ISSUE PAPER SERIES

How Winter is Changing in the Tug Hill Region

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NEW YORK STATE TUG HILL COMMISSION

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The Tug Hill Commission Technical and Issue Paper Series are designed to help local officials and citizens in the Tug Hill region and other rural parts of New York State. The Technical Paper Series provides guidance on procedures based on questions frequently received by the Commission. The Issue Paper Series provides background on key issues facing the region without taking advocacy positions. Other papers in each series are available from the Tug Hill Commission. Please call us or visit our website for more information.

Snowy field in Boylston, NY

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1. Introduction

In Harold Samson's book published in 1971, *Tug Hill Country, Tales from the Big Woods*, he wrote, "Tug Hill is, and always has been, noted for its winter snows." He also wrote, "In winter, the Tug Hill plateau becomes a vast wilderness of white; favorite playground of snowmobilers and other winter sports enthusiasts." An economic study estimated that 34,254 unique snowmobile users ride Tug Hill's trails each year, bringing in nearly $81.6 million in sales from snowmobile activity (Camoin Associates 2021).

The Tug Hill region, located east of Lake Ontario and west of Adirondack Park, is one of the most rural and remote areas of New York State and the Northeast, covering 2,100 square miles, or 1.2 million acres. Nearly 104,000 residents live in 41 towns and 18 villages throughout portions of Jefferson, Lewis, Oneida, and Oswego counties (NYS Tug Hill Commission 2020). The Tug Hill Plateau rises approximately 2,100 feet (640 meters) above Lake Ontario's eastern shore and is shown in Figure 1, where darker colors represent lower elevation and lighter colors represent higher elevation.

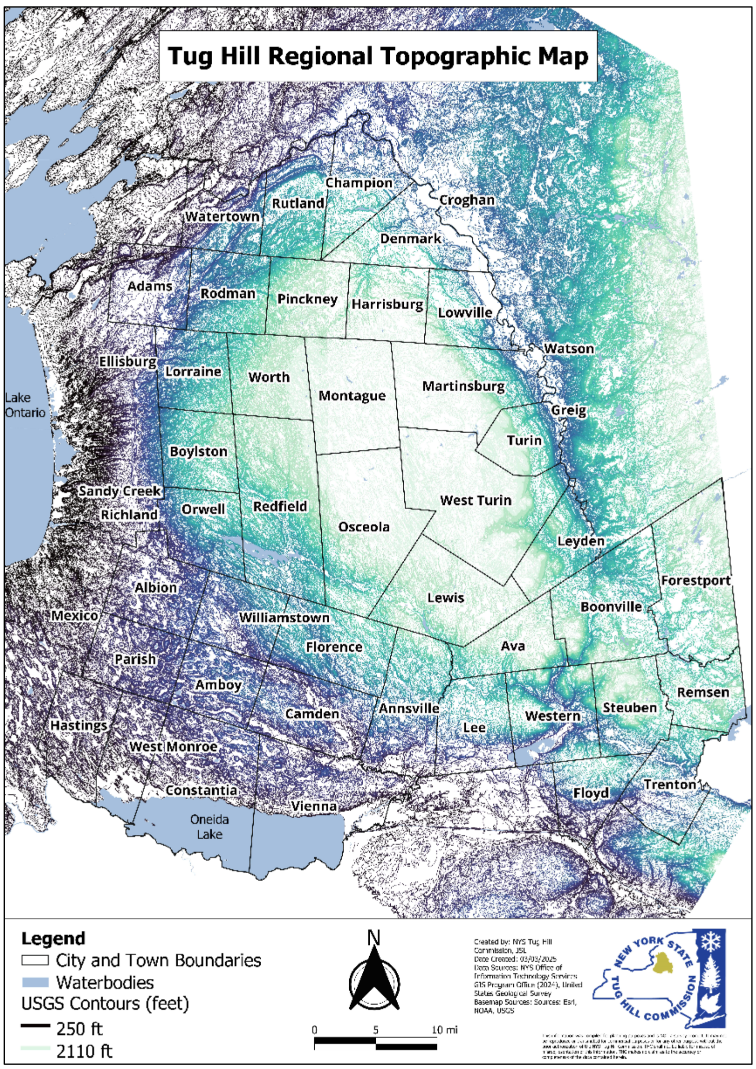

Figure 1. The Tug Hill regional elevation.

The Tug Hill region is historically known for its heavy snowfall patterns and prime winter conditions for outdoor recreation. Redfield resident Carol Yerdon has recorded snowfall data for almost 30 years. One of her highest snowfall records is from the winter season of 1996-1997 where she recorded 424.25 inches of snow. More recently, though, communities in the Tug Hill region have experienced a wide array of changing winter conditions. Winter events are often postponed or canceled, and winter recreation has been unreliable at times because of snowfall uncertainty. This issue paper aims to:

- Inform readers about changes in Tug Hill winters by presenting data analysis from four stations located around the Tug Hill region: Bennetts Bridge, Boonville, Highmarket, and Lowville;
- Define weather and climate, explain climate data and its sources, and highlight the importance of climate normals;
- Show trends in air temperature and snowfall and examine why the Tug Hill region is experiencing changes in the winter season and
- Discuss potential future implications on communities in the Tug Hill region.

2. Weather and Climate: What is the Difference?

This section includes some meteorological terms and their definitions to help understand changes in winter conditions in the Tug Hill region.

2.1 Weather

Weather is defined as “the state of the atmosphere at any given time” (Lutgens and Tarbuck 2013, 497). The American Meteorological Society’s (AMS) Glossary of Meteorology says, “Weather consists of the short-term (minutes to days) variations in the atmosphere.” Weather can be thought of as temperature, humidity, precipitation, cloudiness, visibility, and wind. Various types of weather can occur, which include but are not limited to thunderstorms, tornadoes, liquid precipitation (e.g., rain), freezing precipitation (e.g., freezing rain), and frozen precipitation (e.g., snow). In other words, when you look out your window, you observe the weather because you see what is happening at that specific time. Mark Twain once said, “If you don’t like the weather in New England now, just wait a few minutes.”

2.2 Winter Weather

A meteorological winter includes December, January, and February. This is based on annual temperature cycles and the calendar (NCEI 2023). Winter weather events can include different types of storms and precipitation. The National Oceanic and Atmospheric Administration (NOAA) National Severe Storms Laboratory (2024b) defines a winter storm as a combination of heavy snow, blowing snow, and/or dangerous wind chills. Winter storms include blizzards, ice storms, snow squalls, and snowstorms (e.g., lake-effect storms).

- Blizzards are a combination of wind and blowing snow that results in very low visibility. Heavy snowfalls and severe cold are not required for an event to be called a blizzard, but they can accompany it.
- Ice storms accumulate at least 0.25 inches of ice on surfaces, creating hazardous walking and driving conditions.

- Snow squalls are brief, intense snowfall with strong, gusty winds.
- A variety of snowstorms affect New York State. A research study determined that 11 different snowstorm types can contribute to snowfall in central New York (including the Tug Hill region). These include lake-effect snowstorms, clippers, Colorado lows, frontal storms, Great Lakes lows, Hudson lows, Nor-easters, Oklahoma hooks, Texas hooks, tropical cyclones, and upper air disturbances (Hartnett 2020).
    - Out of the 11 types, lake-effect storms contribute the most seasonal snowfall totals (Hartnett 2021). Lake-effect storms occur as a cold air mass moves over a warm body of water, like Lake Ontario. As the cold air moves over the waterbody, warmth and moisture are moved into the lowest portion of the atmosphere, or closest to the ground (NWS 2024b). Unlike Nor'easters in the Atlantic coastal regions, these storms do not form from low-pressure systems.

If interested in learning more about winter weather, such as lake-effect storms, visit this National Weather Service website: https://www.weather.gov/safety/winter-lake-effect-snow

To learn more about different types of snowstorms that affect New York State, read the research study here: doi 10.3389/frwa.2021.780869

Types of winter precipitation include snow, sleet, and freezing rain. Hail is often a misconception of winter precipitation. Hail is precipitation in the form of hard, rounded pellets or irregular lumps of ice and is produced in large cumulonimbus clouds, which are clouds that produce thunderstorms (Lutgens and Tarbuck 2013, 147). While uncommon at times, graupel is a type of winter precipitation that is often confused with hail. Graupel is precipitation in the form of white, opaque ice particles and is also referred to as snow pellets (AMS Glossary) (Figure 2). Sleet forms when snow falls through a shallow layer of warm air, then a layer of freezing air, and reaches the ground as frozen raindrops that bounce on impact (Figure 3) (NWS 2013).

Figure 2. Different types of frozen precipitation. Source: NSSL 2024a

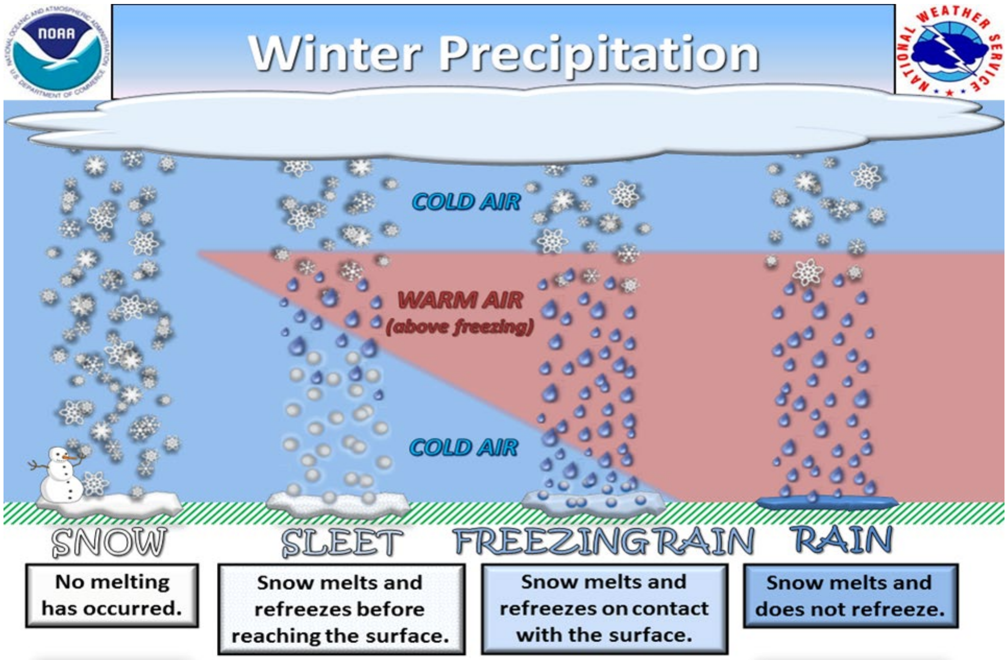

Figure 3. Winter precipitation types. Source: NWS Northern Indiana 2013

2.3 Climate

Climate is defined as "a description of aggregate (or collective) weather conditions; the sum of all statistical weather information that helps describe a place or region" (Lutgens and Tarbuck 2013, 489). The National Weather Service (2024a) states, "Climate encompasses the weather over different periods of time and also relates to mutual interactions between the components of the earth system (e.g., atmospheric composition, changes in the Earth's orbit around the sun, etc.). In other words, when someone looks out their window, they observe the weather, which shapes the climate each day. A single weather event, such as a lake-effect snowstorm, contributes to the overall climate but cannot define it. The climate is a collective of weather. In other words, think about a book, and each page is one single day of the weather, and the book is called "The Climate." This book would then encompass years of daily weather data throughout the pages.

3. Understanding Climate Data: Sources, Normals, and Regional Trends

It is important to know where the data come from to understand changes in precipitation (e.g., snowfall) and air temperature in the Tug Hill region. Various atmospheric variables are measured most frequently today, including air temperature, barometric pressure, cloud type, cloud height and cloud cover, current or prevailing weather, dewpoint temperature, precipitation, sunshine, and wind speed and direction.

3.1 Data Sources

Nearly 15,000 stations alone in the United States record at least one of these variables listed above (NCEI 2021). The international agency responsible for worldwide climatic data is the World Meteorological Organization (WMO), located in Geneva, Switzerland. The Intergovernmental Panel on Climate Change's Data Distribution Center is a gateway to various data sets used to assess global climate changes. The World Data Center for Climate, part of the World Data System, includes climatological, meteorological, astronomical, oceanographic, and geophysical data sets. NOAA's National Centers for Environment Information (NCEI) in Asheville, North Carolina, is the main library for weather records in the United States. The U.S. Historical Climatology Network maintains a high-quality dataset for over 1,000 stations in the contiguous United States to quantify national and regional-scale temperature changes (NCEI 2024).

NCEI manages the Regional Climate Center Program, encompassing six regional offices throughout the United States. The Northeast Regional Climate Center serves Maine, New Hampshire, Vermont, Massachusetts, Connecticut, Rhode Island, Delaware, New York, Pennsylvania, New Jersey, Maryland, West Virginia, and Washington D.C.

> The Northeast Regional Climate Center provides a wealth of weather and climate information. To visit, go to https://www.nrcc.cornell.edu/.

3.2 Understanding the Importance of Climate Normals

Climate normals can provide insight into growing seasons for farmers, including first and last freeze dates, drought conditions, winter conditions, and energy usage for heating and cooling days. If someone walks outside and thinks the weather is hotter, colder, wetter, or drier than they remember, they think about climate normals. What does normal mean, though? Normals are another way of saying expected conditions from the recent (30-year) past. More specifically, climate normals are 30-year averages for climate variables like precipitation and air temperature. Data consist of annual/seasonal, monthly, daily, and hourly averages (NCEI 2021). These datasets provide a baseline that compares a location's current weather to the expected, or normal, weather. Climate normals are continuously updated, with previous 30-year averages being 1931-1960 and 1961-1990. The WMO creates specific guidelines on calculating climate normals to be consistent worldwide (WMO 2017). The most current set of climate normals data is from 1991-2020. Note that subtracting 2020 from 1991 is 29. Due to counting the full, inclusive years of 1991 through 2020, the total is 30.

An example of using climate normals to understand air temperature in Boonville is as follows:

- The average maximum air temperature in February 2024 was 34.2°F.
- The climate normal for February's average maximum air temperature is 27.2°F.
- February 2024 was 7° above the climate normal. This means that February was warmer than normal.

3.3 Tug Hill Regional Climate Data

This paper analyzes data from four stations in the Tug Hill region: Bennetts Bridge, Boonville, Highmarket, and Lowville, to understand air temperature and snowfall trends in winter seasons. Bennetts Bridge is in Oswego County, Lowville and Highmarket are in Lewis County, and Boonville is in Oneida County. No comprehensive dataset with an adequate timeframe was available for Jefferson County. Data for these stations are from NOAA's NCEI, and Table 1 shows the types of data each station has. Figure 4 shows each station's location within the Tug Hill regional boundary.

Table 1. The four stations analyzed for snowfall and air temperature in the Tug Hill region.

Station	Data Analyzed	Time Frame
Bennetts Bridge	▪ Snowfall	1974-2024 (50 years)
Boonville	▪ Snowfall ▪ Average Minimum Air Temperature ▪ Average Maximum Air Temperature	
Highmarket	▪ Snowfall	
Lowville	▪ Snowfall ▪ Average Minimum Air Temperature ▪ Average Maximum Air Temperature	

Average maximum (high) and minimum (low) air temperature and snowfall totals are compared to the climate normals provided by NCEI for January, February, March, November, and December 1991-2024. These months were selected since they are the primary snowfall periods in the Tug Hill region. April, May, September, and October have recorded snowfall, but the heavier snowfall months were analyzed for this paper.

Figure 4. Locations of the four weather stations that were analyzed.

3.3.1 Tug Hill Air Temperature Data

Boonville and Lowville have 50-year air temperature datasets from 1974 to 2024. Air temperature data for Bennetts Bridge and Highmarket were unavailable. The average minimum (low) and maximum (high) air temperatures are analyzed for winter and extended winter seasons.

- The winter season is December, January, and February. The extended winter season is from September through May.
    - For example, the 2023-2024 season includes September through December 2023 and January through May 2024.
- Monthly average air temperatures (minimum and maximum) were calculated by totaling daily temperatures and dividing by the number of days in the month.
- The winter season's average minimum and maximum air temperatures were determined by averaging the monthly values for December, January, and February. The same process was completed for extended winter seasons from September through May.

The following graphs are shown for each station, starting with the average minimum temperature and then the average maximum temperature for winter seasons in the order of Boonville, then Lowville. The extended winter season graphs are in Appendix A.

- The orange line shows the minimum air temperature and the red line shows the maximum air temperature.
- The dark blue dotted line on each graph is the trendline.
    - The trendline is added to show the overall pattern or direction of the data. It helps to understand if the data points indicate increasing or decreasing trends or remain unchanged over the analyzed period.
    - The trendline is like drawing a smooth path through a bumpy trail, helping one see the general direction even if there are ups and downs.

This section will indicate whether air temperature increased, decreased, or remaining unchanged over the analyzed period. Section 4 summarizes the results. Note that no seasons were removed from any of the air temperature datasets. All data analyzed can be found in Appendix C.

Boonville

Average Minimum Temperature Winter Season: The winter seasons from 1974 to 2024 indicate the minimum air temperature has increased (i.e., getting warmer) (Figure 5). The extended winter seasons show the same results, which can be found in Appendix A.

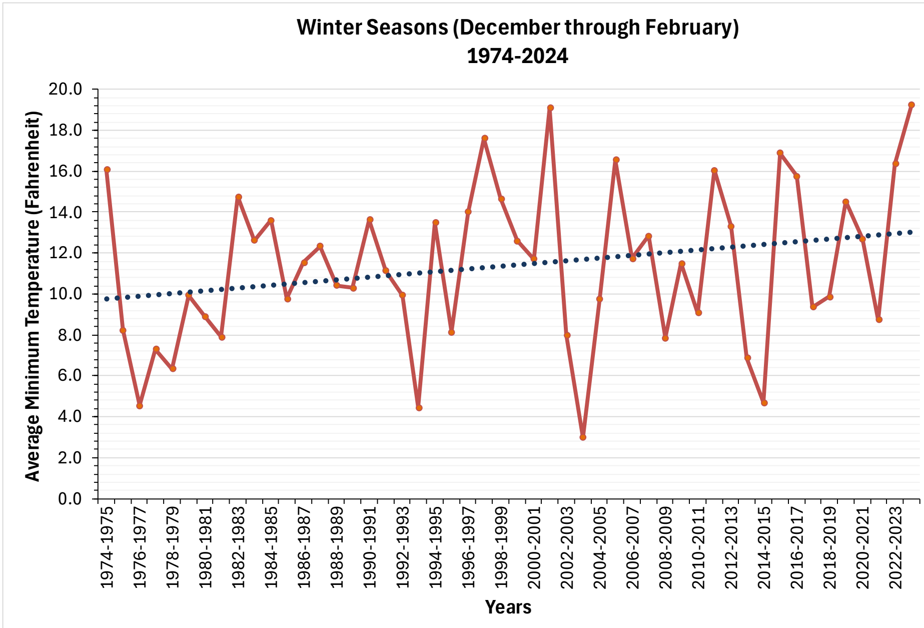

Figure 5. Boonville's average minimum temperature for the winter seasons 1974-2024.

Average Maximum Temperature Winter Season: The winter seasons from 1974 to 2024 indicate the maximum air temperature has increased (i.e., getting warmer) (Figure 6).

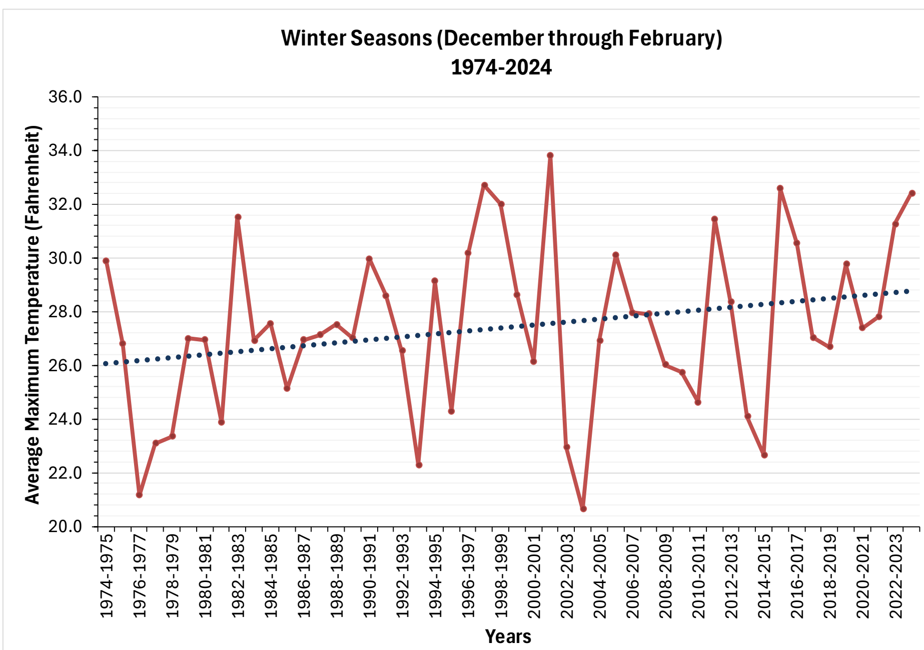

Figure 6. Boonville's average maximum temperature for the winter seasons 1974-2024.

Lowville

Average Minimum Temperature Winter Season: The winter seasons from 1974 to 2024 indicate the minimum air temperature has increased (i.e., getting warmer) (Figure 7). The extended winter seasons show the same results.

