NOAA Technical Memorandum NWS SR-201

A SEVERE WEATHER AND TROPICAL CYCLONE CLIMATOLOGY FOR THE NWSO SHREVEPORT, LOUISIANA COUNTY AND PARISH WARNING AREA

Bruce Burkman
Michael Berry
Timothy Doyle
Donovan Landreneau

NWSO Shreveport, Louisiana

Scientific Services Division
Southern Region
Fort Worth, TX

April 1999

NITED STATES
EPARTMENT OF COMMERCE
William M. Daley, Secretary

National Oceanic and Atmospheric Administration
D. James Baker
Under Secretary and Administrator

National Weather Service
John J. Kelly, Jr.
Assistant Administrator
for Weather Services

1. Introduction

While the National Weather Service (NWS) monitors and forecasts all aspects of meteorology to better serve the public, no responsibility is greater than the preparation and dissemination of critical information about impending severe weather.

Of the 100,000 thunderstorms which occur each year in the United States, only about 10 percent are classified as severe. The NWS definition of a severe thunderstorm is one that produces one or more tornadoes, hail greater than or equal to 0.75 inches in diameter, or convective wind gusts equal or greater than 50 kt (58 mph) or convective wind damage. While severe thunderstorms are no stranger to all parts of the country, this study is a severe weather climatology for the National Weather Service Office in Shreveport, Louisiana.

NWSO Shreveport has severe thunderstorm warning responsibility for portions of four states. This region comprises extreme southeast Oklahoma, southwest Arkansas, northwest/north-central Louisiana and northeast/east Texas; otherwise known as the four-state region. This study will take into consideration each individual severe weather criterion listed above and address climatological trends on an hourly, monthly and annual basis. The total number of severe events reflects the trends of the three types of severe weather; tornadoes, damaging winds, and severe hail for the period 1955-1997 (Figs. 3-6). To conclude this study, tropical cyclone distribution and frequency across the four-state region will also be investigated.

The purpose of this paper is to acquaint different state agencies, meteorologists and the general public on the frequencies of severe weather in the study area. Likely factors associated with each severe weather aspect are discussed briefly, and this will hopefully lead to more accurate forecasts and warnings. The results should provide a basis for additional severe weather research in the future.

2. Population and Population Density

Figure 1 shows a map of the NWSO Shreveport County Warning Area (CWA). This map shows not only the county and parish names but also the population and population density of that area. The Shreveport CWA covers parts of four states; one county in southeast Oklahoma; 11 counties in southwest Arkansas; 21 counties in northeast/east Texas and 17 parishes in northwest and north-central Louisiana. The population for the Shreveport county warning area in 1990 which covered an area of 34,342 square miles was 1,844,655. The breakdown by state: 193,414 in Arkansas; 781,380 in Louisiana; 33,433 in Oklahoma; and 836,428 in Texas. Average population density in 1990 was 53.7 per square mile. The heaviest concentration of people lies along the Interstate 20 corridor in northeast Texas and northern Louisiana, including the population centers of Monroe and Shreveport in Louisiana; and Longview and Tyler in Texas. Three other cities of significant population are Texarkana, Arkansas/Texas on Interstate 30, and Lufkin and Nacogdoches, in east Texas.

Of the 48 counties and parishes which make up the NWSO Shreveport CWA, 18 have populations of greater than 30,000 people. Of those 18 counties and parishes, four have populations of more than 100,000. The vast majority of their populations are in each area's largest city (Shreveport in Caddo

Parish, Monroe in Ouachita Parish, Longview in Gregg County and Tyler in Smith County). Much of Shreveport's CWA is rural with 30 counties and parishes consisting of a population less than 30,000. Perhaps this is described best by the population density figüres (per square mile) for each individual area. Population density can be misleading, however, in counties and parishes with large cities. For example, if the population of Shreveport was subtracted from the total population figure of Caddo Parish, the Caddo Parish population density would be similar to other rural areas. The same can be said for most counties and parishes in the Shreveport CWA.

Low population density is significant because it makes it inherently difficult to obtain severe weather reports, unless severe weather happens to occur in the area's larger cities. The implementation of storm spotter networks in conjunction with SKYWARN, automated surface observing systems (ASOS) and our Cooperative Program Network consisting of nearly 250 observers in the field have all helped to bridge the gap for obtaining severe weather reports in counties and parishes with low populations.

3. Topography

The Shreveport CWA has a low average elevation of less than 500 ft (Fig. 2). The exception to this is the southern edge of the Ouachita Mountains located across most of McCurtain County, Oklahoma and extending into parts of three counties in southwest Arkansas. The elevations in the Ouachita Mountains range from near 500 ft along the southern edge to about 1500 ft in northern Howard County, Arkansas and McCurtain County, Oklahoma. The major river basin is the Red River Valley, which extends across the entire region from northeast Texas and southeast Oklahoma, across extreme southwest Arkansas and northwest and north-central Louisiana. Two other significant rivers across the western and eastern sections are the Sabine in northeast Texas, and the Ouachita in north-central Louisiana. Most of the terrain of the region is rolling hills of about 200 to 500 ft elevation. Lower, flatter terrain exists along the major river valleys.

4. Tornado Climatology

Tornado data for this study were extracted from Storm Data (National Climatic Data Center 1959-1997), Significant Tornadoes 1680-1991 (Grazulis 1993), and Significant Tornadoes Update 1992-1995 (Grazulis 1997). A few tornadoes were also found in climatic records contained in weather files at NWSO Shreveport which were not included in other sources listed above.

-Yearly Distribution

The overall trends in tornado climatology show a marked increase in reported tornadoes over the last 120 years in the four-state region. Similar trends are seen elsewhere in the county and are mainly due to population increases and greater emphasis on reporting tornado occurrences. The annual frequency in the four-state region of southeast Oklahoma, northeast Texas, southwest Arkansas and northern Louisiana has risen significantly since 1875 (Figs. 7-8). Between 1950 and 1970, an average of about 10 to 15 tornado days occurred per year (Fig. 9). From 1970 to present the average has been 15 to 20. Two years, 1982 and 1990, reached more than 40 tornado days. Fluctuations have occurred during the 1970s and 1980s with numbers ranging from 15 to 30 tornado days. The 1990s have seen the average drop to about 15 tornado days per year.

Noteworthy trends are apparent in the annual tornado data but it must be remembered that population increases, verification techniques, and data collection methods (to name a few factors) can significantly skew any meaningful statistical results (e.g., Hales and Kelly 1985, Hales 1993).

The number of reported tornadoes increased dramatically from previous decades during the 1970s and 1980s, but in 1991 the number of reported tornadoes began to take a downturn which continued through 1997 (Fig. 10). The cause of this decline throughout the 1990s is not understood, but it could be the result of the installation of the WSR-88D radar in Shreveport. The radar improved detection capabilities and with it a vigorous public Severe Weather and Tornado Awareness Program was initiated with the modernization of the Shreveport weather office.

- Monthly Distribution

Two significant tornado "seasons" were identified in the monthly data, hence, the data were divided into the two seasons. The first and most significant (primary) season runs from March through August (Fig. 11) while the secondary season runs from September through February (Fig. 12). The primary season is most active in April and May while the secondary season is most active in November and December, and again in February.

- Hourly Distribution

Also noteworthy are the hours of tornado occurrence. It was believed by many locally that most tornadoes occur at night. In reality, the data contradict that (Figs. 13 and 14). The majority of tornadoes have occurred during the late afternoon and early evening hours in both seasons. It stands to reason the hours shift forward from between 1600 and 1800 CST during the secondary season to around 1900 CST during the spring season, given the hours of maximum heating.

Hourly frequency shows a distinct peak during mid-afternoon to early evening (Figs. 13 and 14) when most thunderstorms occur, with 90 to about 140 occurrences for the hours between 1400 and 2000 CST. While a relative minimum of tornadoes have occurred during the hours of midnight and 0800 CST (fewer than 20 occurrences per hour), a slight peak occurs between 0200 and 0300 CST with slightly more than 20 (Fike 1993).

5. Damaging Wind Climatology

There was a significant increase in reported damaging wind events since 1979 and again during the 1990s, possibly because more emphasis was placed on verification in 1980. Also, increasing population has increased the number of reports over the last 40 years. During the last 10 years the increased use of video cameras and cellular phones has enabled the public to report storm damage in a more timely way. The Storm Spotter Network has grown considerably from the mid-1950s to the mid-1970s, and again since 1994 with the addition of a Warning Coordination Meteorologist and increased staffing at the Shreveport NWS office.

- Yearly Distribution

According to data compiled by Vescio (1995) and data collected for the years 1996 and 1997 from Local Storm Data; 5,120 damaging wind events were reported in the Shreveport CWA for the period 1955-1997 (Fig. 15). The highest yearly total was 394 events in 1992. For the period 1955 to 1979 the average number of reports per year was about 50. Increasing reports due to verification improvements and better storm spotter networks since 1980 raised the average to 222 reports from 1980-1997. The average for the entire 43 year period 1955-1997 was 199 per year.

- Monthly Distribution

For the period 1955-1997, 65% of the damaging wind events occurred from April through July and 78% of events from March through August (Fig. 16). The spring months of March through mid-June see active polar and subtropical jet streams across the four-state region. Numerous cold fronts develop over the Southern Plains states during the spring, and squall line development ahead of the cold fronts can produce damaging winds. Damaging winds from collapsing single-cell pulse thunderstorms are associated with the majority of damaging wind events during July and August. This six month period is the primary severe weather season. May and June have been the most active months with 936 and 909 reports, respectively; over one-third of the total reports (Fig. 16). A second minor severe weather season occurs during the late fall with a peak in November (Fig. 17). December through February recorded the fewest reports, averaging 130 reports per month.

- Hourly Distribution

Time of day is important in the occurrence of thunderstorms with damaging winds. Late afternoon, evening and the early morning hours have the most reports. Looking at the damaging wind data by hour, the majority of reports have come between the hours of 1600 and 2100 CST, (Fig. 18). Almost 50% of reports have come between these hours. The fewest damaging wind reports occurred between 0600 and 1100 CST, only 6% of the total. A large number of reports, 14%, have occurred between midnight and 0400 CST (Fig. 18), probably due to the high occurrence of nocturnal thunderstorms in this region (Fike 1993).

In a climatological study of nocturnal severe thunderstorm outbreaks Fike (1993) showed a high frequency of severe, nocturnal thunderstorms near the center of the NWSO Shreveport County/Parish warning area. The major outbreaks which he analyzed occurred during the period 1970-1991, about half of the years in this study. The majority of the outbreaks occurred between February and May. An NSSO, or nocturnal severe local storm outbreak was defined by a set of conditions, the most important of which was the timing of the first severe event between 2100 and 0600 CST. Each outbreak had to include seven or more severe events and the time interval between severe events during the outbreak could not exceed two hours.

6. Severe Hail Climatology

One National Weather Service criterion for a severe thunderstorm is one which produces a hailstone three-quarters of an inch in diameter or larger. For this study, hailstones were subdivided into three categories: 0.75" to less than 1.75", 1.75" to less than 2.75" and 2.75" or greater. All severe hail events recorded for the period from 1955 to 1997 for the Shreveport CWA were examined.

- Yearly Distribution

Overall, hail reports showed a steady increase beginning in the early 1970s (Fig. 19) with decreases in the late 1970s and early 1980s. Decreases were also evident in the mid- to late 1980s and in the mid- to late 1990s. Substantial increases were observed in the middle 1970s, the middle 1980s and the early 1990s. Greater than 80% of the documented severe hail reports have occurred since 1980. This overwhelming percentage is most likely due to the NWS severe thunderstorm verification program which began in 1980. This is not to say reports were undocumented pre-1980, but just that there was not as much attention paid to severe thunderstorm warning verification as there has been since 1980. There were a total of 3997 hail reports of 0.75" in diameter or greater in the Shreveport CWA from 1955-1997. The record for severe hail events for a given year was 382 in 1992 (Fig. 19).

