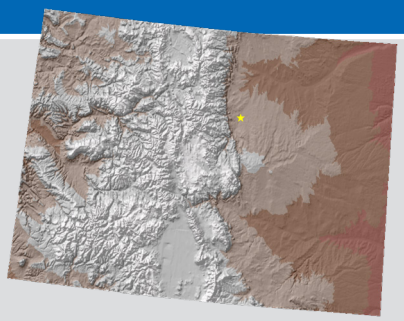


COLORADO

Key Messages

Temperatures in Colorado have risen about 2.5°F since the beginning of the 20th century. Warming has occurred in all 4 seasons, and it has been characterized by an above average occurrence of very hot days since 2000. Under a higher emissions pathway, historically unprecedented warming is projected during this century.

Colorado's mountains are the headwaters of 4 major rivers that supply water to 18 other states downstream. While future changes in annual precipitation are uncertain, warming temperatures are projected to exacerbate the recent trend of reduced overall water availability and earlier snowmelt and runoff.

Severe droughts have occurred in recent years. Projected warming will increase the rate of soil moisture loss during dry spells, increasing the intensity of future naturally occurring droughts. As a result, the frequency and severity of wildfires are projected to increase in Colorado.

Due to its inland continental location and wide range of topography, Colorado's climate is varied. Major geographic features include the High Plains in the east, the high mesas and canyons in the far west, and the Rocky Mountains in the central part of the state. Due to Colorado's semiarid climate and changes in elevation across the state, temperatures vary widely from day to night and over short distances. Colorado has 58 mountain peaks higher than 14,000 feet, and it has the highest average elevation of any U.S. state, at 6,800 feet.

Temperatures in Colorado have risen about 2.5°F since the beginning of the 20th century (Figure 1) **and have remained consistently higher than the long-term (1895–2020) average since 1998.** Since 2000, the state has experienced the highest summer and spring average temperatures in the historical record (Figures 2a and 2b). The hottest year on record was 2012, with an average temperature of 48.3°F, which was 3.4°F above the long-term average. Six of the 8 warmest years on record for Colorado have occurred since 2012. In addition to the overall trend of higher average temperatures, the number of very hot days has been above average since 2000 (Figure 3), and the number of very cold nights has been near or below average since 1990 (Figure 4). Colorado rarely experiences warm nights due to its high elevation and generally dry climate. The greatest number of warm nights occurred in the 1930s, and in recent years, Colorado, along with other parts of the United States, has had an above average number of such nights (Figure 5a). A new state record for maximum temperature (115.0°F) was set at John Martin Dam on July 20, 2019.

