Harmful severe weather events in the United States

Summary

This report examines the impact of storms and severe weather events in the United States in terms of human fatalities, human injuries and economic damage. The data were extracted from the U.S. National Oceanic and Atmospheric Administration's (NOAA) storm database and correspond to the years 1996-2011. The data were organized with 49 classifications corresponding to the 48 NOAA-designated event types and an additional "ambiguous" classification for a relatively small number of cases that were difficult to classify. The impact of storms and extreme weather on public health were estimated based by the cumulative number of fatalities and injuries that were linked to each classification. Economic damages were estimated by summing the cumulative amount of property damages and crop damages. Classifications were ranked based on cumulative values and bar plots were generated to represent the top 15 classifications for fatalities, injuries and economic damage. This analysis indicates that (in descending order) excessive heat, tornadoes and flash floods caused the most human deaths, which represents approximately 48% of the total fatalities across all classifications. Tornadoes, floods and excessive heat were responsible for the most human injuries (59% of the total across all classifications). Additionally, floods, hurricanes/typhoons and tornadoes were linked to the greatest amount of economic damage (82% of the total across all classifications).

Data Processing

```r
# required packages
library(dplyr)
library(ggplot2)
library(grid)
library(gridExtra)
library(gtable)
library(tidyr)
library(knitr)
library(xtable)
library(pander)
```

The StromData file was downloaded, unzipped and read into R as follows:

```r
# download data as a csv file and read into R
if(!file.exists(".data")){dir.create("./data")}
URL<-"https://d396qusza40orc.cloudfront.net/repdata%2Fdata%2FStormData.csv.bz2"
download.file(URL, destfile = "./data/StormData.csv")
StormData <- read.csv(("./data/StormData.csv"))
```

The data were subset such that the retained columns included the event begin dates, the event types, the number of fatalities, the number of injuries as well as four columns containing information about property and crop damages. The data were also then subset to exclude cases not associated with fatalities, injuries, property damage, or crop damage.

```r
# remove un-needed columns
storm <- select(StormData, -(STATE__), -(BGN_TIME:STATE), -(BGN_RANGE:MAG),
                  -(WFO:REFNUM))
# rename remaining columns
names(storm) <- c("date", "event", "fatalities", "injuries", "propdmg",
                  "propdmg.exp","cropdmg","cropdmg.exp")
# subset for cases that involve fatalities, injuries and damage
storm <- filter(storm,
                fatalities > 0 | injuries > 0 | propdmg > 0 | cropdmg > 0)
```

The data were subset further to include only the years 1996-2011 because prior to 1996 NOAA did not keep records on all 48 storm/weather events types. This approach was selected to allow for accurate cross-event comparisons of cumulative.

```r
# subset data for the years 1996-2011
storm$year <- as.character(storm$date)
storm$year <- strptime(storm$date, format = "%m/%e/%Y %T", tz = "GMT")
storm$year <- strftime(storm$year, format="%Y")
storm$year <- as.numeric(storm$year)
storm <- select(storm, year, event:cropdmg.exp)
storm.data <- filter(storm,year > 1995)
```

The National Weather Service Instruction (10-1605, August 17 2007, Table 1) designates these 48 event types

```r
# list of event types
et <- c("Astronomical Low Tide", "Avalanche", "Blizzard","Coastal Flood",
  "Cold/Wind Chill", "Debris Flow", "Dense Fog", "Dense Smoke","Drought",
  "Dust Devil", "Dust Storm", "Excessive Heat", "Extreme Cold/Wind Chill",
  "Flash Flood", "Flood", "Frost/Freeze", "Funnel Cloud", "Freezing Fog",
  "Hail", "Heat", "Heavy Rain", "Heavy Snow","High Surf", "High Wind",
  "Hurricane (Typhoon)","Ice Storm", "Lake-Effect Snow", "Lakeshore Flood",
  "Lightning", "Marine Hail", "Marine High Wind", "Marine Strong Wind",
  "Marine Thunderstorm Wind","Rip Current", "Seiche", "Sleet",
  "Storm Surge/Tide", "Strong Wind", "Thunderstorm Wind", "Tornado",
  "Tropical Depression", "Tropical Storm", "Tsunami", "Volcanic Ash",
  "Waterspout", "Wildfire" ,"Winter Storm ","Winter Weather")

# count number of unique event labels in storm.data$event variable
unique.event.labels <- as.character(unique(storm.data$event))
num.unique <- length(unique.event.labels)
```

