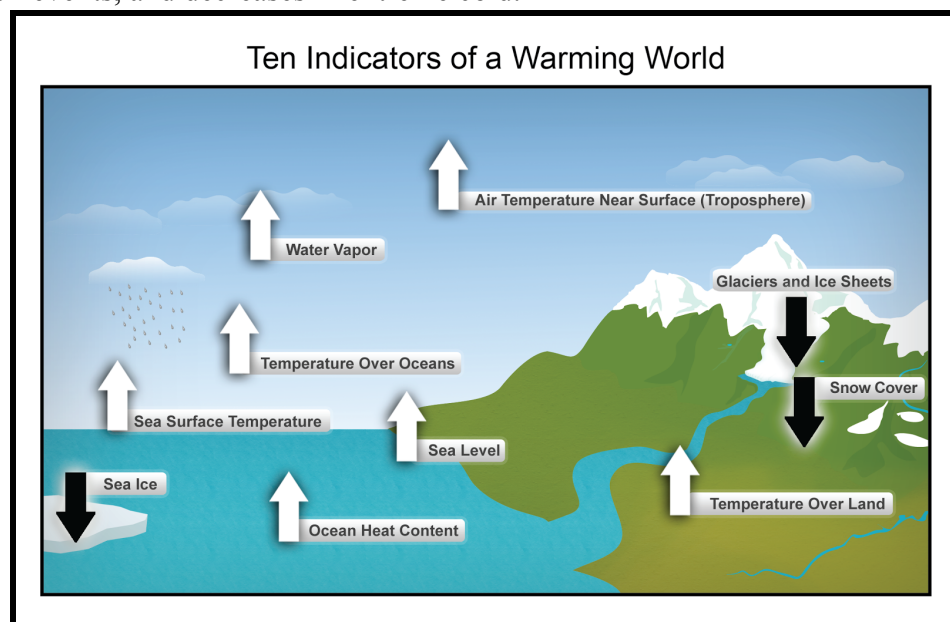


Evidence of Global Climate Change

Climate is the long-term pattern of weather conditions in a particular region, over several decades. Land, oceans, atmosphere, and ice sheets make up Earth's climate system. Many features of global climate are changing quickly. Evidence of these changes is abundant from the atmosphere to the oceans. Around the world, scientists and engineers have collected evidence of global climate change using a variety of tools. These tools include weather balloons, satellites, surface stations, and thermometers. Compiling evidence from these sources has led scientists to the following claim: the planet is warming.

Temperatures at Earth's surface, in the oceans, and in the troposphere (the lowest layer of Earth's atmosphere where weather occurs) have increased during recent decades. Scientists have found that the poles have experienced the largest temperature increases, particularly the Arctic. Snow and ice cover are decreasing, water vapor is increasing in the lower levels of the atmosphere, and sea levels are rising. Other evidence that suggests climate change includes variation in the length of the growing season. Growing season refers to the period of the year when crops and other plants in an area can grow successfully. Around the world, scientists have observed changes in average weather conditions, increases in the frequency of extreme heat and precipitation events, and decreases in extreme cold.

