Hydrologic Trend Analysis of the Chesapeake Bay TMDL

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Background

- Since 1910, precipitation has increased in the US by about ten percent and half of the total increase is due to changes in frequency and intensity in the upper ten percentiles of the precipitation distribution (Karl and Knight, 1998).

- Projections from global climate models suggest that these trends are anticipated to continue and accelerate over the next century.

- Climate change model projections suggest that nutrient and sediment loads in the Chesapeake Bay region will increase (Najjar, R. et al., 2010).

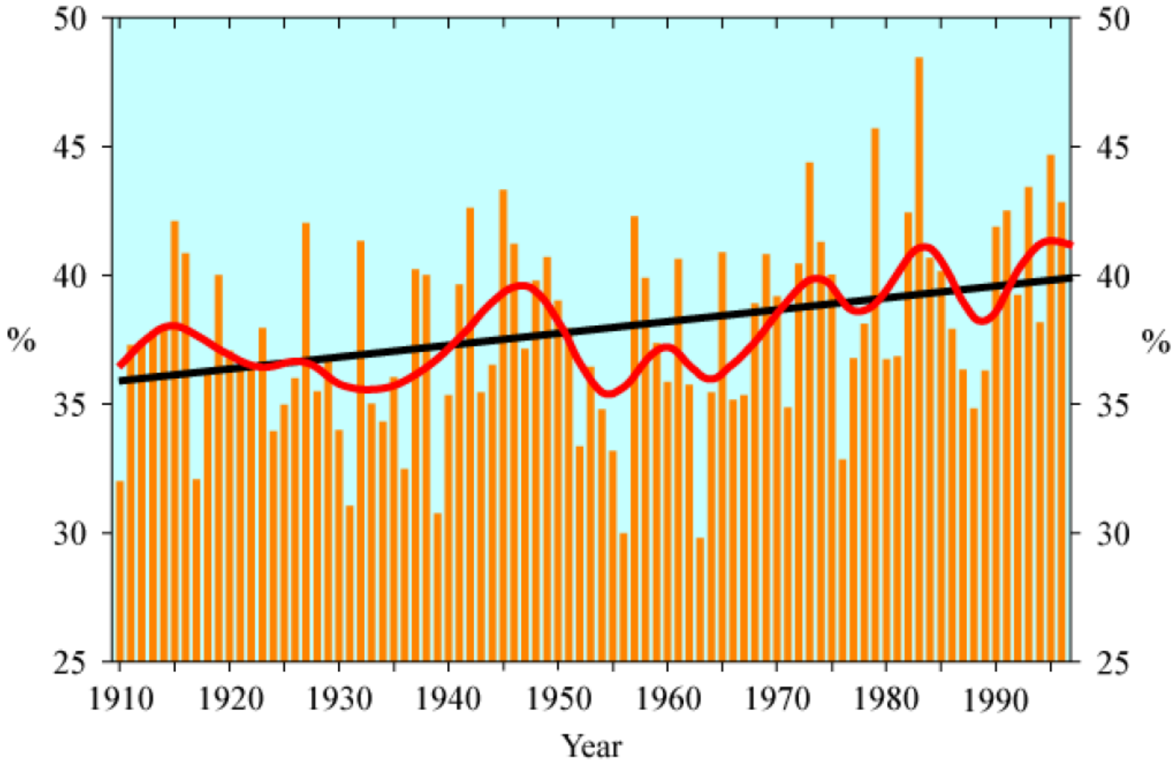
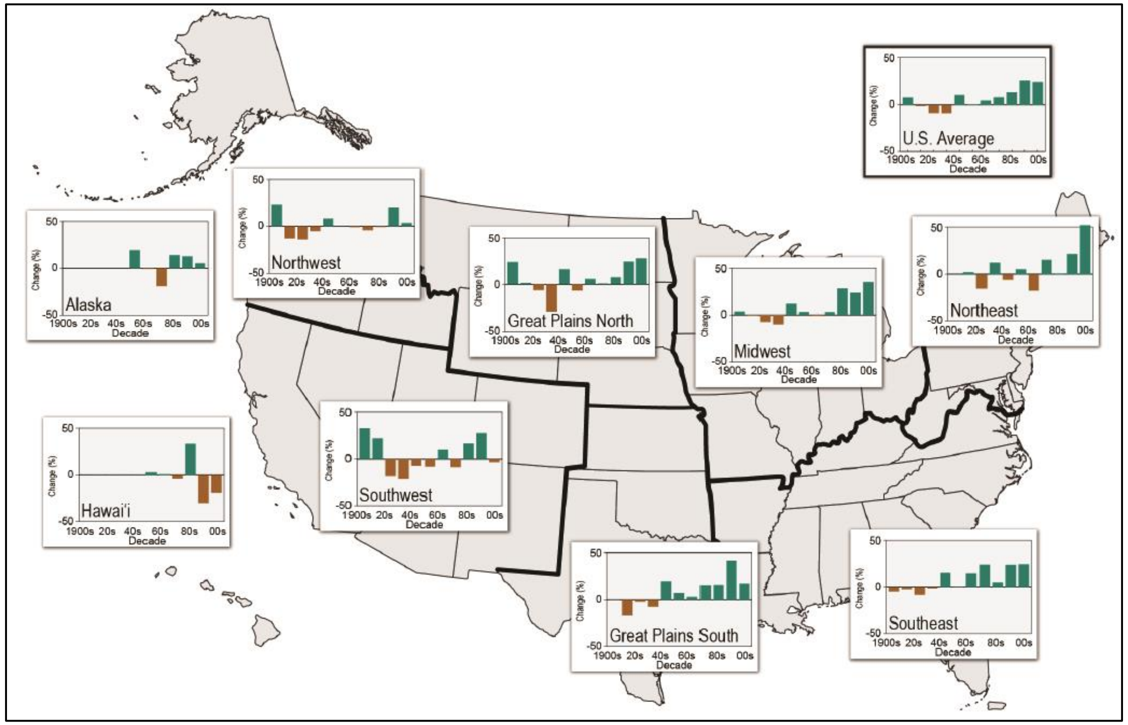


