2020 Northern Institute of Applied Climate Science Workshop,
"Planning and Practices for Water Supply
Reservoir Forests in the Mid-Atlantic"

MARYLAND'S CLIMATE: VARIABILITY AND CHANGE

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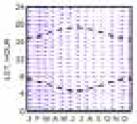
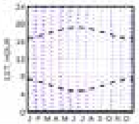
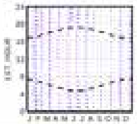
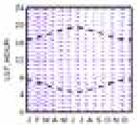
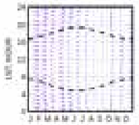
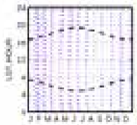
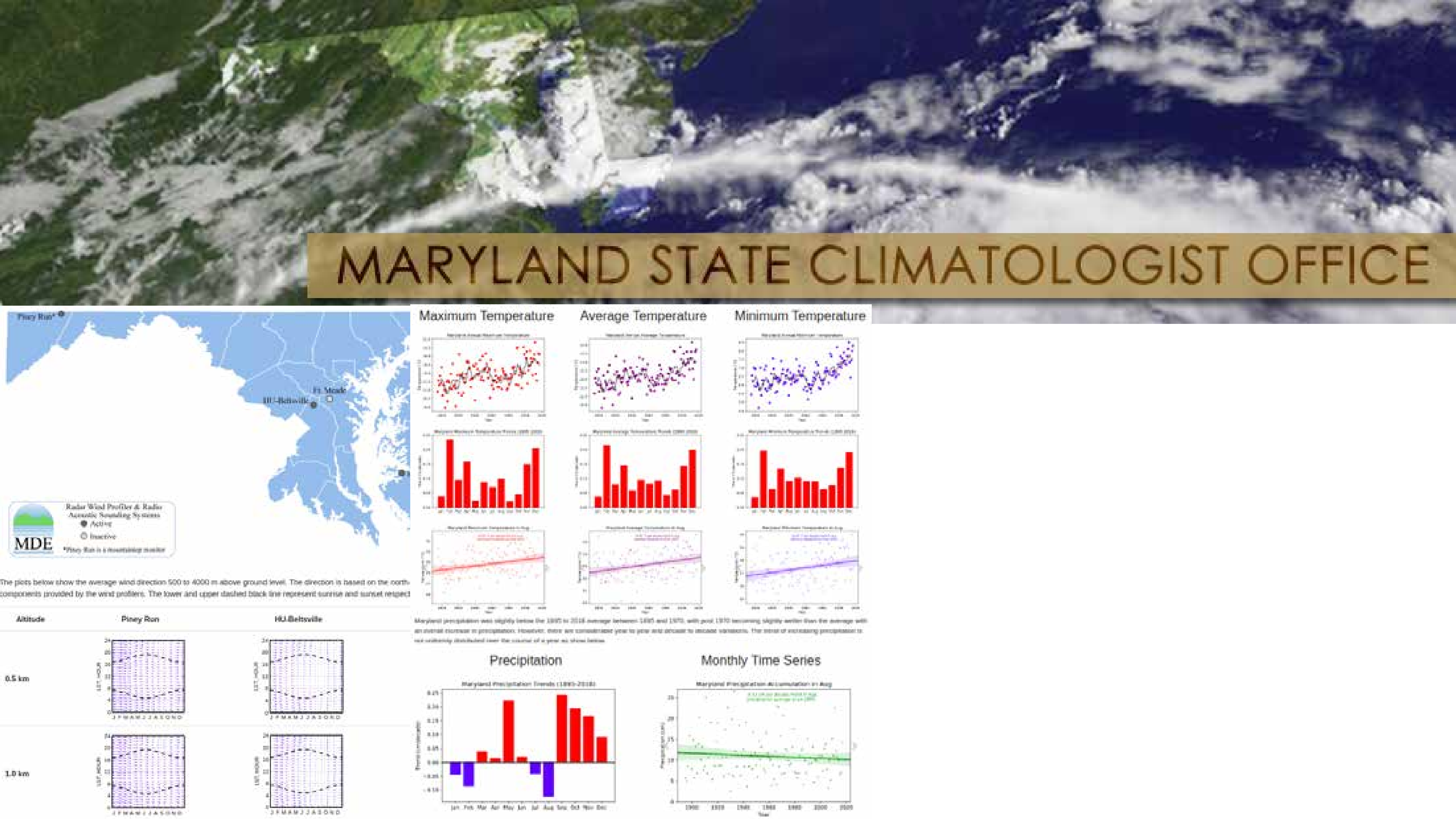
University of Maryland at College Park, MD

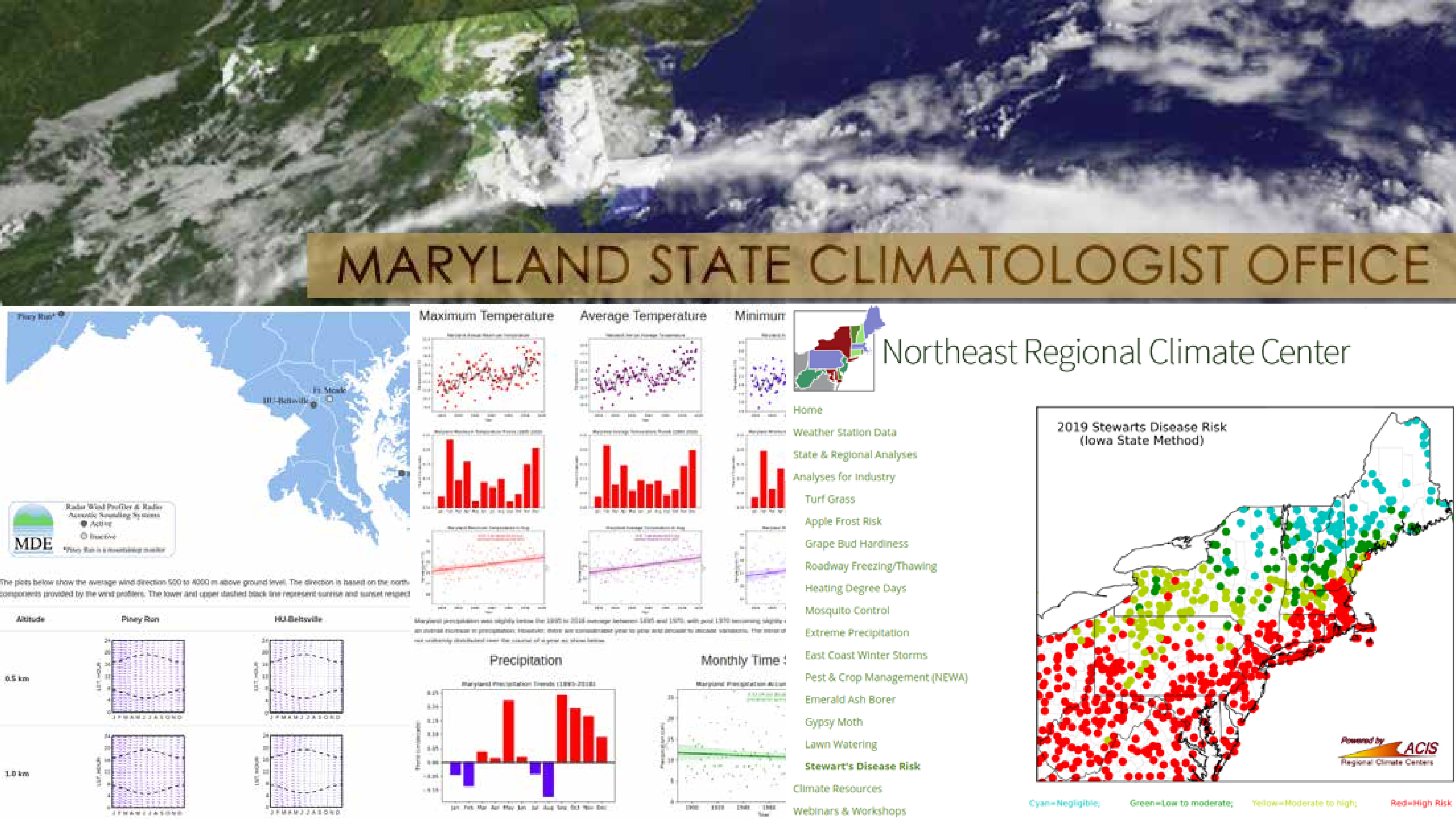
North Point State Park, Edgemere, Maryland, January 30, 2020

The plots below show the average wind direction 500 to 4000 m above ground level. The direction is based on the north-south and east-west vector components provided by the wind profilers. The lower and upper dashed black line represent sunrise and sunset respectively.

Altitude	Piney Run	HU-Beltsville	Horn Point
0.5 km			
1.0 km			



MARYLAND STATE CLIMATOLOGIST OFFICE
Piney Run*
Ft. Meade
HU-Beltsville
Radar Wind Profiler & Radio Acoustic Sounding Systems
Active
Inactive
MDE
*Piney Run is a mountaintop monitor
The plots below show the average wind direction 500 to 4000 m above ground level. The direction is based on the north-
components provided by the wind profilers. The lower and upper dashed black line represent sunrise and sunset respect
Altitude
Piney Run
HU-Beltsville
0.5 km
1.0 km
Maximum Temperature
Average Temperature
Minimum Temperature
Maryland precipitation was slightly below the 1895 to 2018 average between 1895 and 1970, with post 1970 becoming slightly wetter than the average with an overall increase in precipitation. However, there are considerable year to year and decade to decade variations. The trend of increasing precipitation is not uniformly distributed over the course of a year as show below.
Precipitation
Maryland Precipitation Trends (1895-2018)
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Monthly Time Series
Maryland Precipitation Accumulation in Aug
Year


MARYLAND STATE CLIMATOLOGIST OFFICE
Piney Run*
Ft. Meade
HU-Beltsville
Radar Wind Profiler & Radio Acoustic Sounding Systems
Active
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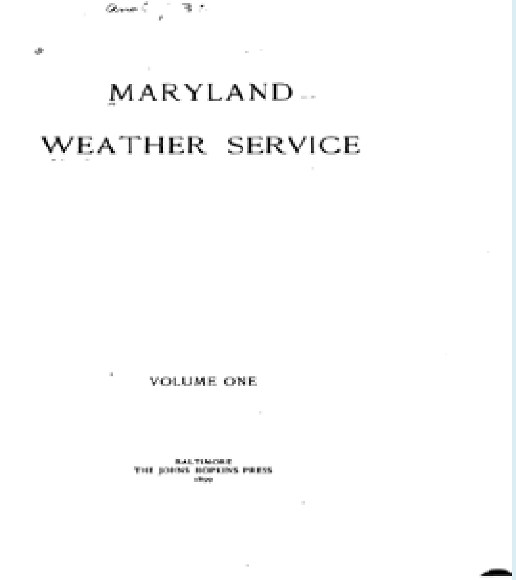
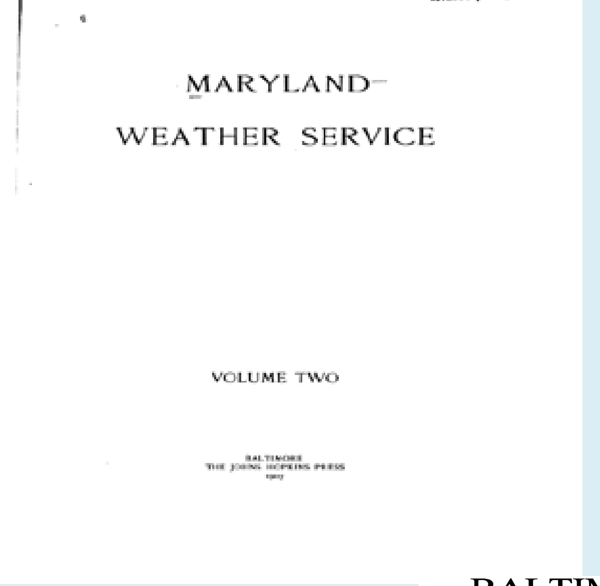
*Piney Run is a mountaintop monitor
Altitude
Piney Run
HU-Beltsville
0.5 km
1.0 km
Maximum Temperature
Average Temperature
Precipitation
Maryland Precipitation Trends (1895-2018)
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Northeast Regional Climate Center
Home
Weather Station Data
State & Regional Analyses
Analyses for Industry
Turf Grass
Apple Frost Risk
Grape Bud Hardiness
Roadway Freezing/Thawing
Heating Degree Days
Mosquito Control
Extreme Precipitation
East Coast Winter Storms
Pest & Crop Management (NEWA)
Emerald Ash Borer
Gypsy Moth
Lawn Watering
Stewart's Disease Risk
Climate Resources
Webinars & Workshops
2019 Stewarts Disease Risk
(Iowa State Method)
Powered by ACIS
Regional Climate Centers
Cyan=Negligible;
Green=Low to moderate;
Yellow=Moderate to high;
Red=High Risk


