Predicted impacts of climate change on the success of alternative management actions in the Chesapeake Bay

Using multiple models in support of hypoxia decision-making

CHAMP: Chesapeake Hypoxia Analysis and Modeling Program
September 2016 – September 2021
NOAA CSCOR funded ($1.4M)

CHAMP PIs:

Marjorie Friedrichs (VIMS)
Lewis Linker (CBP/EPA)
Gary Shenk (CBP/USGS)
Ray Najjar (PSU)
Hanqin Tian (Auburn)
Eileen Hofmann (ODU)

CHAMP goals

Use multiple models in Chesapeake scenario-forecast modeling system:

- To predict the impacts of future (i) climate change and (ii) anthropogenic nutrient inputs on hypoxia
- To predict the future effectiveness of various nutrient reduction scenarios in reducing hypoxia

(not effectiveness of BMPs in leading to TMDL reductions!)

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

CHAMP methods

Use multiple models in Chesapeake scenario-forecast modeling system:

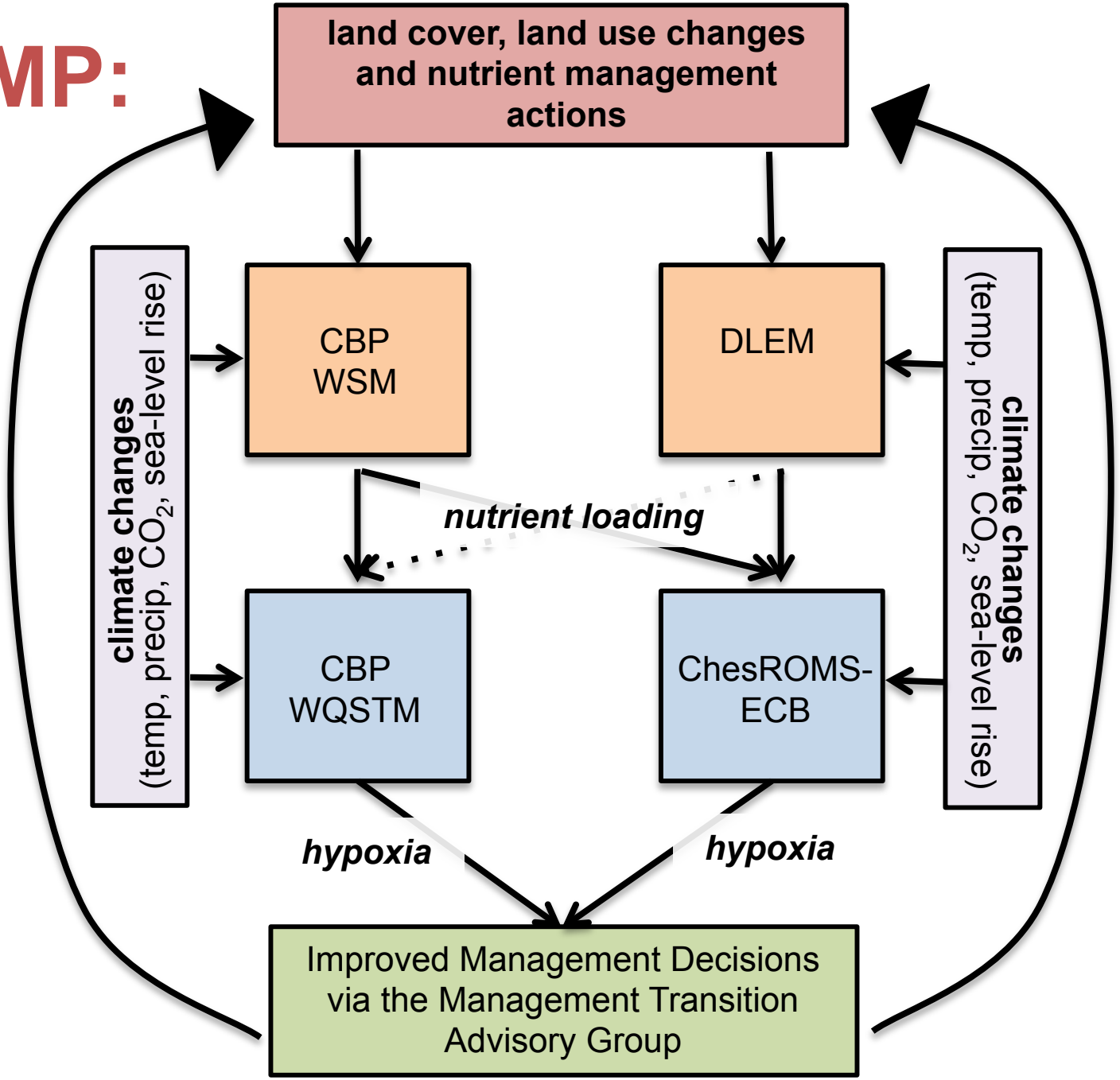
- Multiple climate and land use projections
  - Climate – statistically downscaled (**Najjar**)
  - Land use projections (**Tian** & **Shenk/Linker**)
- 2-3 watershed models
  - CBP WSM (**Shenk/Linker**)
  - DLEM (**Tian**)
  - Sparrow? (**Ator**)
- 2 estuarine models
  - WQSTM (CBP) (**Shenk/Linker**)
  - ChesROMS-ECB (**Friedrichs**)
- Oyster population model (**Hofmann**)
  - To examine impact of hypoxia on living resources

