Stat 133 Final Project Report

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======= Directories Creating and Data Downloading =======

First and foremost, we create all the directories needed for this project. After that, we download all the files needed for this project. All the code below is also present in the "skeleton.R" file:

```
system('mkdir code')
system('mkdir rawdata')
system('mkdir data')
system('mkdir resources')
system('mkdir report')
system('mkdir images')
download.file('ftp://eclipse.ncdc.noaa.gov/pub/ibtracs/v03r06/wmo/hurdat_format/basin/Basin.NA.ibtracs_
              'rawdata/Basin.NA.ibtracs_hurdat.v03r06.hdat')
download.file('ftp://eclipse.ncdc.noaa.gov/pub/ibtracs/v03r06/wmo/csv/basin/Basin.EP.ibtracs_wmo.v03r06
              'rawdata/stormsEP.csv')
download.file('ftp://eclipse.ncdc.noaa.gov/pub/ibtracs/v03r06/wmo/csv/basin/Basin.NA.ibtracs_wmo.v03r06
              'rawdata/stormsNA.csv')
```

======== Libraries Initializing ========

Then we run all the libraries needed for this project:

```
library(stringr)
library(dplyr)
library(maps)
library(ggplot2)
```

Now, with all the trivialities prepared and ready, we may commence our journey.

========= Data Processing =========

The first part is data processing. To create storms.csv from raw data 'Basin.NA.ibtracs_hurdat.v03r06.hdat', we have:

```
sid <- c() #id column
sdate <- c() #date column
sdays <- c() #days column
sname <- c() #name column
data <- read.table("rawdata/Basin.NA.ibtracs_hurdat.v03r06.hdat",
                   sep = '\t', header = FALSE) #Read in the table
# Obtain each column with a series of data extraction
for (num in 1:nrow(data)) {
  row <- as.character(data[num,])
  if (nchar(row) == 85) { # if the line is a header
    sid <- c(sid, str_extract(str_extract(row, 'SNBR=.{4}'), '[0-9]+'))
    sdate <- c(sdate, substr(row, 7, 16))
    sdays <- c(sdays, str_extract(str_extract(row, 'M=.{2}'), '[0-9]+'))
    sname <- c(sname, str_extract(substr(row, 36, 48), '[A-Z]+'))
```

```
  }
}
#Combine the obtained columns into a data frame
storms <- data.frame(id = as.numeric(sid),
                     date = format(as.Date(sdate, '%m/%d/%Y'), '%m/%d/%Y'),
                     days = as.numeric(sdays), name = as.character(sname))
#Write the table into storms.csv
write.table(storms, "data/storms.csv")
```

To create tracks.csv from raw data 'Basin.NA.ibtracs_hurdat.v03r06.hdat', we have:

```
#stage_convert function is used for converting symbols in Hurdat file into cyclone types
stage_convert <- function(symbol) {
  switch (symbol,
          '*' = 'cyclone',
          'S' = 'subtropical',
          'E' = 'extratropical',
          'W' = 'wave',
          'L' = 'remnant low')
}

tid <- c() #id column
tdate <- c() #date column
tperiod <- c() #period column
tstage <- c() #stage column
tlat <- c() #latitude column
tlong <- c() #longitude column
twind <- c() #wind speed column
tpress <- c() #pressure column

#Obtain the column using a series of data extraction
for (num in 1:nrow(data)) { # we iterate through each line of the hurdat file
  row <- as.character(data[num,])
  if (nchar(row) == 85) { # if the line is a header
    id <- str_extract(str_extract(row, 'SNBR=.{4}'), '[0-9]+')
    year <- substr(row, 13, 16)
  }
  if (nchar(row) == 80) { # if the line is daily data
    tid <- c(tid, rep(id, 4))
    tdate <- c(tdate, rep(paste0(substr(row, 7, 11), '/', year), 4))
    tperiod <- c(tperiod, c('00h', '06h', '12h', '18h'))
    tstage <- c(tstage, c(stage_convert(substr(row, 12, 12)),
                          stage_convert(substr(row, 29, 29)),
                          stage_convert(substr(row, 46, 46)),
                          stage_convert(substr(row, 63, 63))))
    tlat <- c(tlat, c(as.numeric(substr(row, 13, 15)) / 10,
                      as.numeric(substr(row, 30, 32)) / 10,
                      as.numeric(substr(row, 47, 49)) / 10,
                      as.numeric(substr(row, 64, 66)) / 10))
    tlong <- c(tlong, c(as.numeric(substr(row, 16, 19)) / 10 - 360,
                        as.numeric(substr(row, 33, 36)) / 10 - 360,
                        as.numeric(substr(row, 50, 53)) / 10 - 360,
                        as.numeric(substr(row, 67, 70)) / 10 - 360))
```

```
    twind <- c(twind, c(as.numeric(substr(row, 20, 23)),
                        as.numeric(substr(row, 37, 40)),
                        as.numeric(substr(row, 54, 57)),
                        as.numeric(substr(row, 71, 74))))
    tpress <- c(tpress, c(as.numeric(substr(row, 25, 28)),
                          as.numeric(substr(row, 42, 45)),
                          as.numeric(substr(row, 59, 62)),
                          as.numeric(substr(row, 76, 79))))
  }
}
#Combine the obtained columns into a data frame
tracks <- data.frame(id = as.numeric(tid),
                     date = format(as.Date(tdate, '%m/%d/%Y'), '%m/%d/%Y'),
                     period = as.character(tperiod),
                     stage = as.character(tstage),
                     lat = tlat, long = tlong, wind = twind, press = tpress)
#Get rid of rows that have latitude, longitude, wind and pressure all 0s, as required
tracks <- filter(tracks, !(lat == 0 & long == -360 & wind == 0 & press == 0))
#Reorder the row numbers after removing those rows
row.names(tracks) <- 1:nrow(tracks)
#Write the table into tracks.csv
write.table(tracks, 'data/tracks.csv')
```

========== Data Analysis ==========

After cleaning the data, we are able to analyze the data:

```
#We first read the data just created
storms <- read.table("data/storms.csv")
tracks <- read.table("data/tracks.csv")

#Select the data from tracks which are between years 1980 and 2010
#and write it into a new variable track_anal
tracks_anal <- subset(tracks, format(as.Date(tracks$date, "%m/%d/%Y"), '%Y') >= 1980 &
                        format(as.Date(tracks$date, "%m/%d/%Y"), '%Y') <= 2010)
#Convert the date columns from numeric format to date format
tracks_anal$date <- as.Date(tracks_anal$date, "%m/%d/%Y")
#Select out few columns to analyze storms per year
wind_year <- data.frame(year = as.numeric(format(tracks_anal$date, '%Y')),
                        id = tracks_anal$id, wind = tracks_anal$wind)
#Select out few columns to analyze storms per month
wind_month <- data.frame(month_id = paste0(as.numeric(format(tracks_anal$date, '%m')),
                                           ' ', tracks_anal$id),
                         year = as.numeric(format(tracks_anal$date, '%Y')),
                         wind = tracks_anal$wind)

temp <- aggregate(wind_year[, c('wind', 'year')], list(id = wind_year$id), max)
temp1 <- aggregate(wind_month[, c('wind')], list(id = wind_month$month_id), max)
temp2 <- data.frame(month = month.name[as.numeric(str_extract(temp1$id, '.+\\s'))],
                    wind = temp1$x)
temp2$month = factor(temp2$month, levels = month.name)
#Obtain the table for each data and ready to answer the following questions
table1 <- table(temp$year)
table2 <- table(temp$year[temp$wind >= 35])
```

```
table3 <- table(temp$year[temp$wind >= 64])
table4 <- table(temp$year[temp$wind >= 96])
```

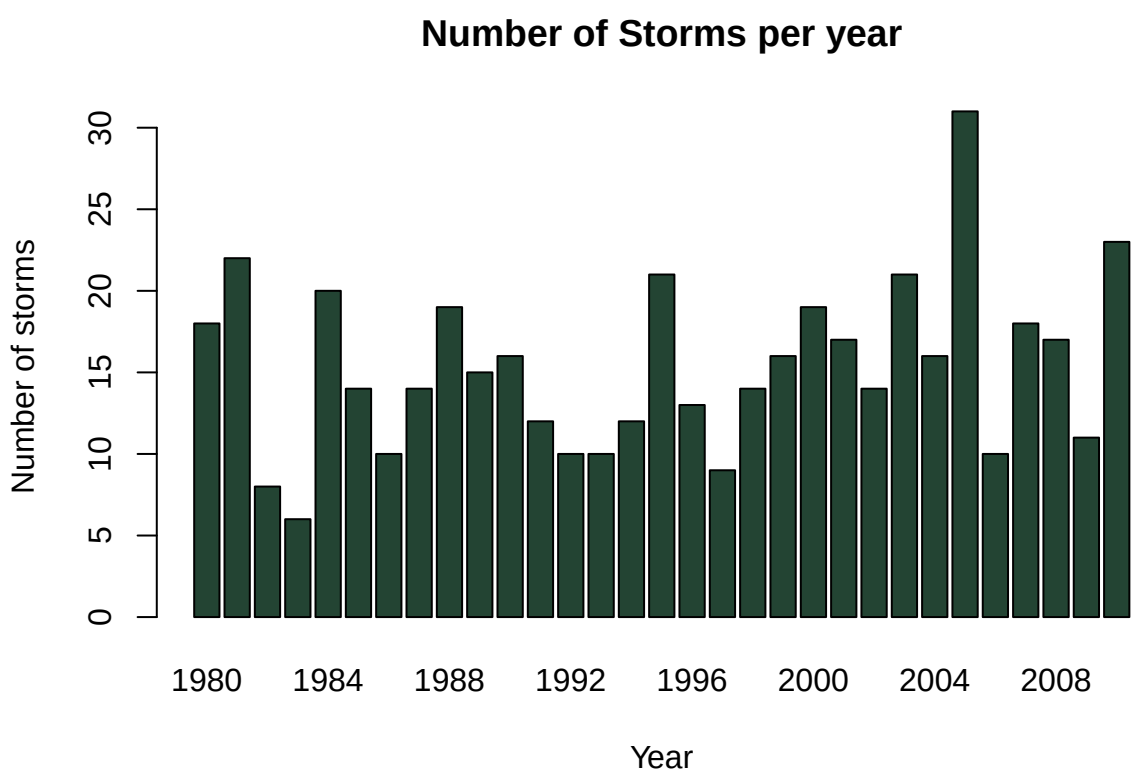
Analysis Per Year Obtain frequencies and barplots for:

