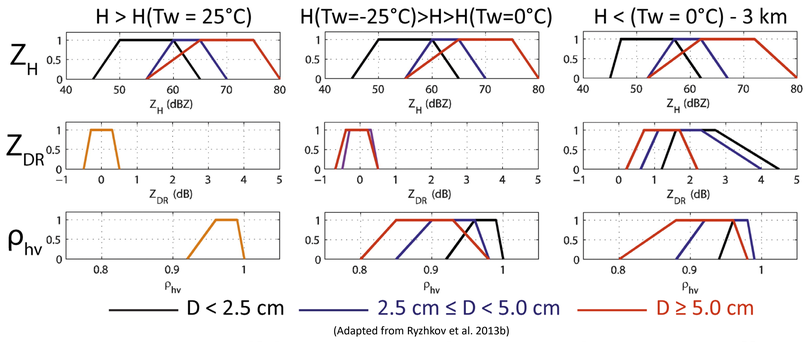
Identifying Polarimetric Radar Signatures Aloft Associated with Large Hail

Jeffrey Snyder Alexander Ryzhkov
Cooperative Institute for Mesoscale Meteorological Studies
Norman, OK

John Krause Charles Kuster
Cooperative Institute for Mesoscale Meteorological Studies
Norman, OK

Introduction and Motivation

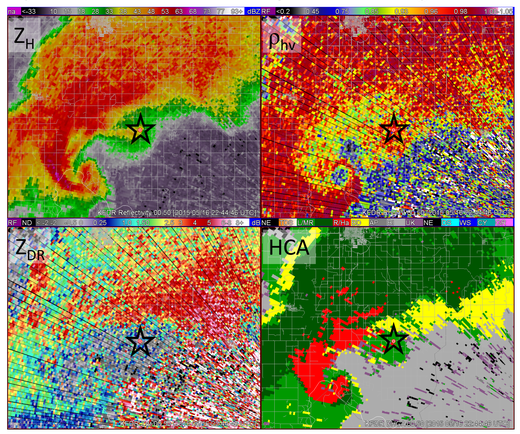
- Large (D > 1 cm) and very large (D > 2 cm) hail is often, but not always, associated with very high Z_H (e.g., 60–75+ dBZ)
- *Strong size sorting* in supercells can result in hail distributions composed solely of a *very low number concentration* of very large hail, resulting in comparatively *low* Z_H
- The Hail Size Discrimination Algorithm (HSDA; Ryzhkov et al. 2013a,b; Ortega et al. 2016) often fails to identify giant hail in these situations
- Instead of detecting large hail in the low levels, we seek to identify signatures aloft associated with hail growth in an effort to allow meteorologists to improve warning lead time for large and very large hail
  - *Proximity to intense updraft* (BWER, Z_{DR}/K_{DP}/DR column, etc.)
  - *Reduced ρ_{hv} aloft* – previous studies observed reduction in ρ_{hv} near top of Z_{DR} column
  - *Negative Z_{DR} aloft* – -1 dB to -2 dB or lower above/near Z_{DR} column



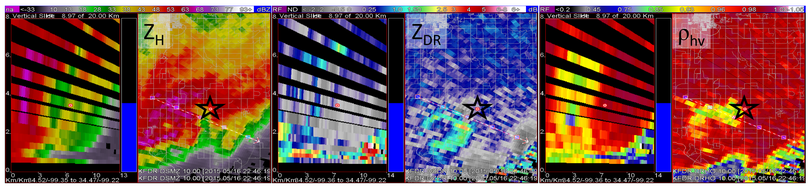
(Adapted from Ryzhkov et al. 2013b)

Very Large Hail in Low–Moderate Z_H in Supercells

A supercell in southwestern OK on 16 May 2015 produced hail of at least 7 cm in diameter at the location where the photograph was taken, marked by the black star in the 4-panel radar figure

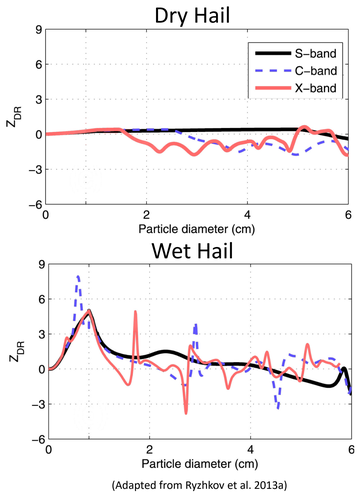


Note moderate Z_H (20–40 dBZ), a modest reduction in ρ_{hv}, and low Z_{DR} (-0.5 – 0.5 dB). The HCA classifies the area as light/moderate rain.



