

# STAC Workshop

# Climate Change Modeling 2.0

Gary Shenk CBPO

WQGIT

September 27, 2021

# STAC Climate Change Modeling 2.0

- Workshop held in 2018 in response to PSC decision in 2017 to take a longer look at climate change as part of the Midpoint Assessment
- Purpose: Guidance on the models and assessment framework used to assess the effect of climate change on the TMDL

## **Workshop Steering Committee:**

Co-Chair: Mark Bennett (USGS)

Co-Chair: Lewis Linker (EPA CBPO)

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Rachel Dixon, Chesapeake Research Consortium

Annabelle Harvey, Chesapeake Research Consortium

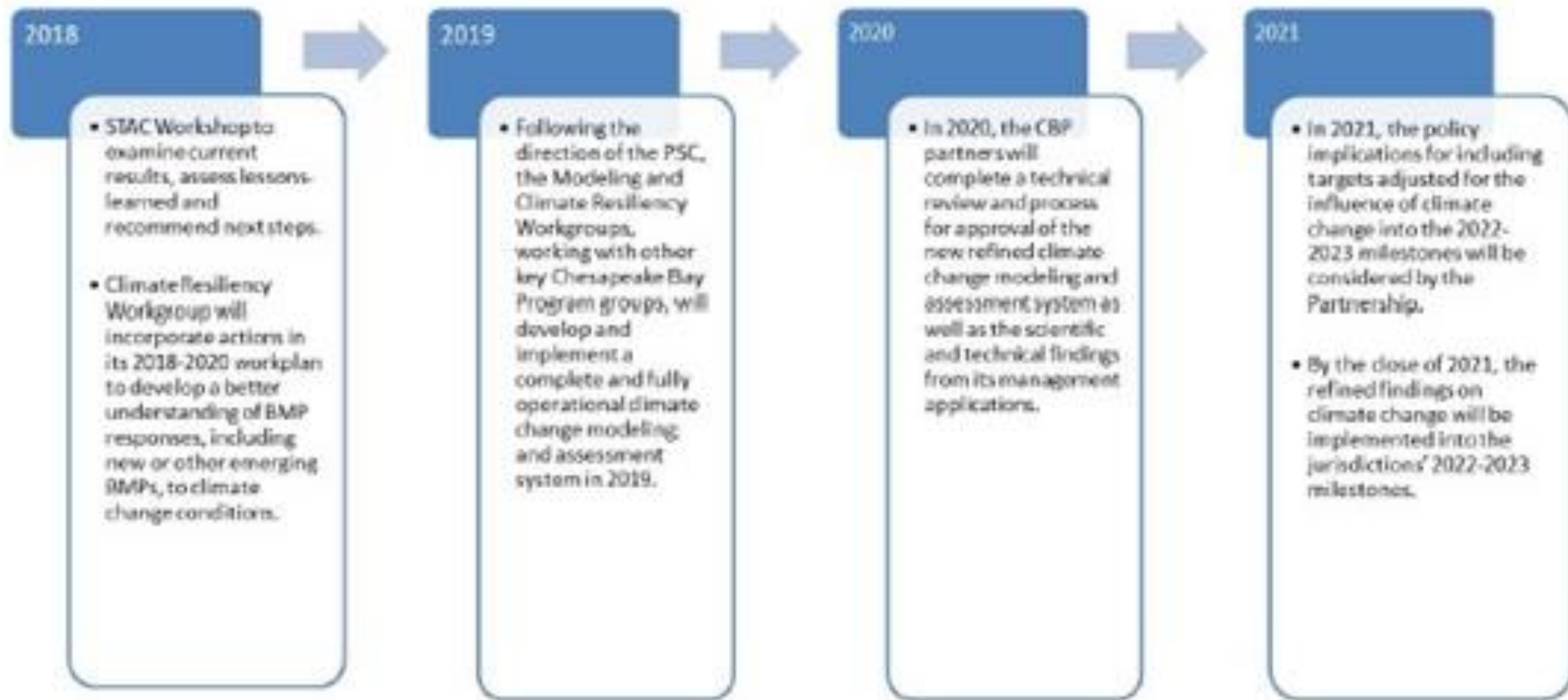
## **Chesapeake Bay Program Climate Change Modeling 2.0**



**STAC Workshop Report  
September 24-25, 2018  
Annapolis, MD**

**STAC Publication 21-003**

# Why is it coming out now?

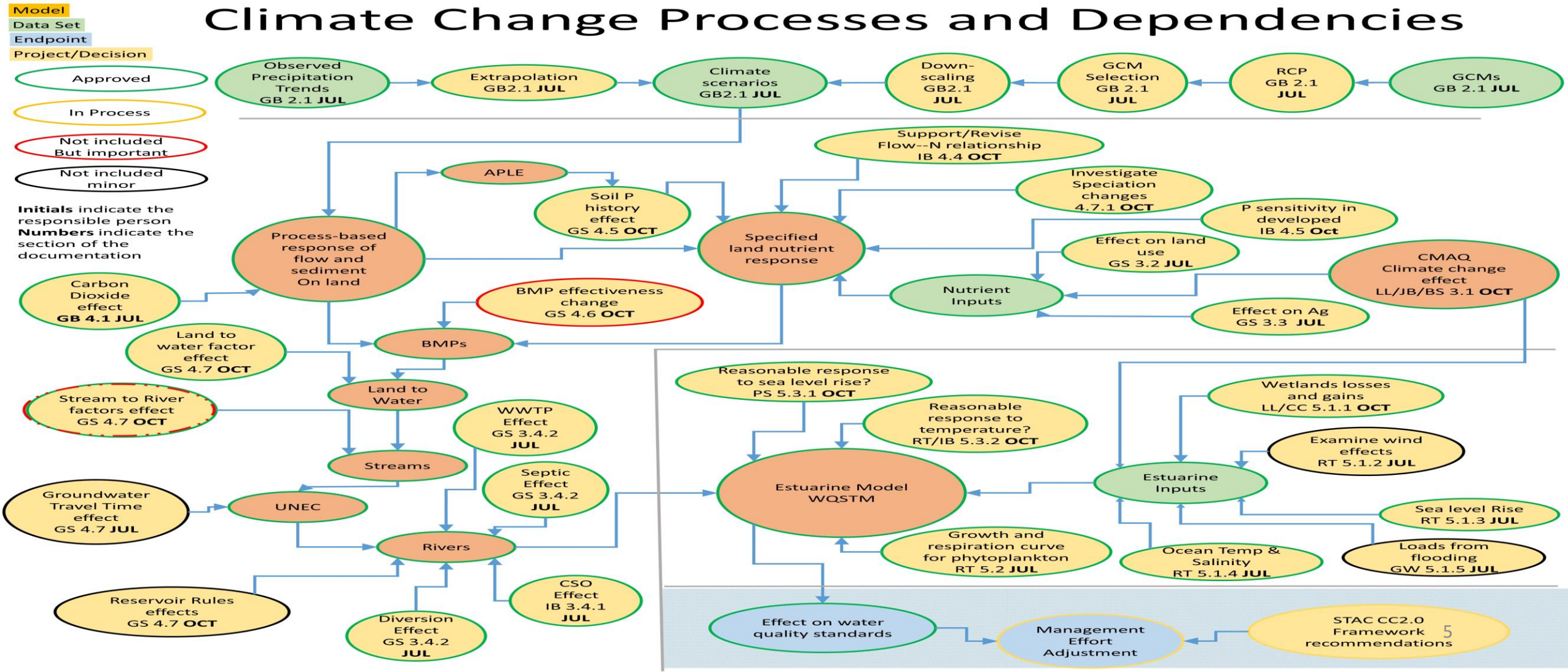


Too busy implementing recommendations!

# Near Term Recommendations (by 2021)

- Introduce the estimation of **uncertainty** into the decision process.
- Closely **examine** all climate-related sensitivities in the watershed and estuarine models and characterize the relative importance of these effects on dissolved oxygen.
- With the knowledge gained from sensitivity analyses of recommendation #2, prioritize **improvements** and enhanced quantification of uncertainties in model inputs.
- Compare **multiple** existing estuarine **model** simulations, including the CBP's Water Quality and Sediment Transport Model, from 1985 through recent wet years.

# Near term: Closely examine sensitivities and make improvements





# Near term: Closely examine sensitivities and make improvements- watershed

- ✓ • Spatially vary the relationship between nitrogen and flow
- ✓ • Developed area sensitivity to Phosphorus
- ✓ • Investigate potential changes to wastewater overflows
- ✓ • Change the nitrogen and phosphorus speciation methods
- Incorporate the effects of climate change into the BMP effectiveness estimates

Climate change documentation:

<https://cast.chesapeakebay.net/FileBrowser/GetFile?fileName=P6ModelDocumentation%2FClimateChangeDocumentation.pdf>

# Near term: Closely examine sensitivities - watershed

- Incorporate the effects of climate change into the BMP effectiveness estimates
  - Virginia Tech scientists are producing a comprehensive literature survey on the effects of climate change on nutrient cycling and BMP effectiveness.
  - WQGIT-funded project produced updated intensity-duration-frequency curves for all counties in the watershed will supply necessary estimates of climate effects.

