New Hampshire Climate Assessment 2021

Mary D. Lemcke-Stampone
University of New Hampshire, Durham, mary.stampone@unh.edu

Cameron P. Wake
University of New Hampshire, Durham, cameron.wake@unh.edu

Elizabeth Burakowski
University of New Hampshire, Durham, elizabeth.burakowski@unh.edu

New Hampshire Climate Assessment

M.D. Lemcke-Stampone, C.P. Wake, and E.A. Burakowski, Univerisity of New Hampshire

June 2022

IMAGE CREDIT: JENNIFER DUBOIS

FUNDING AND ACKNOWLEDGEMENTS

The writing of this report was supported by funding from the New Hampshire Department of Environmental Services under the project "Model Review and Drought/Flood Outlook for New Hampshire."

The acquisition and analysis of downscaled global climate model simulations was supported by the National Science Foundation - Established Program to Stimulate Competitive Research (EPSCoR) Ecosystems and Society Project (EPS-1101245).

SUGGESTED CITATION

Lemcke-Stampone, M.D, C.P. Wake, and E.A. Burakowski (2022) New Hampshire Climate Assessment 2021. Sustainability Institute, University of New Hampshire. https://scholars.unh.edu/sustainability/71/

GRAPHIC DESIGN

New Hampshire Department of Environmental Services

University of New Hampshire Sustainability Institute

New Hampshire Department of Environmental Services

New Hampshire Coastal Program

TABLE OF CONTENTS

IMAGE CREDIT: SANDT MICHENER

1. INTRODUCTION

1.1 Background

The Sixth Assessment Report (2021) from Working Group 1 of the Intergovernmental Panel on Climate Change (IPCC),[1] and the Fourth U.S. National Climate Assessment on climate science,[2] clearly document past and likely future climate change in response to increasing human-derived emissions of global warming-causing greenhouse gases. These reports review a broad range of scientific evidence combined with new climate model output and analyses to conclude that human influence has unequivocally warmed the atmosphere, ocean and land since 1750, and that the rate of warming is unprecedented in at least the last 2,000 years. The scientific evidence also shows the human influence on increasing atmospheric water vapor, precipitation and frequency of extreme precipitation events; increasing intensity and duration of drought and forest fires; increasing heatwaves; and increasing melting and calving of ice from the Greenland and West Antarctic ice sheets, which are increasing the rate of global sea-level rise. Additional changes include reductions in the volume and areal extent of spring and summer Arctic sea ice, reductions in northern hemisphere snow cover, and melting of mountain glaciers.

The Fourth U.S. National Climate Assessment on The Impacts, Risks, and Adaptation in the United States[3] finds a strong and direct connection between our warming planet and impact on our lives, our communities and our livelihoods, today and in the future. The report concludes that "*climate-related threats to Americans' physical, social, and economic well-being are rising*."

The wide range of impacts and risks associated with changing climate across the U.S. Northeast are well reviewed in the Fourth U.S. National Climate Assessment.[4] Key messages include:

1. Changing seasons are affecting rural ecosystems, environments and economies.
2. Changing coastal and marine habitats threaten ecosystem services and livelihoods.
3. The changing climate poses challenges to maintaining urban centers and their interconnections.
4. The changing climate poses threats to human health.

Recent research focused on the U.S. Northeast provides detailed insights and impacts of our warming climate, now and in the future.[5] Over the past century, warmer winters with less snow and a longer winter-spring transition period (vernal window) are likely to have negative consequences on northern forest ecosystems, impacting valuable rural industries, including logging and outdoor recreation, and increasing exposure to vector-borne diseases. Winters in the U.S. Northeast will continue to warm with increases in days above freezing and reduction in snow cover days and duration of deep snow cover. The effects of increases in total annual precipitation and a more than 50% increase in extreme precipitation from 1996-2016 compared to 1901-1995, most which occurred during summer and fall, include increasing flood frequency and magnitude in watersheds with minimal human influence, increasing warm-season extreme streamflow events, and increasing variability of maximum streamflow. By the end of the 21st century, winter and spring precipitation is projected to increase by 10-15% with little change in summer and fall precipitation across the U.S. Northeast. Without significant reductions in atmospheric greenhouse gases (GHG), extreme precipitation events are projected to increase a minimum of 20%, leading to an increase in freshwater flooding regionally. Flood risk in New Hampshire's coastal watershed will continue to increase due to rising seas and more extreme precipitation events.

The Intergovernmental Panel on Climate Change published a special report in 2018 on the impacts of global warming of 1.5°C and 2.0°C.[6] The report concludes that the adverse impacts on human and natural systems are already occurring across the globe at the current 1.0°C level of warming. Because the impacts will be much more severe and destructive at 2.0°C compared to 1.5°C, the report recommends countries around the world work together to limit global warming to 1.5°C (1.5°C is approximately 2.7°F). There is a high probability that this goal can be achieved if global greenhouse gas emissions are reduced by 45% below 2010 levels by 2030 and are reduced to net-zero by 2050. The 2015 Paris Climate Agreement and the 2021 Glasgow Climate Pact both affirmed the importance of reducing anthropogenic emissions of greenhouse gases to net-zero by 2050 to keep global warming below 1.5°C. Despite this clarion call from the IPCC, global emissions of greenhouse gases continued to grow through 2019.[7] Reductions in carbon-dioxide emissions due to the COVID-19 pandemic, estimated to be about 7% lower in 2020 compared to 2019, are expected to be temporary.[8]

In this report, we compare two global atmospheric concentration pathways (Representative Concentration Pathway [RCP] 4.5 and RCP 8.5). The RCP 4.5 results in global warming of ~2.4°C by 2100 (compared to 1850-1900) while RCP 8.5 results in global warming of ~4.3°C (compared to 1850-1900). Limiting global warming to 1.5°C will require a reduction in greenhouse gas emissions below those represented by RCP 4.5.

1.2 Overview of Report

This report provides a statewide update to the 2014 climate change assessment reports for southern and northern New Hampshire (*2014 NH Climate Assessment*).[9] Chapter 2 covers historical change with analyses for 10 individual weather stations from across New Hampshire updated through 2020, and an analysis of statewide change from 1901-2020 that includes indicators for heating, cooling and drought. Chapter 3 summarizes results of 29 statistically downscaled global climate model simulations representing state-averaged and local climate conditions projected through 2099 for lower (RCP 4.5) and higher (RCP 8.5) atmospheric greenhouse gas concentration pathways. Additional information on the potential impacts of climate change on New Hampshire is provided in the 2019 New Hampshire Coastal Flood Risk Report[10] and the 2014 Assessment of the Impact of Climate Change on Human Health in New Hampshire.[11]

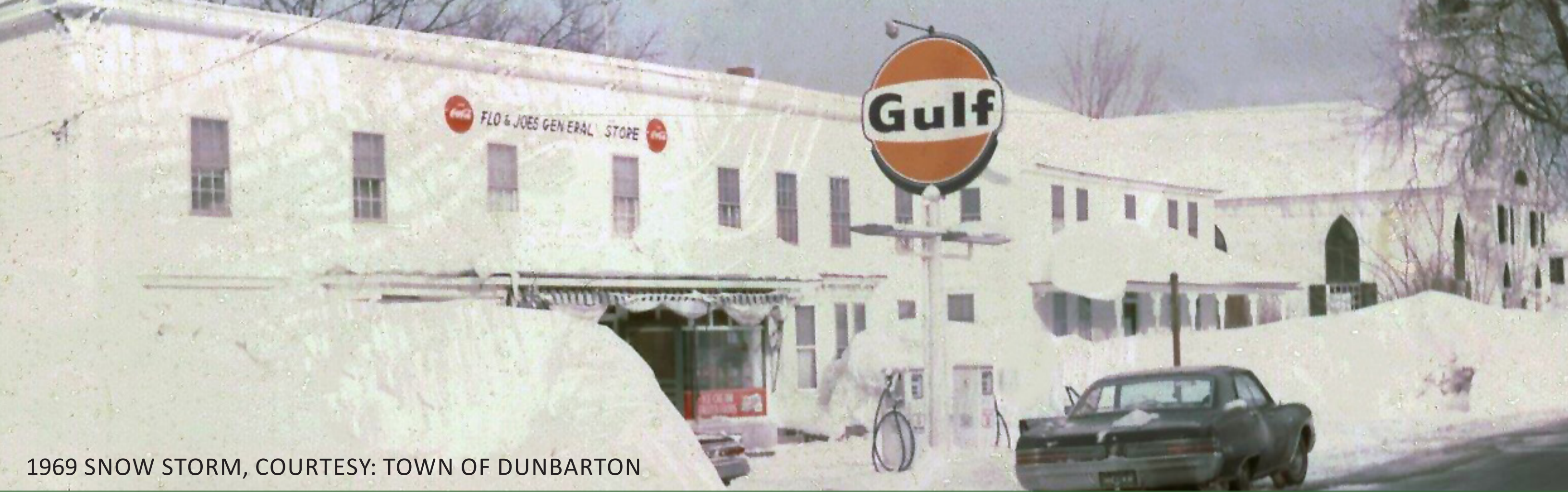
1.3 Changes since 2014 Climate Change in New Hampshire reports

Historical Climate Change (1901-2020)

- Analysis of the historical record was extended to 2020. The *2014 NH Climate Assessment* only included historical data through 2012.
- The number of climate indicators was expanded to include heating and cooling degree days as well as precipitation on wettest day of the year. An analysis of trends in annual maximum snow water equivalent since 1971 based on the New Hampshire Department of Environmental Services' (NHDES) snow course data is also new.
- Analysis of drought based on the Standardized Precipitation Index (SPI) as well as the U.S. Drought Monitor categories is included.
- The overall magnitude of climate change over the past 120 years described in this report is consistent with the findings of the *2014 NH Climate Assessment*. New Hampshire's climate has gotten warmer and wetter with greater warming during the cold season. As winters warmed, the length of the cold season decreased with fewer days with snow on the ground and fewer cold temperature extremes, especially after 1970. This is already impacting people, ecosystems and our economy across the state.

Projected Climate Change (2010-2099)

- Analysis of projected future climate change relies on statistically downscaled simulations from 29 global climate model simulations (using the same technique used in the 2017 National Climate Assessment – Climate Science Special Report) as opposed to four global climate model simulations used in the *2014 NH Climate Assessment*. This raises confidence in the model simulation results presented in this report.
- The higher concentration pathway (RCP 8.5) and lower concentration pathway (RCP 4.5) were used in place of the older higher (A1fi) and lower (B1) emission scenarios used in the 2014 report.
- The number of climate indicators was expanded to include heating and cooling degree days, precipitation on the wettest day of the year, bare ground days, and annual snowfall.
- The overall magnitude of climate change over the 21st century described in this report is consistent with the findings of the *2014 NH Climate Assessment*. Over the near term, our climate will continue to get warmer and wetter, although warming summer temperatures combined with little to no increase in summer precipitation will likely lead to more short-term drought conditions during the summer season. Also consistent with the findings of the *2014 NH Climate Assessment*, the rate at which New Hampshire's climate changes by mid- to late-century depends fundamentally on how much the concentration of atmospheric greenhouse gases rise, with much lower rates of change projected for the lower concentration pathway.



1969 SNOW STORM, COURTESY: TOWN OF DUNBARTON

2. HISTORICAL CLIMATE CHANGE

2.1 Key Findings

- Temperatures across New Hampshire increased by an average of 3°F since 1901. The rate of warming was greatest during the fall and winter seasons and at night. As winters warmed, there was a decrease in the frequency and severity of cold extremes and an increase in the number of thaw events. Overall, temperatures warmed at a faster rate over the past 50 years, resulting in a 10% decrease in heating degree days and 74% increase in cooling degree days annually since 1971.
- There was a 12% increase in annual precipitation over the past 120 years largely due to an increase in heavy precipitation since 1971. The number of multi-day precipitation events exceeding four inches increased near the coast and in the White Mountains while areas inland and in the far north saw an increase in the number of daily one-inch events. Statewide, there were fewer periods of short-term drought over the past 30 years compared to the early 20th century.
- From 1971-2020, the amount of water stored in the snowpack decreased from 59-91% across central New Hampshire. Over the same period, spring ice-out dates on Lake Winnipesaukee and Lake Sunapee shifted eight and 11 days earlier, respectively.

2.2 Temperature and Precipitation

Trends in average statewide temperature, precipitation and heating/cooling degree days over the past 120 years (1901-2020) are quantified using data from NOAA's U.S. Climate Divisional Database (nClimDiv).[12] Derived from the daily Global Historical Climatological Network (GHCNd) dataset, the nClimDiv database is a complete, quality-controlled, long-term record of temperature, precipitation and drought for U.S. climate divisions. Area-weighted state average climate variables are available at monthly, seasonal, and annual time scales for 1895 to present. Divisional-scale drought frequency is evaluated using the one-month and three-month Standardized Precipitation Index (SPI) values obtained from the North American Drought Monitor (NADM) indicator database. The nClimDiv database does not include divisional and state-averaged time-series data on snowfall and daily indicators for temperature and precipitation extremes. These variables were evaluated for individual weather stations only.

Local-scale variability and trends were quantified for an expanded set of 32 climate indicators (Appendix 1) using daily meteorological data from 10 GHCNd stations representing New Hampshire's seven physiographic regions with records dating back to the 1970s (Figure 1; Table 1). These stations were chosen for record length and completeness as well as minimal discontinuities due to changes in station location, instrumentation and environment. Metadata documenting each station's history are published in the National Centers for Environmental Information (NCEI) Historical Observing Metadata Repository (HOMR).[13] Station data are subject to realtime manual and automated quality control procedures by NWS Weather Forecast Office personnel. Additional manual quality control measures were taken to eliminate outliers due to missing data and checked for constancy over time prior to calculating trend statistics.[14]

Trends for 1971-2020 were computed at all 10 stations to quantify change over the past five decades. Century-scale trends were evaluated from 1901-2020 at the three long-term stations included in the U.S. Historical Climate Network (USHCN) database[15] (Durham, Hanover, Keene) and from 1917-2020 for Berlin. All trends were calculated and tested for statistical significance ($p < 0.05$) using the non-parametric Sen's Slope[16] and Mann-Kendall test.[17] The Sen's Slope statistic represents the median slope value, making it less sensitive to outliers and a more appropriate measure of change over time given the high interannual variability of New Hampshire's climate.

Figure 1. Locations of meteorological stations in New Hampshire referred to in this report

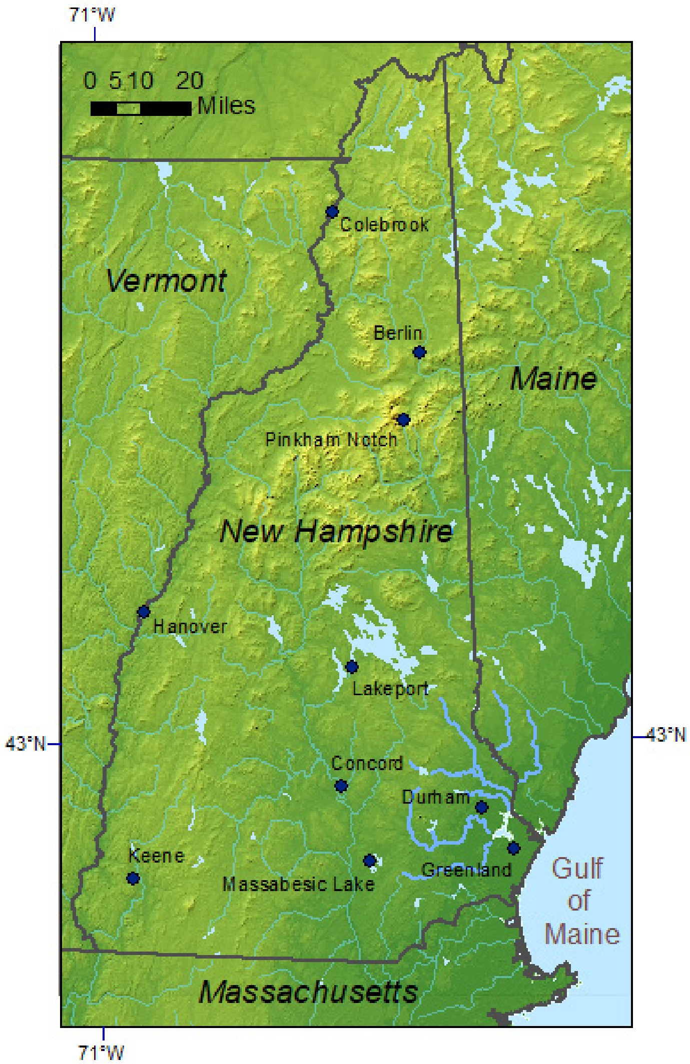


Table 1. List of meteorological stations in New Hampshire referred to in this report

Station Name	Lat	Long	Elevation (ft)	Physiographic Region
Berlin	44.454	-71.186	920	Great North Woods
Colebrook	44.861	-71.539	1120	Great North Woods
Concord	43.205	-71.503	343	Merrimack Valley
Massabesic Lake	42.989	-71.393	253	Merrimack Valley
Durham	43.142	-70.950	76	Seacoast
Greenland	43.021	-70.826	95	Seacoast
Hanover	43.705	-72.286	585	Dartmouth/Lake Sunappee
Keene	42.939	-72.325	511	Monadnock
Lakeport	43.549	-71.465	500	Lakes
Pinkham Notch	44.258	-71.253	2025	White Mountains
Mt Washington	44.270	-71.303	6288	White Mountains

The statewide average trends in temperature, precipitation, and heating/cooling degree days are summarized in Table 2. This table provides trends for 17 climate indicators (10 for temperature, five for precipitation, and two for heating/cooling degree days) over a 120-year period (1901-2020) and a 50-year period (1970-2020) for 1) the absolute change over the period of record and 2) the rate of change per decade. Table 2 also provides a comparison of the New Hampshire statewide average for two different time periods: early 20th century (1901-1960) and the climate normal (1991-2020).

Temperature Trends

Temperature measurements are one of the most referred to indicators of climate change. The temperature records analyzed here provide a continuous record of state-averaged, mean annual and seasonal maximum temperatures (Figures 2 and 3) and minimum temperatures (Figures 4 and 5) over the past 120 years. As is common in New England, there is considerable year-to-year variability in annual and seasonal maximum and minimum temperatures. Even with this interannual variability, there are significant trends[18] over the past 120 years and over the past 50 years.[19] (Trends are considered statistically significant if $p<0.05$; significant trends appear in **bold and are underlined** in tables and figures).

The mean annual maximum temperature in New Hampshire (Figure 2) increased 2.3°F since 1901 and 2.0°F since 1971. The significant increase of 0.19°F per decade since 1901 doubled to 0.39°F per decade since 1971. The largest significant seasonal warming trends in maximum temperature (Figure 3) since 1971 occur in the fall (0.65°F per decade) and winter (0.57°F per decade) seasons. These rates are also double compared to the longer 120-year rate of warming. Compared to fall and winter, the warming of maximum temperatures in spring and summer was relatively modest (~ 0.2°F per decade) but significant over the full 120-year period of record. Overall, average maximum temperatures for the climate normal period (1991-2020) are 1.0-2.4°F greater compared to the early 20th century (1901-1960; Table 1).

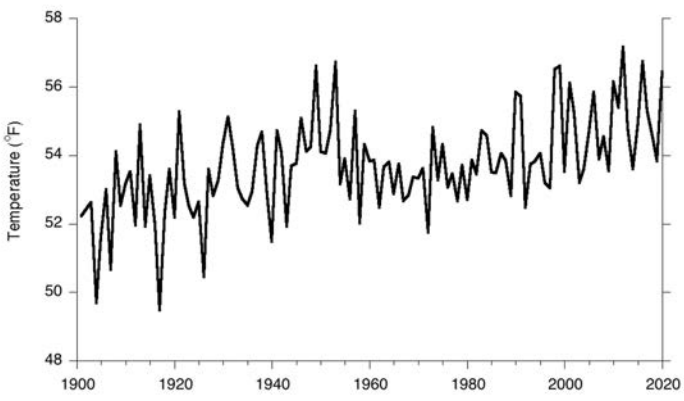
Table 2. Trends in New Hampshire's Climate (1901-2020)

Significant trends appear in **bold and are underlined**.

Indicator	New Hampshire Trends				New Hampshire Average		Difference
	1901-2020	1971-2020	1901-2020	1971-2020	1901-1960	1991-2020	
Temperature MAX	deg F period of record		deg F per decade		deg F		
Annual	**2.3**	**2.0**	**0.19**	**0.39**	53.2	54.7	1.5
Winter	**3.5**	**2.9**	**0.29**	**0.57**	29.1	31.5	2.4
Spring	**2.2**	1.0	**0.18**	0.20	51.8	53.3	1.5
Summer	**2.1**	1.3	**0.17**	0.25	75.9	77.0	1.1
Fall	**1.8**	**3.3**	**0.15**	**0.65**	56.2	57.2	1.0
Temperature MIN	deg F period of record		deg F per decade		deg F		
Annual	**3.5**	**3.1**	**0.29**	**0.62**	30.9	33.3	2.4
Winter	**5.9**	**5.9**	**0.49**	**1.17**	8.4	12.4	4.0
Spring	**2.2**	0.8	**0.19**	0.17	29.0	30.4	1.4
Summer	**3.5**	**2.4**	**0.29**	**0.48**	51.6	53.8	2.1
Fall	**3.2**	**3.8**	**0.27**	**0.75**	34.6	36.7	2.1
Precipitation	inches period of record		inches per decade		inches		
Annual	**8.1**	3.7	**0.67**	0.74	42.7	47.9	5.2
Winter	**8.6**	5.7	**0.72**	1.14	9.5	10.5	0.9
Spring	1.4	0.5	0.12	0.09	10.6	11.4	0.8
Summer	**2.1**	1.5	**0.17**	0.31	11.6	13.2	1.6
Fall	**3.0**	1.1	**0.25**	0.22	10.9	12.8	1.9
Heating and Cooling Days	degree days (DD) period of record		DD per decade		DD		
Heating Degree Days	**-921**	**-812**	**-77**	**-162**	8082	7454	-628
Cooling Degree Days	**151**	**150**	**13**	**30**	202	298	96

Figure 2. New Hampshire Annual Maximum Temperature, 1901-2020

Trends are estimated using Sen's slope; statistically significant trends ($p \leq 0.05$) are highlighted in **bold and are underlined**.



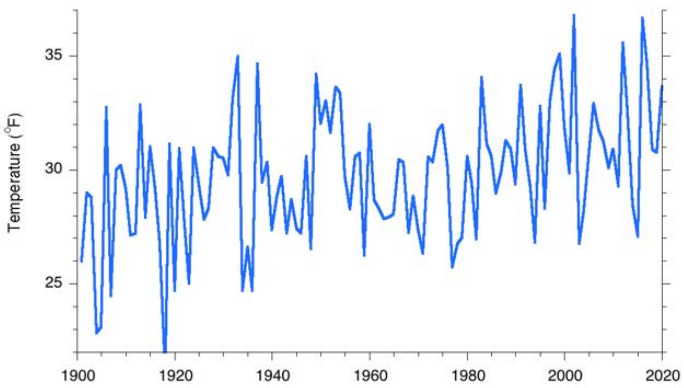
1901–2020: **0.19**°F per decade
1971–2020: **0.39**°F per decade

IMAGE CREDIT: NICK FONTAINE

Figure 3. New Hampshire Seasonal Maximum Temperature, 1901-2020

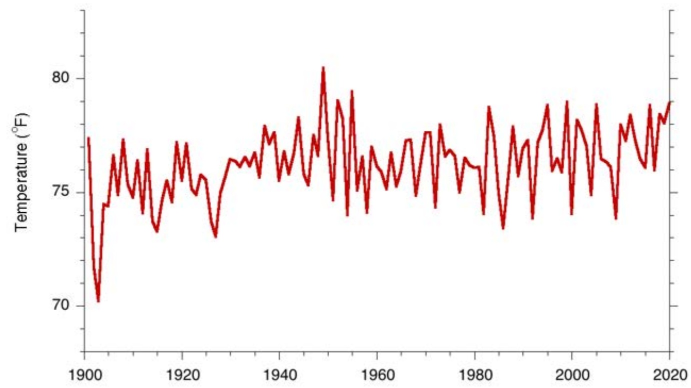
Trends are estimated using Sen's slope; statistically significant trends ($p \leq 0.05$) are highlighted in **<u>bold and are underlined</u>**.

Winter (DJF)



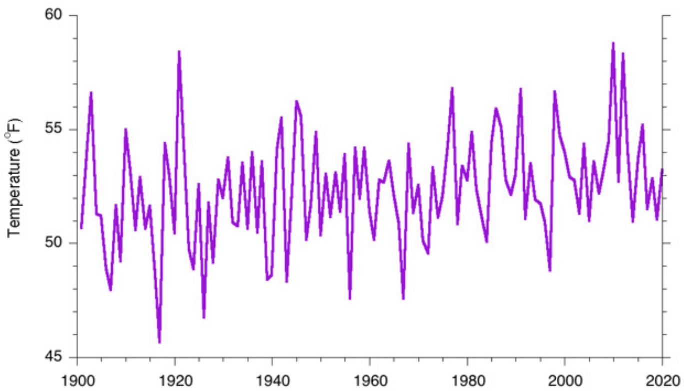
1901–2020: **<u>0.29</u>**°F per decade
1971–2020: **<u>0.57</u>**°F per decade

Summer (JJA)



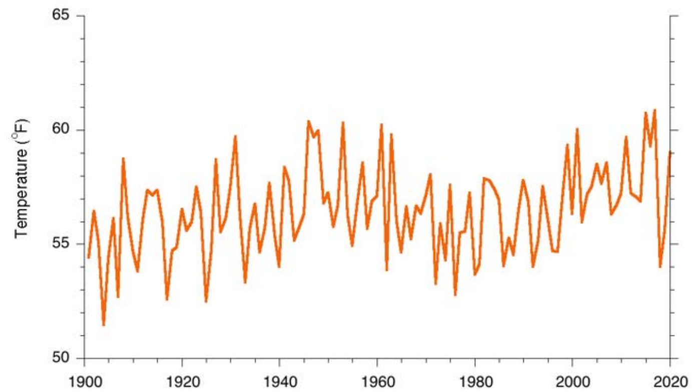
1901–2020: **<u>0.17</u>**°F per decade
1971–2020: 0.25°F per decade

Spring (MAM)



1901–2020: **<u>0.18</u>**°F per decade
1971–2020: 0.20°F per decade

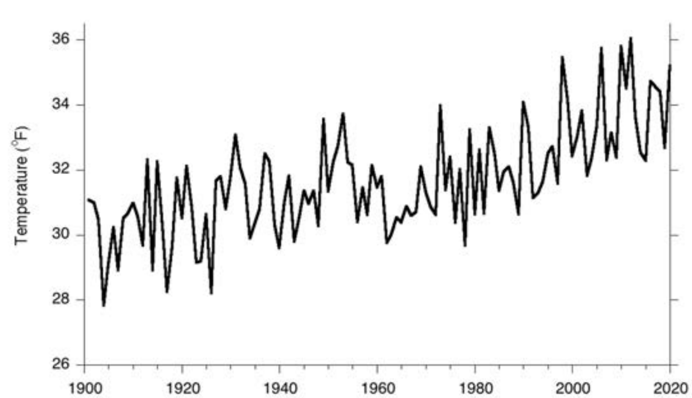
Fall (SON)



1901–2020: **<u>0.15</u>**°F per decade
1971–2020: **<u>0.65</u>**°F per decade

The mean annual minimum temperature in New Hampshire (Figure 4) increased 3.5°F since 1901 and 3.1°F since 1971. Annual and seasonal minimum temperatures increased more rapidly than maximum temperatures. Annual minimum temperatures increased significantly at a rate of 0.29°F per decade since 1901 and 0.62°F per decade since 1971. There was a significant increase in winter minimum temperatures of 1.17°F per decade since 1971 (Figure 5). Summer and fall also show significant warming in minimum temperatures since 1971 of 0.48°F and 0.75°F per decade, respectively. Overall, average minimum temperatures for the climate normal period (1991-2020) are 1.4-4.0°F greater compared to early 20th century (1901-1960; Table 2).

Figure 4. New Hampshire Annual Minimum Temperature, 1901-2020

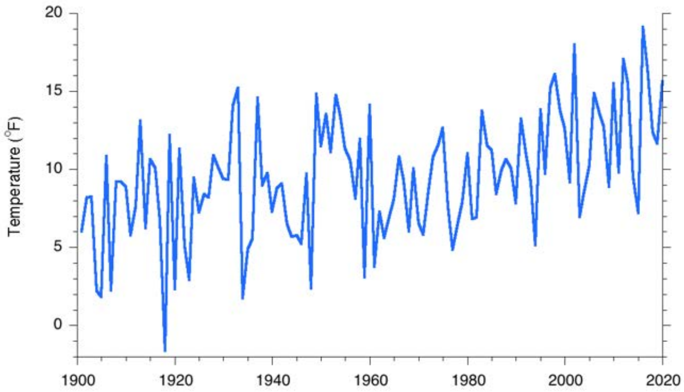


1901–2020: **<u>0.29</u>**°F per decade
1971–2020: **<u>0.62</u>**°F per decade

Figure 5. New Hampshire Seasonal Maximum Temperature, 1901-2020

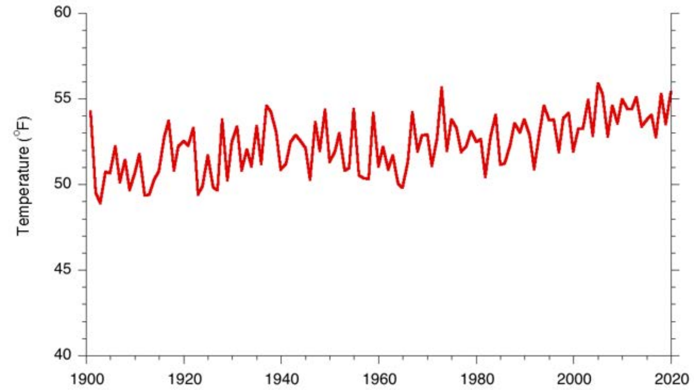
Trends are estimated using Sen's slope; statistically significant trends ($p \leq 0.05$) are highlighted in **<u>bold and are underlined</u>**.

