Variations in Hail and Small Drop Distributions in Classic Supercells and their Relationship to Environmental Variables

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Introduction

Background

Hodometers can be classified using values of different polarimetric radar variables including reflectivity factor (Z_h), differential reflectivity (ZDR) and correlation coefficient (ρ_v). The polarimetric hail signature includes Z_h > 45 dBZ, ZDR < 0 dB, and ρ_v < 0.95, the polarimetric small drop signature includes Z_h < 30 dBZ, ZDR > 0 dB, and ρ_v > 0.97 (Straka et al. 2000). In this study, polarimetric signatures of three classic supercells were examined at the lowest elevation angle, and the relationship of the areal extent of hail and small drops to environmental variables was explored.

Objectives

• Compare signature areal extent for both hail and small drops through the temporal duration of each supercell event
• Relate the hail and small drop areal extents to environmental variables (such as relative humidity and wind speed) obtained from sounding that are representative of the storm environment

Methods

• Tornado events and nontornado supercell events were identified using the NCDC Storm Events Database. These three cases were chosen out of a larger database of supercell events, based on the following criteria:
  - Events had to be within ~93 km (~50 miles) of a WSR-88D
  - Rotation was present in the updraft region (either at base level or midlevel scans)
• The nearest polarimetric WSR-88D radar dataset was identified and gathered for each event
• Environmental data for each event was gathered from RUC/RAP soundings that were representative of the storm environment (e.g., on the same side of a boundary) using Burkit. Values of numerous environmental parameters were collected, including different measures of moisture, instability, and shear.
• Areal extent (km²) of the hail and small drop size distributions were estimated for each event at the 0.5° elevation angle

Results

Conclusions and Future Work

Conclusions

• Areal extent of both hailfall and small drop distributions was cyclic throughout the lifetime of the storm at the lowest elevation angle, with the period of hailfall cyclicality generally remaining consistent throughout the time series (showing bursts of hailfall) and the period of small drop cyclicality increasing throughout the time series similar to results in Van Den Broeke et al. 2008.
• KDDC had a higher average areal extent for both hail and small drops. This case had a higher LCL height and the 0°C level.
• There was greater average areal extent in both hail and small drops when the hodograph was less curved similar to findings in Van Den Broeke et al. 2010.
• Higher shear values, at all three levels, produced lower average areal extent values for both hail and small drops which contrasted with findings in Van Den Broeke et al. 2010 and Gilmore et al. 2004.
• Higher RH values and lower LCL heights did not have higher average areal extents for small drops in this small sample of storms as suggested in Frehlich et al. 2015.

Future Work

• Time series comparison of signatures throughout lifetime of storms for a large dataset of storms
• Signature comparison to more environmental variables for a large dataset of storms

Acknowledgements

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References

http://www.ncdc.noaa.gov/stormevents/

Table 1: Comparison of average areal extent (in km²) for both hail and small drops for each of the three cases.

<table>
<thead>
<tr>
<th>Storm</th>
<th>Hail Areal Extent</th>
<th>Small Drop Areal Extent</th>
</tr>
</thead>
<tbody>
<tr>
<td>KDDC</td>
<td>52.9</td>
<td>69.5</td>
</tr>
<tr>
<td>KDDC</td>
<td>15.9</td>
<td>26.7</td>
</tr>
<tr>
<td>KLBB</td>
<td>21.2</td>
<td>34.0</td>
</tr>
</tbody>
</table>

Table 2: Comparison of environmental variables for the different cases. The RH values are layer-averaged values, rather than values at specific levels. *It is worth noting that the period of hail cyclicality is different with this storm (KLBB being less cyclic) than with the other cases. This may be because the storm was interacting with a boundary.

<table>
<thead>
<tr>
<th>Storm</th>
<th>Tornadic hailfall (%)</th>
<th>Hail Areal Extent (%)</th>
<th>Small Drop Areal Extent (%)</th>
<th>Period of small drop cyclicality</th>
</tr>
</thead>
<tbody>
<tr>
<td>KDDC</td>
<td>42.78%</td>
<td>91.77%</td>
<td>91.51%</td>
<td>- 1 hour</td>
</tr>
<tr>
<td>KDDC</td>
<td>61.01%</td>
<td>50.02%</td>
<td>55.78%</td>
<td>18-28 minutes</td>
</tr>
<tr>
<td>KLBB</td>
<td>66.67%</td>
<td>71.58%</td>
<td>67.94%</td>
<td>- 5 minutes</td>
</tr>
</tbody>
</table>

Fig. 1: Z_h images from storms in the domain of a) Dyess Air Force Base, Texas WSR-88D (KDYX) on 24 April 2014, b) Dodge City, Kansas WSR-88D (KDDC) on 30 April 2012, and c) Lubbock, Texas WSR-88D (KLBB) on 23 May 2013. All scans are from the 0.5° elevation angle.