ModularityHW_Kelly

Michelle Kelly

June 21, 2018

Introduction

Average surface temperature on Earth has increased by 0.7°C since the onset of the industrial era (United Nations Framework Convention on Climate Change (UNFCC) 2007). Widespread fossil fuel use, and the following spike in atmospheric CO2, have acted as a global insulation blanket: trapping heat in the atmosphere and slowing it's release (Asfaw et al. 2018). Increased temperatures are also impacting precipitation regimes; in the United States, increases in the severity of drought and flood events are expected (Dore 2005). However, the impact of global change on a local level is expected to be more spatially heterogenous, with different regions of the US experiencing varied climate and precipitation responses (Trenberth 2011).

We assess these expectations using 40 years of weather station data, asking (1) can climate warming be seen across the United States, (2) are the effects of climate warming regionally-dependent, and (3) what change has occured in precipitation?

Methods

We used annualy averaged weather-station temperature (50 states, 3014 weather stations) and precipitation data (3 states, 270 weather stations) from 1950 to 2008. Only weather stations with at least 40 years of measurement data were included in this analysis.

Yearly summary statistics were calculated by taking the mean observation within a state during any given year. To compare changes across time, a mean value for the duration of observations within a state was calculated, and subtracted from the annual value (Equation 1).

$$Deviation\,from\,average_{state} = Annual\,average_{state} - Time\,series\,average_{state} \quad (1)$$

Therefore, negative values represent time periods when a state was experiencing below average temperatures, and positive values represent periods when a state was experiencing above average temperatures.

Results and Discussion

We see that deviations in temperature from local averages have generally increased from 1950-2008 (p-value < 0), with rapid increases from 1980 onwards (Figure 1). However, warming has not been homogenous across the USA: states at northern latitudes and those located in the American Southwest have experienced more extreme effects.

We know that the Earth has undergone two main periods of warming within the last century, one from 1910 and 1945, and the other from 1976 to present day (Walther et al. 2002). These results support the latter half of that assessment. It is also known that the Southwest and Upper Midwest regions have experienced the highest increases in annual temperature above normal since 1976 (Walther et al. 2002).

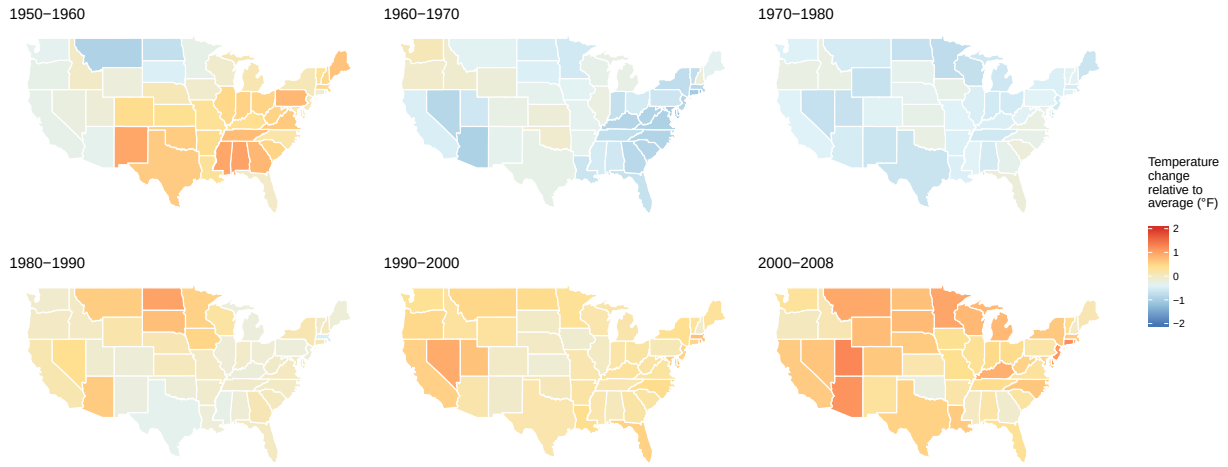

Figure 1: Change in temperature per decade, relative to 1950-2008 state average.

