about 8 inches. It has risen even more along the Virginia coast with a rise of 14.5 inches between 1930 and 2010 at Sewell Point, **Global sea level is projected to rise another 1 to 4 feet by 2100 as a result of both past and future emissions due to human activities (Figure 7) with greater rises possible along the Virginia coast 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 occurring in 2007 (Figure 8).

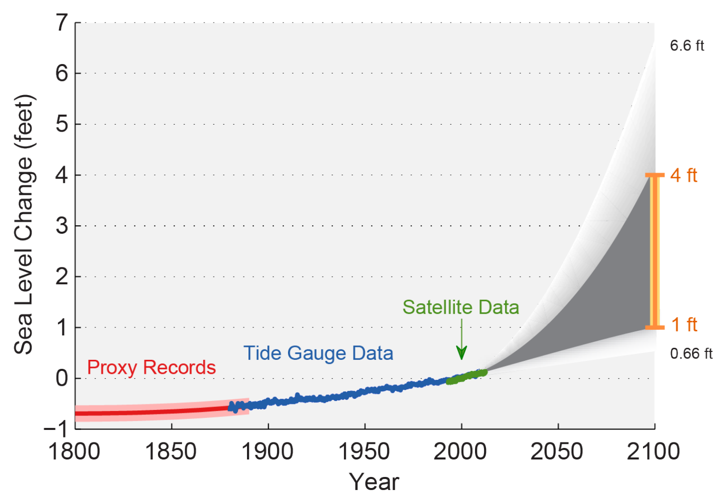


Figure 7: Estimated, observed, and possible future amounts of global sea level rise from 1800 to 2100, relative to the year 2000. The orange line at right shows the most likely range of 1 to 4 feet by 2100, based on an assessment of scientific studies, which falls within a larger possible range of 0.66 feet to 6.6 feet. Source: Melillo et al. 2014 and Parris et al. 2012.

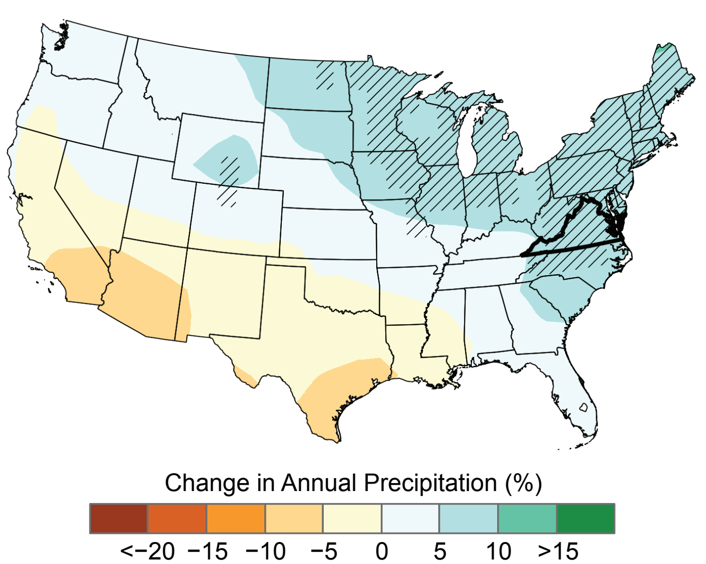


Figure 6: Projected change in annual precipitation (%) for the middle of the 21st century compared to the late 20th century under a higher emissions pathway. Hatching represents areas where the majority of climate models indicate a statistically significant change. Virginia is part of a large area of projected increases that includes all of the northeastern United States. Source: CICS-NC, NOAA NCEI, and NEMAC.

