Western Region Technical Attachment
No. 91-10
March 5, 1991

A DIFFERENT WAY TO LOOK AT MODEL OUTPUT

One of the primary tasks facing forecasters every day is interpretation of NMC model output. Perhaps the most difficult forecast problem at most sites is related to precipitation, whether there will be any, how much, and when will it begin and end. In the process of interpreting model output, forecasters implicitly try to estimate the vertical motion that will occur over their region of interest. These vertical motions may be due to orographic lift or dynamic lift. In theory, the model can predict both of these, but in reality, the model terrain is quite coarse. Most forecasters in the western U.S. tend to look for dynamic lift in the output, and then subjectively add in orographic effects based on their knowledge of the local topography. This Technical Attachment (TA) will show an example of how difficult interpretation of dynamic forcing can be given the limited capabilities to view model output currently available on AFOS. This will be contrasted with just a few other ways of looking at model forcing that are possible with model gridded data.

For the purposes of this example, consider the forecast problem at Salt Lake City, Utah, on February 27, 1991. Figure 1 is a 4-panel display of 500 mb height and vorticity from the NGM 12Z, February 27, 1991. A strong, upper-level trough strikes southern California at 12 hours and moves inland by 36 hours. There are a series of vorticity troughs associated with the system, but they appear to weaken considerably as they approach Salt Lake City. There is some weak PVA at Salt Lake City by 24 hours, then a bit more by 36 hours, but it is not terribly strong as there are few height contours over northern Utah.

Looking at the forcing in a quasi-geostrophic perspective (combining differential vorticity advection and the Laplacian of temperature advection) is difficult with AFOS graphics, but the best method available is to combine 1000-500 mb thickness and 500 mb vorticity in order to estimate the advection of vorticity by the thermal wind (Trenberth, 1978). Figure 2 shows the 24- and 36-hour prognoses of these fields. At 24 hours, there is weak NVA by the thermal wind, and at 36 hours there is weak PVA with a very weak thickness gradient indicating a light thermal wind. Thus, with only AFOS capabilities, an estimate of the QG forcing shows little reason to expect much dynamically forced upward vertical motion near Salt Lake City.

Figure 3 shows the 24- and 36-hour NGM relative humidity prognoses. They show an area of 90 percent RH moving northeast through Salt Lake City by 36 hours. Why does this large area of moisture move through when the dynamics for upward motion appear to be weakening? It could be due to the model terrain and subsequent orographic lift. Is the moisture mainly just being advected along, but with little dynamic support to produce precipitation? These RH progs might appear "overdone" given the weak dynamic forcing.

In figure 4, a 4-panel display of the NGM 12Z, February 27, 1991 run is displayed in a series of time/height charts. In each display, time runs to the left. The right-most columns represent NGM analyzed fields up through 12Z, February 27, 1991, and then progressing left, each column represents 6-hour output through the 48-hour prognosis which is the left-most column. These figures were produced by the University of Utah Meteorology Department from NGM gridded model output. Each panel presents different fields for the NGM run at Salt Lake City. In figure 4a, winds (m/s) and RH are presented; RH greater than 70% is shaded. A deep layer of moisture is forecast to move over Salt Lake City between 24 and 30 hours with nearly saturated air from the surface to 200 mb. A trough passage can be seen at mid-levels between 36 and 42 hours, while no wind shift is present at low-levels. Figure 4b shows vorticity advection. At 500 mb, weak PVA can be seen at Salt Lake City between 24 and 36 hours as was seen in the AFOS graphics. However, strong PVA is forecast at 300 mb at this time. Thus, there is quite strong differential vorticity advection, and hence strong forcing indicated by the NGM. This was not evident in the 500 mb AFOS graphics, even when PVA by the thermal wind was considered. Figure 4c shows a kinematic vertical velocity calculated from NGM winds. It shows strong upward motion at 30 hours centered below 500 mbs. Figure 4d shows divergence of the Q-vectors (Hoskins et al., 1978). Convergence of Q-vectors is shown near 30 hours through a considerable depth of the atmosphere. This indicates good QG forcing for upward vertical motion.

In looking at the time/height sections for Salt Lake City from the NGM, it is easy to see that the model is forecasting strong dynamics to move through, and thus the high RH forecast seems reasonable, and precipitation would appear likely. This was not nearly so clear with the AFOS graphics as the strength of the dynamics associated with the trough appeared quite weak. It was also somewhat difficult to explain why such a large area of RH was moving northward in what appeared to be a rapidly weakening trough (at least at 500 mb).

