a NOAA Mid-Atlantic RISA team

Piloting the Development of Probabilistic Intensity Duration Frequency (IDF) Curves for the Chesapeake Bay Watershed

Chesapeake Bay Program
Urban Stormwater Workgroup Meeting
June 16, 2020

Michelle Miro (RAND), Krista Romita Grocholski (RAND), Art DeGaetano (Cornell), Costa Samaras (CMU)

CBTRUST Chesapeake Bay Trust · NOAA · RAND Corporation · Cornell University · Carnegie Mellon University

Agenda

- Intro to our team and the MARISA Program
- Overview of project motivation, approach and outcomes
- Using downscaled climate model data for deriving IDF curves – challenges and approaches
- Overview of future projected IDF curves and data access tool for NY State
- Questions and discussion

Our team Draws on a Diverse Range of Climate, Policy, and Engineering Expertise

RAND CORPORATION

Cornell University

Carnegie Mellon University

Michelle Miro

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Jordan Fischbach

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MARISA
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Members of the MARISA Team

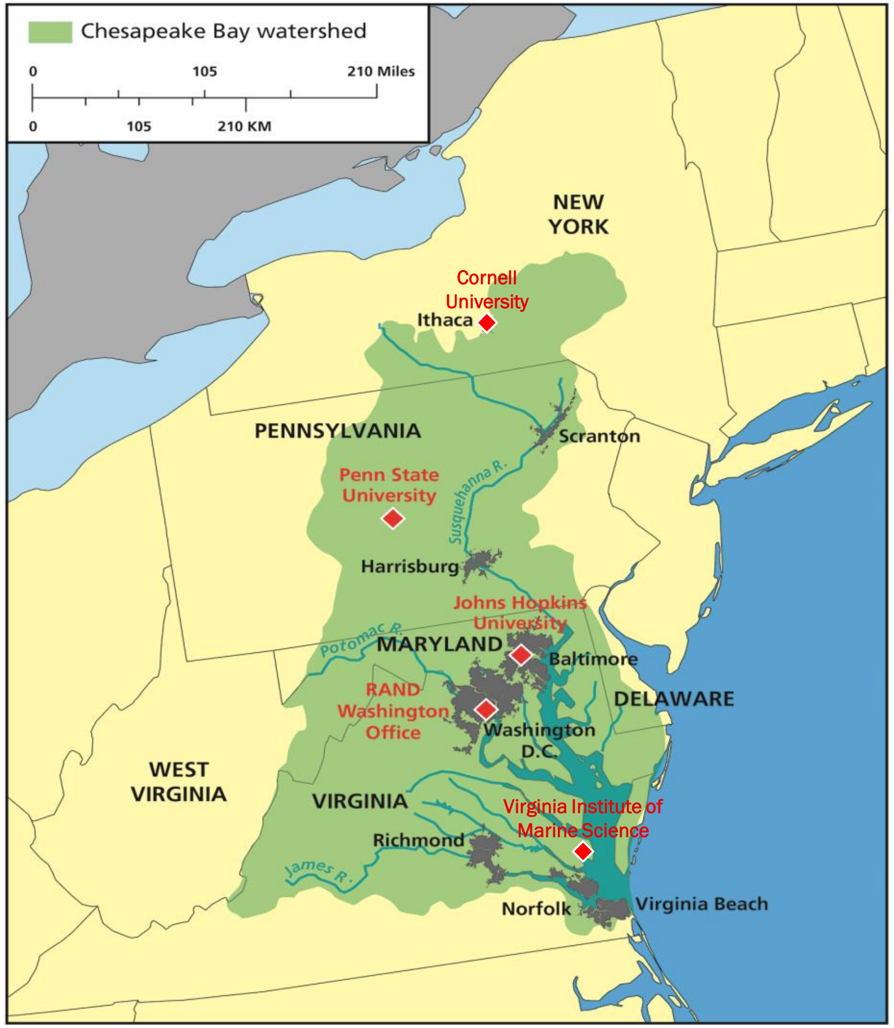
Mid-Atlantic Regional Integrated Sciences and Assessments (MARISA) Program

MARISA is a NOAA-funded research program that brings together diverse disciplines and sectors to enhance learning and decision making to prepare for the impacts of climate variability and change.

Our team includes researchers from: the RAND Corporation, Penn State University, Johns Hopkins University, Cornell University, and the Virginia Institute of Marine Science

Mission: Helping Mid-Atlantic communities become more resilient to a changing climate through improved data, place-based decision support, and public engagement

Initial focus on the Chesapeake Bay watershed



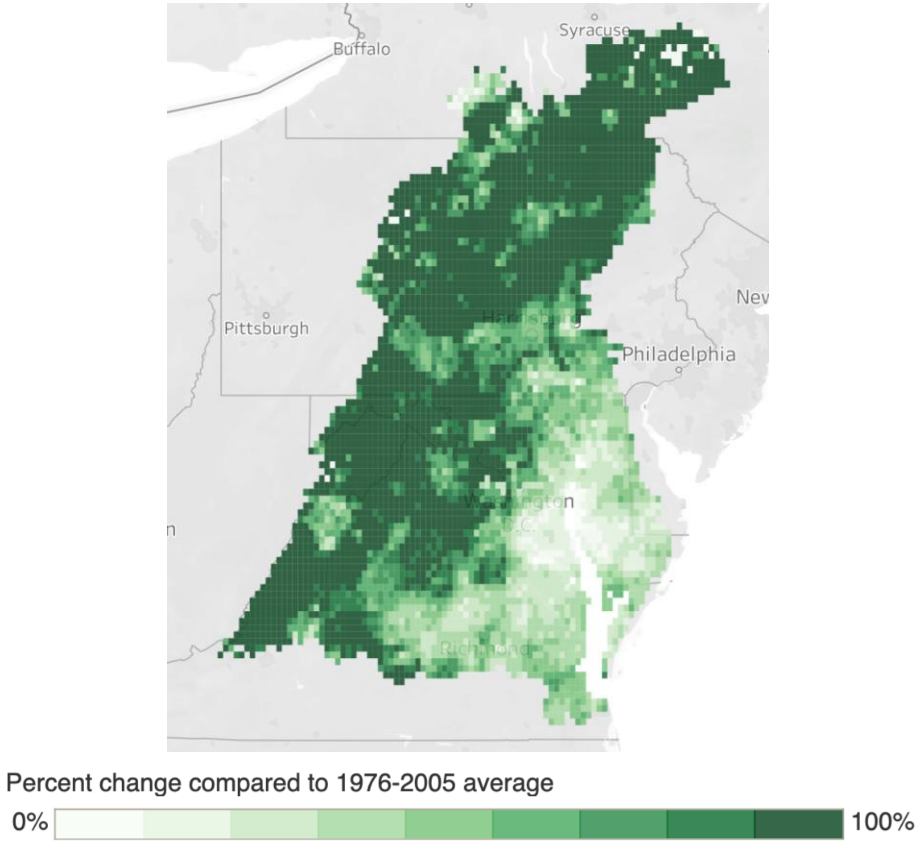
MARISA
a NOAA Mid-Atlantic RISA team

Project Motivation

- Over the past decade, the Chesapeake Bay Watershed has experienced increases in extreme precipitation.
- Increases in heavy rainfall events are anticipated to continue over the next several decades and grow by mid to late 21st century.

To design and build infrastructure assets to withstand anticipated future precipitation conditions, design standards should reflect future precipitation projections and not solely be based on historical precipitation records.

Projected Change in Average Annual Number of Days with Precipitation above 3” (2036-2065, High Emissions Future)



Fischbach et al., 2018. https://www.midatlanticrisa.org/climate-summaries/2018/11.html

This project will develop future projected IDF curves for the entire Chesapeake Bay Watershed and host them on a web-based tool

1. Data collection
    - Station data – National Weather Service Cooperative Observer Program
    - Climate model data – NA-CORDEX, BCCA, MACA, LOCA
2. Downscaling projected precipitation extremes
    - Dynamical and statistical
3. Downscaling method evaluation and uncertainties
    - Examine downscaling methods and datasets for bias and outliers
    - Examine range of projected precipitation values across GCMs and emissions scenarios
4. Develop probabilistic IDF curves
5. Develop a web-based tool and engage in outreach

Project Outcomes

IDF Curves - via an interactive webpage:

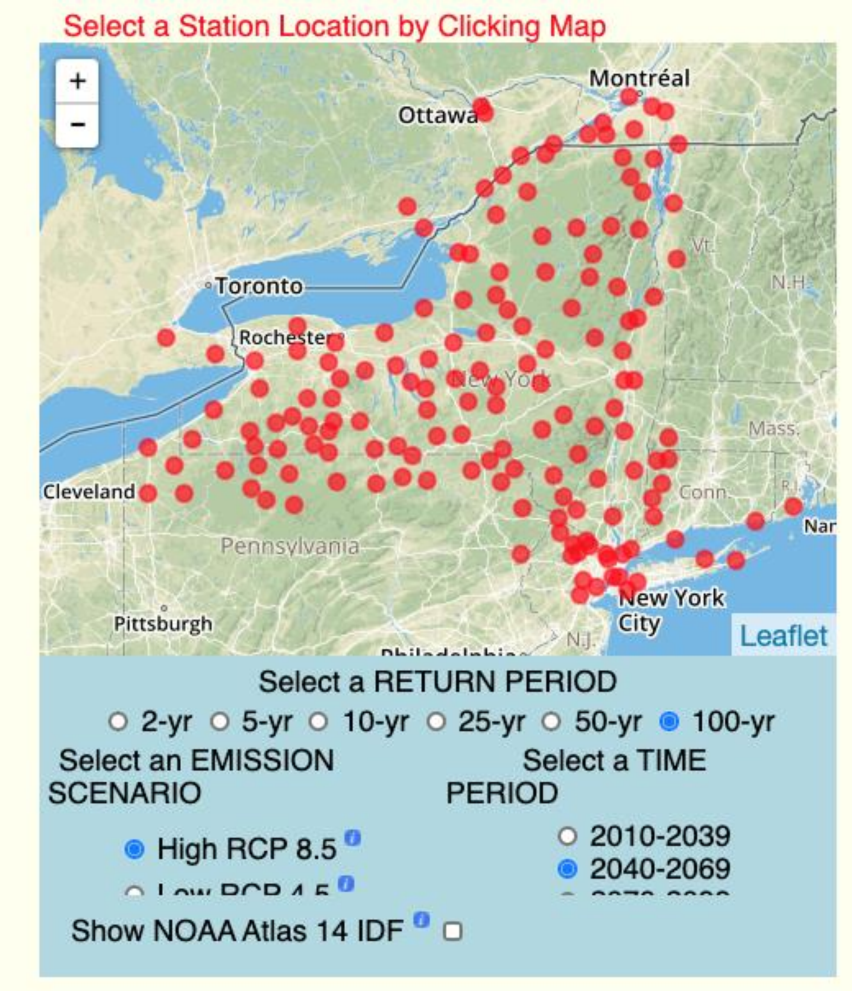
- Station-specific IDF curves and historical and future 2-, 5-, 10-, 25-, 50-, and 100-year recurrence interval precipitation amounts computed for 1-, 2-, 3-, 6-, 12-, 18-, and 24-hour durations for the entire CBW.
- The webpage will be hosted on the NRCC website, as well as embedded in the MARISA website.
- *Dataset complete by 2/26/2021, website by 5/21/2021*

Project Report:

- This report will detail study motivations, data and metadata, methods, and findings, as well as IDF curve uncertainties and recommendations.
- Draft project report will be submitted to the Urban Stormwater Workgroup on *3/31/2021, final report on 5/21/2021*

Outreach:

- An instructional webinar explaining the motivations for the project, the results, and how to use the IDF curves and other final products, data, and reports, *complete on 3/31/2021*
- The recorded webinar and a frequently asked questions document will be included on the interactive webpage to enhance usability.



http://ny-idf-projections.nrcc.cornell.edu/

Final deliverables complete on 5/21/2021 and our next webinar to USWG by 5/21/2021

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Informing Resilient Stormwater Infrastructure Decisions Under Uncertainty

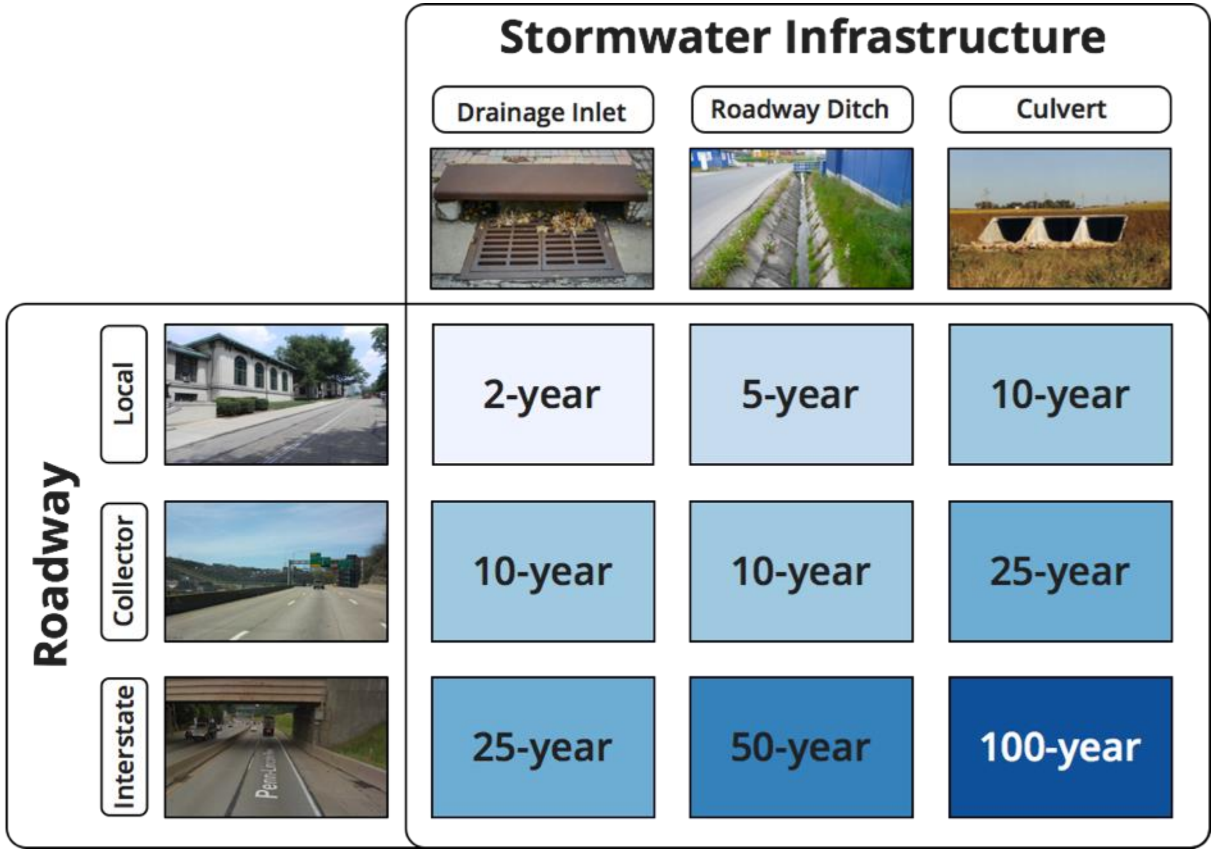
Constantine Samaras, Tania Lopez-Cantu, Marissa Webber

