SOA Research Institute

Catastrophe and Climate

Actuarial Weather Extremes: August 2021

Historic High Temperature, Impactful Storms and Precipitation

September 2021

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Historic High Temperature, Impactful Storms and Precipitation

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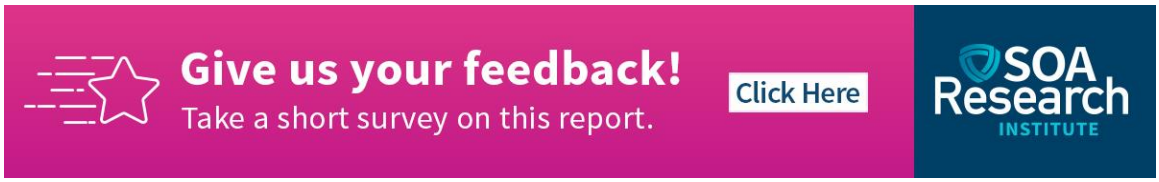

CONTENTS

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Overview

This report examines weather conditions for daily maximum and minimum temperature (TMAX and TMIN), inland storm activity from wind, hail and tornadoes, record precipitation, tropical cyclone activity and the resultant flooding.

Hottest Summer in U.S. and Canada Looking Back to 1960: Using Global Historical Climatology Network (GHCN) data back to 1960, the three-month period June 1 to August 31, 2021 was the hottest "full meteorological summer" in the period of available data 1960-2021 for both the U.S. and for Canada as a whole.

Record Precipitation Levels for August: As seen in Figure 3, many GHCN weather stations had August monthly precipitation records in 2021 in the context of Augusts in 1960-2021. A large number of stations were in or near Tennessee. Figure 4 further illustrates the streamflow impacts during August 2021 showing that the areas of heavy monthly precipitation led to much above normal streamflow.

August Storm Impacts: As seen in Tables 2, 3, 4 and Figures 5 and 6, August 2021 was an active month for Wind, Hail, Tornadoes and Flooding. Many of the storms were coincidental with Tropical Storm Fred moving through the Southeastern U.S. and into Pennsylvania in mid-August.

Hurricane Ida: Hurricane Ida brought severe precipitation, tornadoes, and moderate and major flooding from Louisiana to New York over the August 28 to September 5, 2021 period. Figure 7 shows the geographic distribution of observed events. As reported by AP NEWS, one risk modeling company estimates damages could exceed $50 billion, with an estimated $18 billion insured. [1] As of September 9, the official death toll attributed to Ida was 82. [2]

Other Extreme Catastrophe: While not a "weather" event, it is noteworthy that outside of the US, there was a tragic 7.2 magnitude earthquake that killed 2,200 people in Haiti on August 14, 2021. The U.S. Agency for International Development sent $32 million in aid to support humanitarian efforts. [3] Relief and recovery efforts were slowed by the arrival of Tropical Depression Grace two days later.

