Trends in Heating and Cooling Days in Suburban and Urban Settlements in the U.S. Southwest

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1 Rationale and Research Questions

Climate change, long-term shifts in temperatures and weather patterns, is a naturally-occurring process that has been accelerated by human actions, primarily the burning of fossil fuels. One of the impacts of climate change is rising temperatures, which has negative impacts on Earth's ecosystems, such as melting glaciers, intensifying storms, and worsening drought conditions. Humans are directly impacted by rising temperatures: as the number of hot days and heat waves increase, so do the number of heat-related illnesses.

The U.S. has not escaped these impact. The southwest region of the US which we defined as Arizona, California, and Nevada has witnessed an uptick in droughts. Nevada which utilizes water from Lake Me has seen record lows in recent years cautioning them to adopt water conservation strategies while California has been no stranger to forest fires. We plan to do this by analyzing data from the National Centers for Environmental Information, using max temperature, and minimum temperature. Thus, our research questions are:

1. Has there been an increase in the number of heating and cooling days in the U.S. Southwest from 1972 to 2022?
2. Is there a difference in heating and cooling days in urban and rural spaces in the U.S. Southwest over time?
3. How have minimum and maximum temperatures changed over time?

2 Dataset Information

Our datasets were retrieved from NOAA's National Centers for Environmental Information (NCEI), specifically from the GHCN (Global Historical Climatology Network). We selected a total of six stations, encompassing three major cities and each with an associated nearby suburban location. We selected the nearby suburban locations to be within 50 miles of the major city and with a population of less than 50,000 in 2022. The selected locations are as follows:

- Phoenix and Fountain Hills, Arizona
- Las Vegas and Pahrump, Nevada
- San Diego and Ramona, California

We primarily examined the daily data for TMAX = Maximum temperature (Fahrenheit) and TMIN = Minimum temperature (Fahrenheit) for each of the six locations. Our datasets had varying levels of coverage and start dates for each location. All the datasets had high coverage from 1998-2022, and all but Ramona, CA have data from 1980-1998. More information about this data's documentation can be found at https://www.ncei.noaa.gov/pub/data/cdo/documentation/GHCND_documentation.pdf and in the Metadata folder of this project's repository.

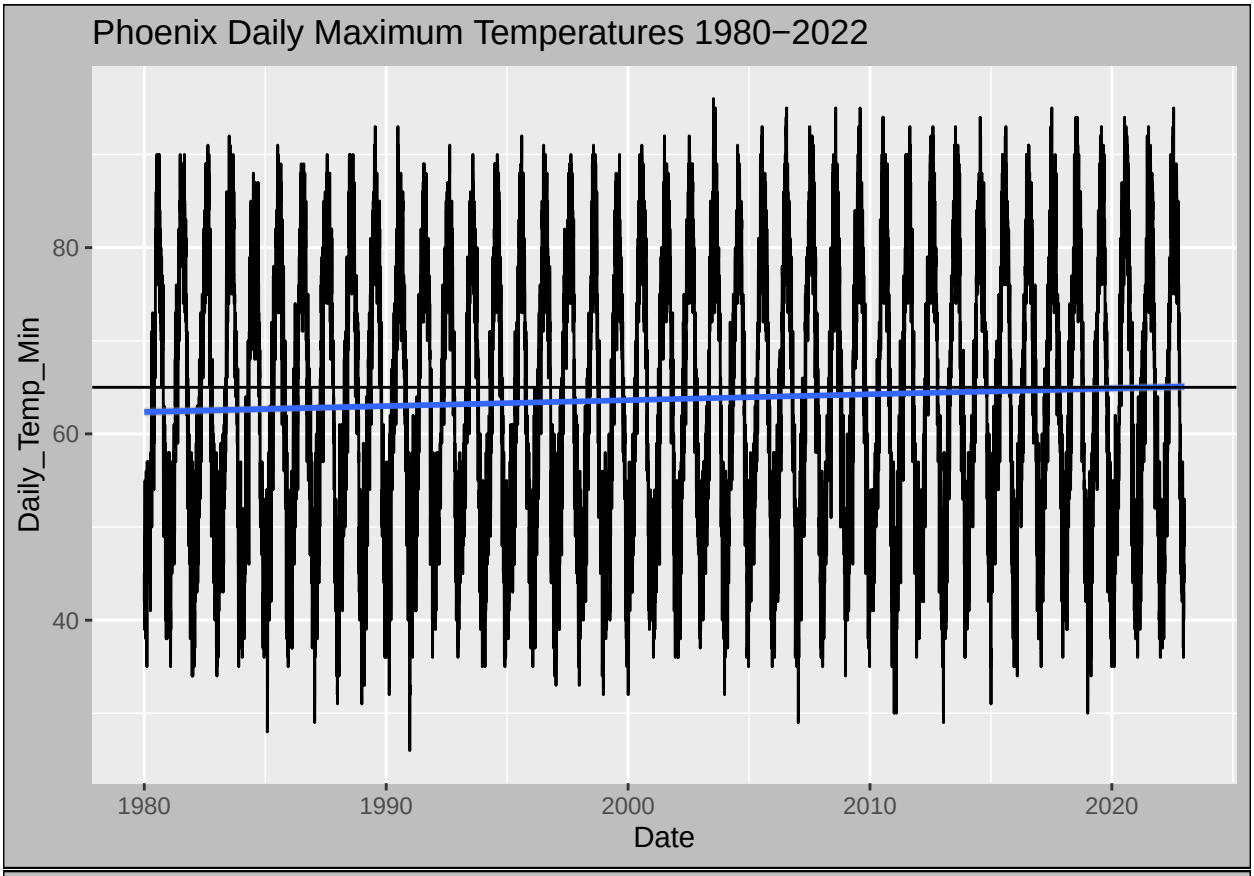
Describe how you wrangled your dataset in a format similar to a methods section of a journal article.

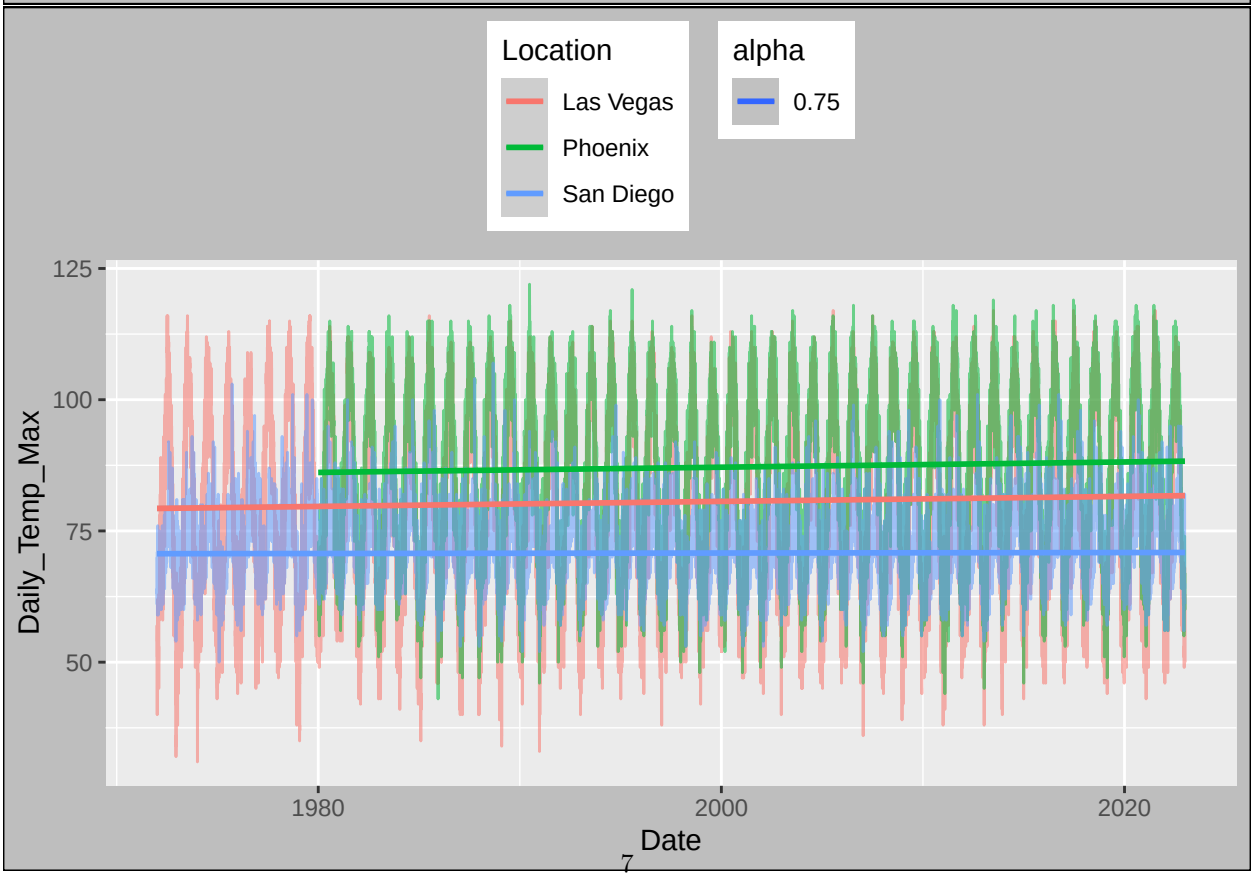
To wrangle our data, we: * Read in the .csv's * Filtered by location and created new files for each location * Kept certain columns (name, date, precipitation, sun coverage %, max temp, min temp, average tem, total sun) * Format the date column into a date object * Changed the station name to the city name * Created a column for month, year, and day of year by extracting the information from the existing date column * Updated the column names to the full title ** Check the NAs with the summary function * Saw that some cities have NAs in max, min, and average temperature * Interpolate gaps in min and max using linear interpolation in Fountain Hills, Pahrump, and Ramona * Calculate the average daily temperature and fill in the existing column * Created separate columns for heating and cooling degrees and calculated the values ** As we created the two columns, we filled them with 0s ** We calculate heating degrees by indexing the

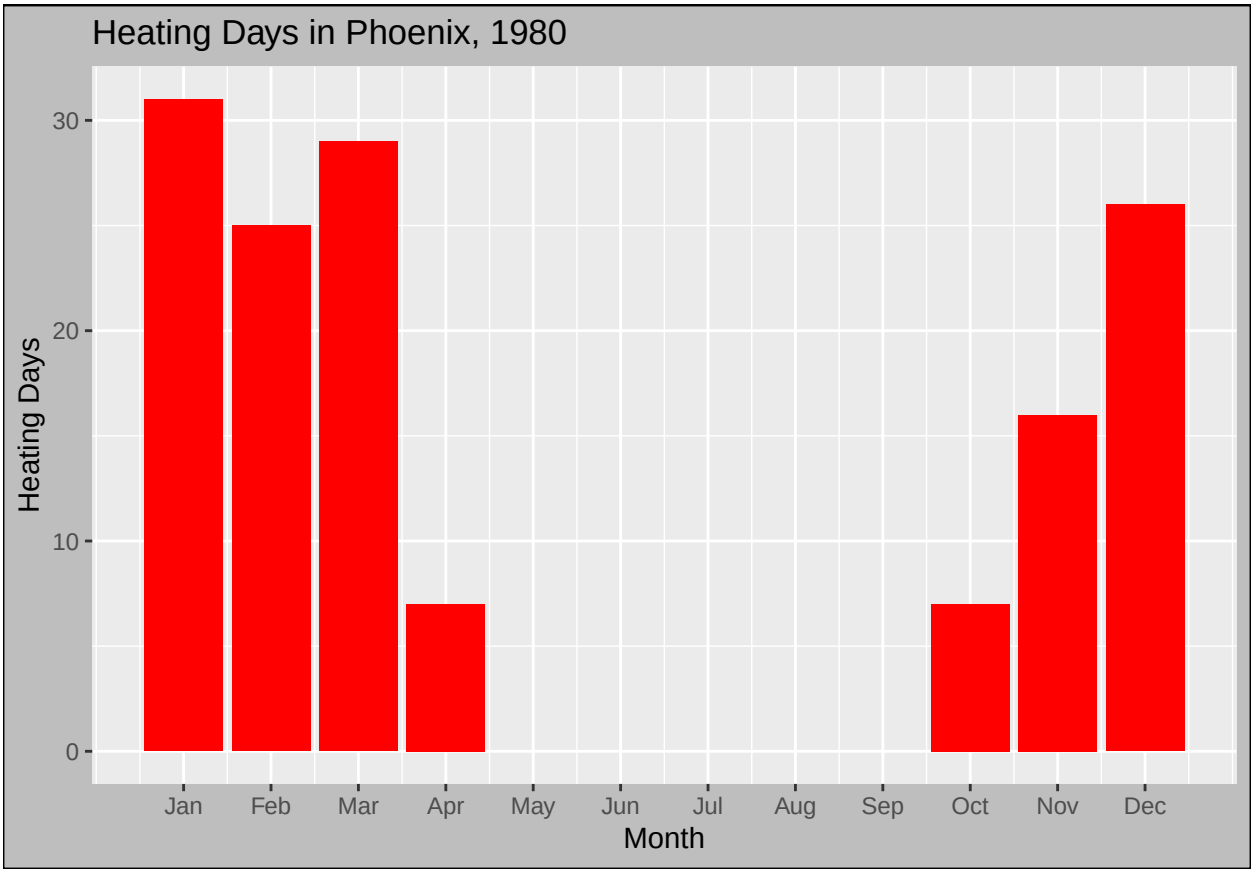
mean temperatures that are below 65F then subtracting the mean temp from 65 ** We calculate cooling degrees by indexing the mean temperatures that are above 65F then subtracting 65 from the mean temp

