Western Region Technical Attachment
89-21
August 1, 1989

ANOTHER EXAMPLE OF A MADDOX TYPE I FLASH FLOOD PATTERN IN THE GREAT BASIN

A March 1988 Western Region Technical Attachment (TA No. 88-12) discussed a classic example of a Maddox Type I flash flood situation in the Great Basin, which occurred in June of 1987. The basic synoptic situation associated with these types of events, although frequently not depicted well by NMC analyses, is a weak upper-level (500 mb) short-wave trough moving northward over the west side of a long-wave ridge, with instability and deep moisture ahead of it. [See also Maddox, et al, 1980.] Figure 1 is taken from the 1988 TA, and shows the Aviation model 500 mb initial analysis of heights and vorticity for 00Z June 7 in the upper-left, and the 12 and 24 hour forecasts below that. On the right is the NGM 700 mb height and relative humidity (RH) fields starting with the initial analysis in the upper-right. During the afternoon and evening of June 6, 1987, about the time of the analyses in Figure 1, there were many reports of heavy rainfall in the Salt Lake Valley (around a half an inch in less than 30 minutes), as well as some strong wind gusts. The next day, severe conditions developed from southeast Washington, through Idaho, and into Wyoming, where the Cheyenne WSFO issued a severe thunderstorm warning, tornado warning, and flash flood warning.

A similar event occurred in July of 1989 over approximately the same region. Figures 2a and 2b show the Aviation and NGM initial analyses of the 500 mb height and vorticity fields for 12Z on July 12. Both models compare favorably in the location of a weak short wave over Nevada and Utah. The pattern is remarkably similar to the June 1987 situation. Figure 2c shows the NGM 700 mb RH field the next morning to be much like the forecasted 700 mb NGM moisture pattern during the second morning of the 1987 event (Figure 1, lower right). The Salt Lake City sounding on the morning of July 12, 1989, and the Great Falls sounding that same evening both indicate how unstable the air mass was ahead of the short-wave trough (Figures 3a and 3b).

There was another interesting forecast problem that was present on July 12. A second, and much weaker, short wave was depicted just off the coast of California by both the Aviation and NGM analyses (Figure 2a and 2b). [It is interesting to note that there was also a similar secondary short wave in this vicinity during the June 1987 event (Figure 1).] Weak short waves over the ocean such as this one require a search of all evidence to determine if they are indeed "real" or not. In this case, visible and IR satellite imagery showed no clouds in the immediate vicinity of the location where the models placed the short wave at 12Z (Figure 4d). Even water vapor imagery at 12Z did not show any clear evidence by itself (Figure 4c). Only by going back and looking at the water vapor imagery several hours prior to 12Z, was it possible to see the dark region associated with cold air advection and subsidence behind the short wave (indicated by the white arrows in Figures 4a and 4b). Looping these water vapor images clearly identified the short wave. The Satellite Interpretive Message (SIM) from the NSSFC in Kansas City confirmed that a vorticity maximum could be seen only in water vapor imagery. After 12Z, however, there was no longer any evidence the short wave was there.

By Wednesday afternoon (July 12), heavy thunderstorms had developed over the Salt Lake Valley as well as parts of Idaho and Wyoming. These storms produced local amounts of one inch or more of rain in short periods of time in the Salt Lake Valley, and caused flash flooding in southwest Wyoming later in the evening as they intensified. Already at 19Z, convective precipitation associated with the primary short wave could be seen on the IR satellite image to be developing in Utah, and was well underway in Idaho and Wyoming (Figure 5a). Meanwhile, the 19Z satellite image also indicated convection beginning to develop in central Nevada, associated with the weak secondary short wave.

Figures 5b and 5c show that by Wednesday evening, most of the heavy precipitation associated with the primary short wave had moved into Montana, with some isolated storms moving out of northern Utah and into southwestern Wyoming. The storms associated with the secondary short wave had become very intense and were moving to the northeast into Utah. The 24-hour accumulated lightning strike pattern from the next morning (Figure 5d) shows further evidence for a primary and a secondary short wave influence on the convection.

By Thursday morning (July 13), the secondary short wave appeared to have moved into northeast Wyoming, while the primary short wave was in northwestern Montana. The visible/IR composite image (Figure 6a) shows a distinct comma shape in the cloud pattern in southeastern Montana and northeastern Wyoming, with enhanced tops just to the northeast of the vorticity maximum location. A large area of enhanced tops associated with the main short wave indicated that most of the heavy precipitation had moved into Canada. The NGM 500 mb height and vorticity analysis valid 12Z July 13 shows the main vorticity center in northwest Montana, with a significant vorticity lobe extending to the southeast over northeast Wyoming. Apparently, the secondary short wave caught up to the primary short-wave trough and intensified in the lee of the Rockies.

The precipitation pattern for Thursday July 13 is shown in Figure 6b. The data is a combination of standard surface observations and a network of GOES satellite platform data. The pattern reflects the locations of the primary and secondary short waves as they moved through northwest Montana and northeast Wyoming, respectively.

Western Region forecasters did a very good job with a potentially surprising situation. Still, much can be learned from this particular case. The emphasis here is twofold. To reiterate one of the points in the 1988 TA, it is important to be able to recognize certain patterns that show up from time to time, especially those that are associated with significant weather situations. In this case, the pattern was very similar to the June 1987 flash flood event, and the results were just as similar. The second point of emphasis in this paper is the importance of examining water vapor imagery (and all possible data for that matter) to verify the existence of features depicted on model analyses (especially over the ocean). The weak short wave off the coast of California was only evident in the water vapor imagery, and only for a short period of time as it soon became invisible again, until convection eventually developed over Nevada. It then intensified into a significant short wave which resulted in heavy rainfall over eastern Wyoming and Montana. The ability to identify weak upper-level impulses, and also to recognize them as potential weather producers well ahead of time, in many cases can make a world of difference in the forecast.

References:

Carle, Ed, 1988: "An Example of a Maddox Type I Flash Flood Event in the Great Basin", Western Region Technical Attachment No. 88-12, March 29, 1988.

Maddox, R.A., L.R. Hoxit, and F. Conova, 1980: "Meteorological Characteristics of Heavy Precipitation and Flash Flood Events over the Western United States." NOAA Technical Memorandum ERL APCL-23.

