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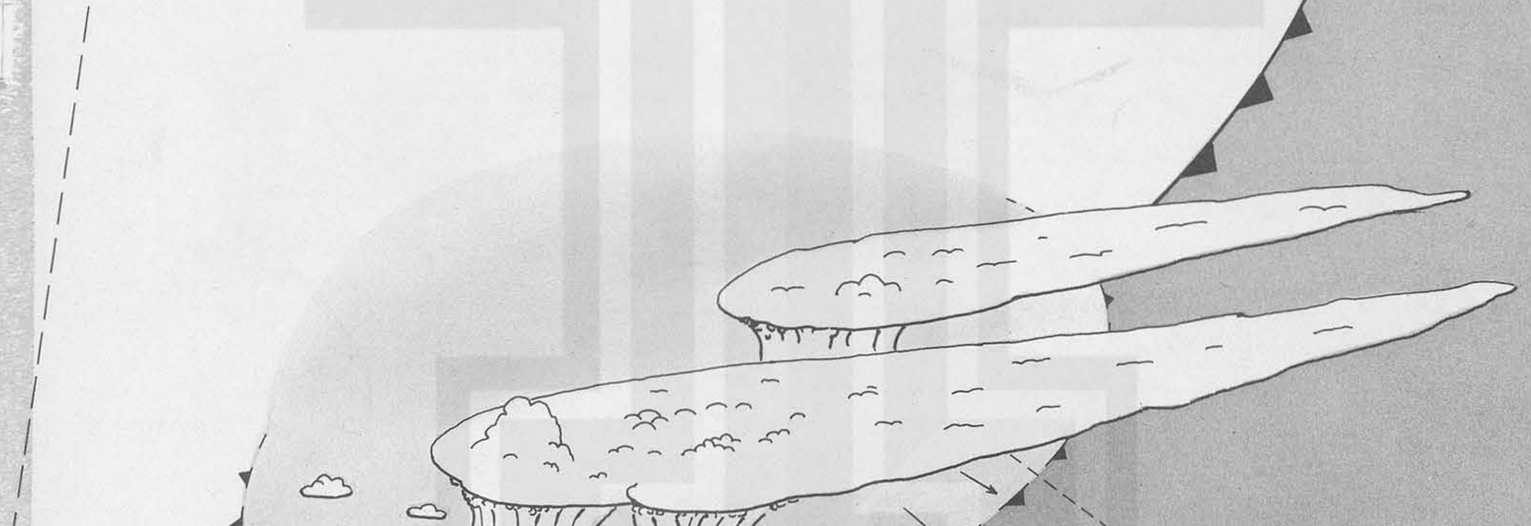
SATELLITE & MESOMETEOROLOGY RESEARCH PROJECT

Department of the Geophysical Sciences
The University of Chicago

JOLIET TORNADO OF APRIL 6, 1972

by

Edward W. Pearl



SMRP Research Paper

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Abstract

On April 6, 1972 a large tornado cyclone swept through Joliet, Illinois and the surrounding area to the west. The path was 33 miles long and averaged an exceptional 3-1/2 miles wide but within the Joliet damage area there were four smaller, stronger swaths. The meteorological sequence of events leading up to the storm are examined. The analysis includes a series of surface charts, the radar investigation, and a potential temperature cross-section as well as a thorough ground and aerial survey of the damage. A shallow layer of cold polar air existed, creating an inversion over the area where the tornadoes occurred.

The rare nature of the storm was such that it was difficult to call it a tornado, several tornadoes, or no tornado at all. Through careful gathering of the available data and other information a conclusion is reached which does not correspond to the conclusions reported in the Storm Data report. There is no doubt that the problems involved in a proper tornado survey are great and that an aerial survey is quite important. Hopefully, the author's observations will be helpful in answering some of the questions which arise in the future.

1. INTRODUCTION

The topic of tornadoes is one area of Meteorology which is of utmost importance to the general public and one which is least well known. The dissemination of public watches and warnings has been accomplished by the National Weather Service through radio and television. These broadcasts are issued whenever it has been determined that the likelihood of a tornado exists or one is already occurring.

The research reported in this paper was sponsored by the National Severe Storms Laboratory under grant E-22-93-71 G .

All published tornado information, thus far, has been accumulated by the NOAA climatologists. During the early part of the 1950's the number of tornadoes reported increased significantly. One reason was the better method of reporting developed through the greater knowledge of what to look for. The question arises as to whether or not the number reported is a good estimate of the number that actually occur. Damage reported from activity occurring at night may not be listed at all or it may be listed as one or more tornadoes or as a plow (straight) wind. The same problem occurs during the day if the tornado touches down away from a visual observation.

