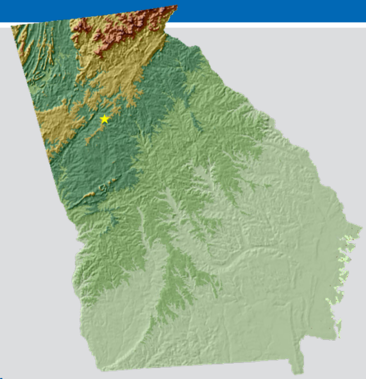

GEORGIA

Key Messages

Temperatures in Georgia have risen by 0.8°F, about half of the warming for the contiguous United States, since the beginning of the 20th century, but the warmest consecutive 5-year interval was 2016–2020. However, under a higher emissions pathway, historically unprecedented warming is projected during this century, including increases in heat wave intensity and decreases in cold wave intensity.

Higher temperatures will increase the rate of soil moisture loss during dry spells, which could lead to more intense droughts and increased competition for the state's water resources.

Global sea level has risen by about 7 to 8 inches since 1900 and is projected to rise another 1 to 4 feet by 2100. Sea level rise will increase the frequency, extent, and severity of coastal flooding, posing a grave risk to developments along Georgia's coastline.

Due to its location at subtropical latitudes and proximity to the warm waters of the Gulf of Mexico and the Atlantic Ocean, Georgia has a climate characterized by long, hot and humid summers and short, usually mild winters. Georgia is the largest U.S. state in land area east of the Mississippi River and encompasses diverse geographic features. Elevation ranges from sea level along the coast to higher than 4,700 feet in the Blue Ridge Mountains in the northeast. Temperatures vary substantially across the state. Inland cities, such as Macon and Columbus, experience very high summertime temperatures, with an average of around 20 days per year exceeding 95°F, while Atlanta averages only 7 such days and areas in the Appalachian Mountains less than 1. The number of very warm nights also varies across Georgia. Locations in the Appalachian Mountains rarely experience such nights, while Atlanta averages 4 per year and Brunswick, located along the southeastern coast, more than 30.

Temperatures in Georgia have risen by 0.8°F, about half of the warming for the contiguous United States, since the beginning of the 20th century, but the warmest consecutive 5-year interval was 2016–2020 (Figure 1). During the last century, temperatures in Georgia were highest in the 1920s and 1930s, followed by a cooling of almost 2°F by the

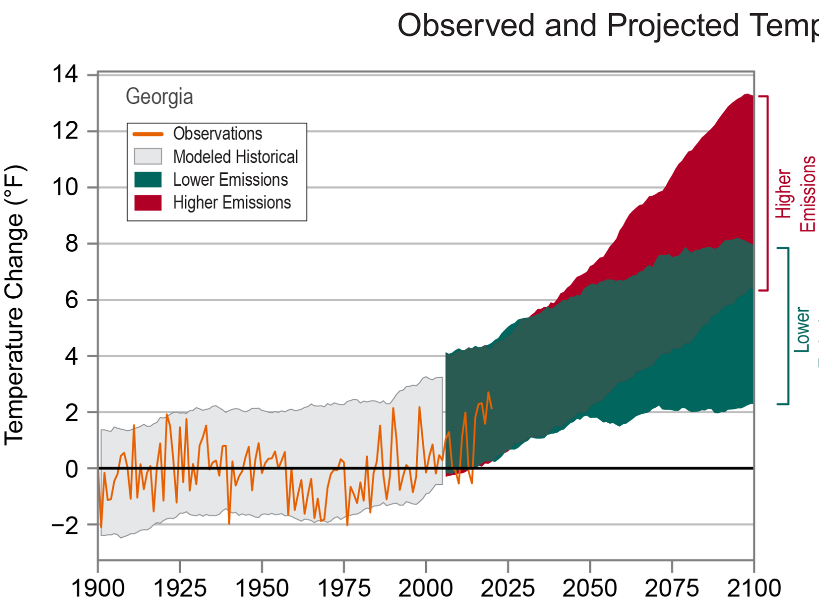

Figure 1: Observed and projected changes (compared to the 1901–1960 average) in near-surface air temperature for Georgia. Observed data are for 1900–2020. Projected changes for 2006–2100 are from global climate models for two possible futures: one in which greenhouse gas emissions continue to increase (higher emissions) and another in which greenhouse gas emissions increase at a slower rate (lower emissions). Temperatures in Georgia (orange line) have risen by 0.8°F, about half of the warming for the contiguous United States, since the beginning of the 20th century, but the warmest consecutive 5-year interval was 2016–2020. 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 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.

