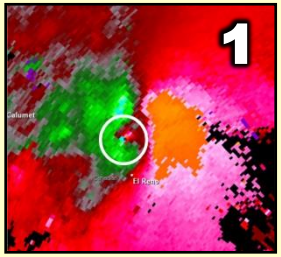
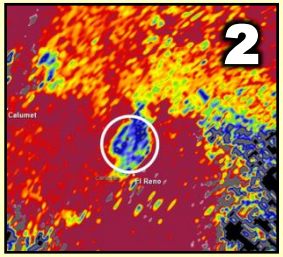
Radar Tornado Intensity Estimation Guidance

Identifying a Tornadic Debris Signature (TDS)

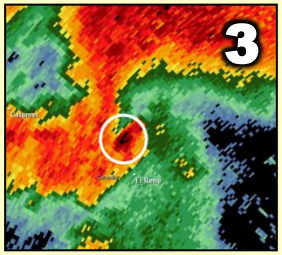
Provides radar confirmation of a damaging tornado in progress.



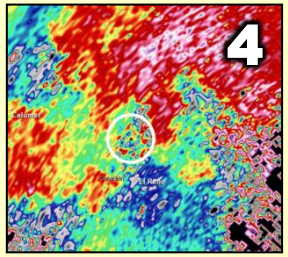
First, identify a valid velocity circulation.



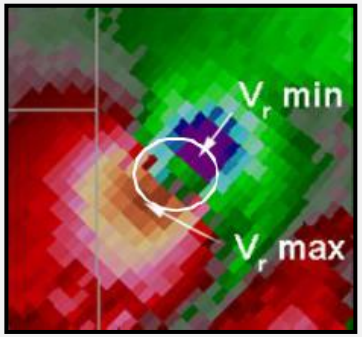
Next, ensure correlation coefficient (CC) is below 0.90



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.



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

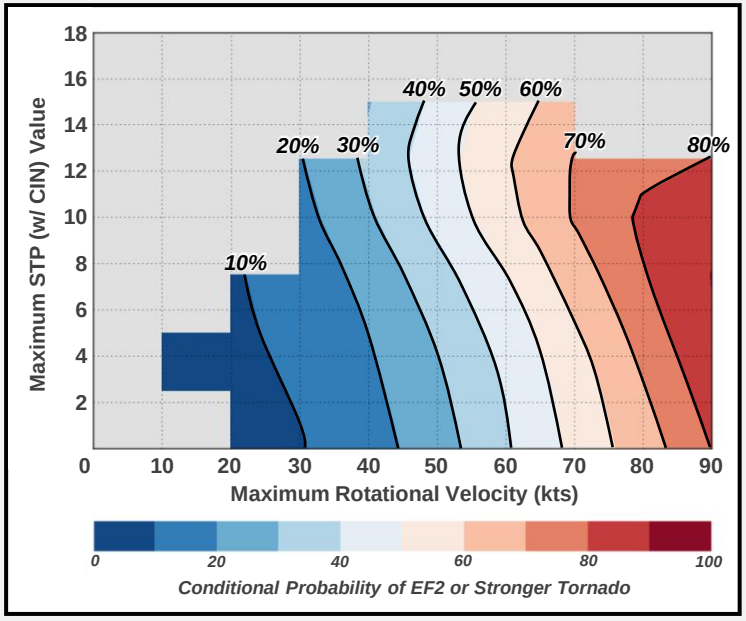
To determine rotational velocity, add the absolute value of the highest inbound and outbound velocity values in the couplet, and then divide by 2.

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	QLCS Only	MOST RELIABLE: Maximum TDS Height
	Rotational Velocity (kts) — *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

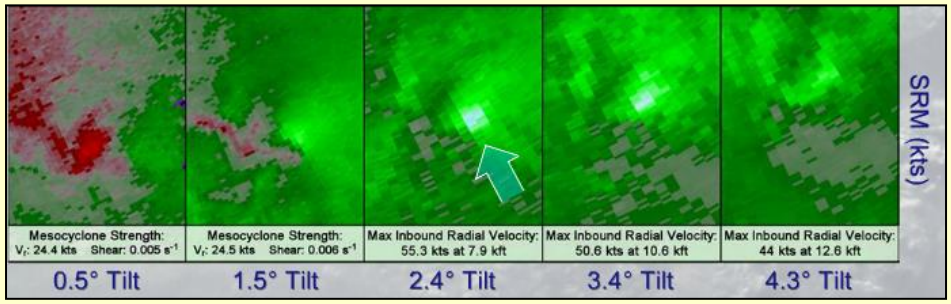


Tropical Cyclone Tornado Guidance (WDTB, 2014)

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

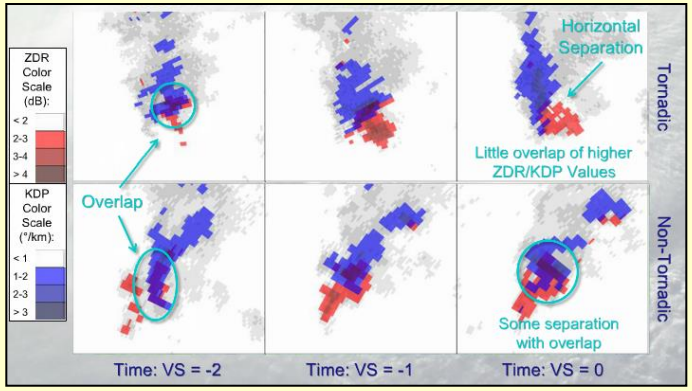
"Velocity Enhancement Signature" – enhanced radial velocities of 30+ knots between 7,000 and 14,000 feet AGL on the right flank of a mesocyclone

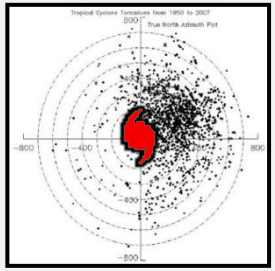


- Occurs when storm motion deviates from mean flow, leading to an asymmetric mesocyclone velocity pattern.
- Located above low-level inflow and vertically co-located with the low-level mesocyclone and hook signature.
- WDTB analysis showed about **85% of tornadic events had this signature** while about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

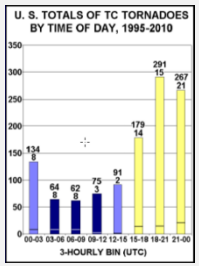
Horizontal Displacement of ZDR/KDP

- 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*)