

P1.28 An Updated Version of the V-R Shear Technique for Issuing Tornado Warnings Using 8-Bit High Resolution Radar Data

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Motivation

-New tornado climatology was developed over the past few years for the Northeastern US with CSTAR work by undergrad UAlbany students.

-A goal of CSTAR IV is to develop/update tornado warning strategies using the new 8 bit high resolution radar data.

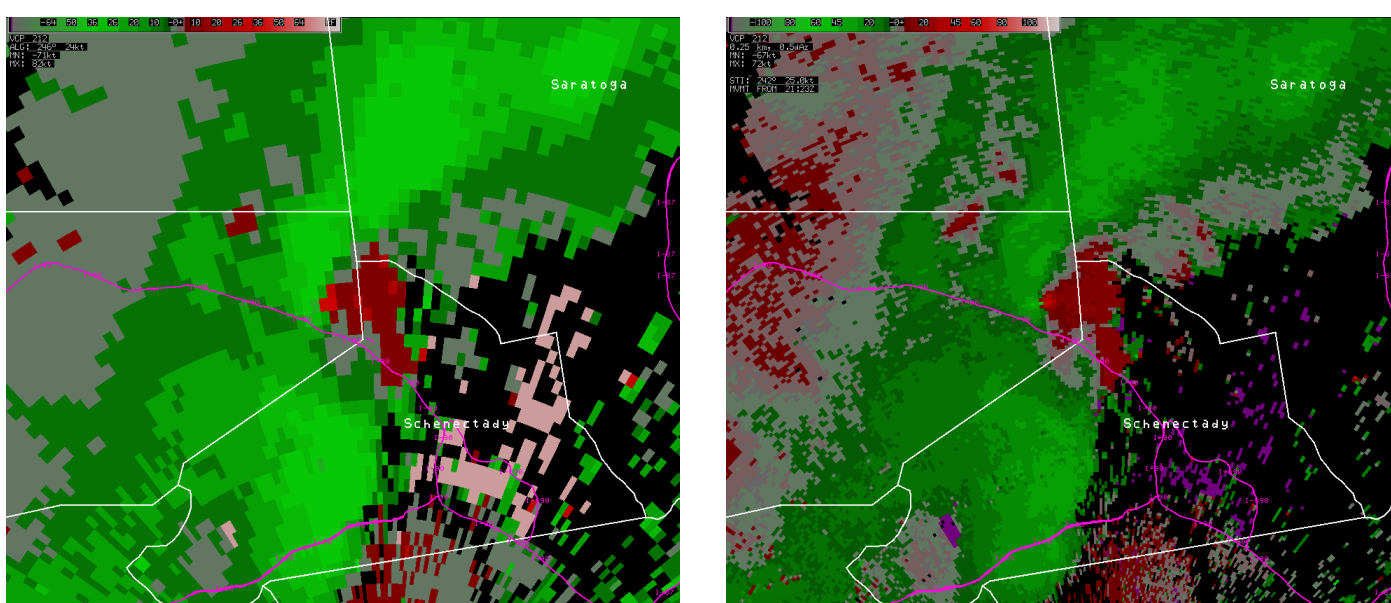
-The V-R shear relationship, developed at the Albany (ALY) Weather Forecast Office (WFO) in 2000, has been an effective method for predicting tornadic development, however, this is based off of 4 bit radar data (La Penta 2000).

-New 8 bit radar data has been available since 2003, but new tornado warning guidance using this higher resolution data had not been developed yet.

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Legacy 4 bit vs. High Resolution 8 bit Radar Data

4 bit: 1 km (0.54 nm) x 1° 8 bit: 0.25 km (0.13 nm) x 1/2°



An example of 4 bit resolution reflectivity (Z) image from KENX from 2123Z 4 Sept 2011 An example of 8 bit super resolution reflectivity (Z) image from KENX from 2123Z 4 Sept 2011

V-R Shear Technique

-Maximum observed gate-to-gate shear below 3 km was found to be useful in identifying tornadic storms (LaPenta et al. 2000)

$$S = V_r / (D * 1800)$$

Shear (S) is measured in units of s⁻¹, rotational velocity (V_r) in knots and D is the diameter of which S is calculated in nm.

-In the LaPenta study, D was set to 0.5 nm for areas within 30 nm of radar and adjusted for areas further away due to beam spreading.

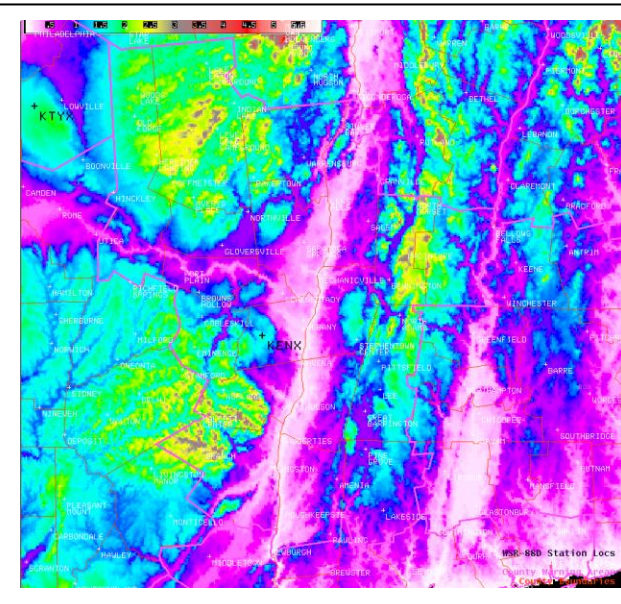
Data and Methodology

-41 tornadic events from 2003-2013 were examined on the Weather Event Simulator (WES) using both plan view graphics in D2D and cross-sections in FSI. 25 of these were from 2008-2013. 11 null cases (mesocyclones that were warned, but tornados didn't occur) were also examined.

-Due to increased radial resolution with the super resolution radar data beginning in 2008, D was set to 0.5 nm for all tornadic storms from 2008 onward within 60 nm of the radar. The previous methodology for setting D was used for storms from 2003 to 2008.

-The maximum velocity differential of the mesocyclone (V_m) was calculated for each storm.

-Results of S and V_m were used to create a new nomogram graphic. The results were compared to the nomogram created in the original LaPenta study.

