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AN EXAMPLE OF EVAPORATIVE COOLING PRODUCING RELATIVELY LOW SNOW LEVELS IN THE NORTHERN SACRAMENTO VALLEY

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Introduction

On January 18, 1996, a surprise snowstorm dumped five to seven inches of snow around the Redding, California area, and as much as nine inches at Shasta Dam, north of the Redding area. This snow event at relatively low elevations was caused by the evaporative cooling process.

Discussion

During the day on January 18, 1996, a strong Pacific storm system brought rain, snow, and strong winds to northern California. Snow levels were initially forecast to range from three to four thousand feet across northern California, and lower to one thousand feet by nightfall. Strong southerly winds from 17 to 35 knots were also forecast for the northern Sacramento Valley. A Winter Storm Warning was in effect for the northern mountains and a Wind Advisory was in effect for the Sacramento Valley during the day.

Nature was indifferent to this reasonable forecast as rain turned to snow at the Redding, CA (RDD) airport (elevation 502 feet) at 1621Z and began to accumulate significantly by 1700Z. The changeover to snow this early in the day was a complete surprise, especially since snow levels were not forecast to lower to one thousand feet until nightfall.

A sequence of Redding surface observations (Table 1) shows surface temperatures were at least 40 degrees Fahrenheit when the precipitation began in the form of rain, and dewpoint temperatures were generally in the upper 30s. The air mass certainly appeared warm and moist enough in the lower layers to sustain the precipitation in liquid form. What was particularly noteworthy at this time was the light northwest winds that occurred during the morning. This was in spite of an advancing low pressure system west of the Oregon coast which had prompted the issuance of a Wind Advisory for south winds 17 to 35 knots over the Northern Sacramento Valley.

The morning sounding from Medford, OR (MFR) was likely quite representative of the air mass over Redding in the lower layers of the atmosphere (Fig. 1). In the layer from the surface to about 850 mb, the temperature profile was above freezing. Using this information alone, one would certainly expect the precipitation to remain in liquid form.

In attempting to diagnose the melting level of snow, however, one cannot simply use the mean temperature in the boundary layer. A closer examination of the Medford 1200Z sounding shows relatively dry air extending from just above the surface to about 800 mb. Evidence of this dry air could be seen in the Redding and Red Bluff surface observations from the previous afternoon. North winds of 10 to 15 knots, which are downslope in this region, effectively mixed the low-level air producing subsidence drying and warming. Dewpoint temperatures dropped to as low as 24 degrees Fahrenheit at Redding and 25 degrees Fahrenheit at Red Bluff. Overnight, what little moisture remained in the low levels became trapped in a very shallow surface layer below the radiative inversion and dewpoint temperatures rebounded into the mid-30s. Further south in the Sacramento Valley, deeper surface moisture and weaker subsidence kept this air from mixing to the surface as dew points remained in the 30s. Thus, by only looking at surface observations, it appeared that when the rain began, it was falling into a boundary layer that was not only well above freezing, but was quite moist as well. Therefore, the precipitation should have continued in the form of rain.

However, as precipitation fell into this layer of drier air, some evaporated, causing the temperature to decrease as heat was removed from the parcel of air (Bluestein, 1993). Thus, as this process continued, the temperature profile caused by the evaporative cooling process began to resemble the wet-bulb temperature of an initially saturated parcel falling into the dry low-level air seen on the 1200Z January 18, 1996 Medford sounding.

Figure 2 is the 1200Z Medford sounding modified for 1200Z surface temperature and dewpoint temperatures (42 degrees and 39 degrees Fahrenheit, respectively) for the Redding area. The wet-bulb temperature from the modified sounding, using the SHARP Workstation, illustrates a wet-bulb temperature profile that was significantly cooler than the temperature profile and was below 0 degrees Celsius above approximately 900 mb. Specifically for the Redding area, it took a little over six hours for the evaporation of precipitation to cool the temperature profile beginning from the top of the dry layer and effectively lowering the melting level to near the surface. At 1621Z, light snow was observed at RDD, as a sufficient depth of air above the valley had been cooled to below freezing and the height of the wet-bulb zero lowered to near the surface (Fig. 3). This process also rapidly lowered the ceilings at the Redding Airport to IFR (Instrument Flight Rules) conditions.

