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EARLY CANCELLATION OF WW NO. 331: ADAP SHOWS WHY

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1. INTRODUCTION

During potential, or evolving severe weather episodes, forecasters rely on a variety of tools in order to make crucial decisions. An important resource that is frequently utilized at the Weather Service Office (WSO) in Cincinnati is the AFOS Data Analysis Program (ADAP) (Bothwell 1988). Through the use of ADAP, it is possible to pinpoint areas of potential severe convective development. ADAP can also be utilized to indicate areas of minimal severe weather threat, or where convective development is no longer likely to occur.

This study describes a case where a severe thunderstorm watch was issued for parts of the Cincinnati Tri-State area, yet was cancelled early due to a decrease in the severe weather threat. For this event, ADAP indicated that the severe weather threat would shift away from the watch area.

2. BACKGROUND

A surface stationary front extended from northern Ohio to northern Iowa at 1500 UTC 14 May 1991 (Figure 1a). The night before, thunderstorms were very active along the front creating several outflow boundaries. Much of the thunderstorm activity had ceased across the Ohio Valley by the early morning hours of May 14. However, a mesoscale convective system (MCS) over northern Illinois continued to flourish (Figure 1b).

The 1200 UTC 14 May 1991 sounding at Dayton, OH (not shown) was moderately unstable. The surface lifted index was -4. Winds aloft were relatively light; north-northwest winds prevailed through 20,000 feet, with speeds of 10 to 15 knots.

Morning forecasts anticipated the MCS to move southeast into Indiana. Further destabilization of the atmosphere was likely throughout the day across the Lower Ohio Valley, as skies were mostly clear.

Around 1600 UTC, the Severe Local Storms (SELS) Unit issued a mesoscale discussion for Illinois, Indiana, and Ohio to highlight the potential for severe thunderstorms (Figure 2a). At 1700 UTC, Severe Thunderstorm Watch #330 was issued for Illinois and Indiana. Around 1900 UTC, Severe Thunderstorm Watch #331 was issued for parts of Indiana, Ohio, and Kentucky (Figure 2b). For the purpose of this study, Weather Watch (WW) #331 will be the focus of attention, since this issuance covered WSO Cincinnati's warning county area.

3. MESOANALYSIS

Between 1500 and 1800 UTC, the MCS that was previously over northern Illinois, moved over northwest Indiana. An east-west oriented outflow boundary from this thunderstorm complex raced southeast across central Indiana. By 1800 UTC, surface analysis and radar reports (not shown) indicated a northeast to southwest line of storms over central Indiana moving southeast at 20 knots. At this time, the outflow boundary was further downwind across southern Indiana and southwest Ohio.

Surface moisture flux convergence (SMC) graphics from ADAP provided important insight into how the convection would evolve during the afternoon of May 14. From 1600 through 2000 UTC, a SMC maxima persisted over southeast Indiana. An area of surface moisture flux divergence was located over northwest Indiana. According to Hirt (1982) and Bothwell (1988), storm severity often increases when a strong convergence center is coupled with a divergence center (C/D couplet), with the highest mixing ratios between the two centers (Figure 3).

The 1800 UTC SMC plot shows a couplet over Indiana (Figure 4). The line of thunderstorms was located in the gradient area between the convergence/divergence maximas. Hence, the convergence over southeast Indiana was likely related to the interaction of the outflow boundary with the environmental low level flow. The divergence area over northwest Indiana was a reflection of a mesohigh associated with the squall line. Initially, it might appear that the couplet in Figure 4 is similar to the Hirt conceptual model in Figure 3. However, as Hirt (1982) first described, and Waldstreicher (1989) further refined, convective development, along with an increased chance of severe storms, takes place in the C/D gradient *downwind of the convergence center* (i.e., the convergence center is upwind from the divergence center). In Figure 4, the convergence maxima near Cincinnati is actually downwind of the divergence center over northwest Indiana. Hence, the couplet over Indiana is actually a divergence/convergence (D/C) couplet, and not a C/D couplet.

