Final Project - Report

Chenbo Fang

In this project, we study the attributes of storms in East Pacific and North Atlantic basins.

We use the database International Best Track Archive for Climate Stewardship (IBTrACS) as our source of data.

Part 1: North Atlantic Storms

As the first part of the project, we focus on storms in the North Atlantic basin. From the IBTrACS Database, we use the HURDAT file of storms in North Atlantic basin.

After cleaning up the raw data, we obtain two clean datasets storms.csv - which record ID, start date, number of days with available position, and name for each storm - and tracks.csv - which record stage, latitude (N), longitude (E), wind speed, and surface pressure for each period of each day of each storm.

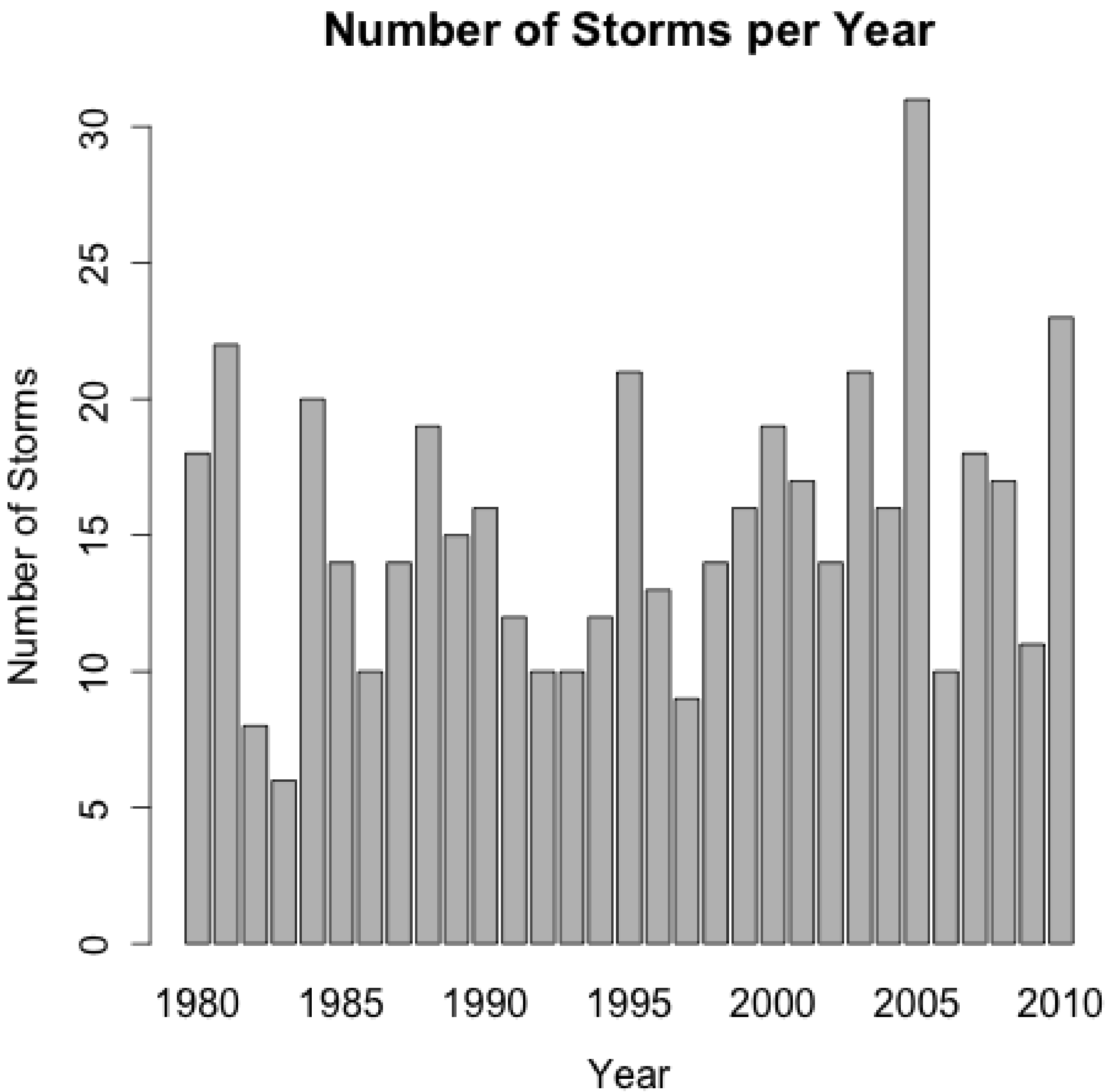
With the cleaned data, and restricting our sample to 1980-2010, we conduct the following four analyses.

1.1 Analysis per Year

First, we obtain frequency table and barplot for number of storms per year.

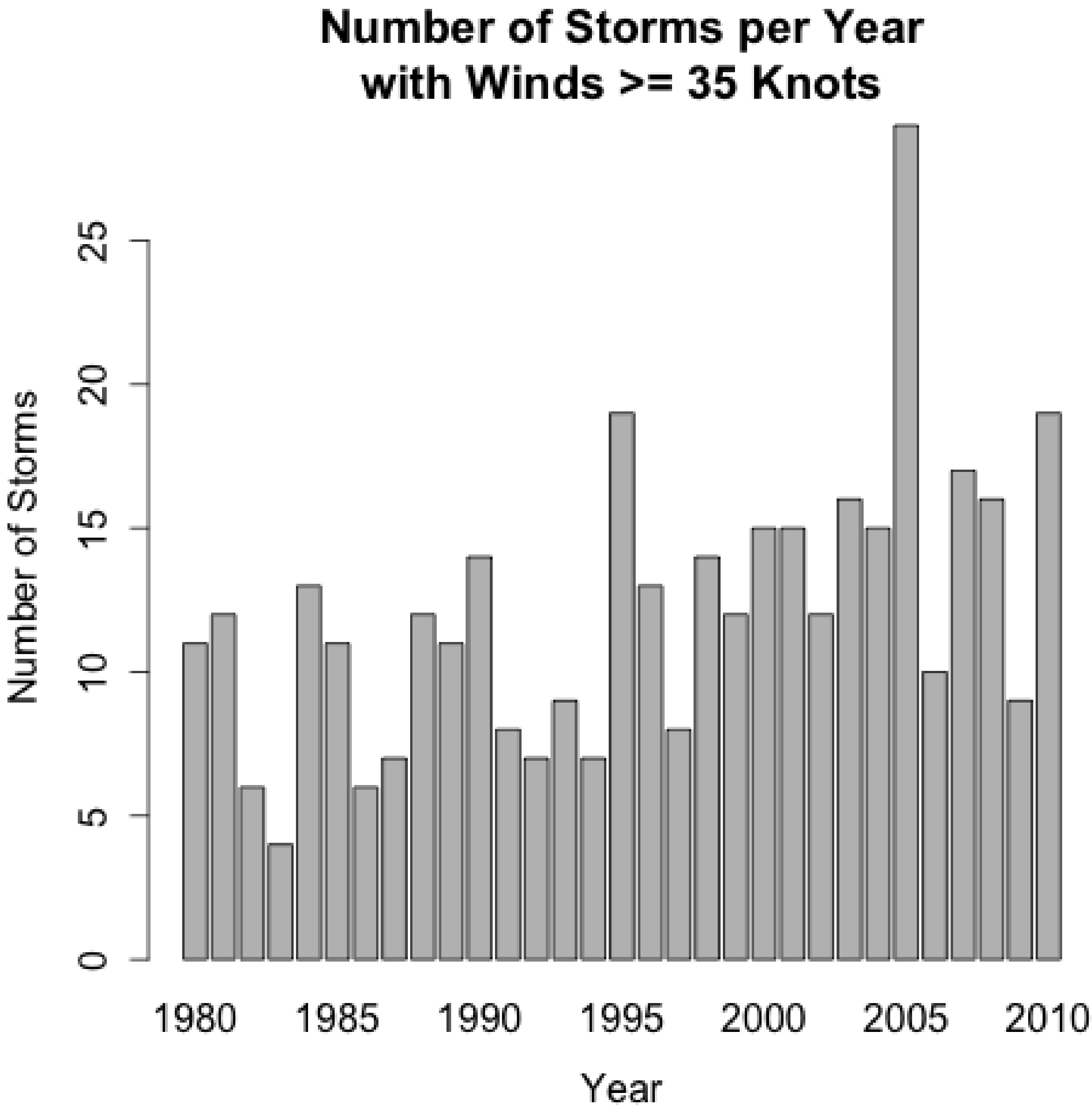
```
## [1] "Number of Storms per Year"
```

```
##
##       1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992
##  [1,]   18   22    8    6   20   14   10   14   19   15   16   12   10
##
##       1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005
##  [1,]   10   12   21   13    9   14   16   19   17   14   21   16   31
##
##       2006 2007 2008 2009 2010
##  [1,]   10   18   17   11   23
```

