

RainScatter

Version 1.0

User's Guide and Reference Manual

By

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Introduction

RainScatter is a program designed to aid Radio Amateurs in making contacts on microwave frequencies by using precipitation particles as a scattering medium. It automatically downloads the latest radar images from the National Weather Service and their associated storm attribute tables to identify possible propagation paths between stations. It is designed to eliminate some of the guesswork in identifying potential scattering regions. I hope that it will foster interest in this exciting mode of propagation.

I wish to extend my thanks to Gary Mohrlant (W0GHZ), Richard Bandla (VE3CVG), Dex McIntyre (W4DEX), Mike Reed (KD7TS), Larry Johnson (K0CQ), and everyone else who has provided me with feedback and bug-catching during the creation of this program.

RainScatter is released under the GNU Public License.¹ This ensures that the source code remains available for everyone, and that RainScatter shall forever be free for non-commercial use.

System Requirements

RainScatter can run on just about any platform provided that you have the Java Runtime Environment version 1.4.2 or later installed on your computer. (JRE 1.4.1 will be able to execute the program, but will throw a runtime exception when attempting to download the storm tables.) You also need an active internet connection to access the NOAA radar images (http, port 80) and Storm Attribute Tables (FTP, port 21). This may mean that you need to configure your firewall to allow outgoing connections for these ports. Because of the large image sizes, RainScatter also requires 1024x768 screen resolution or larger.

Installation

Unzip *RainScatterxxx.ZIP* and place the contents in an empty directory. The program executable is *RainScatterxxx.jar*. The other files are files that are required by the program. Do not edit them by hand:

alarmsettings.dat
RainScatter.dat
radarlocations.txt
stations.dat
quickhelp.html

If you do not have the JRE 1.4.2 or later you should download it from Sun's website (<http://java.sun.com>). In the Windows environment the Sun installer will also link the .jar extension with *javaw*, which will give "double-click" execution of .JAR files.

¹ See the GPL website for more information (<http://www.gnu.org/copyleft/gpl.html>). A copy of the GPL is contained in the ZIP archives with the program distribution.

Do a software update on Mac OS 10.x to get the latest version of Java. Once you have the JRE installed you can run the file by double-clicking the .JAR file. You may also run the file from the command-line (on all platforms) by typing:

```
java -jar RainScatterxxx.jar <enter>
```

Initial Setup

Once the main program window appears you should go to **Settings > Radar List**. This will bring up a window which contains all NOAA NEXRAD radar sites in the continental United States. Place checkmarks by 1 to 10 radars in your area and press **OK**. This will save your personal list of radar locations to disk. You can change them at any time by going to this menu.

Next, select your nearest radar location from the pull-down menu in the **Radar Settings Panel**. This will download the current radar image for this location.

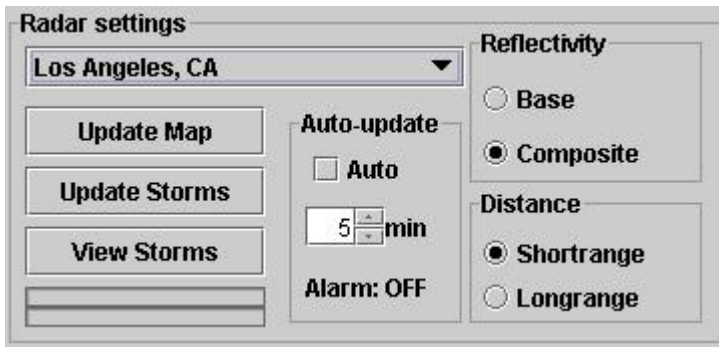


Figure 1: Radar Settings Panel

To set your home location, click the **Set Home Loc** button, type your six-digit grid locator in the box, and press <Enter>. Alternatively you may press the **Set Home Loc** button and click your home location on the map to the left. You may now do the same for the **Set DX Loc** button. You may move these two locations at any time by going through this process. Once set, you should go to **Settings > Save Settings** to record these positions for the next time you start the program.

