

### Activity 3.5 Doppler Radar in a Shoebox

Note: LIVE FROM THE STORM Instructional Materials Development team member (and 8<sup>th</sup> grade science teacher) Tim McCollum demonstrates how to implement this Activity in the Video which is part of the PASSPORT TO WEATHER AND CLIMATE Teacher Resource Kit.

Extensive supplemental information about Doppler radar, how it works and the resourceful men and women who keep the nation's WSR-88D network running may be found online at the LFSTORM website. PASSPORT TO KNOWLEDGE gratefully acknowledges review of this activity by Tim's "Project DataStreme" instructor, Glen Freimuth, Professor of Earth Science, Richland Community College, Decatur, IL

#### Teacher Background

"The National Weather Service has just issued a severe thunderstorm warning for the following counties..."

How often has your favorite television program been interrupted with these familiar words? Whether you live in "Tornado Alley" or face the fury of tropical storms, you and your students are likely to be reminded several times each year of the awesome forces of nature. Because of its geographic location and topography, the United States witnesses some of the most varied and violent weather of any country on Earth. Geostationary satellites give days' notice of the arrival of massive but relatively slow-moving hurricanes, but until recently there has been just a few minutes in which to alert the public to an oncoming tornado. Recent advances in weather prediction technology, however, can now give 30 minutes or more warning of tornadoes. This translates into saving hundreds of lives. What tools do meteorologists use to give advance warnings of these impending storms? One of the most powerful weapons in the arsenal of a storm tracker is Doppler radar.

Radar has been used to track storms since the early 1940's. Following World War II, surplus military radar systems were employed to track storms over short distances. Unfortunately this method gave too little notice to people in the paths of killer tornadoes and supercell thunderstorms. Long-range radar was eventually developed and became a useful tool for meteorologists in day-to-day operations. Today, WSR-88D ("Weather Surveillance Radar, developed in 1988, Doppler"), uses two different modes to locate and measure various significant properties of a severe storm. In what's called the "reflectivity" mode, the radar indicates the location, movement and intensity of precipitation (Activity 3.5.1). In the "velocity" (or Doppler) mode, the radar determines vorticity (rotation) or circulation of the winds within the storm (Activity 3.5.2). All of these measurements are made by sending out short bursts of microwave energy and using a 10 meter diameter dish antenna to detect the echoes. The antenna is housed in a tall round structure called a radome.

A storm analyzed by a modern weather radar image is shown in various colors, each representing a different aspect of the storm. The meaning of the colors varies depending on the mode. In the reflectivity mode, colors run from light green which represents light rain to dark red which represents heavy rain or hail. In the velocity (Doppler) mode, green represents movement of air *toward* the radar antenna and red represents movement *away from* the radar antenna. The same principle which allows police to determine the speed of a passing motorist is used by meteorologists to locate areas of rotating air within a storm. (Again, see the video in the Teacher

Resource Kit.) It's this ability to discern internal air circulation that makes Doppler radar such a powerful short range forecasting and warning tool. Meteorologists look for characteristic "signatures" inside the storm. Every time a forecaster sees side-by-side regions of air moving toward and away from the radar, they know they've "got rotation." (See the JOURNALS from Geoff Haines-Stiles [PTK] and Doug Speheger [NOAA/NWS] relating to the December 2, 1999 tornadoes which hit near Norman, OK.) Another such signature is a backwards "J"-shaped hook which appears near the back of a storm. But some tornadoes have no "hook" and not every hook shape means a tornado! The Doppler radar signature of rotation, however, is currently the clearest and most important clue to the presence of dangerous weather, except for trained spotters on the ground.

### Objectives

Students will create a model to simulate storm tracking by modern weather radar.

Students will transform a concealed 3-dimensional shape into a full-color, 2-D image using a color key corresponding to that used by professional meteorologists.

Students will use the model to distinguish between areas of storm intensity (precipitation levels) and internal air circulation.

Students will use the model to predict the direction and movement of a storm system.

### Vocabulary

circulation

Doppler radar

microwave

radome

reflectivity mode

rotation

velocity mode

vorticity

"warning" (as used by NOAA/NWS)

"watch" (as used by NOAA/NWS)

### Materials (per team of 2-3 students)

1 shoe box with lid

tape

glue

assorted materials of varying hardness (rocks, styrofoam, cardboard, marshmallows, foam rubber, crumbled aluminum foil, Play Doh, etc.)

metal coat hangers (cut and bent straight), knitting needles or wooden skewers

awl, leather punch or other sharp object to punch holes in the shoe box lid (caution in appropriate use)

crayons or colored pencils

Activity 3.5 Worksheet (grid for box lid)

## Engage

Ask the students when they last recall having their TV viewing (which was only being watched for one half hour daily, after homework was completed, and double checked, of course) interrupted by severe weather announcements. During which seasons of the year are these watches and warnings most common? (Severe thunderstorms can occur year round, although “tornado season” in U.S. is typically spring through early summer.) Discuss the difference between a severe storm *watch* (conditions are favorable for the storm to occur) and a *warning* (a severe storm has been sighted).

