THUNDERSTORMS AND TORNADOES OF FEBRUARY 1, 1955

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1. INTRODUCTION

One of the most death-dealing series of convective storms of the last few years occurred during the afternoon and evening of February 1, 1955—the first day of the 1955 "tornado season." This series of severe local storms, accompanied by tornadoes, destructive winds, hail, and heavy rain first struck near Marianna, Ark, at 1400 CST, roared through Commerce Landing, Miss., across northern Mississippi and on to near Huntsville, Ala., where they evidently dissipated around 1830 CST. The times and locations of these storms are shown in figure 1. Most of the injuries and fatalities caused by these storms occurred in northern Mississippi where over 125 persons were injured and 23 other persons—mostly school children—were killed.

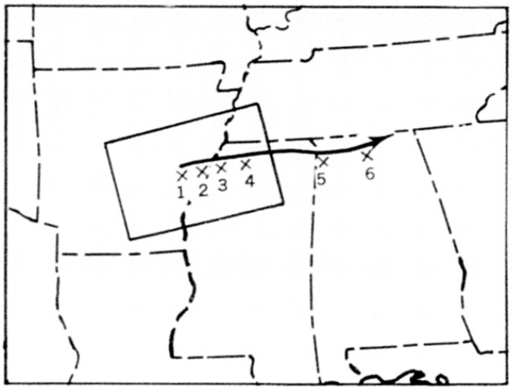

FIGURE 1.—Location and times of reported storms and Severe Local Storms Center tornado forecast area (outlined) on February 1, 1955. Numbered x's signify:

1. 1300 CST, near Stuttgart, Ark. Initial radar echo of squall line.
2. 1400 CST, near Marianna, Ark. Minor damage and some injuries.
3. 1420–1430 CST, Robinsonville and Commerce Landing, Miss. Extensive destruction, several deaths and numerous injuries.
4. 1440–1445 CST, Lewisburg, Miss. Extensive destruction, several deaths, and numerous injuries.
5. 1700 CST, Maud, Barton, and Mynot, Ala. 20 houses severely damaged and several injuries.
6. 1800–1830 CST, near Huntsville, Ala. Minor damage and some injuries.

The purpose of this paper is to describe and illustrate some of the features of this series that are of particular interest in the forecasting of severe local storms. In many respects, this situation presents nearly ideal examples of parameters used in forecasting tornadoes. At the surface, a pronounced Low was moving to the east-northeast at a moderate rate; an mP cold front followed in a V-shaped trough extending south-southwestward; warm, moist air with dewpoints in the 50's was moved northward ahead of the cold front by strong southerly gradient winds; and marked pressure falls occurred ahead of the Low. At the 850-mb. level, a sharp moisture injection, nearly coincident with the temperature ridge [1], was associated with a band of strong winds at this level. One feature of this situation that is different from many tornado outbreaks was the shift in winds at this level from a strong south-southwesterly straight flow at 2100 CST, January 31 to a strong cyclonically-curved flow by 0900 CST February 1. One of the most significant features at the 700-mb. level was the appearance of a moisture "bubble" at Little Rock, Ark. at 0900 CST. At the 500-mb. level, a strong cyclonically-curved jet moved into the area in a nearly ideal manner.

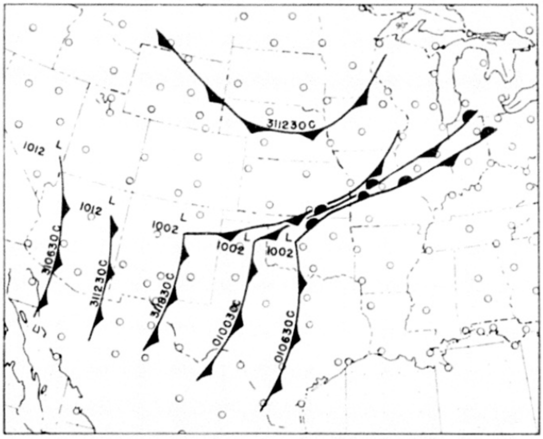

FIGURE 2.—Times and positions of surface fronts and low centers prior to development of storms, 0630 CST, January 31 to 0630 CST, February 1, 1955.

