

STATE CLIMATE EXTREMES COMMITTEE MEMORANDUM

FROM: Russ Schumacher, Colorado State Climatologist, Colorado Climate Center, Dept. of Atmospheric Science, Colorado State University (SCEC Convener), on behalf of: State Climate Extremes Committee (Schumacher, Thede, Mahmood, Bruschi, Gleason)

DATE: 19 September 2023

SUBJ: Colorado State Record Hailstone in Yuma County

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Summary

A series of long-lived supercell thunderstorms moved southward through Yuma County, Colorado on the evening of 8 August 2023. In addition to multiple tornadoes, these storms produced a swath of large, damaging hail. A very large hailstone was identified and collected by a storm chaser between Kirk and Idalia. This stone was measured with a caliper and photographed by the storm chaser, and was then collected, preserved, and transported to the National Weather Service (NWS) in Goodland, where it was kept in a plastic bag in a freezer. Members of the State Climate Extremes Committee (SCEC) and other partnering institutions convened in Goodland to measure the stone and to assess it for potential records for the state of Colorado.

Unfortunately, the hailstone had lost considerable size and mass between when it was first collected and photographed, and when it was measured the following week. These measurements of the weight, circumference, and volume of the hailstone were all smaller than those from the existing record stone from August 2019 near Bethune. However, the high quality of the photograph and measurement of the hailstone when it was first collected provide confidence that this hailstone exceeded the previous record for maximum diameter in Colorado.

- Location: **Approx. 8 mi. ENE of Kirk, Yuma County, Colorado**
- Date: **8 August 2023**
- Maximum Diameter: **5.25 inches**

After considering the photograph, along with comparisons to information about the existing record stone, the **SCEC determined that this value of maximum hailstone diameter is valid, and establishes a new Colorado state record.** The diameter value supersedes the previous record of 4.83 inches, which occurred on 13 August 2019 near Bethune, Colorado. However, the Bethune hailstone will maintain the official record for the other dimensions of weight, volume, and circumference.

About the SCEC

This State Climate Extremes Committee (SCEC) was composed of members representing five institutions: the National Weather Service (NWS) Weather Forecast Office in Goodland, Kansas (WFO Goodland, which has warning responsibility for Yuma County, CO), the NWS Central Region's Climate Services Program Manager, the Colorado Climate Center (CCC, the state climate office), the High Plains Regional Climate Center, and the National Centers for Environmental Information. It is convened to adjudicate potential records for validity. If validated, the observation is considered the state record for that record type. More details about the SCEC are available online at <https://www.ncei.noaa.gov/access/monitoring/scec/details>

About the Observation

On the evening of Tuesday, 8 August 2023, a photograph was posted on social media by storm chaser Dan Fitts that showed a caliper measurement of a very large hailstone that fell in Yuma County, Colorado (Fig. 1). The photo suggests a maximum diameter of approximately 5.25 inches, which would exceed the existing Colorado record of 4.83 inches.



Dan Fitts
@Dan_Fitts



Fell on Highway 36 about 8 miles ENE of Kirk, Colorado just as tornado was developing @nwsgoodland #cowx



7:45 PM · Aug 8, 2023 · 109.1K Views

Fig. 1: Post from Dan Fitts reporting the potential record hailstone.

https://twitter.com/Dan_Fitts/status/1689090378350370817



Fig. 2: Higher resolution photo provided via email by Dan Fitts.

Mr. Fitts preserved the hailstone in a plastic bag in a cooler in his vehicle and transported it to the NWS office in Goodland later that evening of 8 August, where it was stored in a freezer by NWS staff. Members of the SCEC began discussions via email, and some additional information was gathered from Dan Fitts via email (e.g., Fig. 2). The timestamp on the photo indicates that it was taken at 7:20pm Mountain Daylight Time. Mr. Fitts did note that, despite his best efforts to preserve it, the hailstone had undergone some melting in between when he first collected it and when it was delivered to NWS Goodland.

