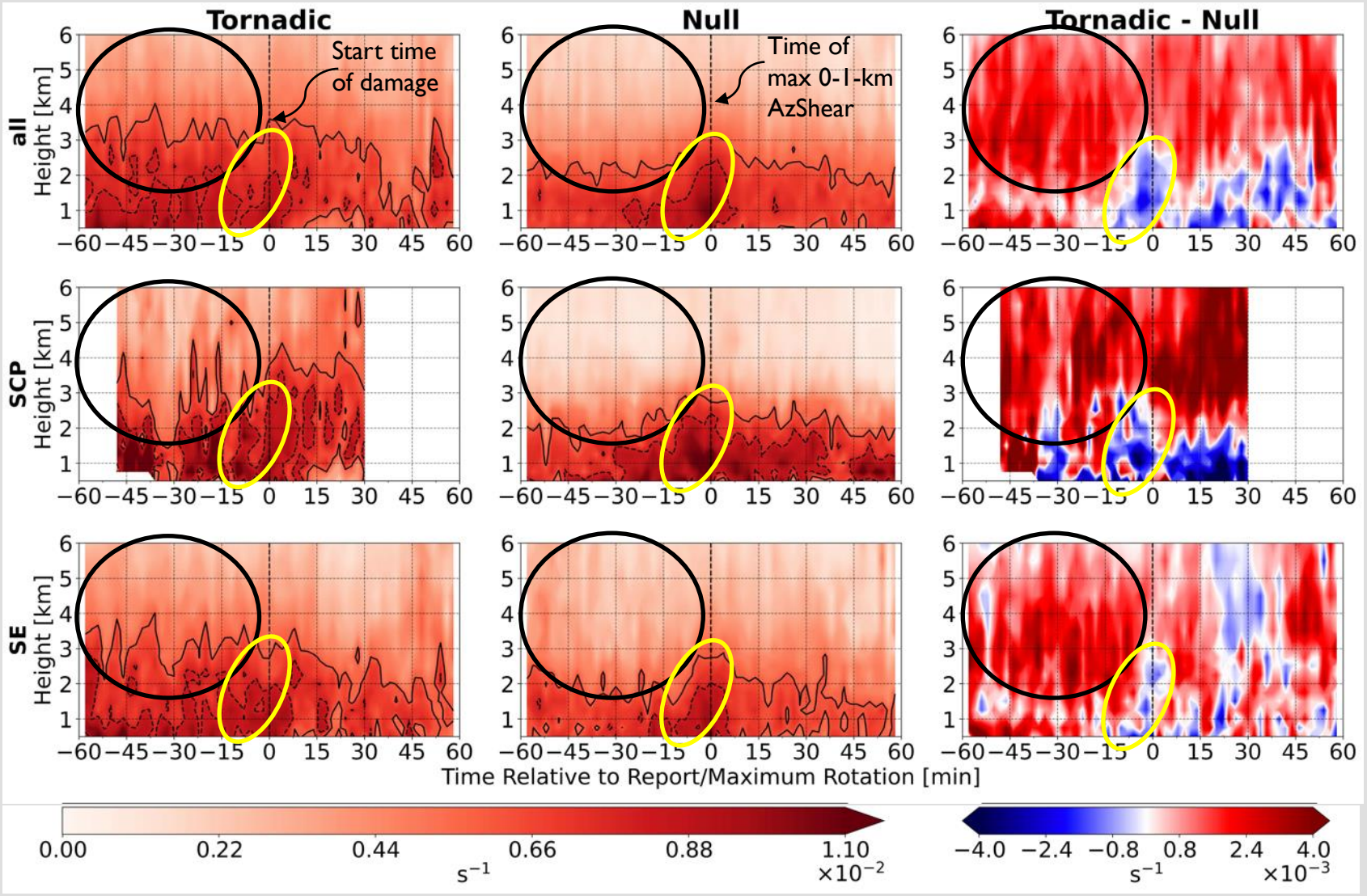
- Composite (median) cross sections of MRMS products are computed if there are 5 or more cases on the time/height grid.
- Max AzShear retained in 0.01° lat by 0.01° lon box surrounding the vortex
- Tornadic vortices display deeper plumes of enhanced AzShear during pre-tornadic phase up to t_0 - 60 min
- From ~ t_0 - 12 min, null vortices have higher median AzShear magnitude relative to tornadic vortices below 2 km AGL