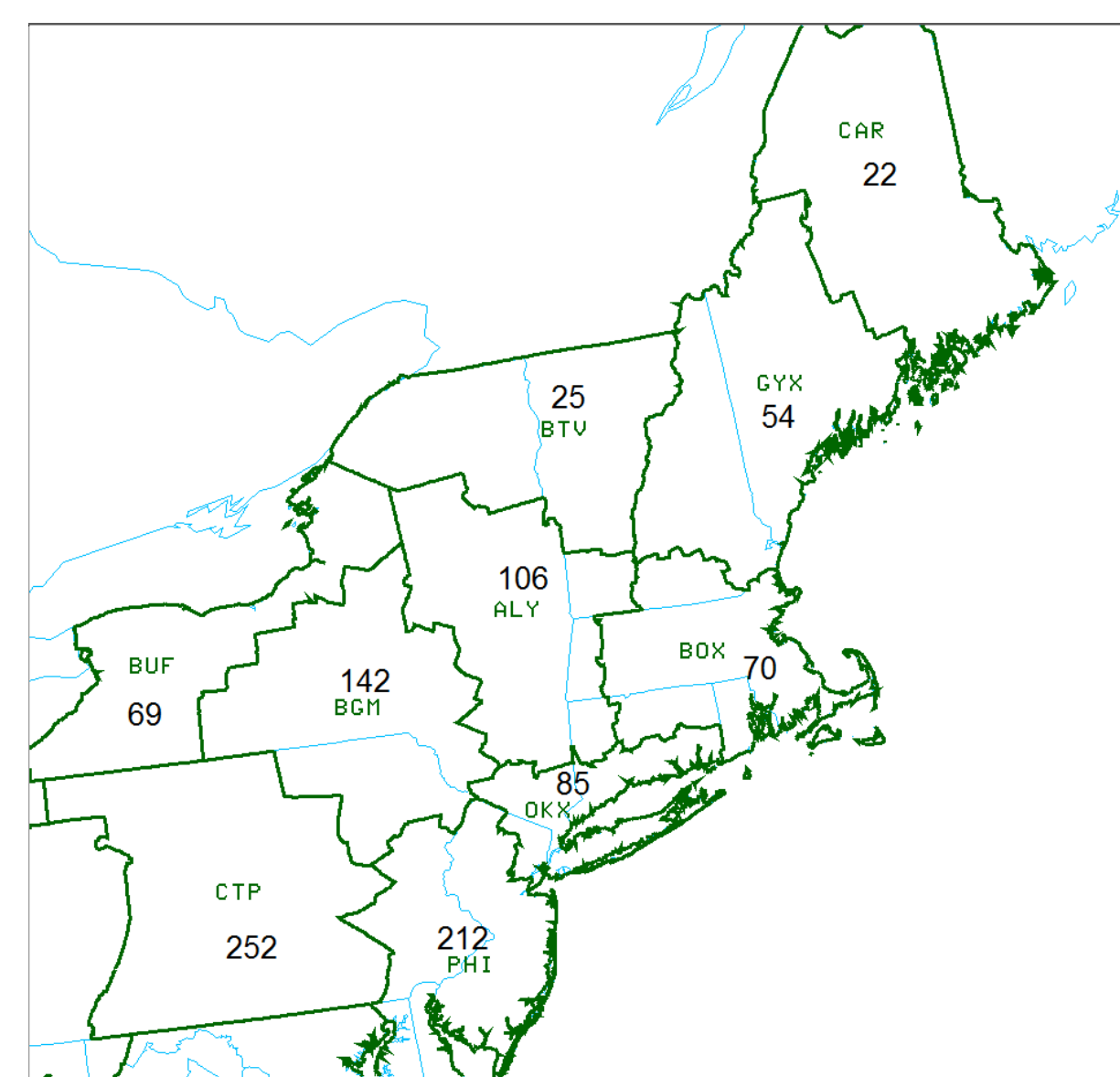


The topography of the Albany CWA, featuring the Adirondacks, Catskills, Green Mountains and Berkshires surrounding the Hudson and Mohawk Valleys. The Catskill Escarpment is located just to the south of the KENX radar site. Elevation above sea level is color coded (kft).

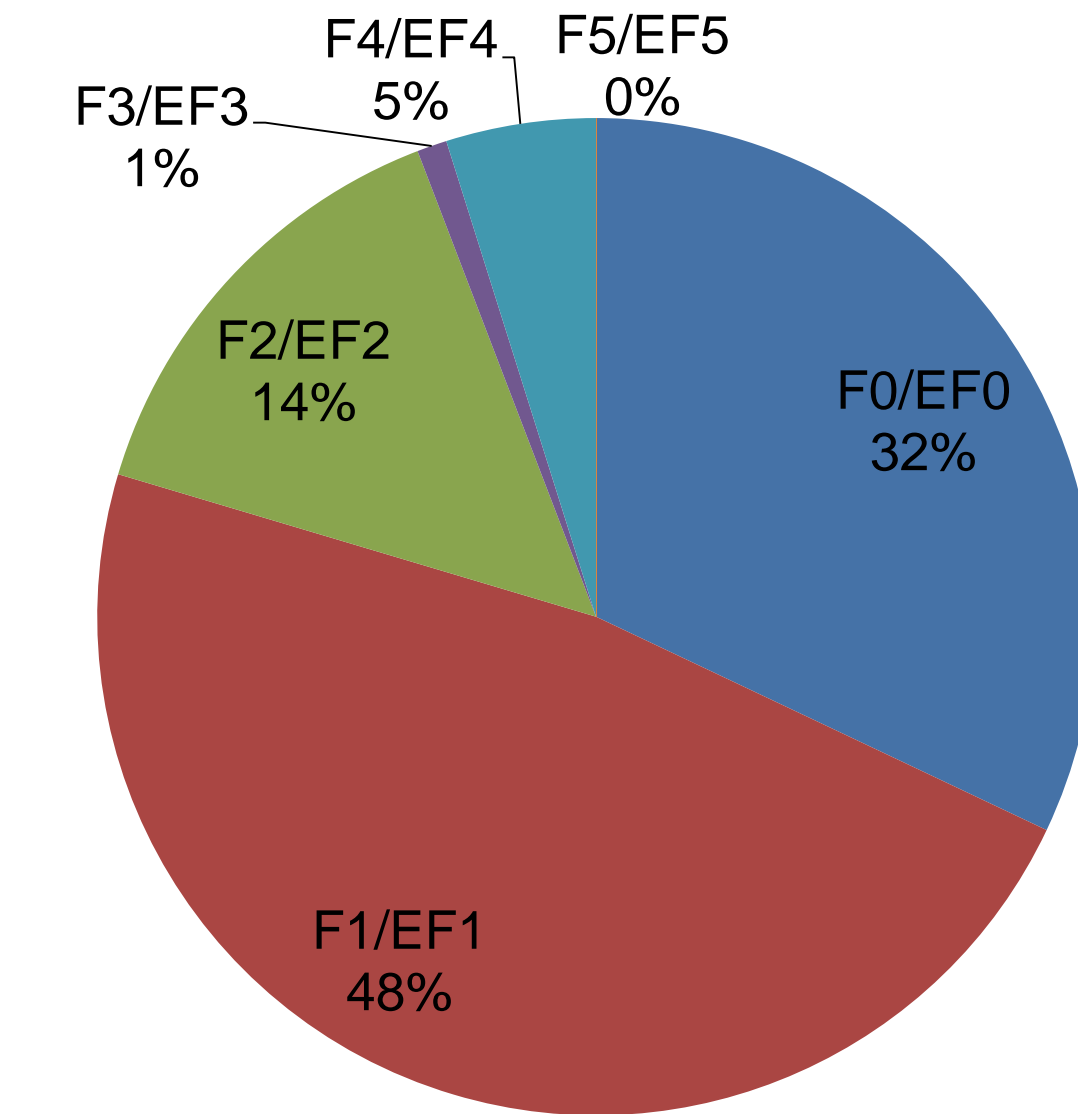
Updated Northeast/NWS Albany Tornado Climatology

Tornadic events as recorded in StormData

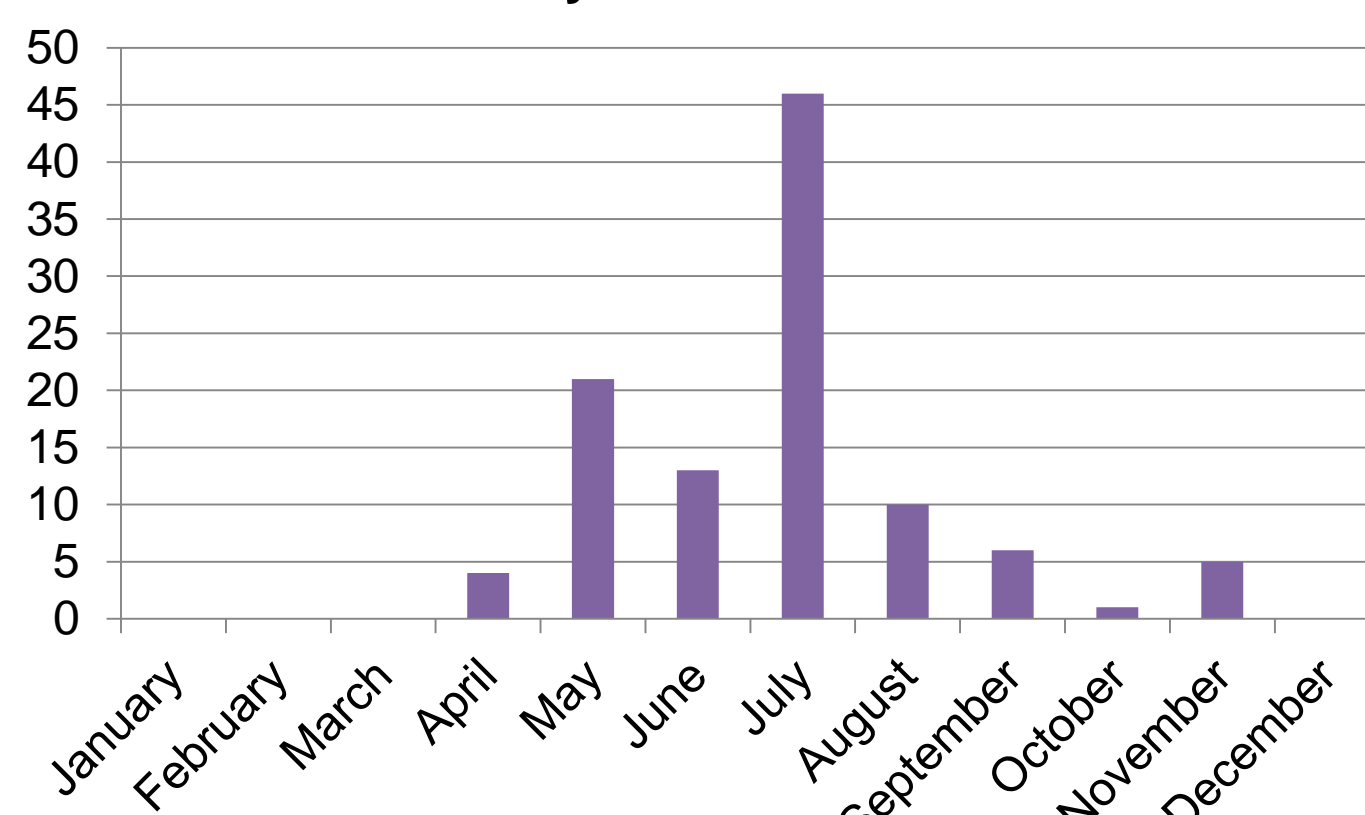
1980-2012 Tornado Climatology by County Warning Area (CWA)



