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USE OF ISENTROPIC CHARTS IN THE 1980s
PART III - EXAMPLE

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This example - 1200Z 19 February 1986 - was chosen to show that isentropic charts can initially be misleading if not carefully interpreted. It is in situations such as the 19th of February that one realizes that the isentropic chart is a supplemental tool which must be integrated into the whole analysis and forecast routine. It is best at calling our attention to the thermal contributions of the vertical motion field that are often overlooked. This particular isentropic chart caused considerable discussion in the forecast Seminar class on the 19th.

Example - 1200Z 19 February 1986

The synoptic situation over the western U.S. on the 19th was complex from a frontal analysis viewpoint. See Figure 1. It took considerable comparison of raobs to finally establish the frontal positions given in Figure 1. Originally we had a front extending from central Idaho to near Medford, but dropped it due to weak upper air and thickness support.

The isentropic chart for 1200Z/19th was constructed for $\theta = 300$ degrees. See Figure 2. The -2^{o} 700-mb and -27^{o} 500-mb isotherms were used to construct the 700- and 500-mb isobars. (See Table 1 in Part I). Note that the isobaric pattern agrees well with the fronts depicted. When the streamlines were added, downward motion was initially implied over much of California and Nevada, neutral motion over Utah and most of Montana and upwards motion over Wyoming and southeastern portions of Idaho and Montana. These implications change drastically when the motion of the θ surface is taken into account by using the 1000-500-mb thickness analysis and 12-hour prognosis (see Figure 3). The 700-mb isobar coincides rather well with the "552" thickness line. The 500-mb isobar is closely related to the "528" thickness line. Over the next 12 hours small thickness changes are forecast to take place in the Pacific northwest and western Montana. This indicates little movement of the θ surface in these areas. However, the large thickness changes over southern Idaho, Nevada, Utah, Wyoming, and Colorado indicate that the θ surface is moving rapidly southward. Thus, the initially implied downward motion in Nevada is in actuality weak upward motion that is getting stronger with time. The raobs for Nevada, Utah, and southern Idaho show the air to be moist and unstable and colloidially unstable (i.e., middle cloud temperatures in a range (-12^{o} to -17^{o} C) where ice crystals grow rapidly due to rather large vapor-pressure differences over ice and supercooled liquid water). These instabilities suggest that very little upward motion is needed to cause precipitation.

The 700-mb thermal advection pattern, Figure 4, (i.e., the Laplacian of the cold advection) is weak over Nevada with a slight increase in magnitude in northern Nevada, southern Idaho, and western Utah. This implies a weak downward motion contribution to the vertical-motion field in these areas, and the LFM 500-mb vorticity chart, Figure 5a, indicates PVA over northern portions of California, extreme western Nevada, and eastern Idaho and Wyoming. This PVA does not appear to be strong enough in Nevada to overcome the negative thermal advection component to give the upward motion indicated by our interpretation of the isentropic chart and the existing weather. On closer examination of the vorticity advection pattern, we found that the corresponding 12-hour LFM prognosis valid at 12Z 19 February (Figure 5b) showed a much stronger PVA pattern over most of Nevada. This led to a reanalysis of the 1200Z 500-mb data which put a trough over Nevada that would support a vorticity advection pattern similar to that of the 12-hour prognosis (see Figure 5c).

Realizing that the vertical motion implied by the isentropic chart is essentially the sum of the vorticity and thermal advection contributions, the PVA contribution was considered dominant. The LFM PVA was forecast to decrease after 12 hours (00Z to 12Z/20th) over Nevada and Utah (Figures 5d, 5e) suggesting a decrease in vertical motion for these areas. However, the changes expected in vertical motion using the projected changes in the isentropic chart indicated that there would still be upward motion in Nevada, Utah, and Wyoming and downward motion over the Pacific northwest and Montana. This means that the thermal advection pattern opposing upward motion was expected to decrease. So, in spite of the forecast decrease in PVA, continued upward motion and precipitation should be forecast for Nevada and in Utah after 00Z/20th. Precipitation did occur over most of Utah on the 20th, and the 700-mb chart for 12Z/20th, Figure 6, shows the decided decrease in the Laplacian of the cold-air advection that took place.

