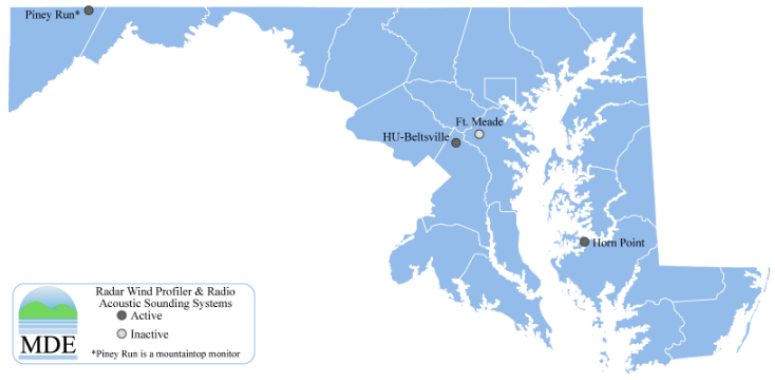
Climate Resiliency Workgroup Conference Call

MARYLAND'S CLIMATE: VARIABILITY AND CHANGE

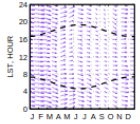
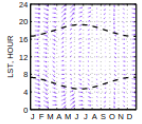
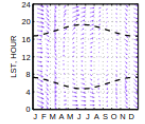
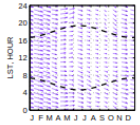
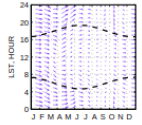
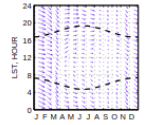
Phillip Stratton, Assistant State Climatologist for Maryland

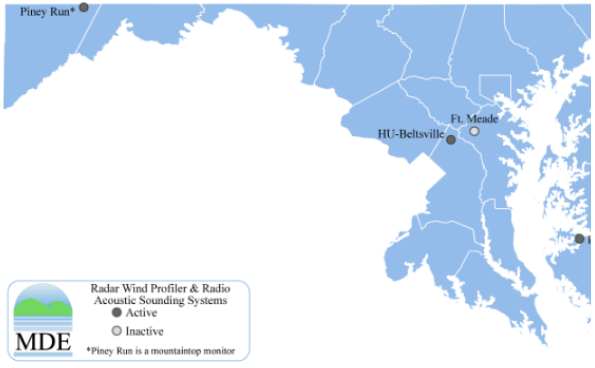
University of Maryland at College Park, MD

Chesapeake Bay Program, Annapolis, Maryland, February 18, 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			



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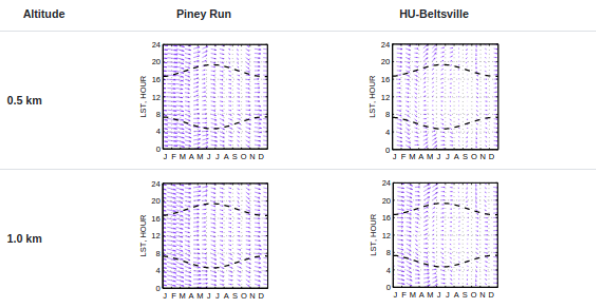
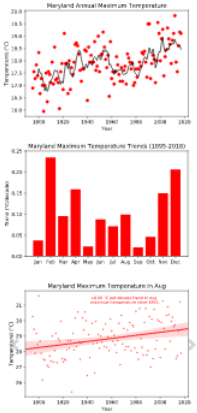
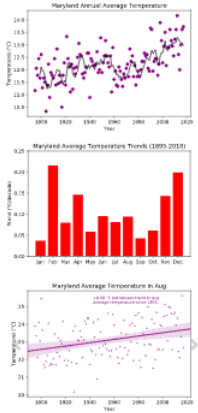


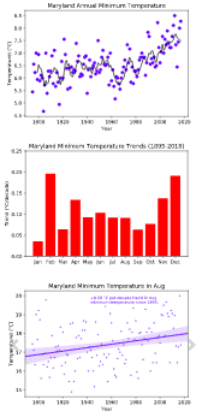
Maximum Temperature



Average Temperature

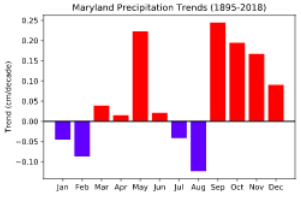


Minimum Temperature

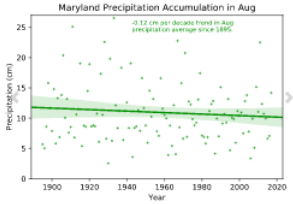


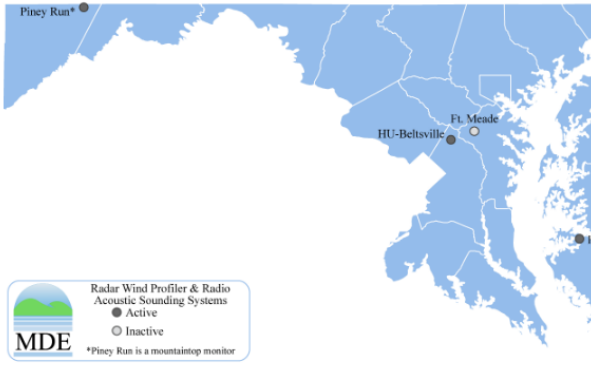
Maryland precipitation was slightly below the 1895 to 2018 average between 1895 and 1970, with post 1970 becoming slightly wetter than the average with an overall increase in precipitation. However, there are considerable year to year and decade to decade variations. The trend of increasing precipitation is not uniformly distributed over the course of a year as show below.

Precipitation



Monthly Time Series





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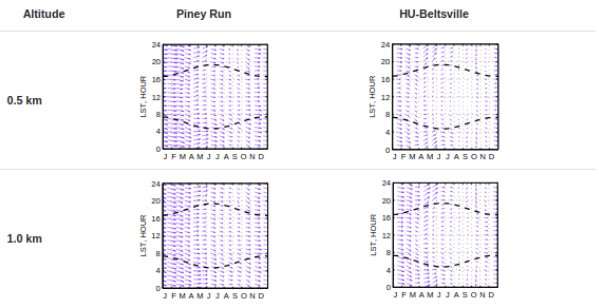
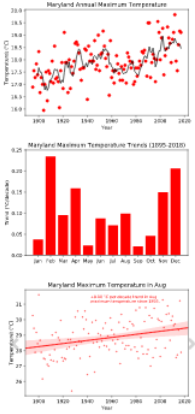
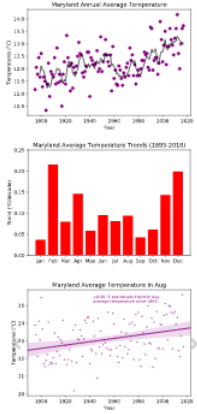


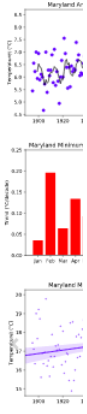
Maximum Temperature



Average Temperature



Minimum



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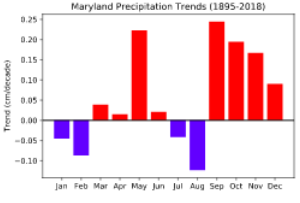
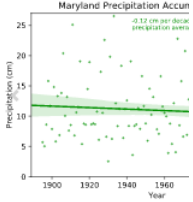
Precipitation



