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A REVEALING ISENTROPIC ANALYSIS

On the morning of December 30, 1985, a widespread area of rain, freezing rain and snow extended across the northern portions of California, Nevada, and Utah (Figures 1, 2a and 2b). The 12Z surface chart and meso-isobaric analysis depicted weak low pressure centers in southern Nevada and central California, and high pressure, centered over Washington, extending southward into Utah. There were no frontal boundaries affecting the central portions of the Western Region.

In the upper levels, split flow (Figures 3 and 4) dominated the Western Region, with a strong northern branch across the northern tier states and a weaker southern branch across southern California and Arizona. The 12Z 700-mb analysis in Figure 3 shows only weak warm air advection across northern Utah and nearly neutral temperature advection throughout Nevada and northern California. In contrast, a strong northwesterly flow and cold air advection is shown east of the thermal trough extending through central Idaho and eastern Utah. A significant short-wave trough, with strong PVA, extends through Montana, as noted on the 500-mb height and vorticity analysis (Figure 4). There is weak PVA in west central California associated with a trough off the coast. Only neutral to negative vorticity advection is noted in Nevada and Utah.

In spite of an apparent lack of dynamics in the central portions of the Western Region, significant precipitation occurred during several hours on the morning of December 30th (see Figure 5). The 12Z soundings for Winnemucca (WMC) and Salt Lake City (SLC) are shown in Figures 6 and 7. Both soundings are quite stable in the lower layers, pseudo-adiabatic above 700 mb and nearly saturated through 500 mb. The weak warm air advection, noted on the 700-mb analysis over this area, suggests a possible source of vertical motion, however, it is not convincing.

An isentropic analysis can often provide important information in cases where dynamics appear to be lacking. A plot of the $293^{\circ}K$ isentropic surface is shown in Figures 8a through 8d. The plotfile was produced on AFOS by the ISEN.sv program (documented in the software mailing instructions dated March 13, 1985) and consists of 3 parameters:

1. pressure (upper right)
2. condensation pressure (upper left and defined below)
3. wind

Figure 8a is an analysis of pressure isolines and offers a lot of information. First, it depicts a topographic view of the isentropic surface, complete with troughs and ridges, which can be correlated with like-features on a constant pressure chart. It should be noted that lines of constant pressure are also lines of constant temperature, since by strict definition,

$$\theta = T(1000/P)^{R/C_p}$$

Furthermore, lines of constant pressure approximate lines of constant height since the pressure level of the isentropic surface is directly related to the mean temperature in the underlying column of air, as is the height on a constant pressure chart. Therefore, a high pressure value on an isentropic surface indicates a high mean temperature, and conversely, low pressure values indicate a low mean temperature. In this way, tongues of warm and cold air are accurately depicted. Figure 8a shows low pressure values in Montana, indicative of the cold air associated with the short wave trough.

The condensation pressure values indicate the moisture content on the isentropic surface. The values shown on the plot in Figure 8b represent the number of millibars the parcel at that point must be raised to reach saturation. The airmass is already saturated at WMC and SLC. Isolines of 25 and 50 mb show tongues of moisture in Montana and in the central portions of the Western Region.

The streamline analysis is the final ingredient to be examined. As shown in Figure 8c, a strong northwesterly flow dominates the northern states, while weaker southwesterly flow is noted over the southern two-thirds of the Western Region. There is a strong convergence zone over Wyoming.

The composite of Figures 8a-8c is given in Figure 8d. Figure 8d dramatically illustrates the reason for the precipitation across the northern portions of Nevada and Utah. Note how the streamlines are "blowing" from high to lower pressure over Nevada and Utah, implying upward vertical motion. It is clearly evident that the saturated airmass in the northern portions of these states is related to the occurrence of non-adiabatic vertical motion and precipitation. Continued ascent of this saturated airmass will result in the release of latent heat (non-adiabatic) and enhancement of the upward vertical motion.

In contrast, the strong PVA (Figure 4) and relatively moist airmass (Figure 8b) in the northeastern part of the region is countered by streamlines "blowing" towards higher pressure. This implies strong subsidence and the lack of precipitation is not surprising (Figure 5).

