Using Specific Differential Phase to Predict Significant Severe Thunderstorm Wind Damage across the Northeastern United States

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Motivation

-Determining severe vs. significant severe thunderstorms can be difficult for a warning meteorologist.

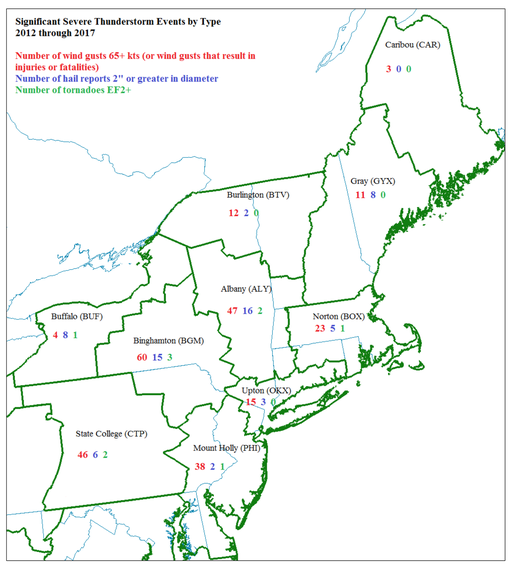
-This has been a challenge for NWS Albany (ALY) forecasters on several occasions during the summers of 2016 & 2017. Several significant thunderstorms were either missed or under warned.

-Impact-based warnings requires the warning forecaster to have specific knowledge of wind speeds & damage potential for warning text/graphics.

-New technology and warning techniques being investigated in research need to be implemented into operations.

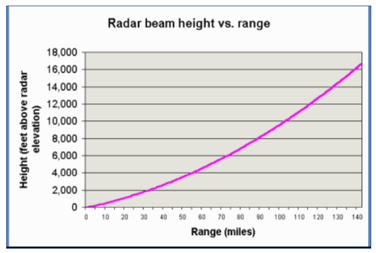
What is a Significant Severe Thunderstorm?
According to the Storm Prediction Center (SPC), a significant severe thunderstorm is one that produces either wind gusts of 65+ kts, 2"+ diameter hail or EF2+ tornado. This study will also consider thunderstorms that produce any injuries or deaths as well.

Climatology of Significant Severe Thunderstorms in the Northeastern* United States by NWS County Warning Area



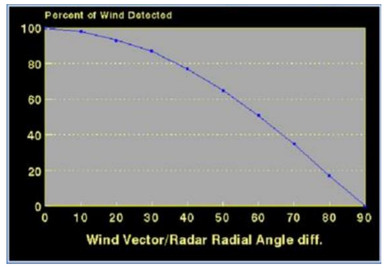
*This study's domain considers the Northeast to be New England, New York, New Jersey, Delaware, northeastern Maryland & central and eastern Pennsylvania

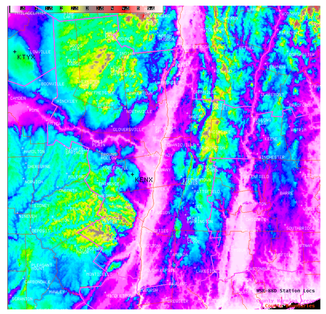
Radar Limitations & Considerations



Images from NOAA/NWS Warning Decision Training Division (WDTD) Radar & Applications Course (RAC, formerly DLOC)

The warning meteorologist must always consider the storm's location and movement in relation to where the radar is located. Storms far away from the radar may not be sampled fully and radial velocity data may not always be showing the true strength of the storm's winds.





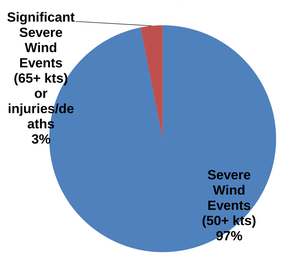
Elevation (in kft) surrounding the Albany KENX radar site.

Catskill Mountains south of KENX cause considerable beam blockage. This is an issue for storms that develop over the high terrain and then track eastward into the mid-Hudson Valley, as it may underestimate strength of storms headed towards populated areas around Kingston and Poughkeepsie.

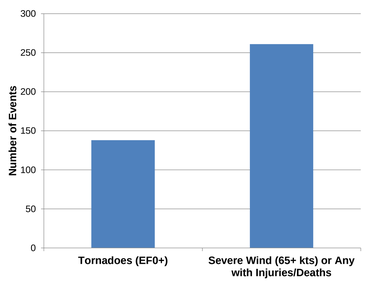
Great Rule of Thumb from NOAA WDTD (RAC training):

Note to self:
When you see something strong - it's probably strong.
When you see something weaker - it may be weaker, but then again, it may not be…

WFO Albany Severe Wind 2012 through 2017



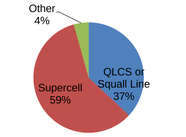
Northeastern US Tornadoes vs. Significant Severe Wind Events



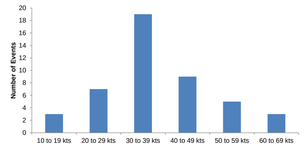
Although significant events only make up 3% of all severe wind events across the Albany County Warning Area, these significant events have had a much greater societal impact. When examined over the entire Northeast, significant wind events occur even more frequently than tornadoes of any strength.

Radar data from the Albany KENX WSR-88D was examined for the 46 thunderstorms that produced significant wind damage across the Albany WFO CWA from 2012 to 2017. Several radar-based parameters, such as radial velocity and Specific Differential Phase (K_{DP}), were collected at the time of and just prior to the time of the damage report via GR2Analyst software. The storm type was noted as well.

