Course Project 2

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September 25, 2016

The Consequences of Weather Events on Population Health and Economic Cost

Synopsis: In this analysis, I explore the NOAA Storm Database to determine which weather events have caused the greatest number of fatalities and injuries, and which weather events have resulted in the greatest economic costs. I download and load the large data file in R and clean it so that similar events are grouped together, circumventing spelling and formatting errors in these event codes. I collapse the data by event type and year, and report the year to year total fatalities, injuries, and costs of each event. In general, excessive heat causes the greatest number of fatalities, tornados and floods cause the greatest number of injuries, and thunderstorms are the most economically costly event.

Introduction

The goal of this analysis is to explore the NOAA Storm Database and answer some basic questions about severe weather events. The analysis provides answers to the following two questions:

1. Across the United States, which types of events are most harmful with respect to population health?
2. Across the United States, which types of events have the greatest economic consequences?

Data Processing

Setting up

I use the **dplyr** and **ggplot2** packages.

```
library(dplyr)
```

```
##
## Attaching package: 'dplyr'
```

```
## The following objects are masked from 'package:stats':
##
##     filter, lag
```

```
## The following objects are masked from 'package:base':
##
##     intersect, setdiff, setequal, union
```

```
library(ggplot2)
```

Loading the data

I download the data directly from the URL provided by the course instructors. The data is stored online in the **.csv.bz2** format, which is unzipped automatically by the **read.csv()** command. The data are large – 561.1 MB – so to save time, the following code chunk is cached:

```
url <- "https://d396qusza40orc.cloudfront.net/repdata%2Fdata%2FStormData.csv.bz2"
download.file(url=url, destfile="StormData.csv.bz2")
stormdata <- read.csv("StormData.csv.bz2")
```

Exploring the data

I use the **summary()** and **str()** commands to look at a summary of every variable in the data, and I use the **head()** command to examine the first five rows in particular:

```
summary(stormdata)
```

```
##      STATE__                  BGN_DATE             BGN_TIME
##  Min.   : 1.0   5/25/2011 0:00:00:  1202   12:00:00 AM: 10163
##  1st Qu.:19.0   4/27/2011 0:00:00:  1193   06:00:00 PM:  7350
##  Median :30.0   6/9/2011 0:00:00 :  1030   04:00:00 PM:  7261
##  Mean   :31.2   5/30/2004 0:00:00:  1016   05:00:00 PM:  6891
##  3rd Qu.:45.0   4/4/2011 0:00:00 :  1009   12:00:00 PM:  6703
##  Max.   :95.0   4/2/2006 0:00:00 :   981   03:00:00 PM:  6700
##                 (Other)          :895866   (Other)    :857229
##    TIME_ZONE          COUNTY           COUNTYNAME         STATE
##  CST    :547493   Min.   :  0.0   JEFFERSON :  7840   TX     : 83728
##  EST    :245558   1st Qu.: 31.0   WASHINGTON:  7603   KS     : 53440
##  MST    : 68390   Median : 75.0   JACKSON   :  6660   OK     : 46802
##  PST    : 28302   Mean   :100.6   FRANKLIN  :  6256   MO     : 35648
##  AST    :  6360   3rd Qu.:131.0   LINCOLN   :  5937   IA     : 31069
##  HST    :  2563   Max.   :873.0   MADISON   :  5632   NE     : 30271
##  (Other):  3631                   (Other)   :862369   (Other):621339
##                EVTYPE         BGN_RANGE           BGN_AZI
##  HAIL             :288661   Min.   :   0.000          :547332
##  TSTM WIND        :219940   1st Qu.:   0.000   N      : 86752
##  THUNDERSTORM WIND: 82563   Median :   0.000   W      : 38446
##  TORNADO          : 60652   Mean   :   1.484   S      : 37558
##  FLASH FLOOD      : 54277   3rd Qu.:   1.000   E      : 33178
##  FLOOD            : 25326   Max.   :3749.000   NW     : 24041
##  (Other)          :170878                      (Other):134990
##         BGN_LOCATI                  END_DATE             END_TIME
##                :287743                     :243411             :238978
##  COUNTYWIDE    : 19680   4/27/2011 0:00:00:  1214   06:00:00 PM:  9802
##  Countywide    :   993   5/25/2011 0:00:00:  1196   05:00:00 PM:  8314
##  SPRINGFIELD   :   843   6/9/2011 0:00:00 :  1021   04:00:00 PM:  8104
##  SOUTH PORTION:   810   4/4/2011 0:00:00 :  1007   12:00:00 PM:  7483
##  NORTH PORTION:   784   5/30/2004 0:00:00:   998   11:59:00 PM:  7184
```

```
##  (Other)      :591444   (Other)          :653450   (Other)    :622432
##    COUNTY_END COUNTYENDN       END_RANGE           END_AZI
##  Min.   :0    Mode:logical   Min.   :  0.0000          :724837
##  1st Qu.:0    NA's:902297    1st Qu.:  0.0000   N      : 28082
##  Median :0                   Median :  0.0000   S      : 22510
##  Mean   :0                   Mean   :  0.9862   W      : 20119
##  3rd Qu.:0                   3rd Qu.:  0.0000   E      : 20047
##  Max.   :0                   Max.   :925.0000   NE     : 14606
##                                                 (Other): 72096
##            END_LOCATI         LENGTH              WIDTH
##                   :499225   Min.   :   0.0000   Min.   :   0.000
##  COUNTYWIDE       : 19731   1st Qu.:   0.0000   1st Qu.:   0.000
##  SOUTH PORTION    :   833   Median :   0.0000   Median :   0.000
##  NORTH PORTION    :   780   Mean   :   0.2301   Mean   :   7.503
##  CENTRAL PORTION  :   617   3rd Qu.:   0.0000   3rd Qu.:   0.000
##  SPRINGFIELD      :   575   Max.   :2315.0000   Max.   :4400.000
##  (Other)          :380536
##        F               MAG            FATALITIES          INJURIES
##  Min.   :0.0      Min.   :    0.0   Min.   :  0.0000   Min.   :   0.0000
##  1st Qu.:0.0      1st Qu.:    0.0   1st Qu.:  0.0000   1st Qu.:   0.0000
##  Median :1.0      Median :   50.0   Median :  0.0000   Median :   0.0000
##  Mean   :0.9      Mean   :   46.9   Mean   :  0.0168   Mean   :   0.1557
##  3rd Qu.:1.0      3rd Qu.:   75.0   3rd Qu.:  0.0000   3rd Qu.:   0.0000
##  Max.   :5.0      Max.   :22000.0   Max.   :583.0000   Max.   :1700.0000
##  NA's   :843563
##     PROPDMG          PROPDMGEXP        CROPDMG          CROPDMGEXP
##  Min.   :   0.00          :465934   Min.   :  0.000          :618413
##  1st Qu.:   0.00   K      :424665   1st Qu.:  0.000   K      :281832
##  Median :   0.00   M      : 11330   Median :  0.000   M      :  1994
##  Mean   :  12.06   0      :   216   Mean   :  1.527   k      :    21
##  3rd Qu.:   0.50   B      :    40   3rd Qu.:  0.000   0      :    19
##  Max.   :5000.00   5      :    28   Max.   :990.000   B      :     9
##                    (Other):    84                     (Other):     9
##       WFO                                         STATEOFFIC
##         :142069                                         :248769
##  OUN    : 17393   TEXAS, North                          : 12193
##  JAN    : 13889   ARKANSAS, Central and North Central: 11738
##  LWX    : 13174   IOWA, Central                         : 11345
##  PHI    : 12551   KANSAS, Southwest                     : 11212
##  TSA    : 12483   GEORGIA, North and Central            : 11120
##  (Other):690738   (Other)                               :595920
##
ZONENAMES
##
:594029
##
:205988
##  GREATER RENO / CARSON CITY / M - GREATER RENO / CARSON CITY / M
:   639
##  GREATER LAKE TAHOE AREA - GREATER LAKE TAHOE AREA
:   592
##  JEFFERSON - JEFFERSON
:   303
##  MADISON - MADISON
```

```
:   302
##  (Other)
:100444
##     LATITUDE      LONGITUDE        LATITUDE_E     LONGITUDE_
##  Min.   :   0   Min.   :-14451   Min.   :   0   Min.   :-14455
##  1st Qu.:2802   1st Qu.:  7247   1st Qu.:   0   1st Qu.:     0
##  Median :3540   Median :  8707   Median :   0   Median :     0
##  Mean   :2875   Mean   :  6940   Mean   :1452   Mean   :  3509
##  3rd Qu.:4019   3rd Qu.:  9605   3rd Qu.:3549   3rd Qu.:  8735
##  Max.   :9706   Max.   : 17124   Max.   :9706   Max.   :106220
##  NA's   :47                      NA's   :40
##                                                    REMARKS           REFNUM
##                                                        :287433   Min.   :     1
##                                                        : 24013   1st Qu.:225575
##  Trees down.\n                                         :  1110   Median :451149
##  Several trees were blown down.\n                      :   568   Mean   :451149
##  Trees were downed.\n                                  :   446   3rd Qu.:676723
##  Large trees and power lines were blown down.\n:   432   Max.   :902297
##  (Other)                                               :588295
```

```
str(stormdata)
```

```
## 'data.frame':    902297 obs. of  37 variables:
##  $ STATE__   : num  1 1 1 1 1 1 1 1 1 1 ...
##  $ BGN_DATE  : Factor w/ 16335 levels "1/1/1966 0:00:00",..: 6523 6523 4242 111
16 2224 2224 2260 383 3980 3980 ...
##  $ BGN_TIME  : Factor w/ 3608 levels "00:00:00 AM",..: 272 287 2705 1683 2584 3
186 242 1683 3186 3186 ...
##  $ TIME_ZONE : Factor w/ 22 levels "ADT","AKS","AST",..: 7 7 7 7 7 7 7 7 7 7 ..
.
##  $ COUNTY    : num  97 3 57 89 43 77 9 123 125 57 ...
##  $ COUNTYNAME: Factor w/ 29601 levels "","5NM E OF MACKINAC BRIDGE TO PRESQUE I
SLE LT MI",..: 13513 1873 4598 10592 4372 10094 1973 23873 24418 4598 ...
##  $ STATE     : Factor w/ 72 levels "AK","AL","AM",..: 2 2 2 2 2 2 2 2 2 2 ...
##  $ EVTYPE    : Factor w/ 985 levels "   HIGH SURF ADVISORY",..: 834 834 834 834
834 834 834 834 834 834 ...
##  $ BGN_RANGE : num  0 0 0 0 0 0 0 0 0 0 ...
##  $ BGN_AZI   : Factor w/ 35 levels "","  N"," NW",..: 1 1 1 1 1 1 1 1 1 1 ...
##  $ BGN_LOCATI: Factor w/ 54429 levels "","  Christiansburg",..: 1 1 1 1 1 1 1 1
1 1 ...
##  $ END_DATE  : Factor w/ 6663 levels "","1/1/1993 0:00:00",..: 1 1 1 1 1 1 1 1
1 1 ...
##  $ END_TIME  : Factor w/ 3647 levels "","  0900CST",..: 1 1 1 1 1 1 1 1 1 1 ...
##  $ COUNTY_END: num  0 0 0 0 0 0 0 0 0 0 ...
##  $ COUNTYENDN: logi  NA NA NA NA NA NA ...
##  $ END_RANGE : num  0 0 0 0 0 0 0 0 0 0 ...
##  $ END_AZI   : Factor w/ 24 levels "","E","ENE","ESE",..: 1 1 1 1 1 1 1 1 1 1 .
..
##  $ END_LOCATI: Factor w/ 34506 levels "","  CANTON","  TULIA",..: 1 1 1 1 1 1 1 1
1 1 ...
##  $ LENGTH    : num  14 2 0.1 0 0 1.5 1.5 0 3.3 2.3 ...
##  $ WIDTH     : num  100 150 123 100 150 177 33 33 100 100 ...
##  $ F         : int  3 2 2 2 2 2 2 1 3 3 ...
##  $ MAG       : num  0 0 0 0 0 0 0 0 0 0 ...
##  $ 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 2.5 25 25 ...
##  $ PROPDMGEXP: Factor w/ 19 levels "","-","?","+",..: 17 17 17 17 17 17 17 17 1
7 17 ...
##  $ CROPDMG   : num  0 0 0 0 0 0 0 0 0 0 ...
##  $ CROPDMGEXP: Factor w/ 9 levels "","?","0","2",..: 1 1 1 1 1 1 1 1 1 1 ...
##  $ WFO       : Factor w/ 542 levels "","  CI","%SD",..: 1 1 1 1 1 1 1 1 1 1 ...
##  $ STATEOFFIC: Factor w/ 250 levels "","ALABAMA, Central",..: 1 1 1 1 1 1 1 1 1
1 ...
##  $ ZONENAMES : Factor w/ 25112 levels "","
"| __truncated__,..: 1 1 1 1 1 1 1 1 1 1 ...
##  $ LATITUDE  : num  3040 3042 3340 3458 3412 ...
##  $ LONGITUDE : num  8812 8755 8742 8626 8642 ...
##  $ LATITUDE_E: num  3051 0 0 0 0 ...
##  $ LONGITUDE_: num  8806 0 0 0 0 ...
##  $ REMARKS   : Factor w/ 436781 levels "","\t","\t\t",..: 1 1 1 1 1 1 1 1 1 1 .
..
##  $ REFNUM    : num  1 2 3 4 5 6 7 8 9 10 ...
```

```
head(stormdata)
```

```
##   STATE__           BGN_DATE BGN_TIME TIME_ZONE COUNTY COUNTYNAME STATE
## 1       1  4/18/1950 0:00:00     0130       CST     97     MOBILE    AL
## 2       1  4/18/1950 0:00:00     0145       CST      3    BALDWIN    AL
## 3       1  2/20/1951 0:00:00     1600       CST     57    FAYETTE    AL
## 4       1   6/8/1951 0:00:00     0900       CST     89    MADISON    AL
## 5       1 11/15/1951 0:00:00     1500       CST     43    CULLMAN    AL
## 6       1 11/15/1951 0:00:00     2000       CST     77 LAUDERDALE    AL
##    EVTYPE BGN_RANGE BGN_AZI BGN_LOCATI END_DATE END_TIME COUNTY_END
## 1 TORNADO         0                                               0
## 2 TORNADO         0                                               0
## 3 TORNADO         0                                               0
## 4 TORNADO         0                                               0
## 5 TORNADO         0                                               0
## 6 TORNADO         0                                               0
##   COUNTYENDN END_RANGE END_AZI END_LOCATI LENGTH WIDTH F MAG FATALITIES
## 1         NA         0                    14.0   100 3   0          0
## 2         NA         0                     2.0   150 2   0          0
## 3         NA         0                     0.1   123 2   0          0
## 4         NA         0                     0.0   100 2   0          0
## 5         NA         0                     0.0   150 2   0          0
## 6         NA         0                     1.5   177 2   0          0
##   INJURIES PROPDMG PROPDMGEXP CROPDMG CROPDMGEXP WFO STATEOFFIC ZONENAMES
## 1       15    25.0          K       0
## 2        0     2.5          K       0
## 3        2    25.0          K       0
## 4        2     2.5          K       0
## 5        2     2.5          K       0
## 6        6     2.5          K       0
##   LATITUDE LONGITUDE LATITUDE_E LONGITUDE_ REMARKS REFNUM
## 1     3040      8812       3051       8806              1
## 2     3042      8755          0          0              2
## 3     3340      8742          0          0              3
## 4     3458      8626          0          0              4
## 5     3412      8642          0          0              5
## 6     3450      8748          0          0              6
```