- Monthly Distribution

Figure 20 gives a month by month distribution of hail sizes in three categorical groups. There is an obvious increase in the number of hail events during the spring months (March through June) with the peak hail occurrence during the month of April. The spring months are considered the most active time of the year for hail producing severe thunderstorms and for all severe thunderstorms in general across the Shreveport CWA (Fig. 16). The peak during the spring is due largely to the influence of the westerlies across the southern Mississippi Valley region. The westerlies typically undergo a transitional period around the winter and summer solstice. Cold fronts are generally stronger and therefore are driven farther south. Additionally during this time, the low levels of the atmosphere also undergo a change. A cold, dry air mass is typically replaced by a warmer, moisture-laden air mass. This helps to destabilize the atmosphere to the extent that when thunderstorms develop, they encounter lower freezing and wet-bulb zero levels, which are optimal for the production of large hail. Nearly 70% of all hail reports occur during the spring season (March through June) and 28% occur during the peak month for large hail, April.

There is also a secondary peak for severe hail events during the fall months (October to November) across the Shreveport CWA, but the peak is not as dramatic as that observed during the spring months (Fig. 20). This secondary peak can again be explained by the transition the westerlies undergo during the fall months which helps to bring cold fronts through the region. Typically during the fall months, Shreveport's CWA is influenced enough by the Gulf of Mexico that the lower levels of the atmosphere remain rather mild and moist and the upper levels also remain rather warm, thus a less dramatic severe hail event peak is experienced.

The chances for hail producing severe thunderstorms are minimized during the summer months (July through September) and for a short period during the winter months (late November through early January). During the summer, while low level moisture, surface heating and instability are often efficient, the mid- and upper levels of the atmosphere are far too warm, leading to high freezing and wet-bulb zero levels. During the winter months, just the opposite is experienced. Mid- and upper level atmospheric temperatures are generally cold enough but sufficient low level heating and instability are often lacking.

- Hourly Distribution

Hourly distribution of hail occurrence in the Shreveport CWA is split into two separate periods which act to highlight the four-state region's two severe weather seasons. Figure 21, which shows an hourly distribution of hail events from March through August, points to a diurnal change with the peak hours occurring from 1400 to 2200 CST. This peak can most likely be explained by diurnal heating and/or the influence of large-scale synoptic weather systems and their migration into the Lower Mississippi Valley. This early afternoon, late evening peak is also experienced in the second severe weather season (Fig. 22).

Of particular interest is the relatively high number of severe hail events during the late night and early morning hours of the second severe weather seasonal period (Fig. 22). From 2300 through 0500 CST, 160 severe hail reports were received which totaled nearly 25% of all reports during that period (September through February). This was higher than the nearly 15% received for the same time period (2300 through 0500 CST) for the primary severe weather hourly distribution graph (Fig. 21). Fike (1993) describes this as nocturnal severe local storm outbreaks (NSSO) which he showed to be maximized across the northwest half of the Shreveport CWA. Reasons for this are not fully understood, but it most likely relates to the displacement of the westerlies to such a low latitude that extreme cold temperatures aloft help make up for a lack of surface heating and surface-based instability.

7. Tropical Cyclones

While it is known that locations closer to the coast have experienced the full brunt of tropical cyclones, the effects on inland areas have often been forgotten. Tropical cyclones have not affected the Shreveport county and parish warning area in the form of devastating hurricane force winds and storm surges, but storms have brought tropical storm force winds, heavy rains, flooding, and tornadoes.

This section will concentrate on tropical cyclones that affected the Shreveport CWA from 1886 to 1997, using primarily data from Neumann, et al. (1993). Data through 1997 were obtained from the Atlantic track file (Jarvinen, et al. 1984) as well as the National Hurricane Center Web site (*http://www.nhc.noaa.gov*). Additional data came from the NOAA home page (*http://www.noaa.gov*) as well as office climatological records.

STORM (Pesek 1995), a computer program using the entire Atlantic track file mentioned earlier, was used to find all stages of tropical cyclones that passed within 150 nm (173 mi) of Shreveport, similar to the work by Roth (1998). This number was chosen to include McCurtain County, Oklahoma. This analysis yielded 70 tropical cyclones within this radius. Of these 70 tropical cyclones, only 33 passed within the CWA boundary. In this study a tropical cyclone is considered to have affected an area (CWA) if the track intersects and enters any portion of the area while at the tropical depression, tropical storm, or hurricane stage. This did not include peripheral effects from cyclones whose tracks did not enter the CWA.

Table A shows the 33 tropical cyclones and the maximum intensity of each as it passed through one or more of the four states of the Shreveport CWA. Of the 33 cyclones found, two had sustained winds up to hurricane force, 21 had sustained winds of tropical storm force, and the other 10 were of only tropical depression strength.

The return period (Huschke 1959, Elsner and Kara 1997) is defined as the average time between occurrences of a quantity, or in this case, tropical cyclones. Analyzing the data from 1886 to 1997 gave a return period of 3.4 years, or a tropical cyclone affected the Shreveport CWA every 3 to 4 years on average. Great variability in the interval between occurrences has been noted. For example, the longest period without a topical cyclone was nearly 20 years between September 1898 and August 1918. In contrast, the most active period of tropical cyclone activity occurred between the years of 1985-1989 with eight storms.

Table B shows Texas and Louisiana had the most occurrences of tropical cyclones with 21 each. Note that a single tropical cyclone can affect more than one state during its journey. Table C shows the distribution of tropical cyclones by months of occurrence. The highest total of cyclones occurred in August (12), with September second (8).

In 1997 and 1998, the media paid great attention to the effects of El Niño and La Niña on global weather. It has been noted by Gray (1984) that the occurrence of the El Niño/Southern Oscillation Event will result in a fewer than average number of tropical cyclones in the tropical Atlantic. How any such effect would influence where these tropical cyclones make landfall in El Niño years verses non-El Niño years is not clear. Several studies along the Gulf Coast have dealt with this issue. Some studies revealed a correlation, while others found no correlation. Table D lists the El Niño and La Niña years using data obtained from the NOAA home page (*http://www.noaa.gov*). In this table, the year listed is the first of two consecutive years, with warm (El Niño) or cold (La Niña) episodes generally lasting into the winter and spring of the following year (i.e., 1982 denotes the 1982/83 El Niño event).

Landreneau (1999) has performed a similar study with the Shreveport CWA comparing this phenomenon with tropical cyclone activity. The cyclones that occurred during El Niño/La Niña years are indicated in Table A with an X. Since data date back only to 1902 for these events, only the 27 cyclones that affected the area after 1902 were considered. Of the 23 El Niño events (46 years) which occurred, only 12 storms affected the area. For the 15 La Niña events (30 years), only eight storms were noted. One storm, Hurricane Betsy, occurred during a transition year from a cold La Niña event to a warm El Niño event. This analysis showed that in about a quarter of the years during these warm/cold events a tropical cyclone affected the area. Conversely, of the 27 storms studied, 44% occurred during El Niño years, 30% occurred during La Niña years, and 26% occurred during transitional or neutral years. While there may be a slight increase in the number of storms which occurred during El Niño years, Landreneau (1999) determined that there was no strong correlation between tropical cyclones in the Shreveport CWA versus El Niño/La Niña events.

Tornadoes have often posed a threat to the Shreveport CWA once a tropical cyclone moved inland, especially in the northeast quadrant of the storm. Tornadoes that have occurred in the Shreveport CWA are discussed in an earlier section of this paper. It was determined by the authors not to distinguish separately the tropical cyclone induced tornadoes. Many times, a strong synoptic system such as a cold front or extratropical low approached the area while a tropical cyclone moved within the CWA. Data availability prohibits the distinction between the two. Regardless, the occurrence of tornadoes has to be considered when tropical cyclones move inland.

One of the most remarkable rainfall totals in the Shreveport CWA was 29.52 inches of rain near Winnfield, Louisiana, during tropical storm Allison from June 27-July 2, 1989. The worst flooding of record associated with tropical storms which affected the city of Shreveport occurred July 23-25, 1933 with 19.08 inches of rain (recorded in downtown Shreveport) from a slow moving tropical storm, which weakened to a synoptic low once it passed just north of Shreveport. Other notable tropical rainfalls in Shreveport were 10.15 inches with tropical storm Allison June 26-July 2, 1989; 7.86 inches on October 3-6, 1949 (recorded in downtown Shreveport) from the 10th storm of the year, which reached hurricane strength before landfall near Houston; and 7.06 inches from tropical storm Bonnie June 25-28, 1986.

8. Conclusion

Through the analysis of severe thunderstorm data collected across the four-state region over the period 1955-1997, yearly, monthly and hourly trends in severe weather events were studied. A dramatic increase of reported severe events occurred since the beginning of the National Weather Service severe thunderstorm verification program in 1980. The highest number of severe events, including tornadoes, damaging winds and severe hail, occurs during the spring months of April, May, and June. Maximum hourly frequency of severe events clusters around maximum heating during the warmer months of the year, which starts at mid-afternoon and peaks at about 1900 CST.

Each of the three types of severe events showed different trends in the four-state region. Annual data show damaging wind events are the most frequent severe event, with large hail and tornadoes frequent during April and May, but much less common in the remaining months of the year. Tornadoes and severe hail occurred predominantly during the spring months of April, May and June, while occurrence of damaging winds slowly decreased through the summer from a peak in late spring.

Tropical cyclone occurrences were observed June through October, as could be expected. August and September have had the highest occurrences of tropical cyclones since 1886. The dangers of tornadoes, damaging winds, and flooding often occur with dissipating tropical cyclones. El Niño and La Niña seem to have no significant correlation with tropical storms that have affected the Shreveport CWA.

While these data help to establish trends for the frequency of severe weather in the four-state region, the data also show severe weather can occur any time during the year, and at any hour. Because of this, forecasters should remain alert to any and all types of severe weather regardless of the time of year. As the NWS continues to modernize operations, severe weather forecasting and verification will always remain a top priority and therefore will continue to advance as well. We hope that future meteorologists can use this paper to develop a personal knowledge of severe weather patterns across the NWSO Shreveport area of responsibility and that this knowledge will be used to better serve the public.

9. Acknowledgments

The authors appreciate the review and recommendations of MIC Lee Harrison, SOO Ken Falk and DAPM Marion Kuykendall at NWSO Shreveport, along with others on the operational staff. Thanks also to Mike Vescio of the NCEP Storm Prediction Center (SPC) in Norman, Oklahoma, for supplying much of the data used in this study.

10. References

Elsner, J. B. and A. B. Kara, 1997: Hurricane Return Periods Along the Gulf Coast and Florida, NOAA, *Technical Memorandum* NWS SR-192.

Fike, P. C., 1993: A Climatology of Nocturnal Severe Local Storm Outbreaks. Preprints, *17th Conference on Severe Local Storms*, American Meteor. Soc., 10-13.

Gray, W. M., 1984: Atlantic Seasonal Hurricane Frequency: Part 1: El Niño and 30 mb Quasi-biennial Oscillation Influences. *Monthly Weather Review*, 112, 1649-1668.

Grazulis, T. P., 1993: *Significant Tornadoes 1680-1991*. The Tornado Project of Environmental Films, St. Johnsbury, VT, 1326 pp.

Grazulis, T. P., 1997: *Significant Tornadoes Update, 1992-1995*. The Tornado Project of Environmental Films, St. Johnsbury, VT, 118 pp.

Hales, John E. Jr. and Donald L. Kelly, 1985: The relationship between the collection of severe thunderstorm reports and warning verification. Preprints, *14th Conference on Severe Local*

Storms, Indianapolis, IN, Amer. Meteor. Soc.,

Hales, John E. Jr., 1993: Biases in the severe thunderstorm data base: ramifications and solutions. Preprints, *13th Conference Weather Forecasting and Analysis*, Vienna, VA, Amer. Meteor. Soc., 504-507.

