Weather Study – Hail & Radar

Introduction

Many structures are struck by hail every year. Therefore, many buildings must be evaluated for hail damage every year. Not all hail is damaging. There is large hail and small hail. Some buildings are damaged. Some are not.

Often, people will site different sources to support a claim that the area had damaging hail. This article summarizes the limitations and benefits of using historical weather data to support a conclusion that there was damaging hail at a certain specific location.

Definitions

Radar – **RA**dio **D**etection **A**nd **R**anging.

WSR-88D – Weather Surveillance Radar **-** 1988 Doppler.

Base Reflectivity – The reflectivity values from the lowest (1/2 degree) elevation scan.

Composite Reflectivity – An image of the highest reflectivity of all compiled values above a certain location.

Hail – Hail is a form of precipitation consisting of solid ice that forms inside thunderstorm updrafts (NOAA).

The Best Weather Data – A photograph

The weather data that surpasses the most elaborate historical weather radar hail study is a picture taken by a homeowner from their cell phone of hail at the site. It is best if there is something in the background that can verify the location of the photo. A typical cell phone will have a time stamp on the photo. If there is a photo of the hail at the location, what more evidence is needed?

Unfortunately, not everyone takes a picture of the hail that falls on a property. Even more unfortunate, some do not want to admit they took a photo because it was small hail. Or even worse, some have presented photos that were taken somewhere other than the location being studied.

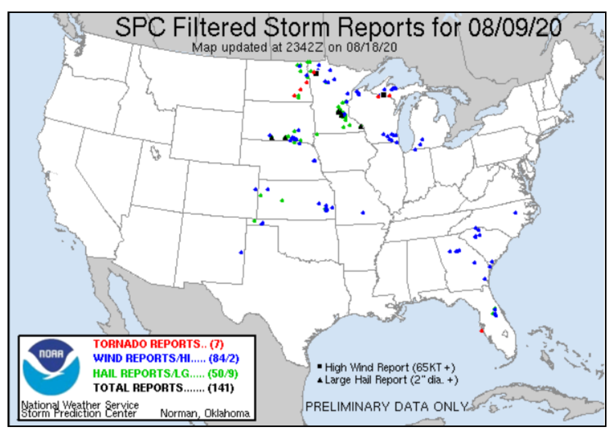
Why Conduct a Weather Search?

When a photo is not taken, eye-witness testimony can provide good information; however, that can be questionable as well. A historical weather search can provide additional information of the hailstorm that passed through an area. A historical weather search can help determine:

- The storm path relative to the loss location
- The reported hail size that was close to the property
- The type of damage that was observed
- The approximate time that the hail fell

National Weather Service (NWS) Storm Reports

Eyewitness storm reports have been around for a long time. The Storm Prediction Center (SPC) gathers and organizes the reports (or sightings) of storm events. The database contains eye-witness accounts of observations.



Source: NOAA's National Weather Service

http://www.spc.noaa.gov/climo/online

The mission of the SPC is to provide forecasts, warnings, watches for severe thunderstorms and tornadoes. It is primarily a warning system to protect life. Wind and Hail data is somewhat of a byproduct.

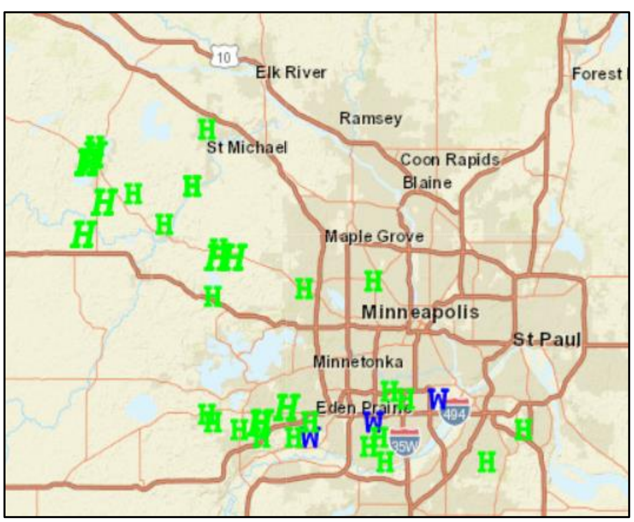
Tabulated NWS Storm Reports

The NWS database records the event type, the time, the location, and a short descriptions of the event. The information is available in table form or in map form. In the case of hailstorms, an approximate hail size is listed for hail that is 1-inch or greater. Hail less than 1-inch is not recorded.

