

WEATHER NOTE

TORNADOES IN NORTHEASTERN COLORADO, 1965

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While the northeastern portion of Colorado is more infamously known for the occurrence of frequent hail, the incidence of tornadoes is not as widespread. The U.S. Weather Bureau [3] statistics indicate an annual average of only 2.23 tornadoes; however, during the 6-year period 1960-65, this average has increased to 12.5 observed tornadoes per year. This figure does not include, of course, observations of funnel clouds. This higher average probably reflects the increased number of "weather conscious" observers.

Data gathered by the Department of Atmospheric Science, Colorado State University, reveal a total of seven confirmed tornadoes and nine funnel clouds reported in the area of Colorado north and east of Denver to the State lines during the period June 1 to July 30, 1965. One funnel cloud was reported sighted in southern Wyoming. On several occasions research aircraft and ground radars provided documentation on storms which are thought to be unusual in this region, particularly in the close proximity of the mountains.

Figure 1 illustrates the locations of tornadoes and/or funnel clouds observed in northeastern Colorado from June 1-July 30, 1965. The dates and times of occurrence are also given. While the most outstanding feature of figure 1 is the concentration of tornado/funnel cloud observations in the close vicinity of the foothills, it must be noted here that this concentration could be due to the increased population density in this region. It can be further seen from figure 1 that all but one observation occurred in June; the only exception occurred on July 27 when a funnel cloud was observed in the vicinity of Snyder, Colo. The most probable time of occurrence appeared to be in mid-afternoon, though observations of tornadoes/funnel clouds occurred as early as 1155 MST and as late as 2100 MST.

The most devastating tornado occurred on June 14; this twister touched down near Loveland, Colo. at 1530 MST, inflicting property damage estimated at \$750,000 and injuring 19 people. The width of the funnel on the ground was estimated to be 100 yd. with winds in this area believed to be in excess of 150 m.p.h. as judged by

the author on his inspection of the damaged area. Evidence of counterclockwise rotation about the tornado vortex was found to extend around a 4-mile radius of the funnel with wind strength estimated at 75 m.p.h. Hailstones up to 2½ in. were reported to accompany this storm.

Severe thunderstorm formation is not unusual in this region of Colorado. Late morning and early afternoon thunderstorms develop over and slightly east of the Front Range of the Colorado Rockies and sometimes propagate across Colorado with such persistent strength as still to be found around midnight in central and eastern Kansas. However, while moving across Colorado, these storms infrequently produce tornadoes or funnel clouds, but devastate the High Plains with large quantities of hail. It, therefore, seems unusual to find a greater number of tornadoes and funnel clouds in 1965, over and above the increase that could be attributed to the greater awareness of observers.

Perhaps an explanation for the great number of tornadoes and funnel clouds in northeastern Colorado in 1965 can be found in the difference in prevailing air masses over this region, especially during the month of June. Typically, low dew points are found over the foothills (e.g., 45° F.) during June. However, beginning about June 10, 1965 a large slow-moving anticyclone over the southeastern United States was providing the High Plains with an abundant supply of low-level moisture raising dew points to the mid-60's (°F.). At 500 mb., persistent troughing and the presence of a jet stream with speeds in excess of 55 m.p.h. occurred simultaneously. These conditions combining for severe thunderstorm genesis (Beebe [1]; Newton and Newton [2]) co-existed in varying intensities throughout the remaining days of June. It was noted that thunderstorms during this period exhibited cloud bases of 3,500 ft. (8,000 ft. m.s.l.) with cloud base temperatures of 50° F. These conditions, which resemble Mid-Western storms, are quite different from the average cloud base heights of 10,000 ft. (14,500 ft. m.s.l.) and cloud base temperatures of 35° F. found in northeastern Colorado. Hence, the moisture-laden air mass, combined with the vertical shear produced by the jet stream overhead, increased both the conditional and