The events of interest are contained in the variable **EVTYPE**. To see a full list of the events, I use the **levels()** command:

```
levels(stormdata$EVTYPE)
```

```
##   [1] "   HIGH SURF ADVISORY"          " COASTAL FLOOD"
##   [3] " FLASH FLOOD"                   " LIGHTNING"
##   [5] " TSTM WIND"                     " TSTM WIND (G45)"
##   [7] " WATERSPOUT"                    " WIND"
##   [9] "?"                              "ABNORMAL WARMTH"
##  [11] "ABNORMALLY DRY"                 "ABNORMALLY WET"
##  [13] "ACCUMULATED SNOWFALL"           "AGRICULTURAL FREEZE"
##  [15] "APACHE COUNTY"                  "ASTRONOMICAL HIGH TIDE"
```

```
##  [17] "ASTRONOMICAL LOW TIDE"           "AVALANCE"
##  [19] "AVALANCHE"                       "BEACH EROSIN"
##  [21] "Beach Erosion"                   "BEACH EROSION"
##  [23] "BEACH EROSION/COASTAL FLOOD"     "BEACH FLOOD"
##  [25] "BELOW NORMAL PRECIPITATION"      "BITTER WIND CHILL"
##  [27] "BITTER WIND CHILL TEMPERATURES" "Black Ice"
##  [29] "BLACK ICE"                       "BLIZZARD"
##  [31] "BLIZZARD AND EXTREME WIND CHIL" "BLIZZARD AND HEAVY SNOW"
##  [33] "Blizzard Summary"                "BLIZZARD WEATHER"
##  [35] "BLIZZARD/FREEZING RAIN"          "BLIZZARD/HEAVY SNOW"
##  [37] "BLIZZARD/HIGH WIND"              "BLIZZARD/WINTER STORM"
##  [39] "BLOW-OUT TIDE"                   "BLOW-OUT TIDES"
##  [41] "BLOWING DUST"                    "blowing snow"
##  [43] "Blowing Snow"                    "BLOWING SNOW"
##  [45] "BLOWING SNOW & EXTREME WIND CH" "BLOWING SNOW- EXTREME WIND CHI"
##  [47] "BLOWING SNOW/EXTREME WIND CHIL" "BREAKUP FLOODING"
##  [49] "BRUSH FIRE"                      "BRUSH FIRES"
##  [51] "COASTAL  FLOODING/EROSION"       "COASTAL EROSION"
##  [53] "Coastal Flood"                   "COASTAL FLOOD"
##  [55] "coastal flooding"                "Coastal Flooding"
##  [57] "COASTAL FLOODING"                "COASTAL FLOODING/EROSION"
##  [59] "Coastal Storm"                   "COASTAL STORM"
##  [61] "COASTAL SURGE"                   "COASTAL/TIDAL FLOOD"
##  [63] "COASTALFLOOD"                    "COASTALSTORM"
##  [65] "Cold"                            "COLD"
##  [67] "COLD AIR FUNNEL"                 "COLD AIR FUNNELS"
##  [69] "COLD AIR TORNADO"                "Cold and Frost"
##  [71] "COLD AND FROST"                  "COLD AND SNOW"
##  [73] "COLD AND WET CONDITIONS"         "Cold Temperature"
##  [75] "COLD TEMPERATURES"               "COLD WAVE"
##  [77] "COLD WEATHER"                    "COLD WIND CHILL TEMPERATURES"
##  [79] "COLD/WIND CHILL"                 "COLD/WINDS"
##  [81] "COOL AND WET"                    "COOL SPELL"
##  [83] "CSTL FLOODING/EROSION"           "DAM BREAK"
##  [85] "DAM FAILURE"                     "Damaging Freeze"
##  [87] "DAMAGING FREEZE"                 "DEEP HAIL"
##  [89] "DENSE FOG"                       "DENSE SMOKE"
##  [91] "DOWNBURST"                       "DOWNBURST WINDS"
##  [93] "DRIEST MONTH"                    "Drifting Snow"
##  [95] "DROUGHT"                         "DROUGHT/EXCESSIVE HEAT"
##  [97] "DROWNING"                        "DRY"
##  [99] "DRY CONDITIONS"                  "DRY HOT WEATHER"
## [101] "DRY MICROBURST"                  "DRY MICROBURST 50"
## [103] "DRY MICROBURST 53"               "DRY MICROBURST 58"
## [105] "DRY MICROBURST 61"               "DRY MICROBURST 84"
## [107] "DRY MICROBURST WINDS"            "DRY MIRCOBURST WINDS"
## [109] "DRY PATTERN"                     "DRY SPELL"
## [111] "DRY WEATHER"                     "DRYNESS"
## [113] "DUST DEVEL"                      "Dust Devil"
## [115] "DUST DEVIL"                      "DUST DEVIL WATERSPOUT"
## [117] "DUST STORM"                      "DUST STORM/HIGH WINDS"
## [119] "DUSTSTORM"                       "EARLY FREEZE"
## [121] "Early Frost"                     "EARLY FROST"
## [123] "EARLY RAIN"                      "EARLY SNOW"
```

```
## [125] "Early snowfall"                  "EARLY SNOWFALL"
## [127] "Erosion/Cstl Flood"              "EXCESSIVE"
## [129] "Excessive Cold"                  "EXCESSIVE HEAT"
## [131] "EXCESSIVE HEAT/DROUGHT"          "EXCESSIVE PRECIPITATION"
## [133] "EXCESSIVE RAIN"                  "EXCESSIVE RAINFALL"
## [135] "EXCESSIVE SNOW"                  "EXCESSIVE WETNESS"
## [137] "EXCESSIVELY DRY"                 "Extended Cold"
## [139] "Extreme Cold"                    "EXTREME COLD"
## [141] "EXTREME COLD/WIND CHILL"         "EXTREME HEAT"
## [143] "EXTREME WIND CHILL"              "EXTREME WIND CHILL/BLOWING SNO"
## [145] "EXTREME WIND CHILLS"             "EXTREME WINDCHILL"
## [147] "EXTREME WINDCHILL TEMPERATURES" "EXTREME/RECORD COLD"
## [149] "EXTREMELY WET"                   "FALLING SNOW/ICE"
## [151] "FIRST FROST"                     "FIRST SNOW"
## [153] "FLASH FLOOD"                     "FLASH FLOOD - HEAVY RAIN"
## [155] "FLASH FLOOD FROM ICE JAMS"       "FLASH FLOOD LANDSLIDES"
## [157] "FLASH FLOOD WINDS"               "FLASH FLOOD/"
## [159] "FLASH FLOOD/ FLOOD"              "FLASH FLOOD/ STREET"
## [161] "FLASH FLOOD/FLOOD"               "FLASH FLOOD/HEAVY RAIN"
## [163] "FLASH FLOOD/LANDSLIDE"           "FLASH FLOODING"
## [165] "FLASH FLOODING/FLOOD"            "FLASH FLOODING/THUNDERSTORM WI"
## [167] "FLASH FLOODS"                    "FLASH FLOOODING"
## [169] "Flood"                           "FLOOD"
## [171] "FLOOD & HEAVY RAIN"              "FLOOD FLASH"
## [173] "FLOOD FLOOD/FLASH"               "FLOOD WATCH/"
## [175] "FLOOD/FLASH"                     "Flood/Flash Flood"
## [177] "FLOOD/FLASH FLOOD"               "FLOOD/FLASH FLOODING"
## [179] "FLOOD/FLASH/FLOOD"               "FLOOD/FLASHFLOOD"
## [181] "FLOOD/RAIN/WIND"                 "FLOOD/RAIN/WINDS"
## [183] "FLOOD/RIVER FLOOD"               "Flood/Strong Wind"
## [185] "FLOODING"                        "FLOODING/HEAVY RAIN"
## [187] "FLOODS"                          "FOG"
## [189] "FOG AND COLD TEMPERATURES"       "FOREST FIRES"
## [191] "Freeze"                          "FREEZE"
## [193] "Freezing drizzle"                "Freezing Drizzle"
## [195] "FREEZING DRIZZLE"                "FREEZING DRIZZLE AND FREEZING"
## [197] "Freezing Fog"                    "FREEZING FOG"
## [199] "Freezing rain"                   "Freezing Rain"
## [201] "FREEZING RAIN"                   "FREEZING RAIN AND SLEET"
## [203] "FREEZING RAIN AND SNOW"          "FREEZING RAIN SLEET AND"
## [205] "FREEZING RAIN SLEET AND LIGHT"   "FREEZING RAIN/SLEET"
## [207] "FREEZING RAIN/SNOW"              "Freezing Spray"
## [209] "Frost"                           "FROST"
## [211] "Frost/Freeze"                    "FROST/FREEZE"
## [213] "FROST\\FREEZE"                   "FUNNEL"
## [215] "Funnel Cloud"                    "FUNNEL CLOUD"
## [217] "FUNNEL CLOUD."                   "FUNNEL CLOUD/HAIL"
## [219] "FUNNEL CLOUDS"                   "FUNNELS"
## [221] "Glaze"                           "GLAZE"
## [223] "GLAZE ICE"                       "GLAZE/ICE STORM"
## [225] "gradient wind"                   "Gradient wind"
## [227] "GRADIENT WIND"                   "GRADIENT WINDS"
## [229] "GRASS FIRES"                     "GROUND BLIZZARD"
## [231] "GUSTNADO"                        "GUSTNADO AND"
```

```
## [233] "GUSTY LAKE WIND"                 "GUSTY THUNDERSTORM WIND"
## [235] "GUSTY THUNDERSTORM WINDS"        "Gusty Wind"
## [237] "GUSTY WIND"                      "GUSTY WIND/HAIL"
## [239] "GUSTY WIND/HVY RAIN"             "Gusty wind/rain"
## [241] "Gusty winds"                     "Gusty Winds"
## [243] "GUSTY WINDS"                     "HAIL"
## [245] "HAIL 0.75"                       "HAIL 0.88"
## [247] "HAIL 075"                        "HAIL 088"
## [249] "HAIL 1.00"                       "HAIL 1.75"
## [251] "HAIL 1.75)"                      "HAIL 100"
## [253] "HAIL 125"                        "HAIL 150"
## [255] "HAIL 175"                        "HAIL 200"
## [257] "HAIL 225"                        "HAIL 275"
## [259] "HAIL 450"                        "HAIL 75"
## [261] "HAIL 80"                         "HAIL 88"
## [263] "HAIL ALOFT"                      "HAIL DAMAGE"
## [265] "HAIL FLOODING"                   "HAIL STORM"
## [267] "Hail(0.75)"                      "HAIL/ICY ROADS"
## [269] "HAIL/WIND"                       "HAIL/WINDS"
## [271] "HAILSTORM"                       "HAILSTORMS"
## [273] "HARD FREEZE"                     "HAZARDOUS SURF"
## [275] "HEAT"                            "HEAT DROUGHT"
## [277] "Heat Wave"                       "HEAT WAVE"
## [279] "HEAT WAVE DROUGHT"               "HEAT WAVES"
## [281] "HEAT/DROUGHT"                    "Heatburst"
## [283] "HEAVY LAKE SNOW"                 "HEAVY MIX"
## [285] "HEAVY PRECIPATATION"             "Heavy Precipitation"
## [287] "HEAVY PRECIPITATION"             "Heavy rain"
## [289] "Heavy Rain"                      "HEAVY RAIN"
## [291] "HEAVY RAIN AND FLOOD"            "Heavy Rain and Wind"
## [293] "HEAVY RAIN EFFECTS"              "HEAVY RAIN; URBAN FLOOD WINDS;"
## [295] "HEAVY RAIN/FLOODING"             "Heavy Rain/High Surf"
## [297] "HEAVY RAIN/LIGHTNING"            "HEAVY RAIN/MUDSLIDES/FLOOD"
## [299] "HEAVY RAIN/SEVERE WEATHER"       "HEAVY RAIN/SMALL STREAM URBAN"
## [301] "HEAVY RAIN/SNOW"                 "HEAVY RAIN/URBAN FLOOD"
## [303] "HEAVY RAIN/WIND"                 "HEAVY RAINFALL"
## [305] "HEAVY RAINS"                     "HEAVY RAINS/FLOODING"
## [307] "HEAVY SEAS"                      "HEAVY SHOWER"
## [309] "HEAVY SHOWERS"                   "HEAVY SNOW"
## [311] "HEAVY SNOW   FREEZING RAIN"      "HEAVY SNOW & ICE"
## [313] "HEAVY SNOW AND"                  "HEAVY SNOW AND HIGH WINDS"
## [315] "HEAVY SNOW AND ICE"              "HEAVY SNOW AND ICE STORM"
## [317] "HEAVY SNOW AND STRONG WINDS"     "HEAVY SNOW ANDBLOWING SNOW"
## [319] "Heavy snow shower"               "HEAVY SNOW SQUALLS"
## [321] "HEAVY SNOW-SQUALLS"              "HEAVY SNOW/BLIZZARD"
## [323] "HEAVY SNOW/BLIZZARD/AVALANCHE"   "HEAVY SNOW/BLOWING SNOW"
## [325] "HEAVY SNOW/FREEZING RAIN"        "HEAVY SNOW/HIGH"
## [327] "HEAVY SNOW/HIGH WIND"            "HEAVY SNOW/HIGH WINDS"
## [329] "HEAVY SNOW/HIGH WINDS & FLOOD"   "HEAVY SNOW/HIGH WINDS/FREEZING"
## [331] "HEAVY SNOW/ICE"                  "HEAVY SNOW/ICE STORM"
## [333] "HEAVY SNOW/SLEET"                "HEAVY SNOW/SQUALLS"
## [335] "HEAVY SNOW/WIND"                 "HEAVY SNOW/WINTER STORM"
## [337] "HEAVY SNOWPACK"                  "Heavy Surf"
## [339] "HEAVY SURF"                      "Heavy surf and wind"
```

```
## [341] "HEAVY SURF COASTAL FLOODING"    "HEAVY SURF/HIGH SURF"
## [343] "HEAVY SWELLS"                   "HEAVY WET SNOW"
## [345] "HIGH"                           "HIGH  SWELLS"
## [347] "HIGH  WINDS"                    "HIGH SEAS"
## [349] "High Surf"                      "HIGH SURF"
## [351] "HIGH SURF ADVISORIES"           "HIGH SURF ADVISORY"
## [353] "HIGH SWELLS"                    "HIGH TEMPERATURE RECORD"
## [355] "HIGH TIDES"                     "HIGH WATER"
## [357] "HIGH WAVES"                     "High Wind"
## [359] "HIGH WIND"                      "HIGH WIND (G40)"
## [361] "HIGH WIND 48"                   "HIGH WIND 63"
## [363] "HIGH WIND 70"                   "HIGH WIND AND HEAVY SNOW"
## [365] "HIGH WIND AND HIGH TIDES"       "HIGH WIND AND SEAS"
## [367] "HIGH WIND DAMAGE"               "HIGH WIND/ BLIZZARD"
## [369] "HIGH WIND/BLIZZARD"             "HIGH WIND/BLIZZARD/FREEZING RA"
## [371] "HIGH WIND/HEAVY SNOW"           "HIGH WIND/LOW WIND CHILL"
## [373] "HIGH WIND/SEAS"                 "HIGH WIND/WIND CHILL"
## [375] "HIGH WIND/WIND CHILL/BLIZZARD"  "HIGH WINDS"
## [377] "HIGH WINDS 55"                  "HIGH WINDS 57"
## [379] "HIGH WINDS 58"                  "HIGH WINDS 63"
## [381] "HIGH WINDS 66"                  "HIGH WINDS 67"
## [383] "HIGH WINDS 73"                  "HIGH WINDS 76"
## [385] "HIGH WINDS 80"                  "HIGH WINDS 82"
## [387] "HIGH WINDS AND WIND CHILL"      "HIGH WINDS DUST STORM"
## [389] "HIGH WINDS HEAVY RAINS"         "HIGH WINDS/"
## [391] "HIGH WINDS/COASTAL FLOOD"       "HIGH WINDS/COLD"
## [393] "HIGH WINDS/FLOODING"            "HIGH WINDS/HEAVY RAIN"
## [395] "HIGH WINDS/SNOW"                "HIGHWAY FLOODING"
## [397] "Hot and Dry"                    "HOT PATTERN"
## [399] "HOT SPELL"                      "HOT WEATHER"
## [401] "HOT/DRY PATTERN"                "HURRICANE"
## [403] "Hurricane Edouard"              "HURRICANE EMILY"
## [405] "HURRICANE ERIN"                 "HURRICANE FELIX"
## [407] "HURRICANE GORDON"               "HURRICANE OPAL"
## [409] "HURRICANE OPAL/HIGH WINDS"      "HURRICANE-GENERATED SWELLS"
## [411] "HURRICANE/TYPHOON"              "HVY RAIN"
## [413] "HYPERTHERMIA/EXPOSURE"          "HYPOTHERMIA"
## [415] "Hypothermia/Exposure"           "HYPOTHERMIA/EXPOSURE"
## [417] "ICE"                            "ICE AND SNOW"
## [419] "ICE FLOES"                      "Ice Fog"
## [421] "ICE JAM"                        "Ice jam flood (minor"
## [423] "ICE JAM FLOODING"               "ICE ON ROAD"
## [425] "ICE PELLETS"                    "ICE ROADS"
## [427] "ICE STORM"                      "ICE STORM AND SNOW"
## [429] "ICE STORM/FLASH FLOOD"          "Ice/Snow"
## [431] "ICE/SNOW"                       "ICE/STRONG WINDS"
## [433] "Icestorm/Blizzard"              "Icy Roads"
## [435] "ICY ROADS"                      "LACK OF SNOW"
## [437] "Lake Effect Snow"               "LAKE EFFECT SNOW"
## [439] "LAKE FLOOD"                     "LAKE-EFFECT SNOW"
## [441] "LAKESHORE FLOOD"                "LANDSLIDE"
## [443] "LANDSLIDE/URBAN FLOOD"          "LANDSLIDES"
## [445] "Landslump"                      "LANDSLUMP"
## [447] "LANDSPOUT"                      "LARGE WALL CLOUD"
```

```
## [449] "LATE FREEZE"                    "LATE SEASON HAIL"
## [451] "LATE SEASON SNOW"               "Late Season Snowfall"
## [453] "LATE SNOW"                      "Late-season Snowfall"
## [455] "LIGHT FREEZING RAIN"            "Light snow"
## [457] "Light Snow"                     "LIGHT SNOW"
## [459] "LIGHT SNOW AND SLEET"           "Light Snow/Flurries"
## [461] "LIGHT SNOW/FREEZING PRECIP"     "Light Snowfall"
## [463] "LIGHTING"                       "LIGHTNING"
## [465] "LIGHTNING  WAUSEON"             "LIGHTNING AND HEAVY RAIN"
## [467] "LIGHTNING AND THUNDERSTORM WIN" "LIGHTNING AND WINDS"
## [469] "LIGHTNING DAMAGE"               "LIGHTNING FIRE"
## [471] "LIGHTNING INJURY"               "LIGHTNING THUNDERSTORM WINDS"
## [473] "LIGHTNING THUNDERSTORM WINDSS"  "LIGHTNING."
## [475] "LIGHTNING/HEAVY RAIN"           "LIGNTNING"
## [477] "LOCAL FLASH FLOOD"              "LOCAL FLOOD"
## [479] "LOCALLY HEAVY RAIN"             "LOW TEMPERATURE"
## [481] "LOW TEMPERATURE RECORD"         "LOW WIND CHILL"
## [483] "MAJOR FLOOD"                    "Marine Accident"
## [485] "MARINE HAIL"                    "MARINE HIGH WIND"
## [487] "MARINE MISHAP"                  "MARINE STRONG WIND"
## [489] "MARINE THUNDERSTORM WIND"       "MARINE TSTM WIND"
## [491] "Metro Storm, May 26"            "Microburst"
## [493] "MICROBURST"                     "MICROBURST WINDS"
## [495] "Mild and Dry Pattern"           "MILD PATTERN"
## [497] "MILD/DRY PATTERN"               "MINOR FLOOD"
## [499] "Minor Flooding"                 "MINOR FLOODING"
## [501] "MIXED PRECIP"                   "Mixed Precipitation"
## [503] "MIXED PRECIPITATION"            "MODERATE SNOW"
## [505] "MODERATE SNOWFALL"              "MONTHLY PRECIPITATION"
## [507] "Monthly Rainfall"               "MONTHLY RAINFALL"
## [509] "Monthly Snowfall"               "MONTHLY SNOWFALL"
## [511] "MONTHLY TEMPERATURE"            "Mountain Snows"
## [513] "MUD SLIDE"                      "MUD SLIDES"
## [515] "MUD SLIDES URBAN FLOODING"      "MUD/ROCK SLIDE"
## [517] "Mudslide"                       "MUDSLIDE"
## [519] "MUDSLIDE/LANDSLIDE"             "Mudslides"
## [521] "MUDSLIDES"                      "NEAR RECORD SNOW"
## [523] "No Severe Weather"              "NON SEVERE HAIL"
## [525] "NON TSTM WIND"                  "NON-SEVERE WIND DAMAGE"
## [527] "NON-TSTM WIND"                  "NONE"
## [529] "NORMAL PRECIPITATION"           "NORTHERN LIGHTS"
## [531] "Other"                          "OTHER"
## [533] "PATCHY DENSE FOG"               "PATCHY ICE"
## [535] "Prolong Cold"                   "PROLONG COLD"
## [537] "PROLONG COLD/SNOW"              "PROLONG WARMTH"
## [539] "PROLONGED RAIN"                 "RAIN"
## [541] "RAIN (HEAVY)"                   "RAIN AND WIND"
## [543] "Rain Damage"                    "RAIN/SNOW"
## [545] "RAIN/WIND"                      "RAINSTORM"
## [547] "RAPIDLY RISING WATER"           "RECORD  COLD"
## [549] "Record Cold"                    "RECORD COLD"
## [551] "RECORD COLD AND HIGH WIND"      "RECORD COLD/FROST"
## [553] "RECORD COOL"                    "Record dry month"
## [555] "RECORD DRYNESS"                 "Record Heat"
```

