NOAA Technical Memorandum NWS ER-57

HEAVY FALL AND WINTER RAIN IN THE CAROLINA MOUNTAINS

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Eastern Region Headquarters
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NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
Robert M. White, Administrator

National Weather Service
George P. Cressman, Director

INTRODUCTION

There were eight known days in the period October 1, 1972 to March 31, 1973 in which more than two inches of rain occurred at any North or South Carolina Mountain Station. These cases were studied to see if common patterns could be identified to assist in recognizing the threat of heavy rain. The dates of the cases studied were:

October 5, 1972	December 21, 1972
November 7, 1972	January 22, 1973
November 13, 1972	February 2, 1973
December 15, 1972	March 16, 1973

The study focused on the 850, 500, 300 mb. analyses, precipitable water and stability charts available just prior to the onset of heavy rain. Also considered was the latest trajectory model forecasts that were available prior to the occurrence of heavy rain.

All eight cases were conducive to flash flooding because most of the rains fell within a four-hour period. Orographic effects probably concentrated the convective activity over the mountains since neighboring Piedmont sections generally received an inch or less of rain. It will be shown that large scale synoptic processes played a part in the occurrence of these events.

500 MB. AND JET STREAM PATTERN

In all eight cases, the precipitation occurred with a strong shortwave pattern at 500 mb. In the 36 hours prior to the heavy rain a jet maximum west of the trough helped dig the trough southward. On the latest 0000Z or 1200Z analysis available before the time of heaviest precipitation, the 500 mb. troughline, in each case, extended through Eastern Oklahoma or Western Arkansas with the southernmost extent of the trough to at least 30°N latitude. A typical 500 mb. pattern with typical jet axis is shown in Figure 1.

According to Smith and Younkin (1972), there is a heavy 12-hour convective rainfall area that can be identified in advance of a "digging" Polar jet stream position at the beginning of the 12-hour period. The area is a trapezoid, 3° of latitude wide with the western edge 2-1/2° in advance of the jet stream position, and 12° of latitude long with the southern edge at the mean latitude of the trough extremum Smith and Younkin also found that the main axis of heavy rainfall occurred about 4° of latitude in advance of the jet stream, with extremely heavy precipitation on this axis, mainly in advance of the inflection point. Smith and Younkin's trapezoidal heavy rainfall threat area just described is illustrated in Figure 1. In the study conducted here, no attempt was made at analyzing for the true jet stream position in the vertical. Rather, it was assumed that the jet stream is vertically above the 500 mb. maximum winds. Using this assumption, in six of the cases, the Carolina mountains were within the northern half of the threat area as described by Smith and Younkin. In the remaining two cases the strongest 500 mb. winds were directly over the Western Carolinas. For these two cases the Smith and Younkin threat area, related to the maximum winds at the 500 mb. level, would have been east of the Carolina mountains.

SURFACE WEATHER FEATURES

The eight cases investigated had some very similar surface features (Figure 2). In each case, twelve to eighteen hours prior to the onset of heavy precipitation a high pressure center was located over the northeastern coastal states. This pressure pattern lead to cold, moist east-northeasterly flow of air off the ocean into the Carolinas. Meanwhile, an approaching cold or occluded front from the west was located in the Mississippi Valley area. Ahead of this front, the winds would turn sharply to the south giving substantial warm advection and warm frontogenesis. Often a substantial drop of pressure at the point of occlusion would cause a secondary low pressure area to form.

These conditions progressed so that at the onset of the heavy rain a strong warm front with the point of occlusion would lie south and west of the Carolina mountains (usually within 150 miles).

850 MB. PATTERN

Strong warm advection occurred in each case ahead of a trough approaching from the west. Winds over the Carolina mountains were between 20 and 60 knots and from the southeast through southwest (see Figure 3). Temperatures ranged from 7°C to 13°C with saturated conditions present. Thus at 850 mb., just prior to the heavy rain, there was saturated warm air advection almost perpendicular to the surface warm front position. The lift due to this flow was also accentuated by topography.

PRECIPITABLE WATER AND STABILITY

The NMC analyzed precipitable water and stability charts were examined for that time closest but prior to the onset of the heavy rain. In each case, precipitable water values at one or more of the surrounding upper air stations (Athens, Georgia; Greensboro, North Carolina; Nashville, Tennessee) were between 1.03 and 1.60 inches. These values ranged from 45 - 90% above normal for the season, with the mean being 75% above normal (climatological normal values for the area are .80 inches in October and .50 inches in February).

