A RECORD ARKANSAS RAINFALL: THE ELDORADO DELUGE

Kenneth M. Labas (1)
National Weather Service
337 North 2370 West
Salt Lake City, UT 84116

1. INTRODUCTION

Excessive 24 hour rainfalls of three to five inches are not uncommon over southwest Arkansas and the Ouachita Mountains of west-central Arkansas especially during the winter and spring. The recurrence of this phenomenon in the same area can be linked in part to the terrain.

During the four day period 5-8 June, 1974 much of the Southern Plains and Lower Mississippi Valley was struck by a series of violent storms including killer tornadoes, severe thunderstorms and floods. One significant facet of the outbreak was the occurrence of over 18 inches (45cm) of rain in less than 12 hours in Union County Arkansas. This phenomenal release, in the absence of any apparent terrain interaction, was quite unexpected and is the subject of this investigation.

Union County is in extreme south-central Arkansas. The area is rolling forested countryside with topographic relief of 60m or less. Showers and thunderstorms associated with a squall line had occurred over this area during the day of 7 June. Around 9 PM CDT the thunderstorms intensified and appeared to remain stationary over Union County until they moved northward at sunrise of the 8th. The Flight Service Station at El Dorado airport (about 10 miles west of town) measured 11.54 inches (29.2cm) of rain during the night. A Monsanto Company observatory approximately 8 miles north of the airport recorded 17.40 inches (44.2cm) during the same period with 9.50 inches (24.1cm) falling between 2AM and 7AM of the 8th. An Arkansas Forestry Commission station 15 miles east of the airport had 18.19 inches (46.2cm) of rain for the maximum total reported during this event. Amounts tapered off quite rapidly outside this small area, although totals in excess of four inches (10cm) covered most of the southwest quarter of the state (Figure 1). Along with the deluge, winds up to 50 knots and a possible tornado occurred just east of El Dorado about 4AM.

2. SYNOPTICS

At 00Z on June 8th, the height contour pattern at 500mb over the western third of the country (Figure 3A) was dominated by a large diffluent trough. The circulation was centered in extreme northeast Utah. This general diffluent trough had persisted for several days prior to this time and was beginning what turned out to be its final phase of development. Major cyclogenesis would be initiated in the Texas Panhandle during the next twelve to eighteen hours.

Short wave impulses had moved eastward from the southern Rockies into the Lower Mississippi Valley for the preceding couple of days. At 00Z on the 8th another rather well defined impulse was entering the western border of Arkansas (Figures 3a and 3b). Consequently, a line of active thunderstorms had organized during the afternoon in south-central Arkansas. This line then moved eastward into northern Mississippi and southward into extreme northern Louisiana during the evening as a well developed meso-system (Figures 2a and 2b).

Moisture was abundant through the 850mb level (Figure 3c) over northeast Texas and Louisiana. Surface dew points were in the mid 70's while 850mb conditions were near saturation with dew points exceeding 18 deg C. Instability, registered by K-values, was high at Shreveport, LA (SHV) with 42 while further south at Lake Charles, LA (LCH) and Victoria, TX (VCT) dryness at 700mb reduced the "K" values to near 12. Experience indicates that very high "K" values, say upper 30s to low 40s, approach the potential K (saturated) thus are more indicative of heavy rains than severe weather. Precipitable water content at 8/00Z were a little above 1.5" (SHV 1.58", LCH 1.61") which is high but not extreme. 20 to 30 kt low level winds were advecting the moist and unstable air over Louisiana and northeast Texas into southern Arkansas.

By 12Z on the 8th the 500 mb circulation in Utah had moved southeastward into Colorado (Figure 3d). Surface cyclogenesis had begun in the Texas Panhandle. The short wave which was along the western Arkansas border at 00Z had moved into northeastern Arkansas and northern Mississippi. Winds at 850mb had strengthened and become southerly from the northeast Texas coast into central Arkansas.

3. DISCUSSION

A quick glance at the synoptic situation presented would indicate a substantial precipitation release for some portion of Arkansas during the night 00Z-12Z June 8. As stated earlier, the southwest and hilly west-central portions of the state are prone to excessive release of moisture when conditions are favorable...as indeed they were here. These areas did receive abundant rainfall but the extreme totals were recorded near El Dorado some distance from the major terrain influence.

To determine the probable reasons for the occurrence of such large rainfall amounts, let us consider in detail the various circumstances, both small and large scale, which were present and how they apparently interacted where and when they did.