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## [557] "RECORD HEAT"                    "RECORD HEAT WAVE"
## [559] "Record High"                    "RECORD HIGH"
## [561] "RECORD HIGH TEMPERATURE"        "RECORD HIGH TEMPERATURES"
## [563] "RECORD LOW"                     "RECORD LOW RAINFALL"
## [565] "Record May Snow"                "RECORD PRECIPITATION"
## [567] "RECORD RAINFALL"                "RECORD SNOW"
## [569] "RECORD SNOW/COLD"               "RECORD SNOWFALL"
## [571] "Record temperature"             "RECORD TEMPERATURE"
## [573] "Record Temperatures"            "RECORD TEMPERATURES"
## [575] "RECORD WARM"                    "RECORD WARM TEMPS."
## [577] "Record Warmth"                  "RECORD WARMTH"
## [579] "Record Winter Snow"             "RECORD/EXCESSIVE HEAT"
## [581] "RECORD/EXCESSIVE RAINFALL"      "RED FLAG CRITERIA"
## [583] "RED FLAG FIRE WX"               "REMNANTS OF FLOYD"
## [585] "RIP CURRENT"                    "RIP CURRENTS"
## [587] "RIP CURRENTS HEAVY SURF"        "RIP CURRENTS/HEAVY SURF"
## [589] "RIVER AND STREAM FLOOD"         "RIVER FLOOD"
## [591] "River Flooding"                 "RIVER FLOODING"
## [593] "ROCK SLIDE"                     "ROGUE WAVE"
## [595] "ROTATING WALL CLOUD"            "ROUGH SEAS"
## [597] "ROUGH SURF"                     "RURAL FLOOD"
## [599] "Saharan Dust"                   "SAHARAN DUST"
## [601] "Seasonal Snowfall"              "SEICHE"
## [603] "SEVERE COLD"                    "SEVERE THUNDERSTORM"
## [605] "SEVERE THUNDERSTORM WINDS"      "SEVERE THUNDERSTORMS"
## [607] "SEVERE TURBULENCE"              "SLEET"
## [609] "SLEET & FREEZING RAIN"          "SLEET STORM"
## [611] "SLEET/FREEZING RAIN"            "SLEET/ICE STORM"
## [613] "SLEET/RAIN/SNOW"                "SLEET/SNOW"
## [615] "small hail"                     "Small Hail"
## [617] "SMALL HAIL"                     "SMALL STREAM"
## [619] "SMALL STREAM AND"               "SMALL STREAM AND URBAN FLOOD"
## [621] "SMALL STREAM AND URBAN FLOODIN" "SMALL STREAM FLOOD"
## [623] "SMALL STREAM FLOODING"          "SMALL STREAM URBAN FLOOD"
## [625] "SMALL STREAM/URBAN FLOOD"       "Sml Stream Fld"
## [627] "SMOKE"                          "Snow"
## [629] "SNOW"                           "Snow Accumulation"
## [631] "SNOW ACCUMULATION"              "SNOW ADVISORY"
## [633] "SNOW AND COLD"                  "SNOW AND HEAVY SNOW"
## [635] "Snow and Ice"                   "SNOW AND ICE"
## [637] "SNOW AND ICE STORM"             "Snow and sleet"
## [639] "SNOW AND SLEET"                 "SNOW AND WIND"
## [641] "SNOW DROUGHT"                   "SNOW FREEZING RAIN"
## [643] "SNOW SHOWERS"                   "SNOW SLEET"
## [645] "SNOW SQUALL"                    "Snow squalls"
## [647] "Snow Squalls"                   "SNOW SQUALLS"
## [649] "SNOW- HIGH WIND- WIND CHILL"    "SNOW/ BITTER COLD"
## [651] "SNOW/ ICE"                      "SNOW/BLOWING SNOW"
## [653] "SNOW/COLD"                      "SNOW/FREEZING RAIN"
## [655] "SNOW/HEAVY SNOW"                "SNOW/HIGH WINDS"
## [657] "SNOW/ICE"                       "SNOW/ICE STORM"
## [659] "SNOW/RAIN"                      "SNOW/RAIN/SLEET"
## [661] "SNOW/SLEET"                     "SNOW/SLEET/FREEZING RAIN"
## [663] "SNOW/SLEET/RAIN"                "SNOW\\COLD"
```

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## [665] "SNOWFALL RECORD"                 "SNOWMELT FLOODING"
## [667] "SNOWSTORM"                       "SOUTHEAST"
## [669] "STORM FORCE WINDS"               "STORM SURGE"
## [671] "STORM SURGE/TIDE"                "STREAM FLOODING"
## [673] "STREET FLOOD"                    "STREET FLOODING"
## [675] "Strong Wind"                     "STRONG WIND"
## [677] "STRONG WIND GUST"                "Strong winds"
## [679] "Strong Winds"                    "STRONG WINDS"
## [681] "Summary August 10"               "Summary August 11"
## [683] "Summary August 17"               "Summary August 2-3"
## [685] "Summary August 21"               "Summary August 28"
## [687] "Summary August 4"                "Summary August 7"
## [689] "Summary August 9"                "Summary Jan 17"
## [691] "Summary July 23-24"              "Summary June 18-19"
## [693] "Summary June 5-6"                "Summary June 6"
## [695] "Summary of April 12"             "Summary of April 13"
## [697] "Summary of April 21"             "Summary of April 27"
## [699] "Summary of April 3rd"            "Summary of August 1"
## [701] "Summary of July 11"              "Summary of July 2"
## [703] "Summary of July 22"              "Summary of July 26"
## [705] "Summary of July 29"              "Summary of July 3"
## [707] "Summary of June 10"              "Summary of June 11"
## [709] "Summary of June 12"              "Summary of June 13"
## [711] "Summary of June 15"              "Summary of June 16"
## [713] "Summary of June 18"              "Summary of June 23"
## [715] "Summary of June 24"              "Summary of June 3"
## [717] "Summary of June 30"              "Summary of June 4"
## [719] "Summary of June 6"               "Summary of March 14"
## [721] "Summary of March 23"             "Summary of March 24"
## [723] "SUMMARY OF MARCH 24-25"          "SUMMARY OF MARCH 27"
## [725] "SUMMARY OF MARCH 29"             "Summary of May 10"
## [727] "Summary of May 13"               "Summary of May 14"
## [729] "Summary of May 22"               "Summary of May 22 am"
## [731] "Summary of May 22 pm"            "Summary of May 26 am"
## [733] "Summary of May 26 pm"            "Summary of May 31 am"
## [735] "Summary of May 31 pm"            "Summary of May 9-10"
## [737] "Summary Sept. 25-26"             "Summary September 20"
## [739] "Summary September 23"            "Summary September 3"
## [741] "Summary September 4"             "Summary: Nov. 16"
## [743] "Summary: Nov. 6-7"               "Summary: Oct. 20-21"
## [745] "Summary: October 31"             "Summary: Sept. 18"
## [747] "Temperature record"              "THUDERSTORM WINDS"
## [749] "THUNDEERSTORM WINDS"             "THUNDERESTORM WINDS"
## [751] "THUNDERSNOW"                     "Thundersnow shower"
## [753] "THUNDERSTORM"                    "THUNDERSTORM  WINDS"
## [755] "THUNDERSTORM DAMAGE"             "THUNDERSTORM DAMAGE TO"
## [757] "THUNDERSTORM HAIL"               "THUNDERSTORM W INDS"
## [759] "Thunderstorm Wind"               "THUNDERSTORM WIND"
## [761] "THUNDERSTORM WIND (G40)"         "THUNDERSTORM WIND 50"
## [763] "THUNDERSTORM WIND 52"            "THUNDERSTORM WIND 56"
## [765] "THUNDERSTORM WIND 59"            "THUNDERSTORM WIND 59 MPH"
## [767] "THUNDERSTORM WIND 59 MPH."       "THUNDERSTORM WIND 60 MPH"
## [769] "THUNDERSTORM WIND 65 MPH"        "THUNDERSTORM WIND 65MPH"
## [771] "THUNDERSTORM WIND 69"            "THUNDERSTORM WIND 98 MPH"
```

