Projected Changes in Extreme Rainfall in New Jersey

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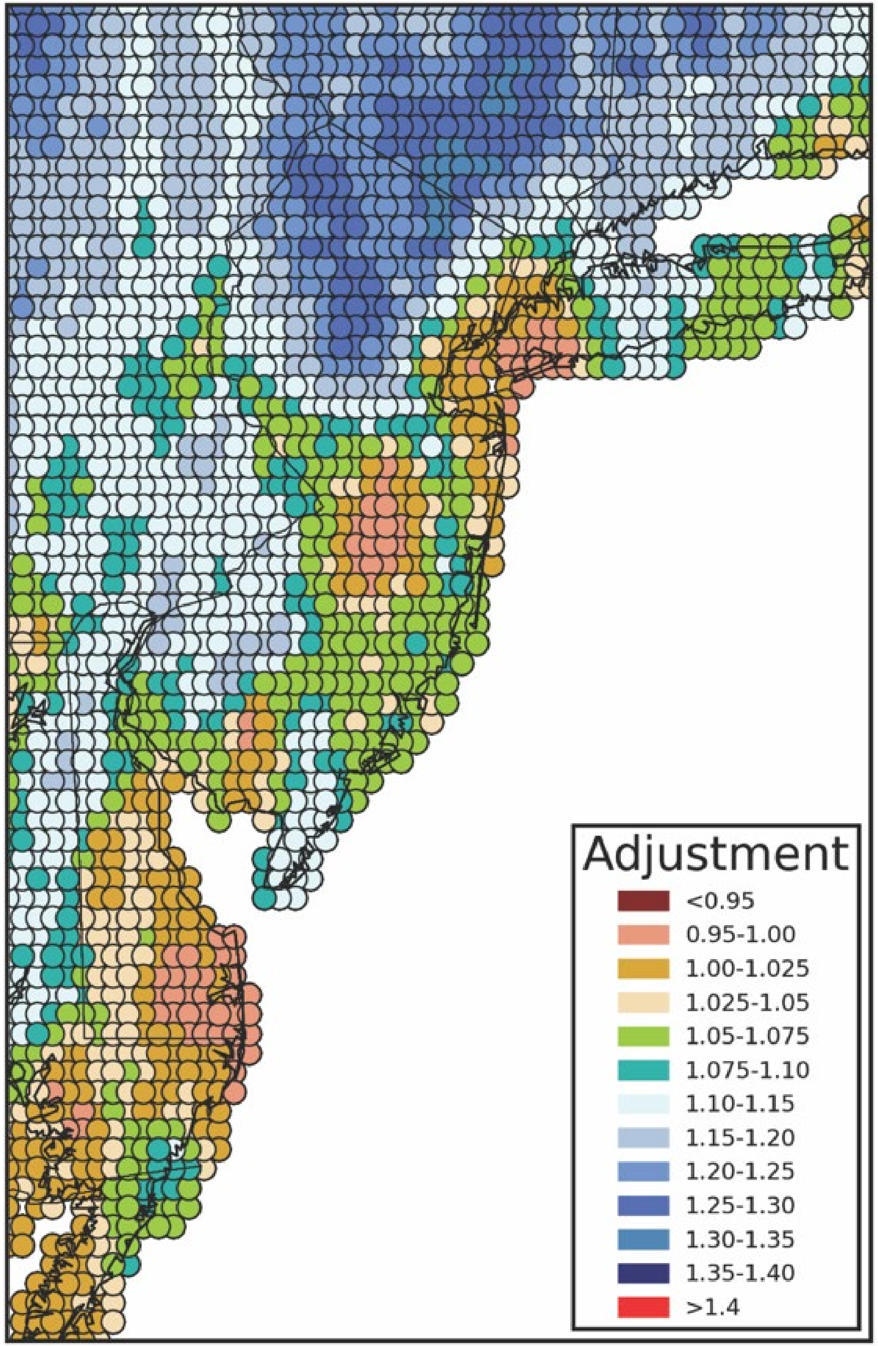

2020 NEW JERSEY

SCIENTIFIC REPORT ON CLIMATE CHANGE

June 30, 2020

CHAPTER 6

RESEARCH AND DATA GAPS/NEEDS

1. Changes in Hourly and Daily Extreme Rainfall Amounts in NJ since the Publication of NOAA Atlas 14 Volume (NOAA/NERCC)

2. Projected Changes in Extreme Rainfall in New Jersey based on an Ensemble of Downscaled Climate Model Projections (NOAA/NERCC)

3. Examining Precipitation Across the Garden State From 1900 to Present (Rutgers/State Climatologist)

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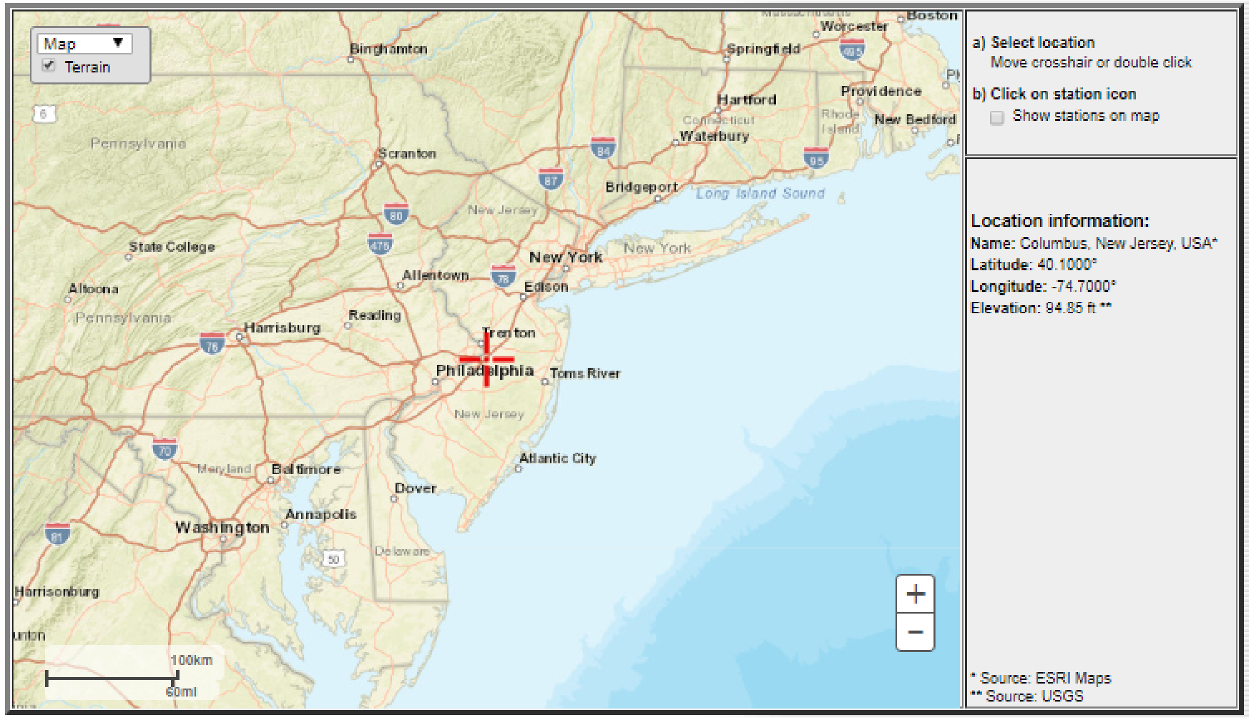