Hart, J. A., 1993: SVRPLOT: A New Method of Accessing and Manipulating the NSSFC Severe Weather Database. Preprints, *17th Conference on Severe Local Storms*, St. Louis, Amer. Meteor. Soc., 40-41.

Huschke, Ralph E., 1959: *Glossary of Meteorology*. American Meteorological Society, Boston, MA, 638 pp.

Jarvinen, Brian E., Charles J. Neumann, and Mary A. S. Davis, 1984: A Tropical Cyclone Data Tape for the North Atlantic Basin, 1886-1983: Content, Limitations, and Uses, NOAA, *Technical Memorandum* NWS NHC-22.

Landreneau, Donovan M., 1999: Atlantic Tropical Storms and Hurricanes Affecting the United States: 1899-1997, in preparation.

Neumann, Charles J., Brian R. Jarvinen, Colin J. McAdie, and Joe D. Elms, 1993: Tropical Cyclones of the North Atlantic Ocean, 1871-1992. *Historical Climatoloty Series 6-2*, Asheville, North Carolina, National Climatic Data Center, 193 pp.

NHC/TPC/NCEP: *National Hurricane Center's Web Page*. http://www.nhc.noaa.gov 1998.

NOAA: *NOAA Home Page*. http://www.noaa.gov 1998.

Pesek, Thomas. *STORM '95*. Computer Software. UTopia Software, 1995.

Roth, David R., 1998: A Historical Study of Tropical Storms and Hurricanes that have affected Southwest Louisiana and Southeast Texas, NOAA, *Technical Attachment* SR/SSD 98-16.

Vescio, M. D., 1995: CLIMO: Software to Generate Severe Weather Statistics for NWS County Warning Areas. NCEP, Storm Prediction Center, Norman, OK.

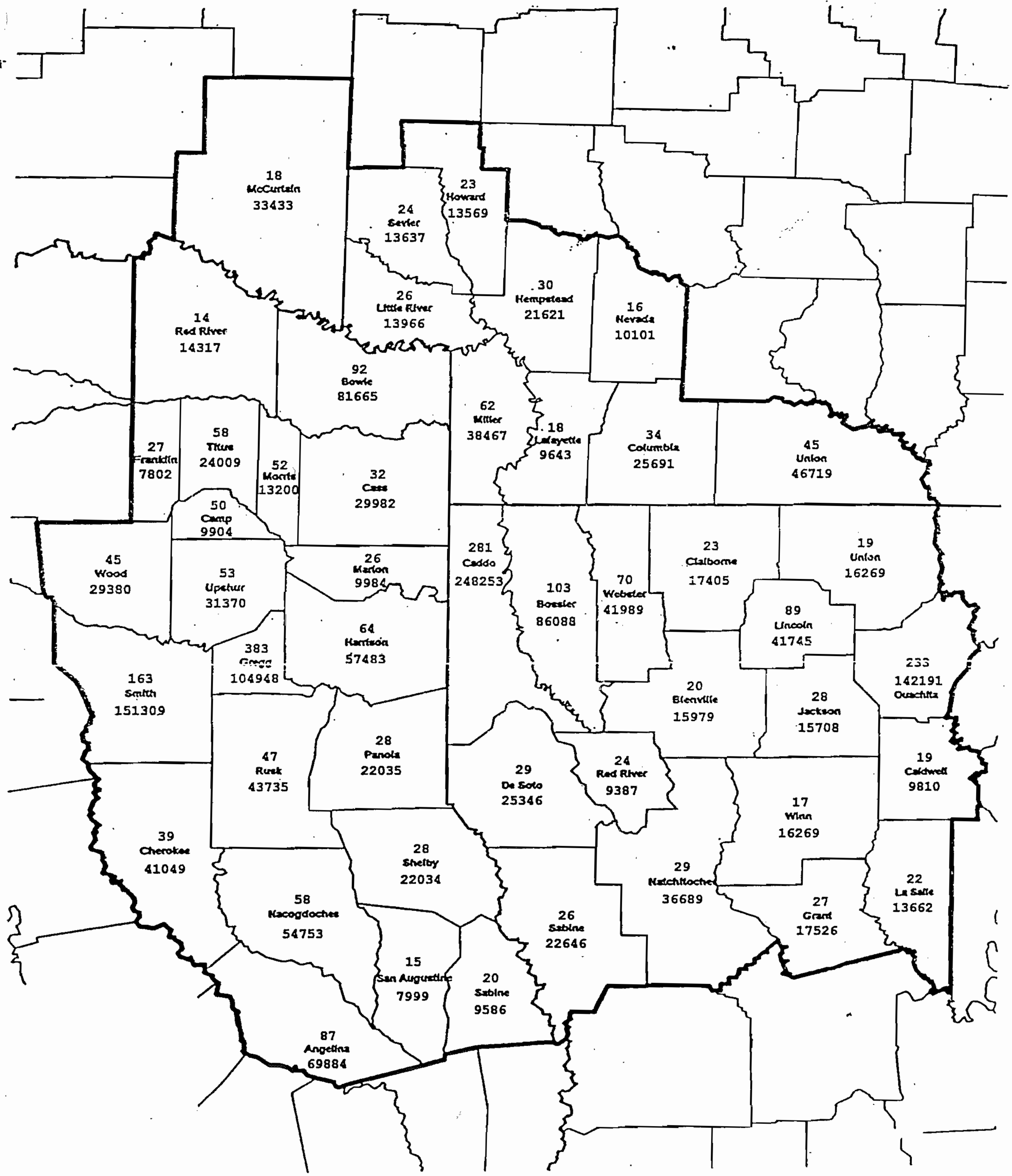

Figure 1 - Top Number: Population Density (per sq. mi) for Counties/Parish
Bot. Number: CWA Population, (Based on 1990 Census)

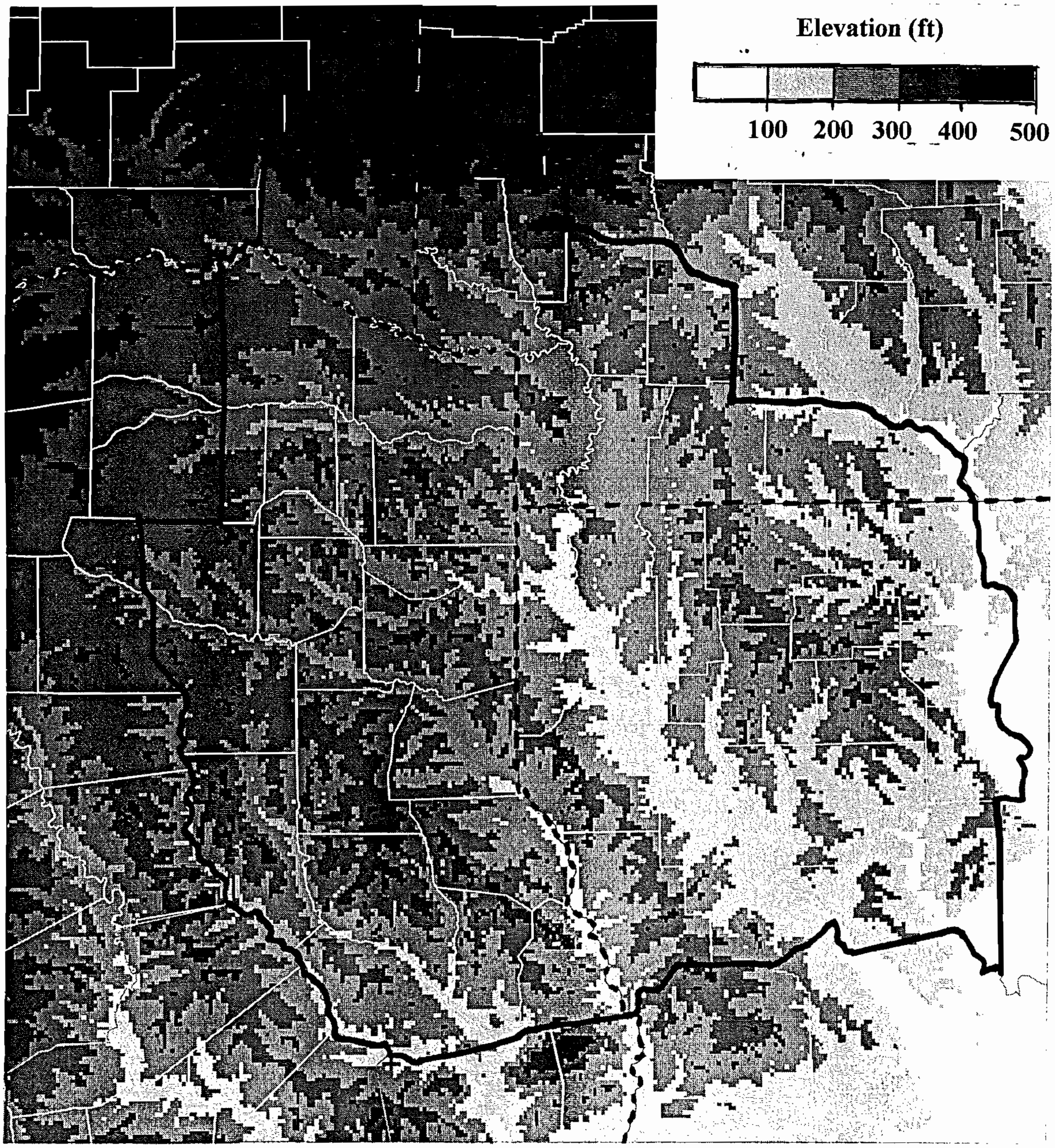

Figure 2. NWSO Shreveport's CWA topography generated By WSR 88-D in Shreveport, Louisiana.