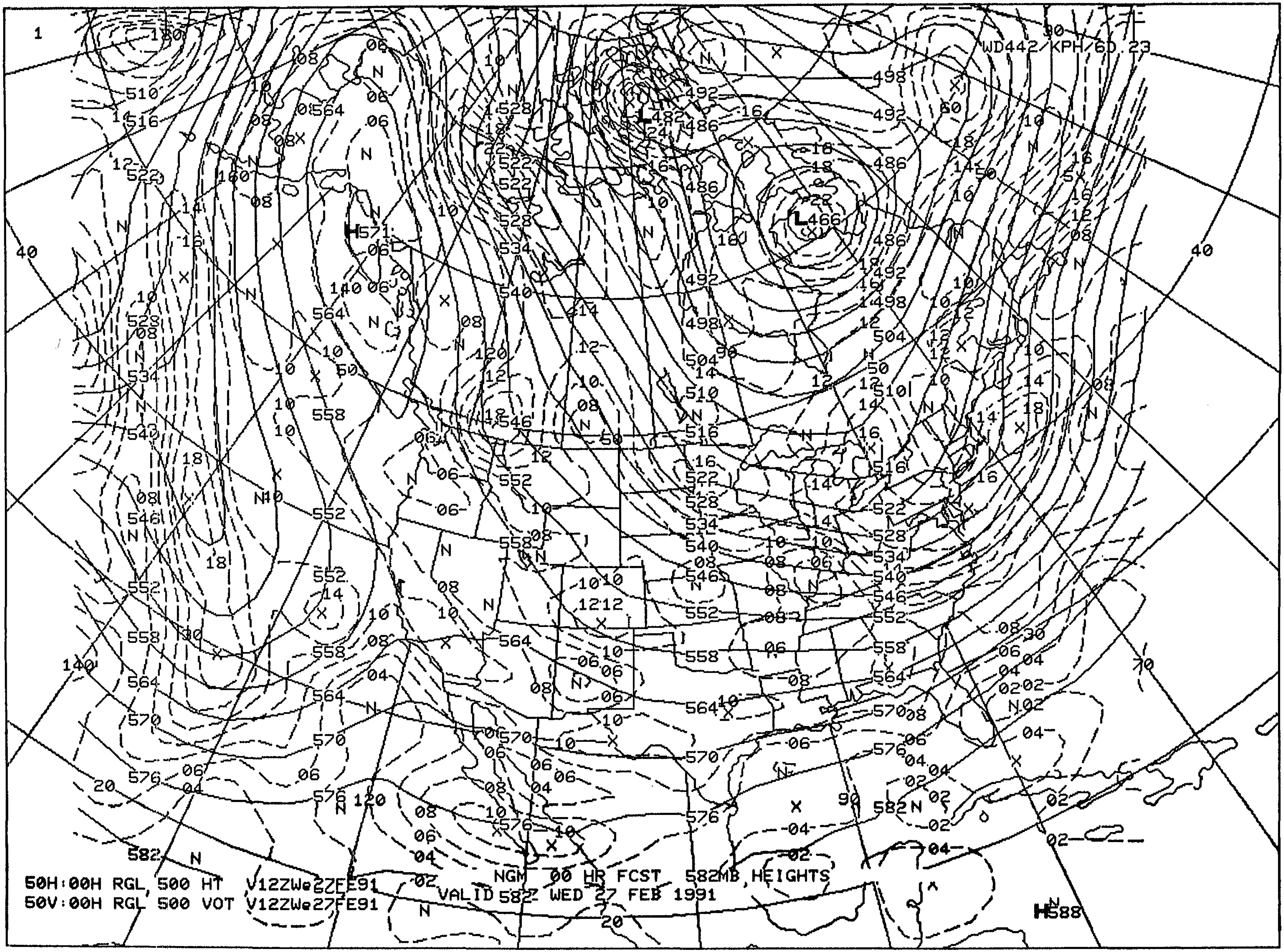
Rain began at Salt Lake City at 1645Z, February 28, 1991, about 29 hours into the NGM forecast presented in this TA. The NGM verified quite well at Salt Lake City. If a forecaster is to be able to use and interpret model output correctly and with understanding, it is clear that better tools are required than the limited graphics available on AFOS.

Model output in gridded form is currently available at the Denver and Norman WSFOs as part of the modernization risk reduction activities. It is also available at the National Centers. Plans are to distribute gridded model output nationally when AWIPS is deployed. However, this output is available commercially, and many university meteorology departments are currently using the data. Western Region SSD is currently developing capabilities to process and display gridded model output in a 386-based system. It is not yet clear how this large volume of data will be made available to field offices, but it is clear that this capability is desirable and efforts are underway to make this happen as soon as possible.

References

Hoskins, B. J., I. Draghici, and H. C. Davies, 1978: A new look at the omega-equations. *Quart. J. Roy. Meteor. Soc.*, **104**, 31-38.

Trenberth, K. E., 1978: On the interpretation of the diagnostic quasi-geostrophic omega equation. *Mon. Wea. Rev.*, **107**, 682-703.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NGM 00 HR FCST 582MB HEIGHTS
VALID 582Z WED 27 FEB 1991