Num. of storms per year:

```
table1
```

```
##
## 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994
##   18   22    8    6   20   14   10   14   19   15   16   12   10   10   12
## 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009
##   21   13    9   14   16   19   17   14   21   16   31   10   18   17   11
## 2010
##   23
```

```
barplot(table1, main = 'Number of Storms per year', xlab = 'Year',
        ylab = 'Number of storms', col = '#234433')
```




```
dev.copy(png, 'images/storms per year.png')
```

```
## quartz_off_screen
##                 3
```

```
dev.off()
```

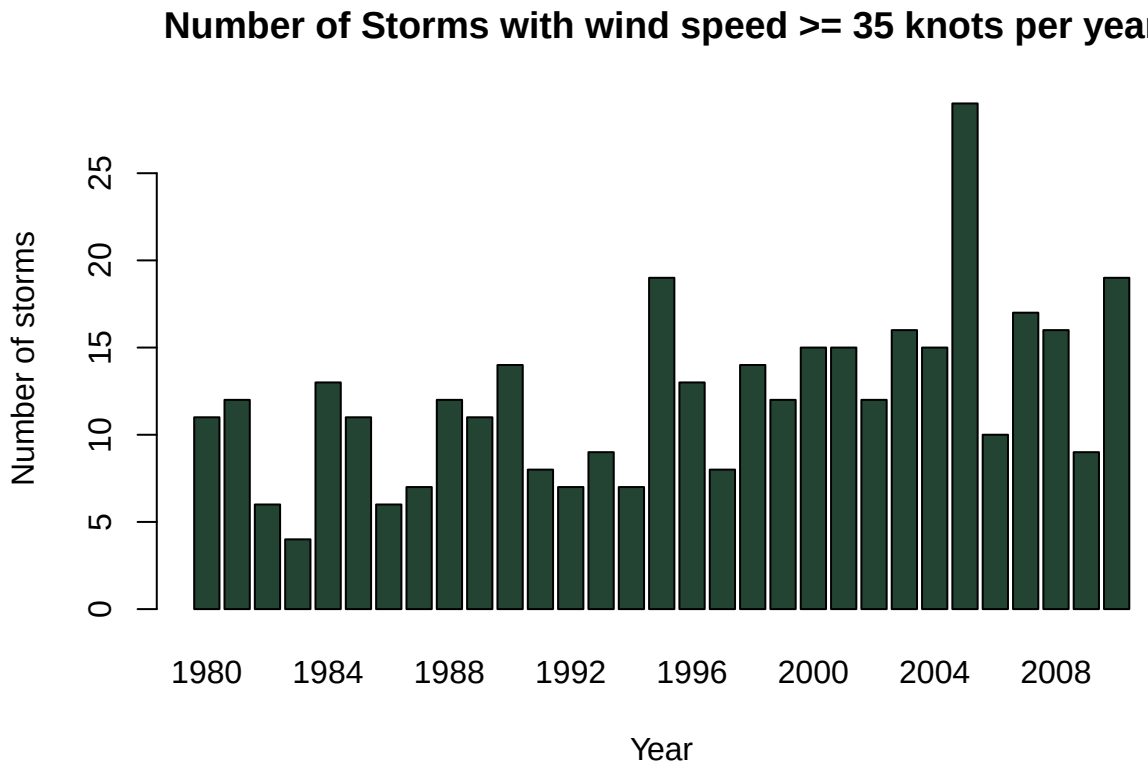
```
## pdf
##   2
```

Num. of storms per year with winds >= 35 knots:

```
table2
```

```
##
## 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994
##   11   12    6    4   13   11    6    7   12   11   14    8    7    9    7
## 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009
##   19   13    8   14   12   15   15   12   16   15   29   10   17   16    9
## 2010
##   19
```

```
barplot(table2,
        main = 'Number of Storms with wind speed >= 35 knots per year',
        xlab = 'Year', ylab = 'Number of storms', col = '#234433')
```




```
dev.copy(png, 'images/storms>=35 per year.png')
```

```
## quartz_off_screen
##                 3
```

```
dev.off()
```

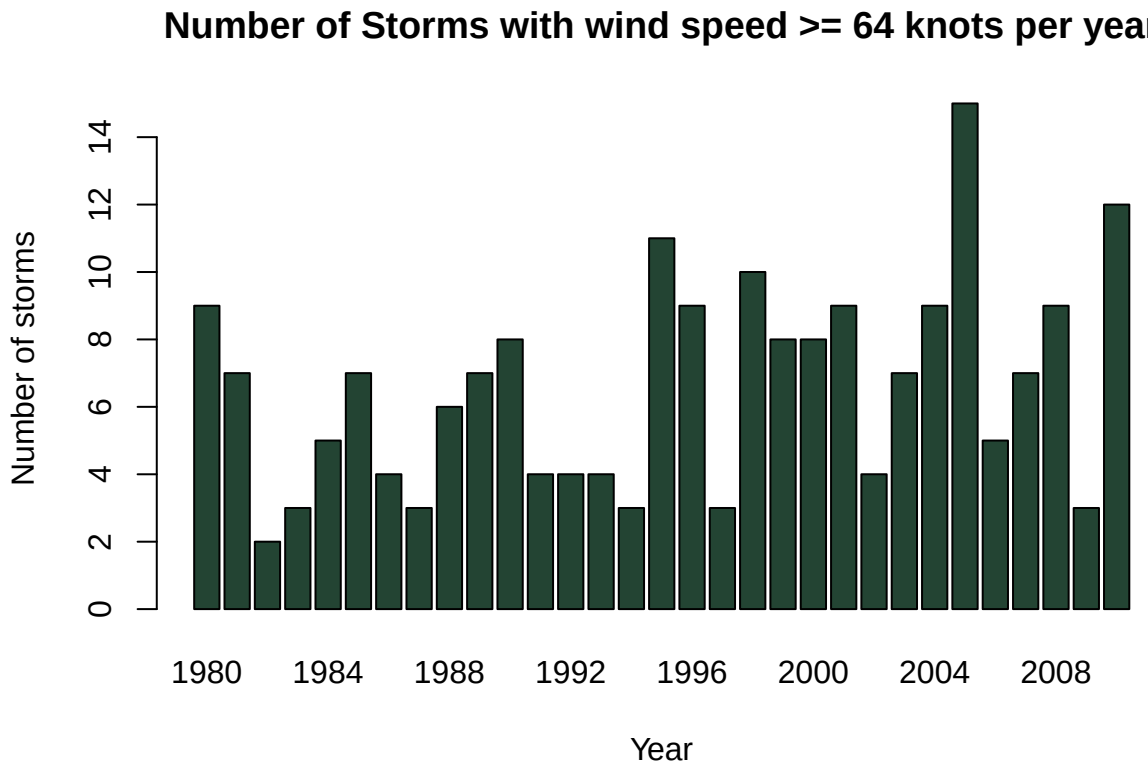
```
## pdf
##   2
```

Num. of storms per year with winds >= 64 knots

```
table3
```

```
##
## 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994
##    9    7    2    3    5    7    4    3    6    7    8    4    4    4    3
## 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009
##   11    9    3   10    8    8    9    4    7    9   15    5    7    9    3
## 2010
##   12
```

```
barplot(table3,
        main = 'Number of Storms with wind speed >= 64 knots per year',
        xlab = 'Year', ylab = 'Number of storms', col = '#234433')
```




```
dev.copy(png, 'images/storms>=64 per year.png')
```

```
## quartz_off_screen
##                 3
```

```
dev.off()
```

