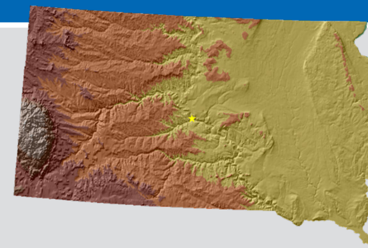

SOUTH DAKOTA

Key Messages

Temperatures in South Dakota have risen almost 2°F since the beginning of the 20th century, with warming concentrated in the winter and nighttime minimum temperatures increasing about twice as much as daytime maximums. Under a higher emissions pathway, historically unprecedented warming is projected during this century.

Increases in evaporation rates due to rising temperatures may increase the rate of warm-season soil moisture loss and the intensity of naturally occurring droughts.

Winter and spring precipitation is projected to increase, with associated increases in total seasonal snowfall. Extreme precipitation events are also projected to increase in frequency and intensity, raising the risk of springtime flooding.

South Dakota lies in the Northern Great Plains, straddling the transition from the moist eastern United States to the semiarid West. Due to its location in the center of the North American continent, far from the moderating effects of the oceans, the state experiences large temperature extremes. Average January temperatures range from less than 10°–15°F in the northeast to more than 25°F in the southwest, while average July temperatures range from about 65°F in Black Hills National Forest to more than 75°F in the south-central region. Temperatures of 100°F or more occur nearly every year. The warmest year on record was 2012, with a statewide average temperature of 49.3°F (4.6°F above the long-term [1895–2020] average). The lack of mountain ranges to the north exposes the state to bitterly cold arctic air masses in winter.

Temperatures in South Dakota have risen almost 2°F since the beginning of the 20th century (Figure 1). Temperatures in the first two decades of this century have been higher than in any other historical period, with the exception of the early 1930s Dust Bowl era, when poor land management likely exacerbated hot summer temperatures. Warming has occurred in all four seasons but has been largest in the winter (Figure 2a). Summers have

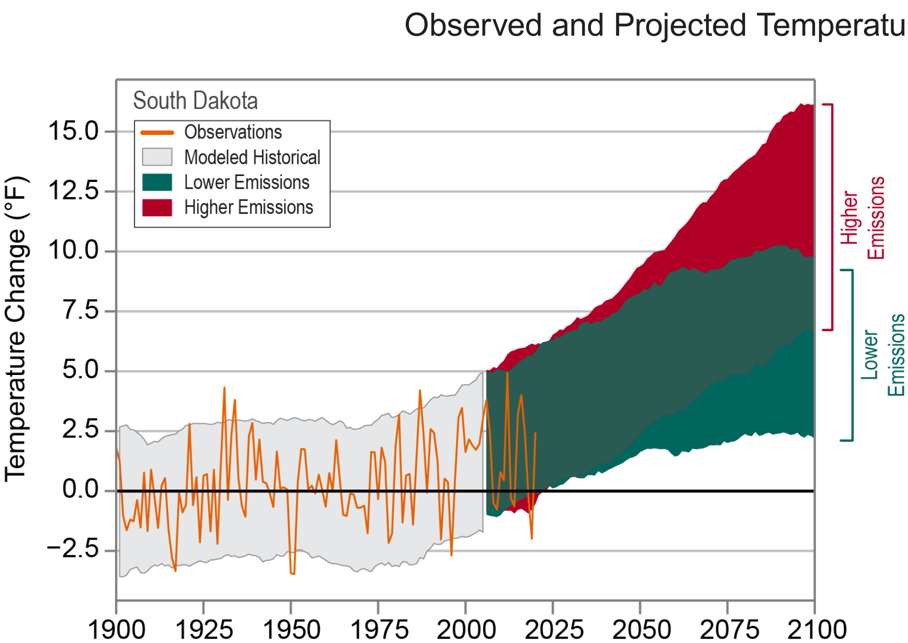

Figure 1. Observed and projected changes (compared to the 1901–1960 average) in near-surface air temperature for South Dakota. Observed data are for 1900–2020. Projected changes for 2006–2100 are from global climate models for two possible futures: one in which greenhouse gas emissions continue to increase (higher emissions) and another in which greenhouse gas emissions increase at a slower rate (lower emissions). Temperatures in South Dakota (orange line) have risen almost 2°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 end-of-century projections being about 2°F warmer than the historical average; green shading) and more warming under a higher emissions future (the hottest end-of-century projections being about 11°F warmer than the hottest year in the historical record; red shading). Sources: CISESS and NOAA NCEI.