Plans were made for the Colorado State Climatologist to visit the NWS in Goodland on 14 August 2023, along with representatives from the Insurance Institute for Business and Home Safety (IBHS). On 14 August, the preserved hailstone was measured via both traditional measurements (weighed on a scale, measured with a caliper and tape measure), as well as with a 3D laser scan ([Giammanco et al. 2017, BAMS](#)).

None of the measurements that were made on 14 August in Goodland exceeded the existing records for Colorado. Specifically, the measurements showed the following:

- Maximum diameter: 4.608 inches (current record: 4.83 inches)
- Circumference: 11.18 inches (current record: 12.875 inches)
- Weight: 7.29 oz (current record: 8.5 oz).

Because the other dimensions (weight, circumference, and volume) were not directly measured at the time the hailstone was collected, **the existing records for weight, circumference, and volume from the August 2019 Bethune hailstone will continue to stand as the official records for Colorado.**

The SCEC then considered how to assess the original photograph from Dan Fitts, which clearly shows the measurement of the hailstone diameter with a caliper. This is a best-practice method for measuring hailstone diameter. Even though the hailstone as measured on 14 August did not have a larger diameter than the existing record, the SCEC discussed whether to accept the photographic documentation as a new record.

As part of this investigation, Ian Giammanco of IBHS provided additional analysis that was done using computer-aided design software. The first analysis compares the Fitts photograph with the 3D scan of that stone that was taken on 14 August (Fig. 3). This clearly illustrates that the photographed and scanned stones have the same shape and characteristics, and also illustrates the smaller size as a result of melting and/or sublimation between when it was photographed and when it was measured and scanned the following week.

