# Historical Summer Rainfall and Lightning Events in the Southern Appalachian Mountains

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## Introduction

The southern Appalachian Mountains (SAMs) are susceptible to rapid and intense rainstorms that can cause flash flooding. Current multi-sensor based quantitative precipitation estimates (QPEs) have proved insufficient for predicting rainfall in the region, particularly for small-scale convective systems.[1] Researchers intend to implement a lightning-based algorithm to improve lead times for flash flooding events in the SAMs based on recognized patterns of lightning and heavy rainfall. To do so, it is first necessary to assemble a collection of past moderate-to-heavy summer rainfall events in the SAMs for the period July-August of 2018-2022.[2]

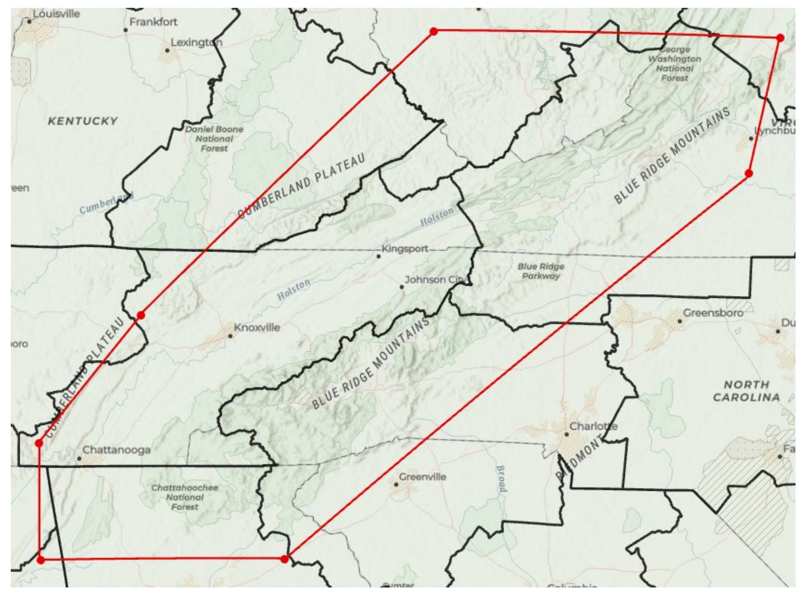

Figure 1: The Southern Appalachian Mountain region with included NWS office locations.

## Data Sources and Methods

A catalog of hourly precipitation was assembled using radar data, rain gauge measurements, streamflow observations, storm reports, COOP observations, and NWS flash flood warning polygons.

Direct observations of rainfall came from rain and stream gauges in the region, including two rain gauge networks:

- Coweeta Hydrologic Lab sub-basin network in Macon County, NC
- Duke Great Smoky Mountains Rain Gauge Network in the Pigeon River Basin
- Automated Surface/Weather Observation Systems (ASOS/AWOS) stations[3]
- USGS stream gauges with precipitation data in the study region.
- USGS streamflow observations were collected for days with above-median discharge rates.[4]

While rain and stream gauges provide the most accurate, direct data, their coverage of the region is limited, necessitating the use of other sources:

- WSR-88D rainfall estimates via the Severe Weather Data Inventory were used to identify storm cells.[5] Pixels with a reflectivity greater than 45 dBZ, corresponding with moderate/heavy rainfall, were used to categorize a rain event as convective.
- Storm reports from the NCEI storm events database
- National Weather Service (NWS) flash flood warning polygons obtained from the Iowa Environmental Mesonet archive.[6,7]

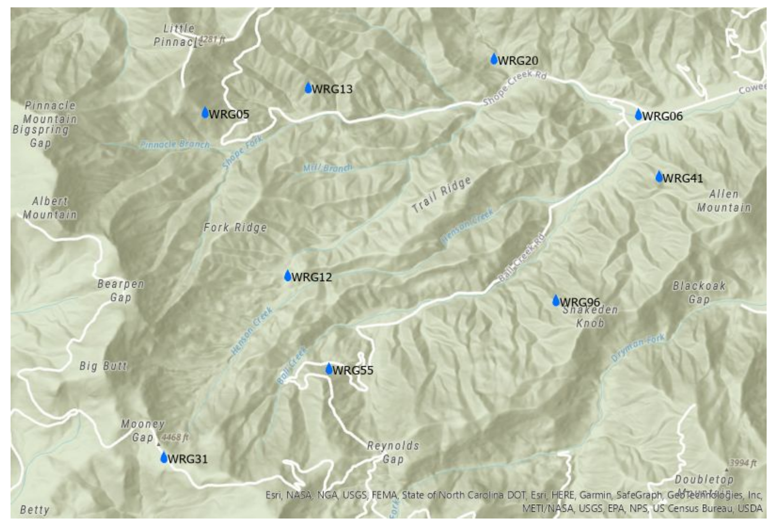

Figure 2: Locations of Coweeta Hydrologic Laboratory rain gauges in the network. Elevations range from 2254 ft to (WRG06) and 4482 ft (WRG31).