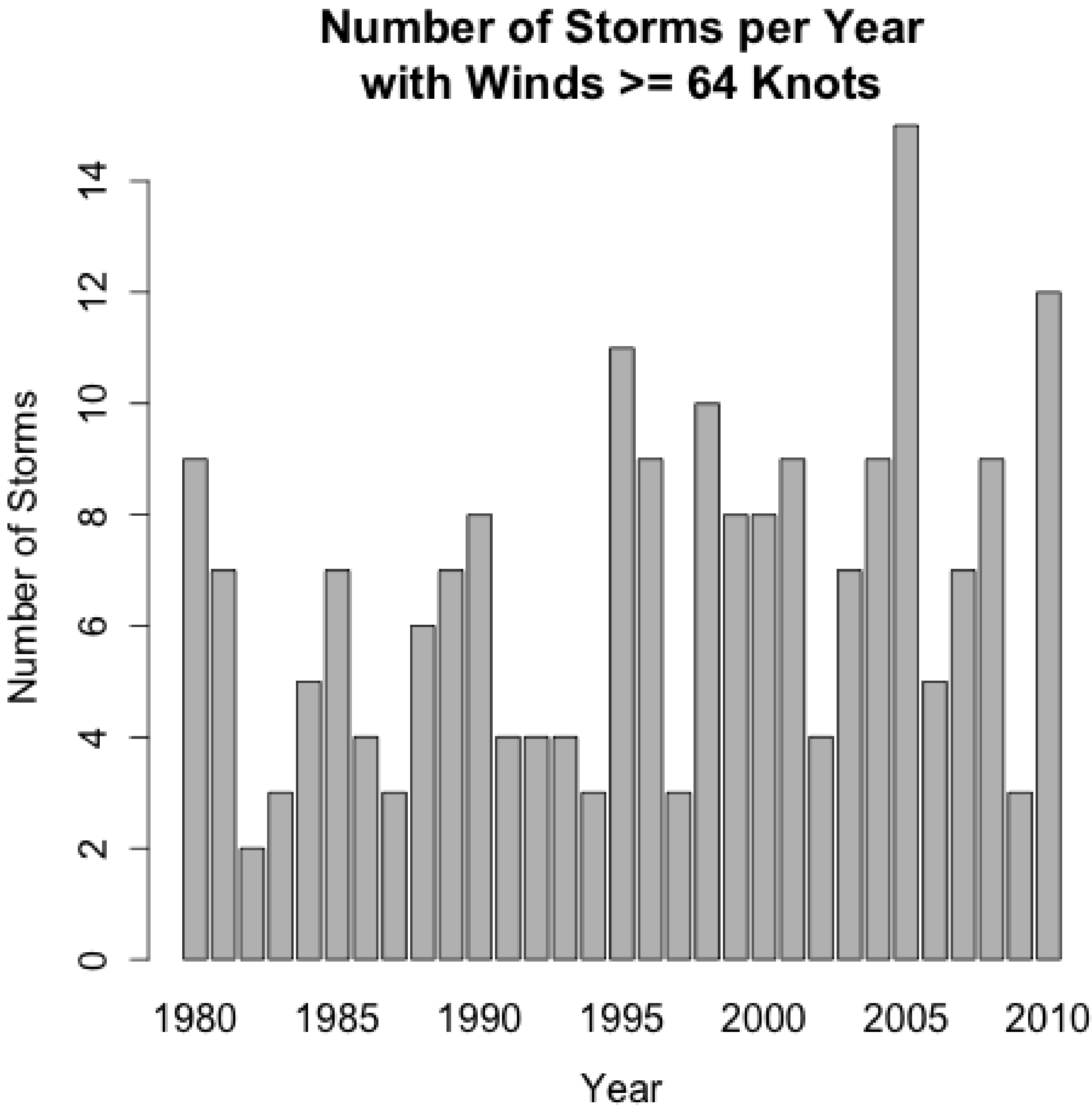


We can subset the storms by maximum wind speeds and reproduce the frequency table and barplot above for each subset.