Tornadoes have been the interest of people for the past several centuries. The actual study of tornadoes and tornado-producing systems is relatively recent from a historical standpoint. The first outlined map of tornado occurrence, drawn in 1884 by John P. Finley, has been reported again by Court (1970). The chart showed the known tornadoes occurring over an eighty-seven year period in the United States. Since then many maps have been drawn to describe the number or frequency of tornadoes over the United States or other areas of the world. One of the most recent maps was drawn by Fujita (1972) showing the distribution of the tornadoes occurring during 1971 along with their intensity. Since this chart shows only those tornadoes reported to the NOAA climatologists for the various states one may question whether these represent all tornadoes that occurred during the year and whether all reported tornadoes really fit into a true tornado category.

In order to determine the exact intensity, path length, and path width of individual tornadoes an aerial and ground survey must be made from one to five days after the occurrence of the storm. Such surveys also lead to a better understanding of the structure of tornado cyclones. The direction of tree-fall, scratch or suction marks over open fields, and/or orientation of debris paths are good indicators of tornado circulation on the ground. Van Tassel (1955) and Prosser (1964) reported on the circular or cycloidal marks left on the ground after the passage of the Scottsbluff, Nebraska tornado of June 27, 1955 and the Shelby, Iowa tornado of May 5, 1964, respectively. One of the first and most extensive damage surveys was made by Fujita on the Palm Sunday tornadoes of April 11, 1965 (Fujita, et al., 1970). In May 1970 he made similar surveys of the Lubbock tornadoes of May 11, 1970 (Fujita, 1970). A more recent survey of tornado damage in Kentucky made by Fujita, Tecson and Schaal (1972) was of particular interest since it showed the tree-fall pattern in relation to local topography.

Although tornadoes described by these researchers were not all found under identical meteorological conditions, evidence from their reports and damage paths showed that they would all be classified as tornadoes.

The Joliet storm of April 6, 1972 described in this paper formed over a shallow layer of cold air. The damage was generally of the straight line type although three of four swaths curved northeastward. The entire track was given an F, P, P of 3, 4, 6 however the individual swaths were also categorized as they were found to be the actual tornadoes.

2. SYNOPTIC ANALYSIS

At 1800 CST on April 6th the surface chart showed a 1026 millibar high pressure area centered just to the west of James Bay and a 1016 millibar high centered to the west of Florida in the Gulf of Mexico. Between these two air masses was a southward moving cold front extending east-west just north of 40 N from the east coast to 95 W, passing through a low pressure center over east-central Nebraska. This center and its accompanying frontal system moved southeastward at a rate of approximately 30 knots.

The polar front passed through Northern Illinois as it progressed southward during the afternoon. Several hours prior to the time of the reported severe activity the temperature in the area dropped from the high in the 60's into the upper 30's and low 40's. The surface winds became northeasterly with a speed of fifteen to twenty miles per hour and higher in gusts. There was a slight wind shift as the thunderstorms passed by each station although all reporting stations were quite far from the severe activity. Therefore there were not enough reports of sharp wind shifts or pressure falls to justify calling this any type of mesosystem other than what is intuitively obvious from the damage type. The tornado damage areas are in agreement with the paths of the most intense thunderstorms. Figure 1 shows the tornado damage areas. The areas of severe thunderstorms moved toward the southeast at an average speed of 40 knots. The storms first developed a few miles northwest of Polo, Illinois (15 mi. NNE of Sterling, Illinois) as was indicated by a radar echo over the northwest corner of Illinois. One hour later, at 1900 CST, the storm area had increased in size and the most intense cell was located northeast of Sterling. Tornadoes were reported at Polo at 1845 CST.

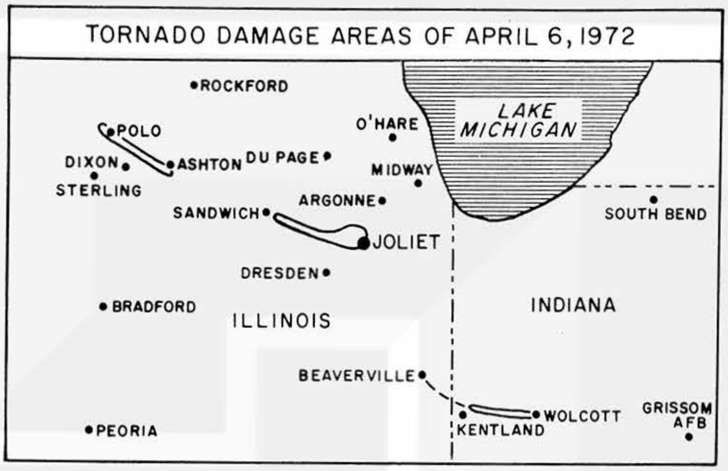

Fig. 1. Tornado related damage areas across northern Illinois and Indiana on April 6, 1972.

