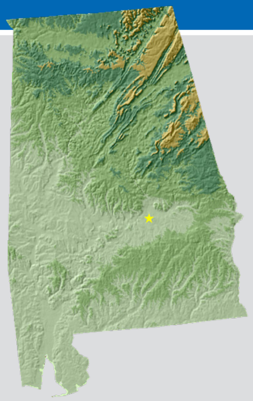
ALABAMA



Key Messages

Temperatures in Alabama have not risen since the beginning of the 20th century, one of the few areas globally to experience no net warming. However, recent years have been very warm, and the warmest consecutive 5-year interval was the most recent, 2016–2020. Under a higher emissions pathway, historically unprecedented warming is projected during this century.

There are no robust trends in total annual precipitation and the number of extreme precipitation events. Future changes in average precipitation are uncertain, while increases in the frequency and intensity of extreme rainfall are projected.

Global sea level is projected to rise, with a likely range of 1–4 feet by 2100. Sea level along the Alabama coast has risen at the rate of 1.6 inches per decade, faster than the global rate. Projected sea level rise poses widespread and continuing threats to both natural and built environments in coastal Alabama.

Alabama is located at subtropical latitudes between the Gulf of Mexico and the southern end of the vast, relatively flat plains of central North America, which extend from the Arctic Circle to the Gulf of Mexico. The state is therefore exposed to the influences of diverse air masses, including the warm, moist air from the Gulf of Mexico and dry continental air masses, which are cold in the winter and warm in the summer. Clockwise circulation of air around a semipermanent high-pressure system in the North Atlantic (known as the Bermuda High) causes a persistent southerly flow of air off the gulf during the warmer half of the year. Thus, relatively mild winters, hot summers, and year-round precipitation characterize Alabama's climate. In addition to serving as a predominant source of moisture, the Gulf of Mexico helps moderate temperatures along the coast. Alabama's mild climate is an important economic driver for agricultural production and tourism.

Temperatures in Alabama have not risen since the beginning of the 20th century, one of the few areas globally to experience no net warming. However, recent years have been very warm, and the warmest consecutive 5-year interval was the most recent, 2016–2020 (Figure 1). Temperatures in Alabama were highest in the 1920s and 1930s, followed by a substantial cooling of almost 2°F into the 1960s and 1970s. Since that cool period,

