Reproducible Research Project2: Weather Events - Impact Analysis - Population Health and Economic Damage

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Introduction/ Synopsis

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

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?

Answering those questions may support preparations for severe weather events, e.g. by prioritizing resources for events likely to cause most population harm and/ or economic damage.

The rest of the report is organised as follows:

- *Dataset* section introduces the data and background information for the analysis,
- *Data Preview & Initial Processing* section includes some basic data processing steps to manage the variety of weather event types,
- *Further Data Processing: Event Types* section includes further processing steps of weather event types, and establishes mapping to an established event taxonomy,
- *Analysis* section produces the basic analysis of weather events and impact on population and economy,
- *Results* section provides answers to the above questions, with illustrations,
- *Concluding Remarks* section summarises the analysis with suggestions for further analysis.

Dataset

The analysis is done in R version 4.1.2 (2021-11-01), Platform: x86_64-w64-mingw32/x64 (64-bit), Running under: Windows 10 x64 (build 19045).

```
sessionInfo()
```

```
## R version 4.1.2 (2021-11-01)
## Platform: x86_64-w64-mingw32/x64 (64-bit)
## Running under: Windows 10 x64 (build 19045)
##
## Matrix products: default
##
## locale:
## [1] LC_COLLATE=English_Singapore.1252  LC_CTYPE=English_Singapore.1252
```

```
## [3] LC_MONETARY=English_Singapore.1252 LC_NUMERIC=C
## [5] LC_TIME=English_Singapore.1252
##
## attached base packages:
## [1] stats     graphics  grDevices utils     datasets  methods   base
##
## loaded via a namespace (and not attached):
##  [1] compiler_4.1.2  magrittr_2.0.3  fastmap_1.1.0   cli_3.4.1
##  [5] tools_4.1.2     htmltools_0.5.3 rstudioapi_0.14 yaml_2.3.5
##  [9] stringi_1.7.6   rmarkdown_2.17  knitr_1.40      stringr_1.4.1
## [13] xfun_0.33       digest_0.6.29   rlang_1.0.6     evaluate_0.17
```

It is based on the dataset downloaded from the url below:

```
## dir.create("data")
## fileUrl = "https://d396qusza40orc.cloudfront.net/repdata%2Fdata%2FStormData.csv.bz2"
## download.file(fileUrl,destfile="./data/StormData.csv.bz2",method="curl")
stormdata <- read.csv("./data/StormData.csv.bz2")
```

The download part of the code is commented out as it only needs to be executed once. Data is cached due to its size, as it would be otherwise inefficient to handle.

Additionally, the analysis will reference the supporting documentation provided along with the dataset:

- "STORM DATA PREPARATION" source file: https://d396qusza40orc.cloudfront.net/repdata%2Fpeer2_doc%2Fpd01016005curr.pdf
- FAQ file: https://d396qusza40orc.cloudfront.net/repdata%2Fpeer2_doc%2FNCDC%20Storm%20Events-FAQ%20Page.pdf

In particular, the "STORM DATA PREPARATION" source file includes a data event table, which will be used in this analysis as the taxonomy of weather event types.

Data Preview & Initial Processing

The following lines provide a preview of the dataset:

```
head(stormdata)
```

```
##   STATE__           BGN_DATE BGN_TIME TIME_ZONE COUNTY COUNTYNAME STATE  EVTYPE
## 1       1  4/18/1950 0:00:00     0130       CST     97     MOBILE    AL TORNADO
## 2       1  4/18/1950 0:00:00     0145       CST      3    BALDWIN    AL TORNADO
## 3       1  2/20/1951 0:00:00     1600       CST     57    FAYETTE    AL TORNADO
## 4       1   6/8/1951 0:00:00     0900       CST     89    MADISON    AL TORNADO
## 5       1 11/15/1951 0:00:00     1500       CST     43    CULLMAN    AL TORNADO
## 6       1 11/15/1951 0:00:00     2000       CST     77 LAUDERDALE    AL TORNADO
##   BGN_RANGE BGN_AZI BGN_LOCATI END_DATE END_TIME COUNTY_END COUNTYENDN
## 1         0                                               0         NA
## 2         0                                               0         NA
## 3         0                                               0         NA
## 4         0                                               0         NA
## 5         0                                               0         NA
## 6         0                                               0         NA
```

2.1.1 Storm Data Event Table

Event Name	Designator	Event Name	Designator
Astronomical Low Tide	Z	Hurricane (Typhoon)	Z
Avalanche	Z	Ice Storm	Z
Blizzard	Z	Lake-Effect Snow	Z
Coastal Flood	Z	Lakeshore Flood	Z
Cold/Wind Chill	Z	Lightning	C
Debris Flow	C	Marine Hail	M
Dense Fog	Z	Marine High Wind	M
Dense Smoke	Z	Marine Strong Wind	M
Drought	Z	Marine Thunderstorm Wind	M
Dust Devil	C	Rip Current	Z
Dust Storm	Z	Seiche	Z
Excessive Heat	Z	Sleet	Z
Extreme Cold/Wind Chill	Z	Storm Surge/Tide	Z
Flash Flood	C	Strong Wind	Z
Flood	C	Thunderstorm Wind	C
Frost/Freeze	Z	Tornado	C
Funnel Cloud	C	Tropical Depression	Z
Freezing Fog	Z	Tropical Storm	Z
Hail	C	Tsunami	Z
Heat	Z	Volcanic Ash	Z
Heavy Rain	C	Waterspout	M
Heavy Snow	Z	Wildfire	Z
High Surf	Z	Winter Storm	Z
High Wind	Z	Winter Weather	Z

Figure 1: Screenshot of Data Event Table from the source file, section 2.1.1, page 6:

```
##   END_RANGE END_AZI END_LOCATI LENGTH WIDTH F MAG FATALITIES INJURIES PROPDMG
## 1         0                      14.0   100 3   0          0       15    25.0
## 2         0                       2.0   150 2   0          0        0     2.5
## 3         0                       0.1   123 2   0          0        2    25.0
## 4         0                       0.0   100 2   0          0        2     2.5
## 5         0                       0.0   150 2   0          0        2     2.5
## 6         0                       1.5   177 2   0          0        6     2.5
##   PROPDMGEXP CROPDMG CROPDMGEXP WFO STATEOFFIC ZONENAMES LATITUDE LONGITUDE
## 1          K       0                                         3040      8812
## 2          K       0                                         3042      8755
## 3          K       0                                         3340      8742
## 4          K       0                                         3458      8626
## 5          K       0                                         3412      8642
## 6          K       0                                         3450      8748
##   LATITUDE_E LONGITUDE_ REMARKS REFNUM
## 1       3051       8806              1
## 2          0          0              2
## 3          0          0              3
## 4          0          0              4
## 5          0          0              5
## 6          0          0              6
```

```
summary(stormdata)
```

```
##     STATE__        BGN_DATE           BGN_TIME          TIME_ZONE
##  Min.   : 1.0   Length:902297      Length:902297      Length:902297
##  1st Qu.:19.0   Class :character   Class :character   Class :character
##  Median :30.0   Mode  :character   Mode  :character   Mode  :character
##  Mean   :31.2
##  3rd Qu.:45.0
##  Max.   :95.0
##
##      COUNTY       COUNTYNAME           STATE              EVTYPE
##  Min.   :  0.0   Length:902297      Length:902297      Length:902297
##  1st Qu.: 31.0   Class :character   Class :character   Class :character
##  Median : 75.0   Mode  :character   Mode  :character   Mode  :character
##  Mean   :100.6
##  3rd Qu.:131.0
##  Max.   :873.0
##
##    BGN_RANGE          BGN_AZI           BGN_LOCATI          END_DATE
##  Min.   :   0.000   Length:902297      Length:902297      Length:902297
##  1st Qu.:   0.000   Class :character   Class :character   Class :character
##  Median :   0.000   Mode  :character   Mode  :character   Mode  :character
##  Mean   :   1.484
##  3rd Qu.:   1.000
##  Max.   :3749.000
##
##    END_TIME           COUNTY_END COUNTYENDN       END_RANGE
##  Length:902297      Min.   :0    Mode:logical   Min.   :  0.0000
##  Class :character   1st Qu.:0    NA's:902297    1st Qu.:  0.0000
##  Mode  :character   Median :0                   Median :  0.0000
##                     Mean   :0                   Mean   :  0.9862
##                     3rd Qu.:0                   3rd Qu.:  0.0000
```

```
##                    Max.   :0                    Max.   :925.0000
##
##    END_AZI           END_LOCATI           LENGTH              WIDTH
##  Length:902297      Length:902297      Min.   :   0.0000   Min.   :   0.000
##  Class :character   Class :character   1st Qu.:   0.0000   1st Qu.:   0.000
##  Mode  :character   Mode  :character   Median :   0.0000   Median :   0.000
##                                        Mean   :   0.2301   Mean   :   7.503
##                                        3rd Qu.:   0.0000   3rd Qu.:   0.000
##                                        Max.   :2315.0000   Max.   :4400.000
##
##        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   Length:902297      Min.   :  0.000   Length:902297
##  1st Qu.:   0.00   Class :character   1st Qu.:  0.000   Class :character
##  Median :   0.00   Mode  :character   Median :  0.000   Mode  :character
##  Mean   :  12.06                      Mean   :  1.527
##  3rd Qu.:   0.50                      3rd Qu.:  0.000
##  Max.   :5000.00                      Max.   :990.000
##
##      WFO              STATEOFFIC         ZONENAMES            LATITUDE
##  Length:902297      Length:902297      Length:902297      Min.   :   0
##  Class :character   Class :character   Class :character   1st Qu.:2802
##  Mode  :character   Mode  :character   Mode  :character   Median :3540
##                                                           Mean   :2875
##                                                           3rd Qu.:4019
##                                                           Max.   :9706
##                                                           NA's   :47
##    LONGITUDE        LATITUDE_E     LONGITUDE_       REMARKS
##  Min.   :-14451   Min.   :   0   Min.   :-14455   Length:902297
##  1st Qu.:  7247   1st Qu.:   0   1st Qu.:     0   Class :character
##  Median :  8707   Median :   0   Median :     0   Mode  :character
##  Mean   :  6940   Mean   :1452   Mean   :  3509
##  3rd Qu.:  9605   3rd Qu.:3549   3rd Qu.:  8735
##  Max.   : 17124   Max.   :9706   Max.   :106220
##                   NA's   :40
##      REFNUM
##  Min.   :     1
##  1st Qu.:225575
##  Median :451149
##  Mean   :451149
##  3rd Qu.:676723
##  Max.   :902297
##
```

