UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL ENVIRONMENTAL SATELLITE DATA
AND INFORMATION SERVICE
NATIONAL CENTERS FOR ENVIRONMENTAL INFORMATION
151 PATTON AVE ROOM 120
ASHEVILLE NC 28801-5001

6 April 2018

MEMORANDUM FOR: State Climate Extremes Committee (Alabama *ad hoc*)

FROM: Derek S. Arndt
Chief, Climate Monitoring Section, Center for Weather and Climate
National Centers for Environmental Information

SUBJECT: SCEC Report for Alabama Hailstone 19 March 2018

Summary:

On 3 April 2018, a State Climate Extremes Committee (SCEC) convened, in accordance with customary federal certification process, to verify / validate several observations related to a hailstone retrieved on 19 March 2018 in the community of Walter, Alabama, located 9 miles ESE from Cullman, Alabama.

The committee considered the validity, meteorological plausibility, and measurement practices associated with the hailstone in question. After reviewing the observational and meteorological evidence, the means and method of measurement, and previously documented stones, the SCEC unanimously agreed that the hailstone retrieved in Walter on 18 March 2018 would set the inaugural SCEC record for the State of Alabama in four dimensions. In particular, the committee found that the following were true and valid:

- LOCATION: Walter, Alabama
- DATE AND TIME: 19 March 2018, approximately 7:16 pm CDT (local time)
- HAILSTONE DIAMETER: 5.38 inches
- HAILSTONE WEIGHT: 9.8 oz. (0.61 lb)
- HAILSTONE VOLUME: 19.80 cubic inches
- HAILSTONE CIRCUMFERENCE: 13.75 inches

General Overview (see attached reports for detail):

Meteorologists from the NWS Weather Forecast Office at Huntsville, Alabama ("WFO Huntsville," which provides NWS's forecast and integrated warning services for the location) traveled to Walter on 21 March to observe the hailstone, ensure its proper preservation, and to take field measurements of the stone. Several days afterward, the diameter, volume and weight of the stone were re-measured by members of the Insurance Institute for Business & Home Safety (IBHS), using three-dimensional (3D) laser imaging. These methods, detailed in Giammanco, et al. (2017), were used for the first time in an SCEC determination. The SCEC agreed that these technologies would serve as the measurement of record for these dimensions. The circumference measurement was considered as measured in the field by NWS WFO Huntsville personnel.

There was no prior established SCEC hailstone record for Alabama. A review of *Storm Data* and the Storm Events Database indicated several instances of 4.5" ("grapefruit sized") hail reported in the state. None of these had additional documentation.

Finding of Committee

The above evidence was reviewed by the SCEC leading to a teleconference call on 3 April 2018.

Based upon the documented evidence, the SCEC agreed unanimously, by four separate votes of 5-0, that the above measurements associated with the hailstone retrieved on 19 March 2018 in Walter, Alabama are valid, and **recommends the NCEI Climate Monitoring Chief approve the SCEC action to acknowledge these values as state records for Alabama**.

Additional recommendations for consideration by future State Climate Extremes Committees are:

- The SCEC recommends that the 3D laser imaging method be pursued in future events of this type, if possible and achievable.
- The SCEC recommends that future hailstone examinations consider volume of a hailstone to be on par with diameter and mass.

Additional Documentation:

For more thorough documentation of the event, please reference two reports attached to this memorandum:

- A report compiled by WFO Huntsville meteorologists, detailing the sequence of events, meteorological plausibility, including a description of the synoptic and mesoscale set-up for the several weather event, the initial retrieval and field measurements of the stone, a list of prior large hailstones documented for Alabama, and
- A report compiled by IBHS details the 3D laser measurements.

References

Giammanco, I.M., B.R. Maiden, H.E. Estes, and T.M. Brown-Giammanco, 2017: Using 3D Laser Scanning Technology to Create Digital Models of Hailstones. *Bull. Amer. Meteor. Soc.,* **98**, 1341–1347, https://doi.org/10.1175/BAMS-D-15-00314.1

NCEI Climate Monitoring Chief Decision

Approved (as recommended in boldface above):

Signed ARNDT.DEREK.SHANE.1384496519 Digitally signed by ARNDT.DEREK.SHANE.1384496519 DN: c=US, o=U.S. Government, ou=DoD, ou=PKI, ou=OTHER, cn=ARNDT.DEREK.SHANE.1384496519 Date: 2018.04.06 13:41:40 -04'00' Date: _____

Not approved (will be returned to SCEC with no action taken):

Signed _____ Date: _____

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Voting Members of the State Climate Extremes Committee:

Dr. John Christy, Alabama State Climatologist, University of Alabama in Huntsville

Victor Murphy, NWS Southern Region Climate Services Program Manager

Chris Darden, Meteorologist in Chief, NWS WFO Huntsville

Deke Arndt, Monitoring Section Chief, NOAA/NCEI

Jordan McLeod, Southeast Regional Climate Center, University of North Carolina at Chapel Hill

