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A WINTER-TIME MADDOX FRONTAL TYPE FLOOD EVENT

Steven J. Naglic
National Weather Service Forecast Office
Cleveland, Ohio

1. INTRODUCTION

During the late night and early morning hours of February 21 and 22, 1990, a flood event occurred over northwest Ohio, northeast Indiana, southeast Michigan and extreme southern Ontario. The event produced 1 to 3 inches of rain over the area in 6 hours, with 2 to 4 inch totals recorded during the 12 hour period from 0600 to 1800 UTC on February 22. This heavy rainfall caused several rivers to rise rapidly and eventually spill out of their banks.

2. BACKGROUND

Maddox et al. (1979) examined 151 flash flood events and determined that certain features were common to almost all of the events. Those features were: 1) heavy rains were produced by convective storms, 2) surface dew point temperatures were very high, 3) substantial moisture content was present through a deep tropospheric layer, and 4) vertical wind shear was weak to moderate through the cloud depth. Other characteristics were used to group these flash floods into four specific types of events. One of those events was the frontal type flood.

Maddox frontal events are one of the more common flash flood or flood producing events. These events comprise about 25% of all flash flood events and occur mainly in the late spring, summer, and early fall months. Precipitation amounts are usually heaviest late at night (around 3 a.m.) then fall off in the morning.

Frontal events require the presence of a stationary, or very slow moving, synoptic scale frontal boundary. The boundary is usually oriented east to west, or northeast to southwest. The heaviest rains fall on the cool side of the boundary where warm moist air flowing over the cooler surface based air causes maximum destabilization (Figure 1). The strongest destabilization, and hence heaviest precipitation, occurs at the point of greatest warm advection and maximum winds at 850 mb (Figure 2). Veering of the winds between 850 mb and 300 mb yields storm motions parallel to the frontal boundary allowing unstable air to flow into the storms. Sometimes a meso-low will ripple along the boundary, increasing small scale convergence and inflow to the storm area. At 500 mb, a meso-alpha scale trough (250-2500 km) usually helps intensify the frontal overrunning, with the area of heaviest precipitation typically occurring near the large scale ridge position (Figure 3).

Maddox et al. (1979) also developed guidelines for frontal type events. Table 1 gives a description of the mean meteorological values associated with these events, which were based primarily on summertime data. Since this was a late winter event, the temperature and dew point values were well below these mean values. However, the temperature and dew point trends were consistent with the guidelines; i.e., temperatures and the dew points were very high for this time of the year. The wind directions were in line with the Maddox composite, but the speeds were stronger. The stronger wind speeds can be attributed to the intense baroclinic zone across the midwest and Great Lakes when this event occurred.

3. METEOROLOGICAL CONDITIONS

At 0000 UTC Thursday, February 22, a developing surface low (1008 mb) was located over the northeast corner of Texas (Figure 4). A trough extended northeast from the low to near St. Louis, while another stretched west into lower New Mexico. A closed 850 mb low (Figure 5) was over north central Texas with a 40-50 kt jet from Louisiana to Missouri. The 850 mb layer was saturated from the Gulf of Mexico to as far north as western Kentucky, with dew point depressions of less than 2°C. The greatest warm advection was over Missouri. The 500 mb pattern (Figure 6) was similar to 850 mb, except its closed low was further west over the Texas panhandle. A 65 kt jet was located from east Texas to Illinois with a meso-alpha scale (short-wave) trough over the upper plains. The 500 mb ridge axis was located from North Carolina to northern Illinois. At 200 mb (Figure 7), a 120-140 kt jet ran from east Texas to eastern Wisconsin.

During the course of the next 12 hours (0000-1200 UTC), warm air advection at 850 mb and cold air advection at 500 mb caused the surface low to deepen considerably. By 1200 UTC, the low was located over southwest Missouri (Figure 8) with a central pressure of 998 mb, deepening 10 mb since 0000 UTC. The frontal boundary now extended northeast from the low to near Buffalo, with substantial convergence at the surface. The 850 mb jet (Figure 9) shifted east and increased in speed. The nose of this 65-75 kt jet was near Toledo. The strongest 850 mb warm advection had also shifted east, and was now over northern Indiana, southeast Michigan, northwest Ohio, and extreme southern Ontario. The combination of these factors, and the strong surface convergence, resulted in substantial upward vertical motion over this region, and a rapid destabilization of the atmosphere. In addition, the short-wave trough at 500 mb over the upper Great Plains (Figure 10) had moved into the northern portion of the ridge axis, while the 200 mb jet (Figure 11) moved over the area as well. This continued to enhance the upward vertical motion over the region.

All the pieces to the "Maddox composite" had come together by 1200 UTC. Moderate to heavy rain began to fall over northern Indiana, southeast Michigan, northwest Ohio, and extreme southern Ontario around 0600 UTC and continued until 1800 UTC. Two to 4 inches of rain fell over this area during this 12 hour period (Figure 12). The greatest amount fell over extreme southern Ontario just east of Lake St. Clair.

As the day progressed, the 850 mb jet and associated warm advection continued it's eastward trek. The area of heavy rainfall shifted northeast along the frontal boundary to near Toronto (Figure 13) where moderate rain continued from 1800 to 0000 UTC on the February 23. Meanwhile, the heavy rain over northeast Indiana, northwest Ohio, and southeast Michigan diminished after 1800 UTC.