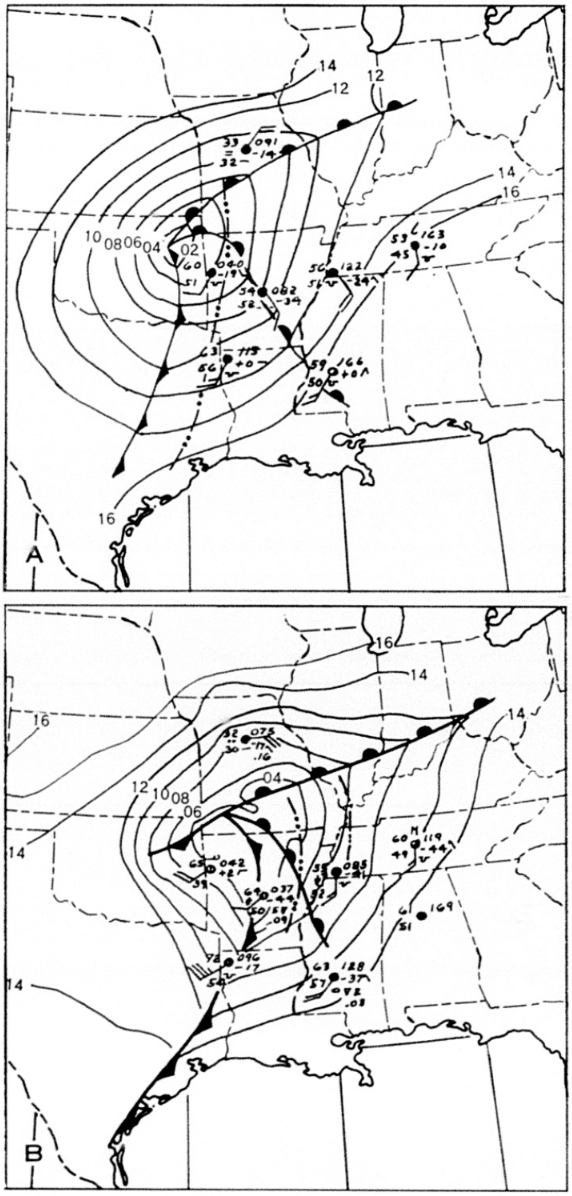

FIGURE 3.—Three-hourly sectional surface maps, February 1, 1955, for (A) 0930 CST, (B) 1230 CST, (C) 1530 CST, and (D) 1830 CST. Analyses are from the Severe Local Storms Center working charts.

2. FEATURES AT THE SURFACE

The surface charts prior to the development of these storms indicate that the associated surface cold front was the leading edge of a mass of Pacific air that entered the west coast early on January 30. The southern portion of this front moved eastward at 20–25 knots to merge with a 1012-mb. low center in central Arizona. The front accelerated to 25–30 knots on January 31 and by noon on February 1 the Low had deepened to 1003 mb. in the vicinity of Springfield, Mo. Positions of the surface fronts and pressure centers prior to the occurrence of the tornadoes are shown in figure 2.

Hourly surface charts which were drawn from 0830 CST through 2030 CST, February 1, are not reproduced here because the 3-hourly maps shown in figure 3 are sufficient for continuity. (Analyses shown here were taken from the Severe Local Storms Center working charts.) The squall line and weak secondary warm front at 0930 CST (fig. 3A) were being followed by Severe Local Storms Center for indications of possible severe storm development. One interesting feature of this series of surface maps is that the relative positions of the surface dew point ridge and the squall line remained nearly coincident throughout the life of the squall line, even in no-precipitation areas.

The low center near Tulsa, Okla. at 0930 CST moved eastward at 45 knots between 0930 and 1230 CST while the cold front and squall line also moved eastward at 45 knots. Around 1230 CST (fig. 3B), the cold front apparently decelerated to 30 knots, and weather activity along the front seemed to decrease, while activity along the squall line began to increase. A micro-low at 1330 CST was detected at the intersection of the squall line and secondary warm front. The echo of a rain area associated with this micro-low was picked up by radar at both Little Rock, Ark. and Memphis, Tenn. As the squall line moved eastward, this echo moved to the northeast and expanded into a line of echoes 70 miles long and 5 miles wide with an isolated echo about 20 miles farther south. When the line of echoes passed over Memphis at 1440 CST, its northern edge was some 25 miles north of Memphis. The storm damage in Arkansas occurred with the passage of the squall line and at its intersection with the secondary warm front. At 1530 CST (fig. 3C), the squall line and its associated severe storms were advancing eastward at 45–50 knots. The micro-low continued to be in evidence and a ridge of high pressure formed between the squall line and the cold front. While the central and northern portions of the squall line were active during the afternoon and evening, the severe damage was confined to the vicinity of the micro-low which continued eastward to the Huntsville, Ala. area by 1830 CST. The center of 3-hourly pressure falls (−4.0 mb.) moved from central Arkansas at 0930 CST to northeastern Alabama (−5.0 mb.) at 1530 CST. These large pressure falls were accompanied by large pressure rises to the west; +6.0 mb. in north central Texas at 0930 CST to +6.0 mb. near Tulsa, Okla. at 1530 CST.

