

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 is the phenomena of the accumulation of greenhouse gases which in turn traps heat increasing global temperature. It is an imminent threat which for a decade has been harped on by environmentalists, and world governments for decades. It took center stage and became a critical focus at the Conference of Parties 2021(COP 21) in which all OECD pledged to decrease carbon emissions. That is because rising temperatures devastate the entire earth's ecosystems by causing adverse weather patterns that have displaced whole communities. These communities often deal with severe flooding or severe droughts caused by this temperature change.

Focusing on the United States there are regions that are more impacted than others. For example, 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, 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.

##	Location	Date	Precipitation	
##	Length:15706	Min. :1980-01-01	Min. :0.0000	
##	Class :character	1st Qu.:1990-10-01	1st Qu.:0.0000	
##	Mode :character	Median :2001-07-01	Median :0.0000	
##		Mean :2001-07-01	Mean :0.0206	
##		3rd Qu.:2012-03-31	3rd Qu.:0.0000	
##		Max. :2022-12-31	Max. :3.3000	
##				
##	Percent_Sunshine_Possible	Daily_Temp_Max	Daily_Temp_Min	Temp_Avg
##	Min. : 0.0	Min. : 43.00	Min. :26.00	Min. : 0.00
##	1st Qu.: 81.0	1st Qu.: 73.00	1st Qu.:51.00	1st Qu.: 63.00
##	Median : 96.0	Median : 88.00	Median :63.00	Median : 77.00
##	Mean : 85.5	Mean : 87.22	Mean :63.71	Mean : 76.46

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## 3rd Qu.:100.0          3rd Qu.:102.00  3rd Qu.:77.00  3rd Qu.: 91.00
## Max. :100.0          Max. :122.00  Max. :96.00  Max. :106.00
## NA's :14245          NA's :9479
## Total_Sunshine      Month          Year          DayofYear
## Min. : 0.0  Min. : 1.000  Min. :1980  Min. : 1.0
## 1st Qu.:387.0  1st Qu.: 4.000  1st Qu.:1990  1st Qu.: 92.0
## Median :624.0  Median : 7.000  Median :2001  Median :183.0
## Mean :528.5  Mean : 6.523  Mean :2001  Mean :183.1
## 3rd Qu.:750.0  3rd Qu.:10.000  3rd Qu.:2012  3rd Qu.:274.0
## Max. :864.0  Max. :12.000  Max. :2022  Max. :366.0
## NA's :8754

## Location          Date          Precipitation
## Length:15188  Min. :1980-01-01  Min. :0.0000
## Class :character  1st Qu.:1990-06-25  1st Qu.:0.0000
## Mode :character  Median :2000-11-16  Median :0.0000
## Mean :2001-03-09  Mean :0.0295
## 3rd Qu.:2011-12-02  3rd Qu.:0.0000
## Max. :2022-12-31  Max. :3.0200
## NA's :374
## Percent_Sunshine_Possible  Daily_Temp_Max  Daily_Temp_Min  Temp_Avg
## Min. : NA  Min. : 25.00  Min. :23.00  Min. : NA
## 1st Qu.: NA  1st Qu.: 72.00  1st Qu.:47.00  1st Qu.: NA
## Median : NA  Median : 87.00  Median :58.00  Median : NA
## Mean :NaN  Mean : 86.23  Mean :58.73  Mean :NaN
## 3rd Qu.: NA  3rd Qu.:101.00  3rd Qu.:71.00  3rd Qu.: NA
## Max. : NA  Max. :125.00  Max. :97.00  Max. : NA
## NA's :15188  NA's :501  NA's :448  NA's :15188
## Total_Sunshine      Month          Year          DayofYear
## Min. : NA  Min. : 1.000  Min. :1980  Min. : 1.0
## 1st Qu.: NA  1st Qu.: 4.000  1st Qu.:1990  1st Qu.: 91.0
## Median : NA  Median : 6.000  Median :2000  Median :181.0
## Mean :NaN  Mean : 6.477  Mean :2001  Mean :181.7
## 3rd Qu.: NA  3rd Qu.: 9.000  3rd Qu.:2011  3rd Qu.:272.0
## Max. : NA  Max. :12.000  Max. :2022  Max. :366.0
## NA's :15188

## Location          Date          Precipitation
## Length:18628  Min. :1972-01-01  Min. :0.00000
## Class :character  1st Qu.:1984-09-30  1st Qu.:0.00000
## Mode :character  Median :1997-07-01  Median :0.00000
## Mean :1997-07-01  Mean :0.01152
## 3rd Qu.:2010-04-01  3rd Qu.:0.00000
## Max. :2022-12-31  Max. :1.65000
##
## Percent_Sunshine_Possible  Daily_Temp_Max  Daily_Temp_Min  Temp_Avg
## Min. : 0.00  Min. : 31.00  Min. :11.00  Min. : 32.00
## 1st Qu.: 80.00  1st Qu.: 64.00  1st Qu.:43.00  1st Qu.: 56.00
## Median : 95.00  Median : 80.00  Median :56.00  Median : 71.00
## Mean : 84.78  Mean : 80.51  Mean :57.26  Mean : 71.02
## 3rd Qu.:100.00  3rd Qu.: 97.00  3rd Qu.:72.00  3rd Qu.: 87.00
## Max. :100.00  Max. :117.00  Max. :95.00  Max. :106.00
## NA's :14254  NA's :12393
## Total_Sunshine      Month          Year          DayofYear
## Min. : 0.0  Min. : 1.000  Min. :1972  Min. : 1.0

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## 1st Qu.:462.0 1st Qu.: 4.000 1st Qu.:1984 1st Qu.: 92.0
## Median :626.0 Median : 7.000 Median :1997 Median :183.0
## Mean :557.8 Mean : 6.523 Mean :1997 Mean :183.1
## 3rd Qu.:760.0 3rd Qu.:10.000 3rd Qu.:2010 3rd Qu.:274.0
## Max. :888.0 Max. :12.000 Max. :2022 Max. :366.0
## NA's :8856