1960s. Temperatures have risen since that cool period by about 3°F, such that the temperatures of the 1990s and 2000s approximated the levels of the 1930s; however, the 2015–2020 period reached a record-high level that far exceeded the one set during the 1930–1934 period. 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 Georgia. 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.

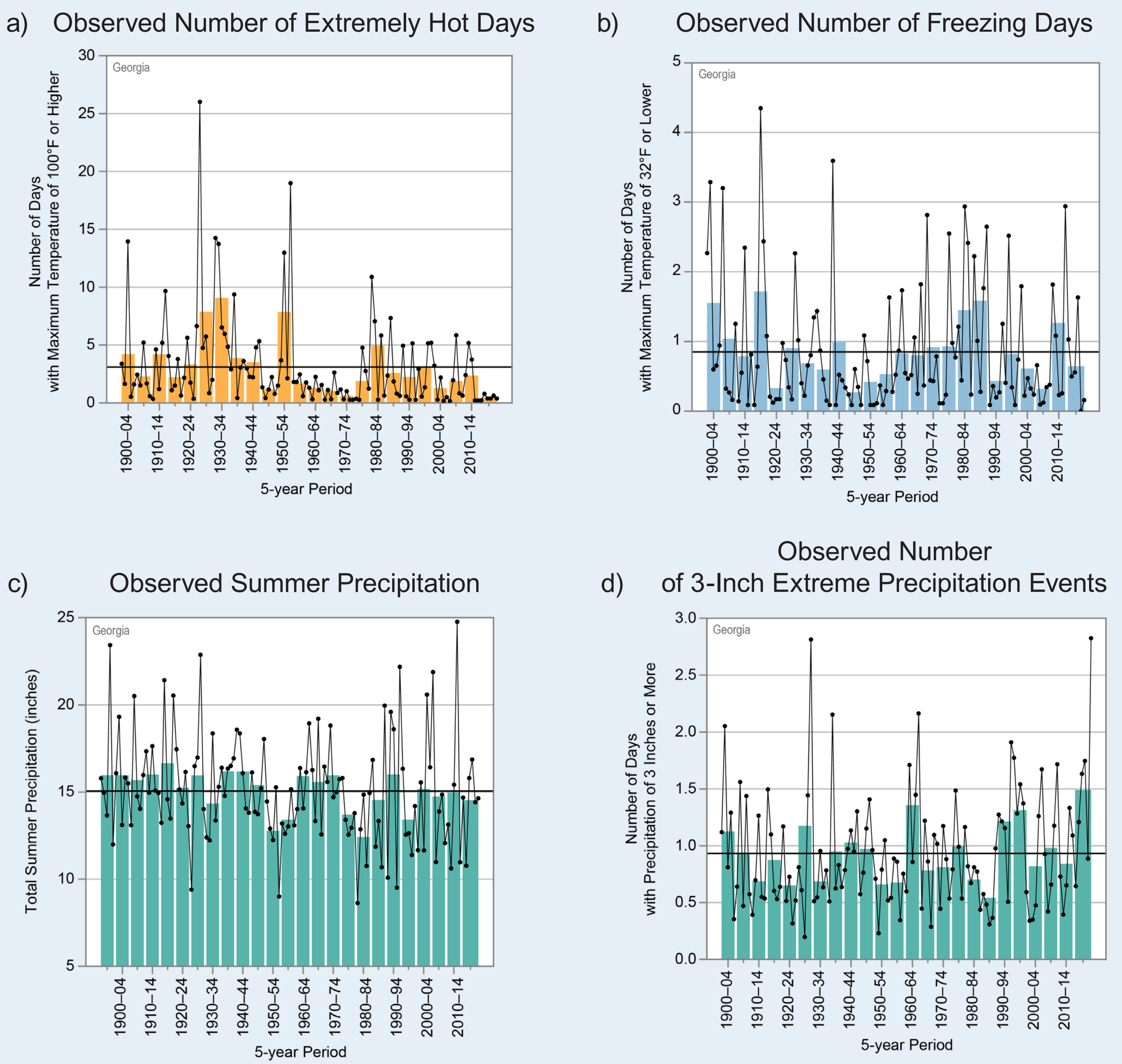

Figure 2: Observed (a) annual number of extremely hot days (maximum temperature of 100°F or higher), (b) annual number of freezing days (maximum temperature of 32°F or lower), (c) total summer (June–August) precipitation, and (d) annual number of 3-inch extreme precipitation events (days with precipitation of 3 inches or more) for Georgia from (a, b, d) 1900 to 2020 and (c) 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) 3.1 days, (b) 0.9 days, (c) 15.1 inches, (d) 0.9 days. The number of extremely hot days and freezing days has generally been below average since 1955 and 1990, respectively. Summer precipitation has been near or below average since 1995. The number of 3-inch extreme precipitation events is variable but reached its highest level during the 2015 to 2020 period. A typical reporting station experiences about 1 event per year. Sources: CISESS and NOAA NCEI. Data: (a, b) GHCN-Daily from 11 long-term stations; (c) nClimDiv; (d) GHCN-Daily from 19 long-term stations.

Extreme high temperatures in Georgia have shown wide variability over the period of record (1895–2020). The highest number of extremely hot days occurred during the late 1920s, early 1930s, and early 1950s; however, since 1955, the number of these days has generally been near or below average (Figure 2a). The number of very warm nights has shown similar variability and, with the exception of the interval between 2005 and 2014, has been below average