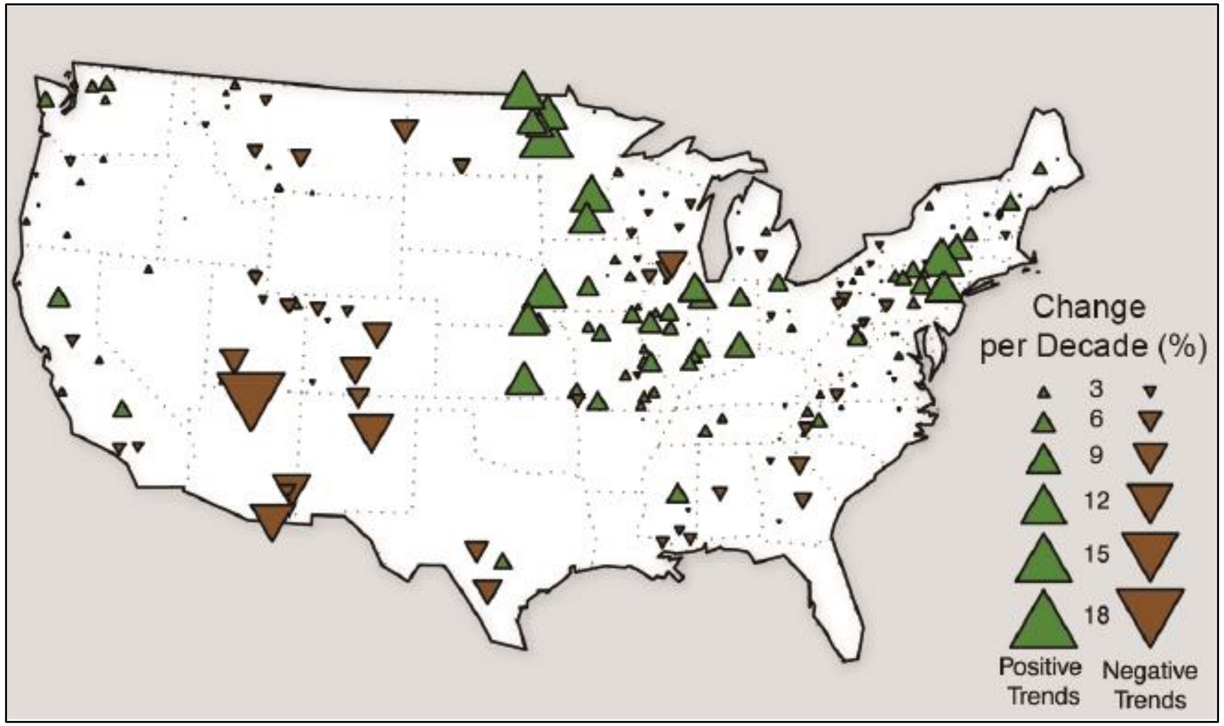
Figure 1. Time series of the percent contribution of the upper 10 percentile of daily precipitation events to the total annual precipitation area-averaged across the United States (Karl and Knight, 1998).

Background

Annual precipitation and river-flow increases are observed now in the US northeast region (Melillo et al., 2014) . Very heavy precipitation events have increased nationally and are projected to increase in all regions.



Percent changes in the annual amount of precipitation falling in very heavy events, defined as the heaviest 1% of all daily events from 1901 to 2012 for each region (Melillo et al., 2014)



Trend magnitude (triangle size) and direction (green = increasing trend, brown = decreasing trend) of annual flood magnitude from the 1920s through 2008. (Melillo et al., 2014)