## Location Date Precipitation
## Length:18402 Min. :1972-01-01 Min. :0.00000
## Class :character 1st Qu.:1984-10-06 1st Qu.:0.00000
## Mode :character Median :1997-07-12 Median :0.00000
## Mean :1997-06-30 Mean :0.01345
## 3rd Qu.:2010-03-01 3rd Qu.:0.00000
## Max. :2022-12-31 Max. :2.70000
## NA's :113
## Percent_Sunshine_Possible Daily_Temp_Max Daily_Temp_Min Temp_Avg
## Min. : NA Min. : 27.00 Min. : -2.00 Min. : NA
## 1st Qu.: NA 1st Qu.: 64.00 1st Qu.:34.00 1st Qu.: NA
## Median : NA Median : 79.00 Median :46.00 Median : NA
## Mean :NaN Mean : 78.89 Mean :46.61 Mean :NaN
## 3rd Qu.: NA 3rd Qu.: 95.00 3rd Qu.:60.00 3rd Qu.: NA
## Max. : NA Max. :115.00 Max. :86.00 Max. : NA
## NA's :18402 NA's :314 NA's :348 NA's :18402
## Total_Sunshine Month Year DayofYear
## Min. : NA Min. : 1.000 Min. :1972 Min. : 1.0
## 1st Qu.: NA 1st Qu.: 4.000 1st Qu.:1984 1st Qu.: 92.0
## Median : NA Median : 7.000 Median :1997 Median :183.0
## Mean :NaN Mean : 6.511 Mean :1997 Mean :182.8
## 3rd Qu.: NA 3rd Qu.:10.000 3rd Qu.:2010 3rd Qu.:274.0
## Max. : NA Max. :12.000 Max. :2022 Max. :366.0
## NA's :18402

## Location Date Precipitation
## Length:18629 Min. :1972-01-01 Min. :0.00000
## Class :character 1st Qu.:1984-10-01 1st Qu.:0.00000
## Mode :character Median :1997-07-02 Median :0.00000
## Mean :1997-07-02 Mean :0.02734
## 3rd Qu.:2010-04-02 3rd Qu.:0.00000
## Max. :2023-01-01 Max. :2.70000
##
## Percent_Sunshine_Possible Daily_Temp_Max Daily_Temp_Min Temp_Avg
## Min. : 0.0 Min. : 50.00 Min. :34.00 Min. : 0.00
## 1st Qu.: 52.0 1st Qu.: 66.00 1st Qu.:53.00 1st Qu.:60.00
## Median : 76.0 Median : 70.00 Median :59.00 Median :64.00
## Mean : 68.8 Mean : 70.78 Mean :58.28 Mean :64.55
## 3rd Qu.: 94.0 3rd Qu.: 75.00 3rd Qu.:64.00 3rd Qu.:69.00
## Max. :100.0 Max. :107.00 Max. :78.00 Max. :87.00
## NA's :14246 NA's :12399
## Total_Sunshine Month Year DayofYear
## Min. : 0.0 Min. : 1.000 Min. :1972 Min. : 1.0
## 1st Qu.:252.0 1st Qu.: 4.000 1st Qu.:1984 1st Qu.: 92.0
## Median :522.0 Median : 7.000 Median :1997 Median :183.0
## Mean :442.9 Mean : 6.523 Mean :1997 Mean :183.1
## 3rd Qu.:636.0 3rd Qu.:10.000 3rd Qu.:2010 3rd Qu.:274.0
## Max. :859.0 Max. :12.000 Max. :2023 Max. :366.0

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## NA's :8427

## Location Date Precipitation
## Length:8979 Min. :1998-04-16 Min. :0.00000
## Class :character 1st Qu.:2004-07-10 1st Qu.:0.00000
## Mode :character Median :2010-09-15 Median :0.00000
## Mean :2010-09-09 Mean :0.03592
## 3rd Qu.:2016-11-08 3rd Qu.:0.00000
## Max. :2023-01-01 Max. :5.05000
## NA's :9
## Percent_Sunshine_Possible Daily_Temp_Max Daily_Temp_Min Temp_Avg
## Min. : NA Min. : 47.00 Min. : 0.00 Min. : 0.00
## 1st Qu.: NA 1st Qu.: 67.00 1st Qu.:37.00 1st Qu.:52.00
## Median : NA Median : 77.00 Median :46.00 Median :59.00
## Mean :NaN Mean : 76.66 Mean :45.41 Mean :60.08
## 3rd Qu.: NA 3rd Qu.: 87.00 3rd Qu.:53.00 3rd Qu.:68.00
## Max. : NA Max. :117.00 Max. :76.00 Max. :86.00
## NA's :8979 NA's :33 NA's :32 NA's :6359
## Total_Sunshine Month Year DayofYear
## Min. :0.000 Min. : 1.000 Min. :1998 Min. : 1.0
## 1st Qu.:0.000 1st Qu.: 4.000 1st Qu.:2004 1st Qu.: 94.0
## Median :0.000 Median : 7.000 Median :2010 Median :185.0
## Mean :0.004 Mean : 6.568 Mean :2010 Mean :184.5
## 3rd Qu.:0.000 3rd Qu.:10.000 3rd Qu.:2016 3rd Qu.:276.0
## Max. :5.000 Max. :12.000 Max. :2023 Max. :366.0
## NA's :7851