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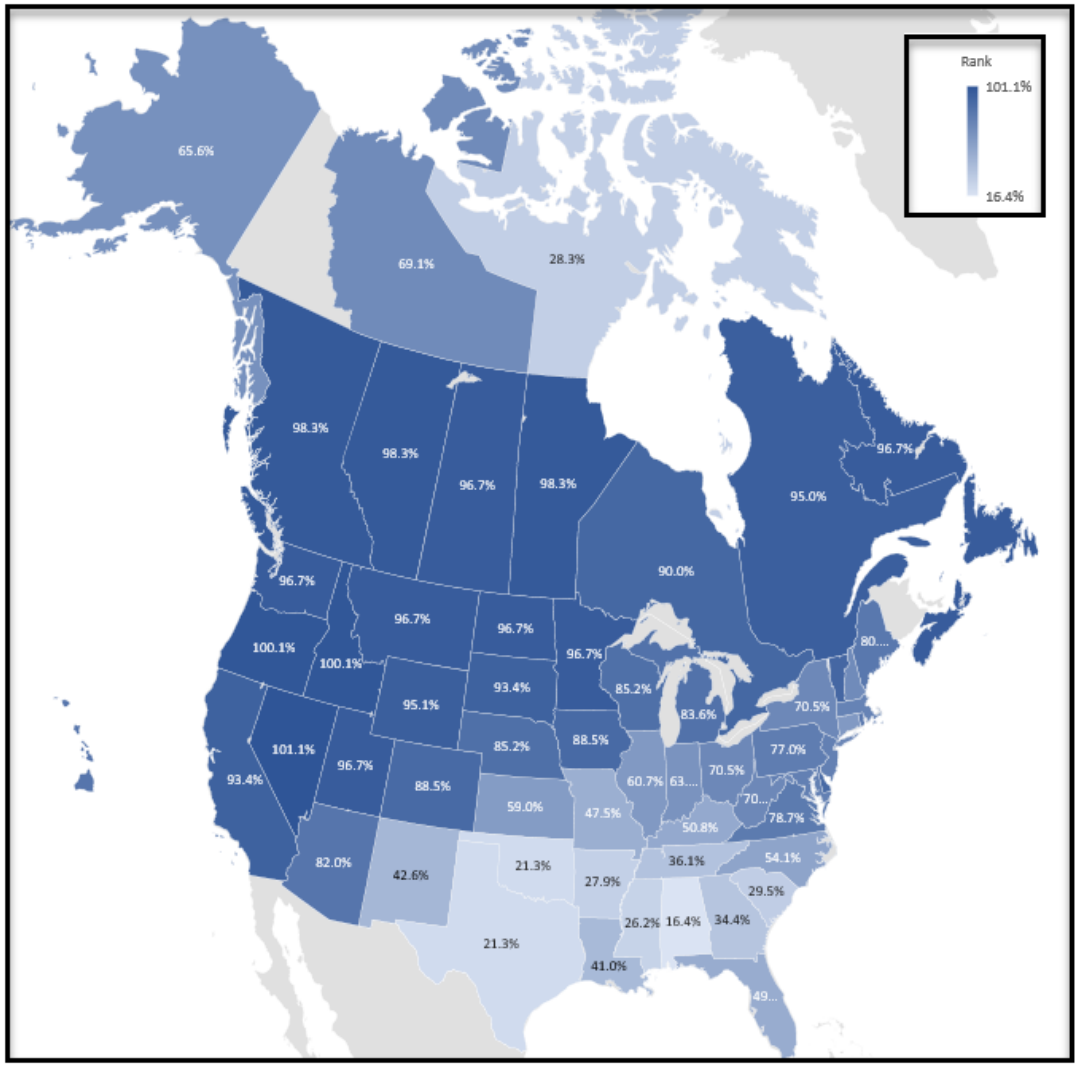
[1] AP NEWS. September 1, 2021. After Ida, small recovery signs amid daunting destruction (apnews.com)
[2] CBS News. September 9, 2021. Hurricane Ida death toll jumps to 82 - CBS News
[3] Reliefweb. August 26, 2021. USAID provides $32 million to respond to Haiti earthquake - Haiti | ReliefWeb

Hottest Summer in U.S. and Canada Looking Back to 1960

As seen in Figure 1, and in Table 1, the full meteorological summer (June 1 to August 31) was the warmest in 2021 for any year back to 1960 for several U.S. states (Figure 1) and for each of the U.S. and Canada as a whole (Table 1). This is derived from the average Daily Maximum Temperature (TMAX) for the states and provinces and the average of the June through August TMAX and Daily Minimum Temperature (TMIN) ranked during Augusts of the 62-year period 1960-2021. As reported by The Weather Channel, Summer 2021 was the hottest in 126 years of record keeping in the continental U.S. [4] As shown in Figure 2, the areas of state record temperatures (Oregon, Idaho, Nevada) are consistent with the progression of drought conditions.

Figure 1

GHCN PERCENTILE RANKINGS OF 2021 DURING 1960-2021 FOR U.S. STATES AND CANADIAN PROVINCES DAILY MAXIMUM TEMPERATURE (TMAX) OVER THE METEOROLOGICAL SUMMER PERIOD (JUNE, JULY, AUGUST)



Source: GHCN station data (Accessed September 7, 2021). https://www1.ncdc.noaa.gov/pub/data/ghcn/daily/

[4] The Weather Channel. September 8, 2021. https://weather.com/news/climate/news/2021-09-09-summer-hottest-on-record-united-states-noaa

Table 1

AVERAGE OF DAILY MAXIMUM TEMPERATURE (TMAX) AND DAILY MINUMUM TEMPERATURE (TMIN) FOR JUNE 1-AUGUST 31 RANKING DURING YEARS 1960 TO 2021 FOR U.S. AND FOR CANADA

