DSPP - Hurricane Prediction

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Data Processing

```r
# load packages
library(HURDAT)
library(tidyverse)
library(lubridate)
library(ggplot2)
library(plotly)
library(ggthemes)
```

All Hurricanes Dataset

This is a dataset of 1873 hurricanes that have been recorded since 1851.

```r
# get hurricanes data using hurdat package
hurs_all <- get_hurdat("AL")
write_csv(hurs_all, "hurricanes_raw.csv")

# examine data
print("Here's a summary of each variable")
```

```
## [1] "Here's a summary of each variable"
```

```r
summary(hurs_all) # there are lots of NAs for everything after "Pressure" variable
```

```
##      Key                Name              DateTime
##  Length:51346       Length:51346       Min.   :1851-06-25 00:00:00
##  Class :character   Class :character   1st Qu.:1915-09-05 12:00:00
##  Mode  :character   Mode  :character   Median :1960-07-28 09:00:00
##                                        Mean   :1952-11-17 00:28:50
##                                        3rd Qu.:1992-09-27 00:00:00
##                                        Max.   :2018-11-04 12:00:00
##
##     Record             Status               Lat             Lon
##  Length:51346       Length:51346       Min.   : 7.20   Min.   :-109.50
##  Class :character   Class :character   1st Qu.:19.10   1st Qu.: -80.80
##  Mode  :character   Mode  :character   Median :26.60   Median : -67.50
##                                        Mean   :27.19   Mean   : -65.26
##                                        3rd Qu.:33.30   3rd Qu.: -51.90
##                                        Max.   :81.00   Max.   :  63.00
##
##      Wind            Pressure           NE34             SE34
##  Min.   : 10.00   Min.   : 882.0   Min.   : 10.0   Min.   : 10.0
##  1st Qu.: 35.00   1st Qu.: 984.0   1st Qu.: 70.0   1st Qu.: 60.0
##  Median : 45.00   Median : 999.0   Median :110.0   Median :100.0
##  Mean   : 52.96   Mean   : 992.2   Mean   :126.3   Mean   :123.7
##  3rd Qu.: 70.00   3rd Qu.:1006.0   3rd Qu.:160.0   3rd Qu.:150.0
##  Max.   :165.00   Max.   :1024.0   Max.   :780.0   Max.   :600.0
```

```
##  NA's   :338        NA's   :30960      NA's    :46276    NA's    :46535
##      SW34            NW34              NE50              SE50
##  Min.   : 10.0   Min.   : 10.0   Min.   :  5.00   Min.    :  5.0
##  1st Qu.: 45.0   1st Qu.: 50.0   1st Qu.: 40.00   1st Qu.: 30.0
##  Median : 80.0   Median : 90.0   Median : 60.00   Median : 60.0
##  Mean   :102.3   Mean   :107.7   Mean   : 66.71   Mean    : 67.2
##  3rd Qu.:125.0   3rd Qu.:140.0   3rd Qu.: 90.00   3rd Qu.: 90.0
##  Max.   :660.0   Max.   :600.0   Max.   :360.00   Max.    :300.0
##  NA's   :47554   NA's   :46956   NA's   :48456    NA's    :48640
##      SW50            NW50              NE64              SE64
##  Min.   : 10.00   Min.   : 10.00   Min.   : 10.00   Min.    : 10.00
##  1st Qu.: 30.00   1st Qu.: 30.00   1st Qu.: 20.00   1st Qu.: 20.00
##  Median : 45.00   Median : 50.00   Median : 30.00   Median : 30.00
##  Mean   : 55.21   Mean   : 59.08   Mean   : 38.62   Mean    : 37.56
##  3rd Qu.: 70.00   3rd Qu.: 75.00   3rd Qu.: 50.00   3rd Qu.: 50.00
##  Max.   :330.00   Max.   :360.00   Max.   :180.00   Max.    :250.00
##  NA's   :49107   NA's   :48863    NA's   :49721    NA's    :49773
##      SW64            NW64
##  Min.   :  5.00   Min.   : 10.00
##  1st Qu.: 15.00   1st Qu.: 20.00
##  Median : 25.00   Median : 30.00
##  Mean   : 30.11   Mean   : 35.11
##  3rd Qu.: 40.00   3rd Qu.: 45.00
##  Max.   :180.00   Max.   :300.00
##  NA's   :49978   NA's   :49935
```

```r
hurs_all <- hurs_all %>% arrange(Key)

# get separate date, year, month, day, and hour variables
hurs_all$Date <- date(hurs_all$DateTime)
hurs_all$Year <- year(hurs_all$DateTime)
hurs_all$Month <- month(hurs_all$DateTime)
hurs_all$Day <- day(hurs_all$DateTime)
hurs_all$Hour <- hour(hurs_all$DateTime)

hurs_all <- hurs_all[, c(1:3, 22:26, 4:21)]

# recode Record and Status variables
hurs_all <- hurs_all %>%
  mutate(Record = recode(Record, "L" = "Landfall")) %>%
  mutate(Status = recode(Status,
                         "TD" = "Tropical depression (<34 knots)",
                         "TS" = "Tropical storm (34-63 knots)",
