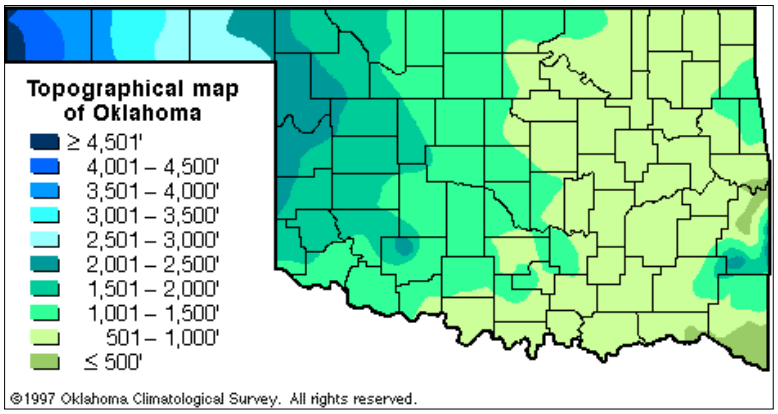
OKLAHOMA'S CLIMATE: AN OVERVIEW

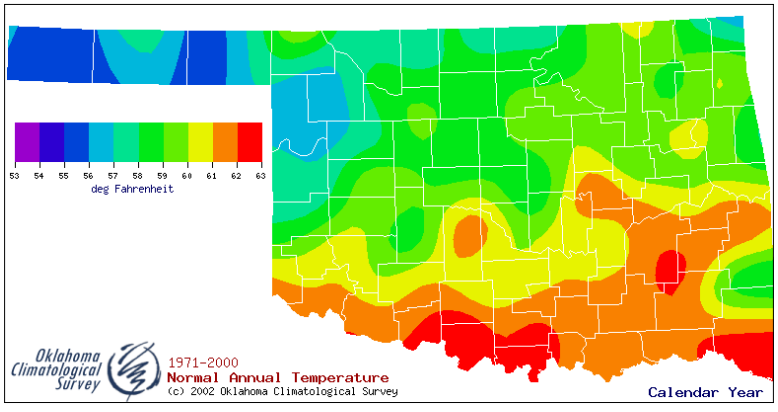
Topography



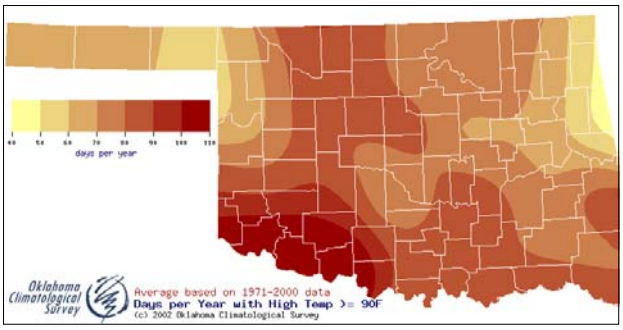
Oklahoma is located in the Southern Great Plains. Of the 50 states, it ranks 20th in size, with an area of 69,903 square miles, about 1,224 of which are covered by water. The terrain is mostly plains, varying from nearly flat in the west to rolling in the central and near east, with a general slope upward from west to east. The plains are broken by scattered hilly areas where most points are 600 feet or less above the adjacent countryside. These hilly areas include the Wichita Mountains in the southwest and the Arbuckle Mountains in the south-central. The Ouachita Mountains dominate much of the southeast, with peaks that rise as much as 2,000 feet above their base. Extreme northeastern counties are part of the Ozark Plateau, which is marked by steep, rocky river valleys between large areas of hills and rolling plains. The western tip of the panhandle features part of the Black Mesa complex, a fractured terrain featuring large mesa overlooking seasonal creek and riverbeds. Elevations range from 287 feet above sea level where the Little River exits in southeastern Oklahoma to 4,973 feet on Black Mesa near the New Mexico border.

