Integrating Climate Change into the Chesapeake Bay Program Watershed Model: A Preliminary Approach

$$\int_{Climate_{t=0}}^{Climate_{t=35?}} CBP\ WSM$$

Kyle Hinson, Chesapeake Research Consortium/Chesapeake Bay Program Office

June 23, 2016

Climate Integration Objectives

- Determine estimate of expected changes to hydrology and temperature
- Apply estimates to the Chesapeake Bay Program's Watershed Model
- Assess changes in the level of restoration efforts needed

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- Determine estimate of expected changes to hydrology and temperature
  - Receive input from external scientific panel
  - Gather data for different RCPs
  - Apply downscaled data to watershed area, potentially work to bias correct simulations with NLDAS data record
  - Determine secondary effects of changes in precipitation and temperature, e.g. PET
- Apply estimates to the Chesapeake Bay Program's Watershed Model
  - Implement different RCP scenarios for the Watershed Model
  - Format output by jurisdictional, watershed level efforts
- Assess changes in the level of restoration efforts needed
  - Determine changes to expected watershed implementation plans (WIPs) among state and jurisdictional partners based on expected assessments of risk to TMDL goals

Prior CBP Efforts

- Guido Yactayo and Gopal Bhatt led efforts to develop rainfall projections using regression slopes from an extrapolation of 30 year rainfall datasets

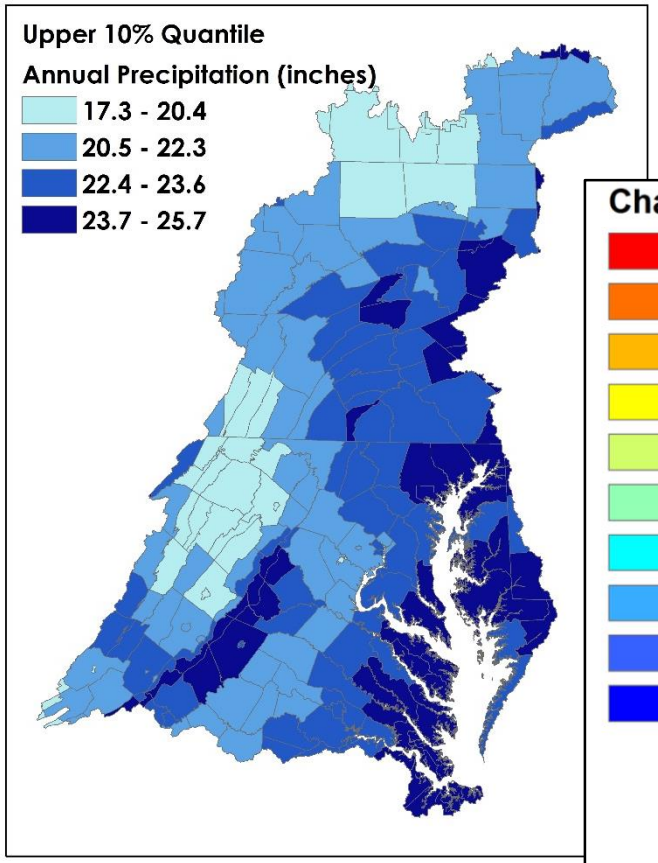
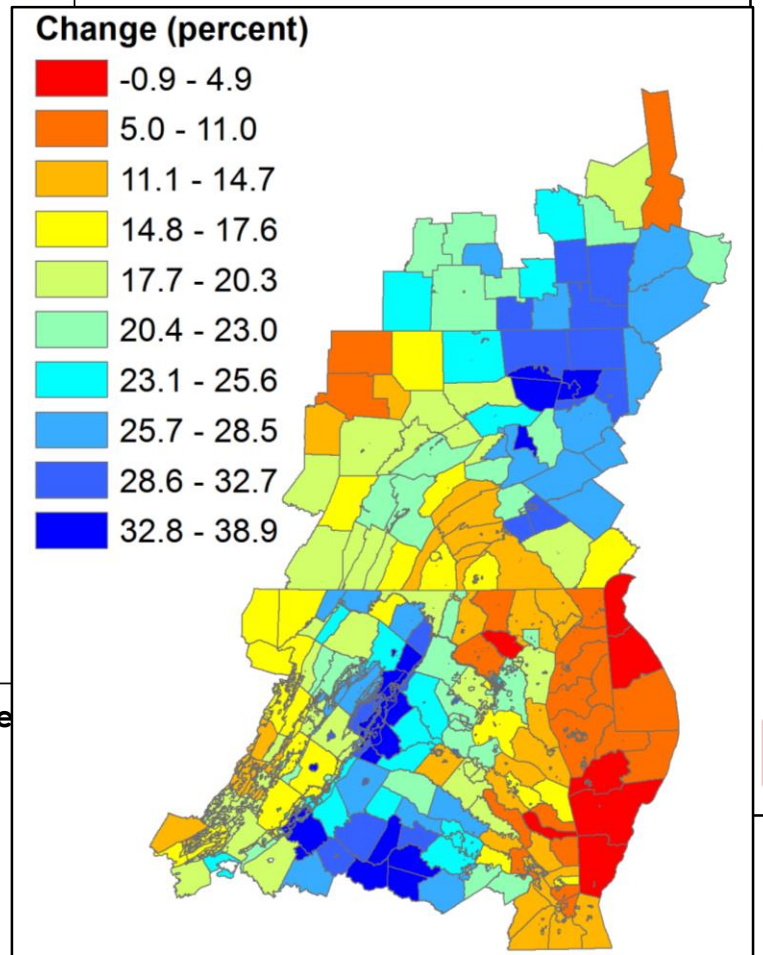
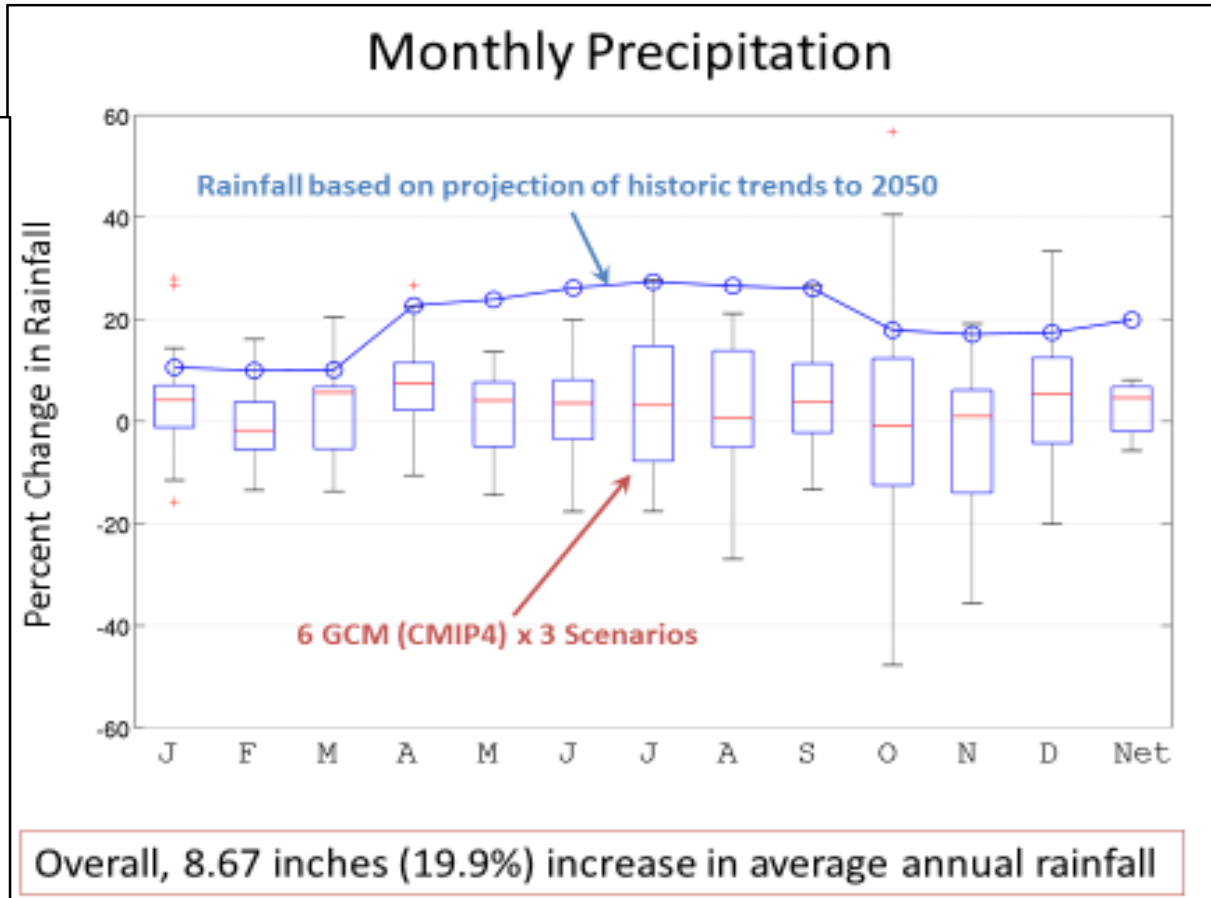


Figure. Total Precipitation within the Upper 10th Percentile in Chesapeake Bay Watershed.

