

Extreme Rainfall Statistics Past, Present and Future

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Cast

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Marissa Webber – CMU

Michelle Miro – Rand
Dave Robinson - Rutgers

Credits

Chesapeake Bay Trust

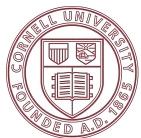
Virginia Transportation Research Council (VTRC)

The Commonwealth Center for Recurrent Flooding Resiliency (CCRFR)

State of New Jersey

NYS Energy Research and Development Authority (NYSERDA)

NOAA



Cornell University

Presented to an advisory committee of the DRBC on January 26, 2022. Contents should not be published or re-posted in whole or in part without the permission of the presenter or DRBC.



The Washington Post

Democracy Dies in Darkness

Climate and Environment

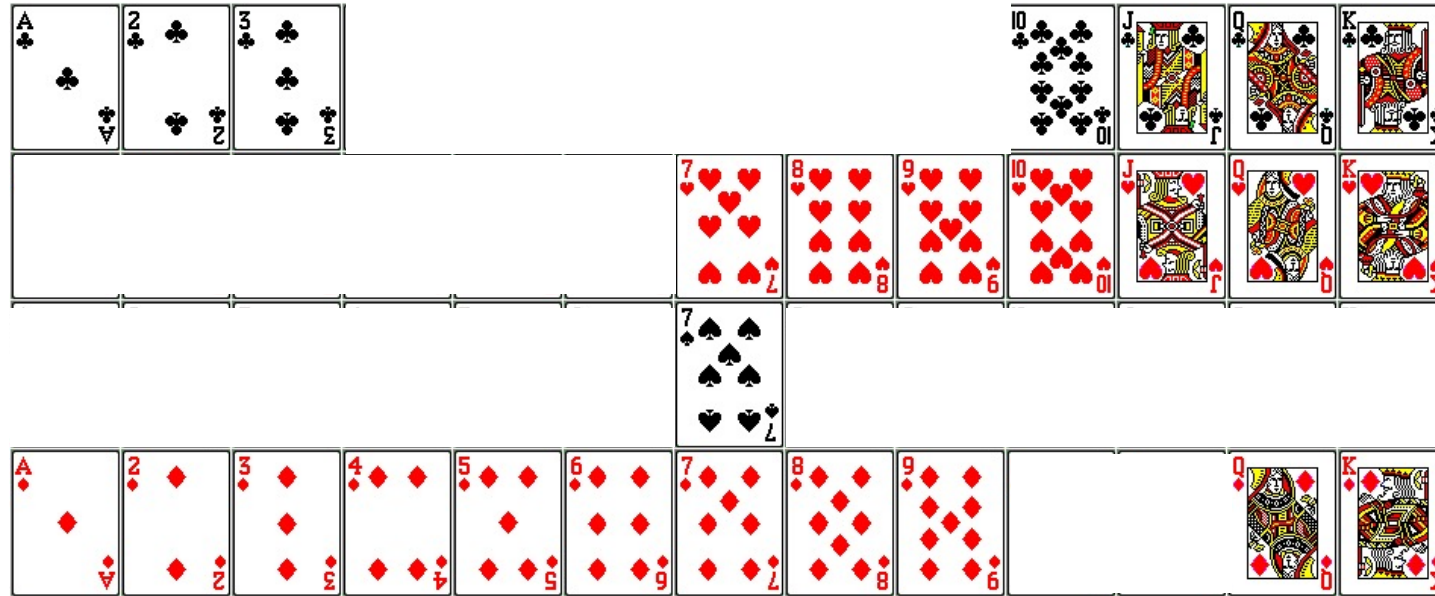
As rainstorms grow more severe and frequent, communities fail to prepare for risks

Lack of a current, national rainfall database means some states use 60-year-old statistics as they design roads, bridges and dams that are supposed to last 50 years

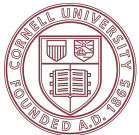


People walk through flood water near Interstate 10 in Houston after Hurricane Harvey hit Texas in August 2017. (Jabin Botsford/The Washington Post)

Estimating Current Rainfall Extremes is like.....



Estimating the probabilities of poker hands
Without knowing the values and suits of all the cards!



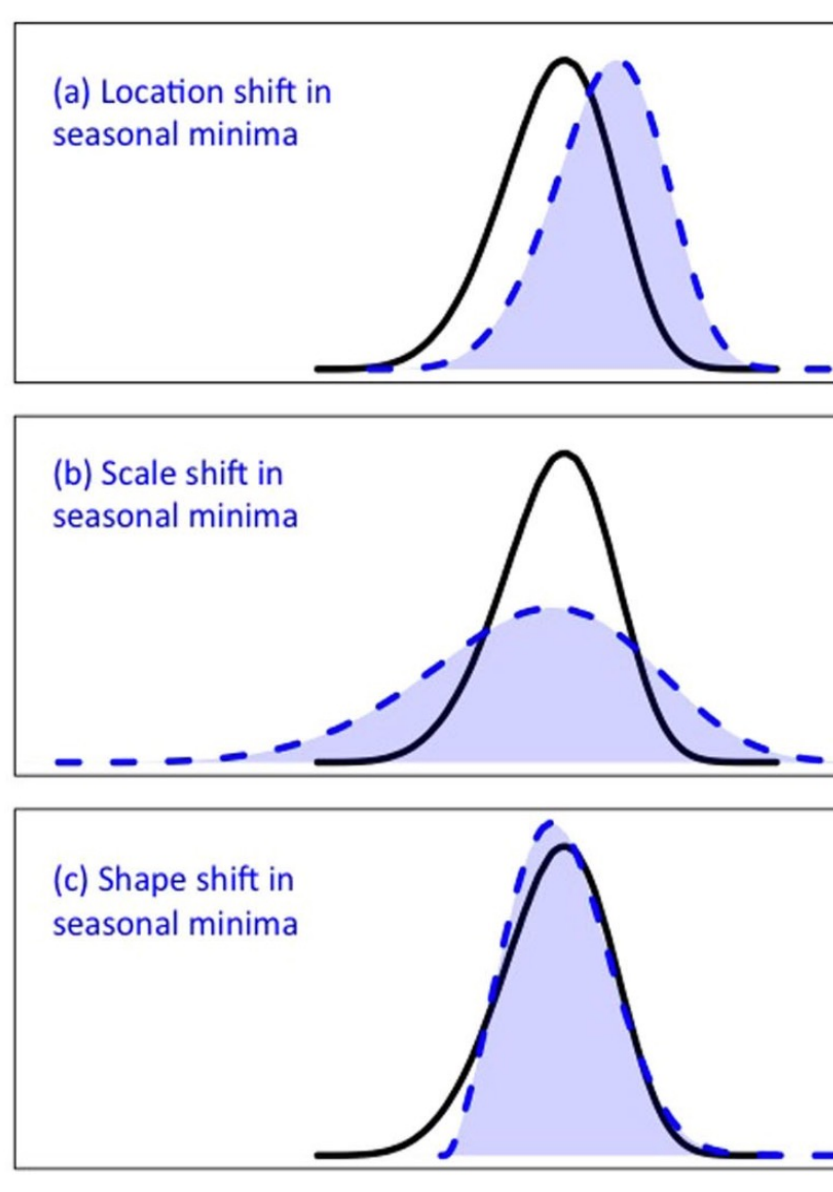
Partial Duration Series

Boston Logan International Airport (#190770) – 1936-2008 (72 complete years)						
7.06"	3.84"	3.11"	2.81"	2.64"	2.52"	2.42"
6.11"	3.77"	3.00"	2.80"	2.64"	2.52"	2.40"
5.69"	3.58"	2.98"	2.77"	2.63"	2.50"	2.40"
5.63"	3.51"	2.95"	2.77"	2.60"	2.50"	2.40"
4.88"	3.49"	2.94"	2.76"	2.59"	2.49"	2.39"
4.71"	3.36"	2.91"	2.76"	2.59"	2.49"	2.38"
4.47"	3.34"	2.90"	2.71"	2.58"	2.47"	
4.29"	3.32"	2.89"	2.67"	2.55"	2.46"	
4.21"	3.31"	2.89"	2.66"	2.54"	2.46"	
4.12"	3.16"	2.87"	2.64"	2.54"	2.46"	
4.00"	3.15"	2.82"	2.64"	2.53"	2.42"	

Atlas 14: The estimates are based on the analysis of annual maximum series and then converted to partial duration series results.