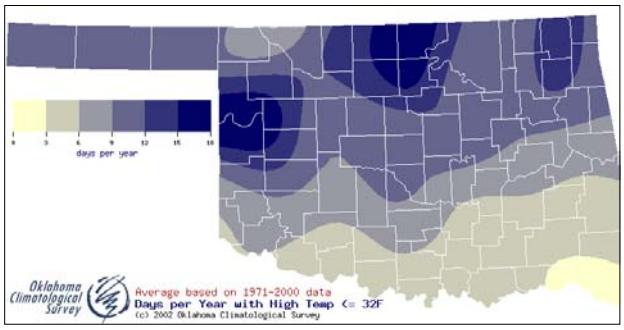
Oklahoma lies entirely within the drainage basin of the Mississippi River. The two main rivers in the state are the Arkansas, which drains the northern two-thirds of the state, and the Red, which drains the southern third and serves as the state's southern border. Principal tributaries of the Arkansas are the Verdigris, Grand (Neosho), Illinois, Cimarron, Canadian and North Canadian. The Washita and Kiamichi serve as the Red's principal tributaries in Oklahoma, with the Little River flowing into the Red after it crosses into Arkansas.

Temperature



The mean annual temperature over the state ranges from 62 F along the Red River to about 58 F along the northern border. It then decreases westward to 56 F in Cimarron County. Temperatures of 90 F or greater occur, on average, about 60-65 days per year in the western panhandle and the northeast corner of the state. In the southwest, the average is about

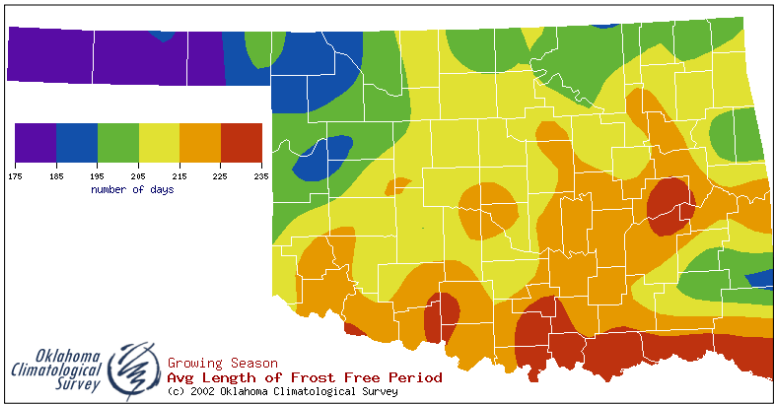




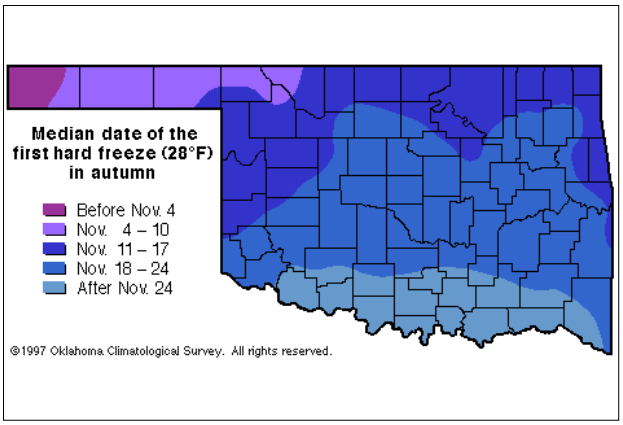
115 days, and in the southeast about 85 days. Temperatures of 100 F or higher occur, frequently during some years, from May through September, and very rarely in April and October. The western half of the state, excluding most of the panhandle, averages 15 or more days with triple-digit temperatures, ranging from about 35 in the southwest corner and 25 in the northwest. The eastern half of the state and most of the panhandle average less than 15 such days. Years without 100 F temperatures are rare, ranging from about one of every seven years in the eastern half of the state to somewhat rarer in the west.

