

STATE CLIMATE EXTREMES COMMITTEE
Proposed standards for the collection, storage and measurement of hail stones
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Compiled by representatives of the State Climate Extremes Committee in cooperation with the NOAA National Weather Service and the American Association of State Climatologists

1. FORWARD

On 16 July, 2009, a 3 ¼-inch diameter hail stone was observed and collected in Westford, VT, and the State Climate Extremes Committee SCEC was convened to adjudicate the hail stone as the largest hail stone on record for the state of Vermont. During the course of discussion, the members of the committee questioned whether there existed a prescribed set of standards for the collection, storage and measurement of hail stones. Because hail annually causes several million dollars in damage to the United States, the quantification of maximum hail stone size is important in considering potential damage capabilities of severe thunderstorms. In fact, as of 5 January, 2010, the National Weather Service will change its hail size threshold for issuing severe thunderstorm warnings (SVR), and severe weather statements (SVS) from 0.75 inch (penny size) diameter to 1.0 inch (quarter size) diameter. However, a review of authoritative documents failed to reveal an accepted methodology for consistently and objectively deriving hail size measurements. Therefore, the SCEC discussed the basic methodologies it would wish to see applied to hail stone collection, storage and measurement in order to ensure consistency and comparability in hail stone observation.

2. EXISTING INFORMATION

Presumably owing to the lack of precision measuring devices (*e.g.*, rulers, calipers) possessed by the general public, historical measurement of hail stone size has generally been done by estimating the hail stone size relative to the approximate size of a known object, such as a penny or grapefruit. These objects are usually common items of a particular culture or region, and may not be directly comparable to estimates from other locations. For the United States, Table 1 contains a list of common comparison items compiled from information published on the Internet by the NOAA Storm Prediction Center and by the NOAA NWS Eastern Region Headquarters (Skywarn Training). These comparisons are primarily intended for the lay public to provide some estimated size information when making a report of hail to the National Weather Service.

For official weather observing stations in the United States, the Office of the Federal Coordinator for Meteorology provides some measuring and reporting guidance in the Federal Meteorological Handbook FMH-1. For example, "Table 8-6 contains a summary of the present weather observing and reporting standards according to the type of station." Hail is an "Augmented" report at designated automated stations. When hail is manually reported, "Report GR, time of beginning and time of ending, estimated size of largest hailstone in inches preceded by 'GR'." For small hail and/or snow pellets, "Report GS, time of beginning and time of ending." Further on, in section 12.7.1.n the precision of measurement is described. "At designated stations, the hailstone size shall be coded in the format, GR_[size], where GR is the remark identifier and [size] is the diameter of the largest hailstone. The hailstone size shall be coded in ¼ inch increments (see paragraph 8.5.1.c(8)). For example, "GR 1 ¾" would indicate that the largest hailstones were 1 ¾ inches in diameter. If GS is coded in the body of the report, no hailstone size remark is required."

Table 1: Common Object-to-Size conversion for hail stones.

From: <http://www.spc.noaa.gov/misc/tables/hailsiz.htm> and <http://www.erh.noaa.gov/lwx/skywarn/hail.html>. Rose shaded sizes indicate diameters considered to contribute to the classification of a "severe" thunderstorm or weather event (effective 5 January 2010).

HAIL SIZE (in.)	OBJECT ANALOG REPORTED
0.25	Pea
0.50	Small marble*, moth ball
0.75	Penny, large marble*
0.88	Nickel
1.00	Quarter
1.25	Half dollar
1.50	Walnut*, Ping Pong ball
1.75	Golf ball
2.00	Hen egg*, Lime*
2.50	Tennis ball
2.75	Baseball
3.00	Tea cup*, Hockey puck
4.00	12" Softball
4.50	Grapefruit*
4.75	Computer CD or DVD

* Items of widely variable diameter, such as marbles or walnuts have been used in the past, but are discouraged for reporting purposes.

The World Meteorological Organization, in its standards for meteorological phenomena reporting codes (WMO Code 6001 NCM Table 23), provides coding classifications for four categories of hail size to be used in the "Day of Hail" section of the report. These categories are: less than 5 mm diameter, 5-9 mm diameter, 10-19 mm diameter, and 20 mm diameter or greater. However, the procedure for measuring hail diameter is not defined.

