

# NOAA Storm Events in Literature

## What is the Storm Events Database

[Add a brief description of this database, including: who collects it; what data is collected; how it's collected; where the database is available; any major changes over time to what data have been collected and how they've been collected; information about what's included in each "entry" in the database.]

From NOAA Storm Events Website: "The Storm Events Database contains the records used to create the official NOAA Storm Data publication, documenting:

The occurrence of storms and other significant weather phenomena having sufficient intensity to cause loss of life, injuries, significant property damage, and/or disruption to commerce; Rare, unusual, weather phenomena that generate media attention, such as snow flurries in South Florida or the San Diego coastal area; and Other significant meteorological events, such as record maximum or minimum temperatures or precipitation that occur in connection with another event.

The database currently contains data from January 1950 to February 2020, as entered by NOAA's National Weather Service (NWS). Due to changes in the data collection and processing procedures over time, there are unique periods of record available depending on the event type. NCEI has performed data reformatting and standardization of event types but has not changed any data values for locations, fatalities, injuries, damage, narratives and any other event specific information."

[BA: I think that one of the things it's important to understand about this database is how they record with a hierarchy, so there will be different listings for one storm both across several types of hazards and several geographic locations. For example, a big hurricane is one storm system but would result in listings for lots of counties and for multiple hazards (storm surge, wind, extreme rain, etc.) within some of those counties. They've got ID numbers that help in joining together different listings for the same storm. It might be helpful for us to add a figure somewhere early in the draft to explain this aspect of how listings are included in the database. You could take a look through the noaastormevents to see if there's a figure or illustration there that might make a good starting point for helping to illustrate that.]

## Use of Storm Events Database in research on societal impacts

[BA: Let's add some examples of papers in which this database was used to identify storm exposures, and then the paper was looking at how they impacted humans.]

## Concerns with Storm Events Database

[BA: Could we start on a paragraph here that gives an introduction to this section about potential biases? One thing here would be to talk about the idea of the probability of an event being recorded given that it happens.]

[BA: Maybe it would be helpful for us to start a small table here that lists each type of bias that we cover and a short description of each? We can start that as an itemized list, because that will be easier to format right now, and then convert it to a table later.]

- **hazard bias:** [Add a short definition / description]
- **temporal bias:** [Add a short definition / description]
- **threshold bias:** [Add a short definition / description]
- **accounting bias:** [Add a short definition / description]
- **geographic bias:** [Add a short definition / description]

## Hazard Bias

[BA: I think there might be a few different things going on with this one. Let's talk about how we can make sure we bring these different elements together in describing this type of bias. Here are some of the elements that seemed to me to be coming up here: (1) some types of events might be more likely to be recorded than others; (2) some types of hazards within an event might be more likely to be recorded than others; (3) for some types of events, maybe there's some encouragement to list it as a single event; (4) for the events that are listed, they can differ a lot in severity, and there's not much information in the database to help figure out how severe they are; (5) some of the listings are coming from different sources (e.g., media rather than the NWS)]

Within the Storm Events database, there may be inaccurate recording in the number of certain hazard types [BA: Could we be more precise with this statement? For example, is this likely to always (or almost always) be an underreporting rather than an overreporting? Also, for this type of bias, maybe we want to clarify that, even when storms are entered into the database, all of their associated hazards might not be entered. That's what's going on with this type of bias, right? If I've understood this correctly, maybe move towards something like, "The Storm Events database aims to record listings for all hazards brought by a particular storm event. However, in some cases, when a storm event is recorded certain types of hazards within the storm can tend to go unreported." Have I gotten the idea right here?]. This may arise from the difficulty of sorting storm events that include multiple types of hazards. There are definitional differences between events as well as certain events correlating to multiple event categories. NOAA Storm Events defines the types of events that are allowed in the data set. This can be found under Table 1 of Section 2.1.1 of NWS Directive 10-1605 at <http://www.nws.noaa.gov/directives/sym/pd01016005curr.pdf>. NOAA Storm Events also states that "In the event it is obvious that a continuous or nearly continuous swath of thunderstorm wind or hail damage occurred, a single event should be entered into Storm Data. This single event would be described as occurring from Point A to Point B, during Time C to Time D. The related event narrative could describe the width and length of the damage swath. Scientifically, a swath is more accurate and reduces the chance of a researcher interpreting a single event as a series of events occurring across multiple points."

