

# Historical Climatology: Ann Arbor, Michigan



## Overview

Ann Arbor's climate is mostly continental and is strongly influenced by the movement of high and low pressure systems across the continent. It experiences larger seasonal temperature ranges than areas closer to the Great Lakes which have moderated temperatures. Prevailing westerly winds deliver some lake effect precipitation to the area, but it is essentially limited to increased cloudiness during the late fall and early winter. While the day-to-day weather is highly variable, prolonged periods of hot, humid weather in the summer or extreme cold during the winter are relatively uncommon. Precipitation is well-distributed throughout the year, although the wettest months of the year tend to occur during the warm season. Summer precipitation comes mainly from afternoon thunderstorms.

## Summary of Observed Changes

**More precipitation:** Total precipitation increased 44.2% (13.4 inches), from 1951 through 2014. Winter increases over that time exceed 75% (4.4 inches).

**More heavy precipitation:** The number of very heavy precipitation events has increased by 41.2% (comparing the 1951-1980 total to the 1981-2010 total).

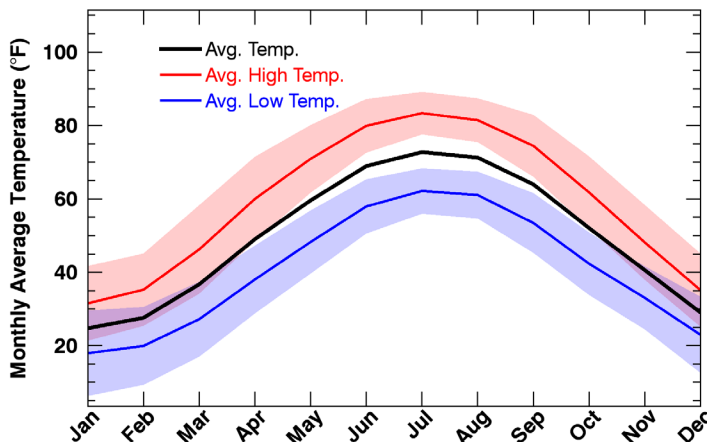
**Rising average temperatures:** Annual average temperatures warmed by 0.7°F from 1951-2014, slower than regional, national, and global rates. Average low and high temperatures have warmed at approximately the same pace.

**Shorter freeze-free season:** Despite warming average temperatures, the freeze-free period of the year has actually shortened slightly, by approximately 4 days, from 1951-2014.

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

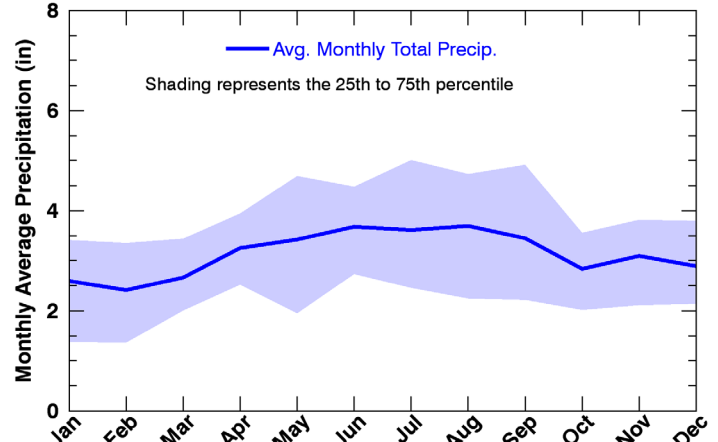
Average Temperature	49.8°F
Average Low Temperature	40.4°F
Average High Temperature	59.1°F
Days/Year that exceed 90°F	8.4
Days/Year that fall below 32°F	122
Lowest Annual Average Temperature	47.8°F
Highest Annual Average Temperature	53.3°F
Average Precipitation Total	37.6 in
Lowest Annual Precipitation Total	30.5 in
Highest Annual Precipitation Total	47.6 in
Days/Year that exceed 1.25" of Precipitation	3.7

