Severe Weather

HEAVY THUNDERSTORMS OVER SOUTH AND CENTRAL MISSISSIPPI, Monday, July 7, 1980

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ABSTRACT

An important, though often overlooked aspect of southern summertime thunderstorm forecasting is that of cool air injections into anticyclonic flow regions. Sometimes very heavy thunderstorms can develop over a large area without any pronounced associated shortwave, but rather in response to a strong destabilization of the atmosphere due to a "cold pool" of air aloft. This destabilization is especially effective when surface temperatures are very high and moisture is abundant.

1. DESCRIPTION OF EVENT

On Sunday afternoon, 6 July, 1980, heavy thunderstorms developed along a weak cold front extending from western Tennessee into northern Alabama. On Sunday evening, while these thunderstorms were diminishing, an isolated heavy thunderstorm formed in western Alabama (just east of Meridian, MS), moved south, and arrived and weakened at Mobile Bay by 0400 CDT (09Z).

The next day, Monday, 7 July, 1980, thunderstorms began to develop vigorously during the late morning hours in extreme southeastern Mississippi, and spread over east central and south central Mississippi during the afternoon hours. This unexpected widespread convection moved into the southwest and west central counties around sunset. Several severe thunderstorm warnings had to be issued for some southwest Mississippi counties as reports of small hail, power outages, uprooted trees, and partially unroofed buildings were received

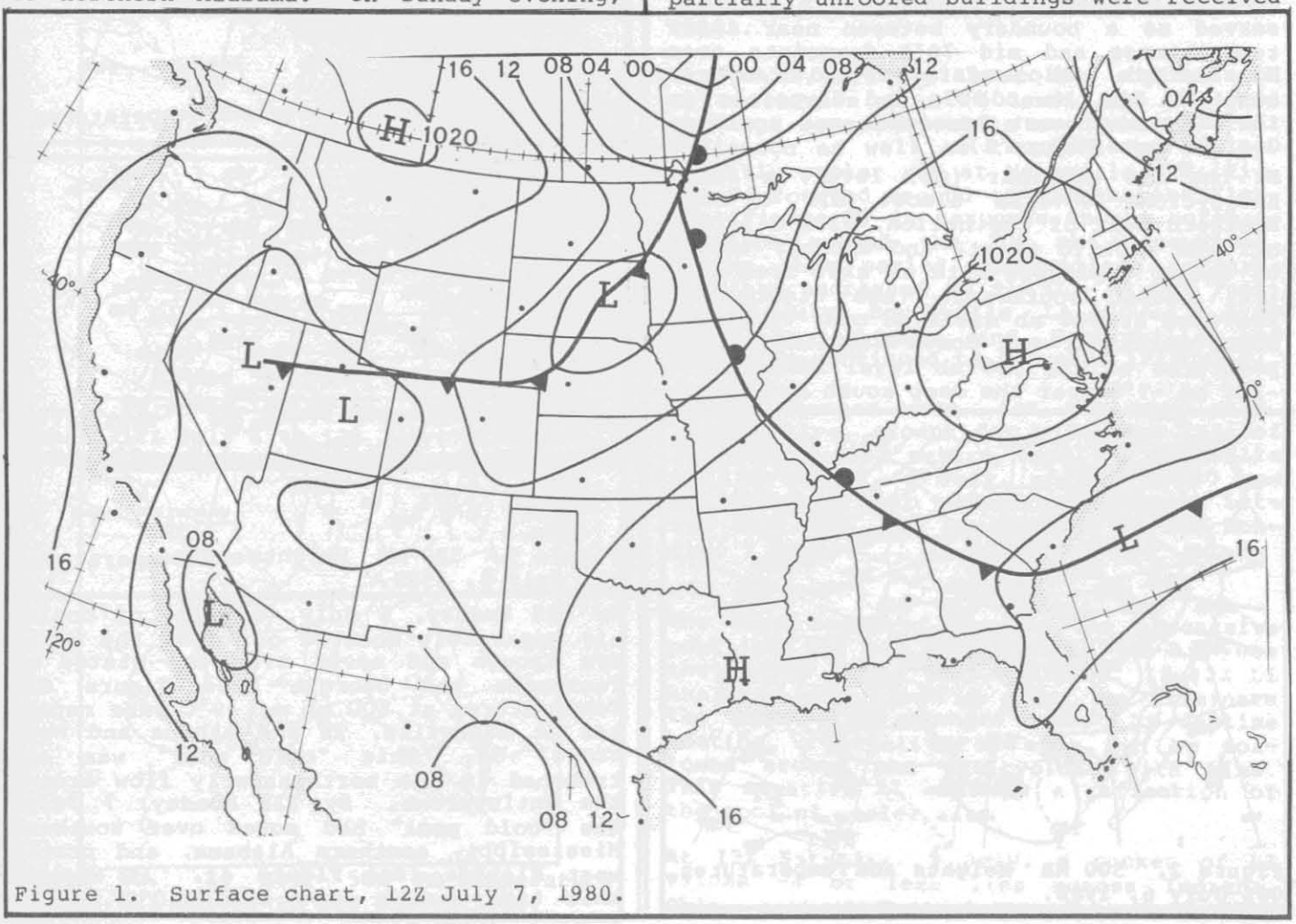

Figure 1. Surface chart, 12Z July 7, 1980.

at the Weather Service Forcast Office in Jackson. In addition, a small plane crashed a few miles north of Jackson's Thompson Field around 2045 CDT (0145Z), killing the passenger and seriously injuring the pilot.