3. STANDARDS FOR HAIL COLLECTION, STORAGE, MEASUREMENT, AND REPORTING

Owing to the lack of scientifically accepted standards for the collection, storage and measurement of hail stones, the SCEC convened for the adjudication of the aforementioned Vermont hailstone has compiled the following recommendations that hereafter shall be required for consideration of a statewide record status for a hail stone. It is hoped that these standard guidelines will permit hail stone records to be compared against each other both in space and time, and will minimize the vagueness that currently exists in hail size estimates.

A. Summary of proposed collection and measurement guidelines:

While the following guidelines go into detail, the observer may successfully retrieve and store a large hailstone for later measurement by following a few simple steps:

- 1. Never retrieve a hailstone until it's safe to do so.**
2. Take pictures of the stone if a camera is available – put a ruler or object of known dimensions on the ground next to the stone for perspective.
3. Wear gloves or use a towel or tongs to minimize heat transfer when you pick up the stone.
4. If a ruler and/or scale is available, take direct measurements, otherwise estimate the size.
 - a. Measure the maximum diameter, the maximum circumference, and/or the total weight.
5. Place the stone, alone, in a sealable, transparent plastic bag and seal it.
6. Place the bag with the stone in a freezer as soon as possible.
7. Call the local National Weather Service office to report the stone.

B. Detail of proposed collection and measurement guidelines:

1. Hail Collection

- a. The observer should place their personal safety above the immediate collection of any hail stone. Severe weather conditions pose a significant risk of serious injury or even death. Do not attempt to retrieve a hail stone during such conditions.
- b. Once the observer deems it safe to recover a fallen hail stone, they should retrieve it using gloves, a towel, a pair of tongs, or some other implement that will minimize damage to or melting of the hail stone.
- c. If practical, the hail stone should be immediately placed in a sealable plastic bag, such as a Ziploc® bag. Direct handling should be kept to a minimum.
- d. If the observer has a camera, several photographs should be taken of the hail stone. Photographs should include a ruler or other object of known dimensions for perspective. Photographs may be taken where the stone lies, or during measurement – preferably both.

2. Hail Measurement

- a. If a hail stone is not observed, but rather evidence of the stone having fallen is available (*e.g.*, from a hail pad), measurements may be taken of the impression left by the stone, but the measurements will be considered estimates only.
- b. Observers are encouraged to have a flexible measuring tape in units of at least 0.125 (1/8) inch, and a scale capable of recording to at least the nearest 0.25 (1/4) ounce.
- c. The observer may make the measurements where the hail stone lies, or may transport it, using the procedure outlined in 3.B.1.b, to a location where the ambient temperature, lighting, or other factors are more favorable, or where measurement tools are more readily accessible.
- d. If measurement devices are not immediately accessible, the hail stone should be stored in accordance with Section 3.B.3 until such time as the measurements may be made. The

longer the hailstone resides in an above-freezing environment, the greater will be the reduction in mass and dimensions.

- e. Measurements should be to as precise a resolution as possible, and may be measured in either imperial or metric units, but reported to the nearest tenth of an inch for diameter and circumference and to the tenth of an ounce for weight.
- f. If the hail stone has broken, no attempt shall be made to repair or restore the stone to its original composition. For evaluation of a potential record hail stone, only the largest coherent piece of hail will be considered.
- g. Diameter (maximum diameter of the stone):
 - i. If the observer has a caliper available, they should find the widest part of the hail stone, and apply the caliper ends to each end point of the stone.
 - ii. If the observer has a ruler, they should place the stone on a flat horizontal surface, and place a vertical surface (*e.g.*, a brick, box, etc) touching each end of the widest part of the stone. Use the ruler to measure the distance between the two vertical surfaces. The ruler must have a minimum precision of 1/8 inch.
 - iii. In the absence of a ruler, the distance between the two vertical surfaces may be marked on an underlying sheet of paper for later measurement.
 - iv. If the stone's diameter falls between measurement increments, the lower increment should be used. The observer should not interpolate between measurement increments (*e.g.*, if the diameter falls between 3 1/8 and 3 1/4 inches, 3 1/8 inches should be used, and reported as 3.1 inches).
- h. Circumference (maximum circumference of the stone):
 - i. Using a flexible tape measure (*e.g.*, a tailor's tape), the observer should locate the greatest cross section of the hail stone and encircle the stone with the tape measure and obtain a measurement.
 - ii. If a measuring tape is not available, a length of string will suffice. Preferably, the string should be synthetic so that it does not stretch or contract during or after measurement. Using the string, encircle the widest cross section of the stone, and cut the string at the point it overlaps with its beginning. At a later time, the section of string may be laid flat and measured.
 - iii. As with measuring diameter (Sec. 3.B.2.g.iv), the ruler must be able to at least measure to the nearest 1/8 inch, and if the stone's circumference falls between measurement increments, the lower increment should be used.
- i. Weight:
 - i. Observer should place the hail stone on a scale that is at the least capable of measuring to the nearest 1/4 ounce. Ensure the scale has been zeroed (tared).
 - ii. If the observer does not have access to a scale, he or she shall store in accordance with Section 3.B.3 until a scale can be procured or the stone transferred to a location with an appropriate scale.