Winter (DJF)



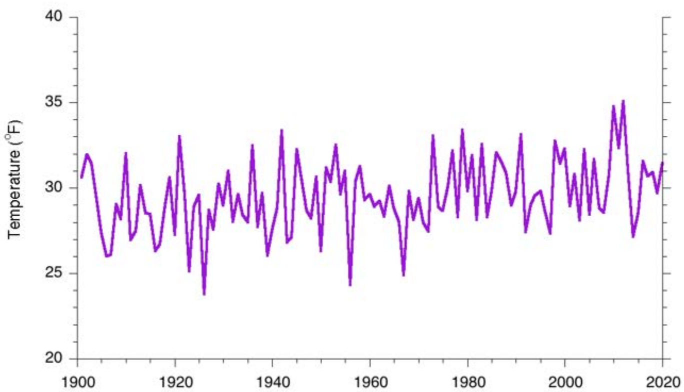
1901–2020: **<u>0.49</u>**°F per decade
1971–2020: **<u>0.17</u>**°F per decade

Summer (JJA)



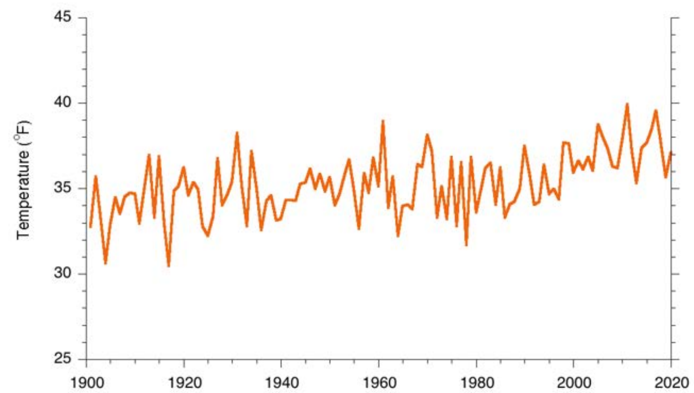
1901–2020: **<u>0.29</u>**°F per decade
1971–2020: **<u>0.48</u>**°F per decade

Spring (MAM)



1901–2020: **<u>0.19</u>**°F per decade
1971–2020: 0.17°F per decade

Fall (SON)



1901–2020: **<u>0.27</u>**°F per decade
1971–2020: **<u>0.75</u>**°F per decade

Box 1. Temperature Trends at the Summit of Mount Washington

Brian Fitzgerald, Mount Washington Observatory

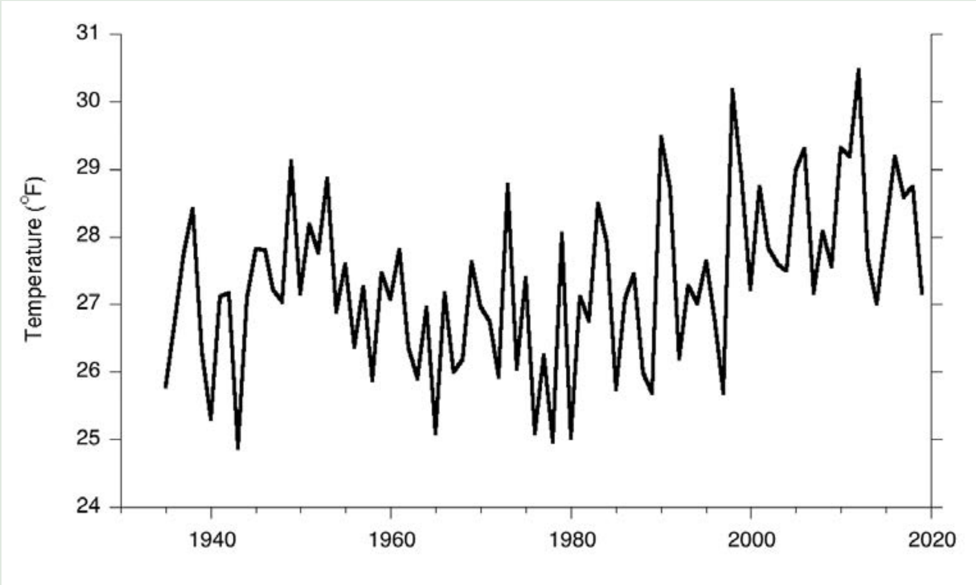
Taylor Regan, Uptime Solutions – Asset Monitoring

As the highest peak in the Northeastern U.S., Mount Washington (also known as *Kawdahkwaj*, *Agiocochook*, and *Waumbik*)[20] is famous for the "world's worst weather." Located at an elevation of 6,288 feet, meteorologists at the observatory's summit have monitored the full range of mountain weather conditions daily since 1935. The Observatory's nearly 85-year record of summit weather is one of the world's longest archives of mountain weather and climate conditions.[21]

The increase in temperature since the early 20th century observed statewide is not limited to the low elevation stations evaluated here and in other recent climate assessments.[22] Previous research[23] identified significant warming trends in annual summit temperatures but noted that the summit was warming at a slower rate than lower elevations. Building on these studies, in 2020 the Observatory conducted a review and digitization of the extensive summit temperature archive to preserve historic paper records and document procedures. The resulting robust, quality-controlled daily temperature dataset also shows a significant increase in the mean annual summit temperature over the full period of record consistent with recent published findings (Box 1 Figure).

Box 1 Figure. Mt Washington Annual Mean Temperature

Trends are estimated using Sen's slope; statistically significant trends ($p \leq 0.05$) are highlighted in **<u>bold and are underlined</u>**.



1935–2020: **0.16**°F per decade
1971–2020: **0.49**°F per decade

Heating and Cooling Degree Days

Heating degree days (HDD) provide a measure of how cold the temperature was over a given period. We calculate HDDs over the calendar year by summing the number of degrees a day's average temperature was below 65°F. Cooling degree days (CDD) provide a measure of how warm the temperature was over a given period. We calculate the CDDs over the calendar year by summing the number of degrees that a day's average temperature was above 65°F.

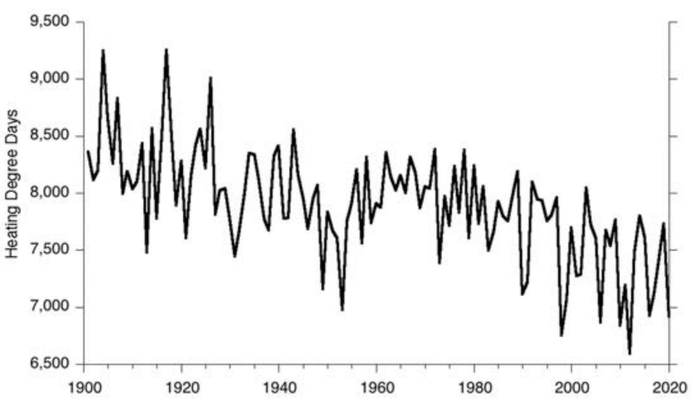
A high number of heating or cooling degree days is commonly related to higher levels of energy use for space heating or cooling, respectively.[24]

Annual HDDs (Figure 6) decreased by a total of 921 since 1901 and 812 since 1971 (Table 2). Both trends are significant and represent more than a doubling of the rate of change over the past 50 years and a decrease of 10% since 1971. For the climate normal period (1991- 2020) there are 628 fewer HDDs compared to the early 20th century (1901-1960; Table 2).

Conversely, CDDs (Figure 7) increased by 151 since 1901 and 150 since 1971. The rate of increase was 13 CDDs per decade since 1901 and 30 CDDs per decade since 1971. Both trends are significant and represent more than a doubling of the rate of change over the past 50 years and an increase of 74% since 1971. For the climate normal period (1991-2020) there are 96 more CDDs compared to the early 20th century (1901-1960; Table 2).

Figure 6. New Hampshire Heating Degree Days (HDD), 1901-2020

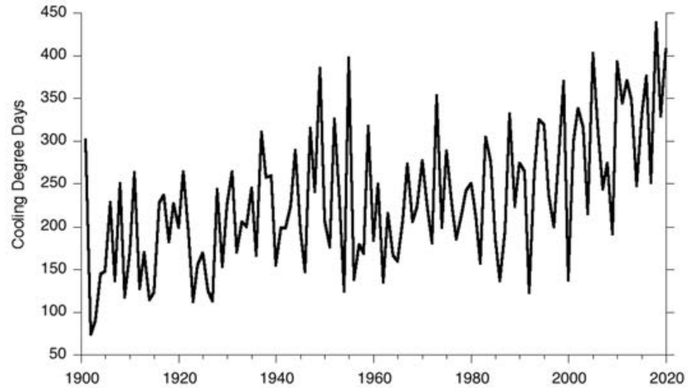
Trends are estimated using Sen's slope; statistically significant trends ($p \leq 0.05$) are highlighted in **<u>bold and are underlined</u>**.



1901–2020: **<u>-77 HDD</u>** per decade
1971–2020: **<u>-162 HDD</u>** per decade

Figure 7. New Hampshire Cooling Degree Days (CDD), 1901-2020

Trends are estimated using Sen's slope; statistically significant trends ($p \leq 0.05$) are highlighted in **<u>bold and are underlined</u>**.



1901–2020: **<u>13 CDD</u>** per decade
1971–2020: **<u>30 CDD</u>** per decade

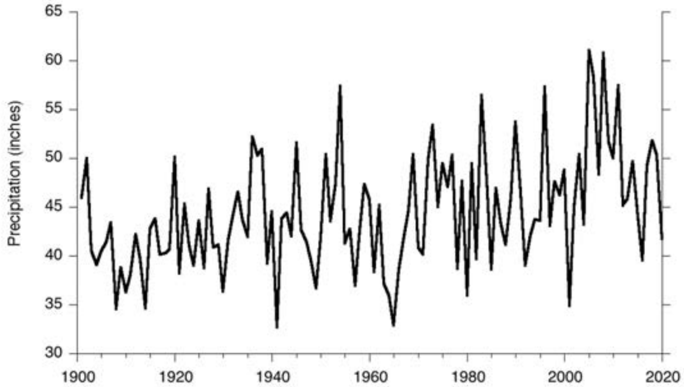
Precipitation Trends

Temperature and precipitation trends are closely linked in Earth's climate system through the hydrological cycle. Increases in precipitation may accompany increases in temperature because warmer air can evaporate more moisture. All things being equal, regions near warm offshore ocean currents, such as New England, can expect to see increases in the total amount and intensity of precipitation as temperatures continue to rise.[25]

Along with temperature, precipitation measurements are also commonly used indicators of climate change. The records analyzed here provide a continuous measure of total annual and seasonal precipitation averaged across all of New Hampshire for the past 120 years (Figures 8 and 9). Total annual precipitation in New Hampshire increased 8.1 inches (19%) since 1901 and 3.7 inches (8.7%) since 1971 (Table 2). Since 1901, annual precipitation increased significantly at a rate of 0.67 inches (1.6%) per decade. Seasonally, the largest significant increases in precipitation since 1901 occurred in winter (0.72 inches or 7.6% per decade) with more modest, but still significant, increases in fall (0.25 inches or 2.5% per decade) and summer (0.17 inches or 1.5% per decade). While there are no significant trends in annual and seasonal precipitation over the most recent 50 years, annual precipitation for the climate normal period (1991-2020) is 5.2 inches greater compared to the early 20th century (1901-1960; Table 2).

Figure 8. New Hampshire annual precipitation, 1901-2020

Significant trends are highlighted in **<u>bold and are underlined</u>**.

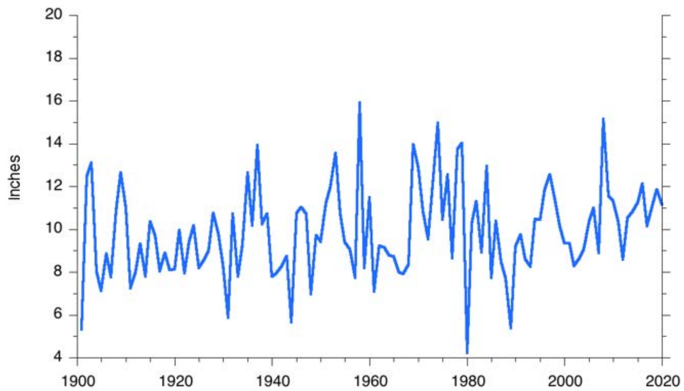


1901–2020: **<u>0.67</u>** inches per decade
1971–2020: 0.74 inches per decade

IMAGE CREDIT: MELINDA BUBIER

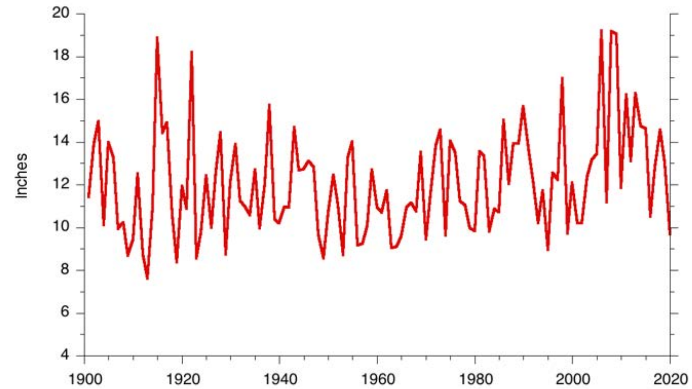
Figure 9. New Hampshire Seasonal Precipitation, 1901-2020

Winter (DJF)



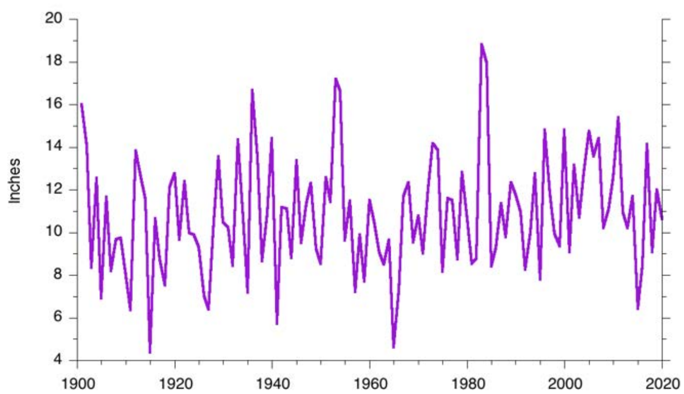
1901–2020: **<u>0.72</u>** inches per decade
1971–2020: 1.14 inches per decade

Summer (JJA)



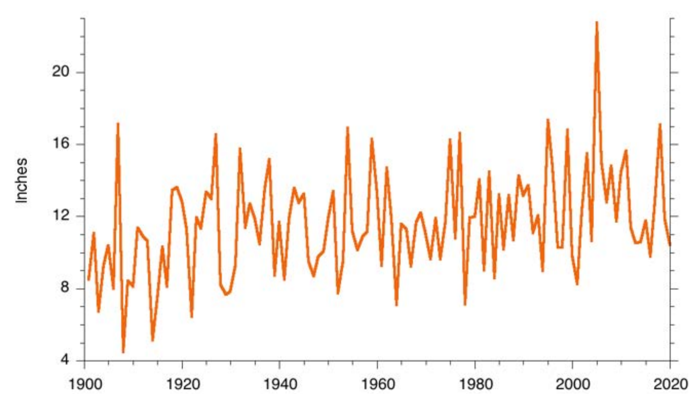
1901–2020: **<u>0.17</u>** inches per decade
1971–2020: 0.31 inches per decade

Spring (MAM)



1901–2020: 0.12 inches per decade
1971–2020: 0.09 inches per decade

Fall (SON)



1901–2020: **<u>0.25</u>** inches per decade
1971–2020: 0.22 inches per decade

Wall cloud advancing over Pleasant Lake in Elkins, NH

2.3 Standardized Precipitation Index

The Standardized Precipitation Index (SPI)[26] is a precipitation-derived drought indicator that normalizes variability in observed daily precipitation over a specified time period from a single month to years. Because the SPI accounts for precipitation only, the calculation is less complex than other drought indices (for example, Palmer Drought Severity Index, PDSI) and is available as a station-based and climate division-scale product.[27] Because the SPI is comparable across regions with different climates, it is widely used to quantify meteorological drought on a range of timescales. Evaluated over short time scales (< 12 months), operationally, the SPI is related to soil moisture conditions while SPI values calculated over 12 or more months are related to streamflow and groundwater storages.[28]

As a standardized value with a median value of zero, SPI values between -1.0 and 1.0 represent normal variability that falls within plus or minus one standard deviation of the long-term mean. While commonly used to monitor drought, the SPI captures the probability of both above (SPI > 1.0) and below normal (SPI < -1.0) precipitation occurring (Table 3). "Moderately" wet/dry conditions have SPI values between one and two standard deviations from the mean and SPI values beyond ±2 indicate wet/dry extremes that fall outside of two standard deviations.

Table 3. Range of SPI values and associated meteorological drought conditions.

SPI value	Condition	Probability
>2.0	Extremely Wet	2%
1.5 to 2.0	Moderately Wet	4%
1.0 to 1.5	Wet	9%
-1.0 to +1.0	Normal	68%
-1.5 to -1.0	Dry	9%
-2.0 to -1.5	Moderately Dry	4%
<-2.0	Extremely Dry	2%

For southern New Hampshire, the three-month SPI calculated over the spring and summer months shows an average of 1.5 to 1.8 events per decade with SPI < -1 (for instance, dry conditions) from 1901-2020 (Table 4A, Figure 10A). Comparing early 20th century values (1901-1960) to the climate normal period (1991-2020), there was an overall decrease in the number of three-month dry events of 0-69%. The one-month SPI values for southern New Hampshire range from 4.9-5.3 events per decade with values less than zero. The frequency of one-month events decreased by 7-21% over the past 30 years for the months of June, July and August, but increased by 3% for the month of September. Figure 10A also clearly shows the multi-year drought conditions that existed in southern New Hampshire during the spring and summer from 1963-1966, especially for the April to June and May to July time periods. This long-term drought is unique in the state's 120-year record and was the most severe drought on record for the Northeast region.[29]

For northern New Hampshire, the three-month SPI calculated over the spring and summer months shows an average of 1.7-2.0 events per decade with SPI < -1 (for instance, dry conditions) from 1901-2020 (Table 4B, Figure 10B). Comparing early 20th century values (1901-1960) to the climate normal period (1991-2020), there was an overall decrease in the number of three-month dry events of 27-60%. The one-month SPI values for northern New Hampshire range from 4.8-6.2 events per decade with values less than zero. Overall, the frequency of one-month events decreased by 0-14% over the past 30 years.

Table 4A. Southern New Hampshire – Historical Standardized Precipitation Index (SPI)

Drought Indicator	1901-2020	1901-1960	1991-2020	Percent Change (1991-2020 vs. 1901-1960)
SPI (3 months)	**number of periods <-1 per decade**			
April-June	1.5	1.3	1.3	0%
May-July	1.8	2.2	1.0	-54%
June-August	1.8	2.2	0.7	-69%
July-Sept.	1.6	1.3	1.0	-25%
SPI (1 month)	**number of periods <0 per decade**			
June	5.3	5.5	4.3	-21%
July	4.9	4.8	4.3	-10%
Aug	4.8	4.7	4.3	-7%
September	5.2	4.8	5.0	3%

Table 4B. Northern New Hampshire – Historical Standardized Precipitation Index (SPI)

Drought Indicator	1901-2020	1901-1960	1991-2020	Percent Change (1991-2020 vs. 1901-1960)
SPI (3 months)	**number of periods <-1 per decade**			
April-June	1.5	1.3	1.3	0%
May-July	1.8	2.2	1.0	-54%
June-August	1.8	2.2	0.7	-69%
July-Sept.	1.6	1.3	1.0	-25%
SPI (1 month)	**number of periods <0 per decade**			
June	5.3	5.5	4.3	-21%
July	4.9	4.8	4.3	-10%
Aug	4.8	4.7	4.3	-7%
September	5.2	4.8	5.0	3%

Overall, the trends in the three-month and one-month SPI indicate that short-term *meteorological drought* as quantified by the SPI, which only represents the supply side of the equation, decreased modestly over the past 30 years compared to earlier in the 20th century. This is consistent with the significant increase in summer precipitation since 1901 (Table 2, Figure 9).

Figure 10. Standardized Precipitation Index (SPI) for 3-month periods over spring and summer for (a) southern and (b) northern New Hampshire.

The threshold for "Dry" conditions (SPI <-1.0) is identified with the horizontal red line.

Figure 10A. Southern New Hampshire – 3 Month SPI

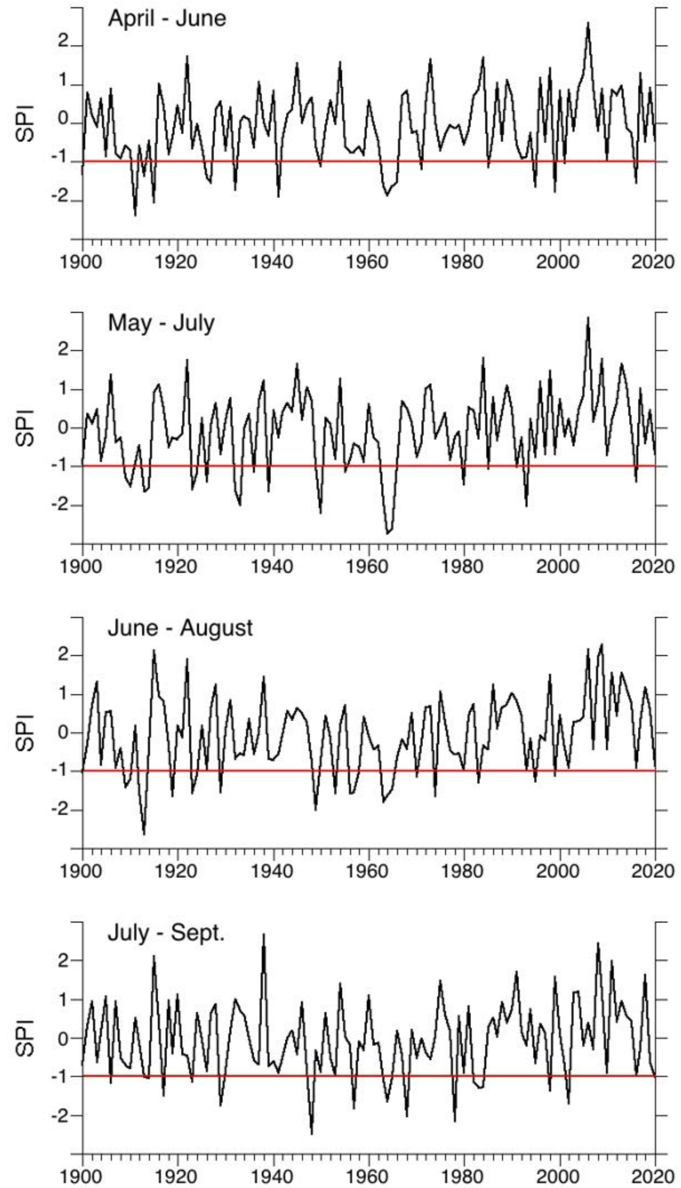
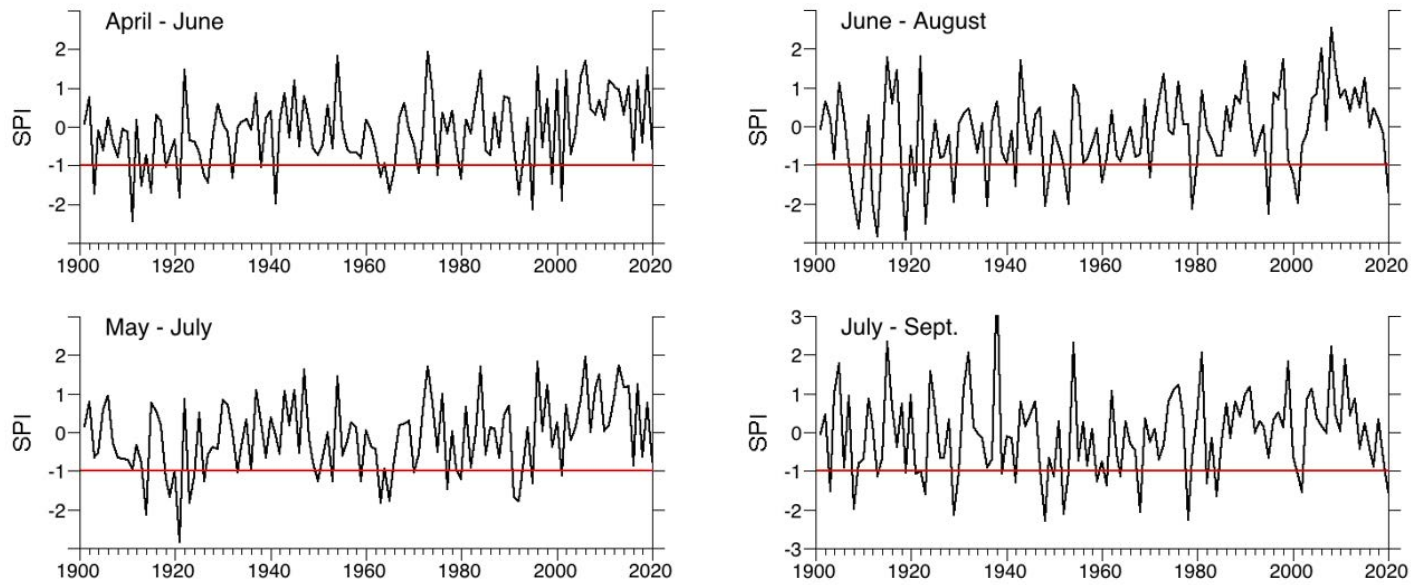
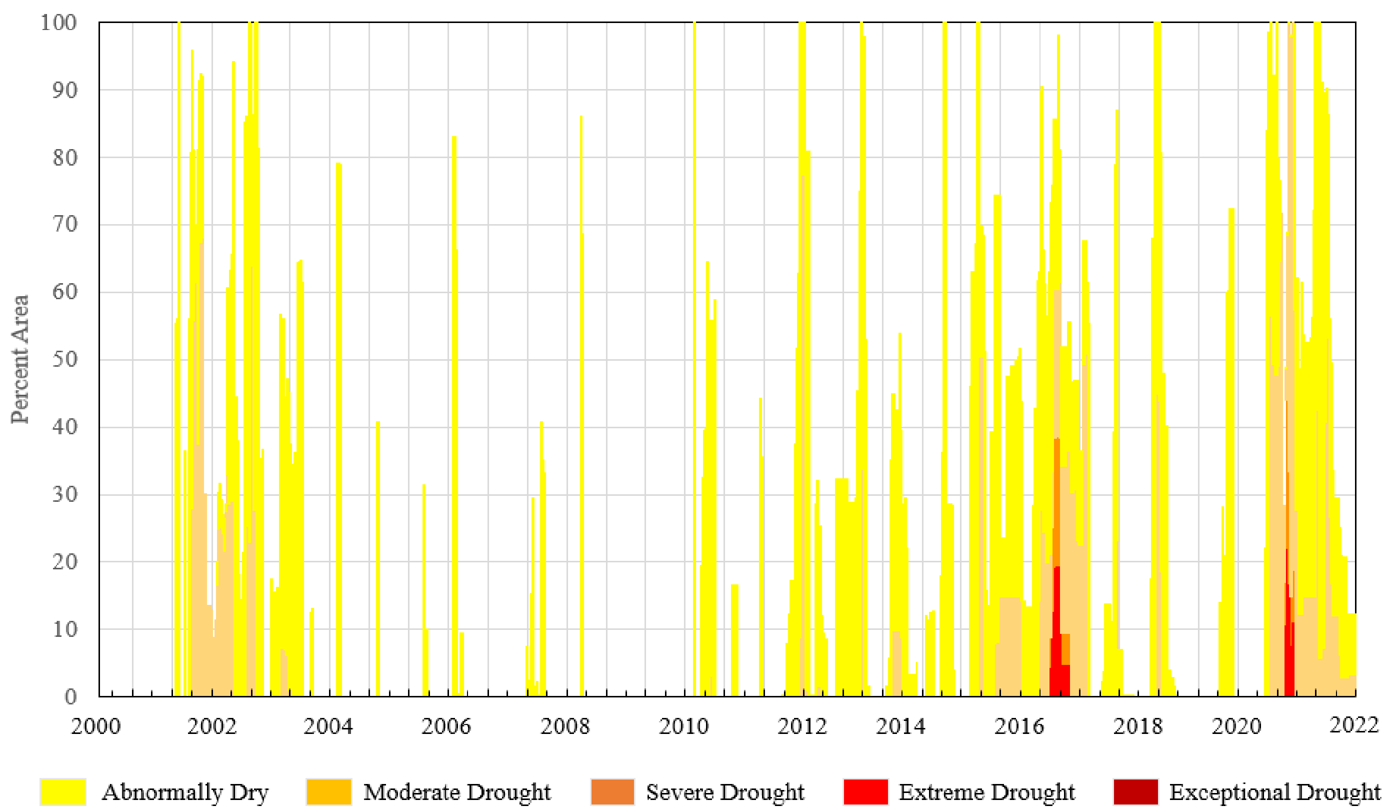


Figure 10B. Northern New Hampshire – 3 Month SPI



The US Drought Monitor categorizes drought severity from moderate (D1) to exceptional (D4) based on a set range of probabilistic drought indicators.[30] However, these national metrics do not always reflect the severity of local conditions. In communicating local conditions to the U.S. Drought Monitor (Figure 11), the State of New Hampshire[31] recommends a drought "alert" for "Moderate Drought" (D1) when the three-month SPI and PDSI drop below 0.0 and hydrologic indicators (for instance, 28-day streamflow, monthly groundwater levels) fall below normal. A drought "warning" for "Severe Drought" (D2) is issued for "moderately dry" atmospheric conditions (three-month SPI/PDSI < -1.0) and continued below normal hydrologic conditions. An "emergency" for "Extreme Drought" (D3) is declared if the SPI is below normal over a six-month period (SPI < - 1.0/PSDI < - 2.0), and below-normal streamflow and groundwater levels persist.

Figure 11. New Hampshire Percent Area in U.S. Drought Monitor Categories, 2000–2022



Data from U.S. Drought Monitor Comprehensive Statistics

Bellamy River Reservoir, October 2016

Box 2. Flash Drought

Drought is simply defined as a period of abnormal dryness leading to a shortage in water supplies. It is a slow-moving hazard that usually develops in response to precipitation deficits that accumulate over seasonal to annual time-scales.[32] However, the rapid development of several severe drought events in recent decades led to the identification of the drought subset referred to as "flash drought." Flash drought is generally described by the rate of onset and quantified as drought conditions that develop over two to six weeks but the criteria and technical definition, which also considers duration, are still an area of active research.[33] The rapid intensification of drought across New Hampshire in the spring/summer of 2016, 2020 and 2021 can be described as flash drought using this definition.

Due to the speed at which it forms and intensifies, observations indicate that flash drought develops in response to a lack of precipitation combined with other extreme weather conditions that increase evapotranspiration leading to accelerated soil moisture loss. In many cases, a developing meteorological drought is exacerbated by an extended period of abnormally high temperatures, including heat waves, and/or low humidity leading to rapid drought intensification. Given the additional weather extremes required for flash drought development, it is more common during the warm season and can have severe impacts on vegetation health, agriculture productivity and water availability.

While wildfires continue to destroy communities across western North America and also impact air quality in the northeast (Box 3, following page), the drought conditions in 2016-2017 and 2020-2021 across New England raised concerns regarding an increase in wildfires in the region.[34] Currently, little is known concerning the direct (for instance, changes in temperature and precipitation) and indirect (for instance, changing ecosystem-wide species distribution) impacts of climate change on future fire risk in the northeast.[35] However, recent studies on future fire risk in the northeast indicate that continued warming along with variability in precipitation could result in earlier start date to the fire-season and significant increases in the length of high-risk episodes. Furthermore, the regional fire risk increases more under a higher concentration pathway (RCP 8.5).[36]

Haze from West Coast wildfires in New London, NH – July 20, 2021

Box 3. Air Quality Impacts from Wildfires

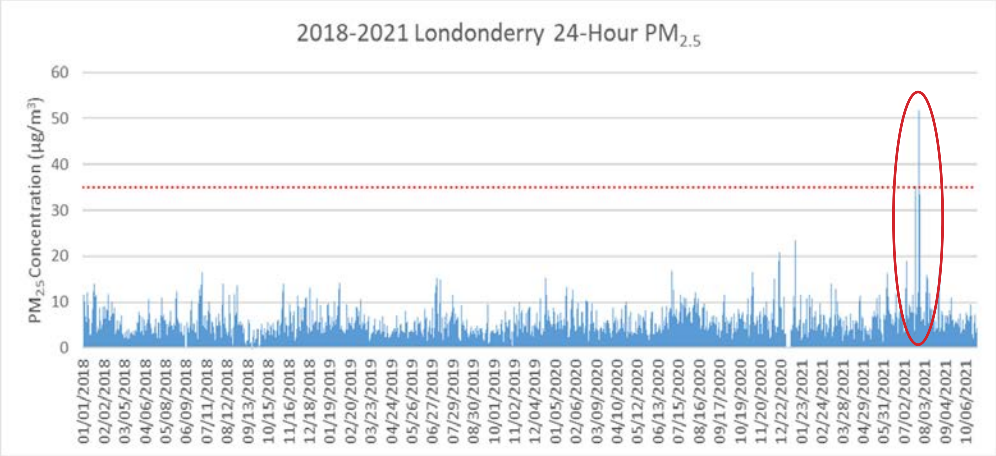
Jeff Underhill, Air Resources Division, NHDES

In 2021, record-setting fires burned across of the western U.S., destroying homes, threatening wildlife and national parks, and causing hazardous breathing conditions for nearby communities. Beyond these direct effects, smoke from these western wildfires, carried by prevailing, westerly upper-level winds, traveled across the North American interior, causing reduction in air quality as far east as New Hampshire. As the smoke moved east, it remained in the air as a thick band that could be seen with the naked eye and weather forecasters could see its approach on satellite images.

While New Hampshire occasionally experiences localized wood smoke events caused by residential heating in certain valley communities during winter, the western wildfire smoke events that occurred on July 20 and 26 were unprecedented in state history. On these two days, New Hampshire – and the Northeastern United States – experienced widespread poor air quality. On July 20, smoke covered southern New Hampshire and caused air pollution levels considered unhealthy for certain sensitive population groups, such as those with asthma or other lung conditions. On July 26, the smoke grew thick enough over portions of the state that it caused air pollution levels considered unhealthy for the general population, not just those who are particularly sensitive. These episodes are illustrated in the Box 3 Figure, showing levels of particulate matter less than 2.5 microns (PM2.5, also commonly referred to as fine particulate matter), which serves as an indicator for wood smoke. The red dashed line in the figure shows the level of the fine particulate matter that is harmful to public health and the environment as defined by the National Ambient Air Quality Standards; the red oval highlights the events in July, 2021. While the smoke only lasted a few days in New Hampshire, portions of the country further west experienced several weeks of unhealthy or hazardous air quality due to the western wildfires.

