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A CASE STUDY OF A SEVERE WEATHER EVENT IN THE GREAT BASIN

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Introduction

On 23 September 1992, separate thunderstorms formed over northeast Nevada and southern Idaho. These thunderstorms merged northwest of the Great Salt Lake, quickly became severe, and propagated southeastward toward Salt Lake City (SLC). The merging storms developed into a mesoscale convective system (MCS) and produced dry microburst winds in excess of 70 mph at several locations around northern Utah. For example, the Automated Weather Observing System (AWOS) at Wendover reported numerous wind gusts up to 76 mph between 2334 UTC and 0013 UTC. Lakeside (located on the west shore of the Great Salt Lake) measured a wind gust of 75 mph, and the Salt Lake City International Airport's wind shear network measured 74 mph. Only .02" of rain fell at the SLC Forecast Office. Low-level equivalent potential temperature (Θe) ridge and the associated upstream gradient likely played a key role in the propagation and maintenance of the MCS. This paper will discuss the initial causes of the convection and possible reasons for why it moved southeast and became severe.

Synopsis

The 1200 UTC, 23 September 1992 SLC sounding (Fig. 1a) indicated a convective temperature of 88°F, and a nearly dry adiabatic lapse rate above 740 mb. The temperature-moisture profile resembled an inverted-V with moist air near 530 mb and drier air below. At 0000 UTC, 24 September, the temperature lapse rate was dry adiabatic from the surface to approximately 550 mb (Fig. 1b). During the day, moisture advection above 550 mb amplified the inverted-V profile of the sounding. The temperature at SLC reached 88°F by 1900 UTC, and the subsequent observed maximum was 92°F, which further destabilized the atmosphere.

The surface analysis showed a thermal pressure trough over central Nevada at 1800 UTC (Fig. 2a). The trough moved rapidly eastward, reaching northwest Utah by 2100 UTC (Fig. 2b), and then stalled. A surface low had formed along the thermal trough near SLC by 0000 UTC (Fig. 2c) and a well-defined meso-high was located behind the squall line. At 0300 UTC, the trough had moved into northeast Utah and the meso-high shifted southeast over SLC (Fig. 2d).

At 1700 UTC, enhanced infrared (IR) satellite imagery (Fig. 3) showed a line of convective clouds forming over northeast Nevada and southwest Idaho. This was near an 850 mb moisture flux convergence maximum extending through western Nevada at 1200 UTC (Fig. 4). Chaston (1992) has shown that initial convection associated with a MCS will often form near a surface moisture convergence maximum. Low-level forcing from the surface thermal trough coupled with the 850 mb moisture convergence maximum initiated the convection along the Nevada-Idaho border. Short-wave energy at 700 mb and 500 mb (Figs. 5a and 5b) further enhanced the upward motions initiated by the low-level convergence.

The 2000 UTC water vapor satellite imagery (Fig. 6) showed mid- and upper-level moisture over northeast Nevada and northwest Utah. Through extrapolation, this moisture likely was located above the 700 mb Θ_e ridge and gradient at 0000 UTC (Fig. 7). The 700 mb Θ_e ridge was likely strongly biased by very warm temperatures rather than copious moisture at that level.

According to Campbell (1991), MCSs tend to form in the Θ_e gradient in the presence of moderate to strong upward vertical velocity. In concert with no low-level moisture convergence, divergence at 300 mb indicated that upward vertical velocity over northeast Nevada and northwest Utah was present through a deep layer (Fig. 8). It cannot be proven whether this divergence was a product of the storm's outflow or was a contributing factor of the long-lived upward motion. At 2300 UTC, enhanced IR satellite imagery (Fig. 9a) showed the MCS over northwest Utah and southeast Idaho, and by 0030 UTC (Fig. 9b), the MCS extended from southwest of the Great Salt Lake to northwest Wyoming.