Fig. 1A

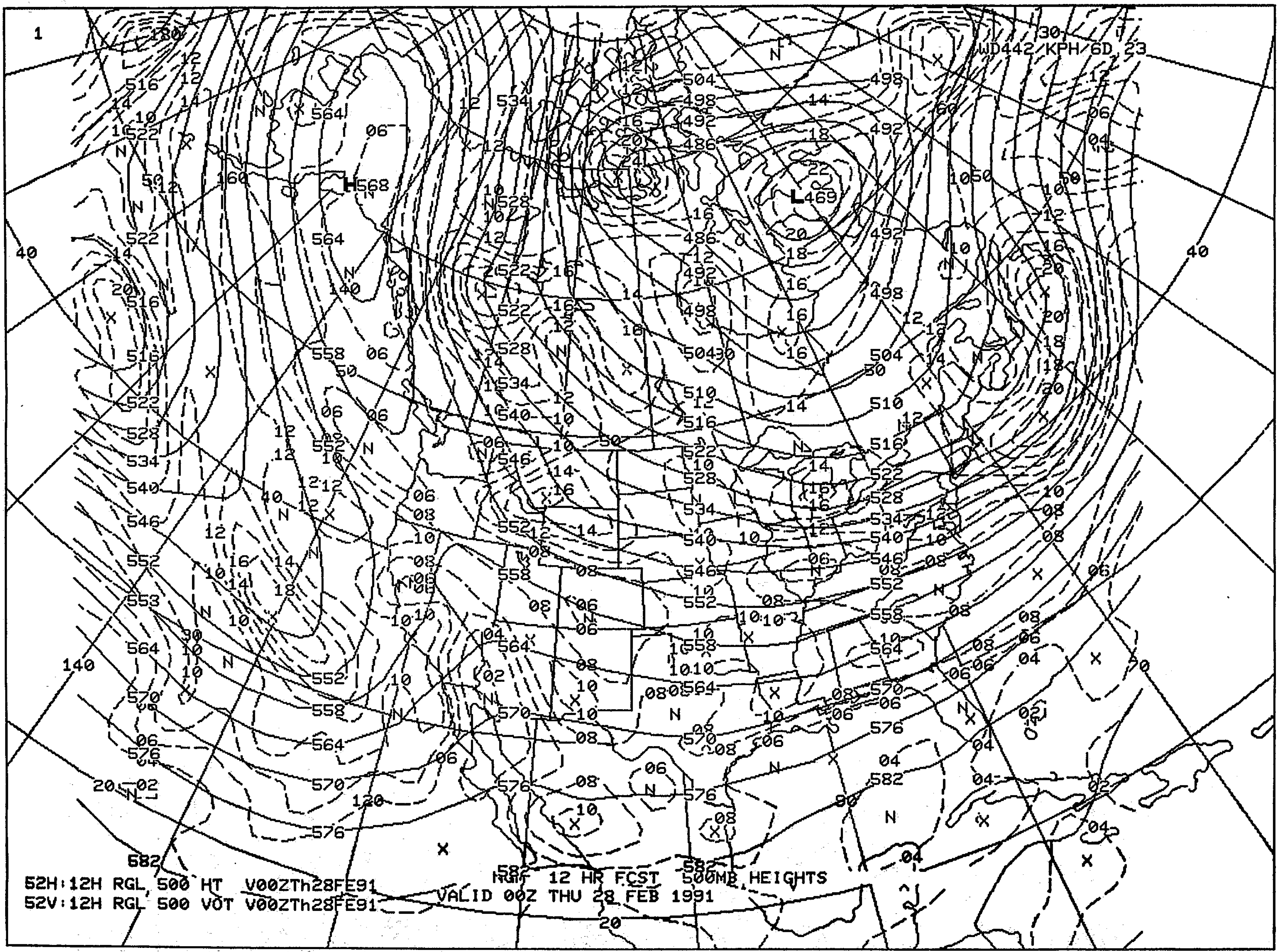
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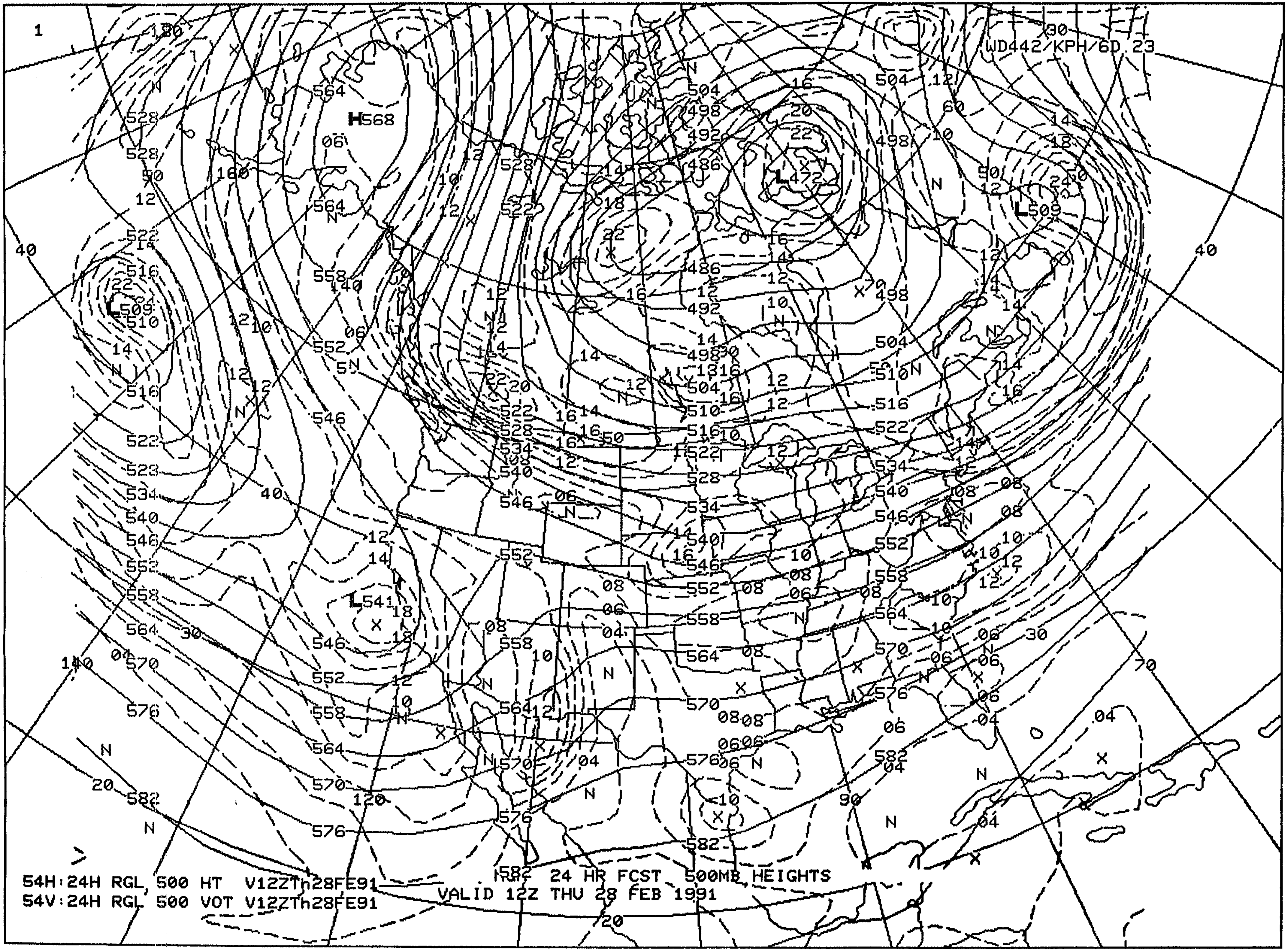
Fig. 1B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VALID 12Z THU 28 FEB 1991
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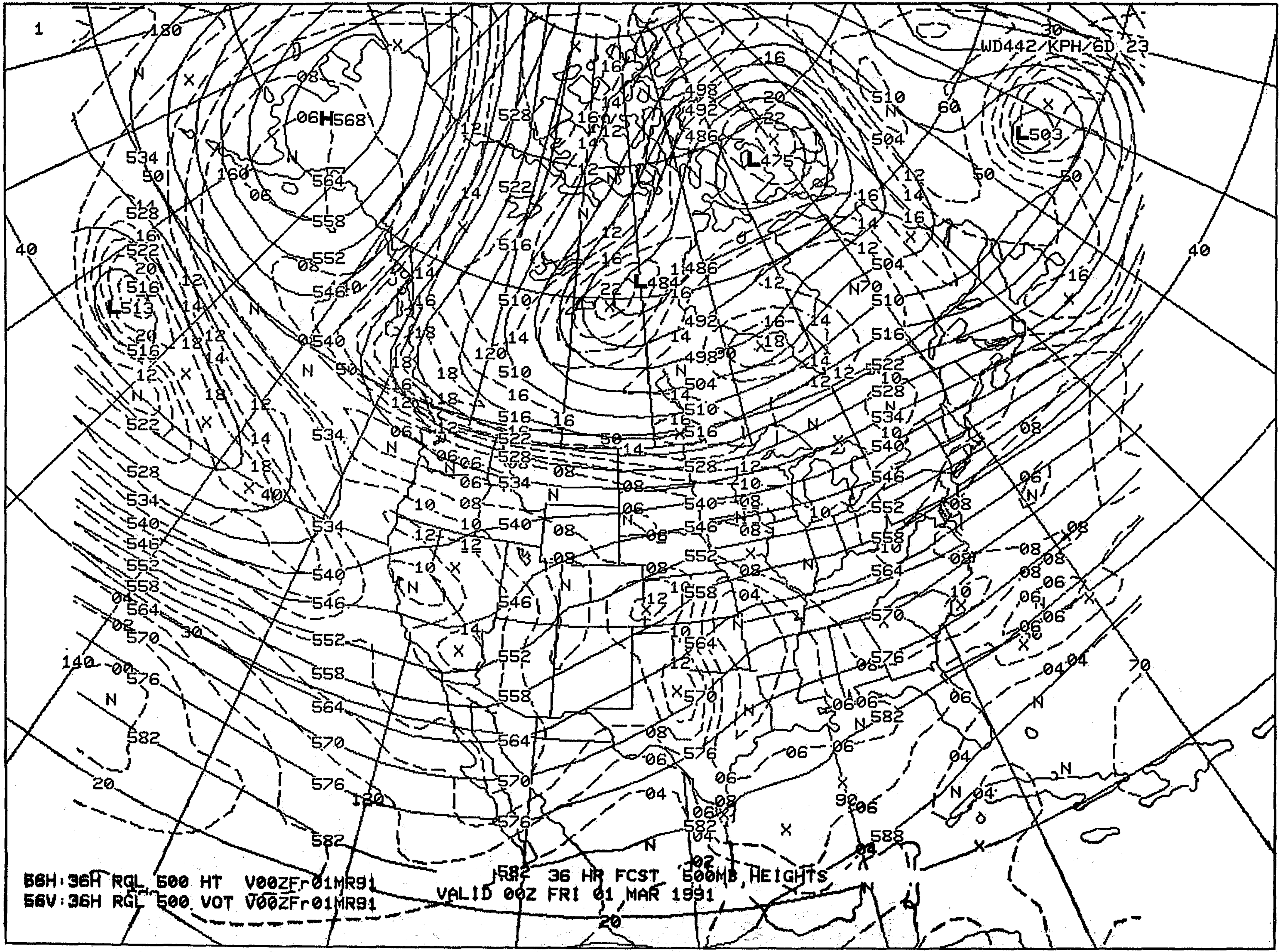
L472
L509
L509
L541