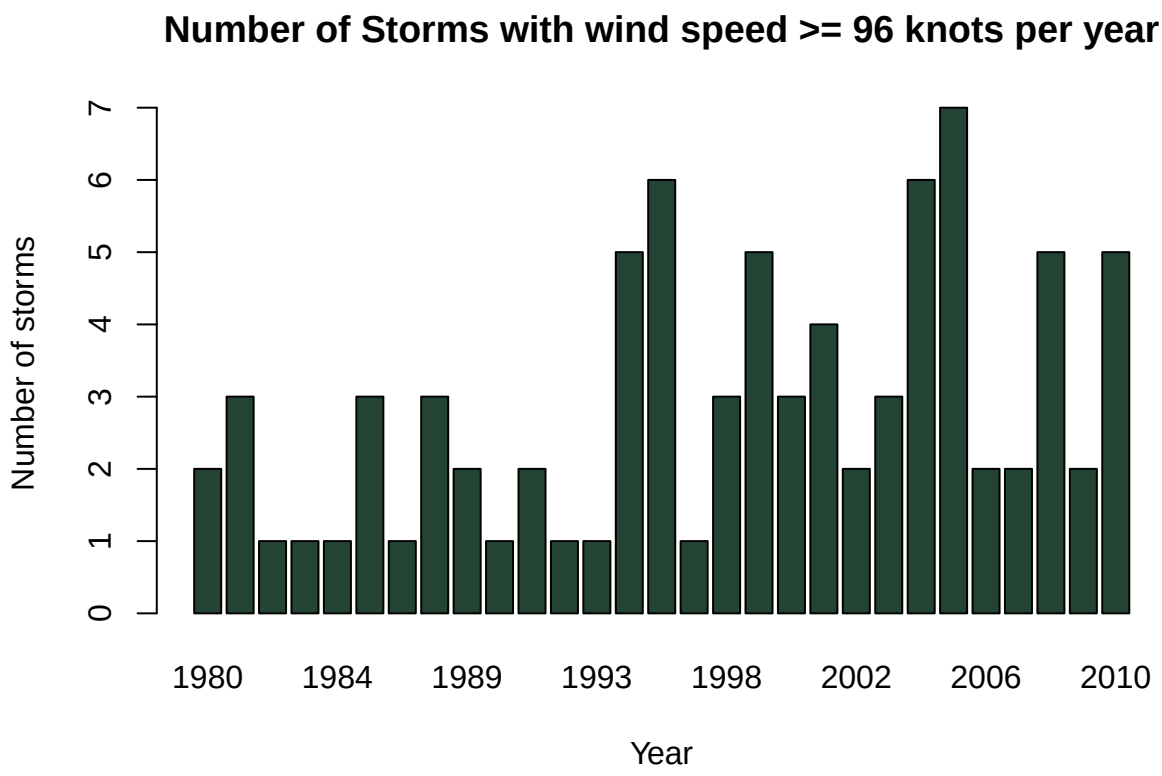
```
## pdf
##   2
```

Num. of storms per year with winds >= 96 knots:

```
table4
```

```
##
## 1980 1981 1982 1983 1984 1985 1987 1988 1989 1990 1991 1992 1993 1995 1996
##    2    3    1    1    1    3    1    3    2    1    2    1    1    5    6
## 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010
##    1    3    5    3    4    2    3    6    7    2    2    5    2    5
```

```
barplot(table4,
        main = 'Number of Storms with wind speed >= 96 knots per year',
        xlab = 'Year', ylab = 'Number of storms', col = '#234433')
```




```
dev.copy(png, 'images/storms>=96 per year.png')
```

```
## quartz_off_screen
##                 3
```

```
dev.off()
```

```
## pdf
##   2
```

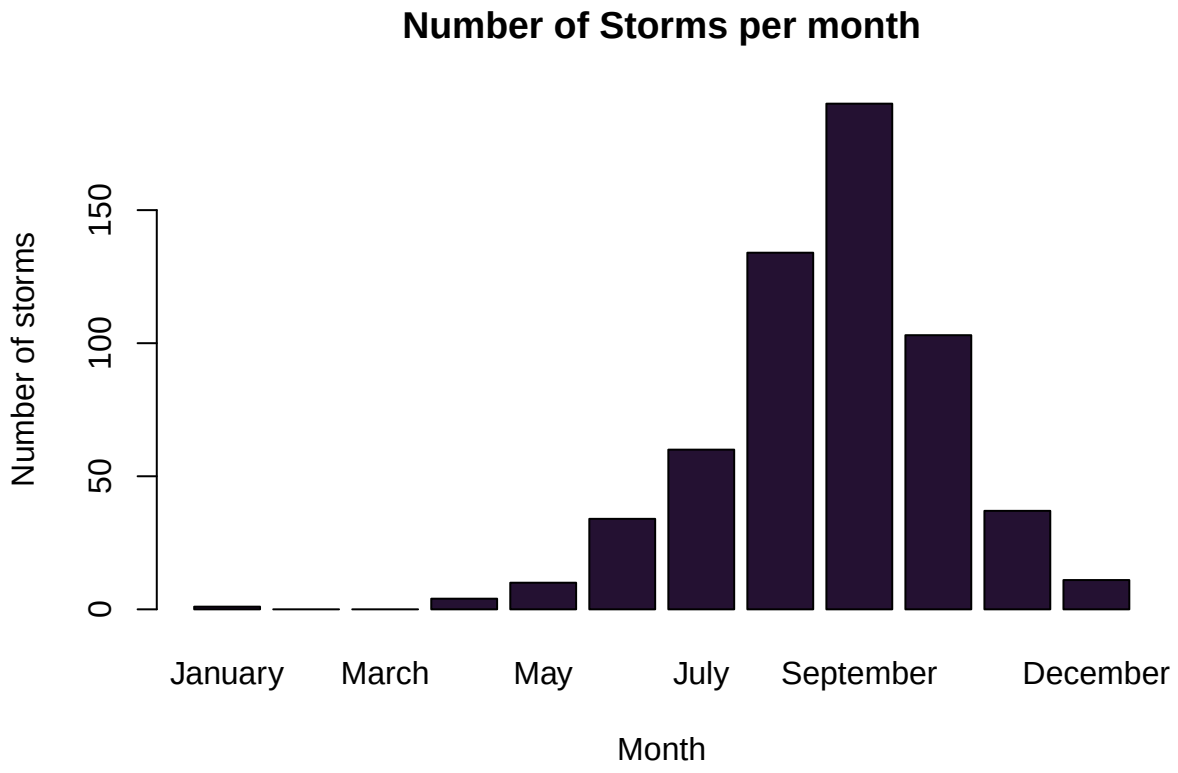
Analysis Per Month Obtain frequencies and barplots for:

Num. of storms per month:

```
table(temp2$month)
```

```
##
##   January  February     March     April       May      June      July
##         1         0         0         4        10        34        60
##    August September   October  November  December
##       134       190       103        37        11
```

```
barplot(table(temp2$month), main = 'Number of Storms per month',
        xlab = 'Month', ylab = 'Number of storms', col = '#241132')
```




```
dev.copy(png, 'images/storms per month.png')
```

```
## quartz_off_screen
##                 3
```

```
dev.off()
```

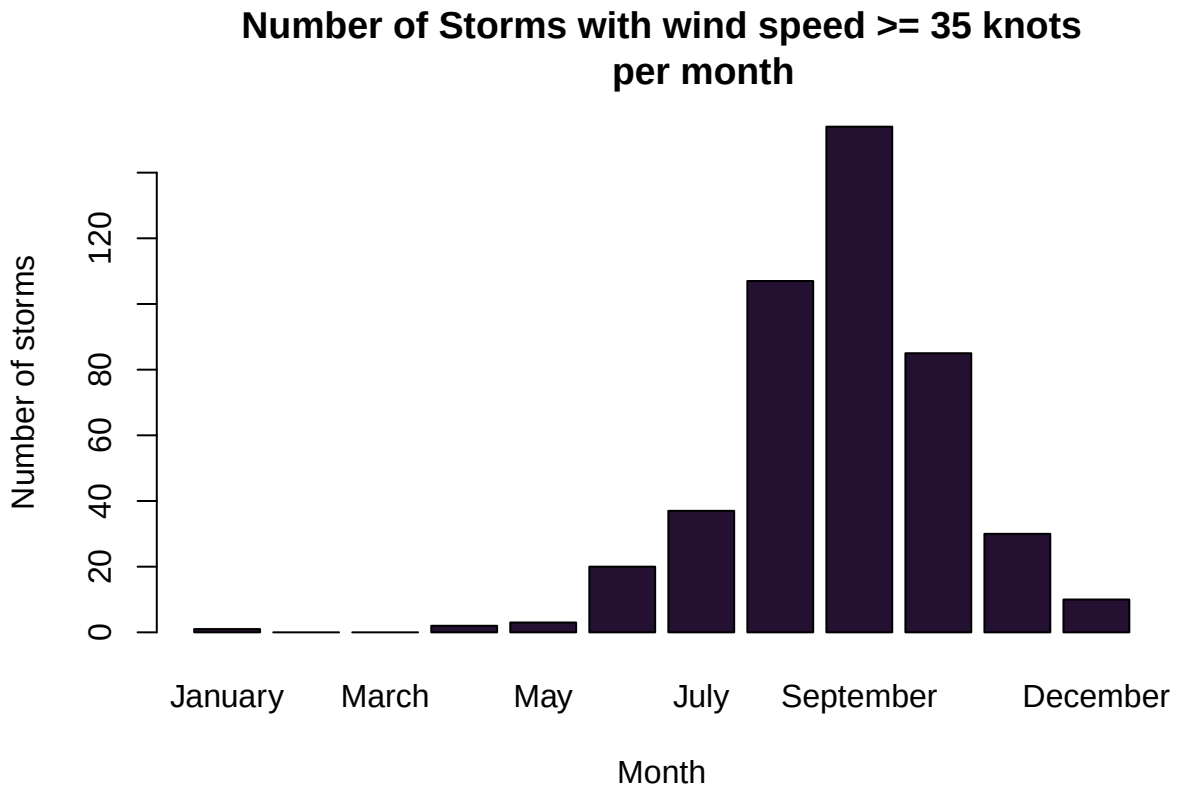
```
## pdf
##   2
```

Num. of storms per month with winds >= 35 knots:

```
table(temp2$month[temp2$wind >= 35])
```

```
##
##   January  February     March     April       May      June      July
##         1         0         0         2         3        20        37
##    August September   October  November  December
##       107       154        85        30        10
```

```
barplot(table(temp2$month[temp2$wind >= 35]),
        main = 'Number of Storms with wind speed >= 35 knots
        per month', xlab = 'Month', ylab = 'Number of storms',
        col = '#241132')
```




```
dev.copy(png, 'images/storms>=35 per month.png')
```

```
## quartz_off_screen
##                 3
```

```
dev.off()
```