Figure 2 shows the surface weather conditions at 2000 CST or 8 minutes before the tornado struck northwest of Joliet. The polar front is represented by the thick dark line. The radar echoes are indicated by the closed black lines. The dashed lines are those echoes observed while the radar was on reduced gain. All wind speeds shown

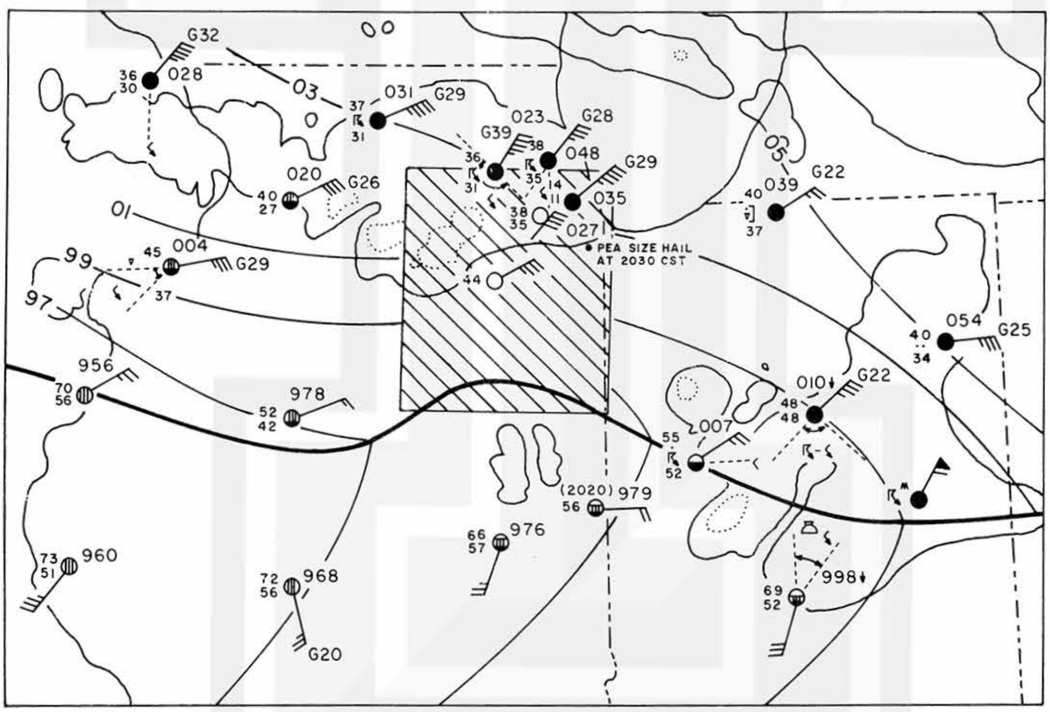

Fig. 2. Surface chart for 2000 CST. The hatched box is shown in the conclusions.

are doubled. The hatched box area found in this figure refers to the blown up area of the surface conditions found in the conclusion of this report. After 2000 CST the severe storm activity continued southeastward. A tornado was reported at 2100 CST near the Illinois-Indiana border at Beaverville, Illinois. The last tornado report was at 2130 CST in the Kentland-Wolcott area of Indiana. There were many other reports of high winds and hail damage along the storm's path from northwest Illinois into Indiana.

The 850mb chart for 1800 CST is seen in Fig. 3. The dashed lines represent the temperature in degrees centigrade. The chart shows the advection of cold air from the north-northeast and warm air from the southwest and west converging in the vicinity of the northwest corner of Illinois. The trough was the triggering mechanism for the severe storms which were to occur for the following three and a half hours. A 21 C temperature differential existed between Peoria, Illinois and Green Bay, Wisconsin. The 20 C isotherm had entered Iowa which is of a magnitude that is above average even for mid-summer. At the other extreme Sault Sainte Marie, Michigan had -16 C which