The observed K values ranged from the upper 20's to near 40. This indicates that above the shallow cold surface layer (ahead of the warm front) conditions were ripe for general convective activity with enhancement by topographic lift near the mountains.

TRAJECTORY MODEL FORECASTS

The forecast Net Vertical Displacement (NVD) at 700 mb. was noted for the eight cases. For the 24-hour period, during which the heaviest precipitation occurred in the last 12 hours, the 24-hour forecast NVD ranged from 72 to 135 mb./24 hours and in an upward direction. The average was 108 mb./24 hours. The forecast NVD for the final 12 hours of this 24-hour period ranged from 66 to 99 mb./12 hours (averaging 82 mb./12 hours). It is stressed that the trajectory model forecast message and chart was available several hours prior to the time of onset of heavy rain.

Forecast K values from the same trajectory model output ranged from 20 to 36 with all but two cases having a forecast K value of 27 or higher.

In every case, the predicted 24-hour surface trajectories terminating near the area and time of heavy rain originated over water and preceeded upslope into the mountains.

CONCLUSION

Eight cases of heavy fall or winter rainfall in the Carolina Mountains were examined. There were common characteristics found in the synoptic scale patterns and trajectory model forecasts available prior to the onset of heavy rain. In the future, if these features are identified in the fall and winter months, the threat of locally heavy rain is established. The extent of overwarning, however, is not known since it was not determined how often these features occurred and heavy rain did not fall.

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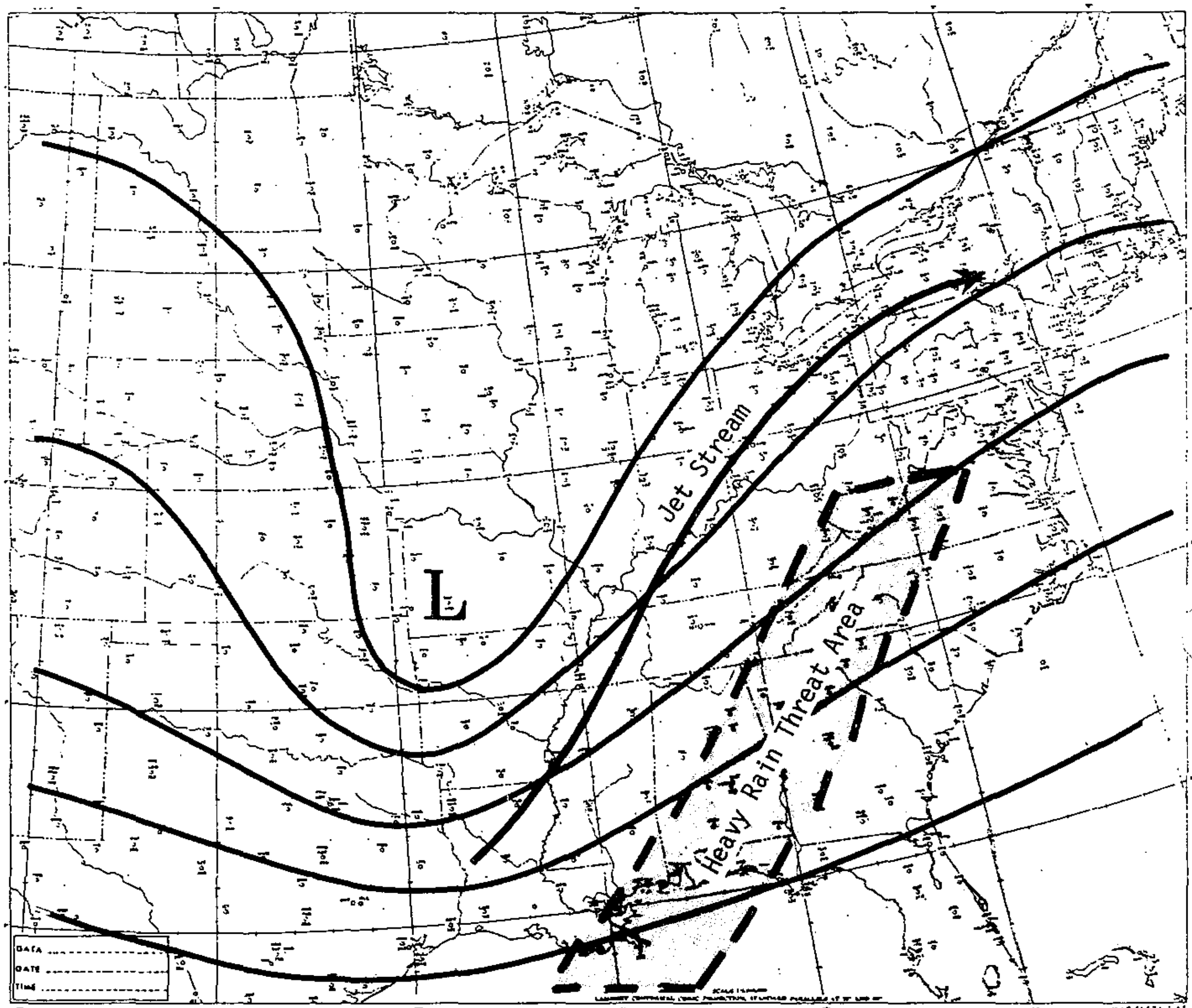

