STAC Workshop
Climate Change Modeling 2.0

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MWG

October 10, 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

Chesapeake Bay Program
Climate Change Modeling 2.0

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

STAC Publication 21-003

Workshop Steering Committee:
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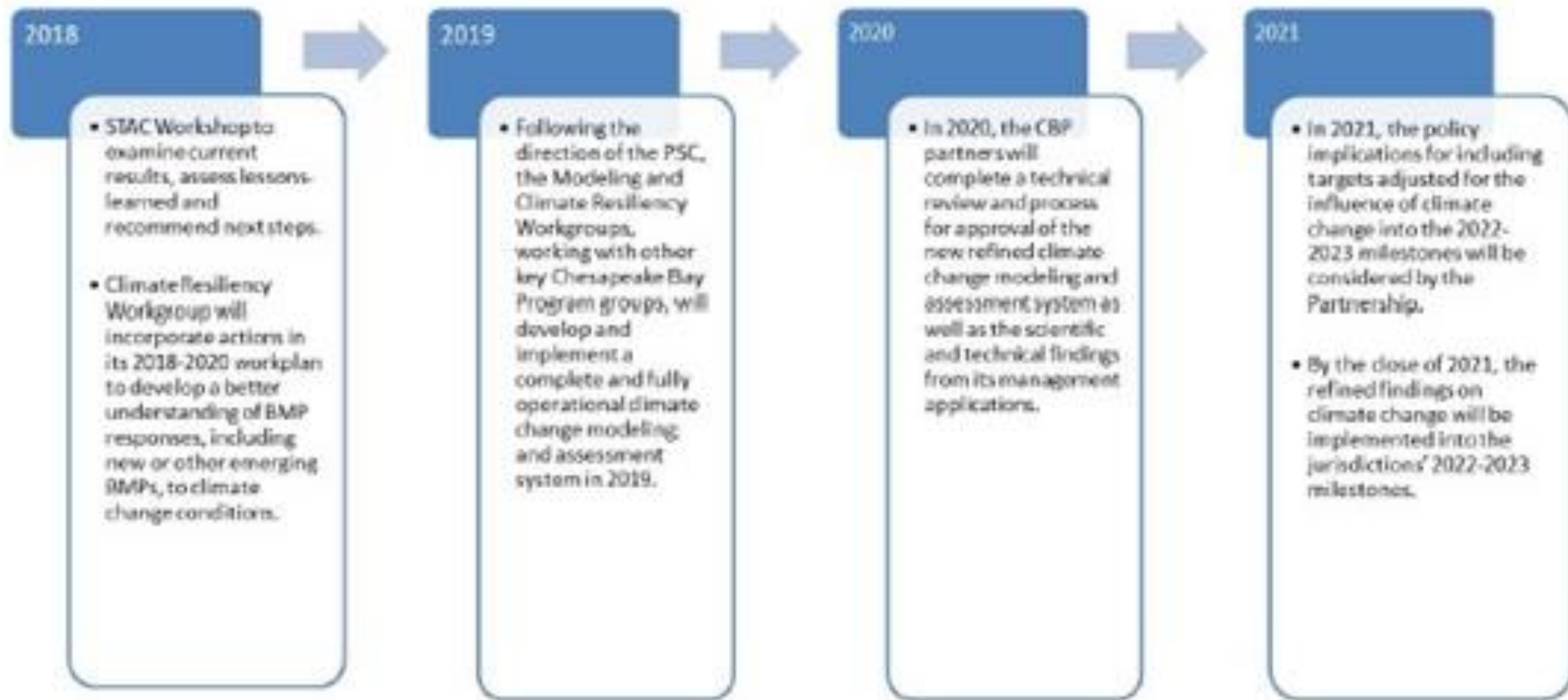Annabelle Harvey, Chesapeake Research Consortium

Why is it coming out now?

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.

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

Climate Change Processes and Dependencies
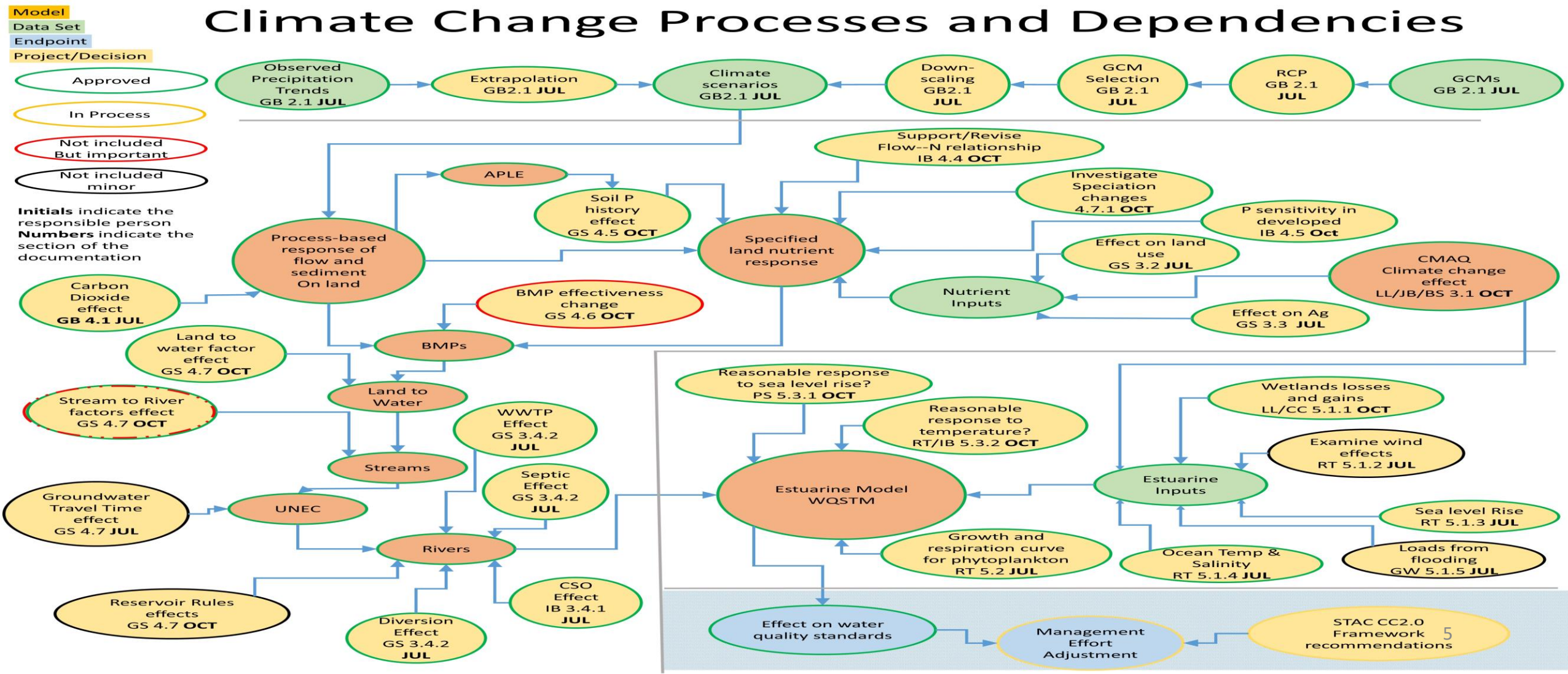
Near term: Closely examine sensitivities and make improvements- watershed

