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A RECORD SOUTHEASTERN SNOWFALL IN THE ABSENCE OF A RAPIDLY DEEPENING EXTRATROPICAL CYCLONE

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I. Introduction

In recent years much attention has been given to the rapidly deepening, high amplitude cold season synoptic scale systems, also known as meteorological bombs and nor'easters, which have affected much of the United States East Coast, including large metropolitan areas. Most of the East Coast snowstorms cited by Kocin and Uccellini (1990) included rapid cyclogenesis. These massive and impressive winter storms produce large amounts of snowfall and blizzard conditions which have a significant impact on everyday life. The "President's Day" Storm of February 1979 (Bosart 1981), the "Storm of the Century" of March 1993 (Kocin et al. 1995) and the 24-25 January 2000 snowstorm are examples of such extratropical cyclones that paralyzed communities from the Southern Appalachians to New England.

While such powerful winter storms receive most of the scrutiny from media and researchers, other less well-defined synoptic systems, which produce just as much snow and cause similar socioeconomic impacts, are often ignored. The snowstorm of 7-8 January 1988 is an example of a system that did not appear to have the obvious synoptic-scale features normally associated with heavy snow in the southern states. Yet, this storm produced the greatest single storm snowfall (12.0 inches) recorded at the Greenville-Spartanburg International Airport (GSP) since the weather station opened in 1962, and the second greatest snowfall since records were kept for the Greenville and Spartanburg areas starting in 1911. (The snowstorm of 17-18 December 1930 produced 14.4 inches of snow.) This paper describes and summarizes the snowfall distribution across Georgia, North Carolina, and South Carolina, including the GSP County Warning Area (CWA), socio-economic impacts, and synoptic pattern associated with the 7-8 January 1988 event. It should be noted that the GSP CWA was only a small portion of the country affected by this system. Heavy snow of greater than 8 inches fell in a strip from western Kansas and Oklahoma, across Arkansas, northern Mississippi, northern Alabama, through the extreme southern Appalachians and into central Virginia from 5-8 January 1988 (NOAA 1988a). The intent of this paper is not to provide a detailed meteorological analysis, but instead to demonstrate that major winter storms in the western Carolinas and northeast Georgia can occur in the absence of a rapidly deepening surface cyclone.

II. Snowfall Distribution and Impacts

Snowfall began in the northwest corner of

Georgia around 0600 UTC 7 January and spread quickly east. Snowfall started at GSP between 0700 and 0800 UTC 7 January and continued until 0500 UTC 8 January. Sleet mixed with the snow at times during the late afternoon and early evening (Fig. 1). In Georgia, accumulations of snow totaled 10 to 16 inches across the extreme northern counties, with two to four inches in a band from Atlanta to Athens. Clayton received 14 inches and Toccoa measured 8.5 inches of snow. In South Carolina, an unofficial snowfall of 27.0 inches was reported in the Bad Creek area of Oconee County. However, several official snow depths of 18.0 inches were reported in the mountains and foothills. Longcreek, also in Oconee County, measured 15.0 inches and Caesars Head reported 16.5 inches, with drifts up to 40 inches. In North Carolina, up to a foot of snow was reported across much of the state, with 18 inches of snow common in the west. Macon County reported the maximum snowfall of 20.0 inches (NOAA 1988a-d). As Fig. 2 shows, a large swath of greater than 12 inches of snow fell basically centered over the GSP CWA.

The resulting socioeconomic impact was felt far and wide. Eighty chicken houses collapsed from the weight of the snow and ice in northern Georgia, killing 516,000 chickens. Major disruptions to travel occurred across the region including Interstates 85, 40 and 77. Schools were closed for more than a week in most places as snow and ice remained on the ground for an unusually long time - more than two weeks in portions of northwest South Carolina and western North Carolina. The cost of snow removal, disruption of the economy, and mitigation activities were very large. North Carolina alone spent $8 million on its cleanup effort (NOAA 1988a).

III. Meteorological Analysis

The surface pattern throughout the event was dominated by a large, cold anticyclone. The high pressure center of 1040 mb was near Chicago, IL at 0000 UTC 7 January (Fig. 3) and over Washington, D.C. at 1200 UTC. Central high pressure weakened to 1033 mb by 1200 UTC 8 January as it retreated into New England. A wedge-like surface ridge east of the Appalachians was most noticeable between 1200 UTC 7 January and 0000 UTC 8 January (Figs. 4 and 5), and not surprisingly occurred simultaneously with the period of heaviest precipitation (Fig. 6). A surface trough was positioned along the coastal regions of Texas and Louisana at 0000 UTC 7 January and amplified a bit while moving directly east to a position near the panhandle of Florida by 0000 UTC 8 January. At this time, an inverted trough was west of the Appalachians and a coastal trough was off the southeast coast. Weak low pressure appeared to develop off the southeast coast within the coastal trough by 1200 UTC 8 January (Fig. 7), but by this time, all precipitation across the western Carolinas and northeast Georgia had abated. It is obvious from looking at the surface pattern that high precipitation rates during the day of 7 January 1988 were not induced by a rapidly deepening surface low pressure system.

