Climate Change 2.0: Where Do We Go From Here?

Scientific and Technical Advisory Committee
Quarterly Meeting
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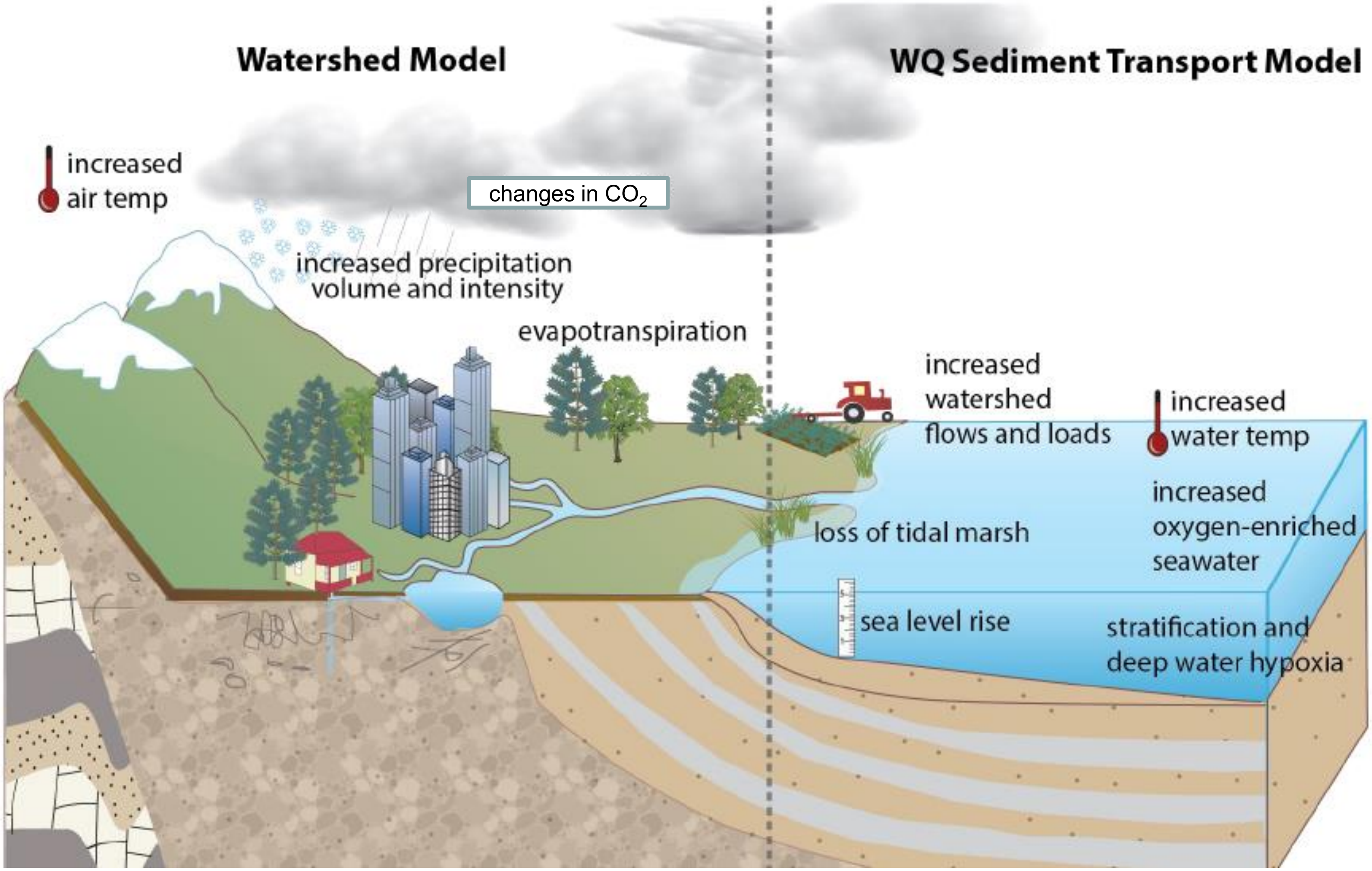
The 2019 CBP Climate Change Assessment

- The CBP is developing the tools to quantify the effects of climate change on Chesapeake water quality standards through changes in watershed flows and loads, storm intensity, estuarine temperatures, sea level rise, and ecosystem influences including loss of tidal wetland attenuation with sea level rise.
- Current efforts are to frame initial future climate change scenarios based on estimated 2025 (short term), 2035 (moderate term), and 2050 conditions (long term) by the close of 2019.
- We should also keep in mind the potential long-term task of developing a 2025 Next Generation Model to support CBP decision making in 2025. The sequence of a 2019 and 2025 build of a CBP climate change analysis provides the opportunity of considering foundational strategic investments for 2019.

Accounting for Changing Conditions



Approaches, Methods, and Findings from the Watershed

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Analysis of Climate Change in the Chesapeake Watershed

For the analysis of climate change in the Chesapeake watershed, the primary components considered are precipitation volume, precipitation intensity, temperature, and evapotranspiration with an additional consideration to CO_2 concentrations.

Overall, increased precipitation volumes and intensity are estimated to increase nutrient and sediment loads from the watershed in 2025, 2035, and 2050 compared to 1995.

However, increased future temperatures substantially ameliorates the effect of estimated increased precipitation volume in the watershed through evapotranspiration.

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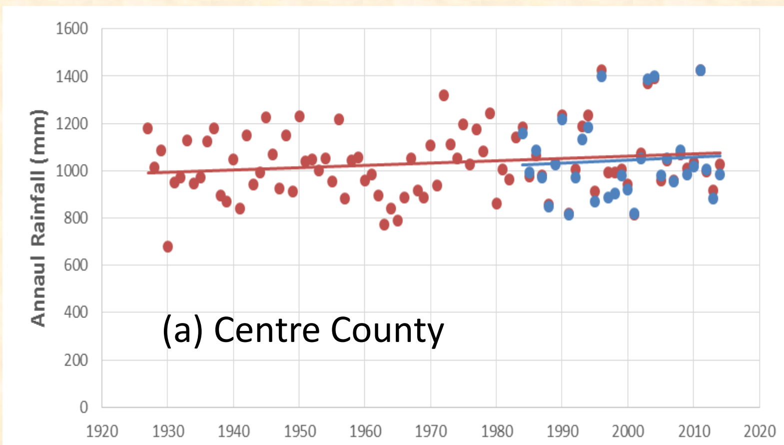
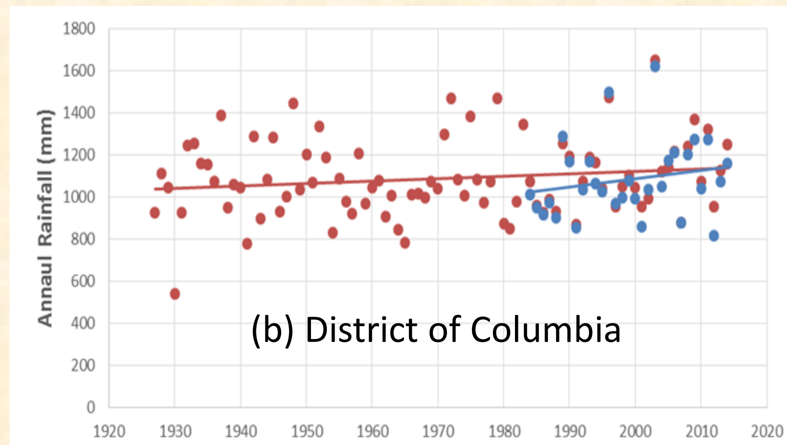
For the 2025 Climate Change Estimate:

The trends in annual precipitation on a county level were developed through the application of PRISM data and analysis provided and recommended by Jason Lynch, EPA, and Karen Rice, USGS. The annual PRISM dataset for the years 1927 to 2014 (88 years) were used in for the regression trend analysis. For the analysis PRISM data were first spatially aggregated for each Phase 6 land segments. The Phase 6 land segments typically represent a county. For each land segment a simple linear trend was fitted to the annual rainfall dataset.





Annual rainfall volumes for the 88-year period linear regression lines are shown in red for the two land segments (counties) – (a) Centre County in Pennsylvania and (b) District of Columbia. The values for the slope of the regression lines, and the corresponding 30-year projections in the rainfall volume (1995 to 2025) are also shown.

Source: Section 12 of Phase 6 Documentation

Assessment of Influence of 2025 Climate Change in the Watershed

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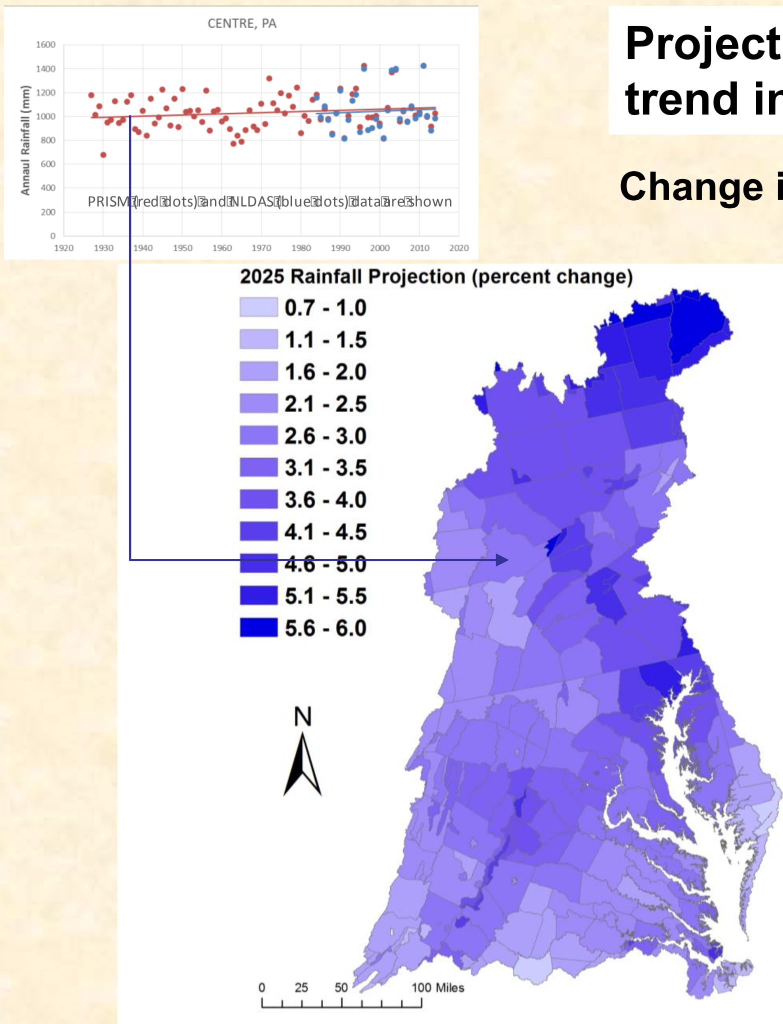

Projections of rainfall increase using trend in 88-years of annual PRISM[1] data

Change in Rainfall Volume 2021-2030 vs. 1991-2000

Major Basins	PRISM Trend
Youghiogheny River	2.1%
Patuxent River Basin	3.3%
Western Shore	4.1%
Rappahannock River Basin	3.2%
York River Basin	2.6%
Eastern Shore	2.5%
James River Basin	2.2%
Potomac River Basin	2.8%
Susquehanna River Basin	3.7%
Chesapeake Bay Watershed	**3.1%**