# Near term: Closely examine sensitivities - estuarine

- ✓ • Resolve the effect of sea-level rise
- ✓ • Increase phytoplankton growth at high temperatures.
- ✓ • Include a temperature dependent mortality or grazing rate in the model.
- ✓ • Re-examine the outer boundary conditions
- ✓ • Investigate downscaled future wind products.



# Near Term: Compare Multiple Water Quality Models

- VIMS-led CHAMP project
  - Multiple climate models
  - Multiple watershed models
  - Multiple estuarine models

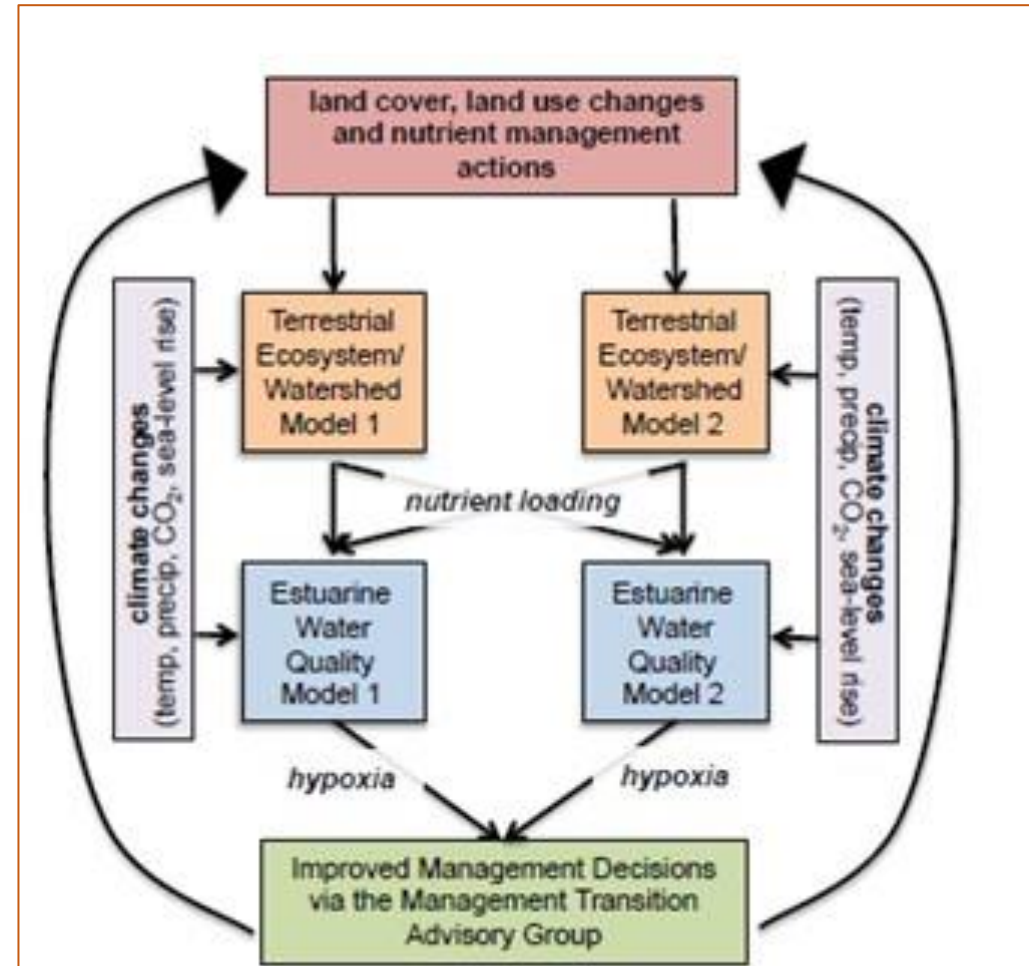


Fig. 2. Overall framework for proposed research, showing direct links between various components of the ecosystem-based scenario forecast modeling system.

# Near Term Recommendations (by 2021)

C<sup>-</sup>

- Introduce the estimation of **uncertainty** into the decision process.

B<sup>+</sup>

- Closely **examine** all climate-related sensitivities in the watershed and estuarine models and characterize the relative importance of these effects on dissolved oxygen.

A

- With the knowledge gained from sensitivity analyses of recommendation #2, prioritize **improvements** and enhanced quantification of uncertainties in model inputs.

A<sup>-</sup>

- Compare **multiple** existing estuarine **model** simulations, including the CBP's Water Quality and Sediment Transport Model, from 1985 through recent wet years.

# In the longer term (by 2025)

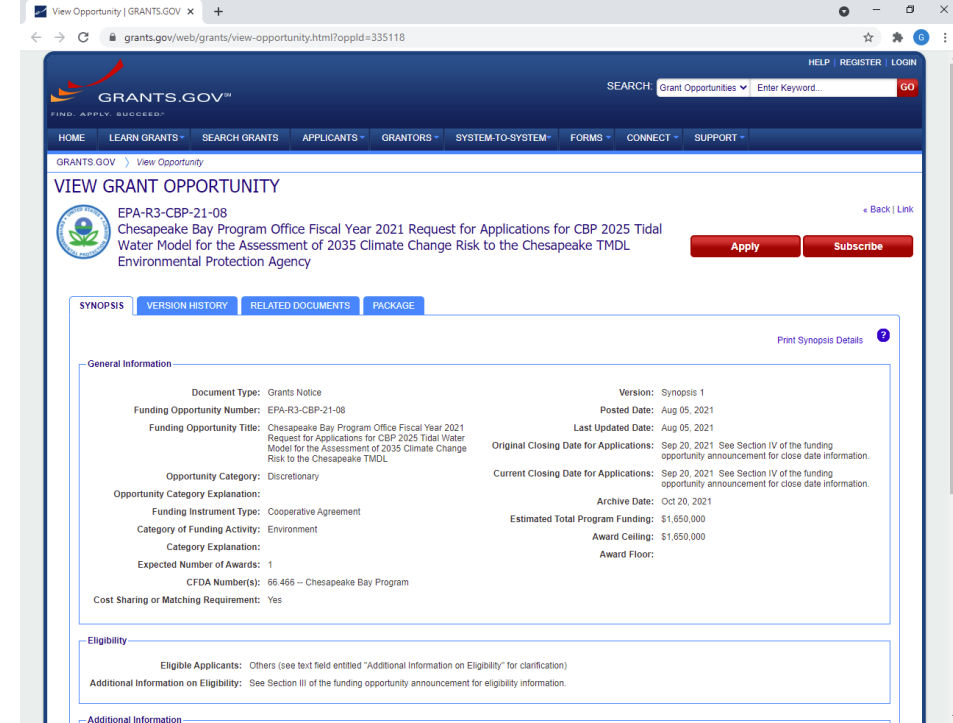
- Develop a **new estuarine model**
- **Continue development** of climate-related watershed model capabilities with particular attention to BMP effectiveness.
- Create a more **sophisticated evaluation framework** that incorporates various sources of uncertainty:

# Long Term: Develop a new estuarine model

- Use an unstructured grid
- Simulate wetting and drying
- Develop a spectral wave model
- Extend the boundary onto the coastal shelf
- Improve biogeochemical parameterizations
- Improve model forcing

# Long Term: Estuarine model RFA

- Unstructured Grid
- May be part of new model
  - Simulate wetting and drying
  - Develop a spectral wave model
  - Extend the boundary onto the coastal shelf
  - Improve biogeochemical parameterizations
  - Improve model forcing



# Long Term: Watershed model

- Continue watershed model refinement with particular attention to BMP effectiveness
- Modeling team working on scale issues
- Waiting on prioritization from WQGIT and other partners



# Long term: framework

- Climate inputs
  - Use models rather than trend
  - Evaluate multiple RCPs (now SSPs)
  - Use climate models at a finer spatial scale
- Develop improved suite of mechanistic models
- Interact with similar efforts world-wide
- Create a climate research strategy
- Re-evaluate goals relative to climate change
- Use uncertainty in the decision process

# Long term: framework

- Climate inputs
  - Use climate models rather than observed trend
  - Evaluate multiple RCPs (now SSPs)
  - Use climate models at a finer spatial scale
- CBP will consider these in 2024-2025
- Develop improved suite of mechanistic models
- Yes for estuarine model: No for watershed model
- Interact with similar efforts world-wide
- Yes for scientists; ??? for managers

# Long term: framework

- Create a climate research strategy
  - the CBP should consider developing, supporting, and periodically updating a Strategic Research Framework that identifies ongoing activities and priority knowledge gaps.