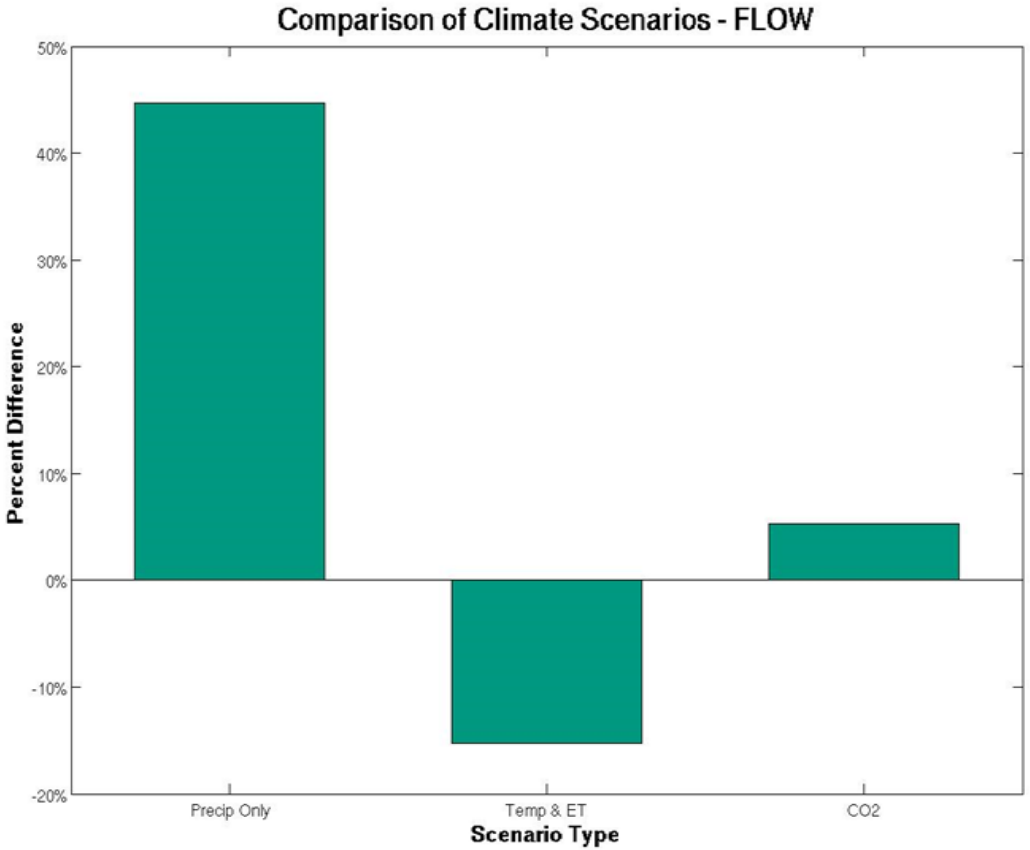


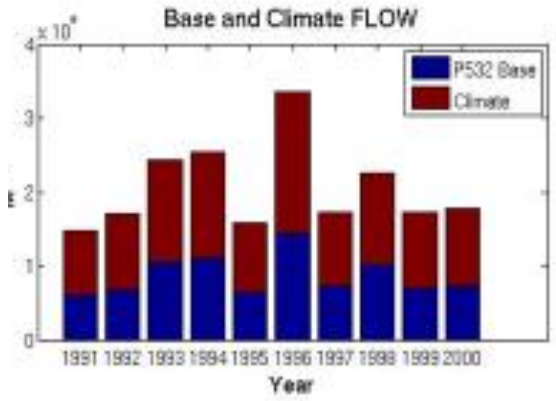


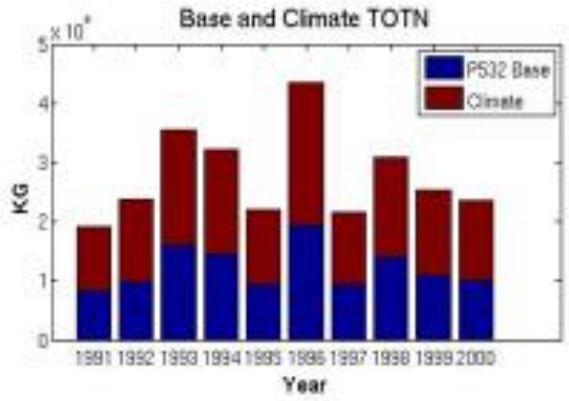
Overall, 8.67 inches (19.9%) increase in average annual rainfall

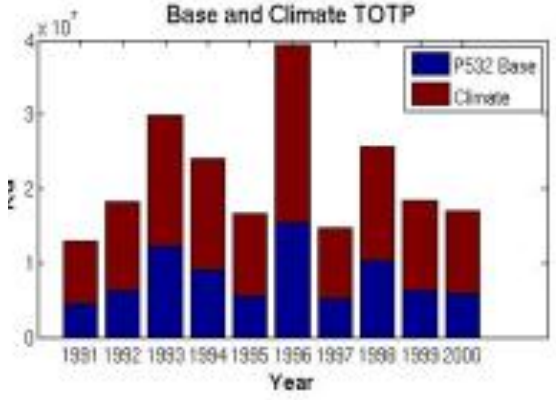
Prior CBP Efforts

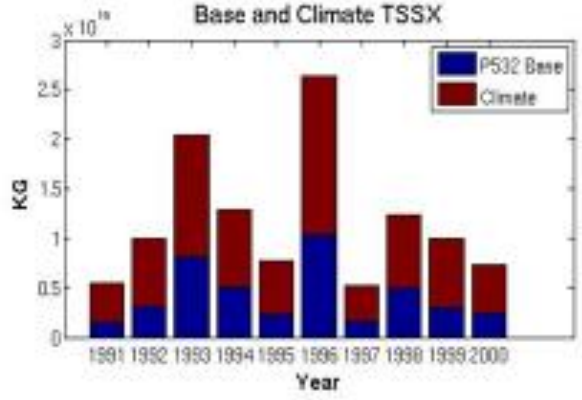
- The use of the extrapolation methodology and PET adjustment recommended by Butcher et al (2014) produced dramatic changes in flow and load outputs





