AN EXCESSIVE RAINFALL EVENT CAUSED BY THE INTERACTION OF A CONVECTIVELY-INDUCED UPPER LEVEL VORT MAX, A FRONT, AND AN OUTFLOW BOUNDARY

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ABSTRACT

Heavy thunderstorms produced excessive rainfall and local flooding at Bloomington, Indiana on June 24, 1985. The meteorological keys to this event were the interaction of an outflow boundary from previous thunderstorms, an east-west synoptic scale front, and a convectively-induced upper vorticity maximum. This vort max was poorly handled by the short-range numerical model forecasts, thus amplifying the difficulty in forecasting the event. A critical upper air sounding, taken the previous evening, is evaluated with respect to its proximity to a mesoscale convective complex and the resultant unusual temperature profile.

1. INTRODUCTION

Heavy thunderstorms hit south central Indiana on Monday, June 24, 1985, during the late afternoon. These storms dumped over three inches of rain in less than 1 1/2 hours at Bloomington, Indiana (southwest of Indianapolis), which caused flooding of creeks and roadways in that area. The meteorological keys to this event were the interaction of an outflow boundary from previous thunderstorms, an east-west synoptic-scale front, and a convectively-induced upper vorticity maximum. This vort max was poorly handled by the short-range numerical model forecasts.

2. METEOROLOGICAL SCENARIO

A Mesoscale Convective Complex (MCC) had developed Sunday afternoon and evening, June 23, 1985, in southeast Nebraska, southern Iowa and northern Missouri (Fig. 1a). This produced tornadoes, large hail, and very heavy rains. Lincoln, Nebraska had 4.2 inches of rain, 3-inch diameter hail, and 84 mph winds from this storm. Tornadoes, large hail, and up to 5 inches of rain occurred in southwest Iowa (3). The MCC dissipated quickly as it drifted southeast into Missouri.

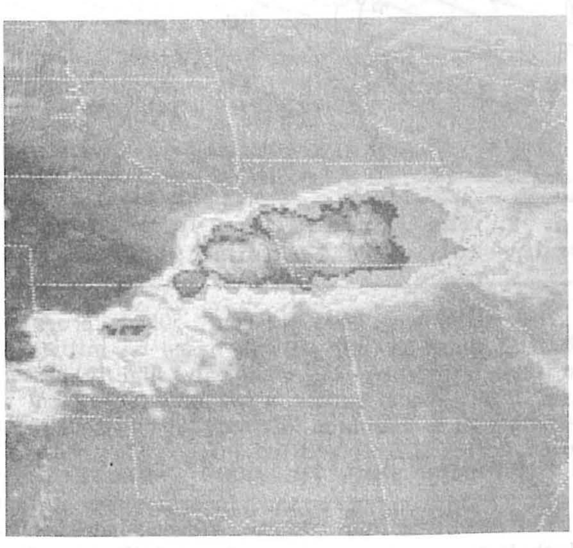

Fig. 1a. Monday 0000 GMT 24 June 1985 (IR) imagery shows MCC over Iowa and Nebraska.

By 1200 GMT Monday, June 24, satellite pictures showed that the MCC remnants had acquired a distinct comma shape, indicating an upper vorticity maximum had formed (2). This was displayed well on the first visible satellite picture of the morning at 1230 GMT Monday (Fig. 1b).