NOAA ATLAS 14 POINT PRECIPITATION FREQUENCY ESTIMATES

https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html?bkmrk=nj

POINT PRECIPITATION FREQUENCY (PF) ESTIMATES

WITH 90% CONFIDENCE INTERVALS AND SUPPLEMENTARY INFORMATION

NOAA Atlas 14, Volume 2, Version 3

PF tabular | PF graphical | Supplementary information | Print page

PDS-based precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	0.347 (0.316-0.381)	0.414 (0.377-0.455)	0.492 (0.447-0.540)	0.549 (0.497-0.603)	0.619 (0.558-0.679)	0.671 (0.601-0.737)	0.722 ([illegible])	0.770 (0.683-0.851)	0.831 (0.729-0.924)	0.877 (0.763-0.982)
10-min	0.555 (0.505-0.609)	0.663 (0.604-0.728)	0.788 (0.716-0.865)	0.878 (0.795-0.964)	0.987 (0.890-1.08)	1.07 (0.958-1.17)	[illegible]	1.22 (1.08-1.35)	1.31 (1.15-1.46)	1.38 (1.20-1.55)
15-min	0.693 (0.631-0.761)	0.833 (0.759-0.916)	0.997 (0.906-1.10)	1.11 (1.01-1.22)	1.25 (1.13-1.37)	1.35 (1.21-1.49)	[illegible]	1.54 (1.37-1.70)	1.65 (1.45-1.84)	1.73 (1.51-1.94)
30-min	0.950 (0.865-1.04)	1.15 (1.05-1.26)	1.42 (1.29-1.56)	1.61 (1.46-1.77)	1.85 (1.67-2.03)	2.04 (1.83-2.24)	[illegible]	2.40 (2.13-2.65)	2.63 (2.31-2.93)	2.81 (2.44-3.14)
60-min	1.19 (1.08-1.30)	1.44 (1.32-1.59)	1.82 (1.65-1.99)	2.10 (1.90-2.30)	2.47 (2.22-2.71)	2.76 (2.48-3.03)	[illegible]	3.36 (2.98-3.72)	3.78 (3.31-4.20)	4.10 (3.57-4.59)
2-hr	1.44 (1.30-1.58)	1.75 (1.59-1.93)	2.21 (2.01-2.43)	2.57 (2.33-2.82)	3.06 (2.75-3.36)	3.45 (3.09-3.79)	[illegible]	4.27 (3.77-4.72)	4.86 (4.23-5.41)	5.32 (4.59-5.96)
3-hr	1.57 (1.43-1.74)	1.92 (1.74-2.12)	2.43 (2.20-2.69)	2.83 (2.55-3.13)	3.39 (3.04-3.74)	3.84 (3.42-4.25)	[illegible]	4.82 (4.21-5.35)	5.51 (4.75-6.16)	6.08 (5.17-6.83)
6-hr	1.98 (1.79-2.20)	2.40 (2.17-2.67)	3.03 (2.73-3.37)	3.55 (3.18-3.93)	4.29 (3.82-4.75)	4.91 (4.34-5.44)	[illegible]	6.30 (5.45-7.00)	7.34 (6.23-8.21)	8.20 (6.87-9.25)
12-hr	2.39 (2.17-2.69)	2.90 (2.62-3.25)	3.69 (3.32-4.13)	4.36 (3.91-4.87)	5.36 (4.75-5.97)	6.23 (5.48-6.95)	[illegible]	8.24 (7.03-9.24)	9.82 (8.21-11.1)	11.2 (9.18-12.7)
24-hr	[illegible] (2.54-3.01)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	8.40 (7.51-9.09)	9.66 (8.55-10.5)	11.6 (10.1-12.6)	13.2 (11.3-14.4)
2-day	3.18 (2.92-3.48)	3.85 (3.55-4.22)	4.93 (4.53-5.39)	5.84 (5.34-6.38)	7.18 (6.52-7.81)	8.32 (7.50-9.05)	9.57 (8.56-10.4)	11.0 (9.69-11.9)	13.0 (11.3-14.2)	14.7 (12.7-16.2)
3-day	3.37	4.08	5.19	6.12	7.48	8.63	9.88	11.3	13.3	15.0

Problem:

Last updated in 2006
with data through 2000

How have precipitation patterns changed?