4. DISCUSSION

The Maddox frontal event of February 22, 1990, was recognized in the early morning hours as a developing and potentially dangerous situation by forecasters at WSFO Cleveland. The main key used in forecasting the event was the abnormally warm, moist low level 850 mb jet that moved into a position nearly perpendicular to the stationary front. The NGM 850 mb progs (not shown) did a good job in packing in the isobars indicating the position of the low level jet. The progged 850 mb thermal field was also well defined showing the thermal ridge right under the jet and heading into the area of concern.

A flood watch was issued at 0920 UTC on February 22. Many small streams rose quickly and spilled out of their banks. River Flood Warnings were issued for several rivers in northwest Ohio. The following warnings were issued for this event:

RIVER/ LOCATION	TIME ISSUED	OBSERVED STAGE	FLOOD STAGE	TIME ABOVE FLOOD STAGE	CREST STAGE
Tiffin...					
Stryker	22/1440 UTC	8.9 ft	11 ft	22/1800 UTC	16 ft
St. Joseph..					
Montpelier	22/1440 UTC	8.4 ft	12 ft	23/0400 UTC	16 ft
Portage...					
Woodville	22/1510 UTC		9 ft	23/0800 UTC	11 ft
Maumee...					
Waterville	22/1725 UTC	6.0 ft	9 ft	23/0100 UTC	12 ft
Defiance	22/1725 UTC	6.9 ft	10 ft	23/0300 UTC	13 ft
Grand Rapids	22/1725 UTC	7.8 ft	15 ft	23/1200 UTC	16 ft
Napoleon	22/1725 UTC		12 ft	23/1400 UTC	13 ft

These rivers rose to 2 to 5 feet above their flood stages. WSO Toledo also issued a small stream and urban flood warning for 6 counties in northwestern Ohio at 1540 UTC. Numerous reports of flooded roadways were received throughout the area.

Due to the early recognition of the event, warnings were issued with plenty of lead time allowing the public sufficient time to take appropriate action and precautions.

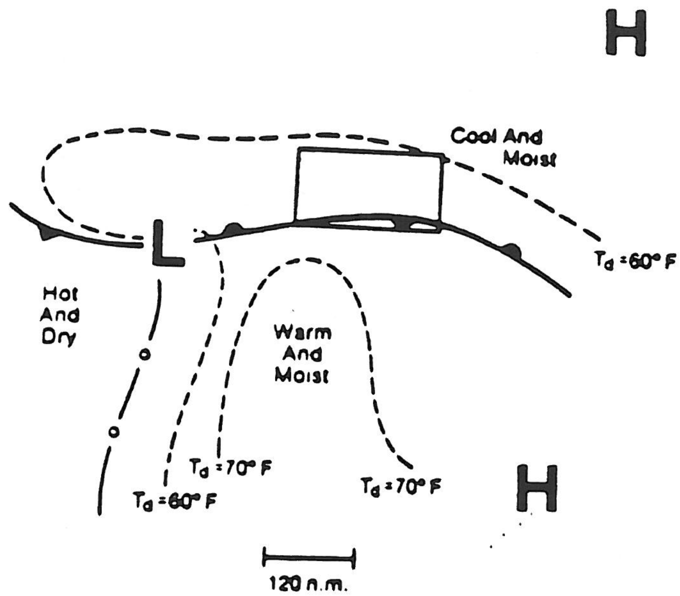
5. REFERENCES

Maddox, R.A., C. F. Chappell, and L. R. Hoxit, 1979: Synoptic and Meso-Scale Aspects of Flash Flood Events. Bull. Amer. Meteor. Soc., 60, 115-123.

TABLE 1. Mean values and standard deviations of temperature and wind associated with frontal type flash flood events (surface pressure reduced to sea level).

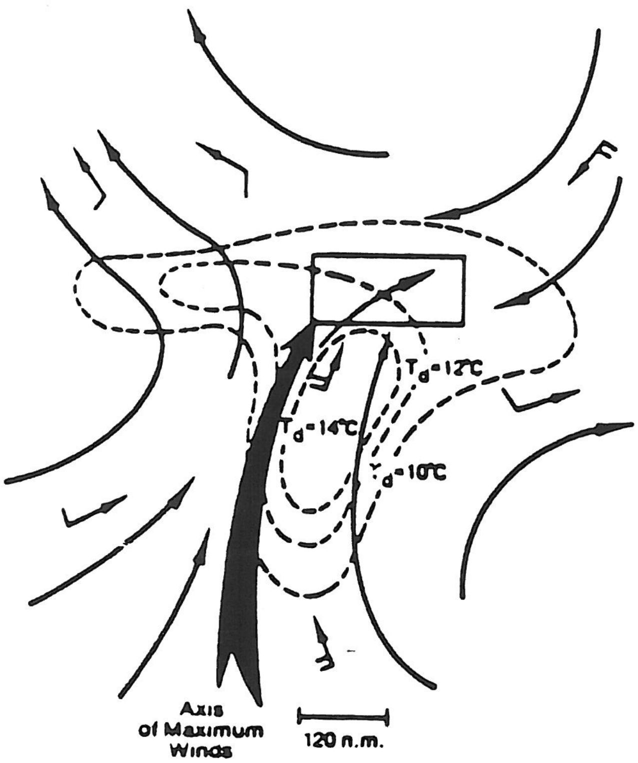
Level		T	T_d	Wind Direction	Wind Speed
Surface					
1013 mb / 4	Mean / Std. Dev.	70(°F) / 6	65(°F) / 5	100° / 36	9 (kt) / 2
			$T - T_d$		
850 mb		17(°C) / 3	4(°C) / 2	200 / 26	20 / 8
700 mb		7 / 2	3 / 3	235 / 30	20 / 10
500 mb		−10 / 3	6 / 7	250 / 34	28 / 12
300 mb		−36 / 3	15 / 11	260 / 29	40 / 16
200 mb		−56 / 3	—	270 / 22	47 / 21