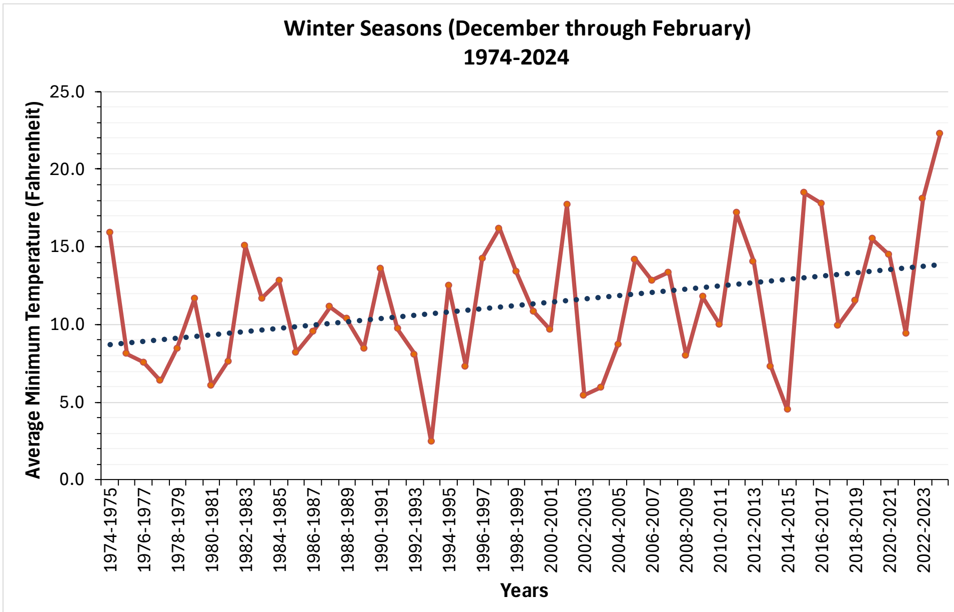

Figure 7. Lowville's average minimum temperature for the winter seasons 1974-2024.

Average Maximum Temperature Winter Season: The winter seasons from 1974 to 2024 indicate the maximum air temperature has increased (i.e., getting warmer) (Figure 8). The extended winter seasons show the same results.

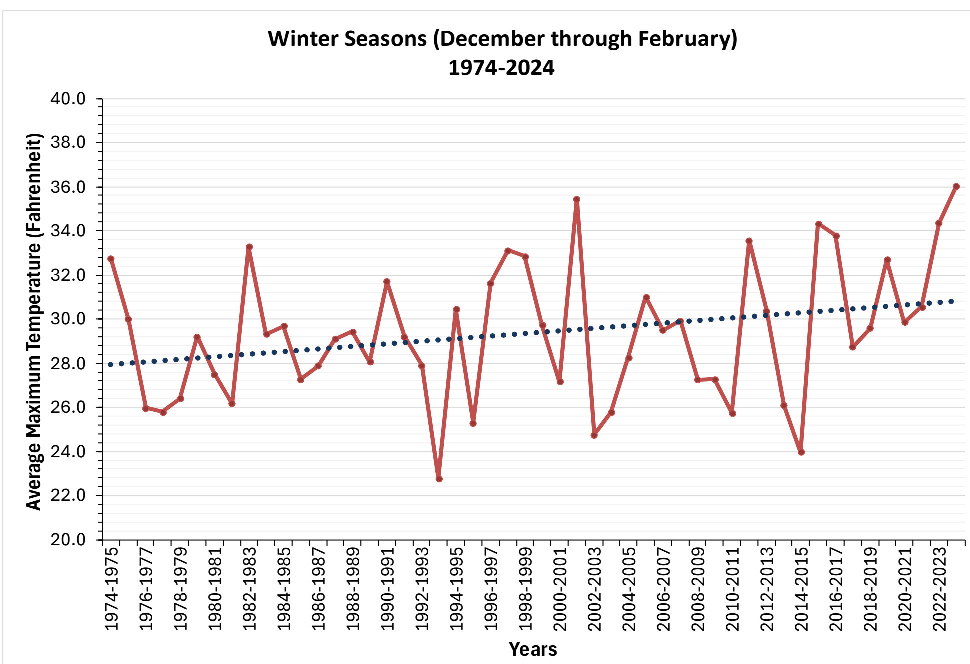

Figure 8. Lowville's average maximum temperature for the winter seasons 1974-2024.

3.3.2 Tug Hill Snowfall Data

All four stations have a 50-year snowfall dataset from 1974 to 2024. Snowfall totals are analyzed for winter and extended winter seasons.

- As mentioned in Section 3.3.1, the winter season is December, January, and February. The extended winter season is from September through May.
    - For example, the 2023-2024 season includes September through December 2023 and January through May 2024.
- The winter season's snowfall totals were determined by adding the monthly snowfall values for December, January, and February. The same process was completed for extended winter seasons from September through May.

The following graphs are shown for each station's winter season in the alphabetical order of Bennetts Bridge, Boonville, Highmarket, and Lowville.

- The blue bars indicate the amount of snowfall in inches for each season.
- The orange dotted line on each graph is the trendline.
    - The trendline is added to show the overall pattern or direction of the data. It helps to understand if the data points indicate increasing or decreasing trends or remain unchanged over the analyzed period.
    - The trendline is like drawing a smooth path through a bumpy trail, helping one see the general direction even if there are ups and downs.

Section 4 summarizes the results and provides more information about the data. Note that for Boonville, the seasons of 1977-1978, 1978-1979, 2006-2007, and 2007-2008 were removed from the graph because the dataset was incomplete for at least two months. All data analyzed can be found in Appendix C.

Bennetts Bridge

Winter Season Snowfall Totals: The winter seasons from 1974 to 2024 indicate snowfall totals have decreased (Figure 9). The extended winter seasons show the same results, which can be found in Appendix A.

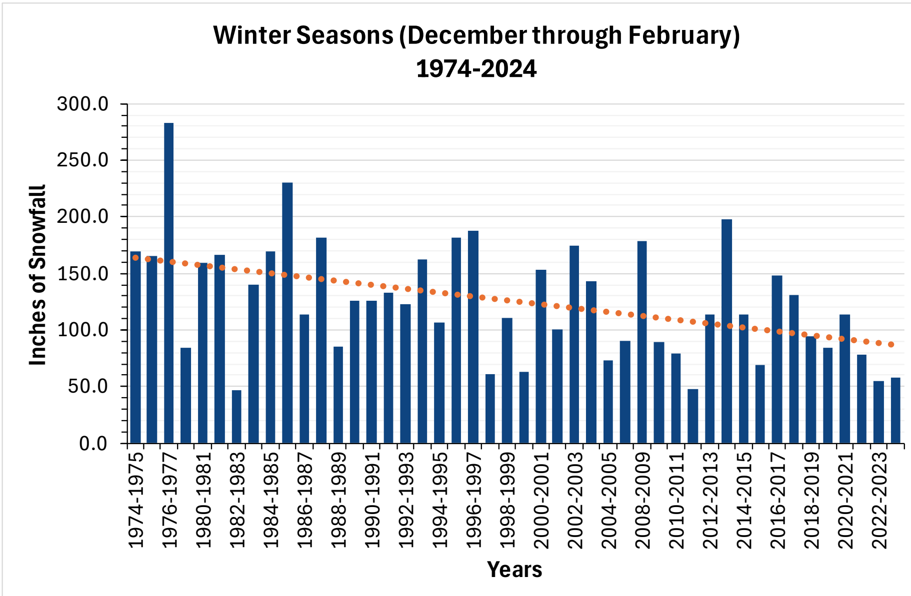

Figure 9. Bennetts Bridge snowfall totals for the winter seasons 1974-2024.

Boonville

Winter Season Snowfall Totals: The winter seasons from 1974 to 2024 indicate snowfall totals have decreased (Figure 10). The extended winter seasons show the same results.

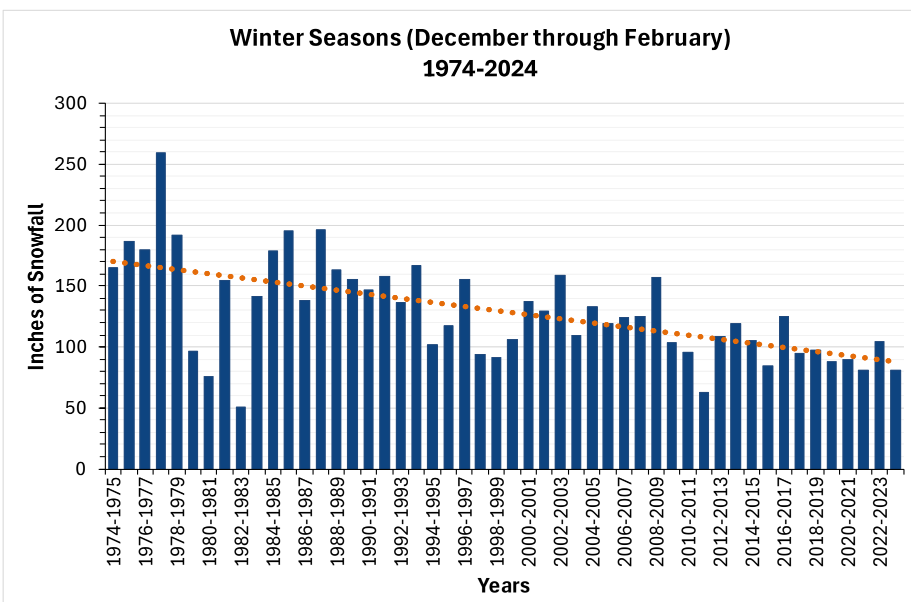

Figure 10. Boonville snowfall totals for the winter seasons 1974-2024.

Highmarket

Winter Season Snowfall Totals: The winter seasons from 1974 to 2024 indicate little to no change in snowfall amounts (Figure 11). The extended winter seasons show the same results.

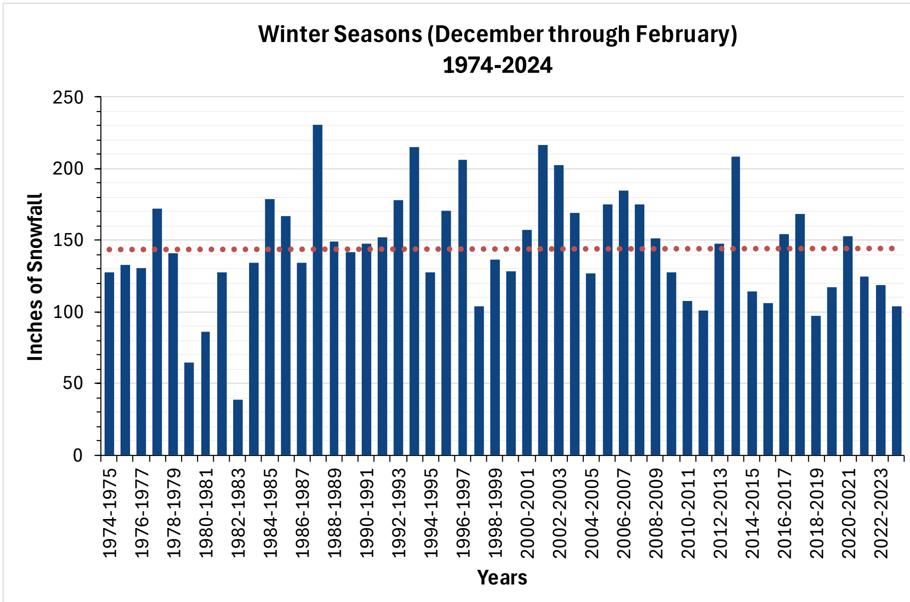

Figure 11. Highmarket snowfall totals for the winter seasons 1974-2024.

Lowville

Winter Season Snowfall Totals: The winter seasons from 1974 to 2024 indicate little to no change in snowfall amounts (Figure 12). The extended winter seasons show the same results.

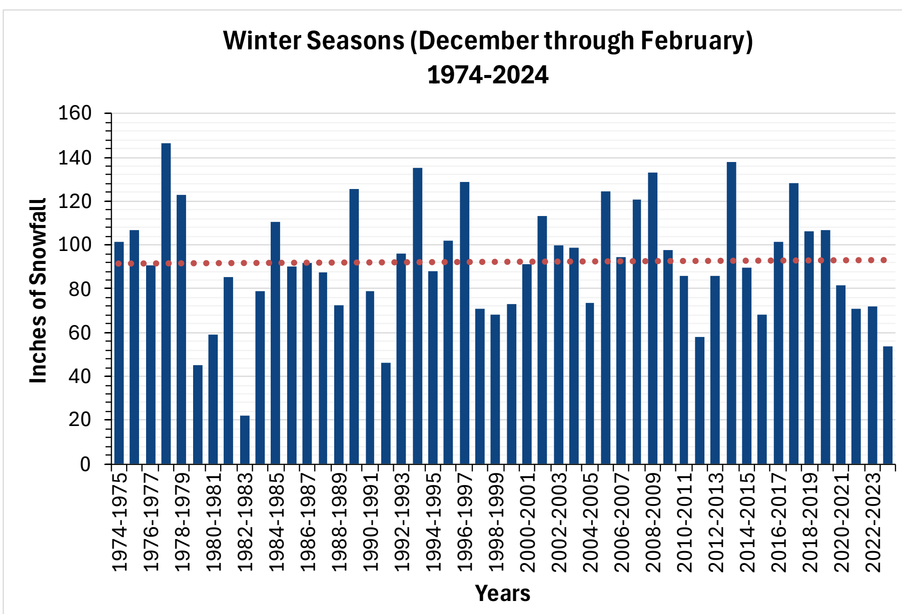

Figure 12. Lowville snowfall totals for the winter seasons 1974-2024.

3.4 Tug Hill Climate Normals: Comparing Winter Months

Average maximum (high) and minimum (low) air temperature and snowfall totals are compared to the climate normals provided by NCEI for January, February, March, November, and December 1991-2024. The months are listed chronologically because comparisons are made by year, not by season, as previously shown in Sections 3.3.1 and 3.3.2.

Note only snowfall climate normals were available for Highmarket, while neither snowfall nor air temperature climate normals were available for Bennetts Bridge. The following graphs show monthly data compared to the climate normals.

- The black line on each graph indicates the climate normal for the month being shown.
- The darker-shaded boxes indicate when a year was above normal.
- The lighter-shaded boxes indicate if a year was below normal.

This level of detail is being shown to understand how each month can vary above or below the climate normal for that period.

- Note that the y-axis (vertical, showing air temperature and snowfall amounts) is not uniformly the same for all months.
    - For example, January is colder than March, so the averages will be lower for January.

Boonville Average Maximum Air Temperature Compared to Normal

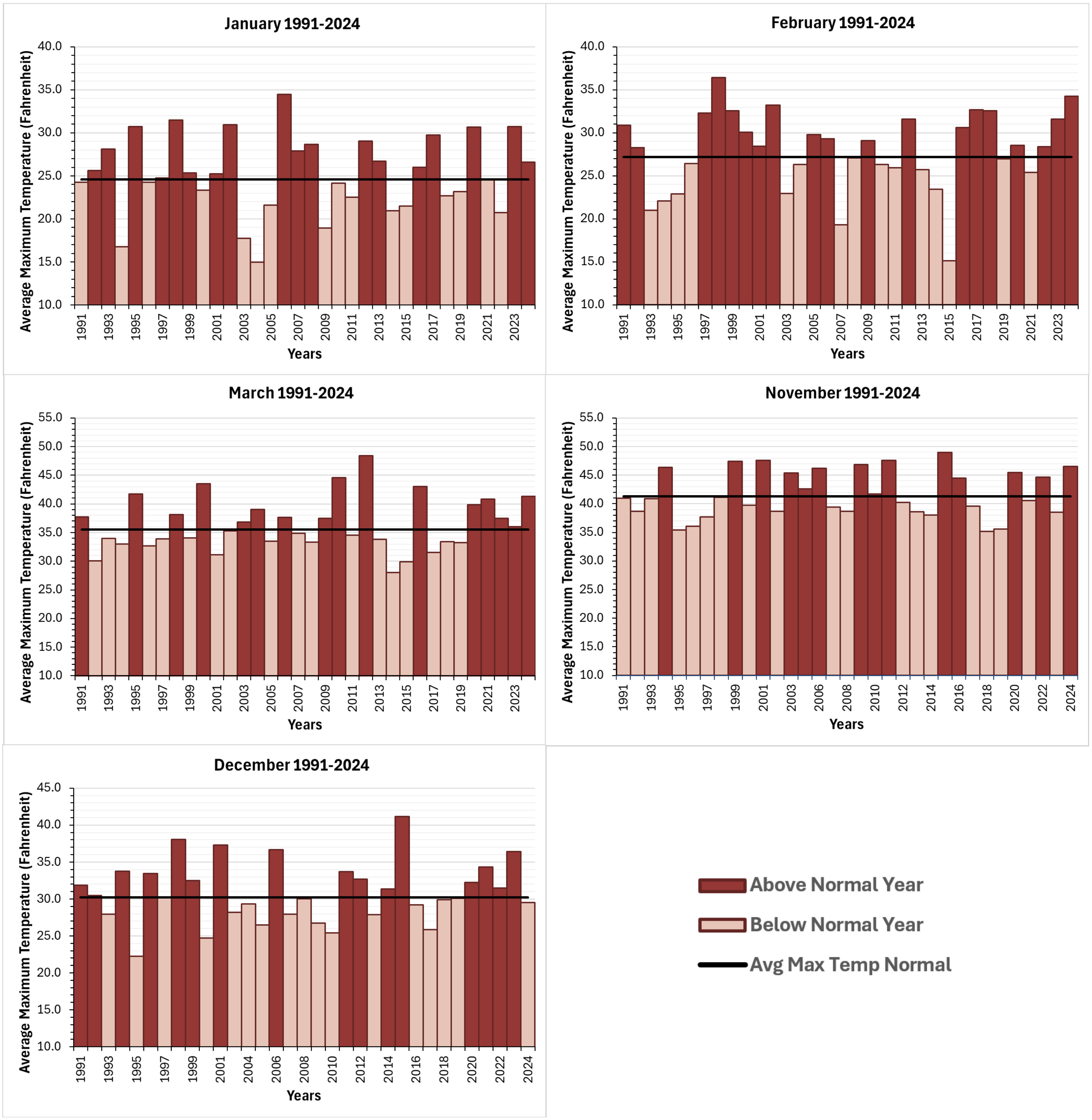

Figure 13. Boonville's average maximum air temperature compared to normal from 1991 to 2024.

Boonville Average Minimum Air Temperature Compared to Normal

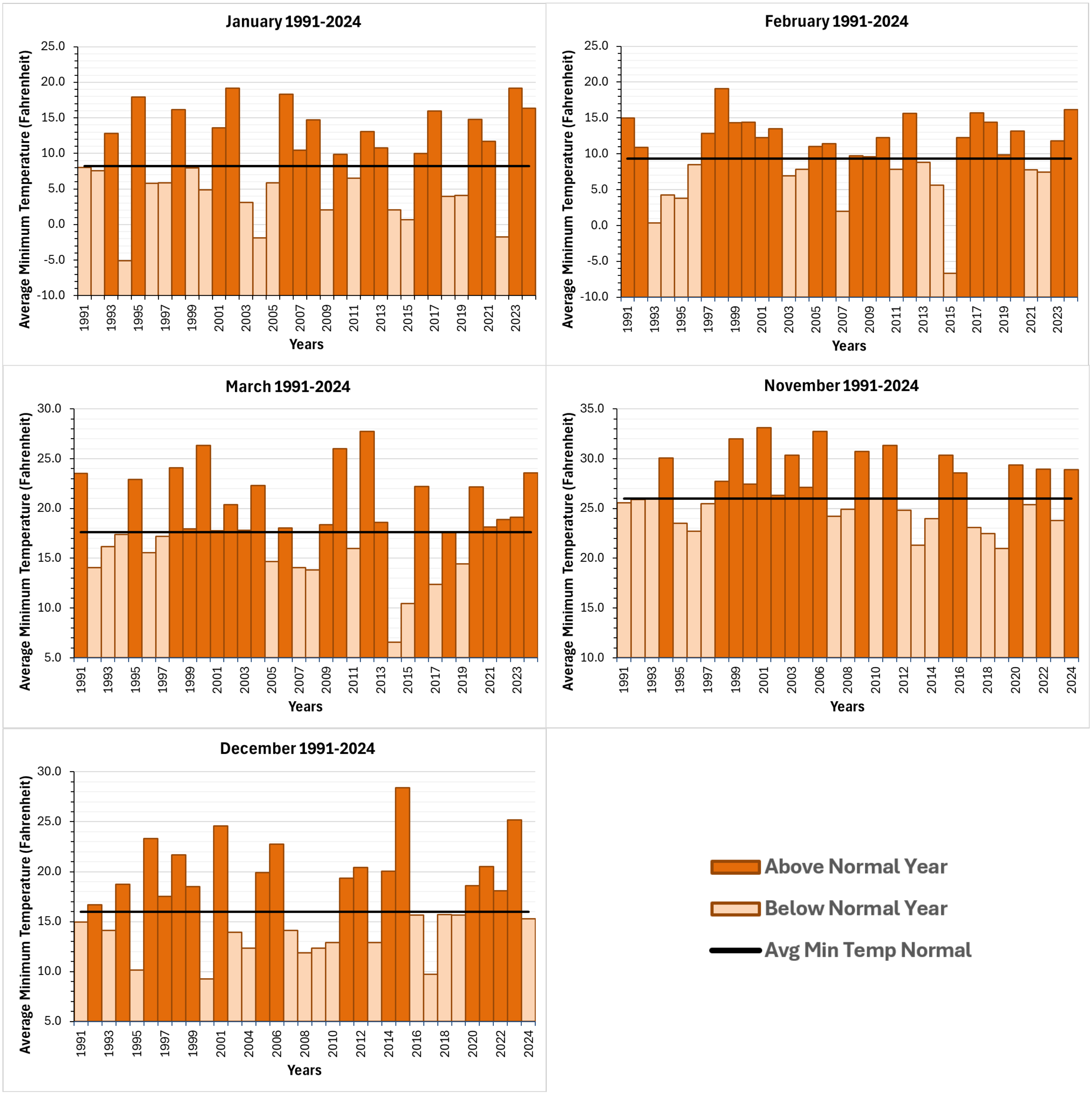

Figure 14. Boonville’s average minimum air temperature compared to normal from 1991-2024.