At 00Z/8th a well supported 500mb short wave with a marked tongue of cold air is approaching south- central Arkansas (Figure 3a) and will be positioned over the impact zone during the heavy release time. The initial 500 mb vorticity analysis, Figure 4, shows a sharp tongue of high vorticity associated with the short wave. Absolute vorticity values were forecast to be in excess of the 10×10^{-5} s^{-1} which is above the approximate zero relative value for this latitude of about 8×10^{-5} s^{-1}. Because of grid length and smoothing, vorticity values in Figure 4 associated with this particular feature are likely understated as the sharpness of the actual trough is quite marked (Figure 3a).

It is obvious that moisture supplies were abundant and were being advected into the impact area by the low level wind field, represented by the 850mb level (Figure 3c). Gradient wind directions were from the south southwest which experience has demonstrated is often associated with heavy rains in Arkansas.

Initially, one might wish to counteract these positive rain indicators with a negative one. The squall line and meso system which developed in south Arkansas during the afternoon of the 7th would normally tend to stabilize the lower atmosphere and inhibit convection. Perhaps it did initially, but therein lies a key to the phenomenon which was to unfold during the night. As the squall line developed near El Dorado during the afternoon of the 7th, convective overturning brought low θ_w (wet bulb potential temperature) air to the surface..as denoted by surface dew points lowering into the mid and upper 60's within the confines of the meso high-low dipole. Potential wet bulb temperature of an air parcel is conservative; it does not change for wet or dry adiabatic motion or for rain falling into it. Therefore it should be possible to "tag" and trace a parcel or series of vertically stacked parcels, i.e., vertical profile, over a finite time/distance frame. This conservative nature in mind, the vertical θ_w profiles of the airmass at Shreveport, LA at 00Z and Little Rock, AR (LIT) at 12Z are presented in Figure 5. Winds were advecting air directly from SHV to LIT. Comparing profiles we see that by matching points A-A', B-B', etc., LIT is an elevated mirror image of SHV. This suggests that the air column present near SHV at 00Z was essentially the same (in characteristics) present at LIT 12 hours later. The lift, which reached 55mb (977mb to 922mb) from SHV to LIT, most likely occurred along the mesoscale boundary south of El Dorado.

Low θ_w surface air and associated low dew points were to remain in south central Arkansas through the night. Its effect on the surface analysis was constant from late afternoon through the night...showing up as a minor frontal discontinuity along the Arkansas/Louisiana border (see Figures 2c-2f). Characteristic of the boundary was cyclonic curvature and convergence in the surface and near surface wind fields. Further, the dome of low θ_w air near the surface was to be perpetuated through the night by additional convective overturning and evaporative cooling.

From available data and analysis it appears as if the following reasoning would explain the Union County deluge. During the period 00Z to 12Z June 8th, a distinct short wave with very cold temperatures in mid levels and high vorticity values moved through south central Arkansas. An afternoon squall line and meso-system had developed in the same area leaving a pool of low θ_w air in the boundary layer. Exceedingly warm and moist high θ_w air was located over Louisiana and northeast Texas and was being advected northward into south central Arkansas by the gradient flow. This flow, represented by the 850mb winds, had some anticyclonic curvature in Arkansas at 00Z but was to back and become uniformly southerly with increasing speed during the night. This was in response to cyclogenesis in the Texas Panhandle which commenced after 06Z.

Warm moist air moving northward into southern Arkansas was lifted over the "cold dome" of low θ_w air which remained below 970mb. The lifted air was destabilized further by the cold pocket and high vorticity values in the mid troposphere associated with the short wave. Evaporative cooling near the surface and convective overturning perpetuated the low θ_w bubble; therefore conditions conducive to lift and massive convection remained unchanged in the same location for many hours. A classic case of meso-scale overrunning was in progress!

Radar patterns indicated an elongated east-west area of convection developed during the evening along the Arkansas/Louisiana border and intensified markedly after 05Z. The northern edge of the area spread slowly northward during the early morning hours of the 8th but the southern edge remained nearly stationary until moving north of the El Dorado area about 13Z. During the entire event, radar also indicated cell movement backing from 260 deg/40kts early in the night to 210 deg/18kts by dawn.

By shortly after sunrise, as the southern edge of the precipitation echoes had begun to shift northward, rainfall ended rather abruptly over Union County. Termination of precipitation in southern Arkansas can be linked to at least two synoptic events. The first was the intrusion of warmer and drier air at mid levels (near 500mb) over the impact zone. This air can be identified over the western half of Texas at 00Z (Figure 3a) and further east into northwest Louisiana by 12Z (Figure 3d). The second event concerns the development of the cyclonic circulation over the Texas Panhandle by 12Z. In response to the development, the 850mb jet was shifted westward toward the mid Red River Valley creating strong anticyclonic horizontal shear over the impact area. Relocation of the low level jet into eastern Oklahoma and Texas may have helped end the excessive rains in Arkansas but served to set the stage for the killer Drumwright and Tulsa tornadoes with occurred the evening of the 8th.