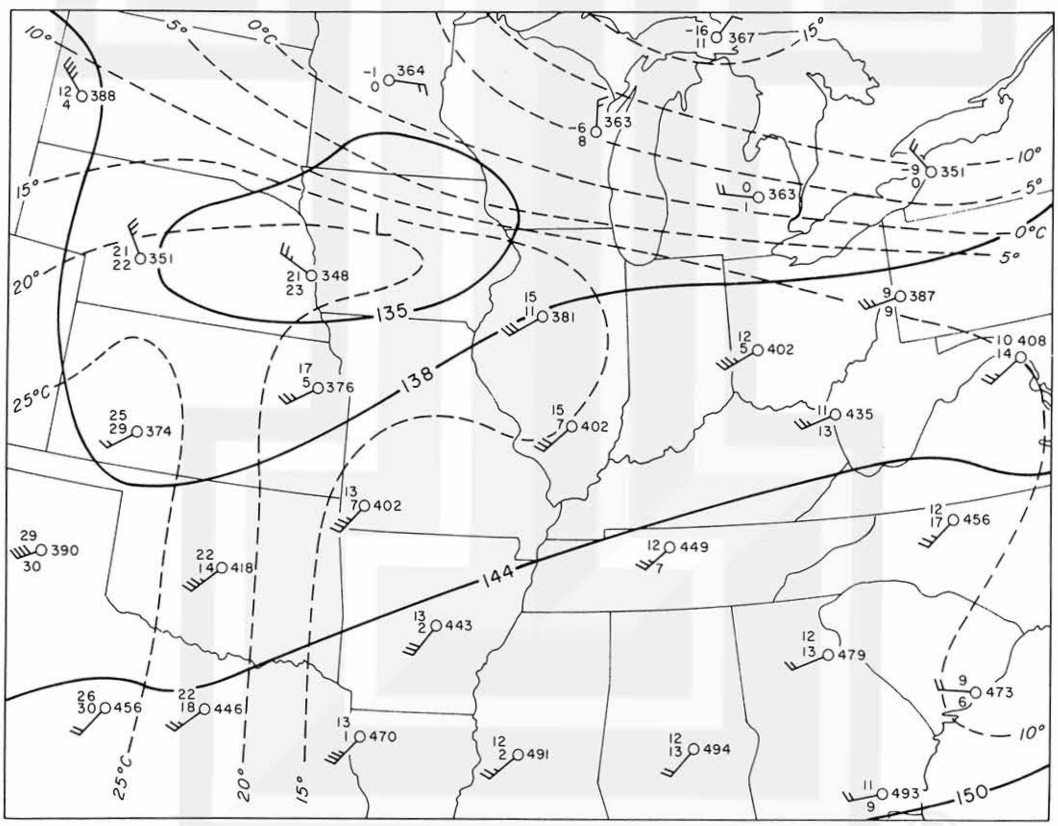

Fig. 3. Analysis of the 850mb level.

was quite low for the first week of April. Omaha indicated dry air with a 23 C dew point spread whereas Topeka, Kansas to the south indicated a relatively moist depression of only 5 C. In general the mechanism at the 850 mb level was quite potent for severe activity. Together with the west-northwest flow at 500 mb and the temperature difference all of the factors for mixing were available at this time.

A careful analysis of a series of synoptic surface charts gave evidence of a small wave propagating from west to east along the southward moving polar front. The small wave which was not seen on the official surface chart appears to be the initial cause of an area of increased convergence and precipitation. The wave and the main area of severe activity show a close correlation.

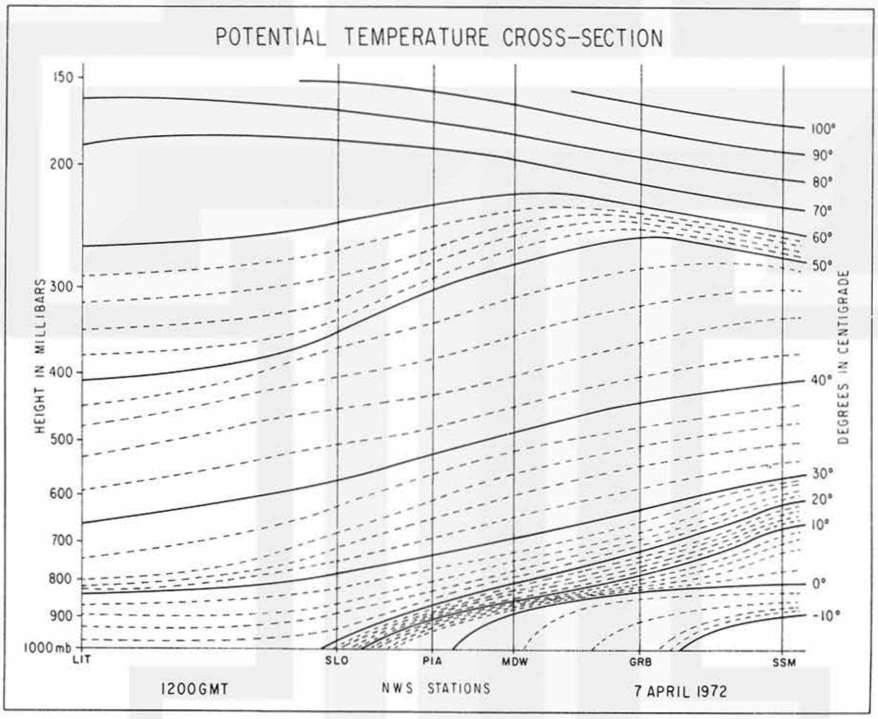

Fig. 4. Potential temperature cross-section.