Vertical cross-sections (left side of each panel) and 10.0° elevation angle PPI (right side of each panel). Very large hail fell along the northeast side of the weak echo region, northeast of a crescent-shaped Z_{DR} column or Z_{DR} ring. The north side of the Z_{DR} column was characterized by ρ_{hv} as low was 0.85. Z_{DR} as low as -1.5 dB was located immediately northeast of the Z_{DR} column.

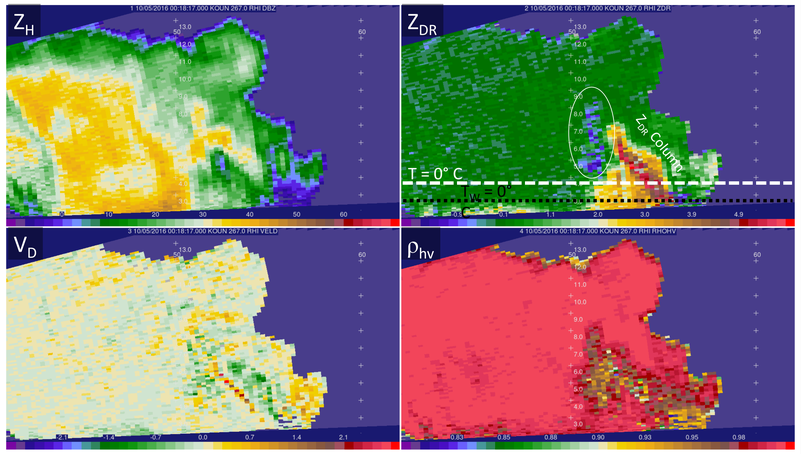
Hail Scattering Simulations



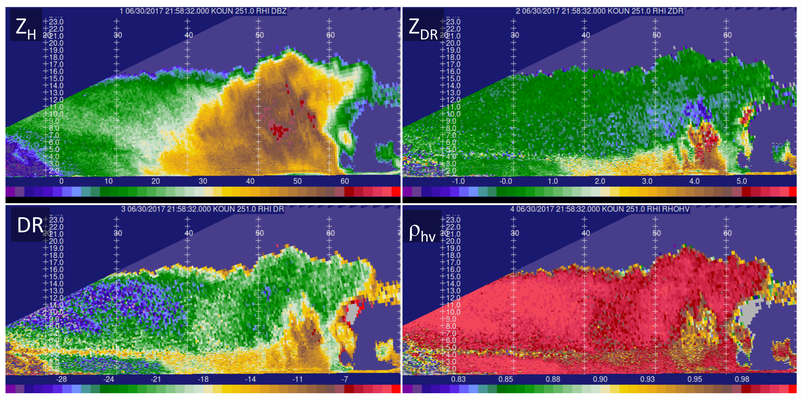
(Adapted from Ryzhkov et al. 2013a)

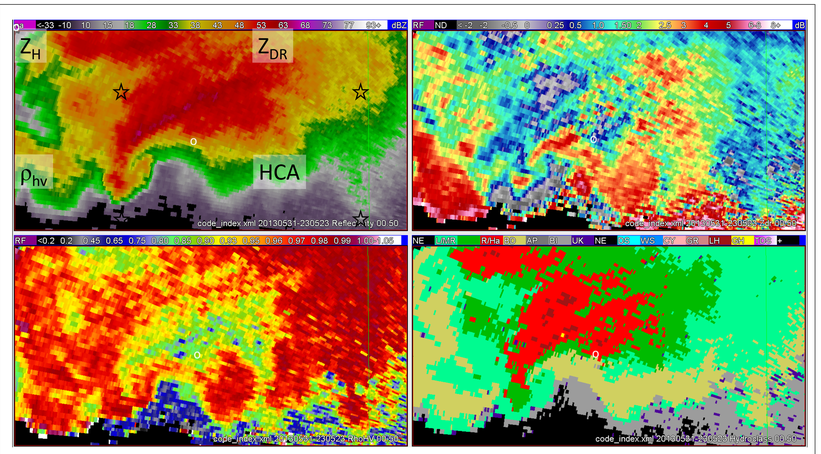
Question: Is the negative Z_{DR} aloft caused by resonance or by vertically oriented scatterers?
Answer: We do not know for sure. Unfortunately, *there is a dearth of in-situ observations* of very large hail in supercell updrafts (where most of the largest hailstones grow). Exotic shapes *may* be present where hail is undergoing rapid growth in the updraft. Resonance effects associated with hail, depending upon radar wavelength, *can* produce Z_{DR} of -2 dB or lower, however. At S band, *Z_{DR} of -1.5 dB or lower occurs from wet hail that is at least ~6 cm in diameter*, indicating that such negative Z_{DR} may be an indication of very large hail aloft.