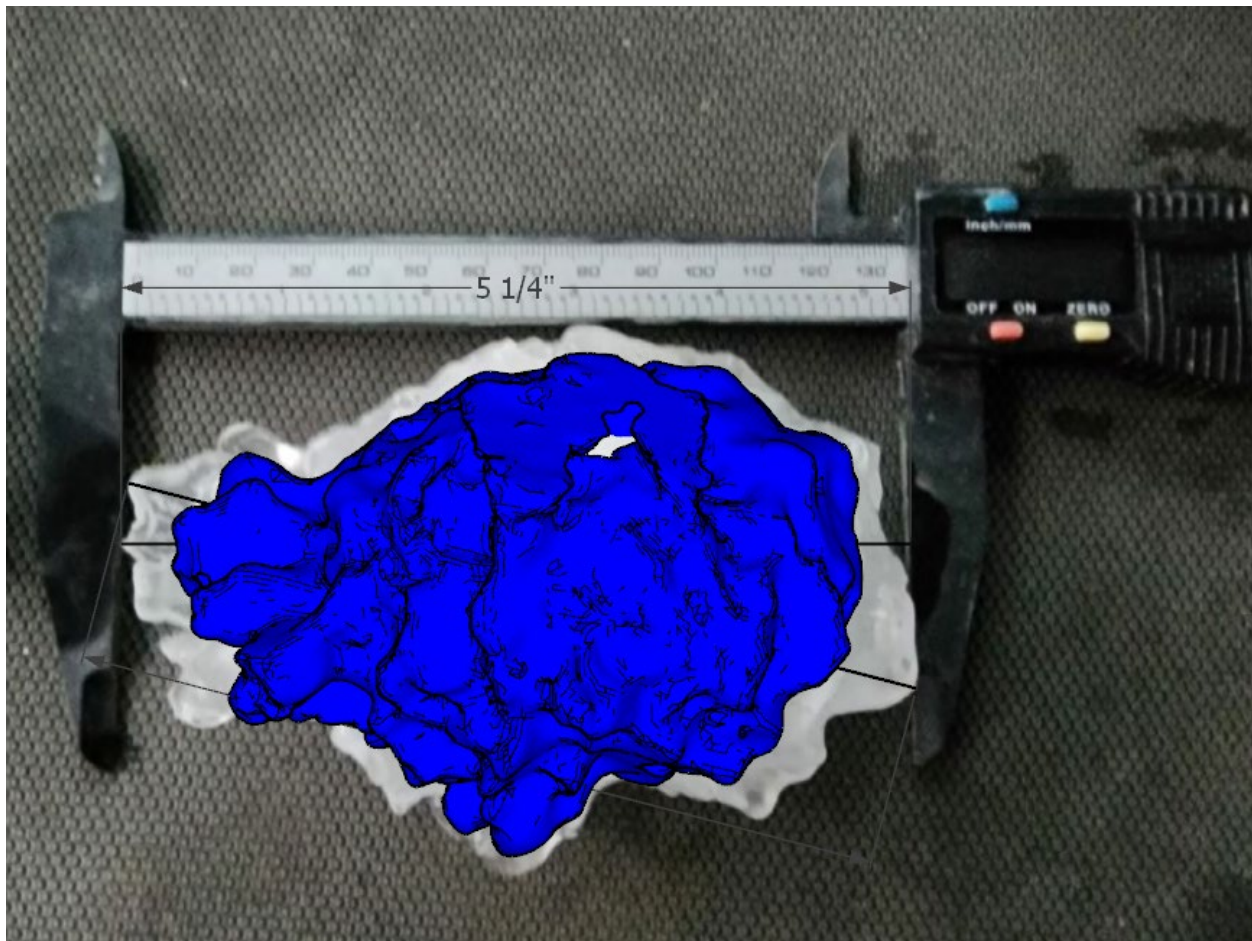


Fig. 3: Comparison of the hailstone photographed by Dan Fitts with a rendering of the stone as it was scanned on 14 August 2023. This illustrates the melting/sublimation that took place between when the hailstone was photographed and when it was preserved at NWS Goodland. Provided by Ian Giammanco of IBHS.

The second comparison, shown in Fig. 4, compares the photograph with a rendering of the 3D scan of the existing record hailstone from 2019. This clearly shows that the August 2023 hailstone as photographed was larger than the existing record.

