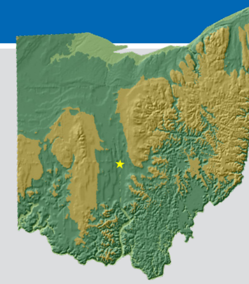

OHIO

Key Messages

Annual average temperature in Ohio has risen more than 1.5°F since the beginning of the 20th century. Under a higher emissions pathway, historically unprecedented warming is projected to continue through this century. Extreme heat is a particular concern for the state's urban areas, where high temperatures and high humidity can cause dangerous health conditions.

Ohio has experienced a significant increase in heavy rain events. Increases in winter and spring precipitation are projected and will enhance the risk of springtime flooding.

Severe drought is a risk to this agriculture-dependent state. Projected temperature increases may increase the intensity of naturally occurring droughts.

Ohio's mid-latitude, interior location and the lack of mountains to the north or south expose the state to incursions of very cold air masses from the Arctic in the winter and warm, humid air masses from the Gulf of Mexico in the summer. Lake Erie also has a significant influence on the local climate. Near-shore locations are considerably warmer during the winter and cooler during the summer than locations farther away from the shores. Lake-effect snow, caused by the warming and moistening of arctic air masses over the Great Lakes, is a hazard along the southeastern shoreline of Lake Erie.

Since the beginning of the 20th century, temperatures in Ohio have risen more than 1.5°F, and temperatures in the 2000s and 2010s were warmer than in any other historical period (Figure 1). The warming has not been steady. The 1930s through the mid-1950s were generally above the long-term average but were followed by the coldest period on record: the 1960s and 1970s. Since the 1970s, annual average temperature has risen more than 2°F. Based on observations through 2020, 1998 was the hottest year on record, with an annual average temperature for the state of 54.1°F. The second hottest year was 2012, with an average temperature of 54.0°F. This warming has been concentrated in the winter and spring. Summer days have not warmed substantially in the state, a feature characteristic of much of the Midwest. This lack of summer warming is reflected in a below average occurrence of very hot days (Figure 2a). However, in addition to the overall higher summer average nighttime temperatures,

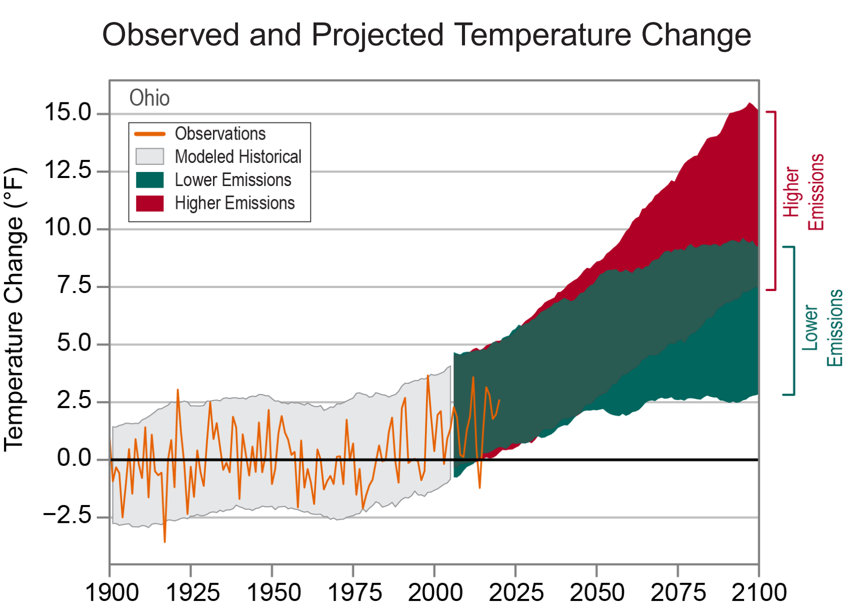

Figure 1: Observed and projected changes (compared to the 1901–1960 average) in near-surface air temperature for Ohio. Observed data are for 1900–2020. Projected changes for 2006–2100 are from global climate models for two possible futures: one in which greenhouse gas emissions continue to increase (higher emissions) and another in which greenhouse gas emissions increase at a slower rate (lower emissions). Temperatures in Ohio (orange line) have risen more than 1.5°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 to continue through this century. Less warming is expected under a lower emissions future (the coldest end-of-century projections being about 3°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). Source: CISESS and NOAA NCEI.

