SOA Research Institute

Catastrophe and Climate

# Actuarial Weather Extremes: December 2021

## High Temperatures, Moderating Drought, Extreme December Storm Activity

January 2022

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## High Temperatures, Moderating Drought, Extreme December Storm Activity

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## High Temperatures, Moderating Drought, Extreme December Storm Activity

### Overview

This report examines weather conditions for high temperature, drought conditions, and late in the year tornadoes that are extreme in an historical context.

**Record Monthly December High Temperature:** As gathered from Global Historical Climatology Network (GHCN) stations, several Central U.S. States experienced the highest monthly average daily high temperatures (TMAX) in December 2021 vs Decembers dating back to 1960.

**Drought Conditions Moderate in Western U.S. States:** In the Western U.S. states, several areas of the most severe drought conditions, Extreme Drought and Exceptional Drought, moderated to lesser drought conditions. Figure 2 shows the shift in coverage areas from these extreme to more moderate conditions. Consistent with these changes, Figure 3 shows increased streamflow activity in areas of the Western U.S.

**December Tornado, Wind and Hail-storm Activity:** The December 10-11 tornado activity in the Arkansas, Tennessee and Kentucky area and December 15 tornado and derecho activity were significant in terms of their late in the year timing, and also in terms of their number and losses.

**2021 Billion Dollar Disasters:** There were twenty "Billion-dollar Disaster" events in 2021 totaling $145 billion, the third most in dollar terms since 1980. [1] One of the "Events" was the Western U.S. Wildfires which included the December 2021 Marshall Fire, the most destructive wildfire that has been recorded in Colorado. [2]

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[1] https://www.ncdc.noaa.gov/billions/
[2] Events | Billion-Dollar Weather and Climate Disasters | National Centers for Environmental Information (NCEI) (noaa.gov)