Figure 1. Typical 500 mb. height pattern (sixty-meter contour intervals) and jet stream axis at latest map time before the start of heavy rain in the Carolina Mountains. The Smith and Younkin (1972) threat area of heavy convective rain in the next 12 hours (stippled) is also shown, relative to the jet stream axis.

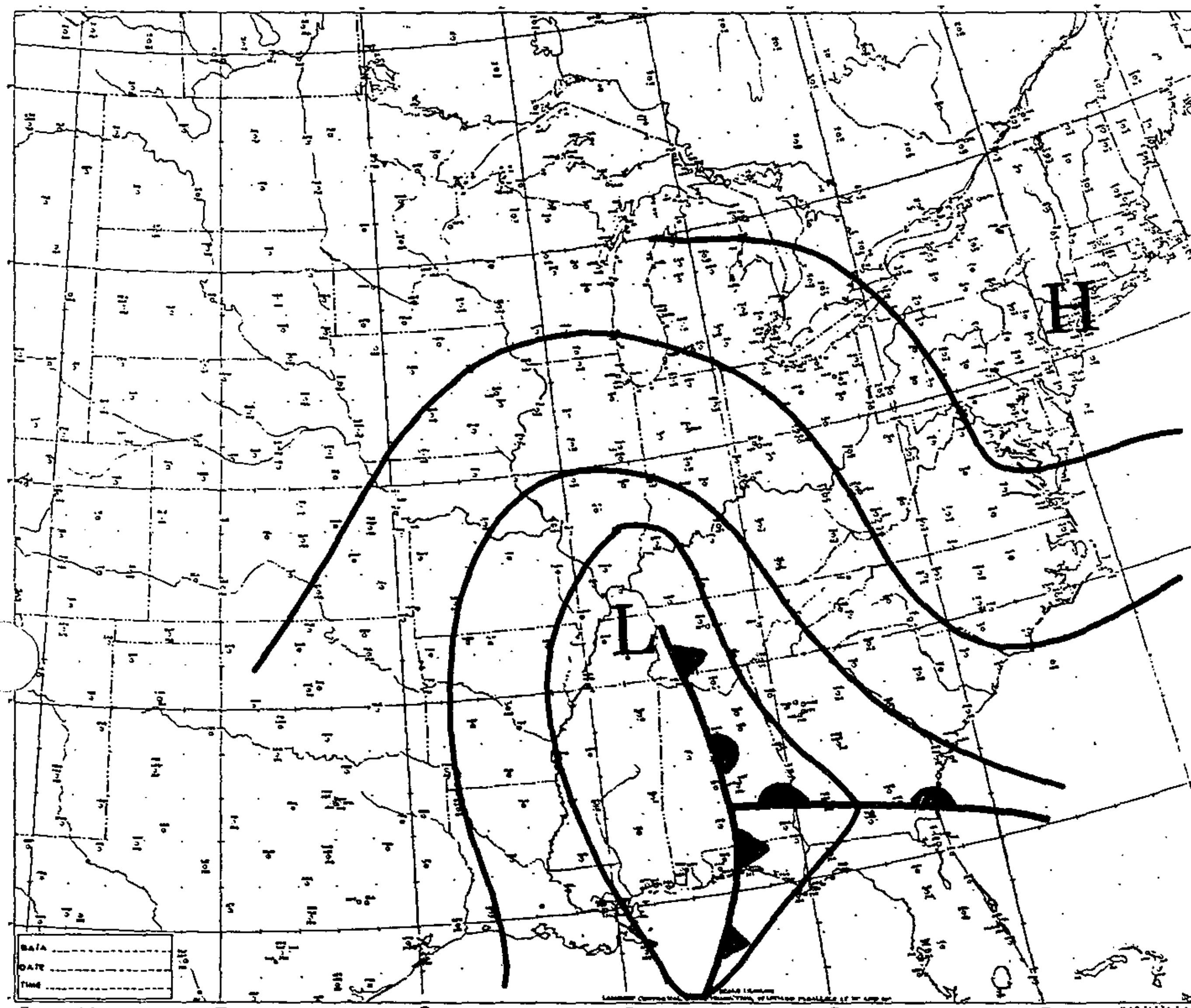

Figure 2. Typical surface pressure pattern (4 mb. isobar intervals) approximately six hours before the start of heavy rain in the Carolina Mountains.