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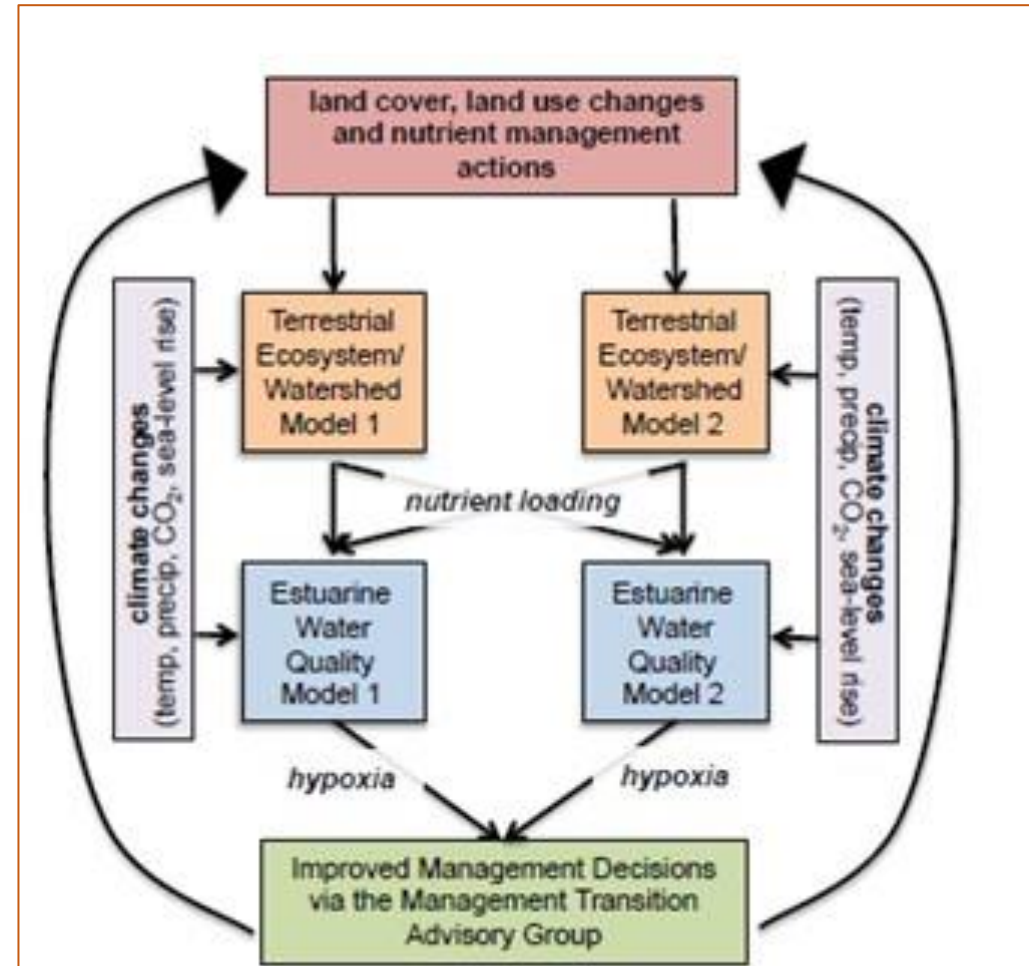
Fig. 2. Overall framework for proposed research, showing direct links between various components of the ecosystem-based scenario forecast modeling system.

Near Term Recommendations (by 2021)

- 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.

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
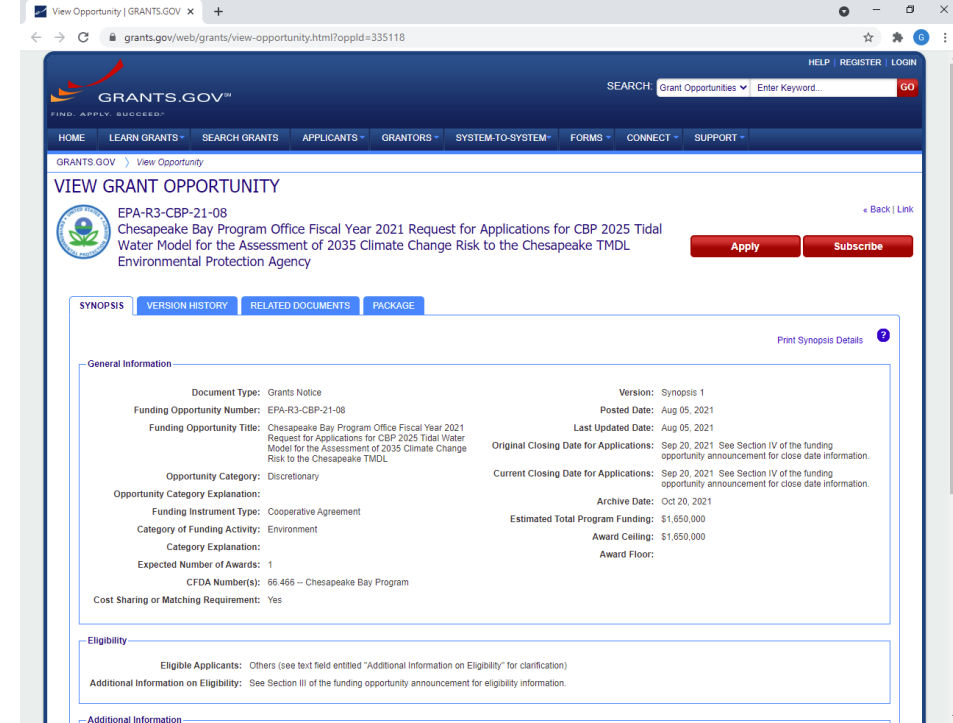
Long Term: Watershed model

- 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
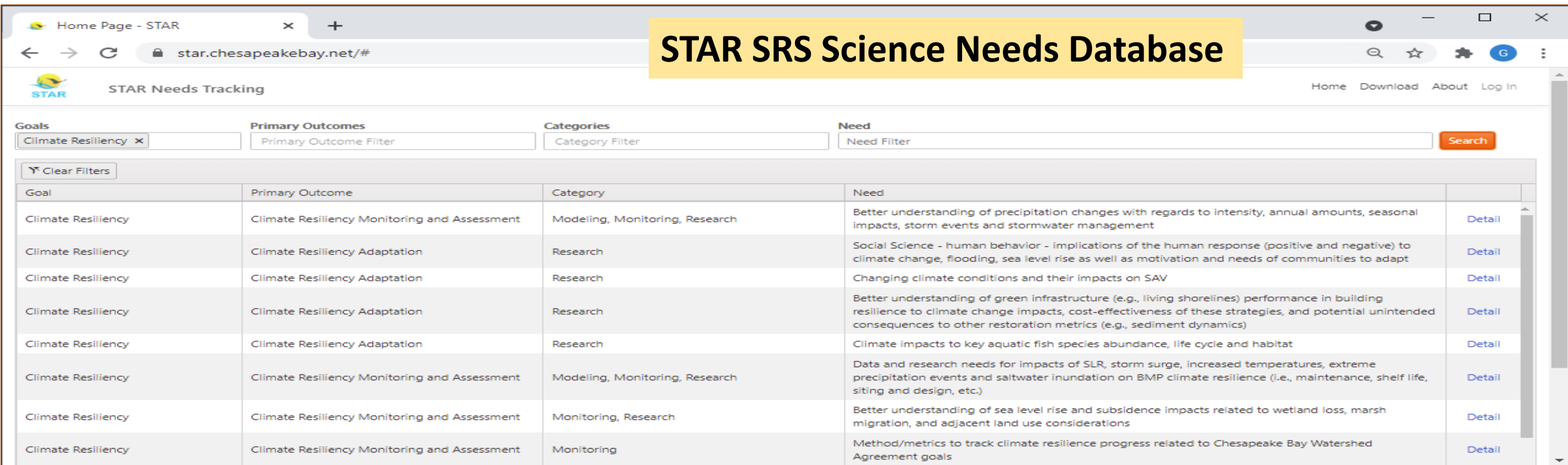
- Climate inputs
  - Use climate models rather than observed trend
  - Evaluate multiple RCPs (now SSPs)
  - Use climate models at a finer spatial scale
- CBP will consider these in 2024-2025
- Develop improved suite of mechanistic models
- Yes for estuarine model: No for watershed model
- Interact with 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
  - the CBP should consider developing, supporting, and periodically updating a Strategic Research Framework that identifies ongoing activities and priority knowledge gaps.

