Beginner Tutorial

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Open Data Science

What is Open Data and Reproducible Science?

Open data documents and shares research data openly for re-use.

Open data research aims to transform research by pushing change in the way that research is carried out and disseminated by digital tools. Open data should be:

- Publicly available: Open data is freely available on the internet.
- Reusable: Proper licensing is essential for research outputs so that users know any limitations on re-use
- Transparent: With appropriate metadata to explain how research output was produced and what it contains

Importing Data From Cardinals

- Cardinal is a high-powered, user-oriented, one-stop-shop for North Carolina weather and climate data housed at the North Carolina State Climate Office.
- Cardinal makes weather and climate data more accessible to users, with features and prompts that take the guesswork out of station and parameter identification and selection.

Using data inspection functions

- `str` is a powerful function that allows you to determine what kind of variable we are working with

Data Types

- Date
- Str
- Char
- Double
- Num

```
library(readr)
cardinal <- read_csv("cardinal_data.csv")
```

```
## Rows: 731 Columns: 11

## -- Column specification ------------------------------------------------------
## Delimiter: ","
## chr (4): Date, Maximum Air Temperature (F), Minimum Air Temperature (F), Ave...
## dbl (7): Average Air Temperature (F), Total Precipitation (in), Average Rela...
```

```
##
## i Use ‘spec()‘ to retrieve the full column specification for this data.
## i Specify the column types or set ‘show_col_types = FALSE‘ to quiet this message.
```

```
#cardinal%>%filter(colnames(cardinal)!="MV")
```

```
## Warning: One or more parsing issues, see ‘problems()‘ for details
```

Cleaning Data

- usually a lot more messy
- R can handle a lot of small details

```
# drop rows of missing values
cardinal<-drop_na(cardinal)

#determine data types of all cols
str(cardinal)
```

```
## tibble [729 x 11] (S3: tbl_df/tbl/data.frame)
##  $ Date                                 : chr [1:729] "1/1/20" "1/2/20" "1/3/20" "1/4/20" ...
##  $ Average Air Temperature (F)          : num [1:729] 43.1 44.9 52.8 57.2 42.1 44.1 41.4 42.5 40.4 5
##  $ Maximum Air Temperature (F)          : num [1:729] 53.6 55.4 64.9 65.1 50.5 58.5 52 57.6 50.5 65
##  $ Minimum Air Temperature (F)          : num [1:729] 35.1 35.2 45.7 42.6 34.9 32 31.3 29.7 31.3 38
##  $ Average Experimental Leaf Wetness (mV): num [1:729] 266 274 362 373 265 ...
##  $ Total Precipitation (in)             : num [1:729] 0 0.05 0.95 0.52 0 0 0.07 0 0 0 ...
##  $ Average Relative Humidity (%)        : num [1:729] 63.8 72 92.1 83.5 57 ...
##  $ Average Soil Moisture (m3/m3)        : num [1:729] 0.28 0.28 0.29 0.35 0.33 0.31 0.3 0.3 0.3 0.29
##  $ Average Soil Temperature (F)         : num [1:729] 48.6 47.6 51 54.6 48.3 46.1 44.6 43.3 43.3 46
##  $ Average Solar Radiation (W/m2)       : num [1:729] 134.8 66 31.1 44.9 135.4 ...
##  $ Average Station Pressure (mb)        : num [1:729] 999 1003 998 993 1005 ...
```

```
#create a date
cardinal$Date<-as.Date(cardinal$Date, tryFormats= c("%m/%d/%y"))
view(cardinal)

#changes col names
colnames(cardinal)=c("date","AvgT","MaxT","MinT","AvgLw","Tprep","AvgHum","AvgSm","AvgSt","AvgSr","AvgS
```

Making new Data

When does it Rain ?

```
#me making new data

cardinal$IfRain<- (cardinal$Tprep>0)
cardinal$IfRain<-as.factor(as.integer(cardinal$IfRain))
cardinal
```

```
## # A tibble: 729 x 12
##    date        AvgT  MaxT  MinT AvgLw Tprep AvgHum AvgSm AvgSt AvgSr AvgStp
##    <date>     <dbl> <dbl> <dbl> <dbl> <dbl>  <dbl> <dbl> <dbl> <dbl>  <dbl>
##  1 2020-01-01  43.1  53.6  35.1  266.  0      63.8  0.28  48.6 135.    999.
##  2 2020-01-02  44.9  55.4  35.2  274.  0.05   72.0  0.28  47.6  66.0  1003.
##  3 2020-01-03  52.8  64.9  45.7  362.  0.95   92.1  0.29  51    31.1   998.
##  4 2020-01-04  57.2  65.1  42.6  373   0.52   83.5  0.35  54.6  44.9   993.
##  5 2020-01-05  42.1  50.5  34.9  265.  0      57.0  0.33  48.3 135.   1005.
##  6 2020-01-06  44.1  58.5  32    265.  0      57.6  0.31  46.1 138.   1005.
##  7 2020-01-07  41.4  52    31.3  274.  0.07   75.2  0.3   44.6  40.9  1002.
##  8 2020-01-08  42.5  57.6  29.7  314.  0      58.9  0.3   43.3 136.   1010.
##  9 2020-01-09  40.4  50.5  31.3  265.  0      60.2  0.3   43.3 122.   1022.
## 10 2020-01-10  52    65.8  38.1  266.  0      73.5  0.29  46.1  74.6  1019.
## # ... with 719 more rows, and 1 more variable: IfRain <fct>
```

