Health and Economic Impact of Weather Events in the US

Storms and other severe weather events can cause both public health and economic problems for communities and municipalities. Many severe events can result in fatalities, injuries, and property damage, and preventing such outcomes to the extent possible is a key concern.

This project involves exploring the U.S. National Oceanic and Atmospheric Administration's (NOAA) storm database. This database tracks characteristics of major storms and weather events in the United States, including when and where they occur, as well as estimates of any fatalities, injuries, and property damage.

Synopsis

The analysis on the storm event database revealed that tornadoes are the most dangerous weather event to the population health. The second most dangerous event type is the excessive heat. The economic impact of weather events was also analyzed. Flash floods and thunderstorm winds caused billions of dollars in property damages between 1950 and 2011. The largest crop damage caused by drought, followed by flood and hails.

Data Processing

The analysis was performed on Storm Events Database (http://www.ncdc.noaa.gov/stormevents/ftp.jsp), provided by National Climatic Data Center (http://www.ncdc.noaa.gov/). The data is from a comma-separated-value file available here (https://d396qusza40orc.cloudfront.net/repdata%2Fdata%2FStormData.csv.bz2). There is also some documentation of the data available here (https://d396qusza40orc.cloudfront.net /repdata%2Fpeer2_doc%2Fpd01016005curr.pdf).

The first step is to read the data into a data frame.

```
storm <- read.csv(bzfile("data/repdata-data-StormData.csv.bz2"))
```

Before the analysis, the data need some preprocessing. Event types don't have a specific format. For instance, there are events with types `Frost/Freeze`, `FROST/FREEZE` and `FROST\\FREEZE` which obviously refer to the same type of event.

```
# number of unique event types
length(unique(storm$EVTYPE))
```

```
## [1] 985
```

```
# translate all letters to lowercase
event_types <- tolower(storm$EVTYPE)
# replace all punct. characters with a space
event_types <- gsub("[[:blank:][:punct:]+]", " ", event_types)
length(unique(event_types))
```

```
## [1] 874
```

```
# update the data frame
storm$EVTYPE <- event_types
```

No further data preprocessing was performed although the event type field can be processed further to merge event types such as `tstm wind` and `thunderstorm wind`. After the cleaning, as expected, the number of unique event types reduce significantly. For further analysis, the cleaned event types are used.

Dangerous Events with respect to Population Health

To find the event types that are most harmful to population health, the number of casualties are aggregated by the event type.

```
library(plyr)
casualties <- ddply(storm, .(EVTYPE), summarize,
                    fatalities = sum(FATALITIES),
                    injuries = sum(INJURIES))

# Find events that caused most death and injury
fatal_events <- head(casualties[order(casualties$fatalities, decreasing = T), ], 10)
injury_events <- head(casualties[order(casualties$injuries, decreasing = T), ], 10)
```

Top 10 events that caused largest number of deaths are

```
fatal_events[, c("EVTYPE", "fatalities")]
```

```
##              EVTYPE fatalities
## 737         tornado       5633
## 109 excessive heat       1903
## 132     flash flood        978
## 234            heat        937
## 400       lightning        816
## 760       tstm wind        504
## 148           flood        470
## 511     rip current        368
## 309       high wind        248
## 11        avalanche        224
```

Top 10 events that caused most number of injuries are

```
injury_events[, c("EVTYPE", "injuries")]
```

```
##                EVTYPE injuries
## 737           tornado    91346
## 760         tstm wind     6957
## 148             flood     6789
## 109    excessive heat     6525
## 400         lightning     5230
## 234              heat     2100
## 377         ice storm     1975
## 132       flash flood     1777
## 670 thunderstorm wind     1488
## 203              hail     1361
```

Economic Effects of Weather Events

To analyze the impact of weather events on the economy, available property damage and crop damage reportings/estimates were used.

