Radar Observations of Hailstorms Producing Giant Hail

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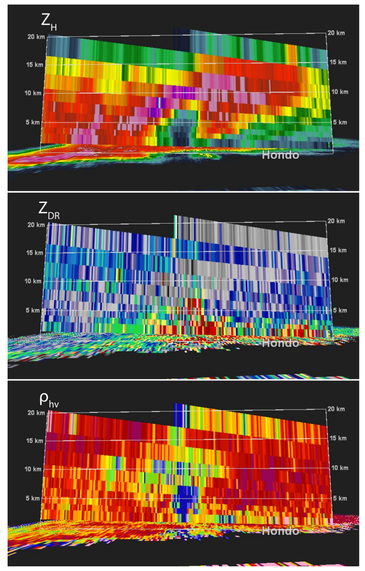
Introduction

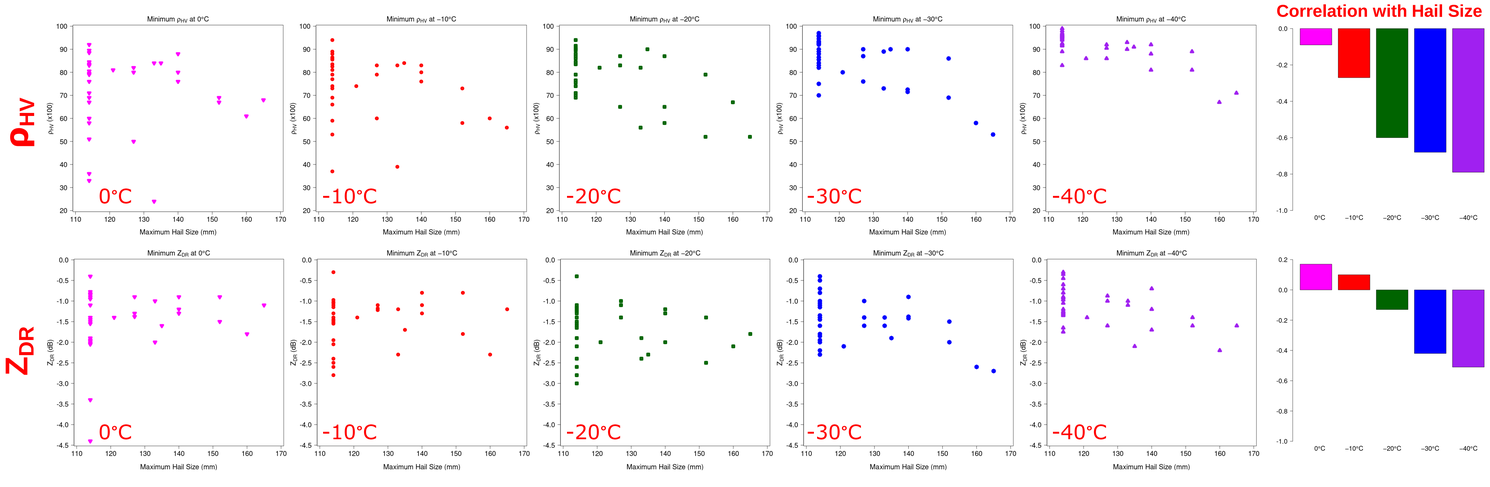
- Reports of giant hail have become increasingly common owing to ubiquitous cameras and social media
- Gutierrez and Kumjian (2021) examined 12 gargantuan hail-producing storms (≥6 inches in maximum dimension) but didn't include analysis of dual-polarization data
- Because a storm's ability to produce large hail depends on the character (e.g., strength and size) of its updraft, this study examined both “Traditional” (single-polarization) and dual-polarization radar signatures/parameters associated with a storm’s updraft
- Questions: What are the characteristics of commonly used radar-based hail detection quantities for giant hail events? Can we improve detection using mid-level polarimetric signatures?