warmed very little (Figure 2b), which is characteristic of most states in the Great Plains and Midwest. The lack of summer warming is reflected in a below average number of extremely hot days since 1990 (Figure 3a) and no overall trend in warm nights (Figure 3b). In addition, nighttime minimum temperatures have risen at about twice the rate of daytime maximum temperatures, which might be attributed to an increase in absolute humidity. Winter warming is reflected in a below average number of very cold days since 2000 (Figure 4).

Annual average precipitation ranges from around 16 inches in the northwest to about 28 inches in the southeast. Statewide total precipitation has varied widely from year to year, ranging from a low of 10.9 inches in 1936 to a high of 31.4 inches in 2019 (Figure 3c). The driest multiyear periods occurred in the 1930s and the wettest in the late 1990s and from 2008 onward. Annual precipitation has ranged from an average of 14.3 inches per year during the driest consecutive 5-year interval (1933–1937) to an average of 23.2 inches per year during the wettest consecutive 5-year interval (2007–2011). Summer precipitation has generally been above average since 2008 (Figure 3d). Most of the state's precipitation falls between April and September, when thunderstorm activity is highest. The most severe thunderstorms can produce hail, high winds, and tornadoes. A hailstone from a severe thunderstorm that fell on July 23, 2010, in Vivian holds the national record for hail weight (1.938 pounds) and diameter (8.00 inches). While most of the state averages at least 30 inches of snow annually, portions of Black Hills National Forest can receive upwards of 70 inches annually. South Dakota has generally experienced an increase in snowfall.

Like other Great Plains states, South Dakota experiences periodic episodes of severe drought, which can last for several years. The 1930s drought of the Dust Bowl era was one of the worst in the state's history, when extreme heat exacerbated dry conditions. Not only was 1936 the driest summer on record, with only 3.5 inches of precipitation (4.6 inches below the long-term average), it was also the hottest summer, with an average temperature of 76.4°F (6.7°F above the long-term average). Recent drought years include 2012 and 2017. The 2017 Northern Plains drought, which primarily impacted North Dakota, South Dakota, and Montana, as well as adjacent Canadian Prairies, was devastating for livestock and agricultural production. Emerging in the spring, the drought rapidly spread and intensified throughout the summer, leading to crop failure, the culling of livestock herds, widespread wildfires, low water supplies, and losses exceeding $2.5 billion.