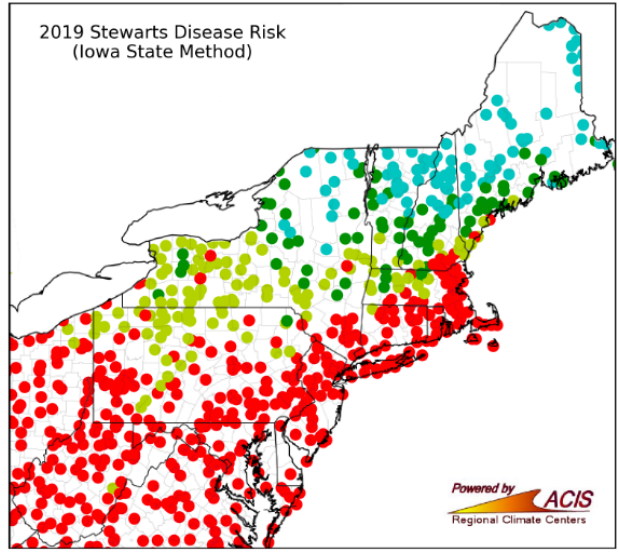
Monthly Time S



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



Cyan=Negligible; Green=Low to moderate; Yellow=Moderate to high; Red=High Risk

MARYLAND

WEATHER SERVICE

VOLUME ONE

BALTIMORE
THE JOHNS HOPKINS PRESS
1899

MARYLAND

WEATHER SERVICE

VOLUME TWO

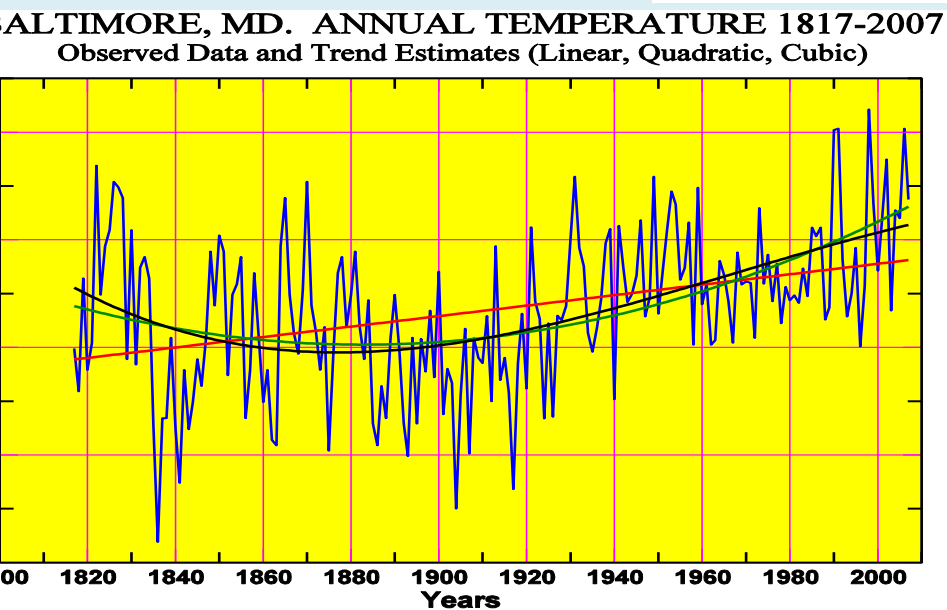
BALTIMORE
THE JOHNS HOPKINS PRESS
1907

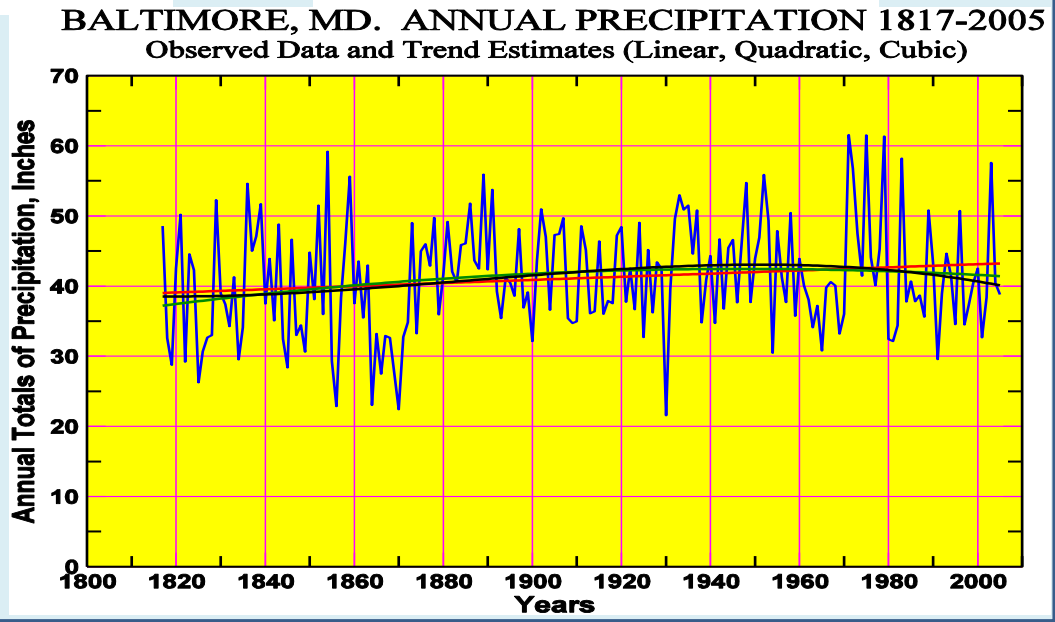
MARYLAND

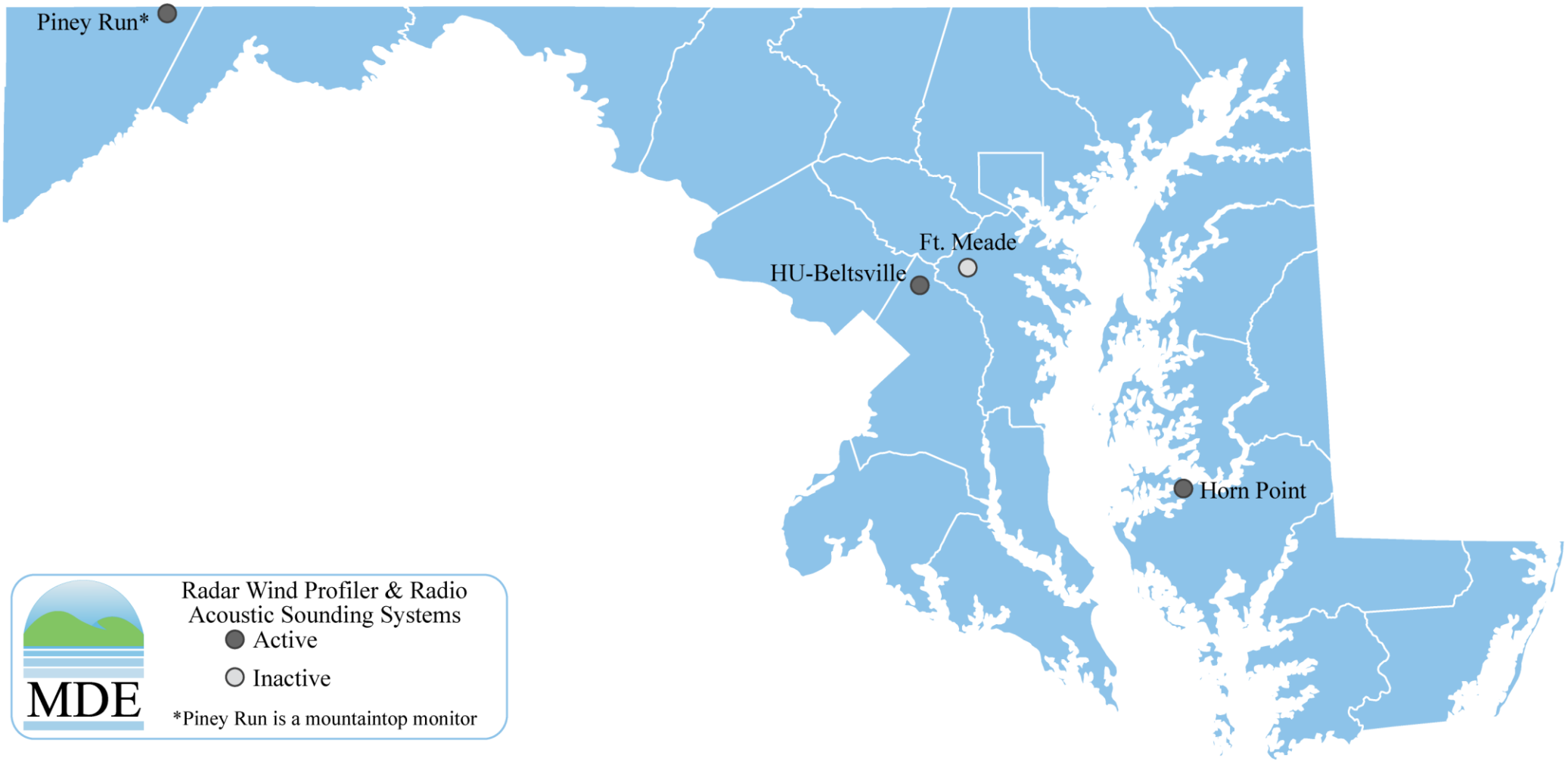
WEATHER SERVICE

VOLUME THREE

BALTIMORE
The Johns Hopkins Press
1910.

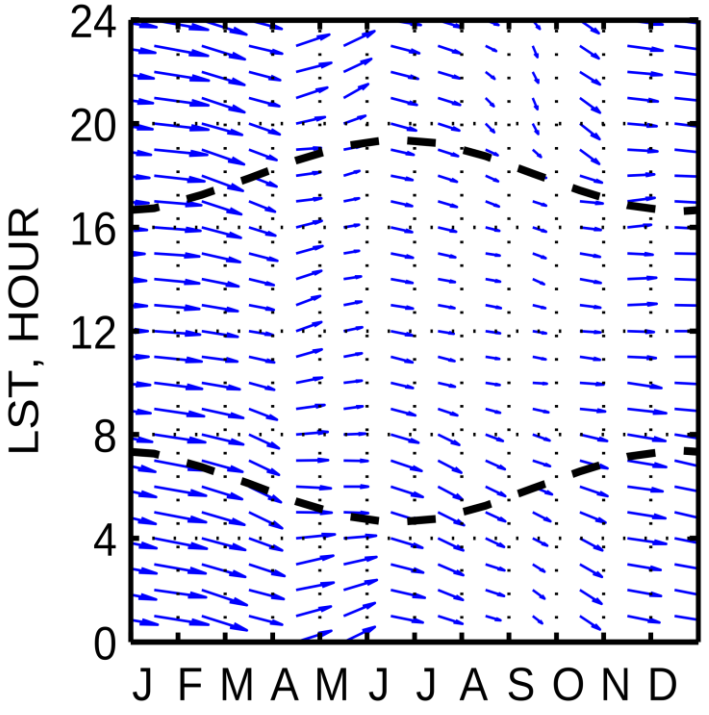




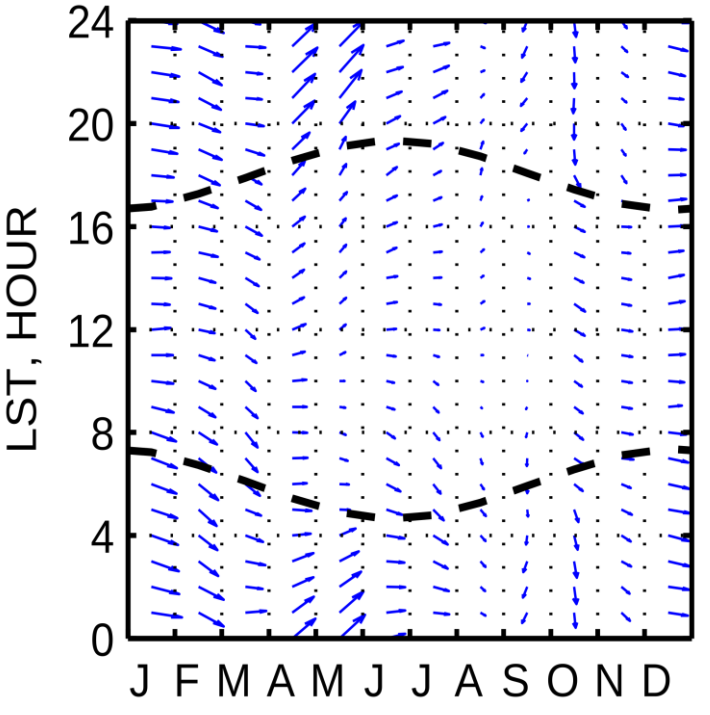

Piney Run*
Ft. Meade
HU-Beltsville
Horn Point
MDE
Radar Wind Profiler & Radio Acoustic Sounding Systems
Active
Inactive
*Piney Run is a mountaintop monitor