Month Factor variable

- Factor variable is a category or bin we can place a value in.

```
# month variable
cardinal$month<-month(cardinal$date)
cardinal$month<-as.factor(cardinal$month)

# str factor
str(cardinal)
```

```
## tibble [729 x 13] (S3: tbl_df/tbl/data.frame)
##  $ date  : Date[1:729], format: "2020-01-01" "2020-01-02" ...
##  $ AvgT  : num [1:729] 43.1 44.9 52.8 57.2 42.1 44.1 41.4 42.5 40.4 52 ...
##  $ MaxT  : num [1:729] 53.6 55.4 64.9 65.1 50.5 58.5 52 57.6 50.5 65.8 ...
##  $ MinT  : num [1:729] 35.1 35.2 45.7 42.6 34.9 32 31.3 29.7 31.3 38.1 ...
##  $ AvgLw : num [1:729] 266 274 362 373 265 ...
##  $ Tprep : num [1:729] 0 0.05 0.95 0.52 0 0 0.07 0 0 0 ...
##  $ AvgHum: num [1:729] 63.8 72 92.1 83.5 57 ...
##  $ AvgSm : num [1:729] 0.28 0.28 0.29 0.35 0.33 0.31 0.3 0.3 0.3 0.29 ...
##  $ AvgSt : num [1:729] 48.6 47.6 51 54.6 48.3 46.1 44.6 43.3 43.3 46.1 ...
##  $ AvgSr : num [1:729] 134.8 66 31.1 44.9 135.4 ...
##  $ AvgStp: num [1:729] 999 1003 998 993 1005 ...
##  $ IfRain: Factor w/ 2 levels "0","1": 1 2 2 2 1 1 2 1 1 1 ...
##  $ month : Factor w/ 12 levels "1","2","3","4",..: 1 1 1 1 1 1 1 1 1 1 ...
```

Numerical Variable, Rain Difference

- Dollar sign + “Name of Variable”

```
cardinal$TDiff <- cardinal$MaxT-cardinal$MinT
```

Numerical Summaries

- Help us determine basic trends in data from printouts.

- Summary gives as a 5 number summary of numeric variables
- Basic counts of factor variables

```
summary(cardinal)
```

```
##       date                AvgT           MaxT           MinT      
##  Min.   :2020-01-01   Min.   :29.20   Min.   :34.20   Min.   :21.20  
##  1st Qu.:2020-07-03   1st Qu.:50.40   1st Qu.:60.80   1st Qu.:39.40  
##  Median :2021-01-01   Median :62.30   Median :72.90   Median :52.90  
##  Mean   :2020-12-31   Mean   :61.43   Mean   :71.61   Mean   :52.14  
##  3rd Qu.:2021-07-03   3rd Qu.:73.80   3rd Qu.:84.20   3rd Qu.:66.20  
##  Max.   :2022-01-01   Max.   :84.10   Max.   :95.00   Max.   :76.30  
##                                                                      
##      AvgLw           Tprep            AvgHum           AvgSm       
##  Min.   :260.4   Min.   :0.0000   Min.   :26.36   Min.   :0.1300  
##  1st Qu.:270.0   1st Qu.:0.0000   1st Qu.:62.10   1st Qu.:0.2700  
##  Median :287.7   Median :0.0000   Median :71.95   Median :0.3000  
##  Mean   :306.0   Mean   :0.1586   Mean   :69.93   Mean   :0.2975  
##  3rd Qu.:322.7   3rd Qu.:0.0700   3rd Qu.:79.80   3rd Qu.:0.3300  
##  Max.   :603.4   Max.   :4.3500   Max.   :95.03   Max.   :0.4500  
##                                                                   
##      AvgSt          AvgSr            AvgStp       IfRain      month    
##  Min.   :37.9   Min.   :  6.33   Min.   : 986.0   0:449   1      : 63  
##  1st Qu.:52.0   1st Qu.:107.62   1st Qu.: 999.9   1:280   3      : 62  
##  Median :64.2   Median :166.82   Median :1003.6           8      : 62  
##  Mean   :63.7   Mean   :175.05   Mean   :1003.9           10     : 62  
##  3rd Qu.:76.9   3rd Qu.:247.28   3rd Qu.:1007.5           12     : 62  
##  Max.   :86.0   Max.   :437.72   Max.   :1022.4           7      : 61  
##                                                           (Other):357  
##      TDiff      
##  Min.   : 2.90  
##  1st Qu.:15.00  
##  Median :19.50  
##  Mean   :19.47  
##  3rd Qu.:23.60  
##  Max.   :37.30  
## 
```

- Frequency Table to compare categorical / factor variables.

