INDIANA

Key Messages

Temperatures in Indiana have risen almost 1.5°F since the beginning of the 21st century. Warming has been concentrated in winter and spring, with a general lack of summer warming. Under a higher emissions pathway, historically unprecedented warming is projected during this century, with corresponding decreases in cold wave intensity and increases in heat wave intensity.

Spring and summer precipitation has generally been above average since the 1990s, affecting agriculture both positively (adequate soil moisture) and negatively (delays in spring planting). Projected increases in winter and spring precipitation pose a continuing risk of spring planting delays.

Severe flooding and drought have occurred periodically in recent years. Future increases in the frequency and intensity of extreme precipitation events may increase the frequency and intensity of floods, while increases in evaporation rates due to rising temperatures may increase the intensity of naturally occurring droughts.

Indiana's location in the interior of North America and the lack of mountains to the north and south expose the state to incursions of bitterly cold air masses from the Arctic in the winter and warm, humid air masses from the Gulf of Mexico in the summer. Annual average temperature varies widely across the state, with a range of about 10°F from north to south. In northwestern Indiana, Lake Michigan moderates the temperature, causing cooler summers and warmer winters. Lake Michigan is also the source of lake-effect snows, which can extend as far inland as Elkhart (north-central Indiana).

Temperatures in Indiana have risen almost 1.5°F since the beginning of the 20th century (Figure 1). Temperatures in the 2000s have been higher than in any other historical period with the exception of the early 1930s Dust Bowl era. Warming has been concentrated in winter and spring (Figure 2a), while summers have not warmed substantially (Figure 2b), a feature characteristic of much of the Midwest. The lack of summer warming is reflected by a below average number of very hot days (Figure 2c), although the number of very warm nights has generally been near average since the early 1980s (Figure 2d).

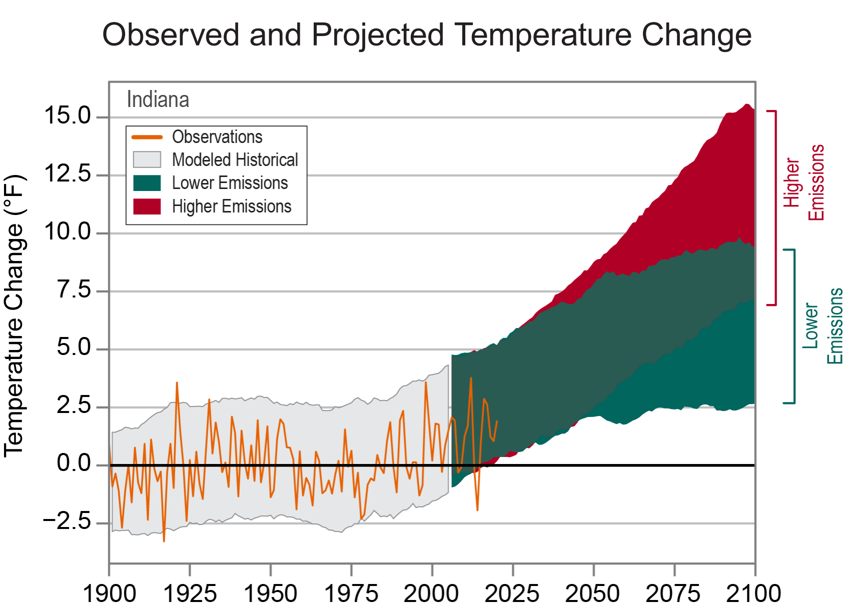

Figure 1: Observed and projected changes (compared to the 1901–1960 average) in near-surface air temperature for Indiana. Observed data are for 1900–2020. Projected changes for 2006–2100 are from global climate models for two possible futures: one in which greenhouse gas emissions continue to increase (higher emissions) and another in which greenhouse gas emissions increase at a slower rate (lower emissions). Temperatures in Indiana (orange line) have risen almost 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 during 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 12°F warmer than the hottest year in the historical record; red shading). Sources: CISESS and NOAA NCEI.