When the LFM precipitation forecast for 1200Z/20th, Figure 7, was first referred to in the weather discussion, it was considered by most to be a gross overforecast. This was based on the fact that the PVA was nil and a weak ridge was forecast to be along the Utah/Nevada border by 12Z/20th (Figure 5e). However, after taking into account the change expected in the thermal advection pattern to decrease opposition to upward motion, (implied by isentropic chart), considerable confidence was placed in the LFM precipitation forecast.

Summary

The isentropic chart has been found to be a useful diagnostic and short-range prognostic tool in the 1980s. Its main contribution is in calling the forecaster's attention to the thermal contribution of the existing field of vertical motion as well as the vorticity advection contribution, plus how these contributions are likely to change with time. Armed with this information, the forecaster can examine the often overlooked thermal field more carefully and thus have a more systematic way of evaluating and weighing the NWP guidance available before it is used.

Acknowledgement

I am grateful to Mr. Glenn Rasch for the opportunity to present my ideas on the construction and use of isentropic charts. My hope is that as forecasters experiment with these charts, they will exchange their findings by writing WRTAs for SSD to publish or give SSD the information to distribute. There is a lot yet to learn and to be said about using isentropic charts in the modern NWP age (e.g., the changing advective wind field), but their use thus far suggests the practice will be rewarding.

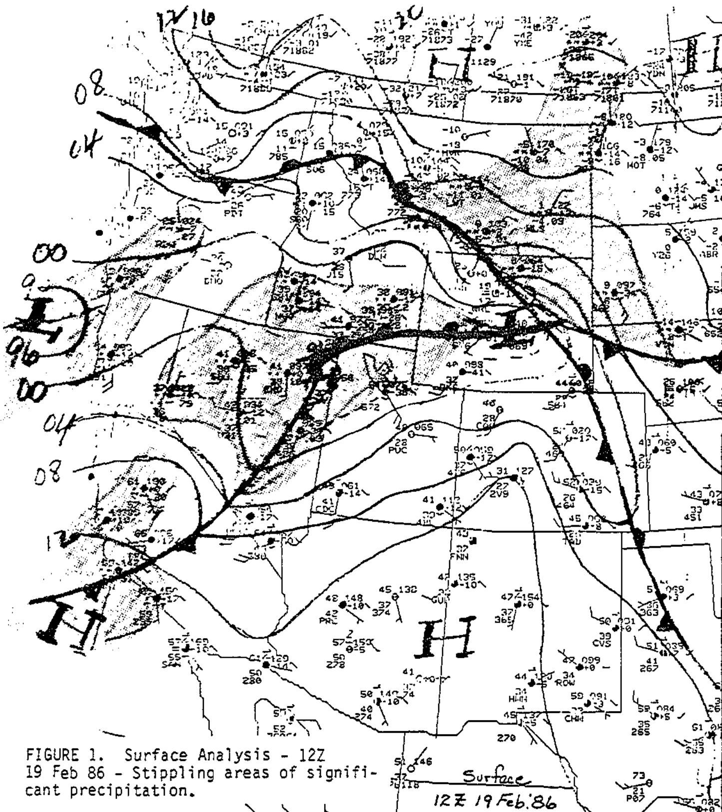

FIGURE 1. Surface Analysis - 12Z 19 Feb 86 - Stippling areas of significant precipitation.