Large wildfires are expected to occur in the future including wildfires large enough to impact New Hampshire. While an event like the 2021 western wildfires is unlikely to happen in the near future, there is an increasing risk for moderate air pollution from an increasing wildfire problem in the West.

Box 3 Figure. Daily particulate matter (PM) concentrations at Londonderry, NH, 2018-2021



2.4 Snowpack

The winter snowpack provides essential ecosystems services ranging from the critical role it plays in regional hydrology to supporting the state's multimillion-dollar winter recreation industry. For several decades, NHDES maintained a set of snow sampling sites across the state to better quantify the amount of water stored in the seasonal snowpack.[37] Data from 14 sites were continuously collected since 1971 and from one site (Hemenway) since 1994. The sampling sites provide data for watersheds in four regions: Lake Winnipesaukee, central New Hampshire, coastal New Hampshire and Lake Sunapee (Table 5). The data were evaluated for trends in annual maximum snow water equivalent (SWE), irrespective of the specific timing of that maximum. Results for all 15 stations (Figure 12) show remarkable consistency in year-to-year variability in maximum annual snowpack even though the absolute amounts of SWE differ. Additionally, the data indicate a long-term decline in the maximum annual SWE despite substantial year-to-year variability (Table 5). Three of the five sampling sites in the Lake Winnipesaukee watershed and the Owl Brook sampling site in the Squam Lake watershed indicate significant declines in annual maximum SWE, ranging from a decrease of 59% to 91% compared to the 1971-2019 mean value. The other two Lake Winnipesaukee watershed sites and three sites in other central New Hampshire watersheds show non-significant decreases in annual maximum SWE. In total, nine of sites show a non-significant decline in annual maximum SWE while two stations near Barrington (in the seacoast region) show no trends. No sites show an increase over the period of record.

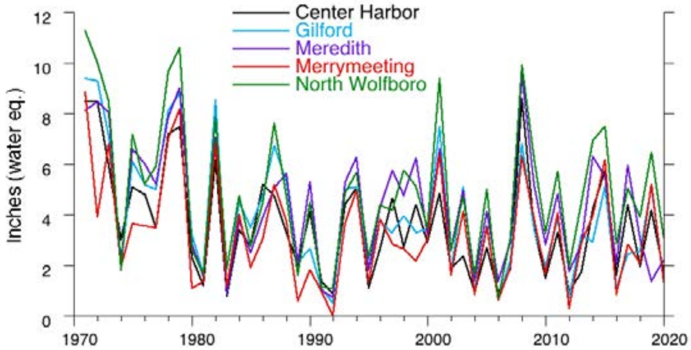
Table 5. Trends in annual maximum snow water equivalent for 15 snow sampling sites maintained by NHDES. Significant trends appear in **bold and are underlined**.

Region	Station Name	Watershed	Municipality	Elev. (ft.)	1971-2020 mean (in. SWE)	50-yr trend	percent decrease from 50-yr mean
Lake Winnipesaukee	Center Harbor	Lake Winnipesaukee	Center Harbor	932	3.6	**<u>-2.6</u>**	-72%
Lake Winnipesaukee	Gilford	Lake Winnipesaukee	Gilford	946	4.0	**<u>-3.7</u>**	-91%
Lake Winnipesaukee	Meredith	Lake Winnipesaukee	Meredith	960	4.4	**<u>-2.7</u>**	-60%
Lake Winnipesaukee	Merrymeeting	Lake Winnipesaukee	New Durham	700	3.3	-1.5	-44%
Lake Winnipesaukee	North Wolfboro	Lake Winnipesaukee	Wolfboro	1,112	4.9	-1.9	-38%
Central New Hampshire	Owl Brook	Squam Lake	Holderness	833	5.2	**<u>-3.1</u>**	-59%
Central New Hampshire	Goose Pond	Goose Pond	Canaan	882	3.7	-0.5	-12%
Central New Hampshire	Hemenway*	Ossipee Lake	Tamworth	906	4.9	-2.2	-46%
Central New Hampshire	Scribner Brook	Great East Lake	Wakefield	940	4.7	-1.0	-21%
Coastal New Hampshire	Ayers lake	Isinglass River	Barrington	345	3.3	0.0	0%
Coastal New Hampshire	Mendums Pond	Lamprey River	Barrington	365	2.9	0.0	0%
Coastal New Hampshire	Nelson Brook	Crystal Lake	Gilmanton	770	3.9	-1.1	-27%
Sunapee Lake	Granliden	Sunapee Lake	Sunapee	1,231	4.6	-2.4	-51%
Sunapee Lake	Little Sunapee	Sunapee Lake	New London	1,515	4.8	-1.9	-40%
Sunapee Lake	Newbury	Sunapee Lake	Newbury	1,322	5.5	-2.9	-52%

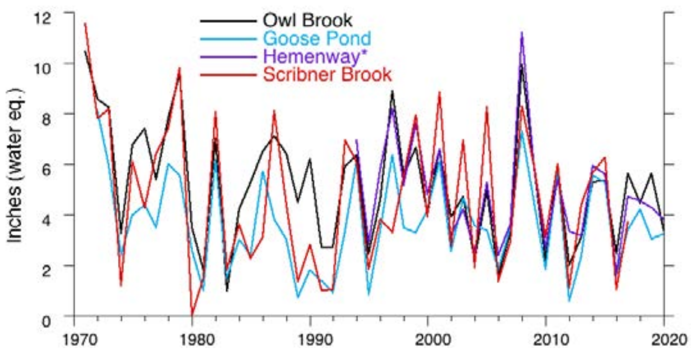
*Hemenway only has a 27-year record, starting in 1994.

Figure 12. Annual maximum snow water equivalent at 15 New Hampshire snow sampling sites 1971-2020 for three regions:

A. Lake Winnipesaukee Watershed

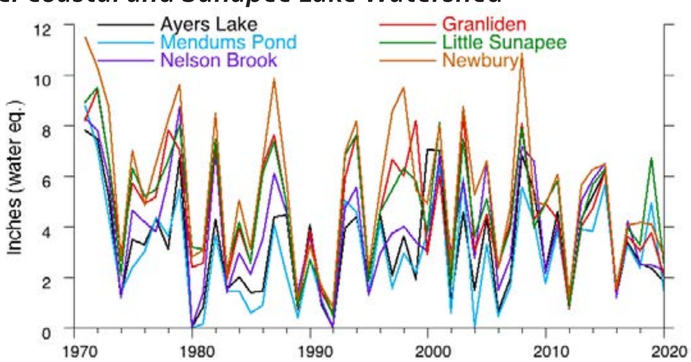


B. Central New Hampshire Sites



*Hemenway only has a 27-year record, starting in 1994.

C. Coastal and Sunapee Lake Watershed



2.5 Lake Ice-out Dates

While definitions of "ice-out" vary locally and regionally, generally lake ice-out refers to the date when lake ice begins to melt. Lake ice-out dates are frequently used as an indicator of winter/early spring climate change due to the close correlation with surface air temperature in the months before ice break-up.[38] Earlier ice-out dates also impact the pond-hockey, ice fishing and snowmobiling industry by shortening the winter recreation season or, worse, eliminating it altogether during years when lakes do not ice over completely.

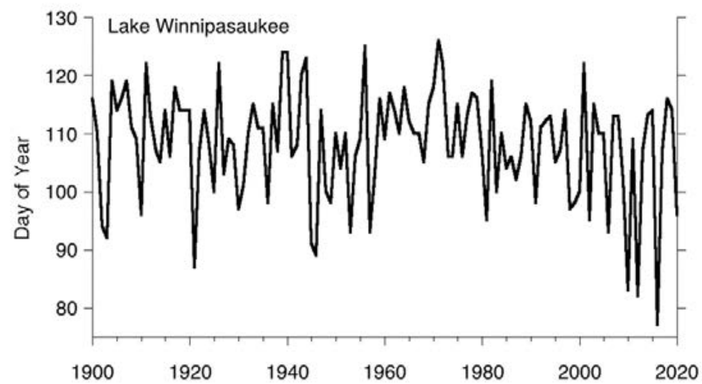
Records of lake ice-out on Lake Winnipesaukee and Lake Sunapee began in the late 1800s. For Lake Winnipesaukee, the criteria used to determine the official date of lake ice-out varied over the years. However, for most of the record, ice-out was declared when the 230-foot M/S Mount Washington cruise ship safely navigated between the port stops of Alton Bay, Center Harbor, Weirs Beach, Meredith and Wolfeboro. The criteria for the official declaration of lake ice-out on Lake Sunapee also varied throughout the years.

The earliest ice-out date of March 18 was recorded on both lakes in 2016 (Figure 13). Three of the earliest ice-out dates occurred since 2010 on Lake Winnipesaukee and two on Lake Sunapee occurred since 2012. Overall, ice-out dates trended earlier over the past 50 years with ice-out occurring on average eight days earlier on Lake Winnipesaukee and 11 days earlier on Lake Sunapee.

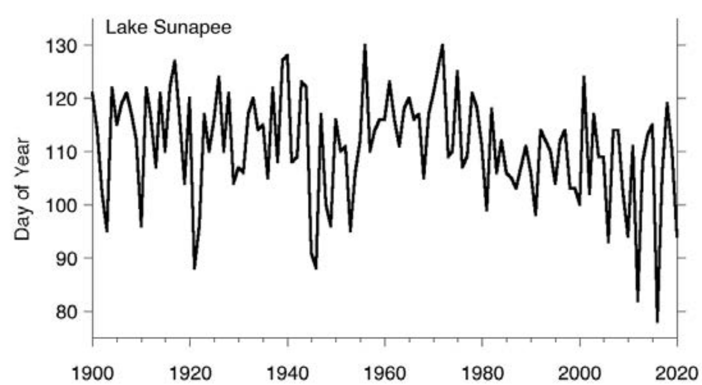
Earlier ice-out dates for Lake Winnipesaukee and Lake Sunapee are consistent with 28 other long-term ice-out records from New Hampshire, Maine and Massachusetts.[39] In addition, the ice extent on the Great Lakes decreased substantially since 1973 due to warmer winters.[40]

Figure 13. Ice-out dates on Lake Winnipesaukee and Lake Sunapee, 1900-2020

Significant trends appear in **bold and are underlined**.



1901–2020: **0.5** days earlier per decade
1971–2020: 1.5 days earlier per decade



1901–2020: **1.3** days earlier per decade
1971–2020: **2.2** days earlier per decade

2.6 Extreme Precipitation and Temperature Trends for Meteorological Stations

In addition to analyzing 17 statewide climate indicators (Table 2), a suite of 15 additional climate indicators (Figure 14) representing local-scale, daily extremes were quantified using daily meteorological data from 10 stations (Figure 1). Records from 1901-2020 were analyzed for three stations (Durham, Hanover and Keene) and from 1917-2020 at Berlin (Appendix 2). Records from 1971-2020 were analyzed for six additional stations (Colebrook, Concord, Greenland, Lakeport, Massabesic Lake and Pinkham Notch). Summarized in Figure 14, the x-axis of the scatter plot for each indicator is the 1991-2020 climate normal and the y-axis is the 50-year trend (1971-2020). The black dots represent trends that are significant at the p<0.05 level. The climate indicator tables in Appendix 2 provide details on local climate trends at the 10 weather station locations across the state for those seeking more local information.

While Figure 14 illustrates the spatial variability in climate indicator trends, there are important trends in the climate indicators that are coherent across most of the locations. For example, three of the four extreme precipitation indicators (> 1 inch in 24 hours, > 4 inches in 48 hours, and wettest day of the year; Figures 14 a, c, d) show positive (wetter) trends at most of the sites. This has important implications for the state's infrastructure, much of which was designed for rainfall intensity-duration frequencies based on precipitation observations taken prior to 1971.[41] Across the 10 stations, the number of days with > 1 inch of precipitation increased by 0-5.6 days over the past 50 years (four trends are significant), and for nine of the 10 stations, the wettest day of the year became wetter by 0-1.3 inches (four trends are significant). The number of > 4-inch events in 48 hours also increased at nine of the 10 stations, ranging from an additional 1.3-10 events per decade. While these trends in > 4-inch in 48 hours precipitation events are not statistically significant due in part to the small number of data points (n = 5 for the trend in events per decade over 50 years), the increase at some stations (for example, Durham, Greenland, Pinkham Notch) is large. Figure 15 provides more detail on the spatial variability in the trends for the > 4 inches of precipitation in 48 hours events, including the large increases at seacoast stations (Durham and Greenland), the White Mountains (Pinkham Notch) and, to a lesser extent, in Keene, Lakeport and Massabesic Lake. While there is no trend in the days > 2 inches of precipitation at seven of the 10 stations, there was a significant increase in these events at the three stations located in the western and northern regions of the state (Hanover, Keene, Pinkham).

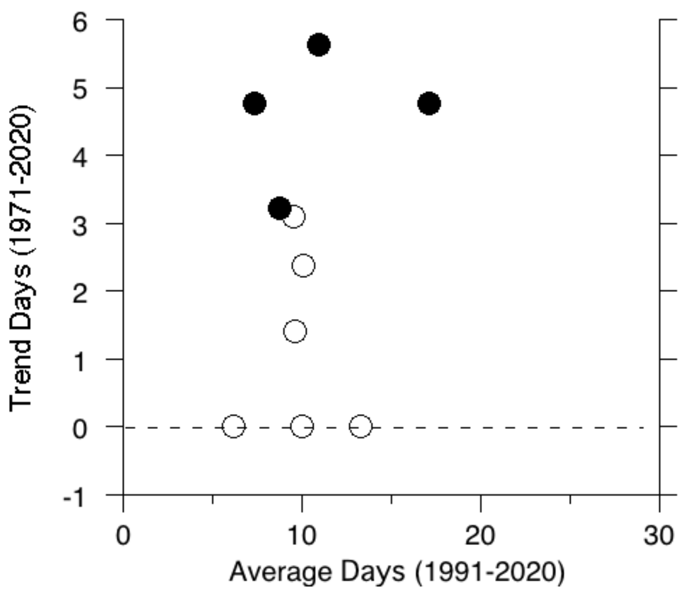
There are also spatially coherent warming trends in climate indicators related to cold temperatures, which is consistent with the large warming trend in statewide minimum temperatures (Figure 4). For the minimum temperature value on the coldest night of the year (Figure 14f), all the stations show an increase of 6-14°F over the past 50 years and all but one of them is significant. At all but one station, the number of days with a minimum temperature below 0°F decreased by 5-19 days over the past 50 years (Figure 14g) and the number of days with a minimum temperature below 32°F decreased by 8-32 days (Figure 14h).

There is much less spatial coherence in trends in hot temperatures and hot days across the 10 stations (Figures 14i through 14l). However, there was an increase in the number of thaw days, defined here as days with a minimum temperature > 28°F, at most stations, including four with significant trends (Figure 14m). There was also an increase in the number of bare-ground days, defined for observations as days with less than one inch of snow depth, at most station (two trends are significant; Figure 14n). Most stations also show a decrease in snowfall (Figure 14o) though only one of the trends is significant.

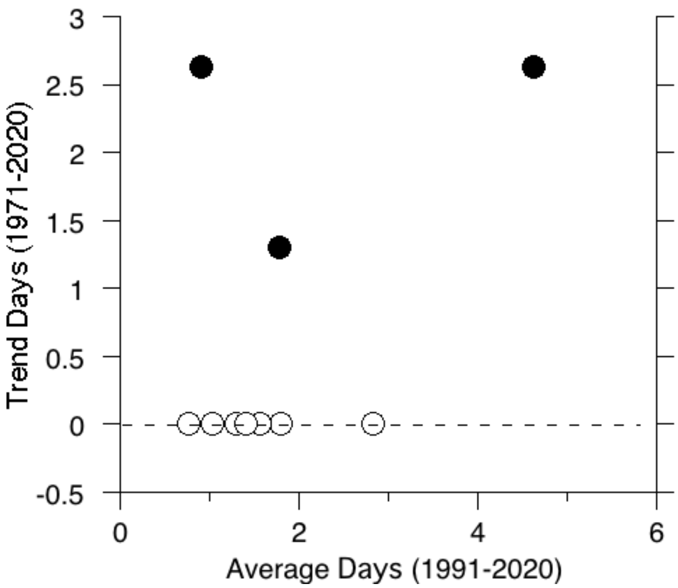
Figure 14. Trends in Historic Station Data from 1971-2020

The black dots represent trends that are significant at the p<0.05 level.

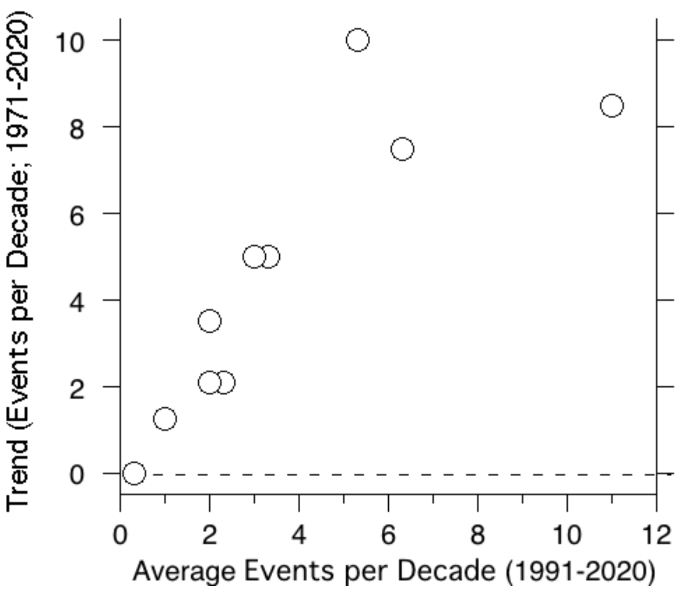
A. Days with greater than one inch of precipitation



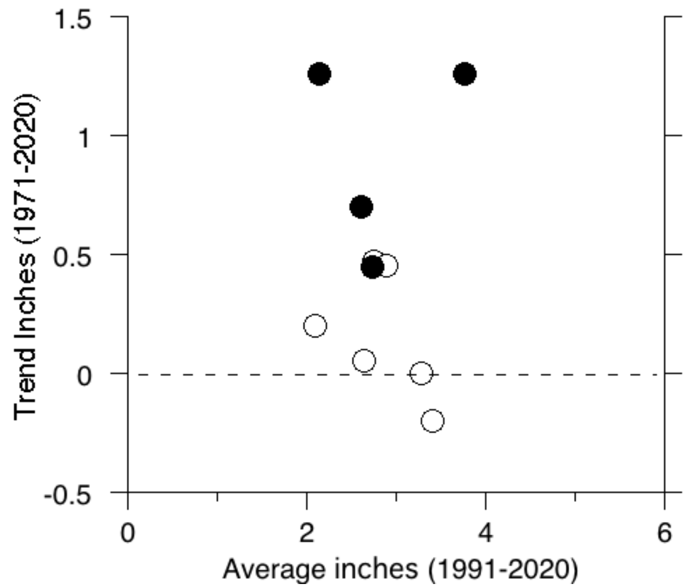
B. Days with greater than two inches of precipitation



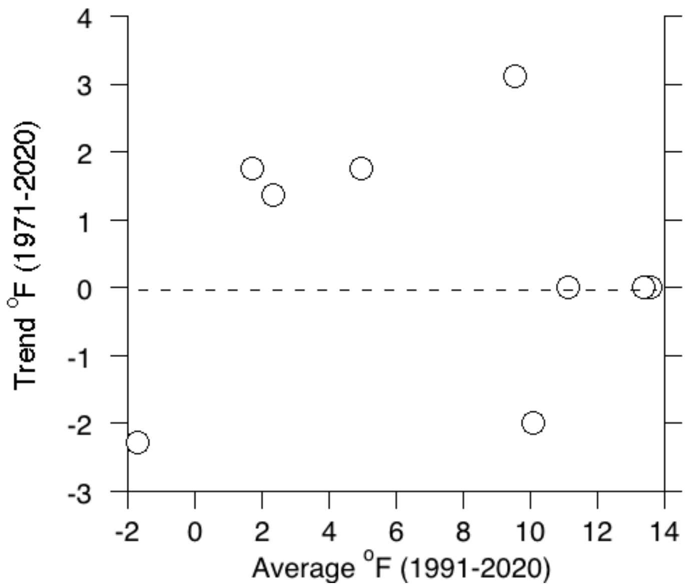
C. Unique events that drop more than four inches of precipitation in 48 hours



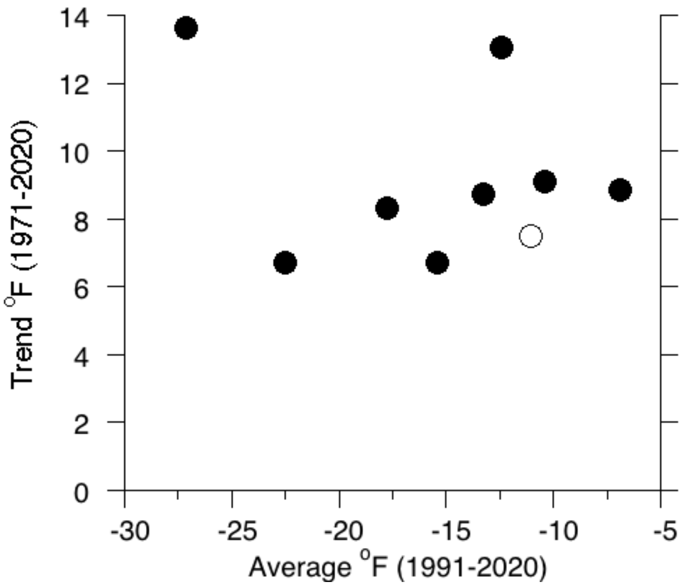
D. Wettest day of the year



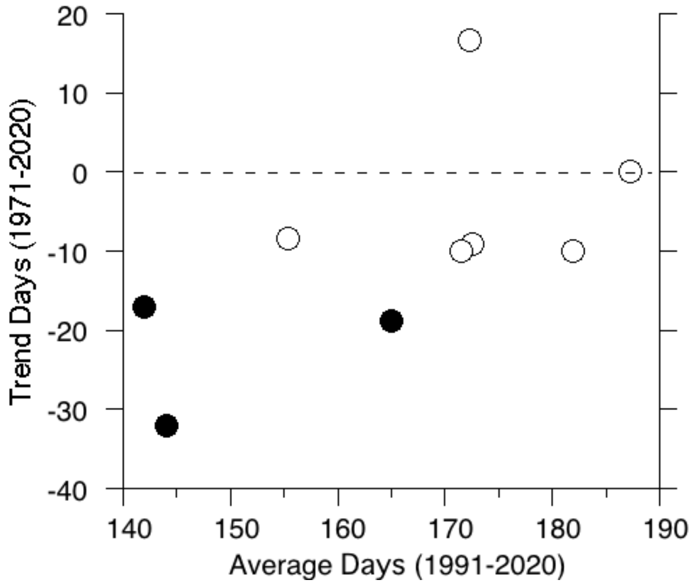
E. Maximum temperature on coldest day of the year



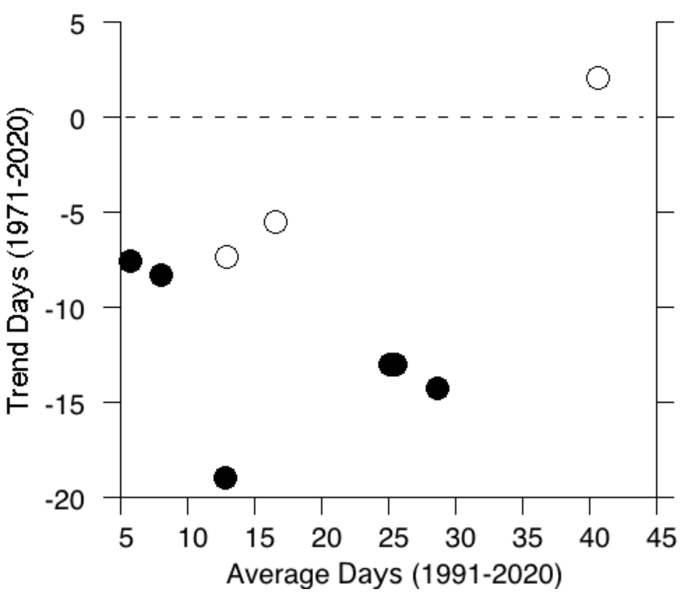
F. Minimum temperature on coldest night of the year



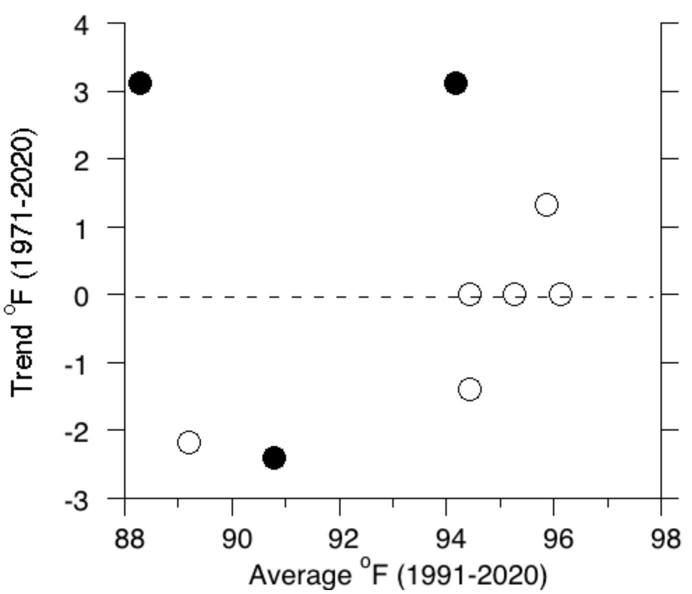
H. Number of days with minimum temperatures less than 32°F



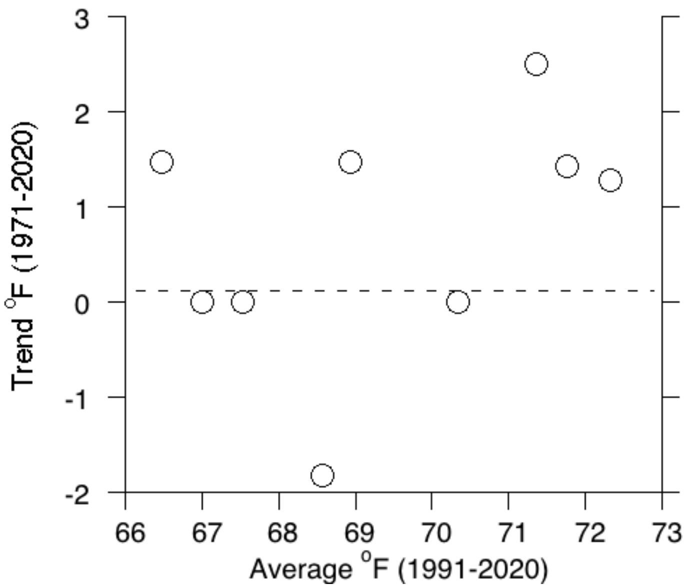
G. Number of days with minimum temperatures less than 0°F



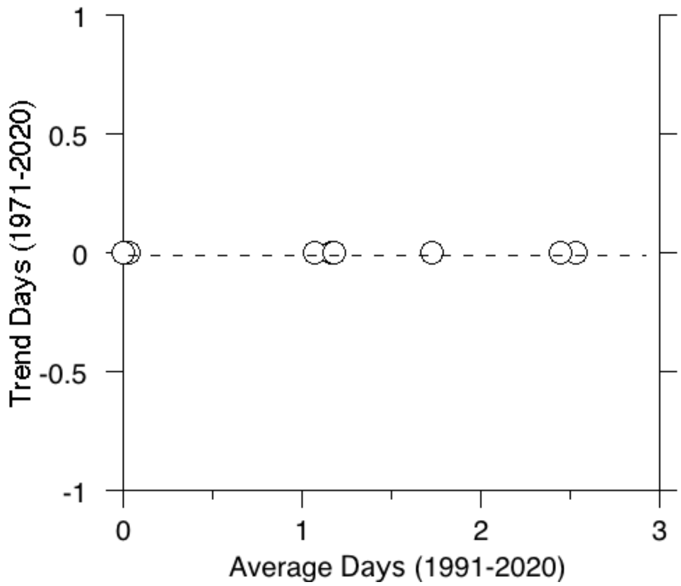
I. Maximum temperature on hottest day of the year



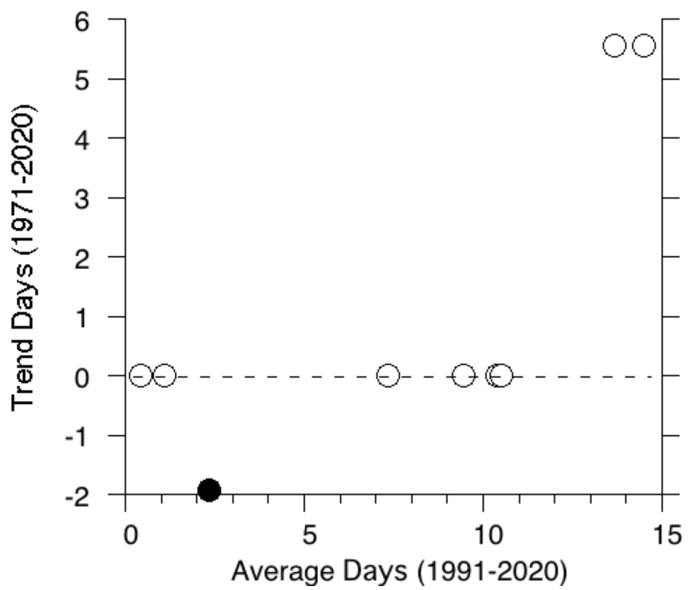
J. Maximum temperature on hottest night of the year



L. Number of days with maximum temperatures greater than 95ºF



K. Number of days with maximum temperatures greater than 90ºF



M. Thaw days (minimum temperature greater than 28ºF)

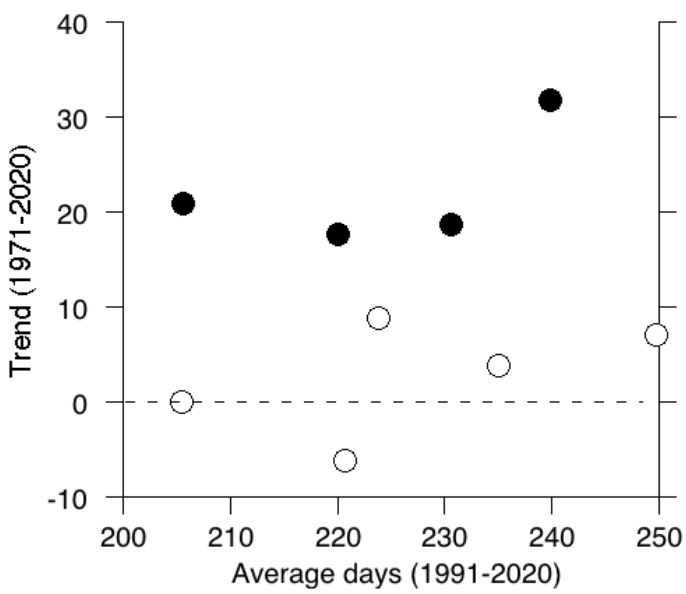
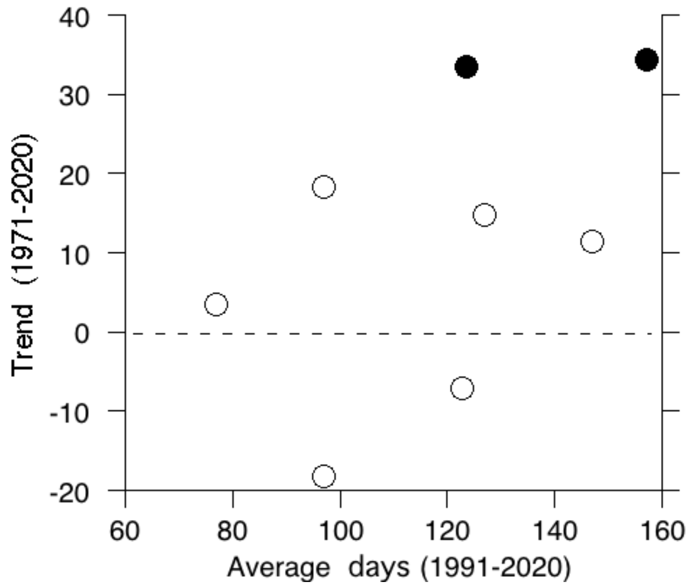


