Actuarial Weather Extremes Series
Heavy U.S. Precipitation: July 26-29, 2022

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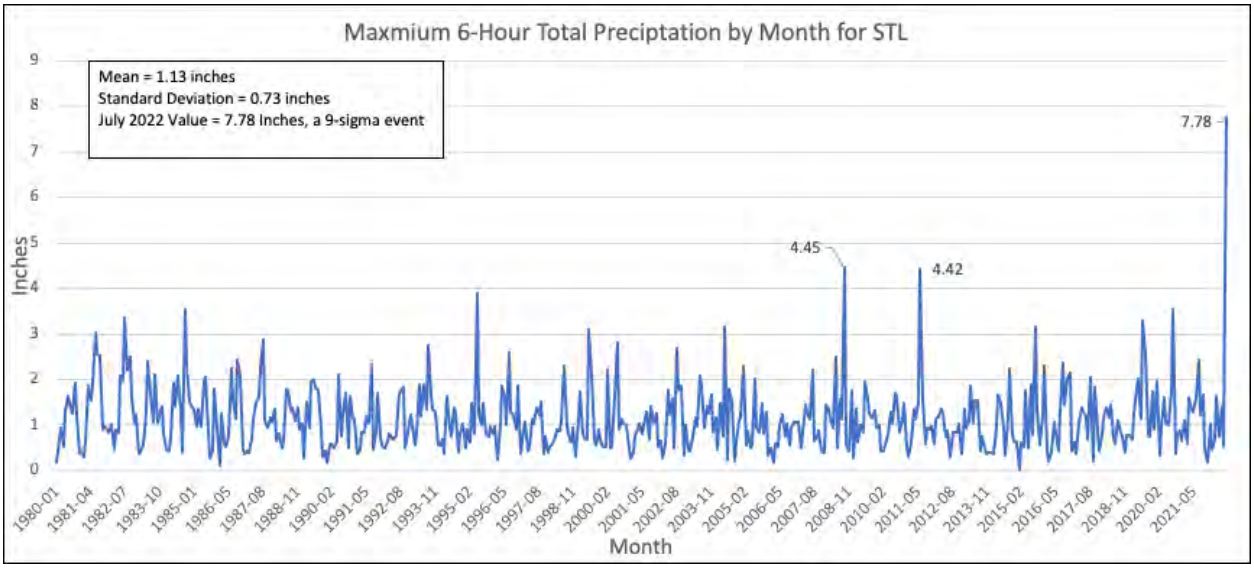
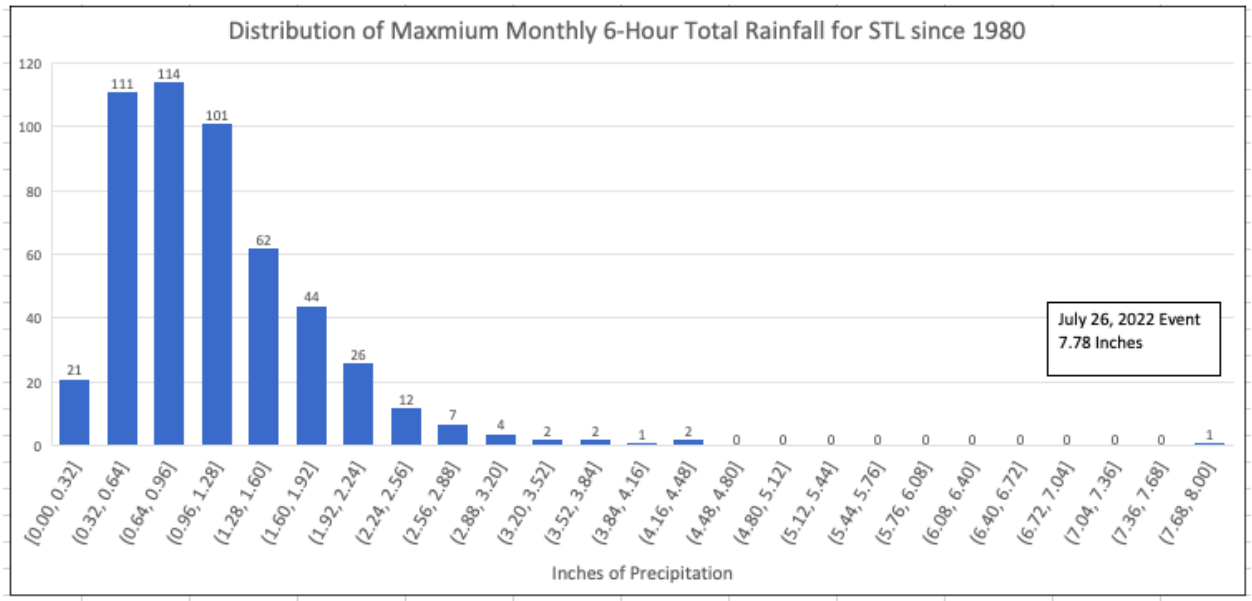
Event Description