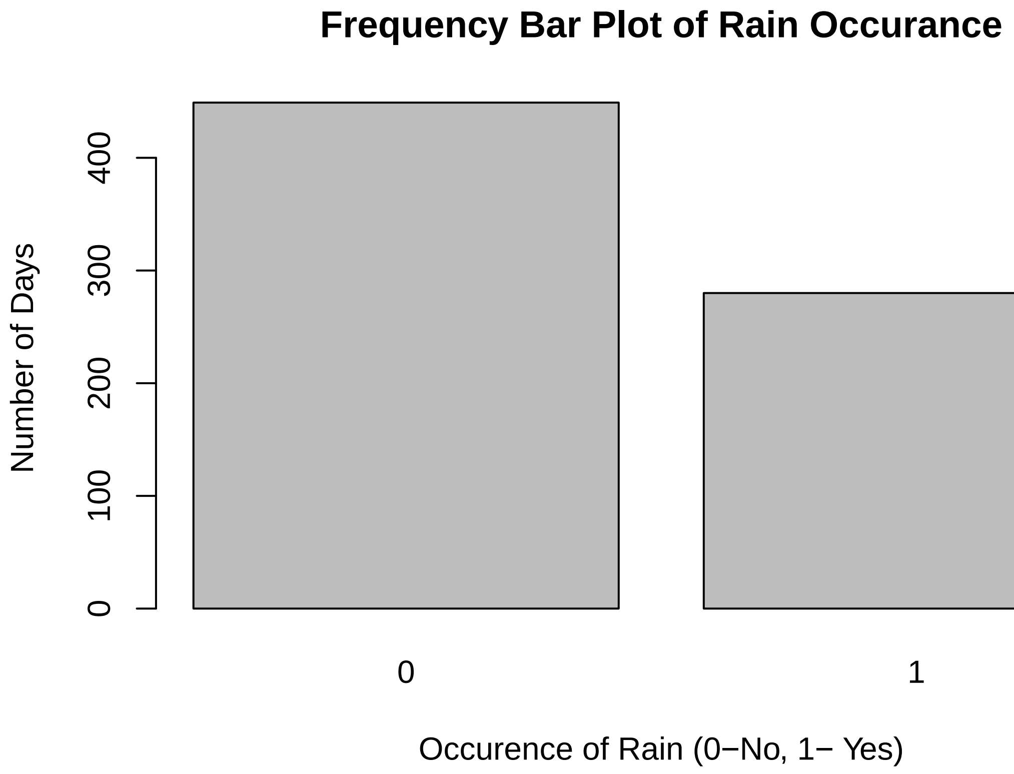
```
# Frequency Table
table(cardinal$month,cardinal$IfRain)
```

```
##     
##       0  1
##   1  34 29
##   2  27 30
##   3  39 23
##   4  43 17
##   5  37 23
##   6  38 22
##   7  35 26
##   8  38 24
##   9  38 22
##   10 40 22
##   11 39 21
##   12 41 21
```

Plotting Basic

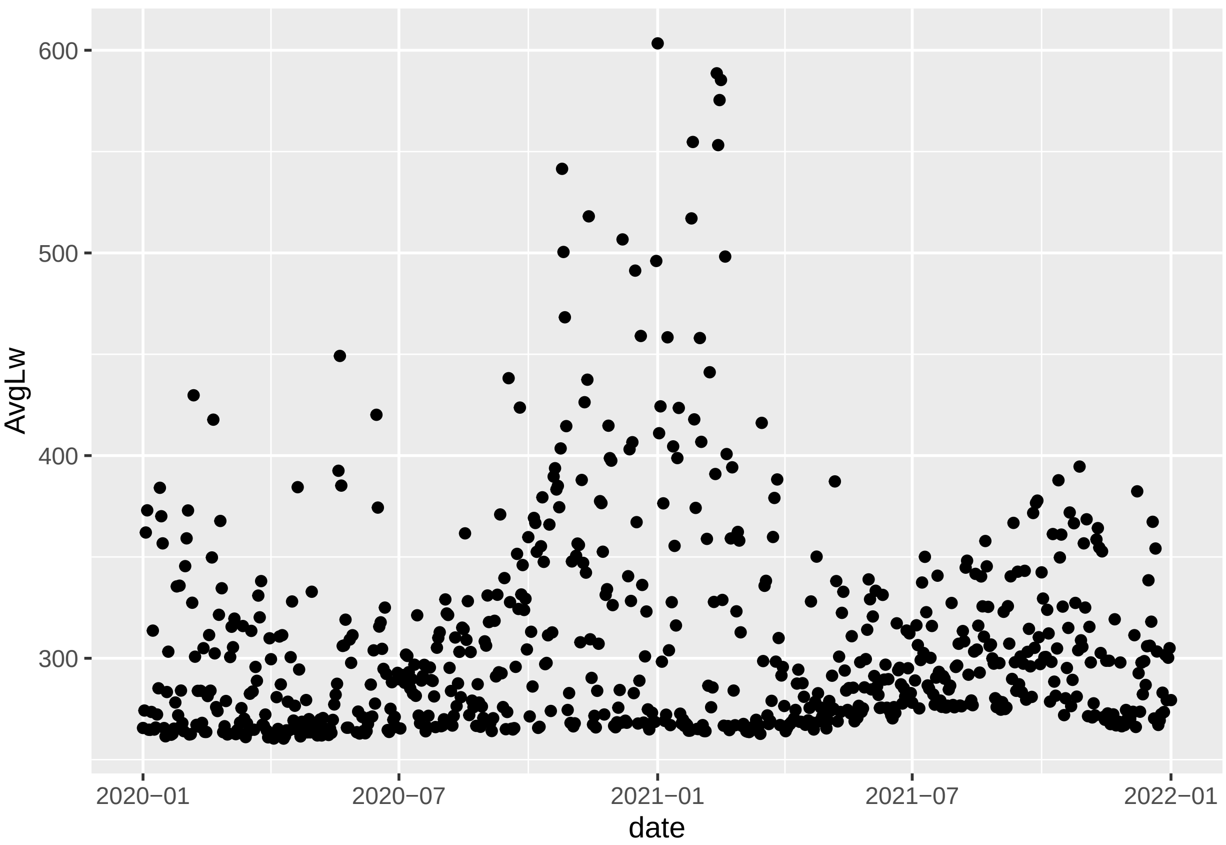
- Simple visual of frequency count

```
# base plots in R, categorical variables
#does a count
plot(cardinal$IfRain,main ='Frequency Bar Plot of Rain Occurance',xlab="Occurence of Rain (0-No, 1- Yes
```