STAR SRS Science Needs Database

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

No Shading — Open Water, surface to bottom

Open Water over Deep Water

Open Water over Deep Water over Deep Channel
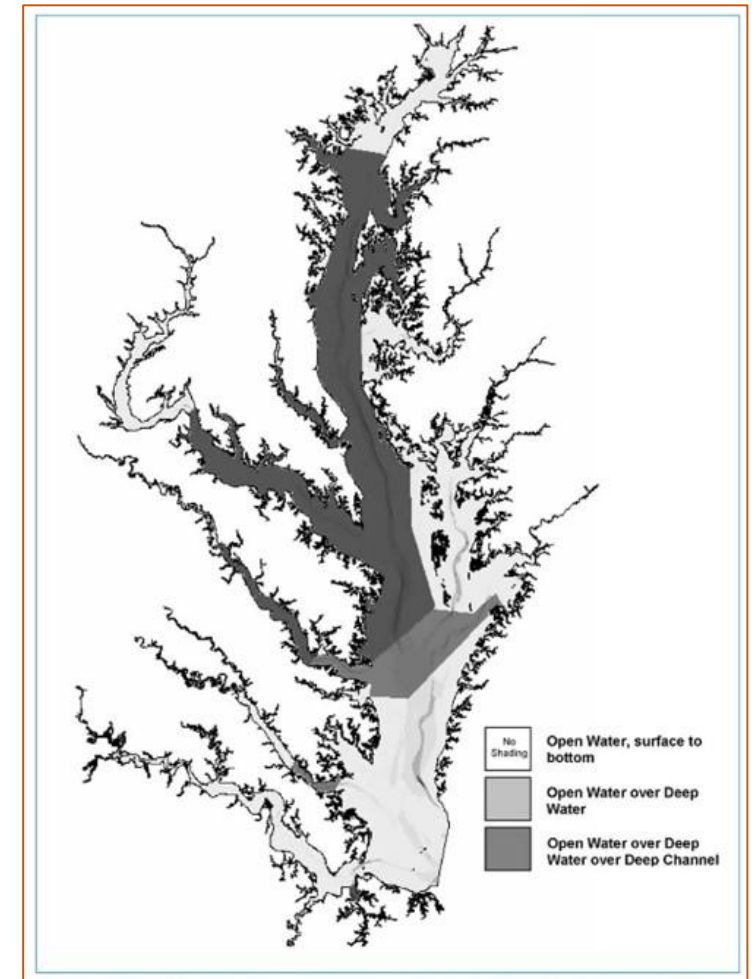
Use of uncertainty in Decision Process

(b)

prob. of attainment vs N load (10^6 lb)
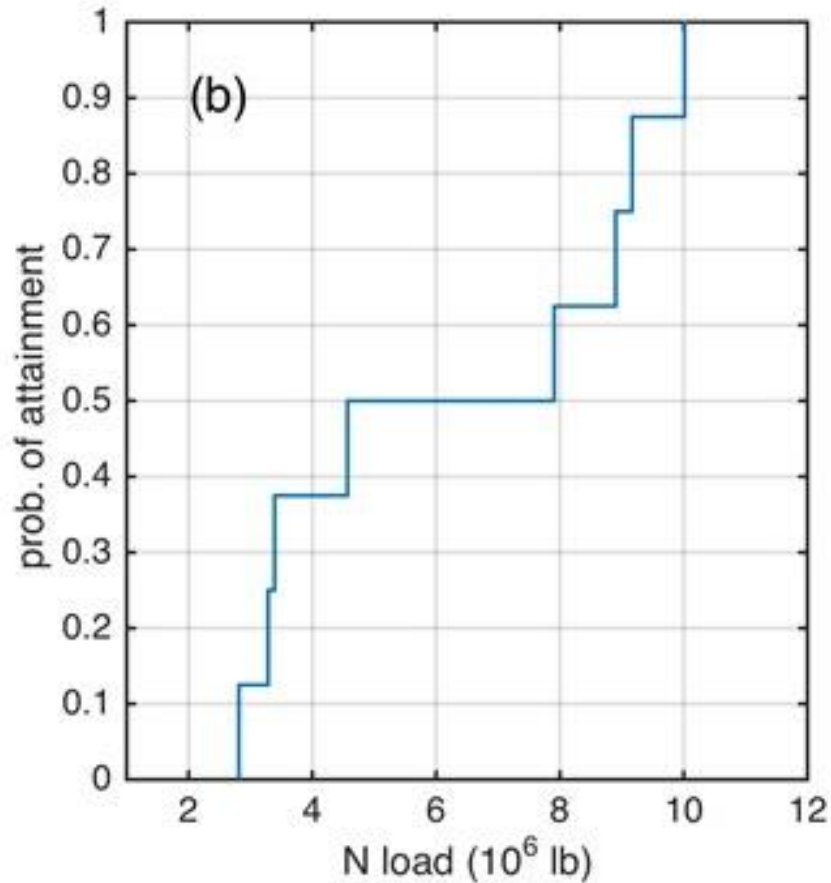
- Workshop Suggestion: Use of multiple scenarios to define a probability of attainment for a particular load reduction goal.

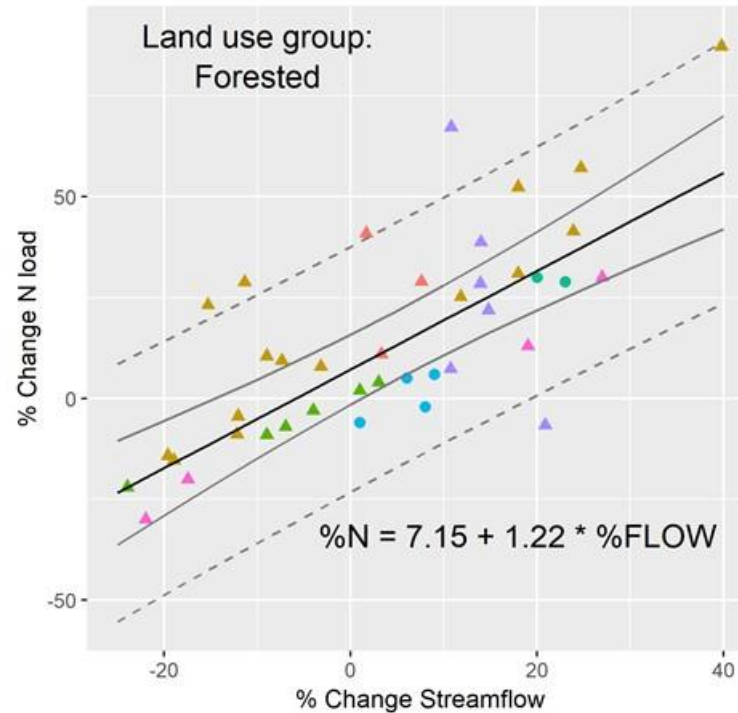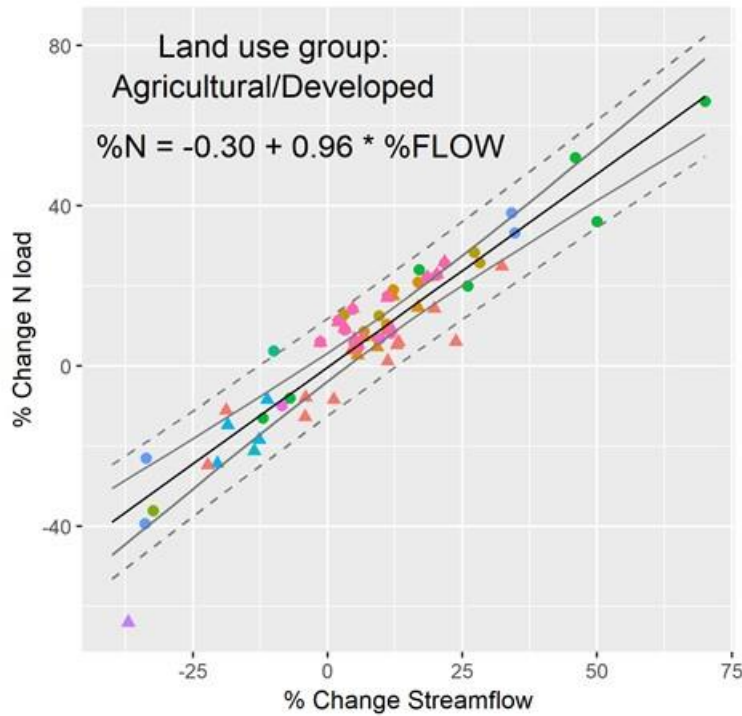- CBP could consider in 2024-2025

