

# Historical Climatology: Minneapolis-Saint Paul, Minnesota



## Overview

The Twin Cities experience some of the widest ranging temperatures in the United States. Summers are often hot and humid, similar to cities farther south such as Chicago, with heat indices occasionally exceeding 110°F. On the other hand, winters can be bitterly cold. Because there are no major topographic barriers to keep air from moving south out of Canada, arctic air masses commonly bring extremely cold temperatures and strong winds, resulting in dangerous wind chill values.

Fueled by humidity, summer precipitation accounts for roughly half of the annual total and falls primarily during thunderstorms. Severe, damaging storms are not uncommon. Winter precipitation is variable and includes snow, sleet, freezing rain, and the occasional liquid rain.

## Summary of Observed Changes

**Rising average temperatures:** Annual average temperatures warmed by 3.2°F from 1951-2012, faster than the national and global rates. Average low temperatures have warmed much faster than high temperatures.

**Longer freeze-free season:** The length of the freeze-free season (growing season), increased 16 days from 1951-2012.

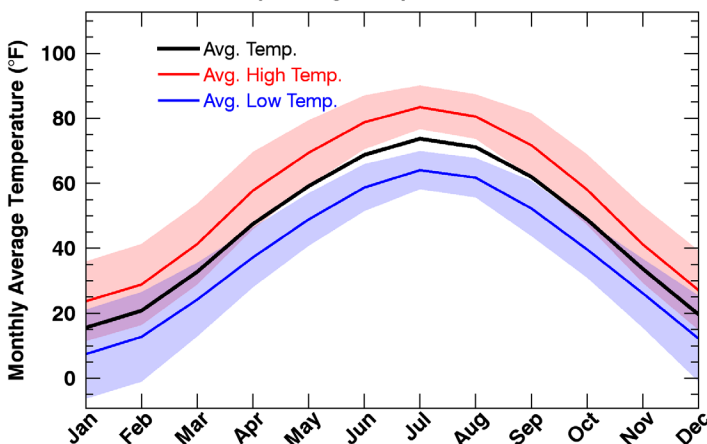
**More precipitation:** Total precipitation increased 20.7% (5.5 inches), from 1951 through 2012. Fall and spring increases over that time exceed 25% (1.9 and 1.5 inches, respectively).

**More heavy precipitation:** The number of very heavy precipitation events has increased by 58.3% (comparing the 1951-1980 total to the 1981-2010 total).

## Recent Climate Summary: 1981-2010 Temperature and Precipitation

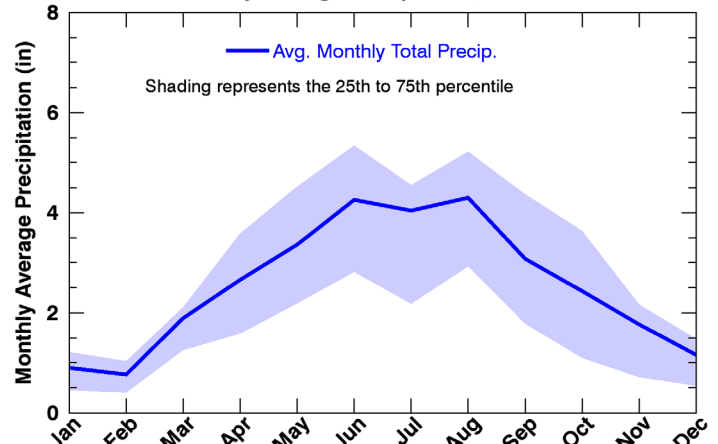
Average Temperature	46.2°F
Average Low Temperature	37.2°F
Average High Temperature	55.3°F
Days/Year that exceed 90°F	10.1
Days/Year that fall below 32°F	143.8
Lowest Annual Average Temperature	42.4°F
Highest Annual Average Temperature	49.7°F
Average Precipitation Total	30.6 in
Lowest Annual Precipitation Total	19.1 in
Highest Annual Precipitation Total	39.1 in
Days/Year that exceed 1.25" of Precipitation	3.8