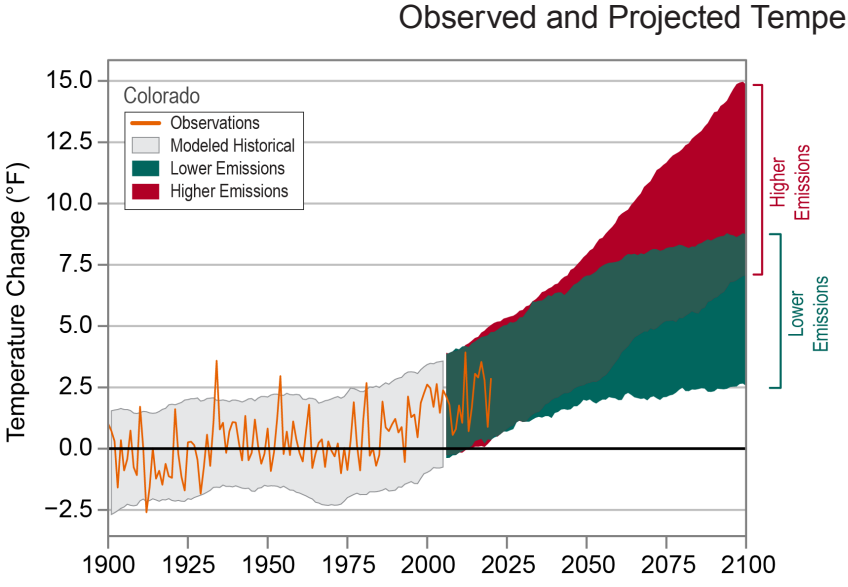


Figure 1: Observed and projected changes (compared to the 1901–1960 average) in near-surface air temperature for Colorado. Observed data are for 1900–2020. Projected changes for 2006–2100 are from global climate models for two possible futures: one in which greenhouse gas emissions continue to increase (higher emissions) and another in which greenhouse gas emissions increase at a slower rate (lower emissions). Temperatures in Colorado (orange line) have risen about 2.5°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.

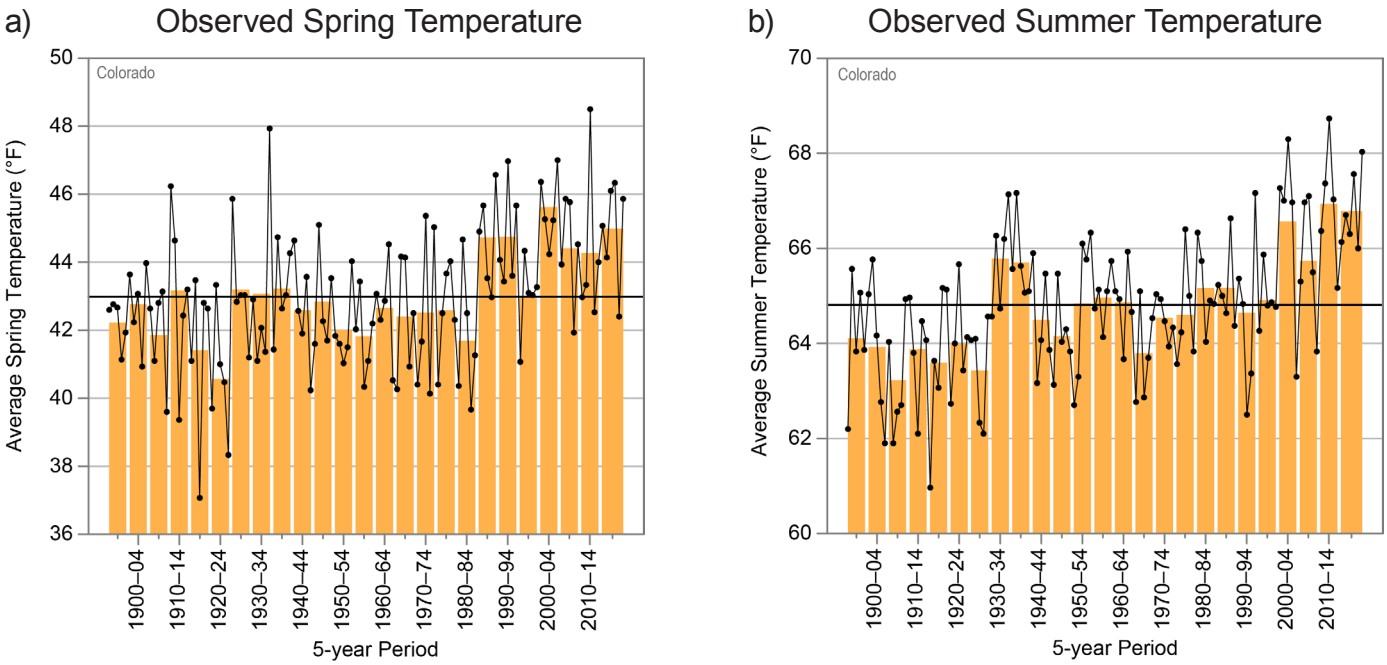


Figure 2: Observed (a) spring (March–May) average temperature and (b) summer (June–August) average temperature for Colorado from 1895 to 2020. Dots show annual values. Bars show averages over 5-year periods (last bar is a 6-year average). The horizontal black lines show the long-term (entire period) averages of (a) 43.0°F and (b) 64.8°F. Since 1985, Colorado has experienced some of its highest springtime average temperatures, and since 2000, summer average temperatures have been even higher than the extreme heat of the 1930s Dust Bowl era. Sources: CISESS and NOAA NCEI. Data: nClimDiv.