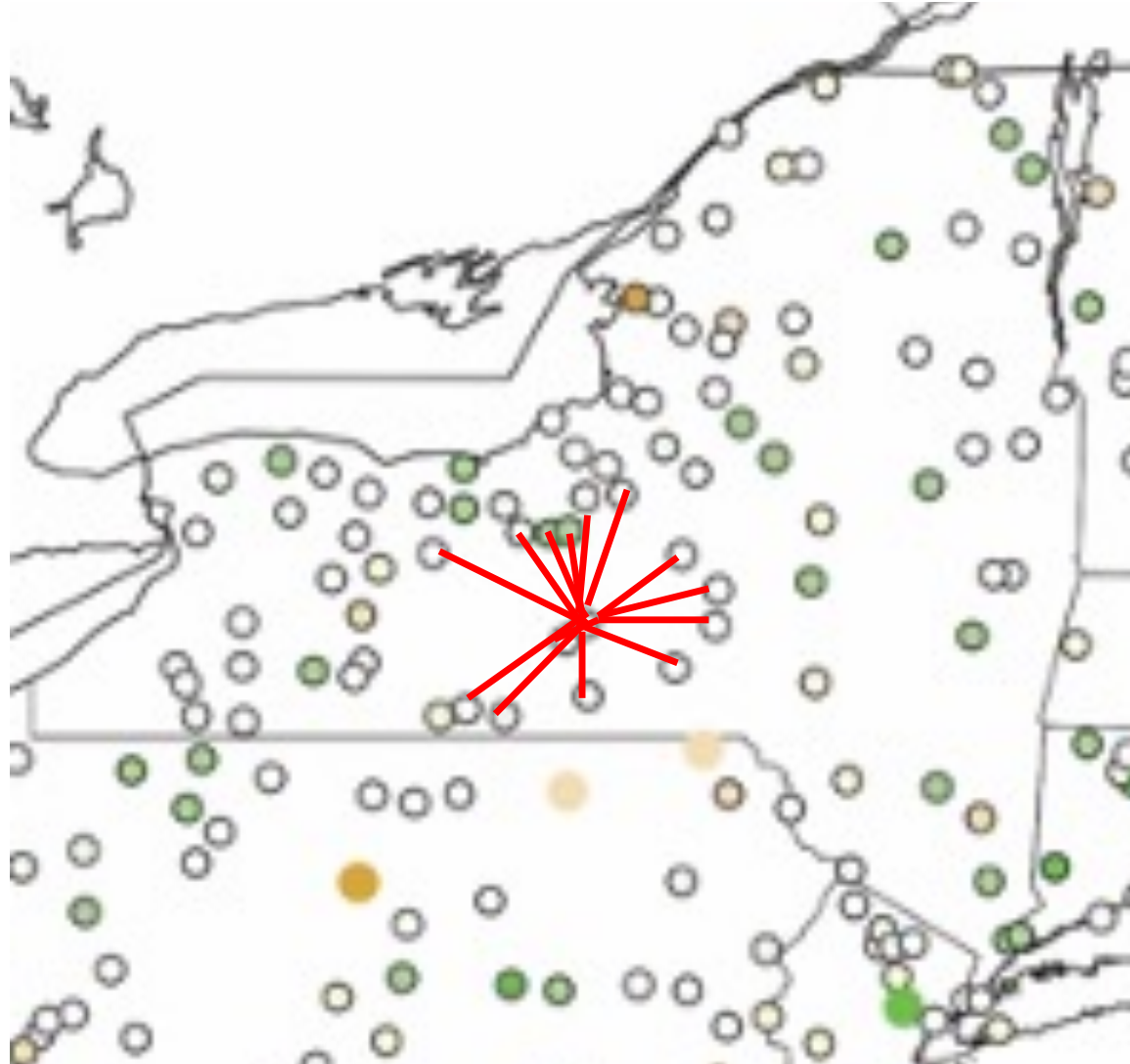


The GEV Distribution



Regional L-moments Fitting

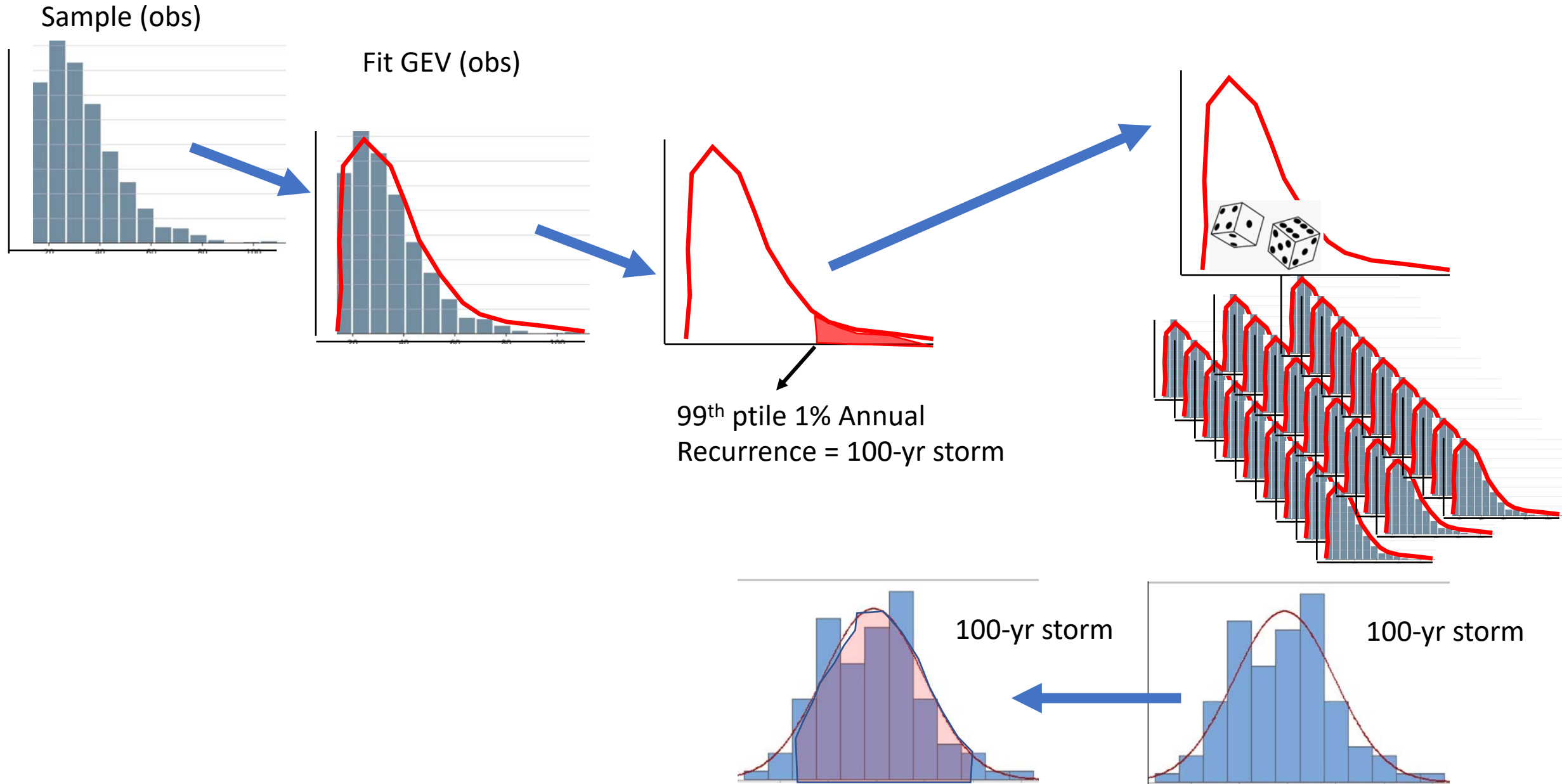
Average higher order moments of surrounding stations.



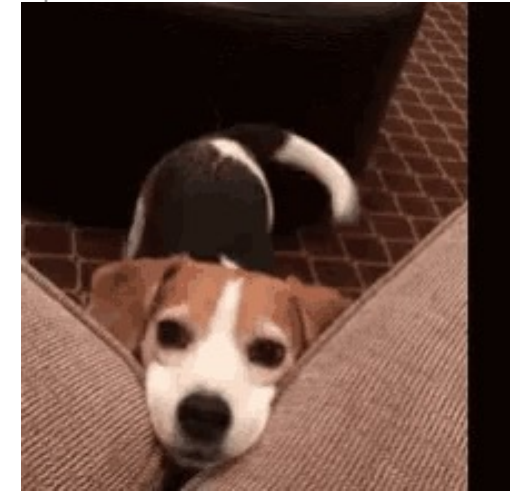
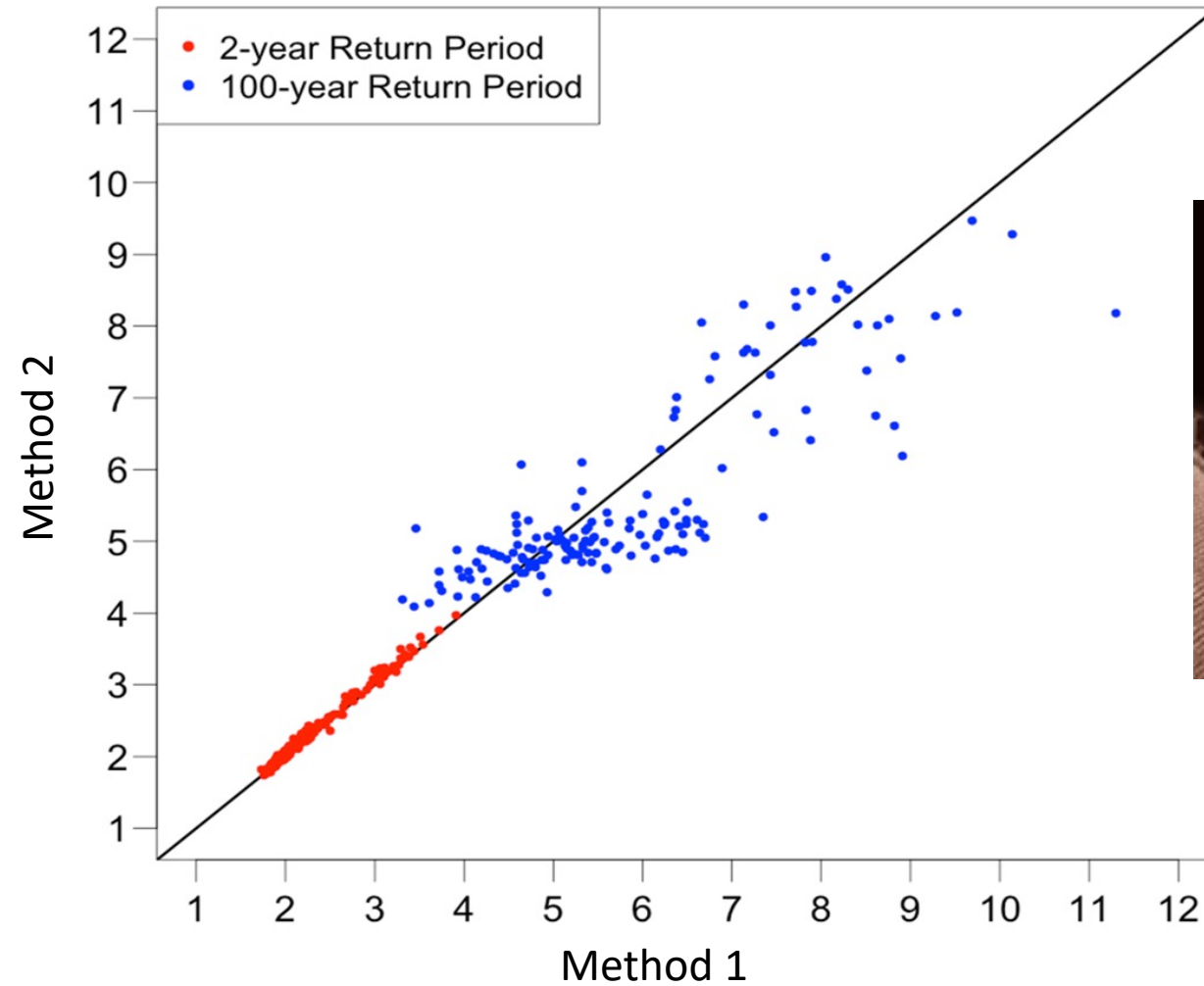
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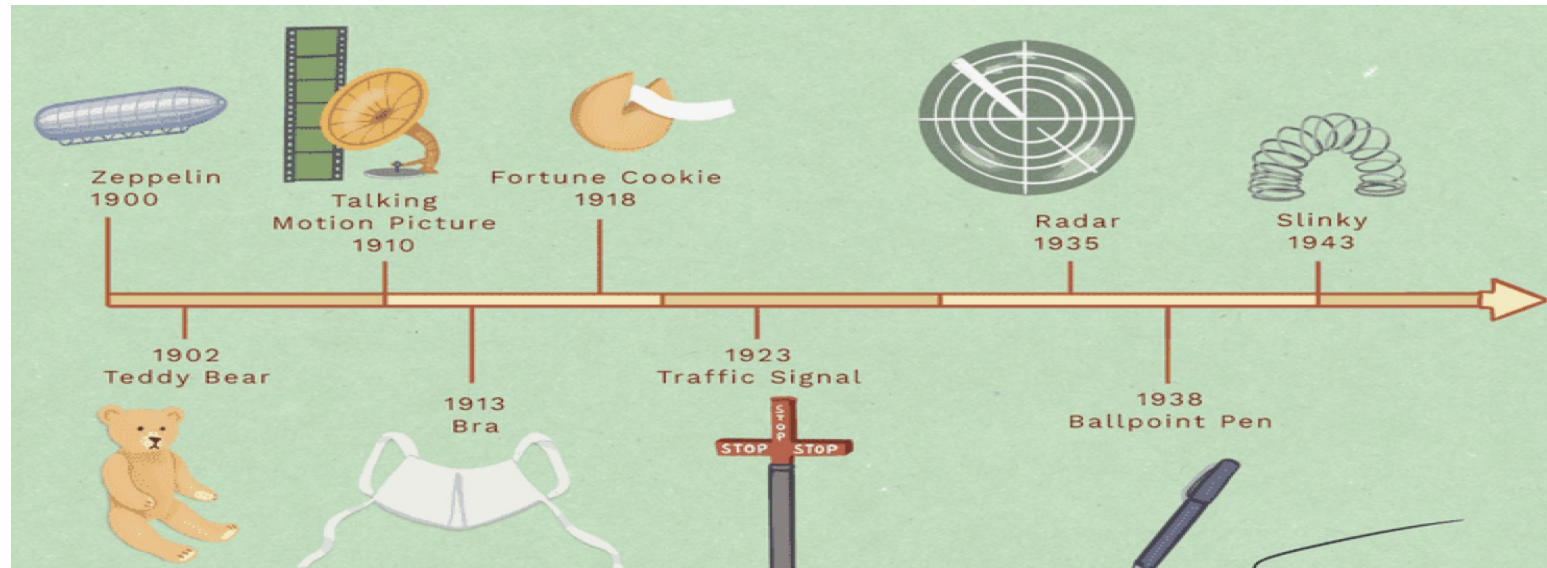
Resampled Confidence Intervals



