Simulating Impacts of Climate Change on the Bay

Marjorie Friedrichs & Raleigh Hood

Carl Cerco
Ming Li
Jian Shen
Ray Najjar
Scott Doney
Wenfei Ni
Richard Tian
Joseph Zhang
Kevin Sellner
Charlie Stock
Blake Clark
Kyle Hinson

Simulating Impacts of Climate Change on the Bay

1. **Comparison of existing climate change simulation results**
   - What are the largest discrepancies and how can they be remedied before 2019?

2. **Next generation estuarine model**
   - What is needed to extend climate change simulations 2050?
   - What needs to be done before 2025? After 2025?

3. **Uncertainty**
   - How can model uncertainty be quantified?
   - How can confidence/uncertainty be communicated to stakeholders?

4. **STAC Synthesis**
   - What are the most critical needs for synthesis and research?

Short-term Recommendations from STAC Climate Change Workshop

1. Examine model parameterizations – temperature-dependence:

- Revise WQSTM temperature parameterizations
  - → Modify growth curve for phytoplankton (exponential rather than flattening; should not change calibration too much, because only changing impact of very higher temperatures)
  - → Also examine T-dependent mortality/grazing/remineralization terms

2. Examine forcing – wind:

- M. Herrmann has provided the CBP MW with future winds (MACA); how do these (minor) changes in winds impact hypoxia in WQSTM?
  - → weaker winds? Small change in direction?
  - → run scenario with delta change in winds

3. Examine conflicting results for impact of sea level rise on hypoxia:

- Why are very similar models getting opposite SLR results?
  - → Same result with and without reduced nutrients
  - → Is this a water quality discrepancy or a hydrodynamic discrepancy?

Recommendations for medium-term analyses

Medium term

- Conduct rigorous multiple model comparison and skill assessment over historical time period over which we have data (1985-2018)

  → If models can reproduce past interdecadal variability, we will gain confidence in future climate change analyses

Recommendations for long-term analyses
(Important modeling issues that need to be examined for next generation model)

Physical model structure:

- Carefully add high resolution where we need it (not where we don't)
  → unstructured grid is required
- Wetting/drying (expanding coastline)
- Include spectral wave model (to get shoreline erosion and sediment transport)
- Moving boundary condition offshore
  → Relax to observations where we have them at Bay mouth
  → Re-examine outer boundary conditions – obtain from Mid-Atlantic Bight modeling efforts (Note not clear yet if MAB is increasing or decreasing salinity; right at latitude between reducing and increasing S)

Recommendations for long-term analyses
(Important modeling issues that need to be examined for next generation model)

Model WQ parameterizations:

- Improve temperature-dependent and salinity-dependent parameterizations
- Investigate invasive species (with scenario runs)
- Consider potential for new HAB species
- Examine changing stoichiometric relationships (e.g. N:P ratios)
- Improved marsh/wetland models (account for changes in Zostera)
- Consider adding zooplankton back into WQ model (perhaps single group)
- Acidification (critical for oysters)

Recommendations for long-term analyses
(Important modeling issues that need to be examined for next generation model)

Model forcing:

- Look at future atmospheric forcing; more low pressure systems?
- Examine impact of change in tide range (15% change?)

Model impacts:

- Look at things other than hypoxia – examine impact on water clarity, chlorophyll, productivity….
- Look at impacts on higher trophic levels

Q3: Uncertainty

How can model uncertainty be quantified?

- Ensemble of different estuarine models
- Examining different parameters and formulations
- Examining different GCMs and downscaling methods
- Emission scenario less important by 2025 and 2050

How can uncertainty be communicated to stakeholders? (Requirement of providing one number to managers may be unreasonable)

How much risk are stakeholders willing to take?

- If OK with 10% risk that this will happen, then….. x
- If OK with 30% risk that this will happen, then….. y
- If OK with 50% risk that this will happen, then….. z

We can really provide "one number" only if managers tell us what amount of risk they want

Q4: STAC Synthesis

Resolution of SLR discrepancy!

