Occurrences of Extreme Precipitation Events and Resulting Impacts in New Jersey

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Introduction

This study investigates heavy precipitation occurrences in New Jersey and potential changes stemming from climate change. We utilized weather data from various sources, consisting of monthly and annual averages, along with recorded extremes, from historical climate databases, including the Monthly Climate Tables from the Office of the New Jersey State Climatologist, David A. Robinson at Rutgers University. The climate observations for New Jersey date back to 1895, when statewide weather observations began. Various factors regarding the conditions for formation of heavy precipitation were analyzed and trends were identified. Specifics in respective events were recorded, namely the frequency and intensity of precipitation events.

Methods

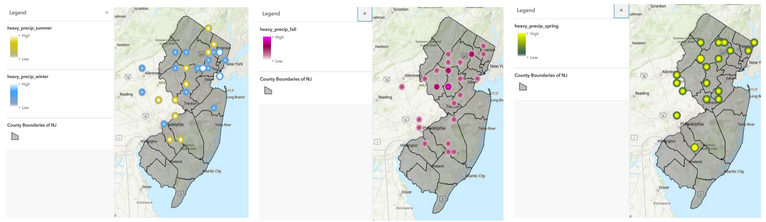
- Identified and explored top precipitation values in Monthly Total Precipitation charts (NJ Statewide)
- Listed and summarized major precipitation events in New Jersey's history
- Reviewed state, national, and global precipitation reports and forecasts for New Jersey
- Georeferenced heavy precipitation events listed by Harnack, et al. (1999), and summarized Harnack's findings on seasonal trends in heavy precipitation events.

Key Sources:

- Monthly Climate Tables: https://climate.rutgers.edu/stateclim_v1/nclimdiv/
- Examining Precipitation across the Garden State from 1900 to 2020: https://dep.nj.gov/wp-content/uploads/dsr/precipitation-1900-2020.pdf
- New Jersey Extreme Precipitation Projection Tool: https://ora-devserver.njaes.rutgers.edu:27015/
- Weather.gov: https://www.weather.gov/phi/eventreview20210822#:~:text=Rainfall%20amounts%20were%20highly%20variable,Jersey%20and%20into%20eastern%20Pennsylvania
- USGS https://www.usgs.gov/news/summary-flooding-new-jersey-caused-hurricane-irene-august-27-30-2011

Heavy Precipitation Events by Location

Figures 1-3 below depict the occurrences of heavy precipitation by location recorded, differentiated by season. Summer and Winter occurrences are plotted in a single map, *Figure 1,* as they have differing distribution patterns, with minimal overlap. *Note: a small, darker dot may only indicate a single event, while a large, lighter dot may indicate several events.*



Figures 1-3: Mapping Historical Extreme Precipitation Events, Harnack, Robert P., Kirk Apffel, and Cermak,Joseph R., I.,II. "Heavy Precipitation Events in New Jersey: Attendant Upper-Air Conditions." Weather and Forecasting 14.6 (1999): 933-54. ProQuest. Web. 3 Oct. 2024. [https://arcg.is/1SmWy2]

High Impact Events

2021 - Hurricane Ida (maximum of over 9 inches in some NJ locations)
2021 - Hurricane Henri (up to 10 inches of rain in some areas)
2020 - Tropical Storm Isaias (maximum of 6 inches of rain)
2020 - Tropical Storm Fay (up to 6-8 inches of rain)
2011 - Hurricane Irene (during the wettest August, 15.67 statewide avg.)
1999 - Hurricane Floyd (notable for catastrophic flooding)
1971 - Tropical Storm Doria (up to about 10 inches of rain)
1939 - Tuckerton, heaviest 24-hour rainfall event (14.81 inches)

