Impact of Climate Change on Hypoxia in the Chesapeake Bay: Results from ChesROMS-ECB

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CHAMP:

land cover, land use changes and nutrient management actions

CBP WSM

climate changes (temp, precip, CO₂, sea-level rise)

DLEM

climate changes (temp, precip, CO₂, sea-level rise)

ChesROMS-ECB

nutrient loading

hypoxia

improved management decisions via the management transition advisory group
Overview

• Previous CHAMP Climate Change Research
  – Irby, Friedrichs, Da and Hinson, 2018

• Preliminary Results: Impact of 2025 climate change on future NO$_3$ loading
  • Global Climate Models (20+ models)
  • Downscaling Methods (BCSD vs. MACA)
  • Emission Scenarios (RCP 4.5 vs. 8.5)
  • Watershed Models (DLEM vs. CBP-Phase6)

• PhD Chapters
• Rivers/precip have a small negative impact on bottom DO
• Temperature has a large negative impact on bottom DO
• SLR has a small positive impact on bottom DO

→ Of these three climate impacts, temperature is greatest
Warmer temperatures (+5°C) cause:

Spring: Hypoxia Begins Earlier

Summer: Hypoxic Volume 25-50% Greater

Fall: Hypoxia Dissipates Earlier
Effects of Climate Watershed Model Forcings on Bay Water Quality

Emissions Scenarios
RCP 4.5 vs RCP 8.5

Downscaling Methodology
BCSD vs MACA

Watershed Model
DLEM vs CBP WSM
Overview

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• Preliminary Results: Impact of 2025 climate change on future NO$_3$ loading
  • Downscaling Methods (BCSD vs. MACA, 20+ GCMs)
  • Emission Scenarios (RCP 4.5 vs. 8.5)
  • Watershed Models (DLEM vs. CBP-Phase6)

• PhD Chapters
Downscaling Effect: MACA vs. BCSD

Using same GCM, two different downscaling methods often give opposite results.

Constants:
- Emissions
- GCM
- Watershed Model
Downscaling Effect: MACA vs. BCSD

Constants:
- Emissions
- GCM
- Watershed Model

- Using KKZ method to choose GCM, two different downscaling methods again give opposite results.
Downscaling Effect: Ensemble GCM

Constants:
- Emissions
- GCM
- Watershed Model

- Ensemble Median estimates are most consistent between downscaling methodologies
- Both show small decrease in average annual NO₃ loading in all years
Effect of Emission Scenario Choice

**Constants:**
- Downscaling
- GCM
- Watershed Model

- Very little difference between RCP4.5 and RCP8.5 in 2025 (BCSD-EnsMed)
Impact of DLEM Model Selection

- Scenarios include effects of climate change and land use change
- Variability among potential future DIN loading
- Overall similar trends due to application of delta approach

DLEM River DIN: RCP 8.5 2025 MACA Scenarios

DIN Loading, Gg N yr\(^{-1}\)
DLEM – Impact of Climate vs Land Use

- Climate impacts $\ll$ Land-use impacts on NO$_3$ loading by 2025
Watershed Model Comparison: DLEM vs. P6

- Watershed models often show opposite results in terms of climate change impacts on NO3 loading
Hypoxic Volume

CBP WSM HV: DO < 2 mg L\(^{-1}\)

DLEM HV: DO < 2 mg L\(^{-1}\)

- Different effects in hypoxia response for the two watershed models
Chapter 1 – Long Term Model Comparison

• Model(s) vs Observations
  • 30 year record of CBP mainstem data (1985-2014)
  • ChesROMS, WQSTM, & SCHISM simulations over 30 years
    • Watershed forcings from CBP WSM
    • Watershed forcings from DLEM

• How well do models reproduce historical long-term change?
Chapter 2 – Isolating Climate Effects

• Can climate effects on the past 30 years of conditions in the Chesapeake Bay be isolated from local anthropogenic impacts?

• By what amount has climate change made Bay water quality restoration efforts more difficult?
Chapter 3 – The future of climate change in the Chesapeake Bay

• How might Chesapeake Bay hypoxia change with projected climate impacts?

• How certain are we when using global climate model outputs?
  • How much error is due to different downscaling techniques?
  • How much error is due to different emissions scenarios?
Questions?