Detailed investigation of this event disclosed a number of other circumstances which may have played a role in the massive release of rainfall. First, it appears that maximum undisturbed moisture influx at low levels took place into south central Arkansas. During the 00Z-12Z period (Figure 3c and 3e) drier air at 850mb was being advected into northeast Texas from the southwest and central Mississippi from the south. Between these two areas the flow was unmodified.

Second, a time series plot of the SHV RAOB (Figure 6) indicates that about 24 hours prior to the heavy rain episode a closed cyclonic circulation passed over SHV at 200mb. Within the trailing ridge the tropopause rose and cooled significantly...from 160mb/-66.3° C to 115mb/-74.3° C. This high cold tropopause feature continued through the rain sequence and may have allowed more vertical development of convective clouds by raising the stable tropopause lid. A similar but less dramatic cooling and rising occurred at LIT during the same period.

Third, only massive convection over a prolonged period of time would result in the rainfall totals observed with this event. Radar tops continuously near 60,000 ft for many hours are evidence that this was indeed occurring. Cell diameters were quite large or the cells were grouped in clusters. The cores were therefore well insulated from environmental entrainment, thus allowing for a very high efficiency of rain production.

4. SUMMARY

There is no question that a rainfall event of this magnitude is rare and, realistically, impossible to forecast. Historically, this was the greatest 24 hour rainfall ever recorded in Arkansas up until this time...but has since been exceeded.

A number of common indicators pointed towards a significant rainfall release in south Arkansas and northwest Louisiana during the period 00Z-12Z June 8, 1974. These include: (1) an abundant moisture supply in the form of unstable Gulf air over northern Texas and Louisiana being advected rapidly northward and (2) a short wave impulse moving eastward from southeast Oklahoma into southern Arkansas intent upon overrunning the influx of moist air.

Further examination of the data reveals additional circumstances which were present over the impact zone and likely had a significant contribution to the events to come. These include: (1) a persistent dome of low θ_w air near the surface in south Arkansas which was initiated by an afternoon squall meso-system and perpetuated through the night by evaporative cooling and convective downdrafts; (2) a very cold and high tropopause over the area; (3) the convective area, once formed, remained stationary with cells moving through it; (4) massive cell diameters allowed minimal outside entrainment and maximum rain producing efficiency.

It is felt that the primary circumstances responsible for the 18 inch release near El Dorado was the thrust of moist Gulf air being lifted over the dome of low θ_w air and simultaneously cooled aloft under the mid-tropospheric short wave.

Precipitation was ended when warm dry air was introduced at mid levels and the low level wind jet receded westward in response to cyclogenesis over the southern Plains resulting in strong horizontal anticyclonic shear in southern Arkansas.