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

Land use group: Agricultural/Developed

$\%N = -0.30 + 0.96 * \%FLOW$

Land use group: Forested

$\%N = 7.15 + 1.22 * \%FLOW$

Land use group: Mixed

$\%N = -0.42 + 0.80 * \%FLOW$
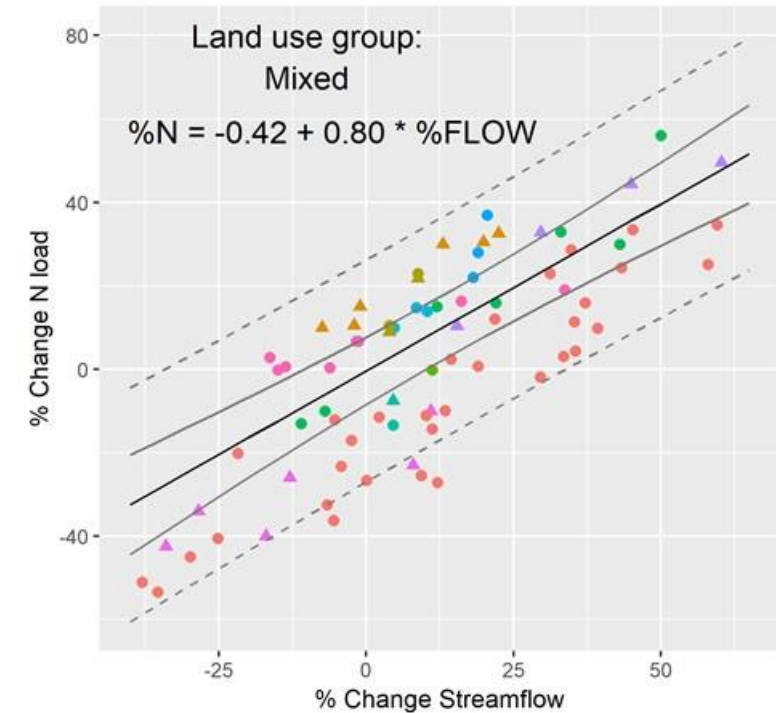
- No consistent relationship to land use found

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.

Bertani
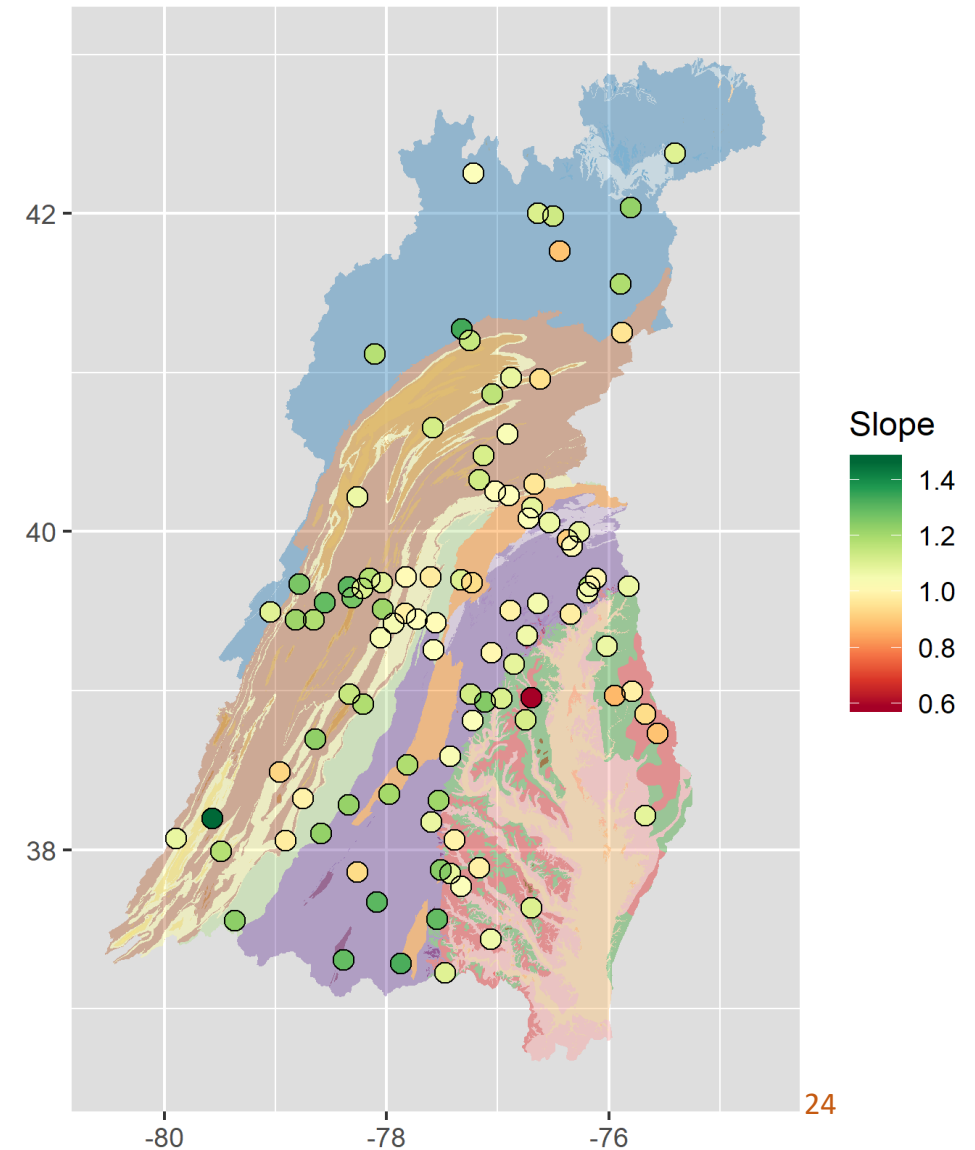
Near term: Closely examine sensitivities - watershed

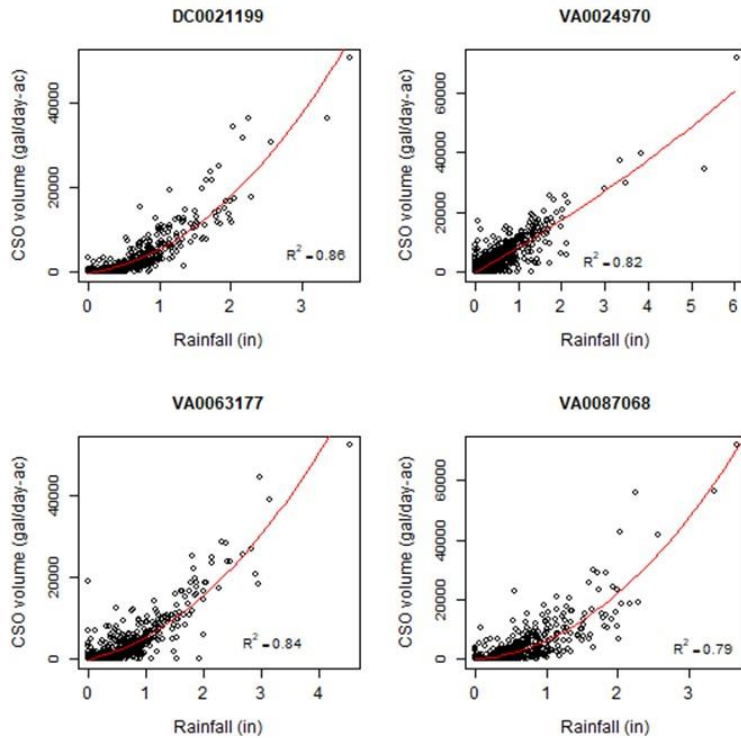- Developed area sensitivity to Phosphorus