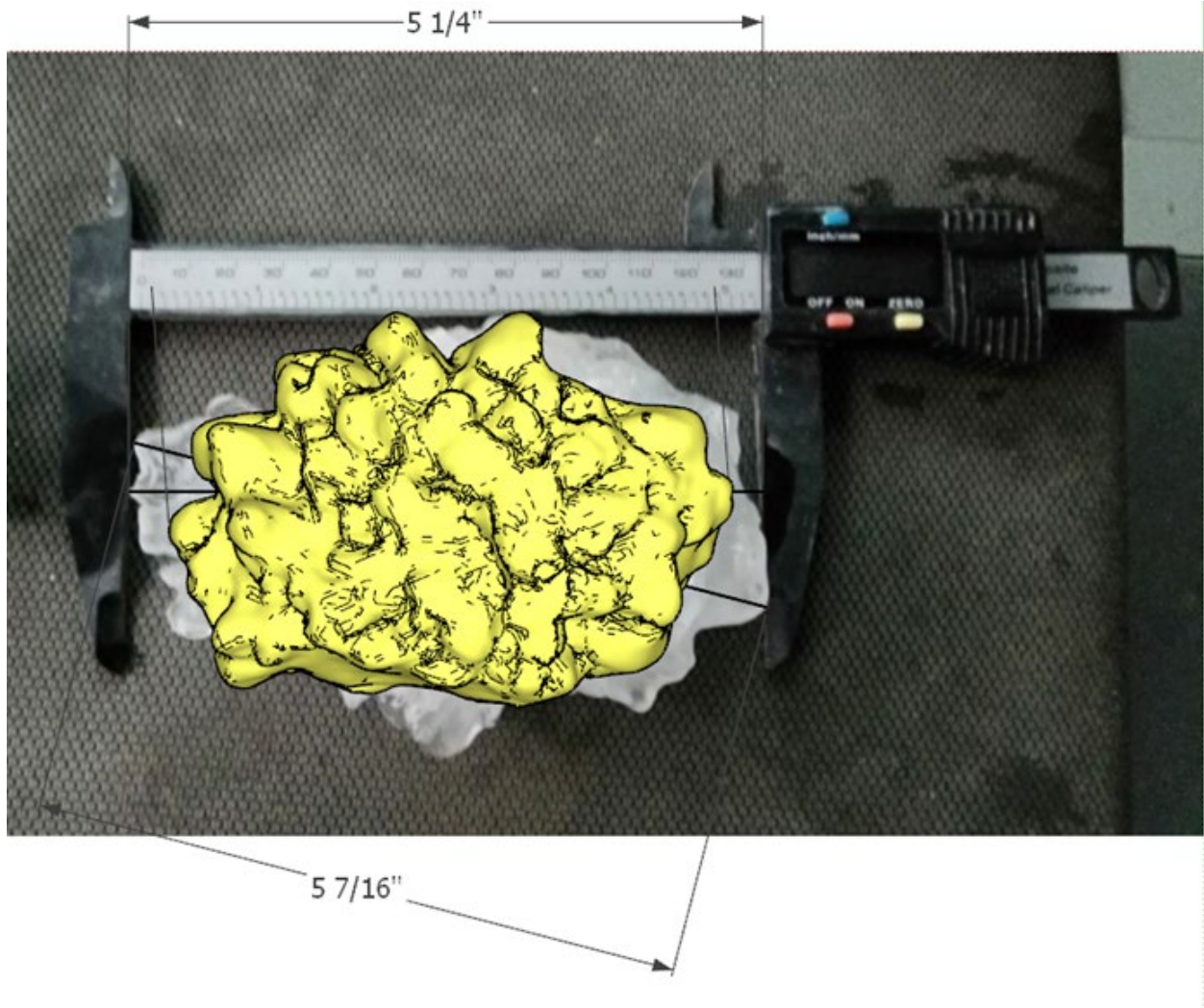


Fig. 4: Comparison of the hailstone photographed by Dan Fitts with a rendering of the existing record hailstone from Bethune in August 2019 (shown in yellow). Provided by Ian Giammanco of IBHS.

Finally, the analysis shown in Fig. 5 compares the 5.25" distance on the caliper, with an estimate of the axis of the hailstone with the maximum diameter, which was very slightly offset from the axis that was measured. This analysis indicates a maximum diameter of $5 \frac{7}{16}$ inches, or 5.44 inches.