0.5 km Wind Climatology

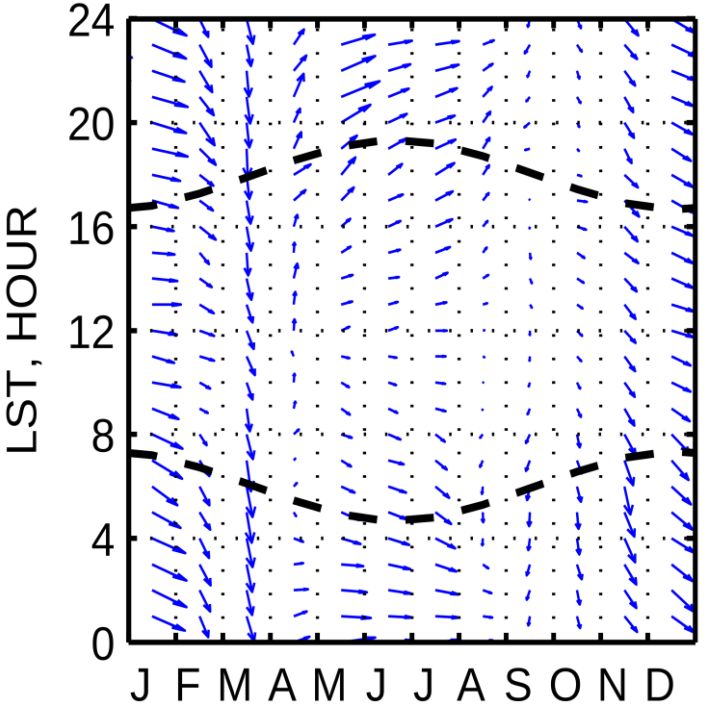
Piney Run



HU-Beltsville

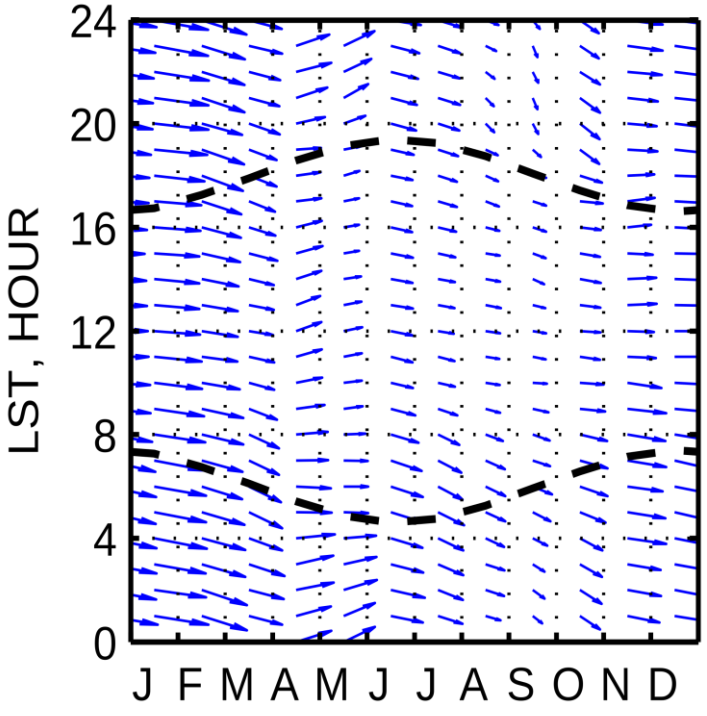


Horn Point

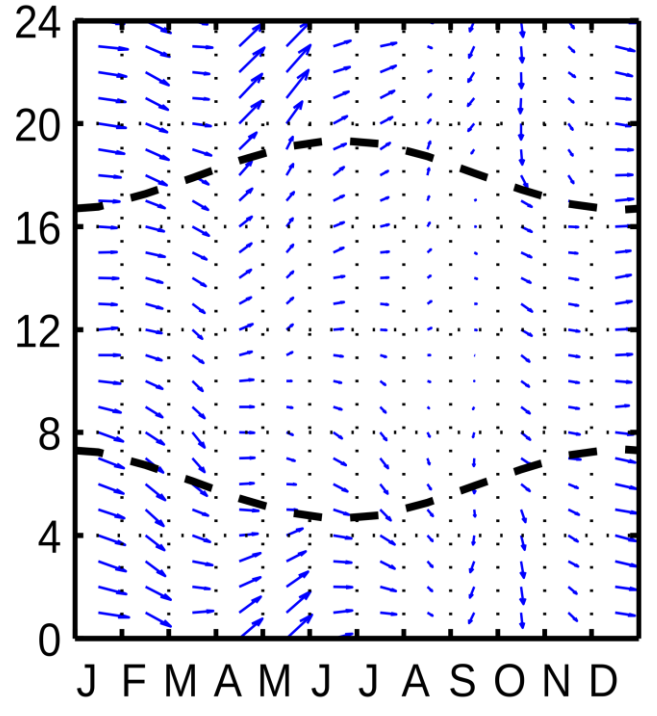


0.5 km Wind Climatology

Piney Run



HU-Beltsville



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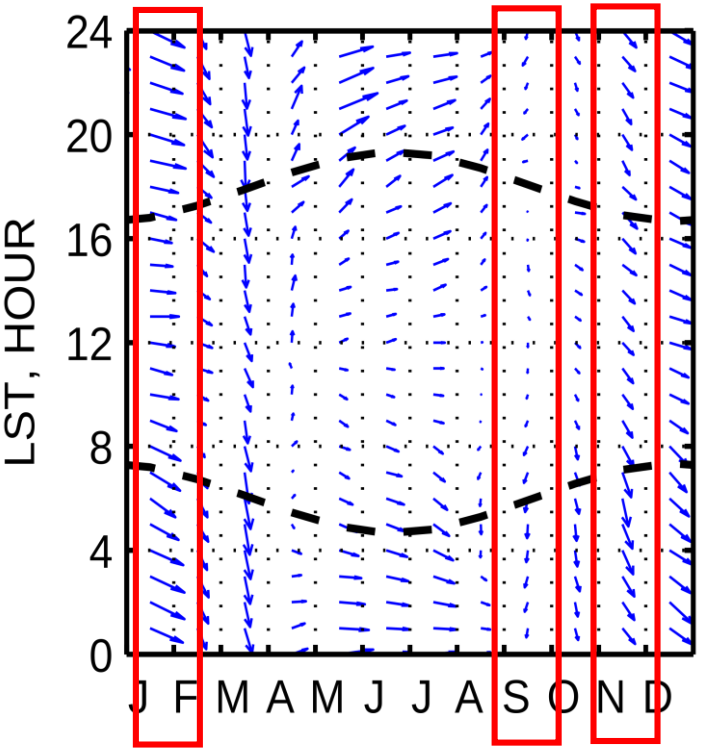
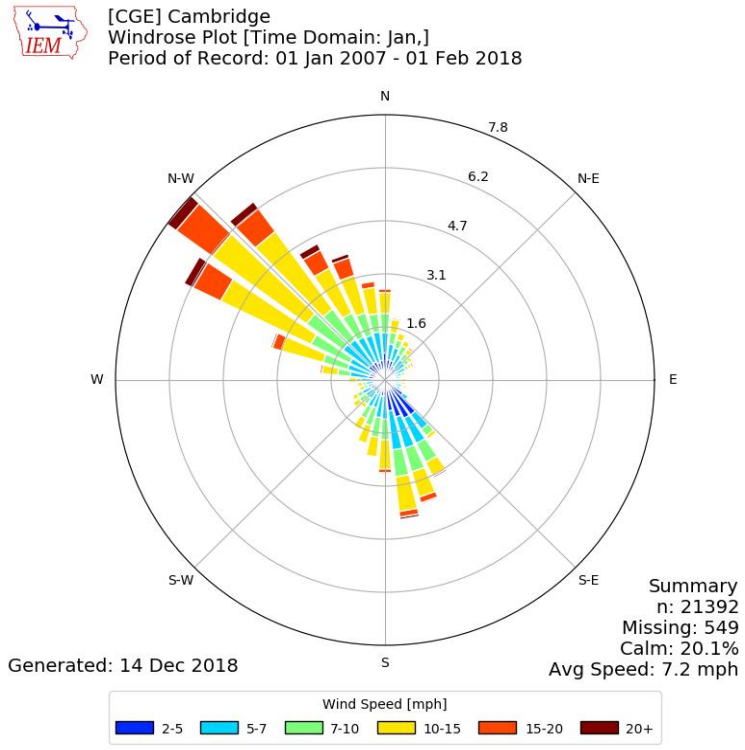
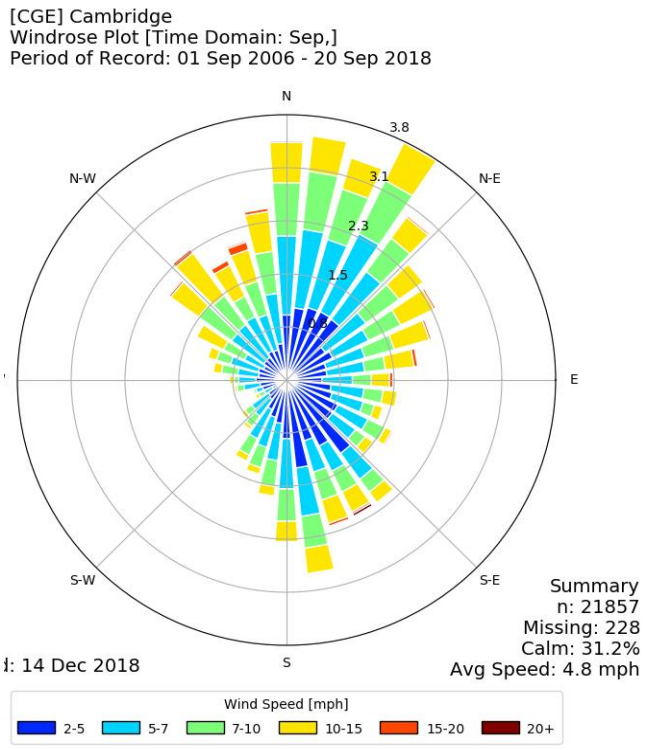
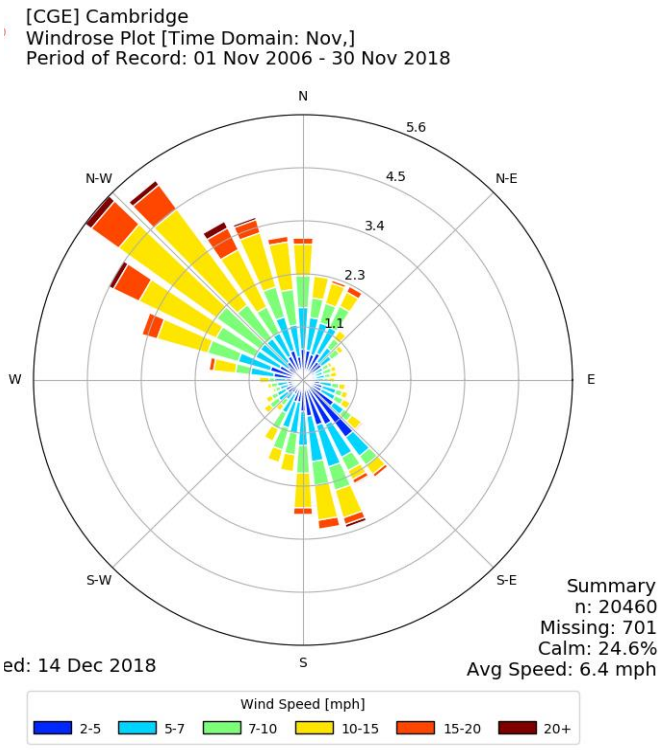


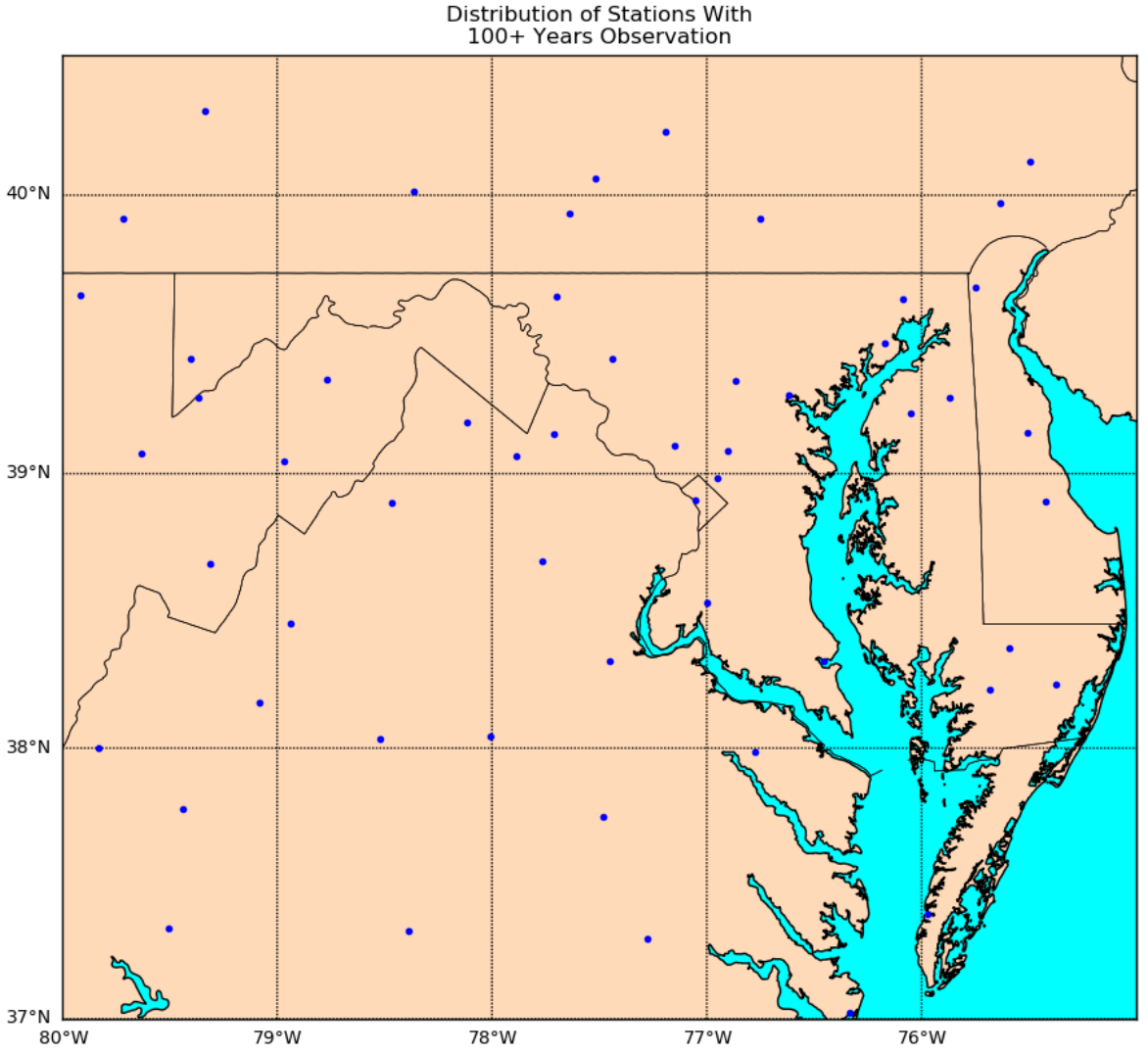
Monthly Surface Winds Near (~7mi) Horn Point



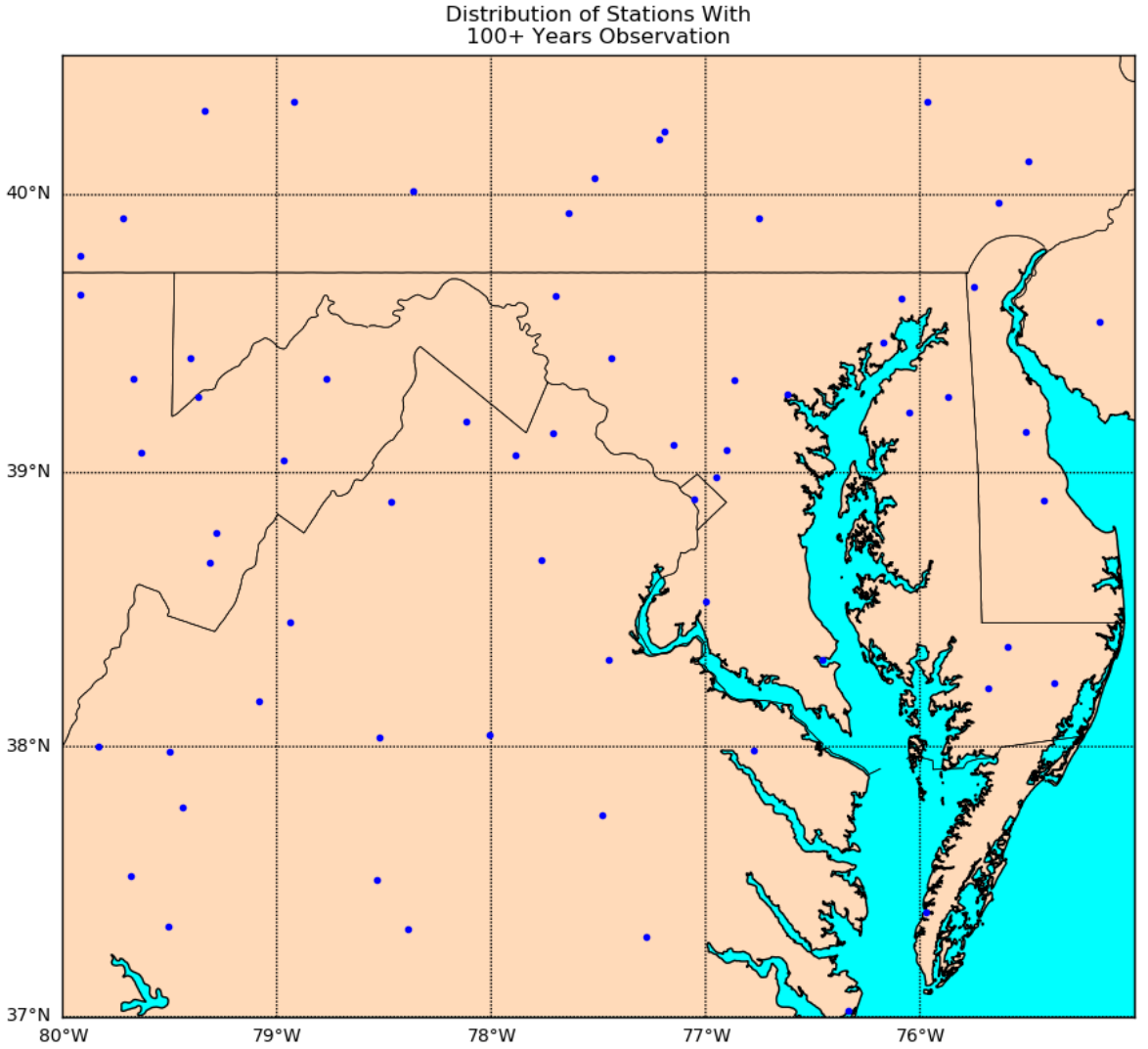




55 stations with 100+ years between first T_{max}/T_{min} observation and last.