The 500-mb height contours at 0000 UTC 7 January showed a confluent flow over the eastern U.S. due to merging northern and southern streams. A shortwave trough in the southern stream was noted entering the Southern Plains (Fig. 8). As the shortwave trough progressed east during the next 36 hours it became less amplified and eventually became absorbed into a broad, low amplitude longwave trough over the eastern U.S. (Figs. 9-11). There is no doubt the approaching shortwave trough had an impact on the overall synoptic scale lift realized over the southeastern states, but again, this pattern was not conducive to rapid cyclogenesis as described by Kocin and Uccellini (1990). The question remains as to what generated the lift that aided the production of such widespread heavy snow observed in this case.

One can find an answer by examining the lower atmospheric conditions. At 0000 UTC 7 January, the 850-mb pattern showed a low in the southern Rockies, high heights over Florida, and a strong temperature gradient across the southern U.S. (Fig. 12). Over the next 24 hours, the 850-mb low moved east into western Kentucky and the high moved off the southeast Coast. Assuming a geostrophic flow, strong warm advection occurred during the day on 7 January (Fig. 13) across the Gulf Coast States and Carolinas. The 850-mb temperature along the North Carolina/South Carolina border rose from -6 °C at 1200 UTC 7 January to 0 °C at 0000 UTC 8 January (Fig. 14). Because an isotherm on a constant pressure surface corresponds to a unique isentrope (Uccellini 1976), the region across the southern states shown in Figs. 12 and 13 had a well-defined north-south gradient of isentropes. Therefore, a steep south to north slope of isentropic surfaces resided over the southern states. The southerly flow up this slope of isentropic surfaces contributed to significant upward motion across the region, including the GSP CWA. Therefore, if one could observe the isentropic surfaces for this event, one would most certainly find that strong isentropic lift was the main contributor to the heavy precipitation rates and resulting high snowfall totals.

IV. Conclusion

The 7-8 January 1988 heavy snow event across Georgia and the Carolinas is an illustration of a record-setting snowfall that resulted from a flow pattern significantly different than a flow pattern associated with the more heralded nor'easter. In the absence of strong digging shortwaves, high amplitude troughs, and a rapidly deepening surface cyclone, heavy snow fell across a significant portion of north Georgia and the Carolinas, including the metropolitan areas of Greenville-Spartanburg, Asheville, Charlotte, Greensboro, Raleigh and Columbia. The heavy snow, greater than 12 inches along and north of the Interstate 85 corridor in the western Carolinas shut down commerce and closed schools for days. This case study simply serves as a reminder that forecasters should be just as aware of prolonged, strong isentropic lift as they are of strong cyclogenesis when anticipating significant snowfall events in the southeastern United States.

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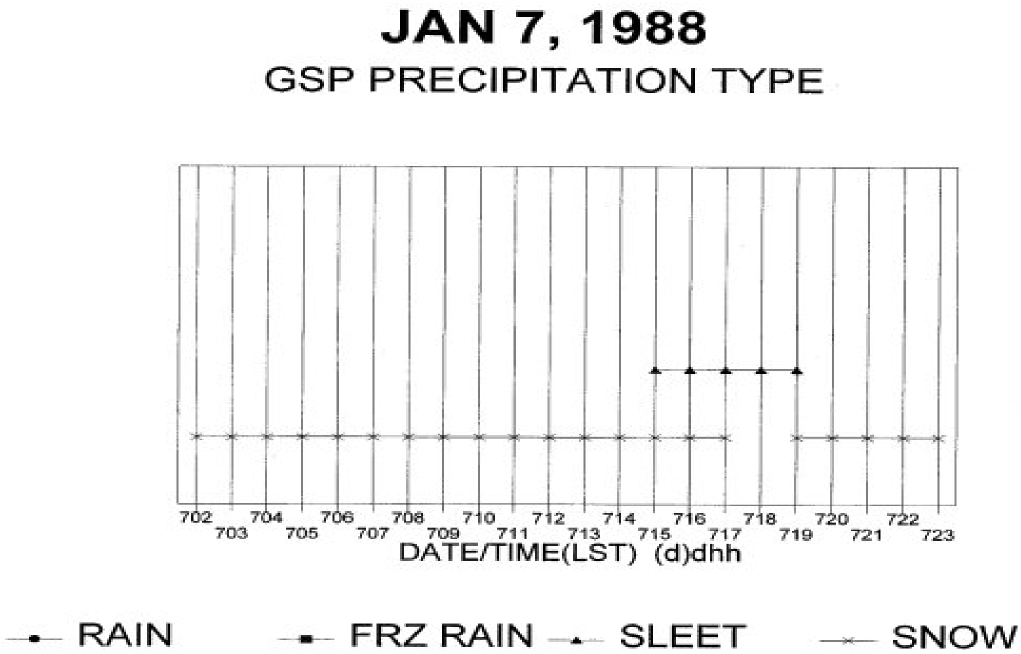

Figure 1. Time series for GSP showing precipitation type observed each hour of the event.