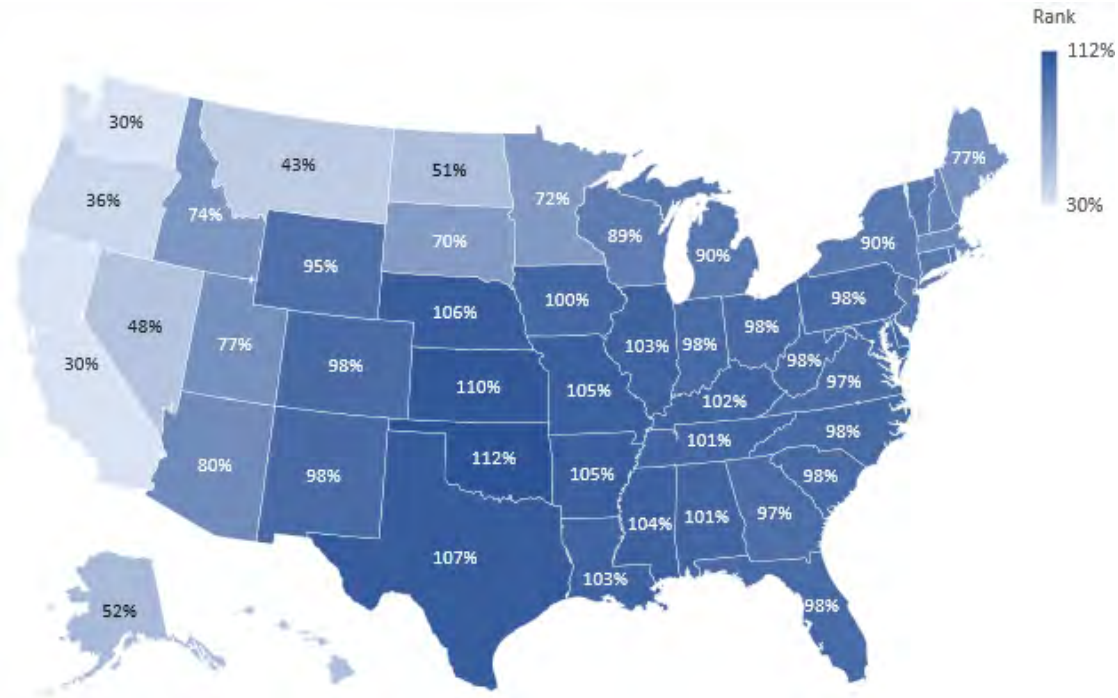
## Record December High Temperature

As seen in Figure 1, December 2021 was a record warm month when viewing December average monthly temperatures dating back to 1960. Many states had from five to more than ten percent increases during December 2021 vs that state's previous high December TMAX average in the period 1960-2020. As we will see later, these warm temperatures were in areas which also had high storm activity in December 2021. As explained by NOAA, tornado likelihood on a December day is 12%-15%, vs 90% on an early June day. [3]

Nationwide, December 2021 in the U.S. was the warmest December looking back to 1960. As shown in Table 1, The December U.S. TMAX of 49.8 degrees Fahrenheit was 102.4% of the previous high of 48.6 degrees Fahrenheit.

Figure 1

PERCENTILE RANKING FOR GHCN MONTHLY DAILY HIGH TEMPERATURE (TMAX) IN DECEMBER 2021 AMONG DECEMBERS FROM 1960-2021. GREATER THAN 100% IS THE AMOUNT OF A NEW RECORD AMOUNT (FOR EXAMPLE NEBRASKA IS 106% OF THE PREVIOUS RECORD HIGH BACK TO 1960).




Source: GHCN station data (Accessed January 7, 2022). https://www1.ncdc.noaa.gov/pub/data/ghcn/daily/

[3] The December 2021 tornado outbreak, explained | National Oceanic and Atmospheric Administration (noaa.gov)

Table 1

GHCN TMAX TOTAL U.S. AVERAGE DECEMBER 2021 VS DECEMBER MONTHLY AVERAGES 1960-2021.

| Country | Degrees F | Recent-Avg | Rank | Percentile | Historical Min | Historical Avg | Historical Max |
|---|---|---|---|---|---|---|---|
| United States | 49.8 | 6.8 | 1 | 102.4% | 34.2 | 43.0 | 48.6 |

Source: GHCN station data (Accessed January 7, 2022). https://www1.ncdc.noaa.gov/pub/data/ghcn/daily/

## Drought Conditions Moderate in Western U.S. States

As seen in Figure 2, drought conditions in the Western U.S. have moderated over the month of December. For example, the most severe drought condition (Exceptional Drought) shrunk from covering 16.28% of the Western U.S. area to 5.81% of the area. By contrast, areas of No Drought or less extreme conditions increased in coverage area of the Western U.S. region.

Looking at Figure 3, shows areas of higher and lower stream flow in November and December 2021 vs the last 30 years. Areas with drought moderation are consistent with areas of more streamflow in December vs November 2021.

Figure 2

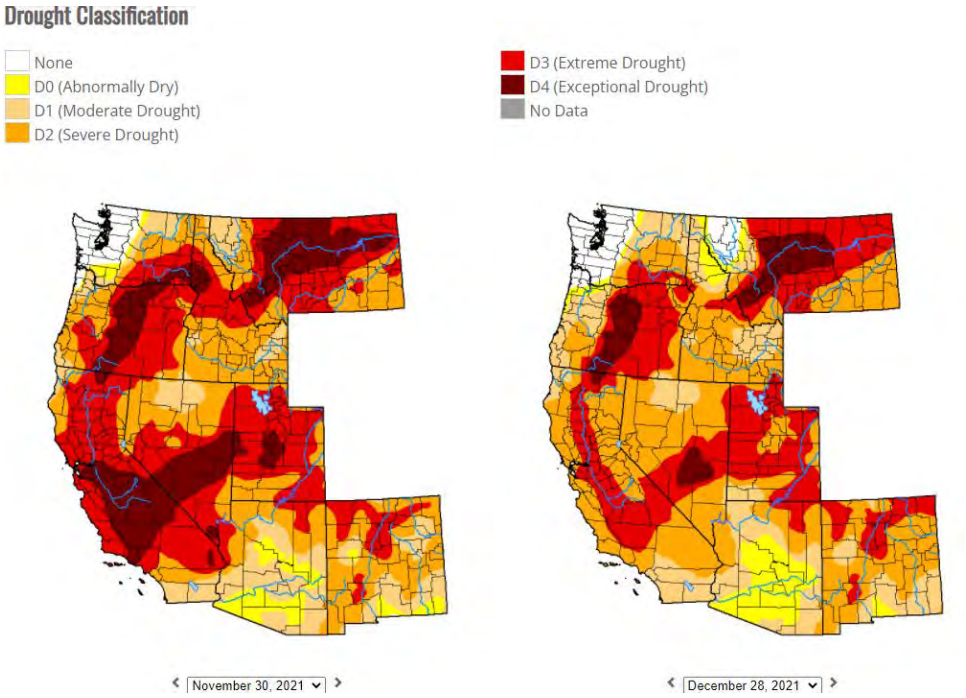
COMPARISON OF DROUGHT CONDITIONS IN THE WESTERN U.S. OVER DECEMBER 2021. AMOUNTS IN THE TABLE BELOW ARE PERCENTAGE OF THE WESTERN U.S. IN EACH DROUGHT CLASSIFICATION