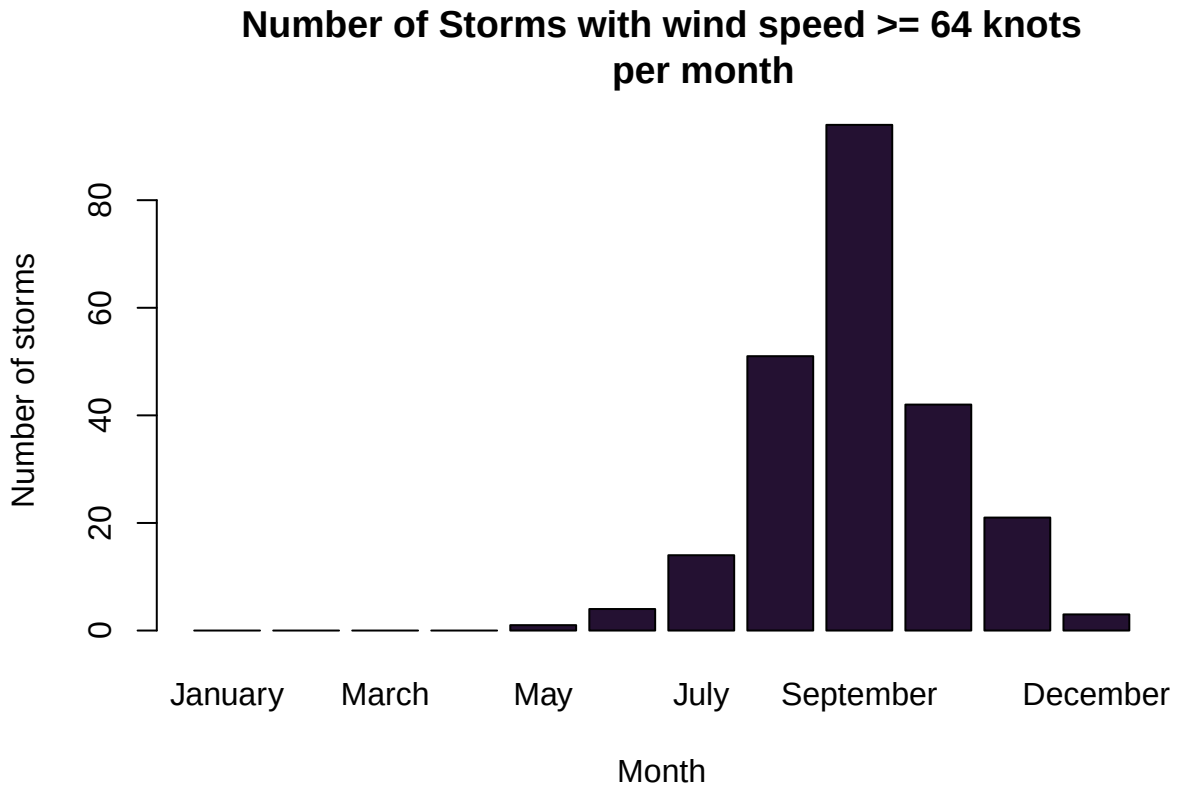
```
## pdf
##   2
```

Num. of storms per month with winds >= 64 knots:

```r
table(temp2$month[temp2$wind >= 64])
```

```
##
##   January  February     March     April       May      June      July
##         0         0         0         0         1         4        14
##    August September   October  November  December
##        51        94        42        21         3
```

```r
barplot(table(temp2$month[temp2$wind >= 64]),
        main = 'Number of Storms with wind speed >= 64 knots
        per month', xlab = 'Month', ylab = 'Number of storms',
        col = '#241132')
```




```r
dev.copy(png, 'images/storms>=64 per month.png')
```

```
## quartz_off_screen
##                 3
```

```r
dev.off()
```

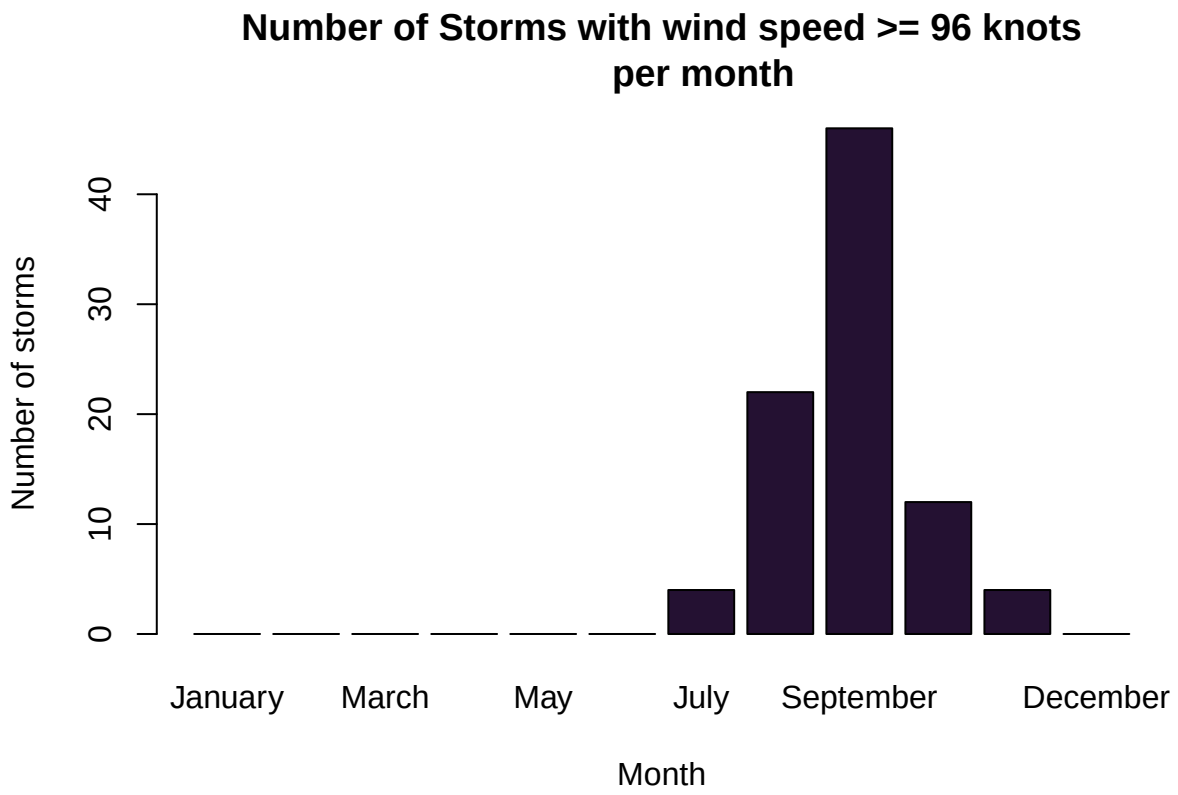
```
## pdf
##   2
```

Num. of storms per month with winds >= 96 knots:

```
table(temp2$month[temp2$wind >= 96])
```

```
##
##   January  February     March     April       May      June      July
##         0         0         0         0         0         0         4
##    August September   October  November  December
##        22        46        12         4         0
```

```
barplot(table(temp2$month[temp2$wind >= 96]),
        main = 'Number of Storms with wind speed >= 96 knots
        per month', xlab = 'Month', ylab = 'Number of storms',
        col = '#241132')
```




```
dev.copy(png, 'images/storms>=96 per month.png')
```

```
## quartz_off_screen
##                 3
```

```
dev.off()
```

```
## pdf
##   2
```

Annual Avg Number of Storms Subsequently, we compute the following statsitics for storms >=35 knots, >=64 knots, >=96 knots, average value, std deviation, 25th percentile, 50th percentile and 75th percentile.