Monthly Average Temperature, 1981-2010



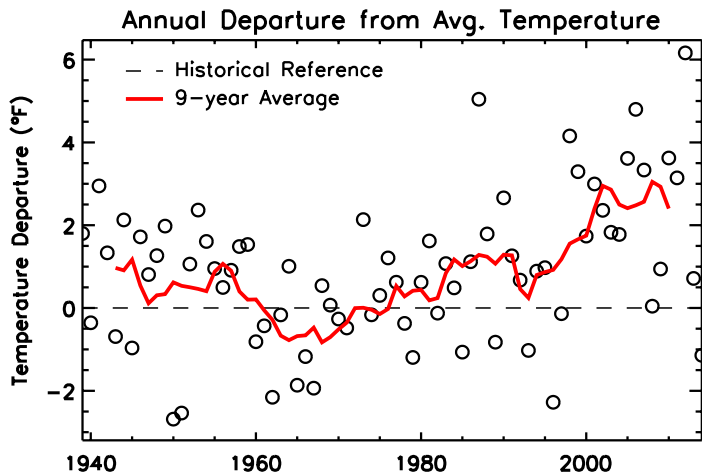
Average monthly temperatures during the 1981-2010 period. Shaded bands represent the standard deviation in the 30-year monthly average.

Monthly Average Precipitation, 1981-2010

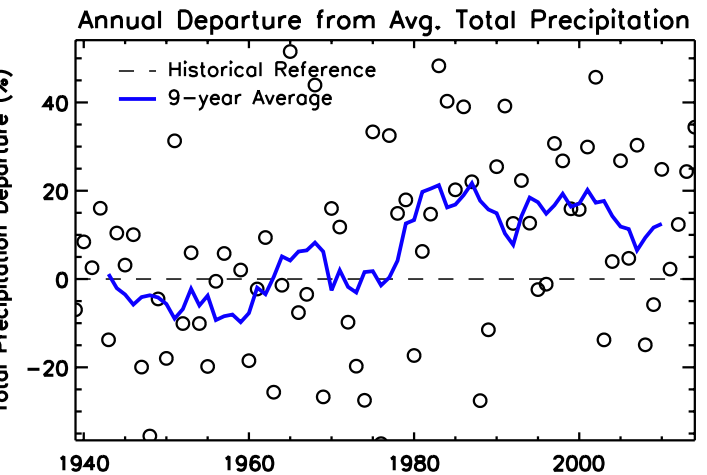


Average monthly total precipitation for the 1981-2010 period. The shaded band represents the 25th to 75th percentile.

## Changes in Average Temperature and Precipitation



Annual departures from the 1951-1980 average annual temperature. The solid red line is the 9-year moving average. Open circles represent the departure from the 1951-1980 historical reference for a single year.



Annual departures from the 1951-1980 average of total annual precipitation. The solid blue line is the 9-year moving average. Open circles are departures from the 1951-1980 average for single years.

### Changes in Average Temperature 1951-2012

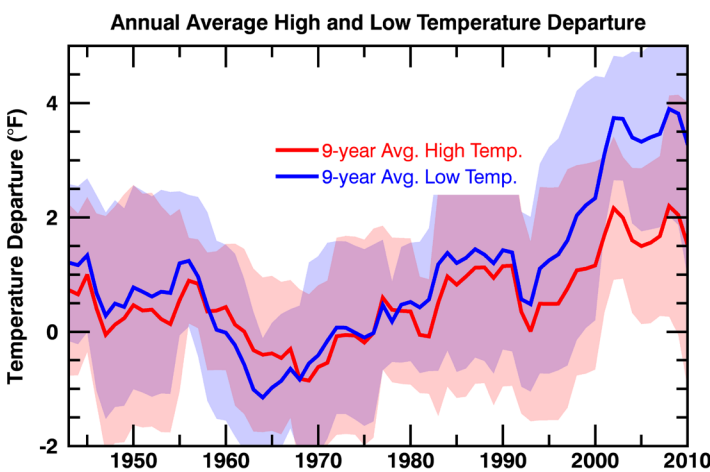
	°F	°C
Annual	3.2	1.8
Winter, December-February	4.5	2.5
Spring, March-May	4.4	2.5
Summer, June-August	1.9	1
Fall, September-November	2.1	1.2

Typical for the Midwest, temperatures in the Twin Cities fell from warm periods during the Dust Bowl of the 1930s before rising steadily since the 1950s. Annual average temperatures warmed by 3.2°F from 1951-2012, faster than the national and global rates. All seasons have warmed with winter and spring warming the fastest.