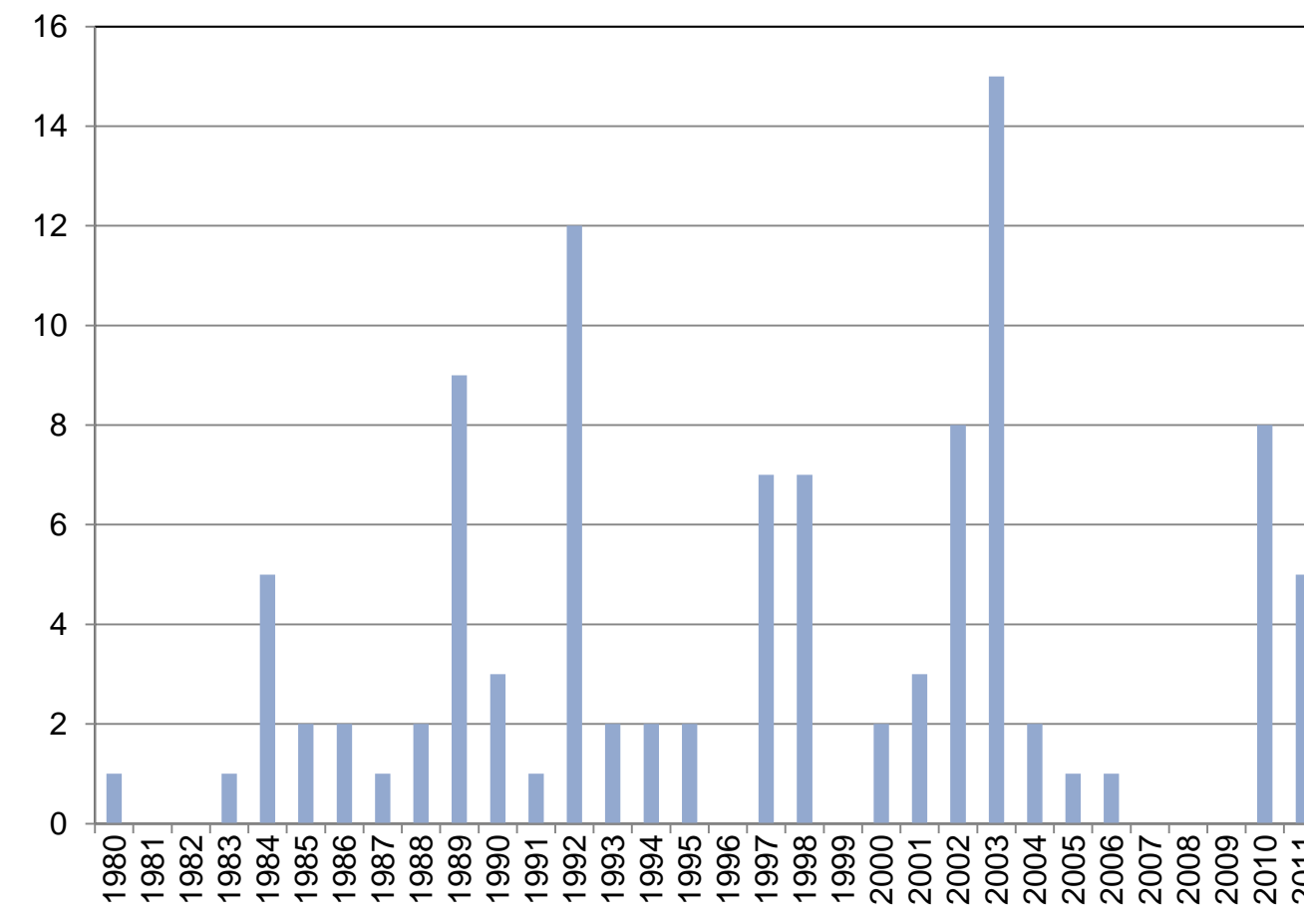
Tornado Strength within the Albany CWA from 1980-2012



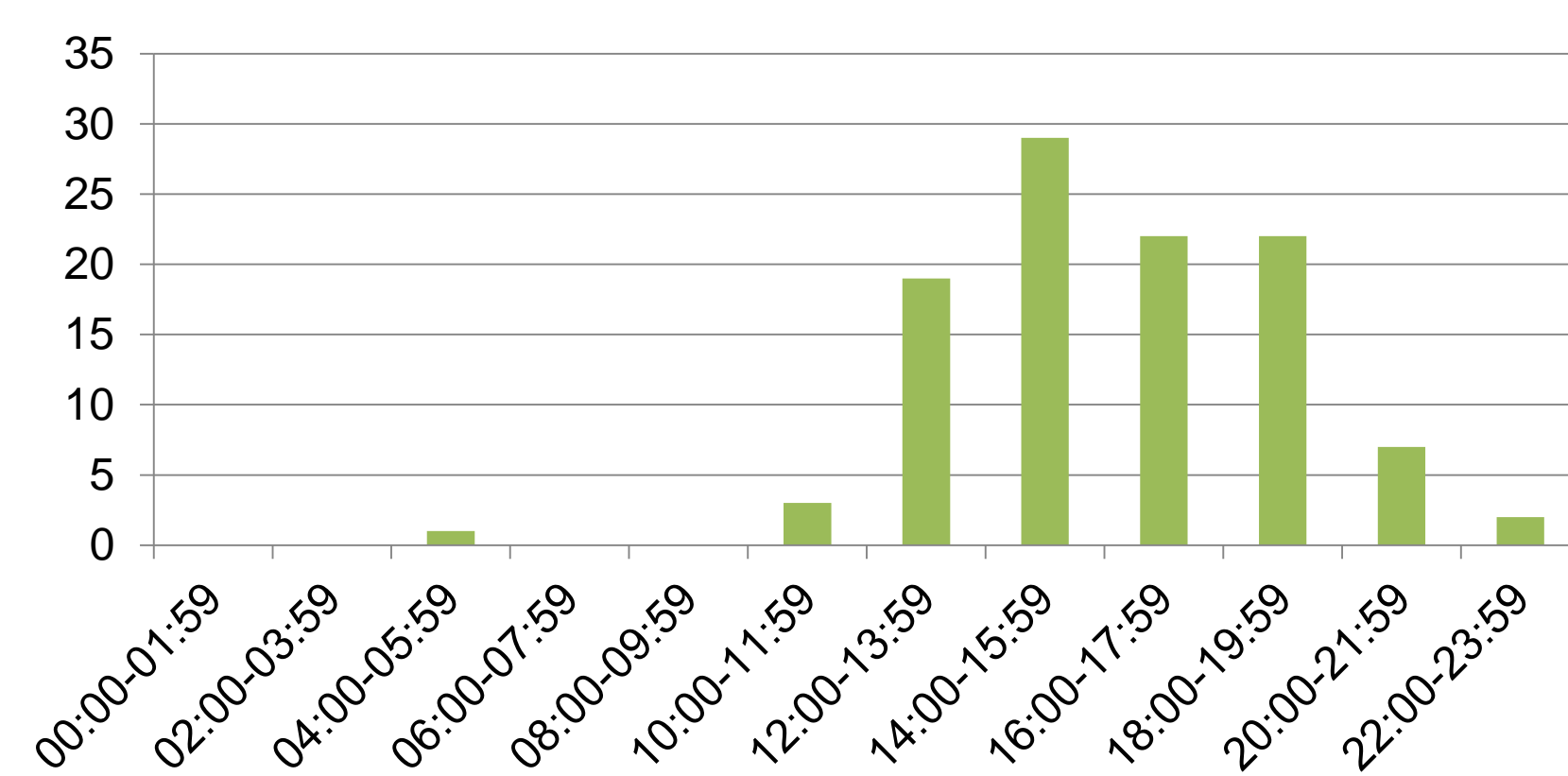
Number of Tornadoes by Month in the Albany CWA 1980-2012



