

OKLAHOMA

KEY MESSAGES

Average annual temperature has increased by less than 1°F since the early 20th century. Winter warming has been characterized by the much below average occurrence of extremely cold days since 1990. Under a higher emissions pathway, historically unprecedented warming is projected by the end of the 21st century.

Precipitation can vary greatly from year to year in this region of transition from humid to semi-arid conditions. Heavy precipitation events are projected to increase, which may increase the risk of flooding and associated increases in soil erosion and non-point source runoff into streams and lakes.

The agricultural economy of Oklahoma makes the state particularly vulnerable to droughts, several of which have occurred in recent years. Higher temperatures will increase the rate of soil moisture depletion, leading to an increase in the intensity of naturally occurring future droughts.

Oklahoma lies in the central Great Plains, straddling the transition from relatively abundant precipitation (more than 50 inches annually) in the southeast to semi-arid conditions (less than 20 inches) in the west. Due to its location in the interior of the United States and some distance from the moderating effects of any oceans, the state experiences a wide range of temperatures, averaging less than 40°F in the winter to almost 80°F in the summer. The hottest year on record was 2012 with an average temperature of 63.2°F, which is 3.5°F degrees warmer than the long-term average. Extreme temperatures for the state range from 120°F, observed at several locations in the summer of 1936, to -31°F observed in northeastern Oklahoma during the winter of 2011.

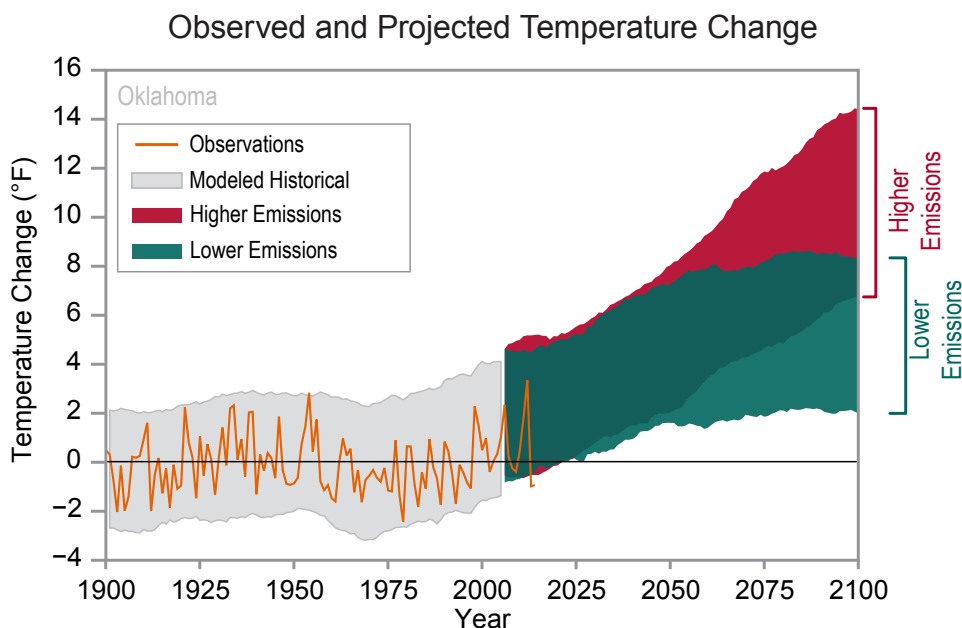


Figure 1: Observed and projected changes (compared to the 1901–1960 average) in near-surface air temperature for Oklahoma. Observed data are for 1900–2014. Projected changes for 2006–2100 are from global climate models for two possible futures: one in which greenhouse gas emissions continue to increase (higher emissions) and another in which greenhouse gas emissions increase at a slower rate (lower emissions)¹. Temperatures in Oklahoma (orange line) have risen less than 1°F since the beginning of the 20th century. Shading indicates the range of annual temperatures from the set of models. Observed temperatures are generally within the envelope of model simulations of the historical period (gray shading). Historically unprecedented warming is projected during the 21st century. Less warming is expected under a lower emissions future (the coldest years being about 2°F warmer than the long-term average; green shading) and more warming under a higher emissions future (the hottest years being about 11°F warmer than the hottest year in the historical record; red shading). Source: CICS-NC and NOAA NCEI.

