

Debris Balls As Tornado Indicators in Spring 2011

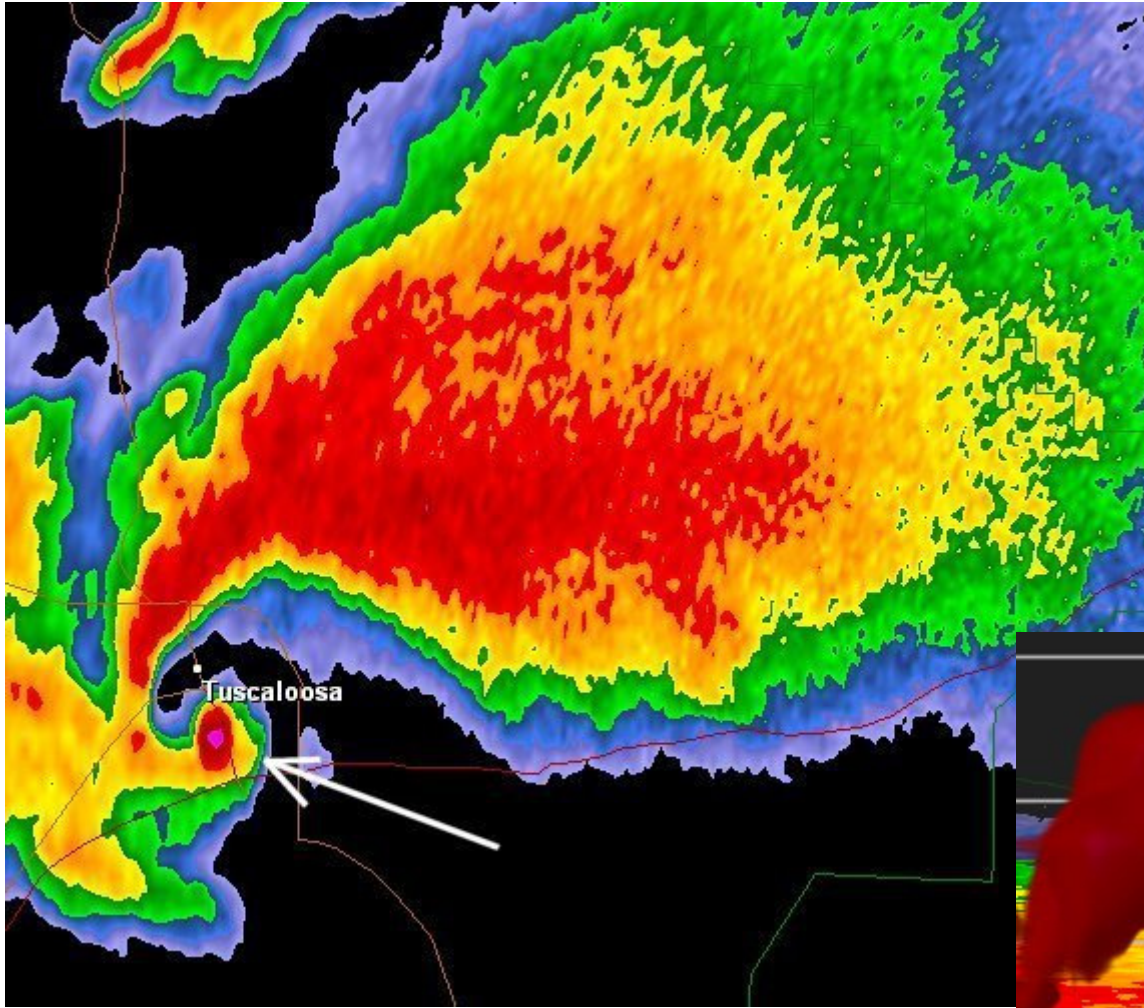
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The Weather Channel
Atlanta, GA**

Radar Debris Balls* – What Do They Tell Us?