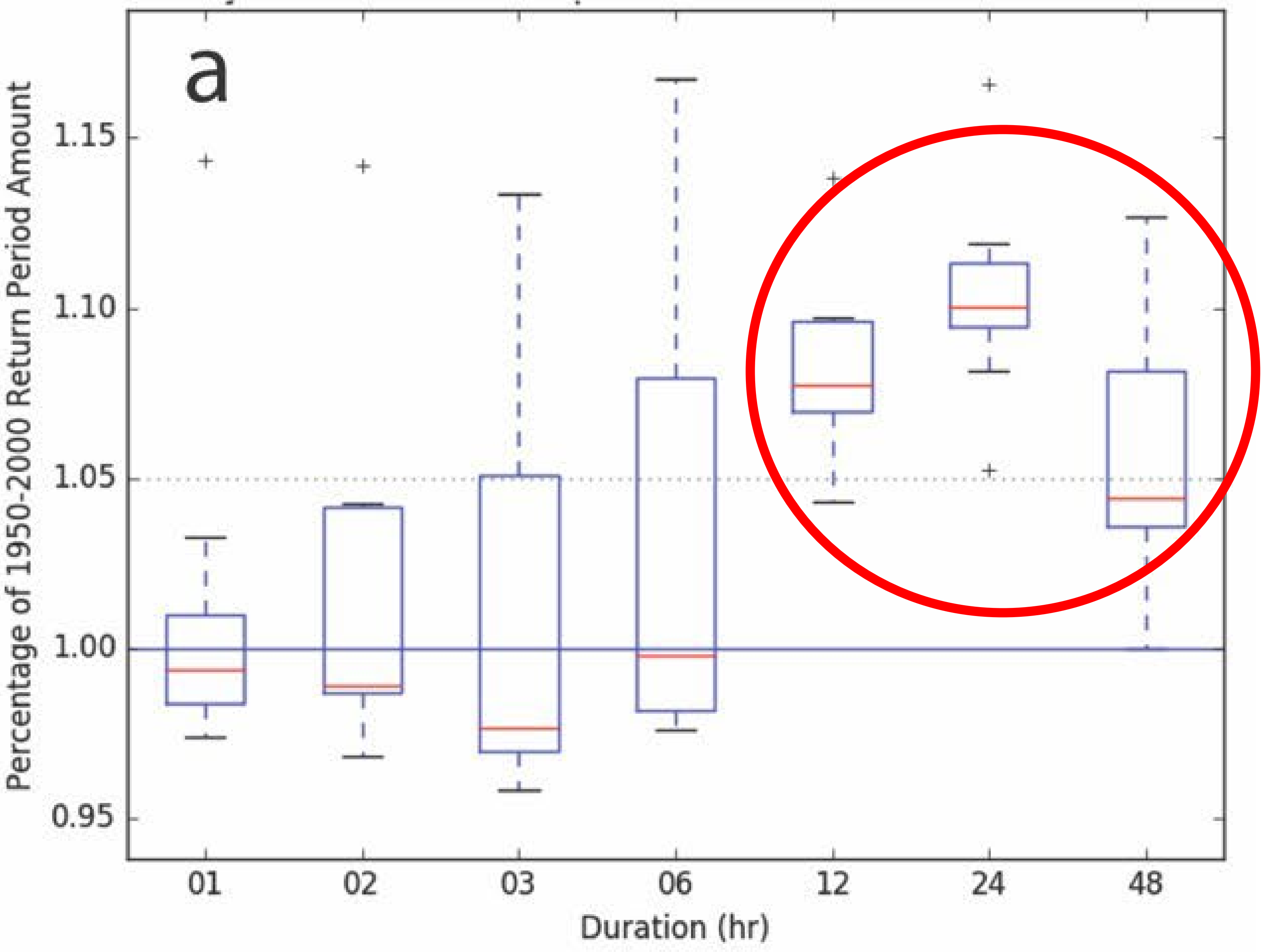
Are storms more intense?

Changes in Hourly and Daily Extreme Rainfall Amounts in NJ since Publication of NOAA Atlas 14

- ✓ Design standards and regulations in New Jersey rely on climate data from NOAA Atlas 14 (2006).
  - Potential problem: The data used in this publication end in 2000 and results assume that past rainfall trends are expected to continue in the future.

- ✓ Several locations in New Jersey and surrounding states have experienced record rainfall events since 2000, or at least rainfall events that are among the highest in the pre-2000 record.

- ✓ This work supplements the current record and proposes necessary adjustments or *change factors* to the Atlas 14 rainfall extremes.



Boxplots showing the ratios of hourly RI precipitation amounts for the 100yr storm computed using the 1950-2019 PDS to those based on a 1950-2000 PDS. Boxplots shows distribution across stations in NJ.

Changes in Hourly and Daily Extreme Rainfall Amounts in NJ since Publication of NOAA Atlas 14: Key Findings:

- The current version of NOAA Atlas 14 does not accurately reflect precipitation intensity conditions in the state, particularly for 24-hour and 48-hour storm events.

- Changes (or change factors, CFs) can be applied to the NOAA Atlas 14 precipitation data to *update current* extreme rainfall conditions.

- At more than half of the stations analyzed, extreme precipitation amounts are 2.5% higher now than those published in 2006.

- In some places, the additional data result in a more than 10% increase in rainfall amounts above the outdated estimates.

- The results presented in this report suggest that future rainfall patterns cannot simply be assumed to follow historical trends.

1. Changes in Hourly and Daily Extreme Rainfall Amounts in NJ since the Publication of NOAA Atlas 14 Volume (NOAA/NERCC)

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Projected Changes in Extreme Rainfall

- ✓ Projections from up to 47 downscaled climate model simulations* were used to estimate the *change in magnitude* of future extreme rainfall events.

- ✓ Projections based on two different climate models
  - (NA-CORDEX) - North American Coordinated Regional Downscaling Experiment
  - (LOCA) - Localized Constructed Analog

- ✓ These changes (or change factors, CFs) can be applied to the NOAA Atlas 14 precipitation data to update future extreme rainfall conditions.

* Global Climate Models provide "coarse" representations of global climate dynamics and work well for large-scale investigations. **Downscaling** is a technique that allows for the extrapolation of these large-scale climate processes to address questions at higher-resolution, regional scales (such as rainfall patterns in NJ.)

Projected Changes in Extreme Rainfall

Projections are provided for 2 time periods: Mid-century 2020-2069 and late-century 2050 – 2099.

- The 50-year length was selected to assure an adequate sample size for extreme value analysis, and to minimize the influence of the non-stationarity of the record and the potential effect of natural interdecadal variations in the extreme rainfall record

Simulations from the models' historical period and two future emission scenarios (RCP4.5 and RCP 8.5) were used to derive projections.

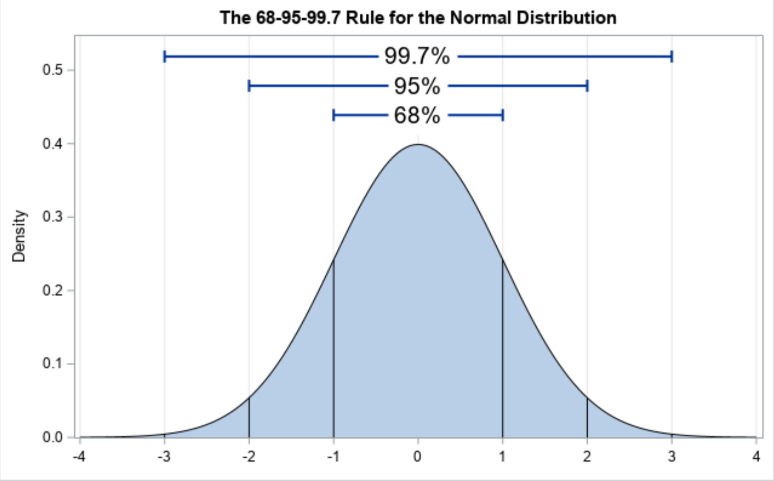
Projected Changes in Extreme Rainfall

Change Factors (CFs) are calculated as follows:

- ✓ A methodology analogous to that described in NOAA Atlas 14 was used to calculate annual average return period precipitation amounts from modeled data for the near-term (2020-2069) and late-century (2050-2099) periods.
- ✓ These amounts were then ratioed to historical trends (1950-1999), allowing for the computation of change factors (CFs).
- ✓ CFs lower than 1 represent a decrease in precipitation amounts relative to historical trends, while CFs higher than 1 indicate an increase.
- ✓ CFs can be translated into % change using the following conversion:

$$\% \text{ change} = (CF - 1)*100$$

Projected Changes in Extreme Rainfall



General Process:

For each grid (LOCA or CORDEX spatial resolution) a 50-year record of *daily precipitation* values is determined.

