

Understanding and Assessing Climate Change: Preparing for Nebraska's Future

2024 Climate Change Impact Assessment Report

Chapter 3 - Observed Changes in Nebraska's Climate



Chapter 3

Observed Changes in Nebraska's Climate

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Key messages

1. Nebraska is getting warmer and wetter.
2. Over recent decades, June, September, and November have all experienced pronounced warming.
3. Annual precipitation trends have been weakly positive since the late 19th century; however, eastern Nebraska shows negative precipitation trends in summer.
4. Since 2000, all locations in the state have set at least one new monthly record for the warmest average temperature and at least one record dry or record wet month.
5. Warming winter temperatures have led to decreases in days with snow cover and a reduction in the number of heating degree days.

Introduction

This chapter assesses trends in the primary indicators of Nebraska's climate—average temperature and precipitation—for monthly, seasonal, and annual values.

Average climate

Nebraska is a landlocked U.S. state with a continental climate that naturally experiences significant variability. Extremes of temperature and precipitation are not uncommon. While generally considered flat, the state gains over 4000 feet in elevation from east to west. This elevation gradient, combined with decreasing access to moisture from the Gulf of Mexico in western Nebraska, increases precipitation from west to east across the state. This gradient in precipitation is sharper across the state of Nebraska than it is from Omaha to New York. Thirty-year averages and statistics of key climate observations are called climate normal. Climate normals help put the weather into proper context. It is how we judge whether the temperature, rainfall, and other climate conditions are normal for a given location. The current reference period is 1991–2020. This period is updated every 10 years, and new climate normals are calculated. The once-per-decade update also means that climate normals gradually reflect the “new normal” of climate change caused by increasing greenhouse gas emissions.

Temperature

Nebraska has cold winters and warm to hot summers. January is the coldest month on average, and July is the warmest month. Temperatures in the winter tend to be warmer in western Nebraska, where it is sunnier, and downslope winds from the Rockies can elevate temperatures. Temperatures of -20°F or colder occur with more regularity in the northern and western sections of the state. Temperatures in the

summer are often warmest in southeast Nebraska, where higher humidity keeps minimum temperatures warmer. Temperatures above 95°F occur statewide but are most frequent in southwest Nebraska. The annual average temperature across the state ranges from the mid 40s in northwest Nebraska to the lower 50s across southeast Nebraska (Figure 3.1).

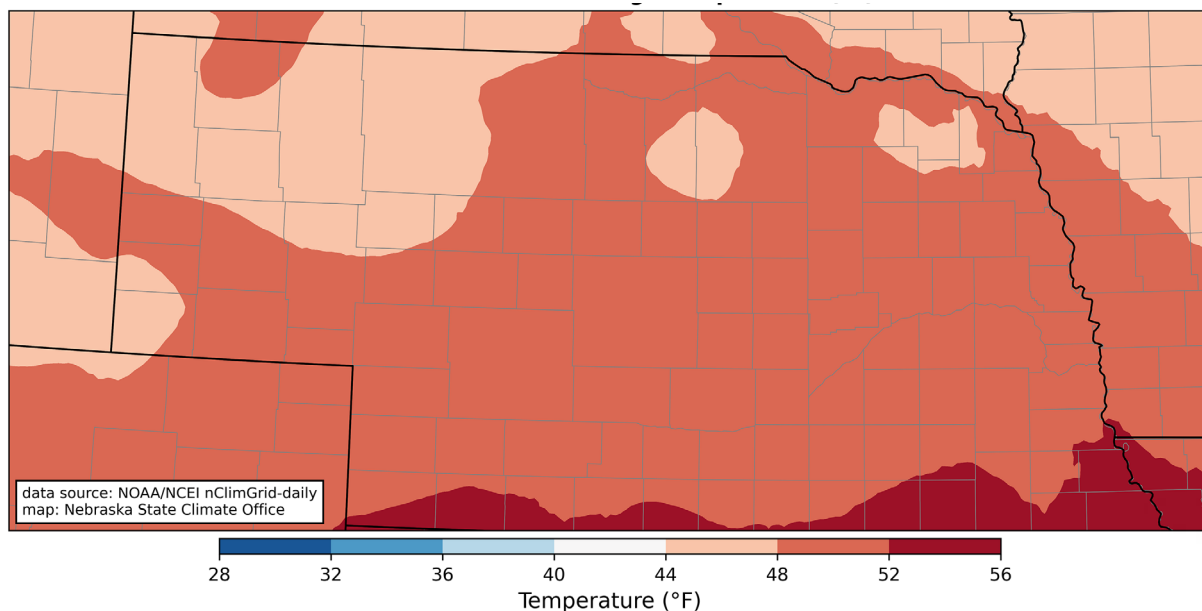


Figure 3.1. Nebraska's annual average temperature from the NCEI 1991–2020 normals. (Source: NOAA NCEI, n.d.)

Precipitation

The annual average precipitation in Nebraska ranges from under 15 inches in the western Panhandle to around 36 inches in the far southeast corner (Figure 3.2). Precipitation falls year-round in the state but peaks in May and June and is lowest in January. Precipitation is also highly variable, with periods of drought and excessive precipitation occurring with some regularity statewide. Some of the annual precipitation falls as snow during the cold season, with a higher percentage occurring as snow in the Panhandle.

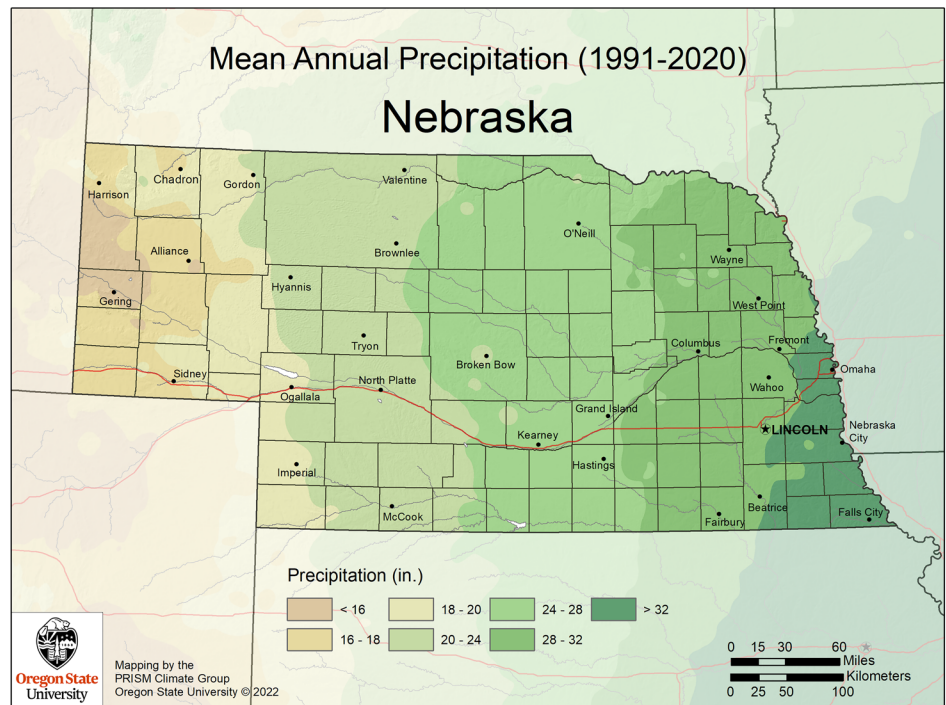


Figure 3.2. Annual average precipitation for the 1991–2020 period. (Source: PRISM Climate Group, 2022)

Data and reference periods

Data used to calculate trends in this report are from NOAA's National Center for Environmental Information and the Applied Climate Information System (ACIS) (Hubbard et al., 2004) unless otherwise specified. The trends discussed in the report are broken into two separate analysis periods for temperature and precipitation: long term (1895–2023) and short term (1980–2023). The former covers the entire observational record. The short term coincides with our satellite period of record. Additionally, each section on seasonal trends contains figures referencing the period from 1895 to 1960 compared to the last thirty years (1994–2023). This follows the practice established in the National Climate Assessment (Marvel et al., 2023).

Climate divisions

Nebraska has a total of eight climate divisions, as assigned by the old U.S. Weather Bureau in the early part of the 20th century. The skipping of the number 4 is a mystery. Figure 3.3 (right) shows the geographic breakdown of the climate divisions. The National Center for Environmental Information determined climate divisions to be areas in the state having common climate characteristics (NOAA NCEI, 2024b).