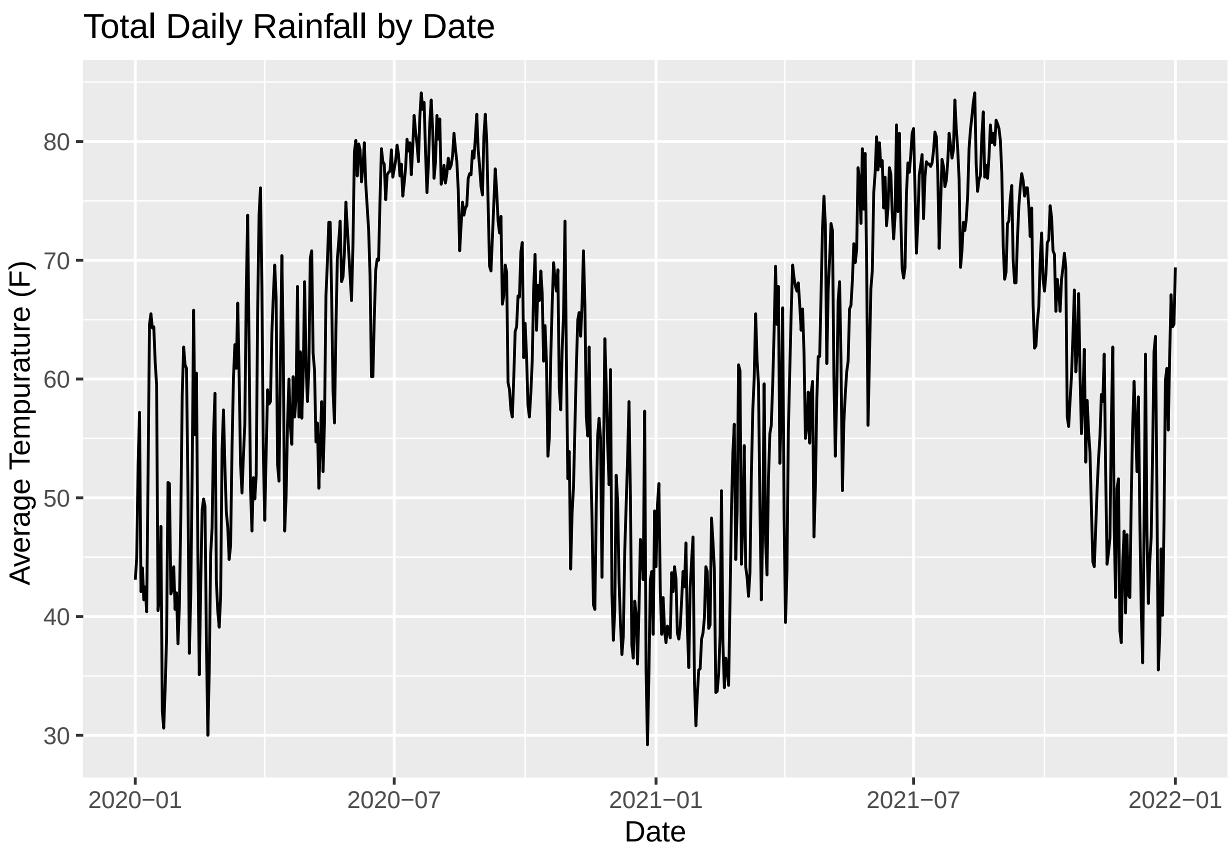
- We will be using a package called `ggplot2`.
- Here is a good link: https://www.rstudio.com/resources/cheatsheets/
- Two basic functions: ggplot() & geom_plottype
  - Note we have not even had a title or label specs yet

```
# first ggplot figure

ggplot(cardinal,aes(x= date ,y= AvgLw))+ geom_point()
```



- Observe correlation and possible trend numerical variables
- Using cheatsheet, we can find a lot more plot types and options!
  - Note the use of `labs` statement