Figure 2: Observed (a) annual number of very hot days (maximum temperature of 95°F or higher), (b) annual number of very cold nights (minimum temperature of 0°F or lower), (c) total annual precipitation, (d) total winter (December–February) precipitation, and (e) total summer (June–August) precipitation for Ohio from (a, b) 1900 to 2020 and (c, d, e) 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) 3.5 days, (b) 6.2 nights, (c) 38.9 inches, (d) 8.0 inches, (e) 11.6 inches. The number of very hot days has been below the long-term average since the mid-1950s. The number of very cold nights has generally been near to below average since 1990, following overall winter warming, except for very high values in 2014 and 2015. Both annual and seasonal (winter and summer) precipitation amounts have been above the long-term average since 1990. Sources: CISESS and NOAA NCEI. Data: (a, b) GHCN-Daily from 20 long-term stations; (c, d, e) nClimDiv.

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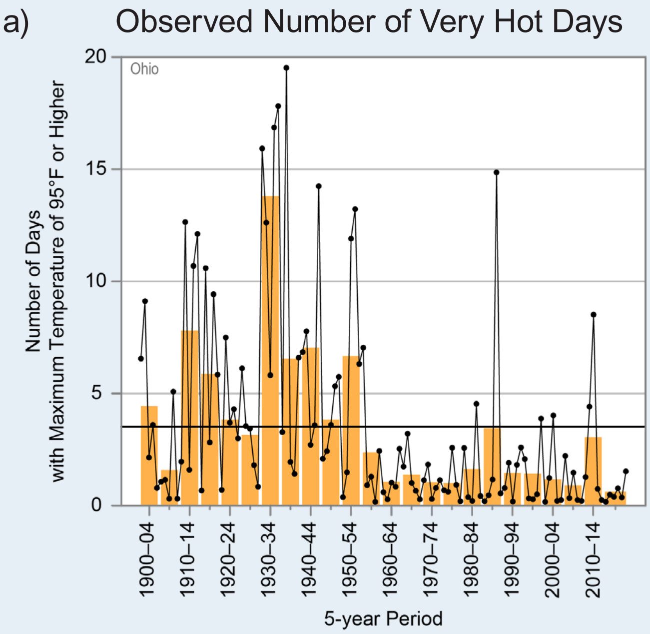

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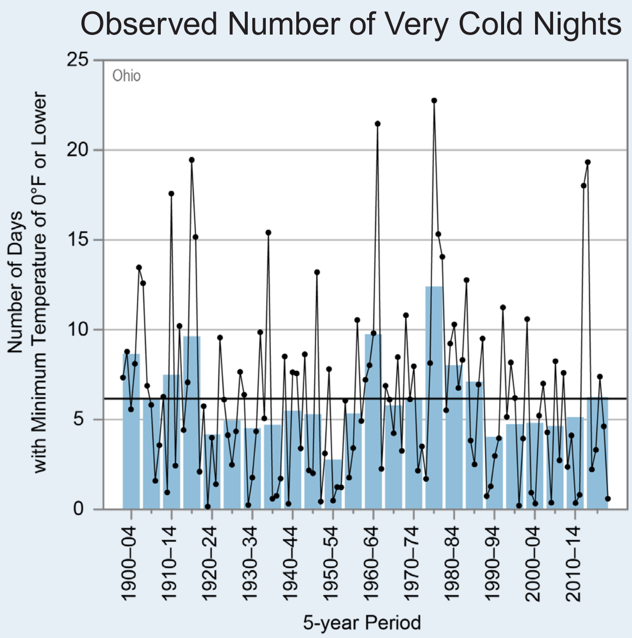