In the early morning of July 26, 2022, an extreme precipitation event hit St. Louis, leading to a new all-time record for daily precipitation and widespread flash flooding in the metro area, with one fatality reported so far **[2][3]**. Government officials at the state, county, and city levels declared states of emergency, allowing affected residents and business to access assistance and resources **[3]**. Several roads and Metrolink stations were submerged and impassable **[3]**. Metrolink damage is estimated at $18-20 million, with some stations expected to be shut down for two weeks **[4]**.



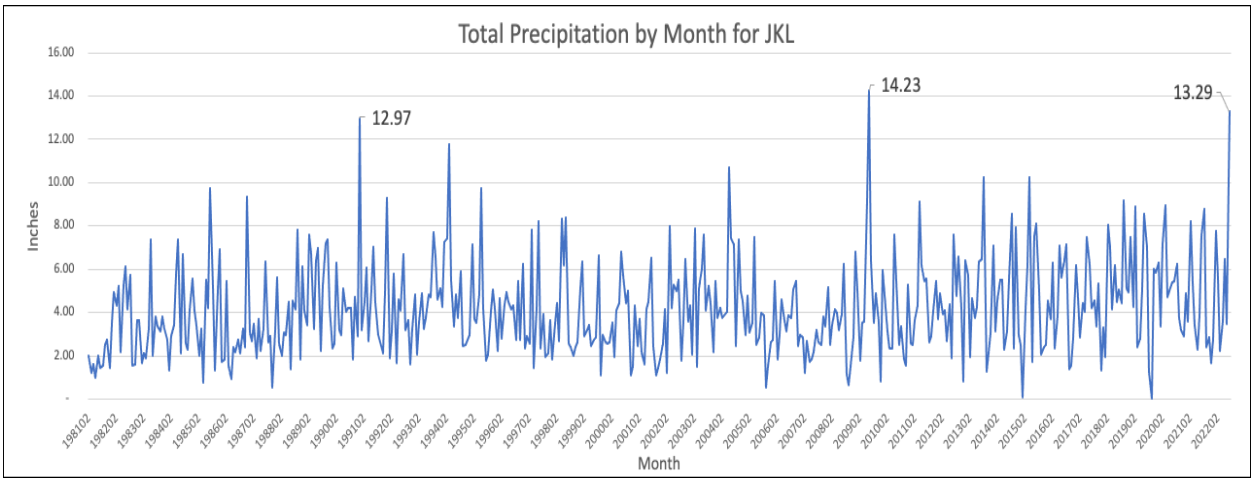
Source: **[1] Iowa State Mesonet for St. Louis International Airport (STL) Automated Surface Observing System (ASOS) station**
Note: The Mean and Standard Deviation in the above graph are calculated for the Monthly Maximum 6-Hour Total Precipitation.