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## [773] "THUNDERSTORM WIND G50"           "THUNDERSTORM WIND G51"
## [775] "THUNDERSTORM WIND G52"           "THUNDERSTORM WIND G55"
## [777] "THUNDERSTORM WIND G60"           "THUNDERSTORM WIND G61"
## [779] "THUNDERSTORM WIND TREES"         "THUNDERSTORM WIND."
## [781] "THUNDERSTORM WIND/ TREE"         "THUNDERSTORM WIND/ TREES"
## [783] "THUNDERSTORM WIND/AWNING"        "THUNDERSTORM WIND/HAIL"
## [785] "THUNDERSTORM WIND/LIGHTNING"     "THUNDERSTORM WINDS"
## [787] "THUNDERSTORM WINDS      LE CEN" "THUNDERSTORM WINDS 13"
## [789] "THUNDERSTORM WINDS 2"            "THUNDERSTORM WINDS 50"
## [791] "THUNDERSTORM WINDS 52"           "THUNDERSTORM WINDS 53"
## [793] "THUNDERSTORM WINDS 60"           "THUNDERSTORM WINDS 61"
## [795] "THUNDERSTORM WINDS 62"           "THUNDERSTORM WINDS 63 MPH"
## [797] "THUNDERSTORM WINDS AND"          "THUNDERSTORM WINDS FUNNEL CLOU"
## [799] "THUNDERSTORM WINDS G"            "THUNDERSTORM WINDS G60"
## [801] "THUNDERSTORM WINDS HAIL"         "THUNDERSTORM WINDS HEAVY RAIN"
## [803] "THUNDERSTORM WINDS LIGHTNING"    "THUNDERSTORM WINDS SMALL STREA"
## [805] "THUNDERSTORM WINDS URBAN FLOOD" "THUNDERSTORM WINDS."
## [807] "THUNDERSTORM WINDS/ FLOOD"       "THUNDERSTORM WINDS/ HAIL"
## [809] "THUNDERSTORM WINDS/FLASH FLOOD" "THUNDERSTORM WINDS/FLOODING"
## [811] "THUNDERSTORM WINDS/FUNNEL CLOU" "THUNDERSTORM WINDS/HAIL"
## [813] "THUNDERSTORM WINDS/HEAVY RAIN"  "THUNDERSTORM WINDS53"
## [815] "THUNDERSTORM WINDSHAIL"          "THUNDERSTORM WINDSS"
## [817] "THUNDERSTORM WINS"               "THUNDERSTORMS"
## [819] "THUNDERSTORMS WIND"              "THUNDERSTORMS WINDS"
## [821] "THUNDERSTORMW"                   "THUNDERSTORMW 50"
## [823] "THUNDERSTORMW WINDS"             "THUNDERSTORMWINDS"
## [825] "THUNDERSTROM WIND"               "THUNDERSTROM WINDS"
## [827] "THUNDERTORM WINDS"               "THUNDERTSORM WIND"
## [829] "THUNDESTORM WINDS"               "THUNERSTORM WINDS"
## [831] "TIDAL FLOOD"                     "Tidal Flooding"
## [833] "TIDAL FLOODING"                  "TORNADO"
## [835] "TORNADO DEBRIS"                  "TORNADO F0"
## [837] "TORNADO F1"                      "TORNADO F2"
## [839] "TORNADO F3"                      "TORNADO/WATERSPOUT"
## [841] "TORNADOES"                       "TORNADOES, TSTM WIND, HAIL"
## [843] "TORNADOS"                        "TORNDAO"
## [845] "TORRENTIAL RAIN"                 "Torrential Rainfall"
## [847] "TROPICAL DEPRESSION"             "TROPICAL STORM"
## [849] "TROPICAL STORM ALBERTO"          "TROPICAL STORM DEAN"
## [851] "TROPICAL STORM GORDON"           "TROPICAL STORM JERRY"
## [853] "TSTM"                            "TSTM HEAVY RAIN"
## [855] "Tstm Wind"                       "TSTM WIND"
## [857] "TSTM WIND  (G45)"                "TSTM WIND (41)"
## [859] "TSTM WIND (G35)"                 "TSTM WIND (G40)"
## [861] "TSTM WIND (G45)"                 "TSTM WIND 40"
## [863] "TSTM WIND 45"                    "TSTM WIND 50"
## [865] "TSTM WIND 51"                    "TSTM WIND 52"
## [867] "TSTM WIND 55"                    "TSTM WIND 65)"
## [869] "TSTM WIND AND LIGHTNING"         "TSTM WIND DAMAGE"
## [871] "TSTM WIND G45"                   "TSTM WIND G58"
## [873] "TSTM WIND/HAIL"                  "TSTM WINDS"
## [875] "TSTM WND"                        "TSTMW"
## [877] "TSUNAMI"                         "TUNDERSTORM WIND"
## [879] "TYPHOON"                         "Unseasonable Cold"
```

```
## [881] "UNSEASONABLY COLD"              "UNSEASONABLY COOL"
## [883] "UNSEASONABLY COOL & WET"        "UNSEASONABLY DRY"
## [885] "UNSEASONABLY HOT"               "UNSEASONABLY WARM"
## [887] "UNSEASONABLY WARM & WET"        "UNSEASONABLY WARM AND DRY"
## [889] "UNSEASONABLY WARM YEAR"         "UNSEASONABLY WARM/WET"
## [891] "UNSEASONABLY WET"               "UNSEASONAL LOW TEMP"
## [893] "UNSEASONAL RAIN"                "UNUSUAL WARMTH"
## [895] "UNUSUAL/RECORD WARMTH"          "UNUSUALLY COLD"
## [897] "UNUSUALLY LATE SNOW"            "UNUSUALLY WARM"
## [899] "URBAN AND SMALL"                "URBAN AND SMALL STREAM"
## [901] "URBAN AND SMALL STREAM FLOOD"   "URBAN AND SMALL STREAM FLOODIN"
## [903] "Urban flood"                    "Urban Flood"
## [905] "URBAN FLOOD"                    "URBAN FLOOD LANDSLIDE"
## [907] "Urban Flooding"                 "URBAN FLOODING"
## [909] "URBAN FLOODS"                   "URBAN SMALL"
## [911] "URBAN SMALL STREAM FLOOD"       "URBAN/SMALL"
## [913] "URBAN/SMALL FLOODING"           "URBAN/SMALL STREAM"
## [915] "URBAN/SMALL STREAM  FLOOD"      "URBAN/SMALL STREAM FLOOD"
## [917] "URBAN/SMALL STREAM FLOODING"    "URBAN/SMALL STRM FLDG"
## [919] "URBAN/SML STREAM FLD"           "URBAN/SML STREAM FLDG"
## [921] "URBAN/STREET FLOODING"          "VERY DRY"
## [923] "VERY WARM"                      "VOG"
## [925] "Volcanic Ash"                   "VOLCANIC ASH"
## [927] "Volcanic Ash Plume"             "VOLCANIC ASHFALL"
## [929] "VOLCANIC ERUPTION"              "WAKE LOW WIND"
## [931] "WALL CLOUD"                     "WALL CLOUD/FUNNEL CLOUD"
## [933] "WARM DRY CONDITIONS"            "WARM WEATHER"
## [935] "WATER SPOUT"                    "WATERSPOUT"
## [937] "WATERSPOUT FUNNEL CLOUD"        "WATERSPOUT TORNADO"
## [939] "WATERSPOUT-"                    "WATERSPOUT-TORNADO"
## [941] "WATERSPOUT/"                    "WATERSPOUT/ TORNADO"
## [943] "WATERSPOUT/TORNADO"             "WATERSPOUTS"
## [945] "WAYTERSPOUT"                    "wet micoburst"
## [947] "WET MICROBURST"                 "Wet Month"
## [949] "WET SNOW"                       "WET WEATHER"
## [951] "Wet Year"                       "Whirlwind"
## [953] "WHIRLWIND"                      "WILD FIRES"
## [955] "WILD/FOREST FIRE"               "WILD/FOREST FIRES"
## [957] "WILDFIRE"                       "WILDFIRES"
## [959] "Wind"                           "WIND"
## [961] "WIND ADVISORY"                  "WIND AND WAVE"
## [963] "WIND CHILL"                     "WIND CHILL/HIGH WIND"
## [965] "Wind Damage"                    "WIND DAMAGE"
## [967] "WIND GUSTS"                     "WIND STORM"
## [969] "WIND/HAIL"                      "WINDS"
## [971] "WINTER MIX"                     "WINTER STORM"
## [973] "WINTER STORM HIGH WINDS"        "WINTER STORM/HIGH WIND"
## [975] "WINTER STORM/HIGH WINDS"        "WINTER STORMS"
## [977] "Winter Weather"                 "WINTER WEATHER"
## [979] "WINTER WEATHER MIX"             "WINTER WEATHER/MIX"
## [981] "WINTERY MIX"                    "Wintry mix"
## [983] "Wintry Mix"                     "WINTRY MIX"
## [985] "WND"
```

There appear to be several problems with the data, as described below.

Description and justification for data transformations

I intend to collapse the data by year and examine the annual total fatalities, injuries, and cost of each event. There are two issues, however, that need to be addressed.

First, the year is only contained within the **BGN_DATE** variable, which is coded as a character vector. To pull the year of each event out of this variable, I convert it to the date format using the **strptime()** command, then I save the **year** attribute of this variable as a new variable. Since this attribute counts the number of years since 1900, I add 1900 to generate the calendar year.