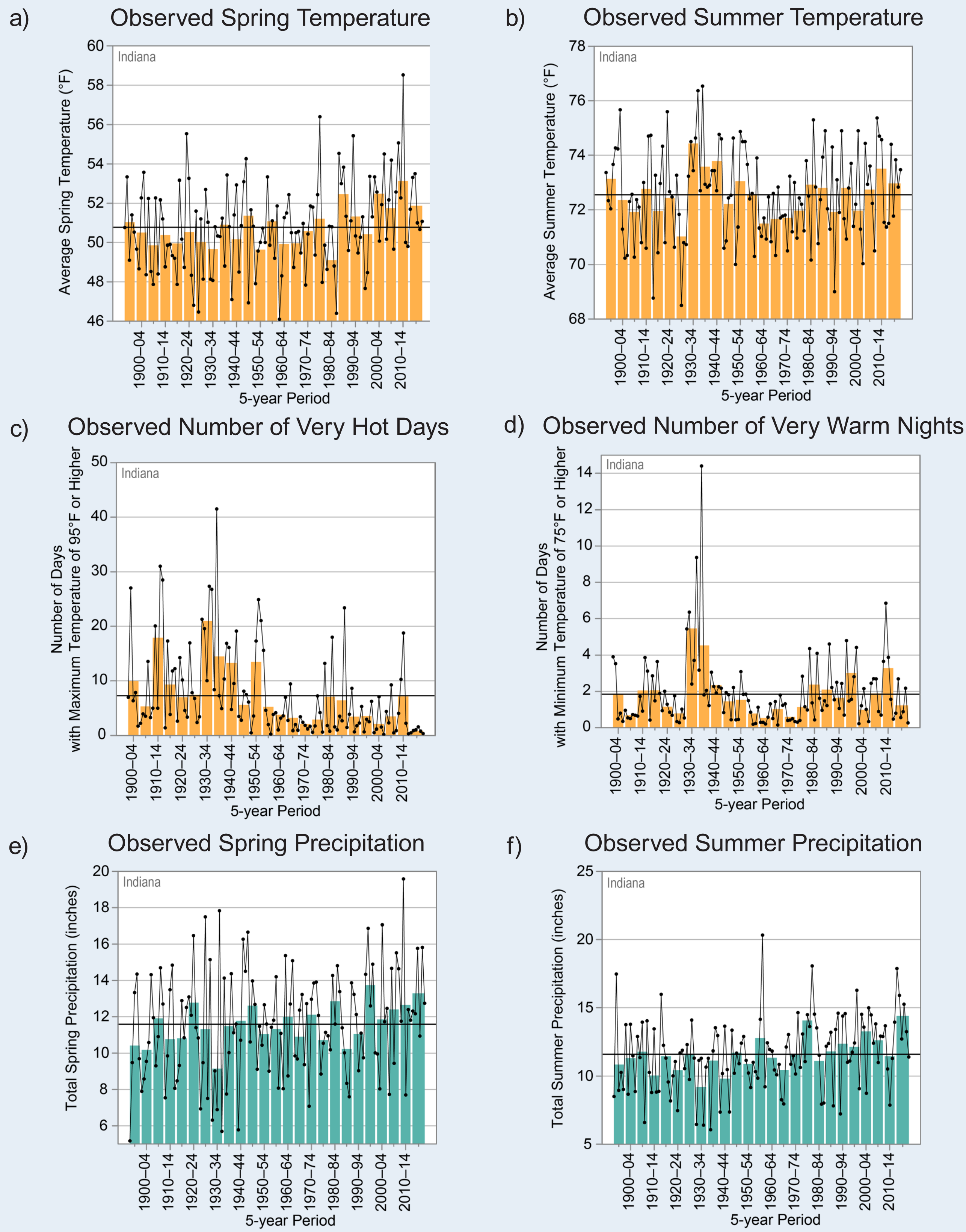

Figure 2: Observed (a) spring (March–May) average temperature, (b) summer (June–August) average temperature, (c) annual number of very hot days (maximum temperature of 95°F or higher), (d) annual number of very warm nights (minimum temperature of 75°F or higher), (e) total spring precipitation, and (f) total summer precipitation for Indiana from (a, b, e, f) 1895 to 2020 and (c, d) 1900 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) 50.8°F, (b) 72.6°F, (c) 7.3 days, (d) 1.9 nights, (e) 11.6 inches, (f) 11.6 inches. Spring temperatures have generally trended upward, while summer temperatures show little change. Since 1955, the number of very hot days has been below average, while the number of very warm nights has generally trended upward but has not reached the levels of the 1930s. Spring and summer precipitation has generally trended upward. Sources: CISESS and NOAA NCEI. Data: (a, b, e, f) nClimDiv, (c, d) GHCN-Daily from 17 long-term stations.

Due to extreme drought and poor land management practices, the summers of the 1930s and early 1940s remain the warmest on record. Winter warming is reflected in a below average number of very cold nights since the early 1990s (Figure 3).

Annual precipitation has varied from a low of 29.1 inches in 1963 to a high of 55.2 inches in 2011. The driest multiyear periods were in the 1930s, 1940s, and 1960s and the wettest in the 2010s (Figure 4). The driest consecutive 5-year interval was 1940–1944, averaging 35.2 inches per year, and the wettest was 2015–2019, averaging 47.2 