From Maddox et. al. 1979



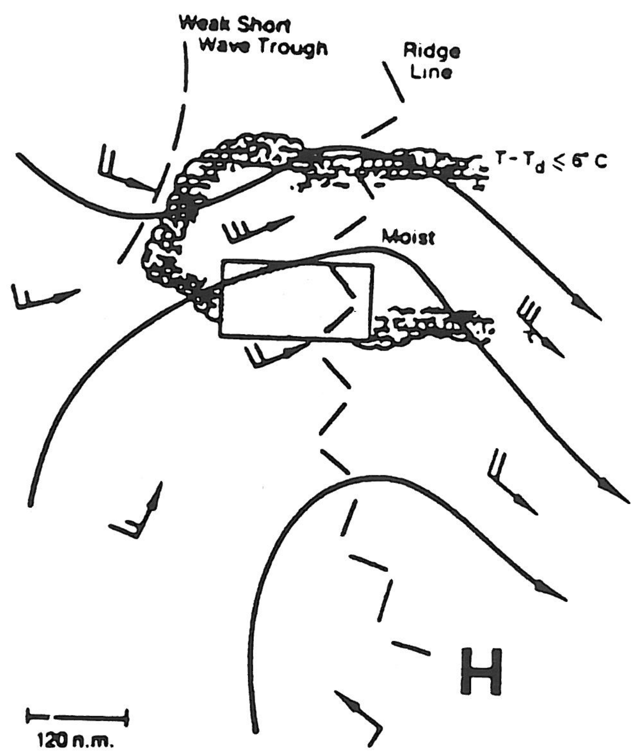
Surface pattern for a typical frontal event.

Figure 1



Corresponding 850 mb pattern for a typical frontal event.

Figure 2



Corresponding 500 mb pattern for a typical frontal event.

Figure 3

From Maddox et. al. 1979

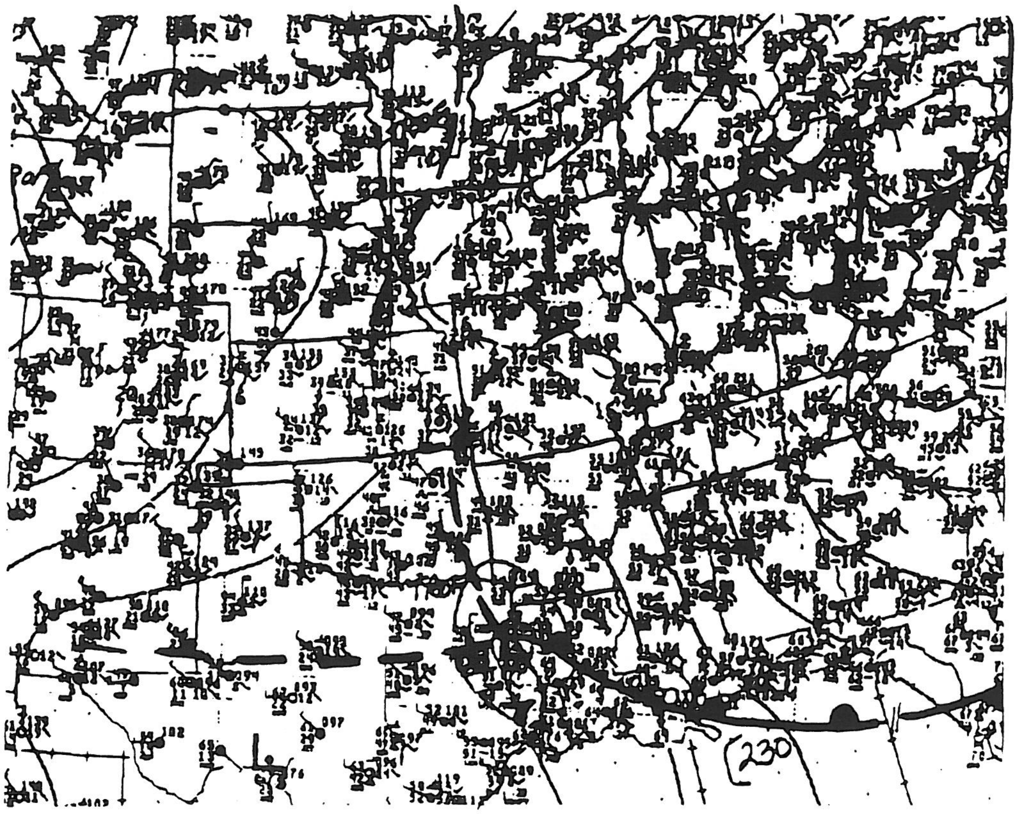


Figure 4. Surface analysis for 0000 UTC, February 22, 1990.