Boonville Snowfall Compared to Normal

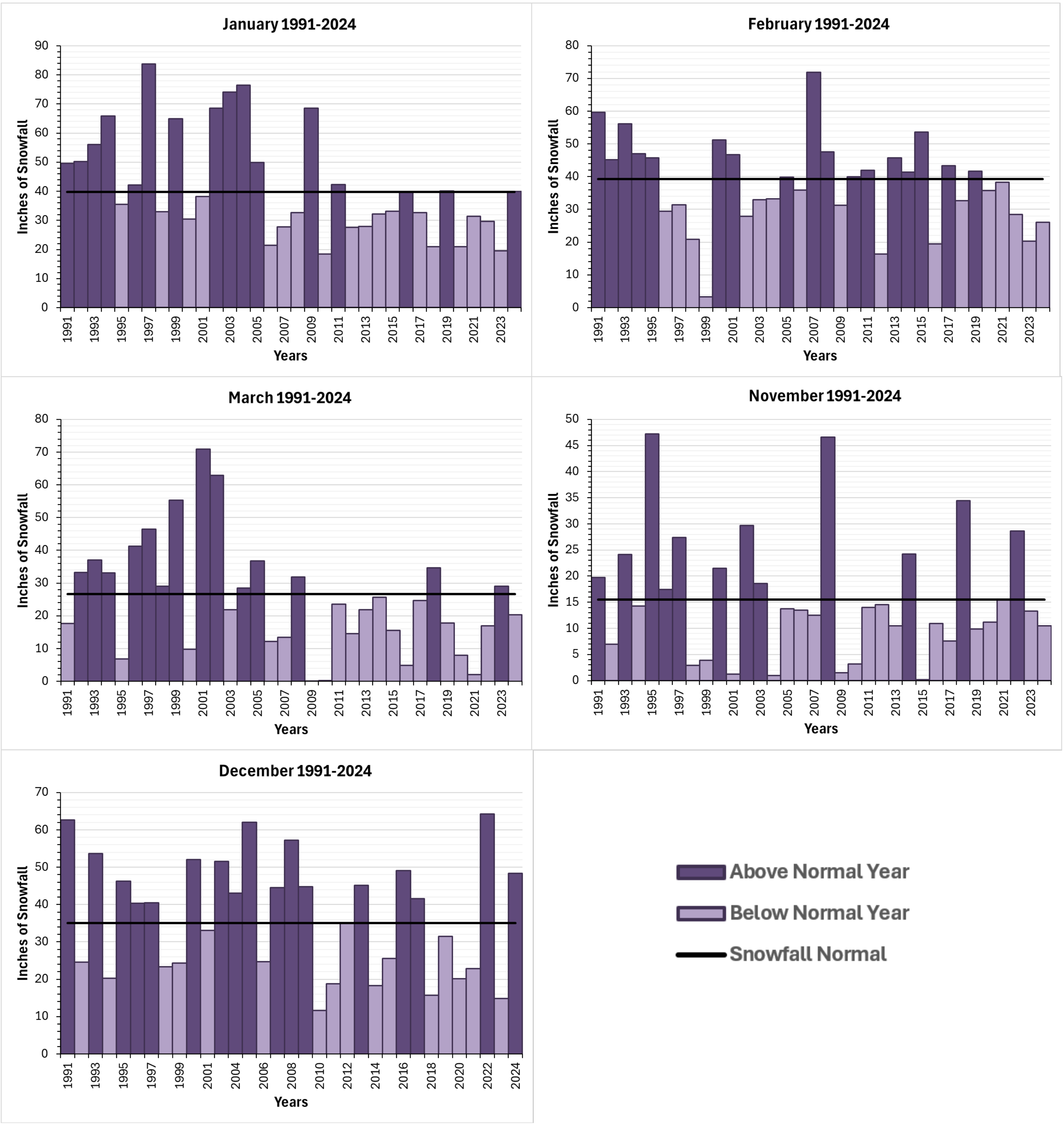

Figure 15. Boonville's snowfall normals compared to normal from 1991-2024.

Highmarket Snowfall Compared to Normal

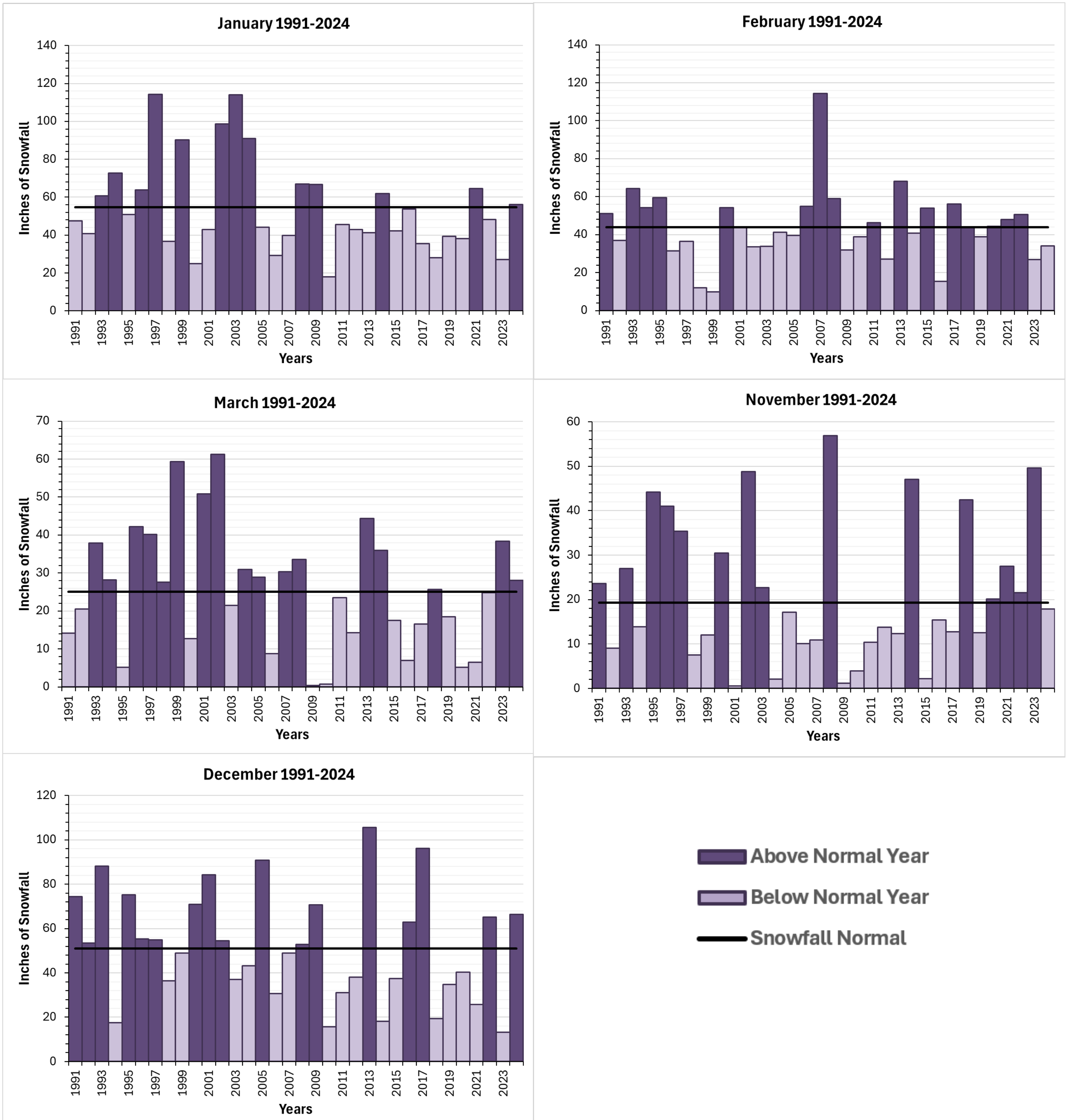

Figure 16. Highmarket's snowfall compared to normal from 1991-2024.

Lowville Average Maximum Air Temperature Compared to Normal

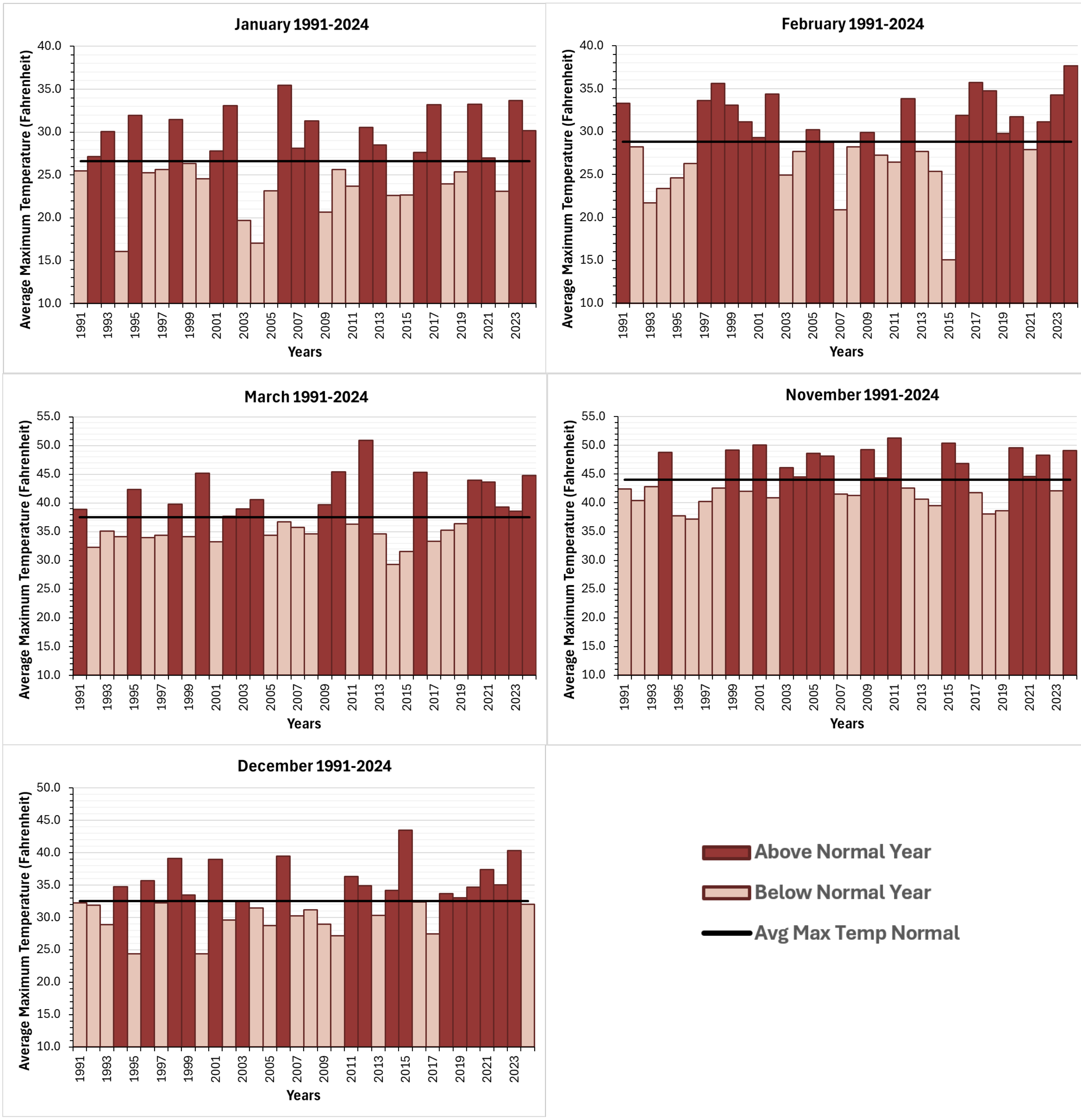

Figure 17. Lowville's average maximum air temperature compared to normal from 1991-2024.

Lowville Average Minimum Air Temperature Compared to Normal

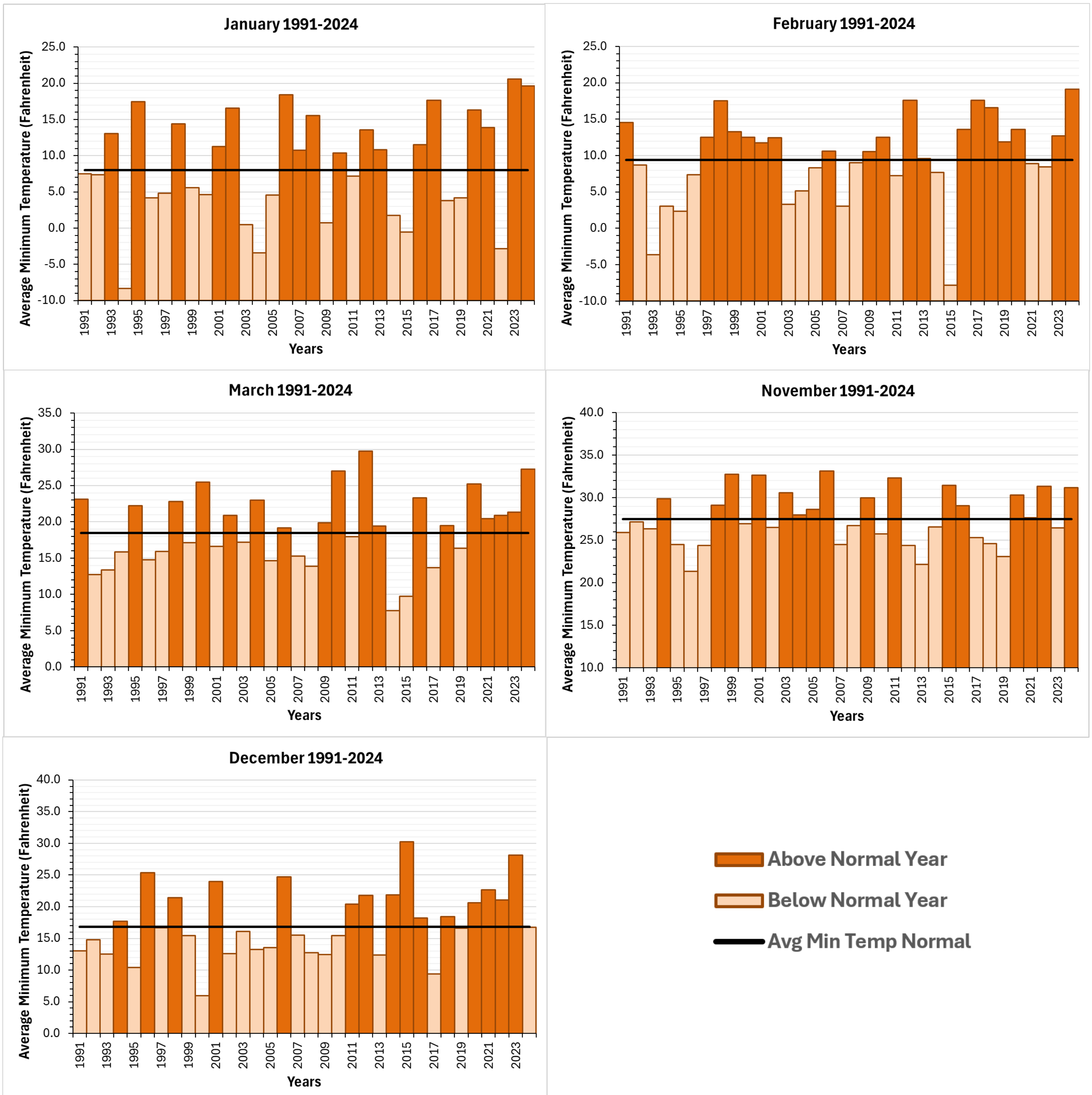

Figure 18. Lowville’s average minimum air temperature compared to normal from 1991-2024.

Lowville Snowfall Compared to Normal

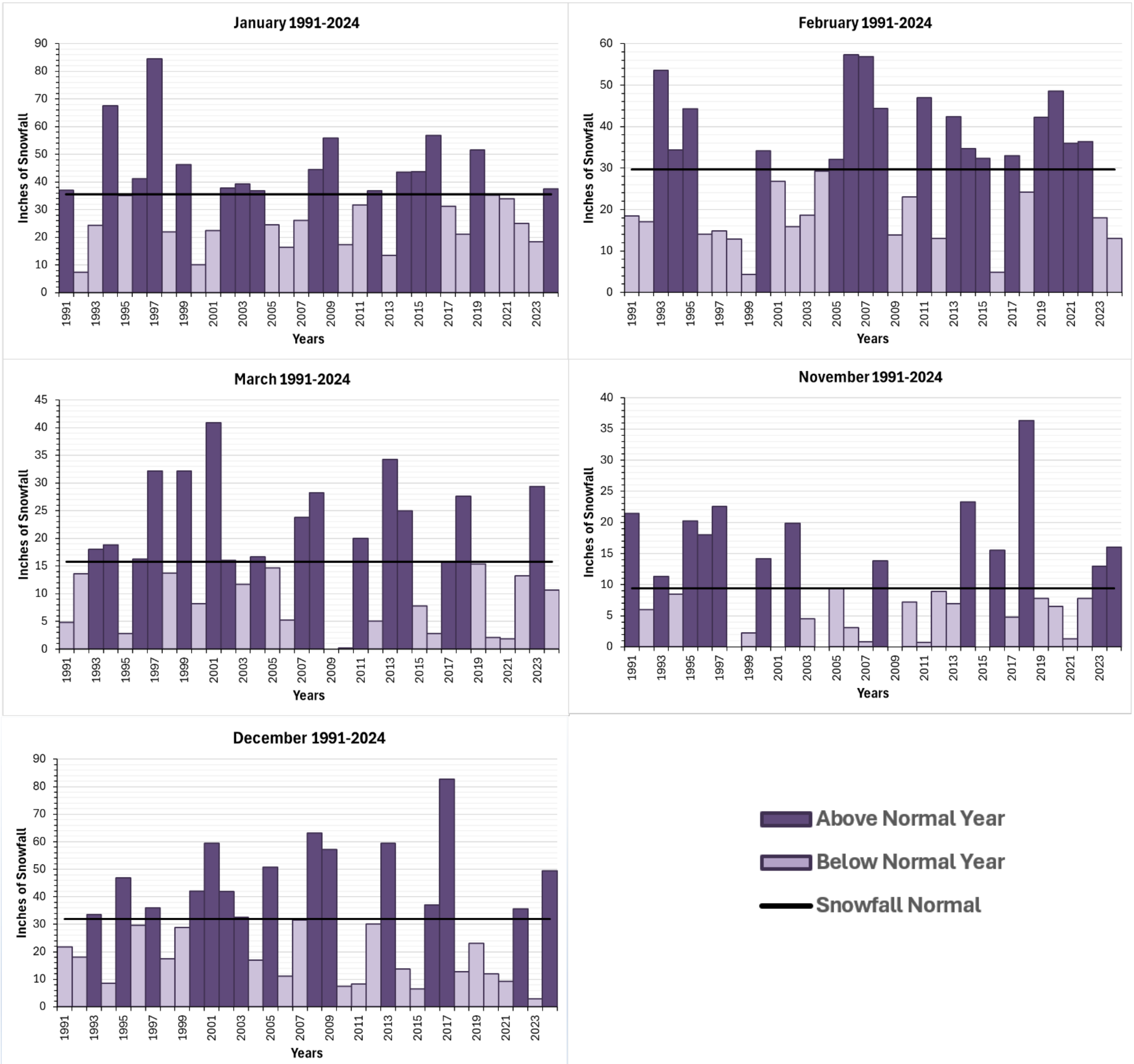

Figure 19. Lowville's snowfall compared to normal from 1991-2024.

4. Results

These graphs can tell a story, showing how snowfall and air temperatures change over time. Table 2 presents each station's average minimum and maximum air temperature trends. Over the past 50 years, all four stations have shown increasing minimum and maximum temperatures, indicating a warming trend.

Table 2. Average minimum and maximum air temperature trends for the four stations' winter and extended winter seasons.

<table>
<tr><th rowspan="2">Station</th><th colspan="2">Average Minimum Air Temperature</th><th colspan="2">Average Maximum Air Temperature</th></tr>
<tr><th>Winter Season</th><th>Extended Winter Season</th><th>Winter Season</th><th>Extended Winter Season</th></tr>
<tr><td>Boonville</td><td rowspan="2">Increasing/warming</td><td rowspan="2">Increasing/warming</td><td rowspan="2">Increasing/warming</td><td rowspan="2">Increasing/warming</td></tr>
<tr><td>Lowville</td></tr>
</table>

Note Bennetts Bridge and Highmarket were not evaluated.

Table 3 also displays snowfall trends. Bennetts Bridge and Boonville show a decline in snowfall over the 50-year period, while Highmarket and Lowville exhibit relatively stable snowfall trends with little change.

Table 3. Snowfall trends for the four stations' winter and extended winter seasons.

Station	Snowfall Trend	
	Winter Season	**Extended Winter Season**
Bennetts Bridge	Decreasing	Decreasing
Boonville	Decreasing	Decreasing
Highmarket	Steady/little change	Steady/little change
Lowville	Steady/little change	Steady/little change

Key Results: Overall, winters are changing in the Tug Hill region. The data indicate that temperatures are increasing. Additionally, two stations have a decreasing trend, or reduction, in snowfall, and two have little to no change.

The following section will explore questions related to these results, including why air temperatures indicate a warming trend and what this means for Tug Hill winters.

5. Discussion: What is causing air temperatures to warm?

People are observing changing weather patterns and conditions in the Tug Hill region and throughout the world. Questions are being asked about winter conditions. Will there be enough snow to snowmobile? Will the winter be cold enough to keep the snowpack? Will winter events be canceled? How will this winter impact business? These are valid questions as winter conditions are changing, especially given that this analysis identified warming temperatures in the Tug Hill region.

What is causing air temperatures to warm? Scientists can reconstruct climate as far back as 570 million years ago on a geologic time scale. Over these periods, the climate has changed, with several ice ages occurring about 18,000 years ago, a cooling period occurring approximately 10,200 years ago, and a warming period peaking about 5,500 years ago (Hidore et al. 2010, 185-186). The Earth then went through a warming period between years 950-1250, known as the Little Climatic Optimum or Medieval Warm Period, and then between 1250-1450, the climate widely cooled, and from 1450-1850, the Little Ice Age occurred. By the end of the 19th century, instrumental records show the climate started to warm, and the 20th century also had both warm and cool times; however, an exceptionally warm period started in the 1980s and continues today (Hidore et al. 2010, 185-190).