3. FEATURES AT 850 MB.

The positions of the 850-mb. temperature and moisture ridges at various times prior to storm development are shown in figure 4. At 0900 CST, January 31, a warm ridge extended from west Texas to central Nebraska and a moisture ridge was indicated about 300 miles to the east. During the next 24 hours, the warm ridge moved eastward at about 17 knots while the axis of the moisture ridge moved eastward at about 5 knots. At 0900 CST, February 1, the temperature and moisture ridges were approaching coincidence. It is interesting to note that an extrapolation of these positions and movements indicates coincidence near Memphis around 1500 CST. Figures 5A, B, and C show the 850-mb. features at 0900, 1500, and 2100 CST, February 1.

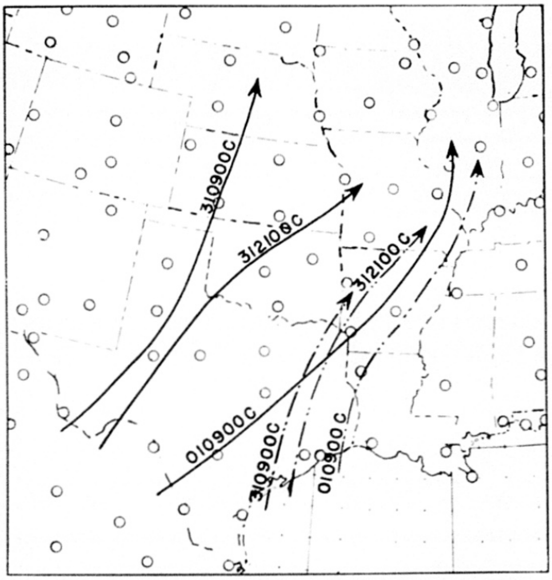

Figure 4.—Times and positions of 850-mb. temperature ridge (solid lines) and 850-mb. moisture ridge (dashed lines) prior to development of storms.

An important change in the flow at this level occurred between the charts for 2100 CST January 31, and 0900 CST February 1. The earlier chart (and even 12 hours prior to that) showed a strong moisture injection resulting from a strong south-southwesterly flow from the Gulf of Mexico. However, at 0900 CST, February 1 (fig. 5A) the winds over Arkansas intensified along with the development of marked cyclonic curvature. Such a cyclonic curvature of the flow at this level tends to cut off the northward flow of moisture and is not normally associated with the formation of tornadoes.

4. FEATURES AT 700 MB.

At 700 mb., the line of "no-change", separating the area of apparent warm air advection to the east from the following cold air advection to the west progressed eastward and was generally followed by a 4° C. drop in temperature which tended to decrease the stability of the air mass. The positions of this line at 0900, 1500 and 2100 CST, February 1, are shown in figure 6.

As previously mentioned, one of the significant features at 700-mb. was the "bubble" of moisture that suddenly appeared over Little Rock as indicated by data at 0900 CST, February 1. Such a high moisture value (dew point of −4° C.) could not have resulted from horizontal advection since prior upstream values were much lower.