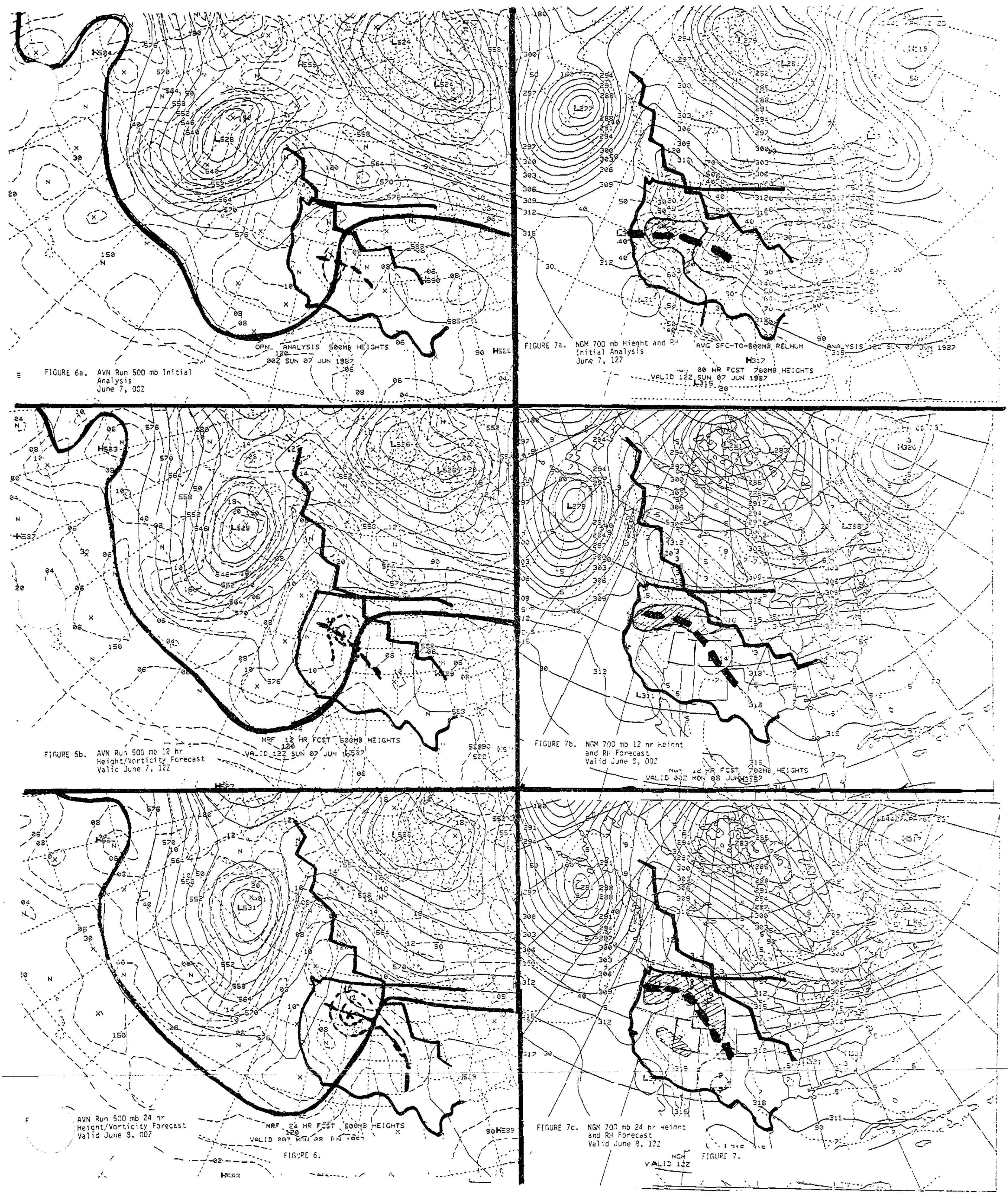


Figure 1. From WR Technical Attachment
No. 88-12

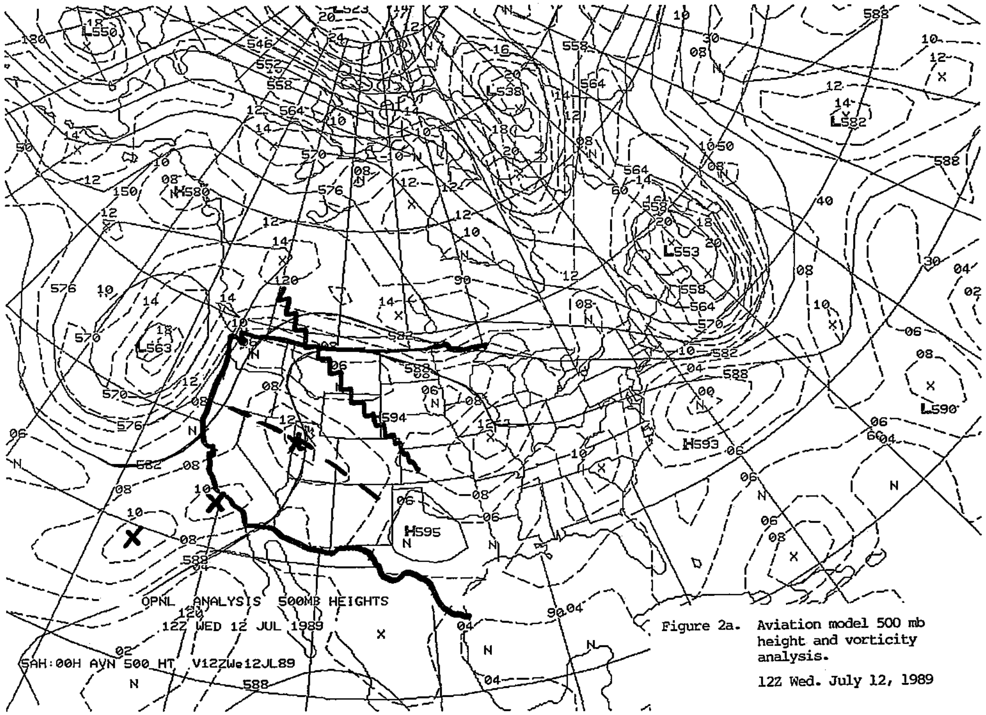


Figure 2a. Aviation model 500 mb height and vorticity analysis.
12Z Wed. July 12, 1989