IMAGE CREDIT: KATHRYN MICHENER

N. Bare ground days (snow depth less than approx. one inch)



O. Snowfall (inches of snow water equivalent)

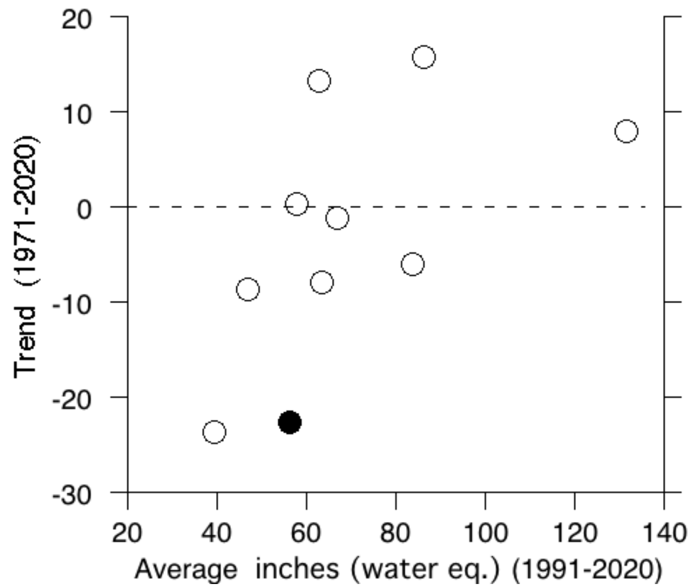
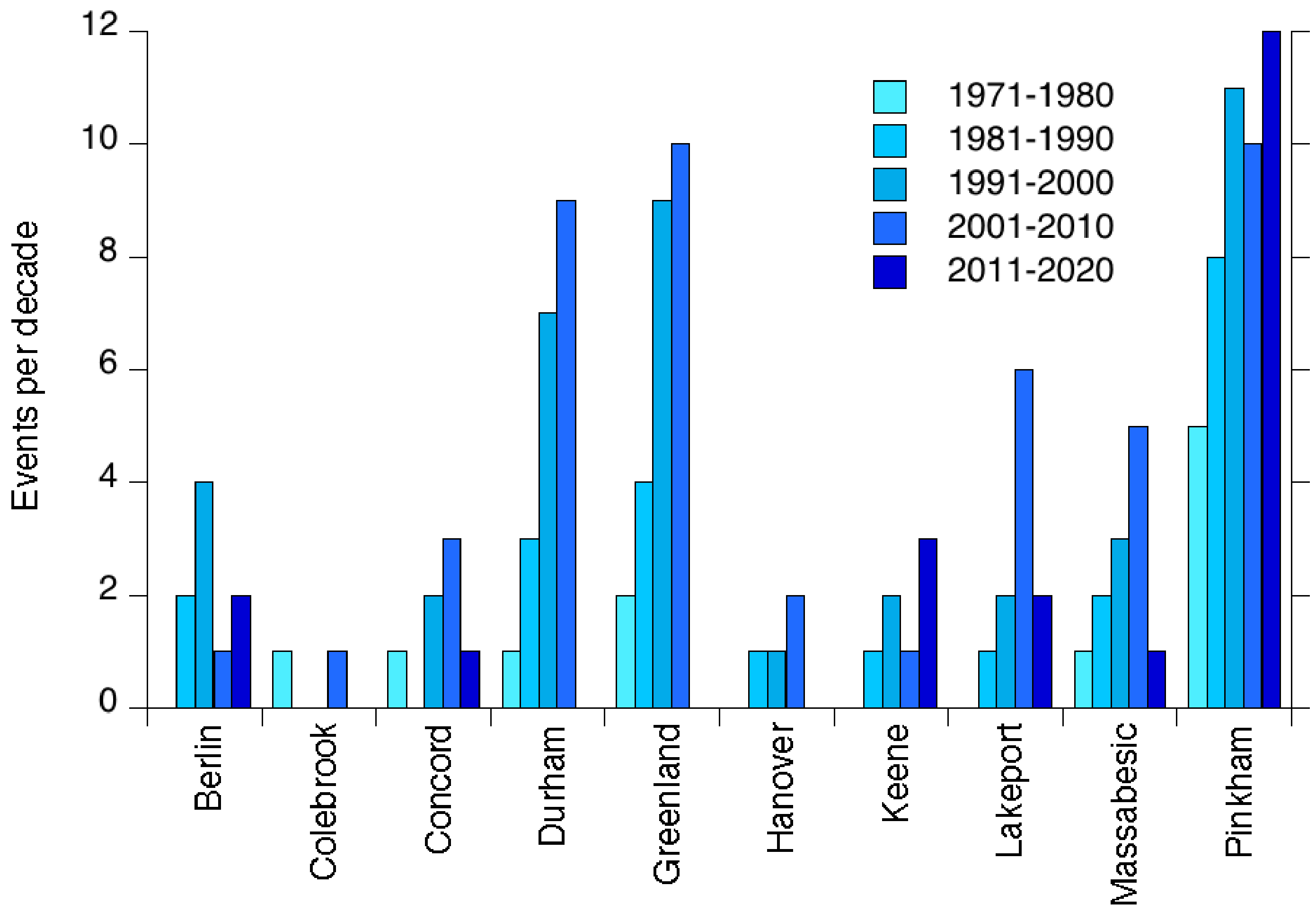


Figure 15. Days with greater than four inches of precipitation in 48 hours (per decade)



Box 4. Economic Impacts of Extreme Weather in New Hampshire

One measure of the impact of weather disruption on New Hampshire is the money that the Federal Emergency Management Administration (FEMA) spent on Presidentially Declared Disasters and Emergency Declaration (Box 4 Figure).[42] From the period 1984 to 2004, there was only one event (the 1998 ice storm) with damages paid by FEMA exceeding $15 million (in 2020 dollars). Since 2004, there were five extreme weather events with over $15 million (in 2020 dollars) damages paid by FEMA. The most costly damages since 2004 resulted from floods and ice storms. The shift in 2005 is not only due to an increase in extreme weather events, but also reflects the increased vulnerability of our aging infrastructure (buildings, roads, electrical grid) to damage from extreme weather events.

Box 4 Figure. Federal expenditures on Presidentially Declared Disasters and Emergency Declarations, 1984-2020

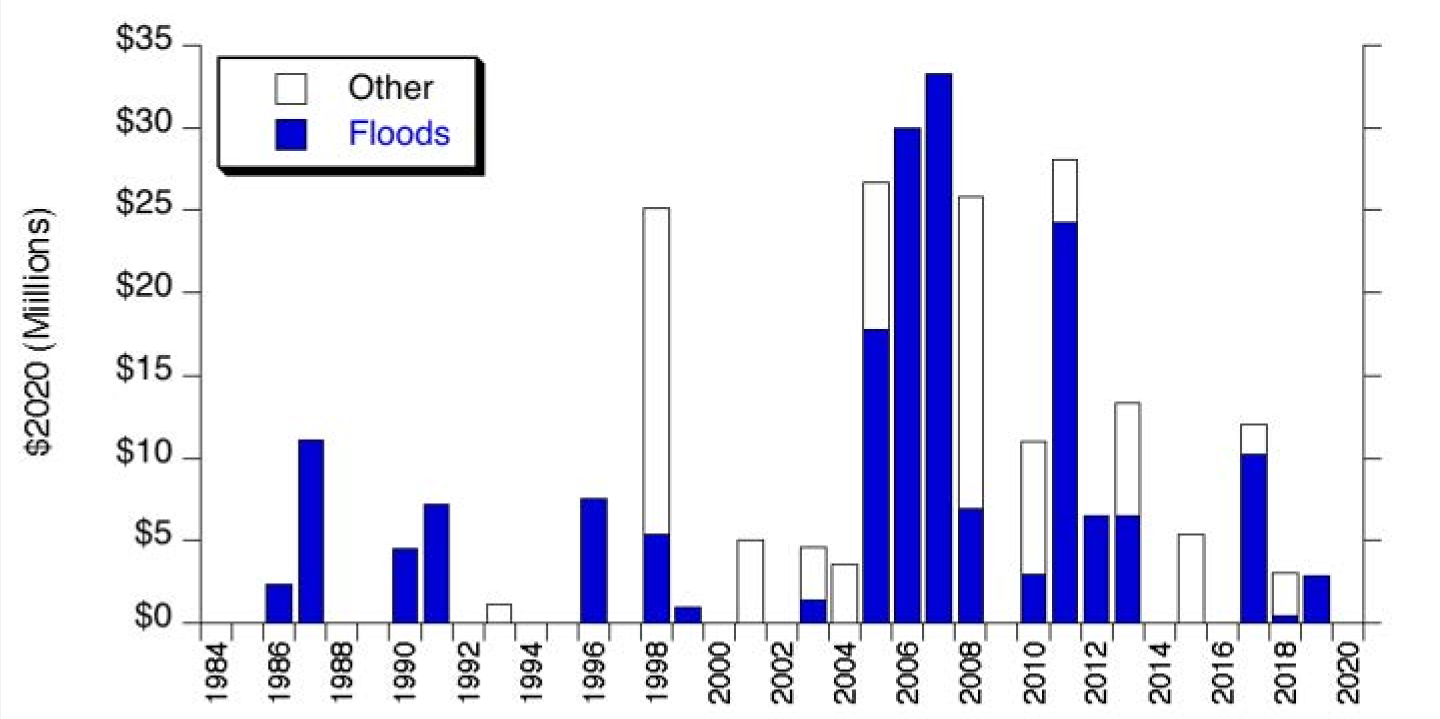


IMAGE CREDIT: MARIE SAPIENZA

3. FUTURE CLIMATE CHANGE

3.1 Key Findings

- Temperatures across New Hampshire are likely to continue rising through the 21st century. Compared to the 1980-2009 model ensemble mean, increases of 2.2-2.4°F are projected for annual average maximum and minimum temperatures over the next two decades under both a lower (RCP4.5) and higher (RCP8.5) projected atmospheric greenhouse gas concentration pathways. But by the end of the century, the projected warming for higher concentration pathway is 9.2-9.5°F, which is about 4°F more than the warming projected for lower concentration pathway (5.2-5.4°F). The warming temperatures also result in a 19-35% decrease in heating degree days and more than a doubling in cooling degree days by the end of the century.
- The warmest daily temperatures are also expected to increase throughout this century along with an increase in the frequency of hot temperature extremes. Projected 21st century increases in the hottest day and night range from 5°F to 12°F statewide under lower and higher concentration pathways, respectively. By the end of the century, the increase in days above 90°F projected for the higher concentratios pathway (50-60 days) is twice as high as the projected increases for the lower concentration pathway (20-30 days).
- As winters continue to warm, the severity of cold extremes will likely decrease, along with snowfall and snow cover. The coldest day and coldest night are projected to warm as much as 12°F (lower concentration pathway) and 22°F (higher concentration pathway) across northern New Hampshire by the end of the century. Statewide, the number of thaw days (minimum temperatures above 28°F) and modeled bare ground days are projected to increase by 20-35 days for the lower concentration pathway, while snowfall decreases by 20-50% by 2099.
- An increase in total annual precipitation is projected under both lower and higher concentration pathways largely due to increases during the winter and spring seasons. The smaller increase in summer and fall season precipitation projected for both lower and higher concentration pathways is not likely to offset the potential decrease in soil moisture loss as summer temperatures increase, setting the stage for more frequent, short-term, warm-season drought.
- The frequency and intensity of extreme precipitation events is expected to continue to increase over the course of this century. The most extreme precipitation events (i.e., greater than two inches in 24 hours and greater than four inches in 48 hours) are projected to increase for both lower and higher concentration pathways. The amount of precipitation on the wettest day of the year is also projected to increase.

3.2 Temperature and Precipitation

Historical (1980-2005) and future projections (2006-2099) of New Hampshire's climate were simulated using a 29-member, high-resolution, statistically downscaled Coupled Model Intercomparison Project (CMIP5) ensemble under lower (RCP4.5) and higher (RCP8.5) Representative Concentration Pathways (RCP).[43] Under RCP4.5, global temperature rises by 2.4°C (4.3°F) with a likely range of 1.7-3.3°C by 2100 compared to 1850-1900. Under RCP8.5, global temperature rises by 4.3°C (7.7°F) with a likely range of 3.2-5.4°C by 2100 compared to 1850-1900. While the pathway to RCP8.5 is less likely than that for RCP4.5, the projections for RCP8.5 are used here to represent the long-term, "worst case scenario." With the world on the path to 3°C, neither RCP4.5 and RCP8.5 meet the mitigation targets needed to limit global warming to below 1.5°C or even 2°C.[44]

Statistical downscaling was performed using Localized Constructed Analogs (LOCA), the same technique used in the supporting materials for the Fourth National Climate Assessment Climate Special Science Report.[45] LOCA establishes statistical relationships between historical observations of precipitation and temperature and global climate model fields to refine the spatial resolution of 29 global climate models from 1° to 1/16° (~4.5 miles). Ensemble means are weighted following techniques used in the 2017 National Climate Assessment Climate Special Science Report.[46]

Dunbarton Center, mid-1800s.
Courtesy: Town of Dunbarton

Dunbarton Center, June 2022.
Credit: Anne Zeller

Box 5. Global Climate Models and Downscaling

What is a climate model?

Scientists use global climate models to project future changes in Earth's climate. Climate models simulate Earth system processes such as the water cycle, radiative transfer and the carbon cycle as a series of mathematical and physical equations based on peer-reviewed literature. However, global climate models are typically run at spatial resolutions too coarse (1° latitude x 1° longitude, or ~68 miles) to resolve finer scale features relevant to local policy makers and regional planners.

What is downscaling?

Downscaling methods produce finer resolution climate projections through two main approaches – dynamical downscaling or statistical downscaling. Dynamical downscaling can include running global climate models at finer spatial resolution (e.g., 0.25°), refining a "nest" in a global climate model at higher spatial resolution (i.e., 0.125°), or running a regional climate model over a small part of the globe (< 10 km). However, dynamical downscaling techniques are computationally more expensive than statistical downscaling techniques. Statistical downscaling establishes robust statistical relationships between global climate models and historical observations and uses those relationships to project changes in the future at low computational cost.

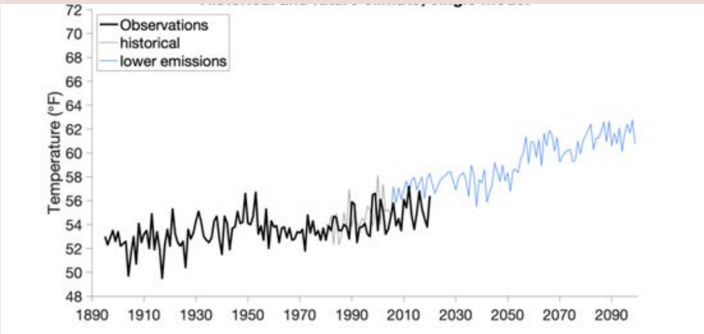
Why use an ensemble?

A climate model ensemble is a group of climate models. Scientists use a wide variety of climate models to assess the uncertainty in future climate projections due to the differences in how the models simulate various processes in the Earth system. Here we use the ensemble mean to summarize the results of the 29 different model runs. Ensemble means are simple, straightforward and transparent. As mentioned above, the ensemble means presented here are weighted following the technique used in the 2017 National Climate Assessment Climate Special Science Report.

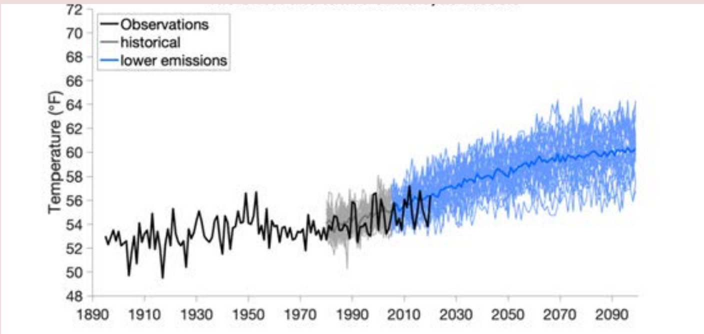
The figures for projected future temperature and precipitation include observations (1895-2020), historical simulations (1980-2005) and the future projections themselves (2006-2009). The thick black line shows historical observations (Box 5 Figures, following page). In Box 5 Figure A, the thin line is a single model simulation from the 29-model ensemble for the historical period (grey) and lower concentration pathway (blue). Box 5 Figure B shows the full 29 model ensemble simulation of historical (grey) and future projections under the lower concentration pathway (blue) with the model ensemble mean (thick blue line). Box 5 Figure C includes the future projections for the full ensemble under the low concentration pathway (blue) and higher concentration pathway (red) with the model ensemble mean (thick red/blue lines).

Continued on page 26

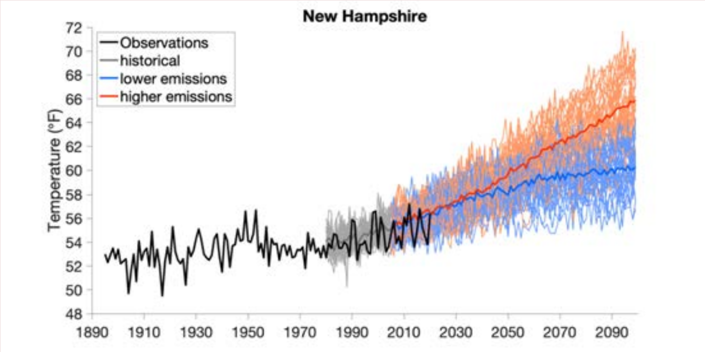
BOX 5 Figure A. Historical and future climate, single model



BOX 5 Figure B. Historical and future climate, 29 models



Box 5 Figure C. Historical and future climate, 29 models, 2 scenarios



Annual Temperature and Precipitation

Annual temperatures in New Hampshire will continue to rise regardless of whether the globe follows a lower or higher concentration pathway in the future. However, the magnitude of warming clearly depends on which concentration pathway we follow (Table 6A; Figures 16 and 17). Note that 88 of the 90 trends quantified in Table 6 are significant; only the near-term (2010-2039) trends for fall precipitation are not significant. During the first part of the 21st century (2010-2039), increases in mean annual maximum and minimum temperatures are similar for the lower (RCP4.5) and higher (RCP8.5) concentration pathways with ensemble mean warming of 2.1-2.3°F relative to the ensemble mean for 1980-2009. The magnitude of warming diverges during the middle part of the 21st century (2040-2069), with greater warming for the higher concentration pathway compared to the lower concentration pathway. Relative to the ensemble 1980-2009 mean, end of century (2070-2099) annual maximum temperatures warm 5.3°F under the lower concentration pathway and 9.2°F under the higher pathway. The projected warming is similar for annual minimum temperatures (Figure 17) ranging from 5.4-9.5°F under the lower and higher concentration pathways respectively.

Annual precipitation is projected to increase slightly under both the higher and lower concentration pathways (Table 6; Figure 18). By the middle of the century (2040-2069), annual precipitation is projected to increase by 3.1-3.9 inches (7-9%) relative to the 1980-2009 ensemble mean. By the end of the century (2070-2099) annual precipitation is projected to increase 5.5 inches (12%) under the higher concentration pathway and 3.6 inches (8%) under the lower concentration pathway. Note, however, that the differences between the lower and higher concentration pathways are not significant (Figure 18).

FLOOD WATERS AT AVERY DAM, LACONIA, CREDIT: PAT BELL

Table 6A. New Hampshire Climate Projections (2010-2099) for absolute change from historical (1980-2009)

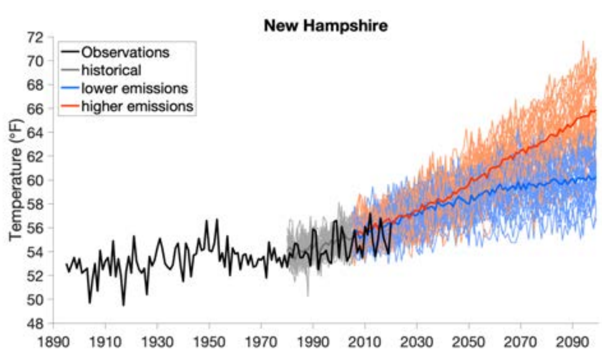
Trends are estimated using Sen's slope; statistically significant trends (p<0.05) are highlighted in **bold and are underlined**.

Indicators	Historical 1980-2009	Change from historical (+ or -)					
		2010-2039		2040-2069		2070-2099	
		Low Emissions	High Emissions	Low Emissions	High Emissions	Low Emissions	High Emissions
Precipitation (inches)							
Annual	45.4	**1.8**	**1.9**	**3.1**	**3.9**	**3.6**	**5.5**
Winter (DJF)	10.3	**0.7**	**0.6**	**0.9**	**1.5**	**1.4**	**2.2**
Spring (MAM)	11.2	**0.5**	**0.6**	**0.8**	**1.1**	**0.9**	**1.8**
Summer (JJA)	11.8	**0.4**	**0.5**	**0.7**	**0.7**	**0.9**	**1.0**
Fall (SON)	12.1	0.3	**0.2**	**0.6**	**0.6**	**0.4**	**0.5**
TMAX (def F)							
Annual	54.6	**2.2**	**2.3**	**4.1**	**5.6**	**5.2**	**9.2**
Winter (DJF)	30.7	**2.1**	**2.5**	**4.1**	**5.5**	**5.3**	**9.0**
Spring (MAM)	52.9	**2.0**	**1.9**	**3.8**	**5.1**	**5.0**	**8.3**
Summer (JJA)	77.1	**2.2**	**2.4**	**4.3**	**5.9**	**5.4**	**10.0**
Fall (SON)	57.2	**2.2**	**2.5**	**4.2**	**5.8**	**5.4**	**9.5**
TMIN (deg F)							
Annual	32.3	**2.2**	**2.4**	**4.2**	**5.8**	**5.4**	**9.5**
Winter (DJF)	10.3	**2.8**	**3.3**	**5.4**	**7.2**	**6.9**	**11.5**
Spring (MAM)	29.9	**1.9**	**1.9**	**3.6**	**4.9**	**4.7**	**8.1**
Summer (JJA)	52.9	**2.0**	**2.2**	**3.9**	**5.4**	**5.0**	**9.2**
Fall (SON)	35.7	**1.9**	**2.2**	**3.8**	**5.4**	**5.0**	**9.0**

Table 6B. New Hampshire Climate Projections (2010-2099) for percent change from historical (precipitation only)

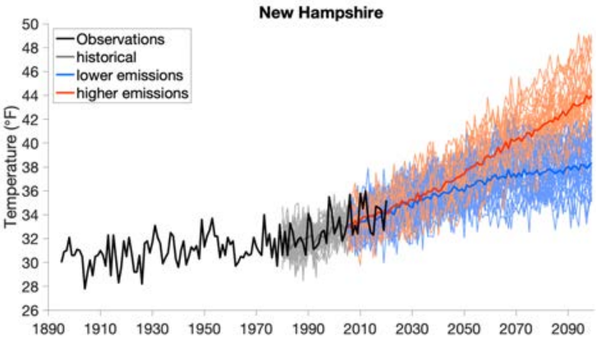
Indicators	Historical 1980-2009	Change from historical (+ or -)					
		2010-2039		2040-2069		2070-2099	
		Low Emissions	High Emissions	Low Emissions	High Emissions	Low Emissions	High Emissions
Precipitation (inches)							
Annual	45.4	4%	4%	7%	9%	8%	12%
Winter (DJF)	10.3	6%	6%	9%	14%	13%	22%
Spring (MAM)	11.2	4%	6%	7%	10%	8%	16%
Summer (JJA)	11.8	4%	4%	6%	6%	7%	9%
Fall (SON)	12.1	2%	2%	5%	5%	4%	4%

Figure 16. New Hampshire mean annual maximum temperature, 1895-2099



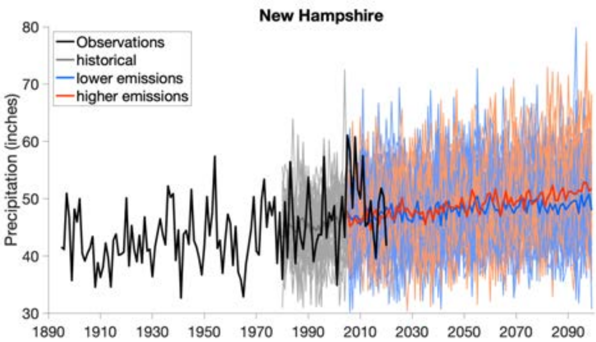
The thick black line shows observed, state average mean annual maximum temperature from NOAA's U.S. Climate Divisional Database (1895-2020). Global climate model ensemble mean historical (1980-2005) are in gray and projected future annual mean maximum temperatures under lower concentration pathway (blue) and higher concentration pathway (red). The bold lines represent the global climate model ensemble mean while the lighter lines represent the results from each individual model run. Refer to Box 5 for a detailed description of graph symbology.

Figure 17. New Hampshire mean annual minimum temperature, 1895-2099



Refer to Box 5 for a detailed description of graph symbology.

Figure 18. New Hampshire mean annual precipitation, 1895-2099



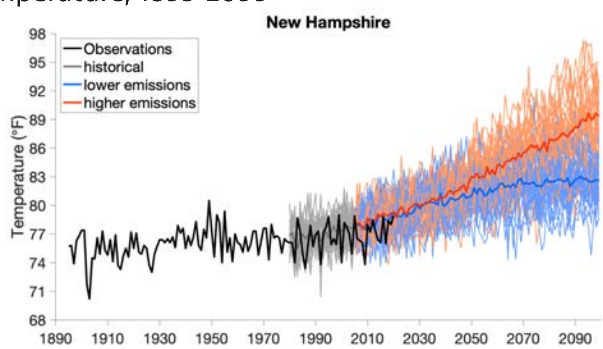
Refer to Box 5 for a detailed description of graph symbology.

Summer Temperature and Precipitation

For the near-term (2010-2039), summer maximum and minimum temperatures under both higher and lower concentration pathways show warming from 2.0-2.4°F relative to the 1980-2009 baseline (Table 6A, Figures 19 and 20). This is similar to the values for annual temperature increases (Table 6A, Figure 16 and 17). The amount of summer season warming diverges by mid-century, with increases in maximum and minimum temperatures of 5.9°F and 5.4°F, respectively, under the higher concentration pathway, compared to 4.3°F and 3.9°F under the lower concentration pathway. By the end of the century, these differences are amplified with maximum and minimum temperatures warming 10.0°F and 9.2°F under the higher concentration pathway, compared to 5.4°F and 5.0°F for the lower concentration pathway. Note that under both concentration pathways, New Hampshire will experience hotter days and warmer nights during the summer season.

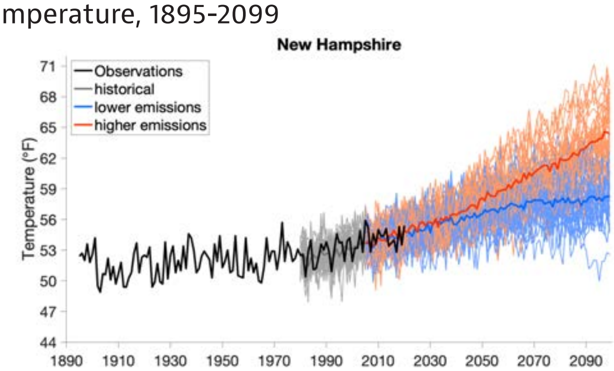
Unlike the increase in summer temperatures, summer precipitation remains almost constant over the 21st century for both the lower and higher concentration pathways (Figure 21). The trends detailed in Table 6 show an increase of less than one inch (4-9%) in summer and fall precipitation under both concentration pathways over the 21st century. This is important as warmer summer temperatures will likely lead to more evapotranspiration, which will not be offset by an increase in summer/fall precipitation. This sets the stage for more frequent, short-term warm-season drought. However, the dynamics of drought involve more than temperature and precipitation, and depend in part on the response of ecosystems – and especially New Hampshire's extensive forests – to increases in temperature. A more detailed analysis using a fully coupled land-atmosphere model to project future changes in soil moisture and drought conditions with greater precision is recommended. Nonetheless, projected summer temperature and precipitation trends create the necessary conditions for progressively more short-term drought during summer and fall in New Hampshire through the 21st century.

Figure 19. New Hampshire mean summer maximum temperature, 1895-2099



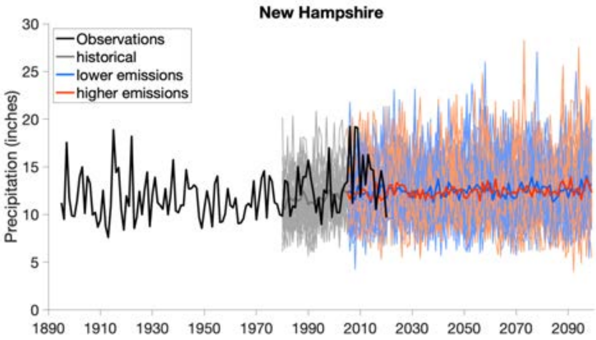
Refer to Box 5 for a detailed description of graph symbology.

Figure 20. New Hampshire mean summer minimum temperature, 1895-2099



Refer to Box 5 for a detailed description of graph symbology.

Figure 21. New Hampshire mean summer precipitation, 1895-2099



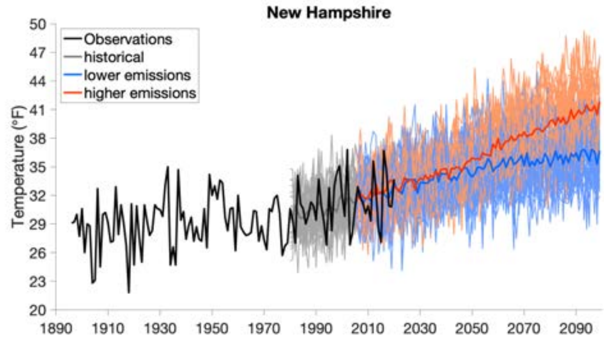
Refer to Box 5 for a detailed description of graph symbology.

Winter Temperature and Precipitation

For the near-term (2010-2039), winter minimum and maximum temperatures for both concentration pathways show warming from 2.1-3.3°F (Table 6A, Figure 22 and 23). By mid-century, maximum and minimum winter temperatures are projected to warm by 5.5°F and 7.2°F, respectively, under the higher concentration pathway, compared to 4.1°F and 5.4°F under the lower concentration pathway. By the end of the century, these differences are amplified with maximum and minimum temperatures warming 9.0°F and 11.5°F under the higher concentration pathway, compared to 5.3°F and 6.9°F for the lower concentration pathway. Note that in contrast to the projected summer warming, when maximum temperature warmed the most, winter minimum temperature is projected to warm more than winter maximum temperature.

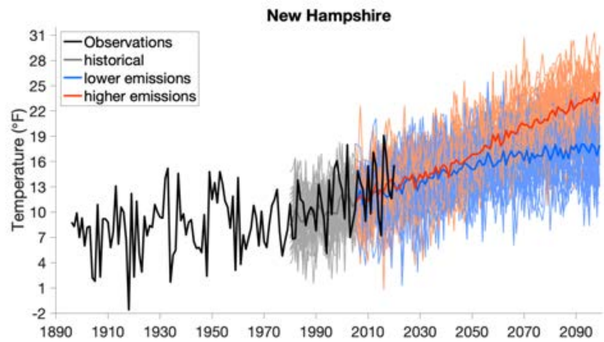
Winter precipitation is projected to increase slightly over the 21st century by 0.6-0.7 inches (6%) in the near-term, 0.9-1.5 inches (9-14%) by mid-century, and 1.4-2.2 inches (13-22%) by the end of the century (Table 6; Figure 24). As both minimum and maximum winter temperatures increase, outstanding questions include, how much of this precipitation will fall as snow versus rain, and at what point in the future will most winter precipitation become predominantly rain? This will have a serious impact on the New Hampshire ski industry (see Box 6) and other winter season recreational industries. In addition, the combination of projected increases in spring precipitation (7-10% by mid-century and 8-16% by end of the century) and extreme precipitation events (described in Section 3.4) will likely increase the risk for late winter/spring flooding – both in terms of magnitude and frequency.

Figure 22. New Hampshire mean winter maximum temperature, 1895-2099



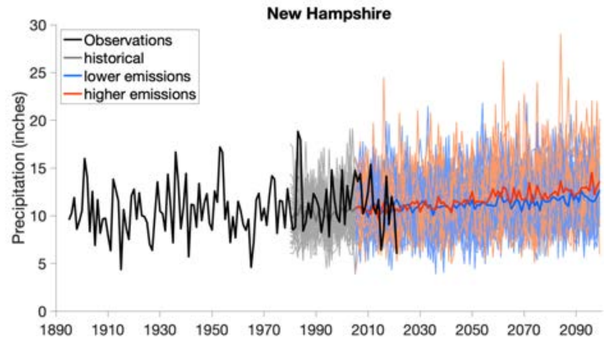
Refer to Box 5 for a detailed description of graph symbology.