Number of Tornadoes in the Albany CWA by Year from 1980-2012

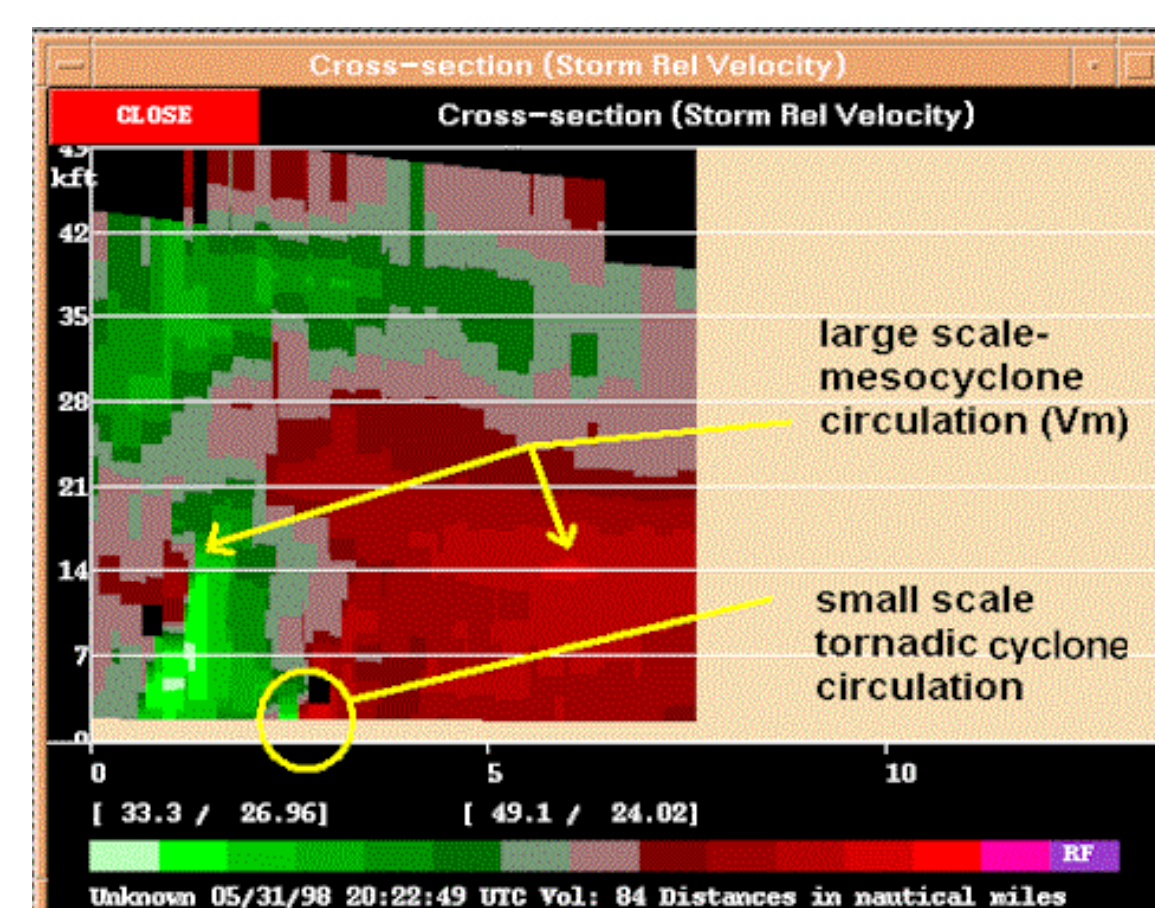


Number of Tornadoes at Specific Time Ranges (EST) within the Albany CWA from 1980-2012



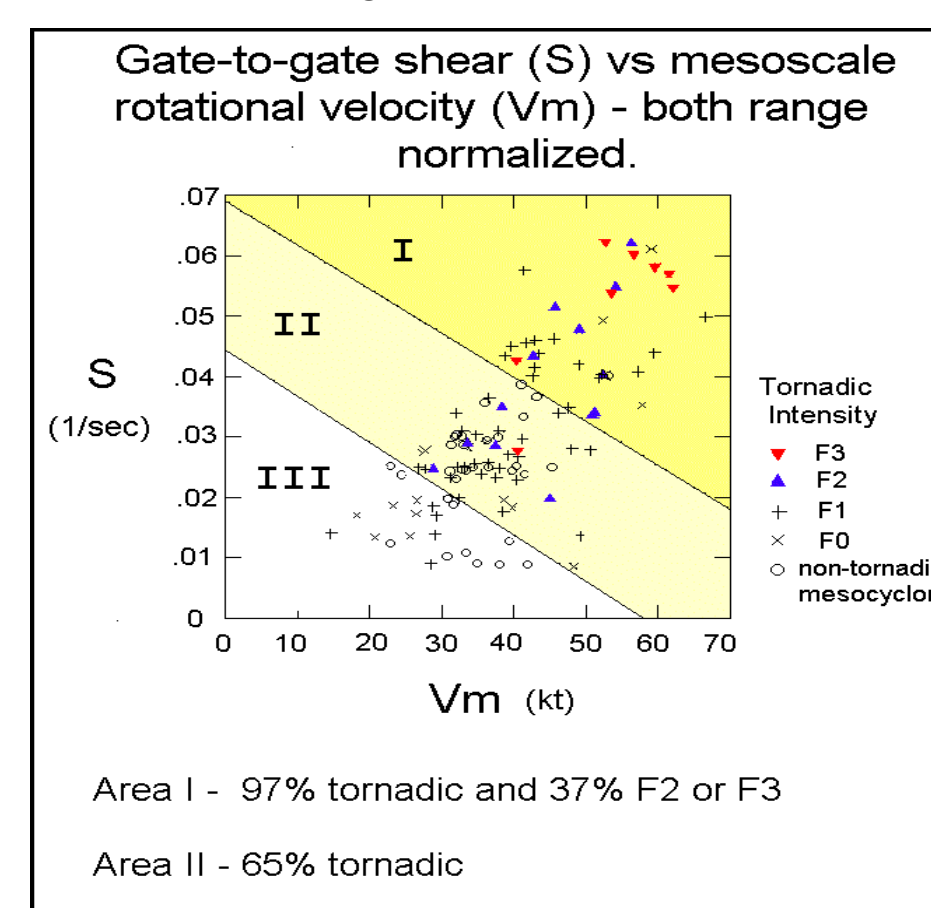
Previous Study Work

Calculation of Maximum Velocity of Mesocyclone using a Velocity Cross-Section



Mechanicville, NY F3 from 31 May 1998 2022Z

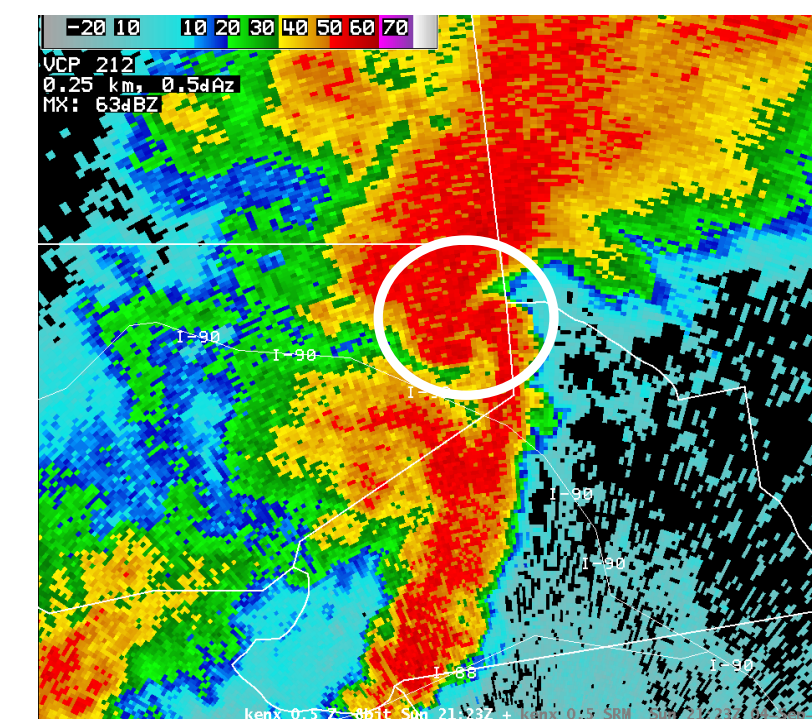
Nomogram for operational use during storm interrogation based on 4 bit data