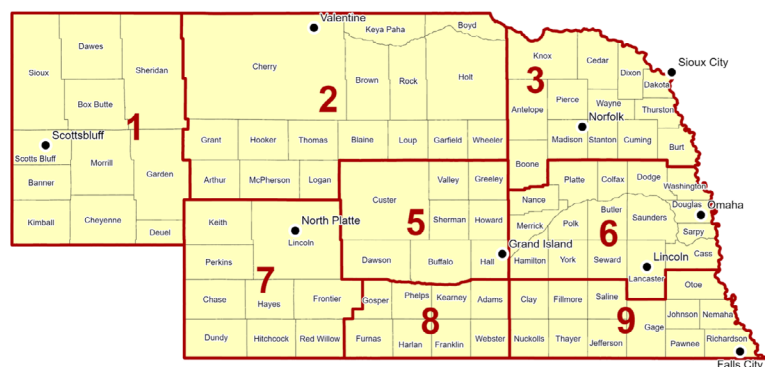


Figure 3.3. Nebraska's climate divisions as determined by the National Centers for Environmental Information. (Source: NOAA NCEI, 2024b)

Trends

Annual

Annual average temperatures have been increasing at a rate of $\sim 0.016^{\circ}\text{F}$ per year since 1895, and the rate of temperature increase has doubled since 1980 (Figure 3.4), with a rate of $0.034^{\circ}\text{F}/\text{year}$. The five-year moving average temperature had periods of below and above average for most of the 20th century. For example, the 1930s and 1950s were consistently above the 20th-century average, and the 1960s and 1970s were generally below it. However, the oscillating periods of below- and above-average temperatures began to end in the early 1980s as temperatures throughout the 1980s and 1990s were generally above the 20th-century average. Since 2000, the five-year moving average has been above the long-term average. Furthermore, four of the top 10 warmest years on record in Nebraska have occurred since 2006, with 2012 being the warmest on record for the state. Only four years since 2000 (2008, 2009, 2018, 2019) have been cooler than the 20th-century average, and no year in the 21st century has been ranked in the top 25 coldest, dating back to 1895.

Precipitation has also increased since the late 19th century at a rate of 0.012 inches/year, a rate that has increased slightly to 0.014 inches/year since 1980

(Figure 3.5). Neither precipitation trend was statistically significant. Like temperatures, precipitation across the state has been highly variable, with distinct wet and dry periods. Precipitation has generally been above historical averages over the past 25 years in Nebraska (Flanagan & Mahmood, 2021), which is reflected in the persistence of the five-year running average being above the 20th-century average so far in the 21st century (Flanagan & Mahmood, 2021). However, during the 21st century, the state has also experienced two extreme drought events (2012 and 2022) that had a sizable impact on the state's water resources, including groundwater. Annual average temperatures in each climate division in the state from 1994 to 2023 were at least 1.0°F warmer compared to the 1895 to 1960 period (Figure 3.6). The biggest increase (1.9°F) was in the Panhandle, and the smallest was in south central Nebraska (1.0°F). The annual average precipitation was higher in each climate division, averaging 1.5 inches higher in north central, south central, east central, and northeast Nebraska (Figure 3.7).

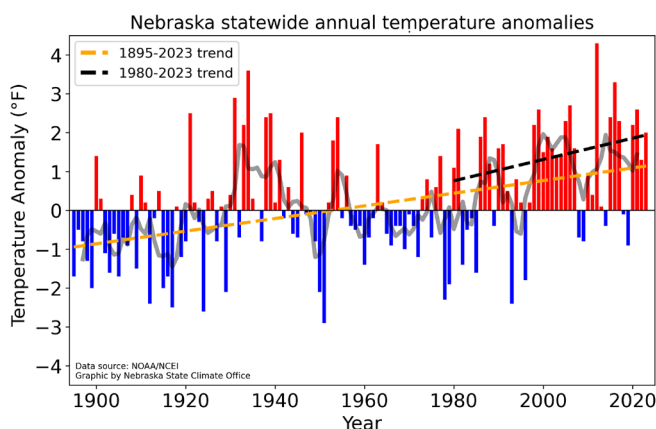


Figure 3.4. Time series of statewide annual temperature anomalies (red for warm, blue for cool) for the period from 1895 to 2023 with respect to the 20th-century average. It also shows temperature trends over the long term (1895–2023, orange dashed line) and the short term (1980–2023, black dashed line). The solid gray line denotes a moving five-year average.

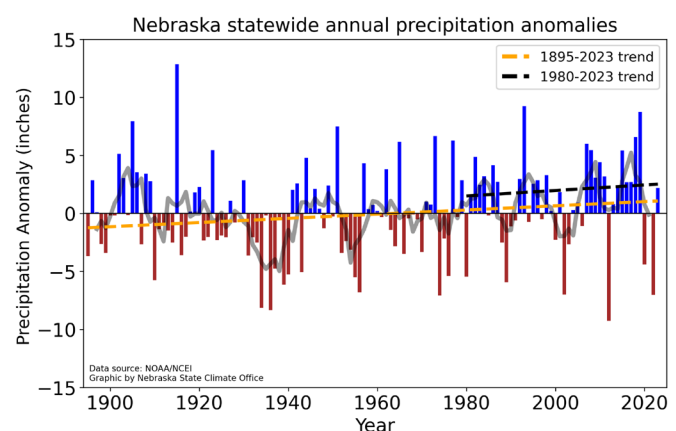


Figure 3.5. Time series of annual precipitation anomalies (blue for wet, brown for dry) for the period from 1895 to 2023 for the 20th-century average. It also shows precipitation trends over the long term (1895–2023, orange dashed line) and the short term (1980–2023, black dashed line). The solid gray line denotes a moving five-year average.

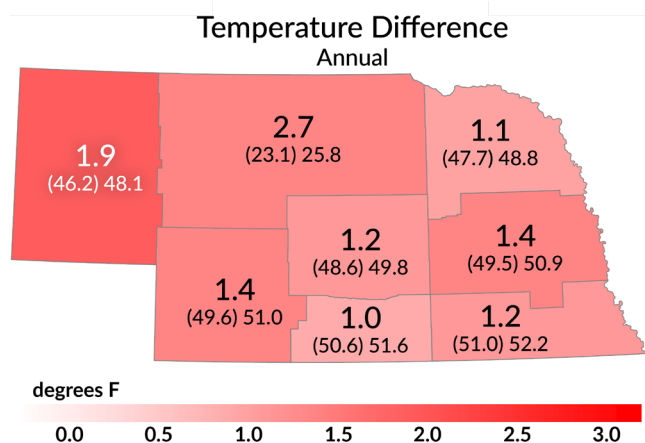


Figure 3.6. Average annual temperature difference from 1994 to 2023 compared to 1895–1960. The number in parentheses in row 2 represents the average temperature from 1895 to 1960, and the number outside of the parentheses represents the temperature from 1994 to 2023.

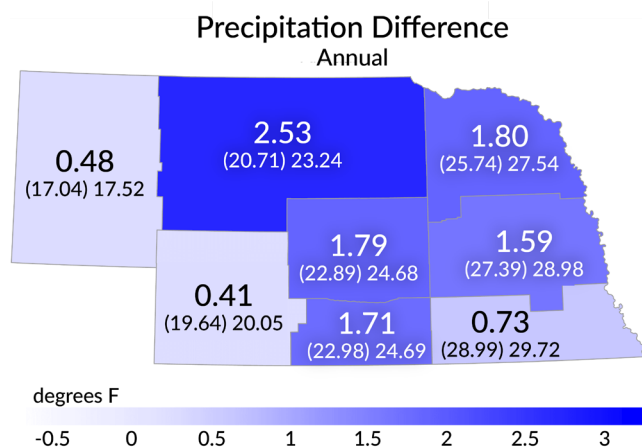


Figure 3.7. Average annual precipitation difference from 1994 to 2023 compared to 1895–1960. The number in parentheses in row 2 represents the average precipitation from 1895 to 1960, and the number outside of the parentheses represents the temperature from 1994 to 2023.

Winter

The winter season—defined climatologically as December, January, and February—has had the strongest warming signal of the four seasons, with an average temperature increase of 0.025°F/year since 1895. All climate divisions in Nebraska, except south central, were more than 2°F warmer in the winter months from 1994 to 2023 compared to 1895 to 1960 (Figure 3.8). Furthermore, the difference in temperature between 1994 and 2023 and 1895 and 1960 was larger in the winter than in any other season for all eight climate divisions in Nebraska. Precipitation changes in the winter have been more mixed. The Panhandle, west central, central, and northeast climate divisions have seen slight decreases in precipitation. In contrast, the north central, south central, southeast, and east central divisions have seen increases in precipitation (Figure 3.9). Statewide, short-term precipitation has increased while the long-term trend is flat (Figure 3.10).

