

# NEW YORK

## Key Messages

Temperatures in New York have risen almost 2.5°F since the beginning of the 20th century. Under a higher emissions pathway, historically unprecedented warming is projected during this century. Extreme heat is a particular concern for densely populated urban areas such as New York City, where high temperatures and high humidity can cause dangerous conditions.

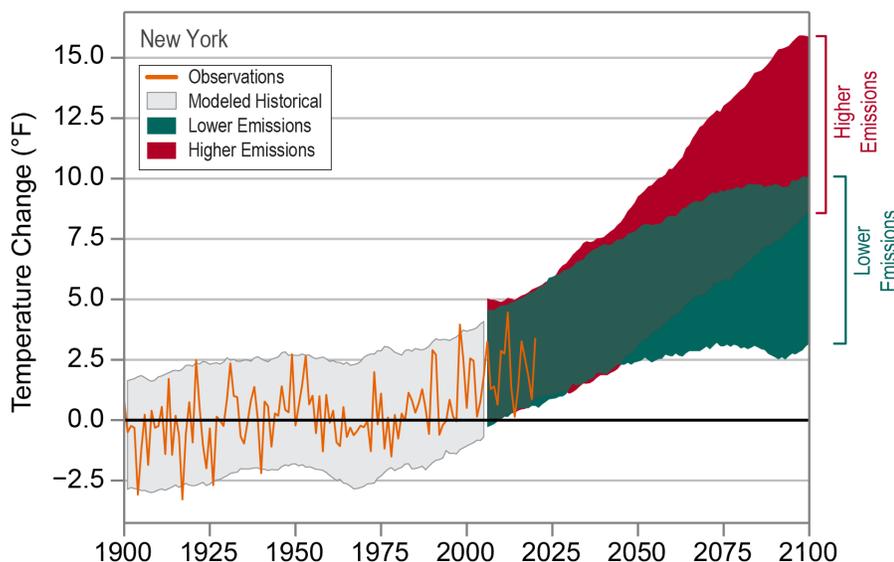
Since 1880, sea level has risen by about 13 inches along the coast of New York, more than the global average rise of 7–8 inches. Global average sea level is projected to rise another 1–4 feet by 2100, but levels along the coast of New York will likely be higher due to local and regional factors. Sea level rise will increase the frequency, extent, and severity of coastal flooding, which is a grave risk to dense, high-value development along New York’s coastline.

New York has experienced a large increase in the frequency and intensity of extreme precipitation events, and further increases are projected. Increases in winter and spring precipitation are projected, raising the risk of springtime flooding, which could cause delayed planting and reduced yields.



New York is regionally diverse, encompassing the Nation’s most populous metropolitan area, as well as large expanses of sparsely populated but ecologically and agriculturally important areas. The state’s climate is heavily influenced by several geographic features. The Atlantic Ocean has a moderating effect on coastal areas, while the Great Lakes and Lake Champlain moderate the northwestern and northeastern parts of the state, respectively. During much of the year, the prevailing westerly flow brings air masses from the North American interior across the entire region, with occasional episodes of bitter cold during winter. The jet stream, which is often located near or over the region during winter, brings frequent storm systems that cause cloudy skies, windy conditions, and precipitation. New York is often affected by extreme events, such as floods, droughts, heat waves, hurricanes, nor’easters, and snow and ice storms.

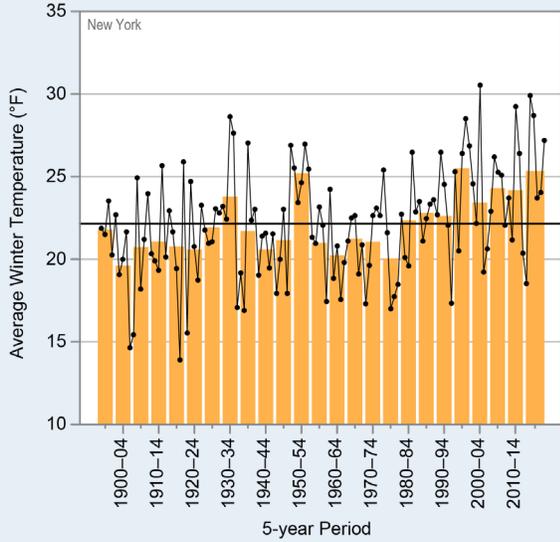
Observed and Projected Temperature Change