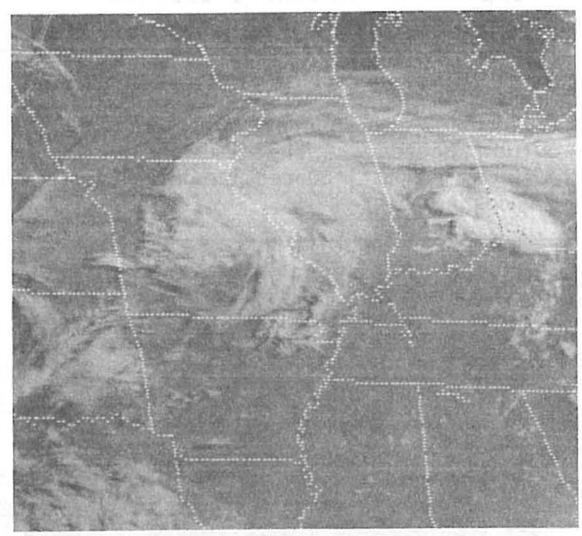

Fig. 1b. Monday 1230 GMT 24 June 1985 (VIS) imagery shows convectively induced Vort Max over eastern Missouri; MCC has decayed, new convection Indiana-Ohio.

Meanwhile, a small but intense thunderstorm cluster also formed late Sunday night over central Illinois, at the eastern edge of the decaying MCC. This new convection drifted southeast into central Indiana by 1200 GMT Monday, and moved through eastern Kentucky and into eastern Tennessee by Monday afternoon. It left behind a well-defined outflow boundary from eastern Tennessee northwest into southern Indiana (See Fig. 1c and Fig. 2).

An east-west front stretched from Iowa through central Indiana into northern West Virginia at 1800 GMT Monday, and was nearly stationary across central Indiana. The Bloomington, Indiana area was very close to both the front and the outflow boundary at 2000 GMT Monday. (Fig. 2).

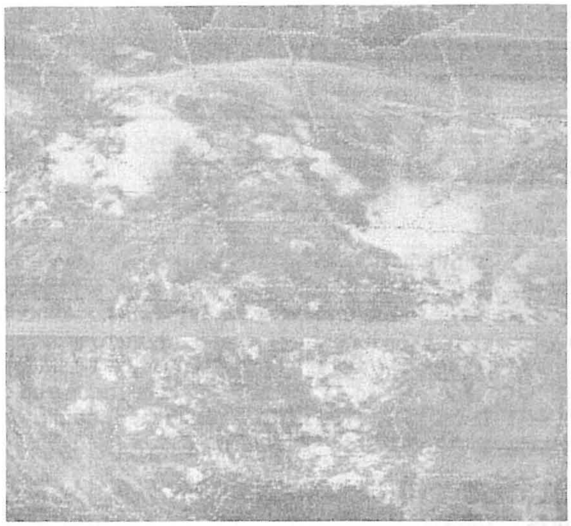

Fig. 1c. Monday 1930 GMT 24 June 1985 (VIS) imagery shows outflow boundary eastern Tennessee central Kentucky-southern Indiana. Convection with Vort Max firing over Missouri-Illinois.

New thunderstorms formed in Illinois and eastern Missouri Monday afternoon, in response to the upper vort max. These thunderstorms moved east into southern Indiana, where they intersected the front and outflow boundary. The resultant enhancement of the thunderstorms produced the excessive rainfall in the Bloomington area.

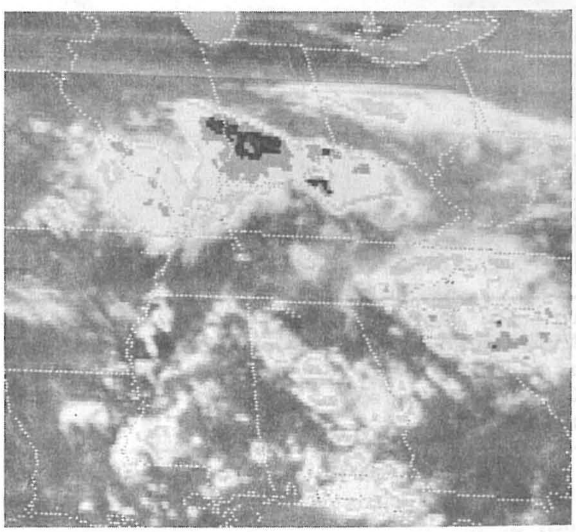

Fig. 1d. Monday 2200 GMT 24 June 1985 (IR) imagery shows heavy thunderstorms and excessive rainfall occurring over southern Indiana.