The movement of the individual cells differed significantly from that of the MCS. The mean wind in the 700-300 mb layer at 0000 UTC 24 September near SLC was from 227° at 31 knots. Salt Lake City radar indicated average cell movements within the MCS from 245° at 20 knots, corresponding well to the 700-300 mb thickness pattern (Fig. 10) and the thermal wind. This cell movement was also 18° to the right of the mean wind. The Salt Lake City radar operator determined movement of the MCS to be from 310° at 20 knots, 65° to the right of the mean wind, and nearly perpendicular to the thickness pattern. Low-level winds in northwest Utah during the morning of 23 September veered strongly with height indicating strong warm advection (refer to Fig. 1a). During the afternoon, the wind profile changed substantially (refer to Fig. 1b) but the MCS still moved toward the low-level inflow. The MCS likely propagated toward the higher Θ_e values and greater instability in order to sustain itself.

Conclusions

A surface thermal trough was located in an area of low-level moisture convergence over northeast Nevada and northwest Utah on the morning of 23 September 1992. A 700 mb Θ_e ridge and strong upstream gradient, strongly influenced by surface heating, were located over the same area. Convection was initiated by low-level forcing via convergence into the thermal trough, with additional low-level instability provided by surface moisture convergence. Synoptic-scale support for the vertical motion was sustained by short-wave energy between 700 and 500 mb. Because of the lack of data at 300 mb at 1200 UTC, it is not certain whether the divergence in the afternoon was a factor contributing to the long-lived MCS, or if it was caused by the storm's outflow. Salt Lake City radar reported aircraft observed tops to 40,000 feet within the system. The MCS which developed likely propagated southeast toward the Θ_e ridge and greater instability.

In the Great Basin, surface moisture is usually inadequate for severe convection. However, the surface moisture flux convergence and 700 mb Θ_e fields on 23 September 1992 proved useful in forecasting the initial development of convection and the propagation of a severe weather producing MCS. The 700 mb Θ_e ridge becomes a semi-permanent feature in the high desert in summer, because of strong surface heating. With the addition of surface moisture convergence and upper-level dynamics, it may be possible to anticipate potential severe weather producing convective storms.

References

Chaston, Peter, 1992: Equivalent Potential Temperature (Training guide), National Weather Service Training Center, Kansas City, Mo.

Campbell, Mike, 1992: Equivalent Potential Temperature (theta-e) Applications, Western Region Technical Attachment No. 91-37.