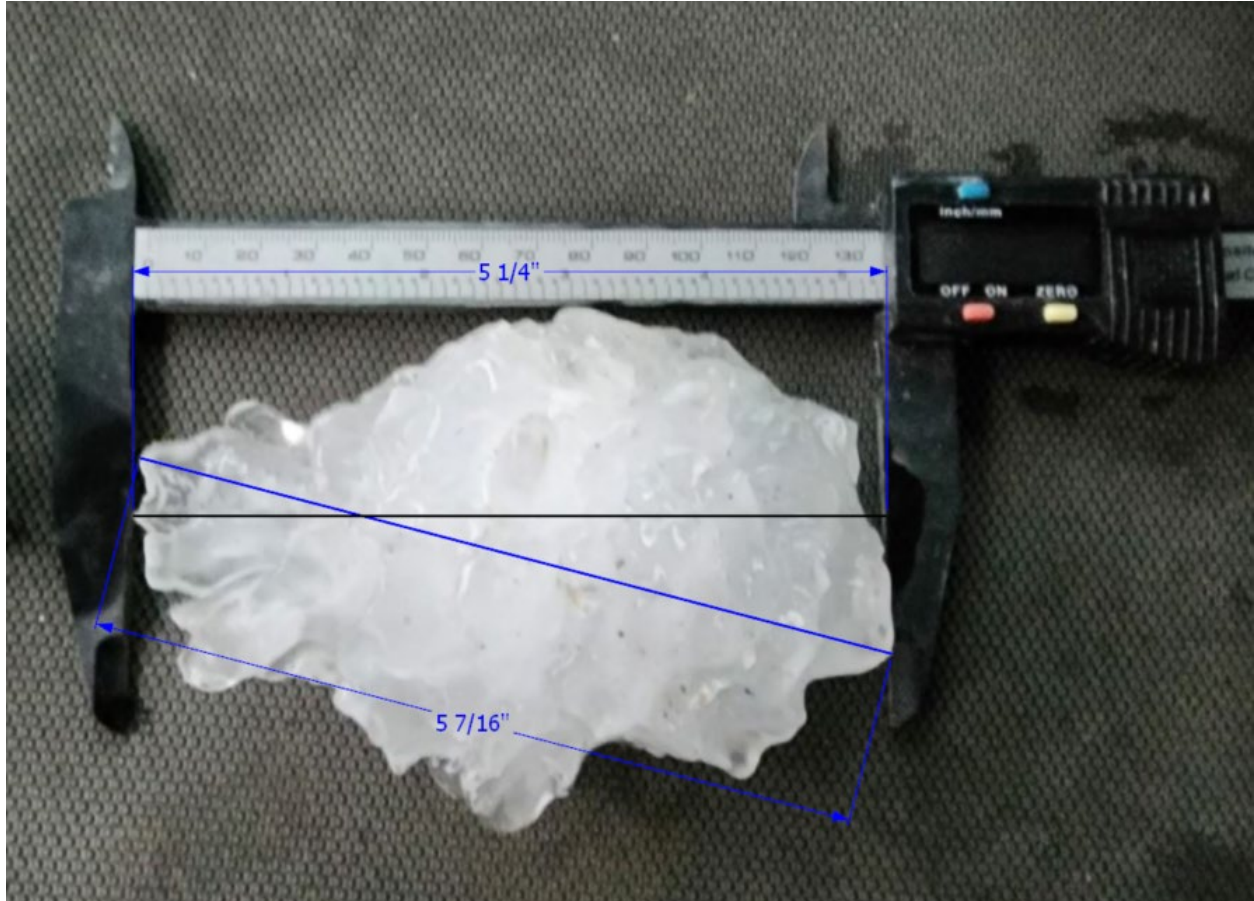


Fig. 5: Analysis of the apparent maximum diameter of the hailstone with respect to the caliper measurement, provided by Ian Giammanco of IBHS.

The committee assessed this line of evidence to determine whether a value larger than 5.25" should be established as the record. Visually, the edge of the hailstone does appear to extend slightly beyond the caliper measurement, and the existing measurement appears to be slightly offset from the maximum diameter. On the other hand, with a 2-D photograph, it is impossible to know what the 3-dimensional structure of the hailstone was on the right side (in the photograph) and where exactly the caliper is touching the stone. As a result, the committee felt more confident in using the caliper as photographed, rather than using the computer-based estimate that is no longer possible to confirm with the physical hailstone.

Meteorological Plausibility of the Observation

The hailstone fell from a long-lived supercell thunderstorm that moved southeastward across Yuma County on 8 August 2023. The Storm Prediction Center highlighted much of northeastern Colorado in a 30% probability for severe hail in their 1630 UTC outlook, with a “hatched” area indicating a greater than 10% probability of hail greater than 2” in diameter.

