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THUNDERSTORM "HOT FLASHES"

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Thunderstorm outflow is characterized by cool moist air and gusty, frequently violent winds right? Wrong! On occasion, thunderstorm downdrafts (downbursts, microbursts) produce dramatic surface warming along with a large drop in relative humidity, and strong, gusty surface winds. Although such a "hot flash" or "heat burst" is a rare enough event that it is seldom seen on SAO roundups, reports of such events from other observers surface several times a year.

For instance, in April of this year Crescent City, California experienced a 25°F temperature rise in about 10 minutes during the late evening as a weak thunderstorm passed near the station.

Shortly after 7:00 a.m. CDT, July 7, 1987, the temperature at Greensburg, Kansas (about 45 miles east-southeast of Dodge City) rapidly rose from 75°F to 95°F. By 8:00 a.m. the temperature had fallen back to 86°F and was holding steady. Along with this sudden jump in temperature "dust devils and other strange cloud formations were observed". The Dodge City temperature at 7:00 and 8:00 a.m. was 76 and 79°F.

The Dodge City SAO's for July 7 showed scattered clouds at 7,000 ft with a higher broken deck at 25,000 ft. Considering the elevation of Dodge City, the cumulonimbus clouds would be based around 700 mb with the higher clouds near 350 mb.

The 12Z Dodge City sounding (Fig. 1) shows a 100 mb thick surface-based inversion layer. Above the top of this layer (about 820 mb) is a deep layer of conditional instability where the potential temperature only increases about 4°C in 330 mb. The moisture trace indicates the sonde encountered clouds near 500 mb and again around 350 mb. The balloon did not sample the lower portions of the CB (levels between 700 mb and 500 mb).

While the general structure of the Dodge City sounding is similar to that associated with other hot flashes (Johnson, 1983) and with dry microbursts (Wakimoto, 1985), the imminent occurrence of a heat burst is not obvious. Note that if a parcel were to descend from the top of the inversion, it would arrive at the surface with a temperature of 95°F (the same as that reported at Greensburg during the hot flash). The question is, what would cause such a downdraft?

In an early heat burst study, Williams (1963) postulated that the downdraft was initiated by evaporative cooling of relatively dry mid-level air as precipitation from the anvil passed through it. After cooling, this air is negatively buoyant and is accelerated downward. Because of the nearly adiabatic structure of the environment, significant momentum is generated in the downdraft before the parcels became positively buoyant at lower levels. This built up momentum causes the parcels to overshoot their equilibrium level and arrive at the surface warmer and drier than their surroundings. Fig. 2 is Williams' schematic of this process.

The sounding can be used to evaluate whether this hypothesis is reasonable. We know that during their descent, temperatures of the hot flash parcels changed according to the adiabat labeled 95 in Fig. 3. Also, thermodynamics tells us that evaporation will cool air to its wet bulb temperature. Thus, for evaporative cooling to be a possible causal mechanism of this downdraft, there must be at least one level where the environmental wet bulb temperature is the same as the temperature of the downdraft adiabat. This occurred at about 505 mb (dotted level on Fig. 3). This level is immediately below a cloud deck. As a check, we analyzed this sounding on a skew T-log P diagram, and found that the negative area between 505 mb and the equilibrium level at 818 mb is larger than the positive area below 818 mb. Thus, a parcel originating at 505 mb would descend all the way to the surface and Williams' mechanism can explain the Greensburg hot flash.

Meteorologically, hot flashes are rather insignificant. Because of its new-found buoyancy, once the hot air reaches the surface it is readily ingested into the updraft. However, since there is no moisture in this air to provide latent heat release, it soon kills the storm (Fig. 4).

However, hot flashes can be quite spectacular. The July 1909 Monthly Weather Review reported that:

> "Between one and three o'clock on the morning of July 11, a strange phenomenon occurred in Cherokee, Okla., and vicinity. The thermometers recorded a rise in temperature to 136°. The effect of the hot winds on vegetation indicated that the center of greatest heat was a few miles south of Cherokee."

This is 2° warmer than the highest temperature ever officially measured in the United States and within 1/2°F of the world's extreme.

References

Johnson, B.C., 1983: The Heat Burst of 29 May 1976, Mon. Wea. Rev., 111, 1776-1792.

Wakimoto, R.M., 1985: Forecasting Dry Microburst Activity Over the High Plains, Mon. Wea. Rev., 113, 1131-1143.

Williams, D.T., 1963: The Thunderstorm Wake of May 4, 1981. National Severe Storms Project Tech. Memo. #18, 23 pp.