Civil and Environmental Engineering,

Carnegie Mellon University

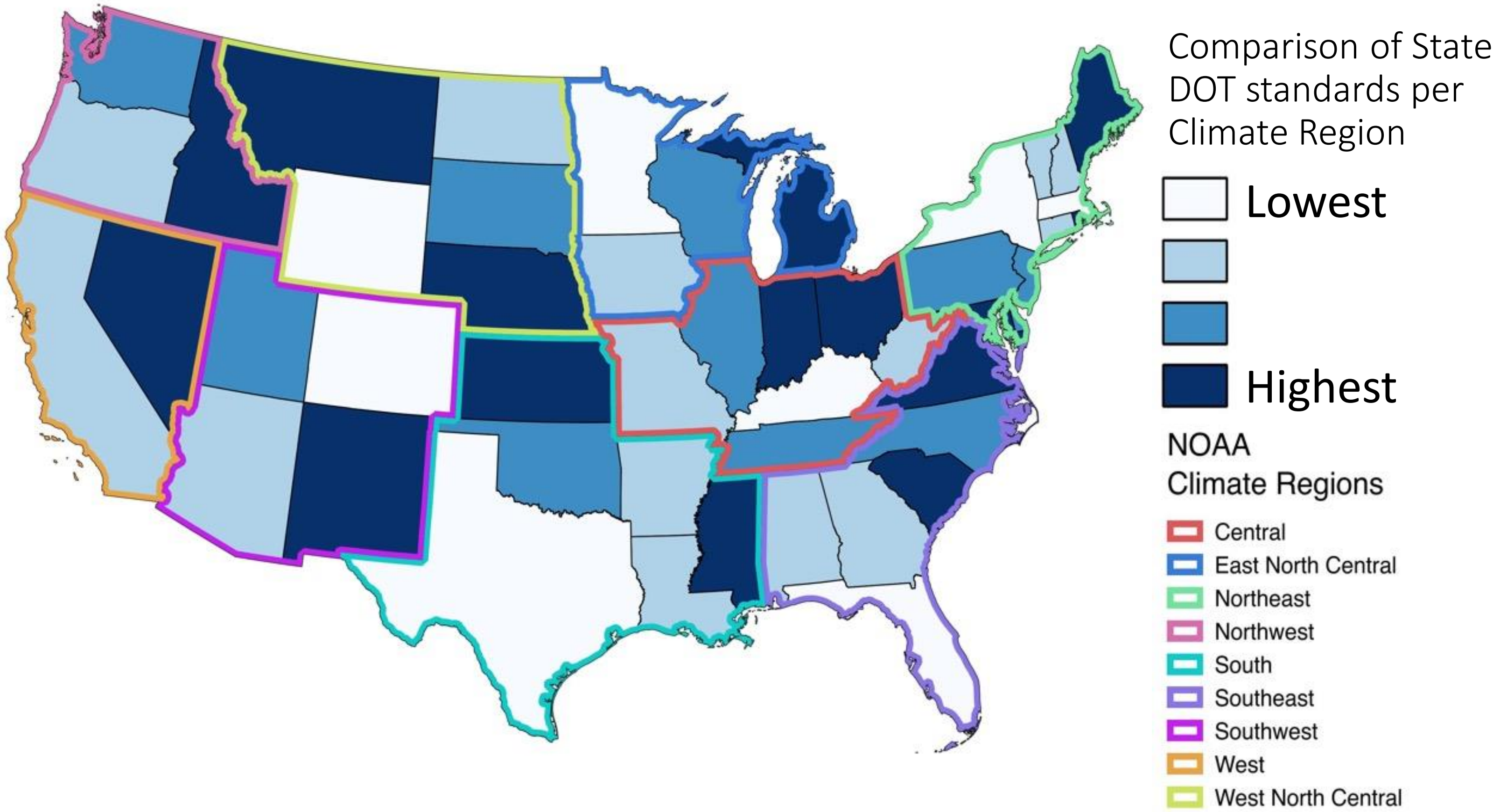
csamaras@andrew.cmu.edu

National And State Agencies Guide Engineers On Selecting Infrastructure Minimum Return Period



Sources: Memphis Stormwater, Google Maps, Carnegie Mellon University Ivioregion, Roadex

We Found Some States Are More Stringent Than Others Within The Same Climate Region

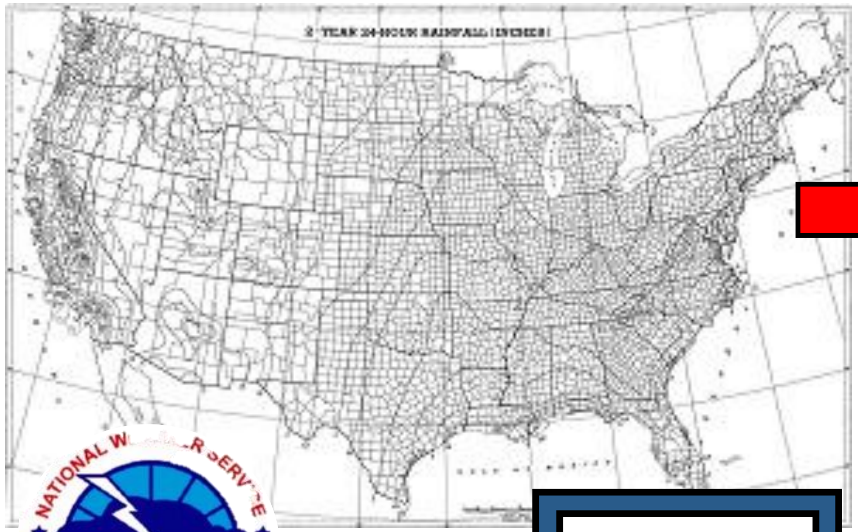


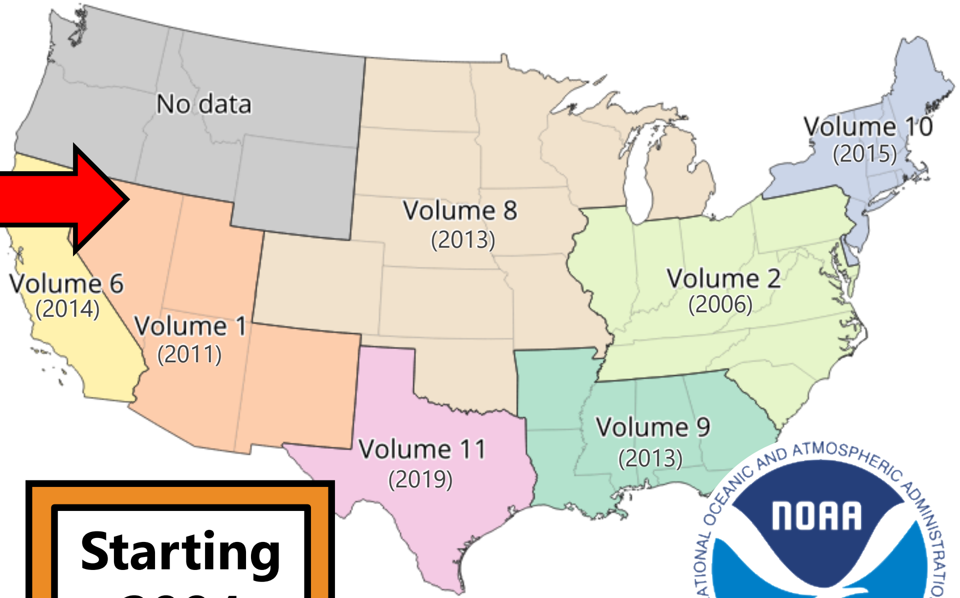
(Lopez-Cantu and Samaras, 2018)

Precipitation Frequency Atlases Are Used To Retrieve Rainfall Characteristics Associated To A Standard

Technical Paper 40 (TP-40)

NOAA Atlas 14

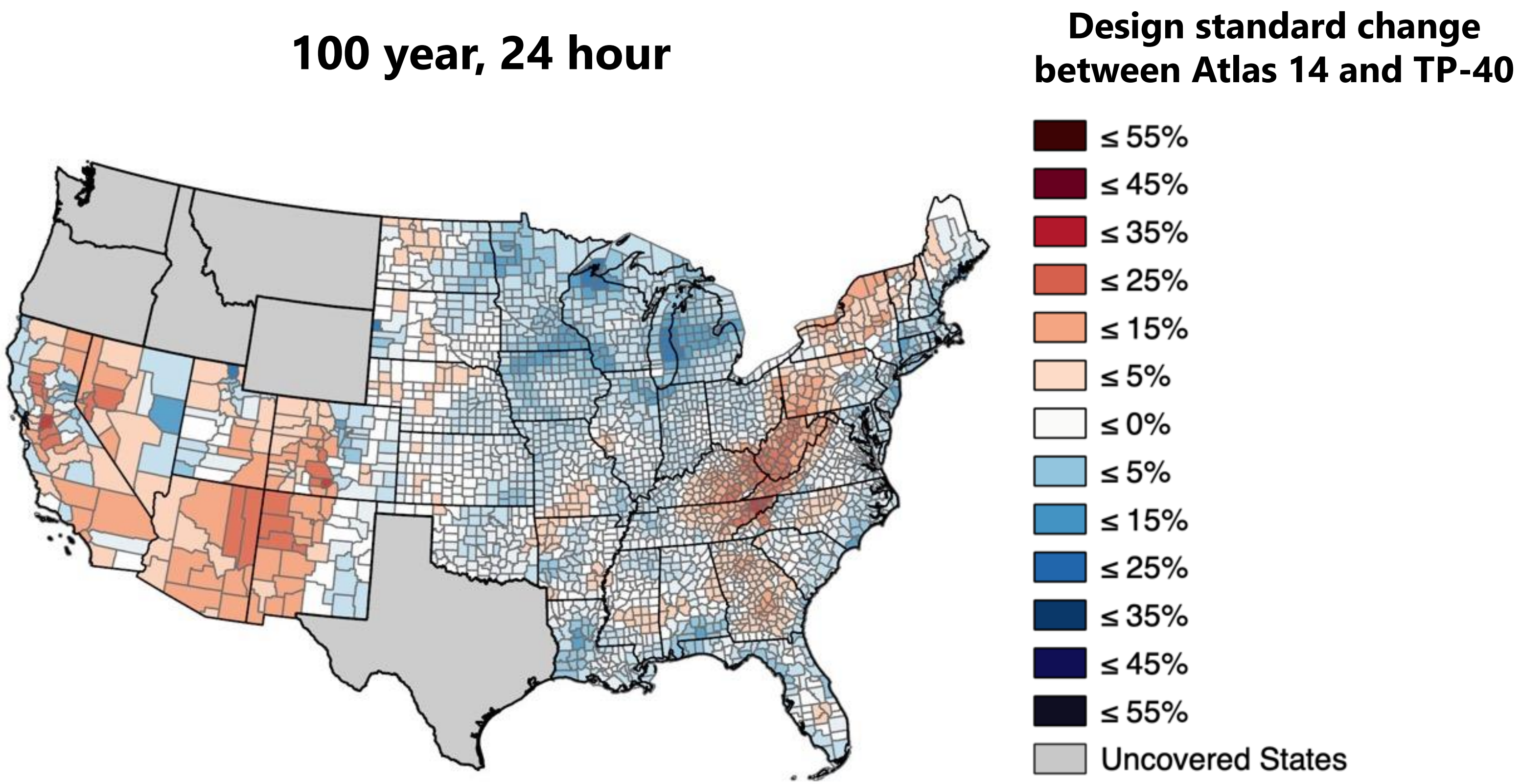




1961

Starting 2004

Update Created Discrepancies Between Old And New Rainfall Depth Associated To Standards

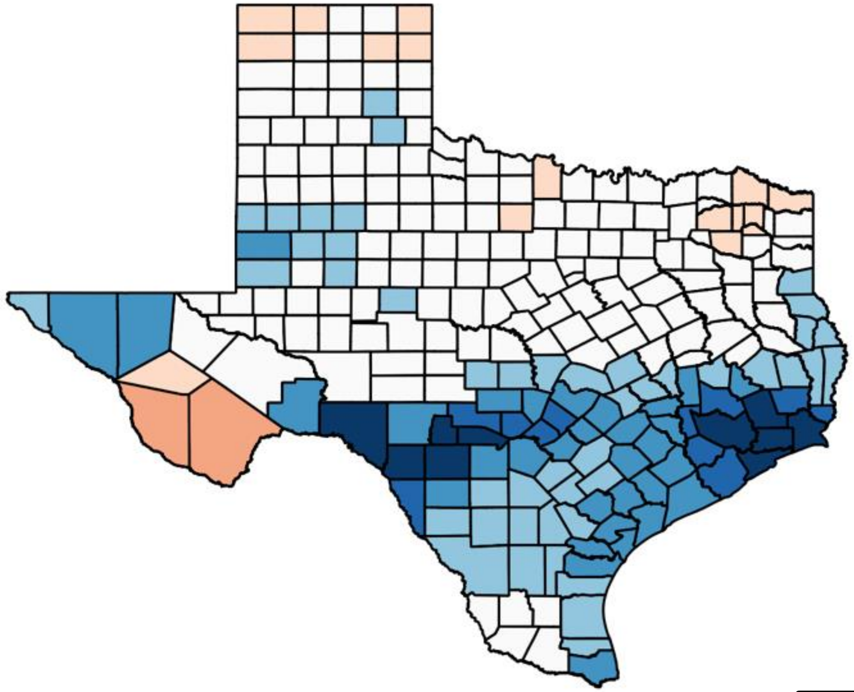


(Lopez-Cantu and Samaras, 2018)