Figure 23. New Hampshire mean winter minimum temperature, 1895-2099



Refer to Box 5 for a detailed description of graph symbology.

Figure 24. New Hampshire mean winter precipitation, 1895-2099



Refer to Box 5 for a detailed description of graph symbology.

3.3 Heating and Cooling Degree Days

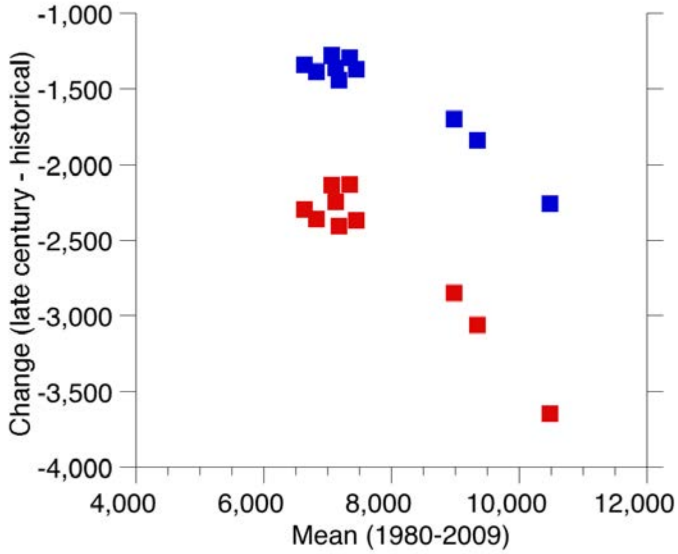
In addition to analyzing 15 statewide statewide climate indicators (Table 6), a suite of 17 additional climate indicators representing local-scale, daily extremes were quantified using statistically downscaled climate model simulations for the 10 weather station locations used in Section Two (Figure 1). Summarized in Figure 25, the x-axis of the scatter plot for each indicator is the 1980-2009 ensemble mean and the y-axis is the difference between late century (2070-2099) and historical (1980-2009) ensemble means. The climate indicator tables presented in Appendix B provide details on future climate trends for 10 weather station locations across the state for those seeking more local information.

The amount of projected change by the end of the century for both heating degree days (HDD) (Figure 25a) and cooling degree days (CDD) (Figure 25b) is substantially larger for the higher concentration pathway than the lower. There is a decrease in HDDs at all station locations by the end of the century; however, the largest decrease for both concentration pathways occur at the stations with the greatest number of observed HDDs (>8900, HDDs per year, Berlin, Colebrook, and Pinkham Notch). This indicates that the northern part of the state will likely experience the greatest amount of winter warming. Conversely, there is an increase in CDDs at all station locations by the end of the century; however, the largest increase for both concentration pathways occur at stations in the southern part of the state with the greatest number of observed CDDs.

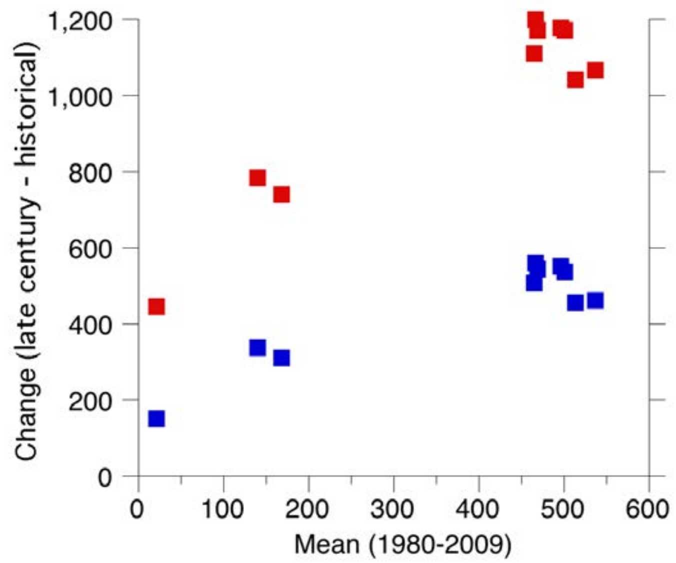
Figure 25. Projected HDD and CDD by Station 2070-2099 versus 1980-2009

Blue boxes show values from the lower concentration pathway (RCP4.5) model runs while the red boxes show values from the higher concentration pathway (RCP8.5) model runs.

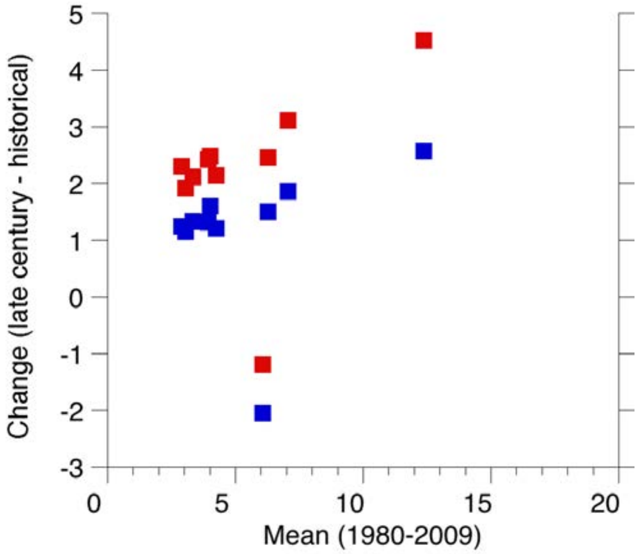
A. Heating degree days



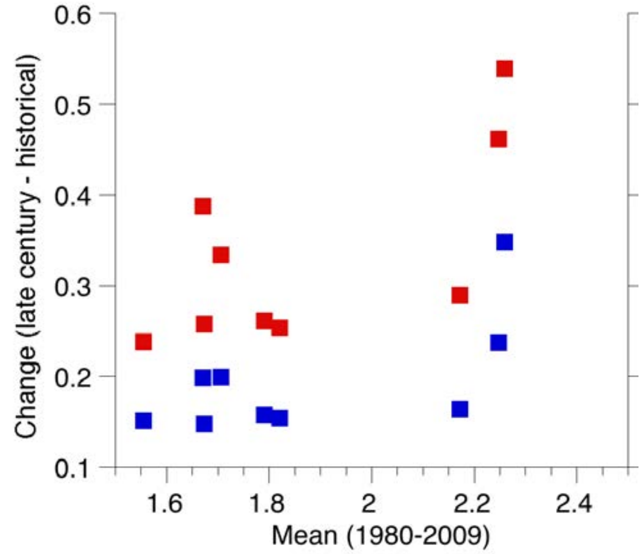
B. Cooling degree days



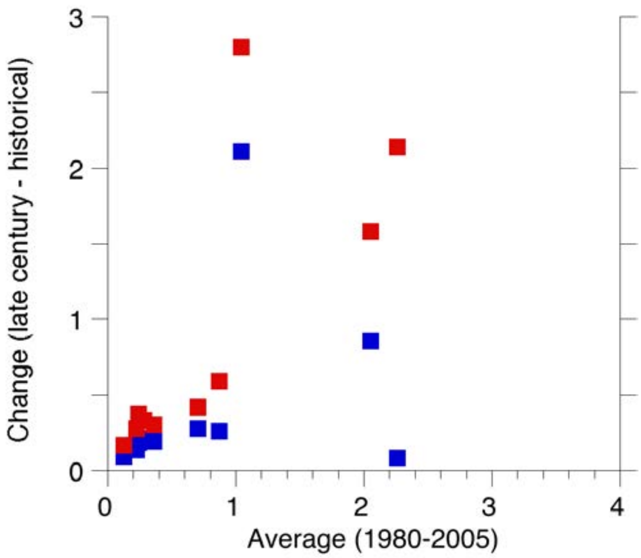
C. Days with greater than one inch of precipitation



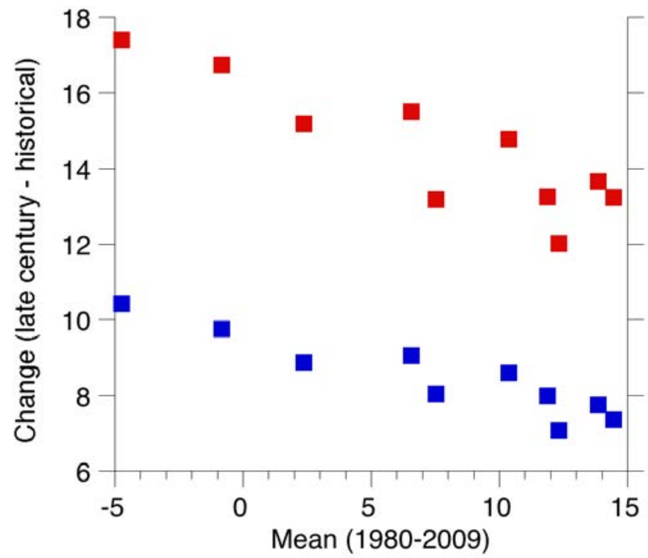
F. Wettest day



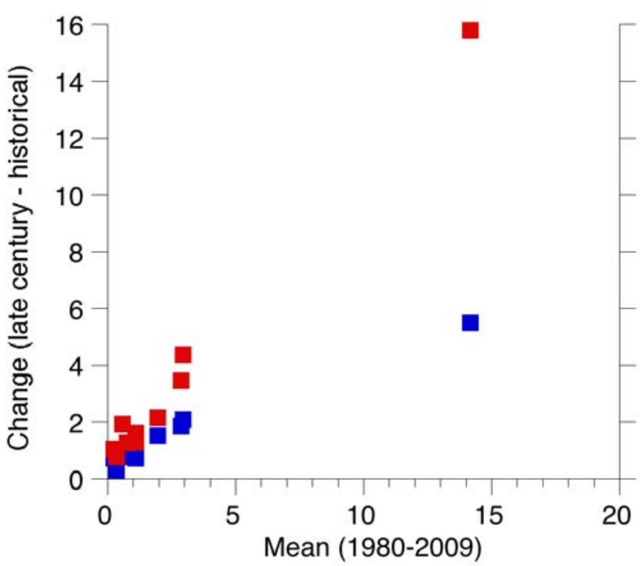
D. Days with greater than two inches of precipitation



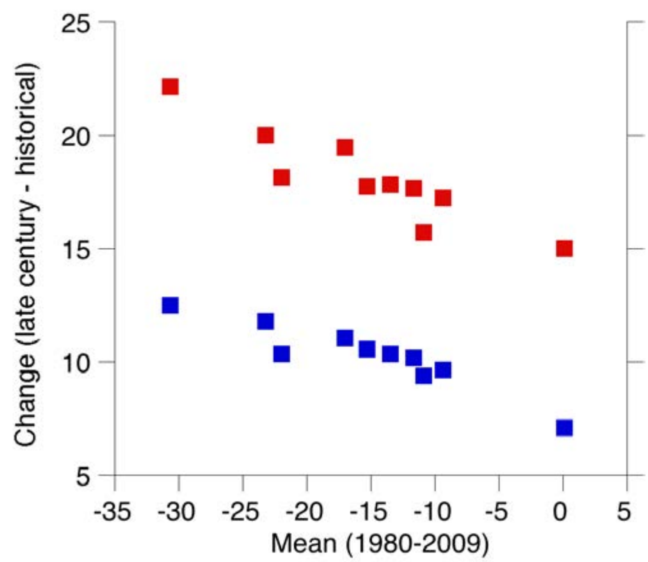
G. TMax on coldest day



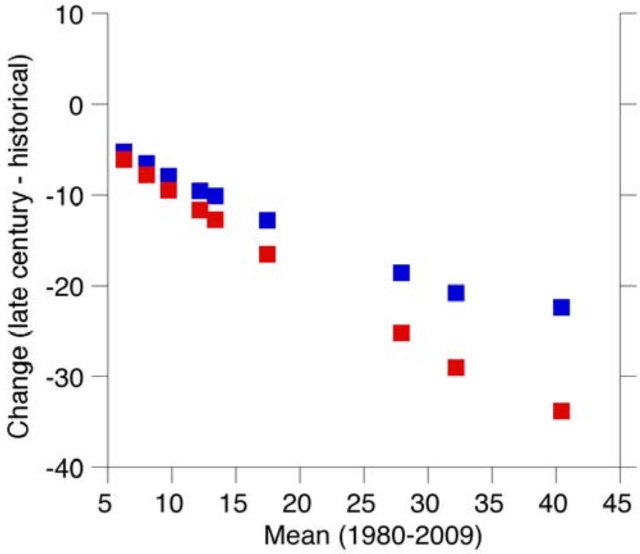
E. Events with greater than four inches in 48 hours (per decade)



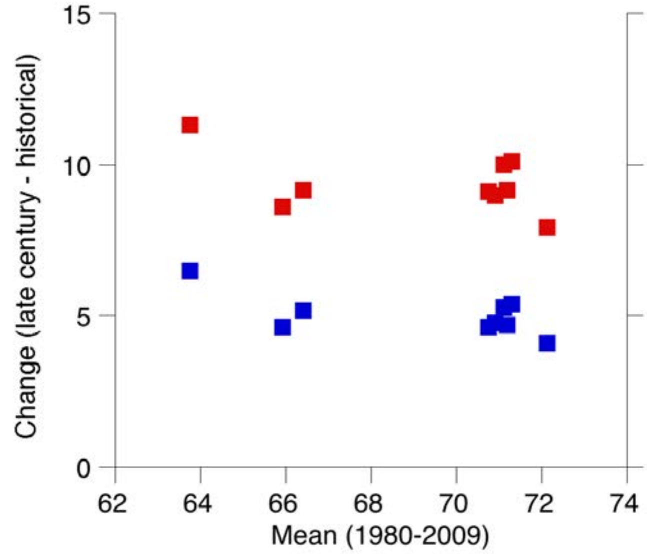
H. TMin on coldest night



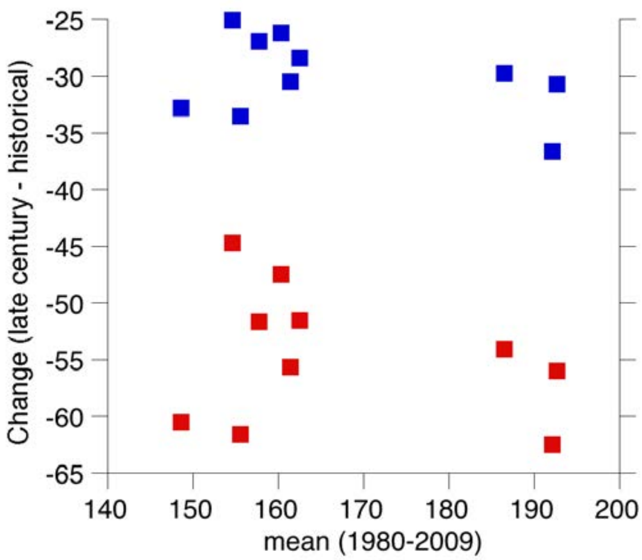
I. Days TMin is less than zero degrees F



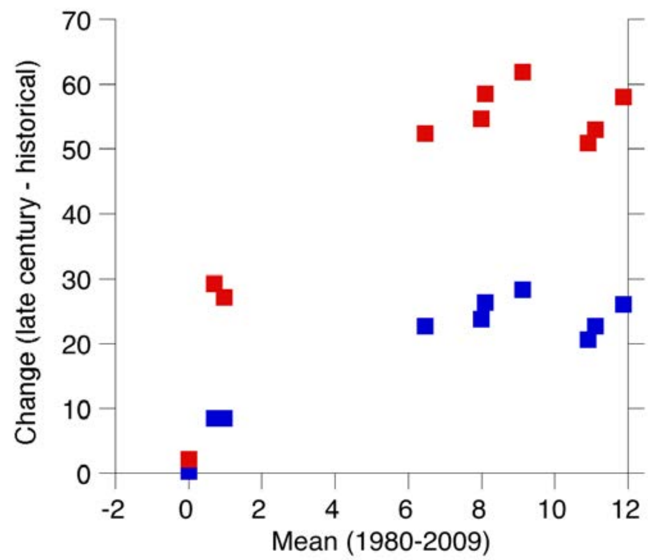
L. TMax on hottest night



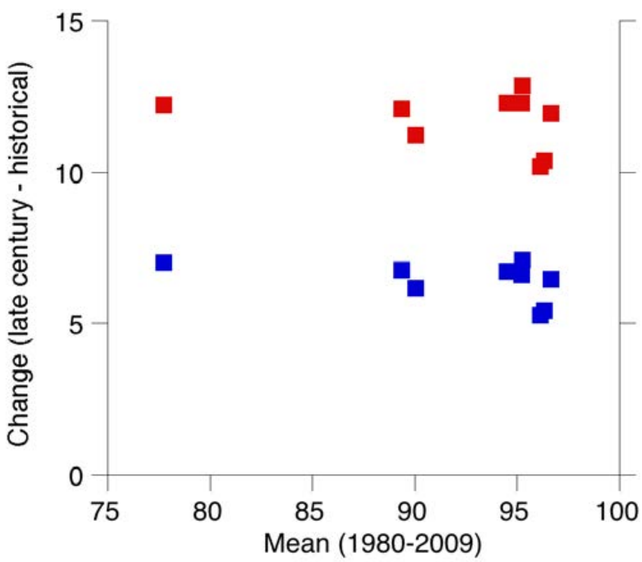
J. Days TMin is less than 32 degrees F



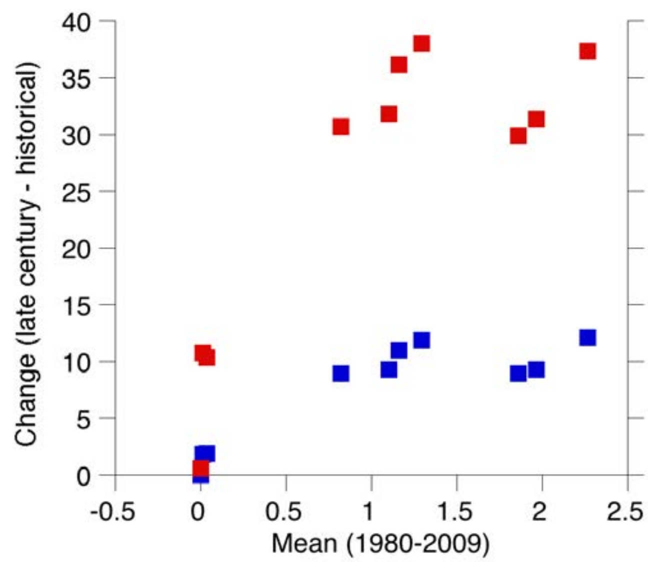
M. Days TMax is greater than 90 degrees F



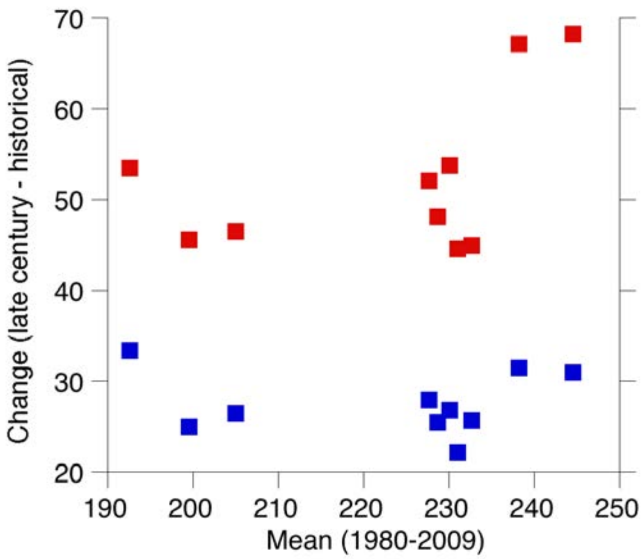
K. TMax on hottest day



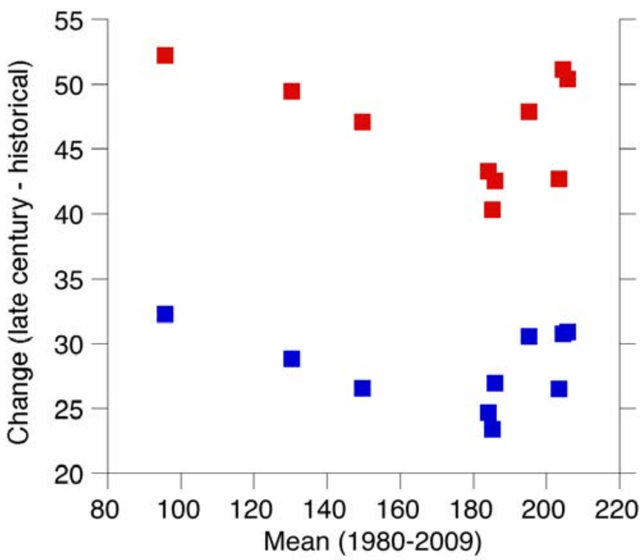
N. Days TMax is greater than 95 degrees F



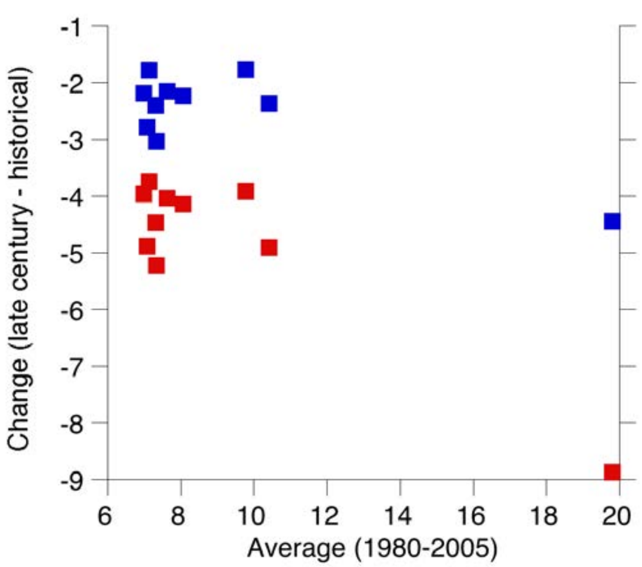
O. Thaw days (TMin greater than 28 degrees F)



P. Bare ground days (modeled)



Q. Snowfall (snow water equivalent)



3.4 Extreme Precipitation and Temperature Trends

All measures of extreme precipitation increase by late century compared to the historical ensemble at almost all the station locations (Figures 25c, d, e, f). While there are some differences between the high and low concentration pathways, overall, the results indicate that New Hampshire will experience more extreme precipitation events under either pathway. However, the wettest day of the year is measurably wetter at all ten stations under the high concentration pathway.

The projected end-of-the-century warming for indicators of extreme cold temperatures (Figure 25g, h, i, j) is substantially greater for the higher concentration pathway than the lower. Generally, the greatest changes are projected for the coldest station locations today (the northern portion of the state).

The projected, end-of-the-century increase in all four indicators of extreme hot temperatures (Figure 25k, l, m, n) is substantially greater for the higher concentration pathway than the lower. The projected change in temperature for both the hottest day and night is similar for all stations across the region by late century. However, the increase in the number of days with maximum temperatures greater than 90°F and 95°F will likely increase more for southern and central portions of the state compared to the northern areas.

3.5 Thaw Days, Bare Ground Days and Snowfall

The projected increase in thaw days (minimum temperatures > 28°F) and modeled bare ground days (number of days with no snow on the ground between November 1 and May 1) by the end of the century (Figure 25o, p, q) is similar for all stations and substantially greater for the higher concentration pathway than the lower. The projected SWE of total snowfall per water year (beginning Oct 1) is included as an additional climate indicator for snowfall.[47] As with thaw and bare ground days, the projected decrease in SWE is also similar for nine of the 10 stations and consistent with winter season warming (Figure 25o). With an average of 20 inches of SWE, Pinkham Notch is an outlier with a substantially larger projected decline of 4.4 inches under the lower concentration pathway and almost nine inches (45%) under the higher concentration pathway.

Box 6. The New Hampshire Ski Industry

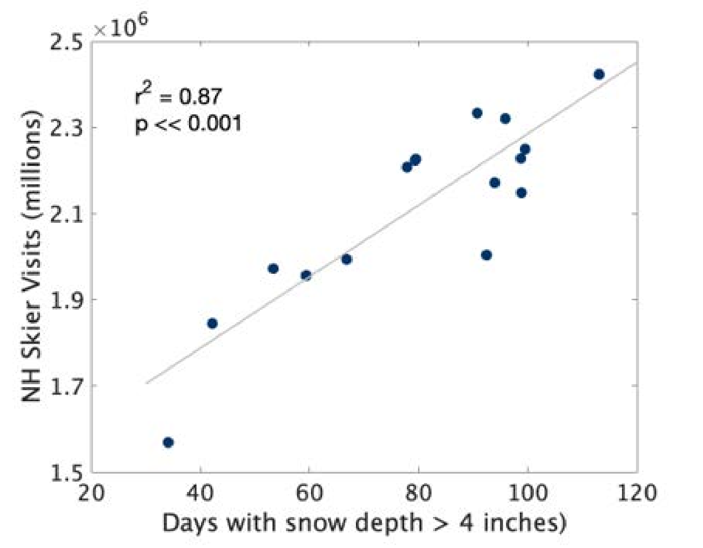
The New Hampshire ski industry is an economic powerhouse for the northern and western counties in the state. From May 2017 through April 2018, the New Hampshire ski industry attracted nearly three million visitors to ski areas and generated over $500 million in economic output.[48]

Most visitors to New Hampshire ski areas are alpine skiers and snowboarders, many of whom travel from neighboring New England states. New Hampshire skier visitation is strongly correlated to the number of days per season with natural snow cover, a pattern that is robust across all New England states[49] (Box 6 Figure A). During the exceptionally warm and low-snow winter of 2015/16, skier visitation in New Hampshire declined 25% relative to the previous decade's average (Box 6 Figure B).

Historically, New Hampshire averages nearly 100 days with deep snow cover (SWE > 30 mm, or about six inches snow depth) between November and May (Box 6 Figure C). By the end of the century, the snow-cover season is projected to shorten to less than two months under the lower concentration pathway. Under the higher concentration pathway, the snow season is projected to last less than one month.

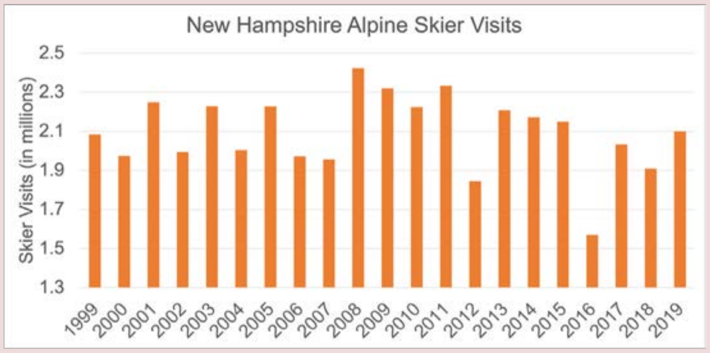
Jessyca Keeler is the President and Executive Director of Ski New Hampshire, an industry trade group representing 29 of the State's alpine and nordic ski areas. Jessyca notes, "New Hampshire's ski industry plays a vital role in the state's travel and tourism economy, particularly in the winter months, when it becomes the forth largest employer in the northern and westernmost counties during the winter months. It is the fifth largest employer in those same counties when looked at from a year-round perspective, which points to the importance of ski areas' "off-season" (spring, summer, fall) operations. With shrinking winters due to a warming climate, these off-season activities as well as improvements and investments in snowmaking technologies will take on greater significance not only to the ski area businesses, but to the often rural and remote communities in which they operate as well."

Box 6 Figure A. Relationship between New Hampshire skier visits and natural snow cover



Continued on next page.

Box 6 Figure B. New Hampshire alpine skier visits, 1999-2019



Box 6 Figure C. Historical and projected days with deep snow cover (> 6 inches deep)

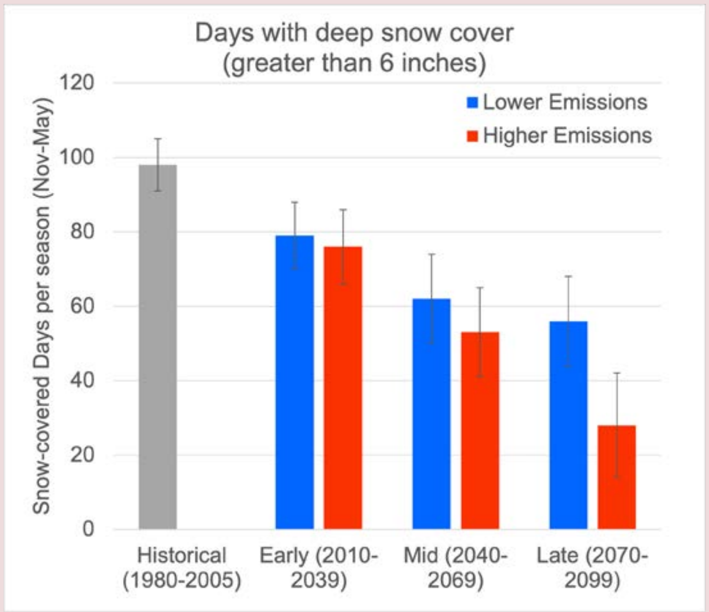


IMAGE CREDIT: CYNTHIA NELSON

IMAGE CREDIT: NHDES STAFF

ENDNOTES

1 IPCC, 2021: Summary for Policymakers. In: *Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* [Masson-Delmotte, V., P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M.I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T.K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, and B. Zhou (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 3–32, https://doi.org/10.1017/9781009157896.001.

2 USGCRP, 2017: *Climate Science Special Report: Fourth National Climate Assessment, Volume I* [Wuebbles,D.J., D.W. Fahey, K.A. Hibbard, D.J. Dokken, B.C. Stewart, and T.K. Maycock (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, 470 pp., https://doi.org/10.7930/J0J964J6.

3 USGCRP, 2018: *Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II* [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, 1515 pp., https://doi.org/10.7930/NCA4.2018.

4 Dupigny-Giroux, L.A., E.L. Mecray, M.D. Lemcke-Stampone, G.A. Hodgkins, E.E. Lentz, K.E. Mills, E.D. Lane, R. Miller, D.Y. Hollinger, W.D. Solecki, G.A. Wellenius, P.E. Sheffield, A.B. MacDonald, and C. Caldwell, 2018: Northeast. In *Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II* [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, pp. 669–742, https://doi.org/10.7930/NCA4.2018.CH18.

5 Armstrong, W.H., M.J. Collins, and N.P. Snyder, 2012: Increased frequency of low-magnitude floods in New England. *J. Amer. Water Resour. Assoc.*, **48**, 306–320, https://doi.org/10.1111/j.1752-1688.2011.00613.x.

Armstrong W.H., M.J. Collins, and N.P. Snyder, 2014: Hydroclimatic flood trends in the northeastern United States and linkages with large-scale atmospheric circulation patterns. *Hydrol. Sci. J.*, **59**, 1636–1655, https://doi.org/10.1080/02626667.2013.862339.

Burakowski, E.A., A.R. Contosta, D. Grogan, S.J. Nelson, S. Garlick, and N. Casson, 2022: Future of Winter in Northeastern North America: Climate Indicators Portray Warming and Snow Loss that will Impact Ecosystems and Communities. *Northeastern Naturalist*, **28**, 11, 180–207.

Contosta, A.R., N.J. Casson, S. Garlick, S.J. Nelson, M.P. Ayres, E.A. Burakowski, J. Campbell, I. Creed, C. Eimers, C. Evans, I. Fernandez, C. Fuss, T. Huntington, K. Patel, R. Sanders-DeMott, K. Son, P. Templer, and C. Thornbrugh, 2019: Northern forest winters have lost cold, snowy conditions that are important for ecosystems and human communities. *Ecological Applications*, **29**, 7, e01974. https://doi.org/10.1002/eap.1974.

Contosta A.R., A. Adolph, D. Burchsted, E.A. Burakowski, M. Green, D. Guerra, M. Albert, J. Dibb, M. Martin, W.H. McDowell, M. Routhier, C. Wake, R. Whitaker, and W. Wollheim, 2017: A longer vernal window: the role of winter coldness and snowpack in driving spring thresholds and lags. *Global Change Biology*, **23**, 4, 1610-1625, https://doi.org/10.1111/gcb.13517.

Contosta, A., N.J. Casson, S.J. Nelson, and S.G. Garlick. 2020. Defining frigid winter illuminates its loss across seasonally snow-covered areas of eastern North America. *Environ. Res. Lett.*, **15**, 3, 034020, https://doi.org/10.1088/1748-9326/ab54f3.