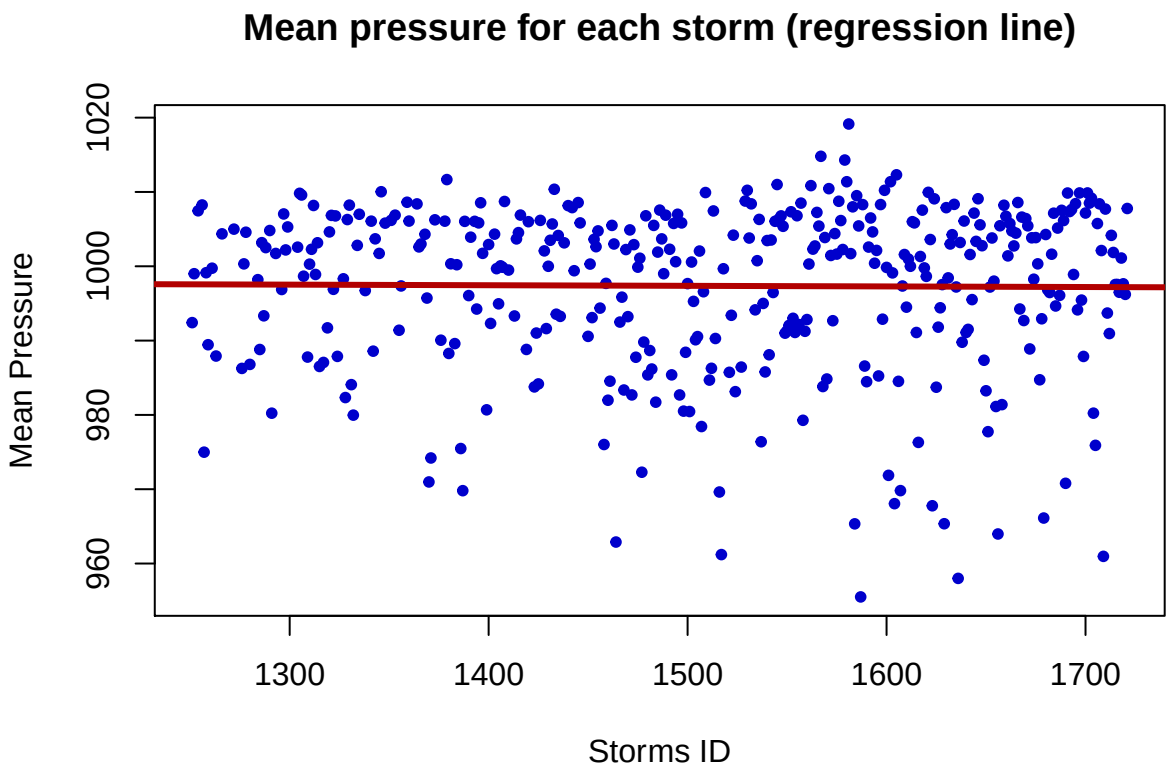
```r
all <- list(as.vector(table2), as.vector(table3),
            as.vector(table4))
stats <- data.frame(round(sapply(all, mean), 1),
                    round(sapply(all, sd), 2),
                    sapply(all, quantile)['25%',],
                    sapply(all, quantile)['50%',],
                    sapply(all, quantile)['75%',])
rownames(stats) <- c('35 knots', '64 knots', '96 knots')
colnames(stats) <- c('Avg', 'Std Dev', '25th', '50th', '75th')
stats
```

```
##           Avg Std Dev 25th 50th 75th
## 35 knots 12.2    4.99  8.5   12   15
## 64 knots  6.6    3.12  4.0    7    9
## 96 knots  2.9    1.79  1.0    2    4
```

Regression Analysis Regression analysis 1: mean pressure and mean wind speed for each storm (remove observations with mean pressure = 0)

```r
tracks_anal$press[tracks_anal$press == 0] <- NA
mean_pw <- aggregate(tracks_anal[, c('press', 'wind')],
                     list(id = tracks_anal$id), mean)
mean_pw <- subset(mean_pw, press != 0)

plot(mean_pw$id, mean_pw$press,
     main = 'Mean pressure for each storm (regression line)',
     xlab = 'Storms ID', ylab = 'Mean Pressure', pch = 20,
     cex = 1, col = '#0000cc')
abline(lm(mean_pw$press ~ mean_pw$id), lwd = 3, col = "#b20000")
```



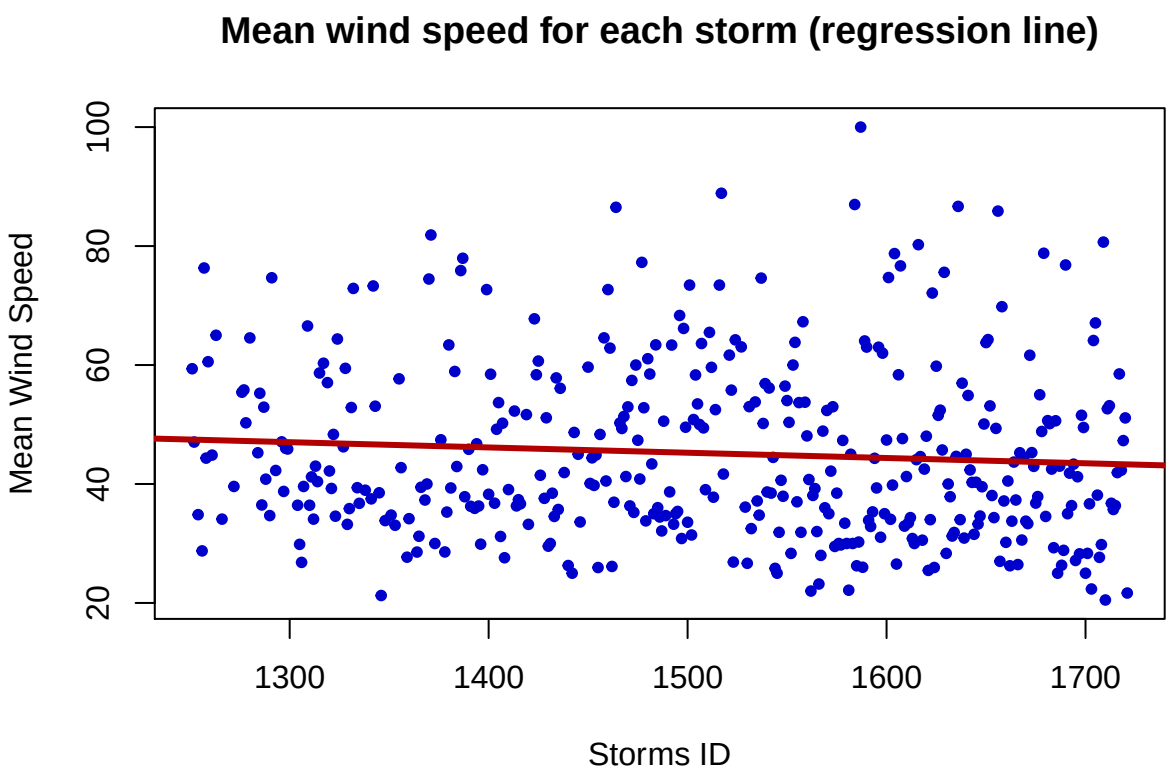
```
dev.copy(png, 'images/mean pressure(regression).png')
```

```
## quartz_off_screen
##                 3
```

```
dev.off()
```

```
## pdf
##   2
```

```
plot(mean_pw$id, mean_pw$wind,
     main = 'Mean wind speed for each storm (regression line)',
     xlab = 'Storms ID', ylab = 'Mean Wind Speed', pch = 20,
     cex = 1, col = '#0000cc')
abline(lm(mean_pw$wind ~ mean_pw$id), lwd = 3, col = "#b20000")
```




```
dev.copy(png, 'images/mean wind speed(regression).png')
```

```
## quartz_off_screen
##                 3
```

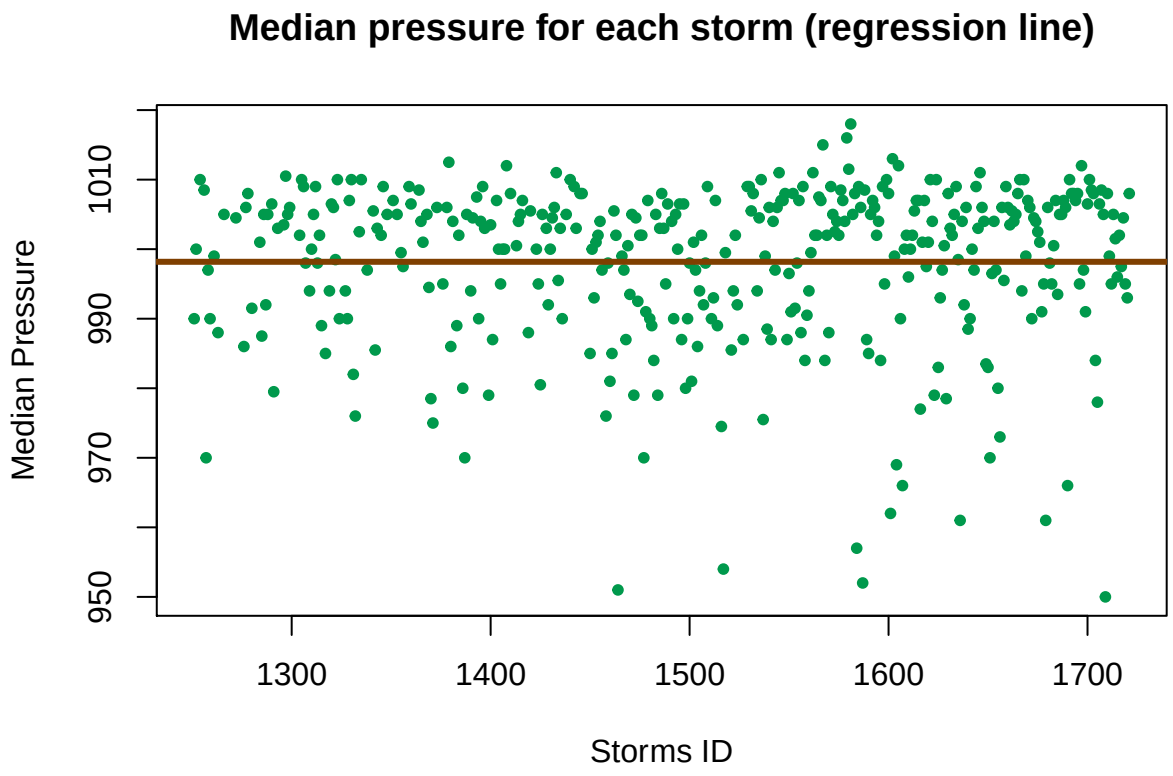
```
dev.off()
```

```
## pdf
##   2
```