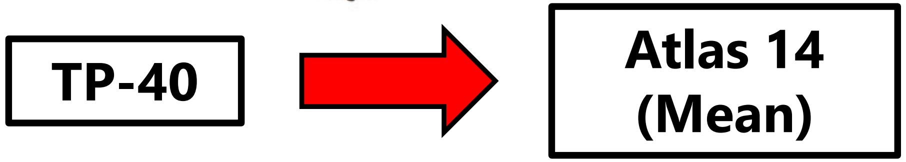
TP-40 → **Atlas 14 (Mean)**

Differences for Southeastern Texas Affect Current Infrastructure

100 year, 24 hour



Design standard change between Atlas 14 and TP-40



(Lopez-Cantu and Samaras, 2018)

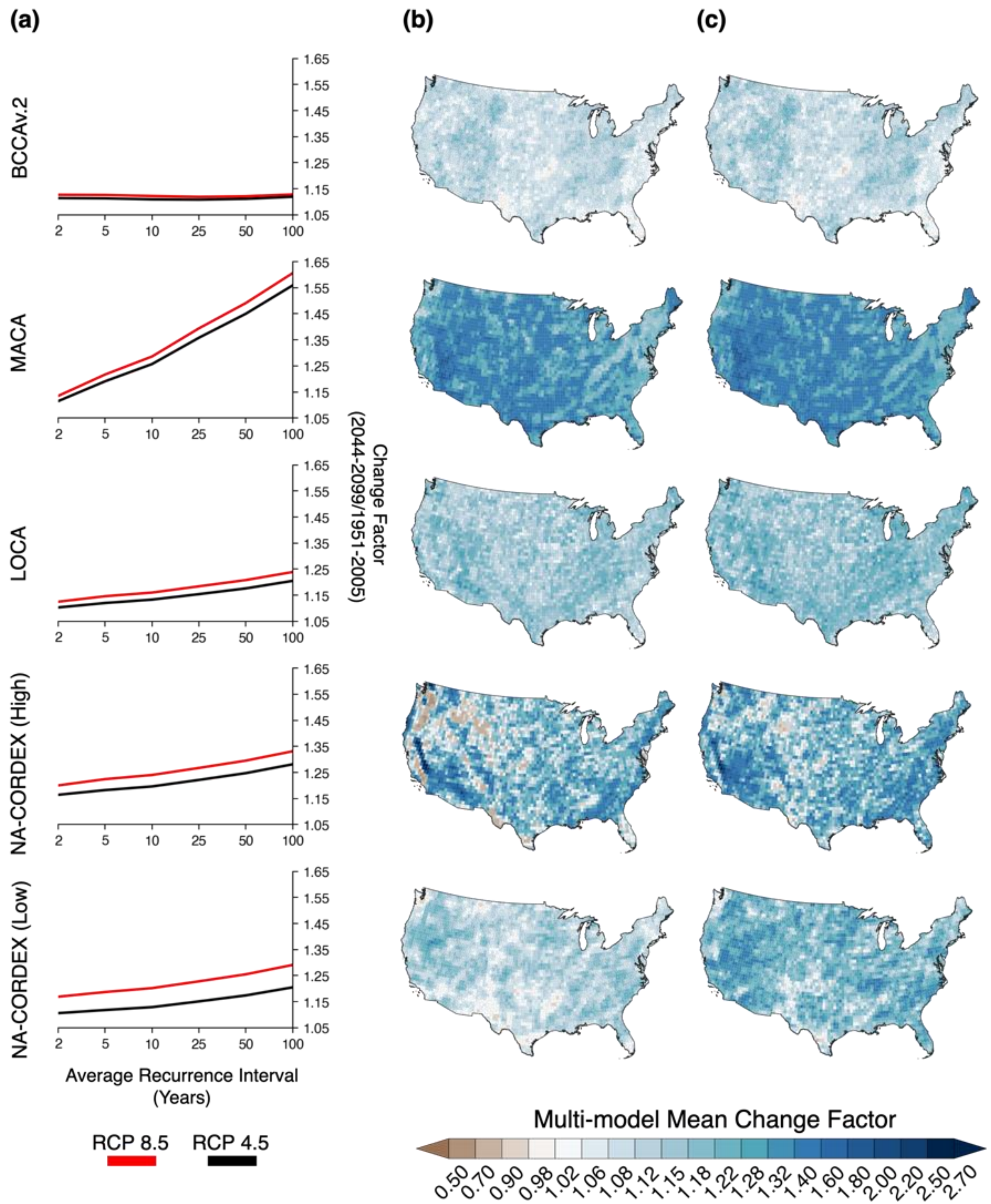
Publicly Available Downscale Climate Projections Differ In Characteristics

Data set	GCM models	Emissions scenario	Downscaled spatial resolution (degrees)	Highest temporal resolution	Downscaling technique
BCCAv2	21	2.6, 4.5, 6.0, 8.5	1/8	Daily	Statistical
MACA	20	4.5, 8.5	1/24	Daily	Statistical
LOCA	32	4.5, 8.5	1/16	Daily	Statistical
NA-CORDEX	6[b]	4.5, 8.5	0.22, 0.44	Hourly	Dynamical

The number of GCM models dynamically downscaled depend on the target resolution and the emissions scenario.

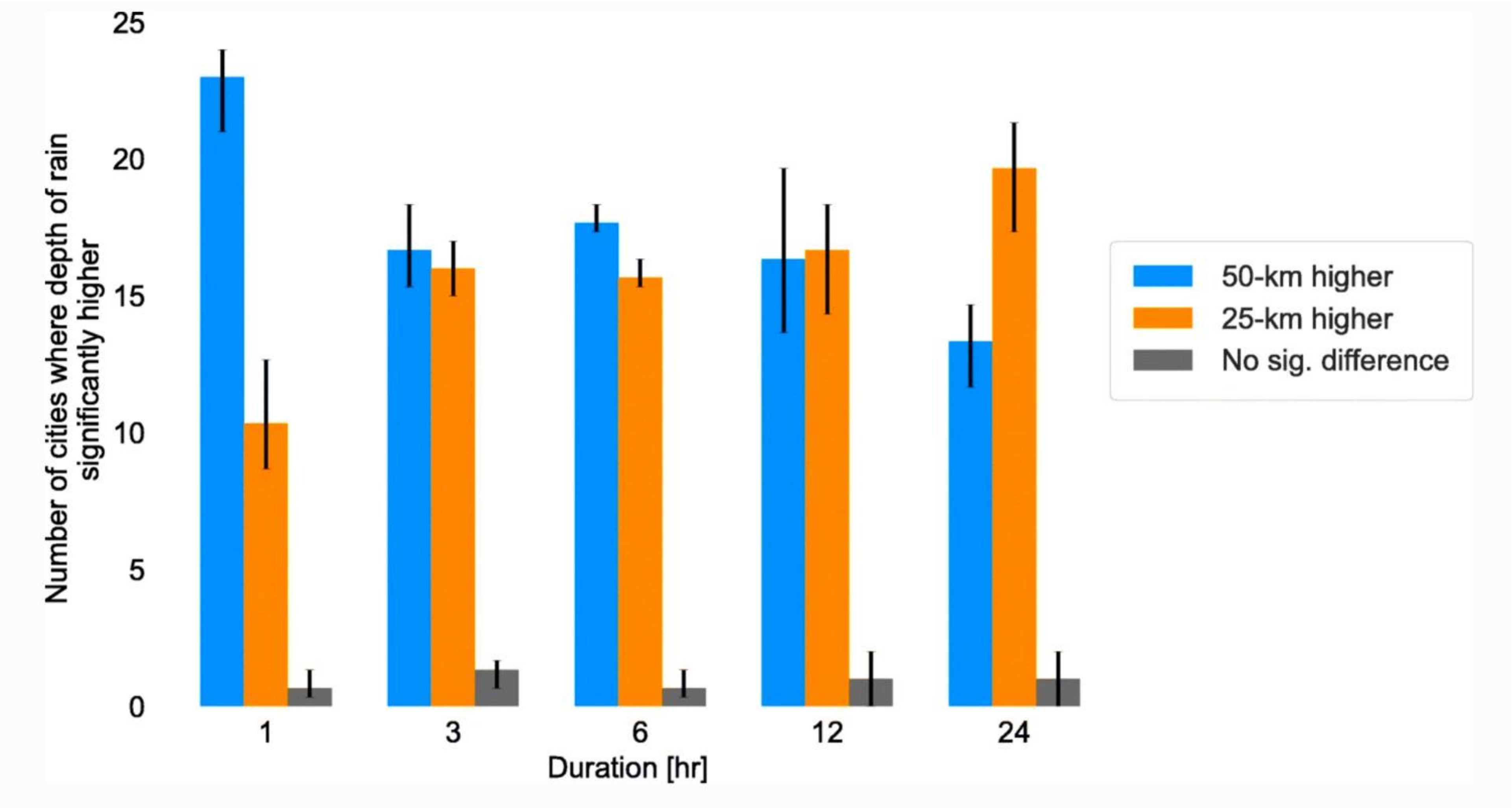
(Lopez-Cantu, Prein, and Samaras, 2020)

Each Climate Projection Dataset Produces A Different Change Factor, Leading To Different IDF Curves



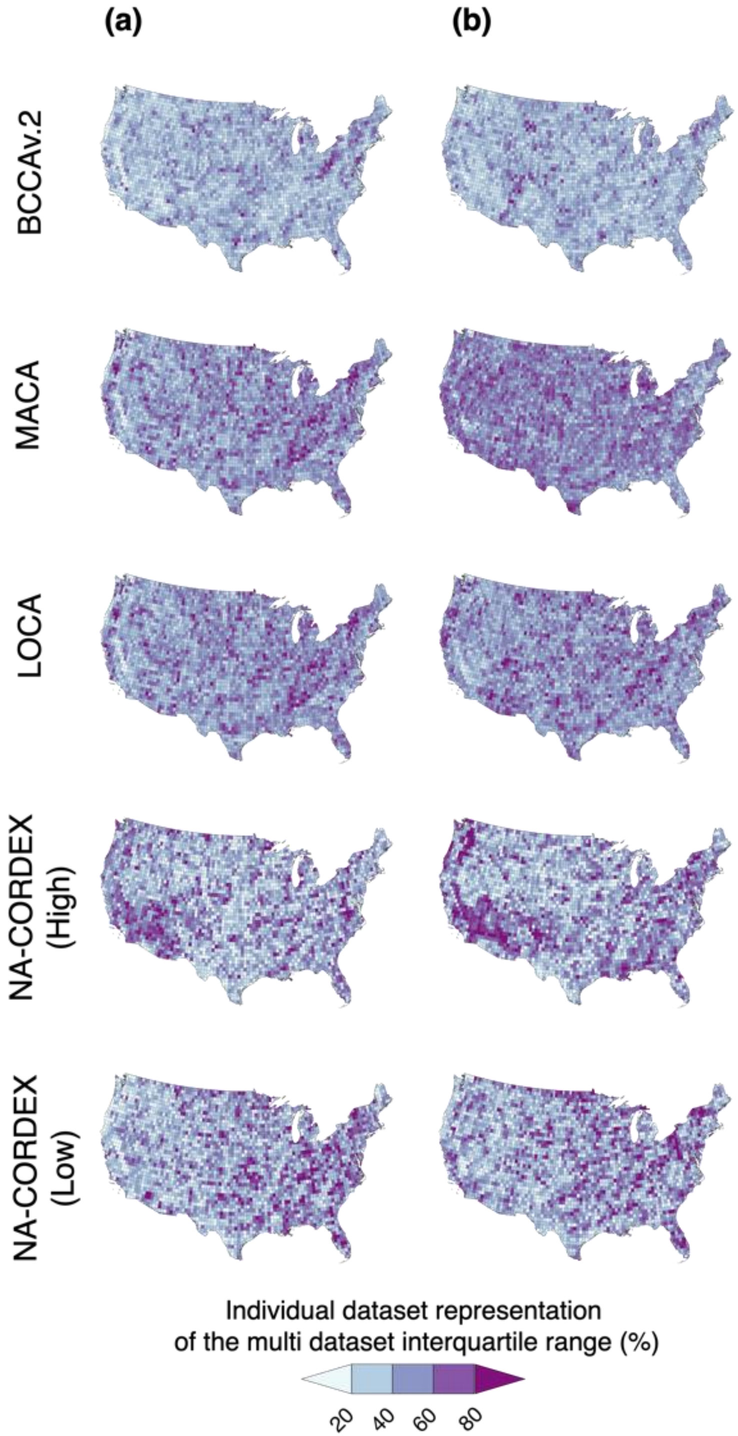
(Lopez-Cantu, Prein, and Samaras, 2020)

Across 34 US Cities We Found Spatial Scale of CORDEX Projections Affected IDF Curves



(Lopez-Cantu, Prein, and Samaras, 2020)

For This Project, We Will Compare Change Factors and IDF Curves Across All Datasets



(Lopez-Cantu, Prein, and Samaras, 2020)

Acknowledgements

NCAR
NATIONAL CENTER FOR ATMOSPHERIC RESEARCH

Jared and Maureen Cohon Graduate Fellowship in Civil and Environmental Engineering

CONACYT
Consejo Nacional de Ciencia y Tecnología

NSF

CERCA
Center for Engineering and Resilience for Climate Adaptation

NSF Collaborative Award Number
CMMI 1635638/1635686

Papers available:

- Lopez-Cantu, T., & Samaras, C. (2018). Temporal and spatial evaluation of stormwater engineering standards reveals risks and priorities across the United States. Environmental Research Letters, 13(7), 074006.