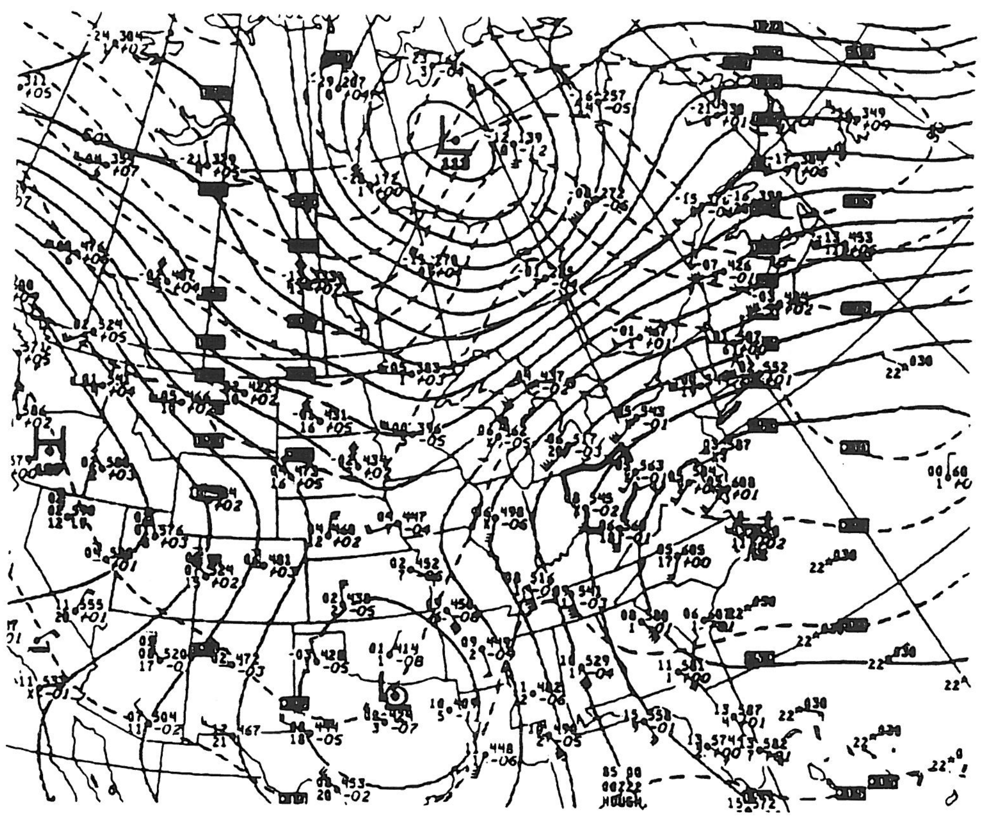


Figure 5. 850 mb analysis for 0000 UTC, February 22, 1990.

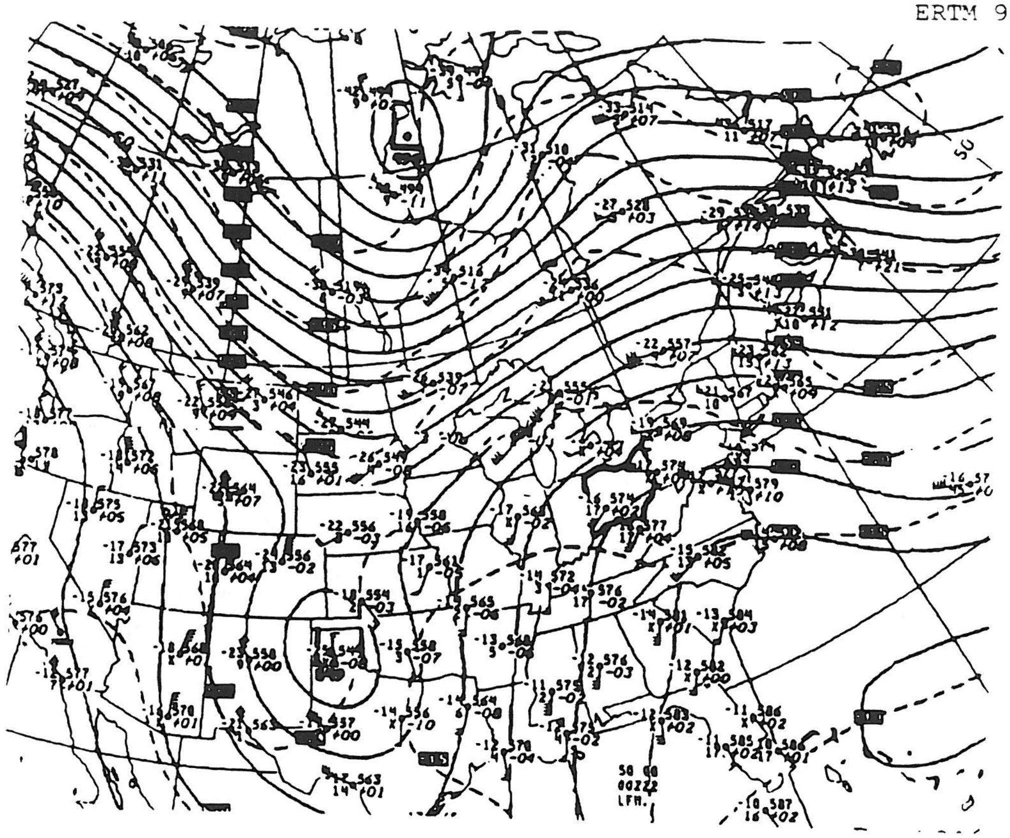


Figure 6. 500 mb analysis for 0000 UTC, February 22, 1990.

