

IMPACT OF WEATHER EVENTS ON PUBLIC HEALTH AND THEIR ECONOMIC CONSEQUENCES

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Background

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

Here I made the following definition:

1. I define "harmful to health" as the total number of injuries and deaths caused by the event
2. I define "Economic loss" as the total value lost caused by property damage and crop damage

According to the definition, I first compute two variables "Health"(by adding up injuries and deaths) and "Economic"(by adding up property damage and crop damage) Then, I grouped all the event entry into major event categories according to National Weather Service Storm Data Documentation. Finally, I plot barcharts and dotplot to demonstrate that Tornado, Wind and Heat are the three most harmful events to public health, whereas Flood, Hurricane and tide led to the greatest economic lost. In addition, it seems like there is a positive correlation between these two consequence.

Data processing

Setup

```
library(ggplot2)
data<-read.csv("repdata_data_StormData.csv.bz2")
```

Initial loading and exploring data

```
#Explore data
head(data,2)
```

```
##   STATE__      BGN_DATE BGN_TIME TIME_ZONE COUNTY COUNTYNAM STATE  EVTYPE
## 1      1 4/18/1950 0:00:00    0130     CST    97    MOBILE   AL  TORNADO
## 2      1 4/18/1950 0:00:00    0145     CST     3    BALDWIN  AL  TORNADO
##   BGN_RANGE BGN_AZI BGN_LOCATI END_DATE END_TIME COUNTY_END COUNTYENDN
## 1          0              0          0          0          0          NA
```

```
## 2      0      0      NA
##  END_RANGE END_AZI END_LOCATI LENGTH WIDTH F MAG FATALITIES INJURIES PROPDMG
## 1      0      14 100 3 0      0      15 25.0
## 2      0      2 150 2 0      0      0 2.5
##  PROPDMGEXP CROPDGM CROPDGMEXP WFO STATEOFFIC ZONENAMES LATITUDE LONGITUDE
## 1      K      0      3040      8812
## 2      K      0      3042      8755
##  LATITUDE_E LONGITUDE_ REMARKS REFNUM
## 1      3051      8806      1
## 2      0      0      2
```

```
names(data)
```

```
## [1] "STATE_" "BGN_DATE" "BGN_TIME" "TIME_ZONE" "COUNTY"
## [6] "COUNTYNAME" "STATE" "EVTYPE" "BGN_RANGE" "BGN_AZI"
## [11] "BGN_LOCATI" "END_DATE" "END_TIME" "COUNTY_END" "COUNTYENDN"
## [16] "END_RANGE" "END_AZI" "END_LOCATI" "LENGTH" "WIDTH"
## [21] "F" "MAG" "FATALITIES" "INJURIES" "PROPDMG"
## [26] "PROPDMGEXP" "CROPDGM" "CROPDGMEXP" "WFO" "STATEOFFIC"
## [31] "ZONENAMES" "LATITUDE" "LONGITUDE" "LATITUDE_E" "LONGITUDE_"
## [36] "REMARKS" "REFNUM"
```

```
#Keep only variables that are relevant to Date/Fatalities/Injuries/Damage
data1<- data[, c("BGN_DATE","EVTYPE", "FATALITIES",
                 "INJURIES","PROPDMG","PROPDMGEXP","CROPDGM","CROPDGMEXP")]
```

```
#See structure of data1
str(data1)
```

```
## 'data.frame': 902297 obs. of 8 variables:
## $ BGN_DATE : Factor w/ 16335 levels "1/1/1966 0:00:00",...: 6523 6523 4242 11116 2224 2224 2260 383
## $ EVTYPE : Factor w/ 985 levels " HIGH SURF ADVISORY",...: 834 834 834 834 834 834 834 834 834
## $ FATALITIES: num 0 0 0 0 0 0 0 0 1 0 ...
## $ INJURIES : num 15 0 2 2 2 6 1 0 14 0 ...
## $ PROPDMG : num 25 2.5 25 2.5 2.5 2.5 2.5 25 25 ...
## $ PROPDMGEXP: Factor w/ 19 levels "", "-", "?", "+",...: 17 17 17 17 17 17 17 17 17 ...
## $ CROPDGM : num 0 0 0 0 0 0 0 0 0 0 ...
## $ CROPDGMEXP: Factor w/ 9 levels "", "?", "0", "2",...: 1 1 1 1 1 1 1 1 1 ...
```