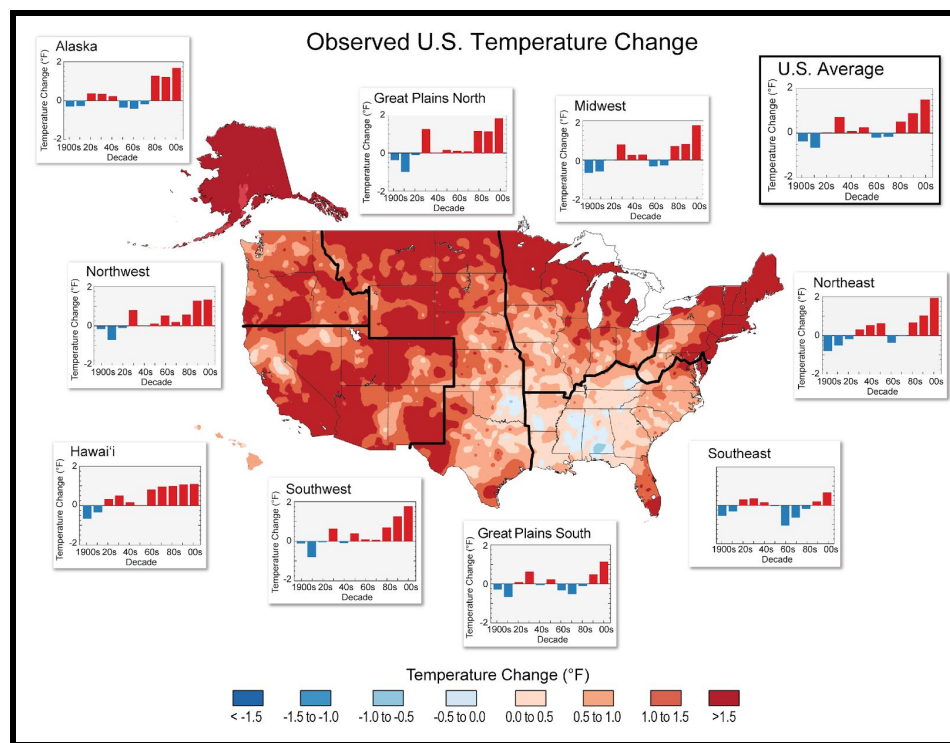


Turn and Talk: In your own words, describe the difference between *climate* and *weather*. What evidence supports scientists' argument that global *climate* is changing?

Temperature Change in the United States

Since scientists began keeping records in 1895, average temperature in the United States has increased by 1.3 to 1.9 degrees Fahrenheit. Most of this increase in temperature has occurred since 1970. In other words, the increase in average temperature has not been constant over time. For example, temperatures increased until around 1940, decreased somewhat until around 1970, and have increased quickly since then. The previous decade (2000-2009) was the warmest on record for the United States and scientists predict that temperatures will continue to rise.

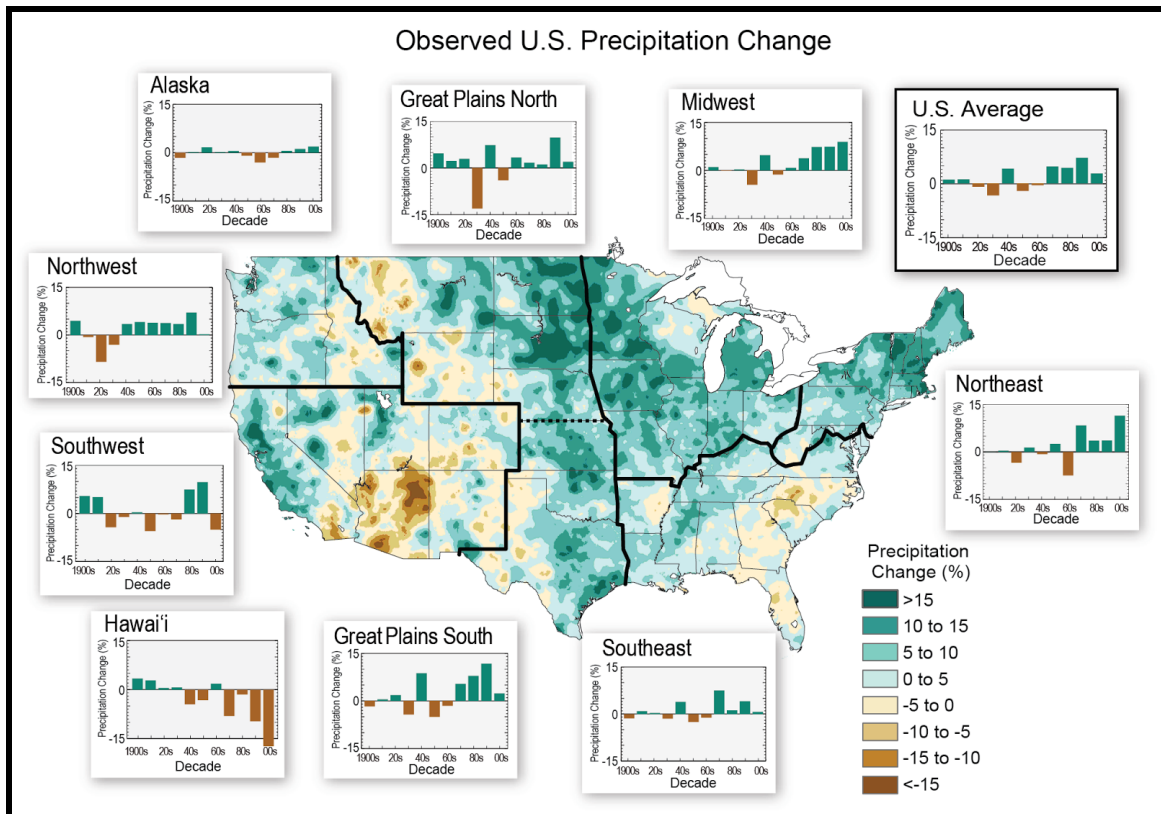
On average, temperatures in most of the United States have been 1 to 1.5 degrees Fahrenheit higher since 1991 in comparison to the years between 1901-1960. However, this pattern is not consistent in the Southeast United States, where observed warming has been less than 1 degree Fahrenheit. Seasonally, long-term warming has been most evident in winter and spring. Following these warming trends, the frost-free or growing season has been increasing across the U.S. since the 1980s, influencing the types of plants and crops that grow well in particular regions. These trends are expected to continue.