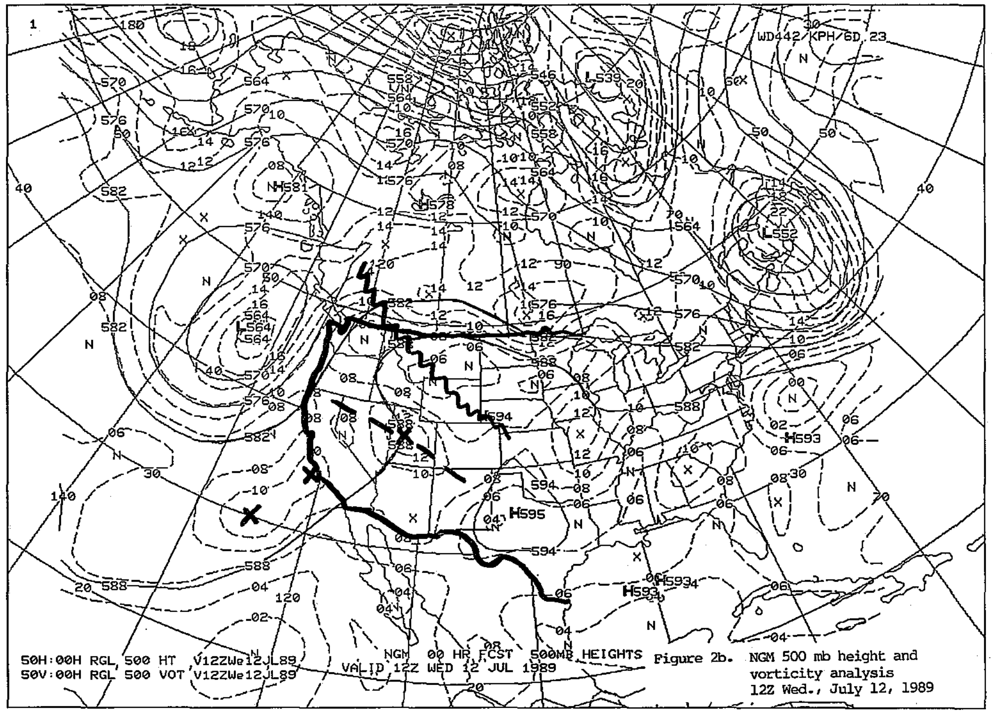


Figure 2b. NGM 500 mb height and vorticity analysis
12Z Wed., July 12, 1989

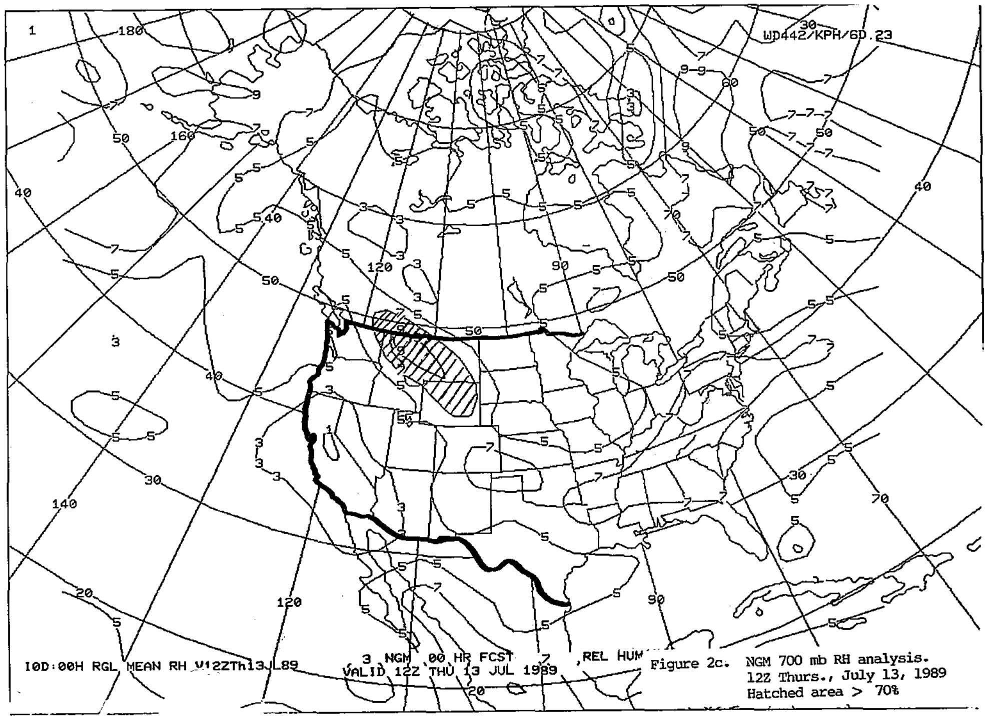