[1] Parameter-elevation Relationships on Independent Slopes Model

1940-2014 streamflow trends based on observations

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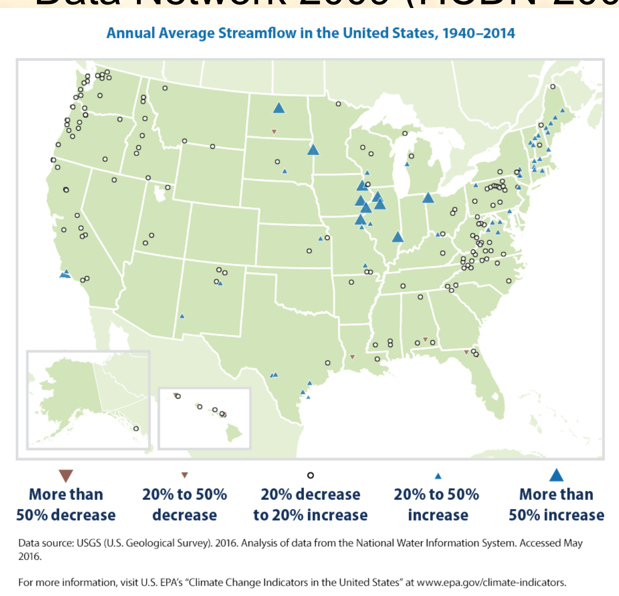
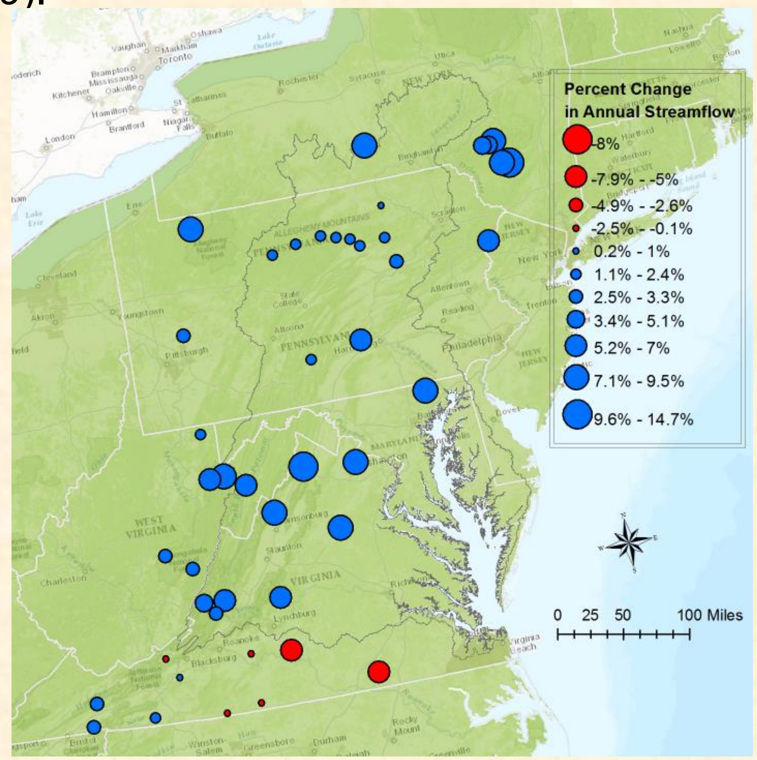
The study analyzed USGS GAGES-II data for a subset of Hydro-Climatic Data Network 2009 (HCDN-2009).





U.S. Environmental Protection Agency. 2016. Climate change indicators in the United States, 2016. Fourth edition. EPA 430-R-16-004. www.epa.gov/climate-indicators.

Karen C. Rice, Douglas L. Moyer, and Aaron L. Mills, 2017. Riverine discharges to Chesapeake Bay: Analysis of long-term (1927 - 2014) records and implications for future flows in the Chesapeake Bay basin *JEM* 204 (2017) 246-254

USGS station ID	Precipitation		Discharge	
	Slope	p-value	Slope	p-value
04252500	0.0007	**0.0011**	0.0021	**<0.0001**
01512500	0.0008	**0.0007**	0.0016	**0.0028**
01503000	0.0007	**0.0022**	0.0013	**0.0181**
01531000	0.0006	**0.0219**	0.0018	**0.0030**
01531500	0.0007	**0.0044**	0.0016	**0.0029**
01532000	0.0006	**0.0374**	0.0015	**0.0330**
01534000	0.0005	**0.0497**	0.0015	**0.0120**
01550000	0.0005	**0.0493**	0.0019	**0.0015**
01543000	0.0004	0.1000	0.0018	**0.0058**
01545500	0.0004	0.0953	0.0017	**0.0026**
01536500	0.0006	**0.0078**	0.0016	**0.0027**
01551500	0.0005	0.0612	0.0017	**0.0017**
01439500	0.0005	0.0972	0.0007	0.1661
01541500	0.0003	0.2357	0.0017	**0.0017**
01540500	0.0006	**0.0111**	0.0016	**0.0023**
01541000	0.0004	0.0985	0.0016	**0.0021**
01567000	0.0004	0.1577	0.0011	**0.0250**
01570500	0.0005	**0.0260**	0.0013	**0.0088**
North-South Split				
01562000	0.0004	0.1693	0.0007	0.2082
01638500	0.0004	0.1150	0.0008	0.1026
01608500	0.0004	0.1725	0.0010	0.0833
01636500	0.0005	0.1245	0.0008	0.0624
01606500	0.0003	0.1958	0.0009	0.1108
01668000	0.0006	0.0794	0.0004	0.4727
02035000	0.0003	0.2653	−0.0001	0.8243
02019500	0.0002	0.4333	0.0003	0.4836
03488000	0.0003	0.2480	0.0006	0.2841

Annual average percent change were calculated using Sen slope (Helsel and Hirsch, 2002).

Lins, H.F. 2012. USGS Hydro-Climatic Data Network 2009 (HCDN-2009). U.S. Geological Survey Fact Sheet 2012-3047. https://pubs.usgs.gov/fs/2012/3047.
Helsel, D.R., and R.M. Hirsch. 2002. Statistical methods in water resources. Techniques of water resources investigations, Book 4. Chap. A3. U.S. Geological Survey. https://pubs.usgs.gov/twri/twri4a3.

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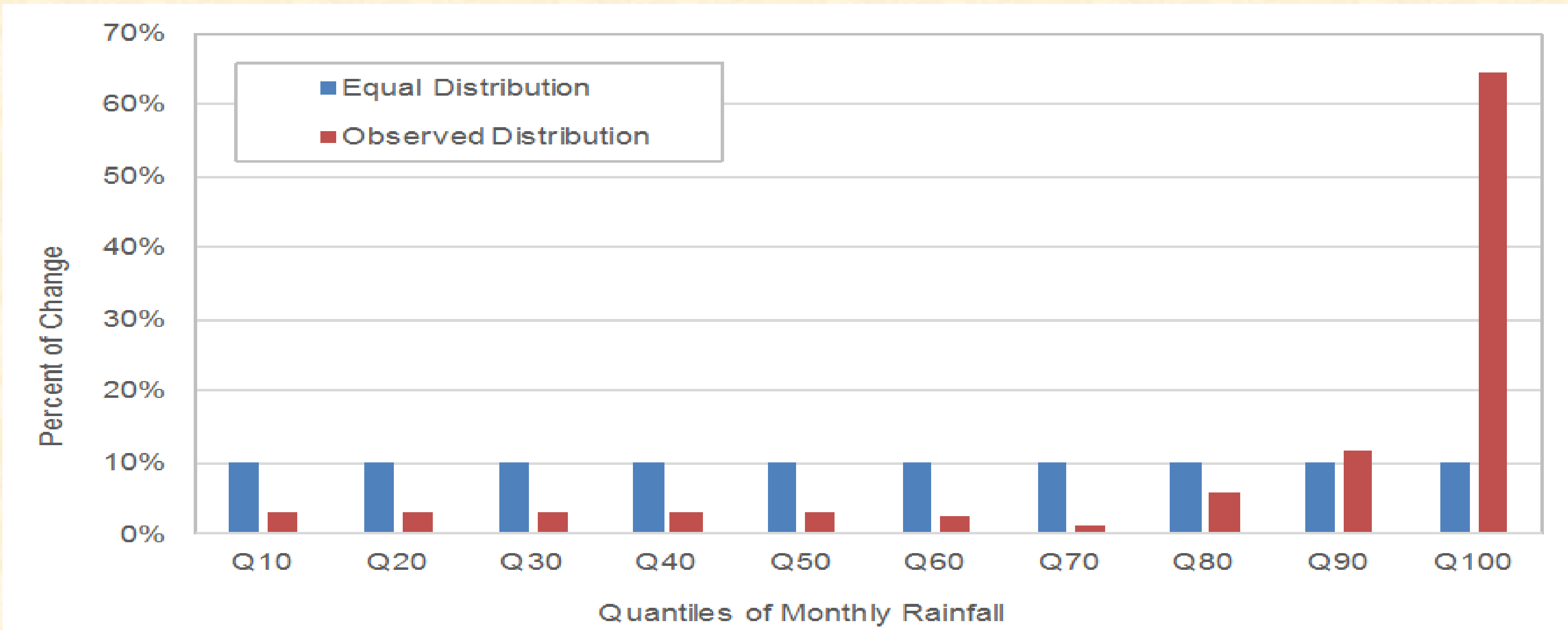
Trends in Observed Rainfall Intensity



Observed changes in rainfall intensity in the Chesapeake region over the last century. The equal allocation distribution (blue) is contrasted with the distribution obtained based on observed changes (red).

Source: Groisman et al. 2004

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An ensemble of GCM projections from BCSD CMIP5[1] was used to estimate 1995-2025 temperature change.

Data unavailable

GCM Used

Selection updated

Updated Ensemble members		
ACCESS1-0	FGOALS-g2	IPSL-CM5A-LR
BCC-CSM1-1	FIO-ESM	IPSL-CM5A-MR
BCC-CSM1-1-M	GFDL-CM3	IPSL-CM5B-LR
BNU-ESM	GFDL-ESM2G	MIROC-ESM
CanESM2	GFDL-ESM2M	MIROC-ESM-CHEM
CCSM4	GISS-E2-H-CC	MIROC5
CESM1-BGC	GISS-E2-R	MPI-ESM-LR
CESM1-CAM5	GISS-E2-R-CC	**MPI-ESM-MR**
CMCC-CM	HadGEM2-AO	MRI-CGCM3
CNRM-CM5	HadGEM2-CC	NorESM1-M
CSIRO-MK3-6-0	HadGEM2-ES	
EC-EARTH	INMCM4	

31 member ensemble

[1] BCSD – Bias Correction Spatial Disaggregation;
[1] CMIP5 – Coupled Model Intercomparison Project 5

Source: Kyle Hinson, VIMS

Reclamation, 2013. 'Downscaled CMIP3 and CMIP5 Climate and Hydrology Projections: Release of Downscaled CMIP5 Climate Projections, Comparison with preceding Information, and Summary of User Needs', prepared by the U.S. Department of the Interior, Bureau of Reclamation, Technical Services Center, Denver, Colorado. 47pp.