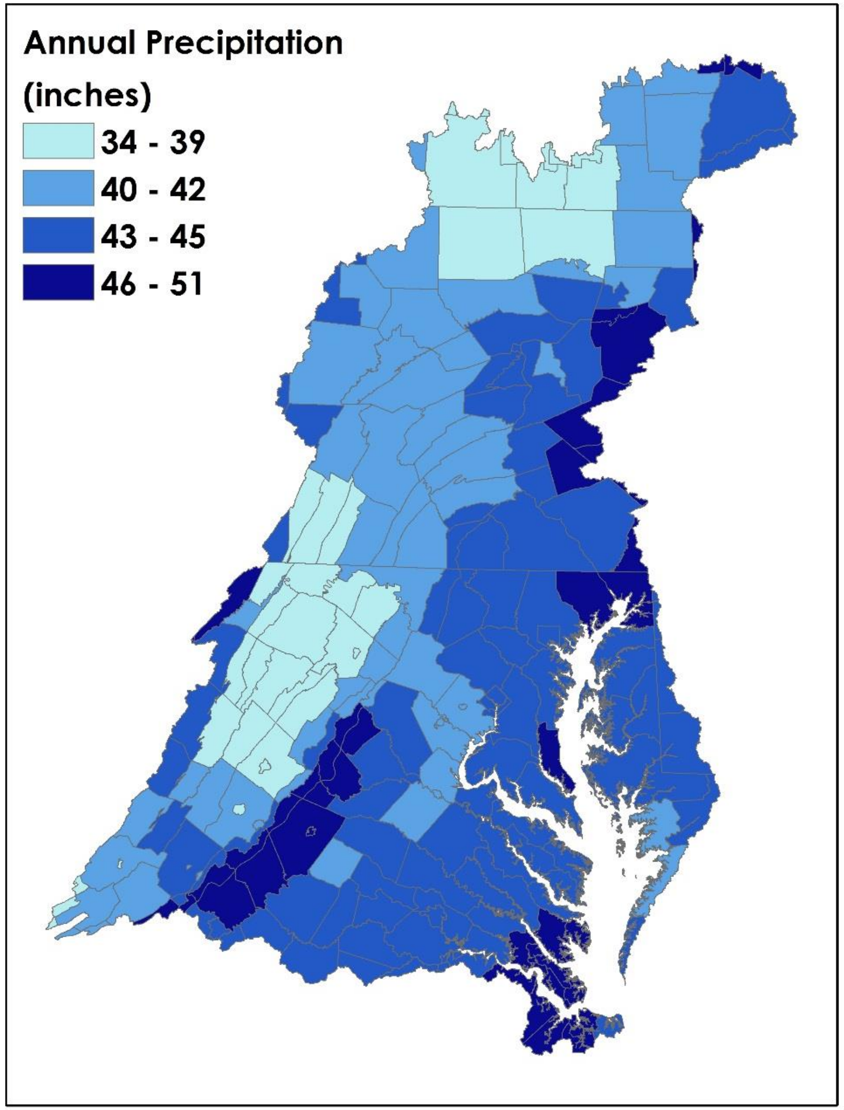
Objectives

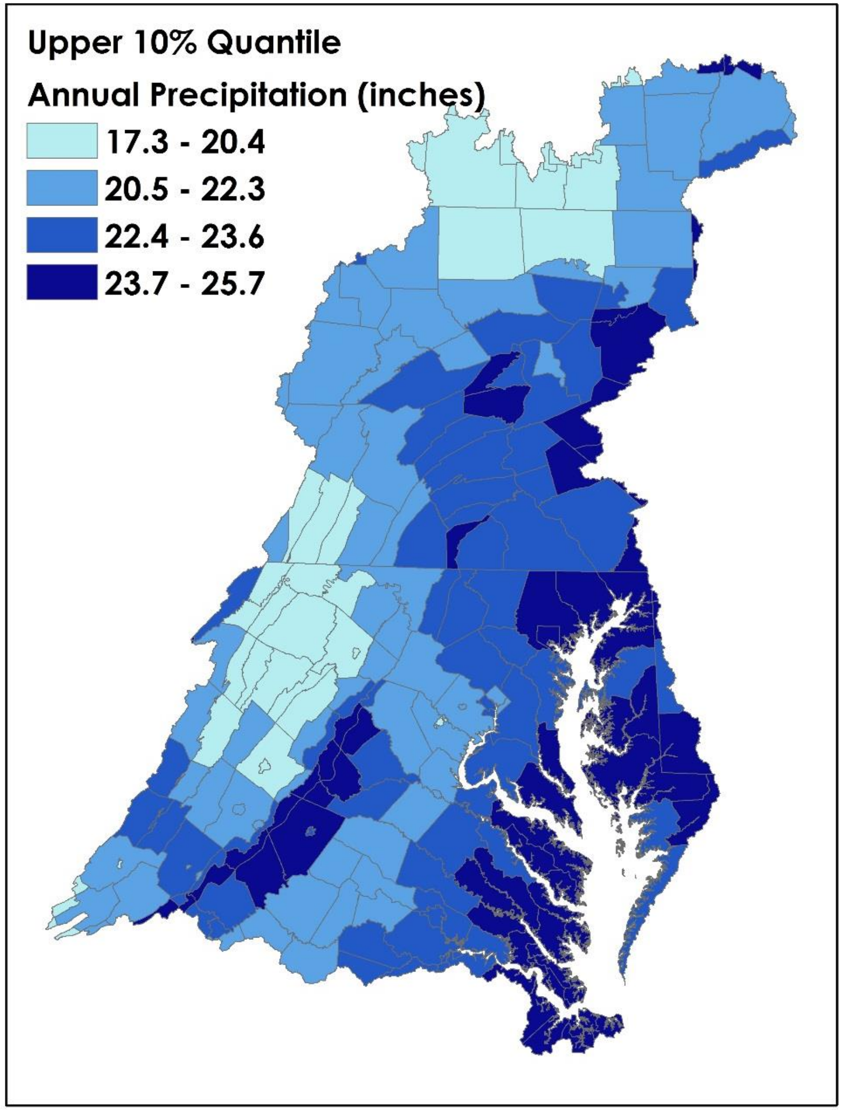
- Analyze the last three decades of observed hourly rainfall in the Chesapeake Bay Watershed (1980 - 2011)
- Perform a trend detection analysis of precipitation in different quantile regions of its distribution
- Develop a 2050 representation of the Chesapeake watershed precipitation

Total Precipitation and Total Precipitation within the Upper 10th Percentile in Chesapeake Bay Watershed (1980 - 2011)

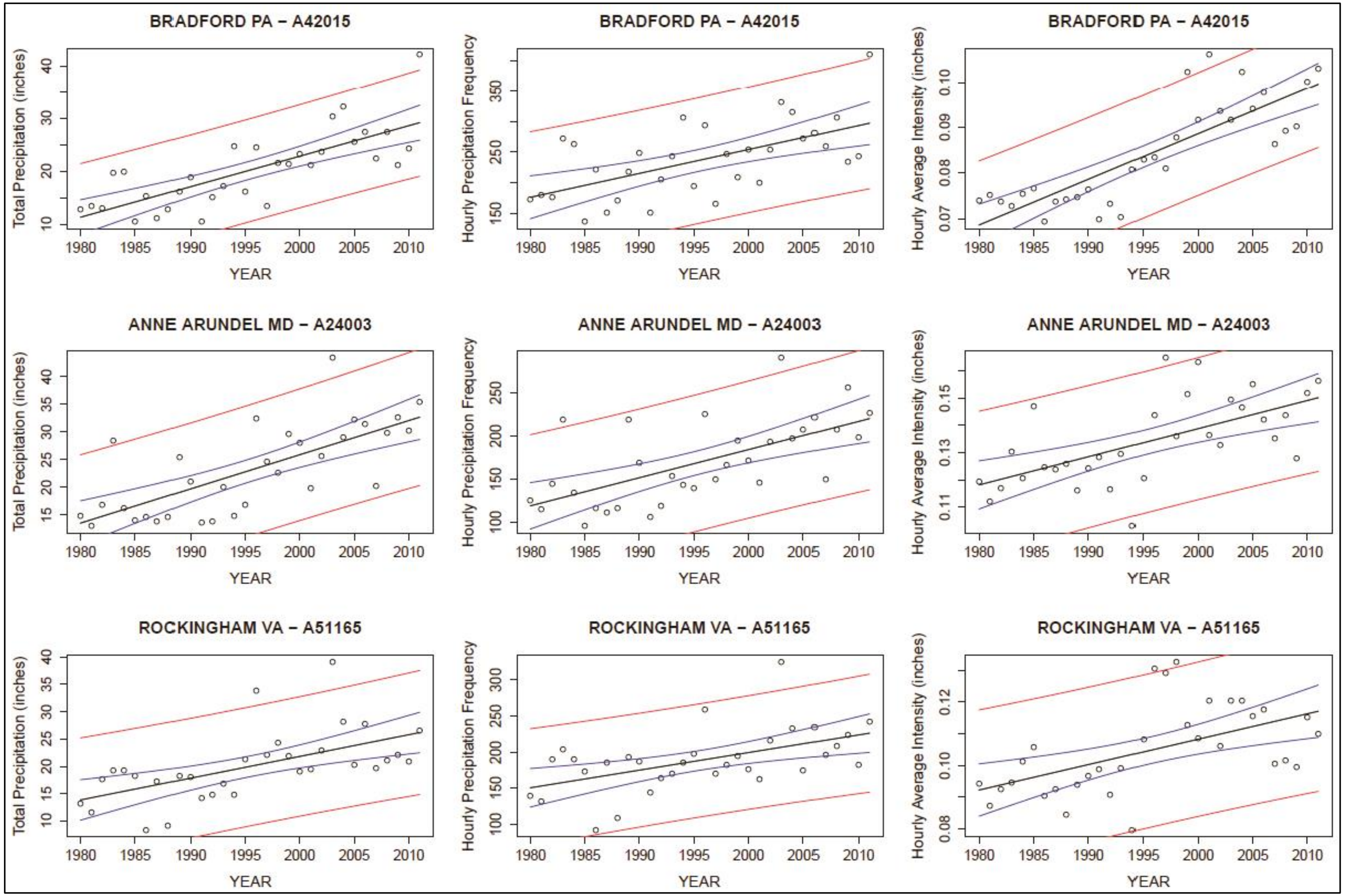
NLDAS-II data, a comprehensive high-resolution data product based on NEXRAD climate reanalysis, was used in this study.

Hourly NLDAS-II data was aggregated to meet the Chesapeake Bay TMDL segmentation from 1980 to 2011.