Exploratory examination of the storm.data "event"" variable indicated that there were 222 unique labels. Some of these elements were due to misspellings, typos, abbreviation, and capitalization differences. There were also many cases that appeared to have non-standard event labels which were not contained in the "et" variable listed above. Consequently, a procedure was developed to reclassify those cases which did not have standard event labels. Two subsets where generated based on whether or not the cases had standard or non-standard labels.

```r
# subset storm.data depending on whether the row contains an event label from et
et <- data.frame(et)
names(et) <- c("Event.type")
et$Event.type <- tolower(et$Event.type)
xx <- storm.data
xx$event <- as.character(xx$event)
xx$event <- tolower(xx$event)
storm.mislabel <- xx[!(xx$event %in% et$Event.type),]
storm.correctlabel <- xx[(xx$event %in% et$Event.type),]

number.mislabled.rows <- nrow(storm.mislabel)
total.cases <- nrow(storm.data)
percent.mislabeled <- (number.mislabled.rows/total.cases)*100
```

This treatment of the data indicated that approximately 33 % of the cases did not exactly match the standard event labels. Therefore, effort was made to reclassify the mislabeled cases. This reclassification was based on guidelines provided in the National Weather Service Instruction (10-1605, August 17 2007). The following code uses string replacement methods to alter the event names. If no satisfactory event label could be determined, it was classified as "ambiguous". An example of an ambiguous case was "gusty wind" because without wind speed information it was deemed unclear whether the event should be considered as "Strong Wind" or "High Wind". *A table in the Appendix section of this document provides a complete list of the reclassifications.*

```r
# clean up the event types by correcting misspellings and typos
# reclassify and combine similar/synonymous event types into single factors
# reclassify ambiguous events
x <- storm.mislabel
x$event <- as.character(x$event)
x$event <- tolower(x$event)
# reclassify ambiguous labels
x$event[grepl("non-tstm wind", x$event)] <- "ambiguous"
x$event[grepl("non tstm wind", x$event)] <- "ambiguous"
x$event[grepl("none|summary|other", x$event)] <- "ambiguous"
x$event[grepl("coastal storm|coastalstorm", x$event)] <- "ambiguous"
x$event[grepl("marine accident", x$event)] <- "ambiguous"
x$event[grepl("no severe weather", x$event)] <- "ambiguous"
x$event[grepl("drowning", x$event)] <- "ambiguous"
x$event[grepl("metro", x$event)] <- "ambiguous"
x$event[grepl("high water", x$event)] <- "ambiguous"
x$event[grepl("non-severe wind damage", x$event)] <- "ambiguous"
x$event[grepl("gusty|gradient wind|wind damage|wind and wave",
              x$event)] <- "ambiguous"
x$event[grepl("whirlwind|rogue wave", x$event)] <- "ambiguous"
x$event[grepl("^wind$|^winds$", x$event)] <- "ambiguous"
x$event[grepl("^rain$|unseasonal rain", x$event)] <- "ambiguous"
x$event[grepl("heavy seas|high seas|rough seas", x$event)] <- "ambiguous"
x$event[grepl("coastal erosion|beach erosion", x$event)] <- "ambiguous"
# reclassify and correct event labels
x$event[grepl("blizzard", x$event)] <- "blizzard"
x$event[grepl("marine tstm wind", x$event)] <- "marine thunderstorm wind"
x$event[grepl("strong winds", x$event)] <- "strong wind"
x$event[grepl("tstm heavy rain|torrential|hvy rain$", x$event)] <- "heavy rain"
x$event[grepl("^tstm wind|^ tstm wind|tstm wnd|downburst|gustnado|microburst",
              x$event)] <- "thunderstorm wind"
x$event[grepl("thunderstorm wind \\(g40", x$event)] <- "thunderstorm wind"
x$event[grepl("coastal flooding|coastal  flooding|cstl flood",
              x$event)] <-"coastal flood"
x$event[grepl("astronomical high tide", x$event)] <-"coastal flood"
x$event[grepl("flash|dam break|ice jam flood", x$event)] <-"flash flood"
x$event[grepl("surge|tidal", x$event)] <- "storm surge/tide"
x$event[grepl("flooding|urban flo|river flo|flood/s", x$event)] <- "flood"
x$event[grepl("fld", x$event)] <- "flood"
x$event[grepl("volca|vog", x$event)] <- "volcanic ash"
x$event[grepl("lightning", x$event)] <- "lightning"
x$event[grepl("heavy rain/high surf|heavy rain", x$event)] <- "heavy rain"
x$event[grepl("surf|swells", x$event)] <- "high surf"
x$event[grepl("^tstm$|thunderstorms|severe thunder",
              x$event)] <- "thunderstorm wind"
x$event[grepl("^thunderstorm$", x$event)] <- "thunderstorm wind"
x$event[grepl("devel", x$event)] <- "dust devil"
x$event[grepl("dust", x$event)] <- "dust storm"
x$event[grepl("waters", x$event)] <- "waterspout"
x$event[grepl("hurric|typhoon|floyd", x$event)] <- "hurricane (typhoon)"
x$event[grepl("small hail|gusty wind/hail", x$event)] <- "hail"
x$event[grepl("torn|landspout", x$event)] <- "tornado"
x$event[grepl("lake effect", x$event)] <- "lake-effect snow"
```

```r
x$event[grepl("mud|landsl|rock", x$event)] <- "debris flow"
x$event[grepl("heavy snow shower|excessive snow|squall",
              x$event)] <- "heavy snow"
x$event[grepl("freeze|frost", x$event)] <- "frost/freeze"
x$event[grepl("heat|hyperthermia|warm weather|unseasonably warm",
              x$event)] <- "heat"
x$event[grepl("extreme windchill", x$event)] <- "extreme cold/wind chill"
x$event[grepl("fire", x$event)] <- "wildfire"
x$event[grepl("high winds|high wind \\(g40", x$event)] <- "high wind"
x$event[grepl("rip currents", x$event)] <- "rip current"
x$event[grepl("extreme cold", x$event)] <- "extreme cold/wind chill"
x$event[grepl("cold |unseasonable cold|extended cold|unseasonably cold",
              x$event)] <- "cold/wind chill"
x$event[grepl("^cold$", x$event)] <- "cold/wind chill"
x$event[grepl("fog", x$event)] <- "dense fog"
x$event[grepl("winter weather|glaze|ice roads|light snow|freezing|wintry|mixed",
              x$event)] <- "winter weather"
x$event[grepl("snow and ice|falling snow/ice", x$event)] <- "winter storm"
x$event[grepl("black ice|blowing snow|ice on road|late season snow|icy roads",
              x$event)] <- "winter weather"
x$event[grepl("rain/snow", x$event)] <- "winter weather"
x$event[grepl("^snow$", x$event)] <- "winter weather"
number.ambiguous.cases <-nrow(filter(x, event == "ambiguous"))
```

