FORECASTING AREAS OF HEAVY PRECIPITATION UTILIZING THE LOCATION OF THE COLD RIDGE (AXIS) AT THE TROPOPAUSE

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1. Introduction

The purpose of this paper is to suggest a practical aid for one of the most significant forecast problems in West Texas . . . that is forecasting possible areas of heavy rainfall, such as those that have resulted in devastating floods of various magnitudes. In an attempt to minimize the problem of delineating areas of potentially heavy rainfall, a comprehevsive study of tropopause temperatures related to heavy precipitation was conducted during the past 3 years by several forecasters at WSFO, Lubbock, TX. It has been noted that from spring into early fall, areas of heavy precipitation in West Texas correlate quite well with the location of the axis of coldest temperatures at the tropopause. Steep temperature lapse rates, normally above the 500 mb level, and high tropopause levels correlated well with large amounts of precipitation, given an adequate precipitable water content.

Utilizing the location of the cold ridge (axis) at the tropopause level and additional parameters such as precipitable water, low-level convergence, positive vorticity advection, antecedent conditions and the forecasted speed of thunderstorm movement, the forecaster can determine if flash-flood prone areas will likely receive enough rainfall to justify the issuance of a flash-flood watch. This procedure applies mainly to short-range forecasts, i.e., 12 to 24 hours, and assumes the forecaster has already determined from evaluation of other parameters and guidance that showers and/or thunderstorms are possible.

2. Data

For this study the tropopause is defined as a single surface of discontinuity that is nearly, but not necessarily, isentropic. The assumption of a quasi-isentropic surface implies that the isobars and isotherms have a closely related pattern at a given time. Data beginning in January 1974 were used, with emphasis placed on the months, March to October. Most of the data analyzed were for the period from spring (late April) through early fall (early October). The method consisted of plotting and analyzing tropopause data twice daily (0000Z and 1200Z) for stations from Arizona and Utah eastward through the Southern Plains to Missouri and Louisiana. When available, data from Mexico were also used. The data plotted were temperature, height, and wind for the tropopause surface. For operational purposes, the data are plotted and analyzed as soon as they (US1) are available so that the tropopause analysis can be incorporated into the late morning forecasts and evening updated forecasts, if required. The tropopause charts are presently not available on facsimile until the data are nearly 12 hours old.

On days when heavy precipitation was observed in any part of West Texas, the plotted and analyzed tropopause chart was compared to the observed rainfall pattern, including areal coverage and 24-hour amounts. Isotherms and height contours were drawn. The axis of coldest temperatures (cold ridge) was depicted on each chart with the area of heavy precipitation outlined. Heavy precipitation is here defined as a 24-hour rainfall amount greater than one inch for Southwest Texas west of the Pecos River Valley and greater than two inches for the remainder of Southwest and Northwest Texas.

More than 60 cases were examined in an effort to correlate areas of heavy precipitation to the axis of coldest tropopause temperatures. Sectional charts were plotted depicting the location and orientation of the cold ridge (axis); including heights, location of wind maxima (if present), areas of heavy precipitation, and 24-hour rainfall amounts along with any reports of flooding. The data were also analyzed to evaluate any effects on areal distribution of the heavy rainfall patterns with respect to latitiude, longitude, and month.

3. Results

After extensive evaluation of isothermal patterns at the tropopause surface for these cases, the conclusion was reached that most areas of heavy precipitation occur near the axis of coldest temperatures. This was usually associated with the highest tropopause heights and lowest pressures of the tropopause surface. In most heavy rainfall occurrences in West Texas, the greatest amounts were reported within two degrees longitude to the west (left) and three degrees to the east (right) of the cold axis. The mean orientation of the axis was found in this study to be northeast (40 degrees) to southwest (220 degrees) over or near West Texas. Tropopause temperatures associated with heavy rainfall generally range from −64°C to −70°C in the spring and from −71°C to −80°C in the summer and early fall (September). These temperatures are 3 degrees or more colder than normal.