While winter overall is warming (Figure 3.11), February has shown a cooling trend over the short term (Figure 3.12). Over the past few decades, there have been several Februaries with average temperatures well below the 20th-century average. This resulted in an overall negative trend in winter temperature over the short term. The five-year moving average has often been below the 20th-century average over the last 20 years. This negative trend is consistent across all climate

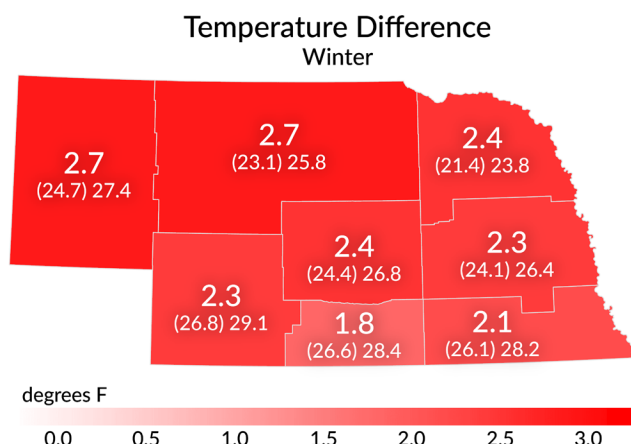


Figure 3.8. Average winter season temperature difference from 1994 to 2023 compared to 1895–1960. The number in parentheses in row 2 represents the average temperature from 1895 to 1960, and the number outside of the parentheses represents the temperature from 1994 to 2023.

divisions. The recent trend toward colder February temperatures has been linked to the increasingly erratic behavior of the polar vortex (Cohen et al., 2020; Cohen et al., 2021; Cohen et al., 2022), including the long stretch of bitterly cold weather in February 2021 that encompassed Nebraska and much of the central U.S. (Millin & Furtado, 2022) (Chapter 2, Case Study 1).

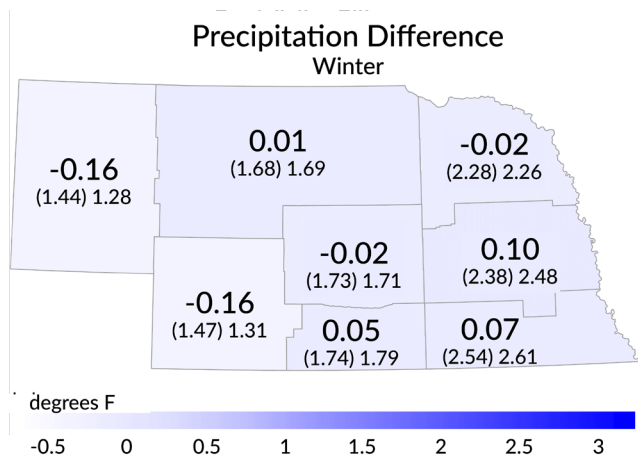


Figure 3.9. Average winter season precipitation difference from 1994 to 2023 compared to 1895–1960. The number in parentheses in row 2 represents the average precipitation from 1895 to 1960, and the number outside of the parentheses represents the temperature from 1994 to 2023.

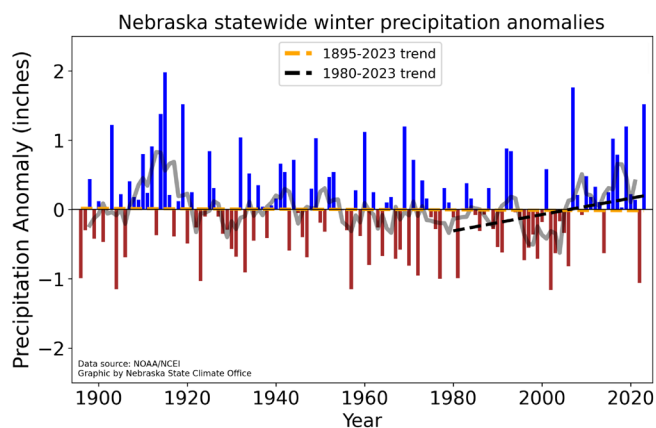


Figure 3.10. Time series of winter precipitation anomalies (blue for wet, brown for dry) from 1895 to 2023 with respect to the 20th-century average. It also shows precipitation trends over the long term (1895–2023; orange dashed line) and the short term (1980–2023; black dashed line). The solid gray line denotes a moving five-year average.

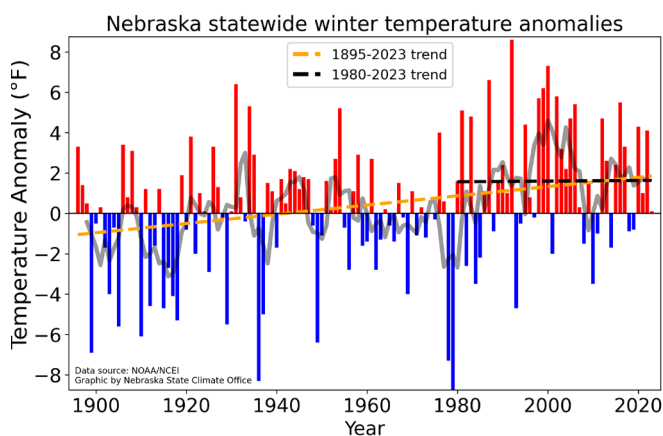


Figure 3.11. Time series of statewide winter temperature anomalies (red for warm, blue for cool) from 1895 to 2023 with respect to the 20th-century average. It also shows temperature trends over the long term (1895–2023, orange dashed line) and the short term (1980–2023, black dashed line). The solid gray line denotes a moving five-year average.

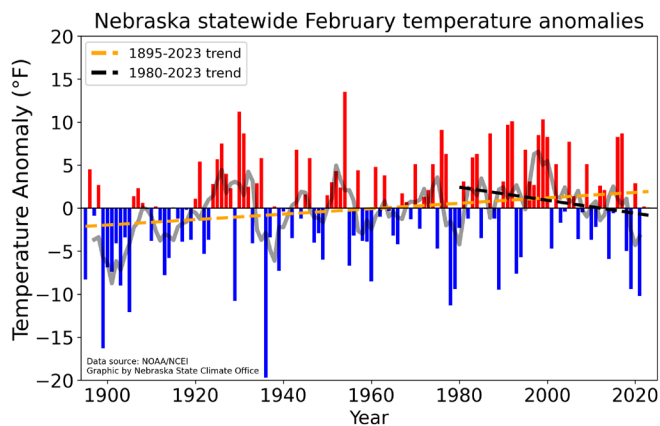


Figure 3.12. Time series of statewide February temperature anomalies (red for warm, blue for cool) for the from 1895 to 2023 with respect to the 20th-century average. It also shows temperature trends over the long term (1895–2023, orange dashed line) and the short term (1980–2023, black dashed line). The solid gray line denotes a moving 5-year average

Even though the overall rate of short-term warming in winter is not as significant as the other three seasons, other metrics show that the characteristics of winter have changed in the past few decades. For example, Figure 3.13 shows that most of Nebraska had at least four more days in a year above freezing in the period from 1991 to 2020 than over the period from 1951 to 1980, according to gridded NOAA data. This agrees well with the observed station data. For example, Lincoln and Valentine averaged seven and nine more days per year, respectively, above freezing yearly from 1991 to 2020 than from 1951 to 1980.

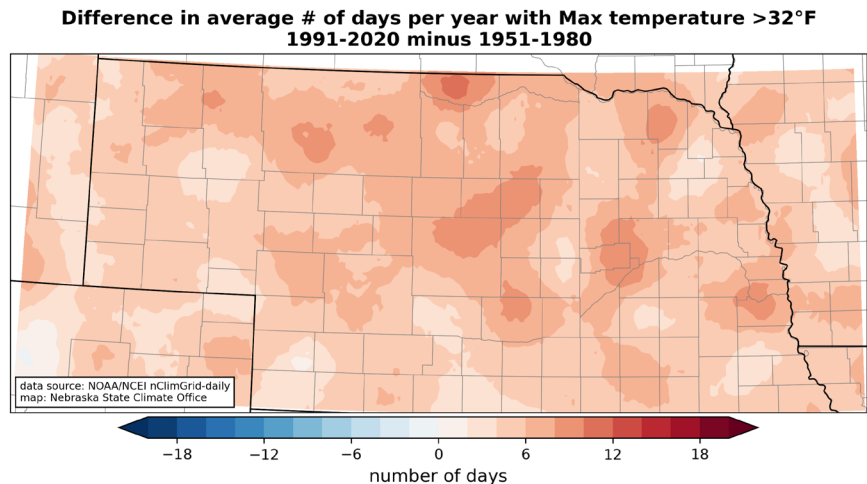


Figure 3.13. Difference in the average number of days per year with maximum temperatures above 32°F from 1951 to 1980 compared to 1991 to 2020.