- Cook, L.M., McGinnis, S., Samaras, C. (2020). The effect of modeling choices on updating intensity duration frequency curves and stormwater infrastructure designs for climate change. *Climatic Change*. 159, 289–308.

- Lopez-Cantu, T., Prein. A., Samaras, C. (2020). Uncertainties in Future U.S. Extreme Precipitation from Downscaled Climate Projections. *Geophysical Research Letters*. 47,
- e2019GL086797

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Projections of Extreme Precipitation Amounts for Climate Adaptation Planning in New York State

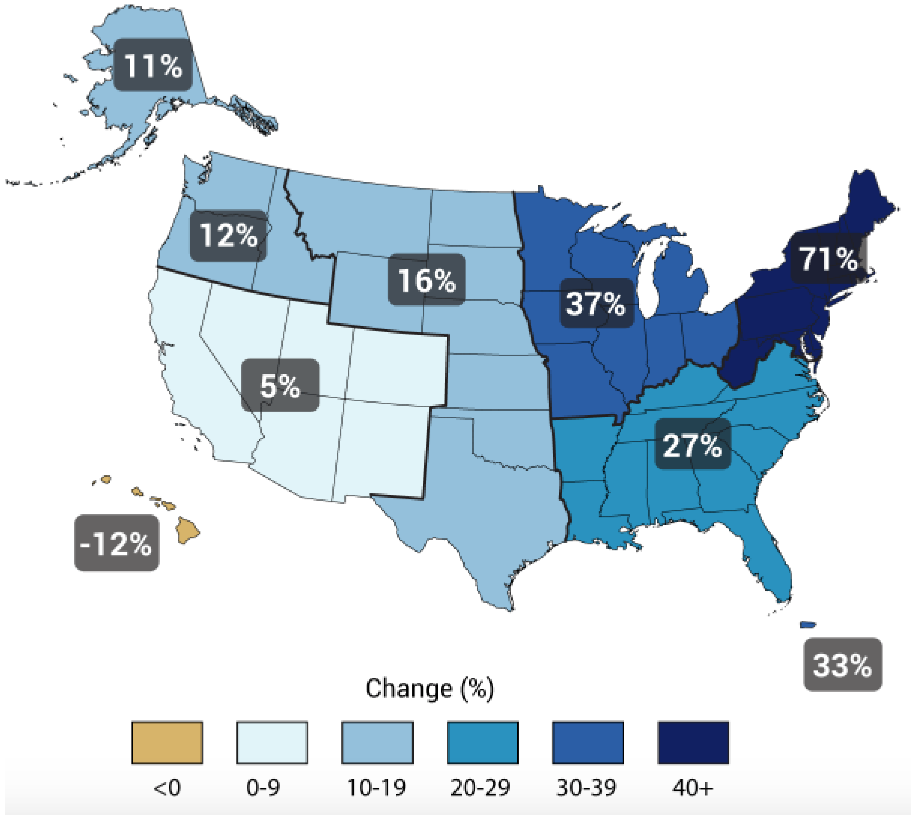
Art DeGaetano

Northeast Regional Climate Center
Department of Earth and Atmospheric Science, Cornell

Cornell University

Northeast Regional Climate Center

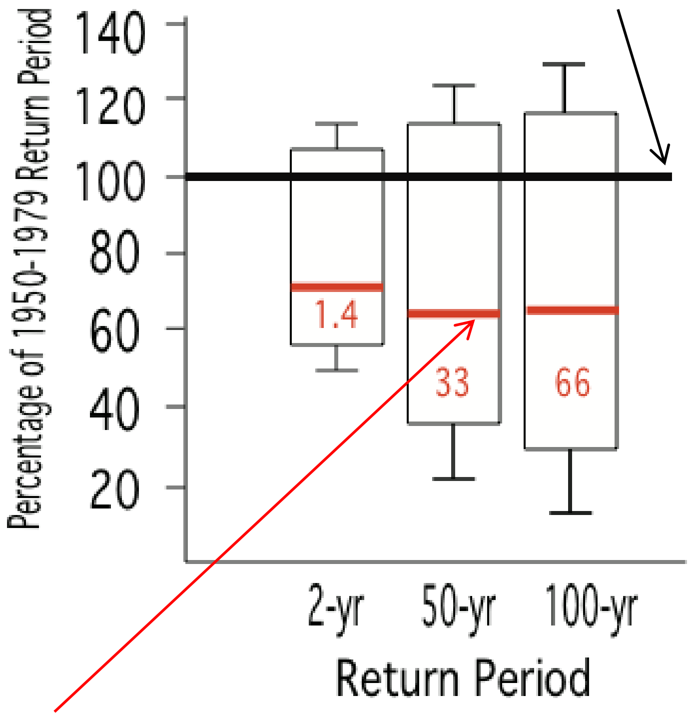
Motivation



Change in heaviest 1% of all daily events 1958-2012

from Karl et al. 2009

1950-79 Return Period =
1980-2009 Return Period



1950-79 50 year storm =
1980-2009 33 year storm

DeGaetano, 2009

Motivation

NY Climate Risk and Resiliency Act CCRA

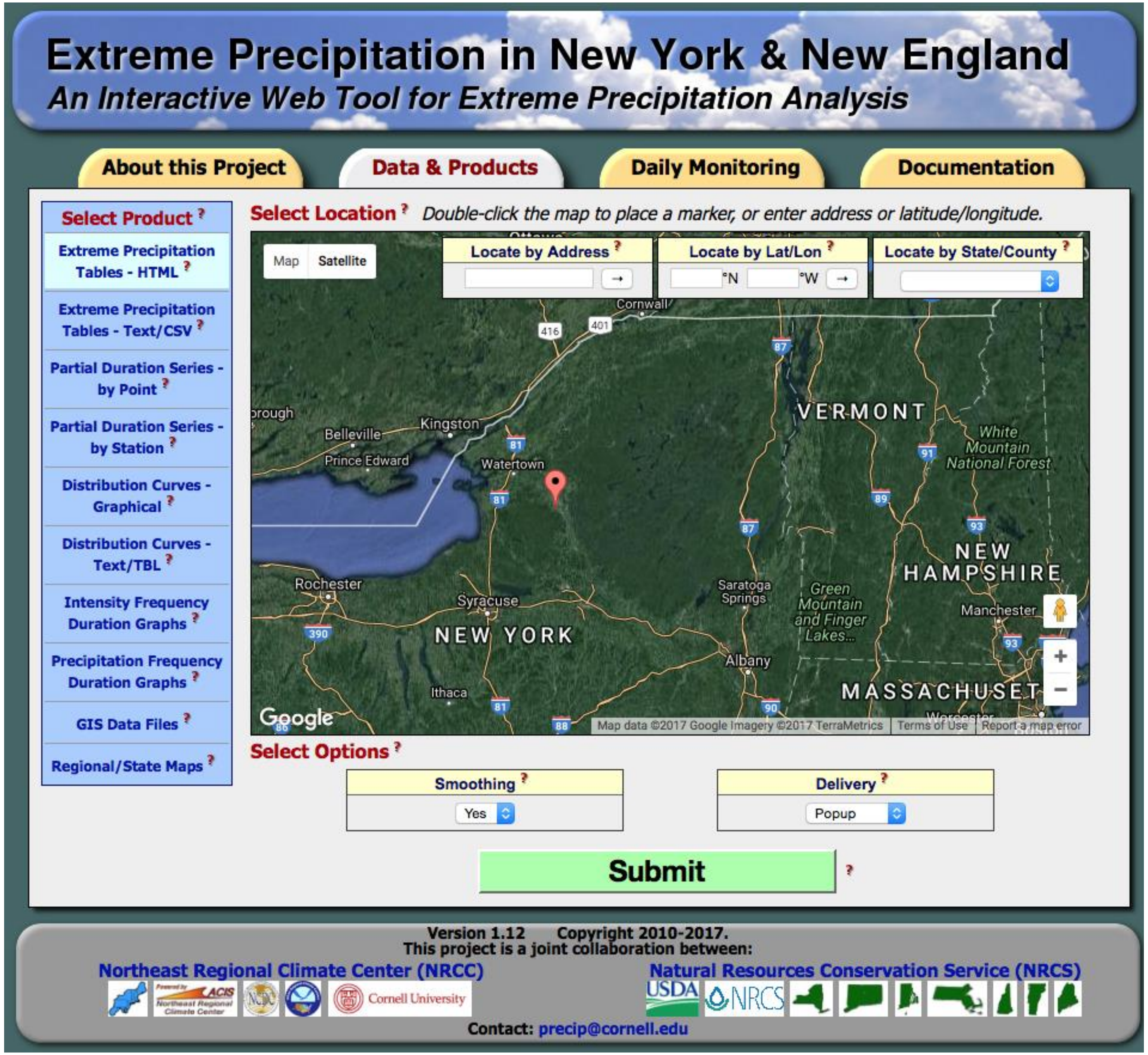
- Applies to **permitting, funding and regulatory decisions**

  For example

  Smart growth assessments
  Wastewater treatment plant funding
  Hazardous waste facilities siting
  Design and construction of petroleum and chemical storage facilities
  Oil and gas drilling
  State acquisition of open space

- Applicants must **demonstrate** that they have taken into account **future** physical climate risks caused by storm surges, sea-level rise or **flooding**.

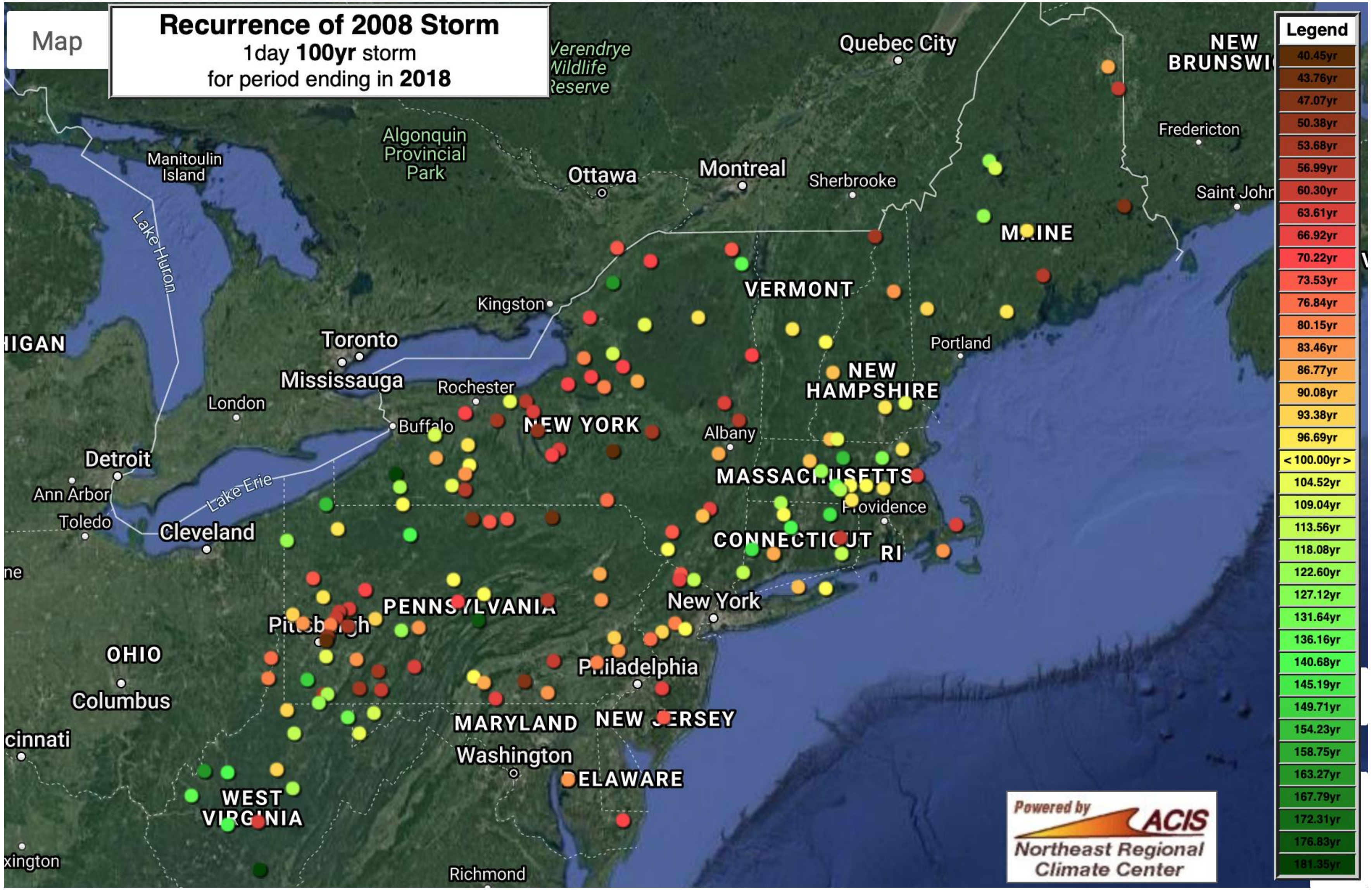
History



- NRCS funded
- Pre Atlas 14
- Tendency for
  Higher 100-yr
  Lower 2-yr
- Promoted beyond NRCS
- Early adaptation in New England States

