WESTERN REGION TECHNICAL ATTACHMENT
NO. 87-17
May 5, 1987

HIGH RESOLUTION PRECIPITATION MEASUREMENTS REFLECT STABILITY CHANGES IN SIERRA NEVADA STORM

Thomas Lee and Robert A. Rilling, Electronic Techniques, Inc., Auburn, California

Very heavy precipitation occurred over the American River Basin in central California during mid-February 1986. After several days of heavy rain and a high snow line, the intense orographic precipitation on February 18 triggered an enormous flood surge on the American River. The flood produced a number of adverse effects, including the destruction of a large coffer dam near Auburn, California. The flooding episode coincided with one of the field observation periods of the Sierra Cooperative Pilot Project (SCPP), a weather research experiment sponsored by the U.S. Bureau of Reclamation. This note illustrates changes in precipitation characteristics during a period of changing atmospheric stability.

The instrumentation network of SCPP was ideally suited to observe the storm. Rawinsonde measurements were taken at Sheridan, California (Figure 1), and a network of 19 high-resolution weighting bucket precipitation gauges were deployed throughout the American River Basin. Four of the gauge locations (Baxter, Blue Canyon, Yuba Gap and Kingvale) are shown in Figure 1. Precipitation data were collected throughout the period in remote, high elevation areas where there is usually a lack of high-quality data. The network gauges recorded accumulated precipitation every five minutes with a resolution of .1 mm (.004 inches) water equivalent. Each gauge was interfaced to a microprocessor that controlled an automatic siphon/antifreeze recharge when the gauge bucket became full, allowing continuous operation of the gauge network. This, coupled with the time and amount resolution, made it possible to infer from the precipitation signature whether different portions of the storm were convective or stratiform.

The 850 mb analysis for 0000 UTC on February 18, 1986 (Figure 2) shows strong west-southwesterly flow and warm air advection just west of California. An IR satellite photo valid at the time (Figure 3) shows an elongated fetch of middle and upper level clouds along a baroclinic zone stretching from just south of the Hawaiian Islands to the west coast of the continental United States. The cloud band remained over northern California for the next 24 hours, producing heavy precipitation. The 0000 UTC NMC surface map (Figure 4) shows an embedded frontal system approaching the coast. By 0900 UTC (Figure 5), this system had progressed inland rapidly with the trailing cold front just south of the American River Basin.

Figure 6 is a time-height section of equivalent potential temperature (θ_e) at Sheridan for February 18, 1986. Shaded areas depict layers of decreasing θ_e with height ($d\theta_e/dz<0$) and therefore potential instability. While there are relevant relationships between both conditinal and potential instability to a θ_e sounding, here we consider only that of potential instability. The reader should remember that "conditional instability" is related to lifted parcel dynamics, and that "potential instability" is related to lifted layer dynamics. For detailed discussions on each of these, refer to the atmospheric thermodynamic text (Holton, 1972).

Figure 6 shows a marked transition from low-level stability early in the period ($d\theta_e/dz > 0$) to instability ($d\theta_e/dx < 0$) later. AT 0400 UTC, the atmosphere was stable up to about 4 km, but by 0600 UTC the depth of the stable layer decreased as a cold surge moved in aloft. The cold surge may have been related to the boundary that NMC analyzed as the surface cold front located just south of the area at 0900 UTC. From 0600 through 2100 UTC the cold surge destabilized the lower atmosphere such that potential instability existed from the surface up to about 3 km. Due to the strong wind component normal to the mountain barrier, the potentially unstable low-level atmospheric layers experienced orographic lifting. The shaded layers (Figure 6) would be expected to become convective upon lifting, while the unshaded layers should have continued to express neutral or stable characteristics.

Figure 7 shows precipitation on February 18 at the 4 aforementioned sites near the northern edge of the American River watershed. Precipitation was heavy throughout the period at all four stations, with average rates of about 6-7 mm/hr. However, the character of the precipitation changed markedly during the period. Until 0600 UTC, steady amounts of precipitation were registered; after 0600 UTC, the character of the precipitation became more sporadic, with short bursts of heavy precipitation followed by lulls. Compared to the earlier period, precipitation after 0600 UTC was on the average lighter, although the greatest 5-minute accumulations tended to occur during the later period. The change from steady to sporadic precipitation suggests a transition from a stable, stratiform precipitation process to a much more convective mechanism. At the Kingvale station, for example, the coefficient of variation of precipitation amounts from 0000 to 0600 UTC was only .29 but rose to .77 over the remainder of the day. This change is consistent with the differences in θ_e profiles shown in Figure 6. Lifting of stable air and warm air advection prior to the cold surge resulted in steady precipitation without apparent convection. After about 0600 UTC, lifting of unstable air associated with the cold surge aloft resulted in highly variable precipitation dominated by convective processes.