Stop and Jot: Using the text and graphic, describe the general trend in temperature changes in the United States. Identify any regions where the temperature change does not follow the general trend.

Precipitation Change in the United States

Since 1900, average precipitation in the U.S. has increased by about 5%. However, there are important regional differences. For example, some areas have seen larger increases, whereas other areas have seen decreases in precipitation. Specifically, in comparison to the years between 1901-1960, precipitation since 1991 increased most in the Midwest (9%), Northeast (8%), and southern Great Plains (8%) regions. In contrast, in the Southeast and Southwest regions, scientists observed areas with increases and decreases in precipitation.

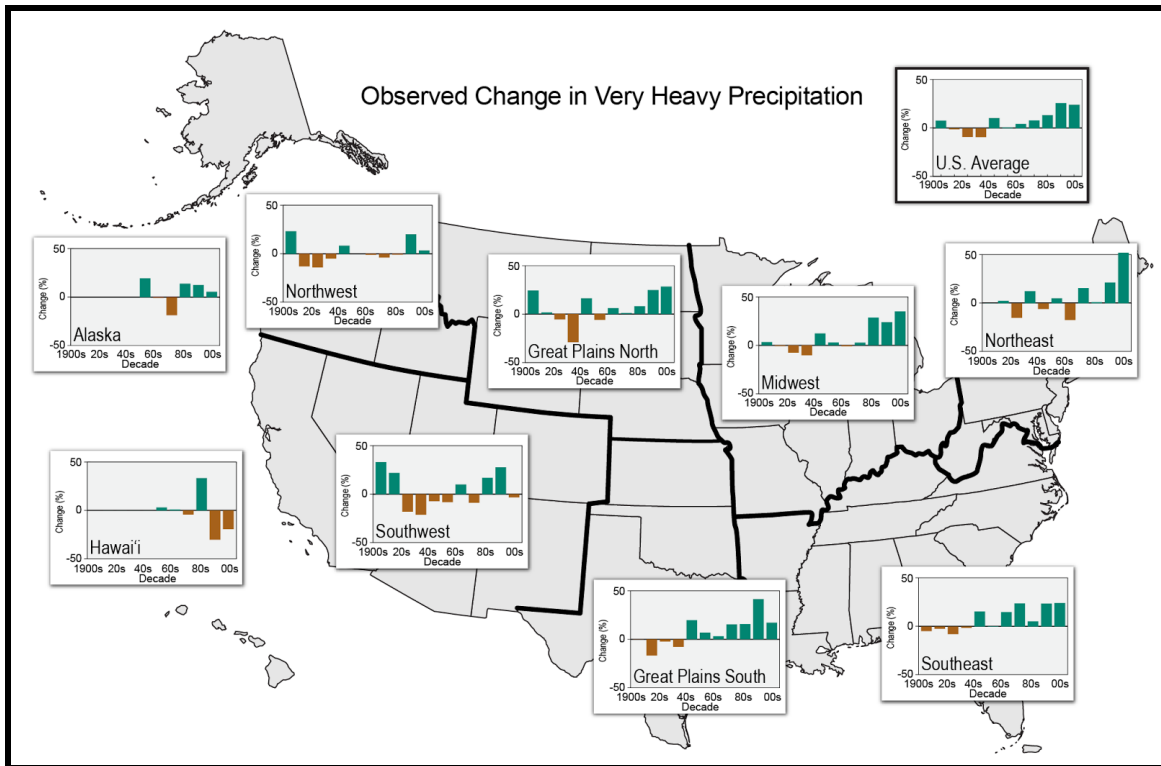


Heavy Downpours Increasing in the United States

