WESTERN REGION TECHNICAL ATTACHMENT
NO. 86-09
March 3, 1986

USE OF ISENTROPIC CHARTS IN THE 1980s
PART I

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Fifty years ago isentropic charts were considered useful in operational forecasting. By 1950 the manual effort that it took to produce them did not make them cost effective. Consequently, their operational use soon stopped. Today an AFOS application program makes isentropic charts available with a small manual effort. So now the question is, "Are these charts useful enough today to be included in the daily operational routine?". In a series of three Technical Attachments I shall discuss the construction, interpretation and use of isentropic charts as a diagnostic and short range (i.e., 24 hours or less) forecast tool. My purpose is to stimulate Western Region forecasters into experimenting with them operationally, and in so doing see if they produce better short range forecasts. The above question can then be answered by each forecaster. My answer has been "yes" regarding situations that contain the threat or occurrence of middle clouds and precipitation.

I - INTRODUCTION

First, a brief review:

a. An isentropic chart is the mapping of a constant potential-temperature surface (θ-surface). Potential temperature is a function of only pressure and temperature. Consequently isotherms on constant-pressure charts are lines of constant potential-temperature.

b. Isentropic charts can give a qualitative indication of the existing vertical motion field and thus an easier assessment of the thermal-advection contribution (i.e., the Laplacian of the thermal-advection) to the mid-tropospheric vertical-motion field. The vorticity-advection contribution to the vertical motion is usually much easier to assess than the thermal contribution. Isentropic charts also show the existence and orientation of moist air tongues. This is covered in the "ancient" literature[1,2], and is more applicable to areas east of the Rockies at this time of year, so it will not be discussed here.

c. When warm air advection is indicated on upper-air charts, one of three things is taking place in that area: 1) temperature is rising; 2) upwards vertical motion exists; or, 3) both warming and vertical motion exist.

II - ANALYSIS

~~The AFOS application program allows you to specify the θ surface that you want.~~ The program plots the pressure of the θ surface at raob stations plus the wind and condensation pressure (Pc, i.e., the number of millibars that a parcel must be raised above the θ surface to reach saturation). See Figure 1. If just one isentropic surface is prepared, it is best to choose a surface that exists between 850 and 400 mb. At this time of year theta values of 295 to 300 degrees usually fit this criterion. The forecaster needs to draw the isobars and streamlines on the chart before it can be used. A Pc analysis can also be made but is not a consideration here.

The isobars must be analyzed independently of the winds. Since we are so used to taking the wind into account when we draw isobars, the winds on a θ chart often influence that analysis. This dilutes the very depiction of up-and-down glide motion on the θ surface that we are trying to analyze. Isotherms on constant-pressure charts can be used to overcome this problem. For example, if you are analyzing a 297-degree θ chart, the 700-mb minus 5°C isotherm corresponds to 700 mbs on the chart (see Figure 2). This isotherm can be copied onto the θ chart and labeled as the 700-mb isobar (see Figure 3 as an example and Table 1). Once the "constant-pressure" isobars, i.e., 850, 700 and 500mb, are drawn, it is a simple matter to make a pressure analysis that is independent of the winds (see Figure 4). A pressure interval of 50 mb is suggested.

Next, the streamlines are drawn. It is usually helpful to follow the corresponding upper-air contours (e.g., θ pressures near 700mb and the 700-mb contours in that area) as guides when drawing streamlines (see Figure 5).