What tools do meteorologists use to locate and track severe weather? (Radar, satellite, weather balloons, trained storm spotters communicating via CB and more.) What can these tools tell us about the storm? (Location, size, type and intensity of precipitation. Human spotters are still the surest reporters of a tornado actually on the ground. Doppler radar can also locate rotation of a column of air inside of a storm.)

Ask students if a friend or relative has even been stopped for speeding? If so, they know that Doppler radar works down here on Earth, but they might not know how and why. This Activity will show them how police, as well as weather, radar actually works.

Perhaps your students have seen weather radar images on a TV weather report or on the Internet. One or more of your local stations (especially if you live in tornado or hurricane-prone territories) may proudly and loudly promote its own “Doppler radar” images during weathercasts. Other stations use NOAA’s NWS Doppler images and forecasts, even if they don’t always make that clear! What do the different colors of the weather radar image represent? (In the *reflectivity* mode they represent size, type, and intensity of precipitation. In the *velocity* mode they represent air movement toward or away from the radar.)

## Procedure

In advance, be sure to have reviewed the procedures on the Student Worksheets, and the sequence on the Teacher Resource Video, if you have it. Divide the class into teams of 2-3 students. Distribute a shoebox with its lid, 2 copies of the grid pattern copy master 3.5.1 (one to paste on the shoebox lid as a guide for the holes and the other as a recording data sheet) and a set of all other materials to each team. Inside each box the students will place items of varying hardness to create a model of a severe storm. Decide whether to have the students do Activity 3.5.1 (reflectivity mode) or Activity 3.5.2 (velocity mode) or both. Distribute Student Worksheets 3.5.1 and/or 3.5.2, and review procedures with students. Circulate (sic), supervise and encourage students as they implement the Activities. Pay special attention to the use of the awl to make holes in the box lid.

## IMPORTANT NOTE TO TEACHERS AND STUDENTS

When simulating the velocity (Doppler) mode of weather radar, the colors in the resulting patterns have different meanings than used in the reflectivity mode. In the velocity (Doppler) mode, *red* represents air moving away from the radar source and *green* shows air flowing towards the radar source.

## TEACHER TIP:

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1. We often use models to make complex processes more understandable for our students. Yet, in every model there exists the potential for the students to draw an unintended conclusion. In our shoebox models, the probes were lowered into the simulated storms from the top down. In reality, Doppler radar scans both horizontally and vertically (from the ground up and out) thereby sweeping out a cone in a series of what are called “volume scans.”
2. Avoid planning the Activity over a weekend or holiday, as the materials can harden and alter the readings
3. Reinforce the idea that when placing the materials in the boxes the most intense precipitation should be modeled by putting the hardest objects to the inside of their model storms and as they move outward the materials should become softer. Also, it’s o.k. to leave parts of the bottom of the box empty. Be sure all the items inside the boxes are fastened down securely before trading boxes between student teams or they will shift and ruin the model storm pattern.
4. The darker colors on the hand-colored grid sheets resulted in better looking simulated radar patterns - perhaps using narrow point markers or transparency pens. They also look better when viewed from a distance.
5. The NIH extension of this Activity was the highlight for me. (See Tim’s Tips for this on the LIVE FROM THE STORM website.)

## Expand/Adapt/Connect

If you have access to a color printer, download and print examples of weather radar images taken off the Internet. (See URL list below.) Display these beside student model storms drawn on the grid sheets.

Locate an Internet site which displays weather radar images for regions near your community. These can often be found on NOAA/NWS sites or local TV station websites.

A memorable way of relating the shoebox model to real world applications is suggested in the AMS “Project Atmosphere” Teacher’s Guide, “Weather Radar: Detecting Precipitation.”

Suspend aluminum foil pieces, smooth or crumbled (Styrofoam packing “peanuts” would work well, too) from the classroom ceiling to represent rain or snow, darken the room and use a flashlight to represent the radar beam. Have the students locate the precipitation and estimate the distance from the radar source. (See Resources.)

Older students can research new technologies used in weather radar which display vertical and 3 dimensional images of storm systems.

How do astronomers use the principle of the Doppler effect in their work? (As evidence of an expanding universe noting the red shift in the spectra of distant galaxies.)

Technologically savvy students and teachers can attempt to render their storm models and radar simulations as computer images. See TEACHER TIPS from Tim McCollum online, in the EDUCATORS section of the LFSTORM website. Be sure to share your successes with the DISCUSS-STORM list.

Suggested URLs

[http://www.comet.ucar.edu/dstreme/images/rad\\_sum.gif](http://www.comet.ucar.edu/dstreme/images/rad_sum.gif)

AMS DataStreme project's current radar image of the USA.

<http://www.wunderground.com/US/Region/US/Radar.html>

Weather Underground National Radar Page.

<http://www.usatoday.com/weather/radpic/wradusa.htm>

Today's radar image linked to a radar movie.

<http://www.fi.edu/weather/radar/radar.html>

The Franklin Institute presents the history and science of radar, and what it can detect.

<http://www.nssl.noaa.gov/~tsmith/may3/>

Radar images of the Oklahoma City Tornado, May 3, 1999