This research was funded by the Bureau of Reclamation, Department of the Interior, under Contract Nos. 4-CR-81-03860 and 4-CR-81-03320.

Editor's Note: WRH is developing an AFOS application program which will compute equivalent potential temperature from raob data as a function of time for one site, or as a spatial cross-section for several sites. The output will be an AFOS graphic.

Reference:

Holton, J. R., 1972: An Introduction to Dynamic Meteorology, First Edition, Academic Press, Inc., New York, pp. 268-271.

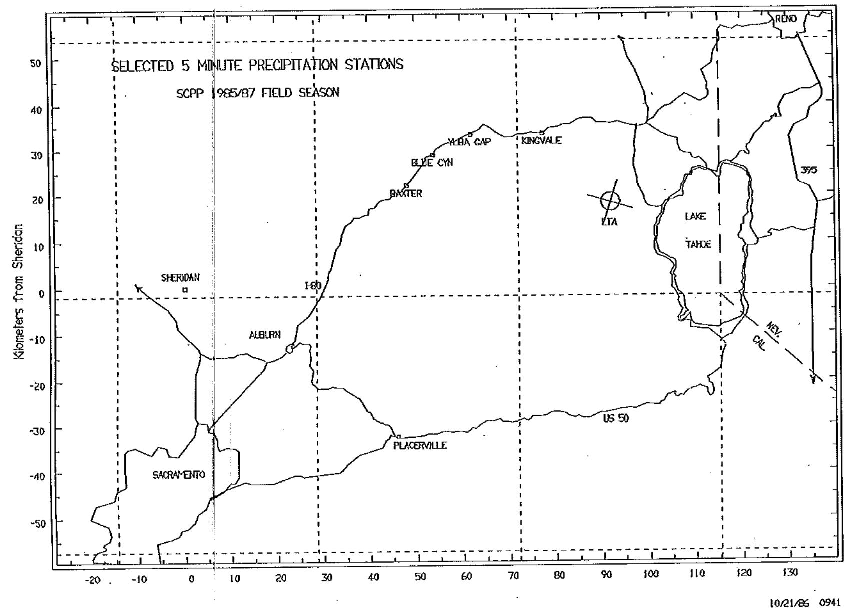

FIGURE 1. Selected 5-Minute Precipitation Stations.