Subject Matter Experts supporting/advising the call

Kristopher White, Applications Integration Meteorologist, WFO Huntsville

Karin L. Gleason, Meteorologist, Monitoring Section, NOAA/NCEI

Attachments:

Appendix I: Summary of event, with photos, descriptions, and measurement details, from WFO Huntsville

Appendix II: Summary of 3-D laser measurements, from IBHS

Appendix I: Record Hail Event in Walter, Alabama on March 19th, 2018

Prepared by National Weather Service Weather Forecast Office Huntsville, AL

Finalized: April 4th, 2018

Background

During the late afternoon into the evening hours of March 19th, a potent storm system and its associated cold frontal boundary aided in the development of scattered severe thunderstorms that moved eastward from northern Mississippi across northern and central Alabama. The environment was conducive for significant weather, given the rather moist low level atmosphere and severe indices indicative of explosive supercell thunderstorm activity. The supercell thunderstorms spawned over a dozen tornadoes in Alabama including several strong tornadoes.

One long lived supercell thunderstorm produced a large hail swath including very large hail in and near the city of Cullman, Alabama. This hailstorm produced extensive damage to cars, businesses, and homes including widespread destruction to several neighborhoods and complete destruction of several businesses and car dealerships. Of particular note, the Cullman County Sheriff's Office sustained significant roof damage and complete loss to their vehicles (Image 1). In addition, hail completely penetrated the industrial strength kitchen freezer at the jail facility and ended up inside the freezer.

Hail also penetrated the roofs of several houses in the Fox Meadows Subdivision and other surrounding homes. Some houses here had nearly entire complete roof destruction and significant siding damage (Image 2). Of particular note is the large divots produced by the hail swaths in yards in around the city of Cullman (Image 3).

The hailstone discussed in this report was ultimately discovered in the community of Walter, Alabama which is approximately 9 miles east southeast of downtown Cullman, Alabama. The hail was retrieved by Mr. Craig Mann in his front yard at 8365 County Road 703, Cullman, Alabama a short time after the hail storm ended. Radar imagery from Hytop, AL (KHTX) shows intense reflectivities near the residence at approximately 0016 UTC (Image 4). The location of the hail collection is noted by the white circle/dot.

Storm Environment and Meteorological Plausibility

During the morning hours of March 19th, a surface warm front was lifting northward across central Alabama as a deepening surface low was moving across the Mid South region. As the warm front began to lift northward, an upper level shortwave trough and associated jet streak began to eject eastward toward the Tennessee Valley. The combination of increasing deep layer shear and an axis of CAPE values approaching 1500 J/kg (Image 5) coupled with convergence along the warm front and set the stage for intense rotating thunderstorms. These storms began to erupt across eastern Mississippi (Image 6) by the mid-afternoon hours and moved eastward with time.

It should be noted that forecast soundings for this event showed potential for rotating thunderstorms including large hail several days in advance. For example, the 12z/March 16th model run of the Operational NAM valid for KHSV (Image 7) for 00z on the 20th showed a very unstable airmass with MLCAPE in excess of 2000 J/kg and 0-1 km shear near 700 m2/s2. Though the extreme CAPE was

overdone, the shear values largely verified and the forecast lapse rates and dry air aloft per water vapor (Image 8) did as well.

Prior Observations

There is currently no official hail record for the state. A review of the NCEI Storm Data Records indicates an unofficial maximum hail report of 4.50 inches recorded on 9 separate occasions.

Hailstone Collection, Measurement, and Report

The stone was collected and photographed by resident Craig Mann (Image 9) shortly after the hail fall on Monday, March 19th. It was handled, photographed and shared on social media shortly after the occurrence. Mr. Mann then collected several of the larger hailstones, photographed them, and placed them in a freezer in his garage.

NWS Huntsville was made aware of the large hail via social media and subsequently contacted Mr. Mann via twitter. Acquiring additional photographs, NWS Huntsville made an initial size estimate in excess of softball size and coordinated with NCEI and State Climatologist John Christy on whether any current records exist. After a review of NWS StormData Publications, the largest hail stone we could locate in the database was 4.50 inches of which there were 9 instances in the database

We then arranged for a site visit to Mr. Mann's location for 3/21/18 to inspect the hail stone. During that visit, which occurred at approximately Noon CST on 3/21/18 the NWS observation team consisting of Andy Kula, Kris White, and Chris Darden inspected 4 preserved hail stones including measuring the diameter (largest), circumference (largest), and weight (using a calibrated scale from Cullman EMA). That process is noted in Images 10 through 13. The completion of these measurements was photographed and also videotaped by 3 news stations - WHNT, WIAT, WVTM

The initial manual ("field") measurements of the largest stone were as follows:

- Diameter: 5.25 inches
- Circumference: 13.75 inches
- Weight: 8.9 ounces
- Time of Occurrence: approximately 716 PM CDT March 19th, 2018 (0016 UTC March 20th)

As noted below, more precise analyses were completed by IBHS on 3/28/18.