¹Technical details on models and projections are provided in an appendix, available online at: <https://statesummaries.ncics.org/ok>.

Observed Summer Temperature

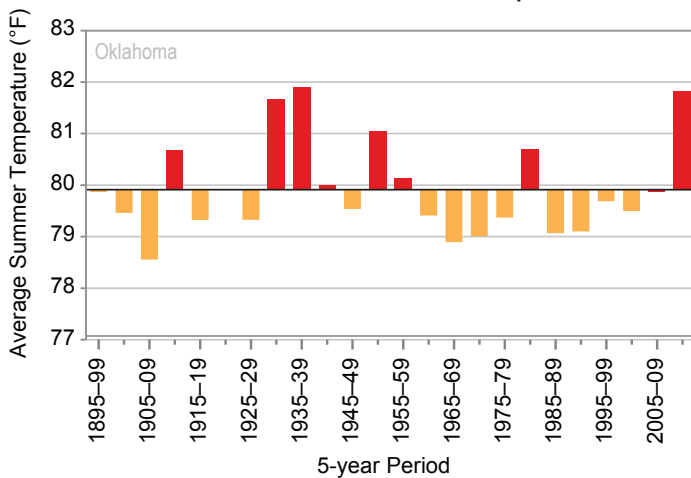
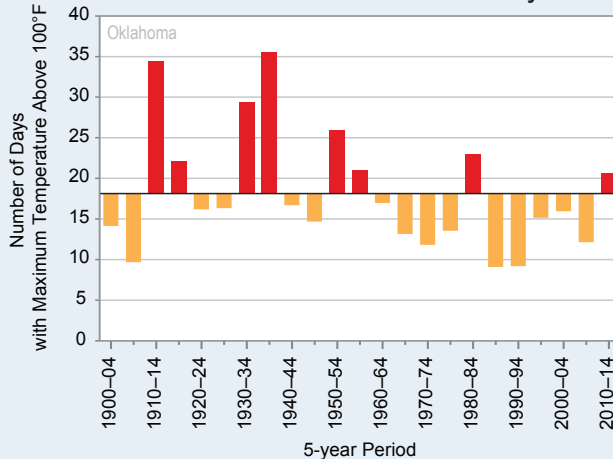
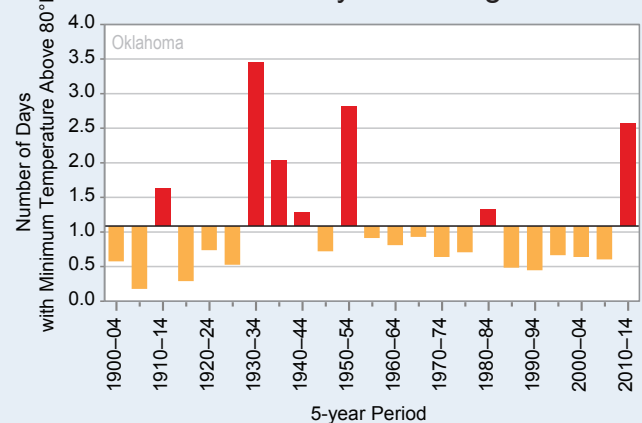


Figure 2: The observed average summer temperatures for 1895–2014, averaged over 5-year periods; these values are averages from NCEI's version 2 climate division dataset. Summer temperatures during the most recent 5-year period (2010–2014) have almost reached the same level as the record extreme heat of the 1930s Dust Bowl era. Due to extreme drought and poor land management practices, the summers of the 1930s remain the warmest on record. The dark horizontal line on each graph is the long-term average of 79.9°F. Source: CICS-NC and NOAA NCEI.