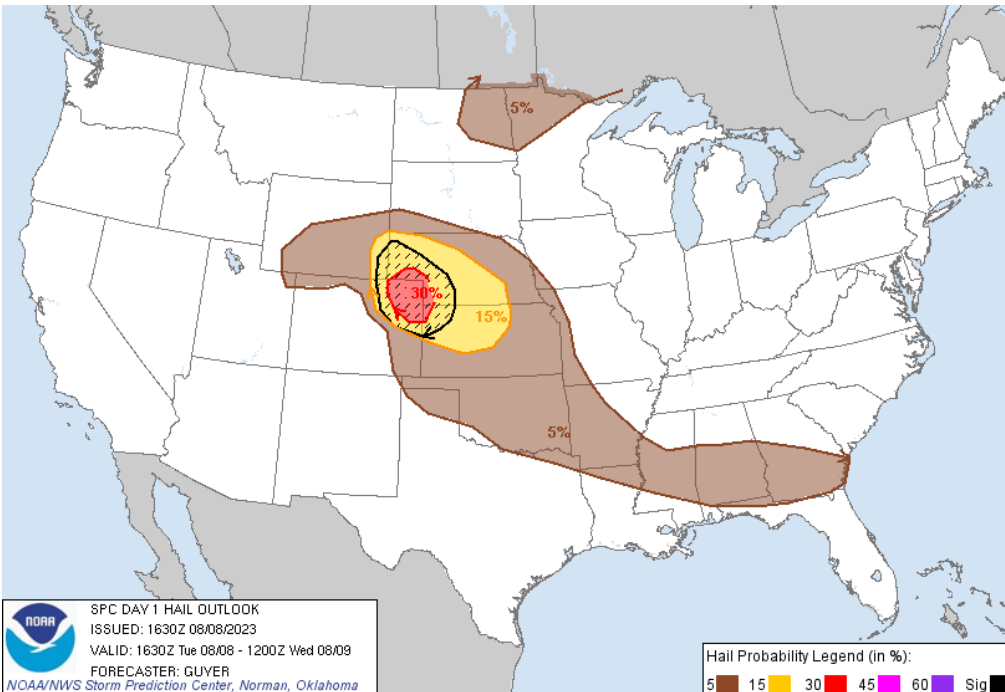
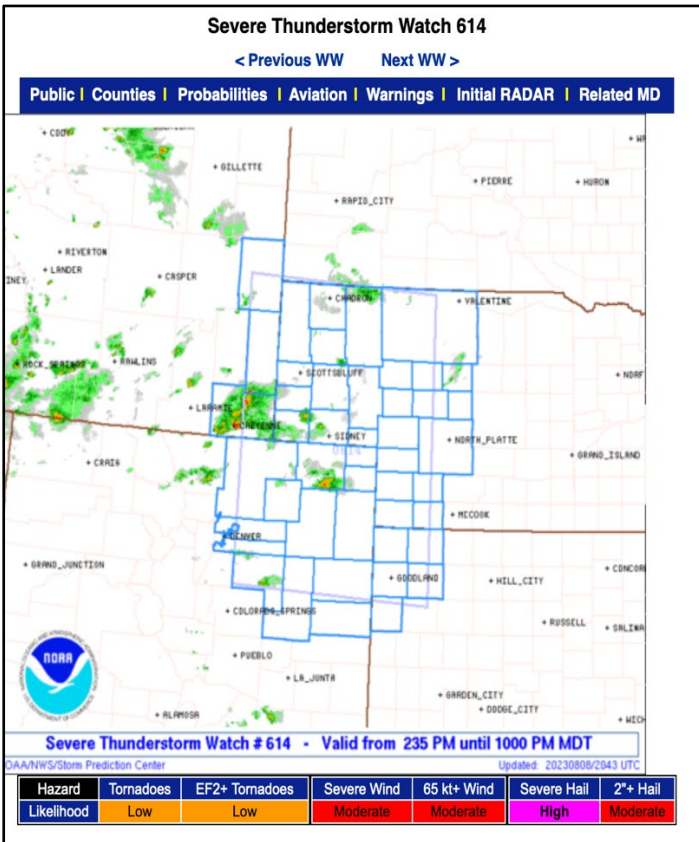


Fig. 5: SPC convective outlook issued at 10:30am local time on 8 August 2023, showing a 30% probability of severe hail, with a “hatched” region indicating a greater than 10% probability of significant (greater than or equal to 2” diameter) hail over northeast Colorado.

From the discussion associated with this outlook (emphasis ours):

Strengthening late-day westerlies (35-45 kt) will contribute to elongated, nearly-straight hodographs, while buoyancy with 2500-3000 J/kg MLCAPE should be maximized across northeast Colorado and southwest Nebraska. Splitting supercells are expected with a north/south-oriented cluster likely evolving relatively quickly as outflows consolidate towards the Colorado/Nebraska/Kansas border vicinity. **The potential for a longer-track discrete supercell or two appears greatest along the southern periphery of convective development owing to lack of interference from other storms. Very large hail, significant severe wind gusts, and a tornado or two are all possible.**

At 2:35pm Mountain Daylight Time, a Severe Thunderstorm Watch was issued that mentioned the potential for very large hail.