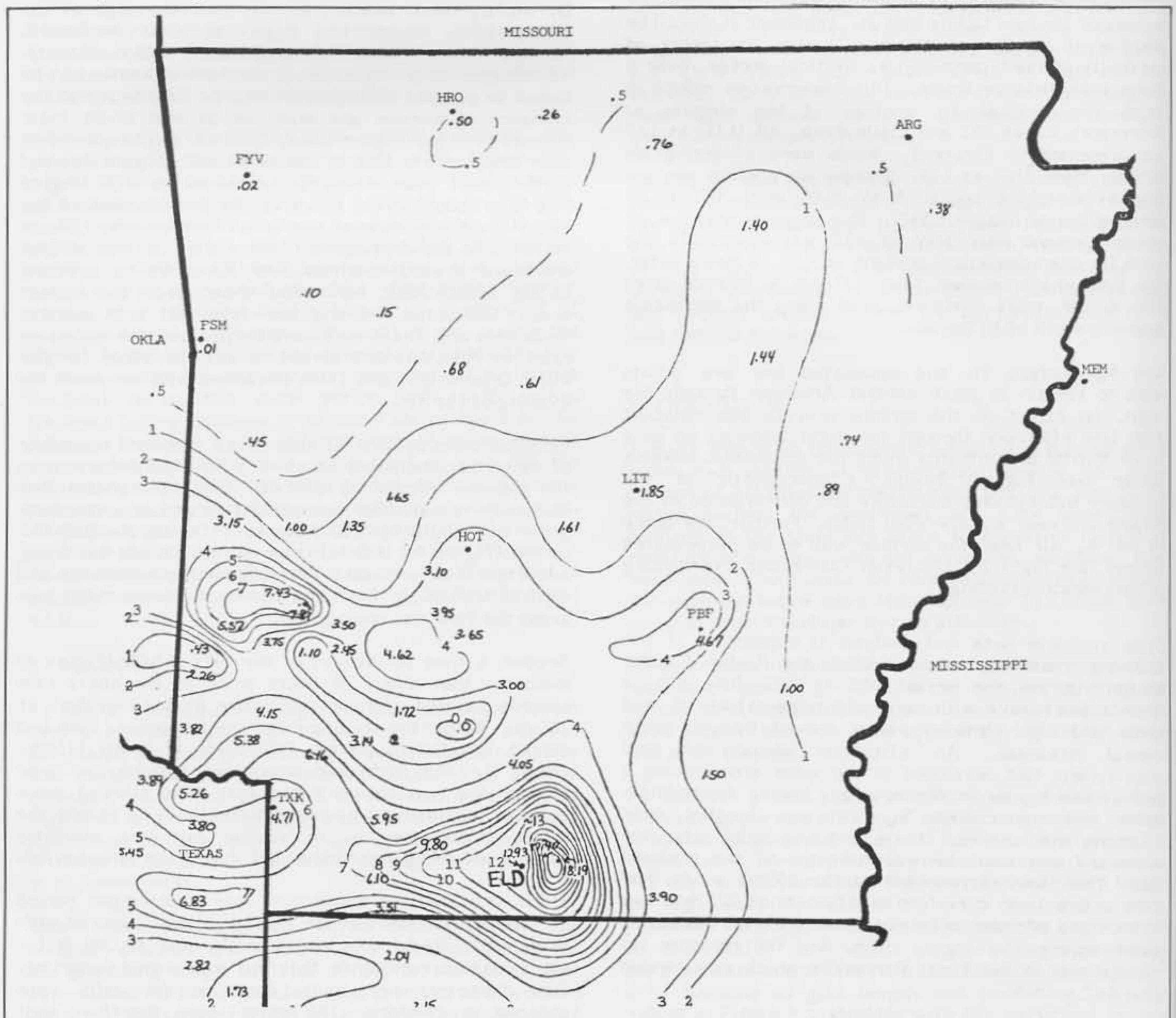

Figure 1. 24 Hour Rainfall (in inches) ending 7 A.M. June 8, 1974

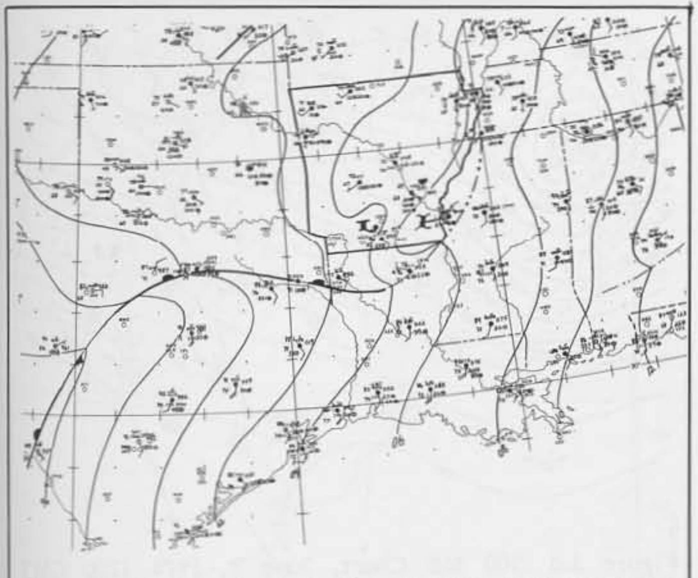

Figure 2.a Surface Analysis, June 7, 1974, 2200 GMT

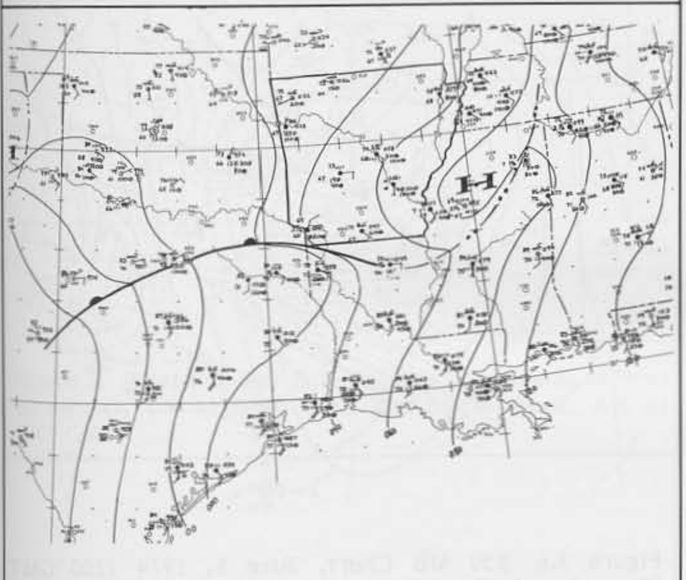

Figure 2.b Surface Analysis, June 8, 1974, 0000 GMT