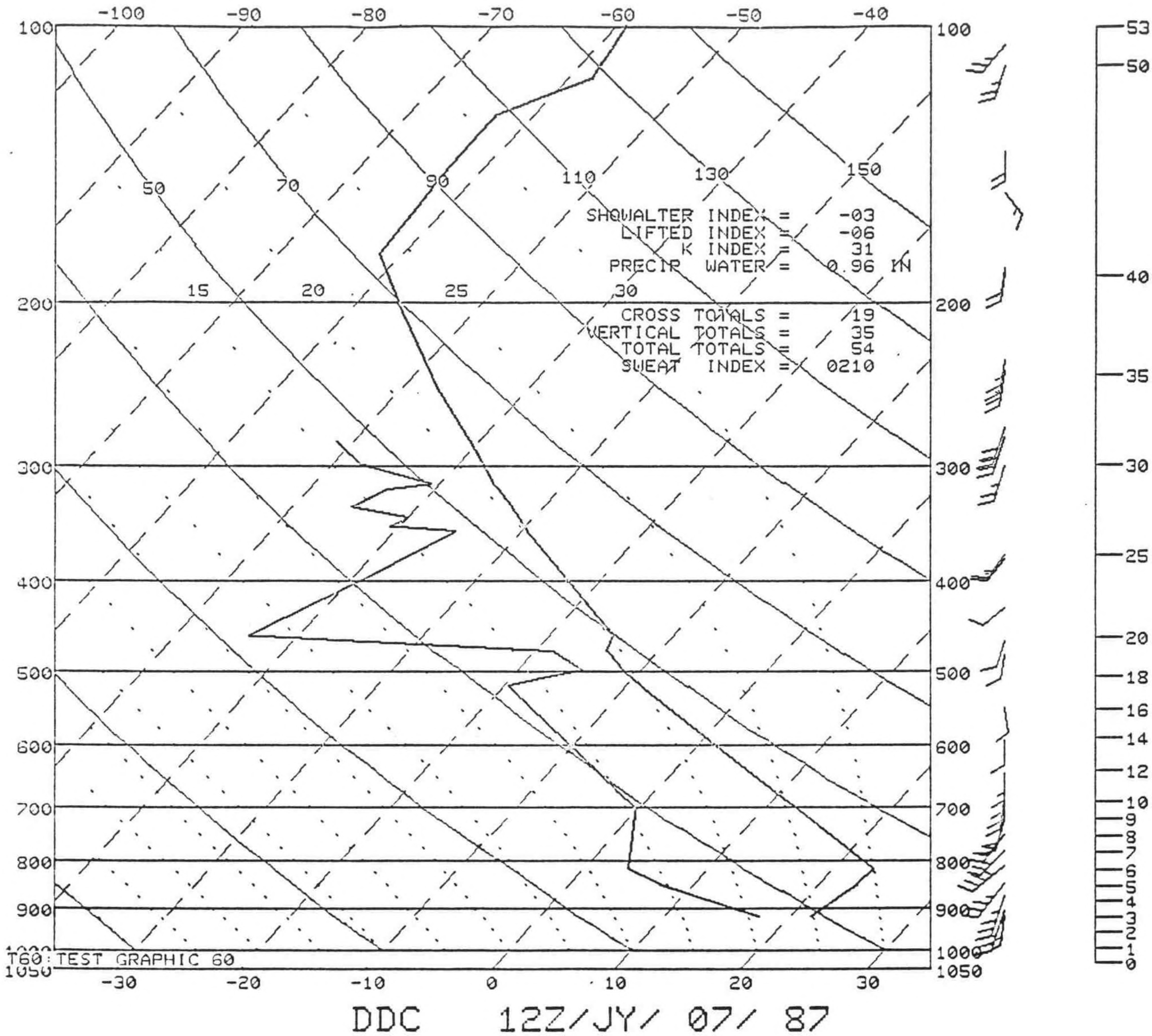


Fig. 1. 12Z July 7, 1987 Dodge City sounding.

