Extreme Weather Has Affected One in Three Americans: Analyzing Extreme Weather Events Trends since 2000

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GitHub: https://github.com/UC-Berkeley-I-School/Project2_Chen_Evans_Ghanem

Primary dataset: https://www.ncei.noaa.gov/pub/data/swdi/stormevents/csvfiles/

The Impact of Extreme Weather on Americans

- **One in three Americans say they have been affected by an extreme weather event** in the last two years according to a Gallup survey released in April 2022.
- Extreme-weather victims are more concerned about climate change.
- In this project, unlike conducting a survey, we are trying to view the story from the perspective of extreme weather events and the data is from National Oceanic and Atmospheric Administration (NOAA)

Americans' Experiences with Extreme Weather

In the past two years, have you been personally affected by an extreme weather event where you live, or not?
What type of extreme weather were you affected by?

	U.S. Adults %
Yes, affected	33
(Extreme cold)	(7)
(Hurricane)	(6)
(Snow/Ice storm/Blizzard)	(5)
(Extreme heat)	(5)
(Flood)	(4)
(Tornado)	(4)
(Fire or wildfire)	(4)
(Drought)	(3)
(High winds)	(3)
(Extreme thunderstorms)	(2)
(Extreme rain/Hail)	(1)
(Earthquake)	(1)
(Other)	(1)
No, not affected by extreme weather	67

The sum of the weather events exceeds 33% because some respondents named multiple weather events.

GALLUP, MARCH 1-18, 2022

Source: https://news.gallup.com/poll/391508/extreme-weather-affected-one-three-americans.aspx

Questions that we are looking to explore:

1. The impact of extreme weather events since 2000, What are the trends of these weather events?
2. What are states with the most property loss/death caused by extreme weather events?
3. What was happening to specific events such as Hurricane Katrina and 2011 Tornadoes?

NOAA Data Structure

NOAA database has been tracking tornado data since 1950. In 1992, they began tracking all storm events in database. There are about 1.7 million rows and 51 columns originally downloaded from NOAA and through the EDA process, the data set is narrowed down to 1.2 million rows and 8 columns. The EDA process will be introduced in the sanity check session explicitly.

storm_event_details
- **date (datetime64):** When events occurred, with format %y-%m%d.
- **year(int64):** The year when events occurred.
- **month(int64):** The month when events occurred, in numerical format, 1 means January.
- **day(int64):** The day in a month when events occurred.
- **state(object):** States where events occurred in the U.S., in the full state name
- **event_Type(object):** Type of extreme weather events
- **ev_type_grp(object):** Manually categorized groups of extreme events
- **injuries_direct(int64):** Direct injuries caused by events, in numerical format
- **injuries_indirect(int64):** Indirect injuries caused by events, in numerical format
- **deaths_direct(int64):** Direct deaths caused by events, in numerical format
- **deaths_indirect(int64):** Indirect injuries caused by events, in numerical format
- **damge_property(float64):** Property loss caused by events, in numerical format, adjusted by the inflation rate according to the U.S Bureau of Labor Statics.

storm_fatalities (merge on event_id)
- **cz_fips(int64):** The county FIPS number is a unique number assigned to the county by the National Institute for Standards and Technology (NIST)
- **state_fips(int64):** The state FIPS is a unique number assigned to the state by the National Institute for Standards and Technology (NIST)
- **fatality_age(int64):** The age in years of the fatality (sometimes 'null' if unknown)
- **fatality_sex(object):** The gender of the fatality (sometimes 'null' if unknown)
- **fatality_location(object):** the location of the fatality, e.g. Permanent Home, Mobile/Trailer Home, Boating

Sanity Check/Assumptions

- The pristine data of extreme weather events from NOAA contains 51 columns and since we want to find out the impact of these events since 2000 based on the fact of climate change, we then narrowed down the columns to columns having necessary information

- Translate format of damage_property from 2k to 2000 and adjust by inflation rate, remove data not in the U.S.

- Originally, we consider entries having different event_id and happened at the same time as duplicates. However, along with data exploration, we find out that owing to the reasons that we picked 8 out of 51 columns and a single event might be reported separately with different information so if we drop the duplicate entries, we may lose some important information. As a result, we decide to keep the duplicates.

