Chose Your Own Project - Machine Learning Submission

HarvardX Data Science Capstone - PH125.9x

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Contents

Introduction

For the 9th Course in the HarvardX Data Science course we have been asked to create two recommendation systems. The first was a Movie Recommendation System using the MovieLens dataset. The second is a "Choose your Own Project." For this a we are targetting a Workforce Recommendation System - mixing weather forecasts with Police 911 call information to see if it is possible to predict Police staffing requirements based on weather based trends.

We are using the Seattle Police Department 911 Incident Response data set found here : https://www.kaggle.com/datasets/sohier/seattle-police-department-911-incident-response

For Weather data we will use National Oceanic and Atmospheric Administration (NOAA) data. Michael Minns' tutorial is inciteful for weather analysis. It can be found here: https://michaelminn.net/tutorials/r-weather/index.html This weather data does not appear to be available via an api call or similar and is quite a manual download process. Due to download constraints we will be using a locally sourced dataset covering the years 2001 to 2002.

In order to test the results of the recommendation system we are using the root-mean-square error (RMSE) to measure the difference between the values predicted by the model and the observed values.

Method

The first step is to clear any set variables so we do not introduce anything unexpected into the data we are working with.

Then we install the packages required to manipulate the data.

```
#####################################################
# This code is divided into the following sections #
# 1. Install required packages                      #
# 2. edx code for creating data sets                #
# 3. Data set exploration                           #
#####################################################

############################################################
# 1. Install required packages and download data           #
############################################################
```

```
# Note: this process takes a couple of minutes

if(!require(tidyverse)) install.packages("tidyverse", repos = "https://cran.us.r-project.org")
if(!require(caret)) install.packages("caret", repos = "https://cran.us.r-project.org")
if(!require(dplyr)) install.packages("dplyr", repos = "https://cran.us.r-project.org")
if(!require(kableExtra)) install.packages("kableExtra", repos = "https://cran.us.r-project.org")
if(!require(lubridate)) install.packages("lubridate", repos = "https://cran.us.r-project.org")
if(!require(scales)) install.packages("scales", repos = "https://cran.us.r-project.org")
if(!require(stringr)) install.packages("stringr", repos = "http://cran.us.r-project.org")
if(!require(readr)) install.packages("readr", repos = "http://cran.us.r-project.org")
if(!require(xts)) install.packages("xts", repos = "http://cran.us.r-project.org")
if(!require(tsbox)) install.packages("tsbox", repos = "http://cran.us.r-project.org")
if(!require(forecast)) install.packages("forecast", repos = "http://cran.us.r-project.org")
if(!require(data.table)) install.packages("data.table", repos = "http://cran.us.r-project.org")
if(!require(measurements)) install.packages("measurements", repos = "http://cran.us.r-project.org")
if(!require(kableExtra)) install.packages("kableExtra", repos = "http://cran.us.r-project.org")
if(!require(ggmap)) install.packages("ggmap", repos = "http://cran.us.r-project.org")
library(tidyverse)
library(caret)
library(dplyr)
library(kableExtra)
library(lubridate)
library(scales)
library(stringr)
library(readr)
library(xts)
library(tsbox)
library(forecast)
library(data.table)
library(measurements)
library(kableExtra)
library(ggmap)
```

Following that, the data is downloaded and then divided into 2 sets. The first set is used to train the algorithm and the second set is used to validate the algorithm. By dividing the data the problem of over-training and thus producing skewed results can be avoided.