Demaria, E.M.C., R.N. Palmer, and J.K. Roundy, 2016: Regional Climate Change Projections of Streamflow Characteristics in the Northeast and Midwest U.S. *J. Hydrol.: Regional Studies*, **5**, 309-323, https://doi.org/10.1016/j.ejrh.2015.11.007.

Frei, A., K.E. Kunkel, and A. Matonse, 2015: The seasonal nature of extreme hydrological events in the Northeastern United States. *J. Hydrometeor.*, **16**, 5, 2065–2085, https://doi.org/10.1175/JHM-D-14-0237.1.

Guilbert, J., A.K. Betts, D.M. Rizzo, B. Beckage, and A. Bomblies, 2015: Characterization of increased persistence and intensity of precipitation in the northeastern United States, *Geophys. Res. Lett.*, **42**, 1888–1893, https://doi.org/10.1002/2015GL063124.

Huang, H., J.M. Winter, E.C. Osterberg, R.M. Horton, and B. Beckage, 2017: Total and Extreme Precipitation Changes over the Northeastern United States. *J. Hydrometeor.*, **18**, 1783–1798, https://doi.org/10.1175/JHM-D-16-0195.1.

Janssen, E., R.L. Sriver, D.J. Wuebbles, and K.E. Kunkel, 2016: Seasonal and regional variations in extreme precipitation event frequency using CMIP5. *Geophys. Res. Lett.*, **43**, 5385–5393, https://doi.org/10.1002/2016GL069151.

Marini, G., R. Zollo, N. Fontana, M. Giugni, V. Singh, 2016: Variability and trends in streamflow in northeast United States. *Proc. Earth and Planetary Science*, **16**, 156-165, https://doi.org/10.1016/j.proeps.2016.10.017.

Runkle, J., K. Kunkel, D. Easterling, R. Frankson, and B. Stewart, 2017: New Hampshire State Climate Summary. NOAA Technical Report NESDIS 149-NH, 4 pp., https://statesummaries.ncics.org/chapter/nh/.

Thibeault, J.M. and A. Seth, 2014: Changing Climate Extremes in the Northeast United States: Observations and Projections from CMIP5. *Climatic Change*, **127**, 273-287, https://doi.org/10.1007/s10584-014-1257-2.

Wake, C., J. Knott, T. Lippmann, M. Stampone, T. Ballestero, D. Bjerklie, E. Burakowski, S. Glidden, I. Hosseini-Shakib, J. Jacobs, 2019: New Hampshire Coastal Flood Risk Summary – Part I: Science. Prepared for the New Hampshire Coastal Flood Risk Science and Technical Advisory Panel. Report published by the University of New Hampshire, Durham, NH, 35 pp., https://dx.doi.org/10.34051/p/2019.1.

6 IPCC, 2018: Summary for Policymakers. In: *Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty* [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds.)], World Meteorological Organization, Geneva, Switzerland, 32 pp., https://www.ipcc.ch/sr15/.

Le Quéré, C., R.B. Jackson, M.W. Jones, A.J.P Smith, S. Abernethy, R.M. Andrew, A.J. De-Gol, D.R. Willis, Y. Shan, J.G. Canadell, P. Friedlingstein, F. Creutzig, and G.P. Peters, 2020: Temporary reduction in daily global CO2emissions during the COVID-19 forced confinement. *Nat. Climate Chang*. **10**, 647–653, https://doi.org/10.1038/s41558-020-0797-x.

Peters, G.P., R.M. Andrew, J.G. Canadell, P. Friedlingstein, R.B. Jackson, J.I Korsbakken, C. Le Quéré, and A. Peregon, 2020: Carbon dioxide emissions continue to grow amidst slowly emerging climate policies. *Nat. Climate Chang*. **10**, 3–6, https://doi.org/10.1038/s41558-019-0659-6.

7 Peters, G.P., Andrew, R.M., Canadell, J.G. Friedlingstein, P., Jackson, R. B., Korsbakken, J. I. Le Quéré C., Peregon A. (2020) Carbon dioxide emissions continue to grow amidst slowly emerging climate policies. *Nat. Climate Change*. **10**, 3–6. https://doi.org/10.1038/s41558-019-0659-6

8 Le Quéré, C, RB Jackson, MW Jones, AJP.Smith, S Abernethy, RM Andrew, AJ De-Gol, DR Willis, Y Shan, JG Canadell, P Friedlingstein, F Creutzig and GP Peters (2020) Temporary reduction in daily global CO_2 emissions during the COVID-19 forced confinement. *Nat. Climate Change*. **10**, 647–653, DOI:10.1038/s41558-020-0797-x

9 Wake, C.P., E. Burakowski, P. Wilkinson, K. Hayhoe, A. Stoner, C. Keeley, and J. LaBranche, 2014: Climate Change in Northern New Hampshire: Past, Present, and Future. Climate Solutions New England Report, published by the Sustainability Institute at the University of New Hampshire, Durham, NH, 77 pp., http://scholars.unh.edu/sustainability/1/.

Wake, C.P., E. Burakowski, P. Wilkinson, K. Hayhoe, A. Stoner, C. Keeley, and J. LaBranche, 2014: Climate Change in Southern New Hampshire: Past, Present, and Future. Climate Solutions New England Report, published by the Sustainability Institute at the University of New Hampshire, Durham, NH, 87 pp., http://scholars.unh.edu/sustainability/2/.

10 Wake, C., J. Knott, T. Lippmann, M. Stampone, T. Ballestero, D. Bjerklie, E. Burakowski, S. Glidden, I. Hosseini-Shakib, J. Jacobs, 2019: New Hampshire Coastal Flood Risk Summary – Part I: Science. Prepared for the New Hampshire Coastal Flood Risk Science and Technical Advisory Panel. Report published by the University of New Hampshire, Durham, NH, 35 pp., https://dx.doi.org/10.34051/p/2019.1.

NH Coastal Flood Risk Science and Technical Advisory Panel, 2020: New Hampshire Coastal Flood Risk Summary, Part II: Guidance for Using Scientific Projections. Report published by the University of New Hampshire, Durham, NH, 63 pp., https://scholars.unh.edu/ersc/211/.

11 Wake, C.P., J. Bucci, and S. Aytur, 2014: An Assessment of the Impact of Climate Change on Human Health in New Hampshire. Prepared for the New Hampshire Department of Health and Human Services, Report published by the Sustainability Institute at the University of New Hampshire, Durham, NH, 69 pp., https://scholars.unh.edu/sustainability/7/.

12 Vose, R.S., S. Applequist, I. Durre, M.J. Menne, C.N. Williams, C. Fenimore, K. Gleason, and D. Arndt, 2014: Improved Historical Temperature and Precipitation Time Series For U.S. Climate Divisions. *J. Appl. Meteor. Climatol.*, **53**, 5, 1232–1251, https://dx.doi.org/10.1175/JAMC-D-13-0248.1.

13 National Centers for Environmental Information (NCEI): Historical Observing Metadata Repository (HOMR). Accessed 1 February 2022, https://www.ncei.noaa.gov/access/homr/.

14 National Weather Service, 2019, 2012: Cooperative Program Management and Operations. Operations and Services Surface Observation Program (Land), NWSPD 10-1307, https://www.nws.noaa.gov/directives/sym/pd01013007curr.pdf.

National Weather Service, 2017, 2014: Observational Quality Control - General. Operations and Services Surface Observation Program (Land), NWSPD 10-1305, https://www.nws.noaa.gov/directives/sym/pd01013007curr.pdf.

15 Menne, M.J., C. N. Williams, B.E. Gleason, J.J. Rennie, and J.H. Lawrimore, 2018: The Global Historical Climatology Network Monthly Temperature Dataset, Version 4. *J. Climate*, **31**, 24, 9835–9854, https://doi.org/10.1175/JCLI-D-18-0094.1.

Menne, M.J., C.N. Williams, and R.S. Vose, 2015: United States Historical Climatology Network Daily Temperature, Precipitation, and Snow Data, Version 2.5.0. Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, Oak Ridge, Tennessee, https://www.ncdc.noaa.gov/cdo-web/.

Menne, M.J., C.N. Williams, and R.S. Vose, 2009: The United States Historical Climatology Network monthly temperature data, Version 2. *Bull. Amer. Meteor. Soc.*, **90**, 993-1007.

16 Sen, P.K. (1968), Estimates of the regression coefficient based on Kendall's tau, *Journal of the American Statistical Association* 63, 1379–1389. September 29, 2021, 3:32 PM

17 Mann, H.B., 1945: Non-parametric tests against trend, *Econometrica*, **13**, 163-171.

18 Gilbert, R.O., 1987: Statistical Methods for Environmental Pollution Monitoring. Van Nostrand Rienhold Company, Inc., New York, 320 pp.

19 We include analysis of trends over the entire 120-year period of the historical record (1901-2020) as well as over the period from 1971-2020. This more recent fifty-year period coincides with a marked increase in global temperatures that began in the 1970s (see endnote 1). Note that each of the last four decades was warmer compared to any previous decade since 1850. We use these trends calculated over two different time periods to explore changes in the rate at which climate is changing.

20 Indigenous New Hampshire Collaborative Collective: The Wobanadenok. Accessed 15 September 2021, https://indigenousnh.com/2018/12/06/the-wobanadenok/.

21 Mount Washington Observatory: About Us. Accessed 15 September 2021, https://www.mountwashington.org/about-us/.

22 Dupigny-Giroux, L.A., E.L. Mecray, M.D. Lemcke-Stampone, G.A. Hodgkins, E.E. Lentz, K.E. Mills, E.D. Lane, R. Miller, D.Y. Hollinger, W.D. Solecki, G.A. Wellenius, P.E. Sheffield, A.B. MacDonald, and C. Caldwell, 2018: Northeast. In *Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II* [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, pp. 669–742, https://doi.org/10.7930/NCA4.2018.CH18.

23 Grant, A.N., A.A.P. Pszenny, and E.V. Fischer, 2005: The 1935–2003 Air Temperature Record from the Summit of Mount Washington, New Hampshire, *J. Climate*, **18**, 21, 4445-4453, https://doi.org/10.1175/JCLI3547.1.

Murray, G., A.M. Colgan, S.J. Nelson, E. P. Kelsey, and K. D. Kimball, 2021: Climate Trends on the Highest Peak of the Northeast: Mount Washington, NH, *Northeastern Naturalist*, **28**, 11, 64-82, https://doi.org/10.1656/045.028.s1105.

24 U.S. Energy Information Administration, 2021: Units and calculators explained: Degree days. Accessed 15 September 2021, https://www.eia.gov/energyexplained/units-and-calculators/degree-days.php.

25 Easterling, D.R., J.L. Evans, P.Ya. Groisman, T.R. Karl, K.E. Kunkel, and P. Ambenje, 2000: Observed variability and trends in extreme climate events: A brief review. *Bull. Amer. Meteor. Soc.*, **81**, 3, 417–425, https://doi.org/10.1175/1520-0477(2000)081<0417:OVATIE>2.3.CO;2.

Groisman, P., R.W. Knight, T.R. Karl, D.R. Easterling, B. Sun, and J.H. Lawrimore, 2004: Contemporary Changes of the Hydrological Cycle over the Contiguous United States: Trends Derived from in situ Observations. **J.Hydrometeor**, **5**, 1, 64–85, https://doi.org/10.1175/1525-7541(2004)005<0064:CCOTHC>2.0.CO;2.

Hayhoe, K., C.P. Wake, T.G. Huntington, L. Luo, MD. Schwartz, J. Sheffield, E. Wood, B. Anderson, J. Bradbury, A. DeGaetano, T.J. Troy, and D. Woldfe, 2007: Past and future changes in climate and hydrological indicators in the U.S. Northeast. *Climate Dynamics*, **28**, 381–407, https://doi.org/10.1007/s00382-006-0187-8.

Huntington, T.G., 2006; Evidence for intensification of the global water cycle: review and synthesis. *J. Hydrol.*, **319**, 83–95, https://doi.org/10.1016/j.jhydrol.2005.07.003.

Trenberth, K.E., A.Dai, R.M. Rasmussen, and D.B. Parsons, 2003: The changing character of precipitation. *Bull. Amer. Meteor. Soc.*, **84**, 9, 1205–1217, https://doi.org/10.1175/BAMS-84-9-1205.

26 McKee. T.B., N.J. Doesken, and J. Kleist, 1993: The relationship of drought frequency and duration to time scales. *Proc. 8th Conf. on Appl. Climatol.*, Boston, MA, American Meteorological Society, pp. 179–184.

McKee. T.B., N.J. Doesken, and J. Kleist, 1995: Drought monitoring with multiple time scales. *Proc. 9th Conf. on Appl. Climatol.*, Boston, MA, American Meteorological Society, pp. 233–236.

27 NOAA-NCEI North American Drought Monitor (NADM), 2021: Drought Indices and Data – Standardized Precipitation Index. Accessed 1 June 2021, https://www.ncdc.noaa.gov/temp-and-precip/drought/nadm/indices.

28 Lloyd-Hughes, B., and M.A. Saunders, 2002: A drought climatology for Europe. *Int. J. Climatol.*, 22, 1571–1592, https://doi.org/10.1002/joc.846.

29 Xue, Z., and P. Ullrich, 2021: A Retrospective and Prospective Examination of the 1960s U.S. Northeast Drought. *Earth's Future*, **9**, 7, e2020EF001930, https://doi.org/10.1029/2020ef001930.

30 U.S. Drought Monitor: Drought Classification. Accessed 15 August 2021, https://droughtmonitor.unl.edu/About/AbouttheData/DroughtClassification.aspx.

31 NH Department of Environmental Services, 2016: Drought Management Plan, 14 pp., https://www.des.nh.gov/sites/g/files/ehbemt341/files/documents/2020-01/drought-managementplan.pdf.

32 Barndollar, H., 2021, September 16: "As wildfires rage in California, fire concerns grow in New England amid changing climate" *The Providence Journal*, https://www.providencejournal.com/story/news/2021/09/16/wildfire-concerns-grow-new-england-warm-climate-drought-fires-maine-massachusetts-vermont/5663101001/.

Rott, N., A. Ropeik, and M. Samuel, 2021, August 10: "United States of Wildfire" *National Public Radio*, https://apps.npr.org/us-wildfires-impact-environment-climate-change/.

33 Miller, D.R., 2019: Wildfires in the Northeastern United States: Evaluating Fire Occurrence and Risk in the Past, Present, and Future. Doctoral Dissertation, Dept. of Geosciences, University of Massachusetts Amherst, 1511, https://doi.org/10.7275/13428743.

34 Kerr, G.H., A.T. DeGaetano, C.R. Stoof, and D. Ward, 2018: Climate change effects on wildland fire risk in the Northeastern and Great Lakes states predicted by a downscaled multi-model ensemble. *Theor. Appl. Climatol.*, **131**, 625–639, https://doi.org/10.1007/s00704-016-1994-4.

35 Otkin, J.A., M. Svoboda, E.D. Hunt, T.W. Ford, M.C. Anderson, C. Hain, and J. Basara, 2018: Flash Droughts: A Review and Assessment of the Challenges Imposed by Rapid-Onset Droughts in the United States. *Bull. Amer. Meteor. Soc.*, **99**, 5, 911–919, https://doi.org/10.1175/BAMS-D-17-0149.1.

36 Lisonbee, J., M. Woloszyn, M. Skumanich, 2021: Making sense of flash drought: definitions, indicators, and where we go from here. *Journal of Applied and Service Climatology*, **001**, 1–19, https://doi.org/10.46275/JOASC.2021.02.001.

Pendergrass, A.G., G.A. Meehl, R. Pulwarty, M. Hobbins, A. Hoell, A. AghaKouchak, C.J.W. Bonfils, A.J.E. Gallant, M. Hoerling, D. Hoffmann, L. Kaatz, F. Lehner, D. Lleqellyn, P. Mote, R.B. Neale, J.T. Overpeck, A. Sheffield, K. Stahl, M. Svoboda, M.C. Wheeler, A.W. Wood, and C.A. Woodhouse, 2020: Flash droughts present a new challenge for subseasonal-to-seasonal prediction. *Nat. Climate Chang.* **10**, 191–199, https://doi.org/10.1038/s41558-020-0709-0.

37 NH Department of Environmental Services, 2021: New Hampshire snow sampling sites. https://www4.des.state.nh.us/rti_home/snow_sampling_stations.asp.

38 Hodgkins, G., 2013: The importance of record length in estimating the magnitude of climatic changes: an example using 175 years of lake ice-out dates in New England. *Climatic Change*, **119**, 705–718. https://doi.org/10.1007/s10584-013-0766-8.

Hodgkins, G.A., 2010: Historical Ice-Out Dates for 29 Lakes in New England, 1807–2008. USGS Open File Report 2010–1214., 38 pp., http://pubs.usgs.gov/of/2010/1214/pdf/ofr2010-1214.pdf.

Hodgkins, G.A., I.C. James II, and T.G. Huntington, 2002: Historical changes in lake ice-out dates as indicators of climate change in New England, 1850–2000. *Inter. J.Climatol.*, **22**, 1819–1827, https://doi.org/10.1002/joc.857.

Magnuson, J.J., D.M. Robertson, B.J. Benson, R.H. Wynne, D.M. Livingstone, T. Arai, R.A. Assel, R.G. Barry, V. Card, E. Kuusisto, N.G. Granin, T.D. Prowse, K.M. Stewart, And V.S. Vuglinski, 2000: Historical trends in lake and river ice cover in the Northern Hemisphere. *Science*, **289**, 5485, 1743–1746, https://doi.org/10.1126/science.289.5485.1743.

39 Hodgkins, G., 2013: The importance of record length in estimating the magnitude of climatic changes, *Climatic Change*, **119**, 705–718, https://doi.org/10.1007/s10584-013-0766-8.

40 Wang, J., X. Bai, H. Hu, A. Clites, M. Colton, and B. Lofgren, 2012: Temporal and Spatial Variability of Great Lakes Ice Cover, 1973–2010. *J. Climate*, **25**, 4, 1318–1329, http://dx.doi.org/10.1175/2011JCLI4066.1.

41 Hershfield, D., 1961: Rainfall Frequency Atlas of the United States for Durations from 30 Minutes to 24 hours and return Periods from 1 to 100 years. Technical Paper No. 40, Engineering Division, Soil Conservation Service, U.S. Department of Agriculture, 61 pp.

42 FEMA: Declared Disasters. Accessed 15 September 2021. https://www.fema.gov/disaster/declarations.

43 The RCPs were developed to represent a broad range of climate outcomes consistent with a range of different socioeconomic and policy futures, including a stabilization scenario (RCP 4.5, representing a radiative forcing of 4.5 watts per square meter) and a scenario with very high greenhouse gas concentrations (RCP 8.5, representing a radiative forcing of 8.5 watts per square meter). Under RCP 4.5, carbon emissions begin to stabilize and then slowly decline after 2050. Global temperatures rise by 2.4°C (4.3°F; likely range 1.7 - 3.2°C) by 2100, compared to 1850-1900. Under RCP 8.5, carbon emissions continue to grow through the end of the century due to continued burning of fossil fuels and high population growth. Global temperatures rise by 4.3°C (7.7°F; likely range 3.2 - 5.4°C) by 2100, compared to 1850-1900. RCP 8.5 is often called “business as usual” because the observed increase in global carbon emissions over the past two decades are consistent with the RCP 8.5 scenario. More detail on RCPs is provided in Moss R.H., and coauthors, 2010: The Next Generation of Scenarios for Climate Change Research and Assessment. *Nature*, **463**, 747–756, http://dx.doi.org/10.1038/nature08823 and van Vuuren, D.P. and Coauthors, 2011: The Representative Concentration Pathways: An Overview. *Climatic Change*, **109**, 5, http://dx.doi.org/10.1007/s10584-011-0148-z.

44 Hausfather, Z. and G.P. Peters, 2020: Emissions–the ‘business as usual’ story is misleading. *Nature*, **577**, 618-620, https://doi.org/10.1038/d41586-020-00177-3.

45 Castellano, C.M. and A.T. DeGaetano, 2017: Downscaling Extreme Precipitation from CMIP5 Simulations Using Historical Analogs. *J.Appl. Meteor. and Climatol.*, **56**, 9, 2421-2439, https://doi.org/10.1175/JAMC-D-16-0250.1.

Easterling, D.R., K.E. Kunkel, J.R. Arnold, T. Knutson, A.N. LeGrande, L.R. Leung, R.S. Vose, D.E. Waliser, and M.F. Wehner, 2017: Precipitation Change in the United States. *Climate Science Special Report: Fourth National Climate Assessment, Volume I* [Wuebbles,D.J., D.W. Fahey, K.A. Hibbard, D.J. Dokken, B.C. Stewart, and T.K. Maycock (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, 207-230, http://dx.doi.org/10.7930/J0H993CC.

Pierce, D.W., D.F. Cayan, and B.L. Thrasher, 2014: Statistical Downscaling Using Localized Constructed Analogs (LOCA). *J. Hydrometeor.*, **15**, 6, 2558-2586, https://doi.org/10.1175/JHM-D-14-0082.1.

Pierce, D.W., D.R. Cayan, E.P. Maurer, J.T. Abatzoglou, and K.C. Hegewisch, 2015: Improved bias correction techniques for hydrological simulations of climate change. *J. Hydrometeor.*, **16**, 2421–2442, https://doi.org/10.1175/JHM-D-14-0236.1.

46 Sanderson, B.M., M. Wehner, and R. Knutti, 2017: Skill and Independence Weighting for Multi-Model Assessment. *Geoscientific Model Development*, **10**, 2379–2395, https://doi.org/10.5194/gmd-10-2379-2017.

47 The projected values for annual snowfall were simulated using the University of New Hampshire Water Balance Model (WBM). The WBM uses daily temperature and precipitation inputs, and determines if precipitation is in the form of snow or rain. For more detailed methodology refer to: Grogan, D.S., E.A. Burakowski, and A.R. Contosta, 2020: Snowmelt control on spring hydrology declines as the vernal window lengthens. *Environ. Res. Lett.*, **15**, 114040, https://doi.org/10.1088/1748-9326/abbd00.

48 Lee, D.S., 2019: Economic Contribution of the Ski Industry in New Hampshire. Prepared for Ski New Hampshire, Plymouth State University, Plymouth, NH, 26 pp.

49 Hagenstad, M., E. Burakowski, and R. Hill, 2018: The economic contribution of winter sports in a changing climate. Protect Our Winters Report, 69 pp., https://protectourwinters.org/wp-content/uploads/2019/12/POW-2018-economic-report.pdf.

IMAGE CREDIT: NHDES STAFF

APPENDIX 1: CLIMATE INDICATORS

Table A1. Definition of 32 climate indicators used in this report

Number of Indicators	Description	Units
5	Annual and seasonal (spring, summer, fall, winter) MAXIMUM TEMPERATURE at 2 m (mean of maximum daily value)	F
5	Annual and seasonal (spring, summer, fall, winter) MINIMUM TEMPERATURE at 2 m (mean of minimum daily value)	F
5	Annual and seasonal (spring, summer, fall, winter) PRECIPITATION	inches
1	Cooling degree days* for daily temperature above 65°F	degree days
1	Heating degree days* for daily temperature below 65°F	degree days
1	Maximum temperature on coldest day of the year	F
1	Minimum temperature on coldest night of the year	F
1	Number of days per year when minimum temperature is equal to or less than 0°F	days
1	Number of days per year when minimum temperature is equal to or less than 32°F	days
1	Number of days per year when maximum temperature is equal to or greater than 90°F	days
1	Number of days per year when maximum temperature is equal to or greater than 95°F	days
1	Maximum temperature on hottest day of the year	F
1	Minimum temperature on hottest day of the year	F
1	Number of days per year when minimum temperature is greater than 28°F	days
1	Number of days per year when precipitation is 1 inch or greater	days
1	Number of days per year when precipitation is 2 inches or greater	days
1	Number of two day periods when precipitation is greater than 4 inches	days
1	Amount of precipitation on the wettest day of the year	inches
1	Observed data: Number of days between November 1 and May 31 when snow cover is less than 1 inch (bareground days observed)	days
	Modeled value: Number of days between November 1 and May 31 when snowpack SWE is less than 0.1 mm (bareground days modeled)	days
1	Total SWE snowfall per water year	inches of water equivalent

APPENDIX 2: HISTORIC TRENDS

Table A2-1. Berlin Station

Indicator	Berlin Trends				Berlin Average		Difference
	1901-2020	1971-2020	1901-2020	1971-2020	1901-1960	1991-2020	
Precipitation (inches)	period of record		per decade		Inches		
Annual	**7.7**	**8.0**	**0.8**	**1.6**	37.7	42.7	5.0
Spring	1.3	2.5	0.1	0.5	9.0	10.0	1.0
Summer	**2.7**	1.5	**0.3**	0.3	10.4	12.0	1.6
Fall	1.7	0.8	0.2	0.2	10.2	11.7	1.5
Winter	**1.4**	1.9	**0.1**	0.4	8.0	9.0	1.0
MAX Temperature (deg F)	period of record		per decade		deg F		
Annual	0.6	1.2	0.1	0.2	53.2	53.9	0.7
Spring	1.6	0.2	0.2	0.0	51.1	52.0	0.9
Summer	-0.5	-0.8	0.0	-0.2	76.8	76.3	-0.5
Fall	0.7	2.4	0.1	0.5	56.5	57.0	0.5
Winter	1.5	2.2	0.1	0.4	29.0	29.9	0.9
MIN Temperature (deg F)	period of record		per decade		deg F		
Annual	**3.0**	**3.5**	**0.3**	**0.7**	29.7	32.3	2.6
Spring	1.5	1.3	0.1	0.3	28.4	29.5	1.2
Summer	**3.1**	**2.2**	**0.3**	**0.4**	51.2	53.4	2.2
Fall	**2.7**	**3.1**	**0.3**	**0.6**	34.2	36.3	2.1
Winter	**5.6**	**6.5**	**0.6**	**1.3**	5.8	9.6	3.8
Cooling and Heating Days	degree days		degree days		degree days		
Cooling Degree Days	6.6	21.0	0.7	4.2	260	262	2.0
Heating Degree Days	**-565**	**-535**	**-57**	**-107**	8465	8082	-383
Extreme Precipitation	period of record		per decade				
Days > 1 inch in 24 hours	**3.7**	**3.2**	**0.4**	0.6	5.9	8.8	2.9
Days > 2 inches in 24 hours	0.0	0.0	0.0	0.0	0.8	1.0	0.3
Events > 4 inches in 48 hours	0.0	0.0	0.0	0.0	0.16	0.23	0.07
Precip. on wettest day of year (in)	0.4	0.1	0.0	0.0	2.3	2.6	0.3
Extreme Temperature	period of record		per decade				
TMAX on coldest day of year (F)	2.5	1.4	0.3	0.3	0.6	2.3	1.7
TMIN on coldest day of year (F)	**10.2**	**8.3**	**1.0**	**1.7**	-25.4	-17.7	7.7
Days < 0F	**-14.4**	**-14.3**	**-1.4**	**-2.9**	37.6	28.6	-9.0
Days < 32F	**-13.8**	-9.2	**-1.4**	-1.8	181	173	-8.8
Days > 90F	**-4.1**	**-1.9**	**-0.4**	**-0.4**	6.0	2.3	-3.6
Days > 95F	0.0	0.0	0.0	0.0	0.5	0.0	-0.5
TMAX on hottest day of year (F)	**-3.4**	**-2.4**	**-0.3**	**-0.5**	93.4	90.8	-2.6
TMIN on hottest day of year (F)	0.0	0.0	0.0	0.0	67.6	67.5	0.0
Days TMIN > 28F (freeze days)	**15.6**	**17.6**	**1.6**	**3.5**	209	220	11.3
Bare Ground Days	n/a	-18.2	n/a	-3.6	n/a	251	n/a
Snowfall (inches water eq.)	n/a	15.7	n/a	3.1	n/a	86	n/a

* Berlin climate data only begin in 1917; trends are for the period of record.