III - INTERPRETATION OF ISENTROPIC CHARTS

Wind flow that is directed toward lower pressure is considered initially to show areas of upwards motion, and vice versa for flow toward higher pressure (see Figure 6). However, that indicated motion may not be correct when the movement of the θ surface itself is taken into account. To evaluate such movement a forecaster can use the 1000-500-mb thickness analysis, 12- and/or 24-hour prognoses and the association of a given thickness line with a θ-chart isobar. Consider the movement of the isobar to be the same as the related thickness line over the forecast period. For example, in Figure 7 the 5520m 1000-500-mb thickness isopleth corresponds roughly to the 700-mb θ isobar. Assuming that this relationship holds through the 12 hours, the 12-hour thickness prognosis indicates the 12-hour movement of the 700-mb θ isobar. Therefore, prognostic thickness charts give a good indication of the motion of θ surfaces.[1] Assessment of the motion of a θ surface before the NWP era was often difficult. As was just demonstrated, assessing this motion now is relatively easy.

IV - SUMMARY

Mid-tropospheric synoptic-scale vertical motions are mainly the function of differential vorticity advection with height (A), and the Laplacian of mid-tropospheric thermal advection (B). The isentropic chart, when the motion of the θ surface is taken into account, gives you A+B. Since B is often difficult to evaluate, the chart becomes a useful diagostic tool for evaluating the thermal contribution to vertical motion.

[1]Non-adiabatic factors (e.g., latent heat of condensation) can be involved here. Our experience, to date, is that since the thickness prognosis includes these factors, and the assumed relationship is useful even when significant precipitation is occurring.

The philosophy being followed in this discussion is that even qualitative evaluation of the contributions of A and B can help in diagnosing causes of synoptic scale weather. This better understanding of initial conditions should lead to better use of NWP and MOS guidance.

Subsequent Technical Attachments will discuss application of the above using relatively recent situations.

V - REFERENCES

[1] Namias,J.et al "Airmass and Isentropic Analysis", American Meteorological Society 1940, pages 136-158.

[2] Saucier,W. "Principles of Meteorological Analysis", University of Chicago Press, 1955, chapter 8.

TABLE I

Constant-Pressure Temperatures that Correspond to Potential Temperature Values used to Construct Isentropic Charts (Rounded to Nearest Degree)

mb	290	292	294	296	298	300	302	304	306	308
850	4	6	8	10	11	13	15	17	18	20
700	-11	-10	-8	-6	-4	-2	-0	1	3	5
500	-35	-34	-32	-30	-29	-27	-25	-24	-22	-21

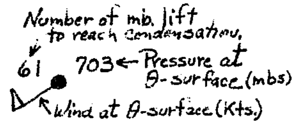

FIGURE 1. Plotting Model

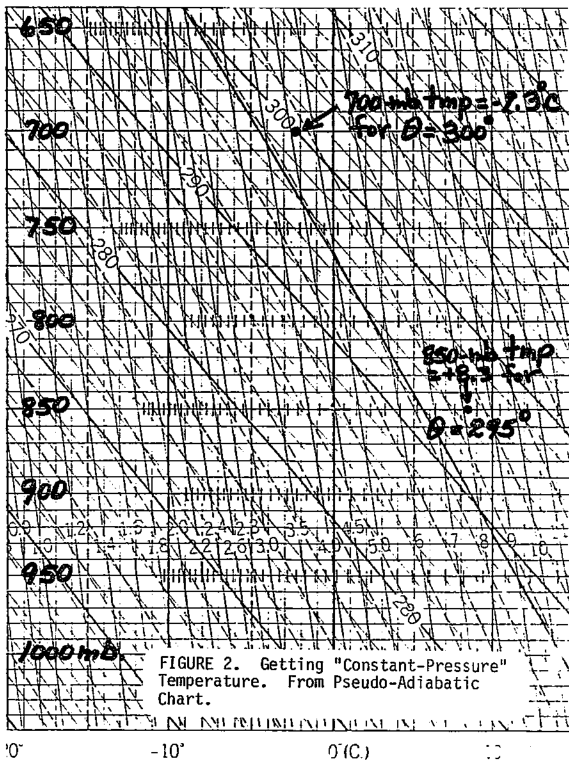

FIGURE 2. Getting "Constant-Pressure" Temperature. From Pseudo-Adiabatic Chart.