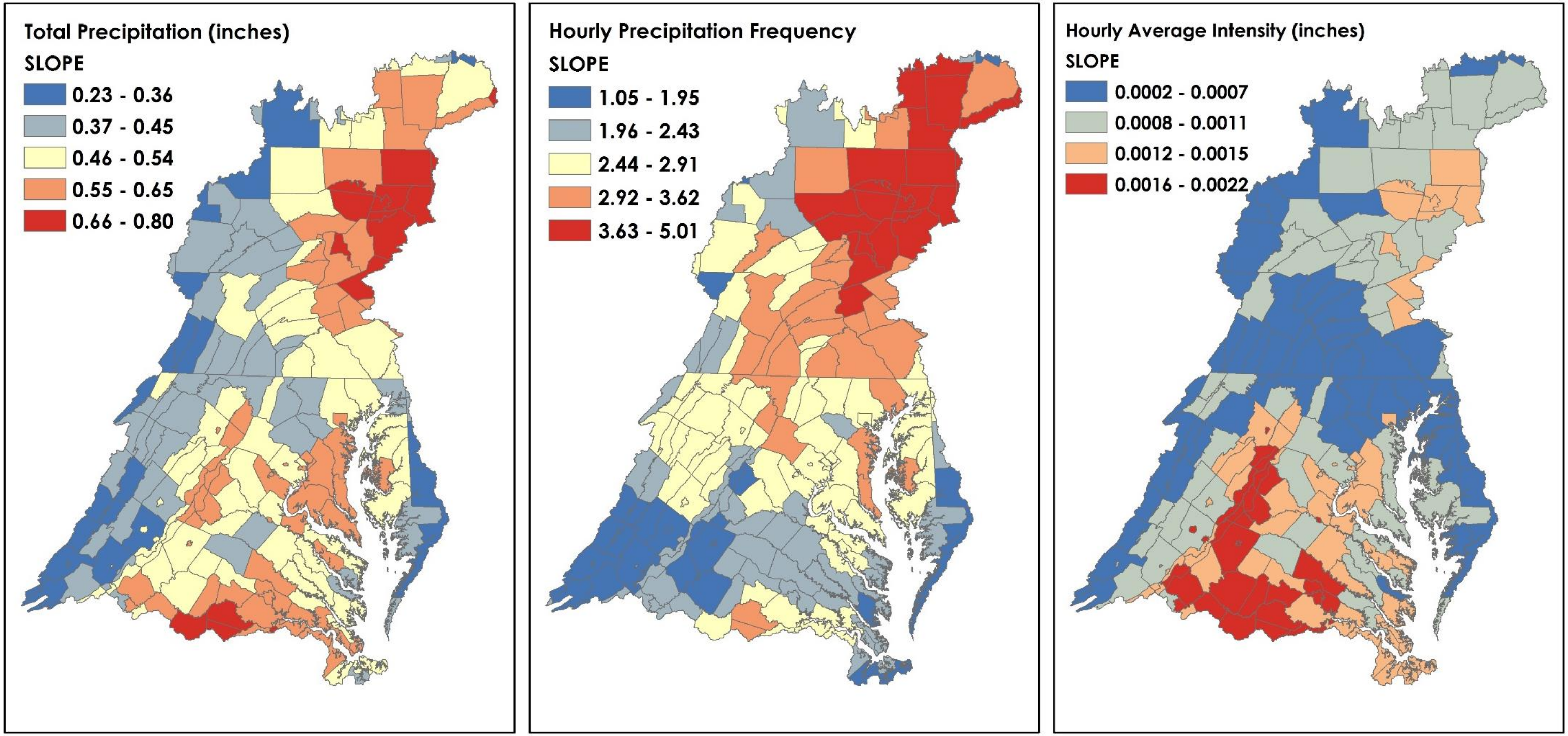




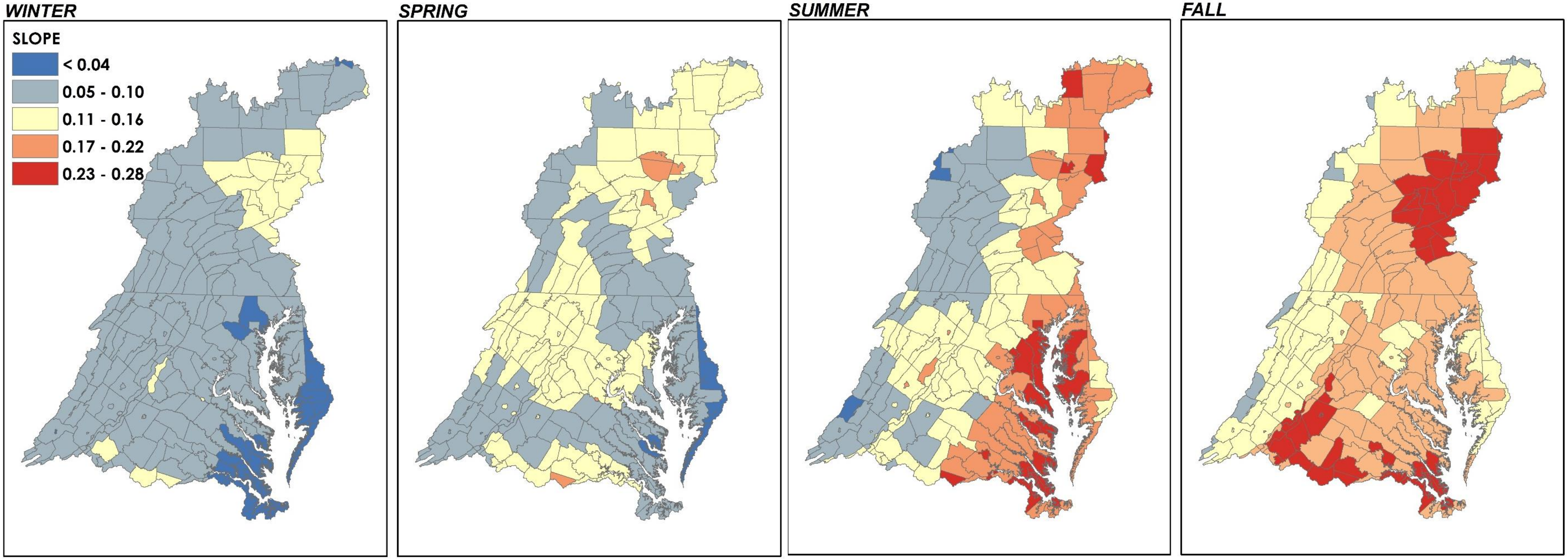
Total Precipitation, Frequency, and Intensity Trends within the Upper 10th Percentile in Three Counties within the Chesapeake Bay Watershed (1980 - 2011)



Slopes of Total Precipitation, Frequency, and Intensity Trends within the Upper 10th Percentile in the Chesapeake Bay Watershed.



Slopes of Seasonal Total Precipitation Trends within the Upper 10th Percentile in the Chesapeake Bay Watershed.