- iii. The observer should place the stone in a sealable plastic bag (Sec. 3.B.1.c), or if a bag is not available, that the stone rests on a towel that can absorb any melt water.
- iv. If the stone is resting atop a towel, the weight of that towel when dry must be subtracted from the total weight of the stone and towel combination. If the stone is in a bag, the weight of the empty bag should be subtracted from the total weight of bag and stone.
- j. Rounding: Size measurements should be reported to the nearest tenth of an inch, and weight measurements to the nearest tenth of an ounce. If a measurement falls halfway between reporting increments, the value shall be rounded away from zero (*e.g.*, 3.25 inches is reported as 3.3 inches, while 3.24 inches would be reported as 3.2 inches).

3. Hail Storage

- a. Once retrieved and placed into a sealable, transparent plastic bag, the bag should be sealed and placed into a freezer with an ambient temperature below 32°F (0°C). The sealed bag will prevent loss of mass by melting or sublimation.
- b. Only the hail stone being measured should be placed in the plastic bag to prevent vapor deposition between hail stones or the conglomeration of stones within the bag.
- c. If the stone is to be transferred, the bag should be placed in a suitable portable insulated unit (*e.g.*, a cooler, or portable refrigerator), and surrounded by ice or cold packs to keep the ambient temperature below freezing. Transport should not be delayed once the stone has been placed in the cooler. The cooler should not be opened until the stone is to be retrieved for measurement.

4. Reporting

- a. Even if the observer has not had the opportunity to take measurements, an initial report, utilizing an estimate of diameter should be made to the observer's NWS Weather Forecast Office (WFO).
- b. Once measurements have been made, the measurements shall be reported to the NWS WFO as soon as possible. Copies of any photographs should be forwarded to the WFO.
- c. Ideally, hail reports should contain:
 - i. Date, time and duration of the hail event.
 - ii. Average size of hail and depth of hail on the ground.
 - iii. Any damage, injuries, or fatalities. (reported in Storm Data publication)
 - iv. Maximum diameter and circumference of largest stone (Secs. 3.B.2.g & h).
 - v. Total weight (Sec. 3.B.2.i).
 - vi. Methods used to determine diameter, circumference and weight.
 - vii. If precise measurements are not available, provide estimates to the WFO and, if the hail is thought to have broken a record, the WFO will arrange for calibrated measurements to be conducted.

4. CONSIDERATION OF A HAIL STONE BY THE STATE CLIMATE EXTREMES COMMITTEE (SCEC)

If the NWS WFO of jurisdiction or the state climatologist for the state in question believes that a hail stone, collected and measured in accordance with the aforementioned procedures would potentially set a state record, they may convene a SCEC. The SCEC may only consider actual measurement taken directly from a hail stone. They will not consider any estimated values for the purposes of establishing a statewide record hailstone size. Additionally, the SCEC will not consider any measurements that were derived from the accumulated measurement of several pieces of a single hail stone that was broken (by any cause) prior to measurement (with the exception that if the stone breaks after it has been placed in a sealed bag but before measurement, total weight may be considered). All procedures for the operation of the SCEC as outlined in NWS Instruction 10-1004 shall be followed.

A. SCEC Committee Members (Vermont Hailstone):

These guidelines were compiled from the input of members of the *ad hoc* SCEC that convened to evaluate the record-setting hail stone for Vermont in July 2009. These SCEC members were:

- Andy Nash, NWS WFO Burlington
- Chuck McGill, NWS WFO Burlington
- Lesley-Ann Dupigny-Giroux, Vermont State Climatologist
- Keith Eggleston, Northeast Regional Climate Center
- Lora Mueller, NWS Eastern Region Headquarters
- Nolan Doeskin, Colorado State Climatologist
- Karsten Shein, National Climatic Data Center

A review and input of these guidelines was also solicited from the participants in the E-mail list of the American Association of State Climatologists (AASC) in November, 2009.

Questions regarding this document, the SCEC, or these standards should be directed to:

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