Table A2-2. Durham Station

Indicator	Durham Trends				Durham Average		Difference
	1901-2020	1971-2020	1901-2020	1971-2020	1901-1960	1991-2020	
Precipitation (inches)	period of record		per decade		Inches		
Annual	**9.3**	3.7	**0.78**	0.75	39.6	44.9	5.3
Spring	2.3	0.1	0.19	0.01	10.0	11.1	1.1
Summer	**2.4**	**4.5**	**0.20**	**0.89**	9.9	11.7	1.8
Fall	**3.9**	0.1	**0.33**	0.02	10.0	12.2	2.2
Winter	0.3	-0.8	0.02	-0.16	9.7	9.4	-0.3
MAX Temperature (deg F)	period of record		per decade		deg F		
Annual	**2.8**	1.3	**0.24**	0.25	58.3	59.7	1.4
Spring	**3.5**	1.3	**0.29**	0.27	56.1	58.1	2.0
Summer	**3.4**	**0.8**	**0.29**	**0.15**	79.7	81.4	1.7
Fall	**1.8**	1.5	**0.15**	0.30	61.5	62.0	0.4
Winter	**3.0**	2.1	**0.25**	0.41	35.2	36.8	1.7
MIN Temperature (deg F)	period of record		per decade		deg F		
Annual	**2.3**	**4.1**	**0.20**	**0.82**	35.5	37.5	1.9
Spring	1.1	**2.1**	0.09	**0.42**	33.2	34.3	1.1
Summer	**3.1**	**4.2**	**0.26**	**0.84**	54.7	57.0	2.4
Fall	**2.0**	**5.0**	**0.16**	**1.00**	38.4	40.3	1.9
Winter	**3.1**	**5.0**	**0.26**	**1.00**	15.0	17.5	2.5
Cooling and Heating Days	degree days		degree days		degree days		
Cooling Degree Days	**228**	**181**	**19**	**36**	426	558	132
Heating Degree Days	-324	**-1102**	-27	**-220**	6587	6234	-353
Extreme Precipitation	period of record		per decade				
Days > 1 inch in 24 hours	0.0	0.0	0.00	0.0	9.7	10.0	0.3
Days > 2 inches in 24 hours	0.0	0.0	0.00	0.0	1.6	1.8	0.2
Events > 4 inches in 48 hours	0.0	0.0	0.00	0.0	0.20	0.53	0.33
Precip. on wettest day of year (in)	0.3	0.0	0.03	0.0	2.8	3.3	0.5
Extreme Temperature	period of record		per decade				
TMAX on coldest day of year (F)	**4.0**	0.0	0.33	0.0	11.9	13.6	1.7
TMIN on coldest day of year (F)	2.2	**9.1**	0.19	**1.8**	-14.3	-10.4	3.8
Days < 0F	-2.4	**-8.3**	-0.20	**-1.7**	11.1	8.1	-3.0
Days < 32F	-8.0	**-32.1**	-0.67	**-6.4**	154.1	144.0	-10.1
Days > 90F	3.4	5.6	0.28	1.1	12.4	14.5	2.1
Days > 95F	0.0	0.0	0.00	0.0	2.8	2.4	-0.4
TMAX on hottest day of year (F)	-0.7	1.3	-0.06	0.3	96.5	95.9	-0.6
TMIN on hottest day of year (F)	0.0	1.4	0.00	0.3	70.9	71.8	0.9
Days TMIN > 28F (freeze days)	**10**	4	**0.82**	0.8	230.6	235.2	4.6
Bare Ground Days	n/a	34	n/a	6.9	n/a	311	n/a
Snowfall (inches water eq.)	n/a	-24	n/a	-4.7	n/a	39	n/a

Table A2-3. Hanover Station

Indicator	Hanover Trends				Hanover Average		Difference
	1901-2020	1971-2020	1901-2020	1971-2020	1901-1960	1991-2020	
Precipitation (inches)	period of record		per decade		Inches		
Annual	**4.8**	**17.0**	**0.4**	**3.4**	36.0	38.9	3.0
Spring	0.3	4.0	0.0	0.8	9.0	9.3	0.3
Summer	1.2	3.4	0.1	0.7	10.3	11.1	0.7
Fall	**1.8**	5.4	**0.2**	1.1	9.2	10.2	1.0
Winter	**2.2**	3.0	**0.2**	0.6	7.4	8.3	1.0
MAX Temperature (deg F)	period of record		per decade		deg F		
Annual	**2.3**	**2.5**	**0.2**	**0.5**	55.6	57.2	1.6
Spring	**3.5**	1.3	**0.3**	0.3	54.5	56.7	2.2
Summer	**3.1**	**2.4**	**0.3**	**0.5**	78.7	80.4	1.7
Fall	**1.3**	**5.4**	**0.1**	**1.1**	58.5	59.3	0.8
Winter	**3.4**	2.4	**0.3**	0.5	30.3	32.5	2.2
MIN Temperature (deg F)	period of record		per decade		deg F		
Annual	**5.1**	**3.2**	**0.4**	**0.6**	33.2	36.7	3.6
Spring	4.1	0.0	**0.3**	0.0	31.2	33.9	2.8
Summer	**5.4**	**2.0**	**0.4**	**0.4**	54.1	57.8	3.6
Fall	**5.0**	**6.1**	**0.4**	**1.2**	36.9	40.2	3.4
Winter	**7.2**	**5.6**	**0.6**	**1.1**	10.1	15.0	4.9
Cooling and Heating Days	degree days		degree days		degree days		
Cooling Degree Days	**236.4**	**65.4**	**19.7**	**13.1**	375.9	533.2	157.4
Heating Degree Days	**-1292.4**	**-838.3**	**-107.7**	**-167.7**	7735.1	6807.8	-927.2
Extreme Precipitation	period of record		per decade				
Days > 1 inch in 24 hours	1.3	**4.8**	0.1	**1.0**	6.1	7.4	1.3
Days > 2 inches in 24 hours	0.0	**2.6**	0.0	**0.5**	0.7	0.9	0.2
Events > 4 inches in 48 hours	0.0	0.0	0.0	0.0	0.12	0.10	-0.02
Precip. on wettest day of year (in)	0.1	**1.3**	0.0	**0.3**	2.1	2.1	0.0
Extreme Temperature	period of record		per decade				
TMAX on coldest day of year (F)	**4.0**	1.8	**0.3**	0.4	5.0	7.5	2.6
TMIN on coldest day of year (F)	**9.9**	**6.7**	**0.8**	**1.3**	-22.5	-15.3	7.2
Days < 0F	**-17.1**	**-13.0**	**-1.4**	**-2.6**	25.5	14.0	-11.5
Days < 32F	**-30.0**	-10.0	**-2.5**	-2.0	171.5	148.9	-22.6
Days > 90F	2.1	0.0	0.2	0.0	7.3	8.2	0.8
Days > 95F	0.0	0.0	0.0	0.0	1.2	1.0	-0.2
TMAX on hottest day of year (F)	0.0	**3.1**	0.0	**0.6**	94.2	94.2	0.0
TMIN on hottest day of year (F)	**2.2**	1.5	**0.2**	0.3	68.9	71.3	2.4
Days TMIN > 28F (freeze days)	**24.0**	**20.9**	**2.0**	**4.2**	222.8	239.9	17.1
Bare Ground Days	n/a	**33.5**	n/a	**6.7**	n/a	277.6	n/a
Snowfall (inches water eq.)	n/a	**-22.7**	n/a	**-4.5**	n/a	56.1	n/a

Table A2-4. Keene Station

Indicator	Keene Trends				Keene Average		Difference
	1901-2020	1971-2020	1901-2020	1971-2020	1901-1960	1991-2020	
Precipitation (inches)	period of record		per decade		Inches		
Annual	**10.3**	**10.8**	**0.9**	**2.2**	39.0	46.3	7.3
Spring	1.3	-0.3	0.1	-0.1	9.9	10.4	0.5
Summer	**2.8**	**4.5**	**0.2**	**0.9**	10.7	13.0	2.3
Fall	**3.8**	**4.3**	**0.3**	**0.9**	9.7	13.0	3.3
Winter	**1.5**	2.7	**0.1**	0.5	8.7	9.8	1.1
MAX Temperature (deg F)	period of record		per decade		deg F		
Annual	**1.6**	-0.7	**0.1**	-0.1	58.0	58.3	0.3
Spring	0.8	-1.5	0.1	-0.3	57.0	56.9	-0.1
Summer	**2.2**	-0.3	**0.2**	-0.1	80.0	80.7	0.7
Fall	0.9	0.2	0.1	0.0	60.9	60.8	-0.2
Winter	1.9	0.0	0.2	0.0	33.7	34.4	0.7
MIN Temperature (deg F)	period of record		per decade		deg F		
Annual	**2.0**	-1.2	**0.2**	-0.2	34.0	34.2	0.2
Spring	0.8	**-3.3**	0.1	**-0.7**	31.8	31.0	-0.8
Summer	**2.6**	-1.5	**0.2**	-0.3	53.8	54.4	0.6
Fall	**1.9**	-0.5	**0.2**	-0.1	36.9	37.2	0.3
Winter	**2.6**	1.4	**0.2**	0.3	13.0	13.8	0.8
Cooling and Heating Days	degree days		degree days		degree days		
Cooling Degree Days	**155.3**	-10.4	**12.9**	-2.1	421.3	453.3	32.1
Heating Degree Days	**-560.4**	574.3	**-46.7**	114.9	7248.2	7150.6	-97.6
Extreme Precipitation	period of record		per decade				
Days > 1 inch in 24 hours	**5.6**	**4.2**	**0.5**	**0.8**	6.9	10.9	4.1
Days > 2 inches in 24 hours	0.0	**1.3**	0.0	**0.3**	0.7	1.8	1.1
Events > 4 inches in 48 hours	0.0	0.0	0.0	0.0	0.12	0.21	0.09
Precip. on wettest day of year (in)	**0.5**	**0.7**	**0.0**	**0.1**	2.2	2.7	0.6
Extreme Temperature	period of record		per decade				
TMAX on coldest day of year (F)	0.0	-2.0	0.0	-0.4	10.6	10.1	-0.5
TMIN on coldest day of year (F)	**8.1**	**8.8**	**0.7**	**1.8**	-19.8	-13.3	6.5
Days < 0F	**-7.5**	-5.5	**-0.6**	-1.1	19.4	16.5	-2.8
Days < 32F	**-11.8**	16.7	**-1.0**	3.3	171.2	172.4	1.1
Days > 90F	2.4	0.0	0.2	0.0	9.4	10.5	1.1
Days > 95F	0.0	0.0	0.0	0.0	1.8	1.1	-0.7
TMAX on hottest day of year (F)	0.0	0.0	0.0	0.0	95.0	94.4	-0.6
TMIN on hottest day of year (F)	0.0	-1.8	0.0	-0.4	69.9	68.6	-1.3
Days TMIN > 28F (freeze days)	2.9	-6.1	0.2	-1.2	226.9	220.7	-6.2
Bare Ground Days	n/a	14.9	n/a	3.0	n/a	281.0	n/a
Snowfall (inches water eq.)	n/a	0.2	n/a	0.0	n/a	57.8	n/a

Table A2-5. Colebrook Station

Indicator	Colebrook Trends		Colebrook Average
	1971-2020	1971-2020	1991-2020
Precipitation (inches)	inches	inches per decade	Inches
Annual	**4.7**	0.9	40.8
Spring	2.2	0.4	9.5
Summer	-1.3	-0.3	12.5
Fall	0.9	0.2	11.0
Winter	0.5	0.1	8.0
MAX Temperature (deg F)	deg F	deg F per decde	deg F
Annual	-0.7	-0.1	52.1
Spring	**-3.0**	-0.6	50.4
Summer	-0.4	-0.1	75.2
Fall	1.5	0.3	55.1
Winter	0.0	0.0	27.5
MIN Temperature (deg F)	degree days	degree days per decade	deg F
Annual	0.0	0.0	29.5
Spring	-1.2	-0.2	26.5
Summer	**1.3**	0.3	51.3
Fall	0.0	0.0	34.0
Winter	3.4	0.7	6.2
Cooling and Heating Days	degree days	degree days per decade	degree days
Cooling Degree Days	1.6	0.3	194
Heating Degree Days	6.5	1.3	8697
Extreme Precipitation			
Days > 1 inch in 24 hours	0.0	0.0	6.2
Days > 2 inches in 24 hours	0.0	0.0	0.8
Events > 4 inches in 48 hours	0.0	0.0	0.03
Precip. on wettest day of year (in)	0.2	0.0	2.1
Extreme Temperature			
TMAX on coldest day of year (F)	-2.3	-0.5	-1.7
TMIN on coldest day of year (F)	**13.6**	2.7	-27.1
Days < 0F	2.1	0.4	40.6
Days < 32F	0.0	0.0	187.2
Days > 90F	0.0	0.0	1.1
Days > 95F	0.0	0.0	0.0
TMAX on hottest day of year (F)	-2.2	-0.4	89.2
TMIN on hottest day of year (F)	0.0	0.0	67.0
Days TMIN > 28F (freeze days)	0.0	0.0	205.5
Bare Ground Days	18.4	3.7	250.9
Snowfall (inches water eq.)	-6.0	-1.2	83.7

Table A2-6. Concord Station

Indicator	Concord Trends		Concord Average
	1971-2020	1971-2020	1991-2020
Precipitation (inches)	inches	inches per decade	Inches
Annual	**7.8**	**1.6**	41.9
Spring	1.2	0.2	10.2
Summer	3.4	0.7	11.0
Fall	2.5	0.5	11.5
Winter	2.2	0.4	9.2
MAX Temperature (deg F)	deg F	deg F per decde	deg F
Annual	**2.4**	**0.5**	58.4
Spring	1.3	0.3	56.9
Summer	1.6	0.3	80.9
Fall	**3.5**	**0.7**	61.0
Winter	**3.9**	**0.8**	34.5
MIN Temperature (deg F)	degree days	degree days per decade	deg F
Annual	**3.8**	**0.8**	35.5
Spring	1.8	0.4	32.8
Summer	**3.3**	**0.7**	56.0
Fall	**4.4**	**0.9**	37.8
Winter	**7.2**	**1.4**	15.0
Cooling and Heating Days	degree days	degree days per decade	degree days
Cooling Degree Days	**176**	**35**	521
Heating Degree Days	**-1000**	**-200**	7018
Extreme Precipitation			
Days > 1 inch in 24 hours	3.1	0.6	9.5
Days > 2 inches in 24 hours	0.0	0.0	1.3
Events > 4 inches in 48 hours	0.0	0.0	0.20
Precip. on wettest day of year (in)	**0.7**	**0.1**	2.6
Extreme Temperature			
TMAX on coldest day of year (F)	3.1	0.6	9.5
TMIN on coldest day of year (F)	**13.0**	**2.6**	-12.4
Days < 0F	**-19.0**	**-3.8**	12.8
Days < 32F	**-18.8**	**-3.8**	165.0
Days > 90F	5.6	1.1	13.7
Days > 95F	0.0	0.0	2.5
TMAX on hottest day of year (F)	0.0	0.0	96.1
TMIN on hottest day of year (F)	0.0	0.0	70.3
Days TMIN > 28F (freeze days)	**18.8**	**3.8**	230.6
Bare Ground Days	-7.1	-1.4	276.8
Snowfall (inches water eq.)	-1.1	-0.2	66.8

Table A2-7. Greenland

Indicator	Greenland Trends		Greenland Average
	1971-2020	1971-2020	1991-2020
Precipitation (inches)	inches	inches per decade	Inches
Annual	5.7	1.1	50.7
Spring	2.0	0.4	13.5
Summer	2.3	0.5	12.0
Fall	-0.2	0.0	13.0
Winter	-0.2	0.0	11.8
MAX Temperature (deg F)	deg F	deg F per decde	deg F
Annual	-0.7	-0.1	58.7
Spring	-2.0	-0.4	56.4
Summer	-0.8	-0.2	79.8
Fall	0.3	0.1	61.4
Winter	0.6	0.1	37.0
MIN Temperature (deg F)	deg F	deg F per decde	deg F
Annual	**4.1**	**0.8**	38.5
Spring	1.4	0.3	35.2
Summer	**4.8**	**1.0**	57.9
Fall	**3.9**	**0.8**	41.4
Winter	**4.4**	**0.9**	19.2
Cooling and Heating Days	degree days	degree days per decade	degree days
Cooling Degree Days	**144.9**	**29.0**	556.3
Heating Degree Days	**-534.4**	**-106.9**	6369.4
Extreme Precipitation			
Days > 1 inch in 24 hours	0.0	0.0	13.3
Days > 2 inches in 24 hours	0.0	0.0	2.8
Events > 4 inches in 48 hours	0.0	0.0	0.68
Precip. on wettest day of year (in)	-0.2	0.0	3.4
Extreme Temperature			
TMAX on coldest day of year (F)	0.0	0.0	13.4
TMIN on coldest day of year (F)	**8.9**	**1.8**	-6.9
Days < 0F	**-7.6**	**-1.5**	5.8
Days < 32F	**-17.1**	**-3.4**	142.0
Days > 90F	0.0	0.0	10.4
Days > 95F	0.0	0.0	1.7
TMAX on hottest day of year (F)	0.0	0.0	95.3
TMIN on hottest day of year (F)	1.3	0.3	72.3
Days TMIN > 28F (freeze days)	7.0	1.4	249.7
Bare Ground Days	11.5	2.3	301.1
Snowfall (inches water eq.)	13.2	2.6	62.8

Table A2-8. Lakeport Station

Indicator	Lakeport Trends		Lakeport Average
	1971-2020	1971-2020	1991-2020
Precipitation (inches)	inches	inches per decade	Inches
Annual	**11.4**	**2.3**	45.7
Spring	1.6	0.3	10.6
Summer	3.0	0.6	12.9
Fall	**3.1**	**0.6**	12.3
Winter	**3.5**	**0.7**	9.9
MAX Temperature (deg F)	deg F	deg F per decde	deg F
Annual	n/a	n/a	n/a
Spring	n/a	n/a	n/a
Summer	n/a	n/a	n/a
Fall	n/a	n/a	n/a
Winter	n/a	n/a	n/a
MIN Temperature (deg F)	deg F	deg F per decde	deg F
Annual	n/a	n/a	n/a
Spring	n/a	n/a	n/a
Summer	n/a	n/a	n/a
Fall	n/a	n/a	n/a
Winter	n/a	n/a	n/a
Cooling and Heating Days	degree days	degree days per decade	degree days
Cooling Degree Days	n/a	n/a	n/a
Heating Degree Days	n/a	n/a	n/a
Extreme Precipitation			
Days > 1 inch in 24 hours	2.4	0.5	10.1
Days > 2 inches in 24 hours	0.0	0.0	1.6
Events > 4 inches in 48 hours	0.0	0.0	0.3
Precip. on wettest day of year (in)	0.5	0.1	2.8
Extreme Temperature			
TMAX on coldest day of year (F)	n/a	n/a	n/a
TMIN on coldest day of year (F)	n/a	n/a	n/a
Days < 0F	n/a	n/a	n/a
Days < 32F	n/a	n/a	n/a
Days > 90F	n/a	n/a	n/a
Days > 95F	n/a	n/a	n/a
TMAX on hottest day of year (F)	n/a	n/a	n/a
TMIN on hottest day of year (F)	n/a	n/a	n/a
Days TMIN > 28F (freeze days)	n/a	n/a	n/a
Bare Ground Days	n/a	n/a	n/a
Snowfall (inches water eq.)	-8.0	-1.6	63.5

Table A2-9. Massabesic Station

Indicator	Massabesic Trends		Massabesic Average
	1971-2020	1971-2020	1991-2020
Precipitation (inches)	inches	inches per decade	Inches
Annual	3.5	0.7	42.0
Spring	-0.4	-0.1	9.9
Summer	1.5	0.3	11.7
Fall	0.6	0.1	11.6
Winter	0.2	0.0	8.8
MAX Temperature (deg F)	deg F	deg F per decde	deg F
Annual	0.3	0.1	58.5
Spring	-0.5	-0.1	56.4
Summer	-0.3	-0.1	80.1
Fall	1.4	0.3	61.4
Winter	2.3	0.5	35.7
MIN Temperature (deg F)	deg F	deg F per decde	deg F
Annual	**3.1**	0.6	36.1
Spring	0.0	0.0	32.6
Summer	**3.3**	0.7	57.0
Fall	**4.1**	0.8	39.2
Winter	**5.3**	1.1	14.4
Cooling and Heating Days	degree days	degree days per decade	degree days
Cooling Degree Days	100.0	20.0	511
Heating Degree Days	-532.0	-106.4	6654
Extreme Precipitation			
Days > 1 inch in 24 hours	1.4	0.3	9.6
Days > 2 inches in 24 hours	0.0	0.0	1.4
Events > 4 inches in 48 hours	0.0	0.0	0.33
Precip. on wettest day of year (in)	0.5	0.1	2.9
Extreme Temperature			
TMAX on coldest day of year (F)	0.0	0.0	11.1
TMIN on coldest day of year (F)	7.5	1.5	-11.0
Days < 0F	-7.4	-1.5	13.0
Days < 32F	-8.3	-1.7	155.3
Days > 90F	0.0	0.0	9.5
Days > 95F	0.0	0.0	1.2
TMAX on hottest day of year (F)	-1.4	-0.3	94.4
TMIN on hottest day of year (F)	2.5	0.5	71.4
Days TMIN > 28F (freeze days)	8.9	1.8	223.8
Bare Ground Days	na	na	296.6
Snowfall (inches water eq.)	-8.6	-1.7	47.0

Table A2-10. Pinkham Station

Indicator	Pinkham Trends		Pinkham Average
	1971-2020	1971-2020	1991-2020
Precipitation (inches)	inches	inches per decade	Inches
Annual	**17.0**	**3.4**	66.1
Spring	4.0	0.8	15.9
Summer	3.4	0.7	16.3
Fall	5.4	1.1	18.7
Winter	3.0	0.6	14.8
MAX Temperature (deg F)	deg F	deg F per decde	deg F
Annual	**2.5**	**0.5**	51.2
Spring	1.3	0.3	48.7
Summer	**2.4**	**0.5**	72.9
Fall	**5.4**	**1.1**	54.4
Winter	2.4	0.5	28.5
MIN Temperature (deg F)	deg F	deg F per decde	deg F
Annual	**3.2**	**0.6**	31.0
Spring	0.0	0.0	27.4
Summer	**2.0**	**0.4**	51.4
Fall	**6.1**	**1.2**	35.3
Winter	**5.6**	**1.1**	9.6
Cooling and Heating Days	degree days	degree days per decade	degree days
Cooling Degree Days	**65.4**	**13.1**	138
Heating Degree Days	**-838.3**	**-167.7**	8552
Extreme Precipitation			
Days > 1 inch in 24 hours	**4.8**	**1.0**	17.1
Days > 2 inches in 24 hours	**2.6**	**0.5**	4.6
Events > 4 inches in 48 hours	0.0	0.0	1.14
Precip. on wettest day of year (in)	**1.3**	**0.3**	3.8
Extreme Temperature			
TMAX on coldest day of year (F)	1.8	0.4	1.7
TMIN on coldest day of year (F)	**6.7**	**1.3**	-15.4
Days < 0F	**-13.0**	**-2.6**	25.1
Days < 32F	-10.0	-2.0	182.0
Days > 90F	0.0	0.0	0.4
Days > 95F	0.0	0.0	0.0
TMAX on hottest day of year (F)	**3.1**	**0.6**	88.3
TMIN on hottest day of year (F)	1.5	0.3	66.5
Days TMIN > 28F (freeze days)	**20.9**	**4.2**	205.6
Bare Ground Days	3.6	0.7	231.0
Snowfall (inches water eq.)	8.0	1.6	131.6

APPENDIX 3: PROJECTIONS BY STATION

Table A3-1A. Berlin Station – Change from Historical

Climate Indicator	Historical 1980-2009	Change from historical (+ or -)					
		2010-2039		2040-2069		2070-2099	
		Low Emissions	High Emissions	Low Emissions	High Emissions	Low Emissions	High Emissions
Maximum Temperature (deg F)							
Annual TMAX	51.9	2.1	2.3	4.2	5.8	5.4	9.6
Winter TMAX	27.9	2.2	2.5	4.2	5.7	5.4	9.5
Spring TMAX	49.9	2.2	2.1	4.3	5.7	5.5	9.2
Summer TMAX	74.8	2.0	2.3	4.1	5.8	5.2	9.8
Fall TMAX	54.7	2.2	2.4	4.2	5.9	5.4	9.9
Minimum Temperature (deg F)							
Annual TMIN	29.9	2.2	2.5	4.4	6.1	5.6	10.1
Winter TMIN	6.5	3.1	3.5	5.9	7.9	7.5	12.9
Spring TMIN	27.8	2.1	2.2	4.2	5.6	5.3	9.2
Summer TMIN	51.1	1.8	2.0	3.7	5.3	4.7	8.9
Fall TMIN	33.7	1.9	2.2	3.8	5.5	5.0	9.3
Precipitation (inches)							
Annual PRECIP	41.8	1.60	1.88	3.00	3.91	3.35	5.43
Winter PRECIP	8.9	0.62	0.59	0.95	1.50	1.42	2.25
Spring PRECIP	9.9	0.42	0.62	0.87	1.16	0.89	1.73
Summer PRECIP	11.7	0.38	0.43	0.53	0.60	0.62	0.63
Fall PRECIP	11.3	0.19	0.22	0.64	0.64	0.47	0.80
Heating and Cooling Degree Days							
Heating Degree Days	8977	-693	-1799	-1344	-1794	-1698	-2847
Cooling Degree Days	168	100	113	230	360	311	741
Extreme Temperature							
TMAX on coldest day of year (F)	2.4	3.2	4.0	6.8	9.2	8.9	15.2
TMIN on coldest day of year (F)	-22.0	3.8	4.9	8.1	10.8	10.4	18.1
Days < 0F	32.2	-9	-11	-17	-22	-21	-29
Days < 32F	186	-11	-13	-23	-32	-30	-54
Days > 90F	1.0	2	2	6	10	8	27
Days > 95F	0.0	0	0	1	3	2	10
TMAX on hottest day of year (F)	90.1	2.5	2.9	4.8	6.8	6.2	11.2
TMIN on hottest day of year (F)	65.9	1.9	2.0	3.6	5.2	4.6	8.6
Days TMIN > 28F	205	9.3	9.3	18.9	26.7	26.5	46.5
Extreme Precipitation							
Days > 1 inch in 24 hours	2.9	0.60	0.69	1.16	1.49	1.25	2.31
Days > 2 inch in 24 hours	0.2	0.06	0.11	0.12	0.22	0.19	0.38
Events > 4 inches in 48 hours	0.1	0.02	0.03	0.07	0.10	0.10	0.19
Precip. on wettest day of year (in)	1.7	0.60	0.09	0.16	0.25	0.20	0.39
Snow Cover Days	165	-12	-13	**-23**	-34	-32	-56

Table A3-1B. Berlin Station – Percent Change from Historical

Climate Indicator	Historical 1980-2009	Change from historical (+ or -)					
		2010-2039		2040-2069		2070-2099	
		Low Emissions	High Emissions	Low Emissions	High Emissions	Low Emissions	High Emissions
Precipitation (inches)							
Annual PRECIP	41.8	4%	4%	7%	9%	8%	13%
Winter PRECIP	8.9	7%	7%	11%	17%	16%	25%
Spring PRECIP	9.9	4%	6%	9%	12%	9%	18%
Summer PRECIP	11.7	3%	4%	5%	5%	5%	5%
Fall PRECIP	11.3	2%	2%	6%	6%	4%	7%
Heating and Cooling Degree Days							
Heating Degree Days	8977	-8%	-20%	-15%	-20%	-19%	-32%
Cooling Degree Days	168	60%	67%	137%	214%	185%	440%
Extreme Precipitation							
Days > 1 inch in 24 hours	2.9	20%	24%	40%	52%	43%	80%
Days > 2 inch in 24 hours	0.2	26%	47%	51%	92%	77%	157%
Events > 4 inches in 48 hours	0.1	28%	56%	111%	194%	161%	363%
Precip. on wettest day of year (in)	1.7	4%	5%	9%	15%	12%	23%
Snow Cover Days	165	-7%	-8%	**-14%**	-20%	-19%	-34%

Table A3-2A. Colebrook Station – Change from Historical

Climate Indicator	Historical 1980-2009	Change from historical (+ or -)					
		2010-2039		2040-2069		2070-2099	
		Low Emissions	High Emissions	Low Emissions	High Emissions	Low Emissions	High Emissions
Maximum Temperature (deg F)							
Annual TMAX	51.2	2.4	2.6	4.6	6.1	5.7	10.2
Winter TMAX	15.3	2.2	3.8	4.3	8.6	5.4	14.3
Spring TMAX	49.9	2.6	2.5	5.0	6.6	6.5	10.6
Summer TMAX	74.4	2.6	2.8	4.9	6.4	5.9	10.6
Fall TMAX	53.9	2.1	2.3	4.0	5.6	5.2	9.7
Minimum Temperature (deg F)							
Annual TMIN	28.4	2.5	2.8	4.8	6.6	6.1	10.9
Winter TMIN	4.3	3.3	3.8	6.4	8.6	8.2	14.3
Spring TMIN	26.1	2.5	2.6	5.0	6.7	6.4	10.8
Summer TMIN	49.9	2.3	2.6	4.3	5.8	5.3	9.6
Fall TMIN	32.9	1.8	2.1	3.6	5.2	4.7	9.1
Precipitation (inches)							
Annual PRECIP	43.0	1.5	1.7	2.4	3.3	2.9	4.7
Winter PRECIP	8.0	0.6	0.5	0.8	1.3	1.1	1.9
Spring PRECIP	9.8	0.4	0.5	0.7	1.1	0.9	1.6
Summer PRECIP	13.9	0.4	0.5	0.4	0.5	0.6	0.8
Fall PRECIP	11.3	0.1	0.2	0.4	0.5	0.3	0.4
Heating and Cooling Degree Days							
Heating Degree Days	9342	-773	-1942	-1460	-1925	-1837	-3062
Cooling Degree Days	141	120	137	260	389	337	785
Extreme Temperature							
TMAX on coldest day of year (F)	-0.8	3.7	4.3	7.6	10.0	9.8	16.7
TMIN on coldest day of year (F)	-30.6	4.5	5.6	9.7	12.8	12.5	22.2
Days < 0F	40.4	-9.7	-10.8	-18.3	-23.5	-22.4	-33.8
Days < 32F	192.7	-11.8	-13.1	-23.5	-32.8	-30.7	-56.0
Days > 90F	0.7	2.1	2.5	5.8	10.7	8.4	29.3
Days > 95F	0.0	0.3	0.4	1.2	2.6	1.8	10.7
TMAX on hottest day of year (F)	89.3	3.0	3.5	5.7	7.5	6.8	12.1
TMIN on hottest day of year (F)	66.4	2.4	2.7	4.3	5.9	5.2	9.1
Days TMIN > 28F	199.4	9.0	9.5	19.6	26.1	25.0	45.6
Extreme Precipitation							
Days > 1 inch in 24 hours	3.9	0.6	0.6	1.0	1.5	1.3	2.4
Days > 2 inch in 24 hours	0.2	0.1	0.1	0.1	0.1	0.1	0.3
Events > 4 inches in 48 hours	0.0	0.0	0.0	0.0	0.0	0.1	0.1
Precip. on wettest day of year (in)	1.7	0.1	0.1	0.1	0.2	0.1	0.3
Snow Cover Days	161	-9	-10	**-18**	-27	-27	-47

Table A3-2B. Colebrook Station – Percent Change from Historical

Climate Indicator	Historical 1980-2009	Change from historical (+ or -)					
		2010-2039		2040-2069		2070-2099	
		Low Emissions	High Emissions	Low Emissions	High Emissions	Low Emissions	High Emissions
Precipitation (inches)							
Annual PRECIP	43.0	4%	4%	6%	8%	7%	11%
Winter PRECIP	8.0	7%	7%	11%	16%	14%	24%
Spring PRECIP	9.8	4%	5%	7%	11%	9%	16%
Summer PRECIP	13.9	3%	3%	3%	3%	4%	5%
Fall PRECIP	11.3	1%	2%	4%	4%	2%	4%
Heating and Cooling Degree Days							
Heating Degree Days	9342	-8%	-21%	-16%	-21%	-20%	-33%
Cooling Degree Days	141	86%	97%	185%	275%	241%	555%
Extreme Precipitation							
Days > 1 inch in 24 hours	3.9	16%	17%	26%	37%	34%	63%
Days > 2 inch in 24 hours	0.23	32%	41%	32%	62%	60%	120%
Events > 4 inches in 48 hours	0.03	71%	150%	43%	150%	314%	400%
Precip. on wettest day of year (in)	1.67	5%	6%	7%	10%	9%	15%
Snow Cover Days	161	-6%	-6%	**-11%**	-17%	-17%	-29%

Table A3-3A. Concord Station – Change from Historical

Climate Indicator	Historical 1980-2009	Change from historical (+ or -)					
		2010-2039		2040-2069		2070-2099	
		Low Emissions	High Emissions	Low Emissions	High Emissions	Low Emissions	High Emissions
Maximum Temperature (deg F)							
Annual TMAX	58.4	2.4	2.5	4.3	5.8	5.4	9.8
Winter TMAX	34.2	2.3	2.6	4.4	5.9	5.5	9.8
Spring TMAX	56.8	2.1	1.9	3.6	4.8	4.6	8.0
Summer TMAX	81.2	2.4	2.6	4.4	6.1	5.3	10.4
Fall TMAX	61.1	2.6	2.9	4.8	6.6	6.0	10.8
Minimum Temperature (deg F)							
Annual TMIN	35.0	2.3	2.6	4.4	5.9	5.4	9.9
Winter TMIN	13.6	2.9	3.3	5.5	7.2	6.7	11.7
Spring TMIN	32.9	1.9	1.9	3.5	4.6	4.3	7.8
Summer TMIN	55.6	2.3	2.5	4.1	5.6	5.0	9.7
Fall TMIN	37.7	2.3	2.6	4.5	6.2	5.7	10.3
Precipitation (inches)							
Annual PRECIP	40.0	1.8	1.9	2.9	3.9	3.9	5.8
Winter PRECIP	9.3	0.7	0.7	1.0	1.5	1.5	2.4
Spring PRECIP	10.0	0.4	0.6	0.6	1.0	0.9	1.8
Summer PRECIP	9.9	0.4	0.4	0.7	0.7	0.9	0.8
Fall PRECIP	10.7	0.3	0.3	0.6	0.7	0.6	0.8
Heating and Cooling Degree Days							
Heating Degree Days	7182	-635	-1540	-1160	-1524	-1439	-2407
Cooling Degree Days	501	223	245	425	616	538	1172
Extreme Temperature							
TMAX on coldest day of year (F)	10.4	3.3	3.9	6.7	9.2	8.6	14.8
TMIN on coldest day of year (F)	-13.5	3.8	4.9	8.4	11.1	10.3	17.8
Days < 0F	12.2	-4.8	-5.9	-8.4	-9.8	-9.5	-11.7
Days < 32F	161.4	-12.9	-14.2	-24.4	-33.2	-30.5	-55.6
Days > 90F	11.9	10.1	11.2	20.4	30.3	26.0	58.1
Days > 95F	2.3	3.7	4.5	9.1	15.4	12.1	37.4
TMAX on hottest day of year (F)	96.7	3.0	3.4	5.2	7.3	6.5	12.0
TMIN on hottest day of year (F)	71.2	2.3	2.6	4.0	5.5	4.7	9.2
Days TMIN > 28F	230.1	11.6	13.3	20.0	30.3	26.9	53.8
Extreme Precipitation							
Days > 1 inch in 24 hours	7.0	0.7	0.8	1.4	2.0	1.9	3.1
Days > 2 inch in 24 hours	0.7	0.1	0.1	0.2	0.3	0.3	0.4
Events > 4 inches in 48 hours	0.2	0.1	0.1	0.1	0.2	0.2	0.2
Precip. on wettest day of year (in)	2.2	0.0	0.1	0.1	0.2	0.2	0.3
Snow Cover Days	121	-13	-11	**-24**	-34	-30	-73

Table A3-3B. Concord Station – Percent Change from Historical

Climate Indicator	Historical 1980-2009	Change from historical (+ or -)					
		2010-2039		2040-2069		2070-2099	
		Low Emissions	High Emissions	Low Emissions	High Emissions	Low Emissions	High Emissions
Precipitation (inches)							
Annual PRECIP	40.0	4%	5%	7%	10%	10%	14%
Winter PRECIP	9.3	7%	7%	10%	16%	16%	26%
Spring PRECIP	10.0	4%	6%	6%	10%	9%	18%
Summer PRECIP	9.9	4%	4%	7%	7%	9%	8%
Fall PRECIP	10.7	3%	3%	5%	6%	6%	7%
Heating and Cooling Degree Days							
Heating Degree Days	7182	-9%	-21%	-16%	-21%	-20%	-34%
Cooling Degree Days	501	45%	49%	85%	123%	108%	233%
Extreme Precipitation							
Days > 1 inch in 24 hours	7.0	10%	11%	20%	29%	26%	44%
Days > 2 inch in 24 hours	0.7	9%	16%	22%	42%	40%	59%
Events > 4 inches in 48 hours	0.2	35%	51%	50%	91%	77%	114%
Precip. on wettest day of year (in)	2.2	2%	3%	6%	9%	8%	13%
Snow Cover Days	121.0	-10%	-9%	**-20%**	-28%	-25%	-60%