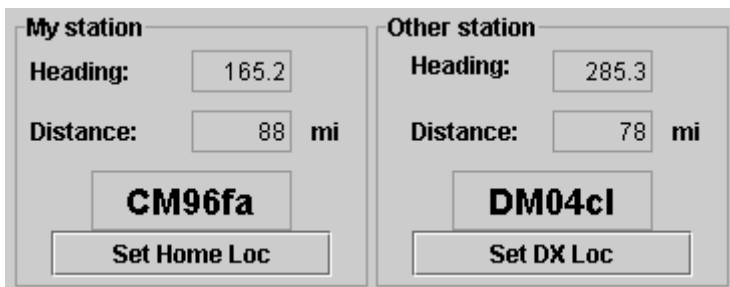


Figure 2: Station Information Panels

Radar Controls

The NEXRAD radar images have two settings: *distance* and *reflectivity*. The **Shortrange** view is the more detailed, but it limits its display to about 140 miles. The **Longrange** view is less detailed but shows reflections out to about 240 miles. The **Base** reflectivity image is produced by scanning for reflections just above the horizon (about 0.5 degrees elevation). The **Composite** image is produced when the radar scans through many elevation angles (up to 22 degrees) to analyze vertical storm structure. This composite image is able to identify potential scattering media held aloft by strong updrafts that may not be visible in the base scan.² Changing either of these settings will update the image accordingly. Pressing the **Update Map** button will refresh the current view. The top progress bar (below the **View Storms** button) will be active while the image is downloading.

The Map Panel

The radar images are downloaded from the NOAA web server and display the reflectivity of the atmosphere on a color scale.³ The scale (on the left side of the image) can be in two ranges depending upon the scanning mode of the radar.⁴ The *clear-air mode* is a very sensitive mode that shows reflectivity up to 28dBZ. This mode is used when the air is generally free of precipitation. The *precipitation mode* is generally used when there is precipitation or the expectation of precipitation. Its scale shows up to 75 dBZ. The very strongest echoes from severe thunderstorms are often in the 60-dBZ range, largely a result of highly-reflective hailstones. Since the NEXRAD radar operates in the 9-GHz range, we may take this to be a reasonable approximation of reflectivity at the 10-GHz amateur band.⁵

The home and DX locations should be visible on the radar image (with a small yellow and white 'X's, respectively), provided that the selected radar includes those areas. There is also a dashed purple line connecting the two with a larger purple 'X' indicating the midpoint between the locations. Clicking the mouse on the map sets the scattering location. In the **Station Information Panels** you will see the headings and distances to this point from both the home and DX locations. Clicking on a storm therefore tells the user where to point the antenna. Both station headings are provided in case the user needs to tell the other station where he should point his antenna when attempting the contact.⁶

Below the map one can see the scattering location as a six-digit grid square, the total path distance between stations via the scattering point, and the scattering angle as measured from the scattering point. Since most 10-GHz stations use horizontal

² It is also the scanning mode that the radar uses to generate the Storm Attributes Table.

³ To see a map of radars and their respective pages, see <http://weather.noaa.gov/radar/national.html>.

⁴ For an overview of the radars' scanning modes, see National Weather Service's radar FAQ page: <http://weather.noaa.gov/radar/radinfo/radinfo.html>.

⁵ It is important to note that the map images themselves do not directly show at what altitude maximum reflectivity was measured. For example, two neighboring storms may show 60dBZ reflections, however one of those storms may register that reflection at an altitude of 15,000 feet and the other at 35,000 feet. This information is provided in the storm tables.

⁶ Headings are calculated by great-circle on a spherical earth.

polarization, the strongest signals will be found when the scattering angle is closest to 180 degrees (storm inline with the direct path) or 0 degrees (direct backscatter), and weakest when near 90 degrees.⁷ When the mouse cursor is over the map the grid square of the cursor's location will appear at the bottom left.

Using the Storm Table

Each NEXRAD radar produces a Storm Attribute Table that contains a list of all storms it can identify along with pertinent information such as height, reflectivity, movement, etc. This table is embedded in a binary file that can be downloaded from the National Weather Service by FTP.⁸ RainScatter will download these files from all of the radars in your personal list (that is, up to 10 radars at once) and parse them into a master storm table. This master table can be viewed at any time by pressing the **View Storms** button in the **Radar Settings Panel**. This master table can be checked against a list of other locations to alert the operator when a storm appears above the horizon for two stations.

To utilize this feature you should enter a list of callsigns and grid squares in the **Station List Window** found under **Settings > Station List**. The callsigns can be any text (usually a callsign, but it does not have to be) as long as it does not contain any spaces. The grid square must be a valid six-digit square. The program will prompt you to fix it if it is not. You can press the **OK** button to save changes. The list will be automatically loaded the next time the program is started.