The creation of the 2 sets involves the following steps. Initially required packages are installed if not installed and then loaded. Next the data is downloaded if the zip files are not found. Column names are set and the data is converted into forms more easily processed. Then the data is joined. Finally the joined data is split into 2 sets - the edx set used to train the algorithm and the final_holdout_test set that will be used to validate the algorithm and calculate the final RMSE score.

```
#Seattle Police Department 911 Incident Response
#https://www.kaggle.com/datasets/sohier/seattle-police-department-911-incident-response/download?datase

#National Oceanic and Atmospheric Administration (NOAA) data
#https://www.ncei.noaa.gov/orders/cdo/3533326.csv

options(timeout = 120)

dl <- "archive.zip"
if(!file.exists(dl))
  download.file("https://www.kaggle.com/datasets/sohier/seattle-police-department-911-incident-response/
```

```
dl <- "3533326.csv"
if(!file.exists(dl))
  download.file("https://www.ncei.noaa.gov/orders/cdo/3533326.csv", dl)
```

```
#Load Seattle 0911 Call data
Seattle_911 <- read_csv("Seattle_Police_Department_911_Incident_Response.csv")
#Load weather data
Weather <- read.csv("3533326.csv", as.is=T)
```

##Data Investigation

```
head(Weather)
```

```
##       STATION              NAME       DATE PRCP SNOW TAVG TMAX TMIN TSUN WT01
## 1 USC00450872 BREMERTON, WA US 2000-01-01 0.23    0   NA   44   38   NA   NA
## 2 USC00450872 BREMERTON, WA US 2000-01-02 0.00    0   NA   44   31   NA   NA
## 3 USC00450872 BREMERTON, WA US 2000-01-03 0.10    0   NA   45   32   NA   NA
## 4 USC00450872 BREMERTON, WA US 2000-01-04 1.38    0   NA   47   35   NA   NA
## 5 USC00450872 BREMERTON, WA US 2000-01-05 0.02    0   NA   51   30   NA   NA
## 6 USC00450872 BREMERTON, WA US 2000-01-06 0.01    0   NA   44   34   NA   NA
##   WT02 WT03 WT04 WT05 WT06 WT07 WT08 WT09 WT11 WT13 WT14 WT15 WT16 WT17 WT18
## 1   NA   NA   NA   NA   NA   NA   NA   NA   NA   NA   NA   NA   NA   NA   NA
## 2   NA   NA   NA   NA   NA   NA   NA   NA   NA   NA   NA   NA   NA   NA   NA
## 3   NA   NA   NA   NA   NA   NA   NA   NA   NA   NA   NA   NA   NA   NA   NA
## 4   NA   NA   NA   NA   NA   NA   NA   NA   NA   NA   NA   NA   NA   NA   NA
## 5   NA   NA   NA   NA   NA   NA   NA   NA   NA   NA   NA   NA   NA   NA   NA
## 6   NA   NA   NA   NA   NA   NA   NA   NA   NA   NA   NA   NA   NA   NA   NA
##   WT19 WT21 WT22 WV01 WV03
## 1   NA   NA   NA   NA   NA
## 2   NA   NA   NA   NA   NA
## 3   NA   NA   NA   NA   NA
## 4   NA   NA   NA   NA   NA
## 5   NA   NA   NA   NA   NA
## 6   NA   NA   NA   NA   NA
```

```
names(Weather)
```

```
##  [1] "STATION" "NAME"    "DATE"    "PRCP"    "SNOW"    "TAVG"    "TMAX"
##  [8] "TMIN"    "TSUN"    "WT01"    "WT02"    "WT03"    "WT04"    "WT05"
## [15] "WT06"    "WT07"    "WT08"    "WT09"    "WT11"    "WT13"    "WT14"
## [22] "WT15"    "WT16"    "WT17"    "WT18"    "WT19"    "WT21"    "WT22"
## [29] "WV01"    "WV03"
```

```
min(range(Weather$DATE))
```

```
## [1] "2000-01-01"
```

```
max(range(Weather$DATE))
```

```
## [1] "2002-12-31"
```