MARYLAND

WEATHER SERVICE

VOLUME ONE

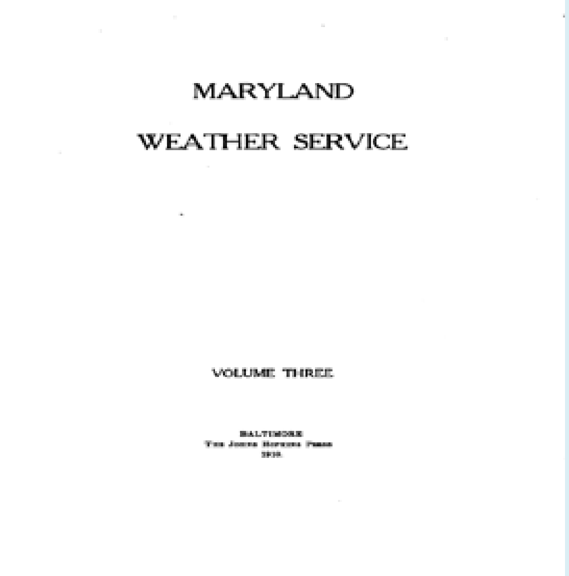
BALTIMORE
THE JOHNS HOPKINS PRESS


MARYLAND

WEATHER SERVICE

VOLUME TWO

BALTIMORE
THE JOHNS HOPKINS PRESS


MARYLAND

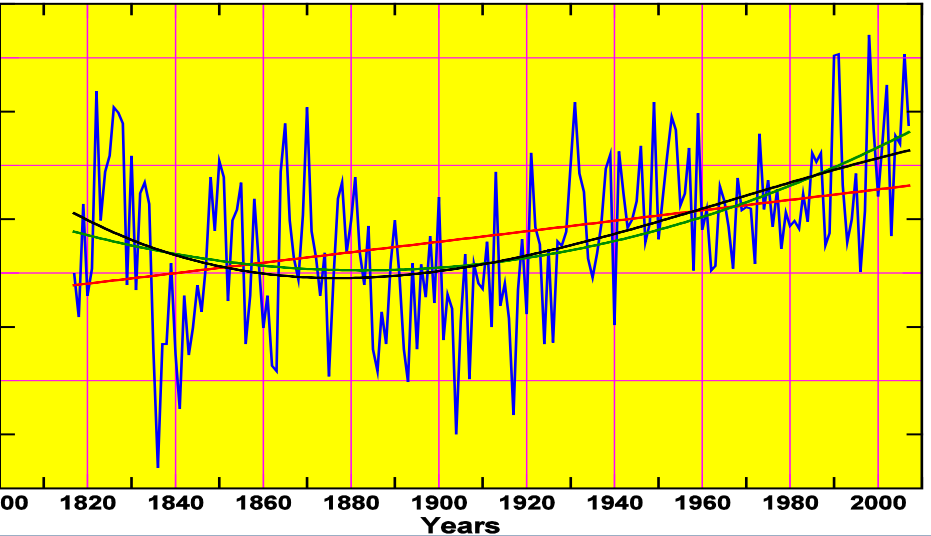
WEATHER SERVICE

VOLUME THREE

BALTIMORE

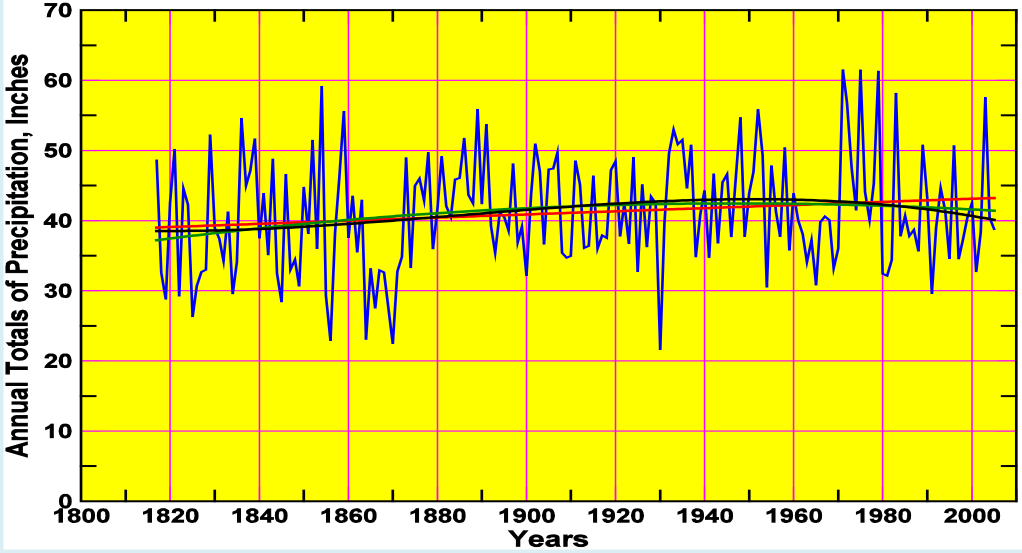
ALTIMORE, MD. ANNUAL TEMPERATURE 1817-2007

Observed Data and Trend Estimates (Linear, Quadratic, Cubic)

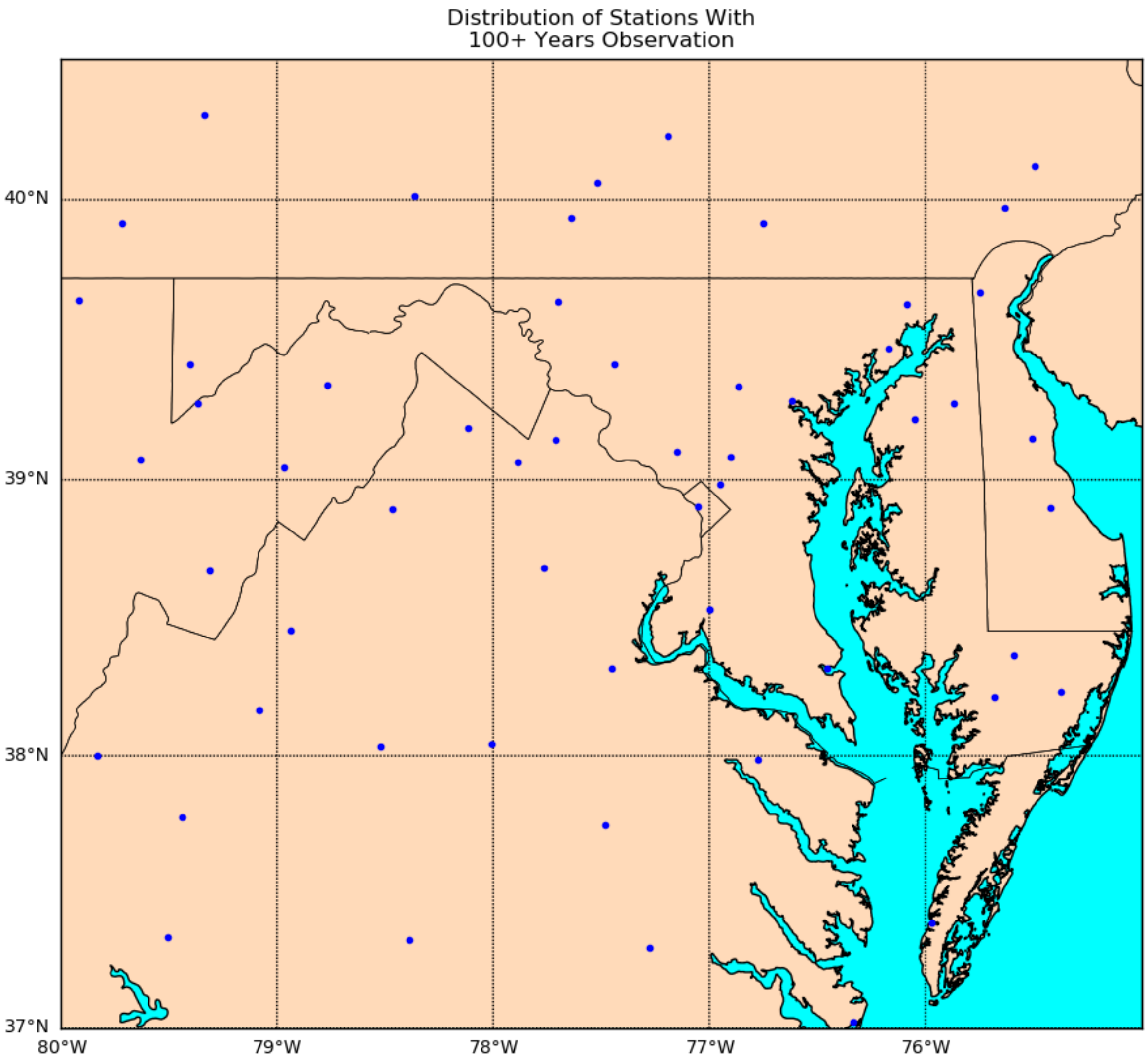


BALTIMORE, MD. ANNUAL PRECIPITATION 1817-2005

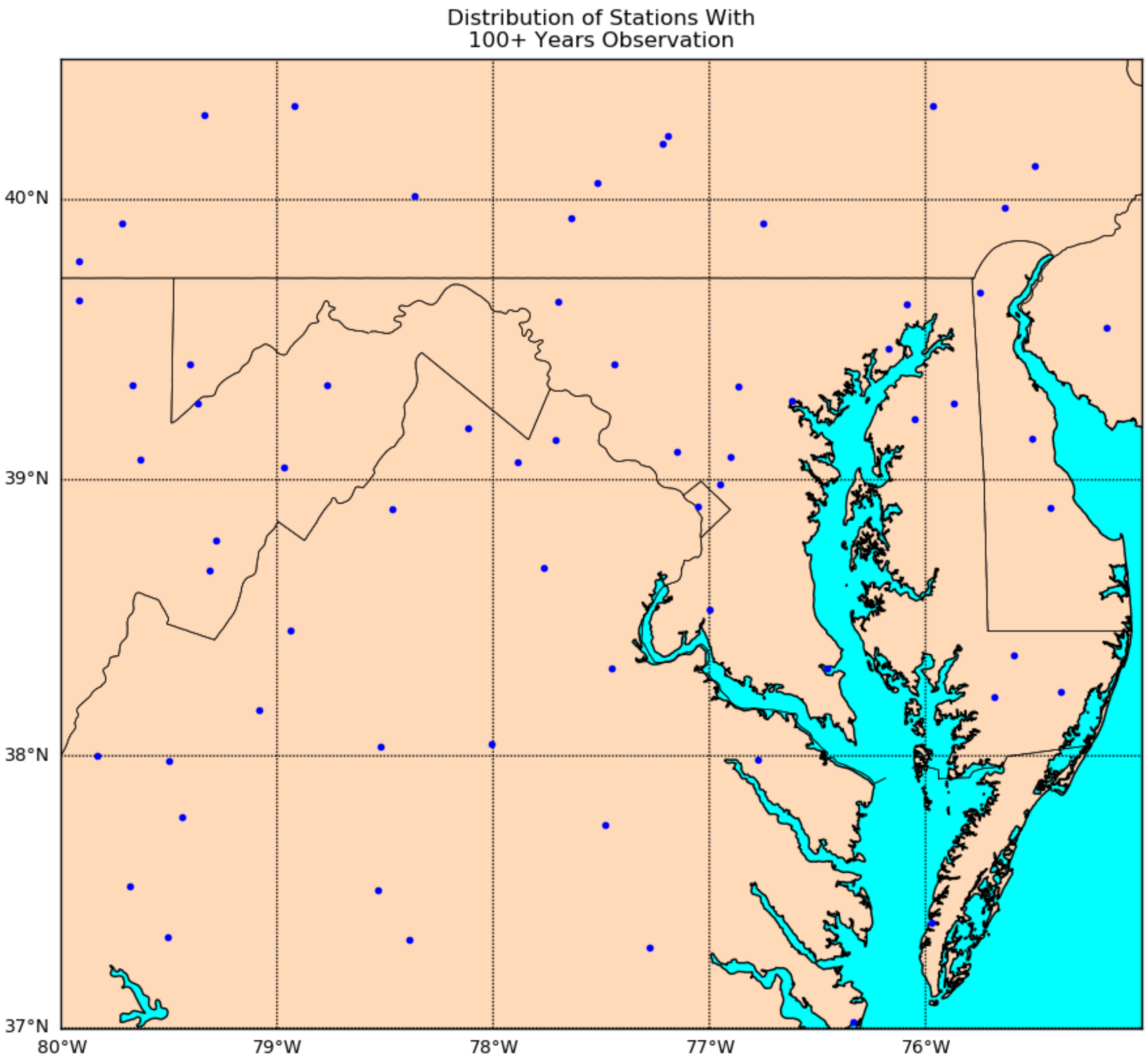
Observed Data and Trend Estimates (Linear, Quadratic, Cubic)



