The 4 September 2011 Tornado in Eastern New York: An Example for Updating Tornado Warning Strategies

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Motivation

-New tornado climatology was developed over the summer of 2010 and 2011 for the Northeastern US with CSTAR work by undergrad UAlbany students

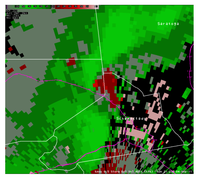
-A goal of CSTAR IV is to develop/update tornado warning strategies using the new 8 bit high resolution radar data

-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

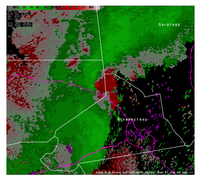
-New 8-bit radar data has been available since 2003, but new tornado warning guidance using this higher resolution data has not been developed yet

CSTAR Grant #: NA01NWS4680002

Legacy 4 bit vs. High Resolution 8 bit radar data



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 n mi.

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

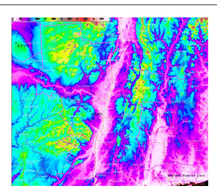
Data and Methodology

-8 bit radar data from 40 tornadoes from 2003-2011 were examined on the Weather Event Simulator (WES) using the Four-Dimensional Storm Investigator (FSI).

-Shear was calculated for each tornado using a diameter of 0.5 nm for all tornadoes within 60 nm of radar since the midpoint of adjacent velocity pixels is 0.5 nm or less up to 60 nm from radar. This is a change from the previous study where the lower resolution data caused for a normalization of D for ranges greater than 30 nm.

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

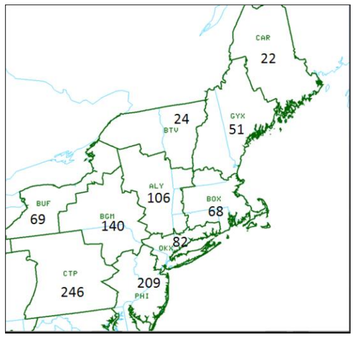
-Results of S and V_m were compared to the nomogram graphic created by the LaPenta study



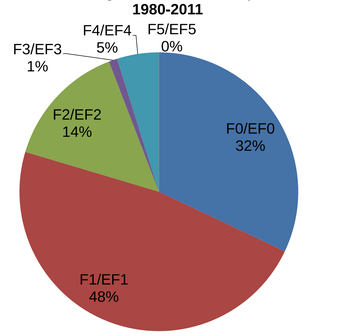
The topography of the Albany CWA, featuring the Adirondacks, Catskills, Green Mountains and Berkshires surrounding the Hudson and Mohawk Valleys. The Catskill Escarpment is located just to the south of the KENX radar site. Elevation above sea level is color coded (kft).

Updated Northeast Tornado Climatology

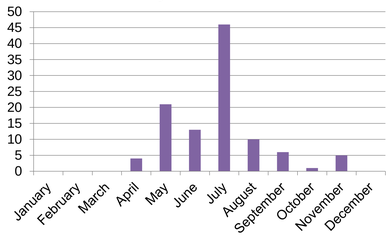
1980-2011 Tornado Climatology by County Warning Area (CWA)



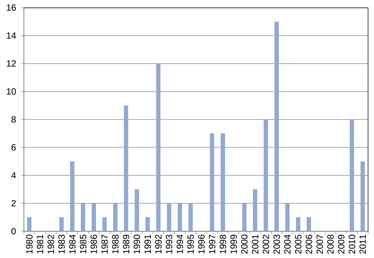
Tornado Strength within the Albany CWA from 1980-2011



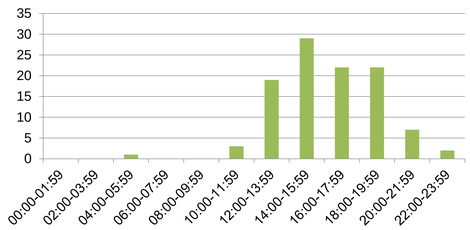
Number of Tornadoes by Month in the Albany CWA 1980-2011



Number of Tornadoes in the Albany CWA by Year from 1980-2011

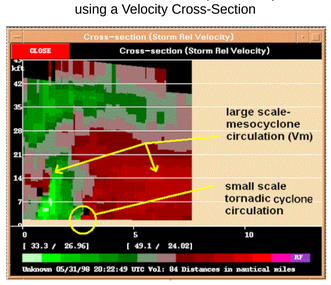


Number of Tornadoes at Specific Time Ranges (EST) within the Albany CWA from 1980-2011



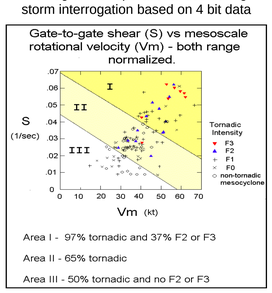
Previous Study Work

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



Mechanicville, NY F3 from 31 May 1998 20:22Z

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

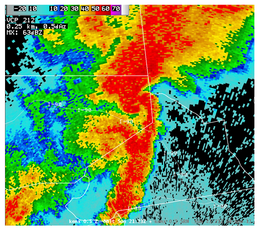
-Rated EF1with top winds of 110 mph by NWS Albany Survey Team