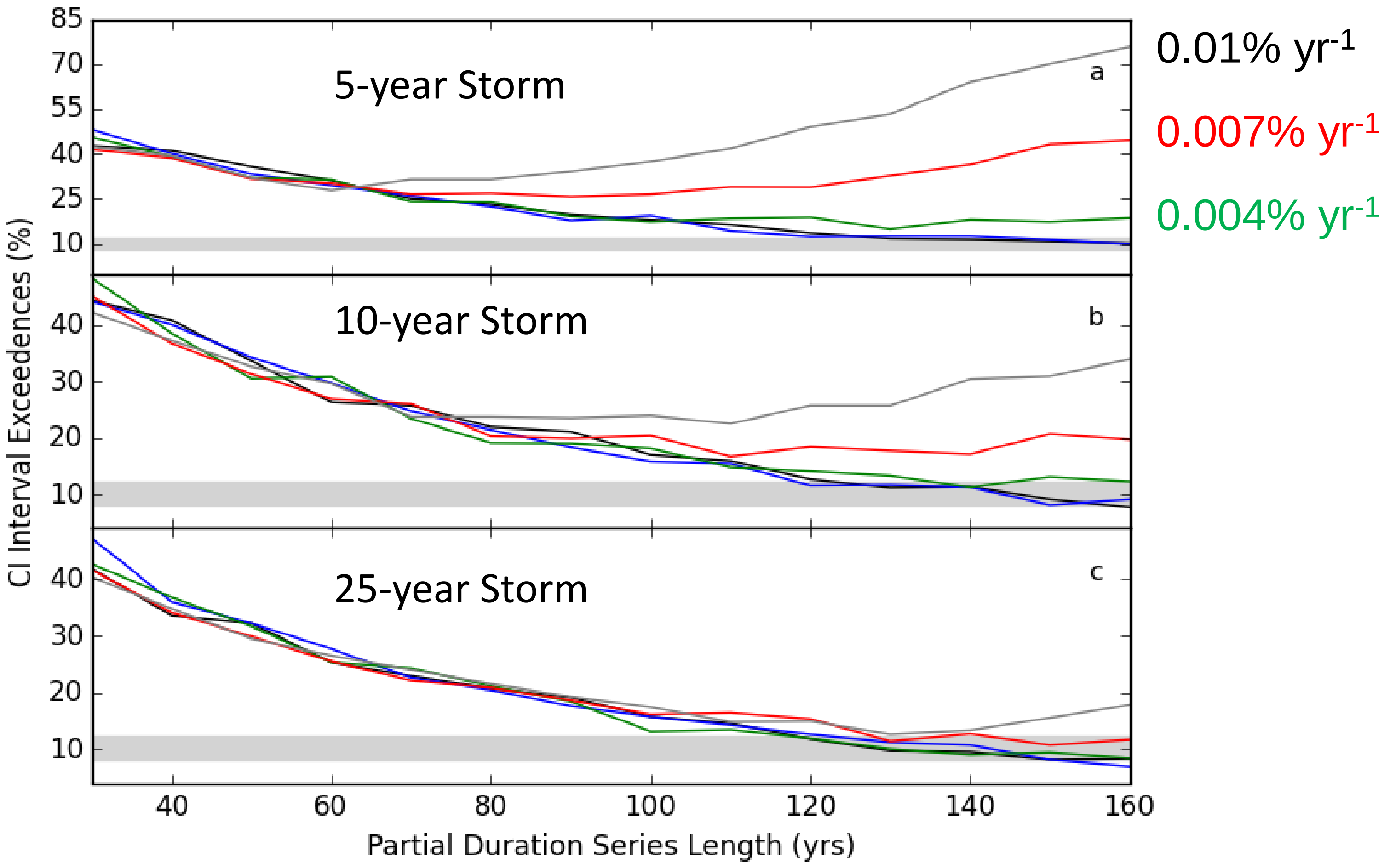
Monitoring Extreme Precip Changes

Automated ANNUAL generation of updated extreme rainfall products.

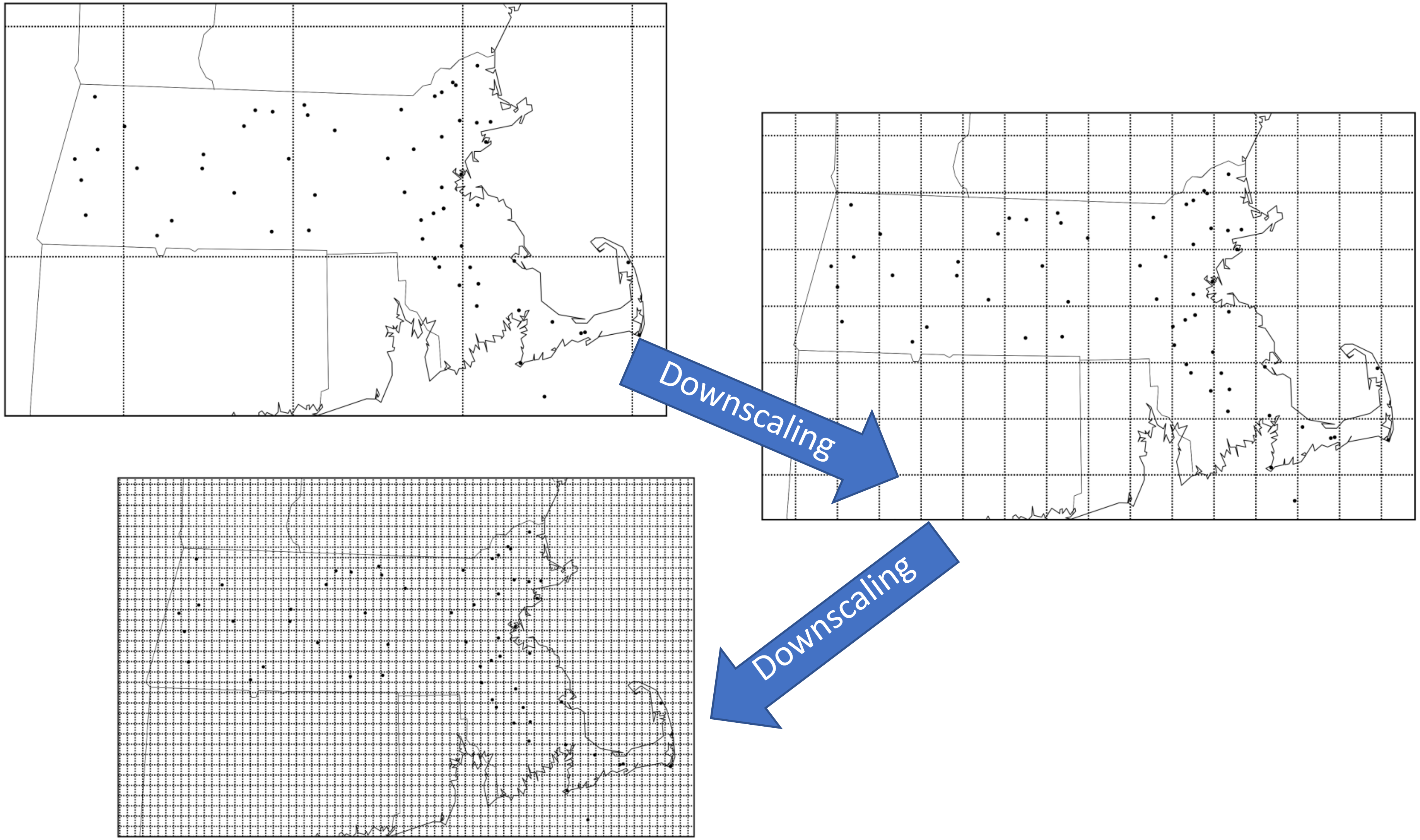


Recurrence of 2008 Storm
1day 100yr storm
for period ending in 2018
Map
Legend
40.45yr
43.76yr
47.07yr
50.38yr
53.68yr
56.99yr
60.30yr
63.61yr
66.92yr
70.22yr
73.53yr
76.84yr
80.15yr
83.46yr
86.77yr
90.08yr
93.38yr
96.69yr
< 100.00yr >
104.52yr
109.04yr
113.56yr
118.08yr
122.60yr
127.12yr
131.64yr
136.16yr
140.68yr
145.19yr
149.71yr
154.23yr
158.75yr
163.27yr
167.79yr
172.31yr
176.83yr
181.35yr
Powered by ACIS
Northeast Regional Climate Center
Quebec City
Montreal
Ottawa
Sherbrooke
Fredericton
Saint John
Algonquin Provincial Park
Manitoulin Island
Lake Huron
Kingston
Toronto
Mississauga
Rochester
Buffalo
London
Detroit
Ann Arbor
Toledo
Lake Erie
Cleveland
Columbus
OHIO
VERMONT
NEW HAMPSHIRE
Portland
Albany
NEW YORK
MASSACHUSETTS
Providence
CONNECTICUT
RI
New York
PENNSYLVANIA
Pittsburgh
Philadelphia
NEW JERSEY
MARYLAND
Washington
DELAWARE
WEST VIRGINIA
Richmond

Record Length??



Downscaling



Downscaling Approaches

1) Dynamical Downscaling (CORDEX) (also NARCCAP)

   → Regional climate models (RCMs) run at 50-km resolution and driven by atmosphere–ocean general circulation (AOGCM) models

2) “Statistical” Downscaling – Delta Method (CMIP5)

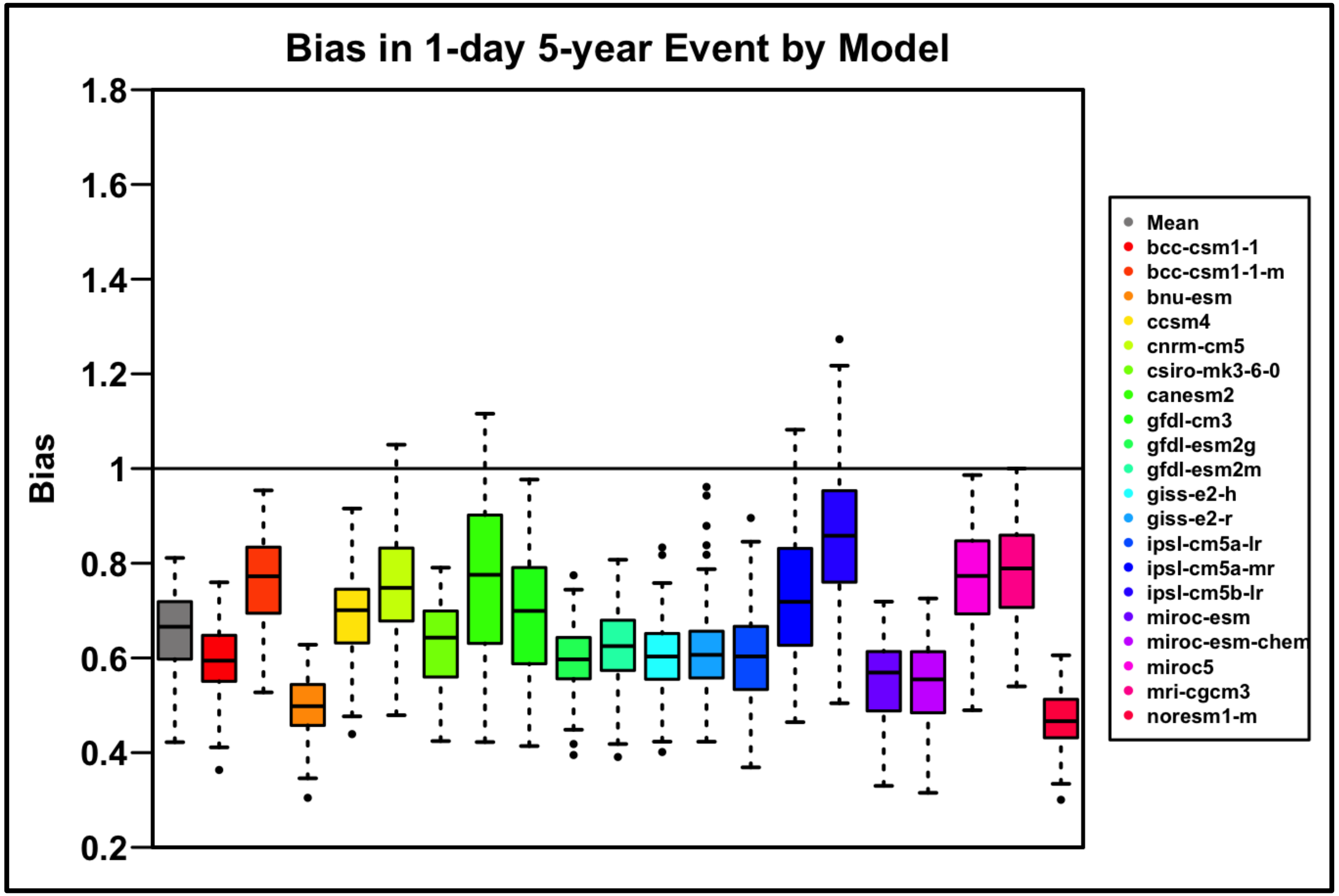
   → Compares model-simulated precipitation extremes between historical and future periods (at GCM resolution)

3) Statistical Downscaling – Analog Method (CMIP5)

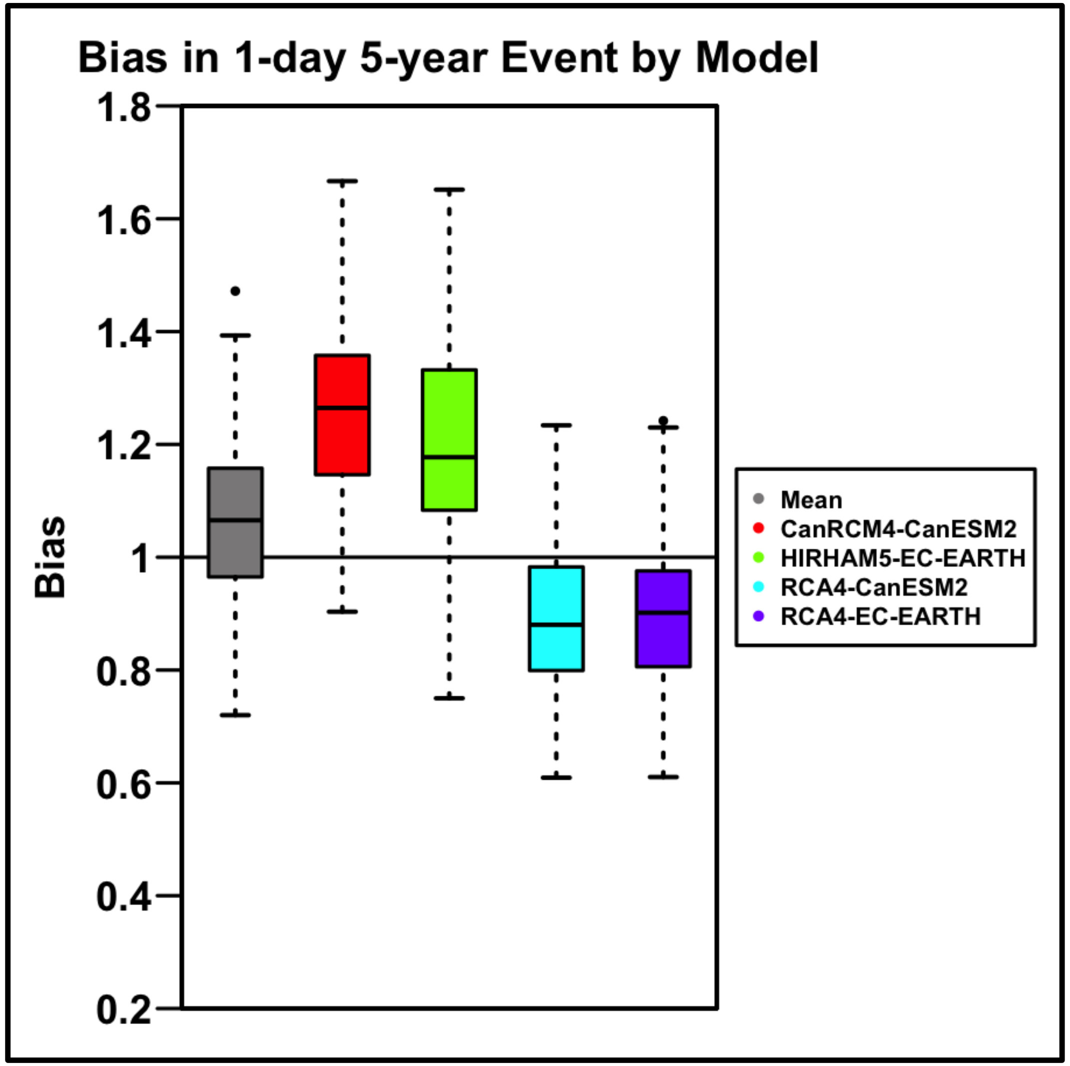
   → Uses historical weather map analogues to predict the occurrence of extreme precipitation on a given day


REALITY
CHECK
AHEAD

Raw CMIP5   No Downscaling vs Obs.