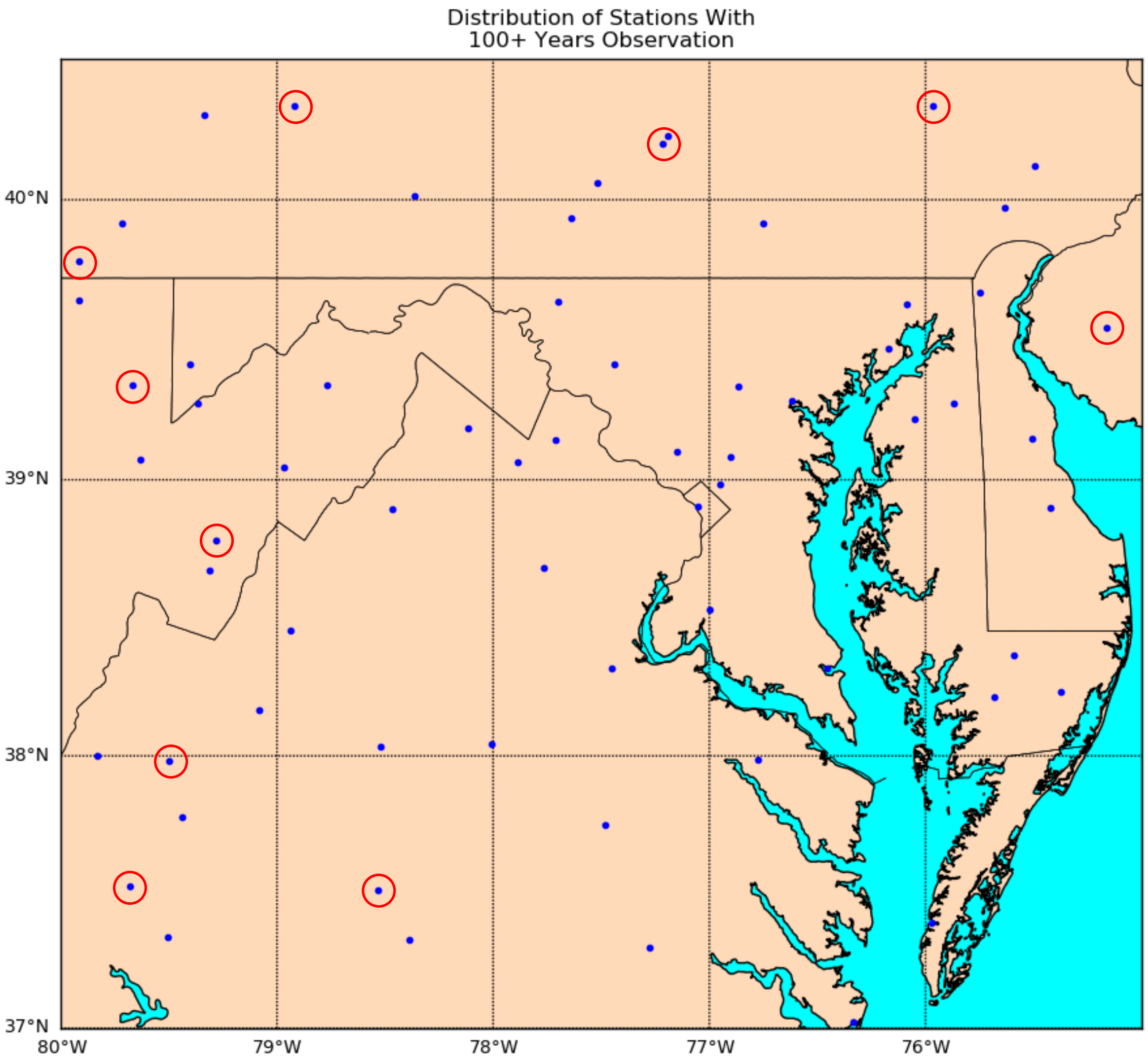
55 stations with 100+ years between first T_{max}/T_{min} observation and last.



65 stations with 100+ years between first precipitation observation and last.



65 stations with 100+ years between first precipitation observation and last.



DATA SOURCES

1. NCEI:

1.1. Global Historical Climate Network Daily

1.2. U.S. Climate Divisional Dataset

2. USGS:

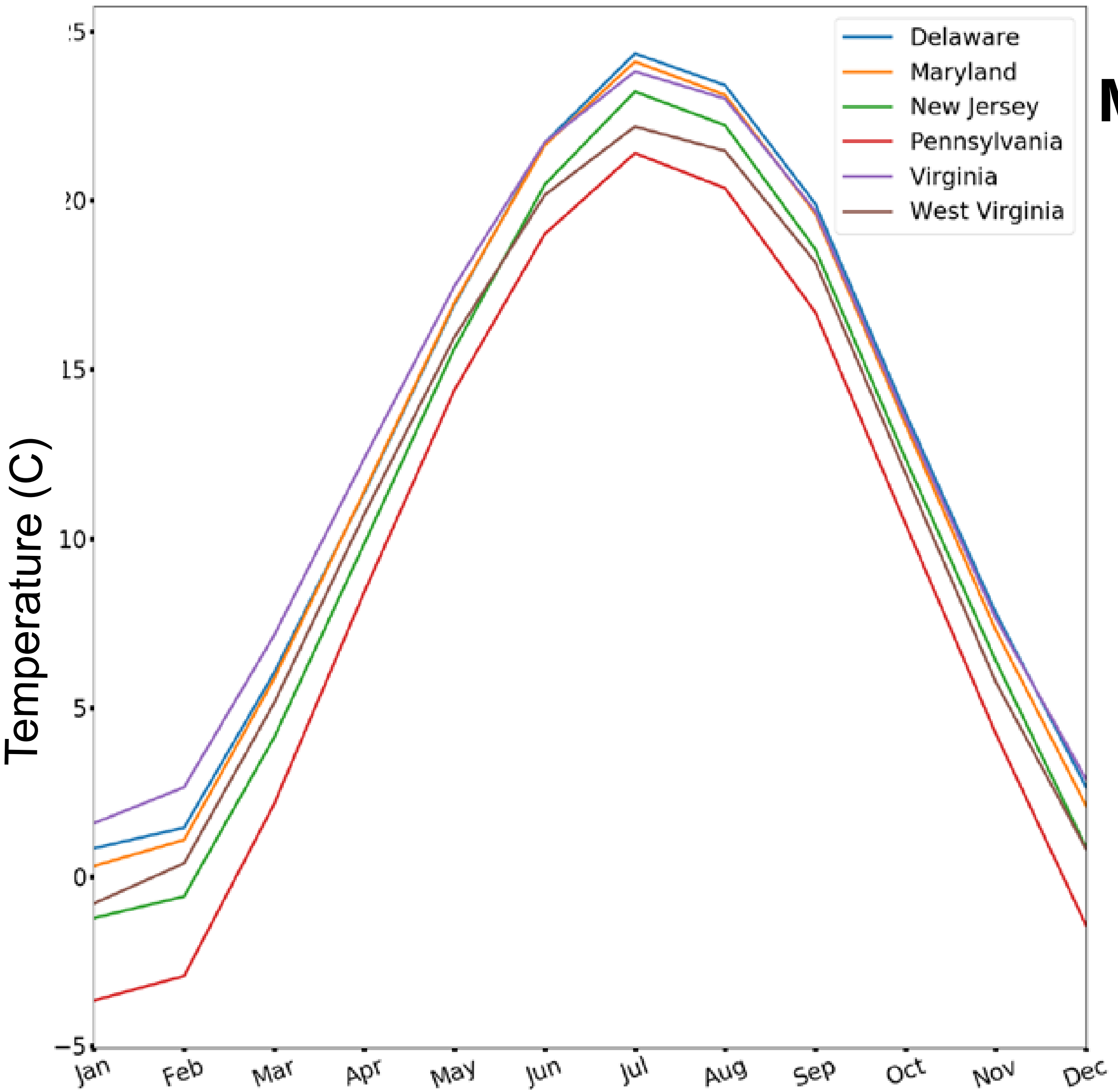
2.1 GAGES-II: Geospatial Attributes of Gages for Evaluating Streamflow

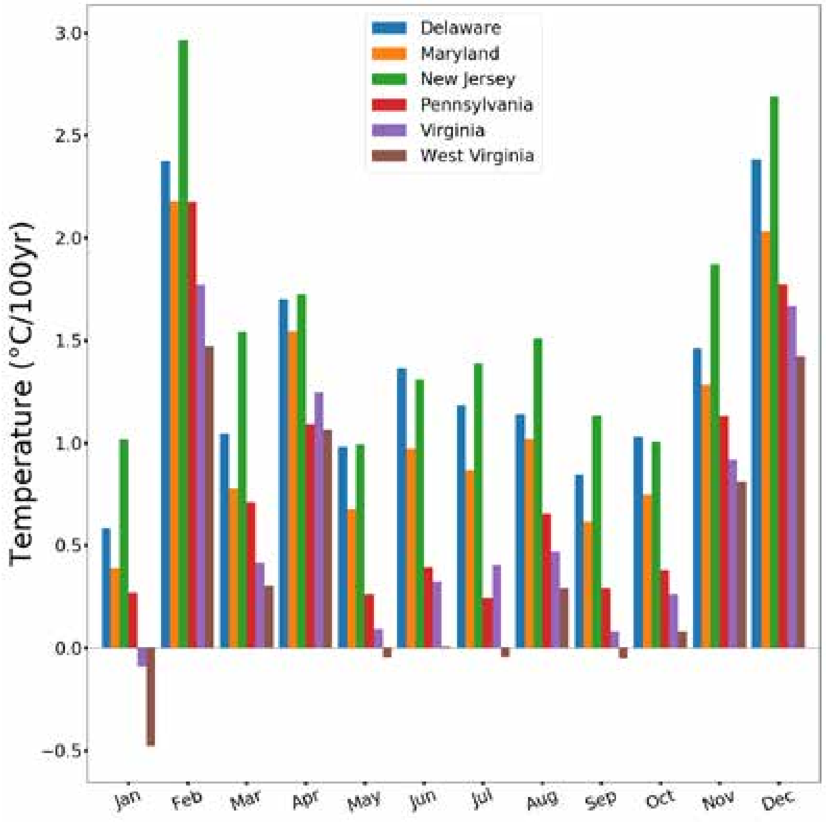
2.1. Daily river discharge

GLOBAL WARMING SIGNATURE IN CLIMATIC RECORDS:

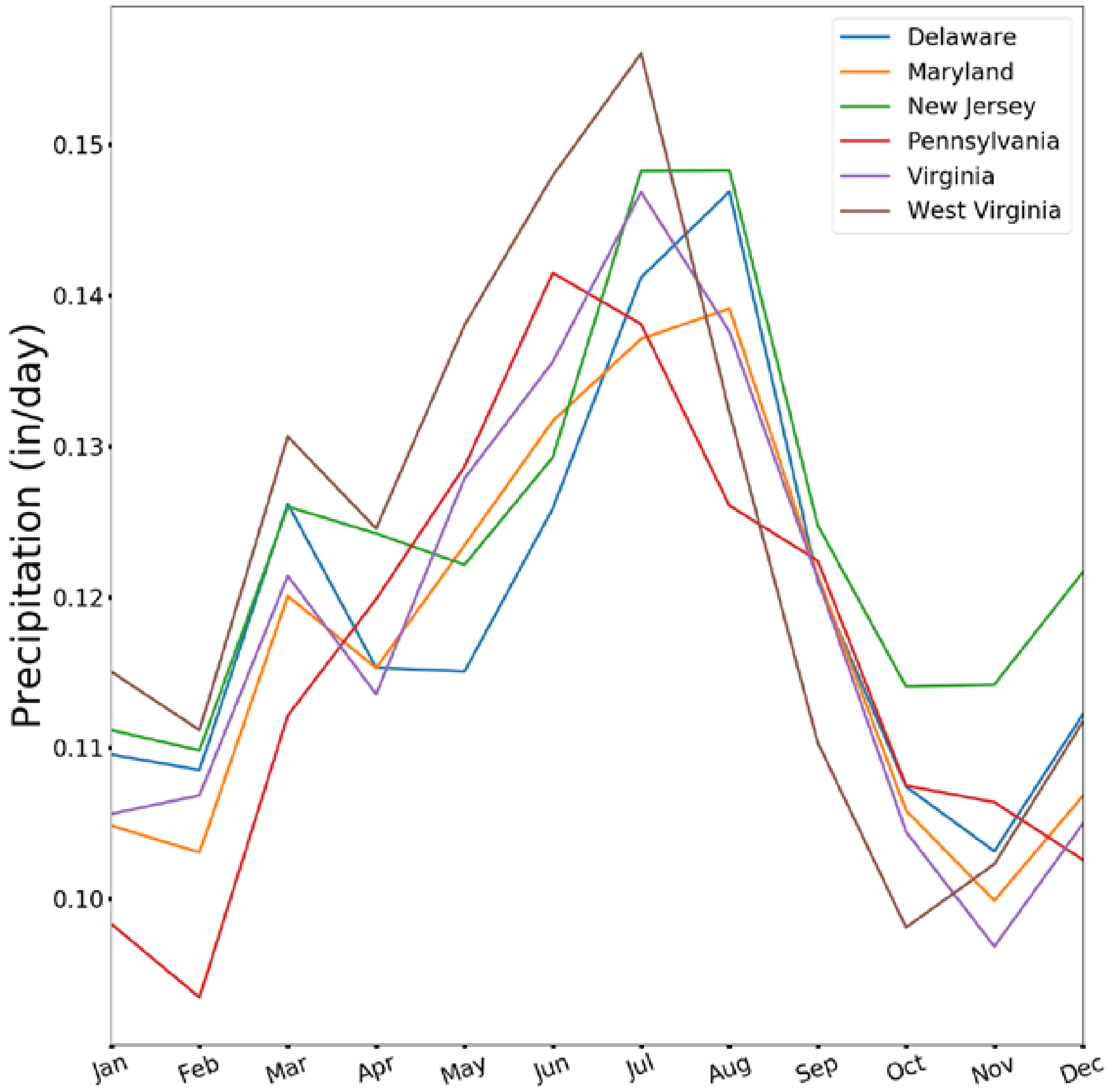
. Warming trend (YES)
. Polar amplification (YES in Arctic, NO in Antarctic)
. Winter amplification (YES)
. Diurnal asymmetry (?)
. Increasing of precipitation (Seasonal)
. Summer desiccation (?)

