

FLORIDA

KEY MESSAGES

Under a higher emissions pathway, historically unprecedented warming is projected by the end of the 21st century. Rising temperatures will likely increase the intensity of naturally-occurring droughts in this area because of increases in rate of loss of soil moisture.

The number of landfalling hurricanes in Florida is highly variable from year to year. Hurricane rainfall rates are projected to increase as the climate continues to warm.

Global sea level has risen about 8 inches since reliable record keeping began in 1880. It is projected to rise another 1 to 4 feet by 2100, likely causing increases in nuisance-level coastal flooding and contributing to saltwater contamination of coastal groundwater reservoirs.

Florida's location at subtropical latitudes and adjacent to the warm waters of the Gulf of Mexico and western Atlantic gives it a climate with hot, humid summers and mild winters. Average temperatures in January range from the lower 50s (°F) in the northern portion of the state to the upper 60s (°F) in the southern portion. During July, typically the hottest month of the year, monthly average temperatures are similar throughout state in the low 80s°F. Annual average precipitation is approximately 54 inches across the state, with more precipitation occurring through the warmer months of June through September. The driest year on record occurred in 2000 with a statewide average of 40 inches of precipitation, and the wettest year on record was in 1947 with about 73 inches of rainfall.

Temperatures in Florida have increased about 1°F since the beginning of the 20th century (Figure 1). While there has been a lack of general daytime warming (Figure 2a), the frequency of very warm nights (minimum temperature above 75°F) has risen dramatically in the last two decades (Figure 3). The number of very warm nights during the first part of the 21st century has nearly doubled when compared to the occurrence of very warm nights in the mid-20th century (1930–1954). While Florida typically experiences far fewer days with temperatures exceeding 100°F than most other southern states, it is the most humid state in the Nation leading to uncomfortable summers for visitors and local residents. Extended periods of extreme heat, especially when combined with high humidity, can result in heat-related illness among vulnerable populations, as well as place excess stress on agricultural production, water supplies, and energy generation.

Observed and Projected Temperature Change

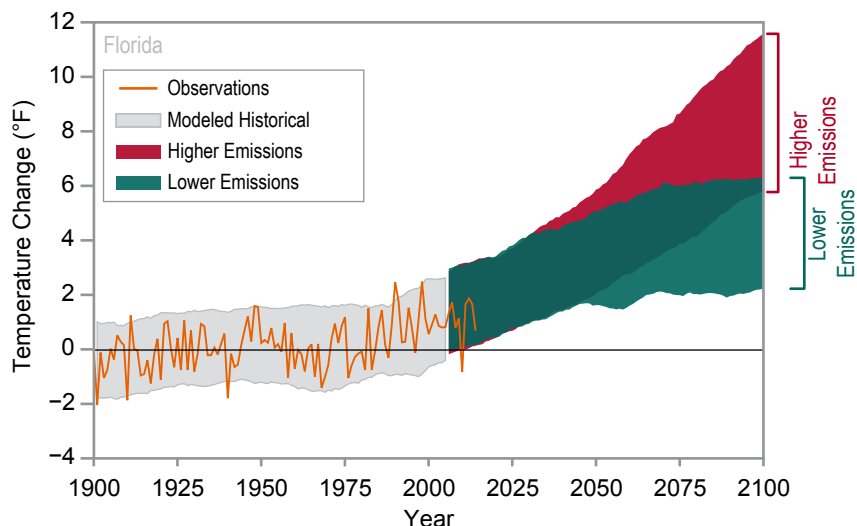
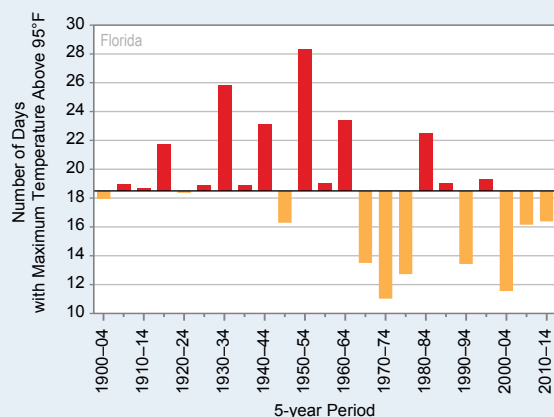