Prior to July 26, 2022, the highest 6-hour total precipitation recorded at St. Louis International Airport (STL) was 4.45 inches, recorded in September 2008. In the morning of July 26, 2022, 7.78 inches of rain was recorded in a 6-hour period, 9 Standard Deviations outside of the historical mean since 1980. According to the National Weather Service (NWS), St. Louis received 25% of the expected annual rainfall in 12 hours **[2].**



Source: **[1] Iowa State Mesonet for STL ASOS station**

Beginning on July 27, 2022, thunderstorms moved from the West and began dropping excessive rainfall on portions of Central and Eastern Kentucky. The extreme rainfall led to significant flooding in cities, with 15 fatalities reported so far **[5]**. The Total Precipitation reported at the Julian Carrol Airport (JKL) in Jackson, KY is 13.3 inches, as seen in the graph below. This total—with observations through early July 29—is the second highest monthly total since 1980.



Source: **[9] Iowa State Mesonet for JKL ASOS station**

The governor has declared a state of emergency and has described the resulting flooding as "one of the worst and most devastating events in Kentucky's history" **[5]**. On July 31, the governor announced that the death toll had risen

to 26 and that the death toll could rise as more rain is expected to come [6]. As shown in the table below, the highest hourly precipitation since 1980 was recorded as 2.3 inches at 9 PM on July 27, 2022. Similarly, the 6-hour and 12-hour totals recorded during the event were the 3rd highest since 1980.

Comparison of July 2022 Precipitation in Jackson, KY to 1980-2022 Observations					
Metric	Maximum Hourly	Maximum 6-Hour Total	Maximum 12-Hour Total	Maximum 24-Hour Total	Monthly Total
July 2022 (Inches)	2.3	3.8	4.7	4.9	13.3
Rank	1	3	3	16	2
Average (Inches)	0.51	1.13	1.60	2.36	4.15
Standard Deviation (Inches)	0.34	0.60	0.80	1.17	2.17

Source: [9] Iowa State Mesonet for JKL ASOS station

Extreme Event Considerations

Such an anomalous event will bring great consideration to insurers and infrastructure planners. For insurers, property damage can be widespread if standard municipal drainage systems are not built to bear such a large volume of water in such a short time. If rainfall cannot drain from the streets, cars and homes may be quickly overtaken by backed up water [7][8]. For infrastructure planners, urban creeks that drain street runoff can suffer erosion of their streambanks, requiring extensive restoration to stabilize the runoff system for future precipitation events [8]. Public transportation systems can be overcome by water and shut down, requiring significant maintenance and restructuring [4].

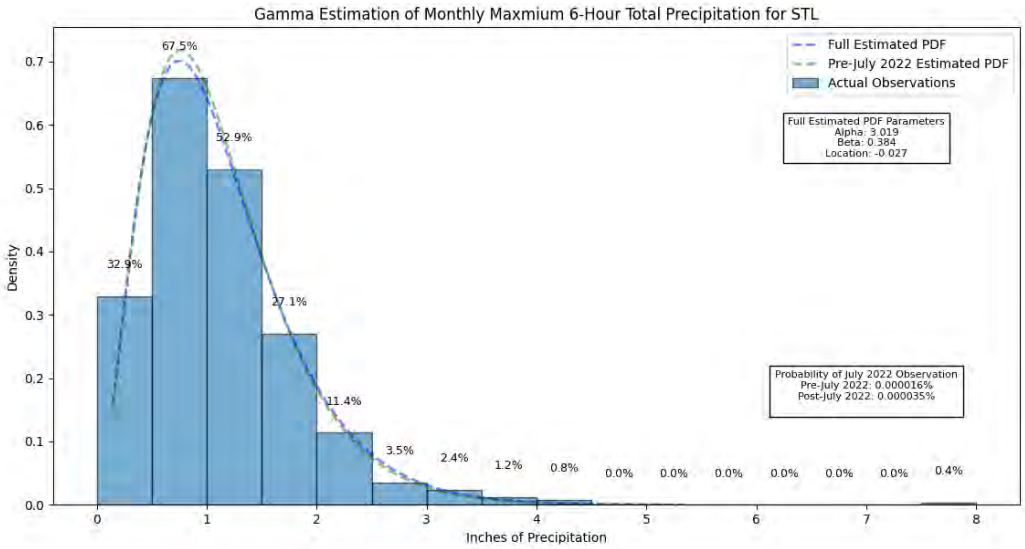
Such extreme events also present the opportunity to consider indirect costs, such as mental health stress and lost productivity. After an extreme event resulting in significant personal property damage, workers may not have the time or resources to continue their regular routine; they may not be able to work as they coordinate insurance claims and financial relief resources, resulting in impacts on local businesses which may also have suffered damages. Infrastructure systems and the people reliant on them may already be under duress after two years in a pandemic and with current economic conditions of high inflation; such an extreme event may push these systems and people past their tolerance point and result in long-term damage.