Figure 3: Station List window showing a list of callsigns.

⁷ For a discussion of scattering angles and polarization, as well as rain scatter in general, see notes by Tom Williams, WA1MBA at <http://www.wa1mba.org/10grain.htm> .

⁸ See the NWS Radar Product Central Collection Dissemination Service at <http://www.nws.noaa.gov/tg/rpccds.html>. The Storm attribute table is appended to Product 37.

To download the storm table, press the **Update Storms** button in the **Radar Settings Panel**. While the data is being transferred you should see the lower progress bar become active. You can also monitor the progress of the download with the messages that appear beneath the **Radar Settings Panel**. The progress bar will turn inactive once the transfer has ended. If any storms in the master table are mutually visible between the home station and any stations in the list, those stations will have buttons in the **Visible Stations Panel**. Likewise, if any storms are visible with the current DX location, there will appear a button labeled “DX”. This list will update every time the storm table is downloaded.



Figure 4: Visible Stations Panel showing that a storm is visible between the home location and KOSM/6, as well as the DX location.

Clicking one of the stations’ buttons will set the DX location to that station’s grid square and bring up the list of storms that mutually visible. This list will appear in the **Storm Table Window** below the **Visible Stations Panel**. It is set to show the most pertinent information about each particular storm. You can view all attributes by using the horizontal scrollbar at the bottom of the window. Clicking on a row in the table will set the scattering location to that storm’s location. This allows the operator to read beam heading and other information for this storm. To see the mutually visible storms with another station, just click on that station’s button.

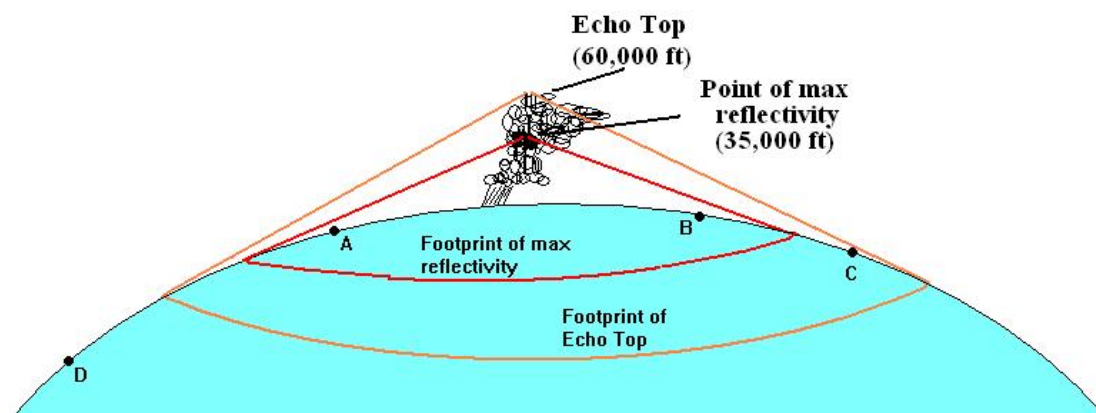


Figure 5: Typical large thunderstorm cell. If station A is the home location, stations B and C would appear in the Visible Stations Window because they are all within the footprint of the storm top. Both A and B are in the footprint of the point of maximum reflectivity. D is not visible to any of the stations because the storm is below D’s horizon.

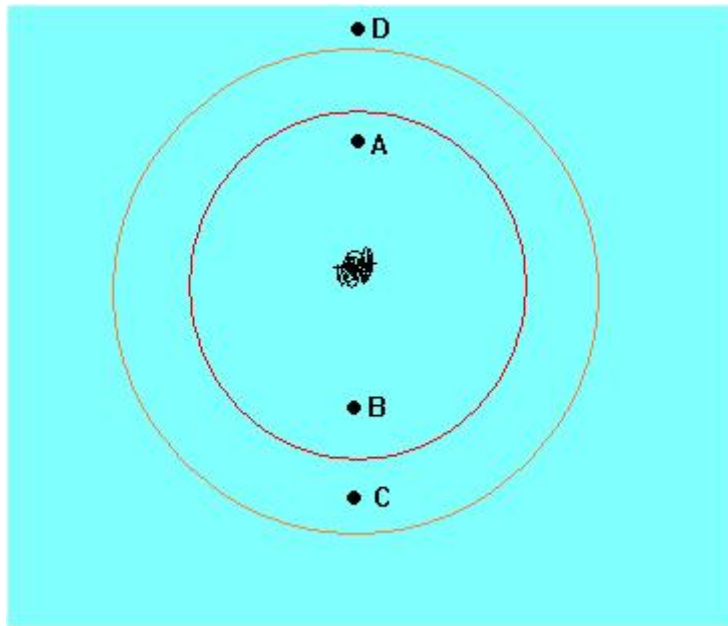


Figure 6: Overhead view of the previous figure.