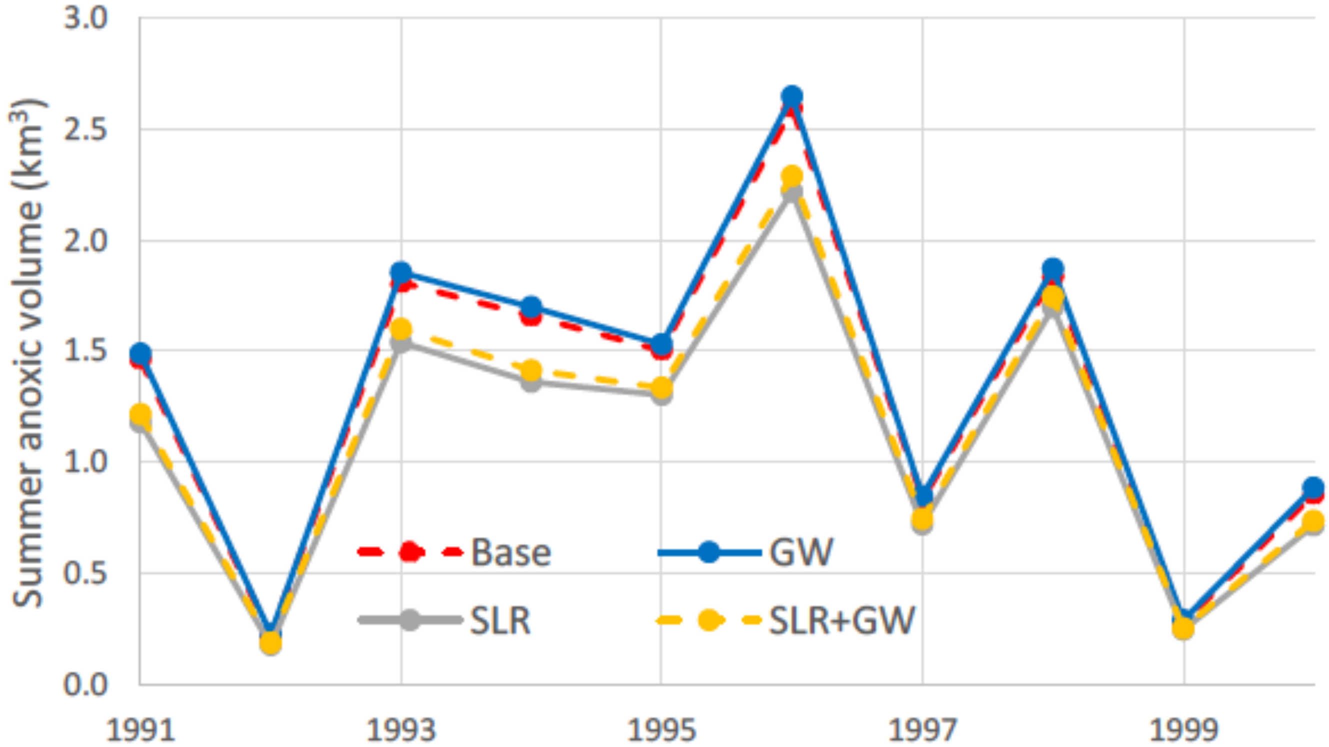
- Why are we getting opposite SLR results?
  → Same result with and without reduced nutrients
  → Is this a water quality discrepancy or a hydrodynamic discrepancy?

→ Absolutely critical
→ Something we can do within 3-8 months

Update: Since the CC Workshop, this has been funded by another mechanism!

Impacts of SLR on hypoxia: Differences between 2050 and 1995

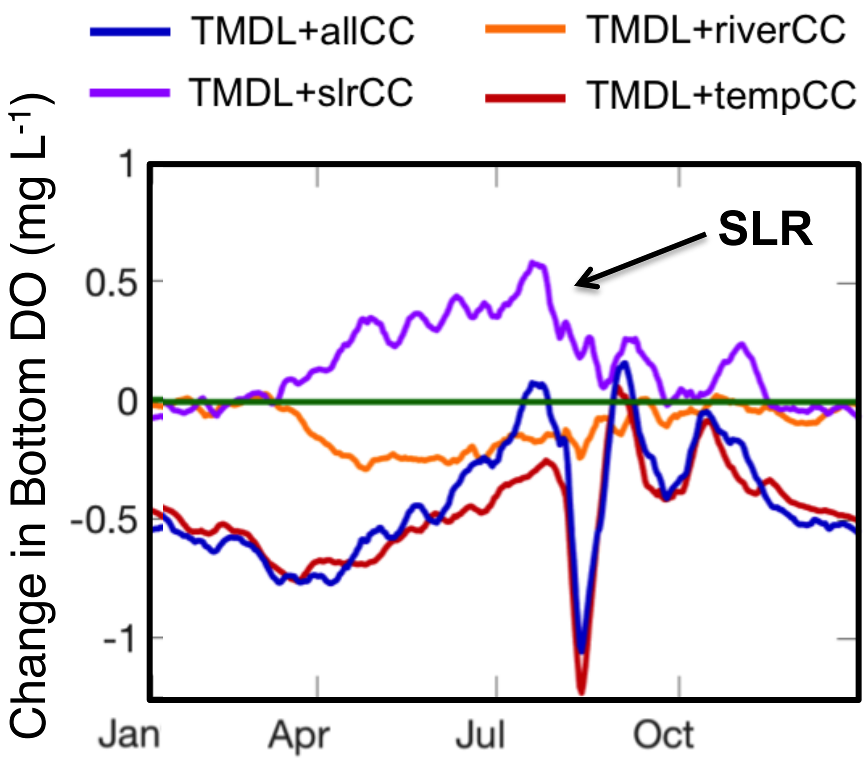
3rd International Conference on Water Resource and Environment (WRE 2017) IOP Publishing
IOP Conf. Series: Earth and Environmental Science **82** (2017) 012001 doi:10.1088/1755-1315/82/1/012001