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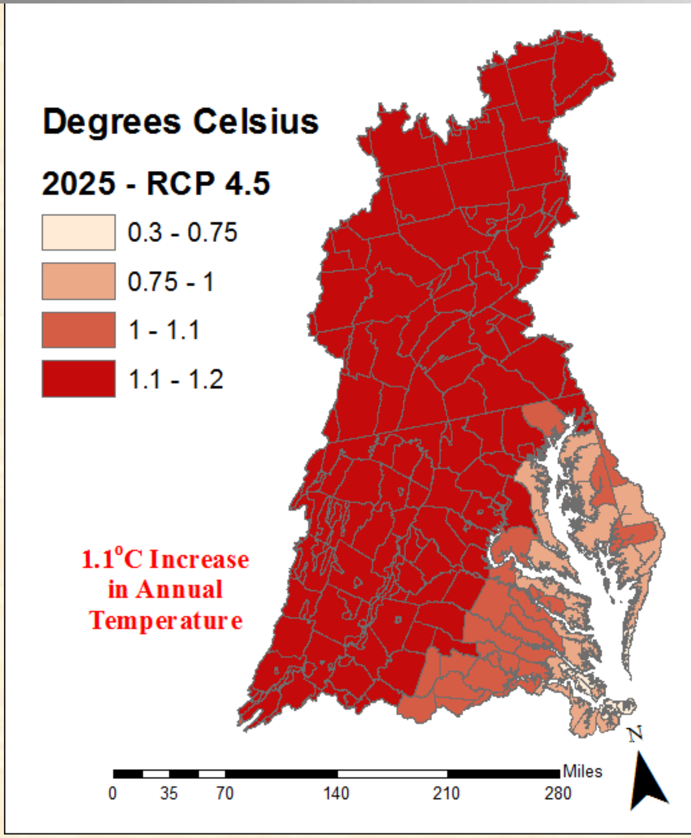
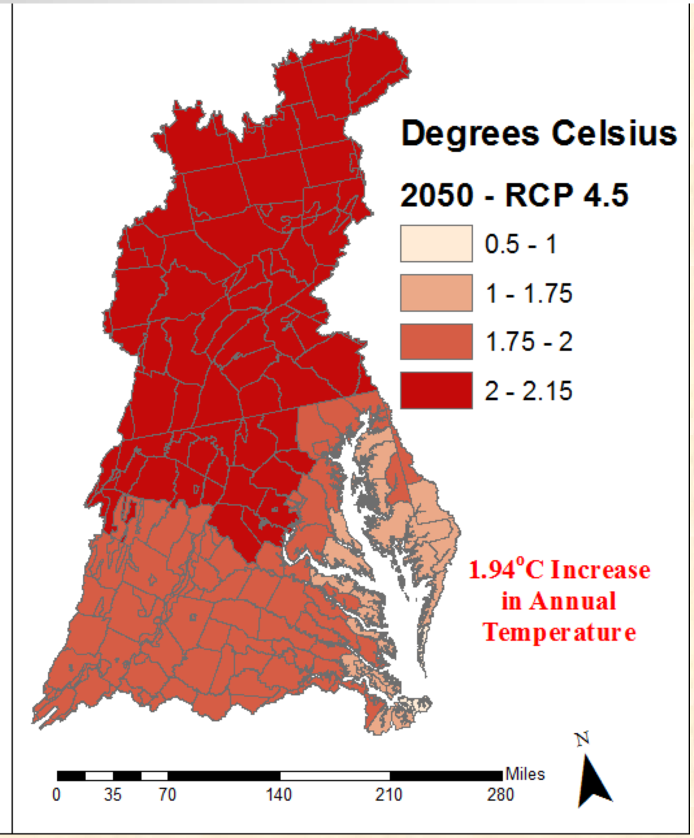
Chesapeake Bay Watershed Annual Change in Temperature





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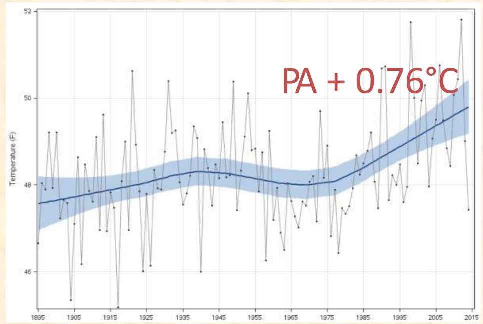
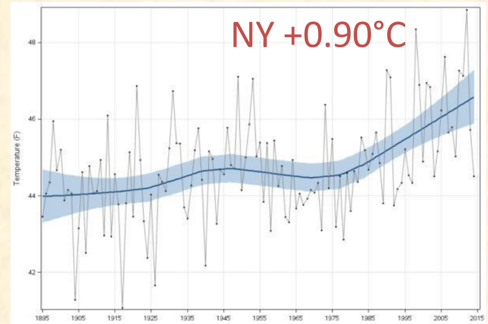
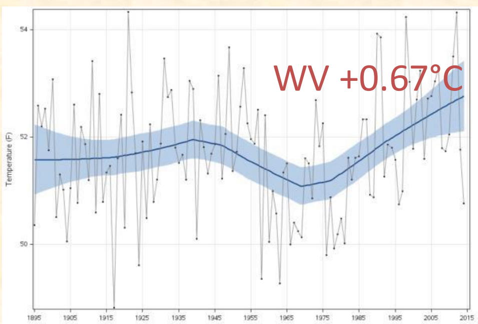
Temperature trends for the six CBP states

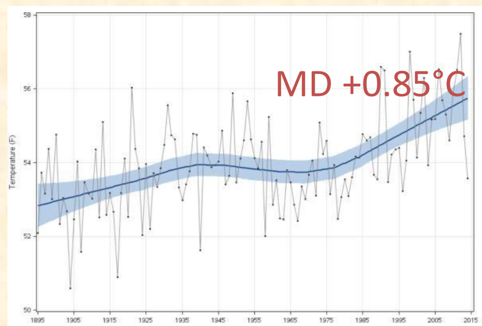
Annual temperature for 1895 to 2015 are shown.

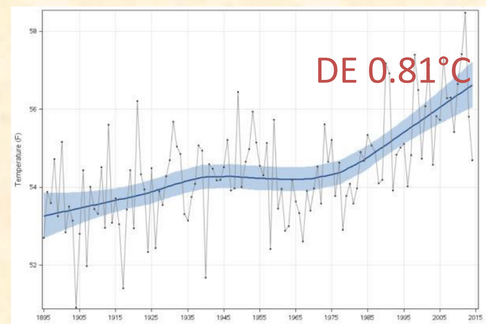
Annual Temperature
Trend Line
95% Confidence Limits

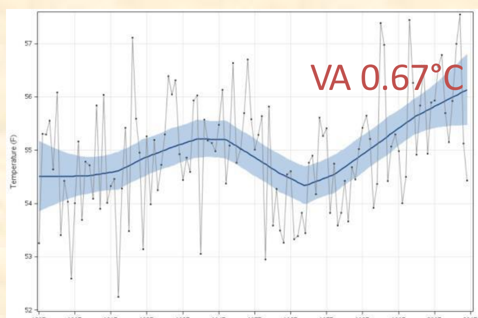












Approx. increases over the last 30 years based on the trend line are shown.

NOAA National Climatic Data Center
https://www.ncdc.noaa.gov/temp-and-precip/state-temps/

Estimated potential evapotranspiration

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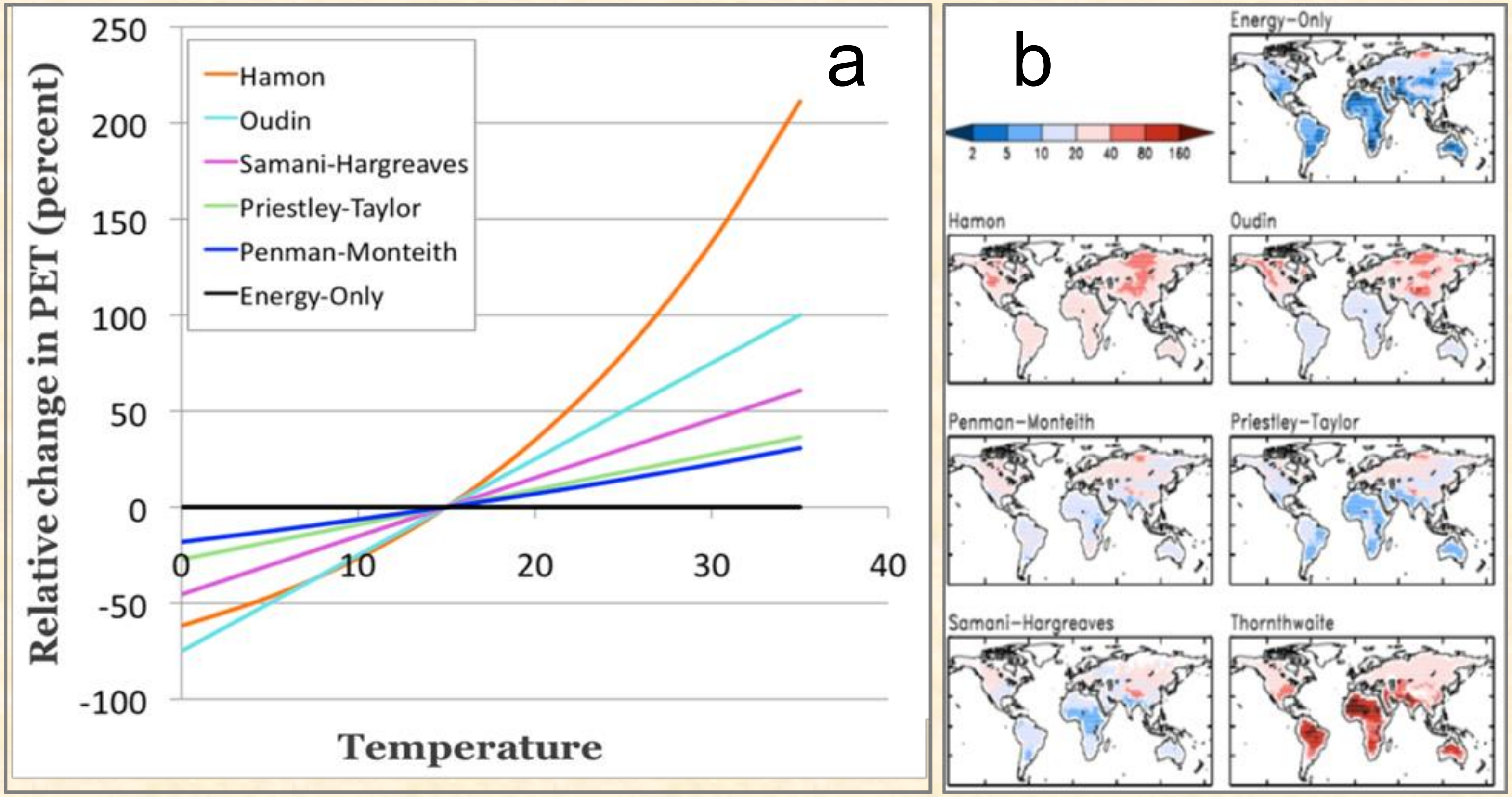

(a) Relative change in estimated change in potential evapotranspiration due to change in temperature is shown from different methods. It shows temperature alone can introduce considerable differences in estimation of potential evapotranspiration with the selection of method. (b) Estimate of percent changes in potential evapotranspiration