Cumulative Category Percentages

| Week | None | D0-D4 | D1-D4 | D2-D4 | D3-D4 | D4 | DSCI |
|---|---|---|---|---|---|---|---|
| 2021-11-30 | 2.54 | 97.46 | 93.58 | 79.56 | 49.92 | 16.28 | 337 |
| 2021-12-28 | 4.14 | 95.86 | 89.41 | 72.36 | 33.66 | 5.81 | 297 |
| Change | 1.60 | -1.60 | -4.17 | -7.20 | -16.26 | -10.47 | -40 |

Percentages by Category

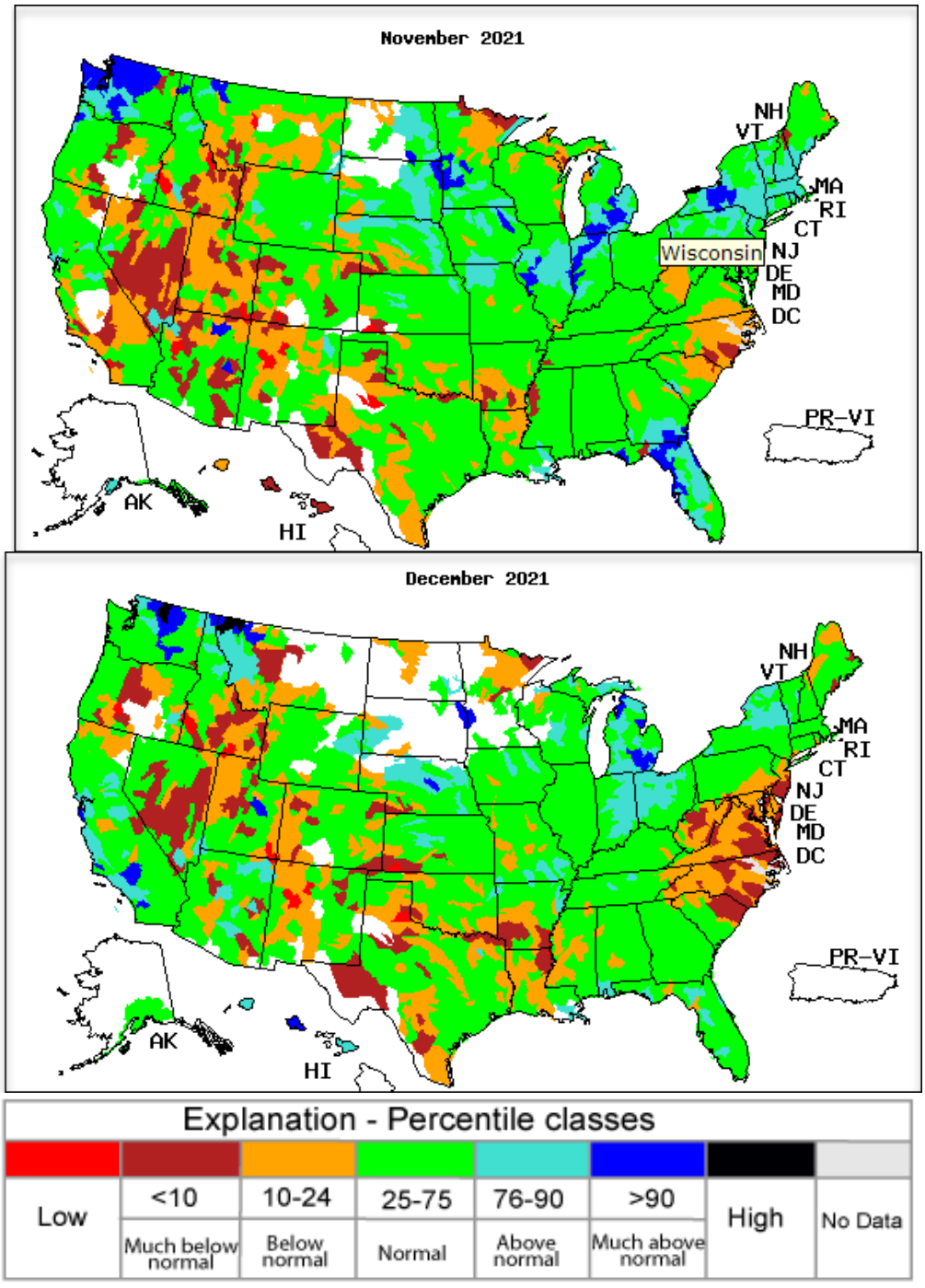
| Week | None | D0-D4 | D1-D4 | D2-D4 | D3-D4 | D4 | DSCI |
|---|---|---|---|---|---|---|---|
| 2021-11-30 | 2.54 | 3.88 | 14.02 | 29.64 | 33.65 | 16.28 | 337 |
| 2021-12-28 | 4.14 | 6.46 | 17.05 | 38.70 | 27.85 | 5.81 | 297 |
| Change | 1.60 | 2.58 | 3.03 | 9.06 | -5.80 | -10.47 | -40 |




