

# MEMORANDUM FOR THE RECORD

1 Nov 2010

Subject: Official Documentation of the Verification of the Vivian, SD record setting hailstone of 2010

From: Deke Arndt, Chief, Climate Monitoring Branch, National Climatic Data Center

## Summary:

On 28 July 2010, the National Climate Extremes Committee (NCEC) reviewed the circumstances surrounding a hailstone that fell at approximately 6pm local time July 23, 2010 in Vivian, South Dakota. Committee Members Jim Zdrojewski (National Weather Service) and Deke Arndt (National Climatic Data Center) participated in the call. Dr. Kelly Redmond, the third member of the committee, reviewed the facts subsequently.

The committee considered the following factors in their decision: *bona fide* nature of hailstone, meteorological plausibility, and methods of handling and measurement. After reviewing the observational evidence, the NCEC unanimously agreed that the hailstone did indeed break the national record for diameter and weight of hailstone falling in the United States. In particular, the committee found that the following were true and valid:

- LOCATION: Vivian, South Dakota
- TIME: approx. 6pm CDT of 23 July 2010
- DIAMETER: 8.0 inches
- WEIGHT: 1.9375 pounds (1 pound, 15 ounces) or 0.879 kg

The diameter and weight both established new records for hailstones observed in the United States. The stone's measured circumference of 18.625 inches was also found to be valid, although a stone with greater circumference fell in Aurora, Nebraska on 22 June 2003.

## Sequence of Events, Examination & Decision

### Background

During the late afternoon and early evening hours of 23 July 2010, thunderstorms developed over portions of central South Dakota. One very strong supercell thunderstorm moved southeastward across portions of Stanley, Jones, and Lyman counties. One of the hardest hit locations was the community of Vivian, South Dakota, where extremely large hail, destructive winds to 80 mph, and a brief tornado were reported.

The hailstone discussed in this report was ultimately discovered in Vivian, South Dakota and was reported to WFO Aberdeen by local observer Mr. Les Scott.

## Storm Environment & Meteorological Plausibility

The stone fell from a storm that developed in a very favorable environment for supercell thunderstorms, which frequently produce large hail. Very warm, moist air at the surface, combined with conditions higher in the atmosphere established very large values of instability (an indicator of the potential strength of storm updraft). In particular, the estimated Convective Available Potential Energy approached 4,500 J/kg in the region (this value is quite extreme: 1,000-1,500 J/kg is often cited as a “rule of thumb” threshold for the potential to support severe weather). Strong wind shear (the turning of winds in the lower atmosphere, related to the potential for storms to tilt and rotate) was also evident in the region.

In addition to the near-storm environment, radar-based observations of the thunderstorm near Vivian had several signatures that indicate a high-end supercell thunderstorm. Radar reflectivity values in excess of 70 dBZ indicated a near-certainty of large hail associated with the storm. Radar velocity information indicated pronounced storm-scale rotation, another indicator of high-end severe weather. Indeed, five hail-related injuries were reported in the wake of this storm.

According to local authorities and NWS Aberdeen, extensive structure damage occurred in the town of Vivian, including broken windows and holes in roofs due to the large hail. Several vehicles on nearby I-90 sustained major damage. Some dents in the vehicles measured 10 inches across.

A more detailed meteorological assessment was provided online by WFO Aberdeen. At the time of this report, it was available at: <http://www.crh.noaa.gov/abr/?n=stormdamagetemplate>. An archived copy of the WFO assessment is also available via the Record Investigation Reports section of the National Climate Extremes Committee website: <http://www.ncdc.noaa.gov/extremes/ncec/>.

## Hailstone Collection, Report and Measurement

Local resident Les Scott collected several very large hailstones on his property in Vivian. They lay on the property for several minutes before he retrieved several. He reported that when he first went outside, the largest stone (the focus of this report) had a diameter of 11 inches. Mr. Scott kept that hailstone in his freezer; however, the stone was uncovered and a loss of power (related to the impact of the parent thunderstorm) resulted in some melting to the hailstones.

A WFO Aberdeen representative arrived the morning of 24 July 2010, and verified that the stones presented were *bona fide* hailstones. The largest stone measured 8 inches in diameter along its longest axis. The term "diameter" is here taken to extend to the ends of the spike-like protrusions, and is further taken to be the largest among all possible measurements of the oblong shaped stone. It also measured approximately 18 5/8 inches in circumference around the same axis. The WFO Aberdeen representative confirmed that, upon measurement, it appeared that some more melting had taken place. The observer subsequently kept the stone in a sealed plastic bag.

Several days later, the stone was measured on a scale provided by the U.S. Post Office in Vivian, SD. The measured weight was 1 lb, 15 oz.

As with many very large hailstones, it is almost certain that this stone was larger upon impact than it was at the time of measurement and documentation. The combination of outdoors exposure before retrieval, repeated handling, and power loss certainly contributed to melting or sublimation of the stone. However, as with any large stone, the official dimensions are taken as those recorded at the time of measurement.