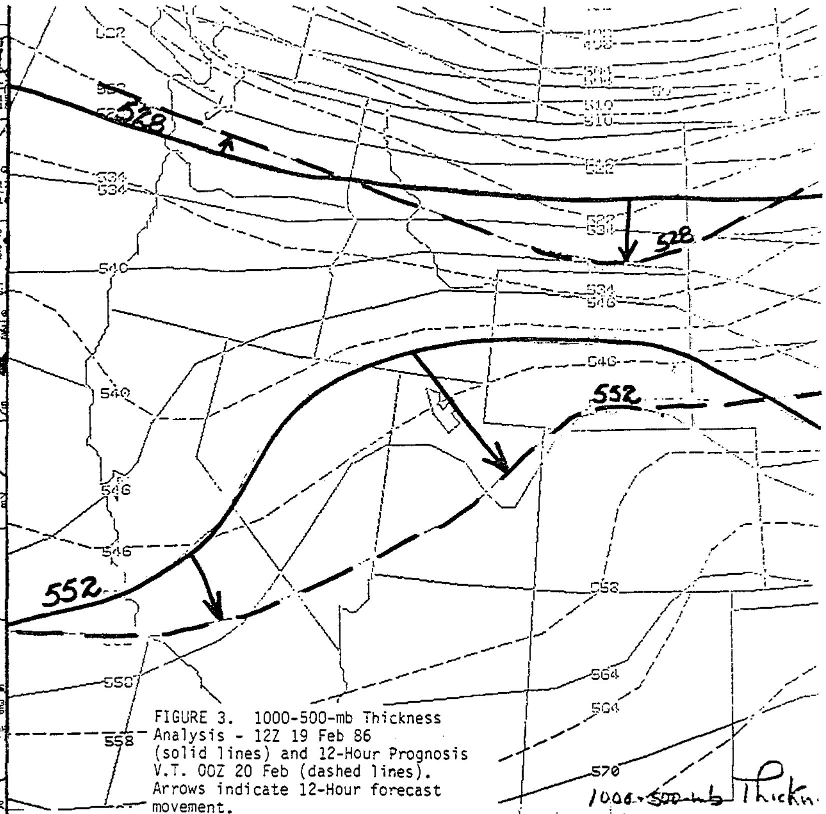

FIGURE 3. 1000-500-mb Thickness Analysis - 12Z 19 Feb 86 (solid lines) and 12-Hour Prognosis V.T. 00Z 20 Feb (dashed lines). Arrows indicate 12-Hour forecast movement.

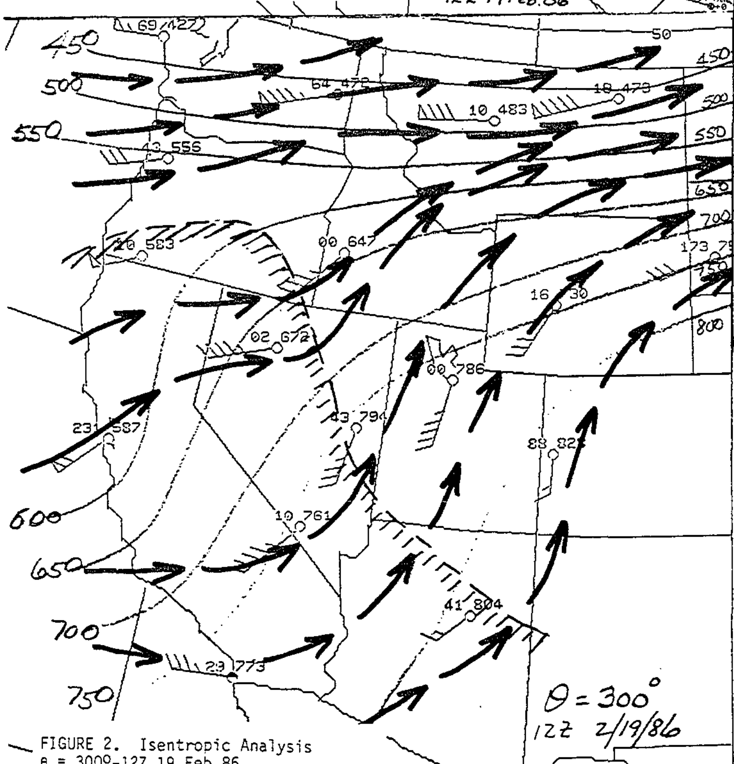

FIGURE 2. Isentropic Analysis $\theta = 300°$-12Z 19 Feb 86
Hatched line is leading edge of implied downward motion assuming θ-surface stationary.

