The Effects of Climate Change on the Yearly Average Temperature of WI and TX

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Introduction

This project began with an interest in determining whether the average yearly temperature had increased in the state of Wisconsin but was expanded to include a southerly state, Texas, in order to study how differences in location may have affected yearly temperature. We hoped to determine whether there was a statistically significant increase in both the average yearly temperature as well as the volatility of the monthly temperature data as measured by standard deviation.

At the conclusion of our analysis we found that there was no significant (p=0.130) difference in Wisconsin's average yearly temperature between the periods 1895-1951 and 1952-2008. However, there was a significant (p=0.0342) difference in temperature in Texas' average yearly temperature between the periods 1899-1959 and 1960-2019. Neither state saw a significant change in temperature volatility throughout either of their periods of study.

Analysis

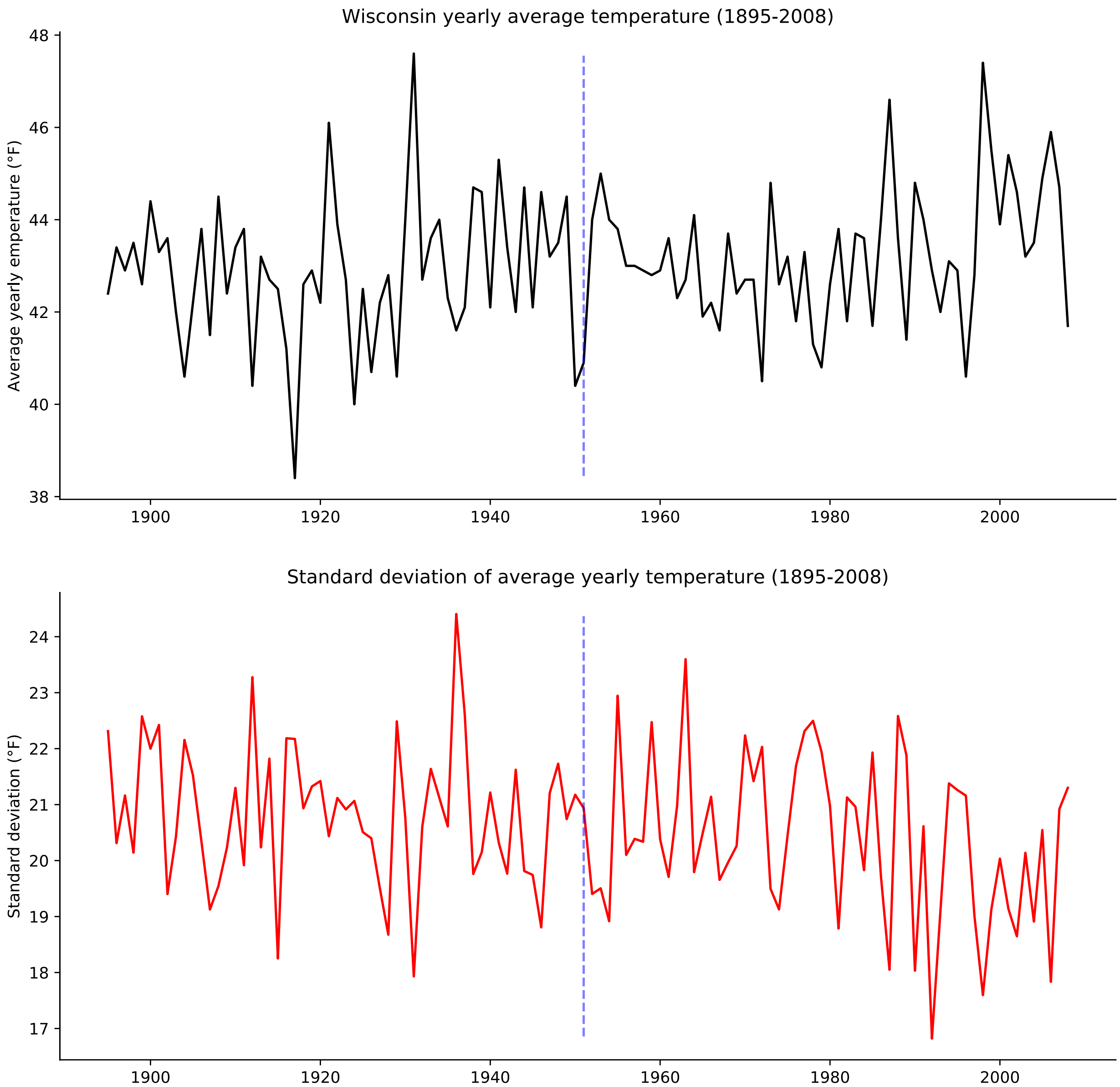
Wisconsin

We retrieved the data for Wisconsin from a large dataset made public by the University of Wisconsin-Madison Department of Oceanic and Atmospheric Sciences. This dataset tracked Wisconsin's average temperature for each month and year from 1895-2008. We were very fortunate that this data was readily available and in a very usable form as we found it more difficult to find state-wide average temperature data for other states. We downloaded this data, cleaned and formatted it, and split the data into two equal length data sets (1895-1951 and 1952-2008). Our goal was to see if there was a significant difference in Wisconsin's average yearly temperature between the two periods, as well as to see if there was a significant change in monthly temperature volatility.

To determine if there was a significant difference in the means of the two annual datasets, we first ran a Bartlett's test to determine if the two samples had significantly different variances, which yielded a p-value of 0.430. Because the variances were assumed to be equal, we ran a simple independent t-test comparing the two periods and received a p-value of 0.130. Based on the results of this test, we cannot reject the null hypothesis that the means of the two annual temperature data sets are equal.

To determine if there was a change in monthly average temperature volatility, we created a separate data frame consisting of the original 1895-2008 data and dropped the annual data. We then created a new column consisting of the standard deviation of the average monthly temperatures for each year. We then split the data into two equal length data sets as we did with average temperature and performed an independent t-test to determine if the average yearly standard deviation was significantly different between the two periods. This yielded a p-value of 0.0564. Based on this, we were unable to reject the null hypothesis that the mean standard deviations between the two periods were the same.

