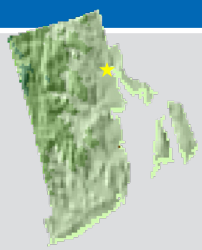
RHODE ISLAND



Key Messages

Temperatures in Rhode Island have risen almost 4°F since the beginning of the 20th century. Under a higher emissions pathway, historically unprecedented warming is projected to continue through this century. Increased intensity of heat waves is also projected, while cold waves are projected to decrease in intensity.

Annual precipitation in Rhode Island has increased since 1895. Extreme precipitation has increased since 1950, with the highest number of extreme events occurring during the 2005–2014 interval. Continued increases in frequency and intensity of extreme precipitation events are projected.

Since 1930, sea level has risen more than 9 inches at Newport, faster than the global average. Global average sea level is projected to rise another 1 to 4 feet by 2100. Increases in sea level will likely increase coastal flooding and erosion during winter storms (nor'easters) and hurricanes.

Rhode Island's geographic position in the mid-latitudes often places it near the jet stream, particularly in the late fall, winter, and spring. The state's frequently changing weather is a result of the regular passing of low-pressure storms associated with the jet stream. In addition, Rhode Island's location on the East Coast of North America exposes it to the cold winter and warm summer air masses of the continental interior and the moderate and moist air masses of the western Atlantic Ocean. In winter, the contrast between the frigid air masses of the continental interior and the relatively warm Atlantic Ocean provides the energy for occasional intense storms known as nor'easters. In Providence, average temperatures in July are around 74°F and in January about 29°F. Statewide annual average precipitation is about 46 inches. The driest year on record (28 inches of precipitation) was 1965, while the wettest year on record (63 inches of precipitation) was 1972. Average accumulated snowfall ranges from 20 inches on Block Island and along the southeastern shores of Narragansett Bay to between 40 and 55 inches in the western portion of the state.

Temperatures in Rhode Island have risen almost 4°F since the beginning of the 20th century (Figure 1)**.** The number of hot days has been above the long-term average since the 1990s with the greatest number occurring

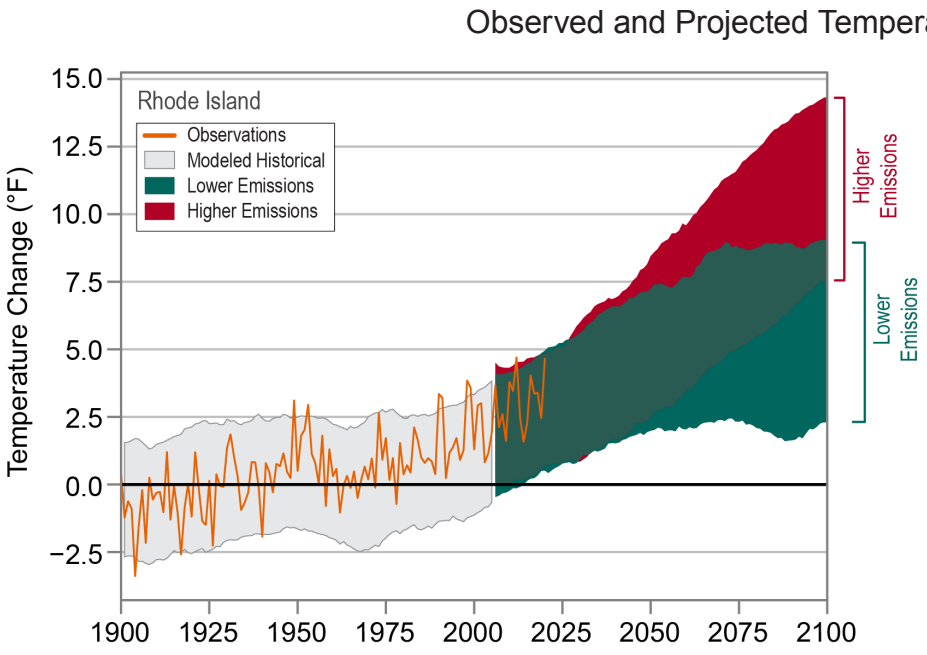


Figure 1: Observed and projected changes (compared to the 1901–1960 average) in near-surface air temperature for Rhode Island. Observed data are for 1900–2020. Projected changes for 2006–2100 are from global climate models for two possible futures: one in which greenhouse gas emissions continue to increase (higher emissions) and another in which greenhouse gas emissions increase at a slower rate (lower emissions). Temperatures in Rhode Island (orange line) have risen almost 4°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 1°F warmer than the historical average; green shading) and more warming under a higher emissions future (the hottest end-of-century projections being about 10°F warmer than the hottest year in the historical record; red shading). Sources: CISESS and NOAA NCEI.