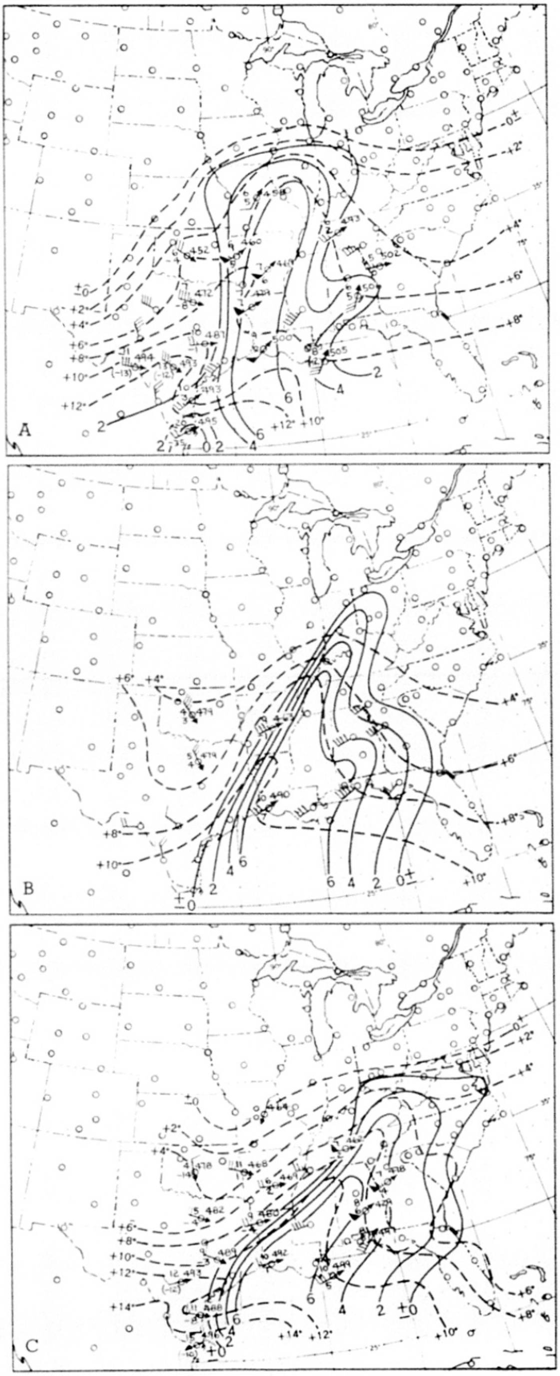

FIGURE 5.—850-mb. charts for February 1, 1955, showing isotherms (dashed) and dew point lines (solid) for 2° C. intervals at (A) 0900 CST, (B) 1500 CST, and (C) 2100 CST.

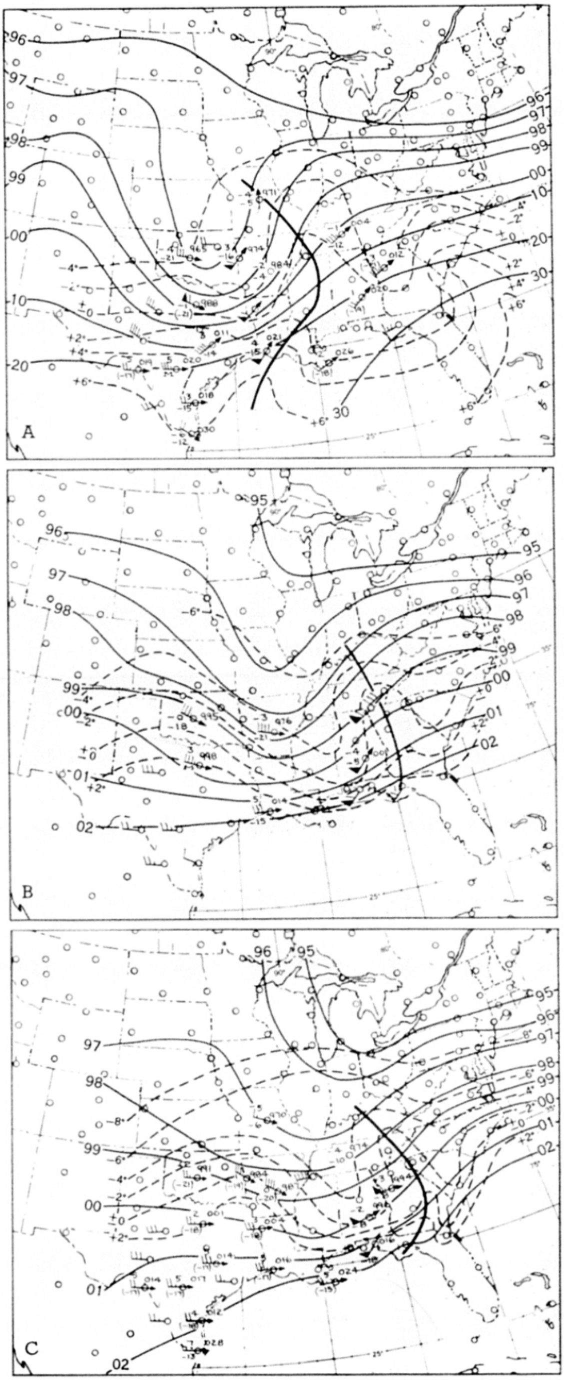

FIGURE 6.—700-mb. charts for February 1, 1955, showing contours (light solid lines) for 100-ft. intervals, isotherms (dashed lines) for 2° C. intervals and the "no-change" line (heavy solid line) at (A) 0900 CST, (B) 1500 CST, and (C) 2100 CST.