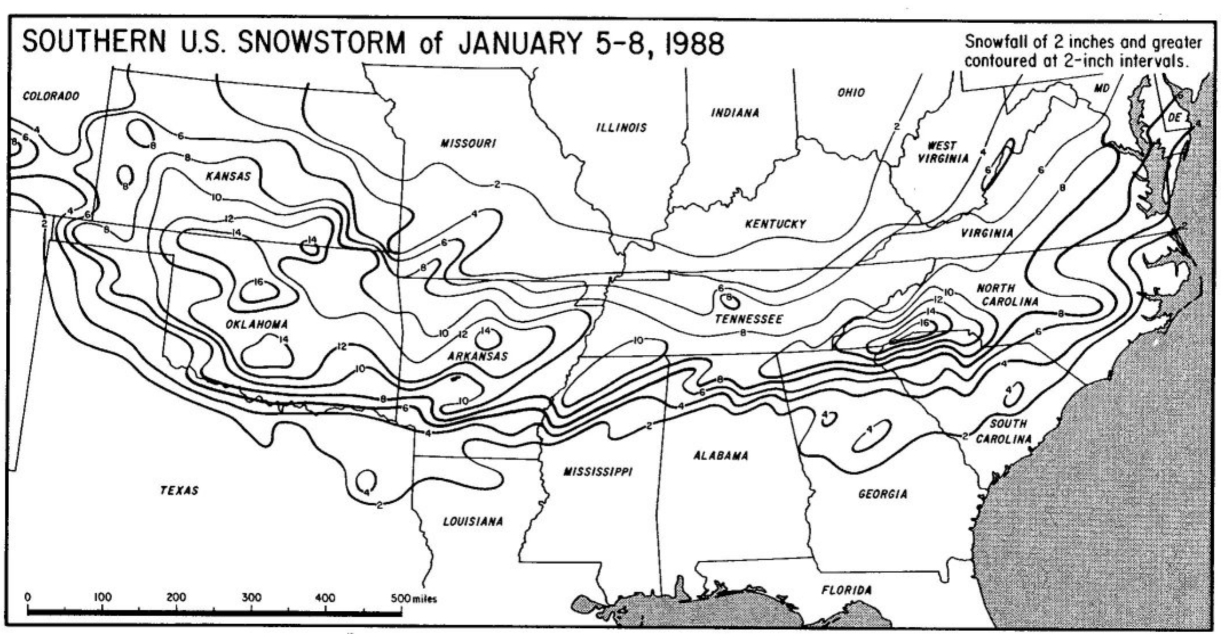

Figure 2. Snowfall totals for 5-8 January 1988 snowstorm (NOAA, 1988a). GSP CWA includes most of western North Carolina, the northwestern third of South Carolina and extreme northeast Georgia where snowfall totals averaged between 8 and 16 inches.

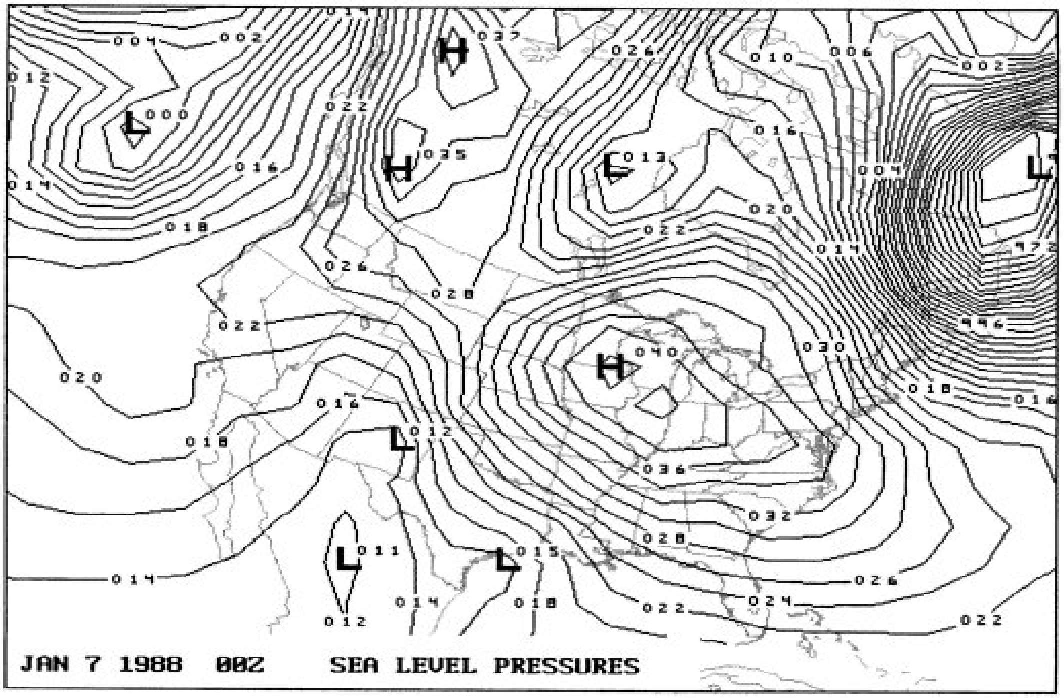

Figure 3 North American mean sea level pressures at 0000 UTC 7 January 1988.