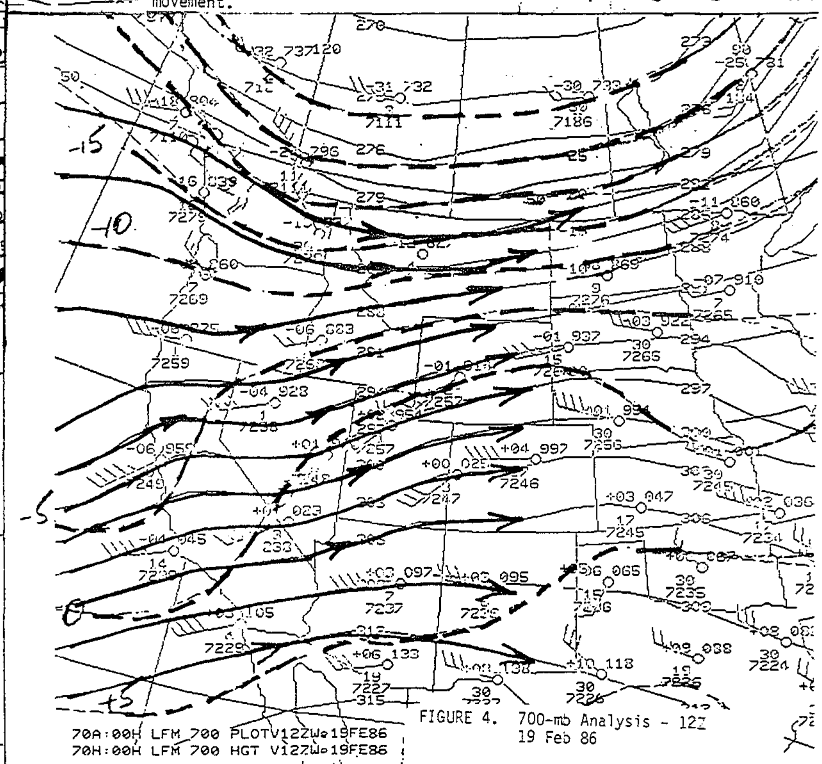

FIGURE 4. 700-mb Analysis - 12Z 19 Feb 86

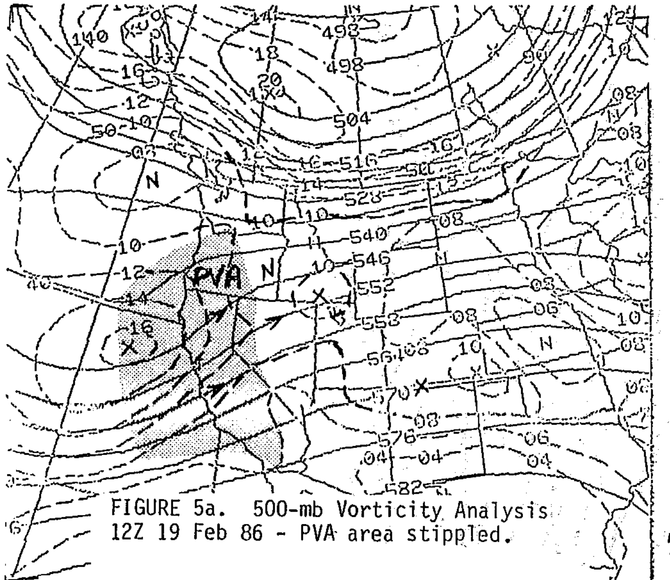

FIGURE 5a. 500-mb Vorticity Analysis 12Z 19 Feb 86 - PVA area stippled.

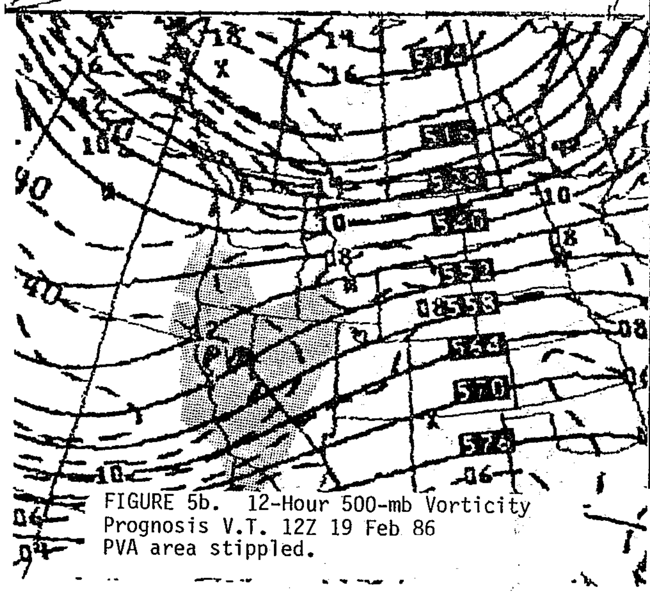

FIGURE 5b. 12-Hour 500-mb Vorticity Prognosis V.T. 12Z 19 Feb 86 PVA area stippled.

