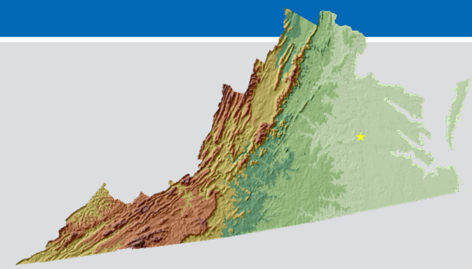

VIRGINIA

Key Messages

Temperatures in Virginia have risen more than 1.5°F since the beginning of the 20th century. Under a higher emissions pathway, historically unprecedented warming is projected during this century.

Naturally occurring droughts are projected to be more intense because higher temperatures will increase evaporation rates, accelerating soil moisture loss and adversely affecting agriculture.

The number and intensity of extreme heat and extreme precipitation events are projected to increase. Cold waves are projected to be less intense.

Virginia has a humid climate with very warm summers and moderately cold winters. There is substantial regional variation in climate due to the state's diverse geographic elements, which include the Appalachian and Blue Ridge Mountains in the west and the Atlantic coastal region in the east. Temperature and precipitation patterns are highly influenced by these geographic features, and the west and north tend to be cooler and drier than the eastern coastal region. Rainfall amounts generally decrease toward the west. For example, annual average (1991–2020 normals) precipitation is less than 40 inches in parts of the central mountain region of the state, compared to around 50 inches along the tidewater coastal region. Statewide average temperatures range from 35°F in January to 75°F in July. The Bermuda High, a semipermanent high-pressure system off the Atlantic coast, plays an important role in the summer climate of the state. Typically, the Bermuda High draws moisture northward or westward from the Atlantic Ocean and Gulf of Mexico, causing warm and moist summers with frequent thunderstorms in the afternoons and evenings. Daily and weekly variations in the positioning of the Bermuda High can strongly influence precipitation patterns.

Since the beginning of the 20th century, temperatures have risen more than 1.5°F in Virginia. The 1930s and 1950s were very warm, followed by a period of generally below average temperatures during the 1960s through the early 1980s (Figure 1). Although the highest number of very hot days and very warm nights occurred in the early 1930s (Figures 2a and 2b), gradual warming has occurred since the early 1990s. Annual average temperatures during this century (2000–2020) have exceeded the previous highs of the 1930s. A winter warming trend is reflected in a below average number of very cold nights since 1990 (Figure 3). Summer average temperatures in the most recent 16 years (2005–2020) exceeded those in the early 1930s (Figure 4).

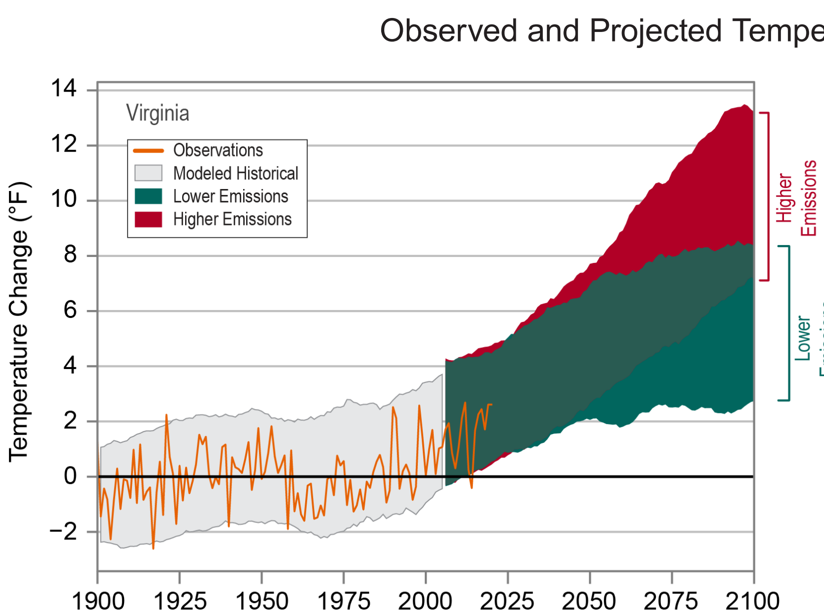

Figure 1: Observed and projected changes (compared to the 1901–1960 average) in near-surface air temperature for Virginia. Observed data are for 1900–2020. Projected changes for 2006–2100 are from global climate models for two possible futures: one in which greenhouse gas emissions continue to increase (higher emissions) and another in which greenhouse gas emissions increase at a slower rate (lower emissions). Temperatures in Virginia (orange line) have risen more than 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 as warm as the hottest year in the historical record; green shading) and more warming under a high 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.

