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THE HIGH UINTA TORNADO

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During the evening of August 11, 1993, a tornado touched down three times along the south slopes of the Uinta Mountains of northeast Utah. Damage from these touchdowns was found as high as 10,880 feet above sea-level (ASL) in the High Uinta Wilderness. High elevation tornadoes are relatively rare, with this event being only the third of its type reported in Utah since 1950. However, high elevation tornadoes occur and can cause considerable damage to forests.

The best documented event of this kind is the Teton-Yellowstone tornado that occurred on 21 July 1987 (Fujita 1989). In that case, aerial surveys and photogrammetric methods were employed to study the damage path. The path was over 23 miles in length and over 15,000 acres of forest (approximately 1 million trees) were leveled. Close examination of the orientation of the downed trees led Fujita to identify four spin-up vortices associated with the tornado and 72 separate microburst signatures. The tornado signature included trees that were oriented in a swirl pattern, while the microbursts were identified by trees laying in a slightly diverging pattern from a single point. The tornado was generally rated as F0-F2, with some areas classified as F4, based on the debarking of the trees and the spread of debris. The tornado traversed a number of ridges, including the Continental Divide, reaching a maximum altitude of over 9200 feet ASL.

Evaluation of the High Uinta tornado has not been nearly as extensive as the above-mentioned study, although an aerial survey of the damage path was conducted by the U.S. Forest Service. A video and still photographs of the survey were supplied to WSFO Salt Lake City. The tornado initially touched down on a northeast facing slope near the Yellowstone River in the mountains of northeast Utah about 20-25 miles north of the town of Roosevelt (Fig.1). A small area of forest (20 acres) between 9580-10,000 feet ASL was toppled as the storm descended towards the river. No damage was observed on the other side of the river as the storm moved northeast and crossed the ridge into the Uintah River drainage. Again damage was observed as the storm descended a northeast facing slope towards the river. Approximately 660 acres of spruce and pine were toppled with evidence of a cyclonic swirl in the pattern of downed trees. This second damage path began at 10,880 feet ASL and continued down to 9400 feet ASL, where a steep escarpment dropped to the river below. There was no damage on the other side of the river as the storm climbed the ridge and crossed into the West Fork of the White Rock River drainage. Damage began again on the northeast facing slope and continued across the river, up the opposite slope, and then down to the White Rock River. This last damage area was approximately 307 acres in size. A scout troop, about to make camp at a nearby lake, observed the approaching storm and moved to a place of safety. No one was killed or injured, but four vehicles at the lake were damaged, including one truck destroyed by falling trees. Hail, up to one inch in diameter, was also observed.

The three damage areas lined up along a southwest-northeast path. The path was approximately 17 miles in length from the first damage area to the last, with about 1000 acres of trees destroyed. Trees were generally uprooted, while some trees with diameters of up to 18 inches were snapped. The trees were not debarked, and the damage would appear to be generally F2 and F3 in nature. In both the second and third touchdown areas, cyclonic circulations can be inferred from the pattern of the fallen trees (using photographs not shown). Other areas showed signs of straight line wind damage, and, as in the Teton-Yellowstone storm, it appears likely that both tornado(s) and microbursts were present. There were other thunderstorms in northern Utah on this day, some with brief heavy rain, and a few with pea- to marble-sized hail. However, there were no other reports of severe weather in the state.

Meteorologically, the event did not appear remarkable (or predictable). The event was observed in the White Rock River Basin at 0150 UTC 12 August 1993. The 0000 UTC 12 August 1993 PCGRIDS analyses from the NGM were examined to characterize the state of the atmosphere at the time of the event. A well-defined 500 mb short-wave trough was located over northern California (Fig. 2), while Utah was in southwest flow. A very subtle 500 mb short-wave trough could be seen by the trough in the 500 mb vorticity isopleths, although the height contours indicate anticyclonic curvature. At 300 mb (Fig. 3), the tornado occurred in a region of moderate southwest winds, removed from the jet entrance region seen over Montana or the jet exit region near the California/Nevada border. Ageostrophic winds at 300 mb near the tornado were quite small on the 0000 UTC 12 August 1993 analysis, due to the lack of along-stream variation in the upper-level winds (i.e., no jet streak).

Kinematically, the analyses were also benign. Divergence at 850 mb and 300 mb (not shown) was nearly zero on the NGM analyses. However, from a quasi-geostrophic perspective, a maximum in the differential vorticity advection was in the area. The 300-700 mb positive vorticity advection (PVA) was maximized over the location of the tornadic thunderstorm (Fig. 4), even more so than in the area around the California trough. The magnitude of the differential PVA maximum was still fairly small and could not be considered unusual.