Update from IBHS On site Review 3/28/18

On 3/28/18, the Insurance Institute for Business and Home Safety (IBHS) traveled to Mr. Manns' home to conduct a formal 3D Analysis and Examination of the hailstone in questions. The findings of this report are noted in the table below and confirmed (with some minor measurement adjustments) the preliminary hand analysis. For note, these more precise measurements for Hailstone #1 will be used for the formal records along with the hand measurement of the circumference completed on 3/21/18. The entire IBHS summary is included as **Appendix II**.

Using a combination of the more precise 3D analytical measurements and the previous manual calculations revealed the following findings for Hailstone #1:

- Hailstone Diameter: 5.38 inches
- Hailstone Mass: 9.8 oz. (0.61 lb)
- Hailstone Volume: 19.80 cubic inches
- Hailstone Circumference: 13.75 inches

Images

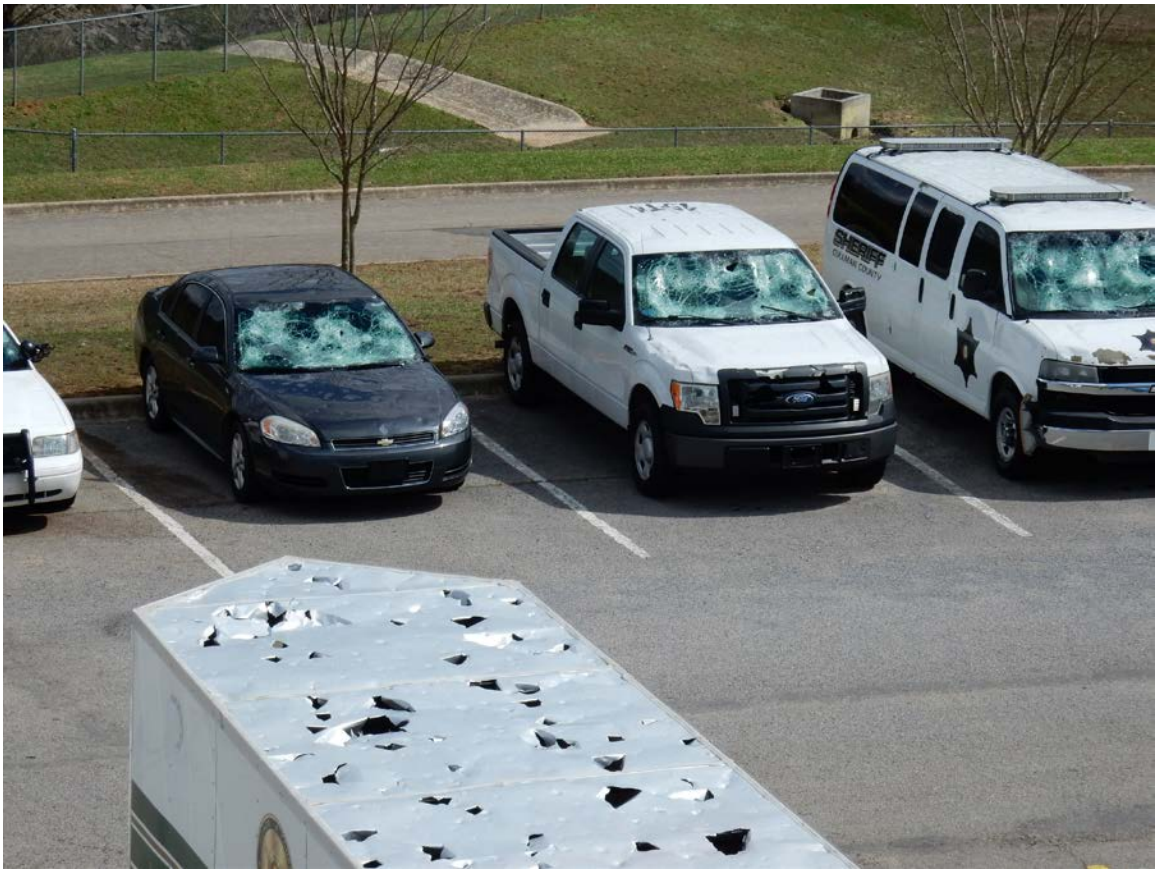

Image 1. Cullman County Sheriff's Office Parking Lot as seen from the roof.

Image 2. Common damage to roof and siding observed at the Fox Meadows Subdivision on the southeast side of Cullman, Alabama.

Image 3. Common hail divots caused by the very large hail penetrating the ground. These divots were noted in many yards in Cullman, Alabama.