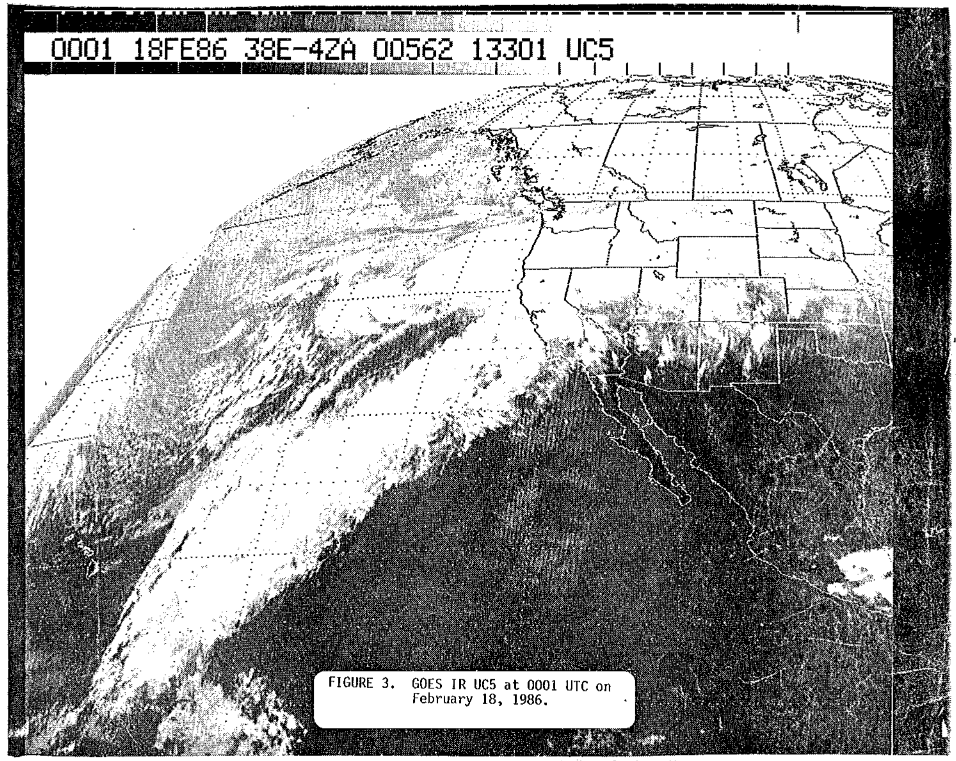

FIGURE 3. GOES IR UC5 at 0001 UTC on February 18, 1986.

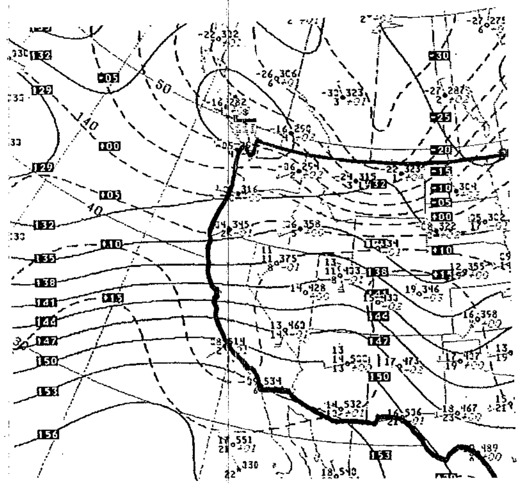

FIGURE 2. 850 mb analysis at 0000 UTC on February 18, 1986.

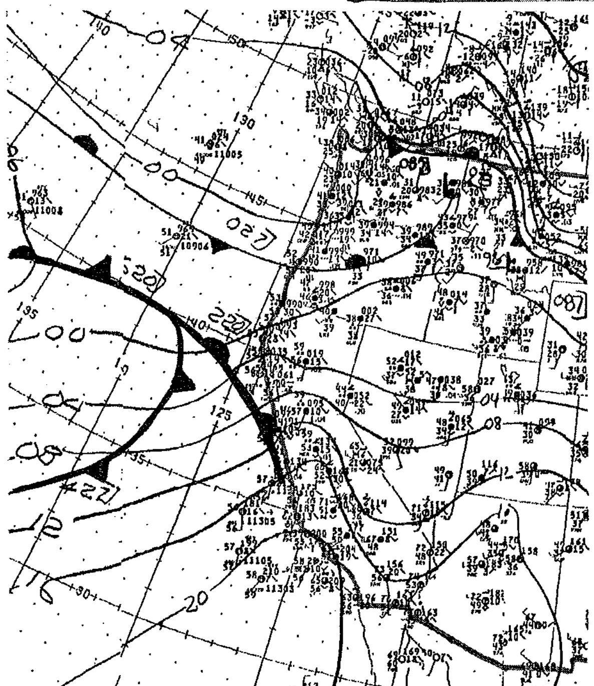

FIGURE 4. Surface analysis at 0000 UTC on February 18, 1986.

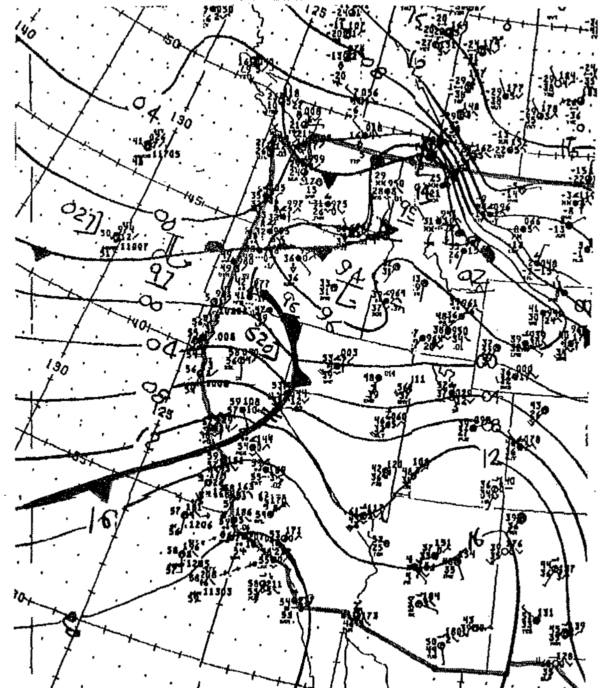

FIGURE 5. Surface analysis at 0900 UTC on February 18, 1986.