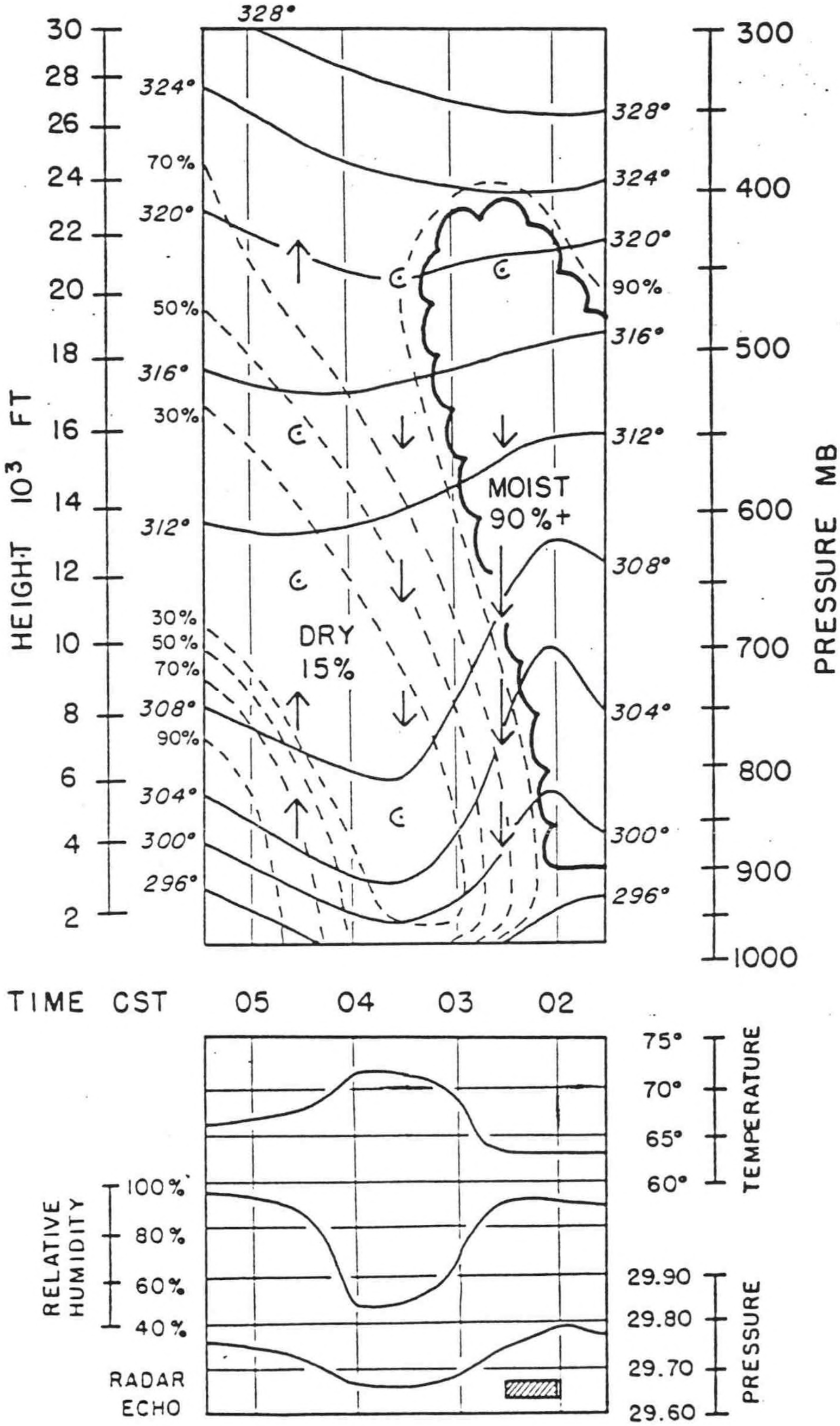


Fig. 2. Composite vertical time section of the thunderstorm hot flash. Isentropes at $4^{O}K$ intervals are shown as solid lines, and isopleths of relative humidity at 20 percent intervals are shown as dashed lines. The probable outline of the visible thunderstorm is indicated within the region in which relative humidity exceeds 90 percent.