Rainfall amounts ranged from a trace to nearly three inches in some sections of south and southwest Mississippi, with a 24 hour amount of 2.82 inches reported at McComb airport.

On Tuesday, 8 July, thunderstorm development was most concentrated in northern Louisiana, but appeared greatly reduced in coverage and intensity from the activity of the day before.

2. SYNOPTIC SITUATION

The large anticyclone that produced the 1980 heat wave remained entrenched over the southern part of the nation at the surface and aloft during the heavy thunderstorm event, with very hot and humid conditions prevailing. Maximum temperatures in Mississippi had been at or above 100°F (38°C) for several days, with the last significant rainfall for most of the state occurring in the last week of June. At the surface the cold front, extending from west Tennessee into northern Alabama, served as a boundary between near 100°F temperatures and mid 70's dewpoints over Mississippi and Louisiana, and temperatures in the lower 90's and dewpoints in the 60's over east Tennessee and northern Georgia (see Figure 1).

At the 500 millibar (mb) level, a large anticyclone covered almost all of the southern half of the nation, with a trough off the Pacific coast, and another trough of lesser amplitude with an axis from central Quebec southward. (see Figure 2). The flow at 500 mb diverged over Virginia, North Carolina, and South Carolina. Temperatures at the 500 mb level ranged from -3°C to -7°C over the deep south and Texas.

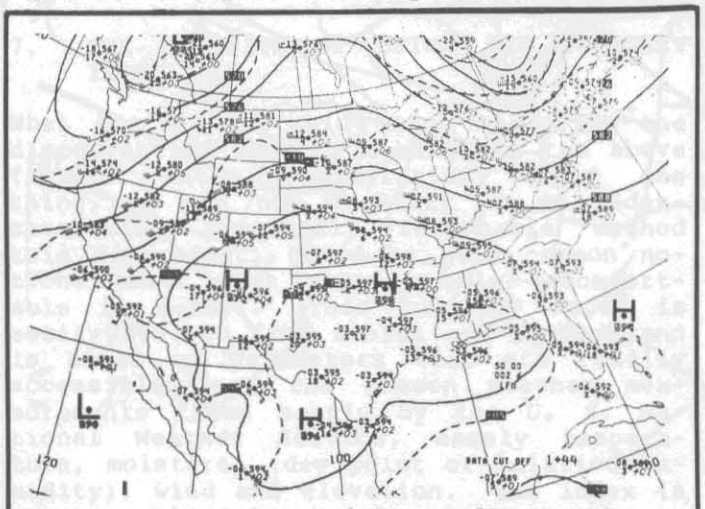

Figure 2. 500 MB Heights and Temperatures, 00Z July 6, 1980.

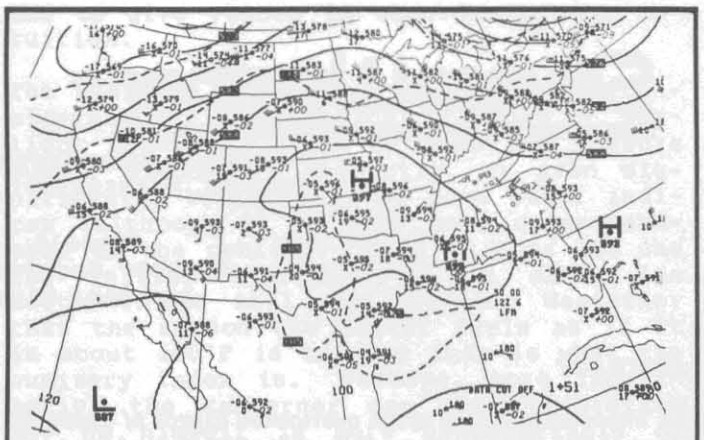

Figure 3. 500 MB Heights and Temperatures, 12Z July 6, 1980.