This procedure classified 195 cases as “ambiguous”.

The output of the procedure was then recombined with the storm.data.correctlabel subset.

```r
# bind corrected df with original storm.correctlabel df
storm.data.new.labels <- rbind(storm.correctlabel, x)
sdnl <- storm.data.new.labels
```

The property damage and crop damage data is represented in 4 columns. The “propdmg” and “cropdmg” variables list numeric values for each case, while the “propdmg.exp” and “cropdmg.exp” variables provide a code for a multiplier representing a thousand, million, or billion. A key-value data frame was created to decode the multipliers and recalculate the cost of the damage associated with each case. The property and crop damage for each case were summated to create a total cost variable represented in billions of US dollars.

```r
# create data frame with key-values of multiplier codes
code <- c("k", "K", "m", "M", "b", "B")
mult <- c("1000", "1000", "1000000", "1000000","1000000000", "1000000000")
key <- cbind(code, mult)
key <- as.data.frame(key)
key$mult <- as.character(key$mult)
key$code <- as.character(key$code)
# add columns for multipler values
sdnl$prop.mult <- ""
sdnl$crop.mult <- ""
sdnl$propdmg.exp <- as.character(sdnl$propdmg.exp)
sdnl$cropdmg.exp <- as.character(sdnl$cropdmg.exp)
#match key and add values data frame
sdnl$prop.mult <- key[,2][match(sdnl$propdmg.exp, key[,1])]
sdnl$crop.mult <- key[,2][match(sdnl$cropdmg.exp, key[,1])]
```

```r
sdnl$prop.mult <- as.numeric(sdnl$prop.mult)
sdnl$crop.mult <- as.numeric(sdnl$crop.mult)
# use multiplier to calclulate cost of each event
sdnl <- mutate(sdnl, prop.cost = propdmg * prop.mult)
sdnl <- mutate(sdnl, crop.cost = cropdmg * crop.mult)
sdnl <- mutate(sdnl, total.cost = (crop.cost + prop.cost)/1000000000)
storm.summary <- select(sdnl, -(propdmg:crop.cost))
```