Radar Data Analysis

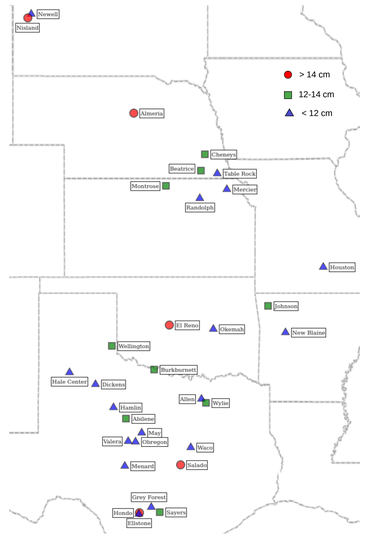
- *Traditional storm intensity parameters examined*:
  - Highest Maximum Expected Size of Hail (MESH)
  - Maximum Midaltitude Rotational Velocity (MRV)
  - Maximum Storm-Top Divergence (STD)
- *Dual-polarization parameters examined*:
  - Minimum differential reflectivity (Z_{DR})
  - Minimum cross-correlation coefficient (ρ_{HV})
  - Minima must be in close proximity to the storm updraft at the 0°C, -10°C, -20°C, -30°C, and -40°C heights (determined by the representative sounding)
- Z_{DR} and ρ_{HV} data are smoothed using a 3 radial x 3 range gate Gaussian filter
- Time window: 30 min before to 10 min after each report
- Cases: March-June in the central U.S.

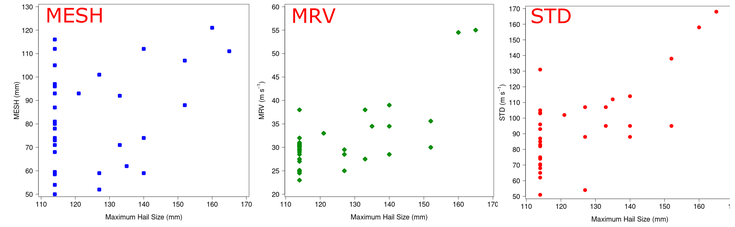
Hondo, TX, Storm

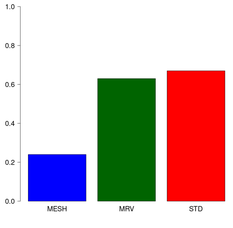




Correlation with Hail Size







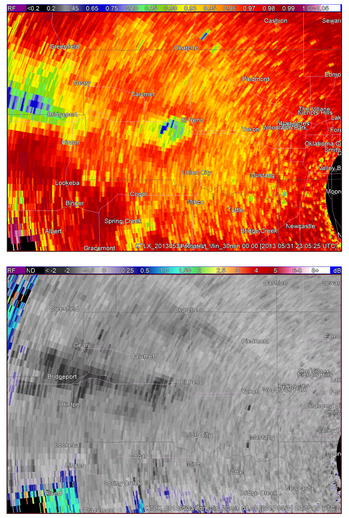
Storm Events Analyzed

Date	Location	Hail Size (mm)	Distance to nearest radar (km)
29 Apr 2021	Hondo, TX	165	111
31 May 2013	El Reno, OK	160	56
30 May 2022	Almeria, NE	152	100
20 Jun 2015	Nisland, SD	152	79
12 Apr 2016	Salado, TX	140	30
04 May 2021	Sayers, TX	140	49
20 May 2019	Wellington, TX	140	125
22 May 2020	Burkburnett, TX	140	50
11 Apr 2016	Wylie, TX	133	87
28 May 2013	Montrose, KS	133	65
04 May 2020	Johnson, AR	127	93
09 May 2016	Cheneys, NE	127	67
11 Jun 2022	Beatrice, NE	127	121
12 Jun 2014	Abilene, TX	121	40
24 Mar 2019	Allen, TX	114	84
27 Mar 2020	Houston, MO	114	128

