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FLOODING IN WESTERN OHIO ON MAY 26, 1989

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1. INTRODUCTION

During the early morning hours of May 26, 1989, thunderstorms with very heavy rain produced serious urban and small stream flooding across parts of the Miami Valley in western Ohio. As a result of the flooding, President Bush declared a major disaster for the state of Ohio on June 10, 1989. This declaration made six counties in western Ohio eligible for federal assistance. Five of the counties, Butler, Greene, Montgomery, Preble, and Warren, are located in southwest Ohio, while the sixth county, Mercer, is located in the west central part of the state (Figure 1).

2. THE WET SPRING OF 1989

Frequent heavy rains during the months of March, April, and May, 1989 resulted in the wettest spring on record at WSO Dayton, dating back to 1900. Total precipitation in March was 5.99 inches or 194% of normal, while the April total of 6.52 inches was 190% of normal. May was the wettest month of the spring, with 8.55 inches of rain, which is 232% of normal. This made May 1989 the second wettest May on record.

The heaviest rain event of the spring occurred over much of the Miami Valley on May 22-23. At Dayton, 3.64 inches of rain was recorded in a 24 hour period. This heavy rain was not the result of an isolated convective event. It was caused by a well developed synoptic scale low pressure system which moved through the Ohio Valley. As a result of this heavy rainfall, some small stream and urban flooding occurred over parts of Preble and Montgomery counties on May 23. However, the most serious flooding of the spring occurred a few days later when heavy thunderstorms moved into the region on May 26. The two events combined to produce over 6 inches of rain across parts of Montgomery and Preble counties (Figure 1).

3. SYNOPTIC SITUATION LEADING TO THE FLOOD EVENT

At 0000 UTC, May 26, the surface and upper air analyses showed that the ingredients necessary for the production of severe weather and heavy rains were coming together across the Ohio Valley.

3.1 0000 UTC May 26 Surface Analysis

The 0000 UTC, May 26, surface map (Figure 2) showed a cold front stretching from north of New York state to southwest Michigan, where it became stationary, and then extended southwest to Oklahoma. Waves of low pressure were located along the front over southwest Michigan, western Illinois, and eastern Oklahoma. The temperature gradient across the front was not impressive, but the moisture gradient was substantial. The dewpoint range across the front was on the order of 30°F, with dewpoints ahead of the front in the low 70s.

3.2 0000 UTC May 26 Upper Air Analyses

The 0000 UTC, May 26, upper air analyses exhibited many of the classic characteristics associated with the development of strong convection. At 850 mb (Figure 3), weak warm air advection, and the nose of a low level jet were indicated over the Ohio Valley. Also, at 850 mb, a ribbon of very moist air, with dewpoints of 15°C to 17°C extended from the lower Mississippi Valley to the Ohio Valley.

Warm air advection was also indicated at 700 mb over Ohio, and there was an approaching speed max located over Kentucky (Figure 4). The atmosphere was still very moist over Ohio at this level, as indicated by the 3°C dewpoint depression at Dayton. However, a tongue of dry air extended from the lower Mississippi Valley into Kentucky. Dewpoint depressions of 10°C to 20°C were common in this area, with dewpoints as low as -10°C. With southwest flow, the result was dry air advecting over Ohio at 700 mb. While this factor often points toward severe weather, it is not usually an indicator of flood producing thunderstorms.

At 500 mb (Figure 5), the atmosphere was still moist over Ohio, with a dewpoint depression of 4°C observed at Dayton. Also, the -13°C 500 mb temperature at Dayton, which was a local minimum, in combination with the +16°C temperature at 850 mb, resulted in a steep lapse rate. Strong synoptic scale speed shear between 850 mb and 500 mb was also observed, with a 60 knot jet nosing into western Ohio at 500 mb.

Even at 300 mb (Figure 6), the atmosphere was still nearly saturated at Dayton, with a dewpoint depression of 5°C. Also, diffluent flow at 300 mb was evident over the Eastern U.S. This situation, combined with the convergence associated with the low level jet present, indicated good upward vertical motion was likely over the Ohio Valley.

As discussed before, the atmosphere was extremely unstable over Ohio at 0000 UTC on May 26. The total-totals index from the Dayton sounding was 57.6, and the lifted index was -8.5°C. The SWEAT index, which combines the effects of stability and wind shear, was 512.6. This high value for the SWEAT index indicated that the atmosphere was favorable for tornadic development.

4. THE FLOOD EVENT

Analysis of surface charts, radar, and satellite data showed how the flood event evolved, and why the flooding was concentrated over southwest Ohio.

4.1 Surface Analyses

The 0000 UTC, May 26, surface analysis (Figure 2) showed a stationary front stretching from Michigan to Oklahoma. Several waves of low pressure developed along the front and moved northeast during the day, preventing the front from making much eastward progress. Between 1800 UTC, May 25, and 0000 UTC, May 26, the portion of the front over Illinois moved very little. After 0000 UTC, the front began to move east, and by 0300 UTC, the front had moved into western Indiana (Figure 7). At this time, a wave was located along the front near the Indiana-Illinois border. By 0600 UTC (Figure 8), the front had moved into northwest Ohio. One low was now over central Indiana, with the last in the series of frontal lows moving into southwest Indiana. Once this final low moved north of Ohio, the front began to move eastward more rapidly, with frontal passage occurring at Dayton, Ohio shortly before 1200 UTC (Figure 9).

4.2 Radar and Satellite

At 0330 UTC, May 26, satellite imagery (Figure 16) and weather radar from Cincinnati, Ohio (CVG) (figure 10), showed thunderstorms and showers over west-central Ohio, and much of eastern Indiana. At this time, the strongest storms were located over Indiana, and were moving to the east at about 35 knots. The VIP 3 storm indicated in east-central Indiana (figure 10) produced two weak tornadoes (F1) in west-central Ohio between 0340 UTC and 0430 UTC. The first occurred in the northwest corner of Mercer county, and the second occurred shortly thereafter in Auglaize county. The thunderstorms then weakened, and by 0430 UTC, CVG radar was showing mostly light rain over west-central Ohio and central Indiana (Figure 11).

At 0530 UTC, CVG radar indicated thunderstorms redeveloping (Figure 12), and by 0630 UTC (Figure 13), a line of very strong thunderstorms extended from central Indiana, across the Dayton, Ohio area, into central Ohio. The rapid development of these storms can be seen in the satellite images from 0600 UTC, and 0700 UTC (Figures 17 and 18). The thunderstorm cells continued moving east at about 35 knots, while the line moved slowly south. The southward movement of the line between 0630 UTC and 0730 UTC (Figure 14) was only about 15 knots in the Dayton area. With the initial rapid development of these thunderstorms, there were estimated wind gusts of 55 to 60 mph between 0600 UTC, and 0630 UTC in Preble county of western Ohio.

There were no other reports of severe weather in western Ohio after the report of high winds in Preble county. However, it was after the severe weather ended that the thunderstorms began causing widespread flooding across western Ohio. The slow southward movement of the line of the line of thunderstorms across southwestern Ohio between 0630 UTC and 0730 UTC caused the eastward moving cells to track over the same areas, resulting in heavy rains in Preble, Montgomery and Greene counties. As this line of thunderstorms moved across the Dayton airport, it produced 0.67 inches of rain in 30 minutes, and 0.80 inches in 80 minutes. The southward movement of the line slowed even more after it moved south of the Dayton airport. By 0830 UTC (Figure 15), the heavy rain finally moved south of Preble and Montgomery counties, but heavy rain continued over parts of Greene county. The rain finally moved out of most of western Ohio by 1100 UTC.