Store the cleaned data in a new dataset

```
#Build a new dataset for analysis
n<-nrow(data1)
data2<-data.frame(matrix(nrow=n,ncol = 8))
colnames(data2)<-c("Year","Event",
                  "Deaths","Injury",
                  "Property_damage", "Crop_damage",
                  "Health","Economic")

#Process data and put into new dataset
data2$Event<-data1$EVTYPE
data2$Deaths<-data1$FATALITIES
```

```
data2$Injury<-data1$INJURIES

datetmp<- as.Date(as.character(data1$BGN_DATE),"%m/%d/%Y %H:%M:%S")
data2$Year<-factor(as.numeric(format(datetmp,"%Y")))

#Convert unit of the property damage into real numbers
summary(data1$PROPDMGEXP)
```

```
##          -      ?      +      0      1      2      3      4      5      6
## 465934    1      8      5     216     25     13      4      4     28      4
##          7      8      B      h      H      K      m      M
##          5      1     40      1      6 424665      7 11330
```

```
data2$Property_damage<-data1$PROPDMG *(
  1 * (data1$PROPDMGEXP == "K" & data1$PROPDMGEXP != "k" &
    data1$PROPDMGEXP != "M" & data1$PROPDMGEXP != "m" &
    data1$PROPDMGEXP != "B" & data1$PROPDMGEXP != "b" ) +
  1000 * (data1$PROPDMGEXP == "K" | data1$PROPDMGEXP == "k") +
  1000000 * (data1$PROPDMGEXP == "M" | data1$PROPDMGEXP == "m") +
  1000000000 * (data1$PROPDMGEXP == "B" | data1$PROPDMGEXP == "b")
)

#Convert unit of the crop damage into real numbers
data2$Crop_damage <- data1$CROPDMG *(
  1 * (data1$CROPDMGEXP != "K" & data1$CROPDMGEXP != "k" &
    data1$CROPDMGEXP != "M" & data1$CROPDMGEXP != "m" &
    data1$CROPDMGEXP != "B" & data1$CROPDMGEXP != "b" ) +
  1000 * (data1$CROPDMGEXP == "K" | data1$CROPDMGEXP == "k") +
  1000000 * (data1$CROPDMGEXP == "M" | data1$CROPDMGEXP == "m") +
  1000000000 * (data1$CROPDMGEXP == "B" | data1$CROPDMGEXP == "b")
)
```

