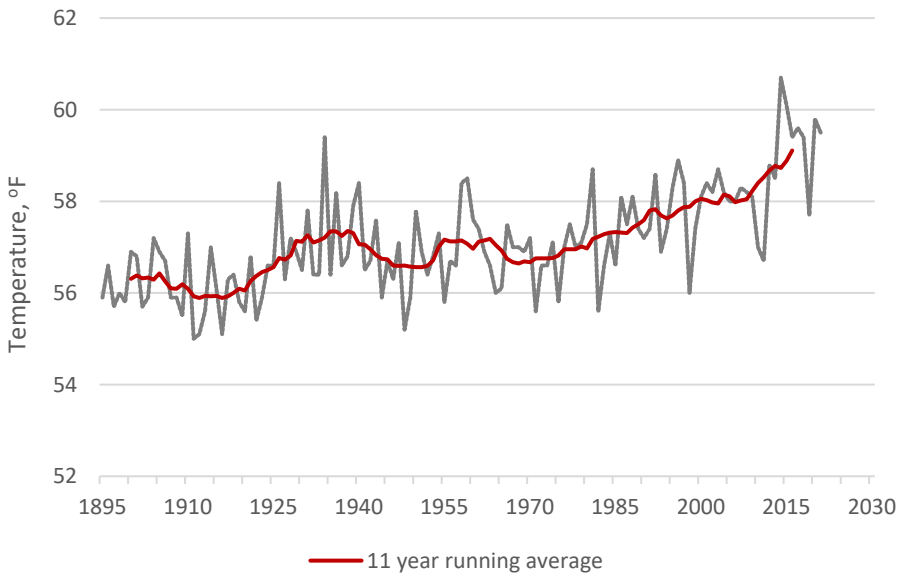
AIR TEMPERATURE

Air temperatures have increased over the past century, driven mainly by changes in nighttime temperatures.

Figure 1. Statewide annual average temperatures



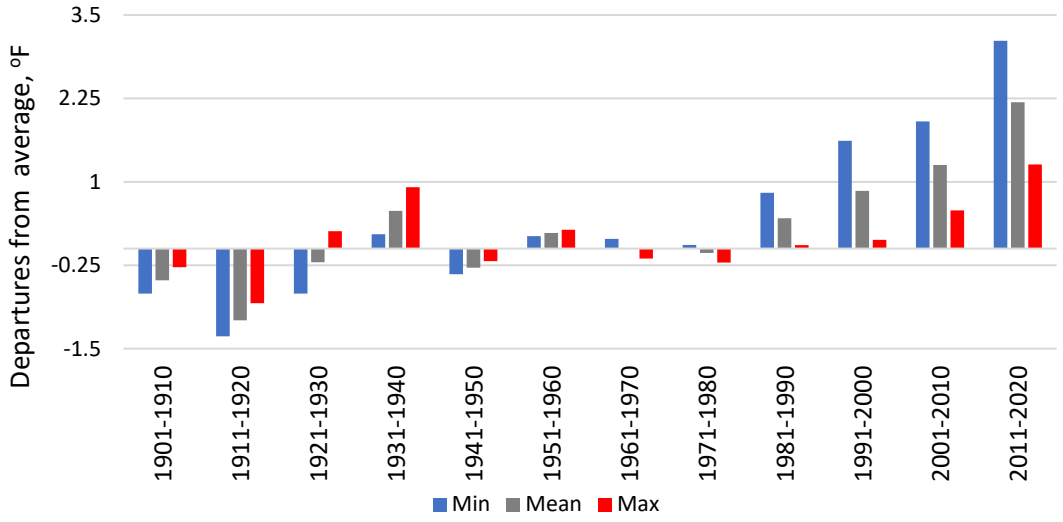
Source: WRCC, 2022

What does the indicator show?

Statewide air temperatures show a warming trend consistent with that found globally (IPCC, 2021; also see the globalwarmingindex). They have been recorded since 1895. Figure 1 presents annual average temperatures statewide. Annual average temperatures have increased by about 2.5 degrees Fahrenheit (˚F) (or about 2°F per century, which is a common way of measuring long-term temperature changes). Recent years were notably warm, with 2014 being the warmest on record, followed by 2015, 2020, 2017, 2016, and 2018. Some of these warmest years coincided with some of the driest years in the instrumental record and led to exacerbated drought conditions due to increased land surface temperatures, evapotranspiration, and evaporative demand.

Figure 2 depicts “departures” by decade from a long-term average (base period of 1901 to 2000) for minimum, mean, and maximum temperatures. Departures are the difference between each decade’s value and the long-term average. Before the 1930s, temperatures were cooler than the long-term average, then hovered around the average between the 1940s and the 1970s. The last four decades showed marked warming, as temperatures increased at a faster rate. Minimum, average, and maximum temperatures have increased overall. Minimum temperatures (which reflect overnight low temperatures) have increased the fastest.