Figure 2c. NGM 700 mb RH analysis.
12Z Thurs., July 13, 1989
Hatched area > 70%

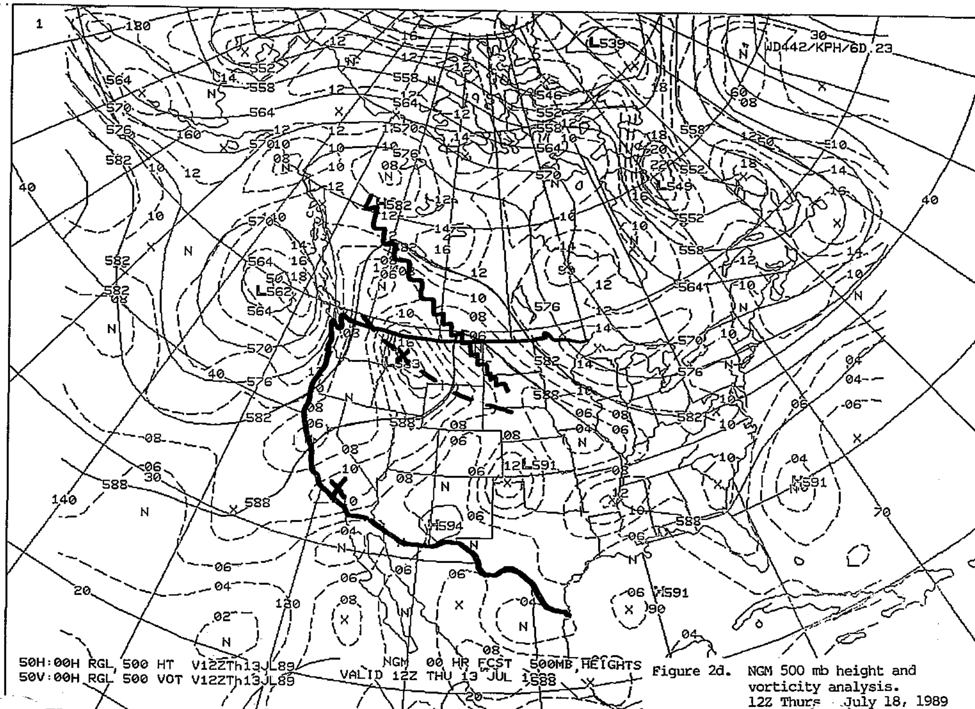
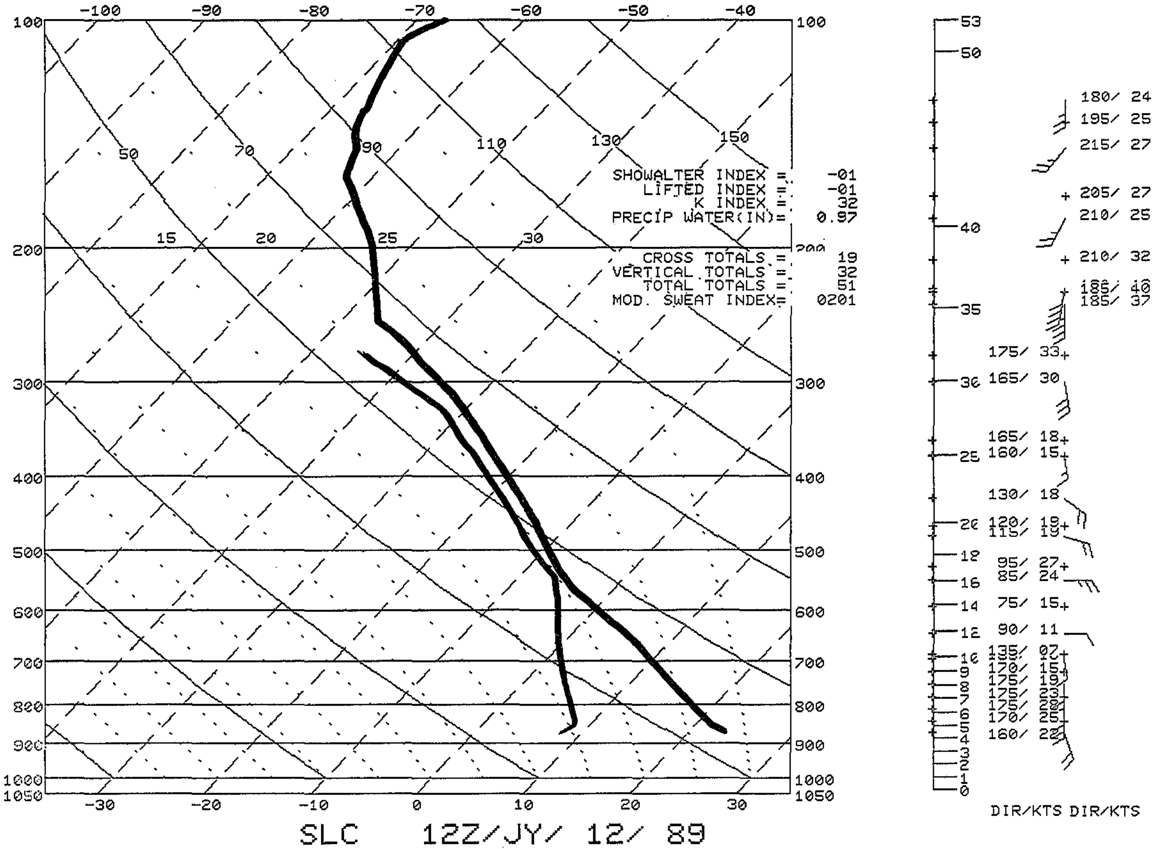