Particularly within the last thirty to fifty years, heavy downpours have increased across the United States. The heaviest rainfall events have become heavier and more frequent than those previously observed. Since 1991, the amount of rainfall from heavy downpours has been significantly above average. Specifically, the Midwest, Northeast, and upper Great Plains regions have experienced the largest increases in heavy downpours – greater than 30% above the recorded average from 1901-1960. The Midwest and Northeast, in particular, have also experienced increased flooding events.

Warmer air can hold more water vapor than cooler air. Analyses across the globe demonstrate that the amount of water vapor in the atmosphere over the land and oceans has increased.

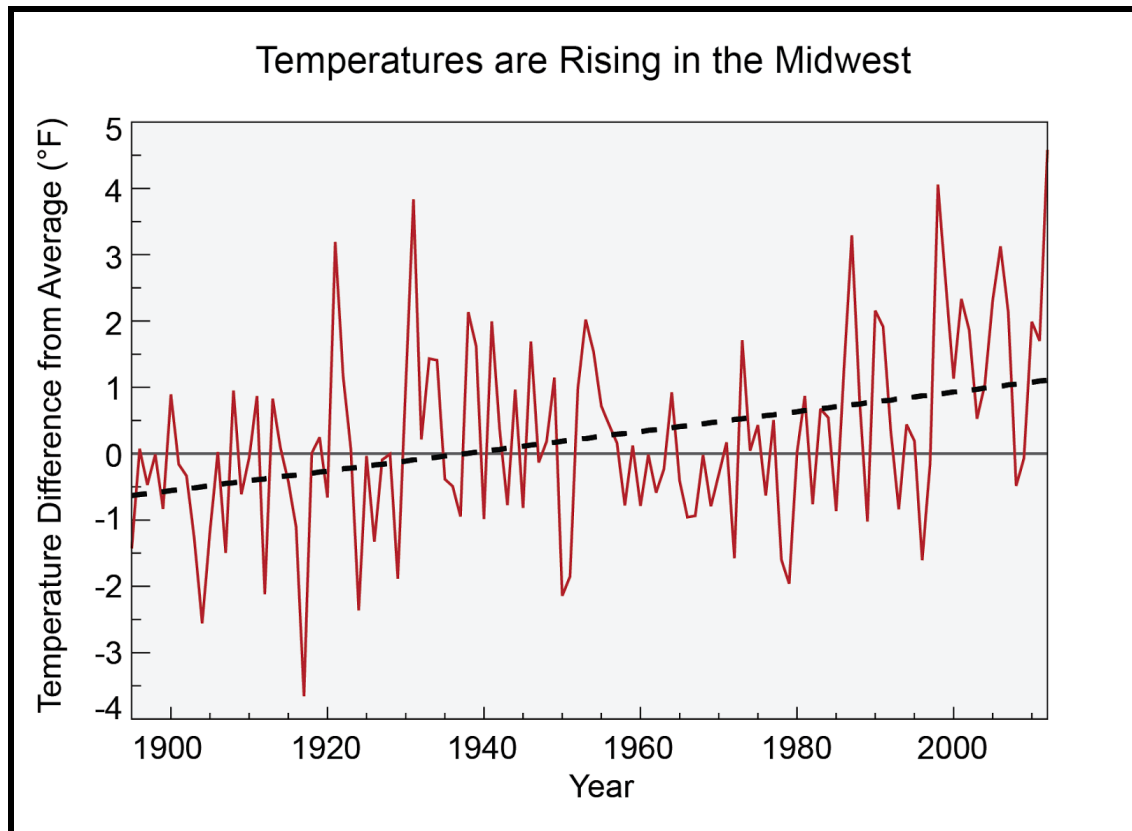
Climate change also impacts other atmospheric characteristics that influence weather patterns and storms. Within the continental United States, this is associated with the observed increase in extreme precipitation.