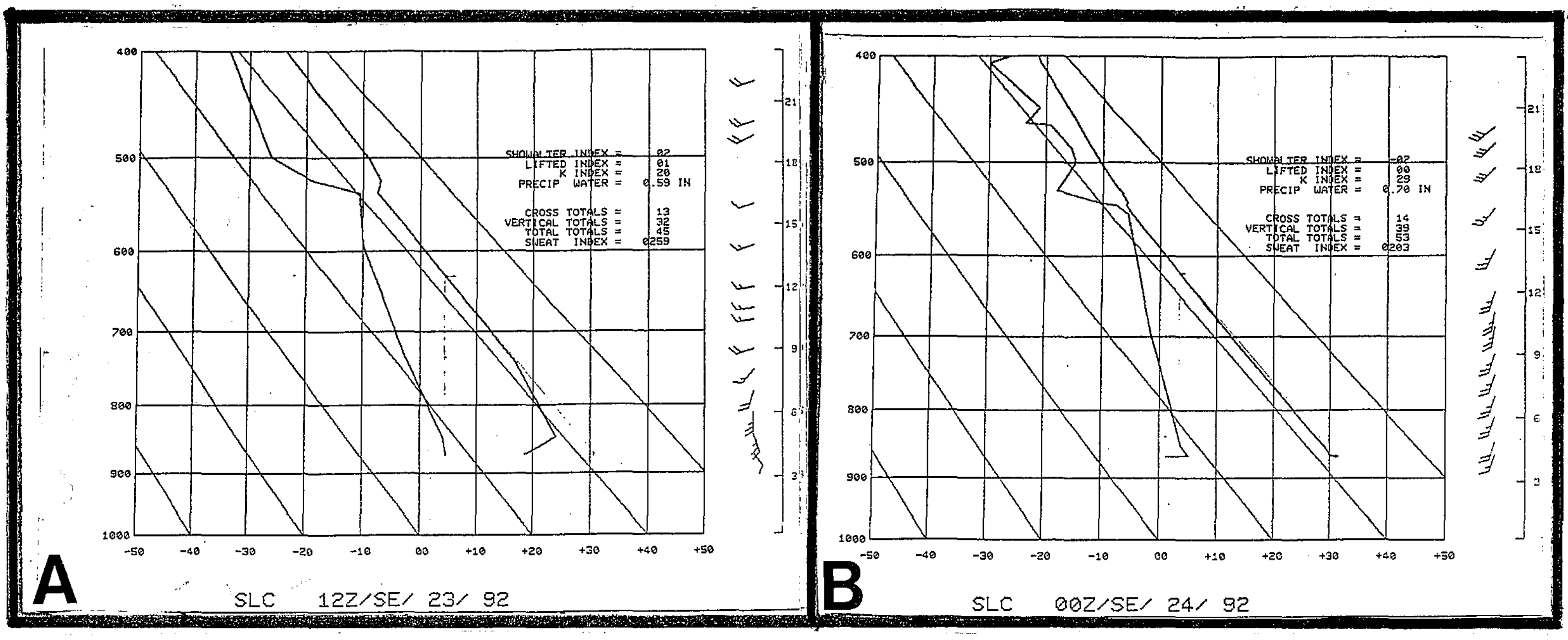


Figure 1. (a) Upper air sounding for Salt Lake City, UT (SLC) at 1200 UTC 23 September 1992 (b) Same as (a) except at 0000 UTC 24 September 1992.

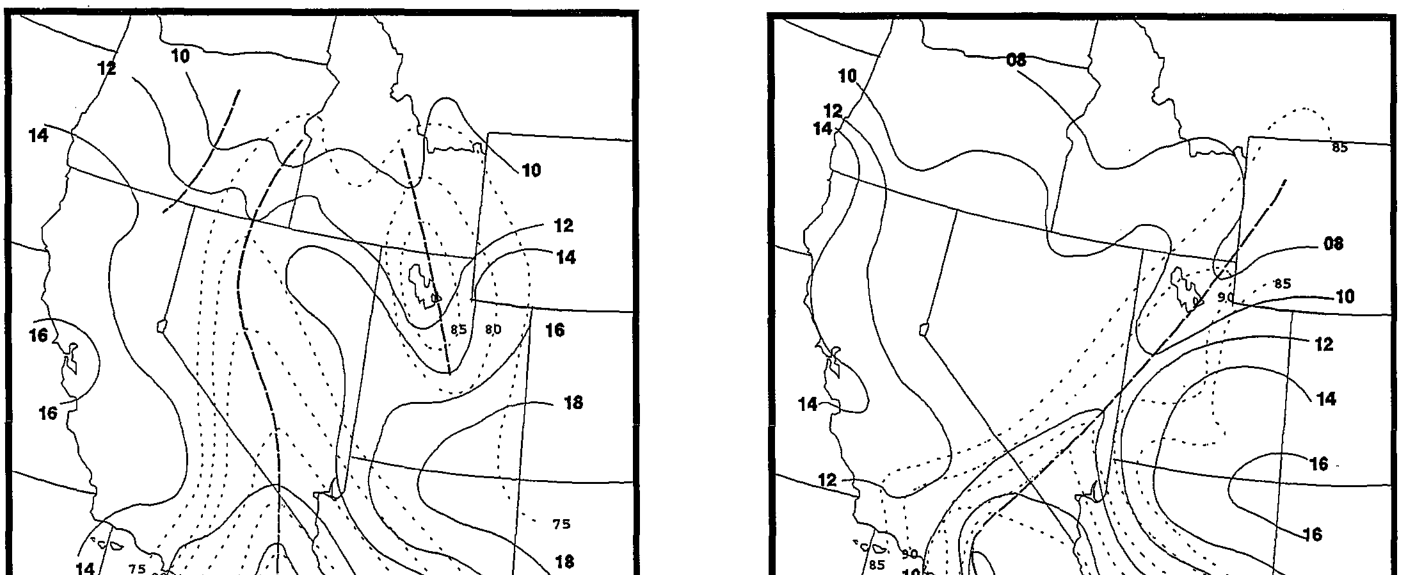
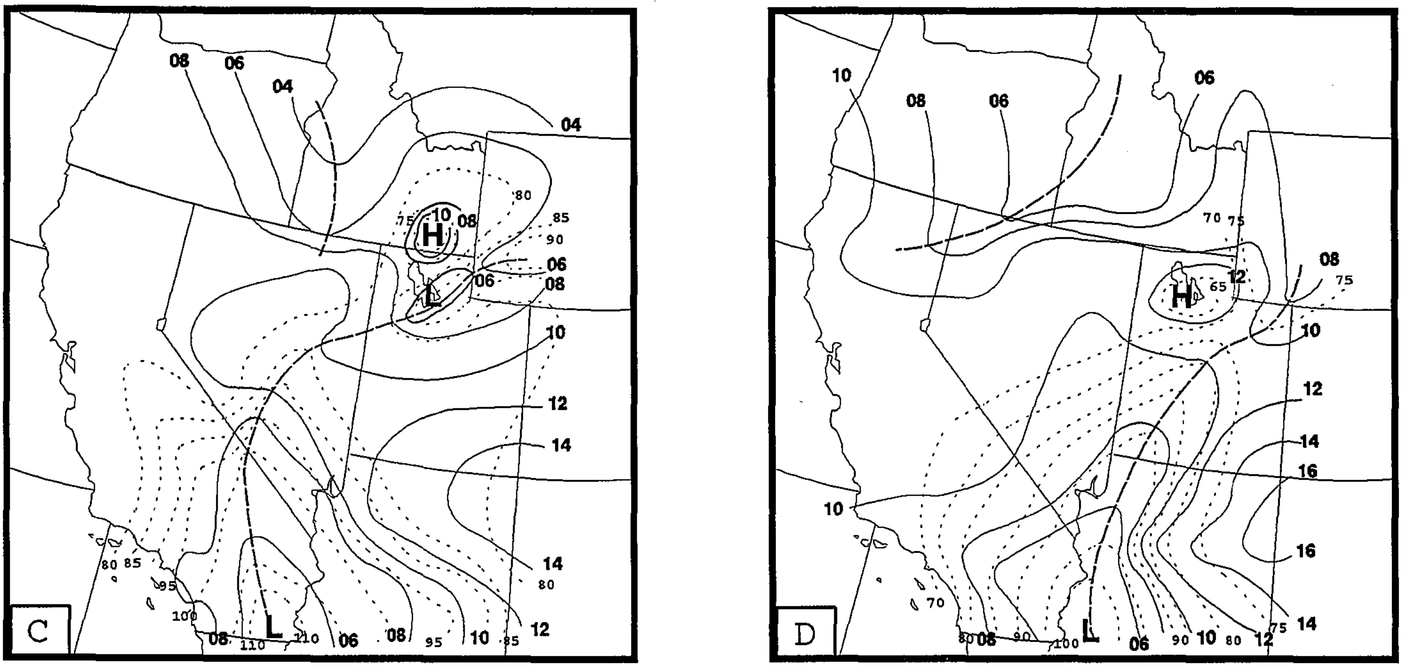


