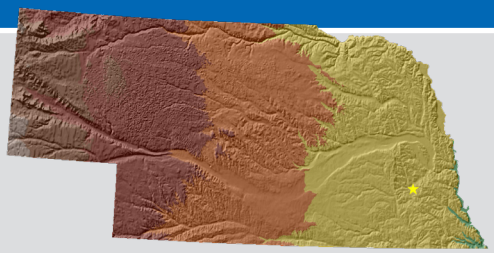
NEBRASKA



Key Messages

Temperatures in Nebraska have risen more than 1.6°F since the beginning of the 20th century, with warming concentrated in the winter and spring. Winter warming is evident in the below average occurrence of very cold nights since 1990. Under a higher emissions pathway, historically unprecedented warming is projected during this century.

Nebraska is a region of transition between the humid conditions to the east of the state and the semiarid conditions to the west, and as a result, precipitation in the state varies greatly from year to year. Projected increases in winter precipitation may have both positive and negative impacts on the state.

Droughts pose a particular risk to Nebraska's agricultural economy, although the impacts can be mitigated where irrigation is possible. Several droughts have occurred in recent years. Projected increases in temperature and evaporation rates may increase the intensity of future naturally occurring droughts.

Nebraska lies in the central Great Plains, straddling the transition from relatively abundant precipitation (averaging more than 34 inches annually; 1991–2020 normals) in the far southeast to semiarid conditions (averaging just over 17 inches) in the panhandle. The state is located far from the moderating effects of the oceans, and temperatures vary widely across seasons, averaging 25.1°F in January and 74.4°F in July. The hottest year on record was 2012, with an average temperature of 52.7°F, which was 4.1°F higher than the long-term (1895–2020) average.

Since the beginning of the 20th century, temperatures in Nebraska have risen more than 1.6°F (Figure 1). Since 2000, annual average temperatures have been higher than the long-term average and generally comparable to the 1930s Dust Bowl era. The warmest summers on record occurred in the 1930s, when drought and poor land management likely exacerbated the hot summer conditions (Figure 2b). Recent warming has been concentrated in the winter and spring, while summers have not warmed substantially, a characteristic of much of the Great Plains and Midwest. This lack of summer warming is reflected in a below average occurrence of extremely hot days (Figure 3a) and no overall trend in the number of warm nights (Figure 3b) since the 1960s. The winter warming trend is reflected in a below average number of very cold nights since 1990 (Figure 4). Winter temperatures peaked around 2000. The warmest consecutive 5-winter interval was 1998–2002. Winter temperatures have been slightly lower since then but have remained above the long-term (1895–2020) average.

