COLLEGE OF SCIENCE
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Record Setting: The Origins of Extreme Hail on 19 March 2018 during VORTEX-SE

Dean Meyer and Ryan Wade
Department of Atmospheric Science
Severe Weather Institute – Radar and Lightning Laboratories

Event Synopsis

- Supercells producing tornadoes and very large, wind-driven hail struck Alabama on 19 March 2018
- At least two car dealerships, 21 shops, and 600 homes were marred by the hail in Cullman county with damage estimated in the millions[4]
- *A Cullman hailstone with* ***diameter 5.38" set the Alabama state record*** (Fig. 1A)
- UAH research facilities collected weather balloon (sounding) data (Fig. 3) as part of the VORTEX-SE tornado field campaign

Event Impacts

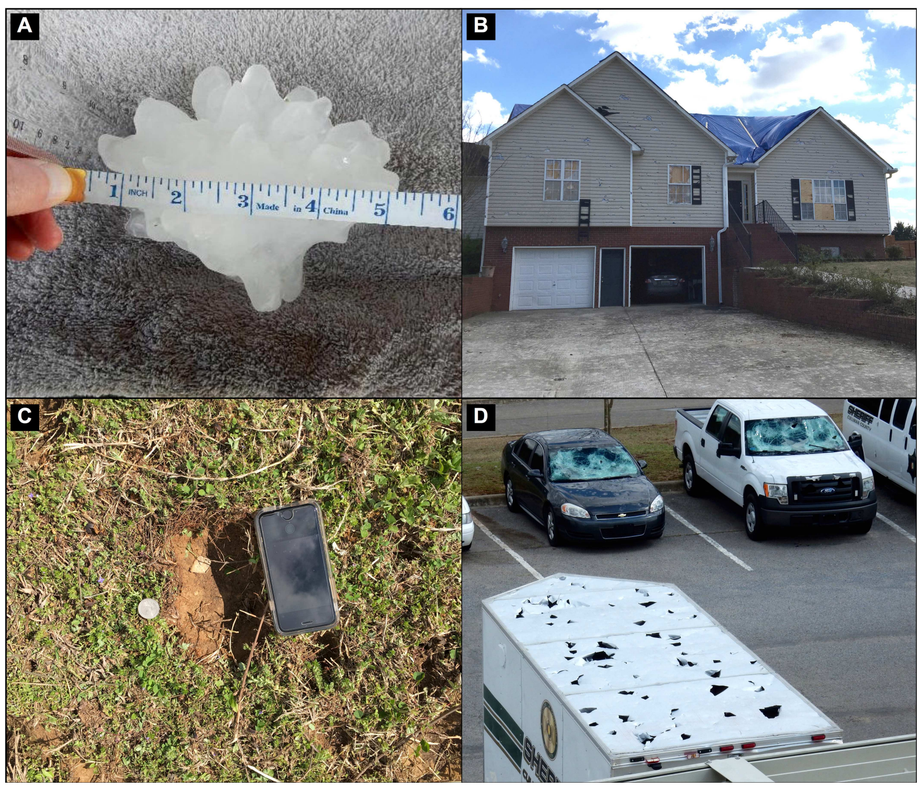

Fig. 1 (A) The record-size hailstone, (B) typical damage to a home, (C) a hailstone impact crater, (D) windshield and trailer damage. Photo credits: NWS Huntsville