Although not obvious at first glance, there was a C/D couplet in Figure 4. The couplet was located along the Indiana/Kentucky border south of the outflow boundary. It is this region where forcing should favor new convection due to the convergence from the southward moving outflow. In addition, with the most unstable air centered over southwest Indiana (Figure 5), the thunderstorm cells on the southwest flank of the squall line in central Indiana appeared to have the potential of becoming severe.

During the next hour, the outflow boundary moved almost due south, while the line of storms moved southeast. New thunderstorm cells formed along the southwest flank, closest to the surface mixing ratio maxima (Figure 6). (Again, the severe weather threat should be greater in this area, since atmospheric instability is highest in this region.) Between 1800 and 1900 UTC, the storms in the northeast part of the line maintained approximately the same strength, remaining below severe limits. Surface moisture flux convergence continued to sustain these cells even though the surface mixing ratios were lower (Figure 7).

By 2000 UTC, thunderstorms had developed to the southwest across southern Indiana, and into the very unstable, moisture-laden airmass. Surface mixing ratios were as high as 18 g/kg over southwest Indiana and western Kentucky, with surface LI's around -10 (Figures 8 and 9). Surface moisture convergence in this region appeared to be rather minimal by this time. However, 2 hours earlier, a divergence center had been located over this area (Figure 4). The 2-hour net increase in moisture flux convergence, in combination with the strong thermodynamics present over this area, helped trigger new storm development.

Surface moisture flux convergence associated with the northeast part of the line began to weaken at 2000 UTC, while moisture flux divergence over western Indiana nearly doubled between 1900 and 2000 UTC (Figure 10). Also note the absence of the C/D couplet south of the outflow at 2000 UTC. As shown by Hirt (1982), when convergence decreases, a weakening trend of thunderstorm intensity is exhibited. An increase of divergence, probably resulting from the mesohigh, also was apparent between 2000 and 2300 UTC. Although data from 2100 and 2200 UTC were not available, the 2300 UTC SMC chart indicates the convergence area had dissipated (Figure 11). All that remained was an area of surface moisture flux divergence.

Cincinnati radar indicated a rapid decrease in thunderstorm intensity in the northeast part of the line shortly after 2100 UTC (not shown). The storms over southwest Indiana persisted as the airmass over that area remained unstable. These storms diminished after sunset when solar heating ended.

4. CONCLUSIONS

The storms which entered WW #331 never had a chance to reach severe limits. Isolated reports of three-quarter inch hail, and wind gusts to 52 knots, were observed over central Indiana, outside of WW #331 (in WW #330). As indicated by ADAP, the thunderstorms with the greatest potential of producing severe weather developed along the southwest flank of the squall line across southern Indiana, away from the WW #331 area. As a result, WSO Cincinnati requested the Watch be cancelled, 2 hours before the normal expiration time.

For this case, the precursor conditions were not suitable for severe weather. Insufficient moisture and instability prevented the storms within WW #331 from reaching severe limits. Development of the stronger storms took place west of the watch area, where higher instability, and greater low-level forcing existed. Storms that developed over eastern Indiana and southwest Ohio were considerably weaker, and lacked the explosive development often typical of severe storms.

Through the use of ADAP the Cincinnati Weather Office was able to assess that the area within WW #331 was less favorable for severe convective development. This determination not only allowed the watch to be cancelled early, but it enabled the radar operator to concentrate on those thunderstorm cells further to the west that had the greater potential to become severe.

ADAP has become an effective forecasting tool at WSO Cincinnati. Its diagnostic capabilities have proven invaluable for thunderstorm forecasting.

5. ACKNOWLEDGEMENTS

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References

Bothwell, P. D., 1988: Forecasting Convection with the AFOS Data Analysis Programs (ADAP-Version 2.0). NOAA Technical Memorandum NWS SR-122, Fort Worth, TX, 92 pp.

Hirt, W. D., 1982: Short Term Prediction of Convective Development Using Dew Point Convergence. Preprints, 9th Conference on Weather Analysis and Forecasting, Amer. Meteor. Soc., Seattle, 201-205.