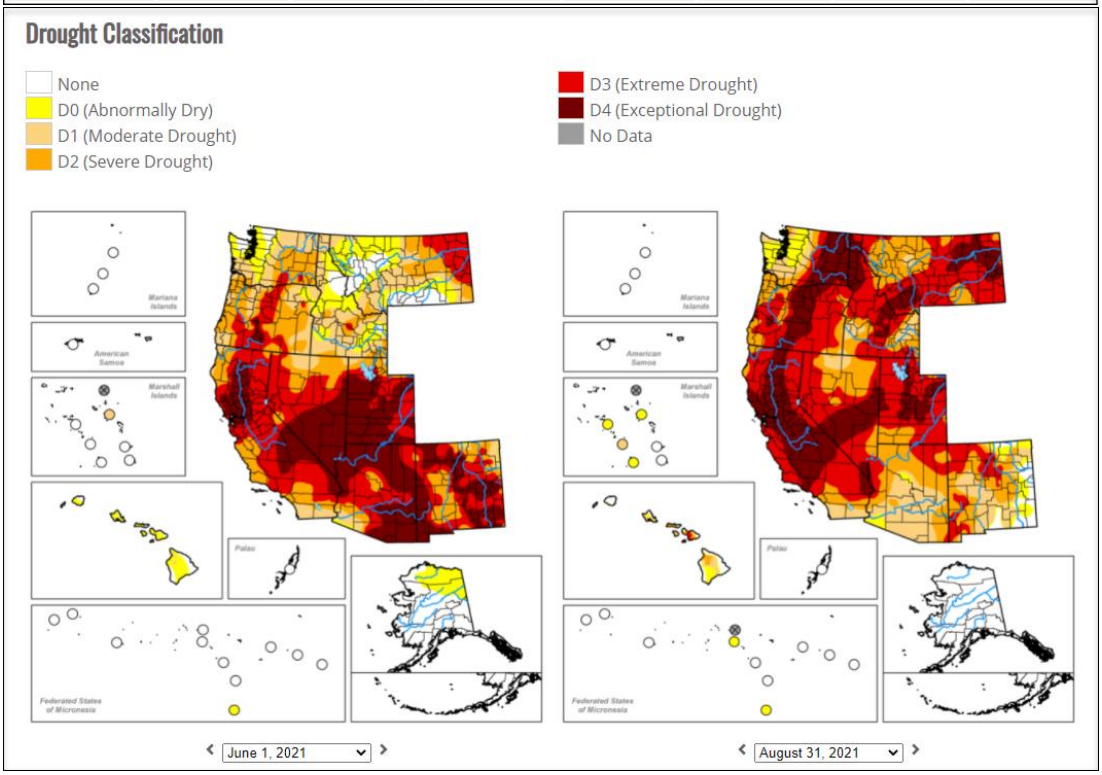
Year	Average (TMAX, TMIN) Canada	Average (TMAX, TMIN) US	Rank Canada	Rank U.S.
2021	65.12	73.92	1	1
2011	61.53	73.87	35	2
2012	63.25	73.86	9	3
2016	64.24	73.82	4	4
2010	61.44	73.68	37	5
1988	62.38	73.66	20	6
2020	#N/A	73.60	#N/A	7
2018	64.27	73.50	3	8
2006	63.48	73.43	7	9
2002	62.60	73.30	14	10

Source: GHCN station data (Accessed September 7, 2021). https://www1.ncdc.noaa.gov/pub/data/ghcn/daily/

Figure 2

COMPARISON OF DROUGHT CONDITIONS IN THE WESTERN U.S. DURING JUNE 1 TO AUGUST 31, 2021

Week	None	D0-D4	D1-D4	D2-D4	D3-D4	D4	DSCI
2021-06-01	31.99	68.01	54.61	45.04	33.03	16.38	217
2021-08-31	38.23	61.77	59.58	52.09	37.87	14.27	226
Change	6.24	-6.24	4.97	7.05	4.84	-2.11	9