Figure 2. (**a**) Surface Analysis at 1800 UTC 23 September 1992 (isobars-solid lines, isotherms-dashed lines) (**b**) Same as (a) except at 2100 UTC (**c**) Same as (a) except at 0000 UTC 24 September 1992 (**d**) Same as (c) except at 0300 UTC.



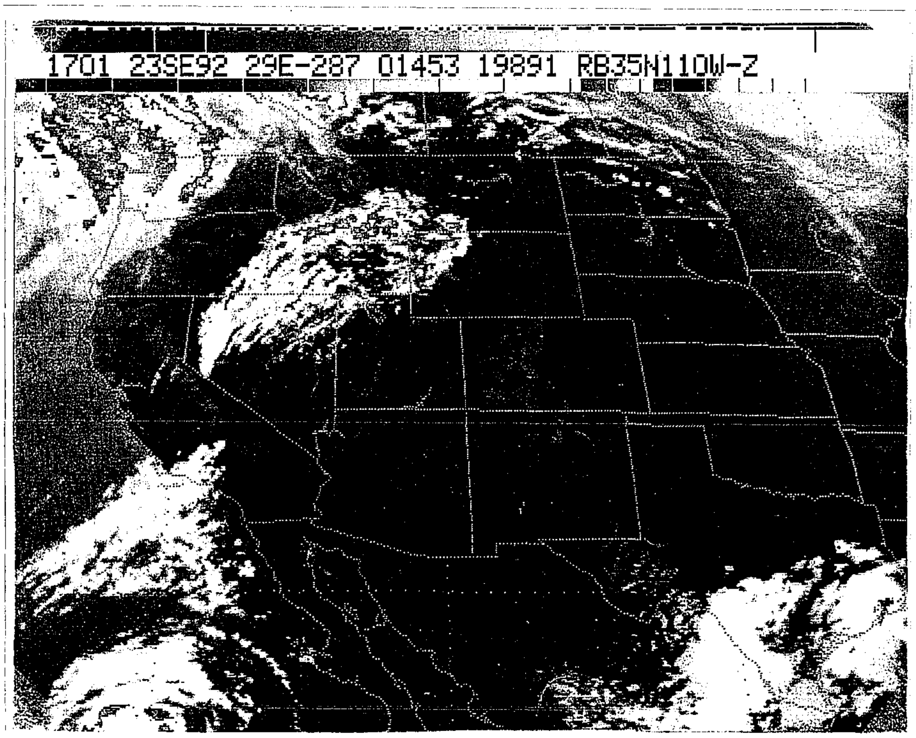


Figure 3. Enhanced infrared satelitte image at 1701 UTC 23 September 1992.

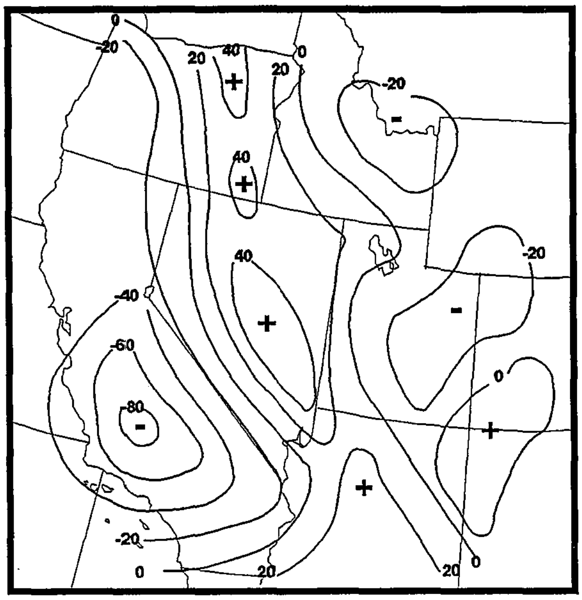


Figure 4. 850 mb moisture flux convergence at 1200 UTC 23 September 1992 (every 20 g/kg/hr*10).