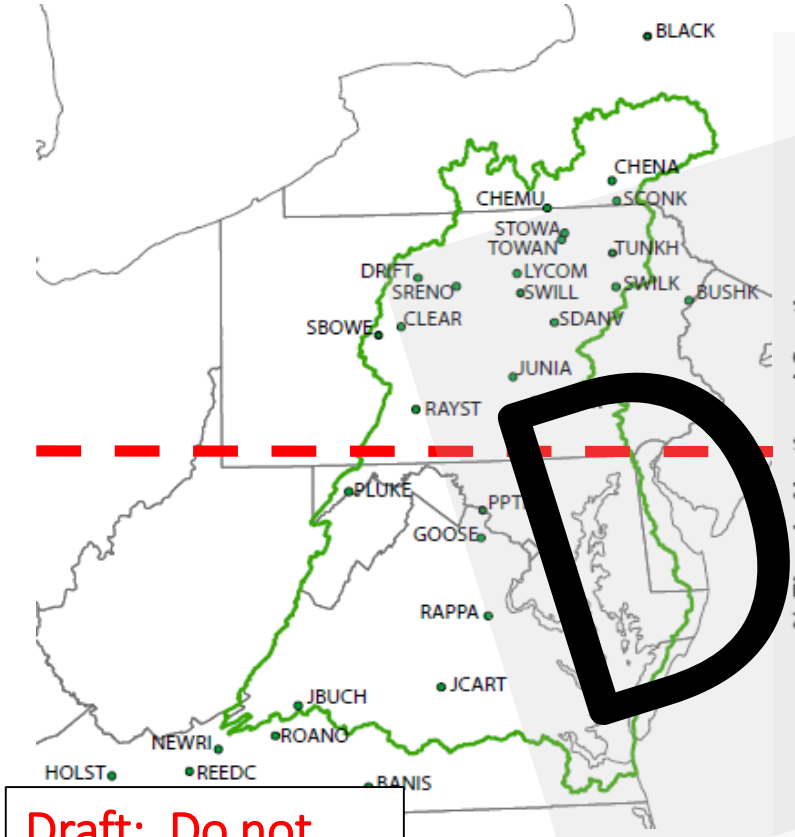


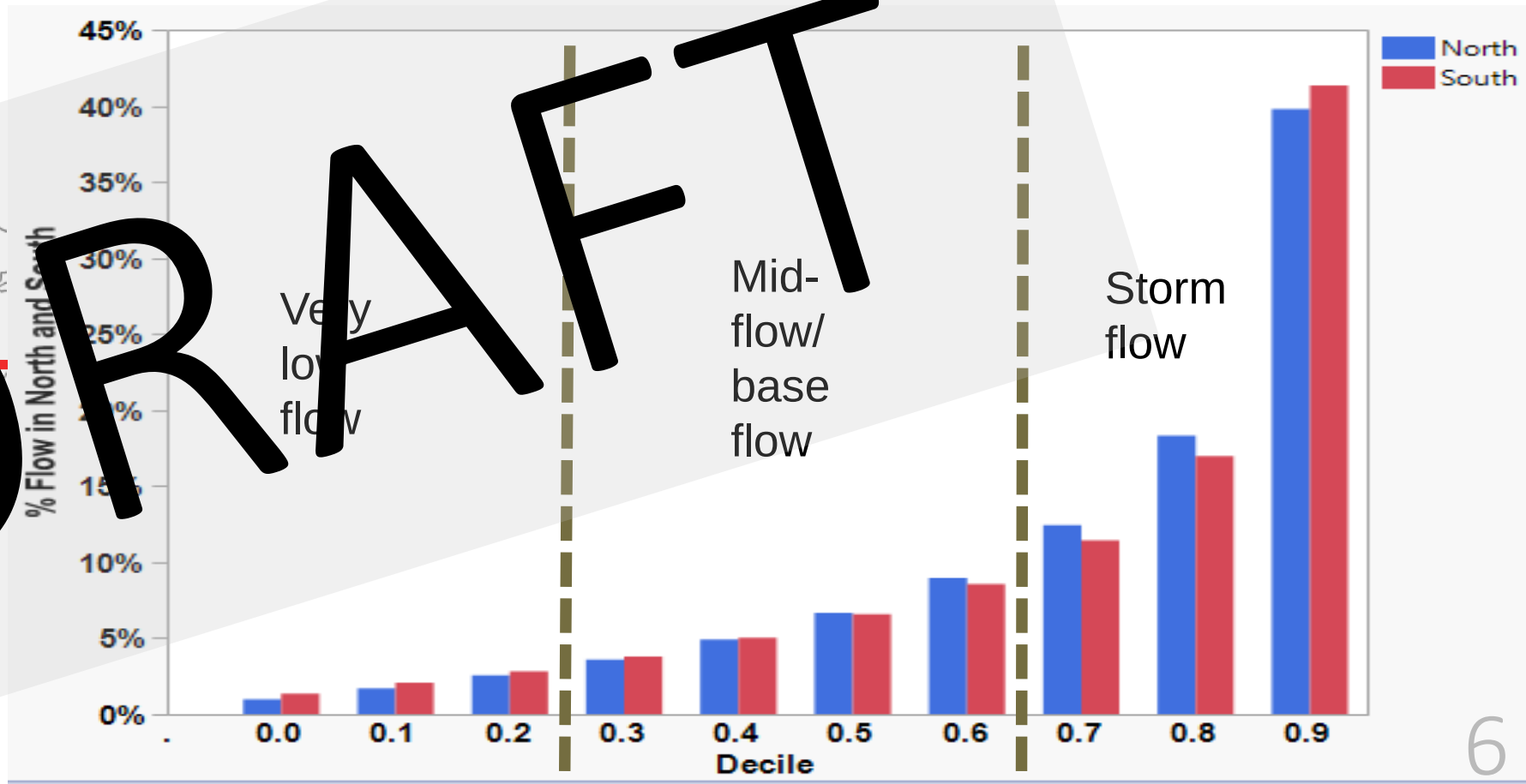




Partner Efforts/Multiple Method Approach

- Karen Rice, USGS VA Water Science Center, is studying changes in discharge and precipitation trends throughout the CB Watershed





