Tornado

The Significant Tornado Parameter and Non-Supercell Tornado Parameter characterize mesocyclonic and non-mesocyclonic tornado potential, respectively. Use the following three tables to better understand those parameters and the three ingredients method to QLCS tornado events. NOTE: Exceeding “preferred values” indicates favorable conditions; Not meeting “necessary values” indicates unfavorable conditions.

Mesocyclonic Parameters	Necessary Value	Preferred Value
0-1 km shear	≥15 kts	≥20 kts
Significant Tornado Parameter (Eff)	**>0**	**>1**
100 mb mean parcel mixed layer CAPE	>0 J/kg	>1500 J/kg
100 mb mean parcel mixed layer CIN	>-200 J/kg	>-50 J/kg
100 mb mean parcel LCL height	<2000 m	<1000 m
Effective storm relative helicity (effective inflow layer SRH)	>0 m2/s2	>150 m2/s2
Effective bulk wind difference (EBWD)	≥25 kts	≥40 kts

Non-Mesocyclonic Parameters	Necessary Value	Preferred Value
Non-Supercell Tornado Parameter		**>1**
0-3 km mixed layer CAPE	>0 J/kg	>100 J/kg
Mixed layer CIN	>-225 J/kg	>-25 J/kg
0-1 km lapse rate		>9˚ C/km
Surface relative vorticity		>8x10^{-5} s^{-1}
0-6 km bulk wind difference	≤35 kts	≤25 kts

QLCS Parameters (Three Ingredients Method)	Necessary Value	Preferred Value
0-3 km line normal bulk shear		≥30 kt
Rear inflow jet or outflow caused surge in line (Y/N)		Yes
0-3 km mixed layer CAPE		≥40 J/kg

When favorable environments for tornadoes exist (Significant Tornado Parameter > 0 or Non-Supercell Tornado Parameter >1), use the following rotational velocities and qualitative radar signatures to aid in tornado decision making.

Radar Signatures	Mesocyclonic	Non-Mesocyclonic	QLCS
Storm Type			
Discrete, surface-based supercell (Y/N)	Yes		
Reflectivity (Z) core aloft (~0 ˚C) co-located w/misoscale vortex along the boundary (Y/N)		Yes	
Quasi-linear convective system (QLCS) (Y/N)			Yes
General Features			
Acceleration & convergence into a strong, low-level mesocyclone prior to tornadogenesis (Y/N)	Yes		
Formation of cold pool (Y/N)		No	
Descending rear inflow jet (RIJ) (Y/N)			Yes
Enhanced surge (Y/N)			Yes
Line break (Y/N)			Yes
Updraft deep convergence zone (UDCZ) entry/inflection point (Y/N)			Yes
Paired front/real inflow notch (Y/N)			Yes
Boundary ingestions (Y/N)			Yes
Front reflectivity nub (Y/N)			Yes
Mesoscyclone/Tornado Features			
Tornado vortex signature (TVS)/ tornado signature (TS) (Y/N)	Yes	Yes	Yes
Contracting bookend vortex (Y/N)			Yes
Tight/strong mesovortex (Y/N)			Yes
Max V_{rot} at 0.5˚	≥30 kts	≥20 kts	≥25 kts
Tornado debris signature (Y/N)	Yes	Yes	Yes

Hail

Significant Hail Parameter and Large Hail Parameter characterize hail size potential. Use this table to better understand some of the key ingredients relating to hail size.

Parameters	Base Severe (≥1")	Significant (≥2")	Giant (≥4")
Important Environmental Parameters Generally Independent of Hail Size			
Freezing/melting (0 ˚C) level			
-20 ˚C level			
Large Hail Parameter (LHP/LGHAIL)	**≥4**	**≥5**	**≥8**
Most unstable CAPE (MUCAPE)	≥1600 J/kg	≥1850 J/kg	≥3000 J/kg
Effective bulk wind difference (EBWD)	≥30 kt	≥40 kt	≥46 kt
700-500 mb lapse rate		≥6.5 ˚C/km	≥7.0 ˚C/km
Surface to equilibrium level bulk shear [$Shear_{EL}$/LCL-EL(Cloud Layer)]		≥46 kt	≥60 kt
Significant Hail Parameter (SHP)		**>1**	

If you think a thunderstorm contains hail, below are some general, radar base-data hail signatures. NOTE: These values are typical, but may not apply in all situations.

Hydrometeors	Z	ZDR	CC	KDP
Severe rain/hail Mix	>55 dBZ	>1 dB	0.93-0.96	>0.5 ˚C/km
Severe, dry hail	>55 dBZ	<1 dB	0.95-0.97	<1 ˚/km
Significant (≥2") hail	>55 dBZ	~0 dB or lower	<0.9	No Data

Common hail sizes:


1" Quarter


1.25" Half-dollar


1.5" Walnut


1.5" Ping-pong ball


1.75" Golf ball


2" Lime


2.5" Tennis ball


2.75" Baseball


3" Large apple


4" Softball


4.5" Grapefruit

The following table can help you determine hail size based on radar signatures. Parameters may not always agree with each other (or may not be visible at all).