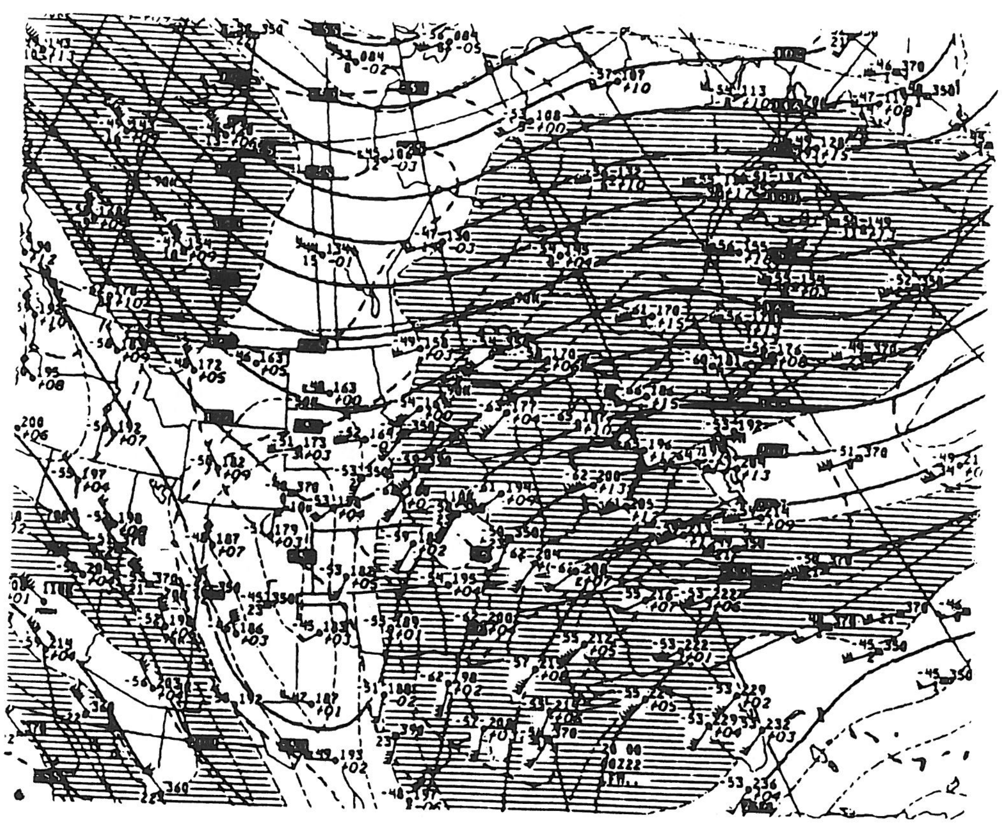


Figure 7. 200 mb analysis for 0000 UTC, February 22, 1990.

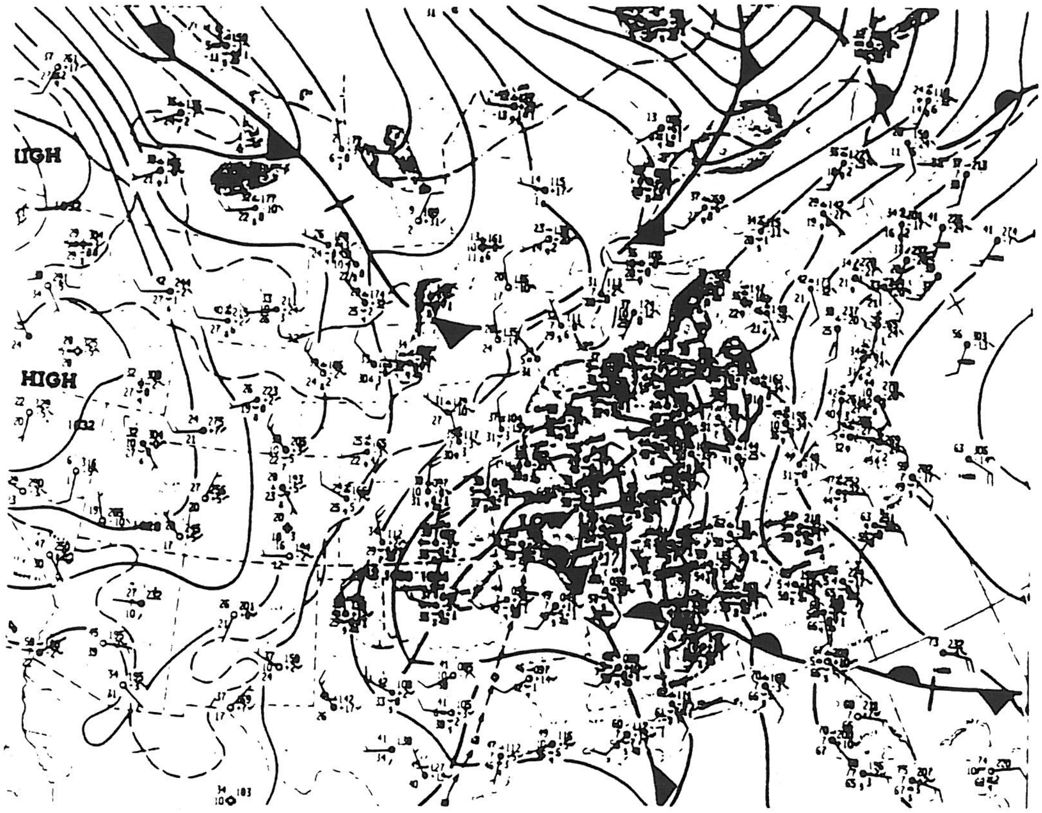


Figure 8. Surface analysis for 1200 UTC, February 22, 1990.