The fundamental reason why the Earth's climate undergoes changes is because change is related to how energy flows into and out of the system and how energy is exchanged within the Earth-ocean-atmosphere system. Natural changes can affect the energy system on "short-term scales," for example, variations in solar irradiance (or solar energy given off from the sun). It is incorrect to explain that the change in climate experienced today is solely based on these natural factors (Hidore et al. 2010, 166-173).

The greenhouse effect makes all life possible on Earth. It is a complex interchange between the Earth's surface and the atmosphere. The atmosphere is made up of nitrogen (78.084%), oxygen (20.946%), argon (0.934%), carbon dioxide (0.042%), and other trace gases, such as neon, helium, methane, and more (NOAA 2021a). Greenhouse gases include carbon dioxide, methane, ozone, nitrous oxide, chlorofluorocarbons, and water vapor (NASA 2020a; NASA 2020c). Greenhouse gases are energy absorbers because they trap heat, with carbon dioxide, methane, and nitrous oxide contributing the most to warming (NCAR 2024).

The greenhouse effect is when the sun emits shortwave solar radiation (i.e., energy from the sun that reaches the Earth as light and heat), followed by the Earth emitting longwave radiation (i.e., giving off heat) back into the atmosphere, which is absorbed by greenhouse gases (Figure 20) (Lutgens and Tarbuck 2013, 54). Longwave radiation is when the Earth releases heat back into the atmosphere. The Earth warms because heat is trapped near the Earth's surface by greenhouse gases. Think of greenhouse gases acting as a blanket around the Earth. Some of the Earth's longwave radiation, or heat, reflects back into space, but greenhouse gases (the blanket) trap the rest in the atmosphere. This is a complicated game of "hot potato," but without this "blanket" surrounding the atmosphere, the surface temperature would be 0°F, and all water on Earth would be frozen (Lutgens and Tarbuck 2013, 54).

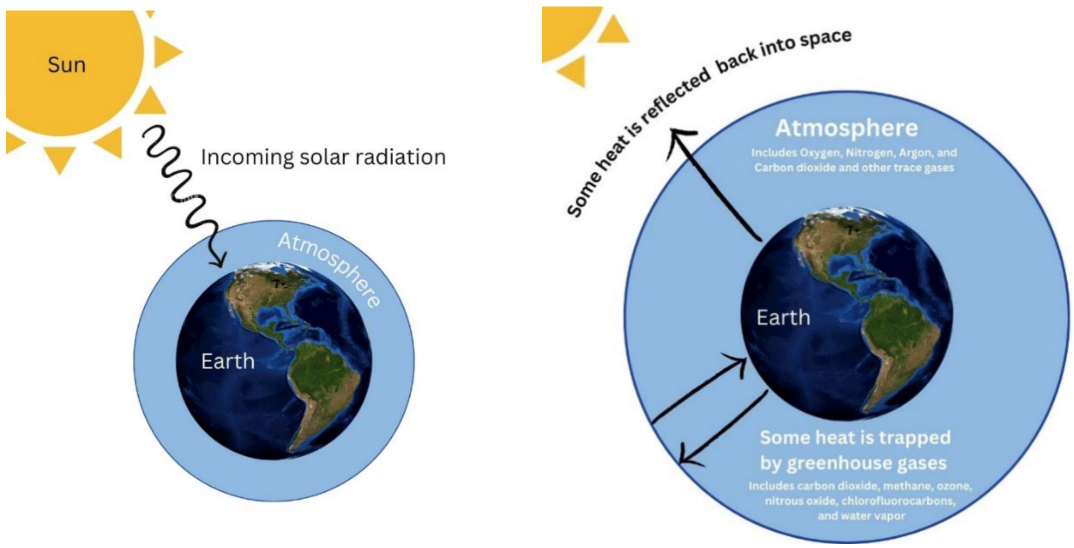

Figure 20. The greenhouse effect.

Carbon dioxide (CO_2) is the most important greenhouse gas because it is very good at trapping heat emitted from the Earth's surface (longwave radiation), influencing how much the atmosphere warms. A direct relationship, or trend, exists between increasing CO_2 levels and air temperature. As CO_2 levels increase, the blanket thickens, causing more heat to become trapped, which causes air temperatures to increase (or warm).

The Global Monitoring Laboratory has measured CO_2 using a globally distributed network of air sampling sites for several decades (Conway et al. 1994). Scientists call this the Keeling Curve (Scripps Institution of Oceanography 2025). Figure 21 shows how global CO_2 levels have increased over time (Lan et al. 2025). Appendix B provides more information about greenhouse gases.

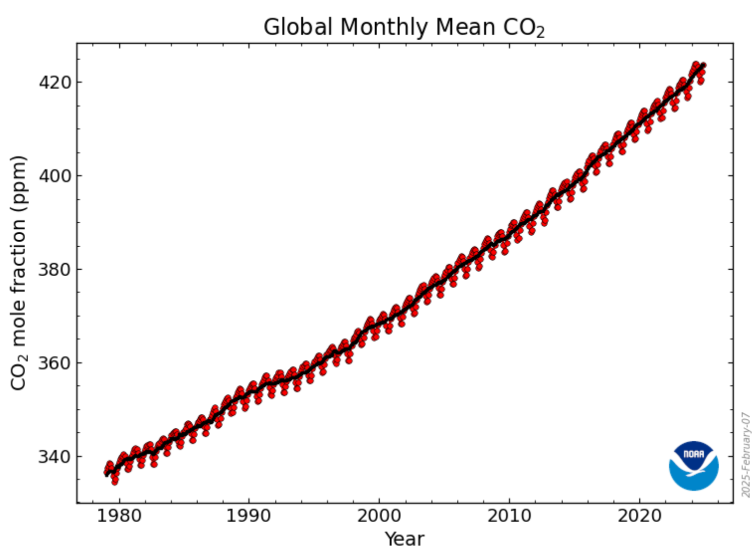

Figure 21. Global monthly average CO_2 levels. Source: Lan et al. 2025

CO_2 levels are higher than they have ever been recorded in the past 800,000 years (Figure 22). Scientists have been able to reconstruct what past climates used to be using proxy data, which are observations of other variables that serve as a substitute or proxy for the actual climatic record. Proxies are paleoclimatological archives, such as ocean sediments, mountain glaciers, ancient soils, ice sheets, bog or lake sediments, ice cores, tree rings, written records, and archeological records (Hidore et al. 2010, 176). Appendix B goes into further detail about CO_2 levels. The question then becomes, why are CO_2 levels so high? The answer is human activities (Hidore et al. 2010, 194; Lutgens and Tarbuck 2013, 392; NOAA 2019; NASA 2024a).

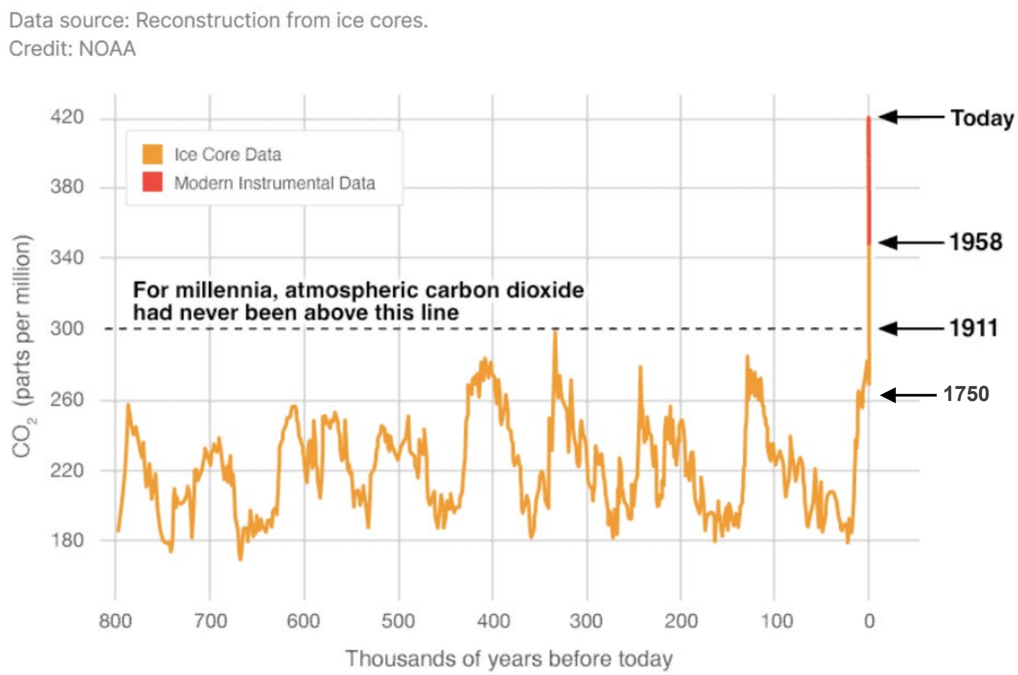

Figure 22. NOAA data showing CO_2 levels from 800 thousand years ago through today. The orange line is ice core data, and the red line is modern instrumental data. Source: NOAA, n.d.

In 1956, Gilbert Plass researched and concluded that industrial and other human activities are adding "considerably more" carbon dioxide than any natural cause. Another term often used is anthropogenic, which means changes caused or influenced by people, either directly or indirectly (USGS 2015). Scientists refer to this as anthropogenic changes, or human-caused changes. Human activities have increased carbon dioxide in the atmosphere by 50 percent. This means the carbon dioxide level is 150 percent of its value in 1750 (around the start of the Industrial Revolution) (NASA 2024a).

Current, real-time CO_2 level measurements are available. To see, visit: https://climate.nasa.gov/vital-signs/carbon-dioxide/?intent=121

Carbon is abundantly found in the Earth as fossil fuels in the form of coal, oil, and natural gas. When additional carbon dioxide is released into the atmosphere from burning fossil fuels, over time, it acts as if another blanket has been knitted and placed around the atmosphere, trapping heat from being released into space and, therefore, increasing the atmosphere's air temperature.

The increase in the atmosphere's air temperature is global warming. Global warming is the long-term heating of Earth's surface caused by human activities since the pre-industrial period (between 1850 and 1900). The term is often used interchangeably with climate change, but this is incorrect (NOAA 2015; NASA 2020b; USGS 2022). As previously mentioned, the greenhouse effect is essential for living on Earth; however, human activities have increased the amount of greenhouse gases in the atmosphere to a point where it contains, or traps, the excess heat that would otherwise be emitted, or go, into space, which has caused the Earth's air temperature to increase, called global warming.

Warming air temperatures have widespread physical impacts on the environment. This ranges from rising sea levels, changing weather patterns, ecosystem changes, economic impacts, health risks, and more. The long-term change in average weather patterns that the Tug Hill region and the world beyond observe is called climate change (NASA 2020b). In other words, climate change is the long-term change being observed in weather conditions, such as precipitation, flooding, droughts, heat waves, and hurricanes. Climate change is a term widely used and is not the same as global warming. Climate change can result in more drastic events, whether that means seasons with very little snowfall or seasons with extremely high snowfall amounts.

As mentioned above, it is true the Earth has undergone climactic changes throughout millions of years. However, natural changes (e.g., variations in solar irradiance, sunspot activity, and atmospheric dust) and long-term changes (e.g., the angle of the Earth's axis and distance from the Earth to the sun) cannot be considered solely on their own to explain why carbon dioxide levels have increased. Human factors increase carbon dioxide emissions, which thickens the "blanket" around the Earth's atmosphere, trapping heat and increasing air temperatures (i.e., global warming). Increasing air temperatures cause changes in weather patterns, called climate change.

6. What does this mean for the Tug Hill region?

Winters are changing in the Tug Hill region. The data indicate that temperatures are increasing. Additionally, two stations have a decreasing trend, or reduction, in snowfall, and two have little to no change. Warming air temperatures can impact winter weather, affecting freeze-thaw cycles for agriculture, road and trail maintenance, and winter recreation.

Find the NYS Climate Impact Assessment online here: https://nysclimateimpacts.org/

The NYS Climate Impacts Assessment explores current and future climate change impacts on communities, ecosystems, and the economy in New York State. Over 250 New York-based, national, and Indigenous climate science experts and representatives from communities and industries across the state contributed to the assessment. It provides an in-depth analysis of how a changing climate impacts the state, including agriculture, buildings, ecosystems, energy, human health and safety, society and economy, transportation, and water resources.

In Chapter 2, Section 3, New York State's Changing Climate, the annual average temperature for the state is graphed from 1901-2022 (Figure 23). Since 1901, the average temperature has increased by almost 2.6°F, and the warmest 10-year period has been since 2000. The assessment further details projected temperature increases for the future as well, including the Tug Hill region, to increase by 4.6-6.7°F by the 2050s and 6.1-10.9°F by the 2080s.

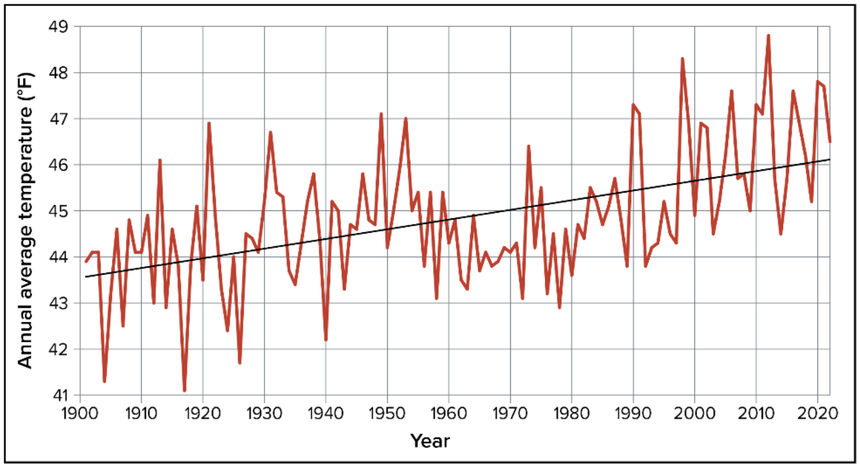

Figure 23. Annual average temperature in New York State, 1901-2022. Source: Lamie et al. 2024

In this paper's evaluation, Figures 9 and 10 in Section 3 show decreased snowfall in Bennetts Bridge and Boonville over the 50-year timeframe, while Highmarket and Lowville data (Figures 11 and 12) show little to no change over the same timeframe. This is still symptomatic of a changing climate. Warming air temperatures are causing more variability in snowfall, making it a challenge to plan ahead for winter seasons.

The Tug Hill region is highly influenced by lake-effect snowfall, and increasing air temperatures can affect this. Lake-effect snow is fueled by open water. As air temperatures rise, lakes also warm, reducing how long a lake is frozen over. Since lake-effect snow is highly influenced by open water, a warmer lake with little to no ice for a longer time increases the potential for more lake-effect snow events. The State of the Great Lakes keeps track of Lake Ontario's surface water temperature and ice cover data and shows a warming trend and decrease in ice cover over nearly 50 years (EPA and Canada 2022). Lars Rudstam and James Jackson from the Cornell Biological Field Station have ice cover data for Oneida and Cazenovia lakes from 1826 to the present day, showing an increasing rate of lake ice loss. The flip side is that warmer air temperatures cause warmer winters, and while lake-effect snowfall may occur, it may also be too warm for it to snow, again making planning challenging. The NYS Climate Impacts Assessment also notes this in Chapter 2, Key Finding 2.

Oneida and Cazenovia lakes ice cover data is available online at doi:10.5063/F1KK9989.

Looking ahead, warmer winters and variability in snowfall mean Tug Hill residents may need to consider different approaches to winter recreation and trail and road maintenance. Warmer winters will lead to less ice on lakes, which can decrease the amount of ice fishing. As mentioned, it can impact snowfall and, therefore, snowmobiling, skiing, snowshoeing, and other winter recreation activities and events. It could also impact the Tug Hill Aquifer because snowmelt helps to recharge it. Diversifying winter recreation may also need to be considered. The impacts on winter recreation can also influence the local economy.

Planning for more variability and extremes in winter will be important. More extreme snowfall events could lead to increased salt and plow usage and impacts on homes and businesses, including building collapses. Warmer winters can lead to more freezing and thawing events, impacting trails and roads, and ice can lead to more injuries and accidents, resulting in more emergency services being needed.

Tug Hill Tomorrow Land Trust notes how climate change can impact bird species, agriculture, wildlife, fish and aquatic life, forests and woodlands, invasive species, communities, and human health as well. Find out more online at https://tughilltomorrowlandtrust.org/climatechange/impact/.

The 2025 winter season will likely be one that Tug Hill residents remember. While the data were not analyzed in the 50-year dataset because the winter season is not yet complete, Table 4 shows January and February 2025 snowfall totals for the four stations compared to their snowfall normals.

Table 4. January and February 2025 snowfall totals compared to snowfall normals.

Station	**Snowfall (inches)**		**Snowfall Normals (inches)**	
	January 2025	February 2025	January	February
Bennetts Bridge	26	Data unavailable	Not Available	
Boonville	97.3	69.7	39.7	39.2
Highmarket	95.1	62	54.8	43.8
Lowville	58.9	35.8	35.6	29.6

7. Conclusions

The Tug Hill region is known for its winter seasons. As Harold Samson wrote in 1971, “Tug Hill is, and always has been, noted for its winter snows.” This paper aims to help residents, municipalities, businesses, and organizations understand how and why winter seasons are changing in the region.

Data show that the average minimum (low) and maximum (high) air temperatures are increasing at all four stations. Snowfall trends, however, vary—two stations recorded decreasing snowfall, while the other two showed little to no change over time. Despite these differences, the overall warming trend aligns with broader climate change patterns, where rising temperatures can lead to more variable snowfall and shifting winter conditions.

Future research on winter seasons could include analyses of snowpack and the number of days above and below freezing. Additionally, studying spring and summer temperatures and rainfall patterns–including intensity, frequency, and dry periods–would help assess climate trends in the Tug Hill region. Developing a model to better understand past changes in climate and forecast future conditions would also help understand how lake-effect snow is affected by climate change and support future planning efforts.

Tug Hill communities may need to prepare for greater variability and extremes in winter conditions. This could mean incorporating proactive measures into comprehensive plans or adjusting winter recreational events to account for changing snowfall patterns. While the causes of these shifts are complex, understanding them is essential for planning the Tug Hill region’s future.

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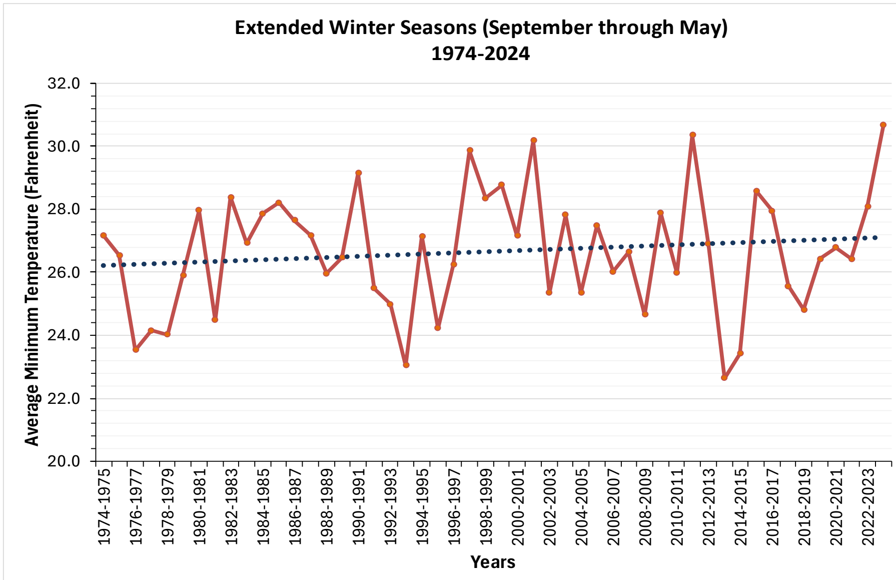
Appendix A

Extended Winter Seasons

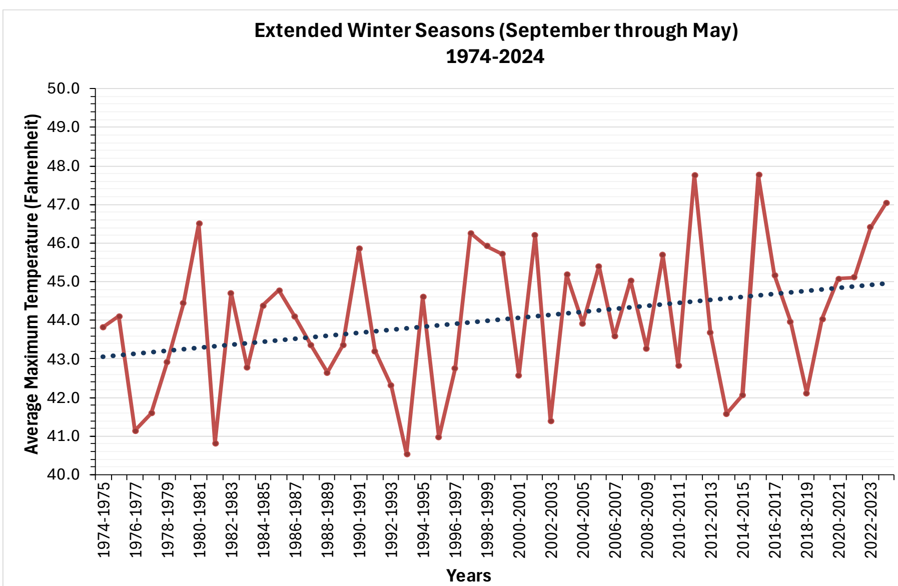
This appendix provides the supplemental extended winter season graphs for average minimum and maximum air temperature and snowfall totals. It begins with air temperature graphs for Boonville and Lovwille, followed by snowfall graphs for Bennetts Bridge, Boonville, Highmarket, and Lowville.