inches per year. Annual precipitation also varies widely across the state, ranging from about 47 inches in the south to 37 inches in the north. For snowfall, the pattern is reversed, with the southwest averaging about 14 inches and some northern locations near Lake Michigan averaging more than 70 inches. Locations close to Lake Michigan occasionally receive heavy winter precipitation from lake effect snows. During January 21–22, 2014, a lake effect storm dropped 18 inches of snow in Gary over a 5-hour period.

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 snow and ice storms, while thunderstorms capable of producing floods, hail, and tornadoes are common in the warmer months. One of the state's worst winter storms occurred during December 22–23, 2004. More than 20 inches of snow fell across the southern part of the state. Many locations reported record amounts, including the city of Washington, with 32 inches of snow. With temperatures below freezing, the snow lingered for several days, shutting down airports and interstates and stranding holiday travelers. The storm killed 5 people, and a state of emergency was declared for 50 counties. Heavy snowstorms during the first week of January 2014 dumped 1 to more than 2 feet of snow over central and northern Indiana.

Indiana has a long and deadly history of tornadic storms. On March 18, 1925, the deadliest tornado in U.S. history—the Tri-State Tornado—struck southwestern Indiana after tracking across Missouri and Illinois. The tornado destroyed parts of Griffin, Owensville, and Princeton and caused hundreds of