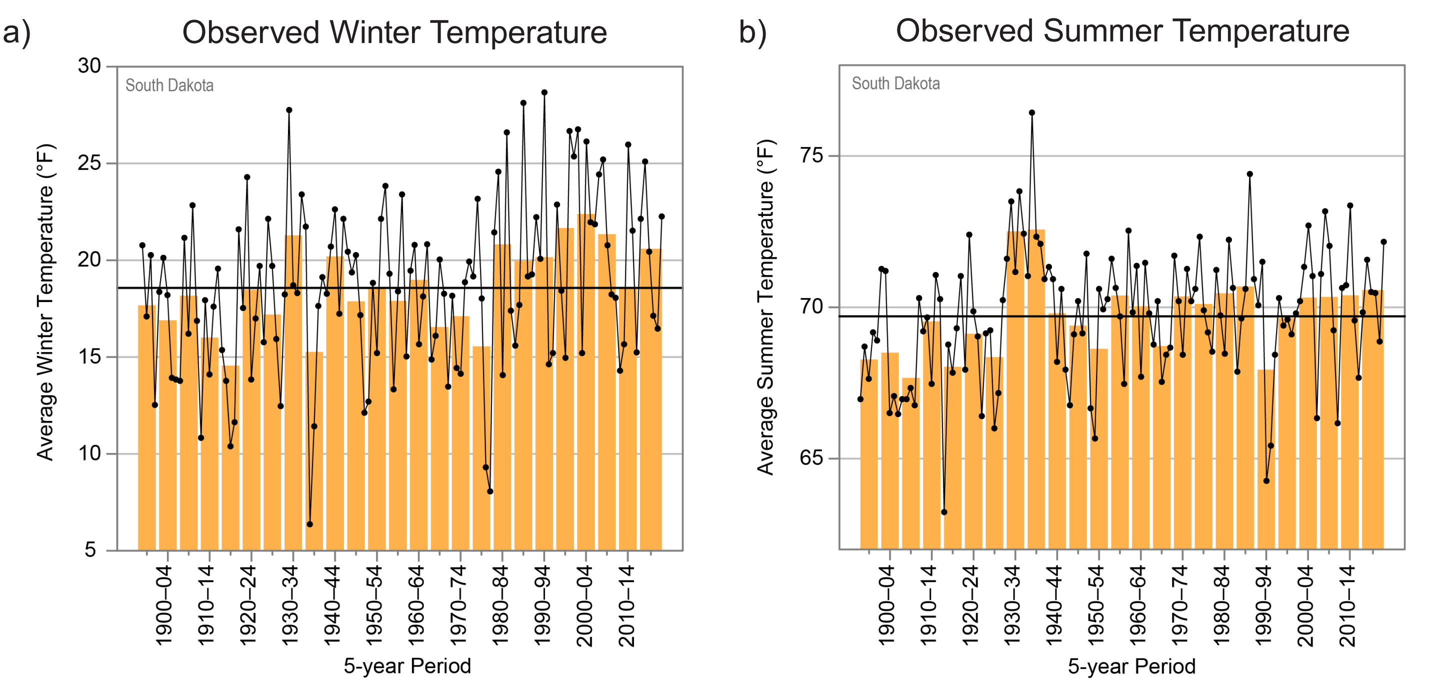

Figure 2. Observed (a) winter (December–February) and (b) summer (June–August) average temperature for South Dakota from (a) 1895–96 to 2019–20 and (b) 1895 to 2020. Dots show annual values. Bars show averages over 5-year periods (first bar in Figure 2a is a 4-winter average, last bar in Figures 2a and 2b is a 6-winter and 6-summer average, respectively). The horizontal black lines show the long-term (entire period) averages: (a) 18.6°F and (b) 69.7°F. The multiyear periods between 1995 and 2009 had the highest winter temperatures on record. Since 2000, summer temperatures have been above average, although they have remained well below the extreme heat of the 1930s Dust Bowl era. Sources: CISESS and NOAA NCEI. Data: nClimDiv.

Figure 3. Observed (a) annual number of extremely hot days (maximum temperature of 100°F or higher), (b) annual number of warm nights (minimum temperature of 70°F or higher), (c) total annual precipitation, and (d) total summer (June–August) precipitation for South Dakota from (a, b) 1900 to 2020 and (c, d) 1895 to 2020. Dots show annual values. Bars show averages over 5-year periods (last bar is a 6-year average). The horizontal black lines show the long-term (entire period) averages: (a) 4.1 days, (b) 5.5 nights, (c) 19.3 inches, (d) 8.1 inches. Since 1990, the number of extremely hot days has been near or below average, while the number of warm nights shows no overall trend. Total annual and summer precipitation varies widely but has been trending upward since 2000. Sources: CISESS and NOAA NCEI. Data: (a, b) GHCN-Daily from 25 long-term stations, (c, d) nClimDiv.

Snowfall is highly variable from year to year. For example, 20th-century annual snowfall totals at Menno varied from around 10 inches (in 1986–87 and 1999–2000) to almost 70 inches (1959–60 and 1983–84), and totals in this century have varied from less than 20 inches (2004–05 and 2011–12) to about 65 inches (2017–18; Figure 5). The year-to-year variations at this station are typical across South Dakota.