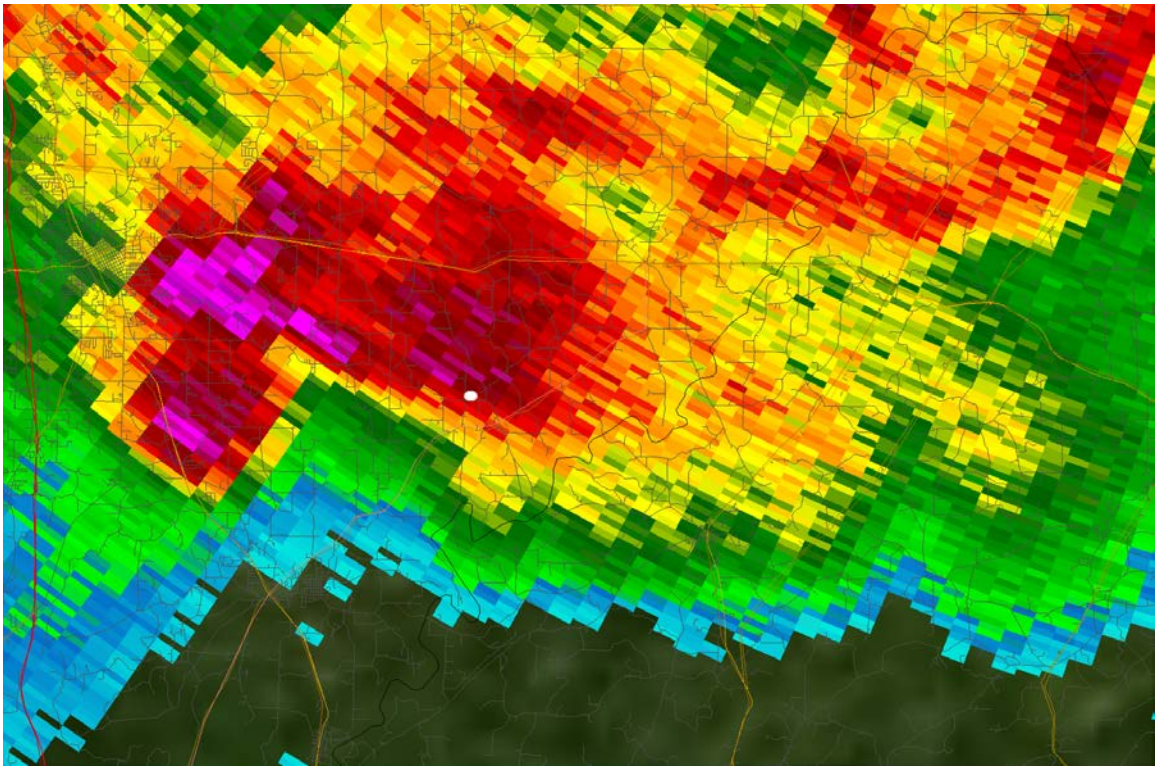

Image 4. 0.5 degree base reflectivity from KHTX at 0016 UTC. Residence of hail fall noted by white circle.