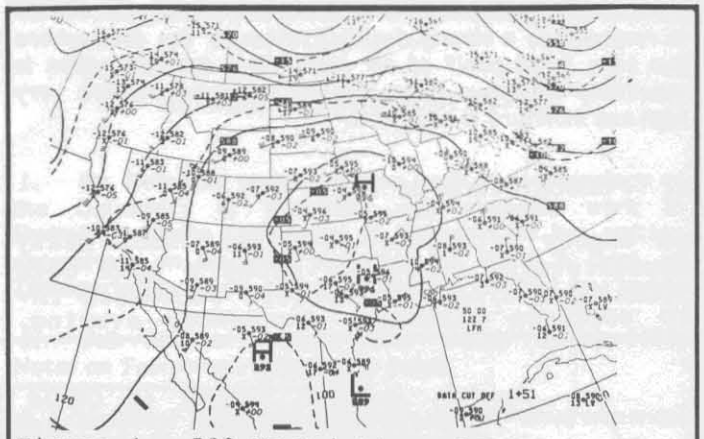

Figure 4. 500 MB Heights and Temperatures, 12Z July 7,1980.

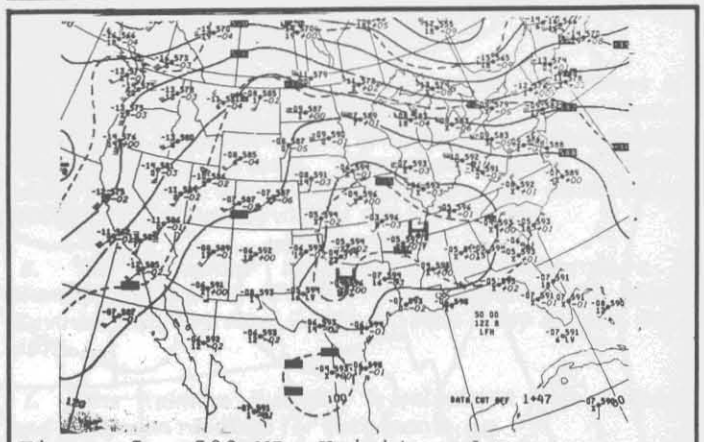

Figure 5. 500 MB Heights and Temperatures, 12Z July 8, 1980.

By 12Z Sunday, 6 July, a bulge of cooler air apparently sheared off from the eastern trough and moved over the states of Tennessee and Georgia (see Figure 3). Temperatures at 500 mb of -9°C were reported at Nashville, TN and Athens and Waycross, GA. This "cold pool" was entrenched in the northeasterly flow around the anticyclone. By 12Z Monday, 7 July, the "cold pool" had moved over southern Mississippi, southern Alabama, and northwest Florida (see Figure 4). It was at this time that a very cold -10°C 500 mb

temperature was reported at Jackson, MS. This was a decrease of 4 degrees from the previous morning's 500 mb temperature. In more easterly flow on the south side of the 500 mb anticyclone, the cooler air moved to a position over western Louisiana and eastern Texas by 12Z Tuesday, 8 July, but had also warmed since the lowest reported temperatures were -7°C readings at Lake Charles, LA and Longview, TX. (see Figure 5).

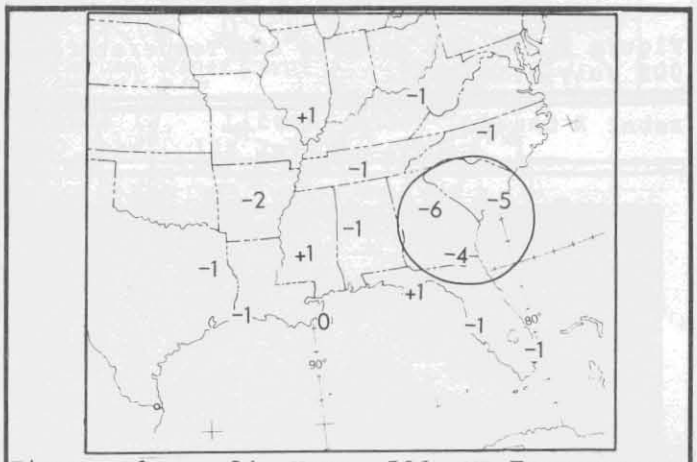

Figure 6a. 24 Hour 500 MB Temperature Change, 12Z July 5 to 12Z July 6,1980.

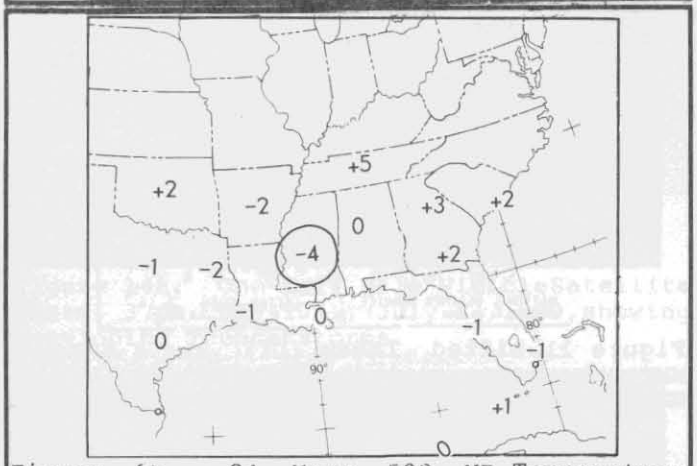

Figure 6b. 24 Hour 500 MB Temperature Change, 12Z July 6 to 12Z July 7,1980.