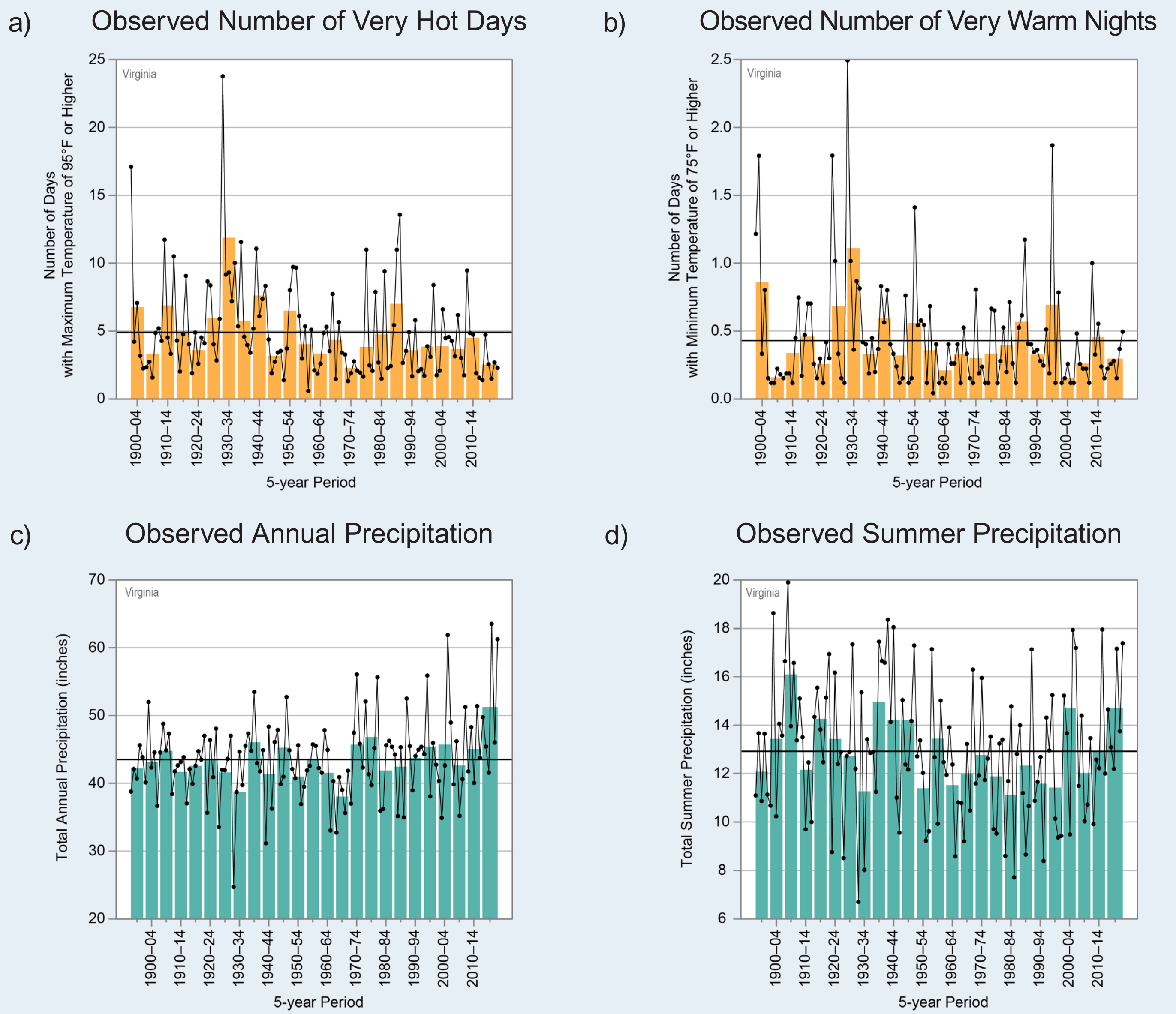

Figure 2: Observed (a) annual number of very hot days (maximum temperature of 95°F or higher), (b) annual number of very warm nights (minimum temperature of 75°F or higher), (c) total annual precipitation, and (d) total summer (June–August) precipitation for Virginia from (a, b) 1900 to 2020 and (c, 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: (a) 4.9 days, (b) 0.4 nights, (c) 43.5 inches, (d) 12.9 inches. The number of very hot days and very warm nights peaked in the 1930s and has subsequently remained near or below the long-term average. Total annual precipitation shows a slight upward trend since 2000. Summer precipitation is highly variable but was above average during the most recent period (2015–2020). Sources: CISESS and NOAA NCEI. Data: (a, b) GHCN-Daily from 8 long-term stations; (c, d) nClimDiv.

Total annual precipitation in Virginia shows a small upward trend (Figure 2c)**, with multiyear values mostly above average since 1995.** The driest multiyear periods were in the early 1930s and late 1960s, and the wettest were in the late 1970s and late 2010s. The driest consecutive 5-year interval was 1963–1967, and the wettest was 2016–2020. The wettest year on record was 2018 (statewide total of 63.5 inches), and 2020 was the third wettest (61.4 inches), while 1930 was the driest (24.7 inches). Total summer precipitation (Figure 2d) is highly variable and was above average during the 2015–2020 period. Since 1990, the number of 2-inch extreme precipitation events has been trending upward, with the 2015–2020 period surpassing the previous high of the late 1990s (Figure 5). Weather hazards in the state include severe thunderstorms, tornadoes, winter storms, tropical storms, hurricanes, droughts, and heat waves. **Virginia was affected by 82 of the 290 U.S. billion-dollar disaster events that occurred between 1980 and 2020.