VERMONT

Key Messages

Temperatures in Vermont have risen about 3°F since the beginning of the 20th century. The last 11-year period (2010–2020) was the warmest 11-year period on record. Under a higher emissions pathway, historically unprecedented warming is projected to continue through this century. The intensity of extreme winter cold is projected to decrease.

Annual average precipitation has increased nearly 6 inches since the 1960s (a decade marked by prolonged, multiyear droughts and cold temperatures), with the largest increases occurring in mountainous regions of the state. Winter and spring precipitation is projected to increase throughout this century, and warming will increase the proportion of that precipitation that will fall as rain.

Extreme weather events, particularly floods and severe storms, are having a stronger impact on Vermont. At the same time, multiyear meteorological and hydrological droughts continue to pose challenges for water-dependent sectors. Extreme rainfall events are projected to become more frequent and intense in the future.

Vermont's northerly latitude and geographic location on the eastern edge of the North American continent expose it to the moderating and moistening influence of the Atlantic Ocean and the effects of the hot and cold air masses from the interior of the continent. Its climate is characterized by cold, snowy winters and pleasantly warm summers. The jet stream that is often located near the state gives it highly variable weather patterns, widely ranging daily and annual temperatures, and generally abundant precipitation throughout the year. Changes in Vermont's elevation, terrain, and its proximity to Lake Champlain and the Atlantic Ocean all contribute to variations in climate across the state. The western part of the state is moderated by the lake and experiences higher temperatures and a longer growing season than the more mountainous northeastern region (also referred to as the Northeast Kingdom). Southeastern Vermont, with its lower elevation and landlocked location, tends to be warmer and more drought-prone than the rest of the state.

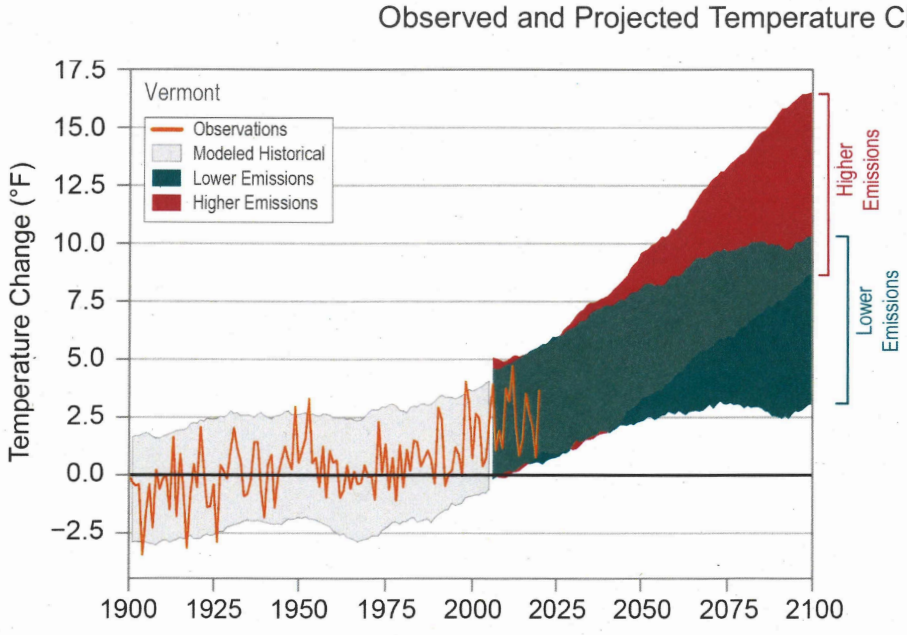
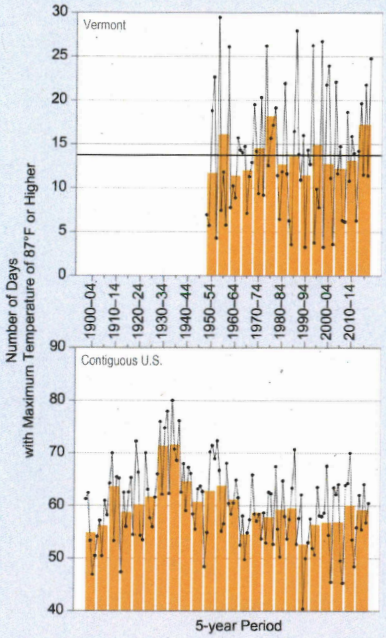
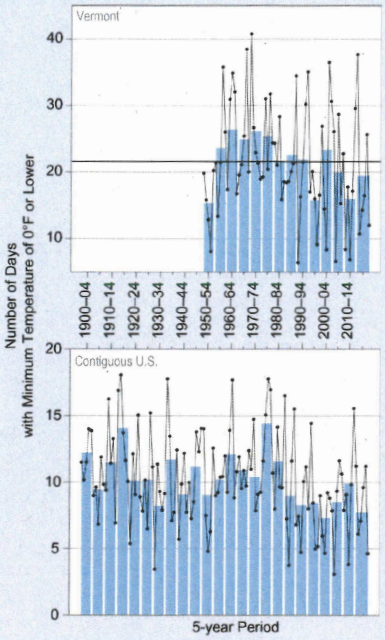