# Long term: framework

- Create a climate research strategy
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## STAR SRS Science Needs Database

Home Page - STAR

star.chesapeakebay.net/#

STAR Needs Tracking

Home Download About Log In

Goals: Climate Resiliency x

Primary Outcomes: Primary Outcome Filter

Categories: Category Filter

Need: Need Filter

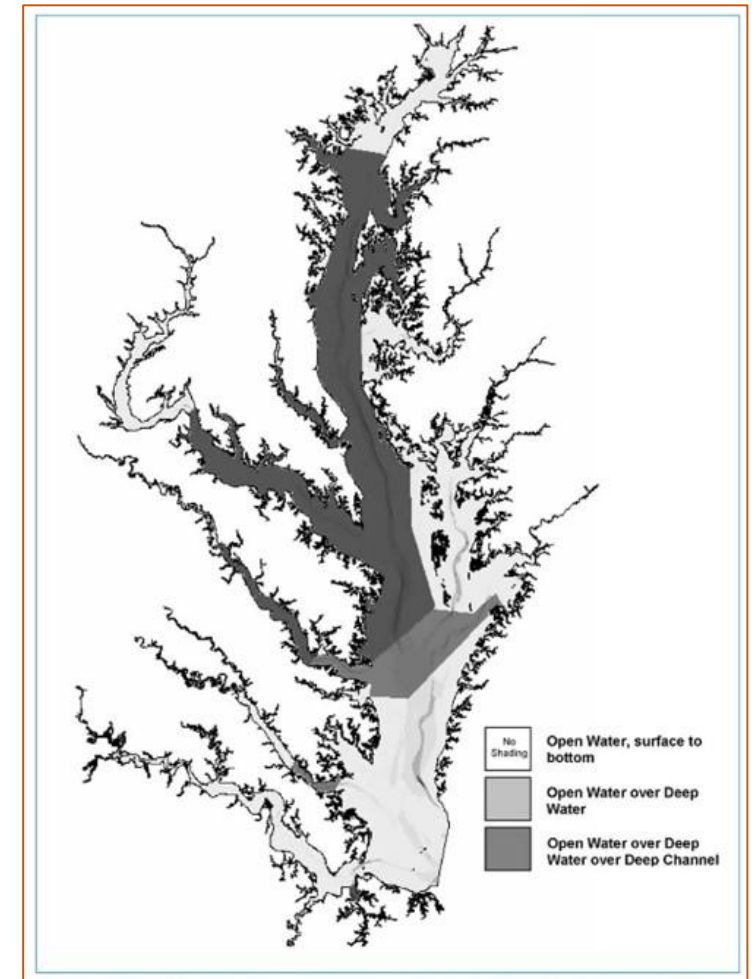
Search

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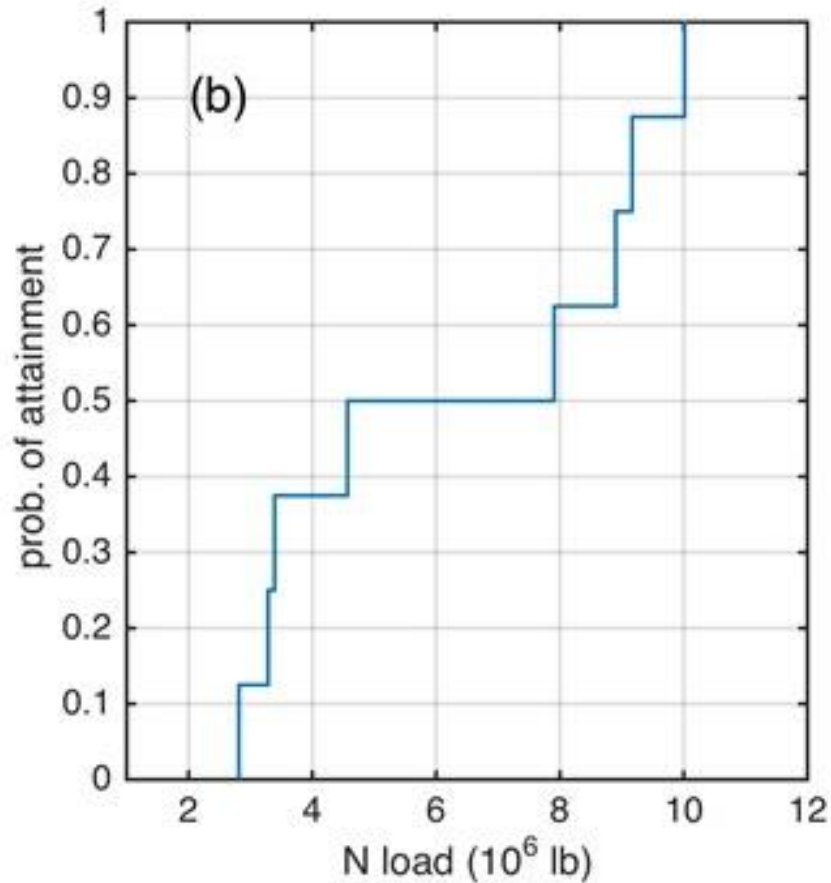
Goal	Primary Outcome	Category	Need	
Climate Resiliency	Climate Resiliency Monitoring and Assessment	Modeling, Monitoring, Research	Better understanding of precipitation changes with regards to intensity, annual amounts, seasonal impacts, storm events and stormwater management	<a href="#">Detail</a>
Climate Resiliency	Climate Resiliency Adaptation	Research	Social Science - human behavior - implications of the human response (positive and negative) to climate change, flooding, sea level rise as well as motivation and needs of communities to adapt	<a href="#">Detail</a>
Climate Resiliency	Climate Resiliency Adaptation	Research	Changing climate conditions and their impacts on SAV	<a href="#">Detail</a>
Climate Resiliency	Climate Resiliency Adaptation	Research	Better understanding of green infrastructure (e.g., living shorelines) performance in building resilience to climate change impacts, cost-effectiveness of these strategies, and potential unintended consequences to other restoration metrics (e.g., sediment dynamics)	<a href="#">Detail</a>
Climate Resiliency	Climate Resiliency Adaptation	Research	Climate impacts to key aquatic fish species abundance, life cycle and habitat	<a href="#">Detail</a>
Climate Resiliency	Climate Resiliency Monitoring and Assessment	Modeling, Monitoring, Research	Data and research needs for impacts of SLR, storm surge, increased temperatures, extreme precipitation events and saltwater inundation on BMP climate resilience (i.e., maintenance, shelf life, siting and design, etc.)	<a href="#">Detail</a>
Climate Resiliency	Climate Resiliency Monitoring and Assessment	Monitoring, Research	Better understanding of sea level rise and subsidence impacts related to wetland loss, marsh migration, and adjacent land use considerations	<a href="#">Detail</a>
Climate Resiliency	Climate Resiliency Monitoring and Assessment	Monitoring	Method/metrics to track climate resilience progress related to Chesapeake Bay Watershed Agreement goals	<a href="#">Detail</a>

# Long term: framework

- Re-evaluate goals relative to climate change
  - CBP noted issues with the Open Water designated uses under climate change and declined to base reductions on Open Water
  - Criteria Assessment Protocols Workgroup looking at changing Open Water boundaries.
  - Potential issues will arise with assessment short-duration Water Quality Standards



# Use of uncertainty in Decision Process



- Workshop Suggestion: Use of multiple scenarios to define a probability of attainment for a particular load reduction goal.
- CBP could consider in 2024-2025



