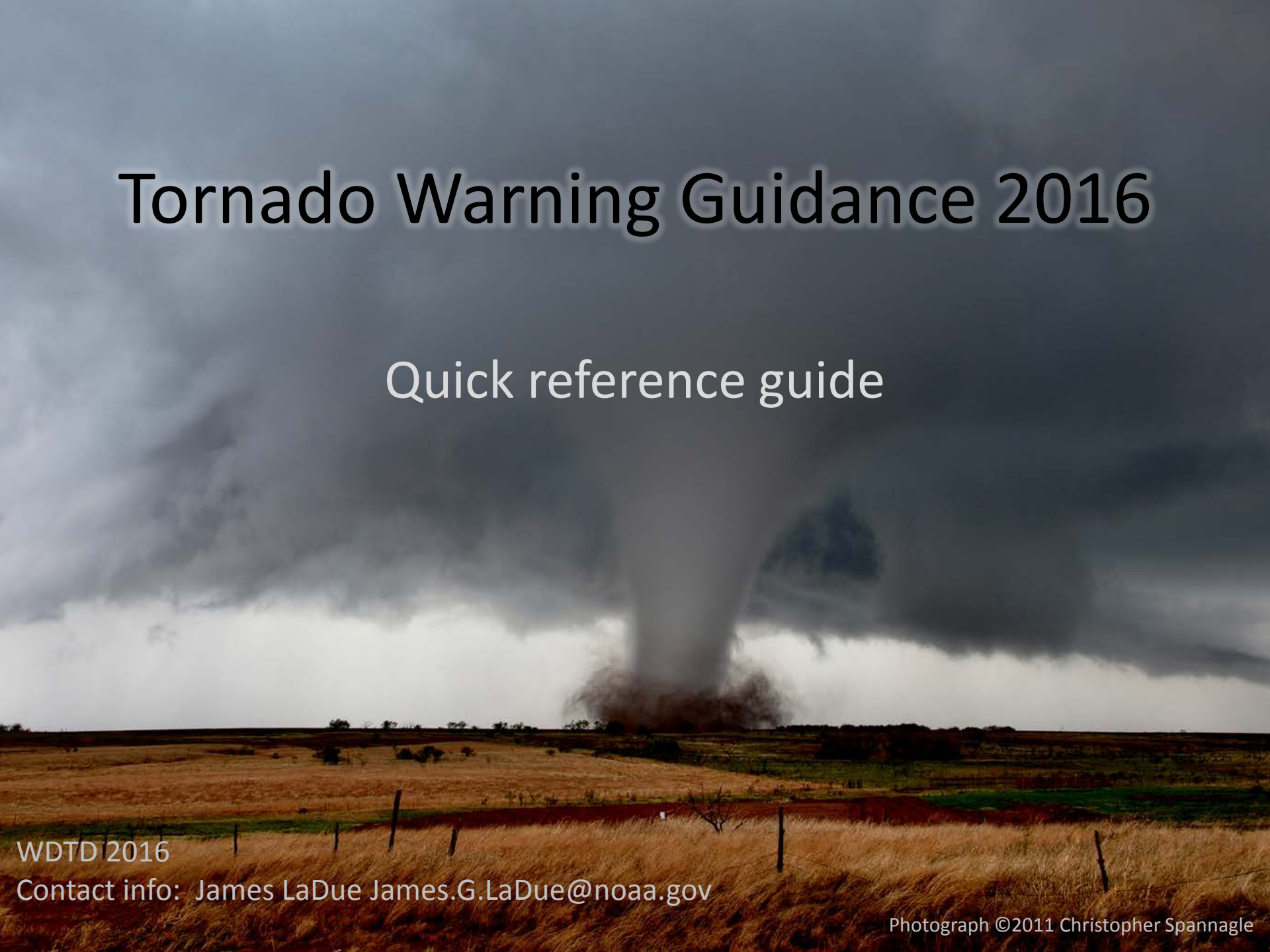
Tornado Warning Guidance 2016

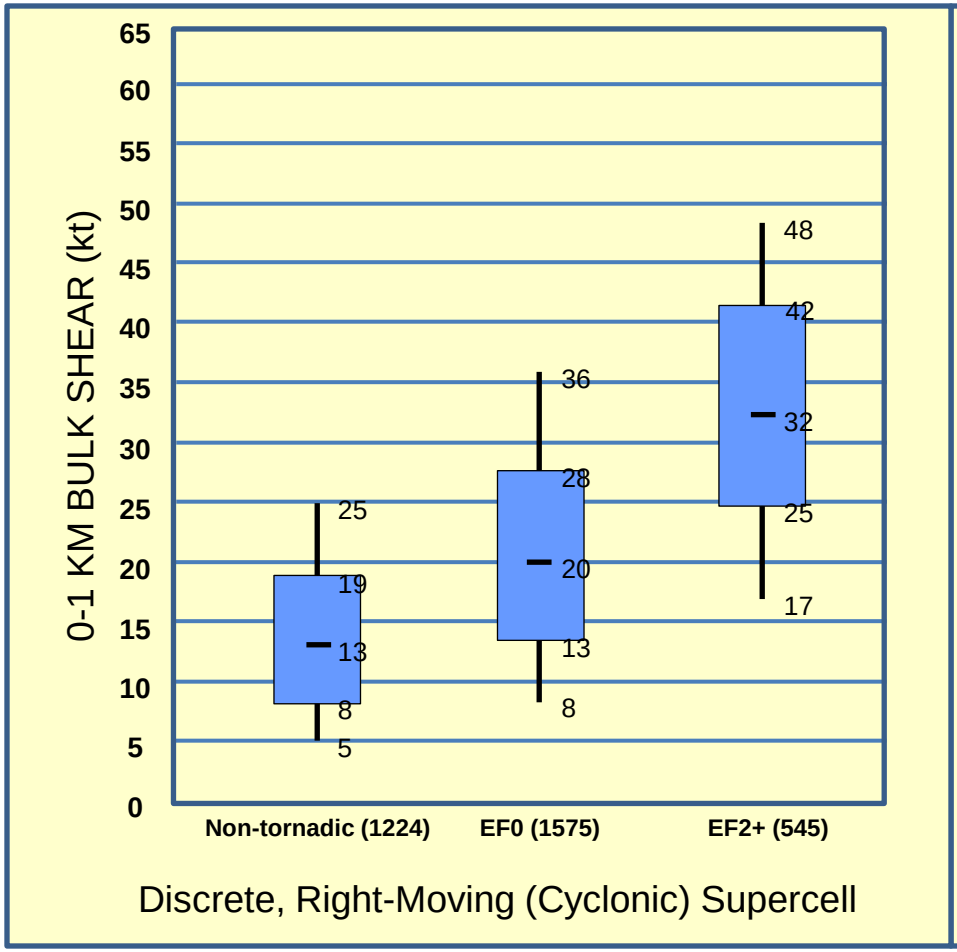
Quick reference guide



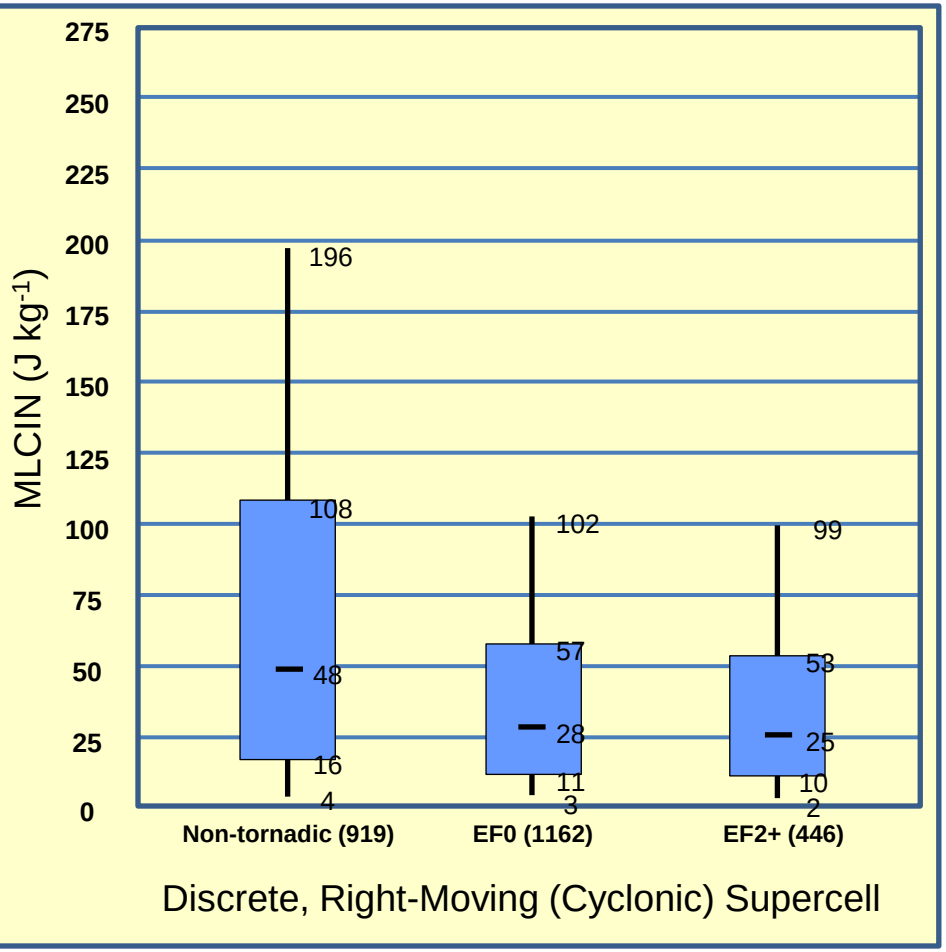
WDTD 2016
Contact info: James LaDue James.G.LaDue@noaa.gov

0 – 1 km bulk shear and MLCIN

These two useful parameters are not displayed in the tornado environment browser. The 0-1 km bulk shear is also not part of the Significant Tornado Parameter. However it serves as a useful quantity to plot in a horizontal cross section since storm motion is not an a-priori requirement for its evaluation.