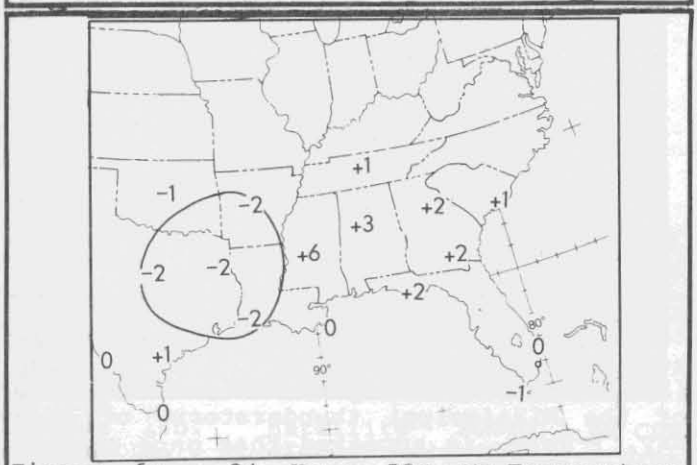

Figure 6c. 24 Hour 500 MB Temperature Change, 12Z July 7 to 12Z July 8,1980.

The cooler air showed up best at 12Z each day. This was probably due to diurnal warming of the atmosphere and the overturning and mixing of the air as a result of the many thunderstorms.

Further, an analysis of 24 hour temperature changes at 500 mb facilitates following the cooler air (see Figures 6a-c). From 12Z Saturday, 5 July, until 12Z Sunday, 6 July, temperature changes were mostly 2°C or less, with the exceptions of Waycross, GA (-4°C), Charleston, SC (-5°C), and Athens, GA (-6°C). In the next 24 hour period (12Z Sunday, 6 July to 12Z Monday, 7 July), the largest temperature drop occurred at Jackson, MS, while the three stations where significant drops occurred the day before showed increases in temperature. In Figure 6c, the largest temperature drops were only 2°C, but were concentrated in Arkansas, eastern Texas, and Louisiana while Jackson showed a temperature increase of 6°C and smaller increases were observed at other southeastern stations.

Thus it seems obvious that a pool of cooler air was moving from east to west around the anticyclone; first over Georgia and South Carolina, then progressing to Mississippi, and finally moving over eastern Texas.

At 700 mb, tracing the colder air was not as conclusive as at 500 mb, and observed readings were subject to even more diurnal variation as well as thunderstorm mixing. Slightly cooler air at Nashville, TN (Figure 7) rotated around to Alabama and Florida (Figure 8) in response to the northerly flow around the 700 mb anticyclone. During that period, Nashville's temperature had increased to +10°C. At 00Z Tuesday, 8 July, Boothville, LA showed a drop while Apalachicola and Centreville and Nashville continued to increase (Figure 9).

Height changes were, for the most part, inconclusive, except for a 24 hour fall of 30 geopotential meters (gpm) at Nashville at 12Z Sunday, 6 July, and 20 to 30 gpm falls for 12 hour periods at Jackson, Little Rock, AR, and Centreville at 12Z Monday, 7 July.

The best means of showing the successive positions of the "cold pool" of air was the Lifted Index (LI) Analysis. If 12Z LI analyses are used in order to eliminate the instability changes caused by daytime heating, a negative LI area can be followed around the anticyclone with time. This negative LI area is a reflection of the pool of cooler air.

At 12Z Saturday, 5 July, a pocket of LI values -4 or less lies across Indiana, Ohio, central Kentucky, and central Ten-

nessee (see Figure 10). By 12Z Sunday, 6 July, LI values of -4 or less extended over much of Arkansas, northern Mississippi, Alabama, and Georgia, in good agreement with the thunderstorm development later that day (Figure 11). On Monday morning, 7 July, values of -4 or less were centered over Mississippi with a -8 LI value computed at Jackson (Figure 12). Again, this was in good agreement with the heavy thunderstorm development that occurred over south and central Mississippi later that day. At 12Z Tuesday, 8 July, the instability was centered in eastern Texas while the LI values showed stability over the rest of the south (Figure 13).