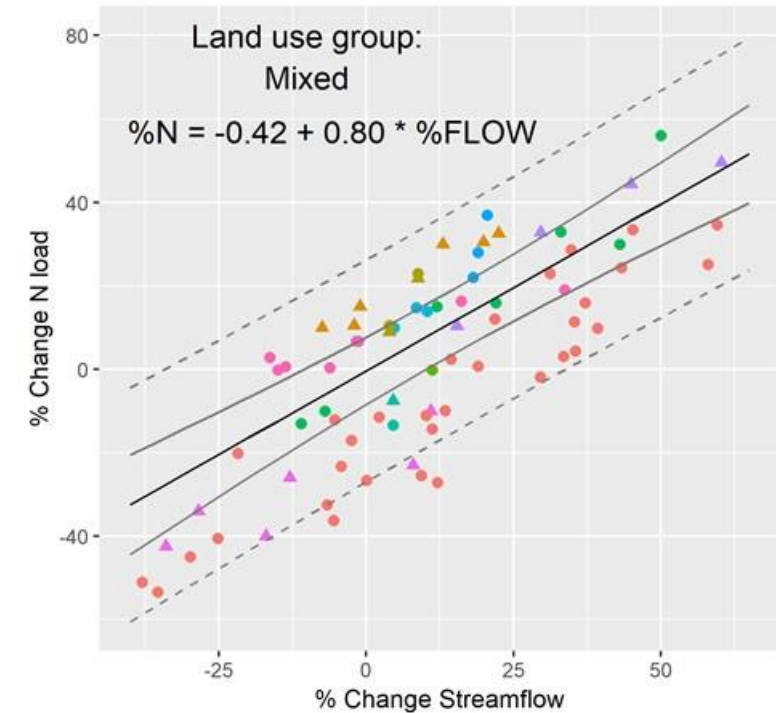
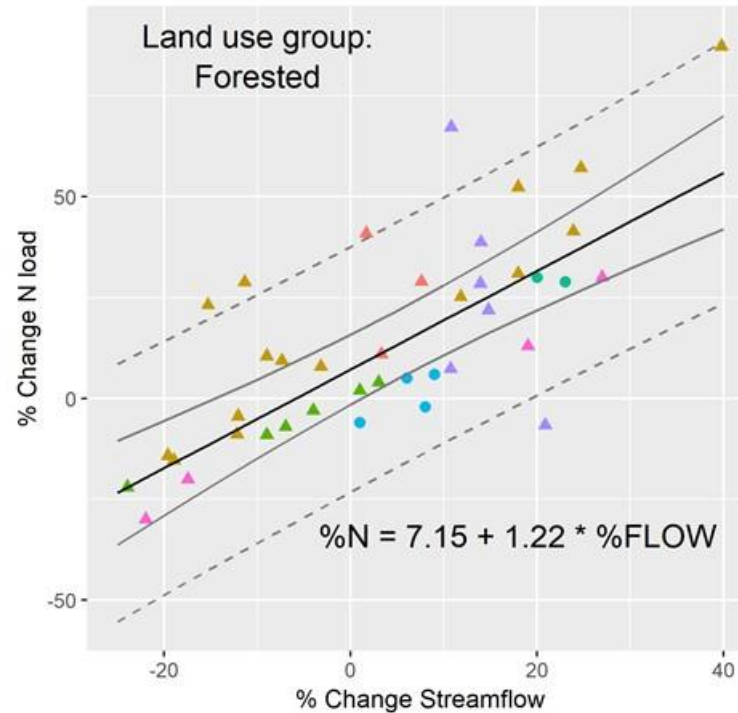
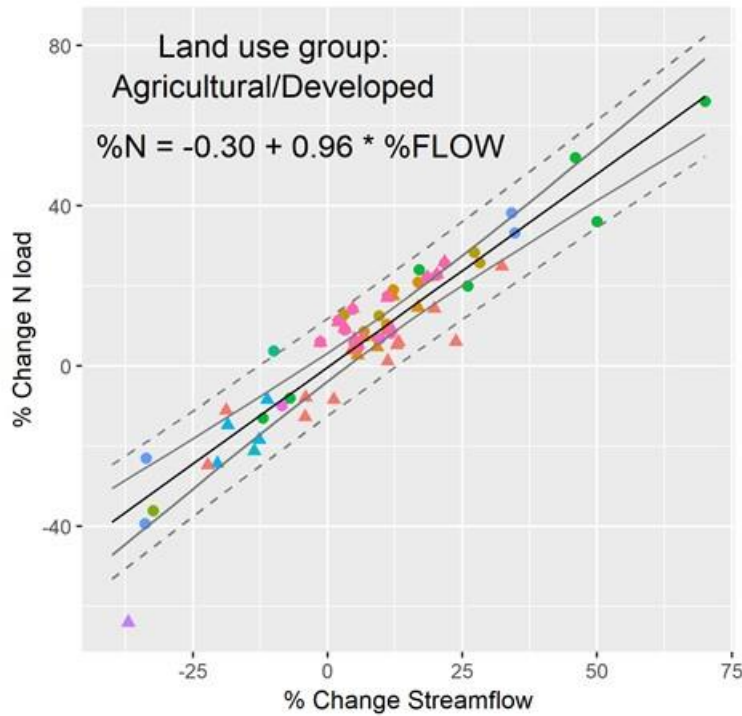
# Summary

- Watershed modeling
  - Significant advances incorporated into 2020 climate decision
  - Little additional work specified
- Estuarine modeling
  - Significant advances incorporated into 2020 climate decision
  - Progress being made toward wholesale changes recommended for the future
- Overall framework
  - Challenge to incorporate uncertainty in decision-making
  - Re-examine climate assumptions
  - Re-examine environmental endpoints

# Extra Slides

# Near term: Closely examine sensitivities - watershed

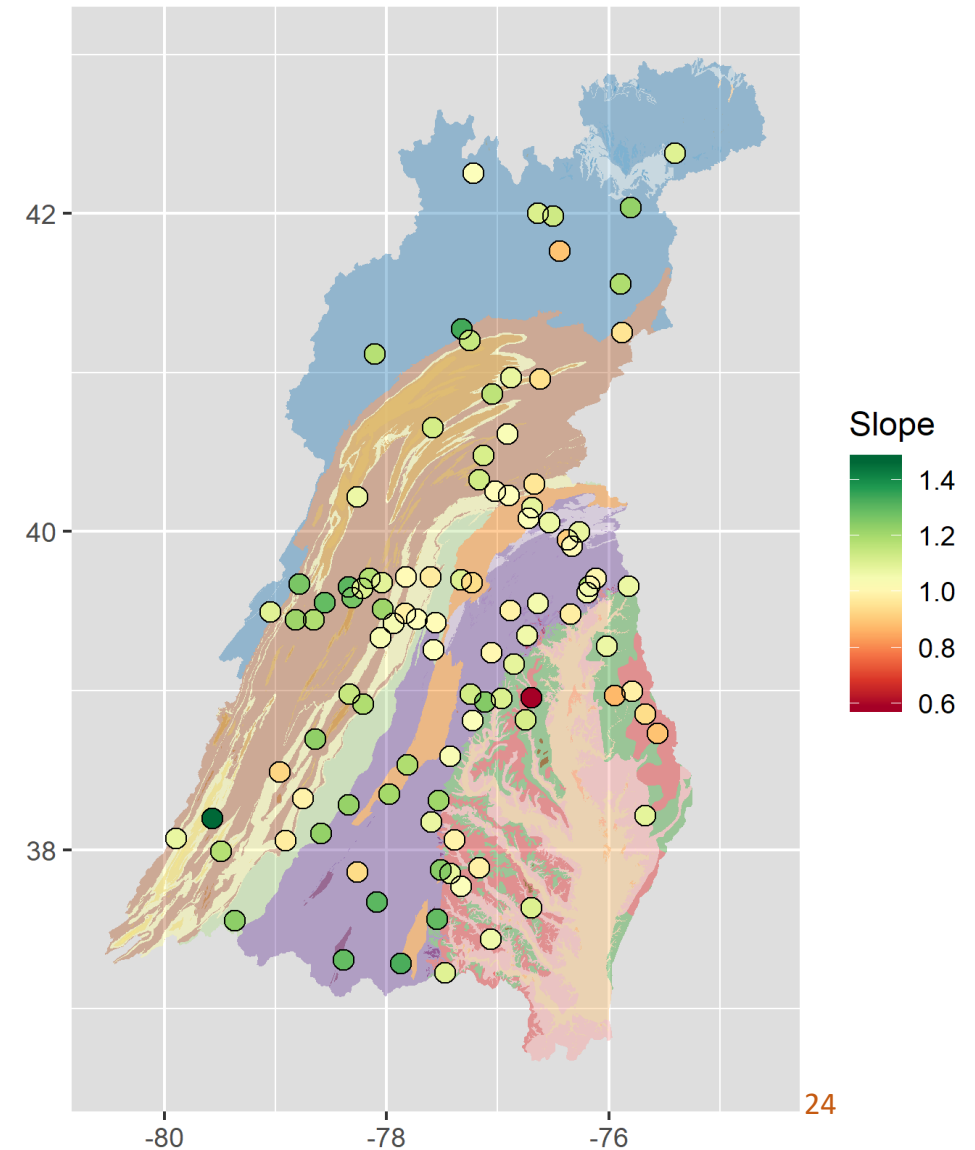
- Spatially vary the relationship between nitrogen and flow