To address the question regarding which event types are the most harmful with respect to population health the storm summary was subset for those cases involving either fatalities or injuries, and the cumulative number for each event was calculated. The data were then ranked and additional subsets were generated which contained only the top 15 event types of each variable.

```r
#subset for fatalities and injuries graph of top 15 events for each
storm.health <- filter(storm.summary, fatalities > 0 | injuries > 0)
# calculate number of fatalities by event type
group_by(storm.health, event) %>%
summarize(sum(fatalities)) -> storm.fat
names(storm.fat) <- c("event", "fatalities")
filter(storm.fat, fatalities >= 115) %>%
arrange(fatalities) -> fatal
fatal$event <- with(fatal, factor(event, levels = event))
# calculate number of injuries by event type
group_by(storm.health, event) %>%
        summarize(sum(injuries)) -> storm.inj
names(storm.inj) <- c("event", "injuries")
filter(storm.inj, injuries >= 700) %>%
arrange(injuries) -> injury
injury$event <- with(injury, factor(event, levels = event))
```

To address the question regarding which event types generated the most economic damage, the storm summary was subset for those cases involving such damage. The data were then ranked an additional subset was generated which contained only the top 15 event types.

```r
#subset for the top 15 event types with respect to cast
storm.cost <- filter(storm.summary, total.cost > 0)

group_by(storm.cost, event) %>%
        summarize(sum(total.cost)) -> storm.cost2
names(storm.cost2) <- c("event", "Billions")
filter(storm.cost2, Billions >= .493) %>%
        arrange(Billions) -> cost
cost$event <- with(cost, factor(event, levels = event))
```

Additional calculations were performed to summarize the results.

```r
# estimate of total number of fatalities across all event types
total.f <- sum(storm.fat$fatalities)
total.f
```

```
## [1] 8732
```

```r
# estimate of total number of injuries across all event types
total.i <- sum(storm.inj$injuries)
total.i
```

```
## [1] 57975
```

```r
# caculate the total number of event types associated with deaths or injuries
deadly.events <- filter(storm.fat, fatalities > 0)
events.with.f <- length(unique(deadly.events$event))
injurious.events <- filter(storm.inj, injuries > 0)
events.with.i <- length(unique(injurious.events$event))
# estimate of proportion of deaths associated with top three event types
top3.fatalities <- (sum(fatal[13:15,2])/total.f) * 100
# estimate of proportion of injuries associated with top three event types
top3.injuries <- (sum(injury[13:15,2])/total.i) * 100
# estimate of economic damage across all event types (in Billions)
total.cost <- sum(storm.cost2$Billions)
total.cost
```

```
## [1] 238.22
```

```r
# estimate of economic damage associated with top three event types (Billions)
top3.cost <- (sum(cost[13:15,2])/total.cost) * 100
top3.cost
```

```
## [1] 82.06867
```

Here is the code for the fatality and injury plots

```r
f1 = ggplot(data = fatal, aes(y = fatalities, x = event)) +
        geom_bar(position="dodge",stat="identity", fill = "darkred") +
        coord_flip() +
        ggtitle("Cumulative fatalities (1996-2011)")+
        scale_fill_grey() +
        theme_bw() +
        theme(
                axis.title.y=element_blank(),
                axis.title.x=element_blank(),
                text=element_text(family="serif",size=15),
                plot.title=element_text(face="bold",hjust=c(0,0)))

f2 = ggplot(data = injury, aes(y = injuries, x = event)) +
        geom_bar(position="dodge",stat="identity", fill = "navy") +
        coord_flip() +
        ggtitle("Cumulative injuries (1996-2011)")+
        scale_fill_grey() +
        theme_bw() +
        theme(
                axis.title.y=element_blank(),
                axis.title.x=element_blank(),
                text=element_text(family="serif",size=15),
```

```
                plot.title=element_text(face="bold",hjust=c(0,0)))

# align two plots by axis
gl <- lapply(list(f1, f2), ggplotGrob)
widths <- do.call(unit.pmax, lapply(gl, "[[", "widths"))
heights <- do.call(unit.pmax, lapply(gl, "[[", "heights"))
lg <- lapply(gl, function(g) {g$widths <- widths; g$heights <- heights; g})
gt = rbind(lg[[1]], lg[[2]], size = "first")
gt$heights[5] = list(unit(0, "lines"))
```

