NEW YORK STATE
Department of Environmental Conservation

Observed and Projected Climate Change in New York State: An Overview

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Background

New York State has undertaken several initiatives that require consideration of future climate conditions. The 2014 Community Risk and Resiliency Act (CRRA), as amended by the 2019 Climate Leadership and Community Protection Act (CLCPA), requires that applicants for permits issued for major projects in all regulatory programs covered by the Uniform Procedures Act demonstrate consideration of future physical climate risk. The amended CRRA authorizes the Department of Environmental Conservation (DEC) to require mitigation of such risk to public infrastructure, natural resources, etc.

The CRRA further requires that DEC consider future physical risk caused by storm surges, sea level rise, and flooding in certain facility-siting regulations, and that applicants to certain funding programs, managed by several agencies, must also demonstrate consideration of such flooding risks. The CRRA also added mitigation of future risks due to storm surges, sea level rise, and flooding to the list of smart growth criteria required for consideration in approval and funding of public infrastructure projects (Environmental Conservation Law Article 6). See https://www.dec.ny.gov/energy/102559.html for additional information on the CRRA and implementing guidance.

In January 2015, Governor Cuomo released his 2015 Opportunity Agenda, which included goals for a “Climate Smart NY,” including a directive that all agencies and authorities regularly assess “climate-related risks to their assets, services and abilities to reduce risk.” Governor Cuomo followed the Climate Smart NY initiative with 2018’s “Resilient NY” initiative. Under Resilient NY, Governor Cuomo directed DEC to issue resilience guidelines, understood to be flood risk management guidance in preparation pursuant to the CRRA, and to update and improve wetland and coastal risk maps. The governor directed the Department of State (DOS) to recommend updates to the building code to enhance resilience and directed all agencies and authorities to develop adaptation plans.

State agencies are also working to support local adaptation through the interagency Climate Smart Communities program, DEC’s local floodplain assessments, and DOS’s model local laws, developed pursuant to the CRRA.

Traditionally, hazard mitigation has been incorporated into planning and permitting decisions using data based on historical conditions and consideration of historical risk, assuming stable climate conditions will persist into the future. At best, changes in risk were projected using simple extrapolation of historical data. Effective planning and decision making require maintaining or improving accurate risk profiles under future conditions that could result in significant changes in hazards and associated risks. Accurate and useful vulnerability and risk assessment, hazard-mitigation planning, and adaptation project implementation are dependent on scientifically derived projections of future conditions under anthropogenic (human-caused) climate change.

This document provides a summary of observed and projected climatic conditions for New York State. This information is primarily derived from the so-called ClimAID report[1] or its 2014 update.[2] In cases for which ClimAID does not include relevant information, or where more recent information is available, that information is included and the sources cited.

Both the original 2011 ClimAID report and the 2014 update provide projections of mean annual changes in precipitation and temperature, and sea level rise through the year 2100, and of frequency and duration of extreme temperature and precipitation events through the 2080s for

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[1] Rosenzweig et al. 2011

[2] Horton et al. 2014

each of seven regions of the state (Figure 1). The full 2011 report articulates, by sector, the likely effects these changes will have across the state. The 2014 ClimAID update was based on new datasets, improved baseline scenarios, and the latest generation of climate models and emissions projections.

Climate projections included in the ClimAID reports were derived by downscaling global climate models and have inherent uncertainty. Climate sensitivity could exceed or fall below the range in the models used. For New York in particular, more research is needed on changes in climate variability in the future, and on microclimatic differences across the state.

This document includes references to the best available sources of quantitative projections, where available, for each climate hazard. Where applicable, examples of the use of these sources are also provided.

This document is intended to provide an introduction and ready reference to climate change projections specific to New York State. A discussion of the effects of projected climate change on humans, infrastructure, and natural resources is beyond the scope of this document. The reader is referred to the 2011 ClimAID report, particularly Chapter 12, for information on sector-specific vulnerabilities. Other useful sources of information on vulnerabilities include the National Climate Assessment, particularly the Northeast section,[3] and the New York State Division of Homeland Security and Emergency Service’s online state hazard mitigation plan.[4]

This document summarizes current information on observed and projected trends in the following climate variables and associated effects:

- Average temperatures
- Extreme temperatures
- Winter–spring transition
- Average precipitation
- Extreme precipitation
- Drought
- Snowfall
- Lake-effect snow
- Snowmelt-related streamflow
- Ocean warming
- Sea level rise
- Coastal storms
- Coastal erosion
- Tornadoes and thunderstorms

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[3] Dupigny-Giroux et al. 2018

[4] NYSDHSES 2019

Climate Change in New York State

New York State's climate can be described as humid continental. The average annual temperature varies from about 40°F in the Adirondacks to about 55°F in the New York City metropolitan area. The wettest parts of the state, including parts of the Adirondacks and Catskills, the Tug Hill Plateau, and portions of the New York City metropolitan area, average 50 inches of precipitation per year. Mountain effects produce localized amounts of precipitation in excess of 60 inches per year at inland locations. Parts of western New York are relatively dry, averaging about 30 inches of precipitation per year. In all regions, precipitation is relatively consistent in all seasons, although droughts and floods are not uncommon.[5]

Average Temperature

Observed

New York has warmed at an average rate of 0.25°F per decade since 1900.[6] Annual average temperatures have increased in all regions of the state. More recently, warming has accelerated: since 1970, the statewide annual average temperature has risen about 0.6°F per decade, with winter warming exceeding 1.1°F per decade.[7]

Projected

Annual average temperatures in New York State are projected to rise 4.1°F to 6.1°F by the 2080s. Climate change modeling predicts that the anticipated increases in temperature will not be uniform across New York State, and some areas may be more affected by these changes than others. By 2100, some regions of New York could experience an increase in average temperature of more than 12°F. Throughout the state, summers will become warmer and winters milder.[8]

Data Sources

Table 1 provides projected changes in average annual temperatures for the seven ClimAID regions. Observations and projections of additional temperature-related parameters for the state and for individual counties are available from the Northeast Regional Climate Center's

Climate Data Grapher. This resource is available at the New York Climate Change Science Clearinghouse (NYCCSC, https://www.nyclimatescience.org/highlights/data_products) and reports trends in the following parameters:

- maximum annual temperatures
- minimum annual temperatures
- average temperature
- growing degree-day accumulation
- heating degree-day accumulation
- cooling degree-day accumulation

For example, **Error! Reference source not found.** displays modeled cooling degree-day accumulation under two greenhouse gas emissions scenarios, compared to a user-selected 1966–1970 baseline for the entire state.

Extreme Temperatures

Recognizing the state's climate variability, ClimAID applies two criteria for both extreme heat and extreme cold days. Extreme heat days are defined as those with maximum temperatures at or above 90°F in northern portions of the state and those with maximum temperatures at or above 95°F in southern

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[5] Rosenzweig et al. 2011
[6] Horton et al. 2014
[7] Rosenzweig et al. 2011
[8] Horton et al. 2014

portions. Heat waves are defined as periods of three or more consecutive days with maximum temperatures at or above 90°F. Extreme cold days are defined as those with maximum temperatures at or below 32°F in southern areas and those with minimum temperatures at or below 0°F in northern areas.[9]

Observed

The frequency of cold waves has decreased across the contiguous U.S since the early 1900s, while the frequency of heat waves has increased since the mid-1960s.[10]

Projected

The total annual number of individual hot days, and the annual frequency and duration of heatwaves in New York State are expected to increase as the century progresses. Conversely, the number of extreme cold days, of either of the above two definitions, will likely decrease. Some research has connected the loss of arctic sea ice with a weakening of the temperature gradient that tends to confine the polar vortex. The weakening of this temperature gradient could allow excursions of the vortex's extreme cold over the Northeast, resulting in periods of extreme cold, but as time progresses, such outbreaks will become increasingly unusual.[11]

Data Sources

Table 2 provides projected annual changes in annual frequency of extreme temperature events in each of the seven ClimAID regions. As discussed above, the Northeast Regional Climate Center's Climate Data Grapher, available at https://www.nyclimatescience.org/highlights/data_products, provides information on trends in several climate parameters. For example, Figure 3 shows the modeled trend in extreme-heat days for Schuyler County.

Winter–Spring Transition

Observed

Winters in the northeastern U.S. have warmed three times faster than have summers, resulting in an increase in the proportion of winter precipitation falling as rain.[12,13]

Projected

As illustrated in Figure 4, the observed shift toward winter rain and away from snow is expected to continue throughout the eastern and central U.S.[14] The decrease in the number of days below freezing will result in fewer days with snow cover, reductions in snow depth and water equivalent, decreased extent of snow cover, earlier snow melt, and less lake ice.[15]

Figure 5 indicates changes in dates of the last spring freeze (left column) and of the first fall freeze (right column) for three time periods through the end of the century under two representative concentration pathways. The bottom row shows the shift in these dates for the end of the century under the higher scenario. The freeze-free period across much of the Northeast is expected to lengthen by as much as two weeks by about 2050 under the lower emissions scenario and by two to three weeks under the higher scenario. The freeze-free period could be at least three weeks longer in the Northeast by 2100.[16]

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[9] Horton et al. 2014
[10] Vose et al. 2017
[11] Cohen et al. 2014
[12] Thibeault and Seth 2014
[13] Feng and Hu 2007
[14] Ning and Bradley 2015
[15] Dupigny-Giroux et al. 2018
[16] Dupigny-Giroux et al. 2018

Representative Concentration Pathways

A representative concentration pathway (RCP) is a trajectory of projected greenhouse gas (GHG) emissions. The number in the label of each RCP refers to the additional radiative forcing anticipated by 2100, in Watts per square meter (W/m^2), assuming each trajectory, e.g., an additional 2.6 W/m^2 for RCP2.6. The IPCC adopted four RCPs (RCP2.6, RCP4.5, RCP6 and RCP8.5) as the basis for the climate projections in its Fifth Assessment Report.

RCP2.6 is considered “very stringent” and would likely limit global temperature rise to 3.6°F by 2100.

Many studies have used it as a low-emissions scenario, but this scenario is now considered unlikely. Many studies use RCP8.5 as a high-emissions scenario, and it had been considered a worst-case scenario, resulting in a likely temperature increase of 4.7 to 8.6°F by 2100. Policies to reduce GHG emissions and lower than projected coal use make this scenario increasingly unlikely but still possible due to the effects of positive feedbacks that are not currently well understood.

https://sedac.ciesin.columbia.edu/ddc/ar5_scenario_process/RCPs.html, accessed August 9, 2021.