Air Temperature Data

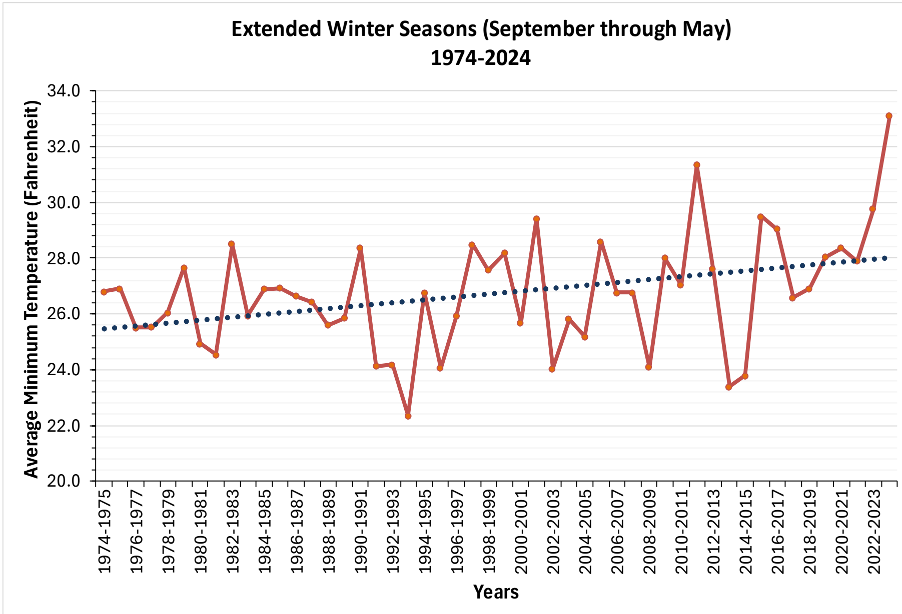
Boonville – Average Minimum Temperature Extended Winter Season: The extended winter seasons from 1974 to 2024 indicate the minimum air temperature is increasing (i.e., getting warmer).



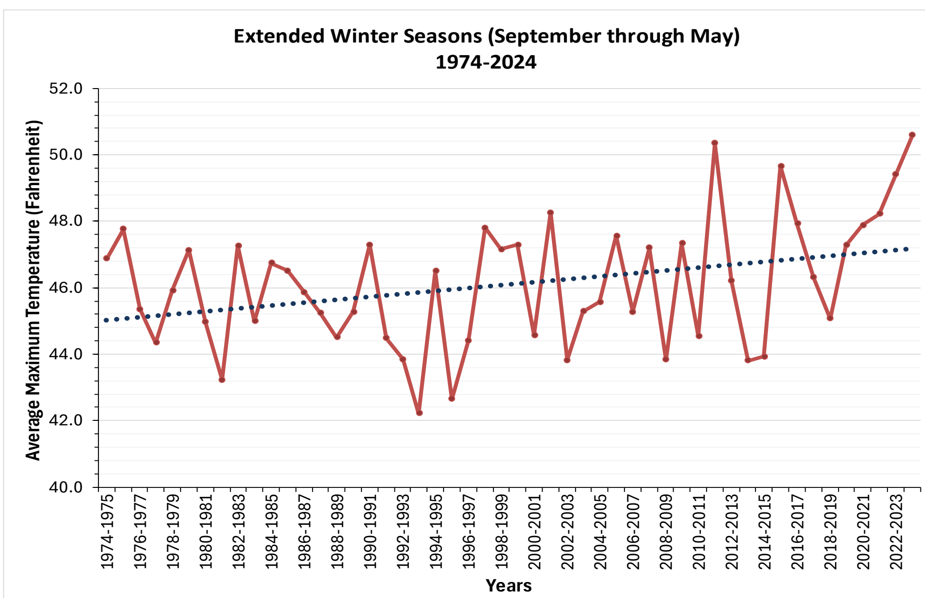
Boonville – Average Maximum Temperature Extended Winter Season: The extended winter seasons from 1974 to 2024 indicate the maximum air temperature is increasing (i.e., getting warmer).



<u>Lowville</u> – Average Minimum Temperature Extended Winter Season: The winter seasons from 1974 to 2024 indicate the minimum air temperature is increasing (i.e., getting warmer).

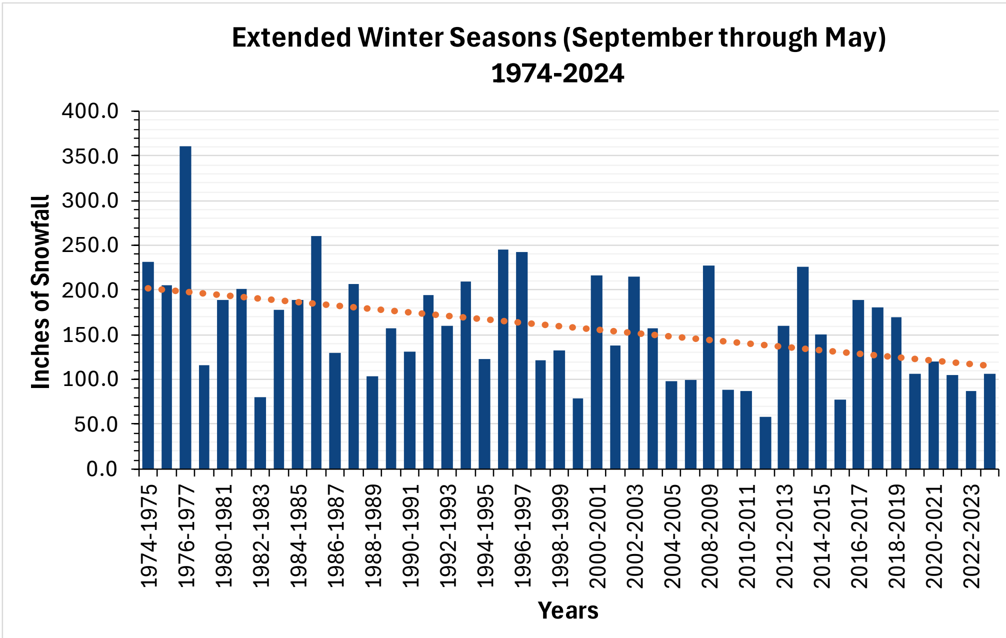


<u>Lowville</u> – Average Maximum Temperature Extended Winter Season: The extended winter seasons from 1974 to 2024 indicate the maximum air temperature is increasing (i.e., getting warmer).



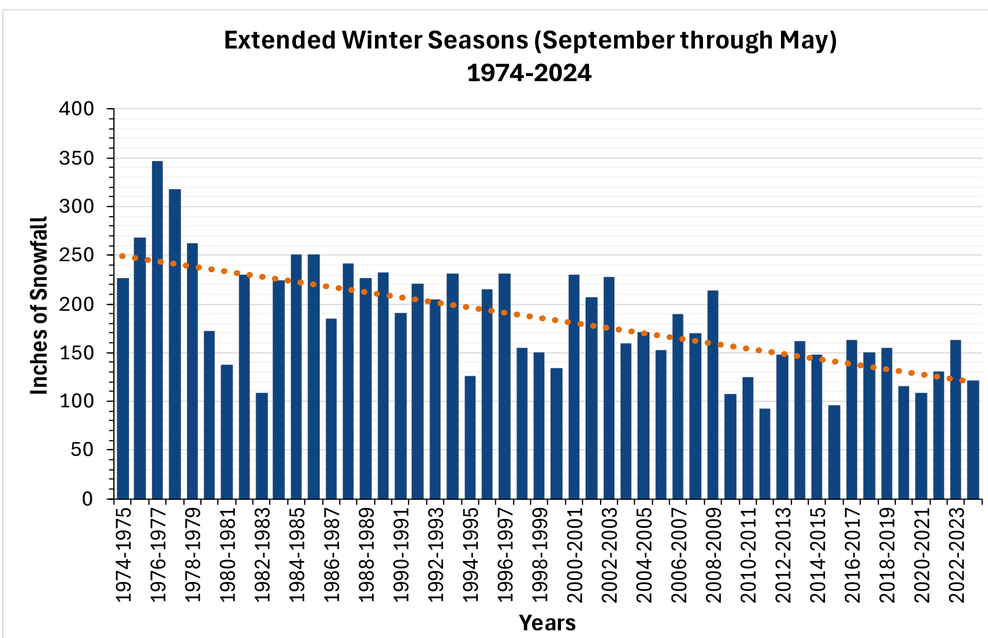
Snowfall

Bennetts Bridge – Extended Winter Season of Snowfall: The extended winter seasons from 1974 to 2024 indicate a decreasing trend in snowfall amounts.

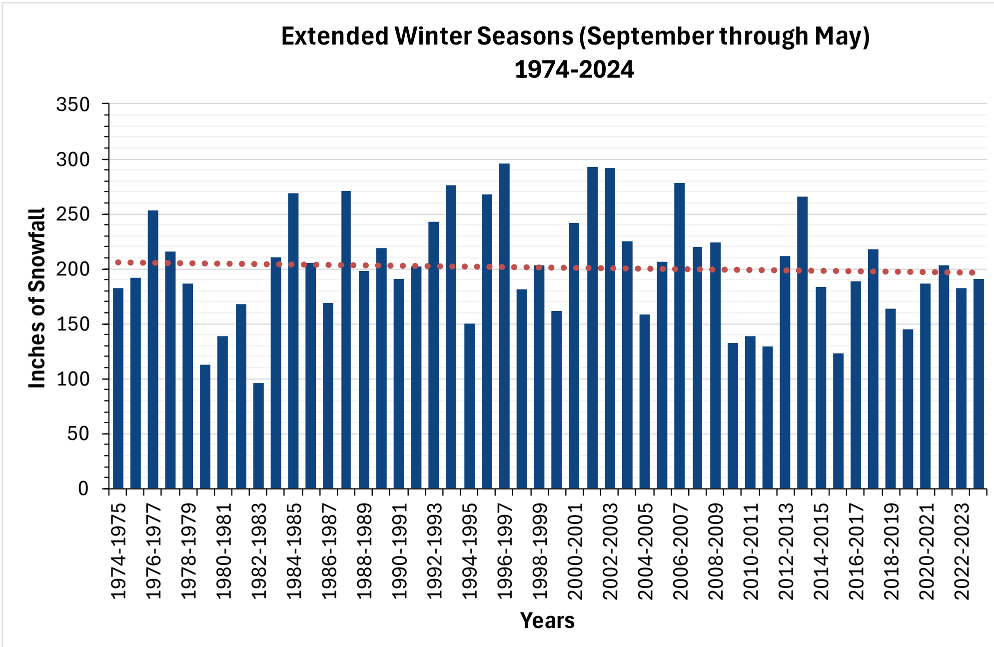


Please note that the seasons of 1977-1978, 1978-1979, 2006-2007, and 2007-2008 were removed from these graphs because the dataset was incomplete for at least two months. See Appendix C for the full dataset.

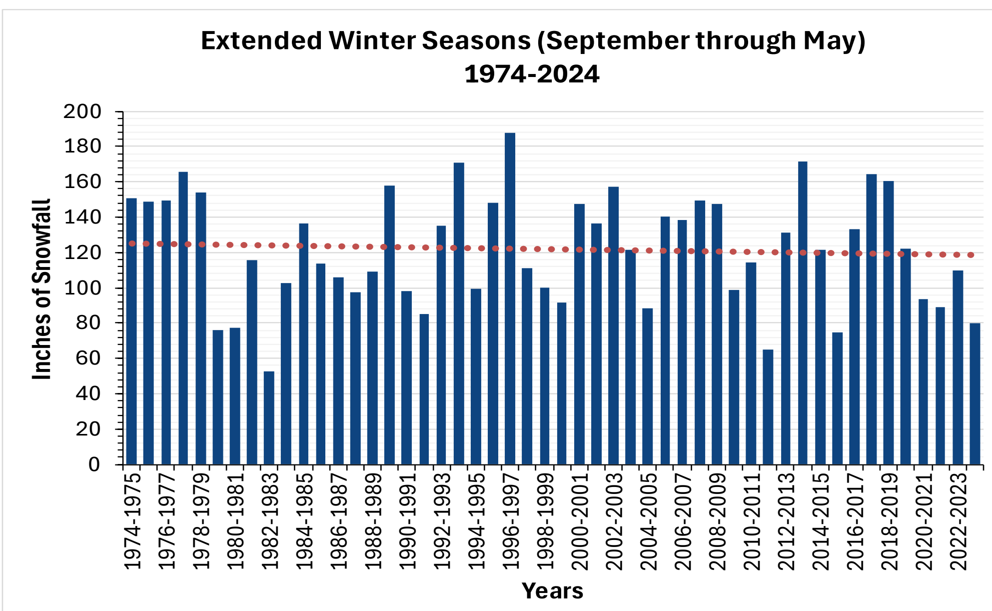
Boonville – Extended Winter Season of Snowfall: The extended winter seasons from 1974 to 2024 indicate a decreasing trend in snowfall amounts.



<u>Highmarket 2 W</u> – Extended Winter Season of Snowfall: The extended winter seasons from 1974 to 2024 indicate little to no change in snowfall amounts.



<u>Lowville</u> – Extended Winter Season of Snowfall: The extended winter seasons from 1974 to 2024 indicate little to no change in snowfall amounts.



Appendix B

Climate Information

Appendix B – Climate Information

This appendix provides further in-depth explanations for climate, including climate history, natural climate cycles, the greenhouse effect, greenhouse gases, global warming and its impacts, and more.

Diving into the Climate: Why are we seeing warming air temperatures?

Climate History

The study of climate has been ongoing for centuries, beginning at least as early as ancient Greek culture. The word climate comes from a Greek word meaning "slope," referring to the slope or inclination of the Earth's axis. The first book about climate was *Airs, Waters, and Places* written by Hippocrates in 400 BC (Hidore et al. 2010, 5).

The 17th century marked the beginning of scientific analysis of the atmosphere. Instruments were designed to measure atmospheric conditions. Galileo invented the thermometer in 1593, and Torricelli invented the barometer in 1643. Boyle discovered the basic relationship between pressure and volume in a gas in 1662 (Hidore et al. 2010, 5).

The 18th century included improving and standardizing instruments, which allowed for extensive data collection and description of regional climates to begin. Carbon dioxide (CO2) was discovered in 1792 (Hidore et al. 2010, 13). The 19th century improved the ability to explain climate through the study of physical processes (Hidore et al. 2010, 5).

Climatic data are measurements of the Earth's climate system, with surface temperature and precipitation being the most widely recorded data. The *National Climate Program Act* (H.R.6669, 95th Congress) was signed into law on September 14, 1978, and was an important event for the development of climatology because the purpose is, "to enable the United States and other nations to understand and respond to natural and man-induced climate processes and their implications."

Natural Climate Cycles

The Earth is 4.5 billion years old, and in that time, the climate has changed. Scientists have been able to reconstruct what past climates used to be using proxy data, which are observations of other variables that serve as a substitute or proxy for the actual climatic record. Proxies are paleoclimatological archives, such as ocean sediments, mountain glaciers, ancient soils, ice sheets, bog or lake sediments, ice cores, tree rings, written records, and archeological records.

One example in further detail is ice sheets, like in Greenland and Antarctica. They hold a lot of important climatic information. Each year, snow falls and builds up layers on the ice sheets. Over time, the snow is compressed into ice, trapping bubbles of air. Scientists can then collect ice cores by inserting hollow tubes into the ice sheets (Hidore et al. 2010, 178). Falling snow often crystallizes around particles in the atmosphere, like pollen, dust, smoke, or volcanic ash, and bubbles of air are trapped within the ice as well, both preserving details about the time the snowflake fell (NSIDC 2021). For example, an ice core from Greenland can show what the climate was like 110,000 years ago, and an Antarctica ice core showed a record as far back as 720,000 years. Ice cores are important to help scientists understand how the climate has changed over time.

Scientists have proven that the climate has gone through periods of warming and cooling. Scientists can reconstruct climate as far back as at least 570 million years ago on a geologic time scale. Over these periods, the climate has changed, with several ice ages occurring, glaciers developing, and glaciers retreating about 18,000 years ago. Both warm and cool periods have occurred since as well. A period of cooling occurred approximately 10,200 years ago, and since then, the climate began to warm, peaking about 5,500 years ago, leaving only the Greenland Ice Sheet and Arctic Ice Sheet that is still on Earth today (Hidore et al. 2010, 185-186).

The years 950-1250 are known as the Little Climatic Optimum or Medieval Warm Period. Evidence from agriculture was used to help reconstruct this time period. Between 1250-1450, the climate widely cooled, and from 1450-1850, the Little Ice Age occurred. During this time, glaciers grew, winters became colder, rivers and lakes froze, and humans were affected, including soldiers in the American Revolution suffering in cold weather. The year 1816 was known as "the year without a summer," and the year had low temperatures throughout, even in May. Indiana experienced snow or sleet for 17 days, severely affecting their crop planting. Snow fell again in June, taking out any remaining crops. The Little Ice Age had detrimental impacts on the Northern Hemisphere and represented a cooling of just 1 degree Celsius (1.8 degrees Fahrenheit) and was not a global event. By the end of the 19^{th} century, instrumental records show the climate started to improve, and the 20^{th} century also had both warm and cool times; however, an exceptionally warm period started in the 1980s and continues to this day (Hidore et al. 2010, 185-190).

Natural Changes in Climate

The fundamental reason why the Earth's climate undergoes changes is because change is related to how energy flows into and out of the system and how energy is exchanged within the Earth-ocean-atmosphere system. As mentioned above, the Earth has undergone climactic changes throughout millions of years. Natural changes that can affect the energy system on "short-term scales" include variations in solar irradiance (or solar energy given off from the sun), sunspot activity, and variation in atmospheric dust. Short-term in this context refers to periods of individual to thousands of years. Long-term changes, as long as millions of years, are influenced by Earth-sun relationships (e.g., the angle of the Earth's axis and distance from the Earth to the sun), continental positions, extraterrestrial impacts (e.g., objects from space striking the Earth), and ocean variations (e.g., sea-surface temperatures) (Hidore et al. 2010, 166-173).

That being said, these factors are on long-term scales and cannot be considered solely on their own. Explaining that the change in climate experienced today is solely based on these factors is incorrect. To show this, Figure 1 displays total solar irradiance (the sun's energy that the Earth receives) and air temperature (in degrees Celsius) and how they have changed since 1880. The yellow lines are total solar irradiance, showing it has actually decreased on average since about 1985, while the red line, air temperature, has continued to increase on average. The increases and decreases shown as the thinner yellow and red lines indicate the yearly data, with the thicker lines representing 11-year average trends. If the air temperature was solely based on solar irradiance, it should be decreasing; however, it continues to increase. Human activity is a significant factor to consider because the natural causes of climate change need to be considered together with the impacts humans have on the Earth and will be discussed in further depth.

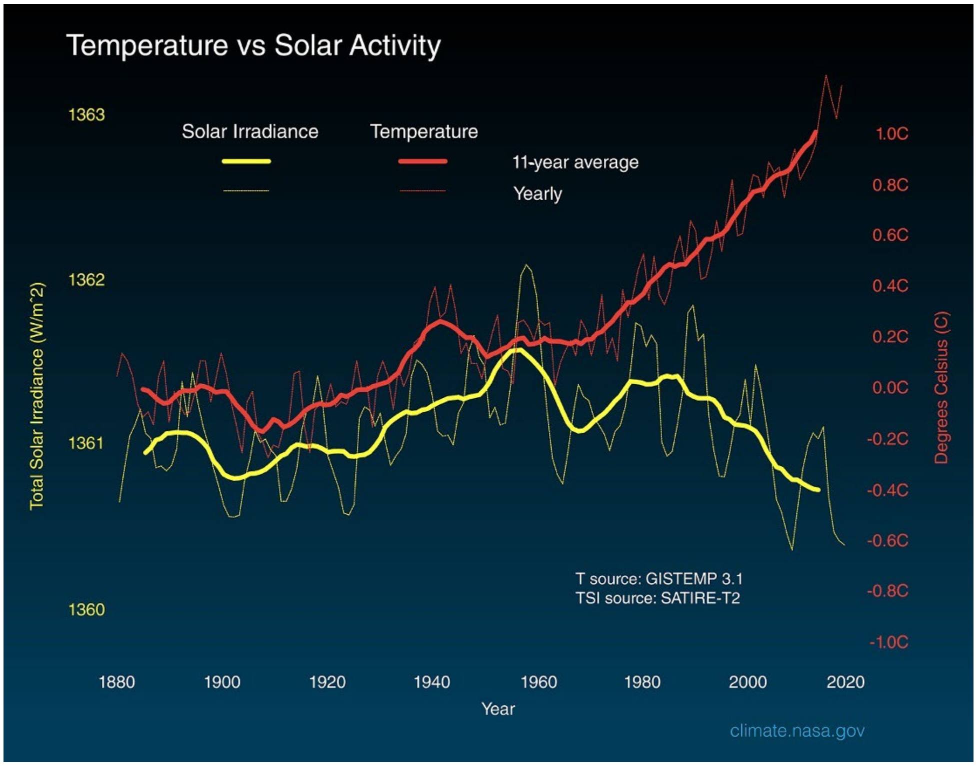


Figure 1. Total solar irradiance and air temperature since 1880. Source: NASA 2020a

The Greenhouse Effect

The greenhouse effect makes all life possible on Earth. It is a complex interchange between the Earth's surface and the atmosphere. The atmosphere is made up of nitrogen (78.084%), oxygen (20.946%), argon (0.934%), carbon dioxide (0.042%), and other trace gases, such as neon, helium, methane, and more (NOAA 2021a). Greenhouse gases include carbon dioxide, methane, ozone, nitrous oxide, chlorofluorocarbons, and water vapor (NASA 2020a; NASA 2020c). Greenhouse gases are energy absorbers because they trap heat, with carbon dioxide, methane, and nitrous oxide contributing the most to warming (NCAR 2024).

The greenhouse effect is when the sun emits shortwave solar radiation (i.e., energy from the sun that reaches the Earth as light and heat), followed by the Earth emitting longwave radiation (i.e., giving off heat) back into the atmosphere, which is absorbed by greenhouse gases (Figure 20) (Lutgens and Tarbuck 2013, 54). Longwave radiation is when the Earth releases heat back into the atmosphere. The Earth warms because heat is trapped near the Earth's surface by greenhouse gases. Think of greenhouse gases acting as a blanket around the Earth. Some of the Earth's longwave radiation, or heat, reflects back into space, but greenhouse gases (the blanket) trap the rest in the atmosphere. This is a complicated game of "hot potato," but without this "blanket" surrounding the atmosphere, the surface temperature would be 0°F, and all water on Earth would be frozen (Lutgens and Tarbuck 2013, 54).