Figure 2d. NGM 500 mb height and vorticity analysis.
12Z Thurs. July 18, 1989



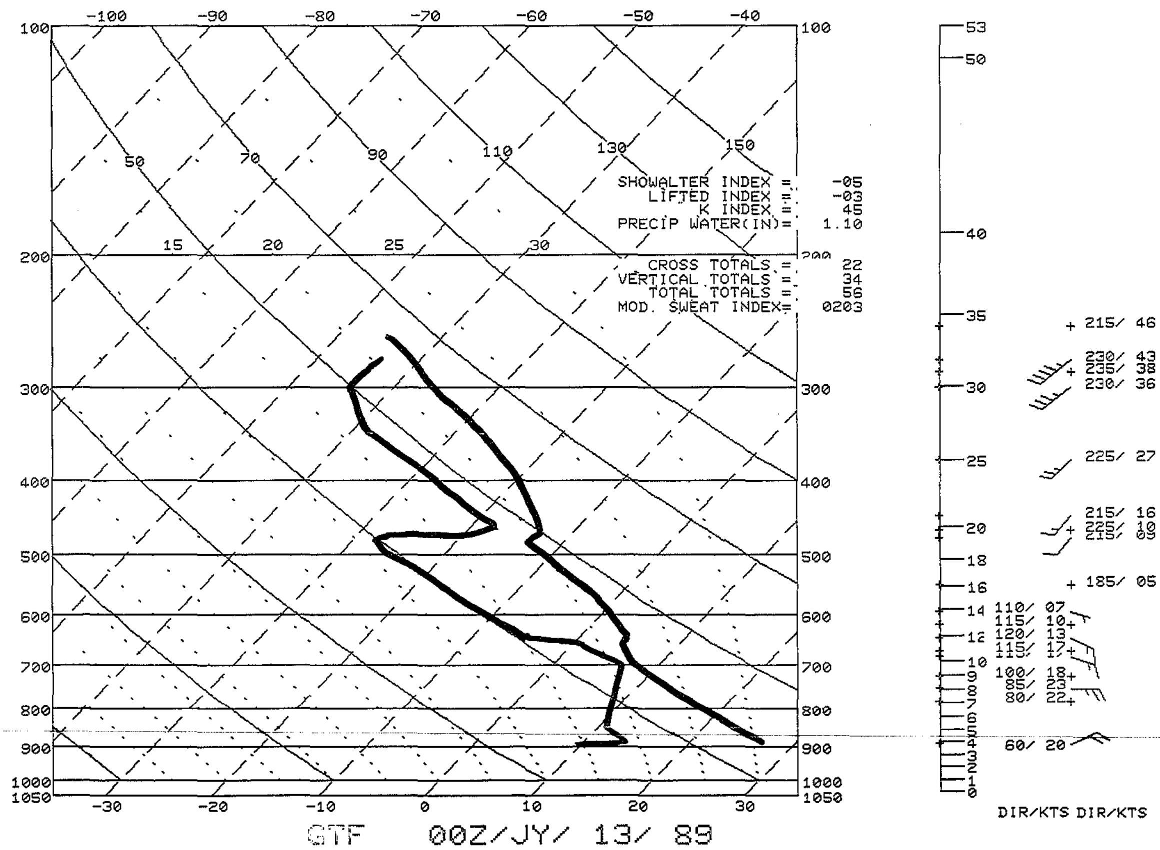


Figure 3a (top)
Salt Lake City sounding
12Z (Wed. morning) July 12, 1989

Figure 3b (bottom)
Great Falls sounding
00Z (Wed. evening) July 13, 1989

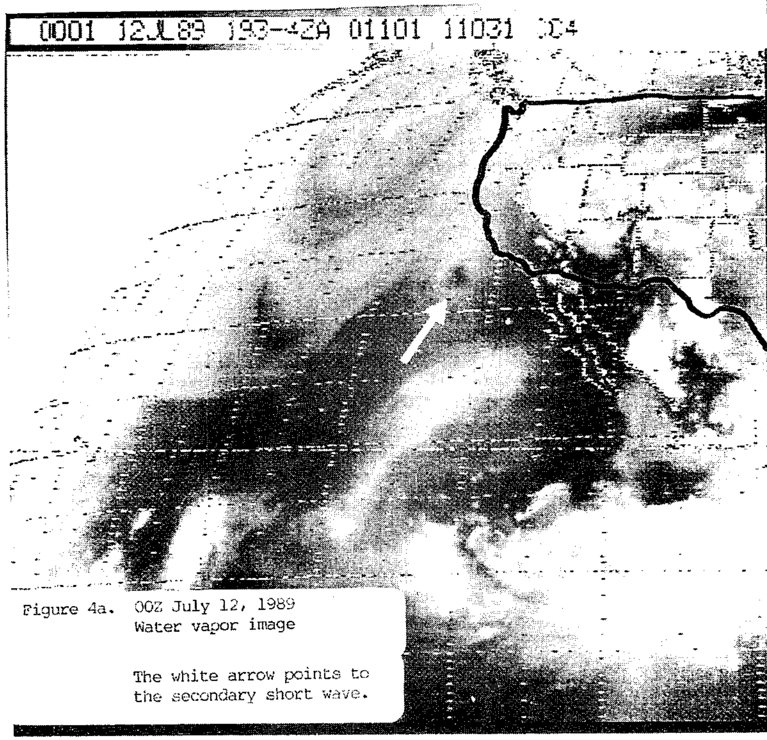


Figure 4a. 00Z July 12, 1989
Water vapor image

The white arrow points to the secondary short wave.