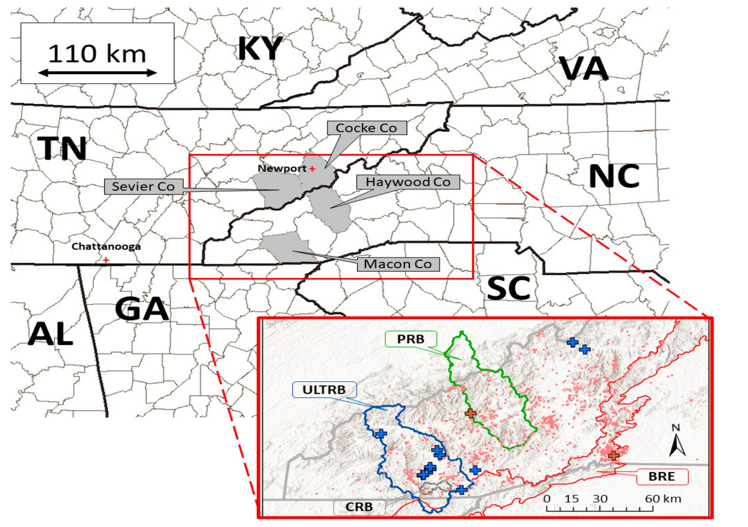


Figure 3: Locations of the Pigeon River Basin (PRB, green outline) and Coweeta sub-River Basin (CRB, gray outline), a sub-basin of the Upper Little Tennessee River Basin (ULTRB, blue outline), and topography (shaded) of the southern Appalachian Mountains.[8]

## Conclusion and Future Directions

The predictive modeling of historical summer rainfall and lightning events in the SAMs will ideally provide insight into the region's extreme weather patterns. The development of accurate predictive models contributes to enhancing early warning systems and preparedness measures for extreme weather events. With the data collected in this catalog, researchers will be able to develop a new lightning algorithm for the SAMs to predict flash flooding and improve lead times by 15-20 minutes. The next steps in this project will involve assembling a catalog of lightning events for July-August 2018 and investigating the relationship between flooding and lightning events to develop the lightning-detection based algorithm.

By combining meteorological advancements with real-time monitoring and proactive planning, researchers and forecasters can prepare communities in the SAMs to be able to address future challenges associated with extreme weather and climate change.

## Acknowledgements

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## Case Study #1: July 30, 2021, 0600-0800 UTC

A heavy rain event was identified via ASOS data from three sites in Kentucky.

- Within a 24 hour period, 2.07 in. of rain fell on the Jackson Airport ASOS station.
- The ASOS stations in London, KY and Williamsburg-Whitley County, KY, reported 0.65 in and 1.03 in, respectively, within an hour.
- All in situ measures of precipitation were accompanied by pixels within five miles of high reflectivity (NexRAD).

NWS warning polygons were issued in Southeastern Kentucky between 0530-1030 UTC.

- Flash flood warnings for 18 counties
- Severe thunderstorm warnings for 6 counties

USGS data for 6 nearby stream gauges showed a significant increase in discharge rates on July 30-31 beginning around 0600 UTC.

- Five gauges in the Kentucky River basin.
- One gauge in the Upper Cumberland River basin (site 03406500).
- Gauges downstream on the Kentucky River saw a significant increase late July 30th-31st.