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



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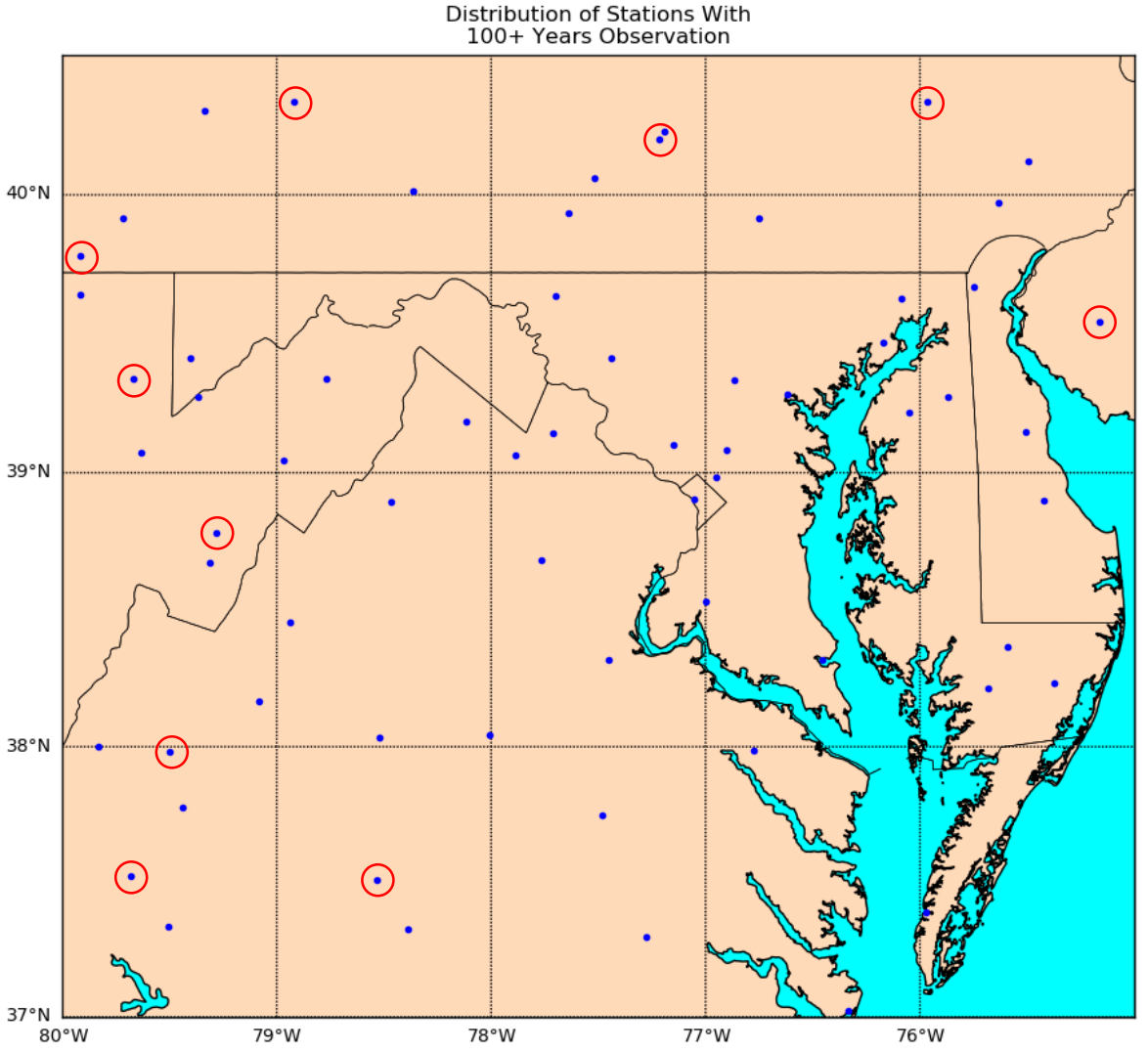
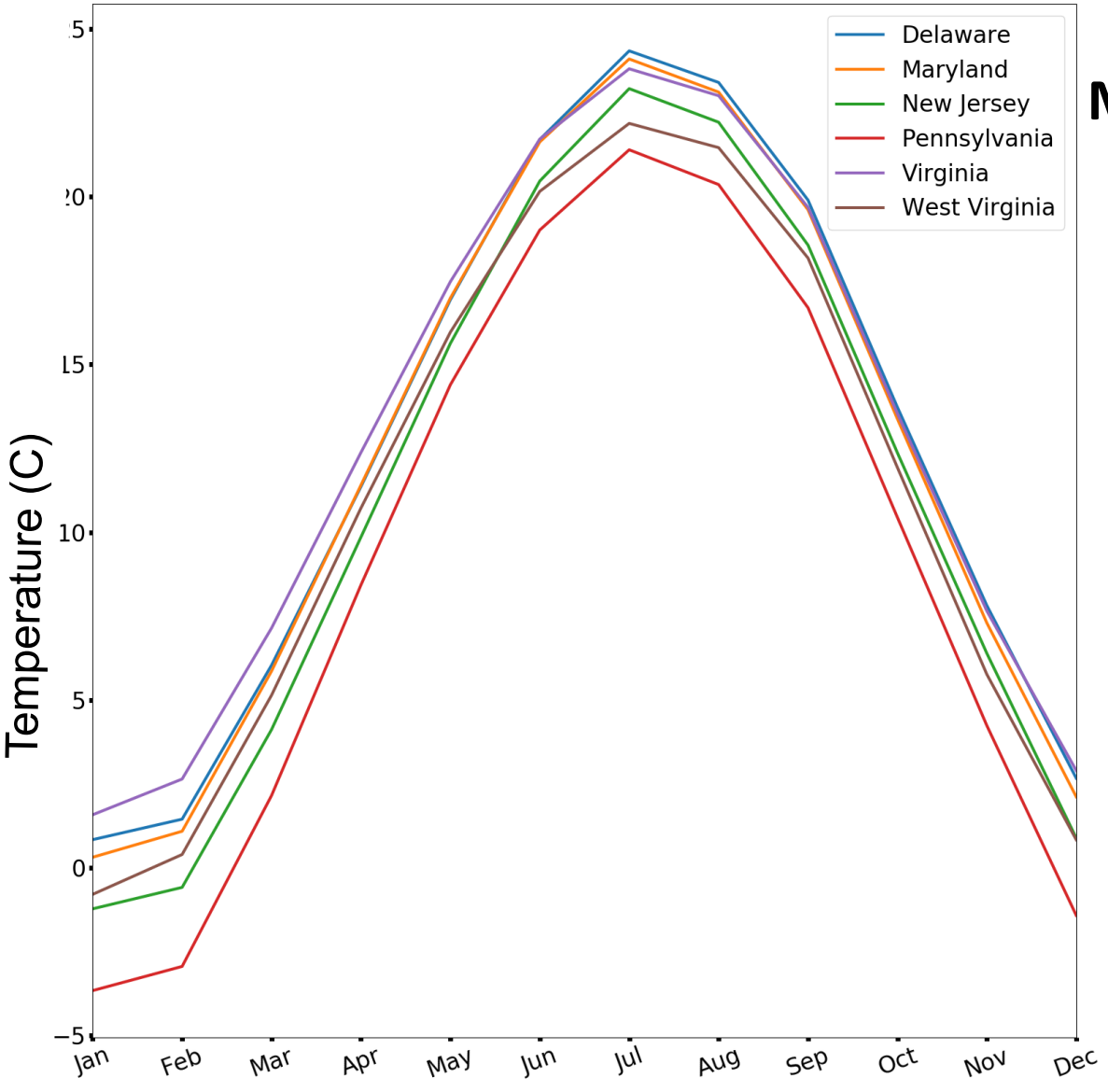
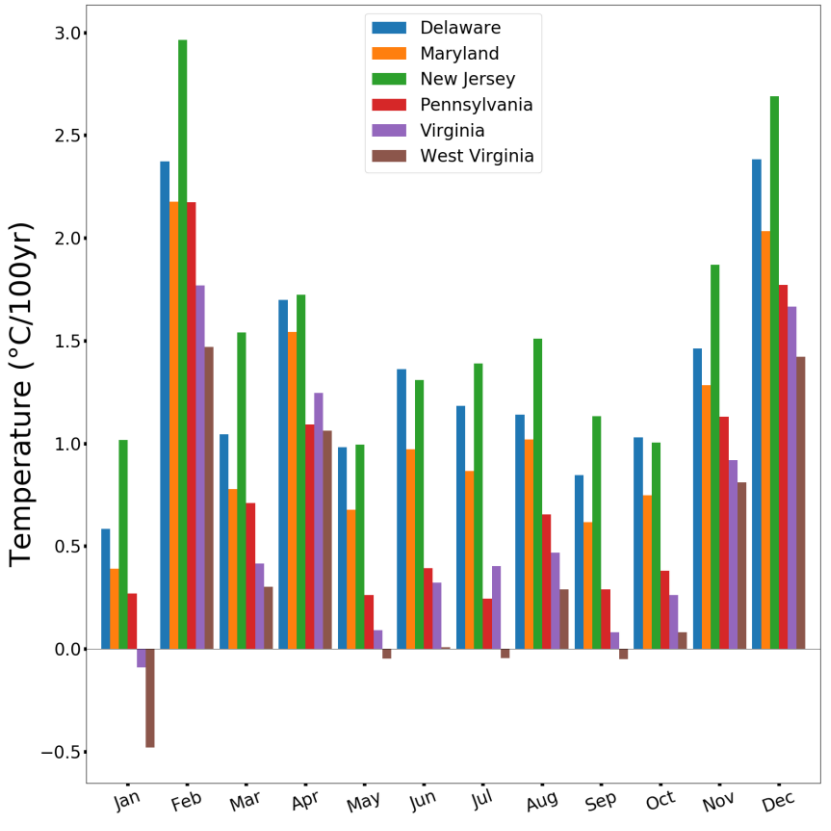
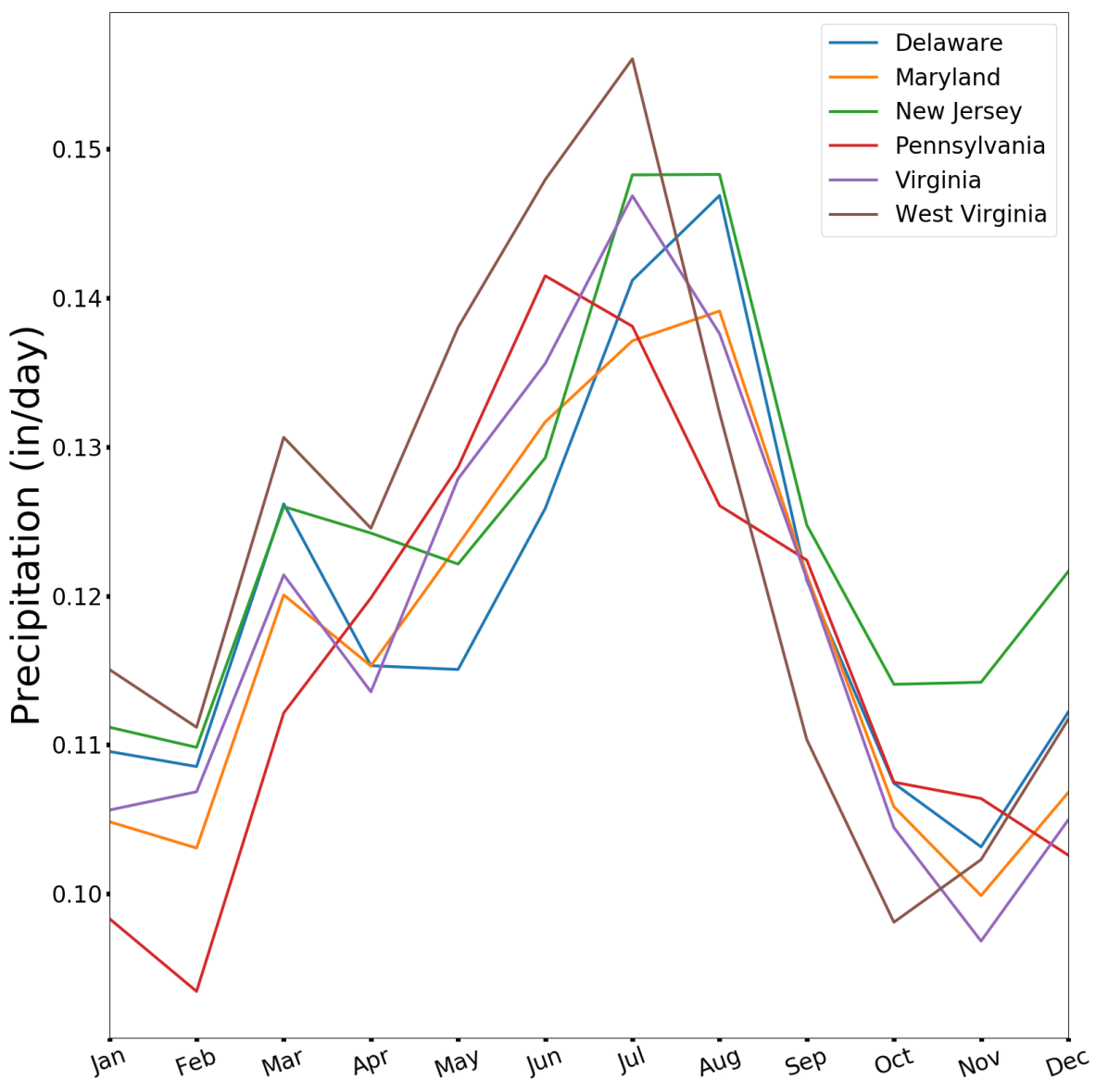


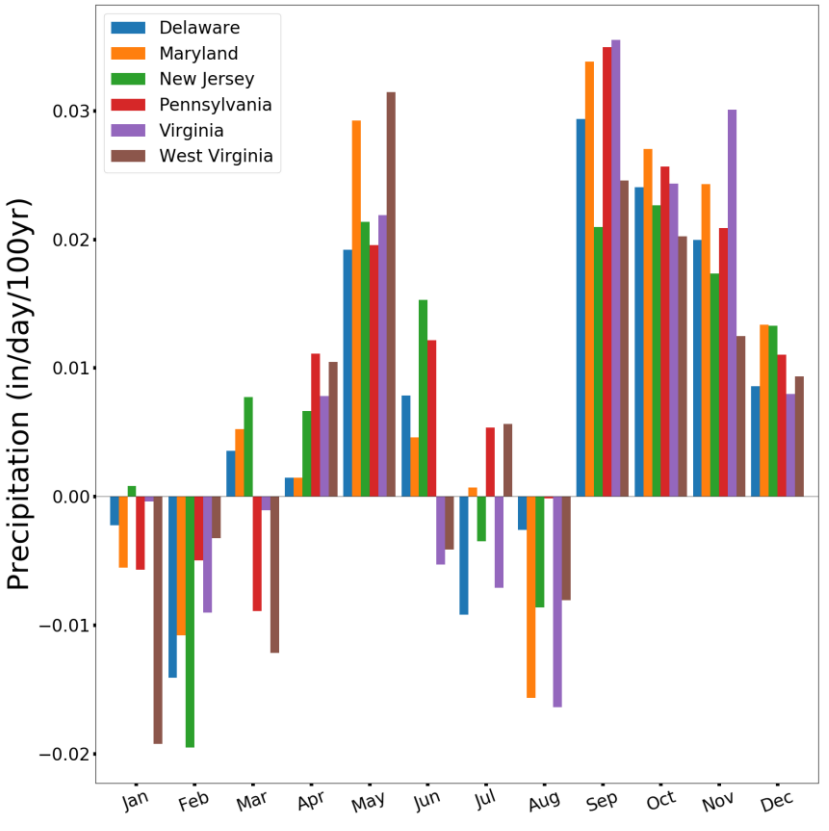
Observed Seasonal Variation of Mean Air Temperature and Trend 1895-2019