** The costliest event to ever affect the state was Superstorm Sandy (a post-tropical storm) in 2012, which caused severe coastal flooding from storm surges. The 2012 North American derecho, an intense, long-lasting series of thunderstorms characterized by hurricane-force winds, was also very costly to the state, causing about $3 billion in total damages. This historic summer derecho interrupted power for more than 1 million residents in Virginia, the District of Columbia, and Maryland. Winds of up to 70 mph were recorded at Reagan National Airport, causing portions of Northern Virginia to lose emergency 911 services. Tropical Storm Lee in 2011 also resulted in total damages of about $3 billion, with Washington Dulles International Airport receiving a total of 8.74 inches of rainfall from the storm.

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 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. If the warming trend continues, future heat waves are likely to be more intense. This will pose human health risks, particularly in the large metropolitan areas. While heat waves are projected to become more intense, cold waves are projected to become less intense.

Annual precipitation is projected to increase in Virginia (Figure 6). The state is part of a large area across the northern and central United States that shows projected increases in precipitation by midcentury. The number and intensity of extreme precipitation events are also projected to increase, continuing recent trends. Periodic droughts, a natural part of Virginia's climate, are projected to be more intense. Even if overall precipitation increases, higher temperatures will increase the rate of soil moisture loss during dry spells.

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 7). **Sea level has risen even more along the Virginia coast, with a rise of 17 inches between 1927 and 2020 at Sewells Point, and greater**