It is clear that the key variable in the dataset is EVTYPE, denoting the type of weather event. It will be helpful to see how many unique event types exist in the dataset.

```
uniq <- length(unique(stormdata$EVTYPE))
sort(unique(stormdata$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 CHI" "BLOWING SNOW & EXTREME WIND CH"
##  [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/FLOODING"
## [295] "Heavy Rain/High Surf"            "HEAVY RAIN/LIGHTNING"
## [297] "HEAVY RAIN/MUDSLIDES/FLOOD"      "HEAVY RAIN/SEVERE WEATHER"
## [299] "HEAVY RAIN/SMALL STREAM URBAN"   "HEAVY RAIN/SNOW"
## [301] "HEAVY RAIN/URBAN FLOOD"          "HEAVY RAIN/WIND"
## [303] "HEAVY RAIN; URBAN FLOOD WINDS;"  "HEAVY RAINFALL"
## [305] "HEAVY RAINS"                     "HEAVY RAINS/FLOODING"
## [307] "HEAVY SEAS"                      "HEAVY SHOWER"
## [309] "HEAVY SHOWERS"                   "HEAVY SNOW"
## [311] "HEAVY SNOW-SQUALLS"              "HEAVY SNOW   FREEZING RAIN"
## [313] "HEAVY SNOW & ICE"                "HEAVY SNOW AND"
## [315] "HEAVY SNOW AND HIGH WINDS"       "HEAVY SNOW AND ICE"
```

```
## [317] "HEAVY SNOW AND ICE STORM"       "HEAVY SNOW AND STRONG WINDS"
## [319] "HEAVY SNOW ANDBLOWING SNOW"     "Heavy snow shower"
## [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-GENERATED SWELLS"     "Hurricane Edouard"
## [405] "HURRICANE EMILY"                "HURRICANE ERIN"
## [407] "HURRICANE FELIX"                "HURRICANE GORDON"
## [409] "HURRICANE OPAL"                 "HURRICANE OPAL/HIGH WINDS"
## [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 EFFECT SNOW"                "LAKE FLOOD"
## [441] "LAKESHORE FLOOD"                 "LANDSLIDE"
## [443] "LANDSLIDE/URBAN FLOOD"           "LANDSLIDES"
## [445] "Landslump"                       "LANDSLUMP"
## [447] "LANDSPOUT"                       "LARGE WALL CLOUD"
## [449] "Late-season Snowfall"            "LATE FREEZE"
## [451] "LATE SEASON HAIL"                "LATE SEASON SNOW"
## [453] "Late Season Snowfall"            "LATE SNOW"
## [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 WIND DAMAGE"
## [525] "NON-TSTM WIND"                   "NON SEVERE HAIL"
## [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"
## [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- HIGH WIND- WIND CHILL"
## [631] "Snow Accumulation"              "SNOW ACCUMULATION"
## [633] "SNOW ADVISORY"                  "SNOW AND COLD"
## [635] "SNOW AND HEAVY SNOW"            "Snow and Ice"
## [637] "SNOW AND ICE"                   "SNOW AND ICE STORM"
## [639] "Snow and sleet"                 "SNOW AND SLEET"
```

```
## [641] "SNOW AND WIND"                "SNOW DROUGHT"
## [643] "SNOW FREEZING RAIN"           "SNOW SHOWERS"
## [645] "SNOW SLEET"                   "SNOW SQUALL"
## [647] "Snow squalls"                 "Snow Squalls"
## [649] "SNOW SQUALLS"                 "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"
## [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"
## [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-"                   "WATERSPOUT-TORNADO"
## [939] "WATERSPOUT FUNNEL CLOUD"       "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"
```

```
sort(table(stormdata$EVTYPE),decreasing=TRUE)[1:10]
```

```
##
##               HAIL          TSTM WIND  THUNDERSTORM WIND            TORNADO
##             288661             219940              82563              60652
##        FLASH FLOOD              FLOOD THUNDERSTORM WINDS          HIGH WIND
##              54277              25326              20843              20212
##          LIGHTNING         HEAVY SNOW
##              15754              15708
```

With 985 unique event type names in the data set, it is evident that they do not closely follow the taxonomy presented at the beginning of this report. Instead, there is a great variety, with certain noticeable patterns. Hail, thunderstorm winds, tornadoes and (flash)floods seem to be the most common weather events.

Initial data processing applies to the variable EVTYPE, and includes: - Conversion to uppercase, - Removing spaces and special characters, typically used to describe concurrent events (this will be analysed in more detail in later sections), e.g. "THUNDERSTORMWINDS/HAIL", - Removing abbreviations, e.g."TSTM" for "THUNDERSTORM", - Correcting typos, e.g. "VOG" for "FOG", or different typos in "THUNDERSTORM". As will be demonstrated later, the latter is a frequent event, causing a lot of population harm as well as economic damage - so it is important to capture asmany related entries as possible, - Consistenl labelling of unknown event types, such as "?", as "NA".

Data processing step 1: Most obvious abbreviations, typos, and unknowns:

```
stormdata$EVTYPE <- toupper(stormdata$EVTYPE)
stormdata$EVTYPE <- gsub(" ","",stormdata$EVTYPE)
stormdata$EVTYPE <- gsub("[(]","",stormdata$EVTYPE)
stormdata$EVTYPE <- gsub("[)]","",stormdata$EVTYPE)
stormdata$EVTYPE <- gsub("\\\\","",stormdata$EVTYPE)
stormdata$EVTYPE <- gsub("\\","",stormdata$EVTYPE, fixed=TRUE)
stormdata$EVTYPE <- gsub("AND", "",stormdata$EVTYPE)
stormdata$EVTYPE <- gsub("&","",stormdata$EVTYPE)
stormdata$EVTYPE <- gsub(";","",stormdata$EVTYPE)
stormdata$EVTYPE <- gsub(",","",stormdata$EVTYPE)
stormdata$EVTYPE <- gsub("-","",stormdata$EVTYPE)
stormdata$EVTYPE <- gsub("//","",stormdata$EVTYPE)
stormdata$EVTYPE <- gsub("/","",stormdata$EVTYPE)
stormdata$EVTYPE <- gsub("TSTM","THUNDERSTORM",stormdata$EVTYPE)
stormdata$EVTYPE<- gsub("WND","WIND",stormdata$EVTYPE)
stormdata$EVTYPE <- gsub("CSTL","COASTAL",stormdata$EVTYPE)
stormdata$EVTYPE <- gsub("HVY","HEAVY",stormdata$EVTYPE)
stormdata$EVTYPE <- gsub("SML","SMALL",stormdata$EVTYPE)
```

```
stormdata$EVTYPE <- gsub("STRM","STREAM",stormdata$EVTYPE)
stormdata$EVTYPE <- gsub("FLD","FLOOD",stormdata$EVTYPE)
stormdata$EVTYPE <- gsub("VOG","FOG",stormdata$EVTYPE)
stormdata$EVTYPE<- gsub("TORNDAO","TORNADO",stormdata$EVTYPE)
stormdata$EVTYPE <- gsub("W(.*)SPOUT","WATERSPOUT",stormdata$EVTYPE)
stormdata$EVTYPE <- gsub("LI(.*)NG","LIGHTNING",stormdata$EVTYPE)
stormdata$EVTYPE <- gsub("THUNDERSTROM","THUNDERSTORM",stormdata$EVTYPE)
stormdata$EVTYPE <- gsub("TUNDERSTORM","THUNDERSTORM",stormdata$EVTYPE)
stormdata$EVTYPE <- gsub("TUNDERTORM","THUNDERSTORM",stormdata$EVTYPE)
stormdata$EVTYPE <- gsub("THU(.*)RM","THUNDERSTORM",stormdata$EVTYPE)
stormdata$EVTYPE <- gsub("THUNDERSTORM$","THUNDERSTORMWIND",stormdata$EVTYPE)
stormdata$EVTYPE <- gsub("THUNDERSTORMW$","THUNDERSTORMWIND",stormdata$EVTYPE)
stormdata$EVTYPE <- gsub("THUNDERSTORMS$","THUNDERSTORMWIND",stormdata$EVTYPE)
stormdata$EVTYPE <- gsub("THUNDERSTORMWINDS","THUNDERSTORMWIND",stormdata$EVTYPE)
stormdata$EVTYPE <- gsub("THUNDERSTORMSWIND","THUNDERSTORMWIND",stormdata$EVTYPE)
stormdata$EVTYPE <- gsub("THUNDERSTORMDAMAGE","THUNDERSTORMWIND",stormdata$EVTYPE)

## length(stormdata$EVTYPE[which(stormdata$EVTYPE=="?")])
## stormdata[which(stormdata$EVTYPE=="?"),]
stormdata$EVTYPE[which(stormdata$EVTYPE=="?")] <- "NA"

## length(stormdata$EVTYPE[which(stormdata$EVTYPE=="NONE")])
## stormdata[which(stormdata$EVTYPE=="NONE"),]
stormdata$EVTYPE[which(stormdata$EVTYPE=="NONE")] <- "NA"
```