Estimated potential evapotranspiration

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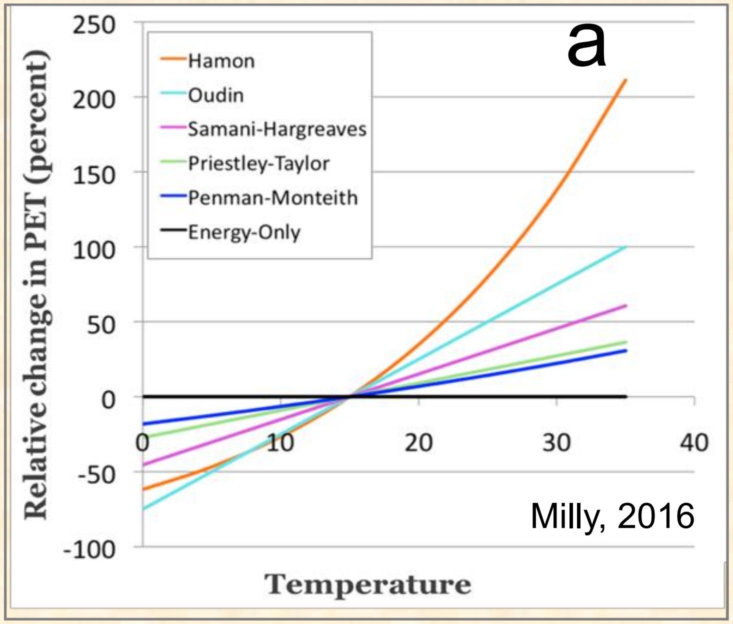
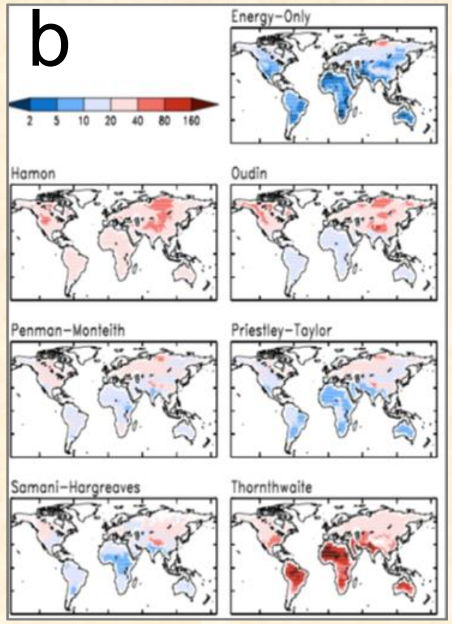
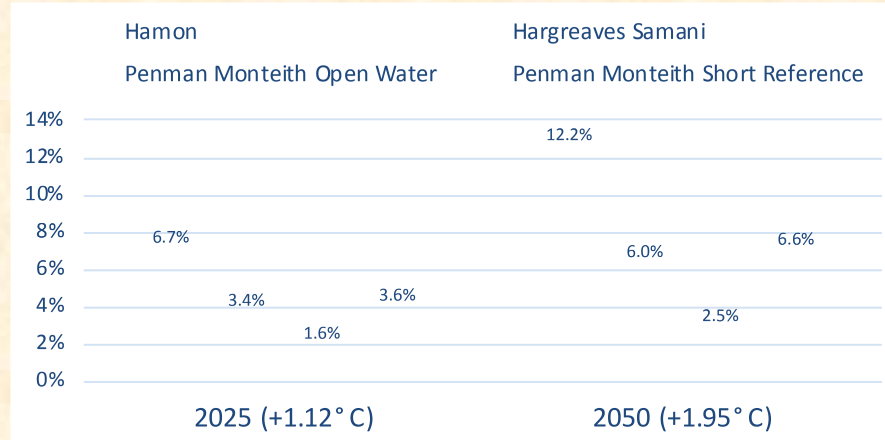
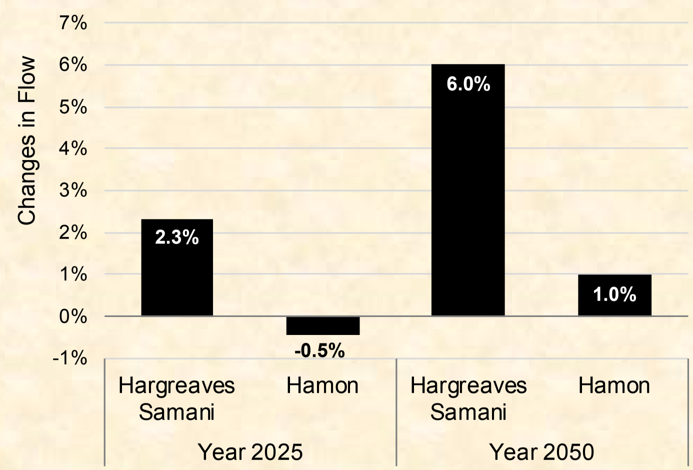




(a) Relative change in estimated change in potential evapotranspiration due to change in temperature is shown from different methods. It shows temperature alone can introduce considerable differences in estimation of potential evapotranspiration with the selection of method. (b) Estimate of percent changes in potential evapotranspiration





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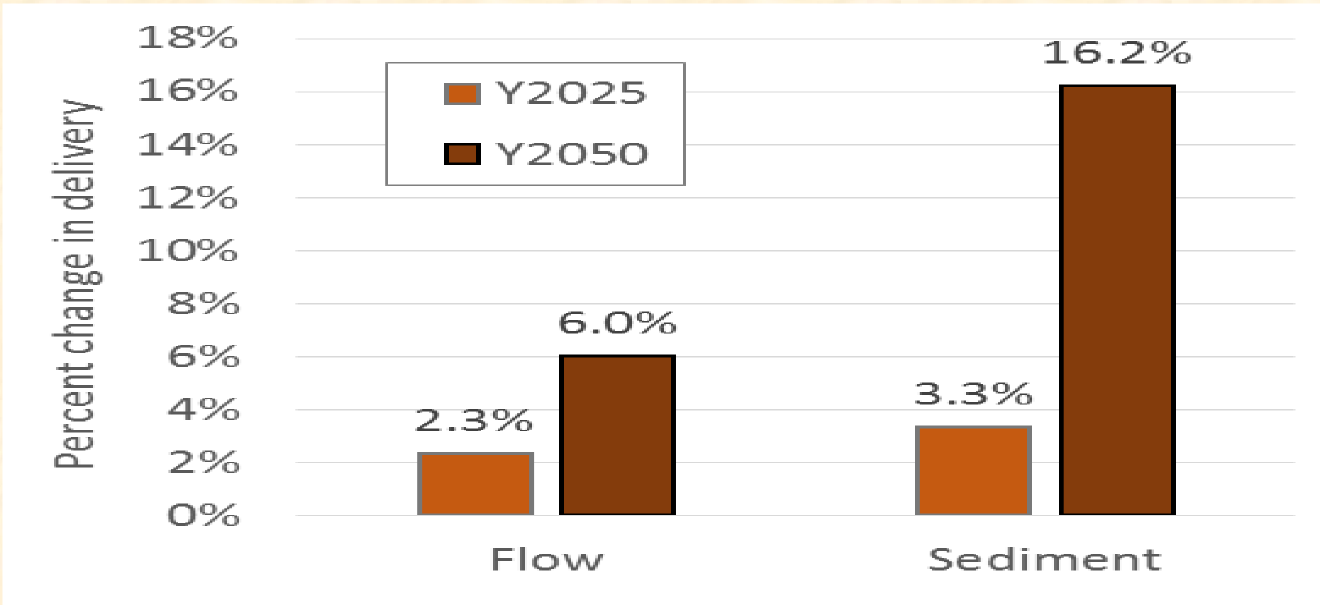
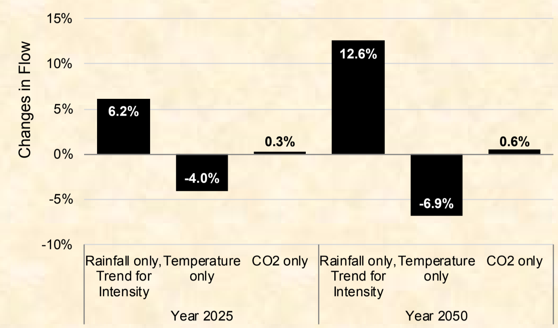
Estimated Flow and Sediment Load from the 2025 and 2050 Climate Change Scenarios



We've had the advantage of being able to sort the various elements of the climate change challenge into "big problems" and "little problems". For example stomatal resistance is a little problem, but evapotranspiration is a big problem.



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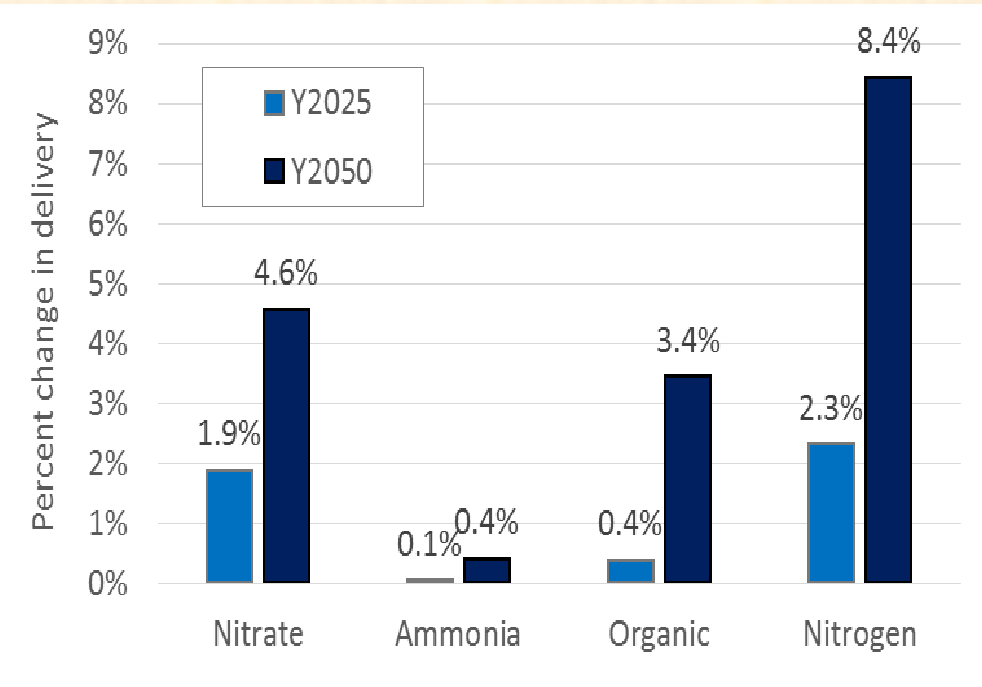
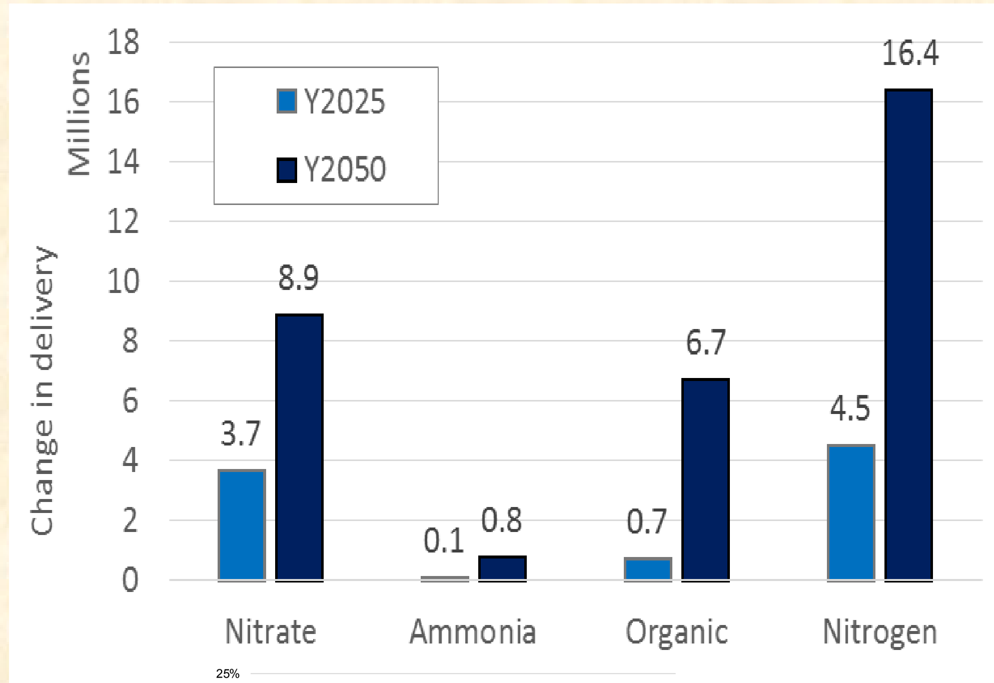
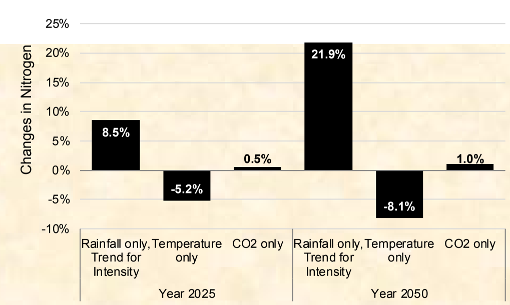
Estimated Nitrogen Loads from the 2025 and 2050 Climate Change Scenarios