Waldstreicher, J. S., 1989: A Guide to Utilizing Moisture Flux Convergence as a Predictor of Convection. Nat. Wea. Dig., 14, 4, 20-35.

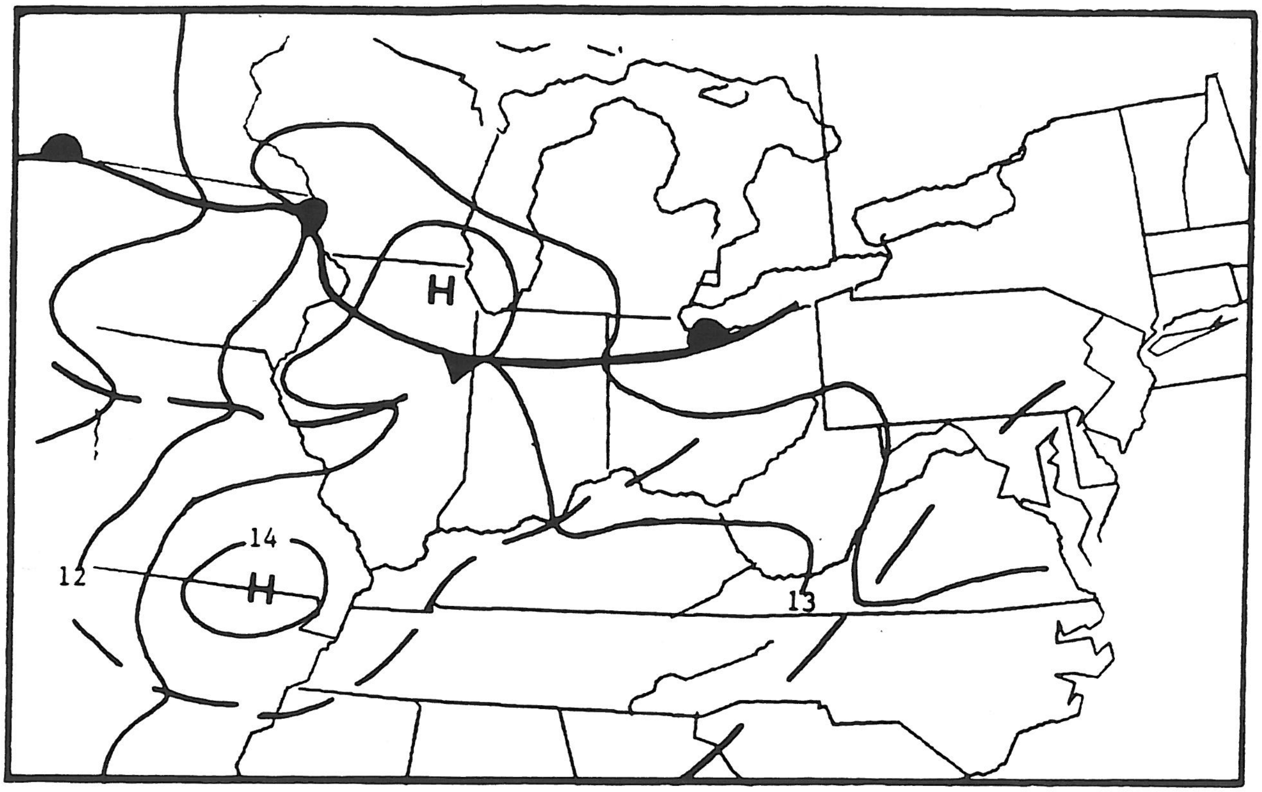

Figure 1a. Surface analysis for 1500 UTC 14 May 1991.