All of these factors indicate a very strong destabilization of the atmosphere due to what Olson (2) of the Satellite Field Service Station (SFSS) in Kansas City, MO, called a "cold pool" of air aloft:

> "convection continues to expand over western Alabama, Mississippi, and eastern Louisiana aided by 500 mb cold pool.... "

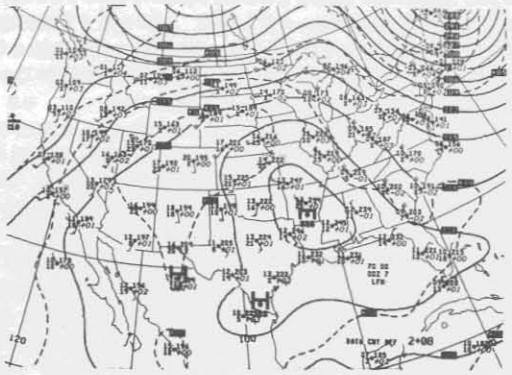

Figure 7. 700 MB Heights and Temperatures, 00Z July 7, 1980.

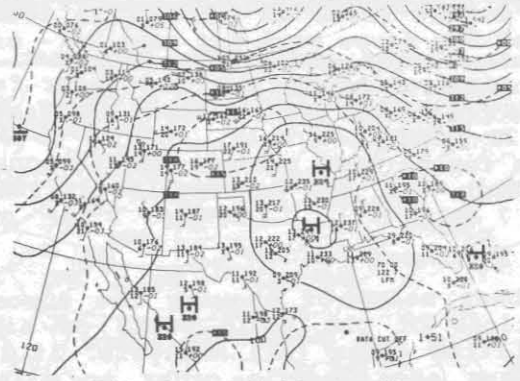

Figure 8. 700 MB Heights and Temperatures, 12Z July 7, 1980.

3. MESOSCALE DISCUSSION

A trigger to the convection in the case of the Alabama and Tennessee thunderstorms of Sunday, 6 July, was provided by the presence of the weak cold front. Development

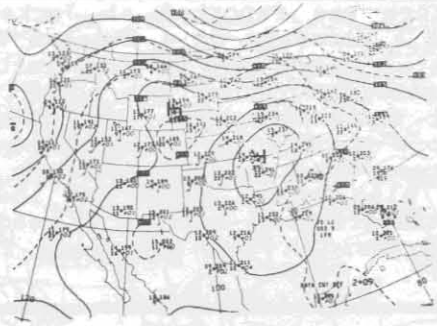

Figure 9. 700 MB Heights and Temperatures, 00Z July 8, 1980.

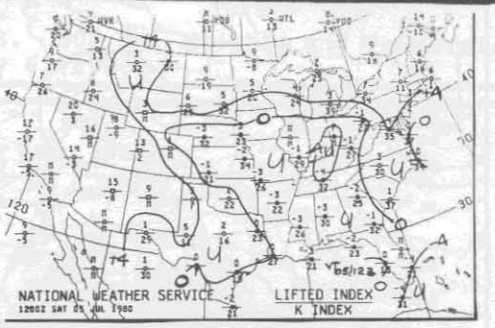

Figure 10. Lifted Index (LI) and K Index NMC Chart, 12Z July 5, 1980.

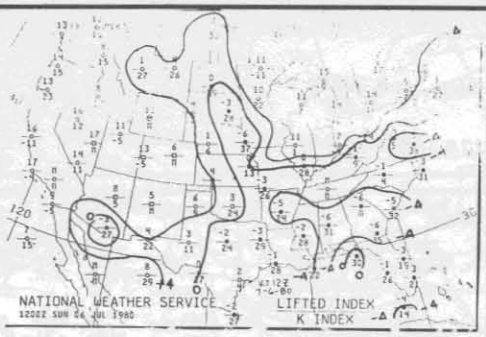

Figure 11. Lifted Index (LI) and K Index NMC Chart, 12Z July 6, 1980.

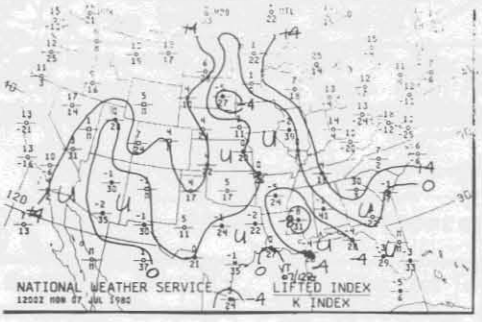

Figure 12. Lifted Index (LI) and K Index NMC Chart, 12Z July 7, 1980.

appeared to take place in close proximity to the front in the satellite pictures taken from 1500 CDT to 1900 CDT on that day (20Z to 00Z) (see Figure 14a&b). In the case of the Mississippi thunderstorms of Monday, 7 July, it appeared that once convection had begun in extreme southeast Mississippi, thunderstorms became self sus-

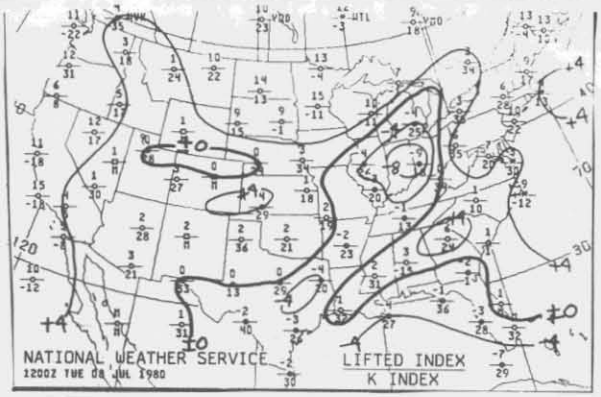

Figure 13. Lifted Index (LI) and K Index NMC Chart, 12Z July 8, 1980.