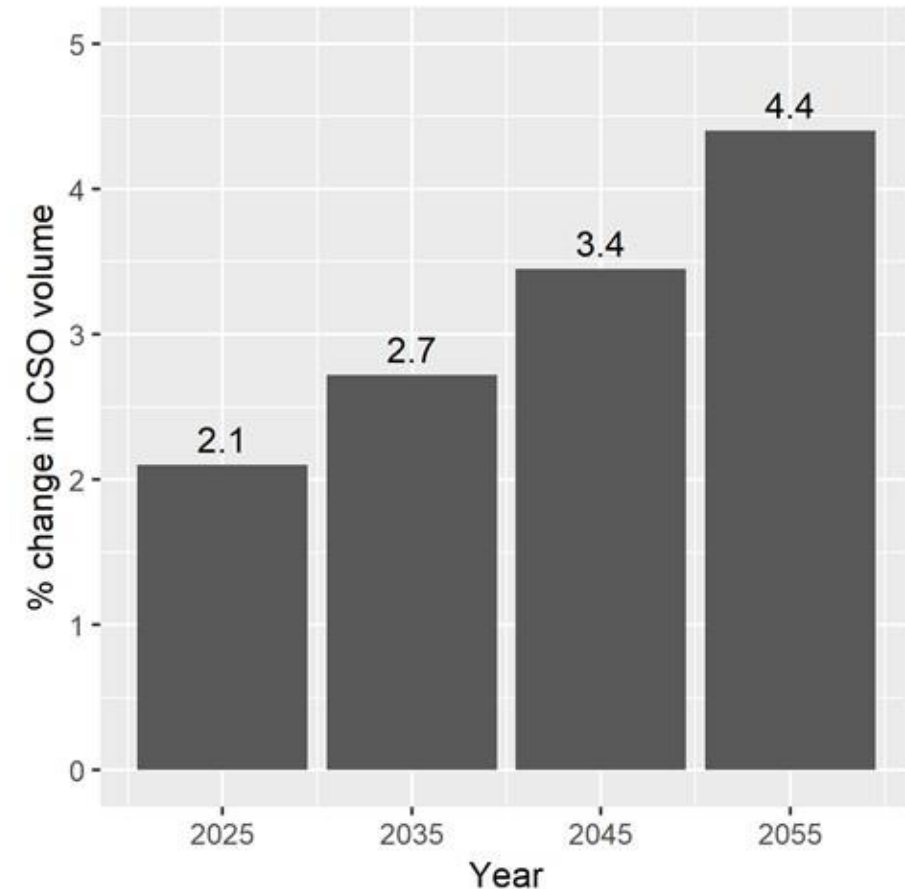Literature review shows 1:1 relationship to flow
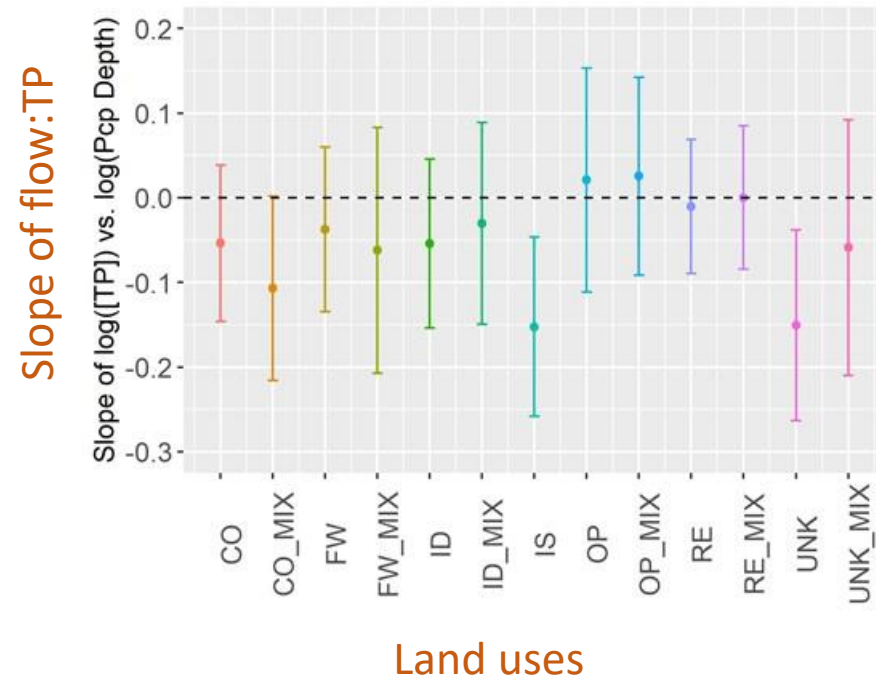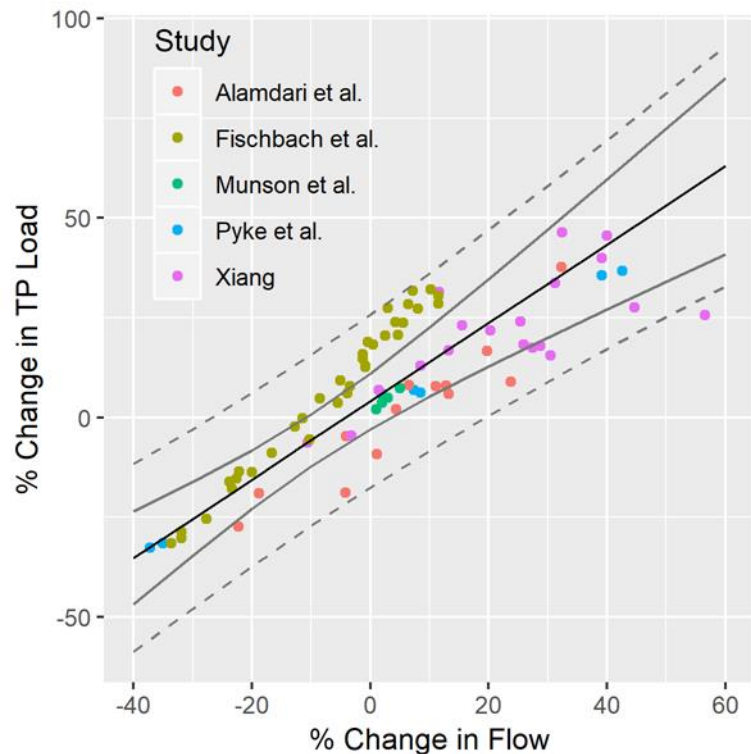
Near term: Closely examine sensitivities - watershed

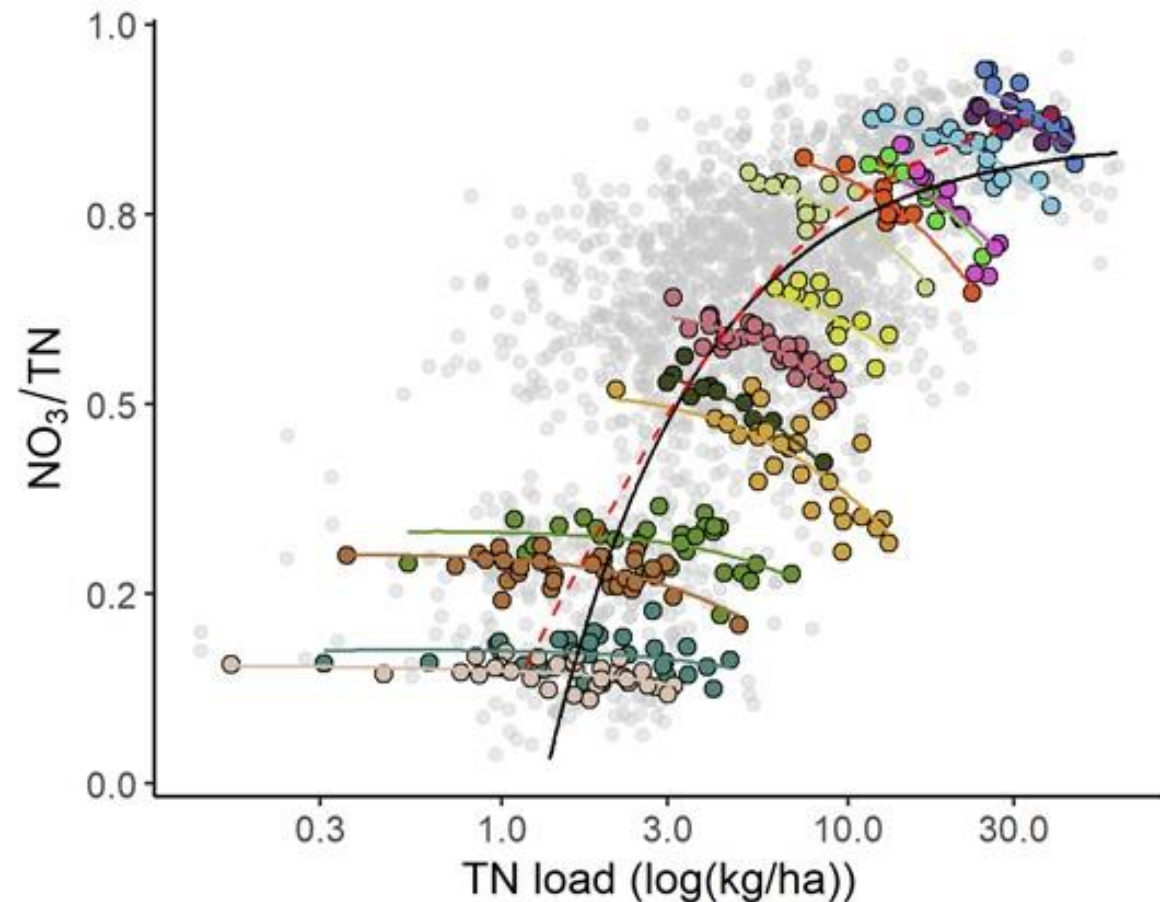- Investigate potential changes to wastewater overflows