## Min. 1st Qu. Median Mean 3rd Qu. Max.
## 43.00 73.00 88.00 87.22 102.00 122.00

## Min. 1st Qu. Median Mean 3rd Qu. Max.
## 26.00 51.00 63.00 63.71 77.00 96.00

## Min. 1st Qu. Median Mean 3rd Qu. Max.
## 27.00 64.00 79.00 78.84 95.00 115.00

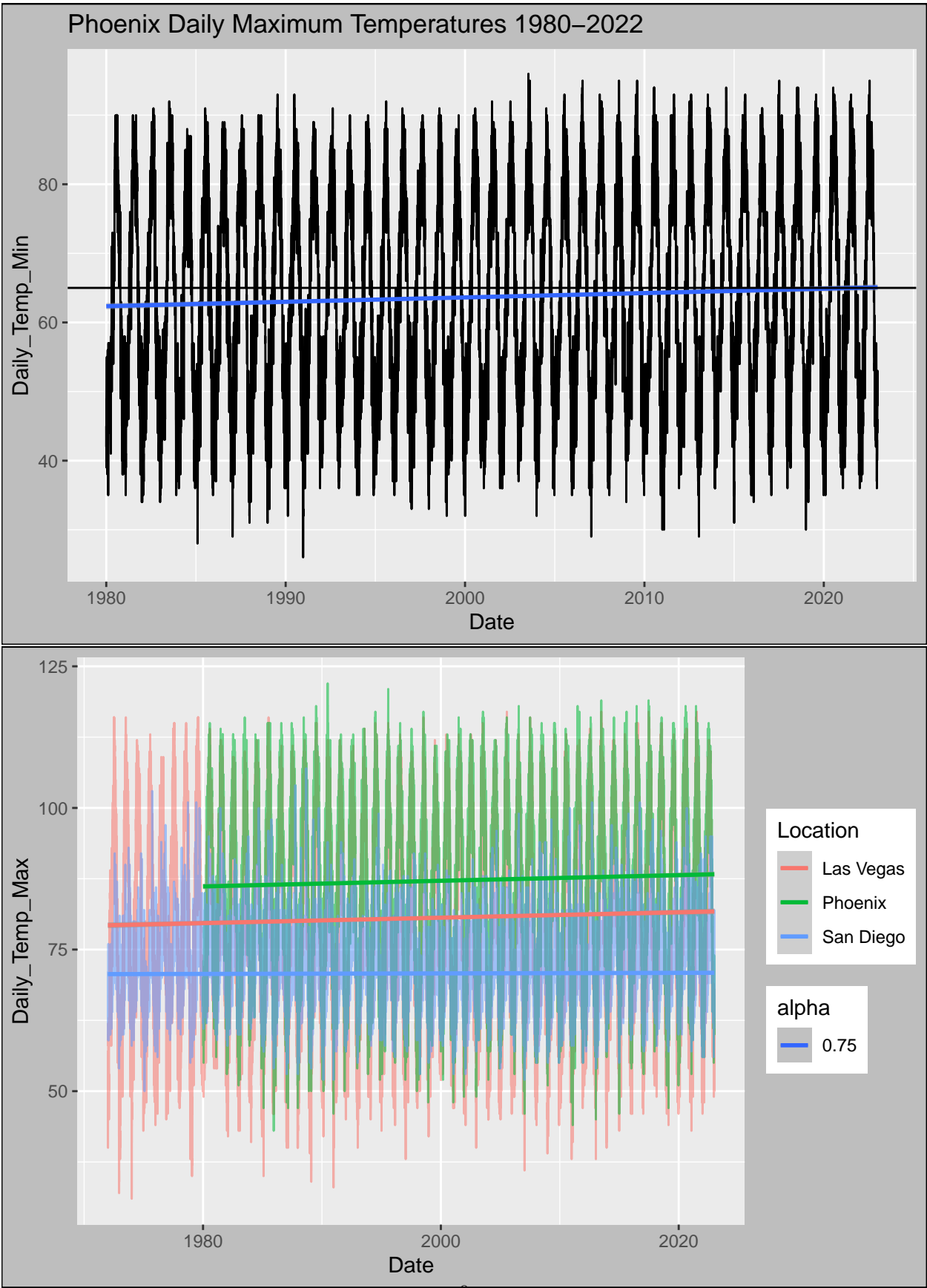
## Min. 1st Qu. Median Mean 3rd Qu. Max.
## -2.0 34.0 46.0 46.6 60.0 86.0

