Wind Profiler

The wind profiler has helped to revolutionize our ability to improve severe weather forecasts including tornadoes. If you want to understand where tornadoes may form, you need to have a good forecast for the upper level winds – upstream from the forecast area. This takes a good computer model of the atmosphere, but it also takes actual accurate real-time measurements of the winds to help constrain the forecast model. The wind profiler was an invention of labs within the Earth System Research Laboratory in order to improve our knowledge of the upper-level winds. The bulk of the wind profilers are located now throughout the mid-section of the U.S. where most of the Nation's tornadic weather occurs and are operational through the NOAA Profiler Network for the National Weather Service, aiding in weather forecasting.

The discovery that radar could determine wind speed and directions patterns in the upper atmosphere was by accident, as many good scientific inventions are. Scientists were using this radar to study the ionosphere by bouncing a radio wave off the ionosphere and each time they would get a noise in the signal. They finally decided to figure out what was causing the noise. We now operate these radars because the noise they discovered was a piece of very valuable information, the actual reflection of the turbulence of the wind patterns above.

The profiler technology works by bouncing radio waves off of turbulence in the atmosphere. It is possible to see the result of atmospheric turbulence with the naked eye. For example, when you see a heat wave shimmering over a road surface; that is turbulence caused by warm air rising up from the hot pavement surface interacting with cooler air not in contact with the pavement. Another example is the appearance of twinkling stars, which results from the turbulent atmosphere that exists between you and the star above your head.

The radar is able to measure the winds because the turbulence that the radar detects is carried by the wind. The radar beam consists of a series of pulses. The time it takes for a pulse to bounce off of turbulence in the atmosphere and return to the radar determines how far the pulse traveled. The returns from thousands of pulses are averaged together. This is necessary because the return power is only a very small fraction of the power that was sent out in the pulse.

Because the frequency of the return signals is Doppler shifted by the speed at which the turbulence is carried by the wind along the direction of the radar beam, the radar can detect whether the air was moving toward or away from the radar antenna. The same type of Doppler shift is heard when you hear a train passing and the sound goes from higher to lower frequency. This apparent shift in tone of the train whistle isn't because the whistle has changed its transmitted frequency, but because in one case the sound waves are being transmitted from a platform moving toward your ear and in the other case the sound waves are being transmitted from a platform moving away from your ear, thus imparting the Doppler shift.

In order to get a 3-dimensional measurement of the wind, the wind profiler sends a beam out in three directions and collects up/down, north/south, and east/west components of the wind. A computer collects these measurements, rotates them with geometric equations, and produces profiles of both wind speed and direction. These profiles are displayed on the Internet for end users and are often color-coded by wind speed.

A wind measurement at a particular altitude is often displayed as a flag, with the pole of the flag pointing in the direction that the wind is coming from. The number of barbs or triangles displayed on the flag determines the wind speed.

The profiler network in the central U.S. has been in operation for about 15 years and has had successes in saving lives, especially on May 3rd, 1999, when Oklahoma City had a tremendous outbreak of tornadoes. It was possible to forecast the atmospheric conditions conducive to tornado formation in advance because earlier that day, the wind profiler at Tucumcari, New Mexico, had detected an unusual anomaly in the jet stream.

The National Weather Service forecast models predicted an extremely convective region in Texas that would be pointing right at Oklahoma City. The local forecasters then advised everyone during the morning commute to pay very close to their radios that afternoon. The convective cell that eventually produced a tornado moved into the southern suburbs of Oklahoma City that afternoon and the local forecast office put out a 30-minute lead time for a tornado warning, which was enough time for the TV stations to get their helicopters in place to actually see the funnel cloud touch down.

Entire subdivisions of southern Oklahoma City were evacuated. What they could not forecast was how strong the tornado would be, and it turned out to be an F-5 tornado, one of the worst kinds, capable of producing a devastating loss of life and property. There were 40 or 50 tornadoes as part of that outbreak, and because of the profiler network, we estimate that NOAA saved about 400 lives that day.