Average Precipitation

Observed

Most regions of the state have experienced an increase in average annual precipitation over the past century. In addition to increased mean annual precipitation across New York State, both year-to-year variability and multiyear variability of precipitation have become more pronounced.[17]

Projected

Natural variability in precipitation amounts across time and geographic areas is large, so precipitation projections are less certain than those for temperature. Most of the increase in total precipitation is expected in winter and spring, with little change expected in the summer. By the late twenty-first century, under a high emissions scenario (Representative Concentration Pathway 8.5, see text box), Northeast monthly precipitation is projected to be about 1 inch greater for the period December through April.[18] Most ClimAID projections indicate increased precipitation across the state, but some do not. Table 3 provides projected changes in average annual precipitation for the seven ClimAID regions.

Extreme Precipitation

Observed

The nationwide trend of increasingly frequent extreme precipitation events has been particularly pronounced in the Northeast, including New York.[19] The proportion of total annual precipitation falling in the heaviest 1% of events increased by 38% in the Northeast, between the periods 1901–1960 and 1986–2016. More recently, from 1958–2016, this increase was 55% (Figure 6).[20]

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[17] Horton et al. 2014
[18] Lynch et al 2016
[19] Hoerling et al 2016
[20] NCA4 Ch. 2

Projected

ClimAID projects increases in the frequency and duration of precipitation events with more than one, two, and four inches of precipitation at daily timescales, and that the frequency and severity of downpours at sub-daily or even sub-hourly timescales are also very likely to increase.[21] By the period 2070–2099, under a lower emissions scenario, portions of New York can expect increases in the proportion of annual precipitation falling in the heaviest 1% of events of 20 to greater than 40% over the period 1986–2015. Under a high emissions scenario, the entire state can expect at least a 40% increase in the proportion of annual precipitation falling in the heaviest 1% of events.[22]

The proportion of total annual precipitation falling in the heaviest 1% of events is projected to increase by 20–39 % under a lower emissions scenario (RCP4.5) and by more than 40% under a high emissions scenario (RCP8.5), relative to 1986–2015, by the period 2070–2099. (Figure 7).[23]

Data Sources

NOAA Atlas 14 provides point precipitation frequency estimates for all of New York. Atlas 14 is based primarily on data available through 2014 and superseded several commonly used precipitation references, including Weather Bureau Technical Paper No. 40.[24,25]

As Atlas 14 does not include regular updates, it is unresponsive to recent changes in the state's precipitation climatology. The Northeast Regional Climate Center, based at Cornell University, provides precipitation intensity and frequency data on a web-based platform (http://precip.eas.cornell.edu/). Estimates are based on annual updates to extreme precipitation data and available in tabular and graphical formats. For example, Figure 8 depicts an intensity-duration-frequency curve for a 1% annual exceedance probability (AEP) 1- to 48-hour event in Albany

The Northeast Regional Climate Center has also developed projections of future extreme precipitation events by downscaling global climate models. These projections are available in a variety of formats at http://ny-idf-projections.nrcc.cornell.edu/. The platform provides historical and future precipitation amounts computed for a range of event durations and recurrence intervals, and historical and future intensity-duration-frequency curves. **Figure 9** and **Figure 10** provide examples of output from this platform.

Drought

Projected

Although projections of drought have not been quantified, Horton et al. [26] project that late-summer, short-term droughts will become more frequent toward the end of the century, but it is not known if the risk of multiyear droughts will change.[27] The effects of drought will be exacerbated by increased evaporation of surface moisture caused by higher temperatures.[28]

Snowfall

Observed

The state averages about 40 inches of snow annually, but annual snowfall varies considerably across the state, from more than 175 inches per year in the Adirondacks and Tug Hill Plateau to less than 36 inches per year on Long Island and in the New York City metropolitan area. However, southern portions

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[21] Horton et al. 2014.
[22] Dupigny-Giroux et al. 2018
[23] Ibid.
[24] Perica et al. 2015
[25] Hershfield 1961
[26] Horton et al. 2014
[27] Rosenzweig et al. 2011
[28] Thibeault and Seth 2014

of the state can experience heavy snowfall events in excess of 20 inches, associated with nor'easters.[29,30]

Projected

Snowfall in New York is likely to become less frequent, and the combination of less early winter snowfall and earlier snowmelt will lead to a shorter snow season; fewer days with snow on the ground; decreased snow depth, water equivalent, and extent; and earlier snowmelt. One modeling study determined that under a high emissions scenario, central and eastern North America would experience, on average, 28 % fewer snowstorms per year and that the amount of snow or frozen precipitation per storm would decrease by one-third by the 2090s.[31,32,33,34,35]

The degree to which the intensity of individual snowstorms will change is uncertain. Cold parts of the state could continue to experience heavy snowfall events due to the capacity of the warmer atmosphere to hold more moisture.

Lake-Effect Snow

Observed

Lake-effect snows are an extreme precipitation phenomenon affecting areas adjacent to Lake Ontario and Lake Erie, and, to a lesser extent, the Finger Lakes. Arctic air masses moving over the relatively warm eastern Great Lakes are warmed, humidified, and destabilized, often leading to intense bands of heavy snowfall, generating as much as 48 inches of snow in a single storm. These events can last anywhere from an hour to a few days. As the climate has warmed, ice coverage on the Great Lakes has fallen. The maximum seasonal coverage of Great Lakes ice decreased at a rate of about 8 % per decade from 1973–2008, amounting to a roughly 30 % decrease in ice coverage. There is evidence of an increase in lake-effect snowfall along and near the southern and eastern shores of the Great Lakes since 1950.[36]

Projected

The probability of extreme lake-effect snows, such as those that affected western New York in 2014, is likely to increase in the near future. Models suggest the decreasing trend in ice cover on the Great Lakes will lead to increased lake-effect snow in the next several decades through greater moisture availability. In the longer term, lake-effect snows are likely to decrease as temperatures continue to rise, with the precipitation then falling as rain.[37]

Snowmelt-Related Streamflow

Observed

In the Northeast, timing of snowmelt-related streamflow is sensitive to slight changes in air temperature. A 1.7°F increase in the average winter–spring air temperature from 1940–2014 is the apparent cause of earlier average streamflow timing (winter–spring center volume date) of 7.7 days in the Northeast.[38]

Projected

A study comparing observed and projected magnitude and timing of maximum spring streamflows between the periods 1951–2005 and 2041–2095, respectively, included five

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[29] Nor'easters are storms that form along the East Coast and are named after the direction from which the strongest winds typically blow over the Northeast states.
[30] Horton et al. 2014
[31] Horton et al. 2014
[32] Notaro et al. 2014
[33] Demaria et al. 2016
[34] Kunkel et al. 2016
[35] Ashley et al. 2020
[36] Burnett et al. 2003
[37] Kunkel et al. 2002
[38] Dudley et al. 2017

New York streams (two in the Southern Tier, three in the Catskills). Under a moderate emissions scenario (RCP4.5), magnitudes of maximum spring flows in all five streams were projected to decrease by 0–20 %. Changes in projected timing of maximum flow under RCP4.5 ranged from 20 days earlier to 10 days later. Projected magnitudes of maximum flows also decrease under the higher emissions scenario (RCP8.5). Under the higher emissions scenario, maximum flows in the two Southern Tier streams were projected to occur 1–20 days later, while the maximum flows in three Catskills streams were projected to occur 1–10 days earlier. Although this study did not include streams in northern New York, peak flows in streams north of latitude 40°N, in other states, were projected to decrease by as much as 35 % and to occur 1–20 days earlier (Figure 11). [39]

Ocean Warming

Observed

Ocean and coastal temperatures along the Northeast Continental Shelf are driven by the northern position of the Gulf Stream, the volume of water entering from the Labrador Current, and large-scale background warming of the oceans. These temperatures increased by 0.06°F per year from 1982–2016, and the rate of warming shows signs of increasing, rising to four times the long-term warming rate during the period 2007–2016. Ocean and coastal warming has been strongest during the summer months, and the duration of summer-like sea surface temperatures has expanded.[40]

Projected

Ocean waters over the Northeast Continental Shelf are expected to continue to warm faster than most other marine waters around the world, increasing by up to 0.76°F per decade by the period 2070–2099, compared to 0.40°F per decade during the period 1976–2005.[41]

Sea Level Rise

Sea level rise is the most directly observable effect of climate change in New York. Sea level rise can result in sunny-day (often called nuisance) flooding during high tides, permanent inundation, and deeper and more extensive flooding during coastal storm events.

Observed

Sea level along New York's ocean coast and in the Hudson River has risen by more than 1 foot since 1900, or about 1.2 inches per decade.[42]

Projected

The CRRA directed DEC to adopt science-based sea level rise projections by regulation. Pursuant to this requirement, DEC adopted 6 NYCRR Part 490, Projected Sea-level Rise, in 2017. Part 490 is applicable to the state's entire tidal coastline and provides projections for three regions: the tidal coast of Long Island; New York City and the lower Hudson River upstream to Kingston; and the mid-Hudson River from Kingston upstream to the federal dam in Troy. The three regions exhibit slight differences in relative sea level rise due to local conditions.

Part 490 provides five projections for each of the three regions: low (L), low-medium (L-M), medium (M), high-medium (H-M), and high (H). These qualitative terms refer to the rate of rise and not to the projected ultimate water level itself. Each of these projections is presented for three different decades: the 2020s (i.e., the years 2020–2029), 2050s, 2080s, and the year 2100. DEC anticipates updating its sea level rise projections in 2022.

Data Sources

The Part 490 projections are provided in Table 4 and are also included in the Part 490 express terms. In addition to the tabular presentations of New York sea level rise projections, several sea

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[39] Demaria et al. 2016
[40] Dupigny-Giroux 2018
[41] Alexander et al. 2018
[42] Horton et al. 2014.

level rise viewers are available for New York. DEC recommends the following viewers for use in these specified regions:

- Nassau and Suffolk counties: *Coastal New York Future Floodplain Mapper* https://services.nyserda.ny.gov/SLR_Viewer/
- New York City: *NYC Flood Hazard Mapper* https://www1.nyc.gov/site/planning/data-maps/flood-hazard-mapper.page
- Hudson River (north of New York City): *Hudson River Flood Hazard Decision Support System* http://www.ciesin.columbia.edu/hudson-river-flood-map/

DEC has provided guidance on the use of these mappers.[43] To facilitate identification of areas at risk of flooding during flood events enhanced by sea level rise, DEC has placed on its internal GIS Data Selector the data layers from these three mappers displaying the horizontal extent of the projected floodplain with six feet of sea level rise, and for Long Island, the area of the projected limit to moderate wave action with six feet of sea level rise (Figure 12).