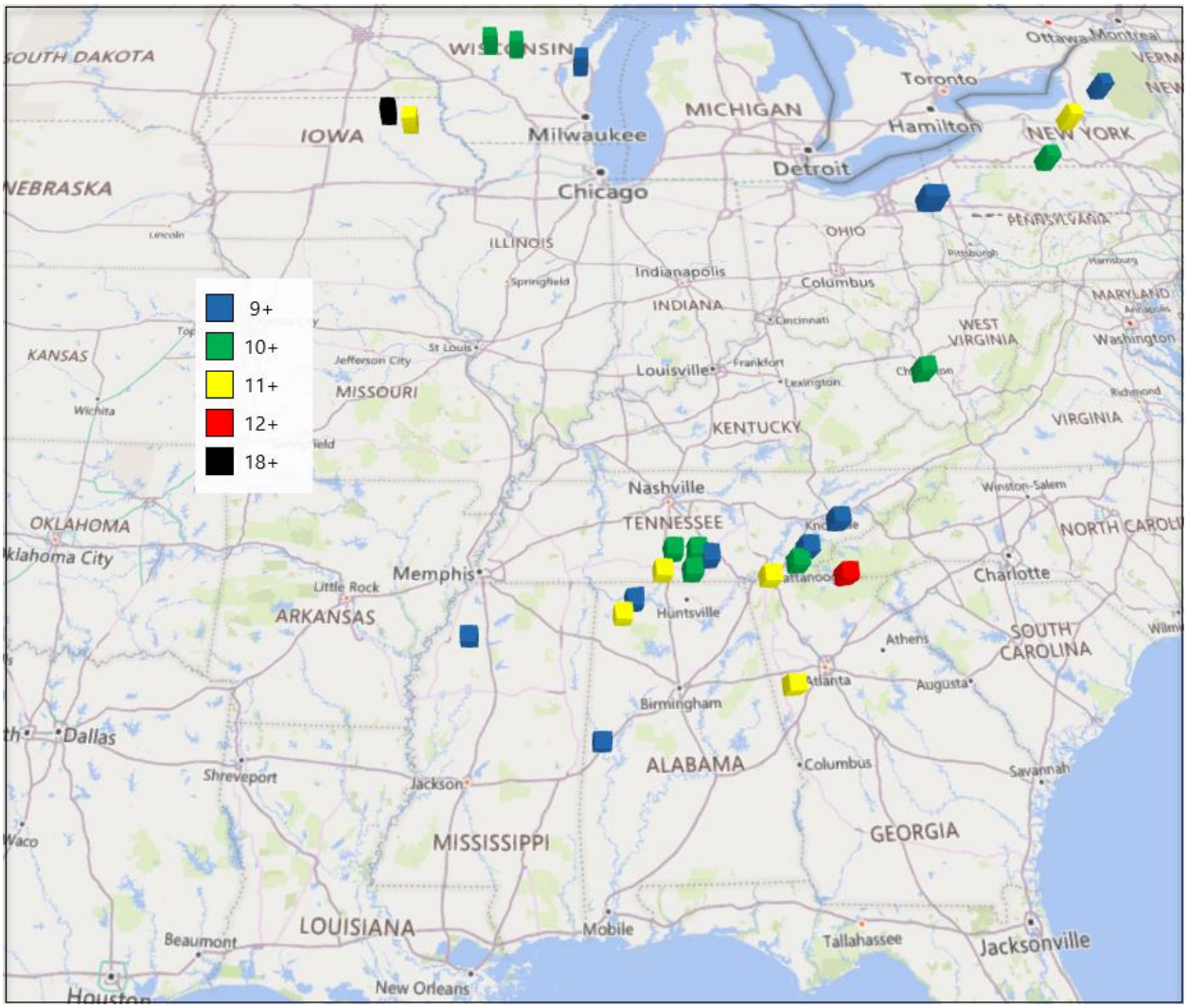
Source: https://droughtmonitor.unl.edu/Maps/CompareTwoWeeks.aspx The U.S. Drought Monitor is jointly produced by the National Drought Mitigation Center at the University of Nebraska Lincoln, the United States Department of Agriculture, and the National Oceanic and Atmospheric Administration. Map courtesy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

Record Precipitation Levels for August

As seen in Figure 3, many stations had August monthly precipitation records in 2021 vs the period 1960-2021. The large number of stations were in or near Tennessee. Figure 4 further illustrates the streamflow impacts during August 2021 showing that the areas of heavy monthly precipitation led to much above normal streamflow.