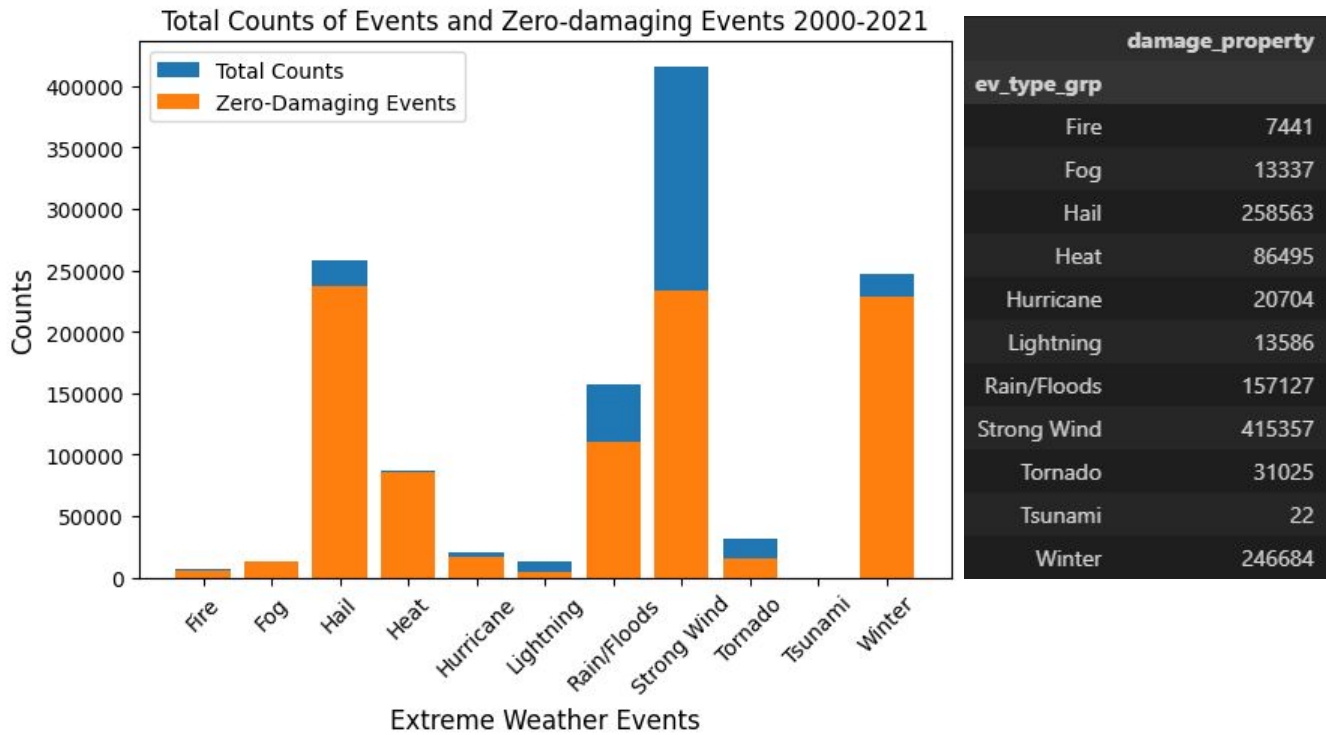|	EVENT_ID	YEAR	MONTH_NAME	BEGIN_DAY	BEGIN_TIME	END_TIME	STATE	EVENT_TYPE	INJURIES_DIRECT	INJURIES_INDIRECT	DEATHS_DIRECT	DEATHS_INDIRECT	DAMAGE_PROPERTY
0	5165377	2000	12	31	600	900	FLORIDA	Extreme Cold/Wind Chill	0	0	0	0	NaN
1	5165378	2000	12	31	600	900	FLORIDA	Extreme Cold/Wind Chill	0	0	0	0	NaN
2	5165379	2000	12	31	700	800	FLORIDA	Extreme Cold/Wind Chill	0	0	0	0	NaN
3	5165449	2000	12	13	2200	400	WEST VIRGINIA	Winter Storm	0	0	0	0	NaN
4	5172568	2000	8	3	1410	1410	MISSISSIPPI	Thunderstorm Wind	0	0	0	0	2K

```
# US States: #'FLORIDA', 'WEST VIRGINIA', 'MISSISSIPPI', 'MAINE', 'CONNECTICUT','GEORGIA', 'NORTH CAROLINA', 'ARIZONA', 'TEXAS', 'TENNESSEE', 'MARYLAND', 'NEW YORK', 'OREGON', 'NEW JERSEY',
            # 'KANSAS', 'MICHIGAN', 'OKLAHOMA', 'PENNSYLVANIA', 'LOUISIANA', 'DELAWARE', 'CALIFORNIA', 'COLORADO', 'INDIANA', 'IOWA', 'ALASKA', 'MONTANA', 'OHIO', 'ILLINOIS', 'ARKANSAS',
            # 'HAWAII', 'WASHINGTON', 'MINNESOTA', 'IDAHO', 'WYOMING', 'SOUTH DAKOTA', 'ALABAMA','VERMONT', 'NEW HAMPSHIRE', 'NORTH DAKOTA', 'MISSOURI', 'DISTRICT OF COLUMBIA', 'NEVADA',
            # 'RHODE ISLAND', 'NEBRASKA', 'NEW MEXICO', 'UTAH', 'KENTUCKY', 'MASSACHUSETTS',, 'VIRGINIA', 'WISCONSIN', 'SOUTH CAROLINA'

# Not US: # 'PUERTO RICO','AMERICAN SAMOA','GUAM', 'LAKE ERIE', 'LAKE HURON', 'GULF OF MEXICO','LAKE ST CLAIR', 'E PACIFIC', 'ATLANTIC SOUTH', 'HAWAII WATERS','LAKE MICHIGAN',
            # 'ATLANTIC NORTH', 'LAKE ONTARIO', 'ST LAWRENCE R','LAKE SUPERIOR''GULF OF ALASKA', 'VIRGIN ISLANDS', nan
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- Categorize extreme weather events to several groups, and tag them depending on whether they linked to climate or not. Remove events that don't link to climate and fill empty entries with 0 in columns injuries, deaths and damage property.

event_type	ev_type_grp	possibly linked to climate
Dense Smoke	Fire	x
Wildfire	Fire	x
Dense Fog	Fog	x
Hail	Hail	x
Heat	Heat	x
Drought	Heat	x
Excessive Heat	Heat	x
Avalanche	Heat	x
Marine Hurricane/Typhoon	Hurricane	x
Coastal Flood	Hurricane	x
Storm Surge/Tide	Hurricane	x
Hurricane (Typhoon)	Hurricane	x
High Surf	Hurricane	x
Hurricane	Hurricane	x
Tropical Storm	Hurricane	x
Tropical Depression	Hurricane	x

event_type	ev_type_grp	possibly linked to climate
Lightning	Lightning	x
Heavy Rain	Rain/Floods	x
Debris Flow	Rain/Floods	x
Flood	Rain/Floods	x
Lakeshore Flood	Rain/Floods	x
Flash Flood	Rain/Floods	x
Dust Devil	Strong Wind	x
Marine Thunderstorm Wind	Strong Wind	x
Marine High Wind	Strong Wind	x
Marine Strong Wind	Strong Wind	x
Thunderstorm Wind	Strong Wind	x
High Wind	Strong Wind	x
Strong Wind	Strong Wind	x
Dust Storm	Strong Wind	x
Waterspout	Tornado	x
Tornado	Tornado	x
Tsunami	Tsunami	x

event_type	ev_type_grp	possibly linked to climate
Extreme Cold/Wind Chill	Winter	x
Freezing Fog	Winter	x
Winter Storm	Winter	x
Ice Storm	Winter	x
Winter Weather	Winter	x
Frost/Freeze	Winter	x
Lake-Effect Snow	Winter	x
Sleet	Winter	x
Cold/Wind Chill	Winter	x
Heavy Snow	Winter	x
Blizzard	Winter	x
Seiche	NaN	NaN
Sneakerwave	NaN	NaN
Rip Current	NaN	NaN
Funnel Cloud	NaN	x
Marine Dense Fog	NaN	NaN
Marine Hail	NaN	NaN

- After the initial EDA process, we have the data set (1259,884 rows x 8 cols) with the desired format below and are ready to execute the analysis. .

date	year	month	day	state	event_type	ev_type_grp	injuries_direct	injuries_indirect	deaths_direct	deaths_indirect	damage_property
2000-12-31	2000	12	31	FLORIDA	Extreme Cold/Wind Chill	Winter	0	0	0	0	0.0
2000-12-31	2000	12	31	FLORIDA	Extreme Cold/Wind Chill	Winter	0	0	0	0	0.0
2000-12-31	2000	12	31	FLORIDA	Extreme Cold/Wind Chill	Winter	0	0	0	0	0.0
2000-12-13	2000	12	13	WEST VIRGINIA	Winter Storm	Winter	0	0	0	0	0.0
2000-08-03	2000	8	3	MISSISSIPPI	Thunderstorm Wind	Strong Wind	0	0	0	0	3500.0
2000-08-09	2000	8	9	MISSISSIPPI	Thunderstorm Wind	Strong Wind	0	0	0	0	3500.0
2000-08-09	2000	8	9	MISSISSIPPI	Thunderstorm Wind	Strong Wind	0	0	0	0	1750.0
2000-01-21	2000	1	21	MAINE	Blizzard	Winter	0	0	0	0	0.0
2000-01-21	2000	1	21	MAINE	Blizzard	Winter	0	0	0	0	0.0