DEC also provides the projected tidal floodplain, with six feet of sea level rise, as a single layer on its public-facing Environmental Resource Mapper, available at https://gisservices.dec.ny.gov/gis/erm/. The Environmental Resource Mapper also includes the projected limit to moderate wave action for Long Island (Figure 13).

Coastal Storms

Coastal storms can strike the state in two forms: tropical cyclones (hurricanes and tropical storms) and extratropical cyclones (nor’easters). Tropical cyclones generally occur between July and October and can bring storm surges, high winds, and heavy precipitation. Nor’easters tend to strike during cooler months and are generally weaker than tropical storms. However, their longer duration can extend their period of high winds, flooding, and wave action over several tide cycles. Higher flood waters, attributable to anthropogenic sea level rise, have caused measurably greater damage during recent storms, e.g., Hurricane Sandy. Warming waters may also drive stronger winds, and additional moisture in a warmer atmosphere can result in heavier precipitation during such storms.

Observed

Approximately 65 tropical or subtropical cyclones have struck New York as hurricanes or tropical storms since the mid-nineteenth century. Approximately 12 of these storms made landfall in New York as hurricanes.[44] The frequency, intensity, and duration of extreme precipitation events and coastal storms and flooding are increasing, exemplified by the pattern of extreme weather in 2011 (Hurricane Irene and Tropical Storm Lee), 2012 (Hurricane Sandy), 2013 (Niagara County and Mohawk Valley flooding), and 2014 (Long Island flooding).

Projected

It is unclear how the number of tropical cyclones will change.[45] Although the number of the most intense hurricanes forming in the North Atlantic Basin will likely increase, the implications of this increase for New York are unclear as the tracks of tropical storms are highly variable and poorly understood.[46,47] Precipitation amounts associated with tropical cyclones will likely increase.[48]

Projected changes in frequency or severity of nor’easters are not clear, but one modeling study projected a westward shift in nor’easter

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[43] NYSDEC 2020
[44] Wikipedia: List of New York hurricanes. Accessed July 1, 2021 at https://en.wikipedia.org/wiki/List_of_New_York_hurricanes .
[45] Horton and Liu 2014
[46] Kozar et al. 2013
[47] IPCC 2013
[48] Knutson et al. 2010

tracks, potentially making nor'easter landfall in New York more likely.[49]

Any increase in frequency or intensity of coastal storms could result in more frequent coastal flood events. However, even absent changes in storm frequency or intensity, sea level rise alone will result in an increase in coastal floods of any particular depth. One study estimated that, by the year 2100, sea level rise alone could cause coastal flood levels that currently have an approximately 1% AEP (the so-called 100-year flood) to occur approximately four times more frequently.[50]

Another study combined downscaled tropical cyclones and projected storm surge and sea level rise to assess flood risk to New York City at the Battery through 2300, specifically for tropical cyclones. (Risks associated with extratropical or post-tropical cyclones, e.g., Sandy, may be substantially different due to increased risk such storms could track toward land, rather than to the ocean.) Although this study found little change in modeled heights of storm surge associated with tropical cyclones, it found that sea level rise had significantly increased flood heights since the pre-industrial era. The elevation of the preindustrial 0.2% annual chance flood has become the elevation of the 4% annual chance flood. The study projected that this elevation will become the 20% annual flood by mid-century.[51]

Coastal Erosion

Sea level rise results in greater nearshore water depths, which, in turn, increase wave energy and coastal erosion rates. A study of East Coast sandy beaches estimated the ratio of the rate of shoreline erosion to the rate of sea level rise to be approximately 150, i.e., approximately 12 feet of beach lost for every inch of sea level rise. This ratio is much greater than would be accounted for by beach inundation alone. This study found the ratio of erosion loss to sea level rise in erosional areas of Long Island not influenced by inlets and coastal engineering to equal 110, i.e., about 9 feet lost for every inch of sea level rise.[52]

Projected

Sea level rise and storms are projected to continue to drive long-term coastal erosion. Although New York-specific projections are not available, one study estimated that at least 30% of U.S. Atlantic Coast sandy beaches are likely to erode inland by at least 3.3 feet per year.[53]

Tornadoes and Thunderstorms

The short duration and limited geographic area of most tornadoes and severe thunderstorms make detection of trends and development of projections difficult.[54,55] Projections of climate change-induced trends in tornadoes and thunderstorms are not available.

Projection Updates

The New York State Energy Research and Development Authority has begun development of a new climate change assessment that will include updates to the ClimAID projections and an expanded set of projections. This summary will be updated as this new information and other relevant reports, e.g., National Climate Assessment, become available.

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[49] Colle et al. 2013
[50] Rosenzweig et al. 2011
[51] Garnera et al. 2017
[52] Leatherman et al. 2011
[53] Gutierrez et al. 2014
[54] Kossin et al. 2017
[55] Kunkel et al. 2013

Tables

Table 1. Projected changes in average annual temperature for seven ClimAID regions of New York[56]

Baseline (1971–2000) 47.7°F	Low Estimate (10th Percentile)	Middle Range (25th to 75th Percentile)	High Estimate (90th Percentile)
Region 1 (Rochester)			
2020s	+1.8°F	+2.3 to 3.2°F	+4.0°F
2050s	+3.7°F	+4.3 to 6.3°F	+7.3°F
2080s	+4.2°F	+5.7 to 9.6°F	+12.0°F
2100	+4.6°F	+6.3 to 11.7°F	+13.8°F
Region 2 (Port Jervis)			
2020s	+1.6°F	+2.2 to 3.1° F	+3.5°F
2050s	+3.1°F	+4.2 to 6.1°F	+6.9°F
2080s	+4.0°F	+5.4 to 9.6°F	+10.7°F
2100	+4.3°F	+6.2 to 11.2°F	+12.6°F
Region 3 (Elmira)			
2020s	+1.8°F	+2.3 to 3.3°F	+3.8°F
2050s	+3.6°F	+4.4 to 6.3°F	+7.1°F
2080s	+4.2°F	+5.7 to 9.9°F	+11.6°F
2100	+4.5°F	+6.3 to 11.7°F	+13.8°F
Region 4 (New York City)			
2020s	+1.5°F	+2.0 to 2.9°F	+3.2°F
2050s	+3.1°F	+4.1 to 5.7°F	+6.6°F
2080s	+3.8°F	+5.3 to 8.8°F	+10.3°F
2100	+4.2°F	+5.8 to 10.4°F	+12.1°F
Region 5 (Saratoga)			
2020s	+1.7°F	+2.3 to 3.2°F	+3.7°F
2050s	+3.5°F	+4.5 to 6.2°F	+7.1°F
2080s	+4.1°F	+5.6 to 9.7°F	+11.4°F
2100	+4.4°F	+6.1 to 11.4°F	+13.6°F
Region 6 (Watertown)			
2020s	+1.9°F	+2.3 to 3.4°F	+3.9°F
2050s	+3.7°F	+4.4 to 6.4°F	+7.2°F
2080s	+4.3°F	+5.9 to 10.0°F	+11.8°F
2100	+4.5°F	+6.3 to 11.9°F	+13.9°F
Region 7 (Indian Lake)			
2020s	+1.8°F	+2.3 to 3.4°F	+3.8°F
2050s	+3.7°F	+4.5 to 6.4°F	+7.4°F
2080s	+4.2°F	+5.8 to 10.1°F	+11.8°F
2100	+4.4°F	+6.2 to 11.9°F	+13.9°F

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[56] Horton et al. 2014

Table 2. Projected changes in annual frequency of extreme temperature events for the seven ClimAID regions of New York[57]

Region 1 – Rochester

Numbers in parentheses indicate baseline.	2020s			2050s			2080s		
	Low Estimate (10th Percentile)	Middle Range (25th to 75th Percentile)	High Estimate (90th Percentile)	Low Estimate (10th Percentile)	Middle Range (25th to 75th Percentile)	High Estimate (90th Percentile)	Low Estimate (10th Percentile)	Middle Range (25th to 75th Percentile)	High Estimate (90th Percentile)
Days over 90°F (8 days)	12	14 to 17	19	18	22 to 34	42	22	27 to 57	73
# of Heat Waves (0.7 heat waves)	2	2 to 2	2	2	3 to 4	5	3	3 to 8	8
Duration of Heat Waves (4 days)	4	4 to 4	4	4	4 to 5	5	4	5 to 6	6
Days below 32°F (133 days)	99	103 to 111	116	78	84 to 96	102	59	68 to 88	97
Days over 1″ Rainfall (5 days)	4	5 to 5	6	4	5 to 5	6	4	5 to 6	7
Days over 2″ Rainfall (0.6 days)	0.6	0.6 to 0.7	0.8	0.5	0.6 to 0.8	0.9	0.5	0.6 to 0.9	1

Region 2 – Port Jervis

	2020s			2050s			2080s		
	Low Estimate (10th Percentile)	Middle Range (25th to 75th Percentile)	High Estimate (90th Percentile)	Low Estimate (10th Percentile)	Middle Range (25th to 75th Percentile)	High Estimate (90th Percentile)	Low Estimate (10th Percentile)	Middle Range (25th to 75th Percentile)	High Estimate (90th Percentile)
Days over 90°F (8 days)	16	19 to 25	27	24	31 to 47	56	31	38 to 77	85
# of Heat Waves (0.7 heat waves)	2	3 to 3	4	3	4 to 6	8	4	5 to 9	9
Duration of Heat Waves (4 days)	4	5 to 5	5	5	5 to 6	6	5	5 to 7	8
Days below 32°F (133 days)	106	108 to 116	120	79	86 to 100	108	59	65 to 89	101
Days over 1″ Rainfall (5 days)	11	12 to 13	14	12	13 to 14	15	12	13 to 15	16
Days over 2″ Rainfall (0.6 days)	2	2 to 2	3	2	2 to 3	3	2	2 to 3	3

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[57] Horton et al. 2014

Table 2. Projected changes in annual frequency of extreme temperature events for the seven ClimAID regions of New York[57]