- No consistent relationship to land use found

# Near term: Closely examine sensitivities - watershed

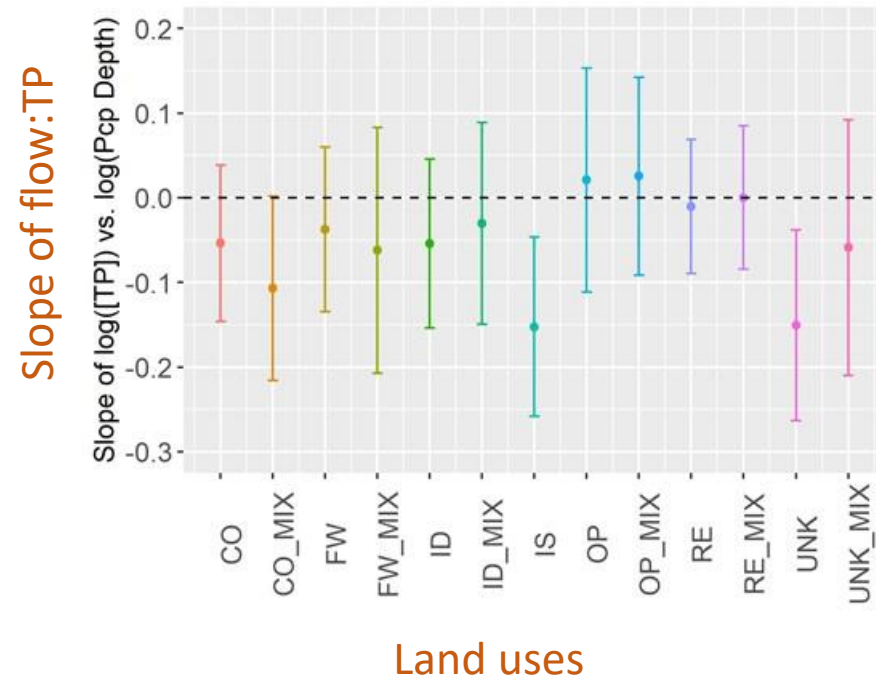
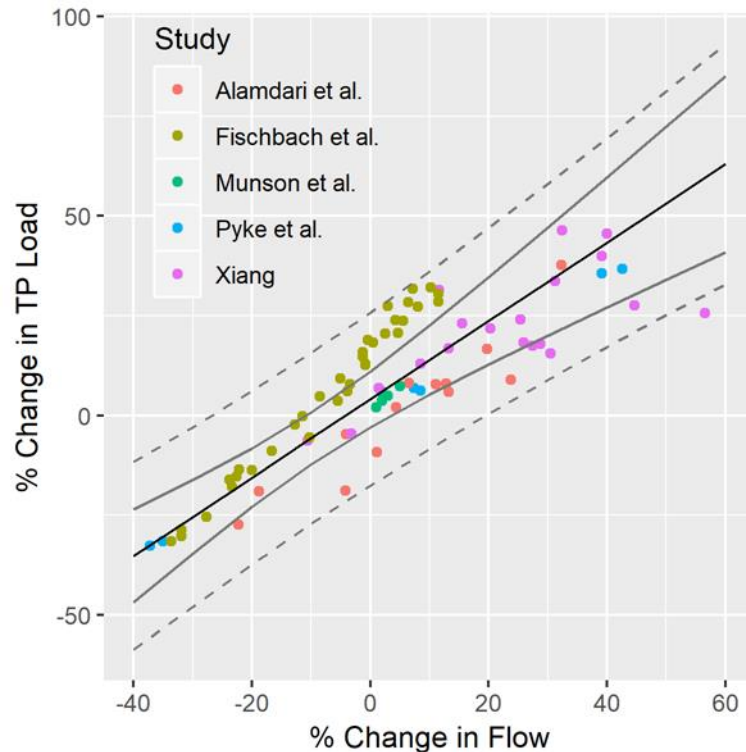
- Spatially vary the relationship between nitrogen and flow
- Using monitoring data, a slightly higher than a 1:1 relationship between flow change and TN change found in lower loading areas, but not a strong enough relationship to include.



# Near term: Closely examine sensitivities - watershed

- Developed area sensitivity to Phosphorus

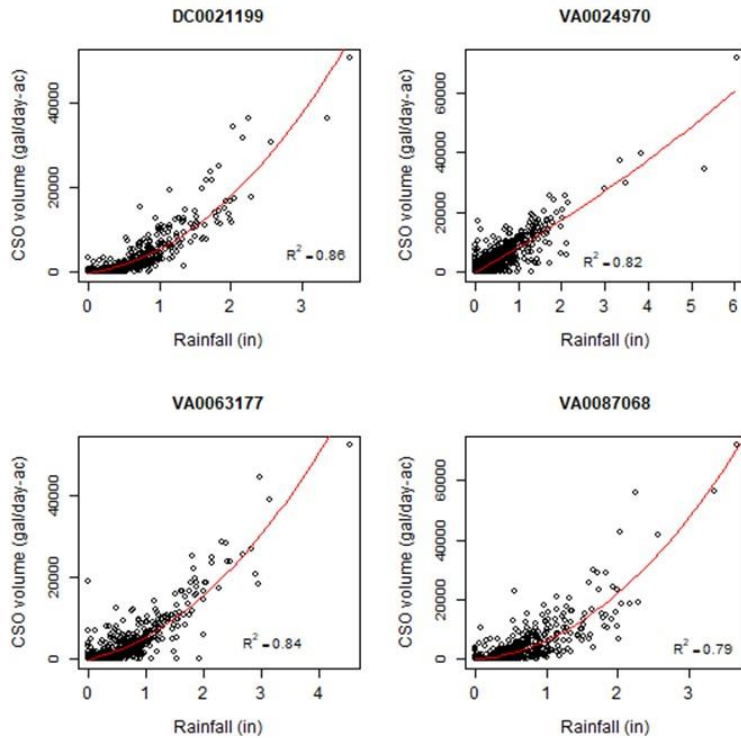
Literature review shows 1:1 relationship to flow



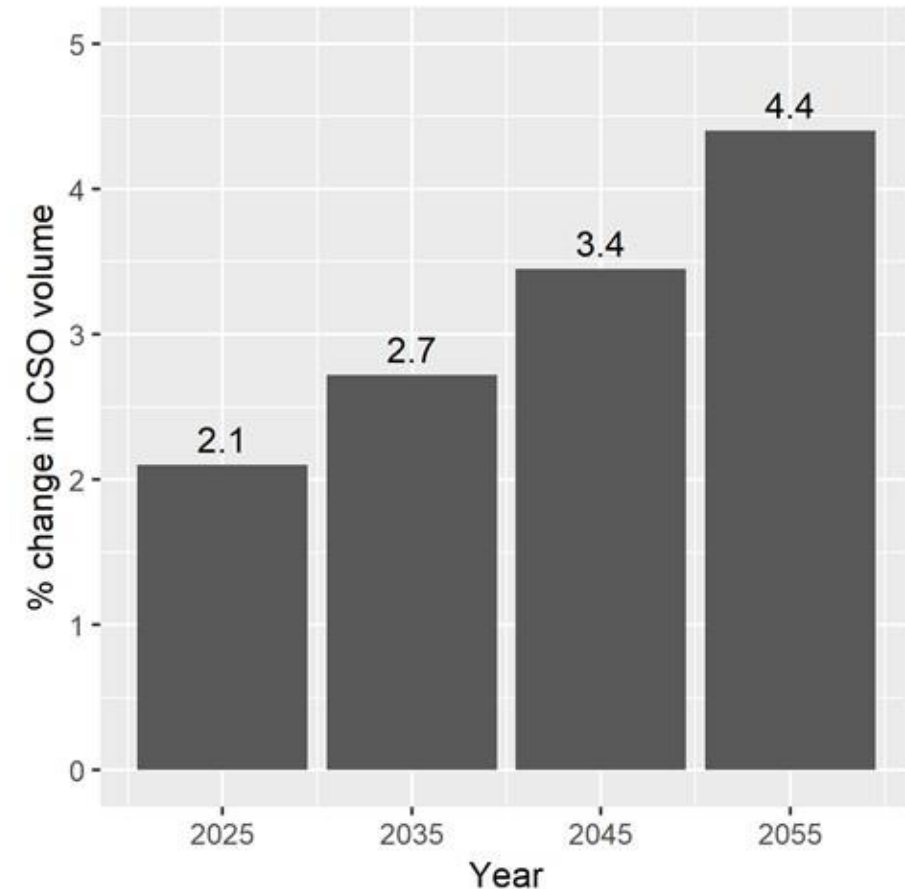
# Near term: Closely examine sensitivities - watershed