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
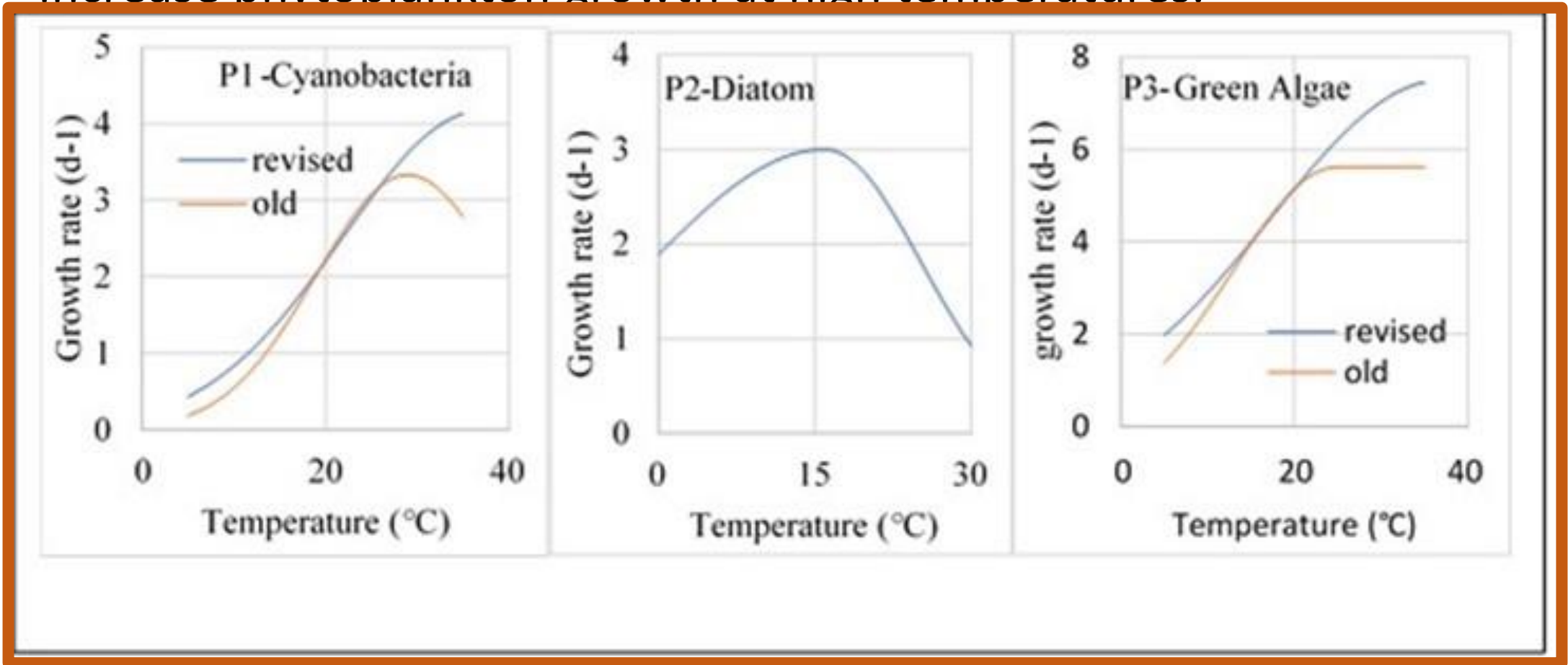
- Resolve the effect of sea-level rise

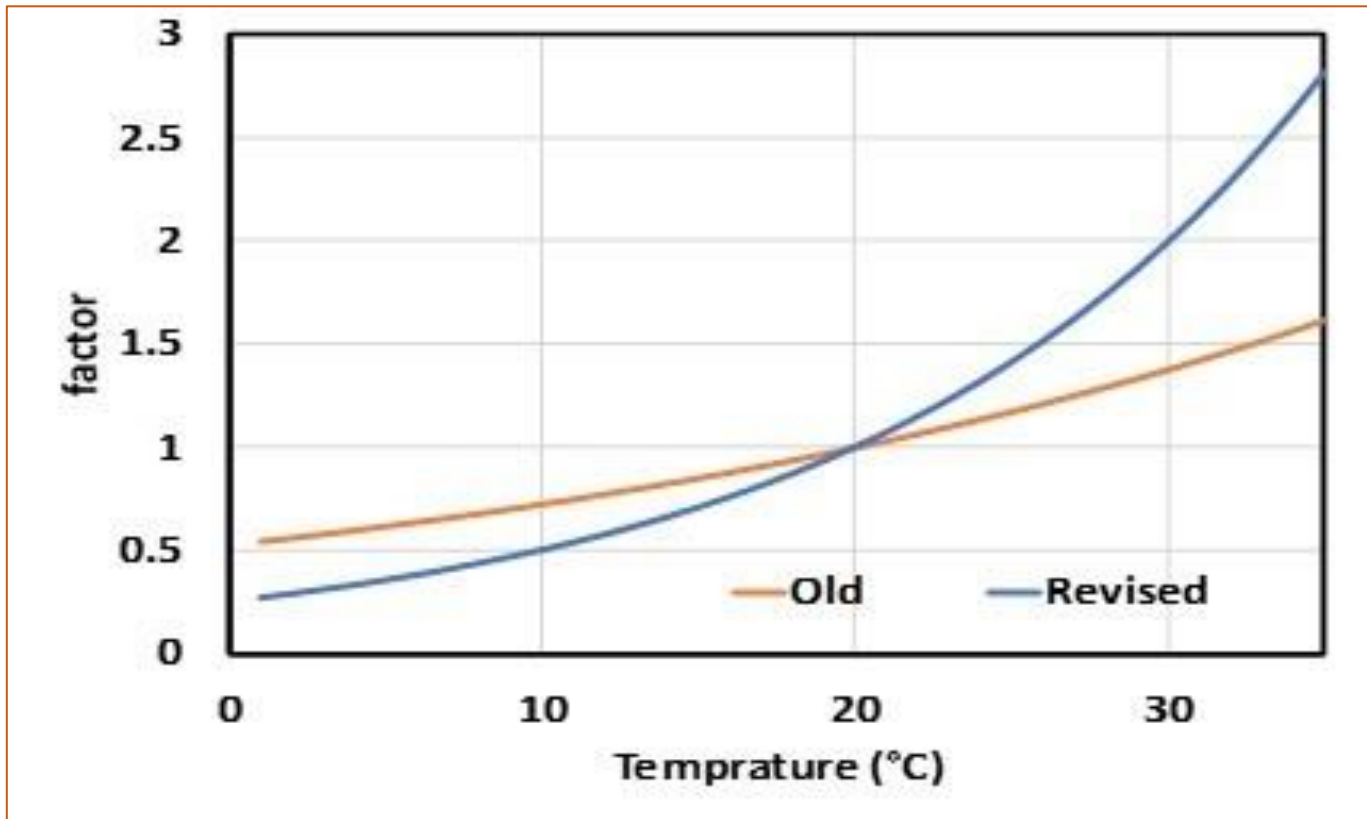Two separate models

Average – used in CBP model

28

Tian

Near term: Closely examine sensitivities - estuarine

- Increase phytoplankton growth at high temperatures.

