Forecasting of Severe Storms Improved

A combination of sophisticated technology and human skills can improve short-term forecasting of severe thunderstorms

Weather forecasters are really fishermen casting a net sewn of wind, temperature, and pressure observations—a net that captures whole weather systems for a moment. With that momentary hold on the weather, forecasters can try to predict how highs and lows, hurricanes, and major snowstorms will behave. That does not work for some kinds of weather. Thunderstorms, flash floods, and tornadoes, for instance, are small enough to easily slip through the forecaster's net to strike without warning. Conventional radar has been used to fill the gap but with limited success.

Preliminary tests have now shown that observations that are made by a network of the most sophisticated instrumentation available, collected by high-speed lines of communication, graphically displayed in various combinations, and interpreted by experienced experts can lead to forecasts significantly better than those of the average weatherman. This demonstration came last summer during tests of the Prototype Observing and Forecasting Service (PROFS) system by the National Oceanic and Atmospheric Administration's Environmental Research Laboratories (ERL) in Boulder, Colorado. The PROFS system depends on a half-dozen different sources of observations. Only two of these sources—standard National Weather Service (NWS) observations and GOES satellite images in the visible and infrared—are routinely available to NWS forecasters. In PROFS, however, satellite images are available as often as every 5 minutes.

The rest of PROFS observations came from experimental instrumentation or from dense networks unavailable to NWS forecasters. A Doppler radar (*Science*, 15 December 1978, p. 1172) that can determine wind speeds scanned the 300-kilometer-diameter study area every 5 minutes. A tightly spaced network of more than 20 instrument sites reported ground-level weather conditions every 5 minutes. The frequency and location of lightning detected through its radio emissions was also reported every 5 minutes. And a remote-sensing profiler determined vertical variations in wind, temperature, and moisture every 20 minutes, measurements normally available only from balloon-lofted instruments every 12 hours.

If today's weatherman had this torrent of data coming into his office, he would be overwhelmed. In the PROFS system, the data are manipulated by computer and displayed in color-coded form on a bank of monitors, which allows the forecaster to select and combine observations. He might overlay a satellite visible or infrared image on a radar scan, or a radar scan on temperature, dew point, and wind streamlines, all quickly enough to forecast the behavior of storms that last for little more than an hour and may be severe for fewer than 20 minutes.

In last summer's test, PROFS outperformed the Denver NWS forecast office in forecasting severe thunderstorms in the high plains study area around Boulder. Of the severe thunderstorms that could be sufficiently verified, PROFS forecast 42 percent, while the Denver NWS office forecast 27 percent. Fifty-seven percent of the Denver office's forecasts of severe thunderstorms were false alarms, but PROFS's false alarm rate was 47 percent. If these scores are weighted to reward forecast warnings for smaller areas and shorter periods of time, PROFS's detection rate jumps from 42 to 69 percent, and its false alarm rate drops to 17 percent. The weighted scores of the Denver NWS differ only slightly from the unweighted scores.

PROFS displays data quickly enough to allow forecasts of the behavior of storms that last for little more than an hour.

PROFS did not do so well in forecasting tornadoes. It detected about one quarter of the verified tornadoes, as did Denver NWS, but it "issued" 17 warnings compared to Denver's 2, giving PROFS a false alarm rate of 82 percent. The reasons are both human and technological, according to Duane Haugen of ERL. The Doppler radar could detect the circular wind pattern that often precedes tornado generation, but the Doppler only scanned at low altitudes, where the signs of future tornadoes are not as reliable, and PROFS forecasters unfamiliar with Doppler radar probably overreacted to its detection of circular wind patterns.

Haugen and others believe that the high technology of PROFS helped achieve the improved scores, but they are quick to point out that there must have been additional reasons for the high scores. The two-person PROFS forecast teams were uninterrupted by phone calls, administrative duties, or other distractions. Operational forecasters are not so lucky. Also, PROFS forecasters were a select group of experienced forecasters and researchers from around the country. In the second phase of PROFS now under way, the influence of such human factors and the relative importance of each data source and its frequency of updating remain to be determined.

Elsewere, a combination of radar observations and computer data manipulation, without human intervention, has proved itself useful in forecasting the severity of thunderstorms around Oklahoma City. In a recent experiment, a computer transformed the strength of radar signals reflected from water droplets in a storm into the total amount of water in a given volume. A computer algorithm developed by the Mesoscale Branch of NWS's Technique Development Laboratory (TDL) in Silver Spring, Maryland, then correlated the distribution and maximum value of the water content of the storm with those of past storms. Given these correlations, the computer determined the probability that the storm was severe in terms of hail or strong winds. If the probability equaled or exceeded 50 percent, the computer issued a "warning."

In the Oklahoma City test, the computer was twice as successful in recognizing severe storms as the average NWS forecaster. The algorithms also served well in prognostication, the warnings remaining valid for more than 30 minutes. A combination of computer guidance and human judgment did even better. Despite this success, Wayne McGovern of the TDL suspects that the algorithms will have to be tailored to the history of storms at a given site before the method will be widely applicable.

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