The thermodynamic situation was more interesting. The NGM relative humidity analysis (not shown) indicated values of 30 percent or lower moving into the area at 700 mb, which would be near cloud base in this case. Surface lifted index analyses (Fig. 5) from the NGM indicated a value of -2, with a maximum of -4 over southeast Idaho. The Salt Lake City rawinsonde (Fig. 6) at 0000 UTC 12 August 1993 had 0.91 inches of precipitable water. This represented 149 percent of the normal precipitable water at this time of year. A parcel with the observed surface and dewpoint temperature produces approximately 2000 J/kg of CAPE from this sounding, which represents significant instability. The sounding also showed considerable vertical shear. The winds increase in speed and veer strongly with height. The surface to 400 mb shear exceeded 50 knots and was supportive of supercell convection (Wiesman and Klemp 1982). The lower portion of the sounding showed cold advection and northwest winds. This was the signature of a very shallow boundary that moved into the Salt Lake Valley during the early afternoon along with the isolated convection. The surface winds at Salt Lake City were variable from the northwest through the northeast the rest of the day, while the surface pressure continued to fall. No evidence of this boundary can be found in the sparse surface observations available over northeast Utah, although sufficient shear existed to support supercell convection.

Satellite imagery (Fig. 7) at the time of the event showed the tornadic storm to be located at the tail end of a comma-shaped cloud that extended into southern Montana. Another thunderstorm complex can be seen over southeast Idaho. No reports of severe weather were received from either southeast Idaho or western Wyoming, although small hail was reported. The satellite imagery suggested a short-wave trough was present from south-central Idaho to northeast Utah with organized convection ahead of the trough axis.

Summarizing the meteorology, the NGM analyses did not depict any synoptic-scale features over northeast Utah at the time of the tornado other than some modest differential PVA. The short-wave trough seen in the satellite imagery is difficult to identify in the NGM analyses. It would appear that the moisture analyses and jet-level winds were also unable to capture the feature responsible for the thunderstorm. The Salt Lake City sounding was somewhat contaminated by convection that moved through the area a few hours before the balloon release. However, some of the ingredients for severe convection were present. These include significant instability and a vertical wind profile with ample shear to support long-lived supercell thunderstorms.

This was an interesting event since tornadoes are relatively rare in Utah (average=2/year) and high elevation tornadoes are particularly unusual. The tornado occurred in an area of virtually no radar coverage, which will not change much with the installation of the WSR-88D, although the upper portion of the cell likely would have been detectable from distant WSR-88D radars. The NGM clearly was unable to adequately identify the feature responsible for the convection over northeast Utah, and was of limited value for this particular forecast problem.

Acknowledgment

Appreciation to Western Region Scientific Services Division for generating Fig. 1.

Reference

Fujita, T., 1989: The Teton-Yellowstone tornado of 21 July 1987. *Mon. Wea. Rev.*, **117**, 1913-1940.

Wiesman, M. L. and J. B. Klemp, 1982: The dependence of numerically simulated convective storms on vertical wind shear and buoyancy. *Mon. Wea. Rev.*, **110**, 504-520.

