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Polarimetric Analysis of Two Giant-Hail-Producing Supercells Observed by X-Band and S-Band Radars

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Data Used in This Study

- Hail Spatial and Temporal Observing Network Effort (HailSTONE; Blair et al. 2012) – 230 hail size observations on 23 May 2011 and 111 on 29 May 2012. The 23 May 2011 dataset includes the Oklahoma state record hail stone (~15 cm in diameter); the maximum hail size observed on 29 May 2012 was 12.7 cm in diameter.
- KOUN – Polarimetric WSR-88D radar located in Norman, OK
- RaXPol – Rapid-scan, X-band, polarimetric mobile radar (Pazmany et al. 2013)

	KOUN	RaXPol
Frequency	2.705 GHz	9.71-9.75 GHz
Pulse width	1.57 and 4.5 μs	0.1–40 μs
Range Gate Spacing	250 m	7.5–75 m
Peak Transmit Power	500 kW	20 kW
3 dB Beamwidth	0.95º	1.0º
Max. Rotation Rate	30º s^{-1}	180º s^{-1}

Table 1. Selected characteristics of the two radars used in this study.

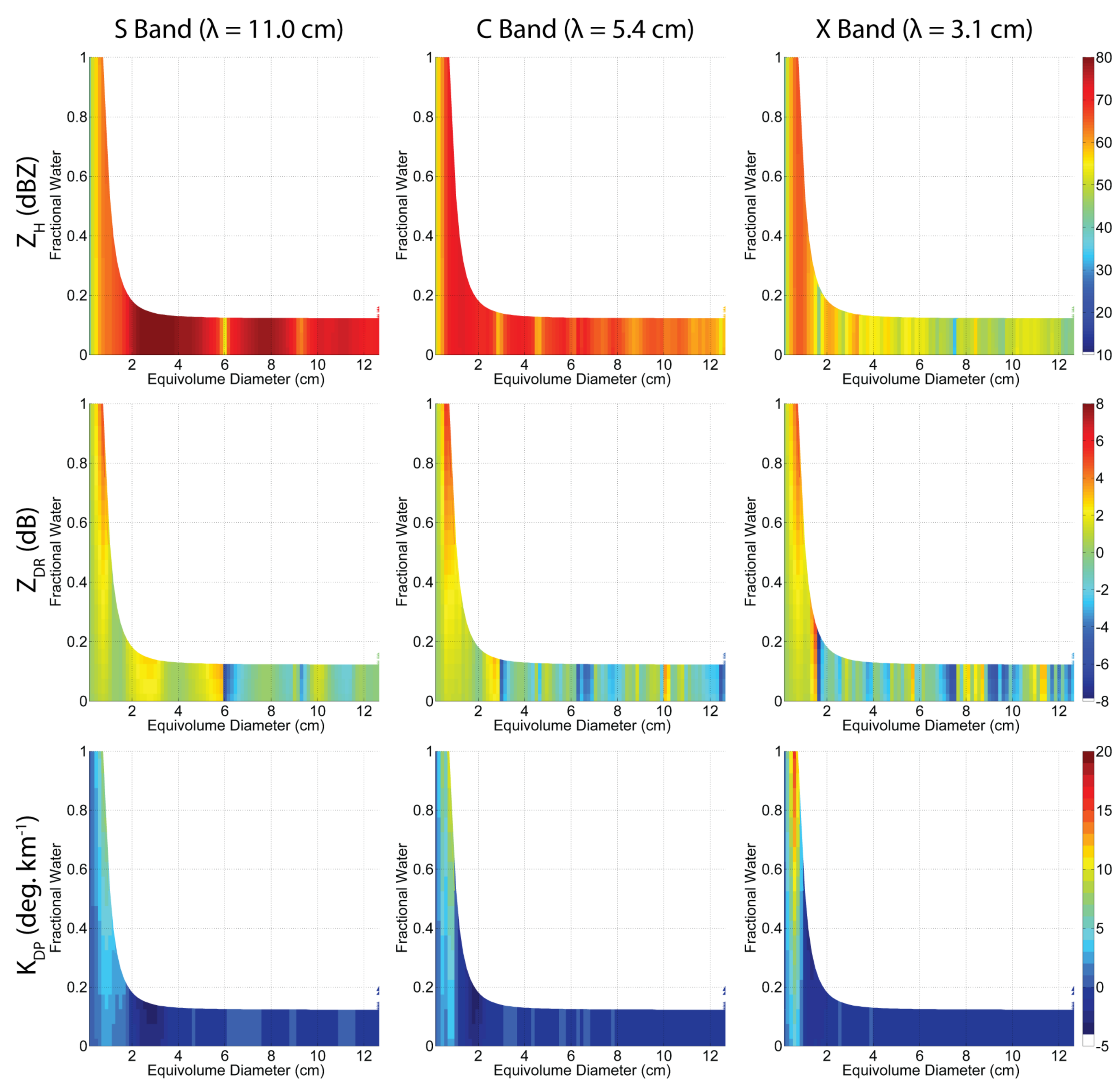


Fig. 1. Z_H, Z_{DR}, and K_{DP} for monodispersed distributions of hail with fixed mass content of 2 g m^{-3} as a function of hail size and fractional water content at S, C, and X bands. The scattering amplitudes were calculated using a two-layer T-matrix method; the hail is modeled as a solid ice core with a liquid water shell. Mean canting angle is assumed to be 0º, with a distribution of canting angles between10-40º depending upon fractional water content. Temperature is set at 20ºC.

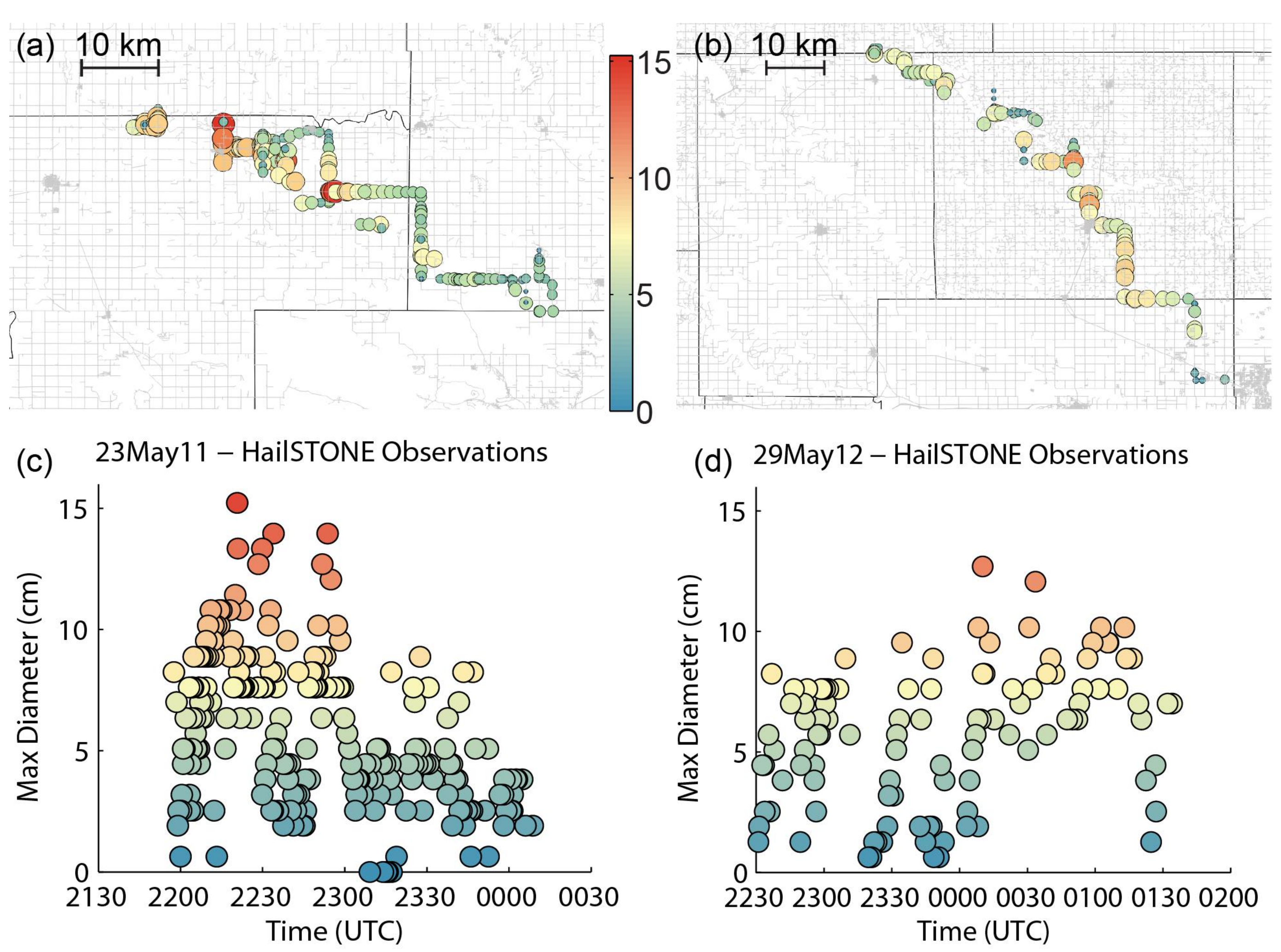


Fig. 2. Plots of the observations collected by HailSTONE on 23 May 2011 and 29 May 2012 as a function of space and time.