Regression analysis 2: median pressure and median wind speed for each storm (remove observations with median pressure = 0)

```
median_pw <- aggregate(tracks_anal[, c('press', 'wind')],
                       list(id = tracks_anal$id), median)
median_pw <- subset(median_pw, press != 0)

plot(median_pw$id, median_pw$press,
     main = 'Median pressure for each storm (regression line)',
     xlab = 'Storms ID', ylab = 'Median Pressure', pch = 20,
     cex = 1, col = '#00994c')
abline(lm(median_pw$press ~ median_pw$id), lwd = 3, col = "#7f3f00")
```



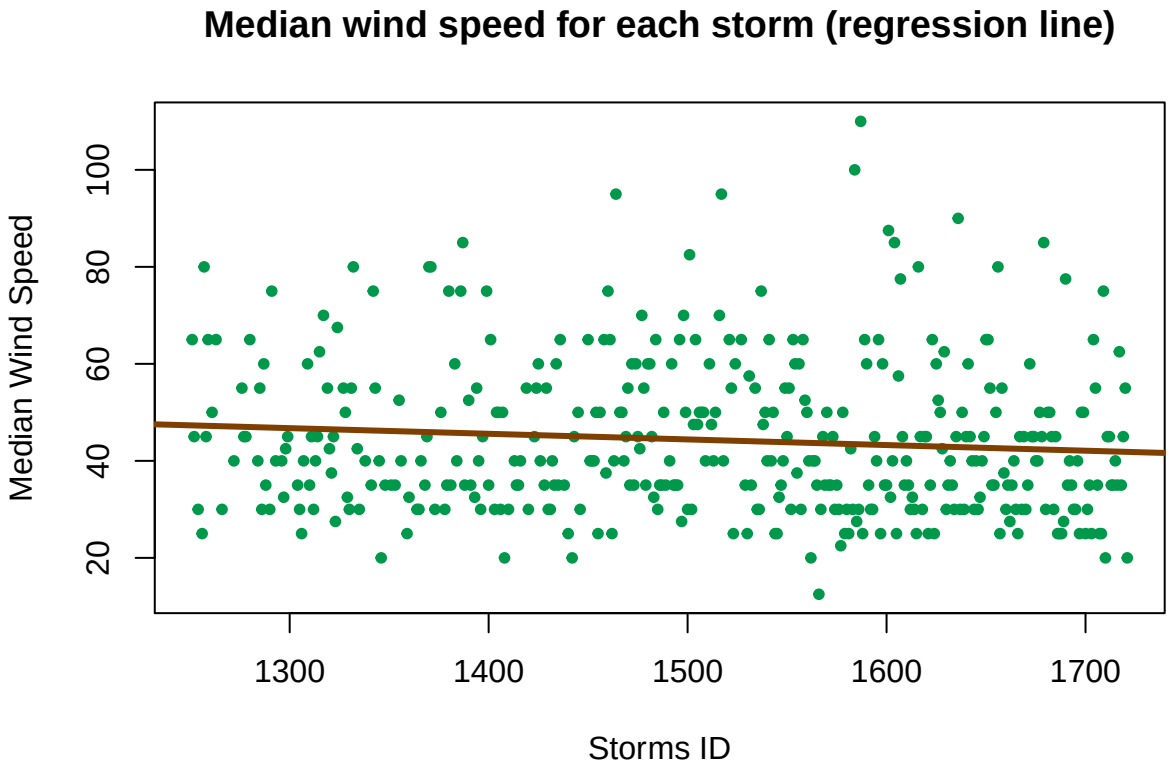

```
dev.copy(png, 'images/median pressure(regression).png')
```

```
## quartz_off_screen
##                 3
```

```
dev.off()
```

```
## pdf
##   2
```

```
plot(median_pw$id, median_pw$wind,
     main = 'Median wind speed for each storm (regression line)',
     xlab = 'Storms ID', ylab = 'Median Wind Speed', pch = 20,
     cex = 1, col = '#00994c')
abline(lm(median_pw$wind ~ median_pw$id), lwd = 3, col = "#7f3f00")
```




```
dev.copy(png, 'images/median wind speed(regression).png')
```

```
## quartz_off_screen
##                 3
```

```
dev.off()
```

```
## pdf
##   2
```

========== Visualization ==========

In this part, we aim to visualize the trajectory of the storms in both the East Pacific (EP) and the North Atlantic (NA) basins during the period 1980-2010. The data needed for this part have been downloaded and stored as 'rawdata/stormsEP.csv' and 'rawdata/stormsNA.csv'.

We read in the data and obtain the rows in which the year is between 1980 and 2010.

```
headerEP <- read.table('rawdata/stormsEP.csv',
                       skip = 1, nrows = 1, header = FALSE, sep = ',')
stormsEP <- read.table('rawdata/stormsEP.csv',
                       skip = 3, header = FALSE, sep = ',')
colnames(stormsEP) <- unlist(headerEP)
stormsEP <- subset(stormsEP, Season >= 1980 & Season <= 2010)

headerNA <- read.table('rawdata/stormsNA.csv',
                       skip = 1, nrows = 1, header = FALSE, sep = ',')
stormsNA <- read.table('rawdata/stormsNA.csv',
```

```
                        skip = 3, header = FALSE, sep = ',')
colnames(stormsNA) <- unlist(headerNA)
stormsNA <- subset(stormsNA, Season >= 1980 & Season <= 2010)
```

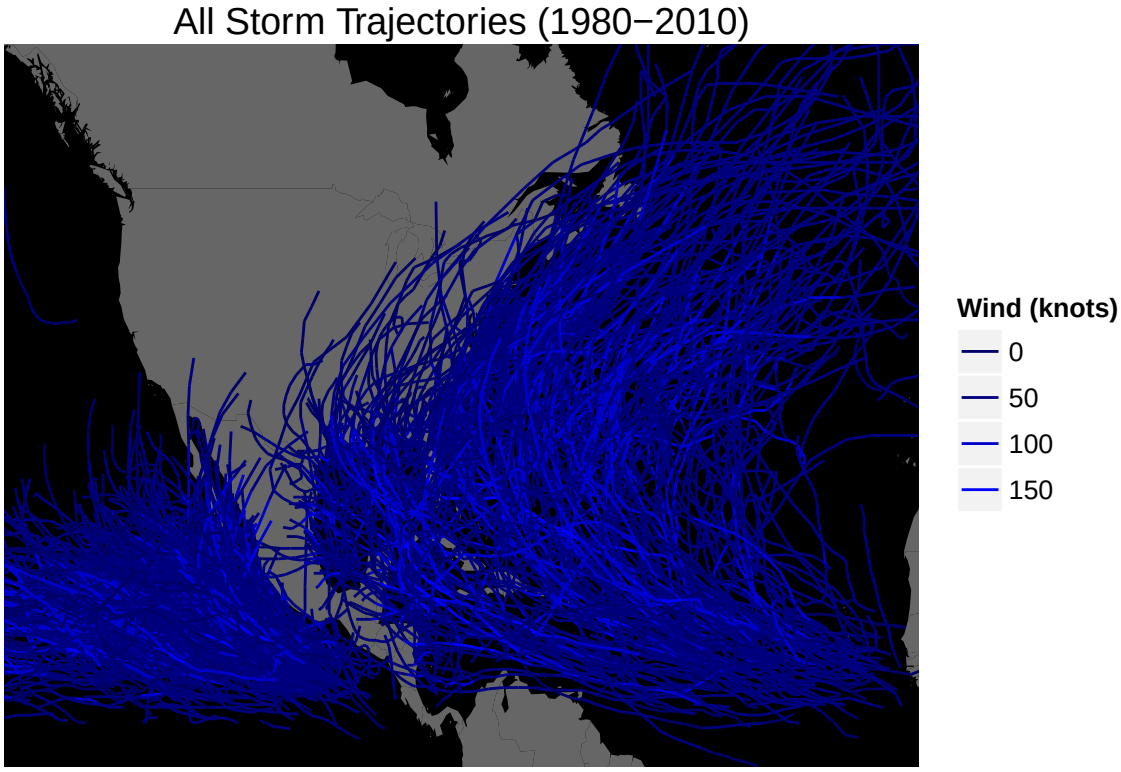
We then combined the two data and add four columns, namely 'windc', 'date', 'month' and 'year', which will make upcoming tasks easier.

```
# We use full_join from dplyr package
combined <- full_join(stormsEP, stormsNA)
# After inspecting the longitude values for all storms, we realize that some of them
#are greater than 100, which might cause trouble when graphing. Therefore, we pre-emptively
#subtract those value by 360, so that the trajectories of storm won't appear stright
#across the map.
combined$Longitude[combined$Longitude > 100] <-
  combined$Longitude[combined$Longitude > 100] - 360
#windc is a column that put wind speed into 4 categories based on the number of knots.
combined$windc <- round(combined$`Wind(WMO)` / 50) * 50
#extract the date of each storm observation
combined$date <- as.Date(str_sub(combined$ISO_time, 1, 10))
#extract the month
combined$month <- factor(format(combined$date, '%B'), levels = month.name)
#extract the year
combined$year <- format(combined$date, '%Y')
```

With the bit of modification of the data frame, we are ready to go and plot out each graph.