URGENT – IMMEDIATE BROADCAST REQUESTED
 Severe Thunderstorm Watch Number 614
 NWS Storm Prediction Center Norman OK
 235 PM MDT Tue Aug 8 2023

The NWS Storm Prediction Center has issued a

- * Severe Thunderstorm Watch for portions of
 Northeast Colorado
 Northwest Kansas
 Western Nebraska
 Southeast Wyoming
- * Effective this Tuesday afternoon and evening from 235 PM until
 1000 PM MDT.
- * Primary threats include...
 Scattered large hail likely with isolated very large hail events
 to 3.5 inches in diameter possible
 Scattered damaging winds and isolated significant gusts to 75
 mph possible
 A tornado or two possible

SUMMARY...Widely scattered severe storms will develop through late
 afternoon/early evening across the region, including supercells
 capable of very large hail and some tornado risk, especially with
 the storms across far northeast Colorado/far northwest Kansas/far
 southwest Nebraska. Storms will gradually cluster by early evening
 with an increased potential for damaging winds, some of them capable
 of significantly strong and destructive winds.

Fig. 6: Storm Prediction Center Tornado Watch #614, issued at 2:35pm local time on 8 August 2023, which mentions "isolated very large hail events to 3.5 inches in diameter."

The supercell storms in Yuma County on the evening of 8 August 2023 produced numerous large hail reports, including other reports of 4-inch diameter hail. The location of the storms at approximately the time of the record hailstone is shown in radar imagery in Fig. 7, along with the locations of other severe weather reports.