- Investigate potential changes to wastewater overflows

CSO volume



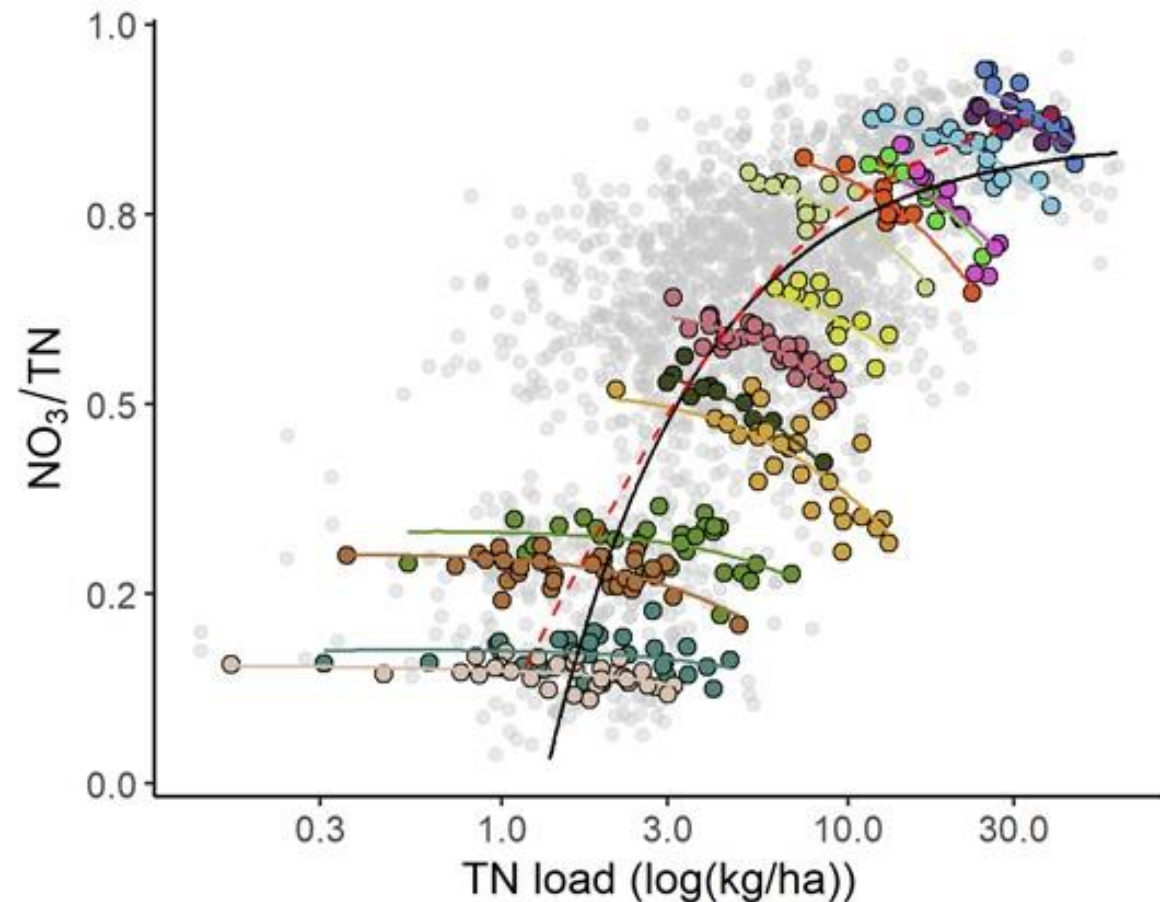
Rain





# Near term: Closely examine sensitivities - watershed

- Change the nitrogen and phosphorus speciation methods



- Nitrate fraction increases with more load across space
- Nitrate fraction decreases with more load at a single station.

**Bertani, I., Bhatt, G., Shenk, G.W. and Linker, L.C., 2021.** Quantifying the Response of Nitrogen Speciation to Hydrology in the Chesapeake Bay Watershed Using a Multilevel Modeling Approach. JAWRA Journal of the American Water Resources Association.

# Near term: Closely examine sensitivities - estuarine

- Resolve the effect of sea-level rise

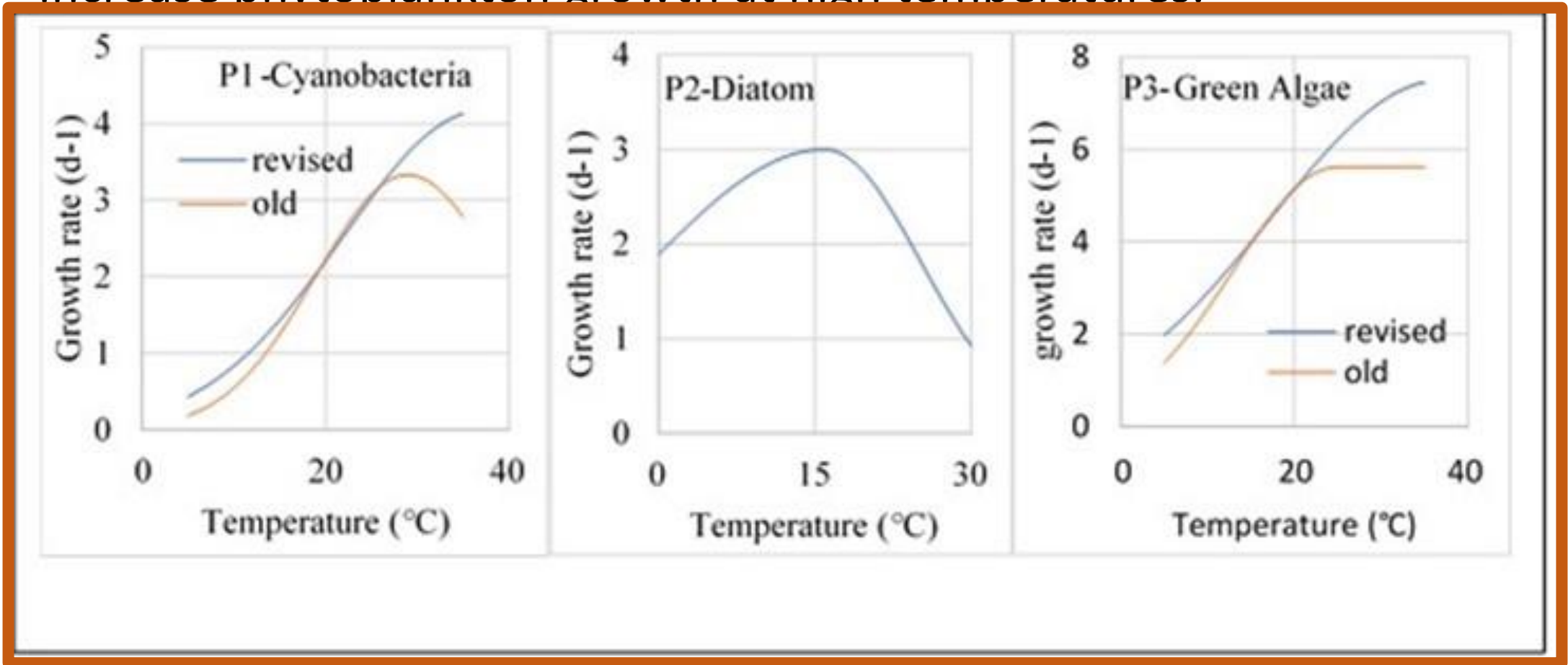


Two separate models

Average – used in CBP model

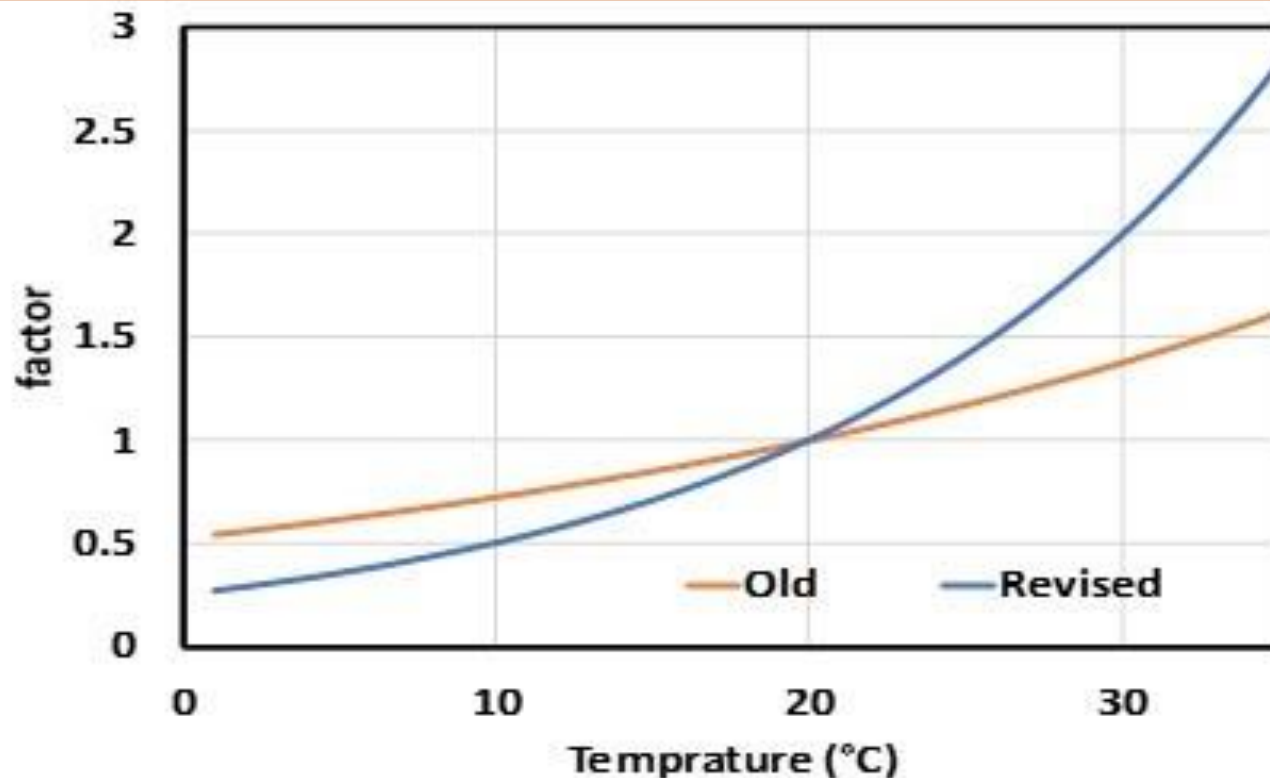
# Near term: Closely examine sensitivities - estuarine

- Increase phytoplankton growth at high temperatures.