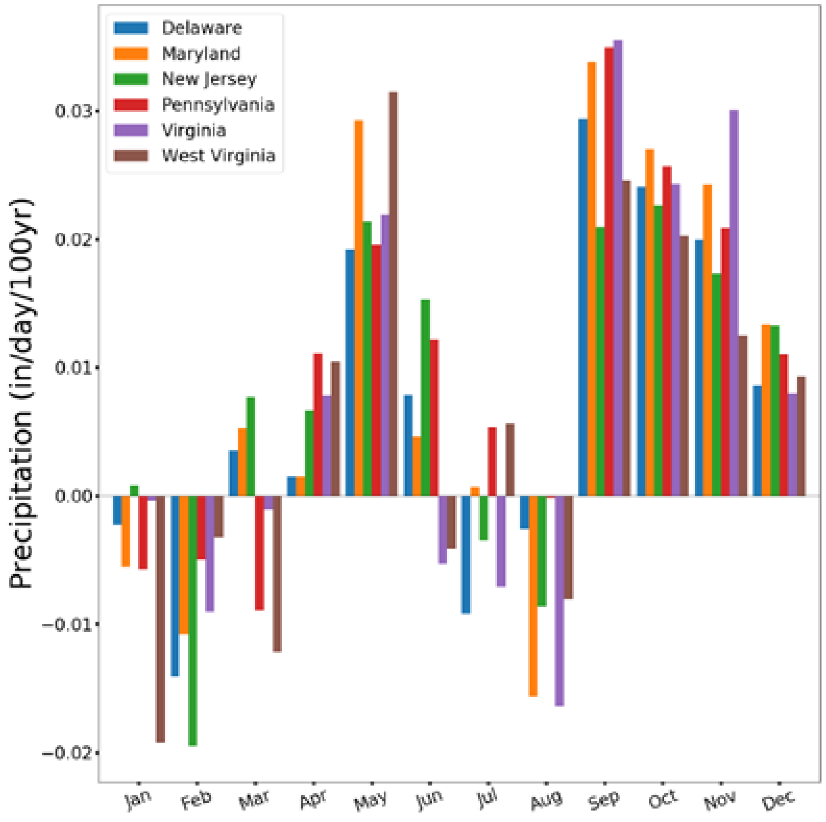
Observed Seasonal Variation of Mean Air Temperature and Trend 1895-2019



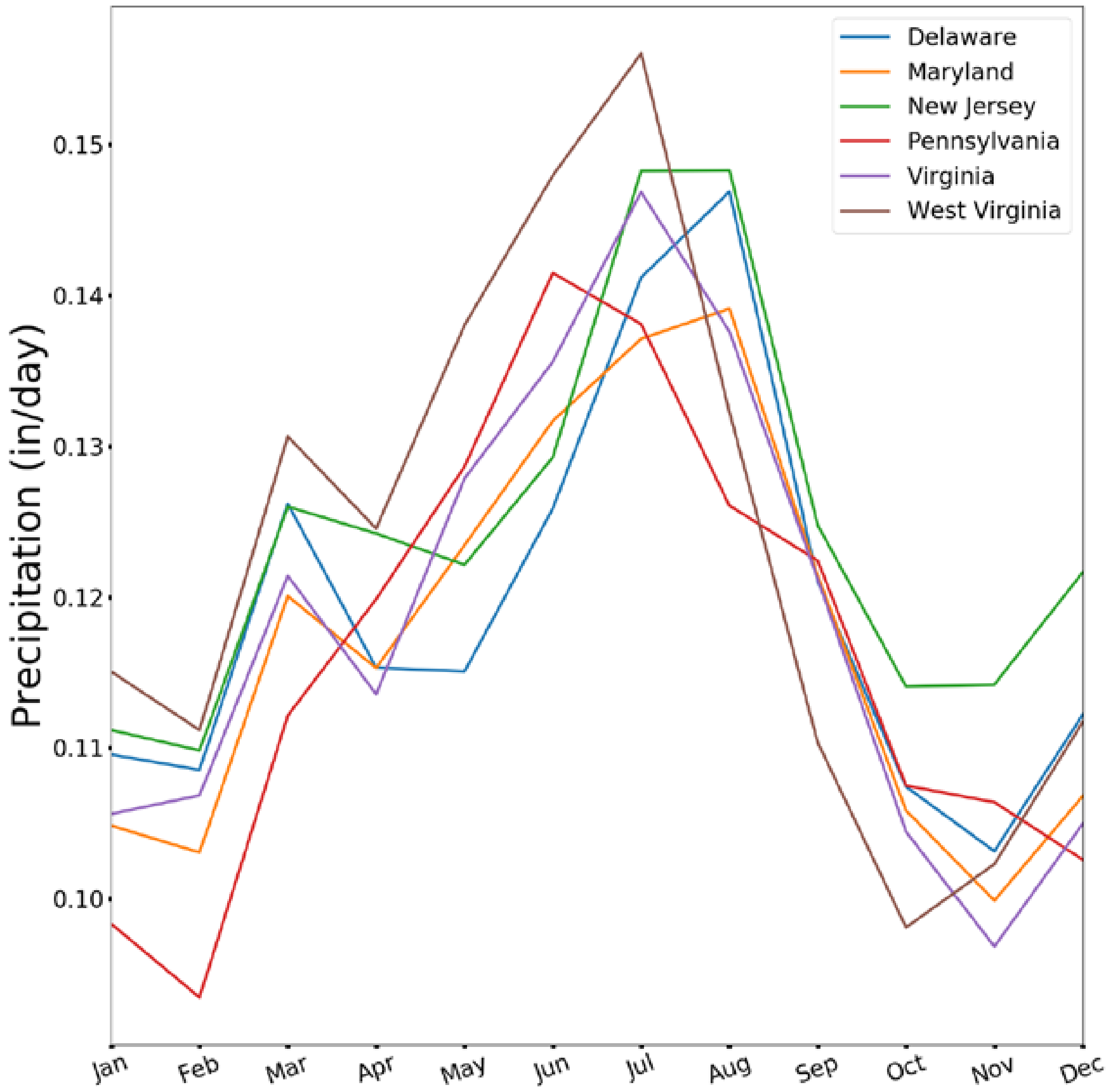


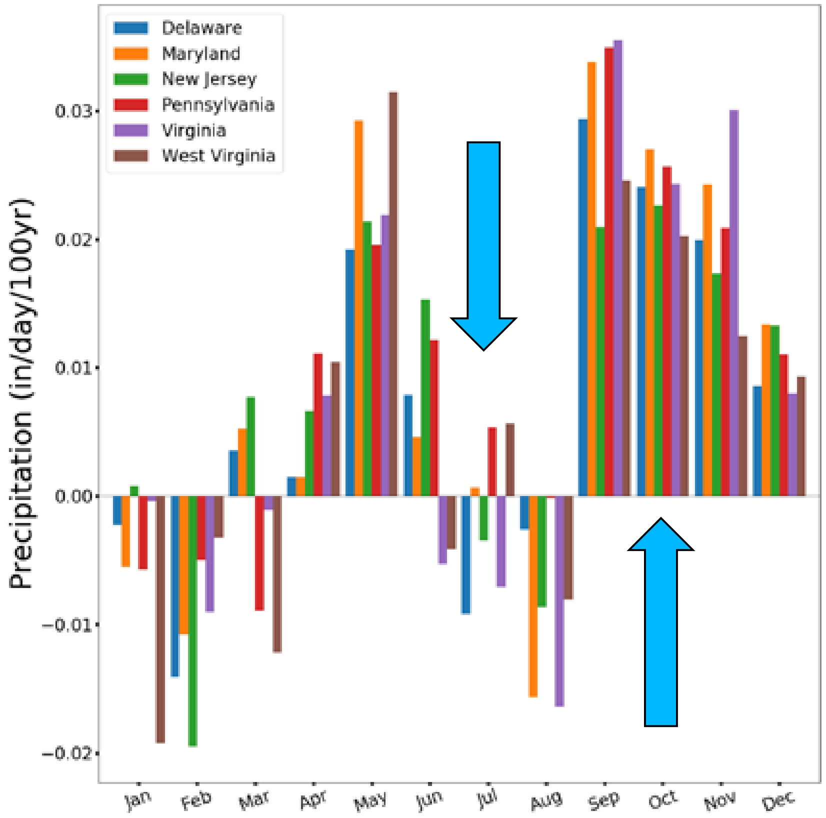
Observed Seasonal Variation of Precipitation and Trend 1895-2019



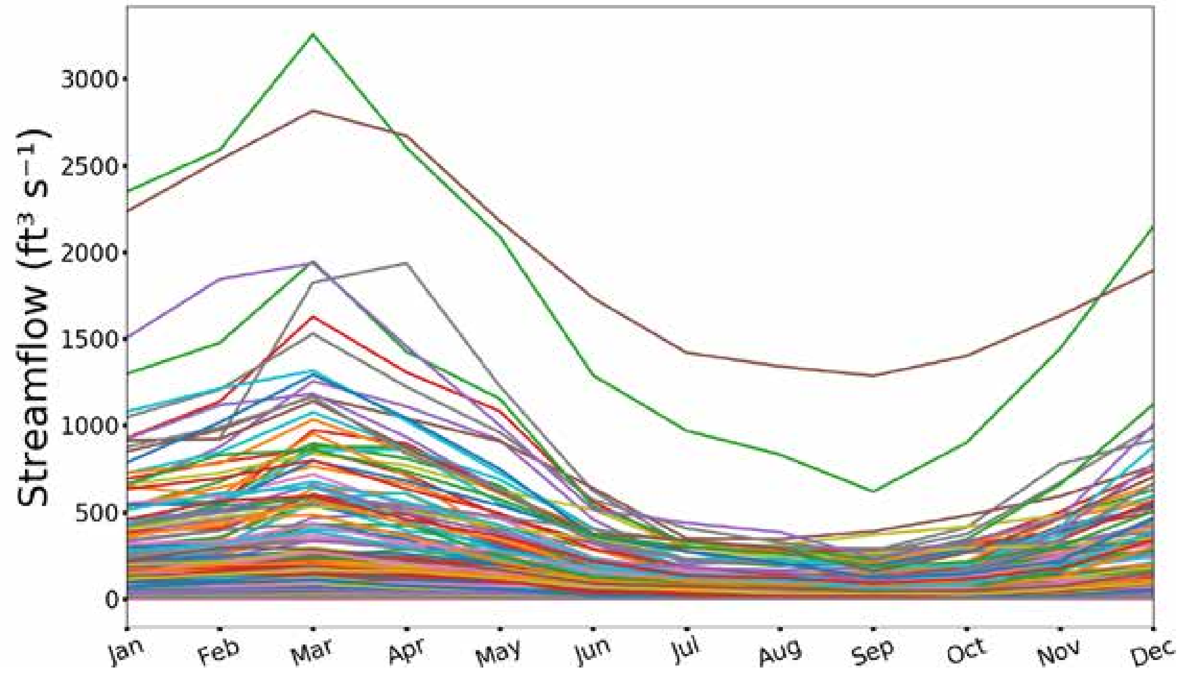


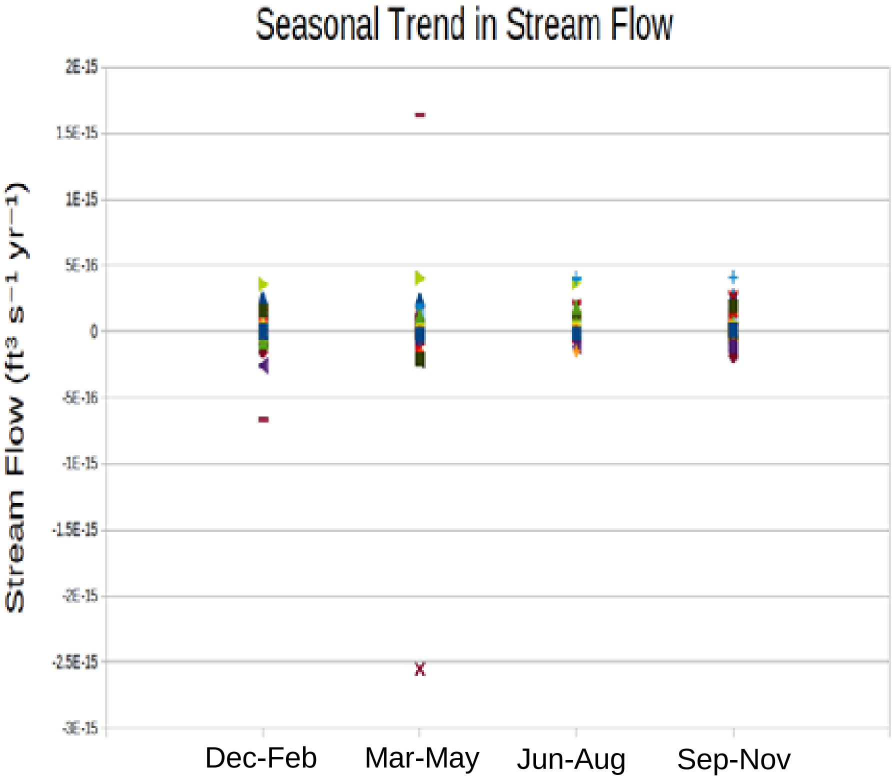
Observed Seasonal Variation of Precipitation and Trend 1895-2019



