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0.1 Introduction

In this study we have analysed the NOAA Storm Database in order to determine what are the worst natural catastrophic events, both in terms of public health and in economic impact.

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

The database currently contains data from January 1950 to January 2017, as entered by NOAA's National Weather Service (NWS).

The database can be found on:

<https://www.ncdc.noaa.gov/stormevents/ftp.jsp>

RPubs version, with fewer plots, for Coursera: <http://rpubs.com/erickfis/noaa>

0.2 Objective

The goal of this study is to answer the questions:

1. Across the United States, which types of events were the most harmful with respect to population health ever recorded in a single occurrence?
2. Which types of events caused most harm to population health along all those years?
3. Which types of events had the greatest economic consequences in a single occurrence?
4. Which types of events had the greatest economic consequences along all those years?
5. Which were the places that were subject to the greatest losses, both in terms of human health and economic losses.

0.3 Methods

To answer each one of those questions, we did a very simple **descriptive analysis** of data.

We used R tools to filter, sort and combine data, so we could get the total sum of fatalities, injuries and economic losses.

0.4 Data Processing

In order to answer our questions, the original database needed to be treated from its raw form to a more useful format.

The necessary transformations were:

- sanitized var names
- evaluated duration of events
- evaluated damages values according to multipliers provided
- sanitized and grouped similar events: strong snow, heavy snow and light snow all became just “snow”
- sanitized county names

This database has 902297 observations. Each observation corresponds to an event occurrence.

To determine the most harmful events to human health, we checked the variables related to human health, which are “fatalities” and “injuries”.

To determine the most harmful events to economy, we checked the variables related to economic measures, from “propdmg” through “cropldmgexp”.

Also, in order to analyse various occurrences of the same event, we measured the duration of the event, its magnitude and where the event occurred (state and county name).

This is a really big database whose data has been being registered by a lot of different people since 1950. Thus, as expected, there are variations on how people registered events. For example, the string “snow” was used to register a lot of events. They are the same type of event, but count as different:

This is why we decided to filter those events: we grouped them by its common strings.

0.5 Human health: the most harmful events

We have determined what events did more harm to human health.

There were occurrences that caused zero fatalities but a lot of injuries. The inverse is also true, so we did a separate analysis to fatal and non-fatal events.

0.5.1 Fatal Occurrences

Most fatal in a single occurrence

Most fatal in a single occurrence

In order to determine what were the most fatal events in a single occurrence, we need to see how fatalities are distributed along the occurrences.

```
## 99.1% 99.2% 99.3% 99.4% 99.5% 99.6% 99.7% 99.8% 99.9% 100.0%
##      0      0      1      1      1      1      1      2      3     583
```

Looking at this distribution, we can infer that the vast majority of those occurrences were not fatal at all: **99.2% occurrences didn't caused any fatalities.**

On the other hand, fatal occurrences had to have at least 1 fatality.

Now, among the fatal occurrences, we are interested in the ones whose fatalities are beyond the confidence interval, ie. above 99% of the most common values.

```
## 99.9%
```

```
## 74.027
```

Looking at this distribution, we can infer that **99.8% of the fatal occurrences caused up to 74.027 fattalities.**

Distribution plots

In this study, we looked on the 1% deadliest occurrences.

Tabela 1: Worst fatal occurrences

rank	event	mag	day	duration	state	countyname	fatalities	mean	m
1	HEAT	0	1995-07-12	0S	IL	ILZ003	583	2.171638	
2	TORNADO	0	2011-05-22	0S	MO	JASPER	158	2.171638	
3	TORNADO	0	1953-06-08	NA	MI	GENESEE	116	2.171638	
4	TORNADO	0	1953-05-11	NA	TX	MCLENNAN	114	2.171638	
5	HEAT	0	1999-07-28	0S	IL	ILZ005	99	2.171638	
6	TORNADO	0	1953-06-09	NA	MA	WORCESTER	90	2.171638	
7	TORNADO	0	1955-05-25	NA	KS	COWLEY	75	2.171638	

The single most fatal event was a **HEAT, that occurred in IL, ILZ003, on 1995-07-12, killing 583 people.**

However, if we compare this single awful event to the mean of fatalities caused, we see that this is very unlikely to happen.

Most fatal in all time

Most fatal in all time

Notice that are several occurrences of the same type of event along the time.

Therefore, in order to know which is the worst type of event along all the years, we summed up the fatalities caused by each one of occurrences of this events.

Notice that we are interested only in the worst of them, ie, the ones which are above the mean.