Observed Seasonal Variation of Precipitation and Trend 1895-2019





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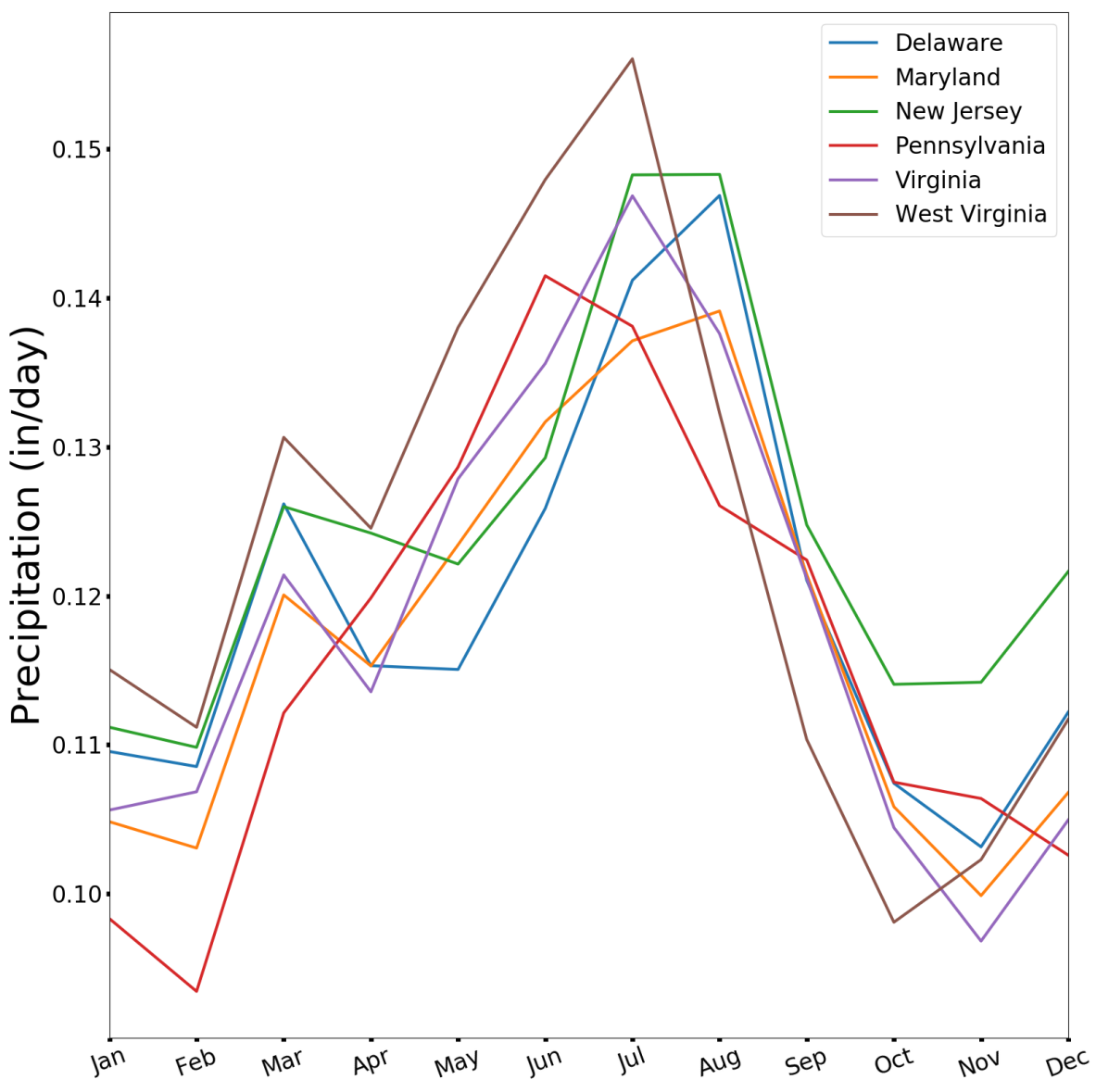
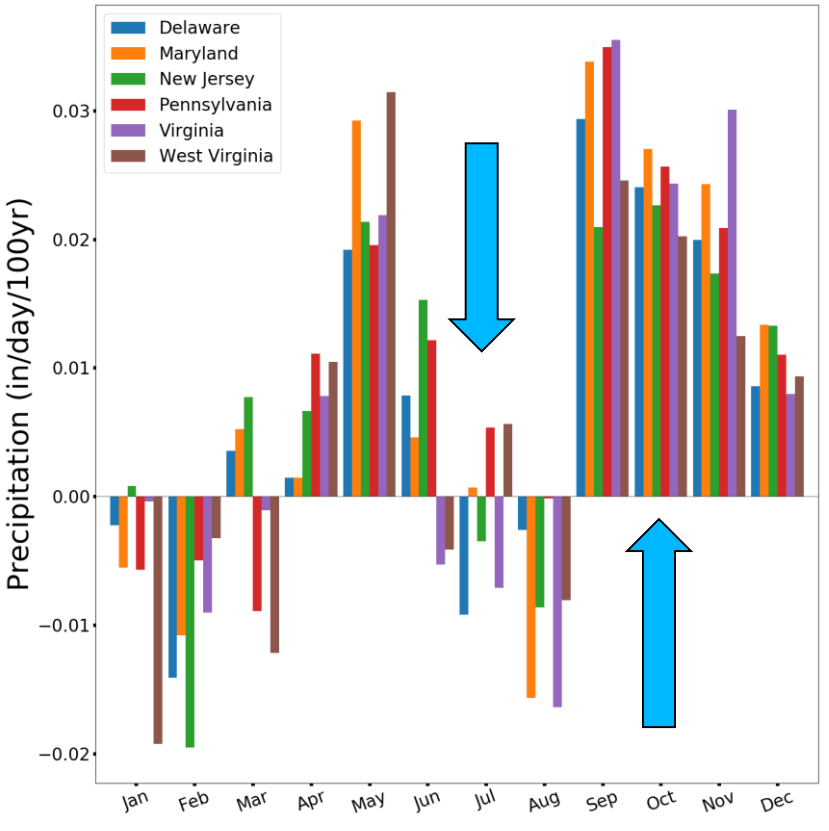
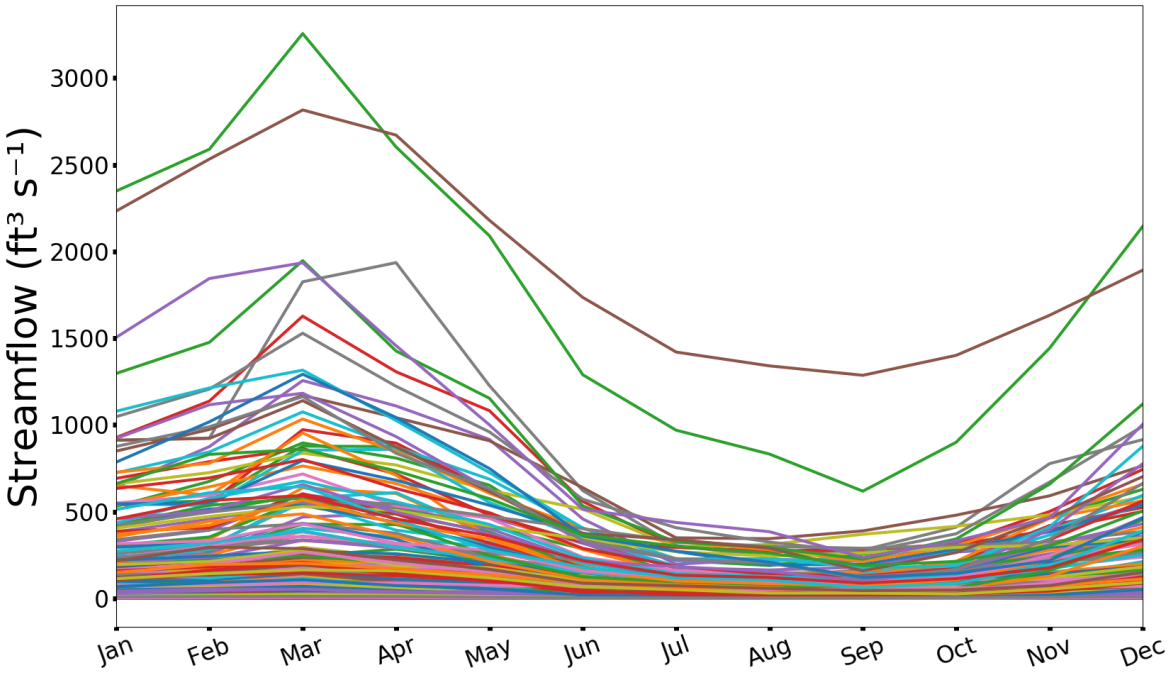
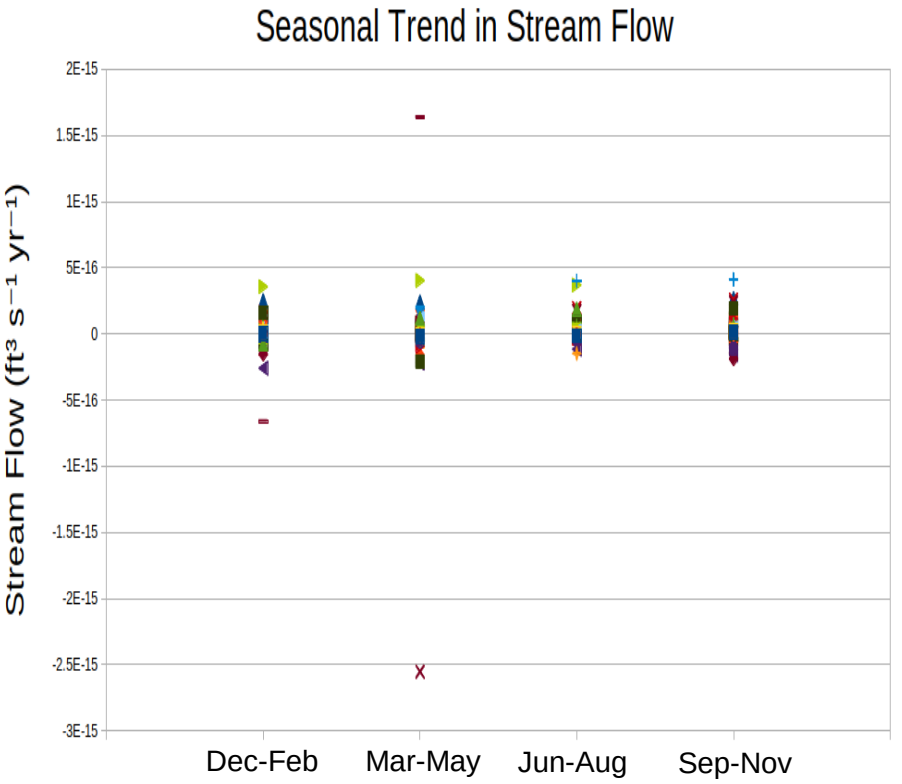