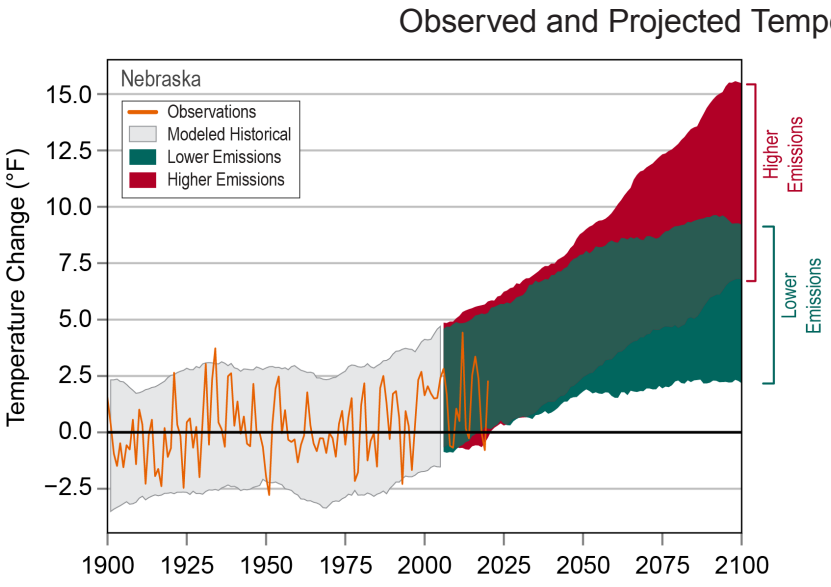


Figure 1: Observed and projected changes (compared to the 1901–1960 average) in near-surface air temperature for Nebraska. Observed data are for 1900–2020. Projected changes for 2006–2100 are from global climate models for two possible futures: one in which greenhouse gas emissions continue to increase (higher emissions) and another in which greenhouse gas emissions increase at a slower rate (lower emissions). Temperatures in Nebraska (orange line) have risen more than 1.6°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 this 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.

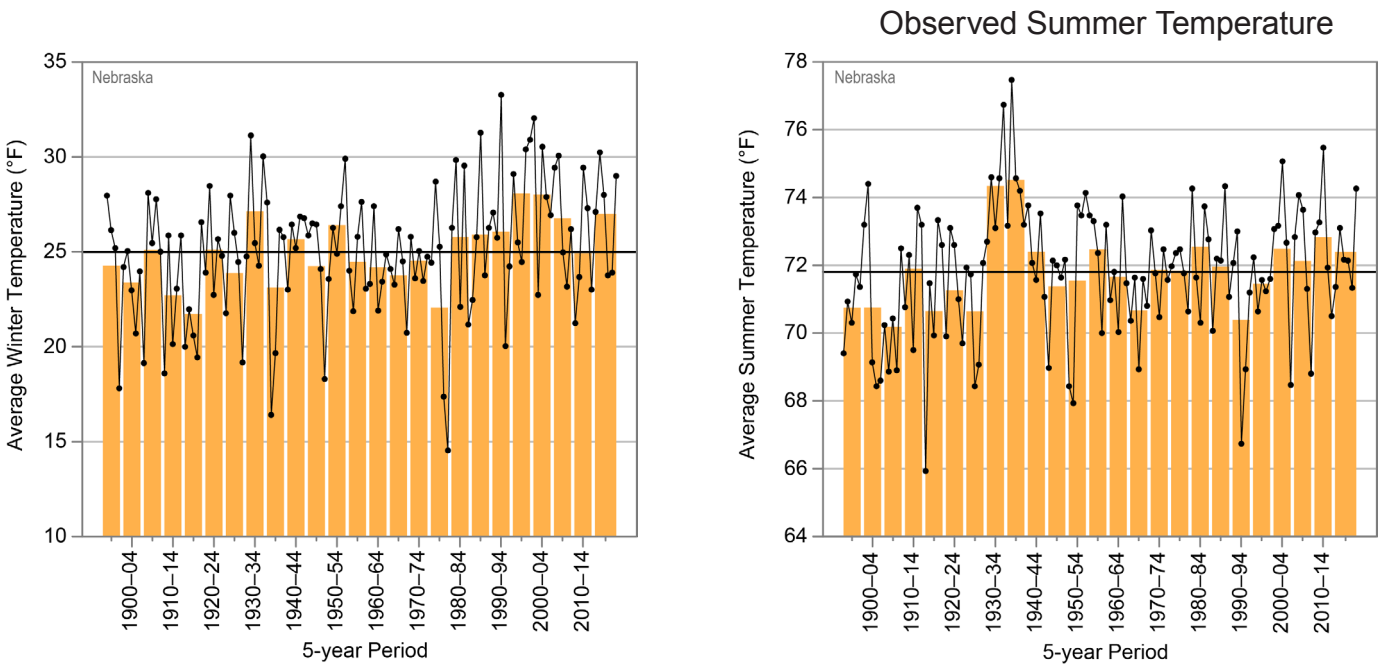


Figure 2: Observed (a) winter (December–February) average temperature and (b) summer (June–August) average temperature for Nebraska from (a) 1895–96 to 2019–20 and (b) 1895 to 2020. Dots show annual values. Bars show averages over 5-year periods (first bar in Figure 2a is a 4-winter average, last bar in Figures 2a and 2b is a 6-winter and a 6-summer average, respectively). The horizontal black lines show the long-term (entire period) averages: (a) 25.0°F and (b) 71.8°F. From 1995 to 2004, Nebraska experienced the warmest winter temperatures on record. Since 2000, summer temperatures have been above average, although they have remained below the extreme heat of the 1930s Dust Bowl era. Sources: CISESS and NOAA NCEI. Data: GHCN-Daily from 38 long-term stations.