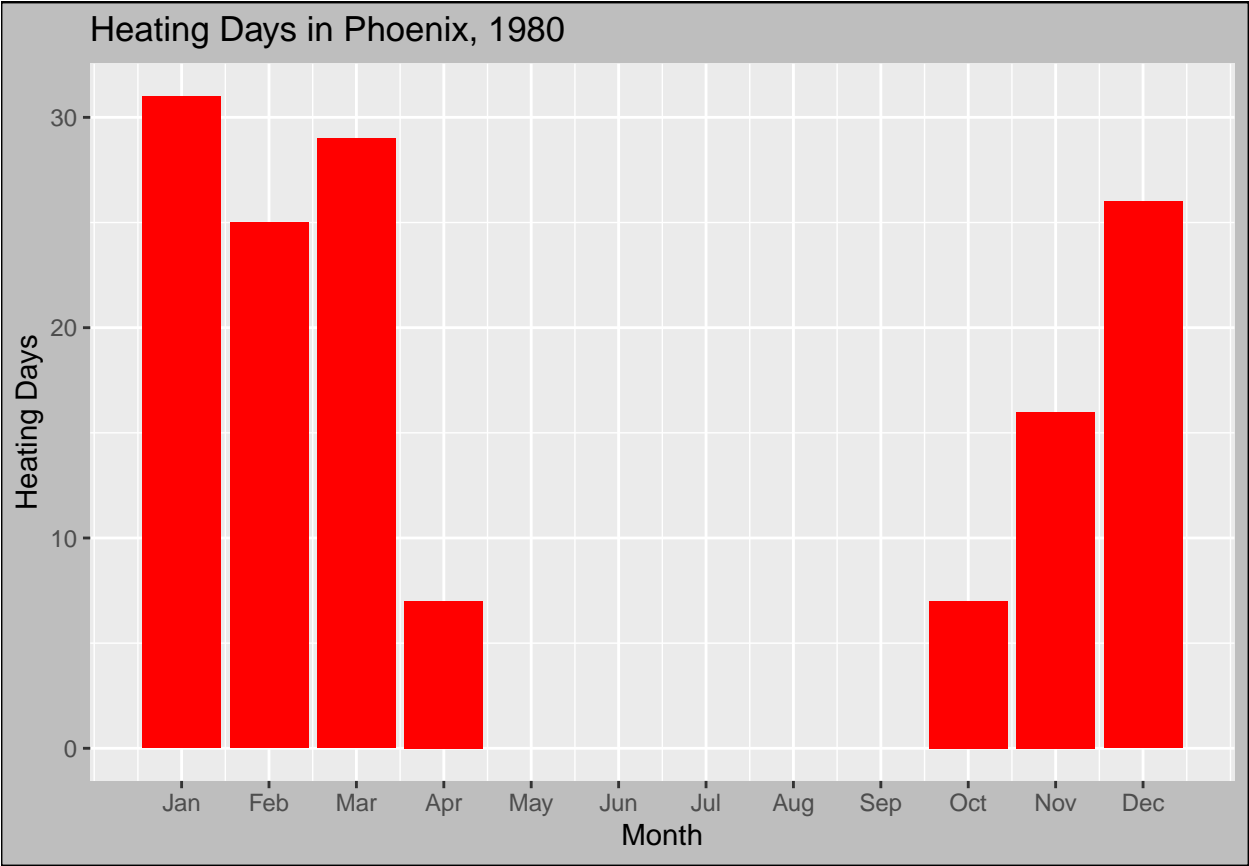
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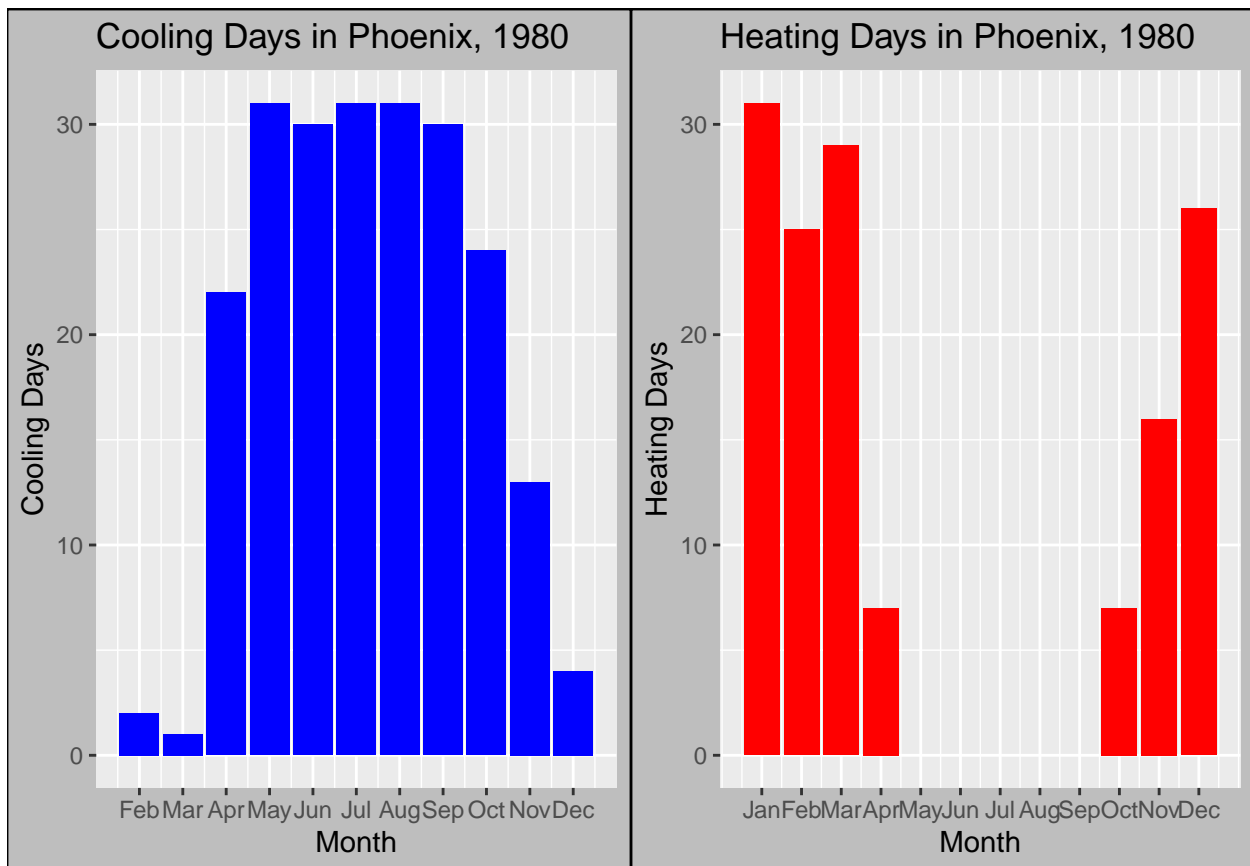
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## 0.00 37.00 46.00 45.42 53.00 76.00