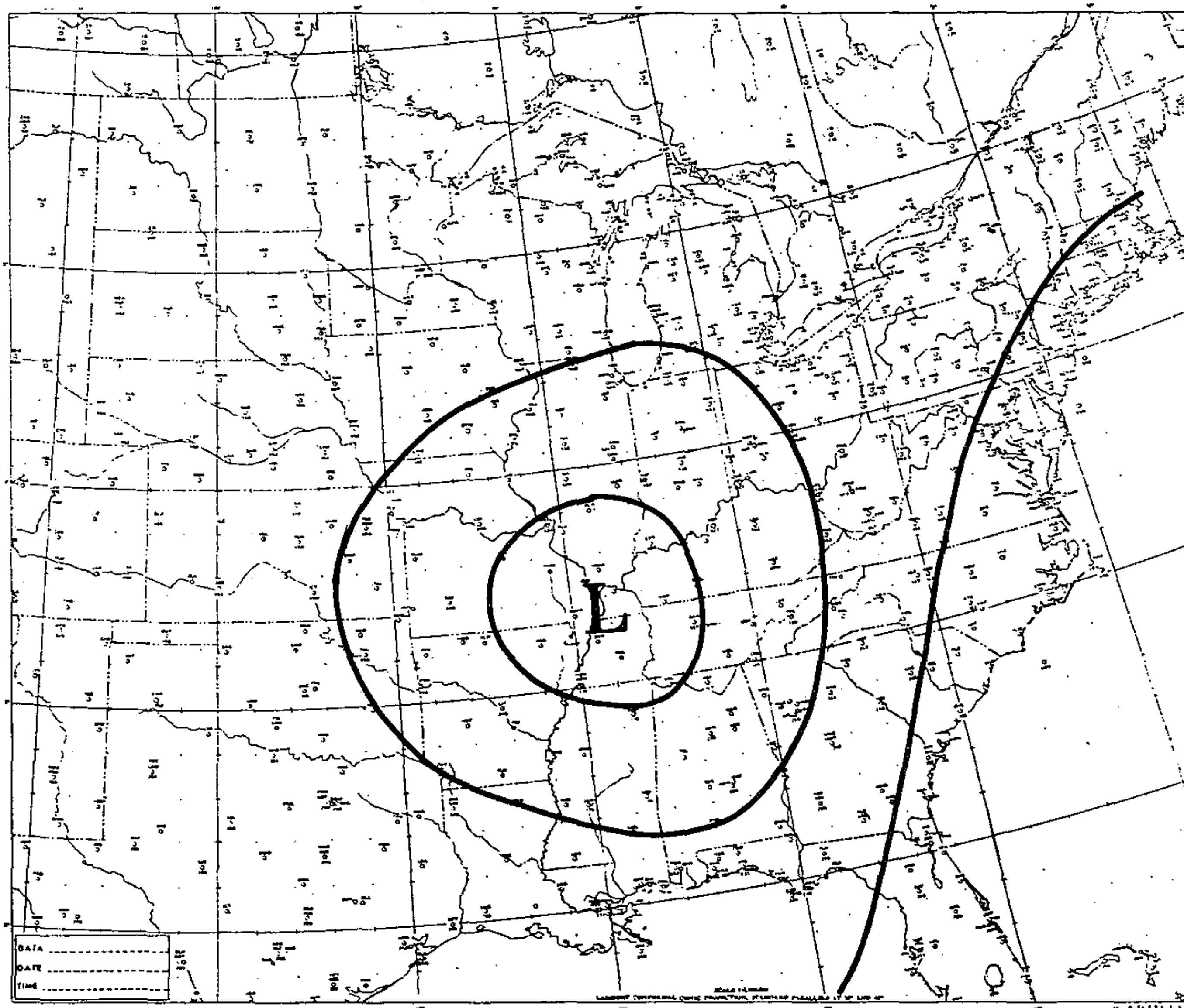

Figure 3. Typical 850 mb. height pattern (sixty-meter contour intervals) at latest map time before start of heavy rain in the Carolina Mountains.