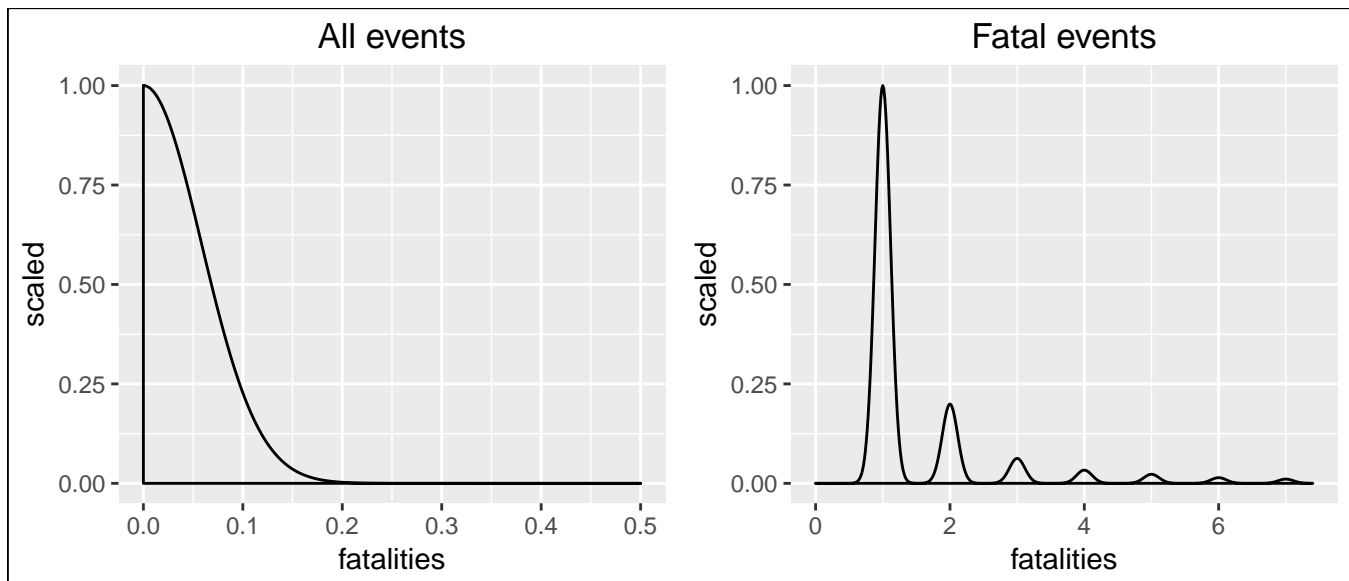


Figure 1: Population distribution for fatalities / occurrences

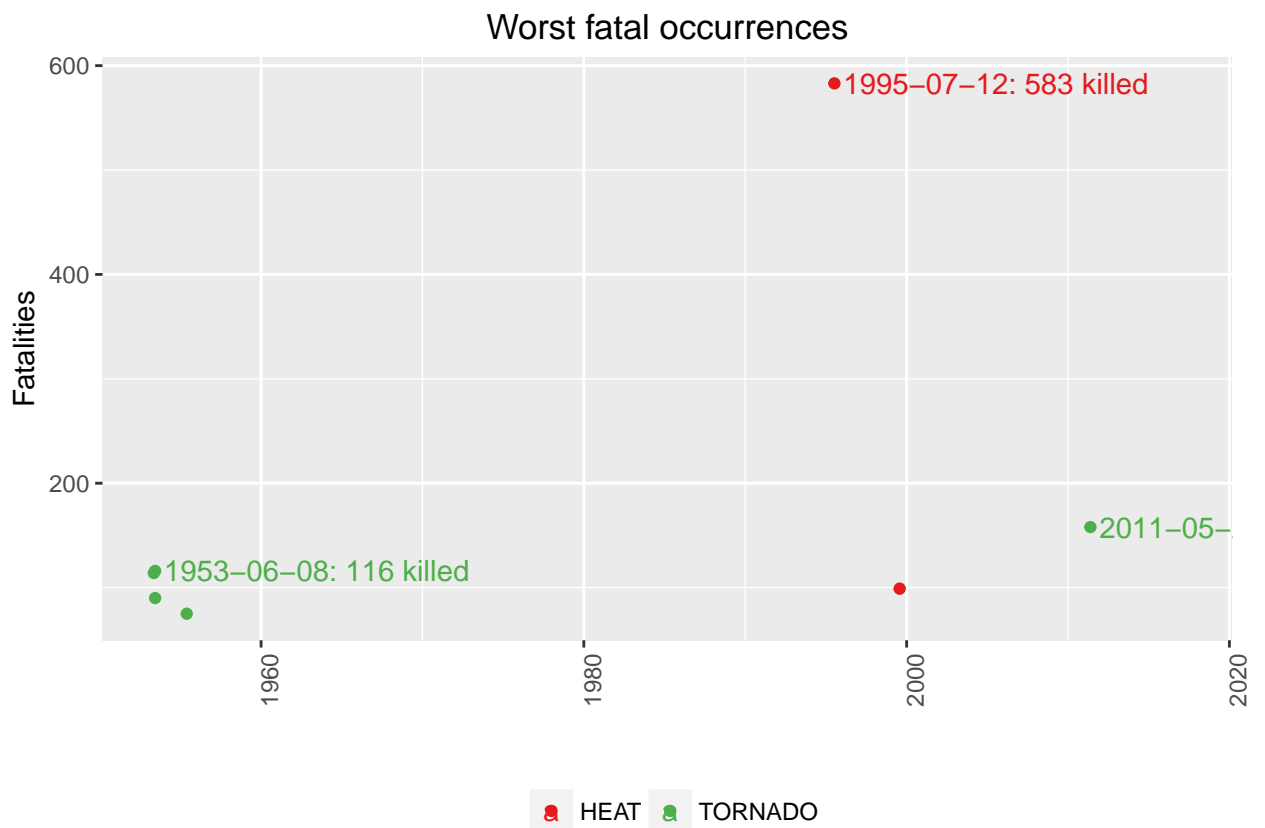


Figure 2: Worst fatal occurrences

Tabela 2: Total fatalities by event

rank	event	total	mean	median
1	TORNADO	5636	398.5526	38.5
2	HEAT	3149	398.5526	38.5
3	FLOOD	1553	398.5526	38.5
4	WIND	1451	398.5526	38.5
5	LIGHTNING	816	398.5526	38.5

The most fatal event along the time is the **TORNADO**. It has killed **5636** people until now.

Least fatal events

Just for curiosity, these are the less fatal among the fatal events:

Tabela 3: Least fatal events

rank	event	total
38	BLACK ICE	1
37	FROST	1
36	HIGH SWELLS	1
35	WINTRY MIX	1
34	DUST DEVIL	2
33	SLEET	2
32	HIGH WATER	3
31	WATERSPOUT	3
30	HIGH SEAS	5
29	ICY ROADS	5

0.5.2 Injuring Occurrences

Most injuring in a single occurrence

Most injuring in a single occurrence

In order to determine what were the most injuring events in a single occurrence, we need to see how injuries are distributed along the occurrences.

##	97.7%	97.9%	98.1%	98.3%	98.5%	98.7%	98.9%	99.1%	99.3%	99.5%	99.7%	99.9%
##	0	0	1	1	1	1	1	2	3	4	8	25

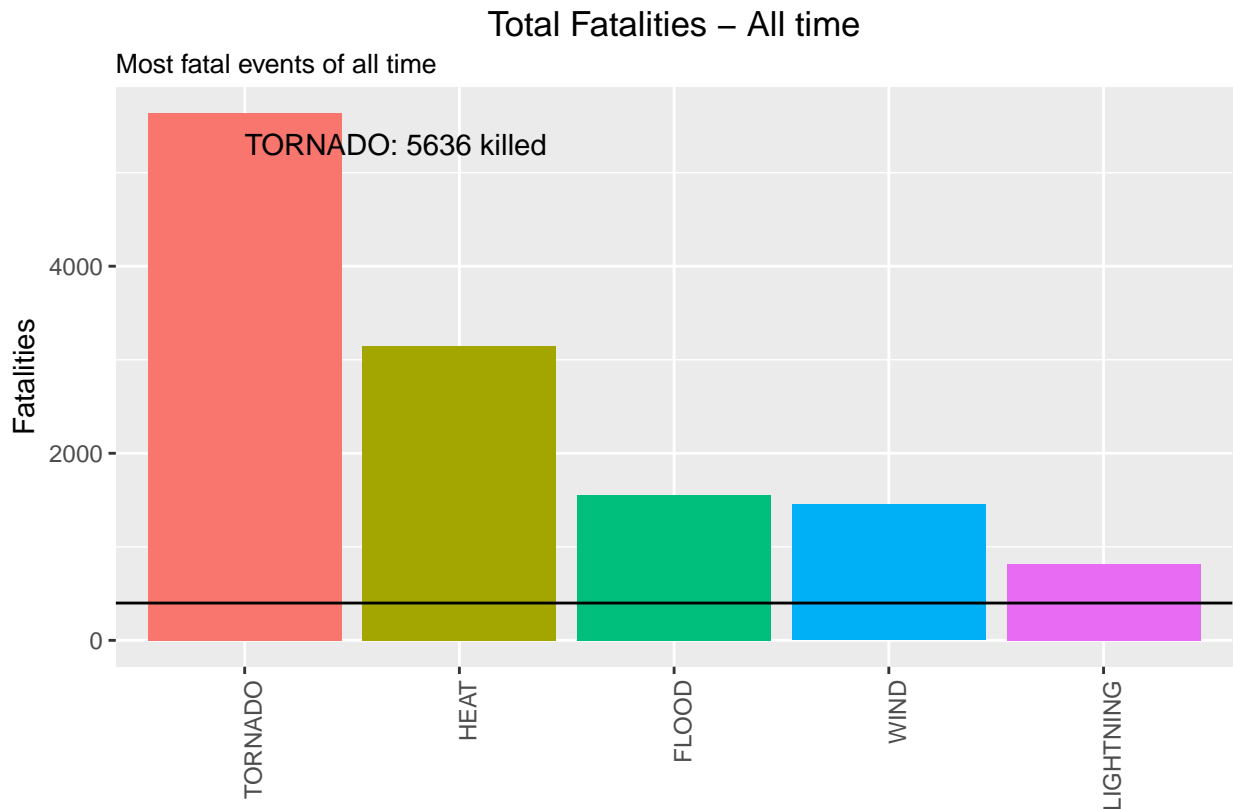


Figura 3: Total fatalities by event

Looking at this distribution, we can infer that the vast majority of those occurrences were not injuring at all: **97.9% occurrences didn't caused any injuries**

On the other hand, injuring occurrences had to have at least 1 injury.

Now, among the injuring occurrences, we are interested in the ones whose harm is beyond the confidence interval, ie. above 99% of the most common values.

99.9%

500

Looking at this distribution, we can infer that **99.8% of the injuring occurrences caused up to 500 injuries**.

Distribution plots

In this study, we looked on the 1% most injuring occurrences.