Observed and Projected Temperature Change

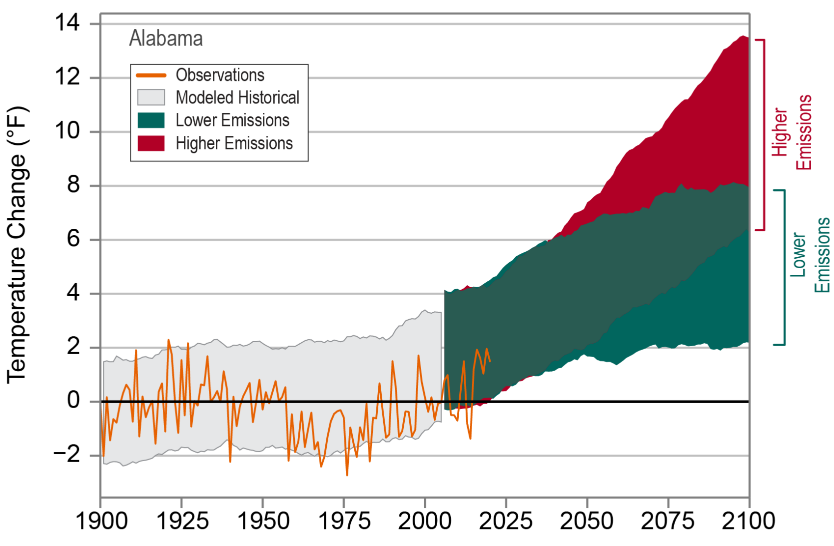


Figure 1: Observed and projected changes (compared to the 1901–1960 average) in near-surface air temperature for Alabama. Observed data are for 1900–2020. Projected changes for 2006–2100 are from global climate models for two possible futures: one in which greenhouse gas emissions continue to increase (higher emissions) and another in which greenhouse gas emissions increase at a slower rate (lower emissions). Temperatures in Alabama (orange line) have not risen since the beginning of the 20th century, one of the few areas globally to experience no net warming. However, recent years have been very warm, and the warmest consecutive 5-year interval was the most recent, 2016–2020. Shading indicates the range of annual temperatures from the set of models. Observed annual temperatures are generally within, but on the very low end of, the envelope of model simulations of the historical period (gray shading). However, for summer daytime maximum temperatures, which have decreased over the 20th century, this localized cooling is not well simulated by climate models. Less warming is expected under a lower emissions future (the coldest end-of-century projections being about as warm as the hottest year in the historical record; 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.

temperatures have risen by more than 2.0°F. The contiguous United States as a whole has warmed by about 1.8°F since 1900, although it also cooled from the 1930s into the 1960s but not by nearly as much as Alabama. Hypothesized causes for this difference in warming rates include increased cloud cover and precipitation, increased small particles from coal burning, natural factors related to forest regrowth, decreased heat flux due to irrigation, and multidecadal variability in North Atlantic and tropical Pacific sea surface temperatures.