```
stormdata$date <- strptime(stormdata$BGN_DATE,
      format="%m/%d/%Y %H:%M:%S")
stormdata$year <- stormdata$date$year + 1900
```

The years range from 1950 to 2011 with the following frequencies:

```
table(stormdata$year)
```

```
##
##  1950  1951  1952  1953  1954  1955  1956  1957  1958  1959  1960  1961
##   223   269   272   492   609  1413  1703  2184  2213  1813  1945  2246
##  1962  1963  1964  1965  1966  1967  1968  1969  1970  1971  1972  1973
##  2389  1968  2348  2855  2388  2688  3312  2926  3215  3471  2168  4463
##  1974  1975  1976  1977  1978  1979  1980  1981  1982  1983  1984  1985
##  5386  4975  3768  3728  3657  4279  6146  4517  7132  8322  7335  7979
##  1986  1987  1988  1989  1990  1991  1992  1993  1994  1995  1996  1997
##  8726  7367  7257 10410 10946 12522 13534 12607 20631 27970 32270 28680
##  1998  1999  2000  2001  2002  2003  2004  2005  2006  2007  2008  2009
## 38128 31289 34471 34962 36293 39752 39363 39184 44034 43289 55663 45817
##  2010  2011
## 48161 62174
```

The second issue that needs to be addressed is cleaning the event codes and collapsing them into reasonable larger categories. For example, note above that **“Coastal Flood”**, **“COASTAL FLOOD”**, and **“coastal flooding”** are coded as three separate events. These events need to be recoded to the same event and grouped with other kinds of flooding. I chose to collapse these 985 distinct events into only 15:

- Wind Damage
- Winter Storms
- Cold
- Fires
- Rain (non-thunderstorm)
- Tornados/waterspouts/microbursts
- Heat/Dryness/Drought
- Volcanic eruption
- Flooding
- Thunderstorms and hail
- Tsunamis and wave damage
- Hurricanes and trop. storms

- Mud/rock/landslides
- Fog
- Other

The **other** category is necessary because several events, such as **“EXCESSIVE”**, **“Summary of May 14”**, and **“?”** are unclear about the weather event they indicate.

I generate each of these 15 larger categories by first creating vectors of the raw event codes for each larger category:

```
fog <- c("DENSE FOG", "FOG", "FOG AND COLD TEMPERATURES", "PATCHY DENSE FOG")

slides <- c("AVALANCE", "AVALANCHE", "LANDSLIDE", "LANDSLIDE/URBAN FLOOD",
            "LANDSLIDES", "Landslump", "LANDSLUMP", "MUD SLIDE", "MUD SLIDES",
            "MUD SLIDES URBAN FLOODING", "MUD/ROCK SLIDE", "Mudslide", "MUDSLIDE",
            "MUDSLIDE/LANDSLIDE", "Mudslides", "MUDSLIDES", "ROCK SLIDE")

other <- c("?", "APACHE COUNTY", "ASTRONOMICAL HIGH TIDE", "ASTRONOMICAL LOW TIDE"
,
           "BLOW-OUT TIDE", "BLOW-OUT TIDES", "DROWNING", "EXCESSIVE", "HIGH",
           "Marine Accident", "MARINE MISHAP", "MONTHLY TEMPERATURE", "No Severe W
eather",
           "NONE", "NORTHERN LIGHTS", "Other", "OTHER", "Record temperature",
           "RECORD TEMPERATURE", "Record Temperatures", "RECORD TEMPERATURES",
           "Saharan Dust", "SAHARAN DUST", "SEVERE TURBULENCE", "SOUTHEAST",
           "Summary August 10", "Summary August 11", "Summary August 17",
           "Summary August 2-3", "Summary August 21", "Summary August 28",
           "Summary August 4", "Summary August 7", "Summary August 9",
           "Summary Jan 17", "Summary July 23-24", "Summary June 18-19",
           "Summary June 5-6", "Summary June 6", "Summary of April 12",
           "Summary of April 13", "Summary of April 21", "Summary of April 27",
           "Summary of April 3rd", "Summary of August 1", "Summary of July 11",
           "Summary of July 2", "Summary of July 22", "Summary of July 26",
           "Summary of July 29", "Summary of July 3", "Summary of June 10",
           "Summary of June 11", "Summary of June 12", "Summary of June 13",
           "Summary of June 15", "Summary of June 16", "Summary of June 18",
           "Summary of June 23", "Summary of June 24", "Summary of June 3",
           "Summary of June 30", "Summary of June 4", "Summary of June 6",
           "Summary of March 14", "Summary of March 23", "Summary of March 24",
           "SUMMARY OF MARCH 24-25", "SUMMARY OF MARCH 27", "SUMMARY OF MARCH 29",
           "Summary of May 10", "Summary of May 13", "Summary of May 14",
           "Summary of May 22", "Summary of May 22 am", "Summary of May 22 pm",
           "Summary of May 26 am", "Summary of May 26 pm", "Summary of May 31 am",
           "Summary of May 31 pm", "Summary of May 9-10", "Summary Sept. 25-26",
           "Summary September 20", "Summary September 23", "Summary September 3",
           "Summary September 4", "Summary: Nov. 16", "Summary: Nov. 6-7",
           "Summary: Oct. 20-21", "Summary: October 31", "Summary: Sept. 18",
           "Temperature record")

hurricane <- c( "HURRICANE", "Hurricane Edouard", "HURRICANE EMILY", "HURRICANE ER
IN",
                "HURRICANE FELIX", "HURRICANE GORDON", "HURRICANE OPAL",
                "HURRICANE OPAL/HIGH WINDS", "HURRICANE-GENERATED SWELLS",
                "HURRICANE/TYPHOON", "REMNANTS OF FLOYD", "TROPICAL DEPRESSION",
```

```
                "TROPICAL STORM", "TROPICAL STORM ALBERTO", "TROPICAL STORM DEAN",
                "TROPICAL STORM GORDON", "TROPICAL STORM JERRY", "TYPHOON"  )

tsunami <- c( "   HIGH SURF ADVISORY", "HAZARDOUS SURF", "HEAVY SEAS", "Heavy Surf
",
              "HEAVY SURF", "Heavy surf and wind", "HEAVY SURF COASTAL FLOODING",
              "HEAVY SURF/HIGH SURF", "HEAVY SWELLS", "HIGH  SWELLS", "HIGH SEAS",
              "High Surf", "HIGH SURF", "HIGH SURF ADVISORIES", "HIGH SURF ADVISOR
Y",
              "HIGH SWELLS", "HIGH TIDES", "HIGH WATER", "HIGH WAVES", "RIP CURREN
T",
              "RIP CURRENTS", "RIP CURRENTS HEAVY SURF", "RIP CURRENTS/HEAVY SURF"
,
              "ROGUE WAVE", "ROUGH SEAS", "ROUGH SURF", "SEICHE", "TSUNAMI")

tstorm <- c(" LIGHTNING", " TSTM WIND", " TSTM WIND (G45)", "Coastal Storm",
            "COASTAL STORM", "COASTALSTORM", "DEEP HAIL", "HAIL", "HAIL 0.75",
            "HAIL 0.88", "HAIL 075", "HAIL 088", "HAIL 1.00", "HAIL 1.75",
            "HAIL 1.75)", "HAIL 100", "HAIL 125", "HAIL 150", "HAIL 175", "HAIL 20
0",
            "HAIL 225", "HAIL 275", "HAIL 450", "HAIL 75", "HAIL 80", "HAIL 88",
            "HAIL ALOFT", "HAIL DAMAGE", "HAIL FLOODING", "HAIL STORM", "Hail(0.75
)",
            "HAIL/ICY ROADS", "HAIL/WIND", "HAIL/WINDS", "HAILSTORM", "HAILSTORMS"
,
            "LATE SEASON HAIL", "LIGHTING", "LIGHTNING", "LIGHTNING  WAUSEON",
            "LIGHTNING AND HEAVY RAIN", "LIGHTNING AND THUNDERSTORM WIN",
            "LIGHTNING AND WINDS", "LIGHTNING DAMAGE", "LIGHTNING FIRE",
            "LIGHTNING INJURY", "LIGHTNING THUNDERSTORM WINDS",
            "LIGHTNING THUNDERSTORM WINDSS", "LIGHTNING.", "LIGHTNING/HEAVY RAIN",
            "LIGNTNING", "MARINE HAIL", "MARINE THUNDERSTORM WIND", "MARINE TSTM W
IND",
            "Metro Storm, May 26", "NON SEVERE HAIL", "SEVERE THUNDERSTORM",
            "SEVERE THUNDERSTORM WINDS", "SEVERE THUNDERSTORMS", "small hail",
            "Small Hail", "SMALL HAIL", "THUDERSTORM WINDS", "THUNDEERSTORM WINDS"
,
            "THUNDERESTORM WINDS", "THUNDERSTORM", "THUNDERSTORM  WINDS",
            "THUNDERSTORM DAMAGE", "THUNDERSTORM DAMAGE TO", "THUNDERSTORM HAIL",
            "THUNDERSTORM W INDS", "Thunderstorm Wind", "THUNDERSTORM WIND",
            "THUNDERSTORM WIND (G40)", "THUNDERSTORM WIND 50", "THUNDERSTORM WIND
52",
            "THUNDERSTORM WIND 56", "THUNDERSTORM WIND 59", "THUNDERSTORM WIND 59
MPH",
            "THUNDERSTORM WIND 59 MPH.", "THUNDERSTORM WIND 60 MPH",
            "THUNDERSTORM WIND 65 MPH", "THUNDERSTORM WIND 65MPH", "THUNDERSTORM W
IND 69",
            "THUNDERSTORM WIND 98 MPH", "THUNDERSTORM WIND G50", "THUNDERSTORM WIN
D G51",
            "THUNDERSTORM WIND G52", "THUNDERSTORM WIND G55", "THUNDERSTORM WIND G
60",
            "THUNDERSTORM WIND G61", "THUNDERSTORM WIND TREES", "THUNDERSTORM WIND
.",
            "THUNDERSTORM WIND/ TREE", "THUNDERSTORM WIND/ TREES",
            "THUNDERSTORM WIND/AWNING", "THUNDERSTORM WIND/HAIL",
```

```
            "THUNDERSTORM WIND/LIGHTNING", "THUNDERSTORM WINDS",
            "THUNDERSTORM WINDS      LE CEN", "THUNDERSTORM WINDS 13", "THUNDERSTO
RM WINDS 2",
            "THUNDERSTORM WINDS 50", "THUNDERSTORM WINDS 52", "THUNDERSTORM WINDS
53",
            "THUNDERSTORM WINDS 60", "THUNDERSTORM WINDS 61", "THUNDERSTORM WINDS
62",
            "THUNDERSTORM WINDS 63 MPH", "THUNDERSTORM WINDS AND",
            "THUNDERSTORM WINDS FUNNEL CLOU", "THUNDERSTORM WINDS G",
            "THUNDERSTORM WINDS G60", "THUNDERSTORM WINDS HAIL",
            "THUNDERSTORM WINDS HEAVY RAIN", "THUNDERSTORM WINDS LIGHTNING",
            "THUNDERSTORM WINDS SMALL STREA", "THUNDERSTORM WINDS URBAN FLOOD",
            "THUNDERSTORM WINDS.", "THUNDERSTORM WINDS/ FLOOD", "THUNDERSTORM WIND
S/ HAIL",
            "THUNDERSTORM WINDS/FLASH FLOOD", "THUNDERSTORM WINDS/FLOODING",
            "THUNDERSTORM WINDS/FUNNEL CLOU", "THUNDERSTORM WINDS/HAIL",
            "THUNDERSTORM WINDS/HEAVY RAIN", "THUNDERSTORM WINDS53",
            "THUNDERSTORM WINDSHAIL", "THUNDERSTORM WINDSS", "THUNDERSTORM WINS",
            "THUNDERSTORMS", "THUNDERSTORMS WIND", "THUNDERSTORMS WINDS", "THUNDER
STORMW",
            "THUNDERSTORMW 50", "THUNDERSTORMW WINDS", "THUNDERSTORMWINDS",
            "THUNDERSTROM WIND", "THUNDERSTROM WINDS", "THUNDERTORM WINDS",
            "THUNDERTSORM WIND", "THUNDESTORM WINDS", "THUNERSTORM WINDS",
            "TORRENTIAL RAIN", "Torrential Rainfall", "TSTM", "TSTM HEAVY RAIN",
            "Tstm Wind", "TSTM WIND", "TSTM WIND  (G45)", "TSTM WIND (41)",
            "TSTM WIND (G35)", "TSTM WIND (G40)", "TSTM WIND (G45)", "TSTM WIND 40
",
            "TSTM WIND 45", "TSTM WIND 50", "TSTM WIND 51", "TSTM WIND 52", "TSTM
WIND 55",
            "TSTM WIND 65)", "TSTM WIND AND LIGHTNING", "TSTM WIND DAMAGE", "TSTM
WIND G45",
            "TSTM WIND G58", "TSTM WIND/HAIL", "TSTM WINDS", "TSTM WND", "TSTMW",
            "TUNDERSTORM WIND")

flood <- c(" COASTAL FLOOD", " FLASH FLOOD", "BEACH EROSIN", "Beach Erosion",
           "BEACH EROSION", "BEACH EROSION/COASTAL FLOOD", "BEACH FLOOD",
           "BREAKUP FLOODING", "COASTAL  FLOODING/EROSION", "COASTAL EROSION",
           "Coastal Flood", "COASTAL FLOOD", "coastal flooding", "Coastal Flooding
",
           "COASTAL FLOODING", "COASTAL FLOODING/EROSION", "COASTAL SURGE",
           "COASTAL/TIDAL FLOOD", "COASTALFLOOD", "CSTL FLOODING/EROSION",
           "DAM BREAK", "DAM FAILURE", "Erosion/Cstl Flood", "FLASH FLOOD",
           "FLASH FLOOD - HEAVY RAIN", "FLASH FLOOD FROM ICE JAMS",
           "FLASH FLOOD LANDSLIDES", "FLASH FLOOD WINDS", "FLASH FLOOD/",
           "FLASH FLOOD/ FLOOD", "FLASH FLOOD/ STREET", "FLASH FLOOD/FLOOD",
           "FLASH FLOOD/HEAVY RAIN", "FLASH FLOOD/LANDSLIDE", "FLASH FLOODING",
           "FLASH FLOODING/FLOOD", "FLASH FLOODING/THUNDERSTORM WI", "FLASH FLOODS
",
           "FLASH FLOOOODING", "Flood", "FLOOD", "FLOOD & HEAVY RAIN", "FLOOD FLASH
",
           "FLOOD FLOOD/FLASH", "FLOOD WATCH/", "FLOOD/FLASH", "Flood/Flash Flood"
,
           "FLOOD/FLASH FLOOD", "FLOOD/FLASH FLOODING", "FLOOD/FLASH/FLOOD",
           "FLOOD/FLASHFLOOD", "FLOOD/RAIN/WIND", "FLOOD/RAIN/WINDS", "FLOOD/RIVER
```