```
date                datetime64[ns]
year                         int64
month                        int64
day                          int64
state                       object
event_type                  object
ev_type_grp                 object
injuries_direct              int64
injuries_indirect            int64
deaths_direct                int64
deaths_indirect              int64
damage_property            float64
dtype: object
```

Insights of property loss caused by extreme weather events since 2000.

- **Not all extreme weather events cause damage.** They can land in nowhere, or too mild to cause any damage
- We notice that most of the events don't actually deal any damage except rain, strong wind, and tornado. About twenty to thirty percent of them do cause damage.


Total Counts of Events and Zero-damaging Events 2000-2021

ev_type_grp	damage_property
Fire	7441
Fog	13337
Hail	258563
Heat	86495
Hurricane	20704
Lightning	13586
Rain/Floods	157127
Strong Wind	415357
Tornado	31025
Tsunami	22
Winter	246684

- **Hurricanes are actually the most destructive, despite rain, strong winds, and tornadoes have higher probability to cause damage.** Hurricanes dealt with more than $250 billion dollars since 2000, and category 5 hurricane Katrina itself, caused over $125 billion in property loss.

Total Property Loss by Events in 2000-2021
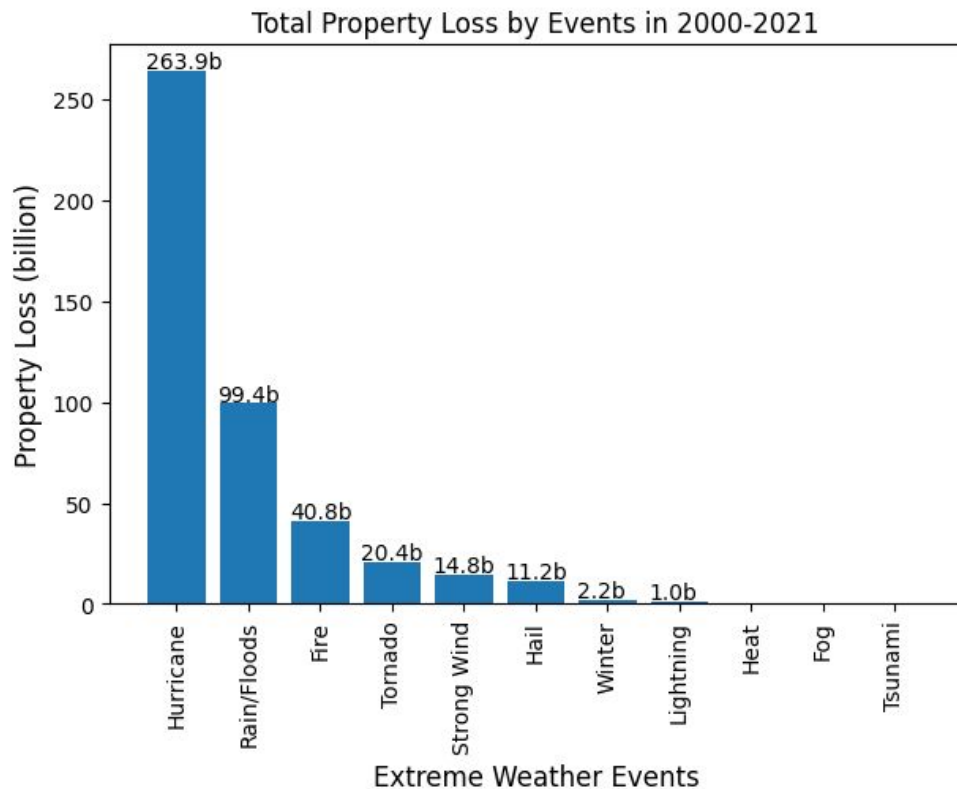
ev_type_grp	damage_property
Hurricane	2.639191e+11
Rain/Floods	9.939835e+10
Fire	4.078525e+10
Tornado	2.039375e+10
Strong Wind	1.483721e+10
Hail	1.122764e+10
Winter	2.159000e+09
Lightning	9.706247e+08
Heat	1.101314e+08
Fog	3.161812e+07
Tsunami	2.493750e+06