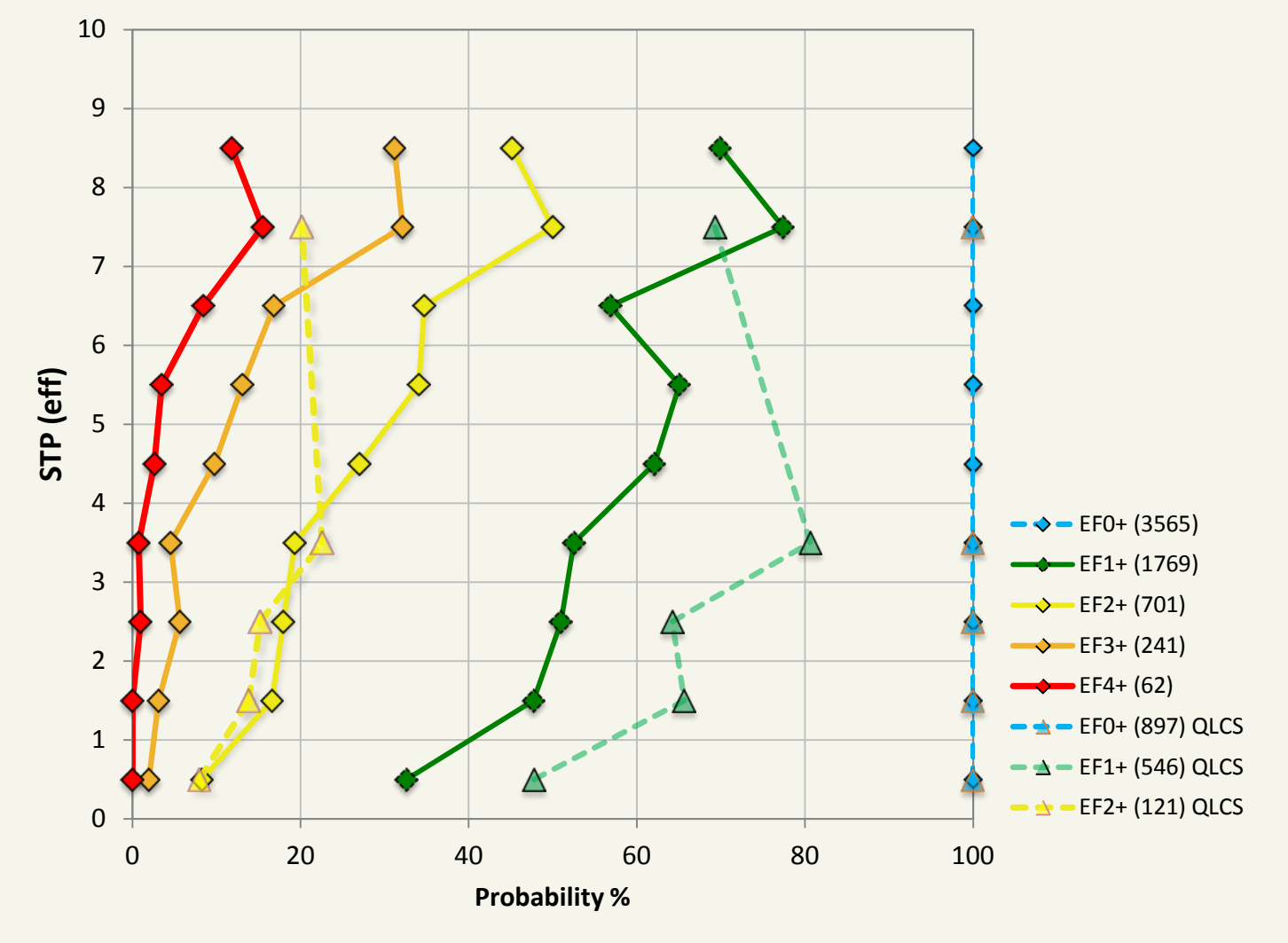
Discrete, Right-Moving (Cyclonic) Supercell



Discrete, Right-Moving (Cyclonic) Supercell

Forecasting tornado intensity

Use the relationship between Significant Tornado Parameter (STP $_{\text{effective layer}}$) and peak EF-scale for a meso-α scale area.



Smith, et al. (2015): http://dx.doi.org/10.1175/WAF-D-14-00122.1

Forecasting severe weather likelihood in low CAPE, high shear environments

Severe Hazards in Environments with Reduced Buoyancy (SHERB)

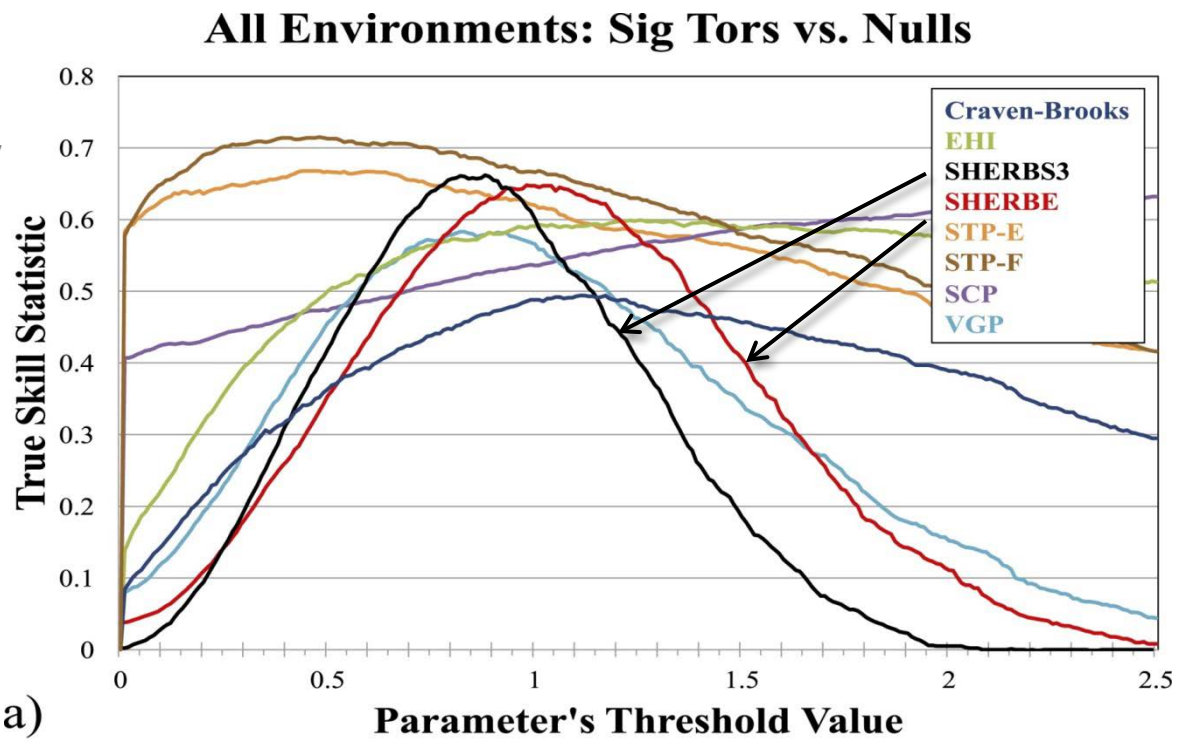
$$SHERBs3 = \frac{|\Delta V_{0\ to\ 3km}|}{26\ m/s}\ X\ \frac{\Gamma_{0\ to\ 3km}}{5.2\ K/km}\ X\ \frac{\Gamma_{700\ to\ 500mb}}{5.6\ K/km}$$ 0-3 km shear version

$$SHERBE = \frac{|\Delta Veff_{ective}|}{26\ m/s}\ X\ \frac{\Gamma_{0\ to\ 3km}}{5.2\ K/km}\ X\ \frac{\Gamma_{700\ to\ 500mb}}{5.6\ K/km}$$ effective shear version