Process data

1. I define “harmful to health” as the total number of injuries and deaths caused by the event
2. I define “Economic loss” as the total value lost caused by property damage and crop damage

```
#Create new variables for indicating "harmful to health"
data2$Health <- data2$Deaths + data2$Injury
#Create new variables for indicating "Economic loss"
data2$Economic <- data2$Property_damage + data2$Crop_damage

#Calculate the total injuries and deaths throught the years by different event
total_health<-aggregate(Health~Event, data=data2, sum)
#Calculate the total injuries and deaths throught the years by different event
total_economic<-aggregate(Economic~Event, data=data2, sum)
#Combine the results in a new variable
total_health_economic<-merge(total_health,total_economic)

#Group weather events according to the storm data event table
Astronomical_Tide<-grep("Astronomical",total_health_economic$Event,ignore.case = TRUE)
```

```

Avalanche<-grep("Avalanche",total_health_economic$Event,ignore.case = TRUE)
Blizzard<-grep("Blizzard",total_health_economic$Event,ignore.case = TRUE)
Coastal_Flood<-grep("Coastal",total_health_economic$Event,ignore.case = TRUE)
Cold_Chill<-grep("chill|cold|cool|freeze|HYPOTHER",total_health_economic$Event,ignore.case = TRUE)
Fog<-grep("fog",total_health_economic$Event,ignore.case = TRUE)
Smoke<-grep("smoke",total_health_economic$Event,ignore.case = TRUE)
Dust_devil_storm<-grep("dust",total_health_economic$Event,ignore.case = TRUE)
Heat<-grep("heat|warm|HYPEROTHER|HOT|HIGH TEMP",total_health_economic$Event,ignore.case = TRUE)
Flood<-grep("flood|fld|stream|URBAN|STRM",total_health_economic$Event,ignore.case = TRUE)
Frost_or_Freeze<-grep("Frost|Freeze",total_health_economic$Event,ignore.case = TRUE)
Funnel_cloud<-grep("funnel",total_health_economic$Event,ignore.case = TRUE)
hail<-grep("hail",total_health_economic$Event,ignore.case = TRUE)
Heavy_Rain<-grep("rain|rain|rainfall|torrential|SHOWER|unseasonal rain|precipitation|precip",total_
Heavy_Snow<-grep("snow",total_health_economic$Event,ignore.case = TRUE)
High_surf<-grep("surf",total_health_economic$Event,ignore.case = TRUE)
Drought<-grep("dry|drought",total_health_economic$Event,ignore.case = TRUE)
Wind<-grep("Wind|wnd",total_health_economic$Event,ignore.case = TRUE)
Hurricane<-grep("hurricane|typhoon",total_health_economic$Event,ignore.case = TRUE)
ice_storm<-grep("ice * storm",total_health_economic$Event,ignore.case = TRUE)
lightning<-grep("light",total_health_economic$Event,ignore.case = TRUE)
thunderstorm<-grep("thunder|microburst|rainstorm",total_health_economic$Event,ignore.case = TRUE)
Current<-grep("current",total_health_economic$Event,ignore.case = TRUE)
seiche<-grep("seiche",total_health_economic$Event,ignore.case = TRUE)
Sleet<-grep("Sleet",total_health_economic$Event,ignore.case = TRUE)
tide<-grep("storm surge|tide|HIGH SEA|HIGH SWELL",total_health_economic$Event,ignore.case = TRUE)
Tornado<-grep("tornado",total_health_economic$Event,ignore.case = TRUE)
Tropical<-grep("tropical",total_health_economic$Event,ignore.case = TRUE)
Tsunami<-grep("tsunami|tstm",total_health_economic$Event,ignore.case = TRUE)
Volcano<-grep("volcan",total_health_economic$Event,ignore.case = TRUE)
Waterspout<-grep("water|WET|spout",total_health_economic$Event,ignore.case = TRUE)
Wildfire<-grep("Wild|forest|forrest|fire",total_health_economic$Event,ignore.case = TRUE)
Winter_WEATHER<-grep("WINTER|WINTRY|ICE|glaze",total_health_economic$Event,ignore.case = TRUE)
Turbulence_Slides<-grep("turbulence|slide",total_health_economic$Event,ignore.case = TRUE)

Wind<-Wind[!Wind%in%thunderstorm]
Cold_Chill<-Cold_Chill[!Cold_Chill%in%c(Heavy_Rain,Heavy_Snow,Wind)]
Eventlist<-list(Astronomical_Tide,Avalanche,Blizzard,Coastal_Flood,Cold_Chill,
               Fog,Smoke, Dust_devil_storm,Heat,Flood,
               Frost_or_Freeze,Funnel_cloud,hail,Heavy_Rain,Heavy_Snow, High_surf,
               Hurricane,ice_storm,lightning,thunderstorm,
               Current,seiche,Sleet,tide,Tornado,
               Tropical,Tsunami,Volcano,Waterspout,Wildfire,
               Wind,Drought,Winter_WEATHER,Turbulence_Slides)

Eventnamelist<-c("Astronomical_Tide","Avalanche","Blizzard","Coastal_Flood","Cold_Chill",
                 "Fog","Smoke", "Dust_devil_storm","Heat","Flood",
                 "Frost_or_Freeze","Funnel_cloud","hail","Heavy_Rain","Heavy_Snow", "High_surf",
                 "Hurricane","ice_storm","lightning","thunderstorm",
                 "Current","seiche","Sleet","tide","Tornado",
                 "Tropical","Tsunami","Volcano","Waterspout","Wildfire",
                 "Wind","Drought","Winter_WEATHER","Turbulence_Slides")

#Assign unclassified events into "Others"

