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HEAVY RAINFALL IN NORTHWEST UTAH

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Two good examples of heavy rainfall producing events in Utah occurred July 8 and 9, 1984. During the prior few days, the airmass over the state was slowly becoming more moist and unstable, but it wasn't until the morning of July 8 that the key ingredients necessary for heavy rainfall, and/or flash flooding materialized.

The first key ingredient was precipitable water (PW) which had increased over all of the state (see Figure 1). A rule of thumb is that about an inch of PW is required before any serious flash flooding will occur in Utah [1]. Although the PW was a little less than an inch on the morning of July 8, it was expected to increase to about one inch, as tropical moisture continued to stream northward from Arizona into the state (see Figure 2). In addition K values and Showalter indices were in the ballpark already and were also expected to become increasingly favorable for convection (see Figures 3 and 4).

With moisture available for a heavy rainfall producing event, the next question was what area was most likely to be affected? The most likely location appeared to be somewhere in northwestern Utah because there was still an old weak frontal boundary in this area. Although somewhat difficult to pinpoint, there were some good clues. This included continuity on the station's surface analyses which indicated a surface cold front had moved into northwestern Utah but had never progressed any farther south. The thickness analysis (see Figure 5), and the station's 700 mb analysis (see Figure 6) also indicated a boundary between colder and warmer air masses. Finally, there was a distinct boundary between the cooler drier and the warmer more moist airmasses at the surface (see Figure 7). The second key ingredient then was the old surface frontal zone which was likely to act as the focusing mechanism over northwest Utah for the abundant tropical moisture as well as a forcing mechanism. Maddox in his work on flash flooding in the West stated that weakening surface fronts were usually present in the flash flood area for most flash flood events [2].

Finally, there was the need for a triggering mechanism, especially one that would be moving over northwest Utah during maximum heating time. The July 8, 12Z 500 mb mesoanalysis chart (see Figure 8) indicated that such a feature was present over Oregon and northern California in the form of a weak short wave trough. Evidence of the short wave was also apparent at 700 mb (see Figure 6) and on the LFM analysis (see Figure 9). Maddox also stated that in western flash flood events weak middle-level, short wave troughs triggered all of the heavy precipitation episodes except for his "synoptic scale" event where strong troughs were the case.

Thus, all of the key ingredients necessary for a heavy rainfall event were present on the morning of July 8. Heavy rainfall did occur late that afternoon around 210OZ in northwest Utah along the old frontal zone. A flash flood observer reported 1.1011 in 20 minutes while an ALERT Station (automatic event reporting station) in the zone clicked off .75" in just 12 minutes. The storm caused some damage from winds estimated at 50 to 60 m.p.h., areas of rock and mud slides, and localized flash flooding. One quarter to one half inch hail was also common. The occurrence of severe or near severe thunderstorm phenomena is not unusual with flash flood events in Utah. The satellite imagery (see Figures 10 and 11) was a classic, indicating the development of thunderstorms along the old frontal zone.

Since there was no push from the north or west, the frontal zone/tropical moisture did not shift out of northwest Utah on July 8. As a result, there was still abundant moisture and a frontal zone across the area on July 9. This, combined with another short wave trough moving across northern Utah on the afternoon of July 9, caused an almost identical repeat performance of the weather conditions experienced on July 8. A flash flood observer one mile north of the previous day's observer reported 1.05" in 20 minutes on July 9, while the same ALERT observing site of the day before recorded .98" in just 12 minutes and 1.02" in 15 minutes. The main activity in the Salt Lake Valley on July 9 occurred around 2200Z. Satellite imagery for this storm again clearly indicated the location of the thunderstorms developing along the frontal zone (see Figures 12 and 13). Fortunately, the associated short wave trough on this day was strong enough to move the front/tropical moisture south out of the area. Note the frontal position at 10/0815Z across southern Utah (see Figure 14).

A couple of interesting sidelights from these storms are worth mentioning. The first was that the ALERT observing device in the middle of both storms appeared to work outstandingly and provided that essential information in any significant weather event -- ground truth. Due to the apparent success of this ALERT device, several state and local officals have expressed interest in purchasing ALERT systems. In an extremely data-sparse area like Utah the addition of more ground truth reports is our most pressing need.