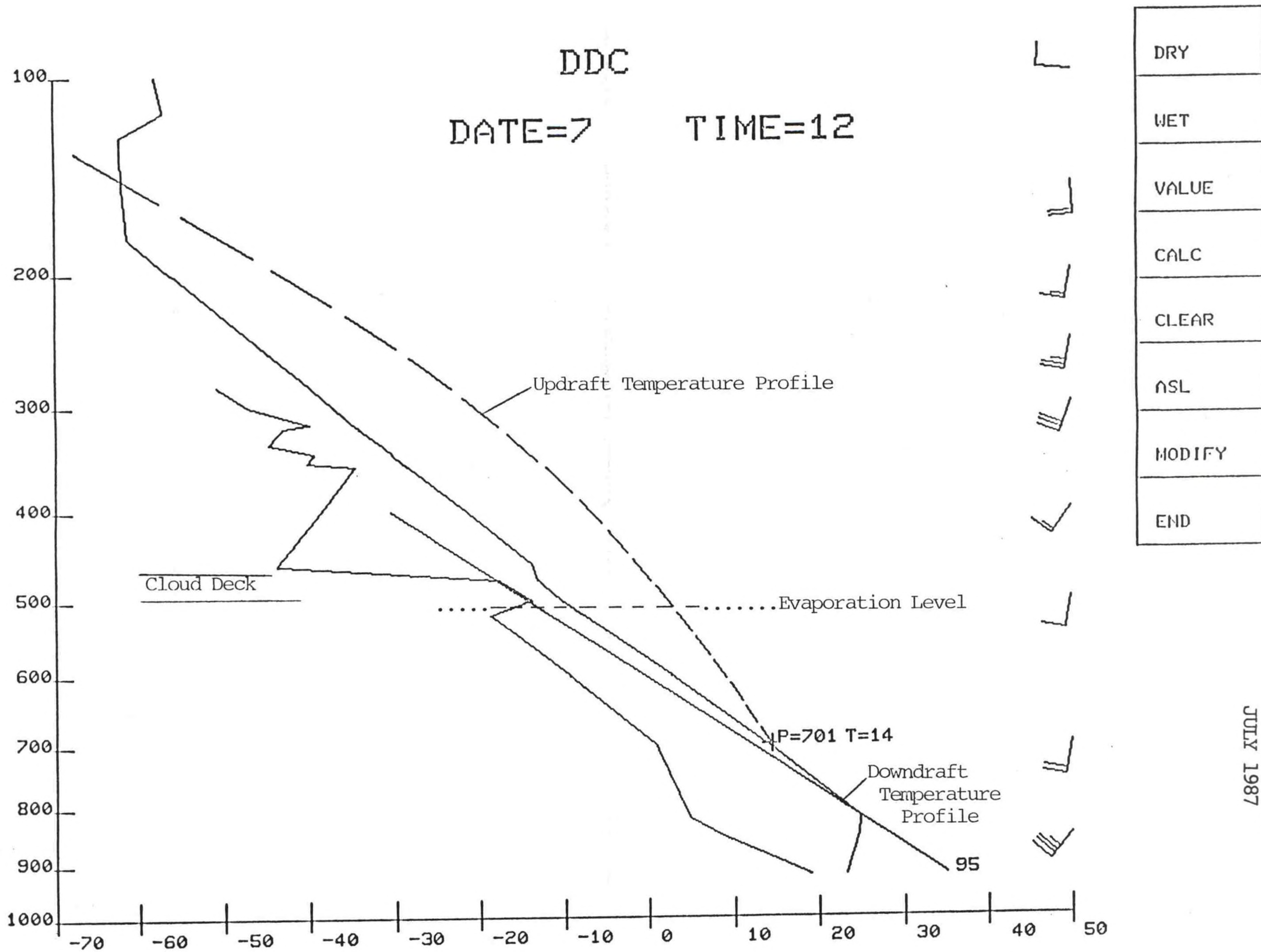
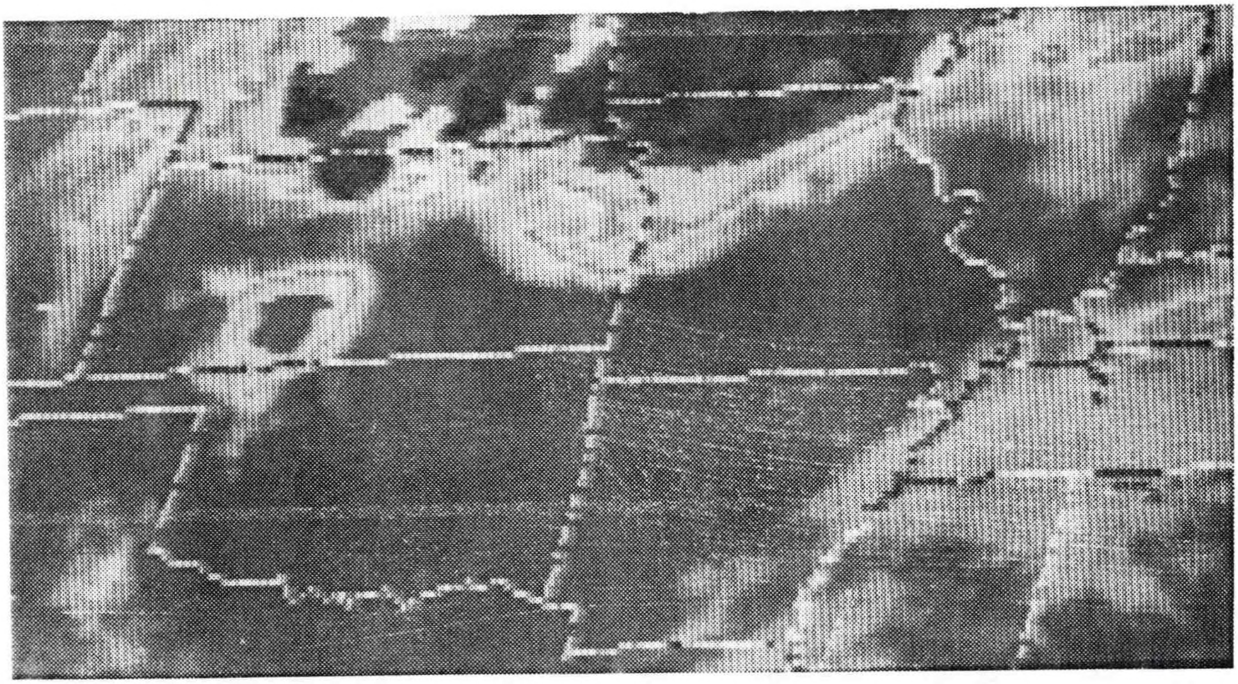