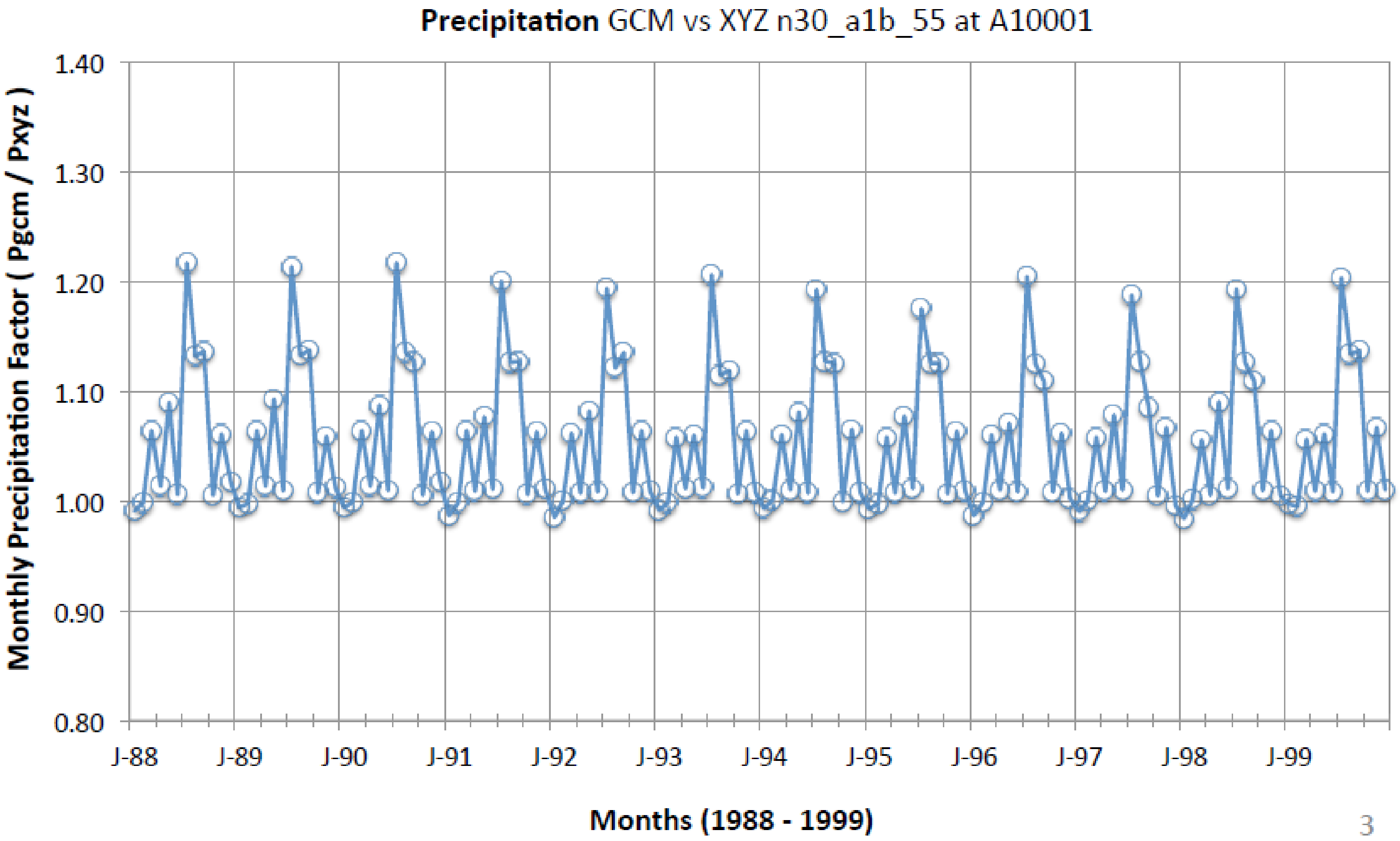


Downscale General Circulation Model Projections

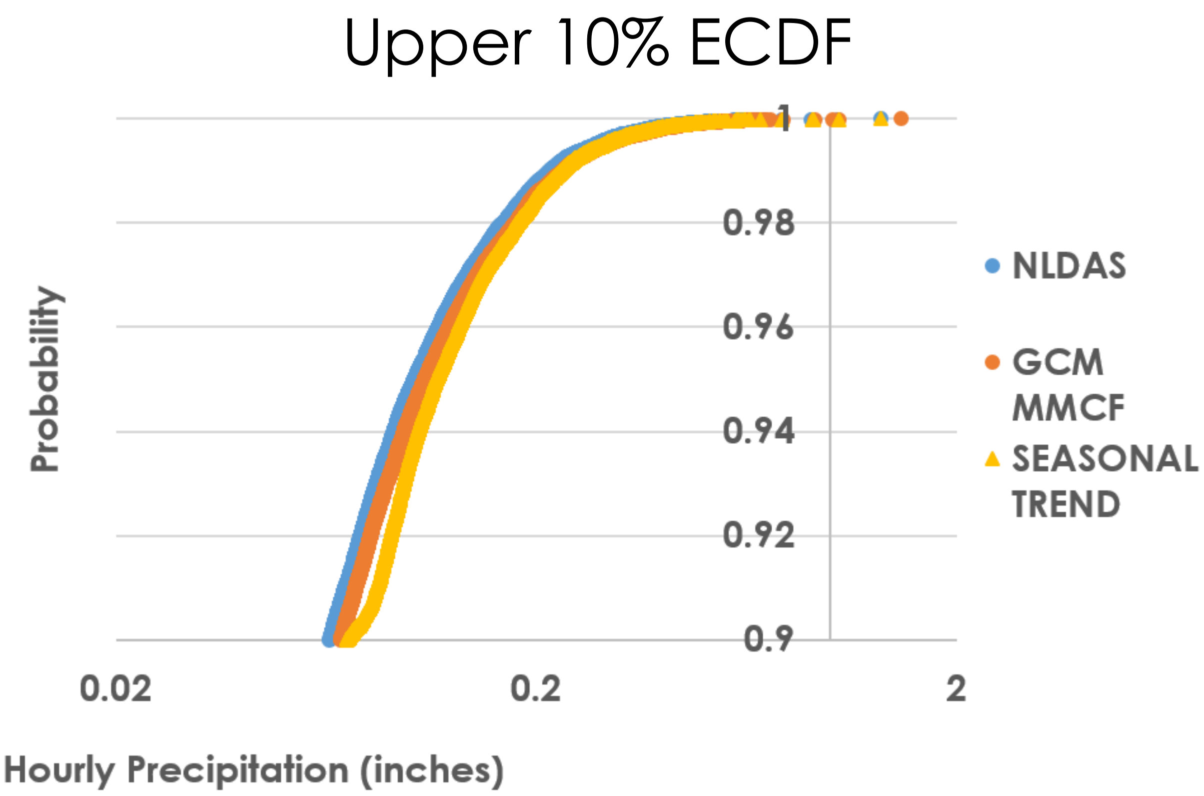
- Markstrom et al. (2012) concluded that simple statistical downscaling methods, such as the 'change factor' method, seem to perform as well as more sophisticated methods in reproducing mean climatic characteristics.