As shown in the above case, the isentropic analysis often yields information that isn't as obvious on constant pressure charts. The use of an isentropic analysis is important since it represents a surface on which adiabatic processes take place. As long as motions remain adiabatic, the exact motion of individual air parcels can be traced. Similarly, water vapor (or in this example, condensation pressure) patterns are conserved and can be traced during adiabatic processes. Of course, as shown in this case study, air parcel movements on an isentropic surface can lead to non-adiabatic processes as well.

Reference:

[1] Anderson, Jeffrey L., "The Use and Interpretation of Isentropic Analyses", <u>Western Region Technical Memorandum, WR-188</u>, 1984.

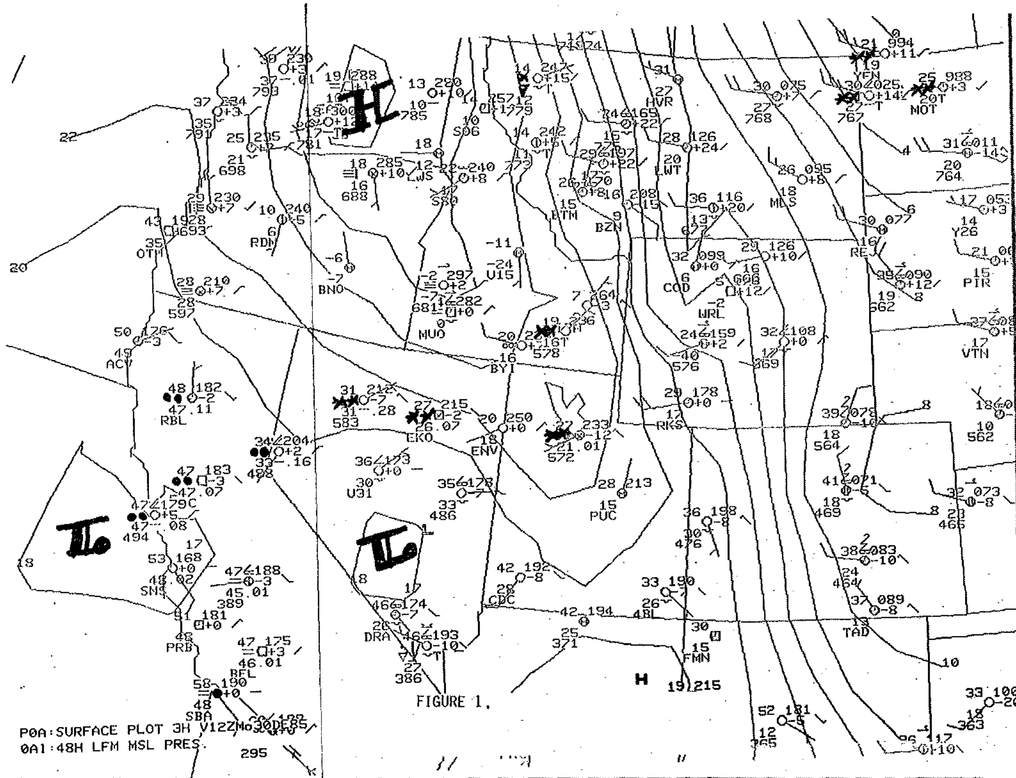

FIGURE 1.

