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CENTRAL REGION TECHNICAL ATTACHMENT 88-20

# A CASE OF EVAPORATIONAL COOLING

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## 1. Introduction

Falling temperatures during the mid-afternoon are not uncommon. Such events are usually associated with a strong cold frontal passage or the occurrence of thunderstorm outflow. A less recognized cause is evaporational cooling. On Saturday, March 5, 1988, the onset of wet snow during the early afternoon at Topeka, Kansas, resulted in five degrees of cooling in less than two hours. Examination of this case suggests that the cause of the temperature drop was evaporational cooling.

## 2. The Physical Process

Penn (1957) discusses evaporational cooling in the context of rain-snow determination. He describes it as one of several non-adiabatic effects on local temperature change, and a means for changing rain to snow. Evaporational cooling takes place when precipitation falls through an unsaturated layer of air between the cloud and ground. The falling precipitation partially evaporates into the unsaturated air. The change of phase requires that latent heat be added to the water during evaporation. This energy is extracted from the surrounding air, cooling it. At the same time the amount of water vapor in the air is increasing due to the evaporation. The net result is cooling of the air to saturation at the wet bulb temperature of the original unsaturated air. The evaporational cooling continues as long as the air remains unsaturated. Once the air approaches saturation, the evaporational cooling effect ceases.

## 3. The Event

Figure 1 shows the hourly temperature (T), wet bulb temperature ($T_W$), and dew point temperature ($T_D$) values represented as a continuous trace. Normal diurnal warming is seen during the morning and early afternoon, despite the overcast skies at 6500 to 7000 feet. The warmest hourly temperature was recorded at 1400 CST.

At 1429 CST light snow began to fall, reducing visibility to the one to two miles range. The evaporational cooling effect is very evident between 1400 and 1600 CST. The temperature fell five degrees during the two hour period, and the dew point temperature, which had been falling prior to 1400, rose dramatically.

By 1600 CST the temperature and dew point temperature had steadied off one degree either side of the wet bulb temperature. Note that the wet bulb temperature was rather steady after 1200 CST. The changes between 1400 and 1600 CST very nicely illustrate the evaporational cooling effect.

4. Other Factors

A review of the synoptic situation on March 5th showed a strong ridge of high pressure extending from Kansas eastward to the Ohio Valley. Weak lee side troughing was present along the eastern slopes of the Rockies. The snow that fell in Topeka was associated with a sharp upper tropospheric trough that moved across Kansas during the day. These charts indicated that the cooling was not frontal in nature.

Figure 2 shows the morning temperature-dew point temperature profile at Topeka. The relatively dry below-cloud air is evident in the sounding. By 0000 UTC that evening, the snowfall had nearly saturated the lower troposphere (Figure 3).

All evidence supports the contention that the cooling which occurred at Topeka on the afternoon of March 5, 1988, was caused by evaporation cooling.

5. Acknowledgements

Special thanks to Tim Seeley and Dana Watkins for calculation of the wet bulb temperatures for March 5th.

6. Reference

Penn, S., 1957: The Prediction of Snow vs. Rain. Forecasting Guide No. 2, U.S. Weather Bureau, 29 pp.