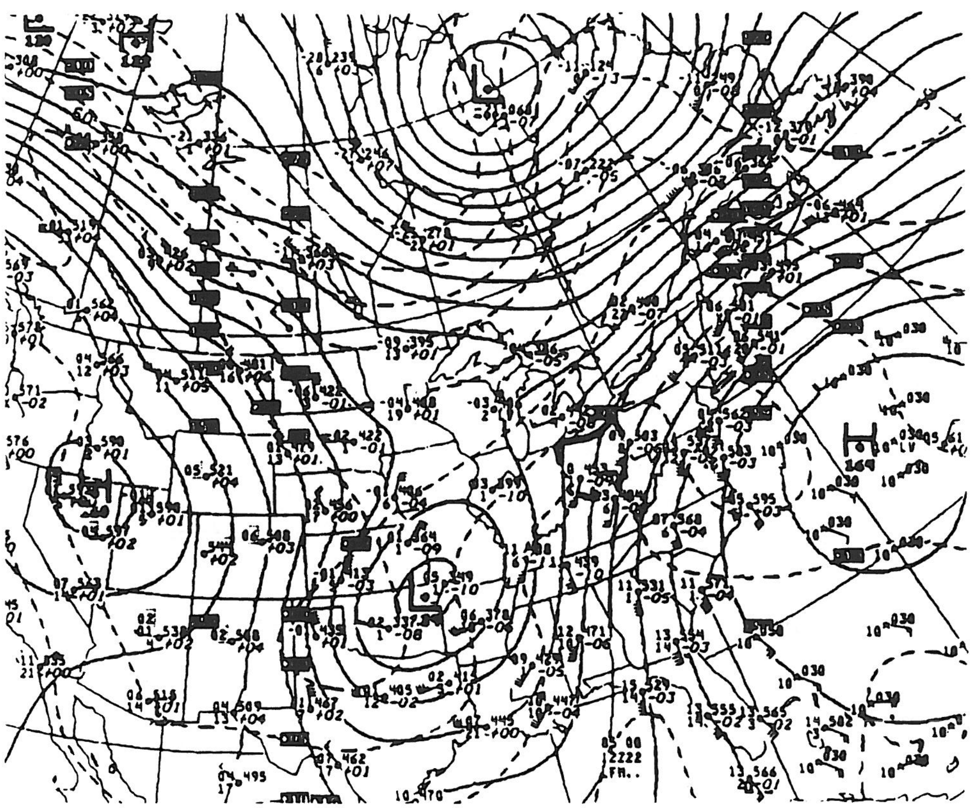


Figure 9. 850 mb analysis for 1200 UTC, February 22, 1990.

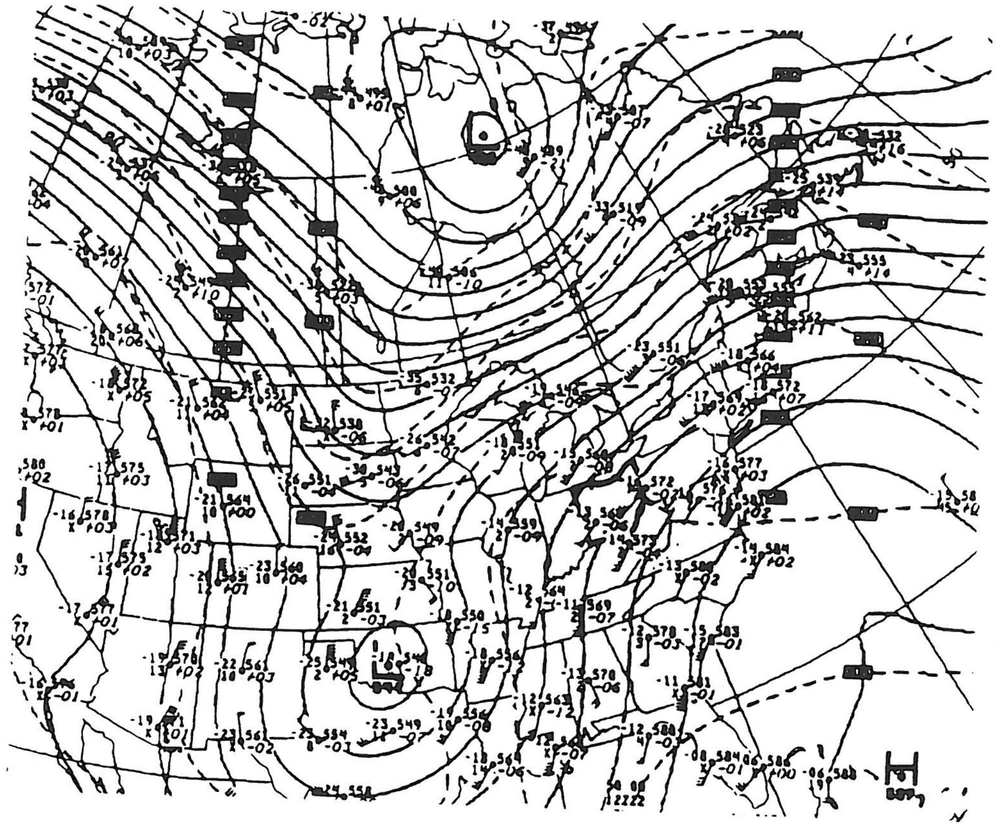


Figure 10. 500 mb analysis for 1200 UTC, February 22, 1990.