Here is the code for the economic damage plot

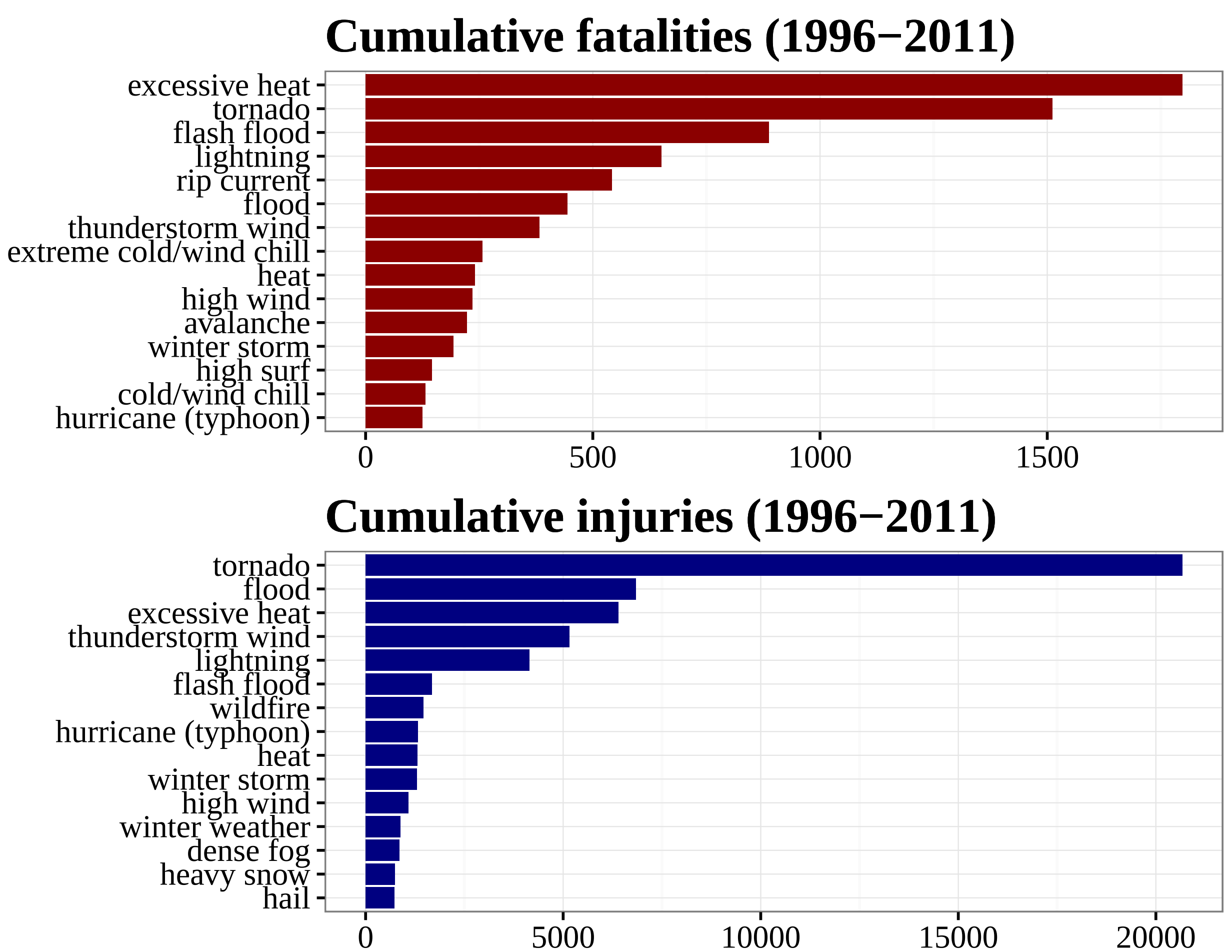
```
f3 = ggplot(data = cost, aes(y = Billions, x = event)) +
        geom_bar(position="dodge",stat="identity", fill = "darkgreen") +
        coord_flip() +
        ylab("Billions of US Dollars") +
        ggtitle("Cumulative economic damage (1996-2011)") +
        scale_fill_grey() +
        theme_bw() +
        theme(
                axis.title.y=element_blank(),
                text=element_text(family="serif",size=15),
                plot.title=element_text(face="bold",hjust=c(0,0)))
```

Results

Which types of events are most harmful with respect to population health?