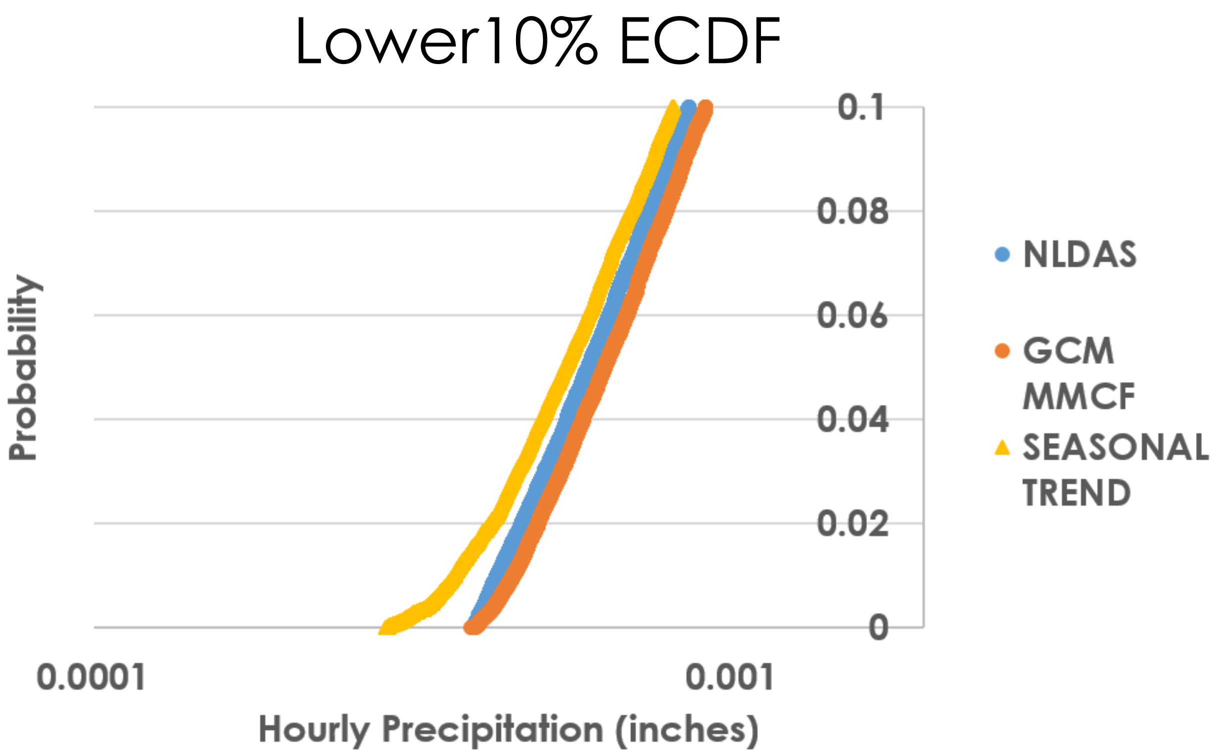
- GCM CCSM3, National Center for Atmospheric Research, USA (N30) was used to calculate the Mean Monthly Change Factors (MMCFs) (2055-2065)