There is one entry where the event type is unknown ("?"), and the remarks do not provide further details (nor any other column, commented-out part of the code shows all the details). Similar situation for event type "NONE". These entries will be labelled as "NA".

```
uniq <- length(unique(stormdata$EVTYPE))
```

By now, the number of unique event type names is reduced to 750. However, it is clear that more patterns exist, and more data processing will be required to categorise event types more consistently, in a way as aligned as possible to the taxonomy presented at the beginning of this analysis (please see the next section).

At this point, categories from the file will be read into the EVCAT variable, noting that: - Uppercase is used, - Spaces, brackets, and other special characters are omitted.

```
EVCAT <- toupper(c("AstronomicalLowTide", "Avalanche", "Blizzard", "CoastalFlood",
"ColdWindChill", "DebrisFlow","DenseFog","DenseSmoke", "Drought", "DustDevil",
"DustStorm", "ExcessiveHeat", "ExtremeColdWindChill", "FlashFlood", "Flood",
"FrostFreeze", "FunnelCloud", "FreezingFog","Hail", "Heat", "HeavyRain","HeavySnow",
"HighSurf","HighWind", "HurricaneTyphoon", "IceStorm","LakeEffectSnow",
"LakeshoreFlood", "Lightning", "MarineHail", "MarineHighWind", "MarineStrongWind",
"MarineThunderstormWind", "RipCurrent","Seiche", "Sleet", "StormSurgeTide",
"StrongWind", "ThunderstormWind", "Tornado", "TropicalDepression","TropicalStorm", "
Tsunami","VolcanicAsh","Waterspout", "Wildfire", "WinterStorm", "WinterWeather"))
```

Besides EVTYPE, the following variables will be used further in this analysis:

- INJURIES and FATALITIES: Variables defining harm with respect to population health,
- PROPDMG and PROPDMGEXP: Variables defining property damage in USD, with an exponential factor if applicable,

- CROPDMG and CROPDMGEXP: Variables denoting crop damage in USD, with an exponential factor if applicable.

For details, please refer to section 2.6 and 2.7 of the "STORM DATA PREPARATION" source file.

Further Data Processing: Event Types

Data processing in this section focuses on event types. The objective is to categorise event types more consistently, in a way as aligned as possible to the taxonomy presented at the beginning of this analysis.

Same Event Type, Many Names

The data preview shows that in many cases, same or similar events are named differently. For example, alternative terms are used: - "COOL" is used for "COLD", - "RECORDHEAT" or "RECORDCOLD" are used to describe extreme temperatures; EVCAT "EXCESSIVEHEAT" will be re-labelled to "EXTREMEHEAT" for easier handling,
- "URBAN/SMALL STREAM" are often used to describe "FLOOD", - "DAMBREAK"/"DAMFAILURE" will be mapped to "FLOOD"; even though it is not a weather event, technically speaking, it is an event creating significant damage similar to "FLOOD".

Elsewhere, additional categories are created, which can be mapped to existing EVCAT categories: - "GUSTY WIND" and "SQUALLS" will be mapped to "STRONGWIND", - "WET" and names including "PRECIP[ITATION]" will be mapped to "HEAVYRAIN",etc.

Finally, it is clear that some of EVCAT categories are a bit narrow, or do not exist, e.g., - "FREEZE" will be used instead of "FROSTFREEZE", and "GLAZE", "FREEZINGRAIN", "ICE" will be be mapped to it, - "STRONGTIDE" will be used instead of "ASTRONOMICALLOWTIDE", and "LOWTIDE", "HIGHTIDE", and "BLOWOUTIDE" will be mapped to it, - "SLIDE" category will be added, and "LANDSLIDE", "MUDLSIDE", "ROCKSLIDE" etc. will be mapped to it, - "HURRICANE" will be used instead of "HURRICANETYPHOON", and "TYPHOON" will be mapped to this category.

The code below provides full transparency of all data transformations (mappings). The reason for having them is two-fold: (1) **To capture as many entries as possible in the analysis, with minimal distortion to the original categories**; And (2) **to capture events with significant population harm and/ or economic damage in the analysis**. This will be demonstrated later.