- **The frequency of extreme events are increasing but not for high-cost disasters.** We can see there are upward trends in rains, strong winds, and hurricanes. However, the number of severe events causing more than 10,000 dollars somehow remains steady since 2000
- **The frequency of lightning across the country is decreasing on average**, but not for California. The increasing frequency of lightning ignite wildfires and threaten residents' safety there.
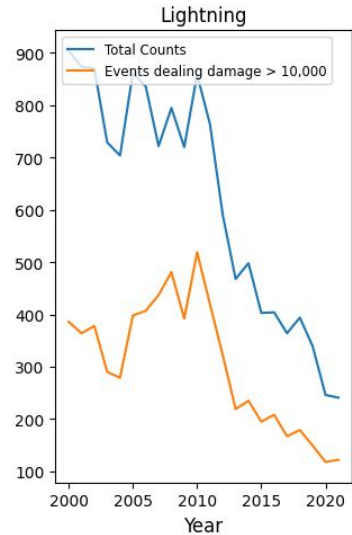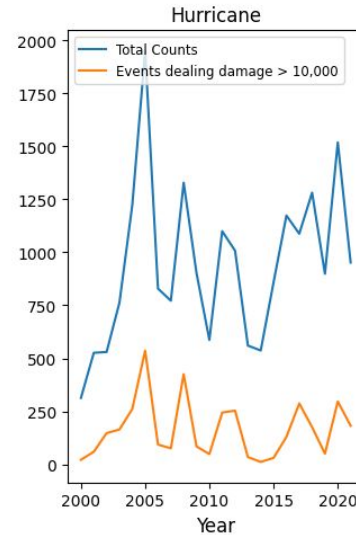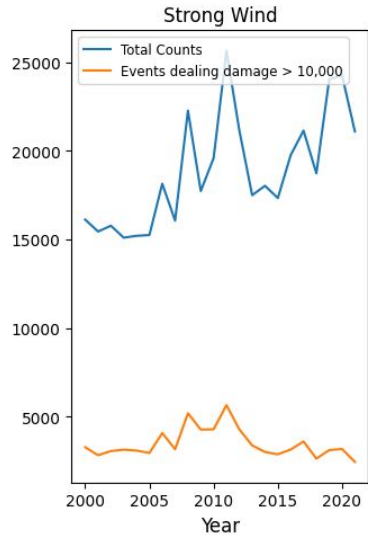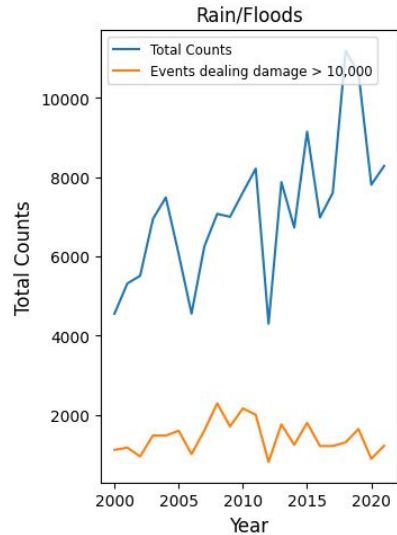
Insights of extreme weather events by states

Texas, **Louisiana** & **Florida** were impacted with the most damage in the US caused by the weather events during 2000-2021

- **Texas**: *$120,263.7 M*

- **Louisiana** *$110,249.9 M*

- **Florida**: *$48,033.85 M*

Total Damage by state