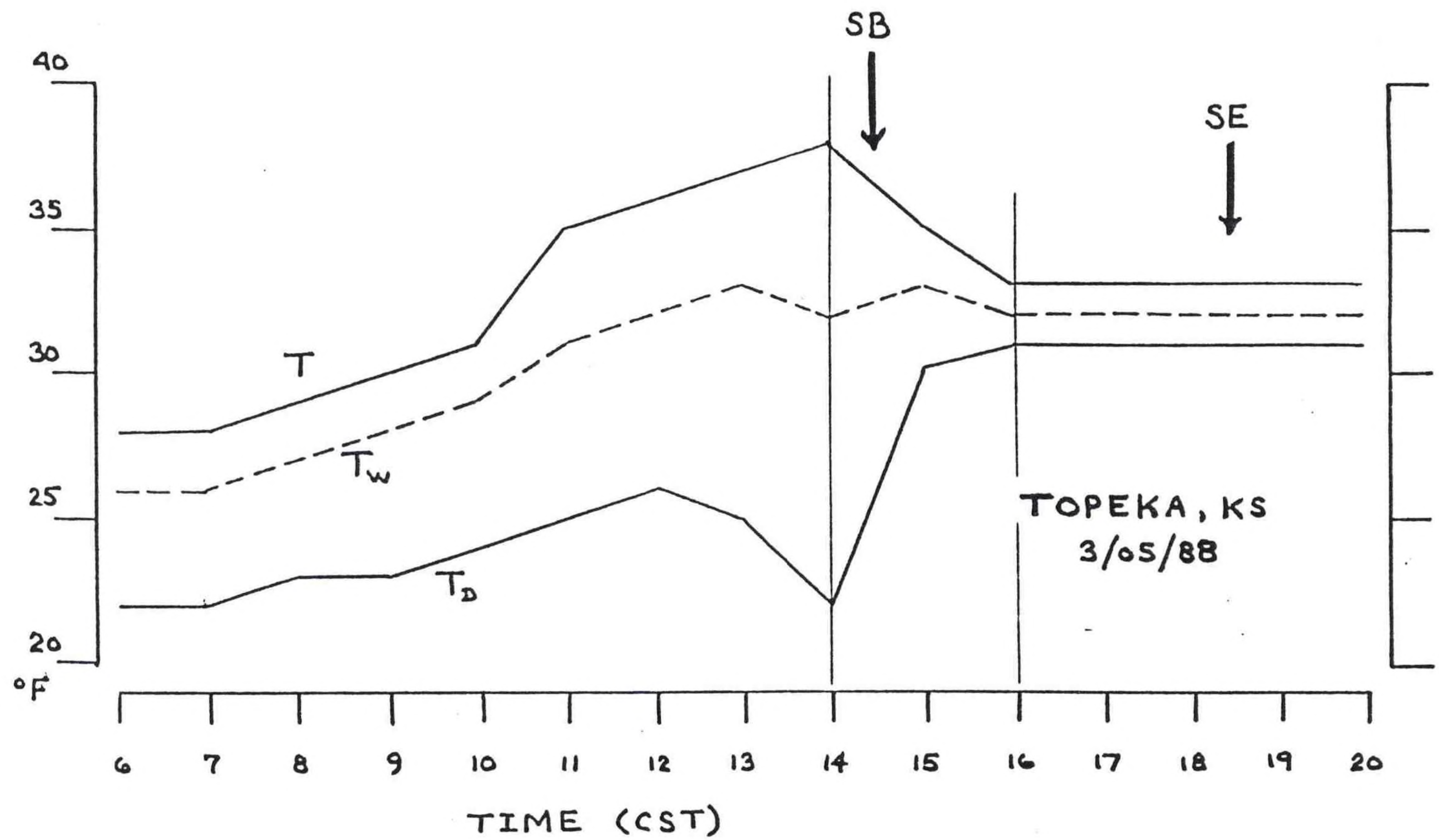


Figure 1. The hourly temperature (T), wet bulb temperature ($T_W$), and dew point temperature ($T_D$) values plotted as a continuous trace for Topeka, Kansas, on March 5, 1988.