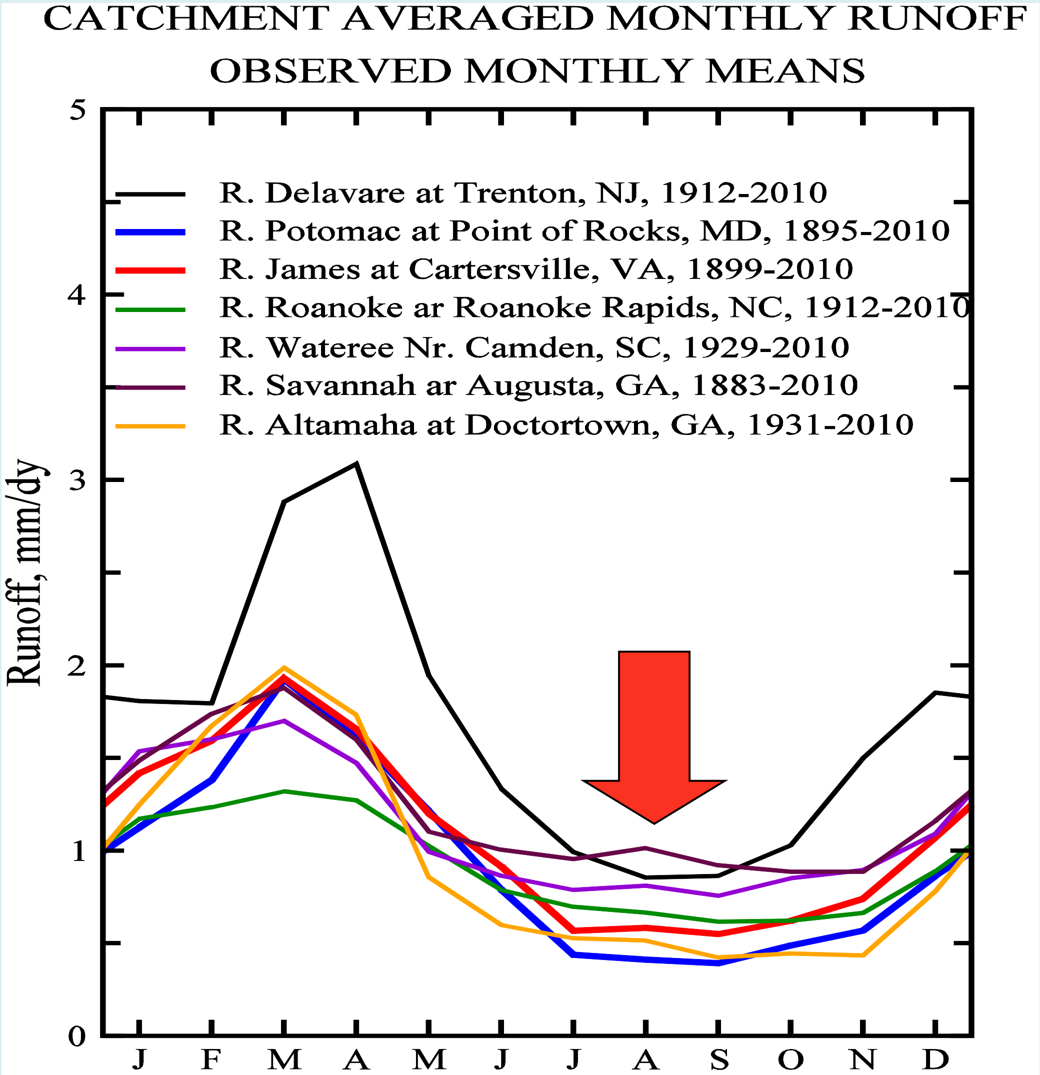


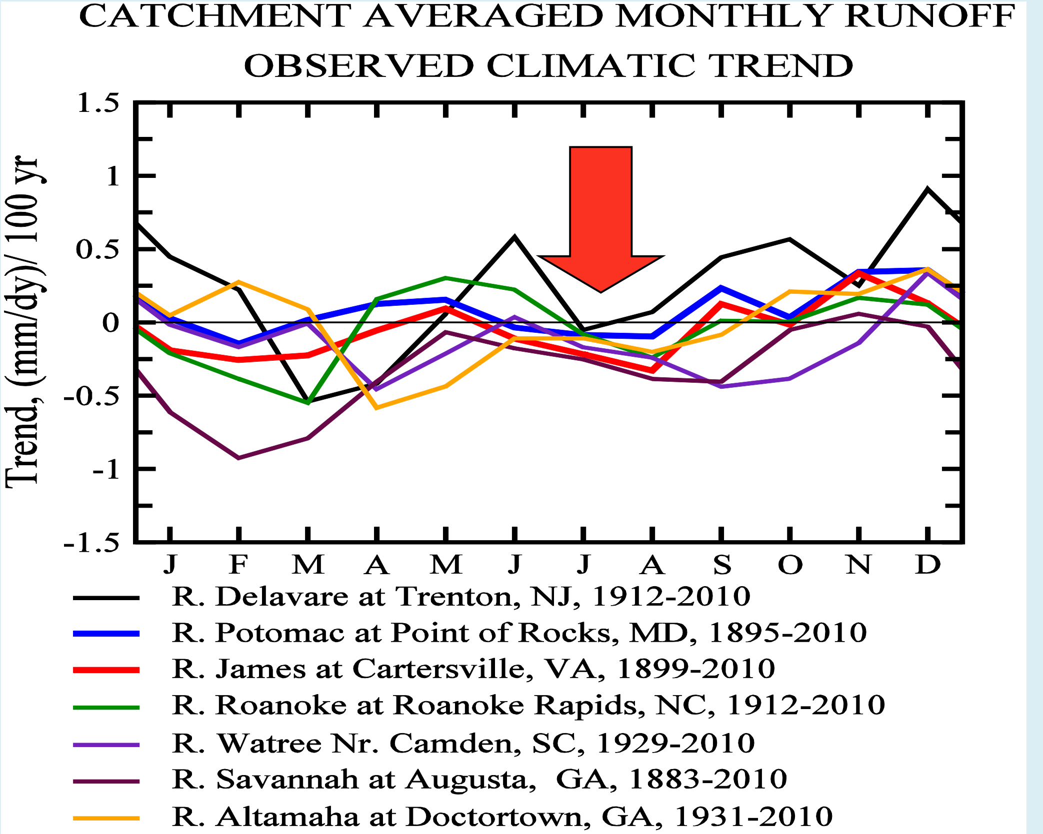
Observed Seasonal Variation of Stream Flow and Trend 1895-2019