The definitions of specific weather events were cross-checked against NOAA glossary: https://forecast.weather.gov/glossary.php

```
stormdata$EVTYPE<- gsub("COOL","COLD",stormdata$EVTYPE)
stormdata$EVTYPE<- gsub("WARM","HEAT",stormdata$EVTYPE)
stormdata$EVTYPE<- gsub("HOT","HEAT",stormdata$EVTYPE)
stormdata$EVTYPE<- gsub("RECORD","EXTREME",stormdata$EVTYPE)
stormdata$EVTYPE<- gsub("EXCESSIVE","EXTREME",stormdata$EVTYPE)
stormdata$EVTYPE<- gsub("VERY","EXTREME",stormdata$EVTYPE)
stormdata$EVTYPE<- gsub("UNUSUALLY","EXTREME",stormdata$EVTYPE)
stormdata$EVTYPE<- gsub("UNUSUAL","EXTREME",stormdata$EVTYPE)
stormdata$EVTYPE<- gsub("SEVERE","EXTREME",stormdata$EVTYPE)

stormdata$EVTYPE <- gsub("EXTREMEWINDCHILL","EXTREMECOLDWINDCHILL",stormdata$EVTYPE)
stormdata$EVTYPE <- gsub("UNSEASONABLYCOLD","EXTREMECOLD",stormdata$EVTYPE)
stormdata$EVTYPE <- gsub("UNSEASONABLECOLD","EXTREMECOLD",stormdata$EVTYPE)
stormdata$EVTYPE <- gsub("EXTENDEDCOLD","EXTREMECOLD",stormdata$EVTYPE)
```

```
stormdata$EVTYPE<- gsub("URBAN","FLOOD",stormdata$EVTYPE)
stormdata$EVTYPE<- gsub("SMALLSTREAM","FLOOD",stormdata$EVTYPE)
stormdata$EVTYPE <- gsub("HIGHWATER","FLOOD",stormdata$EVTYPE)
stormdata$EVTYPE <- gsub("DAMBREAK","FLOOD",stormdata$EVTYPE)
stormdata$EVTYPE <- gsub("DAMFAILURE","FLOOD",stormdata$EVTYPE)

stormdata$EVTYPE<- gsub("GUSTY","STRONG",stormdata$EVTYPE)
stormdata$EVTYPE<- gsub("SQUALL","STRONGWIND",stormdata$EVTYPE)
stormdata$EVTYPE <- gsub("MICROBURST","STRONGWIND",stormdata$EVTYPE)
stormdata$EVTYPE <- gsub("WINDDAMAGE","STRONGWIND",stormdata$EVTYPE)
stormdata$EVTYPE <- gsub("STORMFORCEWINDS","STRONGWIND",stormdata$EVTYPE)
stormdata$EVTYPE <- gsub("^WINDS$","STRONGWIND",stormdata$EVTYPE)
stormdata$EVTYPE <- gsub("WINDSTORM","THUNDERSTORMWIND",stormdata$EVTYPE)
stormdata$EVTYPE<- gsub("GUSTNADO","STRONGWINDTORNADO",stormdata$EVTYPE)

stormdata$EVTYPE <- gsub("GLAZE","FREEZE",stormdata$EVTYPE)
stormdata$EVTYPE<- gsub("FREEZING","FREEZE",stormdata$EVTYPE)
stormdata$EVTYPE<- gsub("FROST","FREEZE",stormdata$EVTYPE)
stormdata$EVTYPE<- gsub("MIXEDPRECIP","FREEZE",stormdata$EVTYPE)
stormdata$EVTYPE<- gsub("HEAVYMIX","FREEZE",stormdata$EVTYPE)
stormdata$EVTYPE <- gsub("ICE$","FREEZE",stormdata$EVTYPE)
stormdata$EVTYPE <- gsub("IC(.*)ROAD","FREEZE",stormdata$EVTYPE)
stormdata$EVTYPE <- gsub("IC(.*)FLOE","FREEZE",stormdata$EVTYPE)

stormdata$EVTYPE<- gsub("ASTRONOMICALLOWTIDE","STRONGTIDE",stormdata$EVTYPE)
stormdata$EVTYPE<- gsub("ASTRONOMICALHIGHTIDE","STRONGTIDE",stormdata$EVTYPE)
stormdata$EVTYPE <- gsub("BLOWOUTTIDE","STRONGTIDE",stormdata$EVTYPE)
stormdata$EVTYPE <- gsub("HIGHTIDE","STRONGTIDE",stormdata$EVTYPE)
stormdata$EVTYPE <- gsub("H(.*)SURF","STRONGTIDE",stormdata$EVTYPE)

stormdata$EVTYPE <- gsub("WETNESS","HEAVYRAIN",stormdata$EVTYPE)
stormdata$EVTYPE <- gsub("WET$","HEAVYRAIN",stormdata$EVTYPE)
stormdata$EVTYPE <- gsub("HEAVYPREC","HEAVYRAIN",stormdata$EVTYPE)
stormdata$EVTYPE <- gsub("EXTREMEPREC","HEAVYRAIN",stormdata$EVTYPE)
stormdata$EVTYPE <- gsub("EXTREMERAIN","HEAVYRAIN",stormdata$EVTYPE)
stormdata$EVTYPE <- gsub("COLDWETCONDITIONS","HEAVYRAIN",stormdata$EVTYPE)
stormdata$EVTYPE <- gsub("UNSEASONALRAIN","HEAVYRAIN",stormdata$EVTYPE)
stormdata$EVTYPE <- gsub("EXTREMESNOW","HEAVYSNOW",stormdata$EVTYPE)
stormdata$EVTYPE <- gsub("ICESNOW","HEAVYSNOW",stormdata$EVTYPE)
stormdata$EVTYPE <- gsub("^SNOW","HEAVYSNOW",stormdata$EVTYPE)
stormdata$EVTYPE <- gsub("COLDSNOW","HEAVYSNOW",stormdata$EVTYPE)
stormdata$EVTYPE <- gsub("BLOWINGSNOW","HEAVYSNOW",stormdata$EVTYPE)
stormdata$EVTYPE <- gsub("HEAVYLAKESNOW","HEAVYSNOW",stormdata$EVTYPE)

stormdata$EVTYPE <- gsub("FORESTFIRE","WILDFIRE",stormdata$EVTYPE)
stormdata$EVTYPE <- gsub("B(.*)FIRE","WILDFIRE",stormdata$EVTYPE)
stormdata$EVTYPE <- gsub("G(.*)FIRE","WILDFIRE",stormdata$EVTYPE)

stormdata$EVTYPE <- gsub("FUNNEL$","FUNNELCLOUD",stormdata$EVTYPE)
stormdata$EVTYPE <- gsub("TYPHOON","HURRICANE",stormdata$EVTYPE)
stormdata$EVTYPE <- gsub("WIN(.*)MIX","WINTERWEATHER",stormdata$EVTYPE)
stormdata$EVTYPE <- gsub("EROSION","SLIDE",stormdata$EVTYPE)
stormdata$EVTYPE <- gsub("SLUMP","SLIDE",stormdata$EVTYPE)
```

```
stormdata$EVTYPE <- gsub("SWELL","COASTALFLOOD",stormdata$EVTYPE)
stormdata$EVTYPE <- gsub("WINDWAVE","STORMSURGETIDE",stormdata$EVTYPE)
stormdata$EVTYPE <- gsub("COASTALSURGE","STORMSURGETIDE",stormdata$EVTYPE)
stormdata$EVTYPE <- gsub("COASTALSTORM","STORMSURGETIDE",stormdata$EVTYPE)
stormdata$EVTYPE <- gsub("ROUGHSEAS","MARINESTRONGWIND",stormdata$EVTYPE)

EVCAT <- toupper(c("STRONGTide","Avalanche","Blizzard","CoastalFlood",
"ColdWindChill", "DebrisFlow","DenseFog", "DenseSmoke", "Drought","DustDevil",
"DustStorm","EXTREMEHeat","ExtremeColdWindChill","FlashFlood","Flood",
"FREEZE","FunnelCloud","FreezingFog","Hail","Heat","HeavyRain","HeavySnow",
"HighWind", "HURRICANE", "IceStorm","LakeEffectSnow","LakeshoreFlood","SLIDE",
"Lightning", "MarineHail", "MarineHighWind", "MarineStrongWind",
"MarineThunderstormWind","RipCurrent","Seiche","Sleet","StormSurgeTide",
"StrongWind","ThunderStormWind","Tornado","TropicalDepression","TropicalStorm",
"Tsunami","VolcanicAsh","Waterspout","Wildfire","WinterStorm","WinterWeather"))
```

It has to be stressed that the ultimate results are sensitive to the event taxonomy (EVCAT) and mapping to specific event types within this taxonomy (EVTYPE). Different mappings may change the results to a degree. No major divergence was observed with respect to Top 5 most harmful event types - both in terms of population harm and economic damage, but within Top 10 - some differences can already be noticed. For a more focused analysis, e.g. for a specific state, year, or a specific subset of events, a more detailed mapping review will likely be required.

```
uniq <- length(unique(stormdata$EVTYPE))
```

The above data processing steps bring the number of unique names to 657.