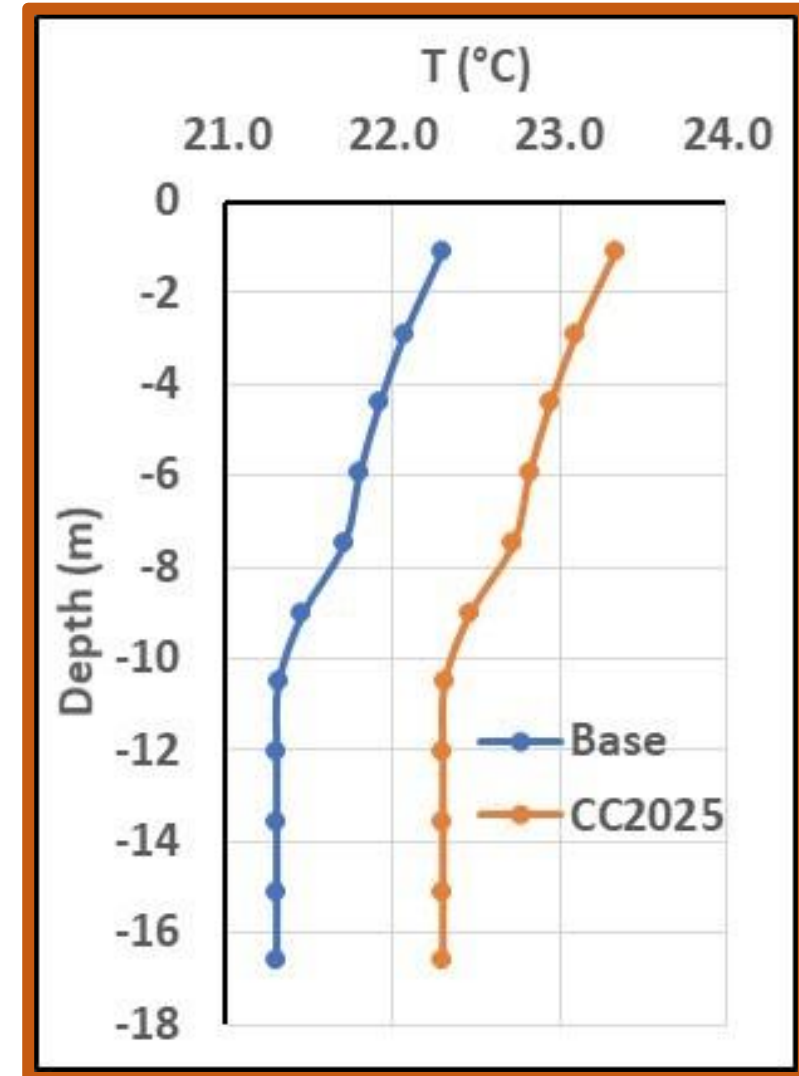# Near term: Closely examine sensitivities - estuarine

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

- More recent and local literature used to modify respiration curve

Tian

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

Tian

Near term: Closely examine sensitivities - estuarine

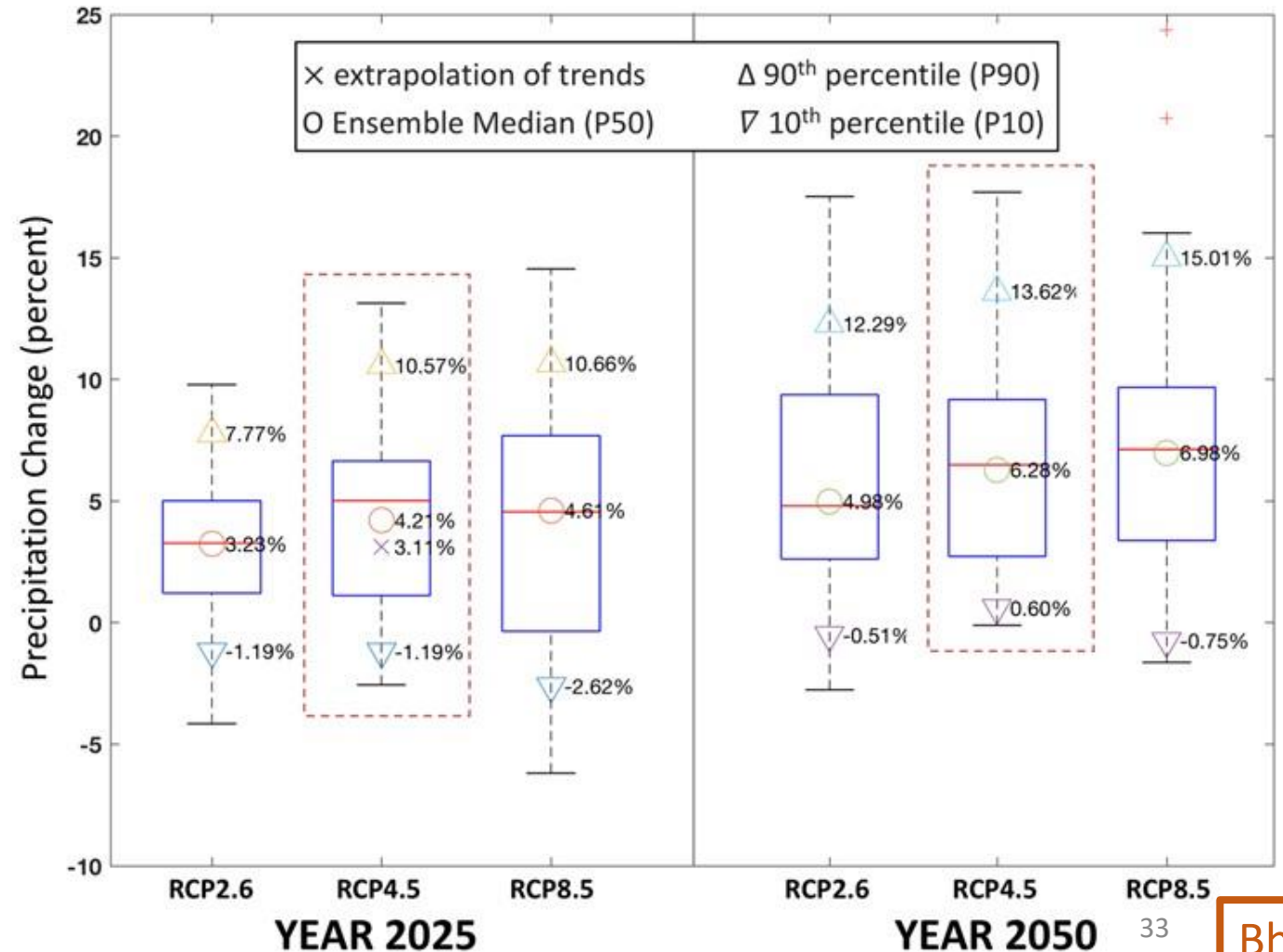- Investigate downscaled future wind products.
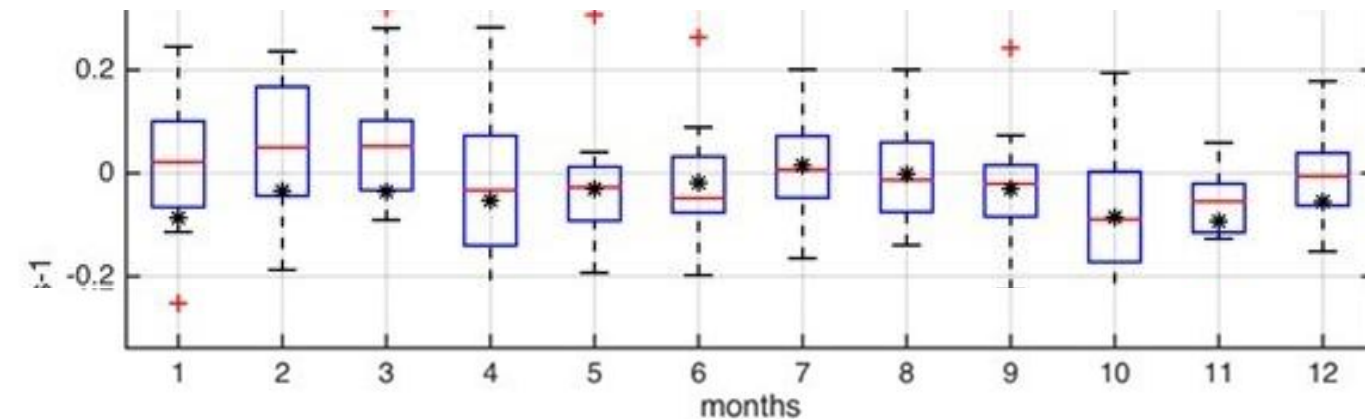
- Need around 4 meters per second to make a significant difference