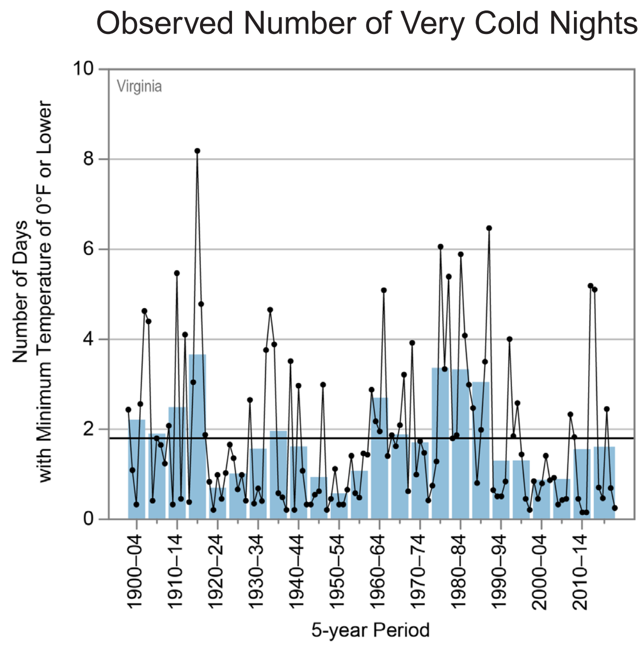

Figure 3: Observed annual number of very cold nights (minimum temperature of 0°F or lower) for Virginia from 1900 to 2020. Dots show annual values. Bars show averages over 5-year periods (last bar is a 6-year average). The horizontal black line shows the long-term (entire period) average of 1.8 nights. The number of very cold nights dropped below the long-term average from the 1920s through the 1950s, followed by an above average number of such events until the early 1990s. The number of very cold nights has remained below average since 1990. Sources: CISESS and NOAA NCEI. Data: GHCN-Daily from 8 long-term stations.

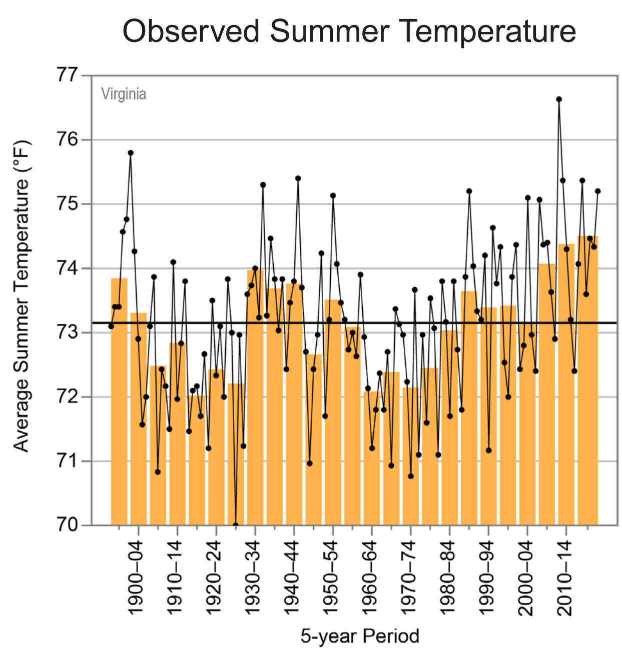

Figure 4: Observed summer (June–August) average temperature for Virginia from 1895 to 2020. Dots show annual values. Bars show averages over 5-year periods (last bar is a 6-summer average). The horizontal black line shows the long-term (entire period) average of 73.2°F. Summer average temperature has been the warmest on record since 2005. Sources: CISESS and NOAA NCEI. Data: nClimDiv.

rises are possible, following historical trends. 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 Virginia coastline, the number of tidal flood days (all days exceeding the nuisance-level threshold) has also increased, with the greatest number (15 days) occurring in 2009 (Figure 8).