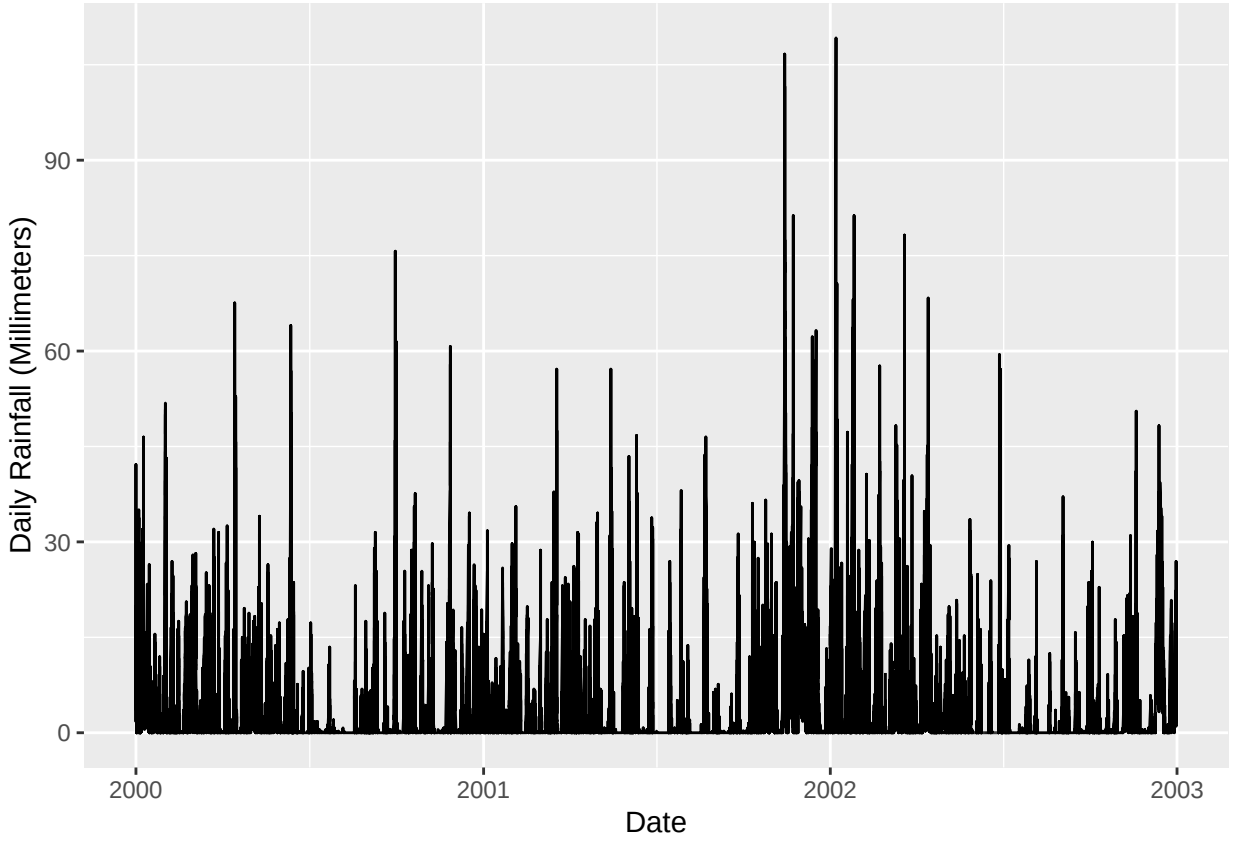
Our data range starts from 2000-01-01 and ends 2002-12-31.

```
#Seattle_Weather <- xts(Weather["Weather$STATION" == 'USC00450872',c("TMAX","TMIN","PRCP")], order.by=a
Seattle_Weather <- xts(Weather[,c("NAME","STATION","DATE","TMAX","TMIN","PRCP")], order.by=as.Date(Weat

Seattle_Weather <- as.data.frame(Seattle_Weather)
#Seattle_Weather = window(Seattle_Weather, start=as.Date("2000-01-01"), end=as.Date("2002-12-31"))
```

```r
class(Seattle_Weather)
```

```
## [1] "data.frame"
```

```r
Seattle_Weather$DATE <- as.Date(Seattle_Weather$DATE)
Seattle_Weather$PRCP <- as.numeric(Seattle_Weather$PRCP)

#Convert Precipitation from Imperial to Metric
Seattle_Weather$PRCP <- conv_unit(Seattle_Weather$PRCP, "inch", "mm")


Seattle_Weather$TMAX <- as.numeric(Seattle_Weather$TMAX)
Seattle_Weather$TMAX <- conv_unit(Seattle_Weather$TMAX, "F", "C")

Seattle_Weather$TMIN <- as.numeric(Seattle_Weather$TMIN)
Seattle_Weather$TMIN <- conv_unit(Seattle_Weather$TMIN, "F", "C")

#Extract Unique Station Names and Identifiers
Seattle_Stations <- unique(Seattle_Weather[, c('NAME', 'STATION')])

# Remove the index column - otherwise it gets printed even though we asked for only Station and Name
rownames(Seattle_Stations) <- NULL

ggplot(Seattle_Weather, aes(x=DATE,y=PRCP)) +
  geom_line() +
  xlab("Date") +
  ylab("Daily Rainfall (Millimeters)")
```



```r
options(digits=2)
```