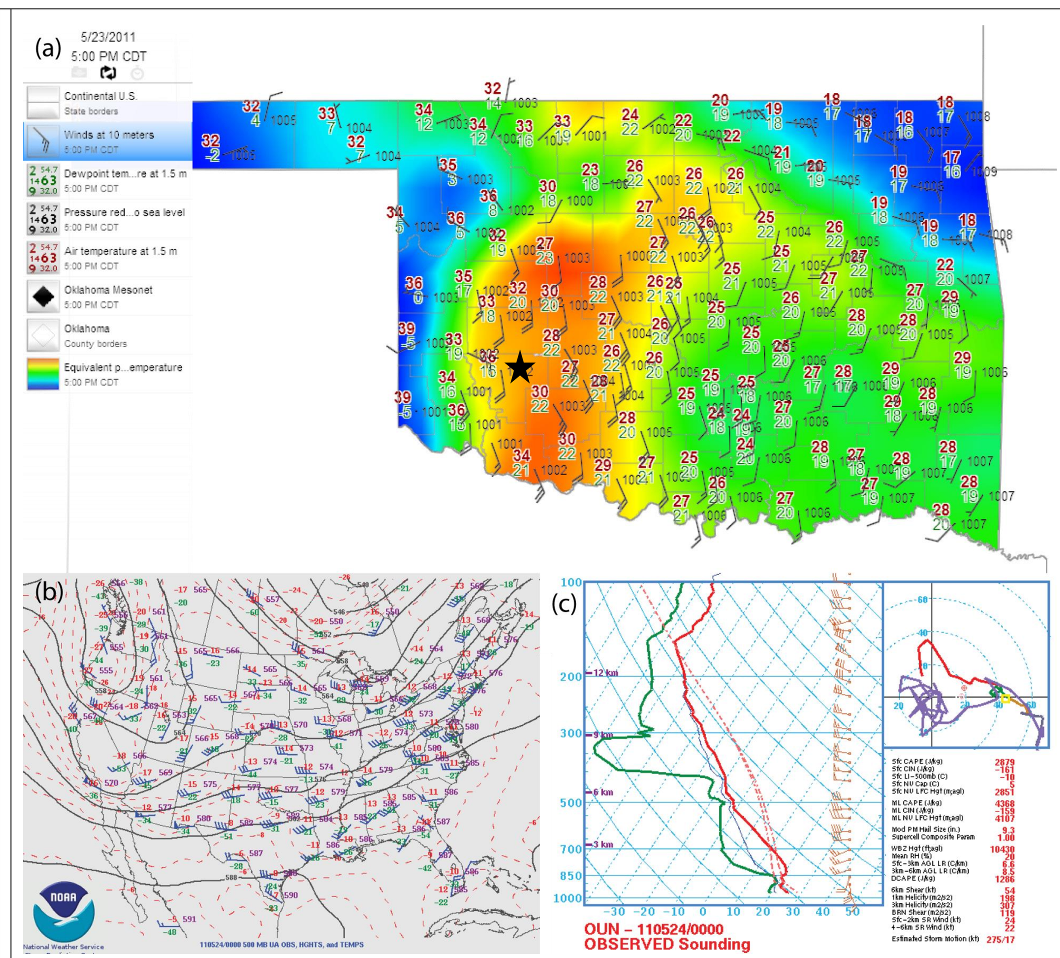


Fig. 3. (a) Surface observations from the Oklahoma Mesonet at 2200 UTC on 23 May 2011 (equivalent potential temperature is shaded). (b) 500 mb analysis (courtesy of the Storm Prediction Center) and (c) Norman sounding valid 0000 UTC 24 May 2011. The black star in (a) marks Gotebo, OK.

Fig. 4. Photographs of (a) the Oklahoma record hail stone collected by HailSTONE near Gotebo, OK, and (b) the supercell near 2315 UTC as seen from the RaXPol deployment location south of Carnegie, OK.