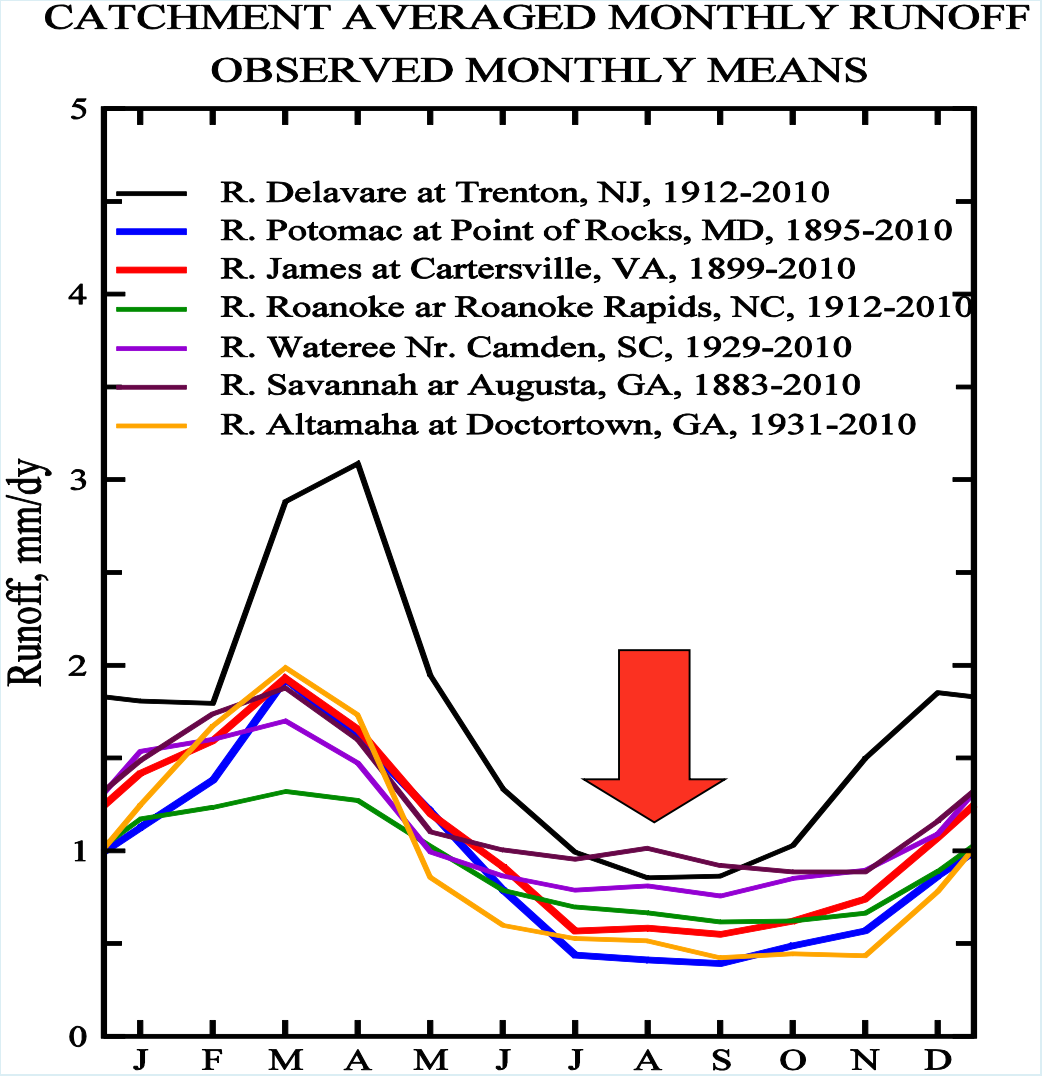


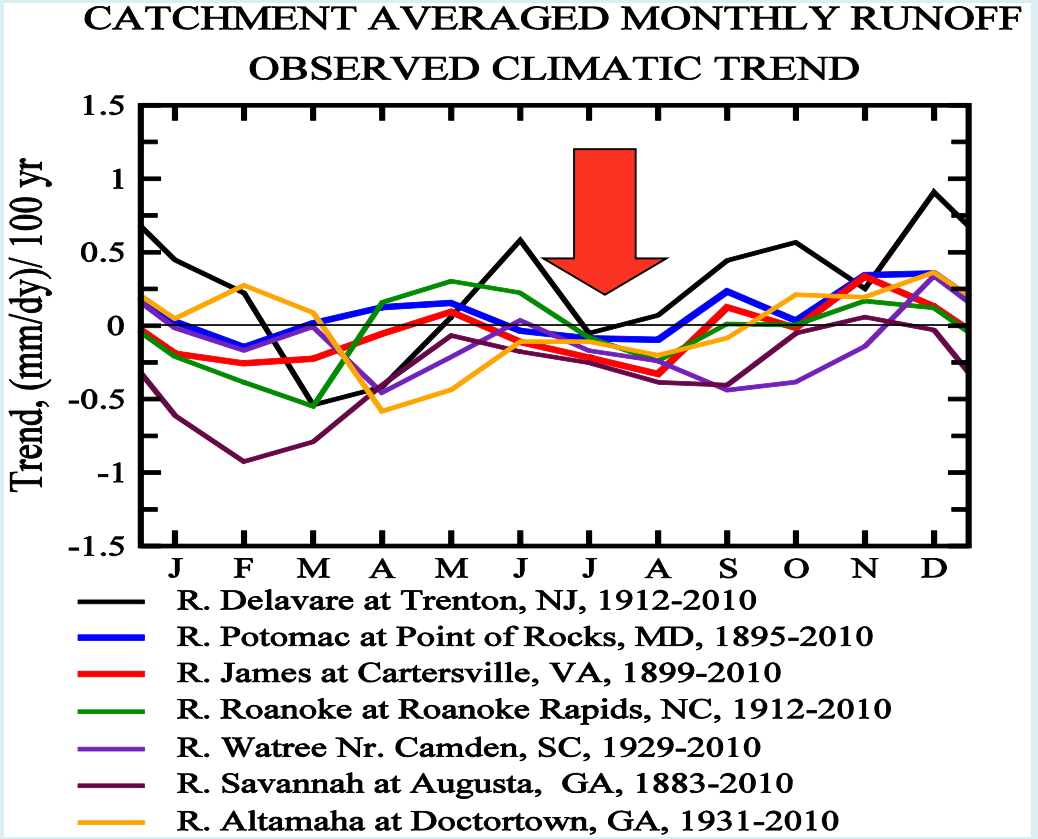
Observed Seasonal Variation of Stream Flow and Trend 1895-2019

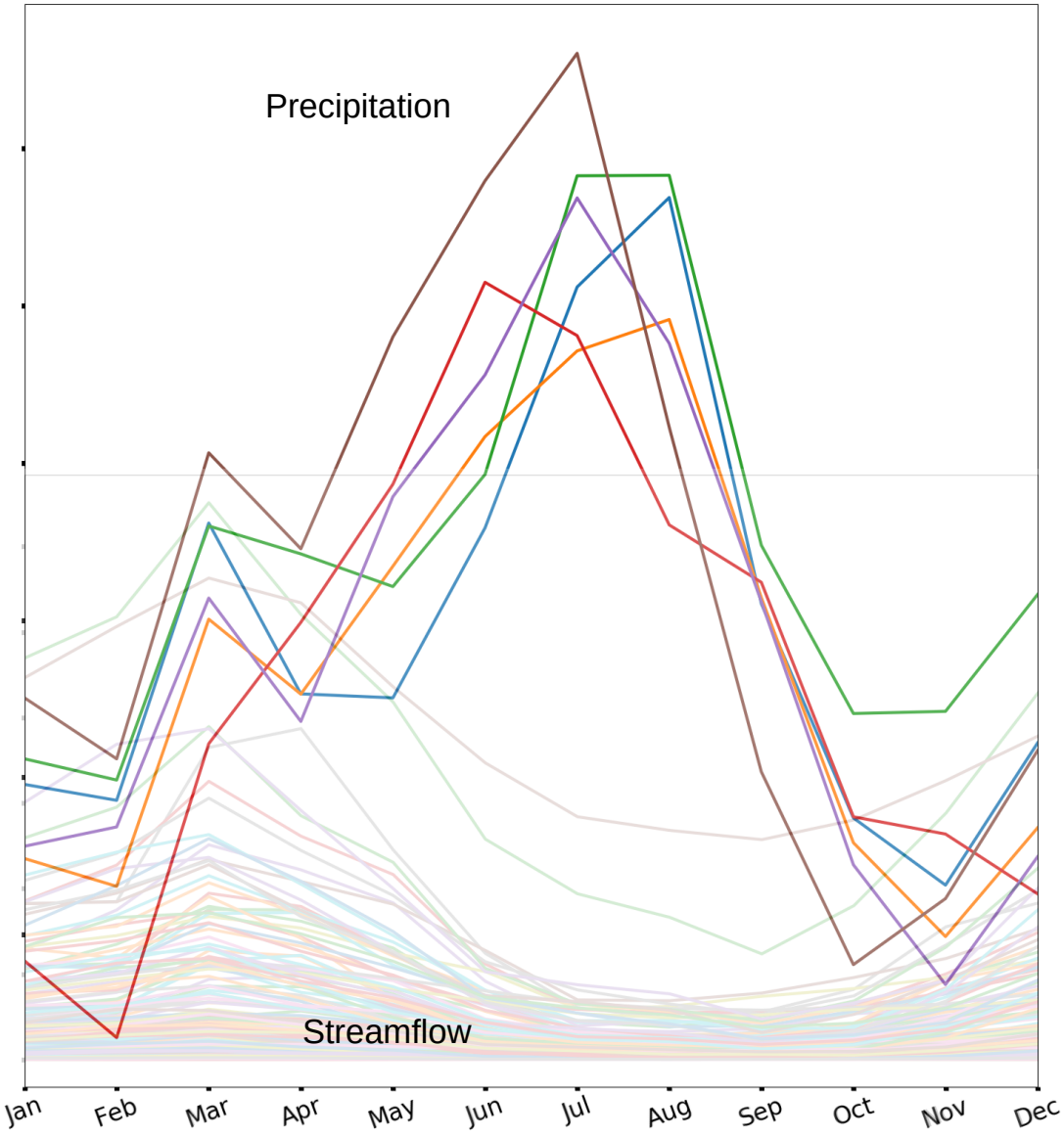




East Coast Rivers: Observed Seasonal Variations of Runoff and Trend

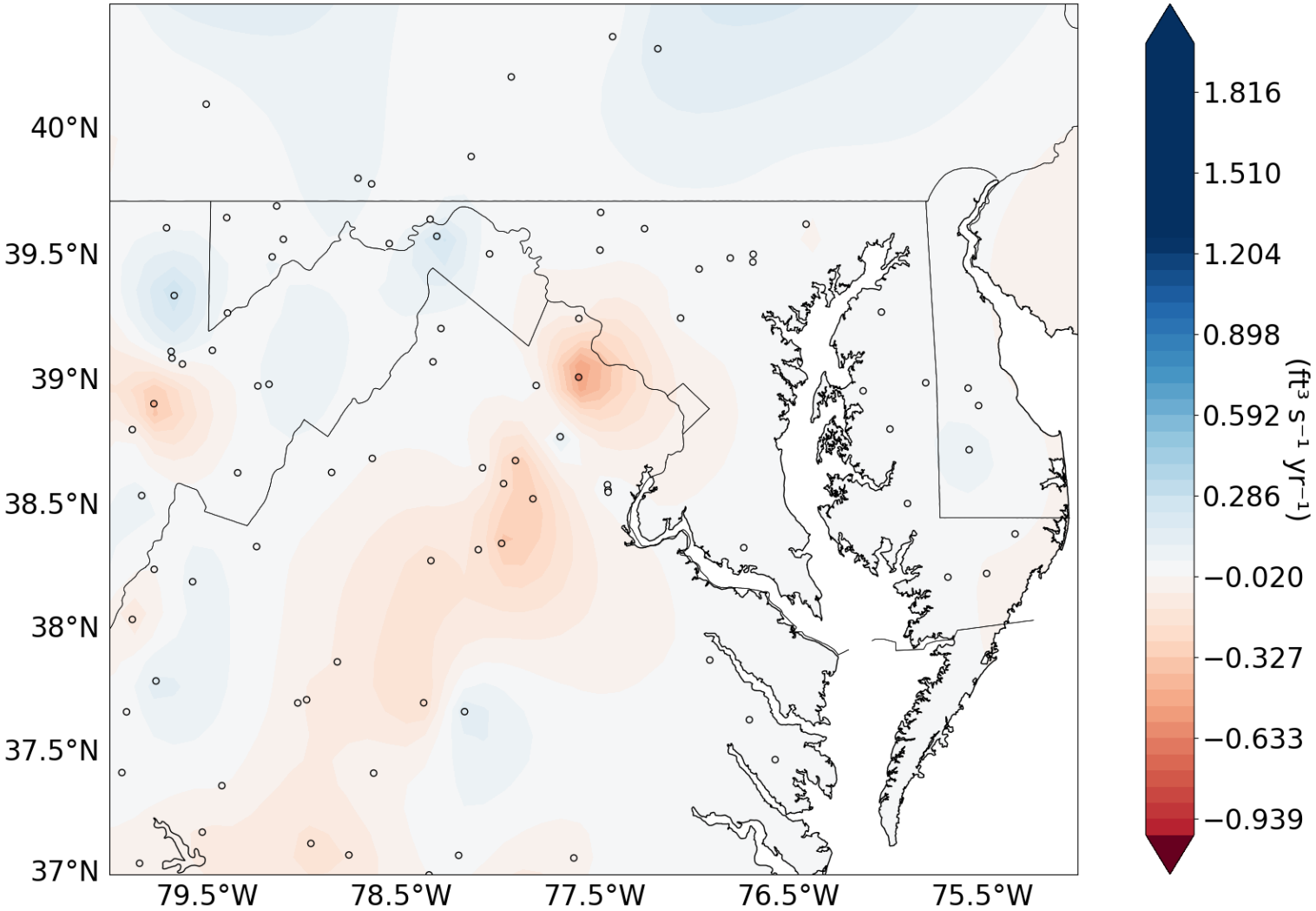






- Maximum precipitation in summer
- Minimum streamflow in Summer
- Summers getting drier with spring and fall getting wetter
- No observable trends in monthly streamflow

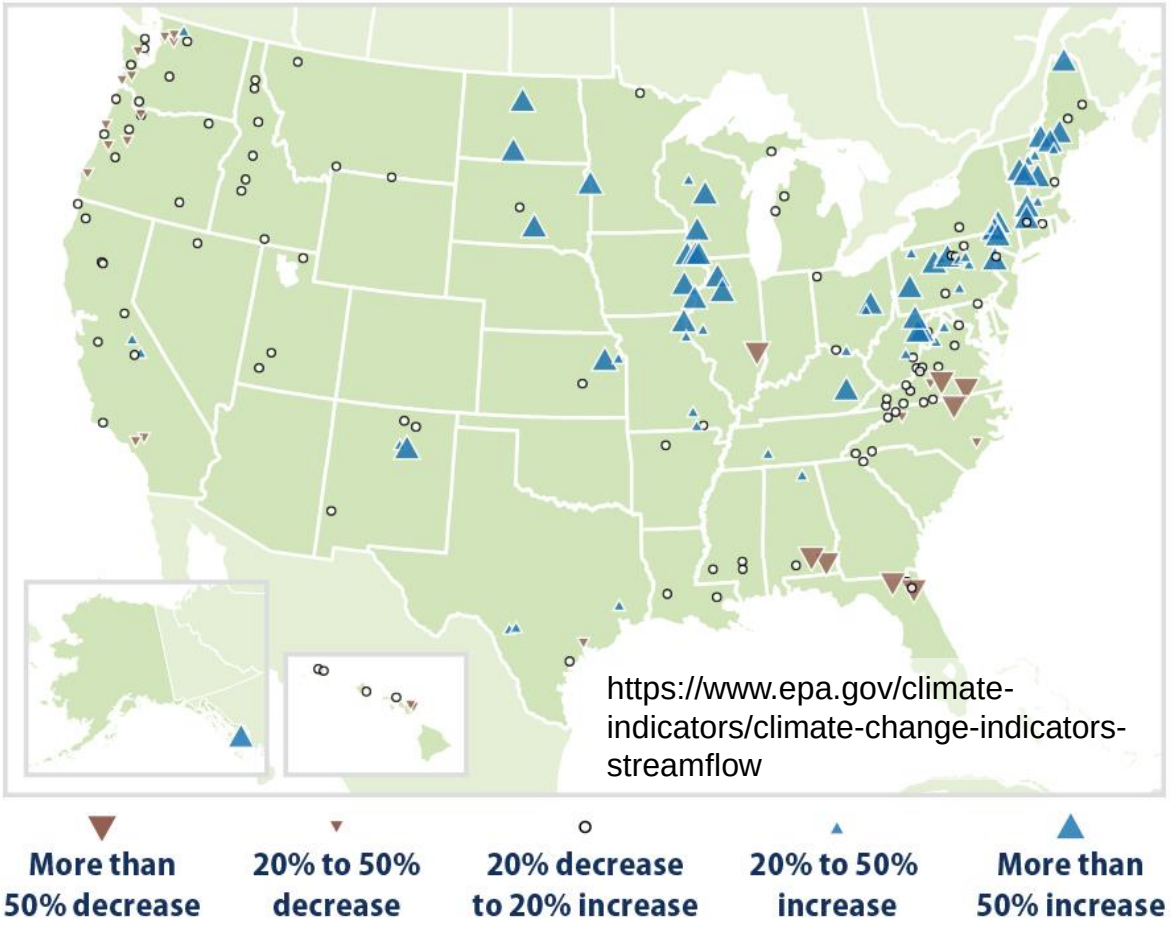
Annual Seven-Day Low Stream Flow Trends
Stations with >= 30 Years observations