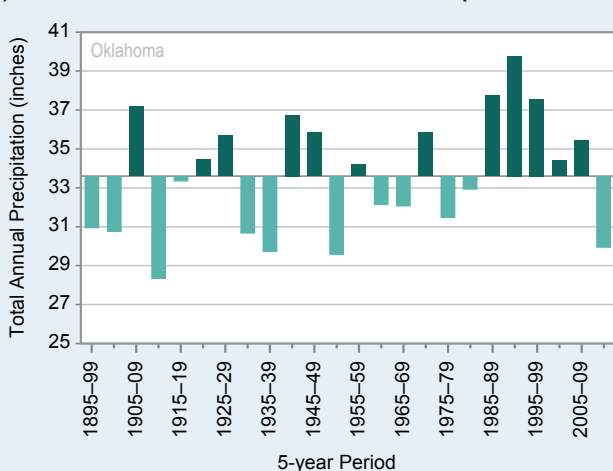
a) Observed Number of Hot Days



b) Observed Number of Extremely Warm Nights



c) Observed Annual Precipitation



d) Observed Summer Precipitation

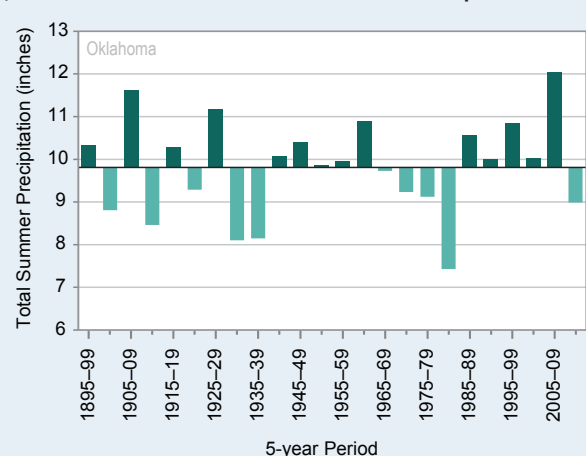


Figure 3: The observed annual average number of (a) extremely hot days (days with maximum temperature above 100°F), (b) extremely warm nights (days with minimum temperature above 80°F), (c) annual precipitation, and (d) summer precipitation, averaged over 5-year periods. The values in Figures 3a and 3b are averages from nine long-term reporting stations. The values in Figures 3c and 3d are from NCEI's version 2 climate division dataset. The dark horizontal line represents the long-term average. The numbers of extremely hot days and extremely warm nights have been primarily below the long-term average, although the most recent 5-year period has been above average in both categories. Due to extreme drought and poor land management practices, the summers of the 1930s remain the warmest on record. Annual and seasonal summer precipitation have been above average in recent decades, except for the most recent 5-year period, which was drier than normal, reflecting the severe multi-year drought in the state. Source: CICS-NC and NOAA NCEI.

Since the beginning of the 20th century, temperatures in Oklahoma have risen less than 1°F (Figure 1).

Temperatures in the past decade have been higher than in the previous 40 years and have approached the levels seen during the 1950s and the 1930s Dust Bowl era, when poor land management likely exacerbated the hot summer temperatures. The recent warming has been concentrated in the winter and spring, while summers have not exhibited substantial warming until the most recent 5-year period (2010–2014), a feature characteristic of much of the Great Plains and Midwest (Figure 2). The lack of summer warming is reflected in the mostly below average number of extremely hot days (maximum temperature above 100°F) in recent years (Figure 3a) and the lack of an overall trend in extremely warm nights (minimum temperature above 80°F) (Figure 3b). However, both measures have been above average in the last 5 years. The winter warming trend is reflected in a below average number of very cold nights (minimum temperature below 0°F) since 1990 (Figure 4).

Precipitation is highly variable from year to year, with the statewide annual average ranging from a low of 20.32 inches in 1910 to a high of 47.88 inches in 1957. The driest multi-year periods were in the 1910s, 1950s, and 1960s, and the wettest in the 1990s (Figure 3c). The driest 5-year period was 1952–1956 and the wettest was 1990–1994. The majority of precipitation falls during the spring and summer months. Summer precipitation was below average during the most recent 5-year period (2010–2014) (Figure 3d). Annual snowfall ranges from less than 2 inches in the extreme southeast to almost 30 inches in the Panhandle. Oklahoma regularly experiences freezing rain, particularly in the southeastern part of the state. **The frequency of extreme precipitation events (more than 2 inches of precipitation) has increased, with the past three decades seeing the highest number of events in the historical record (Figure 5).**

Severe thunderstorms are common in Oklahoma due to the state's geography, which allows cold, dry air from the north and west to clash frequently with warm, moist air from the Gulf of Mexico. Oklahoma experiences approximately 45 to 60 thunderstorm days each year. These storms frequently produce tornadoes: during 1985–2014, Oklahoma averaged 56 tornadoes and 4 fatalities per year. Tornadoes are most frequent