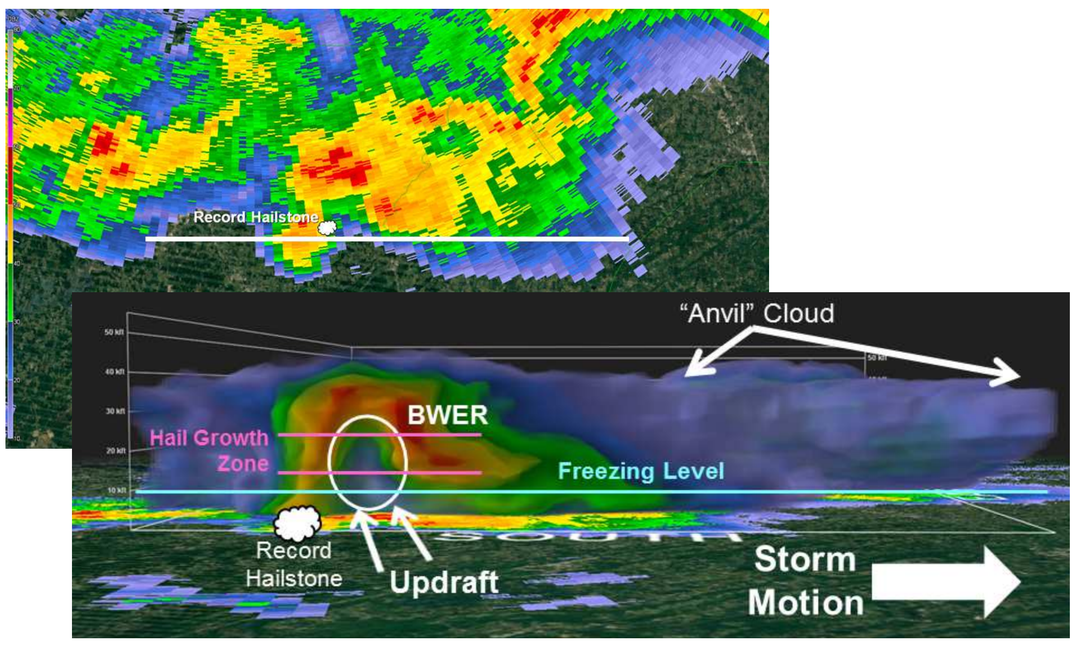

Fig. 2 UAH ARMOR radar images of the Cullman supercell at 7:22 PM. The vertical slice indicates a bounded weak echo region (BWER) and the reported location of the record hailstone

Background and Analysis

- Several values can indicate the likelihood of large hail
  - *Convective Available Potential Energy (CAPE)* describes the buoyancy of parcels integrated from the Level of Free Convection to Equilibrium level
  - The *Freezing Level* is the height the Environmental Temperature = 0°C
  - *Storm Relative Helicity (SRH)* estimates potential for rotating updrafts
  - The *Wet Bulb Zero (WBZ) Height* is level where the lowest temperature reached by evaporative cooling = 0°C
  - *Bulk Shear* is the wind vector difference over a deep atmos layer (0-6km)