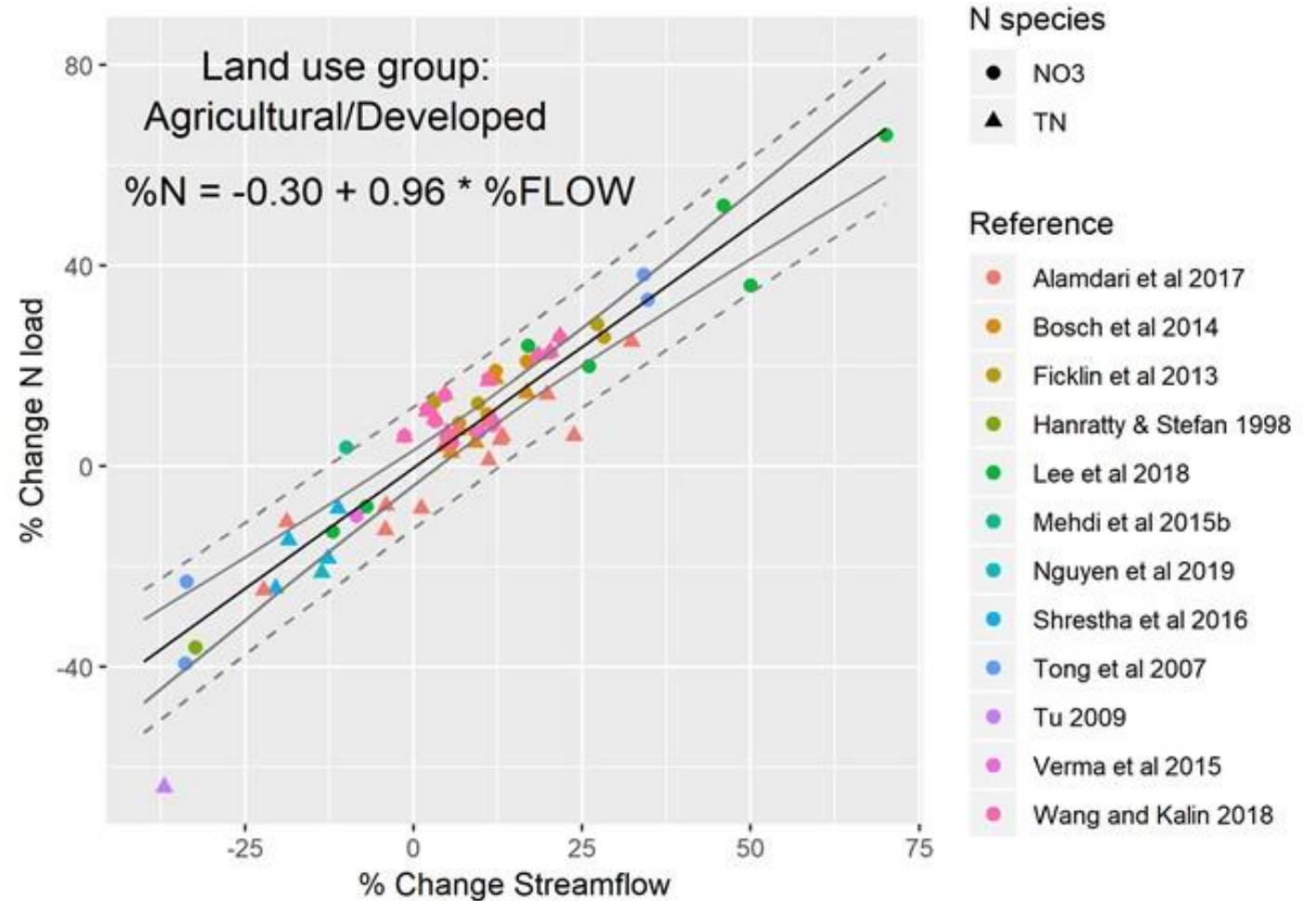- Change in wind speed on the order of 0.1 meters per second

Tian

Near term: Uncertainty

- Evaluated uncertainty of rainfall and temperature extrapolations

Bhatt

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
  - Multiple climate models
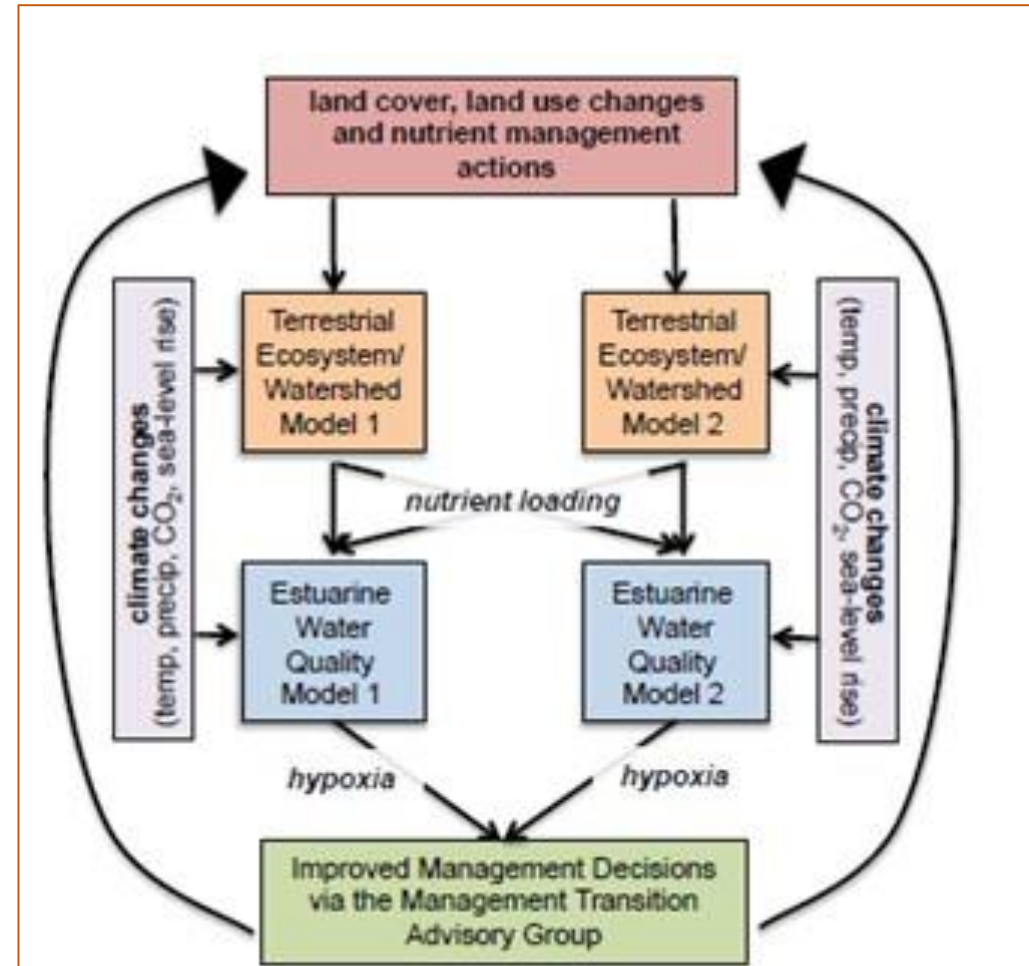 - Multiple watershed models
  - Multiple estuarine models

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