Statewide total annual precipitation is 18.0 inches on average but has ranged from a low of 11.9 inches in 2002 to a high of 25.5 inches in 1941. The driest multiyear periods were in the 1930s and 1950s, and the wettest were in the 1940s, 1980s, and 1990s (Figure 5b). The driest consecutive 5-year interval was 1952–1956, and the wettest was 1995–1999. Local annual precipitation varies widely, from about 7 inches in the middle of the San Luis Valley to more than 60 inches in a few mountain locations. Seasonal patterns also vary: in the eastern plains and valleys, most precipitation falls during spring and summer, but the mountain peaks receive the most precipitation during the winter months. Statewide, seasonal average precipitation has been variable. With the exception of the 2015–2020 period, Colorado has experienced mostly above average fall precipitation since 1980 (Figure 5d) and below average spring precipitation since 2000 (Figure 5c). Snowfall totals also vary across the state, with the high mountains receiving 150 inches to more than 400 inches per year. **Occasional blizzards can have significant impacts.** In March 2019, a "bomb cyclone" produced widespread blizzard conditions and record-high wind gusts and caused avalanches and major travel disruptions. This storm also set a state record for lowest atmospheric sea level pressure (970.4 hPa) on March 13 in Lamar.

Since Colorado is a headwaters state, changes in precipitation can impact a much larger area than just the state itself. Four major U.S. rivers have their source in Colorado: the Colorado, the Rio Grande, the Arkansas, and the Platte. Yearly variations in snowpack depths have implications for water availability across the West and the Plains, as snowmelt from the winter snowpack feeds many rivers and streams. For example, low snowpack levels in 2012 resulted in low spring runoff across the southern Rockies. However, in years with heavy snow cover, a combination of snowmelt and widespread spring rains has the potential to cause spring flooding. Overall, there have been declines in snowpack throughout the western United States. In Colorado, there have been slight declines in northern Colorado and larger declines in southern Colorado (Figure 6), where the average April 1 snow water equivalent has been 9.7 inches since 2000 (compared to 12.3 inches for 1937–1999).

Thunderstorms are common in the eastern plains and eastern mountain slopes, with the more intense storms bringing damaging hail and occasional flash floods. The mountains are effective thunderstorm generators, especially during the summer months, when humidity is highest. Northeastern Colorado lies in Hail Alley, the most hail-prone area in the entire

country, with an average of 7 to 9 hail days per year. One of the most damaging hailstorms occurred on May 8, 2017, in Denver and surrounding communities. Hail size exceeded 2 inches in some places, damaging homes, businesses, and more than 100,000 vehicles. This was the costliest hailstorm in Colorado history, with insured losses exceeding $2 billion. On August 13, 2019, a hailstone that fell 8 miles northwest of Bethune set state records for hail weight (8.5 ounces), circumference (12.875 inches), diameter (4.83 inches), and volume (16.55 cubic inches). Locally, intense thunderstorms can also cause flash flooding, particularly in the lower foothills east of the mountains. **Unlike many areas of the United States, Colorado and other southwestern states have not experienced an upward trend in the frequency of heavy precipitation events** (Figure 5e). However, these events can be devastating when they do occur. During September 10–16, 2013, heavy rainfall from a nearly stationary weather system caused extensive river flooding across the foothills and the Front Range, some of the worst in state history. More than 15 inches of rain fell in some locations, and the storm caused more than $1.5 billion in damages. A new state record for 24-hour precipitation (11.9 inches) was set on September 12 at the U.S. Geological Survey Rod and Gun station at Fort Carson.