South Dakota's northern location and proximity to the typical U.S. winter storm track make it highly susceptible to heavy snows, high winds, and low wind chill temperatures. In any given year, the probability of a blizzard occurring somewhere in the state is greater than 50%. During October 3–5, 2013, western South Dakota was hit by a devastating early-season blizzard, with reported wind gusts as high as 70 mph and widespread snowfall amounts of more than 20 inches. Among long-term weather observation stations, Lead reported one of the highest snowfall amounts of 55 inches over the 3-day period, 42 of which fell on October 4. Rapid City reported 23.1 inches, the city's second-highest 3-day snowfall total on record. Tens of thousands of livestock died from the event in South Dakota alone, with some herds losing more than 90% of their total populations.

With several large rivers running through the state, including the Missouri River, flooding is a great hazard. The frequency of extreme precipitation events has increased. Since 1990, South Dakota has averaged 22% more 2-inch rain events compared to the long-term average (Figure 6). Some historic rain and flooding events have occurred in recent years. The daily rainfall record (at official reporting sites) was set at Groton on May 6, 2007, with 8.74 inches. In June 2011, runoff from a record winter snowpack in the Rocky Mountains, along with heavy May rains in Montana, caused major flooding along the entire length of the Missouri River. Several towns (including Pierre) had to be evacuated and required rapid flood control measures. The extreme volume of water caused long-duration flooding; below the Oahe Dam, the Missouri River at Pierre was above flood stage from May 24 to September 7. South Dakota experienced extreme flooding in 2019 due to a combination of wet antecedent conditions, numerous winter storms, and unrelenting precipitation throughout the spring, late summer, and early autumn. Many flood records were set, particularly along the Missouri and James Rivers. The James River at Columbia was above flood stage for 518 days, which was unprecedented for the Missouri River basin. The 2019 growing season was greatly impacted. Planting delays were widespread, and South Dakota led the Nation in unplanted acres (3.9 million). The persistent wetness and below average summer maximum temperatures slowed the progress of crops, as well as the fall harvest. As of June 2020, U.S. Department of Agriculture crop indemnities exceeded $10 million for most counties in the eastern half of the state. One of the most devastating flash flooding events occurred during June 9–10, 1972, when torrential rainfall (unofficially, as much as 15 inches) fell overnight in the Black Hills area, causing the Canyon Lake Dam to fail. The resulting flooding in Rapid City killed more than 200 people, injured more than 3,000, destroyed 1,300 structures, and resulted in damages of more than $1 billion.