Monthly Average Temperature, 1981-2010



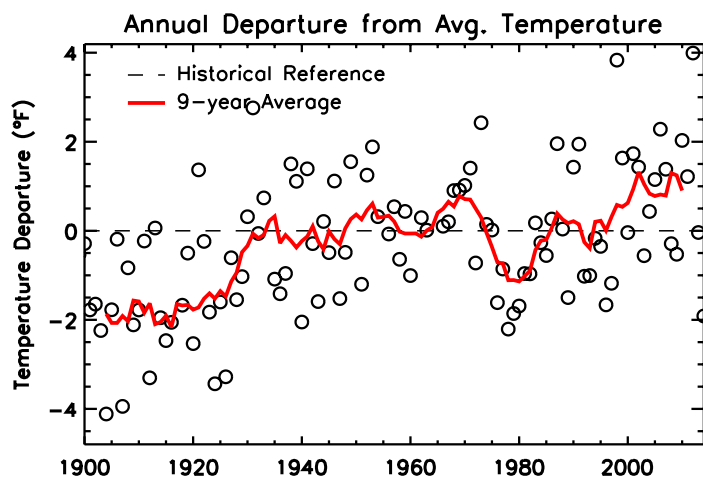
Average monthly temperatures during the 1981-2010 period. Shaded bands represent the standard deviation in the 30-year monthly average.

Monthly Average Precipitation, 1981-2010

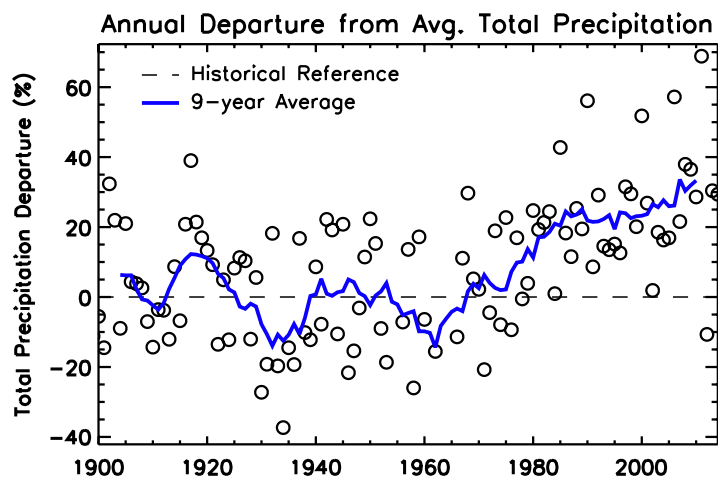


Average monthly total precipitation for the 1981-2010 period. The shaded band represents the 25th to 75th percentile.

## 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  
1951-2014

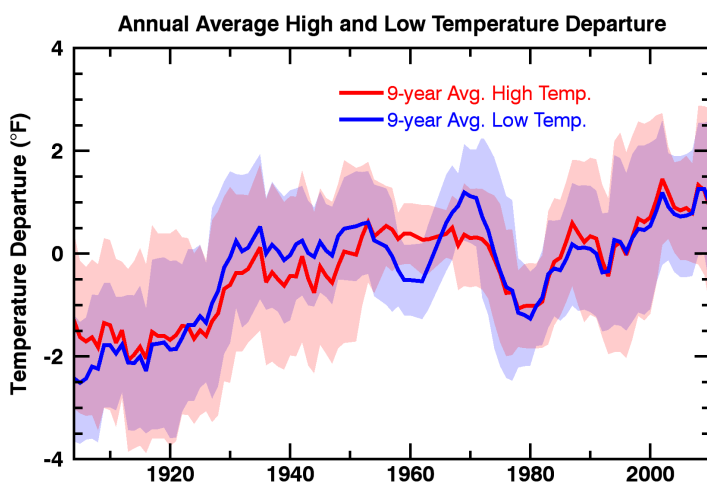
	°F	°C
Annual	0.7	0.4
Winter, December-February	0.7	0.4
Spring, March-May	1.7	0.9
Summer, June-August	0.6	0.3
Fall, September-November	-0.2	-0.1

Temperatures in Ann Arbor have risen since 1900, but have seen more moderate rates of change in recent decades than most other stations in the region. Annual average temperatures warmed by 0.7°F from 1951-2014, slower than than regional, national, and global rates. Spring temperatures have warmed the fastest, while fall temperatures have declined or remained nearly stable.

Changes in Total Precipitation  
1951-2014

	inches	%
Annual	13.4	44.2
Winter, December-February	4.4	75.4
Spring, March-May	2.7	32.7
Summer, June-August	3.1	33.5
Fall, September-November	2.9	41.5

Annual precipitation totals rose 44.2% from 1951-2014, far more rapidly than other locations nearby. All seasons have seen an increase in precipitation, with fall and winter seeing the greatest changes in terms of percentage change relative to the 1951-1980 average and winter and summer seeing the greatest changes in precipitation volume (inches).