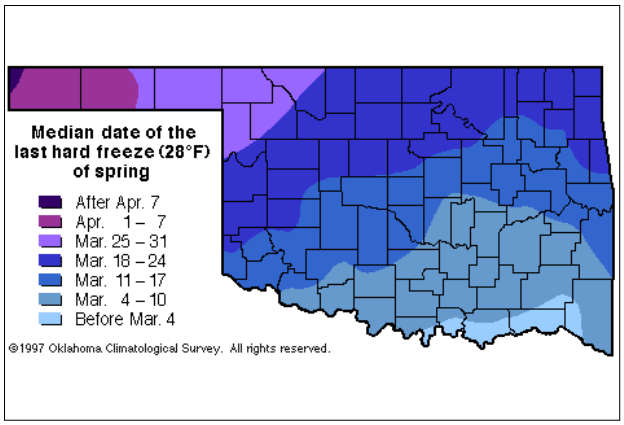
The highest temperature ever recorded in the state was 120 F. This reading was first observed during the brutally hot summer of 1936: at Alva on July 18, at Altus on July 19 and August 12, and at Poteau on August 10. Tishomingo observed 120 F on July 26, 1943. The Oklahoma Mesonet station near Tipton tied the mark on June 27, 1994.

Temperatures of 32 F or less occur, on average, about 60 days per year in the southeast. This value increases to about 110 days per year where the panhandle joins the rest of the state, and further to 140 in the western panhandle. The lowest temperature on record is -27 F, set originally at Vinita on February 13, 1905, and tied at Watts on January 18, 1930.



The average length of the growing season, or freeze-free period, is at a maximum of about 225-230 days in the southern tier of counties and in the Arkansas River valley downstream of Tulsa. The value generally decreases to about 195 days in the eastern panhandle, then more rapidly to 175 in the western panhandle. The general northwest-to-southeast gradient is interrupted in the Ouachita Mountains, where growing seasons are three to four weeks shorter compared to surrounding areas.



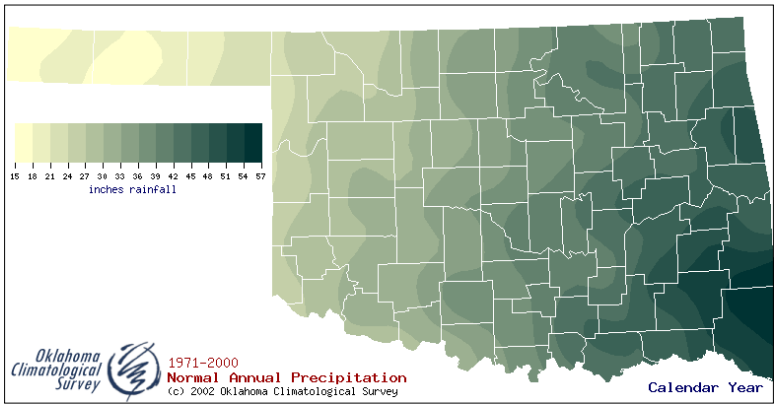


Along the Red River, the average date of the last freeze of spring ranges from about March 15 in the east to April 1 in the west. In northern Oklahoma, the last freeze of spring occurs, on average, from about April 8 near the Missouri border to April 15 in the eastern panhandle to the last week of April in the western panhandle. Freezing temperatures have occurred as late as April 20 along the southern border and in east-central Oklahoma to about May 15 in northwest Oklahoma to the last days of May in the western panhandle. The average date of the autumn's first freeze varies from about October 15 in the western panhandle, to about October 25 along the northern border and in northwestern Oklahoma, to about November 10 along the Red River and in the Arkansas River valley downstream of Tulsa. Autumn freezes have occurred as early as about September 15 in the western third of the state to about October 15 in the southeast corner. Again, the Ouachita Mountains tend to differ from surrounding terrain by about two weeks during either season.