Where Γ = lapse rate, $|\Delta V| = vertical\ shear\ magnitude$

Use when MUCAPE < 1000 j/kg

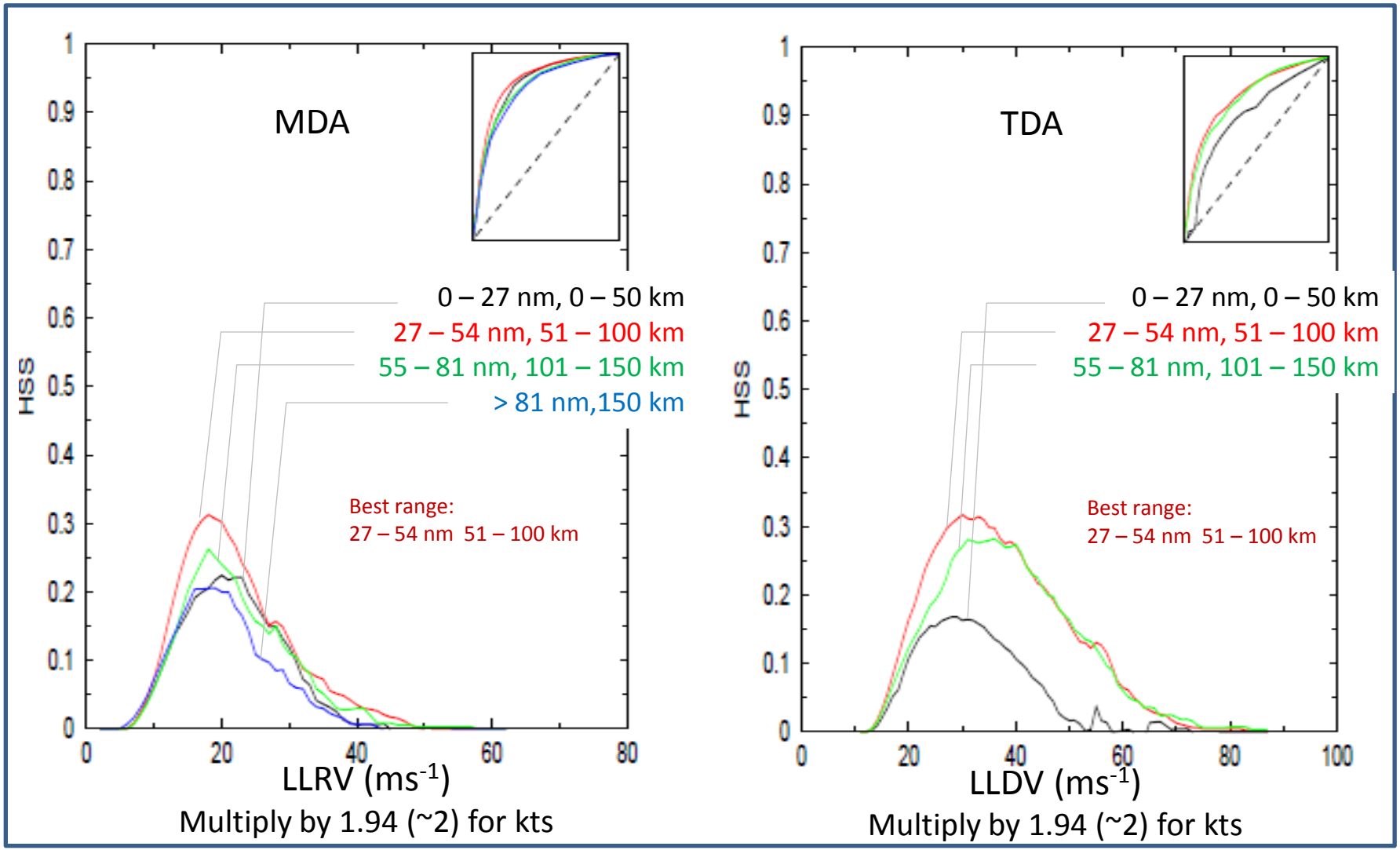
For real-time analysis, go to
http://www.meas.ncsu.edu/mdparker/sherb/