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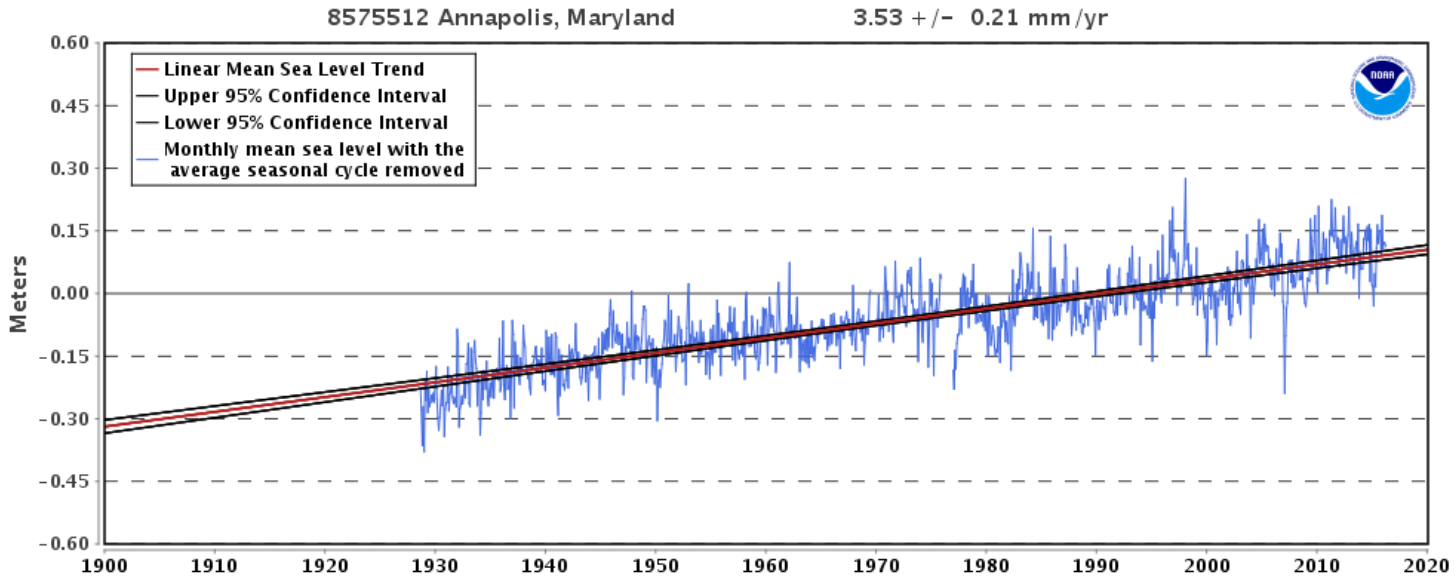
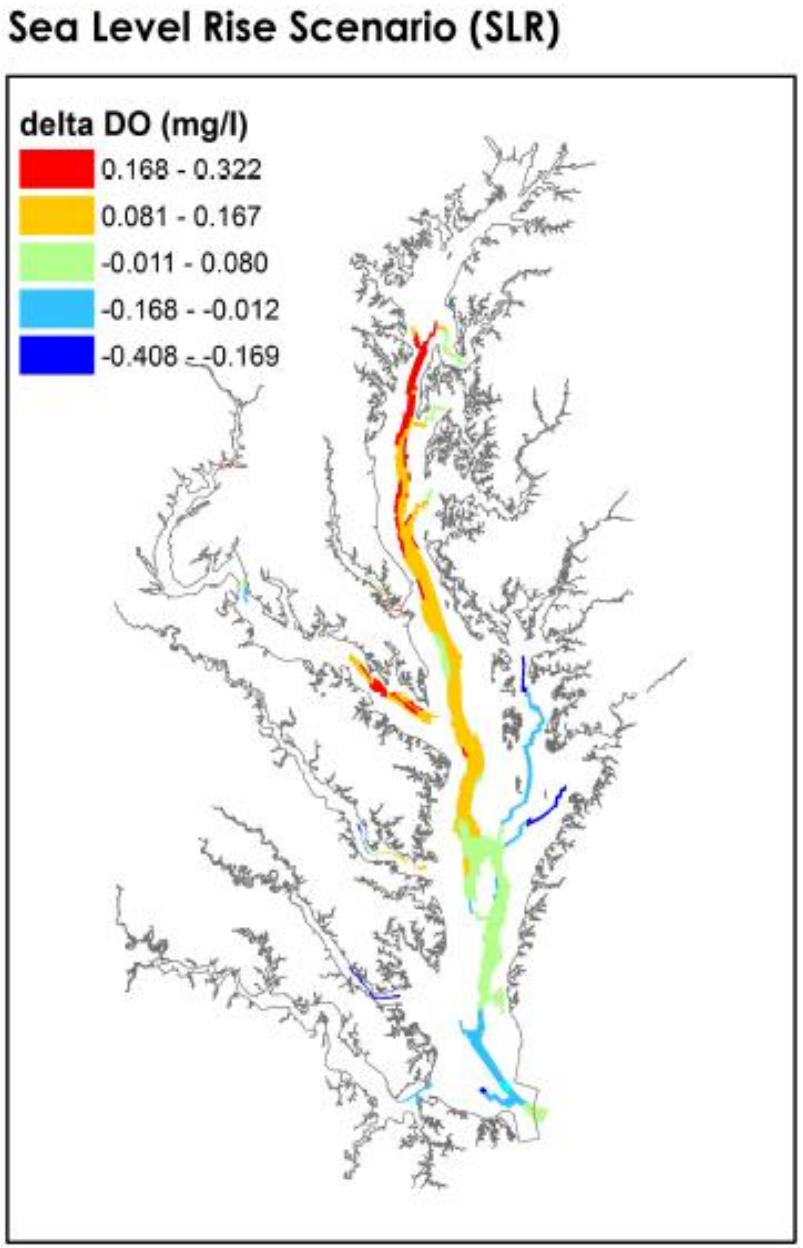
Partner Efforts (contd.)

- Ongoing work to categorize the extent of changes due to expected sea level rise, warming scenarios
- Combination of Carl Cerco's work regarding wetlands inundation as well as refinements to Bay-Wide local SLR rates provided by Capt. Emil Petruncio (USNA) and Robert Kopp (Rutgers University)

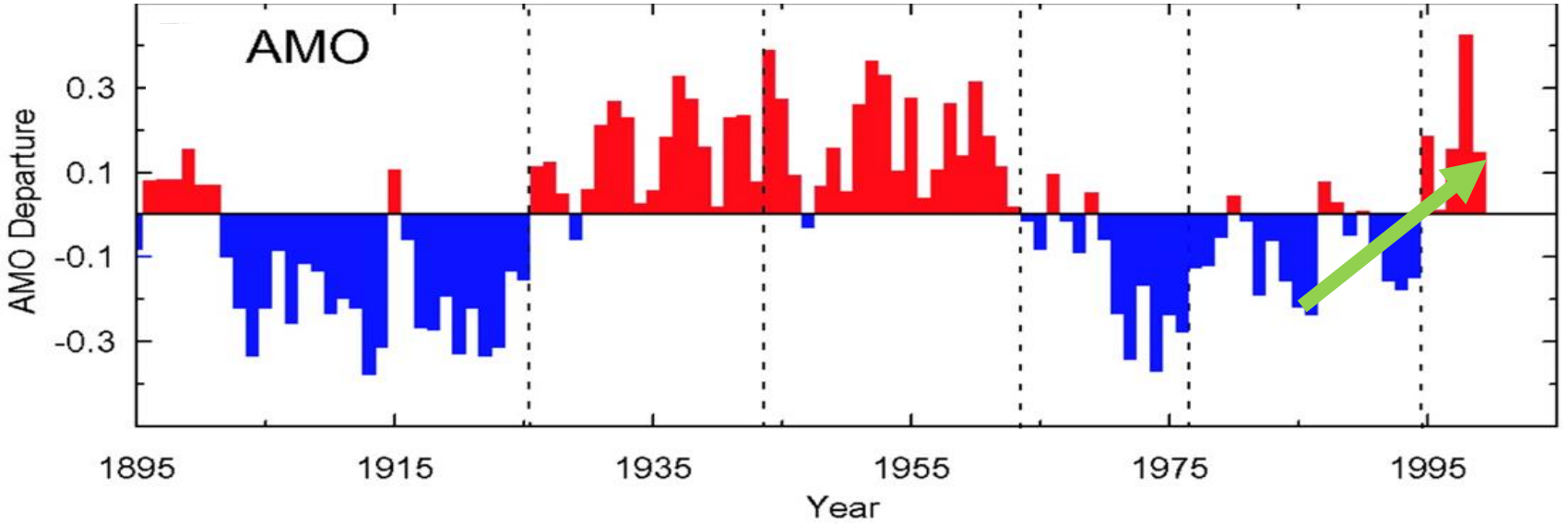


NOAA Tides and Currents: https://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?stnid=8575512



Recommendations from STAC

- The extrapolation of rainfall trends was determined by the CBP's Scientific and Technical Advisory Committee (STAC) to be, by itself, an insufficient representation of expected changes in precipitation
- The final report is still in progress
- Recommendations made thus far have been to use global climate model outputs from several representative concentration pathways (RCPs) in addition to current and prior efforts



Gregory J. McCabe et al. PNAS 2004;101:4136-4141

PNAS

Av[illegible] Climate Model Data

- Monthly [illegible]rojections for the year 2050 wer[illegible] spatial resolutions fo[illegible] Scenarios
  - Hijmans, Rober[illegible]esolution interpolated cli[illegible]obal land areas." *International journal of climato*[illegible]65-1978.
- Data are available for nu[illegible]els, [illegible] temporal ranges (monthly to sub-daily). Narrowing down[illegible] from these parameters is essential