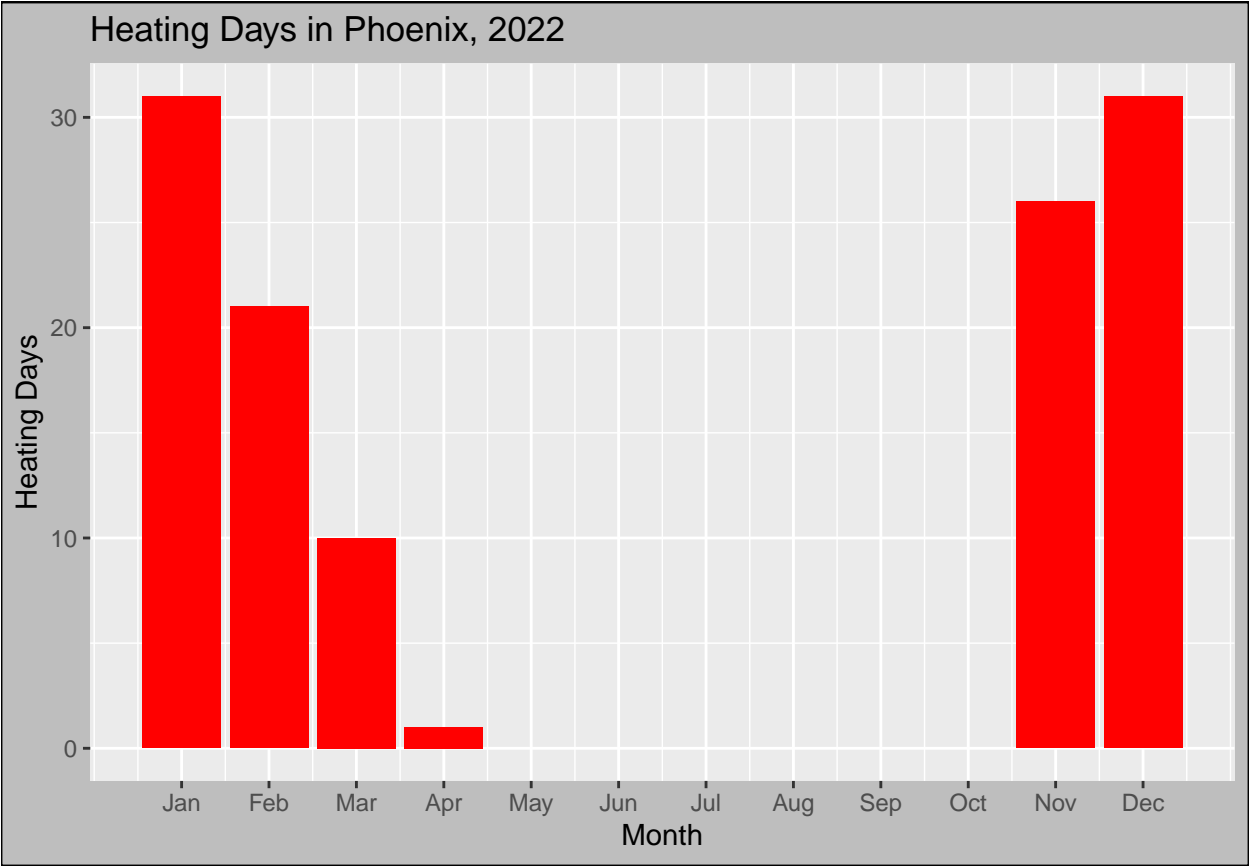
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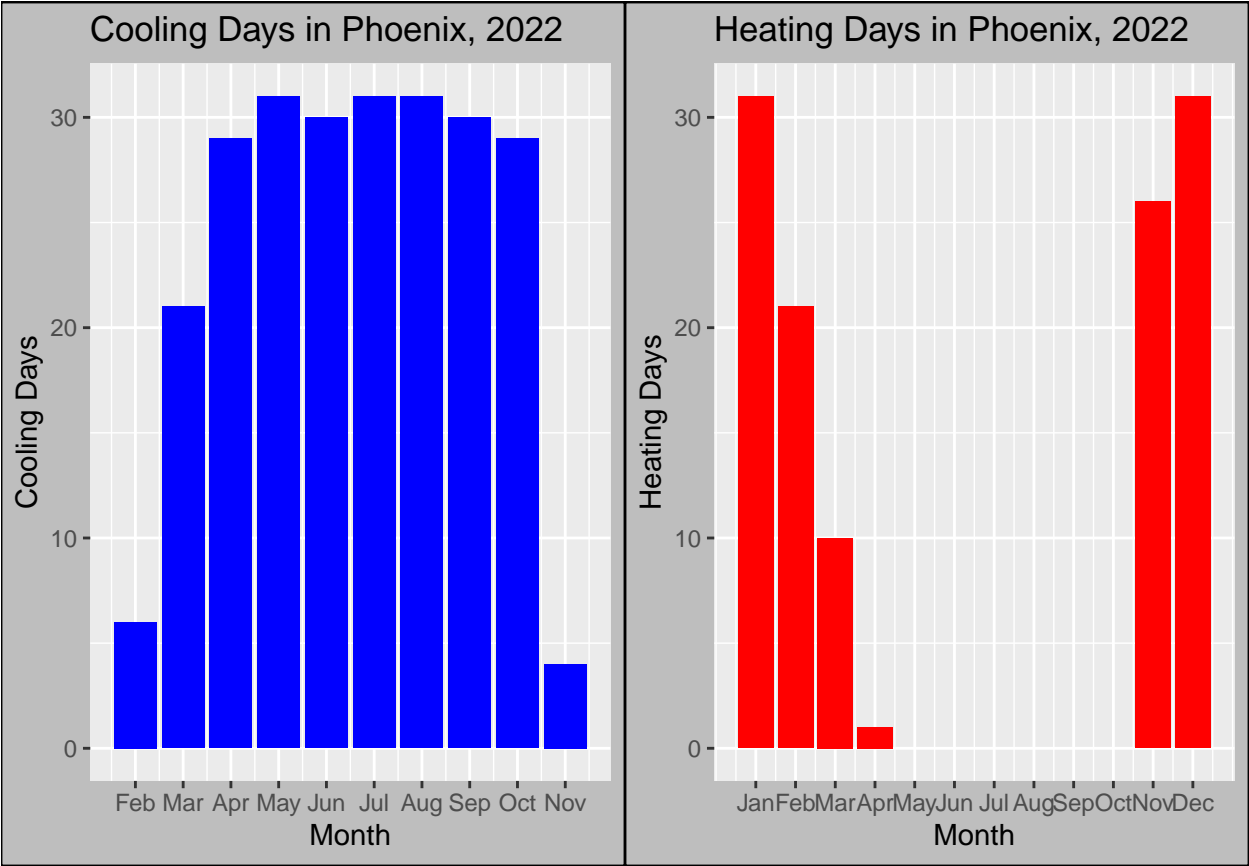