Tabela 4: Worst injuring occurrences

rank	event	mag	day	duration	state	countyname	injuries	mean	r
1	TORNADO	0	1979-04-10	NA	TX	WICHITA	1700	7.982731	
2	STORM	0	1994-02-08	0S	OH	OHZ42	1568	7.982731	
3	TORNADO	0	1953-06-09	NA	MA	WORCESTER	1228	7.982731	
4	TORNADO	0	1974-04-03	NA	OH	GREENE	1150	7.982731	

rank	event	mag	day	duration	state	countyname	injuries	mean	r
5	TORNADO	0	2011-05-22	0S	MO	JASPER	1150	7.982731	
6	FLOOD	0	1998-10-17	0S	TX	COMAL	800	7.982731	
7	TORNADO	0	2011-04-27	0S	AL	TUSCALOOS	800	7.982731	
8	TORNADO	0	1953-06-08	NA	MI	GENESEE	785	7.982731	
9	HURRICANE	0	2004-08-13	0S	FL	FLZ055	780	7.982731	
10	FLOOD	0	1998-10-17	0S	TX	TXZ206	750	7.982731	
11	TORNADO	0	2011-04-27	0S	AL	JEFFERSON	700	7.982731	
12	FLOOD	0	1998-10-17	0S	TX	BEXAR	600	7.982731	
13	TORNADO	0	1953-05-11	NA	TX	MCLENNAN	597	7.982731	
14	TORNADO	0	1965-04-11	NA	IN	HOWARD	560	7.982731	
15	FLOOD	0	1998-10-17	0S	TX	TXZ205	550	7.982731	
16	HEAT	0	2007-08-04	0S	MO	MOZ061	519	7.982731	
17	TORNADO	0	1966-03-03	NA	MS	HINDS	504	7.982731	

The single most injuring event was a **TORNADO, that occurred in TX, WICHITA, on 1979-04-10, injuring 1700 people.**

However, if we compare this single awful event to the mean of injuries caused, we see that this is very unlikely to happen.

Most injuring in all time

Most injuring in all time

Notice that are several occurrences of the same type of event along the time.

Therefore, in order to know which is the worst type of event along all the years, we summed up the injuries caused by each one of occurrences of this events.

Notice that we are interested only in the worst of them, ie, the ones which are above the mean.

Tabela 5: Total injuries by event

rank	event	total	mean	median
1	TORNADO	91407	4015.086	232
2	WIND	11497	4015.086	232
3	HEAT	9243	4015.086	232
4	FLOOD	8683	4015.086	232
5	LIGHTNING	5230	4015.086	232

The most injuring event along the time is the **TORNADO. It has injured 91407**

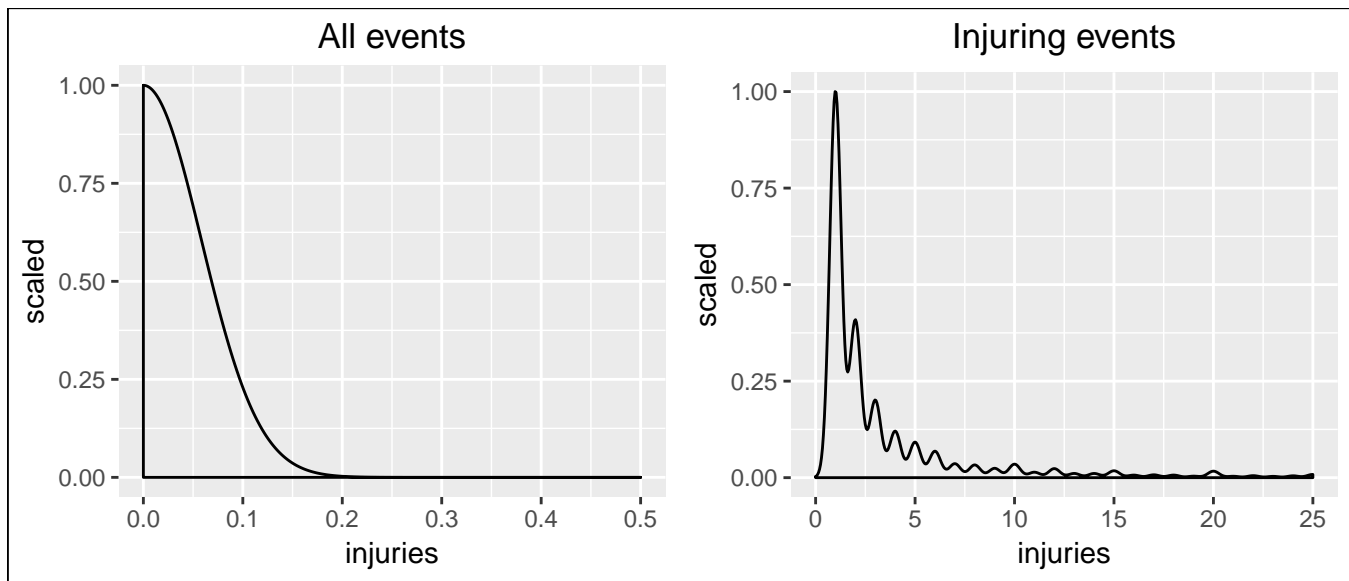


Figura 4: Population distribution for Injuries / occurrences

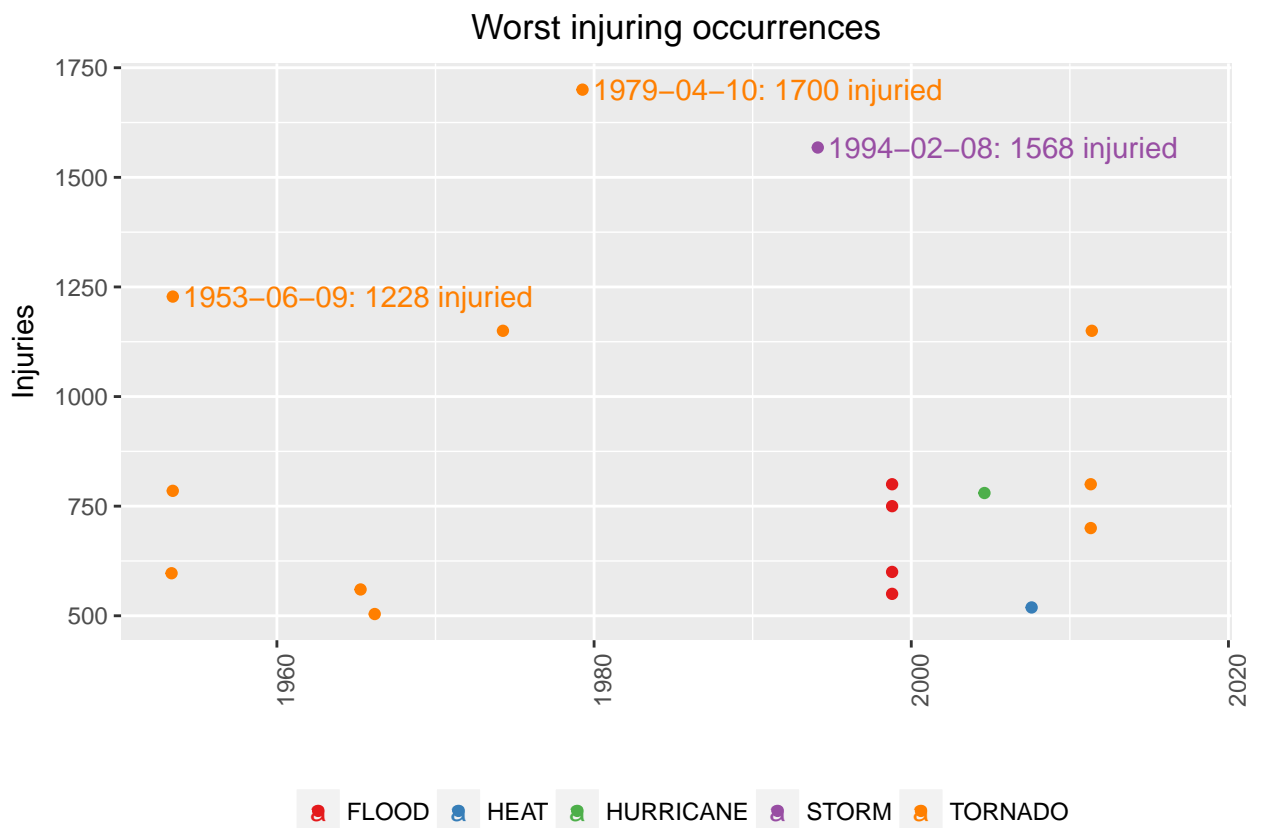


Figura 5: Worst injuring occurrences

people until now.