5. SUMMARY OF WATCHES AND WARNINGS

A flood watch was issued for all of west-central and southwest Ohio at 1940 UTC, May 25, 1989, by WSFO Cleveland. The watch was valid for the upcoming night and the following day. At 2048 UTC, May 25, the National Severe Storms Forecast Center issued a tornado watch that included western Ohio, valid from 2130 UTC, May 25, until 0400 UTC, May 26. At 0330 UTC, this watch was replaced with a severe thunderstorm watch for most of western Ohio, valid until 0900 UTC, May 26.

Several warnings were issued for the western Ohio counties by WSO Dayton on May 26, 1989. A tornado warning was issued for Mercer and Van Wert counties in west-central Ohio at 0406 UTC. This warning was in effect until 0445 UTC. A severe thunderstorm warning was issued for Preble county at 0550 UTC, valid until 0630 UTC. Urban and small stream flood warnings were issued for Preble and Montgomery counties from 0616 UTC until 0915 UTC, and for Greene county from 0844 UTC to 1245 UTC.

6. DISCUSSION AND CONCLUSIONS

It appears that the series of lows that moved northeast along the front enhanced the heavy rainfall across western Ohio. The lows helped increase rainfall by concentrating low level convergence and warm advection, thereby increasing upward vertical motion. The lows appear to have slowed the eastward progress of the front. This caused the convective forcing to remain over the same locations for an extended period of time, resulting in thunderstorm redevelopment along the same axis. If the front had moved eastward at a

quicker pace, one or two thunderstorm cells would still have affected western Ohio, but with a quicker movement, less rainfall would likely have fallen. The frontal low moving across Indiana at 0600 UTC seemed to trigger the line of strong thunderstorms that moved into southwest Ohio and subsequently caused the flooding.
At 0334 UTC, radar indicated an area of thunderstorms and individual cells generally moving east. At 0630 UTC, thunderstorms cells continued to move east, but the newly developed line was now moving south. The portion of the line that moved south through the Dayton area between 0630 UTC, and 0730 UTC was only moving south at about 15 knots. With cell movement still east at about 40 knots, this caused a "training effect" across the central and southern parts of Preble, Montgomery and Greene counties, and as a result, the greatest rainfall, and most serious flooding occurred in these areas.

It is important to note that the heavy rain which occurred on May 26, 1989, might not have caused such significant flooding if it had not occurred within what was already an extremely wet period. The continued rainy weather during the spring of 1989 kept the ground nearly saturated, setting the stage for the flooding which occurred at the end of May.

The heavy rain which fell on May 22-23 did not occur in a short enough time to cause major flooding, but it did result in the greatest 24-hour rainfall of the spring at WSO Dayton. This event, which was a widespread rain, left the ground saturated, and raised stream levels. The ground was still saturated, and many streams were still running high on May 26. All that was needed for significant flooding was some heavy rainfall for a short period, which is what occurred with the strong thunderstorms early on May 26.

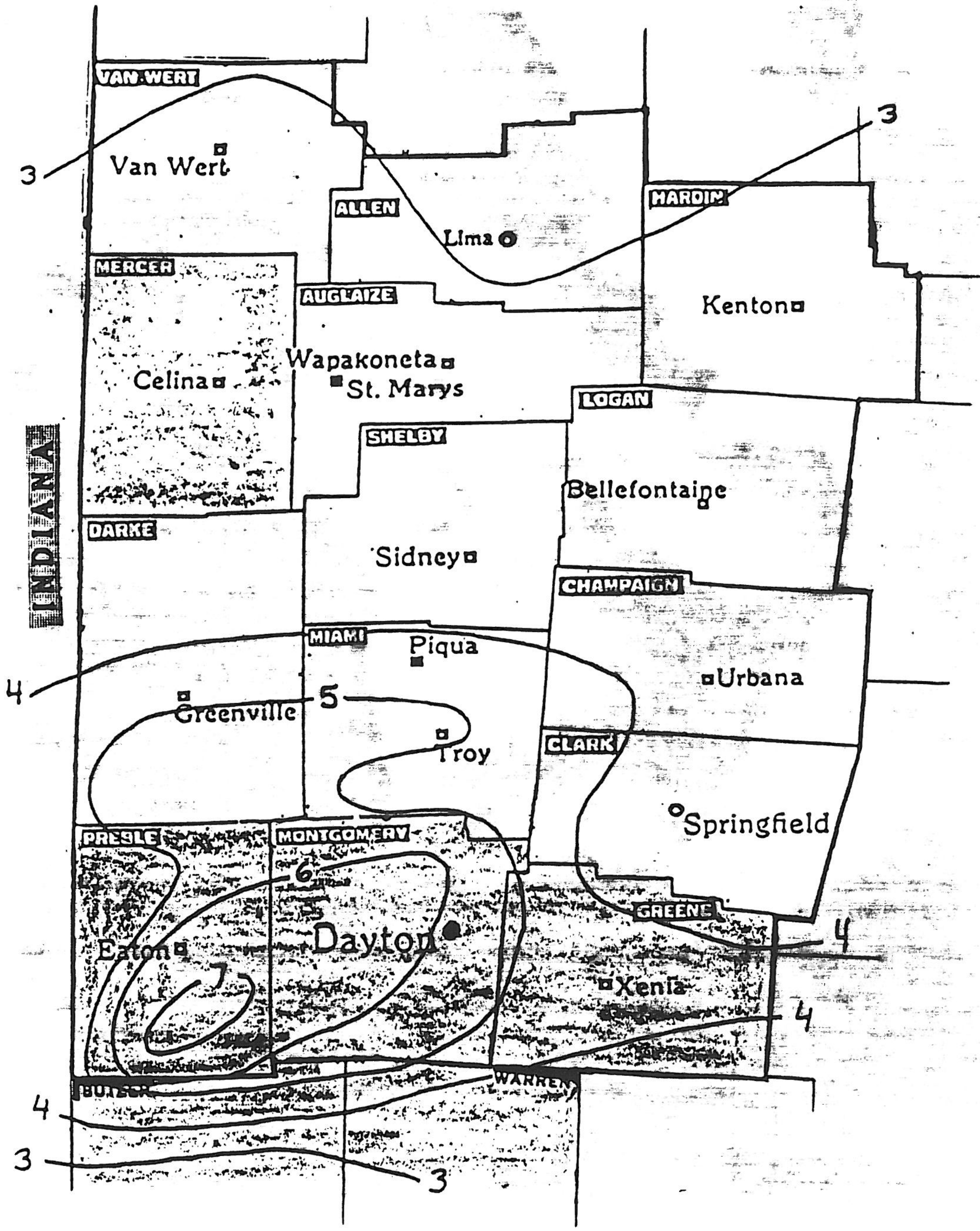

Figure 1. Western Ohio rainfall totals in inches from May 22 to May 26, 1989. (Combined data from NOAA sources and the Miami Conservancy District.) Counties made eligible for federal assistance are shaded.

