# Changes in the Frequency of Sub-Hourly and Hourly Extreme Rainfall Events in North Carolina

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## Background

- Extreme rainfall events are occurring more frequently with time across the Southeastern United States.[1,2]
- North Carolina is vulnerable to extreme rainfall because of Tropical Cyclones.[3]
- Pluvial and Fluvial Flooding are among the leading causes of weather-related deaths in the United States.[4]
- There is a gap in the subdaily timescale of rainfall frequency research for North Carolina.

### Objective

Quantify **rainfall frequency changes** for Average Recurrence Interval thresholds across North Carolina.

## Data and Methods

- Rainfall data between 2005-2024 from 30 ECONet Stations[5] are analyzed by comparing observed values to Average Recurrence Intervals (ARIs) from NOAA Atlas 14[6] for each station at four different durations: 1 hour, 12-hours, 24-hours, and 48-hours.
- A comparison is made in the number of exceedances using point estimate rainfall depths from Atlas 14[6] for the different durations. The number of exceedance events are accumulated across all stations for two decadal periods: (2005-2014) vs. (2015-2024) to quantify changes in the most recent decade.
- The same method is applied to 30-minute rainfall data for eight stations between 2009-2024 and two eight-year periods (2009-2016) vs. (2017-2024). Note that data to quantify sub-daily extremes are limited to recent years and fewer stations.

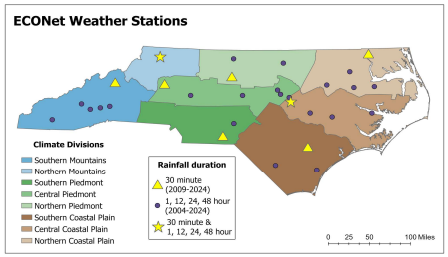


Figure 1: ECONet Weather Stations by Climate Division

## Results

| Period 1 | 30 Min | 1 Hr | 12 Hr | 24 Hr | 48 Hr |
|---|---|---|---|---|---|
| 2 Yr | 55 | 111 | 114 | 94 | 175 |
| 5 Yr | 29 | 44 | 55 | 45 | 92 |
| 10 Yr | 18 | 26 | 26 | 28 | 44 |
| 25 Yr | 9 | 15 | 8 | 9 | 20 |
| 50 Yr | 6 | 4 | 2 | 3 | 8 |
| 100 Yr | 4 | 2 | 0 | 0 | 2 |
| 200 Yr | 1 | 0 | 0 | 0 | 1 |
| 500 Yr | 0 | 0 | 0 | 0 | 0 |
| 1000 Yr | 0 | 0 | 0 | 0 | 0 |

Figure 2: Amount of Exceedance Events by Rainfall Duration & ARI through 2005-2014 ***30 Minute from 2009-2016**

| Period 2 | 30 Min | 1 Hr | 12 Hr | 24 Hr | 48 Hr |
|---|---|---|---|---|---|
| 2 Yr | 22 | 107 | 130 | 144 | 288 |
| 5 Yr | 7 | 49 | 56 | 69 | 132 |
| 10 Yr | 5 | 20 | 32 | 41 | 69 |
| 25 Yr | 2 | 3 | 17 | 20 | 47 |
| 50 Yr | 0 | 2 | 8 | 12 | 27 |
| 100 Yr | 0 | 1 | 2 | 11 | 19 |
| 200 Yr | 0 | 0 | 2 | 4 | 12 |
| 500 Yr | 0 | 0 | 2 | 2 | 4 |
| 1000 Yr | 0 | 0 | 1 | 0 | 0 |

Figure 3: Amount of Exceedance Events by Rainfall Duration & ARI through 2015-2024 ***30 Minute from 2017-2024**

- Cells with yellow highlight in Figure 4 have a >100% increase in exceedance events between the two time periods
- NA* in Figure 4 means the number of events was zero between the two time periods
- NA** In Figure 4 means the number of events was zero for the first period, but not the second
- Percent Difference Formula Used: $((New\ Value/Old\ Value) - 1) * 100$.