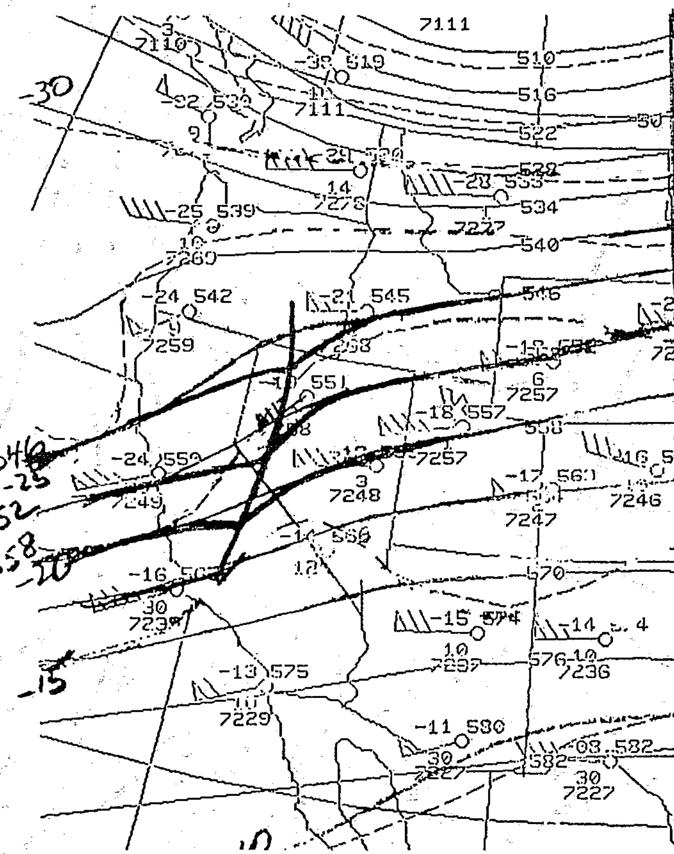

FIGURE 5c. 500-mb Analysis -12Z 19 Feb 86

-50A:00H LFM 500 PLOTV12ZWA19FE86

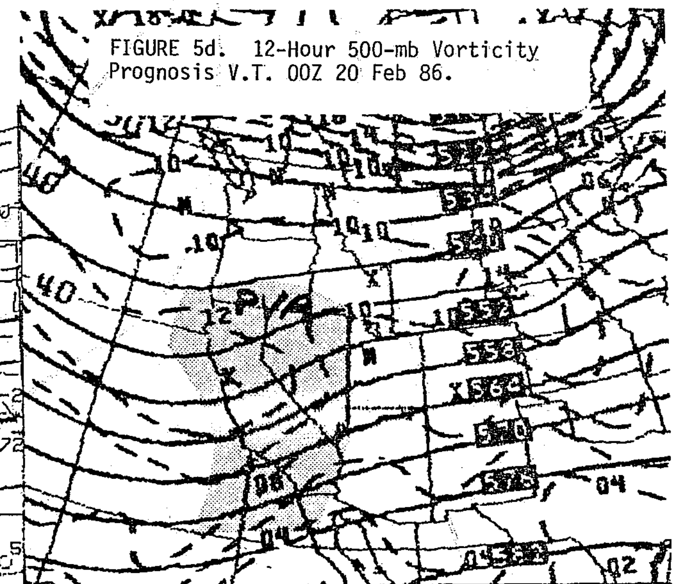

FIGURE 5d. 12-Hour 500-mb Vorticity Prognosis V.T. 00Z 20 Feb 86.

