

Doppler Radar: Introduction

Doppler radar dome (radome)The most effective tool to detect precipitation is radar. Radar, which stands for RAdio Detection And Ranging, has been utilized to detect precipitation, and especially thunderstorms, since the 1940's. Radar enhancements have enabled NWS forecasters to examine storms with more precision.

The radar used by the National Weather Service is called the WSR-88D, which stands for Weather Surveillance Radar - 1988 Doppler (the prototype radar was built in 1988). As its name suggests, the WSR-88D is a Doppler radar, meaning it can detect motions toward or away from the radar as well as the location of precipitation areas.

There are 155 WSR-88D Doppler radars in the nation, including the U.S. Territory of Guam and the Commonwealth of Puerto Rico, operated by the National Weather Service and the Department of Defense.

Exactly how does radar work?

As the radar antenna turns, it emits extremely short bursts of radio waves, called pulses. Each pulse lasts about 0.0000016 seconds, with a 0.00019-second "listening period" in between. The transmitted radio waves move through the atmosphere at about the speed of light.

By recording the direction in which the antenna was pointed, the direction of the target is known as well. Generally, the better the target is at reflecting radio waves (i.e., more raindrops, larger hailstones, etc.), the stronger the reflected radio waves, or echo, will be.

This information is observed within the 0.00019-second listening period with the process repeated up to 1,300 times per second. By keeping track of the time it takes the radio waves to leave the antenna, hit the target, and return to the antenna, the radar can calculate the distance to the target.

The WSR-88D's pulses have an average transmitted power of about 450,000 watts. By comparison, a typical home microwave oven will generate about 1000 watts of energy. However, because of the very short period the radar is actually transmitting, when the time of all pulses each hour are totaled (the time the radar is actually transmitting), the radar is "on" for about 7 seconds each hour. The remaining 59 minutes and 53 seconds are spent listening for any returned signals.

The Doppler Advantage

By their design, Doppler radar systems can provide information regarding the movement of targets as well their position. When the WSR-88D transmits a pulse of radio waves, the system keeps track of the phase (shape, position, and form) of the transmitted radio waves.

By measuring the shift in phase between a transmitted pulse and a received echo, the target's radial velocity (the movement of the target directly toward or away from the radar) can be calculated. A positive phase shift implies motion toward the radar and a negative shift suggests motion away from the radar.

The larger the phase shift, the greater the target's radial velocity. The phase shift effect is similar to the "Doppler shift" observed with sound waves. An object emitting sound waves will transmit those waves in a higher frequency when it is approaching your location (inbound velocity = positive shift) as the sound waves are compressed. As the object moves away from a location, the sound waves will be stretched and have a lower frequency (outbound velocity = negative shift). You have probably heard this effect when an emergency vehicle drove past you with its siren blaring. As the vehicle passed your location, the pitch of the siren lowered.