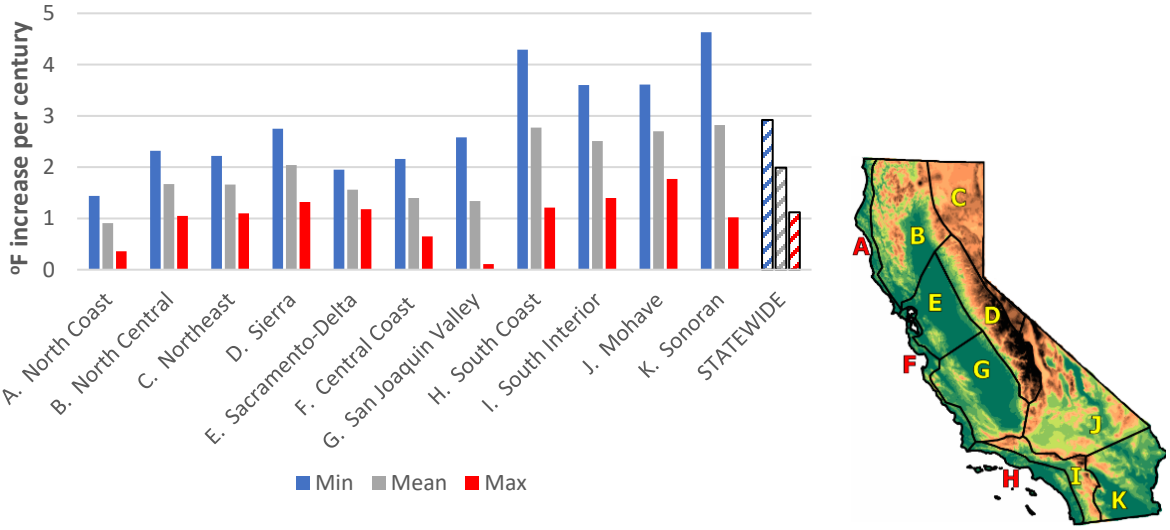
Figure 2. Statewide Temperatures, Decadal Averages (relative to the 1901-2000 long-term average*)



Source: WRCC, 2021

** Values shown for each decade are "departures" from the long-term average, 1901-2000—that is, the difference between the long-term average and the average for the decade.*

Figure 3. Regional and statewide temperature trends (1895 to 2020)



Source: WRCC, 2021

As shown in Figure 3, statewide minimum temperatures rose at a rate of 2.9°F per century. Maximum temperatures rose at 1.1°F per century. As minimum temperatures have increased the fastest, the increasing trend in the average California temperature is driven more by nighttime processes than by daytime processes.

All of California's 11 climate regions have experienced warming trends over the last century, although at varying rates (Figure 3). The greatest increases are observed in the Sonoran Desert and South Coast regions. Minimum temperatures showed the greatest rate of increase in all the regions, consistent with statewide trends.

Why is this indicator important?

Temperature is a basic physical factor that affects many natural processes and human activities. Warmer air temperatures alter precipitation and runoff patterns, influencing the availability of freshwater supplies. Increased temperature leads to a wide range of impacts on ecosystems — including changes in species' geographic distribution, in the timing of life cycle events, and in their abundance — as well as on human health and well-being. In addition, warming temperatures affect energy needed for cooling and heating, which in turn influences the types of energy generation, infrastructure, and management policies needed to meet these demands. Temperature changes can also increase the risk of severe weather events such as heatwaves and intense storms. Understanding observed temperature trends is important for refining future climate projections for climate-sensitive sectors and natural resources within the state (Cordero et al., 2011).

What factors influence this indicator?