AZSHEAR TIME-HEIGHT CROSS SECTIONS

ALL

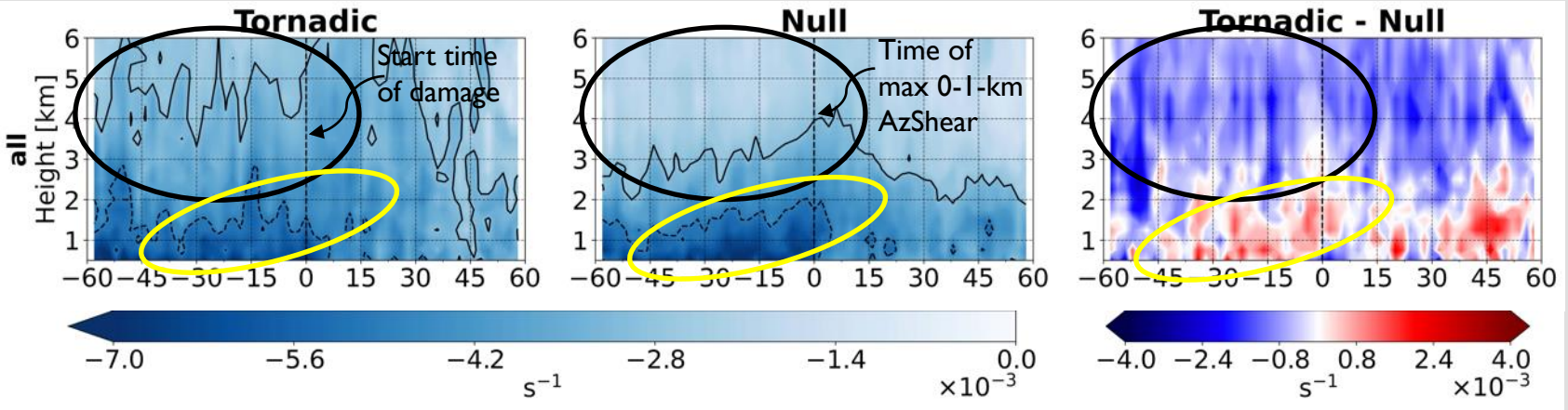
S-C Plains

Southeast



DIVSHEAR TIME-HEIGHT CROSS SECTIONS

ALL



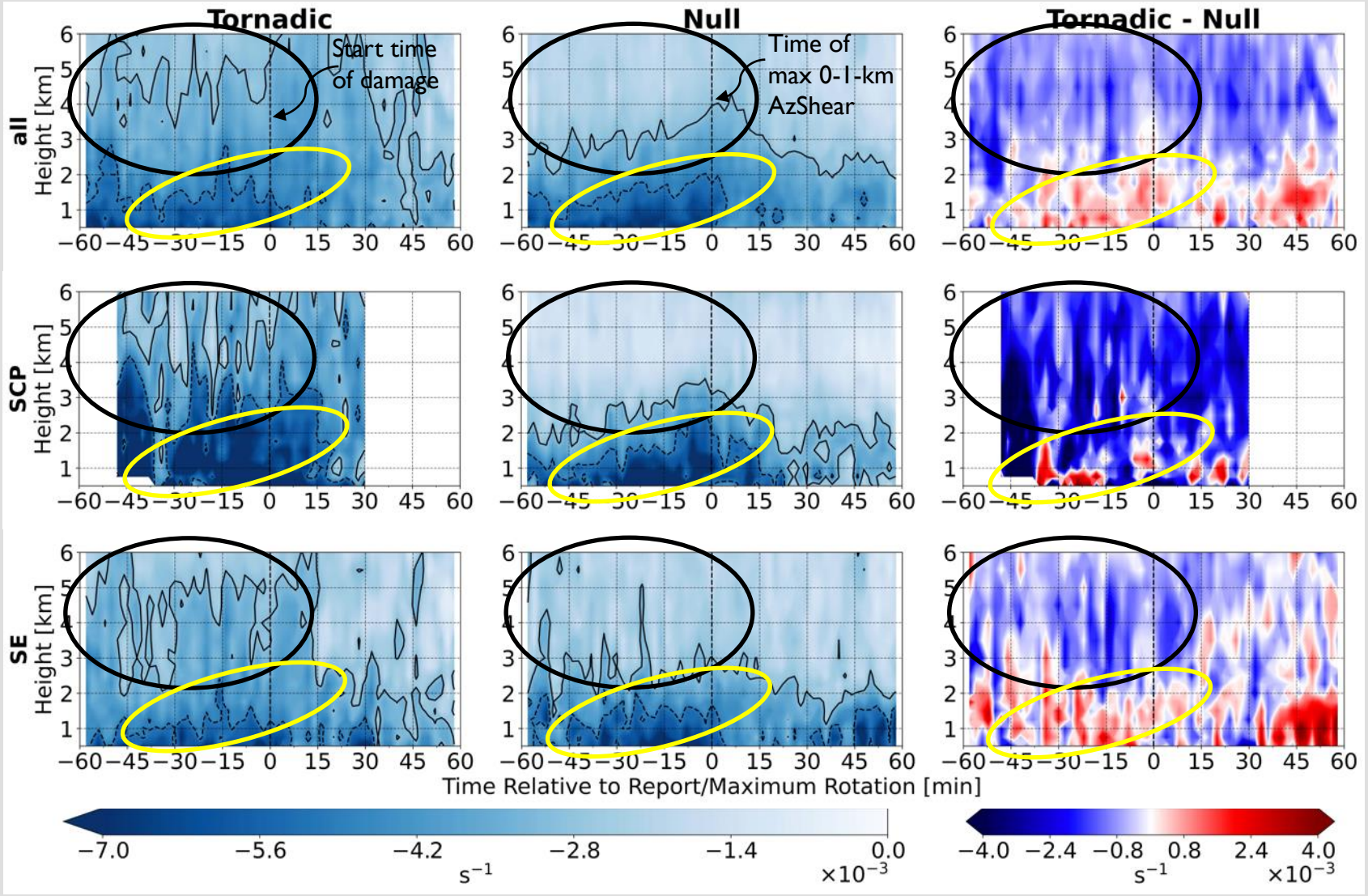
- DivShear minimum taken along vortex path at all levels, illustrating areas of radial convergence/divergence along the radial.
- Throughout the period prior to t_0, tornadic events are characterized with smaller DivShear magnitude (more convergence) above ~2.5 km AGL
- Indicative of deeper updraft plumes preceding tornadic vortices, or just a reflection of the stronger vortex?
- In low-levels, more LL convergence in null vortices leading up to t_0, although no stat. sig. differences in low-levels