Add a table that summarizes your data structure (variables, units, ranges and/or central tendencies, data source if multiple are used, etc.). This table can be made in markdown text or inserted as a kable function in an R chunk. If the latter, do not include the code used to generate your table.

Exploratory Analysis



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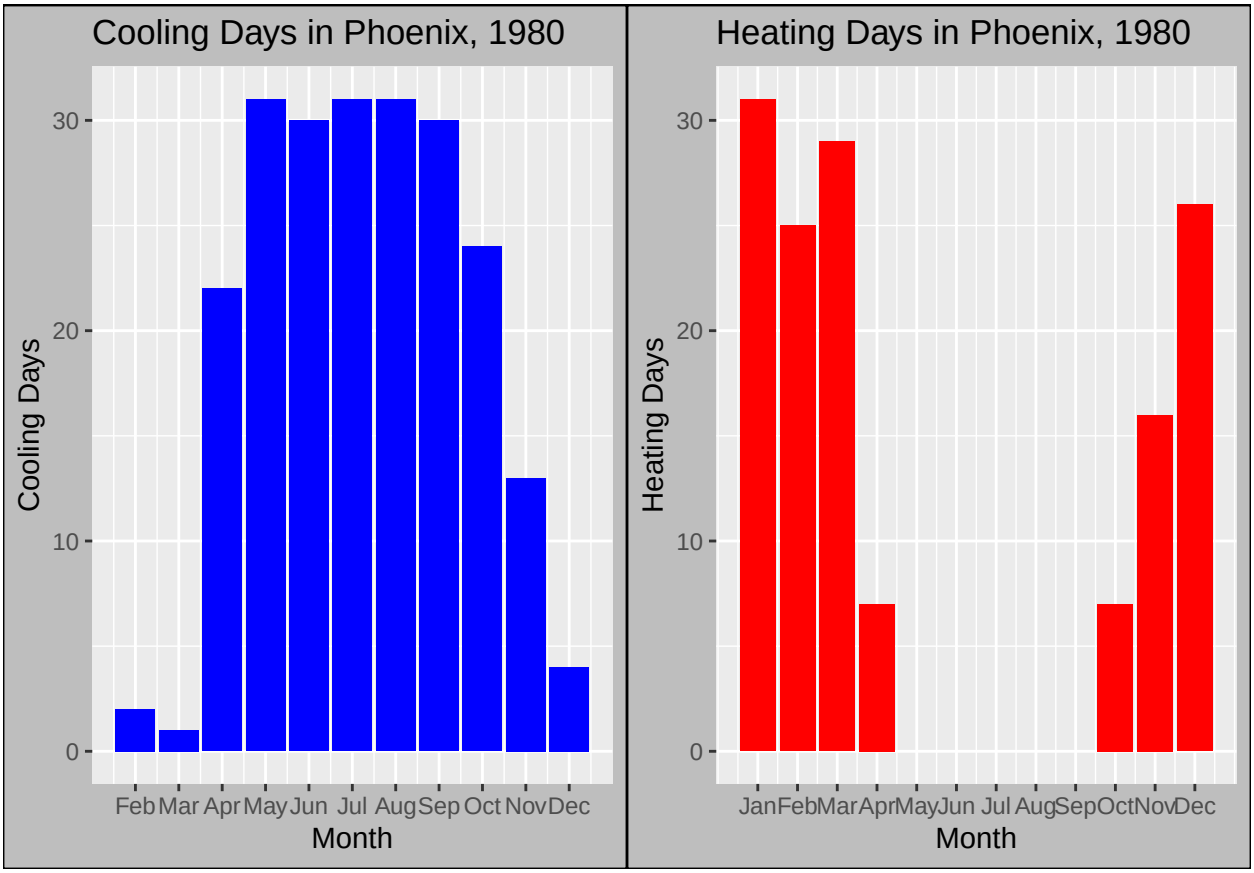
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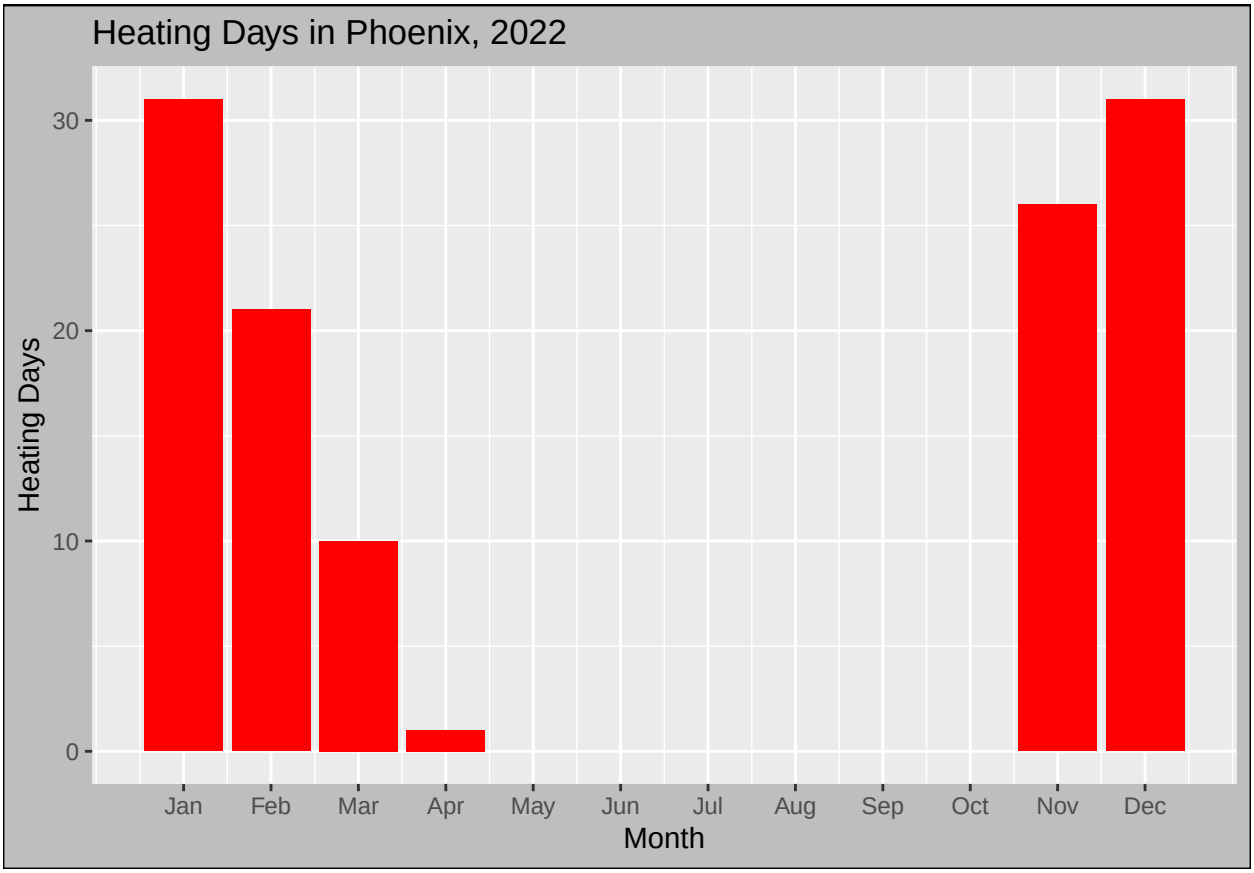