Figure 4 is a potential temperature cross-section showing the position of the cold front between Little Rock, Arkansas and Sault Sainte Marie, Michigan at 1200 GMT April 7, 1972. This time was about 10 hours after the occurrence of the Joliet tornado. The surface front at this time had just passed Salem, Illinois. The depth of the cold layer was estimated to be from 2000 to 2500 feet over Peoria, Illinois. This height indicates the reason the layer of cold air did not hinder the convection.

The shallow layer of cold air existing during the Joliet tornado can be explained if the inflow layer is taken to be greater than 2,000 feet. According to Fulks (1951) the inflow or convergent area may actually exist within the layer between 2,000 and 5,000 feet. It is further described that the resulting tornadic whirl extends rapidly upward and then downward to the ground. If this were the case then this whirl would have to bore through approximately 2,000 feet of cold polar air.

Newton (1963) suggested that the outflow from the base of a thunderstorm is increased by 10m sec in the direction of the storms movement. This is accomplished by the momentum transfer from aloft which is carried to the surface in the downdraft. It should be noted that if the thunderstorm were rotating this value would be further increased. This entire motion of air would have to penetrate the layer of polar air in the lower 2,000 feet as described before.

3. RADAR VIEW OF STORM SYSTEM

The superimposed radar echoes on the surface chart is from 35 millimeter radar film taken by the National Weather Service in Chicago, Illinois. The range was set for 250 miles giving a broad view of the weather occurring north of the surface polar front.

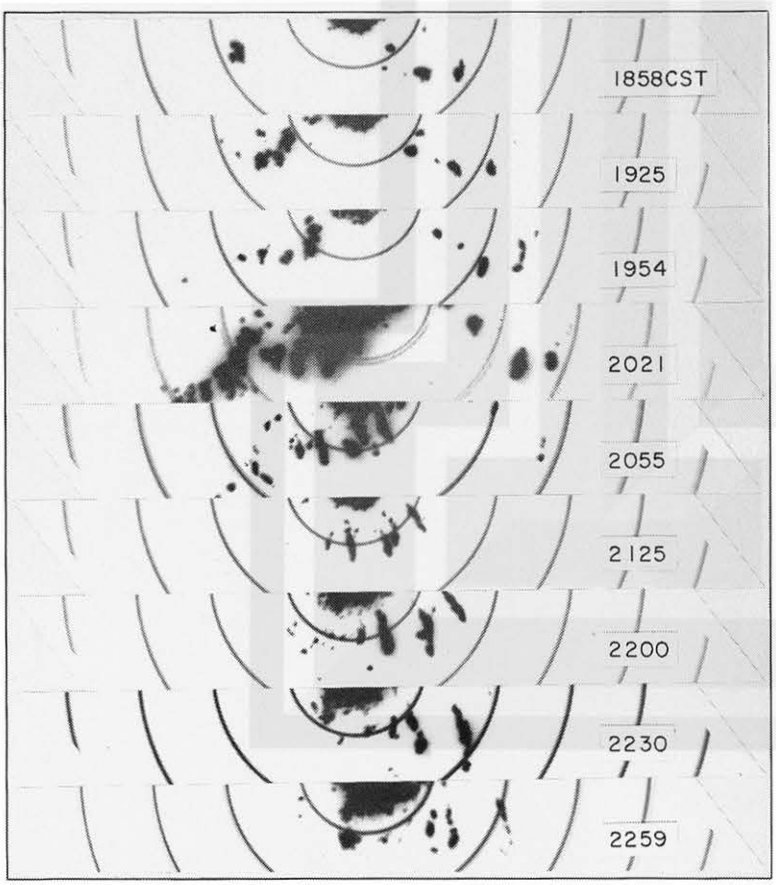

Fig. 5. Series of radar photographs taken at an interval of about 30 minutes.

Figure 5 is a set of radar film photographs showing only the areas of the most intense activity. Each was taken at an interval of about thirty minutes from 1858 CST to 2259 CST. The strongest cells appeared to occur at 2200 CST and were probably intense in appearance because of less attenuation at close range.

The first radar indication of development was just prior to 1845 CST as a small area of precipitation appeared. The growth of this area was rapid at first as three consecutive lines of echoes developed, extending from the main mass of precipitation. Each of the three lines contained severe activity at one point or another along the path. This explains why all of the damage, although occurring in a straight line, did not have continuity of time. The relation between radar film and the ground observers showed a good correlation.

