Recent Examples of Using Specific Differential Phase to Help Predict Severe Thunderstorm Wind Damage

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Motivation

-Local CSTAR research has shown utility in using Specific Differential Phase (K_{DP}) during the severe thunderstorm warning process for *significant* severe thunderstorms.

-High K_{DP} values (greater than 5.0 deg/km) elevated aloft within a thunderstorm have been seen to cause wind damage when they drop towards the surface within both supercell and linear (QLCS) significant thunderstorms.

-This methodology was used during the warning process for numerous thunderstorms during July and August of 2019 for the Albany Forecast area and forecasters noticed the signal also occurring during non-significant (ordinary) severe thunderstorms.

-More ordinary events are being investigated to see how often this signal can be seen within vertical cross-sections of K_{DP}.

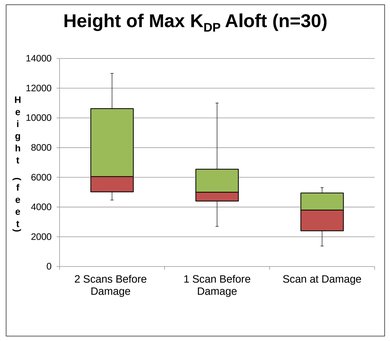
What is a Significant Severe Thunderstorm?
According to the Storm Prediction Center (SPC), a significant severe thunderstorm is one that produces either wind gusts of 65+ kts, 2"+ diameter hail or EF2+ tornado. The study also considered thunderstorms that produced any injuries or deaths as well.

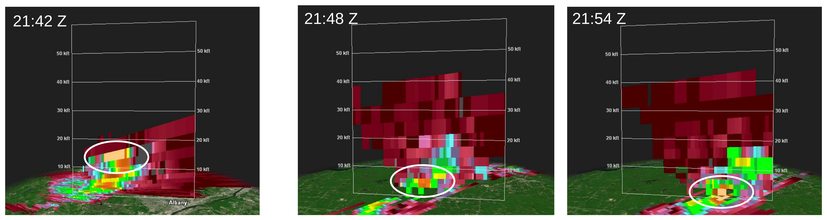
Collapsing K_{DP} Columns & Wet Microbursts within Significant Severe Thunderstorms

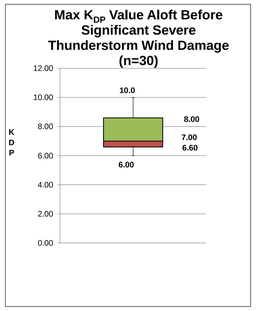
Radar data from the Albany KENX WSR-88D was examined for the 46 thunderstorms that produced significant wind damage across the Albany WFO CWA from 2012 to 2017. Several radar-based parameters, such as radial velocity and Specific Differential Phase (K_{DP}), were collected at the time of and just prior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

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.







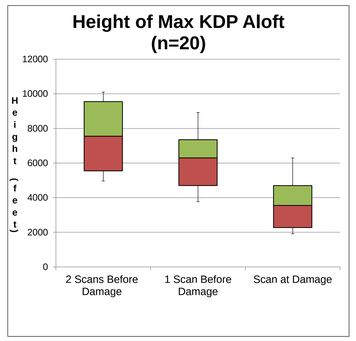
An example of a collapsing K_{DP} column from a supercell severe thunderstorm in Albany, New York on 16 August 2019. High K_{DP} values (above 8 degrees/km) located above 10,000 feet AGL lowered towards the surface within 12 minutes. This produced a microburst that resulted in wind speeds up to 80 mph across parts of eastern Albany and western Rensselaer Counties. This storm caused widespread tree damage around 21:54Z, some of which fell on cars and homes.

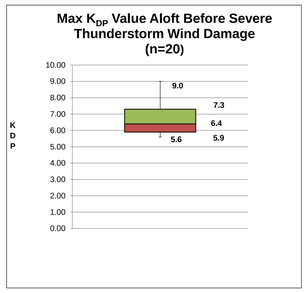
Collapsing K_{DP} Columns & Wet Microbursts within Ordinary Severe Thunderstorms

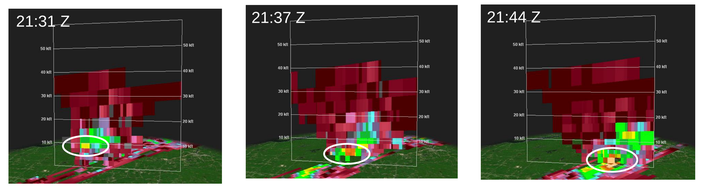
Radar data from the Albany KENX WSR-88D was examined for 51 thunderstorms that produced ordinary (non-significant) wind damage across the Albany WFO CWA from 2014 to 2017. Event dates were chosen to match the same days as when significant damage occurred for comparison to the other dataset. The same parameters measured for the significant events were recorded for the ordinary events as well.

Out of the **51** storms analyzed, **20** 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 20 times this was noted, 8 of those events were associated with supercell thunderstorms and 12 were QLCS/Squall Lines.

The highest K_{DP} value within the suspended column aloft averaged to be 6.9 deg/km within these thunderstorms & the median value was 6.4 deg/km.