Sherburn and Parker, 2014

Range vs. tornado, nontornadic meso/TVS discrimination

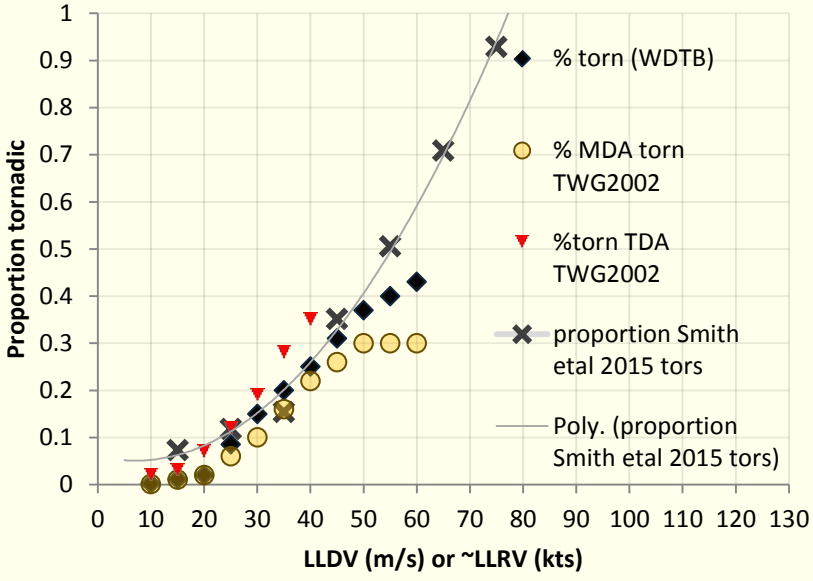
The MDA has not much change in peak skill with range while TDA shows a pronounced sweet spot for best skill from 27 – 54 nm in range.

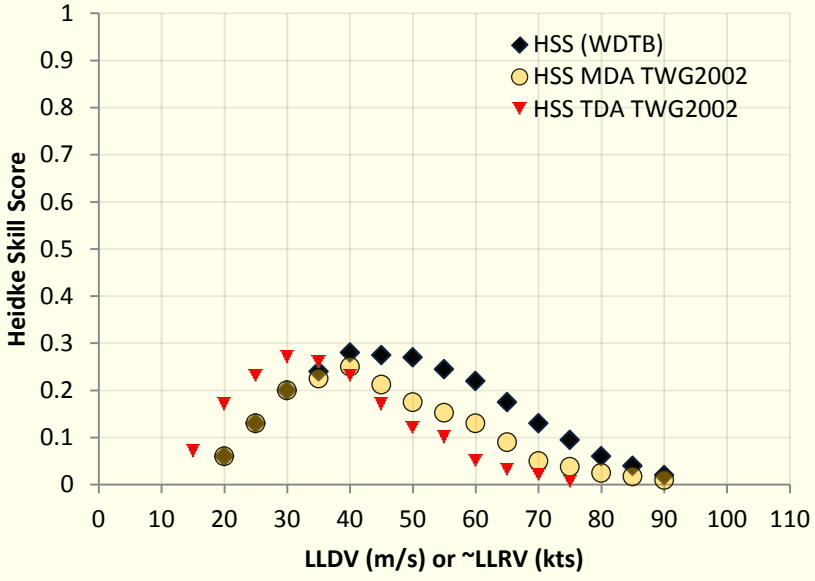


TWG (2002) http://www.wdtb.noaa.gov/modules/twg02/twg2001stats.pdf

Discrimination skill: tornadic vs. nontornadic storm-scale vortices

MDA and TDA detections from TWG2002 were considered tornadic 20 min before to 5 min after tornado. WDTB user-defined detections were considered tornadic 5 min before to 5 min after tornado.





- Environment already favorable enough for tornado watches
- Nonmesocylonic (mesovortex) tornadoes may not exhibit parental vortex signature

- Lower thresholds for
  - Distant signatures (>80 nm)
  - Narrow signatures (<3.5 nm diameter)
- Raise thresholds for
  - Unfavorable environments

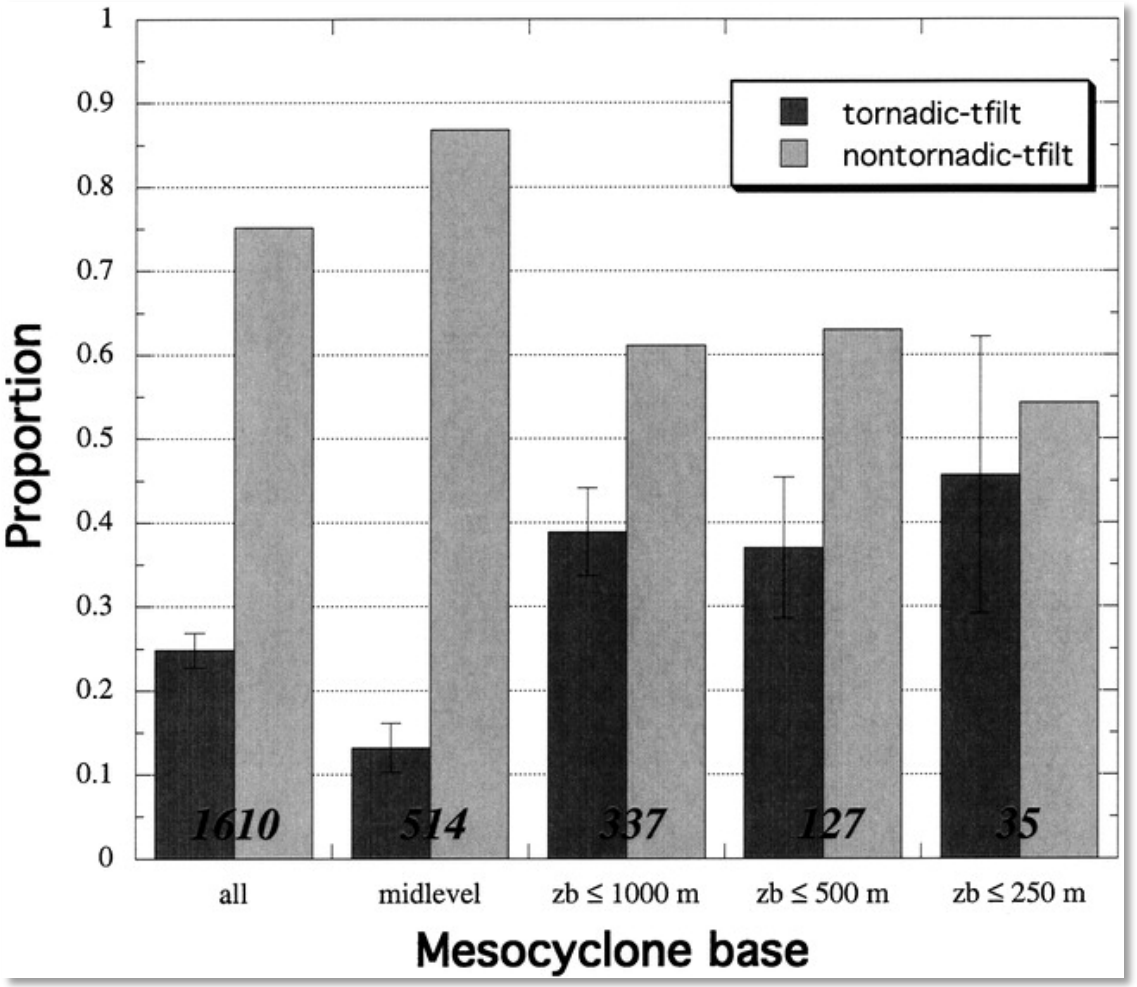
TWG (2002) http://www.wdtb.noaa.gov/modules/twg02/twg2001stats.pdf