Precipitation is highly variable from year to year, with the statewide annual average ranging from a low of 13.4 inches in 2012 to a high of 35.5 inches in 1915. The driest multiyear period was 1935–1939, and the wettest was 2015–2020 (Figure 3c). The driest consecutive 5-year interval was 1936–1940, and the wettest was 2015–2019. The majority of precipitation falls during the spring and summer months (Figure 3d), but seasonal precipitation varies widely.

Because agriculture is a vital sector of Nebraska's economy, the state is particularly vulnerable to both high and low amounts of precipitation. The frequency of extreme precipitation events has increased in recent years, with the state experiencing an above average number of 2-inch precipitation events since 2005 (Figure 5). Nebraska also experiences periodic intense droughts, which can sometimes last for several years. One of the worst in the state's history was the 1930s drought of the Dust Bowl era, when the impacts of the dry conditions were exacerbated by extreme heat. Nebraska's hottest summers on record occurred in 1934 and 1936; they were also among the top 4 driest summers (1934 is fourth and 1936 is second). Conditions in July 1936 were particularly extreme, with Omaha experiencing 16 days with temperatures above 100°F and 1 day with temperatures exceeding 110°F. This combination of heat and dryness, exacerbated by poor land management practices and the close temporal proximity of these two extreme summers, is unique in the record and contributed to the severe impacts of the Dust Bowl era. However, Nebraska's driest year on record was 2012, when statewide precipitation averaged only 3.7 inches during the summer months, well below the historical average of 9.4 inches. By the end of September, more than 75% of the state was experiencing exceptional drought conditions, the U.S. Drought Monitor's highest category of drought severity. The drought, combined with the extreme summer heat, had significant negative impacts on nonirrigated crop yields and pasture conditions, and the state did not see substantial relief from drought conditions for months.

Thousands of miles of rivers flow through Nebraska, and the state is bordered by the Missouri River to the east. Many cities and farmlands located along these waterways are at risk for flooding from extreme precipitation events and snowmelt. In the summer of 1993, heavy rains throughout the central United States caused record flooding along the Missouri (and Mississippi) River. This was Nebraska's wettest summer, with statewide average precipitation totaling