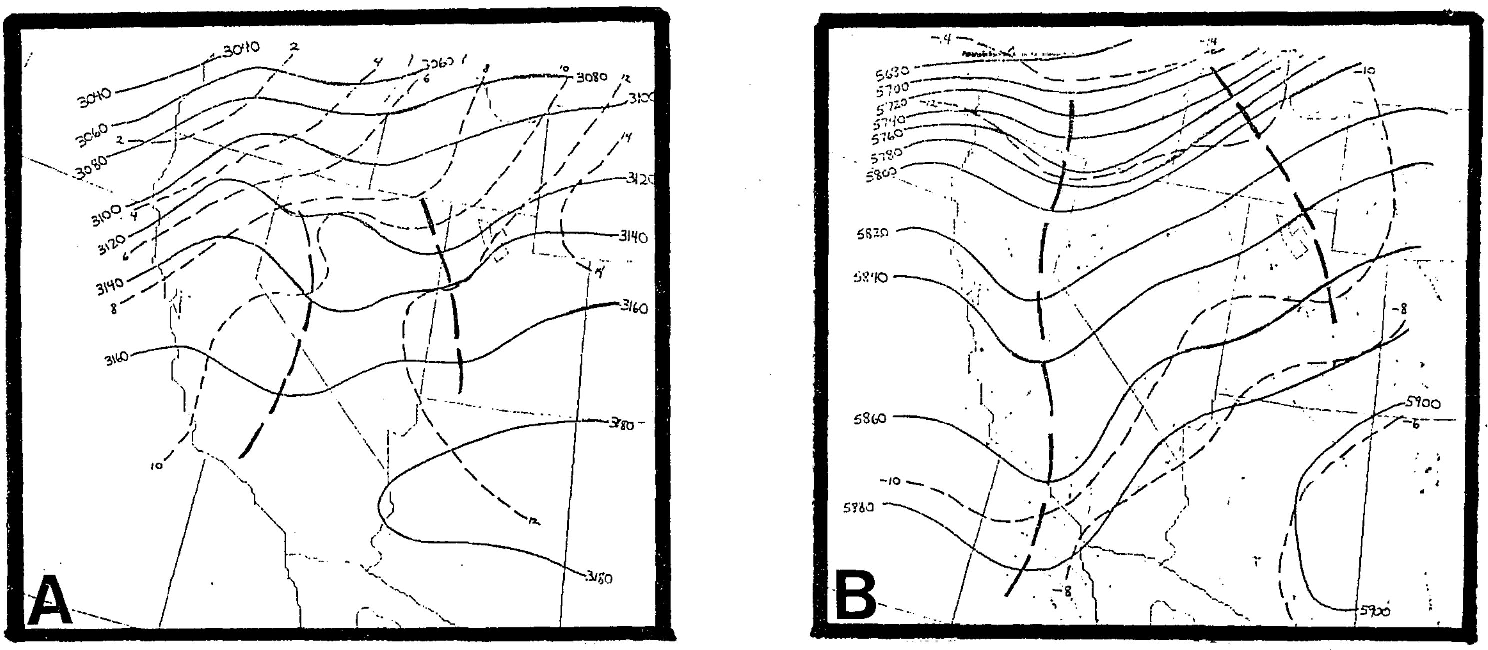


Figure 5. (**a**) 700 mb isohypses (solid, every 20m), isotherms (dashed, every 2°C), and shortwave trough axes (long dashed) at 0000 UTC 24 September 1992 (**b**) Same as (a) except for 500 mb.

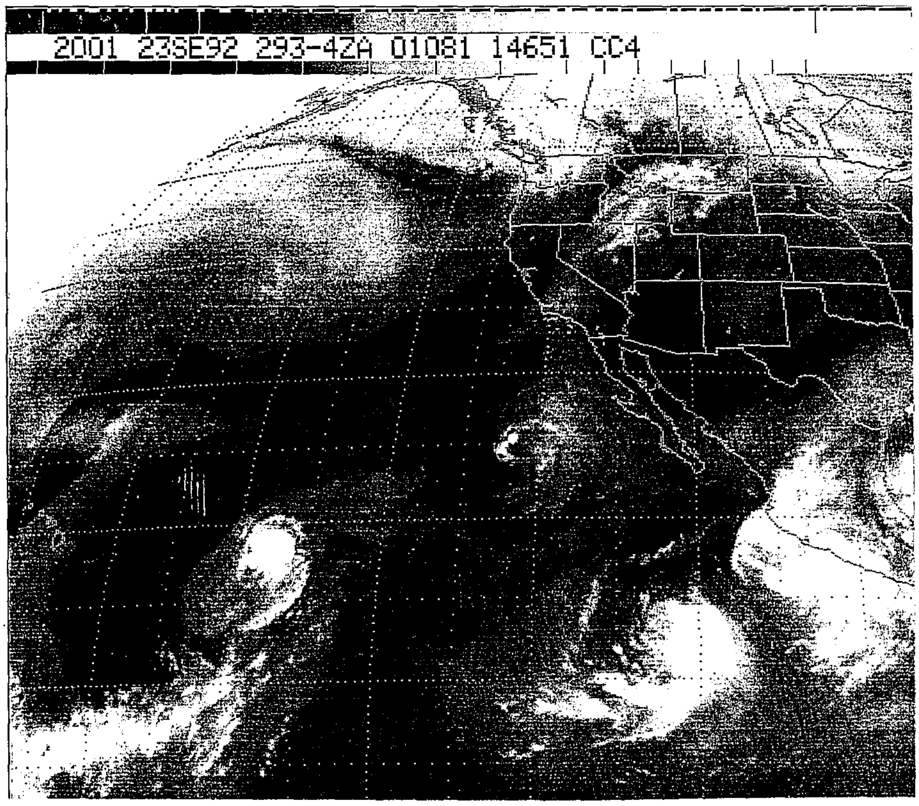


Figure 6. Water vapor satelitte image (6.7μm) at 2001 UTC 23 September 1992.