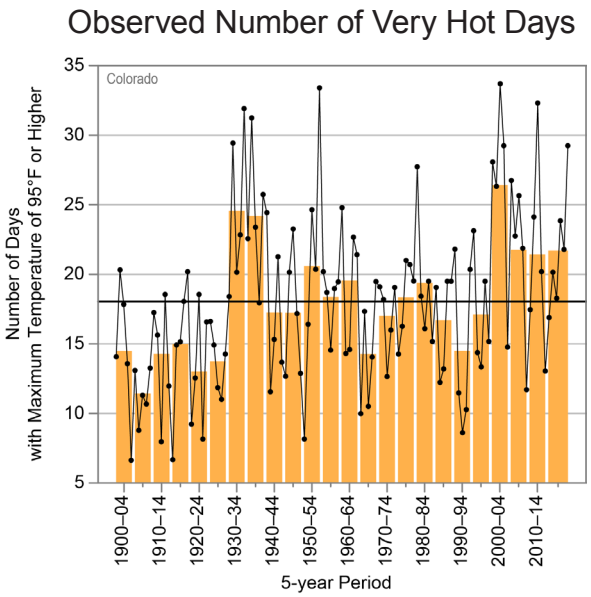


Figure 3: Observed annual number of very hot days (maximum temperature of 95°F or higher) for Colorado from 1900 to 2020. Dots show annual values. Bars show averages over 5-year periods (last bar is a 6-year average). The horizontal black line shows the long-term (entire period) average of 18 days (note that the average for individual reporting stations varies greatly because of the state's large elevation range). The number of very hot days is highly variable. Statewide, the highest number of such days occurred during the 2000–2004 period, surpassing the previous highs of the 1930s. However, the frequency of very hot days varies across the state. In southeast Colorado, the number of such days was substantially higher in the early 1930s than in the 2000s. Sources: CISESS and NOAA NCEI. Data: GHCN-Daily from 14 long-term stations.

Colorado frequently experiences droughts, which can increase the risk of wildfire. During the summer and fall of 2020, Colorado had one of its worst wildfire seasons. Warm and extremely dry conditions, combined with high winds and low relative humidities, led to the ignition and spread of numerous wildfires. Three of these grew to become the largest ever recorded in Colorado—the Cameron Peak Fire, the East Troublesome Fire, and the Pine Gulch Fire, which collectively burned more than a half million acres. Other western states had record-breaking wildfire seasons in 2020, and collectively, these fires cost more than $16 billion in damages, and the smoke created unhealthy air quality conditions for millions of people.

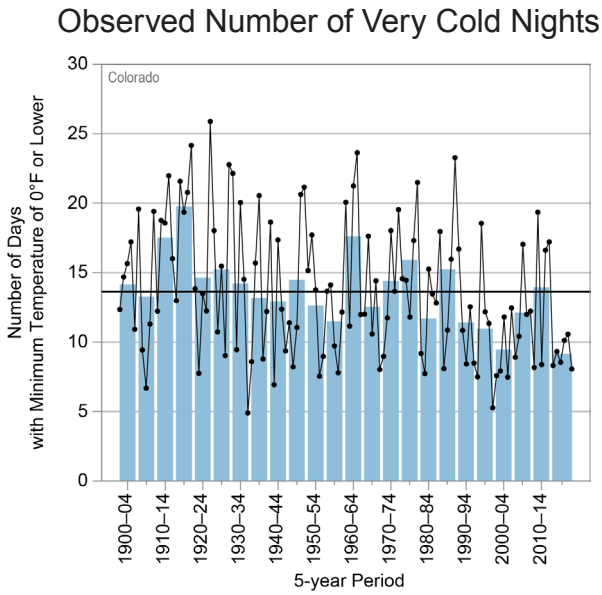
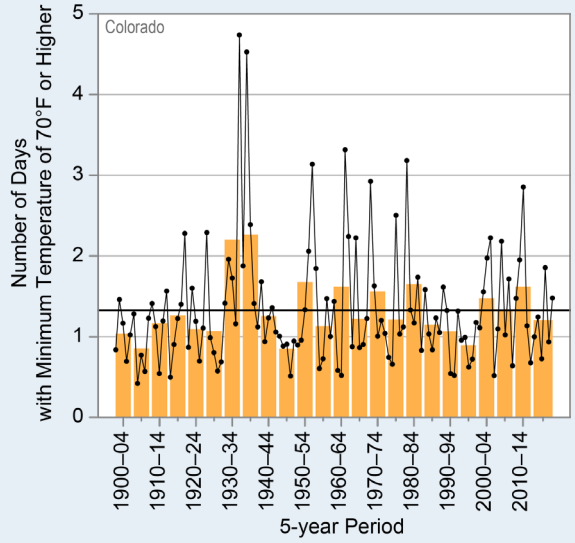