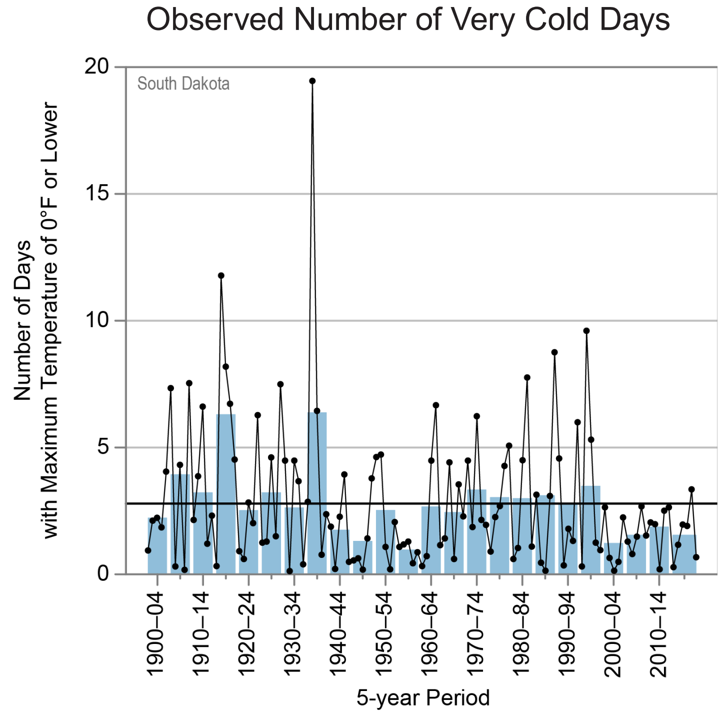

Figure 4. Observed annual number of very cold days (maximum temperature of 0°F or lower) for South Dakota from 1900 to 2020. Dots show annual values. Bars show averages over 5-year periods (last bar is a 6-year average). The horizontal black line shows the long-term (entire period) average of 2.8 days. The number of very cold days has been below average since 2000, indicative of overall winter warming in the region. Sources: CISESS and NOAA NCEI. Data: GHCN-Daily from 25 long-term stations.

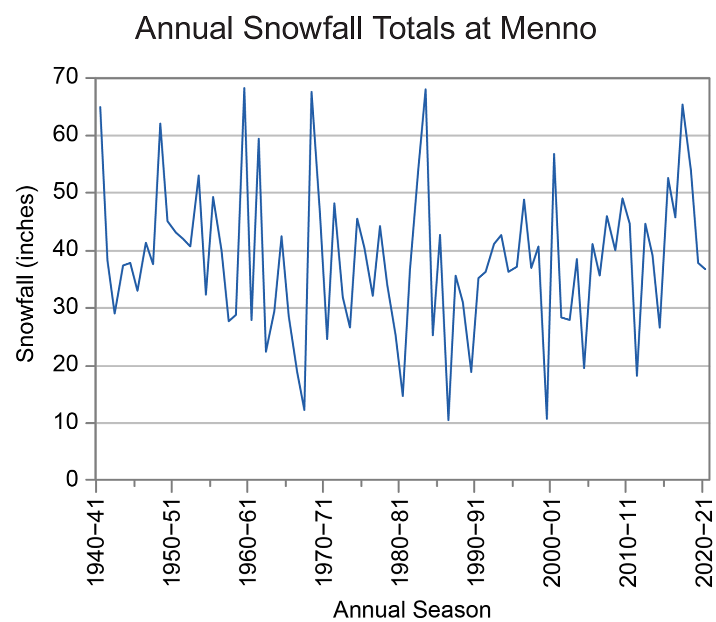

Figure 5. Annual snowfall totals at Menno, South Dakota, from 1940–41 to 2020–21. Snowfall totals at Menno, in the eastern part of the state, vary widely from year to year. Since 2000, snowfall has ranged from less than 20 inches to around 65 inches. Source: MRCC.

Under a higher emissions pathway, historically unprecedented warming is projected during this century (Figure 1). Even under a lower emissions pathway, annual average temperatures are projected to most likely exceed historical record levels by the middle of the century. However, a large range of temperature increases is projected under both pathways, and under the lower pathway, a few projections are only slightly warmer than historical records. Increases in heat wave intensity are projected, but the intensity of cold waves is projected to decrease.

Annual precipitation is projected to increase, with the largest increases occurring during spring and winter (Figure 7). Increased winter and spring precipitation can impact South Dakota's agricultural economy both positively (increased soil moisture) and negatively (loss of soil nutrients, planting delays, and yield losses). **Increases in the frequency and intensity of extreme precipitation events are also projected**, potentially leading to increased runoff and flooding, which can reduce water quality and erode soils. Increased winter snowfall, rapid spring warming, and intense rainfall can combine to produce devastating floods.

The intensity of droughts is projected to increase. Droughts are a natural part of the climate system, and because the projected precipitation increases are expected to occur during the cooler months, South Dakota will remain vulnerable to periodic drought. Increases in evaporation rates due to rising temperatures may increase the rate of soil moisture loss and the intensity of naturally occurring droughts.