Frozen soil is not a major problem, nor much of a deterrent to seasonal activities. Its occurrence is rather infrequent, of very limited depth, and of brief duration. The average maximum depth that frost penetrates the soil ranges from less than three inches in the southeastern corner of the state to more than 10 inches in the northwestern reaches. Extreme frost penetration ranges from about 10 inches in the southeast to almost 30 inches in the western panhandle. Factors having an important bearing on frost penetration are severity and duration of temperature below freezing; condition, character and moisture content of soil; and amount and character of protective cover, including snow cover.

Precipitation

The dominant feature of the spatial distribution of rainfall is a sharp decrease in rainfall from east to west. Although precipitation is quite variable on a year-to-year basis, average annual precipitation ranges from about 17 inches in the far western panhandle to about 56 inches in the far southeast. Only the summer months of July and



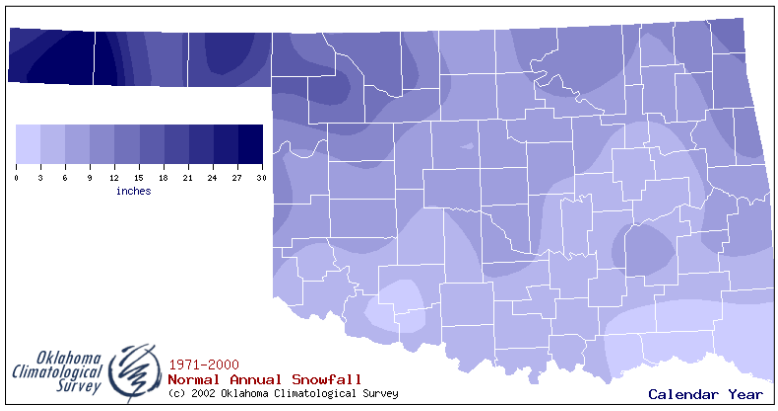
August see a substantial relaxation of this gradient. The greatest annual precipitation recorded at an official reporting station was 84.47 inches at Kiamichi Tower in the southeast in 1957. The least annual rainfall occurred during 1956, when Regnier, in the extreme northwestern panhandle, observed 6.53 inches.

The climatological maximum for precipitation comes in late spring for almost all of the state east of the panhandle. On average, May brings more precipitation than any other month across 90% of Oklahoma. A significant secondary maximum of precipitation exists during early autumn for most of the state. This secondary peak typically occurs in September, and is more pronounced in the eastern third of the state. In the northeast, this secondary maximum can be nearly the same magnitude as the springtime maximum. In the southeast the secondary maximum tends to occur later in autumn, owing largely to the influence of tropical disturbances in the Gulf of Mexico. The panhandle and adjacent counties are the major exception to the pattern described above. As one moves westward in this area, the dual maximum tends to converge into one peak in June. In the western third of the panhandle, July is the rainiest month. Even during these peak months, rainfall normals are less for the panhandle than for eastern Oklahoma.

The frequency of days with measurable precipitation follows the same gradient as the annual accumulation, increasing from 45 days per year in western Oklahoma to 115 near the Arkansas border. On the average, more precipitation falls during the nighttime hours, while greatest rainfall intensities occur during late afternoon.

The character of precipitation also varies by season. Wintertime precipitation tends to be somewhat widespread, stratiform in nature, and tied almost exclusively to synoptic-scale systems. Rainfall is the dominant precipitation type in winter for all but the panhandle region of Oklahoma. Summertime precpitation is almost entirely convective in nature, produced by mesoscale complexes and garden-variety thunderstorms. The transition seasons of spring and autumn offer both convective and stratiform precipitation. A significant portion of the state's precipitation during the transition seasons is associated with systems of severe thunderstorms.

Excessive rainfall occurs at times. Amounts of ten inches or more in 24 hours, while rare, have been recorded. The greatest official rainfall in a 24-hour period is 15.68 inches at Enid on October 11, 1973. Amounts up to 20 inches in a day have also been reported from non-standard sources.