Secondly, it was observed that while all ingredients for a heavy rainfall event came together in "textbook" fashion on July 8 and 9, this is not always the case. This office has experienced several cases when initial conditions appeared very similar to those described here but where the potential was never realized and significant rainfall never occurred. Thus, there was some question as to the value of analyzing for and knowing the above discussed ingredients were present. I believe, however, that knowing the potential exists is in itself of great value to the forecaster. It permits the forecaster early in the day to let the public know that the potential exists for significant weather. This is often of more value to the public because of the lead time than are short-fused watches and warnings. In addition, the forecaster can call upon additional manpower if necessary and can concentrate all of his/her efforts towards monitoring the threat area so he/she will be read to take necessary actions if the threat materializes.

Reference:

[1] WSFO SLC, Station Duty Manual, "Flash Flood Section," WSFO, SLC.

[2] Maddox, R.A., F. Carova, and L.R. Hoxit, 1980: "Meteorological Characteristics of Flash Flood Events over the Western United States." Monthly Weather Review, Vol. 108, No. 11.

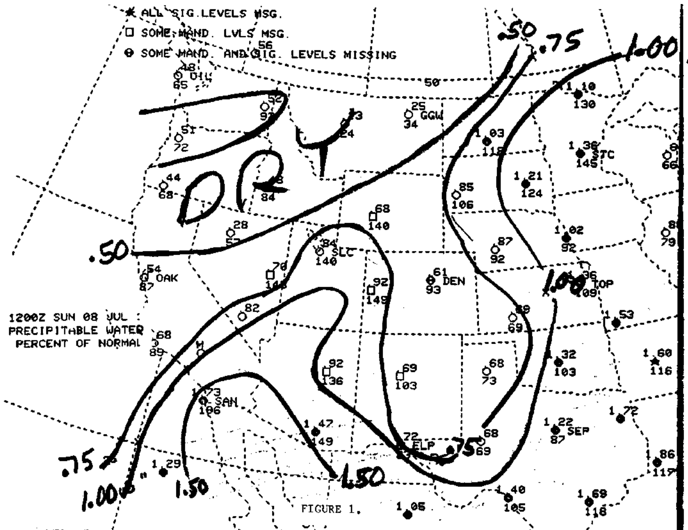

FIGURE 1.

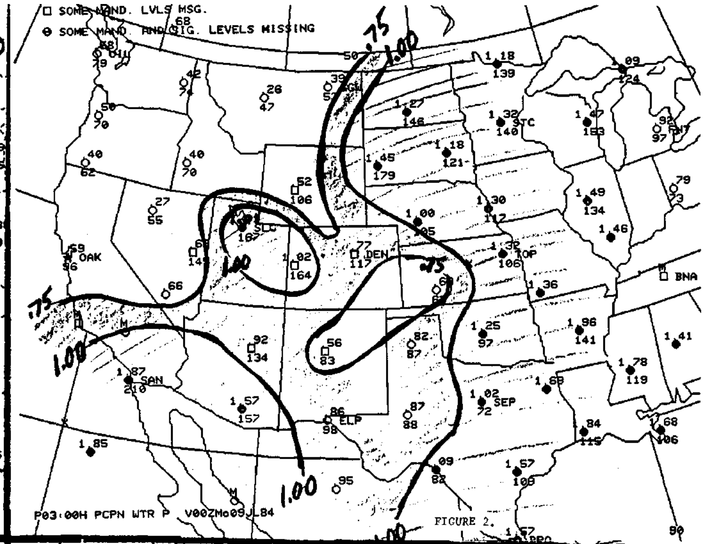

FIGURE 2.