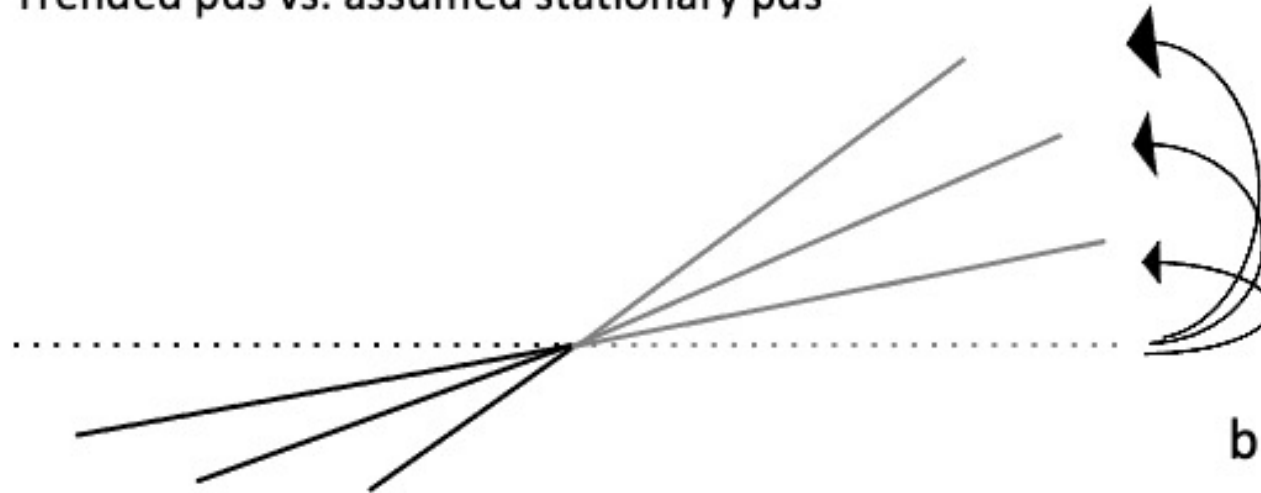
A Happy Dog!



Q1: Are the Longest Record Lengths the Holy Grail?



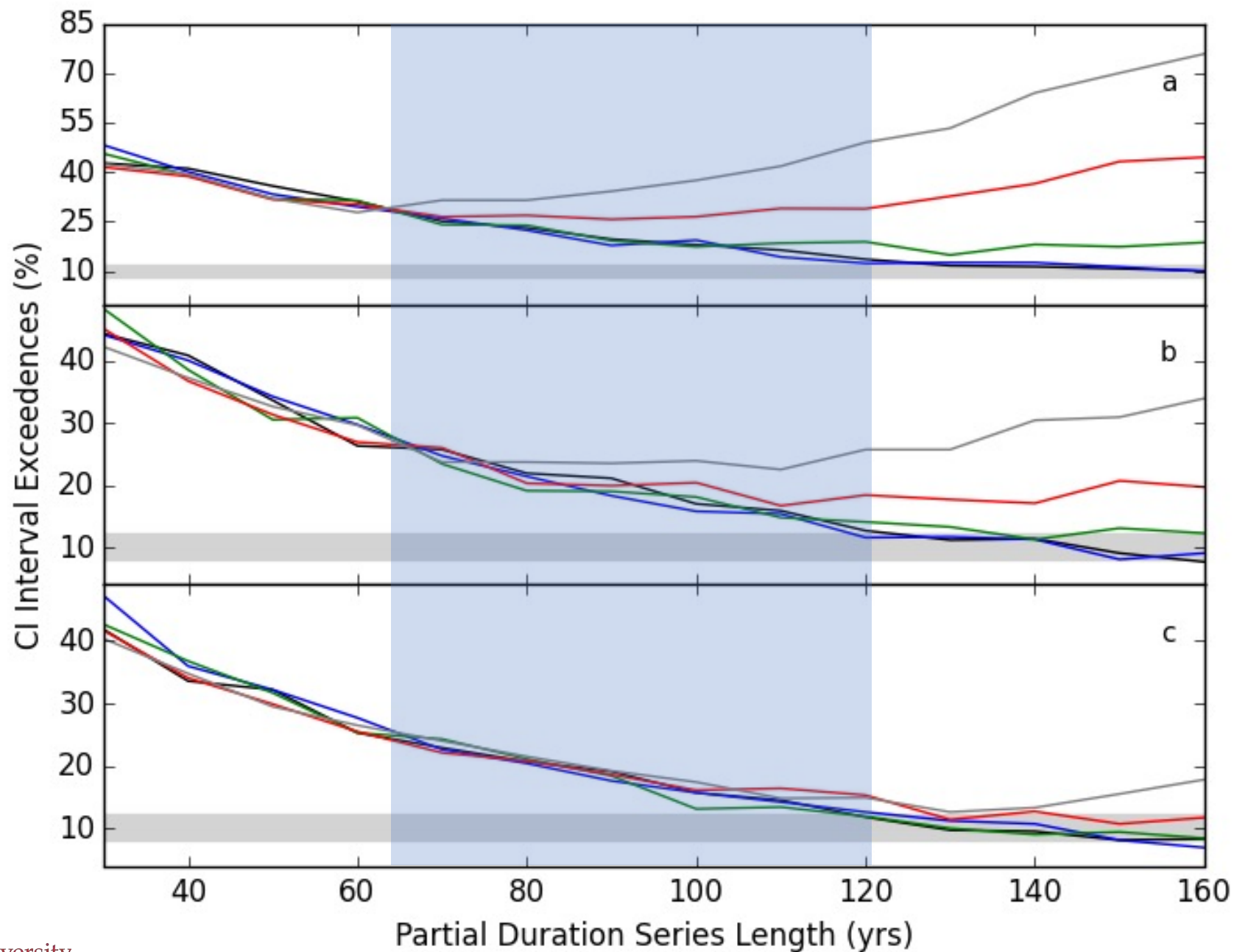
Trended pds vs. assumed stationary pds



5-yr ARI

10-yr ARI

25-yr ARI



Trend

0% decade⁻¹

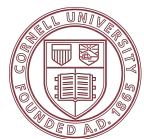
0.02% decade⁻¹

0.04% decade⁻¹

0.07% decade⁻¹

0.1% decade⁻¹

Stationary 150-yr PDS
90% CI



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Q1: Are the Longest Record Lengths the Holy Grail?

A1: Not when they have a trend

Sweet spot 70-120 years



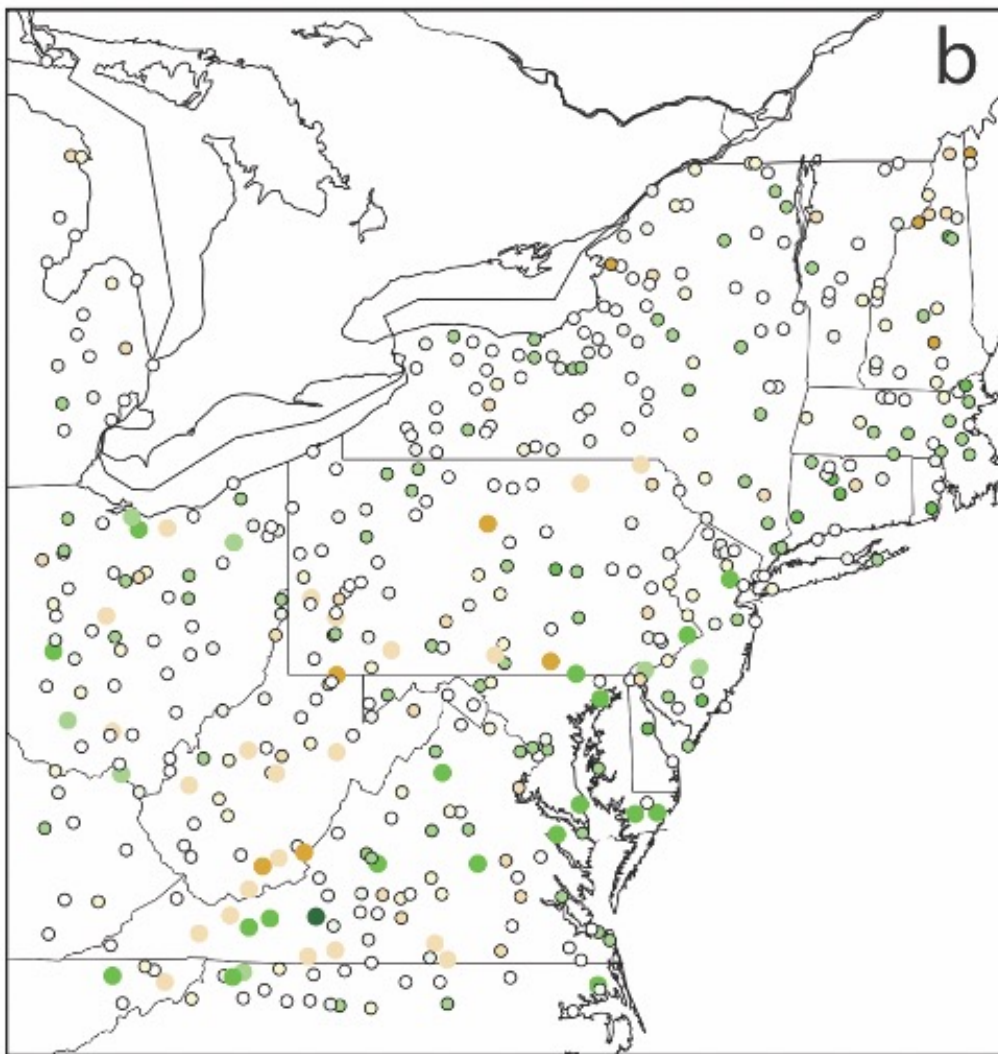
Q2: How often should extreme rainfall atlases be updated?