Given a high precipitable water content, significant low-level convergence and a triggering mechanism, heavy precipitation of 1 to 4 inches in 24 hours appears to be possible with tropopause temperatures of −68°C to −73°C. Very heavy rain, greater than 4 inches in 24 hours, appears to be possible with tropopause temperatures of −74°C to −80°C. Excessive rain that might cause widespread flooding in flash-flood prone areas is most common over Northwest Texas from April through June and again in September and early October and over Southwest Texas from July through September. A wind maximum at the tropopause level has sometimes been observed in close proximity to the cold ridge (axis) during periods of heavy precipitation, especially in the spring and early fall.

Three examples of isothermal analyses at the tropopause level during times of heavy precipitation over West Texas are illustrated in Figures 1–4. Areas of heavy precipitation are depicted on these charts to indicate the correlation with the cold ridge. Also, Figure 4 illustrates heavy precipitation in an area that was considerably colder than normal at the tropopause level.

During the period of April through October this correlation and the seeming continuity and stability of the tropopause temperature field allows the morning (1200Z) analysis to be applied directly to events expected in the following 12 to 24 hour period. During the summer season when the very heavy rains are most likely to occur, the cold ridges are not likely to be migratory.

This method was applied operationally in several situations with very good success during the months of July through September 1974–1976. As a result, several Flash-Flood Watches were is-

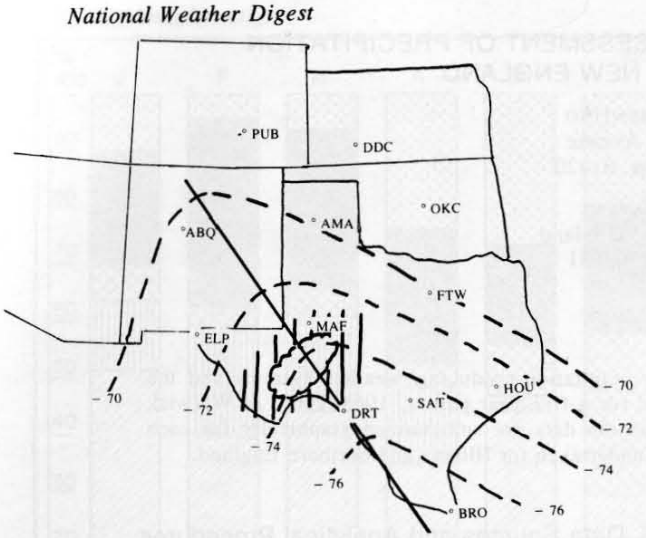

FIG. 1. MEAN TROPOPAUSE TEMPERATURES FOR 12Z September 19–21, 1974 (12Z) (Hatched area had 3–5″ over a 3-day period while central scalloped area had 15–21″ with widespread flooding)

sued for portions of West Texas in the 12 to 24-hour forecast period. Of course, conventional methods had already been used to determine if atmospheric conditions would favor shower and thunderstorm development.

Presently, this study is being expanded in a comprehensive quantitative precipitation forecast (QPF) project for West Texas. Additional parameters such as lifted index, K-index, precipitable water and mean relative humidity are being incorporated into the general QPF program which has been implemented during the wet season of June thru September.

In summary, this study has shown that in West Texas, at least, a tropopause analysis can be very useful in helping to delineate areas of potentially heavy rainfall, especially during the 12 to 24-hour forecast period—after the forecaster has determined that showers and/or thunderstorms are possible over a larger area. At present, the facsimile chart depicting these data is not available in time to be operationally useful.