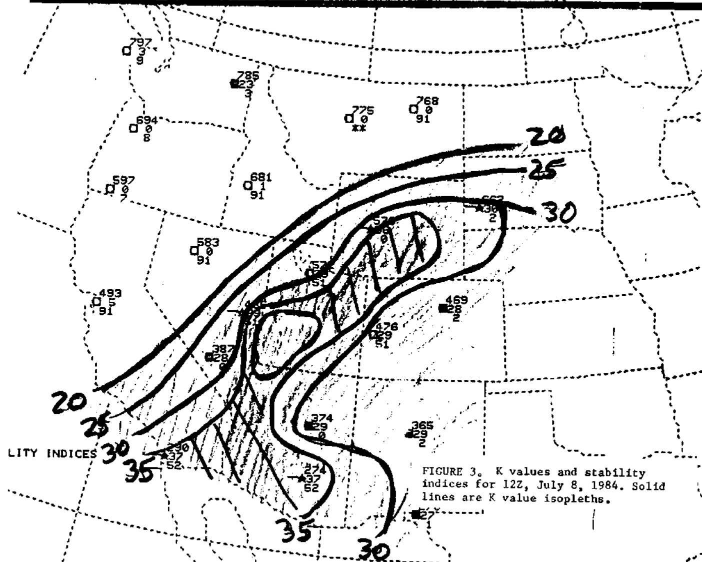

FIGURE 3. K values and stability indices for 12Z, July 8, 1984. Solid lines are K value isopleths.

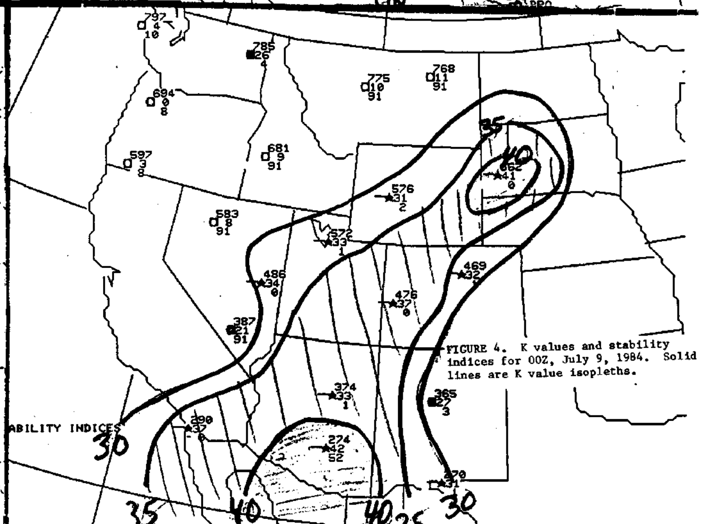

FIGURE 4. K values and stability indices for 00Z, July 9, 1984. Solid lines are K value isopleths.

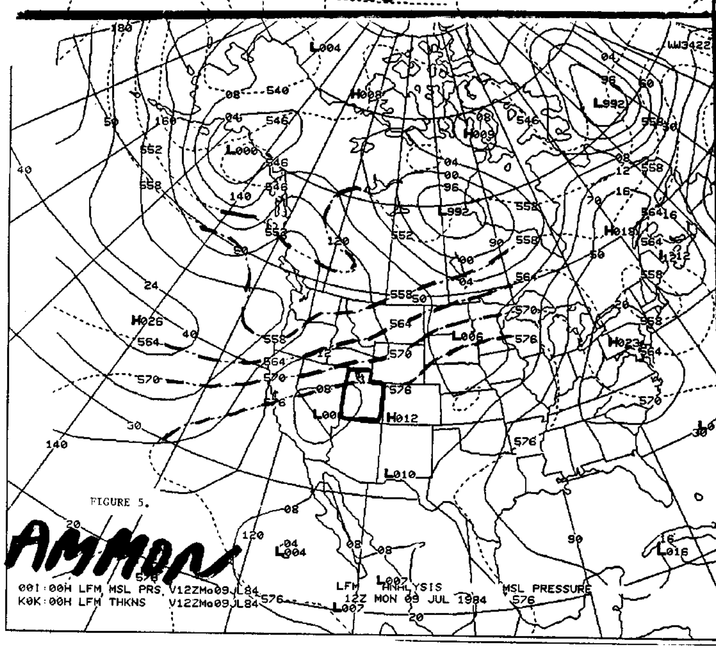

FIGURE 5.