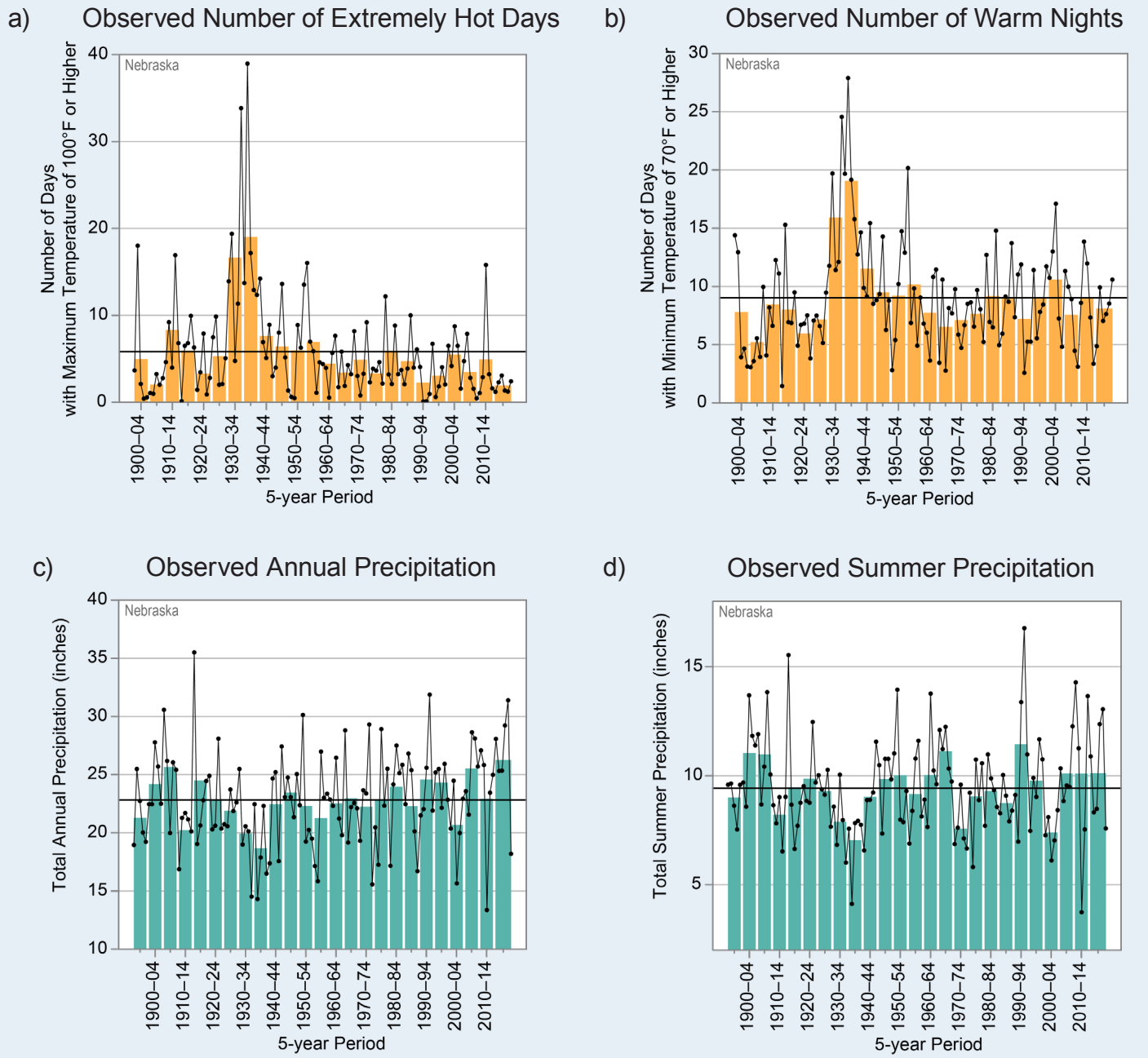


Figure 3: Observed (a) annual number of extremely hot days (maximum temperature of 100°F or higher), (b) annual number of warm nights (minimum temperature of 70°F or higher), (c) total annual precipitation, and (d) total summer (June–August) precipitation for Nebraska from (a, b) 1900 to 1920 and (c, 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) 5.8 days, (b) 9.0 nights, (c) 22.8 inches, (d) 9.4 inches. The state has consistently experienced a near or below average number of extremely hot days since 1960. Annual and seasonal precipitation varies widely. Since 2005, precipitation during the summer months has been above average. Sources: CISESS and NOAA NCEI. Data: (a, b) GHCN-Daily from 38 long-term stations; (c, d) nClimDiv.

16.8 inches, more than 7 inches above the long-term summer average. The flooding caused millions of dollars in damages to crops and infrastructure. In June 2011, runoff from the record winter snowpack in the Rocky Mountains combined with heavy rains, particularly in the upper Missouri River basin, to cause major flooding along the entire length of the Missouri River. In Omaha, the river crested at 36.29 feet on July 2, 2011, the second highest crest on record. Historic flooding also occurred in March 2019, triggered by a "bomb cyclone" event. The stage was set for major flooding to occur, due to a combination of wet antecedent conditions, numerous winter storms, and bitter February cold that caused thick river ice to form. Warm temperatures accompanying the bomb cyclone caused rapid melting of snow and river ice (and subsequent ice jams), and

with soils already saturated from the previous autumn season, rivers were overwhelmed. Multiple dams and levees were breached as record crests occurred on the Big Blue, Elkhorn, Loup, Missouri, and Platte Rivers. Many towns were flooded, state highways and bridges were damaged or washed out, agricultural fields were inundated, and both humans and livestock perished. The entire event, which impacted several surrounding states, cost an estimated $11 billion and was one of the costliest U.S. inland flooding events on record. The year 2019 became Nebraska's third-wettest year on record.