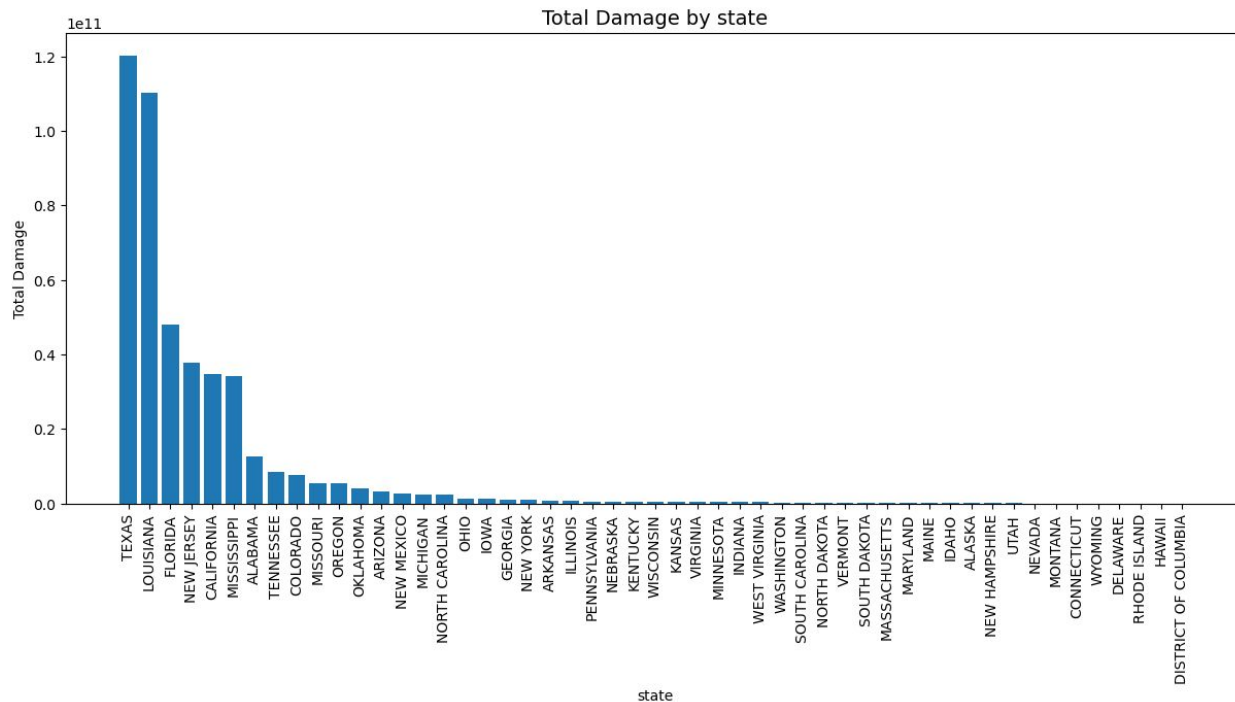
The weather events that cause the biggest loss in the highest 10 states damage (2000-2021)

- **Flood/Rain**:
  - *~50% Texas*
  - *~50% Tennessee*

- **Hurricane**
  - *Louisiana*
  - *Florida*
  - *New Jersey*
  - *Mississippi*
  - *+50% Alabama*

- **Fire**: *California*

- **Tornado**: *Missouri*

Events Damage % by state
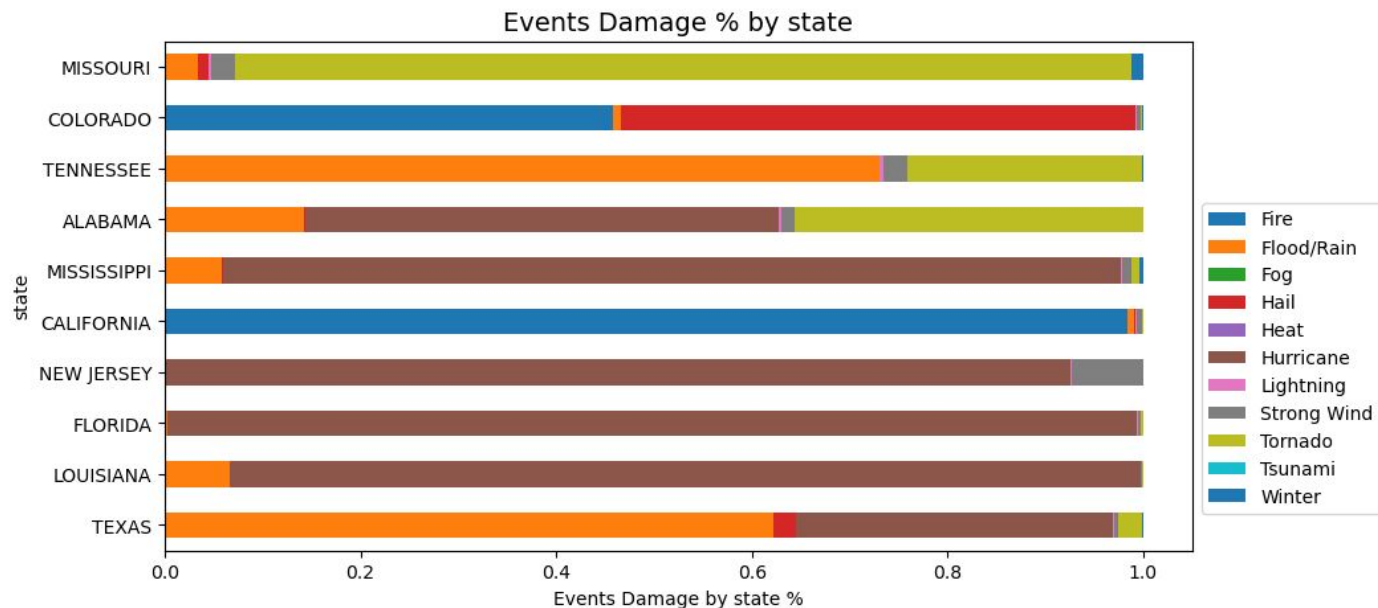
The weather events death cases in US states (2000-2021)

The highest 5 States loss:

- **Louisiana:** *1005*

- **Texas**: *975*

- **Arizona**: *949*

- **California**: *701*

- **Missouri**: *600*

Weather Event Deaths by State (2000-2021)
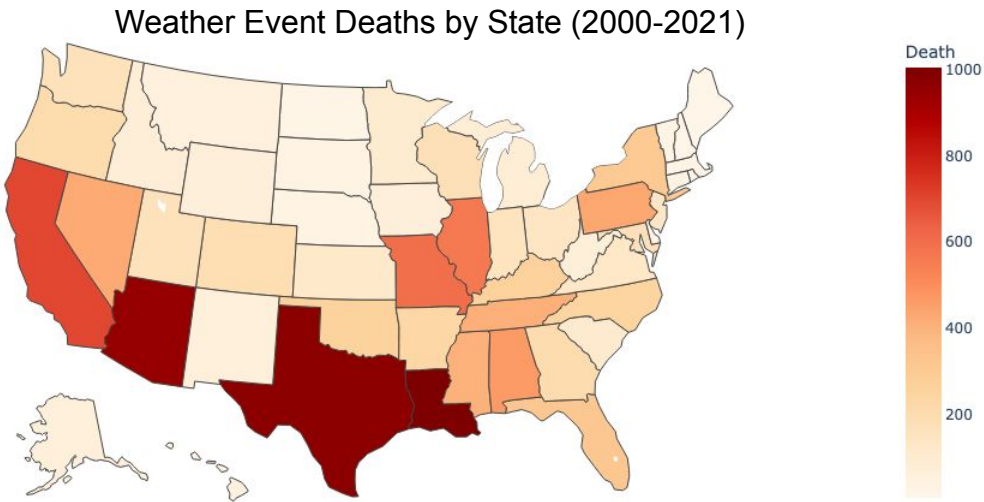
EV_TYPE_GRP state	Fire	Flood/Rain	Fog	Hail	Heat	Hurricane	Lightning	Strong Wind	Tornado	Tsunami	Winter	total_death
LOUISIANA	0.0	36.0	1.0	0.0	39.0	840.0	21.0	28.0	30.0	0.0	10.0	1005