Fall

Fall, defined climatologically as September to November, is becoming warmer over long- and short-term periods. This warming is especially pronounced over the short term, with a temperature increase of 0.067°F/year since 1980 (Figure 3.14). The short-term rate of temperature increase in the fall is considerably higher than the long-term rate of increase (+0.010°F/year). It is easily the most substantial rate of increase of any season over both analysis periods—short and long term. This short-term rate of temperature increase in the fall is statistically significant statewide and across all eight climate divisions. All climate divisions in the state were at least 0.7°F warmer in the period from 1994 to 2023 compared to the period from 1895 to 1960, and the southwest climate division was over 2°F warmer (Figure 3.15).

The short-term increased rate of warming in the fall is not equally distributed across the fall months. Instead, the enhanced short-term rate of warming is almost exclusively driven by September and November, when the statewide rates of temperature increase are 0.093°F/year and 0.095°F/year, respectively. By comparison, the rate of warming in October is comparably less at 0.017°F/year. September and November have statewide statistically significant increases over the short term. The increases in

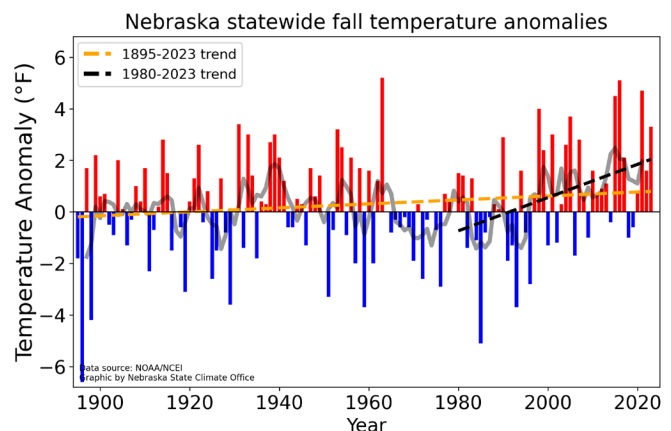


Figure 3.14. Time series of statewide fall temperature anomalies (red for warm, blue for cool) from 1895 to 2023 with respect to the 20th-century average. Also shows temperature trends over the long term (1895–2023, orange dashed line) and the short term (1980–2023, black dashed line). The solid gray line denotes a moving five-year average.

September are statistically significant for all eight climate divisions; only the southeast climate division does not have a statistically significant rate of temperature increase in November.

Fall precipitation is complicated. The long-term signal is weakly positive (Figure 3.16), and most state climate divisions were wetter from 1994 to 2023

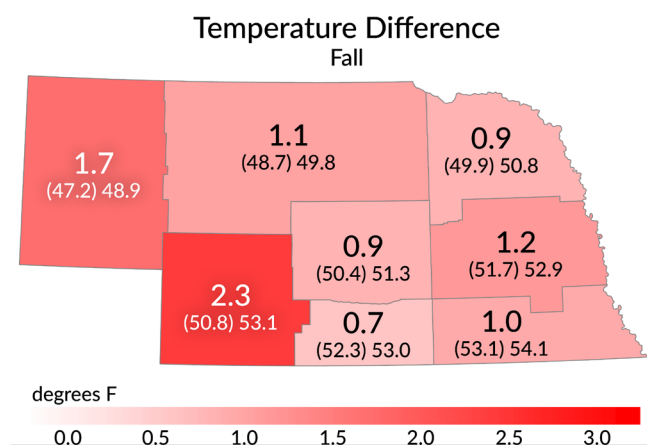


Figure 3.15. Average annual temperature difference in the fall season from 1994 to 2023 compared to 1895 to 1960. The number in parentheses in row 2 represents the average temperature from 1895 to 1960 period, and the number outside of the parentheses represents the temperature from 1994 to 2023.

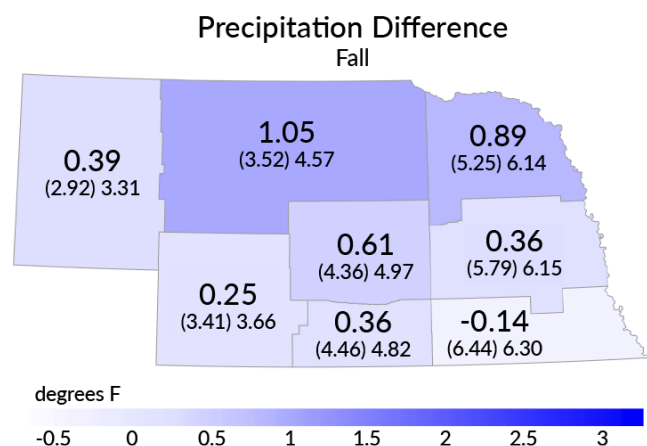


Figure 3.17. Average annual precipitation difference in the fall season from 1994 to 2023 compared to 1895 to 1960. The number in parentheses in row 2 represents the average precipitation from 1895 to 1960, and the number outside of the parentheses represents the temperature from 1994 to 2023.

compared to 1895 to 1960 (Figure 3.17). However, the statewide short-term trend in fall precipitation is weakly negative. This weak negative trend for fall is driven by the statistically significant downward trend of -0.015 inches/year in November in the short term (Figure 3.18). Historically, November in Nebraska has been variable, with prolonged stretches of below- and above-average precipitation.

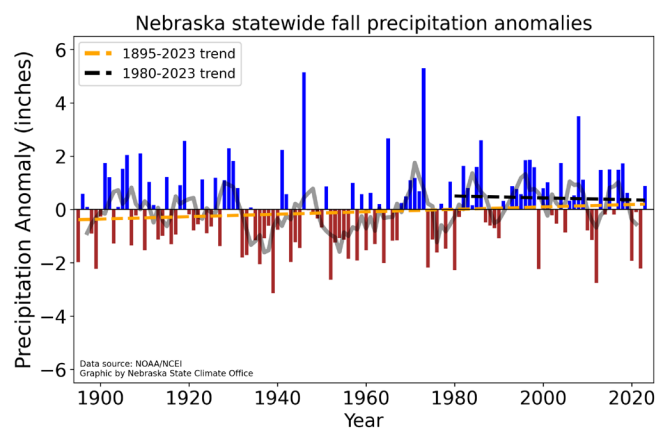


Figure 3.16. Time series of fall precipitation anomalies (blue for wet, brown for dry) from 1895 to 2023 with respect to the 20th-century average. It also shows precipitation trends over the long term (1895–2023, orange dashed line) and the short term (1980–2023, black dashed line). The solid gray line denotes a moving five-year average.

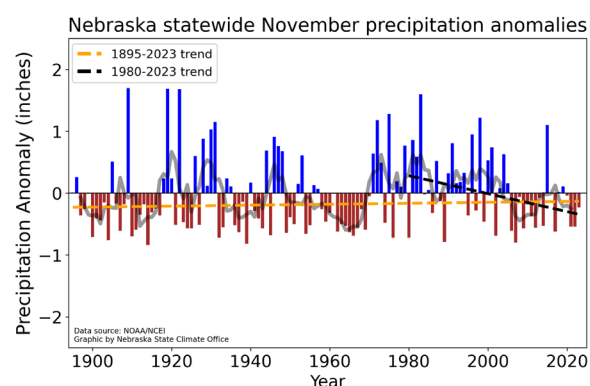


Figure 3.18. Time series of November precipitation anomalies (blue for wet, brown for dry) from 1895 to 2023 with respect to the 20th-century average. It also shows precipitation trends over the long term (1895–2023, orange dashed line) and the short term (1980–2023, black dashed line). The solid gray line denotes a moving five-year average.

Nevertheless, this downward trend is found in every climate division and is statistically significant in all climate divisions except the southeast. The downward trend in the short term has been driven exclusively by the last 25 years, where November precipitation has been almost exclusively below average.