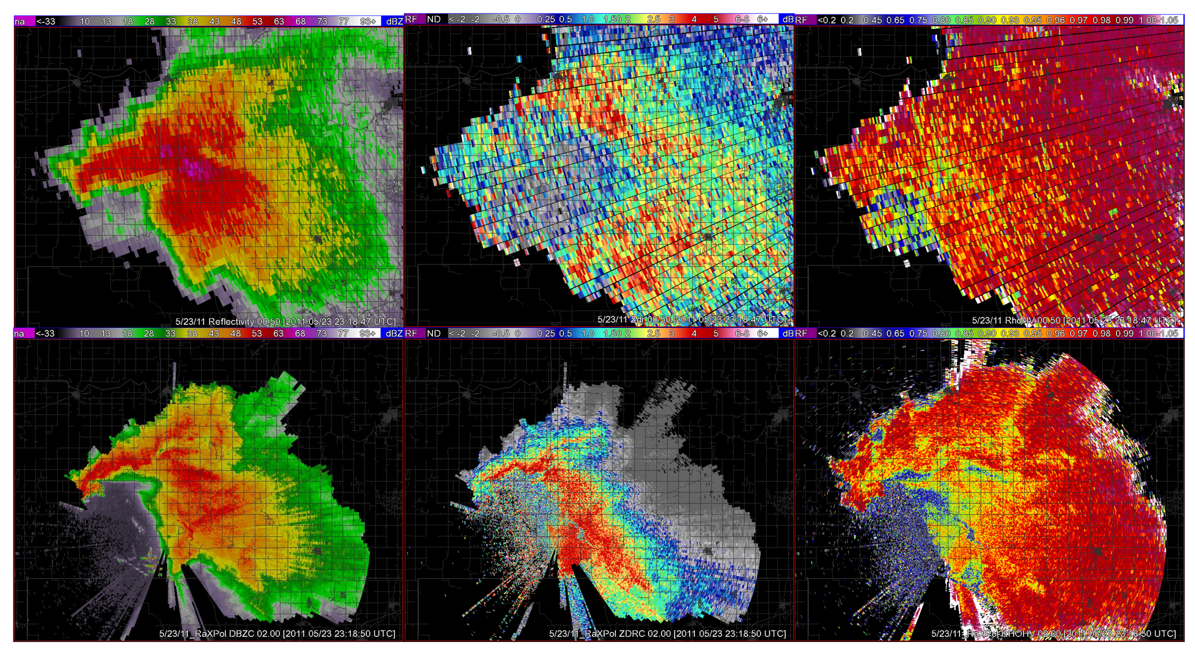
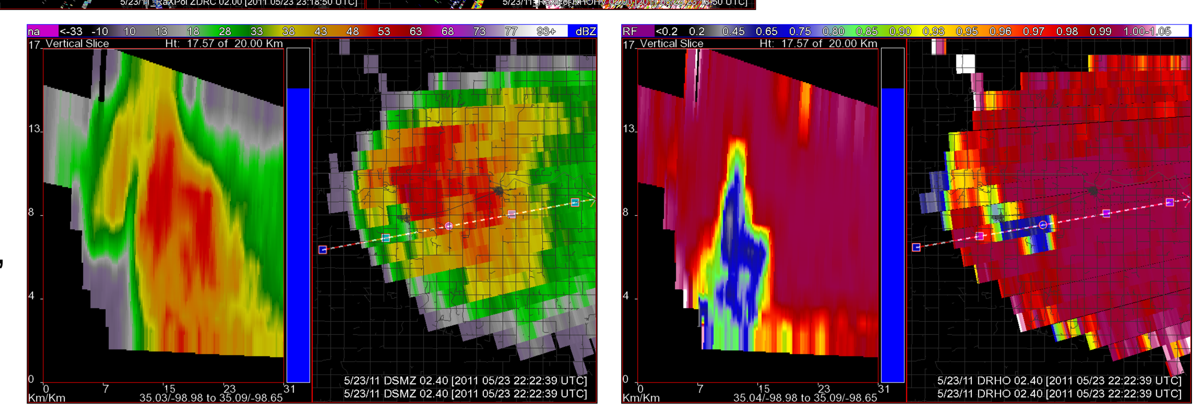


Fig. 5. From let to right, Z_H, Z_{DR}, and ρ_{hv} from (top row) KOUN and (bottom row) RaXPol valid near 2319 UTC. Attenuation in the RaXPol data has been estimated using the ZPHI method. All three quantities plotted are quite different between the two radars.