Figure 3

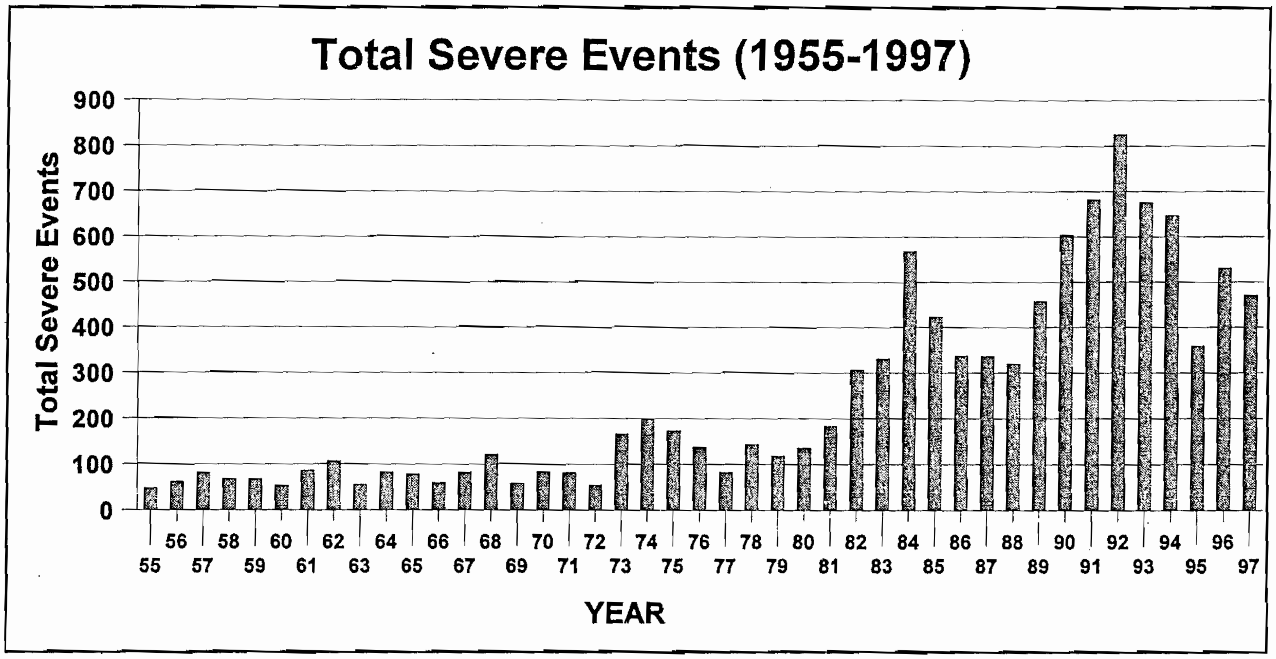

Figure 4

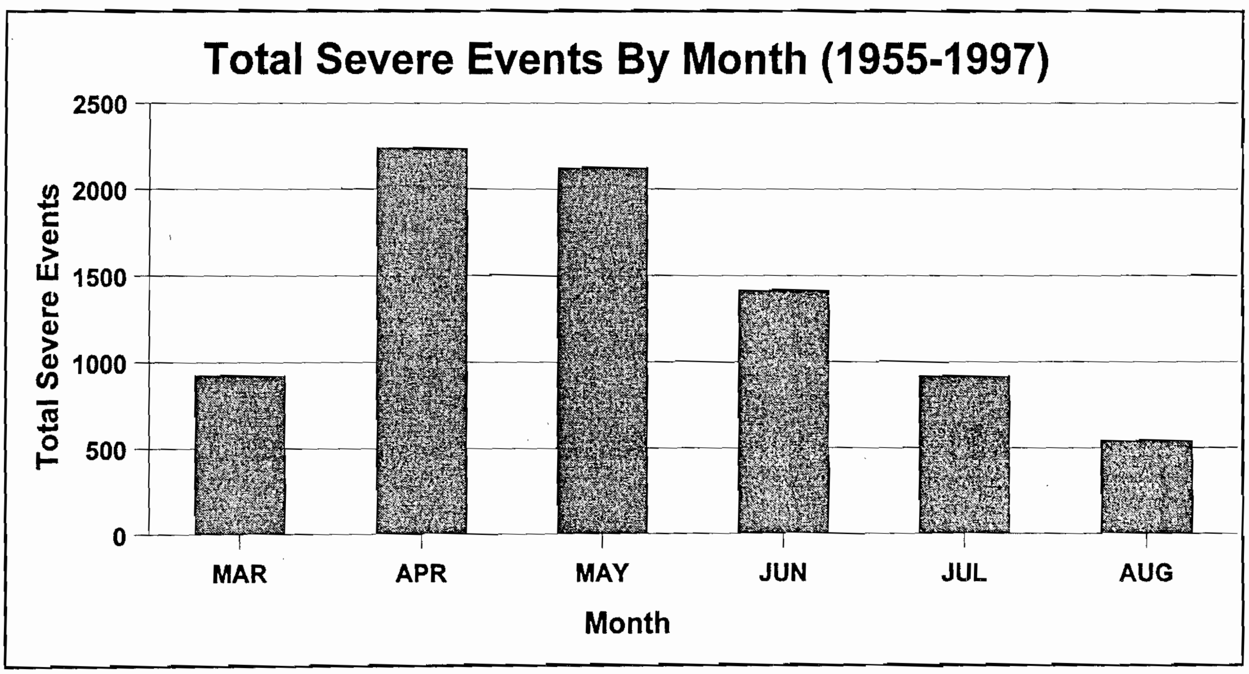

Figure 5

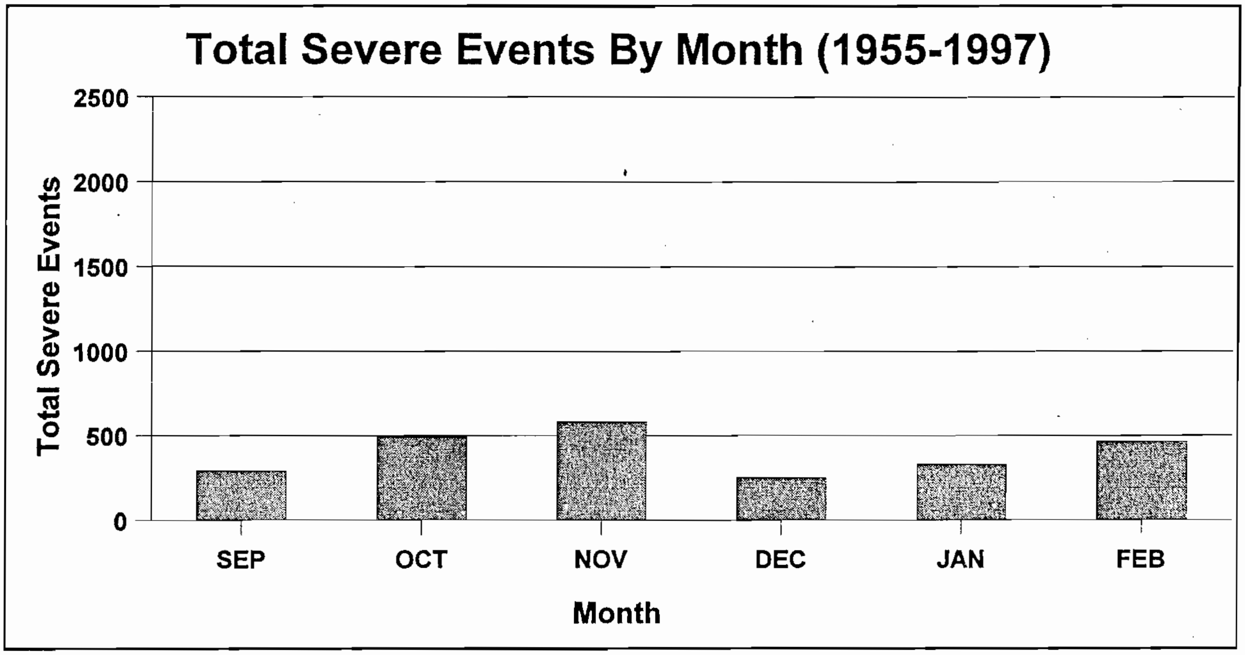

Figure 6

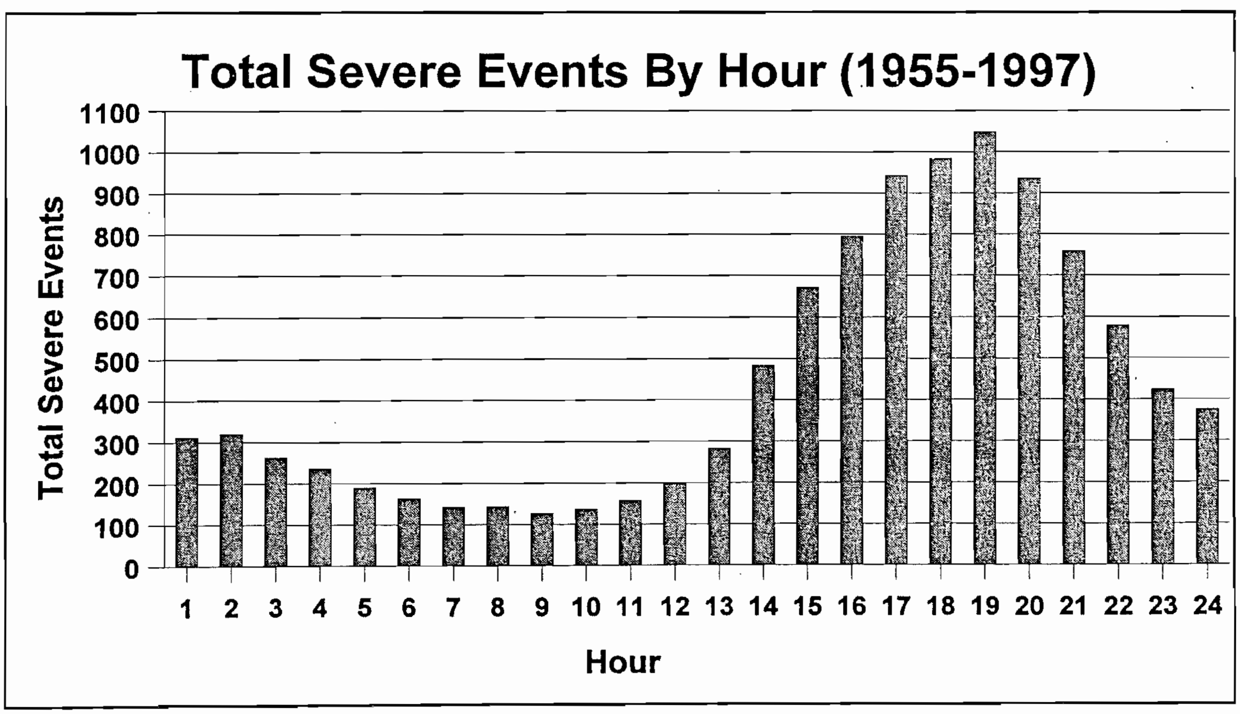

Figure 7

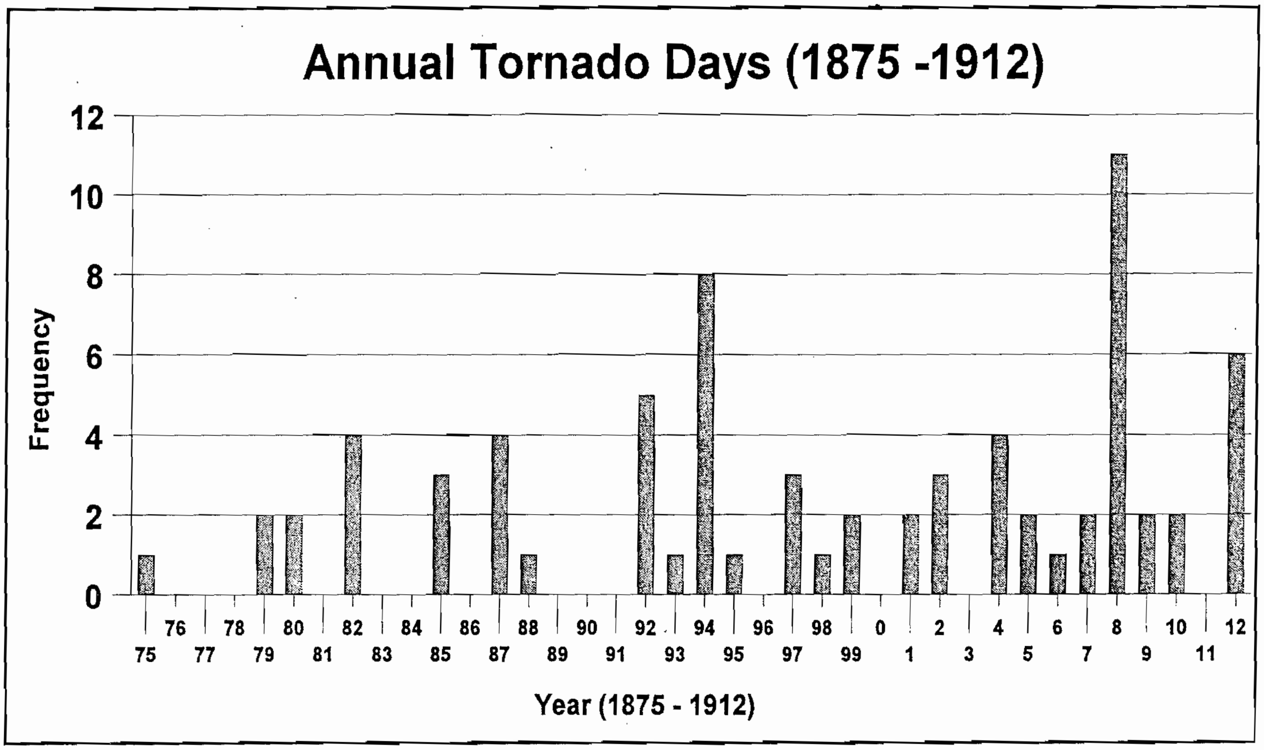

Figure 8

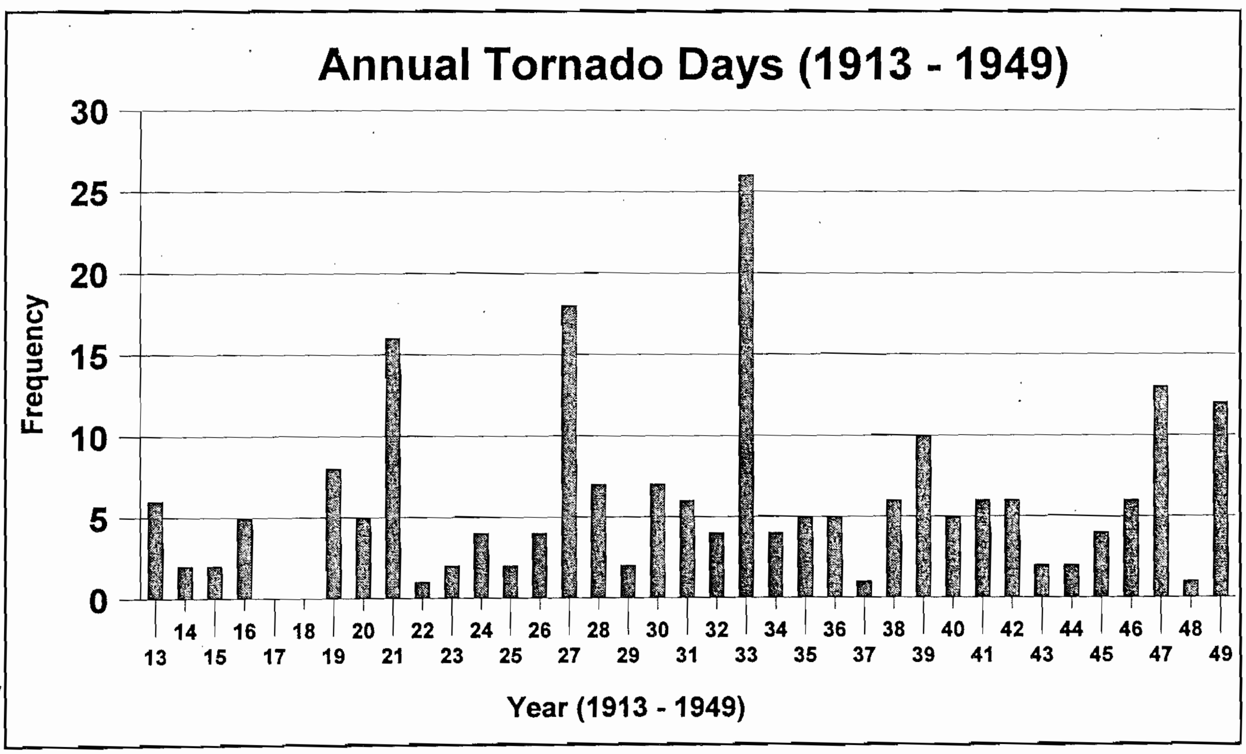

Figure 9

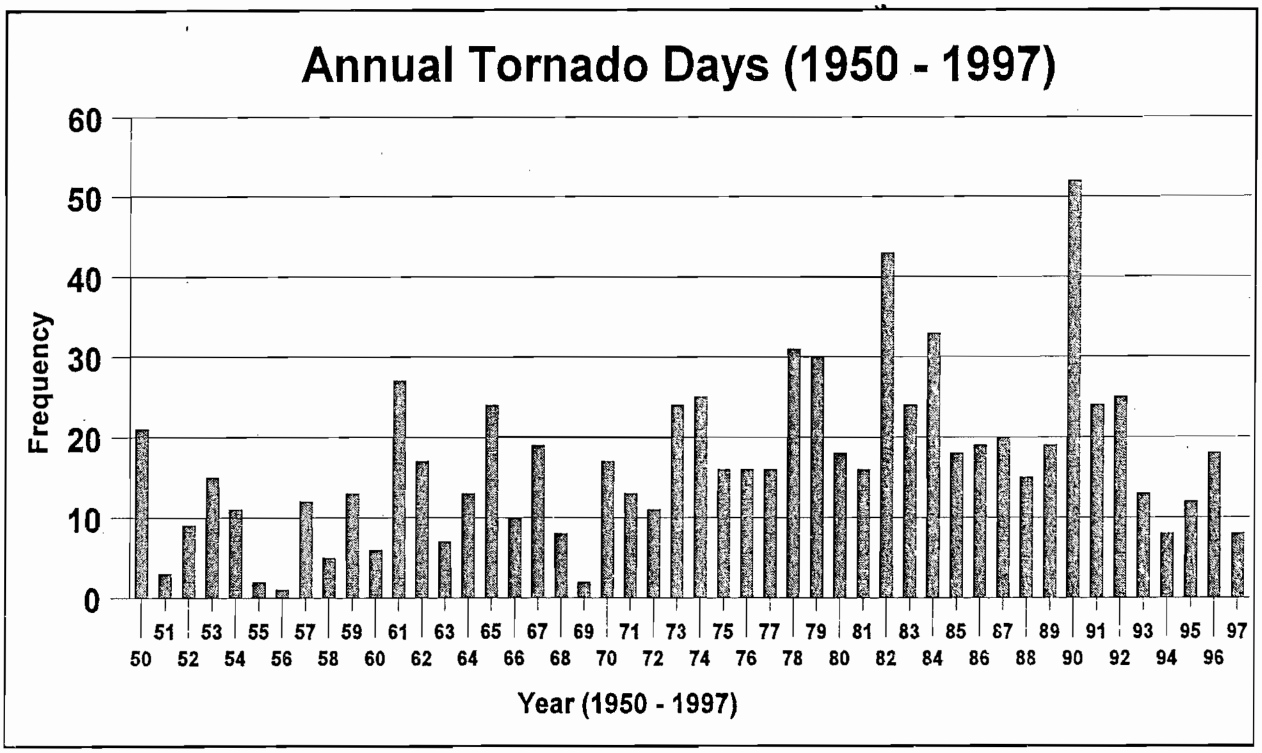

Figure 10

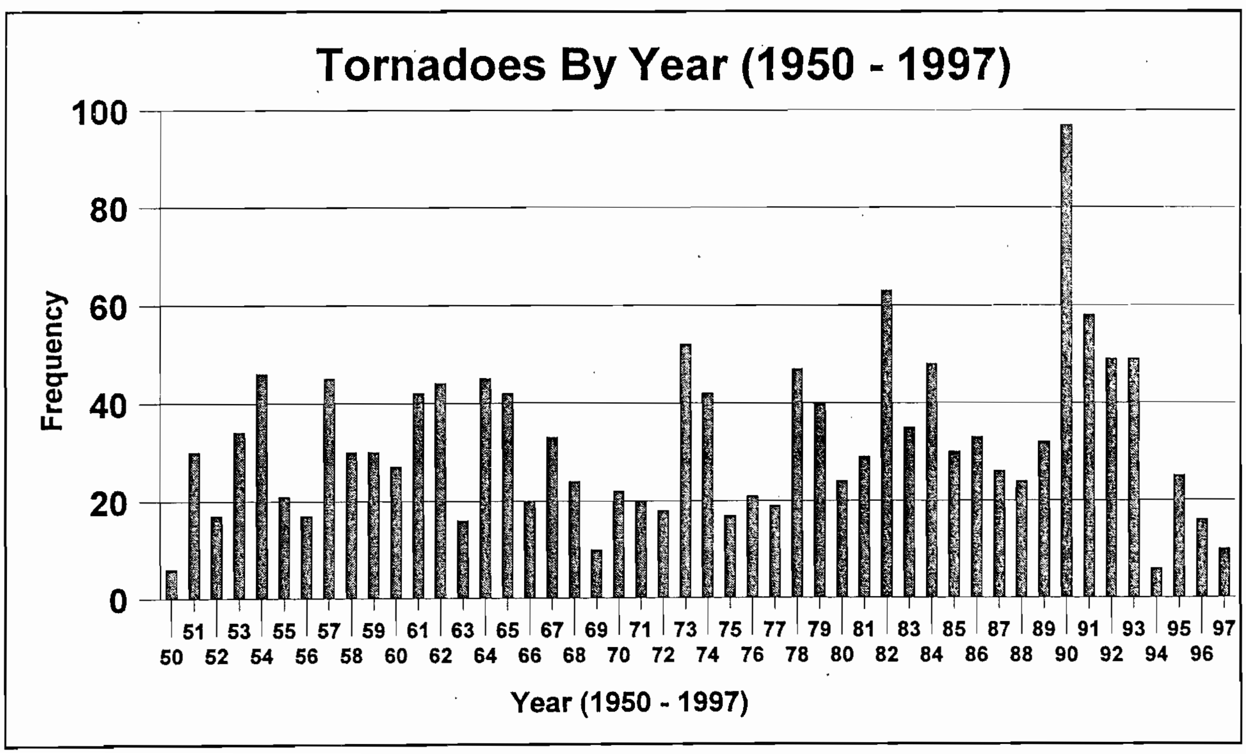

Figure 11

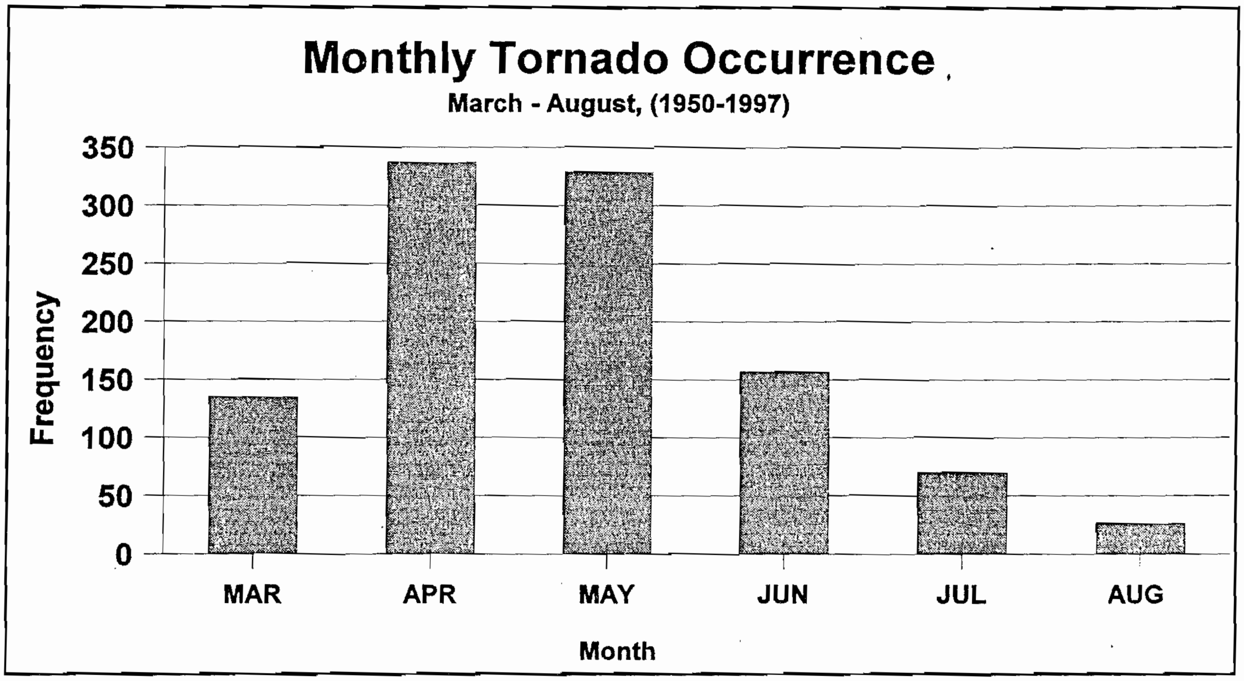

Figure 12

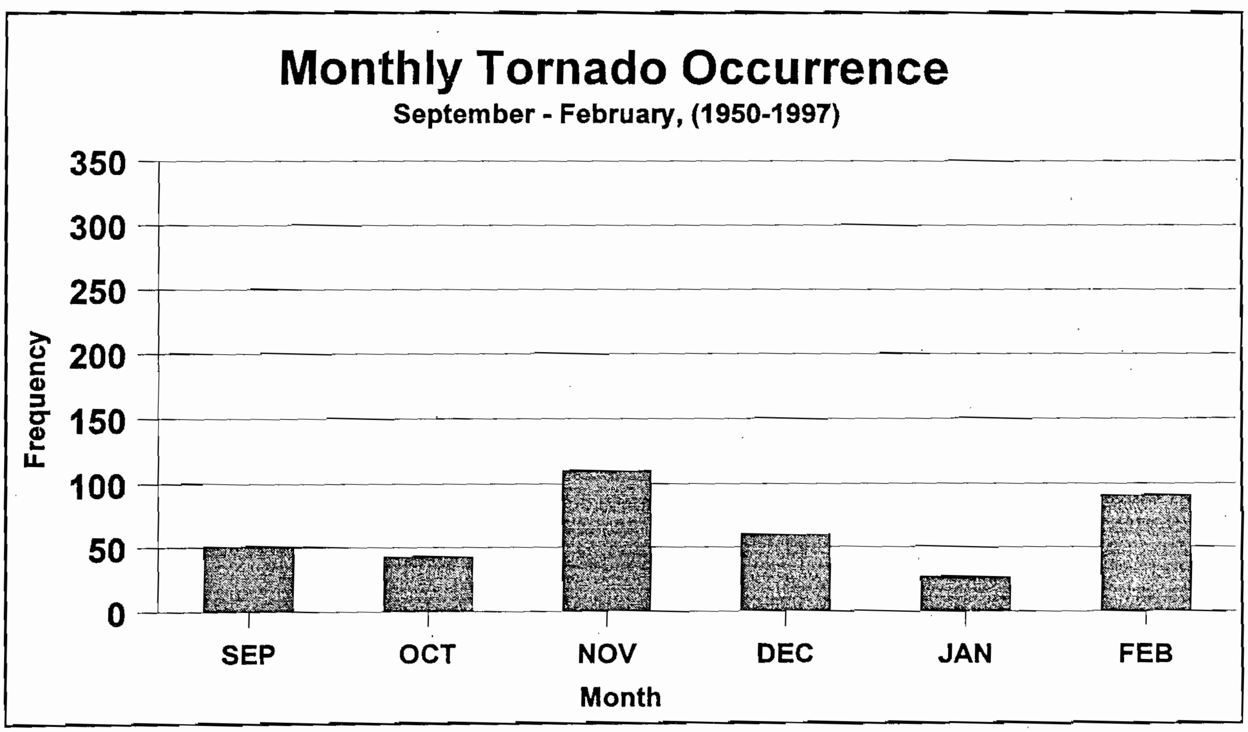

Figure 13

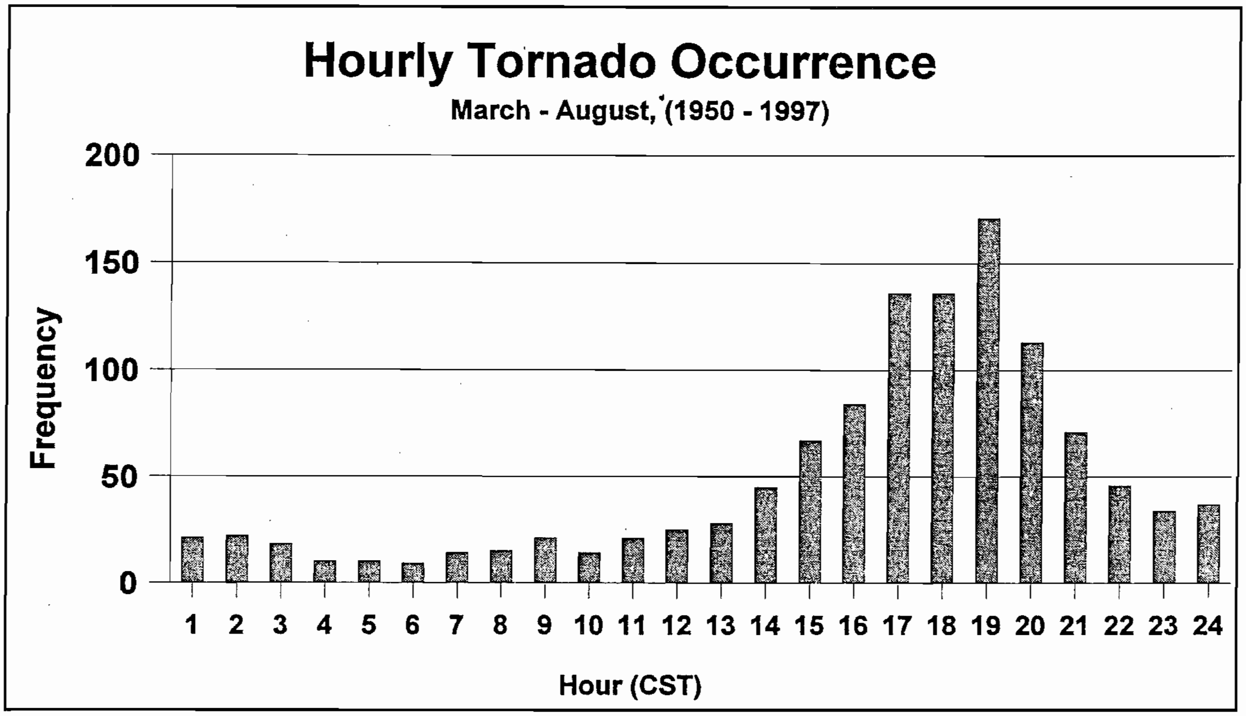

Figure 14

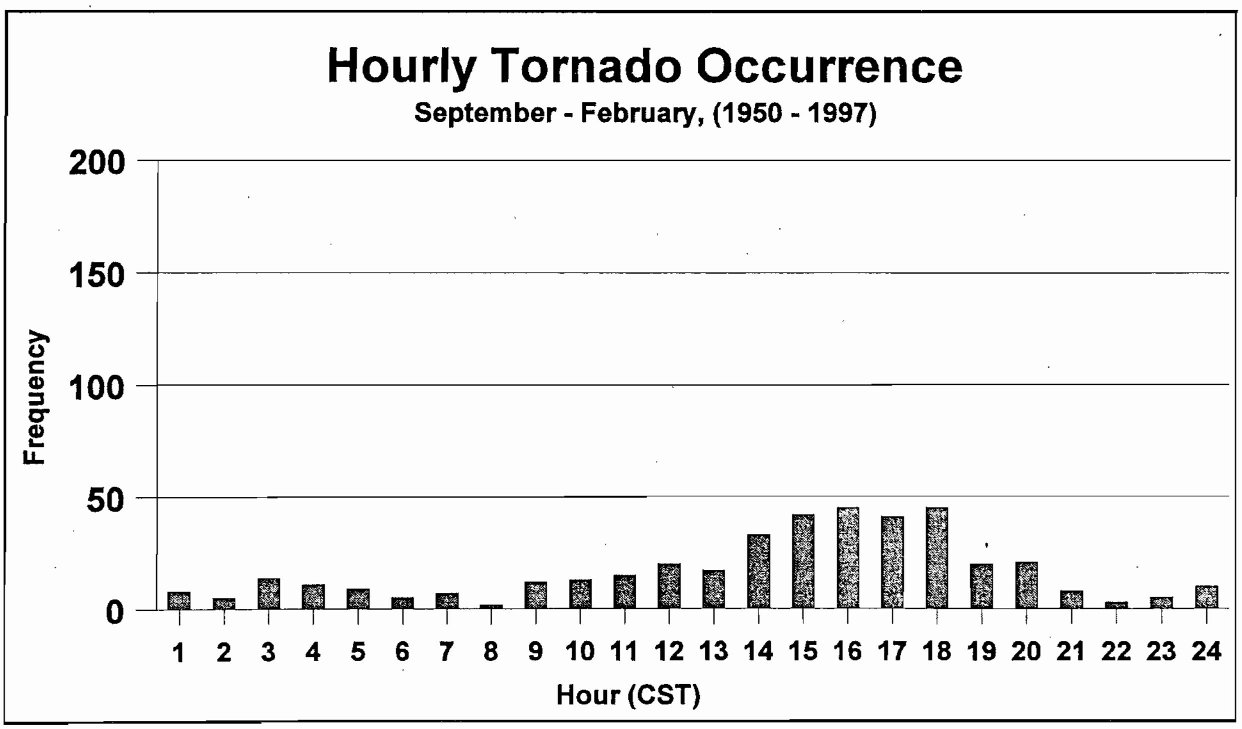

Figure 15

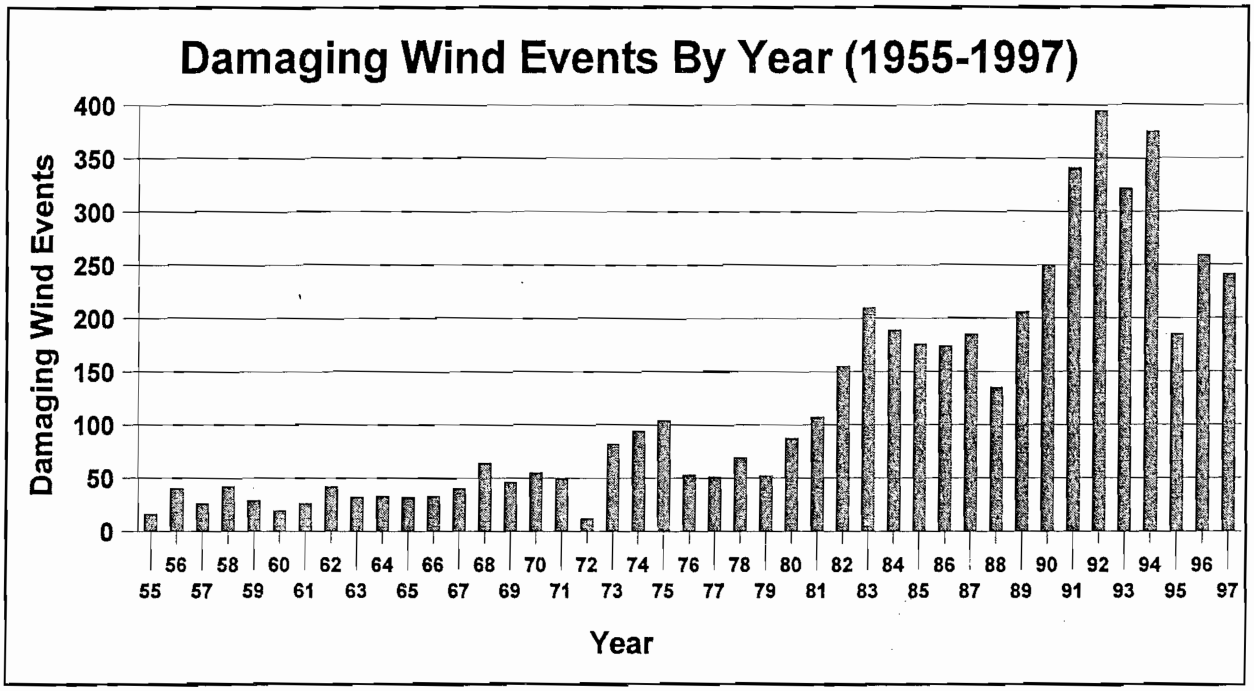

Figure 16

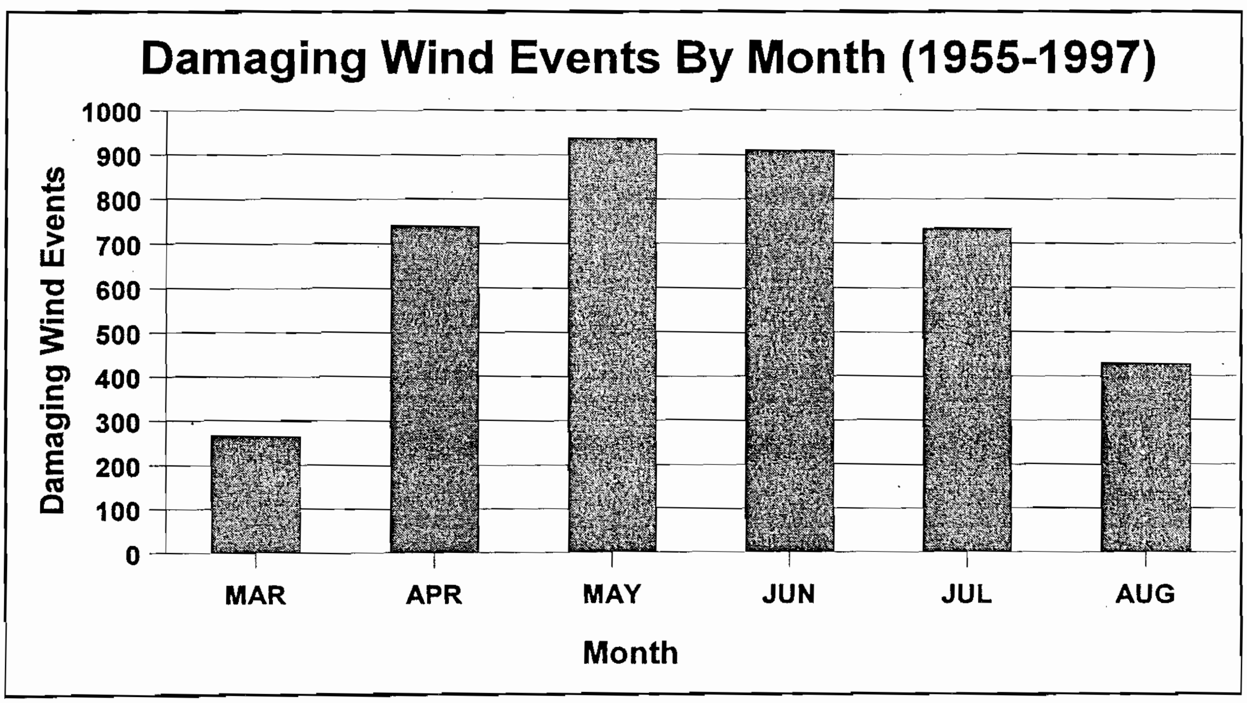

Figure 17

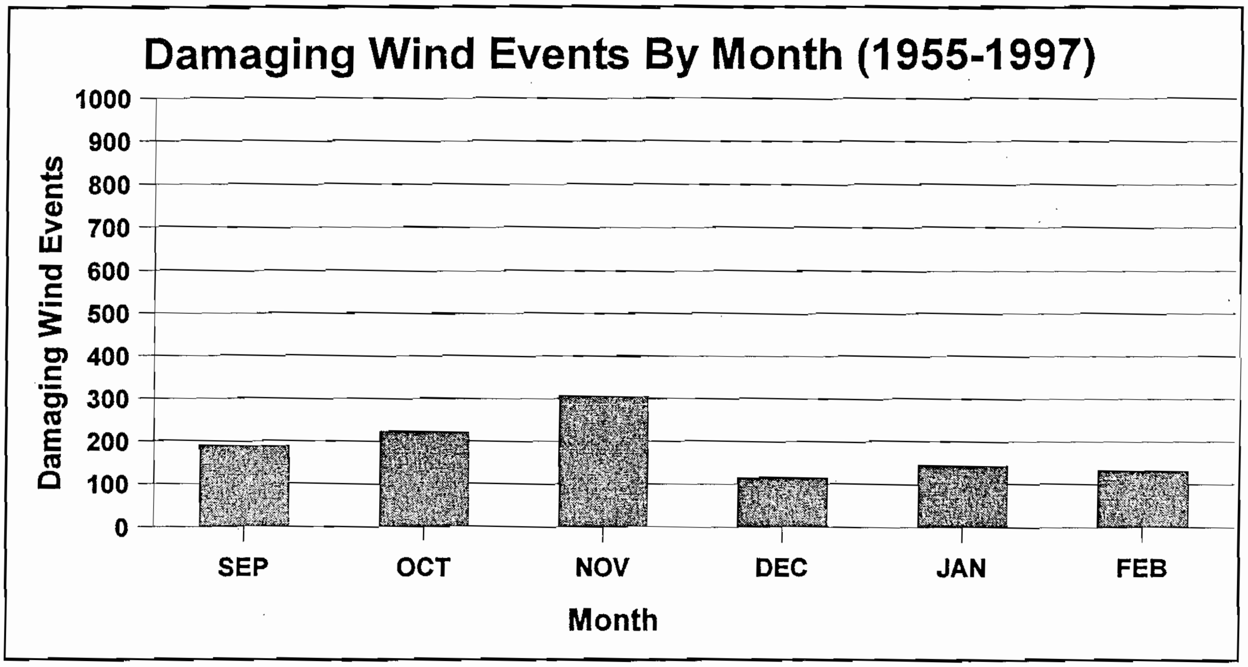

Figure 18

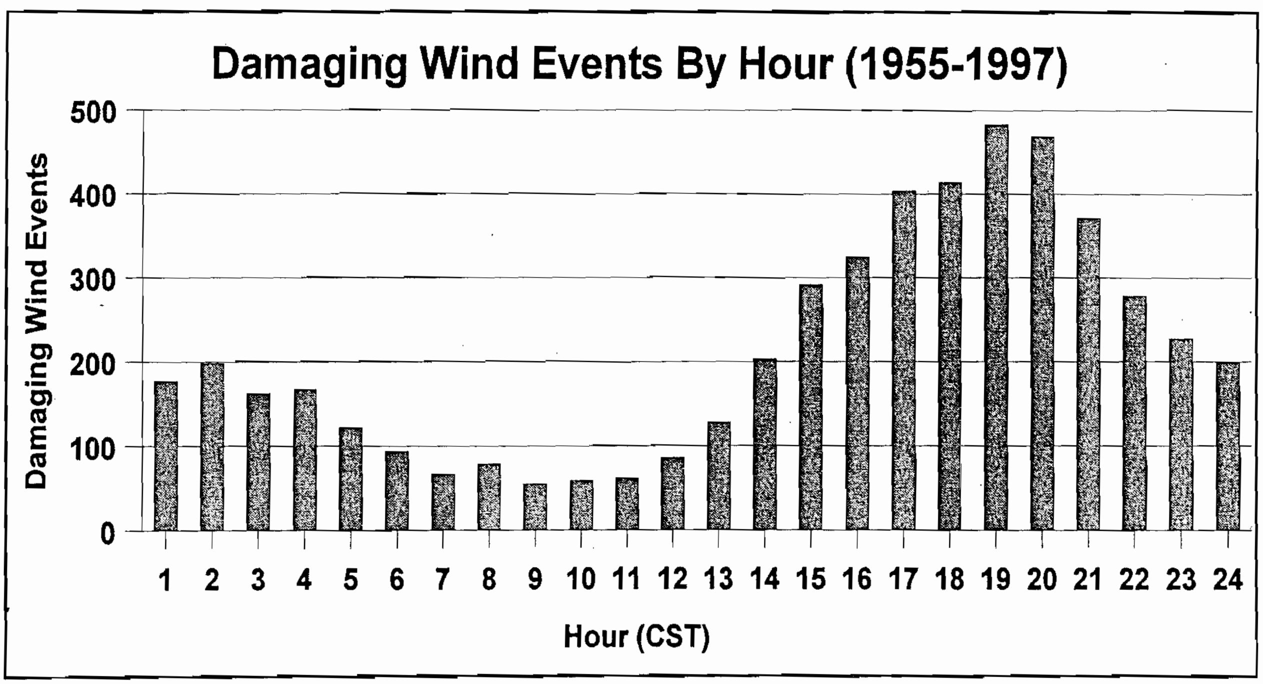

Figure 19

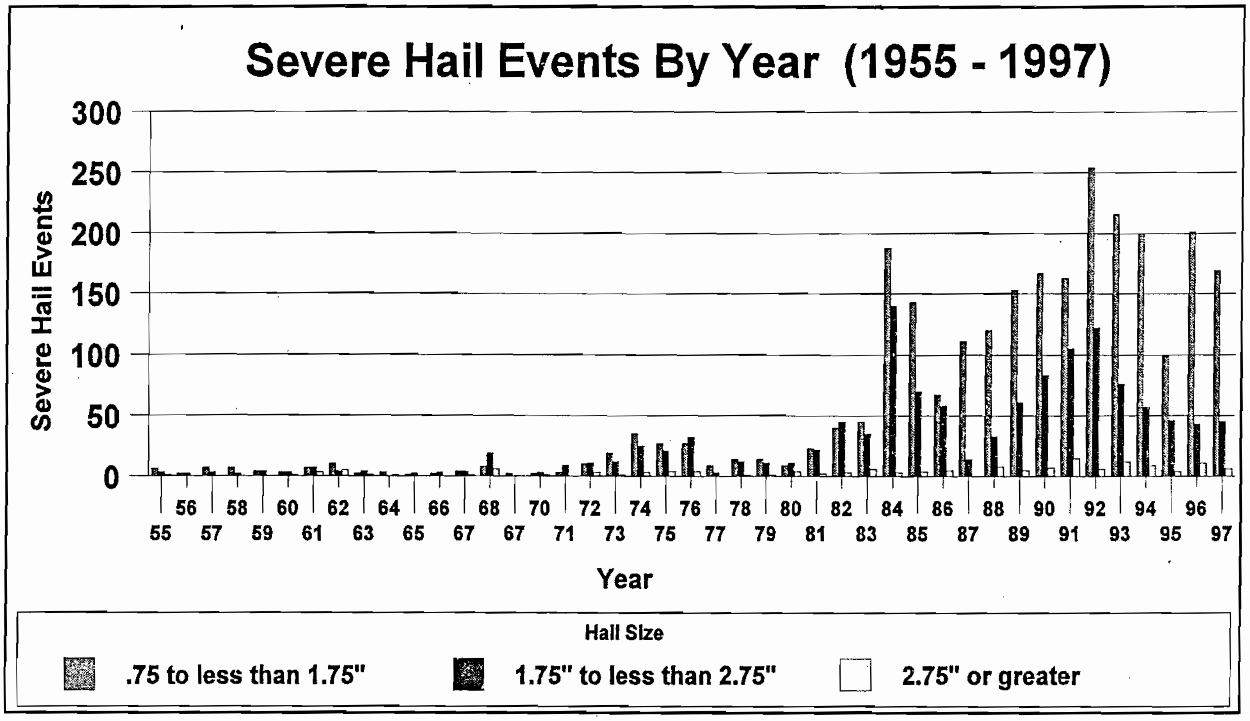

Figure 20