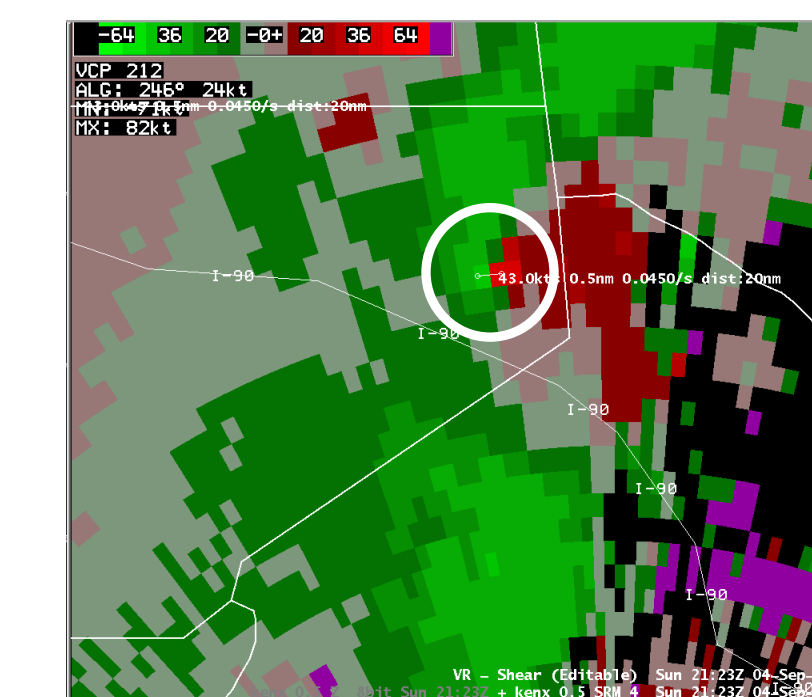
From local COMET research (LaPenta et al., 2000)

4 September 2011

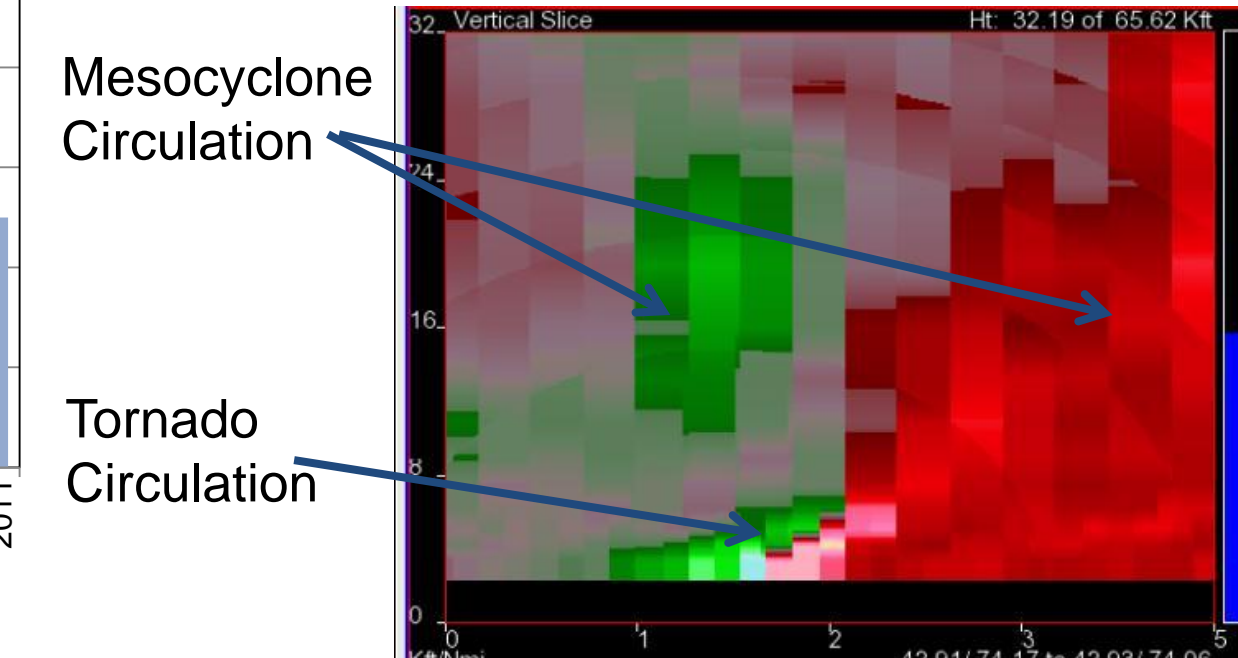
Cranesville-Glenville EF1 Tornado
-Rated EF1 with top winds of 110 mph by NWS Albany Survey Team
-Formed at 2120Z near Florida, NY
-Up to a half-mile wide through Cranesville, NY
-Dissipated at 2135Z near Glenville, NY
-On the ground for 7 miles



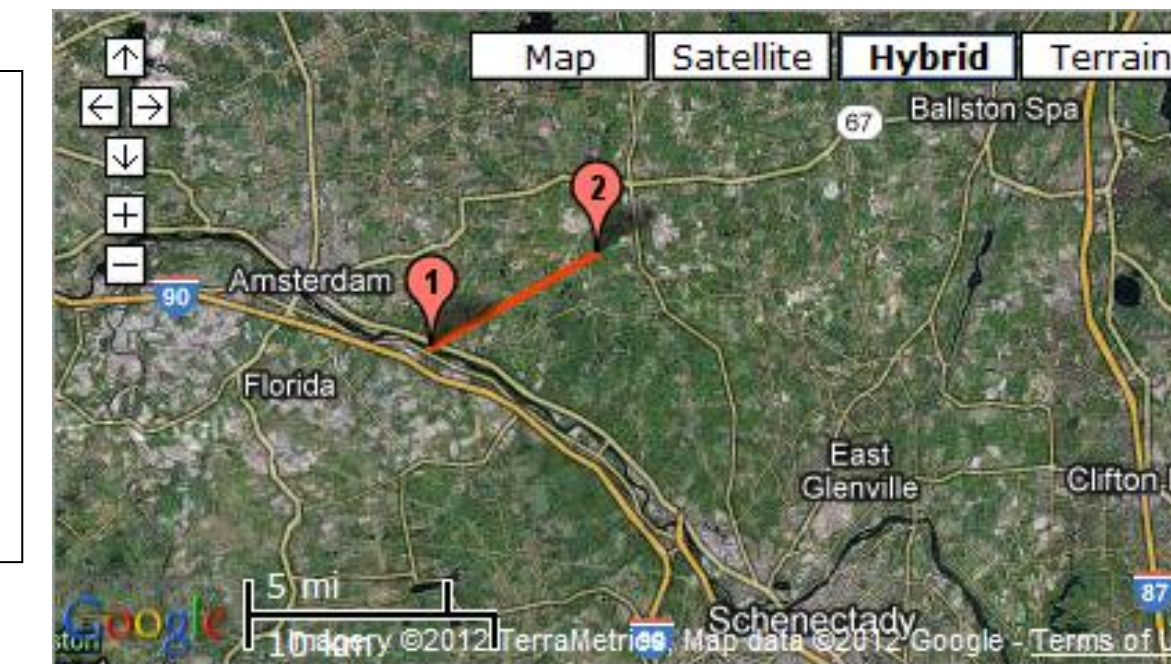
KENX Base (0.5°) Reflectivity (Z) at 2123Z