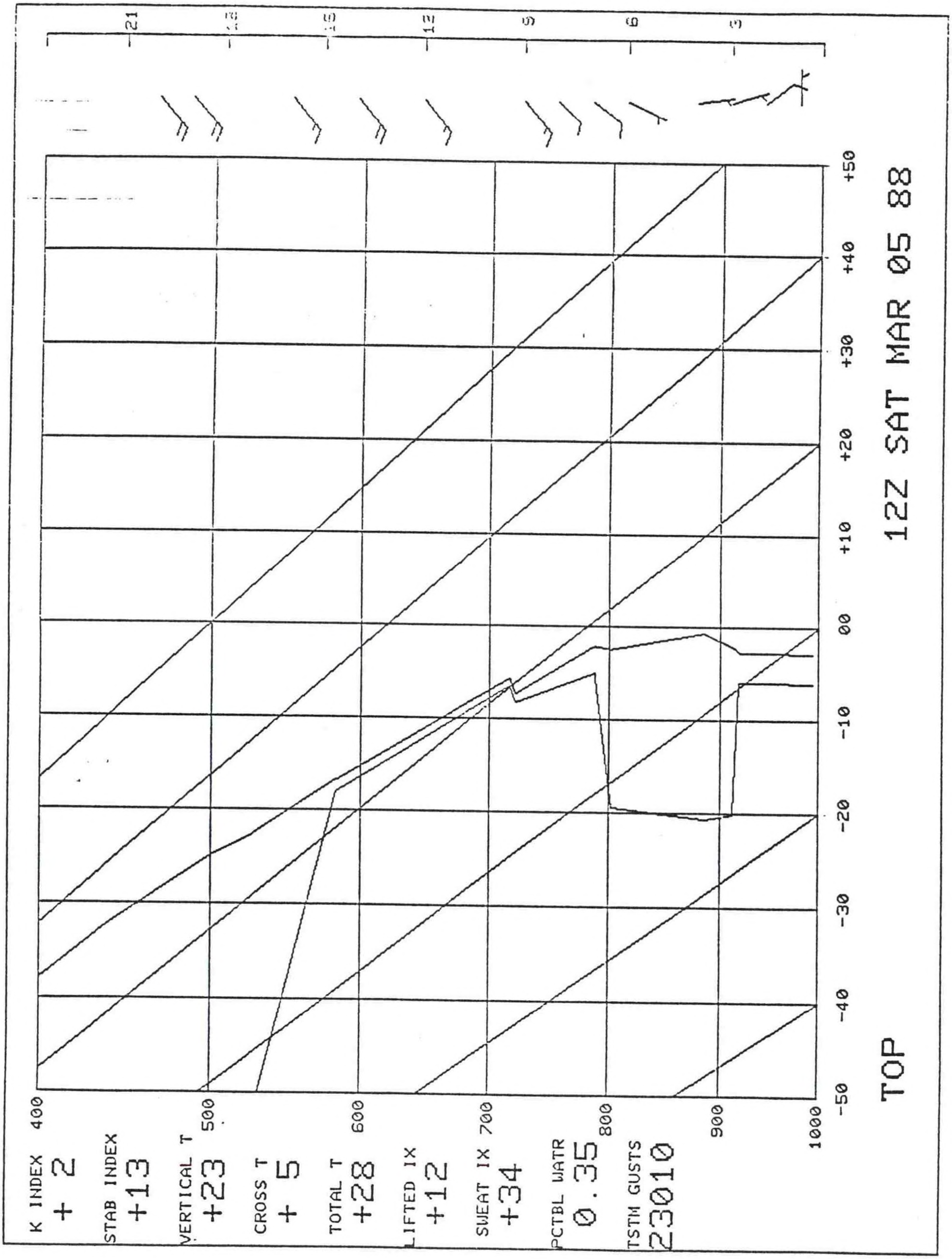


Figure 2. The AFOS RAOB plot for Topeka, Kansas, at 1200 UTC on March 5, 1988.

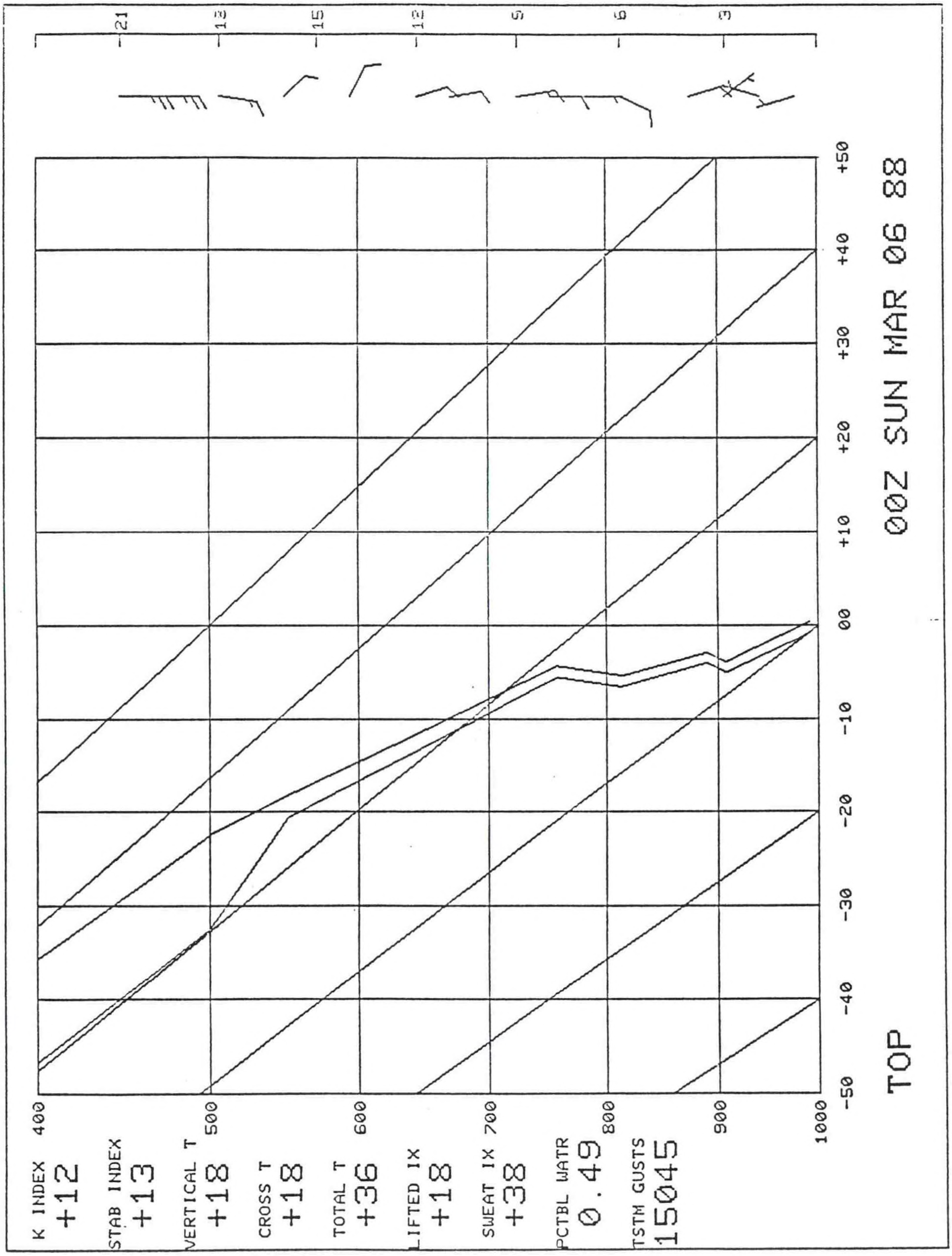


Figure 3. The AFOS RAOB plot for Topeka, Kansas, at 0000 UTC on March 6, 1988.