since 1955 (Figure 3). The number of freezing days has generally been below average since 1990 (Figure 2b). Georgia has recently experienced several warm years: 2016, 2017, and 2019 were the three hottest on record. On June 29, 2012, Athens set a record-high temperature of 109°F, and on the following day, Atlanta set a record of 106°F.

The state's climate is favorable for a wide variety of agricultural crops; however, untimely cold spells can have devastating consequences. After a very warm winter, freezing temperatures from March 14 to 16, 2017, had severe impacts on blueberry and peach crops in particular, with overall industry losses of about $1 billion.

Georgia receives abundant precipitation throughout the year, with totals ranging from more than 70 inches in the mountainous northeastern corner of the state to around 45 inches in the southeastern and central portions. Statewide annual total precipitation has ranged from a low of 31.1 inches in 1954 to a high of 70.5 inches in 1964. The driest multiyear periods were in the early 1930s, early 1950s, and late 1980s and the wettest in the late 1940s, early 1960s, and early 1990s (Figure 4). The driest consecutive 5-year interval was 1954–1958, averaging 43.8 inches per year, and the wettest was 1944–1948, averaging 56.7 inches per year. The year 2013 was the fifth wettest, with a statewide average of 63.5 inches, while 2018 and 2020 were the tenth and eleventh wettest, respectively. Snowfall is generally light in the state. Even in the northern mountains, total annual snowfall averages only 5 inches.

The Bermuda High, a semipermanent high-pressure system off the Atlantic Coast, plays an important role in Georgia's summer climate. Typically, the Bermuda High draws moisture northward or westward from the Atlantic Ocean and the Gulf of Mexico, causing warm and moist summers with frequent thunderstorms in the