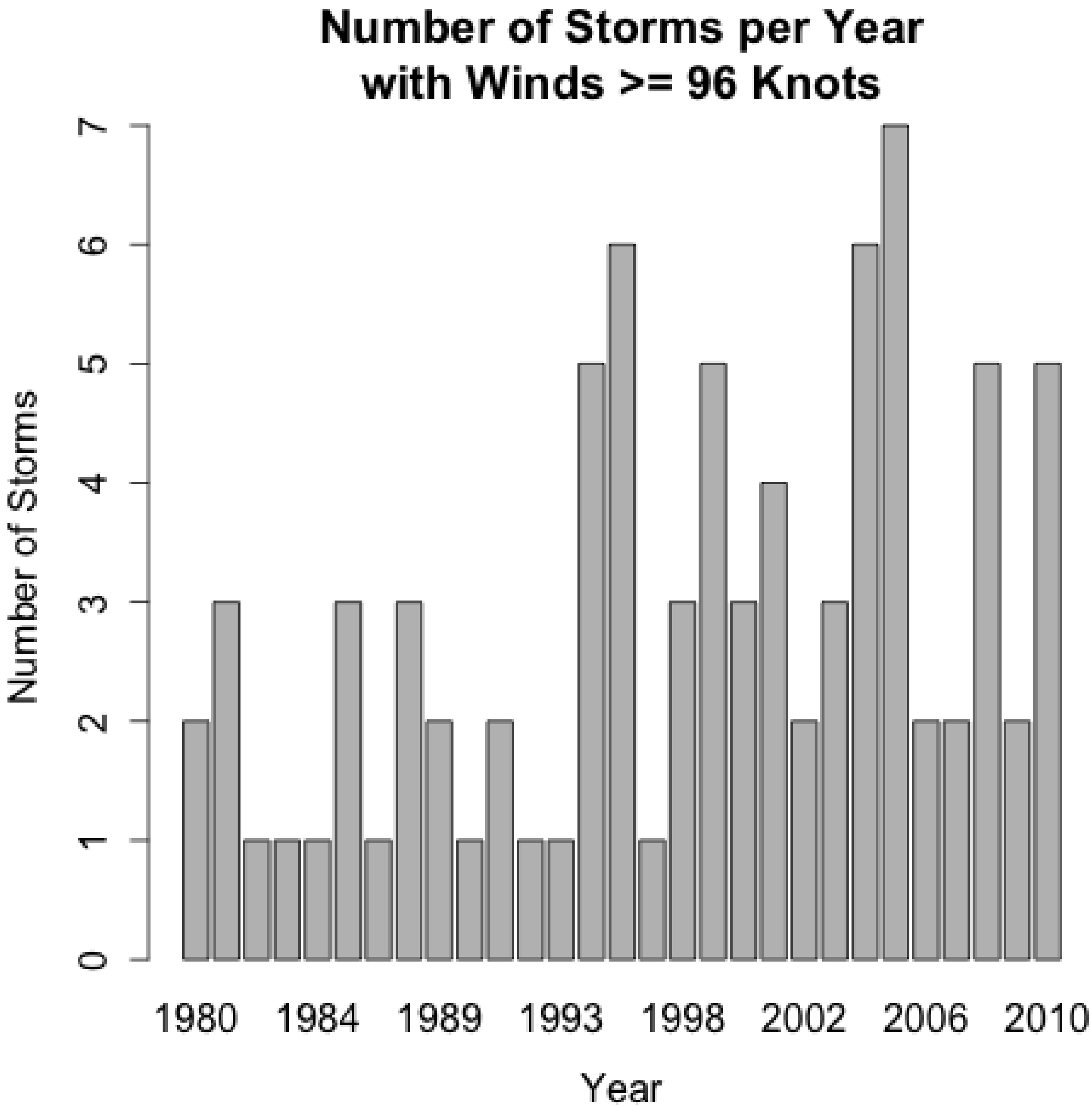
```
## [1] "Number of Storms per Year with Winds >= 35 Knots"

##
##      1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992
## [1,]   11   12    6    4   13   11    6    7   12   11   14    8    7
##
##      1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005
## [1,]    9    7   19   13    8   14   12   15   15   12   16   15   29
##
##      2006 2007 2008 2009 2010
## [1,]   10   17   16    9   19
```




```
## [1] "Number of Storms per Year with Winds >= 64 Knots"

##
##        1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992
##   [1,]    9    7    2    3    5    7    4    3    6    7    8    4    4
##
##        1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005
##   [1,]    4    3   11    9    3   10    8    8    9    4    7    9   15
##
##        2006 2007 2008 2009 2010
##   [1,]    5    7    9    3   12
```




```
## [1] "Number of Storms per Year with Winds >= 96 Knots"

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

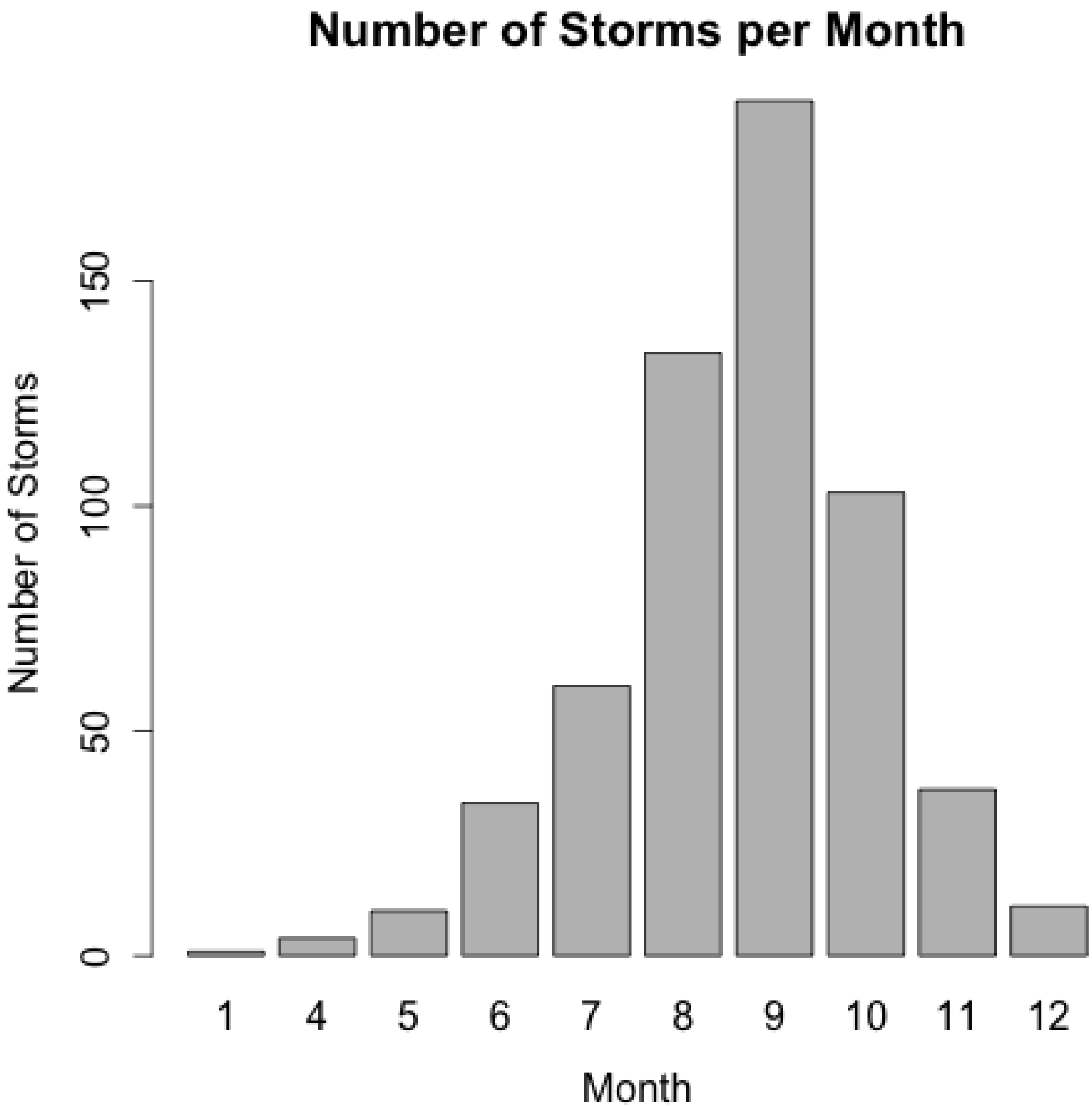


Though not very conspicuous (and certainly not monotonic), we can observe an upward trend of the number of storms over years. Whether it is small storms or large storms, the increase is visible.

1.2 Analysis per Month

Next, we obtain frequency tables and barplots for number of storms per month. Here we simply counts the number of unique storms in a particular month. Note that since a storm can span several months, the total number of storms aggregated over months should be greater than the total number of unique storms.

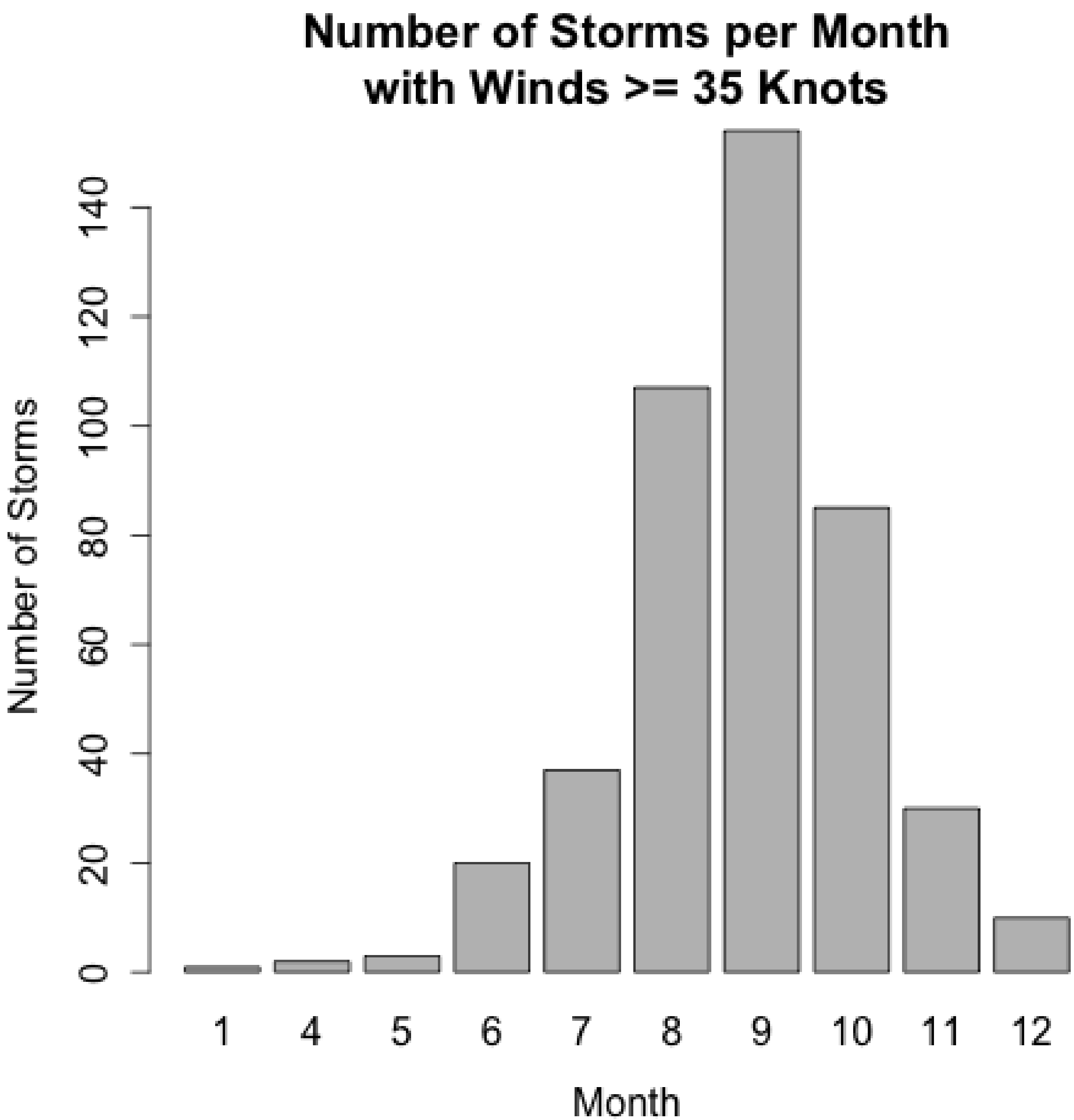
```
## [1] "Number of Storms per Month"