Source (Accessed January 14, 2022): https://droughtmonitor.unl.edu/Maps/CompareTwoWeeks.aspx The U.S. Drought Monitor is jointly produced by the National Drought Mitigation Center at the University of Nebraska Lincoln, the United States Department of Agriculture, and the National Oceanic and Atmospheric Administration. Map courtesy of NDMC.

Figure 3

USGS STREAMFLOW IN NOVEMBER 2021 AND THEN IN DECEMBER 2021 VS HISTORICAL DATA PERCENTILE CLASSES USING STREAMGAGES WITH AT LEAST 30 YEARS OF DATA




Source: United States Geological Survey (USGS) USGS WaterWatch -- Streamflow conditions Date Accessed: 12/8/21 and 1/14/22

## December Tornado, Wind and Hail-Storm Activity

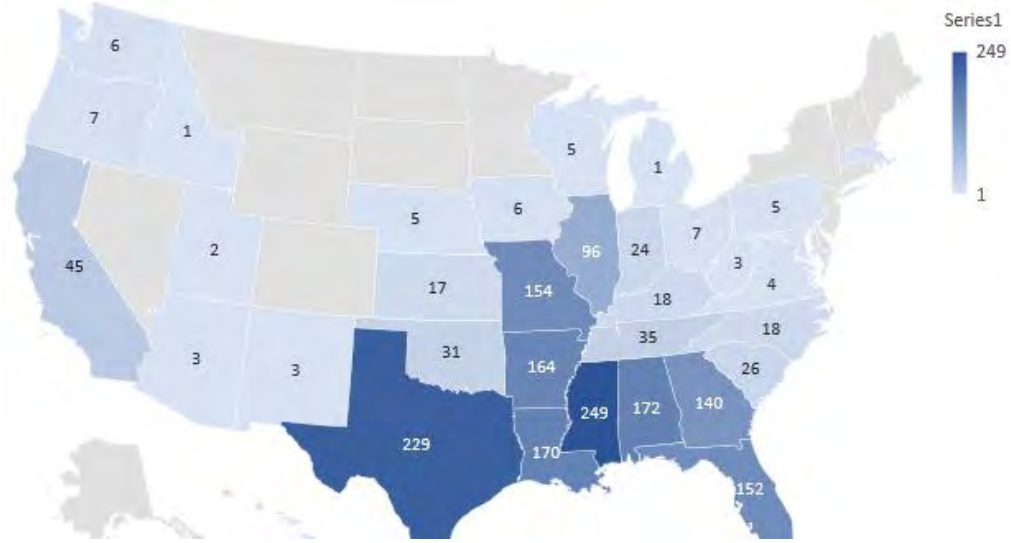
Comparing the historical database of tornado activity and the recent activity, Figure 4 shows the number of December tornadoes during the period 1950-2020 for each U.S. State. Figure 5 shows the number of tornado sightings reported during the month of December 2021, which are considered preliminary. Since one tornado could lead to multiple sightings, it is difficult to compare the figures. However, since the sightings have individual locations recorded, they do give a good sense of how widespread the tornado activity was. Given this, we can see that December 2021 looks to have been very active in certain states when viewed in an historical context. Also, when viewed against the areas of concentration of historical confirmed December tornadoes, the December 2021 tornadoes looks to be focused in areas further north.