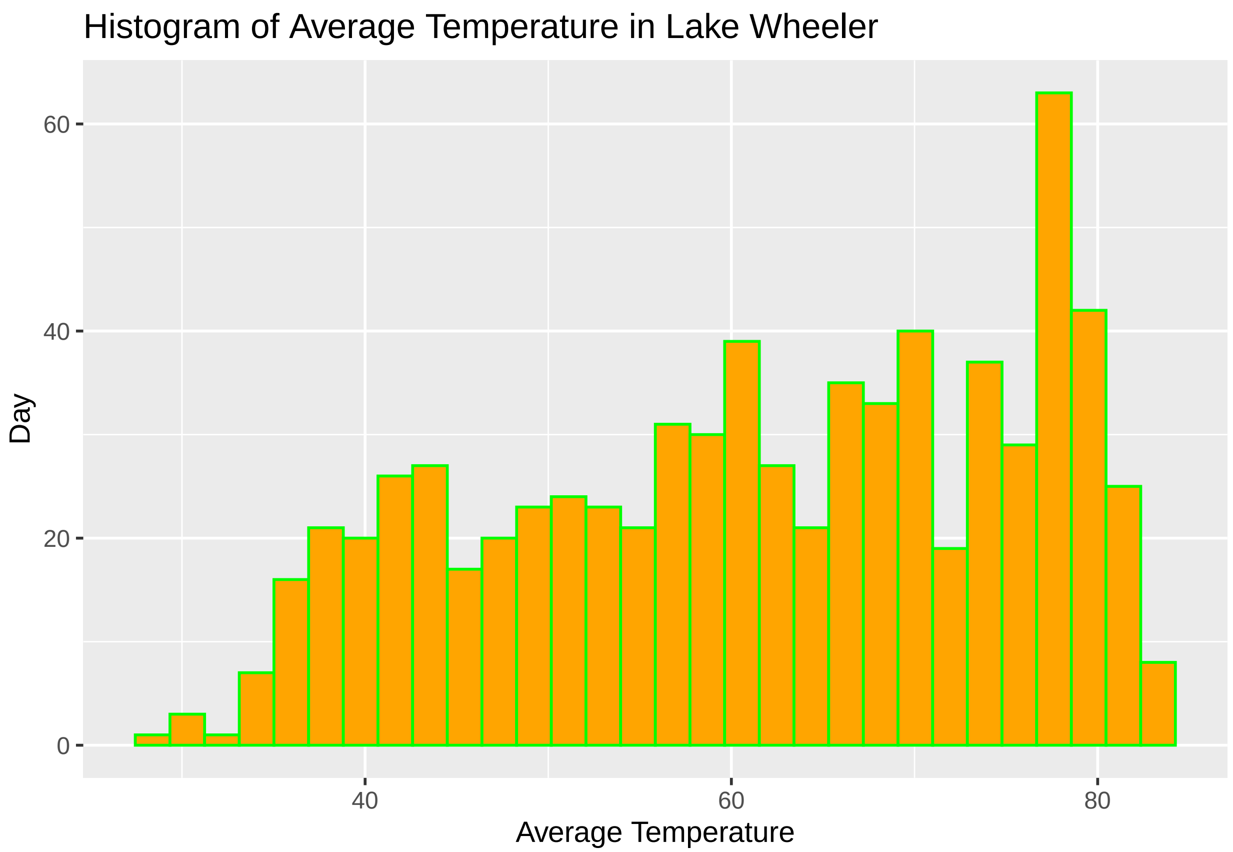
```
ggplot(cardinal,aes(x=date,y=AvgT))+geom_line()+labs(title="Total Daily Rainfall by Date",y="Average Te
```



- options are very versatile inside a `+geom_statement()`
- We can use the cheatsheet to find out information about this
- Note how we change atributes inside the `aes` statment

```
ggplot(cardinal,aes(x=AvgT)) + geom_histogram(color="green",fill="orange")+labs(x="Average Temperature"
```

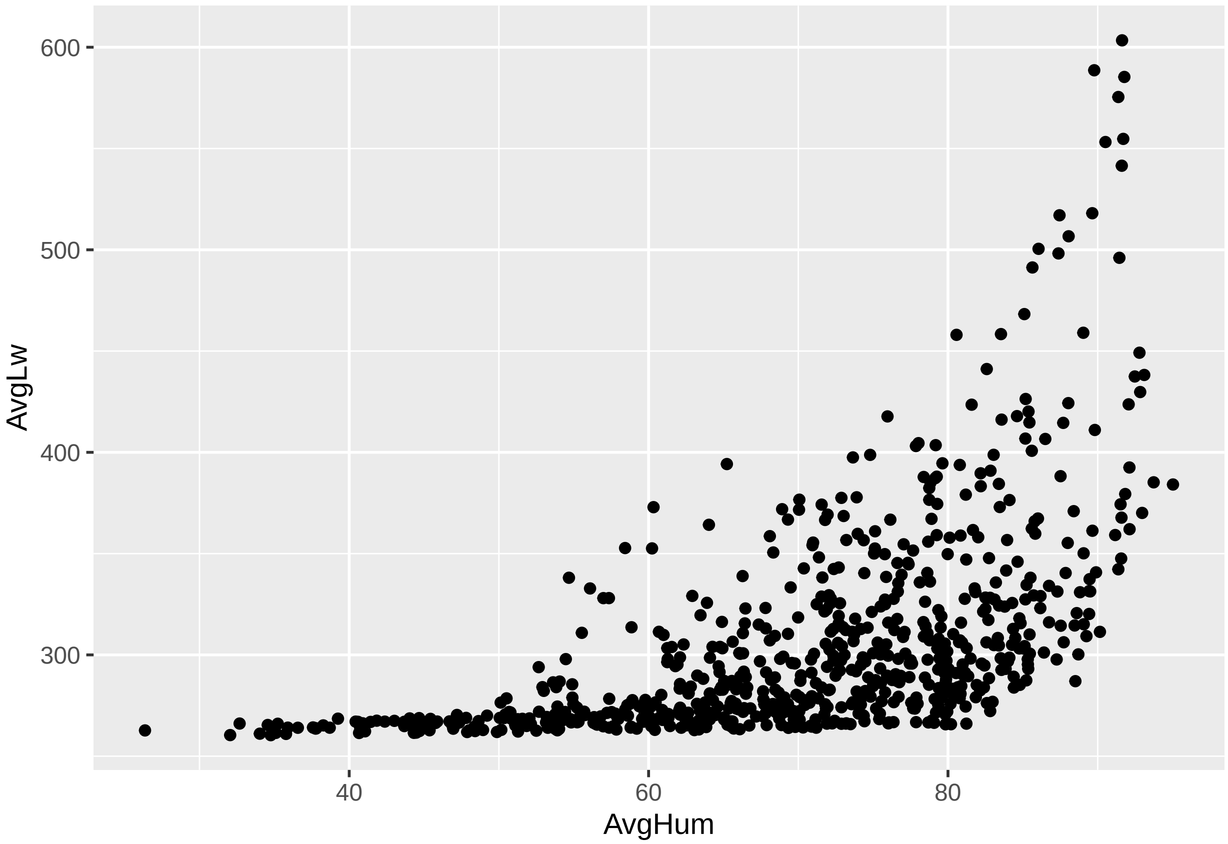
```
## ‘stat_bin()‘ using ‘bins = 30‘. Pick better value with ‘binwidth‘.
```