Hail Reports (CSV) (Raw Hail CSV)(?)							
Time	Size	Location	County	State	Lat	Lon	Comments
1545	100	8 W FORDVILLE	WALSH	ND	4822	9797	(FGF)
1545	100	5 W FORDVILLE	WALSH	ND	4822	9790	(FGF)
1643	100	5 WNW OSNABROCK	CAVALIER	ND	4870	9825	NICKEL TO QUARTER SIZED HAIL AND VERY HEAVY RAIN. (FGF)
1705	125	1 S MOUNTAIN	PEMBINA	ND	4867	9786	A FEW HAIL LARGER THAN QUARTERS. MOST WERE DIME TO NICKEL SIZED. (FGF)
1755	100	2 S HUMBOLDT	Kittson	MN	4889	9709	(FGF)
1812	100	2 N LANCASTER	KITTSON	MN	4889	9680	SOME LARGE HAIL ALONG WITH VERY STRONG WINDS AND VERY HEAVY RAIN. (FGF)
1859	100	3 N WARREN	Marshall	MN	4824	9677	(FGF)
1920	125	2 NE THOMPSON	Grand Forks	ND	4780	9708	HAIL ON INTERSTATE 29 ... JUST NORTH OF THE THOMPSON EXIT ... AROUND MP131. (FGF)
2029	100	4 NNE DEBARY	Volusia	FL	2894	8128	TRAINED SPOTTER VOL300 REPORTED DIME TO QUARTER SIZE HAIL IN ORANGE CITY (MLB)

Mapped NWS Storm Reports

The NWS database provides the same information in map form. The approximate location of the report is mapped. Often there are numerous reports of the same event, so the NWS consolidates identical reports to limit overlap. The following map shows hail and wind reports during the 2020-08-10 storm in central Minnesota.



It must be understood that a specific data entry is a record of a point in time at a specific location that may or may not be close to the property in question.

Hail Maps and the Storm Chaser

Storm Chasers have been given a bad reputation. Contractors will often state, "I am not a storm chaser. I have been doing roofing in this area for a long time. I do quality work."

If a contractor claims to specialize in replacing damaged roofs, it is a good idea to concentrate on the areas that have damage. It does makes sense to look for hail areas.

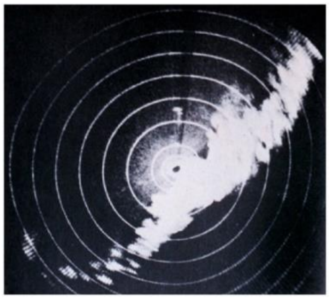
With the advancement in technology, there are several radar based products that provide maps that show areas of likely hail fall. Certain companies produce hail swath maps that show areas where various sizes of hail may have fallen on a certain date. The following image shows a typical hail swath map for the Chicago area.

These maps are not 100% accurate. There are disclaimers attached to these maps that must be read. The following disclaimer is from one such company:

1. This map and the information contained therein are wholly advisory in nature and are provided as is. CompanyName shall have no liability and shall not be responsible for business and legal conclusions, judgments and decisions made with respect to the Map.
2. CompanyName does not warrant and makes no representations regarding the completeness, accuracy, or predictive value of the Map.
3. CompanyName assumes no responsibility for the accuracy of the Map and is not responsible for errors resulting from omitted, misstated or erroneous information or assumptions.

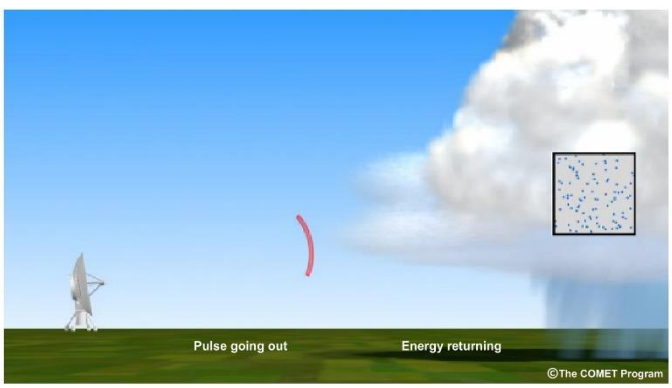
The Invention of the Radar

To understand the limitation of radar, it is important to understand how radar works. Early radar was used to help locate enemy planes in WWII. A signal was sent that bounced off the object and a location was determined. What they also found was interference due to storms. This was the birth of weather radar.