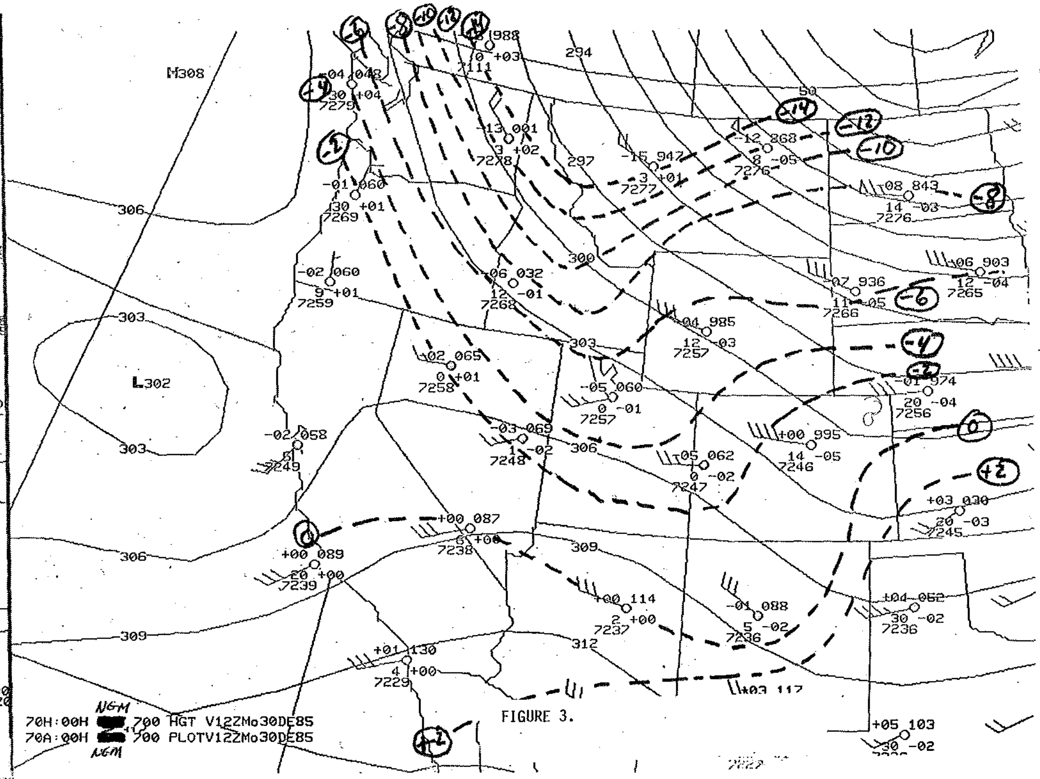

FIGURE 3.