- Between the years 1996-2011, extreme weather events in the USA were associated with 8732 fatalities and 57975 injuries
- There were 37 event types (inclusive of the “ambiguous” classification) associated with fatalities.
- In addition, here were 39 event types (inclusive of the “ambiguous” classification) that were associated with injuries.
- The top 3 most deadly event types (excessive heat, tornadoes and flash floods) were responsible for 48% of the total number of the deaths.
- The top 3 most injurious event types (tornadoes, floods and excessive heat) were responsible for 58% of the total number of the injuries.
- Here is a graph representing the cumulative number of fatalities (top panel) and injuries (bottom panel) for the top 15 ranked event types.

```
# draw figure
grid.newpage()
grid.draw(gt)
```

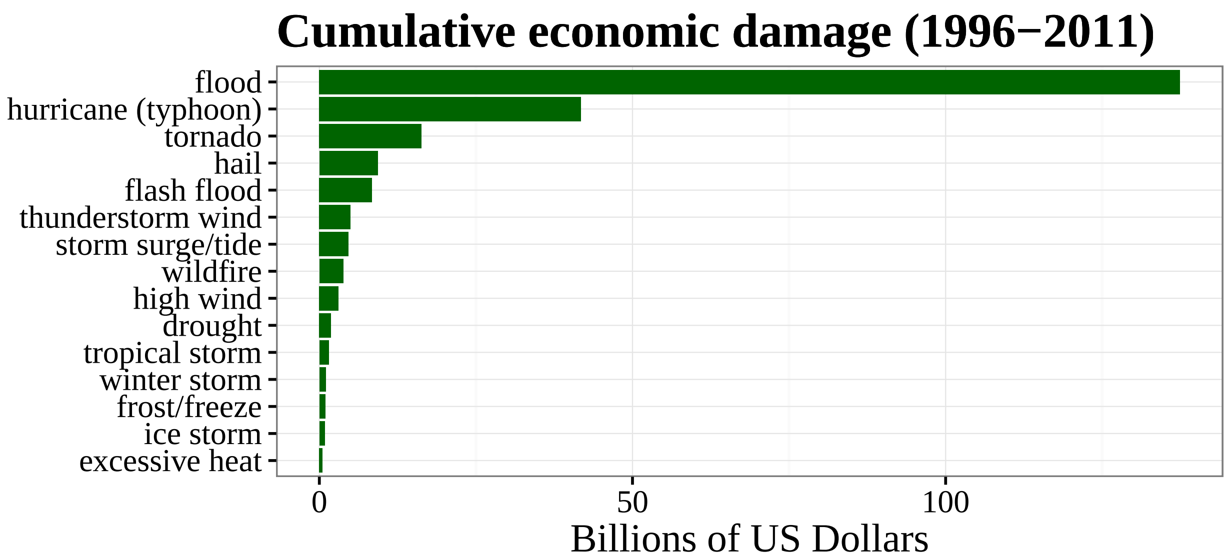


Which types of events have the greatest economic consequences?

- Between the years 1996-2011, extreme weather events were associated with 238 billion US Dollars in damage.
- The top three event types were associated with 82% of the total costs.

Here is a bar plot representing the top 15 most costly storm types.

```
# draw figure
grid.newpage()
grid.draw(f3)
```