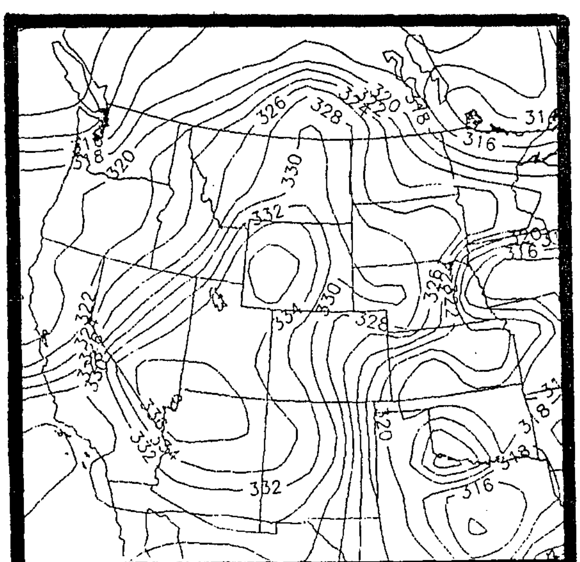


Figure 7. 700 mb equivalent potential (every 2K) temperature at 0000 UTC 24 September 1992.

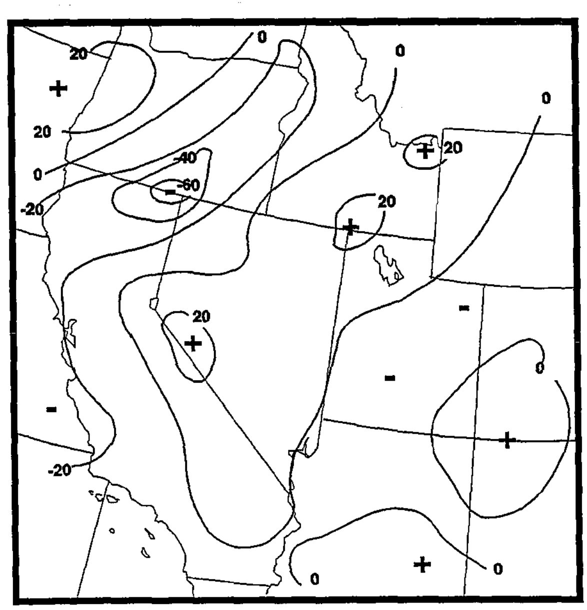


Figure 8. 300 mb divergence (every (every 10**-5/s) at 0000 UTC 24 September 1992.