Figure 6 shows the Wind, Hail, and Tornado sighting activity on December 10, which was a very active storm day. You can see the straight lines of tornado sightings from Arkansas and into Tennessee and Kentucky. One tornado on December 10 caused 55+ deaths in the Paducah, Kentucky coverage area, according to the National Weather Service. [4] As reported by AccuWeather, losses from the widespread tornado activity of December 10-11, from both direct and indirect sources, could reach as much as $18 billion. [5]

In addition to the tornado activity, December 15, 2021 hail and wind activity was classified as a Derecho by the National Weather Service. [6] A derecho is typically characterized by straight-line wind damage, associated with fast moving thunderstorm activity, over a large path of damage, and exceeding a threshold of wind strength. December 15 was the first derecho in December anywhere is the U.S., also according to the National Weather Service. [7] Figure 7 shows the derecho storm activity, in addition to the tornado activity in a core of Midwestern U.S. states on December 15, 2021.

**Figure 4**

U.S. DECEMBER TORNADOES 1950-2020

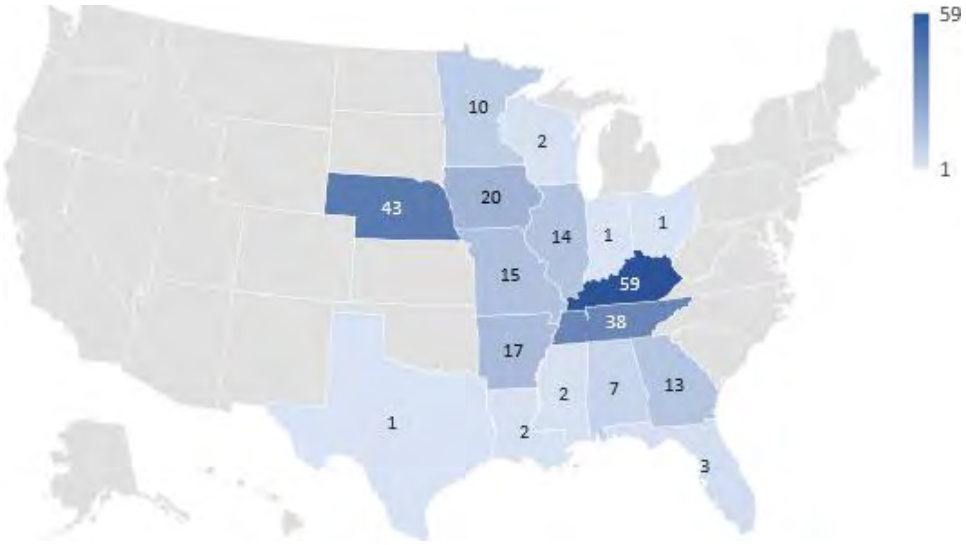



Source: NOAA National Center for Environmental Information: https://www.ncdc.noaa.gov/stormevents/ Date Accessed: 1/5/2022