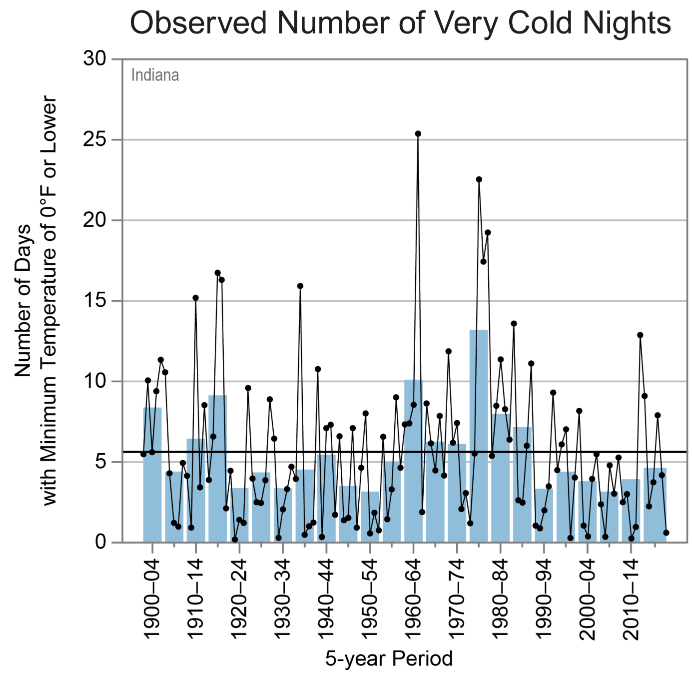

Figure 3: Observed annual number of very cold nights (minimum temperature of 0°F or lower) for Indiana from 1900 to 2020. Dots show annual values. Bars show averages over 5-year periods (last bar is a 6-year average). The horizontal black line shows the long-term (entire period) average of 5.6 nights. The number of very cold nights has been below average since 1990 at an average of 3.9 nights per year, indicative of overall winter warming in the region. Sources: CISESS and NOAA NCEI. Data: GHCN-Daily from 17 long-term stations.

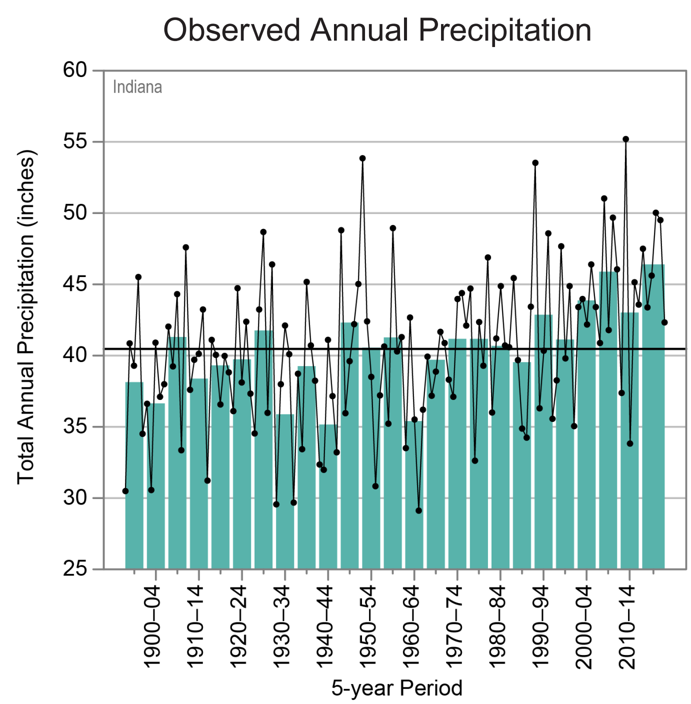

Figure 4: Observed total annual precipitation for Indiana from 1895 to 2020. Dots show annual values. Bars show averages over 5-year periods (last bar is a 6-year average). The horizontal black line shows the long-term (entire period) average of 40.5 inches. Annual precipitation varies widely but has been above average since 1990. The driest consecutive 5-year interval on record (1940–1944) averaged 35.2 inches, while the wettest (2015–2019) averaged 47.2 inches. Sources: CISESS and NOAA NCEI. Data: nClimDiv.

injuries and 76 deaths. The Palm Sunday Outbreak on April 11, 1965, included several tornadoes in Indiana, 8 of them at F4 intensity. The outbreak injured hundreds in the state and killed more than 130 people. Indiana's largest tornado outbreak occurred on June 2, 1990, and included 37 tornadoes, several of them at F4 intensity.

Agriculture is an important sector of Indiana's economy and is particularly vulnerable to a variety of extreme weather conditions. In 2007, unusually warm March temperatures followed by a hard freeze in April devastated much of the state's fruit crops, with total agricultural losses estimated at more than $40 million. In 2012, a large drought across the Midwest severely impacted the state. Rainfall for May, June, and July totaled 6.6 inches, more than 5 inches below average, making this the fourth-driest May–July period (after 1936, 1930, and 1988) in 126 years of record keeping. By early August, almost 70% of the state was in extreme drought, with a quarter of the state experiencing exceptional drought. The drought caused major damage to crops, particularly in the southern third of the state.