Fig. 1C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RAF 36 HR FCST 500MB HEIGHTS
VALID 00Z FRI 01 MAR 1991
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H 568
L 484
L 475
L 503
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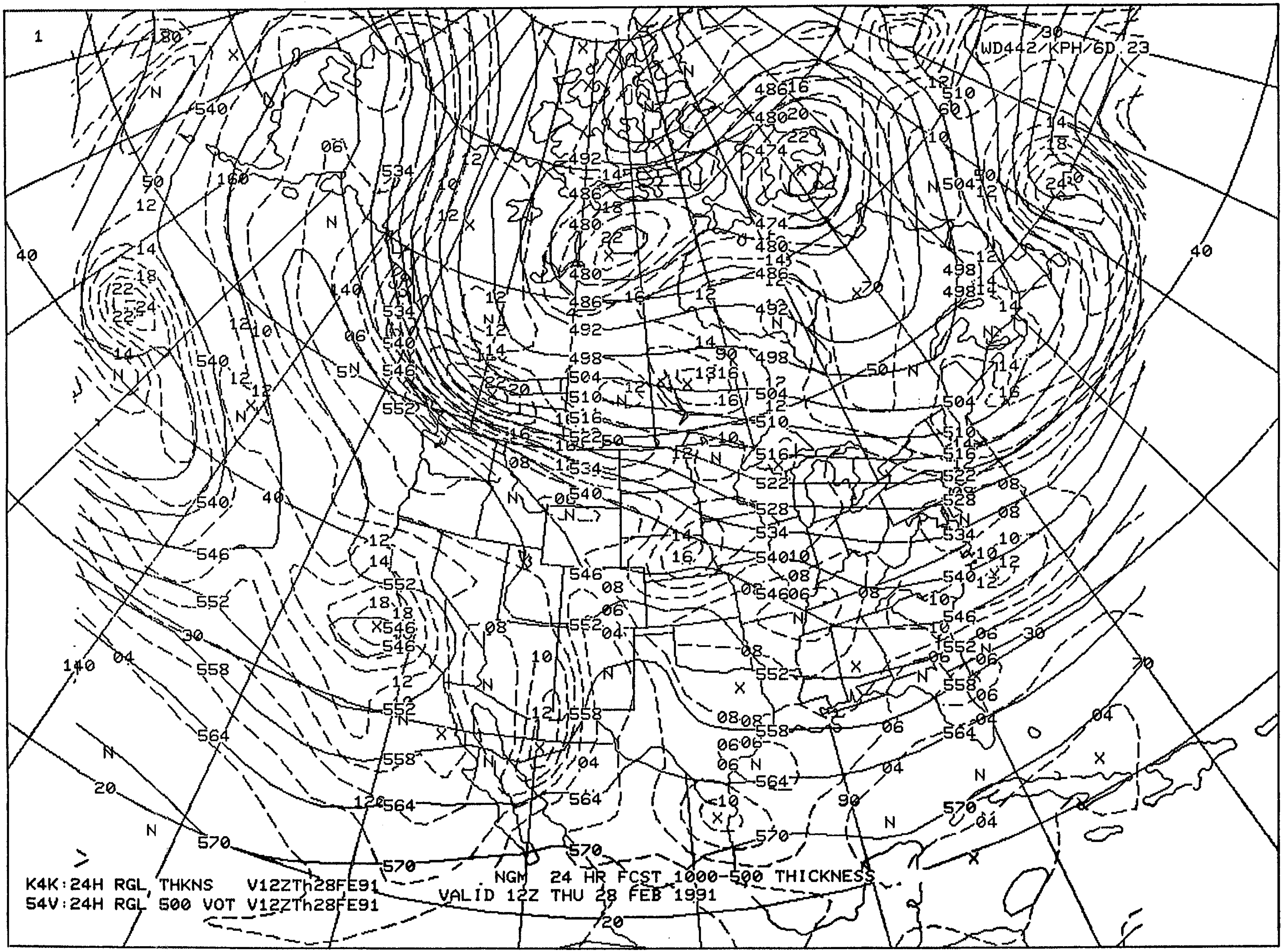
160
140
120
40
70
90
20