                         "HU" = "Tropical Hurricane (>= 64 knots)",
                         "EX" = "Extratropical cyclone",
                         "SD" = "Subtropical depression (<34 knots)",
                         "SS" = "Subtropical storm (>= 34 knots)",
                         "LO" = "Low",
                         "WV" = "Tropical Wave",
                         "DB" = "Disturbance"
                         ))

# tabulate Record and Status variables
print("Tabulation of Record and Status variables")
```

```
## [1] "Tabulation of Record and Status variables"
```

```r
table(hurs_all$Record, useNA="always")
```

```
##
##       C       G       I Landfall       P       R       S       T
##       5       1      28    1003      10       6       7       8
##       W    <NA>
##       4   50274
```

```r
table(hurs_all$Status, useNA="always")
```

```
##
##                    Disturbance                                      ET
##                            149                                       1
##            Extratropical cyclone                                    Low
##                           5346                                    1205
## Subtropical depression (<34 knots)    Subtropical storm (>= 34 knots)
##                            305                                     606
##    Tropical depression (<34 knots)    Tropical Hurricane (>= 64 knots)
##                           9998                                   14940
##       Tropical storm (34-63 knots)                       Tropical Wave
##                          18658                                     138
##                           <NA>
##                              0
```

```r
# view final dataset
head(hurs_all, 10)
```

```
##          Key     Name          DateTime          Date Year Month Day Hour      Record
## 1   AL011851 UNNAMED 1851-06-25 00:00:00 1851-06-25 1851     6  25    0      <NA>
## 2   AL011851 UNNAMED 1851-06-25 06:00:00 1851-06-25 1851     6  25    6      <NA>
## 3   AL011851 UNNAMED 1851-06-25 12:00:00 1851-06-25 1851     6  25   12      <NA>
## 4   AL011851 UNNAMED 1851-06-25 18:00:00 1851-06-25 1851     6  25   18      <NA>
## 5   AL011851 UNNAMED 1851-06-25 21:00:00 1851-06-25 1851     6  25   21 Landfall
## 6   AL011851 UNNAMED 1851-06-26 00:00:00 1851-06-26 1851     6  26    0      <NA>
## 7   AL011851 UNNAMED 1851-06-26 06:00:00 1851-06-26 1851     6  26    6      <NA>
## 8   AL011851 UNNAMED 1851-06-26 12:00:00 1851-06-26 1851     6  26   12      <NA>
## 9   AL011851 UNNAMED 1851-06-26 18:00:00 1851-06-26 1851     6  26   18      <NA>
## 10  AL011851 UNNAMED 1851-06-27 00:00:00 1851-06-27 1851     6  27    0      <NA>
##                               Status  Lat   Lon Wind Pressure NE34 SE34 SW34
## 1   Tropical Hurricane (>= 64 knots) 28.0 -94.8   80       NA   NA   NA   NA
## 2   Tropical Hurricane (>= 64 knots) 28.0 -95.4   80       NA   NA   NA   NA
## 3   Tropical Hurricane (>= 64 knots) 28.0 -96.0   80       NA   NA   NA   NA
## 4   Tropical Hurricane (>= 64 knots) 28.1 -96.5   80       NA   NA   NA   NA
## 5   Tropical Hurricane (>= 64 knots) 28.2 -96.8   80       NA   NA   NA   NA
## 6   Tropical Hurricane (>= 64 knots) 28.2 -97.0   70       NA   NA   NA   NA
## 7       Tropical storm (34-63 knots) 28.3 -97.6   60       NA   NA   NA   NA
## 8       Tropical storm (34-63 knots) 28.4 -98.3   60       NA   NA   NA   NA
## 9       Tropical storm (34-63 knots) 28.6 -98.9   50       NA   NA   NA   NA
## 10      Tropical storm (34-63 knots) 29.0 -99.4   50       NA   NA   NA   NA
##    NW34 NE50 SE50 SW50 NW50 NE64 SE64 SW64 NW64
## 1    NA   NA   NA   NA   NA   NA   NA   NA   NA
## 2    NA   NA   NA   NA   NA   NA   NA   NA   NA
## 3    NA   NA   NA   NA   NA   NA   NA   NA   NA
## 4    NA   NA   NA   NA   NA   NA   NA   NA   NA
```

```
## 5      NA    NA    NA    NA    NA    NA    NA    NA    NA
## 6      NA    NA    NA    NA    NA    NA    NA    NA    NA
## 7      NA    NA    NA    NA    NA    NA    NA    NA    NA
## 8      NA    NA    NA    NA    NA    NA    NA    NA    NA
## 9      NA    NA    NA    NA    NA    NA    NA    NA    NA
## 10     NA    NA    NA    NA    NA    NA    NA    NA    NA
```

```r
# save data with all hurricanes
write_csv(hurs_all, "hurricanes.csv")
```