Region 3 – Elmira

	2020s			2050s			2080s		
	Low Estimate (10th Percentile)	Middle Range (25th to 75th Percentile)	High Estimate (90th Percentile)	Low Estimate (10th Percentile)	Middle Range (25th to 75th Percentile)	High Estimate (90th Percentile)	Low Estimate (10th Percentile)	Middle Range (25th to 75th Percentile)	High Estimate (90th Percentile)
Days over 90°F (8 days)	15	17 to 21	23	22	26 to 41	47	28	33 to 67	79
# of Heat Waves (0.7 heat waves)	2	2 to 3	3	3	3 to 6	6	3	4 to 9	9
Duration of Heat Waves (4 days)	4	4 to 5	5	5	5 to 5	5	5	5 to 6	7
Days below 32°F (133 days)	119	122 to 130	134	94	100 to 114	120	72	79 to 103	116
Days over 1″ Rainfall (5 days)	6	6 to 7	7	6	6 to 7	8	6	7 to 8	8
Days over 2″ Rainfall (0.6 days)	0.6	0.7 to 0.9	1	0.7	0.8 to 1	1	0.7	0.8 to 1	1

Region 4 – New York City

	2020s			2050s			2080s		
	Low Estimate (10th Percentile)	Middle Range (25th to 75th Percentile)	High Estimate (90th Percentile)	Low Estimate (10th Percentile)	Middle Range (25th to 75th Percentile)	High Estimate (90th Percentile)	Low Estimate (10th Percentile)	Middle Range (25th to 75th Percentile)	High Estimate (90th Percentile)
Days over 90°F (8 days)	24	26 to 31	33	32	39 to 52	57	38	44 to 76	87
# of Heat Waves (0.7 heat waves)	3	3 to 4	4	4	5 to 7	7	5	6 to 9	9
Duration of Heat Waves (4 days)	5	5 to 5	5	5	5 to 6	6	5	5 to 7	8
Days below 32°F (133 days)	50	52 to 58	60	37	42 to 48	52	25	30 to 42	49
Days over 1″ Rainfall (5 days)	13	14 to 15	16	13	14 to 16	17	14	15 to 17	18
Days over 2″ Rainfall (0.6 days)	3	3 to 4	5	3	4 to 4	5	3	4 to 5	5

Table 2. Projected changes in annual frequency of extreme temperature events for the seven ClimAID regions of New York[57]

Region 5 – Saratoga

	2020s			2050s			2080s		
	Low Estimate (10th Percentile)	Middle Range (25th to 75th Percentile)	High Estimate (90th Percentile)	Low Estimate (10th Percentile)	Middle Range (25th to 75th Percentile)	High Estimate (90th Percentile)	Low Estimate (10th Percentile)	Middle Range (25th to 75th Percentile)	High Estimate (90th Percentile)
Days over 90°F (8 days)	14	17 to 22	23	22	27 to 41	50	27	35 to 70	82
# of Heat Waves (0.7 heat waves)	2	2 to 3	4	3	4 to 6	7	4	5 to 8	9
Duration of Heat Waves (4 days)	4	5 to 5	5	5	5 to 6	6	5	5 to 7	9
Days below 32°F (133 days)	123	127 to 136	139	98	104 to 119	125	77	84 to 109	120
Days over 1″ Rainfall (5 days)	10	10 to 11	12	10	11 to 12	13	10	11 to 13	14
Days over 2″ Rainfall (0.6 days)	1	1 to 2	2	1	1 to 2	2	1	1 to 2	2

Region 6 – Watertown

	2020s			2050s			2080s		
	Low Estimate (10th Percentile)	Middle Range (25th to 75th Percentile)	High Estimate (90th Percentile)	Low Estimate (10th Percentile)	Middle Range (25th to 75th Percentile)	High Estimate (90th Percentile)	Low Estimate (10th Percentile)	Middle Range (25th to 75th Percentile)	High Estimate (90th Percentile)
Days over 90°F (8 days)	5	6 to 8	10	9	12 to 21	26	12	17 to 44	57
# of Heat Waves (0.7 heat waves)	0.6	0.8 to 0.9	1	1	1 to 3	3	1	2 to 6	7
Duration of Heat Waves (4 days)	3	4 to 4	4	4	4 to 4	5	4	4 to 6	6
Days below 32°F (133 days)	116	119 to 126	130	96	102 to 113	119	78	85 to 104	114
Days over 1″ Rainfall (5 days)	6	7 to 8	8	7	7 to 8	9	7	7 to 9	10
Days over 2″ Rainfall (0.6 days)	0.6	0.7 to 1	1	0.7	0.7 to 1	1	0.7	0.8 to 1	1

Table 2. Projected changes in annual frequency of extreme temperature events for the seven ClimAID regions of New York[57]

Region 7 – Indian Lake

	2020s			2050s			2080s		
	Low Estimate (10th Percentile)	Middle Range (25th to 75th Percentile)	High Estimate (90th Percentile)	Low Estimate (10th Percentile)	Middle Range (25th to 75th Percentile)	High Estimate (90th Percentile)	Low Estimate (10th Percentile)	Middle Range (25th to 75th Percentile)	High Estimate (90th Percentile)
Days over 90°F (8 days)	0.5	0.8 to 2	2	2	3 to 6	10	3	5 to 19	27
# of Heat Waves (0.7 heat waves)	0	0.1 to 0.2	0.2	0.2	0.3 to 0.7	1	0.2	0.5 to 2	3
Duration of Heat Waves (4 days)	3	3 to 4	4	3	3 to 4	4	4	4 to 5	5
Days below 32°F (133 days)	159	162 to 172	177	131	138 to 154	161	107	118 to 143	156
Days over 1″ Rainfall (5 days)	7	7 to 8	9	7	8 to 9	10	8	8 to 10	11
Days over 2″ Rainfall (0.6 days)	0.7	0.8 to 1	1	0.8	0.9 to 1	1	0.8	0.9 to 1	1

Table 3. Projected changes in average annual precipitation for seven ClimAID regions of New York[58]

	Low Estimate (10th percentile)	Middle Range (25th to 75th percentile)	High Estimate (90th percentile)
Region 1 (Rochester): Baseline (1971–2000) 34.0″			
2020s	0%	+2 to +7%	+8%
2050s	+2%	+4 to +10%	+12%
2080s	+1%	+4 to +13%	+17%
2100	-3%	+4 to +19%	+24%
Region 2 (Port Jervis): Baseline (1971–2000) 46.0″			
2020s	-1%	+1 to +8%	+10%
2050s	+1%	+3 to +11%	+14%
2080s	+2%	+6 to +14%	+18%
2100	-6%	+1 to +18%	+24%
Region 3 (Elmira): Baseline (1971–2000) 47.5″			
2020s	-4%	+1 to +7%	+9%
2050s	+2%	+4 to +10%	+15%
2080s	+3%	+6 to +14%	+16%
2100	-2%	+5 to +20%	+26%
Region 4 (New York City): Baseline (1971–2000) 49.7″			
2020s	-1%	+1 to +8%	+10%
2050s	+1%	+4 to +11%	+13%
2080s	+2%	+5 to +13%	+19%
2100	-6%	-1 to +19%	+25%
Region 5 (Saratoga): Baseline (1971–2000) 38.6″			
2020s	-1%	+2 to +7%	+10%
2050s	+2%	+4 to +12%	+15%
2080s	+3%	+5 to +15%	+17%
2100	-1%	+5 to +21%	+26%
Region 6 (Watertown): Baseline (1971–2000) 42.6″			
2020s	0%	+2 to +6%	+8%
2050s	+2%	+4 to +10%	+13%
2080s	+3%	+6 to +12%	+15%
2100	+1%	+7 to +20%	+26%
Region 7 (Indian Lake): Baseline (1971–2000) 40.8″			
2020s	0%	+3 to +6%	+9%
2050s	+2%	+4 to +12%	+15%
2080s	+3%	+6 to +13%	+17%
2100	-2%	+8 to +20%	+26%

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[58] Horton et al. 2014

Table 4. New York State Sea Level Rise Projections, 6 NYCRR Part 490

Region	Long Island					NYC/Lower Hudson					Mid-Hudson				
	Inches of rise over baseline level, defined as the average level of the surface of tidal water over the years 2000–2004														
Descriptor	**L**	**L-M**	**M**	**H-M**	**H**	**L**	**L-M**	**M**	**H-M**	**H**	**L**	**L-M**	**M**	**H-M**	**H**
2020s	2	4	6	8	10	2	4	6	8	10	1	3	5	7	9
2050s	8	11	16	21	30	8	11	16	21	30	5	9	14	19	27
2080s	13	18	29	39	58	13	18	29	39	58	10	14	25	36	54
2100	15	21	34	47	72	15	22	36	50	75	11	18	32	46	71