One should realize that the radar images and storm tables are usually a few minutes old. Since the same dataset is used to generate both the composite radar image and that radar's storm table, the timestamp on the image tells the user how old the the data is. Since storms move, the current location of the storm tower may have changed significantly, particularly on shorter paths. Often the base-reflectivity image will have a newer image to help pinpoint the current location of the storm. The user can then click on the image to get the beam heading. Also, the storm tables keep track of a storms direction and speed, making it possible to extrapolate the current location. This is not likely to be much of an issue over longer distances since the beam headings are not likely to change significantly.

Grid	Top	dBz	Height	Dir	Speed	ID
CM94ks	6.4	41	2.4	NEW	NEW	B0
CM94kr	6.1	41	2.3	NEW	NEW	C0

Figure 7: Example of Storm Table Panel showing mutually visible storm with DX location.

It is important to note that the NEXRAD radar only logs storms within a 140-mile range of its location (essentially what is displayed in the shortrange view). If you wish to have the alarm alert you to a possible path you must have the potential area visible to one of the radars' short-range views, and that radar must be in your personal list. There are pockets of the country that are not visible to any radar's shortrange view. If you are

planning a path that requires coverage of one of these areas, it may be best to watch a radar in your area set to the longrange view. If it shows echoes in this area from a long distance, there is a good chance that you may be able to use them as a scattering medium.

To see the visible range of a storm, you can activate the one or both of the **Footprints** from **Draw > Footprints** menu. Selecting **Echo Tops** will draw a circle that represents the horizon from the very top of the storm. Any station inside of that circle can therefore see the top of the storm. Likewise, selecting **Max reflectivity** will draw a circle showing the visibility from that storm's most reflective point as measured by the reporting radar. You can think of these circles as being analogous to the "footprint" of a satellite. When enabled, these circles will appear anytime a storm is selected in the storm table.

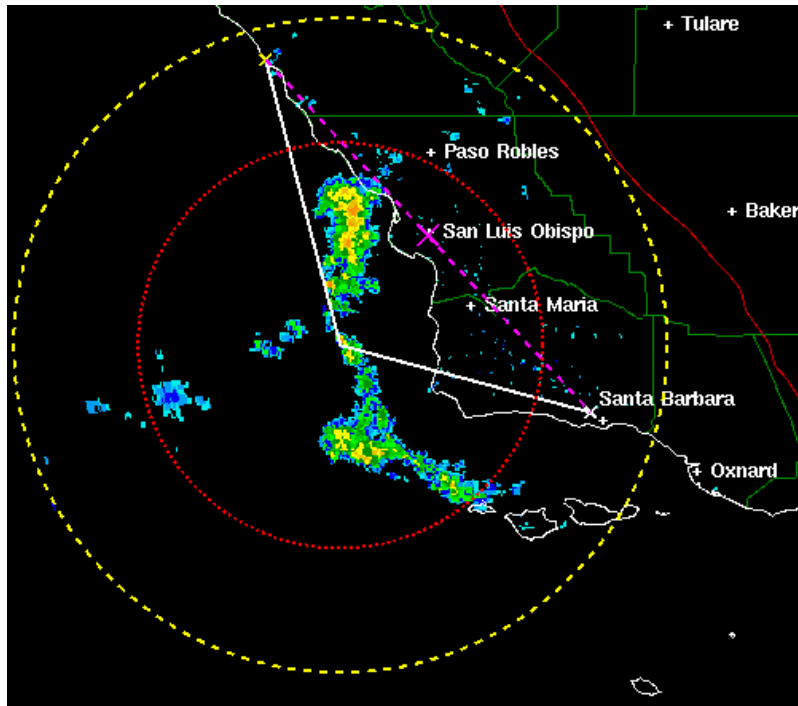


Figure 8: Echo-top circle in yellow (~6400 ft) and max-reflectivity circle (~2400 ft). The dotted purple line shows the direct path between the stations with the purple 'X' showing the midpoint. This image is a result of clicking on the first storm in the previous figure.