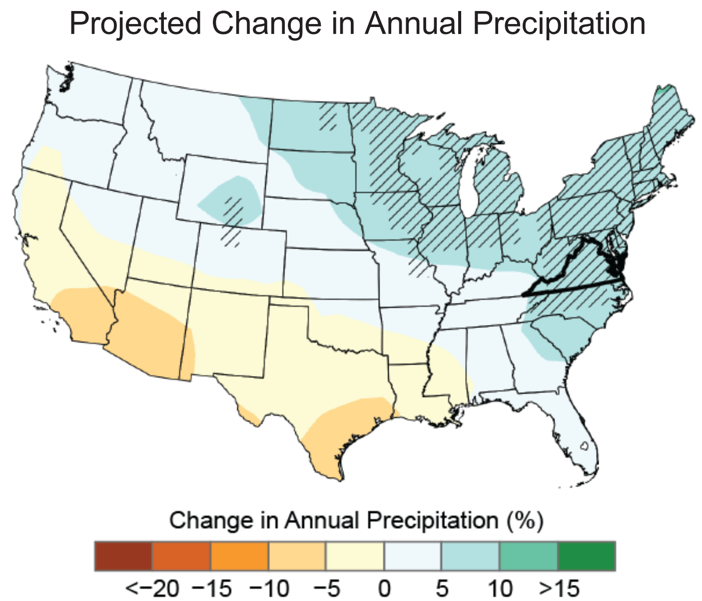

Figure 6: Projected changes in total annual precipitation (%) for the middle of the 21st century compared to the late 20th century under a higher emissions pathway. Hatching represents areas where the majority of climate models indicate a statistically significant change. Virginia is part of a large area of projected increases that includes all of the Northeast. Sources: CISESS and NEMAC. Data: CMIP5.

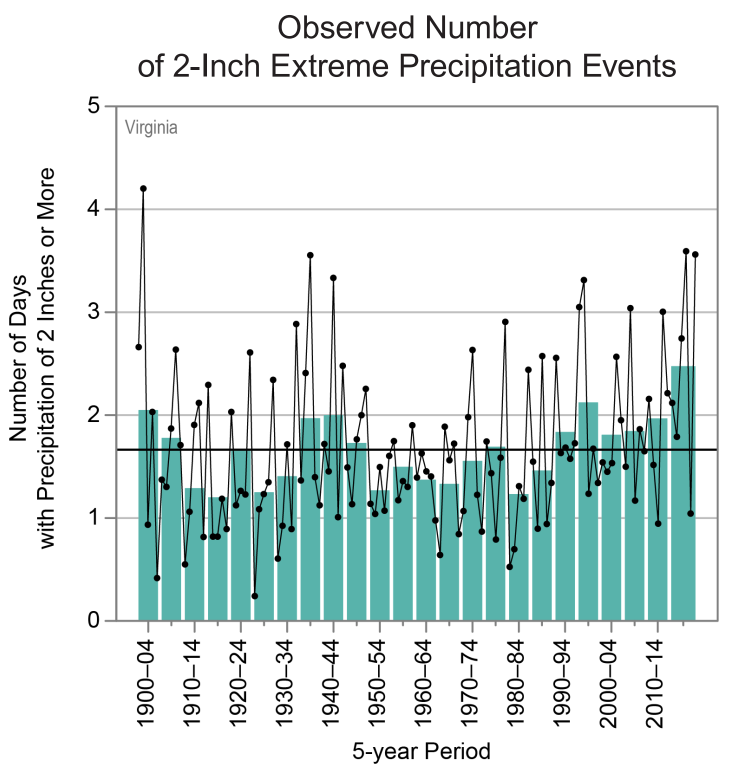

Figure 5: Observed annual number of 2-inch extreme precipitation events (days with precipitation of 2 inches or more) for Virginia from 1900 to 2020. Dots show annual values. Bars show averages over 5-year periods (last bar is a 6-year average). The horizontal black line shows the long-term (entire period) average of 1.7 days. A typical reporting station experiences 1 to 2 events per year. The number of 2-inch extreme precipitation events is highly variable but exhibits a long-term upward trend. The 2015–2020 period surpassed the 1995–1999 record. Sources: CISESS and NOAA NCEI. Data: GHCN-Daily from 11 long-term stations.

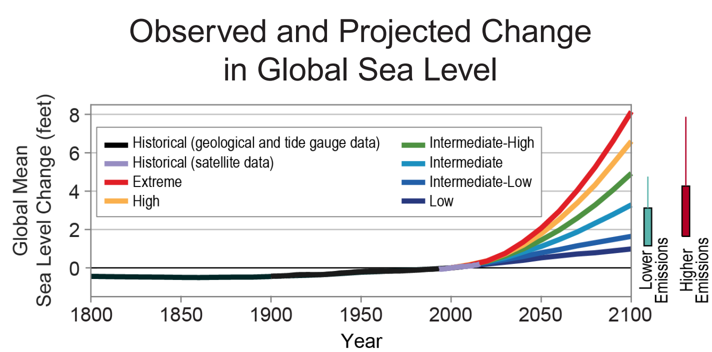

Figure 7: Global mean sea level (GMSL) change from 1800 to 2100. Projections include the six U.S. Interagency Sea Level Rise Task Force GMSL scenarios (Low, navy blue; Intermediate-Low, royal blue; Intermediate, cyan; Intermediate-High, green; High, orange; and Extreme, red curves) relative to historical 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.