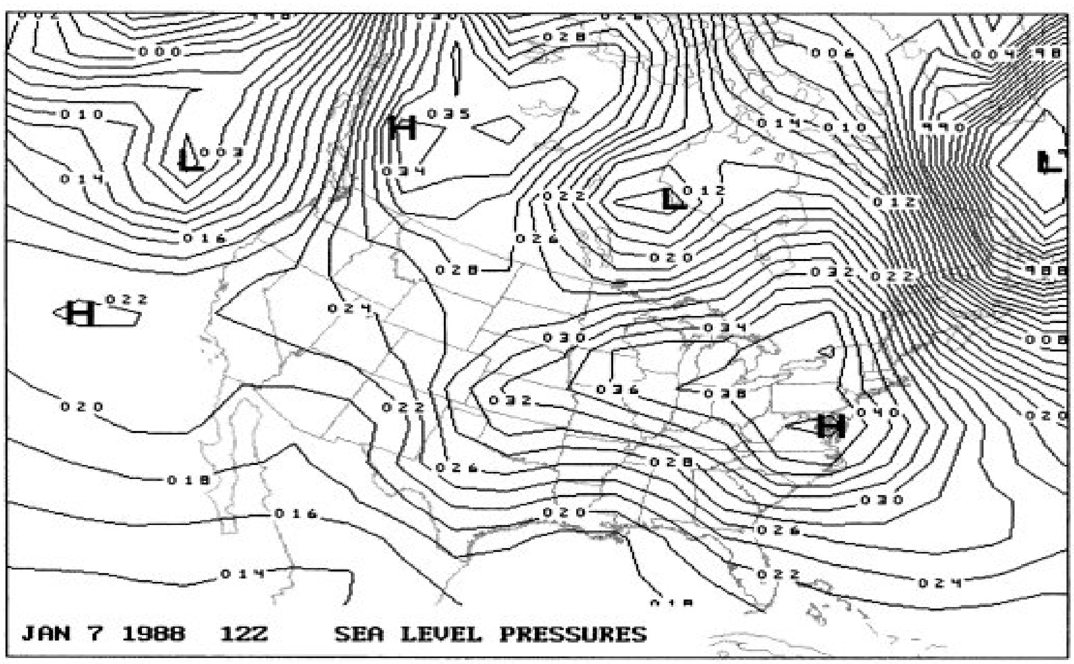

Figure 4 North American mean sea level pressures at 1200 UTC 7 January 1988.

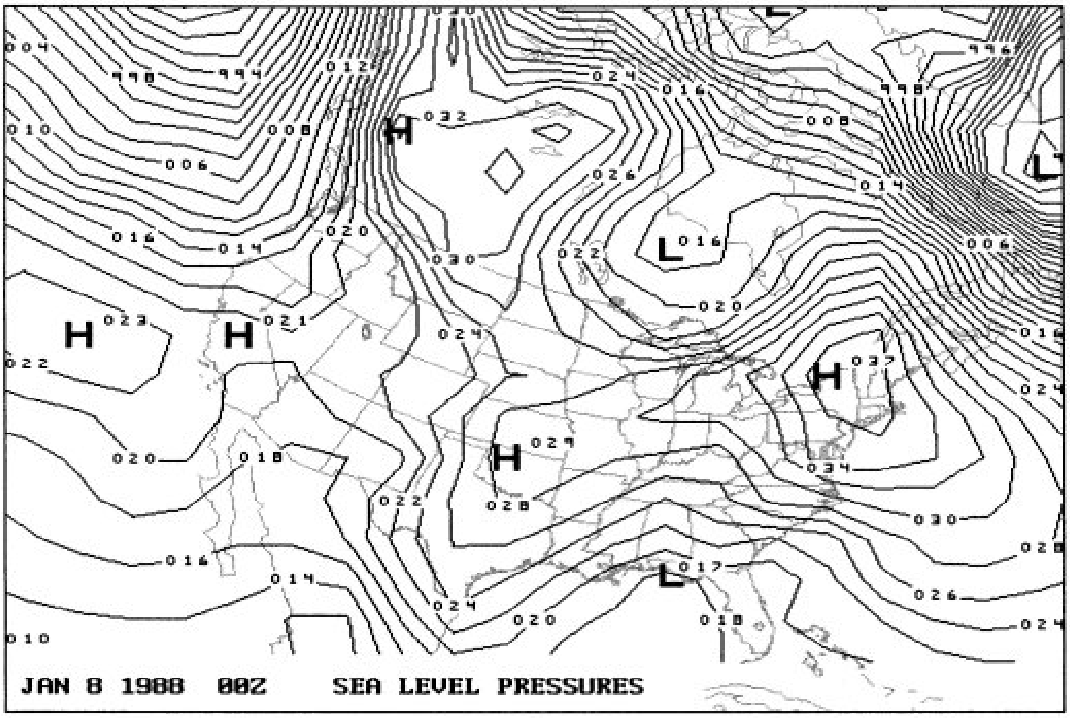

Figure 5. North American mean sea level pressures at 0000 UTC 8 January 1988.