during the most recent 6-year period of 2015–2020 (Figure 2). The greatest number of warm nights also occurred during the 2015–2020 period (Figure 3a). Very cold nights have been mostly below average since the mid-1980s, and the most recent 6-year period (2015–2020) was about average (Figure 4).

Total annual precipitation for Rhode Island has generally been above average in recent decades. The driest multiyear periods were the 1940s and the latter half of the 1960s and the wettest period was the 2000s, although precipitation has been predominantly above average since the 1970s. The driest consecutive 5 years was the 1962–1966 interval, and the wettest 5-year period was 2005–2009, with an annual average of 54 inches of precipitation, which was about 8 inches more than the long-term average (Figure 3c). Since 2000, summer precipitation was above average until the most recent 6-year period (2015–2020), which was below average (Figure 3d). Rhode Island experienced the largest number of 2-inch extreme precipitation events in the 10-year period of 2005–2014 (Figure 3b). In 2010, major rainfall from a nor'easter in late March caused the worst flooding in the state's history. This event set an all-time monthly precipitation record in Providence of 16.34 inches, superseding the previous record of 15.38 inches, which was recorded in October 2005. The flooding of 2010 resulted in an estimated $43 million in national flood insurance claims in the state. Rhode Island experienced severe drought in 2016 and extreme drought in 2020, straining water supplies.

Extreme weather events common to Rhode Island include severe storms (coastal, winter, and thunderstorms), often accompanied by flooding, and on occasion, tropical storms and hurricanes. The state's coastline is highly vulnerable to flood damage from winter and hurricane events. FEMA disaster declarations were sought 4 out of the last 10 years. Landfalling hurricanes produced hurricane-force winds in Rhode Island 6 times from 1900 to 2019. The Great New England Hurricane (Category 3) of 1938 was one of the most destructive and powerful storms ever to impact southern New England. Storm tides of 12 to 15 feet were recorded for Narragansett Bay, and downtown Providence was submerged under a storm tide of 20 feet. In October 2012, Superstorm Sandy (a post-tropical storm) caused a storm surge 9.4 feet above normal high tide in Providence, resulting in extensive coastal flooding. One year earlier, Hurricane Irene brought heavy rainfall and strong southeast winds of up to 70 mph, knocking down power lines and leaving half of Rhode Island's one million residents without power. Both hurricanes demonstrated the region's vulnerability to extreme weather events.