$$P_{GCM}^{Month} \;/\; P_{XYZ}^{Month}$$



Representing Estimated Increased Precipitation Intensity in the 2050





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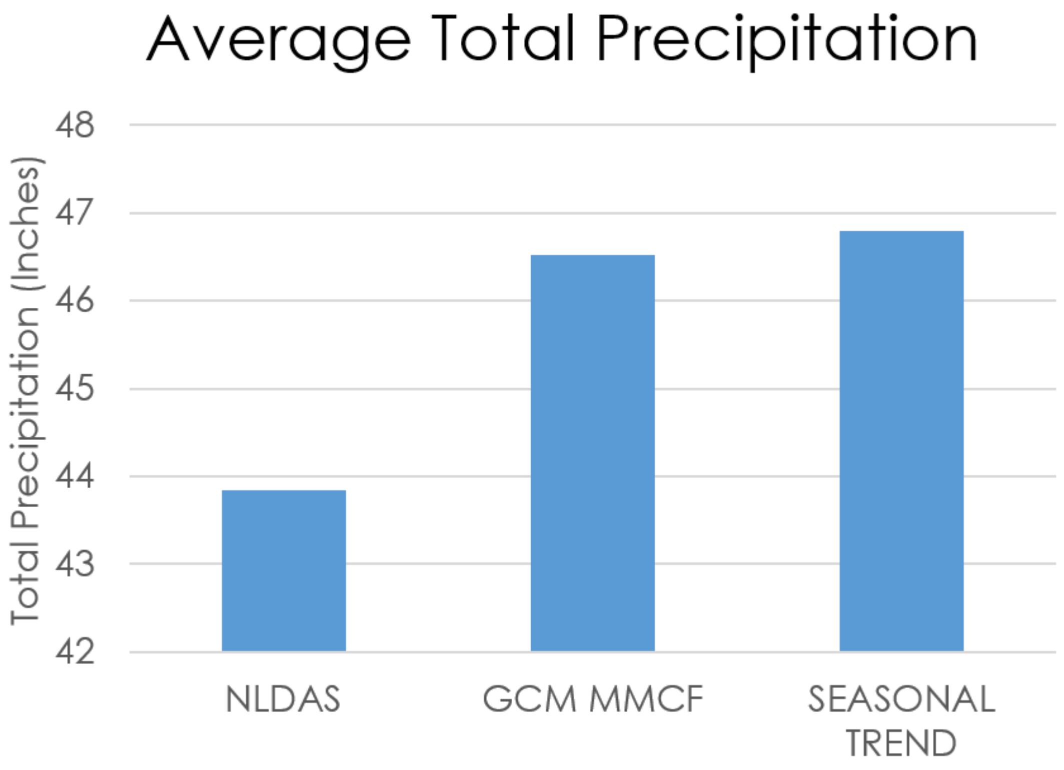
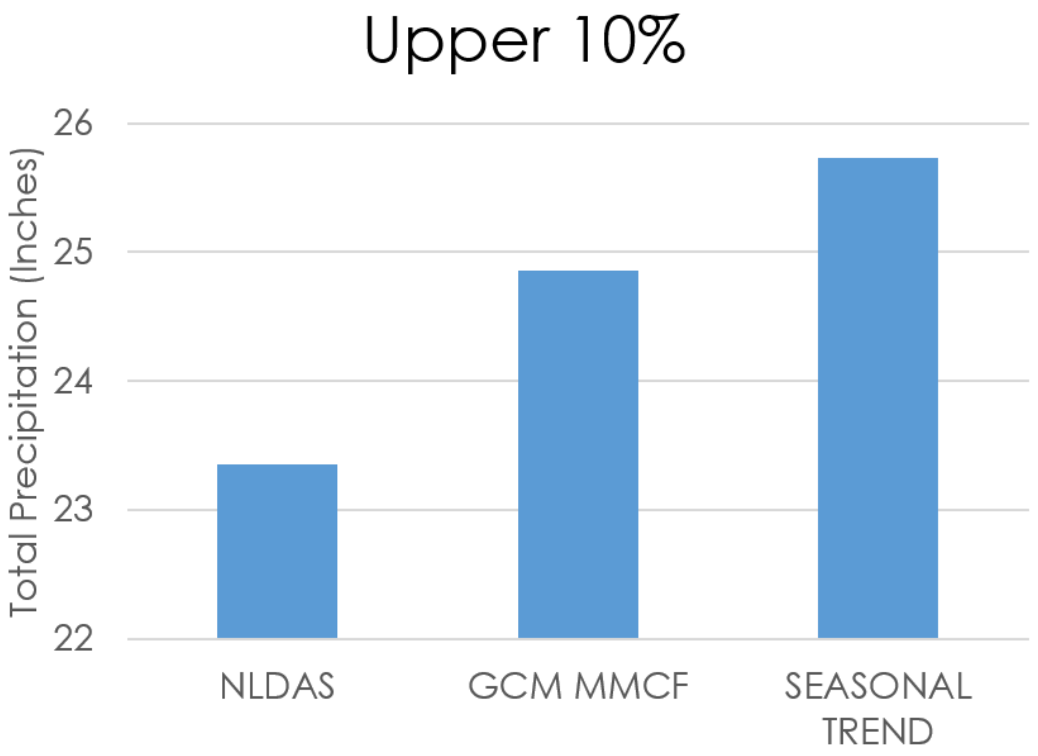
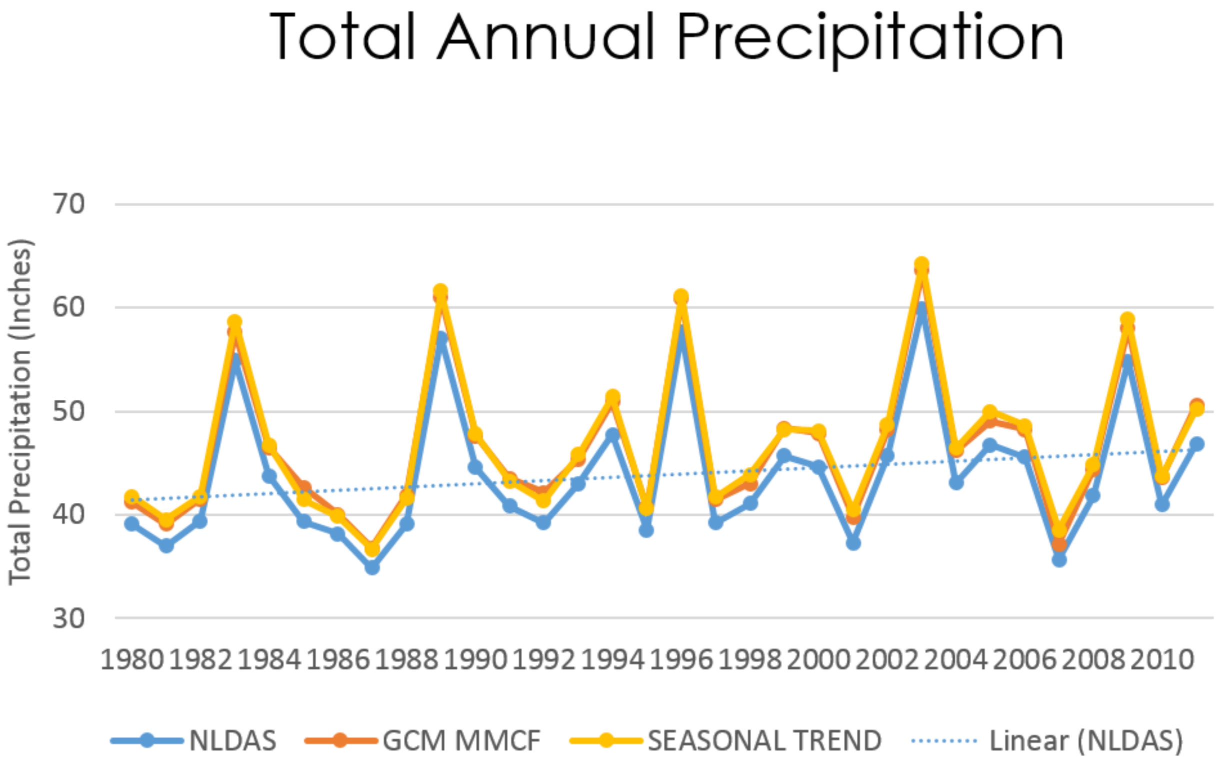
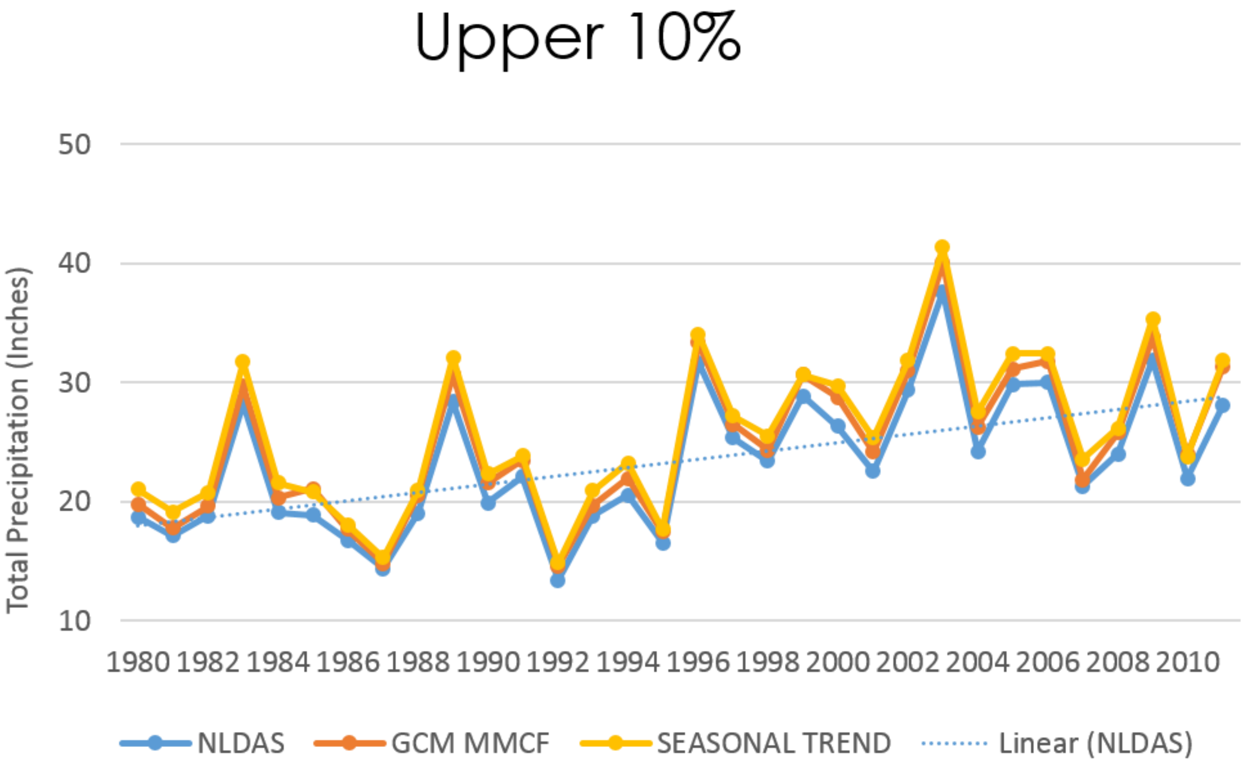