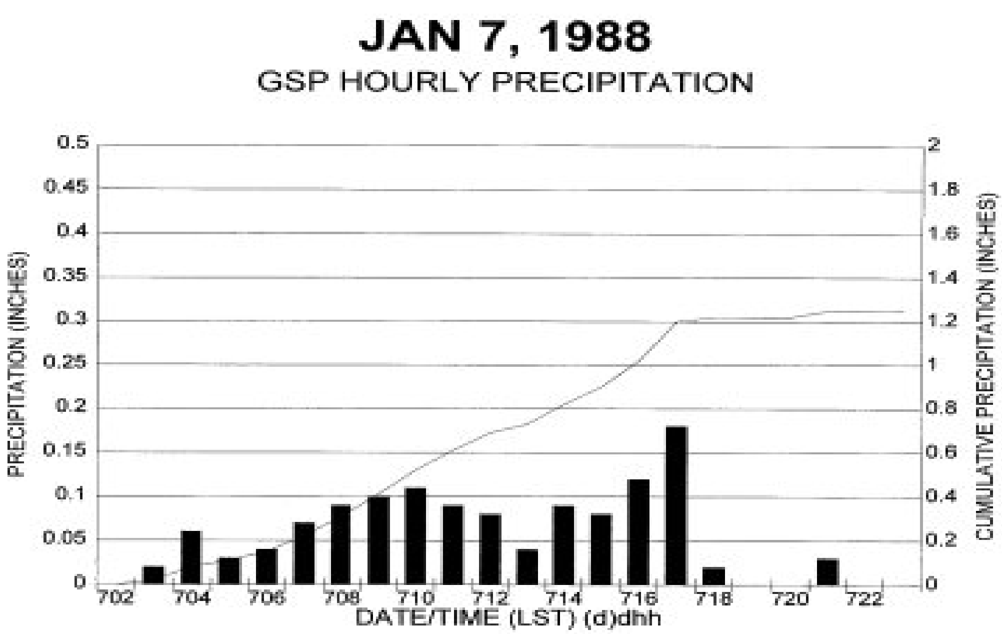

Figure 6. Time series of GSP hourly (columns) and cumulative (line) precipitation in inches from 0200 UTC to 2300 UTC 7 January 1988.

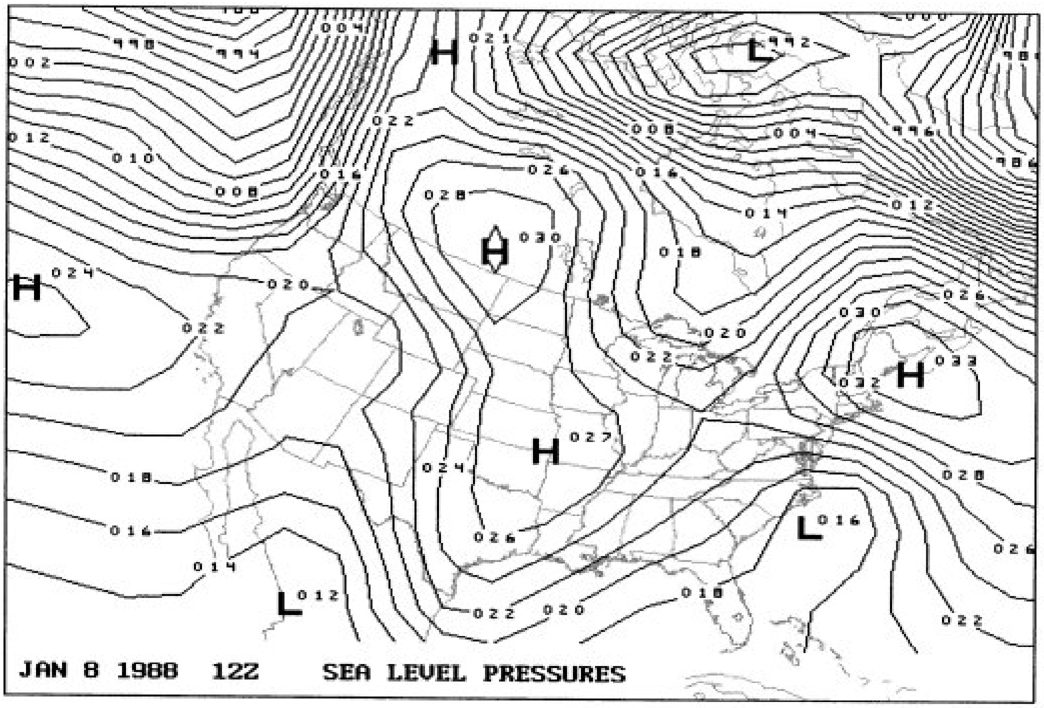

Figure 7.. North American mean sea level pressures at 1200 UTC 8 January 1988.