For each grid, the 50 largest values are selected (not the annual max)

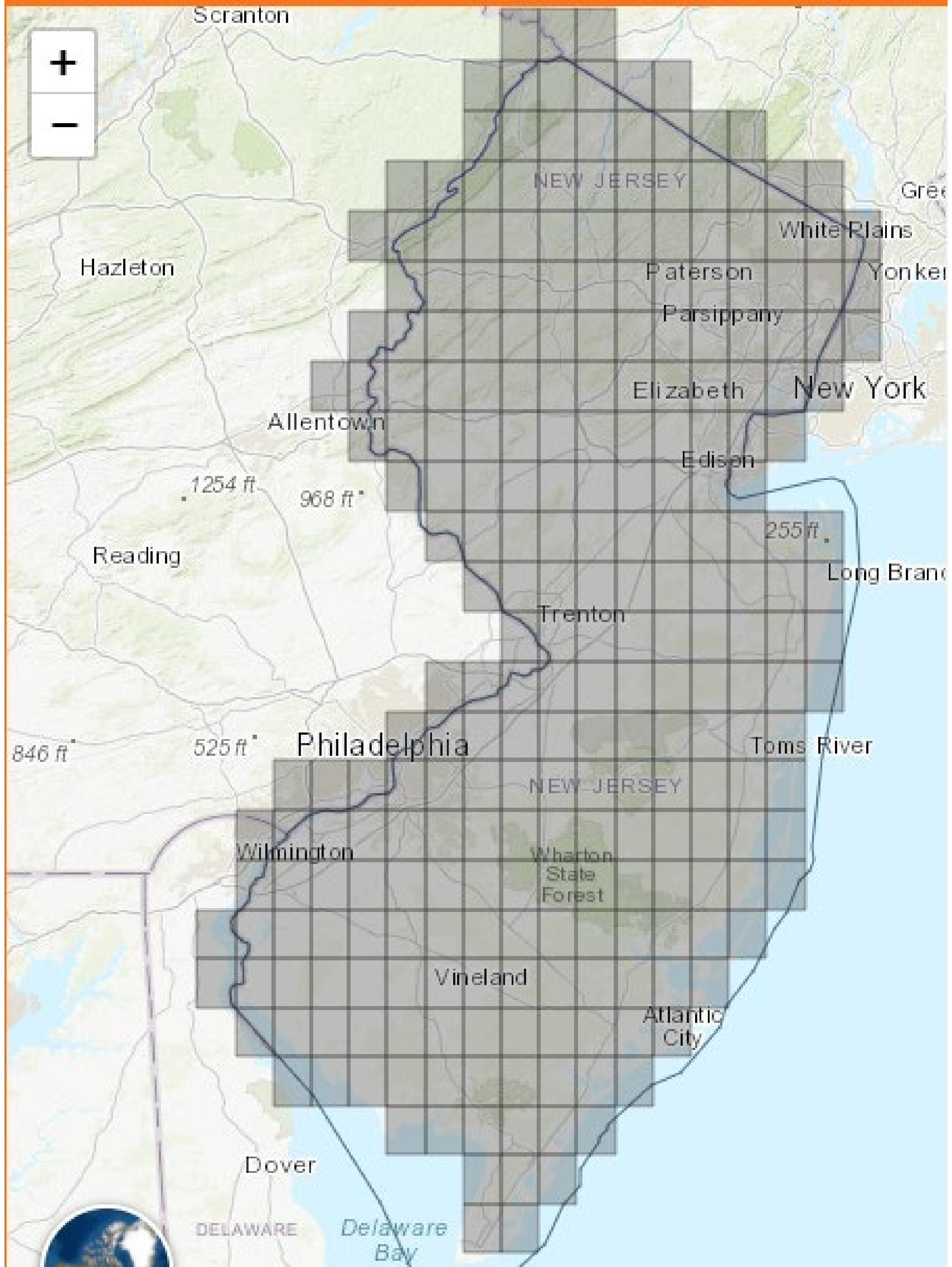
A distribution is fit to those 50 largest values (GEV [generalized extreme values])

Resampling (1,000x) was selected from that distribution to generate confidence intervals.

This is repeated for each model (up to 47x = 47,000 simulations for the combined set of models)

Each model grid interpolated to 0.1° grid to allow the results from the different methods to be combined

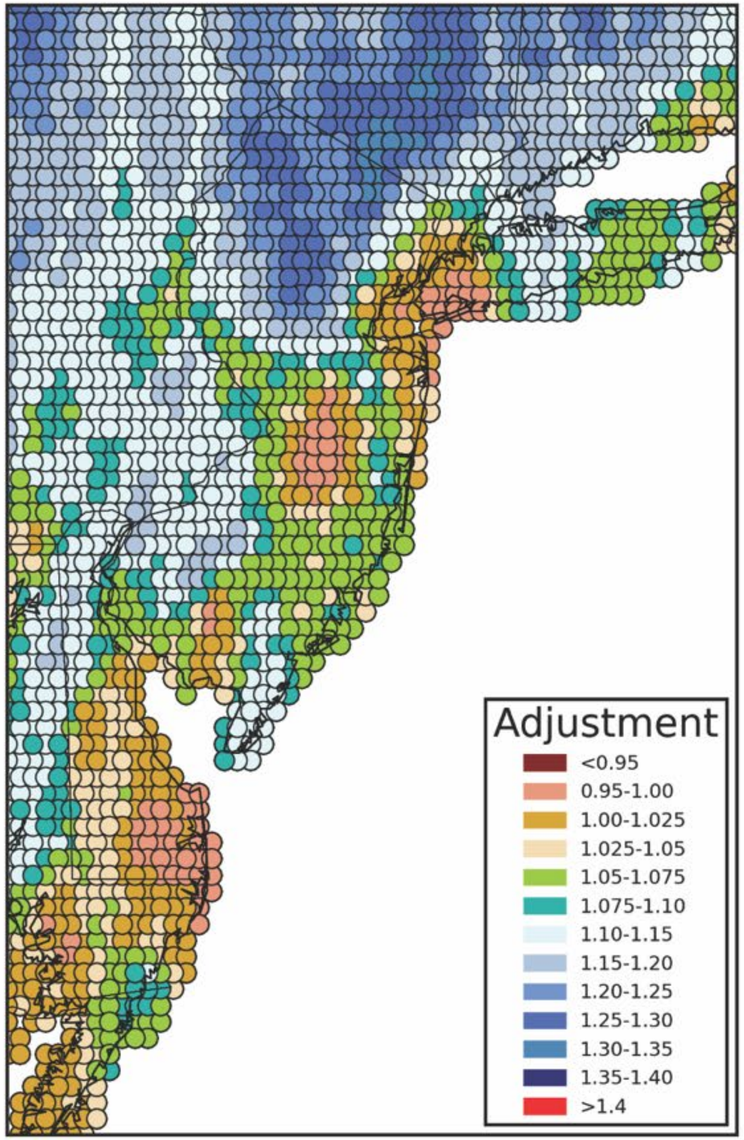
Statistics were drawn from the final 0.1° grids and aggregated to the county level