The gradient of average annual snowfall is nearly opposite that of precipitation, in that it increases from less than two inches in the extreme southeast to nearly 30 inches in the western panhandle. The frequency of snow events also increases sharply along the same gradient. Locations in southeast Oklahoma have gone several years between events, while

northwestern Oklahoma typically records several snow events in one winter. Blowing snow and blizzard conditions can pose significant problems for automobile travelers, but the effects of most snowstorms in the state are short-lived. Snowfall remaining on the ground more than a few days is an uncommon occurrence in northwestern Oklahoma, quite rare in central Oklahoma, and almost unheard of in the southeast. The greatest seasonal snowfall ever recorded in the state was 87.3 inches at Beaver during the winter of 1911-12. Buffalo observed the greatest monthly total of 36.0 inches in February 1971, including a daily snowfall record of 23 inches on the 21st day of that month.

Freezing rain is a distinct wintertime hazard in Oklahoma. The resulting ice cover can down power lines and limbs, causing millions of dollars in damages and widespread power outages. These events make automobile travel very treacherous, especially on secondary roads, where the hazard can last several days. Significant icing events occur with nearly the same frequency as heavy snow events, especially in the southeastern half or so of the state. While ice accumulation is usually less than an inch, storms that deposit several inches can occur once or more per decade. The consecutive winters of 2000-01 and 2001-02 each featured a major ice storm that deposited more than three inches of ice in 24 hours across much of southeast and central Oklahoma.

Floods and Drought

Floods of major rivers and tributaries may occur during any season, but they occur with greatest frequency during those spring and autumn months associated with greatest rainfall. Such floods cost many lives and property damage in the first 50 years of statehood, but flood prevention programs have reduced the frequency and severity of such events. Autumn floods are often associated with widespread heavy rains north of a stalled cold front, or the interaction between a surface front and remnants of a tropical storm. Springtime floods usually occur in the warm sector of a slow-moving cyclone.

Flash flooding of creeks and minor streams remains a serious threat, especially in urban and suburban areas, where development and removal of vegetation have increased runoff.

Drought is a recurring part of Oklahoma's climate cycle, as it is in all the Plains states. Almost all of Oklahoma's usable surface water comes from precipitation that falls within the state's borders. Therefore, drought in Oklahoma is tied almost entirely to local rainfall patterns (i.e., the influence of upstream events on drought is very small). Western Oklahoma tends to be slightly more susceptible to drought because precipitation there tends to be more variable (percentage-wise) and marginal for dryland farm applications.

Drought episodes can last from a few months to several years. Those that last a few months can elevate wildfire danger and impact municipal water use. Seasonal droughts can occur at any time of the year, and those that resonate with crop production cycles can cause billions of dollars of damage to the farm economy. Multi-season and multi-year episodes can severely impact large reservoirs, streamflow and groundwater.

Since modern climatological record-keeping began in the late nineteenth century, the state has seen five major multi-year and multi-regional drought events. These occurred in the late 1890s, from 1909-18, 1930-40, 1952-58 and, to a lesser extent, 1962-72. Each of these episodes contained at least one year of above-normal rainfall. The drought of the 1930s is associated with the Dust Bowl of the Great Plains, when socio-economic conditions, agricultural practices and drought forced the largest emigration of Oklahomans in state history.

