The people of Montana take a certain pride in enduring, and even enjoying, long, cold winters. That said, in the dead of winter the prospect of global warming is greeted by many with happy anticipation. While speculation about trends in Montana climate abounds, little scientific effort has been brought to bear on the topic. In this poster, we report on 20th-century trends in temperature extremes for nine Historical Climate Network stations with at least 100 years of record in the mountains of western Montana.

What are extreme climate events? Weather conditions are highly variable in Montana. In seeking to detect changes in extreme climate events, we defined “extreme climate events” as large areas experiencing unusual climate values over a long period of time. More specifically, we used daily weather records to mine number of days per year exceeding three key thresholds: -17.8ºC (0ºF), 0ºC (32ºF), and 32.2ºC (90ºF); following Easterling et al. 2000.

Why focus on temperature extremes? In Montana, episodes of extreme heat or cold are often associated with major impacts on human health, agricultural production, wildlife, and consumer energy demands (Easterling et al. 2000). Some of these impacts may be socially positive (e.g., reduction in the number of heating degree days). Some of these impacts have the potential to disrupt human livelihoods and local economies (e.g., large wildfires, Westerling et al. 2006).

What causes extreme temperature events? Episodes of extreme climate events are associated with long-term changes in drivers of regional climate change in the American West, particularly Pacific Ocean temperature patterns such as El Niño – Southern Oscillation (ENSO) variability. Trends towards extreme warmth in recent decades provide evidence that Montana’s climate may be warming in sympathy with the overall climate of the Earth. Increasingly, scientific evidence indicates that approximately global temperature rise of 0.8ºC (1.4ºF) over the 20th century can be directly attributed to the accelerated accumulation of greenhouse gases in the atmosphere (Figure 1). IPCC 2001, Hansen et al. 2005.

INTRODUCTION

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DATA RESOURCES

A major goal of this project was to make the data resources and analysis available to other states, counties, and the general public. To meet this goal we sought to 1) compile high-quality, freely available, daily and monthly temperature data, 2) use freely available analysis software, and 3) keep analysis method simple and provide well-documented, easy-to-use code for more difficult functions. These goals were accomplished. The long-term (1895-2002), corrected data used in the analysis presented here are provided by the U.S. Historical Climatology Network (http://cdiac.ornl.gov/pubs/npdf/ushcn/nwusnths.html), and the recent updates (2002-present) from the Western Regional Climate Center (http://www.wrcr.ucar.edu/). Northern Hemisphere and Global temperature data was obtained from the Global Historical Climatology Network (http://cdiac.ornl.gov/trends/temp/lugina/data.html). All statistics and daily data analysis were performed using the R project software environment (free download at http://www.r-project.org/). Code written for a single station daily temperature analysis may be obtained from Greg Pederson (gpederson@montana.edu) and will soon be available on-line from the Big Sky Institute (http://bsi.montana.edu).

GLOBAL CLIMATE CHANGE AND WESTERN MONTANA

The expression of global warming induced climate change may differ by region as well as across seasons. For western Montana we see temperature variability across seasons tracks global (not shown here) and Northern Hemisphere trends on short (interannual) and long-term (multi-decadal) scales (Figure 4). Although this response is strong for the entire region, at the scale of an individual station the strength of the relationship may become quite variable (Figure 5). The decoupling of an individual station from regional or global trends may result from a variety of factors.

REGIONAL TRENDS IN MAXIMUM AND MINIMUM TEMPERATURES

Globally, a major driver of change in average temperatures results from a Decreasing Diurnal Temperature Range (DTR). The decrease in DTR is mainly attributed to a more rapid increase in minimum (nighttime) temperatures rather than in maximum, which is likely caused by a number of factors, such as increased cloudiness and earlier spring weather. In this project the authors have along with several Canadian scientists found a strong decrease in DTR throughout the Canadian Rockies (Glacier National Park, MT to Jasper, AB). For western Montana, however, changes in maximum and minimum temperatures are different across seasons (Figure 2). Results may be summarized as follows:

• Significant (p<0.05) increases in maximum and minimum temperatures.
• A decrease in DTR due to more rapid increase in maximum temperatures.
• Maximum temperatures exhibit greater variability than minimums.
• Over the last 20 years spring minimum temperatures were on average above freezing.
• Since the 1960’s winter maximum temperatures have been trending above freezing.

Fig. 1. (A) Forcing used to drive global climate simulations. (B) Simulated and observed temperature change before 1800, the observed curve is based on observations at meteorological stations and the model is sampled at the same points, whereas after 1800 the observations include sea surface temperatures for the ocean area, and the model is the true global mean. Five climate simulations are carried out that differ only in initial conditions. Figure adapted from Hansen et al. 2005.

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