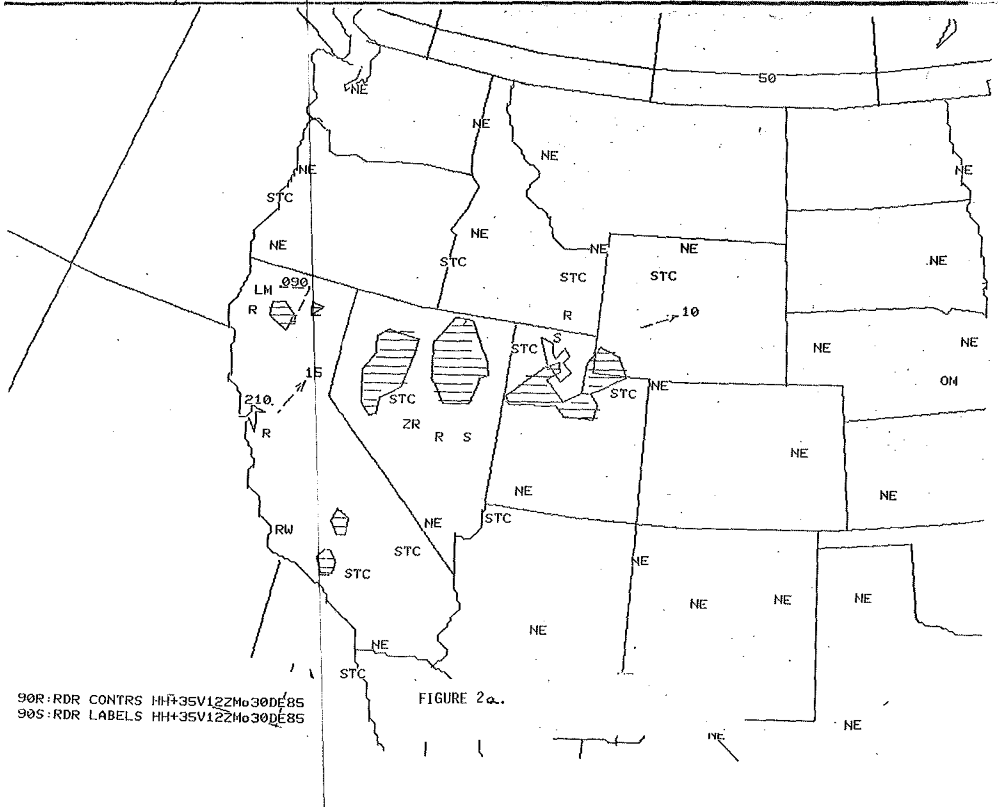

FIGURE 2a.

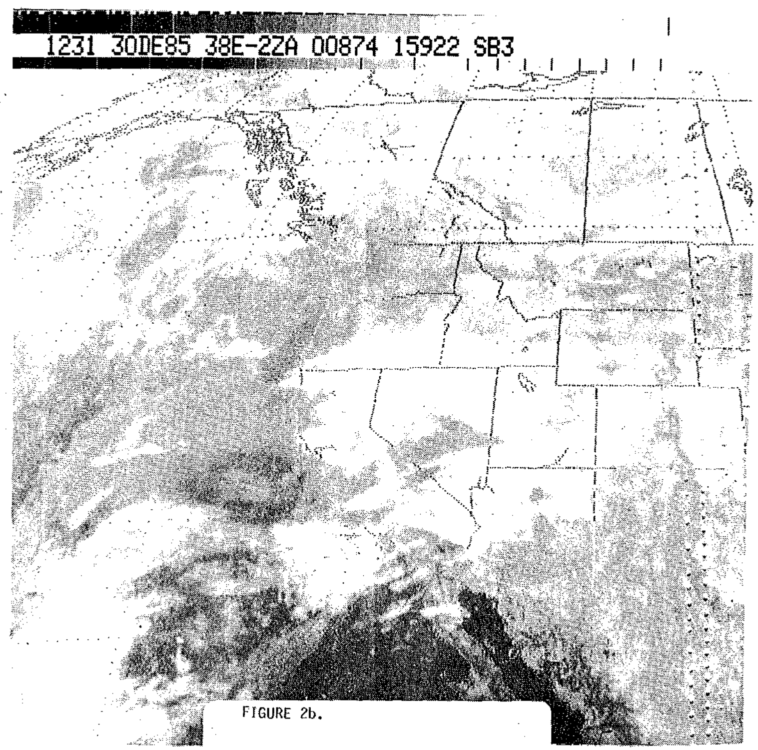

FIGURE 2b.