Nebraska experiences damaging storms during all seasons. During the winter months, snowstorms and ice storms are a frequent hazard. Western Nebraska, along with the Dakotas, has the highest probability of blizzards in the Nation, with a greater than 50% probability of a blizzard occurring in any given year. Convective storms are common in the warmer months, including flash flood–producing rainstorms and severe thunderstorms capable of producing hail, damaging winds, and tornadoes. The southwestern part of the Nebraska Panhandle lies in Hail Alley, the most hail-prone area in the entire country, and averages 7–9 hail days each year. A hailstone that fell in Aurora on June 22, 2003, holds the record for the largest hailstone by circumference (18.75 inches). Nebraska averages 57 tornadoes annually—the fifth-highest number of any state—and these tornadoes can be violent. On May 6, 1975, an F4 tornado struck Omaha, killing 3 people and causing more than $1 billion in damages. On June 16, 2014, a supercell thunderstorm produced four EF4 tornadoes (including a set of rare "twin tornadoes") in the northeastern part of the state, killing 2 and destroying large portions of the town of Pilger.

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 this 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.

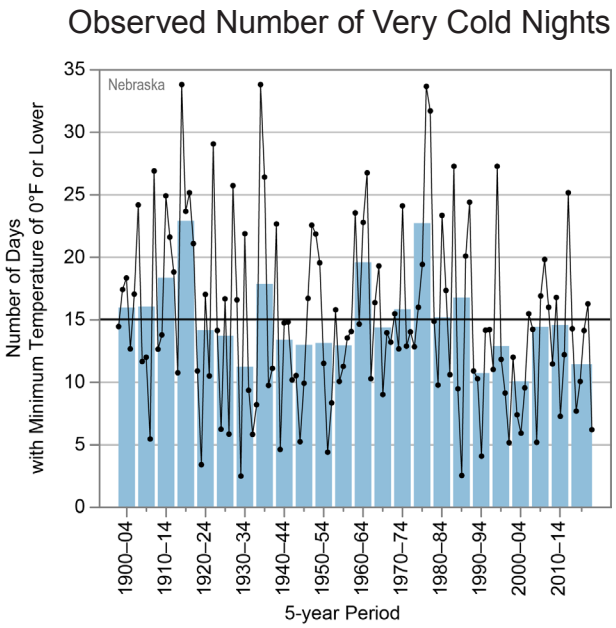


Figure 4: Observed annual number of very cold nights (minimum temperature of 0°F or lower) for Nebraska from 1900 to 2020. Dots show annual values. Bars show averages over 5-year periods (last bar is a 6-year average). The horizontal black line shows the long-term (entire period) average of 15 nights. The number of very cold nights was highest in the late 1910s but has been below average since 1990, indicative of overall winter warming. Sources: CISESS and NOAA NCEI. Data: GHCN-Daily from 38 long-term stations.