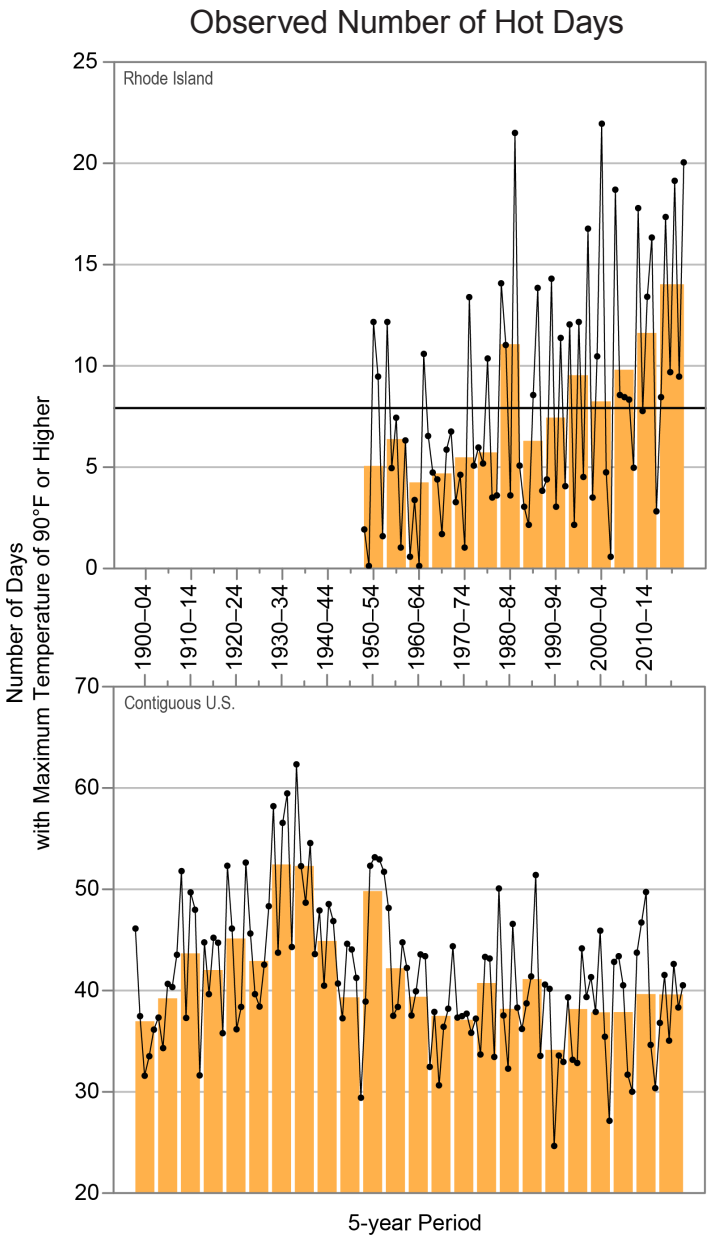


Figure 2: Observed annual number of hot days (maximum temperature of 90°F or higher) for Rhode Island from 1950 to 2020. Dots show annual values. Bars show averages over 5-year periods (last bar is a 6-year average). The horizontal black line shows the long-term (entire period) average of 7.9 days. Long-term stations dating back to 1900 were not available for Rhode Island. Values for the contiguous United States (CONUS) from 1900 to 2020 are included to provide a longer and larger context. The number of hot days has been above average since the mid-1990s. The highest number of such days occurred in the most recent 6-year period (2015–2020), with an average of 14 hot days occurring each year. Sources: CISESS and NOAA NCEI. Data: GHCN-Daily from 2 long-term stations.