We have data from 20 stations:

NAME	STATION
BREMERTON, WA US	USC00450872
EVERETT, WA US	USC00452675
MONROE, WA US	USC00455525
TOLT SOUTH FORK RESERVOIR, WA US	USC00458508
RENTON MUNICIPAL AIRPORT, WA US	USW00094248
KENT, WA US	USC00454169
TACOMA NUMBER 1, WA US	USC00458278
LANDSBURG, WA US	USC00454486
CEDAR LAKE, WA US	USC00451233
SNOQUALMIE FALLS, WA US	USC00457773
WAUNA 3 W, WA US	USC00459021
PALMER 3 ESE, WA US	USC00456295
TACOMA NARROWS AIRPORT, WA US	USW00094274
EVERETT SNOHOMISH CO AIRPORT, WA US	USW00024222
SEATTLE TACOMA AIRPORT, WA US	USW00024233
SEATTLE SAND POINT WEATHER FORECAST OFFICE, WA US	USW00094290
SEATTLE BOEING FIELD, WA US	USW00024234
GIG HARBOR 3.4 NW, WA US	US1WAPR0075
OLALLA 1.4 WNW, WA US	US1WAKP0013
WOODINVILLE 0.9 ENE, WA US	US1WAKG0078

Of 17773 rainfall measurements, 7869 recorded rainfall, and 9794 recorded no rainfall. The maximum rainfall during this period was 109.22mm which fell on 2002-01-07. Heavy rainfall is defined by NIWA as rainfall of over 100mm in 24 hours[1] and this occurred 3 times during the period we have data for.

Over the period we have data for we have a maximum temperature of 37.22 and a minimum of -26.67 degrees Celsius. The mean maximum temperature was 15.08 while the mean minimum temperature was 6.23 degrees Celsius.

```r
#Seattle_Weather %>% group_by(Seattle_Weather$STATION)
```

```r
summary(Seattle_911)
```

```
##   CAD CDW ID        CAD Event Number   General Offense Number
##  Length:1433853     Min.   :9.00e+09   Min.   :2.01e+04
##  Class :character   1st Qu.:1.20e+10   1st Qu.:2.01e+09
##  Mode  :character   Median :1.40e+10   Median :2.01e+09
##                     Mean   :1.37e+10   Mean   :1.64e+09
##                     3rd Qu.:1.60e+10   3rd Qu.:2.02e+09
##                     Max.   :1.70e+10   Max.   :2.01e+10
##
##  Event Clearance Code Event Clearance Description Event Clearance SubGroup
##  Length:1433853       Length:1433853              Length:1433853
##  Class :character     Class :character            Class :character
##  Mode  :character     Mode  :character            Mode  :character
##
##
```