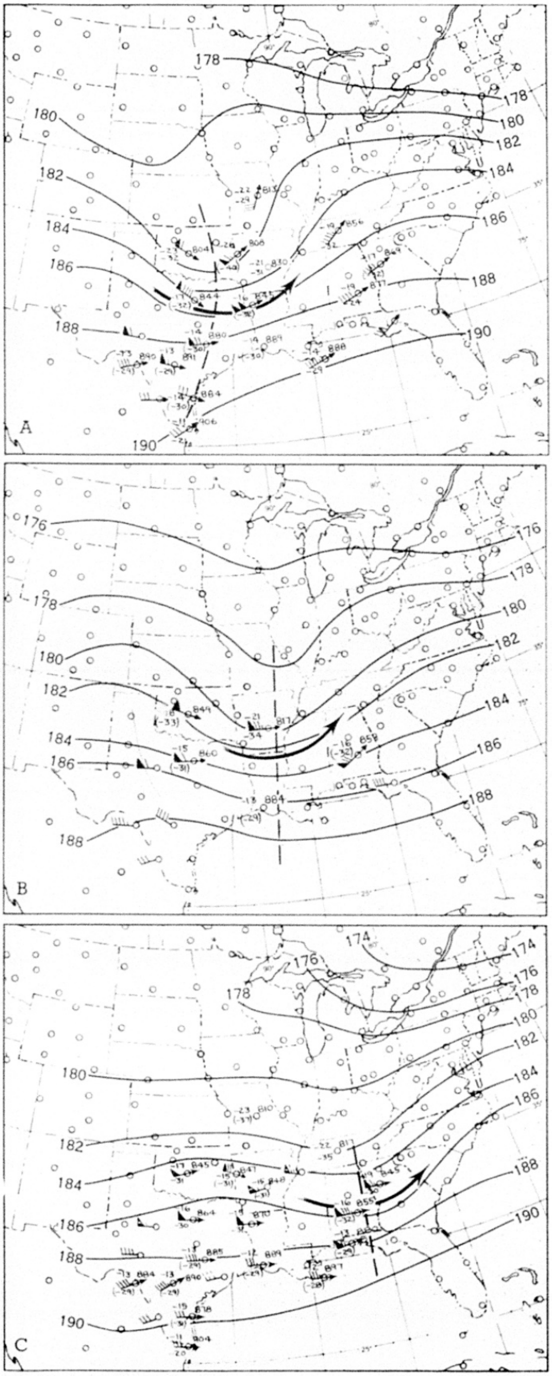

Figure 7.—500-mb. charts for February 1, 1955, showing contours (solid lines) for 200-ft. intervals, trough line (dashed) and the current jet position (curved arrow) at (A) 0900 cst, (B) 1500 cst, and (C) 2100 cst.

Thus it must have been a consequence of an increase in depth of the moist layer through vertical motions rather than horizontal advection.

5. FEATURES AT 500 MB.

The 500-mb. charts for 0900, 1500 and 2100 cst, February 1, are shown in figure 7. The times and positions of the 500-mb. jet and trough lines, taken from the Severe Local Storms Center working charts, are shown in figure 8. According to the model of jet structures proposed by Beebe and Bates [2], the left front quadrant of a 500-mb. jet axis maximum with cyclonic curvature, being an area of divergence at this level, is a contributing factor in effecting the release of convective instability. The jet positions shown at both 0900 and 1500 cst would require positioning a potential severe local storms forecast area to the left (north) of the indicated 500-mb. jet.