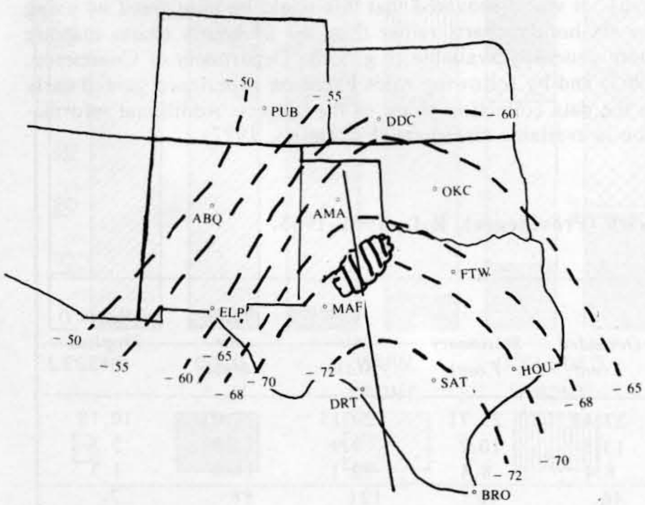

FIG. 2 TROPOPAUSE CHART FOR 12Z May 22, 1975 (Scalloped area on axis had 2–4″ rains late afternoon and night of 5/22/75. Temperatures in this area are about 4 to 8 degrees colder than normal.)

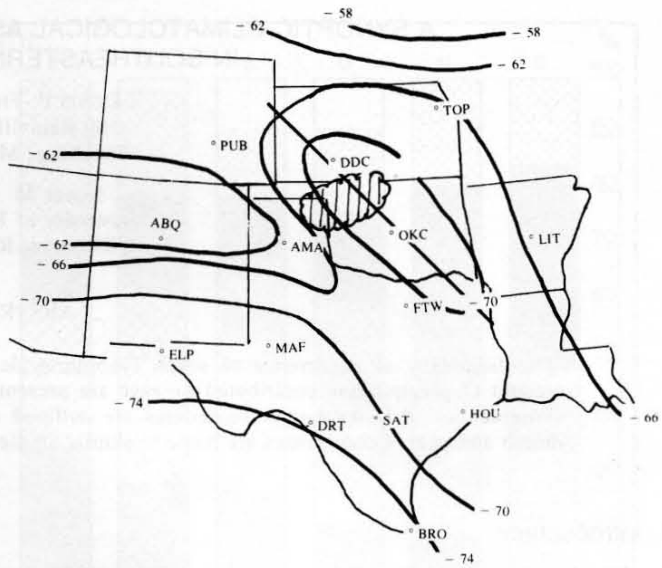

FIG. 3 TROPOPAUSE TEMPERATURES OR COLDEST AIR ALOFT 12Z MAY 31, 1977 (Scattered rainfall amounts of 1½ to 3½″ in shaded area)

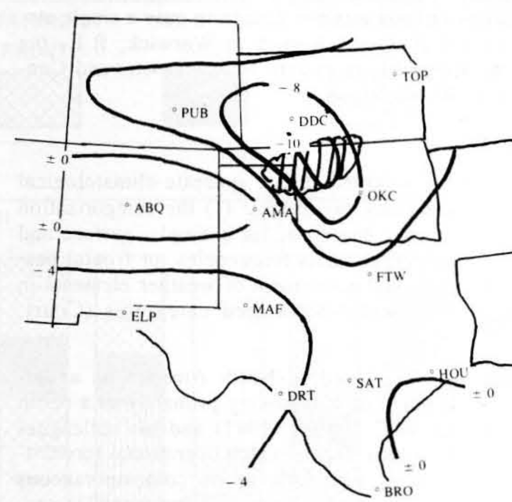

FIG. 4. TROPOPAUSE TEMPERATURES DEPARTURE FROM NORMAL ON MAY 31, 1977—12Z (Normal based on 5 yrs. data)

REFERENCES

Ropar, N.J., 1970: A Preliminary Note on the Use of Tropopause Temperature Analysis as an Aid in Short-Period Forecast. Local Research Study while in Albuquerque, NM.