CORDEX vs. Observed



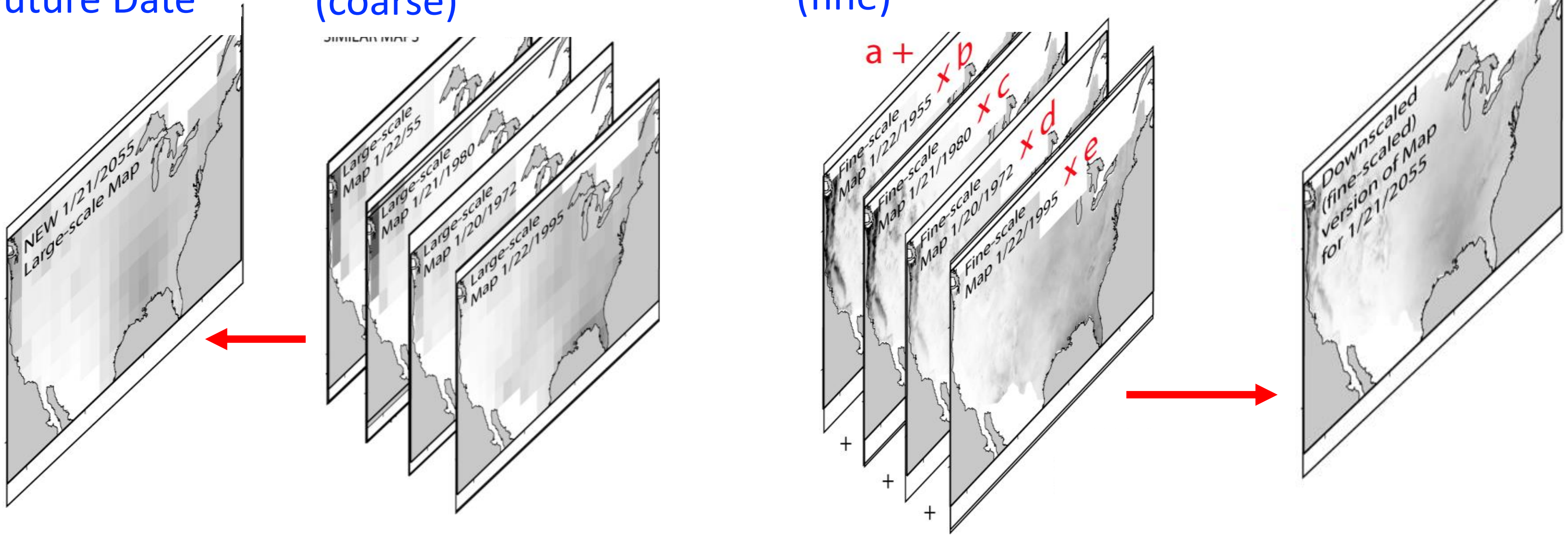
Analog Downscaling

Coarse Resolution Future Date

Similar Historical Observed Days (coarse)

Observed Historical Days (fine)

Future Day (fine)



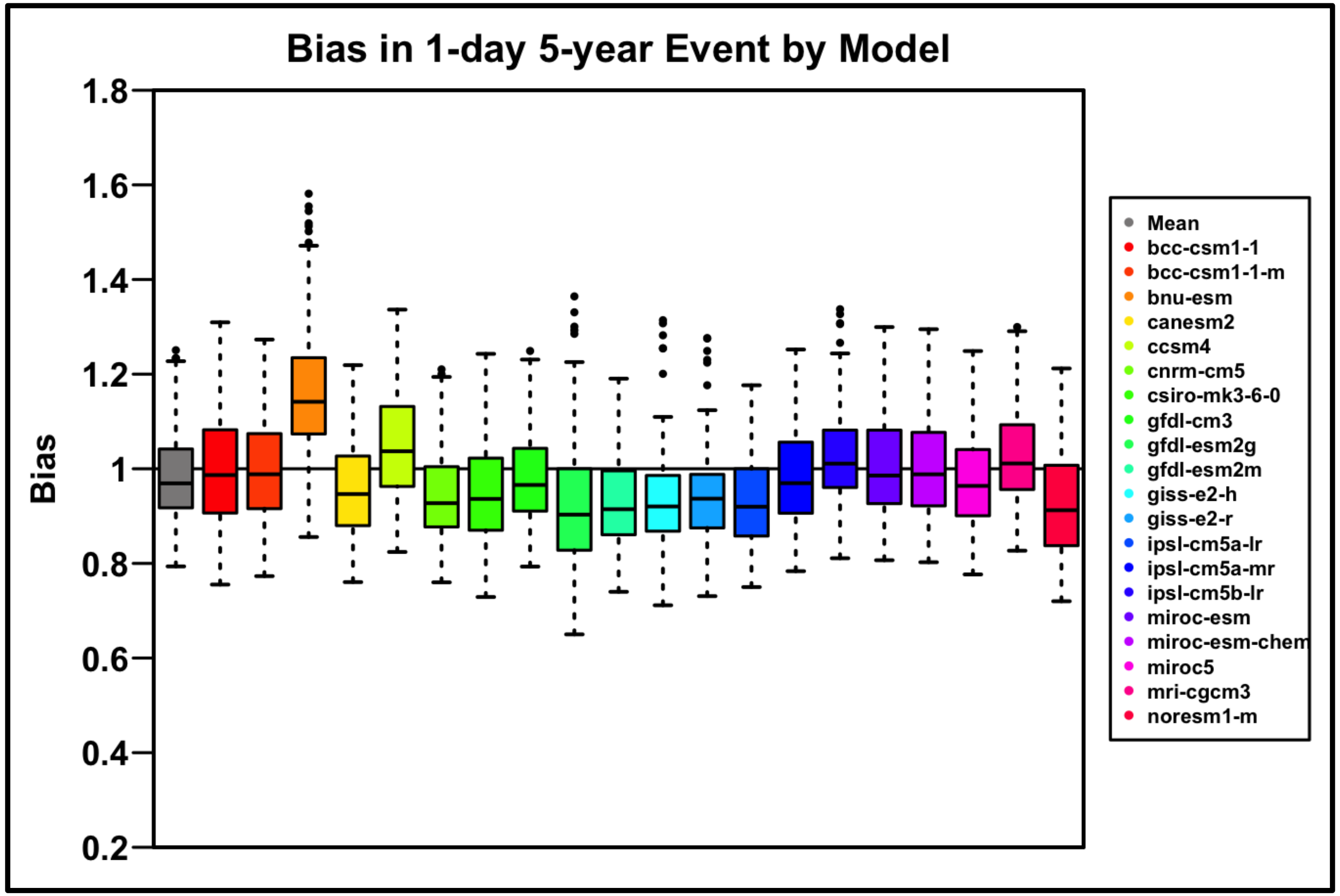
$F_{Low} = b(H1_{Low}) + c(H2_{Low}) + d(H3_{Low}) + e(H4_{Low}) + a$

Develop statistical relationship between analog cases

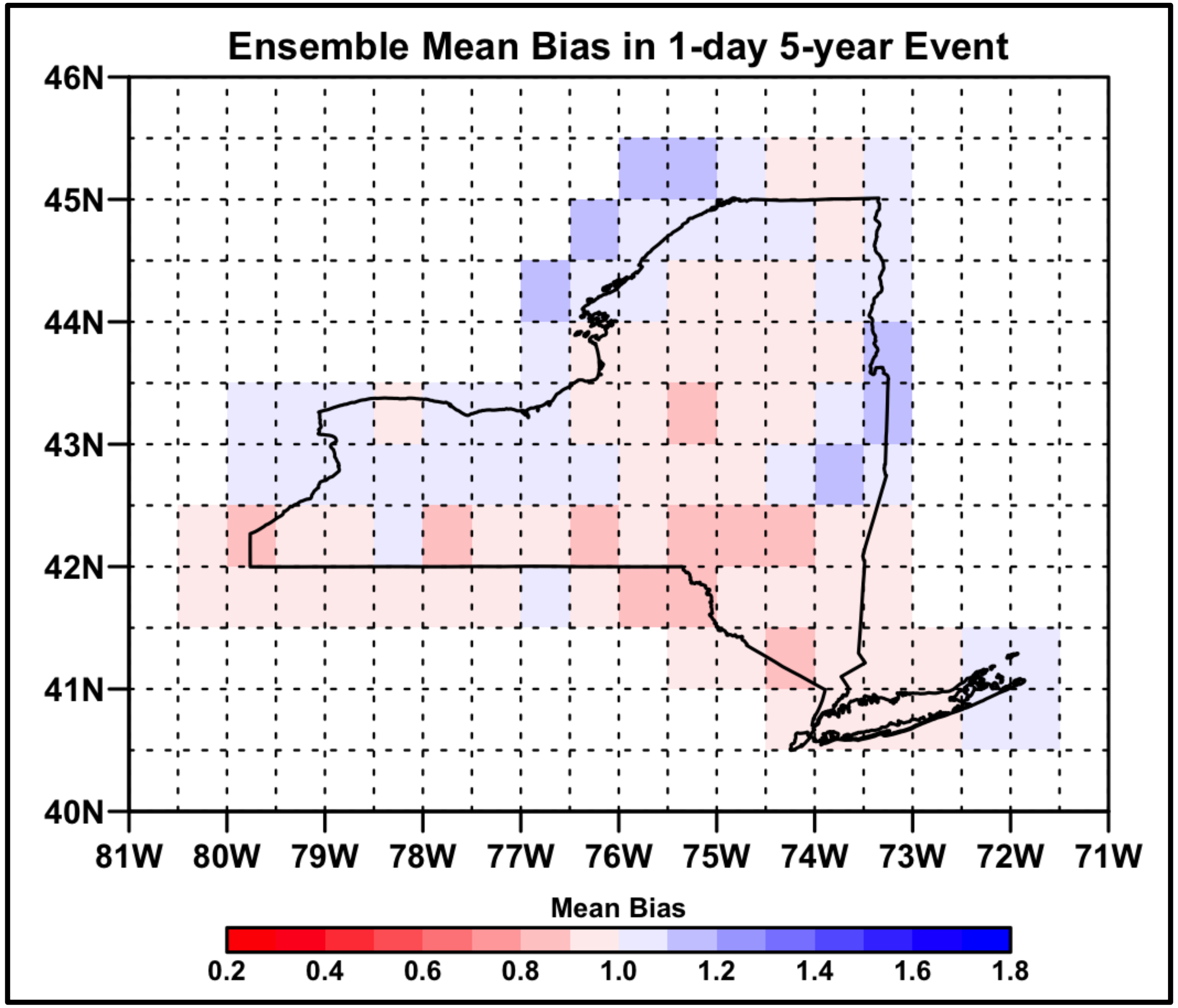
$b(H1_{High}) + c(H2_{High}) + d(H3_{High}) + e(H4_{High}) + a = F_{High}$