- **What constitutes a reliable tornado debris ball?**
- **How far from the radar can they be detected?**
- **How intense must the tornado be to have a debris ball?**
Can this be used reliably to warn the public?
- **Do they tell us how high the tornado extends?**
- **What is the content of the ball (debris/rain/dust/mixture)? → need dual Pol, “ground truth”**

***also called TDS – Tornado Debris Signature; in early days of radar called ASC – Annular Section of Cone**

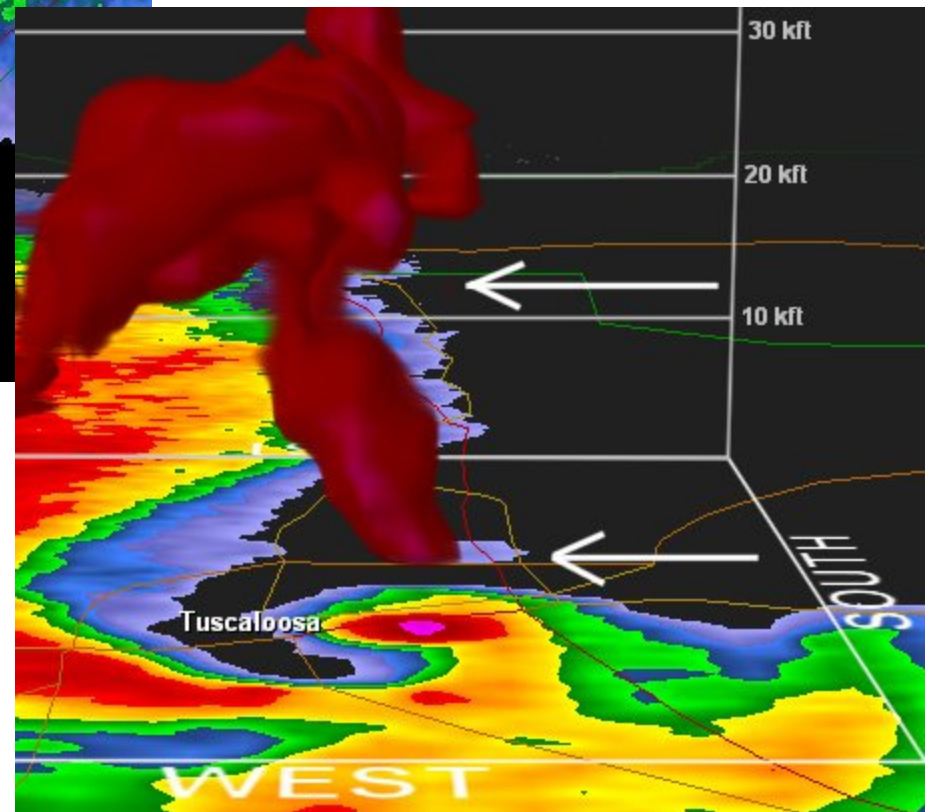
- **Need to be distinguished from DRC – Descending Reflectivity Cores (descending blob with no TVS – Tornado Vortex Signature)**

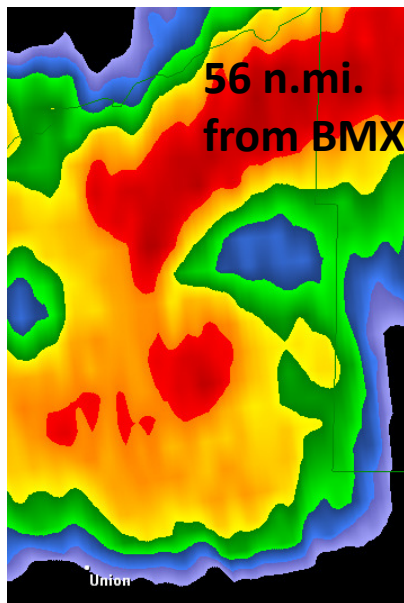


**Radar echo of the
SUPERCCELL
(rotating)
thunderstorm,
spawning the EF4
tornado
at Tuscaloosa AL
April 27, 2011**

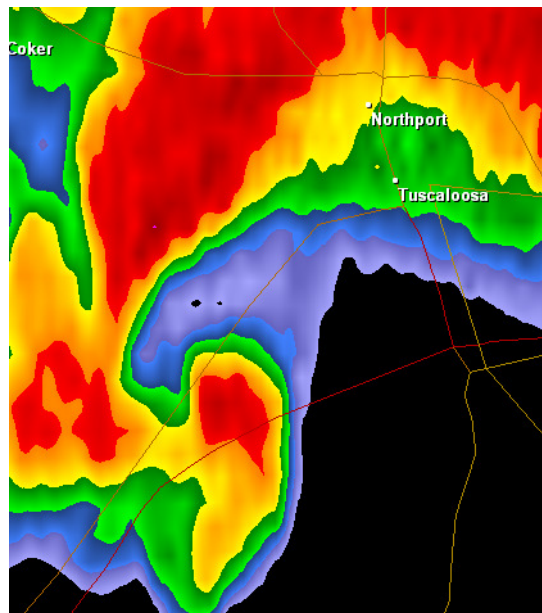
**Lavender-colored ball is due to
debris tossed aloft in the tornado
(Debris Ball/Tornado Debris Signature)**