There is also limited information on event severity or distinction between events within the database (Luh et al. 2015). The NOAA Storm Data Disclaimer states that "Some information appearing in Storm Data may be provided by or gathered from sources outside the National Weather Service (NWS), such as the media, law enforcement and/or other government agencies, private companies, individuals, etc. An effort is made to use the best available information but because of time and resource constraints, information from these sources may be unverified by the NWS" ("Storm Data Faq Page," n.d.). [BA: The last sentence in this paragraph I think we could move earlier, to where we're first describing the database and how data is collected and aggregated for it.]

- $P(\text{event recorded} \mid \text{event happened})$  may be different by events [BA: Here, do we mean that it might be different for tornado events versus avalanche events, for example? Or do we mean that, for any type of event, it might be different depending on some characteristics of the event (for example, how severe a specific event was)? Or maybe both?]
- This is influenced by the goal or audience of the database
  - For example, the US is especially concerned with monetary losses from floods so it may be more likely for flood events to be reported (Gall, Borden, and Cutter 2009)

- The National Flood Insurance Act passed in 1968 created the National Flood Insurance Program which helps provide flood insurance
- \*script to pull up number of floods compared to other events in noaa, no difference in monetary loss estimates pre and post 1968, so is this example not valid here?
- This also arises from the difficulty of sorting storm events that include multiple types of hazards
  - Definitional differences (Gall, Borden, and Cutter 2009) [BA: Could you add some more details or explanation on this point? I’m not sure I get it yet.]
  - one episode can correlates to mulitple events (Konisky, Hughes, and Kaylor 2016)
  - \*script for how noaa deals with this? or examples of this?
- we could list event\_type from database? [BA: I think this is a great idea, either here or earlier when we talk about the database. I think there may already be some code in one of the vignettes for doing that. Take a look and see if you see that—if not, I can help find it if it’s there or give some suggestions for writing some code for this if we don’t already have an example.]
- interrupted time series analysis: change in flood policy since 1996
  - years of big policy changes for floods (flood insurance)

[BA: I love this last idea, but I think that this date (1996) might coincide with the date that they added a lot of new types of events to the database, so we might not be able to separate the influence of the flood policy change from the influence of the changes to the database.]

## Temporal Bias

[BA: We might want to start with this type of bias, and then geographic bias. I think those two are very easy for people to grasp. Then, when we talk about other types of biases, we might want to talk about them just in terms of things that might cause differences within a certain period of time and location, so we can separate them from geographic and temporal issues. There are a few examples that could really fall into several categories (for example, the flood insurance question, which has a time component to it since policies changed over time), so we might want to discuss any time-related things in this section and start with it.]

[BA: Potential reasons for temporal bias: (1) We’ve gotten better at “seeing” extreme weather as it happens—radar, larger networks of monitors, etc. There may be some good examples from measuring tornadoes of this idea, where the improvement in weather monitoring has helped increase the number of reported events; (2) Some changes have increased the chance that we notice / report events when they happen. For example, population growth over time in some areas might mean there’s a higher chance that an event that happens in that area gets reported. (3) Some temporal changes are structural, in terms of the database changing it’s “rules” for what it recorded. The expansion from just tornadoes to other types of events is an example here. This is one where we can help control for any bias, since there’s clear documentation on some of those changes. However, I wonder if there’s still some kind of lead in period, where it takes them a little while once they start adding an event to succeed in recording most or all of them? We could maybe check how the rate of recording changes with time for tornadoes versus some of the “new” events in the database in the late 1990s.]

[BA: I like that we distinguish between the idea of long-term trends in the probability of an event being recorded in the database (e.g., from one decade to the next) versus seasonal time trends (e.g., winter versus summer). We probably want to explicitly write a few sentences introducing that idea that temporal bias can operate at different time scales.]

## Introduction to Temporal Bias:

Within the NOAA Storm Events database, there are comparable differences in event and loss recording over time. Temporal bias is helpful in describing and understanding these changes within the database. There are long term patterns of temporal bias that may be caused by changes in measuring and recording events and losses. There are also seasonal patterns within the database that relate to unique attributes and temporality of certain weather events.