Apply statistical relationship high resolution historical analogs

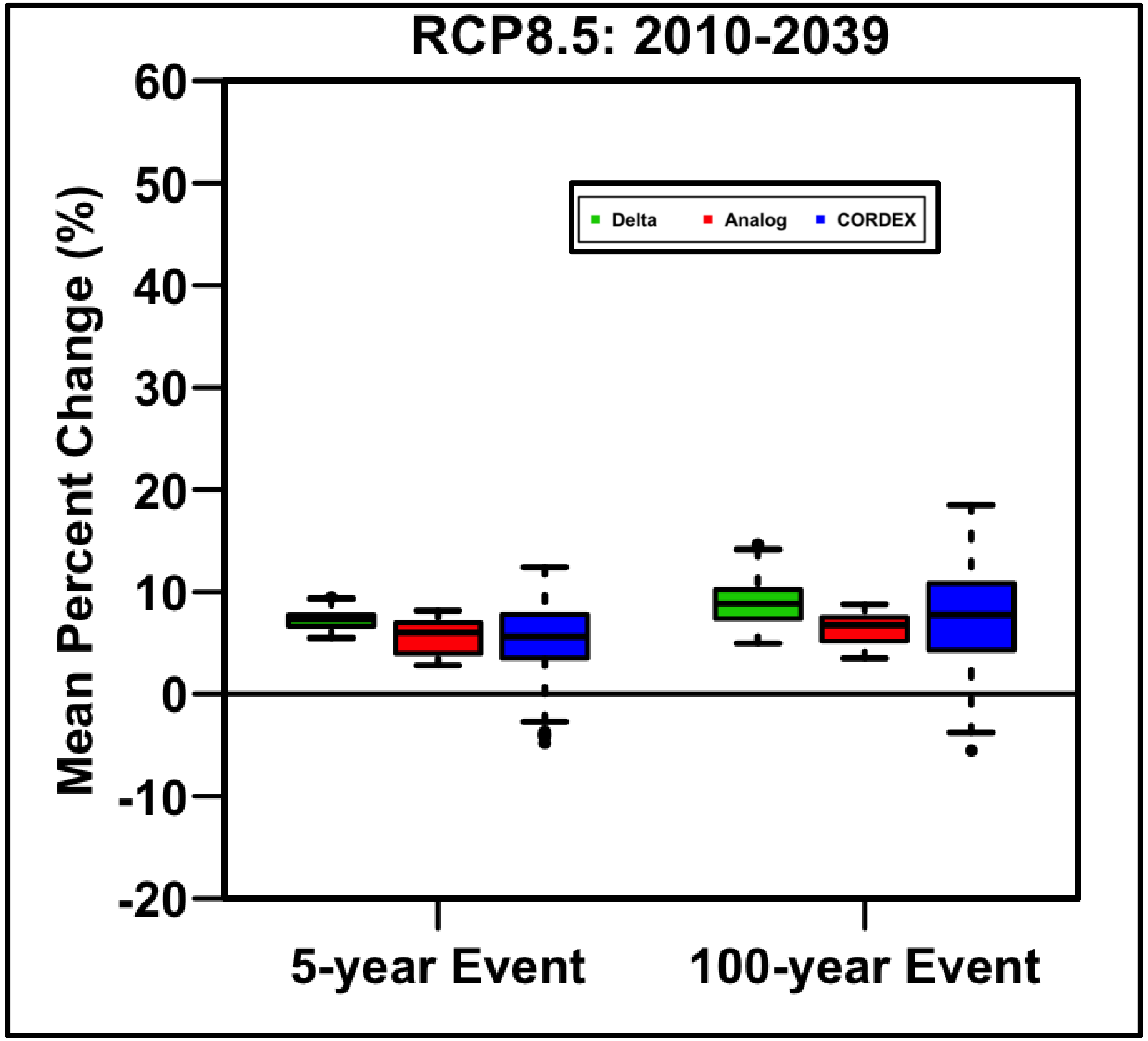
Analog Method vs. Observed



Analog vs Observed Ensemble Mean Bias



Projected Changes in 1-day 5- and 100-Year Rainfall Amounts Relative to 1970–1999



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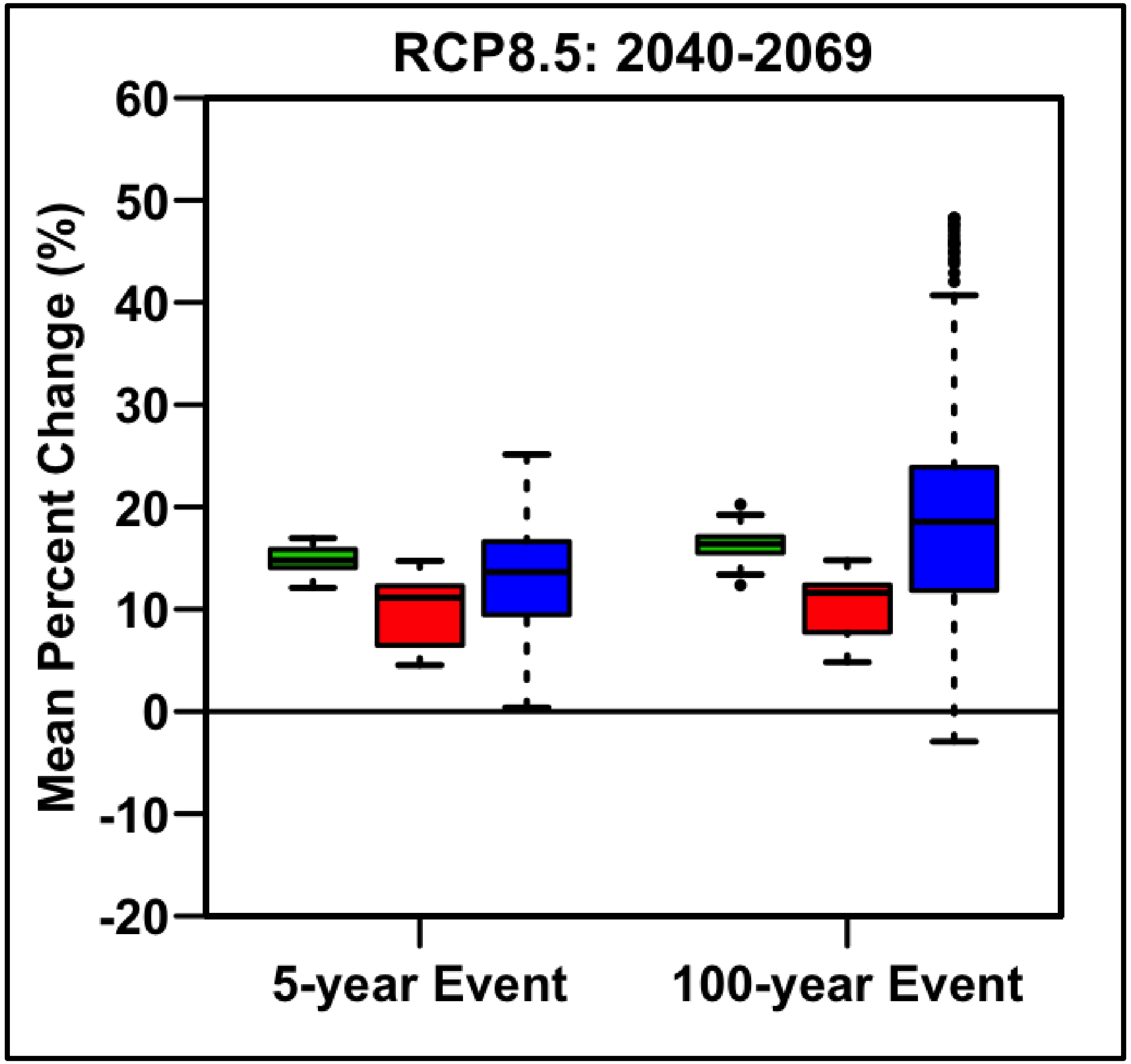

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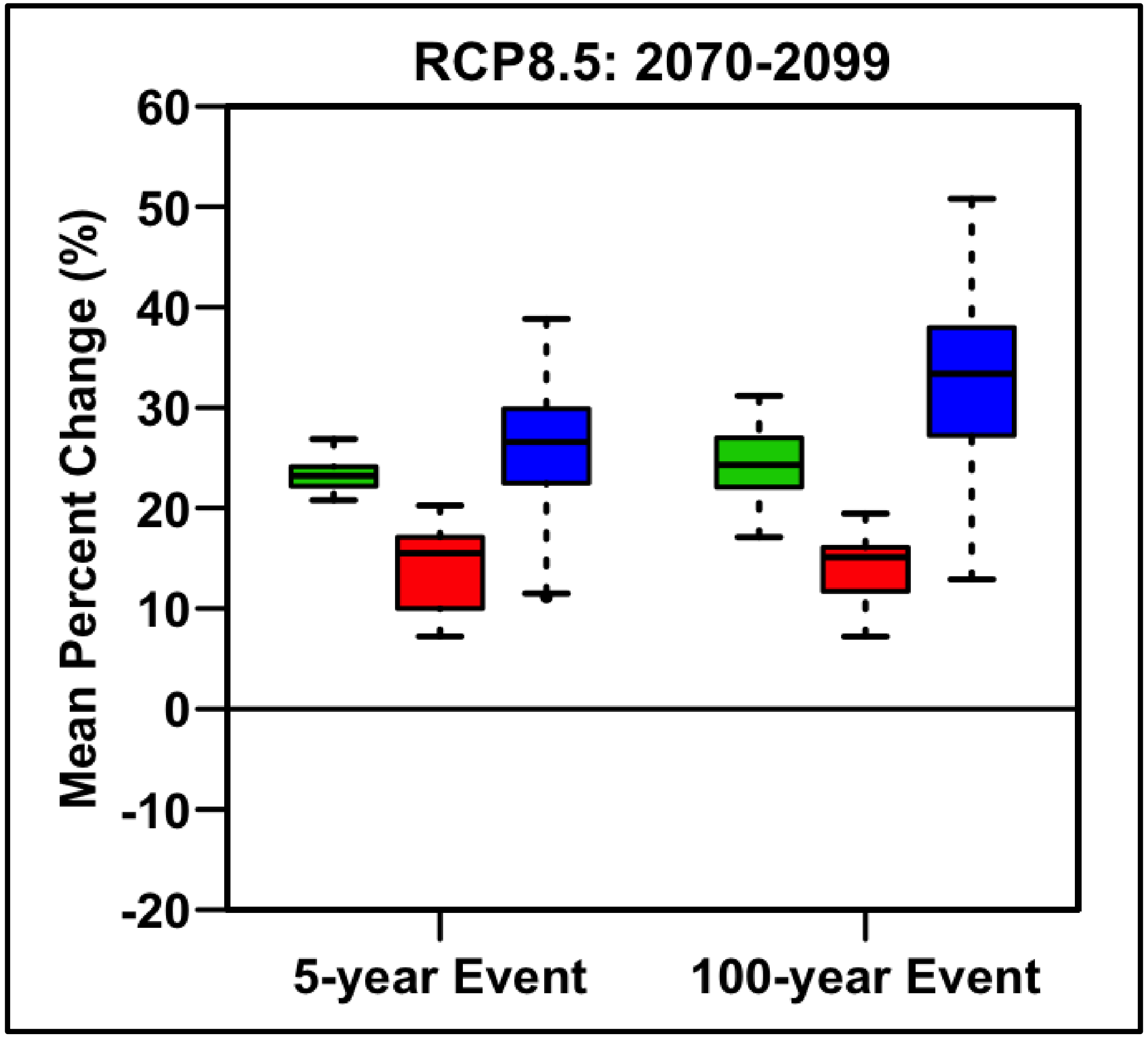
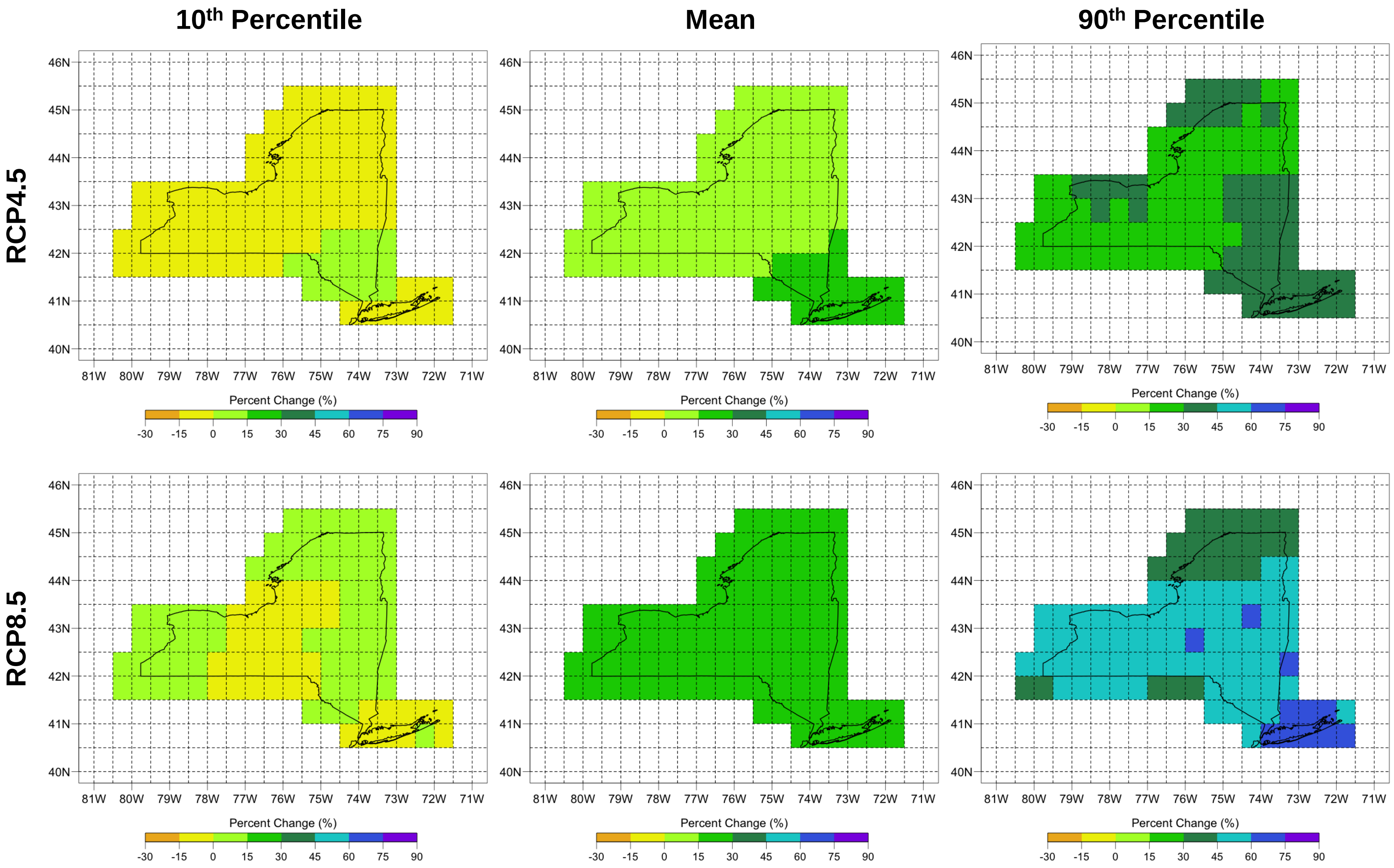
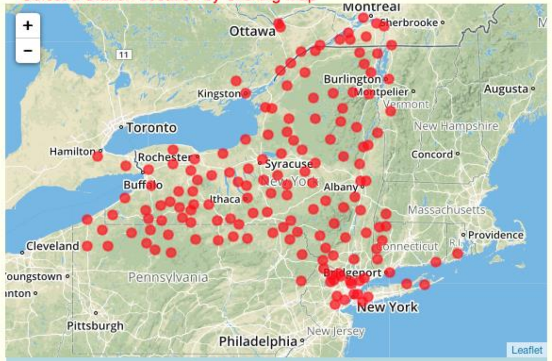