-Formed at 2120Z near Florida, NY

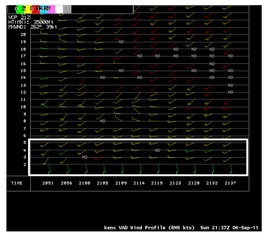
-Up to a half-mile wide through Cranesville, NY

-Dissipated at 2135Z near Glenville, NY

-On the ground for 7 miles

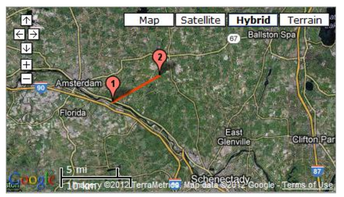


KENX Base (0.5°) Reflectivity (Z) at 2123Z

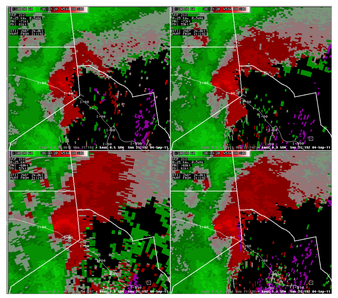


KENX VAD Wind Profile 2051Z to 2137Z. Notice the shear within the lowest few thousand feet

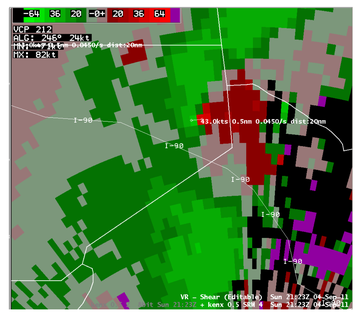
Satellite imagery of some of the damage along the EF1 Cranesville Tornado path from September 2011 (Image courtesy of Google Inc.).



Map of EF1 Cranesville Tornado after it crossed the Mohawk River from 4 Sept 2011 (Image Courtesy of Google, Inc.).

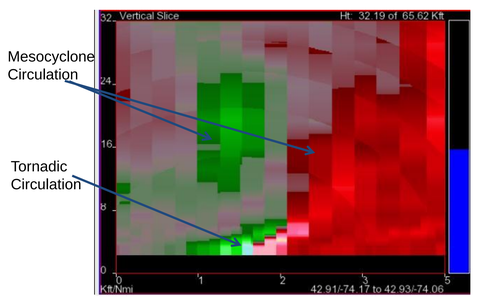


4 Panel KENX Storm Relative Motion (SRM) from 2119Z. (0.5°, 0.9°, 1.3°, 1.8° elevation slices going clockwise). These images were about one minute before the tornado touched down.



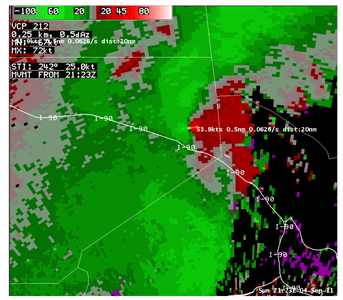
4-bit (1km x 1 degree resolution) SRM from 2123Z

V_r=43.0 kts, D=0.5 n mi, 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.

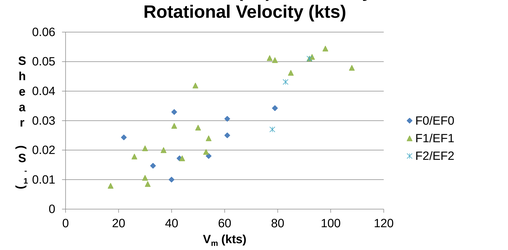
Maximum velocity of mesocyclone (V_m) = 55 kts



8-bit (0.25 km x 0.5 degree resolution) SRM from 2123Z

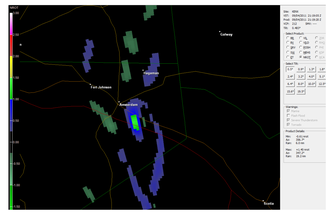
V_r=53.9 kts, D=0.5 n mi, S=0.0626 s^{-1}

Gate to Gate Shear (S^{-1}) vs. Mesocyclone Rotational Velocity (kts)



Preliminary updated nomogram using high resolution 8 bit data based off 34 tornadoes from 2003-2011. This graphic does not include null cases as of yet.

Normalized Rotation (NROT) using GR2Analyst



NROT display from GR2Analyst from 2119Z. NROT values reached a maximum of +1.40 just prior to tornado touchdown.

-78 tornadic cases from 2003-2011 have been examined in GR2Analyst so far

-Average NROT value at the time of tornado touchdown is 0.88 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 0.80 and a median value of 0.81

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 affecting 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

-Differences in the V_r and S values between the 4-bit and 8-bit data show the need of new nomograms for operational use. The example case of 4 Sept 2011 displayed a V_r difference of 10.9 kft and S difference of .0176 s^{-1}, which give significant differences based off the original LaPenta study nomogram.

-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 up to several scans before the tornado formation.

Future Work

-Calculate S/V_m for remainder of useable cases across the Northeast between 2003-2011 and examine null cases as well.

-Complete nomograms for operational use based off 8 bit data (similar to work completed by LaPenta) and incorporate null cases into graphics.

-Examine null cases for NROT values using GR2Analyst and create box and whisker plots for NROT data.