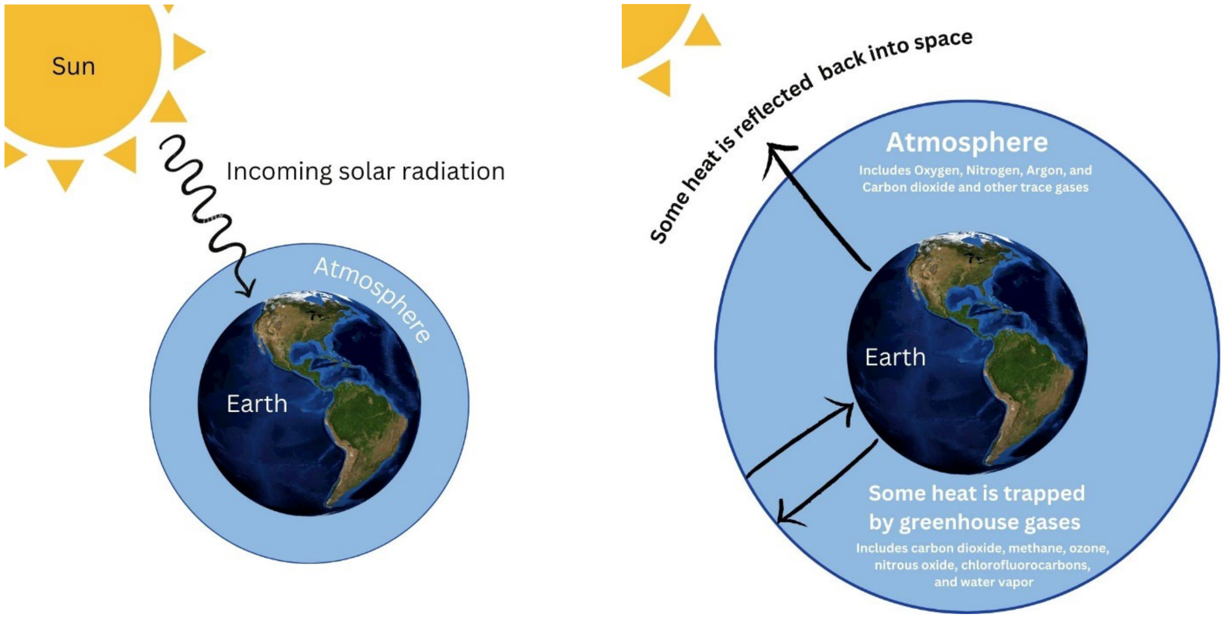


Figure 2. The greenhouse gas effect.

Another way to think about this is with an actual greenhouse. The greenhouse allows solar radiation (sunshine) to enter and be absorbed by the plants, and in turn, the plants radiate (or give) longwave energy but not at the same level as the sun, so the energy is trapped in the greenhouse, and it warms. The greenhouse effect is often used in tandem with global warming, but these are two different concepts. Earth would be inhabitable without the greenhouse effect. The greenhouse effect is a natural process. However, human activities have been shown to affect the natural process and its effects on the Earth, including a warming temperature (Lutgens and Tarbuck 2013, 55).

Carbon Dioxide

Carbon is an element found throughout the environment, with it being the primary element in organic compounds that make up plants and animals. Carbon is most abundantly found in the Earth as fossil fuels in the form of coal, oil, and natural gas. The vegetation on Earth is the second largest storage of carbon, followed by the oceans and atmosphere. In the atmosphere, carbon is in the form of carbon dioxide, or CO_2 (Hidore et al. 2010, 192-193).

Greenhouse gases are energy absorbers, as stated above, because they trap heat. Carbon dioxide (CO_2) is the most important greenhouse gas because it is very good at trapping heat energy that the Earth releases, therefore influencing how much the atmosphere heats.

Many of Earth's processes involve CO_2, making it constantly moving in and out of the atmosphere. One example is photosynthesis, where plants absorb CO_2 from the atmosphere, transform it into organic matter, and then release oxygen (Lutgens and Tarbuck 2013, 18). Natural seasonal changes in carbon dioxide in the atmosphere occur because of changes in the rate of photosynthesis. The amount of carbon dioxide increases in the fall and winter because trees and plants begin to lose their leaves and decay and release the carbon dioxide, which was originally storing the carbon dioxide during the spring and summer months. Carbon dioxide decreases in the spring and summer because of the growing season of trees and plants, which intake carbon dioxide.

Figure 3 shows the amount of carbon dioxide in the atmosphere, dating back to 1958, observed at Mauna Loa Observatory in Hawaii. On the x-axis, or bottom line, is the year, with earlier years starting on the left and progressing to the current year on the right. The y-axis, or left side, is the amount of carbon dioxide in the atmosphere. The red line is the monthly average value of carbon dioxide in the atmosphere. The natural increases and decreases in seasonal changes can be seen as the red line goes up and down over time. The black line represents the average amount of carbon dioxide in the atmosphere for that season, so it takes the average of the fall and winter seasons and then the spring and summer seasons (NOAA 2021b). The big takeaway from this graph is the overall increasing trend in carbon dioxide levels.

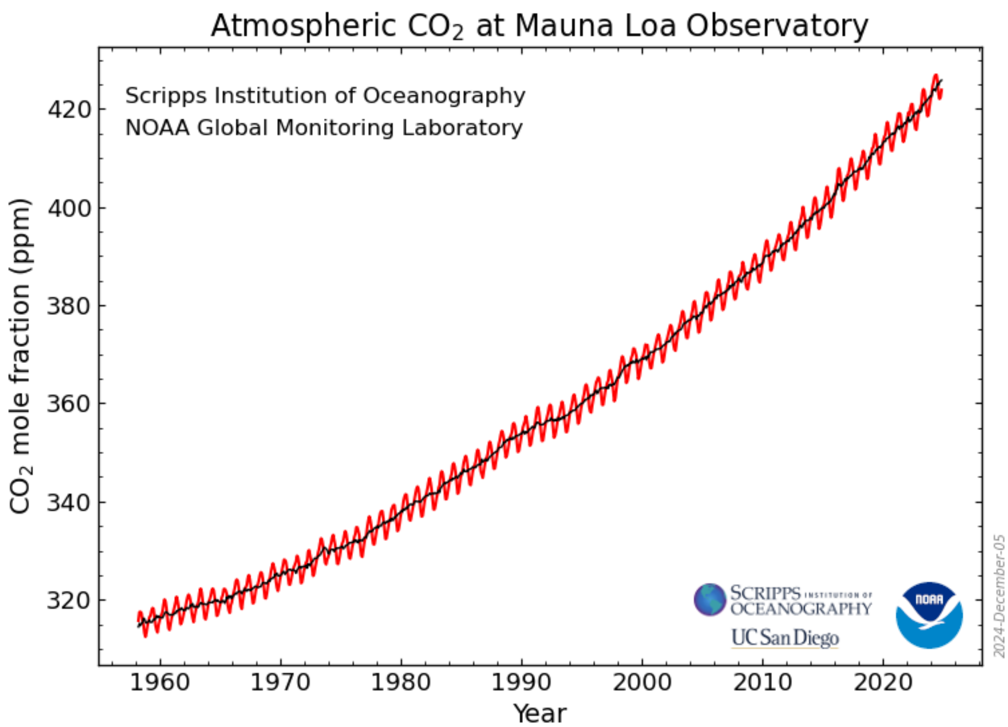


Figure 3. Carbon Dioxide levels since 1958 observed at the Mauna Loa Observatory.
Source: NOAA 2021b

While the Mauna Loa Observatory is one location in the United States, the Global Monitoring Laboratory has measured carbon dioxide and other greenhouse gases using a globally distributed network of air sampling sites for several decades (Conway et al. 1994). The data gathered are very similar to what is being displayed from the Mauna Loa Observatory's data and are shown in Figure 4. The graph is set up the same way as the one above, with the red and black lines representing the same components (Lan et al. 2025). The biggest takeaway from the graph is the same as the previous one: the increasing value of carbon dioxide in the atmosphere.

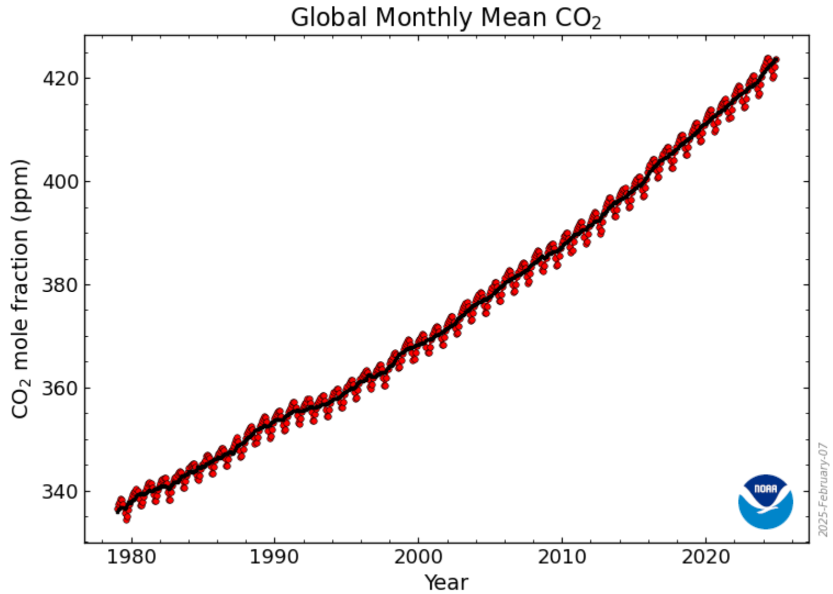


Figure 4. Global monthly average CO_2 levels. Source: Lan et al. 2025

Carbon dioxide has naturally increased and decreased throughout the Earth's history, similar to the natural climate cycles previously mentioned. Scientists have been able to construct how carbon dioxide has changed in the atmosphere dating back 800,000 years ago using ice core data (Lüthi et al. 2008). Figure 5 shows the ice core data (purple line), with years on the x-axis, or bottom line, starting on the left with 800,000 years ago, leading up to 2023. The amount of carbon dioxide in parts per million is on the y-axis, or left side. Parts per million refers to the number of carbon dioxide molecules per million molecules of dry air. The dashed bright purple line shows modern data collected from the sources shown above. A few things to note about this include the highest previous carbon dioxide level was 300 parts per million between 300,000 and 400,000 years ago. This was the highest level noted throughout the entire ice core data evaluated. The dotted purple line representing modern data shows carbon dioxide levels have increased 100 times faster over the last 60 years than previous natural increases, with the 2023 average being 419.3 parts per million (NOAA 2019).

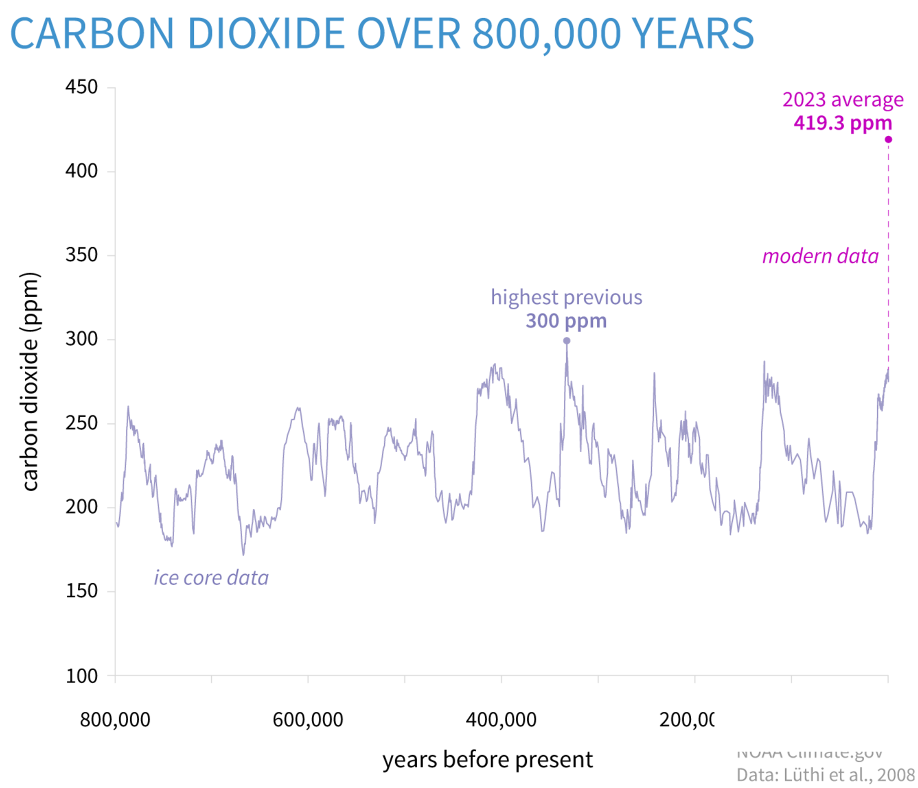


Figure 5. Carbon dioxide levels over the past 800,000 years.
Source: Graph by NOAA Climate.gov based on data from Lüthi, et al., 2008, via NOAA NCEI Paleoclimatology Program.

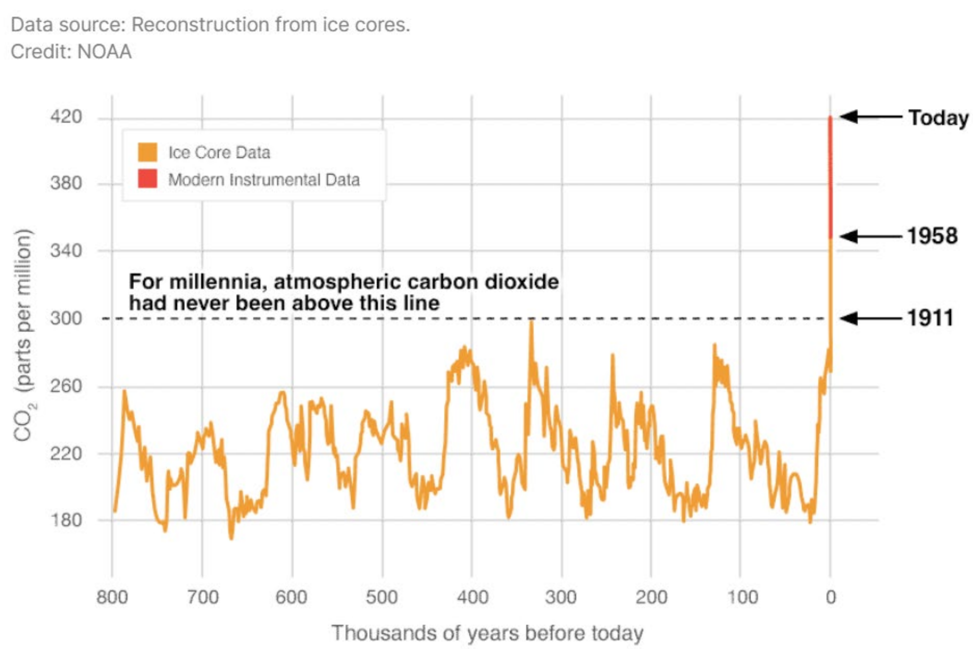


Figure 6. NOAA data showing CO_2 levels from 800 thousand years ago through today. Source: NOAA

What is causing carbon dioxide levels to increase?

In 1896, scientist Svante Arrhenius completed one of the first scientific studies to show the relationship between carbon dioxide and global air temperature. In the 1930s, meteorologist G.S. Callendar researched temperature data from around the world because he hypothesized temperature was increasing due to increasing carbon dioxide levels. Scientist Gilbert Pass then went on to determine how carbon dioxide could increase air temperature and was the scientist who developed the greenhouse effect (Hidore et al. 2010, 196).

As shown in Figures 5 and 6, carbon dioxide has naturally increased and decreased throughout time, but what has caused it to increase so rapidly over the past 60 years? Human activities (Hidore et al. 2010, 194; Lutgens and Tarbuck 2013, 392; NOAA 2019; NASA 2024a). In 1956, Gilbert Plass researched and concluded that industrial and other human activities are adding "considerably more" carbon dioxide than any natural cause. Another term often used is anthropogenic, which means changes caused or influenced by people, either directly or indirectly (USGS 2015). Scientists refer to this as anthropogenic changes, or human-caused changes. Human activities have increased carbon dioxide in the atmosphere by 50 percent. This means the carbon dioxide level is 150 percent of its value in 1750 (around the start of the Industrial Revolution) (NASA 2024a). This is evident to see above in Figures 3 and 4.

Referring to the beginning of this section, carbon is abundantly found in the Earth as fossil fuels in the form of coal, oil, and natural gas. When thinking about the greenhouse effect, greenhouse gases (including carbon dioxide) trap heat in the atmosphere. When additional carbon dioxide is released into the atmosphere from burning fossil fuels, over time, it acts as if another blanket has been knitted and placed around the atmosphere, trapping heat from being released into space and, therefore, increasing the atmosphere's air temperature.

Other Greenhouse Gases

Other greenhouse gases include methane, nitrous oxide, and chlorofluorocarbons. Methane, or CH_4, is produced from both human activities and natural sources, with at least 60 percent of today's emissions from human activities. Fossil fuels, agriculture, and decomposition of landfill waste are the largest sources of methane. Natural processes contribute to about 40 percent of methane emissions, primarily from wetlands, which contain dead or decaying matter with limited oxygen and release methane as a result into the atmosphere (NASA 2024b).

Methane is quite efficient at absorbing the Earth's heat, even more so than carbon dioxide, but there is less of it in the atmosphere compared to carbon dioxide. Even still, it contributes to increasing air temperatures. The Global Monitoring Laboratory also records the global average of methane in the atmosphere, and Figure 7 shows how it has increased over time, similar to carbon dioxide. The red lines and circles are globally averaged monthly mean values and the black line shows the average for each year (NOAA 2021c). Greenhouse gases are increasing at an unprecedented rate, trapping more of the Earth's energy and preventing it from escaping into space, which causes the atmosphere to warm. The following sections will dive deeper into what this means for the environment.

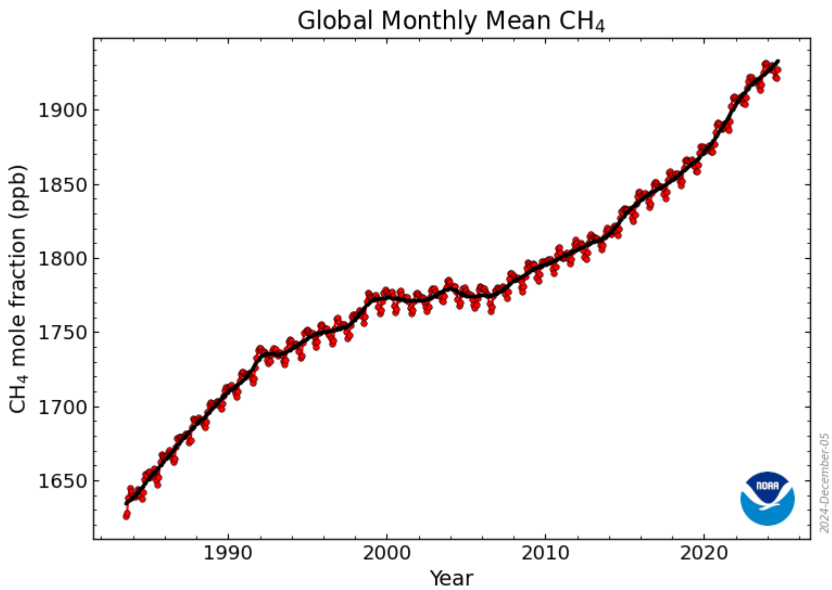


Figure 7. Global monthly average methane values. Source: NOAA 2021c

Global Warming

Global warming is the long-term heating of Earth's surface caused by human activities since the pre-industrial period (between 1850 and 1900). The term is often used interchangeably with climate change, but this is incorrect (NASA 2020b; USGS 2022; NOAA 2015). As previously mentioned, the greenhouse effect is essential for living on Earth; however, human activities have increased the amount of greenhouse gases in the atmosphere to a point where it contains, or traps, the excess heat that would otherwise be emitted, or go, into space, which has caused the Earth's air temperature to increase, called global warming.

The increase in atmospheric air temperature has numerous environmental and societal effects (insert sources). The Earth has water in all three physical states: solid (ice), liquid (water), and gas (water vapor). About 71 percent of the Earth's surface is covered by water, with the oceans holding about 96.5 percent of all water on Earth (USGS 2019). Increasing air temperature can alter the water balance in these states, which is where it ties into winter weather experienced in the Tug Hill region.

Climate Change

Warming air temperatures have widespread physical impacts on the environment. This ranges from rising sea levels, changing weather patterns, ecosystem changes, economic impacts, health risks, and more. Warming air temperatures cause more extreme weather events, including but not limited to flooding, drought, wildfires, hurricanes, and more. The Tug Hill region has experienced flooding and winters of very little snowfall and very high amounts of snowfall. The long-term change in average weather patterns that the Tug Hill region and the world beyond observe is called climate change (NASA 2020b). In other words, climate change is the long-term change being observed in weather conditions, such as precipitation, flooding, droughts, heat waves, and hurricanes. Climate change is a term widely used and is not the same as global warming. Climate change can result in more drastic events, meaning seasons with very little snowfall or seasons with extremely high snowfall amounts.