Figure 1: Two-period temperature data for Wisconsin

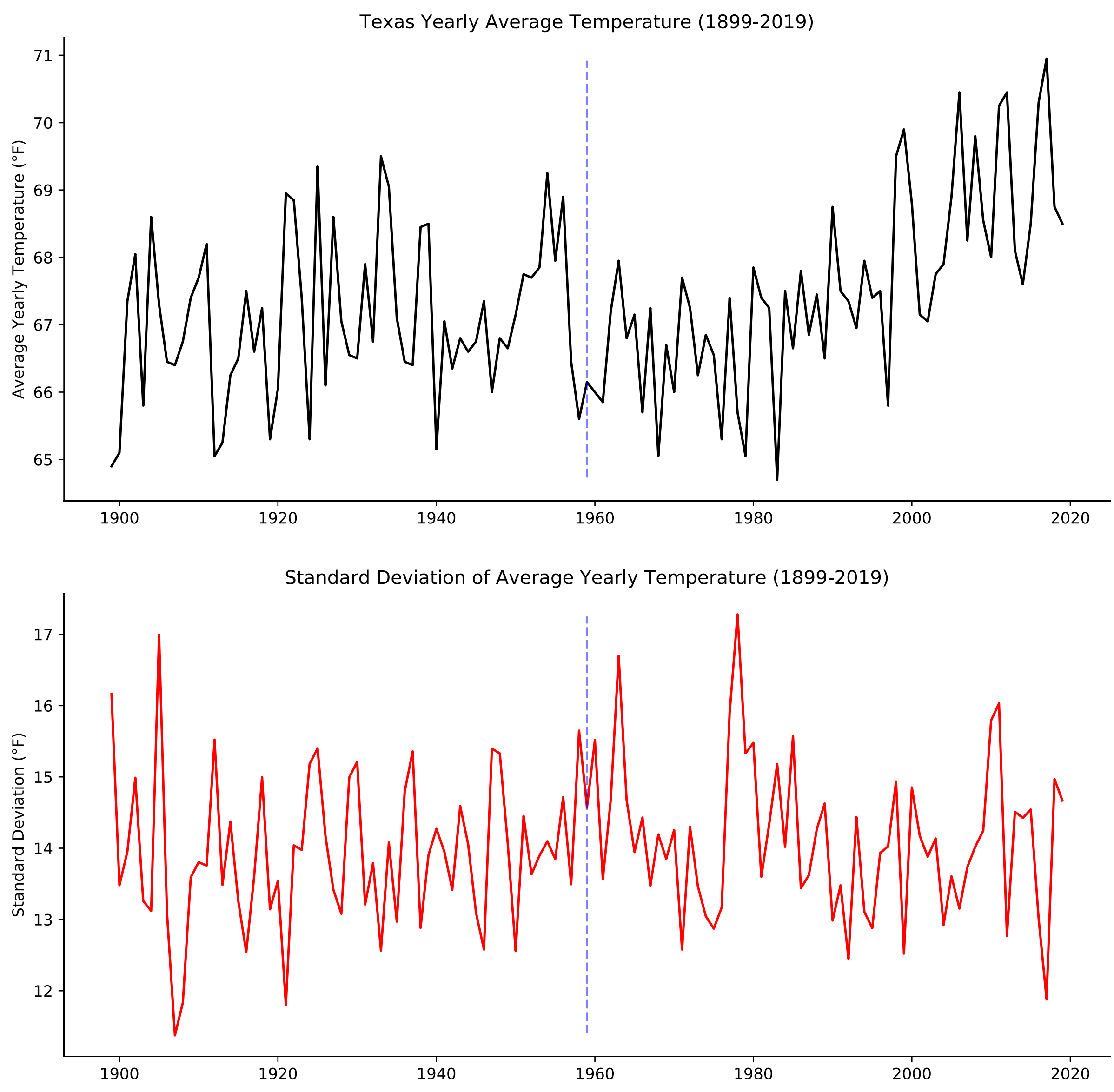


Texas

To determine whether location has played a significant role in the impact of global warming and rising temperatures, we also gathered average temperatures by month for a similar timeframe from both Austin and Fort Worth/Dallas, TX and took the average of both cities for each month. We used this methodology to obtain a close estimate of the average temperature for the state of Texas because we were unable to find a complete dataset for the entire state like the one we used for Wisconsin. These cities were chosen because they are in the southern and northern areas of the state, and due to the differences in location, the variation between cities can be somewhat accounted for without having to obtain data from each city individually.

We conducted analysis in a similar fashion to how we treated the Wisconsin data. First, we split the data in half equally, then performed a Bartlett's test comparing the two yearly mean data groups to ensure equal variances. We then performed an individual t-test comparing the yearly means which yielded a p-value of 0.0342, indicating that there is a significant difference in average Texas' yearly average temperature between the two periods. We performed the exact same process for the average monthly temperature standard deviations and received a p-value of 0.348, indicating that Texas' weather did not undergo a significant change in volatility between the two periods.

Figure 2: Two-period temperature data for Texas



Conclusions and directions for future research

Following the conclusion of our analysis, we found that Wisconsin has not experienced a significant change in neither yearly average temperature nor monthly average temperature volatility between the periods 1895-1951 and 1952-2008. The same cannot be said for Texas, who did experience a significant change in monthly average temperature between the periods 1899-1959 and 1960-2019 with no significant change in volatility during the same period. The data suggests that the state of Texas has experienced a significant increase in mean yearly temperature from period one ($\bar{x}$ = 67.06) to period two ($\bar{x}$ = 67.57)

Further research could undoubtedly expand upon the findings discussed herein. Future analysis of Wisconsin's temperature data should include statewide average temperature for 2009-2019. Due to an inability to find data from 2009-2019, we attempted to create an approximation of statewide average temperature by using temperature data from two Wisconsin cities in a similar fashion to how the Texas data was constructed. However, this proved an unreliable estimate compared to the true temperature means as provided by UW AOS and as a result was omitted from the final data set. In addition, future analysis could involve dividing the time periods into more than two separate data sets. Segmenting the full data set into smaller periods will allow researchers to focus in closer on individual periods and determine exactly when a change did or did not occur.

Appendix A: Additional figures and tables

Figure 3: Wisconsin Temperature Data (Period 1)

