Investigation of Seasonal Trends of Extreme Rainfall Events in the U.S. Northeastern Region

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Introduction

Extreme rainfall events cause severe damage to agriculture, ecology, infrastructure, and even loss of human lives. Moreover, an increase in the frequency of extreme precipitation events has been identified as a likely consequence of climate change. In the other hand, one of the concerns that has been raised as a result of global climate change is its effect on seasonality. Therefore there might be a relation between extreme rainfall events and seasonality change. In the current study, the seasonality change of extreme rainfall events for the northeast area of the U.S is investigated. The goal of this project is to determine whether a trend for seasonal change of extreme rainfall exists, and if so, whether it is increasing or decreasing[1][2].

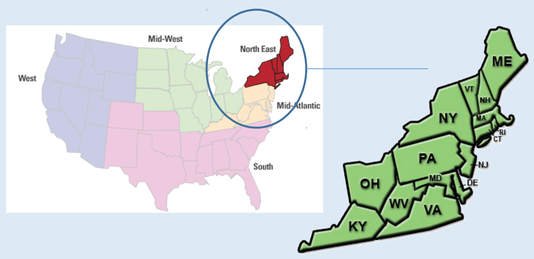


Fig. 1: Study Area; Northeastern United States

Hypothesis

In this project, we are using rainfall data to determine how the possible correlation between seasonality and extreme rainfall events. We hypothesize one of the following three outcomes:

- positive trend
- negative trend
- no trend

We examined the hypothesis for extreme rainfall values and corresponding time of occurrence for 1-h, 1-day and 5-day rainfall durations.

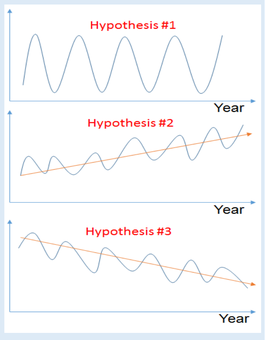


Fig. 2: Three possible outcomes

Methodology

1- First, we downloaded the hourly rainfall data from the National Climatic Data Center (NCDC).

- Resolution: hourly
- Available: 1900-2013
- No. of stations: **786**

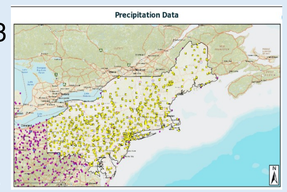


Fig. 3: The 786 rain gauge stations located in the Northeastern climate region[3].

2- We then updated some locations that were initially unknown.
3- After that we used Matlab to first filter out the stations that have data for less than 65 years, leaving us with data for **36** stations.

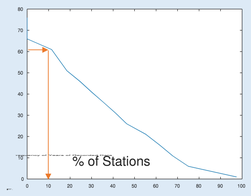


Fig. 4
Variation of available rainfall records among Northeast stations

4- For the rest of the stations, Matlab was used to identify the annual maximum rainfall and corresponding time of occurrence.
5- Then we performed trend analysis by using linear regression and Mann-Kendall methods applied on the 1-h, 1-day and 5 day data. The significance of results was also checked by generating p-values:

Linear regression formulation:

Regression Formula:
$Y=b_1X+b_0$
Where slope of trend is :

$$b_1 = \frac{\sum (x - \bar{x}) * (y - \bar{y})}{\sum (x - \bar{x})^2}$$

And intercept is:

$$b_0 = \bar{y} - (b_1 * \bar{X})$$

Mann- Kendall Formulation:

Kendall's rank correlation coefficient, tau, may be expressed as

$$\tau = S/D$$

$$S = \sum_{i<j} (sign(x[j] - x[i]) * sign(y[j] - y[i]))$$

$$D = n(n-1)/2$$

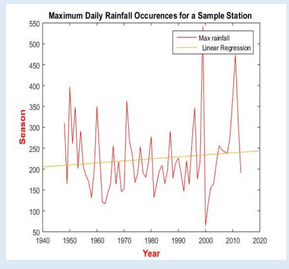


Fig. 5 The linear regression plot shows an increasing seasonal shift for the Albany Airport NY U.S. station.

6-Finally, we produced visualizations of our findings along with plots of the data on CARTODB as well as ARCGIS.

Results

Fig. 6: Linear regression trends of yearly maximum rainfall events. Regression trends shift from positive to negative as rainfall durations increase.