Due to the cooler and denser air now at the surface, a meso-high pressure cell over the Redding area developed (Fig. 4). Beneath the meso-high, winds were light northwest to north, while just 18 nautical miles south, Red Bluff (RBL) reported moderately strong south winds sustained at 15 to 20 knots between 1800Z and 1900Z. This suggested a

mesoscale frontal boundary was also present just south of the Redding area. The cooler and denser air over Redding forced the warmer and more moist air that was moving north, up the valley, aloft and enhanced the upward vertical motion. This mesoscale phenomenon increased the snowfall over Redding and the rainfall around Red Bluff. From 1800Z to 1900Z moderate to heavy snow occurred at Redding and from 1738Z to 1900Z several periods of moderate to heavy rain (R+) occurred at Red Bluff.

The development of this meso-high over the Redding area affected the surface pressure pattern over Northern California. As a result, the forecast 20-40 mph southerly winds 17 to 35 knots over the northern portion of the Sacramento Valley never developed.

Conclusion

The January 18, 1996 snow event in the Redding, CA area was an example of how the evaporative cooling process turned a rain event into a snow event. The presence or advection of drier air into an area can effectively lower the temperature profile causing a change in the type of precipitation. Forecasters need to be aware of this scenario and the ramifications on their forecasts.

Acknowledgments

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References

Bluestein, H.B., 1993: *Synoptic-Dynamic Meteorology in Midlatitudes: Vol. II, Observations and Theory of Weather Systems*. Oxford University Press, Inc., New York, p. 428.

TABLE I

RDD SA 1050 M36 OVC 10R- 190/42/37/3106/009/ RB10
RDD SA 1150 M37 OVC 7R- 186/42/39/3306/007/ 8/02// 50000 6005/
70005 10042 20041
RDD SA 1250 M24 OVC 7R- 184/41/39/0000/007
RDD SA 1350 20 SCT M27 OVC 7R- 174/40/39/3405/004
RDD SA 1450 M17 OVC 5RF 168/40/39/3205/002/ 8/5/// 57017 6023/
RDD RS 1555 8 SCT M12 OVC 5R-F 168/38/37/2905/002
RDD SP 1621 M9 OVC 2S-F 3206/001/ RESB15
RDD SP 1629 M7 BKN 11 OVC 1/2S-F 3106/001
RDD SA 1653 -X M7 BKN 11 OVC 1/2S-F 166/33/32/0000/001/ FS3
RESB15
RDD RS 1750 -X M9 OVC 1/2S-F 162/32/32/0105/000/FS4 SNOINCR 1/2/
8/5// 933003 4/002/ 578008 6078/ 10042 20032
RDD SA 1850 -X E9 OVC 1/4S-F 154/33/32/0203/998/ FS6
SNOINCR 1/2
RDD SA COR 1950 -X E7 OVC 1/4S-F 132/33/32/0000/992/ FS7 PRESFR
SNOINCR 1/3
RDD SA 2050 -X E7 OVC 1/4S-F 115/33/32/3306/986/ F7
SNOINCR 1/3/ 8/5/// 57046 6058/
RDD SA 2150 -X E7 OVC 1/4S-F 104/33/32/3605/983/ F5 SNOINCR 1/5
RDD RS 2250 -X E7 OVC 1/2S-F 094/33/32/0306/980/ F3