In the raw data, the property damage is represented with two fields, a number `PROPDMG` in dollars and the exponent `PROPDMGEXP`. Similarly, the crop damage is represented using two fields, `CROPDMG` and `CROPDMGEXP`. The first step in the analysis is to calculate the property and crop damage for each event.

```
exp_transform <- function(e) {
    # h -> hundred, k -> thousand, m -> million, b -> billion
    if (e %in% c('h', 'H'))
        return(2)
    else if (e %in% c('k', 'K'))
        return(3)
    else if (e %in% c('m', 'M'))
        return(6)
    else if (e %in% c('b', 'B'))
        return(9)
    else if (!is.na(as.numeric(e))) # if a digit
        return(as.numeric(e))
    else if (e %in% c('', '-', '?', '+'))
        return(0)
    else {
        stop("Invalid exponent value.")
    }
}
```

```
prop_dmg_exp <- sapply(storm$PROPDMGEXP, FUN=exp_transform)
storm$prop_dmg <- storm$PROPDMG * (10 ** prop_dmg_exp)
crop_dmg_exp <- sapply(storm$CROPDMGEXP, FUN=exp_transform)
storm$crop_dmg <- storm$CROPDMG * (10 ** crop_dmg_exp)
```

```
# Compute the economic loss by event type
library(plyr)
econ_loss <- ddply(storm, .(EVTYPE), summarize,
                   prop_dmg = sum(prop_dmg),
                   crop_dmg = sum(crop_dmg))

# filter out events that caused no economic loss
econ_loss <- econ_loss[(econ_loss$prop_dmg > 0 | econ_loss$crop_dmg > 0), ]
prop_dmg_events <- head(econ_loss[order(econ_loss$prop_dmg, decreasing = T), ], 10)
crop_dmg_events <- head(econ_loss[order(econ_loss$crop_dmg, decreasing = T), ], 10)
```

Top 10 events that caused most property damage (in dollars) are as follows

```
prop_dmg_events[, c("EVTYPE", "prop_dmg")]
```

```
##                  EVTYPE  prop_dmg
## 132         flash flood 6.820e+13
## 694 thunderstorm winds 2.087e+13
## 737             tornado 1.079e+12
## 203                hail 3.158e+11
## 400           lightning 1.729e+11
## 148               flood 1.447e+11
## 361   hurricane typhoon 6.931e+10
## 155            flooding 5.921e+10
## 581         storm surge 4.332e+10
## 264          heavy snow 1.793e+10
```

Similarly, the events that caused biggest crop damage are

```
crop_dmg_events[, c("EVTYPE", "crop_dmg")]
```

```
##                 EVTYPE  crop_dmg
## 77             drought 1.397e+10
## 148              flood 5.662e+09
## 515        river flood 5.029e+09
## 377          ice storm 5.022e+09
## 203               hail 3.026e+09
## 352          hurricane 2.742e+09
## 361 hurricane typhoon 2.608e+09
## 132        flash flood 1.421e+09
## 118       extreme cold 1.313e+09
## 179      frost freeze 1.094e+09
```

Results

Health impact of weather events

The following plot shows top dangerous weather event types.

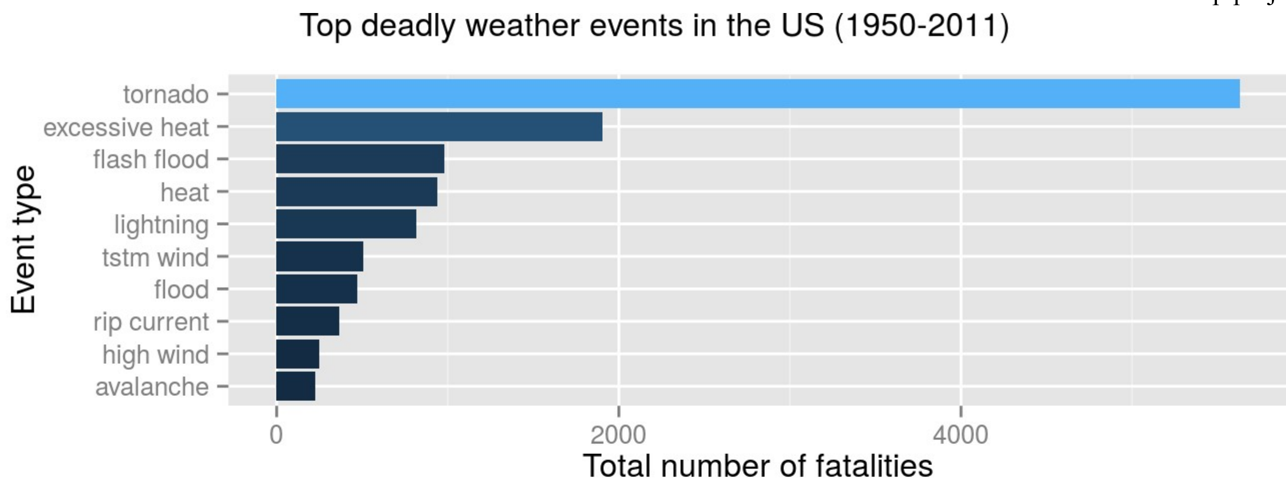
```
library(ggplot2)
library(gridExtra)
```