### Changes in Total Precipitation 1951-2012

	inches	%
Annual	5.5	20.7
Winter, December-February	0.3	11.3
Spring, March-May	1.9	27.9
Summer, June-August	1.6	14
Fall, September-November	1.5	26.5

Annual precipitation totals rose 20.7% from 1951-2012, similar to other locations in Minnesota and the Midwest. All seasons have seen an increase in precipitation, with fall and spring seeing the greatest changes both in terms of percentage change relative to the 1951-1980 average and the volume of total precipitation (inches).



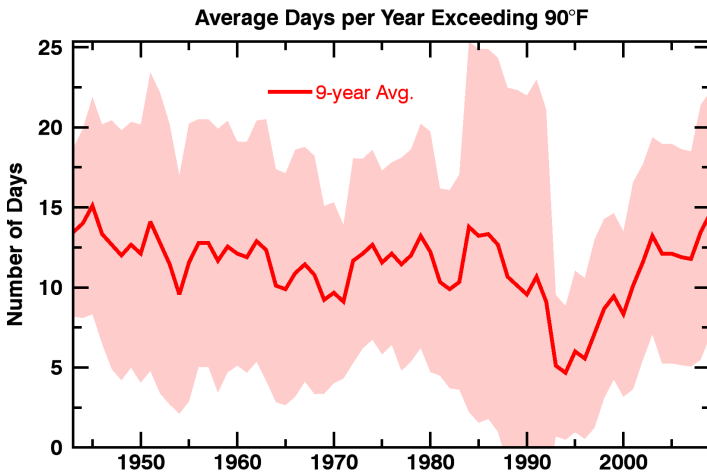
### Changes in Average High and Low Temperatures from 1951 through 2012

	°F	°C
Highs	+2.3	1.3
Lows	+4.1	2.3

Overnight low temperatures warmed almost twice as fast as mid-day high temperatures from 1951 through 2012. This means that temperatures have cooled less overnight than they have warmed during mid-day.

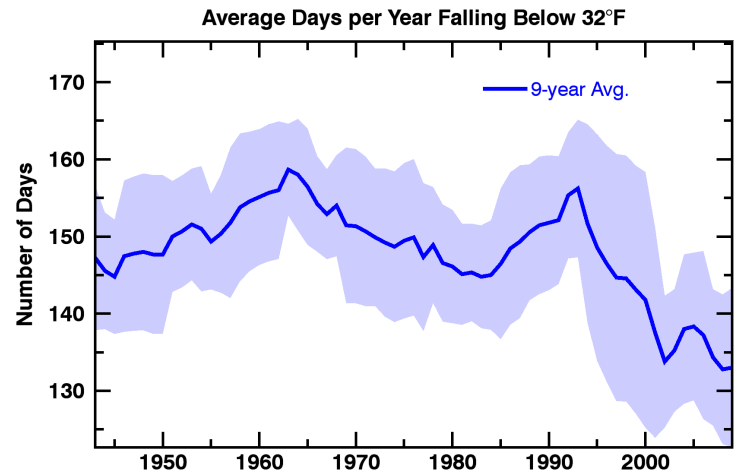
Left: Departures from the 1951-1980 average high and low temperatures. The red and blue lines are the 9-year moving averages. The shaded bands represent the standard deviations.

## Changes in Hot and Cold Days



The red line represents the 9-year moving average of the number of days per year exceeding 90°F. The shaded band represents the standard deviation.