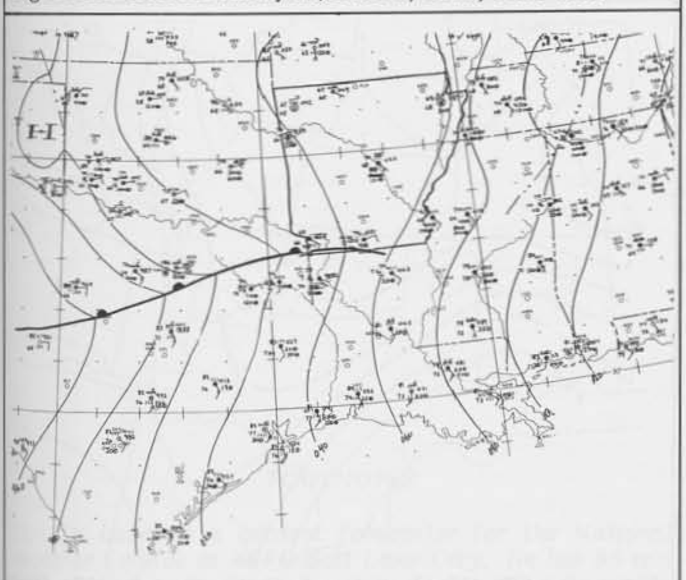

Figure 2.c Surface Analysis, June 8, 1974, 0300 GMT

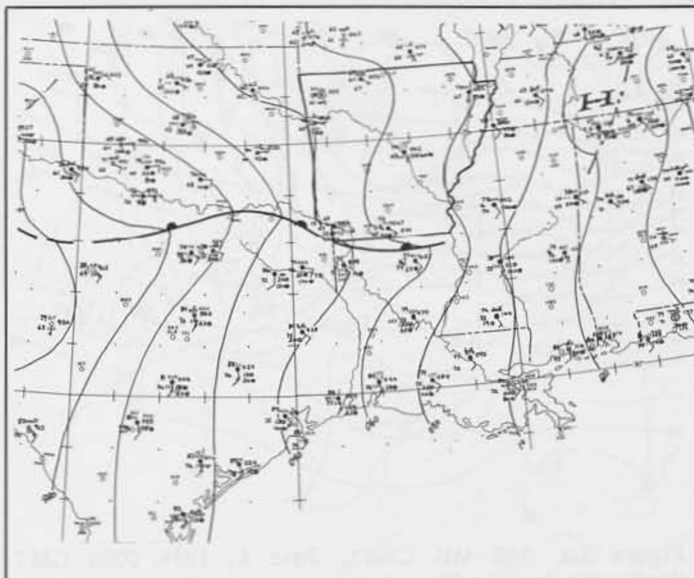

Figure 2.d Surface Analysis, June 8, 1974, 0600 GMT

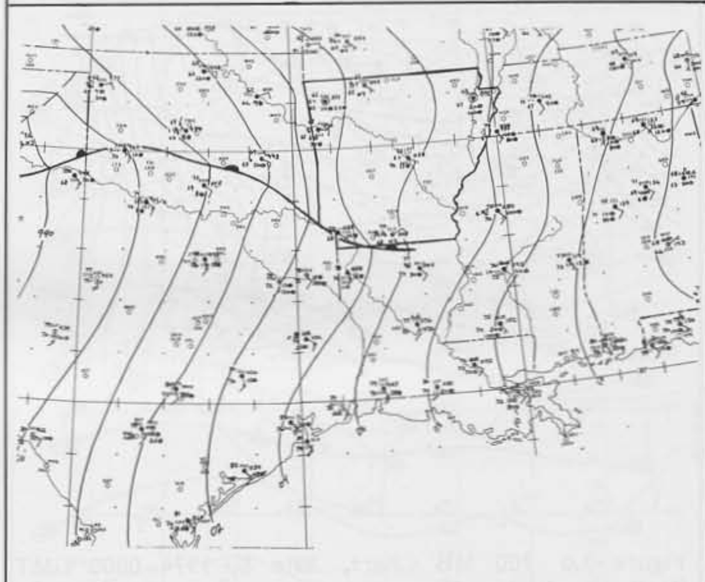

Figure 2.e Surface Analysis, June 8, 1974, 1000 GMT