Figure 1: Observed and projected changes (compared to the 1901–1960 average) in near-surface air temperature for Vermont. Observed data are for 1900–2020. Projected changes for 2006–2100 are from global climate models for two possible futures: one in which greenhouse gas emissions continue to increase (higher emissions) and another in which greenhouse gas emissions increase at a slower rate (lower emissions). Temperatures in Vermont (orange line) have risen about 3°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 (grey 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 3°F warmer than the historical average; green shading) and more warming under a higher emissions future (the hottest end-of-century projections being about 12°F warmer than the hottest year in the historical record; red shading). Sources: CISESS and NOAA NCEI.

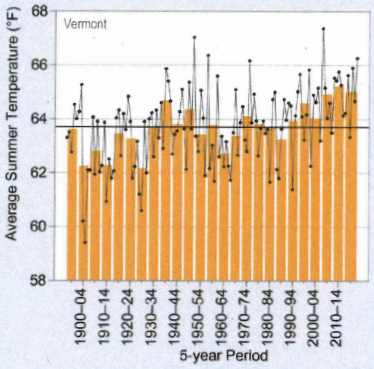
a) Observed Number of Hot Days



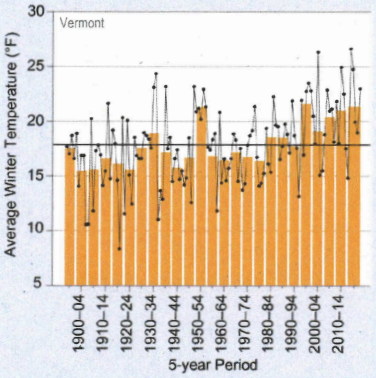
b) Observed Number of Very Cold Nights



c) Observed Summer Temperature



d) Observed Winter Temperature



e) Observed Number of 2-Inch Extreme Precipitation Events

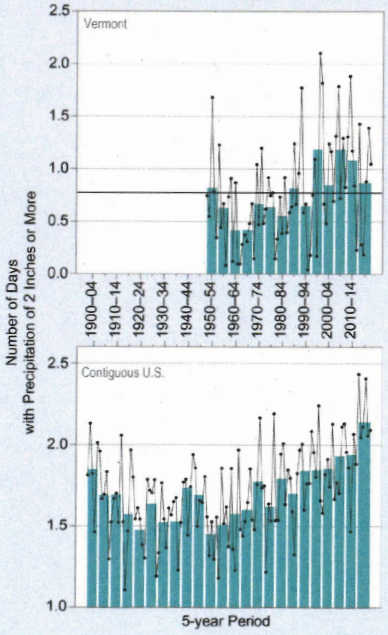


Figure 2: Observed (a) annual number of hot days (maximum temperature of 87°F or higher), (b) annual number of very cold nights (minimum temperature of 0°F or lower), (c) summer (June–August) average temperatures, (d) winter (December–February) average temperatures, and (e) annual number of 2-inch extreme precipitation events for Vermont from (a, b, e) 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 Vermont: (a) 14 days, (b) 22 nights, (c) 63.7°F (d) 17.9°F, (e) 0.8 days. Values for the contiguous United States (CONUS) from 1900 to 2020 are included for Figures 2a, 2b, and 2e to provide a longer and larger context. Very few long-term stations are available dating back to 1900 for Vermont. Vermont's winter and summer temperatures have been above the long-term average since the mid-1990s, with the warmest seasons occurring in the most recent 20 years. The number of extreme precipitation events has also been above the long-term average since the mid-1990s; a typical reporting station experiences an event about every one to two years. There is no trend in the number of hot days, while the number of very cold nights has been below average over the last 16 years (2005–2020). Sources: CISESS and NOAA NCEI. Data: (a, b) GHCN-Daily from 6 (VT) and 655 (CONUS) long-term stations; (c, d) nClimDiv; (e) GHCN-Daily from 11 (VT) and 832 (CONUS) long-term stations.