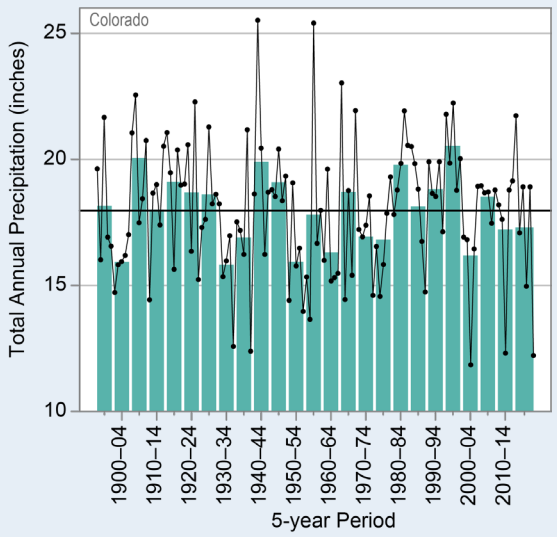
Figure 4: Observed annual number of very cold nights (minimum temperature of 0°F or lower) for Colorado from 1900–2020. Dots show annual values. Bars show averages over 5-year periods (last bar is a 6-year average). The horizontal black line shows the long-term (entire period) average of 14 nights (note that the average for individual reporting stations varies greatly because of the state's large elevation range). Since 1990, the number of very cold nights has generally been below average, indicative of warming in the region. Sources: CISESS and NOAA NCEI. Data: GHCN-Daily from 14 long-term stations.