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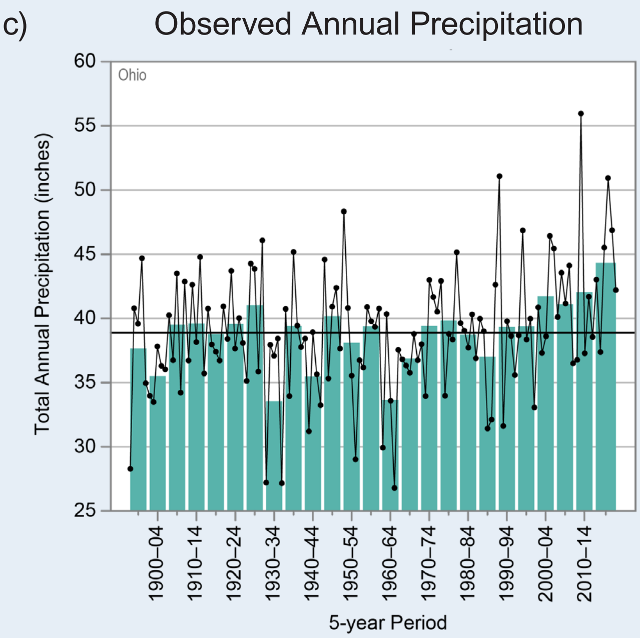

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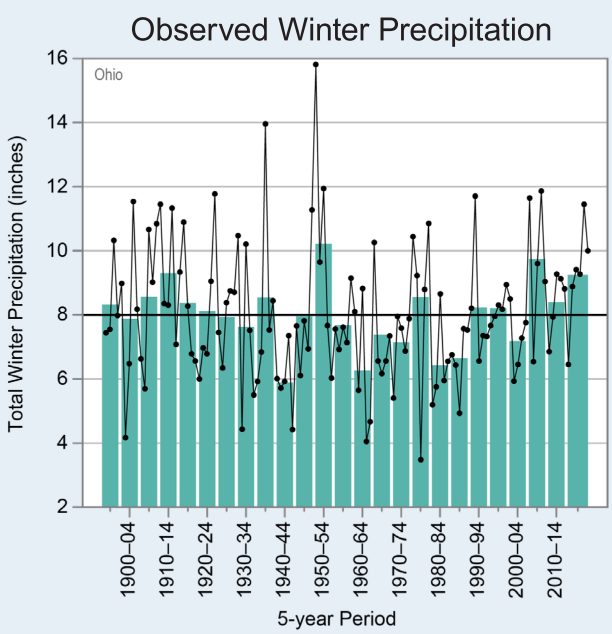

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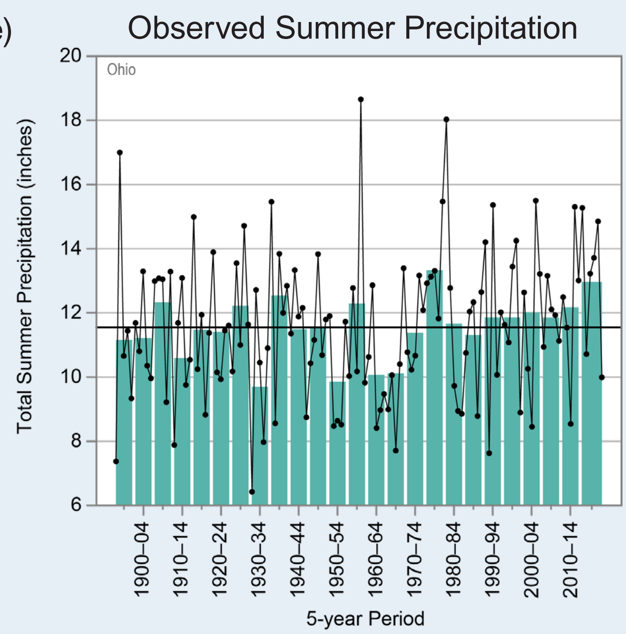