[1] https://niwa.co.nz/natural-hazards/extreme-weather-heavy-rainfall

```
##
##
##  Event Clearance Group Event Clearance Date Hundred Block Location
##  Length:1433853        Length:1433853       Length:1433853
##  Class :character      Class :character     Class :character
##  Mode  :character      Mode  :character     Mode  :character
##
##
##
##
##  District/Sector     Zone/Beat          Census Tract         Longitude
##  Length:1433853     Length:1433853     Length:1433853     Min.   :-122
##  Class :character   Class :character   Class :character   1st Qu.:-122
##  Mode  :character   Mode  :character   Mode  :character   Median :-122
##                                                           Mean   :-122
##                                                           3rd Qu.:-122
##                                                           Max.   :-122
##                                                           NA's   :1
##     Latitude  Incident Location  Initial Type Description Initial Type Subgroup
##  Min.   :47   Length:1433853     Length:1433853           Length:1433853
##  1st Qu.:48   Class :character   Class :character         Class :character
##  Median :48   Mode  :character   Mode  :character         Mode  :character
##  Mean   :48
##  3rd Qu.:48
##  Max.   :48
##  NA's   :1
##  Initial Type Group At Scene Time
##  Length:1433853     Length:1433853
##  Class :character   Class :character
##  Mode  :character   Mode  :character
##
##
##
##
```

```
summary(Weather)
```