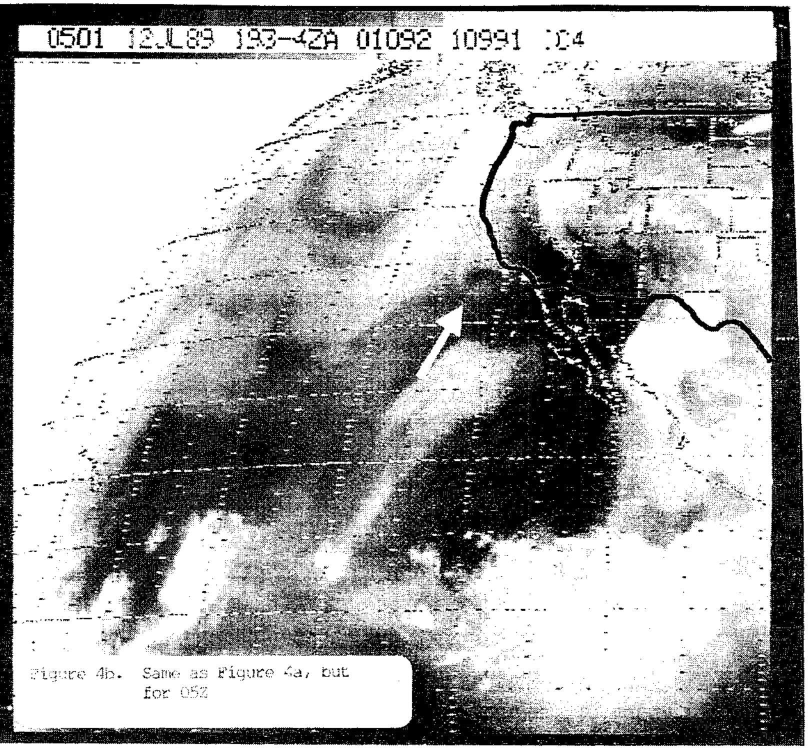


Figure 4b. Same as Figure 4a, but for 05Z

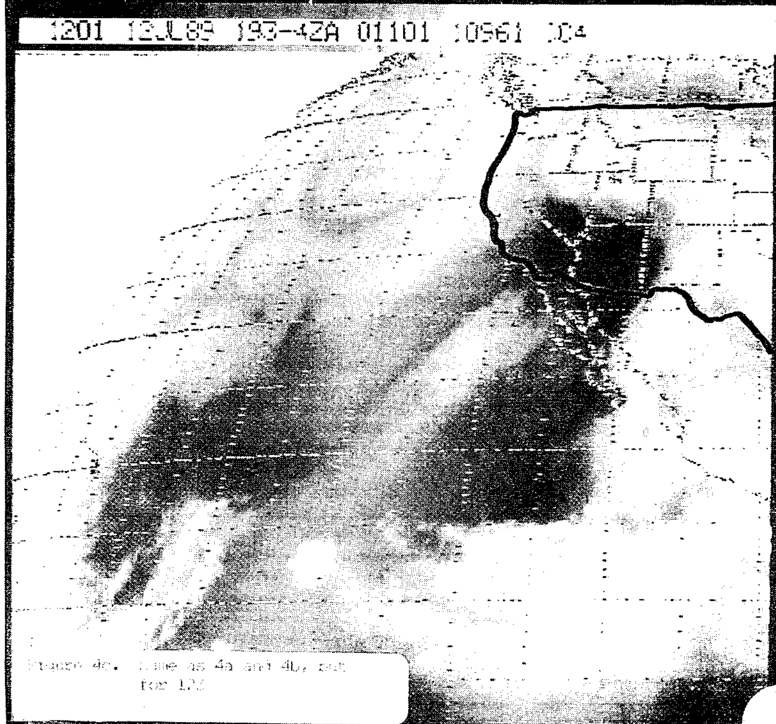


Figure 4c. Same as 4a and 4b, but for 12Z

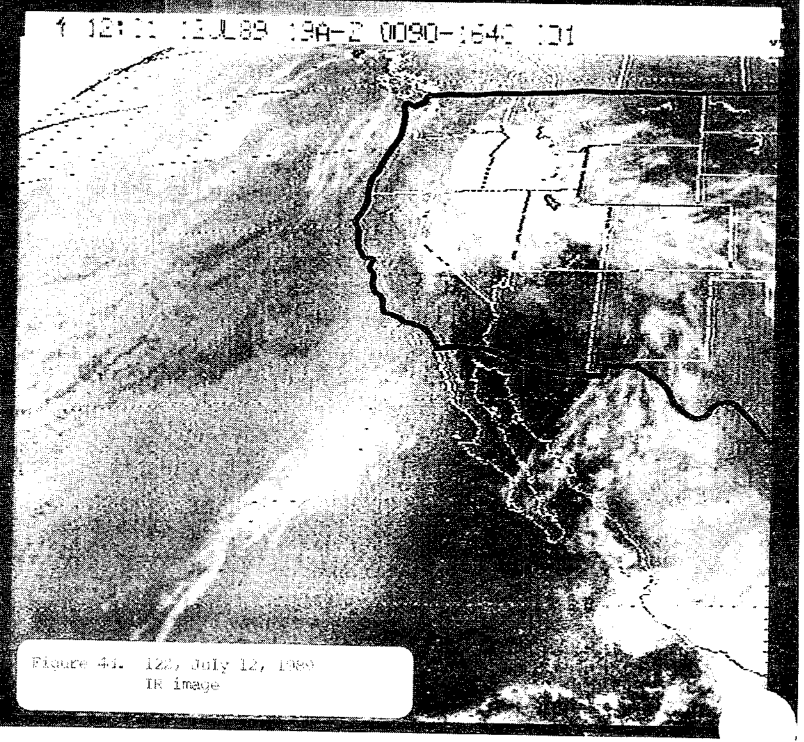


Figure 4d. 12Z, July 12, 1989
IR image

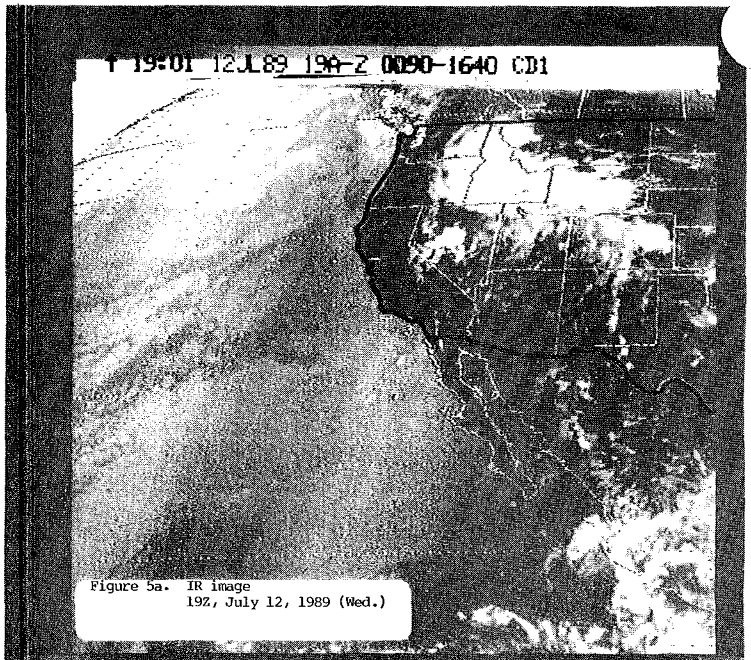


Figure 5a. IR image
19Z, July 12, 1989 (Wed.)

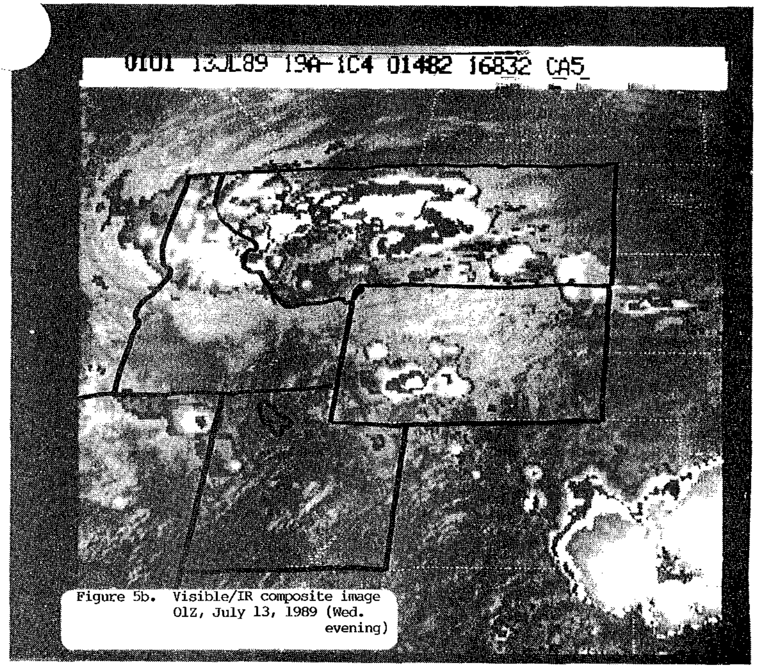


Figure 5b. Visible/IR composite image
01Z, July 13, 1989 (Wed. evening)