Fig. 6. Reconstructed vertical cross-sections of Z_H and ρ_{hv} from KOUN near 2223 UTC showing a BWER, echo overhang, and very deep region of reduced ρ_{hv} extending to nearly 13 km in height.



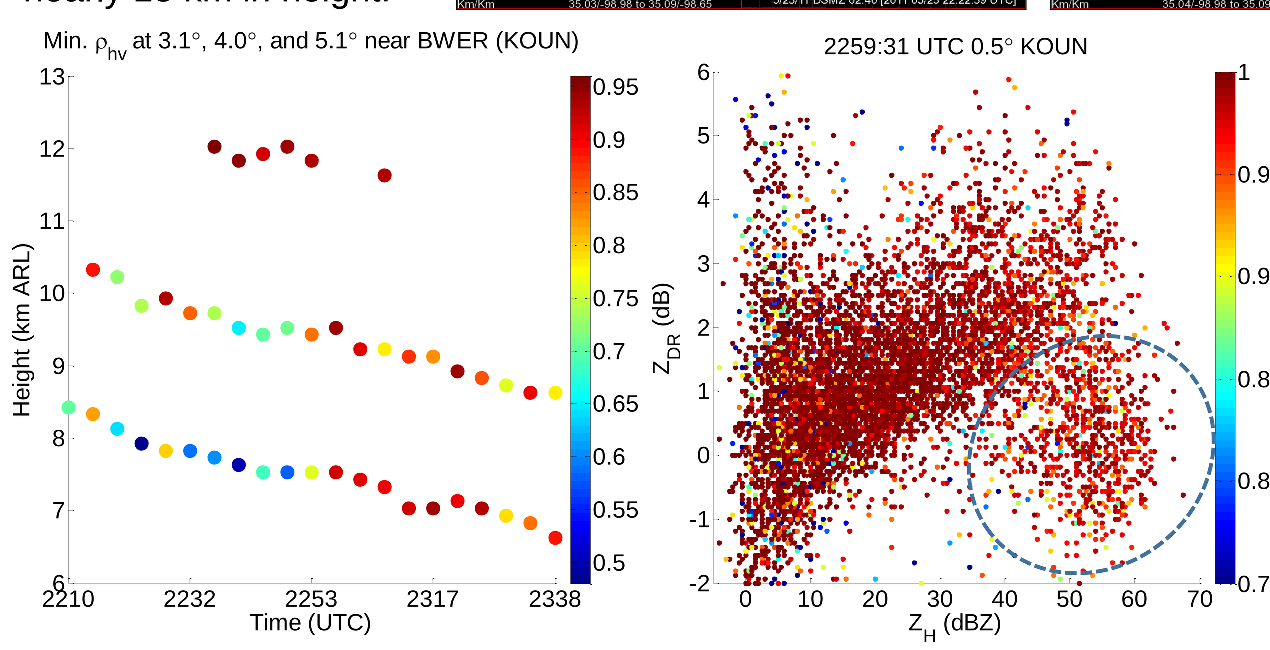


Fig. 7. The minimum ρ_{hv} on the 3.1º, 4.0º, and 5.1º elevation angle scans near or within the BWER. Reductions in ρ_{hv} aloft tended to occur near or slightly before the largest hail was observed on the ground. A scatterplot of Z_H vs. Z_{DR} (colored by ρ_{hv}) valid 2259:31; the encircled points likely represent hail.