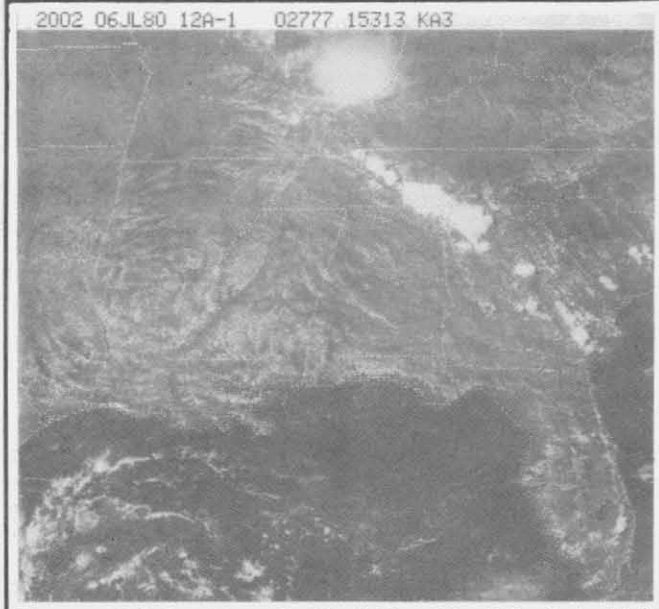

Figure 14a. One-Half Mile VisibleSatellite Photo, 3 pm CDT (20Z), July 6, 1980,showing Developing Thunderstorms.

Figure 14b. Satellite Photo, 7 pm CDT (00Z), July 7, 1980, with thunderstorms reaching their heights.

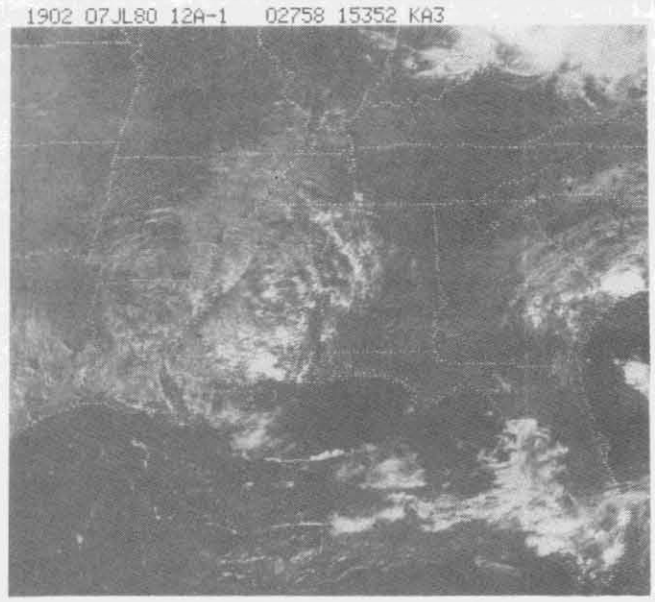

Figure 15a. One-Half Mile Visible Satellite Photo, 2 pm CDT (19Z), July 7, 1980; convection begins in earnest over SoutheasternMississippi.

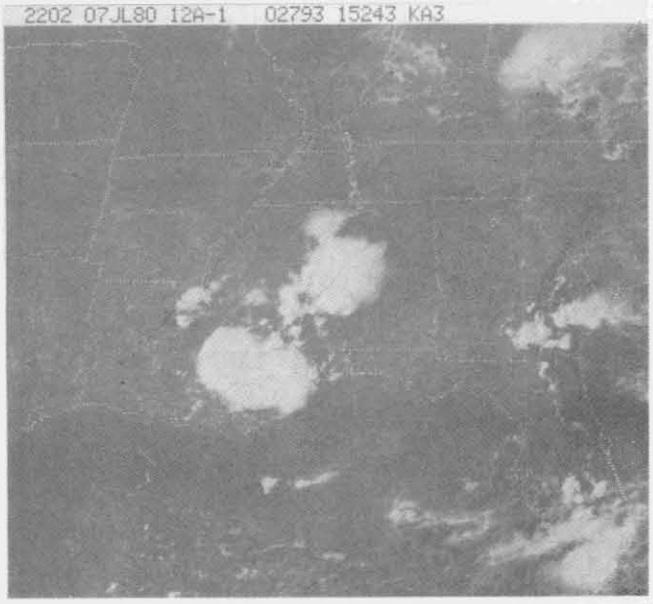

Figure 15b. Satellite Photo, 5 pm CDT (22Z), July 7, 1980;thunderstorms are well developed.