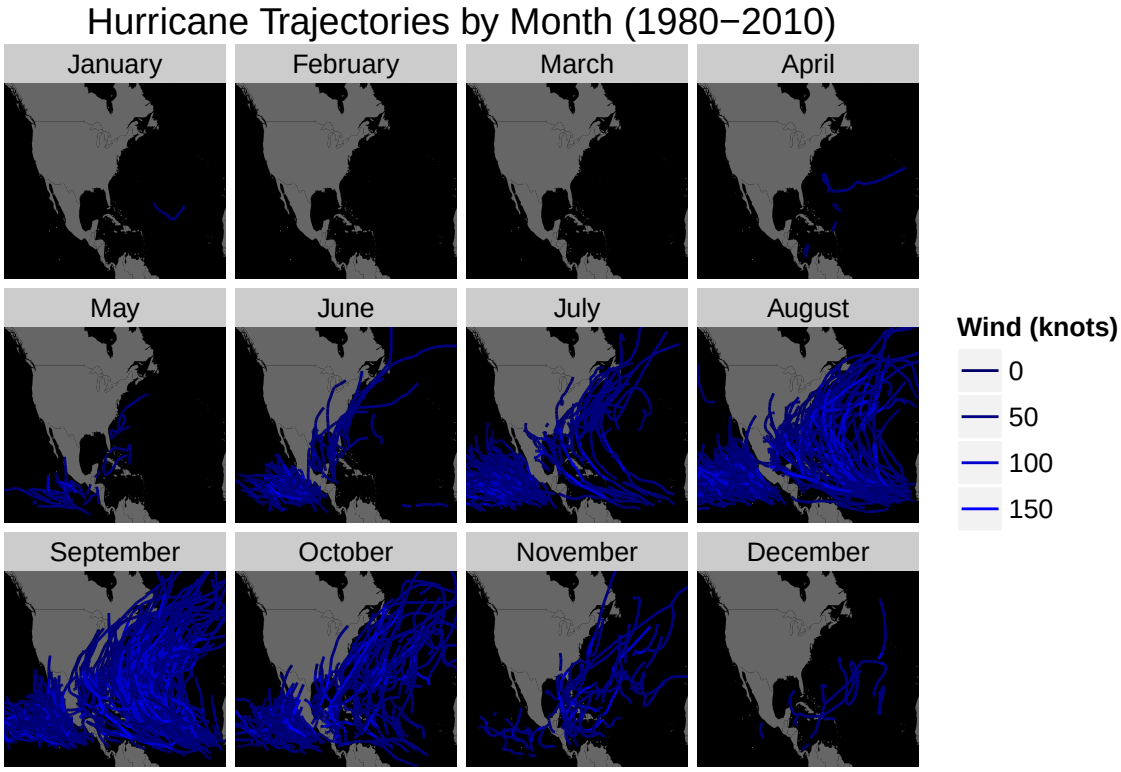
```
#load in world map, using map_data from 'map' package.
states_map <- map_data('world')

#All Storm Trajectories (1980-2010)
ggplot(combined, aes(x = Longitude, y = Latitude, group = Serial_Num)) +
  geom_polygon(data = states_map, fill = '#666666',
               aes(x = long, y = lat, group = group)) +
  geom_path(aes(col = factor(windc))) +
  scale_color_manual(name = 'Wind (knots)',
                     values = c('0' = '#000066', '50' = '#00007f',
                                '100' = '#0000cc', '150' = '#0000ff')) +
  coord_cartesian(xlim = c(-140, -15), ylim = c(5, 60)) +
  ggtitle('All Storm Trajectories (1980-2010)') +
  theme(axis.ticks=element_blank(),
        axis.text.x=element_blank(), axis.text.y=element_blank(),
        axis.title.x=element_blank(), axis.title.y=element_blank(),
        panel.grid.major = element_blank(), panel.grid.minor = element_blank(),
        panel.background = element_rect(fill = '#000000'))
```



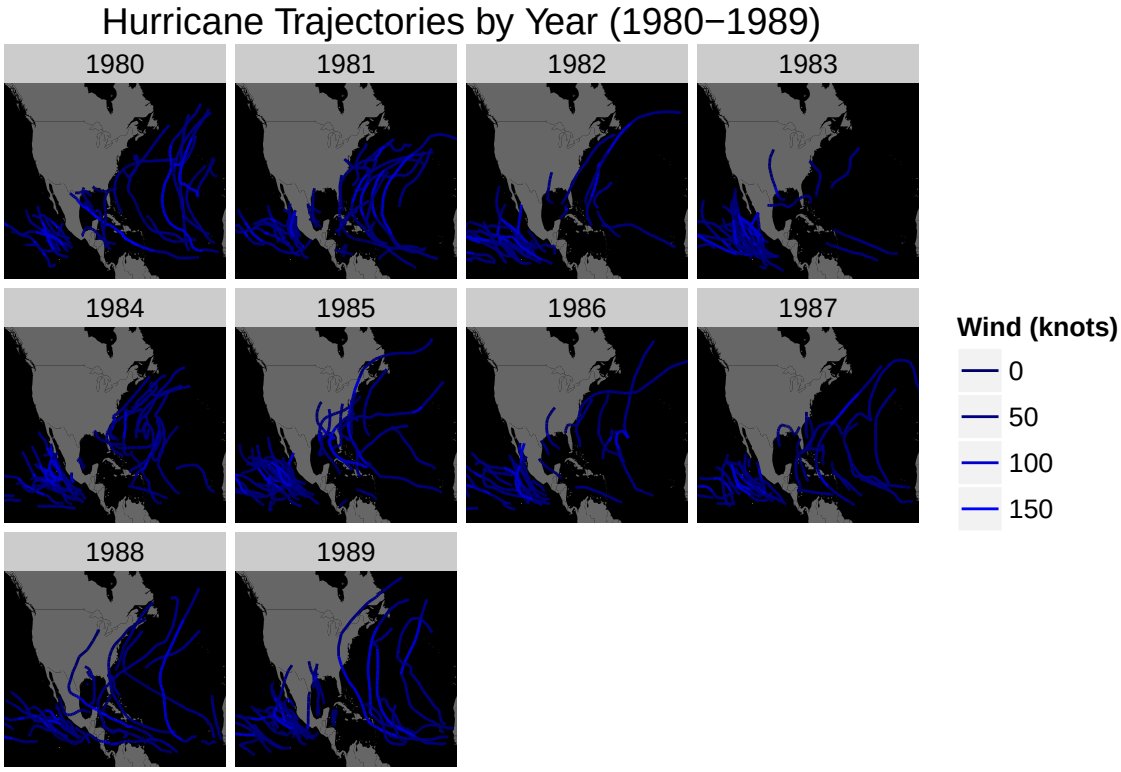

```
ggsave('images/all storm trajectories (1980-2010).png')
```

```
#Hurricane Trajectories by Month (1980-2010)
ggplot(combined, aes(x = Longitude, y = Latitude, group = Serial_Num)) +
  facet_wrap(~ month) +
  geom_polygon(data = states_map, fill = '#666666',
               aes(x = long, y = lat, group = group)) +
  geom_path(aes(col = factor(windc))) +
  scale_color_manual(name = 'Wind (knots)',
                     values = c('0' = '#000066', '50' = '#00007f',
                                '100' = '#0000cc', '150' = '#0000ff')) +
  coord_cartesian(xlim = c(-140, -15), ylim = c(5, 60)) +
  ggtitle('Hurricane Trajectories by Month (1980-2010)') +
  theme(axis.ticks=element_blank(),
        axis.text.x=element_blank(), axis.text.y=element_blank(),
        axis.title.x=element_blank(), axis.title.y=element_blank(),
        panel.grid.major = element_blank(), panel.grid.minor = element_blank(),
        panel.background = element_rect(fill = '#000000'))
```