Summer

Summer temperatures across the state have gradually warmed over the analysis period, with an enhanced warm signal in the short term (Figure 3.19). A closer inspection of the monthly data shows that the warming signal over both the long term and short term is driven mainly by accelerated warming in June, with a rate of temperature increase of 0.060°F/year over the short term. Every climate division in Nebraska has a statistically significant rate of warming over the long term, and only the north central climate division does not have a statistically significant rate of warming over the short term in June.

July and August show weak rates of warming for the state over both analysis periods. In the three eastern climate divisions, at least one summer month shows a *weak cooling trend over the short term*. Only the Panhandle has a statistically significant warming signal in July and August over the long term, and none of the climate divisions have a statistically significant rate of warming over the short term in July and August. One of the possible reasons for the relative lack of warming in midsummer is the amount of cropland and irrigation in the state and region. Recent studies (Lachenmeier et al., 2024; Mahmood et al., 2004; Mahmood et al., 2006; Rappin et al., 2021; Szilagyi & Franz, 2020) have shown that cropping systems and irrigation in the central Plains region have led to an increase in crop evapotranspiration, which in turn has led to a slight reduction in maximum midsummer temperatures in the region. According to gridded NOAA data, fewer days with maximum temperatures above 95°F were recorded over the eastern two-thirds of the state where irrigated cropland is most prevalent (Figure 3.20) in the period from 1991 to 2020 than in the period from 1951 to 1980. The northeast and southeast climate divisions had no change in air temperature in from 1994 to 2023 compared to 1895 to 1960 (Figure 3.21).

The climatological summer months have essentially no trend in precipitation over the long term and a weakly negative trend over the short term at the state level (Figure 3.22). Furthermore, there is a lower frequency of extreme precipitation events

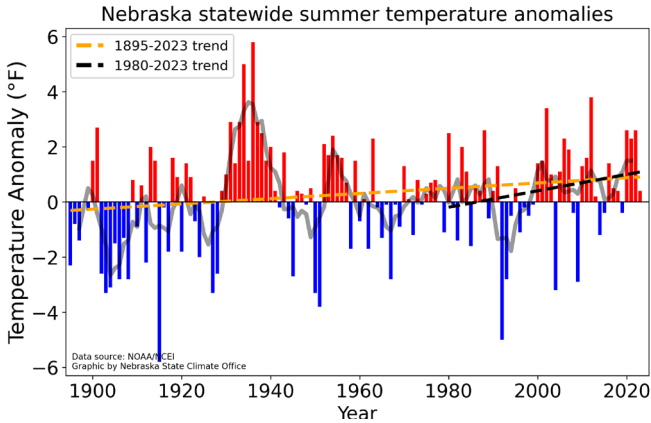


Figure 3.19. Time series of statewide summer temperature anomalies (red for warm, blue for cool) for the from 1895 to 2023 with respect to the 20th-century average. It also shows temperature trends over the long term (1895–2023, orange dashed line) and the short term (1980–2023, black dashed line). The solid gray line denotes a moving five-year average.

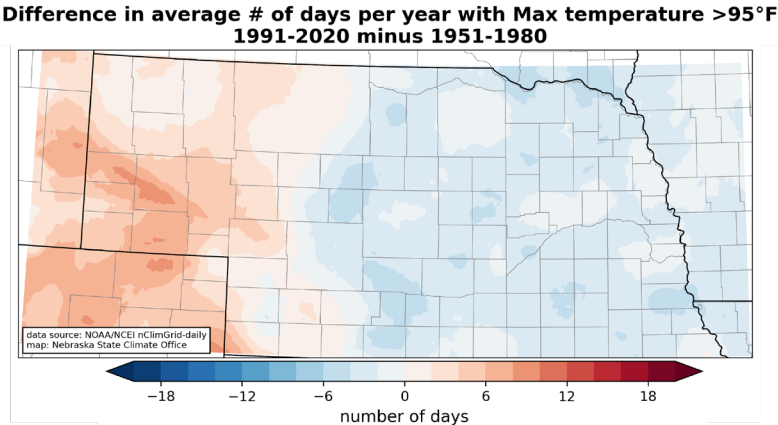


Figure 3.20. The difference in the average number of days per year with maximum temperatures above 95°F from 1951 to 1980 compared 1991 to 2020. (Source: NOAA NCEI, n.d., nClimGrid dataset)

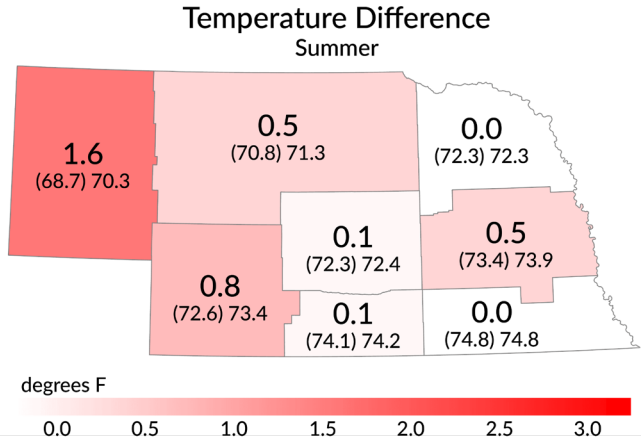


Figure 3.21. Average annual temperature difference in the summer season from 1994 to 2023 compared to 1895 to 1960. The number in parentheses in row 2 represents the average temperature from 1895 to 1960, and the number outside of the parentheses represents the temperature from 1994 to 2023.

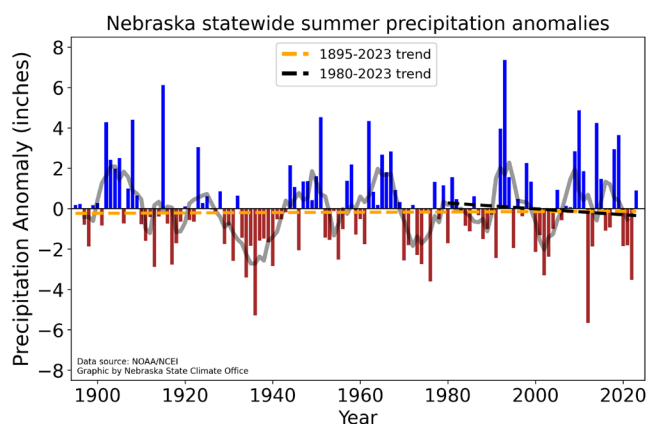


Figure 3.22. Time series of summer precipitation anomalies (blue for wet, brown for dry) from 1895 to 2023 with respect to the 20th-century average. Also shows precipitation trends over the long term (orange dashed line) and the short term (1980–2023, black dashed line). The solid gray line denotes a moving five-year average.

compared to the spring and fall months (Flanagan & Mahmood, 2021). However, the story changes a bit at the climate division level. The three climate divisions in central Nebraska and the southwest and northeast climate divisions have seen an increase in precipitation in the period from 1994 to 2023 compared to 1895 to 1960. Conversely, the east central, southeast, and

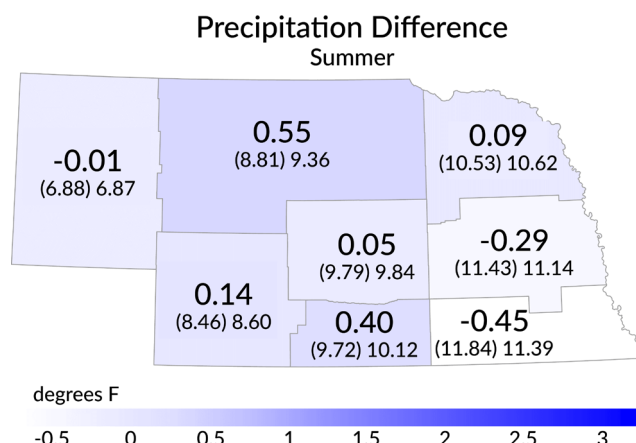


Figure 3.23. Average annual precipitation difference in the summer season from 1994 to 2023 compared to 1895 to 1960. The number in parentheses in row 2 represents the average precipitation from 1895 to 1960, and the number outside of the parentheses represents the temperature from 1994 to 2023.

Panhandle climate divisions have seen a decrease in summer precipitation in the period from 1994 to 2023 compared to the 1895 to 1960 (Figure 3.23). Nevertheless, even a small decreasing trend in precipitation in the summer is concerning for crop production and pastures, especially rain-fed crops, when combined with a warming early summer and fall.