Appendix

Here is a the code and a table describing the reclassification scheme used to reclassify mislabeled event types. In the table each original label is separated by a comma.

```
# generalte table representing the correspondance between the old and new
# labels for those that were recategorized

z <- storm.mislabel
z$event.copy <- z$event
z <- select(z, event.copy, event)
z$event.copy <- as.character(z$event.copy)
z$event.copy <- tolower(z$event.copy)

z$event.copy[grepl("non-tstm wind", z$event.copy)] <- "ambiguous"
z$event.copy[grepl("non tstm wind", z$event.copy)] <- "ambiguous"
z$event.copy[grepl("none|summary|other", z$event.copy)] <- "ambiguous"
z$event.copy[grepl("coastal storm|coastalstorm", z$event.copy)] <- "ambiguous"
z$event.copy[grepl("marine accident", z$event.copy)] <- "ambiguous"
z$event.copy[grepl("no severe weather", z$event.copy)] <- "ambiguous"
z$event.copy[grepl("drowning", z$event.copy)] <- "ambiguous"
z$event.copy[grepl("metro", z$event.copy)] <- "ambiguous"
z$event.copy[grepl("high water", z$event.copy)] <- "ambiguous"
z$event.copy[grepl("non-severe wind damage", z$event.copy)] <- "ambiguous"
z$event.copy[grepl("gusty|gradient wind|wind damage|wind and wave", z$event.copy)] <- "ambiguous"
z$event.copy[grepl("whirlwind|rogue wave", z$event.copy)] <- "ambiguous"
z$event.copy[grepl("^wind$|^winds$", z$event.copy)] <- "ambiguous"
z$event.copy[grepl("^rain$|unseasonal rain", z$event.copy)] <- "ambiguous"
z$event.copy[grepl("heavy seas|high seas|rough seas", z$event.copy)] <- "ambiguous"
z$event.copy[grepl("coastal erosion|beach erosion", z$event.copy)] <- "ambiguous"
z$event.copy[grepl("blizzard", z$event.copy)] <- "blizzard"
z$event.copy[grepl("marine tstm wind", z$event.copy)] <- "marine thunderstorm wind"
z$event.copy[grepl("strong winds", z$event.copy)] <- "strong wind"
z$event.copy[grepl("tstm heavy rain|torrential|hvy rain$", z$event.copy)] <- "heavy rain"
z$event.copy[grepl("^tstm wind|^ tstm wind|tstm wnd|downburst|gustnado|microbu",
    z$event.copy)] <- "thunderstorm wind"
z$event.copy[grepl("thunderstorm wind \\(g40", z$event.copy)] <- "thunderstorm wind"
z$event.copy[grepl("coastal flooding|coastal  flooding|cstl flood", z$event)] <- "coastal flood"
z$event.copy[grepl("astronomical high tide", z$event)] <- "coastal flood"
z$event.copy[grepl("flash|dam break|ice jam flood", z$event.copy)] <- "flash flood"
z$event.copy[grepl("surge|tidal", z$event.copy)] <- "storm surge/tide"
z$event.copy[grepl("flooding|urban flo|river flo|flood/s", z$event.copy)] <- "flood"
z$event.copy[grepl("fld", z$event.copy)] <- "flood"
z$event.copy[grepl("volca|vog", z$event.copy)] <- "volcanic ash"
z$event.copy[grepl("lightning", z$event.copy)] <- "lightning"
z$event.copy[grepl("heavy rain/high surf|heavy rain", z$event.copy)] <- "heavy rain"
z$event.copy[grepl("surf|swells", z$event.copy)] <- "high surf"
z$event.copy[grepl("^tstm$|thunderstorms|severe thunder", z$event.copy)] <- "thunderstorm wind"
z$event.copy[grepl("^thunderstorm$", z$event.copy)] <- "thunderstorm wind"
z$event.copy[grepl("devel", z$event.copy)] <- "dust devil"
z$event.copy[grepl("dust", z$event.copy)] <- "dust storm"
z$event.copy[grepl("waters", z$event.copy)] <- "waterspout"
z$event.copy[grepl("hurric|typhoon|floyd", z$event.copy)] <- "hurricane (typhoon)"
z$event.copy[grepl("small hail|gusty wind/hail", z$event.copy)] <- "hail"
```

```r
z$event.copy[grepl("torn|landspout", z$event.copy)] <- "tornado"
z$event.copy[grepl("lake effect", z$event.copy)] <- "lake-effect snow"
z$event.copy[grepl("mud|landsl|rock", z$event.copy)] <- "debris flow"
z$event.copy[grepl("heavy snow shower|excessive snow|squall", z$event.copy)] <- "heavy snow"
z$event.copy[grepl("freeze|frost", z$event.copy)] <- "frost/freeze"
z$event.copy[grepl("heat|hyperthermia|warm weather|unseasonably warm", z$event.copy)] <- "heat"
z$event.copy[grepl("extreme windchill", z$event.copy)] <- "extreme cold/wind chill"
z$event.copy[grepl("fire", z$event.copy)] <- "wildfire"
z$event.copy[grepl("high winds|high wind \\(g40", z$event.copy)] <- "high wind"
z$event.copy[grepl("rip currents", z$event.copy)] <- "rip current"
z$event.copy[grepl("extreme cold", z$event.copy)] <- "extreme cold/wind chill"
z$event.copy[grepl("cold |unseasonable cold|extended cold|unseasonably cold",
    z$event.copy)] <- "cold/wind chill"
z$event.copy[grepl("^cold$", z$event.copy)] <- "cold/wind chill"
z$event.copy[grepl("fog", z$event.copy)] <- "dense fog"
z$event.copy[grepl("winter weather|glaze|ice roads|light snow|freezing|mixed",
    z$event.copy)] <- "winter weather"
z$event.copy[grepl("snow and ice|falling snow/ice", z$event.copy)] <- "winter storm"
z$event.copy[grepl("black ic|blowing snow|ice on road|late season sno|icy road",
    z$event.copy)] <- "winter weather"
z$event.copy[grepl("rain/snow|wintry", z$event.copy)] <- "winter weather"
z$event.copy[grepl("^snow$", z$event.copy)] <- "winter weather"

zz <- z[!duplicated(z$event), ]
zz <- arrange(zz, event.copy)
zz <- spread(zz, event.copy, event)
zz <- sapply(zz, as.character)
zz[is.na(zz)] <- ""
zz <- as.data.frame(t(zz))
zz <- unite(zz, original.labels, V1:V142, sep = ",")
zz$original.labels <- gsub("^,*|(?<=,),|,*$", "", zz$original.labels, perl = T)
zz <- cbind(event = rownames(zz), zz)
rownames(zz) <- NULL
reclassify.table <- zz
xt <- xtable(reclassify.table)
pander::pander(xt, split.cell = 80, split.table = Inf, justify = c("left", "left"))
```