Fig. 1D

1
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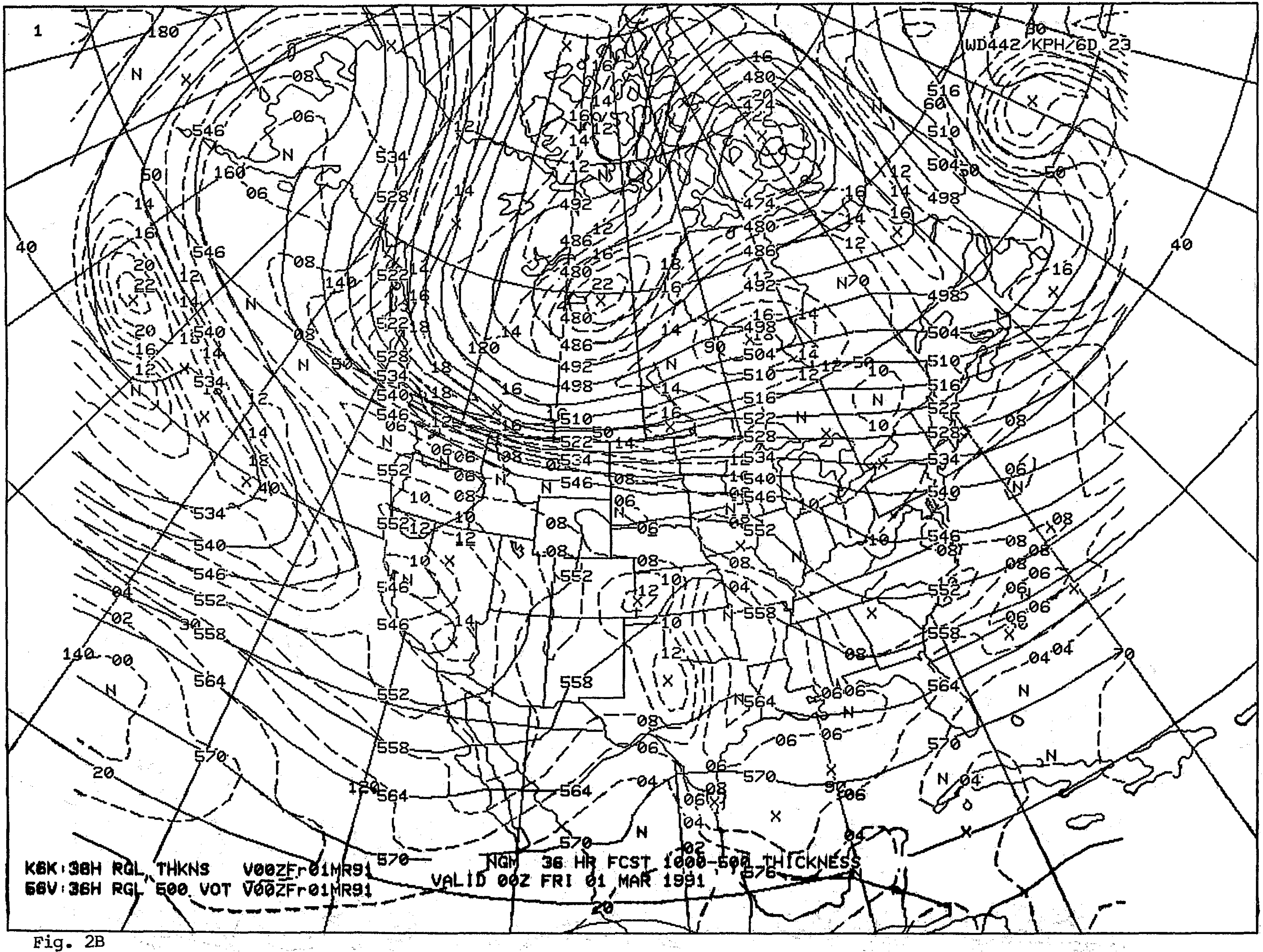
VALID 12Z THU 28 FEB 1991

Fig. 2A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VALID 00Z FRI 01 MAR 1991