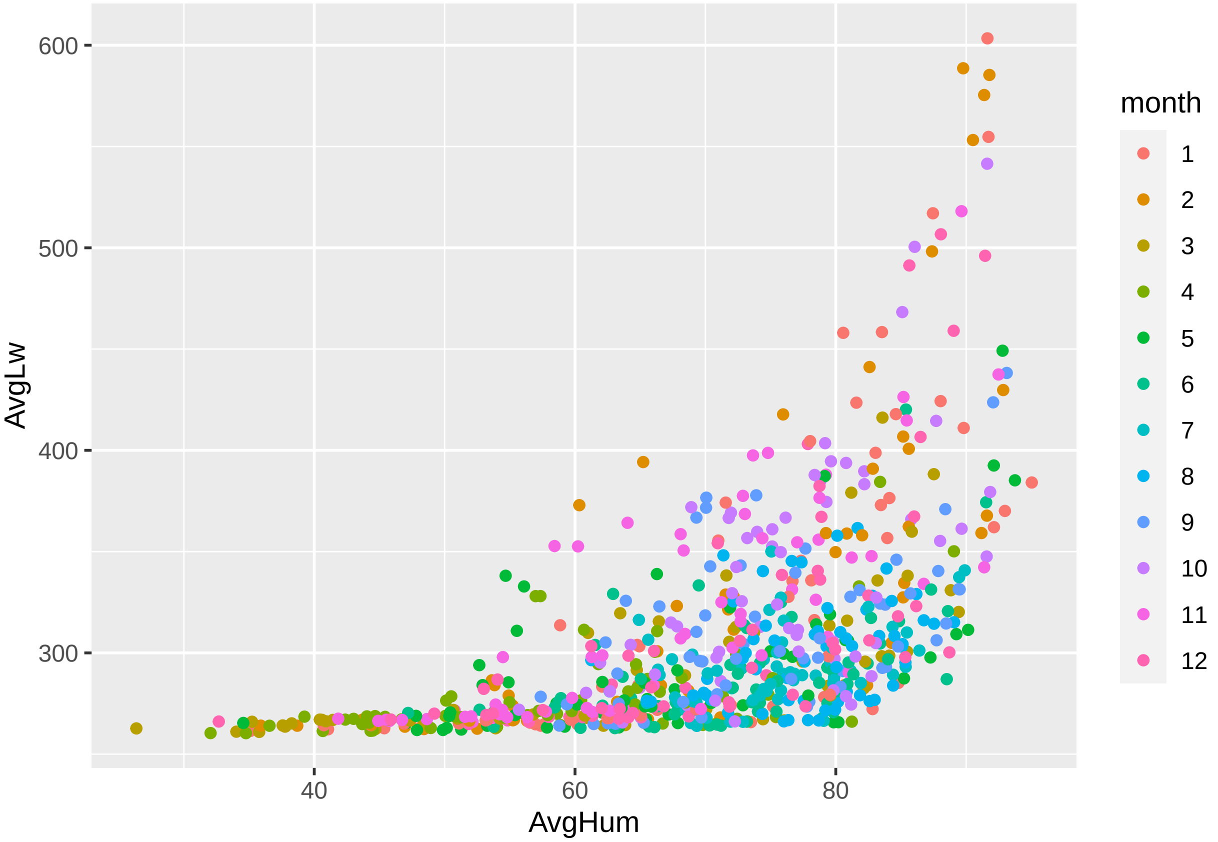
```
# title and all labels included in one more statement
```

- One popular option is to color-code based off of a categorial / factor variable
- See the difference when we include `aes(col=month)`
- Below is a scatter plot

```
# general plot
ggplot(cardinal,aes(x=AvgHum,y=AvgLw))+geom_point()
```