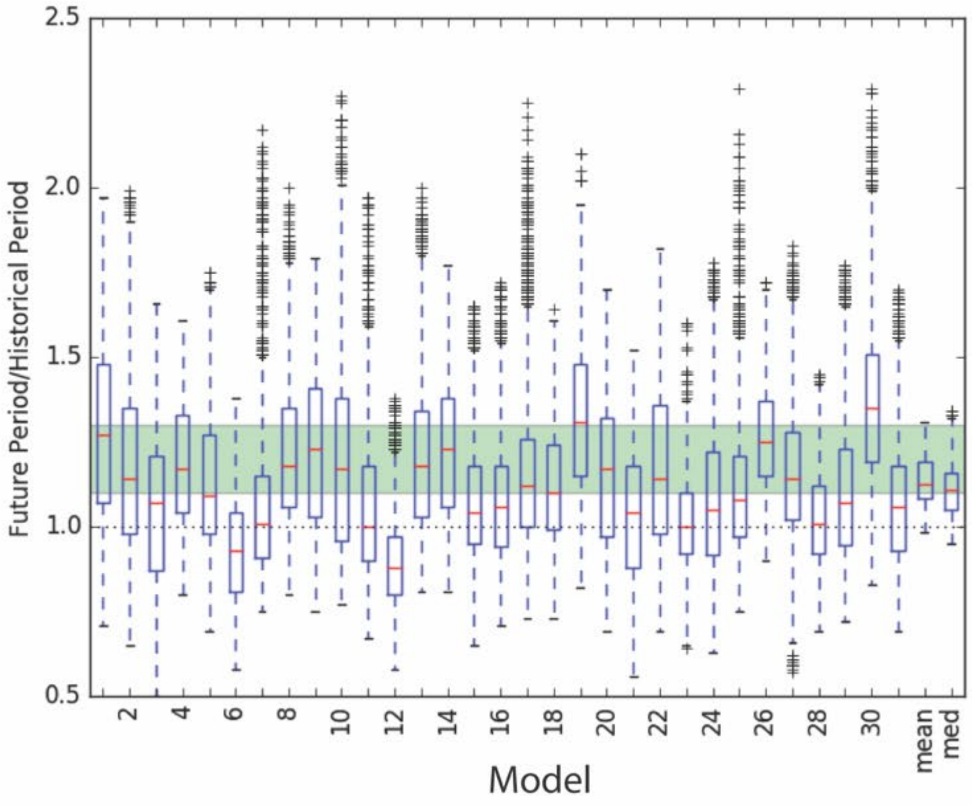


0.1 Degree grids

~6 miles
~11 km

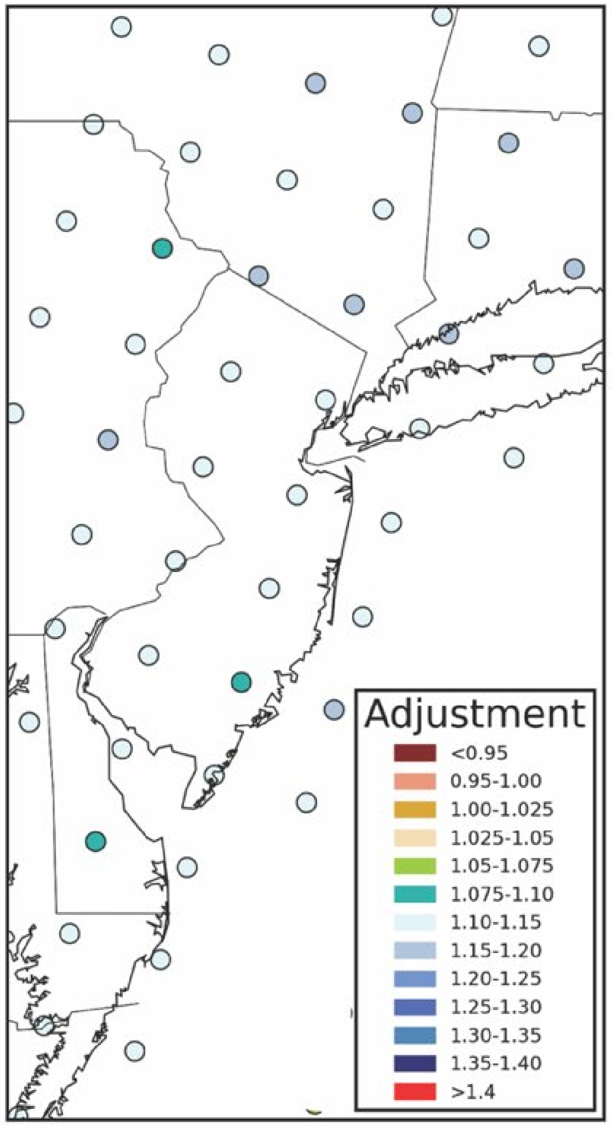
Projected Changes in Extreme Rainfall

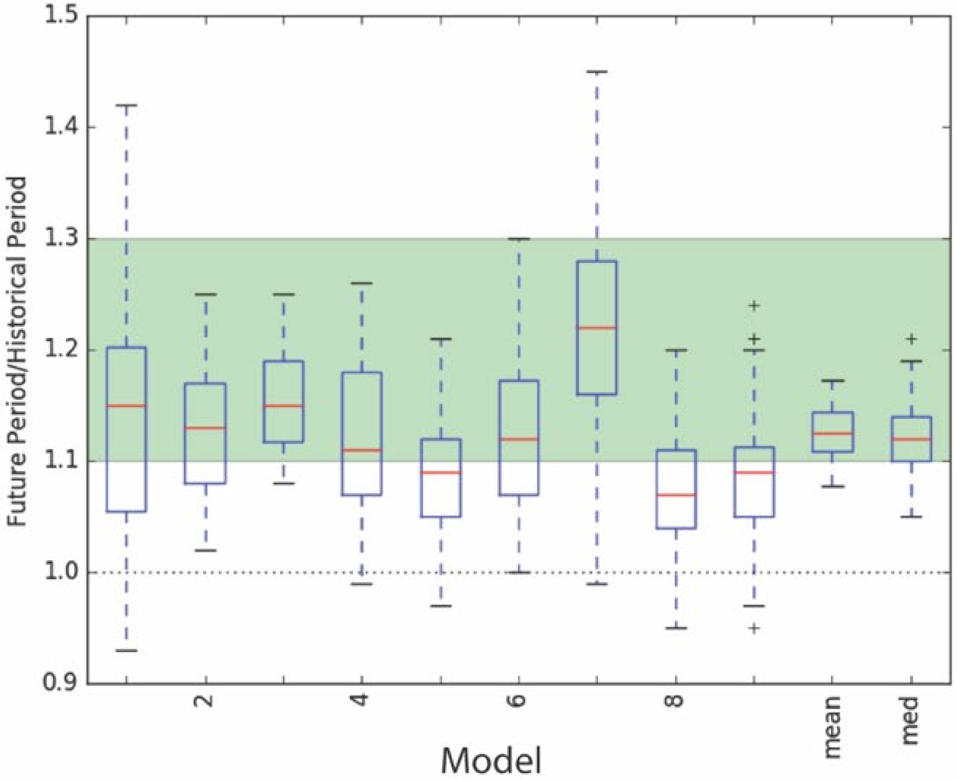




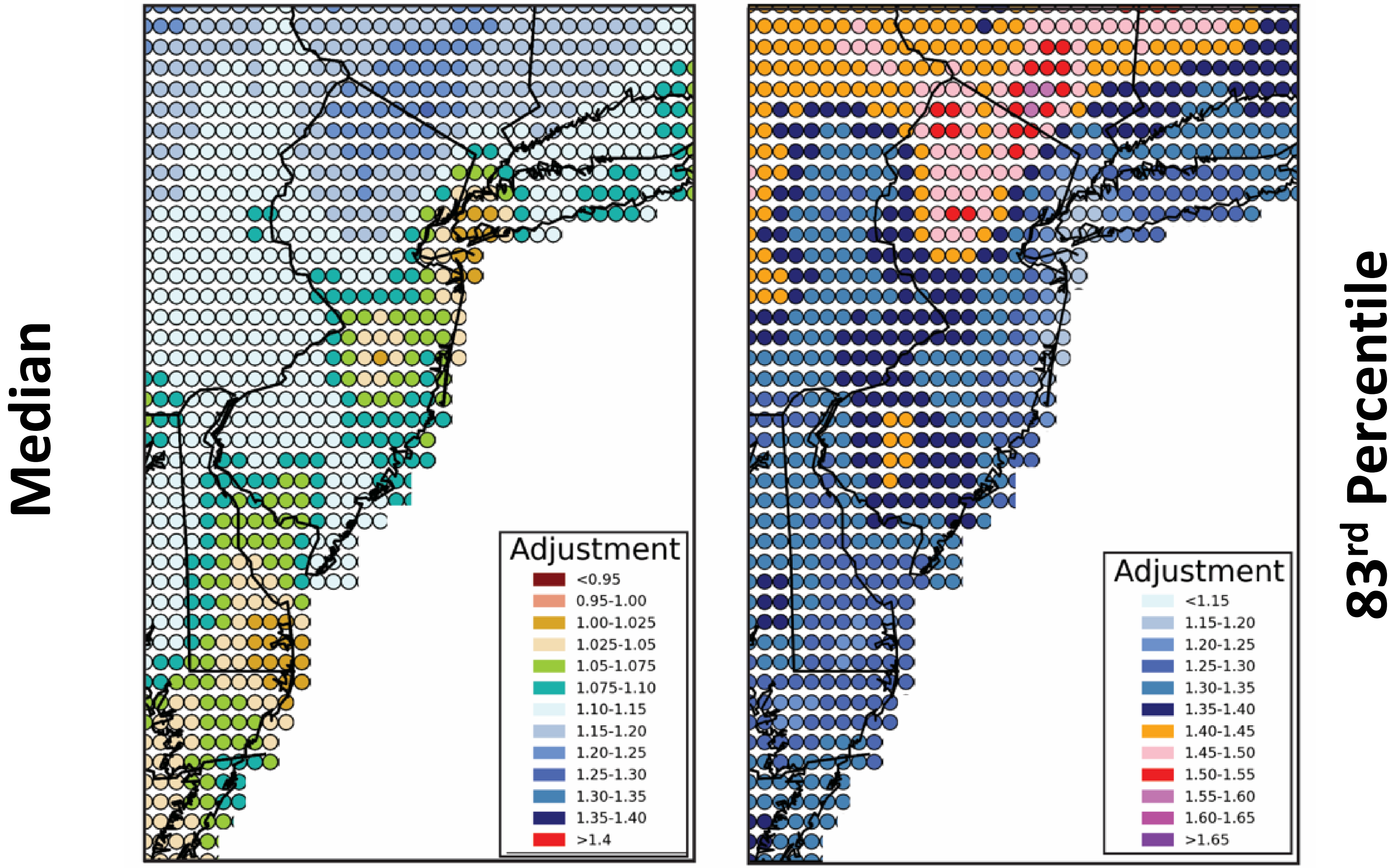
Change in 100-yr ARI precipitation in 2050-2099 under RCP 4.5 relative to the 1950-1999 historical period. In the map, the 31-model LOCA model median is shown for each **LOCA** grid point. The boxplots show the change for each model across all grid points.

Projected Changes in Extreme Rainfall





Change in 2-yr ARI precipitation in 2050-2099 under RCP 4.5 relative to the 1950-1999 historical period. In the map, the 9-model CORDEX model median is shown for each **CORDEX** grid point. The boxplots show the change for each model across all grid points.



Change in 100-yr ARI precipitation in 2050-2099 under RCP 4.5 relative to the 1950 to 1999 historical period for the ensemble of LOCA and CORDEX downscaled models. The ensemble median (50th percentile) is given in the left panel and the 83rd percentile of the ensemble shown in the right panel.