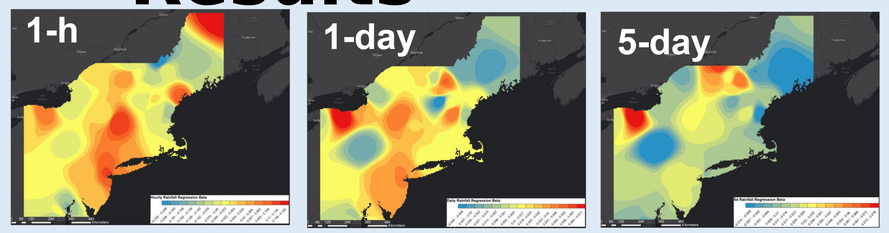


Fig. 7: Seasonal trends of extreme rainfall using linear regression.
P-value results indicate locations with significant trends. P-values are not significant for most of the stations.

P-values in red: Significant

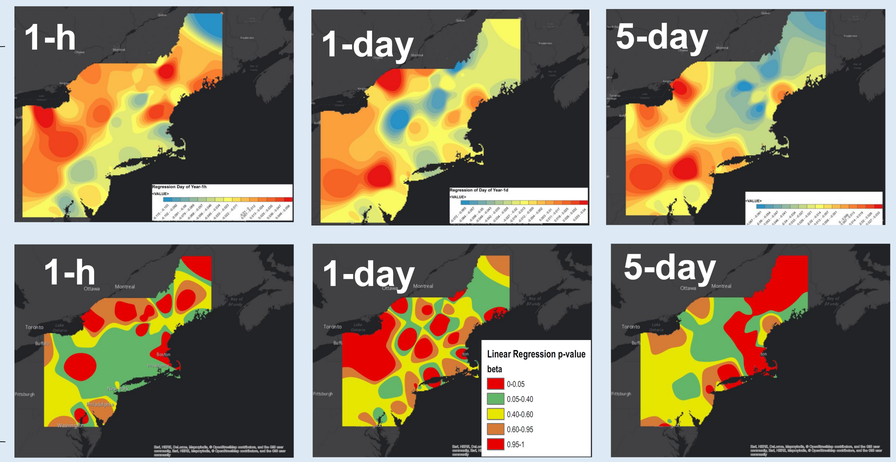
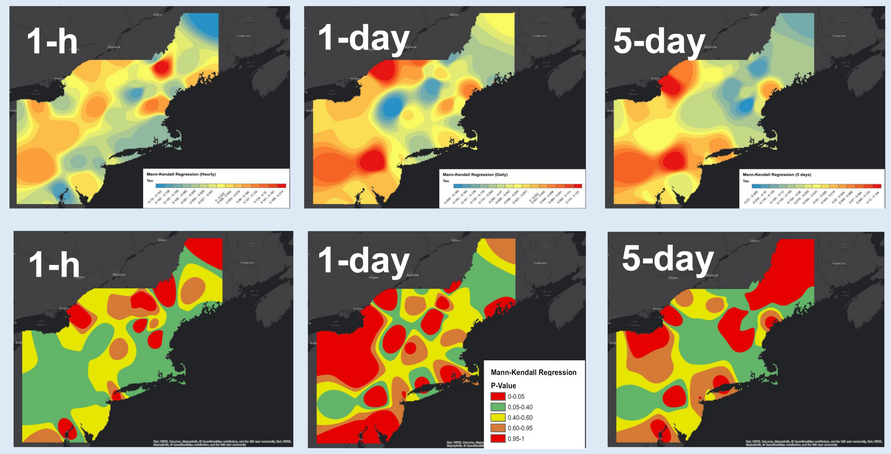


Fig. 8: Seasonal trends of extreme rainfall using Mann-Kendall.
P-value results indicate locations with significant trends.

P-values in red: Significant



Conclusions

- Extreme rainfall values for various durations indicate significant trends for 65 years (from 1948-2013). While the short duration trend is mostly positive, the long duration trend is negative.
- Trend rates are higher for extreme rainfall events of shorter durations.
- Seasonal trend analysis of extreme rainfall events indicates an increasing trend for shorter rainfall events and a decreasing trend for longer rainfall events for most of the Northeast.
- p-value results indicate that the trends for longer rainfall events are more significant.
- **As a final statement we conclude that, for the Northeast, shorter extreme rainfall events are occurring later in the year (mostly for the southern areas) and longer extreme rainfall events are occurring earlier in the year (especially in the northern areas).**

References

[1]http://prism.oregonstate.edu/fetchData.php
[2]http://opensiuc.lib.siu.edu/cgi/80571?article=1012&context=gers_pubs
[3]https://www.ncdc.noaa.gov/ghcnm

Acknowledgements

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