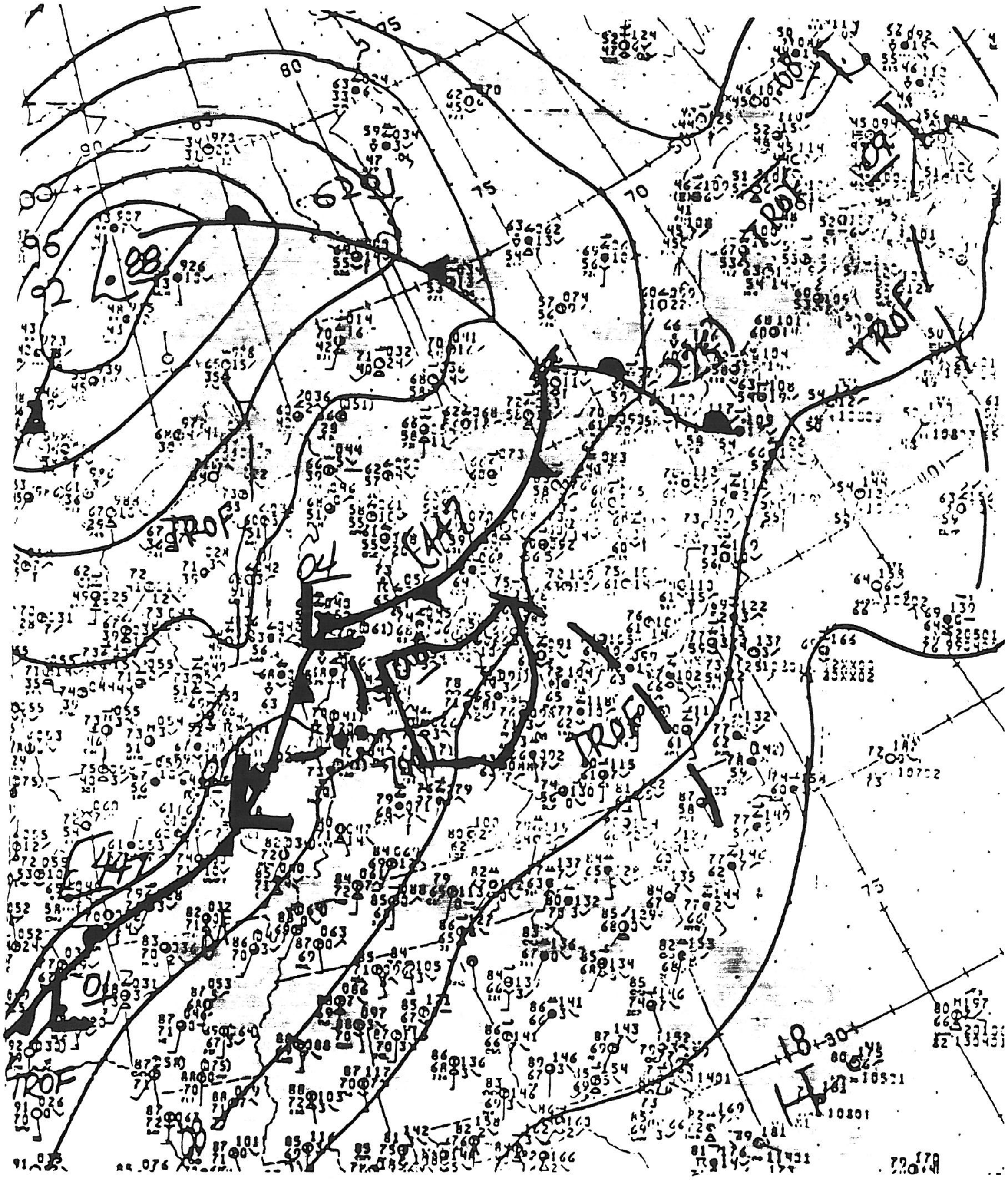

Figure 2. 0000 UTC May 26 surface analysis.

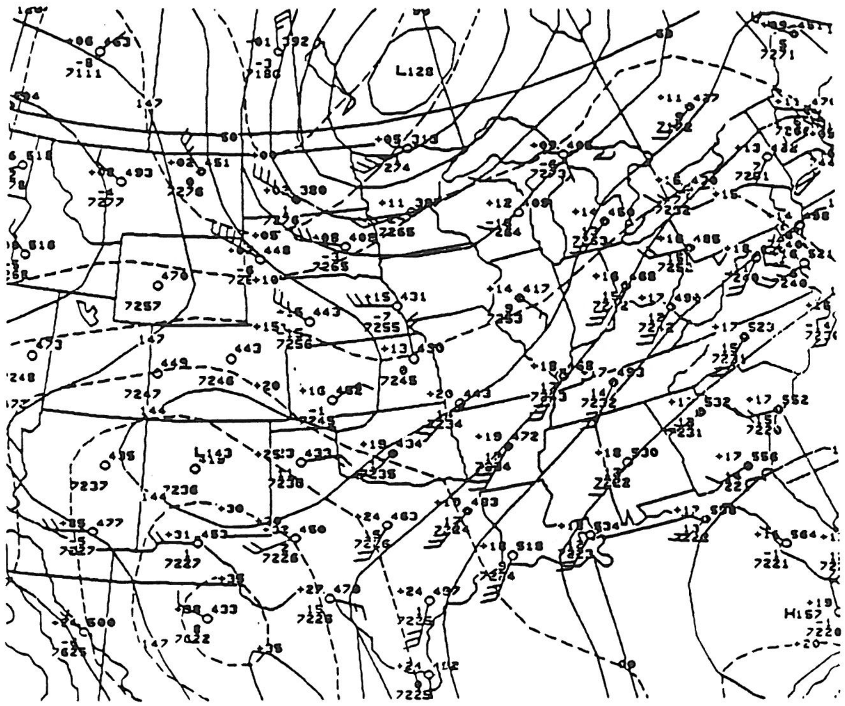

Figure 3. 0000 UTC May 26 850 mb analysis. Actual dewpoints plotted.

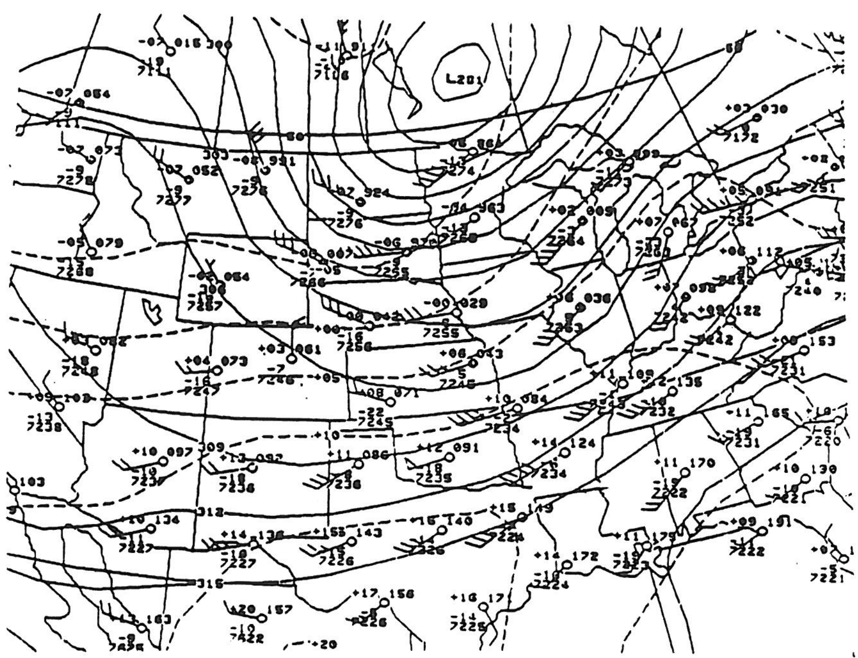

Figure 4. 0000 UTC May 26 700 mb analysis. Actual dewpoints plotted.