##
##          1   4   5   6   7   8   9  10  11  12
##   [1,]   1   4  10  34  60 134 190 103  37  11
```



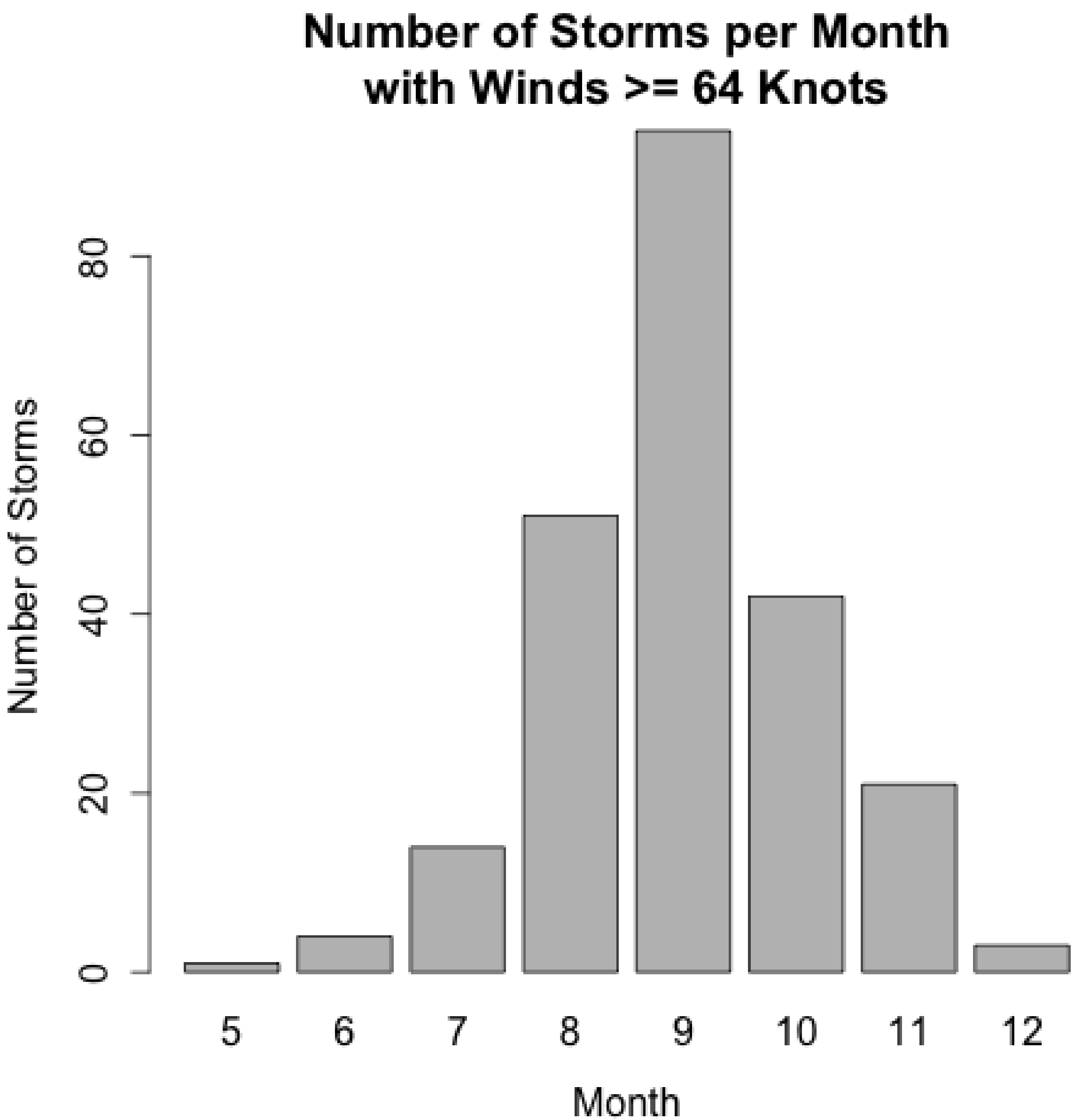
Similarly, we can subset the storms by their maximum wind speeds in that particular month and reproduce the frequency table and barplot above for each subset.

```
## [1] "Number of Storms per Month with Winds >= 35 Knots"
```

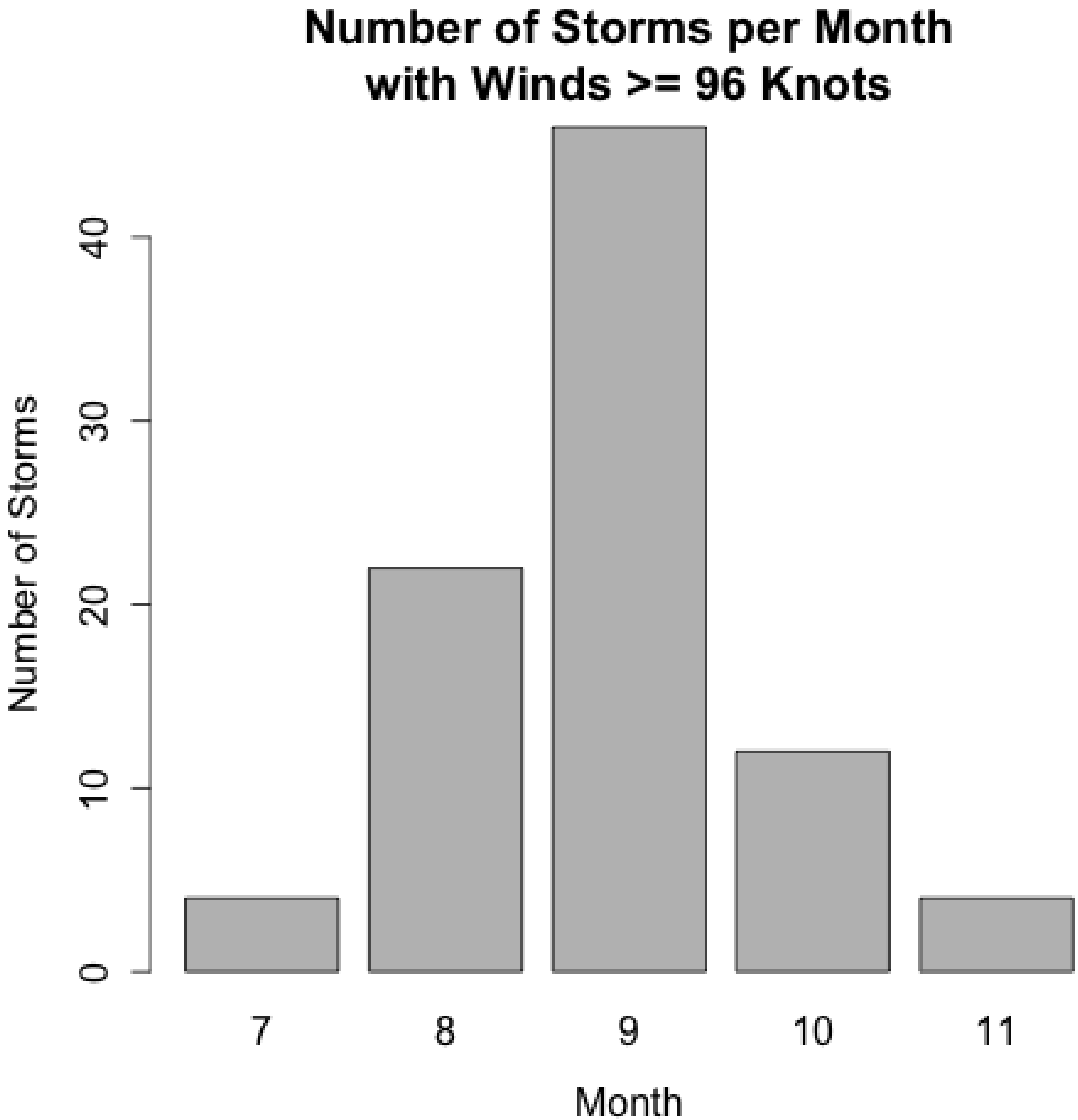
```
##
##          1   4   5   6   7   8   9  10  11  12
##   [1,]   1   2   3  20  37 107 154  85  30  10
```