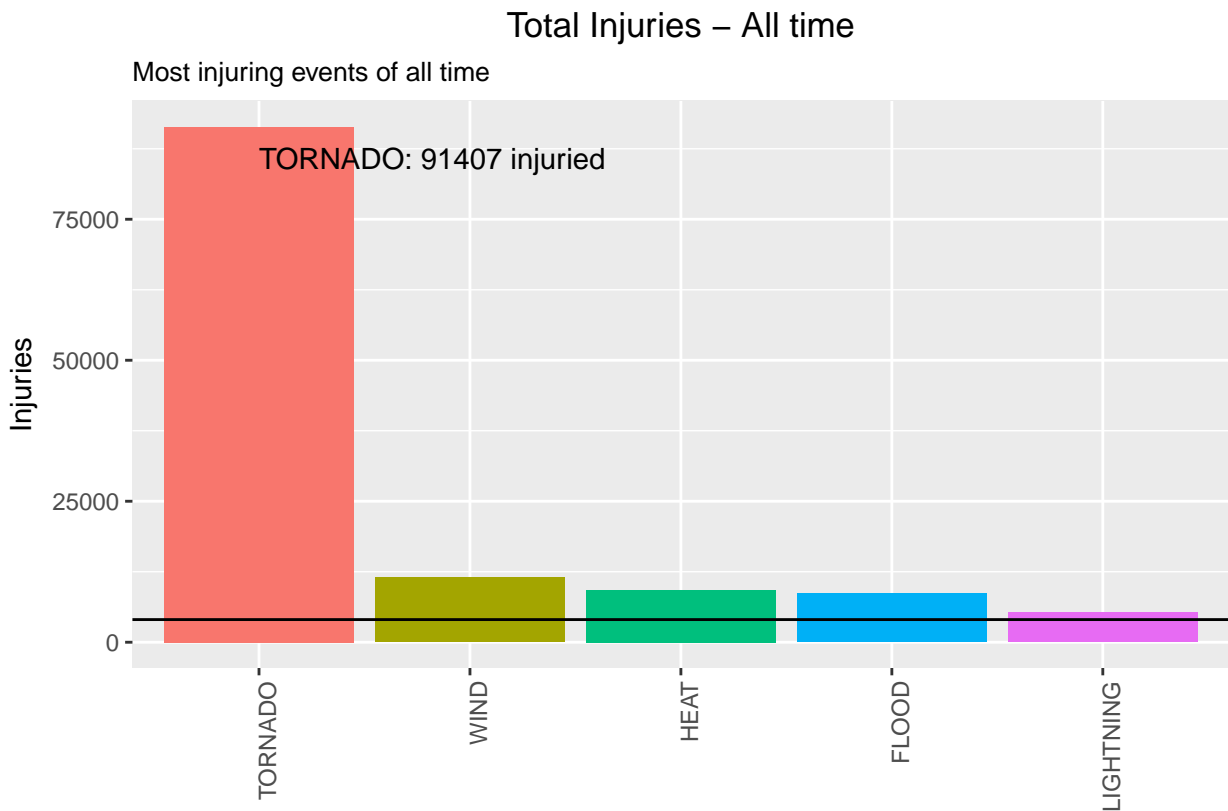


Figura 6: Total Injuries by event

Least injuring events

Just for curiosity, lets show now what are the less injuring among the injuring events:

Tabela 6: Least injuring events

rank	event	total
35	FROST	3
34	FUNNEL	3
33	TIDE	5
32	TYPHOON	5
31	HIGH SEAS	8
30	OTHER	21
29	BLACK ICE	24
28	WATERSPOUT	29
27	ICY ROADS	31
26	DROUGHT	33

0.6 Economy: the the most harmful events

We have determined what events did more harm to economy, both in terms of property and crops damage.

There were events that causes zero property damage but a lot of crop damage. The inverse is also true, so we did a separate analysis to property VS crop damaging events.

0.6.1 Property losses

Most Property Damaging event in a single occurrence

In order to determine what were the most property damaging events in a single occurrence, we need to see how damages are distributed along the occurrences.

99.9%

250000000

Looking at this distribution, we can infer that 99.8% of the occurrences caused less than **\$25,000,000 in losses**.

On the other hand, damaging occurrences had to have damages above zero.

Now, among the damaging occurrences, we are interested in the ones whose damages are above 99.8% of the most common values.

99.9%

120000000

Looking at this distribution, we can infer that **99.8% of the damaging occurrences caused up to \$120,000,000 in losses**.

Distribution plots

In this study, we looked on the 1% most harmful occurrences.

Tabela 7: Worst property damaging occurrences, mean = \$1,790,432 and median = \$10,000

rank	event	mag	day	duration	state	countyname	value
1	FLOOD	0	2006-01-01	0S	CA	NAPA	\$115,000,000,000
2	STORM	0	2005-08-29	0S	LA	LAZ040	\$31,300,000,000
3	HURRICANE	0	2005-08-28	0S	LA	LAZ034	\$16,930,000,000
4	STORM	0	2005-08-29	0S	MS	MSZ080	\$11,260,000,000
5	HURRICANE	0	2005-10-24	0S	FL	FLZ068	\$10,000,000,000
6	HURRICANE	0	2005-08-28	0S	MS	MSZ068	\$7,350,000,000
7	HURRICANE	0	2005-08-29	0S	MS	MSZ018	\$5,880,000,000
8	HURRICANE	0	2004-08-13	0S	FL	FLZ055	\$5,420,000,000

rank	event	mag	day	duration	state	countname	value
9	STORM	0	2001-06-05	0S	TX	TXZ163	\$5,150,000,000
10	WINTER	0	1993-03-12	0S	AL	ALZ001	\$5,000,000,000
11	FLOOD	0	1993-08-31	NA	IL	ADAMS	\$5,000,000,000
12	HURRICANE	0	2004-09-04	0S	FL	FLZ041	\$4,830,000,000
13	HURRICANE	0	2004-09-13	0S	FL	FLZ001	\$4,000,000,000
14	HURRICANE	0	2005-09-23	0S	LA	LAZ027	\$4,000,000,000
15	TIDE	0	2008-09-12	0S	TX	TXZ213	\$4,000,000,000
16	FLOOD	0	1997-04-18	0S	ND	NDZ027	\$3,000,000,000
17	HURRICANE	0	1999-09-15	0S	NC	NCZ007	\$3,000,000,000
18	TORNADO	0	2011-05-22	0S	MO	JASPER	\$2,800,000,000
19	RAIN	0	1995-05-08	0S	LA	LAFOURCHE	\$2,500,000,000
20	HURRICANE	0	2004-09-13	0S	AL	ALZ051	\$2,500,000,000

The single most economic damaging event to properties was a **FLOOD**, that occurred in CA, NAPA, on 2006-01-01, causing U\$ \$115,000,000,000 in losses.

Most Property Damaging event in all time

Most Property Damaging event in all time

Notice that are several occurrences of the same type of event along the time.

Therefore, in order to know which is the worst type of event along all the years, we summed up the losses caused by each one of occurrences of this events.

Notice that we are interested only in the worst of them, ie, the ones which are above the mean.

Tabela 8: Total losses by event

rank	event	total	mean	median
1	FLOOD	\$168,258,894,484	\$9,309,236,278	\$6,537,750
2	HURRICANE	\$84,656,180,010	\$9,309,236,278	\$6,537,750
3	TORNADO	\$57,003,317,876	\$9,309,236,278	\$6,537,750
4	STORM	\$56,197,366,960	\$9,309,236,278	\$6,537,750
5	WIND	\$17,951,214,274	\$9,309,236,278	\$6,537,750
6	HAIL	\$15,977,048,513	\$9,309,236,278	\$6,537,750

The most property damaging event along the time is the **FLOOD**. It has caused \$168,258,894,484 in losses.