Figure 3

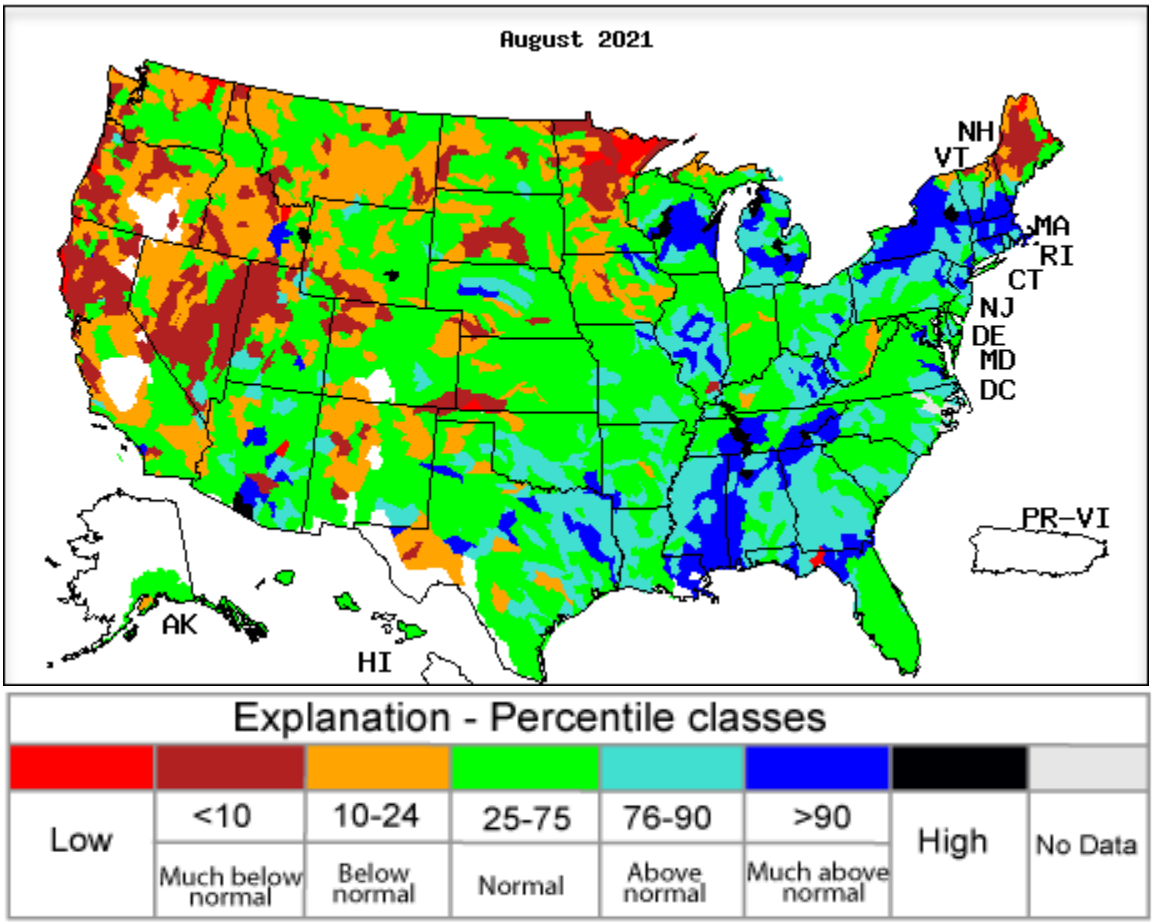
GHCN STATIONS WITH AUGUST MONTHLY PRECIPITATION RECORDS DURING AUGUST 2021 VERSUS AUGUSTS IN THE PERIOD 1960-2021 WHICH EXCEEDED NINE INCHES OF PRECIPITATION FOR THE MONTH



Source: GHCN station data (Accessed September 7, 2021). https://www1.ncdc.noaa.gov/pub/data/ghcn/daily/

Figure 4

UNITED STATES GEOLOGICAL SURVEY (USGS) STREAMFLOW IN AUGUST 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: 9/15/2021

August Storm Impacts

Tropical Storm Fred made landfall on August 16, 2021 in Florida and weakened into a Tropical Depression that moved north over Georgia, South Carolina, North Carolina, and Pennsylvania. As the storm moved over these states, there were several reported tornadoes and flood events. Tornado reports peaked on August 17, 2021, with the National Oceanic and Atmospheric Administration (NOAA) Storm Prediction Center (SPC) recording 15 reports in South Carolina. Flood events continued in Georgia through August 22, 2021. Table 2 shows that Georgia had the most activity during the observation period, while Table 3 shows that August 17, 2021 was the most active day due to the elevated number of Tornado reports in South Carolina. From the high rainfall and flooding in North Carolina and South Carolina, there were 6 fatalities [5] and estimated $300m in damage [6] in one community.

[5] WYFF News 4. August 27, 2021 Haywood County, officials recover final victim of tropical storm (wyff4.com)
[6] Asheville Citizen Times. August 23, 2021. Haywood County switches to search and recovery, 1 missing in flooding (citizen-times.com)

Table 2

FLOOD AND TORNADO COUNT BY STATE AND DATE

Date	GA	NC	SC	PA	Total
20210816	11	0	0	0	11
20210817	5	3	15	0	23
20210818	2	4	0	7	13
20210819	2	1	0	0	3
20210820	2	1	0	0	3
20210821	2	0	0	0	2
20210822	1	0	0	0	1
Total	25	9	15	7	56

Source: NOAA SPC (Accessed September 1, 2021). https://www.spc.noaa.gov/climo/reports/210816_rpts.html