```
## [1] "Number of Storms per Month with Winds >= 64 Knots"

##
##         5  6  7  8  9 10 11 12
##   [1,]  1  4 14 51 94 42 21  3
```




```
## [1] "Number of Storms per Month with Winds >= 96 Knots"

##
##         7  8  9 10 11
##   [1,]  4 22 46 12  4
```



From the graphs we can see that not only does Autumn (August, September and October) see more storms, they also see a majority share of the particularly large storms.

1.3 Annual Avg Number of Storms

As our third analysis, we compute a set of statistics (mean, standard deviation, first quantile, median, and third quantile) for the number of storms with maximum wind speeds of at least 35, 64, and 96 Knots respectively. The results are shown below.

```
## [1] "Annual Avg Number of Storms"
```

```
##         35 knots 64 knots 96 knots
## Avg         12.2      6.6      2.9
```

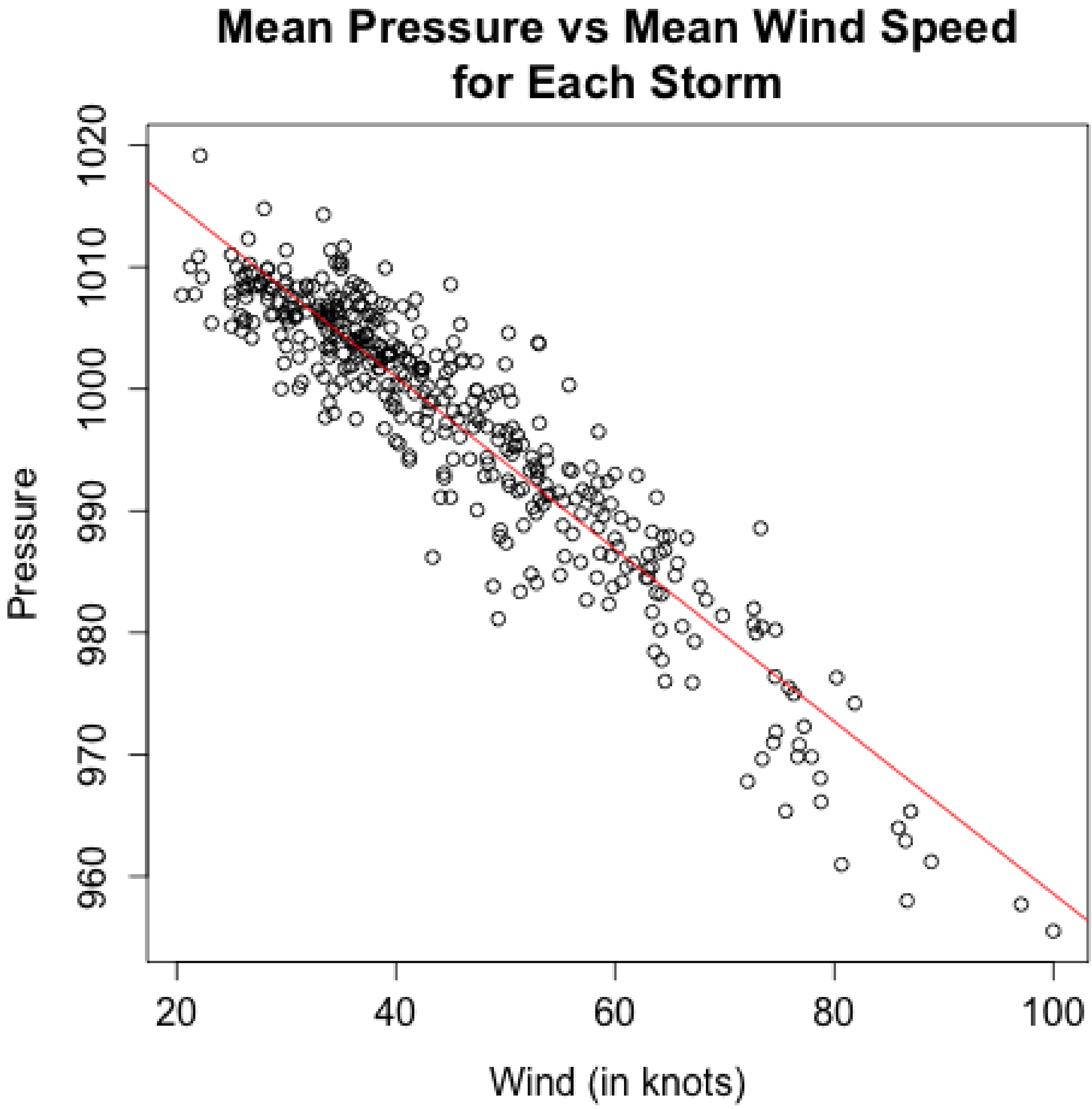
```
## Std Dev      5.0      3.1      1.8
## 25th         8.5      4.0      1.0
## 50th        12.0      7.0      2.0
## 75th        15.0      9.0      4.0
```