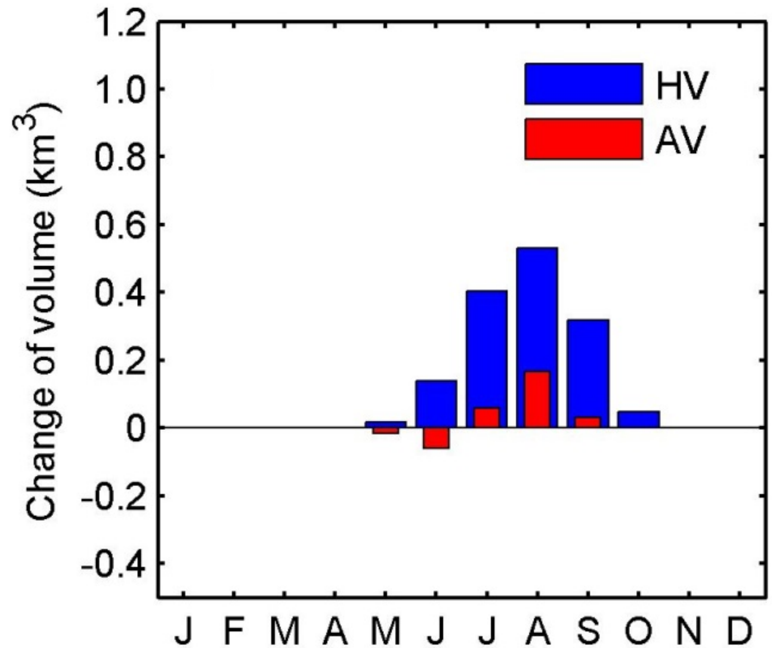
CH3D-WQSTM
Ping Wang et al., WRE2017

SLR improves hypoxia

Impacts of SLR on hypoxia: Differences between 2050 and 1995



***Ches*ROMS-ECB**
Ike Irby, Marjy Friedrichs et al., 2018



UMCES-ROMS-RCA
Wenfei Ni, Ming Li, et al., 2018

SLR improves hypoxia

SLR exacerbates hypoxia

Why do we see opposite results in two similar ROMS-based models?

- Both models show increased estuarine circulation
- Working hypothesis:
    - ***SLR can reduce hypoxia*** because high oxygen water is advected in from shelf
    - Under other conditions, ***SLR can exacerbate hypoxia*** because high salinity water is advected in from shelf, increasing stratification and reducing mixing of high oxygen water from surface
- Why these differences? Possibilities include:
    - Different advection and diffusion schemes
    - One assumes nutrient reductions in place, one does not
    - Differences in outer boundary condition assumptions
    - One run is off-line; one run is coupled
    - Different years: wet (*dry*) → increased (*decreased*) hypoxia
- Which is correct? Different results in different environmental conditions?

Methods

Two ROMS models*:

- UMCES-ROMS-RCA
- *Ches*ROMS-ECB

Four model experiments with P6 WSM:

- Base Run for 1991-1995 (maybe also 1996-2000)
- Base Run + SLR_2025
- Base Run + SLR_2050
  - + Possible additional simulations with P6 WSM-WIP

Analysis:

1. Compare hydrodynamics of two simulations (compare all physical terms in salt budget)
2. Compare biological results of two simulations (compare all terms in oxygen budget)
3. Compare to model outputs from additional models as time allows (SCHISM, EFDC, WQSTM)

* *Relative skill similar, as previously compared in Irby et al., 2016*