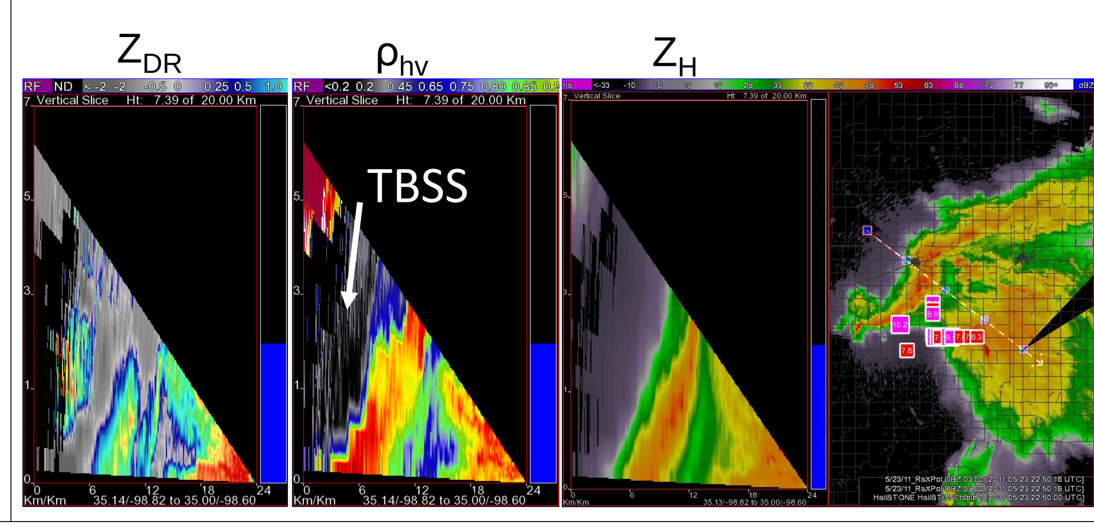


Fig. 8. Reconstructed vertical cross-sections of Z_{DR}, ρ_{hv}, and Z_H from RaXPol valid near 2250 UTC reveals a deep low-reflectivity ribbon and very prominent three-body scatter signature to the rear of the supercell.

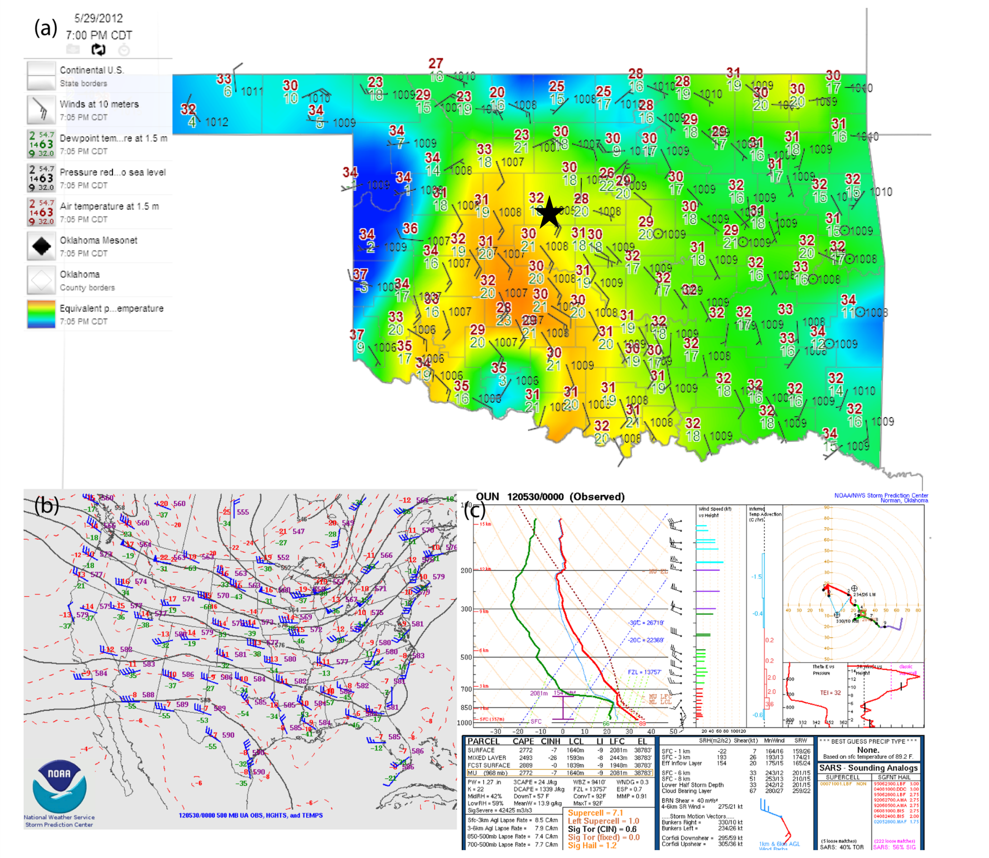


Fig. 9. (a) Surface observations from the Oklahoma Mesonet at 0000 UTC on 30 May 2012 (equivalent potential temperature is shaded). (b) 500 mb analysis (courtesy of the Storm Prediction Center) and (c) Norman sounding valid 0000 UTC on 30 May 2012.