3. UPPER AIR FEATURES

The 500 mb analyses (Fig. 3) show several interesting features. First, the temperature at OMA at 0000 GMT Monday, June 24 was minus 2°C. This is an unusually warm 500mb temperature, even for summer. Since the OMA sounding (Fig. 4) was taken in the core of an MCC, this may indicate the release of latent heat and the warm core convective processes of the MCC, as suggested by Maddox et al (4).

Second, a sharp 500mb trough developed by 1200 GMT Monday, June 24, with the axis through Missouri and eastern Kansas. By 0000 GMT Tuesday, June 25, the trough axis had moved east, into Illinois, Indiana and southern Missouri. The short-range NGM and LFM 500mb progs essentially missed this apparently convectively-induced upper trough and vort max.

Fig. 5 shows the NGM forecasts based on initial data from 0000 GMT June 24, when the MCC was going strong in the central Plains. (Corresponding LFM forecasts were very similar and are not shown). The 12-hour NGM, valid 1200 GMT Monday, June 24, showed a weak vort max near the Missouri-Illinois border. In reality, a noticeably stronger vort max was analyzed in northern Missouri. The 24-hour NGM prog valid 0000 GMT Tuesday, June 25, made a poor forecast of this vort max; where the model had forecast a building ridge, a sharp 500mb trough verified across Illinois and Indiana.

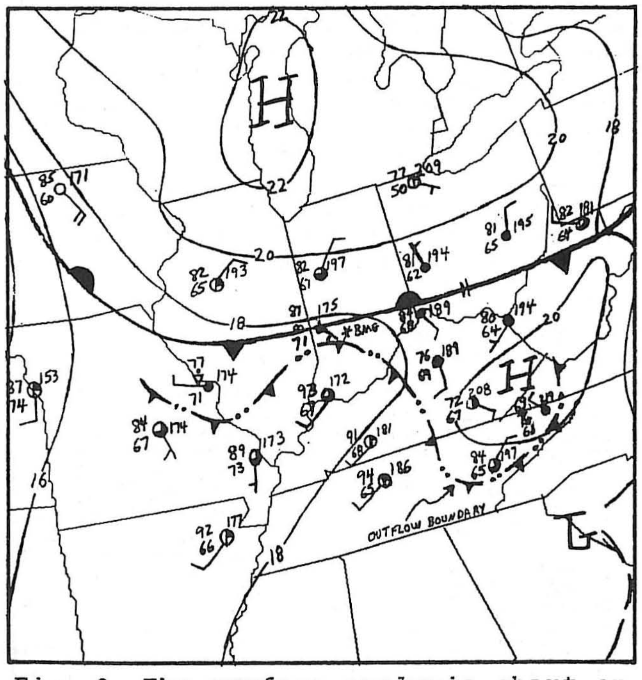

Fig. 2. The surface analysis chart on Monday 2000 GMT 24 June 1985.

The NGM and LFM 12-hour 500mb progs for 0000 GMT June 25 (not shown), based on initial data from 1200 GMT June 24, were only slightly better. These later model runs were also deficient in forecasting the sharpness of the 500mb trough that verified across Illinois and Indiana.

All model runs also underforecast the strength and sharpness of the 500mb ridge that verified through Iowa and Minnesota at 0000 GMT June 25.