[4] National Weather Service. Accessed January 18, 2022. Dec 10-11 2021 Tornado Event (weather.gov)
[5] AccuWeather. December 14, 2022. Total economic impacts of historic tornado outbreak about $18 billion | AccuWeather
[6] National Weather Service. Accessed January 17, 2022. Severe Storms and Extreme Winds - December 15, 2021 (weather.gov)
[7] National Weather Service. Accessed January 17, 2022. Severe Storms and Extreme Winds - December 15, 2021 (weather.gov)

Figure 5

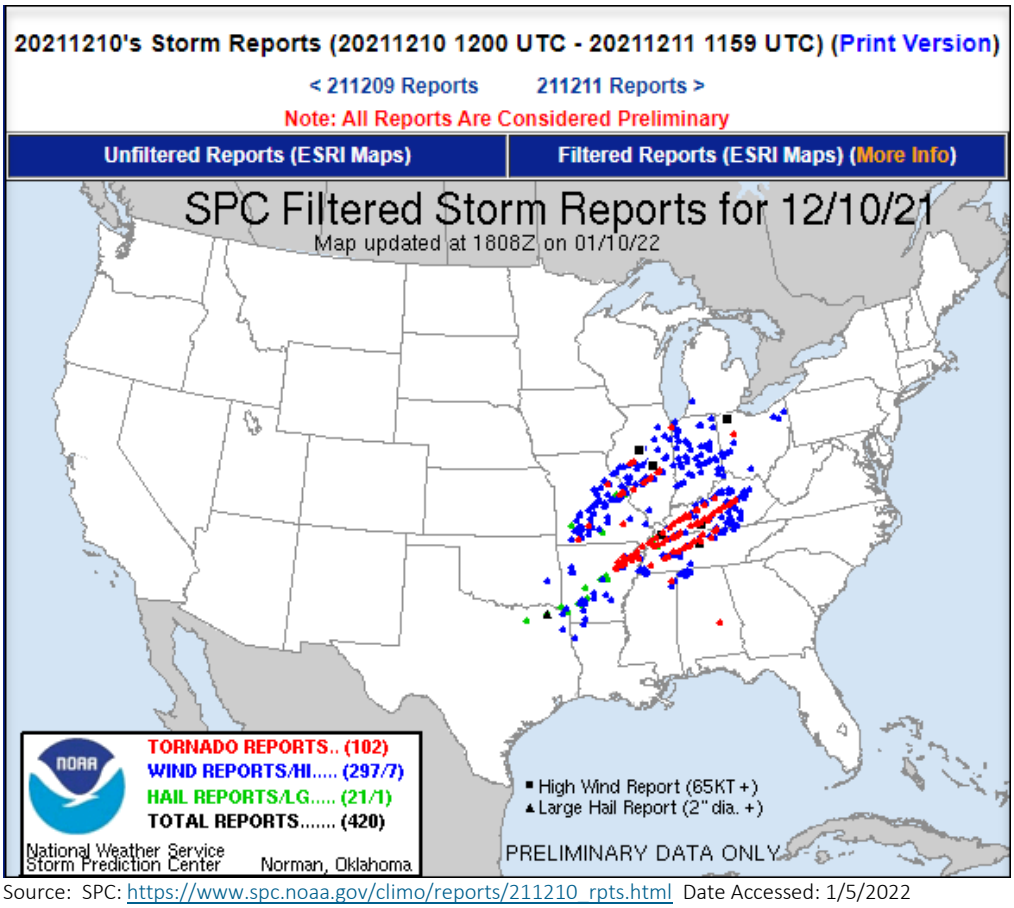
U.S. DECEMBER TORNADO SIGHTINGS IN 2021




Source: NOAA Storm Prediction Center (SPC): https://www.spc.noaa.gov/climo/reports/211210_rpts.html Date Accessed: 1/5/2022