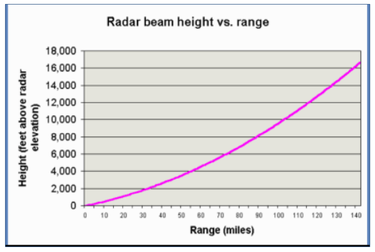


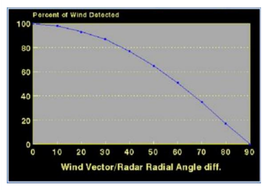




An example of a collapsing K_{DP} column from a squall line producing a severe thunderstorm in Saratoga County, New York on 30 July 2019. Although K_{DP} values weren't initially very strong, they strengthened as they lowered towards the surface. K_{DP} values were around 6 deg/km around 21:44Z, when numerous trees were downed in north-central Saratoga County.

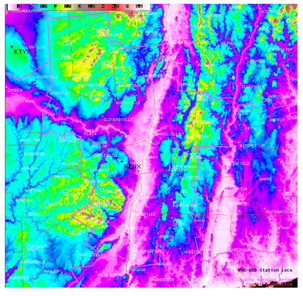
Radar Limitations & Considerations





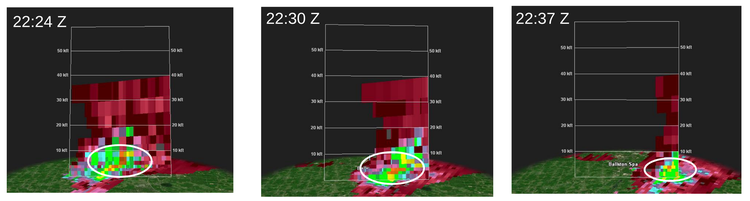
The warning meteorologist must always consider the storm's location and movement in relation to where the radar is located. Storms far away from the radar may not be sampled fully and radial velocity data may not always be showing the true strength of the storm's winds.

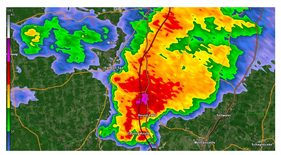
Images from NOAA/NWS Warning Decision Training Division (WDTD) Radar & Applications Course (RAC, formerly DLOC)

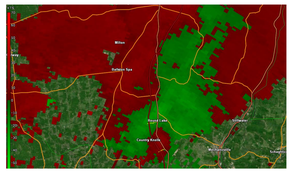


Elevation (in kft) surrounding the Albany KENX radar site.

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.

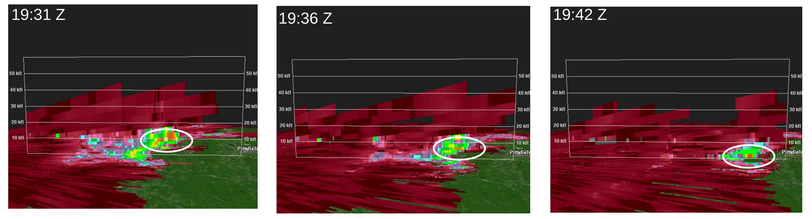






Vertical cross-section of K_{DP} from KENX from a supercell thunderstorm near Malta, New York on 18 August 2019 (above). High values of KDP (around 7 deg/km) aloft lowered towards the surface. This thunderstorm produced a significant microburst around 22:35Z with numerous large trees snapped, downed and uprooted. NWS Storm survey estimated maximum winds to be 90 mph.

KENX 0.5° reflectivity (Z) and velocity (V) are also shown (right). While the reflectivity imagery showed a classic supercell, velocity data only showed winds of about 30 kts. This storm was moving west to east across Saratoga County and was tracking cross-radial, which prevented the velocity data from showing the true potential in the strength of the storm's winds.



Vertical cross-section of K_{DP} from KENX from a supercell thunderstorm across southern Rensselaer and northern Columbia Counties on 17 July 2019 (above). High values of KDP (around 7 deg/km) elevated aloft lowered towards the surface. This thunderstorm produced numerous reports of trees downed in the towns of New Lebanon and Canaan (Columbia County), New York between 19:37Z through 19:48Z.

This storm rapidly strengthened from a multi-cell cluster into a supercell. Warning forecasters noted a lightning jump immediately ahead of the strengthening around 19:10Z, which was then followed by an increase in the values of K_{DP} aloft.

Warning Methodology 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 (at least 5 to 6 deg/km based off this study), a warning decision forecaster can anticipate an increased chance for damage when this column collapses towards the surface.
- Collapsing is considered occurring once these high cores of K_{DP} drop towards the surface (below 5000 feet AGL) and become indistinguishable within 1 to 2 volume scans. This is around the time when damage usually occurs.

*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

- K_{DP} collapses causing wet microburst have been seen in both ordinary and significant severe thunderstorms, although it may be somewhat more common for the significant events.
- Out of 97 total storms examined, 50 of them showed a collapsing K_{DP} core leading to wind damage. 30 of those were significant events.
- The maximum value of K^{DP} aloft is generally above 5 deg/km. The study's average value was 6.9 deg/km for ordinary events & 7.6 deg/km for significant events.
- Significant events have slightly higher values of K_{DP} elevated aloft, but the general lowering towards the surface is seen in both significant and ordinary events.
- 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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