Temperatures in Vermont have risen about 3°F since the beginning of the 20th century (Figure 1). While there is no trend in the number of hot days (Figure 2a), the annual number of warm nights has been near to above average for the past 21 years (2000–2020), with a historically high peak during the 2015–2020 period (Figure 3). Both winter and summer temperatures have increased considerably since 1995 (Figures 2c and 2d). The winter warming trend is reflected in a below average annual number of very cold nights since the mid-2000s (Figure 2b). Higher spring and fall temperatures have resulted in corresponding changes in the length of the freeze-free season, with later first fall freeze and earlier last spring freeze dates. Since 2005, the freeze-free season in Vermont has averaged about a week longer than the average during 1970–2004. Climate change has already increased the growing season by 3.7 days per decade. At the same time, the state continues to experience backward or false springs, which are characterized by the normal progression of warming temperatures in the late winter and early spring followed by snow and freezing rain in April–June, cold temperatures, and winds coming from the northwest.

Annual average precipitation has generally been above the long-term average since 1970 (Figure 4). The driest multiyear periods were in the early 1910s and the early 1960s. The wettest periods were observed from 2005 to 2014. The driest consecutive 5-year interval was 1961–1965, and the wettest was 2007–2011. The annual number of 2-inch extreme precipitation events has been above the long-term average over the past 26 years (1995–2020), with the highest number of events occurring during the periods of 1995 to 1999 and 2005 to 2009 (Figure 2e). Annual average precipitation has increased nearly 6 inches since the 1960s.

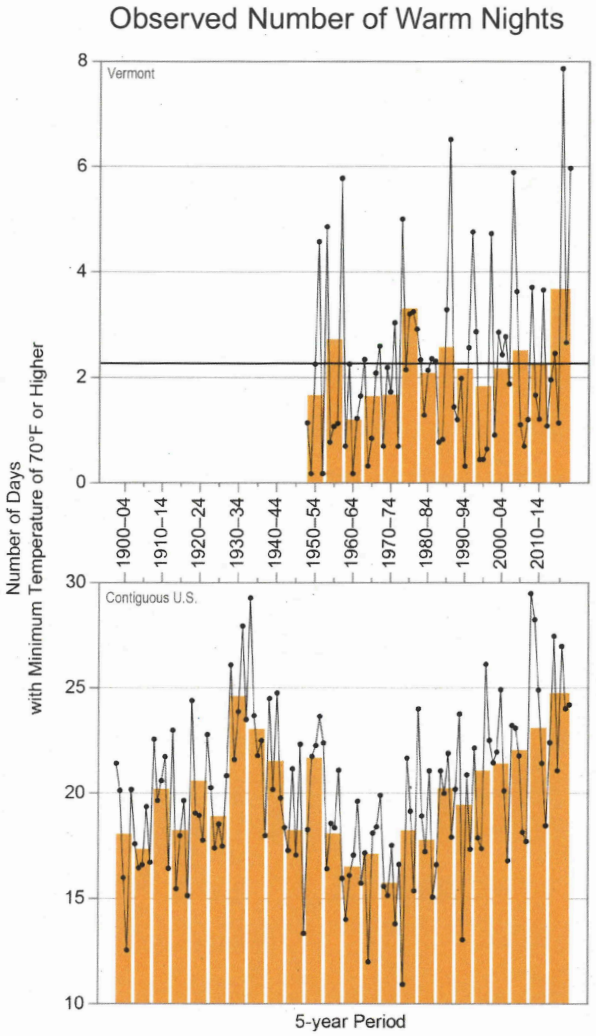


Figure 3: Observed annual number of warm nights (minimum temperature of 70°F or higher) for Vermont from 1950 to 2020. Dots show annual values. Bars show averages over 5-year periods (last bar is a 6-year average). The horizontal black line shows the long-term (entire period) average of 2.8 days. Values for the contiguous United States (CONUS) from 1900 to 2020 are also included to provide a longer and larger context. Very few long-term stations are available dating back to 1900 for Vermont. The number of warm nights in Vermont has been near to above average since 2005. A historically high number of warm nights (3.7 days per year) occurred during 2015–2020. Sources: CISESS and NOAA NCEI. Data: GHCN-Daily from 6 long-term stations.

Extreme weather events in Vermont can take the form of prolonged heavy snowstorms, flash floods, river floods (following snowmelt and heavy rains), severe thunderstorms, droughts, tornadoes, and temperature extremes. Some of the heaviest flooding in the state's history has been due to tropical cyclones or their remnants. In 2011, Tropical Storm Irene transitioned into an extratropical cyclone as it moved quickly northeastward along the Vermont-New Hampshire border. Roughly 3 to 7 inches of rain fell in less than 18 hours, causing the worst flooding in southern and eastern Vermont since the Great Flood of November 1927. Tropical Storm Irene's flooding became the new flood of record for the southern portions of the state, while the 1927 flood remains the flood of record across the north. The flooding resulted in more than $700 million in damages across the state. Vermont continues to be susceptible to both flooding and droughts occurring in the same year. Prolonged drought conditions were observed in 1930–1936, 1939–1943, 1960–1969, 1980–1981, 1988–1989, 1991, 1995, 1998–1999, 2006–2007, 2010, 2011, 2012, 2016–2017, 2018,

and 2020–2021. During the extreme hydrologic drought of 2020–2021, new 30-year record lows were observed across the state.