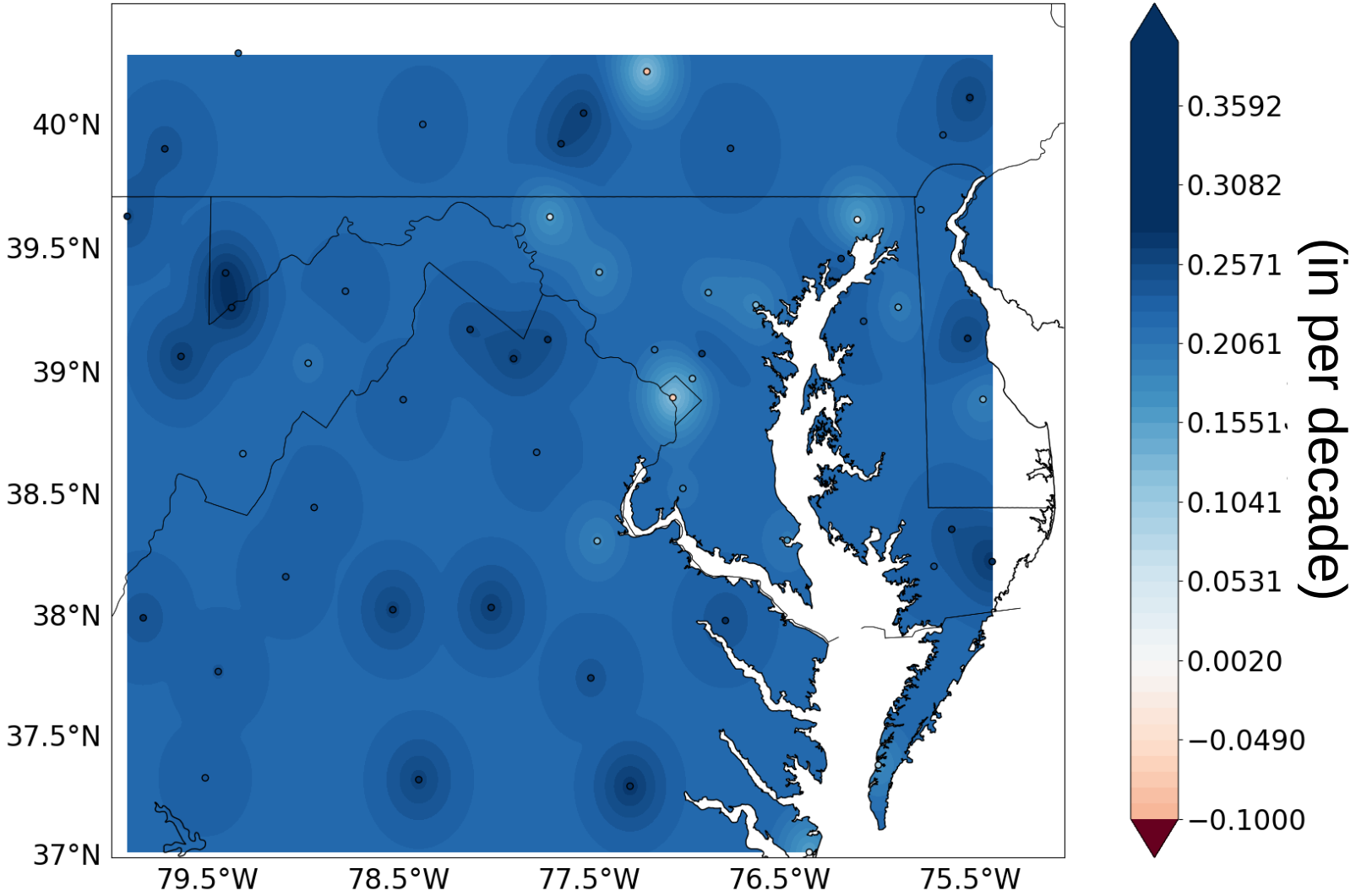
Increase in groundwater

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

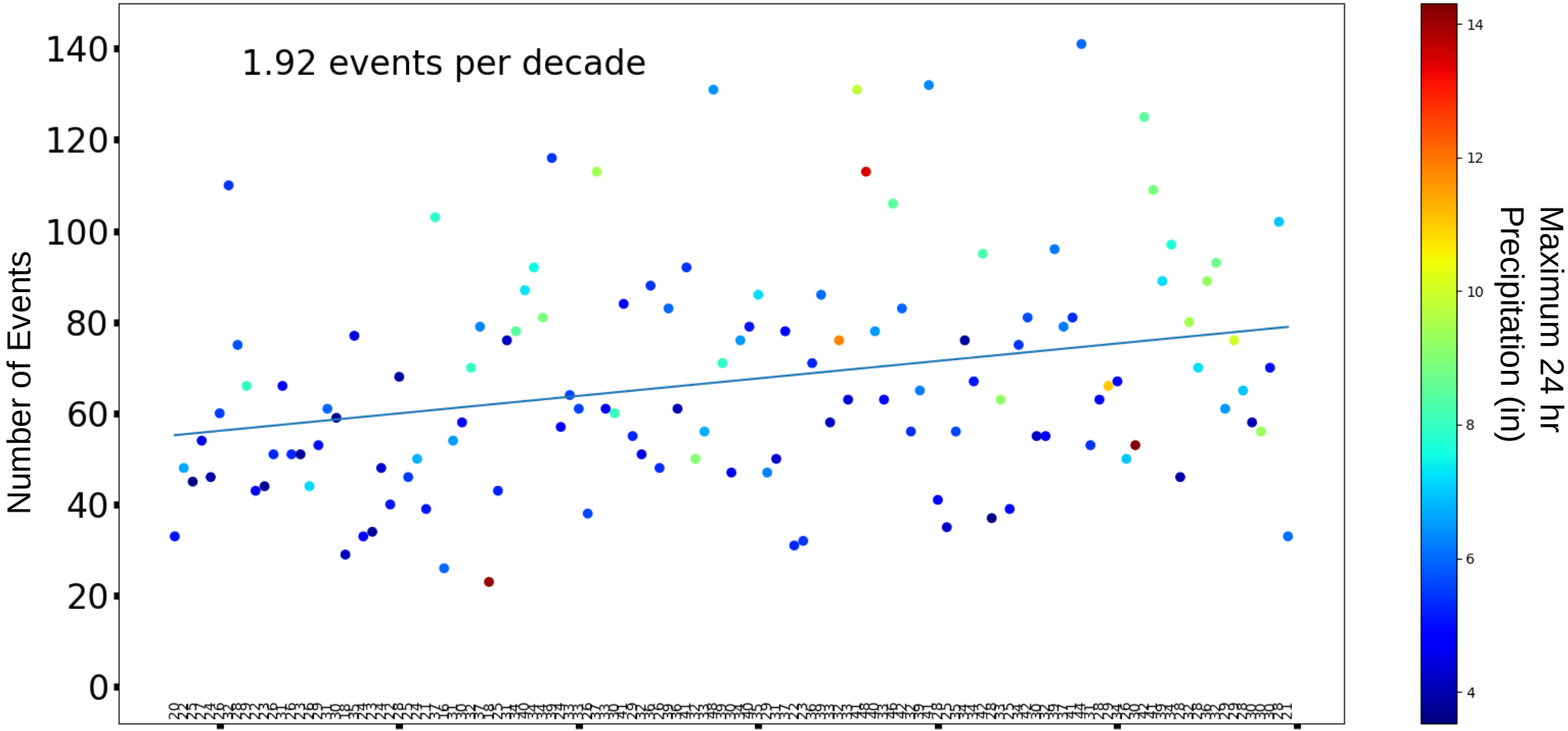
Seven-Day Low Streamflows 1940–2014



Annual Precipitation Trends



Trend in Precipitation Events >= 2”