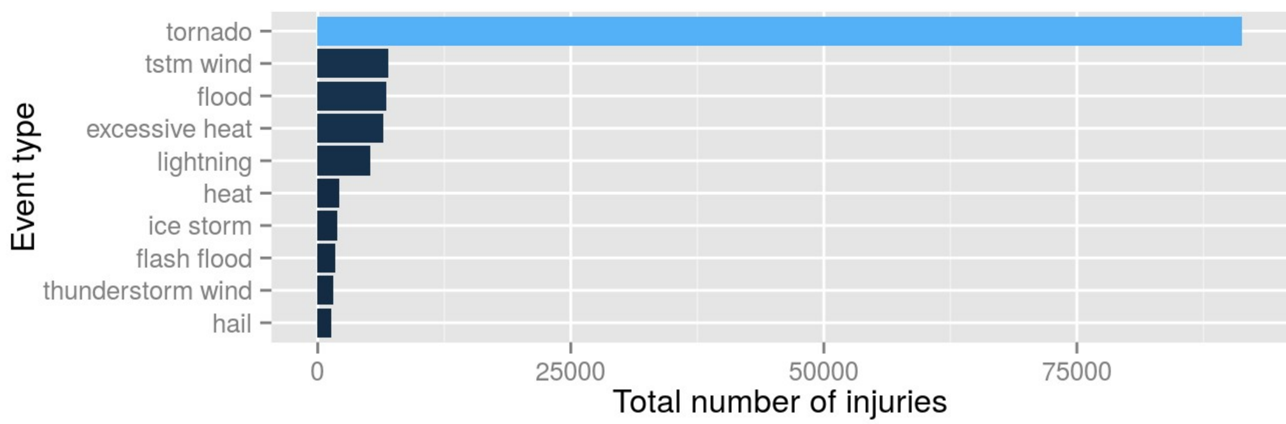
```
## Loading required package: grid
```

```
# Set the levels in order
p1 <- ggplot(data=fatal_events,
             aes(x=reorder(EVTYPE, fatalities), y=fatalities, fill=fatalities)) +
    geom_bar(stat="identity") +
    coord_flip() +
    ylab("Total number of fatalities") +
    xlab("Event type") +
    theme(legend.position="none")

p2 <- ggplot(data=injury_events,
             aes(x=reorder(EVTYPE, injuries), y=injuries, fill=injuries)) +
    geom_bar(stat="identity") +
    coord_flip() +
    ylab("Total number of injuries") +
    xlab("Event type") +
    theme(legend.position="none")

grid.arrange(p1, p2, main="Top deadly weather events in the US (1950-2011)")
```





Tornadoes cause most number of deaths and injuries among all event types. There are more than 5,000 deaths and more than 10,000 injuries in the last 60 years in US, due to tornadoes. The other event types that are most dangerous with respect to population health are excessive heat and flash floods.