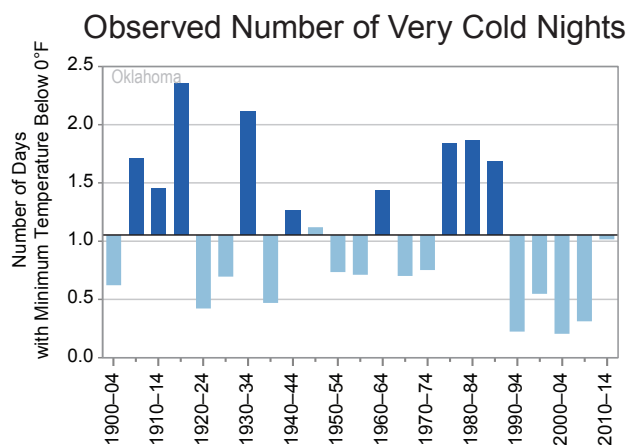


Figure 4: The observed number of very cold nights (annual number of days with minimum temperature below 0°F) for 1900–2014, averaged over 5-year periods; these values are averages from nine long-term reporting stations. Since 1990, Oklahoma has consistently experienced a below average number of very cold nights, indicative of winter warming in the region. The dark horizontal line on each graph is the long-term average of 1.1 days per year. Source: CICS-NC and NOAA NCEI.

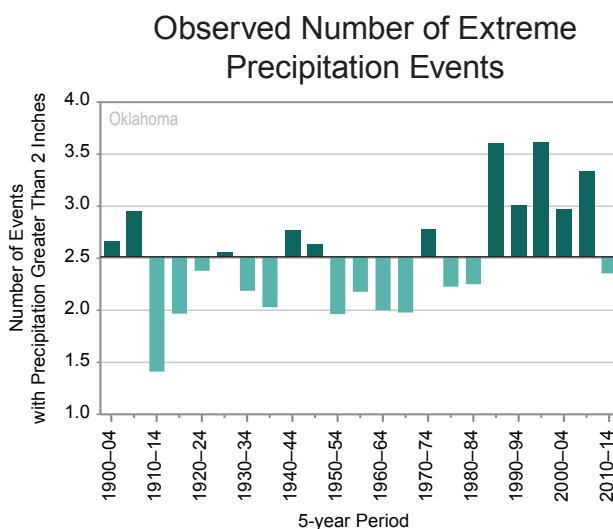


Figure 5: The observed number of extreme precipitation events (annual number of events with precipitation above 2 inches) for 1900–2014, averaged over 5-year periods; these values are averages from 16 long-term reporting stations. Oklahoma has experienced an above average number of extreme precipitation events since 1985, with the exception of the most recent period (2010–2014). The dark horizontal line on each graph is the long-term average of 2.5 events per year. Source: CICS-NC and NOAA NCEI.

during April and May. The state's deadliest tornado occurred on April 9, 1947, killing more than 100 people and injuring more than 700. On May 3, 1999, a supercell thunderstorm spawned more than 60 tornadoes, the largest outbreak ever recorded in the state. One of these tornadoes caused F4–F5 damage in Bridge Creek, Newcastle, Moore, and Oklahoma City, destroying 1,800 homes and causing 36 direct fatalities. On May 20, 2013, the same area was struck

by yet another EF5 tornado, which killed 24 people and caused over \$2 billion in damages.

Droughts are a frequent and severe hazard in Oklahoma (Figure 6). A severe drought occurred in 2011, with the state experiencing its third driest January–October on record, receiving only 19.38 inches of precipitation—more than 10 inches below the long-term average. Although winter precipitation brought some relief to the drought conditions, extremely dry and hot conditions in 2012 once again brought widespread drought conditions to the area. By the end of September, more than 95% of the state was experiencing extreme drought conditions. Since the creation of the United States Drought Monitor Map in 2000, Oklahoma has only been completely drought-free for approximately 21% of the time, and has had at least 50 percent or more drought coverage for approximately 31 percent of the time. **In addition to devastating impacts on the agricultural economy, severe droughts also increase the risk of wildfires.** In 2011, wildfires burned more than 132,000 acres in the state.