On average, Indiana has experienced wet springs and summers since the 1990s (Figures 2e and 2f). While precipitation during these critical growth months is important for adequate soil moisture, it can also make it difficult for farmers to plant crops. **Indiana has also experienced an increase in the number of 2-inch extreme precipitation events** (Figure 5), which can cause severe flooding. The Great Flood of March 23–26, 1913, was the worst flood in Indiana history. Heavy rains caused many rivers across the state to reach flood stage. More than 100 people were killed, with damages estimated at more than $20 million. Heavy rains on saturated ground were also responsible for severe flooding during June 6–7, 2008. Heavy rain fell across central and southern Indiana, with some stations reporting up to 10 inches. Many streams reached record flood levels. In total, 39 counties were declared disaster areas, and damages were estimated at hundreds of millions of dollars. In the summer of 2015, central Indiana experienced historic levels of rainfall; it was the wettest July on record at Indianapolis (8.7 inches above normal). Flooding in June and July exceeded flood control capacity in three reservoirs for the first time since they were built in the late 1960s. The magnitude of this event rivaled that of the exceptional drought that impacted the state in 2012, highlighting the extremes in climate that Indiana has experienced in recent years.

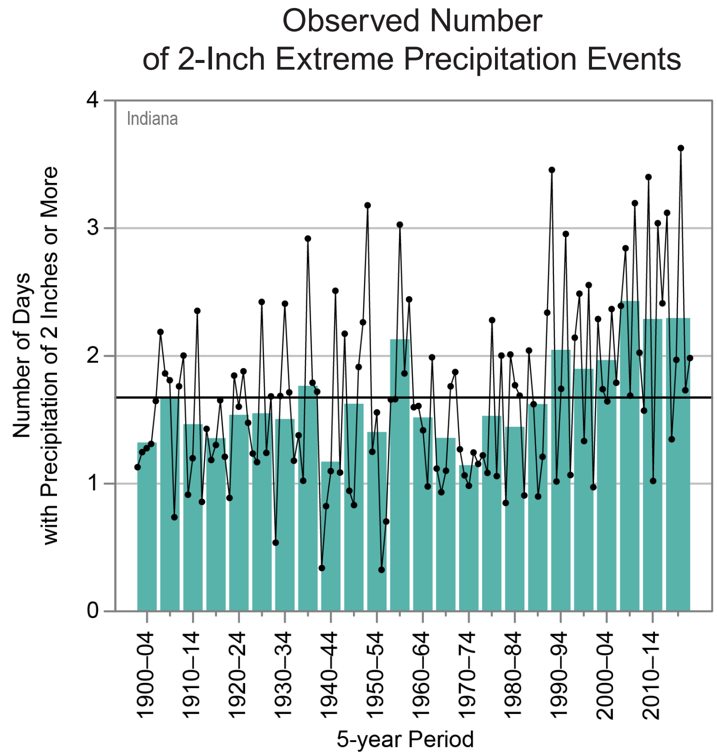

Figure 5: Observed annual number of 2-inch extreme precipitation events (days with precipitation of 2 inches or more) for Indiana from 1900 to 2020. Dots show annual values. Bars show averages over 5-year periods (last bar is a 6-year average). The horizontal black line shows the long-term (entire period) average of 1.7 days. The number of 2-inch extreme precipitation events has been above average since 1990. The 2005–2009 period had the highest multiyear average on record of nearly 2.5 days. A typical station experiences about 2 events per year. Sources: CISESS and NOAA NCEI. Data: GHCN-Daily from 21 long-term stations.

Water levels in the Great Lakes have fluctuated over a range of 3 to 6 feet since the late 19th century (Figure 6). Higher lake levels were generally noted in the late 19th century, the early 20th century, and the 1940s, 1950s, 1980s, and late 2010s. Lower lake levels were observed in the 1920s and 1930s and again in the 1960s. For Lake Michigan–Huron, lower levels occurred during the first decade of this century. Lake levels have risen rapidly since 2013, reaching in 2020 the highest levels since 1886.