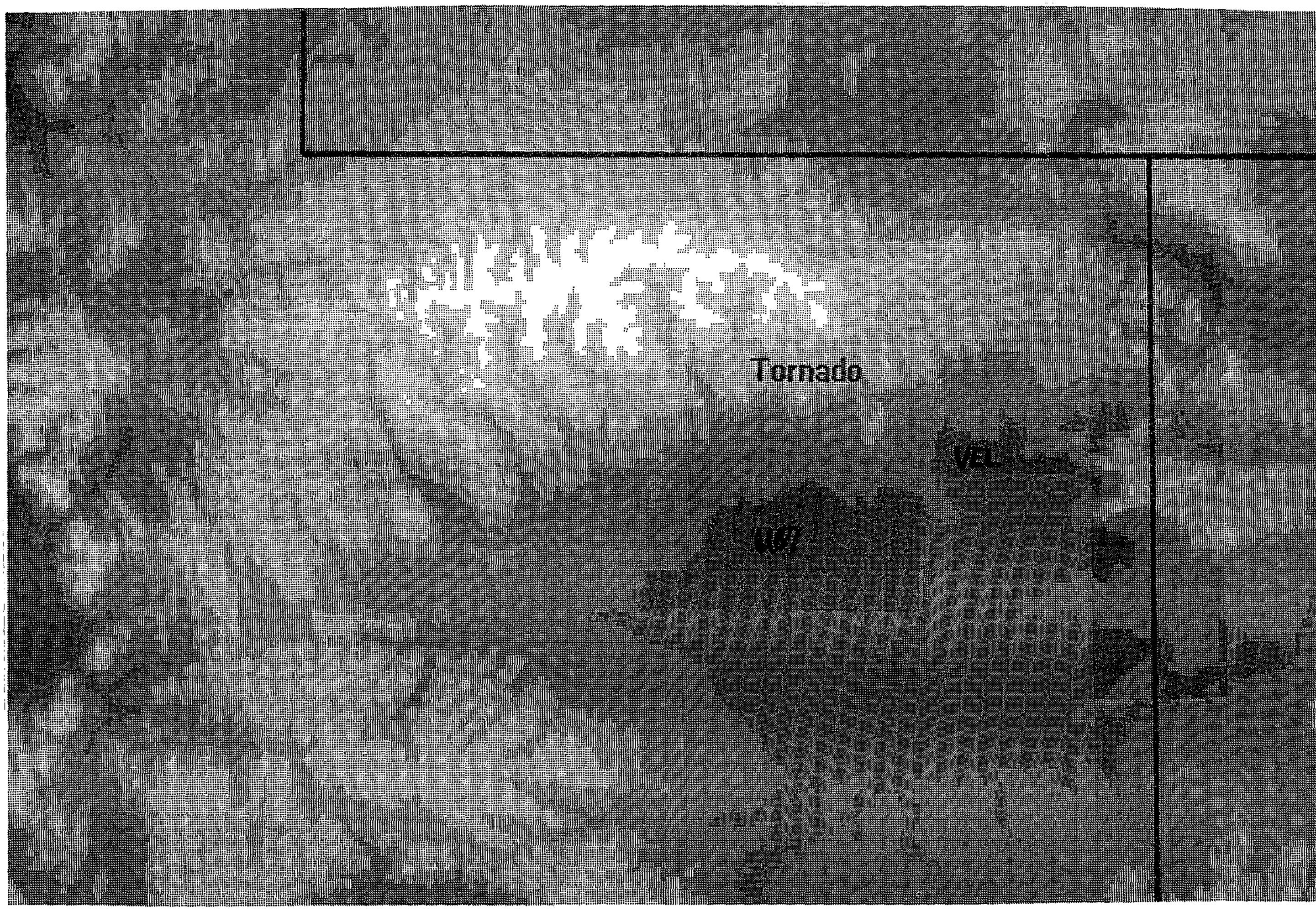

Fig. 1 Geographical location of the event.