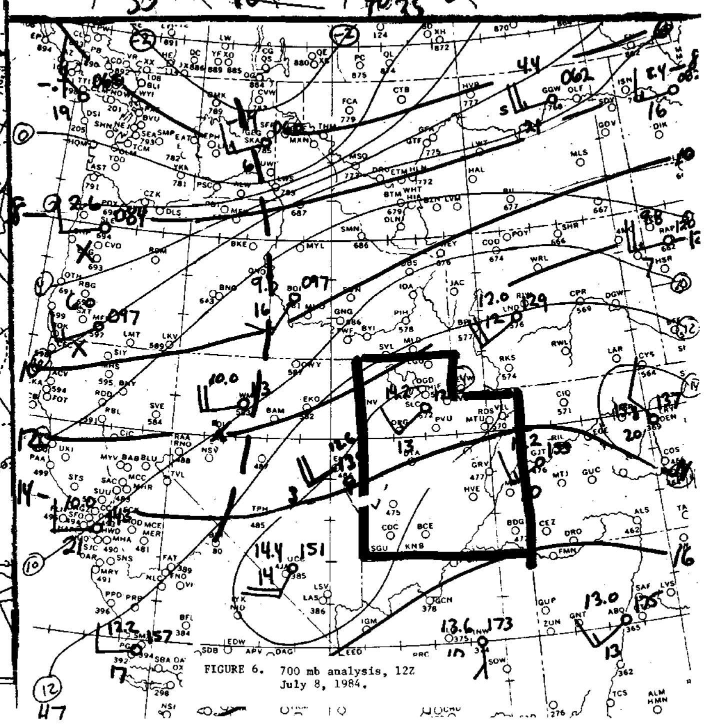

FIGURE 6. 700 mb analysis, 12Z July 8, 1984.