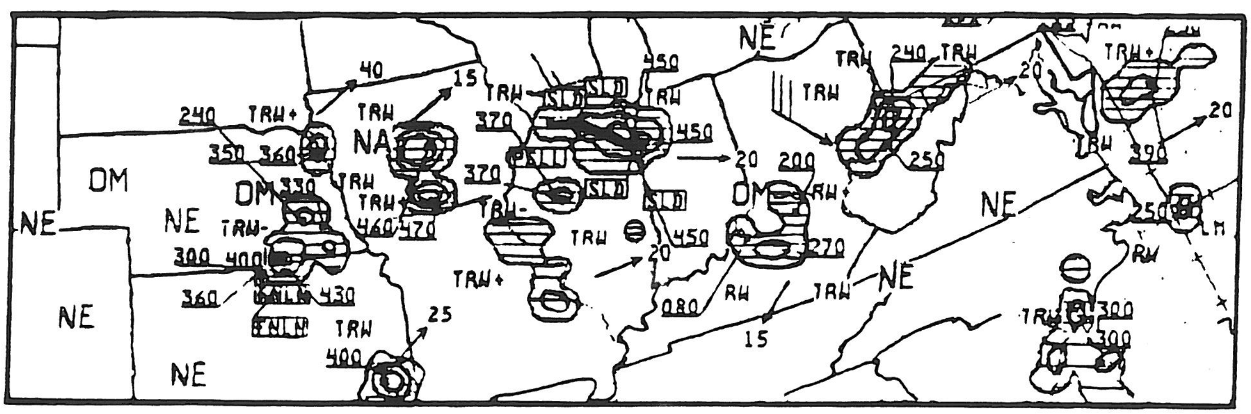

Figure 1b. Radar summary for 1435 UTC 14 May 1991.

MKCSWOMCD
ACUS3 KMKC 141607
MKC MCD 141607

SELS MESOSCALE DISCUSSION FOR ...IL/IN/OH...
CONCERNING... SEVERE THUNDERSTORM POTENTIAL

TSTMS HAVE BECOME BETTER ORGANIZED ACRS NW/WCNTRL IN SINCE 15Z. LN OF TSTMS HAS DVLPD FM BTWN GYY/SBN SSWWD TO NR LAF. TSTMS HAVE ALSO INTSFYD IN CNTRL IL N OF SPI WHERE ERYR TSTM ACTVTY HAS INTERSECTED OUTFLOW BNDRY FM INDIANA CNVTV CLUSTER. AMS CONTS TO DESTBLZ WITH LRG AREA OF 70 DEG DEWPTS ACRS IL/IN ATTM ALLOWING LIFTED INDICES TO APCH MINUS 8. CNVGC BNDRY PRSTS FM CNTRL IL INTO CNTRL OH AND THIS FTR SHOULD PROVIDE A FOCUS FOR DVLPMT/TRANSLATION OF TSTM ACTVTY OVER THE NEXT SVRL HRS. ALTHO FLOW ALF REMAINS QUITE WK...LO LVL CONVGC/INSTBY OF AMS APPR SUF FOR SVR TSTM DVLPMT FM CNTRL/ERN IL INTO WRN OH DURG THE NEXT SVRL HRS. WE ARE MONITORING THIS AREA CLOSELY FOR CONTD TSTM INTSFCN/PSBL WW. (..SAMMLER.. 05/14/91)

Figure 2a. SELS mesoscale discussion issued at 1607 UTC.