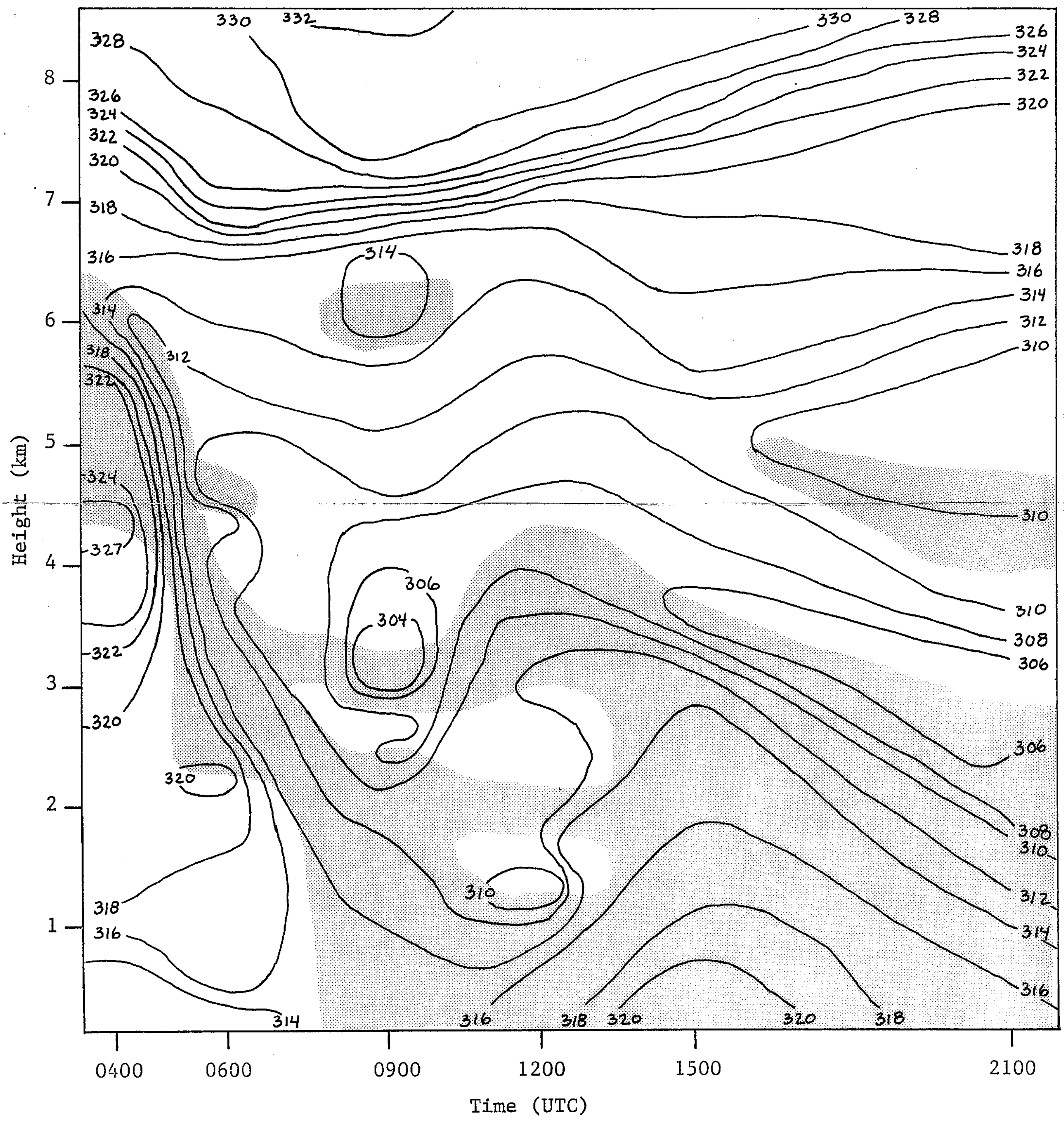

FIGURE 6. Time-height section of equivalent potential temperature at Sheridan, California on February 18, 1986.