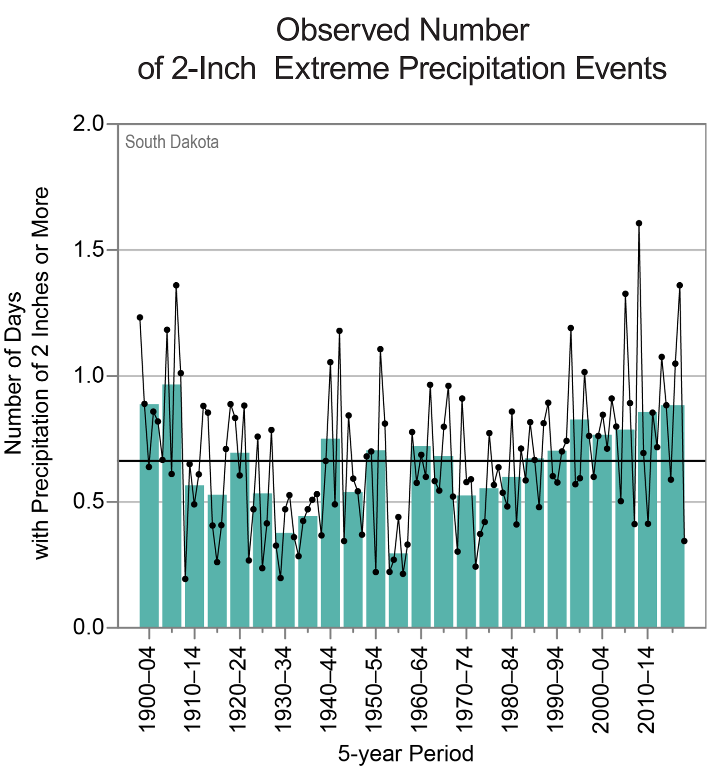

Figure 6. Observed annual number of 2-inch extreme precipitation events (days with precipitation of 2 inches or more) for South Dakota from 1900 to 2020. Dots show annual values. Bars show averages over 5-year periods (last bar is a 6-year average). The horizontal black line shows the long-term (entire period) average of 0.7 days. A typical reporting station experiences an event about once every 1 to 2 years. Since 1970, the number of 2-inch extreme precipitation events has been trending upward. Sources: CISESS and NOAA NCEI. Data: GHCN-Daily from 30 long-term stations.

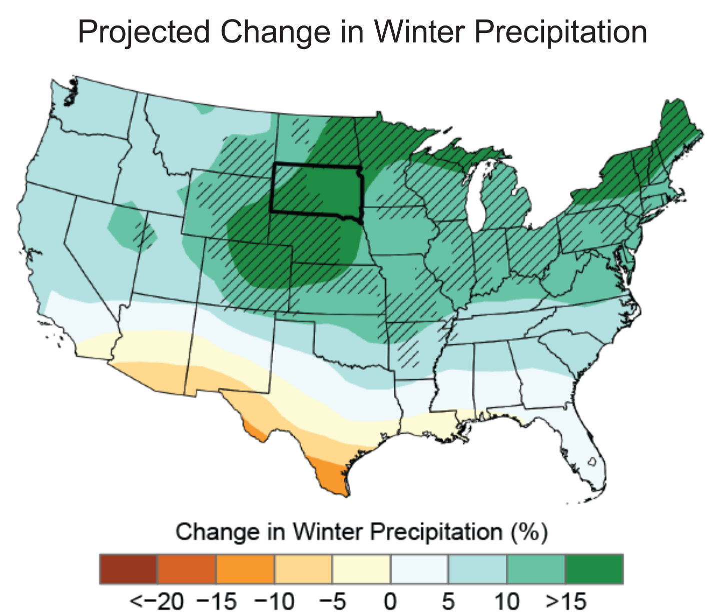

Figure 7. Projected changes in total winter (December–February) precipitation (%) for the middle of the 21st century compared to the late 20th century under a higher emissions pathway. Hatching represents areas where the majority of climate models indicate a statistically significant change. Sources: CISESS and NEMAC. Data: CMIP5.

Technical details on observations and projections are available online at https://statesummaries.ncics.org/technicaldetails.