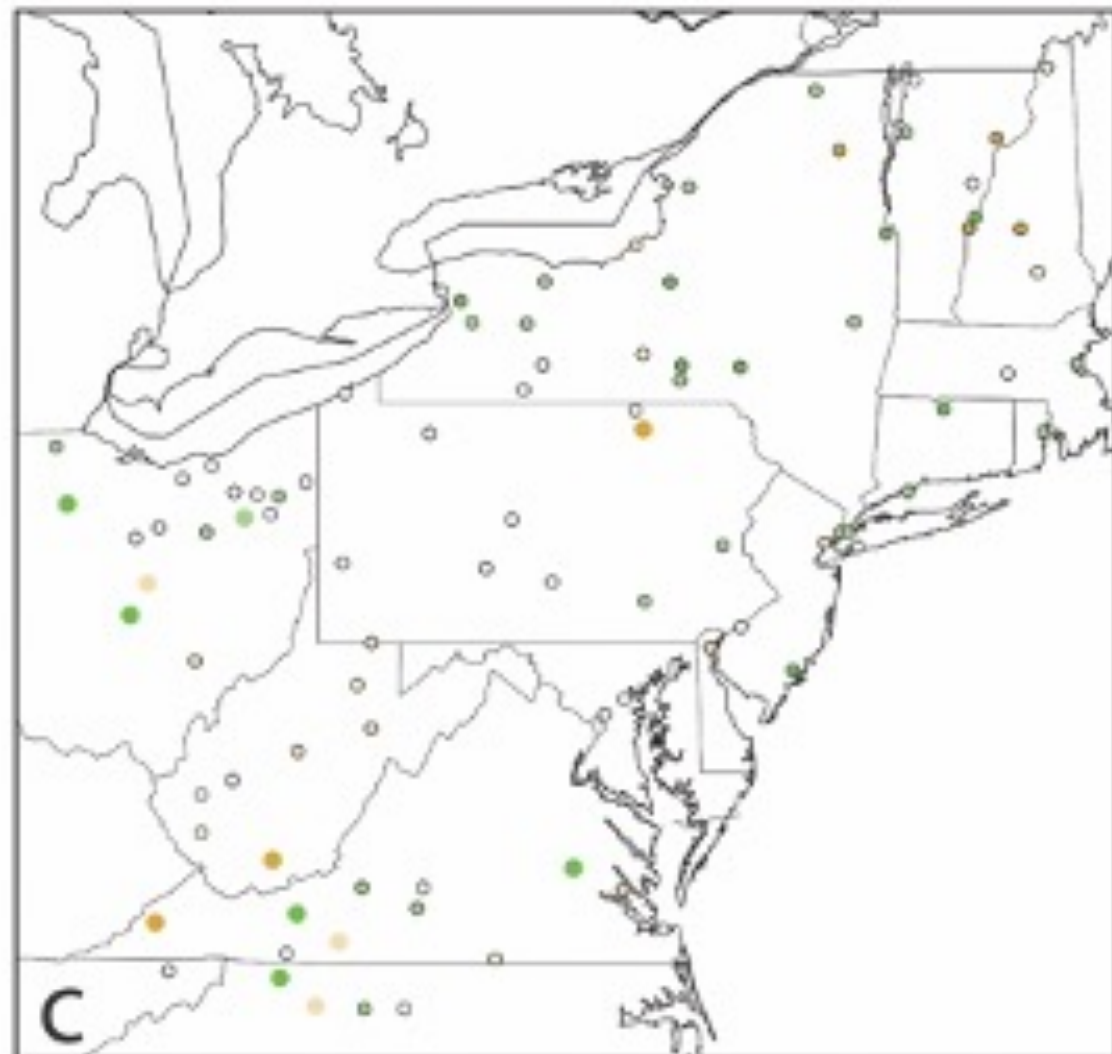
Is NOAA Atlas 14
(circa 2000) out of date?

