National Weather Service and National Severe Storms Laboratory Activities

By Bob Saffle

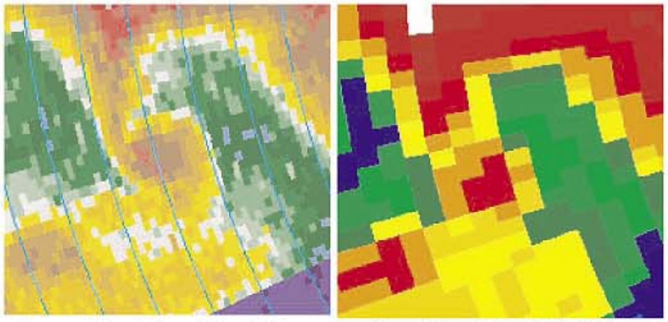
As viewers of television weather programs see daily, the nation made tremendous advances in weather radar technology in the 1990s. The National Weather Service (part of NOAA, the National Oceanic and Atmospheric Administration) fully deployed the NEXRAD (Next Generation Weather Radar) units, and local television stations began using informative color graphic displays of NEXRAD storm intensity and wind data to alert viewers to heavy rainfall, snow, hail, strong winds, and tornadic storms. Many television stations have also installed commercial weather radars having much of the science and technology of the NEXRAD units.

Previous weather radars had provided important information on rainfall intensity and overall shape of such storms, but their capabilities were severely limited due to poor radar beam resolution, lack of Doppler (wind estimation) technology, and lack of sophisticated computer processing of basic radar data. Using NEXRAD, NWS forecasters have dramatically improved the accuracy of tornado, severe thunderstorm, and flash flood warnings. Further, the NWS has partnered with commercial weather companies to distribute NEXRAD data throughout the private sector.

Weather radar science and technology have continued to advance since the NEXRAD design was finalized in 1988. Researchers at the National Severe Storms Laboratory (also a NOAA agency), other laboratories, and universities have improved how the radar data can be collected and analyzed to give better guidance on tornadic and other severe storms. NEXRAD partner agencies (NWS, DOD, FAA) have launched the NEXRAD Product Improvement program to improve NEXRAD by adding new capabilities. In general, they intend to enhance the operational usefulness of weather radar data by combining scientific processing advances and improvements in basic aspects of the data such as timeliness and resolution.

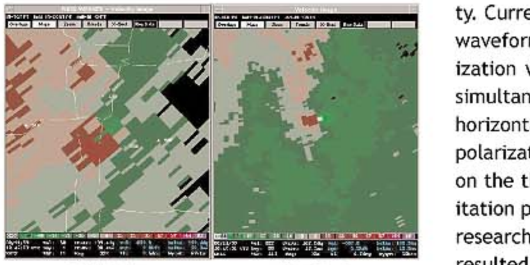
Now and the next several years, the NWS is focused on enhancing the computer processing and signal processing of NEXRAD. These efforts involve migrating the current radar functionality to an open systems design that uses common industry standards for computer programs and also uses hardware components available off the shelf from private industry. The first phase of this project, to provide better scientific processing capability for NEXRAD, has already begun. The next phase, to improve basic radar data collection, will occur over the next four years.

An early use of the enhanced capability will be to increase the NEXRAD data resolution in order to better detect the fine scale features associated with smaller tornadoes. Figure 1 illustrates how the hook pattern of a tornado can be better seen with higher resolution data than with the current NEXRAD resolution.



Improved Resolution: 0.5° x 0.25 km   Current Resolution: 1.0° x 1.0 km

Figure 1. Better Detection of Tornado with Improved Resolution (left) Versus Current Resolution (right)



NEXRAD   FAA Radar

Figure 2. Better Detection of Tornadic Circulation with FAA Radar (right, much closer to storm) Versus NEXRAD (left, longer range)

All weather radars suffer a decrease in resolution as the distance of the storm from the radar increases. One planned NWS radar improvement will be to take advantage of existing weather radars in the FAA air traffic control system to complement NEXRAD data. In cases when a tornadic storm is very close to an FAA radar, that radar s resolution may be better than that from a more distant NEXRADs. Figure 2 illustrates such a case for the Salt Lake City tornado of August 1999.

Velocity data from the NEXRAD Doppler technology provide the main tool for analyzing a storm for its tornadic potential. More people are becoming familiar with the terms mesocyclone (a thunderstorms larger scale rotation pattern which may be associated with a tornado) and tornadic vortex signature (the small scale rotation pattern). Unfortunately, due to the nature of the Doppler processing, the velocity data can sometimes be obscured for a particular storm. Several near-term NEXRAD improvements will address this problem. First, the forecaster will be given a graphical display to manually select a special radar antenna scanning strategy, minimizing obscuration for selected storms. Next, new automatic scanning strategy options will be added to NEXRAD for the forecaster to select as desired. Eventually, new radar transmission and signal processing techniques will be deployed that will greatly reduce such obscuration for all situations.

An exciting NEXRAD potential improvement is the addition of polarization capability. Currently, NEXRAD transmits energy in one waveform oriented horizontally. Dual polarization would allow NEXRAD to transmit two simultaneous beams of energy, one oriented horizontally and one vertically. With dual polarization, NEXRAD can provide information on the three-dimensional structure of precipitation particles and other targets. Laboratory research with dual polarization radars has resulted in learning more about polarimetric signatures of different types of targets. Dual polarization should enable radar identification of different types of precipitation (rain, hail, snow) as well as of insects and birds. An example of the possibilities of dual polarization Doppler is shown in Figure 3. If development and testing go well, dual polarization may be added to NEXRAD by the end of this decade.

As mentioned, timeliness is a crucial factor in the value of radar data for severe weather warnings. The new technologies will enable faster sampling of storms, while retaining the required data accuracy. In the longer term, however, a new type of radar antenna/transmitter combination may be deployed to collect much more data more quickly than the current NEXRAD can. This type of antenna/transmitter, called a phased array antenna, will be developed and tested at NSSL over the next decade.