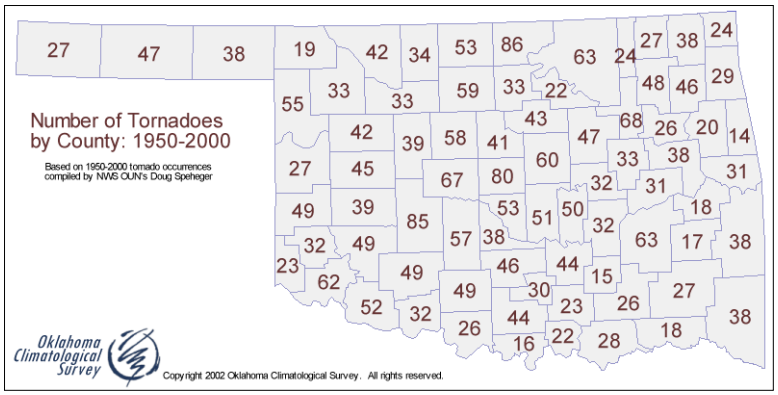
The agricultural impact of drought is increasingly mitigated on a farm-by-farm and year-by-year basis through irrigation of crops, mostly with fossil water. This practice dominates much of the panhandle and some of the rest of western Oklahoma.

Severe Weather

Thunderstorms occur, on average, about 55 days per year in the east, decreasing to about 45 days per year in the southwest. The general gradient relaxes in northwestern Oklahoma, where annual thunderstorm days number about 50. The annual rate increases to near 60 in the extreme western panhandle. Late spring and early summer are the peak seasons for thunder, averaging about eight thunderstorms per month per location during these seasons. For the southeastern two-thirds of the state, thunder occurs most often in May. June is the peak month for much of the remainder of the state, while the western panhandle observes the most thunder in July. December and January, on average, feature the fewest thunderstorms, at a rate of less than one per month per location.

Frequent frontal invasions and dry line development combined with favorable upper-level support make springtime the preferred season for violent thunderstorms, although they can occur at any time of year. Severe weather threats during spring are squall lines, mesoscale convective systems, and rotating supercells that can produce very large hail, damaging winds and tornadoes. Autumn marks a secondary severe weather season, but the relative frequency of supercellular activity is much lower than during spring. General thunderstorms are quite common in the summer, but tend to be less organized storms of relatively short duration. These storms can produce locally heavy rain and some hail. Severe weather events during summer are predominantly mesoscale convective systems. These events tend to be nocturnal in nature.

Severe weather can occur at any time of day, but the maximum frequency for severe weather is from mid-afternoon to sunset. This maximum shifts from afternoon hours in western Oklahoma to late afternoon and early evening in eastern Oklahoma because severe weather is often associated with surface boundaries that move west-to-east during the afternoon. Diurnally, precipitation shows a maximum during the overnight hours. This can be attributed somewhat to the nocturnal nature of heavy rain associated with summertime events, and heavy

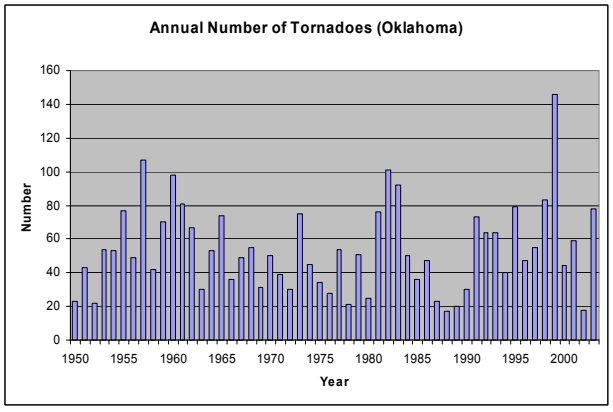


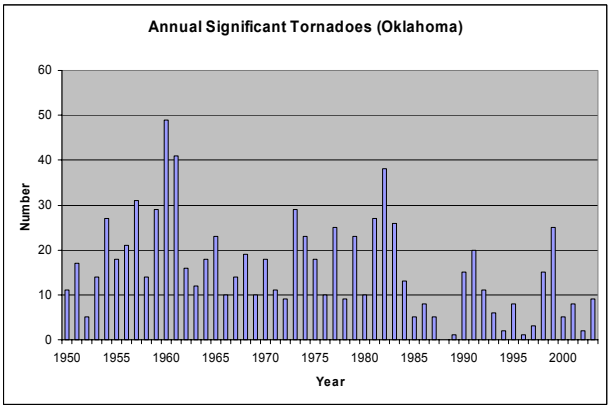
rains associated with the continuance of squall lines into eastern Oklahoma.