```

```

Eventlist_n<-unique(as.numeric(unlist(Eventlist)))
Eventlist_n<-sort(Eventlist_n)
Nrow<-as.numeric(1:nrow(total_health_economic))
diff<-Nrow[!Nrow%in%Eventlist_n]
others<-total_health_economic[diff,]

#Create new list
total<-data.frame(matrix(ncol=3,nrow = length(Eventnamelist)+1))
colnames(total)<-c("Event","Health","Economic")
total$Event[1:34]<-Eventnamelist
total$Event[35]<- "Others"
temp<-NULL
for(i in 1:length(Eventnamelist)){
  temp<-total_health_economic[Eventlist[[i]],]
  total$Health[i]<-sum(temp$Health)
  total$Economic[i]<-sum(temp$Economic)
}
total$Health[35]<-sum(others$Health)
total$Economic[35]<-sum(others$Economic)

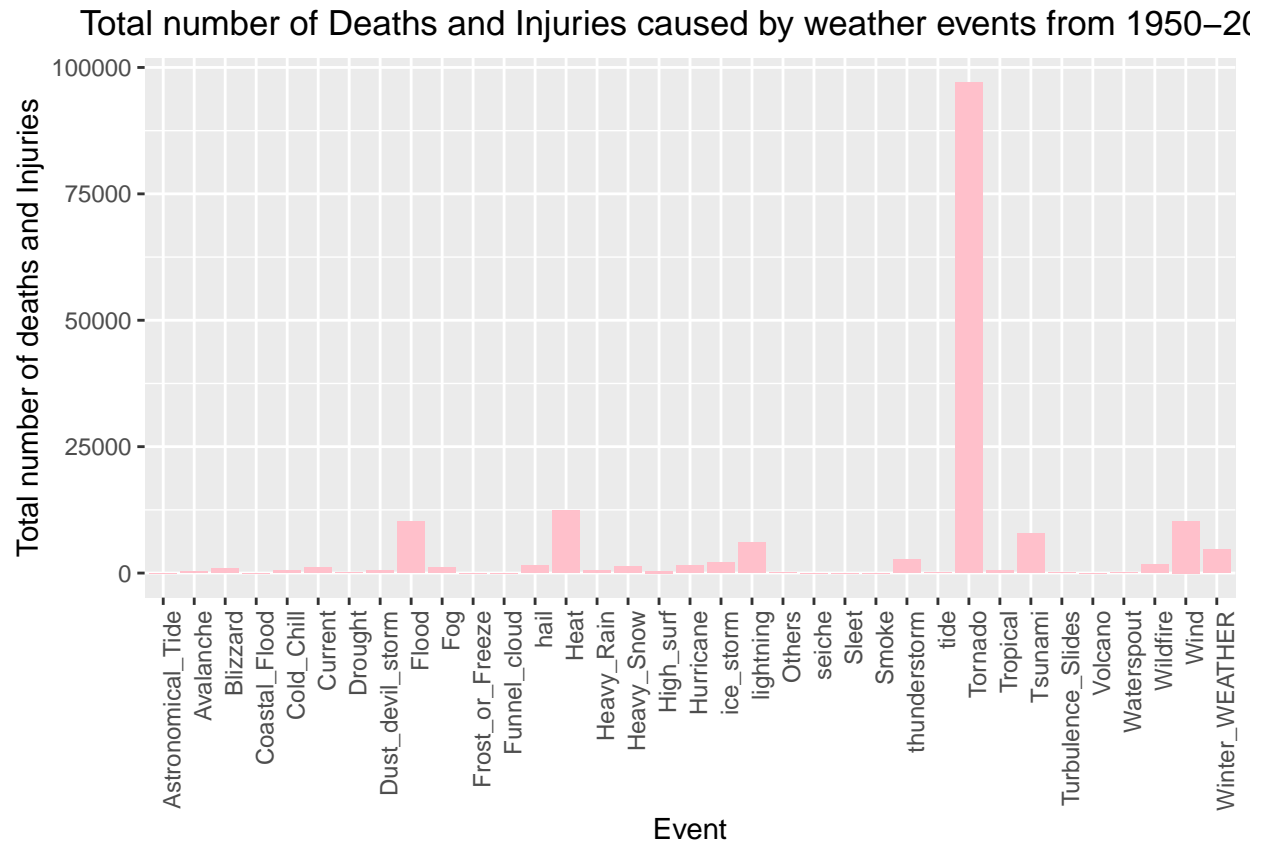
```