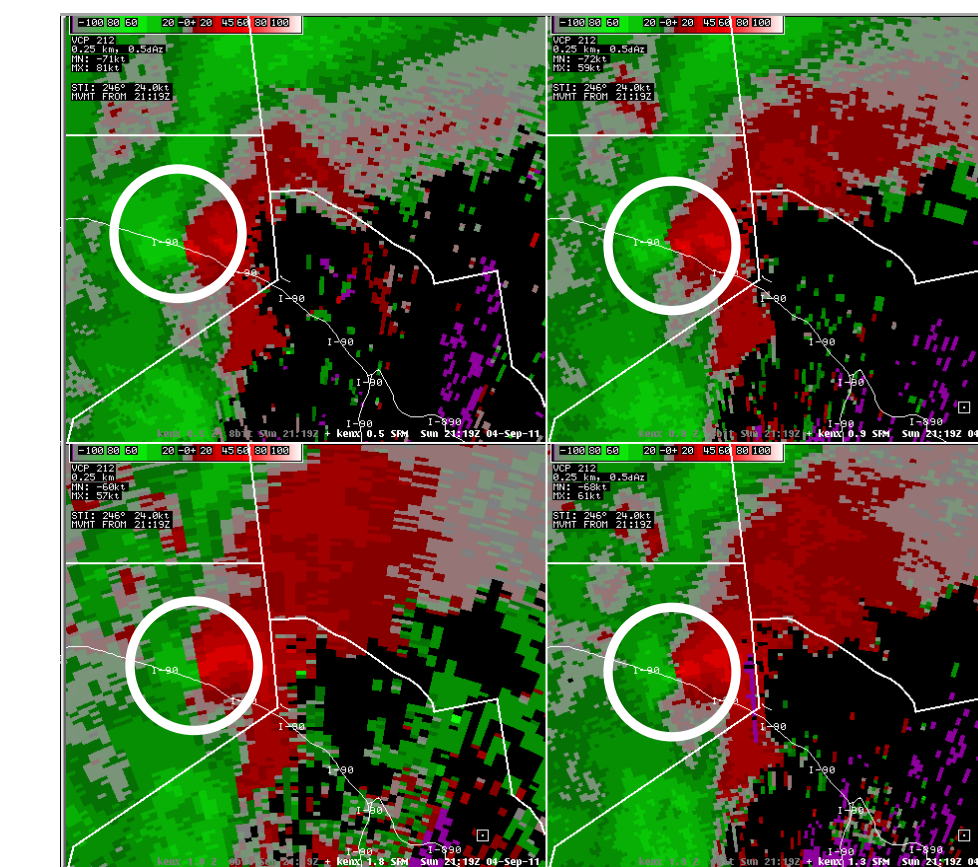
4 bit (1 km x 1 degree resolution) SRM from 2123Z
V_r=43.0 kts, D=0.5 nm, S=0.0450 s⁻¹



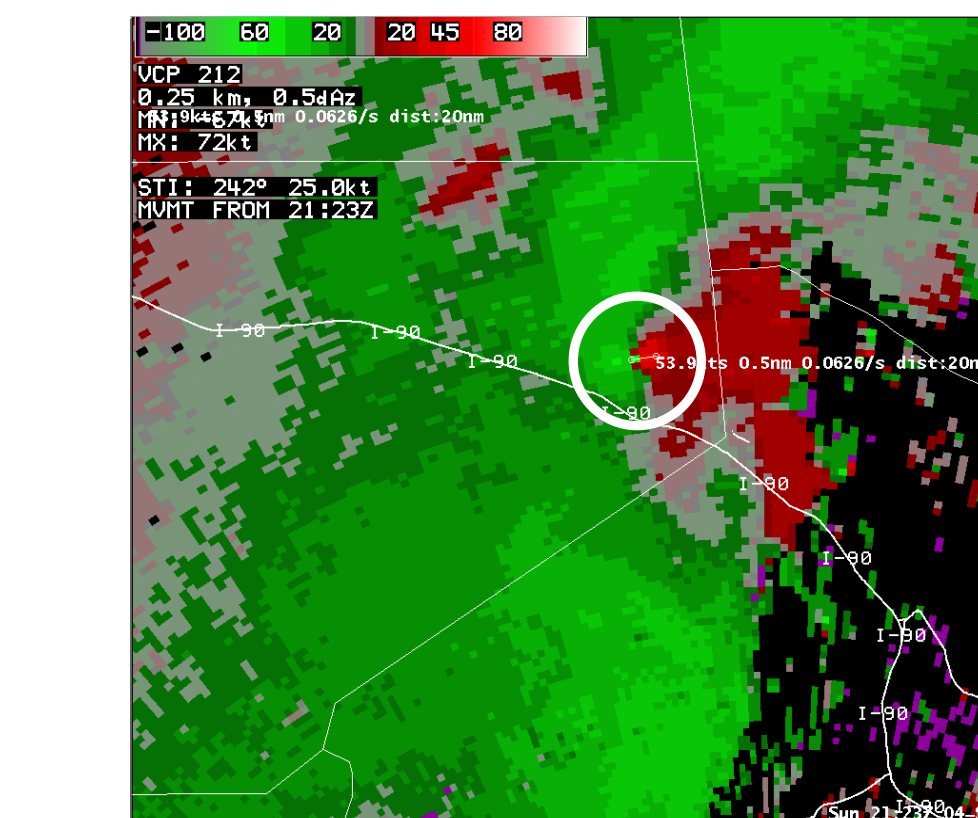
Storm Relative Motion (SRM) cross-section from 2123Z from FSI. This cross-section was over the tornadic thunderstorm, about 20 nm from the KENX radar.
Maximum velocity of mesocyclone (V_m) = 55 kts



Map of path of EF1 Cranesville Tornado from 4 Sept 2011 (Image Courtesy of Google, Inc.).



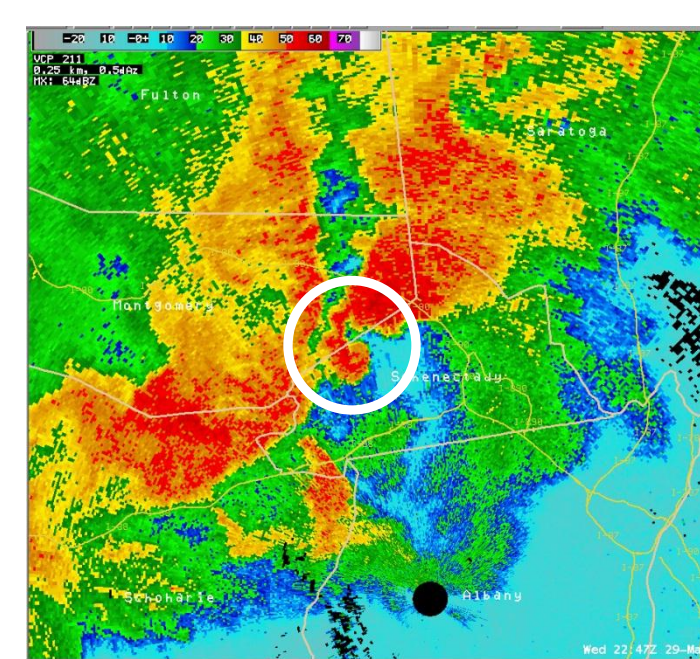
4 Panel KENX Storm Relative Motion (SRM) from 2119Z (0.5°, 0.9°, 1.3°, 1.8° elevation slices going clockwise). These images were about one minute before the tornado touched down.



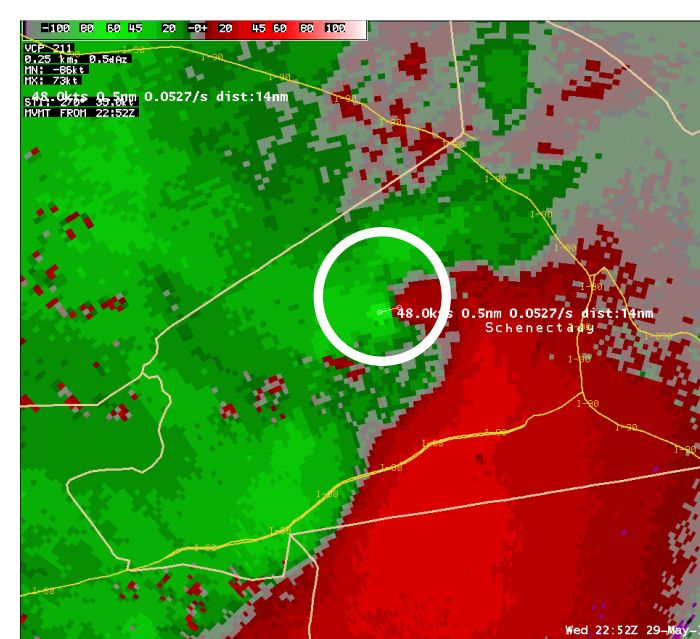
8 bit (0.25 km x 0.5 degree resolution) SRM from 2123Z
V_r=53.9 kts, D=0.5 nm, S=0.0626 s⁻¹