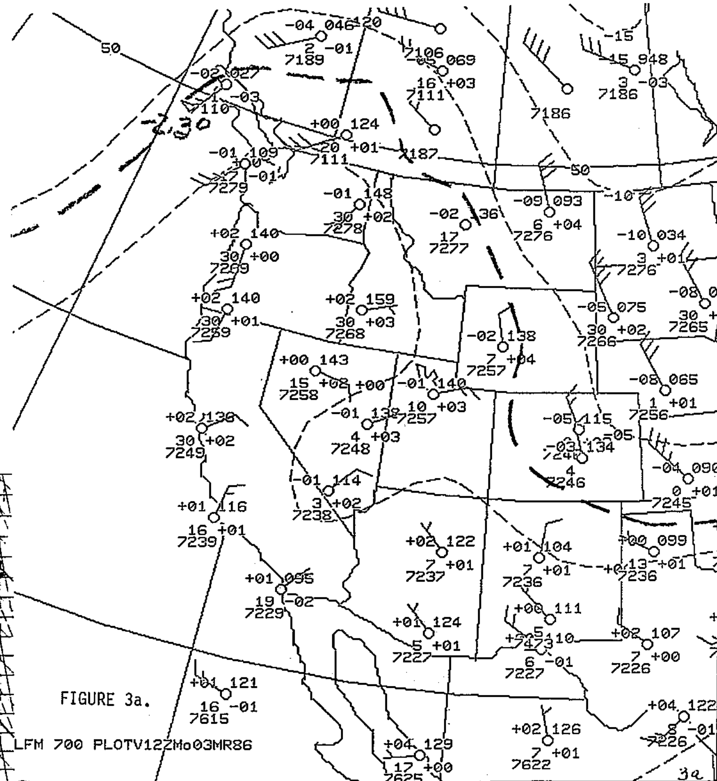

FIGURE 3a.

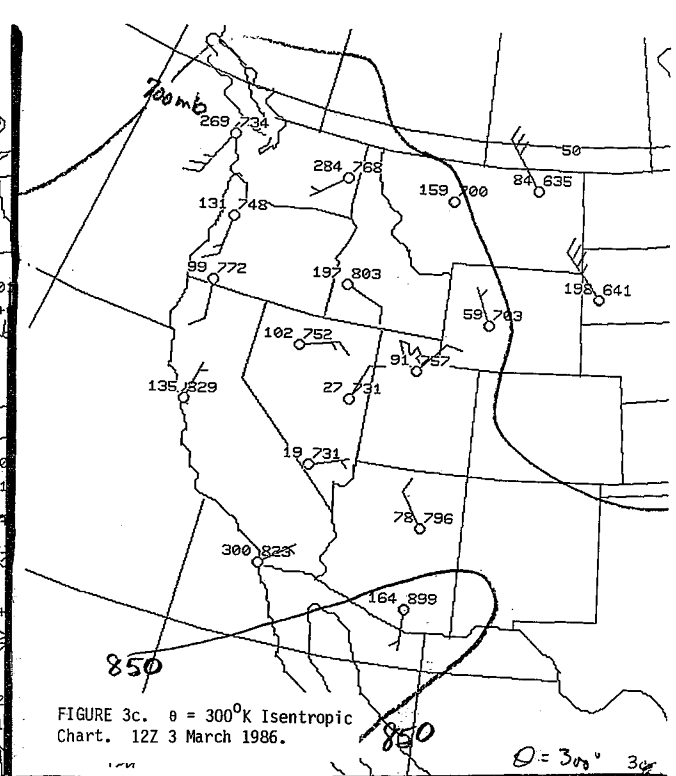

FIGURE 3c. θ = 300°K Isentropic Chart. 12Z 3 March 1986.