Landfall Hurricanes Dataset

This is a dataset of 642 hurricanes that have reached land (center of system crossing a coastline)

```r
# create dataset with hurricanes that reached land
landfall_list <- hurs_all[hurs_all$Record=="Landfall", 1]
hurs_landfall <- hurs_all[hurs_all$Key %in% landfall_list, ]
head(hurs_landfall, 10)
```

```
##          Key    Name              DateTime        Date Year Month Day Hour    Record
## 1  AL011851 UNNAMED 1851-06-25 00:00:00 1851-06-25 1851     6  25    0      <NA>
## 2  AL011851 UNNAMED 1851-06-25 06:00:00 1851-06-25 1851     6  25    6      <NA>
## 3  AL011851 UNNAMED 1851-06-25 12:00:00 1851-06-25 1851     6  25   12      <NA>
## 4  AL011851 UNNAMED 1851-06-25 18:00:00 1851-06-25 1851     6  25   18      <NA>
## 5  AL011851 UNNAMED 1851-06-25 21:00:00 1851-06-25 1851     6  25   21 Landfall
## 6  AL011851 UNNAMED 1851-06-26 00:00:00 1851-06-26 1851     6  26    0      <NA>
## 7  AL011851 UNNAMED 1851-06-26 06:00:00 1851-06-26 1851     6  26    6      <NA>
## 8  AL011851 UNNAMED 1851-06-26 12:00:00 1851-06-26 1851     6  26   12      <NA>
## 9  AL011851 UNNAMED 1851-06-26 18:00:00 1851-06-26 1851     6  26   18      <NA>
## 10 AL011851 UNNAMED 1851-06-27 00:00:00 1851-06-27 1851     6  27    0      <NA>
##                               Status  Lat   Lon Wind Pressure NE34 SE34 SW34
## 1  Tropical Hurricane (>= 64 knots) 28.0 -94.8   80       NA   NA   NA   NA
## 2  Tropical Hurricane (>= 64 knots) 28.0 -95.4   80       NA   NA   NA   NA
## 3  Tropical Hurricane (>= 64 knots) 28.0 -96.0   80       NA   NA   NA   NA
## 4  Tropical Hurricane (>= 64 knots) 28.1 -96.5   80       NA   NA   NA   NA
## 5  Tropical Hurricane (>= 64 knots) 28.2 -96.8   80       NA   NA   NA   NA
## 6  Tropical Hurricane (>= 64 knots) 28.2 -97.0   70       NA   NA   NA   NA
## 7      Tropical storm (34-63 knots) 28.3 -97.6   60       NA   NA   NA   NA
## 8      Tropical storm (34-63 knots) 28.4 -98.3   60       NA   NA   NA   NA
## 9      Tropical storm (34-63 knots) 28.6 -98.9   50       NA   NA   NA   NA
## 10     Tropical storm (34-63 knots) 29.0 -99.4   50       NA   NA   NA   NA
##    NW34 NE50 SE50 SW50 NW50 NE64 SE64 SW64 NW64
## 1    NA   NA   NA   NA   NA   NA   NA   NA   NA
## 2    NA   NA   NA   NA   NA   NA   NA   NA   NA
## 3    NA   NA   NA   NA   NA   NA   NA   NA   NA
## 4    NA   NA   NA   NA   NA   NA   NA   NA   NA
## 5    NA   NA   NA   NA   NA   NA   NA   NA   NA
## 6    NA   NA   NA   NA   NA   NA   NA   NA   NA
## 7    NA   NA   NA   NA   NA   NA   NA   NA   NA
## 8    NA   NA   NA   NA   NA   NA   NA   NA   NA
## 9    NA   NA   NA   NA   NA   NA   NA   NA   NA
## 10   NA   NA   NA   NA   NA   NA   NA   NA   NA
```

```r
# save data with hurricanes that reached land
write_csv(hurs_landfall, "landfall_hurricanes.csv")
```

Hurricane Dataset with Select Variables

This is a dataset that does not include variables that are mostly missing, with the exception of the "Pressure" variable, which is mostly non-missing starting at around 1980, and the "Record" variable, which flags hurricanes that have reached land.

```r
# how many NA's are there for each variable?
print("for all data")
```

```
## [1] "for all data"
```

```r
dim(hurs_all)
```

```
## [1] 51346    26
```

```r
apply(hurs_all, 2, function(x) sum(is.na(x)))
```

```
##      Key     Name DateTime     Date     Year    Month      Day     Hour
##        0        0        0        0        0        0        0        0
##   Record   Status      Lat      Lon     Wind Pressure     NE34     SE34
##    50274        0        0        0      338    30960    46276    46535
##     SW34     NW34     NE50     SE50     SW50     NW50     NE64     SE64
##    47554    46956    48456    48640    49107    48863    49721    49773
##     SW64     NW64
##    49978    49935
```

```r
print("for all data since 1980")
```

```
## [1] "for all data since 1980"
```

```r
hurs_since_1980 <- hurs_all %>% filter(DateTime > "1980-01-01 12:00:00")
dim(hurs_since_1980)
```

```
## [1] 17260    26
```

```r
apply(hurs_since_1980, 2, function(x) sum(is.na(x)))
```

```
##      Key     Name DateTime     Date     Year    Month      Day     Hour
##        0        0        0        0        0        0        0        0
##   Record   Status      Lat      Lon     Wind Pressure     NE34     SE34
##    16778        0        0        0       17      861    12190    12449
##     SW34     NW34     NE50     SE50     SW50     NW50     NE64     SE64
##    13468    12870    14370    14554    15021    14777    15635    15687
##     SW64     NW64
##    15892    15849
```

```r
# create dataset that excludes variables with majority missing data
# keep "Pressure", which has missing values mostly for dates before 1980
# keep "Record" in case we want to do analysis regarding landfall

hurs_select_vars <- hurs_all[,c(1:14)]
head(hurs_select_vars, 10)
```

```
##         Key     Name            DateTime       Date Year Month Day Hour   Record
## 1  AL011851 UNNAMED 1851-06-25 00:00:00 1851-06-25 1851     6  25    0     <NA>
## 2  AL011851 UNNAMED 1851-06-25 06:00:00 1851-06-25 1851     6  25    6     <NA>
## 3  AL011851 UNNAMED 1851-06-25 12:00:00 1851-06-25 1851     6  25   12     <NA>
## 4  AL011851 UNNAMED 1851-06-25 18:00:00 1851-06-25 1851     6  25   18     <NA>
## 5  AL011851 UNNAMED 1851-06-25 21:00:00 1851-06-25 1851     6  25   21 Landfall
## 6  AL011851 UNNAMED 1851-06-26 00:00:00 1851-06-26 1851     6  26    0     <NA>
```

```
## 7  AL011851 UNNAMED 1851-06-26 06:00:00 1851-06-26 1851      6  26    6        <NA>
## 8  AL011851 UNNAMED 1851-06-26 12:00:00 1851-06-26 1851      6  26   12        <NA>
## 9  AL011851 UNNAMED 1851-06-26 18:00:00 1851-06-26 1851      6  26   18        <NA>
## 10 AL011851 UNNAMED 1851-06-27 00:00:00 1851-06-27 1851      6  27    0        <NA>
##                            Status  Lat   Lon Wind Pressure
## 1  Tropical Hurricane (>= 64 knots) 28.0 -94.8   80       NA
## 2  Tropical Hurricane (>= 64 knots) 28.0 -95.4   80       NA
## 3  Tropical Hurricane (>= 64 knots) 28.0 -96.0   80       NA
## 4  Tropical Hurricane (>= 64 knots) 28.1 -96.5   80       NA
## 5  Tropical Hurricane (>= 64 knots) 28.2 -96.8   80       NA
## 6  Tropical Hurricane (>= 64 knots) 28.2 -97.0   70       NA
## 7       Tropical storm (34-63 knots) 28.3 -97.6   60       NA
## 8       Tropical storm (34-63 knots) 28.4 -98.3   60       NA
## 9       Tropical storm (34-63 knots) 28.6 -98.9   50       NA
## 10      Tropical storm (34-63 knots) 29.0 -99.4   50       NA
```

```r
write_csv(hurs_select_vars, "hurricanes_select_vars.csv")
```