Figure 6

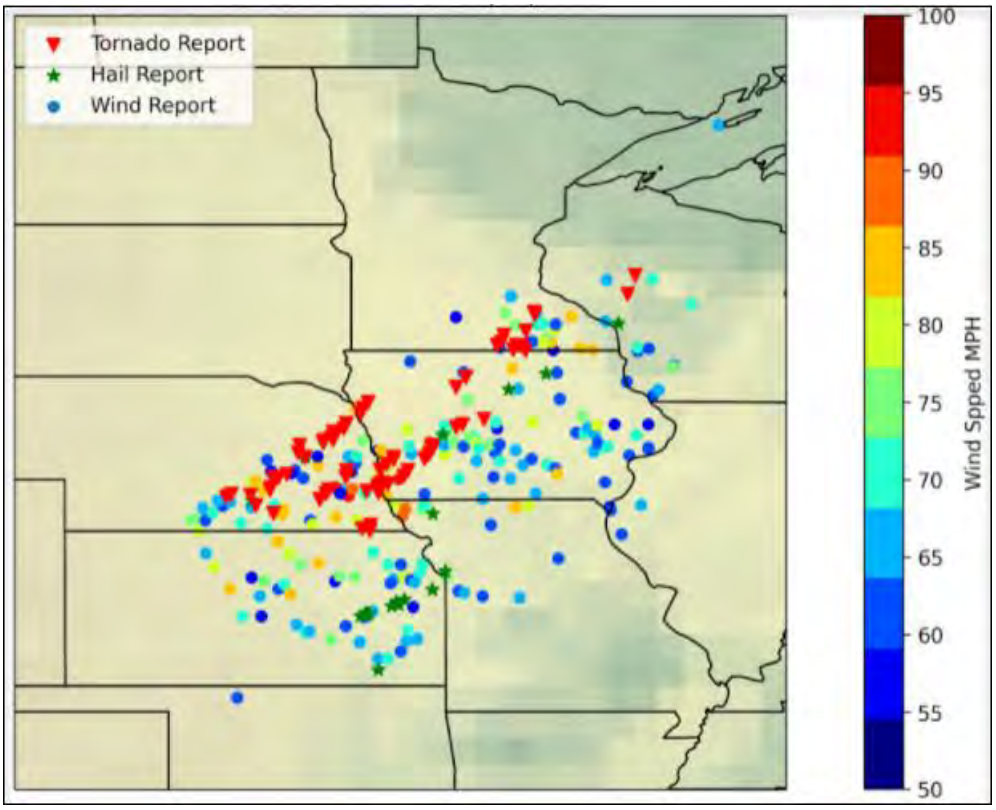
U.S. DECEMBER WIND, HAIL, AND TORNADO SIGHTINGS IN 2021




Source: SPC: https://www.spc.noaa.gov/climo/reports/211210_rpts.html Date Accessed: 1/5/2022