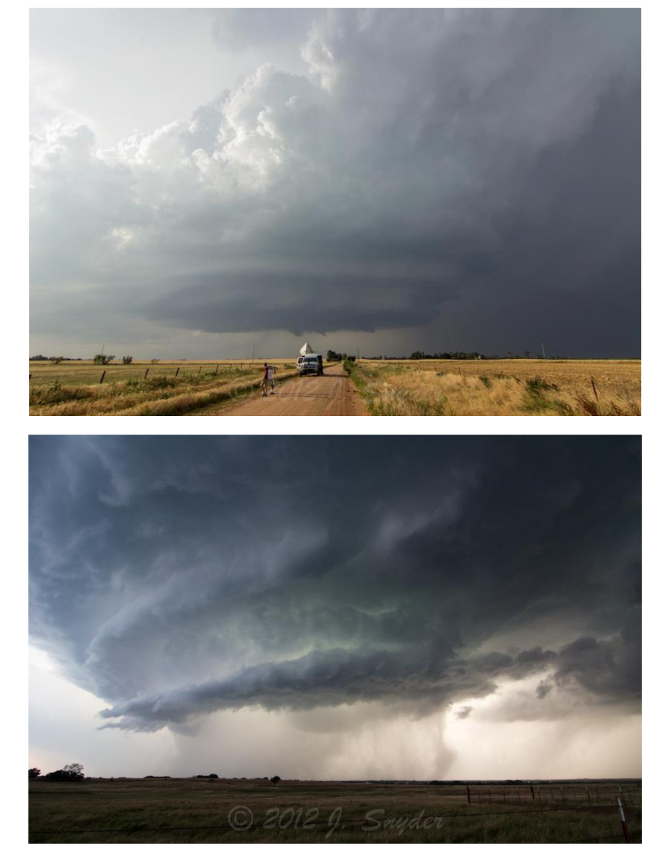


Fig. 10. Photographs of the supercell sampled by RaXPol (a) near 2350 UTC on 29 May 2012 and (b) near 0130 UTC on 30 May 2012 before tornadogenesis. (Photographs courtesy of J. Snyder)

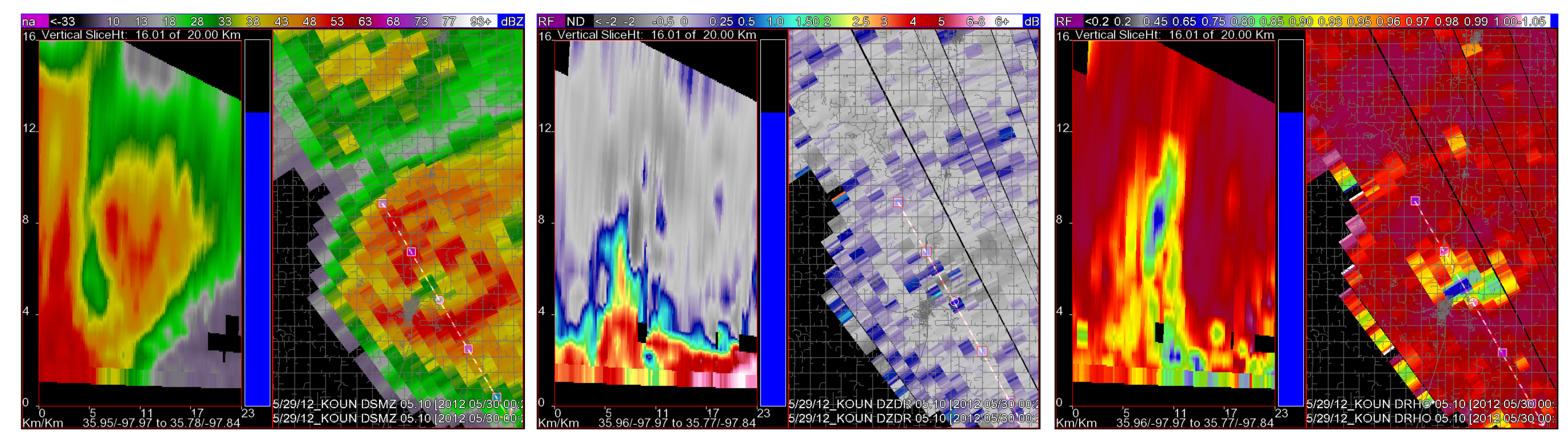


Fig. 11. Reconstructed vertical cross-sections of (left to right) Z_H, Z_{DR}, and ρ_{hv} from KOUN as the supercell was near Kingfisher, OK, showing a BWER, echo overhang, Z_{DR} column, and very deep region of reduced ρ_{hv} extending to nearly 12 km in height. A deep and persistent BWER with ρ_{hv} < 0.8 at 8 km height developed near 2350 UTC. Note Z_{DR} < -1 dB near the top of the Z_{DR} column.