Summary and Other Event Types

Some event types are entered as "SUMMARY" or "OTHER", instead of a specific event type.

```
## length(stormdata$EVTYPE[grep("SUMMARY",stormdata$EVTYPE)])
## stormdata$REMARKS[grep("SUMMARY",stormdata$EVTYPE)]
stormdata[grep("SUMMARY",stormdata$EVTYPE),match(c("EVTYPE","FATALITIES","INJURIES","PROPDMG",
"PROPDMGEXP","CROPDMG","CROPDMGEXP"),colnames(stormdata))]
```

```
##                   EVTYPE FATALITIES INJURIES PROPDMG PROPDMGEXP CROPDMG
## 269504       SUMMARYJAN17          0        0       0                  0
## 269586   SUMMARYOFMARCH14          0        0       0                  0
## 269610   SUMMARYOFMARCH23          0        0       0                  0
## 269679   SUMMARYOFMARCH24          0        0       0                  0
## 269784  SUMMARYOFAPRIL3RD          0        0       0                  0
## 269843   SUMMARYOFAPRIL12          0        0       0                  0
## 269854   SUMMARYOFAPRIL13          0        0       0                  0
## 269874   SUMMARYOFAPRIL21          0        0       0                  0
## 269959    SUMMARYAUGUST11          0        0       0                  0
## 270136   SUMMARYOFAPRIL27          0        0       0                  0
## 270171    SUMMARYOFMAY910          0        0       0                  0
## 270218     SUMMARYOFMAY10          0        0       0                  0
## 270227     SUMMARYOFMAY13          0        0       0                  0
## 270268     SUMMARYOFMAY14          0        0       0                  0
```

```
## 270275   SUMMARYOFMAY22AM          0         0         0                 0
## 270291   SUMMARYOFMAY22PM          0         0         0                 0
## 270334   SUMMARYOFMAY26AM          0         0         0                 0
## 270338   SUMMARYOFMAY26PM          0         0         0                 0
## 270433   SUMMARYOFMAY31AM          0         0         0                 0
## 270439   SUMMARYOFMAY31PM          0         0         0                 0
## 270515     SUMMARYOFJUNE3          0         0         0                 0
## 270553     SUMMARYOFJUNE4          0         0         0                 0
## 270571      SUMMARYJUNE56          0         0         0                 0
## 270597       SUMMARYJUNE6          0         0         0                 0
## 270640    SUMMARYOFJUNE11          0         0         0                 0
## 270663    SUMMARYOFJUNE12          0         0         0                 0
## 270672    SUMMARYOFJUNE13          0         0         0                 0
## 270685    SUMMARYOFJUNE15          0         0         0                 0
## 270691    SUMMARYOFJUNE16          0         0         0                 0
## 270712    SUMMARYJUNE1819          0         0         0                 0
## 270782    SUMMARYOFJUNE23          0         0         0                 0
## 270791    SUMMARYOFJUNE24          0         0         0                 0
## 270808    SUMMARYOFJUNE30          0         0         0                 0
## 270816     SUMMARYOFJULY2          0         0         0                 0
## 270828     SUMMARYOFJULY3          0         0         0                 0
## 270854    SUMMARYOFJULY11          0         0         0                 0
## 270872    SUMMARYOFJULY22          0         0         0                 0
## 270915    SUMMARYJULY2324          0         0         0                 0
## 270941    SUMMARYOFJULY26          0         0         0                 0
## 270947    SUMMARYOFJULY29          0         0         0                 0
## 270980   SUMMARYOFAUGUST1          0         0         0                 0
## 270985    SUMMARYAUGUST23          0         0         0                 0
## 271019     SUMMARYAUGUST7          0         0         0                 0
## 271027     SUMMARYAUGUST9          0         0         0                 0
## 271031    SUMMARYAUGUST10          0         0         0                 0
## 271070    SUMMARYAUGUST17          0         0         0                 0
## 271081    SUMMARYAUGUST21          0         0         0                 0
## 271087    SUMMARYAUGUST28          0         0         0                 0
## 271096  SUMMARYSEPTEMBER4          0         0         0                 0
## 271110 SUMMARYSEPTEMBER20          0         0         0                 0
## 271125 SUMMARYSEPTEMBER23          0         0         0                 0
## 271154   SUMMARYSEPT.2526          0         0         0                 0
## 271210   SUMMARY:OCT.2021          0         0         0                 0
## 271340  SUMMARY:OCTOBER31          0         0         0                 0
## 271349     SUMMARY:NOV.67          0         0         0                 0
## 271399     SUMMARY:NOV.16          0         0         0                 0
## 275076   SUMMARYOFMARCH23          0         0         0                 0
## 275208   SUMMARYOFAPRIL12          0         0         0                 0
## 275431   SUMMARYOFAPRIL21          0         0         0                 0
## 275843     SUMMARYOFMAY22          0         0         0                 0
## 276017     SUMMARYOFJUNE6          0         0         0                 0
## 276037     SUMMARYAUGUST4          0         0         0                 0
## 276486     SUMMARYOFJUNE3          0         0         0                 0
## 276629    SUMMARYOFJUNE10          0         0         0                 0
## 276705    SUMMARYOFJUNE13          0         0         0                 0
## 276788    SUMMARYOFJUNE18          0         0         0                 0
## 277073    SUMMARYAUGUST10          0         0         0                 0
## 277086    SUMMARYAUGUST11          0         0         0                 0
```

```
## 277385  SUMMARYSEPTEMBER3          0        0       0                  0
## 277501    SUMMARY:SEPT.18          0        0       0                  0
## 277677 SUMMARYSEPTEMBER23          0        0       0                  0
## 278098     SUMMARY:NOV.16          0        0       0                  0
## 298058    BLIZZARDSUMMARY          0        0       0                  0
## 299357 SUMMARYOFMARCH2425          0        0       0                  0
## 299447   SUMMARYOFMARCH27          0        0       0                  0
## 299496   SUMMARYOFMARCH29          0        0       0                  0
##        CROPDMGEXP
## 269504
## 269586
## 269610
## 269679
## 269784
## 269843
## 269854
## 269874
## 269959
## 270136
## 270171
## 270218
## 270227
## 270268
## 270275
## 270291
## 270334
## 270338
## 270433
## 270439
## 270515
## 270553
## 270571
## 270597
## 270640
## 270663
## 270672
## 270685
## 270691
## 270712
## 270782
## 270791
## 270808
## 270816
## 270828
## 270854
## 270872
## 270915
## 270941
## 270947
## 270980
## 270985
## 271019
## 271027
## 271031
```

```
## 271070
## 271081
## 271087
## 271096
## 271110
## 271125
## 271154
## 271210
## 271340
## 271349
## 271399
## 275076
## 275208
## 275431
## 275843
## 276017
## 276037
## 276486
## 276629
## 276705
## 276788
## 277073
## 277086
## 277385
## 277501
## 277677
## 278098
## 298058
## 299357
## 299447
## 299496
```

```
## length(stormdata$EVTYPE[which(stormdata$EVTYPE=="OTHER")])
## stormdata$REMARKS[which(stormdata$EVTYPE=="OTHER")]
stormdata[which(stormdata$EVTYPE=="OTHER"),match(c("EVTYPE", "FATALITIES","INJURIES","PROPDMG",
"PROPDMGEXP","CROPDMG","CROPDMGEXP"),colnames(stormdata))]
```

```
##        EVTYPE FATALITIES INJURIES PROPDMG PROPDMGEXP CROPDMG CROPDMGEXP
## 217959  OTHER          0        0     0.0              0.00
## 249470  OTHER          0        0    50.0          K   0.00
## 267121  OTHER          0        0     0.0              0.00
## 272928  OTHER          0        0     0.0              0.00
## 283221  OTHER          0        0     0.0              0.00
## 283270  OTHER          0        0     0.0              0.00
## 296061  OTHER          0        0     0.0              0.00
## 296122  OTHER          0        0     0.5          K   0.00
## 298603  OTHER          0        0     0.0             34.48          K
## 298604  OTHER          0        0     0.0             34.48          K
## 298605  OTHER          0        0     0.0             34.48          K
## 298606  OTHER          0        0     0.0             34.48          K
## 298607  OTHER          0        0     0.0             34.48          K
## 298608  OTHER          0        0     0.0             34.48          K
## 298609  OTHER          0        0     0.0             34.48          K
## 298610  OTHER          0        0     0.0             34.48          K
```

```
## 298611  OTHER          0        0     0.0                34.48          K
## 298612  OTHER          0        0     0.0                34.48          K
## 298613  OTHER          0        0     0.0                34.48          K
## 298614  OTHER          0        0     0.0                34.48          K
## 298615  OTHER          0        0     0.0                34.48          K
## 298616  OTHER          0        0     0.0                34.48          K
## 298617  OTHER          0        0     0.0                34.48          K
## 298618  OTHER          0        0     0.0                34.48          K
## 298619  OTHER          0        0     0.0                34.48          K
## 298620  OTHER          0        0     0.0                34.48          K
## 298621  OTHER          0        0     0.0                34.48          K
## 298622  OTHER          0        0     0.0                34.48          K
## 298623  OTHER          0        0     0.0                34.48          K
## 298624  OTHER          0        0     0.0                34.48          K
## 298625  OTHER          0        0     0.0                34.48          K
## 298626  OTHER          0        0     0.0                34.48          K
## 298627  OTHER          0        0     0.0                34.48          K
## 298628  OTHER          0        0     0.0                34.48          K
## 298629  OTHER          0        0     0.0                34.48          K
## 298630  OTHER          0        0     0.0                34.48          K
## 298631  OTHER          0        0     0.0                34.48          K
## 298632  OTHER          0        0     0.0                34.48          K
## 308653  OTHER          0        0     0.0                 0.00
## 312860  OTHER          0        0     0.0                 0.00
## 350419  OTHER          0        0     0.0                 0.00
## 350534  OTHER          0        0     0.0                 0.00
## 357396  OTHER          0        0     0.0                 0.00
## 357404  OTHER          0        0     0.0                 0.00
## 357405  OTHER          0        0     0.0                 0.00
## 357406  OTHER          0        0     0.0                 0.00
## 357719  OTHER          0        0     0.0                 0.00
## 378699  OTHER          0        0     0.0                 0.00
## 381907  OTHER          0        0     0.0                 0.00
## 398543  OTHER          0        0     0.0                 0.00
## 399112  OTHER          0        0     5.0           K     0.00
## 435359  OTHER          0        4     0.0                 0.00
```

The REMARKS variable offers some insights (can be un-commented out to make all them visible), typically of multiple events occurring at the same time. However, no harm or damage data are available for most event types named as "SUMMARY", except for no. 73 and 74 on the list, named as "BLIZZARDSUMMARY" and "SUMMARYOFMARCH2425", respectively:

[73] "The economic impact these 4 blizzards had on North Dakota were staggering. On the agricultural side alone, it is estimated that over 6 million was lost for buildings and machinery, 4.7 million in livestock deaths, 21.7 million for extra feed consumption, and $50,000 worth of dumped milk when transporters couldn't get to the farms. In addition, its estimated that $600,000 was spent by the Game and Fish Dept. to help farmers battle the deer that was eating their hay reserves. Also, its estimated thta the National Guard spent $800,000 in January to help with snow removal. Many communities spent up to 10 times their snow removal budget just in January alone, with the state itself spending an estimated additional $125,000 in salaries and operating expenses. Damage totals are still coming in as of this writing. The January of 1997 will be long remembered in the minds of many North Dakotans."

The event type will be categorised as "BLIZZARD". In line with the guidelines presented in section 2.6 of the "STORM DATA PREPARATION" source file, the costs of lost buildings/ machinery/ livestock/ feed/ transported goods will be entered as PROPDMG.

[74] "Severe thunderstorms moved across northern... central... and south-central Oklahoma during the evening of March 24th, lasting into the early morning hours of the 25th. The storms across northern Oklahoma produced hail as large as ping-pong balls at Vance Air Force Base and severe wind damage in several locations. Extensive wind damage occurred in Noble County in and around Morrison and Perry. Other significant damage occurred in Payne County in and north of Stillwater and in Garfield County west-northwest of Carrier. The thunderstorms over central and south-central Oklahoma generated numerous large hail reports. The largest hail was reported in McLoud in Pottawatomie County, where hail as large as golf balls fell. See individual Storm Data entries for further details and additional reports."

The event type will be categorised as "THUNDERSTORMWINDHAIL". The damage data is already populated in this case.

In turn, for event types named as "OTHER", certain damage and injuries data is available, and in those cases, event types will be categorised in line with REMARKS.

```
stormdata$PROPDMG[which(stormdata$EVTYPE=="BLIZZARDSUMMARY")] <- 6*(10^6)+
  4.7*(10^6)+21.7*(10^6)+50*(10^3)
stormdata$PROPDMGEXP[which(stormdata$EVTYPE=="BLIZZARDSUMMARY")] <- 1
stormdata$EVTYPE[which(stormdata$EVTYPE=="BLIZZARDSUMMARY")] <- "BLIZZARD"

stormdata$EVTYPE[which(stormdata$EVTYPE=="SUMMARYOFMARCH2425")] <- "THUNDERSTORMWINDHAIL"

stormdata$EVTYPE[which(stormdata$EVTYPE=="OTHER")] <- c("","AVALANCHEHEAVYSNOWFLOOD",
rep("",7), rep("HEAVYRAIN",29),rep("",12),rep("DUSTDEVIL",2))
```

Concurrent Events

The data preview indicates that multiple event types concur, e.g. Thunderstorm Winds and Hail, Flood and Landslide/ Mudslide. At this stage, it does not seem appropriate to just look at the dominant event - and which one is dominant? - as it may, or may not, have an impact on the results of the analysis. For example, concurrent events may cause more fatalities/injuries, or more damage.