Fig. 3. Work-up of Dodge City sounding 12Z Jul[illegible], 1987.



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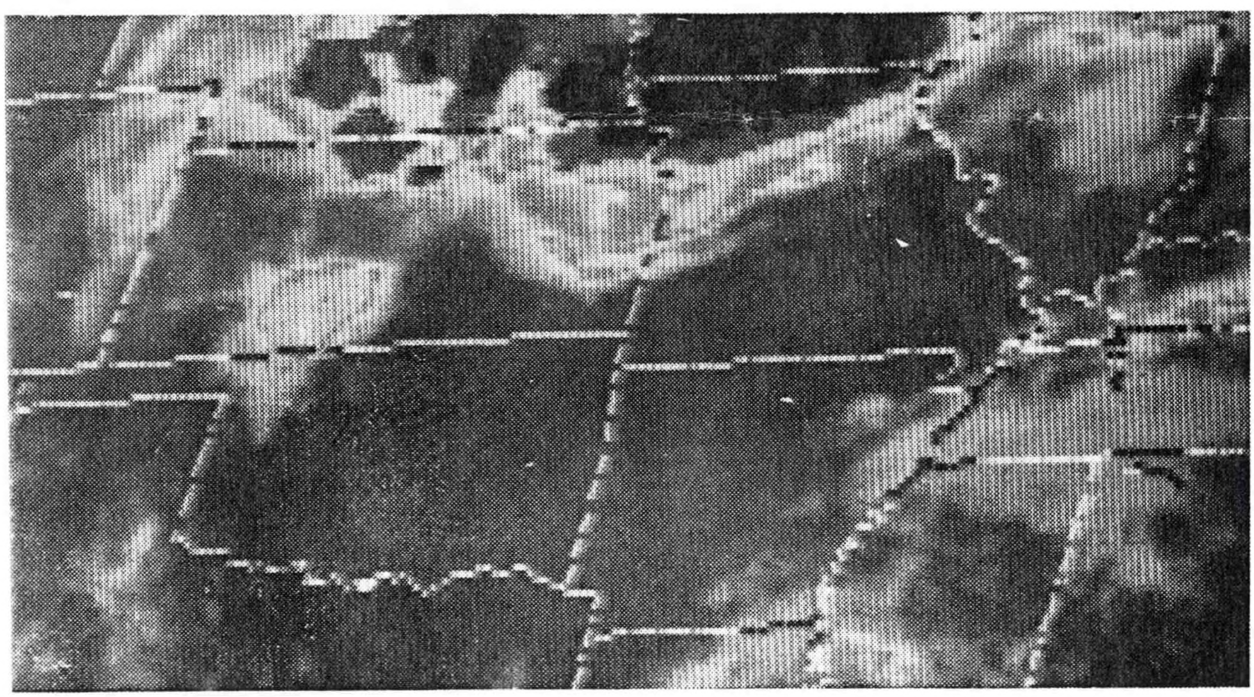

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Fig. 4. Satellite imagery (MB curve) of downburst storm: (a) 1231Z - about the time of hot flash. The west center portion of the Kansas storm is near Greensburg. (b) 1301Z - Note how cold top has completely disappeared.