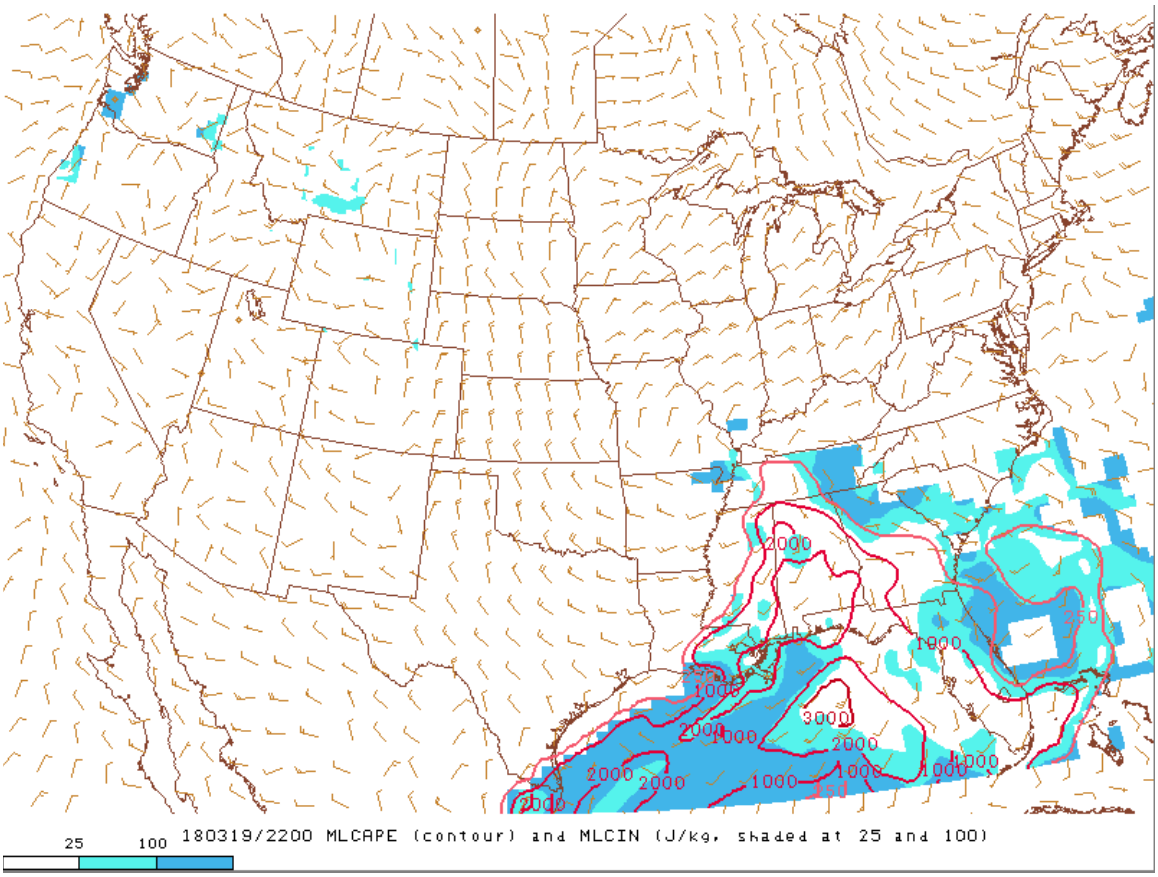

Image 5. MLCAPE analysis for 2200 UTC on 3/19/18

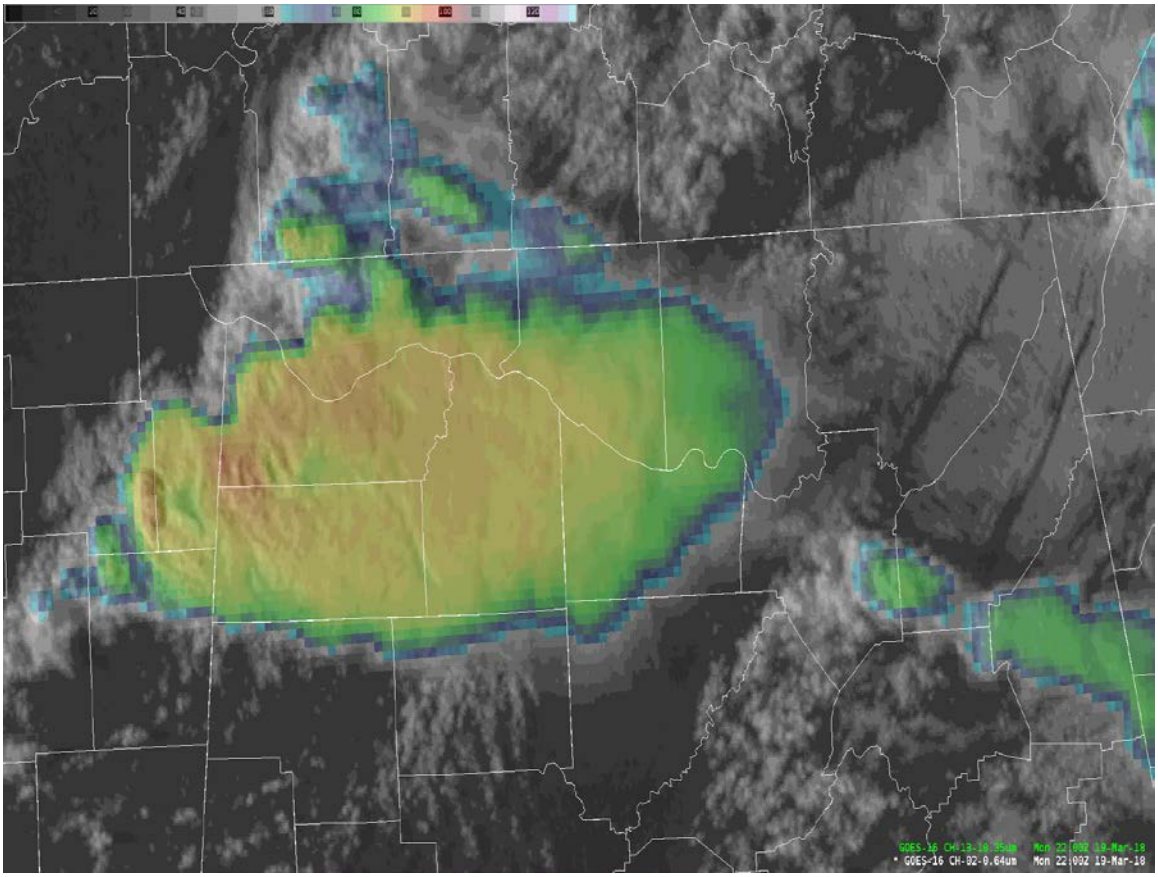

Image 6. GOES-E loop showing overshooting tops in NW Alabama and NE Mississippi at the onset and above-anvil cirrus plumes (coordination with Kristopher Bedka at NASA Langley).