### **Finding of Committee**

All of the above evidence was presented to the NCEC during a one-hour teleconference call on 28 July 2010. The NCEC solicited the input of WFO Aberdeen and several highly-regarded hail experts to assist with its analysis.

The storm and storm environment supported the probability of very large hail. In addition to the largest hail stone, many other stones with diameters exceeding 6 inches were noted during WFO Aberdeen's storm survey. Another very large stone, collected from the same property, would have been considered for the national record if not for the 8.0-inch stone in question.

Based upon the thoroughly-documented evidence (photographic and field notes), the NCEC and all experts on the teleconference agreed that all measurements associated with the stone were valid.

Consequently, the Vivian, SD hailstone was unanimously acknowledged (by a vote of 3-0) by the NCDC to establish new United States records for the dimensions of diameter and weight. These exceeded existing records of 7.0 inches (on 22 June 2003 in Aurora, NE) and 1.67 pounds (on 3 September 1970 in Coffeyville, KS), respectively. The Aurora, Nebraska hailstone retained the record for circumference (18.75 inches).

The NCEC commends WFO Aberdeen on their expert handling of the stone and the situation. Their participation in the process was vital to the quickness and confidence of verifying this extreme event.

### **Participation:**

Committee members:

- Deke Arndt, National Climatic Data Center
- Jim Zdrojewski, National Weather Service
- Dr. Kelly Redmond, Western Regional Climate Center

Also participating in the call:

- Jim Scarlett, NWS WFO Aberdeen, SD
- John Eise, NWS Central Region Climate Services Program Manager
- Nolan Doesken, Colorado Climate Center
- Dr. Karsten Shein, National Climatic Data Center

**Appendix I: A Photograph of the Stone Showing Diameter**

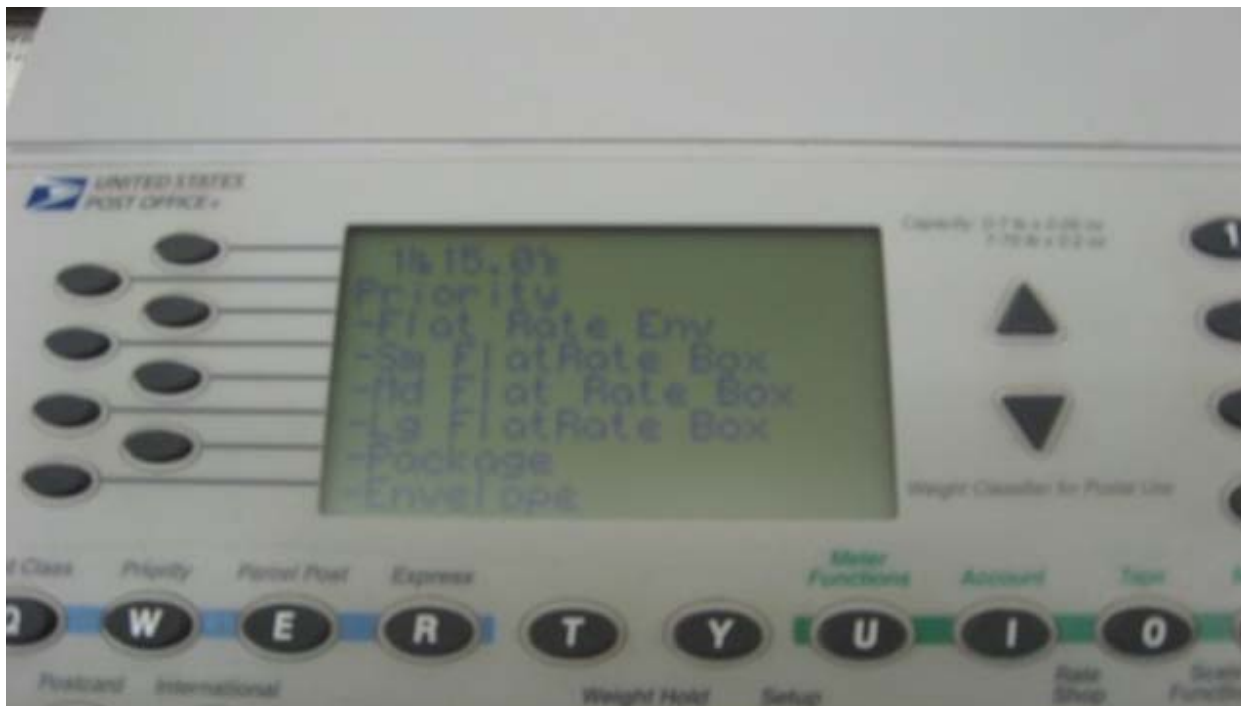




## Appendix II: A Photograph of the Stone Showing Circumference



### Appendix III: Photographs of the Stone Showing Weight





#### Appendix IV: A Photograph of the Stone's Divot