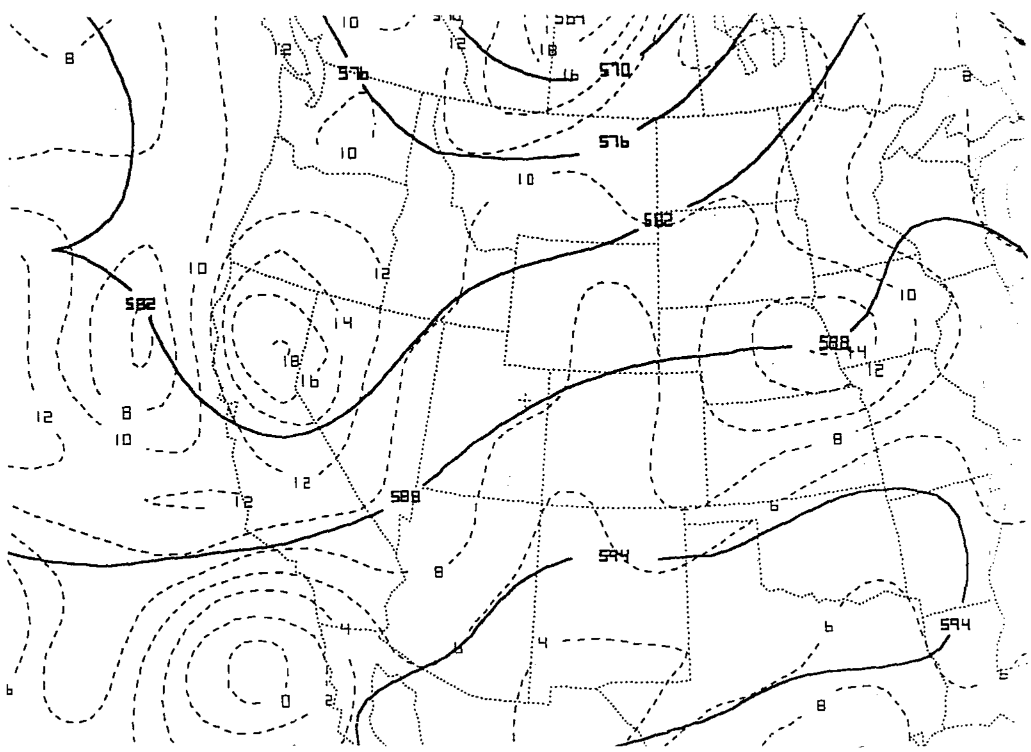

Fig. 2 0000 UTC 12 August 1993 NGM 00 h analysis of 500 mb heights (solid, contoured every 6 dam) and absolute vorticity (dashed, contoured every $2x10^{-5}$).

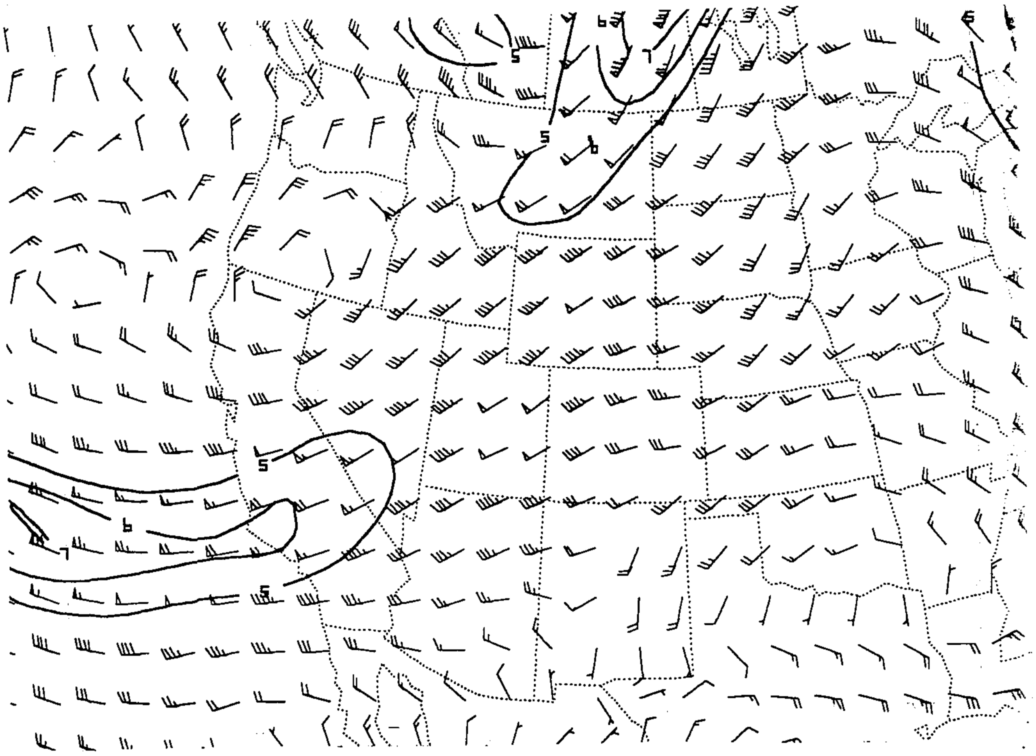

Fig. 3 0000 UTC 12 August 1993 NGM 00 h analysis of 300 mb winds and isotachs (contoured every 20 knots, beginning at 50 knots).

Fig. 4 0000 UTC 12 August 1993 NGM 00 h analysis of 300-700 mb advection of absolute vorticity by the observed wind (contoured every $1x10^{-9}$, negative values are dashed).