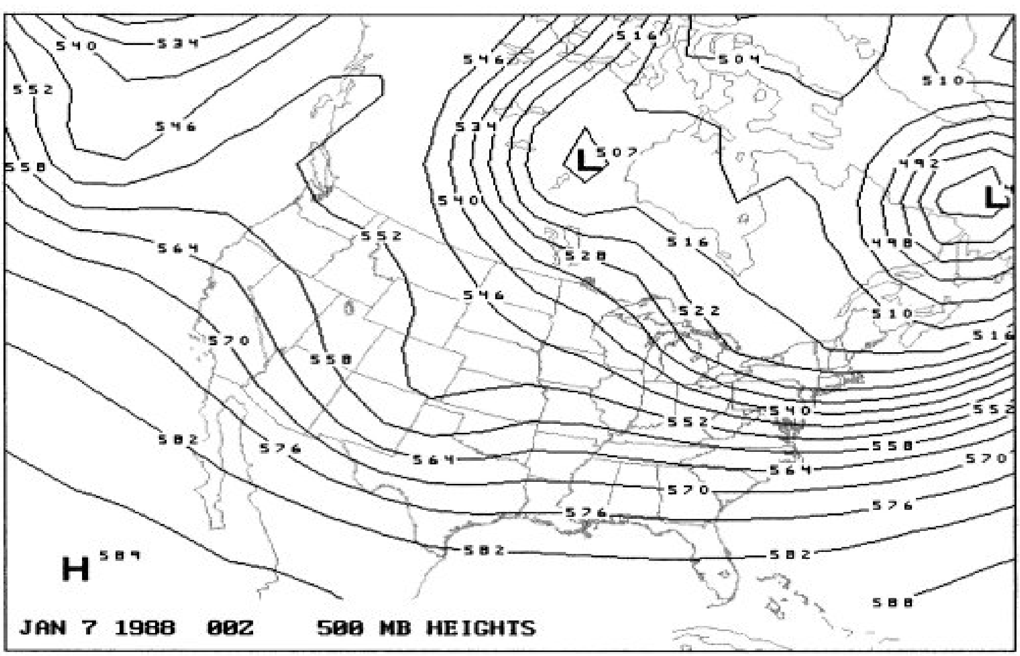

Figure 8. North American 500 mb heights at 0000 UTC 7 January 1998.

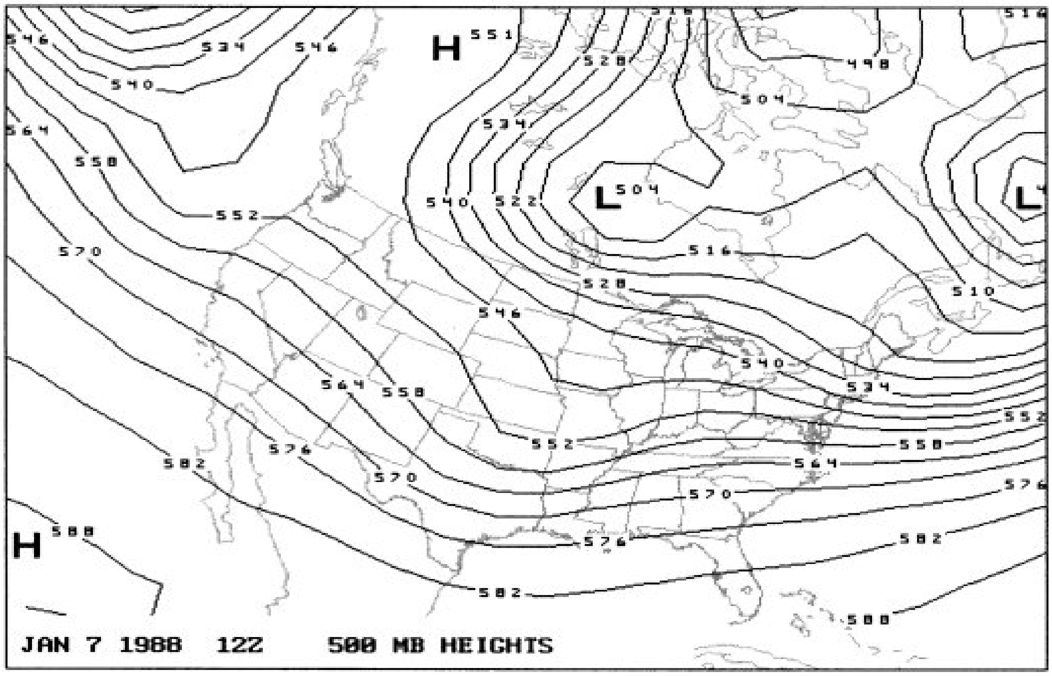

Figure 9. North American 500 mb heights at 1200 UTC 7 January 1998.

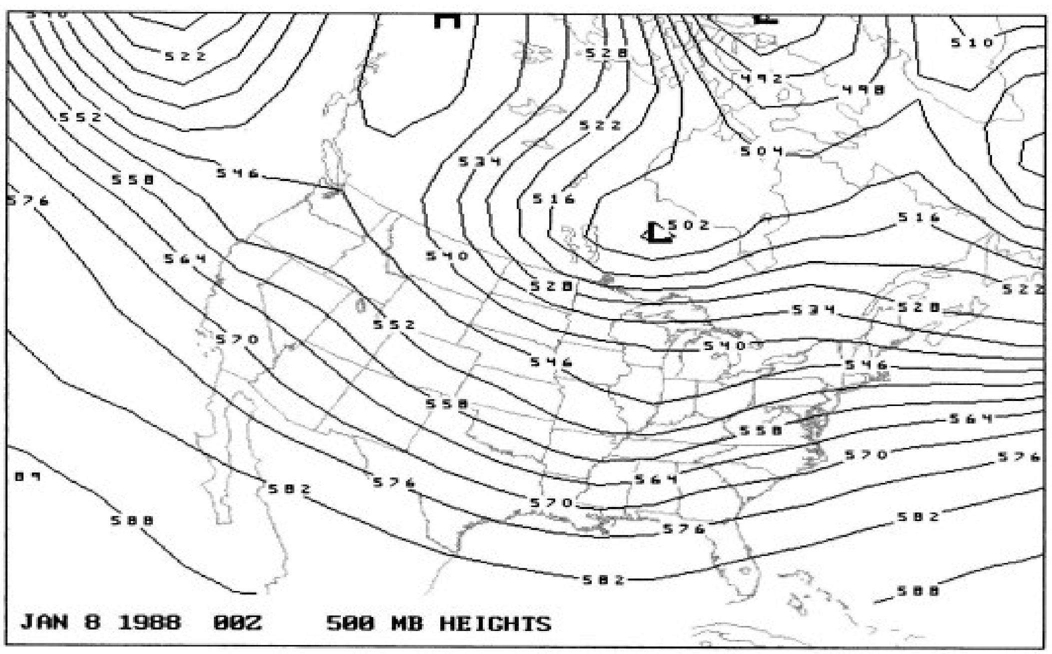

Figure 10. North American 500 mb heights at 0000 UTC 8 January 1998.