Table 3

STORM EVENT COUNT BY DATE AND EVENT TYPE

Date	Tornado	Flood	Moderate Flood	Total
20210816	8	3	0	11
20210817	20	3	0	23
20210818	7	5	1	13
20210819	0	2	1	3
20210820	0	3	0	3
20210821	0	2	0	2
20210822	0	1	0	1
Total	35	19	2	56

Source: NOAA SPC (Accessed September 1, 2021). https://www.spc.noaa.gov/climo/reports/210816_rpts.html

From August 10, 2021 to August 13, 2021, there were a significant number of Hail, Tornado, and, in particular, Wind reports. In Midwestern and Eastern states, which each had over 50 storm events, there were a total of 1,705 NOAA SPC reports over these four days. Table 4 shows that more than one-third of the reports occurred on August 11, 2021, with the highest number of reports on that date being in Michigan and Ohio. Figure 5 shows the geographic distribution of these reports during the four-day period for the continental U.S.

Table 4

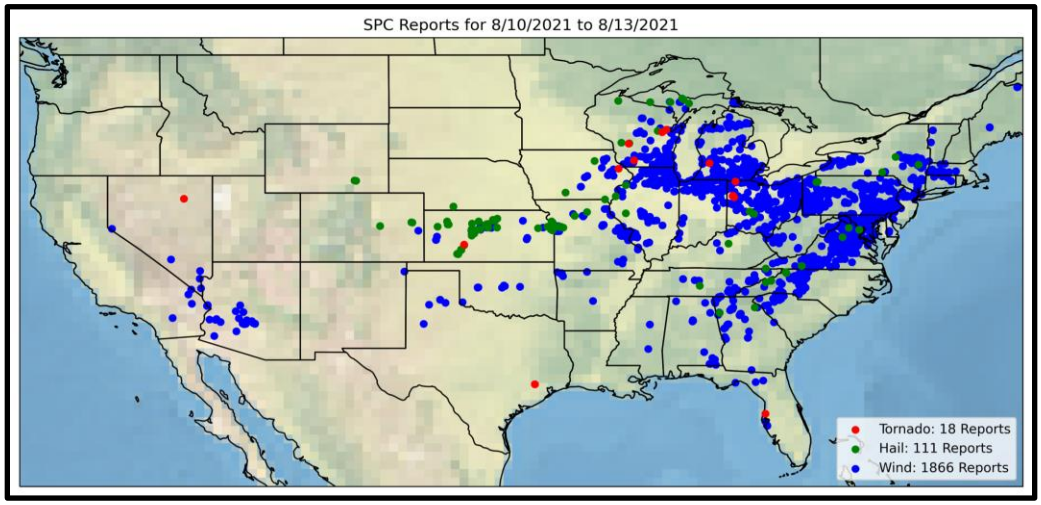
WIND, HAIL AND TORNADO REPORTS BY STATE AND DATE

State	20210810	20210811	20210812	20210813	Total
IL	52	76	45	-	173
IN	17	81	6	-	104
KS	39	2	45	-	86
MD	19	34	-	69	122
MI	57	116	1	1	175
MO	3	2	77	-	82
NC	9	15	24	4	52
NY	18	12	17	47	94
OH	14	124	38	37	213
PA	51	57	100	57	265
VA	55	72	10	117	254
WI	52	33	-	-	85
Total	386	624	363	332	1,705

Source: NOAA SPC (Accessed September 1, 2021). https://www.spc.noaa.gov/climo/reports/210810_rpts.html

Figure 5

NOAA SPC TORNADO, WIND AND HAIL REPORTS FROM AUGUST 10, 2021 TO AUGUST 13, 2021

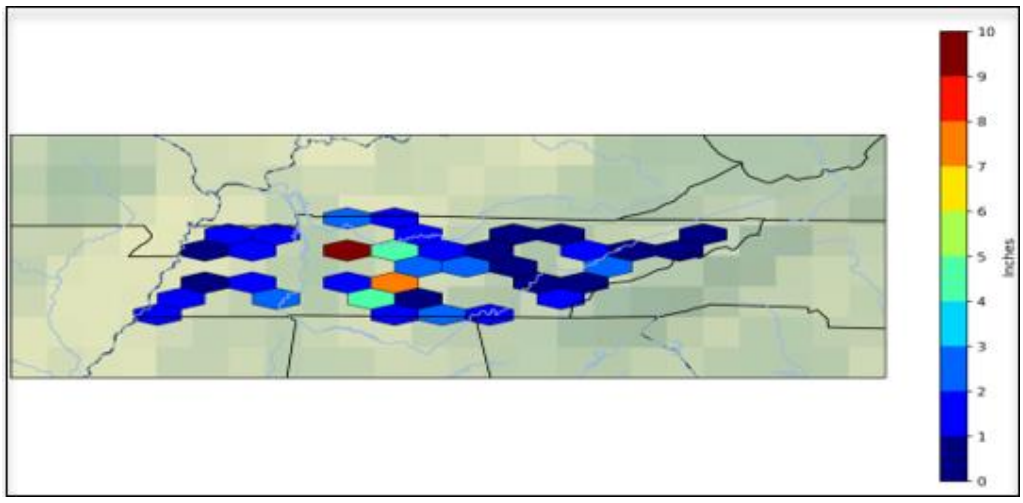


Source: NOAA SPC (Accessed September 1, 2021). https://www.spc.noaa.gov/climo/reports/210810_rpts.html