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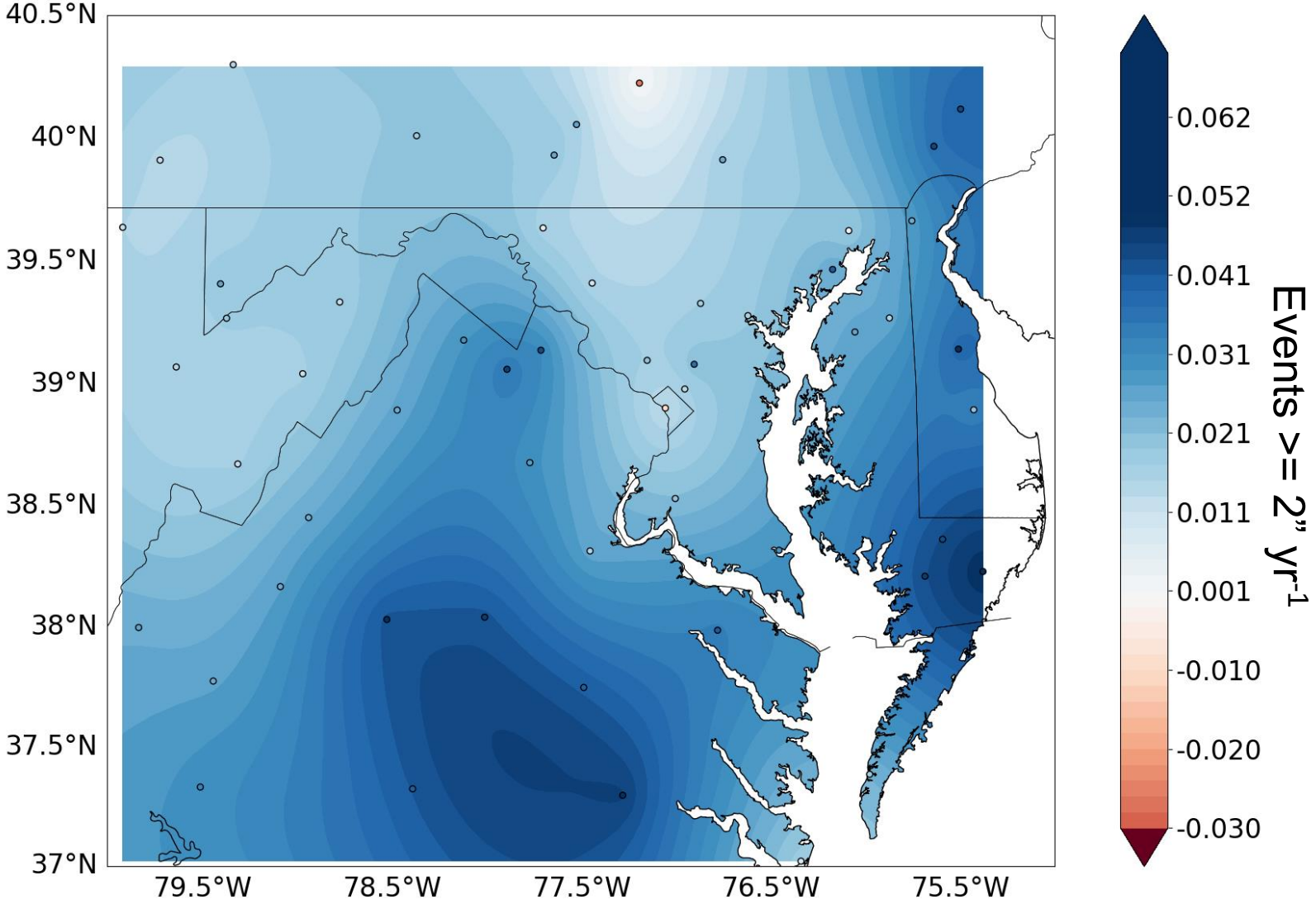
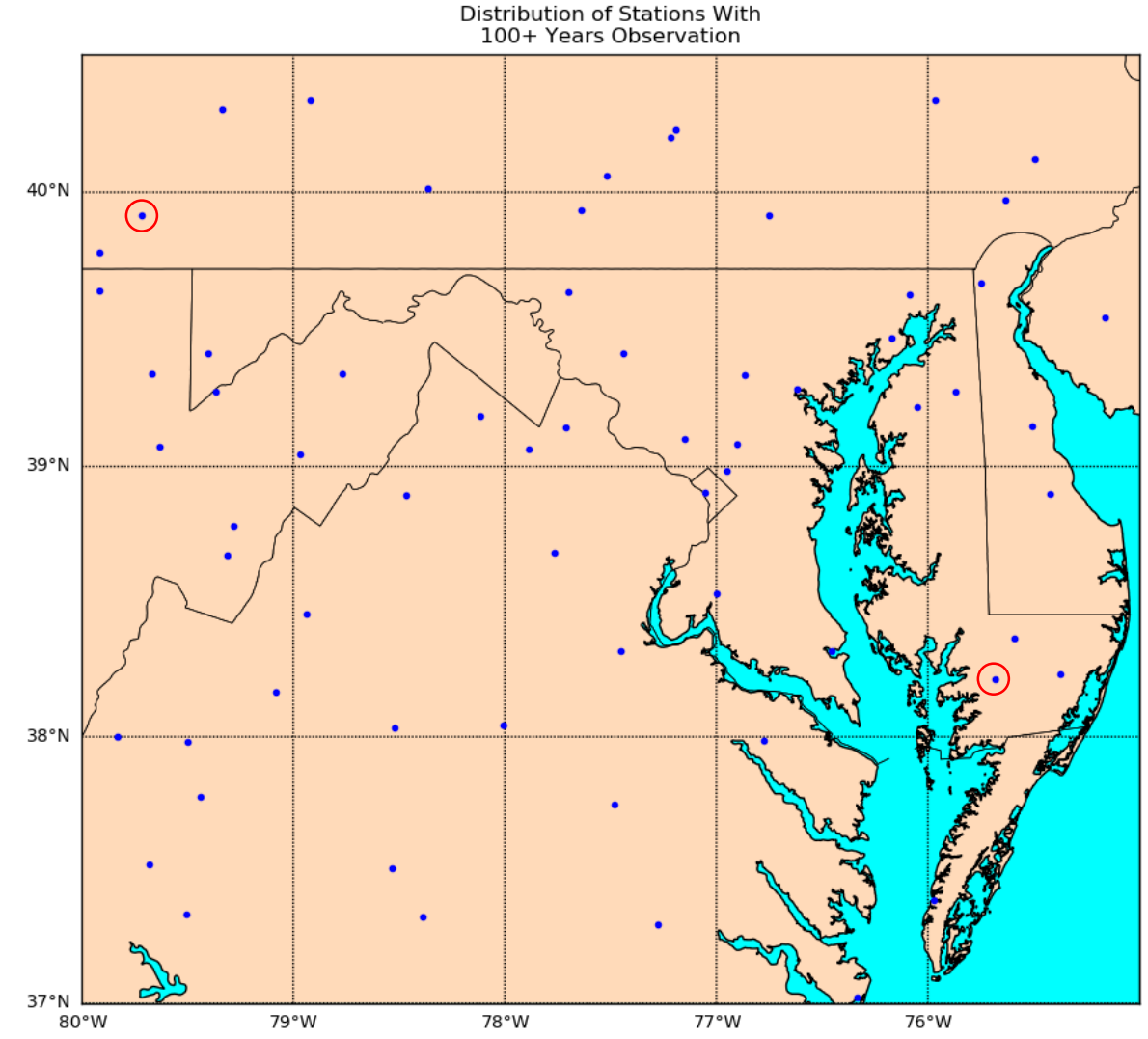
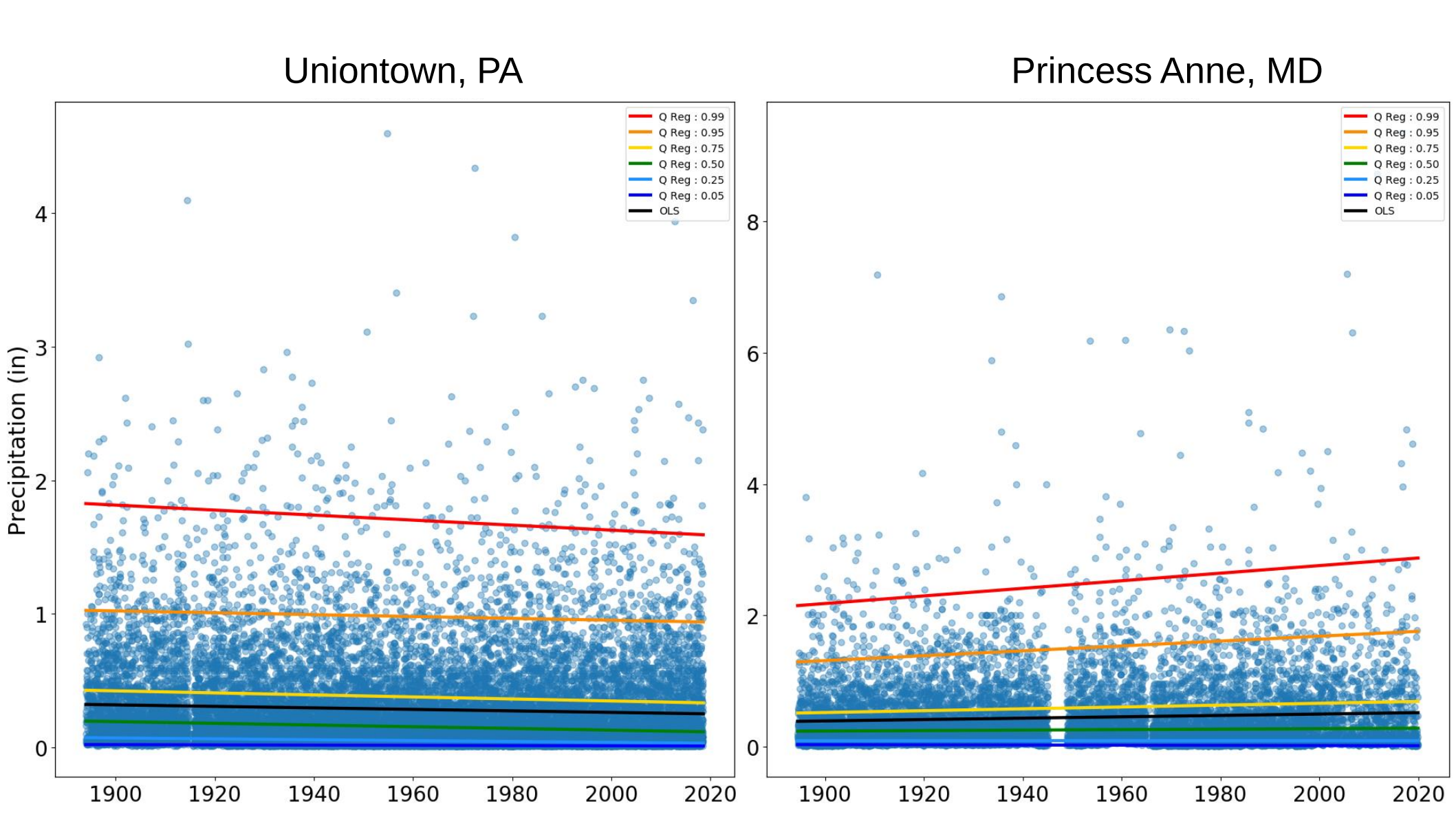


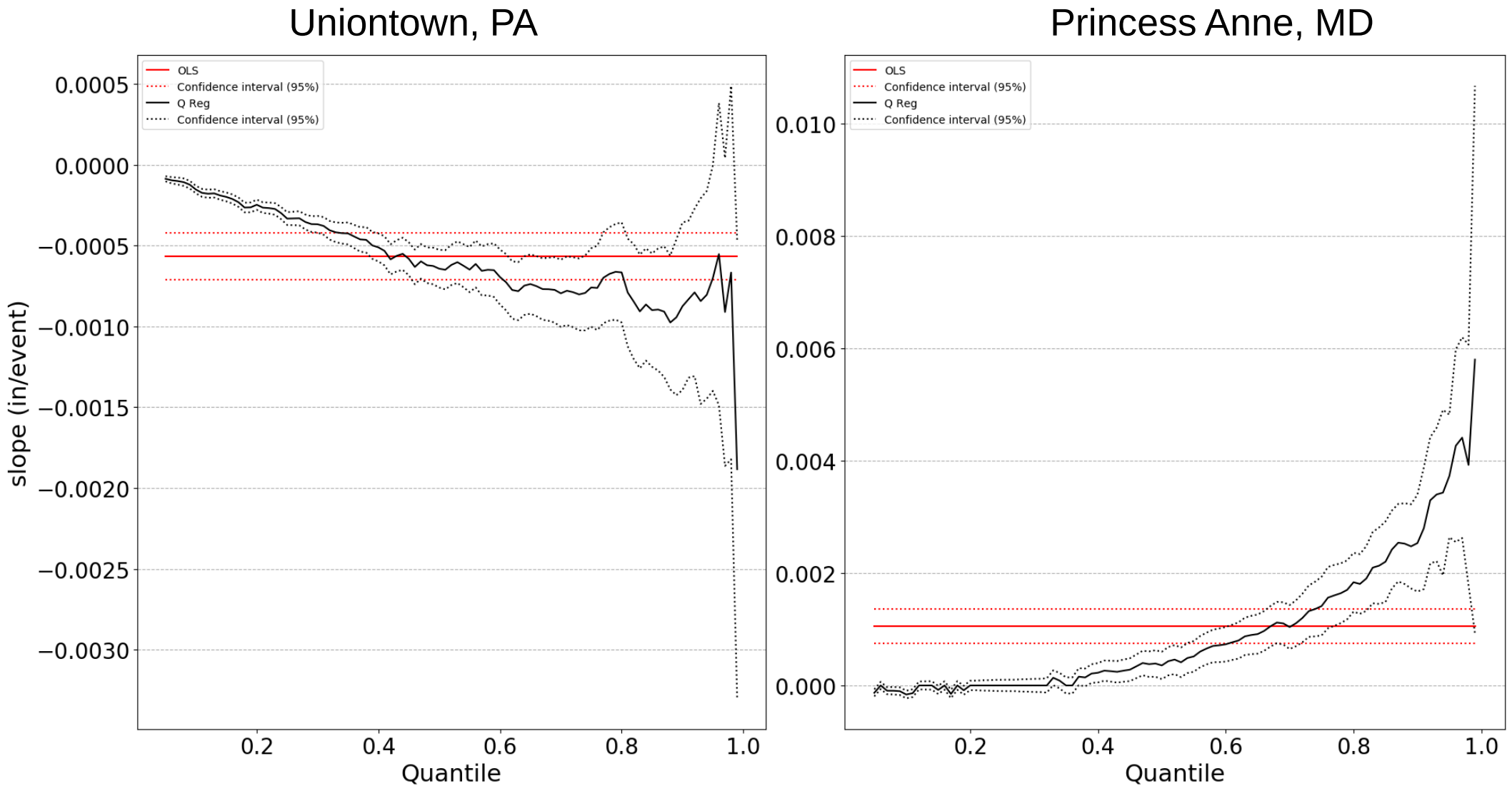


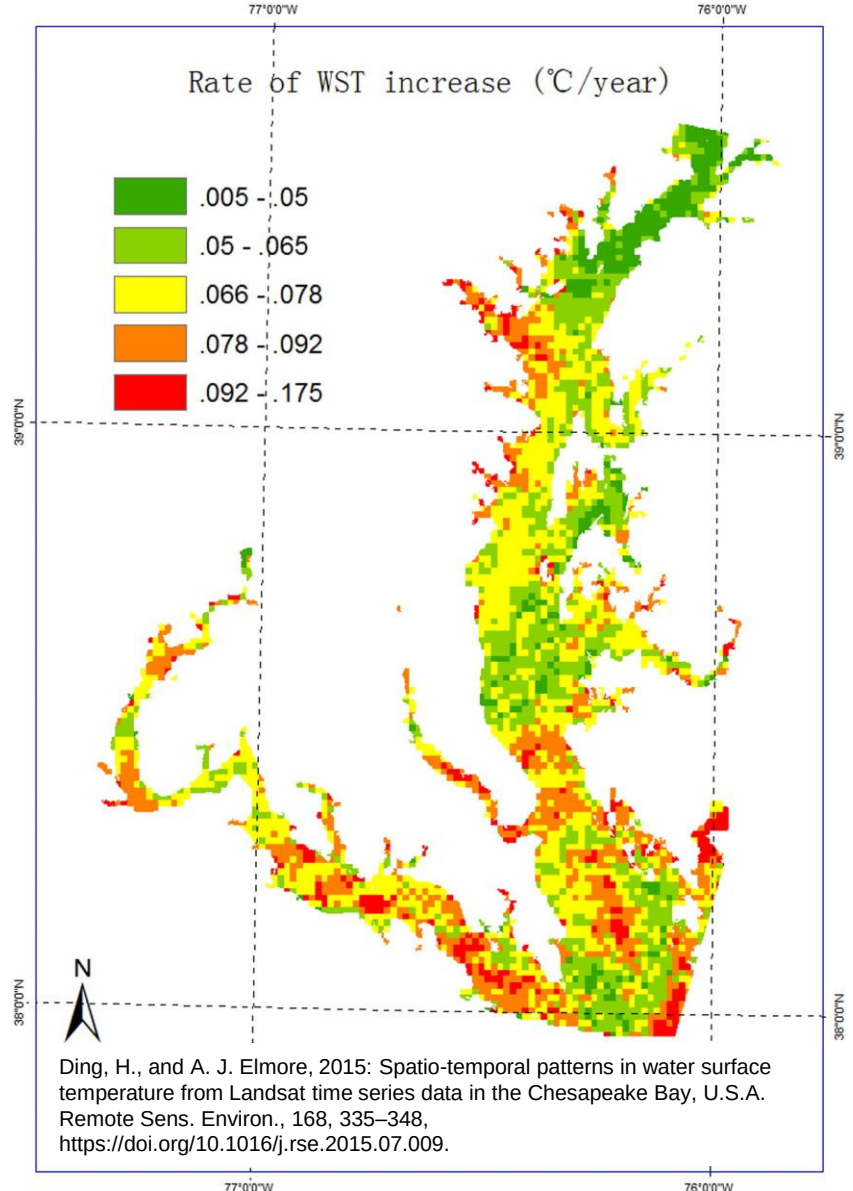
Quantile Regression

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
0
2
4
6
8
1900
1920
1940
1960
1980
2000
2020


Uniontown, PA
Princess Anne, MD
OLS
Confidence interval (95%)
Q Reg
Confidence interval (95%)
slope (in/event)
0.0005
0.0000
−0.0005
−0.0010
−0.0015
−0.0020
−0.0025
−0.0030
0.010
0.008
0.006
0.004
0.002
0.000
0.2
0.4
0.6
0.8
1.0
Quantile



Ding, H., and A. J. Elmore, 2015: Spatio-temporal patterns in water surface temperature from Landsat time series data in the Chesapeake Bay, U.S.A. Remote Sens. Environ., 168, 335–348, https://doi.org/10.1016/j.rse.2015.07.009.

- Divide the Landsat record into 5-year intervals advancing by one-year increments (1984-1988, 1985–1989, 1986–1990, etc.)
    - Human activity such as urbanization and power generation
    - Influence of ocean water on the water temperature

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

- We’re data rich and resource/project poor. Help us help you.

Thank You!

www.atmos.umd.edu/~climate

(301) 405 - 7223

climate@umd.edu