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

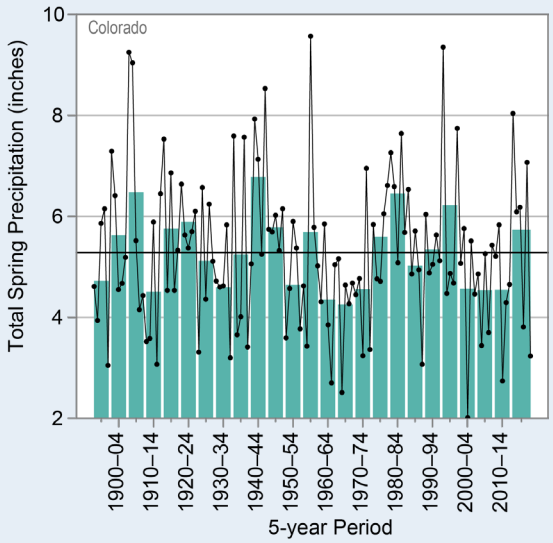
a) Observed Number of Warm Nights



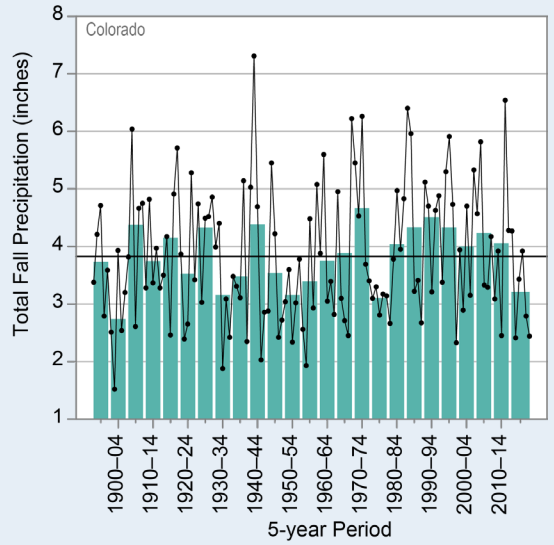
b) Observed Annual Precipitation



c) Observed Spring Precipitation



d) Observed Fall Precipitation



e) Observed Number of 1-Inch Extreme Precipitation Events

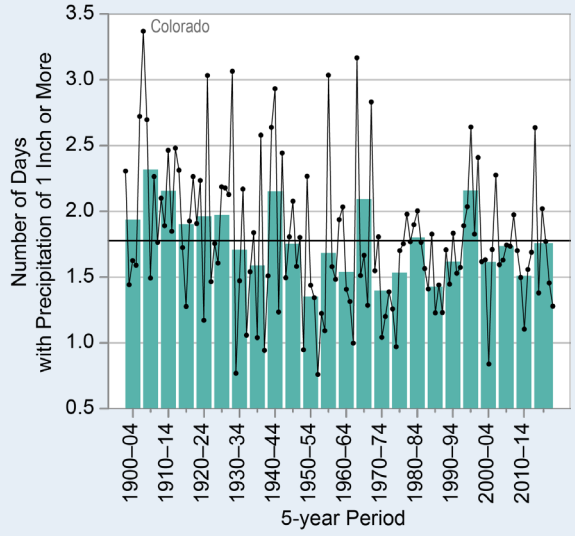


Figure 5: Observed (a) annual number of warm nights (minimum temperature of 70°F or higher), (b) total annual precipitation, (c) total spring (March–May) precipitation, (d) total fall (September–November) precipitation, and (e) annual number of 1-inch precipitation events (days with precipitation of 1 inch or more) for Colorado from (a, e) 1900 to 2020 and (b, 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) 1.3 nights, (b) 18.0 inches, (c) 5.3 inches, (d) 3.8 inches, (e) 1.8 days. (Note that for Figures 5a and 5d, the average for individual reporting stations varies greatly because of the state's large elevation range.) Colorado rarely experiences warm nights but has had an above average number in recent years. Precipitation varies widely from year to year. Since 2000, annual and spring precipitation totals have been generally below average. Fall precipitation was near to above average since the 1980s, until the 2015–2020 period. The number of 1-inch precipitation events has been near or below average since 2000; a typical reporting station experiences 1 to 2 events per year. Sources: CISESS and NOAA NCEI. Data: (a) GHCN-Daily from 14 long-term stations; (b, c, d) nClimDiv; (e) GHCN-Daily from 21 long-term stations.

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, continuing recent trends (Figure 4).

Although projections of overall annual precipitation are uncertain, precipitation is projected to increase in the winter (Figure 7) **and possibly decrease in the summer.** Although heavier winter precipitation could provide important water for the water-scarce Southwest, projected rising temperatures will raise the snow line—the average lowest elevation at which snow falls. More precipitation will likely fall as rain instead of snow, which will reduce water storage in the snowpack, particularly at those lower mountain elevations that are now on the margins of reliable snowpack accumulation. Warmer temperatures will also result in an earlier melting of the snowpack, increased evaporation rates, and decreased soil moisture, further decreasing water availability during the already-dry summer months. Increases in atmospheric water vapor (due to rising sea surface temperatures in the oceanic regions that are the moisture sources for Colorado precipitation) may increase the frequency and intensity of heavy precipitation events.