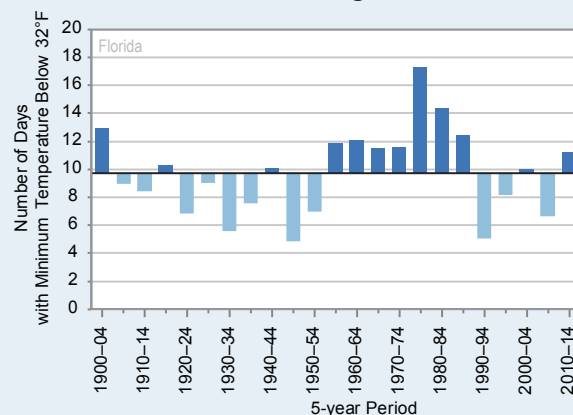
Figure 1: Observed and projected changes (compared to the 1901–1960 average) in near-surface air temperature for Florida. Observed data are for 1900–2014. Projected changes for 2006–2100 are from global climate models for two possible futures: one in which greenhouse gas emissions continue to increase (higher emissions) and another in which greenhouse gas emissions increase at a slower rate (lower emissions)¹. Temperatures in Florida (orange line) have risen about 1°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 the 21st century. Less warming is expected under a lower emissions future (the coldest years being about as warm as the hottest year in the historical record; green shading) and more warming under a higher emissions future (the hottest years being about 9°F warmer than the hottest year in the historical record; red shading). Source: CICS-NC and NOAA NCEI.

¹Technical details on models and projections are provided in an appendix, available online at: <https://statesummaries.ncics.org/fl>.