As insurers and infrastructure planners evaluate the aftermath of this precipitation event, they can explore new methods for identifying, tracking, quantifying, and modeling these indirect costs. Although these efforts would surely prove challenging, they would also provide policymakers with a more holistic context for weighing the future expected costs of extreme events and determining the appropriate measures for mitigating such extreme events.

Following the excessing flooding in St. Louis, it's clear that U.S. cities and infrastructure are vulnerable to extreme precipitation events, even with the advantage of several days' notice from NWS offices. Although the 6-hour and 12-hour precipitation totals in Jackson, KY were not unprecedented, the high number of fatalities reported so far can help drive consideration of how more extreme rainfall or more frequent extreme rainfall events would affect cities and infrastructure.

Modeling Considerations

After evaluating and summarizing the historical observations for STL, we fit a Gamma Distribution in Python using the SciPy library and Maximum Likelihood Estimation [10]. For this fit, we used the Monthly Maximum 6-Hour Total Precipitation from January 1980 through July 2022 at St. Louis International Airport.



To isolate the impact of the July 2022 rainfall event, we first fit the data to a Gamma distribution using observations through June 2022 (green line). We then fit the data to a Gamma distribution using the full data set (blue line). As shown by the green dotted line, the limited fit results in a higher probability around 1 inch. Using the parameters from each fit, we then calculated the probability of a rainfall event of at least 7.78 inches. As seen in the box at the bottom right of the graph, the probability of such an event has more than doubled after including the July 2022 observations.

For insurance purposes, a doubling of the likelihood of an extreme event could have material financial impacts on loss projections. After observing the extreme events in this report, insurers should evaluate their tolerance for increases in their likelihood and even how the likelihood might change further if another extreme event is observed in the near future.

Sources

- [1] Source: Iowa State Mesonet
  - https://mesonet.agron.iastate.edu/cgi-bin/request/hourlyprecip.py?network=MO_ASOS&station=STL&year1=1980&month1=1&day1=1&year2=2022&month2=7&day2=31&tz=America%2FChicago
  - Date Accessed: 7/27/2022
  - Data: Hourly Precipitation Data from 1980-2022
- [2] NWS. July 26, 2022, July 26th, 2022 Historic Flash Flooding in the St. Louis Metro Area
- **[3]** St. Louis Public Radio. July 26, 2022, Rainfall Breaks all-time record in St. Louis
- **[4]** St. Louis Post-Dispatch. July 27, 2022, Metrolink Damage Estimated at least $18 million
- [5] Accuweather. July 29, 2022. Catastrophic Flooding in Kentucky
- [6] Twitter. July 31, 2022. Governor's Public Statements.
- **[7]** St. Louis Public Radio. July 27, 2022, St. Louis Residents asked officials to address flooding
- **[8]** St. Louis Public Radio. July 27, 2022, Climate Change could cause more heavy storms
- [9] Source: Iowa State Mesonet
  - ASOS Data
  - Date Accessed: 7/29/2022
  - Data: Hourly Precipitation Data from 1980-2022
- **[10]** SciPy Gamma Fit documentation