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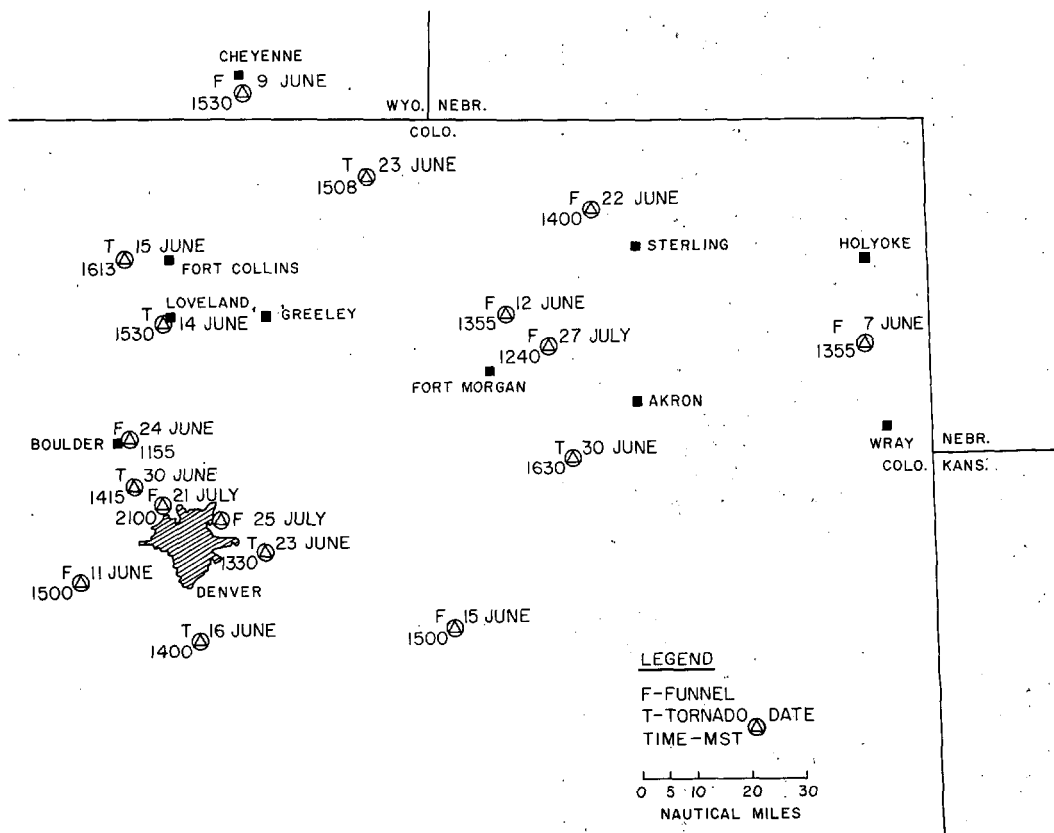


FIGURE 1.—Map showing locations, dates, and times of tornado and funnel cloud sightings in northeastern Colorado during the period of June 1 to July 30, 1965.

TABLE 1.—Summary of radar characteristics during and following the occurrence of tornadoes on June 14, 15, and 23, 1965 in northeastern Colorado. Information is based on data gathered from a 3-cm. wavelength radar system located at New Raymer, Colo. and a 10-cm. wavelength radar system located 10 mi. east of Fort Collins, Colo.

Date	Time (MST) of hook echo	Time (MST) of tornado sighting	Duration of tornado (min.)	Echo heights (m.s.l.)	Hook echo	Flank	5,000-10,000 ft. decrease in height within 30 min. of tornado occurrence	Echo dissipation within 30 min. of tornado occurrence
June 14.....	1530	1530	15 estimated.....	50,000	Yes.....	Right rear.....	Yes.....	No.
June 15.....	1613	1613	2.....	50,000	Yes.....	do.....	Yes.....	Yes.
June 23.....	1501	1508	13.....	40,000	Yes.....	Left front.....	Yes.....	Yes.

convective instability throughout the atmosphere; instability, in turn, manifested itself in numerous storms producing tornadoes and funnel clouds.