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. If temperatures continue rising, future heat waves are likely to be more intense. Extreme heat is a particular concern for Indianapolis and other urban areas, where high temperatures combined with high humidity can cause dangerous heat index values, a phenomenon known as the urban heat island effect. By contrast, the intensity of cold waves is projected to decrease.

Increases in precipitation are projected for Indiana, most likely during the winter and spring (Figure 7). The frequency and intensity of extreme precipitation events are also projected to increase, potentially increasing the frequency and intensity of floods. Springtime flooding in particular poses a threat to Indiana's important agricultural economy by delaying planting and reducing yields.

The intensity of future droughts is projected to increase even if precipitation increases. Rising temperatures will increase evaporation rates and the rate of soil moisture loss. Thus, future summer droughts, a natural part of Indiana's climate, are likely to be more intense.

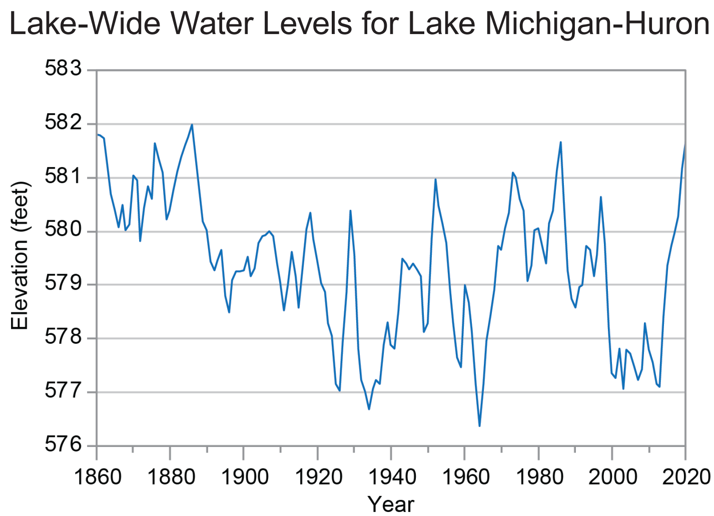

Figure 6: Annual time series of the average water levels for Lake Michigan–Huron from 1860 to 2020. Water levels in the Great Lakes have fluctuated widely over the years. Lake Michigan–Huron levels were very low during 2000–2013 but have since risen rapidly to the highest levels since 1886. Source: NOAA GLERL.

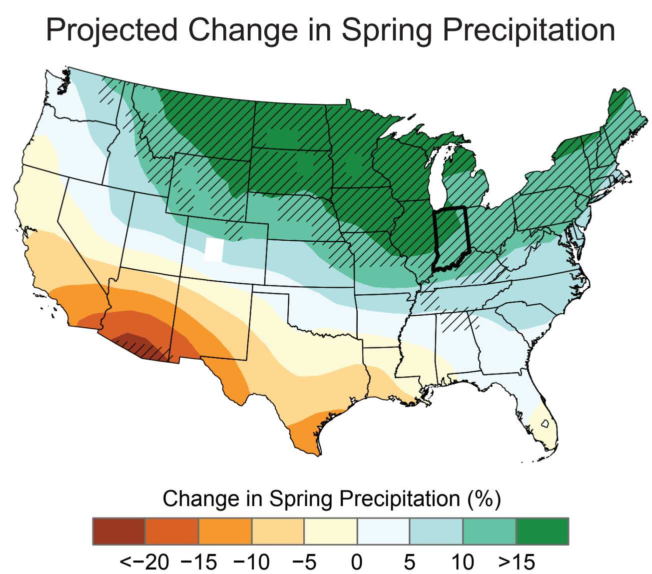

Figure 7: Projected changes in spring (March–May) precipitation (%) for the middle of the 21st century compared to the late 20th century under a higher emissions pathway. The whited-out area indicates that the climate models are uncertain about the direction of change. Hatching represents areas where the majority of climate models indicate a statistically significant change. Spring precipitation in Indiana is projected to increase in the range of 10% to greater than 15% by 2050. Source: CISESS and NEMAC. Data: CMIP5.

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