Significant Wind Damage Storm Type WFO Albany CWA 2012-2017



KENX 0.5° Radial Velocity Value at Time of Significant Damage



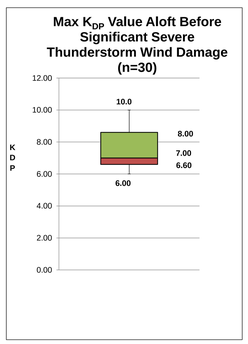
Significant wind damage not always associated with high radial (pure) velocity values due to mentioned radar limitations.

Collapsing K_{DP} Columns due to Wet Microburst

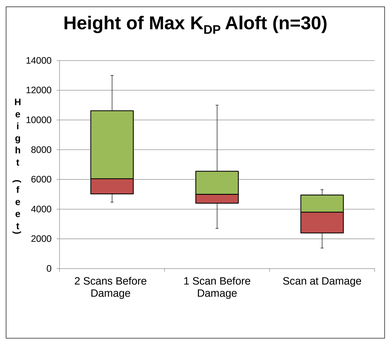
Out of the 46 storms analyzed, 30 of them showed an elevated K_{DP} column suspended aloft for several scans before the wind damage occurred. This K_{DP} column collapsed towards the surface at the time of the wind damage report as a result of a wet microburst. Within the 30 times this was noted, 22 of those events were associated with supercell thunderstorms.

The highest K_{DP} value within the suspended column aloft averaged to be 7.6 deg/km within these thunderstorms & the median value was 7.0 deg/km.

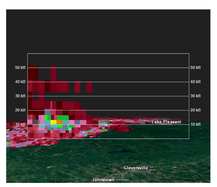
Max K_{DP} Value Aloft Before Significant Severe Thunderstorm Wind Damage (n=30)



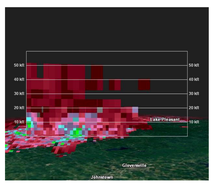
Height of Max K_{DP} Aloft (n=30)



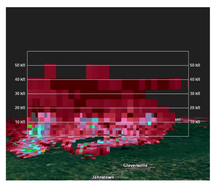
Descending K_{DP} Columns During a Squall Line Event



KENX K_{DP} Cross-section
13 Aug 2016 22:14Z



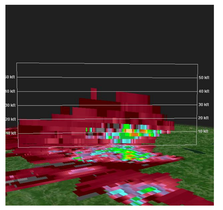
KENX K_{DP} Cross-section
13 Aug 2016 22:20Z



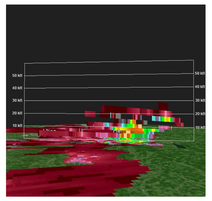
KENX K_{DP} Cross-section
13 Aug 2016 22:26Z

Cross-section of K_{DP} from KENX show the elevated K_{DP} column falling down to the surface on 13 August 2016 thanks to a strong microburst within a severe squall line. Significant damage occurred at 22:25Z at the Pine Lake Campground in the town of Caroga in Fulton County, New York. The max value of the K_{DP} within the elevated column was around 5.6 deg/km.

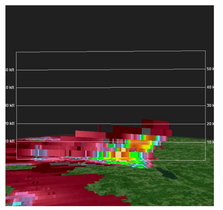
Descending K_{DP} Columns During a Supercell Event



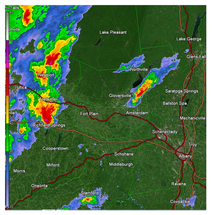
KENX K_{DP} Cross-section
3 Jul 2014 20:02Z



KENX K_{DP} Cross-section
3 Jul 2014 20:08Z



KENX K_{DP} Cross-section
3 Jul 2014 20:13Z



KENX Z 0.5° Elevation
3 Jul 2014 20:13Z

Cross-section of K_{DP} from KENX show the elevated K_{DP} column falling down to the surface on 3 July 2014 thanks to a strong microburst within a supercell thunderstorm. Significant damage occurred at 20:14Z in the hamlet of Jordanville in the town of Warren in Herkimer County, New York. The max value of the K_{DP} within the elevated column was around 8.8 deg/km.

Use During the Warning Process

While a warning forecaster is interrogating other base data products, they can look for building columns of K_{DP} within a thunderstorm. If values appear to remain elevated and reach critical values (around 6 deg/km based off this study), a warning decision forecaster can anticipate an increased chance for significant damage when this column collapses towards the surface. While base velocity can have its flaws based on beam angle and direction, K_{DP} columns can help alleviate this limitation. Still, inherent issues with beam width and terrain blockage will cause issues when evaluating K_{DP} as well. In addition, storms that contain large hail may not always show K_{DP} columns, as K_{DP} is not plotted when associated with low values of correlation coefficient (<0.90).

Conclusions

- Significant severe thunderstorms do occur over the Northeastern United States, with significant wind damage being the highest threat.
- Determining if a severe thunderstorm will produce significant damage can be difficult at times for warning forecasters to pick out based on radial (pure) velocity alone. Knowing how strong a thunderstorm will be is valuable information for impact-based warnings.
- Radar limitations (beam blockage, larger angles, distance from RDA) can all have an impact on the quality of radar data and need to be kept in mind during warning decisions.
- Watching for collapsing K_{DP} columns may be helpful during the warning process, especially within supercells with elevated K_{DP} values of greater than 6.5 to 7 deg/km.
- This feature has been seen mostly in supercells, but also has some potential in squall line cases as well.
- Additional cases, including null cases, will need to be examined over the next few years to fully learn the utility of these items.

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