1.4 Regression Analysis

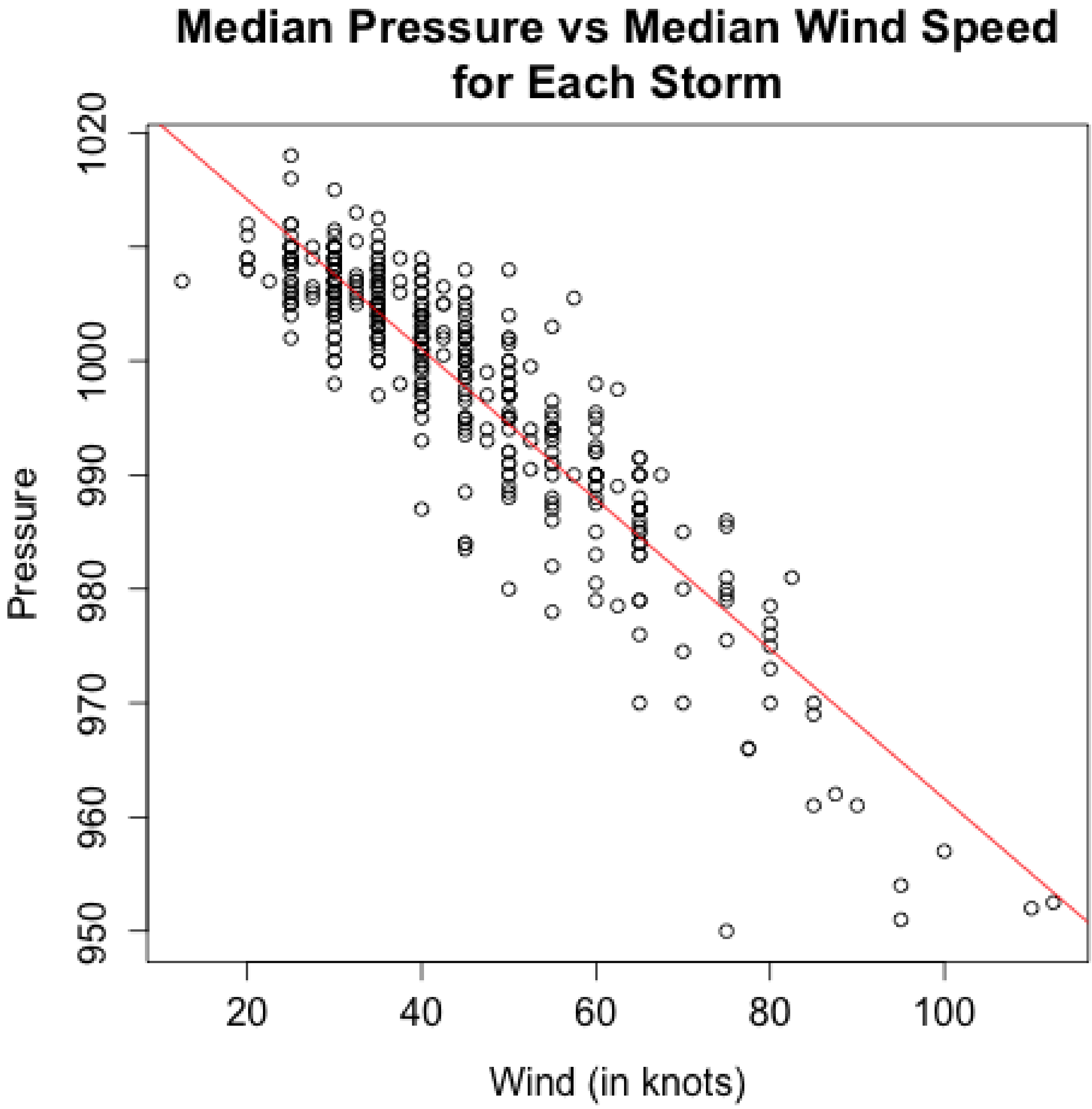
As our last analysis, we look at the regression between surface pressure and wind speed. For each storm, we compute the mean of its surface pressure and wind speed. We then run regressions betweense the two variables. The graph below shows a scatter plot of the two variables with the regression line highlighted in red.

After some exploration, we found that taking out storms with mean surface pressure at 0 and treating 0 surface pressure as NA yield much more significant result, and hence adopted as our assumption.

The graph below shows that higher mean wind speed is associated with lower mean surface pressure.



As a robustness check, we reproduce the analysis with the median of surface pressures and the median of wind speeds for each storm. As shown in the graph below, the result is consistent in that higher wind speed is associated with lower surface pressure.



Part 2: East Pacific and North Atlantic Storms