Result

```

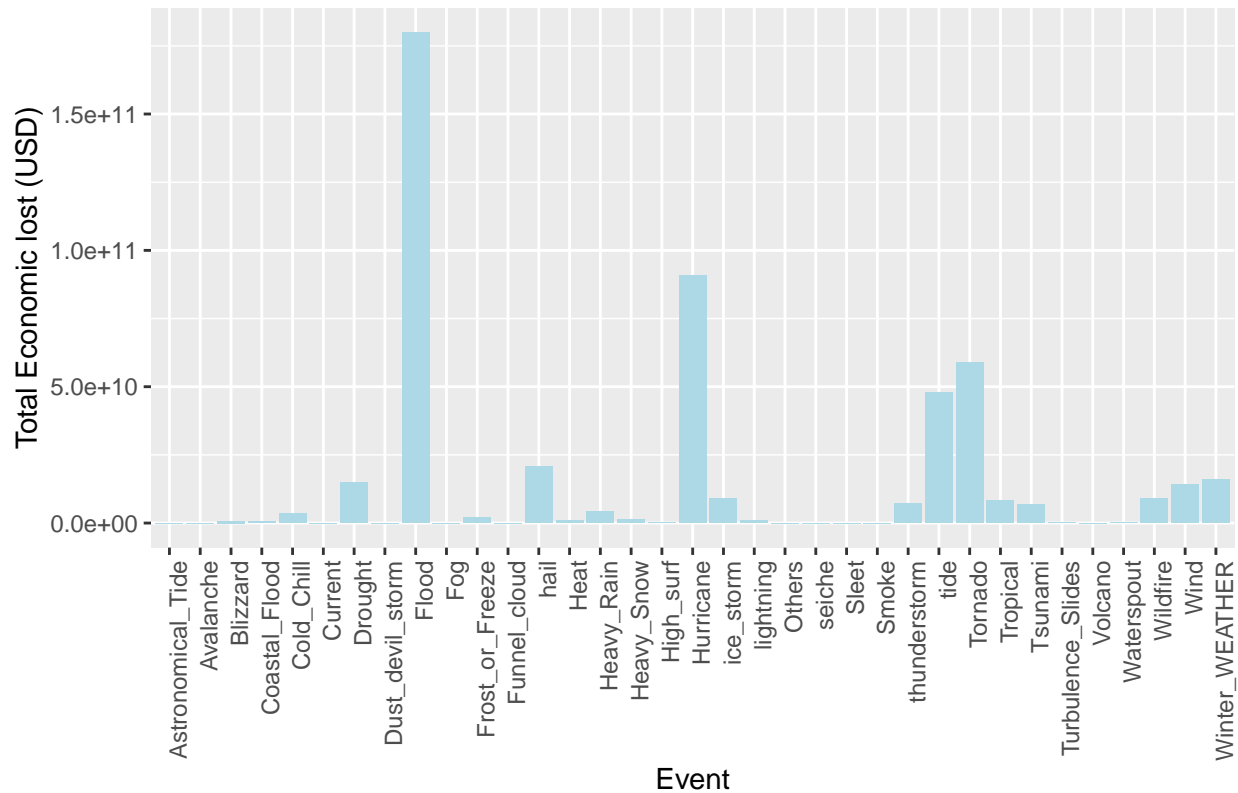
# Plot the total number of death and injuries caused by different events
library(ggplot2)
healthplot<- ggplot(aes(x=Event,y=Health,fill="pink"),data =total) +
  geom_bar(data=total,aes(x=Event,y=Health), stat="identity") +
  theme(axis.text.x = element_text(hjust = 1,angle=90), plot.title = element_text(hjust=0.5)) +
  ggtitle("Total number of Deaths and Injuries caused by weather events from 1950-2017") +
  ylab("Total number of deaths and Injuries") +
  scale_fill_manual(values="pink")
plot(healthplot)