The intensity of droughts, a natural part of Colorado's climate (Figure 8)**, is projected to increase, and with so many river basins originating in the state, any changes in precipitation patterns pose a risk to water supplies for cities and farms across the region.** Colorado has almost constantly been in drought since 2001, with 3 historic droughts occurring in the past 20 years, beginning in 2002, 2012, and 2018. Three of the 5 driest years on record for Colorado have occurred since 2002. Higher temperatures will increase the rate of soil moisture loss, leading to more intense drought conditions. Increased drought intensity, along with possibly decreased summer precipitation, will increase the risk of wildfire occurrence and severity.

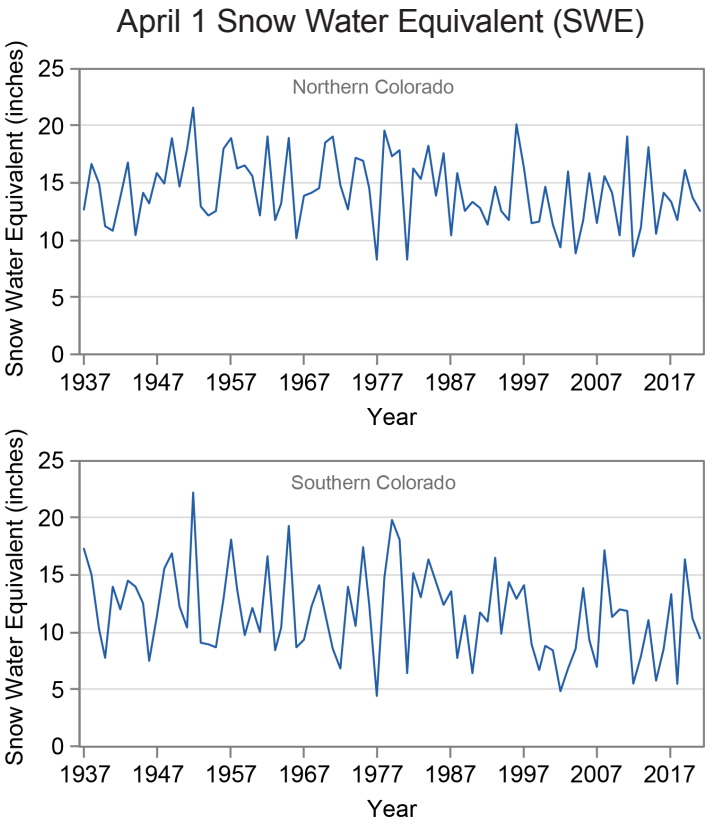


Figure 6: Variations in the annual April 1 snow water equivalent (SWE) Colorado snow course sites from 1937 to 2021 averaged over northern Colorado (top) and southern Colorado (bottom). SWE, the amount of water contained within the snowpack, varies widely from year to year. There is slight downward trend (about 0.26 inches per decade) in northern Colorado and a larger downward trend (0.42 inches per decade) in southern Colorado. The low levels seen in 2012 were exacerbated by warm and dry conditions during the month of March. Source: NRCS NWCC.