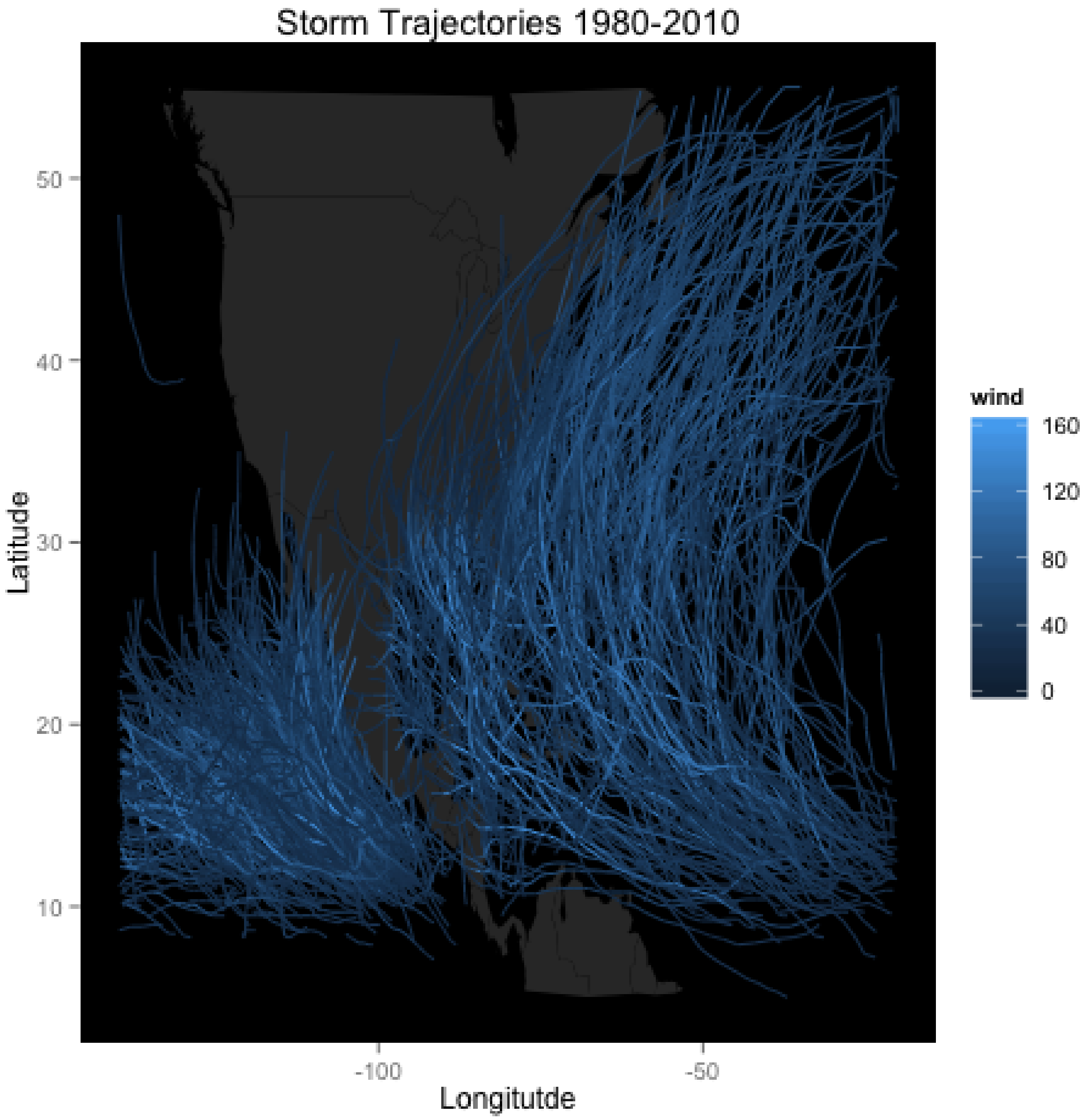
Part 2 of the project considers storms in both East Pacific and North Atlantic basins and focuses on the trajectories of the storms. We use the CSV files from IBTrACS Database for this part of the project.

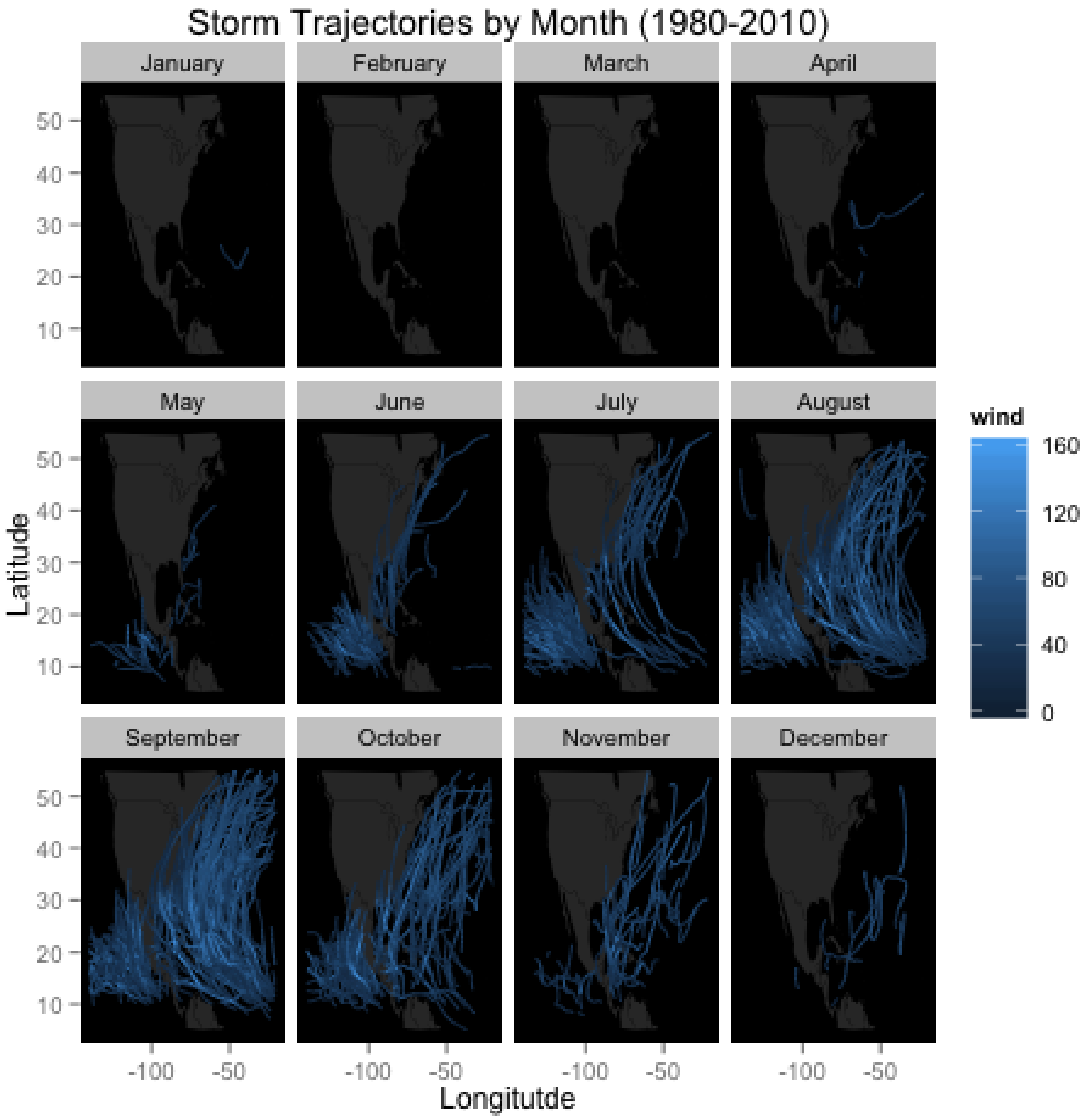
After cleaning up the data, we can produce on a map of the trajectory for each storm from the series of longitudes and latitudes.

We restrict our map view to around the North America Continent, where location reference is easy to interpret. Therefore, the limits for the longitude and latitude of the map are W140 to W20, and N5 to N55.

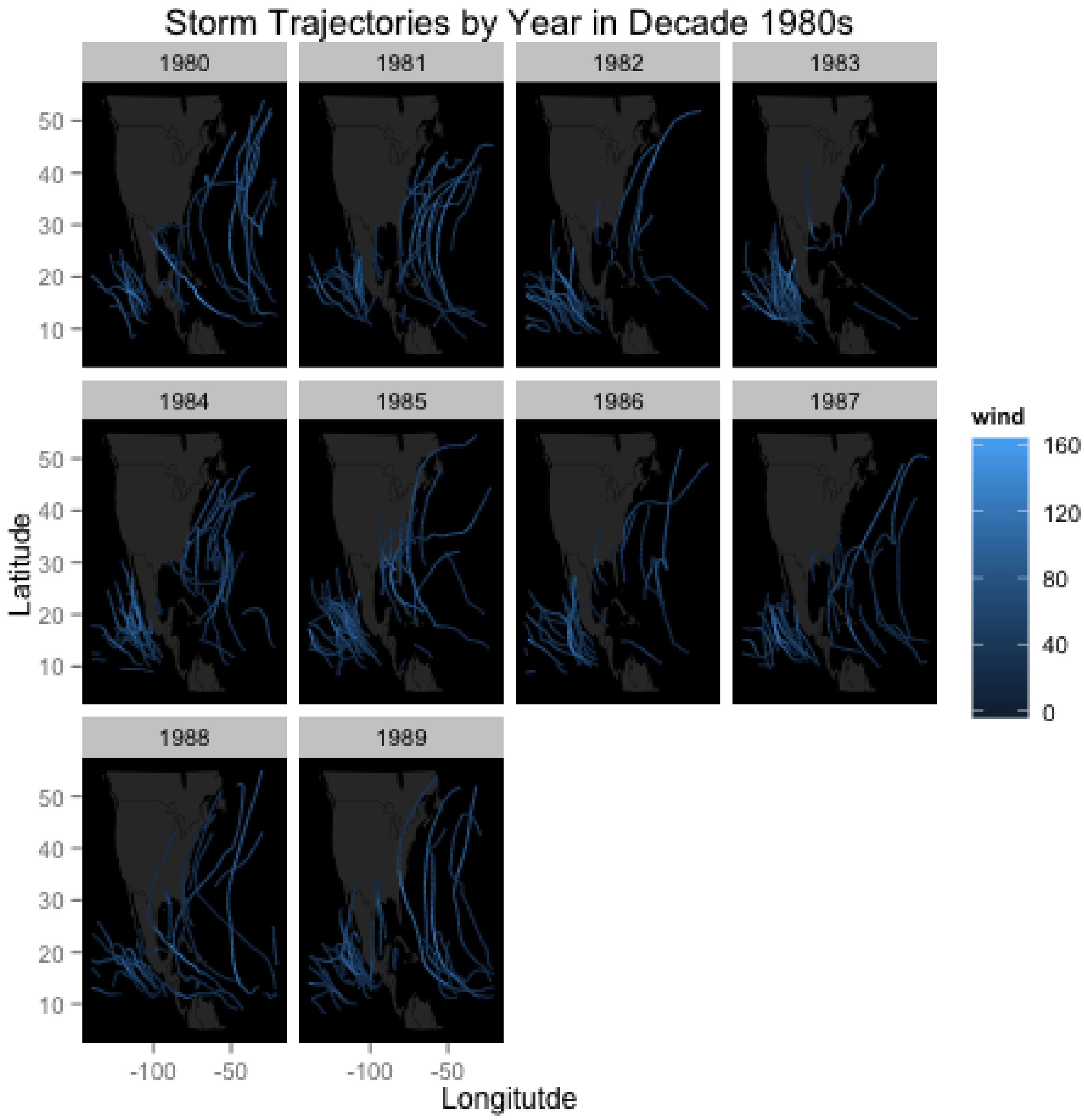
For each trajectory we color each position by the associated wind speed.

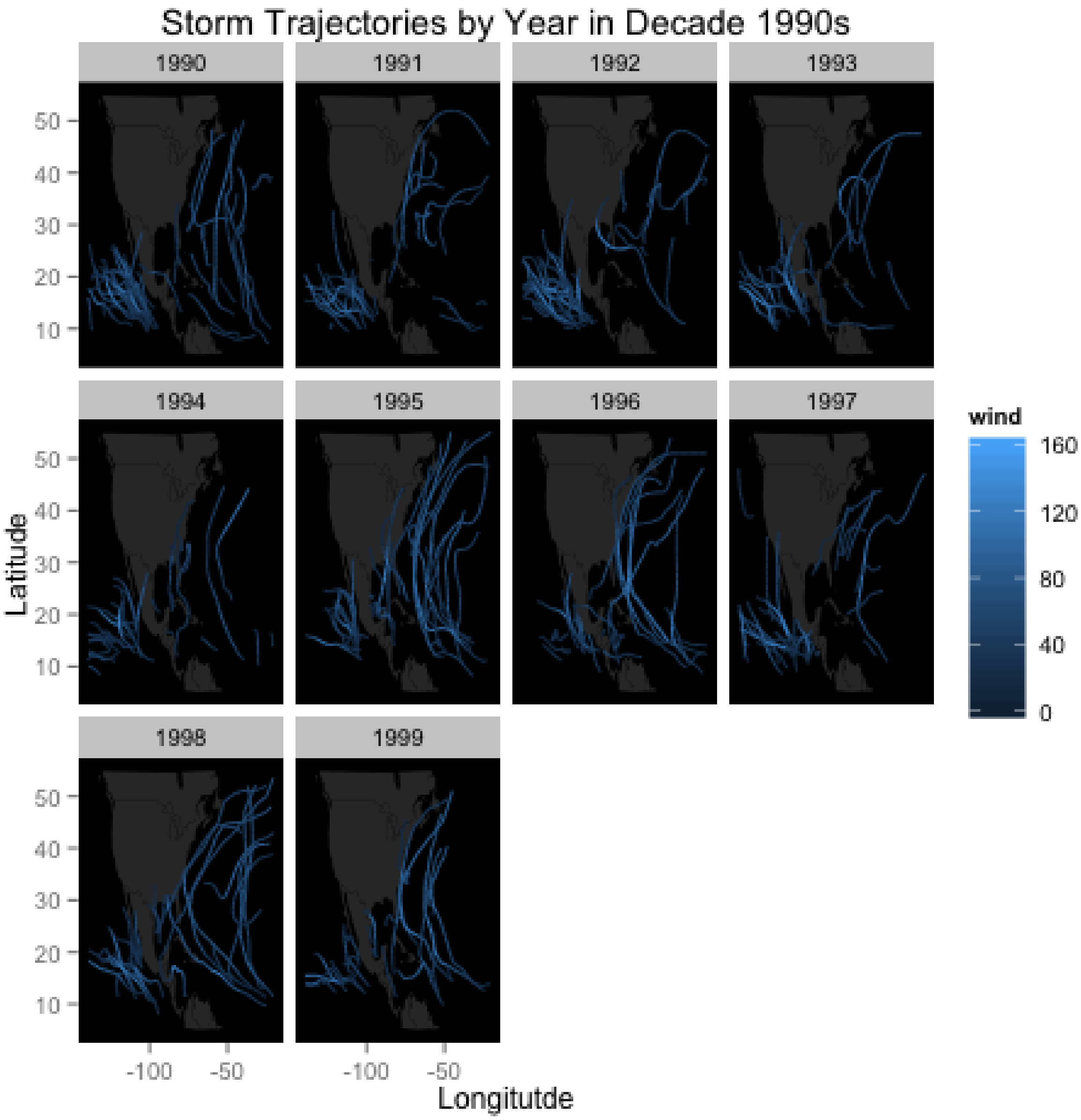
The following graphs are trajectories of storms corresponding to different attributes.

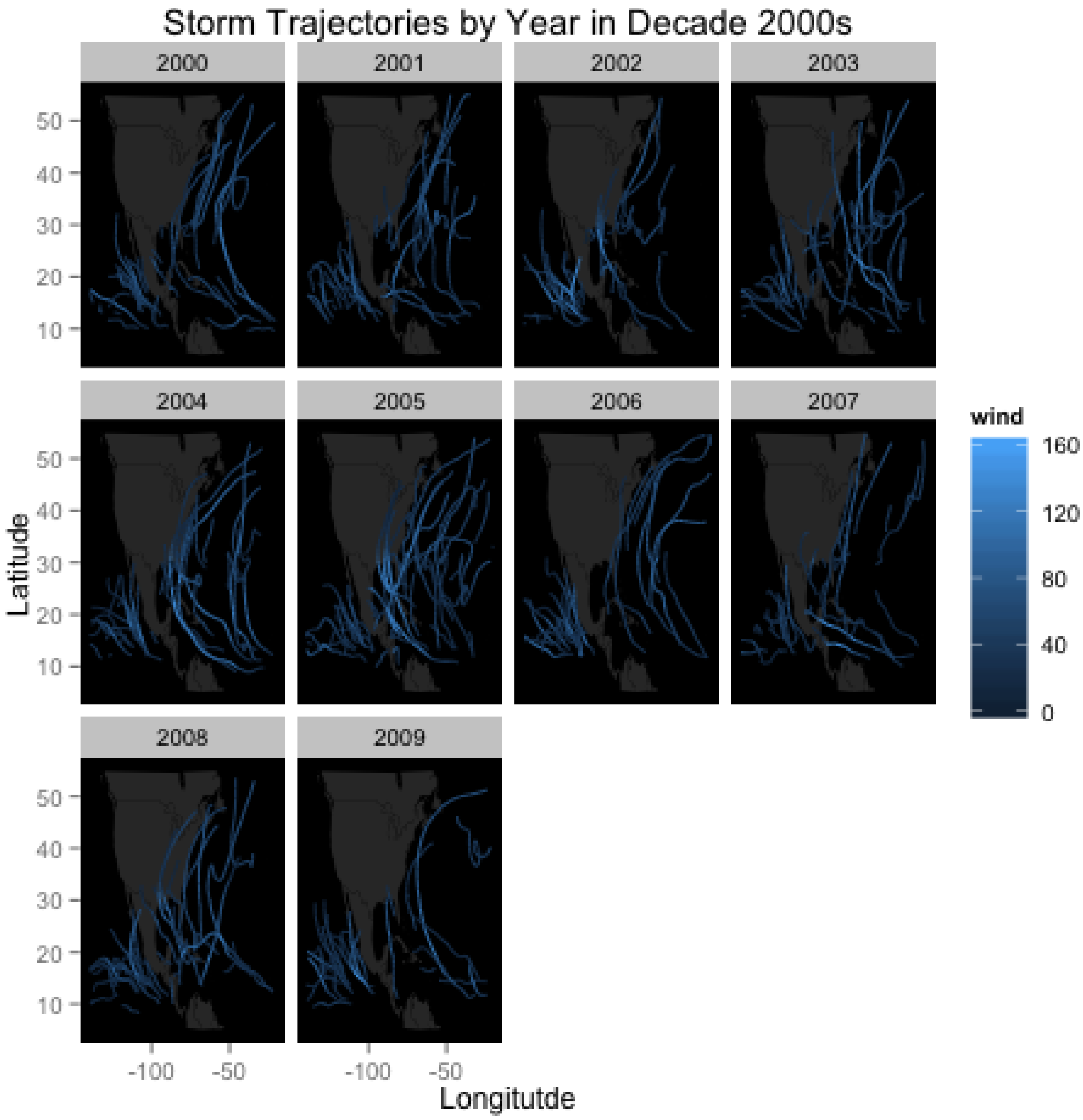

Storm Trajectories 1980-2010
Latitude
50
40
30
20
10
-100
-50
Longitutde
wind
160
120
80
40
0



Storm Trajectories by Month (1980-2010)
January
February
March
April
May
June
July
August
September
October
November
December
Latitude
50
40
30
20
10
-100
-50
Longitutde
wind
160
120
80
40
0


Storm Trajectories by Year in Decade 1980s
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
Latitude
50
40
30
20
10
-100
-50
Longitutde
wind
160
120
80
40
0


Storm Trajectories by Year in Decade 1990s
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
Latitude
50
40
30
20
10
-100
-50
Longitutde
wind
160
120
80
40
0



As we can see from the graphs, regardless of month or decade, trajectories of storms in the North Atlantic basin follow a general pattern of curving in towards the continent. In addition, the intensity of a storm (indicated by its wind speed) generally goes up as the storm move towards the continent and subsides as it moves away.

From monthly graph, we can also confirm our previous observation in Part 1 that storms concentrate around Autumn (August, September, and October).