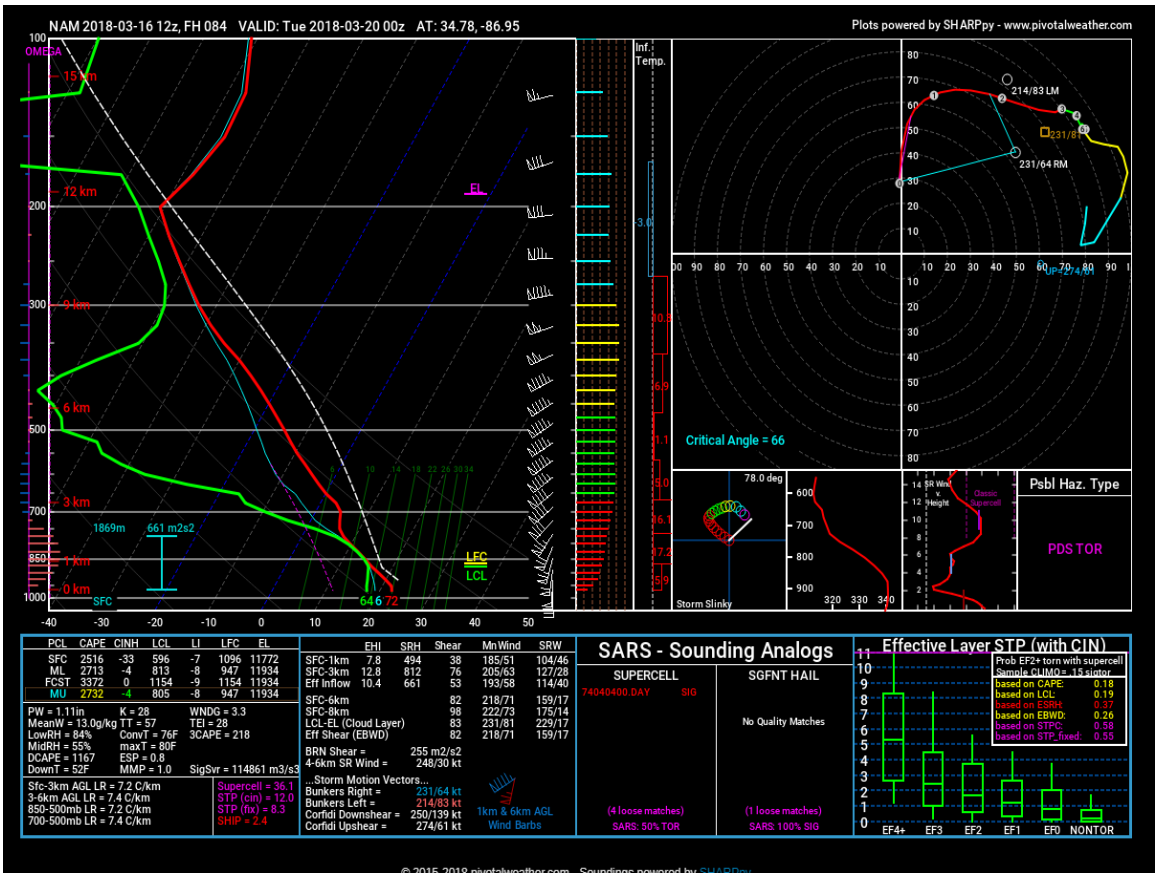

Image 7: 12z/Friday March 17th NAM Forecast for KHSV 00z/March 20th.