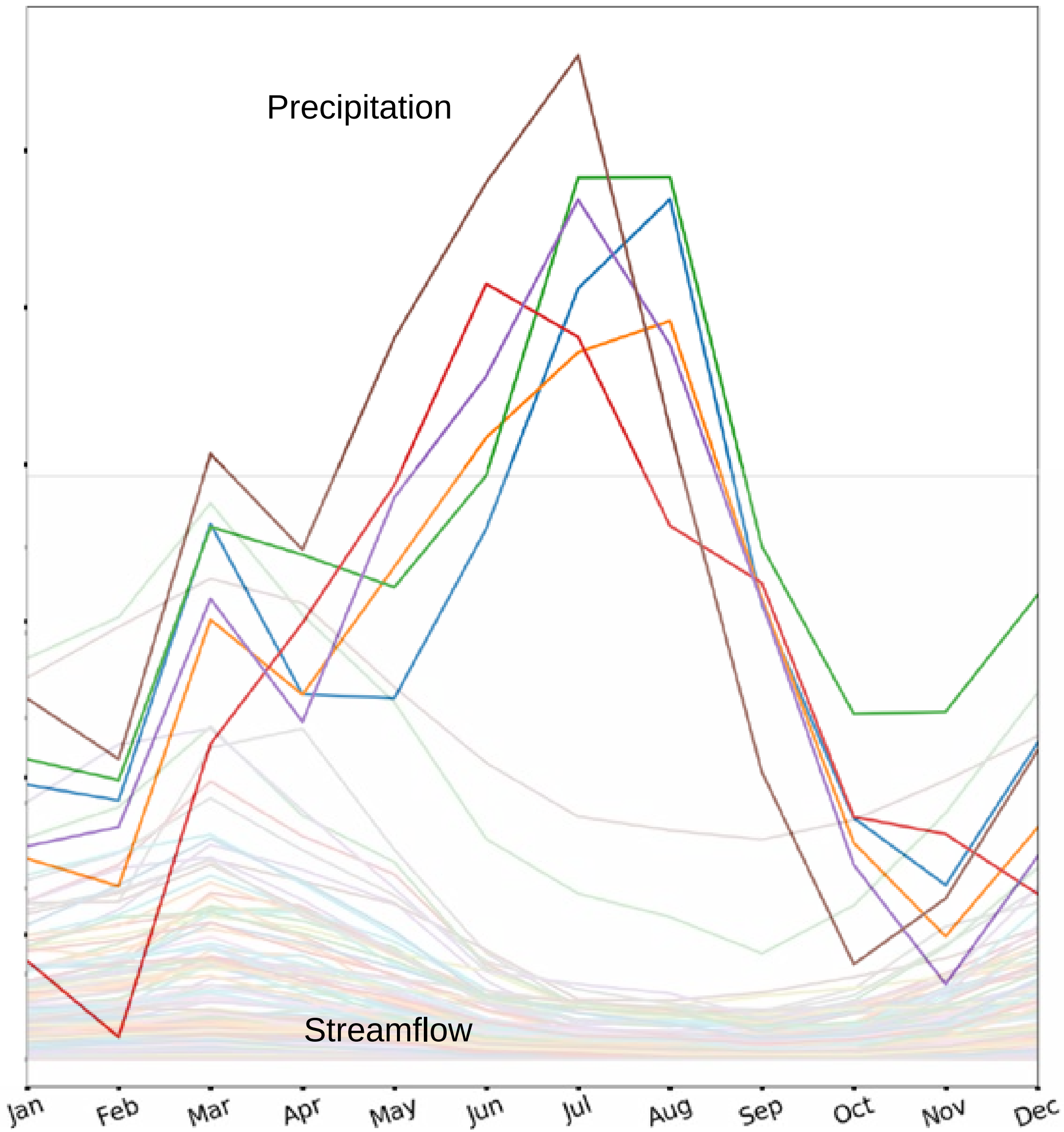




East Coast Rivers: Observed Seasonal Variations of Runoff and Trend

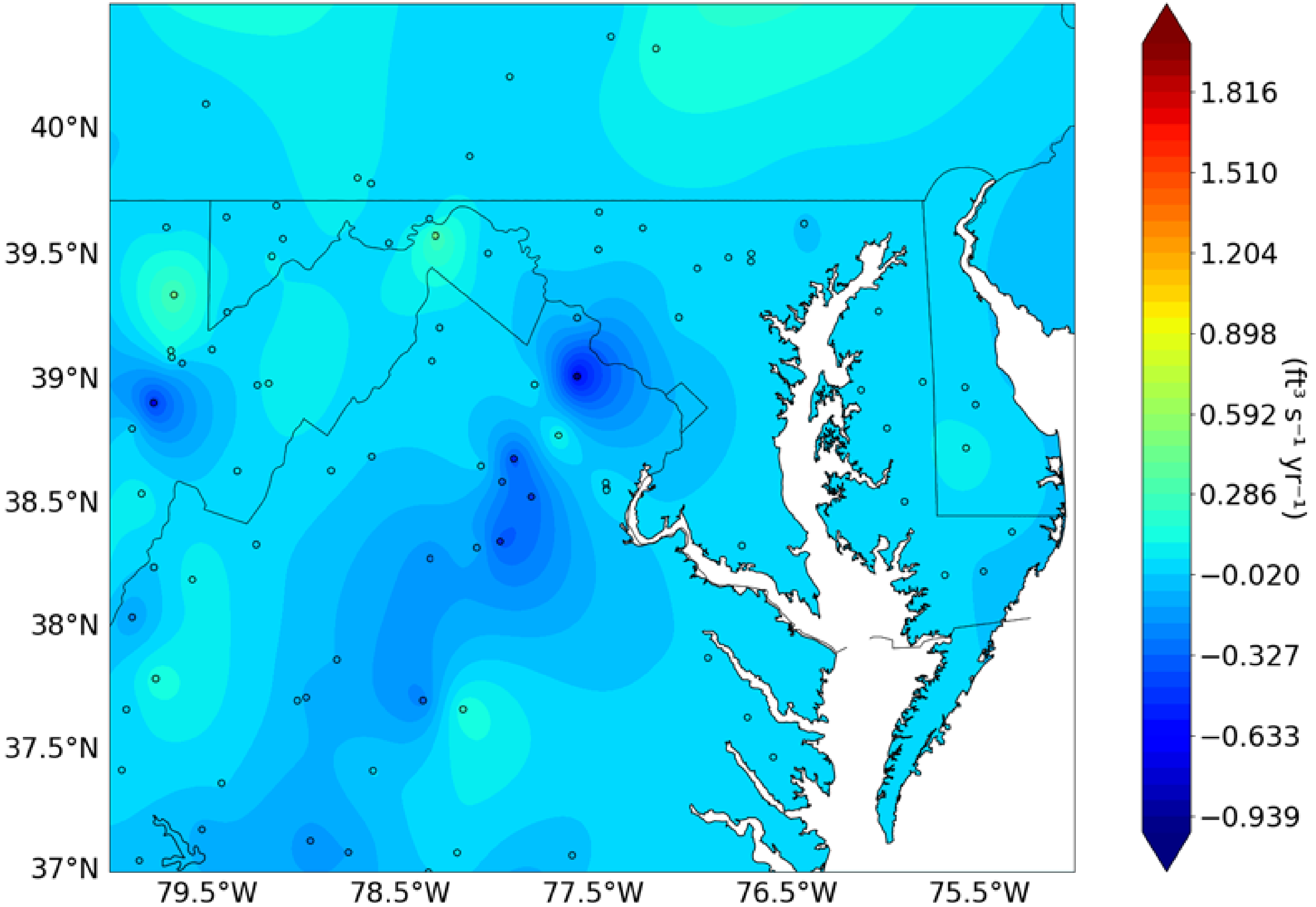






- Maximum precipitation in summer
- Minimum streamflow in Summer
- Summers getting drier with spring and fall getting wetter
- No observable trends in monthly streamflow

Annual Seven-Day Low Stream Flow Trends
Stations with >= 30 Years observations

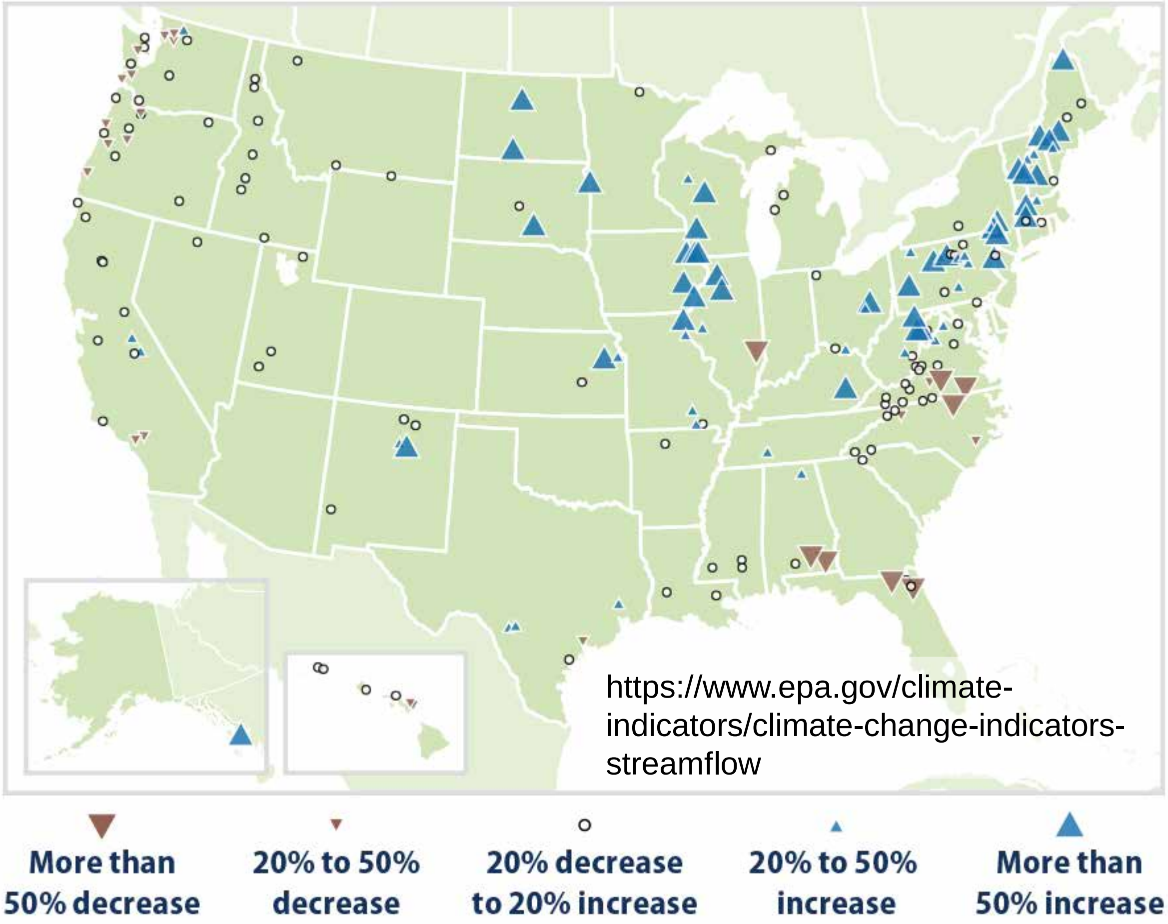


Increase in groundwater

- from greater recharge
- More extreme flows from higher intensity storms

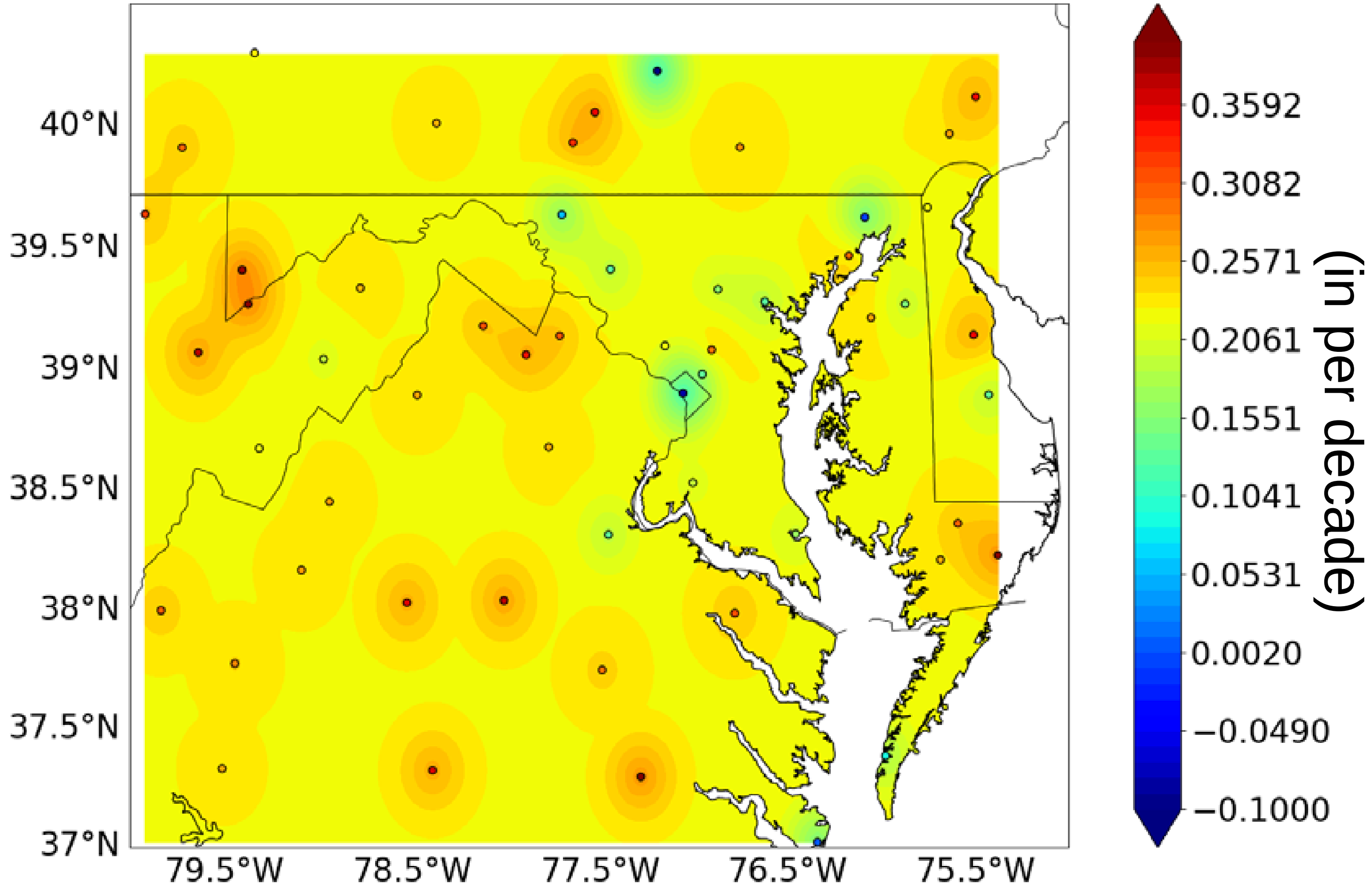
- Decrease rain on snow events in spring