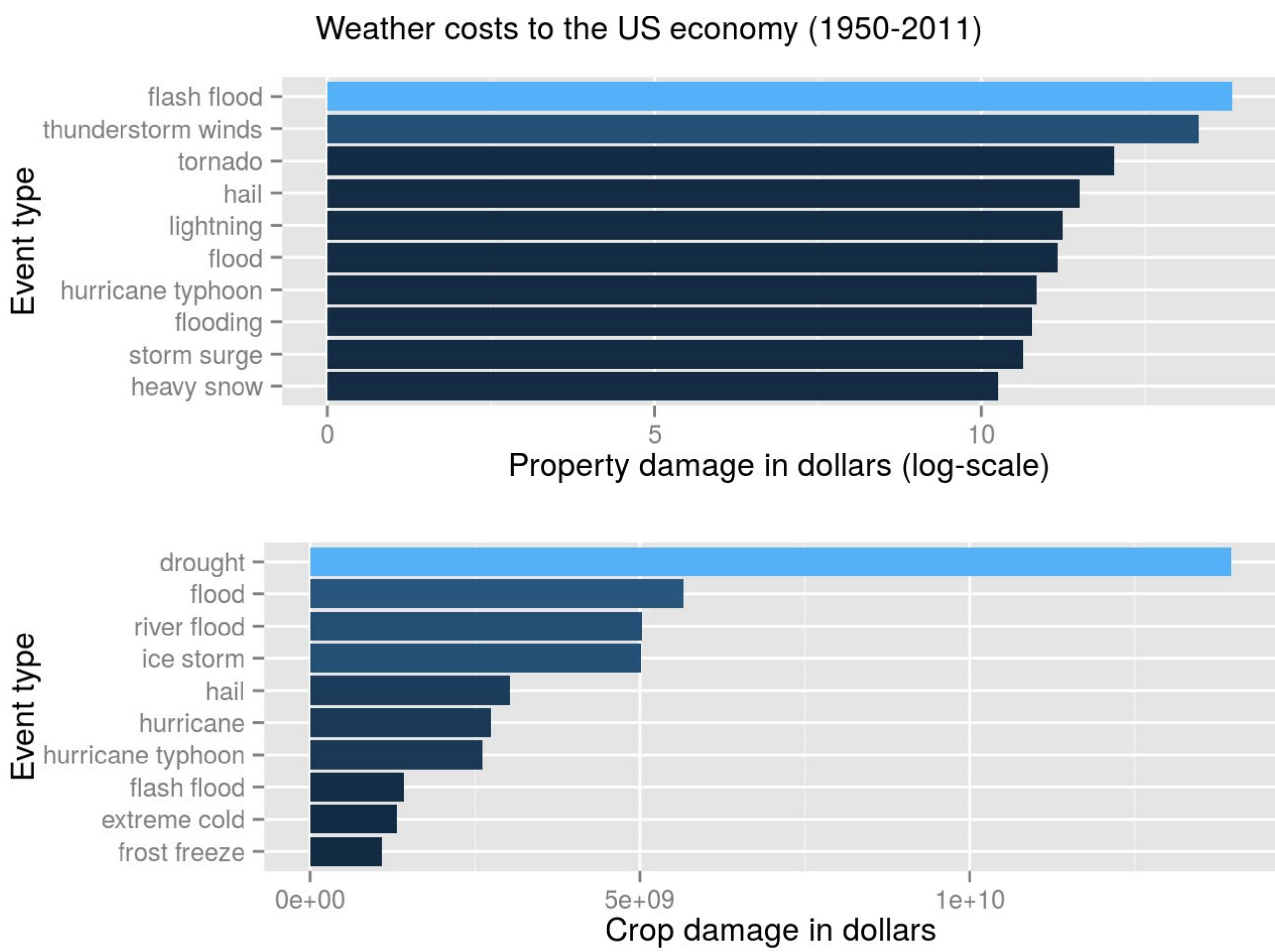
Economic impact of weather events

The following plot shows the most severe weather event types with respect to economic cost that they have costed since 1950s.

```
library(ggplot2)
library(gridExtra)
# Set the levels in order
p1 <- ggplot(data=prop_dmg_events,
             aes(x=reorder(EVTYPE, prop_dmg), y=log10(prop_dmg), fill=prop_dmg )) +
    geom_bar(stat="identity") +
    coord_flip() +
    xlab("Event type") +
    ylab("Property damage in dollars (log-scale)") +
    theme(legend.position="none")

p2 <- ggplot(data=crop_dmg_events,
             aes(x=reorder(EVTYPE, crop_dmg), y=crop_dmg, fill=crop_dmg)) +
    geom_bar(stat="identity") +
    coord_flip() +
    xlab("Event type") +
    ylab("Crop damage in dollars") +
    theme(legend.position="none")

grid.arrange(p1, p2, main="Weather costs to the US economy (1950-2011)")
```



Property damages are given in logarithmic scale due to large range of values. The data shows that flash floods and thunderstorm winds cost the largest property damages among weather-related natural diseasters. Note that, due to untidy nature of the available data, type `flood` and `flash flood` are separate values and should be merged for more accurate data-driven conclusions.

The most severe weather event in terms of crop damage is the drought. In the last half century, the drought has caused more than 10 billion dollars damage. Other severe crop-damage-causing event types are floods and hails.