DIVSHEAR TIME-HEIGHT CROSS SECTIONS

ALL

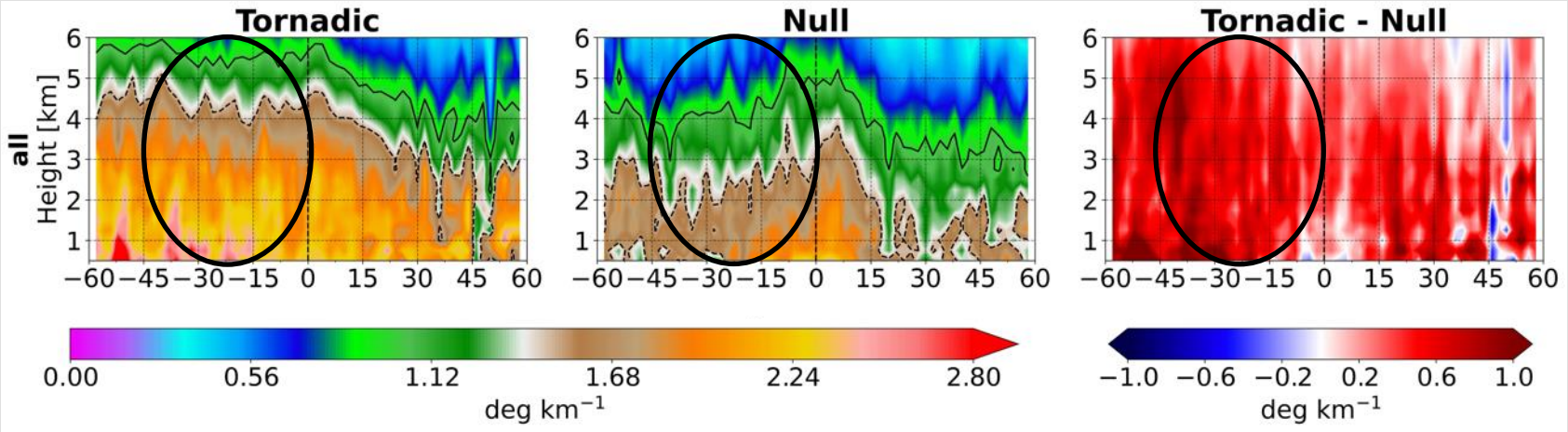
S-C Plains

Southeast



K_{DP} TIME-HEIGHT CROSS SECTIONS

ALL



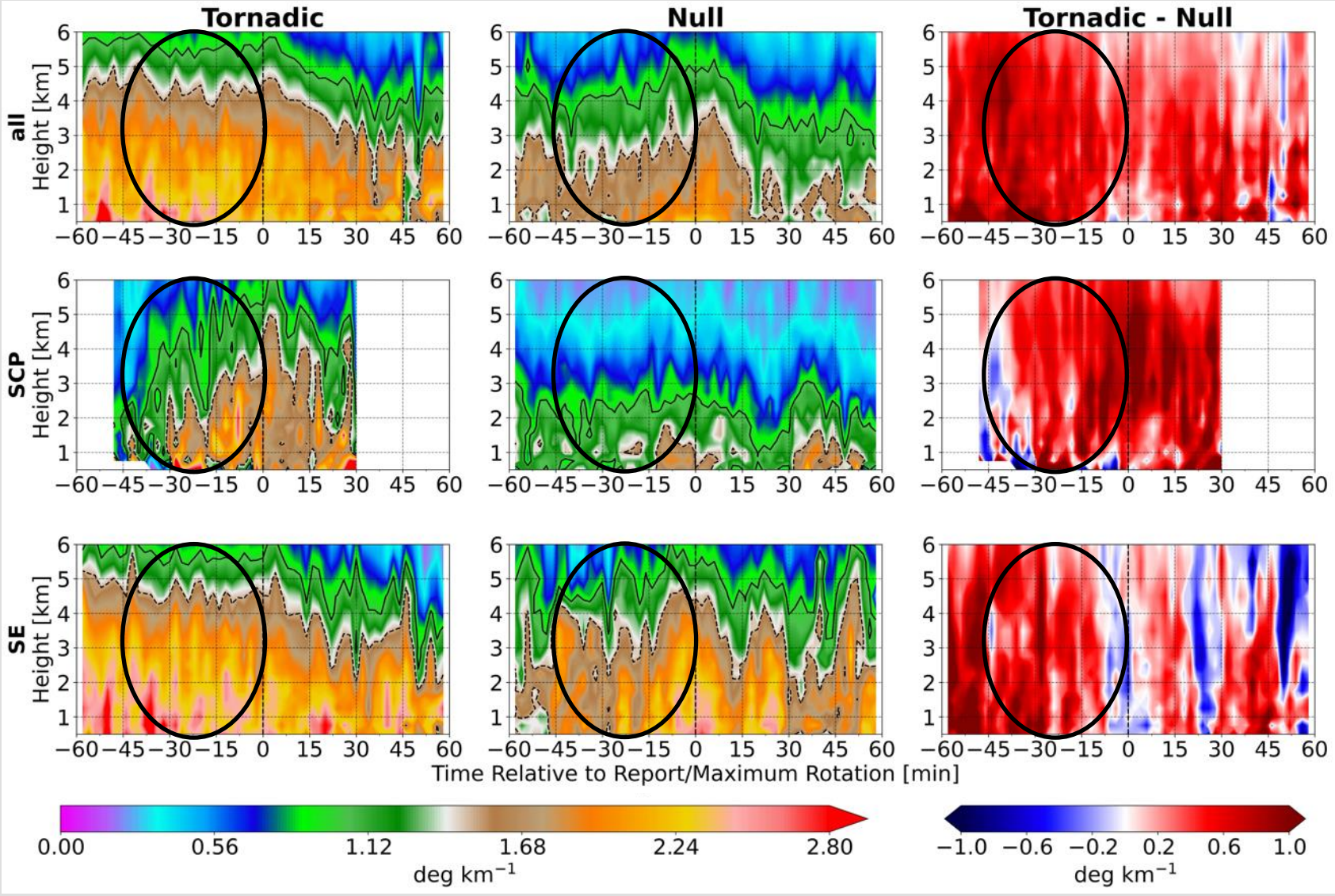
- Overall, tornadic vortices obtain significantly higher K_{DP} at all levels below 10 km AGL during the pre-tornadic / pre-maturity phase (Loeffler 2017, Kuster et al 2023)
- Kdp cores for null vortices are smaller and shallower relative to their tornadic counterpart.
- Indicative of more precip.-laden cores for tornadic vortices…perhaps indicating more potential for the hydrometeor-loading component to downdrafts for the tornadic MVs