proportion of tornadic mesocyclones by base altitude

MDA detections were considered tornadic 20 min before to 5 min after tornado.

Rank 5 or greater with base altitude specified (Zb) and depth of ≥ 3km

Rank 5 ~ LLRV > 30 kts (LLDV > 60 kts) over 3 km



Trapp et al. (2005) http://dx.doi.org/10.1175/WAF864.1

Updraft strength evaluation chart

Use this chart to evaluate the updraft signatures of up to two convective storms of interest. Some of these signatures contain values, or thresholds to help with calibration. Please take these thresholds as a starting point rather than fixed numbers.

Feature	comments	Values and/or confidence (1-10, 10 highest, 6 - 10 favorable for a warning)	
		Storm A	Storm B
Height of strong reflectivity	50 dBZ reaching the equilibrium level suggests powerful updraft.		
Low-level precip core shape	Sharpness, concavity of the reflectivity gradient		
WER/BWER	Distinctiveness of strong echo overhang • WERs should persist longer than 5-10 min. • BWERs are upward extensions of WERs • BWERs rarely exceed 3 nm wide and extend colder than -20° C		
ZDR column	Coldest temperature of ZDR column • Look for the highest extent in the past 15 min. • A strong ZDR column reaches -10° C • ZDR columns rarely extend colder than -20° C		
Stormtop divergence	Delta-V from the max and min velocities around the storm summit. • >100 kts suggests 50% chance of quarters • >200 kts suggests 50% chance of baseballs		
Mesocyclone at midlevels (4-20 kft ARL)	Rotational velocity • Weak (Vr > 20 kts), Moderate (Vr > 30 kts), Strong meso (Vr > 40 kts) – o 20, 30, 40 rule • Relax these criteria at long ranges		
Low-level convergence	Convergence Delta-V > 50 kts is strong. Convergence depth > 10 kft is impressive, > 15 kft is rare		
Updraft trends	Trend in the above updraft strength signatures		
Overall	Average all of the relevant and applicable signatures right.		