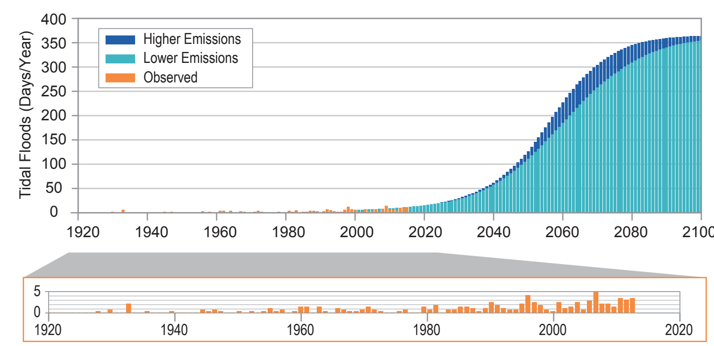
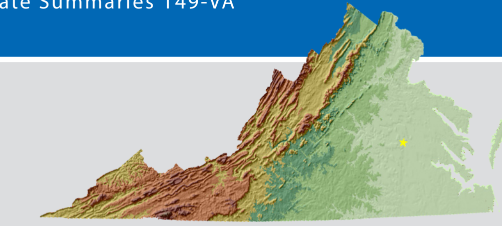


Figure 8: Number of tidal flood days per year for the observed record (orange bars) and projections for two possible futures: lower emissions (light blue) and higher emissions (dark blue) per calendar year for Sewell Point, VA. Sea level rise has caused an increase in tidal floods associated with nuisance-level 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 2007 at Sewell Point. Projected increases are large even under a lower emissions pathway. Near the end of the century, under a higher emissions pathway, 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/va). Source: NOAA NOS.

WWW.NCEI.NOAA.GOV | HTTPS://STATESUMMARIES.NCICS.ORG/VA LEAD AUTHORS: JENNIFER RUNKLE, KENNETH E. KUNKEL | CONTRIBUTORS: LAURA STEVENS, SARAH CHAMPION, BROOKE C. STEWART, REBEKAH FRANKSON, WILLIAM SWEET.



VIRGINIA

Key Messages

Average annual temperature has increased by about 1.5°F since the beginning of the 20th century. Under a higher emissions pathway, historically unprecedented warming is projected by the end of the 21st century.

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

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

Virginia has a humid climate with very warm summers and moderately cold winters. The climate exhibits substantial regional variation due to the state's diverse geographic elements, which include the Appalachian Mountains 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 with the west and north being cooler and drier than the eastern coastal region. Statewide average temperatures range from 35°F in January to 75°F in July. The amount of rainfall generally decreases toward the west. For example, total annual 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.

Since the beginning of the 20th century, temperatures have risen approximately 1.5°F. The 1930s and 1950s were very warm, followed by a period of generally below average temperatures during the 1960s through early 1980s (Figure 1). Although the 5-year average highest number of very hot days (maximum temperature above 95°F) and corresponding number of very warm nights (minimum temperature above 75°F) occurred in the early 1930s (Figures 2a and 2b), gradual warming has occurred since the early 1990s. Average annual temperatures during the 21st century (2000–2014) have exceeded the previous highs of the 1930s. A winter warming trend is reflected in the below average number of very cold nights (minimum temperature below 0°F) since 1990 (Figure 3). Average summer temperatures in the most recent decade (2005–2014) exceeded those in the early 1930s (Figure 4).

There is no overall trend in average annual precipitation in Virginia (Figure 2c)**, although over the past two decades (1995–2014), annual precipitation has been**

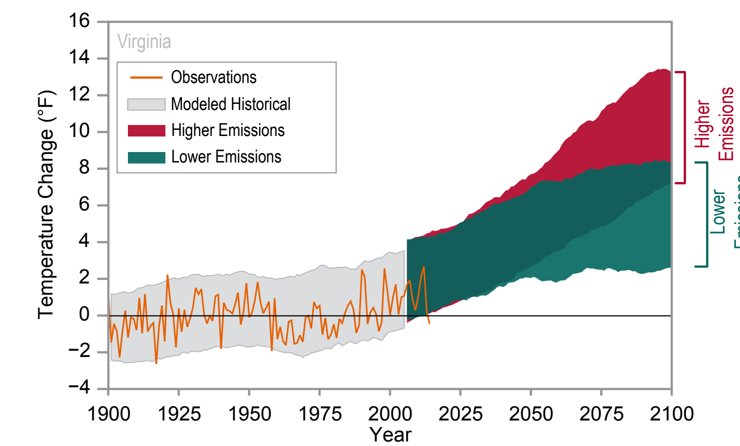


Figure 1: Observed and projected changes (compared to the 1901–1960 average) in near-surface air temperature for Virginia. Observed data are for 1900-2014. Projected changes for 2006–2100 are from global climate models for two possible futures: one in which greenhouse gas emissions continue to increase (higher emissions) and another in which greenhouse gas emissions increase at a slower rate (lower emissions)[1]. Temperatures in Virginia (orange line) have risen about 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 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 high emissions future (the hottest years being about 11°F warmer than the hottest year in the historical record; red shading). Source: CICS-NC and NOAA NCEI.