```

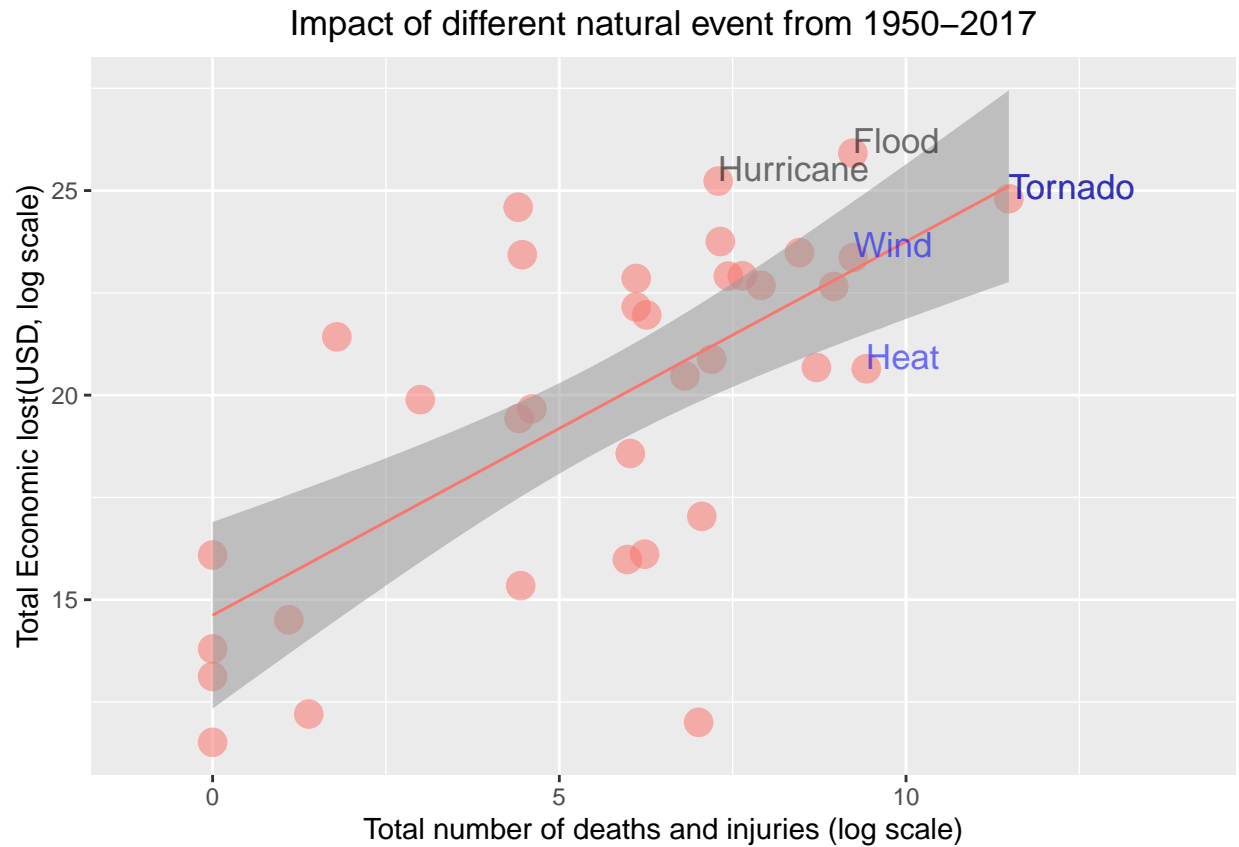


```
# Plot the total number of economic lost caused by different events
economicplot<- ggplot(aes(x=Event,y=Economic,fill="lightblue"), data =total) +
  geom_bar(data=total,aes(x=Event,y=Economic), stat="identity") +
  theme(axis.text.x = element_text(hjust = 1,angle=90), plot.title = element_text(hjust=0.5))
  ggtitle("Total Economic lost caused by weather events from 1950-2017") +
  ylab("Total Economic lost (USD)") +
  scale_fill_manual(values="lightblue")
plot(economicplot)
```

Total Economic lost caused by weather events from 1950–2017



```
#Combine both Health and economic impact
totalplot<-qplot(x=log(Health+1),y=log(Economic+1), data=total,size=2,alpha=0.2,col="pink") +
  theme(legend.position = "none") +
  geom_smooth(method=lm,lwd=0.5) +
  geom_text(aes(label=ifelse(total$Economic>=5.896300e+10,as.character(total$Event),'')),
    hjust=0,vjust=0,col="black") +
  geom_text(aes(label=ifelse(total$Health>10236,as.character(total$Event),'')),
    hjust=0,vjust=0,col="blue") +
  xlim(c(-1,14)) +
  ggtitle("Impact of different natural event from 1950-2017") +
  xlab("Total number of deaths and injuries (log scale)") +
  ylab("Total Economic lost(USD, log scale)") + coord_cartesian(clip = 'off') +
  theme(plot.title = element_text(hjust = 0.5))
plot(totalplot)
```



From these graphs, we can see that Tornado is the most harmful event for public health, followed by Wind and Heat(high temperature).

In terms of economic damage, Flood is on the top of the list, Hurricane and Tornado are the second and third most influential factor.

In addition, the regression model demonstrate the positive correlation between the economic lost and the harm to public health caused by the weather events