The cells creating the tornadoes from Polo, Illinois to Wolcott, Indiana are shown in Fig. 6. These were from the radar at reduced gain. Cell 4 which spawned

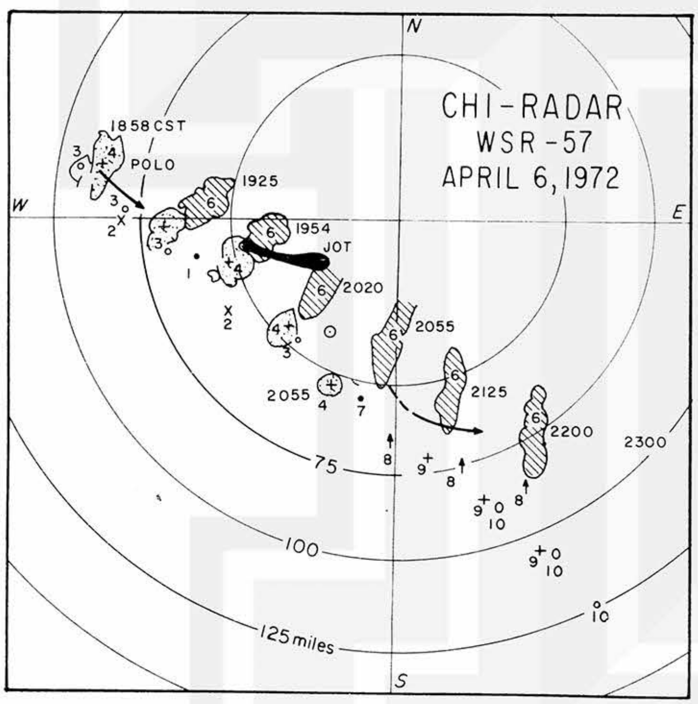

Fig. 6. Composite of the most intense echo activity with the progressive southeast movement shown.

the first tornado appeared to dissipate rapidly and after an hour had almost disappeared. The larger cell, which spawned the Joliet tornado kept its identity for several hours, producing two other areas in its wake, one at Beaverville, Illinois and the other in the Kentland-Wolcott areas of Indiana. These cells did not show the indicative hook echo probably because of the large area of precipitation surrounding individual storms and the angle of the radar.

4. THE JOLIET TORNADO

The Joliet tornado cyclone's first effects were about twenty-five miles west-northwest of the city limits (Fig. 7). The path width was narrow in the beginning and widened continuously before ending slightly east of the city. Most of the northern half of Joliet had some damage whereas there was only isolated damage to the southeast.

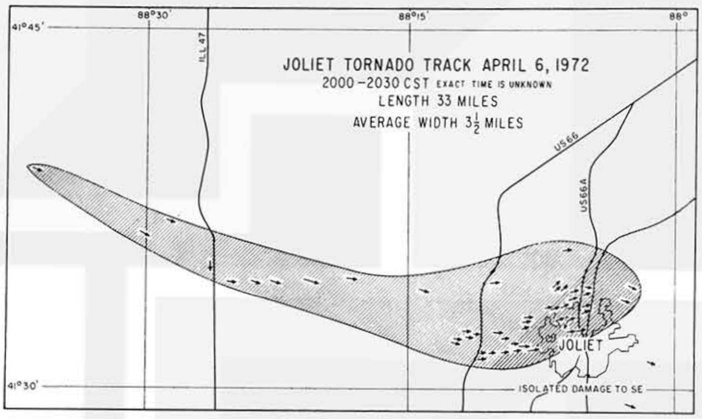

Fig. 7. The entire path of the Joliet tornado drawn from combination of aerial and ground survey.

There were many broken trees, antennas, and damaged roofs. The damage type appears to be from a tornado cyclone which is essentially a rotating thunderstorm. There were apparently several funnels, mainly aloft. They remained aloft due primarily to the cold air at the surface. There were four significant tracks of damage within the main damage area indicating the presence of funnel appendages.

Residents in Joliet reported hearing sounds like that of a plane or sirens. One man who had been through a tornado before said that "... it sounded as though a freight train were coming through, just like the one that I was in, in Kansas".

5. GROUND AND AERIAL SURVEY

On April 11, 1972 the author made a ground survey of the Joliet area and followed it by an aerial survey in a Cessna aircraft. The ground investigation showed four main tracks of scattered to continuous damage. All four tracks were from a west-southwest to an east-northeast orientation. The three northern tracks curved northeastward before ending (Fig. 8). The two most northern tracks appeared to join together and continue northeastward as one. Also note the individual F, P, P rating for each track.

The aerial survey showed the damage to be more widespread than first thought. The four paths still appeared but not as clear cut as the ground survey indicated,