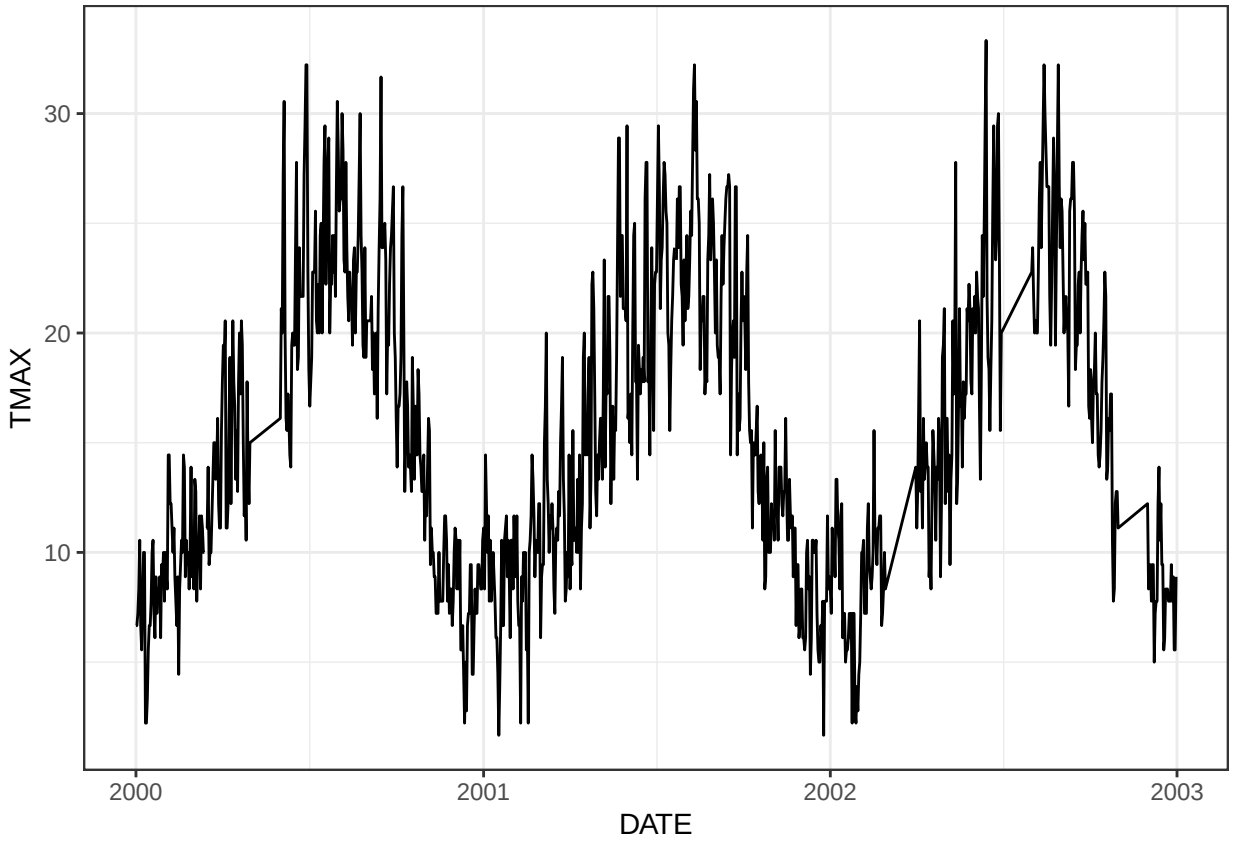
```
##    STATION              NAME               DATE                PRCP
##  Length:17773       Length:17773       Length:17773       Min.   :0
##  Class :character   Class :character   Class :character   1st Qu.:0
##  Mode  :character   Mode  :character   Mode  :character   Median :0
##                                                           Mean   :0
##                                                           3rd Qu.:0
##                                                           Max.   :4
##                                                           NA's   :110
##       SNOW            TAVG            TMAX            TMIN            TSUN
##  Min.   : 0     Min.   : 0      Min.   : 0     Min.   :-16    Min.   :  0
##  1st Qu.: 0     1st Qu.:44      1st Qu.:50     1st Qu.: 36    1st Qu.:  0
##  Median : 0     Median :51      Median :58     Median : 43    Median :  0
##  Mean   : 0     Mean   :52      Mean   :59     Mean   : 43    Mean   : 32
##  3rd Qu.: 0     3rd Qu.:60      3rd Qu.:68     3rd Qu.: 50    3rd Qu.:  0
##  Max.   :24     Max.   :82      Max.   :99     Max.   : 77    Max.   :931
##  NA's   :7233   NA's   :11397   NA's   :2511   NA's   :2537   NA's   :14935
##       WT01            WT02            WT03            WT04
##  Min.   :1       Min.   :1       Min.   :1       Min.   :1
```

```
##  1st Qu.:1       1st Qu.:1       1st Qu.:1       1st Qu.:1
##  Median :1       Median :1       Median :1       Median :1
##  Mean   :1       Mean   :1       Mean   :1       Mean   :1
##  3rd Qu.:1       3rd Qu.:1       3rd Qu.:1       3rd Qu.:1
##  Max.   :1       Max.   :1       Max.   :1       Max.   :1
##  NA's   :16900   NA's   :17707   NA's   :17755   NA's   :17766
##       WT05            WT06            WT07            WT08          WT09
##  Min.   :1       Min.   :1       Mode:logical   Min.   :1       Mode:logical
##  1st Qu.:1       1st Qu.:1       NA's:17773     1st Qu.:1       NA's:17773
##  Median :1       Median :1                      Median :1
##  Mean   :1       Mean   :1                      Mean   :1
##  3rd Qu.:1       3rd Qu.:1                      3rd Qu.:1
##  Max.   :1       Max.   :1                      Max.   :1
##  NA's   :17761   NA's   :17772                  NA's   :17752
##    WT11              WT13            WT14          WT15              WT16
##  Mode:logical   Min.   :1       Min.   :1       Mode:logical   Min.   :1
##  NA's:17773     1st Qu.:1       1st Qu.:1       NA's:17773     1st Qu.:1
##                 Median :1       Median :1                      Median :1
##                 Mean   :1       Mean   :1                      Mean   :1
##                 3rd Qu.:1       3rd Qu.:1                      3rd Qu.:1
##                 Max.   :1       Max.   :1                      Max.   :1
##                 NA's   :17286   NA's   :17688                  NA's   :17209
##       WT17            WT18            WT19            WT21
##  Min.   :1       Min.   :1       Min.   :1       Min.   :1
##  1st Qu.:1       1st Qu.:1       1st Qu.:1       1st Qu.:1
##  Median :1       Median :1       Median :1       Median :1
##  Mean   :1       Mean   :1       Mean   :1       Mean   :1
##  3rd Qu.:1       3rd Qu.:1       3rd Qu.:1       3rd Qu.:1
##  Max.   :1       Max.   :1       Max.   :1       Max.   :1
##  NA's   :17772   NA's   :17748   NA's   :17771   NA's   :17725
##       WT22            WV01            WV03
##  Min.   :1       Min.   :1       Min.   :1
##  1st Qu.:1       1st Qu.:1       1st Qu.:1
##  Median :1       Median :1       Median :1
##  Mean   :1       Mean   :1       Mean   :1
##  3rd Qu.:1       3rd Qu.:1       3rd Qu.:1
##  Max.   :1       Max.   :1       Max.   :1
##  NA's   :17766   NA's   :17767   NA's   :17771
```