From August 18, 2021 to August 22, 2021, there was extensive precipitation through Tennessee, with one Automated Surface Observing System (ASOS) station recording 8.17 inches on August 21, 2021. Figure 6 shows the concentration of precipitation in Western Central Tennessee. The death toll from subsequent flooding has been set at 20 and a federal disaster was declared for Humphreys County, TN. [7] 2021 has seen the highest number of deaths from flooding in Tennessee since 1996. [8]

Figure 6

ASOS PRECIPITATION TOTALS IN TENNESSEE FROM AUGUST 18, 2021 TO AUGUST 22, 2021



Source: IA State Automated Surface Observing System (ASOS): (Accessed September 1, 2021). https://mesonet.agron.iastate.edu/request/download.phtml

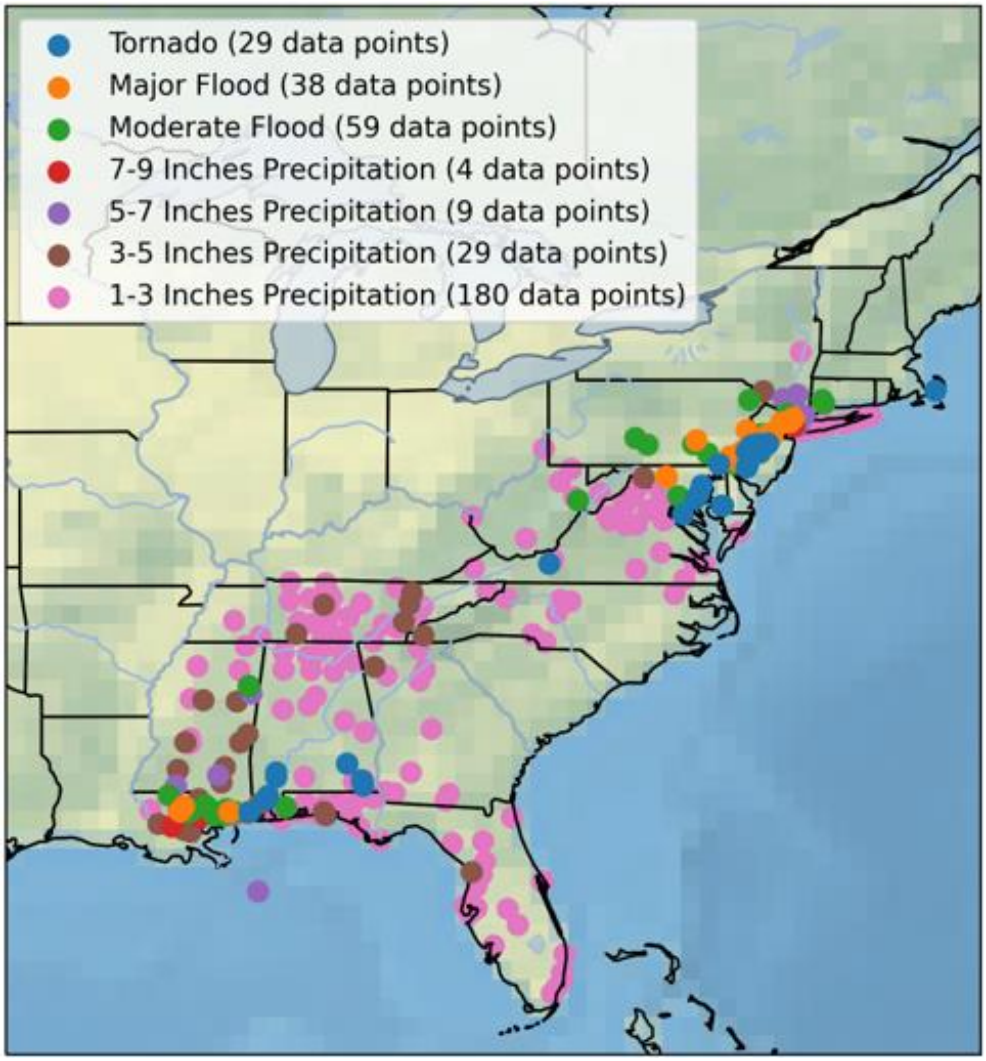
[7] WKRN.com. August 24, 2021. 20 people dead, 0 considered missing after Middle Tennessee flooding (wkrn.com)
[8] NOAA National Weather Service. Tennessee Flash Flood Stats (weather.gov)