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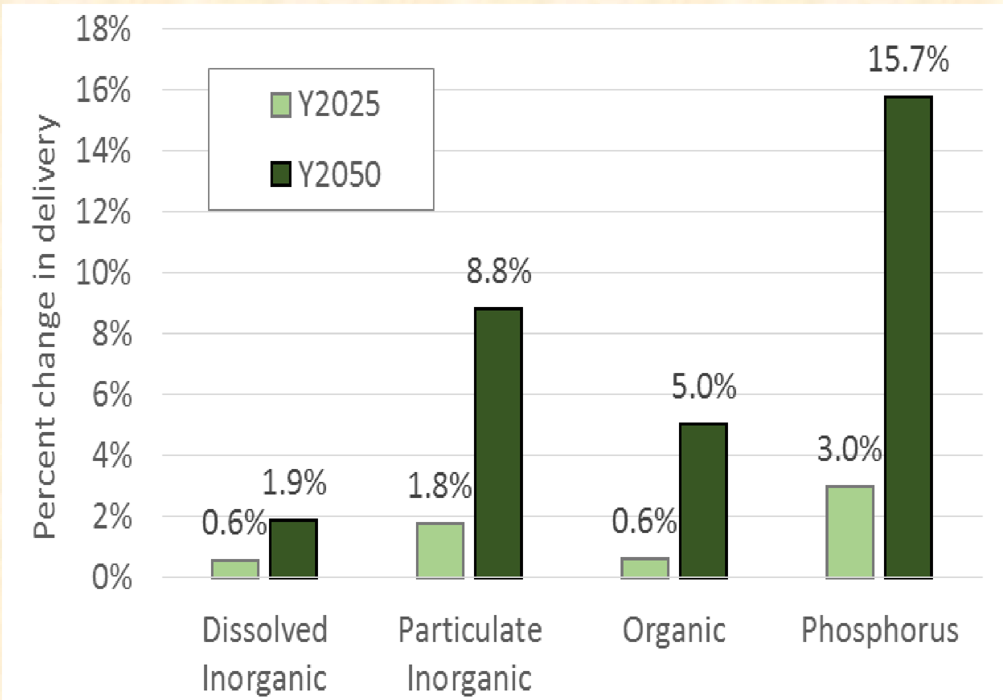
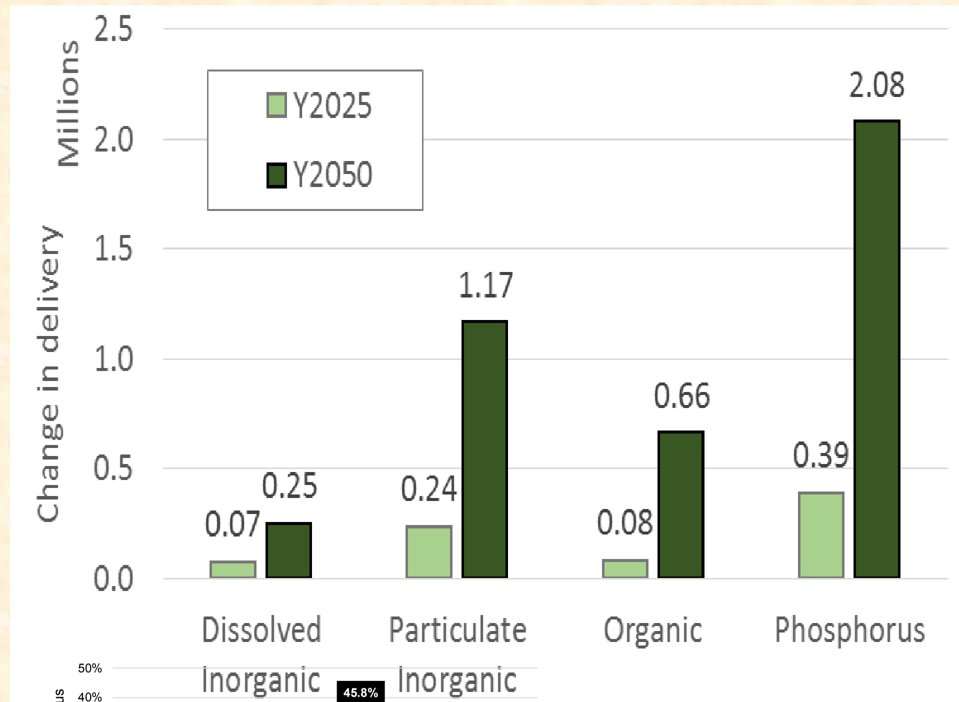
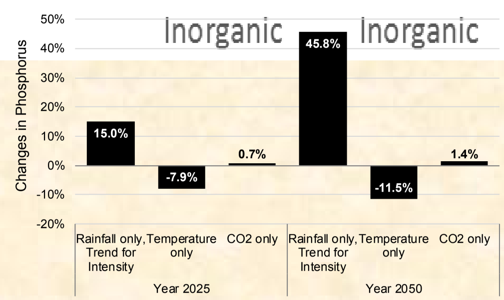
Estimated Phosphorous Loads from the 2025 and 2050 Climate Change Scenarios







Approaches, Methods, and Findings from the Tidal Bay

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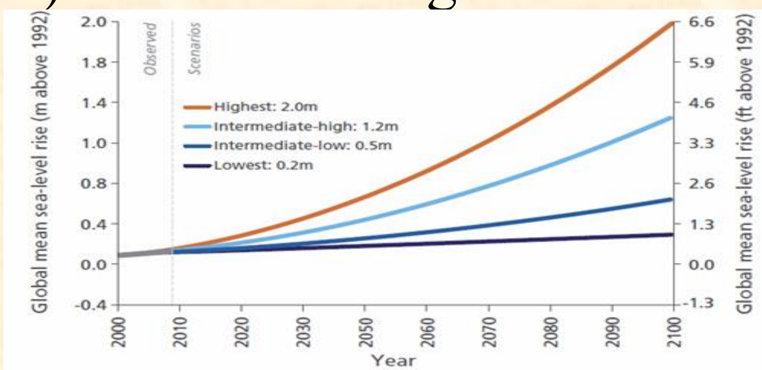
Analysis of Climate Change in the Tidal Bay

Estimates of the influence of sea level rise, increased temperature of tidal waters, and tidal wetland loss were incorporated into the Water Quality and Sediment Transport Model (WQSTM) of the tidal Bay (Cerco and Noel 2017). Guidance for increasing levels of regional sea level rise based upon global tide gauge rates and regional land subsidence rates came from the Climate Resiliency Workgroup CRWG). Specifically, the CRWG recommended that sea level rise projections for 2025 be based on long term observations at Sewells Point, VA (0.17 m) and that a range be used for 2050 (0.3 - 0.8 m) be applied in the WQSTM. The approximate median of the 2050 range (0.5 m) was used for initial simulations.



Analysis of Climate Change in the Tidal Bay

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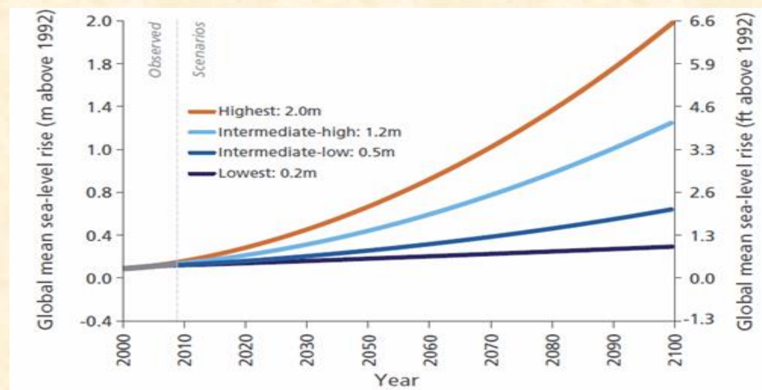
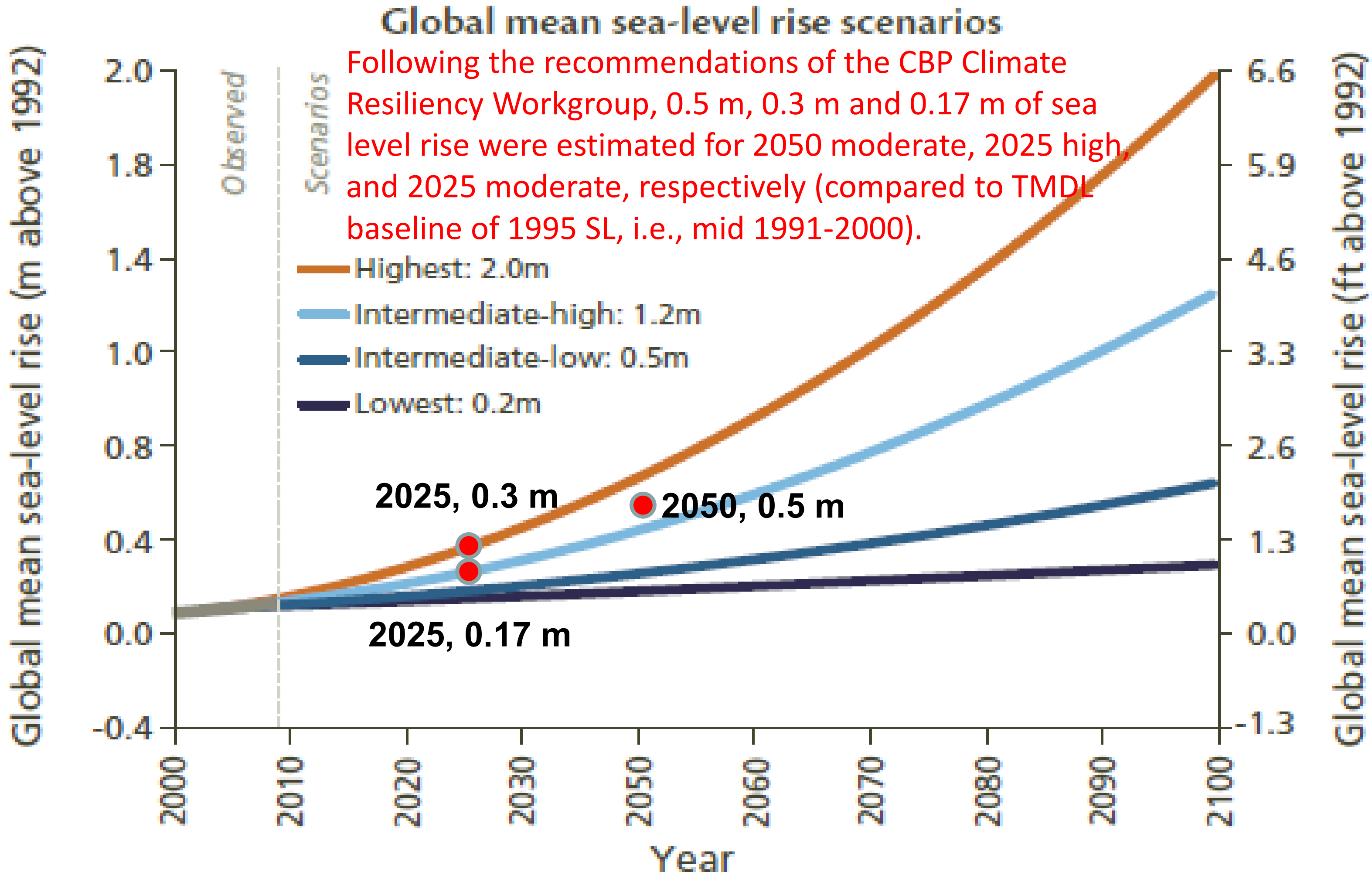
Overall, higher temperatures and loads from the watershed increases hypoxia in the tidal Bay.

However, increases in sea level rise, salinity increases at the Bay mouth, and increased watershed flows all increase estuarine gravitational circulation which in turn decreases estimated hypoxia in the Chesapeake under estimated 2025 and 2050 conditions of sea level rise and watershed flows.