To do - investigation of police data map weather station locations correlate weather station locations with police data

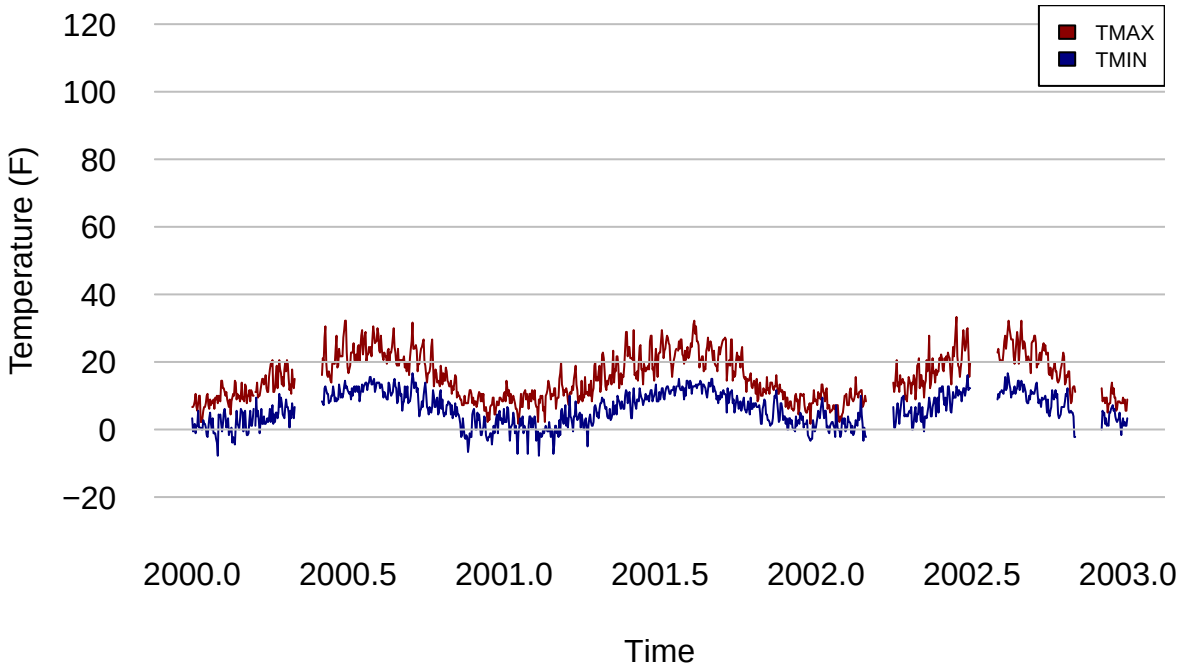
```
# Group Data by weather station
weather_data_grouped <- Seattle_Weather %>%
  group_by(STATION)

# find average maximum temperature
average_max_temp <- weather_data_grouped %>%
  summarise(avg_max_temp = mean(TMAX, na.rm = TRUE))

# Get unique station codes
station_codes <- unique(Seattle_Weather$STATION)

# Create a list to store data frames for each station
station_data_list <- list()
```

```r
# Loop through each station code and filter data for that station
for (station_code in station_codes) {
  station_data <- filter(Seattle_Weather, STATION == station_code)
  station_data_list[[station_code]] <- station_data
}
ggplot(station_data_list[["USC00450872"]], aes(x=DATE, y=TMAX)) +
 geom_line() +
 theme_bw()
```