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Appendix C

The Data

Boonville Average Maximum Temperature Data (Fahrenheit)

Year	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Extended Winter Season Average	Winter Season Average
1974-1975	64.6	51.4	42.7	30.7	30.2	28.8	32.3	43.5	70.2	43.8	29.9
1975-1976	62.4	57.3	47.8	28.8	19.4	32.2	39.2	51.4	58.5	44.1	26.8
1976-1977	64.0	48.2	34.1	22.9	15.4	25.2	40.8	51.5	68.1	41.1	21.2
1977-1978	64.1	52.9	43.9	27.6	21.5	20.1	32.4	46.5	65.3	41.6	23.1
1978-1979	66.5	52.9	43.5	29.5	23.5	17.1	39.6	49.2	64.5	42.9	23.3
1979-1980	68.1	52.5	46.3	31.6	26.5	22.9	34.2	52.4	65.5	44.4	27.0
1980-1981	69.2	51.9	37.1		19.3	34.6	38.5	54.1	67.2	46.5	27.0
1981-1982	60.6	49.6	41.0	28.6	16.8	26.1	33.2	45.7	65.7	40.8	23.9
1982-1983	66.4	56.5	43.5	36.7	26.6	31.3	38.4	45.1	57.9	44.7	31.5
1983-1984	69.4	55.3	41.9	24.5	21.9	34.4	28.8	50.9	57.8	42.8	26.9
1984-1985	62.7	59.1	39.8	35.1	20.1	27.5	38.1	52.4	64.8	44.4	27.6
1985-1986	67.7	56.5	42.8	25.0	25.5	24.9	39.0	55.2	66.5	44.8	25.1
1986-1987	63.0	52.5	37.1	30.6	24.1	26.1	42.4	56.2	64.9	44.1	26.9
1987-1988	63.5	51.8	41.9	31.3	23.4	26.7	36.3	49.1	66.3	43.4	27.1
1988-1989	64.8	49.1	42.2	28.8	29.0	24.7	35.5	46.6	62.9	42.6	27.5
1989-1990	65.1	54.6	39.7	16.5	32.5	32.1	40.5	50.6	58.5	43.4	27.0
1990-1991	63.6	56.2	43.9	34.8	24.3	30.9	37.8	53.4	67.9	45.9	30.0
1991-1992	63.8	57.6	41.0	31.8	25.6	28.3	30.0	46.9	63.7	43.2	28.6
1992-1993	65.8	48.9	38.7	30.5	28.1	21.0	34.0	50.1	63.7	42.3	26.5
1993-1994	63.1	51.0	40.9	28.0	16.8	22.1	33.0	49.6	60.5	40.5	22.3
1994-1995	63.6	55.4	46.3	33.8	30.7	22.9	41.7	45.8	61.2	44.6	29.1
1995-1996	63.8	57.8	35.4	22.2	24.3	26.4	32.7	46.7	59.4	41.0	24.3
1996-1997	66.6	54.9	36.0	33.5	24.8	32.3	33.9	46.8	55.9	42.7	30.2
1997-1998	63.8	53.3	37.7	30.2	31.5	36.4	38.1	55.8	69.5	46.3	32.7
1998-1999	67.6	55.4	41.1	38.1	25.4	32.6	34.1	52.0	67.2	45.9	32.0
1999-2000	70.3	52.5	47.4	32.5	23.4	30.1	43.5	47.6	64.2	45.7	28.6
2000-2001	64.3	54.5	39.7	24.7	25.3	28.5	31.1	50.2	64.8	42.6	26.1
2001-2002	67.0	57.2	47.6	37.3	31.0	33.2	35.3	50.7	56.7	46.2	33.8
2002-2003	70.8	50.4	38.7	28.2	17.7	22.9	36.8	46.0	60.9	41.4	23.0
2003-2004	67.6	51.7	45.4		15.0	26.3	39.0	49.6	66.9	45.2	20.6
2004-2005	69.5	53.9	42.6	29.4	21.6	29.8	33.5	55.5	59.5	43.9	26.9
2005-2006	71.7			26.5	34.5	29.3	37.6	54.3	63.9	45.4	30.1
2006-2007	64.1	51.3	46.2	36.6	27.9	19.3	34.9	45.8	66.1	43.6	28.0
2007-2008	70.4	61.4	39.4	28.0	28.6	27.1	33.3	57.5	59.5	45.0	27.9
2008-2009	67.5	53.0	38.7	30.0	18.9	29.1	37.5	52.5	62.1	43.3	26.0
2009-2010	66.3	50.7	46.9	26.7	24.2	26.3	44.6	57.7	67.9	45.7	25.7
2010-2011	66.4	54.2	41.7	25.4	22.5	26.0	34.5	50.2	64.5	42.8	24.6
2011-2012	67.9	54.5	47.6	33.7	29.1	31.6	48.5	49.3	67.7	47.8	31.5
2012-2013	67.5	54.8	40.3	32.7	26.7	25.7	33.8	47.1	64.6	43.7	28.4
2013-2014	65.1	55.9	38.6	27.9	20.9	23.4	28.0	49.6	64.7	41.6	24.1
2014-2015	66.9	56.3	38.0	31.4	21.5	15.1	29.9	48.3	71.1	42.1	22.7
2015-2016	73.1	53.7	49.0	41.2	26.0	30.6	43.1	48.9	64.4	47.8	32.6
2016-2017	70.7	55.0	44.5	29.2	29.7	32.7	31.5	54.2	58.9	45.2	30.5
2017-2018	70.6	61.8	39.6	25.8	22.7	32.6	33.4	40.9	68.3	44.0	27.0
2018-2019	69.3	51.5	35.1	29.9	23.2	27.0	33.2	50.5	59.4	42.1	26.7
2019-2020	68.3	55.2	35.6	30.1	30.7	28.6	39.8	46.1	62.0	44.0	29.8
2020-2021	67.8	53.6	45.4	32.2	24.5	25.4	40.9	53.1	62.7	45.1	27.4
2021-2022	67.4	60.0	40.6	34.3	20.7	28.4	37.5	49.4	67.7	45.1	27.8
2022-2023	65.5	57.9	44.7	31.5	30.7	31.6	36.0	55.7	64.2	46.4	31.3
2023-2024	69.2	58.5	38.5	36.4	26.6	34.2	41.4	51.4	67.1	47.0	32.4

Boonville Average Minimum Temperature Data (Fahrenheit)

Year	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Extended Winter Season Average	Winter Season Average
1974-1975	45.5	32.3	27.3	20.2	13.6	14.5	16.2	26.2	48.6	27.2	16.1
1975-1976	45.5	40.7	34.2	12.6	-0.5	12.6	18.9	34.3	40.5	26.5	8.2
1976-1977	44.6	32.6	21.0	4.0	-0.8	10.4	25.1	31.7	43.2	23.5	4.5
1977-1978	47.7	33.8	30.4	12.6	7.1	2.1	13.0	26.9	43.7	24.1	7.3
1978-1979	41.9	32.4	25.0	13.7	8.2	-2.9	22.9	31.4	43.6	24.0	6.3
1979-1980	45.0	37.5	31.2	16.9	9.5	3.5	15.5	31.7	42.4	25.9	9.9
1980-1981	47.4	34.4	23.7		-0.6	18.4	22.5	34.1	43.8	28.0	8.9
1981-1982	47.3	33.1	26.4	17.1	-2.8	9.4	17.9	26.9	45.2	24.5	7.9
1982-1983	48.0	38.2	30.1	20.3	10.2	13.7	23.5	30.8	40.7	28.4	14.7
1983-1984	49.5	36.6	29.9	11.1	6.1	20.7	12.5	35.5	40.6	26.9	12.6
1984-1985	45.5	40.1	27.7	22.5	5.3	13.0	20.1	32.7	43.8	27.9	13.6
1985-1986	50.7	38.6	30.6	12.9	7.3	9.1	20.7	37.0	46.9	28.2	9.8
1986-1987	47.1	36.6	24.7	18.3	11.0	5.3	24.7	36.9	44.2	27.6	11.5
1987-1988	49.4	35.6	26.6	19.3	6.8	10.9	17.3	32.5	46.2	27.2	12.3
1988-1989	46.6	34.2	29.6	11.0	12.1	8.2	17.8	28.4	45.8	26.0	10.4
1989-1990	47.4	38.3	23.3	-2.1	20.0	13.0	22.7	34.7	40.8	26.5	10.3
1990-1991	47.3	39.0	28.0	17.8	8.0	15.0	23.5	36.2	47.4	29.1	13.6
1991-1992	44.3	38.3	25.6	14.9	7.5	10.9	14.1	31.2	42.6	25.5	11.1
1992-1993	46.2	31.9	25.9	16.7	12.8	0.4	16.2	32.8	42.0	25.0	9.9
1993-1994	45.8	33.7	26.0	14.1	-5.1	4.3	17.4	30.9	40.3	23.0	4.4
1994-1995	46.8	36.7	30.1	18.7	17.9	3.8	22.9	25.7	41.6	27.1	13.5
1995-1996	44.3	41.5	23.5	10.2	5.8	8.5	15.5	28.1	40.5	24.2	8.1
1996-1997	50.4	36.9	22.7	23.3	5.9	12.9	17.2	28.8	38.1	26.2	14.0
1997-1998	46.7	34.9	25.5	17.5	16.2	19.1	24.1	34.8	50.0	29.9	17.6
1998-1999	49.3	38.7	27.7	21.7	7.9	14.4	18.0	31.9	45.5	28.3	14.7
1999-2000	50.8	34.5	32.0	18.5	4.9	14.4	26.4	31.1	46.3	28.8	12.6
2000-2001	46.7	38.6	27.4	9.2	13.6	12.3	17.7	32.1	46.7	27.2	11.7
2001-2002	48.9	39.0	33.1	24.6	19.2	13.5	20.4	33.9	39.1	30.2	19.1
2002-2003	51.9	35.8	26.3	13.9	3.1	6.9	17.8	29.3	43.0	25.4	8.0
2003-2004	50.8	36.2	30.4		-1.9	7.9	22.3	31.3	45.7	27.8	3.0
2004-2005	49.6	36.3	27.1	12.3	5.9	11.0	14.7	32.5	38.6	25.3	9.7
2005-2006	48.8			19.9	18.3	11.4	18.0	31.7	44.2	27.5	16.5
2006-2007	46.6	35.1	32.7	22.8	10.5	2.0	14.1	29.4	41.0	26.0	11.7
2007-2008	48.1	42.2	24.2	14.1	14.7	9.7	13.8	34.7	38.2	26.6	12.8
2008-2009	47.8	34.1	24.9	11.9	2.1	9.6	18.4	31.8	41.3	24.7	7.8
2009-2010	45.1	34.8	30.7	12.3	9.9	12.3	26.0	34.9	44.9	27.9	11.5
2010-2011	48.9	37.1	26.0	12.9	6.5	7.8	16.0	32.1	46.5	26.0	9.1
2011-2012	50.5	38.3	31.3	19.4	13.1	15.7	27.7	30.0	47.2	30.4	16.0
2012-2013	46.2	40.2	24.8	20.4	10.7	8.8	18.6	28.5	43.8	26.9	13.3
2013-2014	44.4	38.8	21.3	12.9	2.1	5.6	6.5	28.3	43.8	22.6	6.9
2014-2015	46.9	40.6	24.0	20.0	0.7	-6.6	10.4	28.3	46.5	23.4	4.7
2015-2016	52.4	33.8	30.4	28.4	10.0	12.2	22.2	25.6	42.3	28.6	16.9
2016-2017	49.5	38.1	28.6	15.7	15.9	15.7	12.4	34.9	40.9	27.9	15.8
2017-2018	49.5	42.3	23.1	9.7	3.9	14.4	17.7	24.8	44.6	25.6	9.4
2018-2019	51.2	35.5	22.5	15.7	4.1	9.8	14.5	29.4	40.7	24.8	9.9
2019-2020	46.7	38.0	21.0	15.6	14.8	13.1	22.2	27.3	39.1	26.4	14.5
2020-2021	46.5	36.0	29.4	18.6	11.7	7.8	18.1	31.7	41.4	26.8	12.7
2021-2022	49.3	43.8	25.4	20.5	-1.7	7.5	18.9	30.2	44.1	26.4	8.7
2022-2023	48.3	35.1	29.0	18.1	19.2	11.8	19.1	32.8	39.5	28.1	16.4
2023-2024	49.1	42.3	23.8	25.2	16.4	16.1	23.6	32.2	47.5	30.7	19.2

Lowville Average Maximum Temperature Data (Fahrenheit)

Year	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Extended Winter Season Average	Winter Season Average
1974-1975	67.6	54.4	44.2	33.7	33.2	31.3	36.5	46.8	74.2	46.9	32.7
1975-1976	66.0	60.0	50.0	29.7	23.8	36.4	43.4	56.7	63.7	47.8	30.0
1976-1977	67.4	51.1	38.6	28.8	20.0	29.1	44.7	55.9	72.6	45.4	26.0
1977-1978	66.9	54.7	46.2	29.4	24.7	23.3	35.4	48.7	69.9	44.3	25.8
1978-1979	68.9	55.8	45.2	32.5	27.4	19.3	44.0	52.2	68.0	45.9	26.4
1979-1980	71.0	55.6	48.1	35.3	27.9	24.3	38.8	53.6	69.5	47.1	29.2
1980-1981	69.5	53.1	38.8	26.7	18.9	37.0	39.1	55.4	66.2	45.0	27.5
1981-1982	64.0	51.3	43.0	30.9	19.1	28.5	35.7	48.8	67.8	43.2	26.2
1982-1983	69.7	58.6	45.8	39.4	27.7	32.8	41.3	49.2	60.8	47.3	33.3
1983-1984	72.1	57.5	43.8	27.5	24.3	36.2	30.1	52.9	60.6	45.0	29.3
1984-1985	65.5	61.4	43.4	38.5	21.5	29.0	41.2	53.6	66.6	46.7	29.7
1985-1986	69.7	57.7	44.8	27.1	27.5	27.2	40.2	56.6	67.7	46.5	27.3
1986-1987	65.5	55.2	40.1	33.2	25.9	24.5	42.7	58.8	66.9	45.9	27.9
1987-1988	66.8	54.4	44.2	33.5	25.1	28.8	36.1	51.0	67.4	45.2	29.1
1988-1989	67.8	51.8	44.6	31.3	31.3	25.7	35.0	47.7	65.3	44.5	29.4
1989-1990	67.7	57.7	42.8	16.5	35.5	32.3	41.3	53.2	60.6	45.3	28.1
1990-1991	66.1	57.2	44.9	36.4	25.5	33.3	38.9	54.8	68.6	47.3	31.7
1991-1992	65.4	58.7	42.4	32.2	27.1	28.2	32.3	48.6	65.3	44.5	29.2
1992-1993	68.3	50.6	40.4	31.9	30.1	21.7	35.1	51.2	65.2	43.8	27.9
1993-1994	67.3	54.4	42.8	28.9	16.1	23.4	34.2	51.7	61.2	42.2	22.8
1994-1995	66.9	57.6	48.8	34.7	32.0	24.6	42.4	47.9	63.5	46.5	30.4
1995-1996	66.0	60.7	37.8	24.4	25.3	26.3	34.0	48.3	61.2	42.6	25.3
1996-1997	70.2	56.7	37.2	35.7	25.6	33.6	34.4	48.3	58.0	44.4	31.6
1997-1998	66.5	55.7	40.2	32.3	31.5	35.6	39.7	57.4	71.2	47.8	33.1
1998-1999	69.6	56.7	42.6	39.1	26.3	33.1	34.1	53.3	69.5	47.2	32.9
1999-2000	72.9	54.7	49.2	33.5	24.5	31.1	45.2	49.3	65.1	47.3	29.7
2000-2001	66.9	56.7	42.0	24.4	27.8	29.3	33.2	52.2	68.6	44.6	27.2
2001-2002	69.6	59.1	50.1	39.0	33.1	34.4	37.7	52.5	58.9	48.3	35.5
2002-2003	74.8	53.7	40.9	29.6	19.7	24.9	39.0	48.0	63.9	43.8	24.8
2003-2004	70.3	53.9	46.1	32.6	17.0	27.7	40.5	51.4	68.0	45.3	25.8
2004-2005	71.4	56.7	44.5	31.5	23.1	30.2	34.4	56.7	61.7	45.6	28.3
2005-2006	72.6	56.1	48.6	28.7	35.5	28.8	36.7	55.2	65.8	47.6	31.0
2006-2007	66.2	53.4	48.1	39.5	28.1	20.9	35.8	48.2	67.3	45.3	29.5
2007-2008	73.7	63.5	41.5	30.2	31.3	28.2	34.6	60.0	61.6	47.2	29.9
2008-2009	69.2		41.3	31.2	20.7	29.9	39.7	54.3	64.5	43.8	27.3
2009-2010	68.6	52.2	49.3	29.0	25.6	27.3	45.5	59.2	69.4	47.3	27.3
2010-2011	69.0	55.1	44.3	27.2	23.7	26.4	36.3	52.4	66.5	44.5	25.8
2011-2012	70.9	57.4	51.3	36.3	30.5	33.8	50.9	51.2	70.7	50.3	33.6
2012-2013	70.4	57.9	42.6	34.9	28.5	27.7	34.6	50.9	68.3	46.2	30.4
2013-2014	67.8	58.5	40.7	30.3	22.6	25.4	29.3	52.8	66.9	43.8	26.1
2014-2015	69.8	58.7	39.5	34.2	22.7	15.1	31.6	50.9	72.8	43.9	24.0
2015-2016	75.8	55.3	50.4	43.5	27.6	31.9	45.4	50.1	66.9	49.7	34.3
2016-2017	73.4	58.1	46.8	32.4	33.2	35.8	33.4	56.5	61.8	47.9	33.8
2017-2018	73.0	64.3	41.8	27.5	24.0	34.8	35.3	43.8	72.4	46.3	28.7
2018-2019	73.1	54.4	38.1	33.6	25.4	29.8	36.4	52.8	62.1	45.1	29.6
2019-2020	71.3	58.6	38.6	33.1	33.3	31.8	43.9	49.6	65.5	47.3	32.7
2020-2021	71.0	56.9	49.6	34.7	27.0	27.9	43.7	54.6	65.8	47.9	29.9
2021-2022	70.5	62.4	44.6	37.4	23.1	31.1	39.3	53.4	72.1	48.2	30.6
2022-2023	68.4	61.3	48.3	35.1	33.7	34.3	38.6	59.0	66.1	49.4	34.3
2023-2024	72.8	61.2	42.1	40.3	30.2	37.7	44.8	55.6	70.7	50.6	36.0

Lowville Average Minimum Temperature Data (Fahrenheit)

Year	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Extended Winter Season Average	Winter Season Average
1974-1975	43.9	31.8	27.2	20.5	12.5	14.8	17.5	26.8	46.3	26.8	15.9
1975-1976	46.1	40.8	34.2	10.9	-1.4	14.7	21.6	34.5	40.7	26.9	8.1
1976-1977	45.1	33.8	24.6	6.8	2.0	13.8	26.5	33.0	43.9	25.5	7.6
1977-1978	51.1	36.2	32.8	14.5	5.5	-0.9	16.1	29.5	44.8	25.5	6.4
1978-1979	42.9	35.6	26.0	17.1	10.3	-2.0	26.2	32.7	45.5	26.0	8.5
1979-1980	45.1	38.8	33.1	18.7	11.8	4.4	19.3	34.2	43.6	27.7	11.6
1980-1981	46.1	35.0	24.9	4.4	-4.8	18.5	22.2	35.7	42.3	24.9	6.0
1981-1982	47.0	33.5	26.8	17.7	-4.8	10.0	18.1	28.4	44.1	24.5	7.6
1982-1983	45.6	36.3	30.4	20.8	10.3	14.0	25.7	32.8	40.5	28.5	15.1
1983-1984	48.3	36.0	28.0	11.7	4.6	18.7	11.2	34.7	40.3	25.9	11.7
1984-1985	44.0	37.9	25.1	22.5	3.7	12.2	20.2	34.1	42.3	26.9	12.8
1985-1986	48.2	36.9	30.1	12.7	5.9	6.0	21.0	35.6	45.9	26.9	8.2
1986-1987	46.5	35.9	25.5	19.4	8.0	1.1	22.7	36.4	44.3	26.6	9.5
1987-1988	48.5	34.2	26.8	21.4	4.3	7.8	16.6	33.2	45.1	26.4	11.1
1988-1989	44.5	34.6	30.4	12.0	12.0	7.1	15.7	29.2	44.9	25.6	10.4
1989-1990	46.9	37.1	24.8	-6.9	21.0	11.3	21.7	35.4	41.3	25.8	8.5
1990-1991	45.2	38.6	27.3	18.8	7.5	14.6	23.1	35.6	44.6	28.4	13.6
1991-1992	42.0	37.0	25.9	13.1	7.4	8.7	12.7	31.0	39.4	24.1	9.7
1992-1993	45.9	32.1	27.1	14.8	13.1	-3.6	13.4	33.0	42.0	24.2	8.1
1993-1994	45.1	34.9	26.4	12.5	-8.3	3.1	15.9	32.1	39.5	22.4	2.4
1994-1995	46.2	35.8	29.9	17.7	17.5	2.4	22.2	27.0	42.4	26.8	12.5
1995-1996	42.6	41.3	24.5	10.4	4.2	7.4	14.8	29.9	41.4	24.1	7.3
1996-1997	49.6	36.2	21.4	25.4	4.8	12.5	15.9	28.5	39.1	25.9	14.2
1997-1998	45.6	33.7	24.4	16.7	14.4	17.5	22.8	32.8	48.6	28.5	16.2
1998-1999	48.2	38.7	29.1	21.4	5.6	13.3	17.2	30.5	44.1	27.6	13.4
1999-2000	49.7	34.3	32.8	15.5	4.6	12.5	25.5	31.9	47.0	28.2	10.9
2000-2001	45.1	37.5	26.9	6.0	11.3	11.8	16.6	31.4	44.7	25.7	9.7
2001-2002	46.3	38.6	32.7	24.0	16.6	12.5	20.9	33.9	39.4	29.4	17.7
2002-2003	49.8	35.2	26.5	12.6	0.5	3.3	17.2	27.7	43.6	24.0	5.5
2003-2004	48.5	35.5	30.6	16.1	-3.4	5.1	23.0	31.7	45.2	25.8	6.0
2004-2005	49.8	36.2	28.0	13.2	4.6	8.3	14.6	32.1	39.7	25.2	8.7
2005-2006	50.6	39.7	28.6	13.5	18.4	10.6	19.2	32.3	44.5	28.6	14.2
2006-2007	46.2	36.0	33.1	24.7	10.7	3.1	15.3	31.2	40.5	26.8	12.8
2007-2008	47.0	41.8	24.5	15.5	15.5	9.0	13.9	35.9	37.8	26.8	13.3
2008-2009	46.8	0.0	26.7	12.7	0.7	10.5	19.9	33.1	42.3	21.4	8.0
2009-2010	43.7	36.5	30.0	12.4	10.4	12.5	27.0	35.2	44.4	28.0	11.8
2010-2011	49.4	38.2	25.7	15.5	7.2	7.3	17.9	33.8	48.5	27.0	10.0
2011-2012	50.7	39.0	32.3	20.4	13.6	17.6	29.8	31.6	47.1	31.3	17.2
2012-2013	46.1	41.2	24.4	21.8	10.8	9.6	19.4	30.7	44.4	27.6	14.1
2013-2014	44.1	38.1	22.1	12.4	1.8	7.7	7.8	31.2	45.4	23.4	7.3
2014-2015	46.0	41.8	26.5	21.8	-0.5	-7.8	9.7	30.3	46.2	23.8	4.5
2015-2016	51.2	34.8	31.4	30.3	11.5	13.6	23.3	27.3	42.1	29.5	18.5
2016-2017	47.3	39.3	29.1	18.2	17.6	17.6	13.7	36.0	42.8	29.1	17.8
2017-2018	48.5	42.7	25.3	9.4	3.8	16.6	19.5	27.7	45.7	26.6	9.9
2018-2019	51.9	38.3	24.6	18.5	4.2	11.9	16.4	33.4	43.1	26.9	11.5
2019-2020	46.2	38.8	23.1	16.6	16.3	13.6	25.2	30.9	41.7	28.0	15.5
2020-2021	46.3	37.5	30.3	20.6	13.9	8.9	20.5	35.0	42.2	28.4	14.5
2021-2022	49.6	46.1	27.7	22.7	-2.8	8.5	20.9	32.7	45.8	27.9	9.4
2022-2023	50.4	35.6	31.4	21.1	20.6	12.7	21.3	34.9	40.0	29.8	18.1
2023-2024	49.2	43.9	26.4	28.1	19.6	19.1	27.3	34.8	49.5	33.1	22.3