Exploratory Analysis

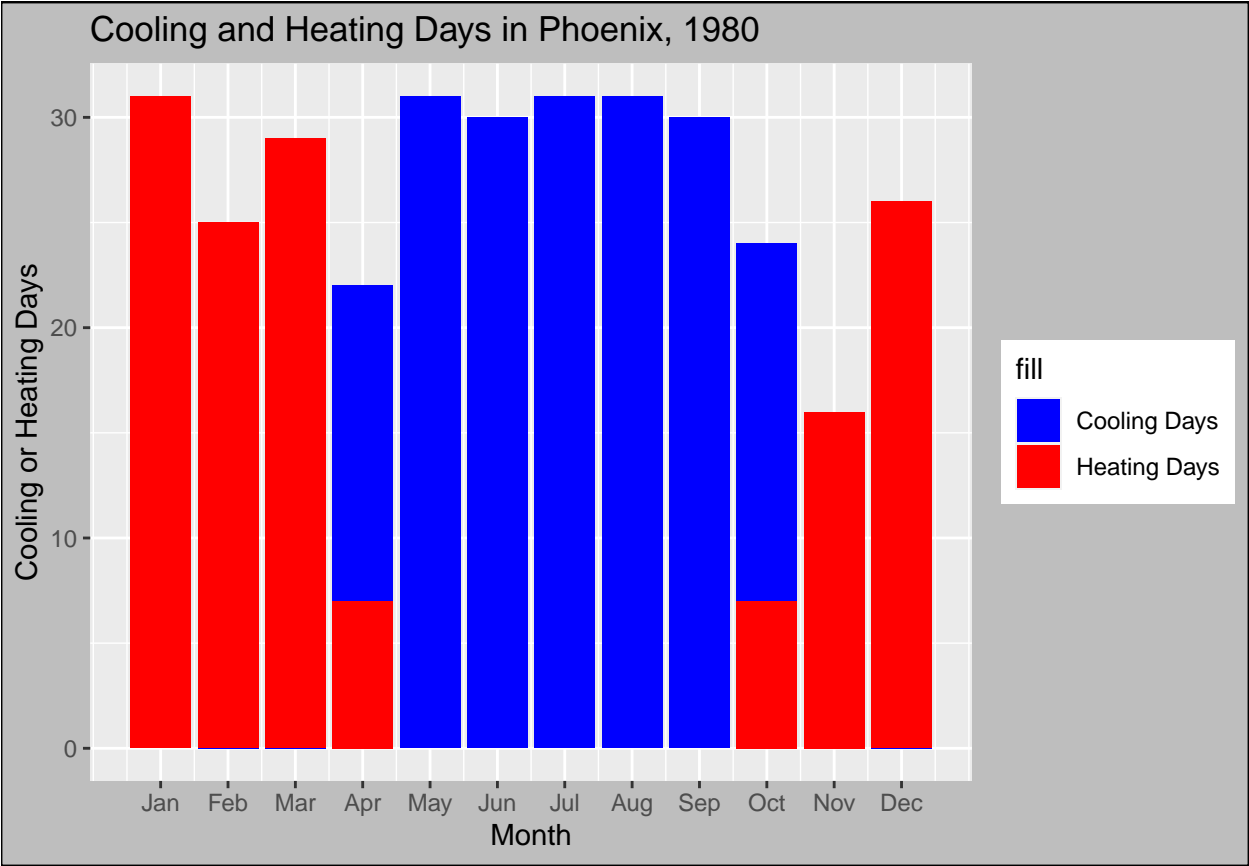


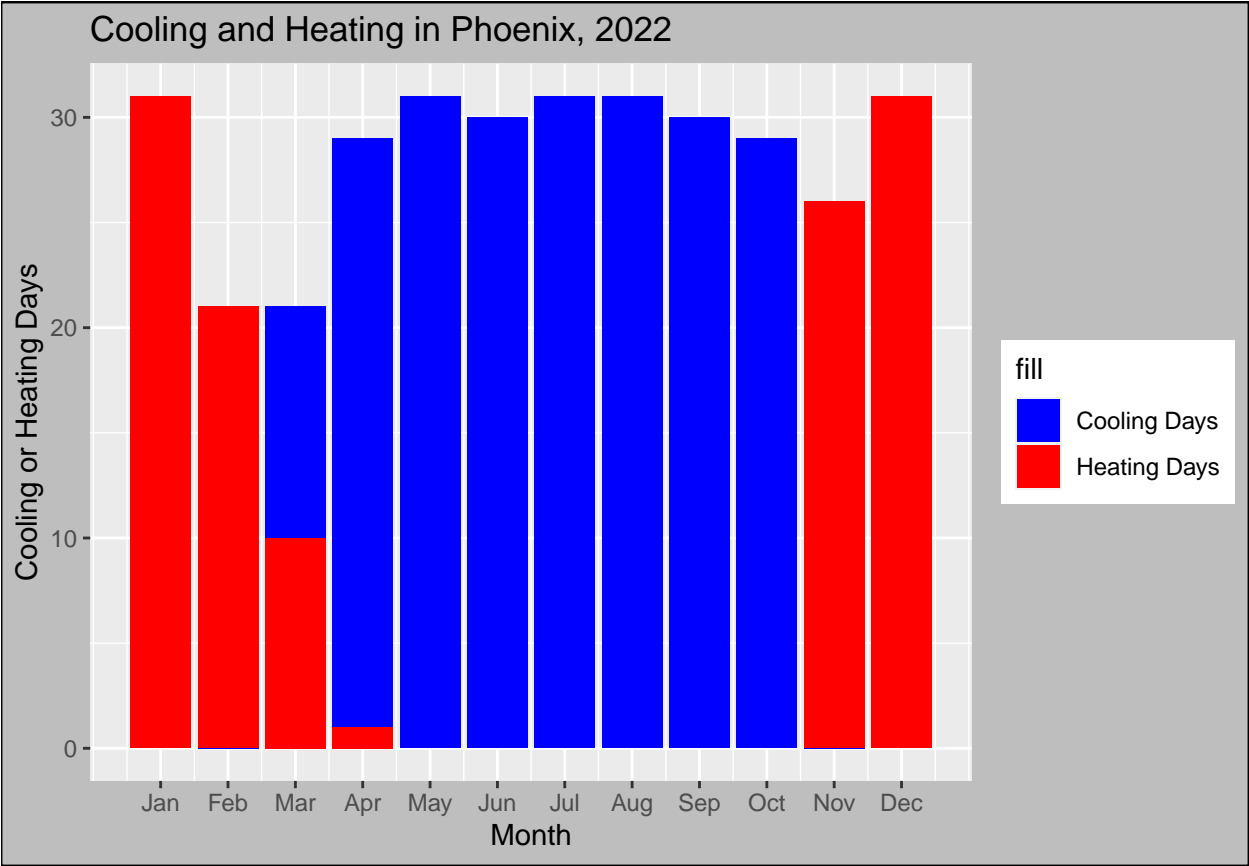


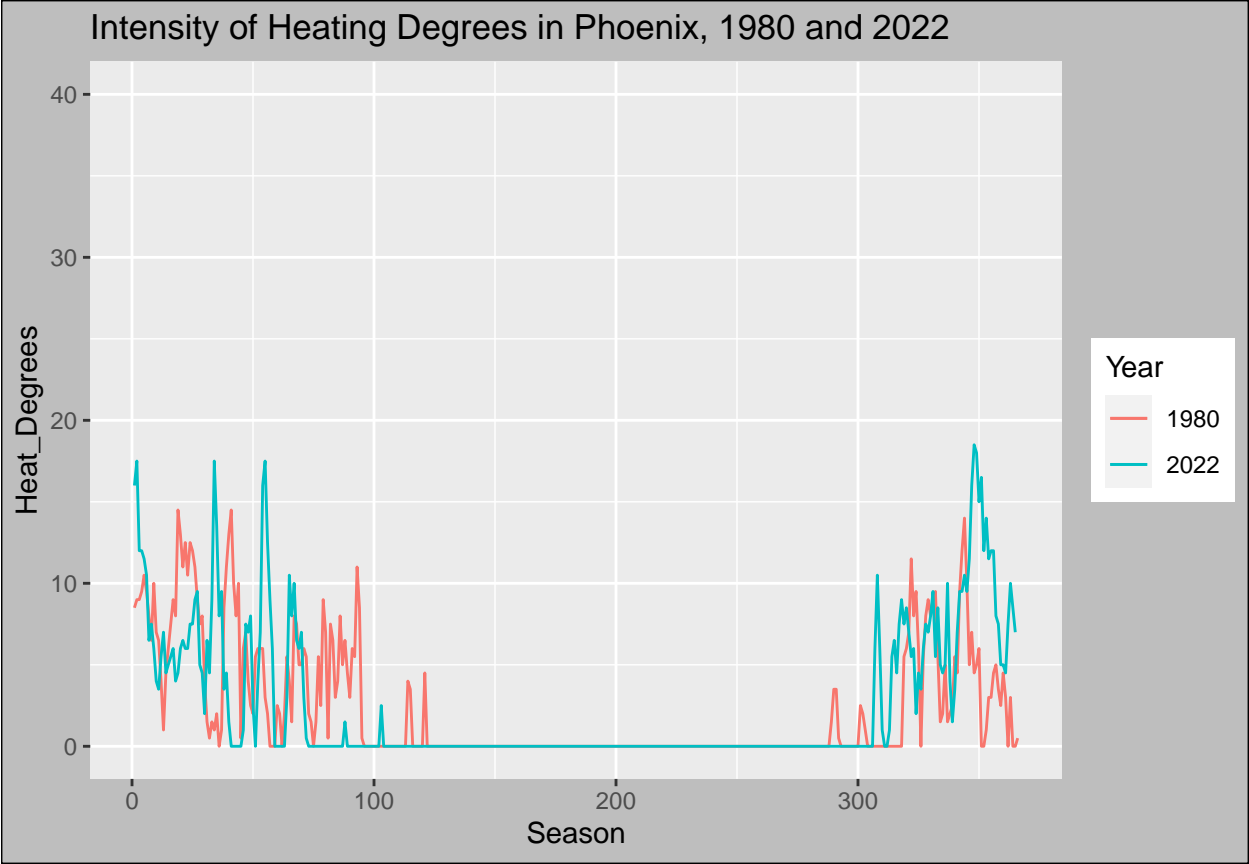