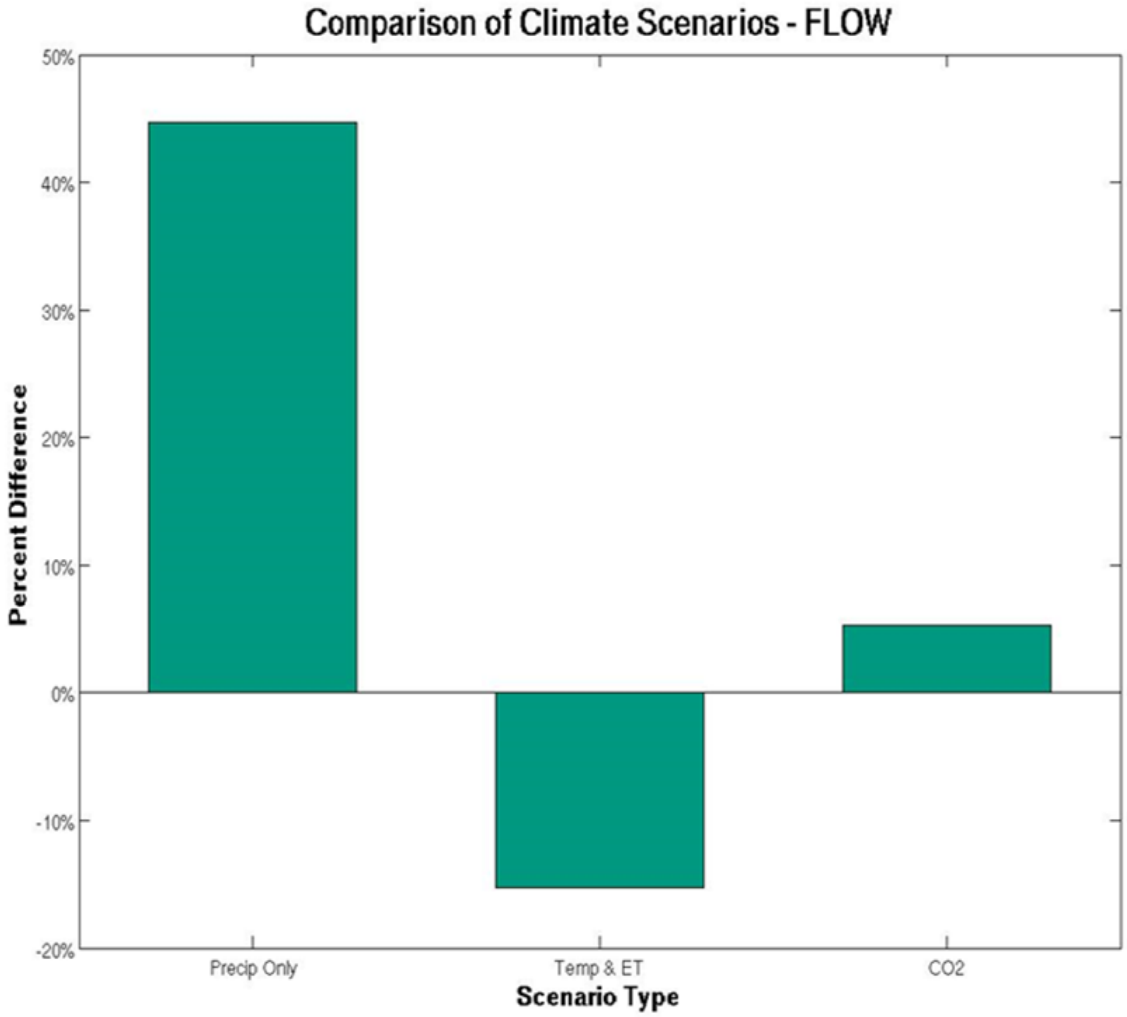
Within-grid cell variation (range of values) of (A) elevation, (B) annual precipitation, and (C) [illegible] on a 30 arc s (~1 km) spatial resolution grid within a 10 arc min (~18 km) grid. This figure is availab[illegible]
www.interscience.wiley.com/ijoc

USGS Data Download

- Click here to show the stuff

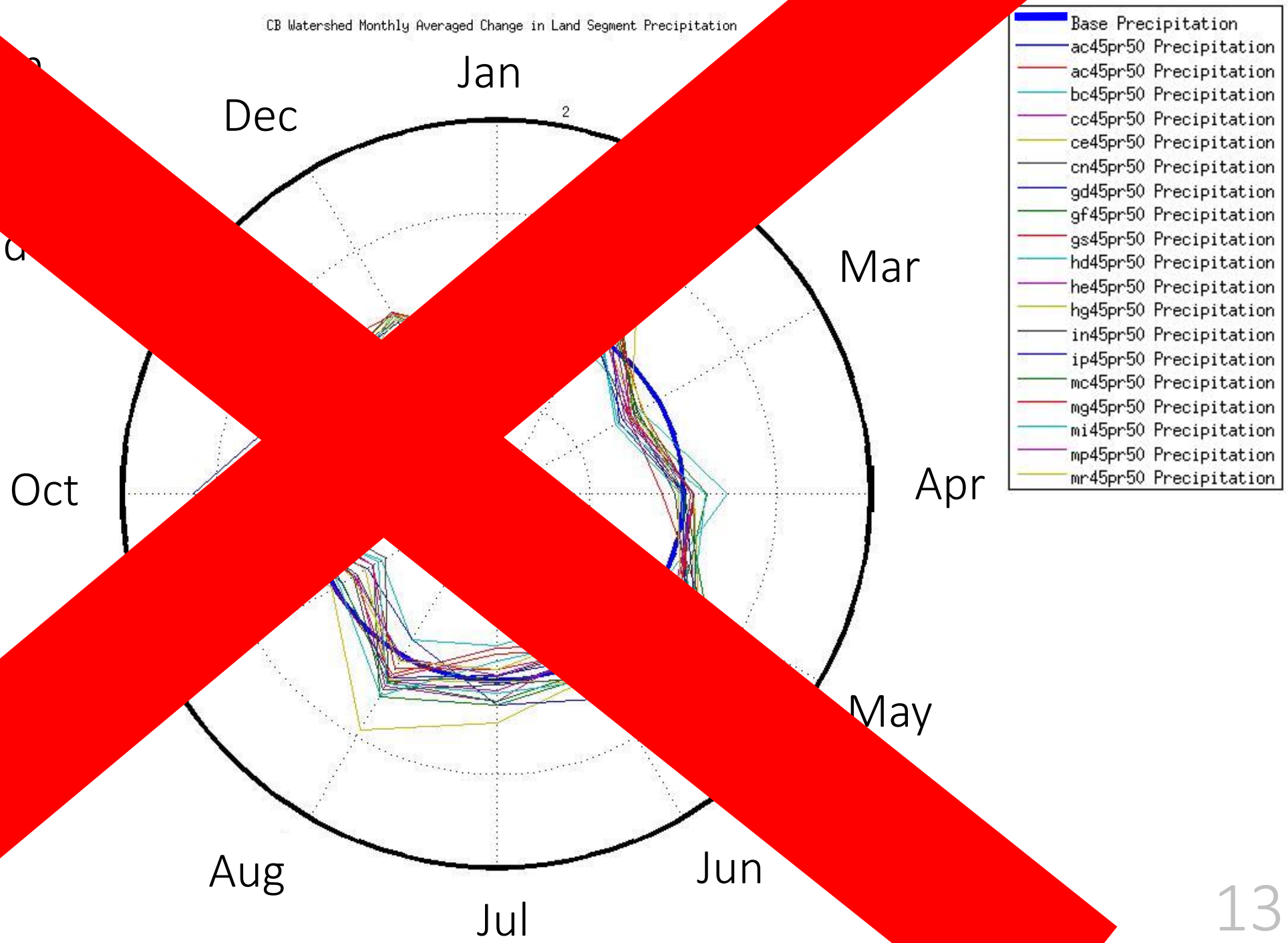
Motivators for Study of Precipitation

- Sensitivities to different climate variables were studied in the initial extrapolation method
- While most GCMs generally agree on increases in temperature, there can be large divergences in projections of precipitation volume and intensity among models
- Readily available monthly patterns may provide insights about the expected timing of watershed nutrient and sediment inputs



Initial Analysis

- RCP 4.5 [illegible]
  Downscale[illegible]
  Monthly Data
- Averaged for Land
  Segments in
  Chesapeake Bay
  Watershed