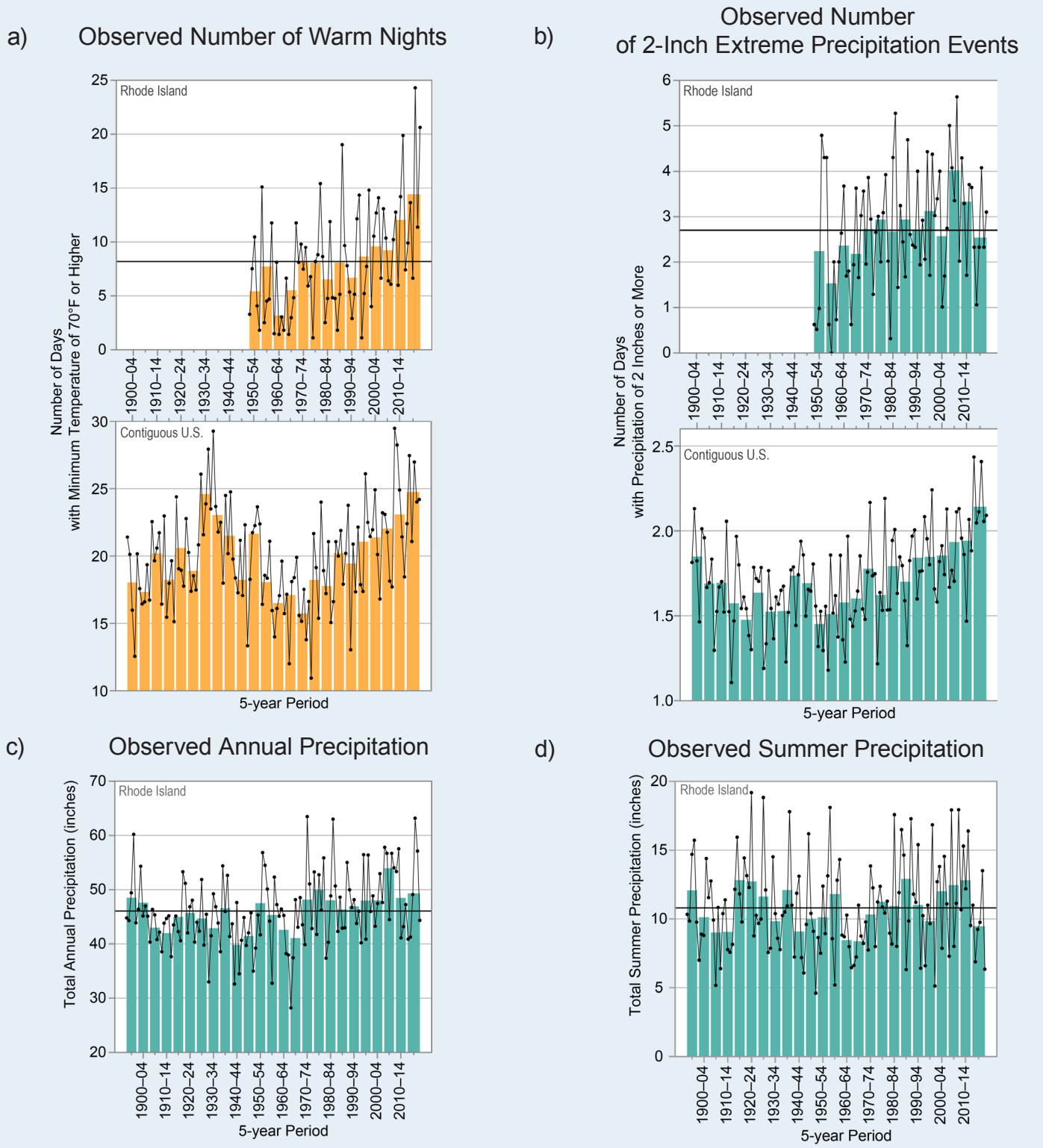


Figure 3: Observed (a) annual number of warm nights (minimum temperature of 70°F or higher), (b) annual number of 2-inch extreme precipitation events, (c) total annual precipitation, and (d) total summer (June–August) precipitation for Rhode Island from (a, b) 1950 to 2020 and (c, d) 1895 to 2020. Dots 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 for Rhode Island: (a) 8.2 days, (b) 2.7 days, (c) 46.1 inches, (d) 10.8 inches. Long-term stations dating back to 1900 were not available for Rhode Island. Values for the contiguous United States (CONUS) from 1900 to 2020 are included for Figures 2a and 2b to provide a longer and larger context. The number of warm nights has been above average since 1995, with the highest number occurring in the most recent 6-year period of 2015–2020. Since 1970, annual precipitation has remained above the long-term average, while summer precipitation has varied. Extreme precipitation events have shown an increasing trend overall, but the number of events was below average during the last 6-year period. The wettest 5-year period on record was 2005–2009, with an estimated 54 inches of annual precipitation. Sources: CISESS and NOAA NCEI. Data: (a) GHCN-Daily from 2 (RI) and 655 (CONUS) long-term stations; (b) GHCN-Daily from 3 (RI) and 832 (CONUS) long-term stations; (c, d) nClimDiv.

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. Heat waves are projected to increase in intensity while cold waves are projected to become less intense. Rhode Islanders may experience more heat-related deaths, and due to the heat island effect, hotter conditions will be most dangerous in urban areas.

Annual average precipitation is projected to increase for Rhode Island, with those increases coming in the winter and spring. Rhode Island is part of a large area of the Northern Hemisphere in the higher middle latitudes that is projected to see increases in precipitation (Figure 5), as well as increases in extreme precipitation events. More precipitation and a greater number of extreme precipitation events may also result in increased flooding risks. Although increased precipitation is projected, naturally occurring droughts are projected to be more intense because higher temperatures will increase evaporation rates.

Since 1900, global average sea level has risen by about 7–8 inches. Tide gauge recordings in Newport between 1930 and 2020 show an average rate of sea level rise of 0.11 inches (2.83 mm) per year, equivalent to about 11 inches over a century. Global average sea level 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) and will be accompanied by large increases in tidal flood events 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 Rhode Island coastline, the number of tidal flood days (all days exceeding the nuisance level threshold) has also increased, with the greatest number occurring in 2017 (Figure 7).