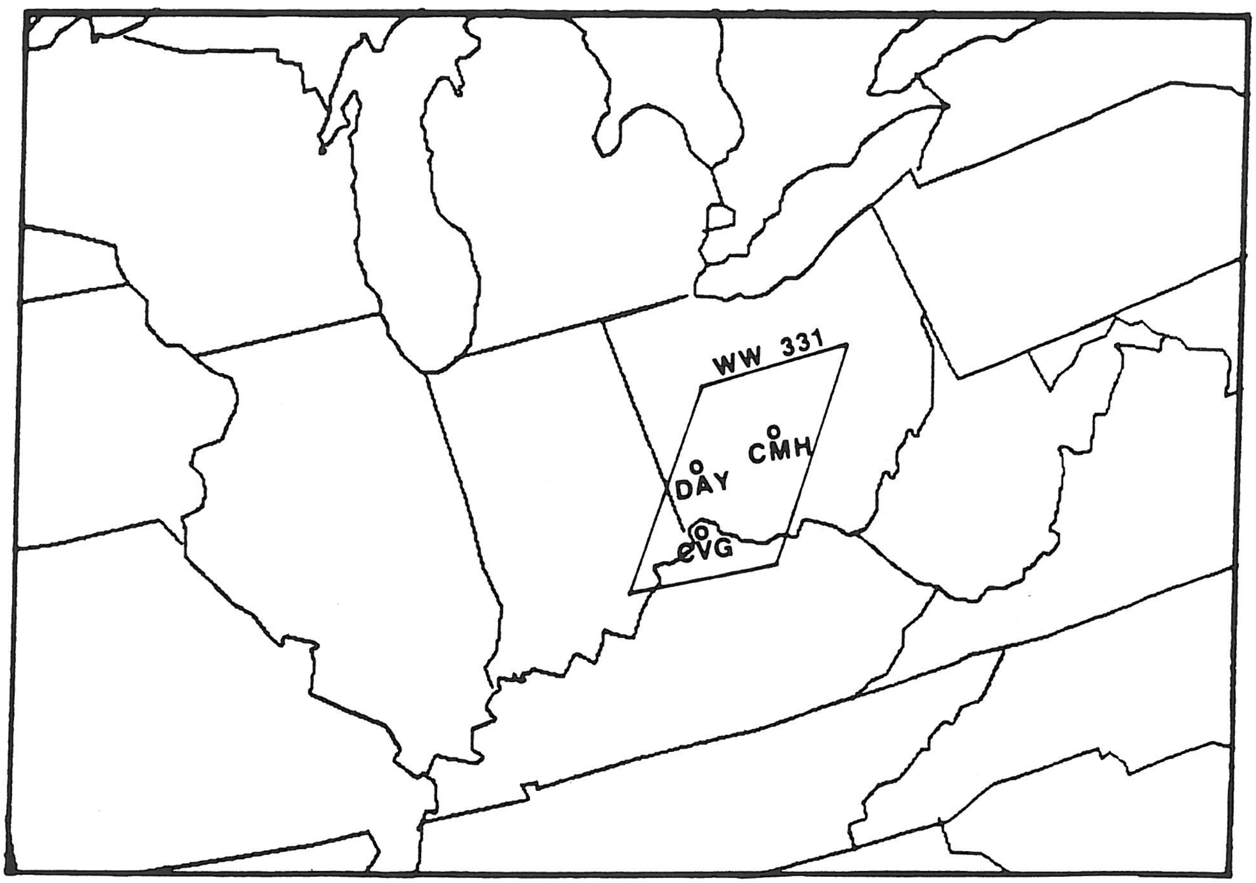

Figure 2b. Severe thunderstorm watch #331 valid from 1930 to 0000 UTC.