- RCP 4.5
  Downscaled
  Monthly Data,
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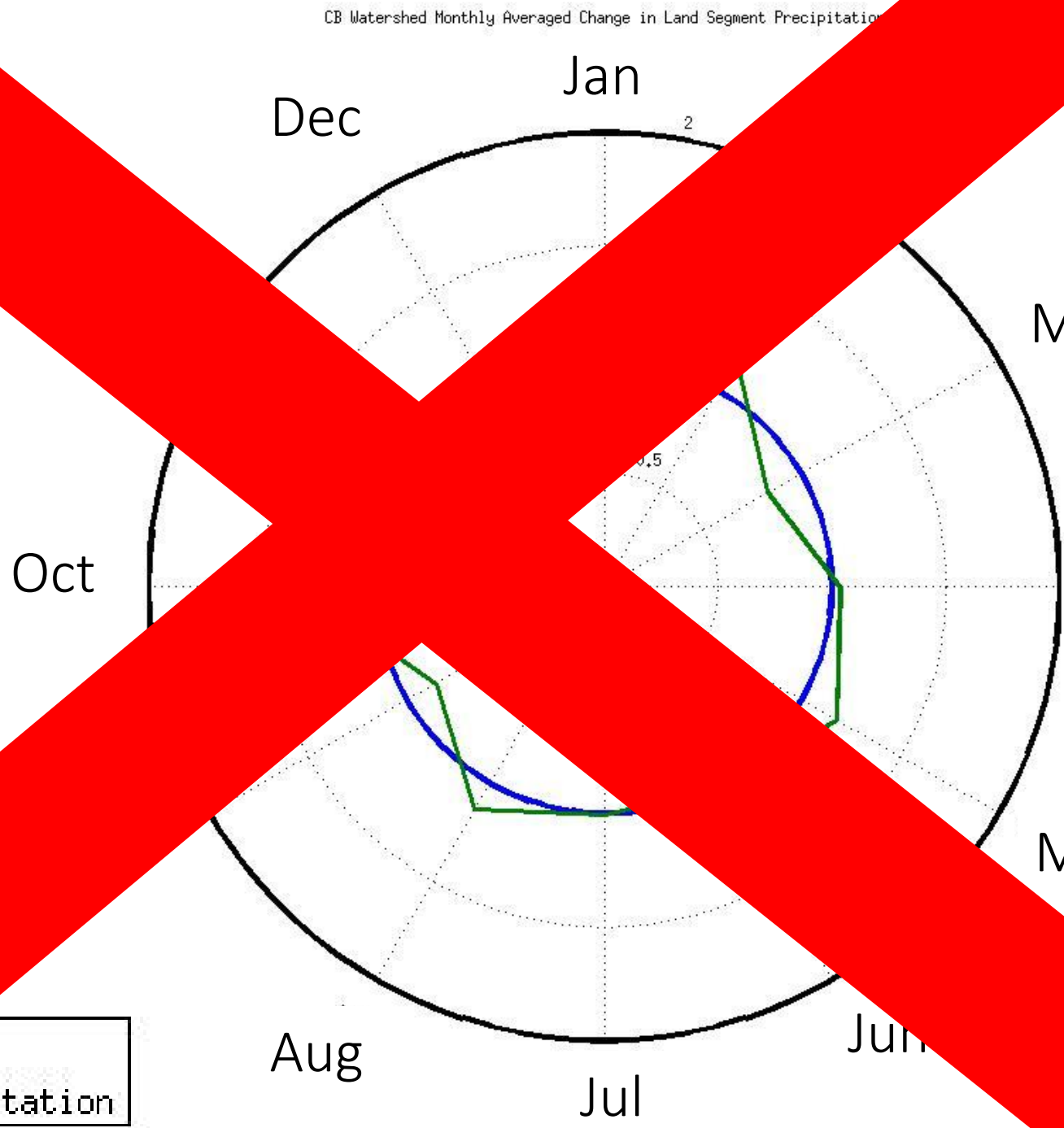
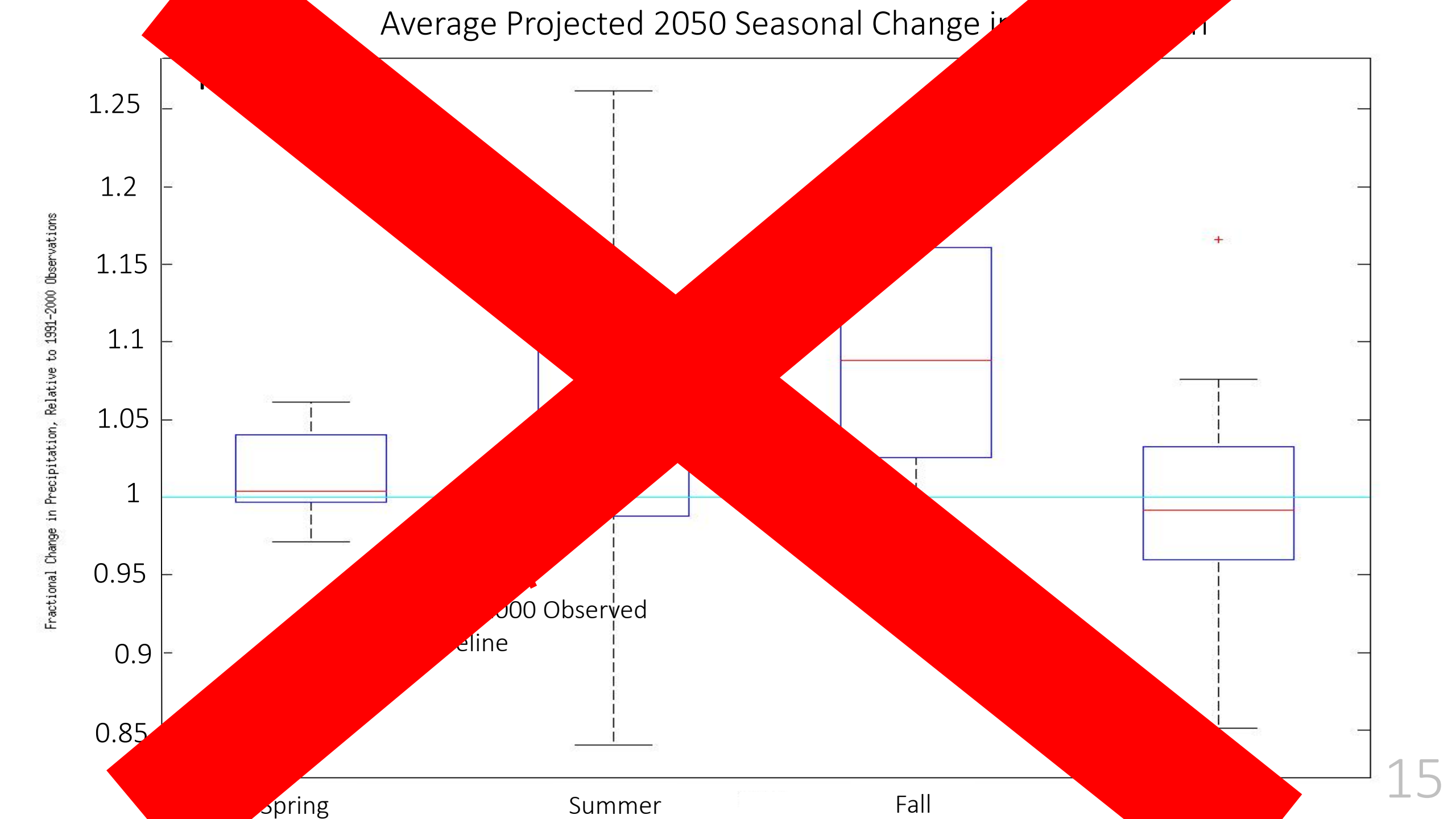
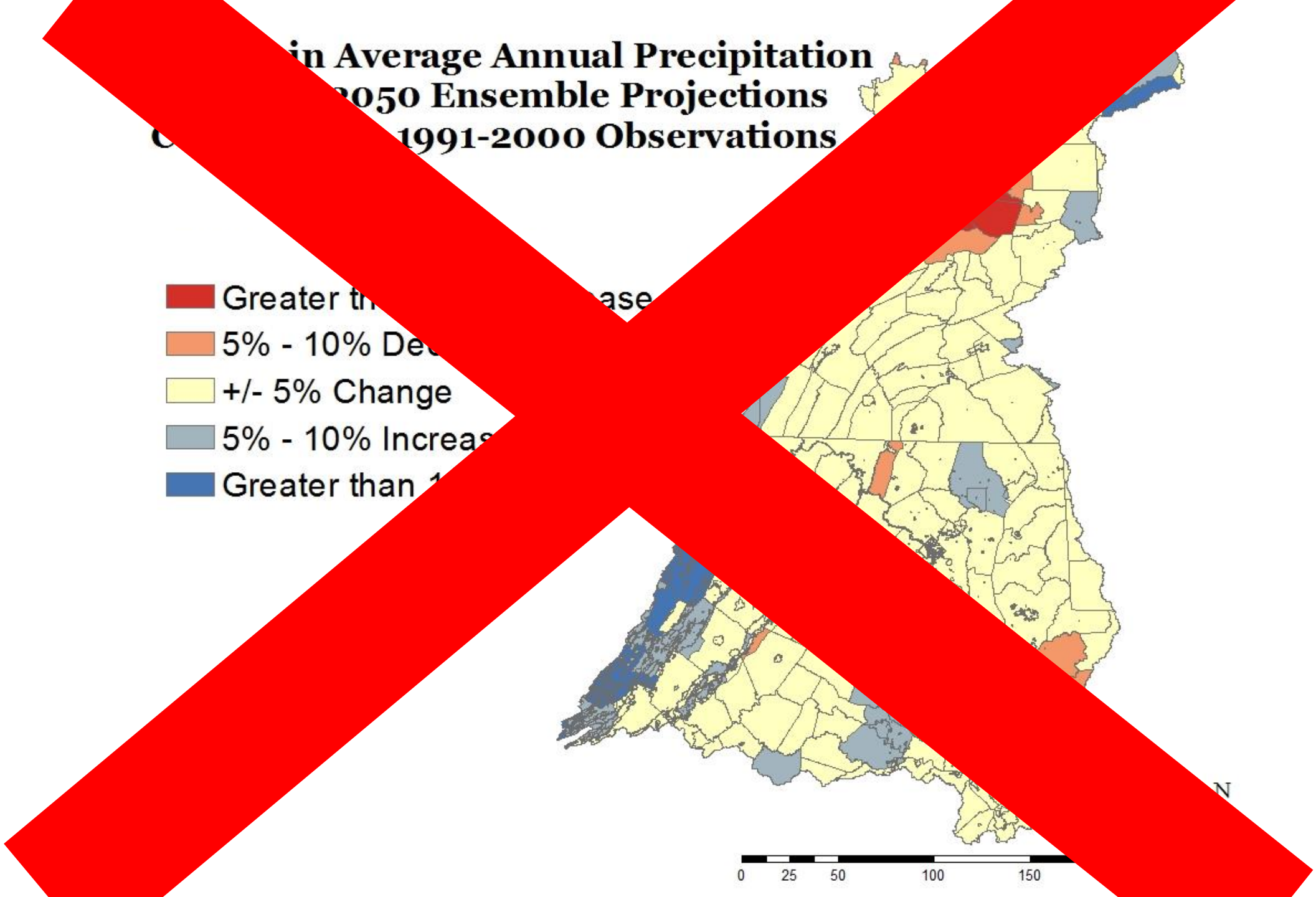