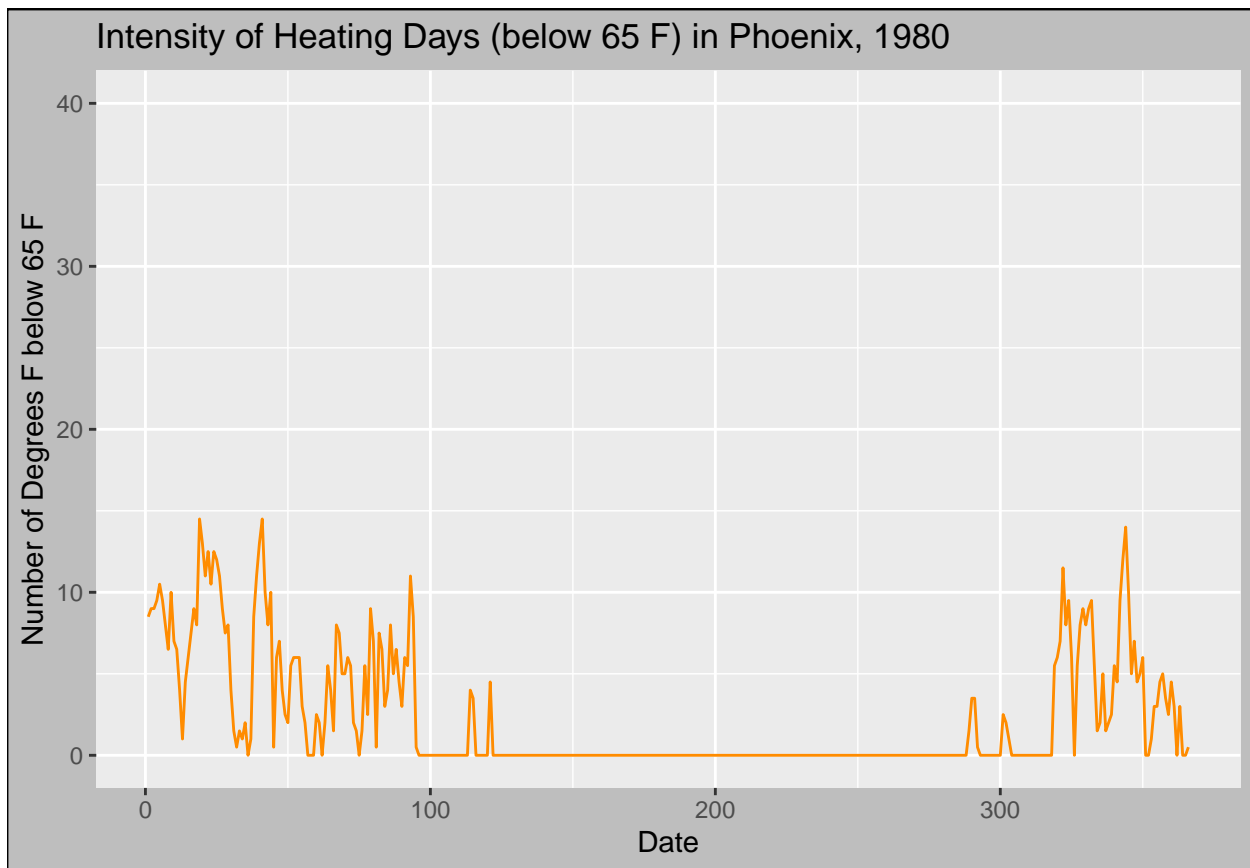


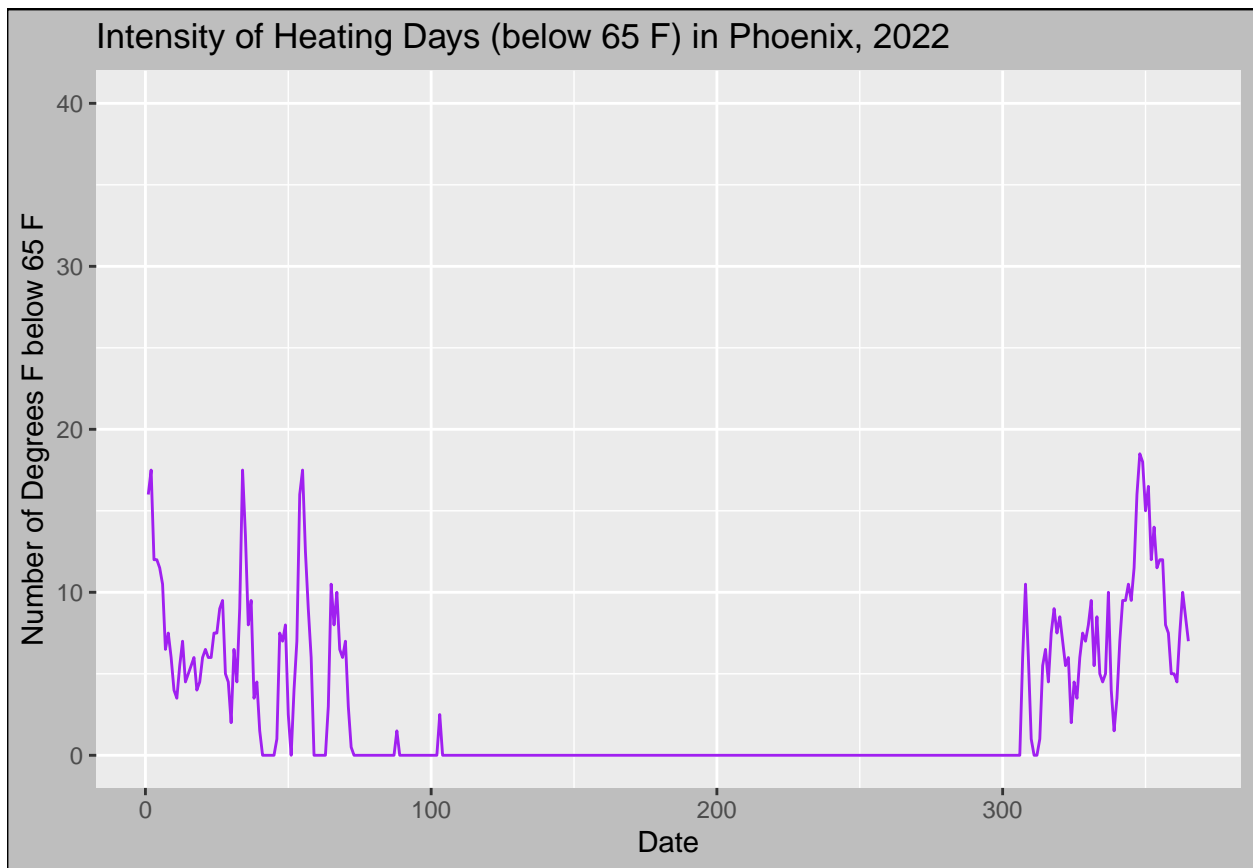


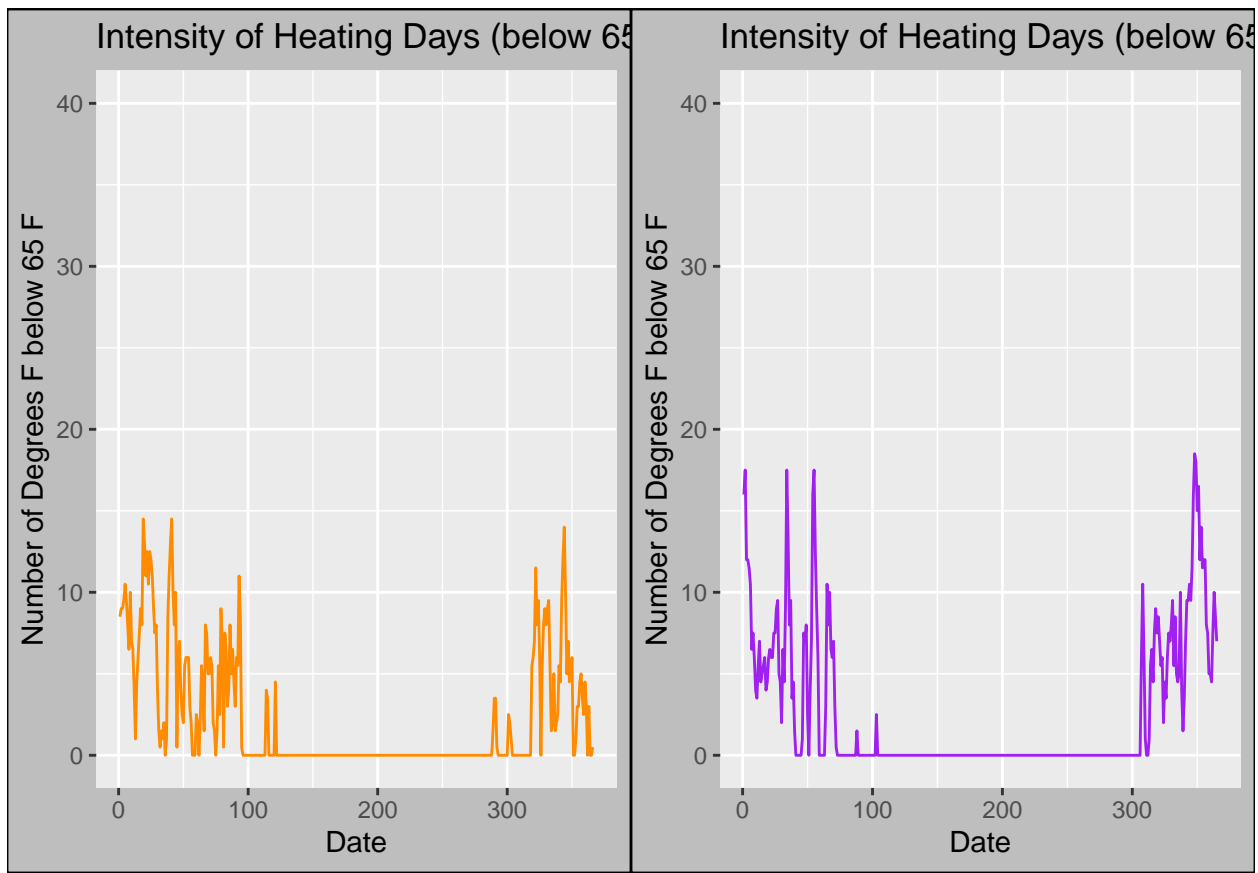












Analysis

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?

Summary and Conclusions

References

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