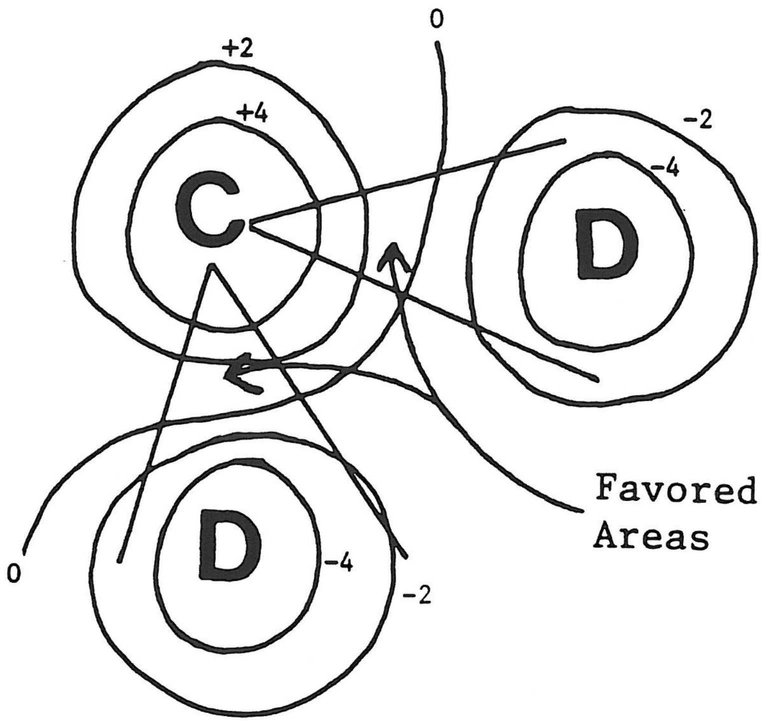

Figure 3. Convergence/Divergence (C/D) couplet indicating favored areas of severe convective development (after Hirt 1982).

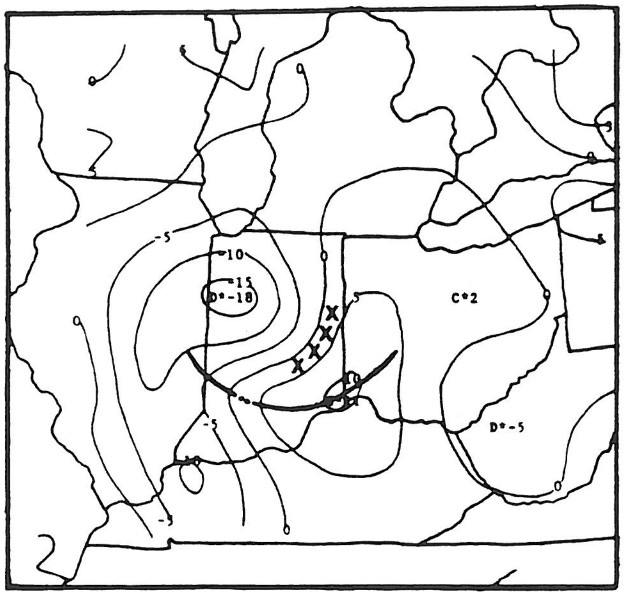

Figure 4. 1800 UTC surface moisture flux convergence (g kg^{-1} hr^{-1} x 10).

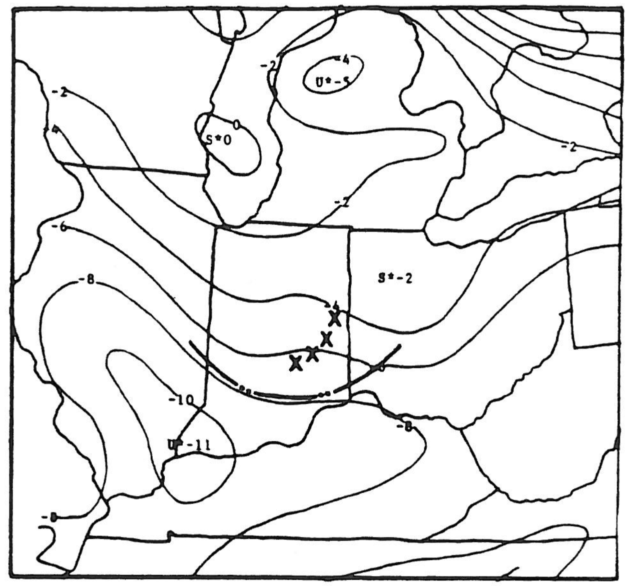

Figure 5. 1800 UTC surface-based lifted index (°C).