Hurricane Sandy (AL182012)

Here's the data related to hurricane Sandy

```r
# get data related to hurricane Sandy
hur_sandy <- hurs_all %>% filter(Year ==2012, Name == "SANDY")
head(hur_sandy, 10)
```

```
##         Key  Name           DateTime       Date Year Month Day Hour Record
## 1  AL182012 SANDY 2012-10-21 18:00:00 2012-10-21 2012    10  21   18   <NA>
## 2  AL182012 SANDY 2012-10-22 00:00:00 2012-10-22 2012    10  22    0   <NA>
## 3  AL182012 SANDY 2012-10-22 06:00:00 2012-10-22 2012    10  22    6   <NA>
## 4  AL182012 SANDY 2012-10-22 12:00:00 2012-10-22 2012    10  22   12   <NA>
## 5  AL182012 SANDY 2012-10-22 18:00:00 2012-10-22 2012    10  22   18   <NA>
## 6  AL182012 SANDY 2012-10-23 00:00:00 2012-10-23 2012    10  23    0   <NA>
## 7  AL182012 SANDY 2012-10-23 06:00:00 2012-10-23 2012    10  23    6   <NA>
## 8  AL182012 SANDY 2012-10-23 12:00:00 2012-10-23 2012    10  23   12   <NA>
## 9  AL182012 SANDY 2012-10-23 18:00:00 2012-10-23 2012    10  23   18   <NA>
## 10 AL182012 SANDY 2012-10-24 00:00:00 2012-10-24 2012    10  24    0   <NA>
##                            Status  Lat   Lon Wind Pressure NE34 SE34 SW34 NW34
## 1                             Low 14.3 -77.4   25     1006   NA   NA   NA   NA
## 2                             Low 13.9 -77.8   25     1005   NA   NA   NA   NA
## 3                             Low 13.5 -78.2   25     1003   NA   NA   NA   NA
## 4   Tropical depression (<34 knots) 13.1 -78.6   30     1002   NA   NA   NA   NA
## 5       Tropical storm (34-63 knots) 12.7 -78.7   35     1000   50   60   NA   NA
## 6       Tropical storm (34-63 knots) 12.6 -78.4   40      998   50   60   NA   NA
## 7       Tropical storm (34-63 knots) 12.9 -78.1   40      998   70   80   NA   NA
## 8       Tropical storm (34-63 knots) 13.4 -77.9   40      995  100  100   NA   NA
## 9       Tropical storm (34-63 knots) 14.0 -77.6   45      993  100  120   NA   NA
## 10      Tropical storm (34-63 knots) 14.7 -77.3   55      990  100  150   40   40
##    NE50 SE50 SW50 NW50 NE64 SE64 SW64 NW64
## 1    NA   NA   NA   NA   NA   NA   NA   NA
## 2    NA   NA   NA   NA   NA   NA   NA   NA
## 3    NA   NA   NA   NA   NA   NA   NA   NA
## 4    NA   NA   NA   NA   NA   NA   NA   NA
## 5    NA   NA   NA   NA   NA   NA   NA   NA
## 6    NA   NA   NA   NA   NA   NA   NA   NA
```

```
## 7    NA    NA    NA    NA    NA    NA    NA    NA
## 8    NA    NA    NA    NA    NA    NA    NA    NA
## 9    NA    NA    NA    NA    NA    NA    NA    NA
## 10   NA    70    NA    NA    NA    NA    NA    NA
```

```r
max(hur_sandy$Wind, na.rm=TRUE)
```

```
## [1] 100
```

```r
min(hur_sandy$Pressure, na.rm=TRUE)
```

```
## [1] 940
```

Hurricane Sandy lasted 10 days at the end of October 2012, peaking in wind speed on October 25th, at 100 knots, with a second peak on the 29th at 85 knots.

The pattern for wind pressure looks similar to the wind speed, where low pressure is an indicator of an intense hurricane. The lowest pressure of the hurricane occured October 29th, at 940 millibars of pressure. The second lowest occured October 25th, at 954 millibars.

```r
graph <- ggplot(hur_sandy, aes(x = DateTime, y = Wind)) +
  geom_line(color="black") +
  geom_point(size = 1.8, shape = 19, color = "black", alpha = 0.7) +
  theme(legend.position = "top") +
  labs(x="Date", y="Wind Speed (Knots)") +
  ggtitle("Hurricane Sandy - Wind Speed Over Time") +
  theme_hc() + theme(axis.text.x = element_text(angle = 90, hjust = 1))

ggplotly(graph, tooltip = c("x", "y"), dynamicTicks=TRUE)
```

```
## PhantomJS not found. You can install it with webshot::install_phantomjs(). If it is installed, pleas
```

```r
graph <- ggplot(hur_sandy, aes(x = DateTime, y = Pressure)) +
  geom_line(color="black") +
  geom_point(size = 1.8, shape = 19, color = "black", alpha = 0.7) +
  theme(legend.position = "top") +
  labs(x="Date", y="Pressure (Millibars)") +
  ggtitle("Hurricane Sandy - Pressure Over Time") +
  theme_hc() + theme(axis.text.x = element_text(angle = 90, hjust = 1))

ggplotly(graph, tooltip = c("x", "y"), dynamicTicks=TRUE)
```