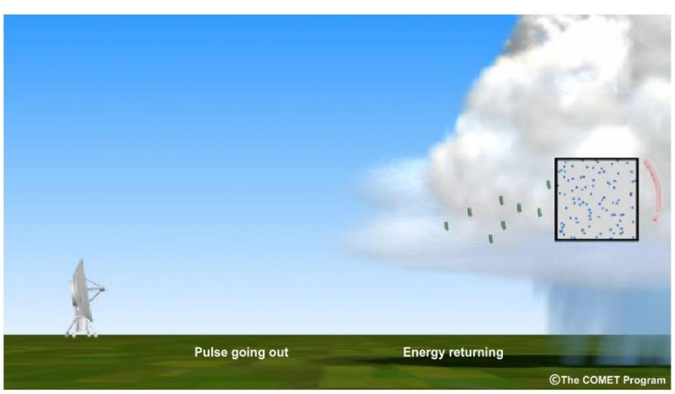


How Radar Works

Modern radar emits pulses of electromagnetic energy at microwave frequencies out into the atmosphere.



The signal bounces off the particles in the storm and is returned to the receiver.



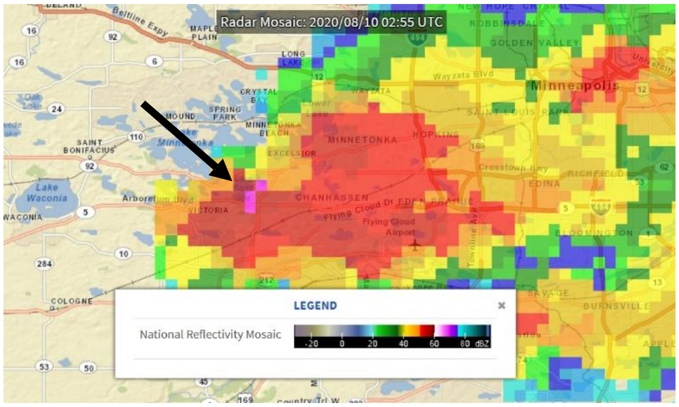
The Radar Equipment

The following is a picture of a radar tower. The dome is a protective barrier. The actual radar is within the dome.

The image below is of a radar within the protective dome. The radar is a two part system that sends out a signal and reads the returning signal.

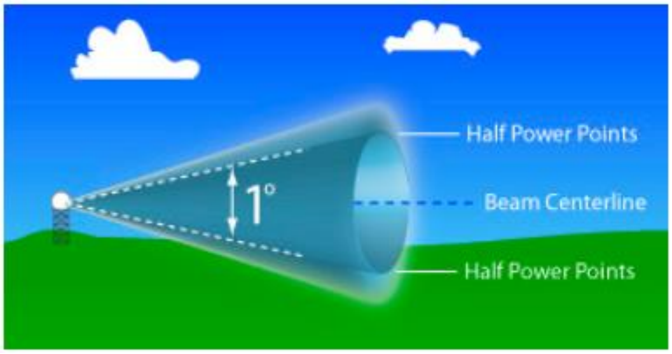
Reflectivity

The data that is returned is presented as reflectivity. The units are in decibels (dBZ). Maps with radar information will normally color code an image showing the highest reflectivity as red or pink. The following image shows a high reflectivity area (pink) at the west end of the storm.



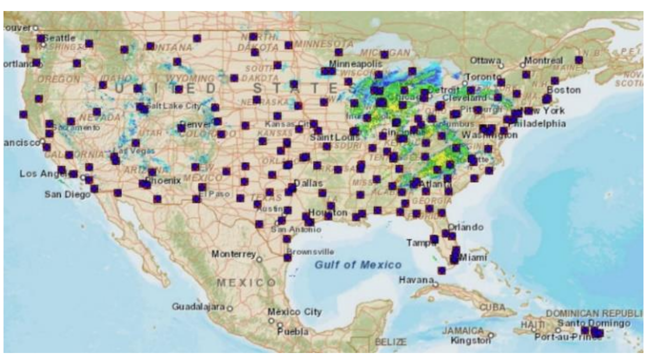
The Radar Signal (Cone Shape)

The radar cone is approximately 1 degree wide and can only capture data at certain elevation. To account for this limitation, radars will go through a pattern of rotating in a full circle and changing the angle of the beam to the ground by physically tilting the dish.