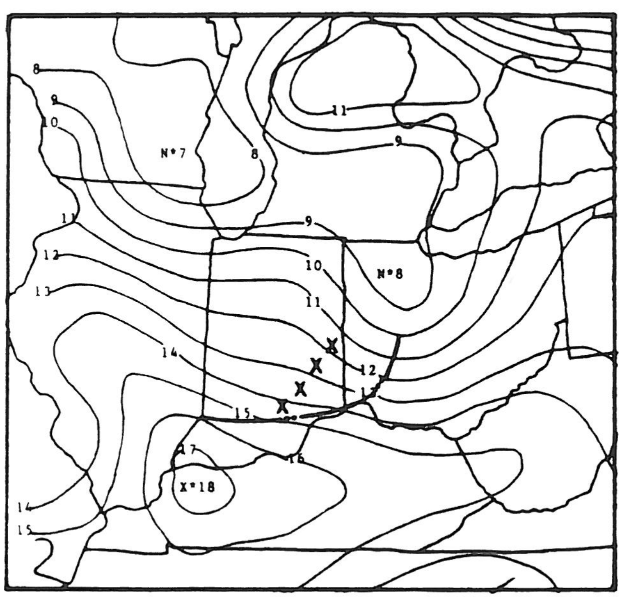

Figure 6. 1900 UTC surface mixing ratio (g kg^{-1}).

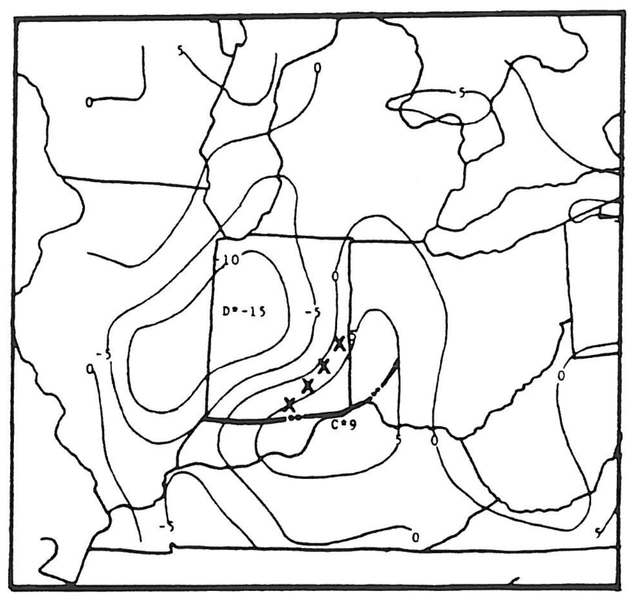

Figure 7. 1900 UTC surface moisture flux convergence (g kg^{-1} hr^{-1} x 10).

XXXX denotes the line of thunderstorms

—•••— denotes the outflow boundary

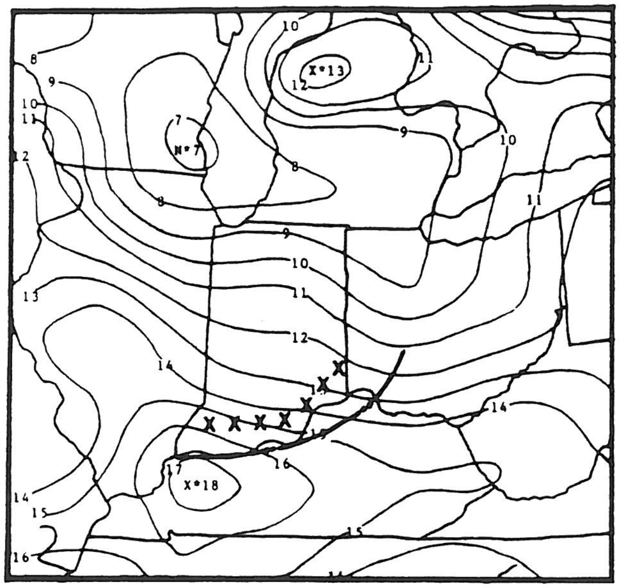

Figure 8. 2000 UTC surface mixing ratio (g kg^{-1}).