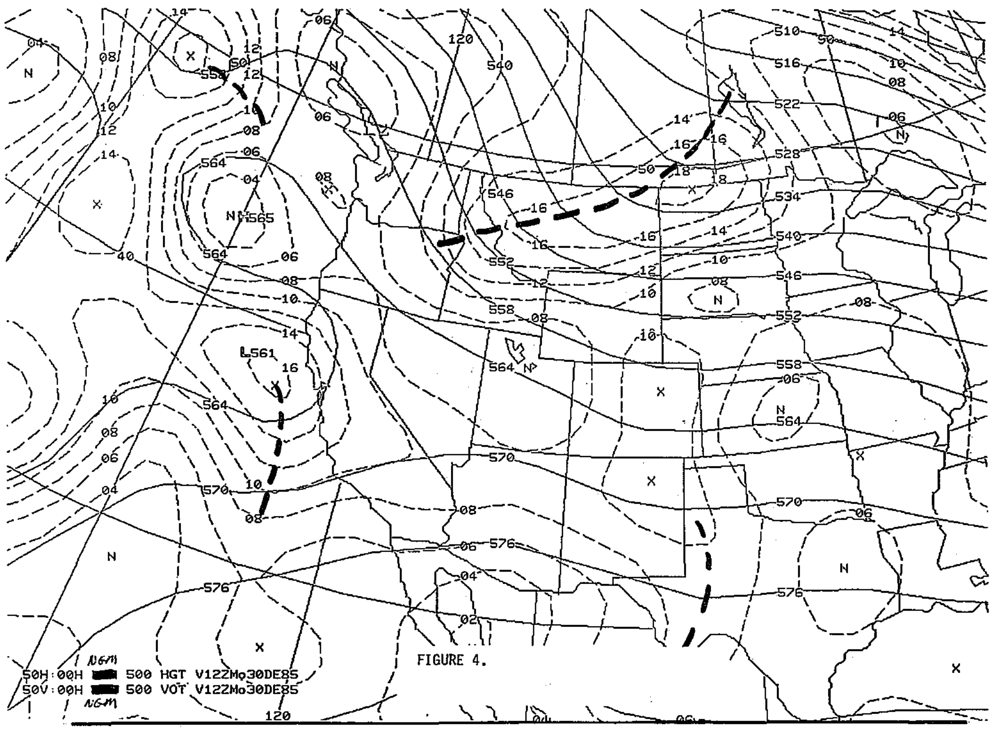

FIGURE 4.

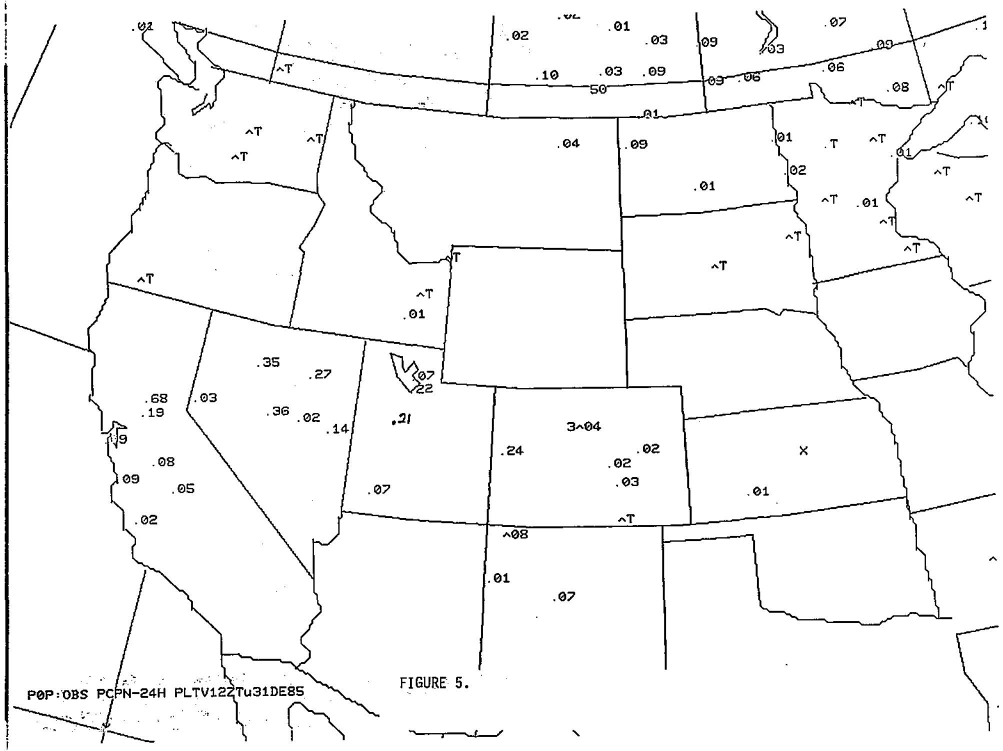

FIGURE 5.