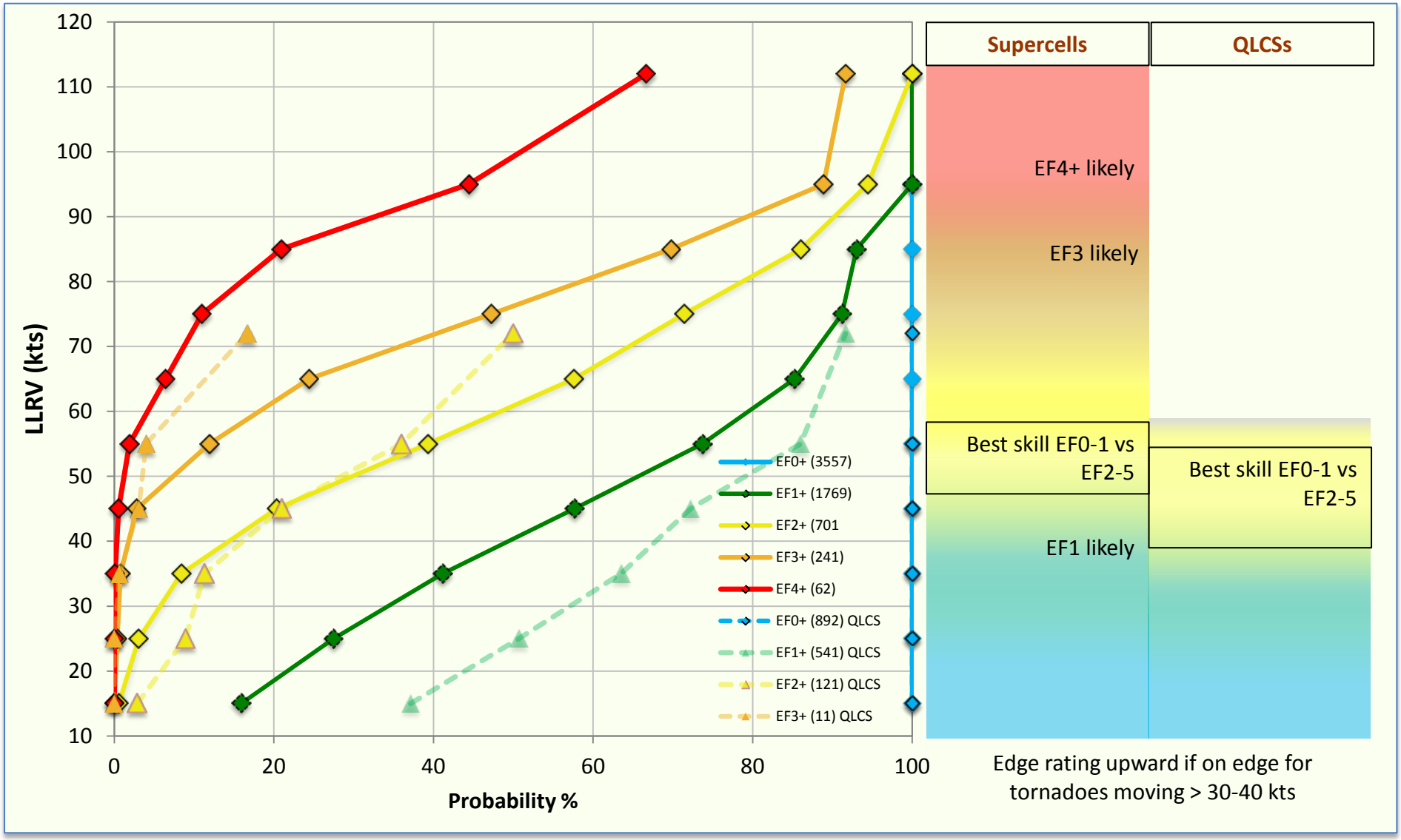
Tornado precursor signatures

Use this chart to evaluate the pre-tornadic signatures of up to two convective storms of interest. Some of these signatures contain values, or thresholds to help with calibration. Please take these thresholds as a starting point rather than fixed numbers.

feature	comments (Do not take thresholds as inflexible values)	Values and/or confidence (1-10, 10 highest, 6-10 favorable for a warning)	
		Storm A	Storm B
Mesocyclonic environment	Effective layer (typical 0-6 km) shear > 40 kts, 0-1 km shear > 10 kts, 0-1 km SRH > 100 m^2s^2, MLLCL < 1500 m, little CIN.		
Nonmeso-cyclonic environment	Pre-existing boundary with vertical vorticity, intersecting or colliding boundaries, steep low-level lapse rates, slow boundary-relative storm motion.		
Updraft strength and type	See signatures in updraft table (e.g., Z aloft, WER/BWER, conv). Updraft features last at least 10 min and trend is upward.		
Low-level storm relative inflow	Storm-relative inflow accelerates into updraft base This indicates that roots of updraft are surface-based. Look in lowest 3 kft ARL (range limited) Best view needs large radial storm motion component.		
Low-level convergence	Strength of low-level convergence below midlevel mesocyclone. Applicable if radar can sample lowest ~3000' AGL.		
Lowest-level mesocyclone strength*	Consider strength inside of Rmax, use TS/TVS Vmax and Vmin if there is one, • Vr > 30 kts means slight chance ~15% • Vr > 40 kts means moderate chance ~ 25% - optimal default HSS value • Vr > 60 kts means significant chance ~40%		
Mesocyclone base altitude (ARL)*	For rank ≥5 mesocyclones via MDA whose base is at • < 3.3 kft (1000)m proportion tornadic is ~40% • Not applicable for if lowest scan is >~3.3 kft (1000 m) • *not applicable for nonmesocyclonic or non-QLCS events		
Presence of TVS/TS	May or may not be embedded within mesocyclone Can be lowlevel meso with LLRV> ~35 kts and obvious Vmin and Vmax		
Trends	Trend in the above signatures		
Overall	Average all of the relevant and applicable signatures right.		

Peak LLRV vs peak EF-scale for supercells and QLCSs

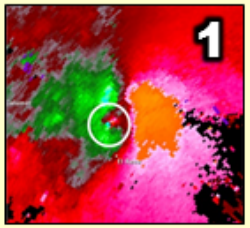
Peak LLRV from more scans of well defined vortex signatures is more reliable.



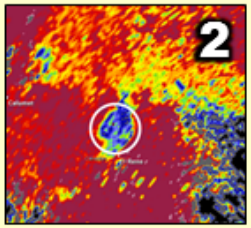
Radar Tornado Intensity Estimation Guidance

Identifying a Tornadic Debris Signature (TDS)

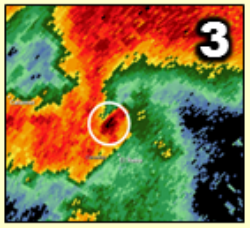
Provides radar confirmation of a damaging tornado in progress.



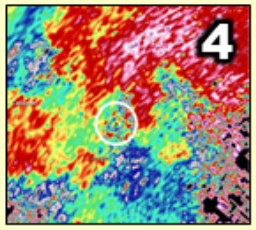
First, identify a valid velocity circulation.



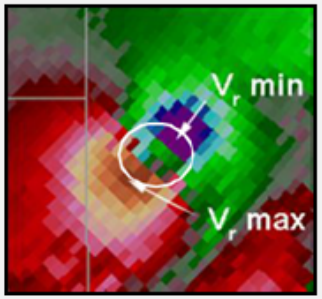
Next, ensure correlation coefficient (CC) is below 0.90



Next, ensure reflectivity is over 35 dBZ and co-located with #1/2



Not necessary but adds confidence: ZDR reduced to ~0 or below zero in spots.



$$V_{rot} = (|V_{in[max]}| + |V_{out[max]}|) / 2$$

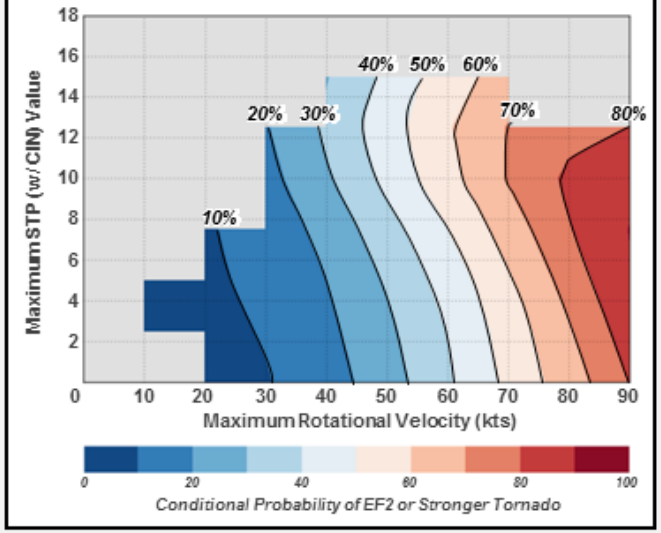
To determine rotational velocity, add the absolute value of the highest inbound and outbound velocity values in the couplet, and then divide by 2.