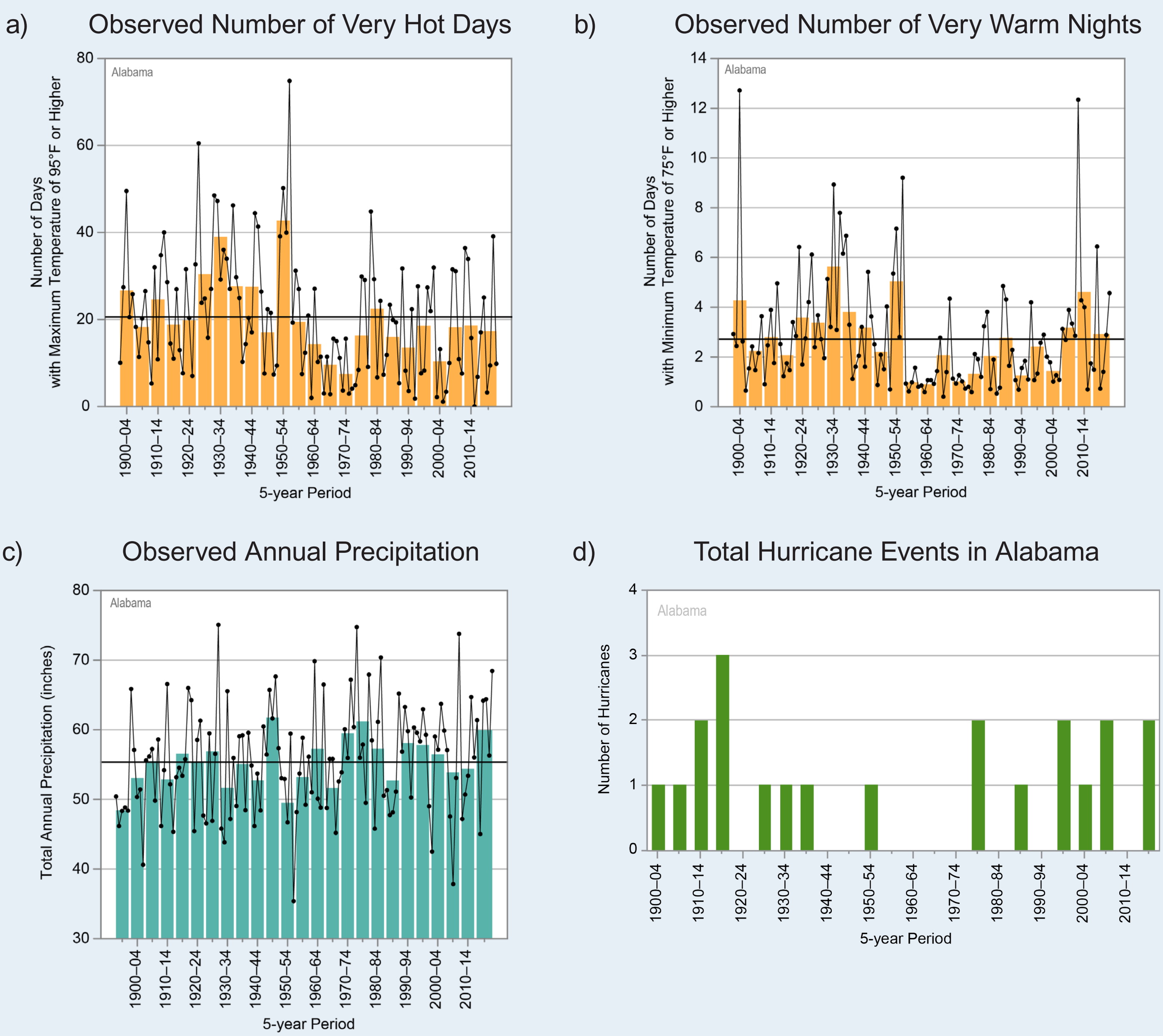


Figure 2: Observed (a) annual number of very hot days (maximum temperature of 95°F or higher), (b) annual number of very warm nights (minimum temperature of 75°F or higher), (c) total annual precipitation, and (d) total number of hurricanes events (wind speeds reaching hurricane strength somewhere in the state) for Alabama from (a, b, d) 1900 to 2020 and (c) 1895 to 2020. In Figures 4a, 4b, and 4c, dots show annual values, bars show averages over 5-year periods (last bar is a 6-year average), and the horizontal black lines shows the long-term (entire period) averages: (a) 21 days, (b) 2.7 nights, (c) 55.4 inches. In Figure 4d, bars show totals over 5-year periods (last bar is a 6-year total). The number of very hot days has been below average since 1985, while the number of very warm nights has been near or above average since 2005. Total annual precipitation shows high year-to-year variability and no overall trend. Notably, the 2005 to 2009 period had the second-driest (2007) and third-wettest (2009) years on record. There is no long-term trend in the number of hurricane events. Since 2000, the state has been impacted by 5 storms. Sources: (a, b, c) CISESS and NOAA NCEI; (d) NOAA Hurricane Research Division. Data: (a, b) GHCN-Daily from 7 long-term stations; (c) nClimDiv.

Statewide summer average daytime high temperatures have historically ranged from about 87°F (in 1967) to about 95°F (in 1902), although daily temperatures exceeding 95°F are common. In recent decades, the number of very hot days has been well below the numbers experienced during the early 1930s and early 1950s (Figure 2a). Since 2005, the number of very warm nights has been near or above average but still below the numbers of the early 1930s and early 1950s (Figure 2b). In the winter, average nighttime low temperatures range from 30°F in the northern portion of the state to more than 45°F along the coast. The annual average (1991–2020 normals) number of nights at or below 32°F is 47 and 56 for Birmingham and Huntsville, respectively, compared to only 21 for Mobile.

Annual precipitation is highly variable from year to year (Figure 2c). Statewide annual average precipitation is 55.4 inches and is distributed rather uniformly throughout the year, except for a relatively dry period between August and October. While there is no long-term trend over the period of record (1895–2020), the 2015–2020 period was above average. The second-driest year on record (2007) and second-driest consecutive 3-year interval (2006–2008) were followed by the third-wettest year (2009). The driest multiyear periods were in the late 1890s and early 1950s and the wettest in the late 1940s and late 1970s. The driest consecutive 5-year interval was 1895–1899, with an annual average of 48.3 inches, and the wettest was 1971–1975, with an annual average of 63.7 inches. The combination of variable summer precipitation patterns and the prevalence of soils with poor water-holding capacity frequently gives rise to short-term drought conditions. **The number of 3-inch extreme precipitation events has been near or above average since 1995 but shows no statistically significant long-term trend** (Figure 3).