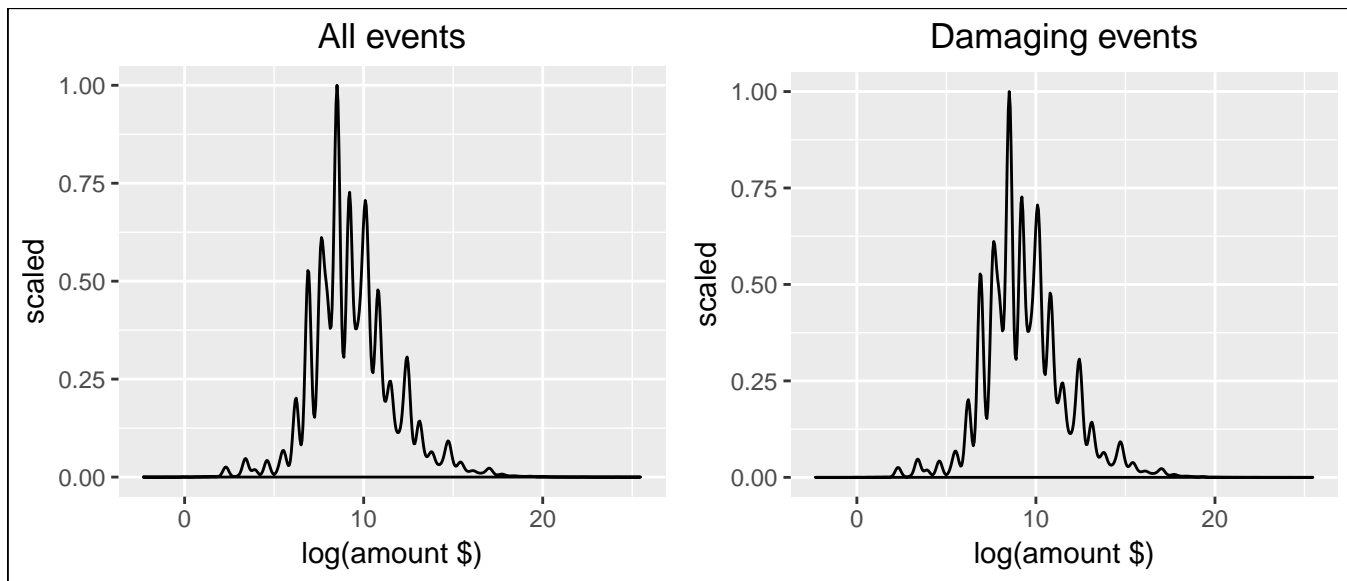


Figura 7: Population distribution for losses / occurrences

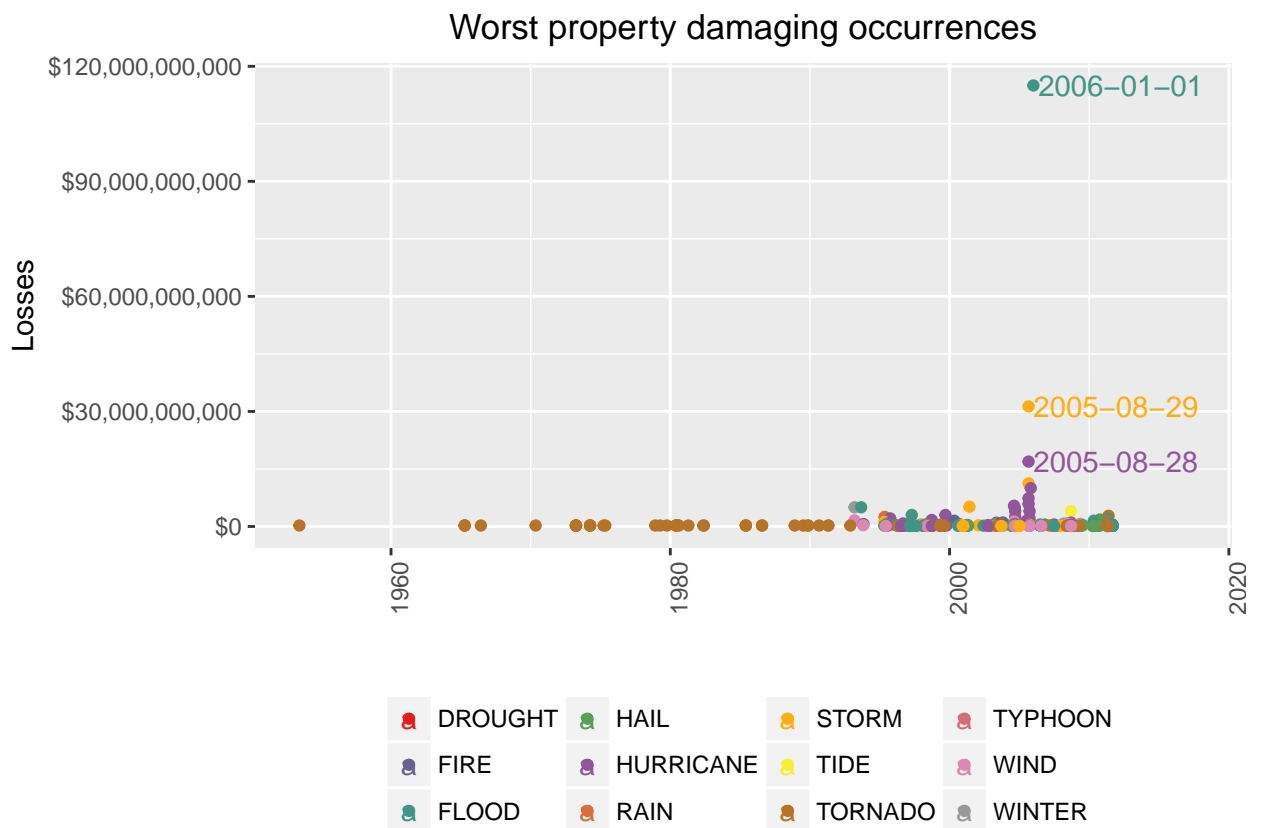


Figura 8: Worst property damaging occurrences

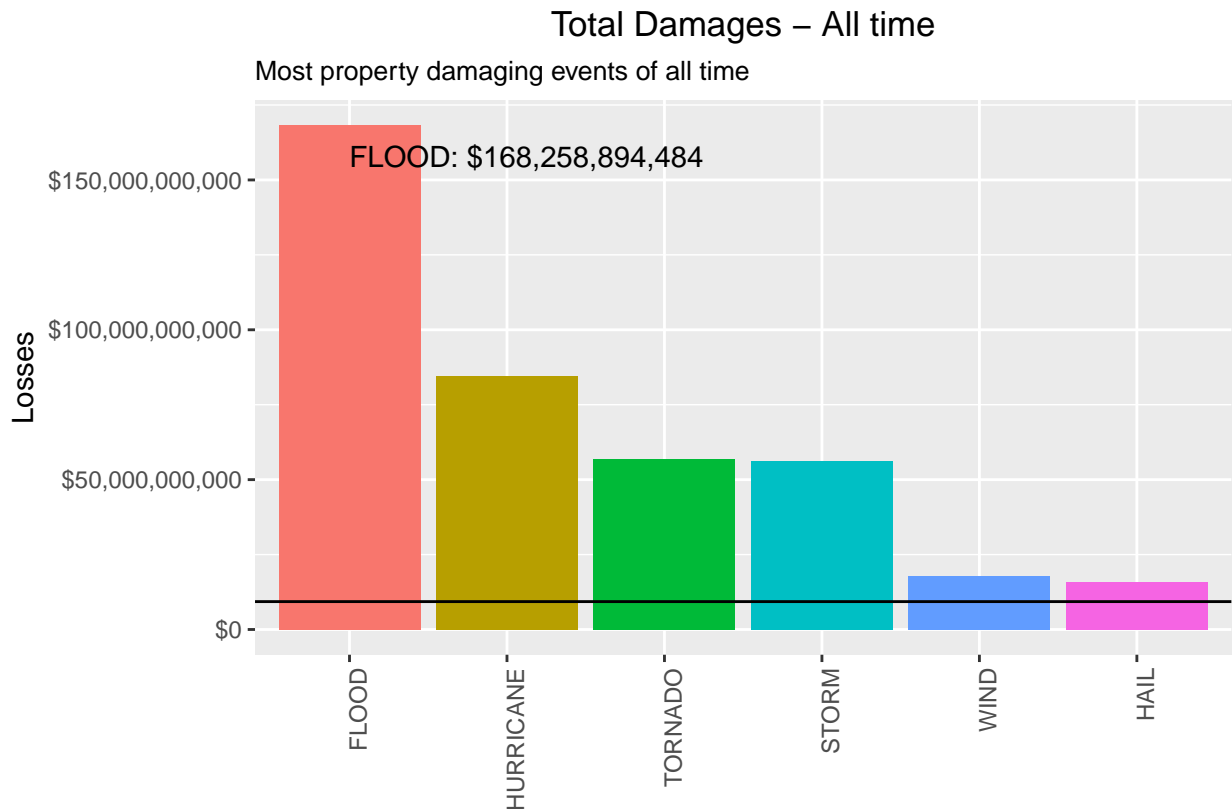


Figura 9: Total Property Damages by event

Least property damaging events

Just for curiosity, these are the less damaging events:

Tabela 9: Least property damaging events

rank	event	total
46	RIP CURRENT	\$1,000
45	HIGH SWELLS	\$5,000
44	URBAN/SMALL STREAM	\$5,000
43	WINTRY MIX	\$12,500
42	FROST	\$15,000
41	HIGH SEAS	\$15,500
40	WET MICROBURST	\$35,000
39	MICROBURST	\$80,000
38	DENSE SMOKE	\$100,000
37	GUSTNADO	\$102,050

0.6.2 Crop losses

Most Crop Damaging event in a single occurrence

In order to determine what were the most crop damaging events in a single occurrence, we need to see how damages are distributed along the occurrences.

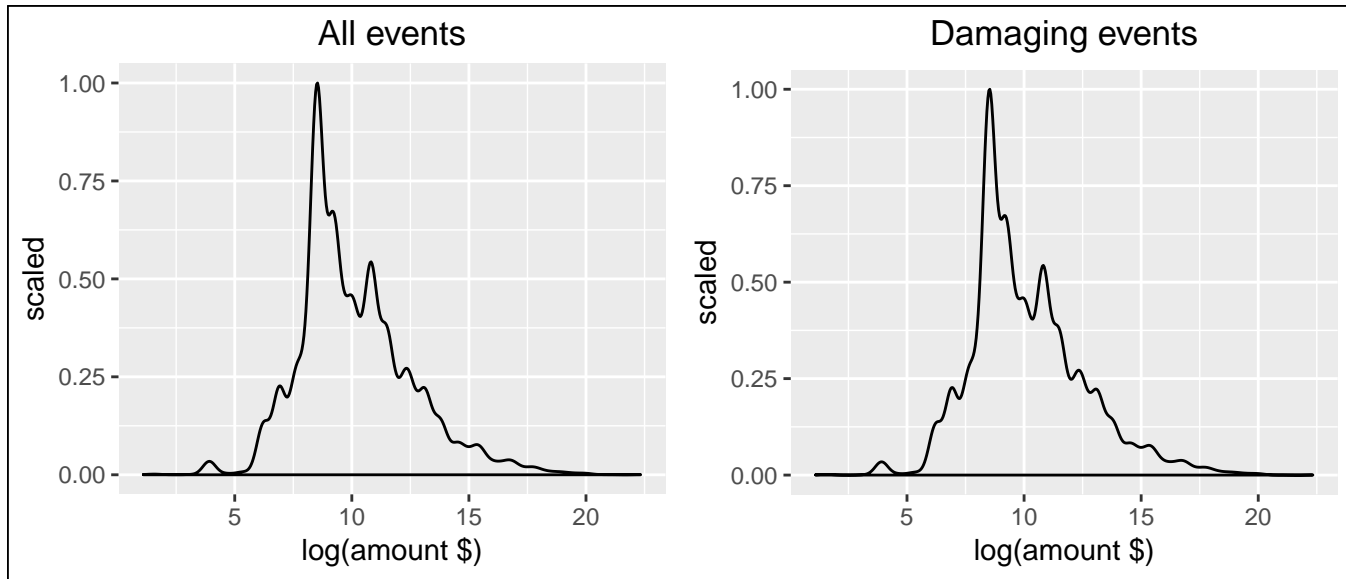


Figura 10: Population distribution for losses / occurrences

Tabela 10: Worst crops damaging occurrences, mean = \$2,222,010 and median = \$15,000

rank	event	mag	day	duration	state	countyname	value
1	FLOOD	0	1993-08-31	NA	IL	ADAMS	\$5,000,000,000
2	STORM	0	1994-02-09	0S	MS	MSZ001	\$5,000,000,000
3	HURRICANE	0	2005-08-29	0S	MS	MSZ018	\$1,510,000,000
4	DROUGHT	0	2006-01-01	0S	TX	TXZ091	\$1,000,000,000
5	COLD	0	1998-12-20	0S	CA	CAZ020	\$596,000,000
6	DROUGHT	0	2001-08-01	0S	IA	IAZ004	\$578,850,000
7	DROUGHT	0	2000-11-01	0S	TX	TXZ021	\$515,000,000
8	DROUGHT	0	1995-08-01	0S	IA	IAZ004	\$500,000,000
9	DROUGHT	0	1998-07-06	0S	OK	OKZ049	\$500,000,000
10	HURRICANE	0	1999-09-15	0S	NC	NCZ007	\$500,000,000
11	DROUGHT	0	1999-07-01	0S	PA	PAZ006	\$500,000,000
12	FLOOD	0	2000-10-03	0S	FL	FLZ072	\$500,000,000
13	FLOOD	0	2007-07-01	0S	MO	HENRY	\$500,000,000
14	HEAT	0	2006-07-16	0S	CA	CAZ089	\$492,400,000
15	DROUGHT	0	2002-12-01	0S	NE	NEZ039	\$480,000,000
16	DROUGHT	0	1998-12-01	0S	TX	TXZ021	\$450,000,000
17	HURRICANE	0	2005-08-25	0S	FL	FLZ068	\$423,000,000
18	DROUGHT	0	2001-12-01	0S	TX	TXZ021	\$420,000,000
19	HURRICANE	0	1999-09-14	0S	NC	NCZ029	\$413,600,000
20	HEAT	0	1995-08-20	NA	AL	TALLADEGA	\$400,000,000

The single most economic damaging event to crops was a **FLOOD**, that occurred in **IL, ADAMS**, on **1993-08-31**, causing **U\$ \$5,000,000,000** in losses.

Most Crop Damaging event in all time

rank	event	total	mean	median
2	FLOOD	\$12,275,747,200	\$2,232,008,736	\$296,658,415
3	STORM	\$5,738,319,500	\$2,232,008,736	\$296,658,415
4	HURRICANE	\$5,505,292,800	\$2,232,008,736	\$296,658,415
5	COLD	\$3,298,176,550	\$2,232,008,736	\$296,658,415
6	HAIL	\$3,046,887,473	\$2,232,008,736	\$296,658,415

The most crop damaging event along the time is the **DROUGHT**. It has caused **\$13,972,581,000** in losses.

Least crops damaging events

Just for curiosity, lets show now what are the less damaging among the events:

Tabela 12: Least crops damaging events

rank	event	total
22	GUSTNADO	\$1,550
21	TSUNAMI	\$20,000
20	TYPHOON	\$825,000
19	TIDE	\$850,000
18	LIGHTNING	\$12,092,090
17	SLIDE	\$20,017,000
16	WINTER	\$42,444,000
15	FROST	\$66,000,000
14	BLIZZARD	\$112,060,000
13	SNOW	\$134,663,100

0.7 Most afflicted locations

We have determined what locations had the worst outcome from those events, both in terms of human health and economic losses.