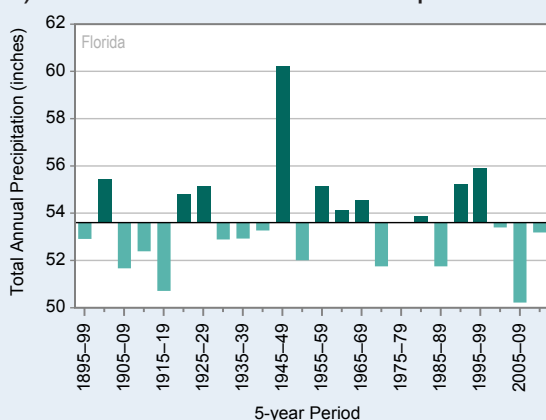
a) Observed Number of Very Hot Days



b) Observed Numbers of Nights Below Freezing



c) Observed Annual Precipitation



d) Total Hurricane Events in Florida, 1900–2013

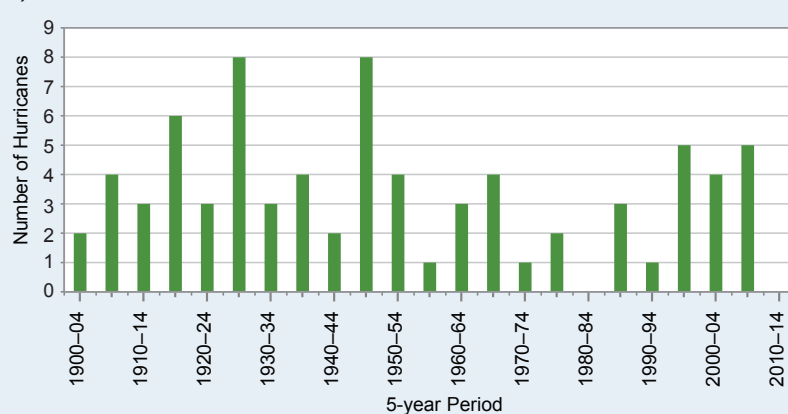


Figure 2: The observed (a) number of very hot days (maximum temperature above 95°F), (b) number of nights below freezing (minimum temperature below 32°F), (c) average annual precipitation, and (d) total number of hurricane events (hurricane-force winds experienced somewhere in the state), averaged over 5-year periods. The values in Figures 2a and 2b are averages from 14 long-term reporting stations. The values in Figure 2c are from NCEI's version 2 climate division dataset. The dark horizontal lines represent the long-term average. The number of very hot days has been variable with a record number of such days occurring during 1950–1954. The number of nights below freezing has also been quite variable, reaching a peak during 1975–1979. Florida has experienced below average precipitation in the last decade (2005–2014) characterized by a simultaneous increase in the occurrence of drought and wild fires. Hurricane strikes are a frequent occurrence along the Florida coast, with most 5-year periods experiencing at least 3 hurricanes. Some time periods are more active than others. For example, following a very active 2004 (4 events) and 2005 (5 events), there were no landfalling hurricanes recorded for the state from 2006 to 2015. Source: CICS-NC, NOAA NCEI, and NOAA AOML.

During the cold season, extratropical cyclones and associated fronts are responsible for significant day-to-day variability in the weather. While the temperatures associated with cold waves are warmer than areas to the north, they can have major impacts on sectors adapted to the generally mild climate. For example, the occurrence of several strong freezes beginning in the 19th century has gradually forced the citrus industry and other industries (e.g., winter vegetables and sugarcane), to migrate from northern Florida into South Florida. The annual number of freezing days (minimum temperature equal to or below 32°F) varies from about 15 days in the far north to near zero in the south (Figure 4); in 80 years of records, Miami's airport has dropped below freezing only 7 times, and never since 1989. Sometimes subfreezing air reaches as far south as Central Florida, causing major damage to citrus crops. A severe cold

outbreak lasting more than a week in January 2010 resulted in more than \$200 million in losses to the Florida citrus crop industry. There is no long-term trend in the number of freezing days, but there has been a decrease since high numbers in the 1970s (Figure 2b)

Annual precipitation for the state varies widely between years (Figure 2c). Florida has experienced below average precipitation in the last decade. The 5-year period (2006–2010) was the driest on record with a little less than 48 inches of precipitation per year while 1945–1949 was the wettest with more than 60 inches per year. Historically the number of extreme precipitation events (precipitation greater than 4 inches) has been highly variable; the highest 5-year average number occurred during 2010–2014 (Figure 5). Two notable extreme precipitation events occurred in 2014. During

January 9-10, torrential rain fell in the West Palm Beach area with more than 10 inches at Ft. Pierce and more than 14 inches in Sun Valley. On April 29 in the Panhandle, more than 15 inches fell in Pensacola and about 20 inches in Milton. Drought is a persistent climate threat for Florida resulting in reductions in water supplies, disruptions to agriculture, and increased risk of wildfires. In every decade since 1900, the state has been impacted by at least one severe and widespread drought.

Thunderstorms are ubiquitous during the summer. Florida experiences the highest annual number of thunderstorms in the United States. The most serious weather threat is hurricanes or intense coastal storms. **Over the past decade, Florida has experienced 13 weather and climate disaster events that exceeded \$1 billion in damages.** The majority of these billion-dollar disaster events have been associated with hurricanes and tropical storms (nine events), while the remaining events have been related to wildfires (2006 and 2008 wildfire events) and drought and heat waves (2006 and 2007, respectively). Hurricane strikes are a frequent occurrence along the Florida coast, with hurricane-force winds striking the state an average of three times every five years (Figure 2d). In 1992, Hurricane Andrew (Category 5) made landfall on the coastline of South Florida causing more than \$26 billion in damages.

Under a higher emissions pathway, historically unprecedented warming is projected by the end of the 21st century (Figure 1). Even under a pathway of lower greenhouse gas emissions, average annual temperatures are projected to most likely exceed historical record levels by the middle of the 21st century. However, there is a large range of temperature increases under both pathways, and under the lower pathway, a few projections are only slightly warmer than historical records. By 2055, projections show an increase over most of the state of more than 50 days with temperatures exceeding 95°F. The summer heat index is projected to increase by 8°F to 15°F, the largest in the Nation.