**Strong radar return used to
simulate the tornado in 3D →
(Gibson Ridge software)**

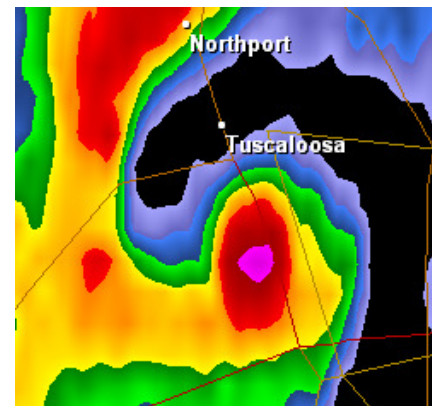




27/2147Z 58.5 dBZ
4 n.mi. NE Union AL
19 n.mi. SW Tuscaloosa
– **EF0+** here
1st sign of ball, then
weakened; 5247 feet

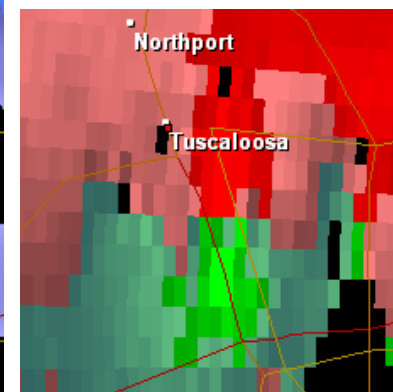


27/2206Z 58dBZ
4 n.mi. SW
Tuscaloosa – **EF2** here
Long-lived ball begins



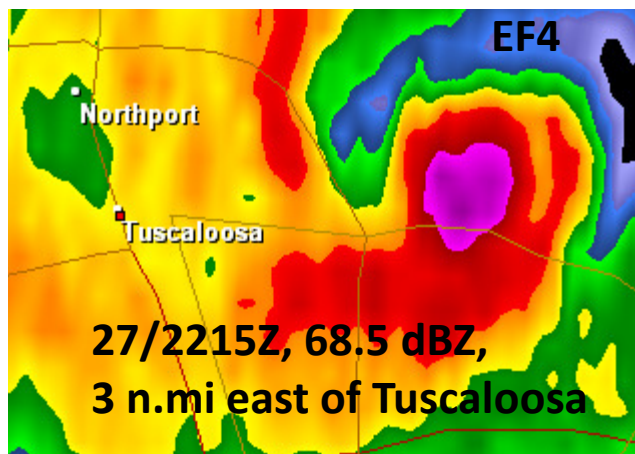
Reflectivity

EF4
Case
Example

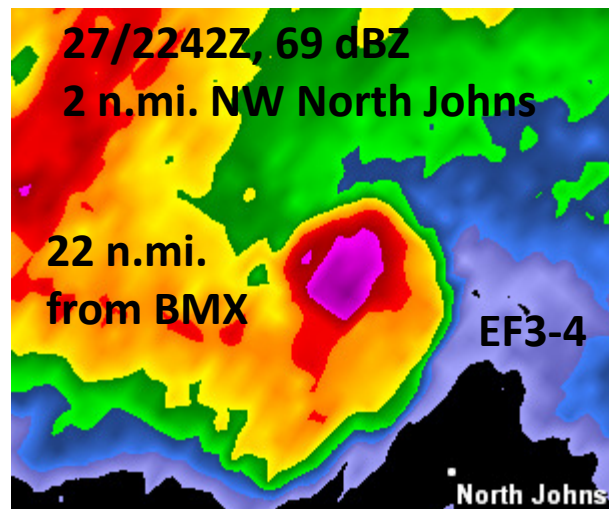


SRV

27/2210Z – **EF4**
1.5 n.mi. S Tuscaloosa
63 dBZ

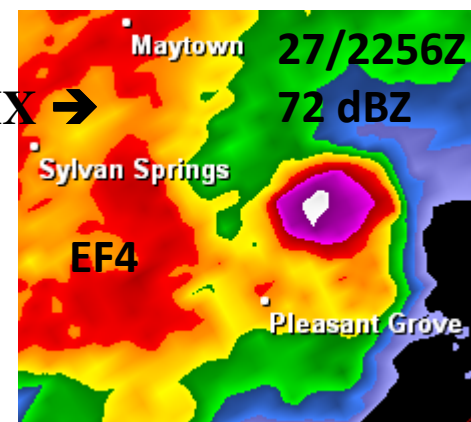


27/2215Z, 68.5 dBZ,
3 n.mi east of Tuscaloosa



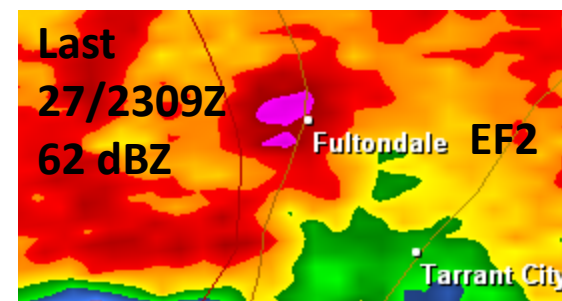
27/2242Z, 69 dBZ
2 n.mi. NW North Johns
22 n.mi.
from BMX

EF3-4



27/2256Z
72 dBZ

EF4



Last
27/2309Z
62 dBZ

EF2

April 27-28, 2011 Radar Debris Ball Study: Preliminary Results

- At least 24 tornadoes had debris balls, some seen by up to 3 radars
- All debris balls that had co-located TVSs were tornadic
- 21 of the 24 tornadoes were at least EF3 - one EF1; two EF2;
possibly one EF0 which would have been 25th tornado
- Debris balls seen by NQA, GWX, DGX, HTX, BMX, FFC, GSP radars
- To be a legitimate debris ball, there had to be a TVS centered within some
part of the reflectivity ball