Longest-Lasting Hurricane (AL031899)

AL031899 is the longest-lasting hurricane. It lasted a month on August 1899. It had a peak wind speed of 130.

```r
# find the longest-lasting hurricane
head(hurs_all %>% group_by(Key, Year) %>% summarise(count=n()) %>% arrange(-count), 10)
```

```
## # A tibble: 10 x 3
## # Groups:   Key [10]
##    Key        Year count
##    <chr>     <dbl> <int>
##  1 AL031899  1899   133
##  2 AL141971  1971   118
##  3 AL201969  1969    99
##  4 AL142012  2012    96
```

```
##  5 AL041926  1926     95
##  6 AL041957  1957     95
##  7 AL092004  2004     94
##  8 AL051964  1964     92
##  9 AL122002  2002     90
## 10 AL132018  2018     89
```

```r
# get data related to this hurricane (AL031899)
hur_AL031899 <- hurs_all %>% filter(Key == "AL031899")
print("Max Wind:")
```

```
## [1] "Max Wind:"
```

```r
max(hur_AL031899$Wind, na.rm=TRUE)
```

```
## [1] 130
```

```r
print("Min Pressure:")
```

```
## [1] "Min Pressure:"
```

```r
min(hur_AL031899$Pressure, na.rm=TRUE)
```

```
## [1] 930
```

```r
head(hur_AL031899, 10)
```

```
##         Key    Name            DateTime       Date Year Month Day Hour Record
## 1  AL031899 UNNAMED 1899-08-03 00:00:00 1899-08-03 1899     8   3    0   <NA>
## 2  AL031899 UNNAMED 1899-08-03 06:00:00 1899-08-03 1899     8   3    6   <NA>
## 3  AL031899 UNNAMED 1899-08-03 12:00:00 1899-08-03 1899     8   3   12   <NA>
## 4  AL031899 UNNAMED 1899-08-03 18:00:00 1899-08-03 1899     8   3   18   <NA>
## 5  AL031899 UNNAMED 1899-08-04 00:00:00 1899-08-04 1899     8   4    0   <NA>
## 6  AL031899 UNNAMED 1899-08-04 06:00:00 1899-08-04 1899     8   4    6   <NA>
## 7  AL031899 UNNAMED 1899-08-04 12:00:00 1899-08-04 1899     8   4   12   <NA>
## 8  AL031899 UNNAMED 1899-08-04 18:00:00 1899-08-04 1899     8   4   18   <NA>
## 9  AL031899 UNNAMED 1899-08-05 00:00:00 1899-08-05 1899     8   5    0   <NA>
## 10 AL031899 UNNAMED 1899-08-05 06:00:00 1899-08-05 1899     8   5    6   <NA>
##                         Status  Lat   Lon Wind Pressure NE34 SE34 SW34 NW34
## 1  Tropical storm (34-63 knots) 11.7 -31.0   35       NA   NA   NA   NA   NA
## 2  Tropical storm (34-63 knots) 11.8 -32.4   45       NA   NA   NA   NA   NA
## 3  Tropical storm (34-63 knots) 12.0 -34.0   50       NA   NA   NA   NA   NA
## 4  Tropical storm (34-63 knots) 12.2 -35.7   55      995   NA   NA   NA   NA
## 5  Tropical storm (34-63 knots) 12.4 -37.4   60       NA   NA   NA   NA   NA
## 6  Tropical storm (34-63 knots) 12.6 -38.8   60       NA   NA   NA   NA   NA
## 7  Tropical storm (34-63 knots) 12.7 -40.3   60       NA   NA   NA   NA   NA
## 8  Tropical storm (34-63 knots) 13.0 -42.0   60       NA   NA   NA   NA   NA
## 9  Tropical storm (34-63 knots) 13.5 -44.0   60       NA   NA   NA   NA   NA
## 10 Tropical storm (34-63 knots) 13.7 -45.5   60       NA   NA   NA   NA   NA
##    NE50 SE50 SW50 NW50 NE64 SE64 SW64 NW64
## 1    NA   NA   NA   NA   NA   NA   NA   NA
## 2    NA   NA   NA   NA   NA   NA   NA   NA
## 3    NA   NA   NA   NA   NA   NA   NA   NA
## 4    NA   NA   NA   NA   NA   NA   NA   NA
## 5    NA   NA   NA   NA   NA   NA   NA   NA
## 6    NA   NA   NA   NA   NA   NA   NA   NA
## 7    NA   NA   NA   NA   NA   NA   NA   NA
## 8    NA   NA   NA   NA   NA   NA   NA   NA
```

```
## 9      NA      NA      NA      NA      NA      NA      NA      NA
## 10     NA      NA      NA      NA      NA      NA      NA      NA
```

```r
# plot wind and pressure over time
graph <- ggplot(hur_AL031899, aes(x = DateTime, y = Wind)) +
  geom_line(color="black") +
  geom_point(size = 1.8, shape = 19, color = "black", alpha = 0.7) +
  theme(legend.position = "top") +
  labs(x="Date", y="Wind Speed (Knots)") +
  ggtitle("Unnamed Hurricane (3rd in 1899) - Wind Speed Over Time") +
  theme_hc() + theme(axis.text.x = element_text(angle = 90, hjust = 1))

ggplotly(graph, tooltip = c("x", "y"), dynamicTicks=TRUE)
```

```r
# pressure data is mostly missing for this hurricane
graph <- ggplot(hur_AL031899, aes(x = DateTime, y = Pressure)) +
  geom_line(color="black") +
  geom_point(size = 1.8, shape = 19, color = "black", alpha = 0.7) +
  theme(legend.position = "top") +
  labs(x="Date", y="Pressure (Millibars)") +
  ggtitle("Unnamed Hurricane (3rd in 1899) - Pressure Over Time") +
  theme_hc() + theme(axis.text.x = element_text(angle = 90, hjust = 1))

ggplotly(graph, tooltip = c("x", "y"), dynamicTicks=TRUE)
```