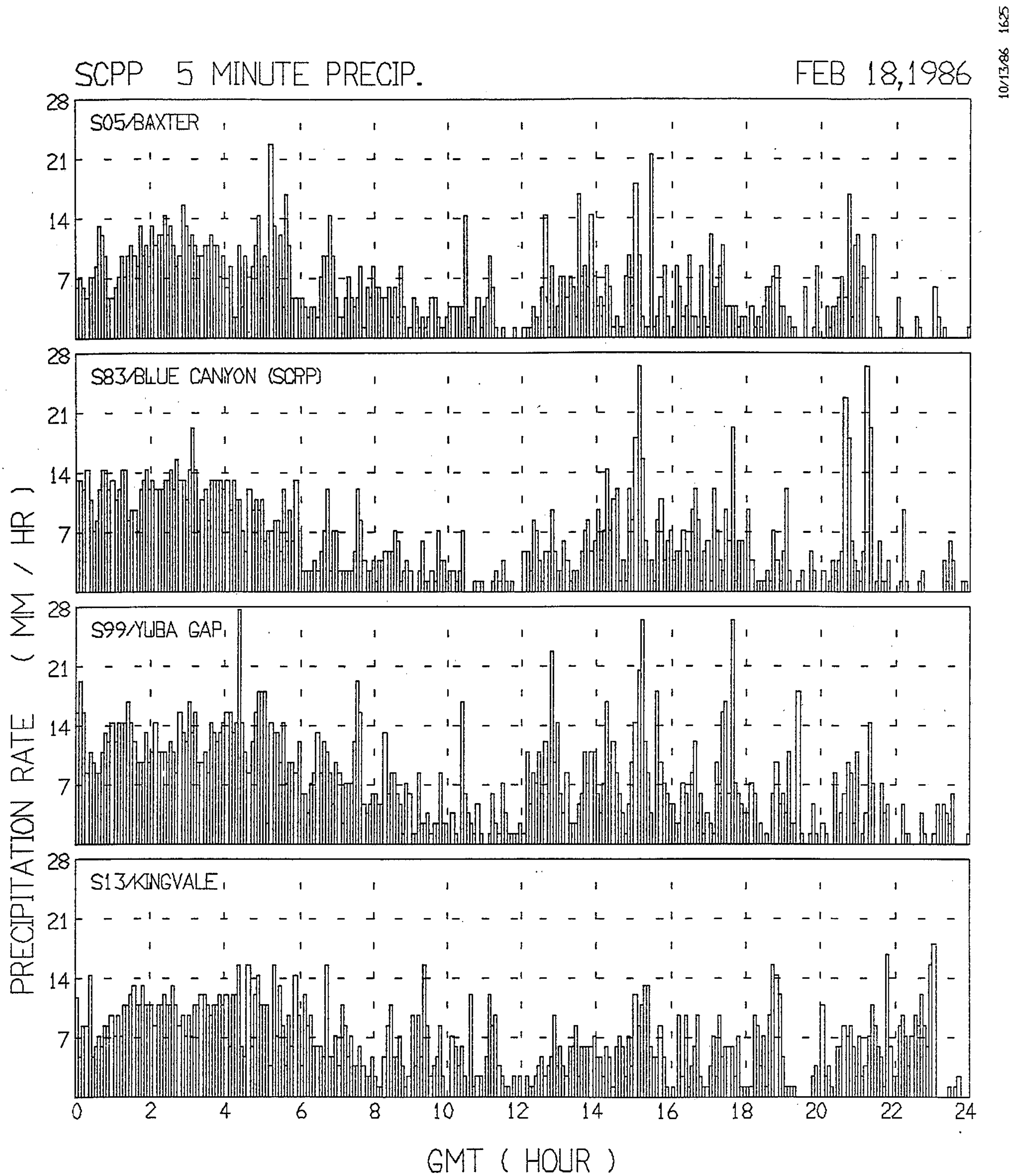

FIGURE 7. 5-minute precipitation on February 18, 1986.