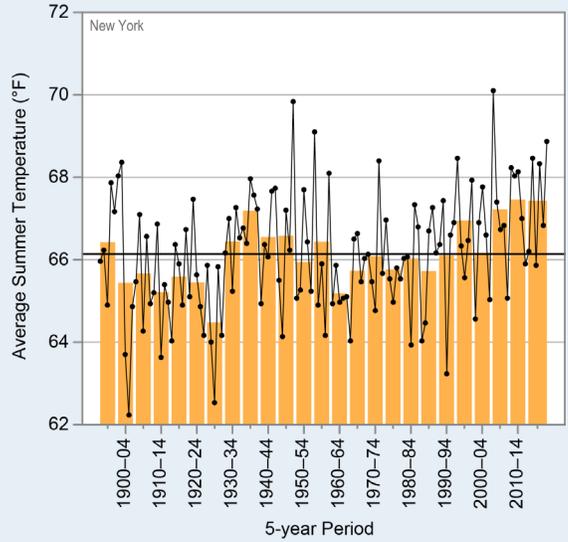
**Figure 1:** Observed and projected changes (compared to the 1901–1960 average) in near-surface air temperature for New York. Observed data are for 1900–2020. Projected changes for 2006–2100 are from global climate models for two possible futures: one in which greenhouse gas emissions continue to increase (higher emissions) and another in which greenhouse gas emissions increase at a slower rate (lower emissions). Temperatures in New York (orange line) have risen almost 2.5°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 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 11°F warmer than the hottest year in the historical record; red shading). Sources: CISESS and NOAA NCEI.