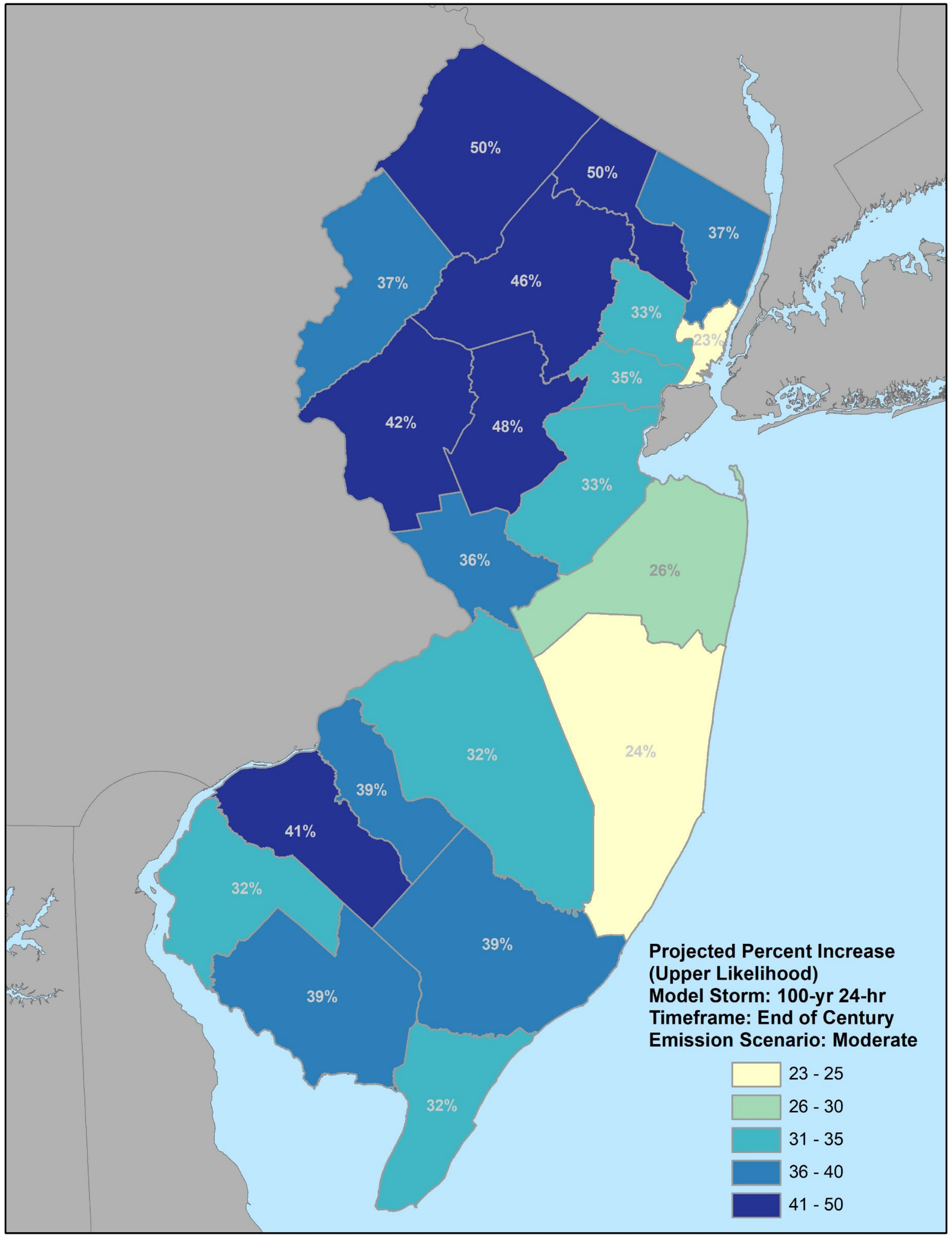
Projected Changes in Extreme Rainfall: Key Findings:

- There is a high likelihood that precipitation intensity will increase into mid and late century in all parts of the state, but the projected changes will be greater in the northern part of the state than in the southern and coastal areas.

- Under a moderate emissions (RCP 4.5) scenario projections suggest that the amount of precipitation associated with the 100-year, 24-hour storm will increase, ***on average***, by as much as 22% in northern counties. *Less than 10% in much of southern NJ*.

- For the 100-year, 24-hour storm, the models suggest a ***17% chance*** that precipitations will increase by as much as 45% to 50% in some counties. *Less than 25% in Ocean and Hudson Co.*

- More frequent storms, such as the 2-year and 10-year, 24-hour storms are expected to see increases in precipitation intensity, ***on average***, of 5% to 15% across the state by the end of the century.



Percentages on the map represent the projected percent increase in rainfall depth relative to current published values

Moderate Emission Scenario End of Century

100yr – 24hr Storm

Upper Likelihood -
(17% likelihood that projections can be higher)

Projected Changes in Extreme Rainfall

SEE EXCEL TABLES FOR CURRENT DATA TABLE B3. County-based 100-yr ARI change factors and projected precipitation estimates for 2050-2099 under RCP4.5 emissions.

	Change Factor				Projected Precipitation		
County	17th Percentile	Median	83rd Percentile		17th Percentile	Median	83rd Percentile
Atlantic	0.85	1.10	1.39		7.53	9.78	12.35
Bergen	0.96	1.15	1.37		8.01	9.67	11.44
Burlington	0.92	1.06	1.32		8.14	9.42	11.66
Camden	0.96	1.14	1.39		8.09	9.64	11.74
Cape May	0.95	1.13	1.32		8.17	9.71	11.37
Cumberland	0.85	1.06	1.39		7.44	9.23	12.12
Essex	0.94	1.12	1.33		8.19	9.70	11.56
Gloucester	0.95	1.14	1.41		8.14	9.73	12.03
Hudson	0.92	1.04	1.23		7.53	8.56	10.08
Hunterdon	0.91	1.13	1.42		7.34	9.06	11.43
Mercer	0.92	1.09	1.36		7.64	8.98	11.21
Middlesex	0.88	1.10	1.33		7.60	9.48	11.47
Monmouth	0.92	1.07	1.26		8.20	9.51	11.25
Morris	0.95	1.20	1.46		7.91	10.00	12.19
Ocean	0.94	1.07	1.24		8.68	9.97	11.50
Passaic	0.93	1.22	1.50		7.95	10.39	12.78
Salem	0.95	1.11	1.32		8.09	9.44	11.29
Somerset	0.93	1.17	1.48		7.58	9.48	11.98
Sussex	0.95	1.21	1.50		7.09	9.05	11.22
Union	0.93	1.11	1.35		8.13	9.72	11.79
Warren	0.95	1.15	1.37		7.42	8.98	10.70

https://njprojectedprecipitationchanges.com/

New Jersey Extreme Precipitation Projection Tool

Northeast Regional Climate Center   Cornell University

Click on a county on the map or select one from the dropdown list to view the precipitation data.

ATLANTIC

Projected Percent Increase (Upper Likelihood)

- < 25
- 25 - 30
- 30 - 35
- 35 - 40
- > 40

Upper likelihood represents a 17% likelihood that precipitation depth will increase more than the value shown relative to the NOAA Atlas 14 published mean values.