**OUT OF
DATE**

Study Domain

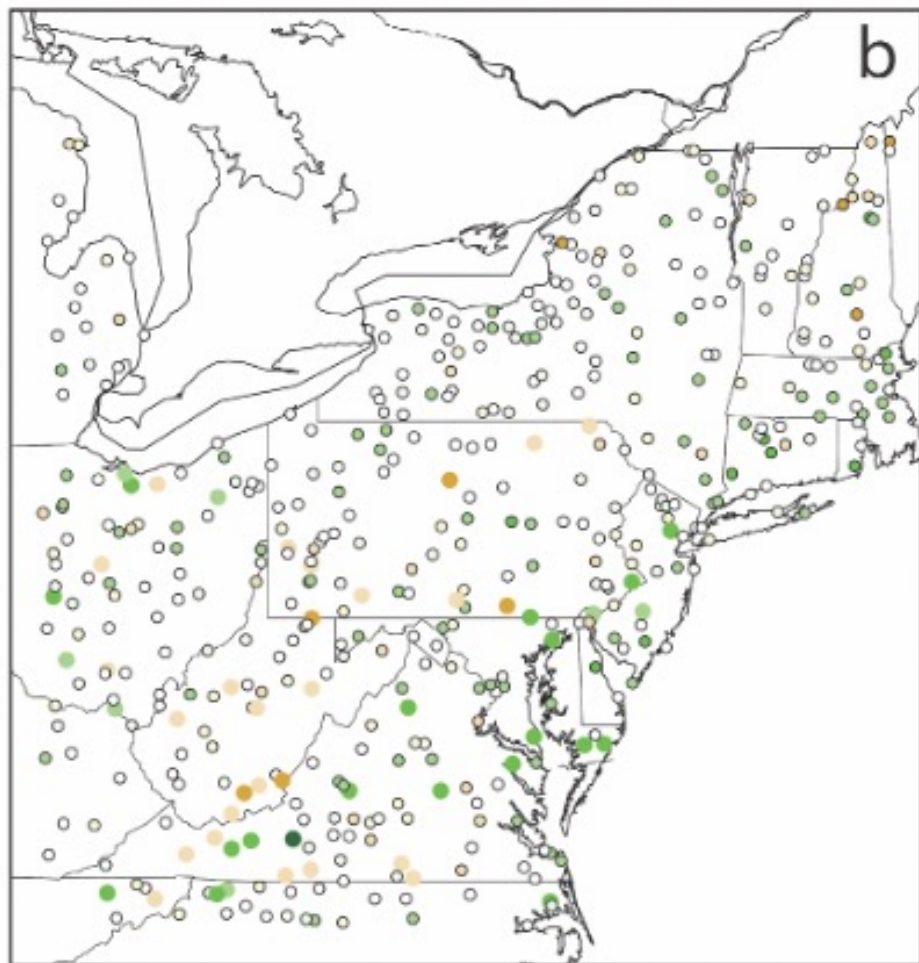


Daily

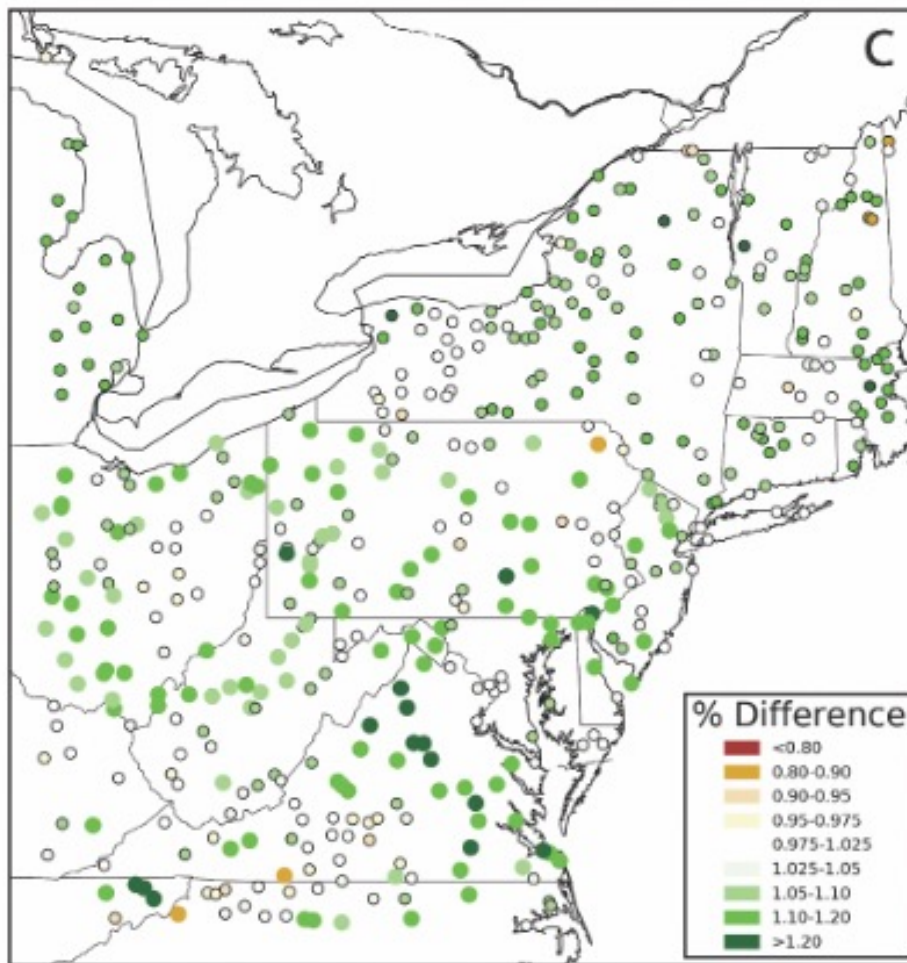


Hourly

Simulation of Atlas 14 Methods



2-year ARI



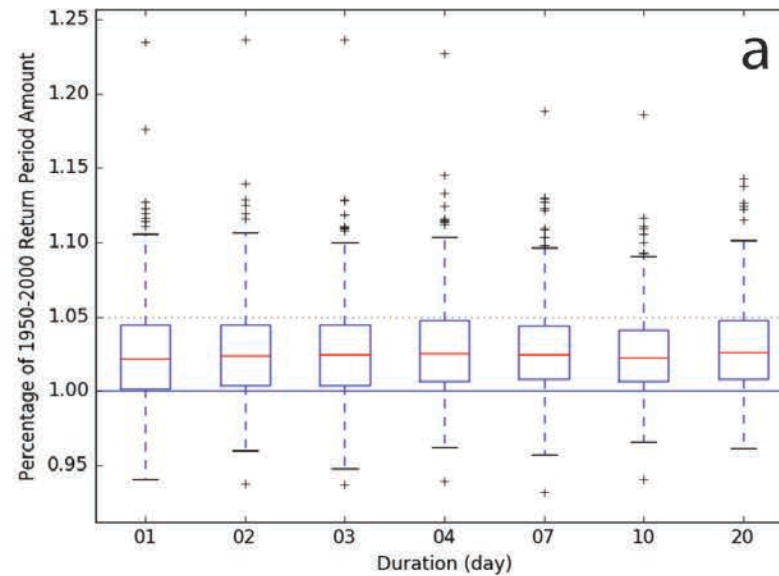
100-year ARI

Differences

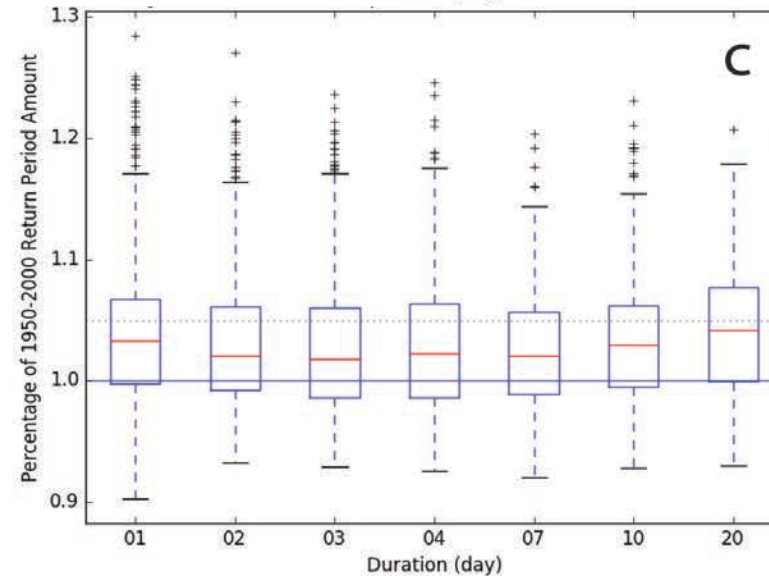
- Period of record
- AMS-PDS
- PA-NY regionalization
- PA-NY GEV
- Station vs grid

1950-2019 vs 1950-2000: Atlas 14 Update vs Original

2-year ARI



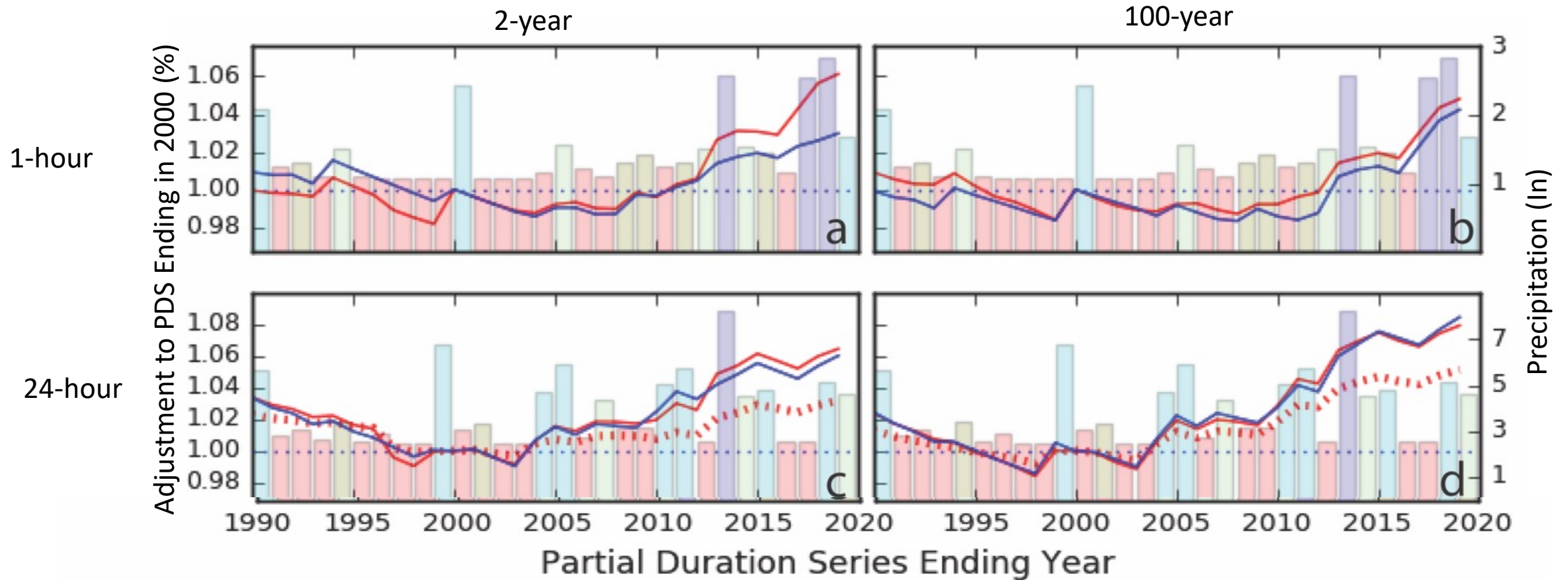
100-year ARI



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Why the Changes and Differences?

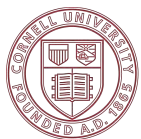
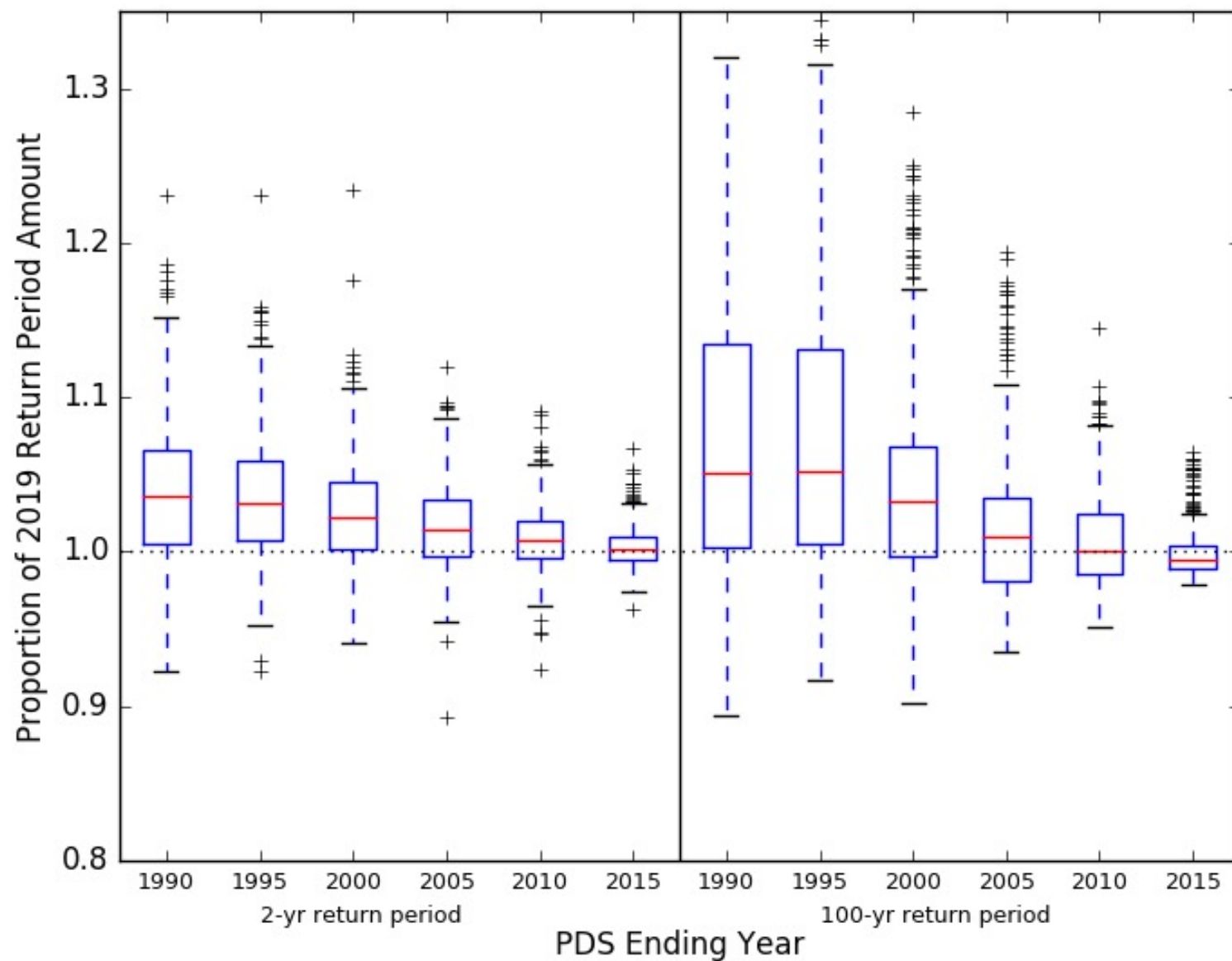


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<https://precipchange.nrcc.cornell.edu>

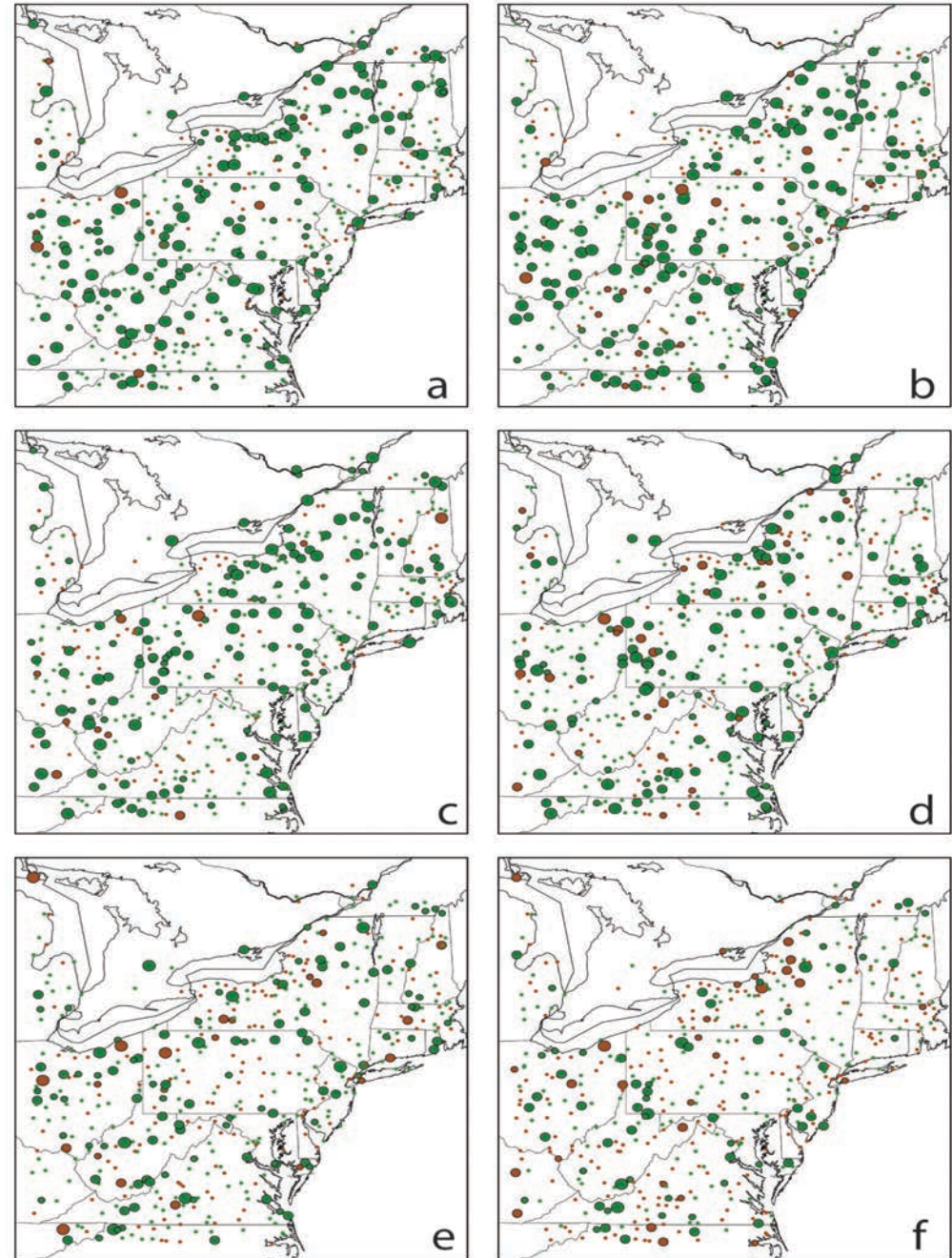


Influence of Ending Year



Significant?