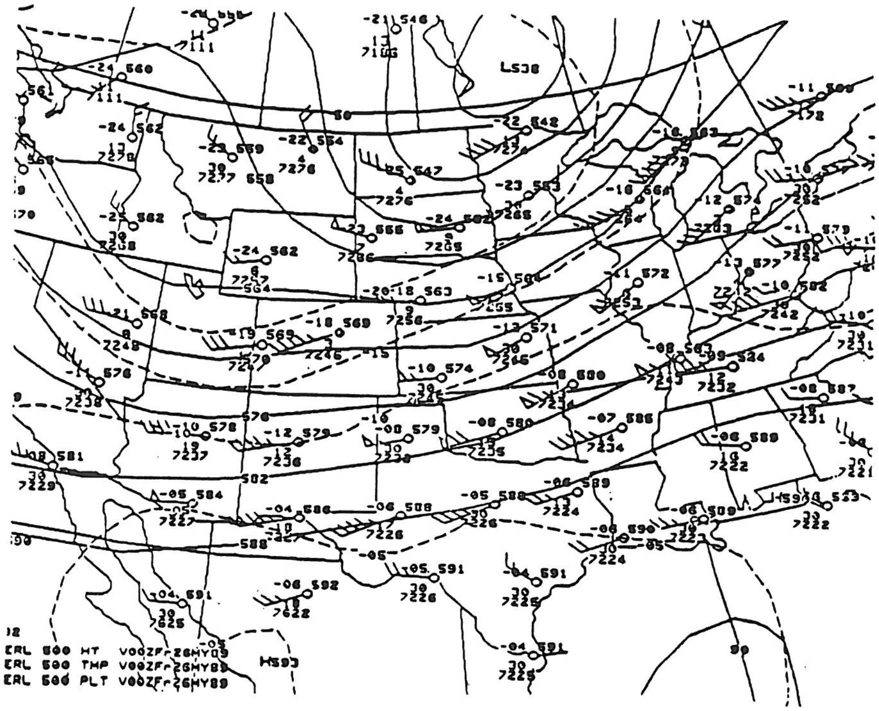

Figure 5. 0000 UTC May 26 500 mb analysis. Dewpoint depressions plotted.

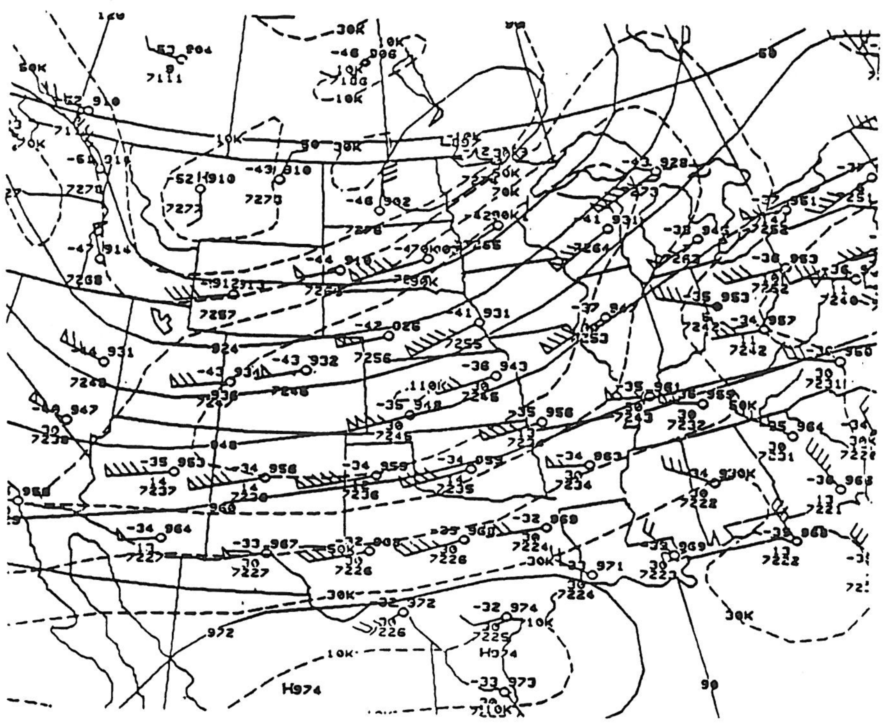

Figure 6. 0000 UTC May 26 300 mb analysis. Dewpoint depressions plotted.

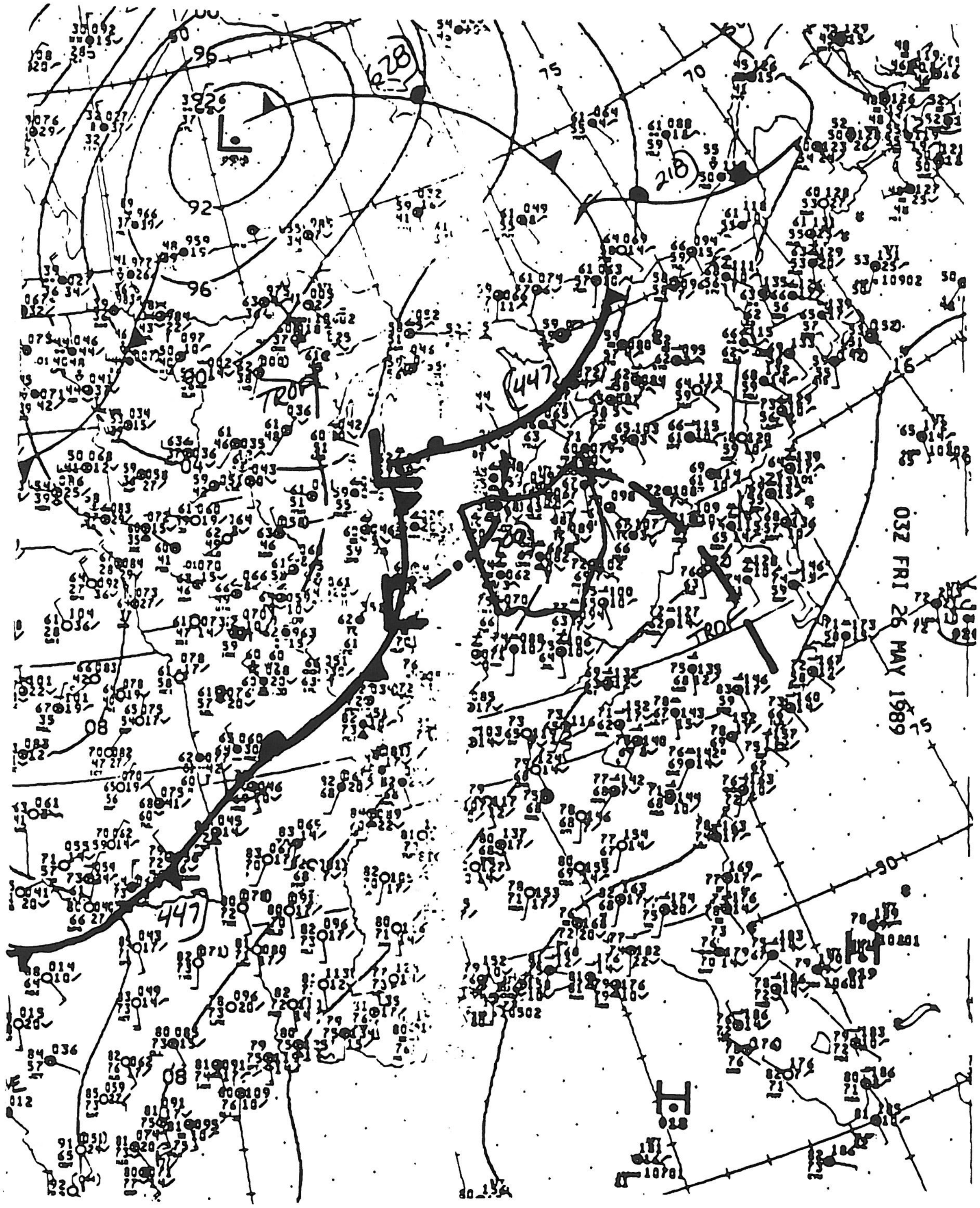

Figure 7. 0300 UTC May 26 surface analysis.