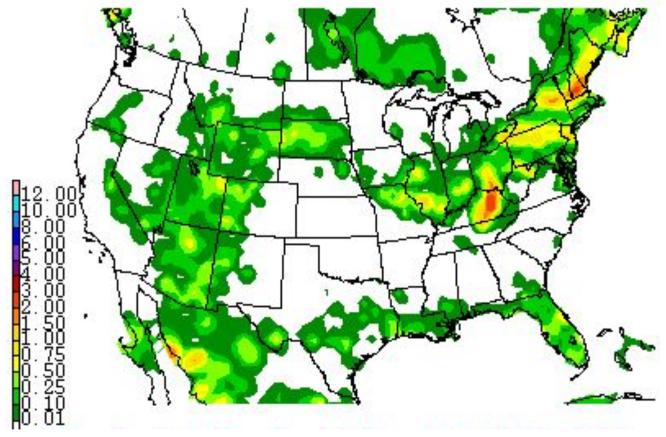

Figure 4: 24-hour national precipitation accumulated between 1200 UTC July 29 - 1200 UTC July 30, prepared by the NCEI Weather Prediction Center.[9]

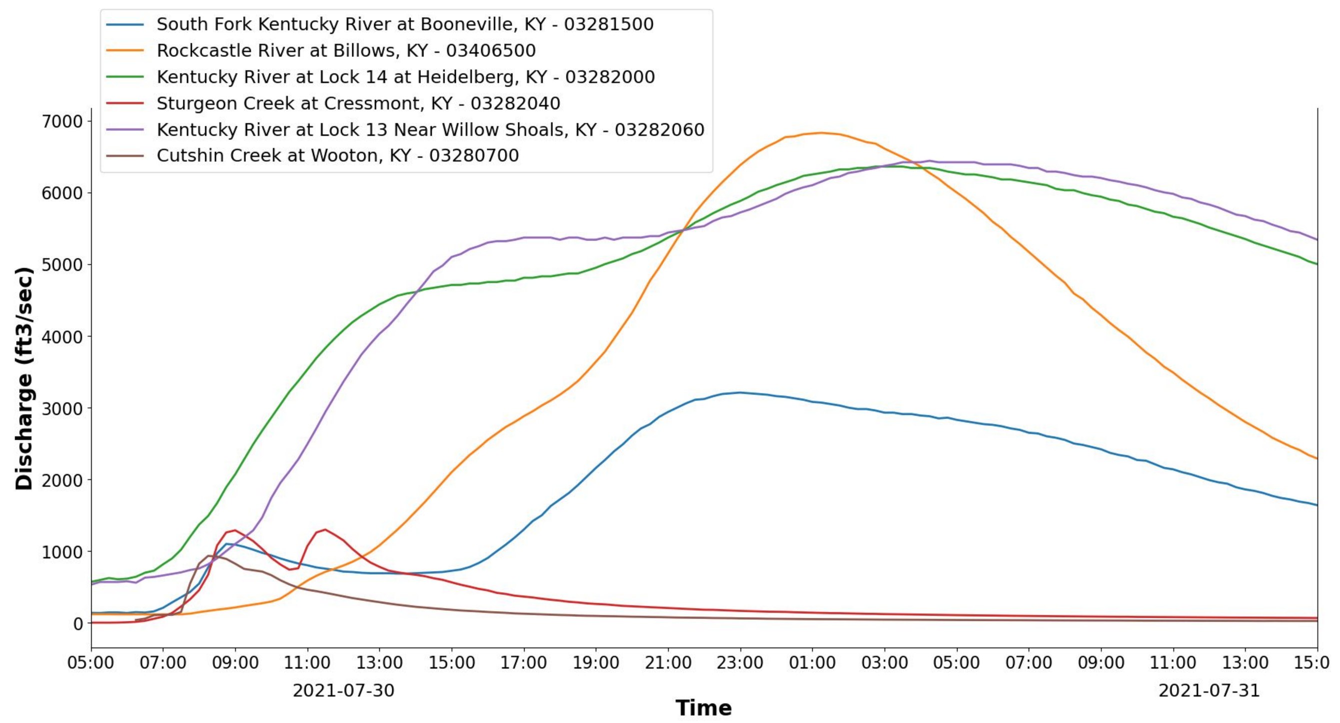


Figure 5: Discharge rates for 6 USGS stream gauges in the path of the storm on July 30. Gauges located downstream (sites 03282060 and 03282000) experienced a delayed increase in discharge due to being downstream in the basin.

## Case Study #2: July 13-14, 2018

The Coweeta rain gauges indicated heavy rainfall from July 13th into the early morning hours of July 14th.

- Ranging from a minimum of 0.03 inches at 2200 UTC from WRG06 to around 1.90 maximum inches at 2300 UTC from WRG05 on July 13th.
- In Fig. 6 there was a significant increase in the stream gauge levels from the storm that occurred. Every stream gauge varied when determining the peak levels, depending on location of streams/rivers.