Projected Changes in 1-day 100-year Rainfall Amounts 2070–2099 vs. 1970–1999



Station-specific IDF Graphs | Statewide Maps of Projected Changes

Select a Station Location by Clicking Map



Select a RETURN PERIOD

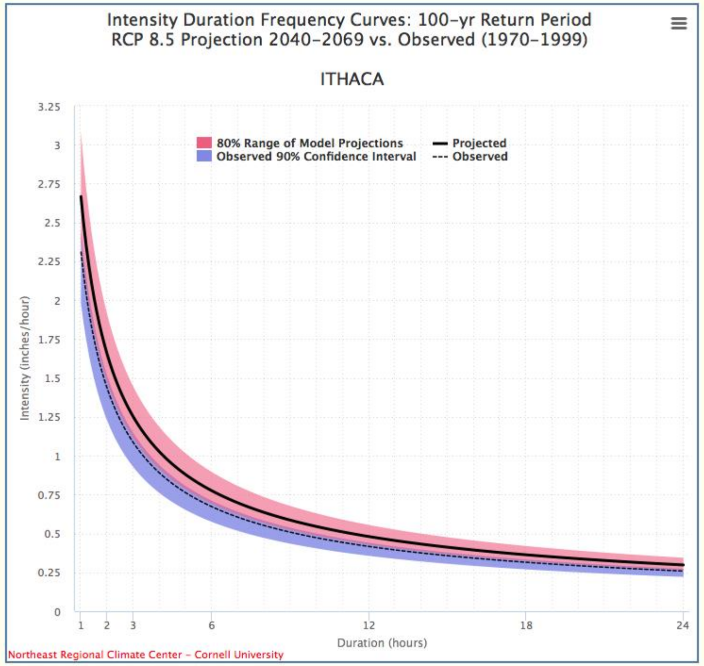
2-yr | 5-yr | 10-yr | 25-yr | 50-yr | 100-yr

Select an EMISSION SCENARIO

- High RCP 8.5
- Low RCP 4.5

Select a TIME PERIOD

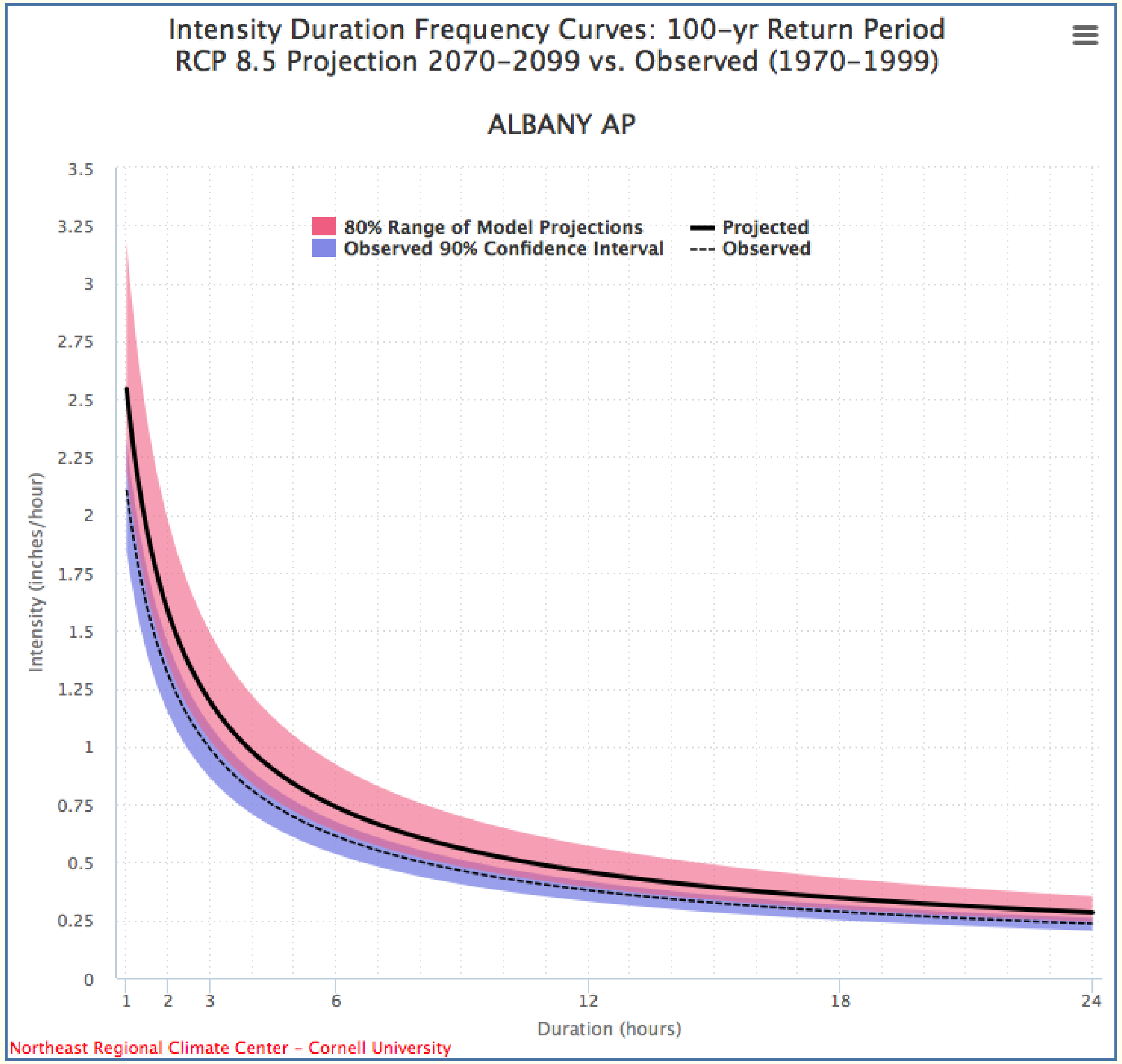
- 2010-2039
- 2040-2069
- 2070-2099



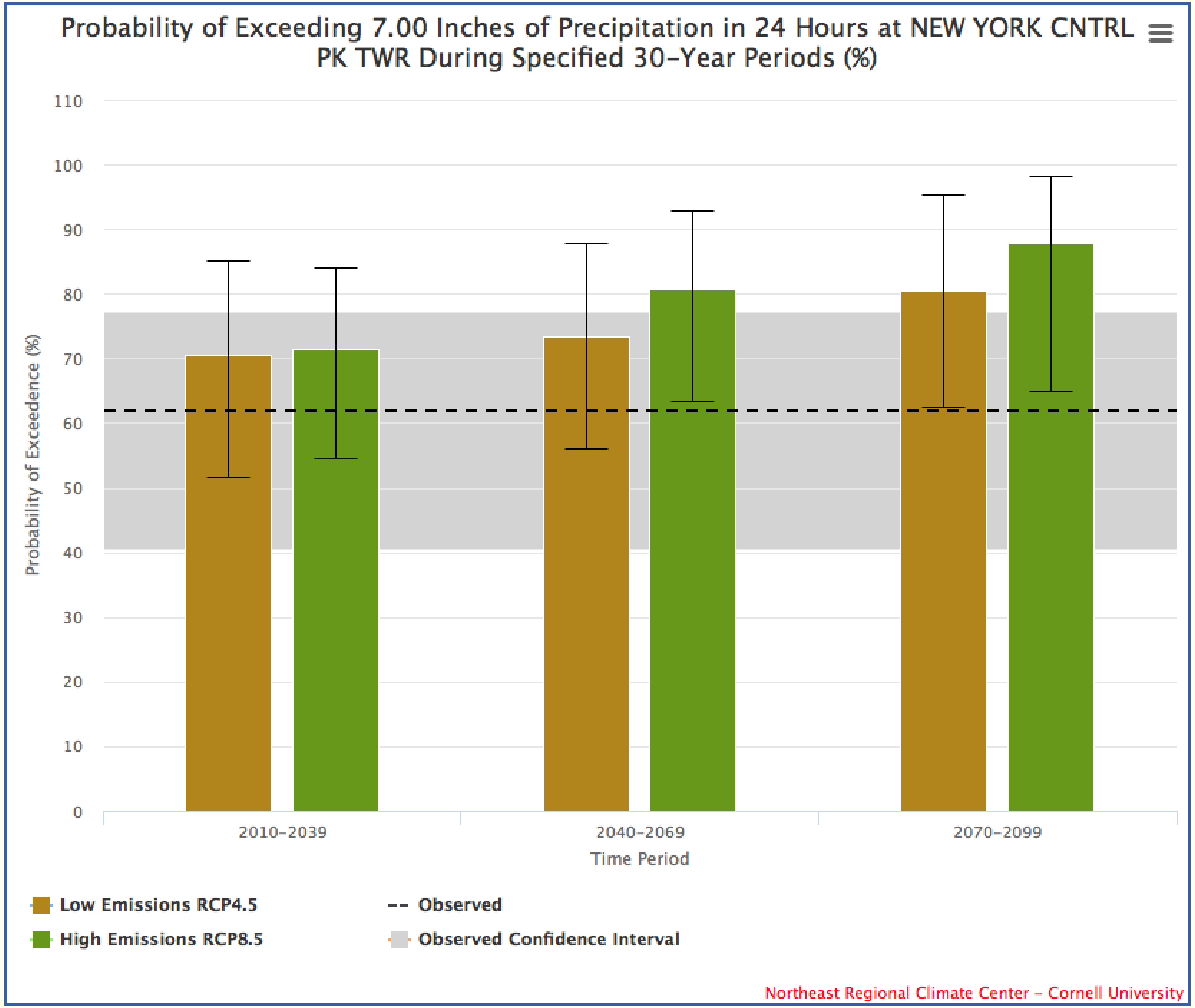
Duration (hrs)	Projected 2040-2069 Intensity Ensemble Member 10th	Mean	90th	Observed 1970-1999 Intensity with Confidence Interval (CI) Bounds Low CI	Mean	High CI
1	2.38	2.67	3.08	1.98	2.31	2.45
2	1.47	1.65	1.91	1.23	1.43	1.52
3	1.11	1.25	1.44	0.93	1.08	1.15
6	0.69	0.77	0.89	0.57	0.67	0.71
12	0.43	0.48	0.55	0.36	0.42	0.44
18	0.32	0.36	0.42	0.27	0.31	0.33
24	0.27	0.30	0.34	0.22	0.26	0.27

About this Project Numerous studies have documented significant increases in both the frequency and magnitude of extreme precipitation in the northeastern U.S. since the mid-to-late 20th century. The most recent assessment from the Intergovernmental Panel on Climate Change (IPCC) suggests that the frequency and magnitude of extreme precipitation in this region will likely continue to increase throughout the 21st century. Such changes could greatly exacerbate the societal impacts of extreme precipitation in the future. In consideration of these impacts, the Northeast Regional Climate Center (NRCC) has partnered with the New York State Energy Research and Development Authority (NYSERDA) to downscale global climate model output and create extreme precipitation projections that will ultimately be incorporated into climate change adaptation planning for New York State. Read more...

http://ny-idf-projections.nrcc.cornell.edu



	Projected 2070-2099 Intensity Ensemble Member			Observed 1970-1999 Intensity with Confidence Interval (CI) Bounds		
Duration (hrs)	10^{th}	Mean	90^{th}	Low CI	Mean	High CI
1	2.19	2.54	3.18	1.84	2.11	2.32
2	1.35	1.58	1.97	1.14	1.31	1.44
3	1.02	1.19	1.49	0.86	0.99	1.09
6	0.63	0.74	0.92	0.53	0.61	0.67
12	0.39	0.46	0.57	0.33	0.38	0.42
18	0.30	0.35	0.43	0.25	0.29	0.32
24	0.24	0.28	0.35	0.21	0.24	0.26



Probability of Exceeding 7.00 Inches of Precipitation in 24 Hours at NEW YORK CNTRL PK TWR During Specified 30-Year Periods (%)
110
100
90
80
70
60
50
40
30
20
10
0
Probability of Exceedence (%)
2010-2039
2040-2069
2070-2099
Time Period
Low Emissions RCP4.5
High Emissions RCP8.5
Observed
Observed Confidence Interval
Northeast Regional Climate Center - Cornell University

This project will draw on both portfolios of research to develop projected IDF curves for the entire Chesapeake Bay Watershed and host them on a web-based tool

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2. Downscaling projected precipitation extremes
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3. **Downscaling method evaluation and uncertainties**
    - **Examine downscaling methods and datasets for bias and outliers**
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5. Develop a web-based tool and engage in outreach

Questions and Discussion

Points for Discussion

Future time periods

Projected IDF curves will only be produced for two time periods, 2000-2050 and 2050-2100, in addition to the 1950-2000 hindcast period. We will work with the Urban Stormwater Workgroup to determine if we need to adjust these time periods to those in the RFP (2010-2029; 2030-2049; 2050-2069) since 20-year periods are suboptimal for the estimation of extremes, particularly those which are expected to occur only once in 50 or 100 years.

Is the USWG okay with our shift in time periods of interest for producing IDF curves? Any challenges or concerns?

Points for Discussion

Regions of interest

While IDF curves will be generated at the station-level, these will be mapped in the interactive webpage according to regions of interest determined by the Urban Stormwater Workgroup.

Are there regional levels of aggregation that would be most useful for filter and/or visualizing the data?

Points for Discussion

IDF Curve data

i. formatted and cleaned precipitation data from precipitation stations and GCM output that will be used for downscaling and validation;
ii. downscaled projections of future precipitation across the entire CBW;
iii. The project team with work with the Urban Stormwater Workgroup to determine the best means for sharing datasets i) and ii).

Do you have recommendations on how you'd like to see i) and ii) shared?

Points for Discussion

Outreach

We will develop additional outreach material based on project results and evaluation, and stakeholder feedback. This likely to include presentations at conferences, webinars and professional meetings and fact sheets.

Are there recommendations on outreach activities, audiences and/or materials?

a NOAA Mid-Atlantic RISA team

Thank you!

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