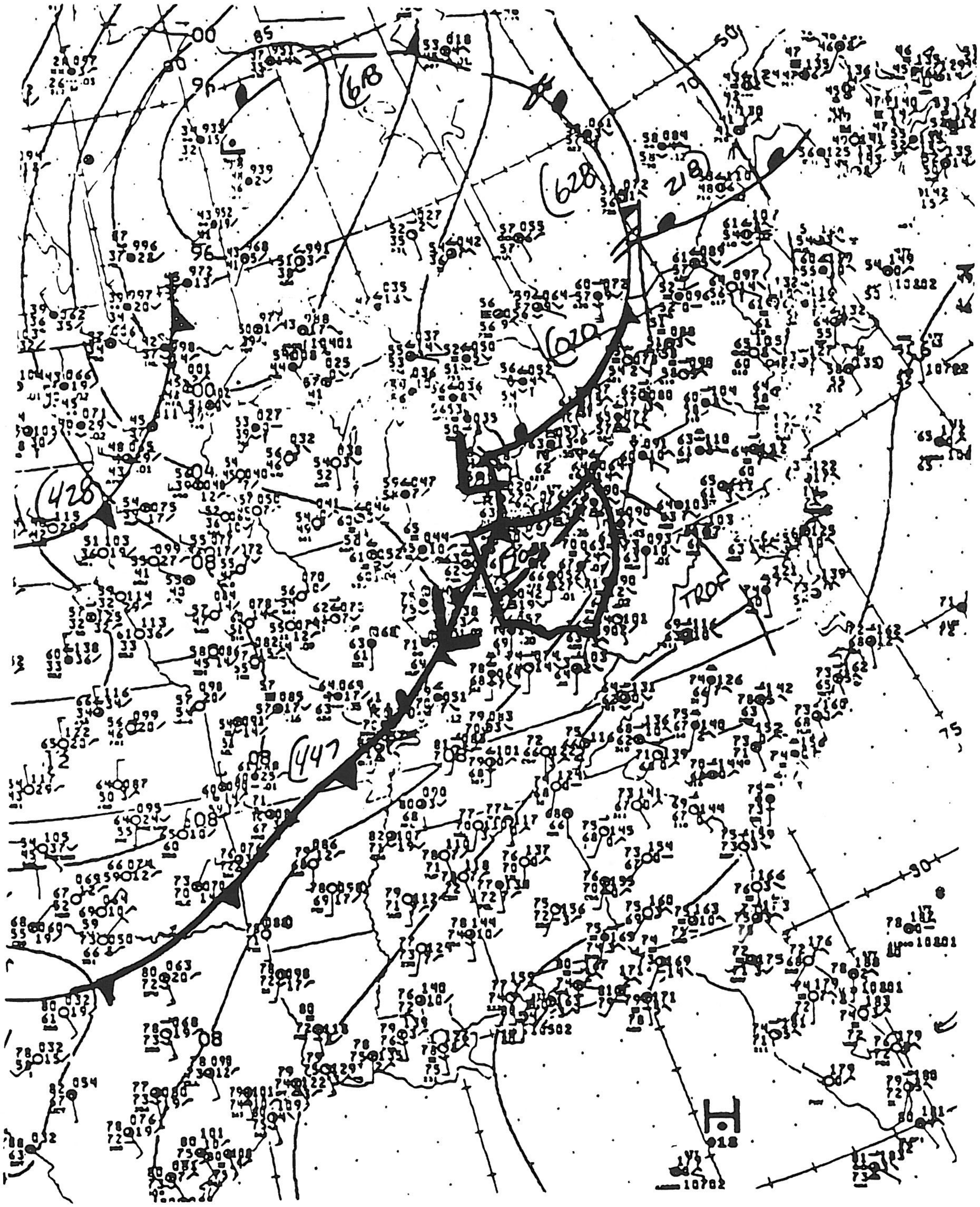

Figure 8. 0600 UTC May 26 surface analysis.

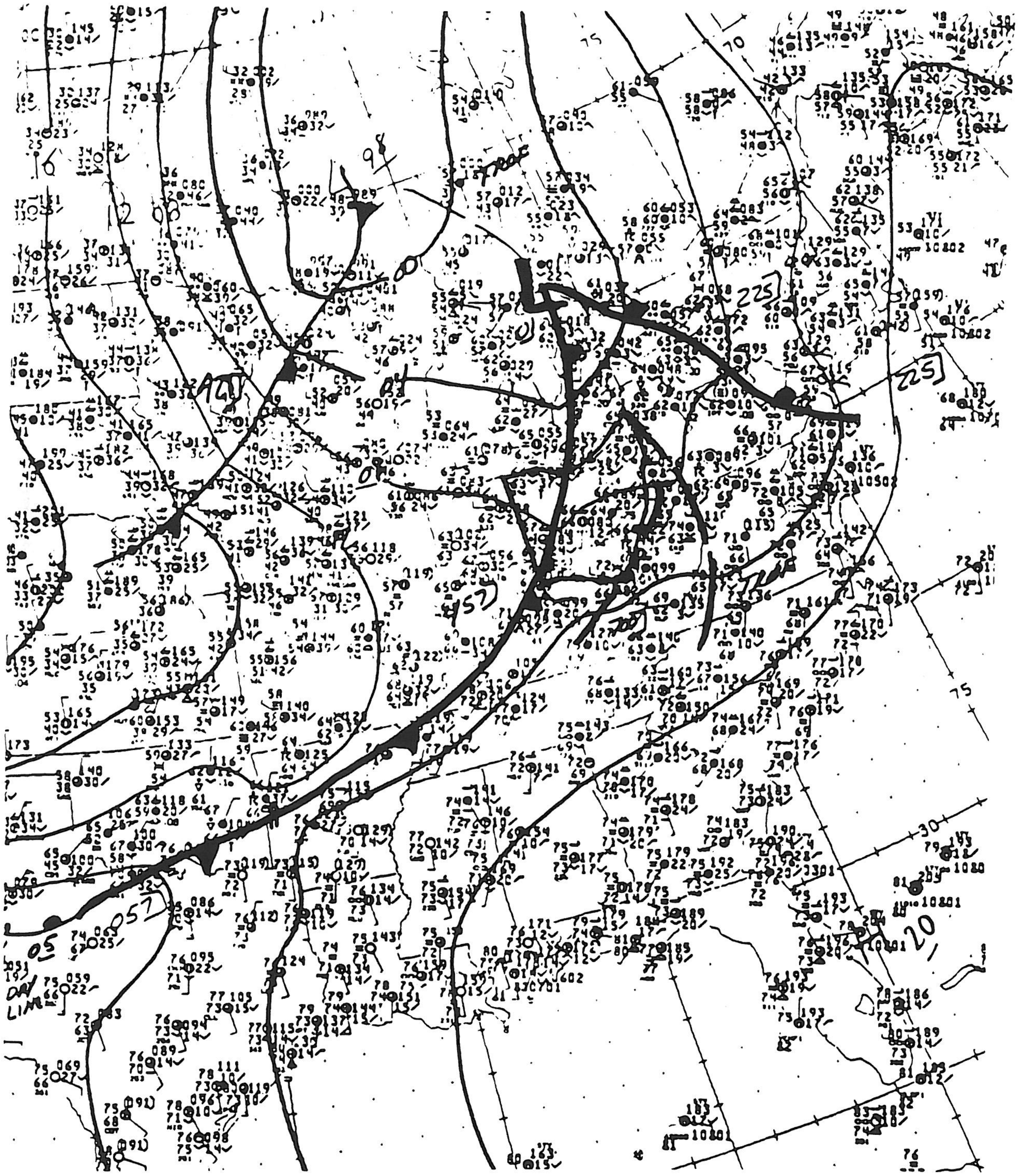

Figure 9. 1200 UTC May 26 surface analysis.