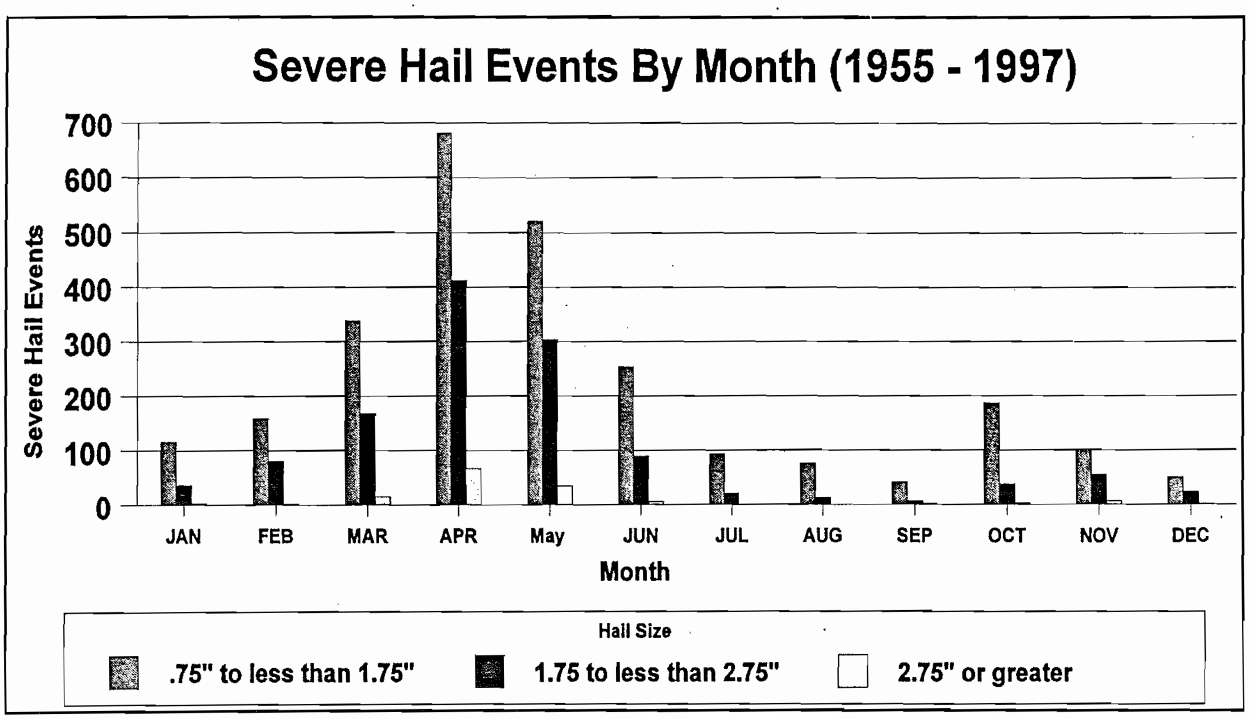

Figure 21

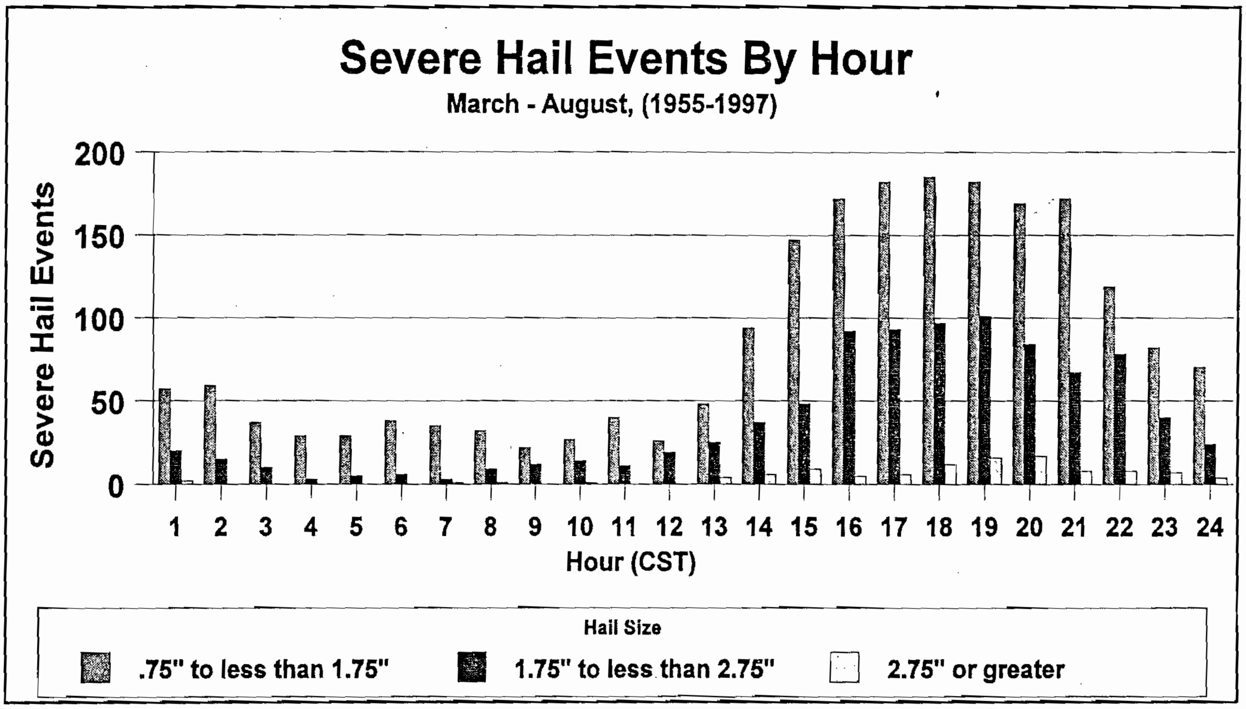

Figure 22

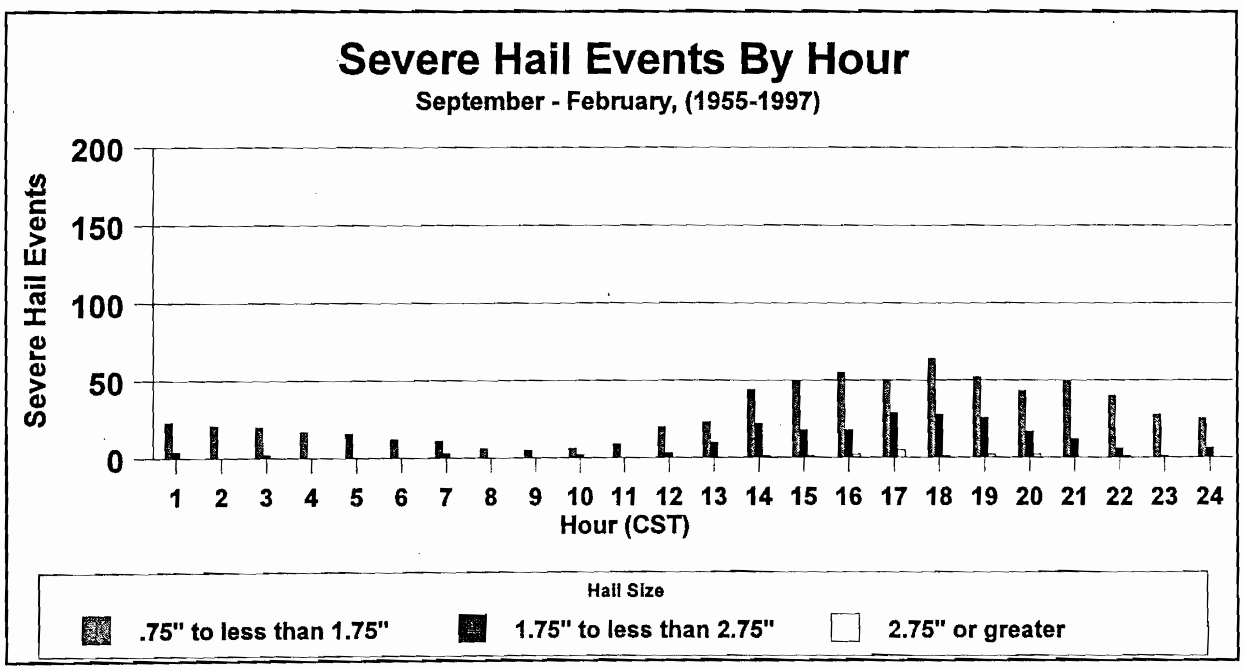

TABLE A. Tropical cyclones passing directly through the CWA (with stage of cyclone as it passed through one or more of the four states) and years during El Niño/La Niña.

Storm Name	Date	Arkansas	Louisiana	Oklahoma	Texas	El Niño	La Niña
Number 9	October 13, 1886	TS	H		H		
Number 2	July 6, 1888				TS		
Number 3	August 20, 1888		H				
Number 1	July 6-7, 1891	TS	TS		TS		
Number 4	October 7, 1895		TS				
Number 4	September 21, 1898		TS				
Number 1	August 7, 1918				TS	X	
Number 2	September 22, 1920	TS	TS				
Number 3	August 27, 1926		TS		TS	X	
Number 2	July 16, 1931	TD	TD			X	
Number 4	July 24, 1933				TS	X	
Number 2	August 15, 1938				TD		X
Number 2	August 8-10, 1940			TD	TS	X	
Number 2	September 24, 1941	TS	TS		TS	X	
Number 4	September 20, 1947		TS		TS		