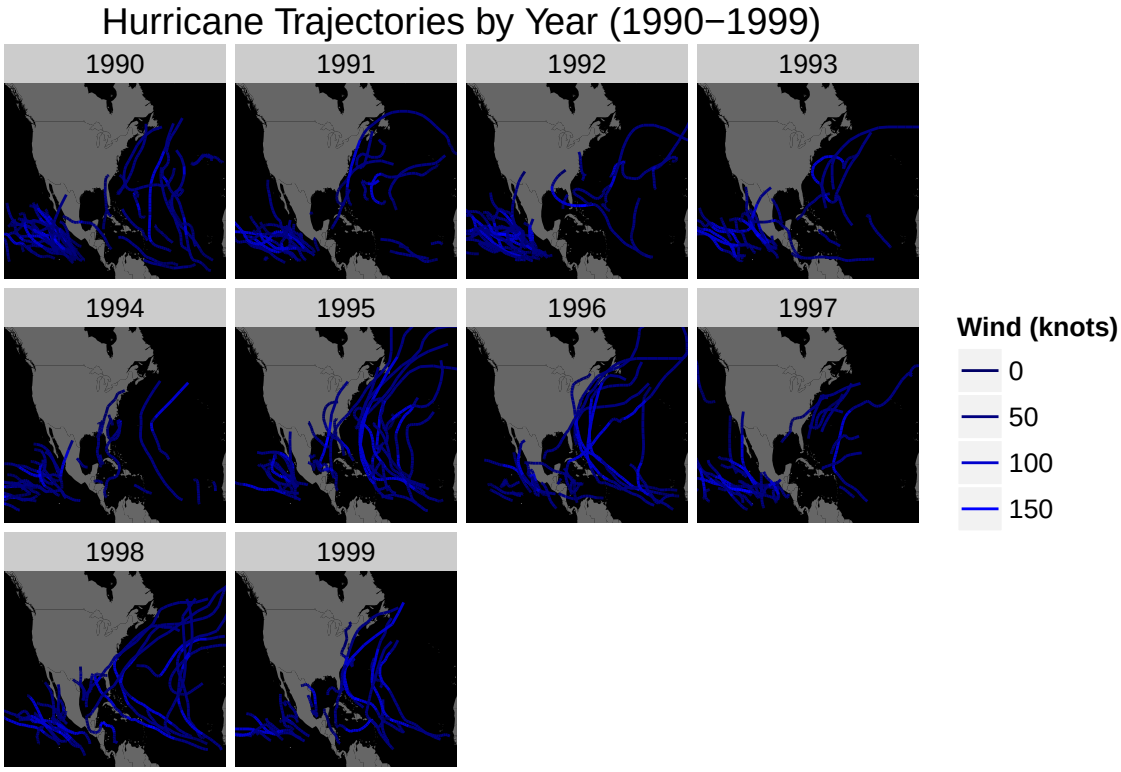

```
ggsave('images/hurricane trajectories by month (1980-2010).png')
```

```
#select out the data in the 1980s
combined1980s <- subset(combined, year >= 1980 & year <= 1989)
#Hurricane Trajectories by Year (1980-1989)
ggplot(combined1980s, aes(x = Longitude, y = Latitude, group = Serial_Num)) +
  facet_wrap(~ year) +
  geom_polygon(data = states_map, fill = '#666666',
               aes(x = long, y = lat, group = group)) +
  geom_path(aes(col = factor(windc))) +
  scale_color_manual(name = 'Wind (knots)',
                     values = c('0' = '#000066', '50' = '#00007f',
                                '100' = '#0000cc', '150' = '#0000ff')) +
  coord_cartesian(xlim = c(-140, -15), ylim = c(5, 60)) +
  ggtitle('Hurricane Trajectories by Year (1980-1989)') +
  theme(axis.ticks=element_blank(),
        axis.text.x=element_blank(), axis.text.y=element_blank(),
        axis.title.x=element_blank(), axis.title.y=element_blank(),
        panel.grid.major = element_blank(), panel.grid.minor = element_blank(),
        panel.background = element_rect(fill = '#000000'))
```



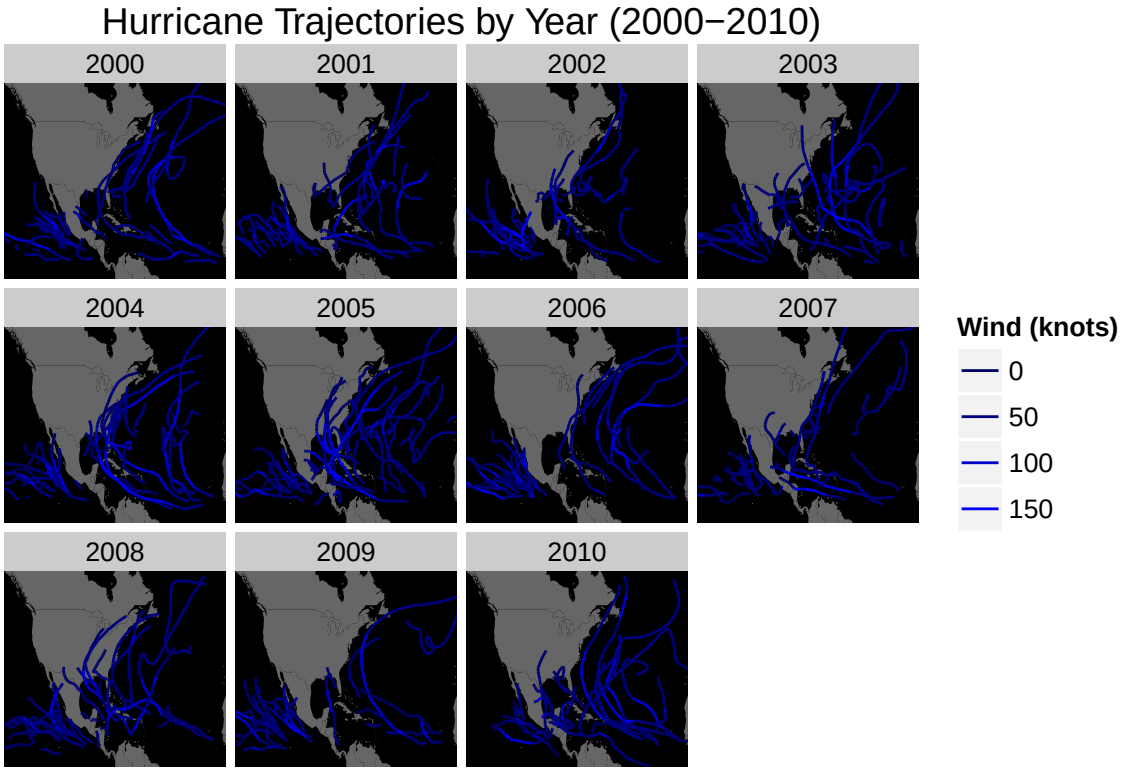

```
ggsave('images/hurricane trajectories by month (1980-1989).png')
```

```
#select out the data in the 1990s
combined1990s <- subset(combined, year >= 1990 & year <= 1999)
#Hurricane Trajectories by Year (1990-1999)
ggplot(combined1990s, aes(x = Longitude, y = Latitude, group = Serial_Num)) +
  facet_wrap(~ year) +
  geom_polygon(data = states_map, fill = '#666666',
               aes(x = long, y = lat, group = group)) +
  geom_path(aes(col = factor(windc))) +
  scale_color_manual(name = 'Wind (knots)',
                     values = c('0' = '#000066', '50' = '#00007f',
                                '100' = '#0000cc', '150' = '#0000ff')) +
  coord_cartesian(xlim = c(-140, -15), ylim = c(5, 60)) +
  ggtitle('Hurricane Trajectories by Year (1990-1999)') +
  theme(axis.ticks=element_blank(),
        axis.text.x=element_blank(), axis.text.y=element_blank(),
        axis.title.x=element_blank(), axis.title.y=element_blank(),
        panel.grid.major = element_blank(), panel.grid.minor = element_blank(),
        panel.background = element_rect(fill = '#000000'))
```




```
ggsave('images/hurricane trajectories by month (1990-1999).png')
```

```
#select out the data in the 2000s
combined2000s <- subset(combined, year >= 2000 & year <= 2010)
#Hurricane Trajectories by Year (2000-2010)
ggplot(combined2000s, aes(x = Longitude, y = Latitude, group = Serial_Num)) +
  facet_wrap(~ year) +
  geom_polygon(data = states_map, fill = '#666666',
               aes(x = long, y = lat, group = group)) +
  geom_path(aes(col = factor(windc))) +
  scale_color_manual(name = 'Wind (knots)',
                     values = c('0' = '#000066', '50' = '#00007f',
                                '100' = '#0000cc', '150' = '#0000ff')) +
  coord_cartesian(xlim = c(-140, -15), ylim = c(5, 60)) +
  ggtitle('Hurricane Trajectories by Year (2000-2010)') +
  theme(axis.ticks=element_blank(),
        axis.text.x=element_blank(), axis.text.y=element_blank(),
        axis.title.x=element_blank(), axis.title.y=element_blank(),
        panel.grid.major = element_blank(), panel.grid.minor = element_blank(),
        panel.background = element_rect(fill = '#000000'))
```




```
ggsave('images/hurricane trajectories by month (2000-2010).png')
```

That's it for the project. Thanks for reading!!