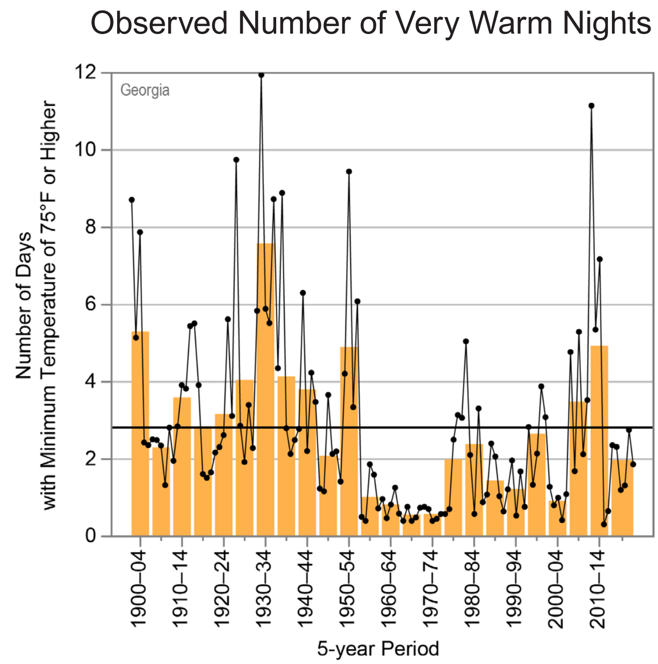

Figure 3: Observed annual number of very warm nights (minimum temperature of 75°F or higher) for Georgia from 1900 to 2020. Dots show annual values. Bars show averages over 5-year periods (last bar is a 6-year average). The horizontal black line shows the long-term (entire period) average of 2.8 nights. During the first half of the 20th century, Georgia experienced a high frequency of very warm nights. With the exception of the interval between 2005 and 2014, the number of these nights has been below average since 1955. Sources: CISESS and NOAA NCEI. Data: GHCN-Daily from 11 long-term stations.

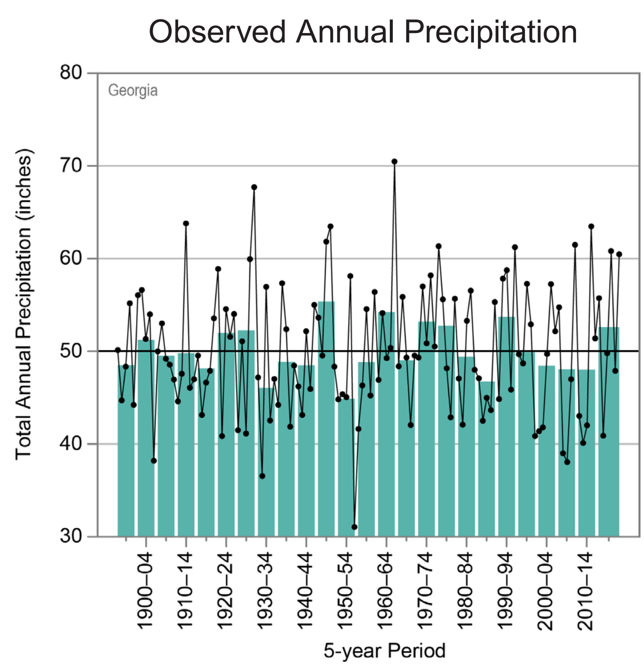

Figure 4: Observed total annual precipitation for Georgia from 1895 to 2020. Dots show annual values. Bars show averages over 5-year periods (last bar is a 6-year average). The horizontal black line shows the long-term (entire period) average of 50.0 inches. Georgia receives abundant precipitation throughout the year. There is no long-term trend in annual precipitation. Sources: CISESS and NOAA NCEI. Data: nClimDiv.

afternoons and evenings. Daily and weekly variations in the positioning of the Bermuda High can strongly influence precipitation patterns. When it extends westward into the southeastern United States, hot and dry weather occurs, which can result in heat waves and drought. In 2007, as a result of a strong Bermuda High over the Southeast and a strengthening La Niña, Georgia experienced its third-driest year on record. This very dry year, compounded by low precipitation in 2006 (the state's fifth-driest year), led to one of Georgia's worst droughts. By the end of August, most of the state was in severe or extreme drought.