1.56% Increase in Total Precipitation


Average Projected 2050 Seasonal Change in
1.25
1.2
1.15
1.1
1.05
1
0.95
0.9
0.85
Fractional Change in Precipitation, Relative to 1991-2000 Observations
000 Observed
eline
Spring
Summer
Fall


in Average Annual Precipitation
2050 Ensemble Projections
1991-2000 Observations
Greater th
ase
5% - 10% De
+/- 5% Change
5% - 10% Increas
Greater than 1
N
0
25
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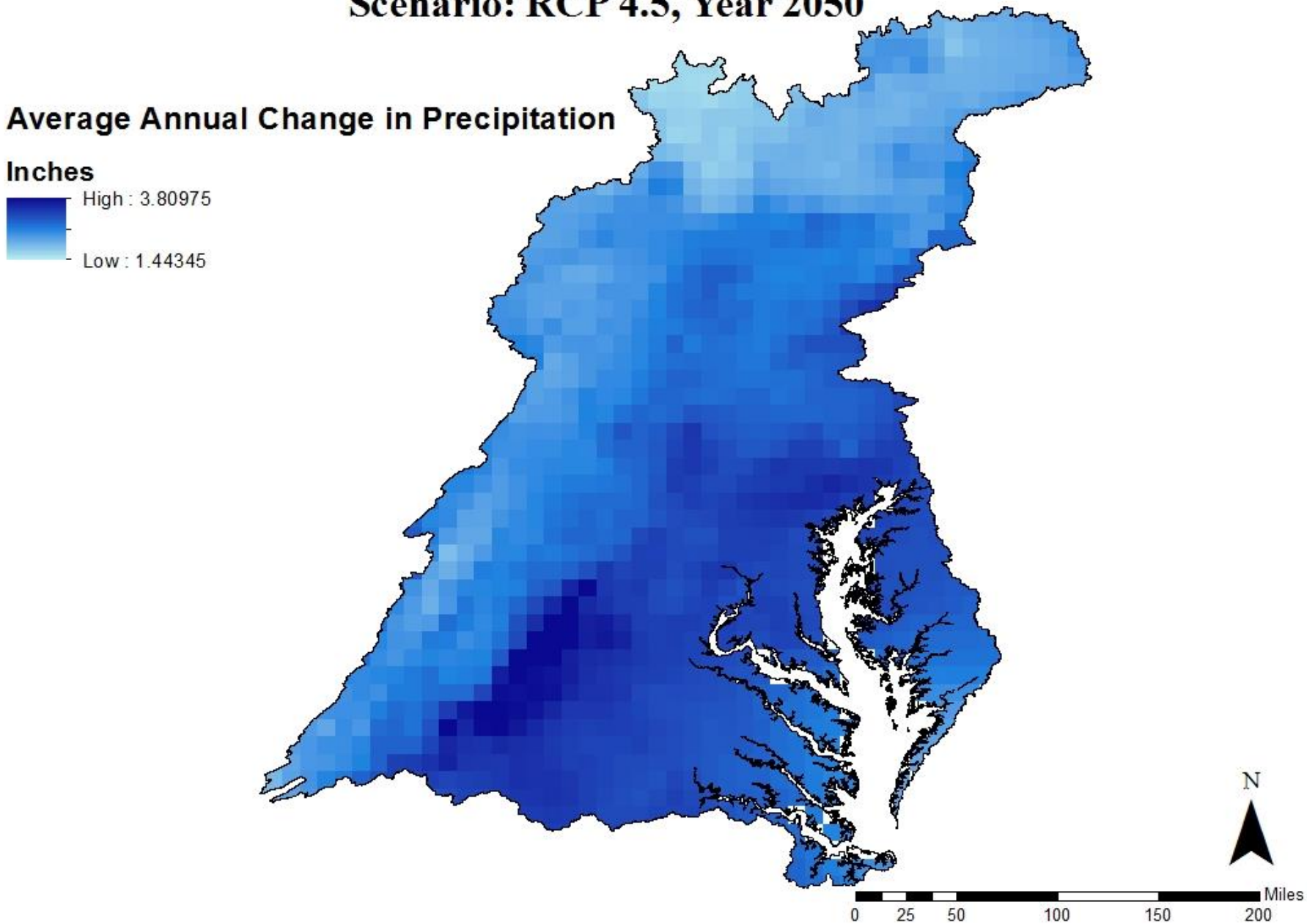
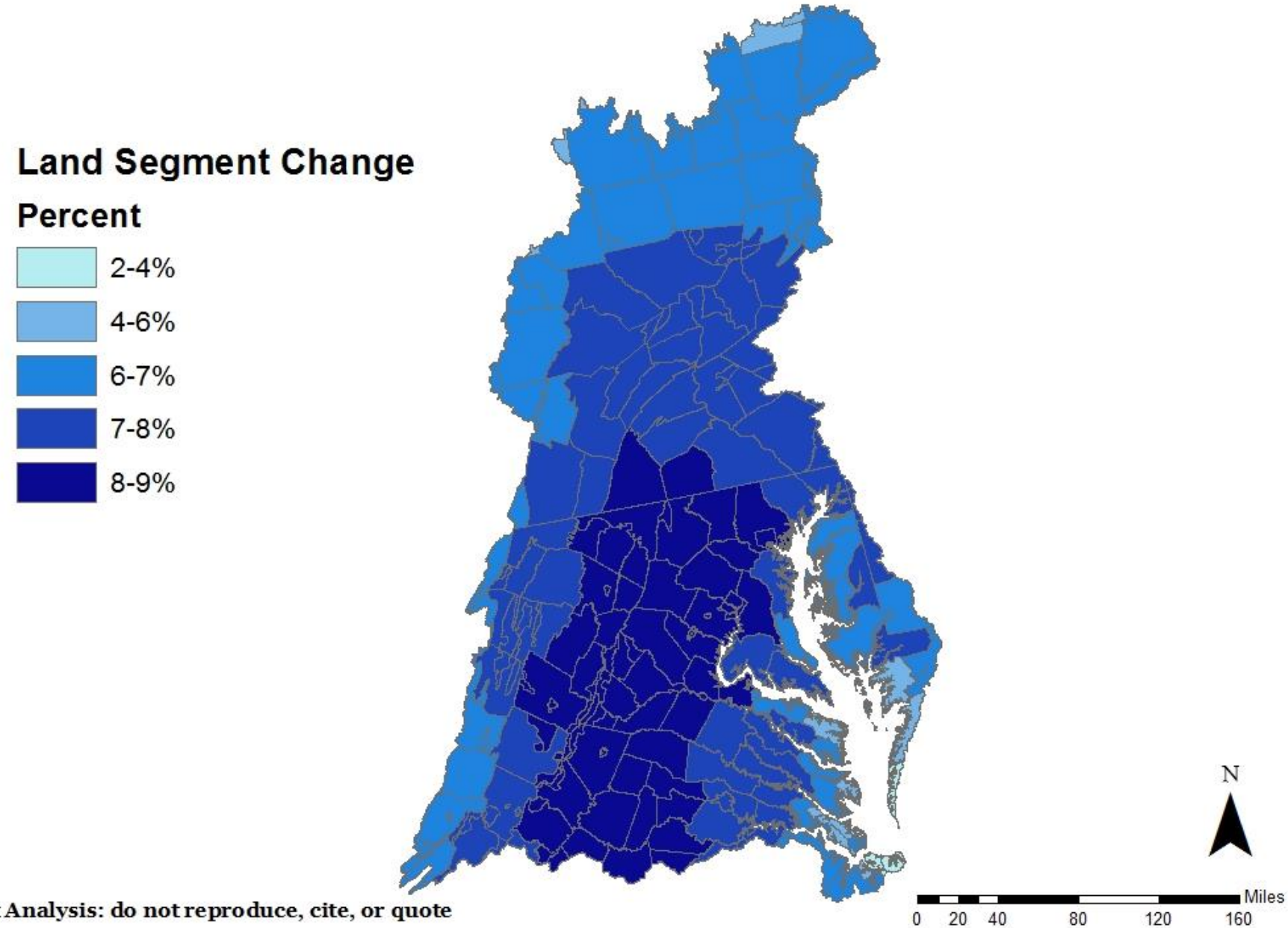
100
150