# Near term: Closely examine sensitivities - estuarine

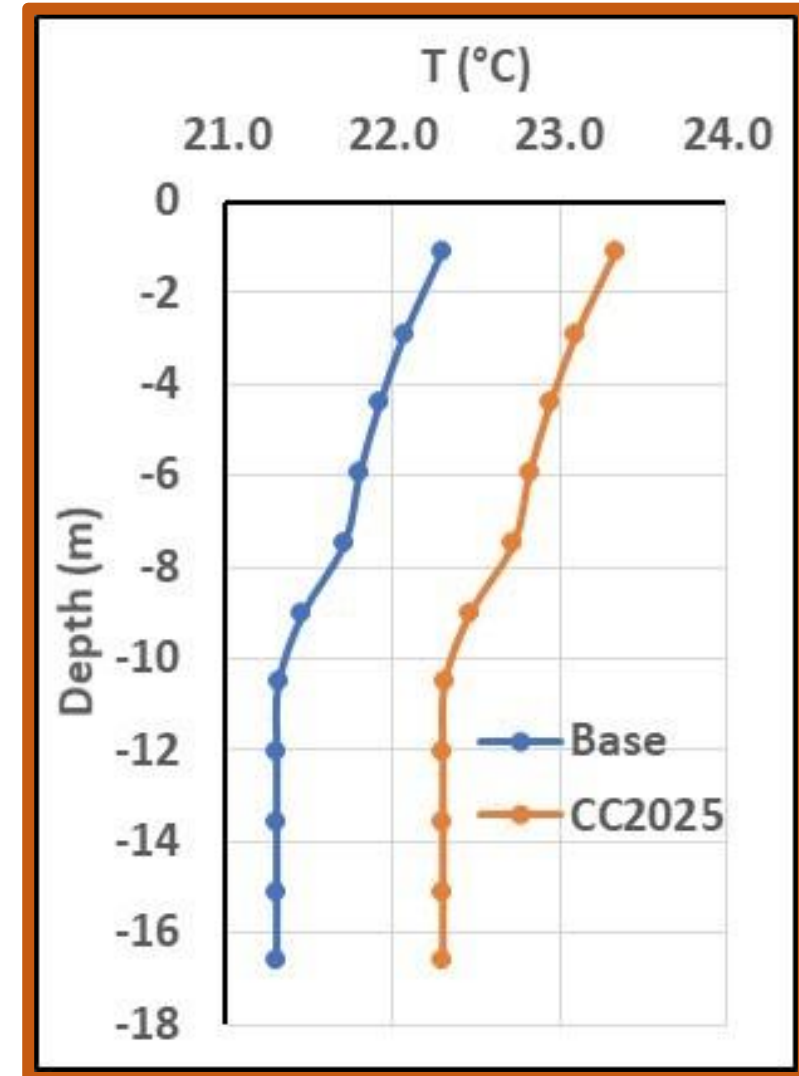
- Include a temperature dependent mortality or grazing rate in the model.



- More recent and local literature used to modify respiration curve

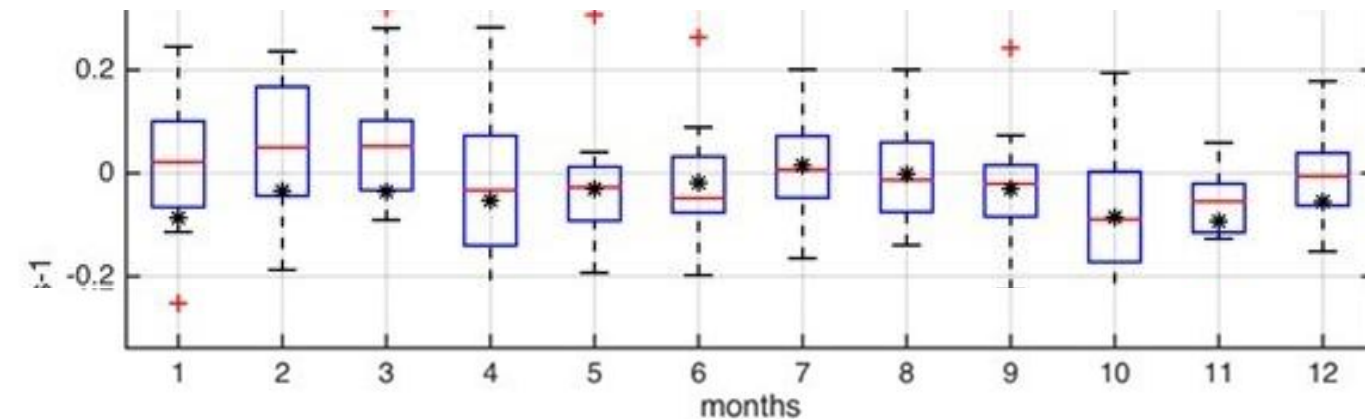
# Near term: Closely examine sensitivities - estuarine

- Re-examine the outer boundary conditions
- Change in surface temperature is 90% of the air temperature change
- Change in temperature at depth is the surface change times the ratio of initial temperatures – colder, deeper water changes less



# Near term: Closely examine sensitivities - estuarine

- Investigate downscaled future wind products.



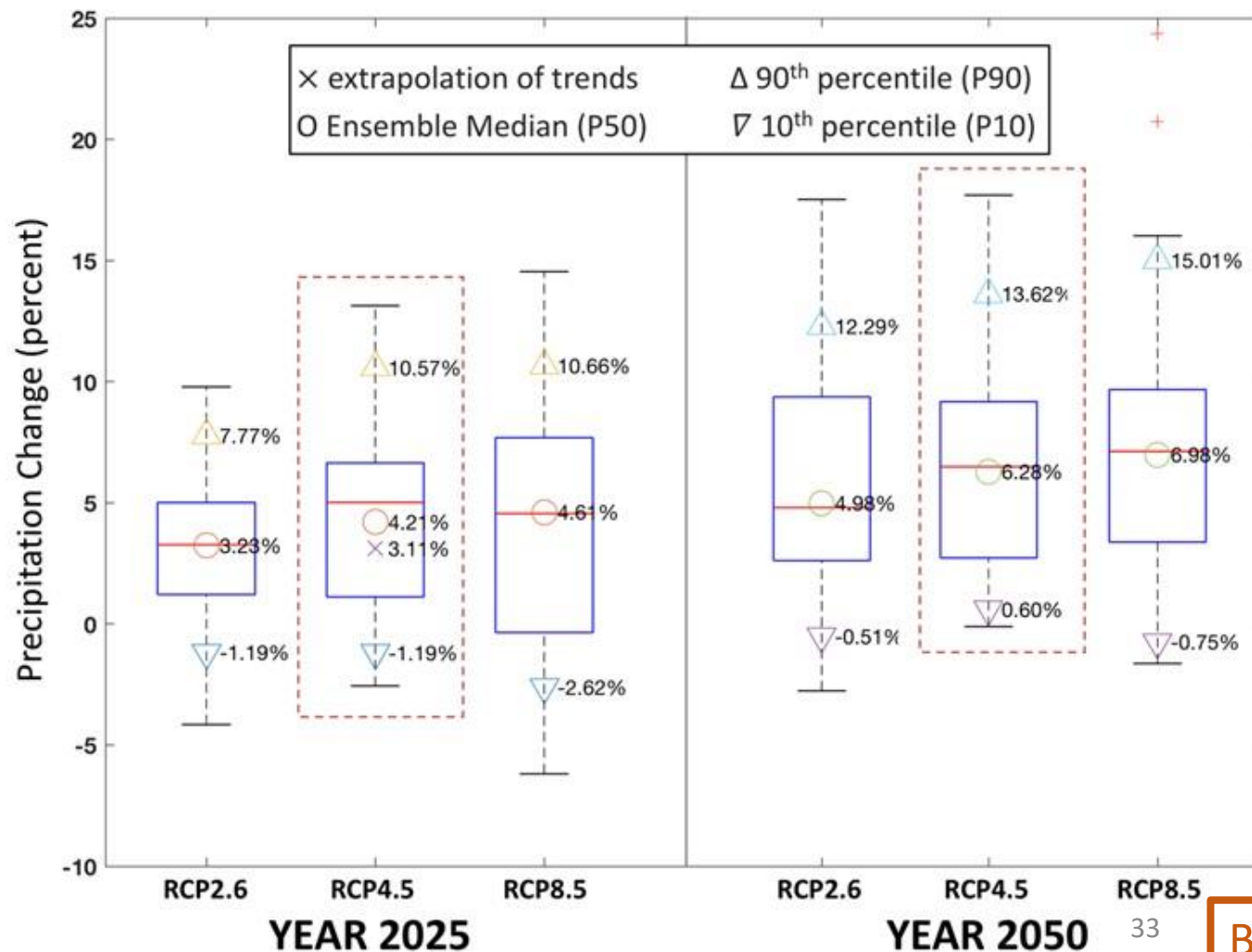
- Need around 4 meters per second to make a significant difference