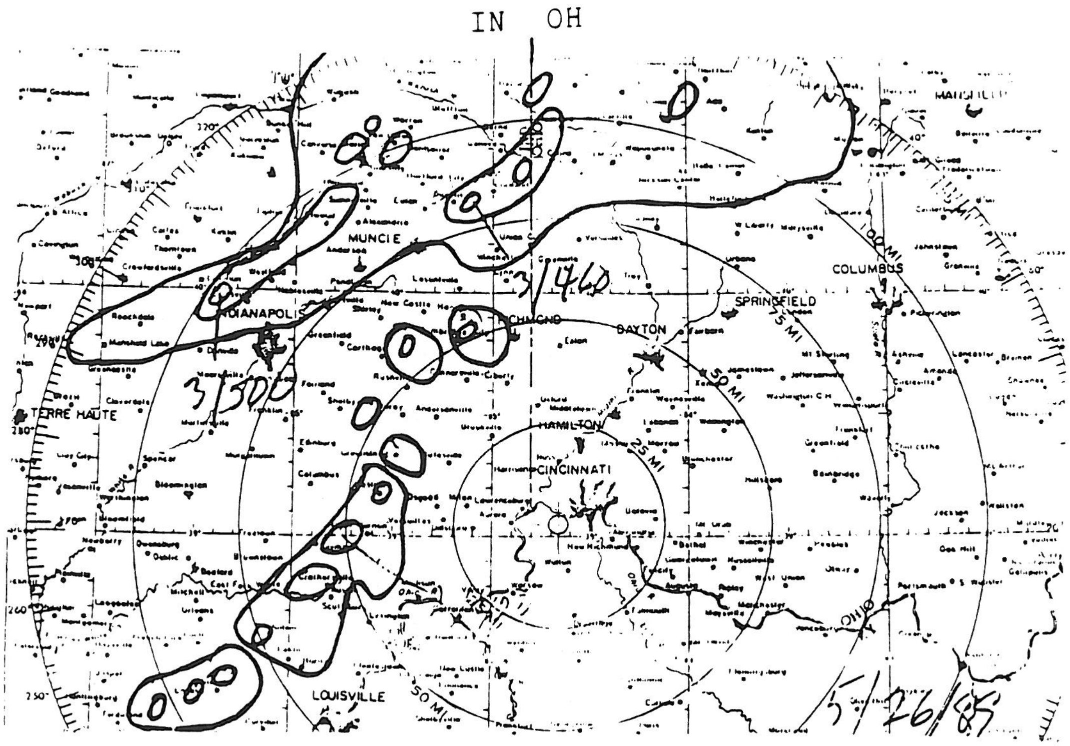

Figure 10. 0334 UTC May 26 radar overlay from CVG.
Contours are D/VIP levels 1, 2 and 3.

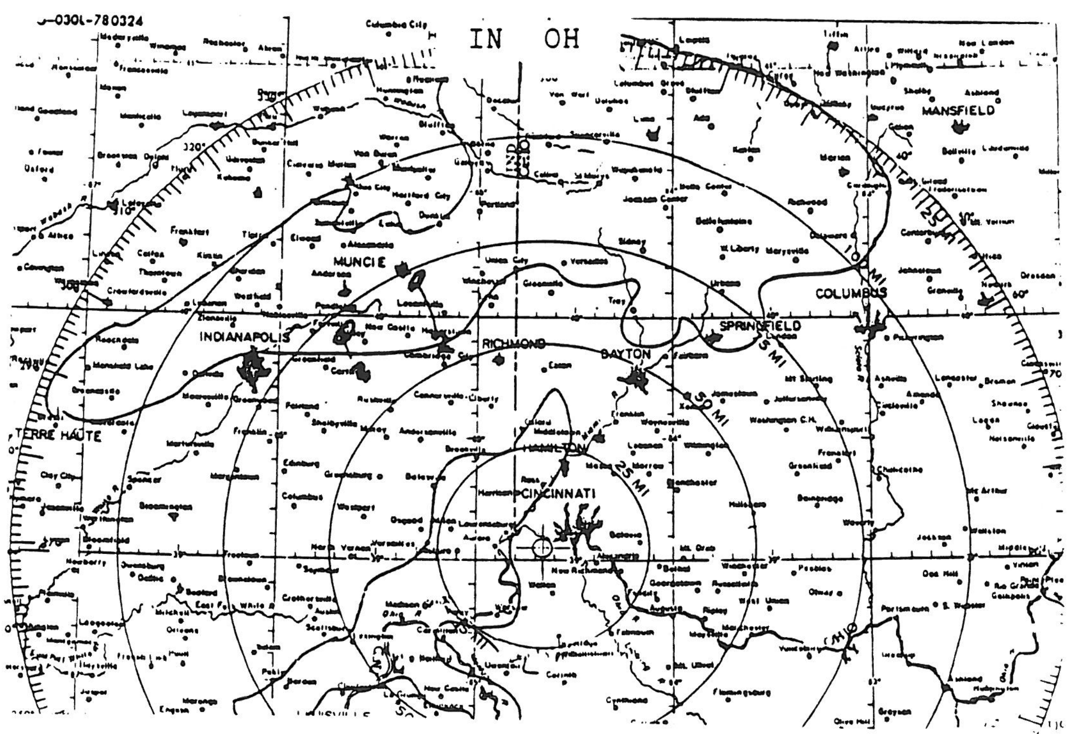

Figure 11. 0430 UTC May 26 radar overlay from CVG.
Contours are D/VIP levels 1 and 2.

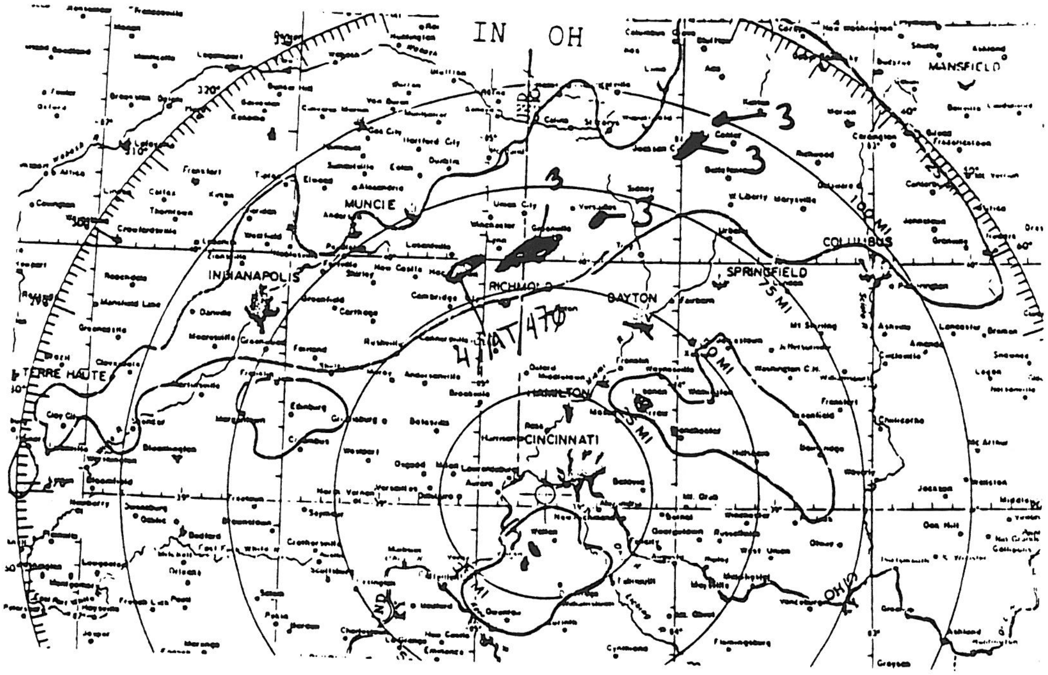

Figure 12. 0533 UTC May 26 radar overlay from CVG. Contours are D/VIP levels 1, 3, and 4.