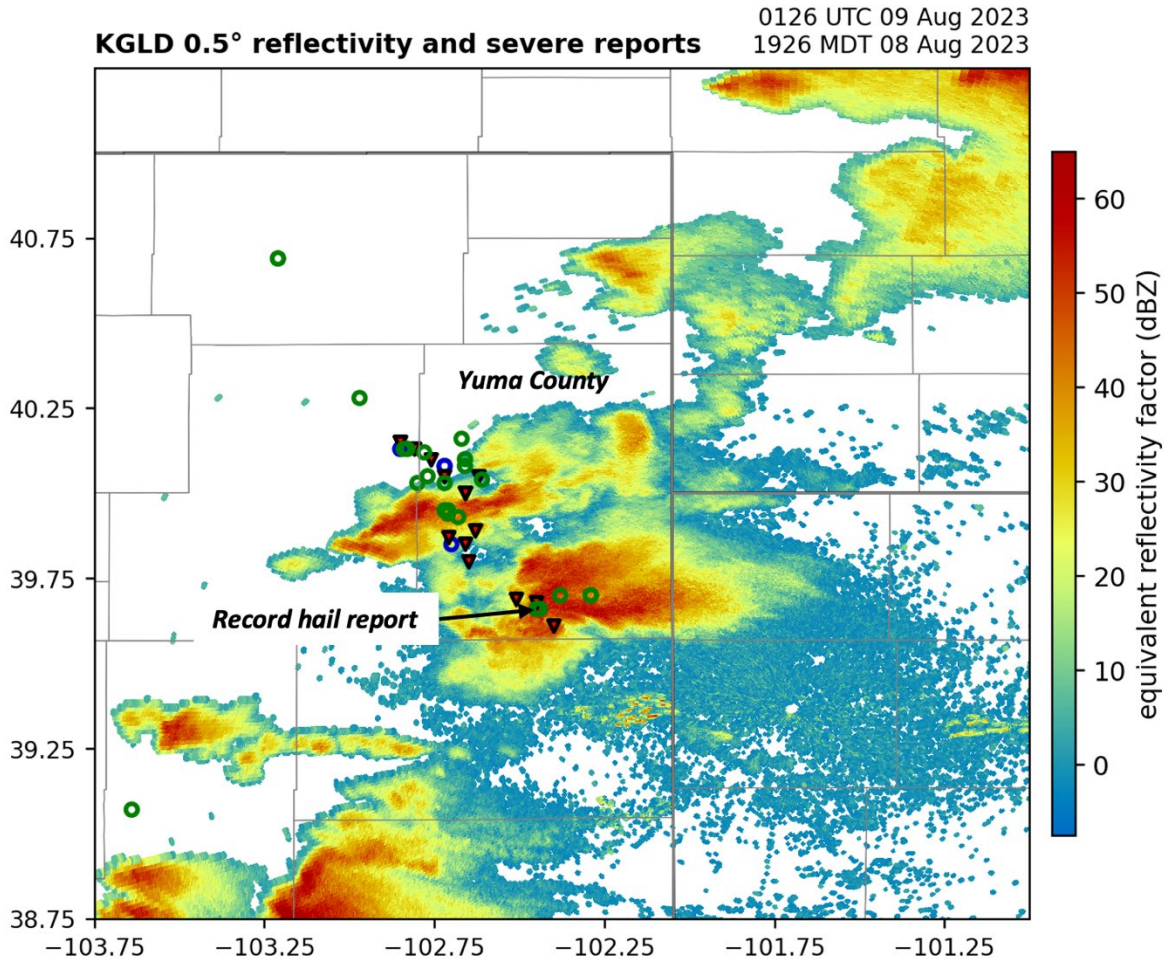


Fig. 7: Radar image from the KGLD radar at 0126 UTC 9 August 2023 (7:26 pm MDT 8 August), with the locations of severe weather reports indicated (green squares indicate severe hail; red triangles indicate tornadoes.)

Previous Records

The previous SCEC-established Colorado state records for hail were all set on 13 August 2019 near Bethune (Schumacher et al. 2019). The weight, circumference, and volume records set from that hailstone will remain the state records for Colorado.

Finding of committee

Owing to the loss of mass from melting of the hailstone between when it was collected and transported to NWS Goodland, the committee was unable to assess its weight, volume, or circumference at its original size. The measurements that were made from the preserved stone did not exceed the existing records set in August 2019 near Bethune, and as such those records will still stand.

However, the clear photographic evidence, along with additional analysis and examination of the meteorological plausibility, led the committee to conclude that the hailstone that fell in Yuma County on 8 August 2023 exceeded the maximum diameter of the existing record. **Therefore, we conclude that a new record hailstone diameter has been established for the state of Colorado, of 5.25 inches.**

Committee Members:

- Russ Schumacher, State Climatologist, Colorado Climate Center, Colorado State University
- Audra Bruschi, NWS Central Region Climate Services Program Manager
- Rezaul Mahmood, Director, High Plains Regional Climate Center
- David Thede, Senior Meteorologist, National Weather Service WFO Goodland, Kansas
- Karin Gleason, Chief, Monitoring Section, National Centers for Environmental Information

Technical experts and contributors:

- Lucas Faulkner, Amaya Emmons, and Ian Giammanco (Institute for Business and Home Safety)

NCEI Climate Monitoring Chief Decision:

Approved

as recommended in boldface above:

Not approved

returned to SCEC with no action taken:

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Recommendations

An additional line of evidence based on computer-aided analysis of the 8 August 2023 hailstone suggests that its diameter was larger than 5.25 inches in the provided photograph. Based on past practice and some uncertainty among the committee regarding this estimation technique, the committee agreed that 5.25 inches was the appropriate value to establish as the record diameter, but that this conclusion could potentially be revisited in the future as computer-aided estimates become more commonly tested and used.

Acknowledgments

The SCEC thanks Dan Fitts for his efforts to collect, document, and preserve this hailstone, and for providing additional information about his observation. We also thank IBHS for their continued

contributions to hailstone measurement techniques, and for providing the additional analyses included in this report.

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>
- Schumacher, R.S. and Coauthors, 2019: State Climate Extremes Committee Memorandum, Colorado Record Hailstone near Bethune: <https://www.ncdc.noaa.gov/monitoring-content/extremes/scec/reports/20191004-Colorado-Hailstone.pdf>