Increases in extreme precipitation and drought are projected. Future projections of average precipitation are uncertain, but an increase in intense rainfall is projected. Though average summer precipitation may not change (Figure 6), higher temperatures will increase the rate

of loss of soil moisture and thereby droughts will likely be more intense. Decreased water availability, exacerbated by population growth and land-use change, will continue to increase competition for water and affect the region's economy and unique ecosystems. Increasing drought intensity will likely trigger more frequent wildfire events. Typically, the state exhibits a peak in wildfire activity from January to mid-June, a period when tropical moisture is reduced and occasional cold fronts usher in dry, windy conditions. An estimated 4,600 fires occur annually in Florida, burning nearly 110,000 acres of land.

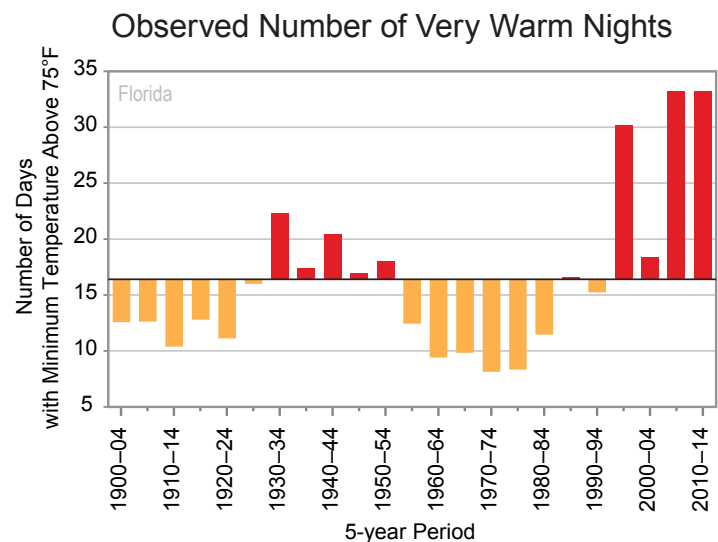


Figure 3: The observed number of very warm nights (annual number of days with minimum temperature above 75°F divided by the number of long-term stations) for 1900–2014, averaged over 5-year periods; these values are averages from 14 long-term reporting stations. The dark horizontal lines represent the long-term average. The number of very warm nights has risen substantially over the last two decades (1995–2014), with the last two 5-yr periods tied for the record number of such nights (about 32 days per station per year over the two 5-year periods). Source: CICS-NC and NOAA NCEI.

Average Annual Number of Days with Minimum Temperature less than or equal to 32°F (1981–2010)

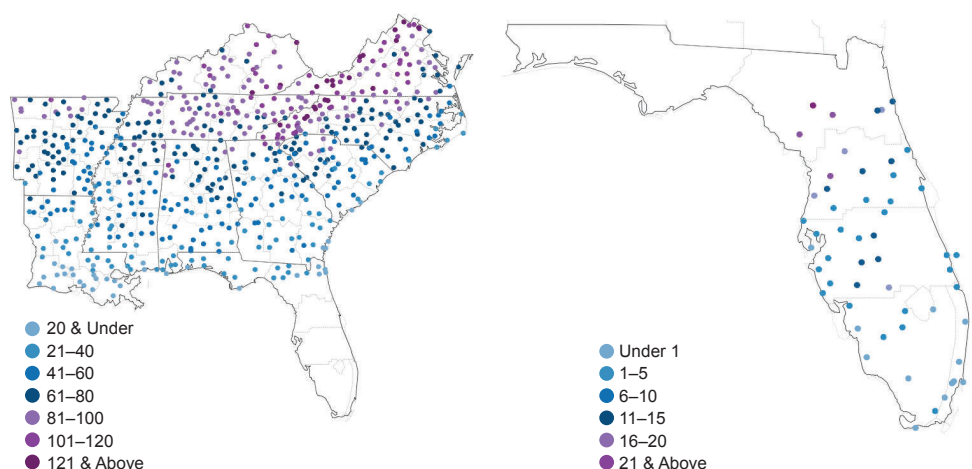


Figure 4: Average annual number of days with a minimum temperature less than or equal to 32°F for the Southeast region (left) and Florida (right, with a different scale). Source: NOAA Southeast Regional Climate Center.