## Long Term Trends:

The long term patterns of temporal bias are related to advancements in monitoring and detecting storm events, changes in population size and locations, and structural changes in recording strategies and monetary loss accounting.

Technological advancements within storm recording such as the development of radar and larger networks of monitors have increased our ability to detect extreme weather events as they happen. For example, over time, forecasters and storm spotters have learned how to recognize key weather patterns and structures that make it more likely for a tornado to form. The development and advancement of doppler radar and dual-polarization radar technology has also increased our ability to collect and use data to detect tornado events (“SEVERE Weather 101: Tornado Detection,” n.d.). One study states that “the number of tornadoes reported in the United States has doubled from about 600 per year in the 1950s to around 1200 in the 2000s”(Verbout et al. 2006). This may be influenced by factors other than meteorological changes.

Increases in population size throughout the US and further land development may also contribute to increased event reporting. For example, population growth over time in some areas might mean there’s a higher chance that an event that happens in that area gets reported.

Some temporal changes are structural, in terms of the database changing what types of events are recorded. In the NOAA database, from 1950 to 1954, only tornado events were recorded (“Storm Events Database,” n.d.). Then, from 1955 to 1996, only tornado, thunderstorm wind and hail events were recorded as digital data (“Storm Events Database,” n.d.). Starting in 1996, the database began including all 48 event types that are recorded today (“Storm Events Database,” n.d.). Additionally, the NWS reports that there was reduced funding from 1976 to 1979 that led to a decrease in flood damage data collection (Downton, Miller, and Pielke Jr 2005). Then, after 1983, Congress began to require The US Army Corps of Engineers to provide yearly flood damage reports in contract with the NWS (Downton, Miller, and Pielke Jr 2005). This provides a more consistent report of flood damage that may not have otherwise been reported. These changes pose inconsistencies in the number of certain storm events over large periods of time.

[BA: We probably want to clarify somewhere here that there’s also, for damages / money, the fact that the value of a dollar has changed over time. This can be addressed by normalizing any dollar measurements to a certain year to prevent bias. That’s a separate idea, though, from this idea that we might be *better* at counting all the damage from a storm with time.]

- New process for loss estimation developed by NWS in 2007
- Switch between categorical estimates to whole dollar figure estimates: uses logarithmic at some point?
  - pull up loss data for events pre and post 1995
  - check for changes in reporting for NOAA under Database Details
- Should we move the whole idea of advancements in monetary loss accounting to accounting bias?

## Seasonal Trends:

More temporal bias may be showcased on a short term scale by seasonal differences in number of events reported for certain storm types. For example, NOAA exhibits higher rates of rip currents in the summer

versus the winter although the probability of a rip current occurring during summer may not be inherently higher. It may be that more people attend the beach and swim in the ocean during the summer and are thus more likely to experience and/or report a rip current.

- Seasonal Differences in number of events reported
  - Example of rip currents in summer vs winter
    - \* run for our data and check literature for seasonality of the weather event
    - \* Direct quote: The strength of rip currents can be seasonal. During hurricane season (from June to November) there is a greater chance for rip currents to develop. (“Rip Current,” n.d.)
    - \* Rip currents are related to several environmental factors including waves (surf heights, period, direction), beach (slope, orientation, material), water levels (tidal cycle, tide ranges), winds (affect wave breaking) and wind-driven currents alongshore, others like local coastal configuration and beach and promontories by natural or human made. (“Rip Currents: A Natural Killer on Beaches,” n.d.)
    - \* The most likely scenario for rip hazards is not high surf but high exposure of beachgoers in the warm water of the summer-fall period. When low-energy, longer-period waves (significant wave heights of 0.5 -1.5 meters in 10-15 second sequences) lead to the highest number of rip incidents. During spring/neap tides or very low daily tidal cycles, a mass rescue event can occur, with hundreds of rescues in several locations on a beach, or at several beaches under the same conditions. (“Rip Currents: A Natural Killer on Beaches,” n.d.)
    - \* create table of number reported by lifeguards or media vs month of the year
  - other events that are more or less reported? [BA: We might want to talk about the idea of some events that truly are seasonal in their occurrence, like avalanches and hurricanes, versus some that happen year-round but have varying chance of being reported. Also, you can look through the package vignette and see if you see any other examples of things that might not be reported evenly throughout the year.]
  - coastal flood? high surf?