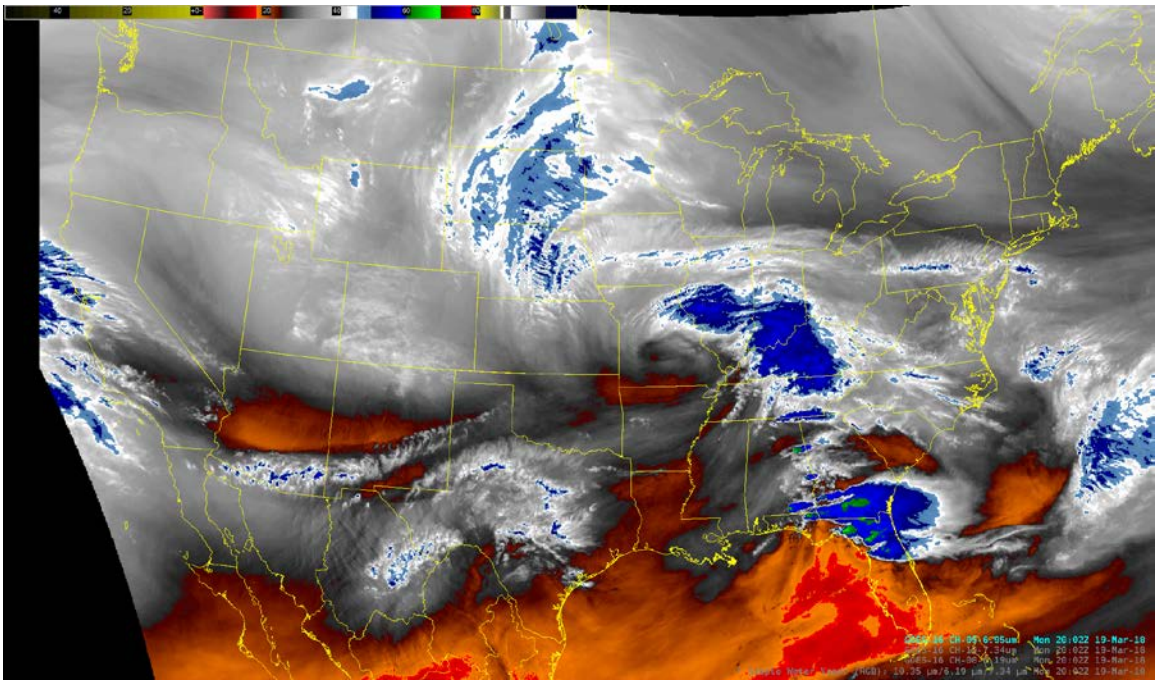

Image 8. GOES-E Mid-level Water Vapor Imagery

Image 9. Mr. Craig Mann from Walter, Alabama with the hailstone shortly after the hail fall on March 19th, 2018

Image 10. Measure the maximum diameter on 3/21/18/

Image 11. Weighing the stone on 3/21/18 (note: the stone was weighted later on a verified horizontal surface)

Image 12. Measuring the circumference on 3/21/18

Image 13. Media viewing the hail stone analysis on 3/21/18

Appendix II: IBHS Report.

This report is adapted directly from the original IBHS assessment. It has been edited for format / fit into this report. No content was changed.

IBHS Field Survey:

Cullman, Alabama Giant Hail

Ian M. Giammanco, PhD | Lead Research Meteorologist | 29 March 2018

Event

During the evening on 19 March 2018 a broken line of supercell thunderstorms impacted northern Alabama. The lead supercell passed Cullman, Alabama just after 00 UTC and produced several reports of giant hailstones, with diameter > 4 inches (Fig 2). Significant property damage occurred due to the large hail.

Several giant hailstones, including the possible largest hailstone reported in the state, were collected and saved by Cullman resident, Mr. W. Craig Mann. The hailstones were surveyed by staff from the National Weather Service Weather Forecast Office in Huntsville on March 21st, 2018. The largest hailstone was manually measured. It was found to have a diameter of 5.25 inches (13.34 cm) and a circumference of 13.75 inches (34.93 cm. In addition to this hailstone, Mr. Mann collected several other very large hailstones.

IBHS Survey

The Insurance Institute for Business & Home Safety (IBHS) was contacted by colleagues from the University of Alabama at Huntsville regarding the possible record- setting hailstones found in Cullman. IBHS has pioneered the use of 3D laser scanning system to create highly accurate and precise digital models of natural hailstones[1].

Following the initial NWS survey, IBHS deployed a team to Cullman, Alabama on March 28th, 2018 to conduct laser scanning of the hailstones preserved by Mr. Mann. The hailstone scans were conducted using a Creaform HandySCAN EXAscan™ system, shown in Figure 1, at a resolution of 0.008 cm. The unit's accuracy is ± 0.004 cm. For each of the five hailstones, the maximum diameter, minimum diameter, and volume were calculated from the digitized 3D hailstone model. The diameters are defined as the maximum (minimum) distance on a line through the center of the hailstone (based on the 3D volume) to two points on the surface. The IBHS field team also weighed each hailstone. The scale was calibrated on March 27th, 2018 before the team departed the IBHS Research Center in Richburg, South Carolina. The measurements of each hailstone are summarized in Table 1 and the digital models of each are provided in Figure 2.

[1]Giammanco, I.M., B.R. Maiden, H.E. Estes, and T.M. Brown-Giammanco, 2017: Using 3D laser scanning technology to create digital models of hailstones, Bull. Amer. Meteor. Soc., 98 (7), 1341-1347.
http://journals.ametsoc.org/doi/pdf/10.1175/BAMS-D-15-00314.1

Table 1. Measurements of the five hailstones laser scanned by the IBHS field team.

Hail stone	D_{max} (in.)	D_{max} (cm)	D_{min} (in.)	D_{min} (cm.)	Mass (g)	Volume (in^3)	Volume (cm^3)	Density ($g\ cm^{-3}$)
#1	5.380	13.665	1.821	4.625	277.83	19.798	324.295	0.86
#2	4.551	11.559	1.991	5.057	232.80	16.524	270.780	0.86
#3*	4.138	10.510	2.355	5.982	251.10	17.718	290.346	0.87
#4	3.606	9.160	2.099	5.331	166.73	11.673	191.286	0.87
#5*	4.057	10.305	1.562	3.967	131.80	9.282	152.104	0.87

*Hailstones #3 and #4 had evidence for non-uniform melting while on the ground and are likely less oblate than their measured axes represent.