Figures

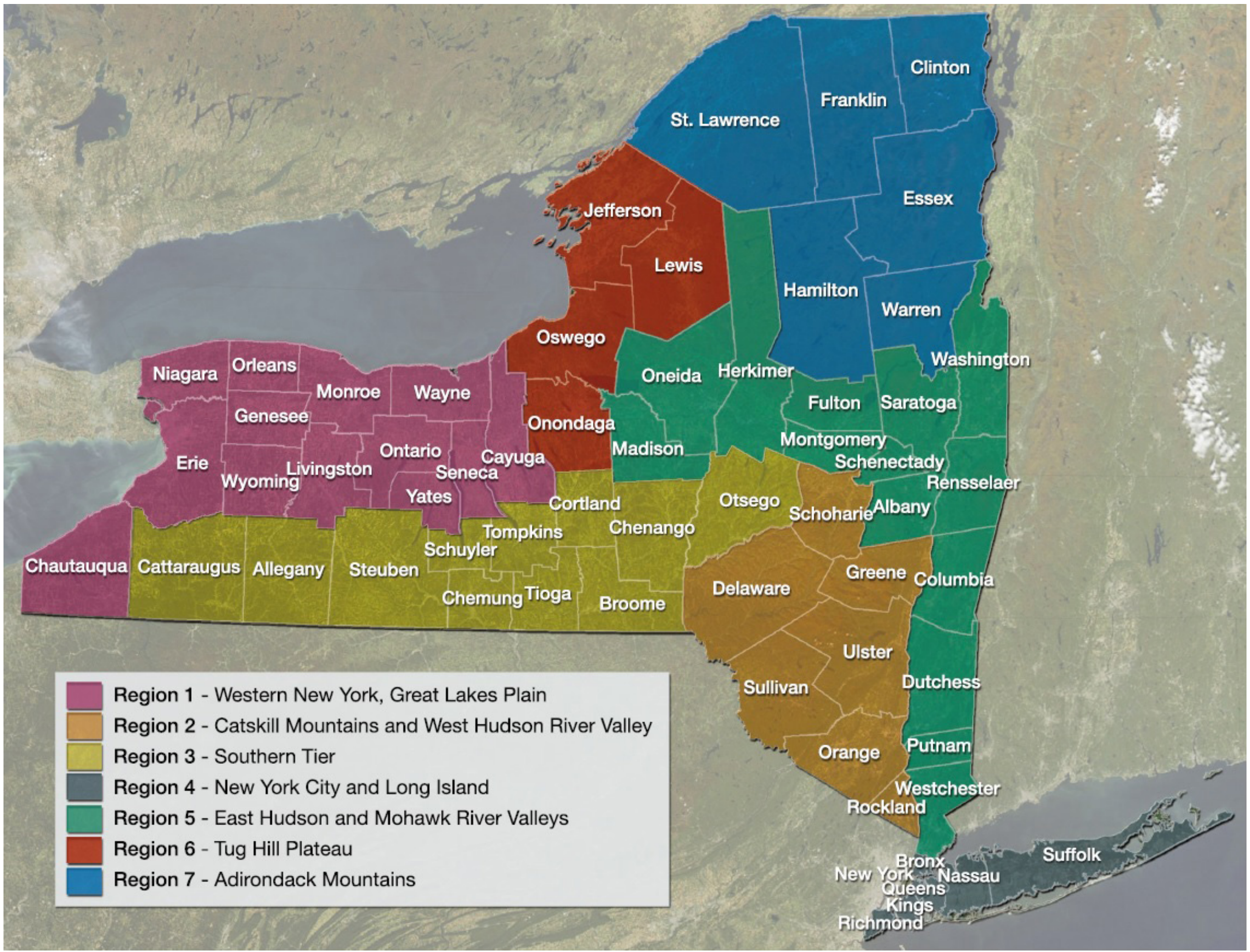
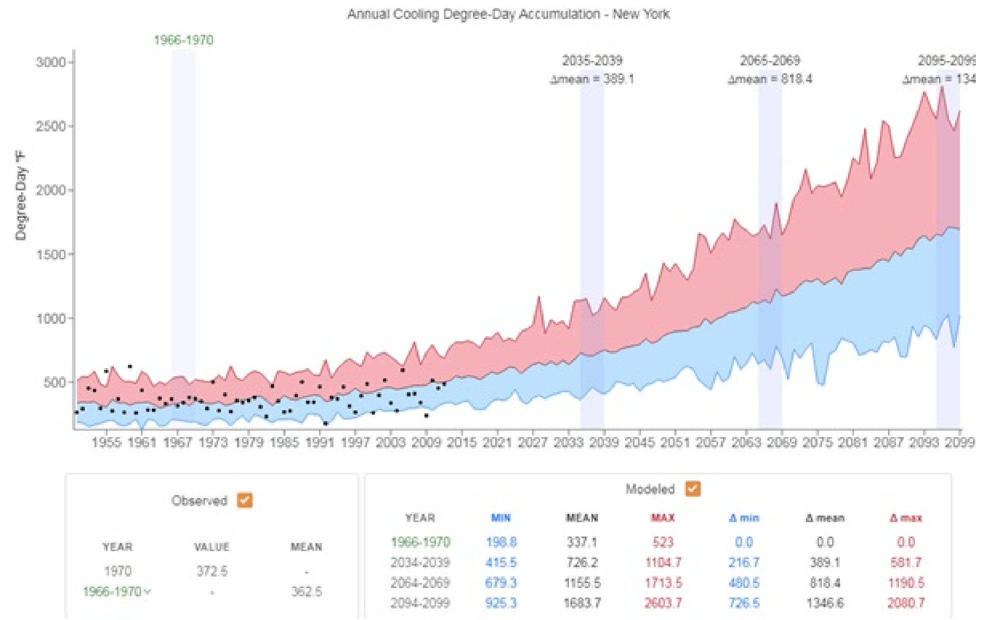


Figure 1. The seven ClimAID regions



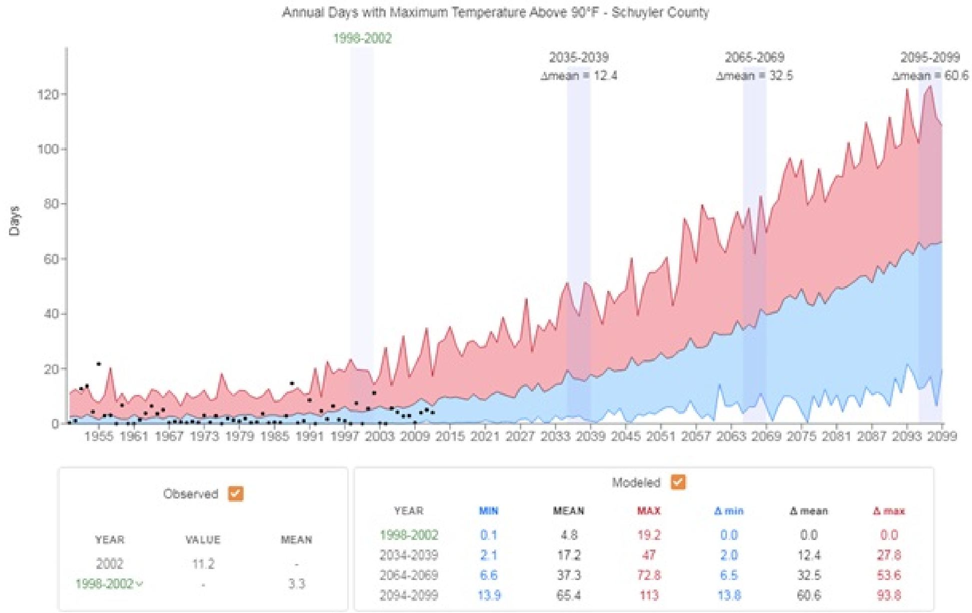
Observed ☑

YEAR	VALUE	MEAN
1970	372.5	-
1966-1970⌄	-	362.5

Modeled ☑

YEAR	MIN	MEAN	MAX	Δ min	Δ mean	Δ max
1966-1970	198.8	337.1	523	0.0	0.0	0.0
2034-2039	415.5	726.2	1104.7	216.7	389.1	581.7
2064-2069	679.3	1155.5	1713.5	480.5	818.4	1190.5
2094-2099	925.3	1683.7	2603.7	726.5	1346.6	2080.7

Figure 2. Modeled change in cooling degree-day accumulation in New York, compared to a 1966–1970 baseline



Observed ☑

YEAR	VALUE	MEAN
2002	11.2	-
1998-2002⌄	-	3.3

Modeled ☑

YEAR	MIN	MEAN	MAX	Δ min	Δ mean	Δ max
1998-2002	0.1	4.8	19.2	0.0	0.0	0.0
2034-2039	2.1	17.2	47	2.0	12.4	27.8
2064-2069	6.6	37.3	72.8	6.5	32.5	53.6
2094-2099	13.9	65.4	113	13.8	60.6	93.8

Figure 3. Modeled change in extreme-heat days, compared to user selected 1998 2002 baseline, Schuyler County, NY

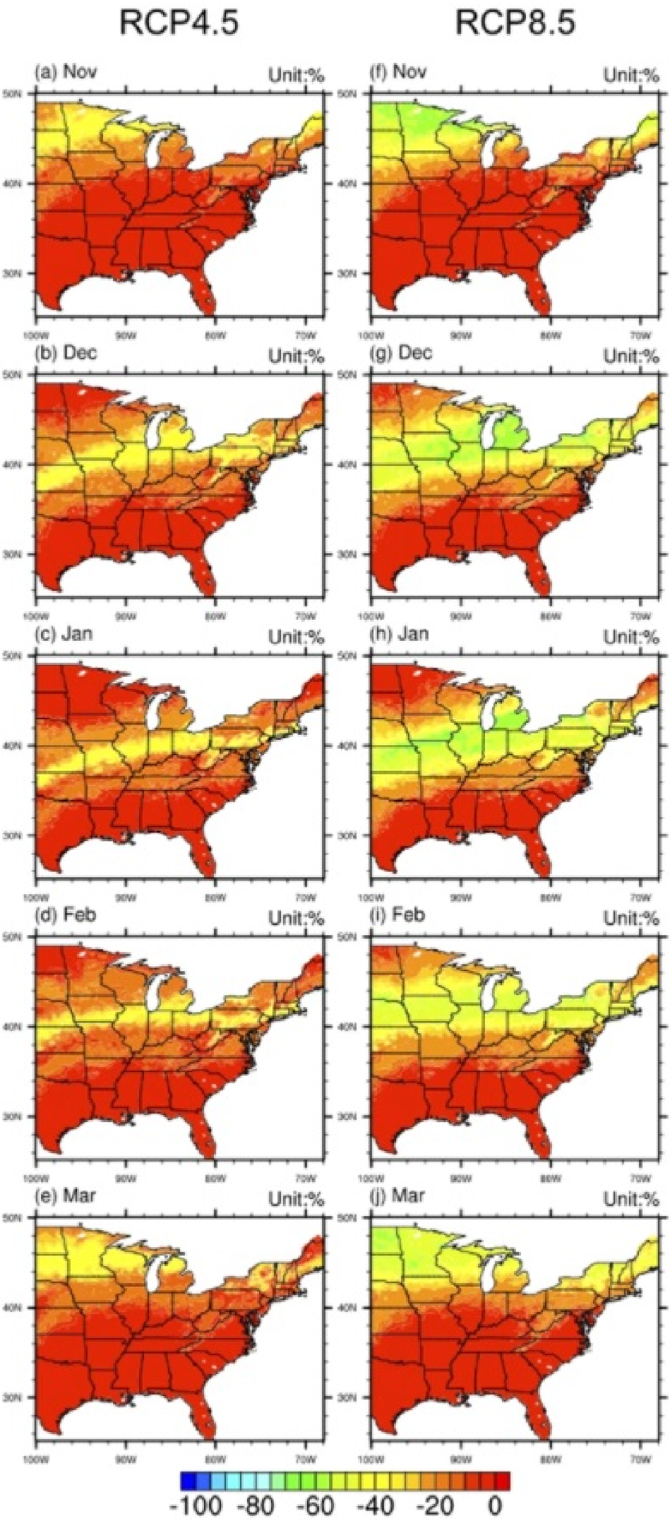


Figure 4. Changes in ensemble averaged snow frequency (RCP scenarios relative to historical simulation) for the RCP4.5 (left column) and RCP8.5 (right column) emission scenarios for the five months, November through March (Unit: percentage change in snow).[59]