Spring

Precipitation shows an increasing trend in the long term (Figure 3.24), and all climate divisions were wetter in the spring from 1994 to 2023 compared to 1895 to 1960 (Figure 3.25). The central, east central, and southeast climate divisions all had increases of over an inch. However, the short-term precipitation signal in the spring is only weakly positive and is negative in the month of March (Figure 3.26). The short-term trend of decreasing precipitation in March is not statistically significant at the state level but is decreasing in seven of the eight climate divisions; the Panhandle the exception. However, recent years have had above-average precipitation in March, including in 2019, when historic rainfall occurred on frozen ground and led to historic flooding (Flanagan et al., 2020). Thus, the decline in March precipitation is a reflection that March has tended to be drier than average over the past few decades.

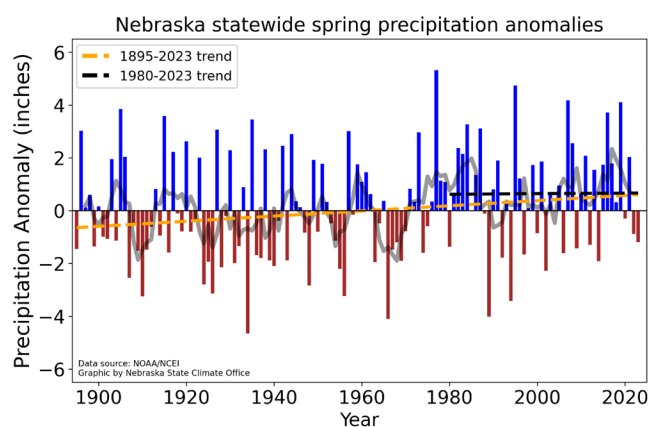


Figure 3.24. Time series of spring precipitation anomalies (blue for wet, brown for dry) from 1895 to 2023 with respect to the 20th-century average. It also shows precipitation trends over the long term (1895–2023, orange dashed line) and the short term (1980–2023, black dashed line). The solid gray line denotes a moving five-year average.

Temperatures in the spring have been warming over the long term (Figure 3.27), and all climate divisions were more than 1°F warmer from 1994 to 2023 compared to 1895 to 1960 (Figure 3.28). However, that trend has been flat in the short term. Spring temperatures rose above the 20th-century average around 1980. Since then, the short-term trend has

remained relatively level and has not made another consistent upward shift. Conversely, the short-term trend in the fall season is strongly positive because the shift to predominantly above-average falls has happened more recently. In other words, the winter and spring seasons showed warming signals about 15 to 20 years earlier than the fall.

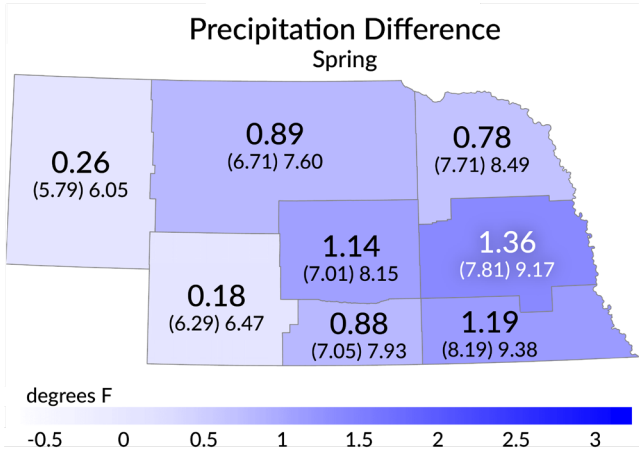


Figure 3.25. Average annual precipitation difference in the spring season from 1994 to 2023 compared to 1895 to 1960. The number in parentheses in row 2 represents the average precipitation from 1895 to 1960, and the number outside of the parentheses represents the temperature from 1994 to 2023.

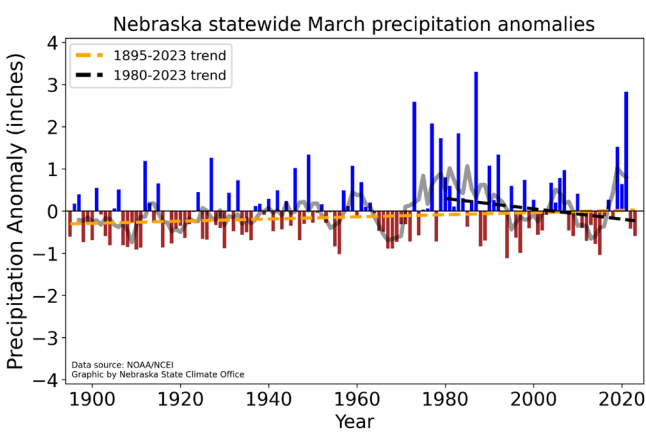


Figure 3.26. Time series of March precipitation anomalies (blue for wet, brown for dry) from 1895 to 2023 with respect to the 20th-century average. It also shows precipitation trends over the long term (1895–2023, orange dashed line) and the short term (1980–2023, black dashed line). The solid gray line denotes a moving five-year average.

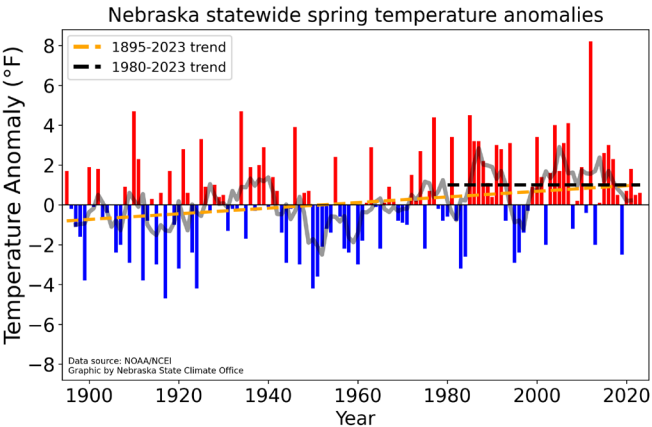


Figure 3.27. Time series of statewide spring temperature anomalies (red for warm, blue for cool) from 1895 to 2023 with respect to the 20th-century average. It also shows temperature trends over the long term (1895–2023, orange dashed line) and the short term (1980–2023, black dashed line). The solid gray line denotes a moving five-year average.

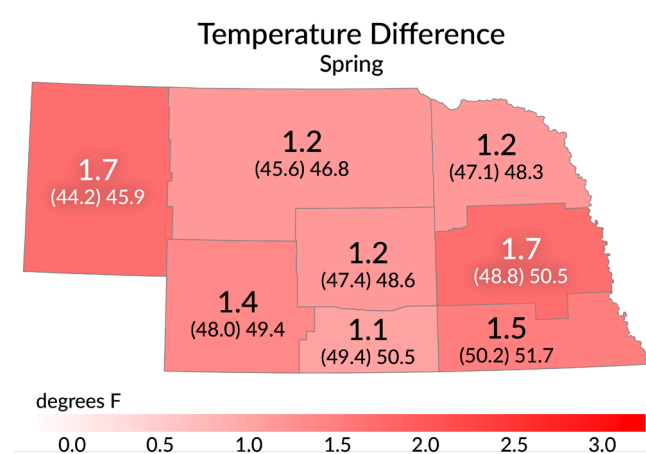


Figure 3.28. Average annual temperature difference in the spring season from 1994 to 2023 compared to 1895 to 1960. The number in parentheses in row 2 represents the average temperature from 1895 to 1960, and the number outside of the parentheses represents the temperature from 1994 to 2023.

Extreme events

Drought

Drought has a long history of causing hardship in Nebraska, including the Dust Bowl of the 1930s, the 1950s drought, and, more recently, the drought of 2012. It is a complex phenomenon that affects nearly all sectors of society. Drought is defined in numerous ways, including meteorological, agricultural, hydrological, flash, ecological, and socioeconomic (Wilhite & Glantz, 1985; Crausbay et al., 2017; Otkin et al., 2018). Given this complexity, quantifying the severity and duration of drought can be challenging. Numerous drought indices can be used to provide useful approximations. In this assessment, we chose the Standardized Precipitation Evapotranspiration Index (SPEI) (Vicente-Serrano et al., 2010) to capture the signal in precipitation and temperature. The SPEI calculation was designed to mimic the widely used Standardized Precipitation Index (SPI) (McKee et al., 1993) and can be captured over various time scales ranging from months to years. The key benefit of SPEI over SPI is that the temperature effect on drought is also accounted for, giving more insight into the overall severity of drought at a given point in time.