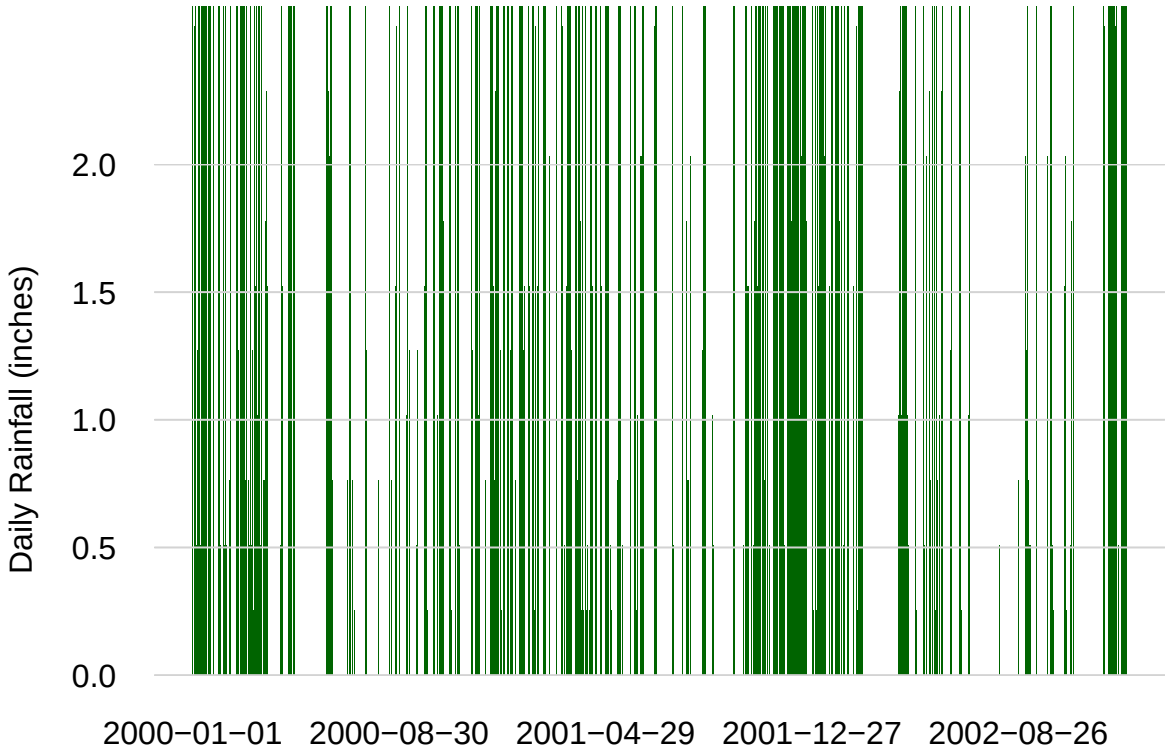



```r
 USC00450872 <- station_data_list[["USC00450872"]]

historical = xts(USC00450872[,c("TMAX","TMIN","PRCP")], order.by=as.Date(USC00450872$DATE))

historical = ts_regular(historical)

historical = suppressWarnings(na.fill(historical, "extend"))

historical = window(historical, start=as.Date("2000-01-01"), end=as.Date("2020-12-31"))



plot(ts_ts(historical$TMAX), col="darkred", bty="n", las=1, fg=NA,
    ylim=c(-20, 120), ylab="Temperature (F)")

lines(ts_ts(historical$TMIN), col="navy")
```

```
grid(nx=NA, ny=NULL, lty=1, col="gray")

legend("topright", fill=c("darkred", "navy"), cex=0.7,
    legend=c("TMAX", "TMIN"), bg="white")
```




```
barplot(historical$PRCP, border=NA, col="darkgreen", ylim=c(0, 2),
    space=0, bty="n", las=1, fg=NA, ylab="Daily Rainfall (inches)")

grid(nx=NA, ny=NULL, lty=1)
```



References

1.
2.
3.
4. https://www.neonscience.org/resources/learning-hub/tutorials/da-viz-coop-precip-data-r