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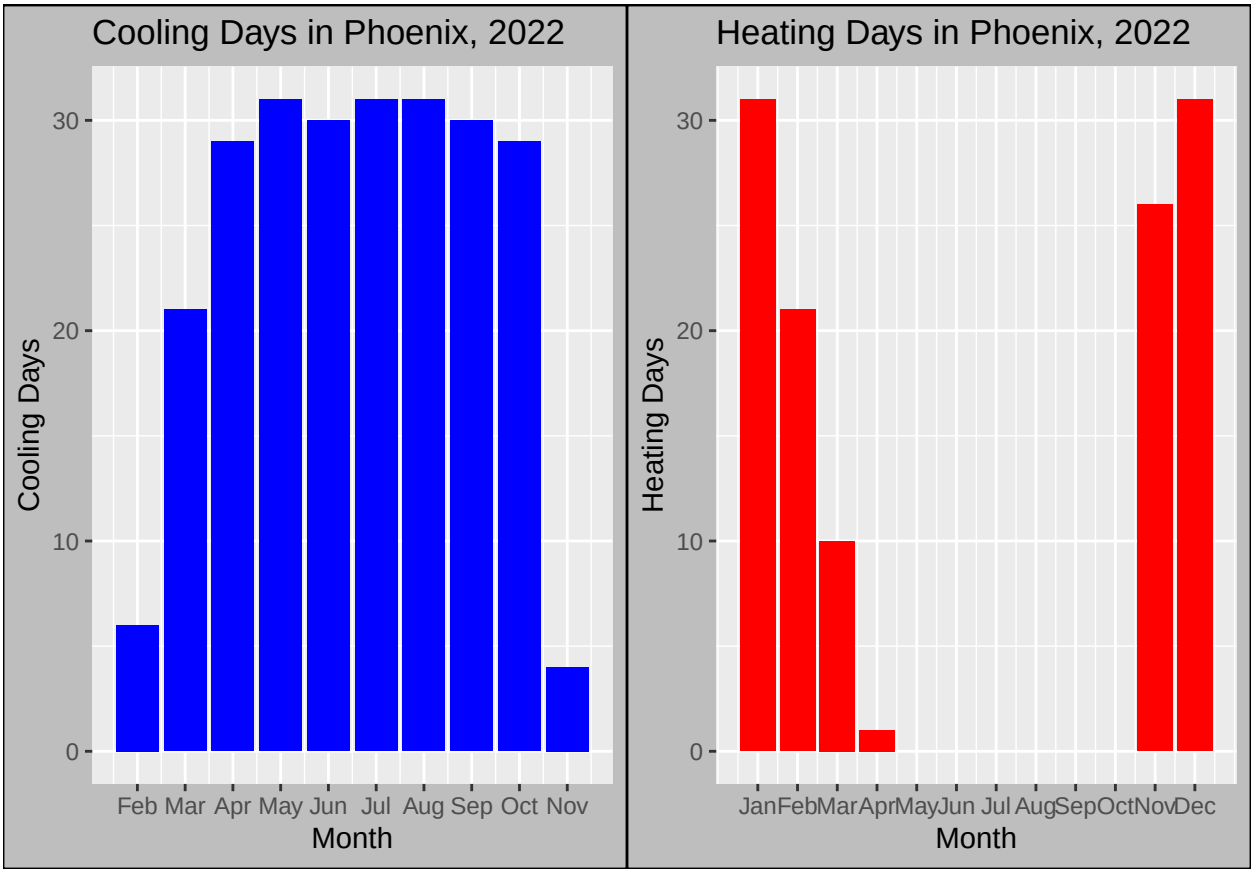
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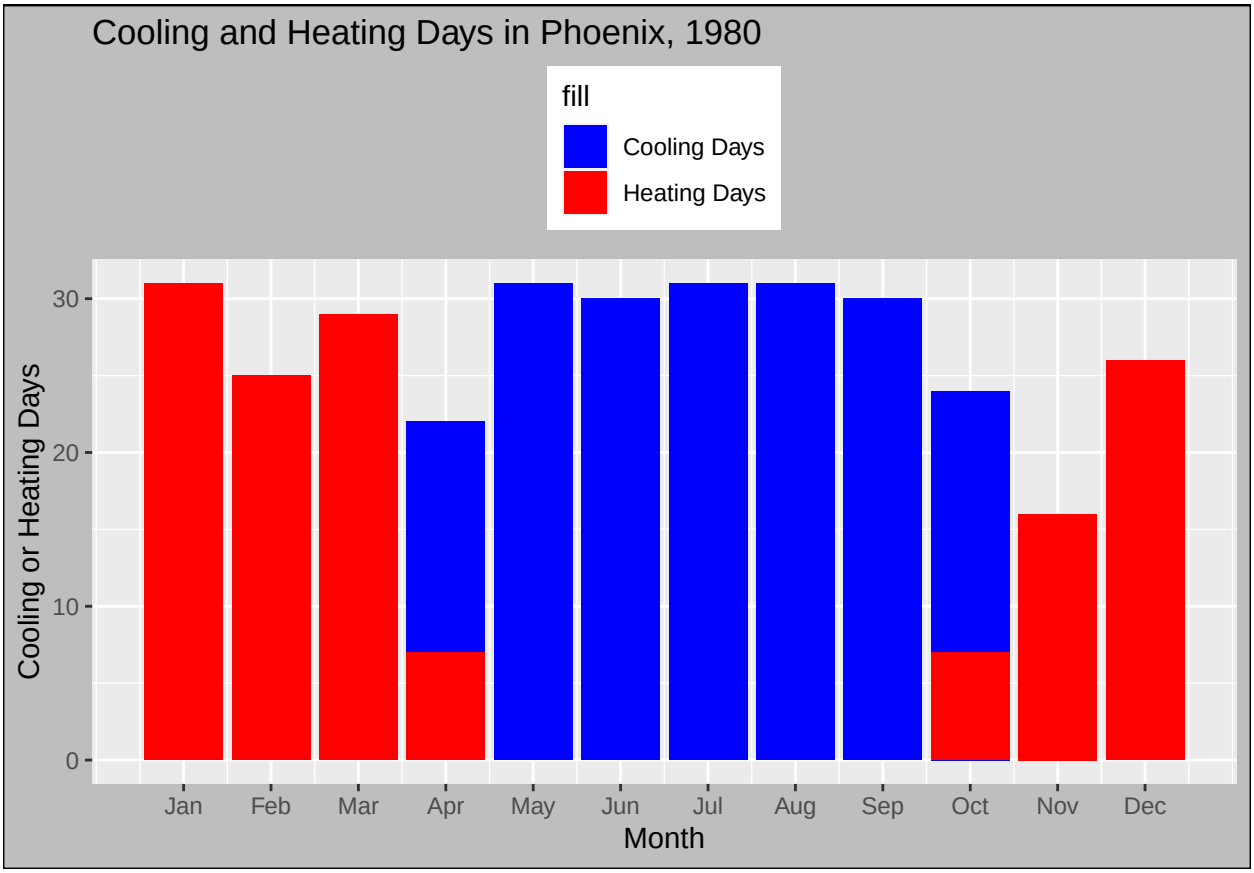
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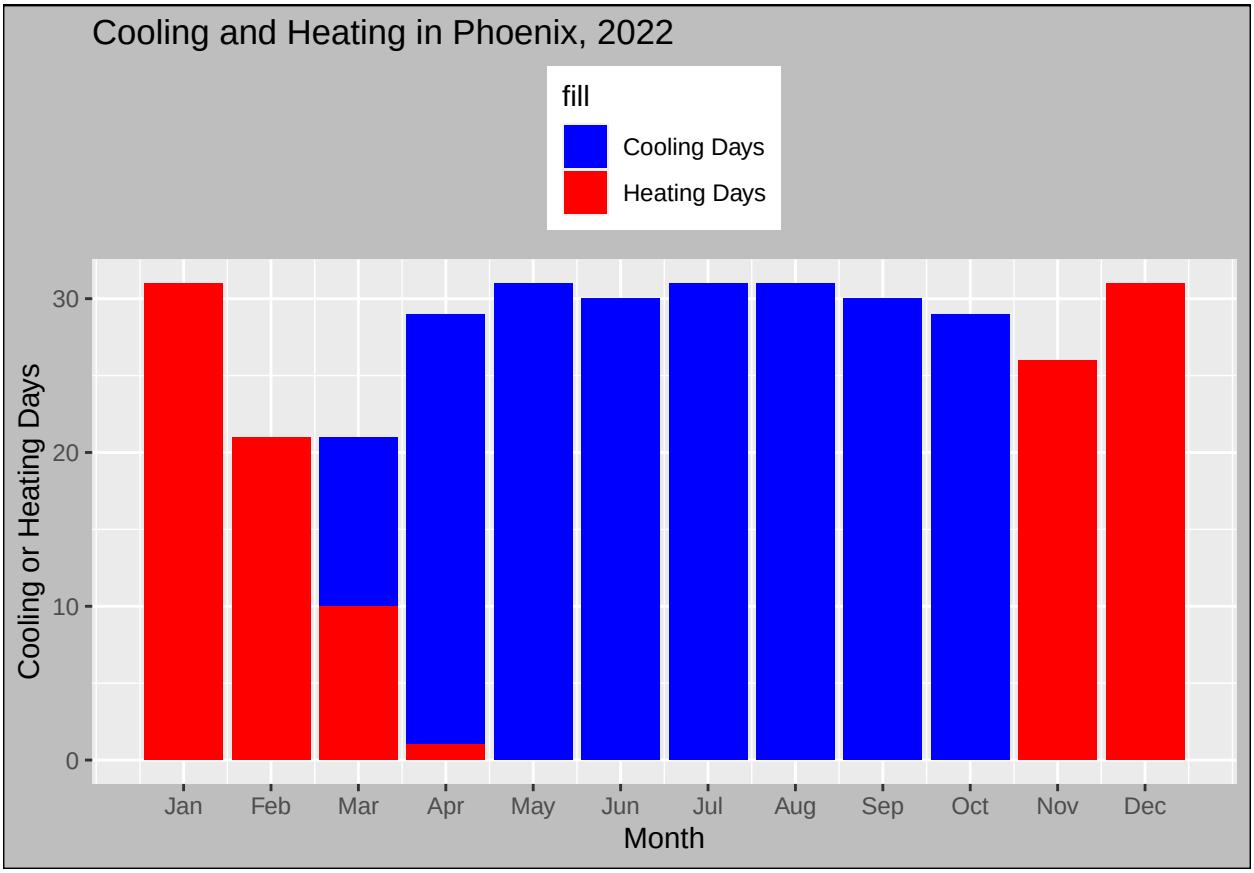
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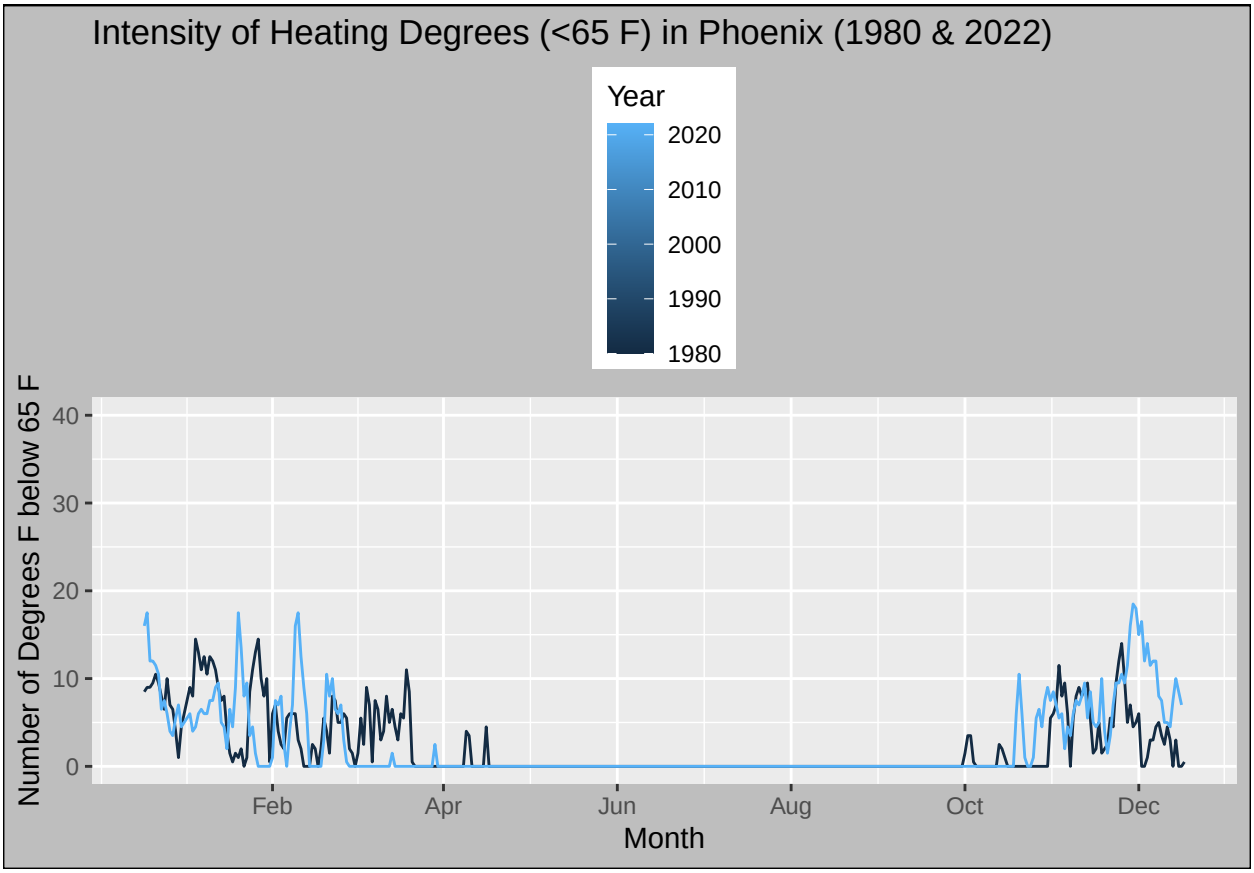
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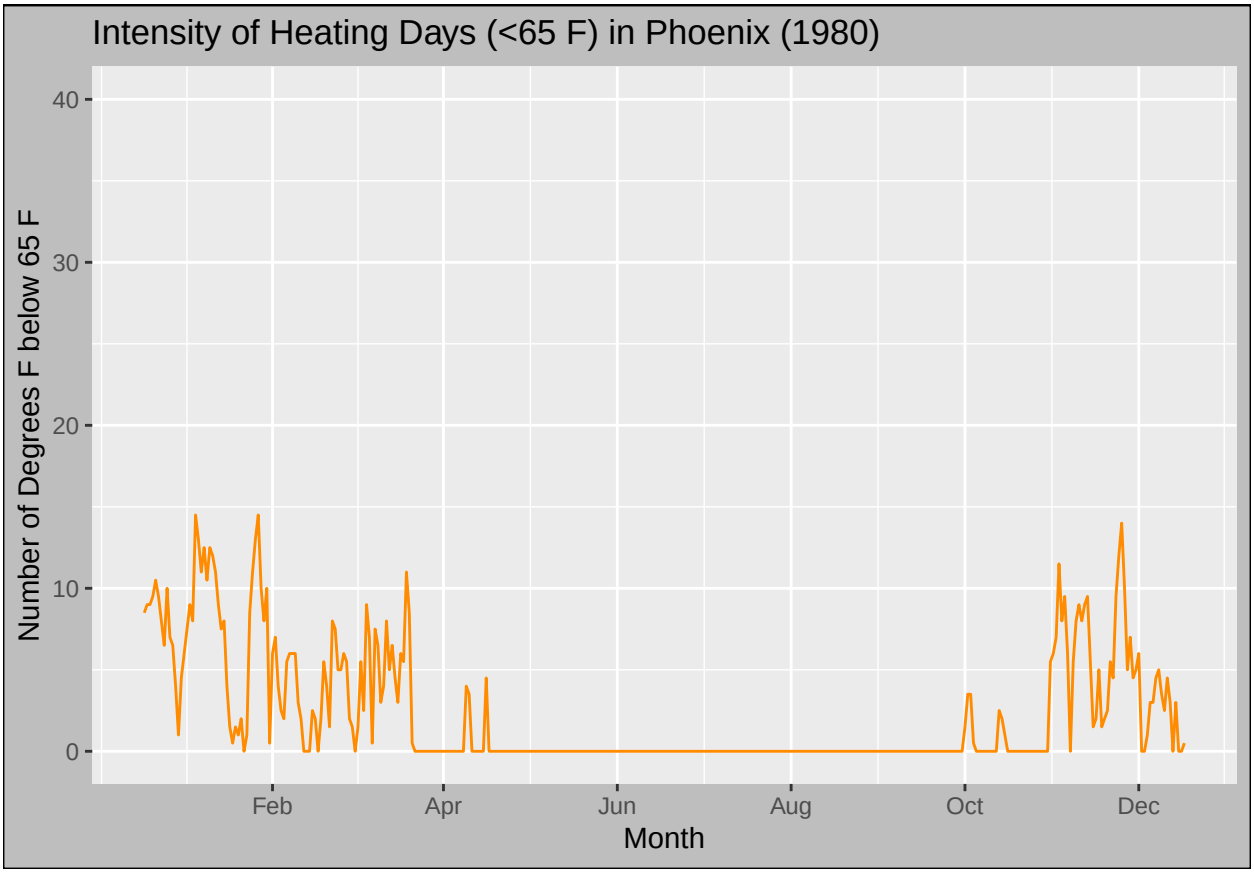
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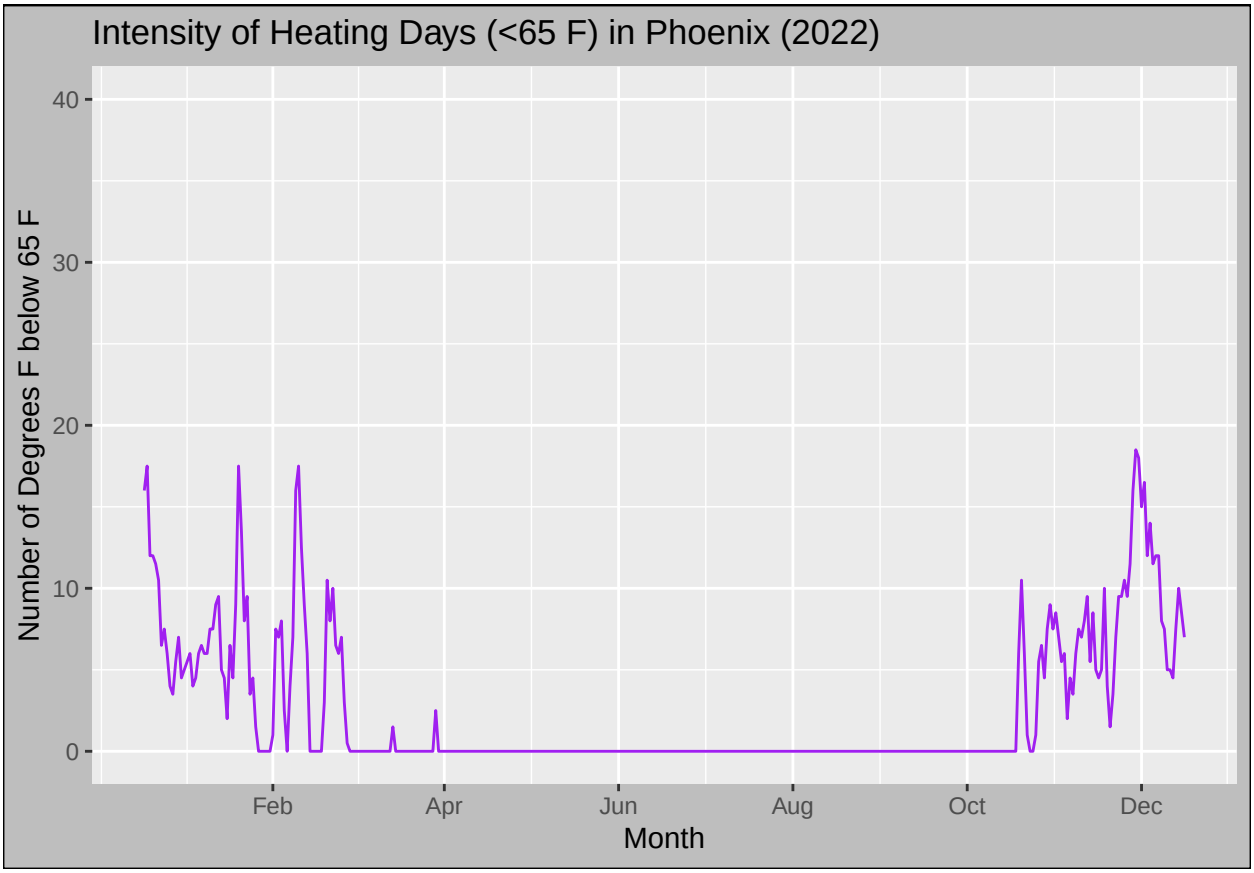