```
FLOOD",
           "Flood/Strong Wind", "FLOODING", "FLOODING/HEAVY RAIN", "FLOODS",
           "HIGHWAY FLOODING", "LAKE FLOOD", "LAKESHORE FLOOD", "LOCAL FLASH FLOOD
",
           "LOCAL FLOOD", "MAJOR FLOOD", "MINOR FLOOD", "Minor Flooding", "MINOR F
LOODING",
           "RAPIDLY RISING WATER", "RIVER AND STREAM FLOOD", "RIVER FLOOD", "River
Flooding",
           "RIVER FLOODING", "RURAL FLOOD", "SMALL STREAM", "SMALL STREAM AND",
           "SMALL STREAM AND URBAN FLOOD", "SMALL STREAM AND URBAN FLOODIN",
           "SMALL STREAM FLOOD", "SMALL STREAM FLOODING", "SMALL STREAM URBAN FLOO
D",
           "SMALL STREAM/URBAN FLOOD", "Sml Stream Fld", "SNOWMELT FLOODING", "STO
RM SURGE",
           "STORM SURGE/TIDE", "STREAM FLOODING", "STREET FLOOD", "STREET FLOODING
",
           "TIDAL FLOOD", "Tidal Flooding", "TIDAL FLOODING", "URBAN AND SMALL",
           "URBAN AND SMALL STREAM", "URBAN AND SMALL STREAM FLOOD",
           "URBAN AND SMALL STREAM FLOODIN", "Urban flood", "Urban Flood", "URBAN
FLOOD",
           "URBAN FLOOD LANDSLIDE", "Urban Flooding", "URBAN FLOODING", "URBAN FLO
ODS",
           "URBAN SMALL", "URBAN SMALL STREAM FLOOD", "URBAN/SMALL", "URBAN/SMALL
FLOODING",
           "URBAN/SMALL STREAM", "URBAN/SMALL STREAM  FLOOD", "URBAN/SMALL STREAM
FLOOD",
           "URBAN/SMALL STREAM FLOODING", "URBAN/SMALL STRM FLDG", "URBAN/SML STRE
AM FLD",
           "URBAN/SML STREAM FLDG", "URBAN/STREET FLOODING")

volcano <- c("VOG", "Volcanic Ash", "VOLCANIC ASH", "Volcanic Ash Plume",
             "VOLCANIC ASHFALL", "VOLCANIC ERUPTION")

heat <- c("ABNORMAL WARMTH", "ABNORMALLY DRY", "BELOW NORMAL PRECIPITATION",
          "DRIEST MONTH", "DROUGHT", "DROUGHT/EXCESSIVE HEAT", "DRY", "DRY CONDITI
ONS",
          "DRY HOT WEATHER", "DRY PATTERN", "DRY SPELL", "DRY WEATHER", "DRYNESS",
          "EXCESSIVE HEAT", "EXCESSIVE HEAT/DROUGHT", "EXCESSIVELY DRY", "EXTREME
HEAT",
          "HEAT", "HEAT DROUGHT", "Heat Wave", "HEAT WAVE", "HEAT WAVE DROUGHT",
          "HEAT WAVES", "HEAT/DROUGHT", "Heatburst", "HIGH TEMPERATURE RECORD",
          "Hot and Dry", "HOT PATTERN", "HOT SPELL", "HOT WEATHER", "HOT/DRY PATTE
RN",
          "Mild and Dry Pattern", "MILD PATTERN", "MILD/DRY PATTERN", "PROLONG WAR
MTH",
          "Record dry month", "RECORD DRYNESS", "Record Heat", "RECORD HEAT",
          "RECORD HEAT WAVE", "Record High", "RECORD HIGH", "RECORD HIGH TEMPERATU
RE",
          "RECORD HIGH TEMPERATURES", "RECORD LOW RAINFALL", "RECORD/EXCESSIVE HEA
T",
          "RECORD WARMTH", "Record Warmth", "RECORD WARM TEMPS.", "RECORD WARM",
          "UNSEASONABLY DRY", "UNSEASONABLY HOT", "UNSEASONABLY WARM",
          "UNSEASONABLY WARM AND DRY", "UNSEASONABLY WARM YEAR", "UNUSUAL WARMTH",
          "UNUSUAL/RECORD WARMTH", "UNUSUALLY WARM", "VERY DRY", "VERY WARM",
```

```
          "WARM DRY CONDITIONS", "WARM WEATHER")

tornado <- c(" WATERSPOUT", "DOWNBURST", "DOWNBURST WINDS", "DRY MICROBURST",
             "DRY MICROBURST 50", "DRY MICROBURST 53", "DRY MICROBURST 58",
             "DRY MICROBURST 61", "DRY MICROBURST 84", "DRY MICROBURST WINDS",
             "DRY MIRCOBURST WINDS", "DUST DEVEL", "Dust Devil", "DUST DEVIL",
             "DUST DEVIL WATERSPOUT", "DUST STORM", "DUST STORM/HIGH WINDS",
             "DUSTSTORM", "FUNNEL", "Funnel Cloud", "FUNNEL CLOUD", "FUNNEL CLOUD.
",
             "FUNNEL CLOUD/HAIL", "FUNNEL CLOUDS", "FUNNELS", "GUSTNADO", "GUSTNAD
O AND",
             "LANDSPOUT", "LARGE WALL CLOUD", "Microburst", "MICROBURST",
             "MICROBURST WINDS", "ROTATING WALL CLOUD", "TORNADO", "TORNADO DEBRIS
",
             "TORNADO F0", "TORNADO F1", "TORNADO F2", "TORNADO F3", "TORNADO/WATE
RSPOUT",
             "TORNADOES", "TORNADOES, TSTM WIND, HAIL", "TORNADOS", "TORNDAO",
             "WALL CLOUD", "WALL CLOUD/FUNNEL CLOUD", "WATER SPOUT", "WATERSPOUT",
             "WATERSPOUT FUNNEL CLOUD", "WATERSPOUT TORNADO", "WATERSPOUT-",
             "WATERSPOUT-TORNADO", "WATERSPOUT/", "WATERSPOUT/ TORNADO",
             "WATERSPOUT/TORNADO", "WATERSPOUTS", "WAYTERSPOUT", "wet micoburst",
             "WET MICROBURST")

rain <- c("ABNORMALLY WET", "EARLY RAIN", "EXCESSIVE PRECIPITATION", "EXCESSIVE RA
IN",
          "EXCESSIVE RAINFALL", "EXCESSIVE WETNESS", "EXTREMELY WET", "HEAVY PRECI
PATATION",
          "Heavy Precipitation", "HEAVY PRECIPITATION", "Heavy rain", "Heavy Rain"
,
          "HEAVY RAIN", "HEAVY RAIN AND FLOOD", "Heavy Rain and Wind", "HEAVY RAIN
EFFECTS",
          "HEAVY RAIN; URBAN FLOOD WINDS;", "HEAVY RAIN/FLOODING", "Heavy Rain/Hig
h Surf",
          "HEAVY RAIN/LIGHTNING", "HEAVY RAIN/MUDSLIDES/FLOOD", "HEAVY RAIN/SEVERE
WEATHER",
          "HEAVY RAIN/SMALL STREAM URBAN", "HEAVY RAIN/SNOW", "HEAVY RAIN/URBAN FL
OOD",
          "HEAVY RAIN/WIND", "HEAVY RAINFALL", "HEAVY RAINS", "HEAVY RAINS/FLOODIN
G",
          "HEAVY SHOWER", "HEAVY SHOWERS", "HVY RAIN", "LOCALLY HEAVY RAIN", "MIXE
D PRECIP",
          "Mixed Precipitation", "MIXED PRECIPITATION", "MONTHLY PRECIPITATION",
          "Monthly Rainfall", "MONTHLY RAINFALL", "NORMAL PRECIPITATION", "PROLONG
ED RAIN",
          "RAIN", "RAIN (HEAVY)", "RAIN AND WIND", "Rain Damage", "RAIN/WIND", "RA
INSTORM",
          "RECORD PRECIPITATION", "RECORD RAINFALL", "RECORD/EXCESSIVE RAINFALL",
          "UNSEASONABLY WARM & WET", "UNSEASONABLY WARM/WET", "UNSEASONABLY WET",
          "UNSEASONAL RAIN", "Wet Month", "WET WEATHER", "Wet Year")

fire <- c( "BRUSH FIRE", "BRUSH FIRES", "DENSE SMOKE", "FOREST FIRES", "GRASS FIRE
S",
           "RED FLAG CRITERIA", "RED FLAG FIRE WX", "SMOKE", "WILD FIRES",
           "WILD/FOREST FIRE", "WILD/FOREST FIRES", "WILDFIRE", "WILDFIRES")
```

```
cold <- c("AGRICULTURAL FREEZE", "BITTER WIND CHILL", "BITTER WIND CHILL TEMPERATU
RES",
          "Cold", "COLD", "COLD AIR FUNNEL", "COLD AIR FUNNELS", "COLD AIR TORNADO
",
          "Cold and Frost", "COLD AND FROST", "COLD AND SNOW", "COLD AND WET CONDI
TIONS",
          "Cold Temperature", "COLD TEMPERATURES", "COLD WAVE", "COLD WEATHER",
          "COLD WIND CHILL TEMPERATURES", "COLD/WIND CHILL", "COLD/WINDS", "COOL A
ND WET",
          "COOL SPELL", "Damaging Freeze", "DAMAGING FREEZE", "EARLY FREEZE",
          "Early Frost", "EARLY FROST", "Excessive Cold", "Extended Cold", "Extrem
e Cold",
          "EXTREME COLD", "EXTREME COLD/WIND CHILL", "EXTREME WIND CHILL",
          "EXTREME WIND CHILL/BLOWING SNO", "EXTREME WIND CHILLS", "EXTREME WINDCH
ILL",
          "EXTREME WINDCHILL TEMPERATURES", "EXTREME/RECORD COLD", "HARD FREEZE",
          "HYPERTHERMIA/EXPOSURE", "HYPOTHERMIA", "Hypothermia/Exposure",
          "HYPOTHERMIA/EXPOSURE", "LATE FREEZE", "LOW TEMPERATURE",
          "LOW TEMPERATURE RECORD", "LOW WIND CHILL", "Prolong Cold", "PROLONG COL
D",
          "PROLONG COLD/SNOW", "RECORD  COLD", "Record Cold", "RECORD COLD",
          "RECORD COLD AND HIGH WIND", "RECORD COLD/FROST", "RECORD COOL", "RECORD
LOW",
          "SEVERE COLD", "Unseasonable Cold", "UNSEASONABLY COLD", "UNSEASONABLY C
OOL",
          "UNSEASONABLY COOL & WET", "UNSEASONAL LOW TEMP", "UNUSUALLY COLD")

winterstorms <- c("ACCUMULATED SNOWFALL", "Black Ice", "BLACK ICE", "BLIZZARD",
                  "BLIZZARD AND EXTREME WIND CHIL", "BLIZZARD AND HEAVY SNOW",
                  "Blizzard Summary", "BLIZZARD WEATHER", "BLIZZARD/FREEZING RAIN"
,
                  "BLIZZARD/HEAVY SNOW", "BLIZZARD/HIGH WIND", "BLIZZARD/WINTER ST
ORM",
                  "blowing snow", "Blowing Snow", "BLOWING SNOW",
                  "BLOWING SNOW & EXTREME WIND CH", "BLOWING SNOW- EXTREME WIND CH
I",
                  "BLOWING SNOW/EXTREME WIND CHIL", "Drifting Snow", "EARLY SNOW",
                  "Early snowfall", "EARLY SNOWFALL", "EXCESSIVE SNOW",
                  "FALLING SNOW/ICE", "FIRST FROST", "FIRST SNOW", "Freeze", "FREE
ZE",
                  "Freezing drizzle", "Freezing Drizzle", "FREEZING DRIZZLE",
                  "FREEZING DRIZZLE AND FREEZING", "Freezing Fog", "FREEZING FOG",
                  "Freezing rain", "Freezing Rain", "FREEZING RAIN",
                  "FREEZING RAIN AND SLEET", "FREEZING RAIN AND SNOW",
                  "FREEZING RAIN SLEET AND", "FREEZING RAIN SLEET AND LIGHT",
                  "FREEZING RAIN/SLEET", "FREEZING RAIN/SNOW", "Freezing Spray",
                  "Frost", "FROST", "Frost/Freeze", "FROST/FREEZE", "FROST\\FREEZE
",
                  "Glaze", "GLAZE", "GLAZE ICE", "GLAZE/ICE STORM", "GROUND BLIZZA
RD",
                  "HEAVY LAKE SNOW", "HEAVY MIX", "HEAVY SNOW", "HEAVY SNOW   FREE
ZING RAIN",
                  "HEAVY SNOW & ICE", "HEAVY SNOW AND", "HEAVY SNOW AND HIGH WINDS
```