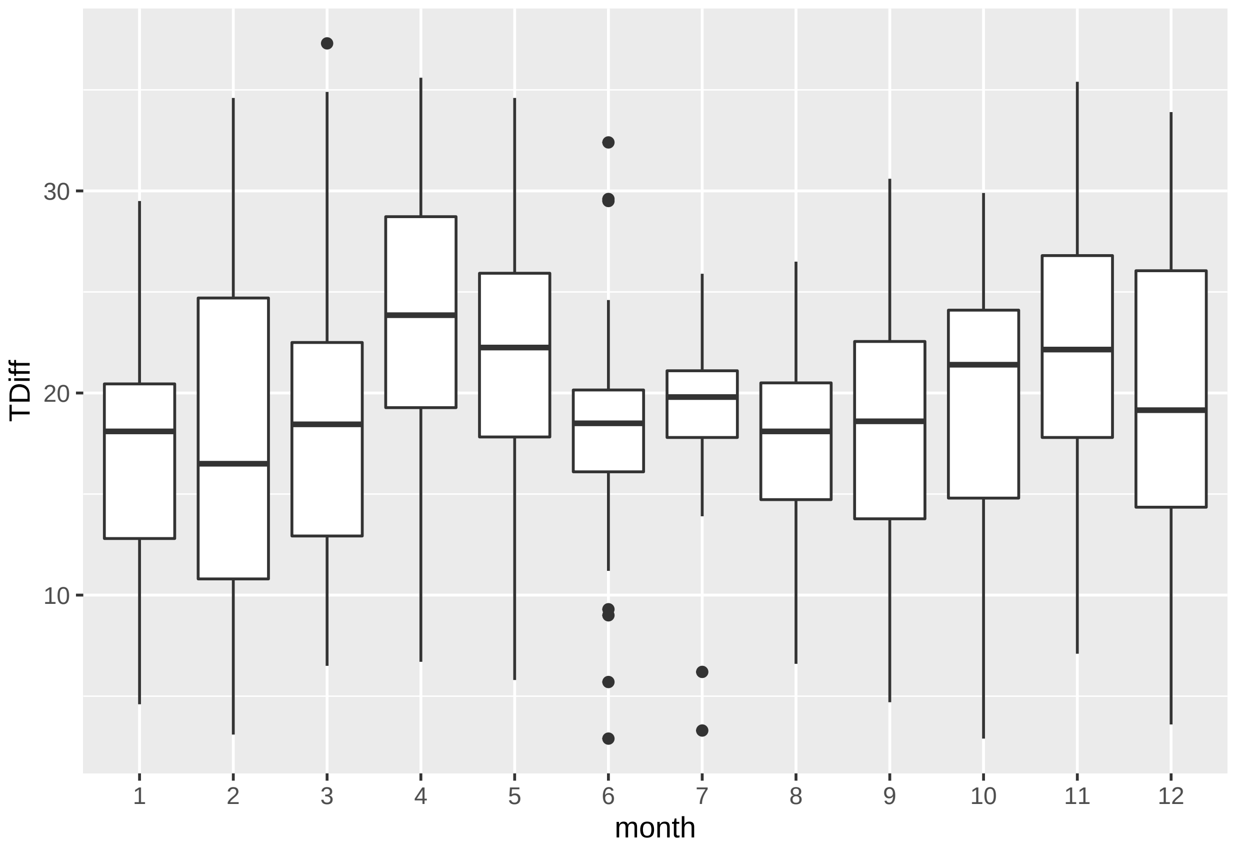


```
# coloring by month to observe trends
ggplot(cardinal,aes(x=AvgHum,y=AvgLw))+geom_point(aes(col=month))
```



- We can also use categorical variables on the x-axis

```
# + geom_boxplot is a great tool to observe spreads

ggplot(cardinal,aes(x=month , y = TDiff))+geom_boxplot()
```

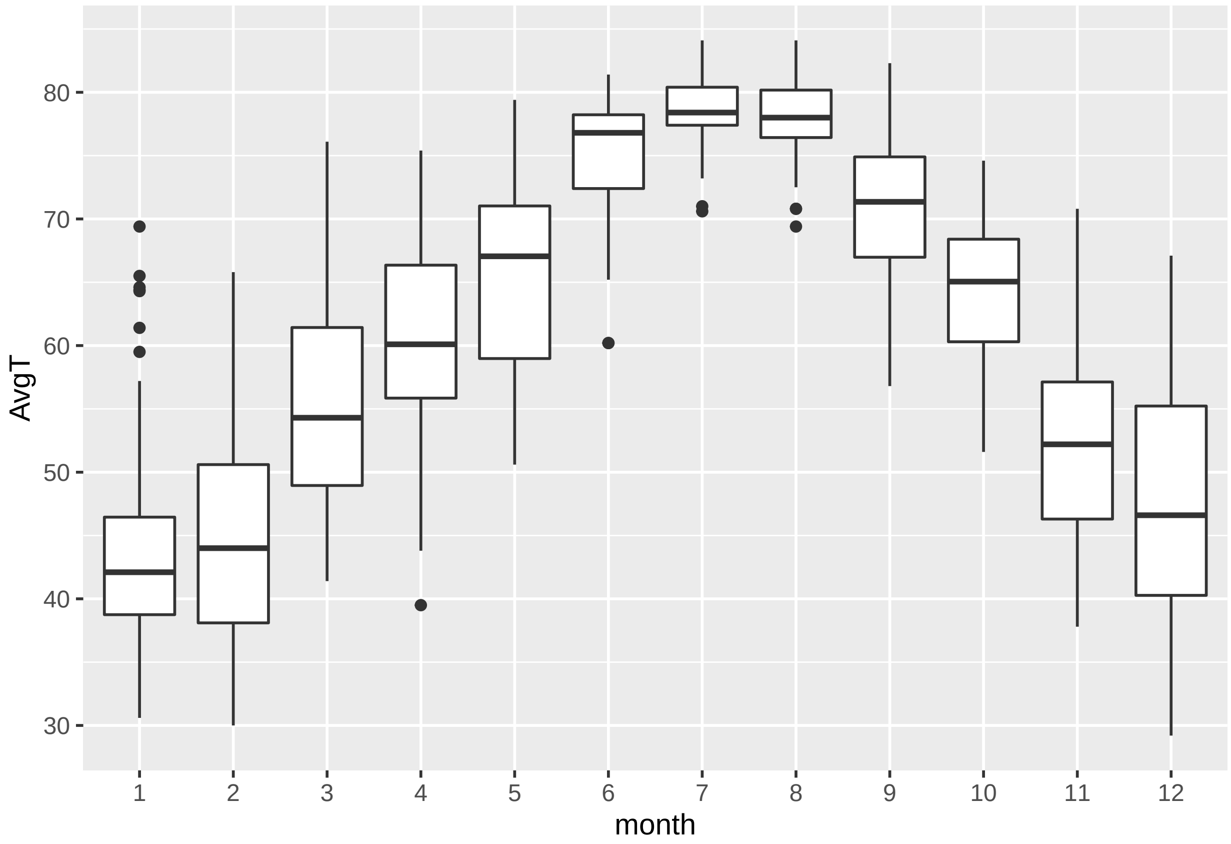


- Box-plots are cumbersome and not super helpful in visalization.