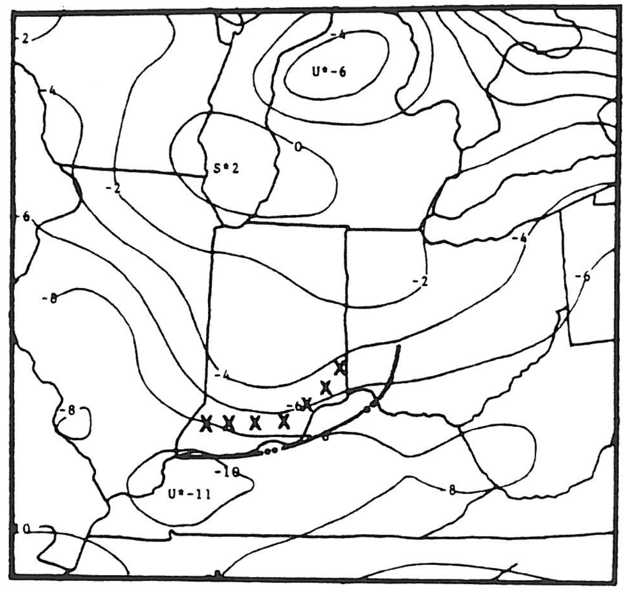

Figure 9. 2000 UTC surface-based lifted index (°C).

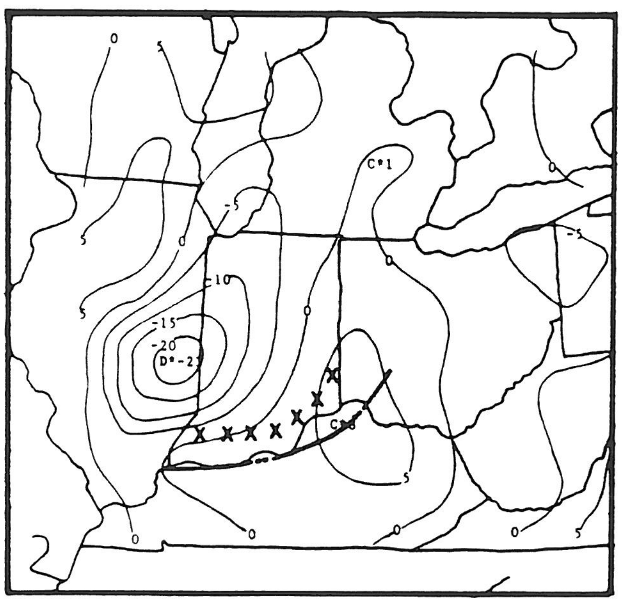

Figure 10. 2000 UTC surface moisture flux convergence (g kg^{-1} hr^{-1} x 10).

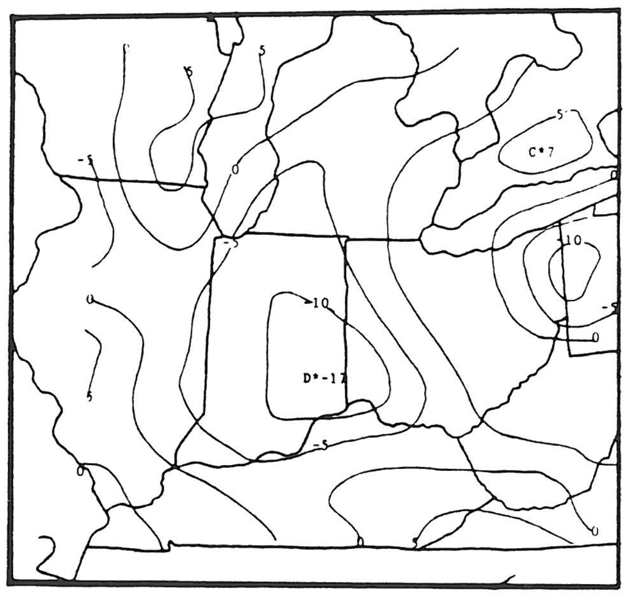

Figure 11. 2300 UTC surface moisture flux convergence (g kg^{-1} hr^{-1} x 10).

XXXX denotes the line of thunderstorms

— • • — denotes the outflow boundary