Radar Signatures	Base Severe (≥1")	Significant (≥2")	Giant (≥4")
Thunderstorm type	Discrete thunderstorm	Discrete supercell	Discrete supercell*
* Mini-supercells (~24-32 kft top) rarely produce hail in the giant category, so identifying one usually can often be exclusionary to giant hail detection			
Reflectivity Height			
50 dBZ thickness above melting level	Use cursor readout *(refer to 50dBZ chart)*		
60 dBZ height (in ˚C)		Above -20 ˚C	
65 dBZ height (in ˚C)			Above -30 ˚C
Storm-Top Divergence ΔV Values (NOTE: Choose Row Based on Environmental 0˚C Height from Sounding)			
freezing level ≈ 10.5-11.5 kft	74-115 kts	126-148 kts	233-267 kts**
freezing level ≈ 11.5-12.5 kft	80-120 kts	135-155 kts	
freezing level ≈ 12.5-13.5 kft	110-143 kts	152-170 kts	
freezing level ≈ 13.5-14.5 kft	115-147 kts	160-180 kts	
freezing level ≈ 14.5+ kft	135-178 kts	188-209 kts	
** Specific values not available for giant hail (Boustead, 2008; Blair et al., 2011)			
Other Features for Hail			
Three Body Scatter Spike (TBSS)	Likely		
Max hail size from algorithm (HDA or MRMS)	≥1"	≥2"	
Bounded weak echo region (BWER) (Y/N)		Yes	
Updraft persists		≥30 min	
Highest V_{rot} at any elevation		≥28 kts	≥40 kts
ZDR column height (if detectable)	> 7.5 km > 8.5 km (more confidence)		
ZDR column intensifying (Y/N)	Yes		
ZDR value at top of ZDR column	> 4.5 dB		
KDP value	<0.5 ˚/km (dry) 0.5-1.5 ˚/km (mix) >1.5 ˚/km (some melt possible)		
CC co-located w/highest Z		<0.85	

Wind

Use the following significant values to better understand the key environment ingredients in wet microburst, dry microburst, and QLCS/derecho situations. NOTE: Exceeding “preferred values” indicates favorable conditions; Not meeting “necessary values” indicates unfavorable conditions.

Wet Microburst Parameters	Necessary Value	Preferred Value
0-3 km maximum theta-e difference (Theta E Diff)		>25 K
Microburst Composite (MBCP)	**5-8**	**≥9**
Surface-based CAPE (SBCAPE)	≥3100 J/kg	≥4000 J/kg
0-3 km lapse rate	>8.4 ˚C/km	
Downdraft CAPE (DCAPE)	≥900 J/kg	≥1100 J/kg
Precipitable water	≥1.5”	

Dry Microburst Parameters	Necessary Value	Preferred Value
Inverted-V sounding (Y/N)		Yes
Most unstable CAPE (MUCAPE)	1-500 J/kg	
100-mb mean parcel LCL height	>3 km AGL	Above Melting Layer
0-3 km lapse rate	≥Dry adiabatic	
Effective bulk wind difference (EBWD)		<30 kts

QLCS/Derecho Parameters	Necessary Value	Preferred Value
Derecho Composite Parameter (DCP)		**>2**
Downdraft CAPE (DCAPE)	>0 J/kg	>980 J/kg
0-6 km mean wind		>16 kts
Most unstable CAPE (MUCAPE)	>0 J/kg	>2000 J/kg
Effective bulk wind difference (EBWD)		>20 kts

In favorable environments for severe wind, use the following signatures in severe thunderstorm decision making for supercell, microburst, and QLCS situations.

Radar Signatures	Supercell	Microburst	QLCS/ Derecho
General Thunderstorm Signatures			
Rear-flank downdraft (Y/N)	Yes		
Rapid formation of strong reflectivity or VII core at -10 ˚C (Y/N)		Yes	
Descending core bottom (Y/N)		Yes	
Mid-altitude radial convergence (MARC) ΔV		>15 kts	>50 kts
Low-level velocity (<1500 ft AGL)	>50 kts	>30 kts	>50 kts
Fast storm motion (Y/N)	Maybe		Yes
Wet/Melting Hail Signature			
Three-body scatter spike (TBSS) (Y/N)		Yes	
Correlation coefficient (CC)		0.93-0.96	
Specific differential phase (KDP)		>3 ˚C/km	
QLCS/Derecho/Cold-Pool Driven Signatures			
Strong leading reflectivity gradient (Y/N)			Yes
Bow echo (Y/N)			Yes
Rear inflow jet (RIJ) (Y/N)			Yes
Deep convergence zone			>10 kft
Gust front hugs close to reflectivity gradient (Y/N)			Yes
Linear weak echo region (WER) along leading edge (Y/N)			Yes