[1]Technical details on models and projections are provided in an appendix, available online at: https://statesummaries.ncics.org/va.

generally above the long-term average. The driest multi-year periods were in the early 1930s and late 1960s; the wettest period was in the 1970s. The driest 5-year period was 1963–1967 and the wettest was 1971–1975 (Figure 2c). The year 2003 was the wettest on record (statewide

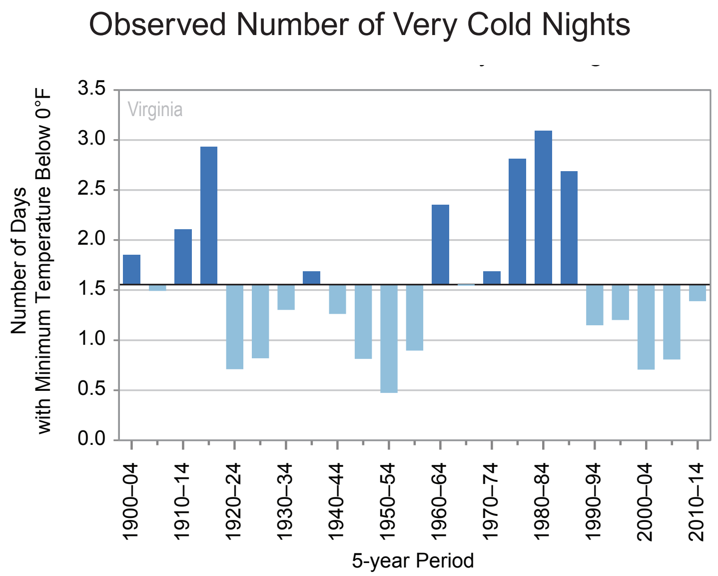


Figure 3: The observed number of very cold nights (minimum temperature below 0°F) for 1900–2014, averaged over 5-year periods; these values are averages from nine long-term reporting stations. The number of very cold nights dropped below the long-term average between the 1920s and 1960s, followed by an above average number of such events until the early 1990s. The number of very cold nights has remained below average for the past two decades (1990–2014). The dark horizontal line is the long-term average (1900–2014) of 1.6 days per year. Source: CICS-NC and NOAA NCEI.

Figure 2: The observed (a) number of very hot days (maximum temperature above 95°F), (b) number of very warm nights (minimum temperature above 75°F), (c) annual precipitation, and (d) summer precipitation, averaged over 5-year periods. The values in Figures 2a and 2b are from nine long-term reporting stations. The values in Figures 2c and 2d are from NCEI's version 2 climate division dataset. The dark horizontal lines represent the long-term average. The number of very hot days and very warm nights peaked in the 1930s and has subsequently remained near to below the long-term average. There is no overall trend in average annual precipitation; summer precipitation has been below or near average during the most recent decade (2005–2014). Source: CICS-NC and NOAA NCEI.