K_{DP} TIME-HEIGHT CROSS SECTIONS

ALL

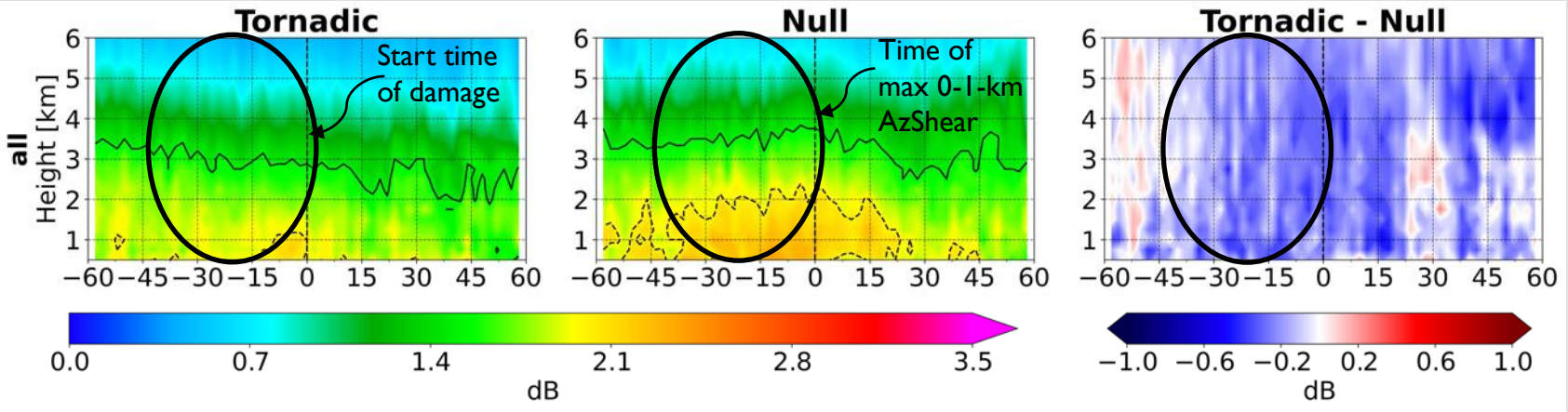
S-C Plains

Southeast



Z_{DR} TIME-HEIGHT CROSS SECTIONS

ALL



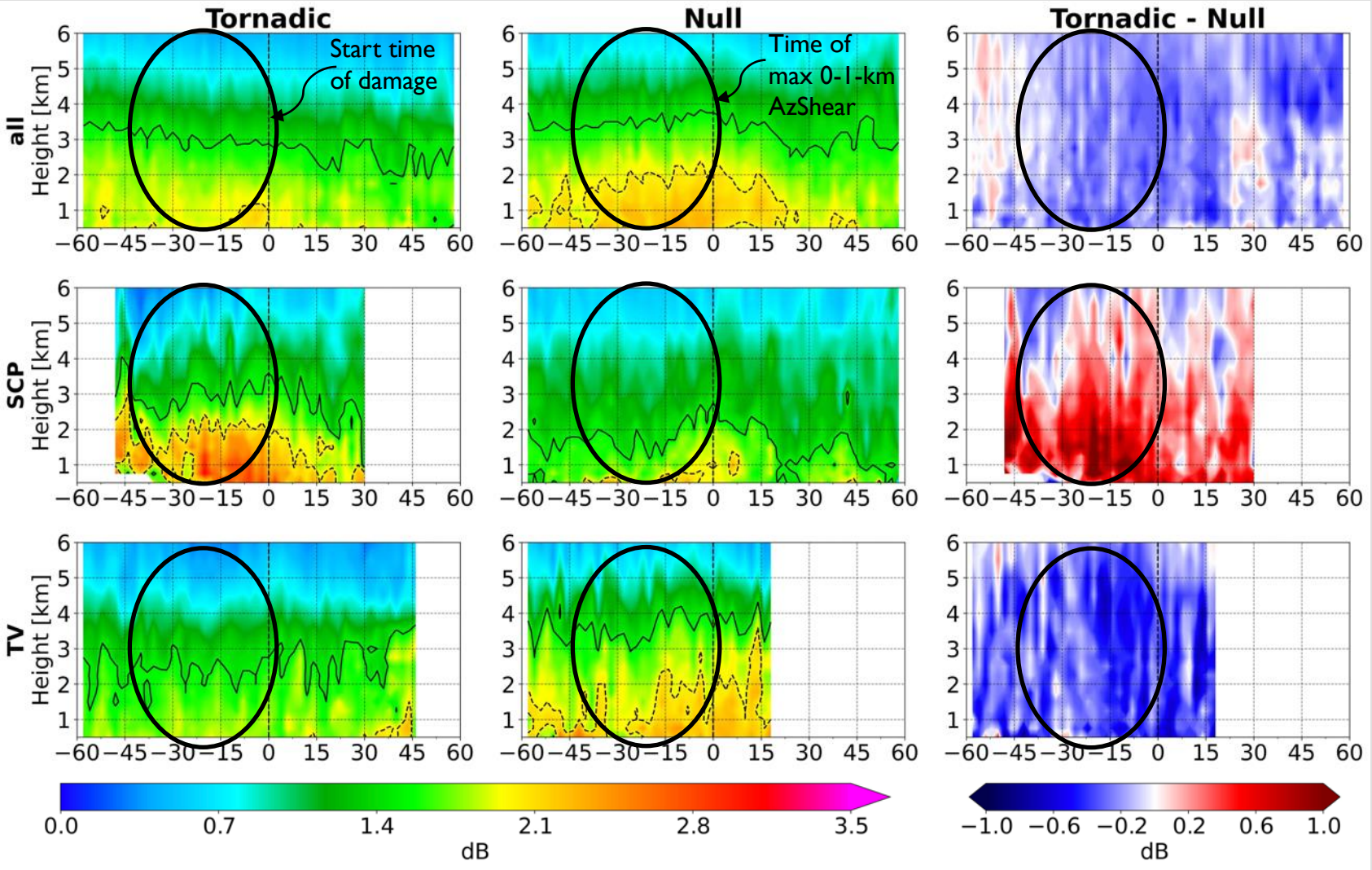
- Median Z_{DR} taken along vortex path at all levels shows smaller values preceding tornadic vortices
- Indicates less evaporation ongoing (fewer small drops)?
- BUT…..

Z_{DR} TIME-HEIGHT CROSS SECTIONS

ALL

S-C Plains

Tenn. Valley



KEY TAKEAWAYS

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- **Tornadic mesovortices** → deeper columns of AzShear during the pre-tornadic phase [consistent with Atkins et al., 2004, 2005; Davis and Parker, 2014), up to 60 min before t0, BUT null vortices display larger AzShear overall near t_0
- **Tornadic mesovortices** → More plumes of deeper convergent shear collocated with enhanced AzShear and higher K_{DP} *may* indicate pulses of stronger updrafts / more precipitation-laden cores during the pre-tornadic phase up to 60 min before t_0, but may just be another reflection of stronger rotation aloft
- **Tornadic mesovortices** → Lower Z_{DR} for longer pre-tornadic periods…maybe less evaporation…. but highly variable ….not sure what to conclude yet (Stronger Z_{DR} columns in S-C Plains but not southeast or TV cases….competing & complex processes impacting drop size distributions)
- Paper ready to submit soon….hopefully provide context and hypotheses for more in-depth studies of individual V-SE / PERiLS cases regarding vortex evolution in kinematic and dual-pol products