taining; i.e., after one storm would begin to dissipate, another would form on a gust front discontinuity or outflow boundary of the first. Development began in extreme southeast Mississippi and progressed north and west until ultimately a line of very heavy thunderstorms formed late Monday evening stretching from north of Jackson to McComb (Figure 15a-d).

A closer examination of the Jackson radiosonde data from 00Z and 12Z Monday, 7 July, revealed other dynamic mesoscale

Figure 15c. One Mile IR Satellite Photo 8 pm CDT (01Z), July 7, 1980; widespread thunderstorm activity over almost all of Southern Mississippi.

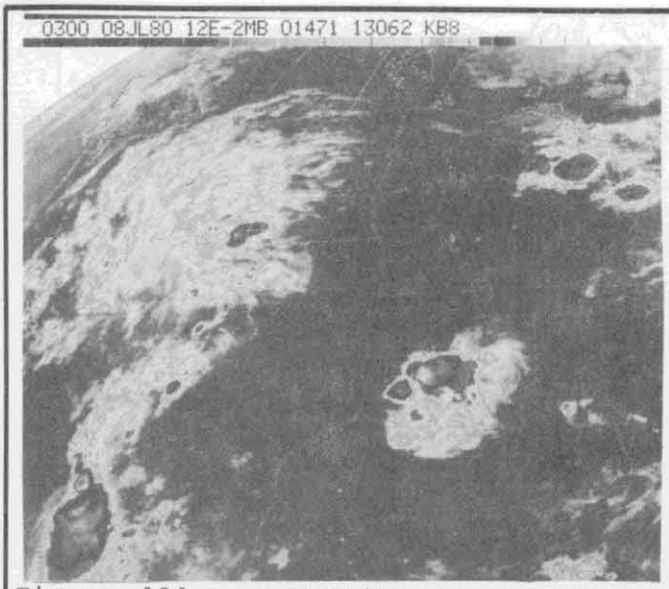

Figure 15d. Satellite Photo, 10 pm CDT (03Z), July 7, 1980; hail reports, wind damage and power outages received in Natchez, MS. Severe thunderstorm warnings are issued.

factors which aided the explosive thunderstorm development of that afternoon. Until 12Z Sunday, 6 July, Jackson's 500 mb wind was light easterly in agreement with the anticyclonic circulation over the southern states. By 12Z Sunday, 6 July, the 500 mb wind at Jackson had become more northeasterly in direction and subsidence had increased and worked its way down to about 750 mb by 00Z Monday, 7 July. At this time, a modest subsidence inversion appeared at about 780 mb. By 12Z Monday, 7 July, winds were stronger and more northerly, which strengthened the subsidence inversion at the same level (see Figure 16).

Moisture had concentrated below the subsidence inversion, and the layer 780 mb to 830 mb was near saturation. In addition, the layer from 830 mb to ground level averaged 80% relative humidity.

With surface temperatures at 95°F by 0945 CDT and at a maximum of 101°F at 1400 CDT at Jackson, moist air from the lower layers began to be released upward through the subsidence inversion. Since the sounding was potentially unstable, the presence of the "cold pool" of air (which showed up well on the 12Z sounding, mainly from about 460 mb to 560 mb) simply made the situation that much more explosive.

Therefore, the destabilization at upper levels of the atmosphere caused by the "cold pool" of air mainly between 460 mb and 560 mb dynamically interacted with subsidence in the middle layers, high moisture content of the lower layers, and very high surface temperatures to make possible the rather violent thunderstorm development of Monday afternoon, 7 July, 1980.

4. GUIDANCE FROM NMC

Computer guidance from the National Meteorological Center (NMC) in Washington, D.C. was not helpful in detecting the possibility of thunderstorms, and issued no more than a 20 percent chance for Jackson or McComb for any of the periods during which the rain occurred. Jackson's Thompson Field received 0.40 inch during the Monday night period, while McComb was deluged with 2.19 inches on Monday, and an additional 0.63 inch on Monday night for a 24 hour total of 2.82 inches.

5. CONCLUSIONS

Although prediction of the resultant large areal coverage of heavy rains in south and central Mississippi on 7 July, 1980, seems next to impossible in view of the current state of the art, forecasters of the southern summertime thunderstorm would be well advised to watch:

(1) Lifted Index Analyses and Forecasts,

(2) 500 mb temperatures and 24 hour changes, especially at 12Z, and

(3) 700 mb temperatures and 24 hour changes.