29 May 2013

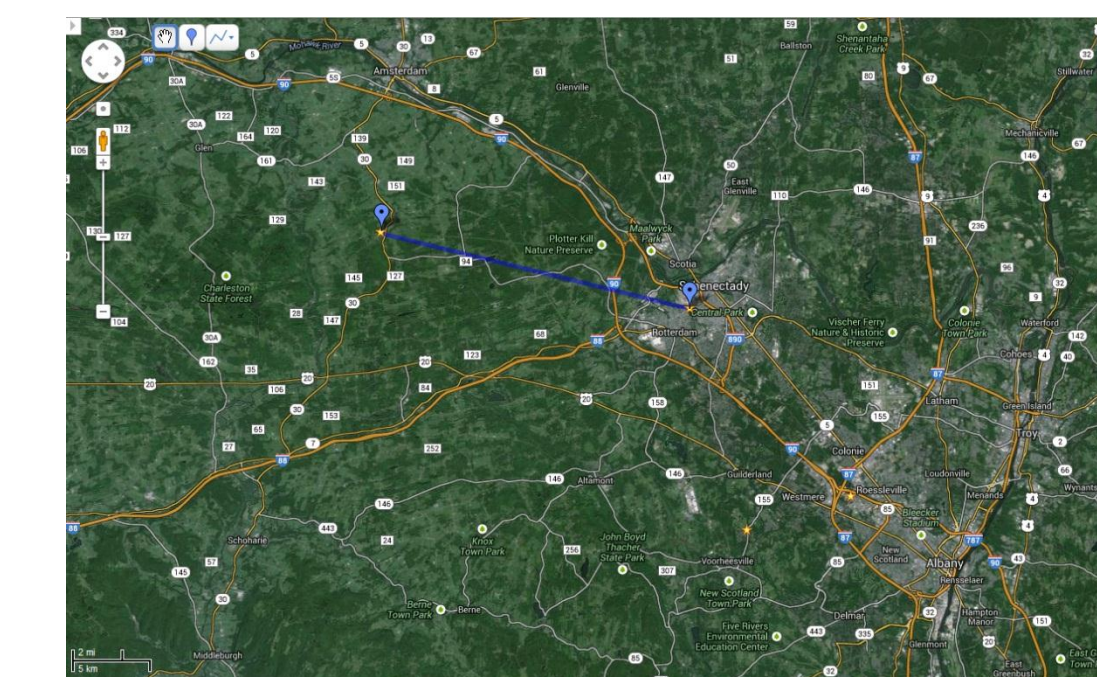
Scotch Bush-Mariaville-Schenctady EF2 Tornado
-Rated EF2 with top winds of 125 mph by NWS Albany Survey Team
-Formed at 2247Z in Scotch Bush (town of Florida), NY
-Damage was nearly one mile wide in Mariaville, NY
-Dissipated at 2304Z in the city of Schenectady, NY
-On the ground for 13 miles



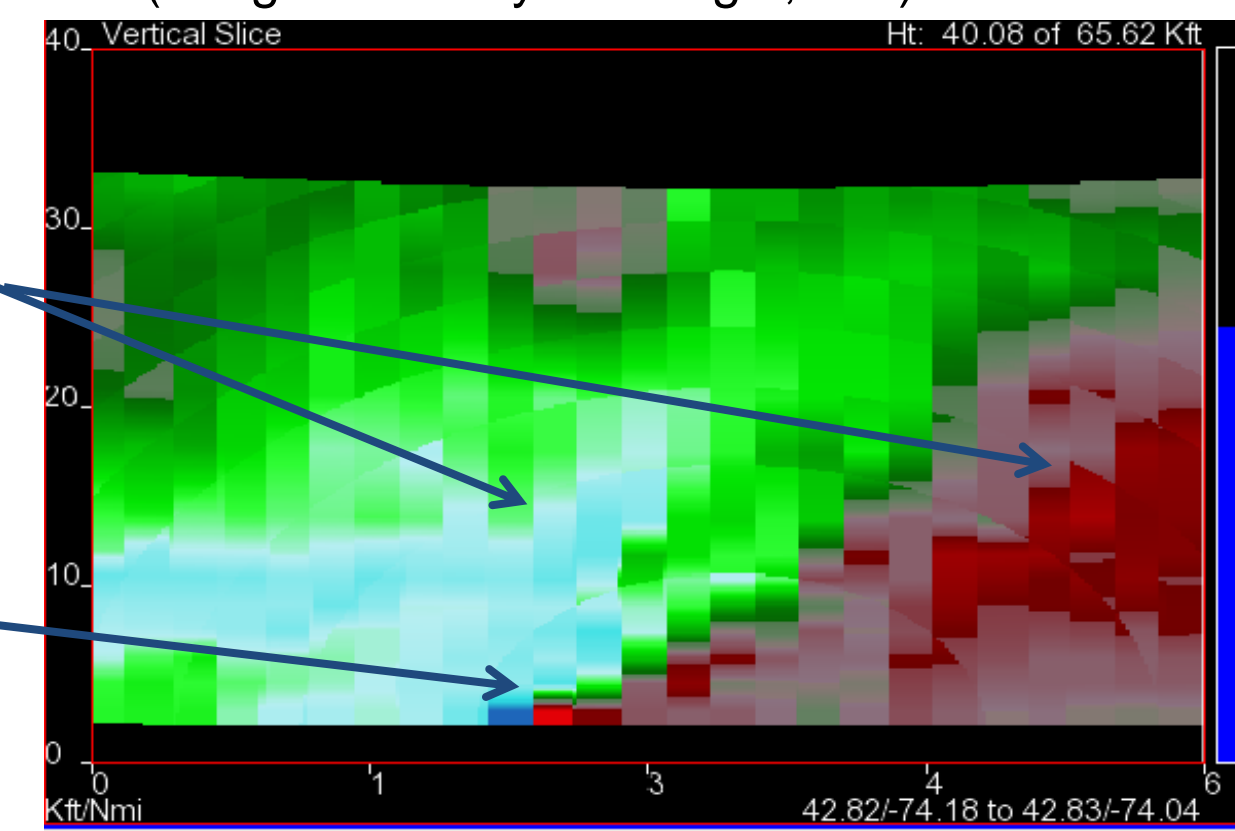
KENX Base (0.5°) Reflectivity (Z) at 2247Z