- 2019 PDS at each station (70 years)
- Fit GEV
- Resample selecting 61, 51 and 41 values (2010, 2000, 1990)
- Fit GEV, compute RI, calculate proportion (2019/base)
- Compare observed to resampled



Q3: How will Design Storms Change in the Future?

2020



1950-2020 PDS



2070



1950-2020 PDS?

Projections

Localized Constructed Analogs (LOCA)

- Statistically Downscaled
- 1/16th ° Spatial Resolution (7 km)
- 31 CMIP5 models
- Daily resolution
- RCP 8.5 and 4.5
- NCA method of choice

Coordinated Regional Climate Downscaling Experiment (CORDEX)

- Dynamically Downscaled
- 0.22° Spatial Resolution (25 km)
- 16 CMIP5 model-RCM combos
- Daily and sub-daily resolution
- RCP 8.5 and 4.5 (3 combos)

Excluded MACA and BCSD (two other common statistical downscaling techniques)



Methods (per model and grid point)

Extract 50-yr PDS:

- 1950-1999 (model hist)
- 2020-2069
- 2050-2099

Fit GEV to PDS to obtain ARIs:

- single grid
- regional (20 grids)

Compute Change Factor CF_{ARI} :

$$\frac{ARI_{Future}}{ARI_{Historical}}$$

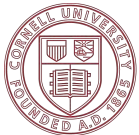
For each LOCA grid (31 x 1000) CF_{ARI} values
For each CORDEX grid (16 x 1000) CF_{ARI} values

Interpolate to common 0.1° grid
Compute median and percentiles

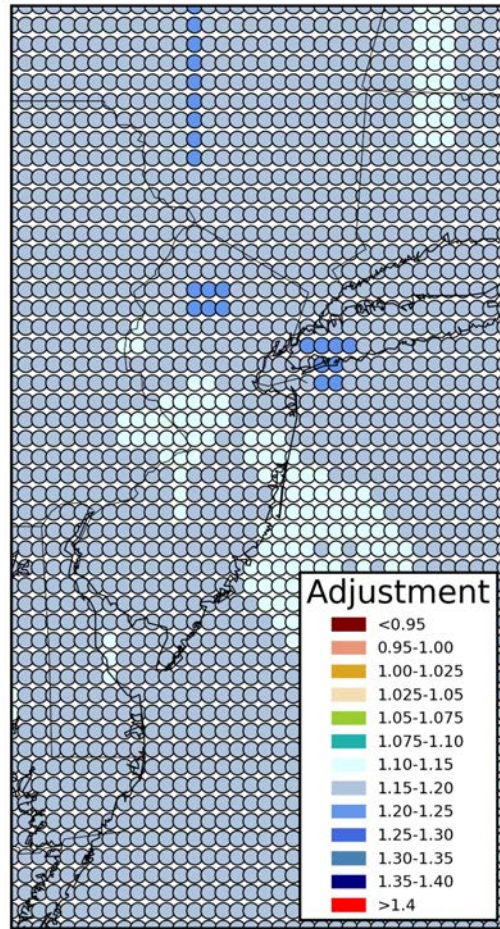
Resample (1000 x):

- select PDS from original future
fit GEV
- fit new GEV and obtain ARI
- compute

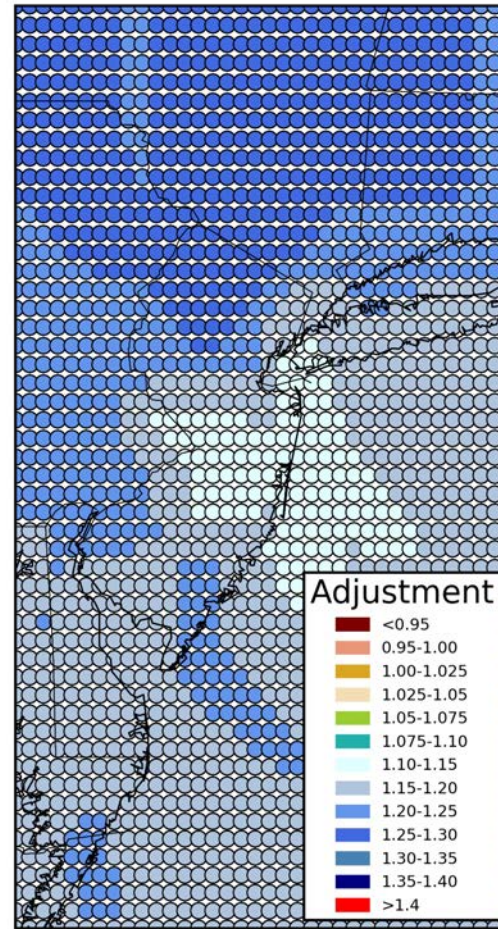
$$\frac{ARI_{Future (resampled)}}{ARI_{Historical}}$$



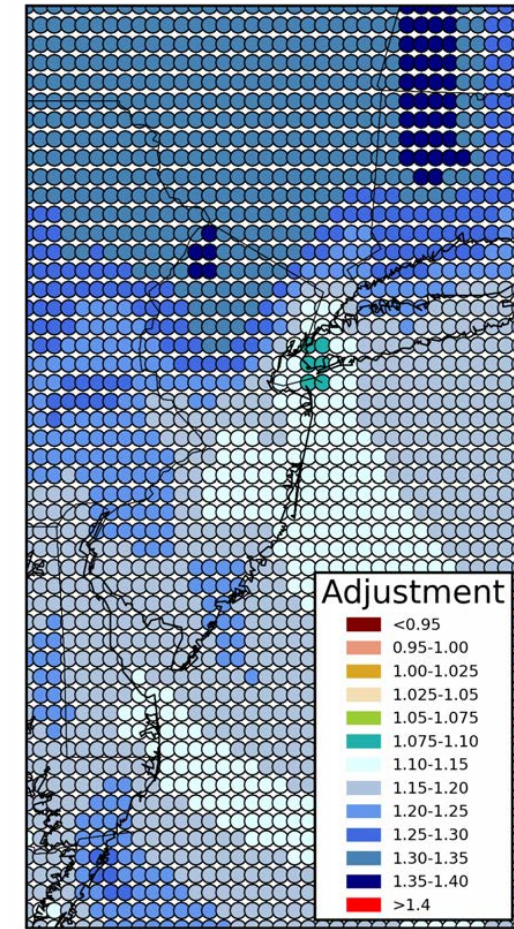
Ensemble Median Change Factor (RCP8.5 2050-2099)



2-yr



25-yr



100-yr

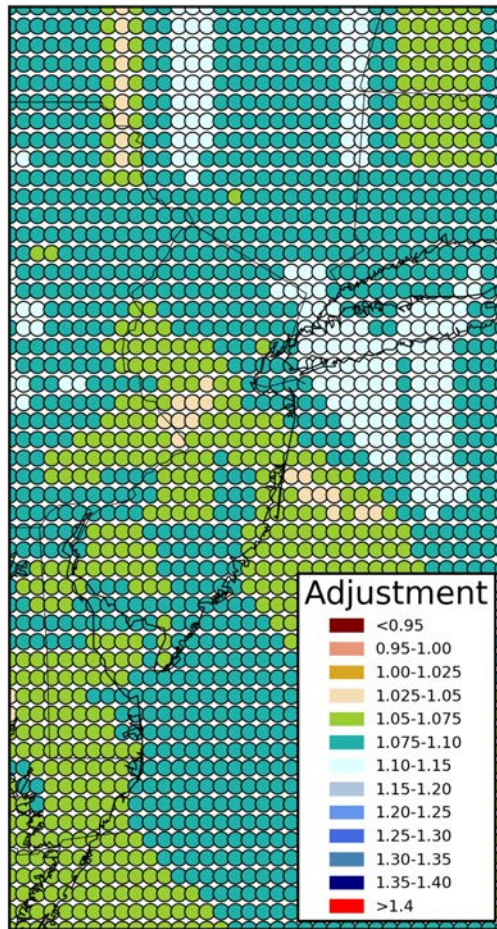


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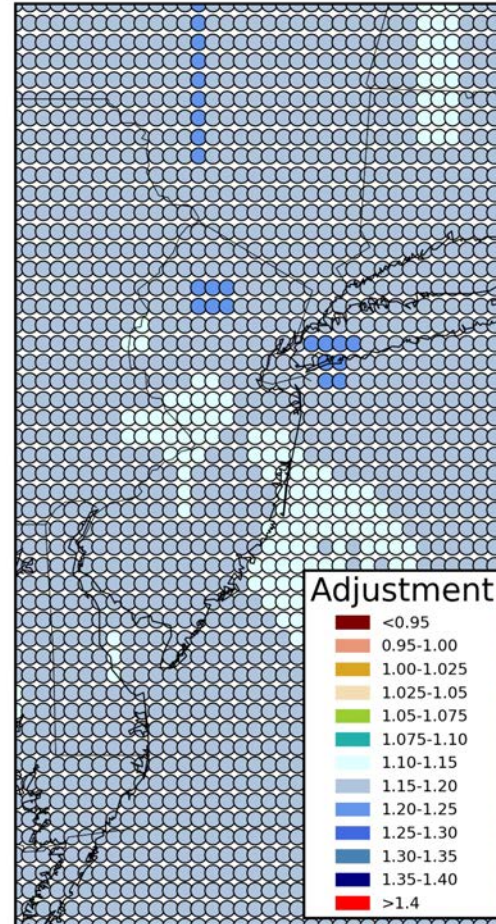