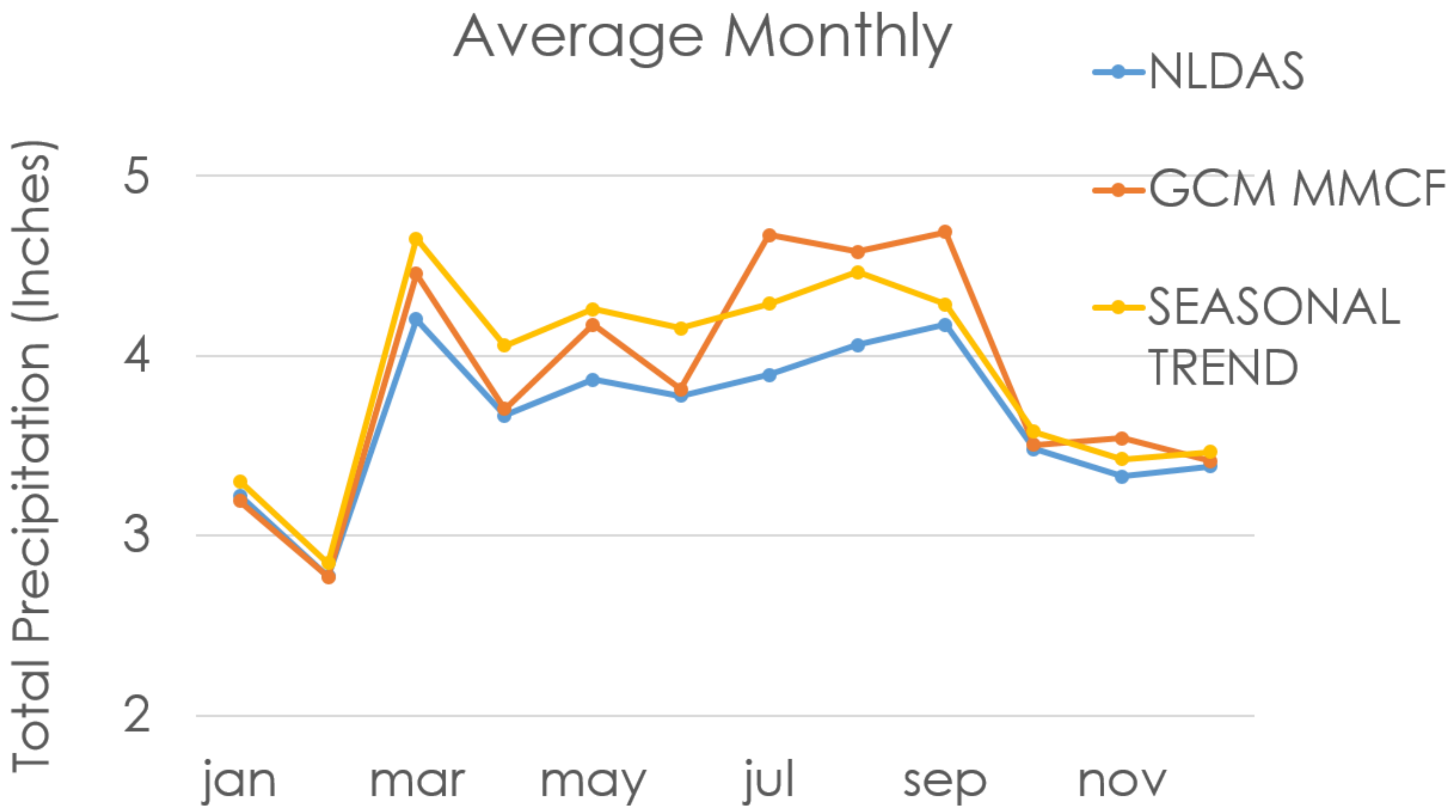


Representing Estimated Increased Precipitation Intensity in the 2050





Representing Estimated Increased Precipitation Intensity in the 2050



Conclusions

- Positive slopes in frequency and intensity of precipitation trends were identified in the upper tenth percentile of the distribution
- Trends of the precipitation frequency in the upper tenth percentile were higher in the Susquehanna Basin
- Trends of the precipitation intensity in the upper tenth percentile were higher in southern regions of the Chesapeake Bay Watershed.
- GCM mean monthly change factor approach (Markstrom et al., 2012) and the extrapolation of current trends in observed precipitation estimate similar 2050 precipitation conditions.

References

- Karl, T., and R. Knight. 1998. Secular Trends of Precipitation Amount, Frequency, and Intensity in the United States. *American Meteorological Society*.
- Markstrom, S., L. Hay, C. Ward-Garrison, J. Risley, W. Battaglin, D. Bjerklie, K. Chase, D. Christiansen, R. Dudley, R. Hunt, K. Koczot, M. Mastin, R. Regan, R. Viger, K. Vining, and J. Walker, 2012, Integrated watershed-scale response to climate change for selected basins across the United States: U.S. Geological Survey Scientific Investigations Report 2011–5077, 143 p.
- Melillo, J., T. Richmond, and G. Yohe. 2014. Climate Change Impacts in the United States: The Third National Climate Assessment. U.S. Global Change Research Program, 841 pp. doi:10.7930/J0Z31WJ2. Online at: nca2014.globalchange.gov
- Najjar, R., C. Pyke, M. Adams, D. Breitburg, C. Hershner, M. Kemp, R. Howarth, M. Mulholland, M. Mulholland, D. Secor, K. Sellner, D. Wardrop, and R. Woodm. 2010. Potential climate-change impacts on the Chesapeake Bay. *Estuarine, Coastal and Shelf Science 86 (2010) 1–20.*