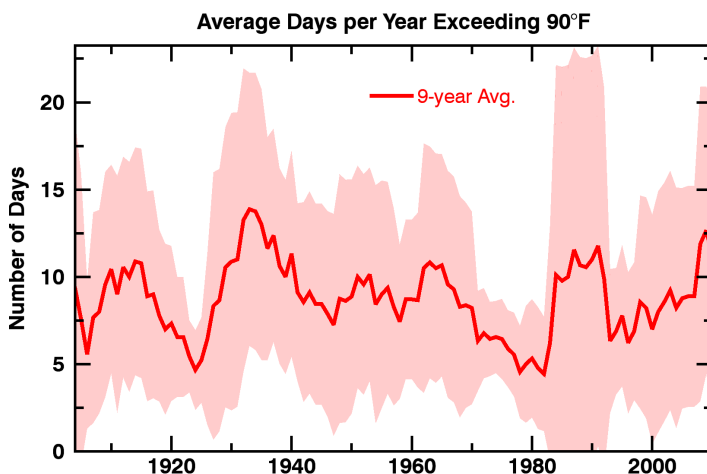
Changes in Average  
High and Low Temperatures  
from 1951 through 2014

	°F	°C
Highs	0.7	0.4
Lows	0.7	0.4

While most locations in the region have seen low temperatures warm faster, overnight low temperatures and mid-day high temperatures have warmed at roughly the same rate in Ann Arbor from 1951 through 2014.

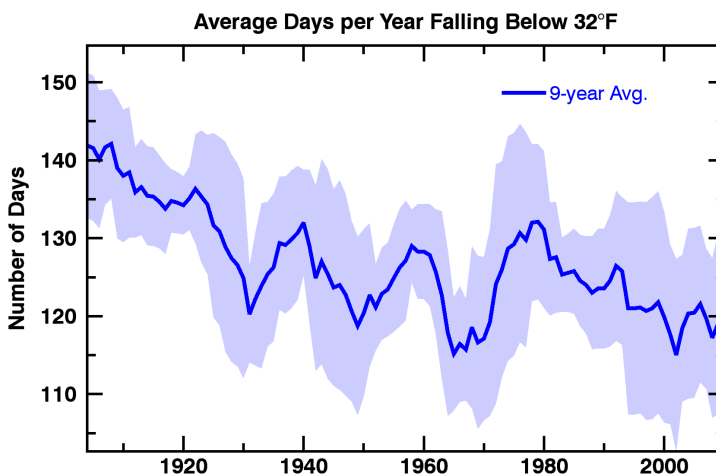
Left: Departures from the 1951-1980 average high and low temperatures. The red and blue lines are the 9-year moving averages. The shaded bands represent the standard deviations.

## 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.

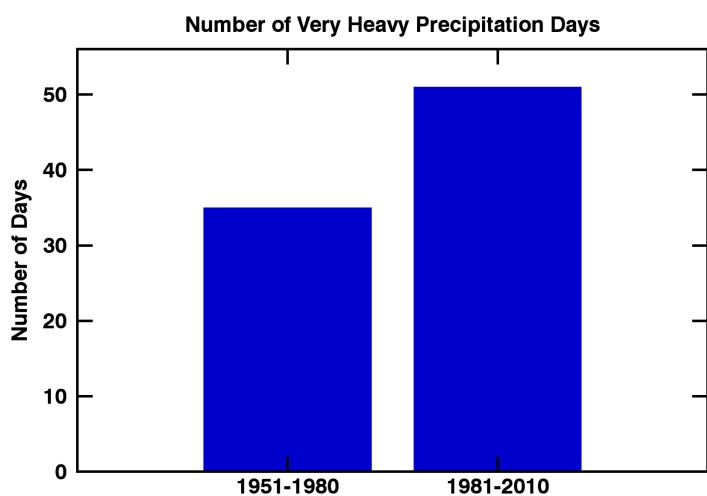
Despite rapidly rising average temperatures, the number of days per year that exceed 90°F has remained relatively stable. This is a trend not uncommon in the region. Why there hasn't been a greater increase in these hot days remains unclear, but other local factors and large-scale changes in land-use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