Precipitation dynamics have changed from 1950 to 2008 (p-value = 0.0504017). Visually, we can see that there are both intense "high" and "low" years (that is, a potential increase in flood and drought events) (Figure 2). To further investigate this phenomenon, we could use United States Geological Survey (USGS) river discharge data as an additional flood and drought predictor. It is not clear by this analysis alone whether location is a predictor of precipitation change. A finer scale (county level) analysis may be useful.

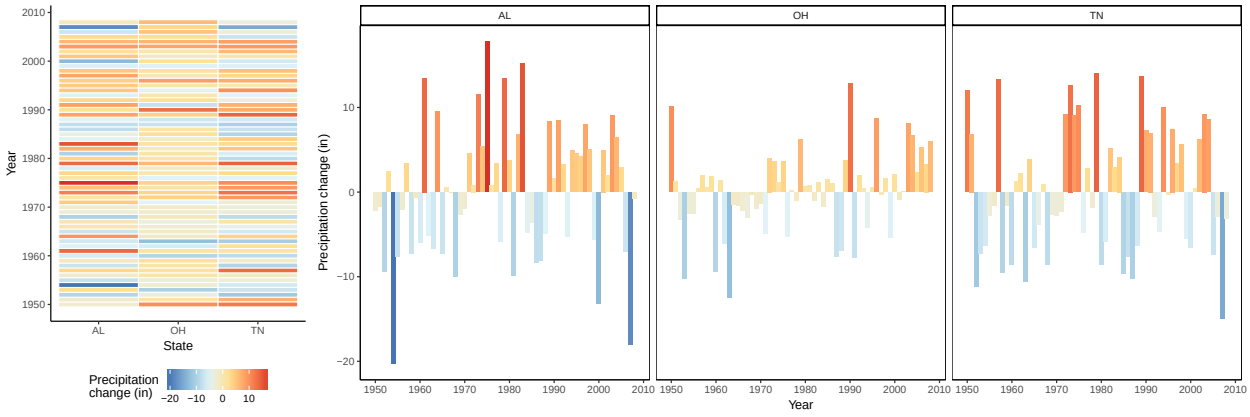

Figure 2: Anomalies in annual precipitation, relative to 1950-2008 state average

In summary, we have determined that climate warming from 1950 to 2008 is highly visually apparent. Generally, the southwest and upper midwest regions are experiencing the most warming, while the southern and southwest regions experienced colder than average temperatures during 1960-1980. We suspect that precipitation has become more "dynamic", with more flood and drought events, although further investigation is needed before a definitive conclusion.