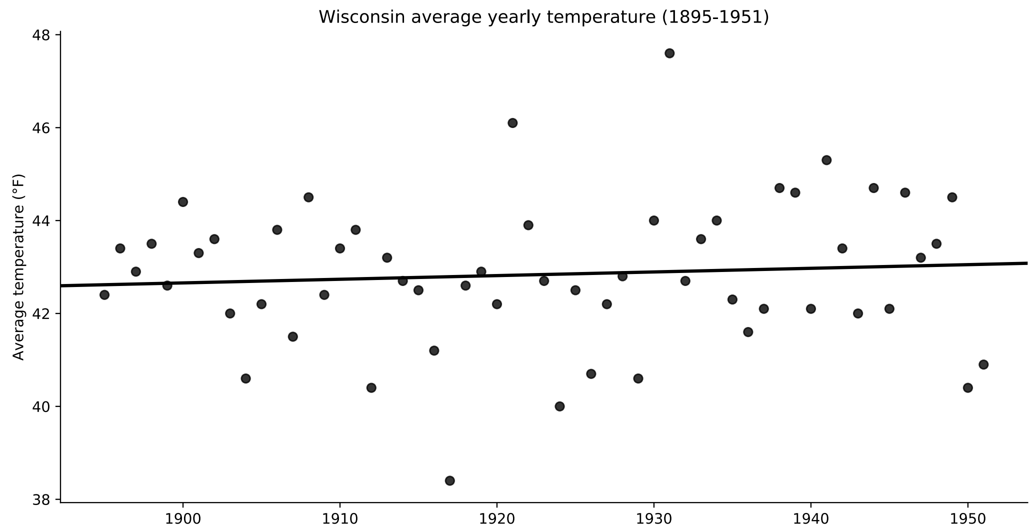


Figure 4: Wisconsin Temperature Data (Period 2)

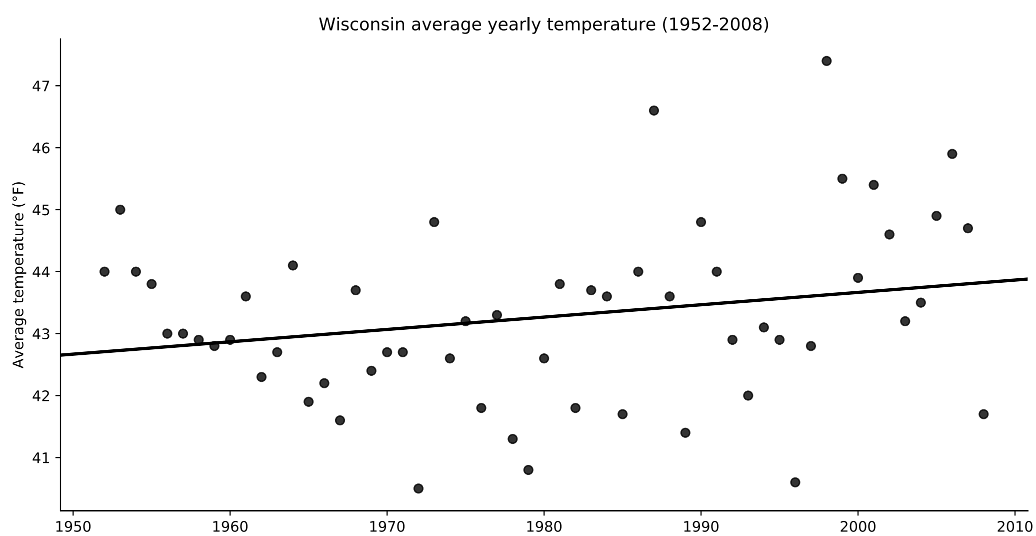


Figure 5: Texas Temperature Data (Period 1)

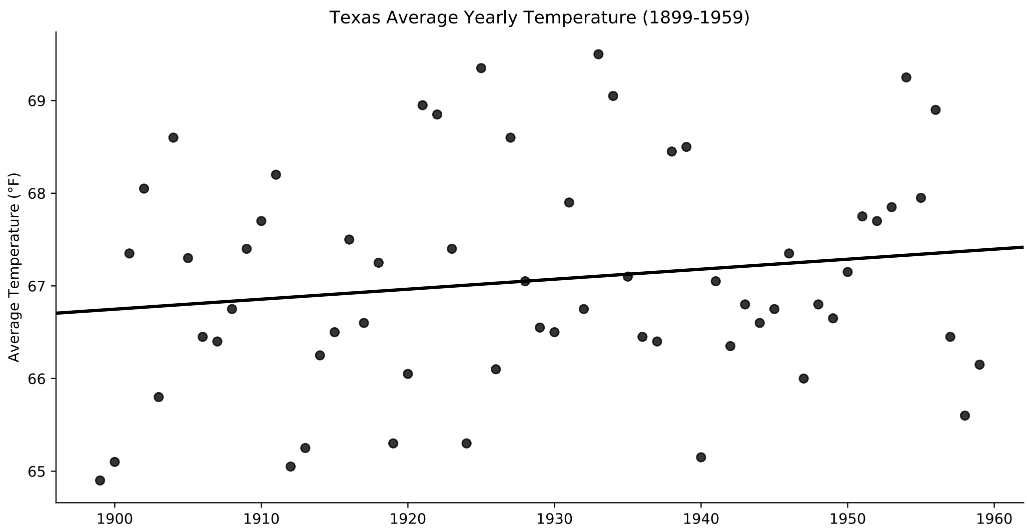


Figure 6: Texas Temperature Data (Period 2)