High-Resolution RHIs

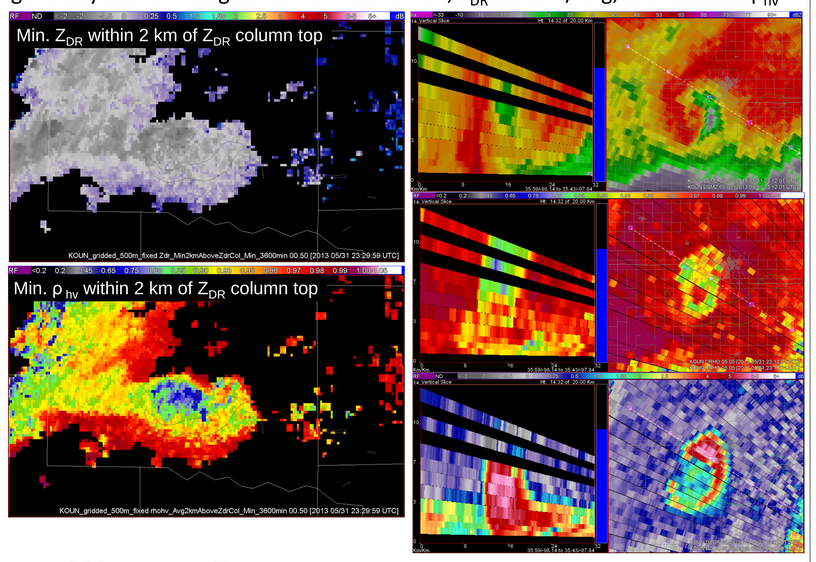


KOUN (in central OK) has been used to collect RHIs for better examining polarimetric characteristics of very large hail and hail growth. Time series data collection enables spectral processing and allows us to examine non-standard products (e.g., differential Doppler velocity, V_D). Z_{DR} < -1 dB is observed near/above the Z_{DR} column in (above) an October 2016 supercell and (below) a June 2017 supercell (depolarization ratio, DR, is shown).





31 May 2013: A supercell produced hail of D ~ 15 cm. The giant hail classification from HSDA was not given at the location of all giant hail reports because Z_H was generally too low Largest hail fell near BWER, Z_{DR} column/ring, and reduced ρ_{hv}.



Work in Progress

We are examining the polarimetric characteristics of large hail aloft to aid identification of large hail and its growth before it falls to the ground. **Negative Z_{DR} aloft** (e.g., above the -20°C height, near/above Z_{DR} columns, etc.) is quite common in strong supercells that produce very large hail in the small sample so far examined. In addition, a **significant reduction in ρ_{hv}** (sometimes down to 0.80 or lower) at higher altitudes within intense updrafts seems to indicate the presence of hail growth and tends to precede reports of very large hail on the ground. Improving the HCA and HSDA by including information from aloft (e.g., proximity to Z_{DR} , KDP, and/or DR columns) requires a change to the way the HSDA works, since the current HDA and HSDA operate on a bin-by-bin basis wherein each range bin is processed independently from all others.

Acknowledgments

This poster was prepared by the authors with funding provided by NOAA/Office of Oceanic and Atmospheric Research under NOAA-University of Oklahoma Cooperative Agreement #NA11OAR4320072, U.S. Department of Commerce. The statements, findings, conclusions, and recommendations are those of the author(s) and do not necessarily reflect the views of NOAA or the U.S. Department of Commerce.