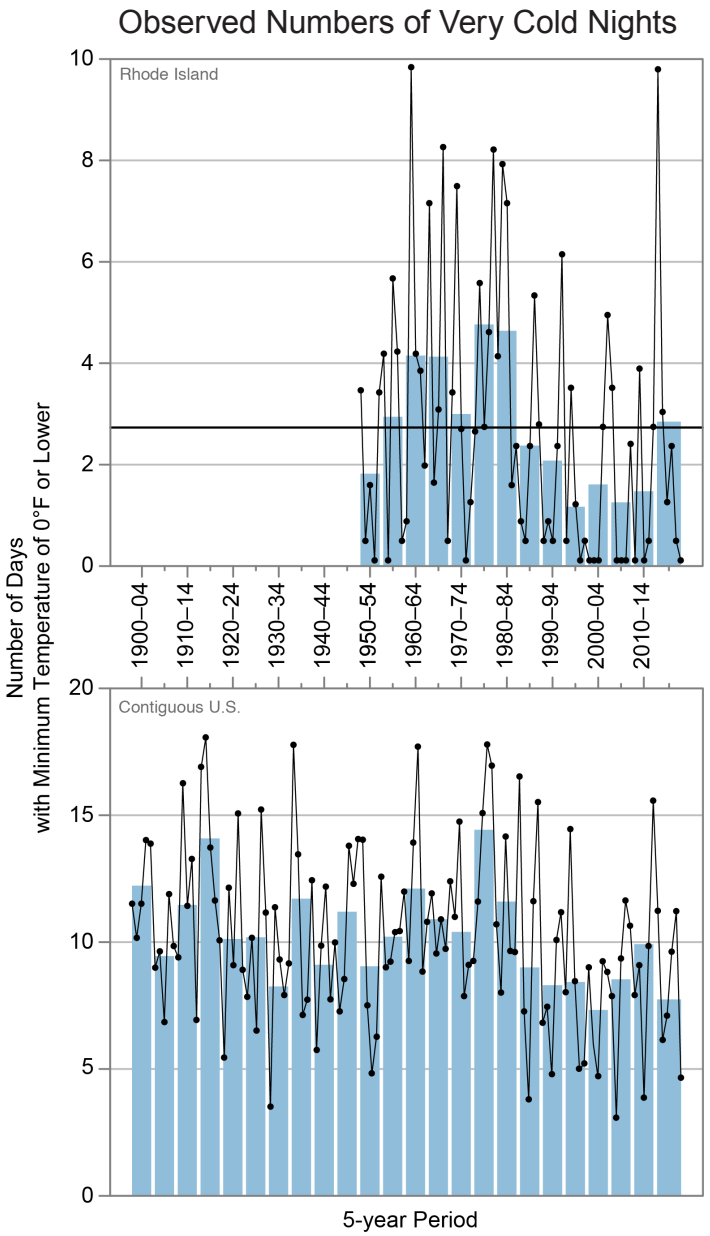


Figure 4: Observed annual number of very cold nights (minimum temperature of 0°F or lower) for Rhode Island from 1950 to 2020. Dots show annual values. Bars show averages over 5-year periods (last bar is a 6-year average). The horizontal black line shows the long-term (entire period) average of 2.7 days. Long-term stations dating back to 1900 were not available for Rhode Island. Values for the contiguous United States (CONUS) from 1900 to 2020 are included to provide a longer and larger context. The average number of very cold nights was highest in the late 1970s and early 1980s. Beginning in the mid-1980s, the observed number of such days was mostly below average, and the most recent 6-year period was about average. Sources: CISESS and NOAA NCEI. Data: GHCN-Daily from 2 long-term stations.

Higher sea levels will likely increase the probability for major flooding events. According to the National Flood Insurance Program, "the increase in the expected annual flood damage by the year 2100 for a representative National Flood Insurance Program (NFIP) insured property subject to sea level rise is estimated to increase by 36 to 58 percent for a one-foot rise" in sea level. Due to local land subsidence, sea level rise along most of the coastal Northeast is expected to exceed the global average rise. A sea level rise of two feet, without any changes in storms, would more than triple the frequency of dangerous coastal flooding throughout most of the Northeast.