Ensemble Change Factor 17th-83rd percentile range

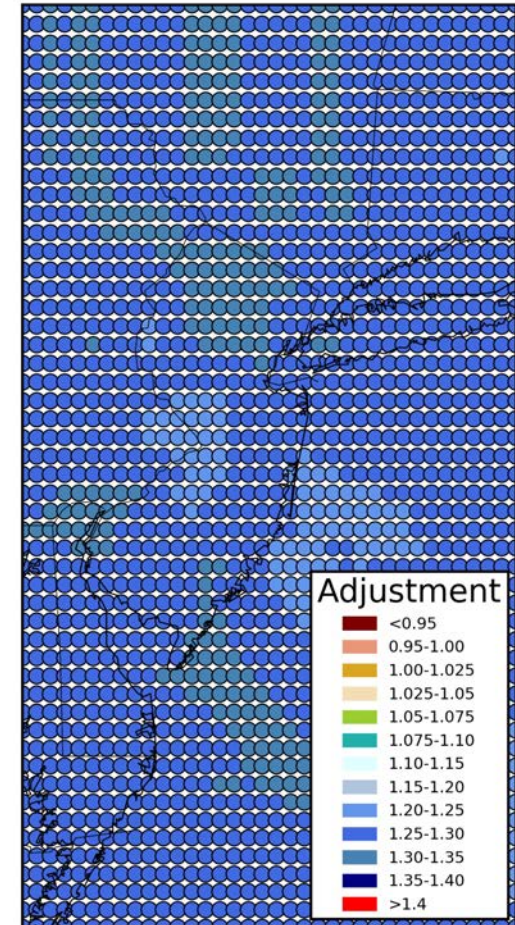
2-year ARI



17th



median



83rd



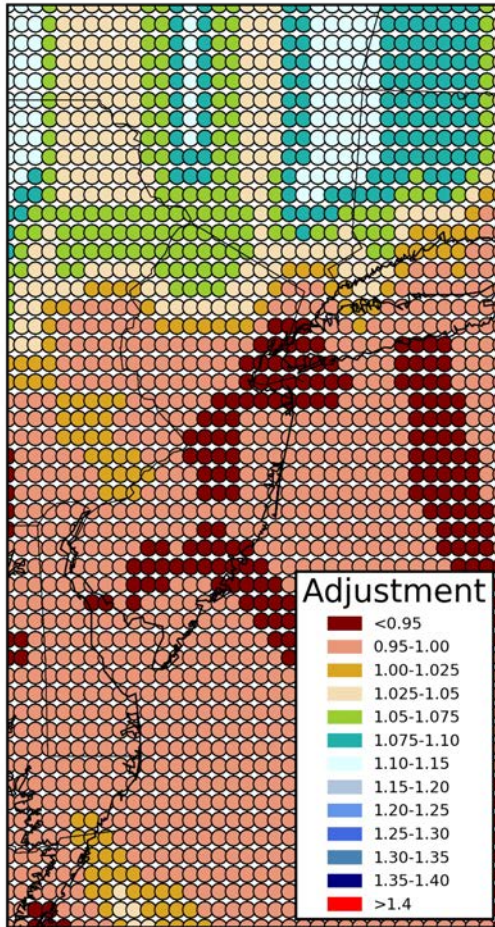
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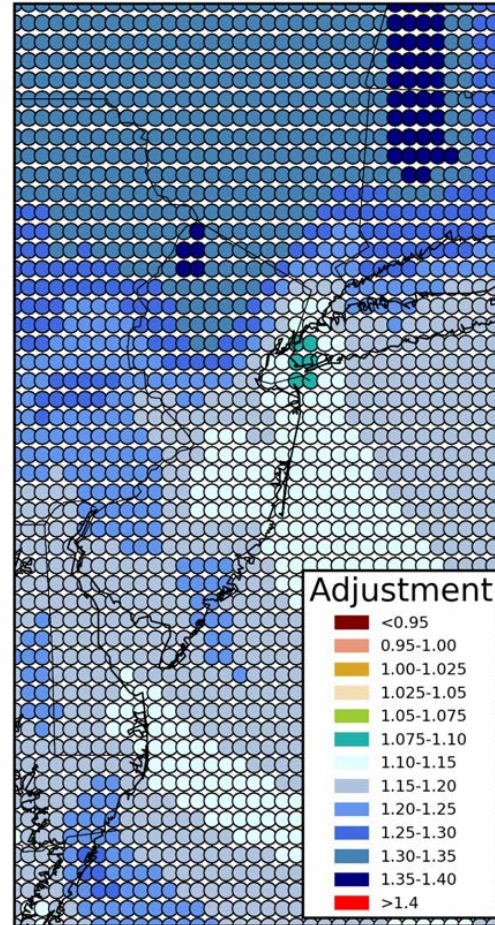
Ensemble Change Factor 17th-83rd percentile range

100-year ARI

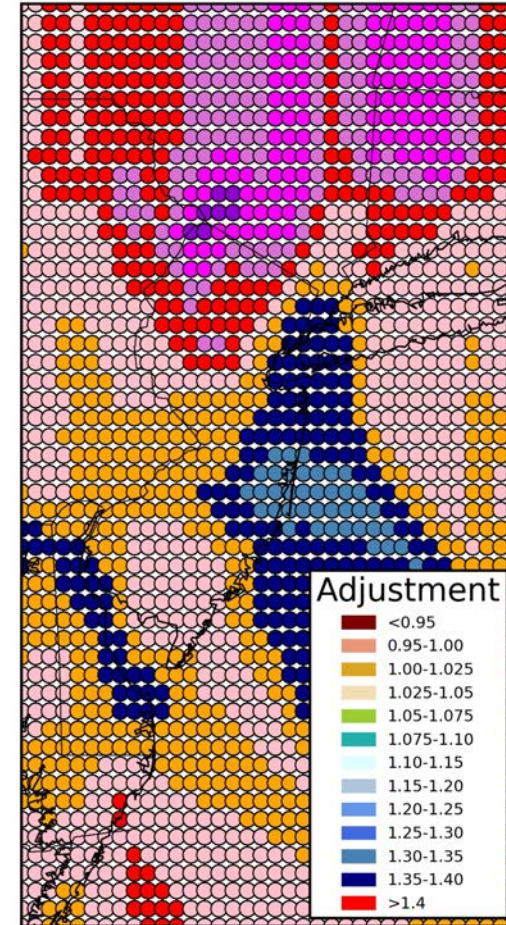
Orange 1.40-1.45
Pink 1.45-1.5
Red 1.5-1.55



17th



median



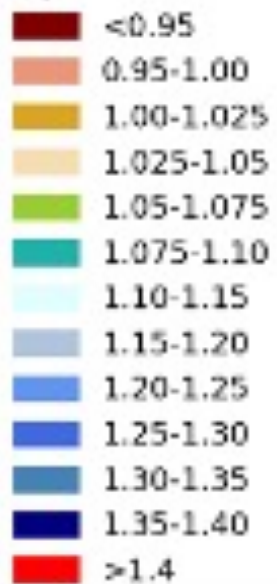
83rd



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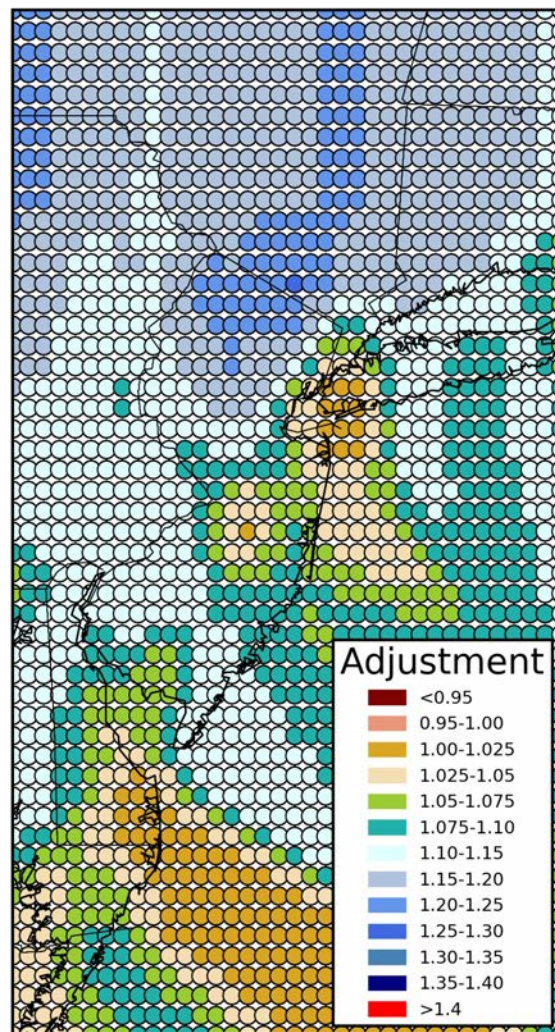