```
",
                "HEAVY SNOW AND ICE", "HEAVY SNOW AND ICE STORM",
                "HEAVY SNOW AND STRONG WINDS", "HEAVY SNOW ANDBLOWING SNOW",
                "Heavy snow shower", "HEAVY SNOW SQUALLS", "HEAVY SNOW-SQUALLS",
                "HEAVY SNOW/BLIZZARD", "HEAVY SNOW/BLIZZARD/AVALANCHE",
                "HEAVY SNOW/BLOWING SNOW", "HEAVY SNOW/FREEZING RAIN",
                "HEAVY SNOW/HIGH", "HEAVY SNOW/HIGH WIND", "HEAVY SNOW/HIGH WIND
S",
                "HEAVY SNOW/HIGH WINDS & FLOOD", "HEAVY SNOW/HIGH WINDS/FREEZING
",
                "HEAVY SNOW/ICE", "HEAVY SNOW/ICE STORM", "HEAVY SNOW/SLEET",
                "HEAVY SNOW/SQUALLS", "HEAVY SNOW/WIND", "HEAVY SNOW/WINTER STOR
M",
                "HEAVY SNOWPACK", "HEAVY WET SNOW", "ICE", "ICE AND SNOW", "ICE
FLOES",
                "Ice Fog", "ICE JAM", "Ice jam flood (minor", "ICE JAM FLOODING"
,
                "ICE ON ROAD", "ICE PELLETS", "ICE ROADS", "ICE STORM",
                "ICE STORM AND SNOW", "ICE STORM/FLASH FLOOD", "Ice/Snow", "ICE/
SNOW",
                "ICE/STRONG WINDS", "Icestorm/Blizzard", "Icy Roads", "ICY ROADS
",
                "LACK OF SNOW", "Lake Effect Snow", "LAKE EFFECT SNOW",
                "LAKE-EFFECT SNOW", "LATE SEASON SNOW", "Late Season Snowfall",
                "LATE SNOW", "Late-season Snowfall", "LIGHT FREEZING RAIN",
                "Light snow", "Light Snow", "LIGHT SNOW", "LIGHT SNOW AND SLEET"
,
                "Light Snow/Flurries", "LIGHT SNOW/FREEZING PRECIP", "Light Snow
fall",
                "MODERATE SNOW", "MODERATE SNOWFALL", "Monthly Snowfall",
                "MONTHLY SNOWFALL", "Mountain Snows", "NEAR RECORD SNOW", "PATCH
Y ICE",
                "RAIN/SNOW", "Record May Snow", "RECORD SNOW", "RECORD SNOW/COLD
",
                "RECORD SNOWFALL", "Record Winter Snow", "Seasonal Snowfall", "S
LEET",
                "SLEET & FREEZING RAIN", "SLEET STORM", "SLEET/FREEZING RAIN",
                "SLEET/ICE STORM", "SLEET/RAIN/SNOW", "SLEET/SNOW", "Snow", "SNO
W",
                "Snow Accumulation", "SNOW ACCUMULATION", "SNOW ADVISORY",
                "SNOW AND COLD", "SNOW AND HEAVY SNOW", "Snow and Ice", "SNOW AN
D ICE",
                "SNOW AND ICE STORM", "Snow and sleet", "SNOW AND SLEET",
                "SNOW AND WIND", "SNOW DROUGHT", "SNOW FREEZING RAIN", "SNOW SHO
WERS",
                "SNOW SLEET", "SNOW SQUALL", "Snow squalls", "Snow Squalls",
                "SNOW SQUALLS", "SNOW- HIGH WIND- WIND CHILL", "SNOW/ BITTER COL
D",
                "SNOW/ ICE", "SNOW/BLOWING SNOW", "SNOW/COLD", "SNOW/FREEZING RA
IN",
                "SNOW/HEAVY SNOW", "SNOW/HIGH WINDS", "SNOW/ICE", "SNOW/ICE STOR
M",
                "SNOW/RAIN", "SNOW/RAIN/SLEET", "SNOW/SLEET", "SNOW/SLEET/FREEZI
NG RAIN",
```

```
                "SNOW/SLEET/RAIN", "SNOW\\COLD", "SNOWFALL RECORD", "SNOWSTORM",
                "THUNDERSNOW", "Thundersnow shower", "UNUSUALLY LATE SNOW", "WET
SNOW",
                "WINTER MIX", "WINTER STORM", "WINTER STORM HIGH WINDS",
                "WINTER STORM/HIGH WIND", "WINTER STORM/HIGH WINDS", "WINTER STO
RMS",
                "Winter Weather", "WINTER WEATHER", "WINTER WEATHER MIX",
                "WINTER WEATHER/MIX", "WINTERY MIX", "Wintry mix", "Wintry Mix",
                "WINTRY MIX")

wind <- c(" WIND", "BLOWING DUST", "gradient wind", "Gradient wind", "GRADIENT WIN
D",
          "GRADIENT WINDS", "GUSTY LAKE WIND", "GUSTY THUNDERSTORM WIND",
          "GUSTY THUNDERSTORM WINDS", "Gusty Wind", "GUSTY WIND", "GUSTY WIND/HAIL
",
          "GUSTY WIND/HVY RAIN", "Gusty wind/rain", "Gusty winds", "Gusty Winds",
          "GUSTY WINDS", "HIGH  WINDS", "High Wind", "HIGH WIND", "HIGH WIND (G40)
",
          "HIGH WIND 48", "HIGH WIND 63", "HIGH WIND 70", "HIGH WIND AND HEAVY SNO
W",
          "HIGH WIND AND HIGH TIDES", "HIGH WIND AND SEAS", "HIGH WIND DAMAGE",
          "HIGH WIND/ BLIZZARD", "HIGH WIND/BLIZZARD", "HIGH WIND/BLIZZARD/FREEZIN
G RA",
          "HIGH WIND/HEAVY SNOW", "HIGH WIND/LOW WIND CHILL", "HIGH WIND/SEAS",
          "HIGH WIND/WIND CHILL", "HIGH WIND/WIND CHILL/BLIZZARD", "HIGH WINDS",
          "HIGH WINDS 55", "HIGH WINDS 57", "HIGH WINDS 58", "HIGH WINDS 63",
          "HIGH WINDS 66", "HIGH WINDS 67", "HIGH WINDS 73", "HIGH WINDS 76",
          "HIGH WINDS 80", "HIGH WINDS 82", "HIGH WINDS AND WIND CHILL",
          "HIGH WINDS DUST STORM", "HIGH WINDS HEAVY RAINS", "HIGH WINDS/",
          "HIGH WINDS/COASTAL FLOOD", "HIGH WINDS/COLD", "HIGH WINDS/FLOODING",
          "HIGH WINDS/HEAVY RAIN", "HIGH WINDS/SNOW", "MARINE HIGH WIND",
          "MARINE STRONG WIND", "NON TSTM WIND", "NON-SEVERE WIND DAMAGE",
          "NON-TSTM WIND", "STORM FORCE WINDS", "Strong Wind", "STRONG WIND",
          "STRONG WIND GUST", "Strong winds", "Strong Winds", "STRONG WINDS",
          "WAKE LOW WIND", "Whirlwind", "WHIRLWIND", "Wind", "WIND", "WIND ADVISOR
Y",
          "WIND AND WAVE", "WIND CHILL", "WIND CHILL/HIGH WIND", "Wind Damage",
          "WIND DAMAGE", "WIND GUSTS", "WIND STORM", "WIND/HAIL", "WINDS", "WND")
```

Next, I use these character vectors to create a new variable called **evcat** that contains the 15 categories matched to the corresponding raw event codes. The result is a character vector which I coerce to a factor.

```
stormdata$evcat <- ""
stormdata$evcat[which(is.element(as.character(stormdata$EVTYPE), wind))] <-
      "Wind Damage"
stormdata$evcat[which(is.element(as.character(stormdata$EVTYPE), winterstorms))] <
-
      "Winter Storms"
stormdata$evcat[which(is.element(as.character(stormdata$EVTYPE), cold))] <-
      "Cold"
stormdata$evcat[which(is.element(as.character(stormdata$EVTYPE), fire))] <-
      "Fires"
stormdata$evcat[which(is.element(as.character(stormdata$EVTYPE), rain))] <-
      "Rain (non-thunderstorm)"
stormdata$evcat[which(is.element(as.character(stormdata$EVTYPE), tornado))] <-
      "Tornados/waterspouts/microbursts"
stormdata$evcat[which(is.element(as.character(stormdata$EVTYPE), heat))] <-
      "Heat/Dryness/Drought"
stormdata$evcat[which(is.element(as.character(stormdata$EVTYPE), volcano))] <-
      "Volcanic eruption"
stormdata$evcat[which(is.element(as.character(stormdata$EVTYPE), flood))] <-
      "Flooding"
stormdata$evcat[which(is.element(as.character(stormdata$EVTYPE), tstorm))] <-
      "Thunderstorms and hail"
stormdata$evcat[which(is.element(as.character(stormdata$EVTYPE), tsunami))] <-
      "Tsunamis and wave damage"
stormdata$evcat[which(is.element(as.character(stormdata$EVTYPE), hurricane))] <-
      "Hurricanes and trop. storms"
stormdata$evcat[which(is.element(as.character(stormdata$EVTYPE), other))] <-
      "Other"
stormdata$evcat[which(is.element(as.character(stormdata$EVTYPE), slides))] <-
      "Mud/rock/landslides"
stormdata$evcat[which(is.element(as.character(stormdata$EVTYPE), fog))] <-
      "Fog"
stormdata$evcat <- as.factor(stormdata$evcat)
```

I can now see the frequencies of the 15 event types:

```
table(stormdata$evcat)
```

```
##
##                             Cold                             Fires
##                             2754                             4262
##                         Flooding                              Fog
##                            86535                             1835
##              Heat/Dryness/Drought      Hurricanes and trop. storms
##                             5589                             1058
##               Mud/rock/landslides                            Other
##                             1037                              492
##           Rain (non-thunderstorm)          Thunderstorms and hail
##                            11998                           641872
## Tornados/waterspouts/microbursts        Tsunamis and wave damage
##                            72352                             1912
##                 Volcanic eruption                      Wind Damage
##                               30                            26344
##                     Winter Storms
##                            44227
```

Collapsing the data

Again, the goal is to examine the total number of fatalities and injuries, and the total cost of each event within each year. I will use the **group_by** command in the **dplry** library to collapse the data. This command does not work with variables of the **date** class, however, so I first covert **date** back to a character class.

```
stormdata$date <- as.character(stormdata$date)
```

Now I collapse by both **evcat** and **year**, saving the total number of fatalities, the total number of injuries, the total cost in property damage, and the total cost in crop damage (not analyzed in this report) in each year and as a result of each event type. Since some of the events have no data earlier than 1993, I restrict the analysis to 1993 and later.

```
storm.event <- group_by(stormdata, evcat, year)
storm.totals <- summarize(storm.event, fatalities = sum(FATALITIES),
      injuries = sum(INJURIES), propdmg = sum(PROPDMG),
      cropdmg = sum(CROPDMG))
storm.totals <- as.data.frame(storm.totals)
storm.totals <- storm.totals[storm.totals$year >= 1993,]
```

Further steps to prepare the data for the figures

I will create line plots for each event over years, overlaid, to show both the variation in each outcome over time and the comparision of events to one another. But 15 lines are too messy to be shown effectively on one plot. For clarity, I keep only the 6 events with the highest averages for each outcome. To see which 6 events have the highest averages, I collapse the data by event across years.

```
storm.means <- summarize(group_by(storm.totals, evcat),
                         fatalities = mean(fatalities), injuries = mean(injuries),
                         propdmg = mean(propdmg), cropdmg = mean(cropdmg))
as.data.frame(storm.means)
```

```
##                              evcat fatalities     injuries      propdmg
## 1                             Cold  25.368421   16.8421053    753.89947
## 2                            Fires   4.736842   84.6315789   6595.69947
## 3                         Flooding  83.052632  459.1578947 130929.50211
## 4                              Fog   4.263158   56.6842105    898.69789
## 5             Heat/Dryness/Drought 167.263158  486.6842105    385.89000
## 6       Hurricanes and trop. storms  10.578947   90.3157895   3992.49105
## 7              Mud/rock/landslides  14.157895   11.8421053   1178.52316
## 8                            Other   0.500000    0.6666667     78.83333
## 9          Rain (non-thunderstorm)   5.421053   15.8947368   2988.06526
## 10          Thunderstorms and hail  68.315789  653.8947368 209012.60105
## 11 Tornados/waterspouts/microbursts  88.368421 1258.6842105  74170.52474
## 12         Tsunamis and wave damage  41.684211   48.3684211    486.25895
## 13               Volcanic eruption   0.000000    0.0000000     45.45455
## 14                    Wind Damage  23.684211  100.1052632  23788.67579
## 15                   Winter Storms  34.473684  335.4736842  21560.22053
##         cropdmg
## 1    392.726842
## 2    503.460000
## 3  19355.133158
## 4      0.000000
## 5   1862.200000
## 6    952.784737
## 7      1.947368
## 8     57.466667
## 9    681.173684
## 10 41286.552632
## 11  5376.172105
## 12     1.052632
## 13     0.000000
## 14  1223.695263
## 15   825.886842
```

The 6 highest averages for fatalities are

- Flooding
- Heat/Dryness/Drought
- Thunderstorms and hail
- Tornados/waterspouts/microbursts
- Tsunamis and wave damage
- Winter Storms

Injuries has the same list, substituing wind damage for tsunamis, and property damage has the same list as injuries, substituting fires for heat.

I clean the variable names for clear presentation in the figures,