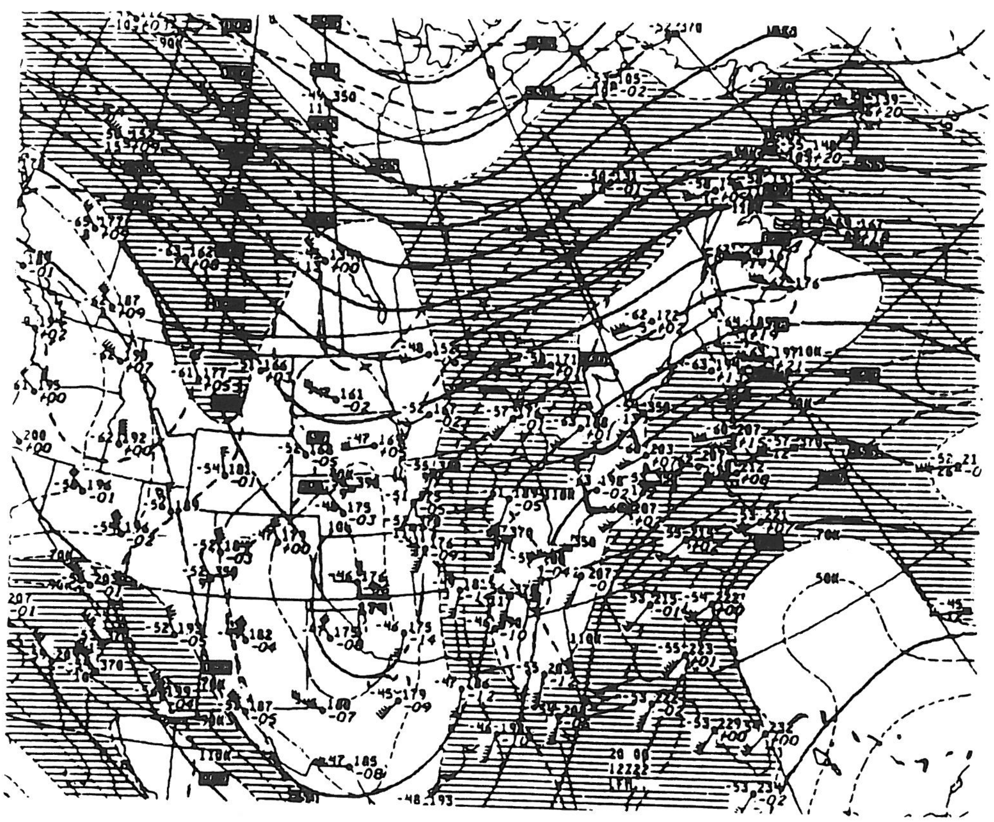


Figure 11. 200 mb analysis for 1200 UTC, February 22, 1990.