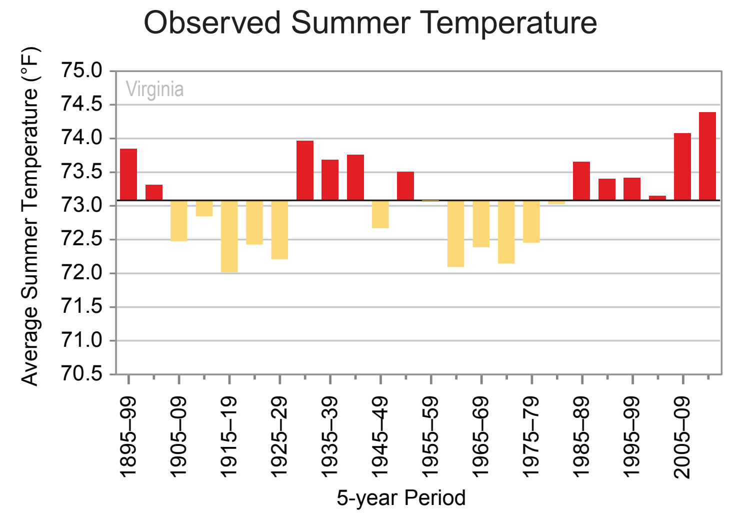


Figure 4: The observed annual summer temperature for 1900–2014, averaged over 5-year periods; these values are averages from NCEI's version 2 climate division dataset. Average annual summer temperature has been the warmest on record over the last decade (2005–2014). The dark horizontal line is the long-term average (1900–2014) of 73.1°F. Source: CICS-NC and NOAA NCEI.

average of 62 inches) while 1930 was the driest (25 inches). There is an upward trend in the annual number of extreme precipitation events (precipitation greater than 2 inches) over the past two decades (1995–2014), with the number of such events in 1995–1999 surpassing record levels of the early 1940s (Figure 5). Average annual summer precipitation (Figure 2d) has been below or near the long-term average during the most recent decade (2005–2014).

Weather hazards in the state include severe thunderstorms, tornadoes, winter storms, tropical storms, hurricanes, droughts, and heat waves. **Virginia was affected by 35 of the 144 U.S. billion-dollar disaster events that occurred between 1980 and 2012.** The

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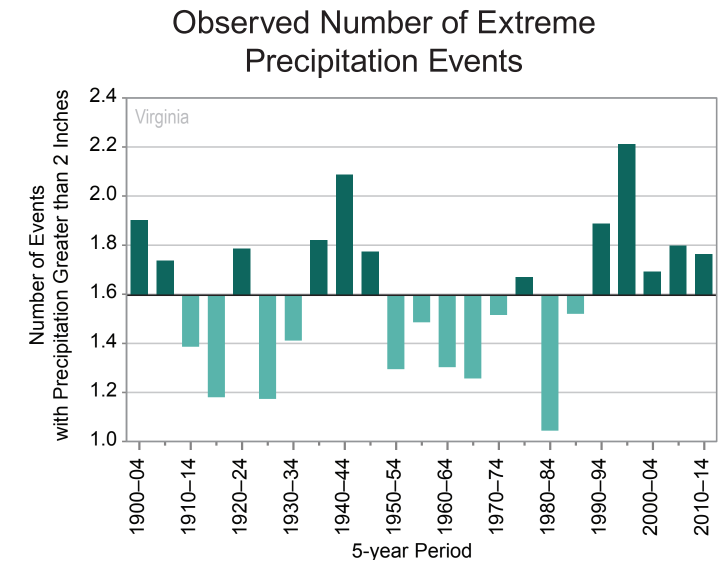

Figure 5: The observed number of extreme precipitation events (precipitation amounts greater than 2 inches) for 1900–2014, averaged over 5-year periods; these values are averages from 10 long-term reporting stations. The number of events is highly variable but exhibits a long-term upward trend. The 5-year period between 1995 and 1999 surpassed a 1940s record. The dark horizontal line is the long-term average (1900–2014) of 1.6 days per year. Source: CICS-NC and NOAA NCEI.

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 $3 billion in total damages. This historic summer derecho event interrupted power for more than 1 million residents in Virginia, Washington D.C., and Maryland. Winds of up to 70 mph were recorded at Reagan National Airport, causing portions of Northern Virginia to be without emergency 911 services. Tropical Storm Lee in 2011 also resulted in total damages of $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 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. 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 of projected increases in precipitation across the northern and central United States by the middle of the 21st century. The number and intensity of heavy precipitation events is also projected to increase, continuing recent trends. Drought is a periodically-occurring natural phenomenon within the state. Even if overall precipitation increases, naturally occurring droughts are projected to be more intense because higher temperatures will increase the rate of loss of soil moisture during dry spells.

Increasing temperatures raise concerns for sea level rise in coastal areas. Since 1880, global sea level has risen by