Tornadoes and hurricanes are two of the deadliest weather hazards in Alabama. Between 1895 and 2019, an estimated 43 tornadoes, typically occurring in the spring and fall, touched down in Alabama each year. In 2011, a deadly tornado outbreak swept across the southern, midwestern, and northeastern United States. Alabama was one of the hardest-hit states, suffering an estimated 238 tornado-related deaths and millions of dollars in property and infrastructure damages. Hurricanes and tropical storms can also cause massive property damage. On average (1900–2020), Alabama is directly impacted by a hurricane about once every 6 years; however, there has been no long-term trend over the past century (Figure 2d). In 2005, Hurricane Katrina brought hurricane-force winds along the Alabama coastline, spawning tornadoes and causing widespread wind damage and flooding following a storm tide (storm surge combined with already-present tide) of 14 to 18 feet. In 2012, Hurricane Isaac resulted in a storm surge (the abnormal rise of water generated by a storm over and above the predicted astronomical tide) of 4.63 feet above normal tide levels in the Mobile Bay area and 3 to 5 feet of inundation (the total water level that occurs on normally dry ground as a result of storm tide) along the coast of Alabama.

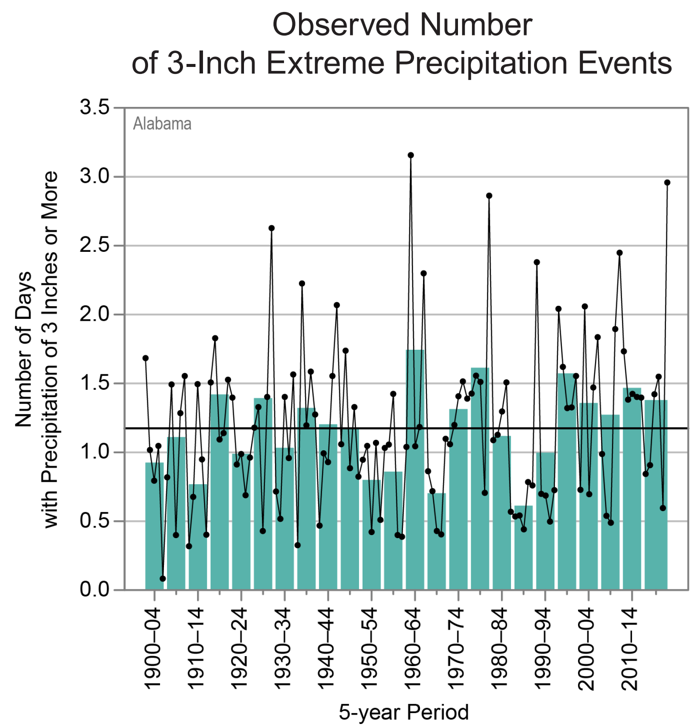


Figure 3: Observed annual number of 3-inch extreme precipitation events (days with precipitation of 3 inches or more) for Alabama from 1900 to 2020. Dots show annual values. Bars show averages over 5-year periods (last bar is a 6-year average). The horizontal black line shows the long-term (entire period) average of 1.2 days. A typical reporting station experiences about 1 event per year. The number of 3-inch extreme precipitation events has been above average since 1995, but there is no statistically significant long-term trend. Sources: CISESS and NOAA NCEI. Data: GHCN-Daily from 12 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 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. Warming is projected despite the lack of a long-term temperature trend because the increased warming influence of greenhouse gases will become greater than the natural variations that have dominated Alabama's temperature climate.

Future changes in total annual precipitation are uncertain (Figure 4). However, any increase in temperature will accelerate the rate of soil moisture loss during dry periods and likely increase the intensity of naturally occurring droughts. **Increases in extreme precipitation are projected for Alabama, because it is virtually certain that atmospheric water vapor will increase in a warmer world**.

Increasing temperatures raise concerns for sea level rise in coastal areas. Since 1900, global average sea level has risen by about 7–8 inches. It is projected to rise another 1–8 feet, with a likely range of 1–4 feet, by 2100 as a result of both past and future emissions from human activities (Figure 5). Based on observed data from 1966 to 2020, the local sea level at Dauphin Island has increased 1.6 inches per decade. Sea level rise has caused an increase in tidal floods associated with nuisance level impacts. Nuisance floods are events in which water levels exceed the local threshold (set by NOAA's National Weather Service) for minor impacts. These events can damage infrastructure, cause road closures, and overwhelm storm drains. Nuisance flooding has increased in all U.S. coastal areas, with more rapid increases along the East and Gulf Coasts. Nuisance flooding events in Alabama are likely to occur more frequently as global and local sea levels continue to rise.