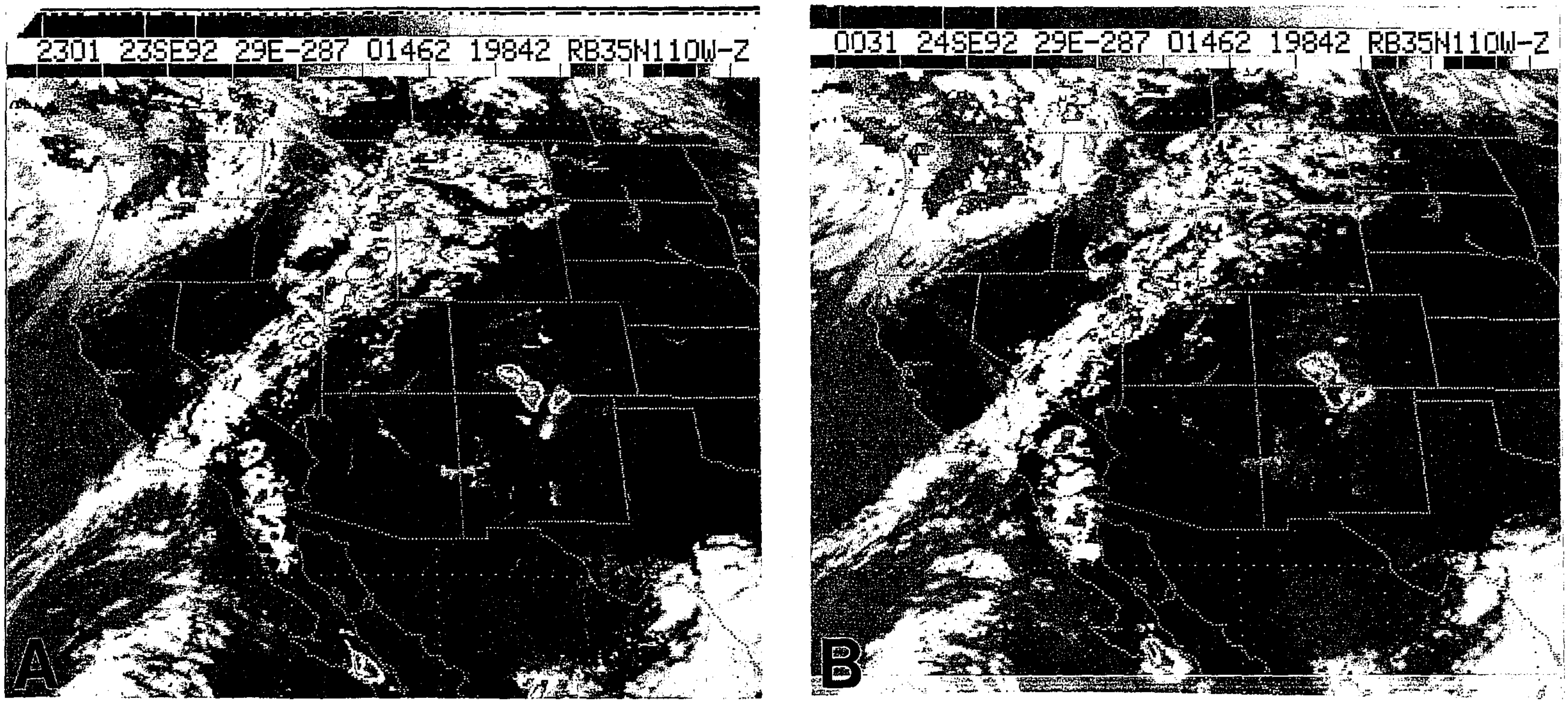


Figure 9. (**a**) Enhanced infrared satelitte image at 2301 UTC 23 September 1992 (**b**) Same as (a) except at 0031 UTC 24 September 1992.

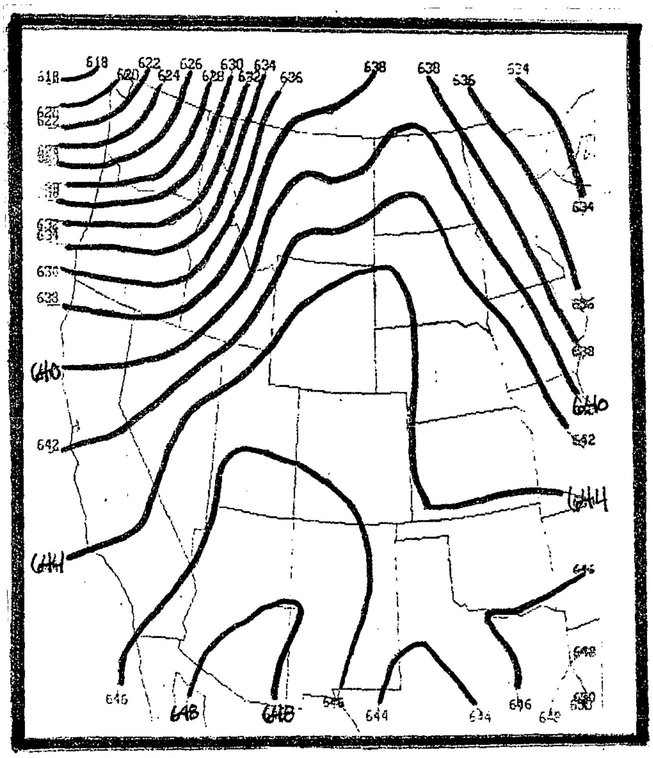


Figure 10. 300-700 mb thickness (every 20 dm) at 0000 UTC 24 September 1992.