Adjustment

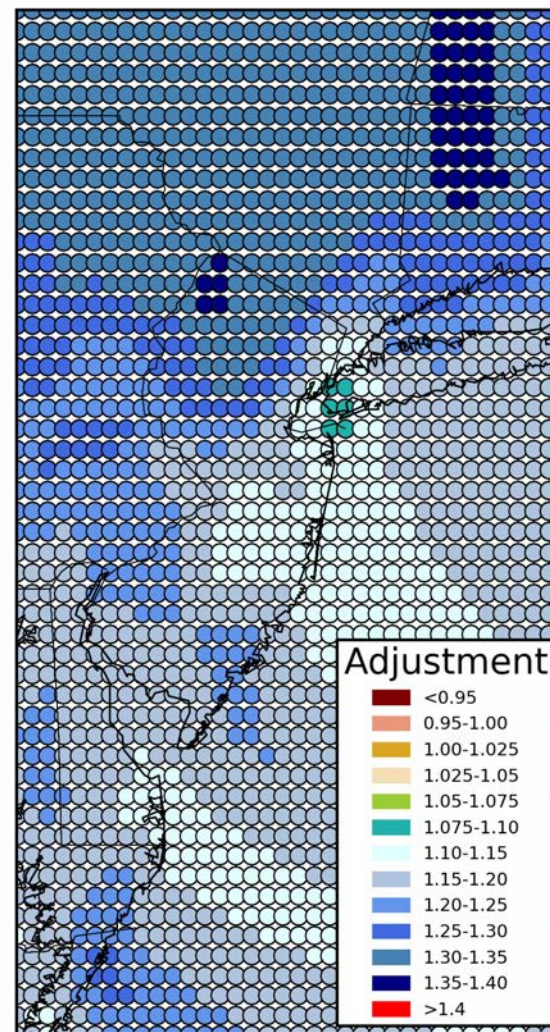


Median Ensemble Change Factors RCP 4.5 vs RCP 8.5

100-yr RCP 4.5. 2050-2099



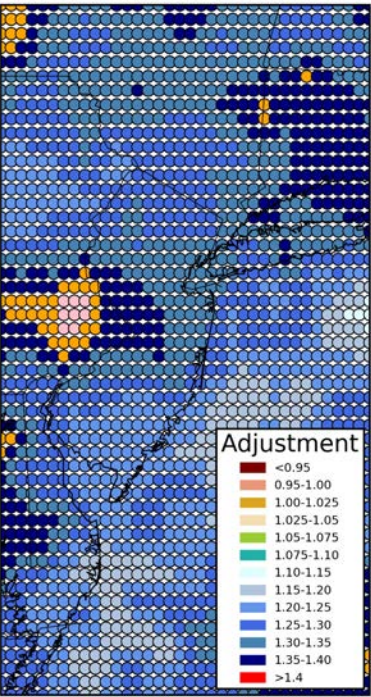
100-yr RCP 8.5. 2050-2099



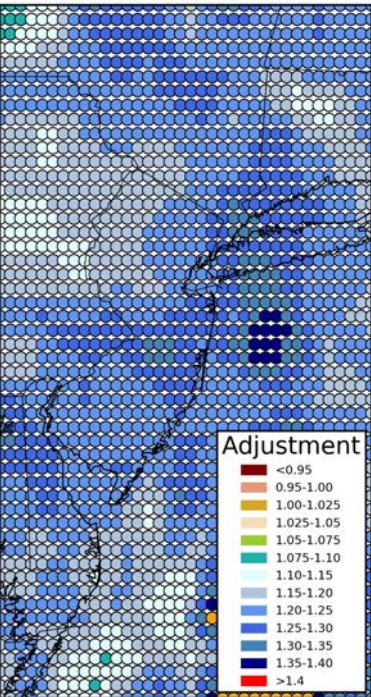
Cornell University



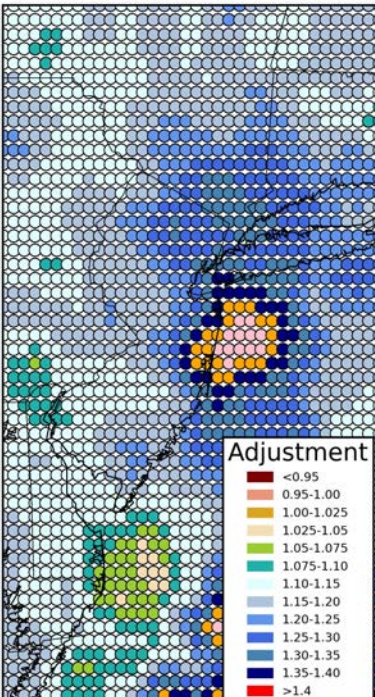
Median Ensemble 100-yr Change Factors RCP 8.5 2050-2099



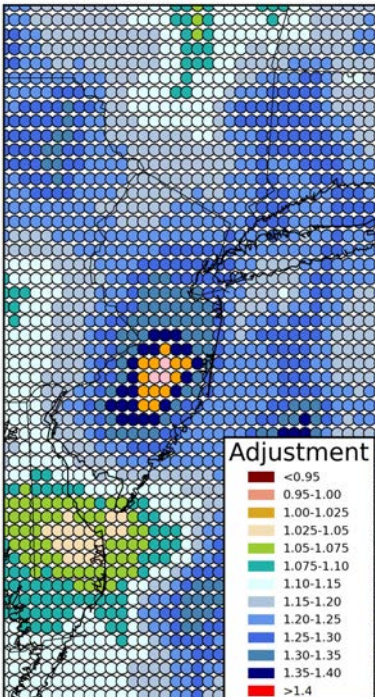
1 –hr



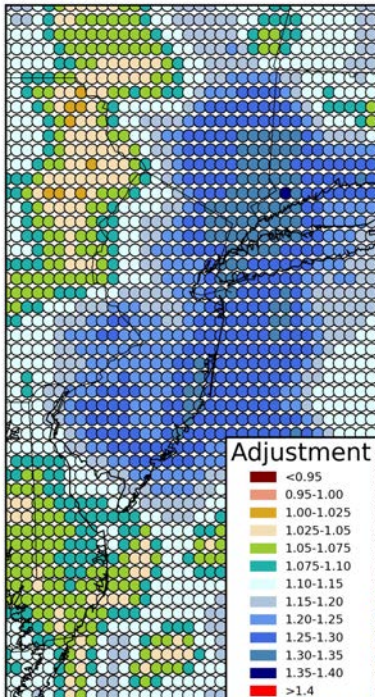
3-hr



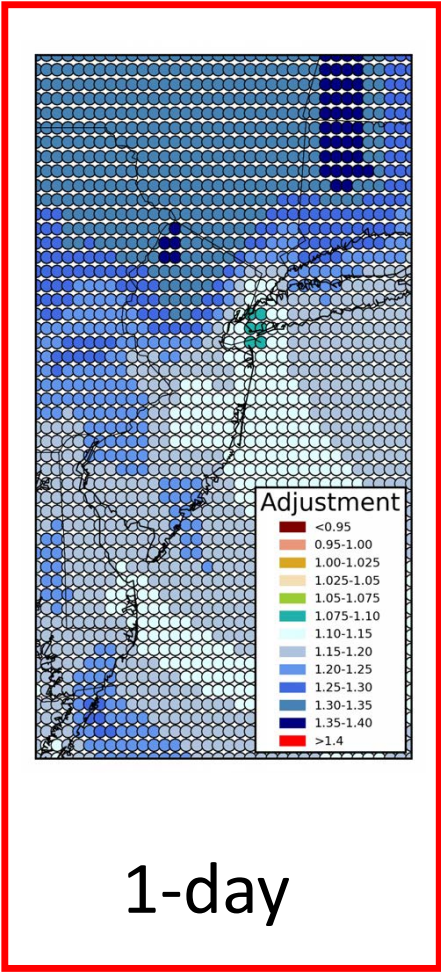
6-hr



12-hr



24-hr



1-day



Final Product: <https://midatlantic-idf.rcc-acis.org>



Projected Intensity-Duration-Frequency (IDF) Curve Data Tool for the Chesapeake Bay Watershed and Virginia



Technical Resources

Using the Data

Using the Tool

Selection Panel

Return Period

50-year

Emissions Scenario

High RCP 8.5

Time Period

2050-2100

Area of Interest

Both

Currently Selected

No station selected.

Favorited Stations

★ SUNBURY

Atlas 14 Change Factors for Snyder County:

10th Percentile:	1.00
25th Percentile:	1.11
Mean:	1.23
75th Percentile:	1.31
90th Percentile:	1.46

See "Using the Data" above for correct and
incorrect application of these change factors.

Mean County Change Factor

0.7

1.0

1.3

Watershed
Boundary
State
Border



© Mapbox © OpenStreetMap Improve this map

Carnegie Mellon University

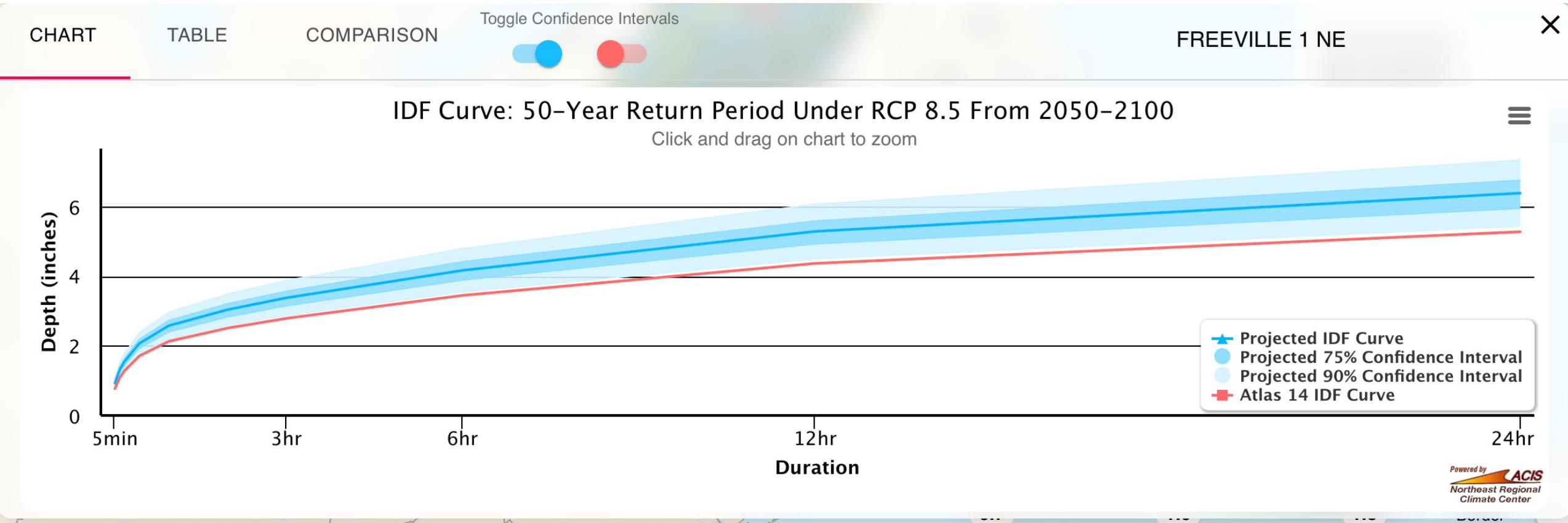


This project was carried out by researchers at [Carnegie Mellon University \(CMU\)](#), the [Northeast Regional Climate Center \(NRCC\)](#) at Cornell University and the [RAND Corporation \(RAND\)](#). The project team members from RAND and NRCC are also a part of the [Mid-Atlantic Regional Integrated Sciences and Assessments \(MARISA\) Program](#).

The project was funded by the [Chesapeake Bay Trust](#) and in partnership with the U.S. Environmental Protection Agency under the [Chesapeake Bay Program's](#) Goal Implementation Team. NRCC and CMU also received funding from the [Virginia Transportation Research Council \(VTRC\)](#) and the [Commonwealth Center for Recurrent Flooding Resiliency \(CCRFR\)](#) to extend the study boundaries to include the full state of Virginia.



Final Product: <https://midatlantic-idf.rcc-acis.org>

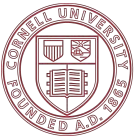


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Final Product: <https://midatlantic-idf.rcc-acis.org>

CHART	TABLE	COMPARISON	DOWNLOAD CSV	FREEVILLE 1 NE						✕
County Change Factors:		1.03	1.1275	1.21	1.28	1.39				
Projected 2050-2100 Depth (inches)							Atlas 14 Depth (inches)			
Duration	10th	25th	Mean	75th	90th					
12 hr	4.50	4.93	5.29	5.59	6.07	4.37				
24 hr	5.44	5.95	6.39	6.76	7.34	5.28				
2 day	6.17	6.75	7.25	7.67	8.33	5.99				



The background of the slide is a light blue color. It is filled with numerous question marks of various sizes and colors (blue, green, orange, and grey). Some question marks are enclosed in circles of the same color. In the lower half of the image, there are many stylized hands of different colors (blue, orange, green, brown, and grey) reaching upwards. The text 'Thank You!' is written in a large, yellow, sans-serif font, slanted slightly to the right, and positioned in the upper middle part of the image. Below it, the text 'Questions??' is written in the same yellow, sans-serif font, also slanted slightly to the right, and positioned in the lower middle part of the image.

Thank You!

Questions??