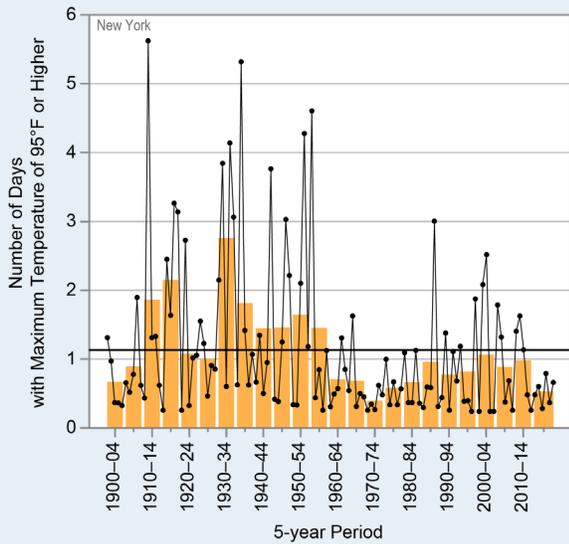
a) Observed Winter Temperature



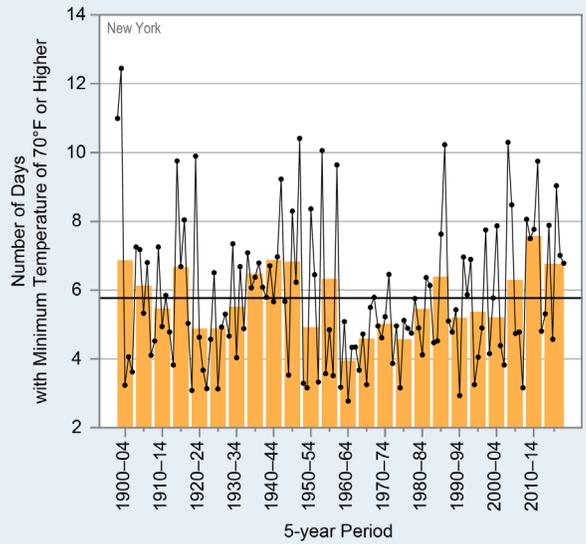
b) Observed Summer Temperature



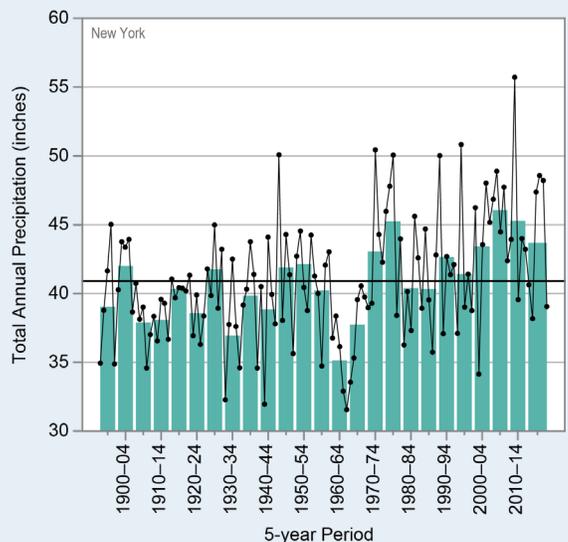
c) Observed Number of Very Hot Days



d) Observed Number of Warm Nights



e) Observed Annual Precipitation



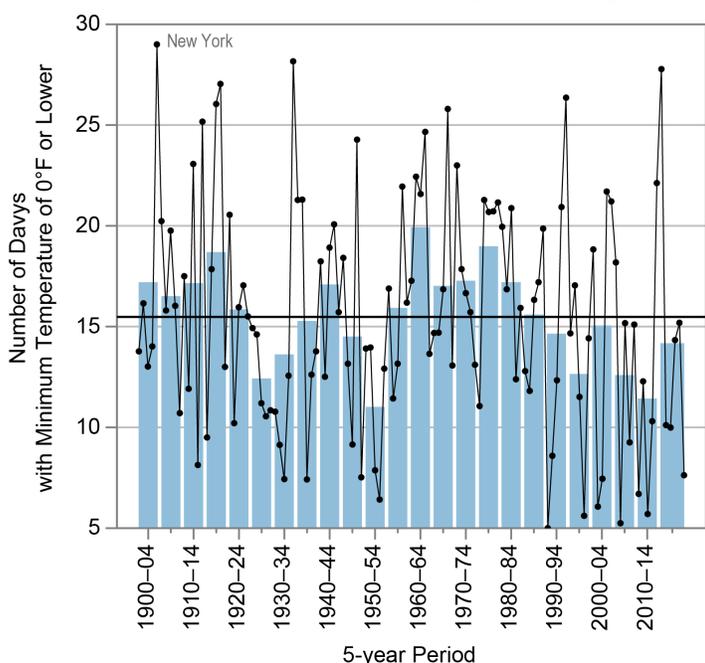
**Figure 2:** Observed (a) winter (December–February) average temperature, (b) summer (June–August) average temperature, (c) annual number of very hot days (maximum temperature of 95°F or higher), (d) annual number of warm nights (minimum temperature of 70°F or higher), and (e) total annual precipitation for New York from (a, b, e) 1895 to 2020 and (c, d) 1900 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) 22.2°F, (b) 66.1°F, (c) 1.1 days, (d) 5.8 nights, (e) 40.9 inches. Recent years have seen some of the warmest winter and summer temperatures in the historical record. The number of very hot days peaked during the 1930–1934 period, while the number of warm nights was highest during the 2010–2014 period. Total annual precipitation has been significantly above average since 2000. Sources: CISESS and NOAA NCEI. Data: (a, b, e) nClimDiv, (c, d) GHCN-Daily from 12 long-term stations.

Since the beginning of the 20th century, temperatures in New York have risen almost 2.5°F, and temperatures in the 2000s have been higher than in any other historical period (Figure 1). As of 2020, the hottest year on record for New York was 2012, with a statewide average temperature of 48.8°F, more than 4°F above the long-term average (44.5°F). This warming has been concentrated in the winter and spring, while summers have not warmed as much (Figures 2a and 2b). Summer warming is more influenced by the number of warm nights than by the occurrence of very hot days (Figures 2c and 2d). The state has experienced an increase in the number of warm nights and a decrease in the number of very cold nights (Figure 3). The increase in winter temperatures has had an identifiable effect on Great Lakes ice cover. Since 1998, there have been several years when Lakes Erie and Ontario were mostly ice-free (Figure 4).