To progress the analysis, variables EVTYPE1, EVTYPE2, EVTYPE3 will be introduced to map the original EVTYPE variable to maximum 3 concurrent events from the EVCAT list. FIRST, exactly matching event types will be populated to EVTYPE1:

```
stormdata$EVTYPE1 <- rep("",length(stormdata$EVTYPE))
stormdata$EVTYPE2 <- rep("",length(stormdata$EVTYPE))
stormdata$EVTYPE3 <- rep("",length(stormdata$EVTYPE))
stormdata$EVTYPE1[which(stormdata$EVTYPE %in% EVCAT)] <-
  stormdata$EVTYPE[which(stormdata$EVTYPE %in% EVCAT)]
```

The proportion of unmapped event types will now be checked:

```
unmapped <- round(length(stormdata$EVTYPE1[which(stormdata$EVTYPE1=="")])/
                    length(stormdata$EVTYPE1),4)*100
```

At this stage, 1.99 % of event types are unmapped to any specific category.

Now, some event types are followed by magnitude, e.g. "HAIL 200" or "HIGH WINDS 66" - they inflate the number of unique event types, but are easily mappable to taxonomy. The final mapping process will be performed 2 ways: First, the code goes through the EVCAT list, and for every element - checks if it can find its match in EVTYPE column, e.g. "HAIL" in EVCAT list should be easily matched to "HAIL 200" in EVTYPE column in this way, "SNOW" in EVCAT list should be mapped to "HEAVYSNOW" as well as

"LIGHTSNOW" in in EVTYPE column. The code only iterates through rows where "EVTYPE1" has not mapped to any event type before; Then, the operation is performed the other way round, so e.g. "FOG" in EVTYPE column gets mapped to "DENSEFOG" in the EVTYPE list.

Furthermore, each way, the code is attempting to find up to 3 matching events, to identify the concurrent ones.

```
d <- which(stormdata$EVTYPE1=="")
c <- charmatch("EVTYPE1",colnames(stormdata))
l <- list()

## go through all elements of EVCAT and find index which EVTYPE1 is empty,
## and EVCAT[i] is part of EVTYPE

for (i in 1:length(EVCAT)) l[[i]] <- d[(d %in% grep(EVCAT[i],stormdata$EVTYPE))]
for (j in d){
  ## go through all elements in the list, and add first 3 when found
  k <- 1;
  for (i in 1:length(l)){
    if (j %in% l[[i]]) {stormdata[j,c-1+k] <- EVCAT[i]; k <- k+1;}
    if (k>3) break
  }
}

## go through all rows where EVTYPE1 is still unmapped and
## find index which and EVCAT[i] is part of EVTYPE

for (i in which(stormdata$EVTYPE1=="")){
  ## where EVTYPE1 is still unmapped, check partial match
  x <- EVCAT[grep(stormdata$EVTYPE[i],EVCAT)]
  if (length(x)>0){
    for (j in 1:min(length(x),3))  stormdata[i,c-1+j] <- x[j]
  }
}
```

Concurrent events are saved on variable EVTYPEALL with separator "/":

```
stormdata$EVTYPEALL <- paste(stormdata$EVTYPE1, stormdata$EVTYPE2, stormdata$EVTYPE3, sep="/")
```

An example how the code works for concurrent events is illustrated well on the earlier "OTHER" EVTYPE entry, which was replaced by "AVALANCHEHEAVYSNOWFLOOD":

```
stormdata[which(stormdata$EVTYPE=="AVALANCHEHEAVYSNOWFLOOD"),]
```

```
##        STATE__          BGN_DATE    BGN_TIME TIME_ZONE COUNTY COUNTYNAME STATE
## 249470       2 2/3/1996 0:00:00 12:00:00 AM       AST     19     AKZ019    AK
##                         EVTYPE BGN_RANGE BGN_AZI BGN_LOCATI          END_DATE
## 249470 AVALANCHEHEAVYSNOWFLOOD         0                     2/10/1996 0:00:00
##           END_TIME COUNTY_END COUNTYENDN END_RANGE END_AZI END_LOCATI LENGTH
## 249470 11:59:00 PM          0         NA         0                          0
##        WIDTH  F MAG FATALITIES INJURIES PROPDMG PROPDMGEXP CROPDMG CROPDMGEXP
## 249470     0 NA   0          0        0      50          K       0
##        WFO       STATEOFFIC
```

```
## 249470 AFC ALASKA, Southern
##                                                                ZONENAMES LATITUDE
## 249470 HAINES BOROUGH AND LYNN CANAL - HAINES BOROUGH AND LYNN CANAL        0
##        LONGITUDE LATITUDE_E LONGITUDE_
## 249470         0          0          0
##
## 249470 After 3 months of drought, snows finally came...followed by avalanches and then flooding.  A
##        REFNUM   EVTYPE1 EVTYPE2   EVTYPE3                EVTYPEALL
## 249470 249429 AVALANCHE   FLOOD HEAVYSNOW AVALANCHE/FLOOD/HEAVYSNOW
```

The mapping operation helped reduce the unmapped event types significantly:

```
unmapped <- round(length(stormdata$EVTYPE1[which(stormdata$EVTYPE1=="")])/
                  length(stormdata$EVTYPE1),4)*100
uniq <- length(unique(stormdata$EVTYPE))
## sort(unique(stormdata$EVTYPE[which(stormdata$EVTYPE1=="")]))
```

After data processing, 0.09 % of event types are unmapped to any specific category, producing a total of 656 unique names, of which 60-odd are summary names (un-commenting the last line of the code shows all unique names of unmapped events). This is considered an acceptable proportion. It will be further demonstrated that the event types unmapped to any specific category only account for only a very small proportion of population harm and economic damage.

Analysis

This section contains some basic analysis of the impact of specific weather event types:
- Population Harm: Fatalities and Injuries, - Economic Damage: property and Crop Damage.

Population Harm

First, the impact on population harm will be analysed, i.e. Fatalities and Injuries. Additionally, HARM variable will be introduced as a sum of fatalities and injuries, denoting total population harm caused by a weather event.

```
stormdata$HARM <- as.numeric(stormdata$FATALITIES, na.rm=TRUE)+
  as.numeric(stormdata$INJURIES, na.rm=TRUE)
TH <- tapply(stormdata$HARM,stormdata$EVTYPEALL,sum,na.rm=TRUE)
TF <- tapply(stormdata$FATALITIES,stormdata$EVTYPEALL,sum,na.rm=TRUE)
TI <- tapply(stormdata$INJURIES,stormdata$EVTYPEALL,sum,na.rm=TRUE)
pophealthimpact <- cbind(as.data.frame(TH),as.data.frame(TF),as.data.frame(TI))
pophealthimpact[order(TH,decreasing=TRUE)[1:10],]
```

```
##                        TH   TF    TI
## TORNADO//           96997 5633 91364
## THUNDERSTORMWIND// 10120  707  9413
## EXTREMEHEAT//       8731 2001  6730
## FLOOD//             7388  514  6874
## LIGHTNING//         6049  817  5232
## HEAT//              3652 1154  2498
## FLASHFLOOD//        2755  978  1777
## ICESTORM//          2064   89  1975
## HIGHWIND//          1763  293  1470
## WILDFIRE//          1698   90  1608
```

```
##pophealthimpact[order(TF,decreasing=TRUE)[1:10],]
##pophealthimpact[order(TI,decreasing=TRUE)[1:10],]
```

The above table shows Top 10 weather events causing most population harm (Total Harm - TH variable). As shown in the table, Tornadoes prove to be most harmful events, both in terms of fatalities (Total Fatalities - TF) and injuries (Total Injuries - TI) caused, by an order of magnitude. However, going further down the list, Extremeheat and Heat are the next most harmful events in terms of fatalities, but it is Thunderstormwinds for injuries. Reordering the table (commented-out part of the code) allows for quick check of Top 10 most harmful events according to each variable.

To note, there is no significant number of fatalities/ injuries in the unmapped event set:

```
unmapped_fatalities <- round(sum(stormdata$FATALITIES[which(stormdata$EVTYPE1=="")],na.tm=TRUE)/
                               sum(stormdata$FATALITIES,na.tm=TRUE),4)*100
unmapped_injuries <- round(sum(stormdata$INJURIES[which(stormdata$EVTYPE1=="")],na.tm=TRUE)/
                             sum(stormdata$INJURIES,na.tm=TRUE),4)*100
stormdata$EVTYPE[which((stormdata$EVTYPE1=="") & (stormdata$FATALITIES>=5))]
```

```
## [1] "MARINEMISHAP"
```

```
stormdata$EVTYPE[which((stormdata$EVTYPE1=="") & (stormdata$INJURIES>=5))]
```

```
## [1] "MARINEMISHAP"
```

Only 0.38 % of all fatalities, and 0.02 % of all injuries are caused by an unmapped event, and so would be unaccounted for in this analysis. Only two such events (both related to sinking vessels) have more than 5 injuries or fatalities (6 in each case).