TEXAS	30.0	345.0	0.0	1.0	241.0	49.0	51.0	56.0	58.0	0.0	144.0	975
ARIZONA	19.0	80.0	0.0	1.0	787.0	0.0	20.0	13.0	0.0	0.0	29.0	949
CALIFORNIA	213.0	111.0	10.0	1.0	187.0	69.0	14.0	60.0	0.0	1.0	35.0	701
MISSOURI	0.0	105.0	0.0	0.0	180.0	0.0	23.0	34.0	247.0	0.0	11.0	600

The weather events death cases per 100,000 in US states (2000-2021)

The highest 3 States loss per 100,000

- **Louisiana**

- **Nevada**

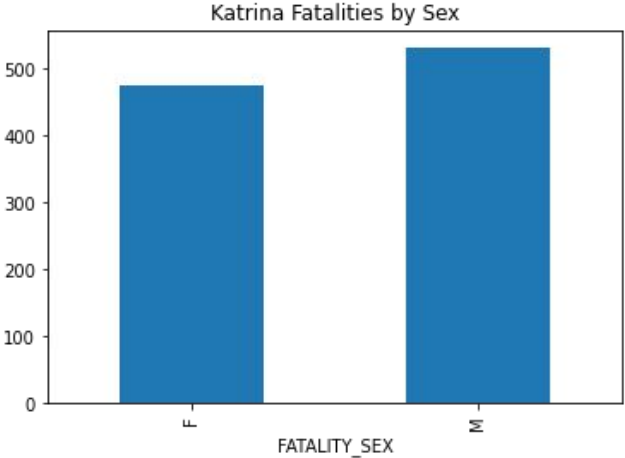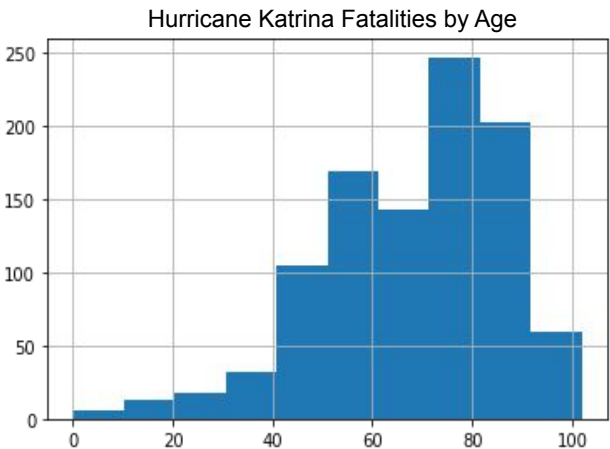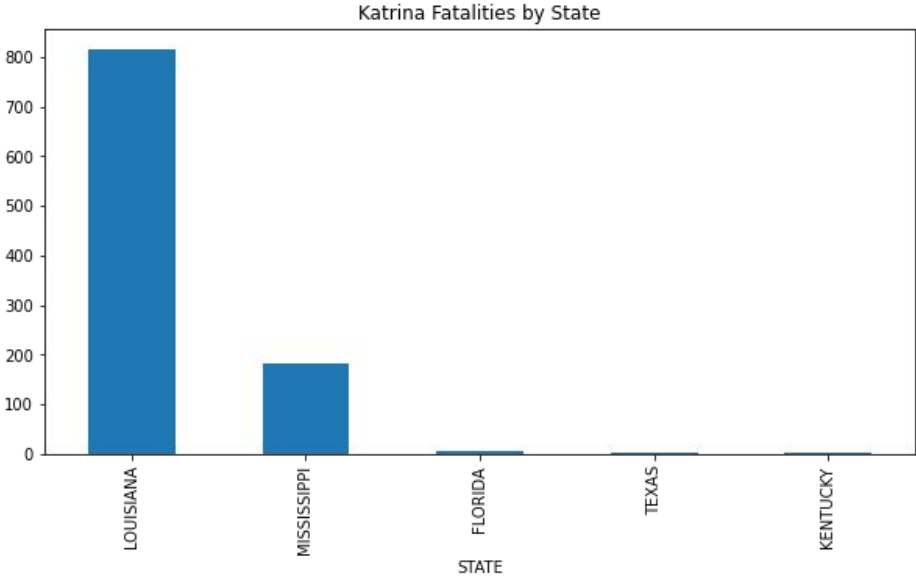- **Mississippi**

Total Death per 100,000
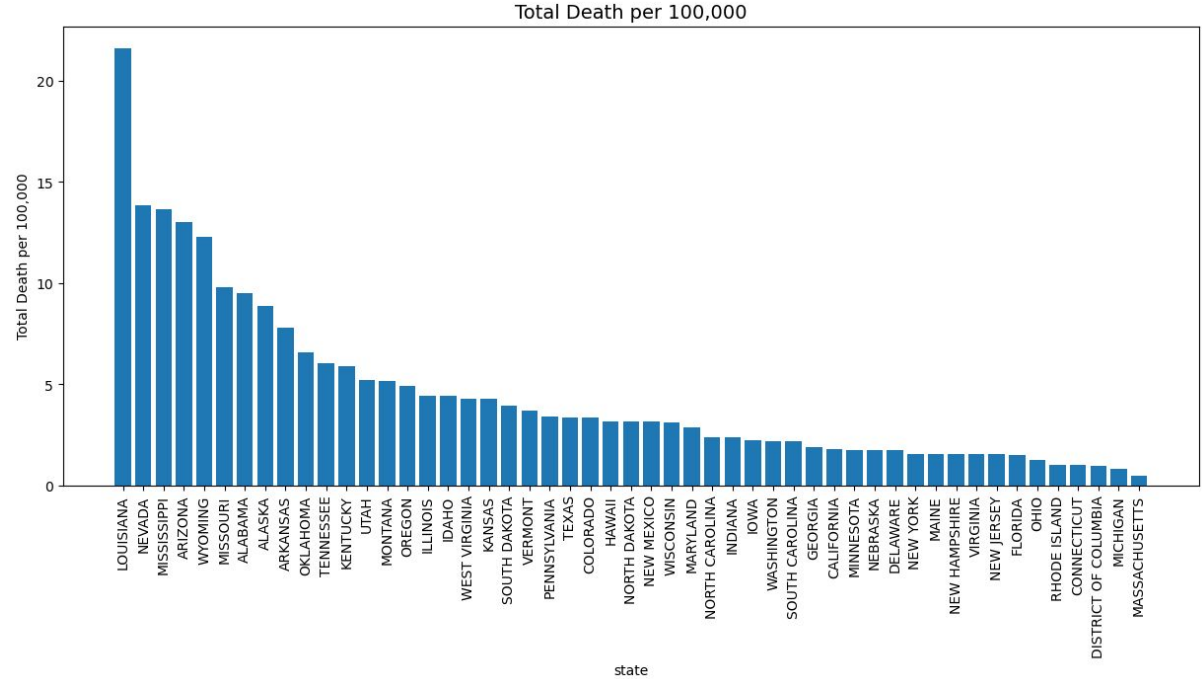
# Severe Storm Fatalities

Severe Storm Fatalities by Year, Month
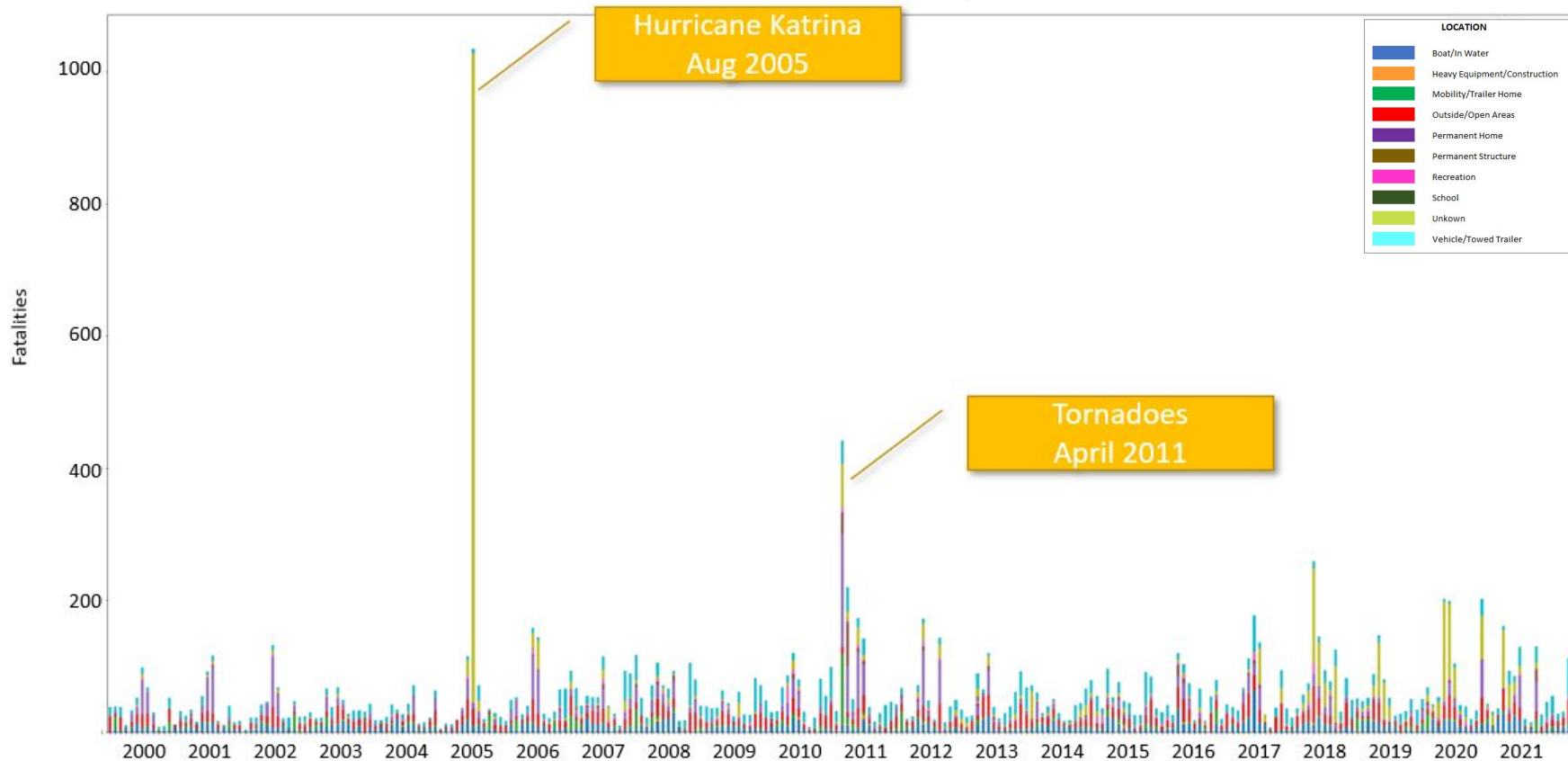
Katrina Fatalities Breakout

Katrina Fatalities by State

Hurricane Katrina Fatalities by Age
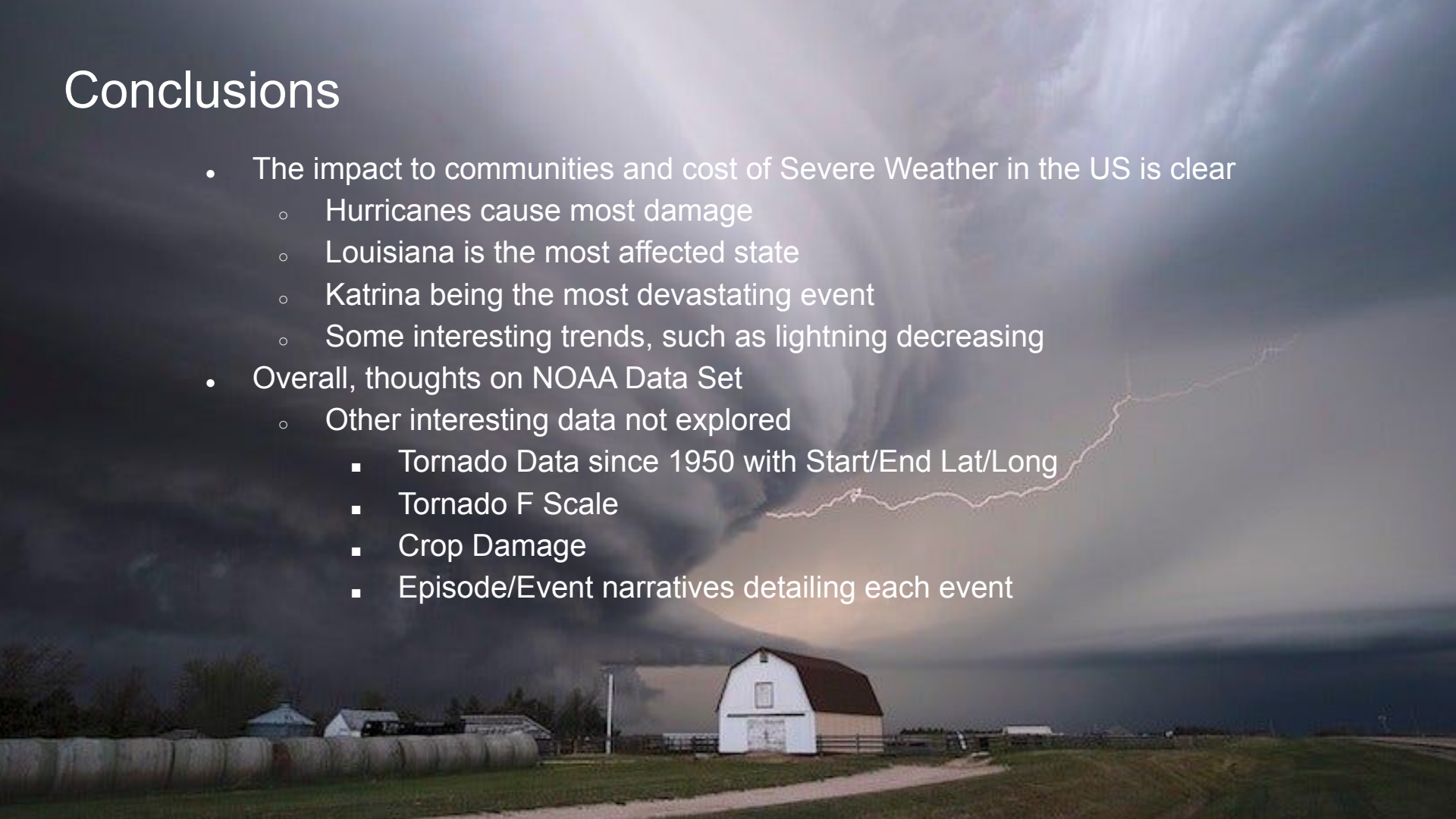