Figure 7

MIDWEST FOCUS OF DERECHO: TORNADO, HAIL, WIND REPORT LOCATIONS DECEMBER 15, 2021



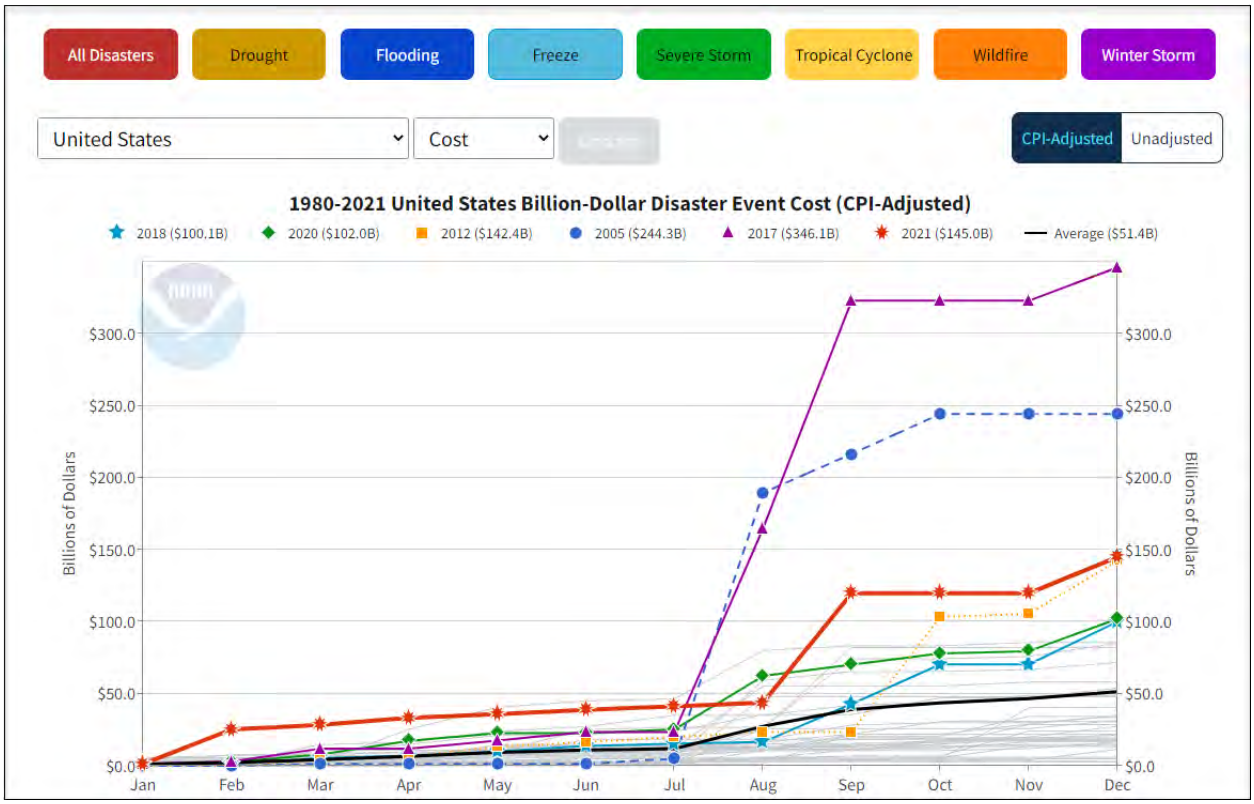

Source: SPC: https://www.spc.noaa.gov/climo/reports/211215_rpts.html Date Accessed: 1/5/2022

## Billion Dollar Disasters in 2021

The Marshall Fire in the Boulder Colorado area was part of the Western Wildfires event in 2021 that led to more than $10 billion damage in total. This event was one of twenty Billion-dollar events in 2021 that totaled $145 billion, the third costliest Billion-dollar event year since 1980. [8] (see Figure 8)

Figure 8

U.S. BILLION-DOLLAR EVENTS 1980-2021




Source: NOAA National Centers for Environmental Information (NCEI) U.S. Billion-Dollar Weather and Climate Disasters (2022). https://www.ncdc.noaa.gov/billions/, DOI: 10.25921/stkw-7w73 Accessed on January 17, 2022.

[8] NOAA National Centers for Environmental Information (NCEI) U.S. Billion-Dollar Weather and Climate Disasters (2022). https://www.ncdc.noaa.gov/billions/, DOI: 10.25921/stkw-7w73

## Data

**Temperature data** used in this report was obtained from the **Global Historical Climatology Network** ("GHCN") weather database, which provides daily weather observations from over 100,000 weather stations worldwide, covering over 180 countries. The database is publicly available through the National Oceanic and Atmospheric Administration (NOAA) via the following FTP site:

Source: https://www1.ncdc.noaa.gov/pub/data/ghcn/daily/

Filename: ghcnd_all.tar.gz

### National Oceanic and Atmospheric Administration (NOAA) National Weather Service Storm Prediction Center Reports

SPC: https://www.spc.noaa.gov/climo/reports/211113_rpts.html
This page will show all Tornado, Wind, and Hail reports for 11/13/2021
Select the "211114 Reports" button at the top to move to the next day

### National Center for Environmental Information

NOAA National Center for Environmental Information: https://www.ncdc.noaa.gov/stormevents/

1. Select the Event Type, e.g. Tornado
2. Select the State of interest or leave un-selected to see all states
3. Select the Date Range of interest
    1. From 1950 through 1954, only tornado events were recorded
    2. From 1955 through 1995, only tornado, thunderstorm, wind, and hail events were recorded
    3. From 1996 to present day, 48 event types are recorded
    d. Results are limited to 500, so you December have to limit the date range in order to see all results.

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