Annual average precipitation is slightly more than 40 inches statewide but varies regionally, with mountainous areas receiving near 50 inches per year. Statewide annual precipitation has ranged from a low of 31.6 inches in 1964 to a high of 55.7 inches in 2011. The driest multiyear periods were in the early 1930s and

early 1960s and the wettest in the late 1970s and since 2000 (Figure 2e). The driest consecutive 5-year interval was 1962–1966, with an annual average of 33.9 inches, and the wettest was 2007–2011, with an annual average of 46.8 inches. **New York has recently experienced a large increase in the number of 2-inch extreme precipitation events** (Figure 5), which peaked during the 2010–2014 period. The annual precipitation record, set in 2011, was partially due to extreme precipitation events caused by Hurricane Irene and Tropical Storm Lee in late August and early September, respectively. Many areas of eastern New York received more than 7 inches of rain from Hurricane Irene, with more than 18 inches in some locations in the Catskill Mountains. Less than two weeks later, Tropical Storm Lee brought additional heavy rainfall, with more than 12 inches falling in the Susquehanna River basin. The extreme rainfall from these two events caused devastating flooding and damage. Nontropical systems can also bring extreme rainfall, such as during August 12–13, 2014, when the state 24-hour precipitation record was broken (13.57 inches) at Islip. New York experienced extreme drought during 2016 and severe drought during 2020, which had major impacts on agriculture in some parts of the state.

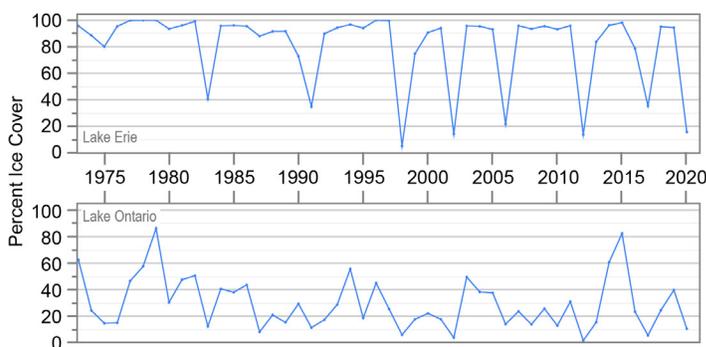
Observed Number of Very Cold Nights



**Figure 3:** Observed annual number of very cold nights (minimum temperature of 0°F or lower) for New York 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 16 nights. The number of very cold nights has been below average since 1990, reflecting a long-term winter warming trend. Sources: CISESS and NOAA NCEI. Data: GHCN-Daily from 12 long-term stations.

**In addition to causing heavy flooding inland, hurricanes and tropical storms can cause coastal damage from storm surge and flooding.** In late October 2012, Superstorm Sandy (a post-tropical storm) caused massive storm surge in New York City. The extensive

Annual Maximum Ice Cover for Lake Erie and Lake Ontario



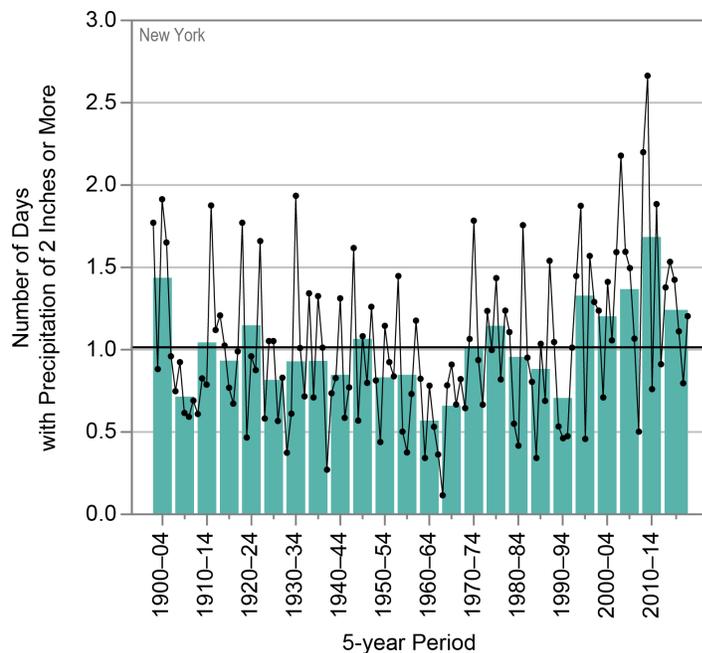
**Figure 4:** Annual maximum ice cover extent (%) for Lake Erie (top) and Lake Ontario (bottom) from 1973 to 2020. During most years, Lake Erie was nearly frozen over, while Lake Ontario was mostly ice-free. There were 6 years when Lake Erie was mostly ice-free, and all of those occurred since 1998. Since 2006, Lake Ontario's ice cover extent has remained below 40%, except for higher values during the cold 2013–14 and 2014–15 winters. Source: NOAA GLERL.