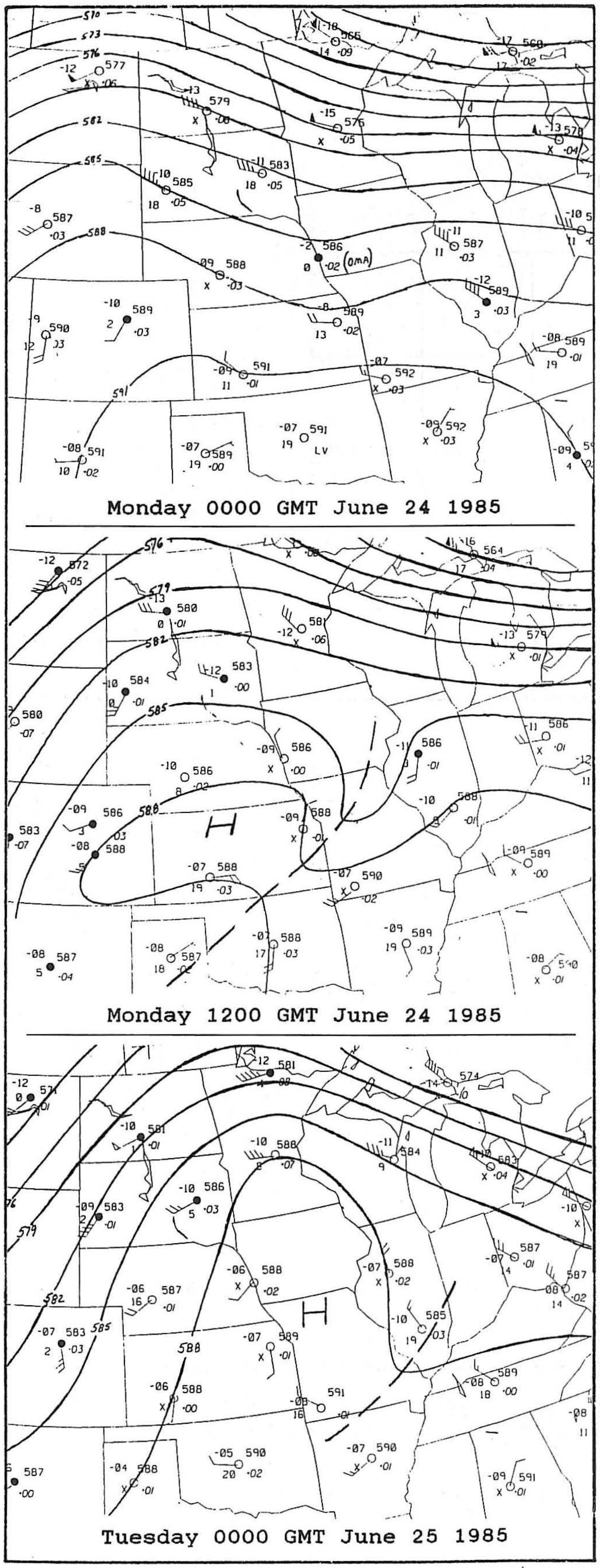

Fig. 3. The 500 mb analyses charts from Monday 0000 GMT 24 June to Tuesday 0000 GMT 25 June 1985.

4. CONCLUSION

The MCC on Sunday evening, June 23, 1985, apparently disrupted the upper wind field and released enough latent heat to greatly alter the 500mb pattern. The convectively-induced vort max was poorly handled by the short-range numerical model forecasts, even though the critical OMA sounding was in the models' initial data base. Monday afternoon's convection turned out to be stronger than what would have been otherwise inferred from the models' 500mb forecasts. The convection intensified as the vort max interacted with key low level features. The outflow boundary from previous thunderstorms and the east-west front helped focus the excessive rainfall over Bloomington.

While fairly straight-forward to hindcast, this type of excessive rainfall event (like many others) would be extremely difficult to forecast more than 2 or 3 hours in advance.