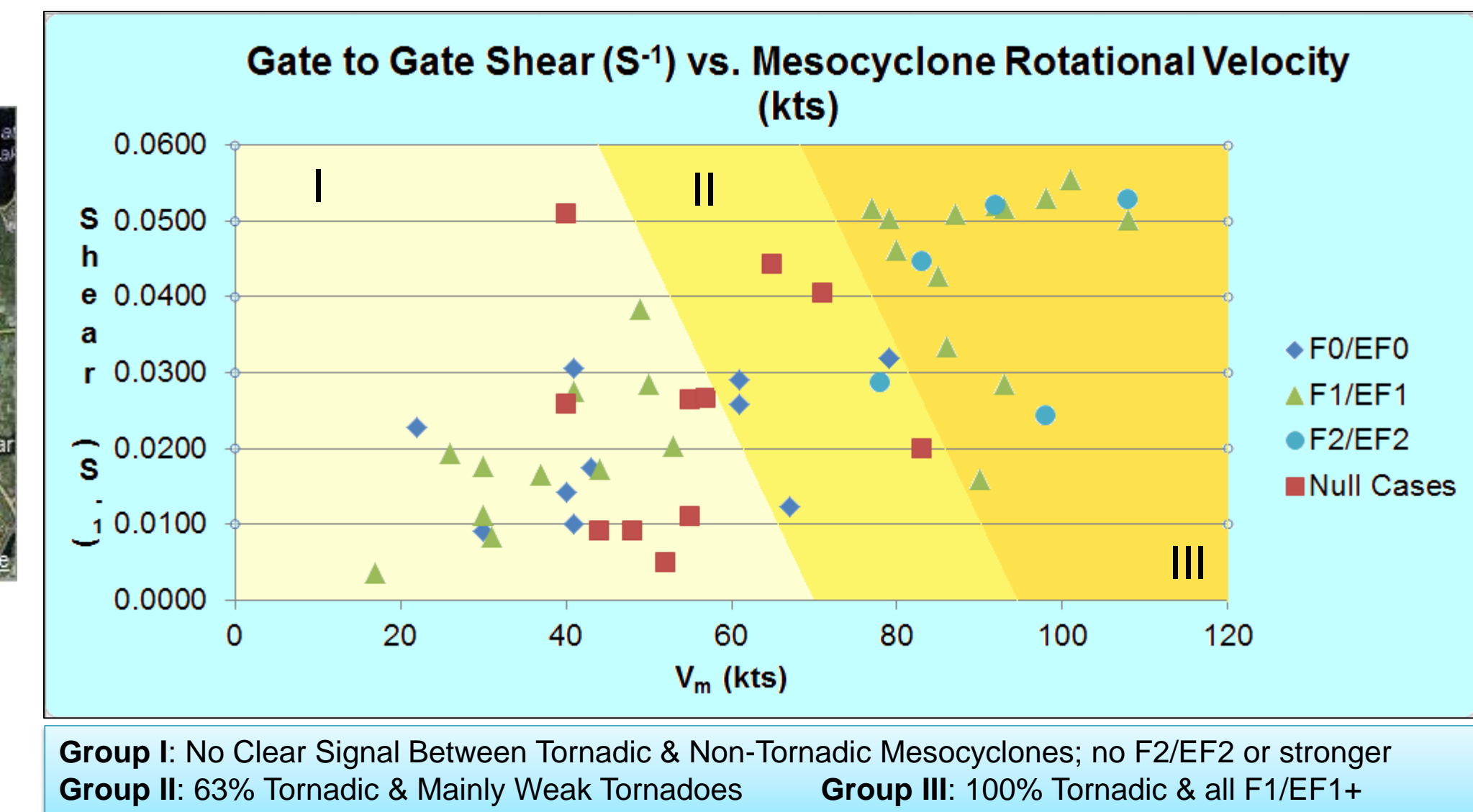
8 bit (0.25 km x 0.5 degree resolution) SRM from 2252Z
V_r=48.0 kts, D=0.5 nm, S=0.0527 s⁻¹



Map of path of EF2 Montgomery County-Schenectady County Tornado from 29 May 2013 (Image Courtesy of Google, Inc.).



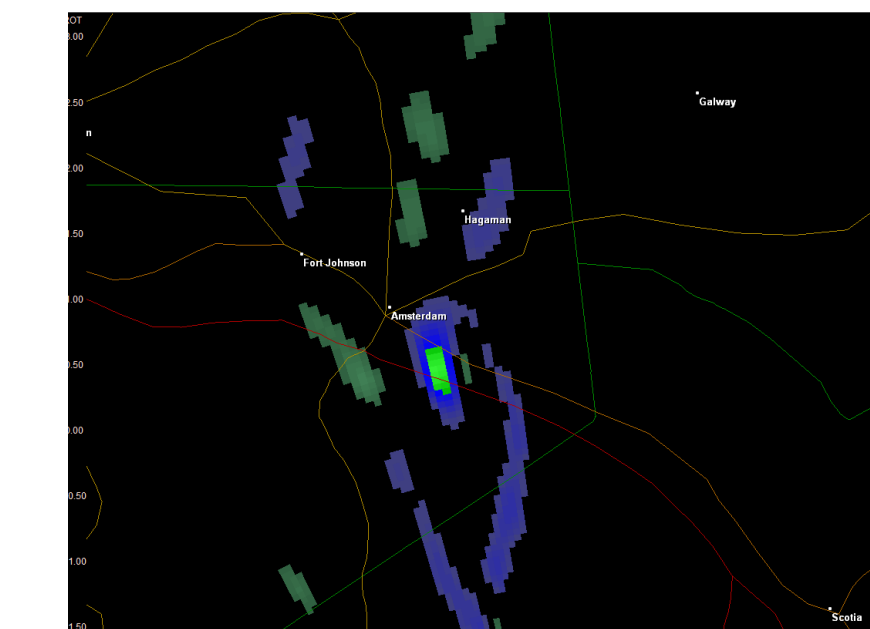
Storm Relative Motion (SRM) cross-section from 2252Z from FSI. This cross-section was over the tornadic thunderstorm, about 15 nm from the KENX radar.
Maximum velocity of mesocyclone (V_m) = 108 kts



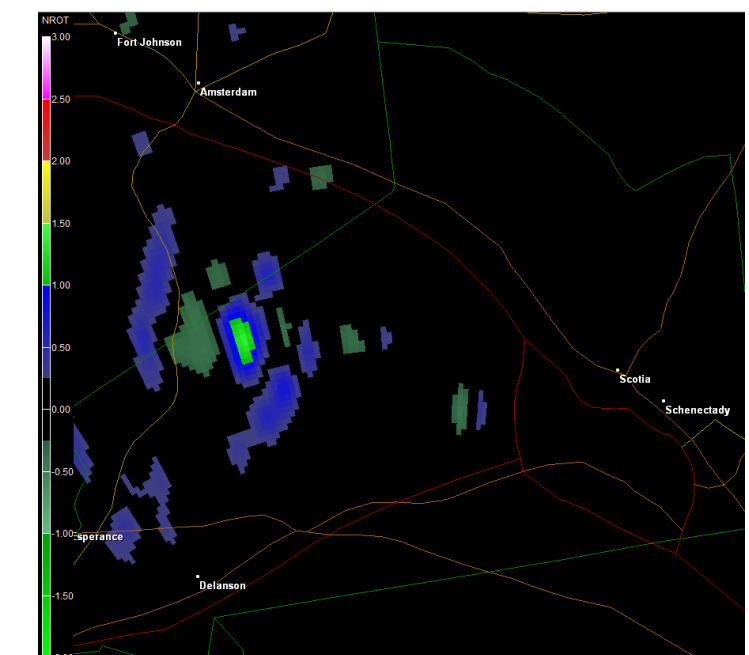
Group I: No Clear Signal Between Tornadic & Non-Tornadic Mesocyclones; no F2/EF2 or stronger
Group II: 63% Tornadic & Mainly Weak Tornadoes Group III: 100% Tornadic & all F1/EF1+

Updated nomogram using 8 bit data, based off 41 tornadoes from 2003-2013. 11 null cases were also included. D was set to 0.5 nm for all storms from 2008-2013.

Normalized Rotation (NROT) using GR2Analyst



NROT display from GR2Analyst from 2119Z from 4 Sept 2011. NROT values reached a maximum of +1.40 just prior to tornado touchdown. An NROT value of 0.89 was present 10 minutes before tornado touchdown at 2110Z.



NROT display from GR2Analyst from 2247Z from 29 May 2013. NROT values reached a maximum of +1.36 just prior to tornado touchdown. An NROT value of 0.85 was present 15 minutes before tornado touchdown at 2232Z.

-82 tornadic cases from 2003-2013 have been examined in GR2Analyst. In addition, 25 null cases from 2008-2012 were also examined.

-For the tornadic storms, average NROT value at the time of tornado touchdown is 0.90 and the median value is 0.81.

-At 3 scans prior to tornado formation (about 10-15 minutes before touchdown), NROT shows an average value of 0.72 and a median value of 0.73.

-For the null cases (mesocyclones that were warned that did not produce a tornado), the average NROT value at the time of the tornado warning was 0.74 and the median value was 0.71.

-At 3 scans prior to the tornado warning time for the null cases (about 10-15 minutes before), NROT shows an average value of 0.69 and a median value of 0.65.

Limitations

-Limited sample of tornadoes across the Northeast since 2003

-Weak tornadoes, which are most common over the Northeast produce little damage. Many times the damage appears similar to microbursts and it can be difficult to classify these tornadoes for our area

-Radar data is affected by the terrain in eastern New York and New England (i.e. beam blockage)

-Some tornadic couplets are below the beam when further away from the radar and radar data is not useable for these cases

Conclusions

-The examples of 4 Sept 2011 & 29 May 2013 show a noticeable difference in both V_r and S between 4 bit and 8 bit values.

-The updated nomogram shows similar findings to the original LaPenta study (2000) and can now be utilized with the 8 bit, high resolution radar data operationally.

-Improvements in radar resolution have removed the need to normalize for range further away from the radar. This will allow for quicker identification of tornadic storms and hopefully an improvement in lead time, as the forecaster will not need to figure out what length to set D when calculating S.

-NROT has shown to be a useful tool in evaluating a storm's tornadic potential. NROT shows a signal several scans before the tornado develops.