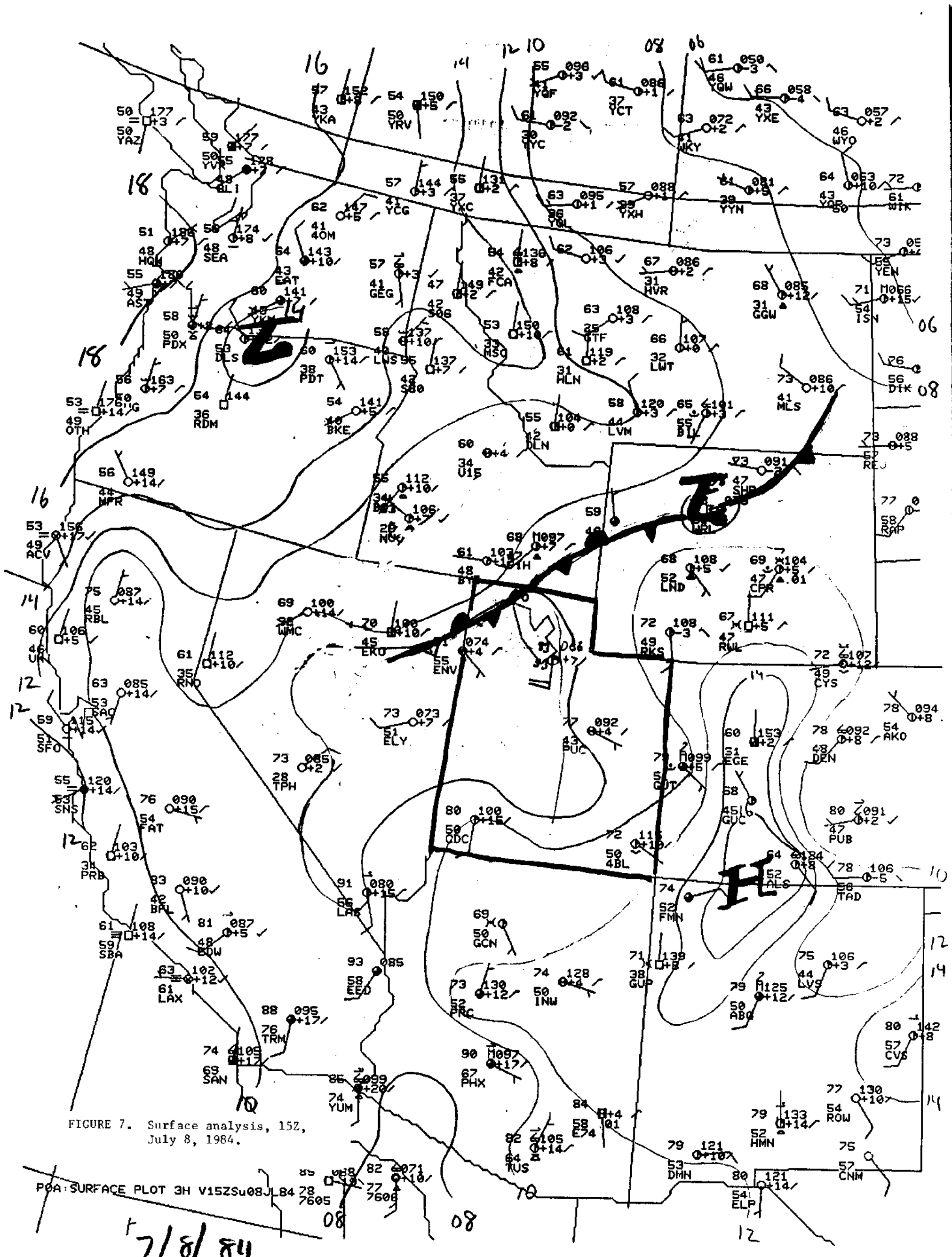

FIGURE 7. Surface analysis, 15Z, July 8, 1984.

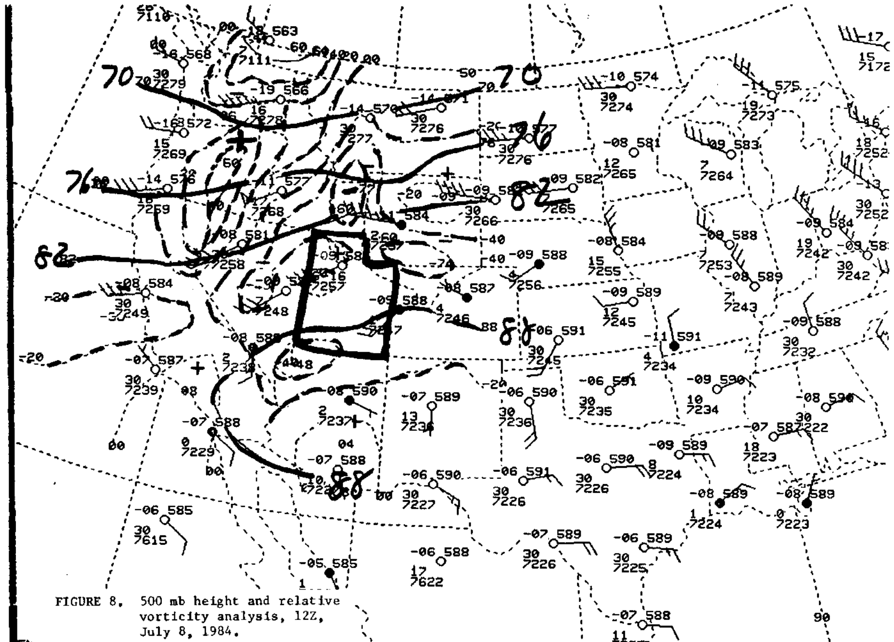

FIGURE 8. 500 mb height and relative vorticity analysis, 12Z, July 8, 1984.