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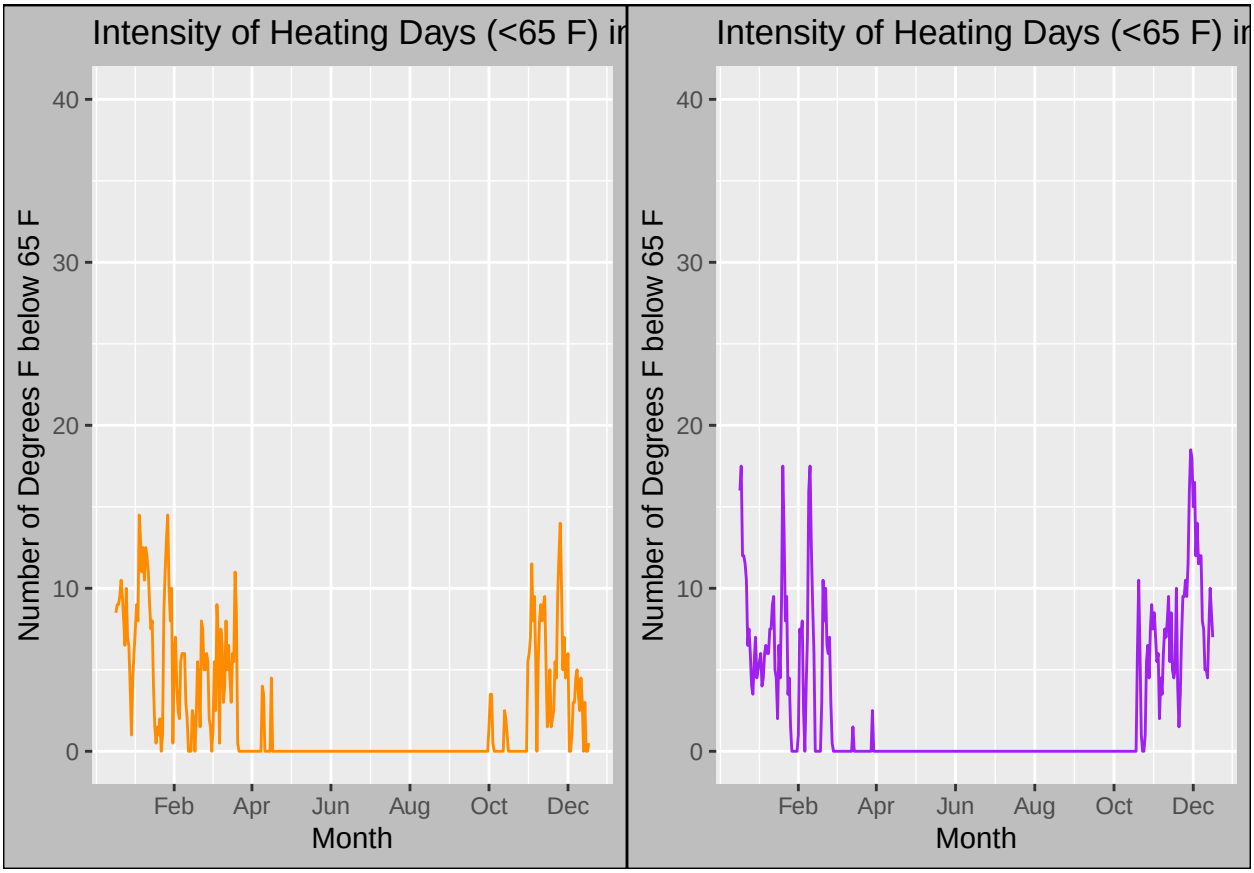
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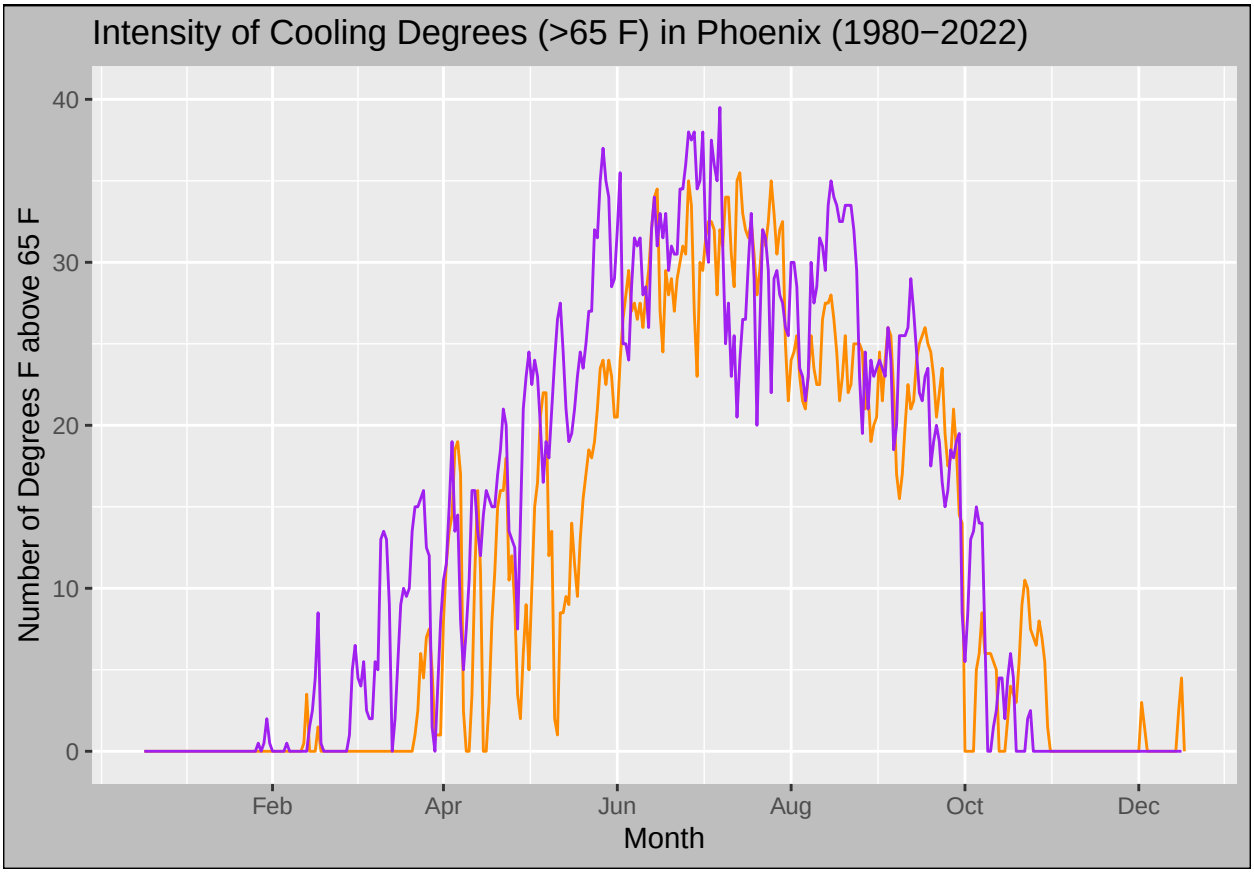
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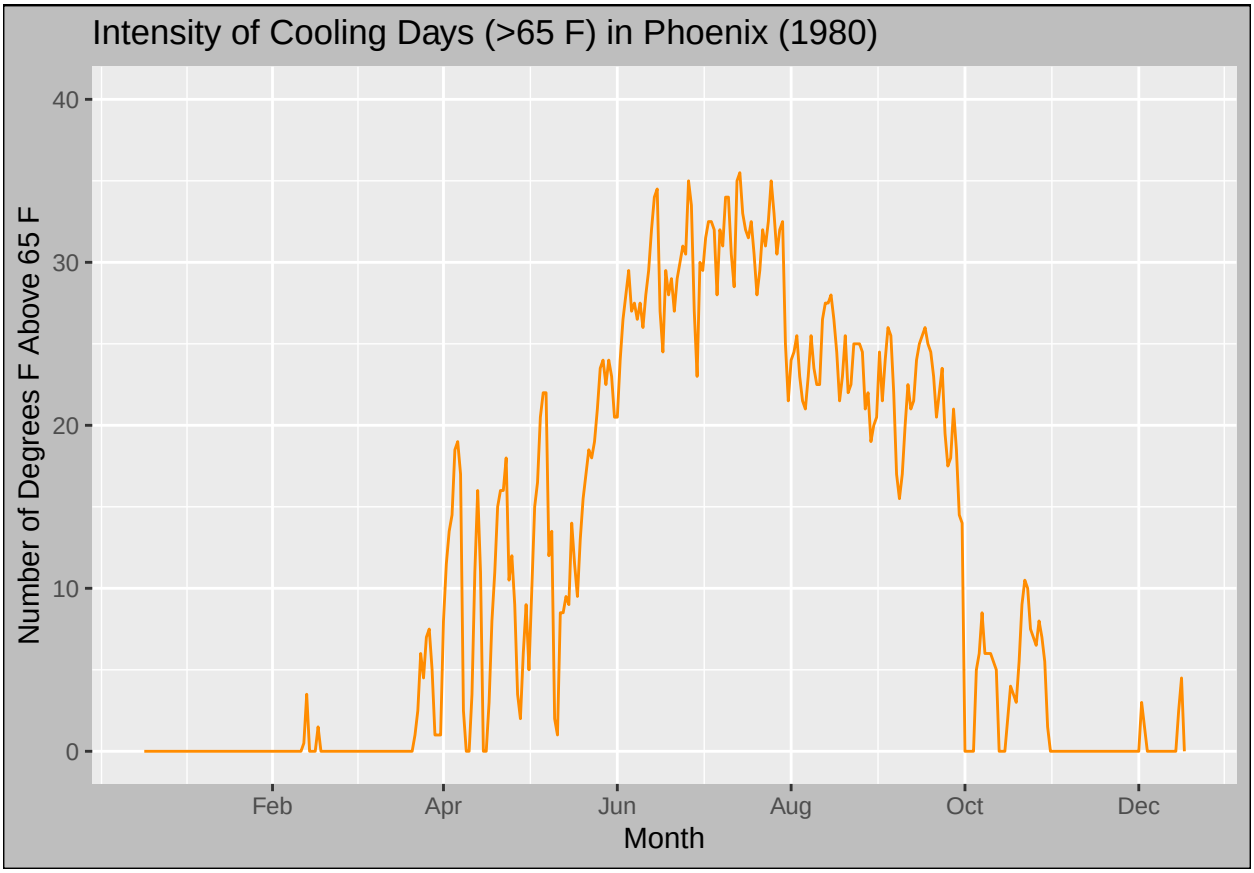
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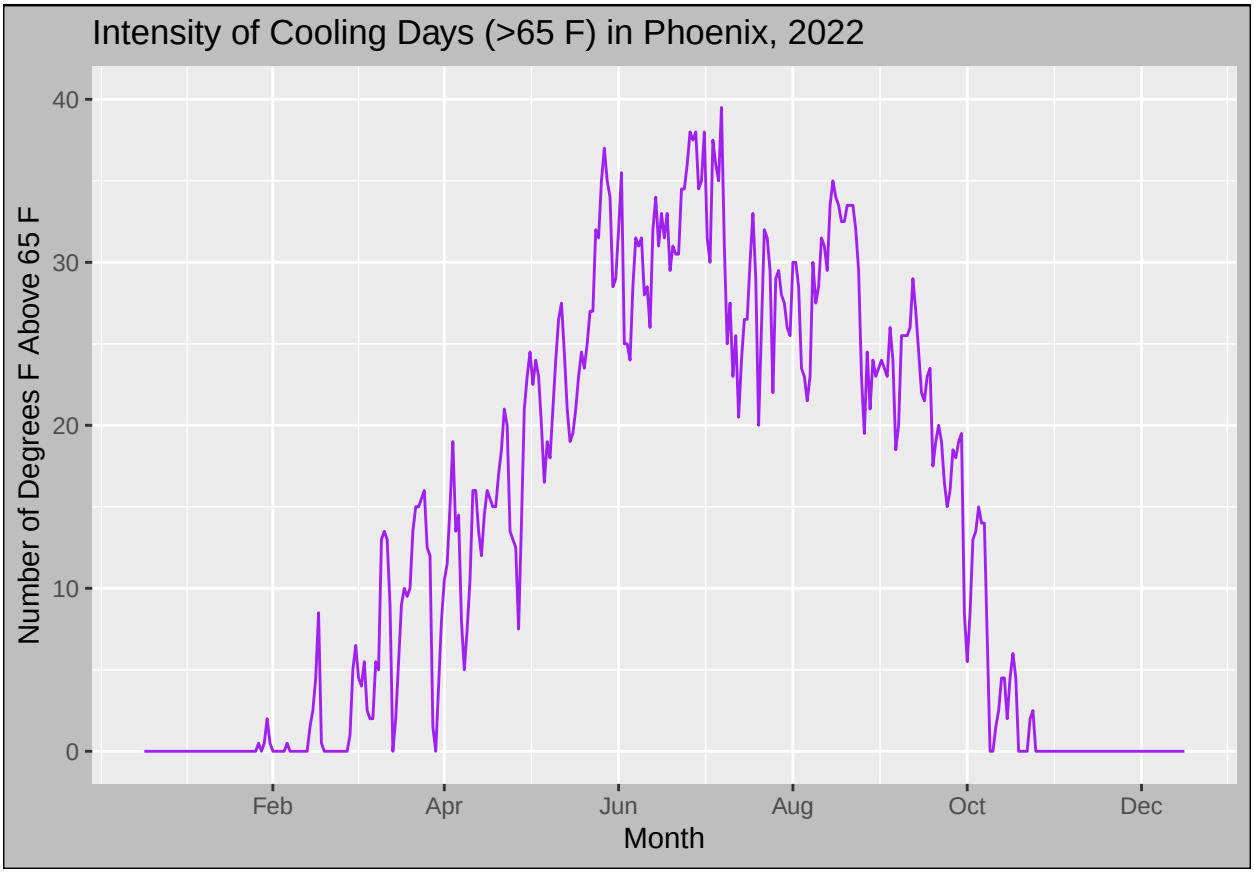
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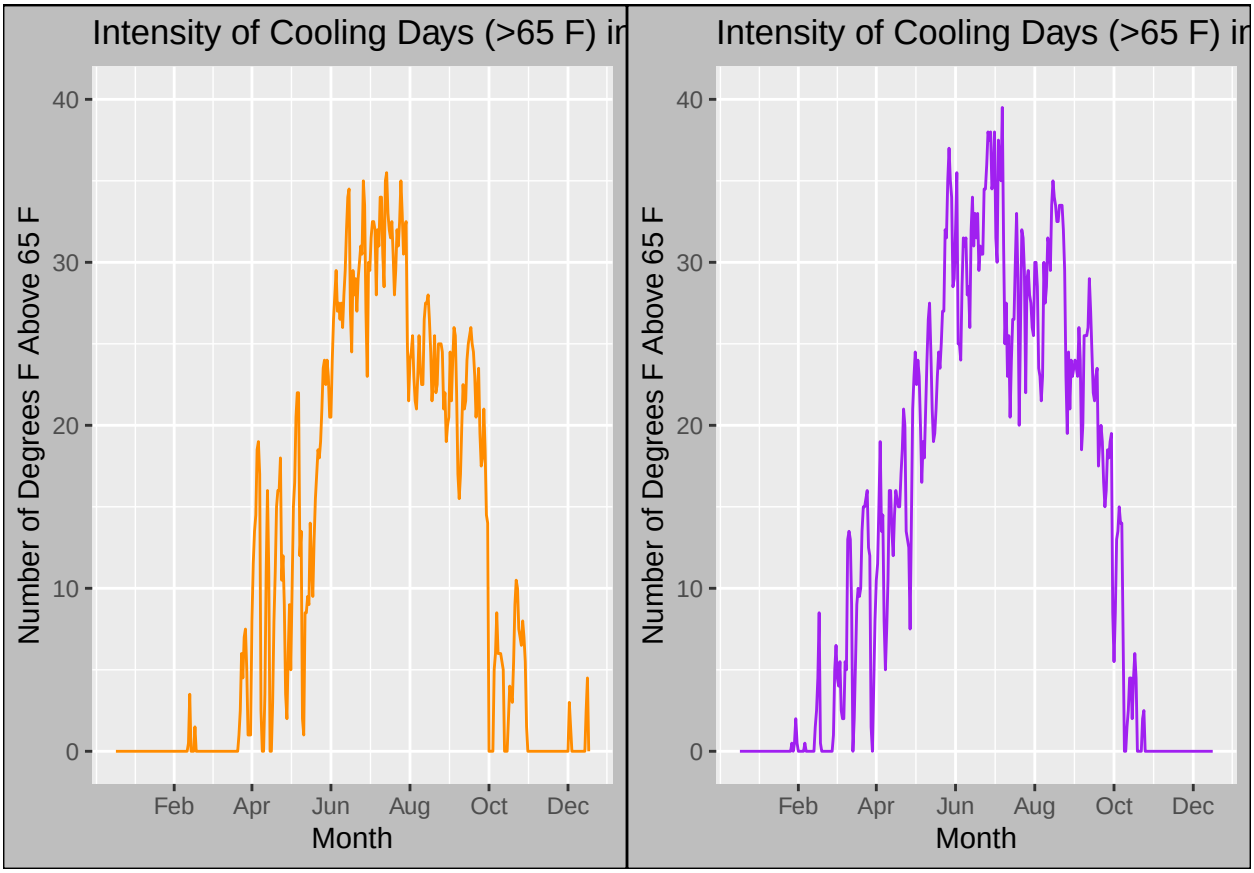
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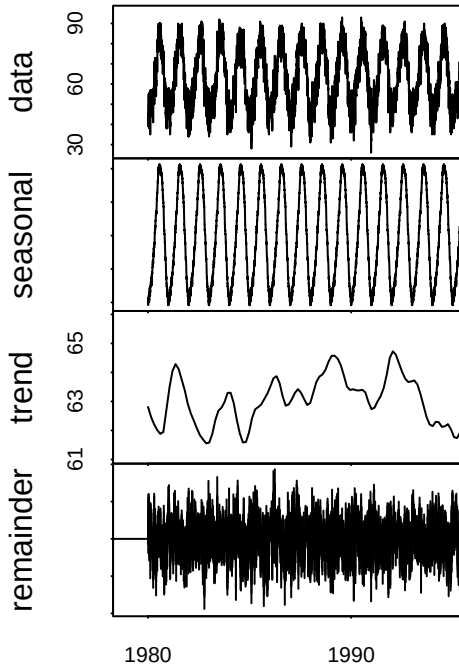
Analysis