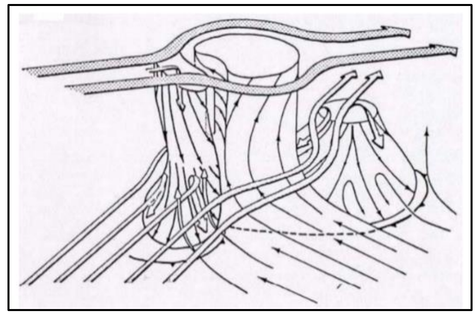
The Radar Signal (Distance Limitation)

Radars have limited distances of coverage area. The limitation in distance is resolved by creating a network of overlapping radars. There are several radar towers constructed throughout the country. The following image shows the location of towers in the USA.



Storms

Storms are very complex. They are ever changing. There are updrafts, down drafts, and rotation. The following image is of a storm showing air flow.

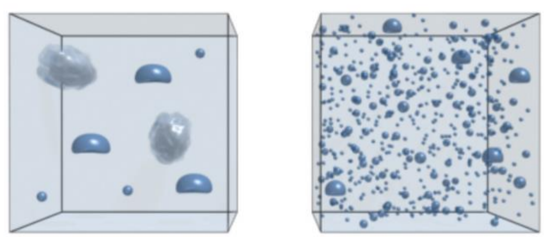


Doppler Radar Meteorological Observations Federal Meteorological Handbook No. 11 Part B Doppler Radar Theory and Meteorology

Sampling a 1 degree slice through a storm is not a great amount of information. Therefore, there are several different angles that are scanned in progression to get readings in a larger volume of the atmosphere.

Identifying Precipitation

The following two boxes show the same amount of matter in the air. The one on the left has big rain drops with large hail. The one on the right has a lot of small rain drops. Both will return the same reflectivity reading.

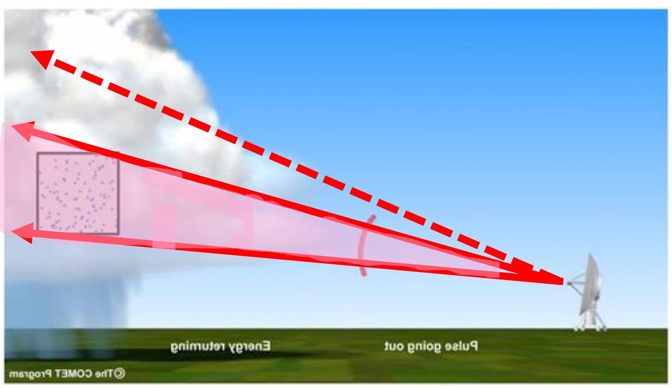


The NWS has upgraded radar to send out waves in both the horizontal and vertical directions (dual-polarization). This technology is able to better distinguish particle size.

The greater the reflection the greater the amount of matter in the sample volume. A value of 45 dBZ indicates intense rain. Anything above 60 dBZ generally means that the sample volume contains some hail.

The Angle of the Radar to the Horizontal

The angle of the radar starts out at 0.5 degrees from the horizontal. The radar rotated 360 degrees as it records information in one full revolution. The dish then rotates upward to measure the reflectivity at a higher elevation. It repeats the process until a representative sample is made that includes multiple cone shaped volumes. The image below shows one such volume at a certain low level angle to the horizontal. The dotted line indicates the next scan angle upward.



For example, a radar set at 10 degrees with a 1 degree wide beam will scan the volume of air at 10 to 11 miles above the surface of the ground 60 miles from the radar.

A radar set at 8 degrees scans the volume of air at 8 to 9 miles above the surface of the ground at 60 miles.

The image below shows 14 angles that are used when scanning the atmosphere for precipitation. This pattern takes approximately 4 minutes to cycle through. After the pattern is complete it starts over again.

The volume that is scanned contain readings at different elevations and at different times based on the limitation of the physical movement of the equipment.

A radar image is not a snapshot image in time of the entire atmosphere. It is a collection of multiple readings at different locations in space representing a total volume.

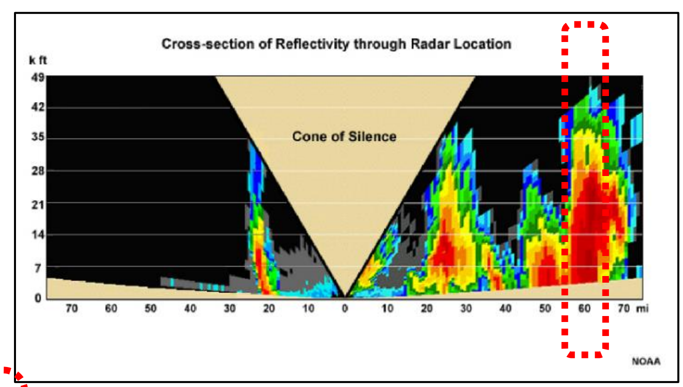
When reading radar information, it will be presented as a base level image or a composite.