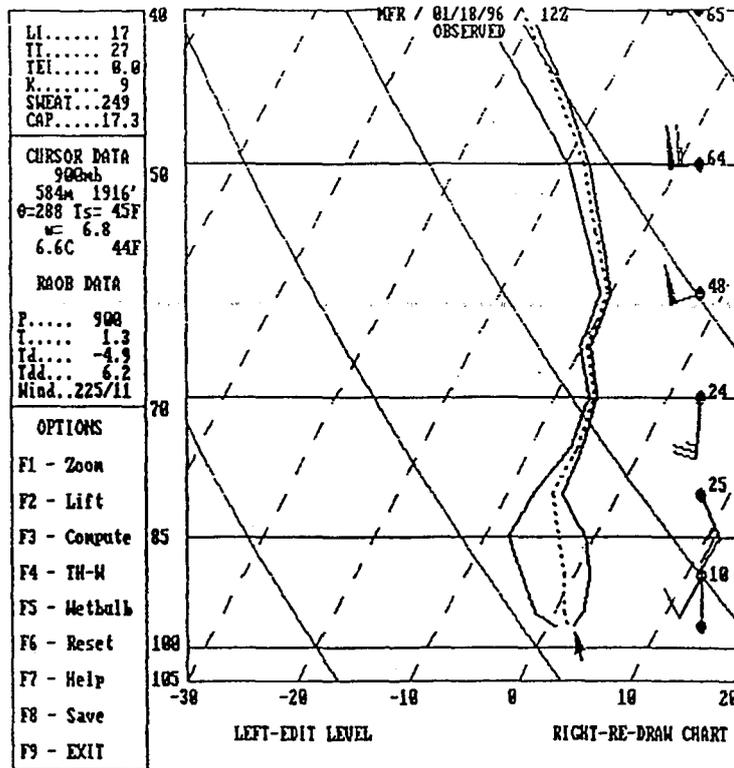


FIGURE 1
Medford Observed Sounding
1200Z 18 January 1996

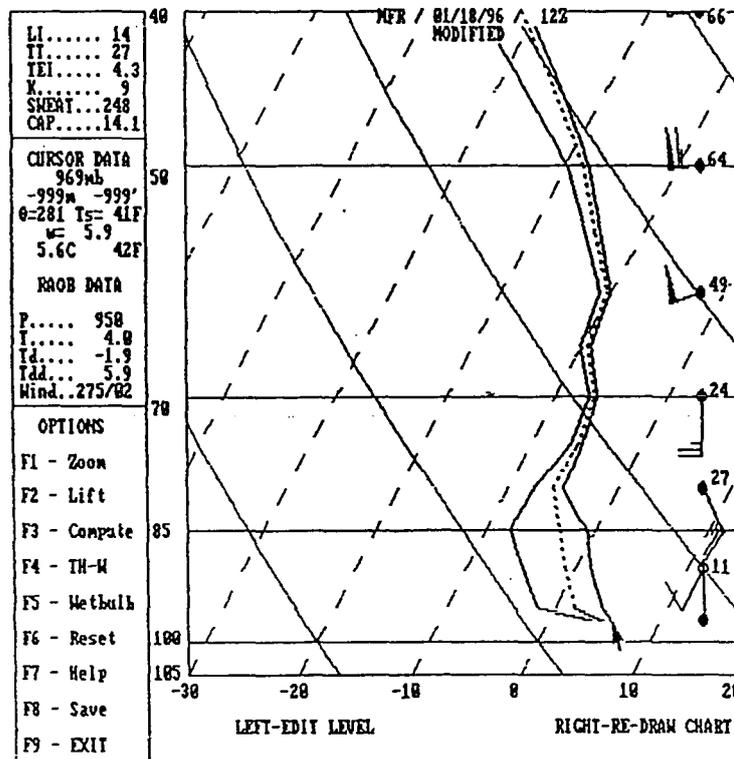


FIGURE 2
Modified Medford Sounding
for Redding, CA (RDD)
1200Z 18 January 1996