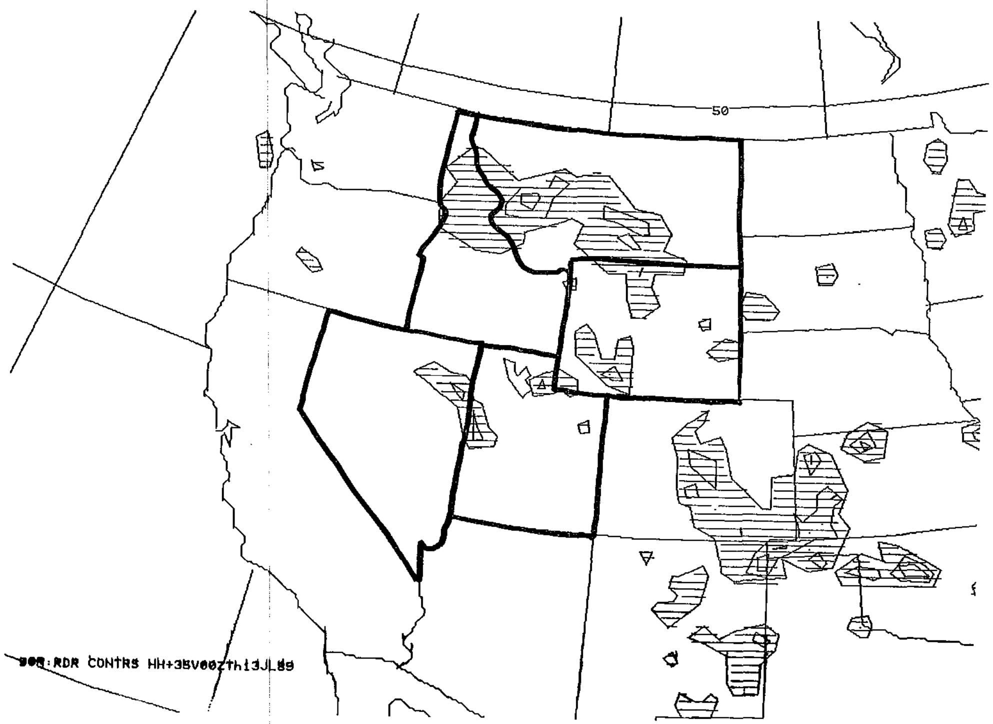


Figure 5c. Radar summary at 0Z
July 13, 1989 (Wed. evening)

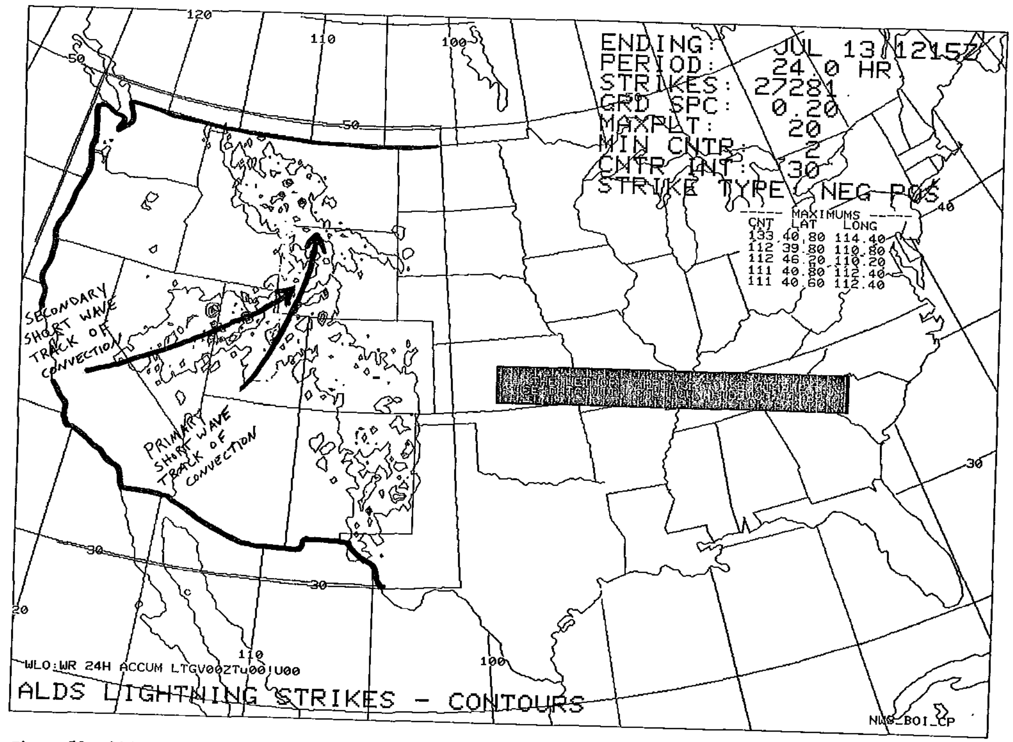


Figure 5d. 24 hr accumulated lightning
strikes from 12Z July 12 -
12Z July 13 (Regional Graphic