the state has experienced an increase in the number of warm nights (Figure 3). Both Cleveland and Columbus have experienced statistically significant increases in the number of warm nights since 1950. Since 2000, Cleveland and Columbus have averaged 17 and 22 warm nights, respectively, per year, compared to an average of 8 and 9 nights, respectively, in the 1950s through 1970s. Although both cities also experienced a higher frequency of warm nights in the 1930s, this was mostly due to extreme high daytime temperatures. While Ohio generally experienced a near to below average number of very cold nights between 1990 and 2020, very high values occurred in 2014 and 2015, when the so-called “polar vortex” pattern dominated winter weather in the eastern U.S. (Figure 2b).

Annual precipitation varies regionally, with the northwestern part of the state averaging 32 inches each year and the southern part of the state averaging 42 inches each year. Statewide total annual precipitation has ranged from a low of 26.8 inches in 1963 to a high of 56.0 inches in 2011. The driest multiyear periods were 1930–1934 and 1960–1964, and the wettest multiyear periods have occurred since 2000 (Figure 2c). Annual average precipitation during the driest and wettest consecutive 5 years has ranged from a low of 33.6 inches for the 1930–1934 period to a high of 43.3 inches for the 2015–2019 interval. Snowfall also varies across the state. The northern portion of the state along the southern shores of Lake Erie receives 60 inches or more annually, and the southern portion of the state receives less than 16 inches annually.

Ohio has experienced a significant increase in the number of 2-inch extreme precipitation events since the mid-1990s (Figure 4). Past episodes of heavy rains have caused severe flooding in the state. The Great Flood of 1913 was one of the deadliest floods in U.S. history and Ohio’s greatest weather disaster. From March 23 to 26, heavy rains caused extreme runoff from soils saturated from winter storms. Levees along the Great Miami River failed, flooding the entire Great Miami River watershed. Downtown Dayton was hit particularly hard, with floodwaters reaching depths of 20 feet. The flooding caused more than $2 billion in damages, and more than 400 people died. One of the worst floods in recent decades occurred in March 1997.

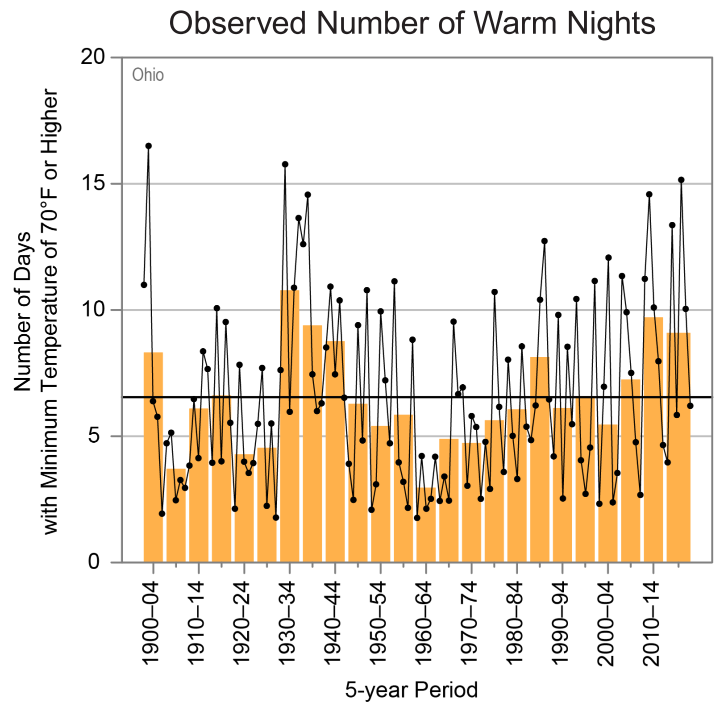

Figure 3: Observed annual number of warm nights (minimum temperature of 70°F or higher) for Ohio from 1900 to 2020. Bars show averages over 5-year periods (last bar is a 6-year average). The horizontal black line shows the long-term (entire period) average of 6.6 nights. Ohio experienced the highest and second-highest number of warm nights during the 1930–1934 period and the 2010–2014 period, respectively. Sources: CISESS and NOAA NCEI. Data: GHCN-Daily from 20 long-term stations.