Considerations and Tips

- EF2+ tornadoes are likely if TDS has debris ball (reflectivity > 50-55 dBZ)
- With split cut mode VCPs, TDS can have a slight offset from velocity sig.
- **Discriminating between supercellular weak and strong tornadoes**: Heidke Skill Scores maximized with LLRV in the 45-55 knot range.
- **In borderline intensity cases, push up a category if**: tornado is moving fast, conditions very favorable for EF2+, or signature is poorly sampled.

Tornado Intensity	Supercells Only: Rotational Velocity (kts)	QLCS Only: Rotational Velocity (kts)	MOST RELIABLE: Maximum TDS Height
	Only valid within 70nm of the radar site		
WEAK *EF0/EF1*	*40 knots or less*	*30 knots or less*	*Under 8,000 ft*
	Overlap 40-55 knots	Overlap 30-45 knots	Overlap 8-10 kft
STRONG *EF2/EF3*	*55 to 75 knots*	*45 knots or more*	*10,000 to 15,000 ft*
	Overlap 75-85 knots		Overlap 15-18 kft
VIOLENT *EF4/EF5*	*85 knots or more*	*Insufficient cases*	*Over 18,000 ft*

Conditional EF2+ Tor Probability

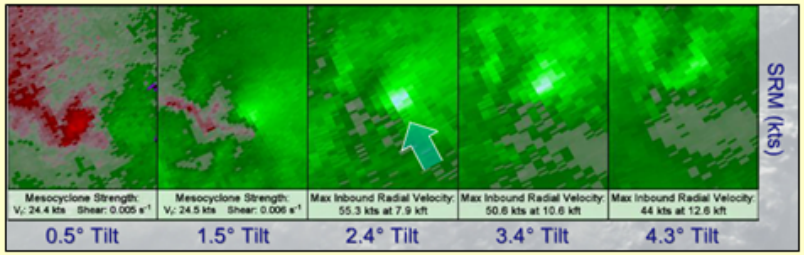


Tropical Cyclone Tornado Guidance (WDTB, 2014)

Range from Radar	LL V_{rot}	LL Shear	Circulation Contracting	Inflow Notch or Hook	ZDR/KDP Displacement	Mesocyclonic VES
0-39 nm	20+ kts	≥ 0.01 s^{-1}	✓	✓	✓ ← 1 of 2 →	✓
40-70 nm	15+ kts	✗	✓	✗	✓ ← 1 of 2 →	✓
>70 nm	12+ kts	✗	✗	✗	✗	✗

Identifying Mesocyclonic VES

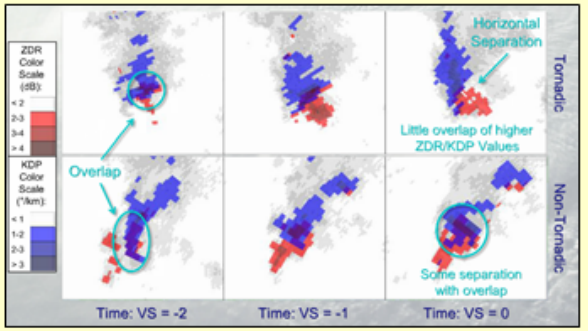
"Velocity Enhancement Signature" – enhanced radial velocities of 30+ knots between 7,000 and 14,000 feet AGL on the right flank of a mesocyclone

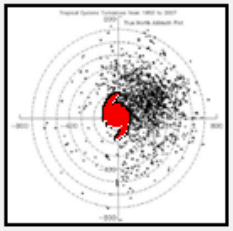


- Occurs when storm motion deviates from mean flow, leading to an asymmetric mesocyclone velocity pattern.
- Located above low-level inflow and vertically co-located with the low-level mesocyclone and hook signature.
- WDTB analysis showed about **85% of tornadic events had this signature** while about 42% of non-tornadic events did.
- **Max values generally 1-4 volume scans before the tornado.**

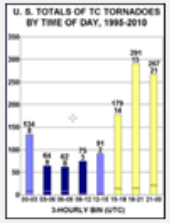
Horizontal Displacement of ZDR/KDP

- Implies size sorting of hydrometeors from increased directional shear within the storm due to strong mesocyclone development.
- Maximum KDP values displaced left of the maximum ZDR values relative to the mean storm motion.
- Can be detected in storms greater than 40 nm from radar.
- WDTB analysis: **70% of tornadic events had this signature** while about 58% of non-tornadic events did.





Most occur in right front quadrant of the TC and within 300mi of center. 80% occur from 350° to 120°



Mid-afternoon peak (19-21Z), earlier than non-TC peak. More nighttime events than non-TC.

INGREDIENTS

- 200mb jet streak NE of cyclone
- Organized, large, directionally symmetric wind field at 850mb
- Reduced RH at 700-500mb
- Baroclinic boundaries.
- Mid-level RH should not be too dry, limiting convection
- 0-1km SRH generally above 170 m^2/s^2 (*supercell tors*).
- 25th and 75th %-ile MLCAPE is 320 and 870 j/kg (*supercell*)

Produced by Alex Lamers, NWS TLH