Under a higher emissions pathway, historically unprecedented warming is projected by the end of the 21st century (Figure 1). Even under a pathway of lower greenhouse gas emissions, average annual temperatures are projected to most likely exceed historical record levels by the middle of the 21st century. However, there is a large range of temperature increases under both pathways, and under the lower pathway, a few projections are only slightly warmer than historical records. If large increases in temperature occur, future heat waves are likely to be more intense while cold waves are projected to become less intense.

Projections of overall annual precipitation are uncertain. **Although summer precipitation is projected to decrease slightly across the state** (Figure 7), **the decreases are smaller than natural variations.** Even if summer precipitation remains the same, higher temperatures will increase evaporation rates and decrease soil moisture. **Thus, the intensity of future droughts, a natural part of Oklahoma's climate, is projected to increase.** Increased drought intensity, along with decreased summer precipitation, will also increase the risk of severe wildfires.

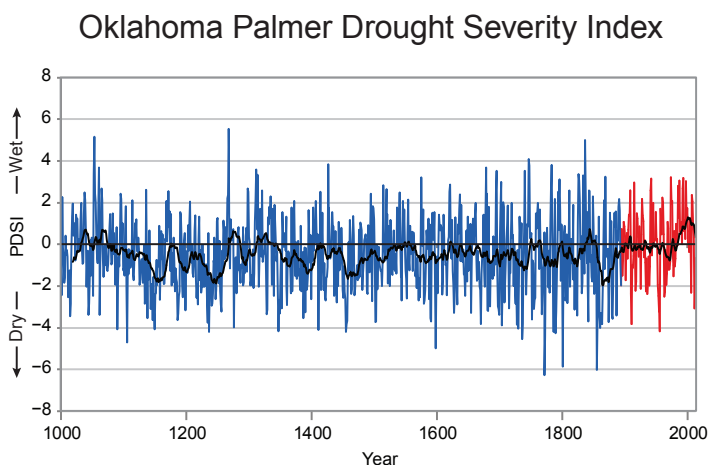


Figure 6: Time series of the Palmer Drought Severity Index from the year 1000 to 2013. Values for 1895–2013 (red) are based on measured temperature and precipitation. Values prior to 1895 (blue) are estimated from indirect measures such as tree rings. The thick solid line is a running 20-year average. In the modern era, the wet periods of the 1980s and 1990s and the dry periods of the 1930s and 1950s are evident. The extended record indicates periodic occurrences of similar extended wet and dry periods. Source: CICS-NC and NOAA NCEI.

Projected Change in Summer Precipitation

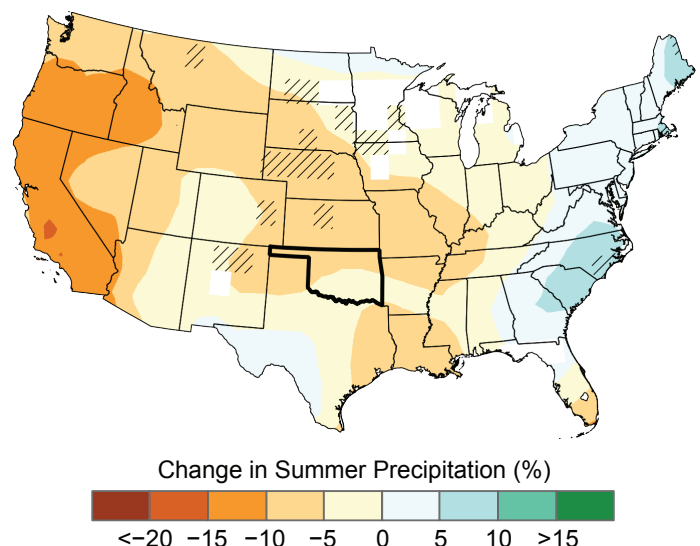


Figure 7: Projected change in summer precipitation (%) for the middle of the 21st century relative to the late 20th century under a higher emissions pathway. Hatching represents areas where the majority of climate models indicate a statistically significant change. Precipitation in the summer is projected to decrease slightly in Oklahoma, but the changes are smaller than natural variations. Source: CICS-NC, NOAA NCEI, and NEMAC.