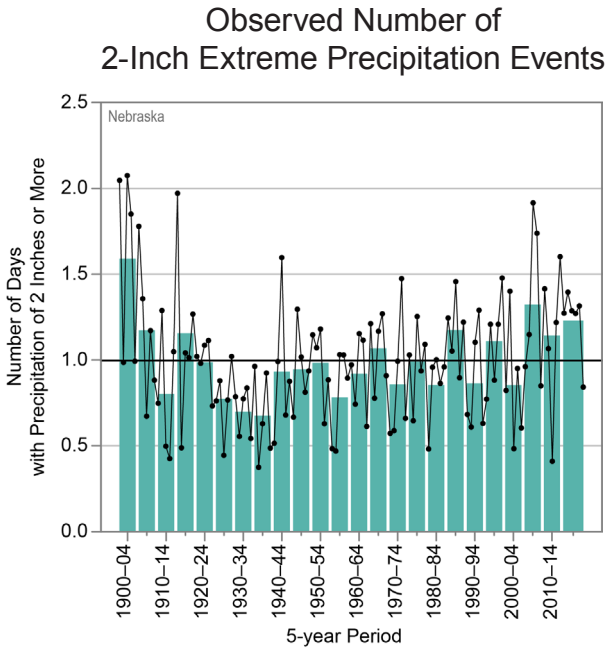


Figure 5: Observed number of 2-inch extreme precipitation events (days with precipitation of 2 inches or more) for Nebraska from 1900 to 2020. Dots show annual values. Bars show averages over 5-year periods (last bar is a 6-year average). The horizontal black line shows the long-term (entire period) average of 1.0 days. A typical reporting station experiences 1 event per year. In the historical record, the highest number of extreme precipitation events occurred during the 1900–1904 period, with an average of 1.6 events per year, followed by the 2005–2009 period, with an average of 1.3 events per year. Sources: CISESS and NOAA NCEI. Data: GHCN-Daily from 54 long-term stations.

Although projections of overall annual precipitation are uncertain, winter and spring precipitation are projected to increase across the state (Figure 6). Heavier winter precipitation could have both positive and negative effects on Nebraska's important agricultural economy, improving soil moisture for winter wheat but potentially delaying planting for summer crops. **Extreme precipitation events are also projected to increase**, leading to increased runoff and flooding, which can reduce water quality and erode soils.

The intensity of droughts is projected to increase. Although projections of overall precipitation are uncertain, and droughts are a natural part of the climate system, higher temperatures will increase evaporation rates and decrease soil moisture, leading to more intense future droughts. This would have negative impacts on dryland farming, although the impacts could be mitigated where irrigation is possible.

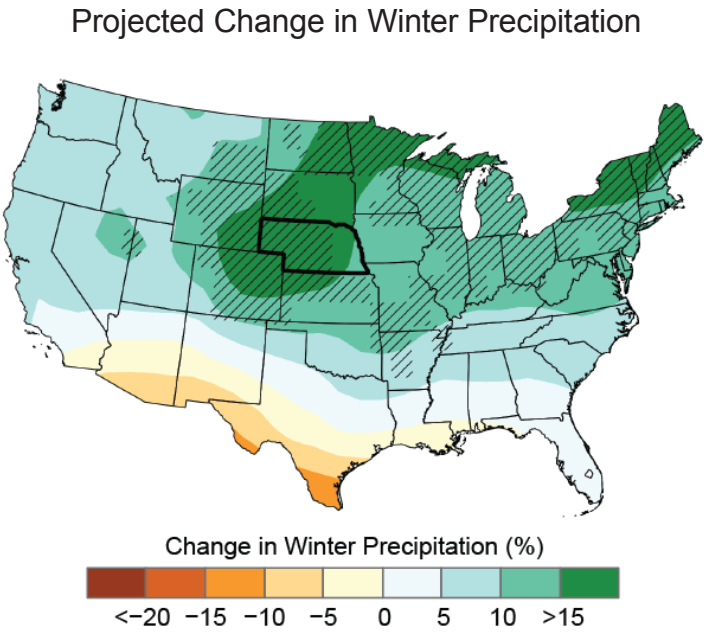


Figure 6: Projected changes in total winter (December–February) precipitation (%) for the middle of the 21st century compared to the late 20th century under a higher emissions pathway. Hatching represents areas where the majority of climate models indicate a statistically significant change. Nebraska is part of a large area across the northern and central United States with projected increases in winter precipitation. Sources: CISESS and NEMAC. Data: CMIP5.

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