Stop and Jot: In your own words, describe the relationship between changes in temperature and changes in precipitation and extreme rain events.

Climate Change in the Midwest

Temperatures are rising in the Midwest. In fact, the rate of warming in this region has accelerated significantly over the last few decades. From 1900 to 2010, the average temperature in the Midwest increased by more than 1.5 degrees Fahrenheit, with observed changes in temperature most rapid from 1980 to 2010. Warming has increased most quickly during the winter and at night. Similarly, since 1950, the length of the frost-free or growing season in the Midwest has lengthened by almost two weeks.



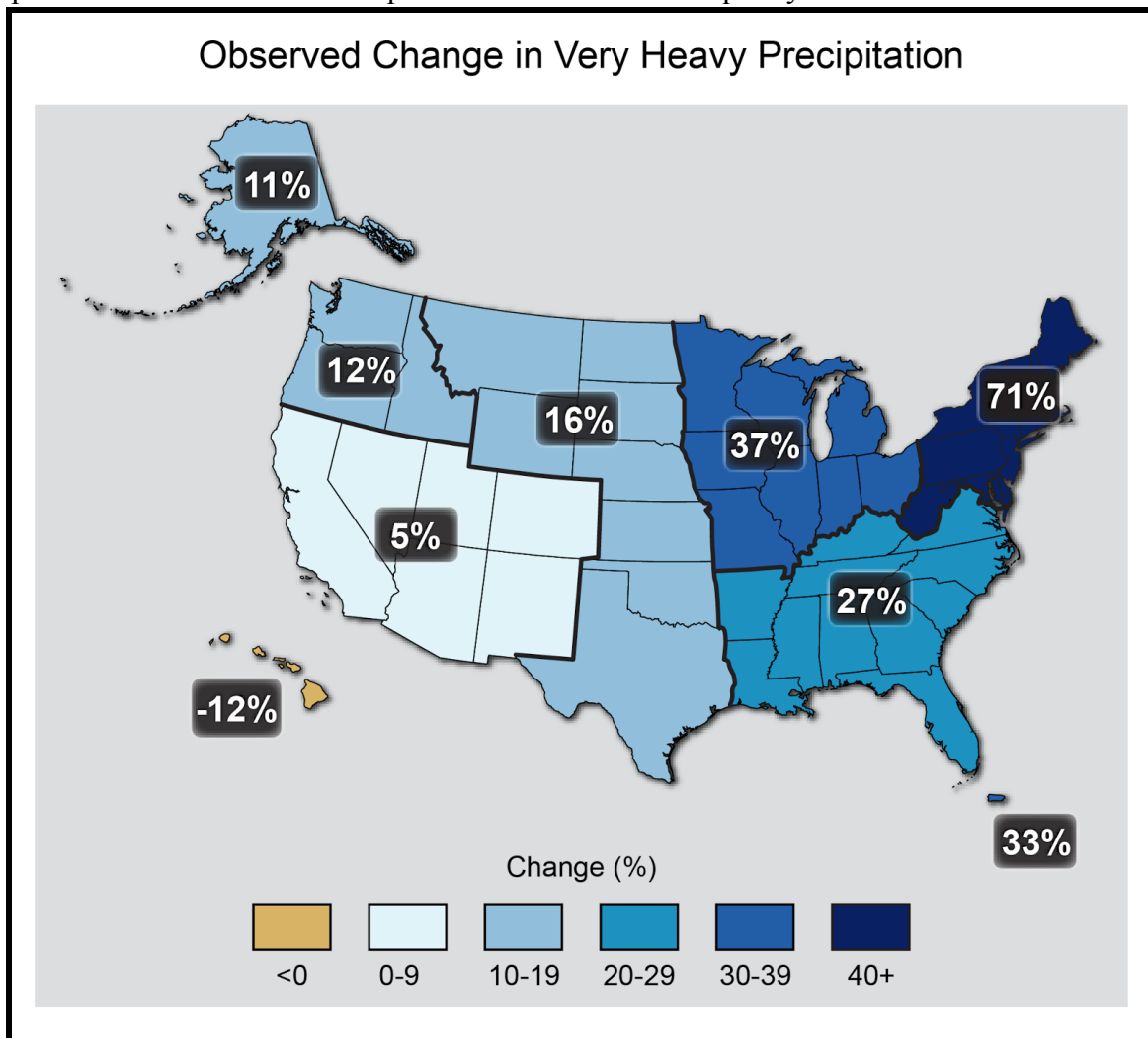
Increased Rainfall and Extreme Precipitation Events in the Midwest