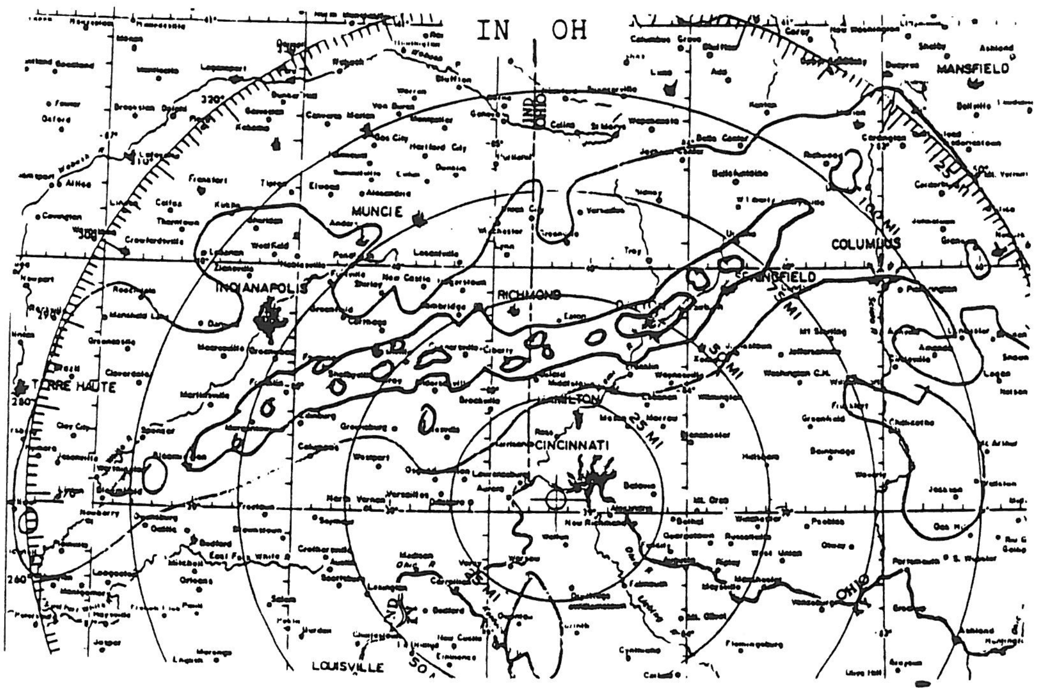

Figure 13. 0635 UTC May 26 radar overlay from CVG. Contours are D/VIP levels 1, 3, and 4.

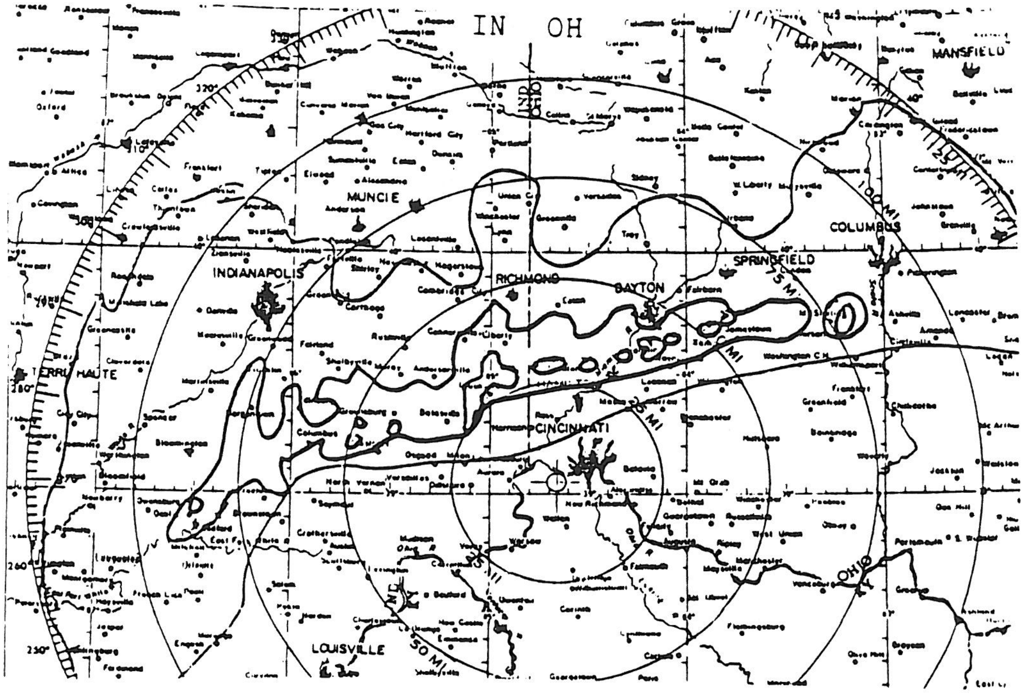

Figure 14. 0735 UTC May 26 radar overlay from CVG. Contours are D/VIP levels 1, 3, and 4.

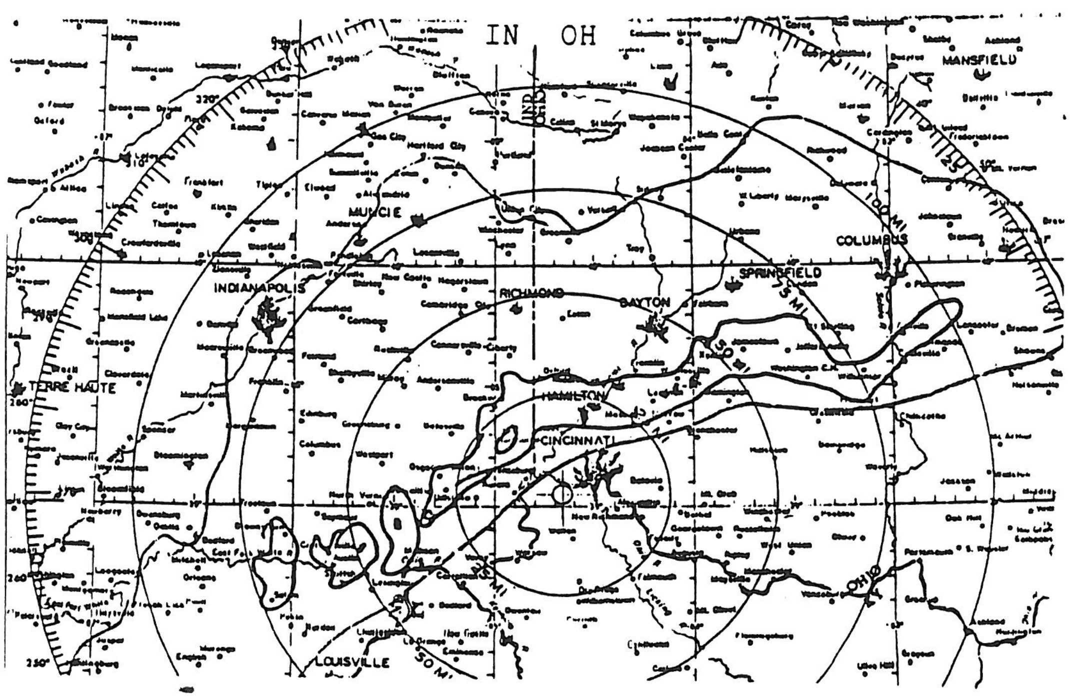

Figure 15. 0830 UTC May 26 radar overlay from CVG. Contours are D/VIP levels 1, 3, and 4.