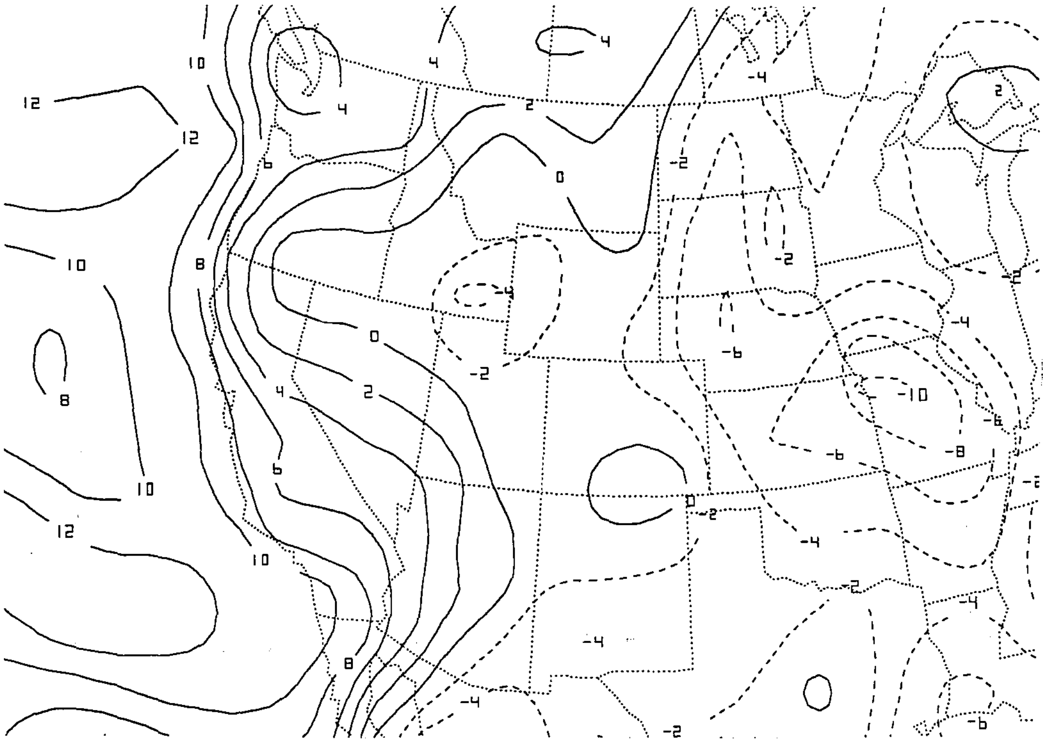

Fig. 5 0000 UTC 12 August 1993 NGM 00 h analysis of surface Lifted Indices (contoured every 2, negative values are dashed).