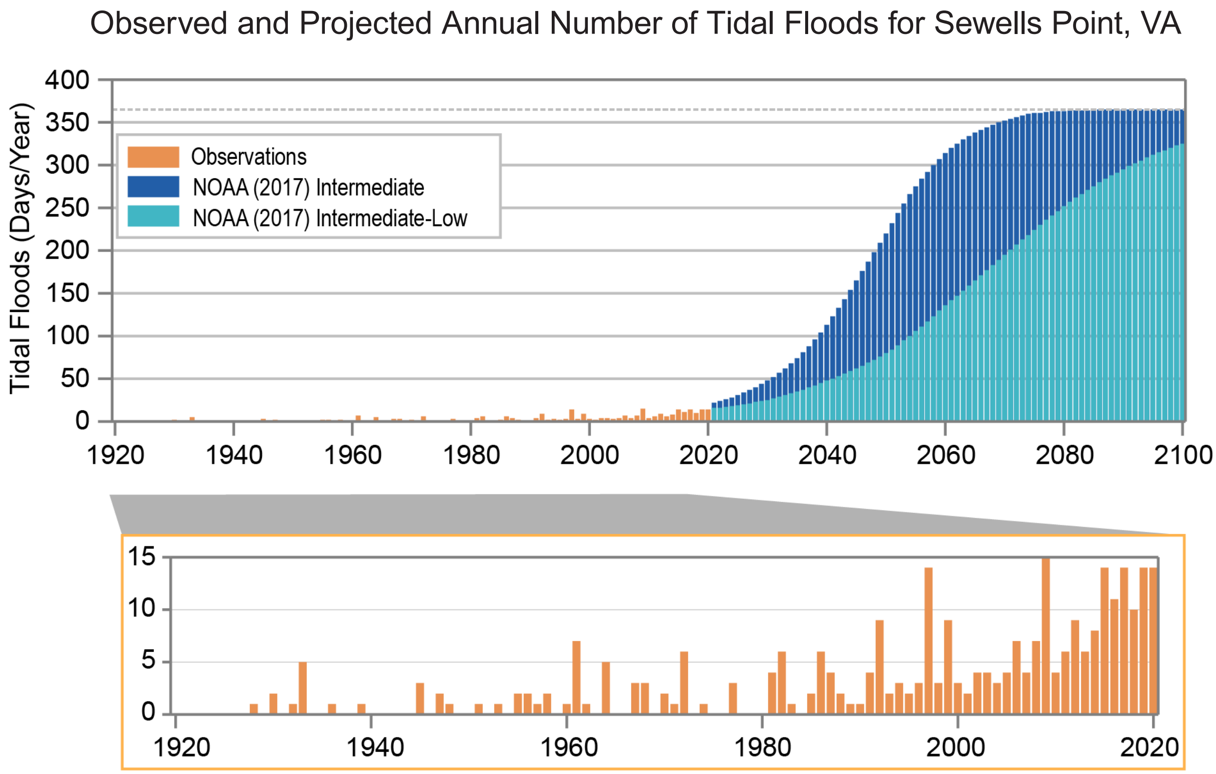

Figure 8: Number of tidal flood days per year at Sewells Point, Virginia, for the observed record (1928–2020; orange bars) and projections for two NOAA (2017) sea level rise scenarios (2021–2100): Intermediate (dark blue bars) and Intermediate-Low (light blue bars). The NOAA (2017) scenarios are based on local projections of the GMSL scenarios shown in Figure 7. 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 2009 at Sewells Point. 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.

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