- 9 of 10 candidate debris balls without co-located TVS were non-tornadic
(the other had an EF0 tornado at 56 n.mi. where velocities were bad)
- So the debris ball adds further confidence that a tornado is present when
the TVS is weak
- Debris ball is often wider than tornado damage, suggesting partly a rain
curtain, but may involve beam-width issues

Number of Detectable Tornadoes with Debris Balls; Maximum Ranges April 27-28, 2011

EF5	3 of 3* seen	max range 92 n.mi.
EF4	7 of 10? seen	max range 87 n.mi.
EF3	11 of 12? seen	max range 115 n.mi.
EF2	2 of 12? seen	max range 57 n.mi.
EF1	1 of 22? seen	max range 42 n.mi.
EF0	1? of 16? seen	max range 56 n.mi.

***** Note 1: Number of detectable tornadoes is preliminary by max EF-Scale (~84% of EF3 and higher; 8% of EF2 and lower?)**

***** Note 2: Listing is by maximum tornado EF-Scale**

***** Note 3: The EF0 debris ball was in a region of indeterminate velocity**

***** Note 4: The fourth EF5 tornado was after HTX had gone down;
likely too distant to be detectable from other radars**

Maximum (Minimum) Lowest-Scan Debris Ball Reflectivities April 27-28, 2011

EF5	66 (47) dBZ	3 tornadoes
EF4	72 (32.5) dBZ	7 tornadoes
EF3	69 (51.5) dBZ	11 tornadoes
EF2	65.5 (52) dBZ	2 tornadoes
EF1	55.5 dBZ	1 tornado
EF0	65 dBZ	1 tornado ?

→ Is debris ball dust at lowest dBZ?

