MONTANA INSTITUTE ON ECOSYSTEMS

The Montana Climate Assessment

MONTANA'S CLIMATE

The climate in Montana is as diverse as the mountains and plains that define its landscapes and regions. It is also incredibly complex.

ARE WEATHER AND CLIMATE THE SAME?

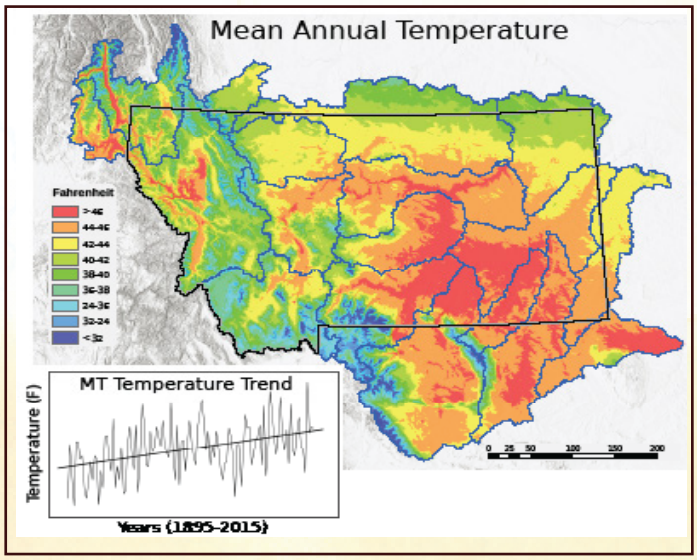
The terms "weather" and "climate" are often used interchangeably. However, they are not the same, and understanding the difference helps us when we talk about Montana's climate. The main difference between the two has to do with time. "Weather" occurs over a short period and is the day-to-day conditions of the atmosphere ("it's a hot day" or "a storm is forecast this weekend"). "Climate" pertains to what happens over decades to centuries. Generally, climate is based on averages of weather data over a 30-year period.

A discussion of Montana's climate—its past, present and future—begins with an understanding of its weather. The weather of Montana is influenced by large air masses that originate in the Pacific Ocean (cool and humid), the Arctic and Canada (cold and dry), and the tropics (warm and, in our region, generally humid). These air masses have specific characteristics of temperature, humidity and stability, and they vary in strength as they move across the region. Their long-term patterns and interactions define the climate.

HOW DO RESEARCHERS STUDY CLIMATE?

In order to understand Montana's current climate and make projections about Montana's future, researchers study large-scale climate patterns and historical trends. Of particular interest is understanding how changes in the large-scale, often global, features of climate play out on the smaller scale. This is called "downscaling."

Climate projections that are useful to stakeholders (farmers, ranchers, foresters, and other citizens) come from analyzing the output of climate models. Climate models are systems of equations based on the basic laws of physics and chemistry that describe the relationship between the atmosphere, land, and bodies of water. These complex models help answer questions about past and future patterns of atmospheric circulation that could not be understood from direct observation alone. Climate models operate at different spatial scales, from coarse resolution for global estimates to fine-scale resolution for regional and local estimates. The finer the resolution, the more math and information are needed to make accurate predictions. The increasing computational complexity partly explains why local climate projections have a high level of uncertainty.



Mean annual temperature map for Montana and adjacent regions. Areas in blue and purple have low annual average temperatures, and those in yellow, orange, and red experience higher temperatures. The map was created using weather station data from the years 1981-2010. The graph in the lower left corner is the average temperature of the state over the years 1895-2015. The straight line is the trend over those years. On average, temperature has been increasing by 0.2 degrees each decade across Montana.

HISTORICAL CLIMATE TRENDS

From 1895 to the present, Montana's average temperature has increased by 0.2° Fahrenheit every decade. This warming applies to most of Montana, except for the northeastern and north-central regions, which have had even larger temperature increases (0.3° Fahrenheit each decade). Over the span of 100+ years, this trend has led to average increases of 2° Fahrenheit across the state.

In contrast to temperature, there have been no significant trends in precipitation over the last century, either in the state as a whole or within regions.

ENSO: WHAT IT IS, WHAT IT MEANS

Montana's climate on interannual time scales is influenced by the El Niño-Southern Oscillation (ENSO). ENSO is a climate pattern created by anomalies in sea surface temperatures in the central and east-central tropical Pacific Ocean. These anomalies create either a warming phase (El Niño) or cooling phase (La Niña) that has impacts across the globe.

Montana's climate is correlated with ENSO, but different regions are affected in different ways. In general, an El Niño year brings warmer and drier conditions than average across the state, while a La Niña year is associated with cooler, wetter conditions. However, the magnitude of these conditions varies across the state. It's nice to know what's coming, and ENSO can be predicted in advance to allow time for planning and preparation.

EL NIÑO THIS YEAR

This winter (2015-2016), the National Oceanic and Atmospheric Administration (NOAA) predicts with 95% confidence that we are entering an El Niño year. Based on past El Niños, most of the state will likely experience warmer and drier conditions than average, and these impacts ought to decrease in severity by spring. Although conditions are likely to be warmer and drier than normal,

they actually may not be as extreme as the winter of 2015 when unusually high temperature and low precipitation occurred throughout the Pacific Northwest and western Montana as a result of large-scale climate anomalies in the Pacific Ocean.