Fig. 2B

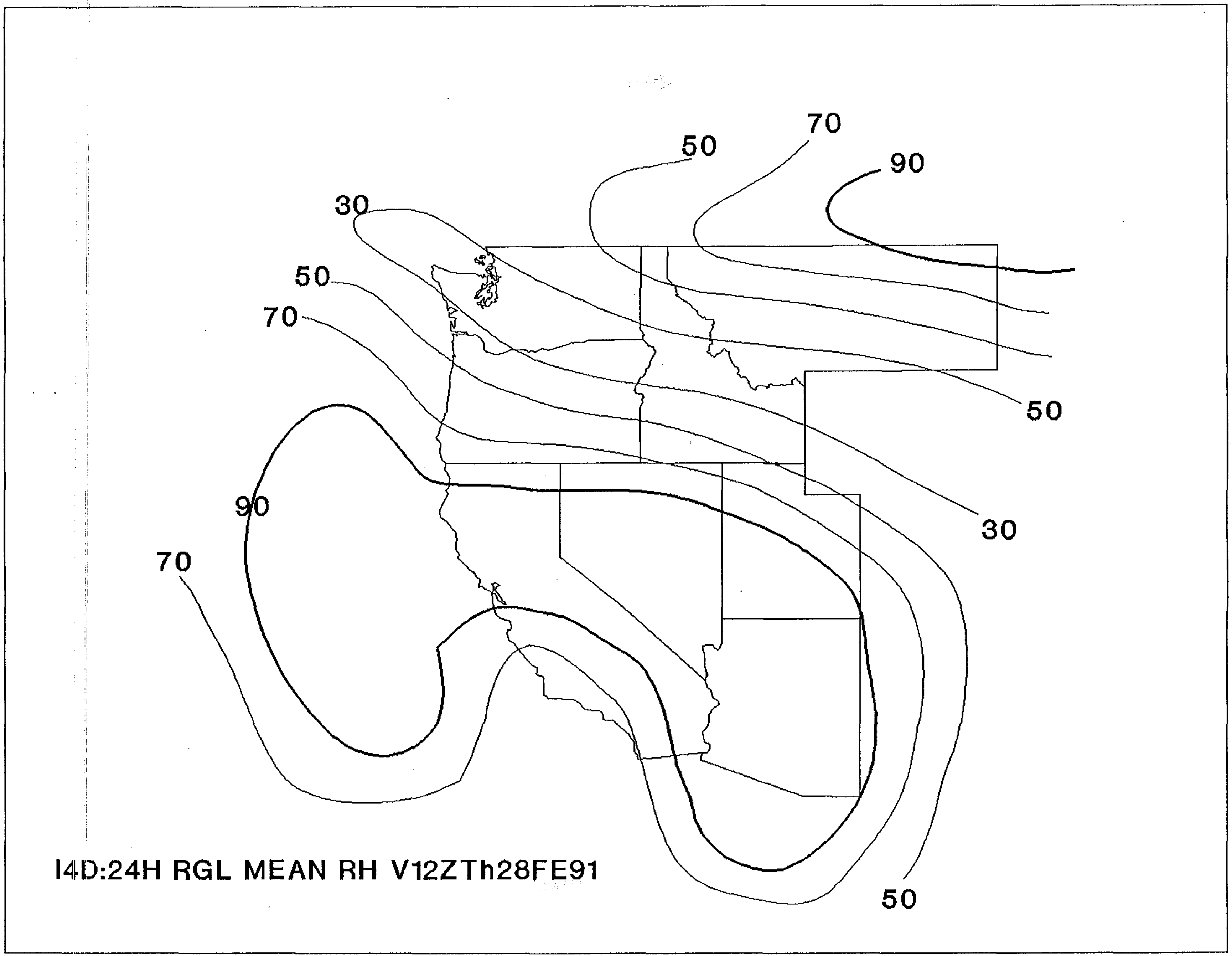
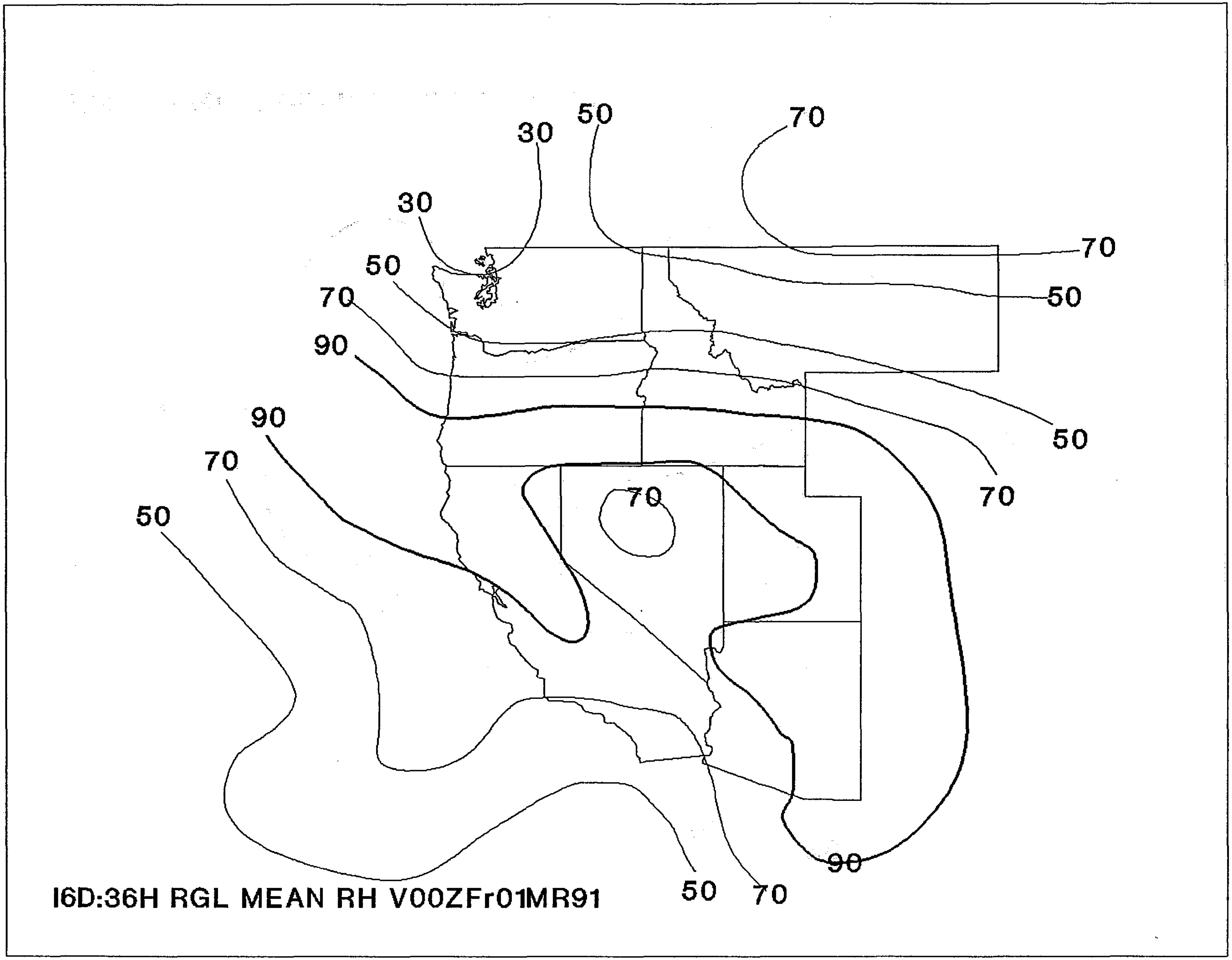