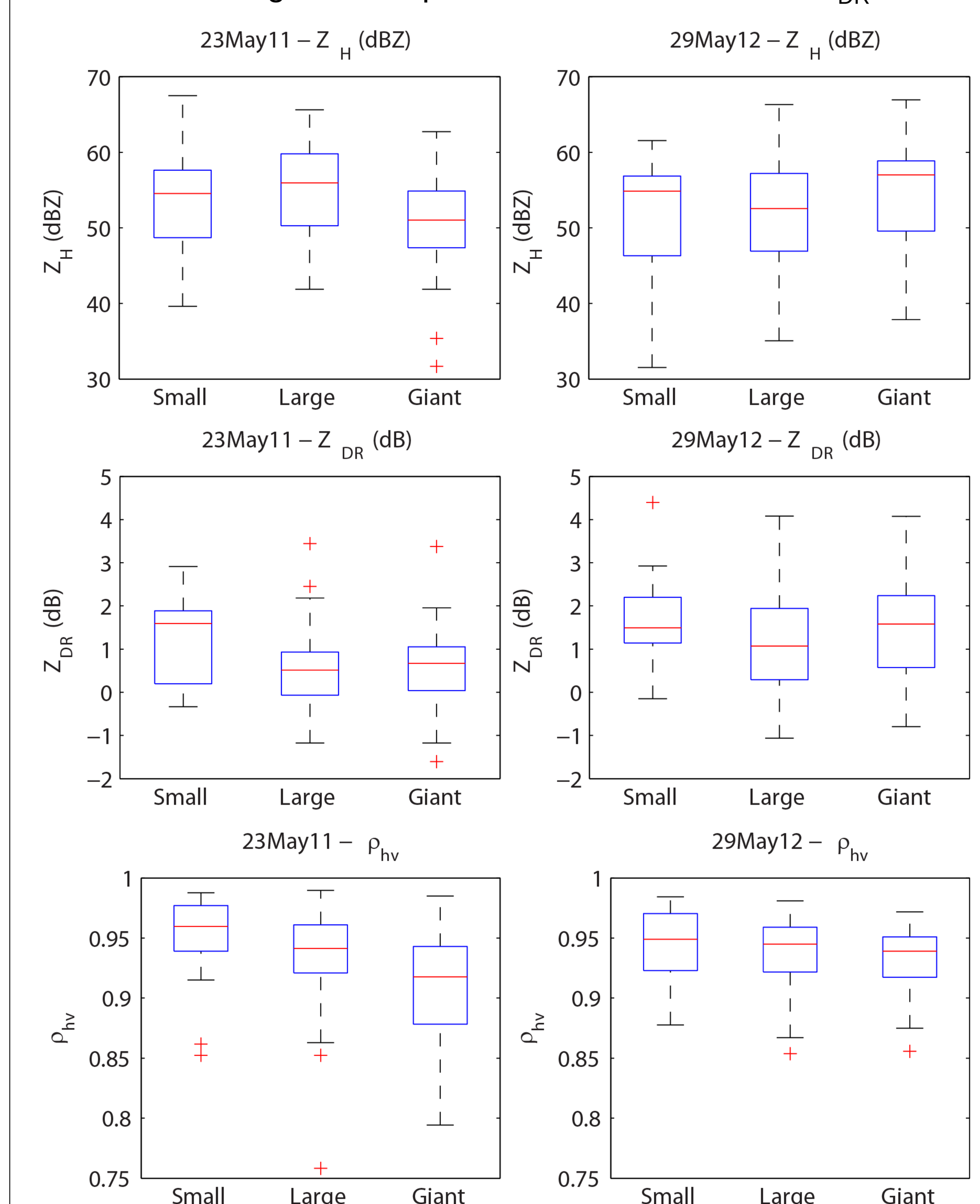


Fig. 12. The HailSTONE observations from the two supercells examined for this project were matched to KOUN radar data in time and space. The distribution of Z_H, Z_{DR}, and ρ_{hv} for small (diameter < 2.54 cm), large (diameter between 2.54 cm and 7.62 cm), and giant (diameter exceeding 7.62 cm) are plotted for each quantity. The blue boxes represent the 25th and 75th percentiles; the whiskers extend to approximately the 1st and 99th percentiles, and the red line marks the median value. Unfortunately, at least for these two datasets, there is an inconsistent trend in the quantities, particularly those characterizing large vs. giant hail. It is likely that additional information regarding updraft intensity (e.g., Z_{DR} column height, magnitude of ρ_{hv} reduction aloft, etc.) will be necessary to better discriminate between large hail and giant hail.

Acknowledgments

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