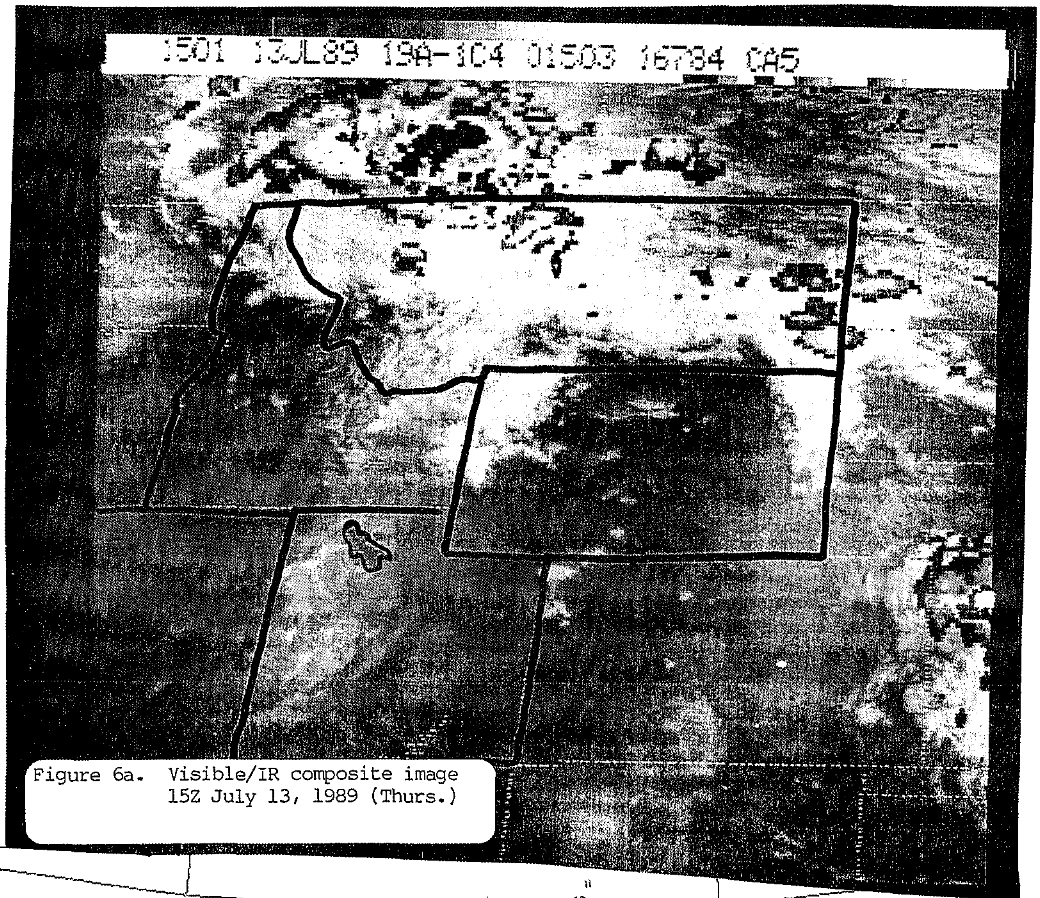


Figure 6a. Visible/IR composite image 15Z July 13, 1989 (Thurs.)

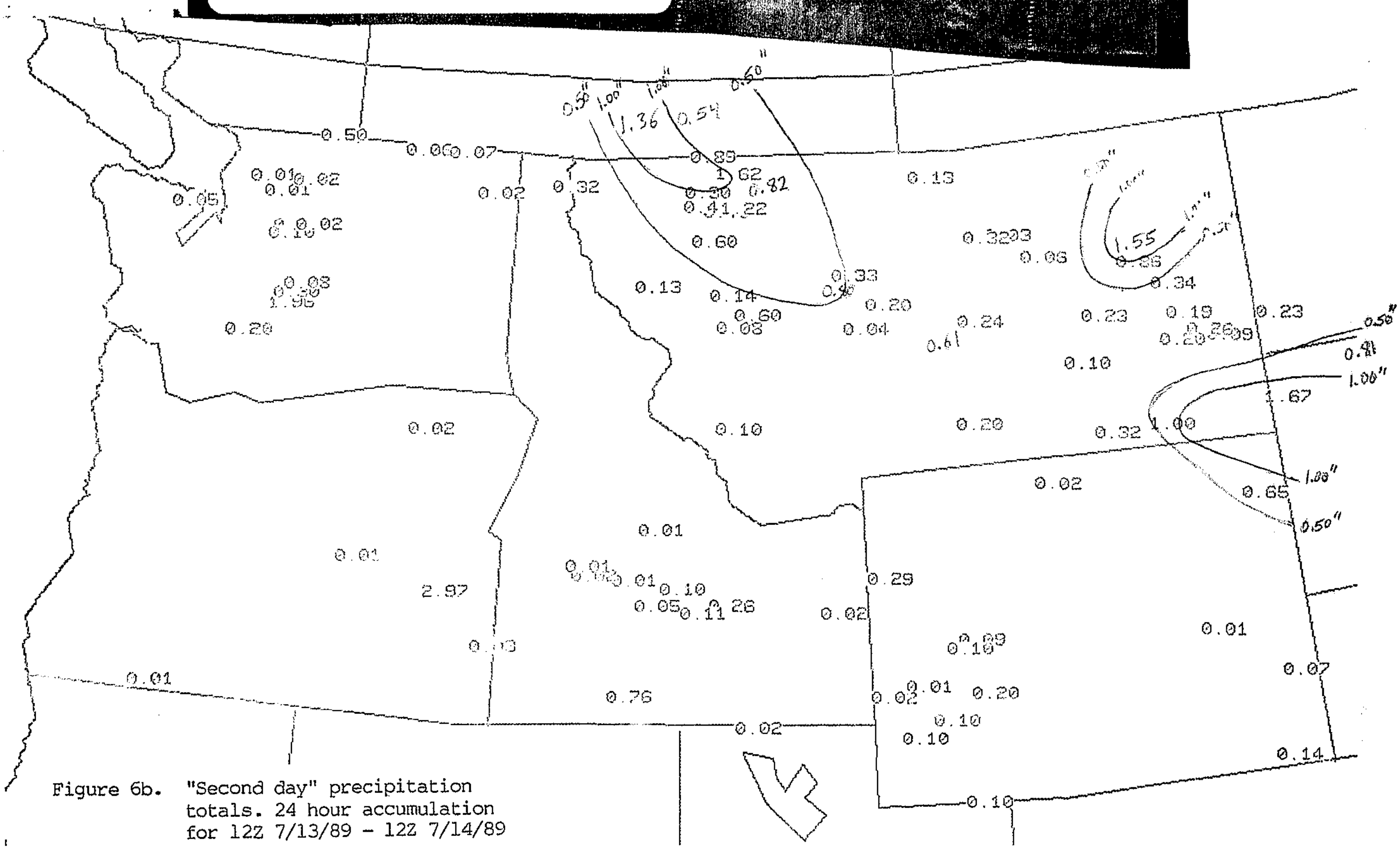


Figure 6b. "Second day" precipitation totals. 24 hour accumulation for 12Z 7/13/89 - 12Z 7/14/89

12 Z Fri. 7/14/89 24 hr PRECIP