Using the Fisheyes

Enabling the Fisheyes (**Draw > Fisheyes**) is useful for investigating potential rain-scatter paths. It will draw a circle around a station's location showing the range for which a storm of a certain height will be visible. For example, setting my home location to EN13vc and the DX location to EN19lu, I can enable the fisheye for 40,000 feet. Two circles will be drawn, one around each location. If a 40,000-ft storm appears inside a circle, that storm will be visible to that station. The intersection of the two circles—the "fisheye"—shows where a 40,000-ft storm will be visible to *both* stations. When planning long paths this feature helps the operator decide which radars need to be monitored for potential rain-scatter paths.

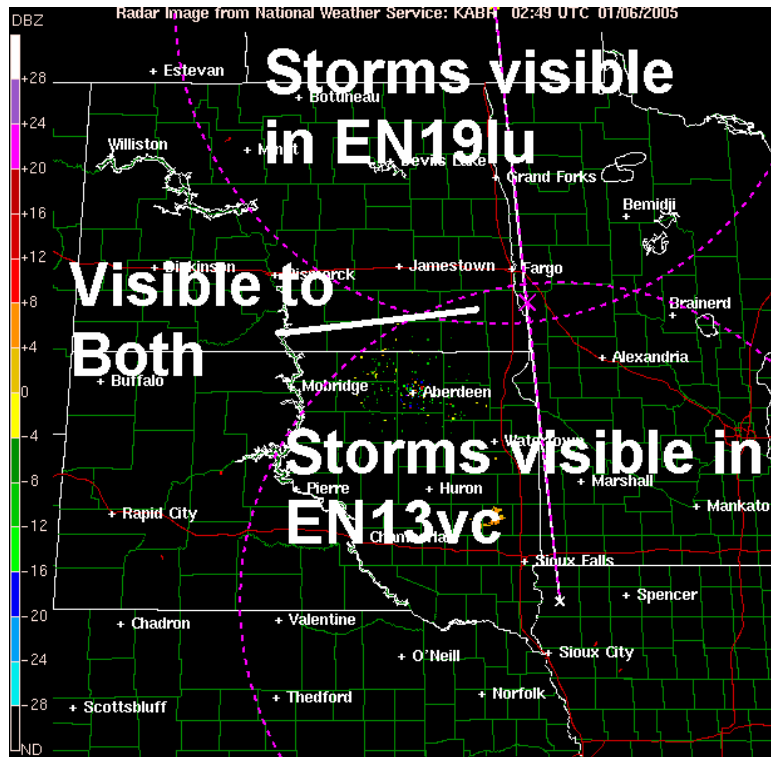


Figure 9: Fisheye for 40,000 feet between EN19lu and EN13vc. These two operators should monitor the Aberdeen, SD and Grand Forks, ND radars in their radar lists because their storm tables will cover this area.

Auto-Update and Alarm

Automatic updating of the image and the storm table is accomplished by placing a check in the **Auto** checkbox in the **Radar Settings Panel**. The updates interval is set by the number of minutes in the box below. When the timer executes, it downloads a new image as well as the most recent storm table.⁹ If pop-ups are enabled in the Alarm Settings Window (available under **Settings > Alarm Settings**) a pop-up window will appear when any of the alarm conditions are met.

This feature has exciting possibilities for contests and overall general activity on the microwaves. For example, if all operators in a region of the country monitor the same radars they will all be aware of the same potential paths at the same time. Such a situation in a contest could result in several long microwave contacts that would otherwise have gone unrealized. In the case of large thunderstorms it may even become possible for operators to call CQ because everyone knows where to point their antennas. One can imagine such a situation turning a lazy summer afternoon into a spectacular DXing event!

Saving and Viewing Images

⁹ While only one image is downloaded, the storm tables for *all* of the radars in the user's personal list will be downloaded.

Radar images may be saved to disk in JPG format by choosing **File > Save image**. This will save only the raw radar image and not any of the graphics produced by the program itself (path lines or any of the circles). A saved image can be opened by choosing **File > Open Local File**. When loading a saved image, be sure to specify the range, reflectivity, and radar location in the panel to the right of the file viewer. This ensures that the image is interpreted properly when the program overlays its graphics.