Fig. 3A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50
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90
90
70
50
70
50
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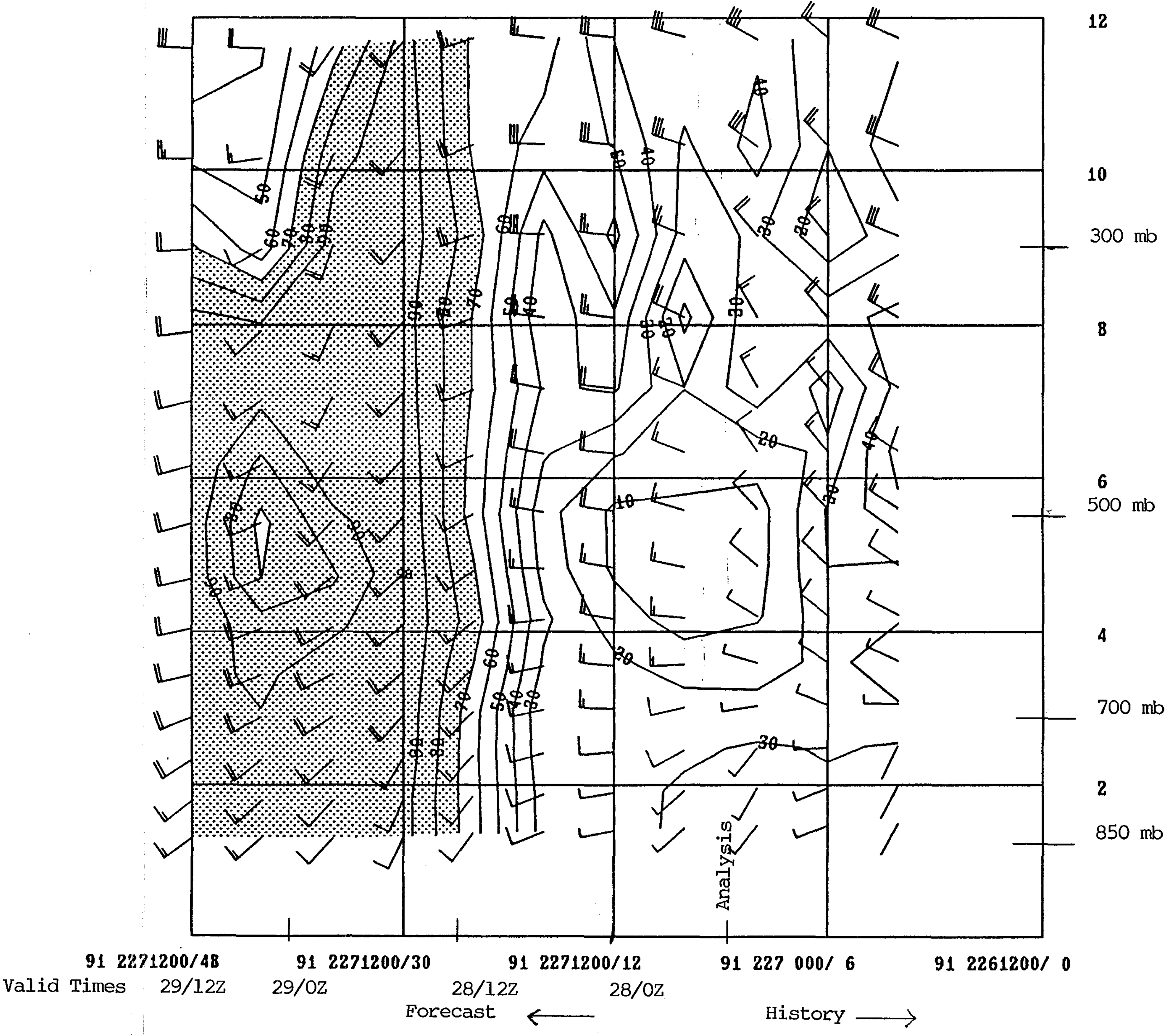
50
70
I6D:36H RGL MEAN RH V00ZFr01MR91

Fig. 3B

Fig. 4A

Time-height section for SLC from NGM - Feb. 27, 12Z
Relative humidity > 70% shaded