Thunderstorms are common in Georgia, particularly in the spring and summer months, and often bring heavy rains that can cause severe flooding (Figure 2d). During September 16–22, 2009, torrential rains caused severe flooding in North Georgia and the Atlanta area. Over this 1-week period, some portions of the state received more than 15 inches of rain, with the Chattahoochee River reaching 100-year flood levels and the Sweetwater Creek basin reaching 500-year flood levels. Seventeen counties were declared federal disaster areas, and damages from the flooding exceeded $500 million. Tornadoes are another hazard of these thunderstorms. On March 14, 2008, a tornado struck downtown Atlanta, causing 1 death and more than $150 million in damages. The following day, the same storm system spawned multiple tornadoes across the state, including an EF3 tornado in northwestern Georgia, which killed 2 people. Only ten EF4 tornadoes have occurred in Georgia since 1950. One such tornado hit Catoosa County on the evening of April 27, 2011, as part of the historic 2011 Super Outbreak. Another EF4 tornado occurred more recently, on March 26, 2021, in Newnan, causing widespread damage and 1 fatality.

Although Georgia rarely experiences direct landfall of hurricanes, tropical storm system remnants can bring heavy rains and strong winds to the state. In 1994, Tropical Storm Alberto passed over the state, resulting in significant rain totals. More than 27 inches of precipitation fell on Americus in the southwestern part of the state—21 of those inches fell within 24 hours, setting a new state record. Alberto caused significant flooding, particularly along the Flint and Ocmulgee Rivers, which resulted in 33 deaths and extensive agricultural losses. In September 2004, precipitation from the remnants of three hurricanes—Frances, Ivan, and Jeanne—resulted in Georgia's wettest September on record and significant flooding across the state. In 2018, Hurricane Michael was the first major hurricane (Category 3+) to directly impact Georgia since the 1890s. Wind gusts as high as 115 mph were recorded in Donalsonville, in southwest Georgia. On the evening of October 10, winds exceeding 70 mph in portions of central Georgia led to widespread tree damage, power outages, and severe crop damage, especially to cotton and peach crops.

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. Heat waves are projected to intensify in this region, which already experiences hot and humid conditions. Extreme heat is a particular concern for Atlanta 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.

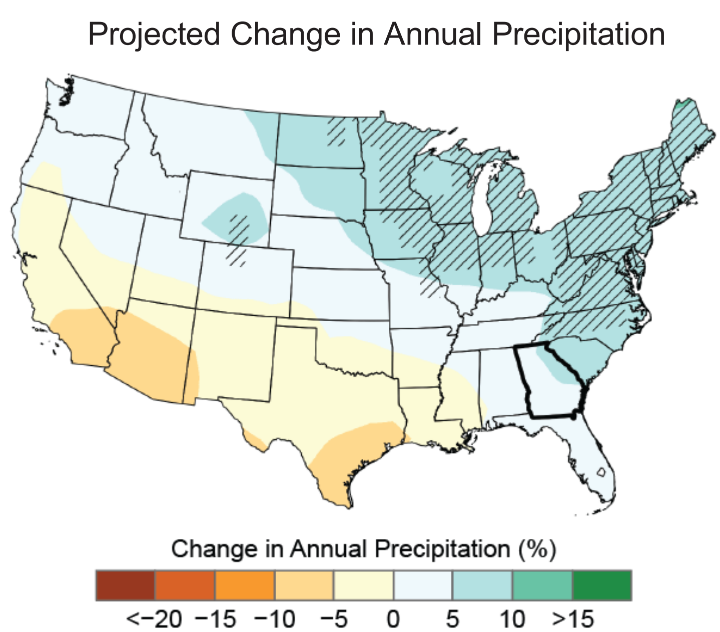

Figure 5: Projected changes in total annual precipitation (%) for the middle of the 21st century compared to the late 20th century under a higher emissions pathway. Hatching represents areas where the majority of climate models indicate a statistically significant change. Precipitation is projected to increase throughout Georgia; however, these changes are small relative to the natural variability in this region. Sources: CISESS and NEMAC. Data: CMIP5.