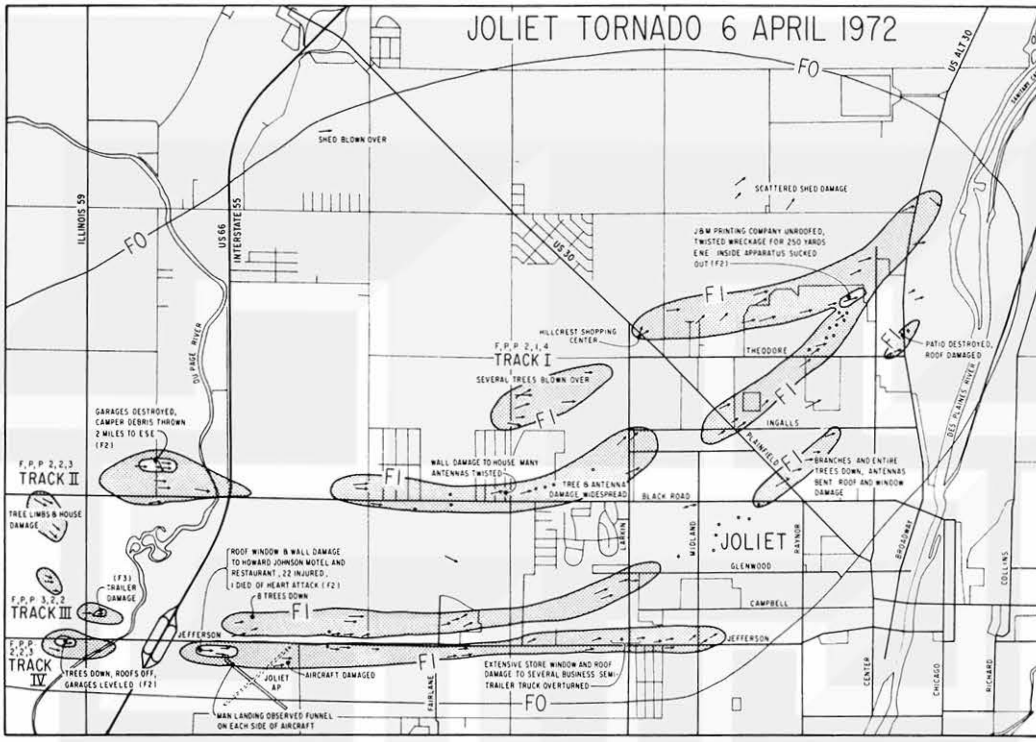

Fig. 8. The ground survey showing possible four tracks.

primarily because most of the wreckage had been cleared. The flight also showed the entire length and width of the path west of Joliet. Much of the scattered damage would not have been visible from the road and, thus, an accurate survey would have been a time consuming and formidable task.

The flight also indicated a variable wind component of damage in several places. It was slight, however, and there were no significant areas of rotation. This indicated that there was some convergence in the area. In the spring suction swaths are not visible and therefore rotation is not readily made evident. It was found that the combination of the aerial observation and the ground survey was the most desirable situation for this case. Some of the pictures taken during the ground survey are found in Fig. 9.

The entire Joliet damage area was 33 miles long and had an average width of 3-1/2 miles. Total coverage was 115.5 square miles of farm and city land. This was a much larger storm than that of the typical straight and relatively narrow tornado. The width of an average tornado being slightly under a quarter of a mile.