Table A3-4A. Durham Station – Change from Historical

Climate Indicator	Historical 1980-2009	Change from historical (+ or -)					
		2010-2039		2040-2069		2070-2099	
		Low Emissions	High Emissions	Low Emissions	High Emissions	Low Emissions	High Emissions
Maximum Temperature (deg F)							
Annual TMAX	59.5	2.1	2.2	3.9	5.4	5.0	9.2
Winter TMAX	36.4	2.2	2.5	4.3	5.7	5.3	9.4
Spring TMAX	57.6	2.2	2.0	3.8	5.1	4.9	8.5
Summer TMAX	81.4	2.0	2.1	3.7	5.2	4.6	9.3
Fall TMAX	62.1	2.0	2.2	3.9	5.6	5.0	9.7
Minimum Temperature (deg F)							
Annual TMIN	36.0	2.1	2.3	4.0	5.5	5.1	9.4
Winter TMIN	16.1	2.7	3.1	5.1	6.8	6.4	11.1
Spring TMIN	33.6	2.1	2.1	3.7	5.0	4.8	8.5
Summer TMIN	55.5	1.9	2.0	3.5	4.8	4.3	8.6
Fall TMIN	38.7	1.8	2.1	3.7	5.4	4.9	9.5
Precipitation (inches)							
Annual PRECIP	43.4	1.6	1.7	2.4	3.2	3.1	4.8
Winter PRECIP	10.5	0.6	0.5	0.8	1.4	1.4	2.2
Spring PRECIP	11.0	0.4	0.7	0.6	1.0	0.9	1.7
Summer PRECIP	9.9	0.3	0.4	0.6	0.4	0.7	0.5
Fall PRECIP	11.9	0.2	0.3	0.4	0.4	0.4	0.3
Heating and Cooling Degree Days							
Heating Degree Days	6820	-586	-1484	-1096	-1461	-1383	-2360
Cooling Degree Days	514	179	192	355	524	457	1042
Extreme Temperature							
TMAX on coldest day of year (F)	13.8	3.1	3.3	6.1	8.3	7.8	13.7
TMIN on coldest day of year (F)	-11.7	3.7	4.5	7.8	10.8	10.2	17.7
Days < 0F	8.0	-3	-4	-6	-7	-7	-8
Days < 32F	155.5	-13	-15	-26	-36	-34	-62
Days > 90F	11.1	8	9	17	27	23	53
Days > 95F	2.0	3	3	7	12	9	31
TMAX on hottest day of year (F)	96.3	2.4	2.8	4.3	6.1	5.4	10.4
TMIN on hottest day of year (F)	72.1	1.9	1.9	3.4	4.6	4.1	7.9
Days TMIN > 28F	238	13.5	15.9	24.3	35.7	31.5	67.1
Extreme Precipitation							
Days > 1 inch in 24 hours	6.1	-2.6	-2.5	-2.2	-1.9	-2.0	-1.2
Days > 2 inch in 24 hours	1.0	1.6	1.7	1.9	2.2	2.1	2.8
Events > 4 inches in 48 hours	0.3	0.1	0.1	0.2	0.3	0.2	0.4
Precip. on wettest day of year (in)	2.3	0.2	0.2	0.2	0.4	0.3	0.5
Snow Cover Days	114	-13	-14	**-27**	-42	-38	-95

Table A3-4B. Durham Station – Percent Change from Historical

Climate Indicator	Historical 1980-2009	Change from historical (+ or -)					
		2010-2039		2040-2069		2070-2099	
		Low Emissions	High Emissions	Low Emissions	High Emissions	Low Emissions	High Emissions
Precipitation (inches)							
Annual PRECIP	43.4	4%	4%	5%	7%	7%	11%
Winter PRECIP	10.5	6%	5%	8%	13%	13%	21%
Spring PRECIP	11.0	4%	6%	5%	9%	8%	16%
Summer PRECIP	9.9	3%	4%	6%	4%	7%	5%
Fall PRECIP	11.9	1%	2%	4%	3%	3%	2%
Heating and Cooling Degree Days							
Heating Degree Days	6820	-9%	-22%	-16%	-21%	-20%	-35%
Cooling Degree Days	514	35%	37%	69%	102%	89%	202%
Extreme Precipitation							
Days > 1 inch in 24 hours	6.1	-42%	-41%	-36%	-30%	-34%	-20%
Days > 2 inch in 24 hours	1.0	154%	163%	183%	209%	202%	271%
Events > 4 inches in 48 hours	0.3	38%	52%	60%	93%	69%	154%
Precip. on wettest day of year (in)	2.3	9%	9%	10%	16%	15%	24%
Snow Cover Days	114.0	-11%	-12%	**-24%**	-37%	-33%	-84%

Table A3-5A. Hanover Station – Change from Historical

Climate Indicator	Historical 1980-2009	Change from historical (+ or -)					
		2010-2039		2040-2069		2070-2099	
		Low Emissions	High Emissions	Low Emissions	High Emissions	Low Emissions	High Emissions
Maximum Temperature (deg F)							
Annual TMAX	56.9	2.2	2.4	4.1	5.6	5.2	9.6
Winter TMAX	31.7	2.1	2.4	4.1	5.7	5.2	9.7
Spring TMAX	56.0	1.9	1.8	3.3	4.4	4.3	7.6
Summer TMAX	80.4	2.4	2.7	4.7	6.6	5.9	11.3
Fall TMAX	58.9	2.3	2.6	4.1	5.8	5.2	9.9
Minimum Temperature (deg F)							
Annual TMIN	35.0	2.2	2.5	4.3	5.9	5.4	9.9
Winter TMIN	12.3	3.0	3.4	5.7	7.7	7.2	12.7
Spring TMIN	32.6	1.9	1.9	3.3	4.4	4.2	7.6
Summer TMIN	55.9	2.1	2.4	4.3	6.0	5.4	10.3
Fall TMIN	38.6	1.9	2.2	3.8	5.3	4.8	9.2
Precipitation (inches)							
Annual PRECIP	37.3	1.7	1.8	2.5	3.4	3.1	4.7
Winter PRECIP	8.0	0.5	0.5	0.8	1.1	1.1	1.8
Spring PRECIP	8.9	0.4	0.5	0.6	0.9	0.8	1.4
Summer PRECIP	10.4	0.5	0.5	0.7	0.7	0.8	0.8
Fall PRECIP	10.0	0.3	0.3	0.5	0.7	0.4	0.8
Heating and Cooling Degree Days							
Heating Degree Days	7447	-599	-1490	-1089	-1457	-1369	-2365
Cooling Degree Days	466	208	235	431	633	560	1200
Extreme Temperature							
TMAX on coldest day of year (F)	6.6	3.7	4.1	7.1	9.7	9.0	15.5
TMIN on coldest day of year (F)	-17.0	4.1	4.9	8.6	11.7	11.1	19.5
Days < 0F	17.5	-6.0	-7.2	-11.1	-13.4	-12.8	-16.6
Days < 32F	157.7	-11.2	-12.4	-21.1	-29.5	-26.9	-51.6
Days > 90F	8.1	8.7	10.0	20.1	30.6	26.4	58.6
Days > 95F	1.2	2.5	3.3	7.6	14.0	11.0	36.2
TMAX on hottest day of year (F)	95.3	2.7	3.5	5.5	7.8	7.1	12.9
TMIN on hottest day of year (F)	71.1	2.1	2.5	4.2	6.0	5.3	10.0
Days TMIN > 28F	231.0	10.4	12.1	16.6	24.2	22.2	44.6
Extreme Precipitation							
Days > 1 inch in 24 hours	3.1	0.5	0.6	0.8	1.3	1.2	1.9
Days > 2 inch in 24 hours	0.3	0.1	0.1	0.1	0.2	0.2	0.3
Events > 4 inches in 48 hours	0.1	0.0	0.0	0.0	0.1	0.1	0.1
Precip. on wettest day of year (in)	1.7	0.1	0.1	0.2	0.2	0.2	0.3
Snow Cover Days	132	-12	-11	**-20**	-27	-26	-57

Table A3-5B. Hanover Station – Percent Change from Historical

Climate Indicator	Historical 1980-2009	Change from historical (+ or -)					
		2010-2039		2040-2069		2070-2099	
		Low Emissions	High Emissions	Low Emissions	High Emissions	Low Emissions	High Emissions
Precipitation (inches)							
Annual PRECIP	37.3	4%	5%	7%	9%	8%	13%
Winter PRECIP	8.0	6%	7%	10%	14%	13%	22%
Spring PRECIP	8.9	4%	6%	6%	10%	9%	16%
Summer PRECIP	10.4	5%	4%	6%	6%	8%	8%
Fall PRECIP	10.0	3%	3%	5%	7%	4%	8%
Heating and Cooling Degree Days							
Heating Degree Days	7447	-8%	-20%	-15%	-20%	-18%	-32%
Cooling Degree Days	466	45%	50%	93%	136%	120%	257%
Extreme Precipitation							
Days > 1 inch in 24 hours	3.1	18%	19%	27%	43%	38%	63%
Days > 2 inch in 24 hours	0.3	28%	43%	48%	76%	73%	120%
Events > 4 inches in 48 hours	0.1	48%	45%	26%	95%	100%	173%
Precip. on wettest day of year (in)	1.7	7%	8%	9%	13%	12%	20%
Snow Cover Days	132	-9%	-8%	**-15%**	-21%	-19%	-43%

Table A3-6A. Keene Station – Change from Historical

Climate Indicator	Historical 1980-2009	Change from historical (+ or -)					
		2010-2039		2040-2069		2070-2099	
		Low Emissions	High Emissions	Low Emissions	High Emissions	Low Emissions	High Emissions
Maximum Temperature (deg F)							
Annual TMAX	58.8	2.2	2.3	4.1	5.6	5.2	9.3
Winter TMAX	34.7	2.1	2.4	3.9	5.3	4.9	8.5
Spring TMAX	57.5	2.0	1.8	3.6	4.8	4.6	7.7
Summer TMAX	81.2	2.3	2.5	4.5	6.4	5.6	10.8
Fall TMAX	61.4	2.4	2.6	4.3	6.0	5.5	10.2
Minimum Temperature (deg F)							
Annual TMIN	34.8	2.2	2.4	4.2	5.7	5.3	9.4
Winter TMIN	13.7	2.9	3.2	5.3	6.9	6.5	10.9
Spring TMIN	32.5	1.9	1.9	3.5	4.7	4.4	7.5
Summer TMIN	54.9	2.0	2.3	4.0	5.8	5.1	9.8
Fall TMIN	37.7	2.0	2.2	3.9	5.5	5.0	9.4
Precipitation (inches)							
Annual PRECIP	41.5	1.5	1.6	2.4	3.0	3.0	4.2
Winter PRECIP	9.3	0.4	0.5	0.7	1.3	1.1	1.9
Spring PRECIP	10.5	0.4	0.5	0.6	0.8	0.7	1.4
Summer PRECIP	10.9	0.5	0.5	0.7	0.6	1.0	0.8
Fall PRECIP	10.8	0.1	0.1	0.4	0.3	0.2	0.2
Heating and Cooling Degree Days							
Heating Degree Days	7123	-594	-1441	-1097	-1441	-1360	-2242
Cooling Degree Days	469	200	222	413	623	545	1173
Extreme Temperature							
TMAX on coldest day of year (F)	11.9	3.2	3.5	6.2	8.3	8.0	13.2
TMIN on coldest day of year (F)	-15.3	3.9	4.9	8.5	11.1	10.6	17.7
Days < 0F	13.4	-5.0	-6.0	-8.9	-10.5	-10.1	-12.7
Days < 32F	162.5	-11.8	-12.9	-22.6	-30.7	-28.4	-51.6
Days > 90F	9.1	9.4	10.4	21.2	33.3	28.3	61.9
Days > 95F	1.3	3.0	3.7	8.1	15.1	11.9	38.0
TMAX on hottest day of year (F)	95.2	2.8	3.3	5.2	7.5	6.6	12.3
TMIN on hottest day of year (F)	70.9	2.0	2.1	3.8	5.4	4.8	9.0
Days TMIN > 28F	227.7	10.9	12.3	20.6	30.5	28.0	52.0
Extreme Precipitation							
Days > 1 inch in 24 hours	3.3	0.5	0.6	1.0	1.4	1.3	2.1
Days > 2 inch in 24 hours	0.1	0.0	0.1	0.1	0.1	0.1	0.2
Events > 4 inches in 48 hours	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Precip. on wettest day of year (in)	1.6	0.0	0.1	0.1	0.2	0.2	0.2
Snow Cover Days	134	-14	-12	**-24**	-32	-30	-56

Table A3-6B. Keene Station – Percent Change from Historical

Climate Indicator	Historical 1980-2009	Change from historical (+ or -)					
		2010-2039		2040-2069		2070-2099	
		Low Emissions	High Emissions	Low Emissions	High Emissions	Low Emissions	High Emissions
Precipitation (inches)							
Annual PRECIP	41.5	4%	4%	6%	7%	7%	10%
Winter PRECIP	9.3	5%	5%	8%	13%	12%	20%
Spring PRECIP	10.5	4%	5%	6%	8%	7%	14%
Summer PRECIP	10.9	5%	5%	7%	6%	9%	7%
Fall PRECIP	10.8	1%	1%	3%	3%	2%	2%
Heating and Cooling Degree Days							
Heating Degree Days	7123	-8%	-20%	-15%	-20%	-19%	-31%
Cooling Degree Days	469	43%	47%	88%	132%	116%	249%
Extreme Precipitation							
Days > 1 inch in 24 hours	3.3	16%	17%	30%	41%	40%	64%
Days > 2 inch in 24 hours	0.1	32%	49%	42%	92%	74%	135%
Events > 4 inches in 48 hours	0.0	25%	63%	75%	150%	75%	288%
Precip. on wettest day of year (in)	1.6	3%	5%	6%	11%	10%	15%
Snow Cover Days	134	-11%	-9%	**-18%**	-24%	-22%	-42%

Table A3-7A. Lakeport Station – Change from Historical

Climate Indicator	Historical 1980-2009	Change from historical (+ or -)					
		2010-2039		2040-2069		2070-2099	
		Low Emissions	High Emissions	Low Emissions	High Emissions	Low Emissions	High Emissions
Maximum Temperature (deg F)							
Annual TMAX	56.3	2.1	2.3	4.0	5.4	5.0	9.0
Winter TMAX	31.9	2.1	2.4	3.9	5.1	4.7	8.0
Spring TMAX	54.7	1.7	1.6	3.3	4.5	4.3	7.6
Summer TMAX	79.3	2.4	2.6	4.5	6.4	5.7	11.0
Fall TMAX	58.6	2.3	2.5	4.1	5.6	5.1	9.3
Minimum Temperature (deg F)							
Annual TMIN	36.3	2.1	2.4	4.0	5.5	5.1	9.2
Winter TMIN	14.1	2.6	3.1	4.9	6.4	6.1	10.1
Spring TMIN	33.1	1.6	1.7	3.2	4.4	4.1	7.5
Summer TMIN	57.6	2.2	2.4	4.2	6.0	5.3	10.2
Fall TMIN	40.0	2.0	2.3	3.8	5.3	4.8	8.8
Precipitation (inches)							
Annual PRECIP	41.3	1.6	1.9	2.8	3.7	3.4	5.1
Winter PRECIP	9.3	0.5	0.5	0.8	1.3	1.2	2.0
Spring PRECIP	10.3	0.5	0.6	0.7	1.0	0.9	1.7
Summer PRECIP	10.4	0.5	0.6	0.8	0.8	1.0	1.0
Fall PRECIP	11.2	0.1	0.2	0.5	0.6	0.3	0.4
Heating and Cooling Degree Days							
Heating Degree Days	7342	-564	-1370	-1042	-1364	-1291	-2129
Cooling Degree Days	496	213	234	421	623	550	1177
Extreme Temperature							
TMAX on coldest day of year (F)	7.5	3.2	3.8	6.4	8.4	8.0	13.2
TMIN on coldest day of year (F)	-10.9	3.5	4.4	7.4	9.7	9.4	15.7
Days < 0F	9.8	-4.0	-4.8	-6.9	-8.0	-7.9	-9.4
Days < 32F	154.6	-10.4	-11.4	-19.7	-26.8	-25.1	-44.7
Days > 90F	6.5	7.6	8.4	16.9	26.6	22.6	52.4
Days > 95F	0.8	2.1	2.5	5.8	11.6	9.0	30.7
TMAX on hottest day of year (F)	94.5	2.7	3.3	5.1	7.4	6.7	12.3
TMIN on hottest day of year (F)	71.3	2.4	2.7	4.2	6.2	5.4	10.1
Days TMIN > 28F	232.7	9.9	10.5	18.8	27.4	25.7	44.9
Extreme Precipitation							
Days > 1 inch in 24 hours	4.0	0.6	0.8	1.2	1.6	1.6	2.5
Days > 2 inch in 24 hours	0.4	0.0	0.1	0.2	0.2	0.2	0.3
Events > 4 inches in 48 hours	0.1	0.0	0.1	0.0	0.1	0.1	0.2
Precip. on wettest day of year (in)	1.8	0.1	0.1	0.1	0.2	0.2	0.3
Snow Cover Days	131	-13	-13	**-24**	-31	-29	-57

Table A3-7B. Lakeport Station – Percent Change from Historical

Climate Indicator	Historical 1980-2009	Change from historical (+ or -)					
		2010-2039		2040-2069		2070-2099	
		Low Emissions	High Emissions	Low Emissions	High Emissions	Low Emissions	High Emissions
Precipitation (inches)							
Annual PRECIP	41.3	4%	5%	7%	9%	8%	12%
Winter PRECIP	9.3	6%	5%	8%	14%	13%	22%
Spring PRECIP	10.3	4%	6%	7%	10%	9%	17%
Summer PRECIP	10.4	5%	6%	7%	8%	9%	9%
Fall PRECIP	11.2	1%	2%	5%	5%	3%	4%
Heating and Cooling Degree Days							
Heating Degree Days	7342	-8%	-19%	-14%	-19%	-18%	-29%
Cooling Degree Days	496	43%	47%	85%	125%	111%	237%
Extreme Precipitation							
Days > 1 inch in 24 hours	4.0	14%	20%	30%	40%	40%	62%
Days > 2 inch in 24 hours	0.4	11%	29%	44%	60%	54%	85%
Events > 4 inches in 48 hours	0.1	33%	56%	39%	103%	94%	153%
Precip. on wettest day of year (in)	1.8	3%	5%	7%	10%	8%	14%
Snow Cover Days	131	-10%	-10%	**-18%**	-24%	-22%	-44%

Table A3-8A. Massabesic Station – Change from Historical

Climate Indicator	Historical 1980-2009	Change from historical (+ or -)					
		2010-2039		2040-2069		2070-2099	
		Low Emissions	High Emissions	Low Emissions	High Emissions	Low Emissions	High Emissions
Maximum Temperature (deg F)							
Annual TMAX	58.6	2.0	2.2	3.8	5.3	4.8	8.8
Winter TMAX	35.7	1.9	2.2	3.4	4.6	4.3	7.7
Spring TMAX	56.5	1.8	1.7	3.5	4.9	4.6	8.2
Summer TMAX	80.4	2.1	2.3	4.0	5.8	5.2	10.1
Fall TMAX	55.5	1.9	2.1	3.7	5.4	4.8	9.4
Minimum Temperature (deg F)							
Annual TMIN	35.3	2.1	2.3	3.9	5.3	4.9	9.0
Winter TMIN	14.1	2.4	2.7	4.4	5.7	5.4	9.3
Spring TMIN	32.7	1.7	1.8	3.4	4.8	4.5	8.1
Summer TMIN	55.5	1.9	2.1	3.7	5.4	4.8	9.4
Fall TMIN	38.4	2.1	2.4	4.0	5.4	5.0	8.9
Precipitation (inches)							
Annual PRECIP	40.3	1.4	1.7	2.4	3.0	3.0	4.4
Winter PRECIP	9.2	0.4	0.5	0.7	1.2	1.1	1.8
Spring PRECIP	10.0	0.4	0.6	0.6	0.9	0.8	1.6
Summer PRECIP	9.9	0.4	0.6	0.7	0.6	0.9	0.8
Fall PRECIP	11.1	0.2	0.1	0.4	0.3	0.3	0.2
Heating and Cooling Degree Days							
Heating Degree Days	7063	-561	-1365	-1028	-1349	-1279	-2135
Cooling Degree Days	465	185	203	381	580	507	1111
Extreme Temperature							
TMAX on coldest day of year (F)	12.3	3.0	3.4	5.6	7.4	7.1	12.0
TMIN on coldest day of year (F)	0.1	3.0	4.1	5.6	9.0	7.1	15.0
Days < 0F	-7.1	-4.1	2.3	-6.8	5.0	-7.9	8.3
Days < 32F	160.3	-11.1	-12.3	-20.5	-28.1	-26.2	-47.4
Days > 90F	8.0	7.8	8.7	17.4	28.2	23.8	54.7
Days > 95F	1.1	2.2	2.5	6.0	11.9	9.3	31.8
TMAX on hottest day of year (F)	34.0	4.0	4.5	10.7	21.4	16.7	57.2
TMIN on hottest day of year (F)	70.7	1.9	2.0	3.7	5.4	4.6	9.1
Days TMIN > 28F	228.7	9.2	9.9	18.5	28.7	25.5	48.1
Extreme Precipitation							
Days > 1 inch in 24 hours	4.3	0.5	0.6	0.9	1.3	1.2	2.1
Days > 2 inch in 24 hours	2.3	0.0	0.6	0.1	1.3	0.1	2.1
Events > 4 inches in 48 hours	0.1	0.0	0.1	0.1	0.1	0.1	0.1
Precip. on wettest day of year (in)	1.8	0.1	0.1	0.1	0.2	0.2	0.3
Snow Cover Days	118	-12	-11	**-24**	-33	-30	-63

Table A3-8B. Massabesic Station – Percent Change from Historical

Climate Indicator	Historical 1980-2009	Change from historical (+ or -)					
		2010-2039		2040-2069		2070-2099	
		Low Emissions	High Emissions	Low Emissions	High Emissions	Low Emissions	High Emissions
Precipitation (inches)							
Annual PRECIP	40.3	4%	4%	6%	7%	7%	11%
Winter PRECIP	9.2	5%	5%	7%	13%	12%	20%
Spring PRECIP	10.0	4%	6%	6%	9%	8%	16%
Summer PRECIP	9.9	4%	6%	7%	6%	9%	8%
Fall PRECIP	11.1	2%	1%	4%	3%	2%	2%
Heating and Cooling Degree Days							
Heating Degree Days	7063	-8%	-19%	-15%	-19%	-18%	-30%
Cooling Degree Days	465	40%	44%	82%	124%	109%	239%
Extreme Precipitation							
Days > 1 inch in 24 hours	4.3	11%	15%	22%	31%	28%	51%
Days > 2 inch in 24 hours	2.3	12%	15%	31%	31%	27%	51%
Events > 4 inches in 48 hours	0.1	33%	73%	47%	103%	61%	130%
Precip. on wettest day of year (in)	1.8	3%	6%	6%	10%	9%	15%
Snow Cover Days	118	-10%	-9%	**-20%**	-28%	-26%	-54%

Table A3-9A. Pinkham Station – Change from Historical

Climate Indicator	Historical 1980-2009	Change from historical (+ or -)					
		2010-2039		2040-2069		2070-2099	
		Low Emissions	High Emissions	Low Emissions	High Emissions	Low Emissions	High Emissions
Maximum Temperature (deg F)							
Annual TMAX	43.6	2.7	2.9	5.2	6.9	6.5	11.1
Winter TMAX	24.1	2.6	3.1	5.4	7.3	6.9	12.0
Spring TMAX	40.7	3.1	3.1	5.7	7.3	7.2	11.4
Summer TMAX	62.9	2.6	2.9	4.9	6.5	6.0	10.6
Fall TMAX	48.2	2.4	2.8	4.6	6.3	5.9	10.2
Minimum Temperature (deg F)							
Annual TMIN	29.2	2.7	3.0	5.3	7.1	6.7	11.3
Winter TMIN	15.7	2.6	3.5	5.4	8.2	6.9	13.4
Spring TMIN	26.0	3.1	3.1	5.7	7.4	7.1	11.5
Summer TMIN	49.9	2.5	2.8	4.7	6.3	5.8	10.2
Fall TMIN	33.0	2.4	2.7	4.6	6.3	5.9	10.3
Precipitation (inches)							
Annual PRECIP	74.8	2.6	2.8	4.4	5.8	5.0	8.4
Winter PRECIP	17.9	1.1	1.1	1.6	2.6	2.3	4.0
Spring PRECIP	18.5	0.5	0.8	1.1	1.5	1.1	2.2
Summer PRECIP	18.4	0.7	0.7	0.9	0.8	0.9	1.1
Fall PRECIP	20.0	0.3	0.3	0.9	0.9	0.8	1.1
Heating and Cooling Degree Days							
Heating Degree Days	10480	-947	-2346	-1806	-2356	-2255	-3647
Cooling Degree Days	21	41	49	105	182	150	446
Extreme Temperature							
TMAX on coldest day of year (F)	-4.7	3.7	4.2	8.1	11.0	10.4	17.4
TMIN on coldest day of year (F)	-23.2	4.1	5.4	8.9	12.3	11.8	20.0
Days < 0F	27.9	-8.4	-9.4	-15.8	-19.3	-18.6	-25.2
Days < 32F	192.1	-14.4	-15.7	-28.0	-38.3	-36.7	-62.5
Days > 90F	0.0	0.0	0.0	0.1	0.3	0.2	2.2
Days > 95F	0.0	0.0	0.0	0.0	0.0	0.0	0.6
TMAX on hottest day of year (F)	77.8	3.1	3.4	5.7	7.6	7.0	12.2
TMIN on hottest day of year (F)	63.7	2.8	3.4	5.2	7.2	6.5	11.3
Days TMIN > 28F	192.6	9.8	10.5	23.8	31.5	33.4	53.5
Extreme Precipitation							
Days > 1 inch in 24 hours	12.4	1.2	1.3	2.1	2.9	2.6	4.5
Days > 2 inch in 24 hours	2.1	0.4	0.4	0.7	1.0	0.9	1.6
Events > 4 inches in 48 hours	1.4	0.3	0.4	0.4	1.0	0.6	1.6
Precip. on wettest day of year (in)	74.2	6.9	7.7	11.2	15.8	12.7	23.7
Snow Cover Days	209	-9	-11	**-24**	-33	-34	-54

Table A3-9B. Pinkham Station – Percent Change from Historical

Climate Indicator	Historical 1980-2009	Change from historical (+ or -)					
		2010-2039		2040-2069		2070-2099	
		Low Emissions	High Emissions	Low Emissions	High Emissions	Low Emissions	High Emissions
Precipitation (inches)							
Annual PRECIP	74.8	3%	4%	6%	8%	7%	11%
Winter PRECIP	17.9	6%	6%	9%	15%	13%	22%
Spring PRECIP	18.5	3%	4%	6%	8%	6%	12%
Summer PRECIP	18.4	4%	4%	5%	4%	5%	6%
Fall PRECIP	20.0	1%	1%	4%	5%	4%	6%
Heating and Cooling Degree Days							
Heating Degree Days	10480	-9%	-22%	-17%	-22%	-22%	-35%
Cooling Degree Days	21	196%	235%	504%	872%	721%	2144%
Extreme Precipitation							
Days > 1 inch in 24 hours	12.4	10%	10%	17%	24%	21%	37%
Days > 2 inch in 24 hours	2.1	20%	19%	32%	51%	42%	77%
Events > 4 inches in 48 hours	1.4	42%	19%	50%	51%	71%	77%
Precip. on wettest day of year (in)	74.2	9%	10%	15%	21%	17%	32%
Snow Cover Days	209	-4%	-5%	**-12%**	-16%	-16%	-26%

Table A3-10A. Portsmouth Station – Change from Historical

Climate Indicator	Historical 1980-2009	Change from historical (+ or -)					
		2010-2039		2040-2069		2070-2099	
		Low Emissions	High Emissions	Low Emissions	High Emissions	Low Emissions	High Emissions
Maximum Temperature (deg F)							
Annual TMAX	59.7	2.0	2.1	3.8	5.3	4.8	9.1
Winter TMAX	37.0	2.1	2.4	4.1	5.6	5.2	9.2
Spring TMAX	57.6	2.1	2.0	3.8	5.1	4.9	8.5
Summer TMAX	81.3	1.8	1.9	3.5	5.0	4.4	9.1
Fall TMAX	62.4	1.9	2.1	3.8	5.4	4.8	9.5
Minimum Temperature (deg F)							
Annual TMIN	59.7	2.0	2.1	3.8	5.3	4.8	9.1
Winter TMIN	17.2	2.5	2.9	4.9	6.6	6.2	10.8
Spring TMIN	34.4	2.0	2.0	3.7	5.0	4.8	8.5
Summer TMIN	56.3	1.7	1.8	3.4	4.8	4.2	8.7
Fall TMIN	39.7	1.8	2.0	3.7	5.3	4.8	9.4
Precipitation (inches)							
Annual PRECIP	45.3	1.5	1.6	2.3	3.0	3.0	4.5
Winter PRECIP	11.7	0.6	0.5	0.8	1.4	1.4	2.2
Spring PRECIP	11.4	0.4	0.7	0.6	0.9	0.8	1.6
Summer PRECIP	9.7	0.4	0.4	0.6	0.4	0.7	0.5
Fall PRECIP	12.5	0.2	0.1	0.4	0.4	0.2	0.4
Heating and Cooling Degree Days							
Heating Degree Days	6631	-554	-1436	-1055	-1412	-1337	-2296
Cooling Degree Days	536	169	183	354	529	462	1066
Extreme Temperature							
TMAX on coldest day of year (F)	14.5	2.9	3.1	5.7	7.8	7.4	13.2
TMIN on coldest day of year (F)	-9.3	3.4	4.3	7.5	10.3	9.7	17.2
Days < 0F	6.2	-2.7	-3.2	-4.6	-5.3	-5.2	-6.1
Days < 32F	148.6	-13.0	-14.3	-25.2	-34.7	-32.8	-60.5
Days > 90F	10.9	7.0	7.6	15.6	24.1	20.6	50.9
Days > 95F	1.9	2.6	2.9	6.4	11.2	9.0	29.9
TMAX on hottest day of year (F)	96.1	2.2	2.6	4.1	5.9	5.3	10.2
TMIN on hottest day of year (F)	43.3	1.8	3.1	3.2	7.8	4.0	13.2
Days TMIN > 28F	244.5	13.2	13.6	23.1	34.6	31.0	68.3
Extreme Precipitation							
Days > 1 inch in 24 hours	6.3	0.6	0.7	1.2	1.6	1.5	2.5
Days > 2 inch in 24 hours	0.9	0.1	0.1	0.2	0.3	0.3	0.6
Events > 4 inches in 48 hours	0.3	0.1	0.1	0.2	0.2	0.2	0.3
Precip. on wettest day of year (in)	2.2	0.1	0.2	0.2	0.3	0.2	0.5
Snow Cover Days	113	-12	-13	**-26**	-43	-38	-97

Table A3-10B. Portsmouth Station – Percent Change from Historical

Climate Indicator	Historical 1980-2009	Change from historical (+ or -)					
		2010-2039		2040-2069		2070-2099	
		Low Emissions	High Emissions	Low Emissions	High Emissions	Low Emissions	High Emissions
Precipitation (inches)							
Annual PRECIP	45.3	3%	4%	5%	7%	7%	10%
Winter PRECIP	11.7	5%	4%	7%	12%	12%	18%
Spring PRECIP	11.4	3%	6%	5%	8%	7%	14%
Summer PRECIP	9.7	4%	4%	6%	4%	7%	5%
Fall PRECIP	12.5	1%	1%	3%	3%	2%	3%
Heating and Cooling Degree Days							
Heating Degree Days	6631	-8%	-22%	-16%	-21%	-20%	-35%
Cooling Degree Days	536	32%	34%	66%	98%	86%	198%
Extreme Precipitation							
Days > 1 inch in 24 hours	6.3	9%	11%	19%	25%	24%	39%
Days > 2 inch in 24 hours	0.9	8%	17%	21%	36%	30%	69%
Events > 4 inches in 48 hours	0.3	36%	44%	56%	82%	64%	124%
Precip. on wettest day of year (in)	2.2	6%	7%	8%	13%	11%	21%
Snow Cover Days	113	-11%	-12%	**-23%**	-38%	-34%	-86%