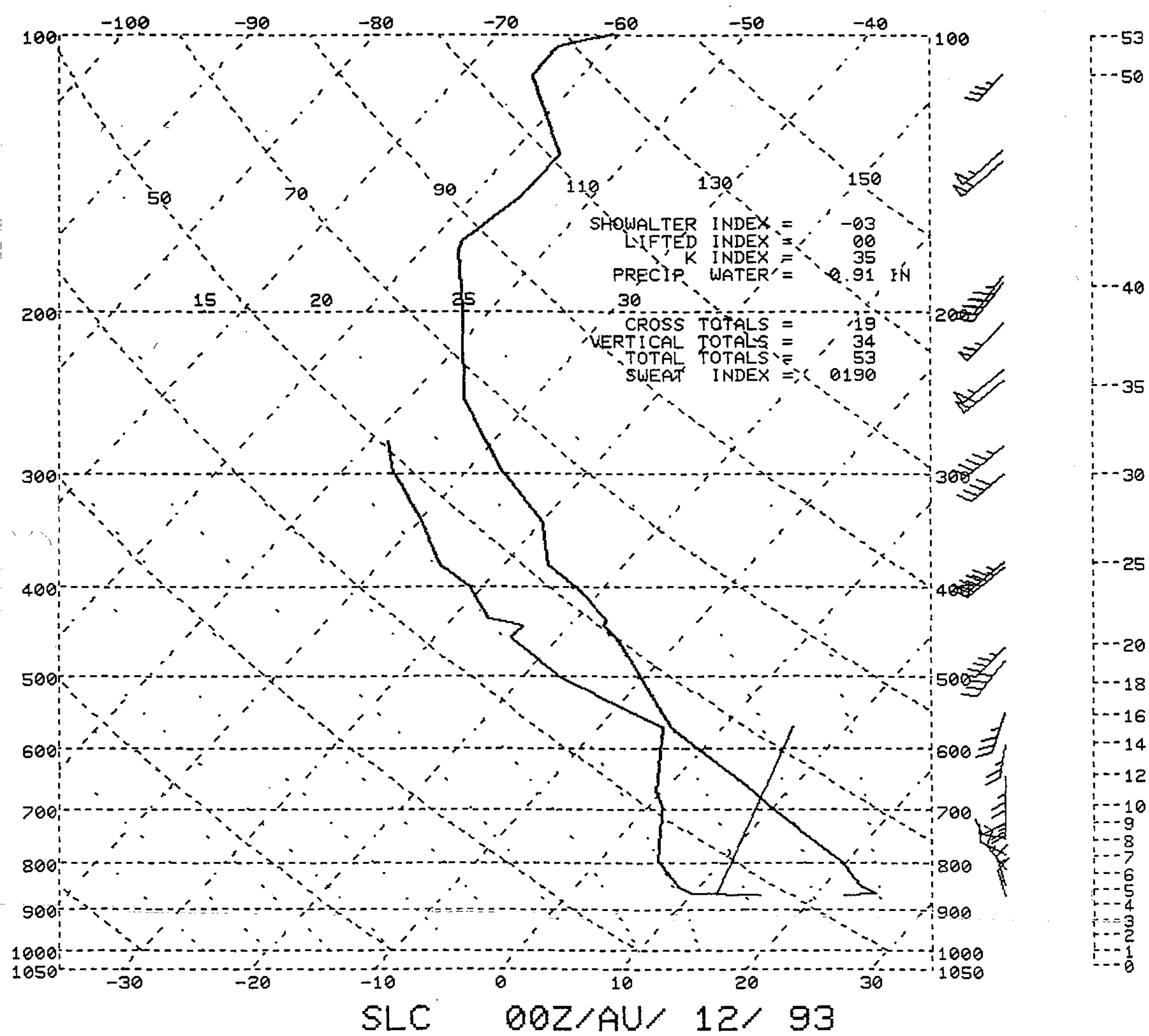

Fig. 6 0000 UTC 12 August 1993 sounding at Salt Lake City.

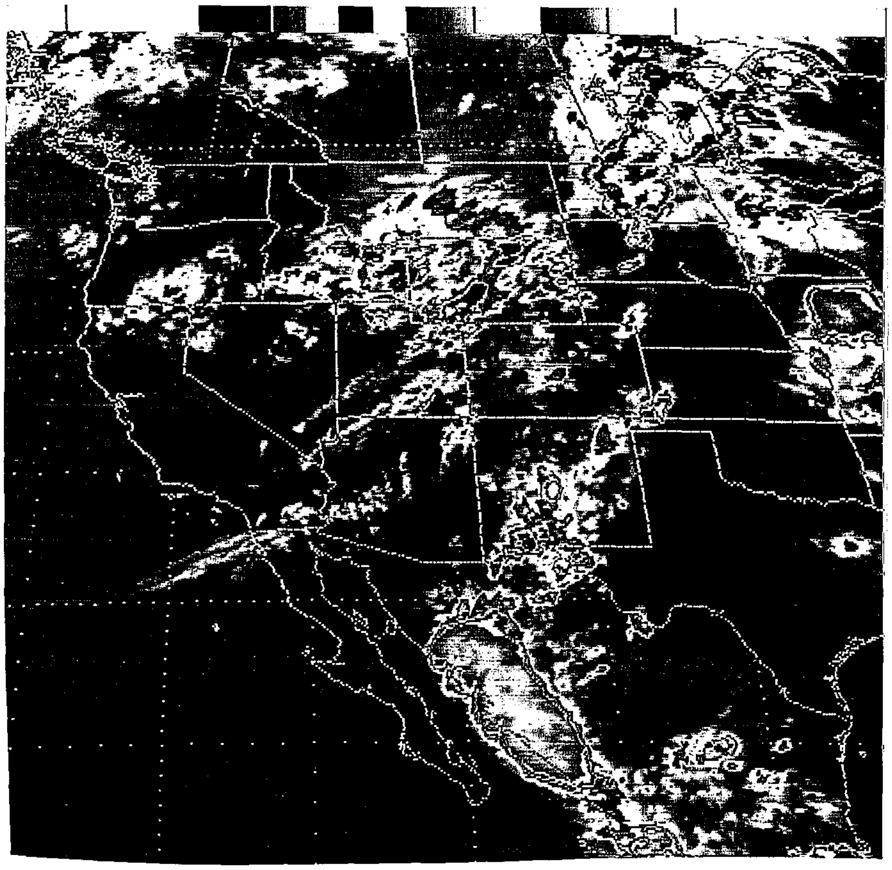

Fig. 7 0202 UTC 12 August 1993 infra-red satellite picture.