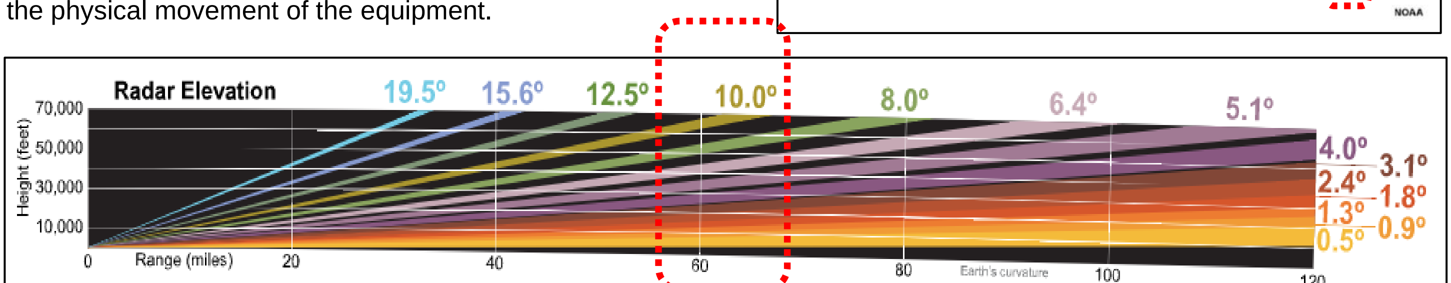
The **base level image** contains the reflectivity reading of the radar at the lowest angle. It captures what has happened near the surface.

The **composite reflectivity image** shows the maximum reflectivity (dBZ) in a given vertical column for all reading at a particular location. For example, at 60 miles from the radar there will be 11 reading above the surface (10, 8, 6.4, 5.1, 4, 3.1, 2.4, 1.8, 1.3, 0.9, 0.5). The composite image will show the highest recorded reflectivity of these 11 reading.

The Dead Zone Above a Radar

The radar cycles through the Volume Coverage Pattern (VCP) which creates a dead spot (a Cone of Silence) above the radar location. The dead zone is shown below. When a storm passes over a dead zone it will appear to fade. The image below shows an exaggerated view of the dead zone above a radar.





VCP 12 & 212 elevations angles.

References

Much of the information in this article can be found at the COMET website and the NOAA websites.

1. The NWS established the Cooperative Program for Operational Meteorology, Education and Training (COMET) in 1989. http://research.atmos.ucla.edu/weather/C227/Documents/tmp/basic_wxradar/print.php.htm#page_contributors
2. National Oceanic and Atmospheric Administration (NOAA) National Centers for Environmental Information has good information regarding radar. https://www.ncdc.noaa.gov/data-access/radar-data

Conclusions

A good inspection at a site is still the best and only means of adequately determining the extent of hail damage to a structure.

Hail damage must be observed and documented. A good inspection will include searching for and identifying collateral evidence of hail.

The following is a summary of what can be concluded from a weather radar study with regard to hail at a certain location:

1. Radar can give an indication of when and where there was hail in the atmosphere. Values above 65 dBZ normally indicate hail in the atmosphere.
2. Radar can give a good indication of the direction of the storm. Therefore, the direction (or path) of the hail can be estimated.
3. Radar normally shows the strong reflectivity readings that coincide consistently with the locations of the NWS storm reports.
4. Hail maps which are produced from radar can give a good indication as to where hail may have fallen out of a storm, but they are not exact.

There are several limitations when using historical weather radar data for a hail study:

1. The collected radar data represents relatively small slices of the atmosphere that are gathered over a period of time.
2. The atmosphere is scanned segmentally in time similar to taking a picture in multiple locations and then re-scanning again approximately four minutes later. A lot of things can move around in four minutes.
3. Material is missed in time. The scans are representative samples. Storms move faster than the equipment.
4. The radar images are large slices of the atmosphere that are thin near the radar and increase in size away from the radar. The scans capture a sample of what has happened. Material is missing in space (location)

   A hailstorm traveling at 40 miles per hour can travel 2.6 miles in 4 minutes. Things change faster than the equipment can record.
5. Where and when hail leaves the atmosphere is not very well understood or readily measured with a high level of accuracy due to how slow the equipment operates and how fast storms move.
6. Hail maps are not exact. There may be hail outside the map locations and there may be areas within the map that have no hail reaching the ground surface.

By Richard T. Abbott, PE, SE
Abbott Consulting Forensics and Design