Between March 1 and 3, 6–12 inches of rain fell in parts of southern Ohio, causing serious flooding, particularly along Brush Creek and the Scioto and Great Miami Rivers. Levels on the main stem of the Ohio River were the highest in more than 30 years. Seventeen counties were declared federal disaster areas, and more than 5,000 homes were damaged or destroyed, resulting in almost $300 million in damages.

Dangerous storms can occur in every season and can cause major impacts, including loss of life, property damage, and disruptions to economic activity. Winter can bring snowstorms and ice storms, while convective storms (including thunderstorms, flood-producing rainstorms, hail, and tornadoes) are common in the warmer months. Although Ohio does not experience as many tornadoes as other states in the Midwest and Great Plains, the state has experienced several deadly tornado outbreaks. On June 28, 1924, Ohio’s deadliest tornado struck the towns of Sandusky and Lorain, killing 85 people and causing more than a billion dollars in damages. Other notable storms include the Palm

Sunday Outbreak on April 11, 1965, which produced 10 tornadoes in the state (4 of which were F4 intensity) and caused 60 deaths; the Xenia tornado (F5 intensity) in the Super Outbreak of 1974 that killed 34 people; and the outbreak of April 8–9, 1999, which produced 54 tornadoes, including an F4 intensity tornado in Blue Ash and Montgomery that killed 4 people.

Agriculture is an important component of Ohio's economy, and this sector is particularly vulnerable to extreme weather conditions. In 2007, unusually warm March temperatures were followed by a hard freeze in April, which devastated much of the state's apple crop. This scenario was again observed in 2012, when March temperatures were 9° to 15°F above average for the state but a cool April followed, with hard freezes. Seasonal precipitation can vary, with no real trend in winter or summer precipitation (Figures 2d and 2e). In 2012, an intense drought throughout the Midwest had severe impacts on Ohio. Rainfall totals for the summer were several inches below average. In addition to low precipitation, the period from January to June was the warmest in 120 years of record, with the warm temperatures compounding the dry conditions. By the end of the year, 86 of Ohio's 88 counties had been declared drought disaster areas.

Under a higher emissions pathway, historically unprecedented warming is projected to continue through 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 extreme heat are a particular concern for Cincinnati, Columbus, and other urban areas, where the urban heat island effect raises summer temperatures. High temperatures combined with high humidity can create dangerous heat index values. From July 17 to 24, 2011, the Ohio River Valley experienced a prolonged heat wave. With temperatures above 90°F for several days in a row and dewpoints in the mid to upper 70s (°F), heat index values rose to between 100° and 110°F during the day. These occurrences are likely to become more common as temperatures continue to rise. However, there have been exceptionally cold winters in recent years. During the winters of 2013–2014 and 2014–2015, persistent weather patterns brought frigid air southward from the Arctic, causing temperatures from December to February to be more than 3°F below average. Although the state averages approximately 6 very cold nights annually, these two winters averaged 18 very cold nights. The intensity of such events is projected to decrease in the future.