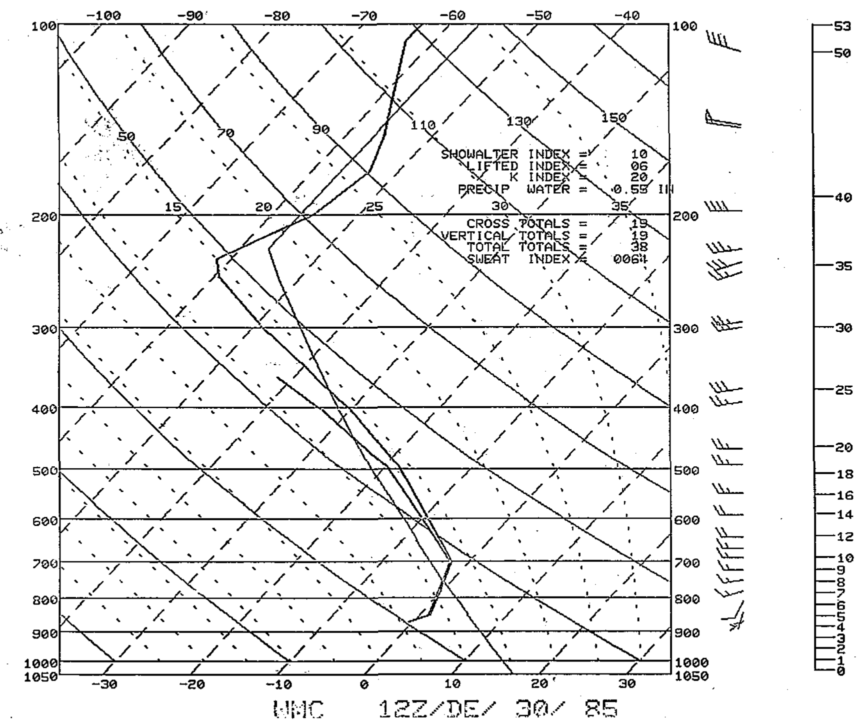

FIGURE 6.

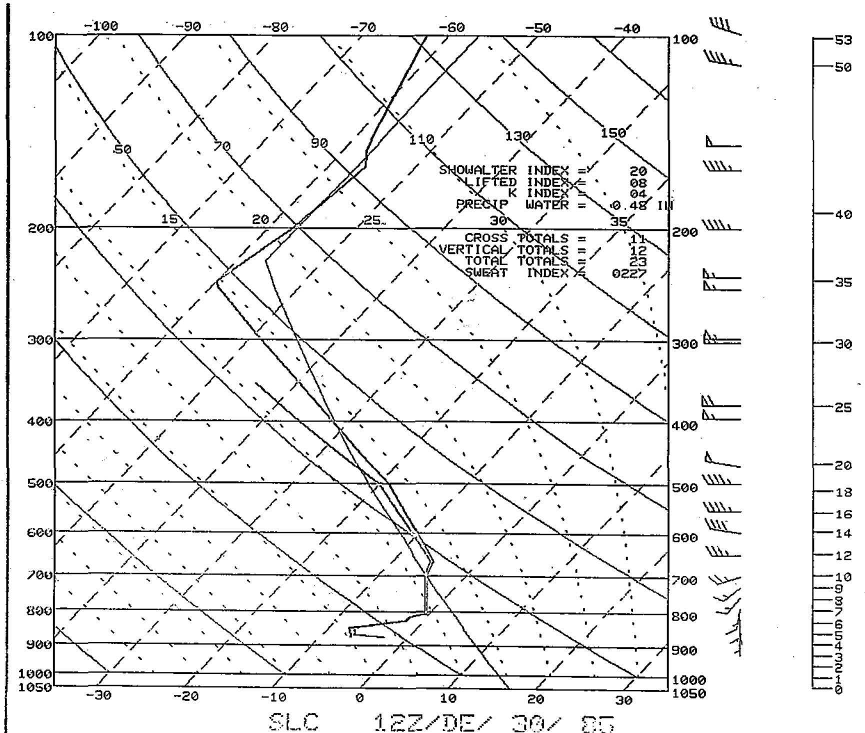

FIGURE 7.