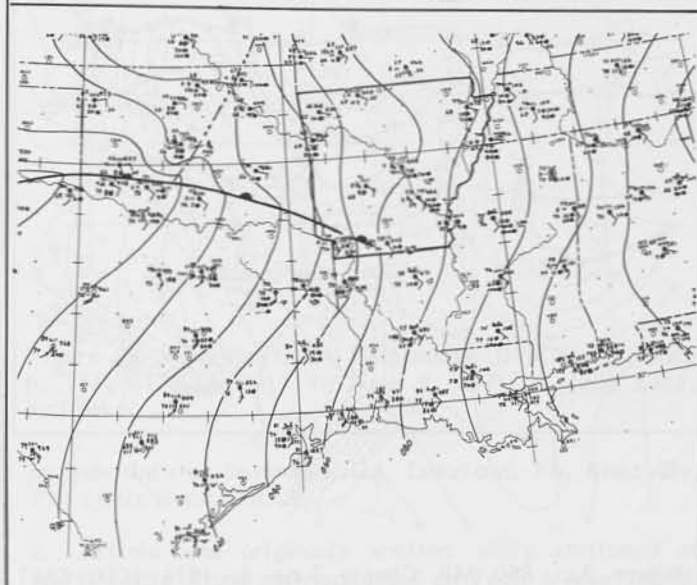

Figure 2.f Surface Analysis, June 8, 1974, 1200 GMT

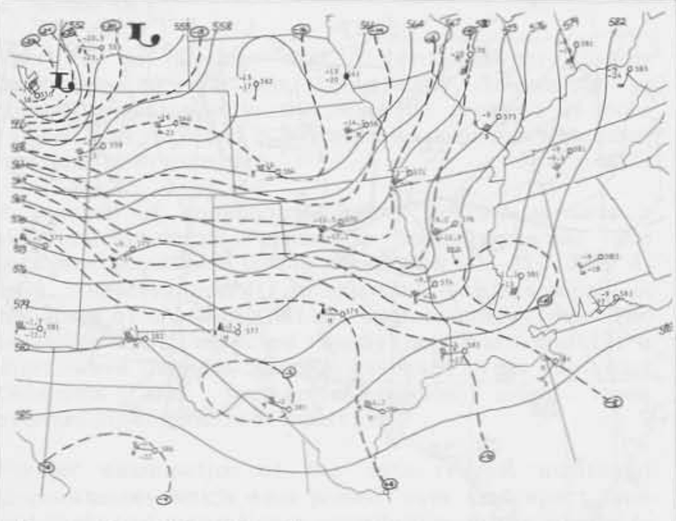

Figure 3.a 500 MB Chart, June 8, 1974 0000 GMT (Isotherms Analyzed)

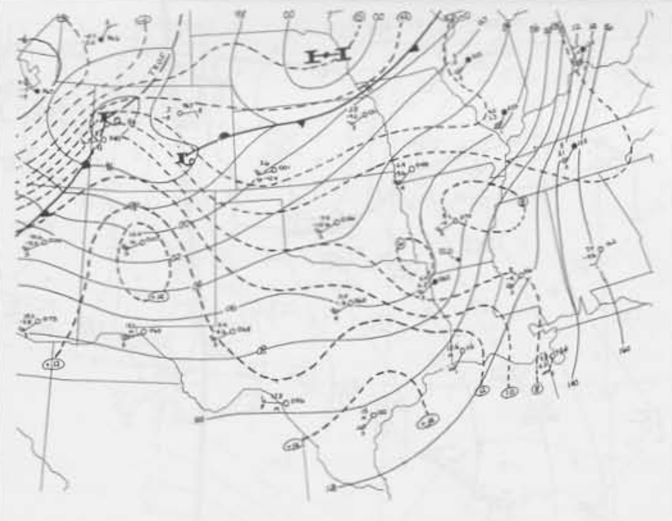

Figure 3.b 700 MB Chart, June 8, 1974 0000 GMT (Isotherms Analyzed)