flooding from the storm surge inundated subway tunnels, damaged the electrical grid, overwhelmed sewage treatment plants, and destroyed thousands of homes. Superstorm Sandy caused tens of billions of dollars in damages in the state, with an estimated \$19 billion in damages to New York City.

Winter storms occur frequently across the state due to the large temperature contrast between the cold interior of the North American continent and the warm moist air of the western Atlantic. **These storms, popularly known as nor'easters, can produce crippling snowfall, flood-producing rainfall, hurricane-force winds, and dangerous cold.** The Blizzard of 1996, January 6–8, was a classic nor'easter, dropping more than 20 inches of snow in New York City and causing an estimated \$70 million in damages across the state. During the Blizzard of 2016, January 22–24, more than 30 inches of snow fell in some areas, such as Kennedy Airport, where near-blizzard conditions persisted for 9 hours; travel bans were also enacted in New York City. The northern part of the state frequently experiences heavy lake-effect snows due to the warming and moistening of arctic air masses as they pass over the Great Lakes. This results in intense bands of heavy snowfall over areas downwind of Lakes Ontario and Erie. During November 17–19, 2014, a lake-effect snowstorm delivered more than 5 feet of snow just east of Buffalo. A second lake-effect event immediately followed during November 19–20, dropping as much as an additional 4 feet of snow; snowfall rates as high as 6 inches per hour were reported, with some areas receiving more than 3 feet of snow in less than 12 hours. These two storms were considered unprecedented events but were characteristic of lake-effect snows that affect the state. The Great Lakes can also experience flooding and erosion due to high water levels. Wet spring conditions contributed to record-high water levels and flooding in 2017 and 2019. Cleanup costs, infrastructure damages, and agricultural losses were in the millions of dollars.

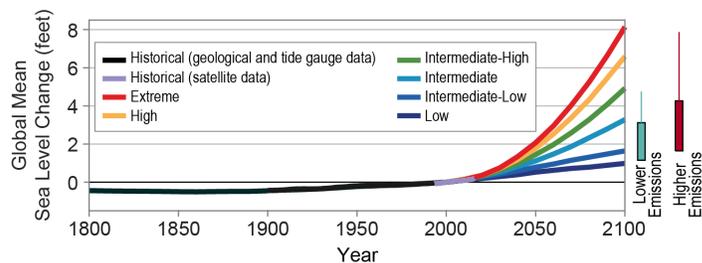
**Under a higher emissions pathway, historically unprecedented warming is projected during this century** (Figure 1). Even under a lower emissions pathway, annual average temperatures are projected to most likely exceed historical record levels by the middle of this century. However, a large range of temperature increases is projected under both pathways, and under the lower pathway, a few projections are only slightly warmer than

### Observed Number of 2-Inch Extreme Precipitation Events



**Figure 5:** Observed annual number of 2-inch extreme precipitation events (days with precipitation of 2 inches or more) for New York 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 1.0 days. A typical station experiences 1 event each year. Since 1995, New York has experienced an above average number of 2-inch extreme precipitation events, with the highest frequency occurring during the 2010–2014 period. Sources: CISESS and NOAA NCEI. Data: GHCN-Daily from 16 long-term stations.