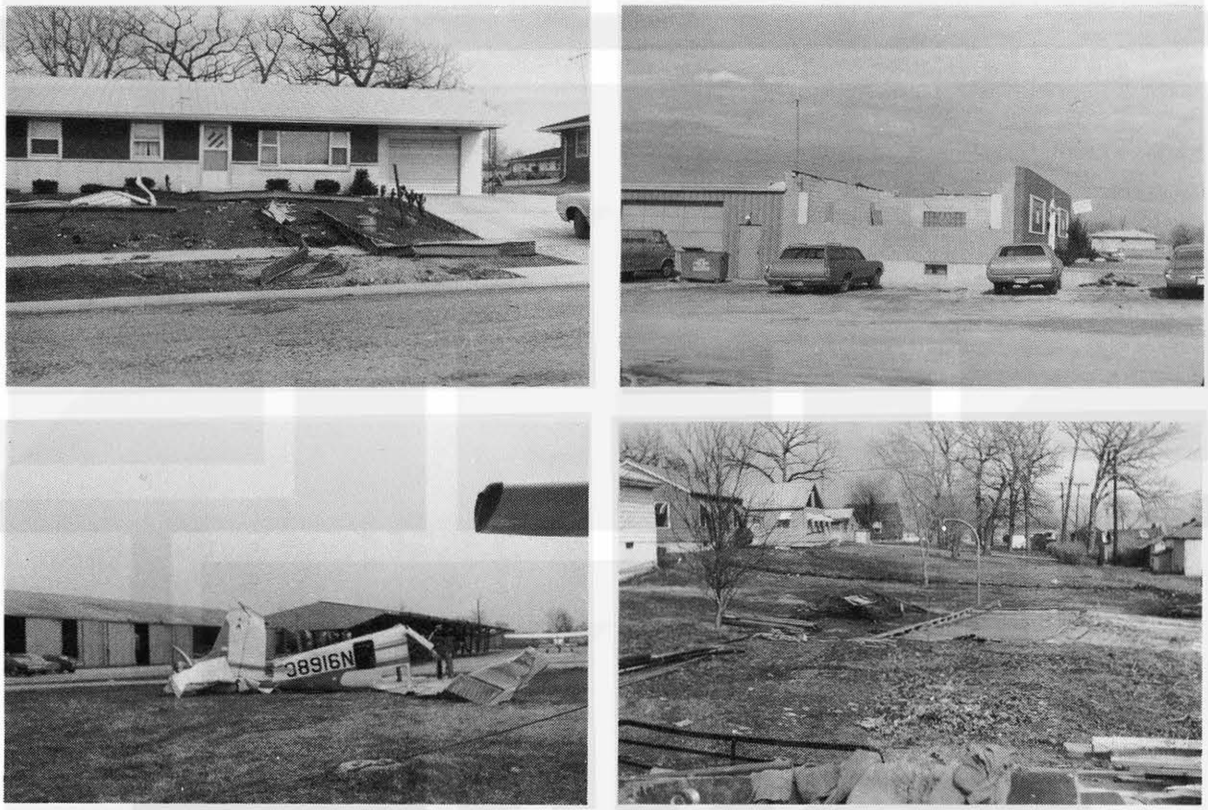

Fig. 9. Joliet damage pictures.

6. CONCLUSIONS

It is proposed that the primary cause of destruction was a series of rotating thunderstorms which developed and moved southeastward across northern Illinois. The paths of destruction were not well defined for the most part. If it had not been for the lifting effect over J. & M. Printers, a printing company in Joliet, and the funnel sighting by an aircraft at the Joliet Municipal Airport then it would have been difficult to classify the storm as a tornado. Also several people heard the roaring sound which so often typifies a tornado. Many of the residential buildings and groups of trees were too widely scattered for the paths to be clearly seen. In addition, the majority of farmland had not yet been planted for the year so this aid to an aerial survey was not of any value. Therefore only in the Joliet area was the damage well defined. The shallow cold layer near the surface probably kept most funnels aloft. Therefore visual observation did not show a path of destruction as in a classic tornado. It was unfortunate that the Joliet storm occurred after dark, thus most people did not get the opportunity to observe the activity.

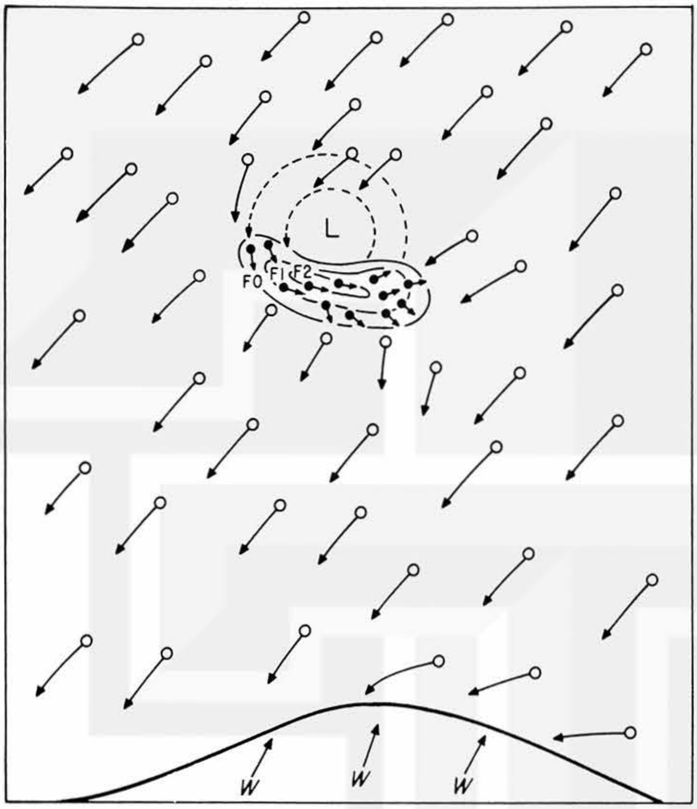

Fig. 10. Rotating thunderstorm producing damage as was found. Open circle is the cold air from the northeast, closed black circles represent air directly from the storm, and w represents the warm air.

The conclusion is that a rotating thunderstorm (Fig. 10), given the right conditions, may produce surface damage like that of a tornado or a plow wind, yet it is quite different from both. The problem lies in the classification of storms of this type. The damage here was found to be widespread and much of it was of the straight line variety. There was a definite broad cyclonic curvature of damage which gave evidence of the rotating thunderstorm aloft and its penetration through the cold shallow surface layer. The four strong swaths are an indication that funnel appendages were probably close to the ground causing damage as they traversed along the southern boundary of the parent thunderstorm. The storms should be characterized both in their entirety and as separate swaths as required. If it appears that separate swaths did occur then they may be classified in the F, P, P scale. The actual definition of the tornado cyclone and its effects should be investigated for further clarification.

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