Seven-Day Low Streamflows 1940–2014

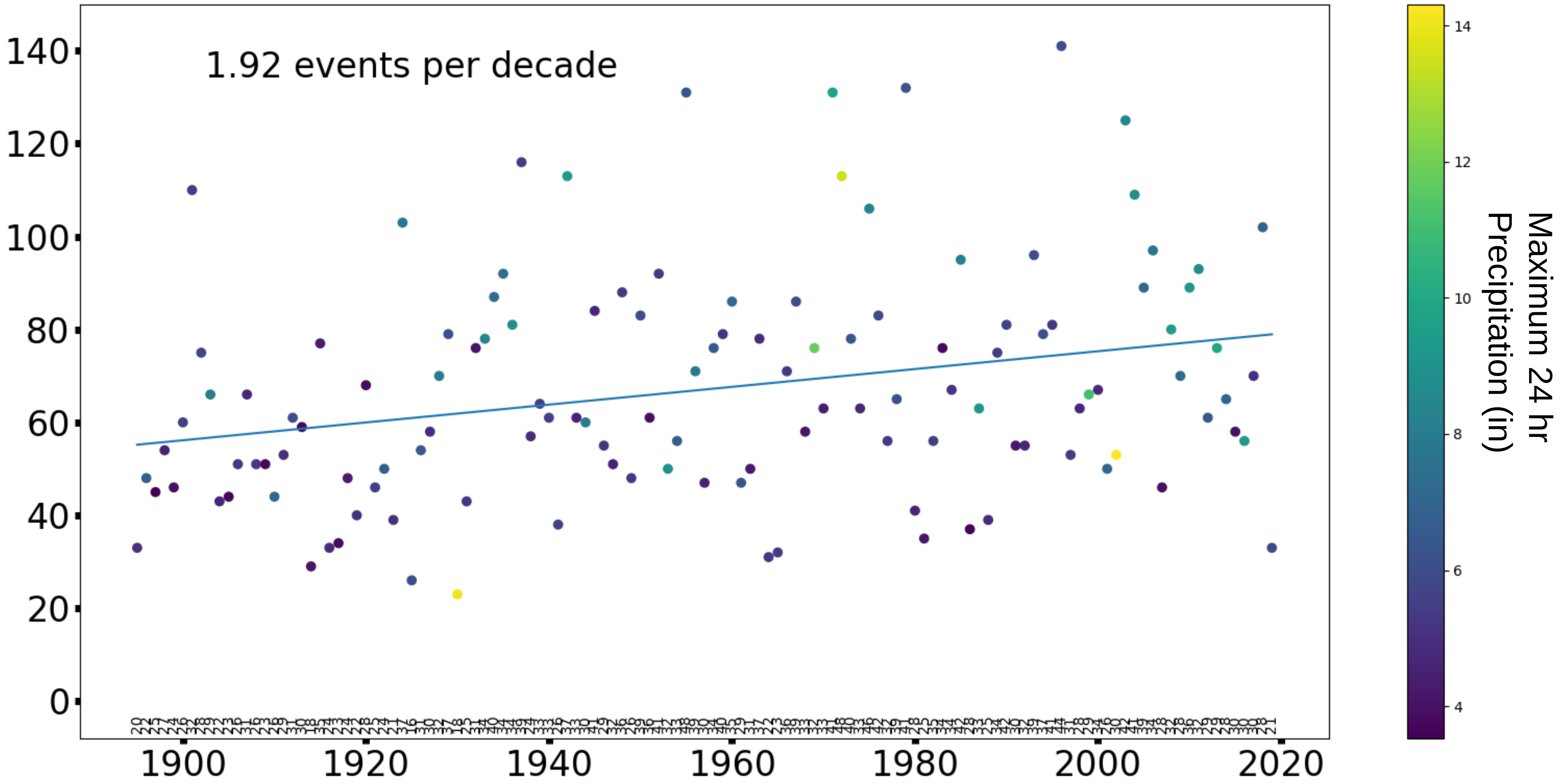


https://www.epa.gov/climate-indicators/climate-change-indicators-streamflow

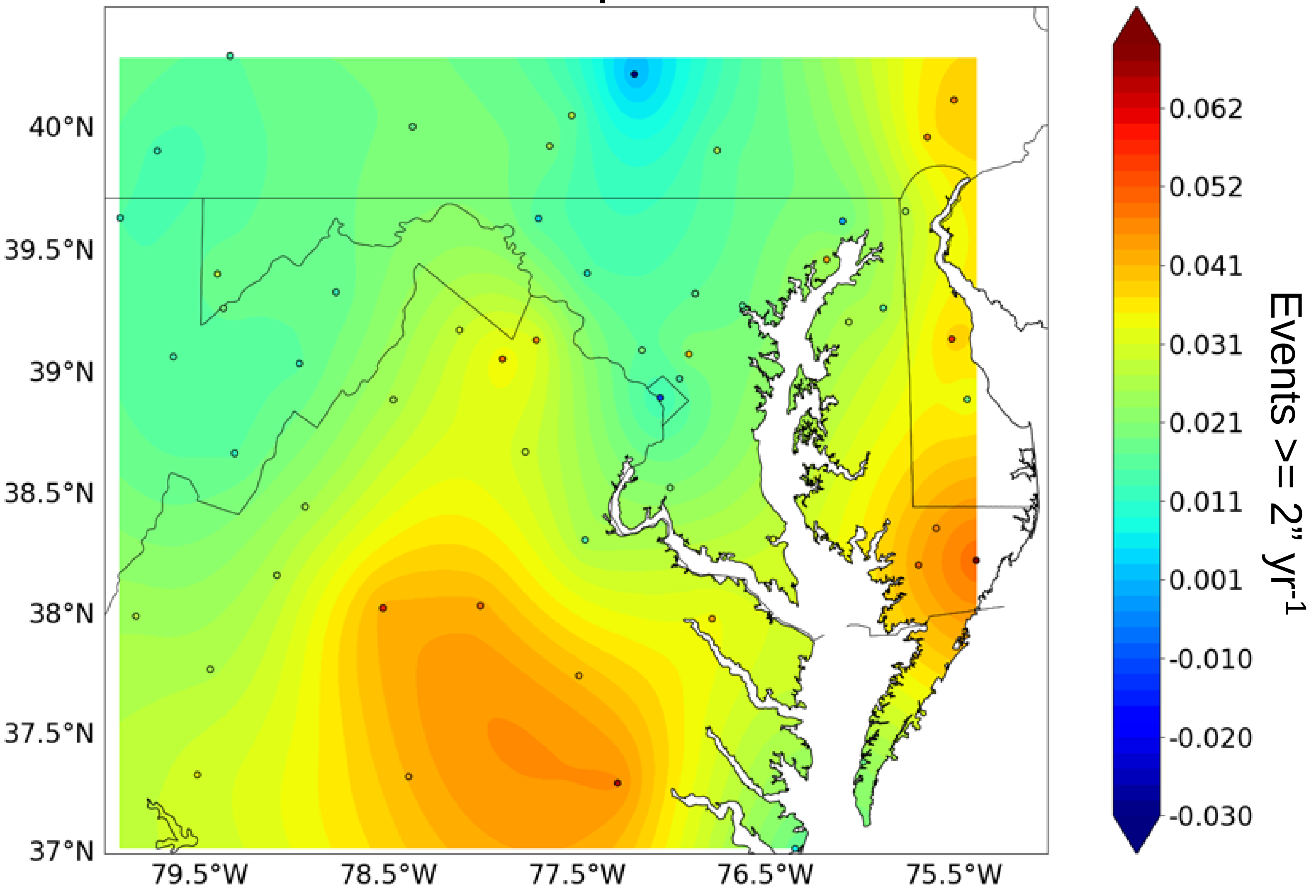
Annual Precipitation Trends

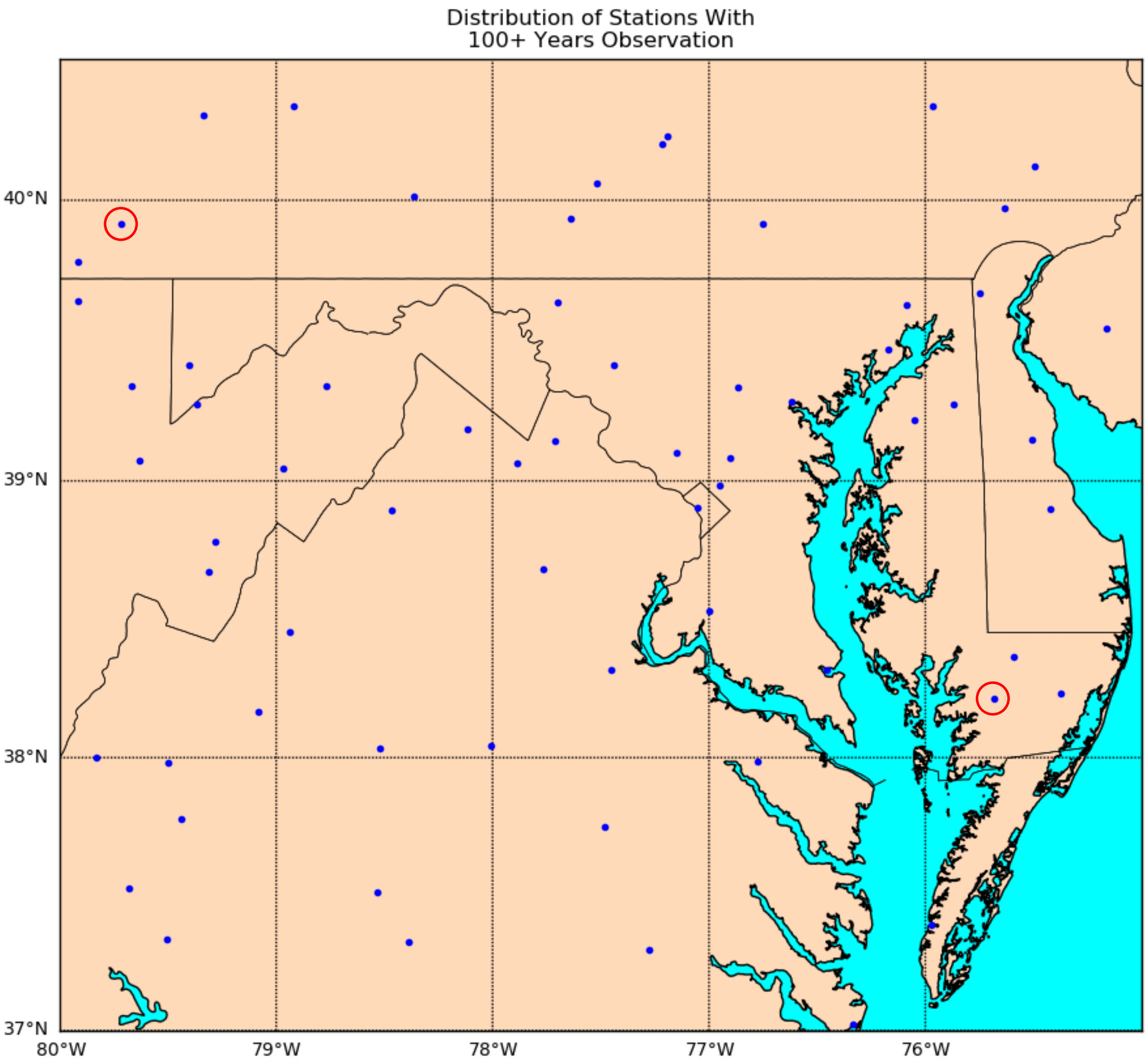


Trend in Precipitation Events >= 2”



Trends in Precipitation Events >= 2”