While the annual frequency of hurricanes has remained relatively stable throughout the 20th and early 21st centuries (Figure 2d), **hurricane rainfall are expected to increase for Florida as the climate continues to warm.**

Since 1880, global sea level has risen by about 8 inches. 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. As sea level has risen along the Florida coastline, the number of tidal flood days (all days exceeding the nuisance level threshold) has also increased, with the greatest number occurring in 2015 (Figure 7). Increased inland flooding during heavy precipitation events in low-lying coastal areas is a threat because just inches of sea level rise have the potential to impair the capacity of stormwater drainage systems to empty into the ocean. **Sea level is projected to rise another 1 to 4 feet by 2100 as a result of both past and future emissions from human activities** (Figure 8), **with large associated increases in tidal flood days** (Figure 7). Sea level rise presents major challenges to South Florida's existing coastal water management system due to a combination of increasingly urbanized areas, aging flood control facilities, flat topography, and permeable limestone aquifers. Increases in in nuisance-level coastal flooding and saltwater contamination of coastal groundwater reservoirs are likely consequences of sea level rise.

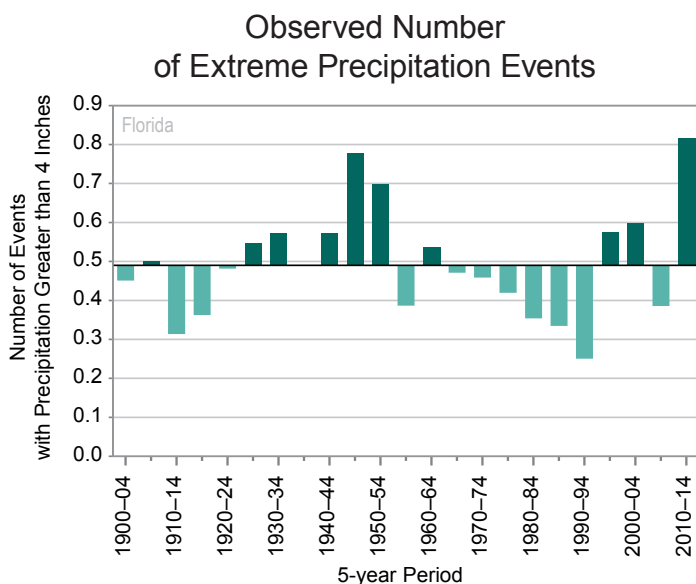


Figure 5: The observed number of extreme precipitation events (annual number of events with greater than 4 inches divided by the number of long-term stations) for 1950–2014, averaged over 5-year periods; these values are averages from 12 long-term reporting stations. The dark horizontal lines represent the long-term average. Significant variability is observed over the recorded 5-year periods. A record number of such events occurred during the most recent 5-year period (2010–2014) with an average of about 0.8 events per station per year. Source: CICS-NC and NOAA NCEI.

Projected Change in Summer Precipitation

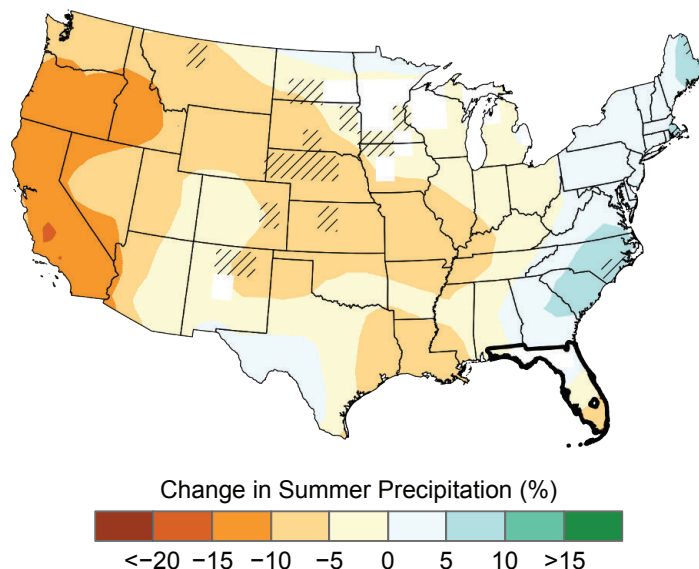


Figure 6: Projected change in summer precipitation (%) for the middle of the 21st century relative to the late 20th century under a higher emissions pathway. Hatching represents areas where the majority of climate models indicate a statistically significant change. Summer precipitation projections are uncertain for Florida, as well as for a larger part of the Southeast. Source: CICS-NC, NOAA NCEI, and NEMAC.