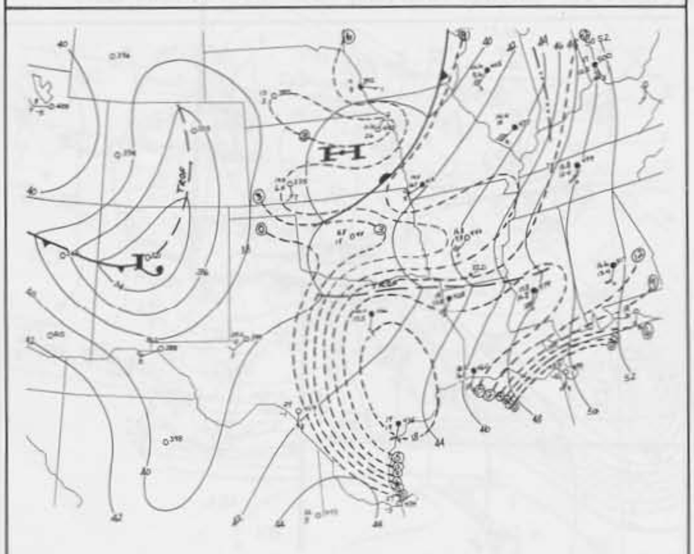

Figure 3.c 850 MB Chart, June 8, 1974 0000 GMT (Dewpoints Analyzed)

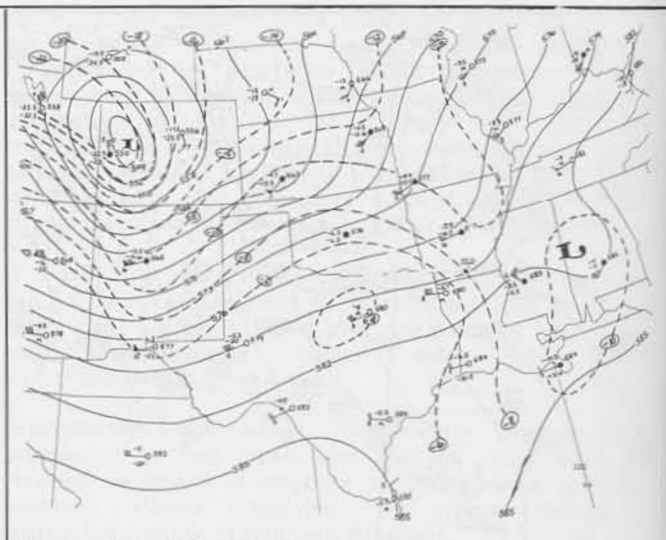

Figure 3.d 500 MB Chart, June 8, 1974 1200 GMT (Isotherms Analyzed)

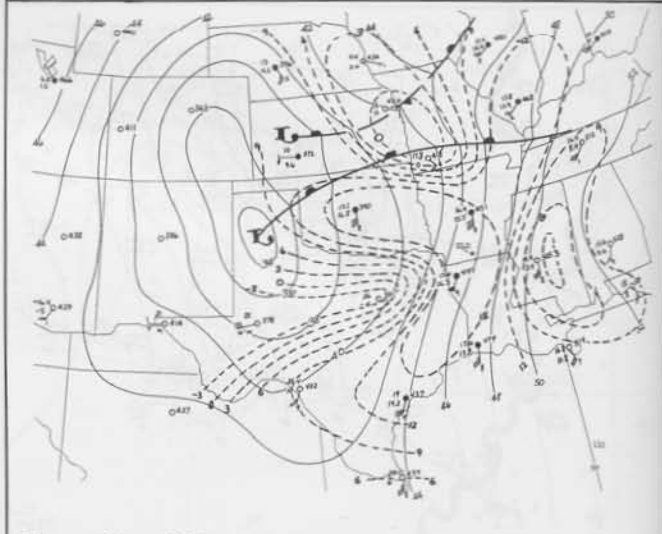

Figure 3.e 850 MB Chart, June 8, 1974 1200 GMT (Dewpoints Analyzed)