A high discharge value indicates that a river is experiencing a substantial flow of water. The flow rates are influenced and determined by the characteristics of the surrounding land and the width of the water body itself.

No NWS watches or warnings were sent out in this region.

- Longer duration storm that did not pose a threat.
- Data from the Coweeta rain gauges indicated that there was a dry spell beforehand, therefore the ground was able to absorb more water.

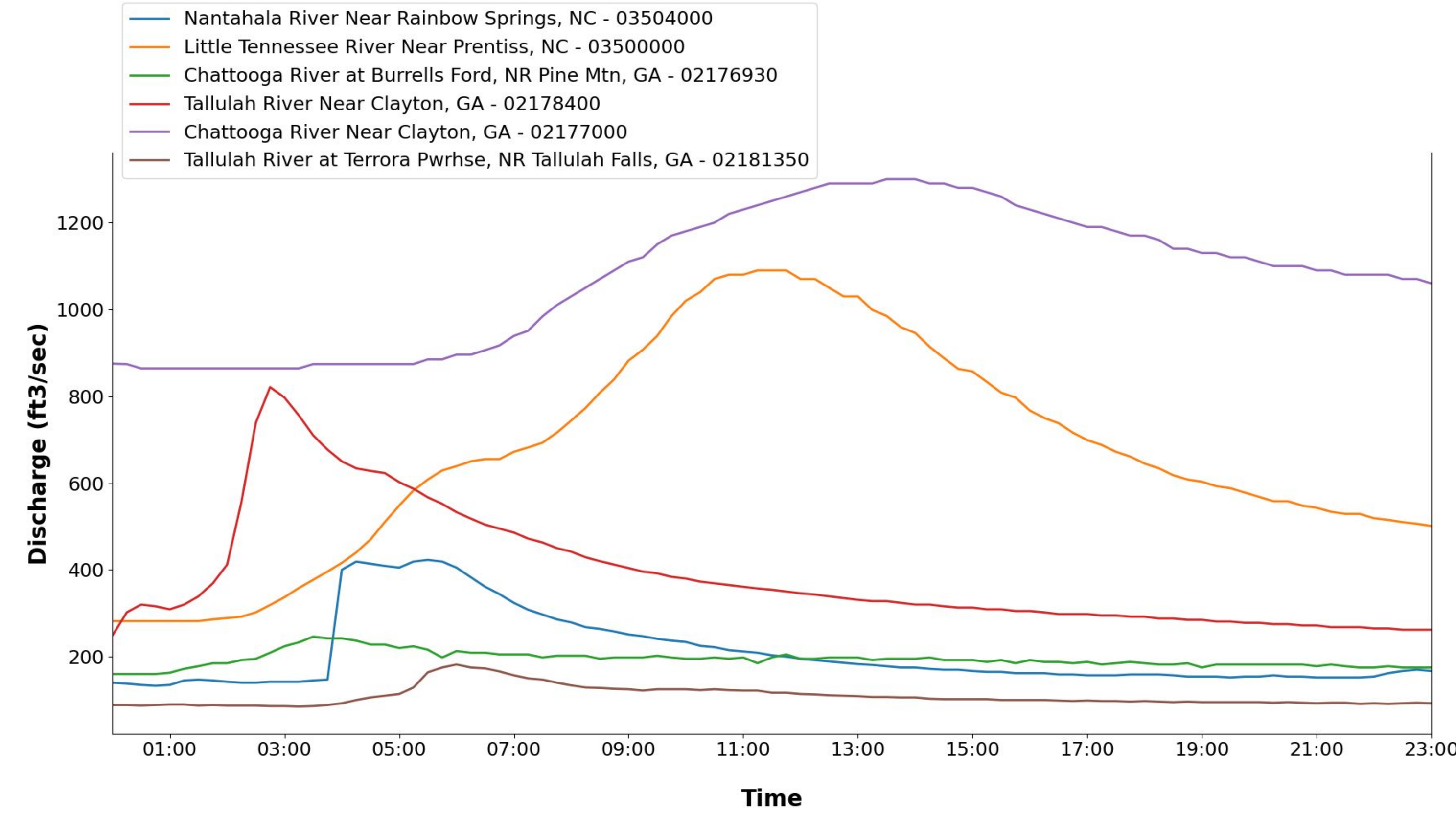


Figure 6: Discharge rates for 6 USGS stream gauges in the path of the storm on July 14.

## References

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