| % | 30 Min | 1 Hr | 12 Hr | 24 Hr | 48 Hr |
|---|---|---|---|---|---|
| 2 Yr | -60 | -3.6 | 14 | 53.2 | 64.6 |
| 5 Yr | -75.9 | -11.4 | 1.8 | 53.3 | 43.5 |
| 10 Yr | -72.2 | -23.1 | 23.1 | 46.4 | 56.8 |
| 25 Yr | -77.8 | -80 | 112.5 | 122.2 | 135 |
| 50 Yr | -100 | -50 | 300 | 300 | 237.5 |
| 100 Yr | -100 | -50 | NA** | NA** | 850 |
| 200 Yr | -100 | NA* | NA** | NA** | 1,100 |
| 500 Yr | NA* | NA* | NA** | NA** | NA** |
| 1000 Yr | NA* | NA* | NA** | NA* | NA* |

Figure 4: Percent Difference Between 2005-2014 & 2015-2024 for each Rainfall Duration and ARI
***30 Minute Between 2009-2016 & 2017-2024**

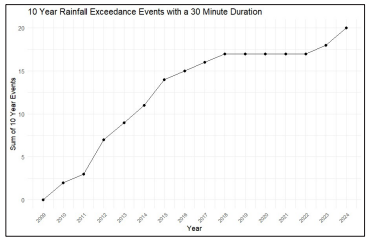


Figure 5: 30 Minute 10 Year Rainfall Exceedance Events 2009-2024

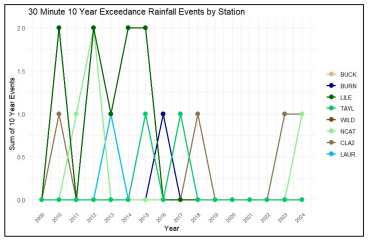


Figure 6: 30 Minute 10 Year Rainfall Exceedance Events 2009-2024 by Station

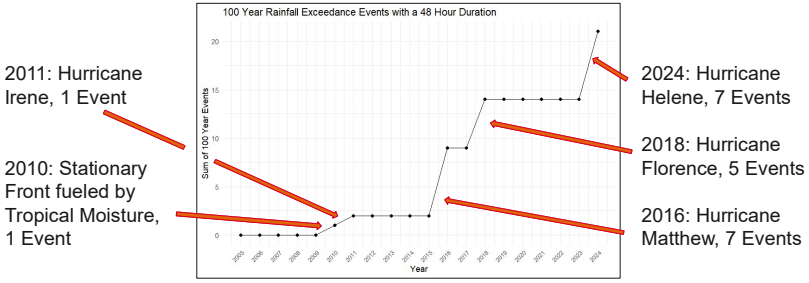


Figure 7: 48 Hour 100 Year Rainfall Exceedance Events 2005-2024

## Conclusions

- In the longer durations of 12-, 24-, and 48-hours, extreme rainfall events (ARI ≥ 25 Yr) have **increased** from 2005-2014 to 2015-2024
- The vast majority of events exceeding the 50-year ARI threshold in the 24- and 48-hour durations are caused by **Tropical Activity**.
- Therefore, it is likely that **Tropical Activity** is causing an increase in longer duration extreme rain events in North Carolina between the two time periods
- Overall, the shorter rainfall durations of 30-minutes and 1-hour have been found to decrease in number of exceedance events between the two time periods. A possible explanation is,
  - The localized nature of thunderstorms and lack of station coverage, especially in the sub-hourly, make these events harder to quantify.
- Figure 6 shows that by station, there are individual changes that stand out in the 30-minute duration.
  - This suggests that if there was more available stations with sub-hourly data, the decreasing tendency could change.

## Recommendations

- More data on a larger time scale with sub-hourly, sub-daily, and daily rainfall observations in North Carolina is needed to establish the potential presence of any concrete trend in rainfall frequency with respect to rainfall duration.
- Having a larger rainfall observation dataset would also help to resolve the spatial issues present with relying on observational data
- Supplementing this data combined with other rainfall datasets to translate it into meaningful information for Climate Change and Flood Resilience planning would be beneficial

## References

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6: Bonnin, G. M., Martin, D., Lin, B., Parzybok, T., Yekta, M., & Riley, D. (2006). *NOAA Atlas 14: Precipitation-frequency atlas of the United States (Vol. 2, Version 3.0)*. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Weather Service.
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