Bennetts Bridge Snowfall Data

Year	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Extended Winter Season Total (in)	Winter Season Total (in)
1974-1975	0	0	3.5	37	62	70	30.5	28.5	0	231.5	169.0
1975-1976	0	0	3	58	70	37	38	0	0	206.0	165.0
1976-1977	0	0	41	69	160	54	32	5	0	361.0	283.0
1977-1978	0	0	18	78.5	192	52.5			0	--	--
1978-1979	0	0			63.5	49.5	7.5	2.5	0	--	--
1979-1980	0	0	10	9.5	45.5	29.5	21.5	0	0	116.0	84.5
1980-1981	0		11	39.5	34	85.5	19	0	0	189.0	159.0
1981-1982	0	0		37.6	93.5	35.6	31.5	2.5	0	200.7	166.7
1982-1983	0	0	4	13	23	11	16.5	12.5	0	80.0	47.0
1983-1984	0	0	12.8	90	27.5	23	24.5	0	0	177.8	140.5
1984-1985	0	0	4.5	40.5	92	36.8	8.6	6.5	0	188.9	169.3
1985-1986	0	0		123	58	49.6	20.3	9	0	259.9	230.6
1986-1987	0	0	9	20.3	76	17.5	2.5	4	0	129.3	113.8
1987-1988	0	0	9.1	32.1	57	92	14.1	2.5	0	206.8	181.1
1988-1989	0	1	0.5	35	20	30.4	10.6	5.5	0	103.0	85.4
1989-1990	0	0	24	68	44	14	1.5	6	0	157.5	126.0
1990-1991		0	3.5	42	31.6	52	1.5	0	0	130.6	125.6
1991-1992	0	0	16.3	48.5	62	22.3	42.5	2.5	0	194.1	132.8
1992-1993	0	2	0	33	31	59	28.5	6	0	159.5	123.0
1993-1994	0	0	12	43	80.5	39	28	7.5	0	210.0	162.5
1994-1995	0	0	7	8.5	34	64	9	0.5	0	123.0	106.5
1995-1996	0	0	25	64	64.5	53	33	6	0	245.5	181.5
1996-1997	0	0	24.5	54	95	38.5	26	5	0	243.0	187.5
1997-1998	0	6	25	23	21	17	30	0	0	122.0	61.0
1998-1999	0	0	5	23	83	5	16	0	0	132.0	111.0
1999-2000	0	0	1	16	13.5	33	8	7	0	78.5	62.5
2000-2001	0	0	11.5	57	58.5	38	51	0	0	216.0	153.5
2001-2002	0	0	1	18	54	28	35	2	0	138.0	100.0
2002-2003	0	0	12	49	89	37	17	11	0	215.0	175.0
2003-2004	0	0	3	21	99	23	8	3	0	157.0	143.0
2004-2005	0	0	0	23	34	16	25	0	0	98.0	73.0
2005-2006	0	0	4	58	13	19	3	2	0	99.0	90.0
2006-2007	0	0	2	24	22			8	0	--	--
2007-2008	0	0		61		101	11	0	0	--	--
2008-2009	0	13	24	83	58	38	1	10	0	227.0	179.0
2009-2010	0	0	0	33	26	30	0	0	0	89.0	89.0
2010-2011	0	0	2		34	45	5	1	0	87.0	79.0
2011-2012	0	0	4	15	21	12	6	0	0	58.0	48.0
2012-2013	0	0	5	17	44	53	41	0	0	160.0	114.0
2013-2014	0	0	5	82	63	53	22.5	1	0	226.5	198.0
2014-2015	0	0	18	13	45.5	55.5	16	2	0	150.0	114.0
2015-2016	0	0	1	16	32	21	3	4	0	77.0	69.0
2016-2017	0	0	27	46.5	38	64	13	0	0	188.5	148.5
2017-2018	0	0	5.5	72.5	35.2	23.5	36.5	7	0	180.2	131.2
2018-2019	0	0	39	15.6	44	34.5	32	5	0	170.1	94.1
2019-2020	0	0	10	30	26	28	11	0	1	106.0	84.0
2020-2021	0	0	2	25	42	47	1	3	0	120.0	114.0
2021-2022	0	0	8	12	42	24.5	16	2	0	104.5	78.5
2022-2023	0	0	17	31.5	9.5	13.5	15	0	0	86.5	54.5
2023-2024	0	0	31	6	35	17	16	2	0	107.0	58.0

Boonville Snowfall Data

Year	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Extended Winter Season Total (in)	Winter Season Total (in)
1974-1975	0	1.1	15	50.8	48.9	65.3	35.4	10	0	226.5	165
1975-1976	0	0	8.9	56.9	82.8	47.2	57.5	7	7.5	267.8	186.9
1976-1977	0	17.8	81.7	44.6	71.7	63.7	52.1	11	3.5	346.1	180
1977-1978	0	0	32.3	67.1	156.4	35.5	24.5	1.1	0.1	317	259
1978-1979	0	0.1	15	96.4	58.4	36.8	21.1	33.5	0	261.3	191.6
1979-1980	0	1.9	14.5	24.4	35.8	36.2	56.8	2.3	0	171.9	96.4
1980-1981	0	10.3	28.4		22.3	53.3	19.9	2.7	0	136.9	75.6
1981-1982	0	3.1	6.7	29.3	93.3	32.3	47.6	17.3	0	229.6	154.9
1982-1983	0	0	11.4	13.1	26.4	11	23.5	22.5	0.3	108.2	50.5
1983-1984	0	0	15.9	85.2	36.3	20.1	65.4	0.3	0.5	223.7	141.6
1984-1985		0	22.6	54.8	78	46.1	24.7	23.7	0	249.9	178.9
1985-1986	0	0	12.9	81.2	65.2	49.1	40.1	1	1	250.5	195.5
1986-1987	0	0	22.4	42.6	72.5	23.2	7.3	16.8	0.1	184.9	138.3
1987-1988	0	3.8	13.9	54.3	68.3	73.2	22.5	4.9	0	240.9	195.8
1988-1989	0	14.6	16.6	56.1	51.6	55.6	17.8	11.6	1.8	225.7	163.3
1989-1990	0	0.1	40.5	53.5	66.8	35.5	20.7	14.4	0	231.5	155.8
1990-1991	0	0.1	17.9	37.2	49.6	59.7	17.6	8	0	190.1	146.5
1991-1992	0.2	0.4	19.7	62.6	50.2	45.2	33.2	8.7	0	220.2	158
1992-1993	0	4.4	7	24.6	56	56.1	37	18.8	0	203.9	136.7
1993-1994	0	2	24.1	53.7	65.9	47	33.1	5.1	0	230.9	166.6
1994-1995	0	0	14.3	20.3	35.5	45.8	6.9	2.6	0	125.4	101.6
1995-1996	0	0	47.2	46.3	42.1	29.4	41.2	7	1.4	214.6	117.8
1996-1997	0	0	17.4	40.4	83.8	31.4	46.5	11	0.4	230.9	155.6
1997-1998	0	3.5	27.4	40.5	32.9	20.9	29.1	0	0	154.3	94.3
1998-1999	0	0	2.9	23.3	64.9	3.3	55.3	0	0	149.7	91.5
1999-2000	0	0.8	3.9	24.3	30.5	51.2	9.8	13.2	0	133.7	106
2000-2001	0	0	21.5	52	38.2	46.7	70.9	0.4	0	229.7	136.9
2001-2002	0	4	1.2	33.1	68.5	27.9	62.9	8.9	0	206.5	129.5
2002-2003	0	3.2	29.7	51.5	74.1	33	21.8	14	0	227.3	158.6
2003-2004	0	1	18.6		76.4	33.2	28.5	1.2	0	158.9	109.6
2004-2005	0	0	1	43	49.9	39.9	36.7	0	0	170.5	132.8
2005-2006	0	4.7	13.7	62	21.5	35.9	12.2	1.7	0	151.7	119.4
2006-2007	0	4	13.5	24.7	27.7	71.8	13.5	34.4	0	189.6	124.2
2007-2008	0	0	12.5	44.5	32.7	47.6	31.8	0	0	169.1	124.8
2008-2009	0	6	46.6	57.2	68.6	31.2	0.1	3.9	0	213.6	157
2009-2010	0	0	1.5	44.8	18.5	40	0.2	1.2	0.8	107	103.3
2010-2011	0	0	3.2	11.6	42.3	41.9	23.6	1.6	0	124.2	95.8
2011-2012	0	0.5	14	18.8	27.6	16.4	14.5	0.2	0	92	62.8
2012-2013	0	0	14.5	35	27.9	45.8	21.9	2.1	0	147.2	108.7
2013-2014	0	5.2	10.5	45.1	32.2	41.4	25.6	1	0	161	118.7
2014-2015	0	0	24.2	18.3	33.2	53.6	15.5	2.9	0	147.7	105.1
2015-2016	0	0	0.2	25.5	39.8	19.4	4.8	5.6	0.7	96	84.7
2016-2017	0	0.2	10.9	49.1	32.6	43.4	24.7	1	0.2	162.1	125.1
2017-2018	0	0	7.6	41.6	20.9	32.7	34.7	12	0	149.5	95.2
2018-2019	0	0	34.4	15.7	40.1	41.7	17.8	4.7	0	154.4	97.5
2019-2020	0	0	9.9	31.5	21	35.8	8	8	1.3	115.5	88.3
2020-2021	0	0	11.2	20.1	31.4	38.3	2.1	4.5	0.2	107.8	89.8
2021-2022	0	0	15.4	22.8	29.6	28.5	17	16.4	0	129.7	80.9
2022-2023	0	0	28.6	64.2	19.6	20.3	29.1	0.1	0	161.9	104.1
2023-2024	0	0	13.3	14.9	39.9	26	20.3	6.3	0	120.7	80.8

Highmarket Snowfall Data

Year	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Extended Winter Season Total (in)	Winter Season Total (in)
1974-1975	0	0	16	31.5	51	45	27	12	0	182.5	127.5
1975-1976	0	0	9	33	63	37	33	7	10	192	133
1976-1977	0	14	59	37	68	26	39	7	3	253	131
1977-1978	0	0.5	24	48.5	100	24	18	1	0	216	172.5
1978-1979	0	0	10	63	42	36	17	18.5	0	186.5	141
1979-1980	0	4	16.5	13	31	21	25	2	0	112.5	65
1980-1981	0	10.5	20.6	29	17	40	19	2.5	0	138.6	86
1981-1982	0	3.5	3	28	70	30	30	3.5	0	168	128
1982-1983	0	0.5	11.5	14	17	8	19	26	0	96	39
1983-1984	0	0	17	77.4	37.1	20	58.1	0.3	0.8	210.7	134.5
1984-1985	0	0	30.6	62.1	72.2	44.2	35	24.7	0	268.8	178.5
1985-1986	0	0	8.8	73.4	55.5	38.3	25.7	1.6	2	205.3	167.2
1986-1987	0	0	19.5	43.2	60.8	30.2	5.1	10.3	0	169.1	134.2
1987-1988	0	9	9	54.6	108.2	67.7	17.7	4.4	0	270.6	230.5
1988-1989	0	9.6	13	52.3	50.2	46.5	19.6	5.4	1.5	198.1	149
1989-1990	0	0.3	51.2	61.8	54	26.3	14	11.2	0	218.8	142.1
1990-1991	0	0.3	23.8	49.2	47.4	51.1	14.2	4.6	0	190.6	147.7
1991-1992	0	0.2	23.6	74.4	40.7	37	20.5	5.8	0	202.2	152.1
1992-1993	0	4.6	9.1	53.5	60.6	64.2	37.9	13.2	0	243.1	178.3
1993-1994	0	2.3	27	88.1	72.8	54.3	28.2	3.7	0	276.4	215.2
1994-1995	0	0	13.9	17.5	50.9	59.5	5.2	3.5	0	150.5	127.9
1995-1996	0	0.2	44.2	75.3	63.7	31.4	42.2	9.8	0.9	267.7	170.4
1996-1997	0	0.1	41	55.3	114.3	36.4	40.2	8.5	0.4	296.2	206
1997-1998	0	14.7	35.4	55	36.6	12.1	27.6	0	0	181.4	103.7
1998-1999	0	0	7.5	36.5	90.2	9.9	59.4	0	0	203.5	136.6
1999-2000	0	0	12	49	25	54.3	12.7	8.6	0	161.6	128.3
2000-2001	0	3.3	30.5	70.9	42.8	43.6	50.8	0.1	0	242	157.3
2001-2002	0	8.1	0.6	84.3	98.7	33.5	61.3	5.8	0.1	292.4	216.5
2002-2003	0	1.1	48.8	54.4	114	33.9	21.5	18.2	0	291.9	202.3
2003-2004	0	1.3	22.7	37.1	91	41.3	30.9	1.3	0	225.6	169.4
2004-2005	0	0	2.1	43.2	44.1	39.7	28.9	0.1	0	158.1	127
2005-2006	0	2.8	17.1	90.9	29.2	54.8	8.8	2.6	0	206.2	174.9
2006-2007	0	17.3	10.1	30.6	39.8	114.4	30.3	35.6	0	278.1	184.8
2007-2008	0	0	10.9	49	67	58.9	33.6	0.1	0	219.5	174.9
2008-2009	0	8.1	56.9	52.8	66.6	32	0.4	7.4	0	224.2	151.4
2009-2010	0	0	1.2	70.8	18	38.8	0.7	1.7	1.3	132.5	127.6
2010-2011	0	0	3.9	15.7	45.5	46.2	23.5	3.7	0	138.5	107.4
2011-2012	0	0.3	10.4	31	43	27	14.3	3.2	0	129.2	101
2012-2013		0	13.8	38.1	41.3	68	44.4	5.5	0.5	211.6	147.4
2013-2014	0	6.8	12.3	105.7	61.8	40.7	36	2.3	0	265.6	208.2
2014-2015	0	0	47.1	18.1	42.2	53.9	17.5	4.2	0	183	114.2
2015-2016	0	0.5	2.2	37.4	53.7	15.3	6.9	6.8	0.7	123.5	106.4
2016-2017	0	0.6	15.4	62.9	35.5	56	16.5	1.5	0.4	188.8	154.4
2017-2018	0	0	12.7	96.2	28.1	44.1	25.7	11	0	217.8	168.4
2018-2019	0	0.8	42.4	19.4	39.2	38.9	18.5	4.8	0.2	164.2	97.5
2019-2020	0	0	12.5	34.7	38.1	44.4	5.2	6.3	3.8	145	117.2
2020-2021	0	0	20.1	40.4	64.6	48	6.5	6.2	1	186.8	153
2021-2022	0	0	27.5	25.8	48.1	50.6	24.8	26.4	0	203.2	124.5
2022-2023	0	0	21.6	65.1	27	26.8	38.4	3.2	0	182.1	118.9
2023-2024	0	0	49.6	13.3	56.2	34.1	28	9.1	0	190.3	103.6

Lowville Snowfall Data

Year	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Extended Winter Season Total (in)	Winter Season Total (in)
1974-1975	0	0.2	8.6	28.2	35.7	37.4	27.7	12.8	0	150.6	101.3
1975-1976	0	0	10.1	28.5	61.3	16.9	29	1.2	1.5	148.5	106.7
1976-1977	0	1	19	18.8	44	27.7	32.4	4.6	2	149.5	90.5
1977-1978	0	0	12.5	59.1	75.9	11.7	6.5	0	0	165.7	146.7
1978-1979	0	0	8.5	53.2	49.4	20.5	4.2	18	0	153.8	123.1
1979-1980	0	0	8.5	6.4	25.2	13.6	22	0.5	0	76.2	45.2
1980-1981	0	0	12.2	20.1	8.5	30.5	6.1	0	0	77.4	59.1
1981-1982	0	0	3	20.6	35.2	29.3	19.5	8.1	0	115.7	85.1
1982-1983	0	0	4.2	10.2	7	4.7	11.6	15.1	0	52.8	21.9
1983-1984	0	0	6.4	49.9	13.9	15.1	17.3	0	0	102.6	78.9
1984-1985	0	0	6.2	36.6	44.7	29.3	14.5	5.2	0	136.5	110.6
1985-1986	0	0	8.1	48.1	28.3	13.7	13.6	0.9	1	113.7	90.1
1986-1987	0	0	10.2	22.9	56.5	12.5	0.9	3	0	106	91.9
1987-1988	0	0.5	4.5	23.4	19.5	44.5	5.2	0	0	97.6	87.4
1988-1989	0	13	3	20.5	26.1	26.1	14.5	6	0	109.2	72.7
1989-1990	0	0	23.5	64	43.2	18.5	4	4.6	0	157.8	125.7
1990-1991	0	0.5	14.2	23.3	37	18.4	4.8	0.2	0	98.4	78.7
1991-1992	0	0	21.4	21.7	7.4	17	13.6	4	0	85.1	46.1
1992-1993	0	1.8	6	18	24.3	53.6	18	13.5	0	135.2	95.9
1993-1994	0	0	11.3	33.5	67.5	34.3	18.8	5.7	0	171.1	135.3
1994-1995	0	0	8.5	8.6	35.1	44.3	2.8	0.4	0	99.7	88
1995-1996	0	0	20.2	46.8	41.1	14.1	16.3	8.5	1	148	102
1996-1997	0	0	18	29.6	84.6	14.8	32.2	8.2	0	187.4	129
1997-1998	0	3.8	22.6	35.9	21.9	12.9	13.7	0	0	110.8	70.7
1998-1999	0	0	0	17.5	46.3	4.3	32.2	0	0	100.3	68.1
1999-2000	0	0	2.2	28.9	10.2	34.1	8.2	8.3	0	91.9	73.2
2000-2001	0	0	14.2	42.1	22.4	26.8	40.9	1	0	147.4	91.3
2001-2002	0	0	0	59.5	37.8	15.9	16	6.4	1	136.6	113.2
2002-2003	0	0.7	19.9	41.9	39.3	18.7	11.7	24.8	0	157	99.9
2003-2004	0	0	4.5	32.6	36.9	29.2	16.7	1.6	0	121.5	98.7
2004-2005	0	0	0	17	24.5	32.1	14.7	0	0	88.3	73.6
2005-2006	0	1	9.4	50.7	16.4	57.3	5.2	0.3	0	140.3	124.4
2006-2007	0	2.3	3.1	11.2	26.2	56.9	23.8	14.6	0	138.1	94.3
2007-2008	0	0	0.8	31.6	44.6	44.4	28.3	0	0	149.7	120.6
2008-2009	0	0	13.8	63.1	55.9	13.8	0	1	0	147.6	132.8
2009-2010	0	0	0	57.2	17.3	23	0.2	0.5	0.6	98.8	97.5
2010-2011	0	0	7.2	7.4	31.7	46.9	20	1	0	114.2	86
2011-2012	0	0	0.7	8.3	36.8	13	5.1	1	0	64.9	58.1
2012-2013	0	0	8.9	30.2	13.5	42.4	34.3	2	0	131.3	86.1
2013-2014	0	0	6.9	59.4	43.5	34.7	25	1.7	0	171.2	137.6
2014-2015	0	0	23.3	13.8	43.7	32.3	7.8	0.6	0	121.5	89.8
2015-2016	0	0	0	6.5	56.8	4.9	2.8	3.6	0	74.6	68.2
2016-2017	0	0	15.5	37.1	31.3	33	15.9	0.5	0	133.3	101.4
2017-2018	0	0	4.8	82.7	21.2	24.2	27.6	3.7	0	164.2	128.1
2018-2019	0	1	36.4	12.8	51.5	42.2	15.4	1	0	160.3	106.5
2019-2020	0	0	7.8	23.1	35.3	48.6	2.1	3.3	2	122.2	107
2020-2021	0	0	6.5	11.9	33.9	35.9	1.9	3.3	0.3	93.7	81.7
2021-2022	0	0	1.3	9.3	25	36.4	13.2	4	0	89.2	70.7
2022-2023	0	0	7.8	35.6	18.5	18	29.4	0.3	0	109.6	72.1
2023-2024	0	0	13	3	37.5	13	10.7	2.9	0	80.1	53.5