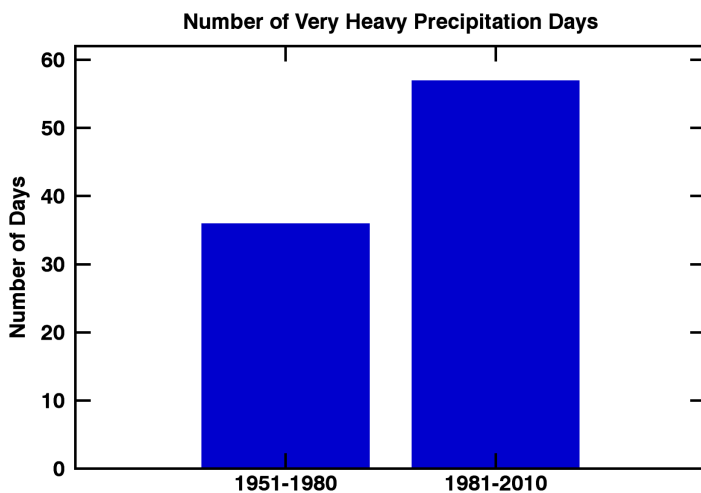
Despite rapidly rising average temperatures, the number of days per year that exceed 90°F has remained relatively stable. This is a trend not uncommon in the region. Why there hasn't been a greater increase in these hot days remains unclear, but other local factors and large-scale changes in land-use near the observing site can play a role.



The blue line represents the 9-year moving average of the number of days per year falling below 32°F. The shaded band is the standard deviation.

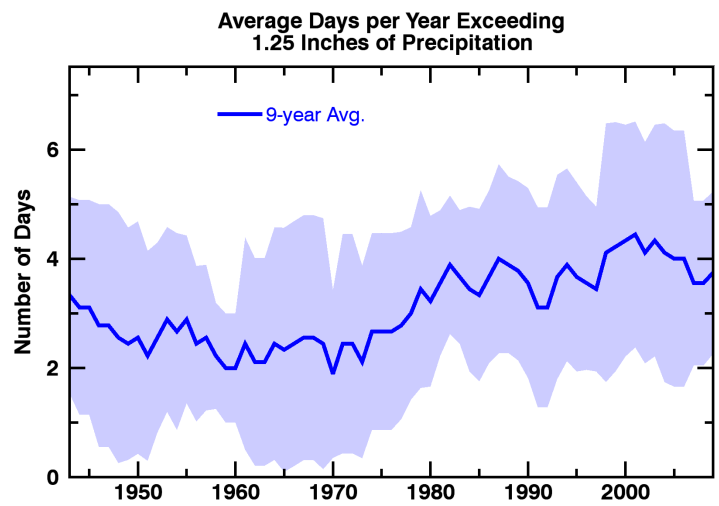
The number of days falling below 32°F per year dropped by 19.7 from 1951-2012. Much of the change has been due to a relatively rapid decrease since the mid-90s.

## Changes in Heavy Precipitation



The number of daily precipitation totals for the 1951-1980 and 1981-2010 periods that exceeded the size of the heaviest 1% of storms as defined by the 1951-1980 period.

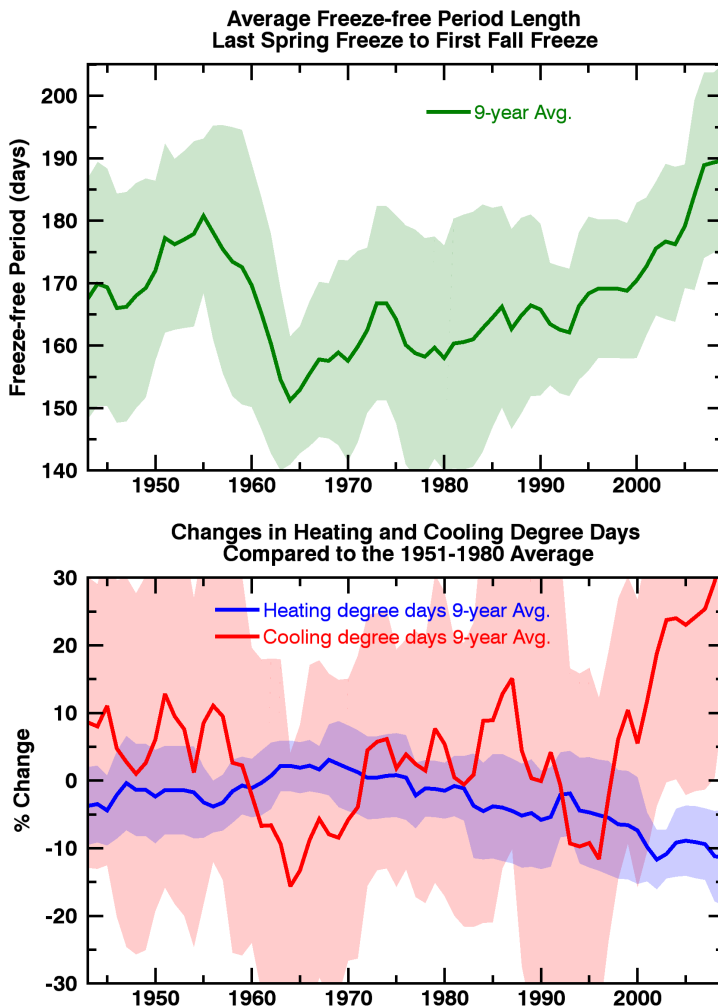
A “Very Heavy” Precipitation Day, as defined by the National Climate Assessment, is in the top 1% of daily precipitation totals. These precipitation events are typically disruptive and can cause infrastructure damage. Saint Paul has seen a 58.3% increase in the number of these precipitation events (36 storms from 1951-1980 to 57 storms from 1981-2010).