Precipitation projections for Georgia are uncertain (Figure 5). Even if annual precipitation remains constant, higher temperatures will increase evaporation rates and decrease soil moisture during dry spells, leading to greater drought intensity. This could increase competition for limited water resources, such as the Apalachicola–Chattahoochee–Flint River basin, which currently supports large population centers in multiple states.

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 6). 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.

Observed and Projected Change in Global Sea Level

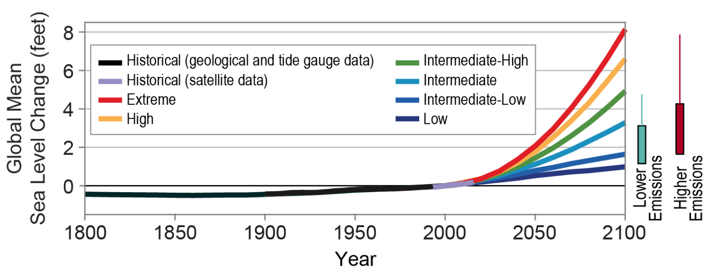

Figure 6: Global mean sea level (GMSL) change from 1800 to 2100. Projections include the six U.S. Interagency Sea Level Rise Task Force GMSL scenarios (Low, navy blue; Intermediate-Low, royal blue; Intermediate, cyan; Intermediate-High, green; High, orange; and Extreme, red curves) relative to historical 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.

These events can damage infrastructure, cause road closures, and overwhelm storm drains. As sea level has risen along the Georgia coastline, the number of tidal flood days (all days exceeding the nuisance-level threshold) has also increased, with the greatest number (13) occurring at Fort Pulaski in 2019 (Figure 7). **Georgia is at extreme risk for sea level rise due to its low elevation along the coast**. Continued sea level rise will present major challenges to Georgia's existing coastal water management system and could cause extensive economic harm through ecosystem damage and losses in property, tourism, and agriculture.

Observed and Projected Annual Number of Tidal Floods for Fort Pulaski, GA

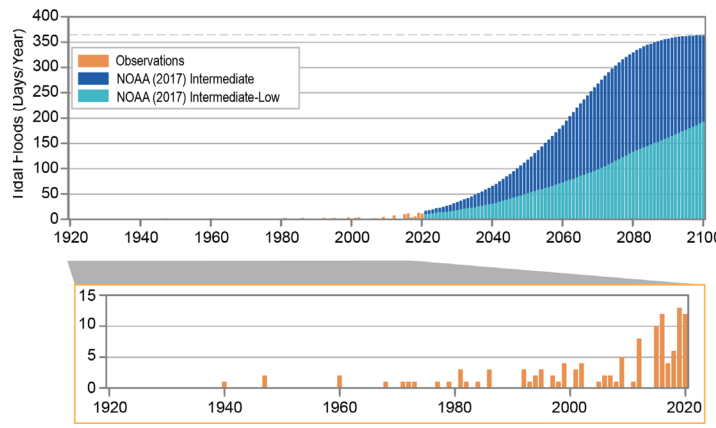

Figure 7: Number of tidal flood days per year at Fort Pulaski, Georgia, for the observed record (1935–2020; orange bars) and projections for two NOAA (2017) sea level rise scenarios (2021–2100): Intermediate (dark blue bars) and Intermediate-Low (light blue bars). The NOAA (2017) scenarios are based on local projections of the GMSL scenarios shown in Figure 6. Sea level rise has caused a gradual increase in tidal floods associated with nuisance-level impacts. The greatest number of tidal flood days (all days exceeding the nuisance-level threshold) occurred in 2019 at Fort Pulaski. Projected increases are large even under the Intermediate-Low scenario. Under the Intermediate scenario, tidal flooding is projected to occur nearly every day of the year by the end of the century. Additional information on tidal flooding observations and scenarios is available online at https://statesummaries.ncics.org/technicaldetails. Sources: CISESS and NOAA NOS.

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

WWW.NCEI.NOAA.GOV | HTTPS://STATESUMMARIES.NCICS.ORG/CHAPTER/GA/ | LEAD AUTHORS: REBEKAH FRANKSON, KENNETH E. KUNKEL
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