Hurricane Ida (Date of Landfall: August 29, 2021)[9]

Hurricane Ida brought severe precipitation, tornadoes, and moderate and major flooding from Louisiana to New York over the 8/28/2021 to 9/5/2021 period. Figure 7 shows the geographic distribution of observed events. As reported by AP NEWS, one risk modeling company estimates damages could exceed $50 billion, with an estimated $18 billion insured. [10] As of September 9, 2021, the official death toll attributed to Ida was 82. [11]

Figure 7

DAILY WEATHER OBSERVATIONS FOR HURRICANE IDA FROM AUGUST 28, 2021 TO SEPTEMBER 5, 2021



Sources (Accessed September 1, 2021): IA State Automated Surface Observing System (ASOS) https://mesonet.agron.iastate.edu/request/download.phtml , United States Geological Survey (USGS) https://waterservices.usgs.gov/rest/IV-Test-Tool.html ,NOAA SPC https://www.spc.noaa.gov/climo/reports/210810_rpts.html

[9] The Weather Channel. August 31, 2021. Photos of Hurricane Ida's Category 4 Landfall (PHOTOS) | The Weather Channel - Articles from The Weather Channel | weather.com

[10] AP NEWS. September 1, 2021. After Ida, small recovery signs amid daunting destruction (apnews.com)

[11] CBS News. September 9, 2021. Hurricane Ida death toll jumps to 82 - CBS News

Data

Temperature data and **Precipitation 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 Weather Service Storm Prediction Center Reports

SPC: https://www.spc.noaa.gov/climo/reports/210801_rpts.html
This page will show all Tornado, Wind, and Hail reports for 8/1/2021
Select the "210802 Reports" button at the top to move to the next day

Automated Surface Observing System (ASOS) temperature and precipitation data

The steps below show how to get the hourly temperature and precipitation at the STL Airport, as an example, from the Iowa State University Automated Surface Observing System (ASOS):

IA State: https://mesonet.agron.iastate.edu/request/download.phtml
1) Select "Missouri ASOS" as the network and click "Switch to Network"

2) In the list of available stations, select the "[STL] ST. LOUIS" station, and click "Add Selected"

3) In the "Select From Available Data" section, choose the "Air Temperature [F]" and "1 hour Precipitation [inch]" options.

4) Set the date range to 2020-October-1 and 2020-October-31 (or whatever range is desired)

5) Select "Yes" for "Include Latitude + Longitude"

6) Click "Get Data" at the bottom

These steps would give you the results from the URL below.

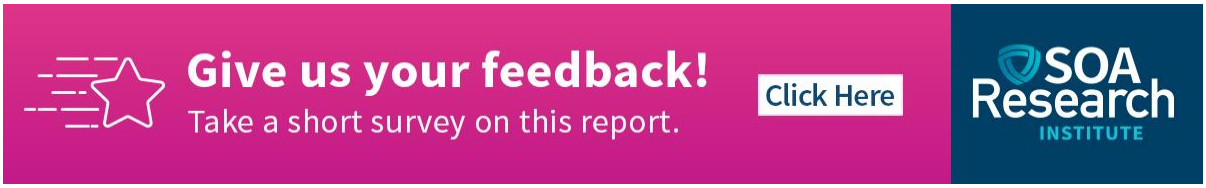
https://mesonet.agron.iastate.edu/cgi-bin/request/asos.py?station=STL&data=tmpf&data=p01i&year1=2020&month1=10&day1=1&year2=2020&month2=10&day2=31&tz=Etc%2FUTC&format=onlycomma&latlon=yes&elev=no&missing=M&trace=T&direct=no&report_type=1&report_type=2

USGS Gauge Heights

Real-Time Values: https://waterservices.usgs.gov/rest/IV-Test-Tool.html

1. Select "List of Sites" in the Major Filters section and enter the Site Number(s) of interest

2. In the Date Ranges section, select “Return all values within an absolute date range” and enter the Date Range of interest
3. For “Parameter Codes”, enter 00060 for Discharge, cubic feet per second or 00065 for Gage Height, feet.
4. At the bottom click “Generate the URL” then click “Run the Generated URL”



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