Severe winter storms are common in Vermont's cold winter climate and may include snowstorms, blizzards, nor'easters, and icing events. In addition to ice jams and melting snowpack as winter hazards, freezing rain and frozen ground conditions can give rise to flooding. During the first week of January 1998, a prolonged storm brought 2 to 5 inches of rain to Vermont. Across the Champlain Valley and parts of northern Vermont, temperatures were below freezing for much of the storm. This resulted in the Great Ice Storm of '98, during which heavy ice accumulation of 1 to 2 inches caused agricultural losses (dairy industry) and severe damage to trees (at varying elevations) and utility lines. Total damage from the ice storm across the whole of the northeastern United States was about $2 billion.

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 (Figure 1). Increases in the number of hot days and decreases in the number of very cold nights are projected to accompany the overall warming.

Annual average precipitation is projected to increase in Vermont throughout this century, particularly during winter and spring (Figure 5). Corresponding increases in temperature will increase the proportion of precipitation that will fall as rain rather than snow. In addition, extreme precipitation is projected to increase, potentially increasing the frequency and intensity of floods.

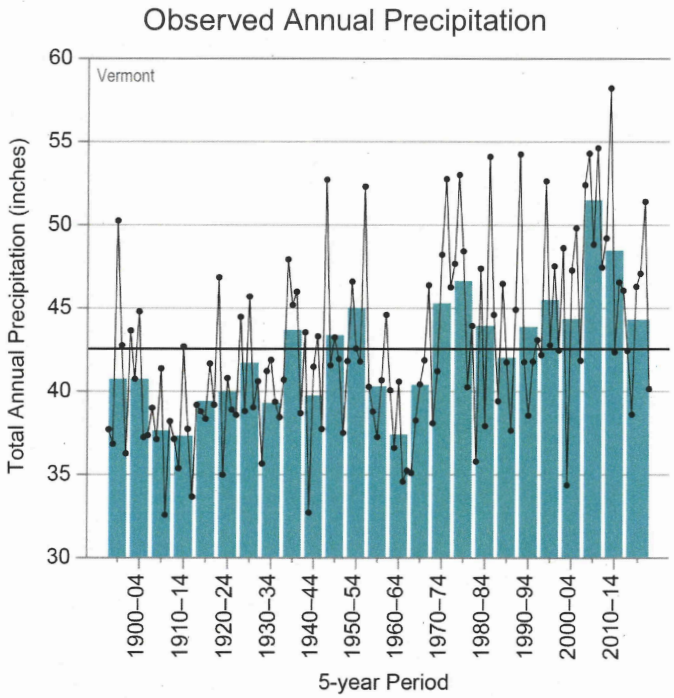


Figure 4: Observed total annual precipitation for Vermont from 1895 to 2020. Dots show annual values. Bars show averages over 5-year periods (last bar is a 6-year average). The horizontal black line shows the long-term (entire period) average of 42.5 inches. Below average annual precipitation occurred in Vermont during the early 20th century. Annual precipitation has largely remained above average since 1970, with the highest multiyear period being 2005–2009. Sources: CISESS and NOAA NCEI. Data: nClimDiv.

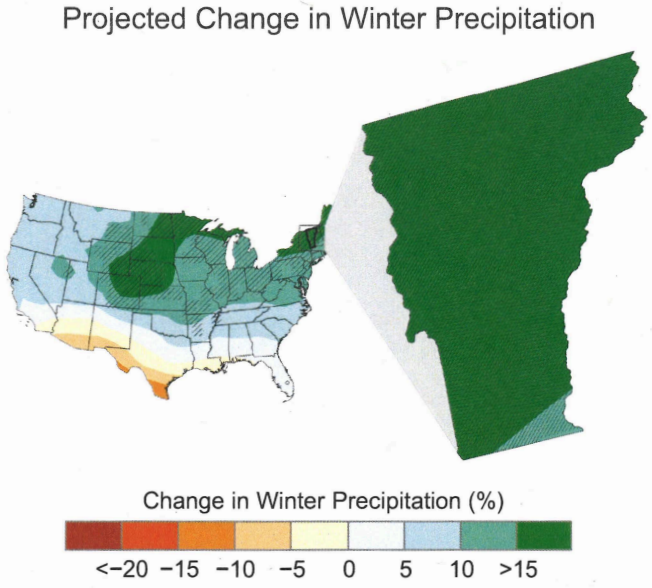


Figure 5: Projected changes in total winter (December–February) precipitation (%) for the middle of the 21st century compared to the late 20th century under a higher emissions pathway. Hatching represents areas where the majority of climate models indicate a statistically significant change. Vermont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

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