Chesapeake Hypoxia Analysis & Modeling Program (CHAMP):

Predicting impacts of climate change on the success of management actions in reducing Chesapeake Bay hypoxia

CHAMP PIs:

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CHAMP goals

Develop a Chesapeake Bay scenario-forecast modeling system to:

- Isolate future impacts on Chesapeake hypoxia of *climate change* from those due to *anthropogenic nutrient inputs*

- Determine whether the WIPs/TMDLs will successfully reduce hypoxia (and meet WQS) under future climate conditions

CHAMP goals

NOAA requirement:

→ Must maintain continual engagement by a Management Transition Advisory Group (MTAG) to ensure our outputs are timely and in a useful form for the regional management of hypoxia

The CHAMP team is proposing:

→ MTAG = Modeling Workgroup, engaged through semi-annual CHAMP reports at Quarterly Meetings

CHAMP models

Use *multiple models* in Chesapeake scenario-forecast modeling system:

- Three watershed models:
  - CBP WSMp6 (**CBP: Shenk/Linker**)
  - DLEM (**Auburn: Tian**)
  - Sparrow (**USGS: Ator**)

} **Up to six model combinations**

- Two estuarine models:
  - CBP WQSTM (**CBP: Shenk/Linker/?**)
  - ChesROMS-ECB (**VIMS: Friedrichs**)

- Oyster population model (**ODU: Hofmann**)
  - To examine impact of hypoxia on living resources

CHAMP models

ODU (Hofmann) Oyster Model:

- Model simulates post-settlement population dynamics (growth, reproduction, mortality)
- Includes larval submodel, Dermo/MSX disease submodels
- Inputs are T, S, food (POC), turbidity, bottom velocity
- Outputs are total number, population size frequency, reproductivity capacity, disease prevalence
- Applied in time dependent (1D) model at specific locations in Chesapeake Bay

- To do: include explicit oxygen dependencies on physiological processes

CHAMP simulations

Four types of watershed+estuarine simulations:

- Realistic hindcasts (1985-2016)
- Future simulations (2017-2050)
- Factorial future simulations (2017-2050)
  climate change vs. land use/population change
- Decision support: alternative management scenarios

CHAMP forcing fields

Forcing fields for Future Simulations:

For an “apples to apples comparison” all model combinations must use same future forcing fields:

- Future Atmospheric Deposition (**Bash**)
- Population/Land use Change (**Shenk/Linker**)
- Temperature, Precipitation, Winds, Humidity (**Najjar**)

(CBP is assembling CHAMP website where all forcing will be available, for use by other research teams as well.)

CHAMP climate scenarios (Najjar)

→ **Estuarine model requires atmosphere—estuary heat & freshwater fluxes, so many downscaled products are not useful since they only provide temperature and precipitation (not wind, humidity, radiation…)**

- Propose using: Multivariate Adaptive Constructed Analogs (MACA) statistical downscaling method (Abatzoglou and Brown, 2011)
- Variables provided: air temperature, precipitation, humidity, wind speed, downwelling radiation
- Spatial resolution: 4 km
- Scenarios available: RCP4.5 and RCP8.5
- GCMs will be selected to bracket the projected future climate
- Wind direction Is unavailable from MACA; will consider using raw model output from GCMs interpolated to the estuarine grid

CHAMP preliminary results

Hindcasts with/without TMDL reductions:

- WSMp5 + WQSTM produces similar WQS as WSMp5 + ChesROMS-ECB (Irby 12/16)

→ Increases our confidence in the TMDL

- To do: How will WSMp6 + WQSTM compare to WSMp6 + ChesROMS-ECB?

CHAMP preliminary results

Initial climate change results (Irby):

Increased precipitation in winter + reductions in summer:

→ Bottom DO decreases in summer of ~0.5-0.8 mg/L
→ Bottom DO increases in winter of ~0.1-0.2 mg/L

✧ Although the impact of climate change on absolute DO concentrations may be small, the impact on attainment of WQS may be significant (changing by several %)

CHAMP Summary

- Opportunity for academic research to impact management decisions
- Opportunity for Modeling Workgroup to suggest management-oriented (hypoxia focused) research questions that need addressing