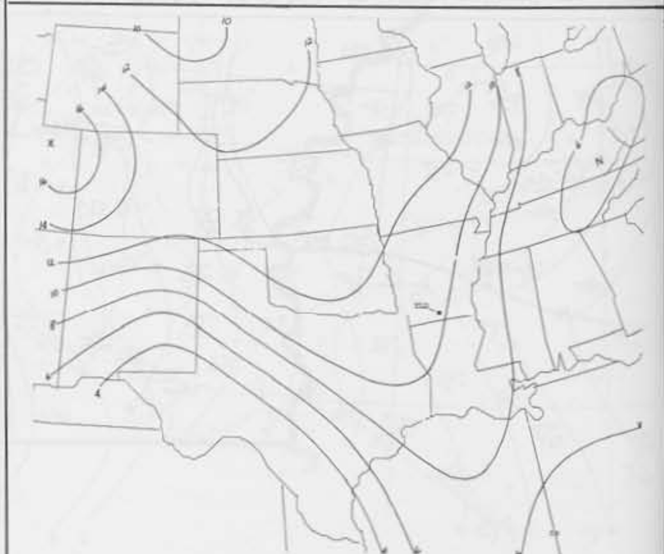

Figure 4. 500 MB Vorticity Analysis, June 8, 1974 0000 GMT

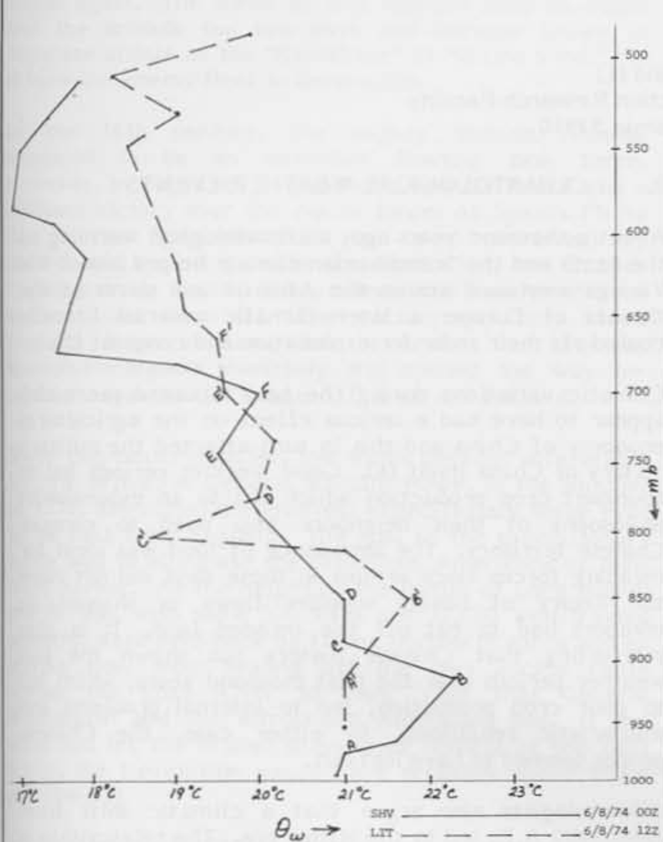

Figure 5. Potential Wet Bulb Profiles for June 8, 1974 at Shreveport, LA at 0000 GMT and Little Rock, AR at 1200 GMT

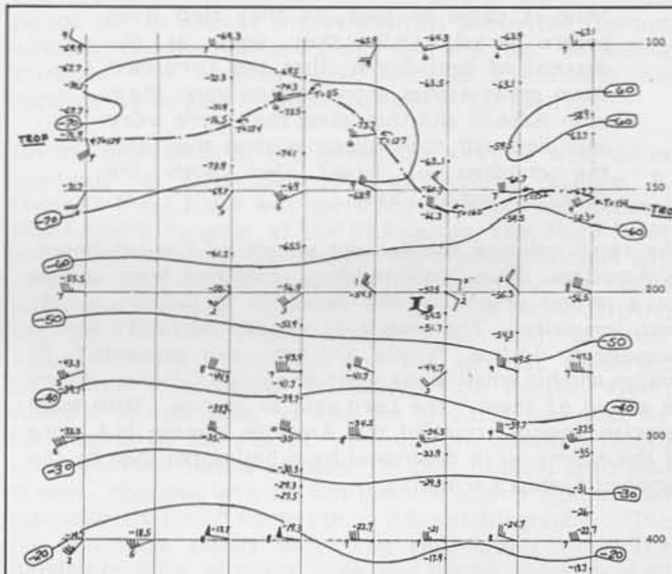

Figure 6. Shreveport, LA Radiosonde time series, June 6, 1974 at 0000 GMT to June 9, 1974 at 1200 GMT, inclusive.

FOOTNOTES

1. Mr. Labas is a general forecaster for the National Weather Service at WSFO Salt Lake City. He has BS and MS degrees in Meteorology from Florida State University. Previous Weather Service assignments include duty at Savannah, GA, Lakeland, FL, Knoxville, TN, Little Rock, AR.

2. Article was originally written while stationed at WSFO Little Rock and published as Tech Memo SR-86, August 1976.