Question 1: Has there been an increase in the number of heating and cooling days in the U.S. Southwest from 1972 to 2022?

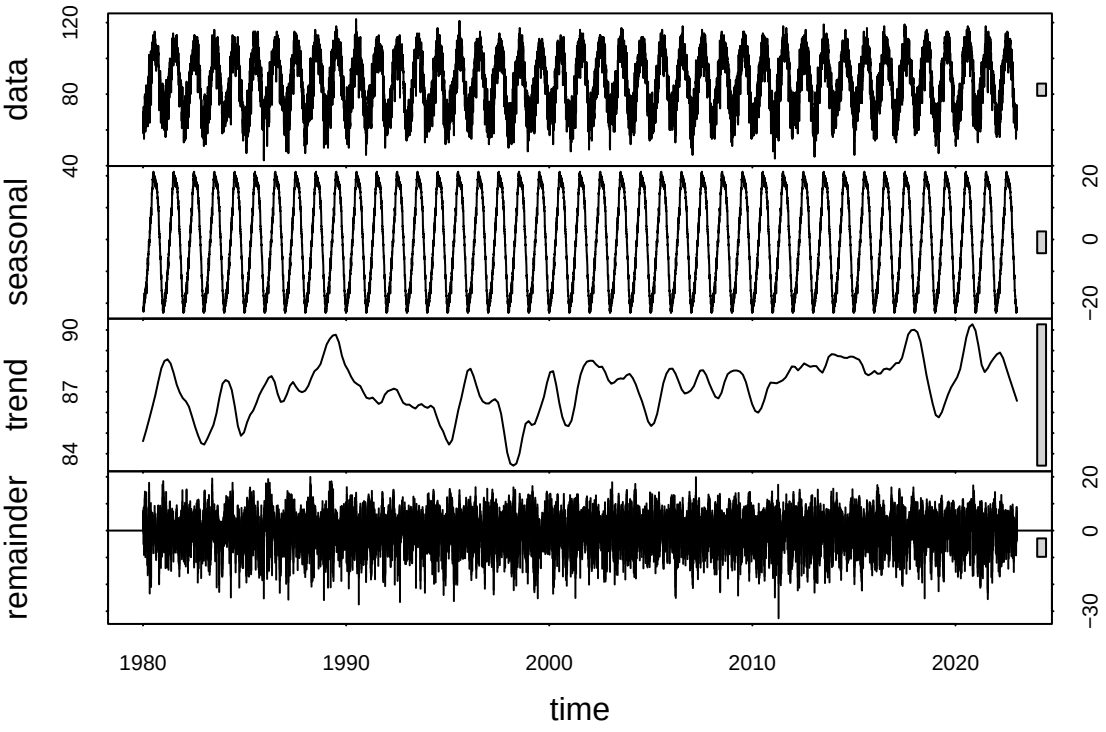
Question 2: Is there a difference in heating and cooling days in urban and rural spaces in the U.S. Southwest over time?

Question 3: How have minimum and maximum temperatures changed over time?

To address the question of whether minimum and maximum temperatures have changed over time, we conducted a time series analysis on every city. We first created univariate time series objects for each measure for each site.