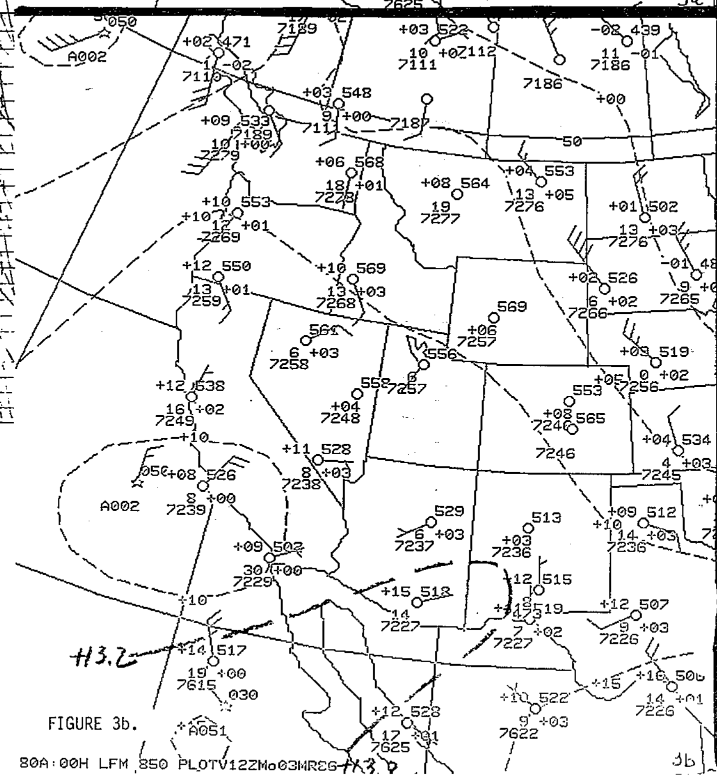

FIGURE 3b.

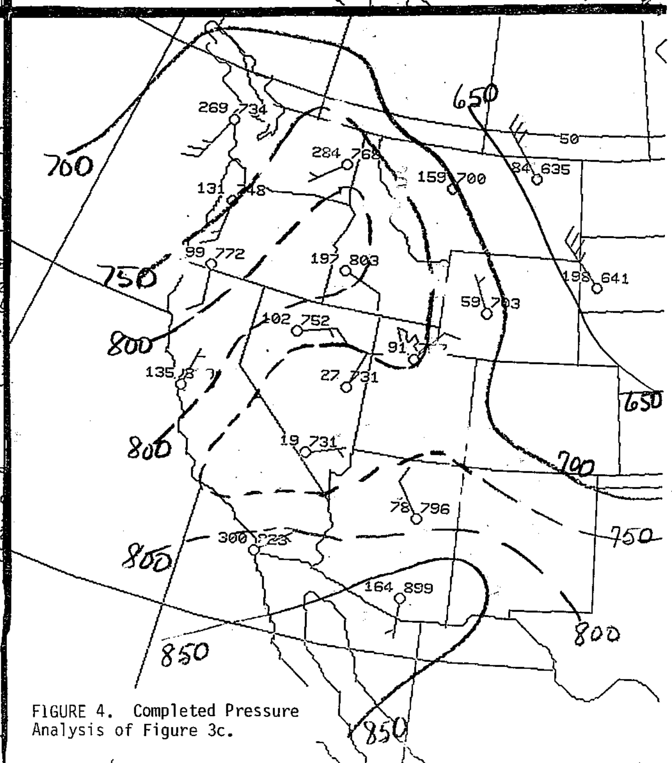

FIGURE 4. Completed Pressure Analysis of Figure 3c.