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NOTES AND REFERENCES

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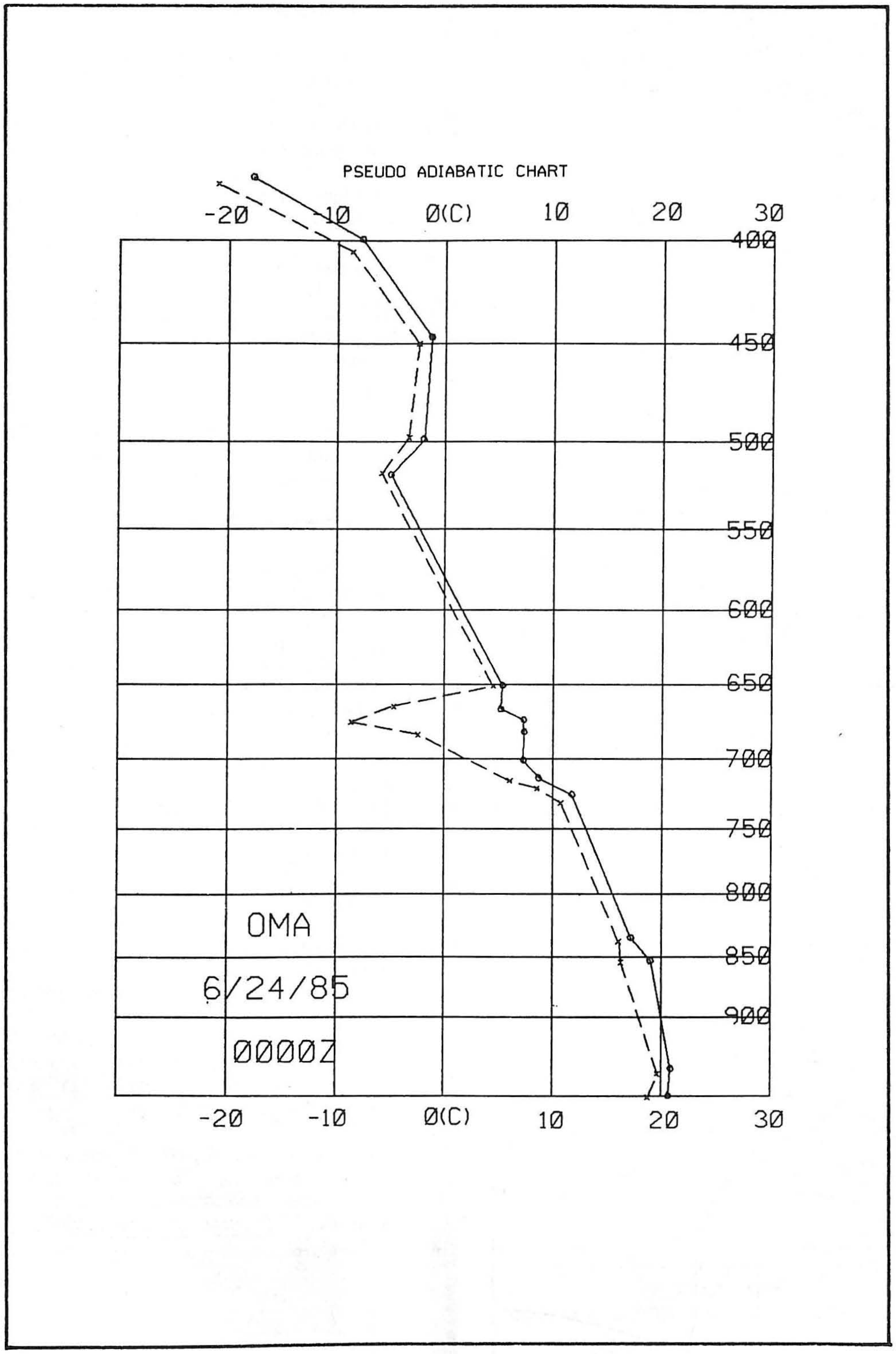

Fig. 4. Sounding released into the core of an MCC at Omaha, Nebraska on Monday 0000 GMT 24 June 1985. Note the unusually warm temperatures from 500 to 450 mb.