**→ Multiparameter radar can help
distinguish dust, rain, debris
(dual-Pol low correlation signature)**

Vertical Extent of Debris Ball and Relation to Tornado vs Updraft

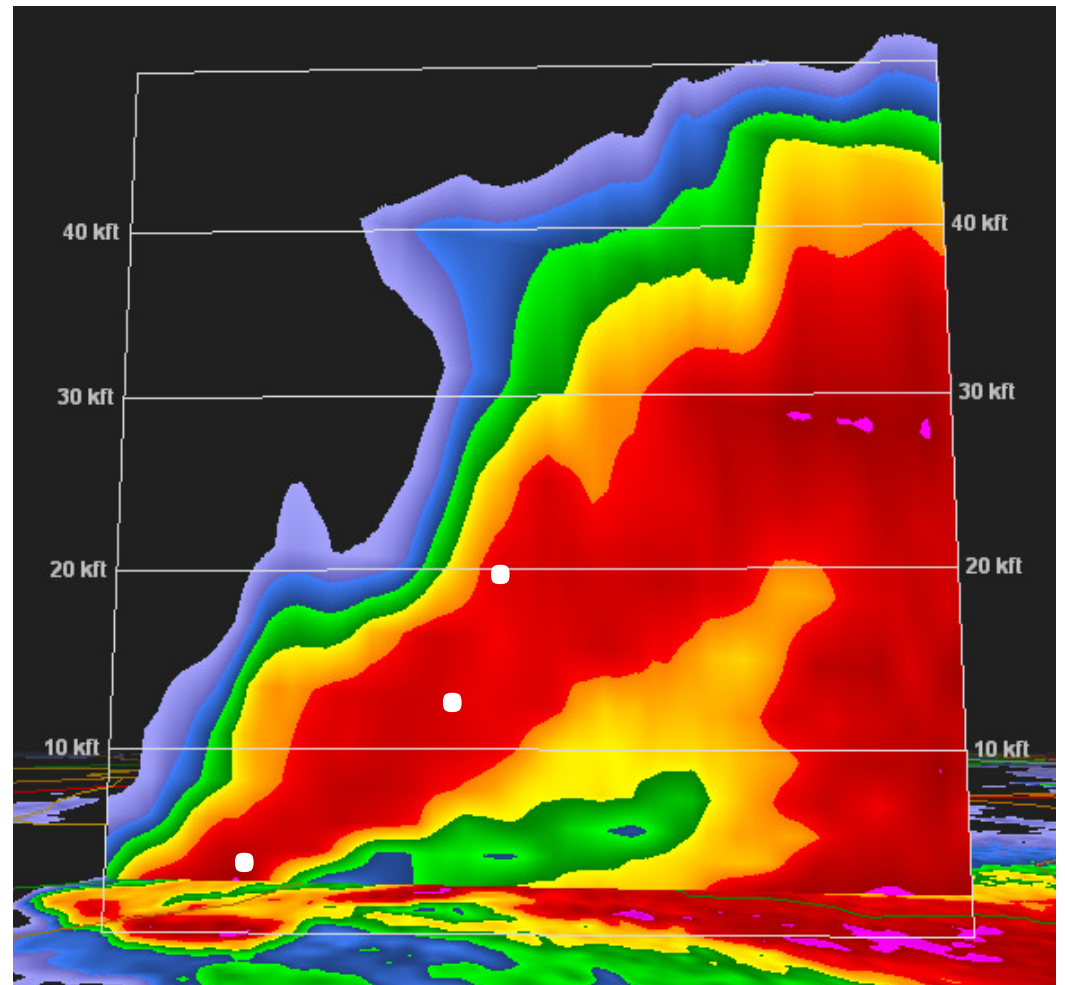
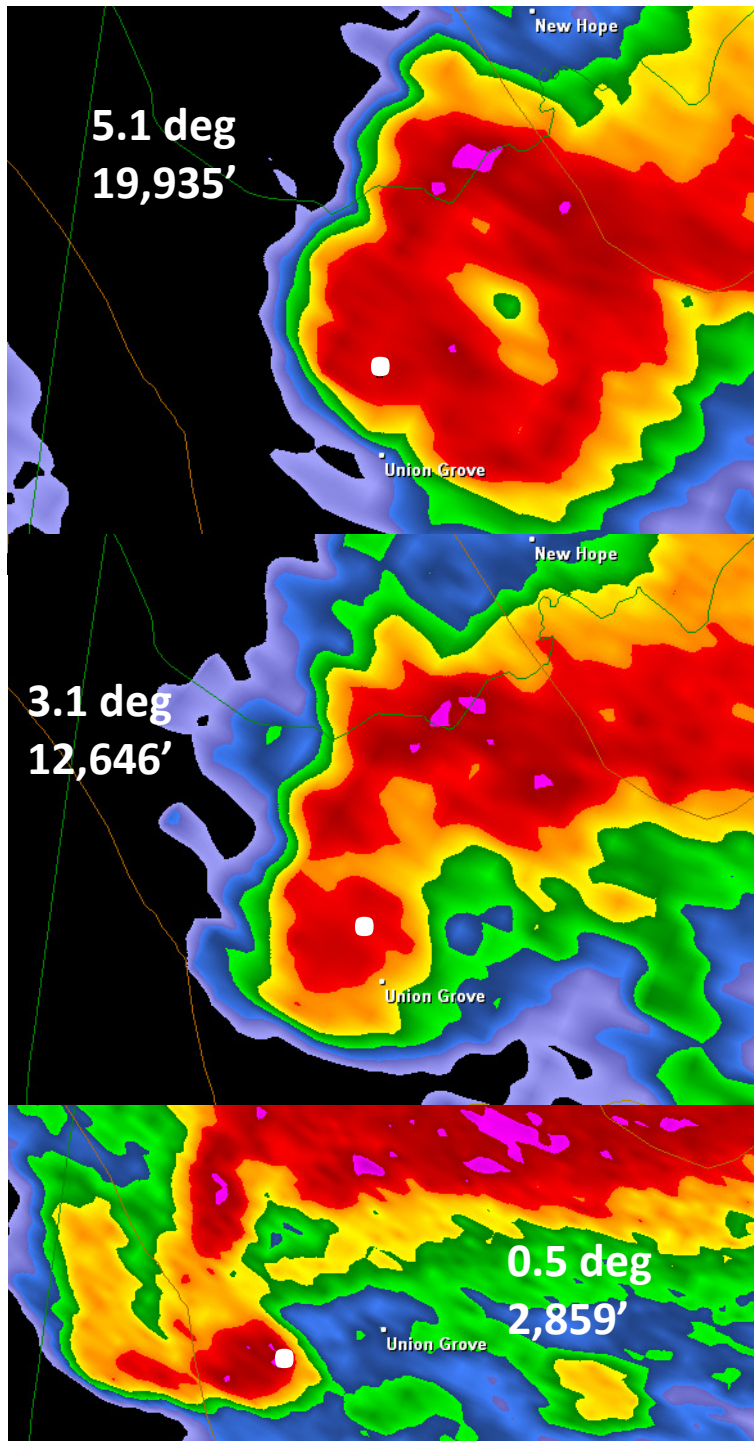
- Debris balls appeared to extend as a tornado-like column often higher than 12,000 feet