Hurricane with the Highest Wind Speed (Allen - AL041980)

AL041980 had the highest wind speed. It lasted 12 days in August 1980, clearly peaking 3 times. It had a peak wind speed of 165 knots and a min pressure of 899 millibars.

```r
head(hurs_all %>% arrange(-Wind), 10)
```

```
##         Key     Name            DateTime       Date Year Month Day Hour   Record
## 1  AL041980    ALLEN 1980-08-07 18:00:00 1980-08-07 1980     8   7   18     <NA>
## 2  AL031935 UNNAMED 1935-09-03 00:00:00 1935-09-03 1935     9   3    0     <NA>
## 3  AL031935 UNNAMED 1935-09-03 02:00:00 1935-09-03 1935     9   3    2 Landfall
## 4  AL031935 UNNAMED 1935-09-03 06:00:00 1935-09-03 1935     9   3    6     <NA>
## 5  AL081988 GILBERT 1988-09-14 00:00:00 1988-09-14 1988     9  14    0     <NA>
## 6  AL252005   WILMA 2005-10-19 12:00:00 2005-10-19 2005    10  19   12     <NA>
## 7  AL041980    ALLEN 1980-08-05 12:00:00 1980-08-05 1980     8   5   12     <NA>
## 8  AL041980    ALLEN 1980-08-07 12:00:00 1980-08-07 1980     8   7   12     <NA>
## 9  AL041980    ALLEN 1980-08-08 00:00:00 1980-08-08 1980     8   8    0     <NA>
## 10 AL041980    ALLEN 1980-08-09 06:00:00 1980-08-09 1980     8   9    6     <NA>
##                              Status  Lat   Lon Wind Pressure NE34 SE34 SW34
## 1  Tropical Hurricane (>= 64 knots) 21.8 -86.4  165      899   NA   NA   NA
## 2  Tropical Hurricane (>= 64 knots) 24.6 -80.5  160      892   NA   NA   NA
## 3  Tropical Hurricane (>= 64 knots) 24.8 -80.8  160      892   NA   NA   NA
## 4  Tropical Hurricane (>= 64 knots) 25.1 -81.1  160       NA   NA   NA   NA
## 5  Tropical Hurricane (>= 64 knots) 19.7 -83.8  160      888   NA   NA   NA
## 6  Tropical Hurricane (>= 64 knots) 17.3 -82.8  160      882  170  125   90
## 7  Tropical Hurricane (>= 64 knots) 15.9 -70.5  155      932   NA   NA   NA
## 8  Tropical Hurricane (>= 64 knots) 21.0 -84.8  155      910   NA   NA   NA
## 9  Tropical Hurricane (>= 64 knots) 22.2 -87.9  155      920   NA   NA   NA
## 10 Tropical Hurricane (>= 64 knots) 25.0 -94.2  155      909   NA   NA   NA
##    NW34 NE50 SE50 SW50 NW50 NE64 SE64 SW64 NW64
```

```
## 1     NA    NA   NA   NA   NA   NA   NA   NA   NA
## 2     NA    NA   NA   NA   NA   NA   NA   NA   NA
## 3     NA    NA   NA   NA   NA   NA   NA   NA   NA
## 4     NA    NA   NA   NA   NA   NA   NA   NA   NA
## 5     NA    NA   NA   NA   NA   NA   NA   NA   NA
## 6    140    70   45   45   70   45   20   20   45
## 7     NA    NA   NA   NA   NA   NA   NA   NA   NA
## 8     NA    NA   NA   NA   NA   NA   NA   NA   NA
## 9     NA    NA   NA   NA   NA   NA   NA   NA   NA
## 10    NA    NA   NA   NA   NA   NA   NA   NA   NA
```

```r
# get data related to this hurricane (AL031899)
hur_AL041980 <- hurs_all %>% filter(Key == "AL041980")
print("Max Wind:")
```

```
## [1] "Max Wind:"
```

```r
max(hur_AL041980$Wind, na.rm=TRUE)
```

```
## [1] 165
```

```r
print("Min Pressure:")
```

```
## [1] "Min Pressure:"
```

```r
min(hur_AL041980$Pressure, na.rm=TRUE)
```

```
## [1] 899
```

```r
head(hur_AL041980, 10)
```

```
##         Key  Name           DateTime       Date Year Month Day Hour Record
## 1  AL041980 ALLEN 1980-07-31 12:00:00 1980-07-31 1980     7  31   12   <NA>
## 2  AL041980 ALLEN 1980-07-31 18:00:00 1980-07-31 1980     7  31   18   <NA>
## 3  AL041980 ALLEN 1980-08-01 00:00:00 1980-08-01 1980     8   1    0   <NA>
## 4  AL041980 ALLEN 1980-08-01 06:00:00 1980-08-01 1980     8   1    6   <NA>
## 5  AL041980 ALLEN 1980-08-01 12:00:00 1980-08-01 1980     8   1   12   <NA>
## 6  AL041980 ALLEN 1980-08-01 18:00:00 1980-08-01 1980     8   1   18   <NA>
## 7  AL041980 ALLEN 1980-08-02 00:00:00 1980-08-02 1980     8   2    0   <NA>
## 8  AL041980 ALLEN 1980-08-02 06:00:00 1980-08-02 1980     8   2    6   <NA>
## 9  AL041980 ALLEN 1980-08-02 12:00:00 1980-08-02 1980     8   2   12   <NA>
## 10 AL041980 ALLEN 1980-08-02 18:00:00 1980-08-02 1980     8   2   18   <NA>
##                          Status  Lat   Lon Wind Pressure NE34 SE34 SW34 NW34
## 1            Disturbance 11.0 -30.0   25       NA   NA   NA   NA   NA
## 2            Disturbance 10.9 -32.2   25       NA   NA   NA   NA   NA
## 3   Tropical depression (<34 knots) 10.8 -34.3   30     1010   NA   NA   NA   NA
## 4   Tropical depression (<34 knots) 10.7 -36.4   30     1009   NA   NA   NA   NA
## 5   Tropical depression (<34 knots) 10.7 -38.6   30     1008   NA   NA   NA   NA
## 6   Tropical depression (<34 knots) 10.7 -40.7   30     1006   NA   NA   NA   NA
## 7      Tropical storm (34-63 knots) 11.0 -42.8   35     1005   NA   NA   NA   NA
## 8      Tropical storm (34-63 knots) 11.4 -44.8   45     1000   NA   NA   NA   NA
## 9      Tropical storm (34-63 knots) 11.9 -46.9   55      995   NA   NA   NA   NA
## 10     Tropical storm (34-63 knots) 12.3 -49.1   60      990   NA   NA   NA   NA
##    NE50 SE50 SW50 NW50 NE64 SE64 SW64 NW64
## 1    NA   NA   NA   NA   NA   NA   NA   NA
## 2    NA   NA   NA   NA   NA   NA   NA   NA
## 3    NA   NA   NA   NA   NA   NA   NA   NA
## 4    NA   NA   NA   NA   NA   NA   NA   NA
```

```
## 5     NA    NA    NA    NA    NA    NA    NA    NA
## 6     NA    NA    NA    NA    NA    NA    NA    NA
## 7     NA    NA    NA    NA    NA    NA    NA    NA
## 8     NA    NA    NA    NA    NA    NA    NA    NA
## 9     NA    NA    NA    NA    NA    NA    NA    NA
## 10    NA    NA    NA    NA    NA    NA    NA    NA
```

```r
# plot wind and pressure over time
graph <- ggplot(hur_AL041980, aes(x = DateTime, y = Wind)) +
  geom_line(color="black") +
  geom_point(size = 1.8, shape = 19, color = "black", alpha = 0.7) +
  theme(legend.position = "top") +
  labs(x="Date", y="Wind Speed (Knots)") +
  ggtitle("Hurricane Allen (1980) - Wind Speed Over Time") +
  theme_hc() + theme(axis.text.x = element_text(angle = 90, hjust = 1))

ggplotly(graph, tooltip = c("x", "y"), dynamicTicks=TRUE)
```

```r
graph <- ggplot(hur_AL041980, aes(x = DateTime, y = Pressure)) +
  geom_line(color="black") +
  geom_point(size = 1.8, shape = 19, color = "black", alpha = 0.7) +
  theme(legend.position = "top") +
  labs(x="Date", y="Pressure (Millibars)") +
  ggtitle("Hurricane Allen (1980) - Pressure Over Time") +
  theme_hc() + theme(axis.text.x = element_text(angle = 90, hjust = 1))

ggplotly(graph, tooltip = c("x", "y"), dynamicTicks=TRUE)
```