Katrina Fatalities by Sex

- Dubbed the **2011 Super Outbreak**, the April 2011 storms killed more than 350 people across the SouthEastern United States in one of the most deadly tornado outbreaks ever recorded
- NOAA Dataset has FIPS (Unique State/County Code) location along with Lat/Long of all Storm Events
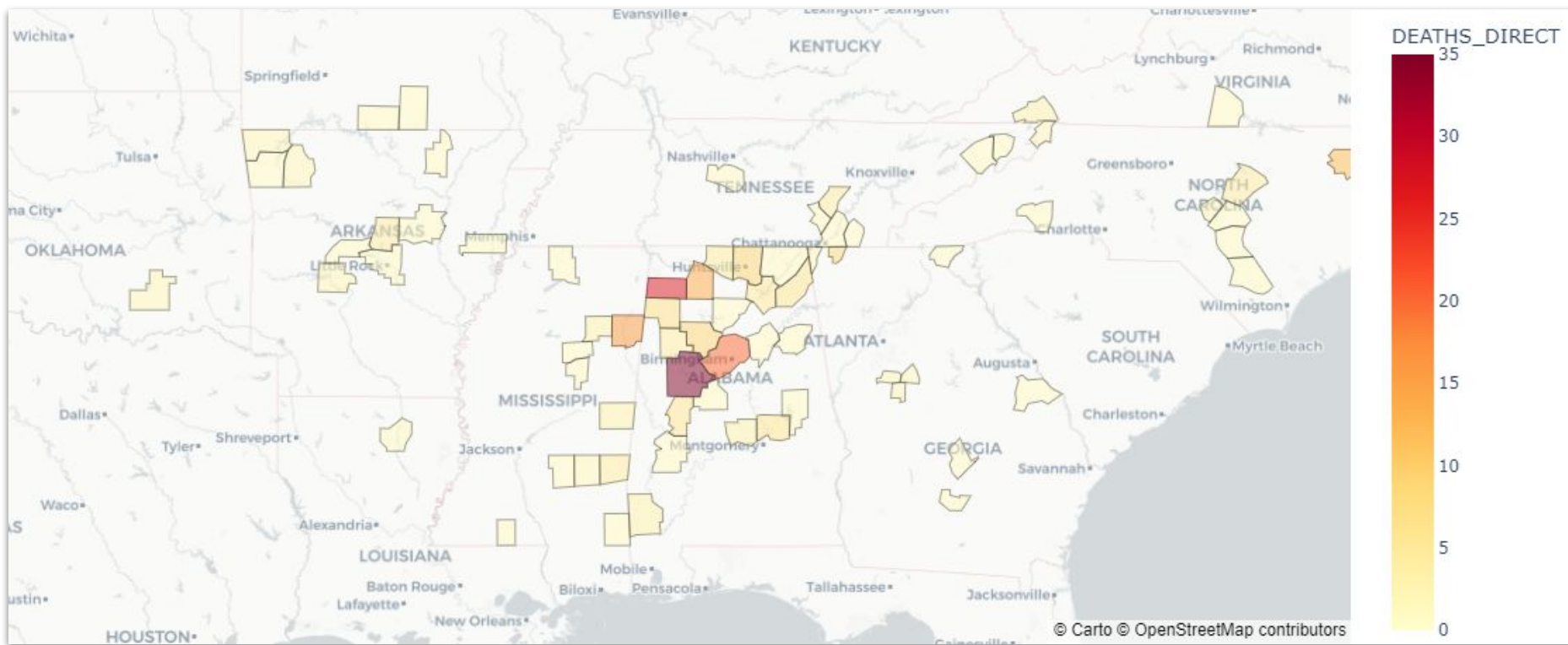
Conclusions

- The impact to communities and cost of Severe Weather in the US is clear
  - Hurricanes cause most damage
  - Louisiana is the most affected state
  - Katrina being the most devastating event
  - Some interesting trends, such as lightning decreasing
- Overall, thoughts on NOAA Data Set
  - Other interesting data not explored
    - Tornado Data since 1950 with Start/End Lat/Long
    - Tornado F Scale
    - Crop Damage
    - Episode/Event narratives detailing each event