	<u>peak height (# tornadoes)</u>
EF5	17,890' [20,380-25,583'?] (3)
EF4	21,534' (7)
EF3	19,436' (11)
EF2	8,038' (2)
EF1	6,733' (1)
EF0?	23,099' ? (1?)

- Debris balls often transitioned to BWER “donut holes” aloft
- Some debris balls appeared from the south part of BWER “donut holes” as the echo approached the radar

Cullman EF4 Tornado Near Union Grove AL

27/2025Z from HTX,
TVS at white dots



Debris Ball Signature Interpretation Seems Rather Robust

Number of Tornadoes Having Debris Balls (within detectable ranges) - approximate

	<u>April 27-28</u>	<u>Other April-June Cases*</u>	<u>Total</u>
EF5	3 of 3**	2 of 2	5 of 5
EF4	7 of 10	3 of 3	10 of 13
EF3	11 of 12	10 of 13	21 of 25
EF2	2 of 12	6 of 19	8 of 31
EF1	1 of 22	3 of 37	4 of 59
EF0	1? of 16	1 of 15	1-2? of 31
=====			
EF3-5	84%	83%	84%
EF2	17%	32%	26%
<u>EF0-1</u>	3-5%	8%	<u>3-6%</u>

*May 24 OK; Apr 22 MO; Apr 16-17 NC/VA; June 1 MA; May 22 MO; Apr 9-10 IA/WI

**One of the EF5 tornadoes on April 27 was undetectable, radar down

Total Study Thus Far

- **7 cases from April-June 2011 (see panel above)**
- **NEXRAD Level 2 data examined for each volume scan, each radar in tornado region**
- **25 radars, 158h**

PRACTICAL IMPLICATIONS

- **Strong indication that strong/violent tornado in progress**
- **Compliments TVS, Dual Pol signatures**

➔ and dual-polarized radar will improve confidence that tornado in progress