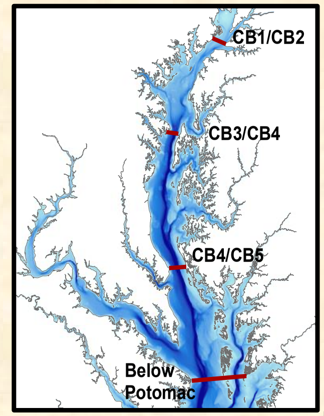
From Parris, A. et al. (2012). *Global Sea Level Rise Scenarios for the United States National Climate Assessment. NOAA Technical Report OAR CPO-1. National Oceanic and Atmospheric Administration, Silver Spring, Maryland.*

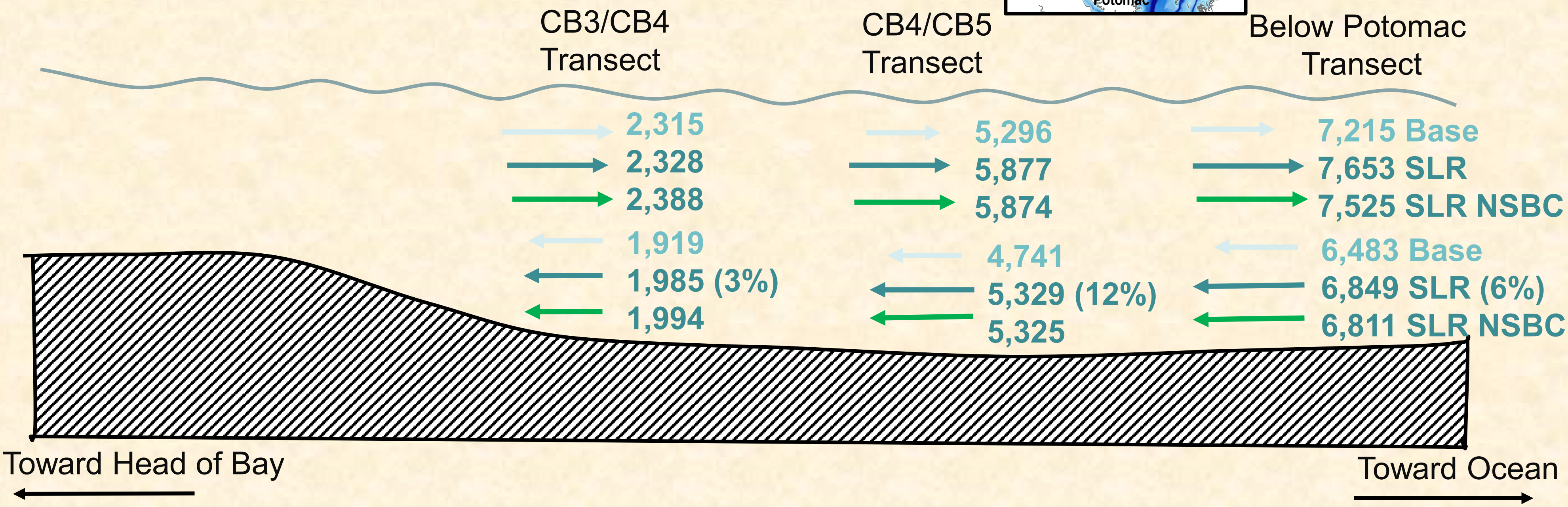
Assessment of Influence of 2025 Climate Change in the Tidal Bay

From the Literature - Responses to Sea Level Rise:

- Increased salinity in Bay
- Increased up-estuary salt intrusion
- Changes in stratification
- Increased gravitational circulation
- Increased salinity at ocean boundary

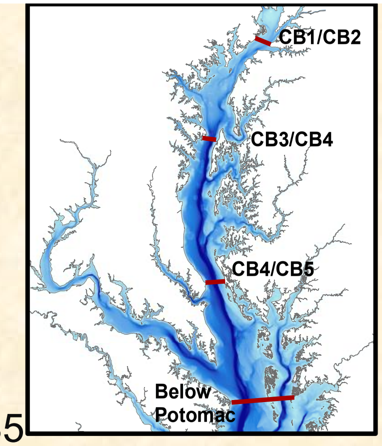
Cross-transect water fluxes (m^3/s) Base case versus sea level rise (SLR) of 0.5m. Summer 1993-1995

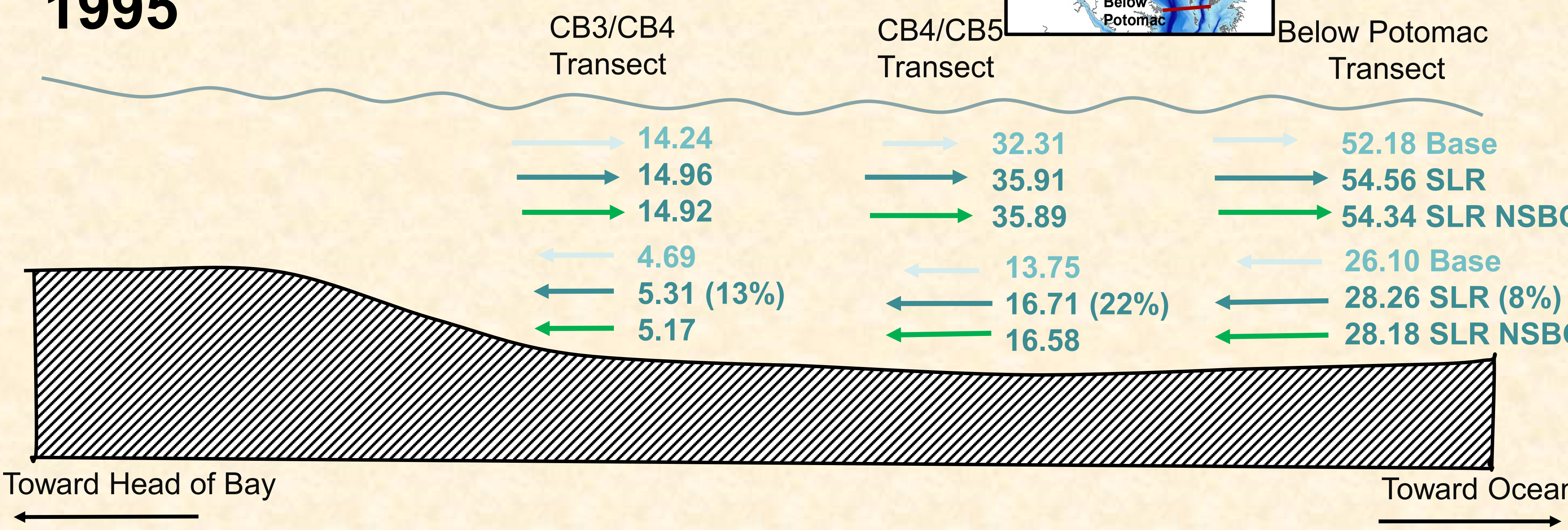




Base = Beta 4 WQSTM, SLR = 0.5m representing relative Chesapeake sea level rise from 1995 to 2050.
Units in mean m^3/s for summer (Jun-Sept) 1993 to 1995; NSBC: No Salt Boundary Change.

Cross-transect DO fluxes (kg/s) Base case versus sea level rise (SLR) of 0.5m. Summer 1993 - 1995





Base = Beta 4 WQSTM, SLR = 0.5m representing relative Chesapeake sea level rise from 1995 to 2050. Units in mean kg DO per second (kg/s) for summer (Jun-Sept) 1993 to 1995; NSBC: No Salt Boundary Change.

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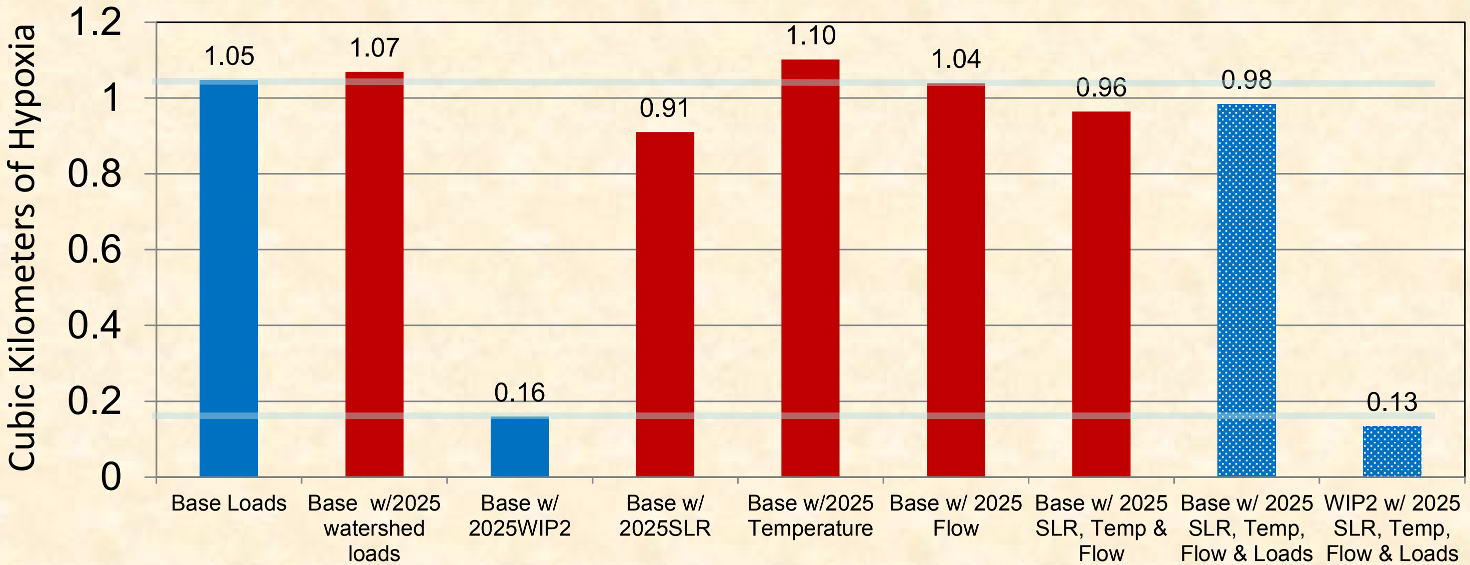
Hypoxic volume (DO <1 mg/l) in CB4MH (summer 1991-2000)

Big problems and little problems: Increased gravitational circulation, watershed loads, and tidal water temperature are big problems, but increased flows into the Bay and changes in atmospheric deposition are little problems.



DO <1 mg/l annual average daily hypoxia from 1991 to 2000 over the summer hypoxic season of May through September. Sea level rise = 0.3m.

solid blue = key scenario, solid red = sensitivity scenario, stippled blue = 2025 climate scenario

This work used the Draft Phase 6 Watershed Model and WQSTM to provide an initial estimate of relative 2025 and 2050 hypoxia under different temperature, sea level rise, and watershed flow and load conditions. We need to run the analysis on the final Watershed and WQSTM models.

Bay Water Quality Responses to 2025 Climate Change Conditions

Changes in estimated 2025 dissolved oxygen criteria attainment for Deep Channel, Deep Water, and Open Water due to observed temperature and precipitation changes since 1991-2000 (years of average Bay hydrology).

Run 223 11/30/17 CAST Loads		WIP2 195TN 13.7TP 1993-1995	WIP2 + Cono Infill 208TN 15.4TP 1993-1995	WIP2 + Cono Infill + CC 210TN 15.3TP 1993-1995
Cbseg	State	Deep Channel	Deep Channel	Deep Channel
CB3MH	MD		0%	0%
CB4MH	MD	6%	8%	10%
CB5MH	MD	0%	0%	0%
CB5MH	VA	0%	0%	0%
POTMH	MD	0%	0%	0%
RPPMH	VA	0%	0%	0%
ELIPH	VA	0%	0%	0%
CHSMH	MD	0%	0%	4%
EASMH	MD	6%	7%	8%

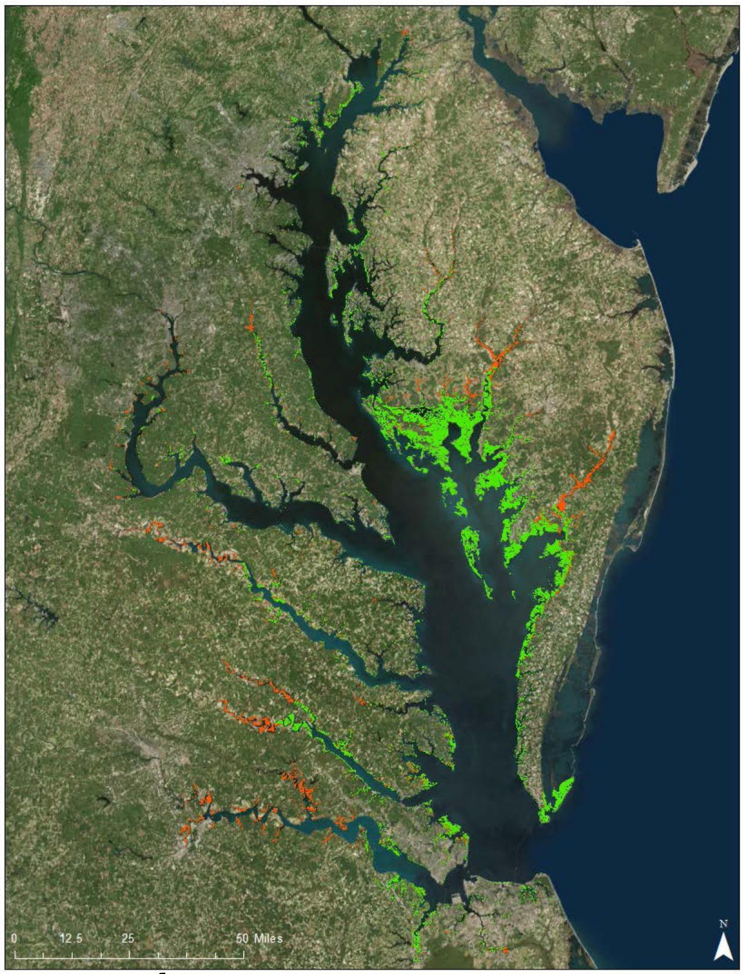
Deep Channel nonattainment increases by 2% in CB4MH