### Observed and Projected Change in Global Sea Level



**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.

historical records. Heat waves are projected to be more intense. Extreme heat is a particular concern for New York City and other urban areas, where the urban heat island effect raises summer temperatures. High temperatures

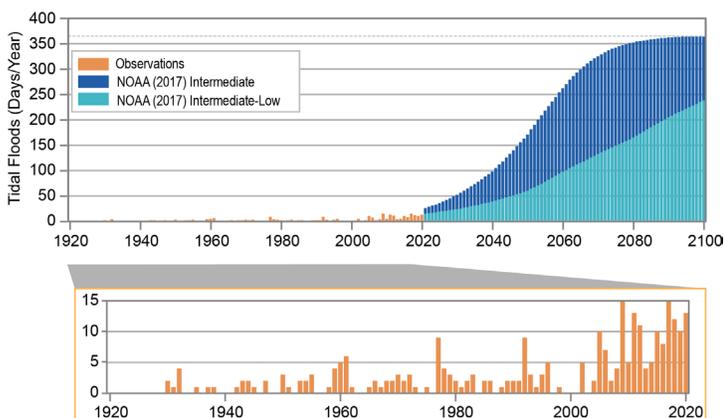
combined with high humidity can create dangerous heat index values. By contrast, cold waves are projected to become less intense.

**Increasing temperatures raise concerns for sea level rise in coastal areas.** Since 1880, sea level has risen by about 13 inches along the coast of New York, more than the global average rise of about 7–8 inches since 1900. Global sea level is projected to rise another 1–4 feet by 2100 as a result of both past and future emissions from human activities (Figure 6), but local and regional factors are expected to cause New York’s sea level to rise more than the global projection. Even if storm patterns remain the same, sea level rise will increase the frequency, extent, and severity of coastal flooding. 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 New York coastline, the number of tidal flood days (all days exceeding the nuisance-level threshold) has also increased, with the greatest number occurring in 2009 and 2017 (Figure 7). This is a particular concern for New York because of dense, high-value development along the coastline.

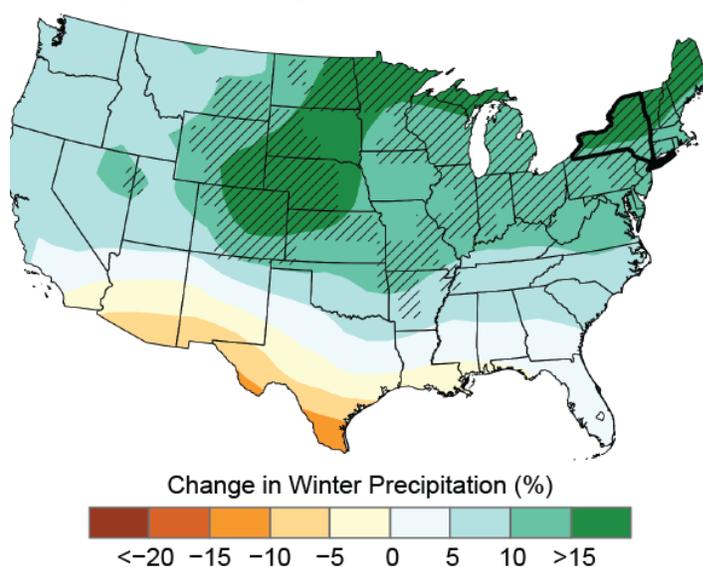
**Winter and spring precipitation is projected to increase in New York** (Figure 8). This could result in enhanced snowpack at higher elevations, but with warmer temperatures, more of the precipitation will fall as rain, particularly at lower elevations. In addition, the frequency and intensity of extreme precipitation events are projected to increase, potentially increasing the frequency and intensity of floods. Heavier precipitation increases the risk of springtime flooding, which could pose a particular threat to New York’s agricultural industry by delaying planting and resulting in yield losses.

Observed and Projected Annual Number of Tidal Floods for The Battery, NY



**Figure 7:** Number of tidal flood days per year at The Battery, NY, for the observed record (1920–2020; 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 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 2009 and 2017 at The Battery. 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.

Projected Change in Winter Precipitation



**Figure 8:** Projected change in 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. By the middle of this century, if greenhouse gas emissions continue to rise rapidly, winter precipitation is projected to increase by 10%–15% in southern New York and 15%–20% in northern New York. Sources: CISESS and NEMAC. Data: CMIP5.

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