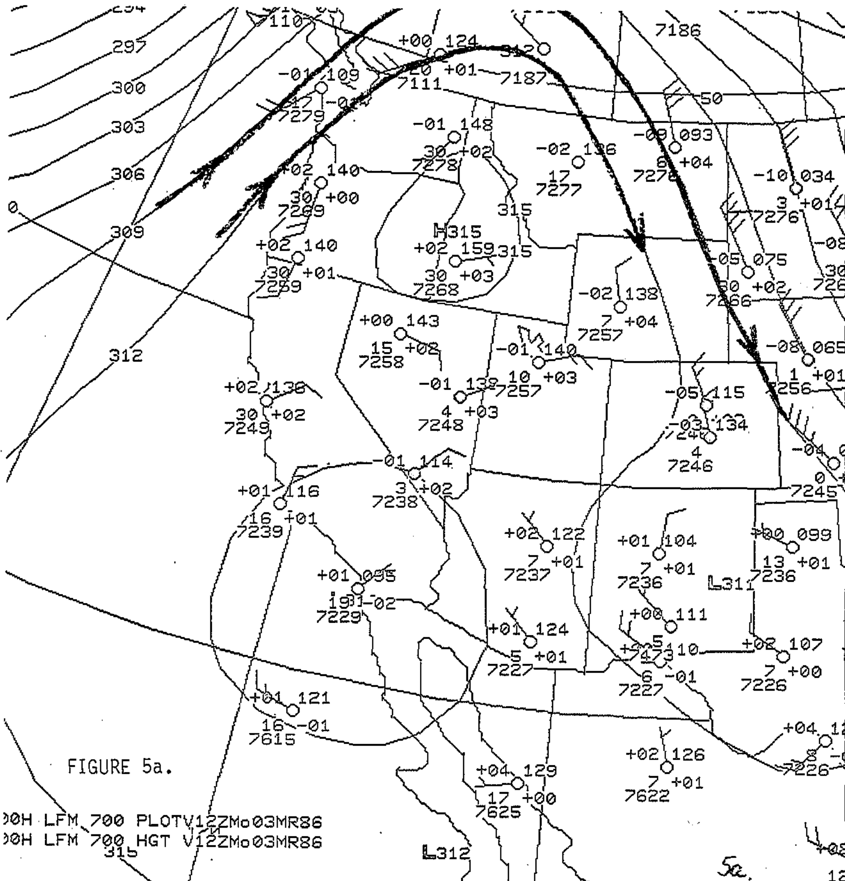

FIGURE 5a.

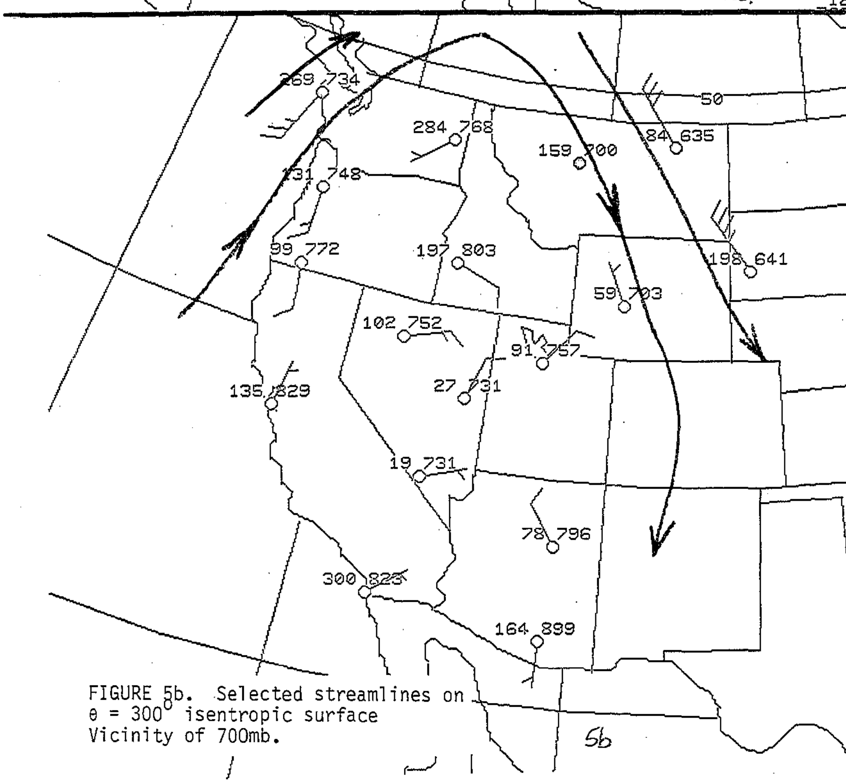

FIGURE 5b. Selected streamlines on θ = 300° isentropic surface Vicinity of 700mb.