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[59] Ning and Bradley 2015

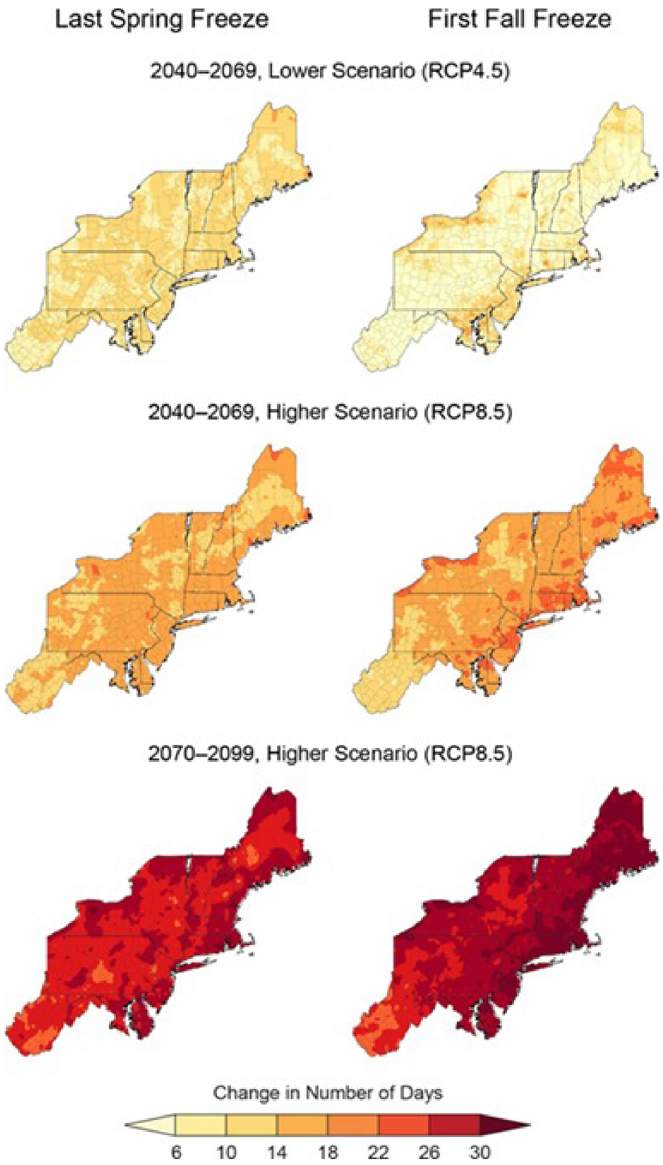

Figure 5. Projected shifts in the date of the last spring freeze (left column) and the date of the first fall freeze (right column) for the middle of the century (as compared to 1979–2008) under the lower scenario (RCP4.5; top row) and the higher scenario (RCP8.5; 2018[60].[61]

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[60] Wolfe et al. 2018

[61] Dupigny-Giroux 2018

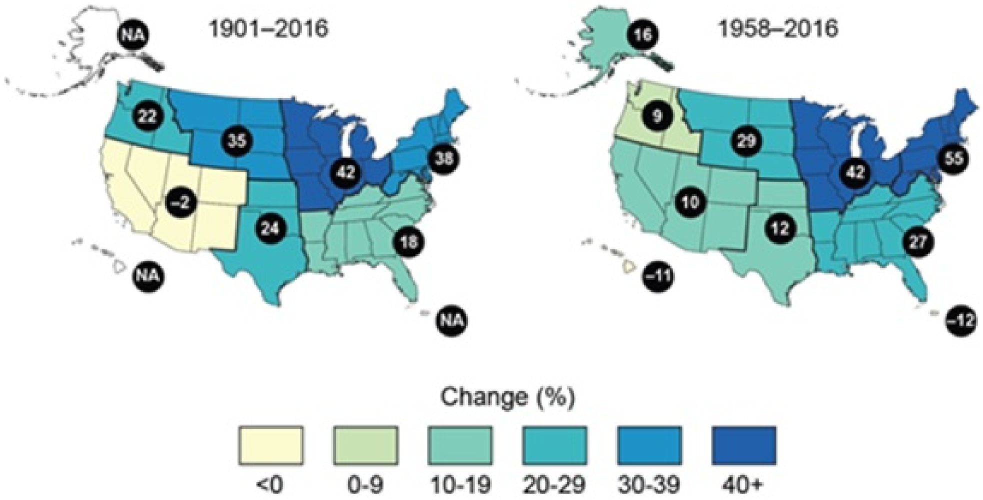

Figure 6. Observed change in total annual precipitation occurring in heaviest 1% of events. The observed trend for 1901–2016 (left) is calculated as the difference between 1901–1960 and 1986–2016. The values for 1958–2016 (right), a period with a denser station network, are linear trend changes over the period.[62]

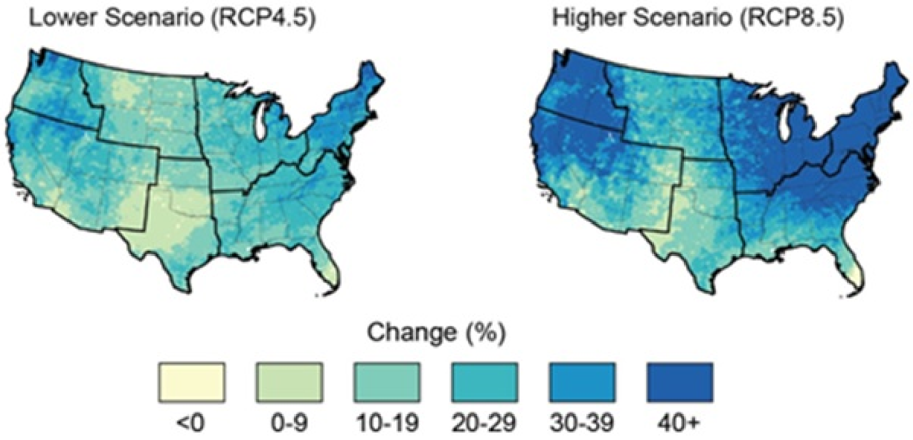

Figure 7. Projected change in total annual precipitation occurring in heaviest 1% of events. Projected future trends are for a lower (RCP4.5, left) and a higher (RCP8.5, right) scenario for the period 2070–2099 relative to 1986–2015.[63]

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[62] Dupigny-Giroux et al. 2018

[63] Dupigny-Giroux et al. 2018

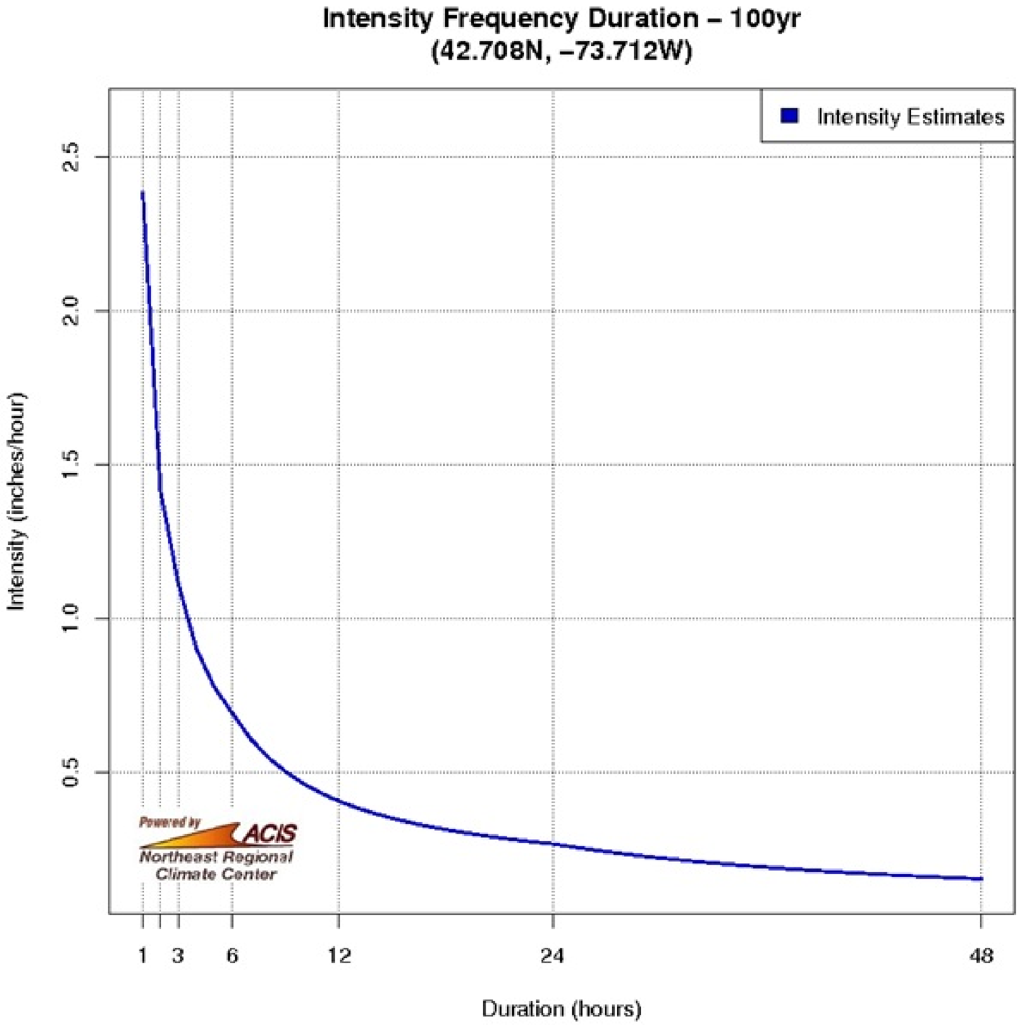

Figure 8. Intensity-frequency-duration curve for 1% AEP, 1- to 48-hour event, for a point in Albany, NY, http://precip.eas.cornell.edu/