For this report, we used the National Drought Mitigation Center's Drought Risk Atlas (Svoboda et al., 2015) to obtain the 12-month SPEI for nine long-term stations around the state from 1951 to 2022. We used the median of the 12-month SPEI at those stations to identify extended periods when drought affected most of the state. Figure 3.29 shows multiple multiyear drought events, most notably in the 1950s, the mid-1970s, and 2000, and more extended periods with less to no drought in the state. The median of the 12 months does not reflect the actual percentage of the state in drought at a given time, nor does it give any insight into which area of the state was experiencing the worst conditions. However, it indicates the spatial prevalence of drought and gives some insight into overall severity.

Chapter 2 discussed how the time series of the SPEI suggests a decreasing trend in drought across the eastern half of the U.S. For Nebraska, the SPEI generally shows a trend toward fewer but more intense droughts. This was especially the case over the last 15 years of

analysis. A negative monthly median statewide SPEI occurred just 25% of the time between April 2007 and December 2022. However, the droughts during that time have been quite intense. The lowest observed SPEI values occurred during the fall of 2012, Nebraska's driest year on record. Data from the Drought Risk Atlas was not fully available for 2023 at the time of analysis, so we stopped with December 2022. However, given the historic nature of drought conditions in central and eastern Nebraska by late spring 2023, it is likely that the 12-month SPEI values in the spring and early summer of 2023 were in the range of late 2012 for negative values.

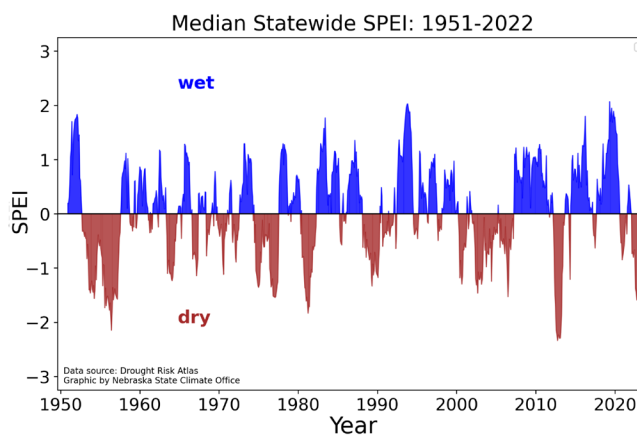


Figure 3.29. The 12-month median statewide SPEI from 1951 to 2022.

Record-breaking temperature and precipitation

Figure 3.30 shows the number of new monthly and annual temperature and precipitation records set at various locations in Nebraska since the start of the 21st century. The story about temperature is straightforward: many new record-warm months than record-cold months have occurred in Nebraska since 2000. Most locations have had at least two calendar months with record warm average temperatures (red circles), and all sites had at least one. The story related to precipitation is more complicated. More dry months (brown circles) have occurred compared to record wet months (dark blue circles), but no significant difference exists. Furthermore, little, if any, consistent spatial signal is apparent for record wet and dry months. For example, Lincoln has set more new record wet months than dry months, while its nearest neighbors (Omaha, Falls City, and Grand Island) have set more record dry months.

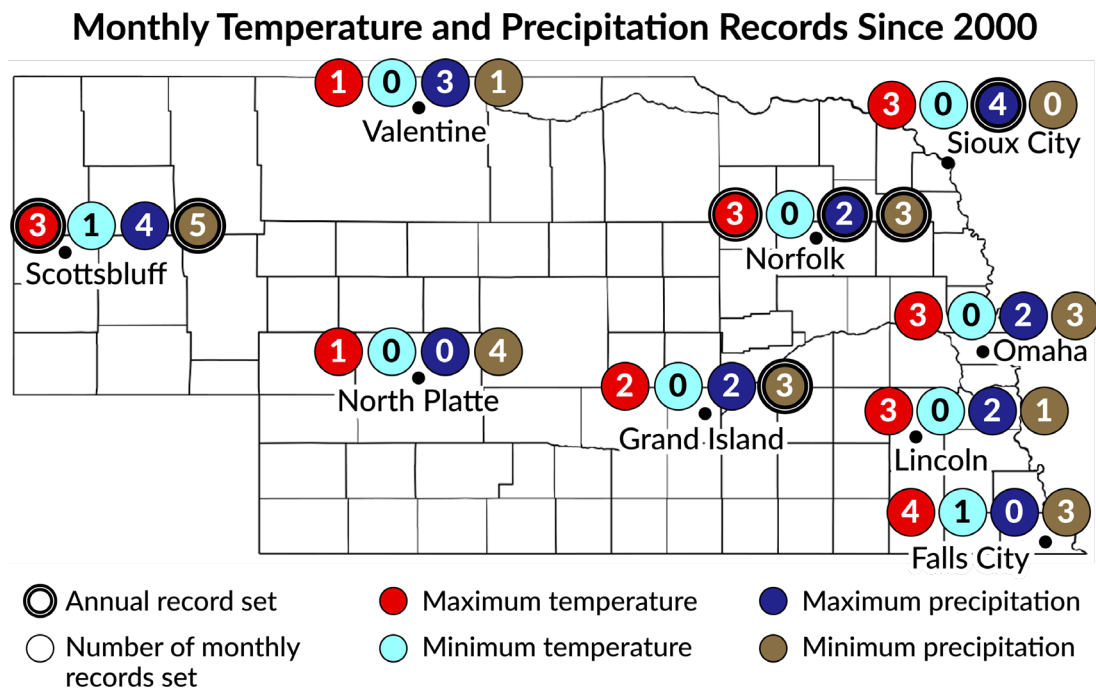


Figure 3.30. Bubble plot of monthly and annual temperature and precipitation records set since 2000. A record warm (cold) month is denoted by the red (light blue) circle with a number corresponding to number of occurrences. A record wet (dry) month is denoted by the dark blue (brown) circle with a number corresponding to number of occurrences. An annual record in any of the four categories is denoted with a bold black line around the circles. (Source: ACIS, 2024)

Scottsbluff stands out as more exceptional than the rest regarding the number of new records. It is the only location that sets records for average temperature and precipitation on the maximum and minimum sides. It also is one of only two sites that set a new highest annual average temperature record and a new lowest annual precipitation record. Also, it is the only site out of the eight that set new records for a warm average temperature during a summer month. In this case, all three climatological summer months have established new records since 2000. The number of record-warm months was lower at the west central sites (North Platte and Valentine had one each) than elsewhere in the state and was highest in Falls City (four total). January 2006 and March 2012 were the most common record-warm months, but no month was a record-warm month at all nine sites. Both Scottsbluff (October 2009) and Falls City (April 2018) have had a record cold month (light blue circles) since the start of the 21st century, but no location was close to setting a new record cold year. Norfolk (2007) and Sioux City (2014) set new annual maximum precipitation records. Norfolk also

had its driest year on record (2022) and is joined by Scottsbluff and Grand Island (both during 2012) as having set new record minimum precipitation values.

Frost-free days

The number of days in a year with minimum temperatures remaining above freezing increased statewide over the 30-year period of 1991 to 2020 compared to the 30-year period between 1951 to 1980 (Figure 3.31), according to NCEI's nClimGrid data (NOAA NCEI, n.d.). The annual increase in the number of days with above-freezing minimum temperatures was most prevalent in the east central section of the state. Indeed, areas around Columbus, Lincoln, Wahoo, and Omaha had 10 to 14 more days per year of above-freezing minimum temperatures between 1991 and 2020 compared to 1951 and 1980. A secondary maximum of increased above-freezing minimum temperatures was also noted around the northern portion of the Panhandle between Chadron and Gordon.