Radar observations of hook echoes were noted on three occasions by the Colorado State University radar network: June 14, 15, and 23. In all three cases, the hook echoes occurred slightly before or simultaneously with the visual observations of the tornado cloud. Furthermore, on the three dates mentioned, the radar echo heights were noted to lower 5,000 to 10,000 ft. within 20 to 30 min. after the formation of the tornado. If one can assume a measure of the energy of a thunderstorm to be given by the value of its height, it would then appear that there is

an energy depletion within the thunderstorm during the time following tornado formation. The results of the radar observations on these three tornadoes are presented in table 1.

Both visual and radar observations confirmed the fact that the tornadoes of June 14 and 15 formed classically on the right-rear flank of the storm cell with respect to its direction of motion. However, on June 23 definite proof can be cited from aircraft photographs and from the position of the hook echo determined from radar scope time-lapse movies that the tornado existed on the left-front edge of the storm cell. Figure 2 is a photograph of the PPI radar scope at New Raymer, Colo., at 1501 MST

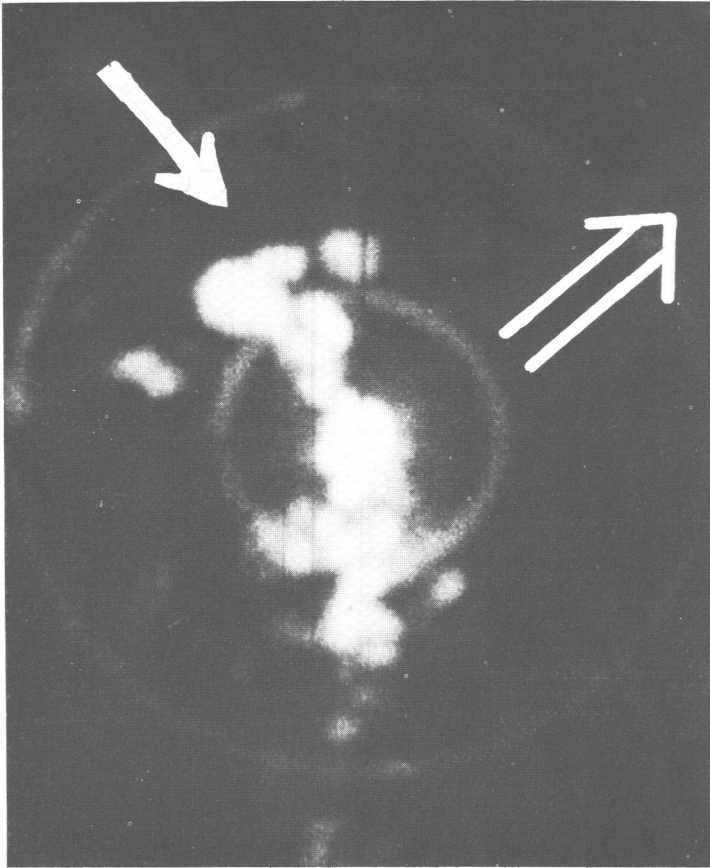


FIGURE 2.—Photograph of the PPI scope of the Colorado State University 3-cm. wavelength radar system at New Raymer, Colo., June 23, 1965 at 1501 MST. Range markers are 20 mi. The solid arrow points out the hook echo on the left-front flank of the cell coinciding with the tornado sighting 25 mi. north-northwest of the radar site. The open arrow indicates the direction of motion of the storm cell.

illustrating this hook echo at the unusual location of the left-front flank of the radar echo.

To summarize, the frequency of tornadoes and funnel clouds reported in northeastern Colorado appeared to increase in 1965 as compared with the preceding years. It is premised that a persistent lingering of both a moist air mass and a jet stream maximum overhead provided instability conditions similar to those in the Midwest for greater frequency of tornado and funnel cloud generation. Efforts to learn more about these storms in northeastern Colorado and in what ways they may resemble their Mid-Western counterparts are now being carried on at Colorado State University.

REFERENCES

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2. C. W. Newton and H. R. Newton, "Dynamical Interactions Between Large Convective Clouds and Environment with Vertical Shear," *Journal of Meteorology*, vol. 16, No. 5, Oct. 1959, pp. 483-496.
3. U.S. Weather Bureau, "Tornado Occurrences in the United States," (revised) *Technical Paper* No. 20, Washington, D.C., 1960, 71 pp.

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