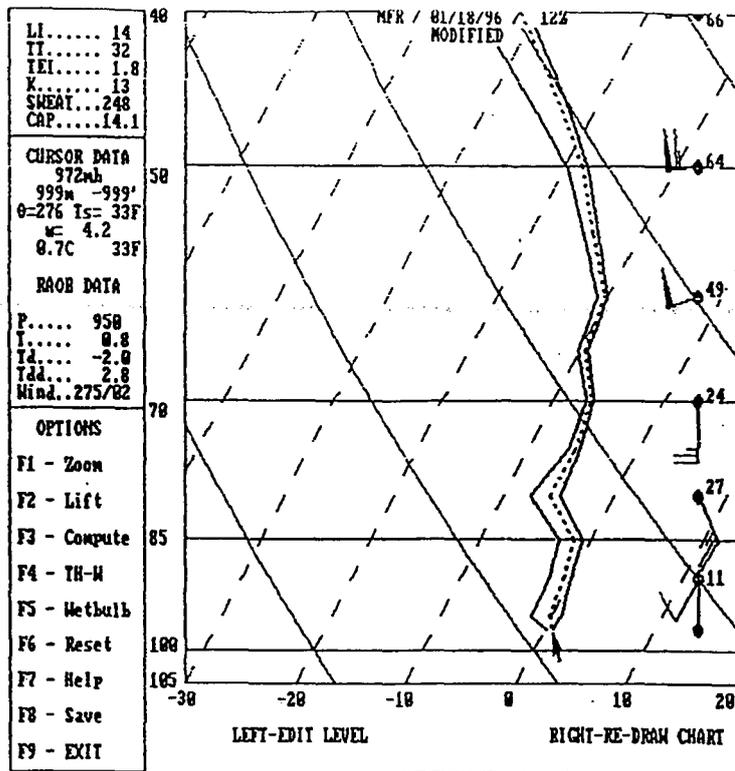


FIGURE 3
 Modified Medford Sounding
 for Redding, CA (RDD)
 1700Z 18 January 1996

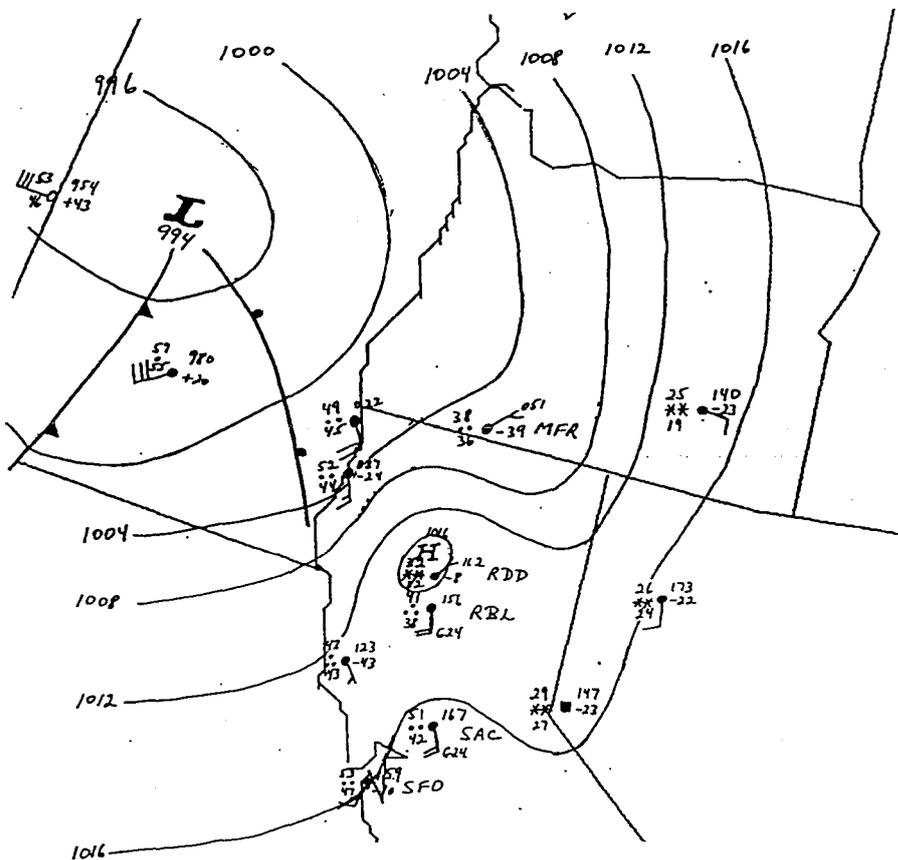


FIGURE 4
 Surface Analysis
 1800Z 18 January 1996