```
names(storm.totals) <- c("Event", "Year", "Fatalities", "Injuries",
      "Property.damage", "Crop.damage")
```

then I create three new data frames, each keeping the 6 events with the highest averages for each outcome:

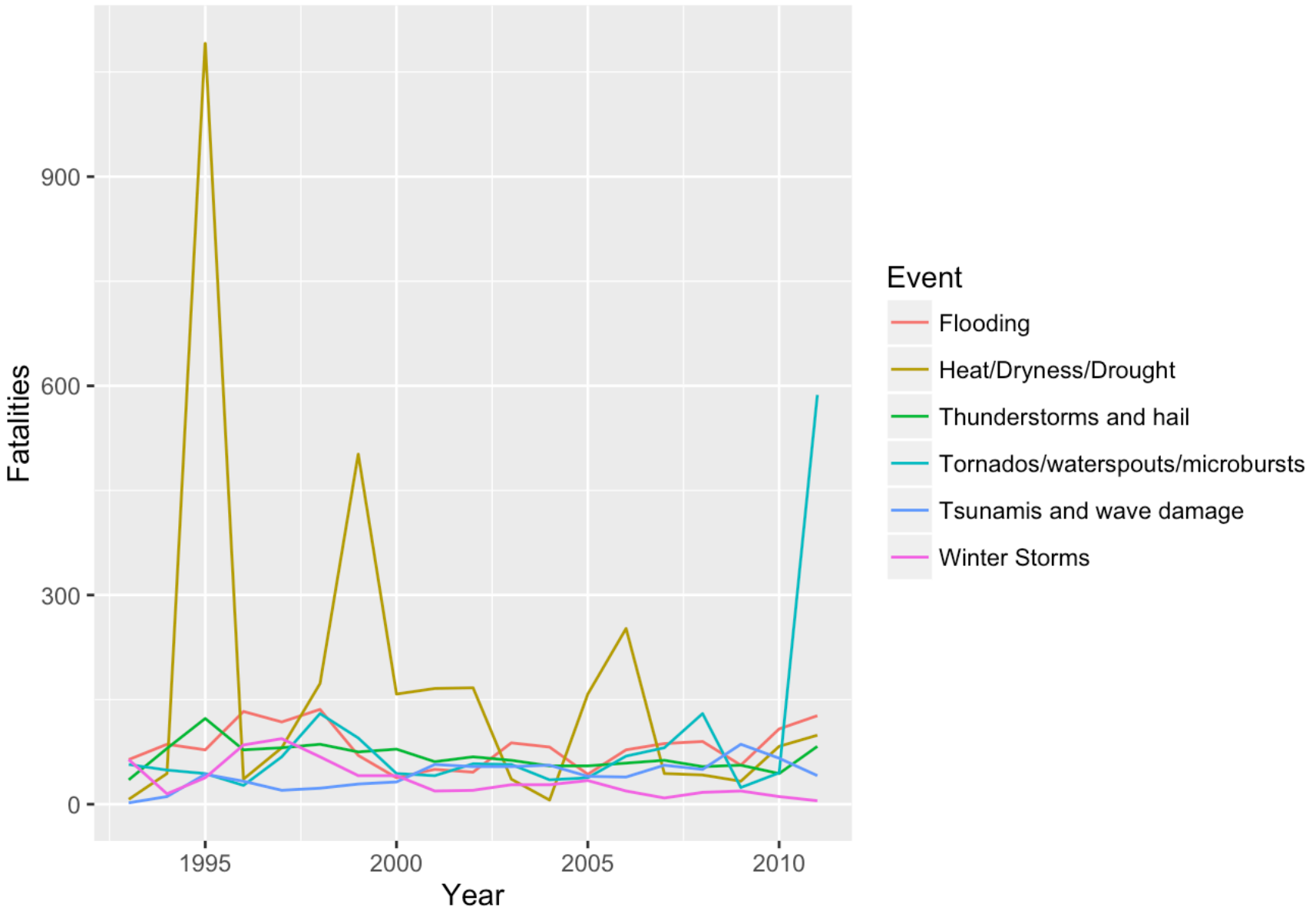
```
storm.totals2 <- storm.totals[storm.totals$Event %in% c("Flooding",
      "Heat/Dryness/Drought",  "Thunderstorms and hail",
      "Tornados/waterspouts/microbursts",
      "Tsunamis and wave damage", "Winter Storms"),]
storm.totals3 <- storm.totals[storm.totals$Event %in% c("Flooding",
      "Heat/Dryness/Drought", "Thunderstorms and hail",
      "Tornados/waterspouts/microbursts",
      "Wind Damage", "Winter Storms"),]
storm.totals4 <- storm.totals[storm.totals$Event %in% c("Flooding",
      "Fires", "Thunderstorms and hail",
      "Tornados/waterspouts/microbursts",
      "Wind Damage", "Winter Storms"),]
```

Results

Fatalities

The total annual fatalities as a result of flooding, excessive heat, thunderstorms and hail, tornados, tsunamis and wave damage, and winter storms are shown below:

```
qplot(Year, Fatalities, data=storm.totals2, geom=c("line"),
      group=Event, color=Event, main="Total Annual Fatalities by Event")
```



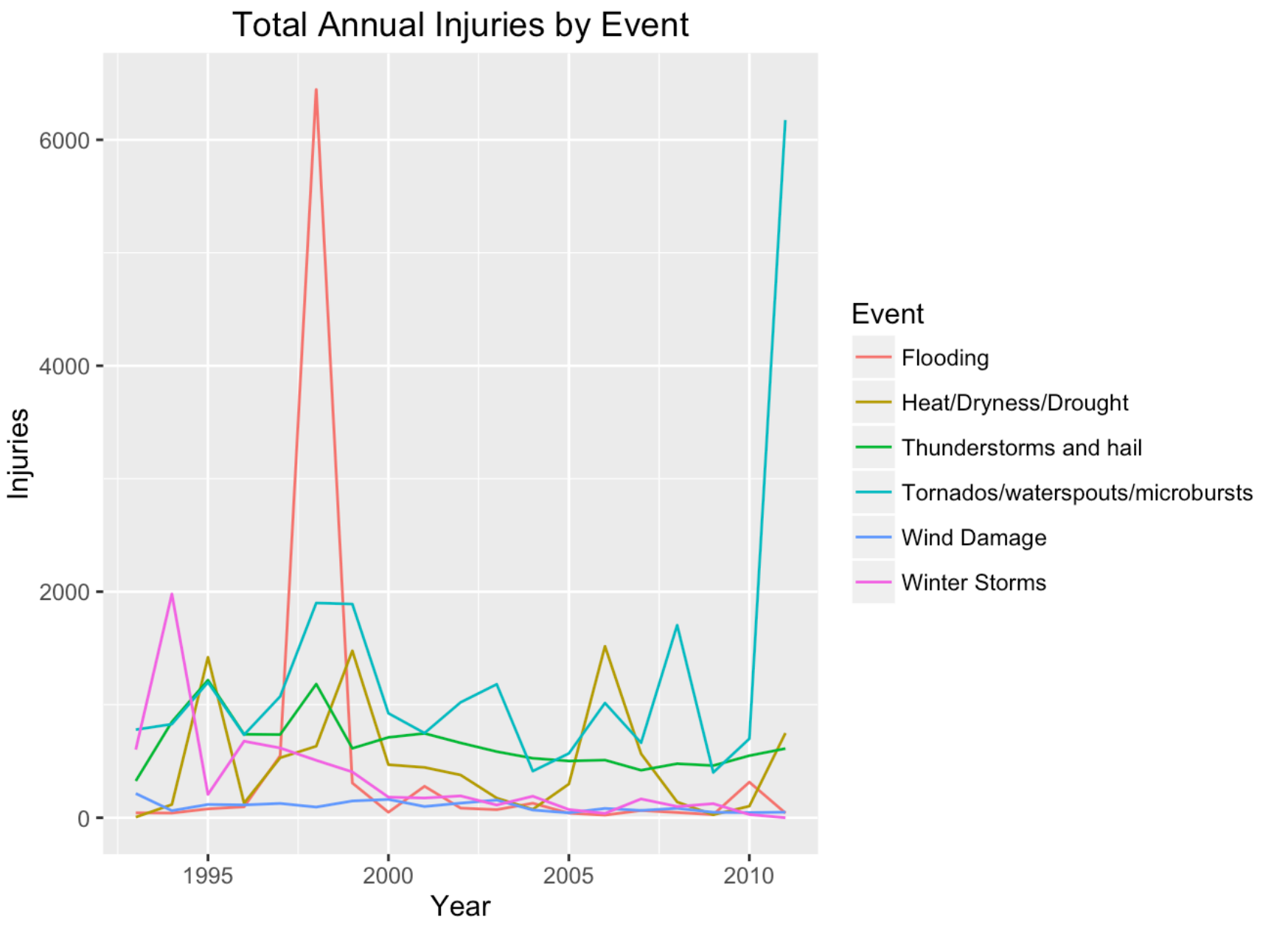
Note: Total fatalities caused by each event in each year. Only the 6 events with the highest average number of fatalities are shown.

By and large, most of the fatalities year to year are caused by excessive heat, especiall prior to 2007. In 2011 the number of fatalities due to thunderstorms and hail spiked.

Injuries

The total annual injuries as a result of flooding, excessive heat, thunderstorms and hail, tornados, wind damage, and winter storms are shown below:

```
qplot(Year, Injuries, data=storm.totals3, geom=c("line"),
      group=Event, color=Event, main="Total Annual Injuries by Event")
```



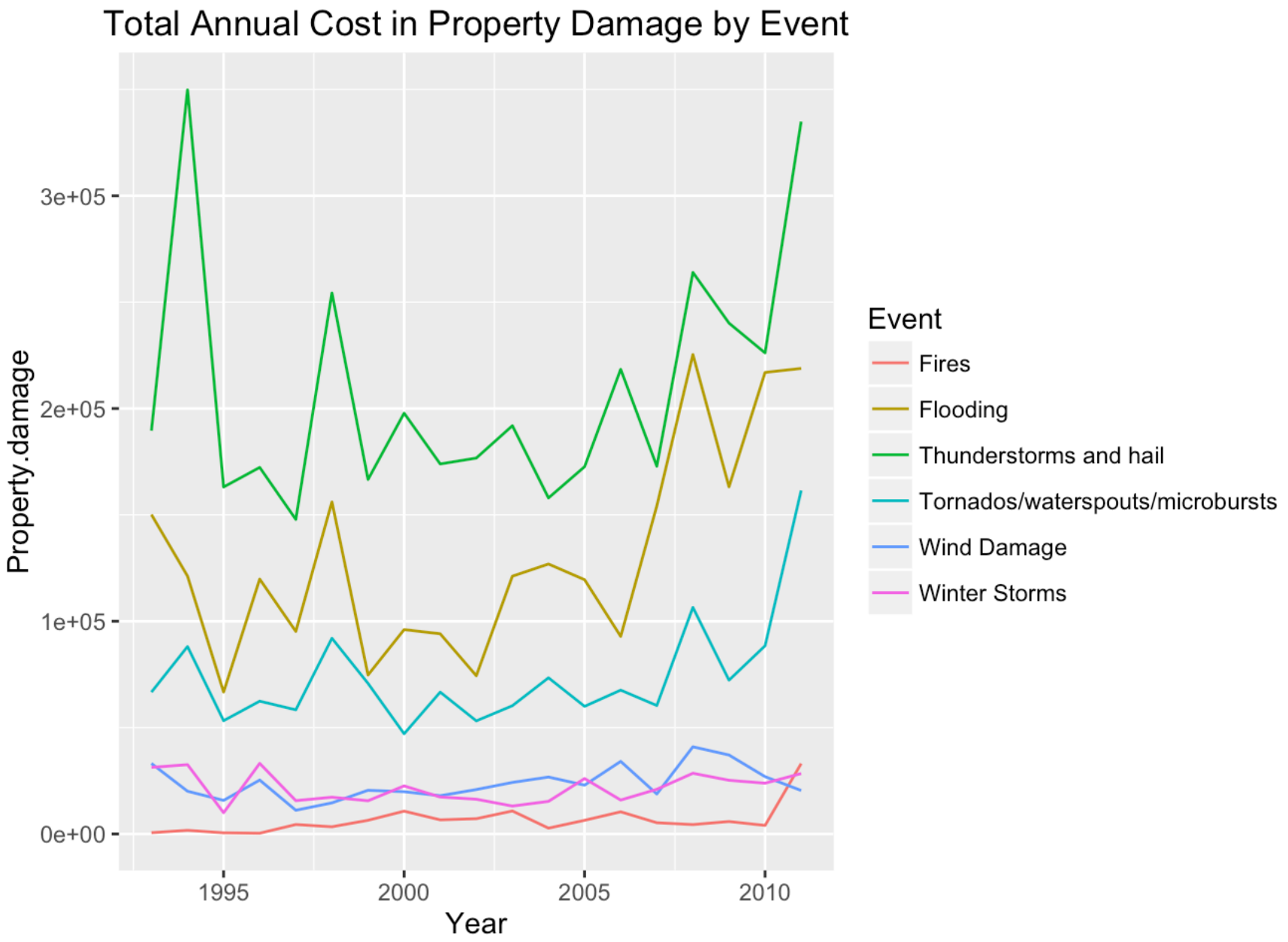
Note: Total injuries caused by each event in each year. Only the 6 events with the highest average number of injuries are shown.

For the most part, and especially in 2011, most injuries year to year are due to tornados, waterspouts, microbursts, and other similar events. 1994 saw a spike in injuries due to winter storms, and 1998 saw increased injuries due to flooding.

Property damage

The total annual cost in property damage as a result of flooding, fires, thunderstorms and hail, tornados, wind damage, and winter storms are shown below:

```
qplot(Year, Property.damage, data=storm.totals4, geom=c("line"),
      group=Event, color=Event, main="Total Annual Cost in Property Damage by Even
t")
```



Note: Total cost in property damage caused by each event in each year. Only the 6 events with the highest average costs are shown.

In every year, most of the cost in property damage is due to thunderstorms and hail. Flooding accounts for the second most cost in property damage.