Naturally occurring land subsidence (sinking) is a major contributor to increases in sea level rise in Alabama, with land in the Dauphin Island area projected to subside an additional 6.6 inches by 2100. A recent U.S. Department of Transportation study found that highways and port and marine waterway systems along the low-lying coast of Mobile, as well as coastal wetlands, are particularly vulnerable to storm surge and sea level rise. The percentage of critical ports exposed to sea level rise ranges from 46% under the study's lowest scenario (1 foot of sea level rise by 2050) to 92% under the highest scenario (6.6 feet by 2100).

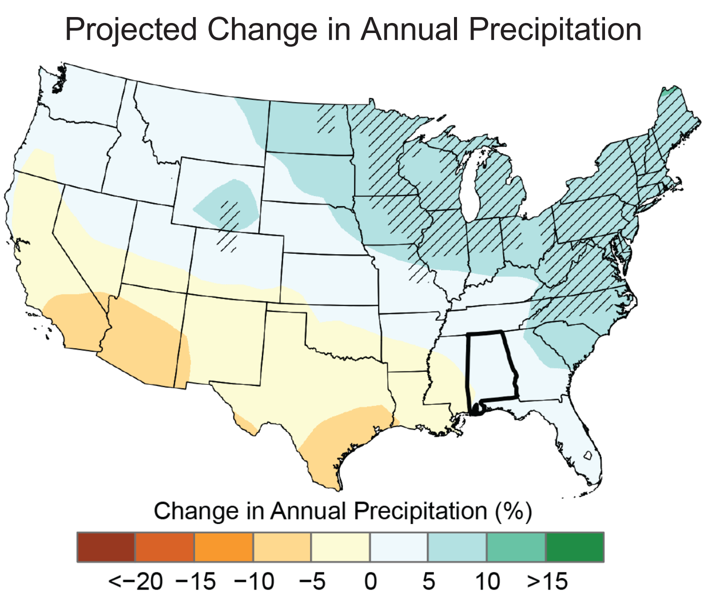


Figure 4: Projected changes in total annual precipitation (%) for the middle of the 21st century compared to the late 20th century under a higher emissions pathway. Hatching represents areas where the majority of climate models indicate a statistically significant change. The southeastern United States, including Alabama, is in a transition zone between projected high-latitude increases and subtropical decreases in precipitation, and as such, future precipitation changes are uncertain. Sources: CISESS and NEMAC. Data: CMIP5.

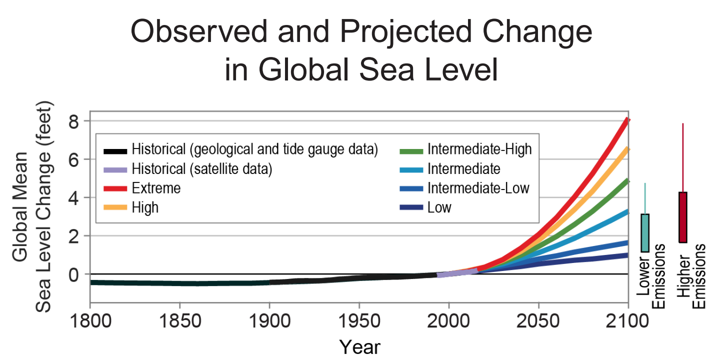


Figure 5: Global mean sea level (GMSL) change from 1800 to 2100. Projections include the six U.S. Interagency Sea Level Rise Task Force GMSL scenarios (Low, navy blue; Intermediate-Low, royal blue; Intermediate, cyan; Intermediate-High, green; High, orange; and Extreme, red curves) relative to historical geological, tide gauge, and satellite altimeter GMSL reconstructions from 1800–2015 (black and magenta lines) and the very likely ranges in 2100 under both lower and higher emissions futures (teal and dark red boxes). Global sea level rise projections range from 1 to 8 feet by 2100, with a likely range of 1 to 4 feet. Source: adapted from Sweet et al. 2017.

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

WWW.NCEI.NOAA.GOV | HTTPS://STATESUMMARIES.NCICS.ORG/CHAPTER/AL/ | LEAD AUTHORS: JENNIFER RUNKLE, KENNETH E. KUNKEL
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