Difference in average # of days per year with Min temperature >32°F 1991-2020 minus 1951-1980

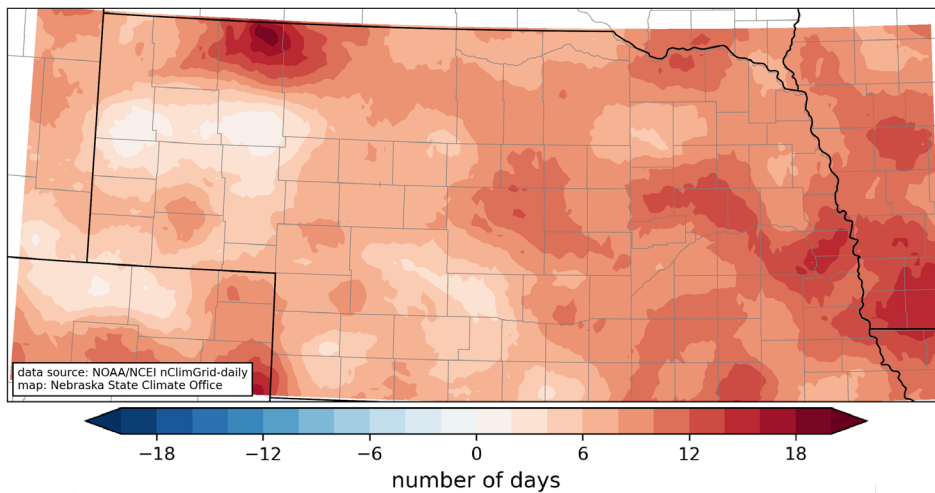


Figure 3.31. The difference in the average number of days per year with minimum temperatures above 32°F from 1951 to 1980 compared to 1991 to 2020. (Source: NOAA NCEI, n.d., nClimGrid dataset)

Heating- and cooling-degree days

Heating (HDD) and cooling (CDD) degree days relate the average daily outdoor temperature to the energy used to heat or cool buildings. Degree days are calculated by taking the daily average temperature and calculating it against a base temperature of 65°F. Nebraska has historically experienced substantially more heating-degree days (average >6000 HDD) than cooling-degree days (average ~900) in a year.

Our analysis shows that Nebraska has been losing 4.8 HDDs per year and gaining about 1 CDD yearly over the long term. The HDD decline is even more pronounced in the short term, with a 7.7 days per year decline since 1980 (Figure 3.32a). In addition, an increase of 2 CDDs per year occurred over the short term (Figure 3.32b). Over recent decades, the increased number of CDDs is mainly due to the increased average temperature in months like June and September. The decrease in heating-degree days is spread out more evenly, but declines are more noticeable in the late fall and early winter.

While the demand for cooling is increasing with an increased trend in CDDs, the demand for heating is not increasing as quickly as the demand for heating is decreasing. If these trends continue in the coming years and decades, the overall energy consumption needed to keep buildings comfortable will likely be less than it is currently in the coming years.

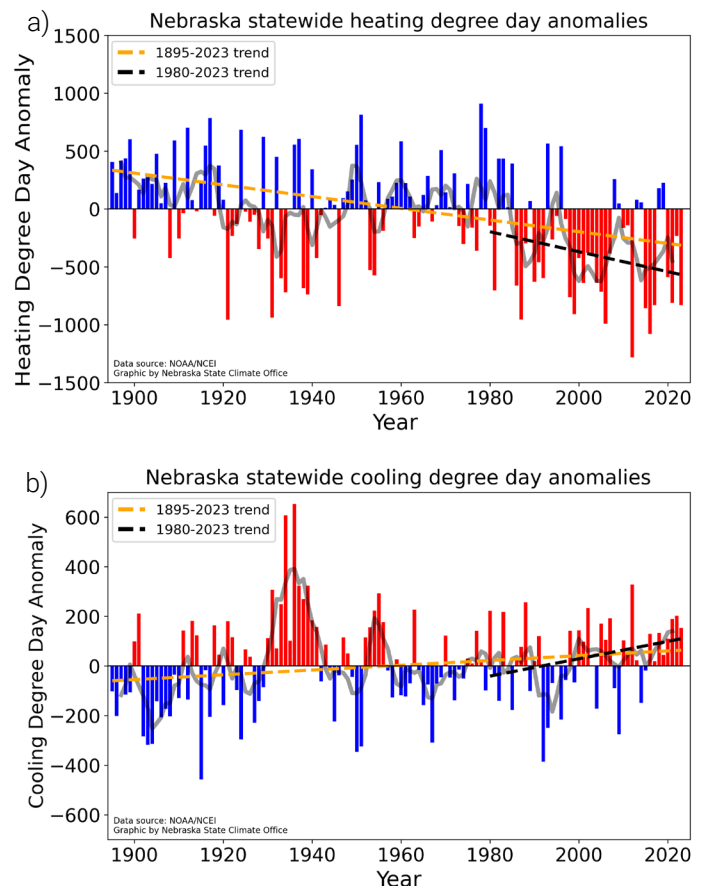


Figure 3.32. Time series of (a) heating and (b) cooling degree day anomalies. Blue bars indicate values greater than the average, while red bars denote values less than the average from 1895 to 2023 compared to the 20th-century average. It also shows temperature trends over the long term (1895–2023, orange dashed line) and the short term (1980–2023, black dashed line). The solid gray line denotes a moving five-year average.

Average number of days with 1 inch of snow on the ground

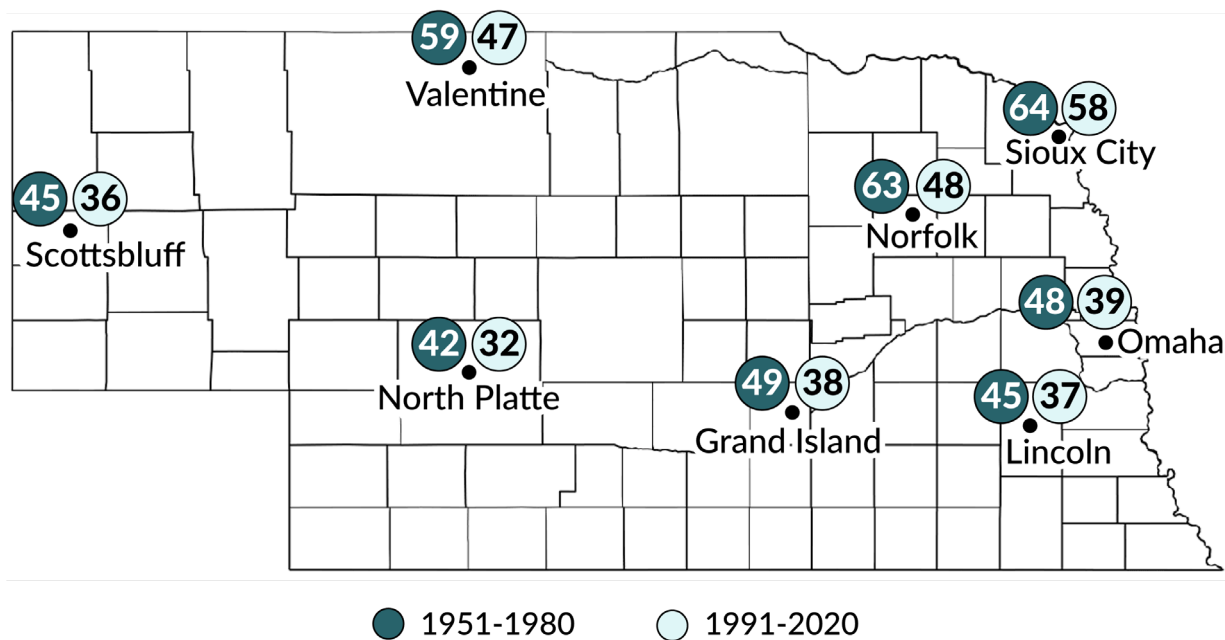


Figure 3.33. The average number of days in a year with one inch or more of snow cover from 1951 to 1980 (darker circles) compared to 1991 to 2020 (lighter circles).

Snow cover

Annual average snowfall in Nebraska has a decreasing gradient from northwest to southeast and considerable year-to-year variability. The number of days with snow cover in a year depends on the snowfall received and temperatures cold enough to preserve it on the ground. The trend toward warmer temperatures in the winter has led to a decrease in the number of days with snow cover of at least 1 inch at all eight sites in Nebraska, as shown in Figure 3.33. Most sites had around 10 fewer days of snow cover in the period from 1991 to 2020 compared to the period from 1951 to 1980. The decrease in the number of days with 1 inch of snow cover was most pronounced in Norfolk, with an average of 48 days between 1991 and 2020 compared to 63 days between 1951 and 1980.

Gaps and needs

- » **Robust statewide Mesonet.** A robust Nebraska Mesonet will provide high-resolution, localized weather data. By providing near real-time information, Mesonet data can help predict and disseminate life-saving warnings for extreme events. In addition, by providing continuous data over time, a Mesonet can improve the monitoring of climate events and trends and help evaluate the impacts of climate change on sectors such as agriculture and water resources.
- » **Statewide climate data portal.** Improved internet access to historical climate data will enable Nebraska's residents to use historical data from the Mesonet for decision-making. Furthermore, it would facilitate the development of climate-related tools to help manage climate-related risks, develop future opportunities and investments, and build resilience to extreme events.