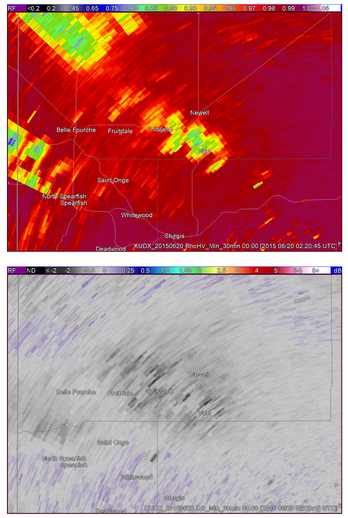
Date	Location	Hail Size (mm)	Distance to nearest radar (km)
02 Apr 2017	Valera, TX	114	92
12 Apr 2022	New Blaine, AR	114	90
13 Apr 2016	Grey Forest, TX	114	64
15 Apr 2016	Randolph, KS	114	66
26 Apr 2023	Dickens, TX	114	90
26 Apr 2023	Waco, TX	114	98
08 May 2015	May, TX	114	62
09 May 2013	Menard, TX	114	91
12 May 2023	Table Rock, NE	114	129
15 May 2022	Okemah, OK	114	89
20 May 2017	Obregon, TX	114	89
25 May 2015	Mercier, KS	114	90
27 May 2015	Hale Center, TX	114	38
28 May 2016	Ellstone, TX	114	112
05 Jun 2013	Hamlin, TX	114	89
29 Jun 2018	Newell, SD	114	82

30-minute "swath" maps, ending near the time of the hail report, for (top) ρ_{HV} at −40°C and (bottom) Z_{DR} at −30°C

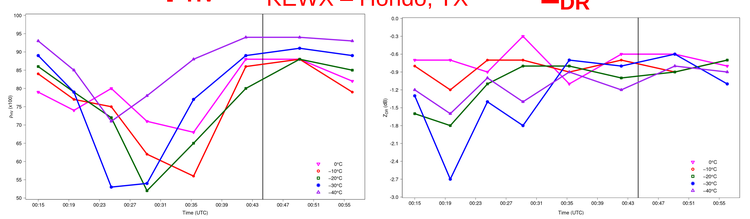
El Reno, OK storm



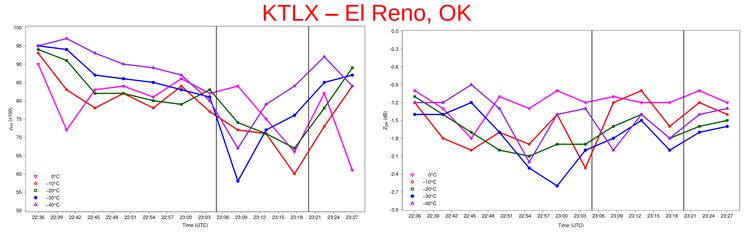
Nisland, SD storm



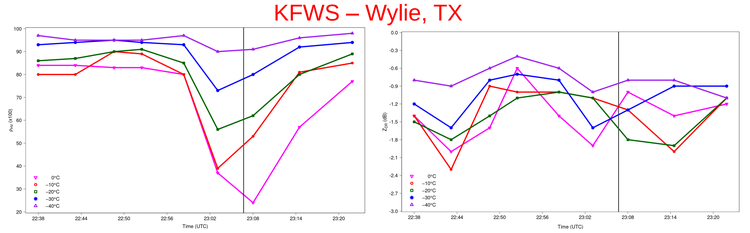
ρ_{HV} KEWX – Hondo, TX **Z_{DR}**



KTLX – El Reno, OK



KFWS – Wylie, TX



Conclusions

- Correlations between maximum hail size and MESH, MRV, and STD were 0.24, 0.63, and 0.67, respectively
- Strongest (most negative) correlations between maximum hail size and the dual-polarization parameters were for minimum ρ_{HV} at -30°C (-0.68) and -40°C (-0.79) and Z_{DR} at -40°C (-0.51)
- The Hondo, TX, and El Reno, OK, storms “stand out” in terms of maximum MRV and STD, minimum for ρ_{HV} at -30°C and -40°C, and minimum Z_{DR} at -30°C

Future work

- Assemble a comparison data set of storm events with maximum hail sizes of 5-10 cm
- Compare the two data sets to similar storm events in other geographical areas and seasons
- Determine lead-time characteristics of the radar parameters

Acknowledgments

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