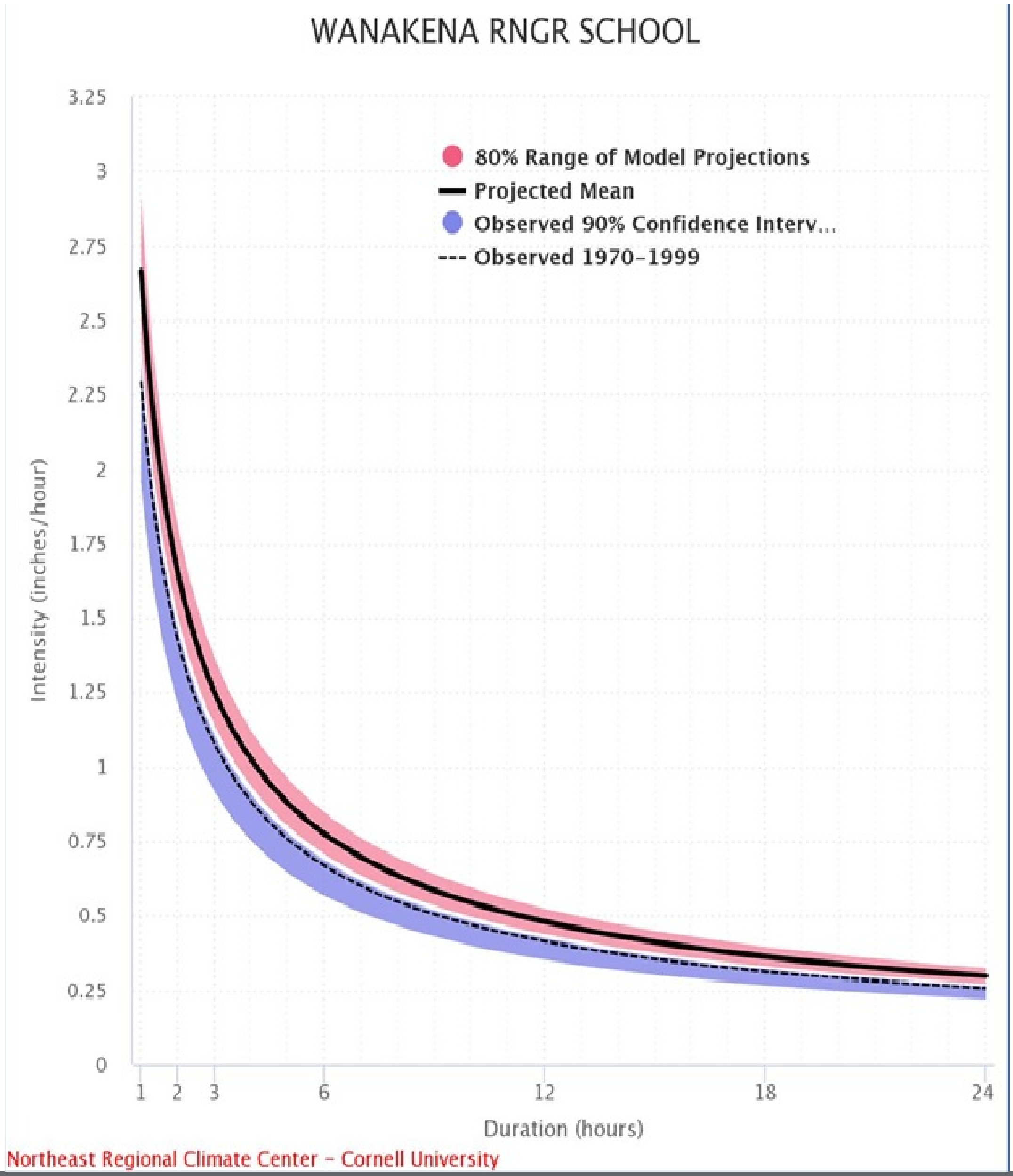

Figure 9. Intensity-duration-frequency curve for the Wanakena Ranger School weather station depicting projected increase in precipitation amounts of the 1% AEP event, under a high emissions scenario by the period 2040 2069, relative to the 1970–1999 baseline. http://ny-idf-projections.nrcc.cornell.edu/

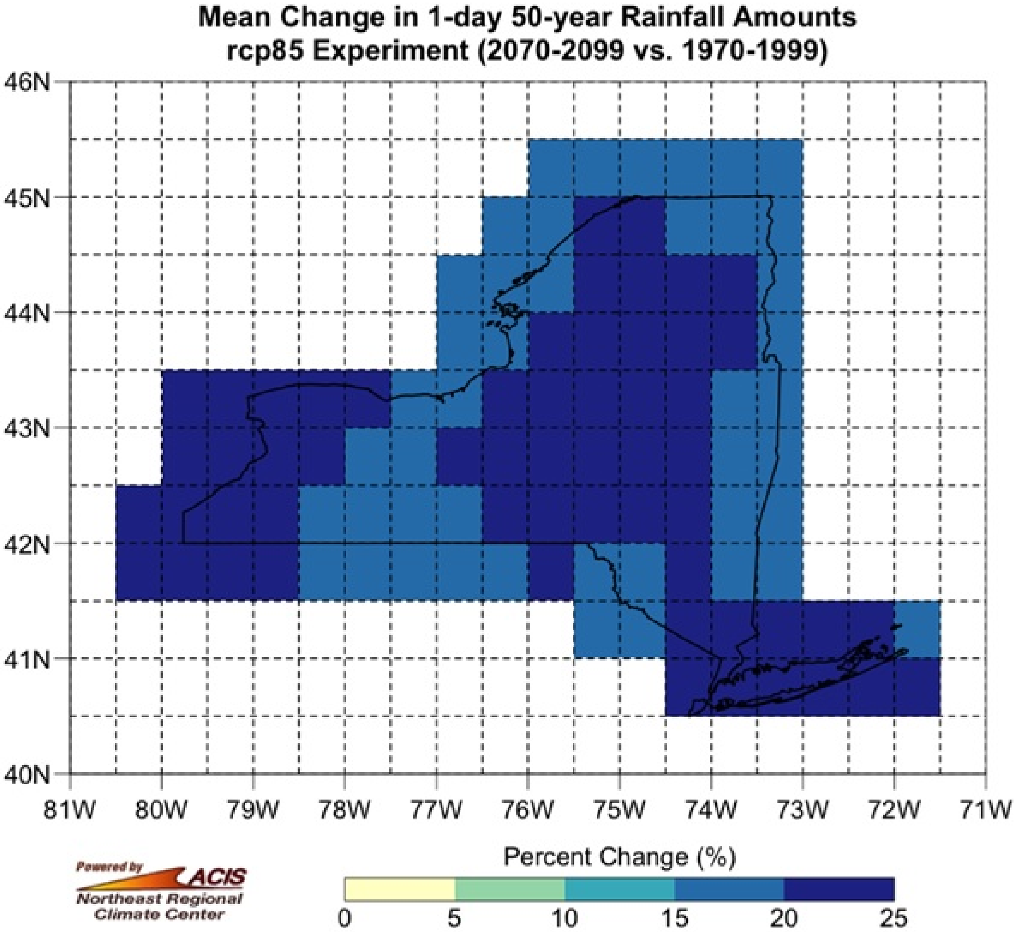

Figure 10. Projected increase in precipitation amounts of the 0.2% AEP event, under a high emissions scenario by the period 2070–2099, relative to the 1970–1999 baseline, http://ny-idf-projections.nrcc.cornell.edu/

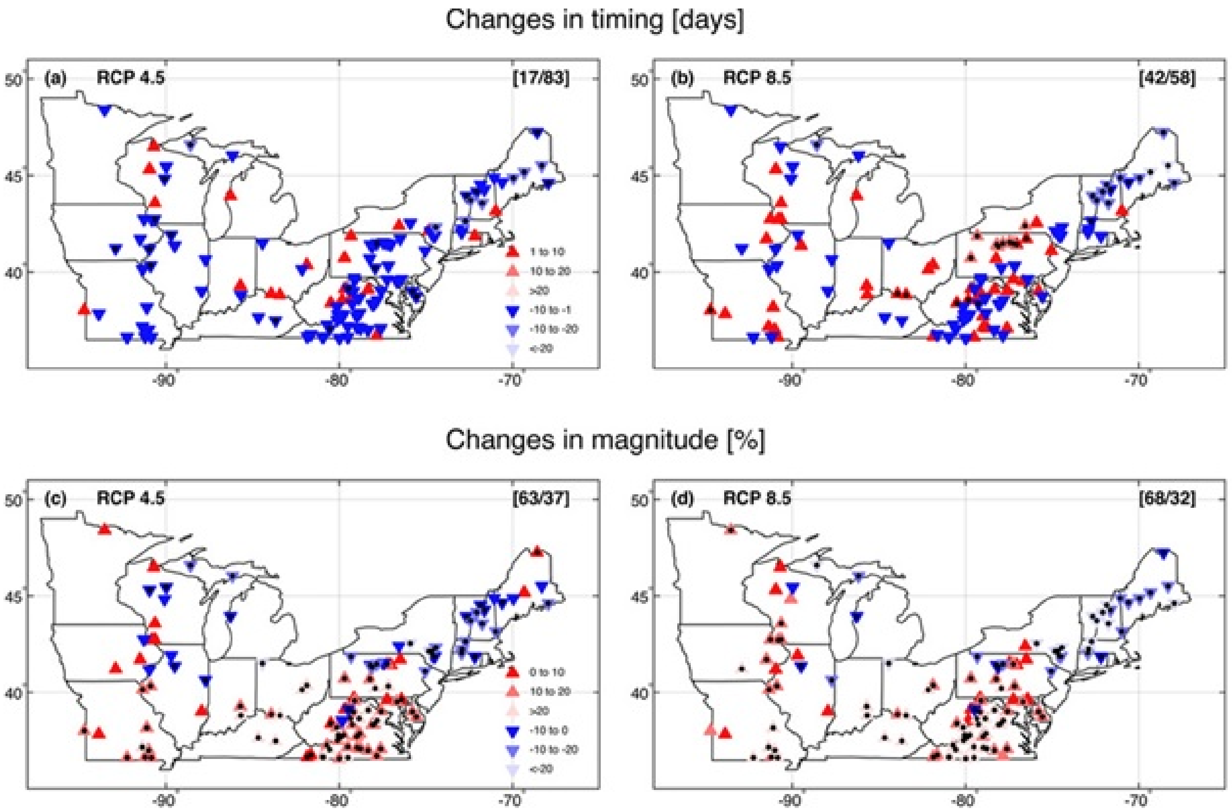

Figure 11. Changes in the (a),(b) timing and (c),(d) magnitude of maximum spring streamflow between (left) the future period (2041–2095) and (right) the historical period (1951–2005). Positive changes are indicated with red upward-pointing triangles. Negative changes are indicated with blue downward-pointing triangles. The numbers within brackets represent the number of positive/negative cases. The stippling indicates changes in the median statistically significant at 95% confidence level.[64]