Hurricane with the Lowest Pressure (AL252005)

AL252005 (Wilma) had the lowest min pressure. It lasted 12 days in October 2005, clearly peaking 3 times.
It had a peak wind speed of 160 knots and a min pressure of 882 millibars.

```r
head(hurs_all %>% arrange(Pressure), 10)
```

```
##         Key    Name            DateTime       Date Year Month Day Hour    Record
## 1  AL252005   WILMA 2005-10-19 12:00:00 2005-10-19 2005    10  19   12      <NA>
## 2  AL081988 GILBERT 1988-09-14 00:00:00 1988-09-14 1988     9  14    0      <NA>
## 3  AL081988 GILBERT 1988-09-14 06:00:00 1988-09-14 1988     9  14    6      <NA>
## 4  AL031935 UNNAMED 1935-09-03 00:00:00 1935-09-03 1935     9   3    0      <NA>
## 5  AL031935 UNNAMED 1935-09-03 02:00:00 1935-09-03 1935     9   3    2  Landfall
## 6  AL081988 GILBERT 1988-09-14 12:00:00 1988-09-14 1988     9  14   12      <NA>
## 7  AL252005   WILMA 2005-10-19 06:00:00 2005-10-19 2005    10  19    6      <NA>
## 8  AL252005   WILMA 2005-10-19 18:00:00 2005-10-19 2005    10  19   18      <NA>
## 9  AL252005   WILMA 2005-10-20 00:00:00 2005-10-20 2005    10  20    0      <NA>
## 10 AL182005    RITA 2005-09-22 03:00:00 2005-09-22 2005     9  22    3         I
##                                Status  Lat   Lon Wind Pressure NE34 SE34 SW34
## 1  Tropical Hurricane (>= 64 knots) 17.3 -82.8  160      882  170  125   90
## 2  Tropical Hurricane (>= 64 knots) 19.7 -83.8  160      888   NA   NA   NA
## 3  Tropical Hurricane (>= 64 knots) 19.9 -85.3  155      889   NA   NA   NA
## 4  Tropical Hurricane (>= 64 knots) 24.6 -80.5  160      892   NA   NA   NA
## 5  Tropical Hurricane (>= 64 knots) 24.8 -80.8  160      892   NA   NA   NA
## 6  Tropical Hurricane (>= 64 knots) 20.4 -86.5  145      892   NA   NA   NA
## 7  Tropical Hurricane (>= 64 knots) 17.0 -82.2  150      892  140   90   90
## 8  Tropical Hurricane (>= 64 knots) 17.4 -83.4  140      892  200  200  100
```

```
## 9  Tropical Hurricane (>= 64 knots) 17.9 -84.0  135       892  200  200  110
## 10 Tropical Hurricane (>= 64 knots) 24.7 -87.3  155       895   NA   NA   NA
##     NW34 NE50 SE50 SW50 NW50 NE64 SE64 SW64 NW64
## 1    140   70   45   45   70   45   20   20   45
## 2     NA   NA   NA   NA   NA   NA   NA   NA   NA
## 3     NA   NA   NA   NA   NA   NA   NA   NA   NA
## 4     NA   NA   NA   NA   NA   NA   NA   NA   NA
## 5     NA   NA   NA   NA   NA   NA   NA   NA   NA
## 6     NA   NA   NA   NA   NA   NA   NA   NA   NA
## 7    140   60   30   30   60   30   15   15   30
## 8    150   75   60   60   75   50   40   40   50
## 9    150   75   75   60   75   60   40   40   60
## 10    NA   NA   NA   NA   NA   NA   NA   NA   NA
```

```r
# get data related to this hurricane (AL031899)
hur_AL252005 <- hurs_all %>% filter(Key == "AL252005")
print("Max Wind:")
```

```
## [1] "Max Wind:"
```

```r
max(hur_AL252005$Wind, na.rm=TRUE)
```

```
## [1] 160
```

```r
print("Min Pressure:")
```

```
## [1] "Min Pressure:"
```

```r
min(hur_AL252005$Pressure, na.rm=TRUE)
```

```
## [1] 882
```

```r
head(hur_AL252005, 10)
```

```