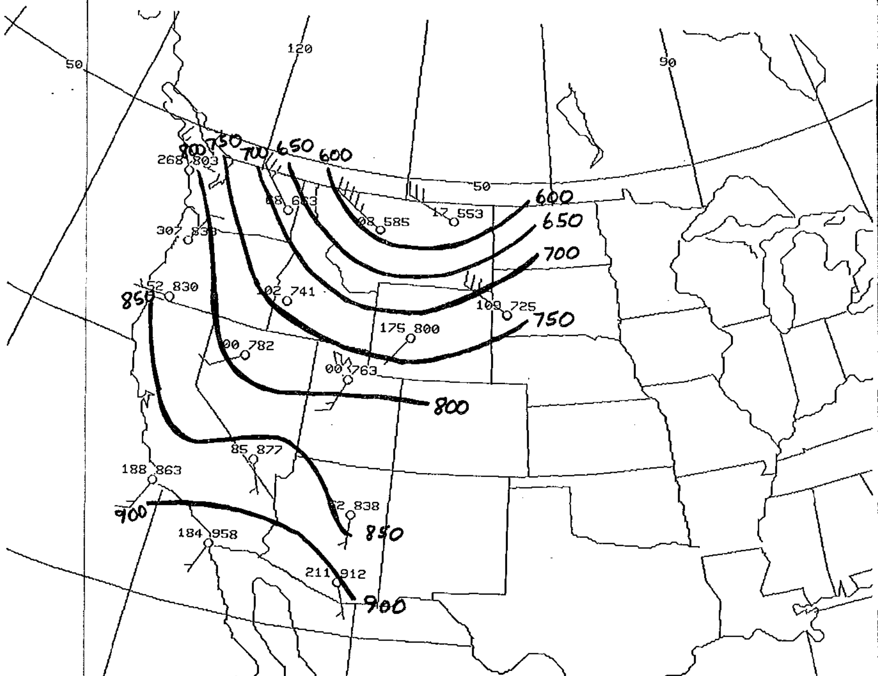

FIGURE 8a.
$293^{O}K$ ISENTROPIC SURFACE WITH CONSTANT PRESSURE ISOLINES

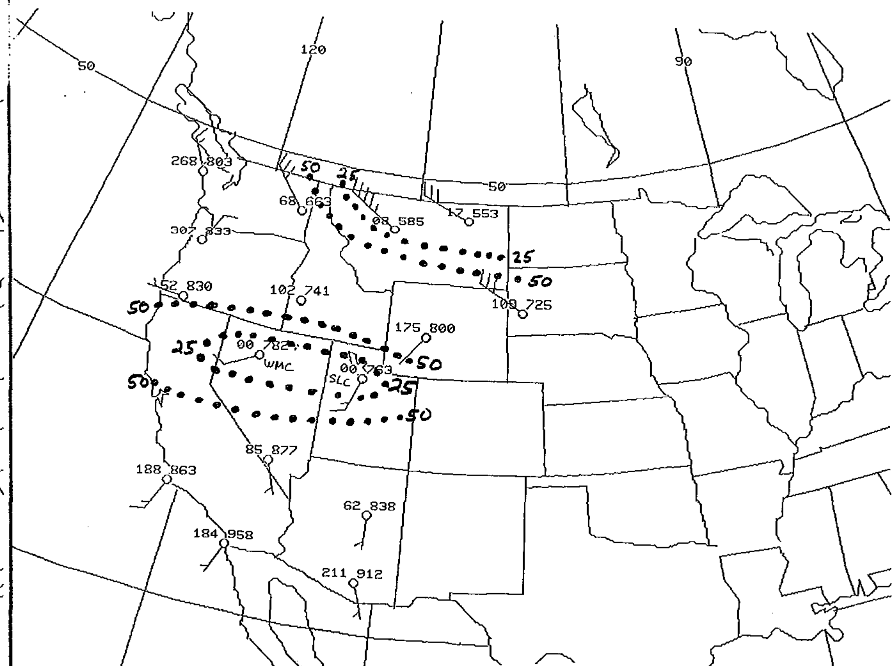

FIGURE 8b.