Projected Change in Precipitation in the Chesapeake Bay Watershed
Scenario: RCP 4.5, Year 2050



Percent Change in CB Land Segment Precipitation
RCP 4.5 Ensemble Model 2050 Projections



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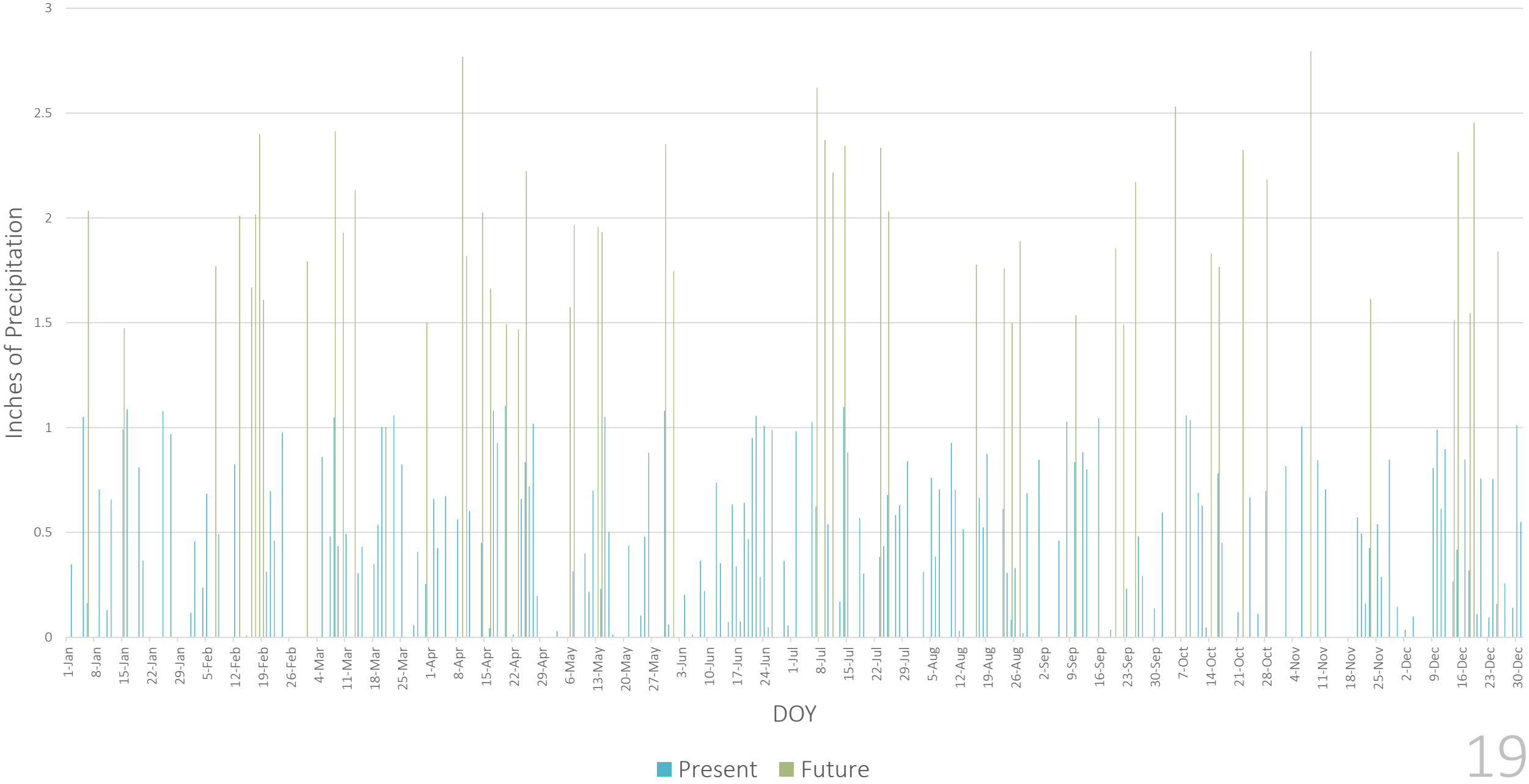
Example Distribution Change



Conclusions

- Precipitation volumes and intensities are increasing, shown in both historical and GCM datasets
- CB Program Modeling is oriented towards a multiple model/lines of evidence approach, interest in looking at long-term history, specific GCMs, or a combination of the two with an ensemble of GCMs
- The Chesapeake Bay Program will begin initial climate change scenario analysis by Fall 2016, and will produce its final decisions by Spring 2017 with respect to the inclusion of climate change considerations within the Phase 3 Watershed Implementation Plans

Questions?

Acknowledgements

- *"We acknowledge the World Climate Research Programme's Working Group on Coupled Modelling, which is responsible for CMIP, and we thank the climate modeling groups (listed in Table XX of this paper) for producing and making available their model output. For CMIP the U.S. Department of Energy's Program for Climate Model Diagnosis and Intercomparison provides coordinating support and led development of software infrastructure in partnership with the Global Organization for Earth System Science Portals."*