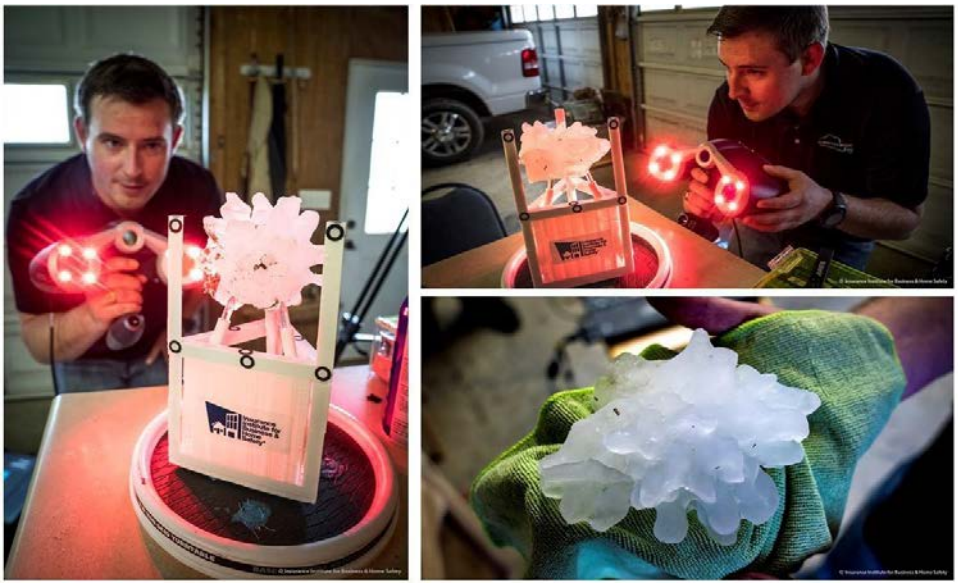

Figure 1: IBHS engineer Ross Maiden 3D laser scans the largest of the five hailstones collected by Mr. W. Craig Mann in Cullman, Alabama. Photographs by Scott Fowler, IBHS.

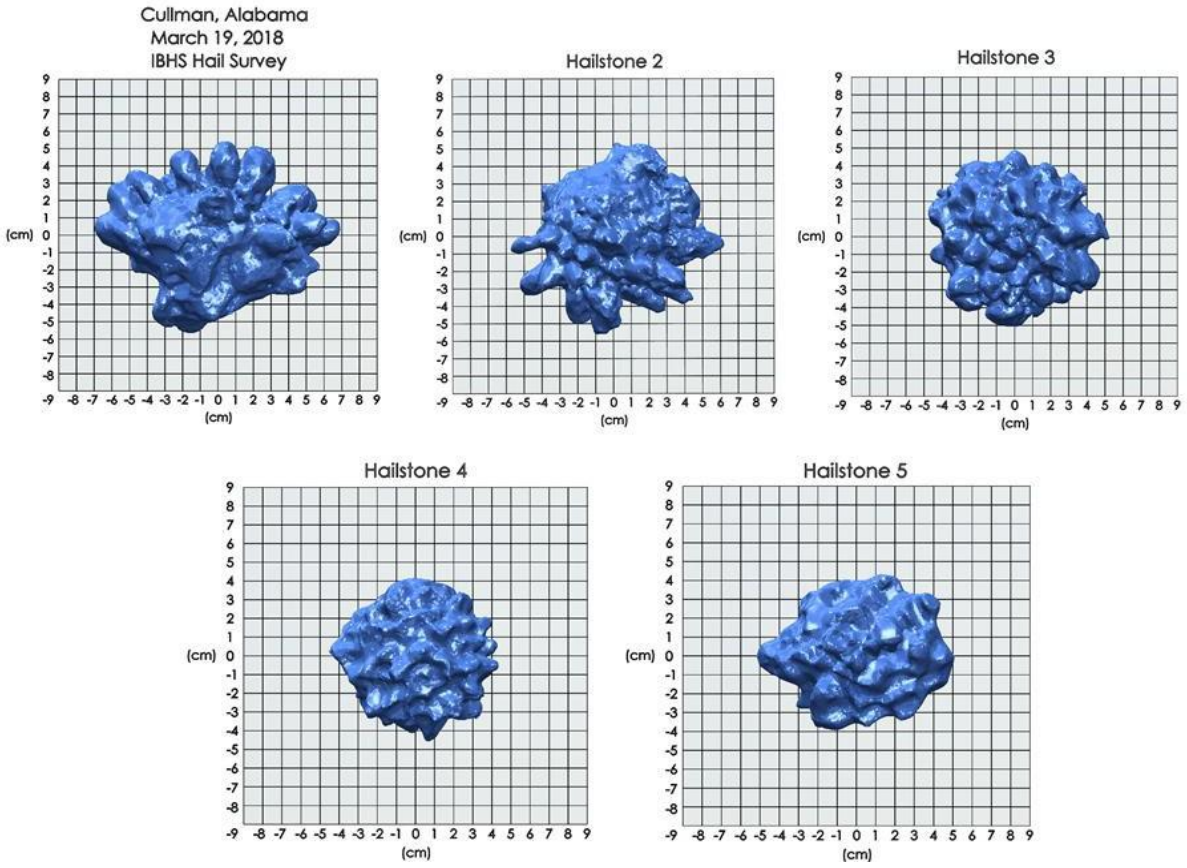

Figure 2: Renderings of the 3D digital model for each of the five Cullman, Alabama hailstones laser scanned.