6. UPPER AIR CONDITIONS

The Little Rock upper air soundings showed the depth of the moist layer to be near 5,000 feet at both 0900 cst (fig. 9A) and 2100 cst (fig. 9B) on January 31. However, a marked change occurred during the next 12 hours and by 0900 cst February 1 (fig. 9C), the moisture had penetrated to a much greater depth, at least 13,000 feet. At Barksdale Air Force Base, Shreveport, La., a similar situation was noted in the soundings. During the 6-hour period from 2100 cst, January 31 (fig. 10A) to 0300 cst, February 1 (fig. 10B), the depth of the moist layer remained near 5,000 feet. During the next 6-hour period, the moisture depth increased to near 8,000 feet (fig. 10C). If the base of the Barksdale inversion noted at 0300 cst were lifted 80 mb. to the 770-mb. level, the same temperature would be obtained as that observed. Further study of the changes in the lower levels of the air mass represented by the difference of the Barksdale sounding at 0900 cst from

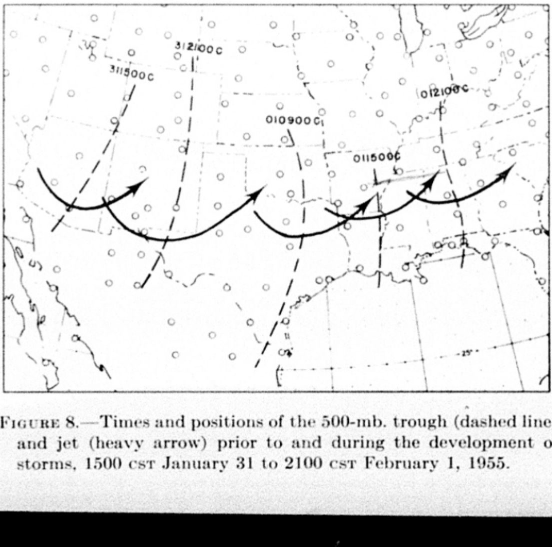

Figure 8.—Times and positions of the 500-mb. trough (dashed line) and jet (heavy arrow) prior to and during the development of storms, 1500 cst January 31 to 2100 cst February 1, 1955.

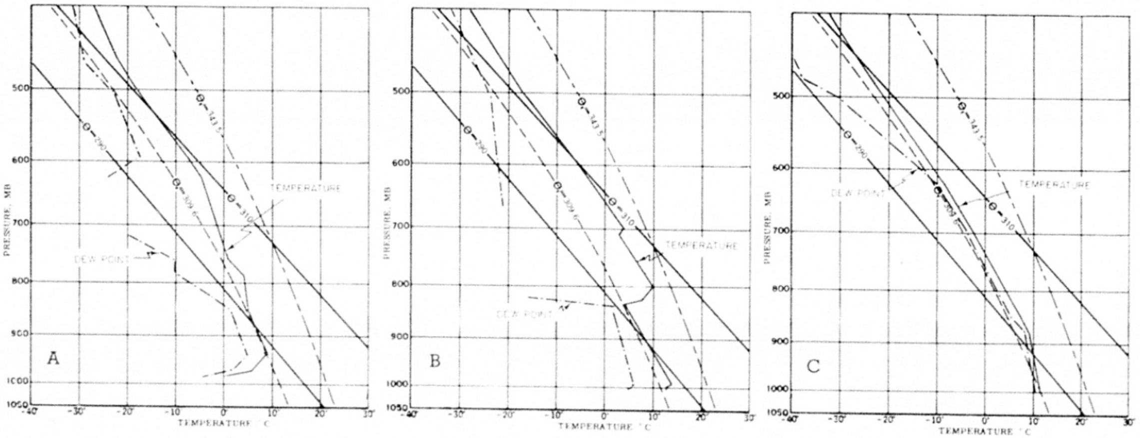

FIGURE 9.—Upper air soundings at Little Rock, Ark. at (A) 0900 CST, January 31, (B) 2100 CST, January 31, and (C) 0900 CST, February 1, 1955.