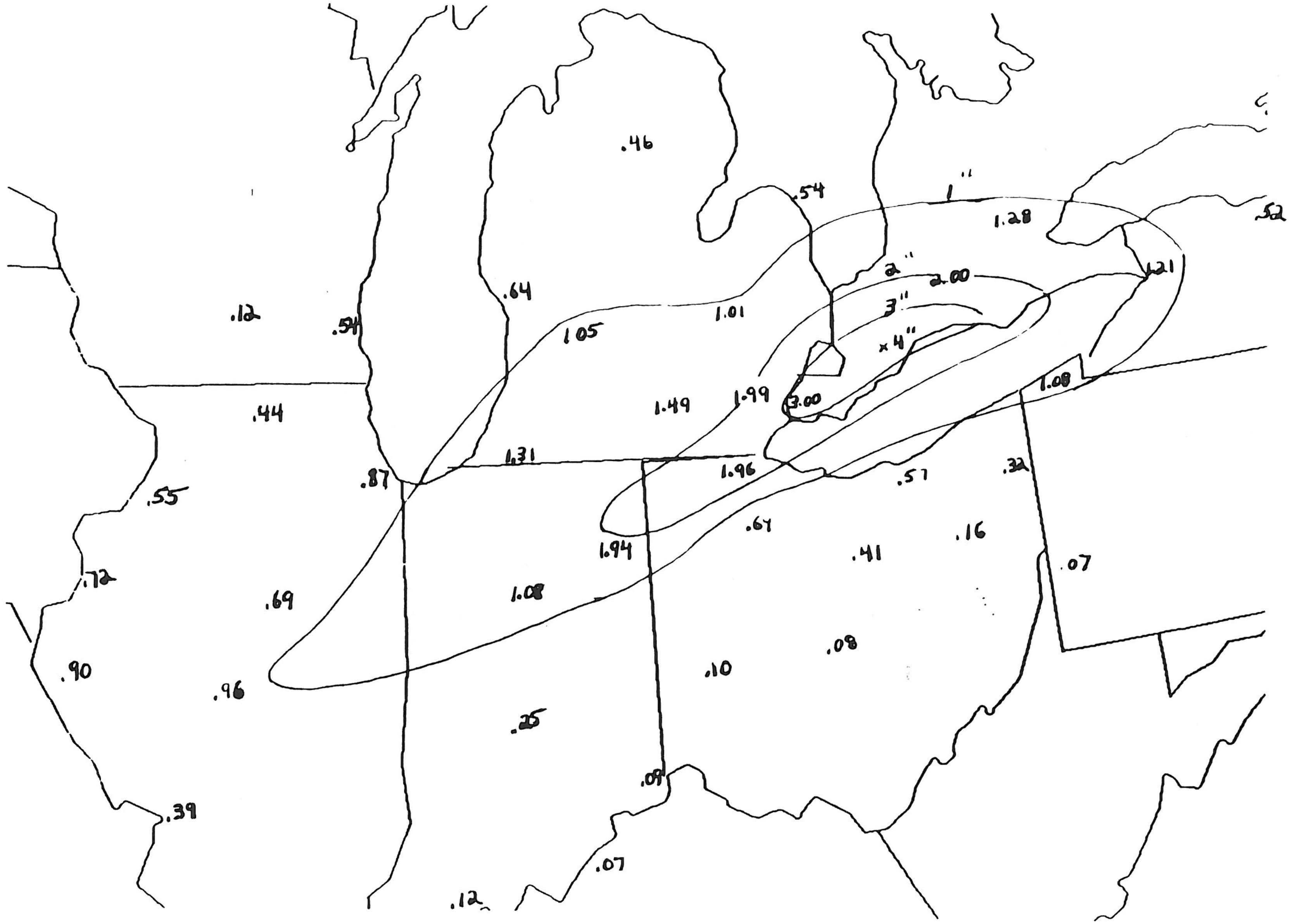


Figure 12. 12 Hour rainfall totals from 0600 to 1800 UTC, February 22, 1990.

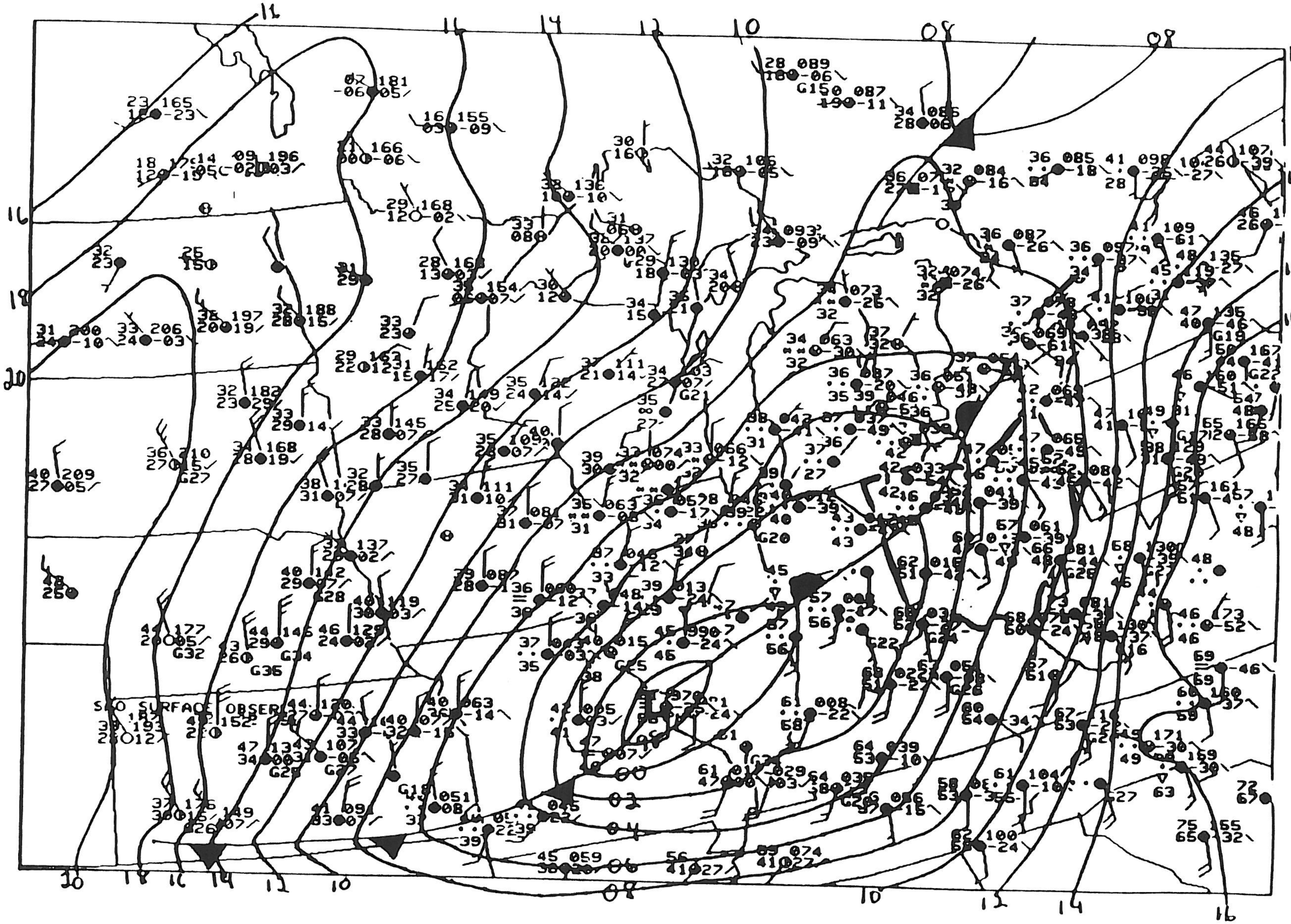


Figure 13. Surface analysis for 1800 UTC, February 22, 1990.