We then decomposed each time series to review the trends and seasonality present.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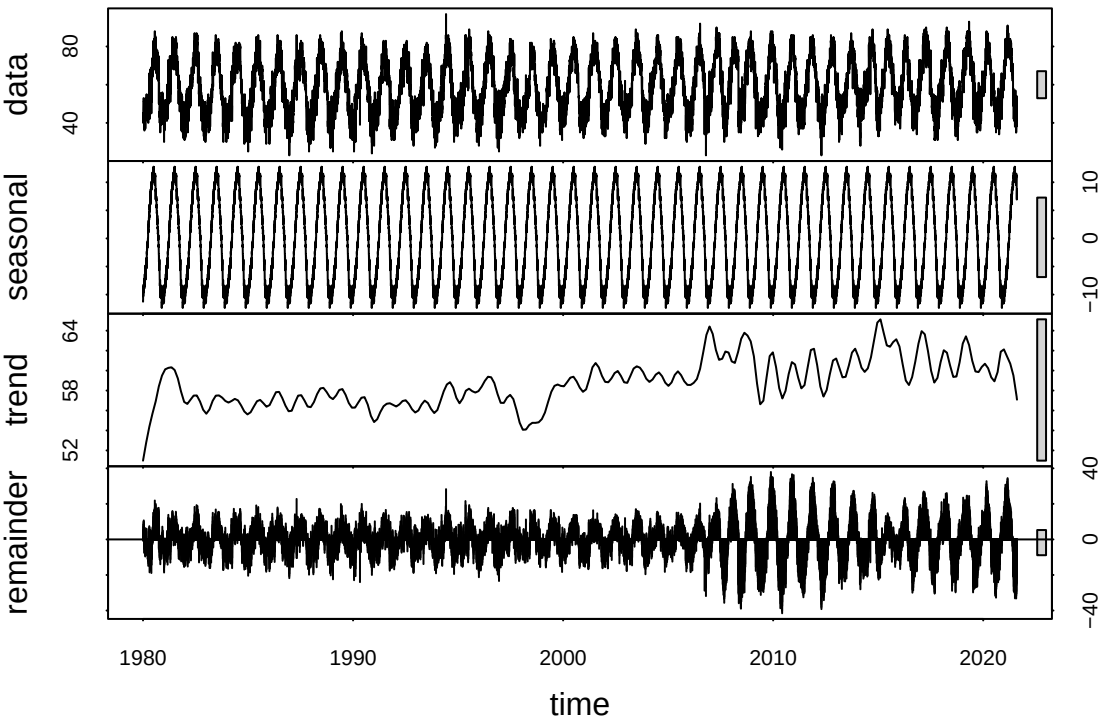
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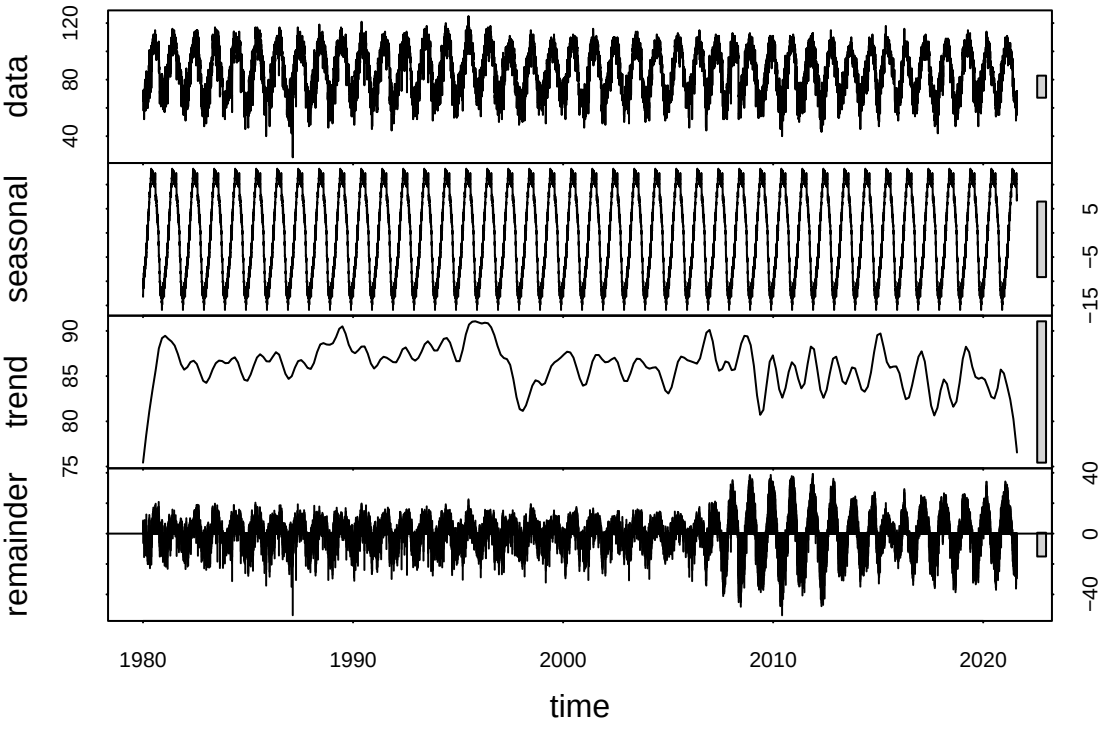
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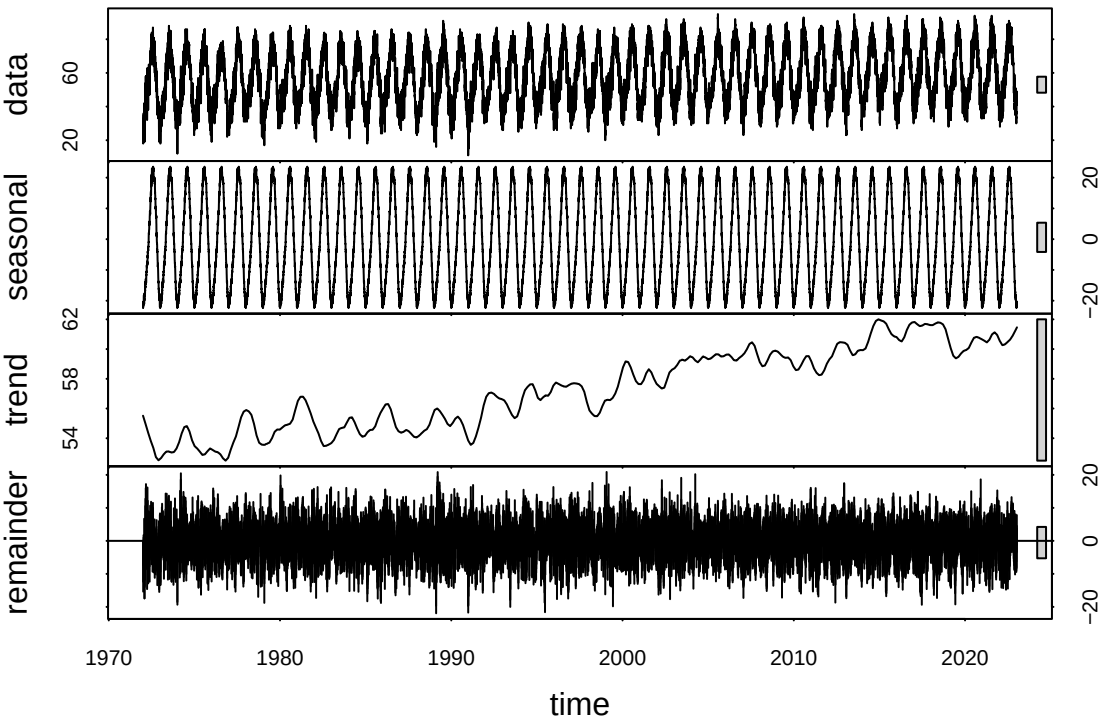
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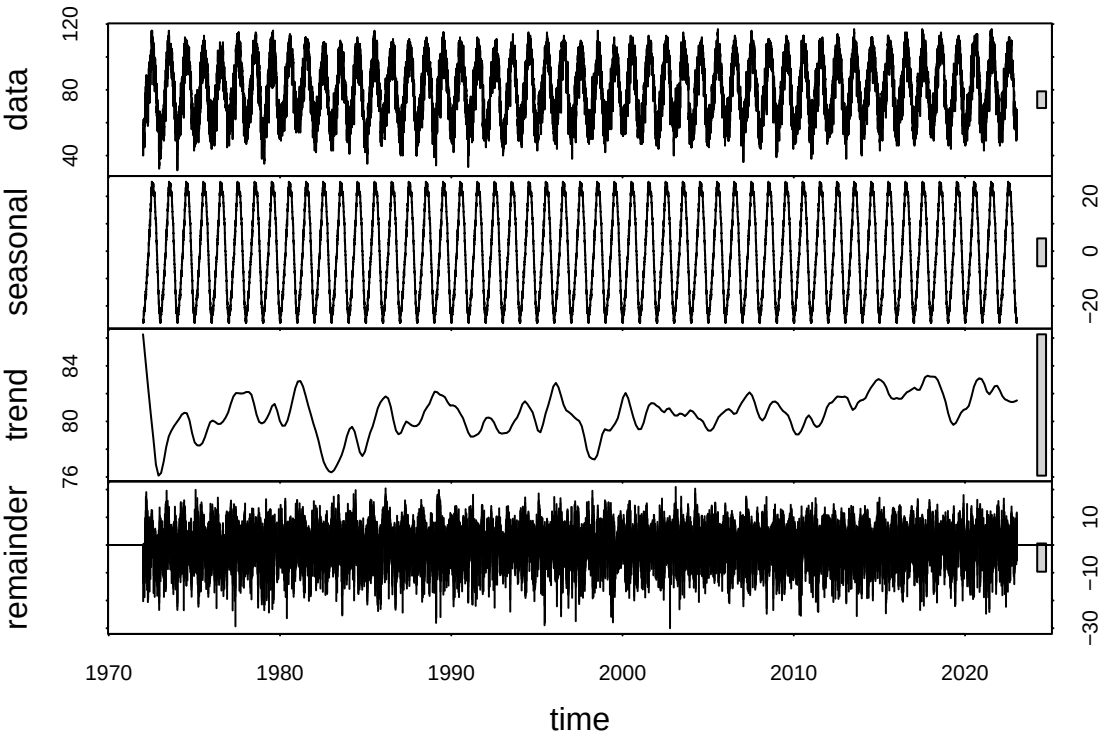
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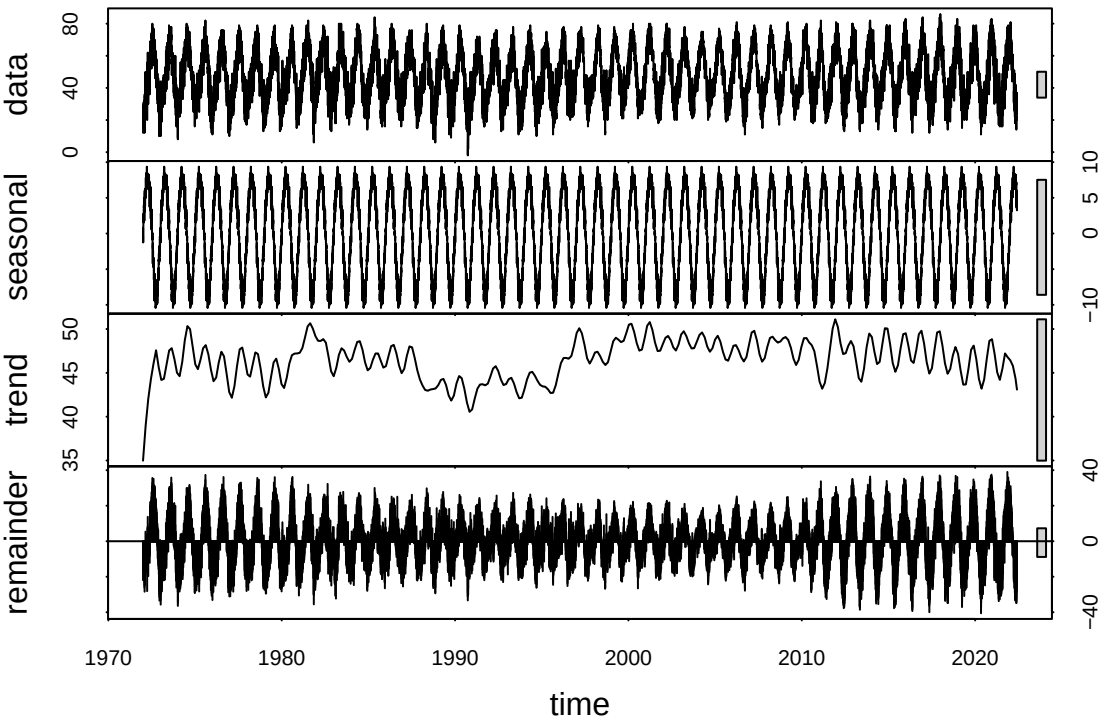