Economic Damage

In the dataset, the economic damage is expressed as USD amount, denoted by variables PROPDMG and CROPDMG for property and crop damage respectively, combined with exponential factors of 10, denoted by variables PROPDMGEXP and CROPDMGEXP, respectively. Again, there is some variety in how the exponential factors are defined:

```
unique(c(stormdata$PROPDMGEXP, stormdata$CROPDMGEXP))
```

```
##  [1] "K" "M" ""  "B" "m" "+" "0" "5" "6" "?" "4" "2" "3" "h" "7" "H" "-" "1" "8"
## [20] "k"
```

While “K”, “M”, “B” (upper- or lowercase) denote thousands/ millions/ billions, it is assumed that (i) “H” (again, upper- or lowercase) denotes hundreds, and (ii) across the dataset, numbers denote powers of 10; Whereas for other non-obvious characters, “?”, “+”, “-”, and ““, it is assumed that (iii) the exponential factor is equal to 1. REMARKS variable does not seem to offer much insight (case for”?” and property damage presented below as example, crop damage can be seen by un-commenting the subsequent portion of code).

```
length(stormdata$PROPDMG[which(stormdata$PROPDMGEXP=="?")])
```

```
## [1] 8
```

```
stormdata$PROPDMG[which(stormdata$PROPDMGEXP=="?")]
```

```
## [1] 0 0 0 0 0 0 0 0
```

```
stormdata$REMARKS[which(stormdata$PROPDMGEXP=="?")]
```

```
## [1] "Hail was again the main feature from these late night thunderstorms.  One report of tree damage
## [2] "  "
## [3] "  "
## [4] "Power lines blown down in Darlington reported by Highway Patrol. "
## [5] "  "
## [6] "  "
## [7] "  "
## [8] "Power lines and several trees were blown down. "
```

```
## length(stormdata$CROPDMG[which(stormdata$CROPDMGEXP=="?")])
## stormdata$CROPDMG[which(stormdata$CROPDMGEXP=="?")]
## stormdata$REMARKS[which(stormdata$CROPDMGEXP=="?")]
```

In the next part of the analysis:

- Exponential factors for damage are mapped to numeric variables,
- The function mapunit() makes a quick work of applying the correct numeric exponential factor to property and crop damage,
- The ultimate USD damage amounts are saved as variables PROPDMGCALC (for property damage), CROPDMGCALC (for crop damage), and ALLDMGCALC (for total damage).

```
dmgmap <- data.frame(unique(c(stormdata$PROPDMGEXP, stormdata$CROPDMGEXP)),
c(10^3, 10^6, 1, 10^9, 10^6, 1, 1, 10^5, 10^6, 1, 10^4, 10^2, 10^3, 10^2, 10^7, 10^2, 1, 1, 10^8, 10^3))

mapunit <- function(x,unitmap){
  z <- rep(1,length(x))
  for (i in 1:length(unitmap[,1])) {
    z[which(x==unitmap[i,1])] <- unitmap[i,2]
  }
  z
}

stormdata$PROPDMGCALC <-  stormdata$PROPDMG * mapunit(stormdata$PROPDMGEXP,dmgmap)
stormdata$CROPDMGCALC <-  stormdata$CROPDMG * mapunit(stormdata$CROPDMGEXP,dmgmap)
stormdata$ALLDMGCALC <- stormdata$PROPDMGCALC + stormdata$CROPDMGCALC
```

Finally, the economic damage caused by specific weather events can be analysed, in a similar manner as population harm:

```
TD <- tapply(stormdata$ALLDMGCALC,stormdata$EVTYPEALL,sum,na.rm=TRUE)
TP <- tapply(stormdata$PROPDMGCALC,stormdata$EVTYPEALL,sum,na.rm=TRUE)
TC <- tapply(stormdata$CROPDMGCALC,stormdata$EVTYPEALL,sum,na.rm=TRUE)
econdamage <- cbind(as.data.frame(TD),as.data.frame(TP),as.data.frame(TC))
econdamage[order(TD,decreasing=TRUE)[1:10],]
```

```
##                             TD           TP          TC
## FLOOD//             161060780427 150204839377 10855941050
## HURRICANE//          90762452810  85256335010  5506117800
## TORNADO//            57367113947  56952152427   414961520
## STORMSURGETIDE//     47967129000  47966274000      855000
## HAIL//               19024483136  15977545513  3046937623
## FLASHFLOOD//         18244541079  16823223979  1421317100
## DROUGHT//            15018672000   1046106000 13972566000
## THUNDERSTORMWIND//   12340499514  11133695776  1206803738
## ICESTORM//            8967041360   3944927860  5022113500
## WILDFIRE//            8904910130   8501628500   403281630
```

```
##econdamage[order(TP,decreasing=TRUE)[1:10],]
##econdamage[order(TC,decreasing=TRUE)[1:10],]
```

The above table shows Top 10 weather events causing most economic damage (Total Damage - TD variable). As shown in the table, Floods prove to be most harmful events in terms of total damage and property damage (Total Property - TP), but Droughts top the list for crop damage (Total Crop - TC). Further down the list, some weather event types are common - with Flood, Flashflood, Hurricane and Hail making Top 7 for both property and crop damage - while some are specific, e.g. Stormsurgetide/ Tornado for property, and Drought/ Icestorm for crop. Reordering the table (commented-out part of the code) allows for quick check of Top 10 most harmful events according to each variable.

Again, to note, there are no significant damage amounts in the unmapped event set. The commented-out portion of the code below shows all unaccounted damage above USD 10k.

```
unmapped_propdmg <- round(sum(stormdata$PROPDMGCALC[which(stormdata$EVTYPE1=="")],na.tm=TRUE)/
                          sum(stormdata$PROPDMGCALC,na.tm=TRUE),4)*100
unmapped_cropdmg<- round(sum(stormdata$CROPDMGCALC[which(stormdata$EVTYPE1=="")],na.tm=TRUE)/
                         sum(stormdata$CROPDMGCALC,na.tm=TRUE),4)*100
#length(stormdata$EVTYPE[which((stormdata$EVTYPE1=="") & (stormdata$PROPDMGCALC >=10^4))])
#unique(stormdata$EVTYPE[which((stormdata$EVTYPE1=="") & (stormdata$PROPDMGCALC >=10^4))])
#length(stormdata$EVTYPE[which((stormdata$EVTYPE1=="") & (stormdata$CROPDMGCALC >=10^4))])
#unique(stormdata$EVTYPE[which((stormdata$EVTYPE1=="") & (stormdata$CROPDMGCALC >=10^4))])
#stormdata[which((stormdata$EVTYPE1=="") & (stormdata$PROPDMGCALC >10^4)),
#which(colnames(stormdata) %in% c("EVTYPE", #"PROPDMGCALC", "CROPDMGCALC"))]
#stormdata[which((stormdata$EVTYPE1=="") & (stormdata$CROPDMGCALC >10^4)),
#which(colnames(stormdata) %in% c("EVTYPE", #"PROPDMGCALC", "CROPDMGCALC"))]
```

Only 0 % of all property damage, and 0 % of all crop damage are caused by an unmapped event, and so would be unaccounted for in this analysis. Most of the unaccounted damage is property damage caused by Lightsnow. What this point illustrates, however, is that if the analysis were to focus specifically on winter events, or a state where snow (light or heavy or any other) is an important weather factor, it would make sense to account for such events, and perhaps refine the mappings as well.

Results

It is now time to answer the key questions, with some visualisation of result:

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

Answer: Tornado, Thunderstorm (TSTM) Wind, Extreme Heat, Flood and Lightning. In the history of recorded events, Tornado is by far the most harmful event to population, having caused over 5,500

fatalities and over 90,000 injuries (nearly 100,000 total). For the remaining Top 5 events, the total number is within 6,000 to 10,000 range, consisting primarily of injuries. To note, Extreme Heat stands out as an event type leading to a large number of fatalities, with the total of just over 2,000 (coming second after Tornado). Heat has also cuased over 1,000 fatalities, even though it comes outside Top 5 of total harm.