Number 10	October 4-5, 1949	TS	TS		TS		
Brenda	August 2-3, 1955		TD		TD		X
Number 5	August 28, 1955				TS		X
Audrey	June 27-28, 1957		TS			X	
Bertha	August 10-11, 1957				TD	X	
Debra	July 26, 1959				TD		
Number 1	June 26-27, 1960			TD	TD		
Betsy	September 10, 1965		TS			X	X
Debra	August 29, 1978	TD	TD				
Chris	September 11-12, 1982	TD	TS			X	
Danny	August 16, 1985		TS				
Elena	September 3, 1985	TD	TS				
Bonnie	June 26-27, 1986	TD			TS	X	
Number 1	August 10-11, 1987		TD		TS	X	
Beryl	August 10, 1988		TD				X
Florence	September 10-11, 1988		TD		TD		X
Allison	June 27-28, 1989				TD		X
Jerry	October 16, 1989	TD			TS		X

Legend:	Stage:	One-Minute Sustained Wind:
	TD = Tropical Depression	Up to 33 knots (38 mph)
	TS = Tropical Storm	34 to 63 knots (39 to 73 mph)
	H = Hurricane	64 knots (74 mph) or greater

Note: In this text, a tropical cyclone is considered to have affected an area (CWA) if the track intersects and enters any portion of the area while the cyclone is at tropical depression, tropical storm, or hurricane intensity. This did not include periphery effects from cyclones that affected adjacent areas outside the CWA. Times and dates are in GMT (Greenwich Mean Time)

TABLE B. Distribution of tropical cyclones affecting CWA using maximum intensity verses areas affected.

Areas	Tropical Depression	Tropical Storm	Hurricane	All Intensities
Entire CWA	*10	*21	*2	*33
Arkansas	6	5	-	11
Louisiana	6	13	2	21
Oklahoma	2	-	-	2
Texas	7	13	1	21

Note: The asterisk (*) denotes the number of tropical cyclones that intersected and entered the CWA while the cyclone is at tropical depression, tropical storm, or hurricane intensity. This did not include periphery effects from cyclones that affected adjacent areas outside the CWA. These numbers are not totals for the four states. As shown in Table A, many tropical cyclones affected more than one state.

TABLE C. Distribution of tropical cyclones affecting the CWA verses months cyclones occurred.

Month	Number of occurrences within CWA (all intensities)
June	4
July	5
August	12
September	8
October	4
November	0

Table D. El Niño and La Niña Years.

The following list of warm and cold episode years indicates the year that the episode began. Warm and cold episodes generally last into the winter and spring of the following year. For example, 1982 denotes the 1982/83 warm episode. The following data was obtained directly from the NOAA Home Page (*http://www.noaa.gov*).

Warm Episode (El Niño Southern Oscillation) Years:

1902, 1905, 1911, 1914, 1918, 1923, 1925, 1930, 1932, 1939, 1941, 1951, 1953, 1957, 1965, 1969, 1972, 1976, 1982, 1986, 1991, 1994, 1997

Cold Episode (La Niña) Years:

1904, 1908, 1910, 1916, 1924, 1928, 1938, 1950, 1955, 1964, 1970, 1973, 1975, 1988, 1995