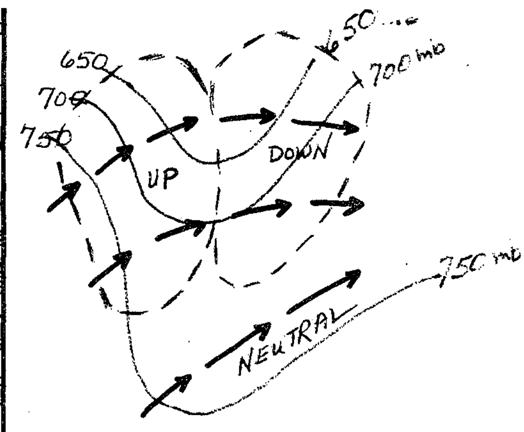

FIGURE 6. Upglide and Downglide Motion with θ-surface stationary.

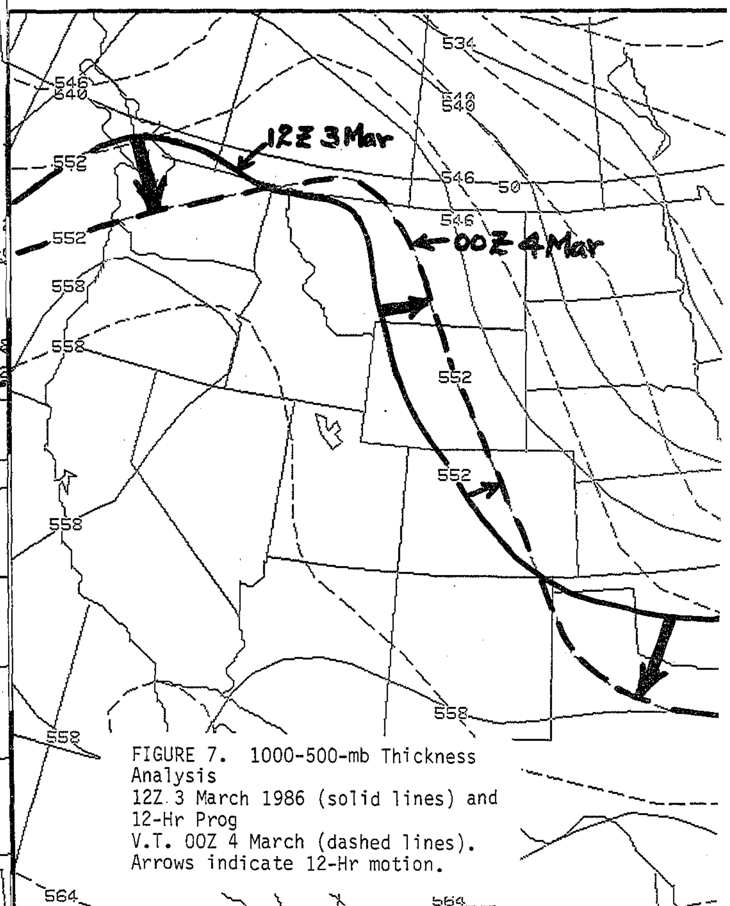

FIGURE 7. 1000-500-mb Thickness Analysis
12Z 3 March 1986 (solid lines) and 12-Hr Prog
V.T. 00Z 4 March (dashed lines).
Arrows indicate 12-Hr motion.