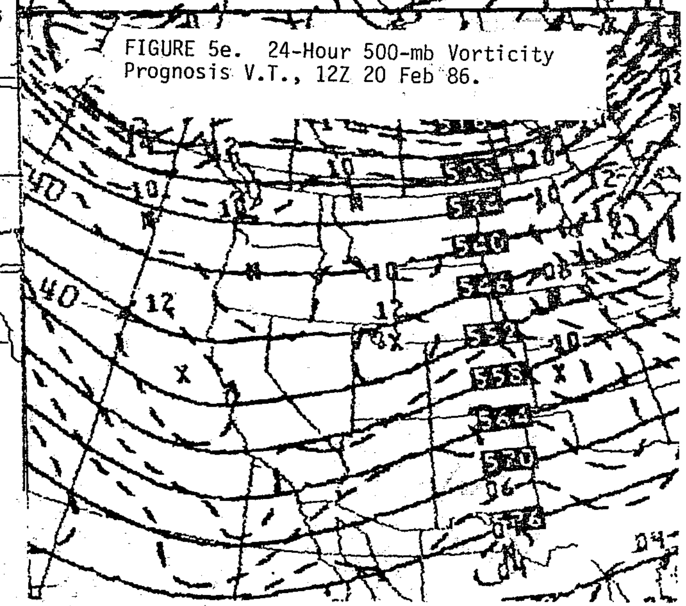

FIGURE 5e. 24-Hour 500-mb Vorticity Prognosis V.T., 12Z 20 Feb 86.