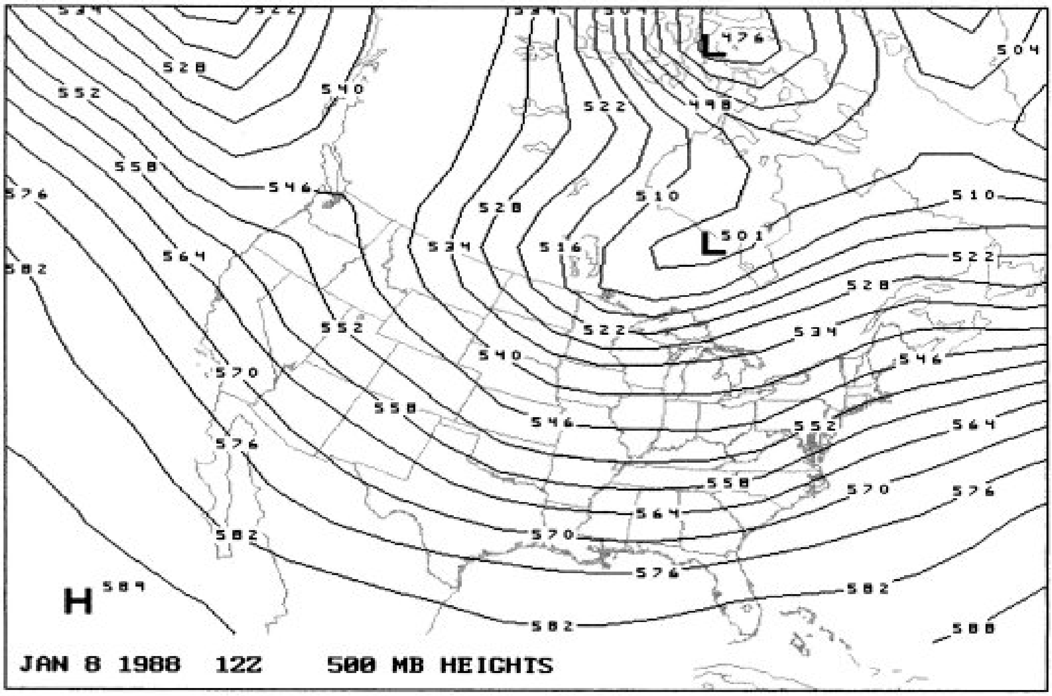

Figure 11. North American 500 mb heights at 1200 UTC 8 January 1998.

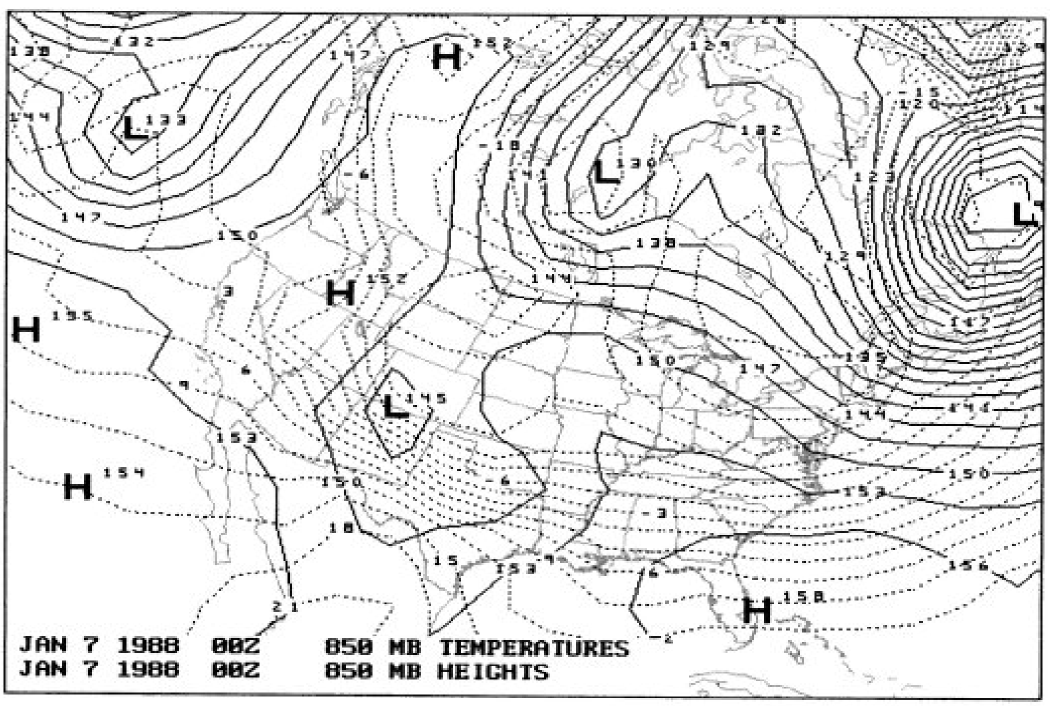

Figure 12. North American 850 mb heights and temperatures at 0000 UTC 7 January 1988.