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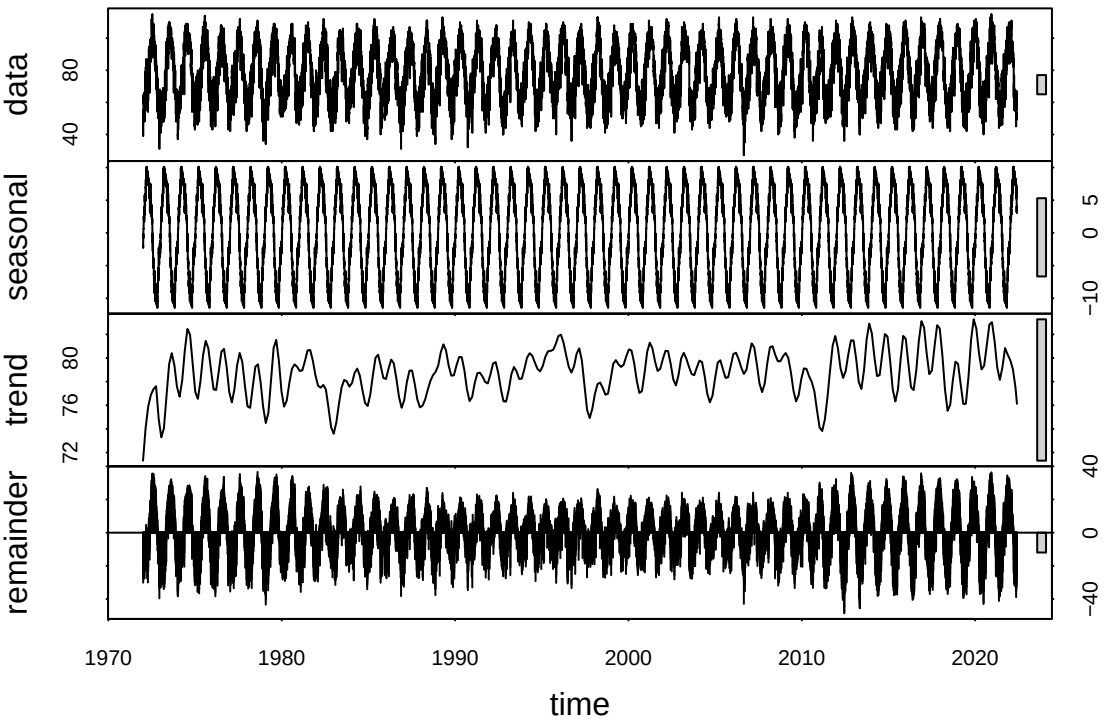
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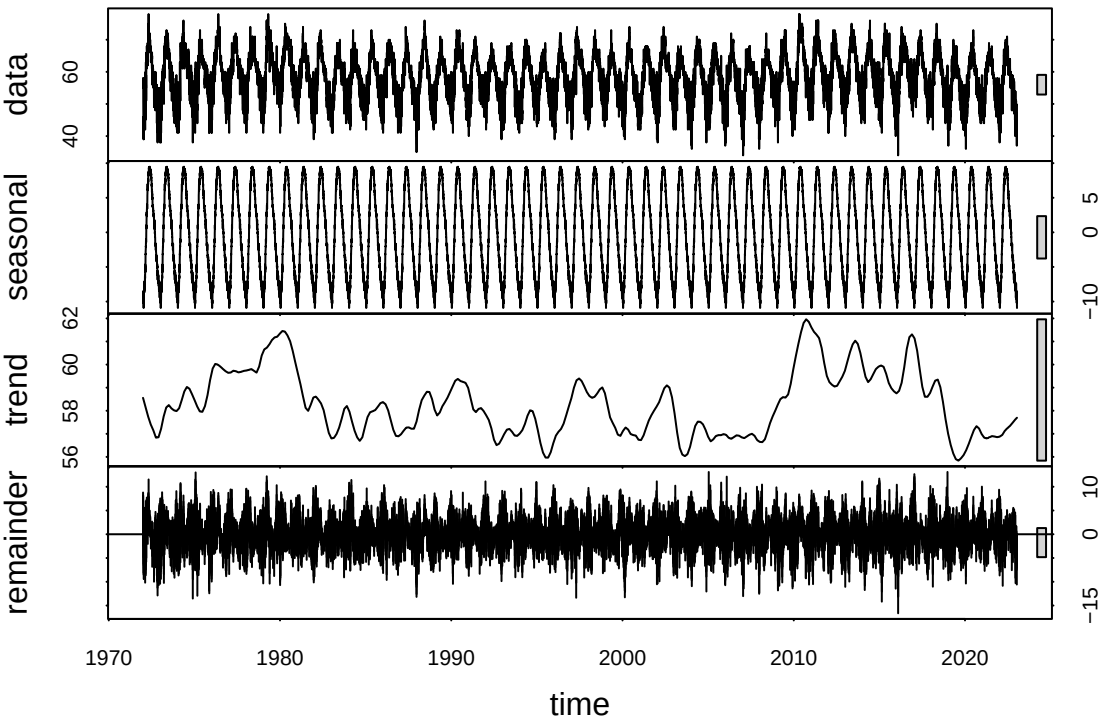
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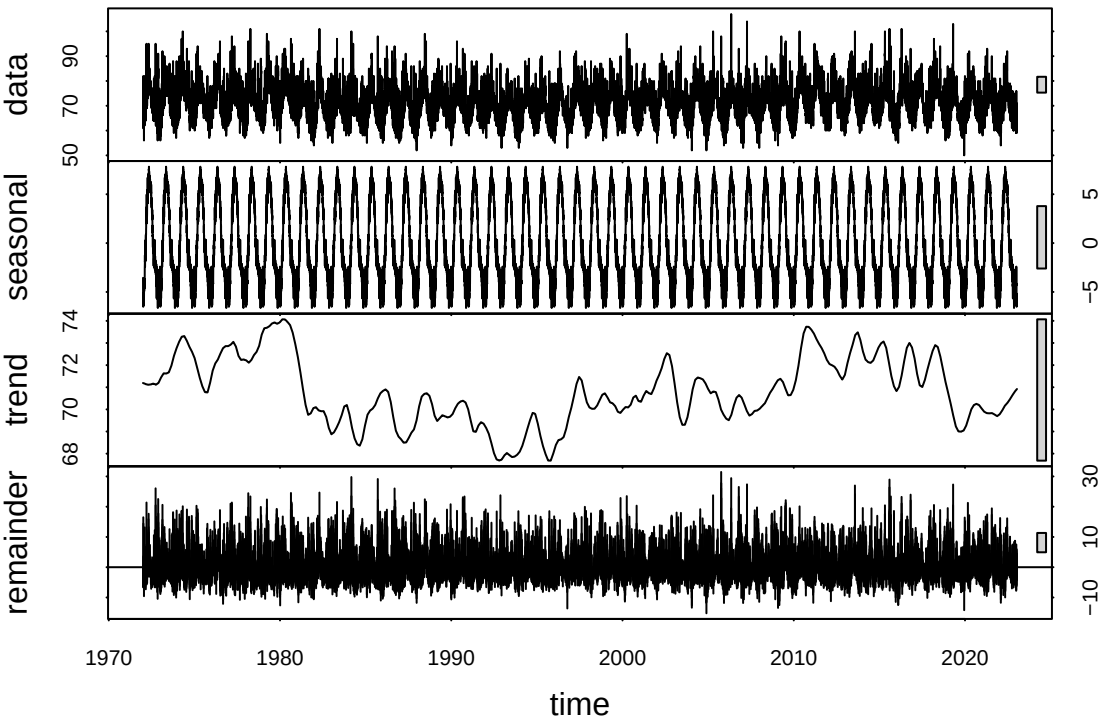
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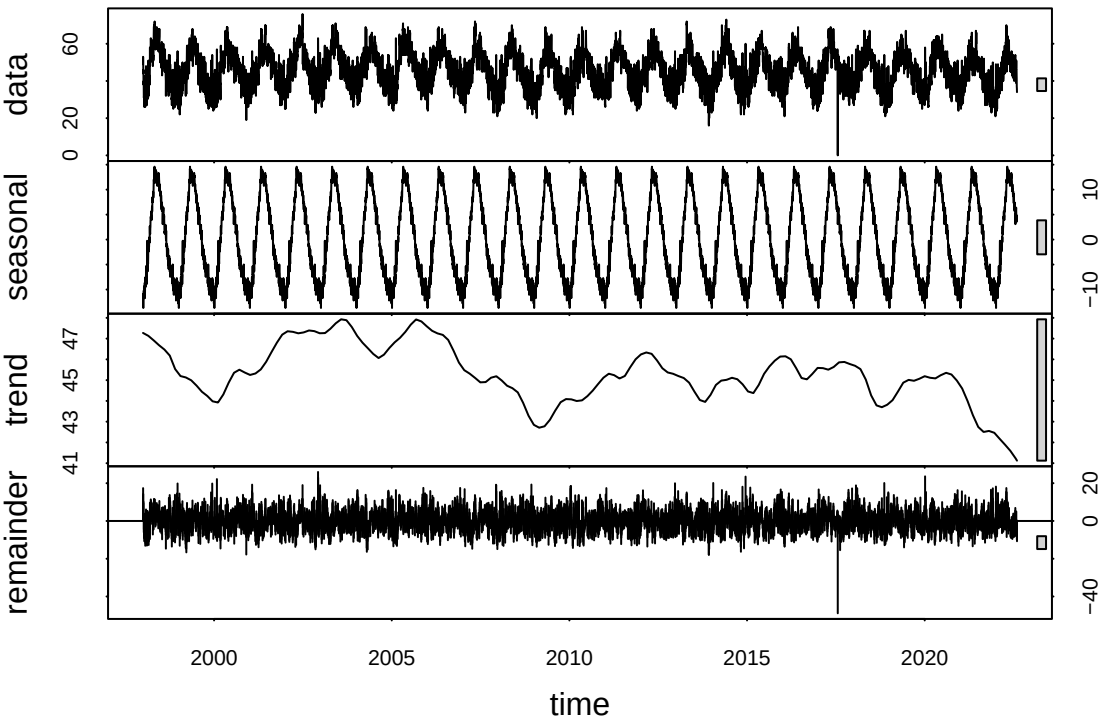
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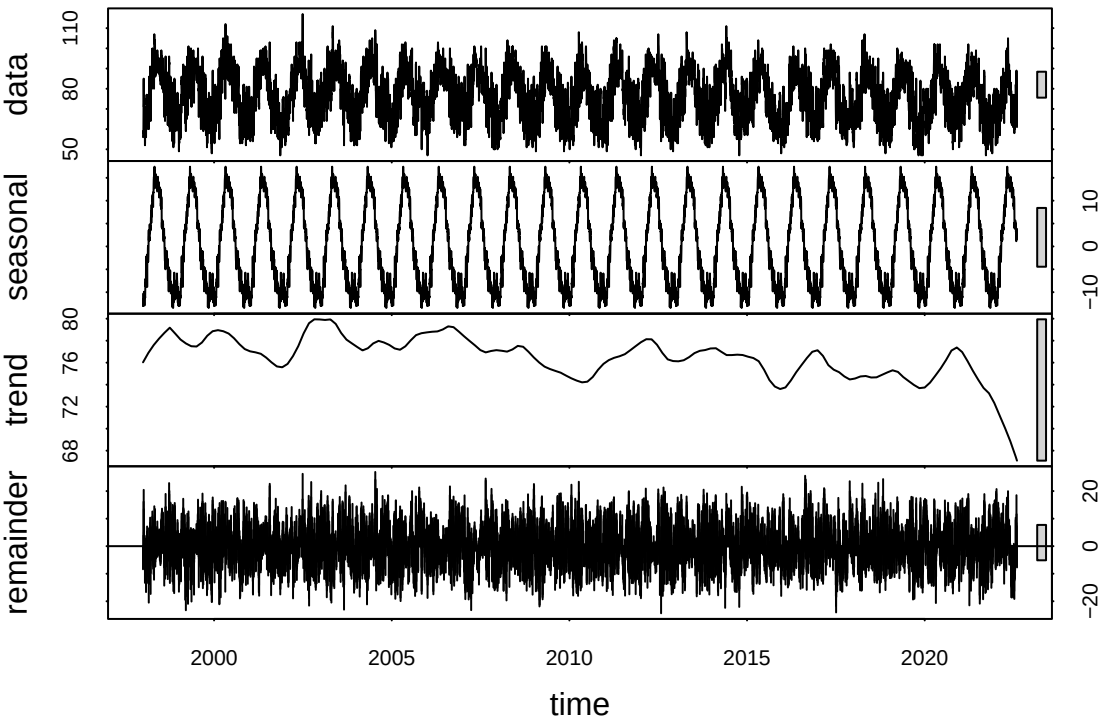
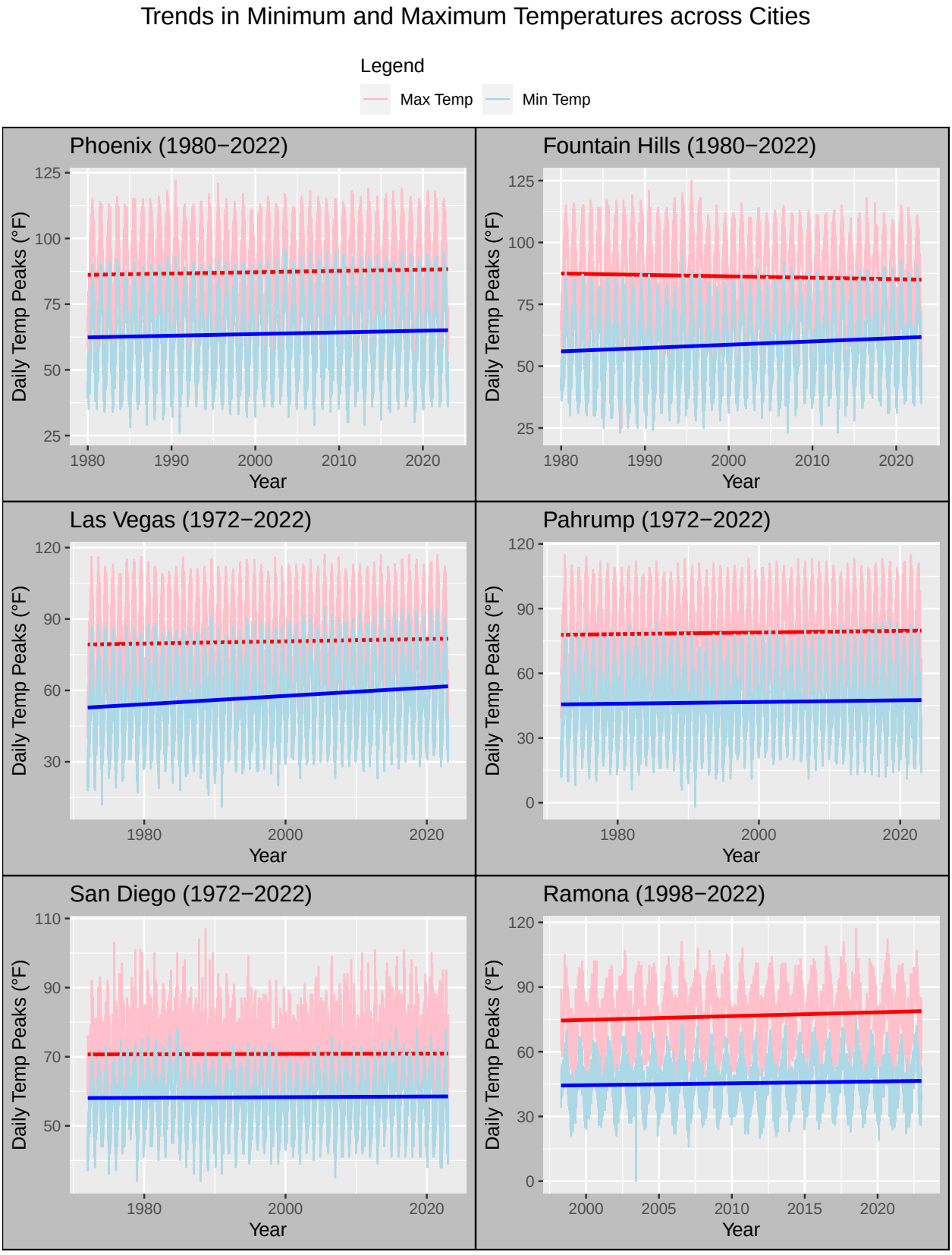