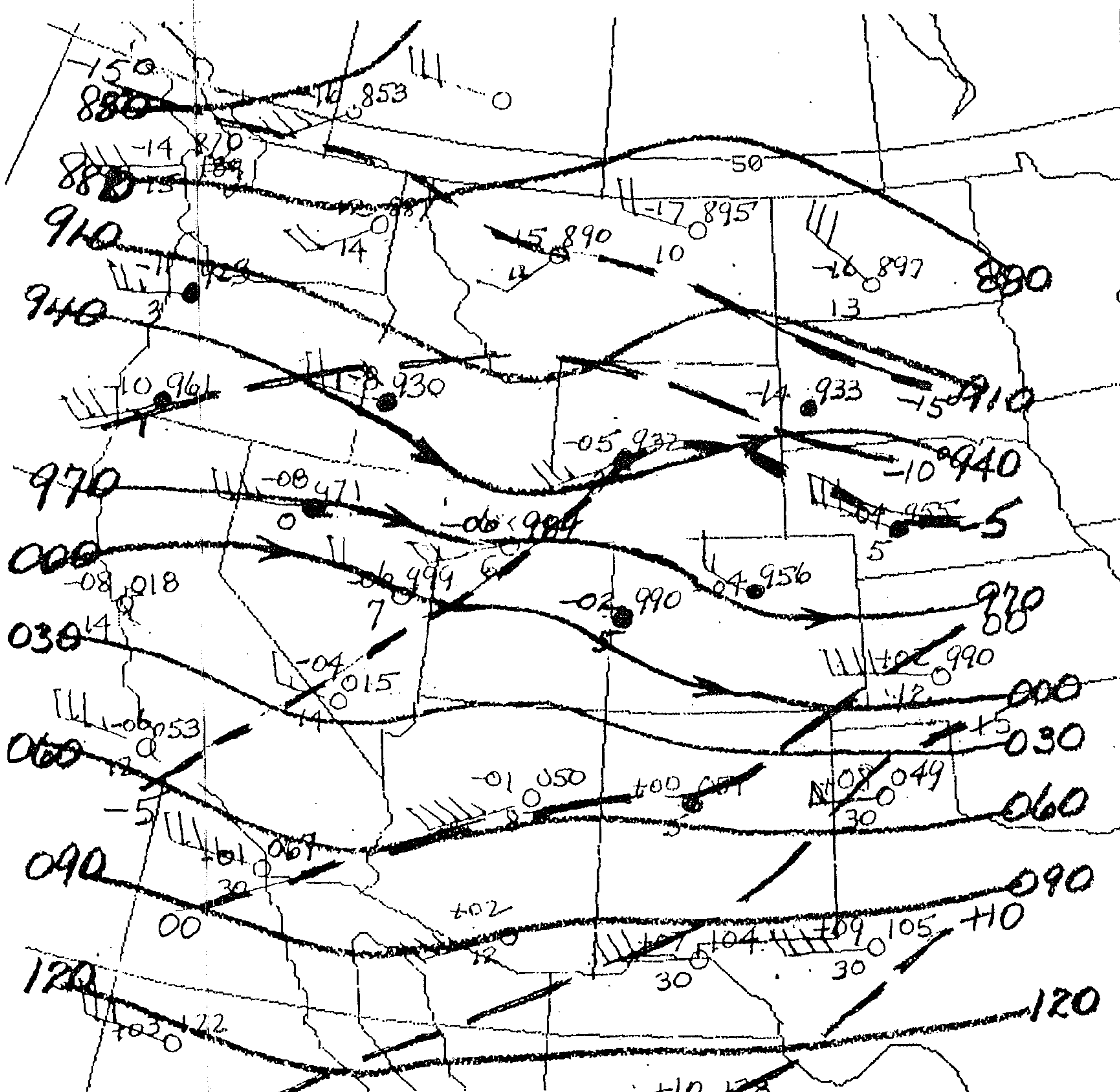

FIGURE 6. 700-mb Analysis - Z
20 Feb 86.

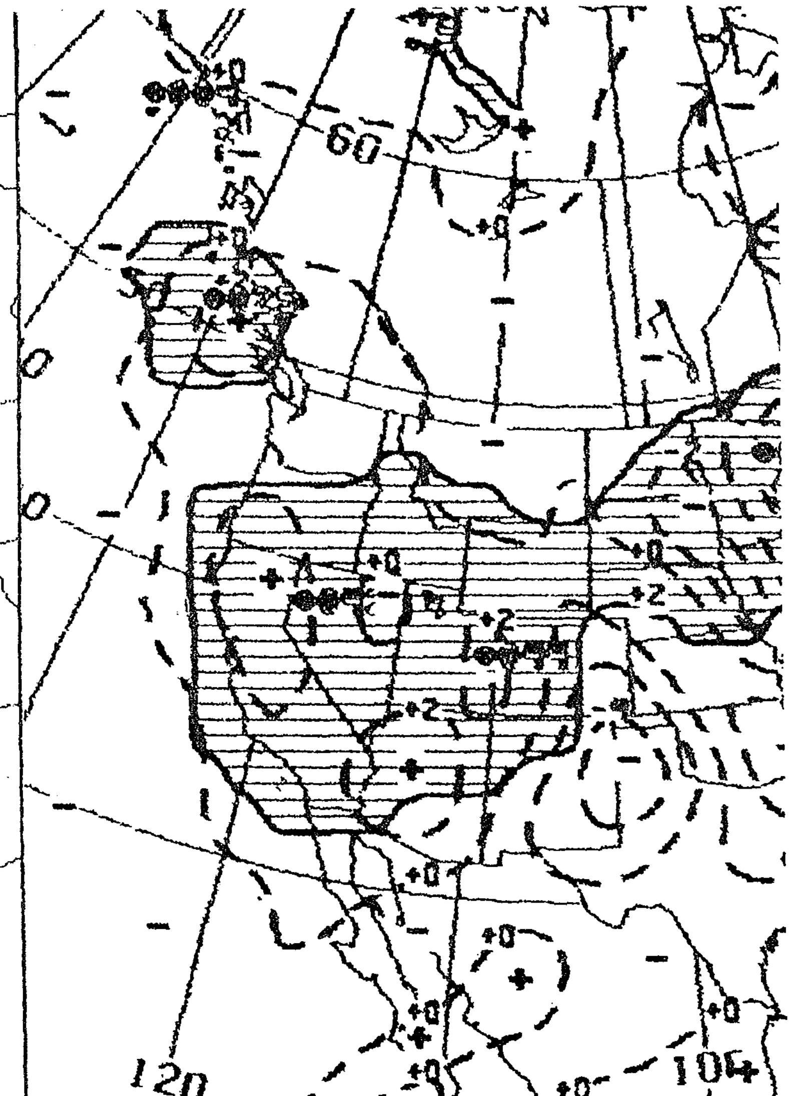

FIGURE 7. 24-Hour LFM Forecast of Precipitation V.T. 12Z 20 Feb 86.