- Change in wind speed on the order of 0.1 meters per second



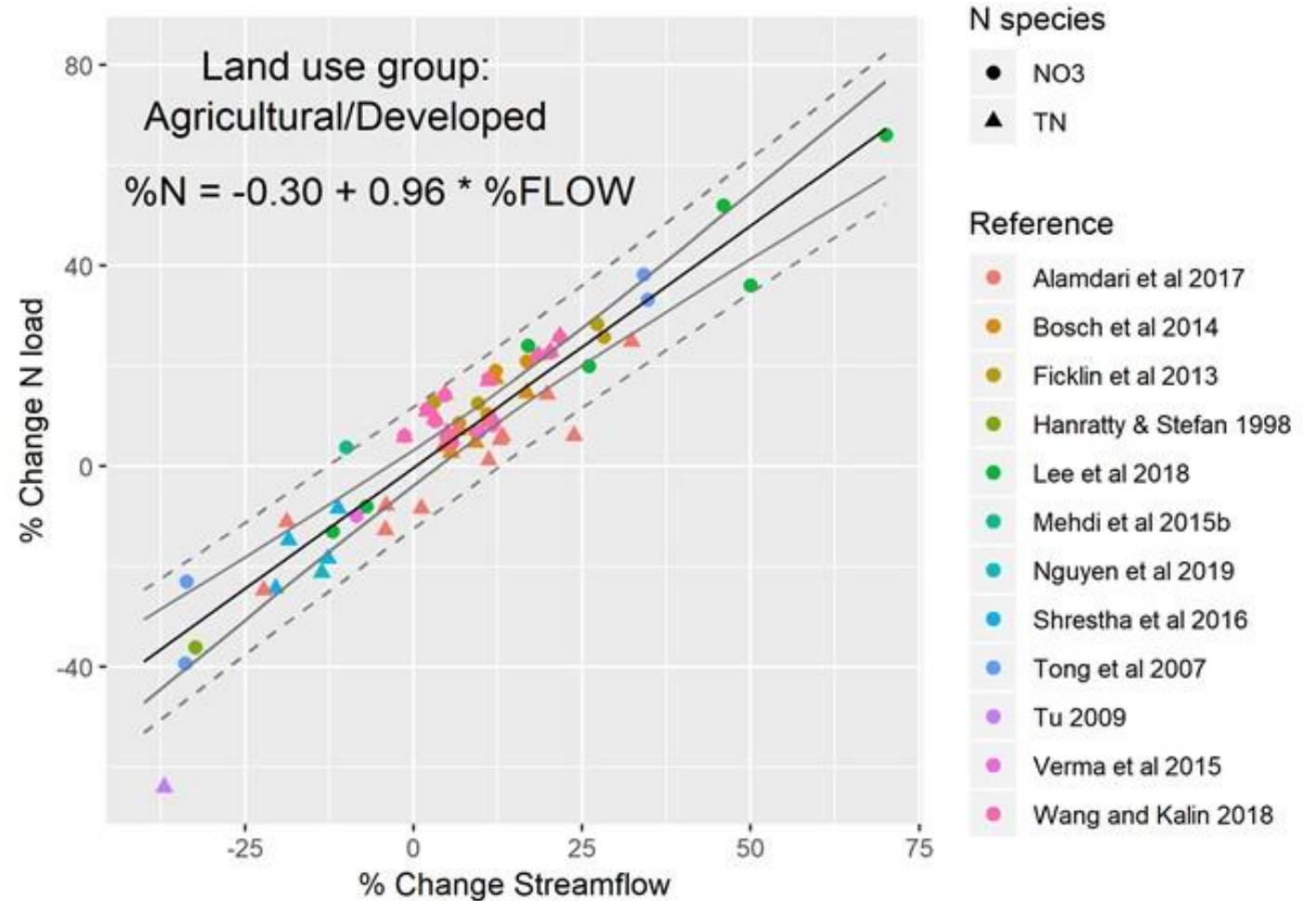
# Near term: Uncertainty

- Evaluated uncertainty of rainfall and temperature extrapolations



# Near term: Uncertainty

- Evaluated uncertainty of individual components
- But did not put it all together to estimate overall uncertainty



# Near Term: Compare Multiple Water Quality Models

- VIMS-led CHAMP project
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  - Multiple watershed models
  - Multiple estuarine models

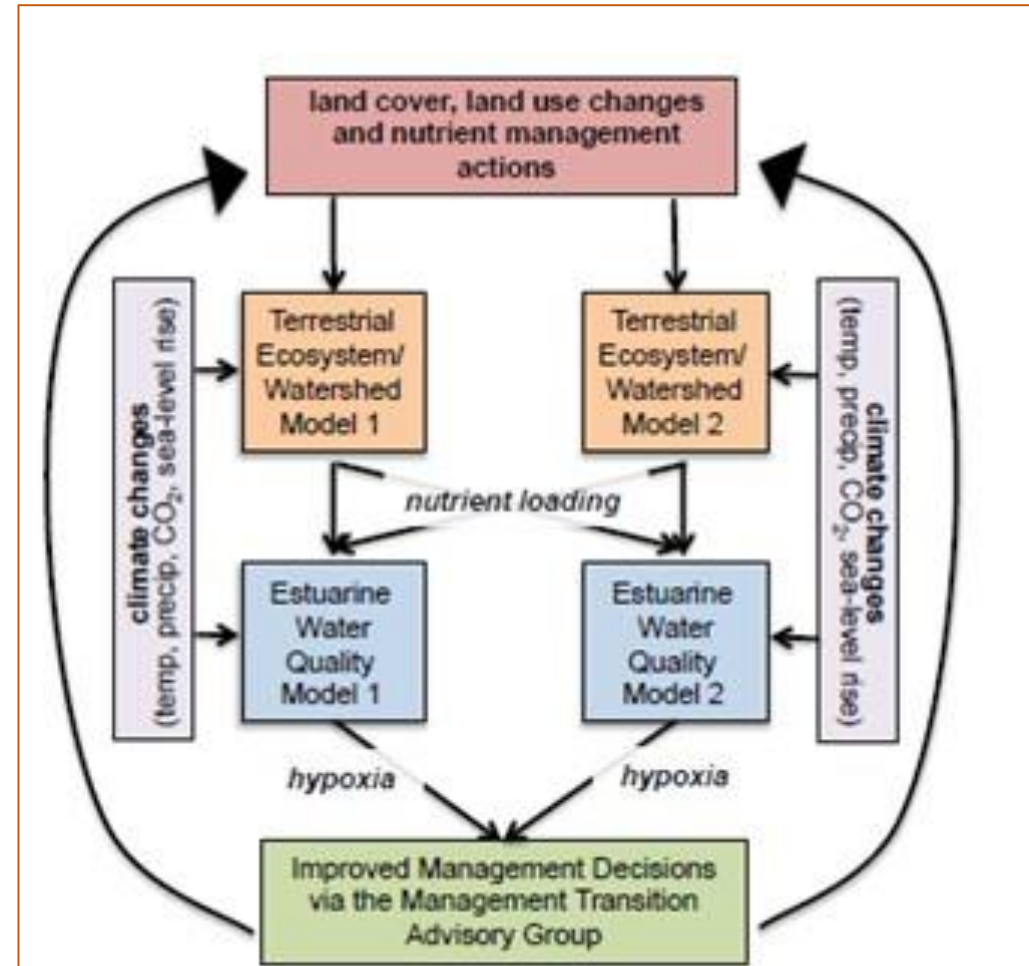


Fig. 2. Overall framework for proposed research, showing direct links between various components of the ecosystem-based scenario forecast modeling system.