Tornadoes are a particular hazard, in that the frequency of occurrence per unit area is among the greatest in the world. Since 1950, an average of 54 tornadoes have been observed annually within the state's borders. Tornadoes can occur at any time of year, but are easily most frequent during springtime. April, May and June represent the months of peak occurrence; these three months account for about three-fourths of the observations. May's average of 20 tornado observations per month is the greatest. The winter months each average less than one tornado per month. About 80 percent of tornadoes are observed between noon and midnight Central Standard Time, with the peak hours being between 4 pm and 8 pm. Most, but not all, of Oklahoma's tornadoes travel to the north and east.

On April 9, 1947, a large tornado killed 101 people in northwestern Oklahoma, almost all of these in Woodward. On May 3, 1999 an outbreak of tornadoes occurred across central Oklahoma. In 21 hours, 75 tornadoes were observed, causing 40 deaths and 700 injuries. The largest of these struck southwestern and southern portions of the Oklahoma City metropolitan area, destroying nearly 1,000 homes and inflicting over one billion dollars in damages. Radar observations indicated winds of 318 miles per hour, the greatest such observation to date. The difference in fatalities between these two events is attributable to improved recognition and warning capabilities and an enhanced awareness among the citizenry of the dangers of tornadoes.

Although the annual number of tornadoes striking Oklahoma is increasing, the proportion of those ranking among the most severe has actually been declining. Improved technology and recording practices have improved counts and documentation of those at the weaker end of the spectrum, thus accounting for the increase in overall number. However, the number of significant tornadoes (those rating as F2 intensity or greater) have declined, particularly since 1982. In fact, the years with the greatest numbers of significant tornadoes were 1960 and 1961, with 49 and 41, respectively. Declining death tolls and declining numbers of significant tornadoes does not necessarily mean Oklahoma is becoming less at risk. As the May 3, 1999 tornado showed, one event can forever impact the lives of many Oklahomans.





Other Climactic Features

The climate of Oklahoma is continental, as is all of the Great Plains. Warm, moist air moving northward from the Gulf of Mexico often exerts much influence, particularly over the southern and eastern portions of the state, where humidity, cloudiness and precipitation are resultantly greater than in western and northern sections. Summers are long and usually quite hot. Winters are shorter and less rigorous than those of the more northern Plains states. Periods of extreme cold are infrequent, and those lasting more than a few days are rare.

Annual average relative humidity ranges from about 60 percent in the panhandle to just over 70 percent in the east and southeast. The average statewide dew point temperature ranges from 27F in January to 68 F in July.

Average annual lake evaporation varies from 48 inches in the extreme east to 65 inches in the southwest, numbers that far exceed the average yearly rainfall in those areas. Evaporation and percolation preclude use of about 80 percent of Oklahoma's precipitation.

Prevailing winds are southerly to southeasterly throughout most of the state during the spring through autumn months. These prevailing winds veer to south-to-southwest in far western Oklahoma, including the panhandle. The winter wind regime is bimodal, with roughly equal split between northerly and southerly winds. In a diurnal sense, prevailing winds tend to oscillate from southeast to southwest to southeast from sunrise to sunset to sunrise. In the panhandle the daytime swing is more dramatic, with westerly winds prevailing. March and April are the windiest months, while July August and September are the calmest.

On the average, cloudiness increases from west to east in Oklahoma. The annual fraction of possible sunshine observed ranges from about 45 percent in eastern Oklahoma to near 65 percent in the panhandle. These fractions are highest in the summer and lowest in the winter for all portions of the state.

Source: Oklahoma Climatological Survey
Derek Arndt, Assistant State Climatologist