## Threshold Bias

The varying severity of an event creates threshold bias in the storm events database. Events of larger magnitude and/or damage to human health are better documented, while events of smaller magnitude are less reported because less people are affected (Gall, Borden, and Cutter 2009). Small events may even be excluded due to threshold criteria in the database (Gall, Borden, and Cutter 2009). For example, if a flood has received a presidential disaster declaration, FEMA storm survey teams go to the scene and provide extra damage assessments (Downton, Miller, and Pielke Jr 2005).

- Events of smaller magnitude are less reported because less people are affected (Gall, Borden, and Cutter 2009)
  - may even be excluded due to threshold criteria (Gall, Borden, and Cutter 2009)
  - verify this under NOAA disclaimer

## Accounting Bias

There are discrepancies in the type of loss information collected in the storm events database leading to accounting bias. Until 1994, damage estimates were recorded on a logarithmic scale (Downton, Miller, and Pielke Jr 2005). NOAA now records damage estimates in thousands of dollars. These estimates are comprised

of direct and indirect monetary losses. Direct monetary losses from damage to infrastructure, buildings, crops, etc. are easier to quantify than indirect losses like lost revenue, business closures, societal losses, environmental damage (Gall, Borden, and Cutter 2009). These monetary losses can also be separated into community, state, regional, and global levels (Gall, Borden, and Cutter 2009). The estimates of damage to insured property are typically obtained from local field office reports that often lack quality and accuracy control (Downton, Miller, and Pielke Jr 2005).

- how does noaa report different types of losses?
- what level does noaa report economic losses at?
- How can nonmonetary losses be quantified?
- provide example/table of how NOAA records financial losses
  - can this be found in NOAA disclaimer?

## Geographic Bias

The reporting of events can be affected by geographic location based on whether or not people are present to record the event. The supply of information is greater in areas closer to the weather event (Konisky, Hughes, and Kaylor 2016). There can also be changes at country or state level over time that lead to excluding or double counting events or loss data (Gall, Borden, and Cutter 2009). The NWS changed its reporting strategy from loss estimates by climate region to loss estimates in specific counties where event occurred around 1995 (Gall, Borden, and Cutter 2009). Currently, the smallest unit of aggregation to use all parts of database are Weather Forecasting Offices and there are about 122 nationwide (Konisky, Hughes, and Kaylor 2016). There may be inconsistencies between county regions and weather forecasting offices. NOAA Storm Events states that “a hydrometeorological event will be referenced, minimally, to the nearest hundredth of a mile, to the geographical center (not from the village/city boundaries or limits) of a particular village/city, airport, inland lake, or location providing that the reference point is documented in the Storm Data software location database.”

- Reporting affected by geographic location (Luh et al. 2015)
  - differences between rural/urban
    - \* tornado example
  - There can be changes at country or state level over time that lead to excluding or double counting events or loss data (Gall, Borden, and Cutter 2009)
  - NWS changed its reporting strategy from loss estimates by climate region to loss estimates in specific counties where event occurred (relevant for data in 1995 during switch) (Gall, Borden, and Cutter 2009)
    - \* script for checking event location pre and post 1995
- Supply of information is greater in areas closer to weather event (Konisky, Hughes, and Kaylor 2016)
- Smallest unit of aggregation to use all parts of database are Weather Forecasting Offices and there are about 122 nationwide (Konisky, Hughes, and Kaylor 2016)
  - zone and fips script
- Direct Quote from NOAA website: Storm Data has gone through many changes and versions over the years. The source data ingested into the database are widely varied and leads to many questions about the precision and accuracy of the location data (“Storm Data Faq Page,” n.d.).
- Direct Quote: 2.4 Location. A hydrometeorological event will be referenced, minimally, to the nearest hundredth of a mile, to the geographical center (not from the village/city boundaries or limits) of a

particular village/city, airport, inland lake, or location providing that the reference point is documented in the Storm Data software location database.

- this concept and hazard bias can be grouped together

## Systemic Bias

- Differences in initial data collection and compilation create difficulties in comparing databases
  - Source and how losses are computed
  - Actual dollar losses vs inflation adjusted losses
  - Whole dollars vs loss categories

## References

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