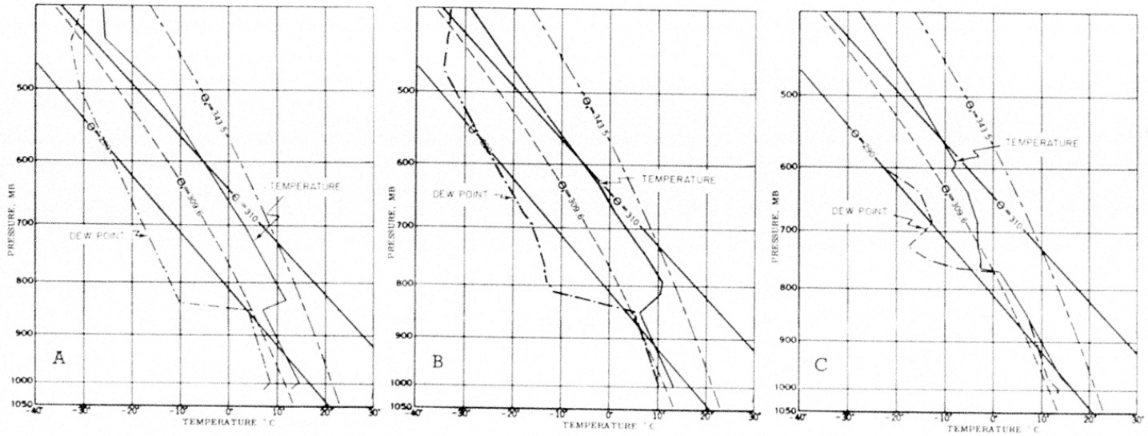

FIGURE 10.—Upper air soundings at Barksdale Air Force Base, Shreveport, La., at (A) 2100 CST, January 31, (B) 0300 CST, February 1, and (C) 0900 CST, February 1, 1955.

that at 0300 CST indicate that this change can be explained through a lift of 80 mb. Considering the moist layer of the Little Rock sounding at 2100 CST, January 31, and increasing the mean temperature by 2° C. and the mixing ratio by 1 gram, the sounding observed at 0900 CST, February 1 could be obtained by lifting the lower 5,000 feet by 150 mb.

One interesting feature of the 0900 CST soundings at Barksdale, Maxwell Air Force Base at Montgomery, Ala., Burrwood, La. and Atlanta, Ga. (all within the warm air mass), was the presence of a superadiabatic lapse rate at the top of the moist layer (base of the inversion). At this time, the moist layer was around 7,500 feet deep except at Burrwood where the depth was near 5,000 feet. The relative humidity at the base of these superadiabatic lapse rates varied from 90 to 100 percent at Barksdale and Maxwell to around 70 percent at Atlanta and Burrwood. Precipitation was not observed at these stations just prior to or during these soundings.

7. FORECASTING TORNADO DEVELOPMENT

The forecasting of this tornado development by the Severe Local Storms Center was based largely upon (1) the recognition of the strong dynamic factors evidenced on the earlier charts (strong 850- and 500-mb. jet structures and intensification of the surface Low over Oklahoma); (2) a prognostic sounding for northeastern Arkansas which took into account a lift of 100 mb.; and (3) the confirmation at 0900 CST by both the Barksdale and Little Rock soundings that the lower layer was undergoing lifting. Actually, the 0900 CST Little Rock sounding evidenced a greater lift than 100 mb. (at least 150 mb.), while the Barksdale sounding showed less than 100-mb. lift, so that the lifting mechanism was even more potent than expected from earlier data. Also, these considerations pointed to a threat area to the east of Little Rock. Static instability indices at 2100 CST, January 31, were all positive but by 0900 CST, February 1 the Showalter stability index [3] lowered to −1 at Little Rock and to −5 at Ft. Smith, Ark. The lifted index (similar to the Showalter index but determined by moisture and temperature values in the lower 3,000 feet rather than at 850 mb.) on the prognostic sounding for 1500 CST was −4 with a level of free convection around 880 mb. While only a moderate degree of instability was available, the indications of a very strong dynamic modification of the air mass tipped the balance in favor of a forecast for tornadoes rather than severe thunderstorms.

The area was determined largely through the positions expected to be swept out by both the divergent quadrant (left, front) of the jet maximum at 500 mb. and the convergent quadrant (left, rear) of the jet maximum at 850 mb. These considerations, plus the Little Rock sounding and prognostic positions of the surface Low, located an area to the left (north) of both the 850- and 500-mb. jets. In such cases the cut-off between violent convective activity and little activity would be expected to be sharply drawn at, and to the right (south) of, the upper jet axis. The forecast area and reported storms are shown in figure 1.

ACKNOWLEDGMENTS

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2. R. G. Beebe and F. C. Bates, "A Mechanism for Assisting in the Release of Convective Instability," *Monthly Weather Review*, vol. 83, No. 1, Jan. 1955, pp. 1–10.
3. A. K. Showalter, "A Stability Index for Thunderstorm Forecasting," *Bulletin of the American Meteorological Society*, vol. 34, No. 6, June 1953, pp. 250–252.

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