Return Period

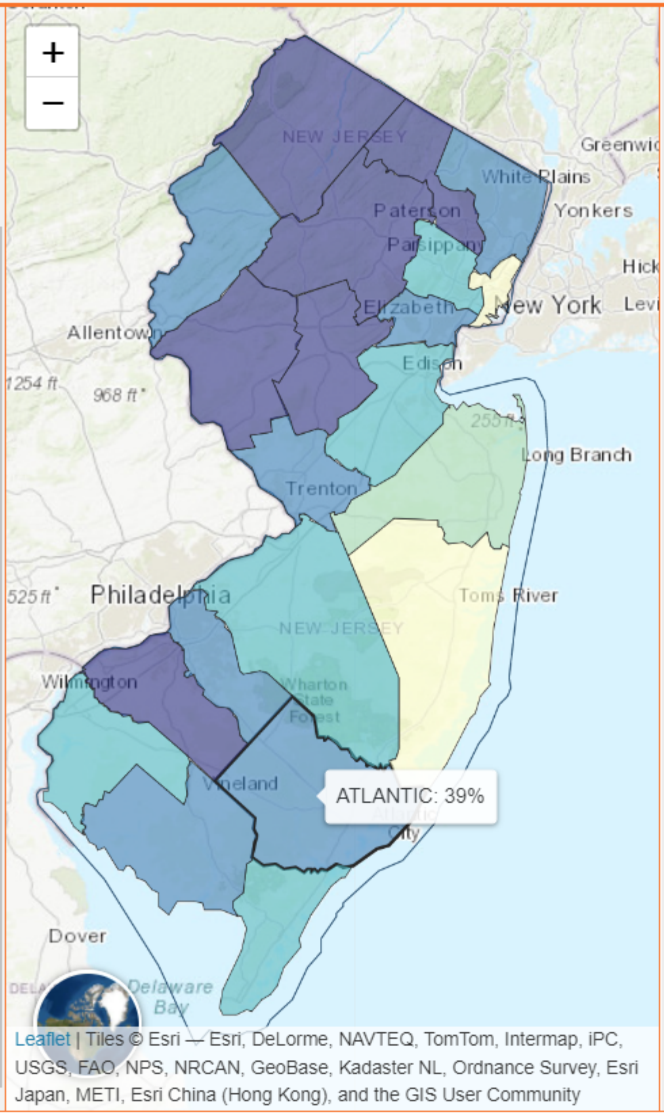
- 2-year
- 5-year
- 10-year
- 25-year
- 50-year
- 100-year

Emission Scenario

- Moderate RCP 4.5
- High RCP 8.5

Time Period

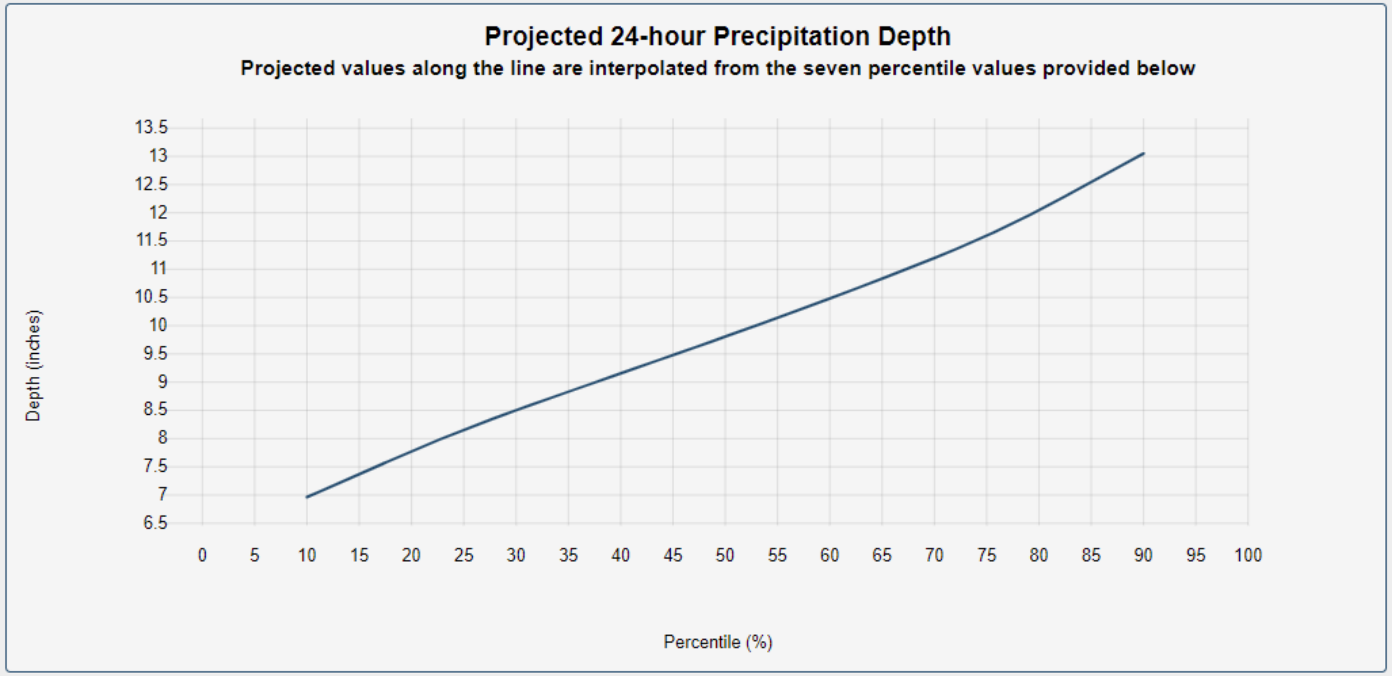
- 2020 - 2069
- 2050 - 2099



User Guide | **Precipitation Projection** | About the Data

100-yr Return Period RCP 4.5 Projection 2050-2099 - ATLANTIC

Excel   PDF



Duration (hrs)	Projected Depth (inches)							NOAA Atlas 14 Values (Inches, data through Dec. 2000)*		
	10th	17th	25th	Median	75th	83rd	90th	Low CI	Mean	High CI
24	6.96	7.53	8.21	9.78	11.52	12.35	13.05		8.89	

The projected precipitation data is referenced from the Full Report and Supplemental Table of the Future Precipitation Study.

**Bonnin, G.M., D. Martin, B. Lin, T. Parzybok, M. Yekta, and D. Riley, D., 2006: NOAA Atlas 14 Precipitation-Frequency Atlas of the United States Volume 2 Version 3.0: Delaware, District of Columbia, Illinois, Indiana, Kentucky, Maryland, New Jersey, North Carolina, Ohio,*

For questions about the data, please contact NJDEP | For website related issues, please contact AECOM

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https://nj.gov/dep/climatechange/data.html
or https://nj.gov/dep/dsr/

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