Run 223 11/30/17 CAST Loads		WIP2 195TN 13.7TP 1993-1995	WIP2 + Cono Infill 208TN 15.4TP 1993-1995	WIP2 + Cono Infill + CC 210TN 15.3TP 1993-1995
Cbseg	State	Deep Water	Deep Water	Deep Water
CB4MH	MD	5%	6%	7%
CB5MH	MD	1%	1%	2%
CB5MH	VA	0%	0%	0%
CB6PH	VA	0%	0%	0%
CB7PH	VA	0%	0%	0%
PATMH	MD	1%	2%	3%
MAGMH	MD	1%	5%	5%
SOUMH	MD	3%	8%	7%
SEVMH	MD	0%	0%	0%
PAXMH	MD	0%	0%	0%
POTMH	MD	0%	0%	0%
RPPMH	VA	0%	0%	0%
YRKPH	VA	0%	0%	0%
ELIPH	VA	0%	0%	0%
CHSMH	MD	0%	0%	0%
EASMH	MD	0%	0%	0%

Deep Water nonattainment increases by 1% in CB5MH

Procedures for assessing Open Water attainment under climate change conditions are being developed.

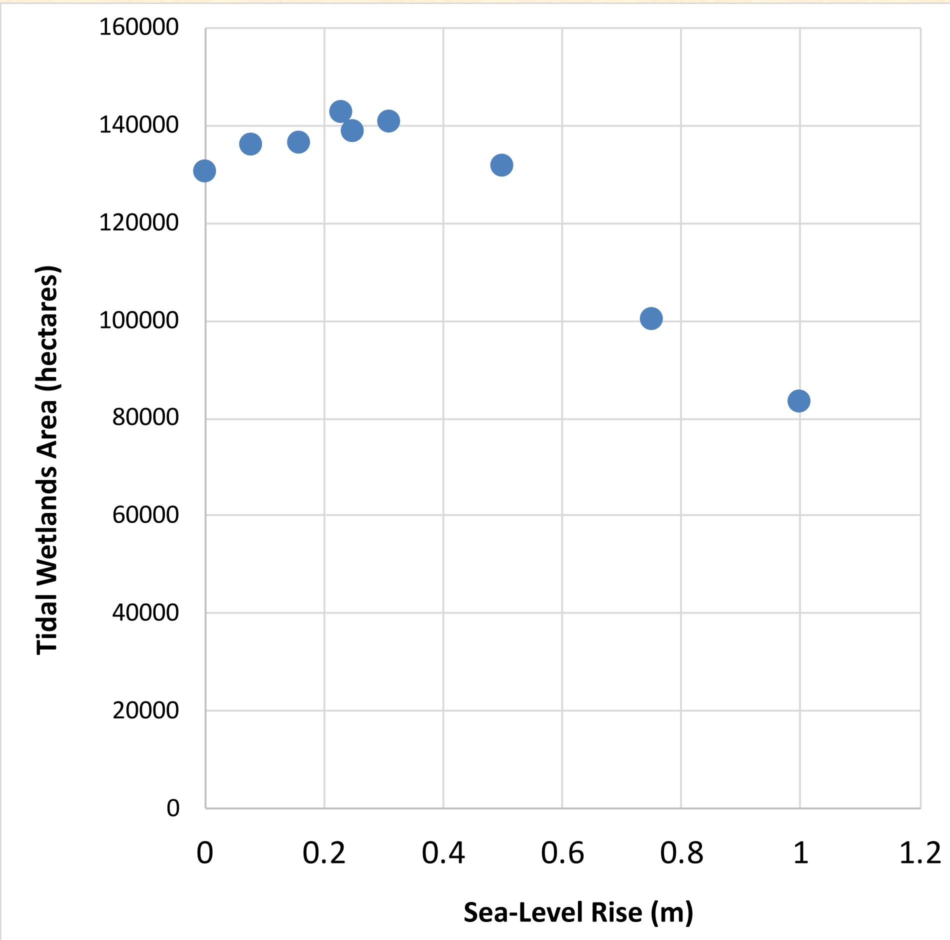
Chesapeake Bay Tidal Wetlands



Source: Carl Cerco, U.S. CoE ERDC

- The extent from National Wetlands Inventory is determined largely from vegetation perceived via aerial photography.
- 190,000 hectares of estuarine (green) and tidal fresh (red) wetlands.
- A tidal wetlands module is now fully operational in the WQSTM. The module incorporates functions of sediment and particulate nutrient removal and burial, denitrification, and respiration. The loss of wetland function due to sea level rise and inundation will be accounted for explicitly.

Influence of Estimated 2025 (0.3 m) and 2050 (0.5m) Sea Level Rise on Tidal Wetland Attenuation



There is little change in estimated total tidal wetland area for 2025 (0.17 - 0.3 m) and 2050 (0.5 m) which equates to negligible changes in tidal wetland attenuation.

Long range (2100) conditions estimate tidal wetland changes to be on the order of a 40% loss in the Chesapeake which could reduce tidal wetland attenuation on the order of about 10 million pounds nitrogen and 0.6 million pounds phosphorus.

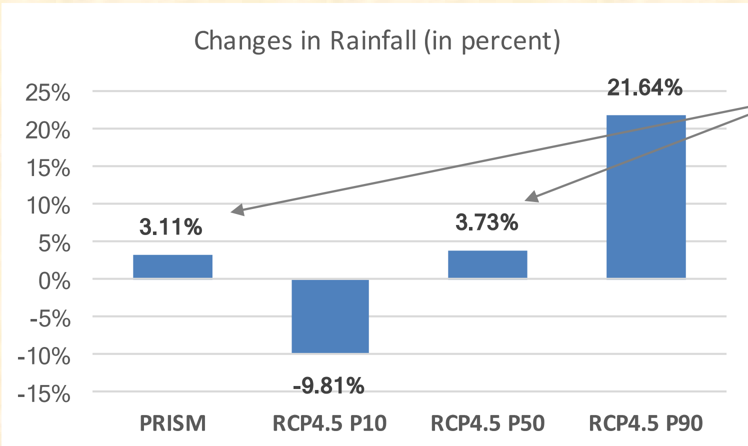
Source: Carl Cerco, CoE ERDC and Lara Harris, UMCES Sea Level Affecting Marshes Model (SLAMM) results.

Uncertainty Analysis

Chesapeake Bay Program

Science, Restoration, Partnership

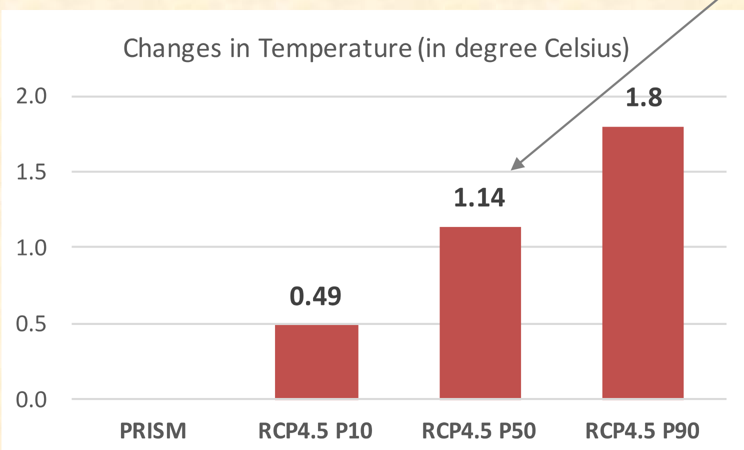
2025 Projections for Chesapeake Bay Watershed

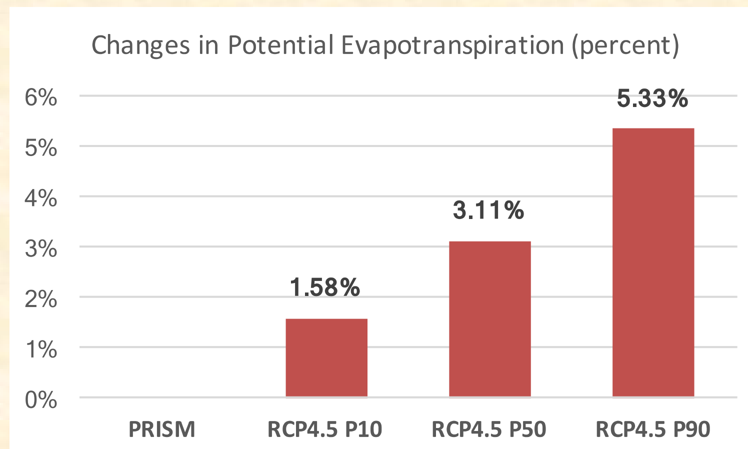


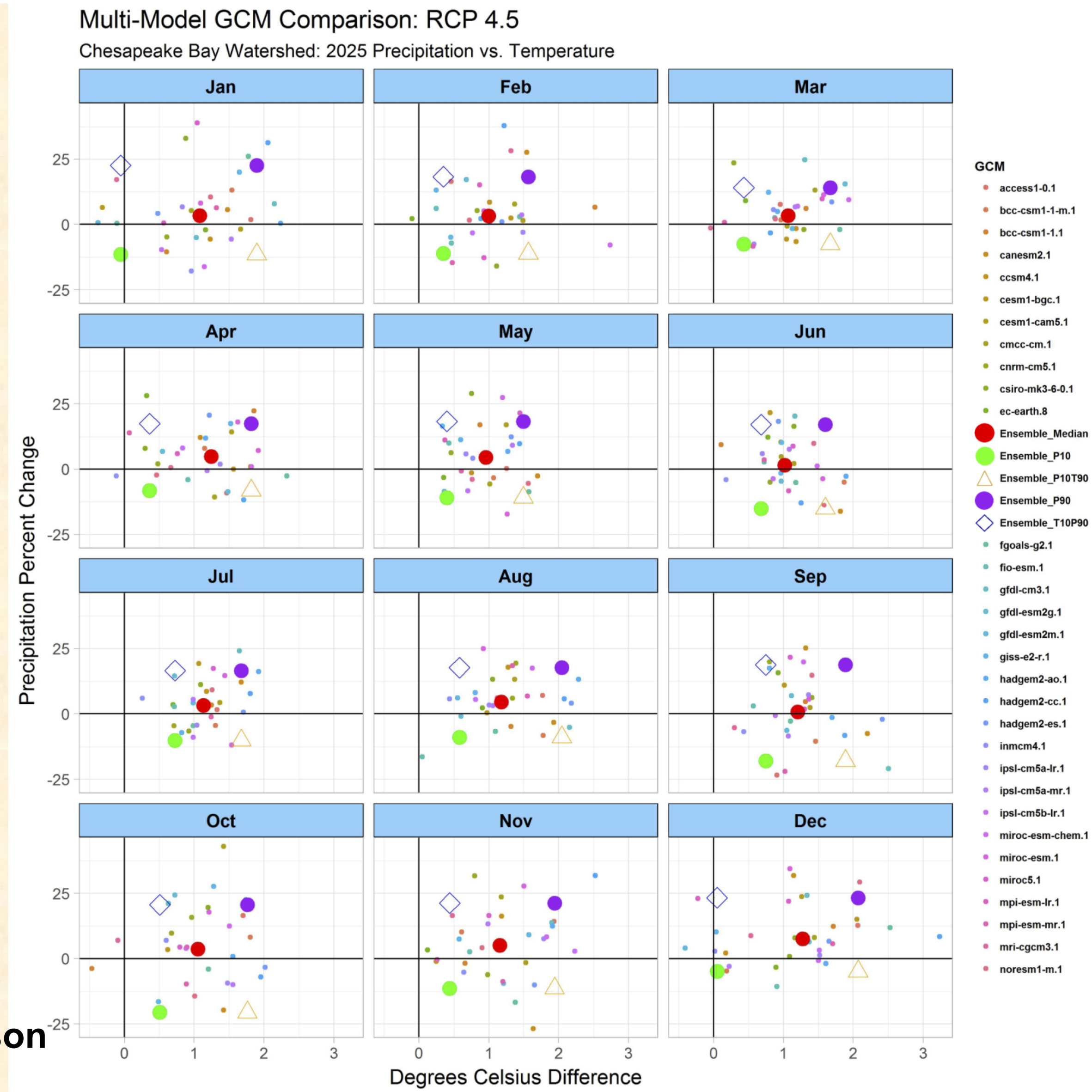
The central tendency of rainfall volume increase projections based on the 31 member ensemble median, P50, matches well with the extrapolation of PRISM's 88-year trends.