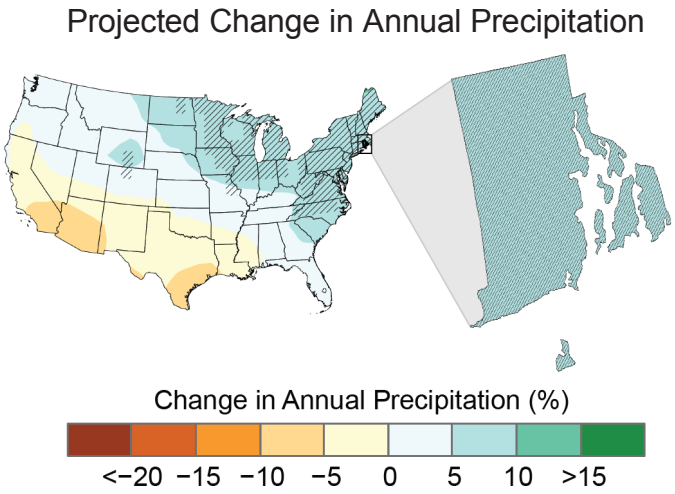


Figure 5: Projected changes in total annual precipitation (%) for the middle of the 21st century compared to the late 20th century under a higher emissions pathway. Hatching represents areas where the majority of climate models indicate a statistically significant change. Rhode Island is part of a large area of projected increases that includes the Northeast region. Sources: CISESS and NEMAC. Data: CMIP5.

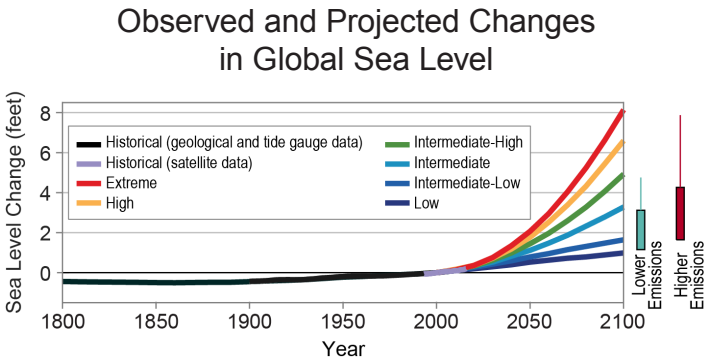


Figure 6: Global mean sea level (GMSL) change from 1800 to 2100. Projections include the six U.S. Interagency Sea Level Rise Task Force GMSL scenarios (Low, navy blue; Intermediate-Low, royal blue; Intermediate, cyan; Intermediate-High, green; High, orange; and Extreme, red curves) relative to historical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

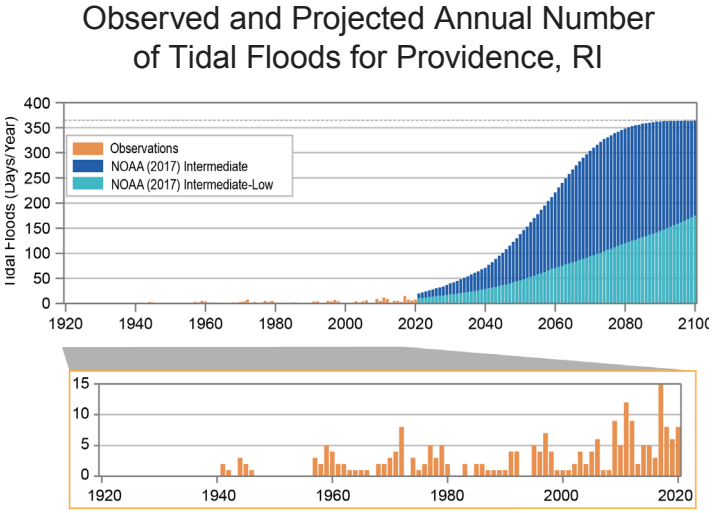


Figure 7: Number of tidal flood days per year at Providence, Rhode Island, for the observed record (1939–2020; orange bars) and projections for 2 NOAA (2017) sea level rise scenarios (2021–2100): Intermediate (dark blue bars) and Intermediate-Low (light blue bars). The NOAA (2017) scenarios are based 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 2017 at Providence. 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 at https://statesummaries.ncics.org/technicaldetails. Sources: CISESS and NOAA NOS.

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