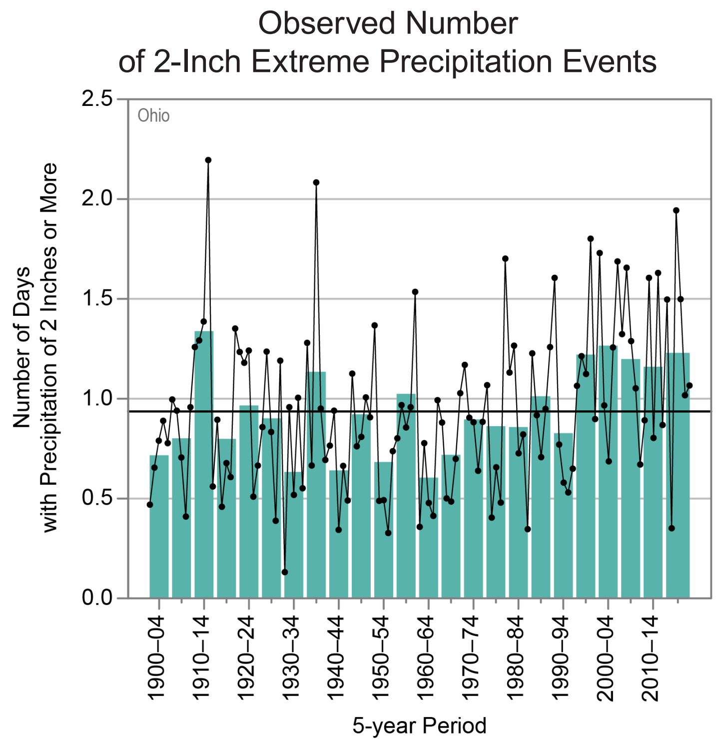

Figure 4: Observed annual number of 2-inch extreme precipitation events for Ohio from 1900 to 2020. Dots show annual values. Bars show averages over 5-year periods (last bar is a 6-year average). The horizontal black line shows the long-term (entire period) average of 0.9 days. A typical reporting station experiences 1 event per year. Ohio has experienced a substantial increase in the number of heavy rain events, with the past 26 years having the some of the highest levels on record since the historic peak from 1910 to 1914. Sources: CISESS and NOAA NCEI. Data: GHCN-Daily from 25 long-term stations.

Although annual precipitation projections are uncertain, winter and spring precipitation is projected to increase (Figure 5). In addition, extreme precipitation is projected to increase, potentially causing more frequent and intense floods. Heavier precipitation and higher temperatures increase the risk of springtime flooding, posing a threat to Ohio's agricultural industry by delaying planting and resulting in a loss of yield.

The intensity of future droughts is projected to increase. Even if precipitation increases in the future, rising temperatures will increase the rate of loss of soil moisture during dry spells. Thus, future summer droughts, a natural part of the Ohio climate, are likely to be more intense.

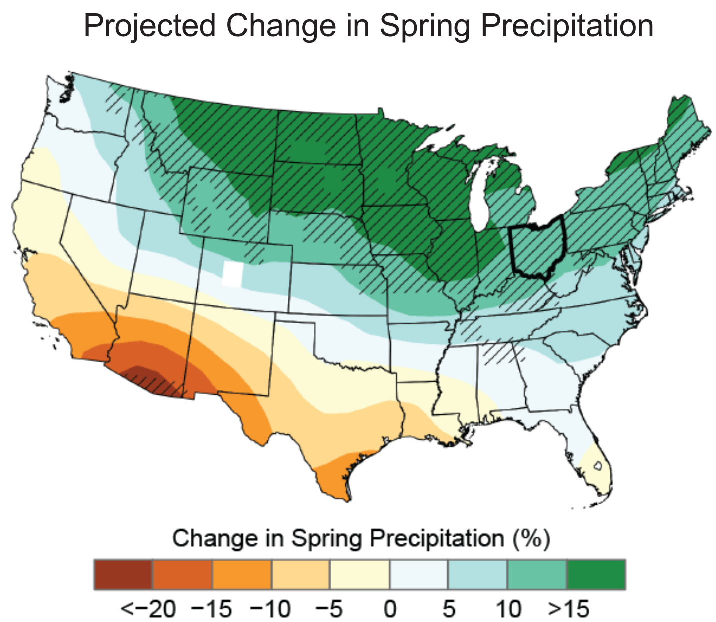

Figure 5: Projected changes in total spring (March–May) precipitation (%) for the middle of the 21st century compared to the late 20th century under a higher emissions pathway. The whited-out area indicates that the climate models are uncertain about the direction of change. Hatching represents areas where the majority of climate models indicate a statistically significant change. Ohio is part of a large area of projected increases in spring precipitation in the Northeast and Midwest. Source: CISESS and NEMAC. Data: CMIP5.

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