In the Midwest, extreme rainfall events have increased during that last one hundred years and are expected to continue. These events have a number of consequences, including the following:

- Erosion
- Declining water quality
- Negative impacts on agriculture, infrastructure, human health, and transportation

In general, annual precipitation in the Midwest increased during the last one hundred years. In some locations, annual precipitation increased by as much as 20%. Much of this increase can be attributed to increased intensity of rain during heavy rainfall events. This trend is expected to continue.

The increased intensity of precipitation events in the Midwest increases erosion, which damages ecosystems. Additionally, increased agricultural runoff due to storms and rising water temperatures have contributed to pollution and other water quality issues in the Great Lakes.



Turn and Talk: What do you think are the most significant consequences of increases in temperature, precipitation, and extreme rainfall events in the Midwest? Are all of these consequences negative? Explain your reasoning.

Source:

[National Climate Assessment Report](#)

Image attributions:

Ten Indicators of a Warming World

<http://nca2014.globalchange.gov/highlights/overview/overview#narrative-page-20884>

Figure source: NOAA NCDC based on data updated from Kennedy et al. 2010; Adapted from: **2009 State of the Climate Highlights** by GlobalChange.gov U.S. Global Climate Change Research Program

Observed U. S. Temperature Change

<http://nca2014.globalchange.gov/report/our-changing-climate/recent-us-temperature-trends#graphic-16683>

Figure source: NOAA NCDC/CICS-NC; Sources: Kenneth Kunkel, Cooperative Institute for Climate and Satellites - NC/Laura Stevens, Cooperative Institute for Climate and Satellites - NC
GlobalChange.gov U.S. Global Climate Change Research Program

Observed U. S. Precipitation Change

<http://nca2014.globalchange.gov/report/our-changing-climate/precipitation-change#graphic-16688>

Figure Source: Adapted from Peterson et al., 2013 **Monitoring and Understanding Changes in Heat Waves, Cold Waves, Floods, and Droughts in the United States: State of Knowledge**/Laura Stevens, Cooperative Institute for Climate and Satellites - NC
GlobalChange.gov U. S. Global Climate Change Research Program

Observed Change in Very Heavy Precipitation

<http://nca2014.globalchange.gov/report/our-changing-climate/heavy-downpours-increasing#graphic-16692>

Figure Source: NOAA NCDC/CICS-NC/Kenneth Kunkel, Cooperative Institute for Climate and Satellites - NC/Laura Stevens, Cooperative Institute for Climate and Satellites - NC
GlobalChange.gov U. S. Global Climate Change Research Program

Temperatures are Rising in the Midwest

<http://nca2014.globalchange.gov/report/regions/midwest#graphic-17078>

Figure Source: Updated from Kunkel et al., 2013 Adapted from: **Regional Climate Trends and Scenarios for the U.S. National Climate Assessment: Part 3. Climate of the Midwest U.S.** NOAA Technical Report NESDIS 142-3/Laura Stevens, Cooperative Institute for Climate and Satellites - NC GlobalChange.gov U. S. Global Climate Change Research Program

Observed Change in Very Heavy Precipitation

<http://nca2014.globalchange.gov/report/our-changing-climate/heavy-downpours-increasing#graphic-16693>

Figure Source: Adapted from Karl et al. 2009; Adapted from: **Global Climate Change Impacts in the United States** by GlobalChange.gov U.S. Global Climate Change Research Program