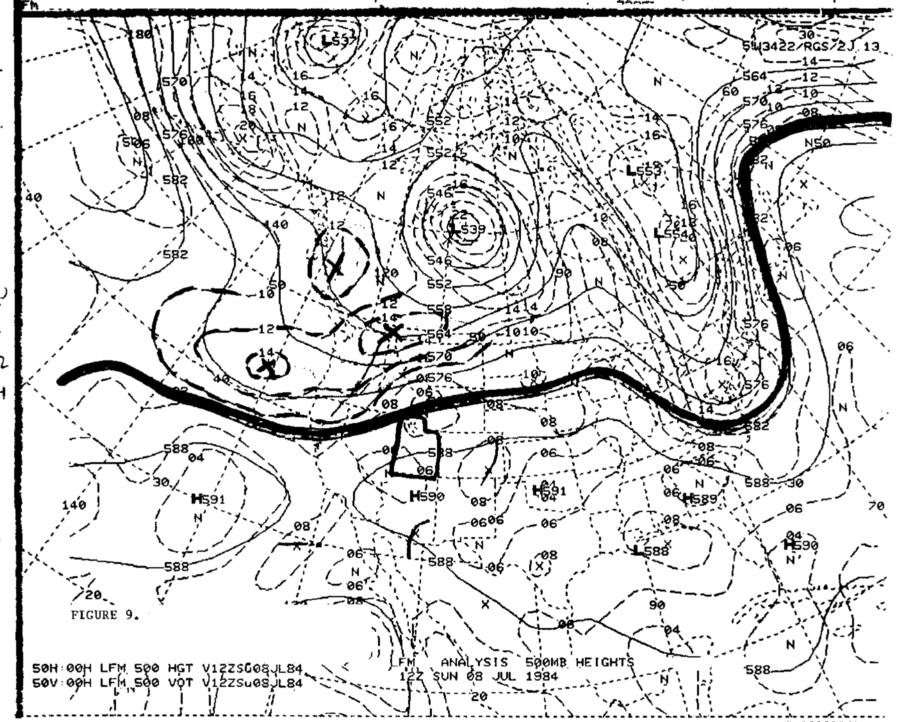

FIGURE 9.

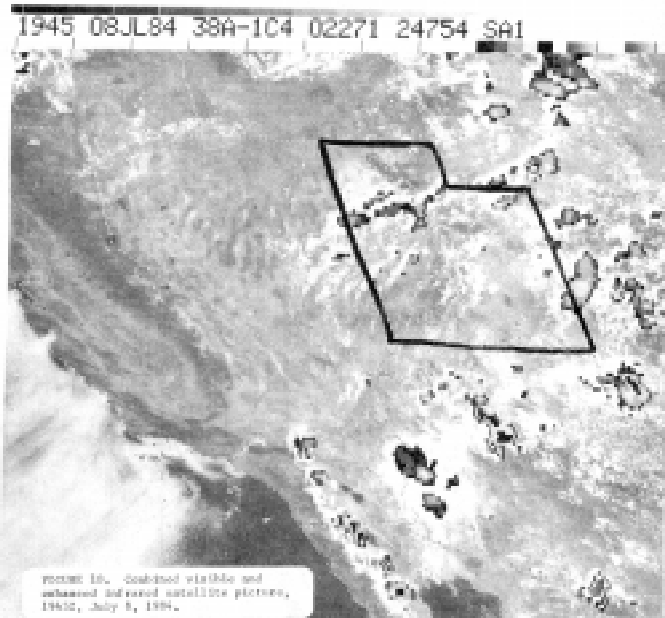

FIGURE 10. Combined visible and enhanced infrared satellite picture, 1945Z, July 8, 1984.

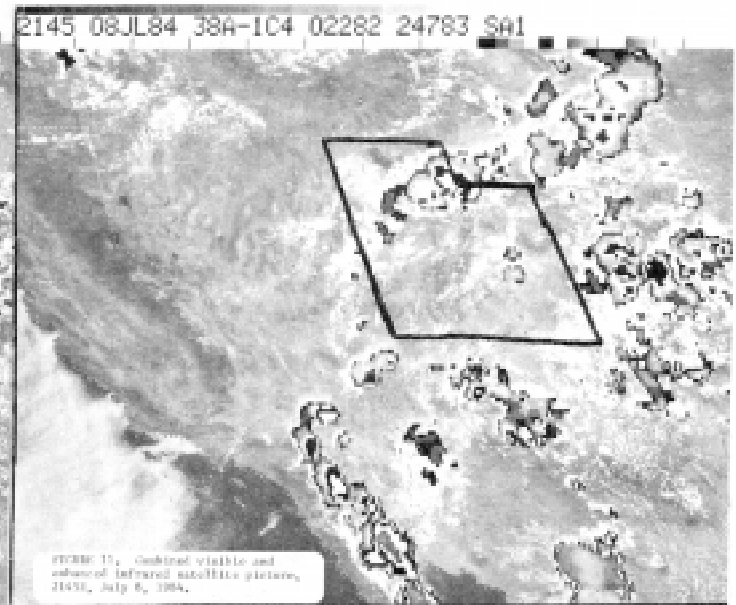

FIGURE 11. Combined visible and enhanced infrared satellite picture, 2145Z, July 8, 1984.

FIGURE 12. Combined visible and enhanced infrared satellite picture, 2045Z, July 9, 1984.

FIGURE 13. Combined visible and enhanced infrared satellite picture, 2145Z, July 9, 1984.

FIGURE 14. Enhanced infrared satellite picture, 0815Z, July 10, 1984.