CHAMP methods

Use multiple models in Chesapeake scenario-forecast modeling system:

2017 → Realistic hindcasts (1985-2016)
2018 → Future simulations (2017-2050)
2019 - 2020 → Factorial future simulations (2017-2050)
climate vs. anthropogenic vs. both
2021 → Decision support: alternative management scenarios

CHAMP:


land cover, land use changes and nutrient management actions
climate changes (temp, precip, CO_2, sea-level rise)
CBP WSM
DLEM
climate changes (temp, precip, CO_2, sea-level rise)
nutrient loading
CBP WQSTM
ChesROMS-ECB
hypoxia
hypoxia
Improved Management Decisions via the Management Transition Advisory Group

Milestone Chart

CHRP2016: Predicted impacts of climate change on the success of alternative management actions in the Chesapeake Bay: using multiple community models in support of hypoxia management decision-making (Y1-3)

	Year 1				Year 2				Year 3				Year 4				Year 5			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Preparations of downscaled climate model and land use data sets (PSU, AU and CBP)																				
Development of DLEM data sets (AU)																				
DLEM modifications (AU)																				
ROMS-ECB modifications (VIMS & ODU)																				
Oyster model modifications (ODU)																				
Simulations for hindcast/skill assessment (conducted at VIMS; analyzed by All)																				
Water Quality Attainment Analysis (VIMS & CBP)																				
Simulations for prediction (conducted at VIMS & CBP; analyzed by All)																				
Water Quality Attainment Analysis (VIMS & CBP)																				
Factorial simulations for attribution (conducted at VIMS & CBP; analyzed by All)																				
Water Quality Attainment Analysis (VIMS & CBP)																				
Simulations for decision-support (conducted at VIMS & CBP; analyzed by All)																				
Water Quality Attainment Analysis (VIMS & CBP)																				
Publication of simulation results (All)																				
Long-term archival of model code, simulations and data sets (All)																				
MTAG Meeting (alternating in person and via WebEx) (All)																				
Science Team Meeting (All)																				

VIMS = Virginia Inst. of Marine Sci.; PSU = Penn. State Univ.; AU = Auburn Univ.; ODU = Old Dominion Univ.; CBP = Chesapeake Bay Prog.

	Run Name	Watershed model	Estuarine model	Time period	Climate forcing	Nutrient forcing
Theme 1: Diagnosis	Ref1	CBWM6	ROMS-ECB	1985-2015	realistic	realistic
	Ref2	DLEM	ROMS-ECB	1985-2015	realistic	realistic
	Ref3	CBWM6	CH3D-ICM	1985-2015	realistic	realistic
	Ref4	DLEM	CH3D-ICM	1985-2015	realistic	realistic
Theme 2: Prediction	F1 (a,b,c)	CBWM6	ROMS-ECB	2016-2050	future (a,b,c)	future
	F2 (a,b,c)	DLEM	ROMS-ECB	2016-2050	future (a,b,c)	future
	F3 (a,b,c)	CBWM6	CH3D-ICM	2016-2050	future (a,b,c)	future
	F4 (a,b,c)	DLEM	CH3D-ICM	2016-2050	future (a,b,c)	future
Theme 3: Attribution	C1 (a,b,c)	CBWM6	ROMS-ECB	2016-2050	future (a,b,c)	2015 levels
	C2 (a,b,c)	DLEM	ROMS-ECB	2016-2050	future	2015 levels
	C3 (a,b,c)	CBWM6	CH3D-ICM	2016-2050	future	2015 levels
	C4 (a,b,c)	DLEM	CH3D-ICM	2016-2050	future	2015 levels
	N1	CBWM6	ROMS-ECB	2016-2050	2005-15 levels	future
	N2	DLEM	ROMS-ECB	2016-2050	2005-15 levels	future
	N3	CBWM6	CH3D-ICM	2016-2050	2005-15 levels	future
	N4	DLEM	CH3D-ICM	2016-2050	2005-15 levels	future
Theme 4: Decision Support	D1 (a,b,c)	CBWM6	ROMS-ECB	2016-2050	future	man. scenario (a,b,c)
	D2 (a,b,c)	DLEM	ROMS-ECB	2016-2050	future	man. scenario (a,b,c)
	D3 (a,b,c)	CBWM6	CH3D-ICM	2016-2050	future	man. scenario (a,b,c)
	D4 (a,b,c)	DLEM	CH3D-ICM	2016-2050	future	man. scenario (a,b,c)