Vorticity Advection - Salt Lake City From NGM - February 27, 12Z

Fig. 4B

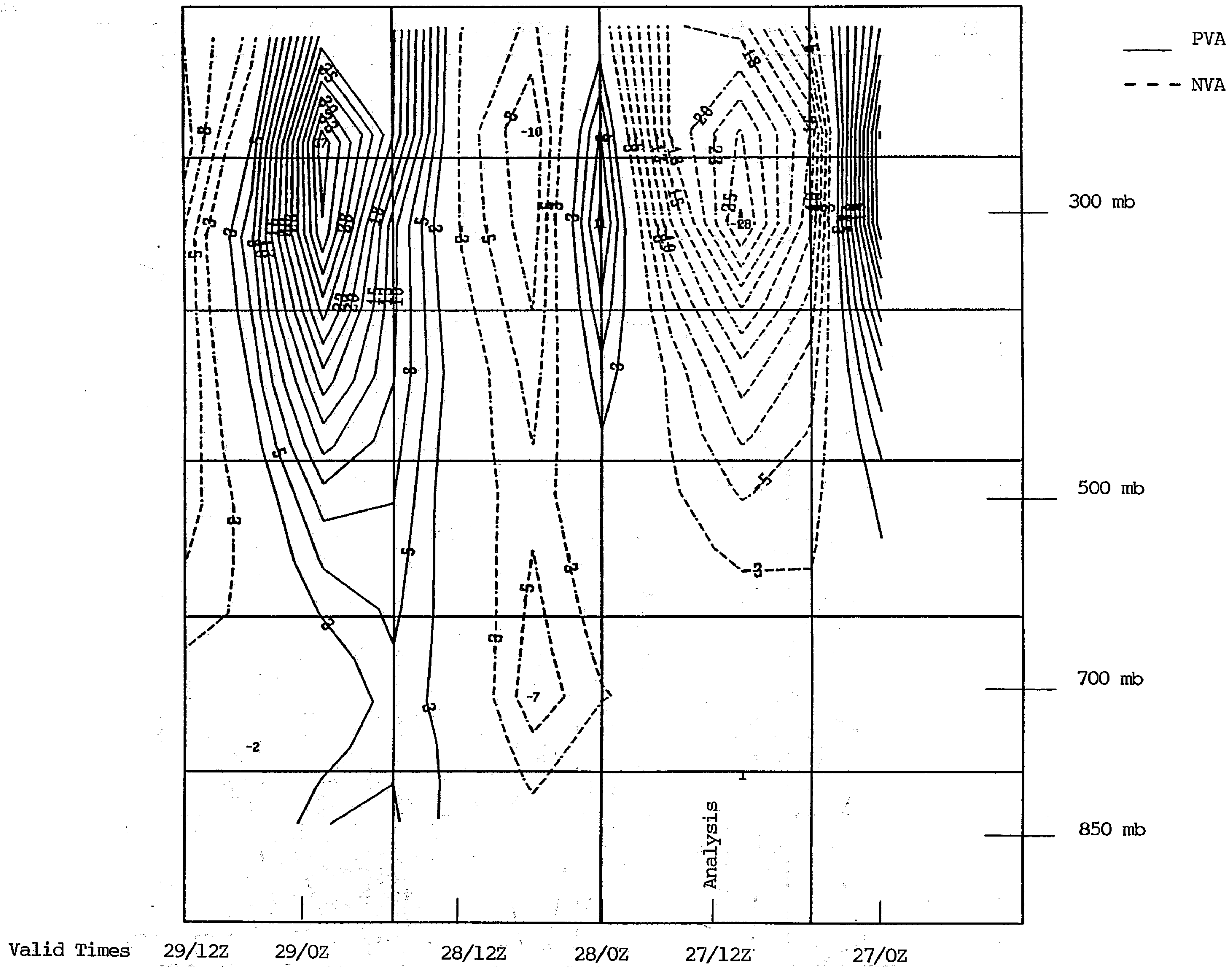


Fig. 4C Diagnostic Vertical Velocity - Salt Lake City From NGM - February 27, 12Z

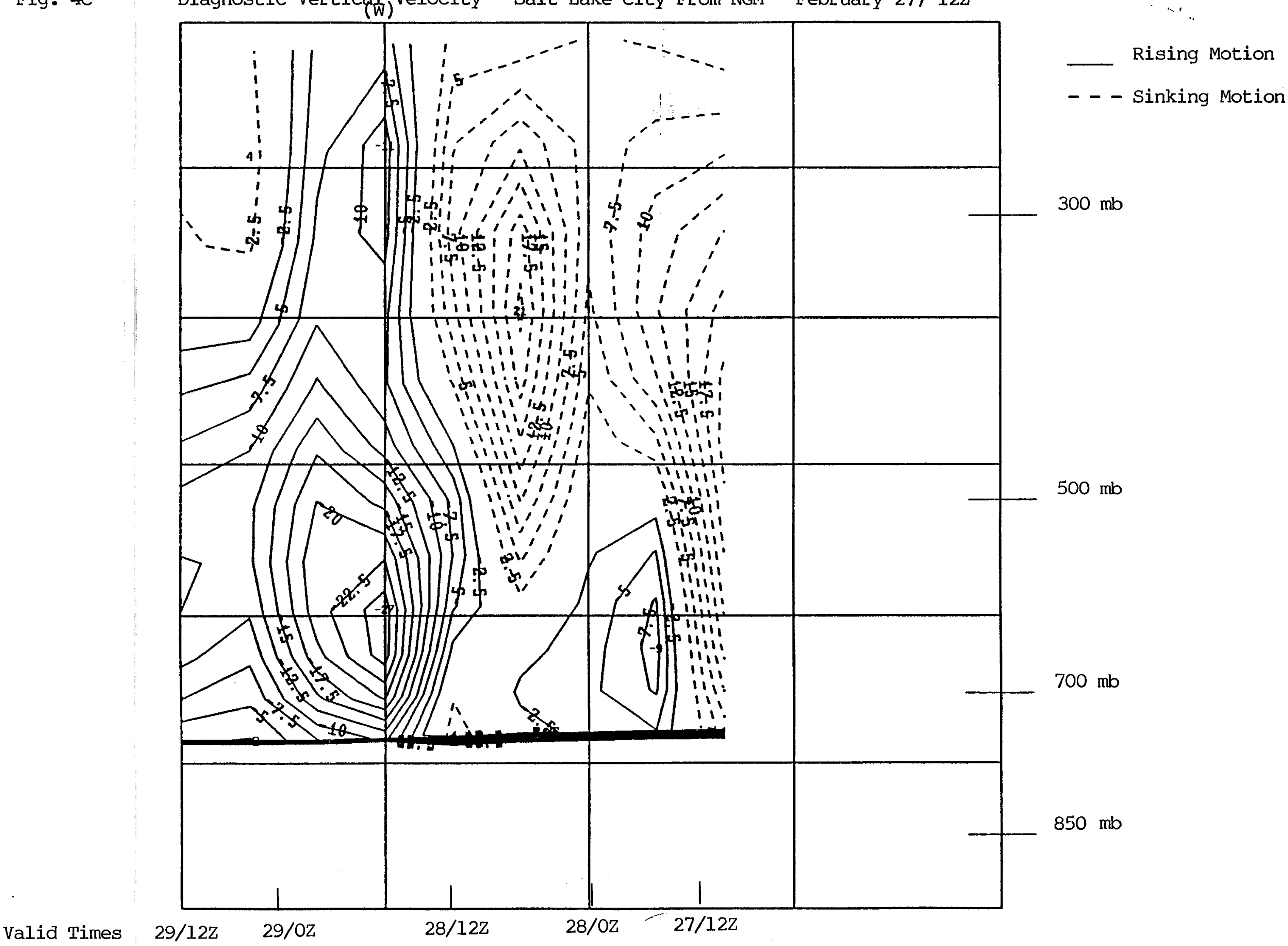


Fig. 4D Div-Q - Divergence of Q-Vector - Salt Lake City From NGM - February 27, 12Z