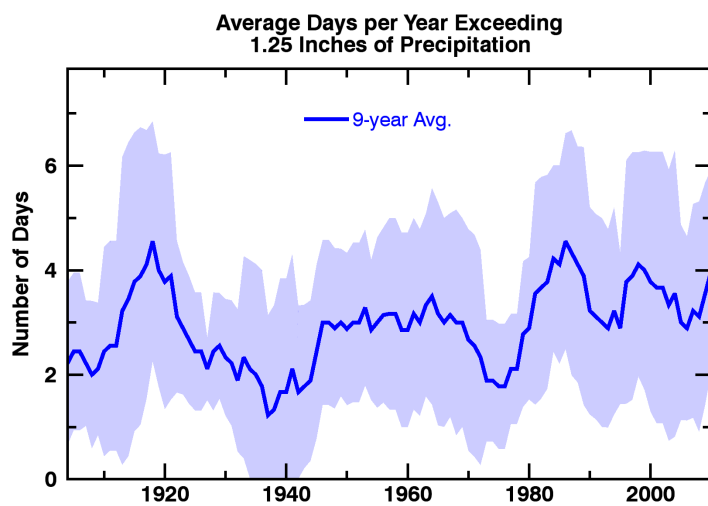
The number of days falling below 32°F per year dropped by 4.1 from 1951-2014, a modest change compared to other locations in the region.

## 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.

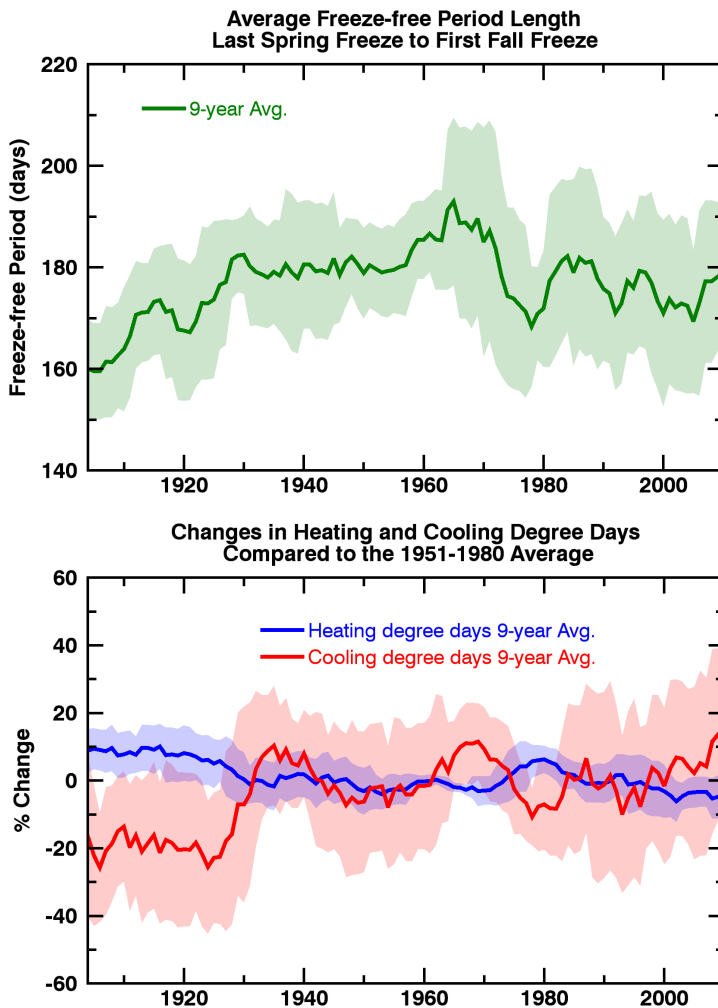
A "Very Heavy" Precipitation Day, as defined by the National Climate Assessment, is in the top 1% of daily precipitation totals. These precipitation events are typically disruptive and can cause infrastructure damage. Ann Arbor has seen a 41.2% increase in the number of these precipitation events (36 storms from 1951-1980 to 51 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. Ann Arbor now sees 1.3 more such days per year than in the past (an increase of 49% 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), shortened by 4 days from 1951-2014, opposite the trend of a longer growing season observed in most of the Great Lakes region. The growing season has been variable, but has decreased slightly in length after the early 1960s. This is also consistent with less observed warming than other locations in the region.

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. Ann Arbor sees 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 1951-2014, cooling degree days have increased by 7.6%, consistent with warming temperatures. Heating degree days have declined slightly. But because Ann Arbor sees more cool days than warm days in a given year, the actual decline of 124 heating degree day units has outpaced the increase of 56 cooling degree day units.

## Projected Future Climate of Ann Arbor

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:** Even though the growing season has shortened slightly in the past at this particular station, it is projected to lengthen by 1-2 months under high emissions scenarios for the region overall.
- **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.