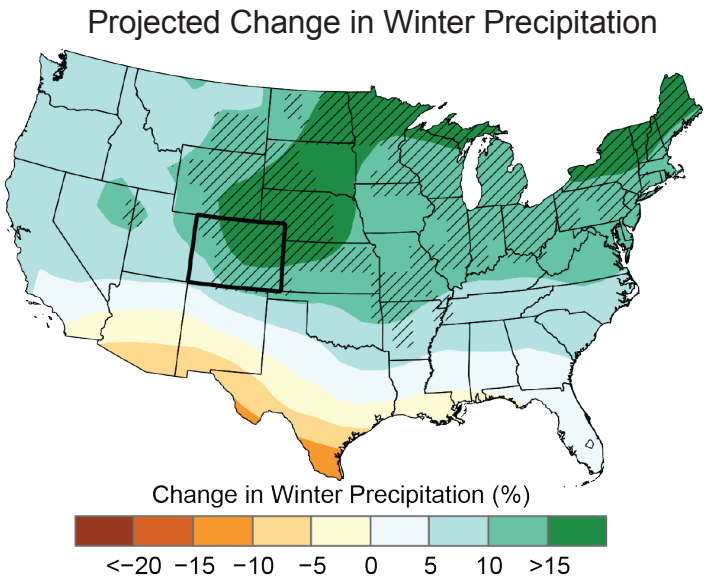


Figure 7: Projected changes in total winter (December–February) precipitation (%) for the middle of the 21st century compared to the late 20th century under a higher emissions pathway. Hatching represents areas where the majority of climate models indicate a statistically significant change. Colorado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

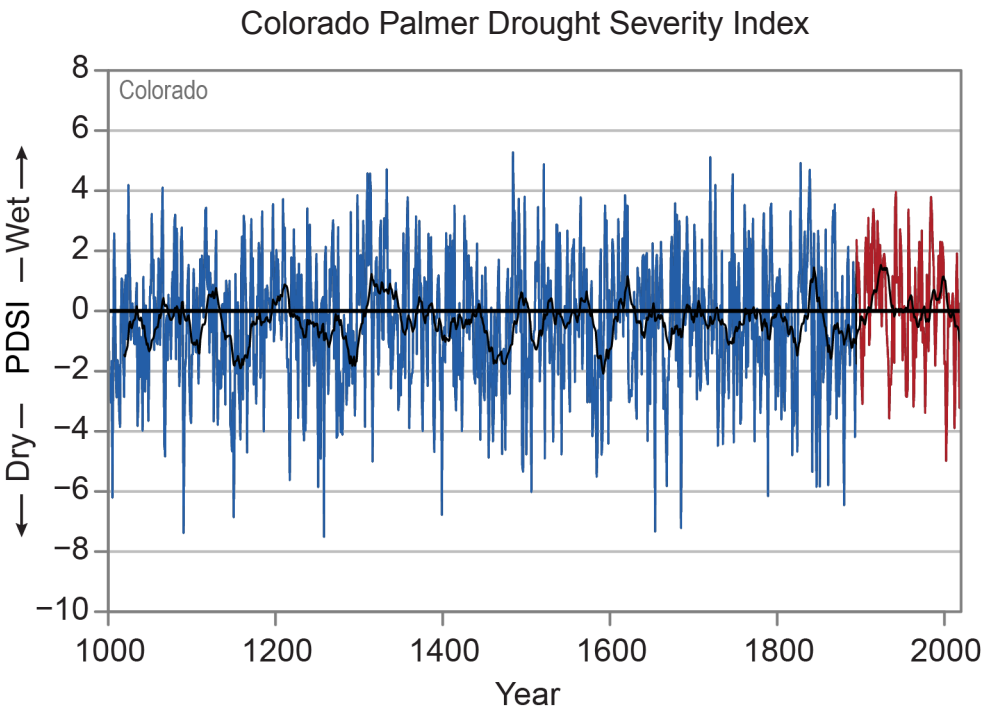


Figure 8: Time series of the Palmer Drought Severity Index for Colorado from the year 1000 to 2020. Values for 1895–2020 (red) are based on measured temperature and precipitation. Values prior to 1895 (blue) are estimated from indirect measures such as tree rings. The fluctuating black line is a running 20-year average. In the modern era, the wet periods of the early 1900s and the 1980s to 1990s and the dry period of the 1950s are evident. The extended record indicates periodic occurrences of even more extreme wet and dry periods. Sources: CISESS and NOAA NCEI. Data: nClimDiv and NADAv2.

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