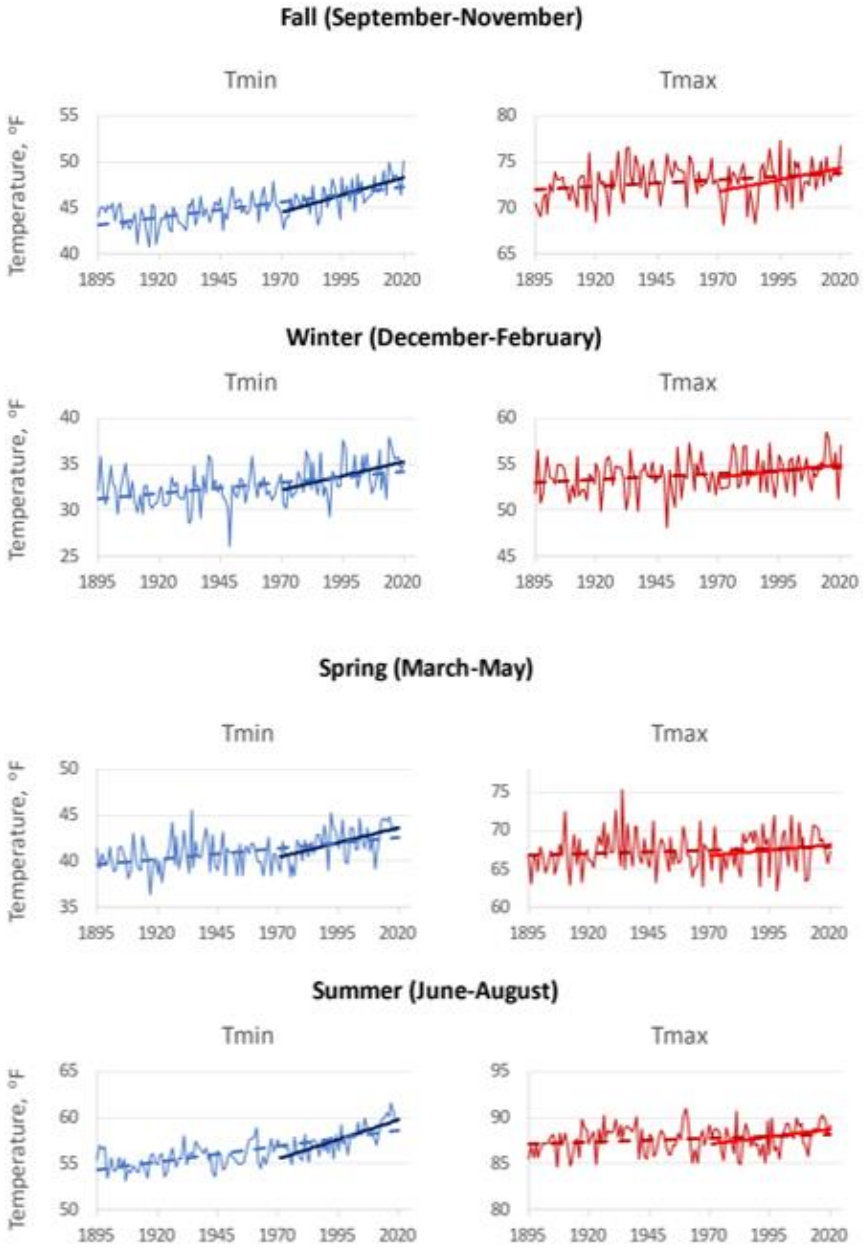
Carbon dioxide and other greenhouse gas emissions into the atmosphere since the Industrial Revolution in the mid-1700s have driven unprecedented warming worldwide. (IPCC, 2021). Emissions of these greenhouse gases intensify the natural greenhouse effect, causing surface temperatures to rise. Greenhouse gases absorb heat radiated from the Earth's surface and lower atmosphere and reflect much of the energy back toward the surface.

Temperatures are influenced by local topography, elevation, proximity to the ocean, and global and regional atmospheric and oceanic circulations. As previously mentioned, Figure 3 illustrates geographic differences in warming trends (WRCC, 2021). Regional information can be obtained from the California Climate Tracker. Climate patterns can vary widely from year to year and from decade to decade, in accordance with large-scale circulation changes around the Earth. The Pacific Ocean has a major effect on California temperatures all year along the coast, especially summer, and farther inland in winter. In addition to topography, local influences on temperature include changes in land surface and land use. For example, urbanization of rural areas is generally known to have a warming effect, due in large part to the heat-absorbing concrete and asphalt in building materials and roadways. Expansion of irrigation has been shown to have a cooling effect on summertime temperatures (Bonfils and Lobell, 2007).

Statewide seasonal temperature trends are shown in Figure 4. Across the seasons, minimum temperatures are increasing faster than maximum temperatures. Trends for the more recent time period (from 1971 to 2021, solid line in Figure 4) are greater than trends since 1895 (dotted line). The greatest increases in minimum temperatures occurred in the summer and fall over both time periods. For maximum temperatures,

the greatest increases over the entire period of record occurred in the fall and winter; since 1971, the greatest increased occurred in the fall and summer.

Figure 4. Seasonal air temperature trends in California



Source: WRCC, 2021

Average minimum temperature (Tmin) and average maximum temperature (Tmax) for each year are presented for each season. The linear trend for the entire period is shown as solid lines, and for 1971-2021 as dashed lines.

Technical considerations

Data characteristics

The Western Regional Climate Center (WRCC)'s California Climate Tracker provides monthly temperature values in California from 1895 to the present using the PRISM Climate Mapping Program from Oregon State University. PRISM is an analytical tool that generates fine scale grid-based estimates of monthly precipitation and temperature. The "About the California Climate Tracker" page provides more information. (WRCC has updated its methodology since the previous report for determining historical temperatures, so values in the current edition of this report slightly differ from the previous edition).

Strengths and limitations of the data

The datasets used are subjected to their own separate quality control procedures, to account for potentially incorrect data reported by the observer, missing data, and to remove inconsistencies such as station relocation or instrument change.

The PRISM dataset offers complete coverage across the state for every month of the record. Limitations include the bias of station data toward populated areas and the limited ability of quality control processes in remote or high terrain areas. The dataset is constantly updated to map climate in the most difficult situations, including high mountains, rain shadows, temperature inversions, coastal regions, and associated complex climate processes.

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