		Run Name	Watershed model	Estuarine model	Time period	Climate forcing	Nutrient forcing
Y1	**Theme 1: Diagnosis**	Ref1	CBWM6	ROMS-ECB	1985-2015	realistic	realistic
		Ref2	DLEM	ROMS-ECB	1985-2015	realistic	realistic
		Ref3	CBWM6	CH3D-ICM	1985-2015	realistic	realistic
		~~Ref4~~	~~DLEM~~	~~CH3D-ICM~~	~~1985-2015~~	~~realistic~~	~~realistic~~
Y2	**Theme 2: Prediction**	F1 (a,b,c)	CBWM6	ROMS-ECB	2016-2050	future (a,b,c)	future
		F2 (a,b,c)	DLEM	ROMS-ECB	2016-2050	future (a,b,c)	future
		F3 (a,b,c)	CBWM6	CH3D-ICM	2016-2050	future (a,b,c)	future
		~~F4~~ (a,b,c)	~~DLEM~~	~~CH3D-ICM~~	~~2016-2050~~	~~future~~ (a,b,c)	~~future~~
Y3-Y4	**Theme 3: Attribution**	C1 (a,b,c)	CBWM6	ROMS-ECB	2016-2050	future (a,b,c)	2015 levels
		C2 (a,b,c)	DLEM	ROMS-ECB	2016-2050	future	2015 levels
		C3 (a,b,c)	CBWM6	CH3D-ICM	2016-2050	future	2015 levels
		~~C4~~ (a,b,c)	~~DLEM~~	~~CH3D-ICM~~	~~2016-2050~~	~~future~~	~~2015 levels~~
		N1	CBWM6	ROMS-ECB	2016-2050	2005-15 levels	future
		N2	DLEM	ROMS-ECB	2016-2050	2005-15 levels	future
		N3	CBWM6	CH3D-ICM	2016-2050	2005-15 levels	future
		~~N4~~	~~DLEM~~	~~CH3D-ICM~~	~~2016-2050~~	~~2005-15 levels~~	~~future~~
Y5	**Theme 4: Decision Support**	D1 (a,b,c)	CBWM6	ROMS-ECB	2016-2050	future	man. scenario (a,b,c)
		D2 (a,b,c)	DLEM	ROMS-ECB	2016-2050	future	man. scenario (a,b,c)
		D3 (a,b,c)	CBWM6	CH3D-ICM	2016-2050	future	man. scenario (a,b,c)
		~~D4~~ (a,b,c)	~~DLEM~~	~~CH3D-ICM~~	~~2016-2050~~	~~future~~	~~man. scenario~~ (a,b,c)

Summer?
Done!
MPA?

Future Plans

This year (2017):

- Model improvements
  - -Temperature dependencies (Irby)
  - -Improving coastal & atm inputs (Da)
  - -Adding phosphorous (post-doc?)
  - -Adding 2P2Z (other projects?)
- Initial climate experiments (Irby)
- 1990-1999 WQS Attainment (Irby)
- 1980-2014 DLEM-ECB (**completed!**)
  - -WQS Attainment
- 1980-2014 WSM-ECB (when P6 WSM is available, summer 2017?)
  - -WQS Attainment
- Compare above simulations with WSM-WQSTM and its WQS Attainment

Future Plans

This year (2018):

- Model improvements
  - Adding phosphorous (post-doc?)
  - Adding 2P2Z (other projects?)
- 1980-2014 DLEM-ECB & WQSA (redo with improved model)
- 1980-2014 WSM-ECB & WQSA (redo with improved model)
- Compare above simulations with WSM-WQSTM
- 2017-2050 DLEM-ECB (use new climate fields from Ray)
- 2017-2050 WSM-ECB (use new climate fields from Ray)

Future Plans

This year (2019-2021+):

- 2017-2050 DLEM-ECB – factorial simulations
- 2017-2050 WSM-ECB – factorial simulations
- Compare with WSM-WQSTM
- Additional simulations for decision support (answer the CBP's question of the day/year)