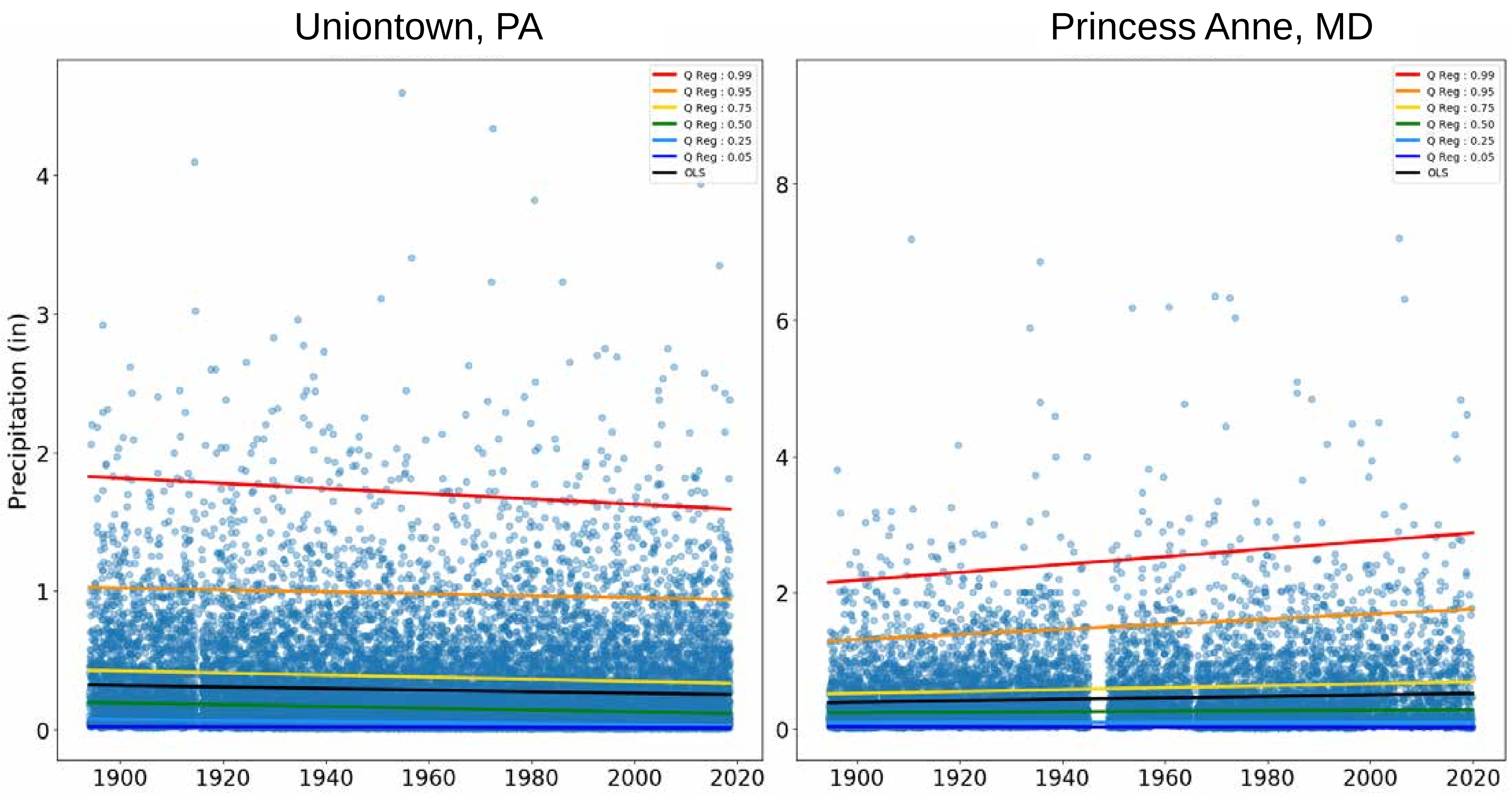




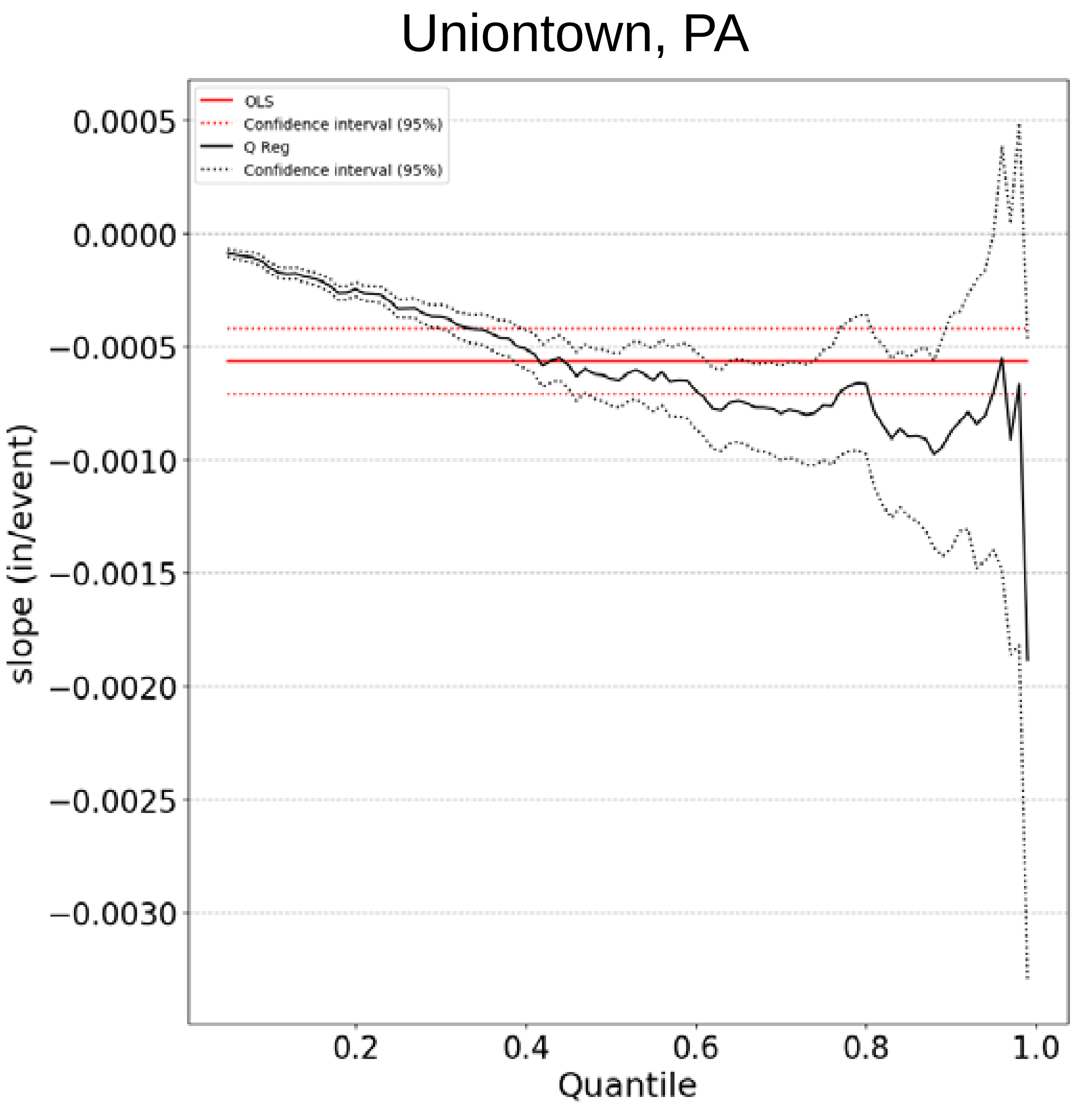
Quantile Regression

Makes no assumptions about the distribution of the residuals.

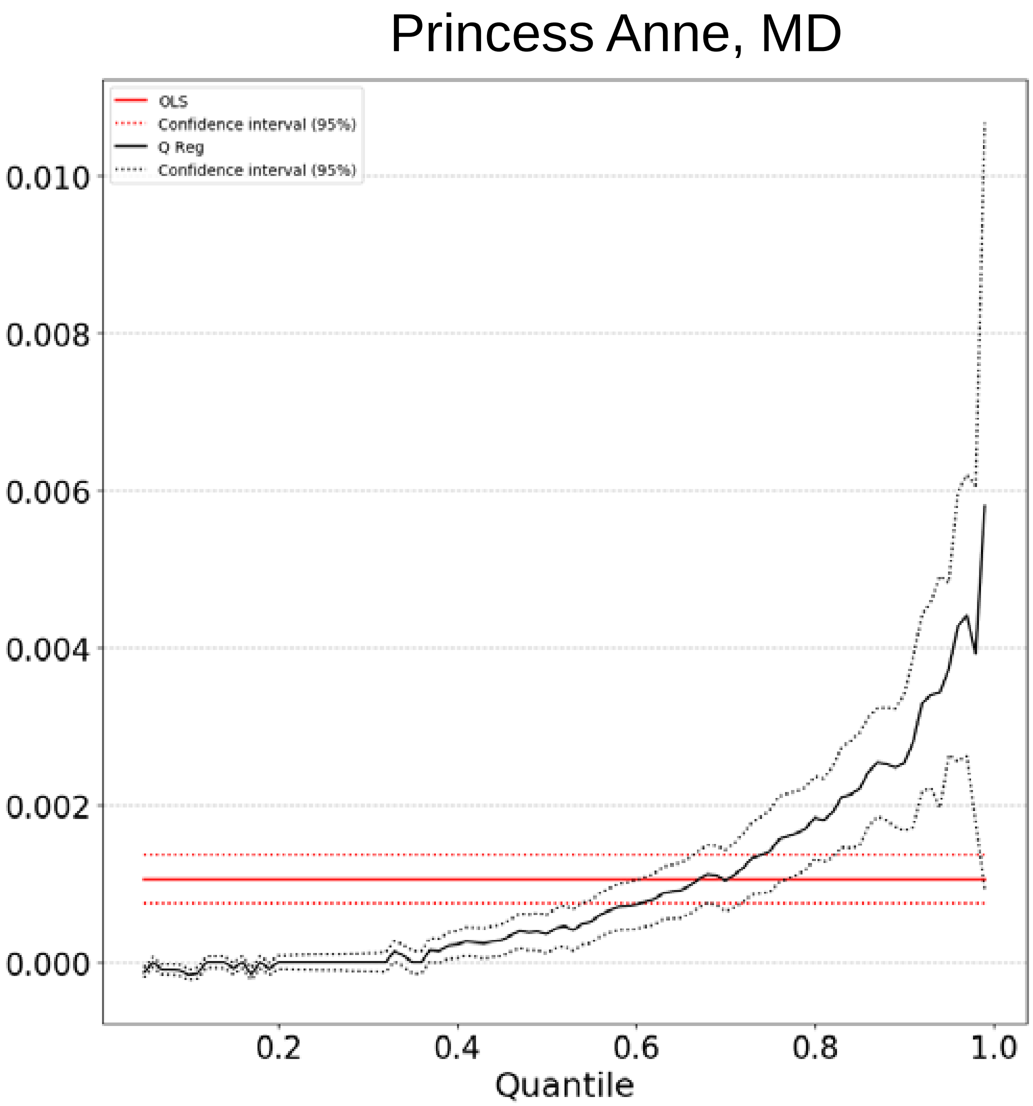
Is more robust to outliers.



Uniontown, PA
Princess Anne, MD
Precipitation (in)
Q Reg : 0.99
Q Reg : 0.95
Q Reg : 0.75
Q Reg : 0.50
Q Reg : 0.25
Q Reg : 0.05
OLS
0
1
2
3
4
6
8
1900
1920
1940
1960
1980
2000
2020



Uniontown, PA
OLS
Confidence interval (95%)
Q Reg
Confidence interval (95%)
0.0005
0.0000
−0.0005
−0.0010
−0.0015
−0.0020
−0.0025
−0.0030
slope (in/event)
0.2
0.4
0.6
0.8
1.0
Quantile



Princess Anne, MD
OLS
Confidence interval (95%)
Q Reg
Confidence interval (95%)
0.010
0.008
0.006
0.004
0.002
0.000
0.2
0.4
0.6
0.8
1.0
Quantile

CONCLUSIONS:

- Mid-Atlantic Coast states enjoy beautiful climate with seasonal maximum of precipitation in the summer and minimum in the fall.
- Global warming 1895-2010 has been accompanied by a decrease in Summer - and increase in fall and winter precipitation.
- In addition to an overall increase in precipitation, heavy precipitation events are increasing as well.
- Quantile regression trend analysis can provide far more detailed information with respect to specific quantities in question.
    - This may be particularly useful for water managers who are more concerned with extreme values rather than the averaged one
- Quantile regression analysis can help build a comprehensive picture of climatic variables in terms of their variation over time at different magnitude/frequency

Thank You!

www.atmos.umd.edu/~climate

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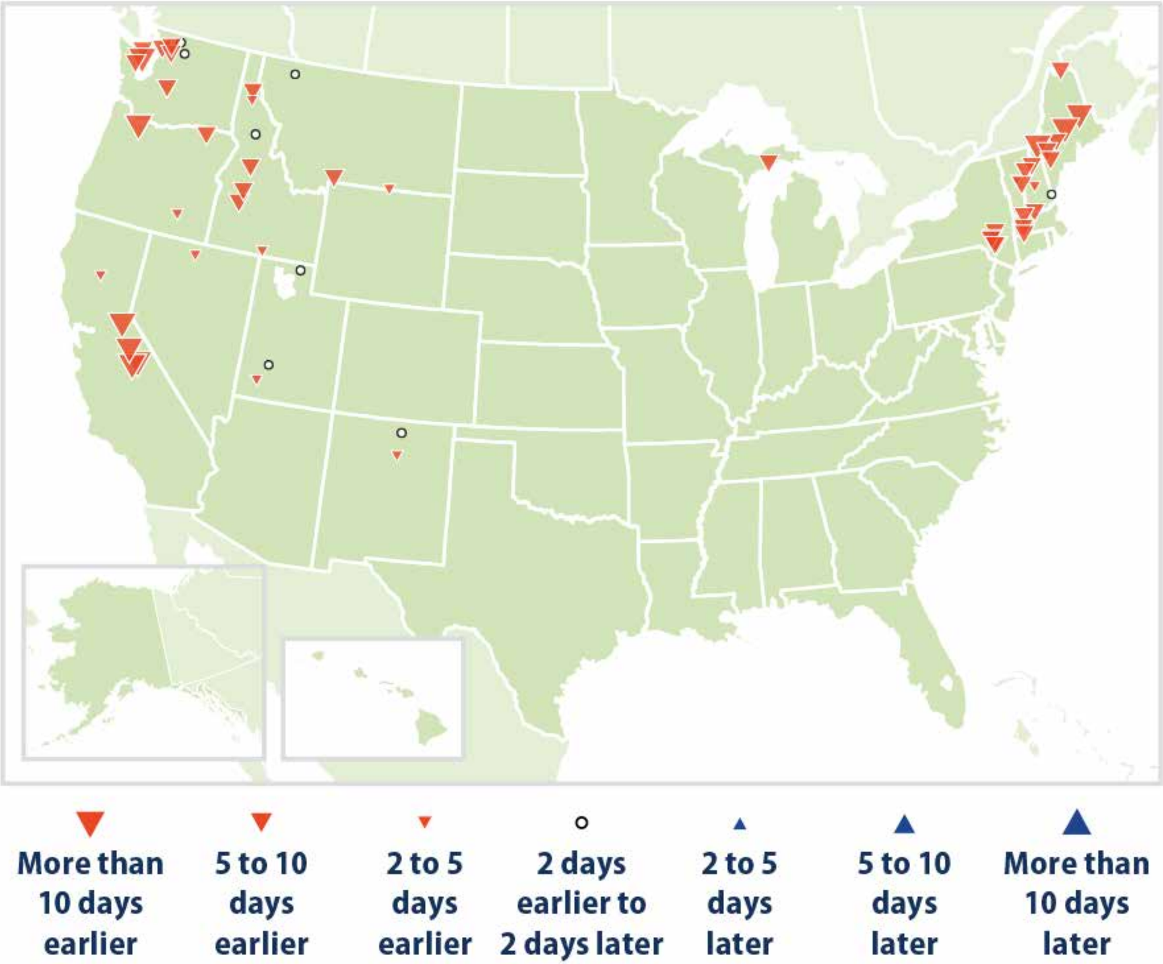
Timing of Winter-Spring Runoff 1940–2014

Trends are based on the winter-spring center of volume has passed by each streamflow gauge, reflecting the timing of spring snow melt

The date half of the total January 1 – July 31 streamflow passes.



The date half of the total January 1–May 31 streamflow passes.