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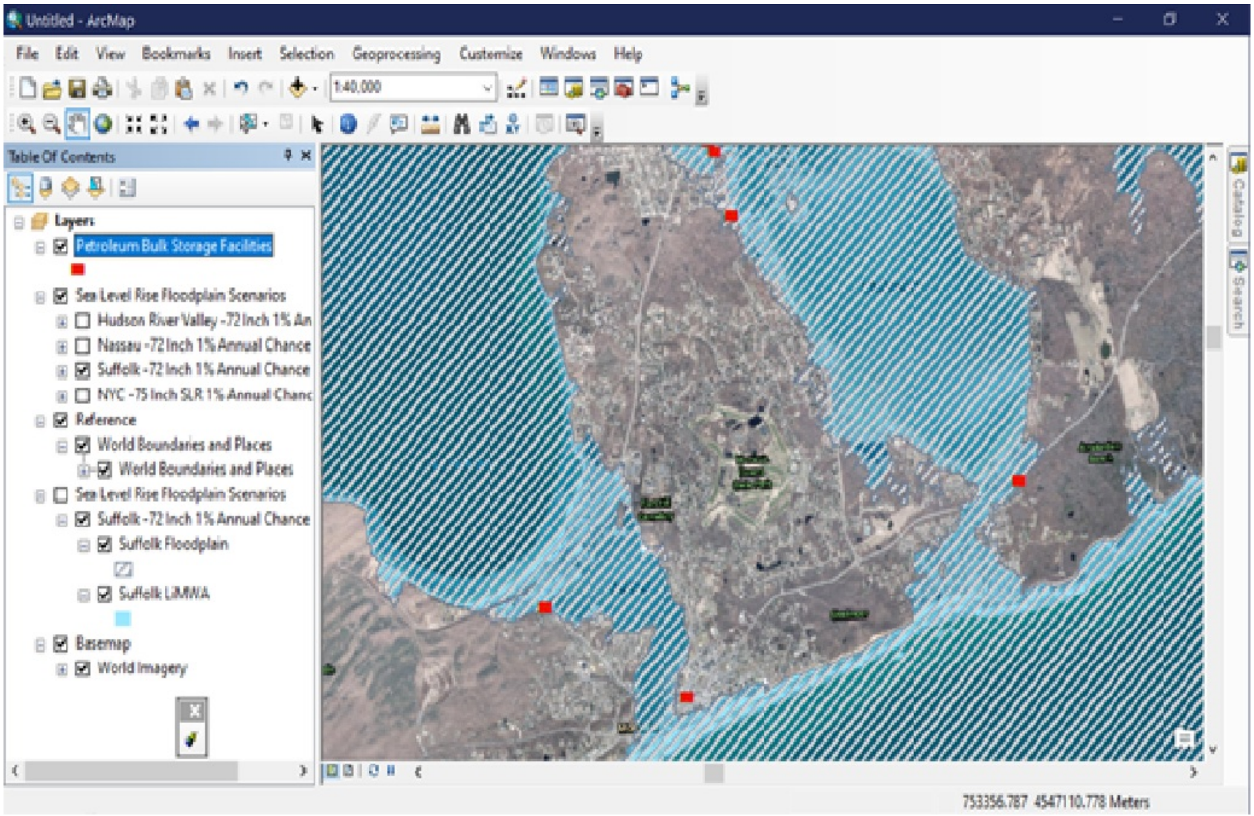
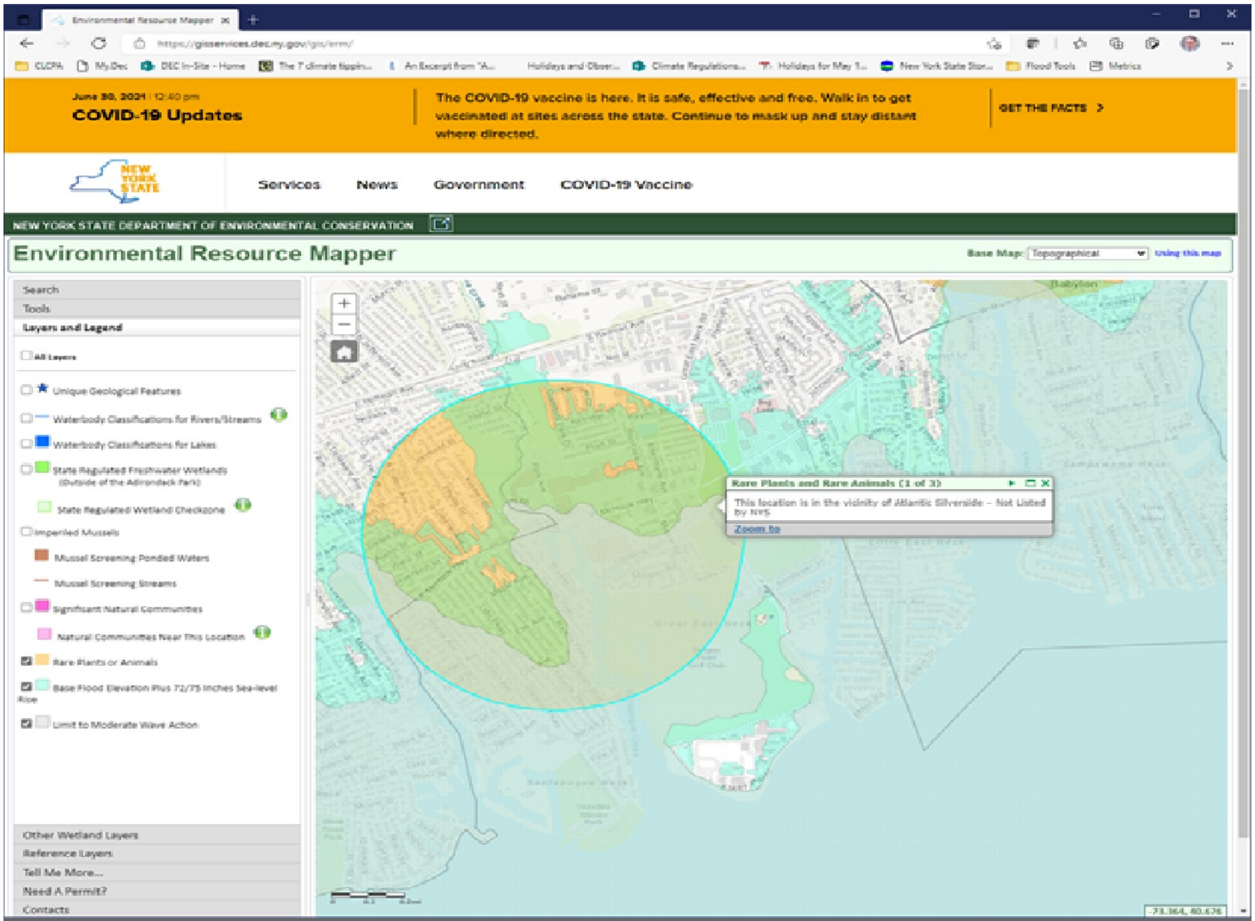
[64] Demaria et al. 2016



- ⊟ Layers
  - ⊟ ☑ Petroleum Bulk Storage Facilities
    - 🟥
  - ⊟ ☑ Sea Level Rise Floodplain Scenarios
    - ⊞ ☐ Hudson River Valley -72 Inch 1% An
    - ⊞ ☐ Nassau -72 Inch 1% Annual Chance
    - ⊞ ☑ Suffolk -72 Inch 1% Annual Chance
    - ⊞ ☐ NYC -75 Inch SLR 1% Annual Chanc
  - ⊟ ☑ Reference
    - ⊟ ☑ World Boundaries and Places
      - ⊞ ☑ World Boundaries and Places
  - ⊟ ☐ Sea Level Rise Floodplain Scenarios
    - ⊟ ☑ Suffolk -72 Inch 1% Annual Chance
      - ⊟ ☑ Suffolk Floodplain
        - ▨
      - ⊟ ☑ Suffolk LiMWA
        - ■
  - ⊟ ☑ Basemap
    - ⊞ ☑ World Imagery

Figure 12. Example of use of DEC internal GIS Data Selector: Petroleum bulk storage facilities, and 1% annual chance floodplain (blue) and limit to moderate wave action (cross-hatching) with six feet of sea level rise, Montauk, NY



June 30, 2021 | 12:40 pm

COVID-19 Updates

The COVID-19 vaccine is here. It is safe, effective and free. Walk in to get vaccinated at sites across the state. Continue to mask up and stay distant where directed.

Base Map: Topographical

☐ All Layers

☐ ★ Unique Geological Features

☐ — Waterbody Classifications for Rivers/Streams

☐ 🟦 Waterbody Classifications for Lakes

☐ 🟩 State Regulated Freshwater Wetlands (Outside of the Adirondack Park)

🟩 State Regulated Wetland Checkzone

☐ Imperiled Mussels

🟫 Mussel Screening Ponded Waters

— Mussel Screening Streams

☐ 🟪 Significant Natural Communities

🟪 Natural Communities Near This Location

☑ 🟧 Rare Plants or Animals

☑ 🟦 Base Flood Elevation Plus 72/75 Inches Sea-level Rise

☑ ⬜ Limit to Moderate Wave Action

Rare Plants and Rare Animals (1 of 3)

This location is in the vicinity of Atlantic Silverside – Not Listed by NYS

Figure 13. DEC Environmental Resource Mapper displaying projected 1% AEP floodplain and projected limit to moderate wave action with six feet of sea level rise for an area of the south shore of Long Island. Also shown is the approximate location of a rare animal

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