##          Key  Name            DateTime       Date Year Month Day Hour Record
## 1  AL252005 WILMA 2005-10-15 18:00:00 2005-10-15 2005    10  15   18   <NA>
## 2  AL252005 WILMA 2005-10-16 00:00:00 2005-10-16 2005    10  16    0   <NA>
## 3  AL252005 WILMA 2005-10-16 06:00:00 2005-10-16 2005    10  16    6   <NA>
## 4  AL252005 WILMA 2005-10-16 12:00:00 2005-10-16 2005    10  16   12   <NA>
## 5  AL252005 WILMA 2005-10-16 18:00:00 2005-10-16 2005    10  16   18   <NA>
## 6  AL252005 WILMA 2005-10-17 00:00:00 2005-10-17 2005    10  17    0   <NA>
## 7  AL252005 WILMA 2005-10-17 06:00:00 2005-10-17 2005    10  17    6   <NA>
## 8  AL252005 WILMA 2005-10-17 12:00:00 2005-10-17 2005    10  17   12   <NA>
## 9  AL252005 WILMA 2005-10-17 18:00:00 2005-10-17 2005    10  17   18   <NA>
## 10 AL252005 WILMA 2005-10-18 00:00:00 2005-10-18 2005    10  18    0   <NA>
##                             Status  Lat   Lon Wind Pressure NE34 SE34 SW34 NW34
## 1  Tropical depression (<34 knots) 17.6 -78.5   25     1004   NA   NA   NA   NA
## 2  Tropical depression (<34 knots) 17.6 -78.8   25     1004   NA   NA   NA   NA
## 3  Tropical depression (<34 knots) 17.5 -79.0   30     1003   NA   NA   NA   NA
## 4  Tropical depression (<34 knots) 17.5 -79.2   30     1003   NA   NA   NA   NA
## 5  Tropical depression (<34 knots) 17.5 -79.4   30     1002   NA   NA   NA   NA
## 6  Tropical depression (<34 knots) 17.4 -79.6   30     1001   NA   NA   NA   NA
## 7      Tropical storm (34-63 knots) 16.9 -79.6   35     1000   NA   NA   40   NA
## 8      Tropical storm (34-63 knots) 16.3 -79.7   40      999   NA   60   40   NA
## 9      Tropical storm (34-63 knots) 16.0 -79.8   45      997   30   60   60   30
## 10     Tropical storm (34-63 knots) 15.8 -79.9   55      988   60   60   60   60
##    NE50 SE50 SW50 NW50 NE64 SE64 SW64 NW64
## 1    NA   NA   NA   NA   NA   NA   NA   NA
```

```
## 2     NA    NA    NA    NA    NA    NA    NA    NA
## 3     NA    NA    NA    NA    NA    NA    NA    NA
## 4     NA    NA    NA    NA    NA    NA    NA    NA
## 5     NA    NA    NA    NA    NA    NA    NA    NA
## 6     NA    NA    NA    NA    NA    NA    NA    NA
## 7     NA    NA    NA    NA    NA    NA    NA    NA
## 8     NA    NA    NA    NA    NA    NA    NA    NA
## 9     NA    NA    NA    NA    NA    NA    NA    NA
## 10    20    20    20    20    NA    NA    NA    NA
```

```r
# plot wind and pressure over time
graph <- ggplot(hur_AL252005, aes(x = DateTime, y = Wind)) +
  geom_line(color="black") +
  geom_point(size = 1.8, shape = 19, color = "black", alpha = 0.7) +
  theme(legend.position = "top") +
  labs(x="Date", y="Wind Speed (Knots)") +
  ggtitle("Hurricane AL031899 - Wind Speed Over Time") +
  theme_hc() + theme(axis.text.x = element_text(angle = 90, hjust = 1))

ggplotly(graph, tooltip = c("x", "y"), dynamicTicks=TRUE)
```

```r
graph <- ggplot(hur_AL252005, aes(x = DateTime, y = Pressure)) +
  geom_line(color="black") +
  geom_point(size = 1.8, shape = 19, color = "black", alpha = 0.7) +
  theme(legend.position = "top") +
  labs(x="Date", y="Pressure (Millibars)") +
  ggtitle("Hurricane Wilma (2005) - Pressure Over Time") +
  theme_hc() + theme(axis.text.x = element_text(angle = 90, hjust = 1))

ggplotly(graph, tooltip = c("x", "y"), dynamicTicks=TRUE)
```

Are Hurricanes More or Less Severe Over Time?

How many "Tropical Hurricanes" have there been per decade?

How many hurricanes with wind speeds higher or equal to Sandy have there been per decade?