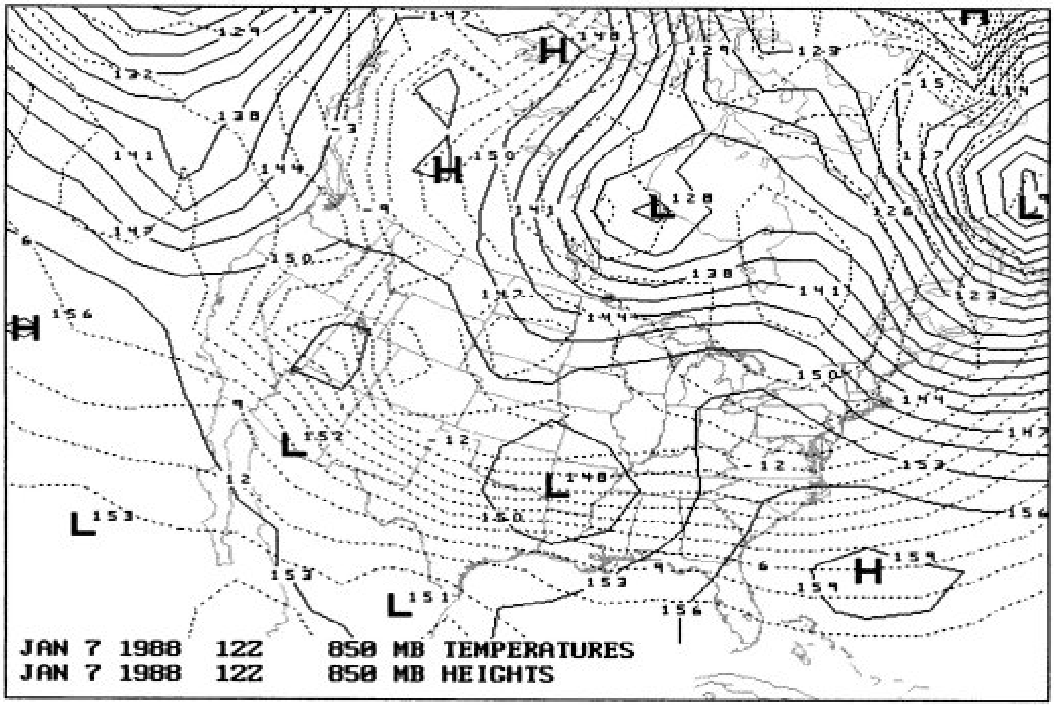

Figure 13. North American 850 mb heights and temperatures at 1200 UTC 7 January 1988.

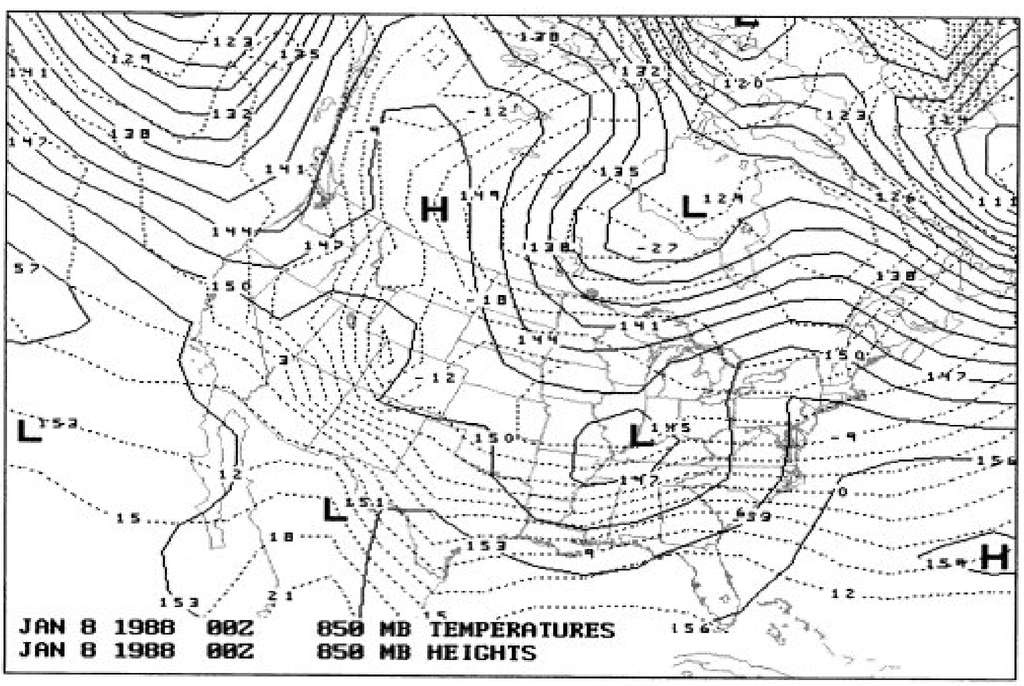

Figure 14. North American 850 mb heights and temperatures at 0000 UTC 8 January 1988.