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Tornado Forecasting Research

FORECASTING the tornado—the most destructive of all weather phenomena—has long been a baffling problem to meteorologists. Detailed observations of tornadoes in the formative stages have been lacking, and no satisfactory theory could explain the development of the vortex. Recently, however, considerable progress has been made, and research is currently proceeding along two quite different lines. One approach is that of systematically defining the particular combination of weather conditions that accompany or precede tornadoes. The other is aimed at discovering the dynamics of the vortex itself, and thus establishing the atmospheric conditions favoring occurrence.

Earlier it had been noticed that tornadoes seemed to require the presence of a very moist layer of air in the lower atmosphere, capped by a much drier layer above, and that they usually occurred along "squall lines"—lines of thunderstorm activity ahead of an advancing cold front. Using these and similar observations as a starting point, E. J. Fawbush and R. C. Miller, of the Air Weather Service at Tinker Air Force Base, Oklahoma, made detailed analyses of many weather situations involving tornadoes, and succeeded in isolating a number of factors that, in combination, frequently prescribed a region of tornado occurrence. These factors included the aforementioned moist and dry layers, the proximity of a front or squall line, a given temperature lapse rate with height, a tongue of moist air extending northward at the surface, and the existence of a narrow belt of strong winds over the area at upper levels. Thus an important step was made in establishing an empirical methodology for the forecasting of tornadoes. Further refinements including studies of the relative importance of the various parameters, together with statistical evaluation of independent data, should lead to additional improvements in forecasting and should also furnish clues as to the mechanism involved in tornado development.

The second approach to tornado research has resulted from the hypothesis proposed by Morris Tepper, U. S. Weather Bureau, that the intersection of two unequal "pressure jumps" creates a vortex sheet, thus affording an explanation for the development of the tornado vortex. Pressure jumps may be likened to hydraulic jumps or shock waves in supersonic flow. With the two-layer atmosphere already mentioned, gravity waves can move along the dividing surface at speeds of around 25–50 mph. If, however, the air below is "pushed" by an advancing cold front faster than the wave speed, the air will tend to pile up, and a jump will form and move outward. Rather strong upward velocities would be expected at the edge of the jump and could serve to initiate and intensify convective activity such as thunderstorms. Tepper has consequently proposed that many if not all squall lines are the result of pressure jumps. When two unequal shock waves intersect, a trailing vortex sheet is formed along the line of intersection. Intersecting pressure jumps should behave similarly and thus account for the generation of the tornado vortex, other conditions being favorable.

The Weather Bureau has established a dense network of surface recording stations in the Kansas-Oklahoma area for the present tornado season, to obtain detailed observations on pressure jumps associated with squall lines and tornadoes. Special upper-air and radar observations are also being made in cooperation with the Air Weather Service. The bureau is also making an independent study of the weather conditions that appear prerequisite to tornadoes and squall lines.

Another aspect is the possibility of detecting tornadoes at a distance by "sferics" (atmospheric static) observations. H. L. Jones, of Oklahoma A. & M. College, believes that tornadoes may be distinguishable from thunderstorms by the type of signals emitted by the lightning flashes in the two cases. Systematic observations are being made during the current season.

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