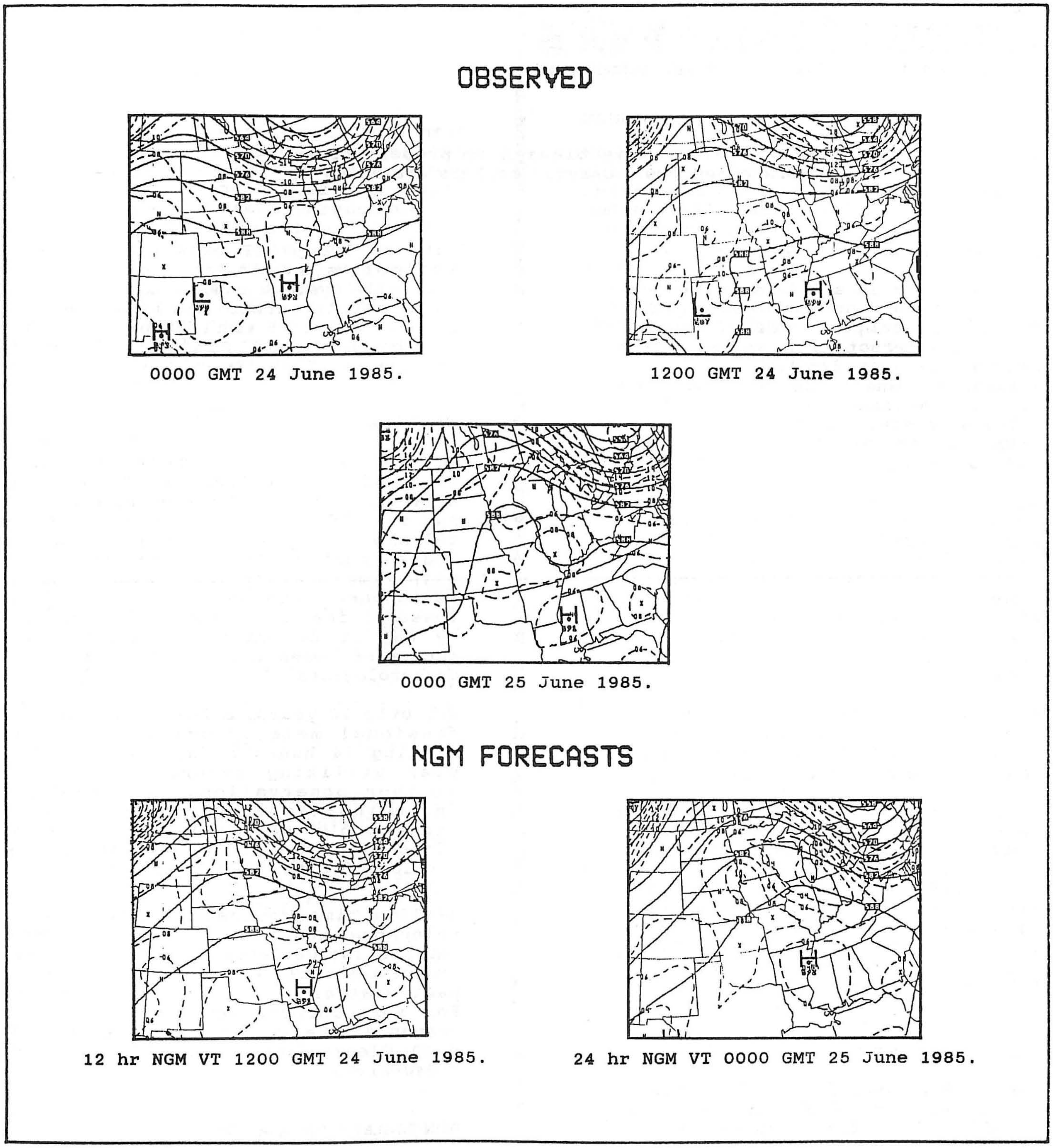

Fig. 5. Initial 500 mb analyses versus corresponding NGM forecasts for period 0000 GMT 24 June through 0000 GMT 25 June 1985.