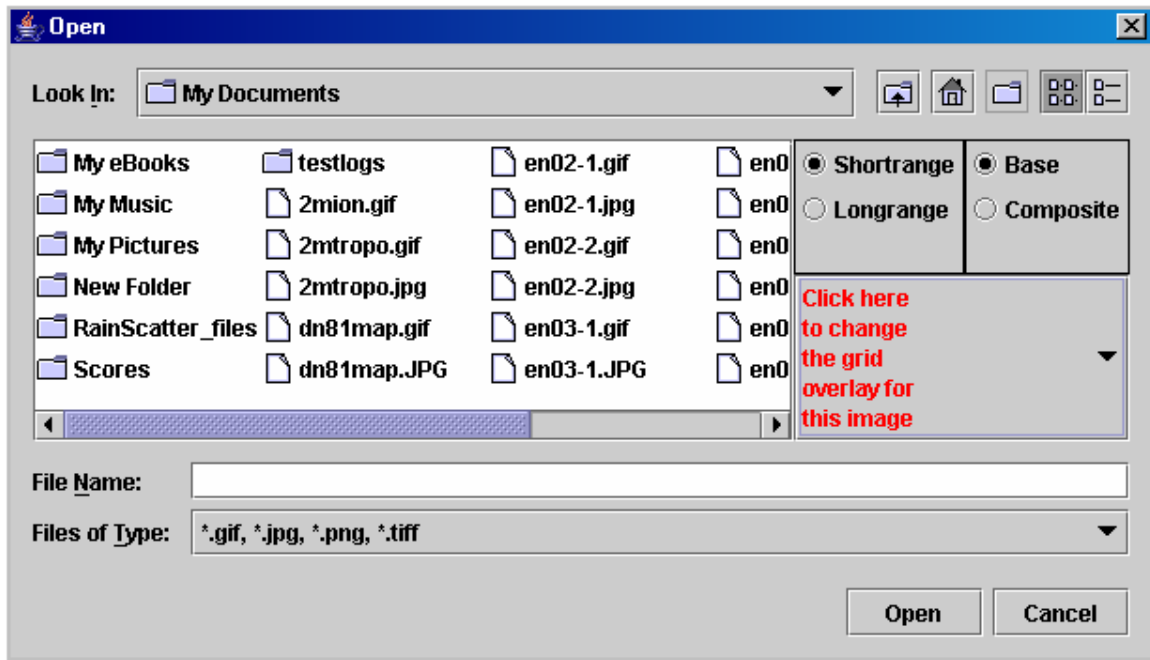


Figure 10: File chooser showing the radar settings

Interpreting the Storm Tables

The storm table presents information about each particular storm identified by the reporting NEXRAD radar. RainScatter parses this information into a format that is useful for rain-scatter communication. The NEXRAD radars have complex algorithms for detecting severe weather, such as TVS, MESO, and hail estimation. This data could be useful for rain-scatter communications, so they are included in the table. Probably the most immediately useful are the altitudes of *maximum reflectivity* and *echo tops*. In addition, large hail may make communication possible on lower microwave frequencies because of the larger scattering particles. This data is provided so that the Amateur Radio community can learn through experimentation.

<u>Attribute</u>	<u>Description</u>
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Grid:	Location of the storm center.
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Top:	The maximum altitude at which the storm returns echoes of 18 dBZ or greater. This altitude is reported in thousands of feet.
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dBZ: The maximum reflectivity of this storm at any altitude.

Height: The altitude of maximum reflectivity in thousands of feet.

Dir: The direction this storm is moving, in degrees.

Speed: Speed at which this storm is moving in knots. (Not maximum winds within the storm)

ID: The alpha-numeric ID of this storm, assigned by the radar.

TVS: Tornadic Vortex Signature (possible tornado)

MESO: Mesocyclone (large-scale storm rotation) Signature. This is often a marker of severe thunderstorms.

POSH: The probability (%) of severe hail, as estimated by the radar.

POH: The probability (%) of hail, as estimated by the radar.

MXSize: An estimate of the maximum size (in) of the hail.

VIL: An estimate of the amount of water in the storm tower in terms of kg of liquid water per square meter.

RAD: The reporting radar's callsign.