Table 1. Seasonal Conditions Associated with NJ Heavy Precipitation Events

Season	Winter	Spring	Summer	Fall
Temperatures	Higher temperatures between 850-300mb, lower temperatures in upper reaches of atmosphere (250-100mb), with temperature departures generally from 2-5 degrees F.	Warmer temperatures in the mid-troposphere (from around 500 to 400mb), with lower temperatures in the upper troposphere near 200mb.	The summer overall shows the smallest deviation from climatology, or average atmospheric conditions, for heavy rain events. Temperatures do not drastically differ from averages at any level.	Similar to conditions in the spring, warmer conditions are present in the mid-troposphere with colder conditions in the upper atmosphere (200-150mb level)
Temperature advection	Large temperature advection (mainly positive or warm) in lower and upper atmosphere, but not middle.	Greater temperature advection, particularly warm advection, in most levels of the troposphere, the level of the atmosphere where most weather occurs.	Temperature advection, specifically warm temperature advection, is prevalent like in other seasons.	Substantial warm advection at all levels of the troposphere, where weather occurs. A generally southerly flow of wind at all levels is the key component of the warm advection.
Moisture (humidity)	Moist conditions from 850-400mb, indicated by dewpoint, mixing ratio, and equivalent potential temperature (theta-e). Significant moisture uptick, generally ranging from a 7-12 degree increase in dewpoint.	More moist conditions along with warmer temperatures	Moist conditions from 700-400mb, with a dew point around 5C higher than average, indicative of higher humidity.	Moisture levels are higher at all levels where analyzed (850-300mb level), with moisture advection and moisture convergence at a greater level in the lower troposphere (measured between 850-700mb).

Figure 4 depicted below shows the projected increases in precipitation over the next century within the municipality of Bound Brook, New Jersey. Bound Brook is a historically vulnerable city to flooding as it is low lying and along the banks of the Raritan River, as well as its tributaries Green Brook and Bound Brook, where the latter merges with the former near the city of Bound Brook.

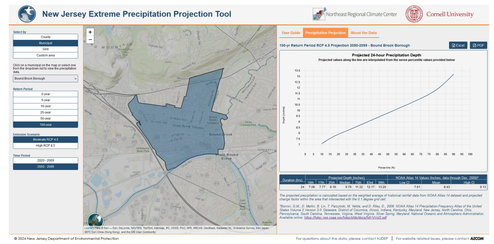


Figure 4 Projected precipitation changes, Bound Brook, NJ

Figure 5 displayed below shows the 100-year projected percent increase of precipitation depth throughout the state, compared with NOAA Atlas 14. The percent increases are classified as the upper likelihood, with a 17% probability that precipitation will exceed the respective increases. The range for precipitation increases varies from a minimum of 25 percent in Ocean County to a maximum of 50 percent in Sussex County.The counties in dark blue have a 40 percent or higher increase in precipitation depth forecasted.

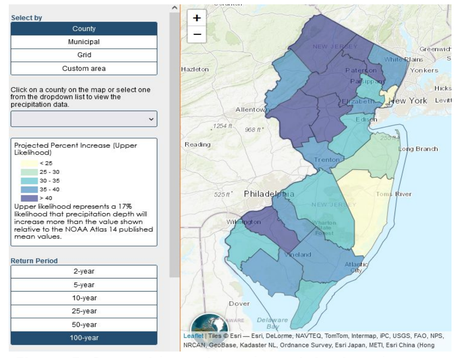


Figure 5: Statewide projected precipitation changes

Conclusions

The data reflect a consensus towards an increase in total rainfall and rainfall intensity within heavy precipitation events in New Jersey, in addition to overall precipitation averages. As depicted in Table 1, relatively warm and moist conditions are prevalent for heavy precipitation over all seasons, and there is ample evidence towards increasing temperatures in the state, with warmer air retaining more moisture, conducive to precipitation. It is probable that heavy precipitation events will increase in frequency and magnitude as these ideal conditions for heavy rainfall occur on a more frequent basis with climate change. The spatial variability of these changes was also highlighted in the study, indicating vulnerable areas that experience more pronounced impacts. The results of the findings are crucial for local infrastructure planning and disaster preparedness, as New Jersey faces increased risks of flooding and related hazards. This research contributes to the broader understanding of climate change in the state of New Jersey and on a global scale.

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