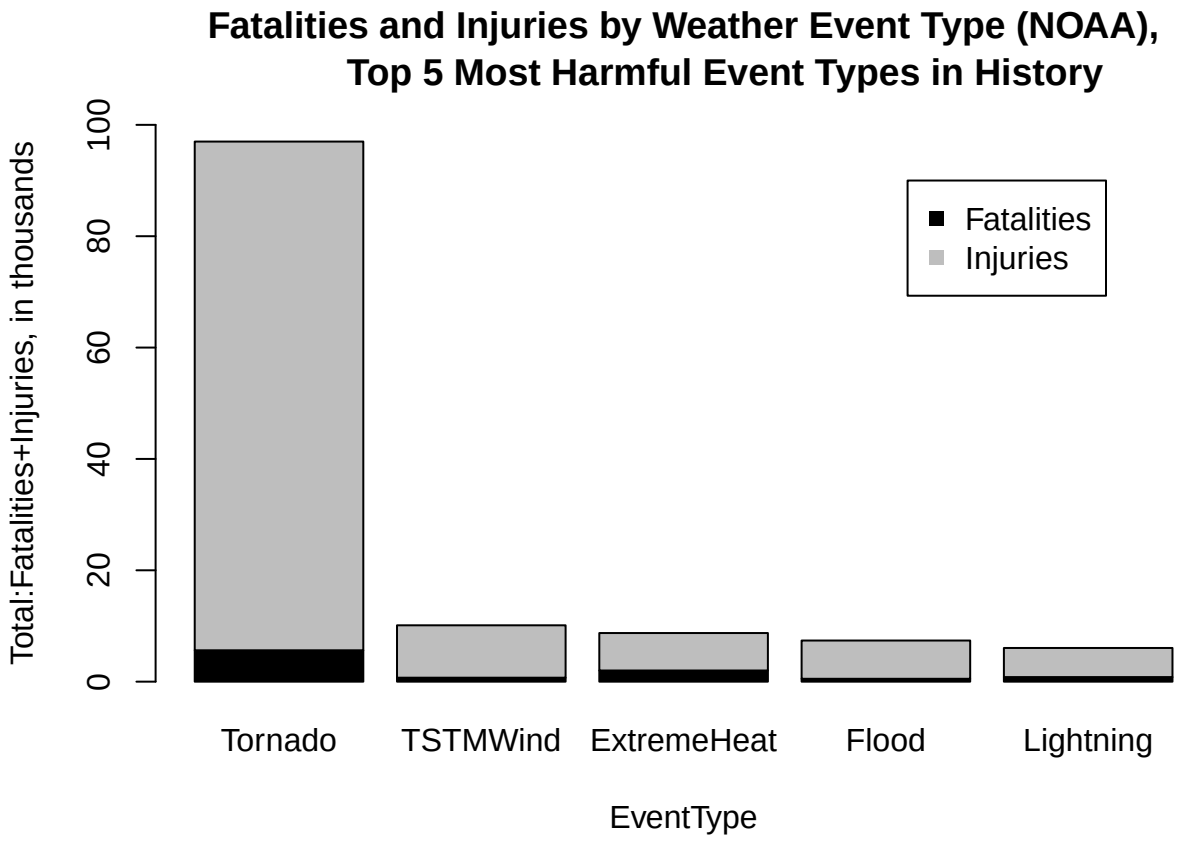

Figure 2: Fatalities and Injuries by Weather Event Type (NOAA).

2. Across the United States, which types of events have the greatest economic consequences?

Answer: Flood, Hurricane, Tornado, Stormsurgetide, and Hail. In the history of recorded events, Flood has caused over 150 billions USD in damage. For Hurricane, the number is just over 90 billions USD, while for for the other Top 5 events the numbers range between 19 and 58 billions USD. The damage has been predominantly to property. The single event type responsible for the most crop damage is Drought, with just under 14 billions USD in crop damage (outside Top 5 for total damage).

A interesting observation is that concurrent events do not stand out as the most harmful - either in terms of population harm or economic damage. In this analysis, "concurrent" means event types of different categories reflected in the respective event entries, such as in the "AVALANCHEHEAVYSNOWFLOOD" example (i.e. where EVTYPE2 and possibly EVTEYPE3 entries are non-empty). Given the variety across event names, which is a sign that some flexibility is needed in the way that the events are being named and categorised, further analysis would be required to investigate this point in more detail.

Among the singular (i.e. not concurrent) type events, Tornado (most harmful event, Top 5 in terms of damage) and Flood (most damaging event, Top 5 in terms of population harm), are the two events featuring in both Top 5 lists. Again, by looking at the event type names alone, there is no evidence that these two event types coincide - unless Thunderstorm Winds account for at least some of the concurring Tornado and Flood/ Flash Flood events. Such event (known as TORFF) present a unique weather response challenge,

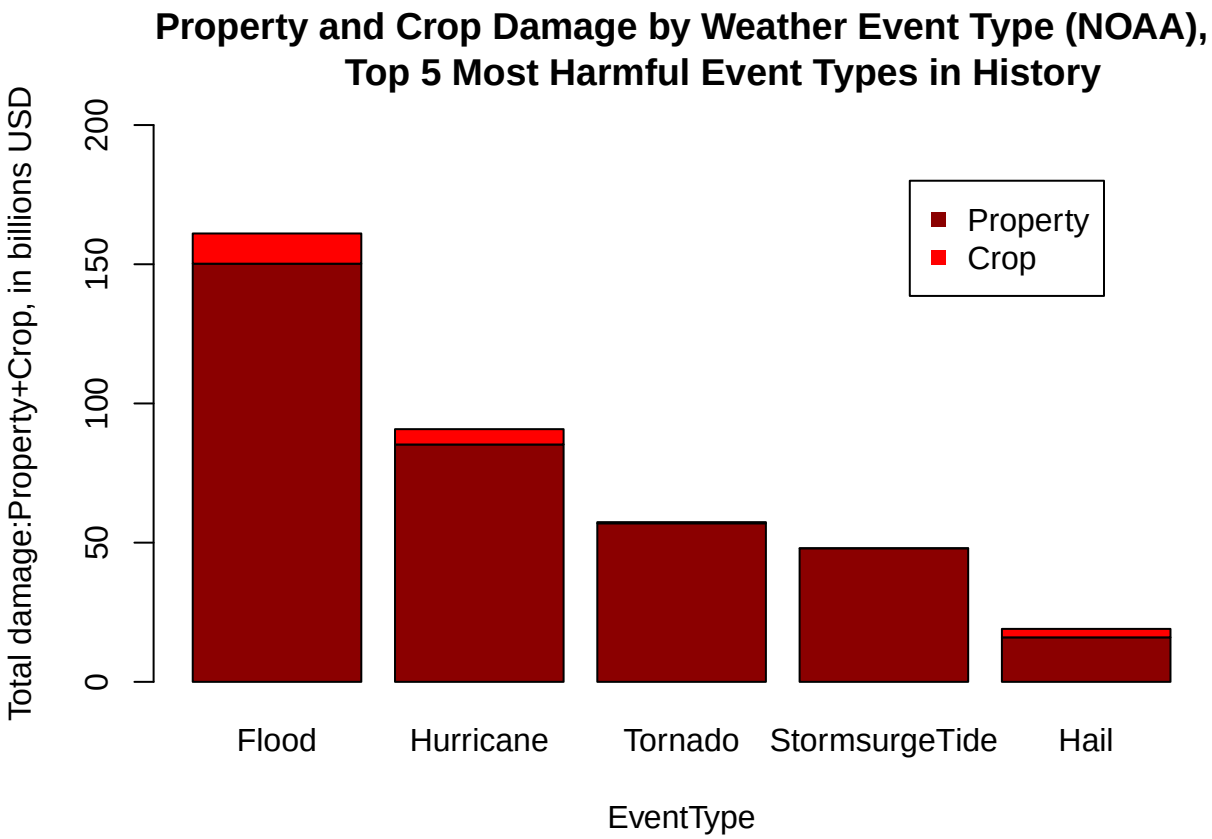

Figure 3: Property and Crop Damage by Weather Event Type (NOAA).

please look at this article for a more detailed description: https://www.washingtonpost.com/weather/2022/05/04/tornado-flood-warning-overlap/ .

A short quote: “Thunderstorms that produce simultaneous tornadoes and flash flooding, known as “dual hazard” or “TORFF” events (TORFF is short for tornado and flash flooding) to meteorologists, have long posed a dilemma: When flash flooding threatens, the worst place to be is below ground; when tornadoes strike, high ground is incredibly dangerous. In the past two decades, thousands of such concurrent events have taken place across the United States, leaving many that are in the path of destruction uncertain on what they should do. While the Weather Service is improving their communication about compound hazards, researchers say individuals should respond to the hazard most pressing at the time and be prepared to quickly move locations if necessary.”

The article is from 2021, while the data set only reaches up till 2011, so perhaps this is a relatively recent trend.

Concluding Remarks

To summarise, the above analysis identifies those weather event types, which cause the most population harm - fatalities and injuries, and the most economic damage - property and crop damage. It is clear that weather events contribute to significant population harm - tens of thousands of fatalities and injuries over the years, as well as to significant economic damage - totalling hundreds of billions USD over the years. Different types of weather events are the most harmful to population vs. most economically damaging - except Tornadoes and Floods, featuring in Top 5 harmful events for both categories.

The analysis was performed based on aggregated data (fatalities and injuries, resp. property and crop damage) across the United States, and throughout the history of recorded events, without break-downs e.g. by state, or year, or other factors which may be significant for a more detailed analysis. To note, the available dataset only stores information up till 2011, which would limit the analysis of more recent trends (such as the analysis of concurring TORFF events).

An important point to bear in mind, is that there is a great variety in naming weather event types, and the analysis is sensitive to how the events in the dataset are mapped to the NOAA taxonomy. Introduction of a closed event list, with an option to select multiple values, would help introduce consistent naming and make future analysis much easier. More detail can always be provided as REMARKS. More detailed review of REMARKS and potentially other descriptive variables using ML-supported technology could help determine further patterns, especially among concurrent events.

The entire R code used for this analysis is inlcuded in this report, to make it reproducible. Hope you enjoyed reading!