These will indicate signs of regular motion of a colder pool of air aloft that could result in destabilization. These parameters should be especially watched in situations involving stagnant, hot, and moist subtropical anticyclones that are so common over the south during the summer.

REFERENCES AND FOOTNOTES

1. Russell Pfost is a Hydrologist with the National Weather Service Forecast Office in Jackson, Mississippi. He is a 1977 graduate (Phi Beta Kappa) of Florida State University in Tallahassee, and also did graduate work at Texas Tech University in Lubbock. As a native Floridian, he grew up accustomed to summertime thunderstorms, and continues to be fascinated with them even now.

2. Olson, Joel, 1980: Satellite Field Service Station (SFSS) Kansas City, Satellite Interpretation Message, 00Z, 8 July, 1980.

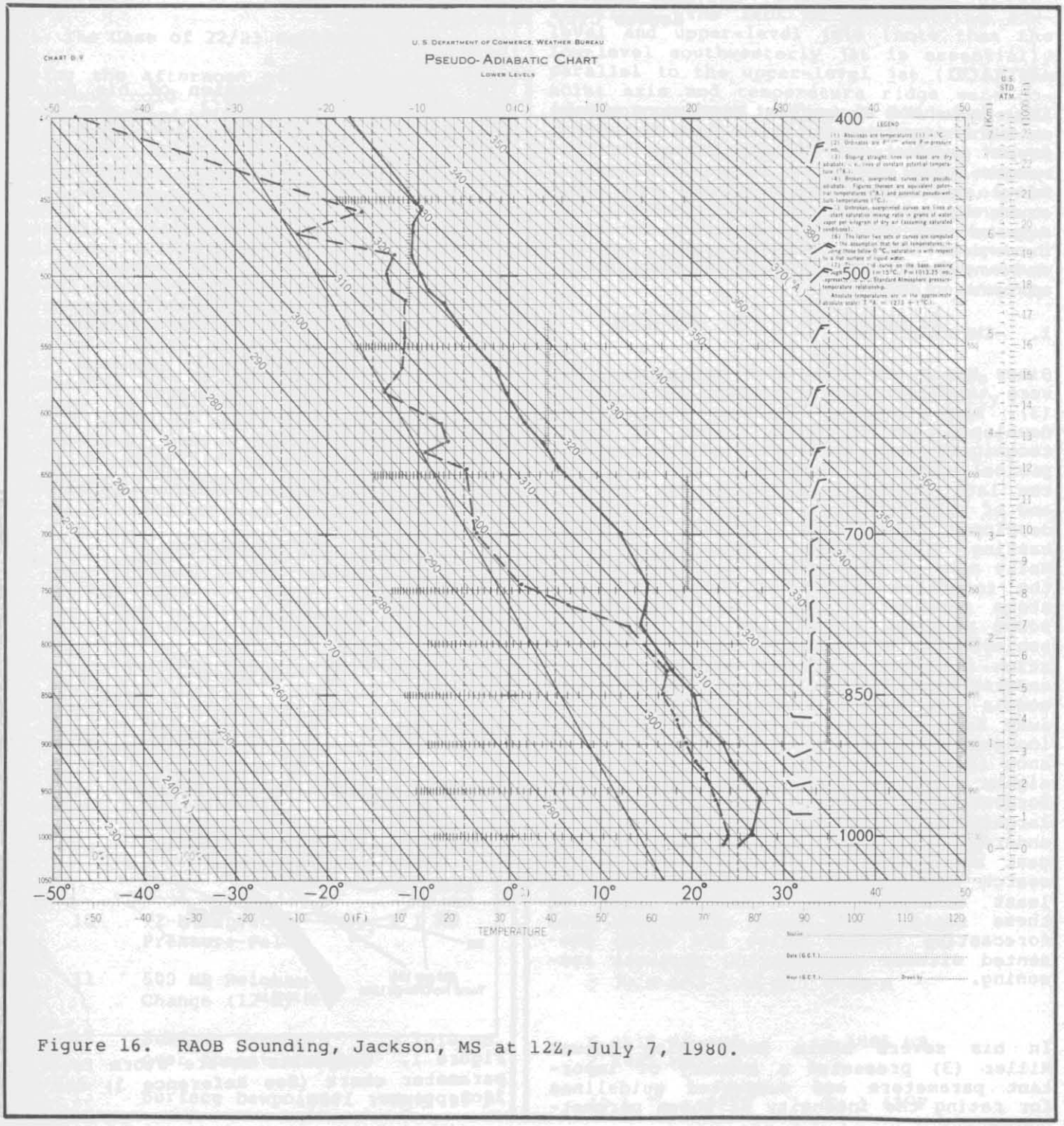

Figure 16. RAOB Sounding, Jackson, MS at 12Z, July 7, 1980.