Supplemental

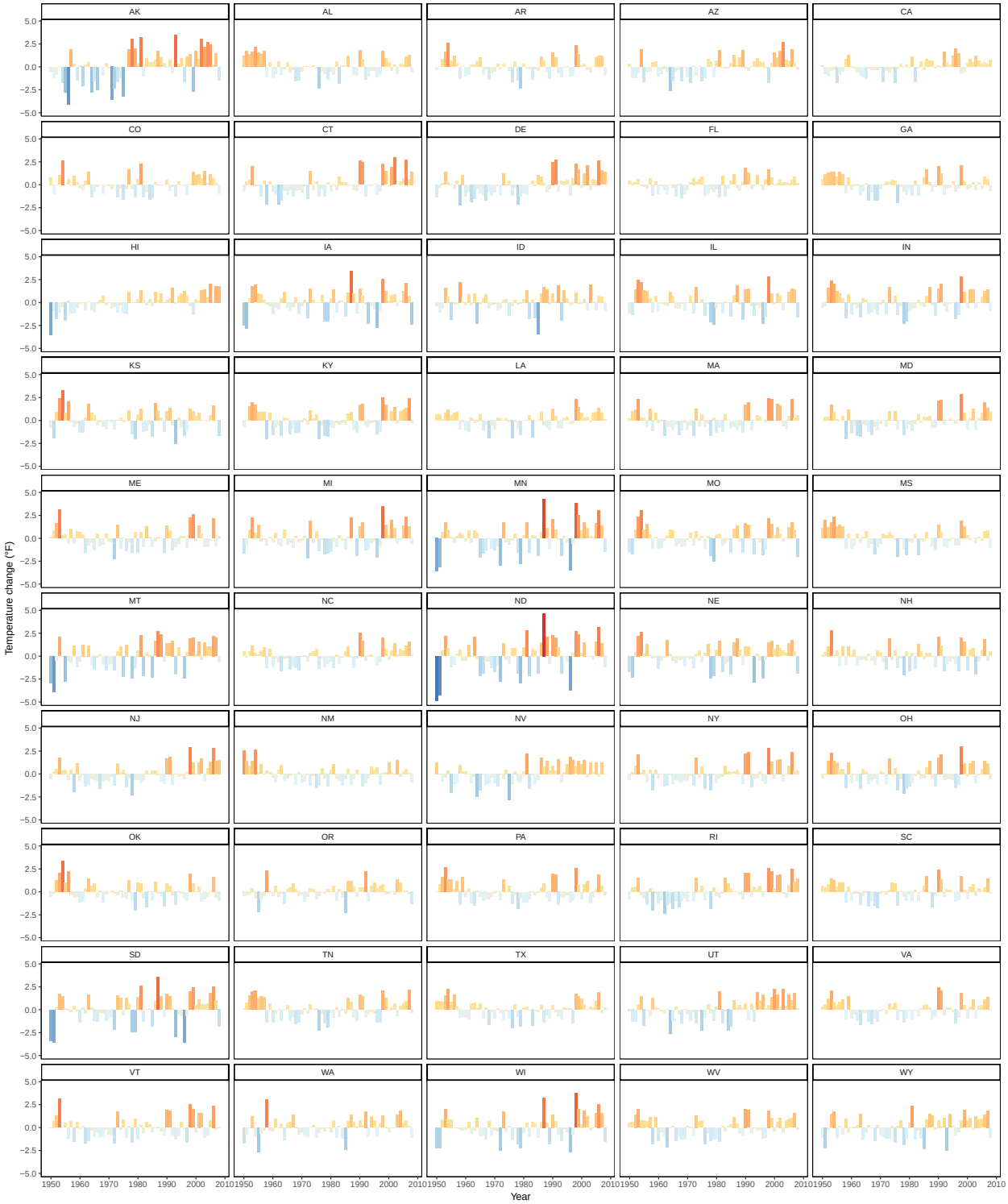

Figure 3: Anomalies in annual mean temperature, relative to 1950-2008 state average

References

Asfaw, Amogne, Belay Simane, Ali Hassen, and Amare Bantider. 2018. "Variability and time series trend analysis of rainfall and temperature in northcentral Ethiopia : A case study in Woleka sub-basin." *Weather and Climate Extremes* 19 (December 2017). Elsevier Ltd: 29–41. doi:10.1016/j.wace.2017.12.002.

Dore, Mohammed H I. 2005. "Climate change and changes in global precipitation patterns: What do we know?" *Environment International* 31: 1167–81. doi:10.1016/j.envint.2005.03.004.

Trenberth, Kevin E. 2011. "Changes in precipitation with climate change." *Climate Research* 47 (1-2): 123–38. doi:10.3354/cr00953.

United Nations Framework Convention on Climate Change (UNFCC). 2007. "Climate Change: Impacts, Vulnerabilities and Adaptation in Developing Countries."

Walther, Gian-reto, Eric Post, Peter Convey, Annette Menzel, Camille Parmesan, Trevor J C Beebee, Jean-marc Fromentin, Ove Hoegh-guldberg I, and Franz Bairlein. 2002. "Ecological responses to recent climate change." *Nature* 416: 389–95.