Observed and Projected Annual Number of Tidal Floods for Key West, FL

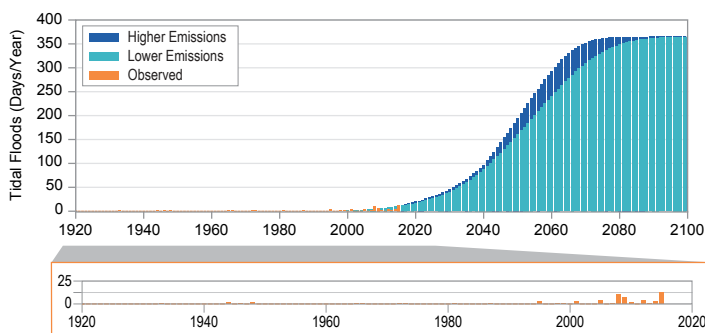


Figure 7: Number of tidal flood days per year for the observed record (orange bars) and projections for two possible futures: lower emissions (light blue) and higher emissions (dark blue) per calendar year for Key West, FL. Sea level rise has caused an increase in tidal floods associated with nuisance-level impacts. Nuisance floods are events in which water levels exceed the local threshold (set by NOAA's National Weather Service) for minor impacts, such as road closures and overwhelmed storm drains. The greatest number of tidal flood days (all days exceeding the nuisance level threshold) occurred in 2015 at Key West. Projected increases are large even under a lower emissions pathway. Near the end of the century, under both higher and lower emissions pathways, some models project tidal flooding nearly every day of the year. To see these and other projections under additional emissions pathways, please see the supplemental material on the State Summaries website (<https://statesummaries.ncics.org/fl>). Source: NOAA NOS.

Past and Projected Changes in Global Sea Level

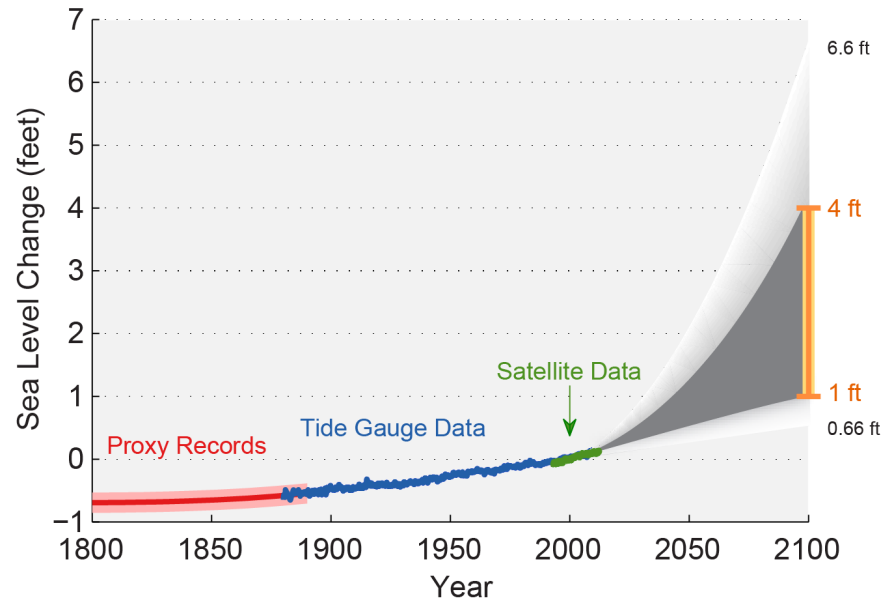


Figure 8: Estimated, observed, and possible future amounts of global sea level rise from 1800 to 2100, relative to the year 2000. The orange line at right shows the most likely range of 1 to 4 feet by 2100 based on an assessment of scientific studies, which falls within a larger possible range of 0.66 feet to 6.6 feet. Source: Melillo et al. 2014 and Parris et al. 2012.