The rainfall uncertainty bounds (P10 and P90) of the ensemble members are quite large.

The central tendency of the temperature increase is potentially bit higher.






Multi-Model GCM Comparison: RCP 4.5
Chesapeake Bay Watershed: 2025 Precipitation vs. Temperature
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Precipitation Percent Change
Degrees Celsius Difference
25
0
-25
0
1
2
3
GCM
access1-0.1
bcc-csm1-1-m.1
bcc-csm1-1.1
canesm2.1
ccsm4.1
cesm1-bgc.1
cesm1-cam5.1
cmcc-cm.1
cnrm-cm5.1
csiro-mk3-6-0.1
ec-earth.8
Ensemble_Median
Ensemble_P10
Ensemble_P10T90
Ensemble_P90
Ensemble_T10P90
fgoals-g2.1
fio-esm.1
gfdl-cm3.1
gfdl-esm2g.1
gfdl-esm2m.1
giss-e2-r.1
hadgem2-ao.1
hadgem2-cc.1
hadgem2-es.1
inmcm4.1
ipsl-cm5a-lr.1
ipsl-cm5a-mr.1
ipsl-cm5b-lr.1
miroc-esm-chem.1
miroc-esm.1
miroc5.1
mpi-esm-lr.1
mpi-esm-mr.1
mri-cgcm3.1
noresm1-m.1

Kyle Hinson

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Uncertainty quantification

Uncertainty estimates for the climate change scenarios for the year 2025 and 2050. Change shown are difference in average annual delivery over the 10-year average hydrology period.

Period	Climate Change Scenario	Flow		Nitrogen		Phosphorus		Sediment	
		B ft3	percent	M lbs	percent	M lbs	percent	M tons	percent
Year 2025	Rainfall, CO2, P10 Temperature	124.78	4.8%	13.55	6.9%	1.61	11.6%	1.10	13.1%
	Rainfall, CO2, P50 Temperature	61.16	2.3%	4.68	2.4%	0.43	3.1%	0.28	3.3%
	Rainfall, CO2, P90 Temperature	-0.44	0.0%	-1.24	-0.6%	-0.22	-1.6%	-0.15	-1.8%
Year 2050	P10 Rainfall, CO2, P10 Temperature	-478.34	-18.3%	-36.01	-18.3%	-3.04	-21.9%	-2.15	-25.6%
	P50 Rainfall, CO2, P50 Temperature	157.25	6.0%	16.44	8.3%	2.13	15.3%	1.36	16.2%
	P90 Rainfall, CO2, P90 Temperature	966.74	36.9%	362.81	183.9%	81.80	588.3%	18.41	219.3%

CBP Management Direction and STAC Guidance

Chesapeake Bay Program
Science, Restoration, Partnership

Recommendations from STAC

The CBP's Scientific and Technical Advisory Committee (STAC) has conducted several assessments of climate science and has recommended processes to integrate consideration of climate change into the Bay Program's management framework (DiPasquale 2014; Johnson et al. 2016; Pyke et al. 2008; Pyke et al. 2012; STAC 2011; Wainger 2016; Benham 2018).

In addition, three STAC Peer Reviews (Chesapeake Bay Program Partnership's Climate Change Assessment Framework and Programmatic Integration and Response Efforts (2017), the Phase 6 Watershed Model (2017) and the Water Quality Sediment Transport Model (2017)) guided much of the data, methods and modeling techniques of the Midpoint Assessment modeling effort.

Recommendations from STAC:

STAC's peer reviews and workshops on the assessment of climate change in the Chesapeake watershed and Bay has made a substantial contribution to the CBP as part of STAC's essential ongoing advice on the state of the science in this field, and particularly with respect to watershed and coastal water restoration in the Chesapeake region. Ongoing, long-term, technical and strategic support by STAC for CBP decision making on climate change going forward provide important guidance going forward. Specifically, there is a need for deeply collaborative work among CBP technical managers (Climate Resiliency Workgroup, Modeling Workgroup, WQGIT, WSWG, etc.) and the CBP scientific community (STAC) to effectively achieve the policy makers (PSC) goal of the first inclusion of climate change management in the CBP by 2022.

Management Actions on CB Climate Change:

The Principal Staff Committee (PSC) in December 2017 directed the CBP, through the Modeling and Climate Resiliency Workgroups, to direct immediate efforts toward a more refined analysis of climate change influence on Chesapeake water quality, to be delivered as a complete and fully operational modeling system by the close of 2019.

PSC Decisions of December 2017

Understand the Science - Address the uncertainty by documenting the current understanding of the science and identifying research gaps and needs:

- Develop an estimate of pollutant load changes (N, P, and S) due to climate change conditions [so that] starting with the 2022-2023 milestones, [the CBP will] determine how climate change will impact the BMPs included in the WIPs and address these vulnerabilities in the two-year milestones.
- Develop a better understanding of the BMP responses, including new or other emerging BMPs, to climate change conditions.
- In 2021, the Partnership will consider results of updated methods, techniques, and studies and revisit existing estimated loads due to climate change to determine if any updates to those load estimates are needed.
- <u>Jurisdictions will be expected to account for additional nutrient and sediment pollutant loads due to 2025 climate change conditions in a Phase III WIP addendum and/or 2-year milestones beginning in 2022</u>.

Next Steps Directed by the PSC: Understanding the Science and Refining the Model Estimates

2018

- STAC Workshop to examine current results, assess lessons-learned and recommend next steps.
- Climate Resiliency Workgroup will incorporate actions in its 2018-2020 workplan to develop a better understanding of BMP responses, including new or other emerging BMPs, to climate change conditions.

2019

- Following the direction of the PSC, the Modeling and Climate Resiliency Workgroups, working with other key Chesapeake Bay Program groups, will develop and implement a complete and fully operational climate change modeling and assessment system in 2019.

2020

- In 2020, the CBP partners will complete a technical review and process for approval of the new refined climate change modeling and assessment system as well as the scientific and technical findings from its management applications.

2021

- In 2021, the policy implications for including targets adjusted for the influence of climate change into the 2022-2023 milestones will be considered by the Partnership.
- By the close of 2021, the refined findings on climate change will be implemented into the jurisdictions' 2022-2023 milestones.

The Upcoming
Climate Change 2.0
STAC Workshop

Chesapeake Bay Program
Science, Restoration, Partnership

STAC Workshop: *Chesapeake Bay Program Climate Change Modeling 2.0*

A two-day workshop that will bring together experts in climate change, estuarine, and watershed sciences to undertake a detailed and focused examination of the current results of the Chesapeake Bay Program's (CBP) Midpoint Assessment climate change modeling efforts, assess lessons-learned, and recommend next steps. The goal of the workshop is to develop recommendations for new and/or refined methods and modeling techniques to be completed and fully operational by 2019 that will assess future impacts of projected climate change on watershed loads and estuarine processes, including the methodology for developing jurisdiction-specific nutrient pollutant loads due to 2025 climate projections.

questions to be addressed at the upcoming STAC-sponsored "Climate Change 2.0" workshop,

Workshop Questions

- How does the CBP Watershed Model (WSM) and Water Quality Sediment Transport Model (WQSTM) response to future climate forcing compare to other comparable modeling efforts and frameworks?
- What additional or different climate change approaches and methods should be incorporated into the WSM and WQSTM?
- How can CBP modeling efforts account for potential impacts of larger landscape-level changes (e.g., changes in land use or agricultural systems) on nutrients and sediments loads?
- What ranges of inputs should be used for the WQSTM for water column temperature and ocean boundary changes?
- How does the relative rate of increasing precipitation, temperature, and sea level rise influence Chesapeake water quality in 2035, 2050 and other future years? In other words, are trends in the impacts of climate change increasing or changing going forward beyond 2025?
- What new and/or refined methods and modeling techniques could be used to better assess projected impacts on watershed loads and estuarine impacts for a range of future scenarios?
- What improvements could be made to the methodology used to develop jurisdiction-specific nutrient pollutant loads due to 2025 climate change conditions and beyond?
- What are the remaining research gaps and highest priority information needs (e.g., data, research, modeling methods and techniques, programmatic efforts)?

Supplemental Slides

Chesapeake Bay Program
Science, Restoration, Partnership

Thoughts On Potential Next Steps and Future Synthesis Activities

Climate change is a multigenerational challenge for the CBP. The CBP needs a better road map to help plan what's ahead.

- For the synthesis think in "out-there long-stretch terms. (The 2019 die has largely already been cast.)
- What about longer growing seasons and increased double crops? How will 10,000 farmers in the Chesapeake watershed respond to climate change conditions
- How about the time we estimate we have to respond to the loss of CB tidal wetlands? Should we use that time to prepare?
- The need for work on co-benefits:
  - WQ response to CC and improved flood control
  - WQ response to CC and better ecosystem restoration/protection
  - WQ response to CC and better storm surge management
  - WQ response to CC and infrastructure improvement/protection

Principals' Staff Committee Meeting March 2, 2018 Final Actions/Decisions on Climate Change

Accounting for Climate Change

• Decision: The PSC agreed to the following language laying out how and when the jurisdictions' Phase III WIPs would address climate change narratively and numerically:

Factoring Climate Change Considerations into the Phase III Watershed Implementation Plans

1. Incorporate Climate Change in the Phase III WIPs

Include a narrative strategy in the Phase III WIPs that describes the state and local jurisdictions' current action plans and strategies to address climate change and commit to adopting climate change targets by 2021, employing the Partnership's suite of models that factor in climate change and other relevant local information. Acknowledging the challenges that lie ahead, reference the preliminary modeling estimates attributable to climate change by 2025 to be roughly an additional 9 million pounds of nitrogen and 0.5 million pounds of phosphorus

Source: https://www.chesapeakebay.net/channel_files/26045/actions.decisions_final_03.02.18_clean.pdf

Principals' Staff Committee Meeting March 2, 2018 Final Actions/Decisions on Climate Change

2. Understand the Science

- By refining the climate modeling and assessment framework, continue to sharpen the understanding of the science, the impacts of climate change, and any research gaps and needs.
- Develop an estimate of pollutant load changes (nitrogen, phosphorus, and sediment) due to 2025 climate change conditions.
- Develop a better understanding of BMP responses, including new, enhanced and resilient BMPs, to better address climate change conditions such as increased storm intensity.
- In March 2021, the Partnership will consider results of updated methods, techniques, and studies and refine estimated loads due to climate change for each jurisdiction.
- In September 2021 jurisdictions will account for additional nutrient and sediment pollutant loads due to 2025 climate change conditions in a Phase III WIP addendum and/or 2-year milestones beginning in 2022.
- Starting with the 2022-2023 milestones, the Partnership will determine how climate change will impact the BMPs included in the WIPs and address these vulnerabilities in the two-year milestones.

Source: https://www.chesapeakebay.net/channel_files/26045/actions.decisions_final_03.02.18_clean.pdf