event	original.labels
ambiguous	other,marine accident,winds,coastal storm,beach erosion,whirlwind,wind damage,gusty wind/rain,gusty wind/hvy rain,wind,gusty winds,gusty wind,hypothermia/exposure,coastalstorm,gradient wind,unseasonal rain,coastal erosion,gusty wind/hail,heavy seas,wind and wave,high seas,rain,rough seas,non-severe wind damage,high water,rogue wave,non-tstm wind,non tstm wind,drowning
coastal flood	erosion/cstl flood,coastal flooding,coastal flooding/erosion,coastal flooding/erosion,astronomical high tide
cold/wind chill	unseasonable cold,extended cold,cold,cold temperature,cold and snow,unseasonably cold,cold weather
debris flow	landslump,mudslides,mudslide,mud slide,landslides,rock slide,landslide
dense fog	fog
dust storm	blowing dust
extreme cold/wind chill	extreme cold,extreme windchill

event	original.labels
flash flood	ice jam flood (minor,dam break,flood/flash/flood,flash flood/flood, flash flood
flood	urban/sml stream fld,river flooding,river flood
frost/freeze	freeze,damaging freeze,early frost,hard freeze,agricultural freeze,frost
hail	small hail
heat	heat wave,unseasonably warm,hyperthermia/exposure,record heat,warm weather
heavy rain	heavy rain/high surf,torrential rainfall
heavy snow	heavy snow shower,snow squalls,snow squall,excessive snow
high surf	rough surf,heavy surf,heavy surf and wind,high swells, high surf advisory,hazardous surf,heavy surf/high surf
high wind	high winds,high wind (g40)
hurricane (typhoon)	hurricane,hurricane edouard,typhoon,hurricane/typhoon
lake-effect snow	lake effect snow
marine thunderstorm wind	marine tstm wind
rip current	rip currents
storm surge/tide	storm surge,tidal flooding
strong wind	strong winds
thunderstorm wind	tstm wind,tstm wind/hail,dry microburst,downburst,microburst,tstm wind (g45),tstm wind 40,tstm wind 45,tstm wind (41),tstm wind (g40),thunderstorm,tstm wind and lightning,wet microburst, tstm wind (g45),tstm wind (g45),tstm wind (g35), tstm wind,tstm wind g45,thunderstorm wind (g40)
tornado	landspout
wildfire	wild/forest fire,brush fire
winter storm	winter storm,snow and ice,falling snow/ice
winter weather	freezing rain,wintry mix,glaze,light snow,mixed precip,freezing spray,snow,light snowfall,freezing drizzle,rain/snow,icy roads,mixed precipitation,black ice,blowing snow,light freezing rain,ice roads,late season snow,winter weather mix,ice on road,winter weather/mix