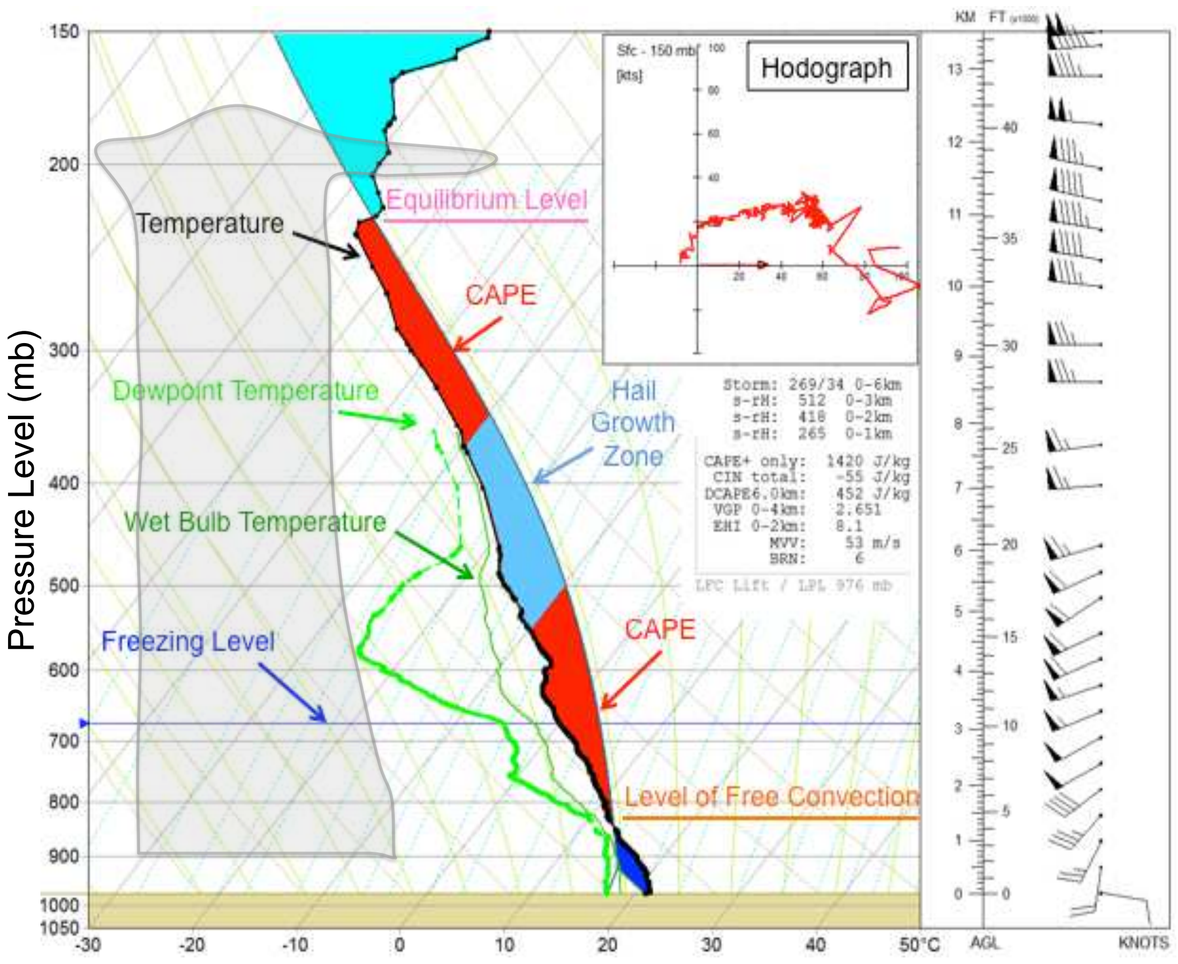

Fig. 3 Composite Skew-T Log-P graph from soundings in Falkville and Birmingham near the time of the Cullman storm. CAPE is therefore approximate. Example storm is shown in gray.

Table 1: Variables with values favorable/moderately favorable/unfavorable for large hail. Observed values are highlighted by favorability

Variable	Very Favorable	Moderate	Unfavorable	Observed
[3] CAPE (J kg^{-1})	> 2,500	1,000 – 2,500	< 0	1,420
[1] Freeze Level (ft)	< 11,000	11,000 – 17,000	> 17,000	10,174
[3] 0-3 km SRH (m^2s^{-2})	> 200	150 – 200	0	512
[3] WBZ Height (ft)	7,000 – 10,000	5,000 – 12,000	< 6,000; > 11,000	9,000
[2] 0-6 km Shear (kts)	> 50	0 – 40	0	75
[1] Mesocyclone Depth	Deep	Moderate	Shallow	Deep (32,000 ft)

Conclusions

- **Buoyancy alone did not provide the updraft strength necessary to produce 5+ inch hail in north Alabama on this day**
- **Additional updraft by strong wind shear yielding updraft rotation**
- Terminal fall velocity for 5 inch hail = ~67 m/s or ~*150 mph*[5], but on this day the realistic updraft strength due to buoyancy is only ~27 m/s or ~*60 mph*[3]
- Extra updraft strength was due to vertical pressure gradient force from dynamic pressure perturbations from deep, persistent updraft rotation caused by strong vertical wind shear (see Bulk Shear and Storm Relative Helicity)
- Future research will examine the exact role wind shear played in promoting extreme hail on March 19, 2018

References

1. https://www.weather.gov/media/lmk/soo/SvrWx_MesoGuide.pdf
2. https://www.weather.gov/media/lmk/soo/SvrWx_Fcstg_TipSheet.pdf
3. https://www.weather.gov/lmk/indices
4. Palmer, David. "Adjusters to begin examining government buildings for storm damage." *Cullman Times.* March 27, 2018.
5. Bohm, J.P., 1989: A general equation for the terminal fall speed of solid hydrometeors. *J. Atmos. Sci.*, **46**, 2419-2427.

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DEPARTMENT OF ATMOSPHERIC SCIENCE
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NOAA
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
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