We then conducted a Seasonal Mann Kendal test to test whether the hypothesis that the data is stationary. This would mean that the data exhibit no statistically-significant upward or downward trend over time, meaning that there is no change in the temperature minimum and maximums over time.

The results of the Seasonal Mann Kendall test show us that .

Table 1: Results for the Seasonal Mann Kendall test on minimum and maximum temperatures

City	Variable	p-value	tau value
Phoenix	max temperature	<2.22 e-16	0.0617
Phoenix	min temperature	<2.22 e-16	0.0951
Fountain Hills	max temperature	7.66 e-07	-0.0282
Fountain Hills	min temperature	<2.22 e-16	0.0979
Las Vegas	max temperature	<2.22 e-16	0.0671
Las Vegas	min temperature	<2.22 e-16	0.29
Pahrump	max temperature	<2.22 e-16	0.0482
Pahrump	min temperature	<2.22 e-16	0.0678
San Diego	max temperature	8.91 e-4	0.0173
San Diego	min temperature	5.10 e-4	-0.0182
Ramona	max temperature	<2.22 e-16	-0.112
Ramona	min temperature	<2.22 e-16	-0.0912



The graphs above show the trends increasing or slightly decreasing in the case of .

Summary and Conclusions

References

<add references here if relevant, otherwise delete this section>