CONDENSATION PRESSURE ANALYSIS

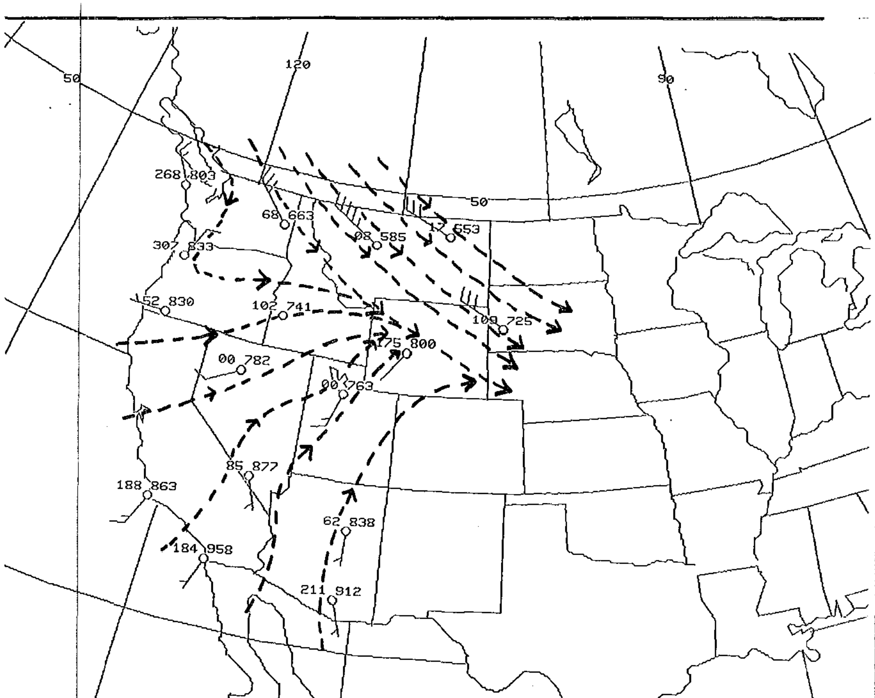

FIGURE 8c.
STREAMLINE ANALYSIS

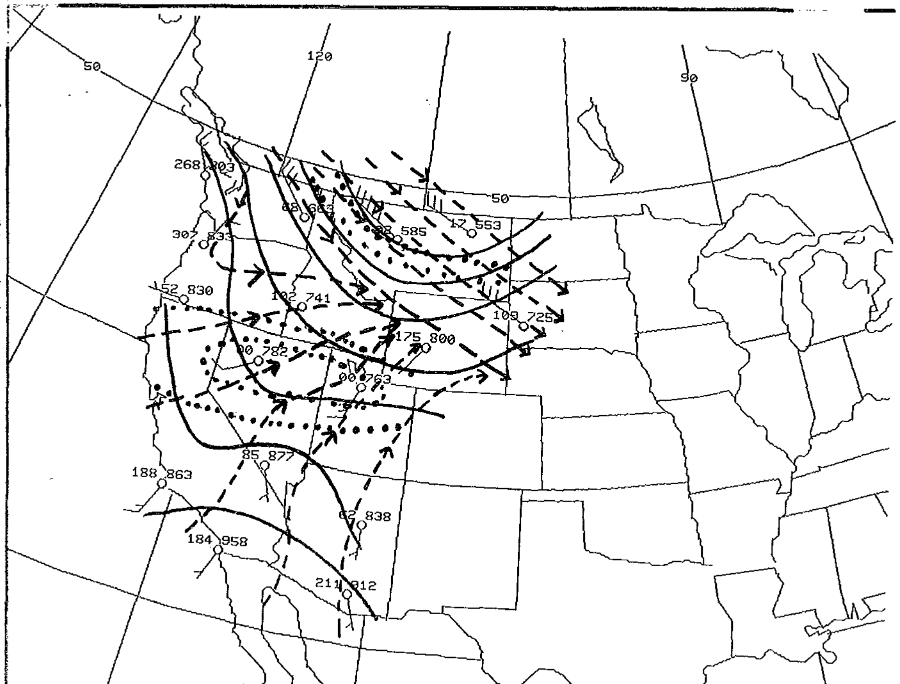

FIGURE 8d.
COMPOSITE