The blue line represents the 9-year moving average of the number of days per year exceeding a daily total of 1.25 inches of precipitation. The shaded band represents the standard deviation.

Daily precipitation totals that exceed 1.25” may lead to nuisance flooding and minor infrastructure impacts in some areas. The Twin Cities now see 1.8 more such days per year than in the past (an increase of 70% relative to the 1951-1980 average).

## Changes in Seasonality



The percent change in heating and cooling degree day units from the 1951-1980 average. The red and blue solid lines represent the 9-year moving average. The shaded bands show the standard deviation.

The freeze-free season (growing season), lengthened by 16 days from 1951-2012. Most of this change has been due to an earlier end date of the freezing season (an earlier spring thaw). In most other parts of the Great Lakes region, the length of the freeze-free season is tied closely to the number of days below freezing. Through the late-80s and early-90s, this was not necessarily the case for Saint Paul, as the freeze-free period increased steadily despite winters with more cold days.

Left: The green line represents the 9-year moving average of length of the time between the last freeze of spring and the first freeze of fall, the freeze-free period. The shaded band represents the standard deviation.

Heating and cooling degree days are indexed units, not actual days, that roughly describe the demand to heat or cool a building. Cooling degree days accumulate on days warmer than 65°F when cooling is required. Heating degree days accumulate on days colder than 65°F when heating is required. Extremely hot days accumulate heating degree day units faster than a mildly warm day, and similarly, bitterly cold days accumulate cooling degree day units much faster than a mildly chilly day. The Twin Cities see far more days that require heating than it does days that require cooling, and so it accumulates far more heating degree days than cooling degree days in a given year.

From 1951 through 2012, total annual cooling degree days have increased by 27% while heating degree days have fallen by 12%, consistent with warming temperatures. Due to its relatively cool, Midwestern climate, however, the actual decline of 978 heating degree day units has outpaced the increase of 190 cooling degree day units.

## Future Climate of the Twin Cities

Many of the observed trends in temperature and precipitation are expected to continue or accelerate in the future.

- **Average Temperature:** Models project average temperatures will continue to rise by 3-5°F in the region through mid-century.
- **More high temperature days:** Despite little observed change in the number of days with high temperatures above 90°F, the number of hot days is expected to increase with rising average temperatures.
- **Freeze-free season:** The freeze-free period is projected to continue to lengthen by an additional 1-2 months under high emissions scenarios.
- **Total Precipitation:** Most models project precipitation will increase overall, though the magnitude of projections vary widely. Many models project that summer precipitation will remain stable or decline.
- **More Heavy Precipitation:** Heavy precipitation events will likely continue to become more intense and more frequent as they have in the recent past.
- **Changing winter precipitation:** With warmer temperatures, rain may fall in place of snow, and mixed winter precipitation events, like freezing rain, may become more likely in some areas.