Unfortunately, these has been the worst counties for living in:

0.7.1 Worst fatality count

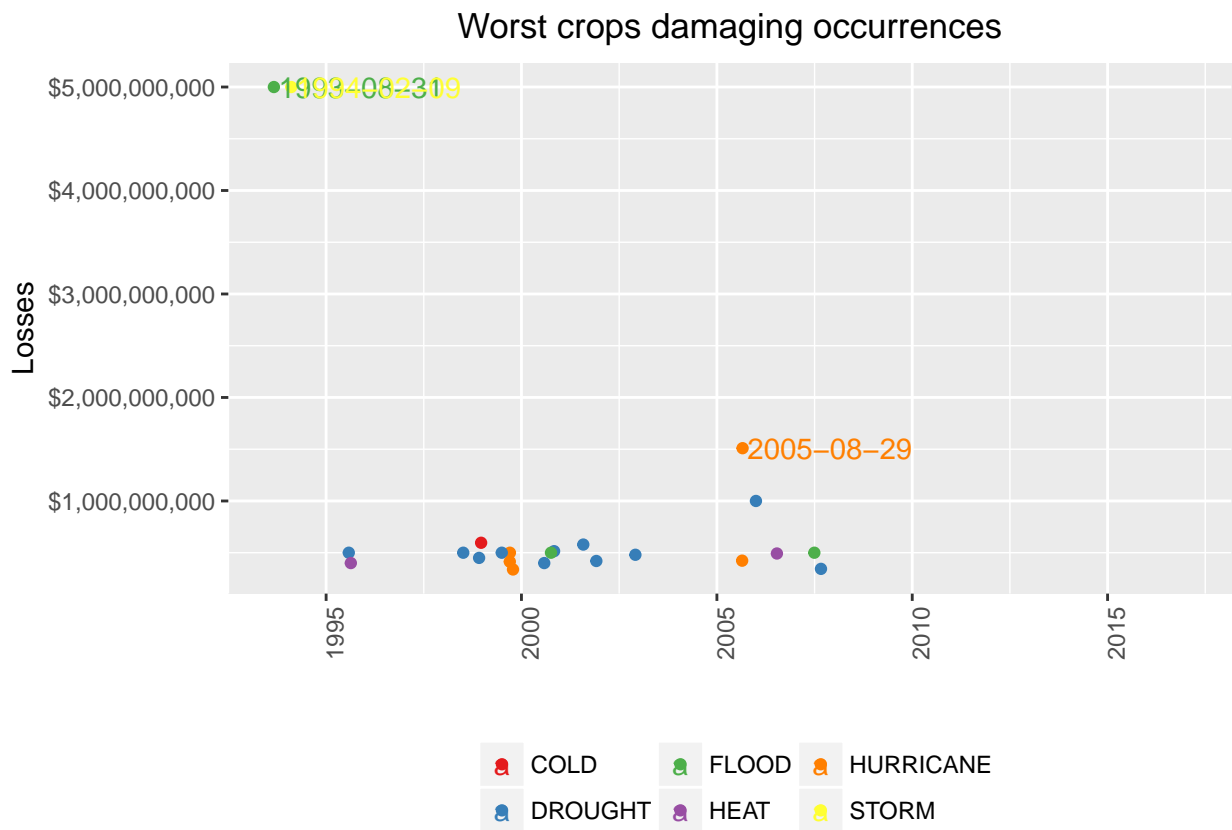


Figure 11: Worst crops damaging occurrences

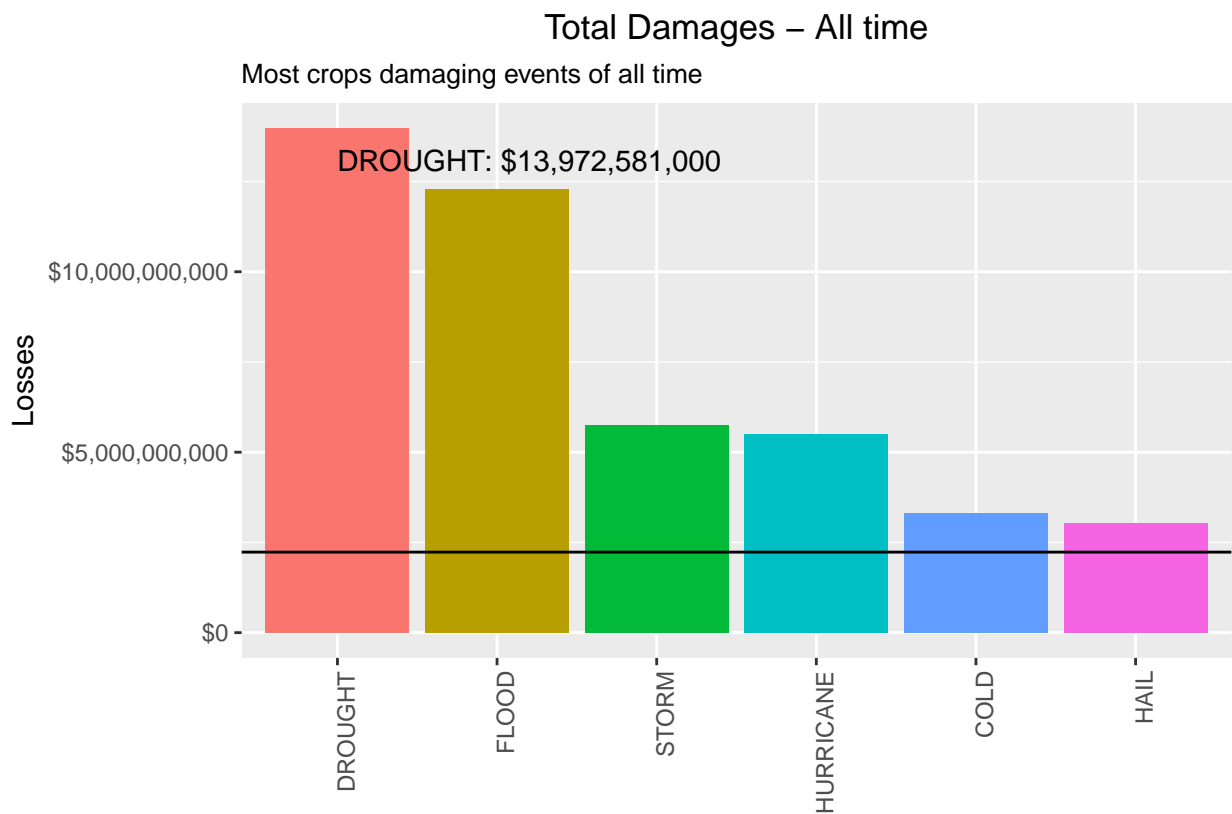


Figure 12: Total Crop Damages by event

Tabela 13: Total fatalities by county

rank	state	countyname	fatalities	injuries	prop.dmg	crop.dmg
1	IL	ILZ003	605	14	\$429,000	\$0
2	IL	ILZ014	300	22	\$2,321,000	\$0
3	PA	PAZ054	174	295	\$124,701,980	\$25,000,000
4	MO	JASPER	165	1271	\$2,858,007,330	\$5,500
5	MI	GENESEE	121	925	\$87,108,750	\$5,000,000
6	TX	MCLENNAN	117	635	\$63,071,100	\$4,000
7	TX	TXZ163	116	3	\$6,131,681,000	\$270,200,000
8	IL	ILZ005	114	0	\$277,000	\$0
9	AL	JEFFERSON	110	1576	\$2,024,930,600	\$2,254,000
10	PA	PAZ037	107	0	\$0	\$0

The county with the biggest fatality count is **ILZ003, in IL, with 605 people killed.**

0.7.2 Worst injuries count

Tabela 14: Total injuries by county

rank	state	countyname	fatalities	injuries	prop.dmg	crop.dmg
1	TX	WICHITA	51	1852	\$310,139,880	\$0
2	AL	JEFFERSON	110	1576	\$2,024,930,600	\$2,254,000
3	OH	OHZ42	1	1568	\$50,000,000	\$5,000,000
4	MA	WORCESTER	96	1289	\$284,569,630	\$0
5	OH	GREENE	37	1275	\$269,935,257	\$0
6	MO	JASPER	165	1271	\$2,858,007,330	\$5,500
7	MO	MOZ061	9	1133	\$1,000	\$0
8	AL	TUSCALOOS	60	1103	\$1,604,059,750	\$725,000
9	MO	MOZ009	73	978	\$3,225,050	\$23,649,200
10	MI	GENESEE	121	925	\$87,108,750	\$5,000,000