CLIMATE IN THE FUTURE

The current collection of global climate models generally agree that Montana temperatures will continue to increase through the 21st century. We're less confident about future changes in precipitation because the results of global climate models and their downscaled projections for Montana don't all agree. As part of the Montana Climate Assessment, the results of 20 different models will be compared under different scenarios of increasing greenhouse gases. The range of model results for each scenario will used to calculate the uncertainty in projected precipitation and temperature estimates for the state.

QUICK FACTS

(Based on 120 years of weather data)

1) The hottest year on record for Montana was 2012.
2) This past year was the third hottest year on record for Montana.
3) The coldest year on record for Montana was 1899.
4) The last water year (Oct. 2014-Sept. 2015) was the 29th driest on record.
5) The driest water year was 1919, and the wettest was 1978.

WHAT AFFECTS CLIMATE?

At the global scale:

1) Natural variations in atmospheric composition, solar radiation, and volcanic eruptions
2) Large-scale interactions between the atmosphere, oceans and hydrosphere (water and water vapor), cryosphere (ice), land surface, and the biosphere (living organisms)
3) Human impacts, such as greenhouse gas emissions

At the regional scale:

1) Teleconnections that link the climate patterns and anomalies in one region with those in another region (e.g., ENSO, the Pacific Decadal Oscillation (PDO), and the North American Oscillation (NAO))
2) Strength, position, and persistence of air masses
3) Proximity to the ocean and the influence of mountain systems
4) Broad topographic features

At the local scale:

1) Local landscape features
2) Land cover characteristics (forests, shrubland, grasses, etc.)
3) Proximity to bodies of water, such as lakes

THE MONTANA CLIMATE ASSESSMENT

An assessment of Montana's climate is currently underway to describe past and future climate trends that affect different sectors of the State's economy. The Montana Climate Assessment (MCA) project involves university researchers, decision makers, and other stakeholders with the goal of providing timely and relevant information for the citizens of the State. The first assessment, available in 2017, will focus on climate issues that affect agriculture, forests, and water resources in Montana.

For more information, see:

www.montanaioe.org/mca
www.climate.umt.edu
http://mco.maps.arcgis.com/
https://www.climate.gov/

The Montana Climate Assessment

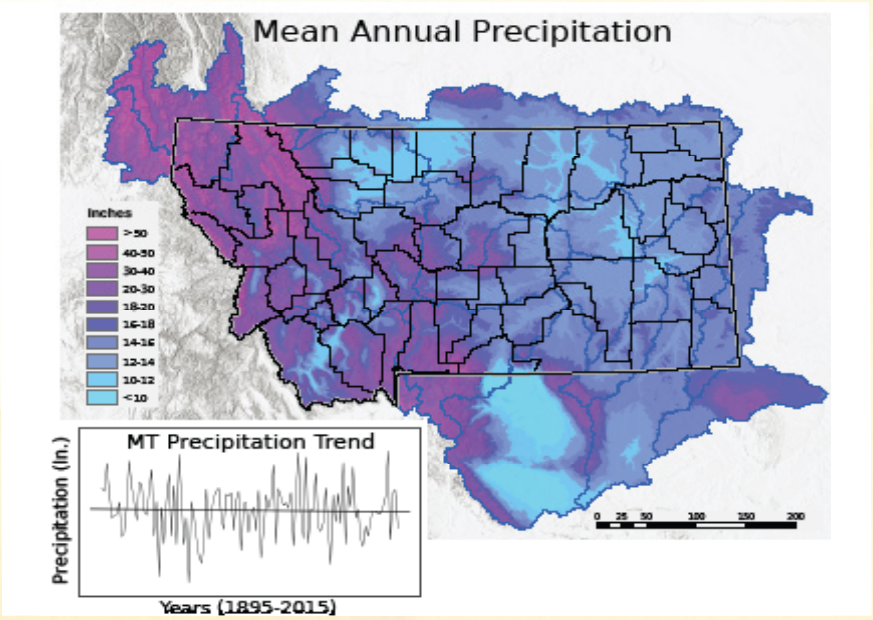
AUTHORS:

THE MONTANA CLIMATE OFFICE

The Montana Climate Office is an independent state-designated body that provides Montanans with high-quality, timely, relevant, and scientifically-based climate information and services. The MCO is working to provide targeted water and climate information on topics of interest for the state and specific regions.

THE MONTANA INSTITUTE ON ECOSYSTEMS

The Montana Institute on Ecosystems is a community of scientists and partners that studies Montana's complex ecosystems. Formed in 2011 with funding from the National Science Foundation's EPSCoR program, the IoE has offices at Montana State University and the University of Montana. IoE partners come from all of Montana's institutions of higher education, state and federal agencies, tribal colleges, non-profit organizations, and small businesses.



Mean annual precipitation map for Montana and adjacent regions based on weather station data from 1981-2010. Areas in light blue have relatively low annual precipitation, and those in purple and pink receive higher levels. Precipitation measurements include both snow and rain. The regional boundaries of the data are formed by the watersheds of Montana. The graph in the lower left corner is the average annual precipitation of the state over the years 1895-2015. The straight line is the trend over those years. On average, precipitation has not changed across Montana.

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