How could we make this boxplot better?

- Note we are looking at average daily tempurature

```
# + geom_boxplot is a great tool to observe spreads

ggplot(cardinal,aes(x=month , y = AvgT))+geom_boxplot()
```



Fancy Plot Time

- Inspiration from ggridges documentation
- We want to stylize the boxplot from the above statement
- We will be using a few libraries here: remeber to use `install.packages("library_name")` first before running the library statment.

```
library(viridis)      ## color palette
```

```
## Loading required package: viridisLite
```

```
library(ggjoy)        ## ridges
```

```
## Loading required package: ggridges
```

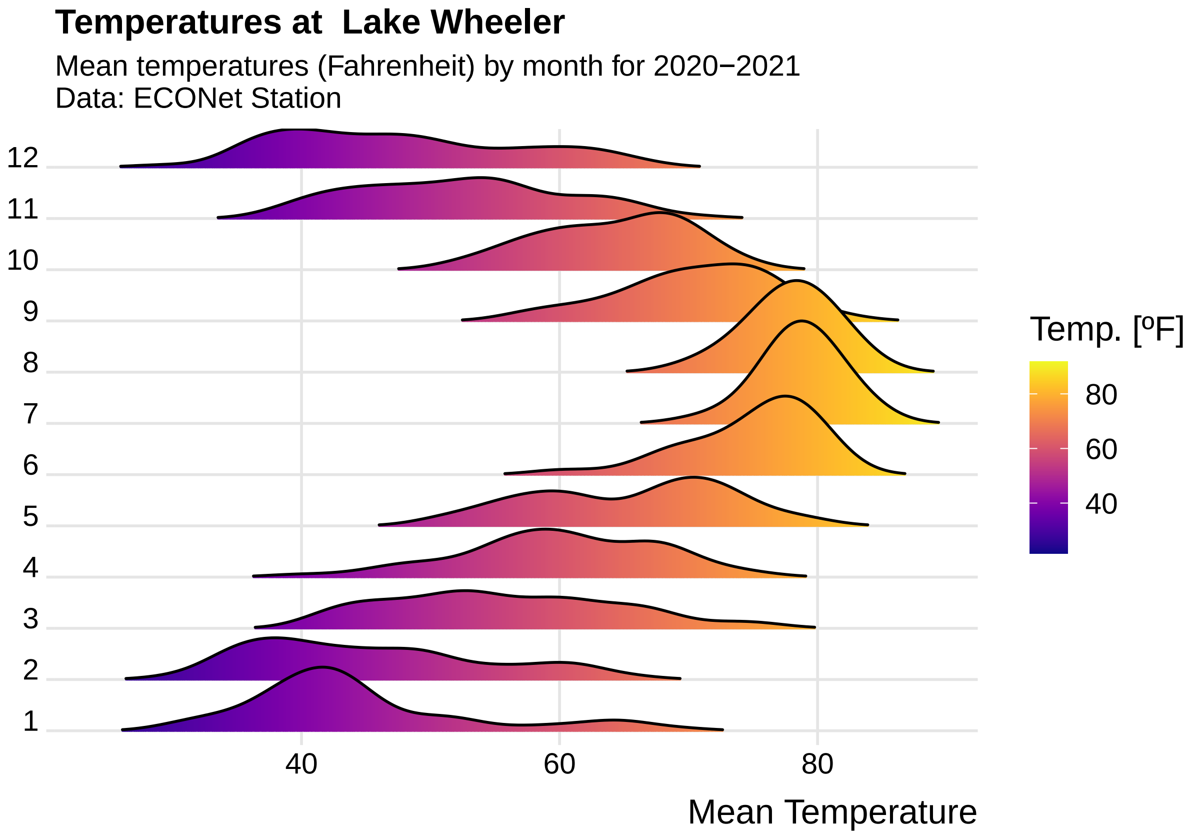
```
## The ggjoy package has been deprecated. Please switch over to the
## ggridges package, which provides the same functionality. Porting
## guidelines can be found here:
## https://github.com/clauswilke/ggjoy/blob/master/README.md
```

```
library(hrbrthemes)  ## plot theme
```

```
## NOTE: Either Arial Narrow or Roboto Condensed fonts are required to use these themes.

##       Please use hrbrthemes::import_roboto_condensed() to install Roboto Condensed and

##       if Arial Narrow is not on your system, please see https://bit.ly/arialnarrow
```

```
ggplot(cardinal, aes(x = AvgT, y = month, fill = ..x..)) +

  geom_density_ridges_gradient(scale = 2, rel_min_height = 0.01, gradient_lwd = 1.) +

  scale_x_continuous(expand = c(0.01, 0)) +

  scale_y_discrete(expand = c(0.01, 0)) +

  scale_fill_viridis(name = "Temp. [ºF]", option = "C") +

  labs(title = 'Temperatures at  Lake Wheeler',
       subtitle = 'Mean temperatures (Fahrenheit) by month for 2020-2021\nData: ECONet Station',
       x = "Mean Temperature") +

  theme_ridges(font_size = 13, grid = TRUE) + theme(axis.title.y = element_blank())
```

```
## Picking joint bandwidth of 2.54
```



```
#
```