The county with the biggest injuries count is **WICHITA, in TX, with 1852 people injured.**

0.7.3 Worst property losses

Tabela 15: Total property losses by county

rank	state	countyname	fatalities	injuries	prop.dmg	crop.dmg
1	CA	NAPA	1	0	\$115,116,385,000	\$66,900,000
2	LA	LAZ040	0	0	\$31,316,850,000	\$0
3	LA	LAZ034	1	0	\$17,152,118,400	\$178,330,000
4	MS	MSZ080	0	1	\$11,264,195,000	\$0
5	FL	FLZ068	19	16	\$10,367,010,000	\$1,047,000,000
6	FL	FLZ001	33	0	\$9,686,320,000	\$87,800,000
7	MS	MSZ068	1	0	\$7,375,405,000	\$0
8	TX	TXZ163	116	3	\$6,131,681,000	\$270,200,000
9	MS	MSZ018	17	104	\$5,908,768,000	\$1,514,706,500
10	FL	FLZ055	9	786	\$5,424,027,000	\$292,000,000

The county with the biggest property losses is **NAPA, in CA, with \$115,116,385,000 in losses.**

0.7.4 Worst crops losses

Tabela 16: Total crops losses by county

rank	state	countyname	fatalities	injuries	prop.dmg	crop.dmg
1	IL	ADAMS	0	23	\$5,009,087,550	\$5,000,084,000
2	MS	MSZ001	4	5	\$2,643,000	\$5,000,000,000
3	TX	TXZ091	69	224	\$182,509,000	\$2,422,471,000
4	TX	TXZ021	2	4	\$12,450,000	\$1,845,050,000
5	IA	IAZ004	10	9	\$737,543,460	\$1,579,805,100
6	MS	MSZ018	17	104	\$5,908,768,000	\$1,514,706,500
7	FL	FLZ068	19	16	\$10,367,010,000	\$1,047,000,000
8	GA	GAZ001	20	29	\$158,011,850	\$926,260,000
9	NE	NEZ039	4	14	\$22,057,020	\$771,550,000
10	NC	NCZ029	29	201	\$1,940,635,500	\$768,600,000

The county with the biggest croperty losses is **ADAMS, in IL, with \$5,000,084,000 in losses.**

0.8 Results

0.8.1 Population Health

The single most fatal event was a **HEAT**, that occurred in **IL**, **ILZ003**, on **1995-07-12**, killing **583** people.

The most fatal event along the time is the **TORNADO**. It has killed **5636** people until now.

The single most injuring event was a **TORNADO**, that occurred in **TX**, **WICHITA**, on **1979-04-10**, injuring **1700** people.

The most injuring event along the time is the **TORNADO**. It has injured **91407** people until now.

0.8.2 Economic Damages

The single most economic damaging event to properties was a **FLOOD**, that occurred in **CA**, **NAPA**, on **2006-01-01**, causing **U\$ \$115,000,000,000** in losses.

The most property damaging event along the time is the **FLOOD**. It has caused **\$168,258,894,484** in losses.

The single most economic damaging event to crops was a **FLOOD**, that occurred in **IL**, **ADAMS**, on **1993-08-31**, causing **U\$ \$5,000,000,000** in losses.

The most crop damaging event along the time is the **DROUGHT**. It has caused **\$13,972,581,000** in losses.

0.8.3 Most afflicted locations

The county with the biggest fatality count is **ILZ003**, in **IL**, with **605** people killed. The county with the biggest injuries count is **WICHITA**, in **TX**, with **1852** people injured.

The county with the biggest property losses is **NAPA**, in **CA**, with **\$115,116,385,000** in losses.

The county with the biggest crop property losses is **ADAMS**, in **IL**, with **\$5,000,084,000** in losses.

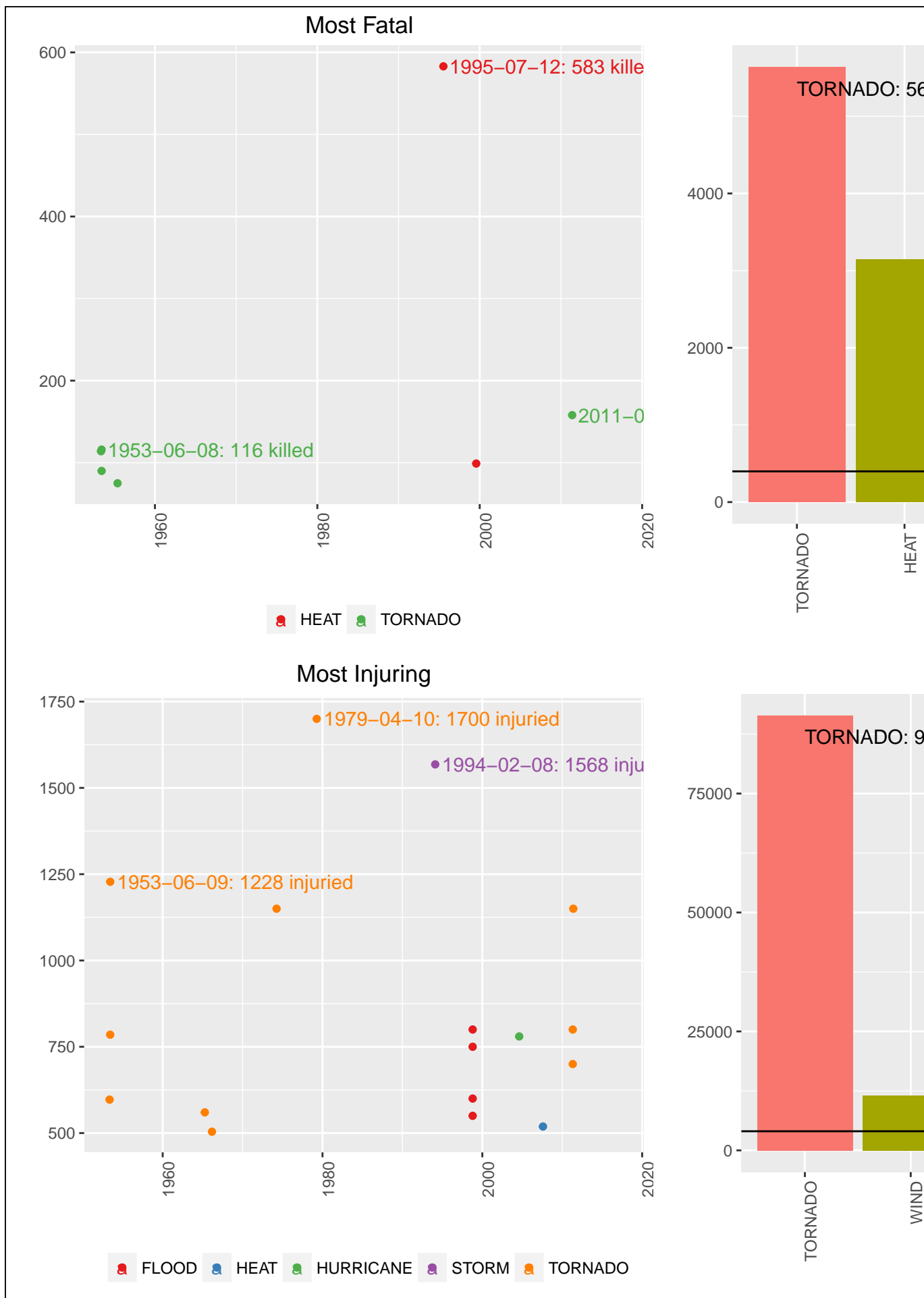


Figura 13: Population Health: fatalities and injuries



Figure 14: Economic Damages: property and crops

0.8.4 Distribution of data