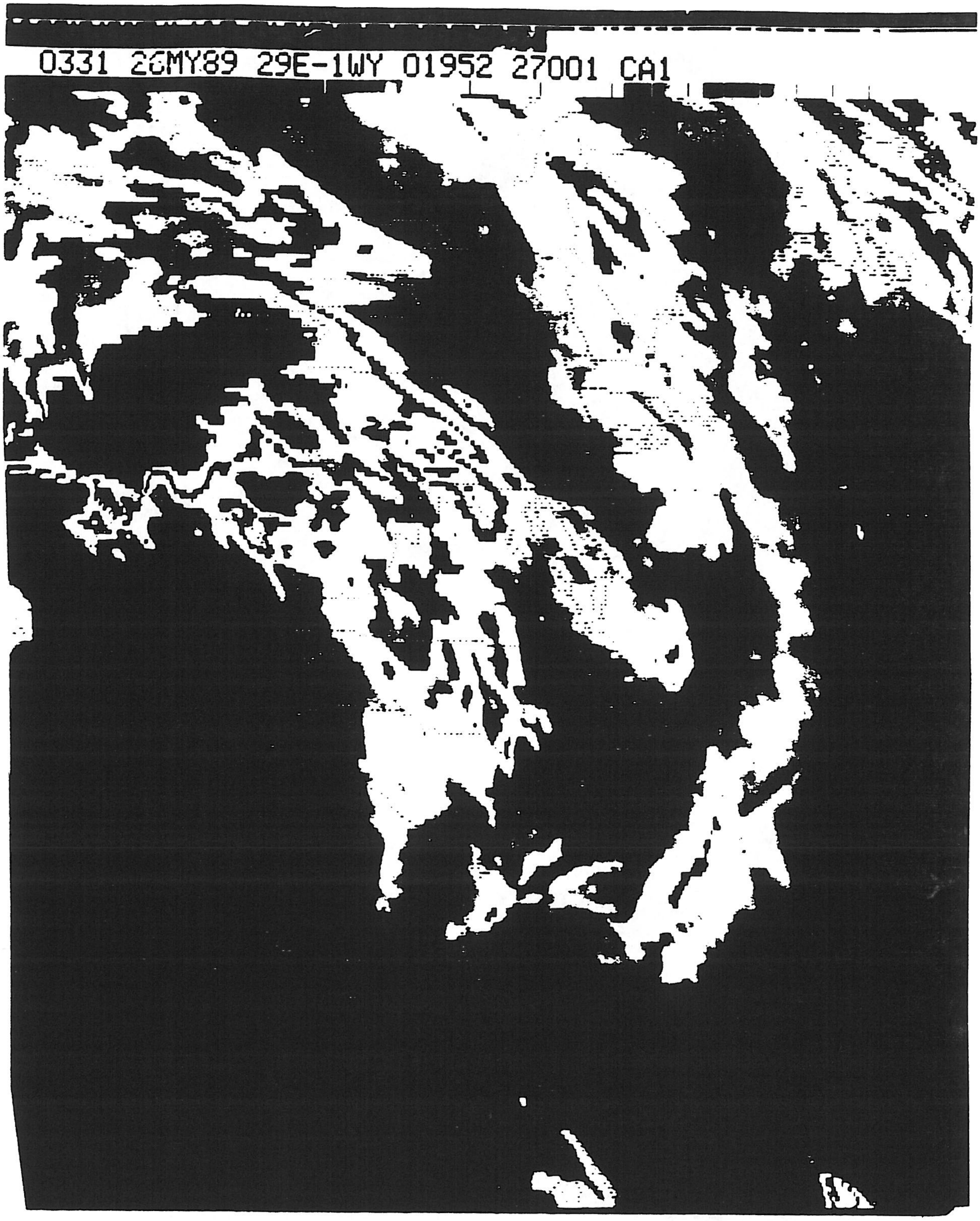

Figure 16. 0331 UTC May 26 infrared satellite image.

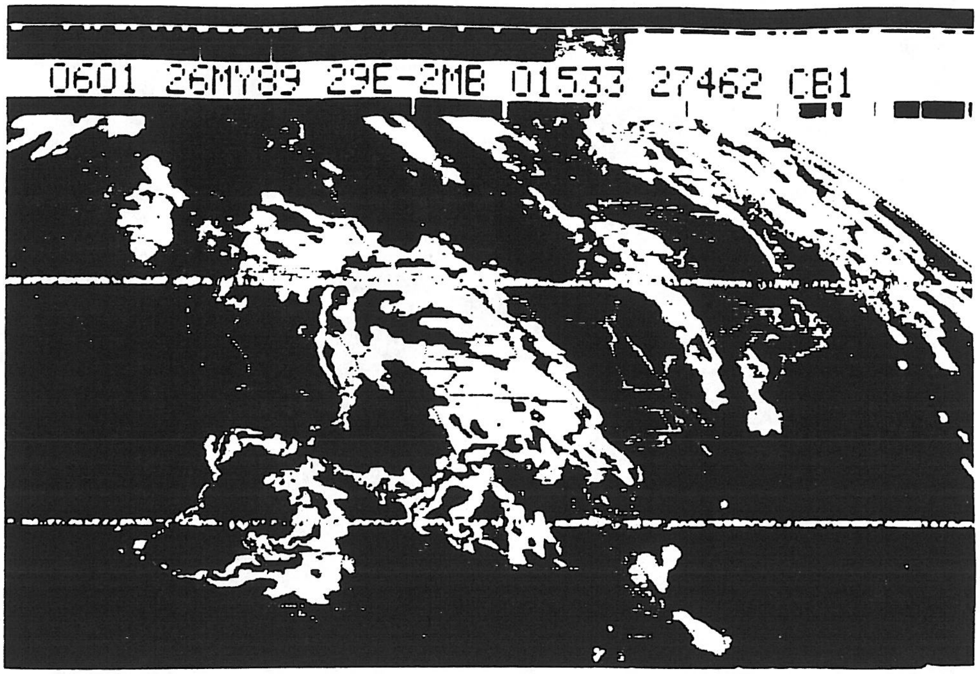

Figure 17. 0601 UTC May 26 infrared satellite image.

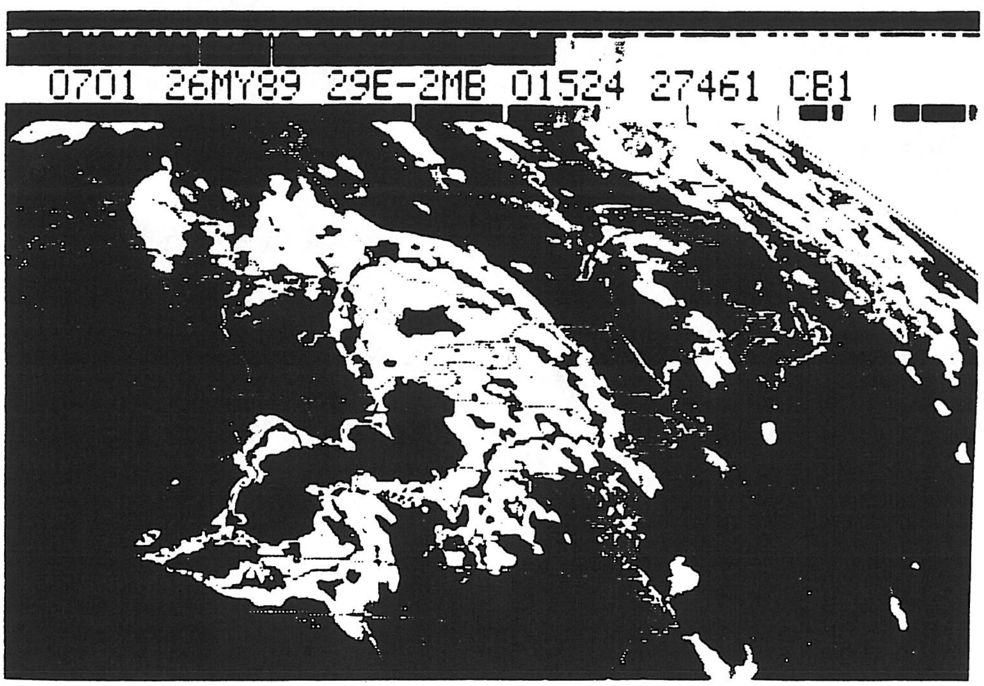

Figure 18. 0701 UTC May 26 infrared satellite image.