

Using Multiple Management Models in the Chesapeake Bay: A Shallow Water Pilot Project

A STAC workshop at the
Virginia Institute of Marine Science
April 26-27, 2012



- **What have we learned from the IOOS testbed CB model comparison project?**
- **How/why was STAC asked to sponsor this workshop to frame a shallow water multiple model pilot project?**



Modeling in the Chesapeake Bay Program: 2010 and Beyond

A 2006 STAC workshop report:

“...workshop participants felt that ... from a regulatory and practical point of view multiple models are not appropriate for the CBP... **If there are multiple models... then court cases are invited. ...Development of multiple models... is often impractical and potentially counterproductive....”**



Scientific Assessment of Hypoxia in U.S. Coastal Waters

A 2010 report by the:

Interagency WG on Harmful Algal Blooms, Hypoxia, & Human Health
Joint Subcommittee on Ocean Science and Technology

Use of a multiple model consensus, where models use different approaches and assumptions, provides one way to better inform management decisions. This approach is well known for its application to forecasting hurricane paths and predicting the effects of carbon dioxide fluctuations on climate...



Scientific Assessment of Hypoxia in U.S. Coastal Waters

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...it is now possible... for several independent or “competing” modeling efforts to address similar issues for the same geographic location. This development is a positive one because scientific debate and consensus building – which promote **scientific advancement** – **cannot occur effectively if there is only a single modeling program.**”



Lessons learned from the U.S. IOOS Testbed Project

PIs:

Rick Luettich (UNC)

Don Wright (SURA)

Four Teams:

Cyberinfrastructure Team

Coastal Inundation Team

Shelf Hypoxia Team (Gulf of Mexico)

Estuarine Hypoxia Team (Chesapeake Bay)



The U.S. IOOS Testbed Project

Estuarine Hypoxia Team:

Marjorie Friedrichs (VIMS)

Carl Friedrichs (VIMS)

Aaron Bever (VIMS)

Jian Shen (VIMS)

Malcolm Scully (ODU)

Raleigh Hood/Wen Long (UMCES)

Ming Li (UMCES)

Kevin Sellner (CRC)

Federal partners

Carl Cerco (USACE)

David Green (NOAA-NWS)

Lyon Lanerolle (NOAA-CSDL)

Lewis Linker (EPA)

Doug Wilson (NOAA-NCBO)



The U.S. IOOS Testbed Project

Overarching Goal of EH Component:

To help improve operational and scenario-based modeling of hypoxia in Chesapeake Bay

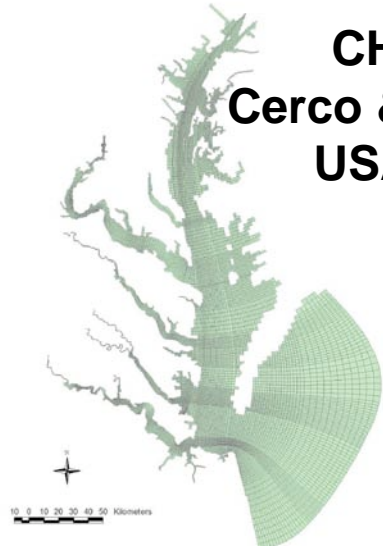
Methods:

Compare hindcast skill of multiple models in CB
e.g. salinity, temperature, stratification, DO

Perform sensitivity tests to identify the factors most significantly affecting model skill

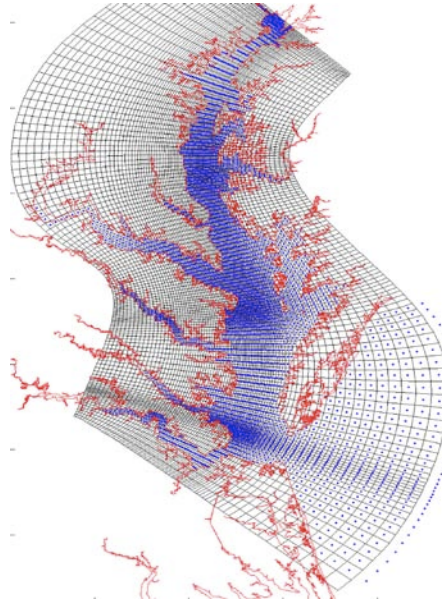


Five Hydrodynamic Models Configured for the Bay



CH3D
Cerco & Wang
USACE

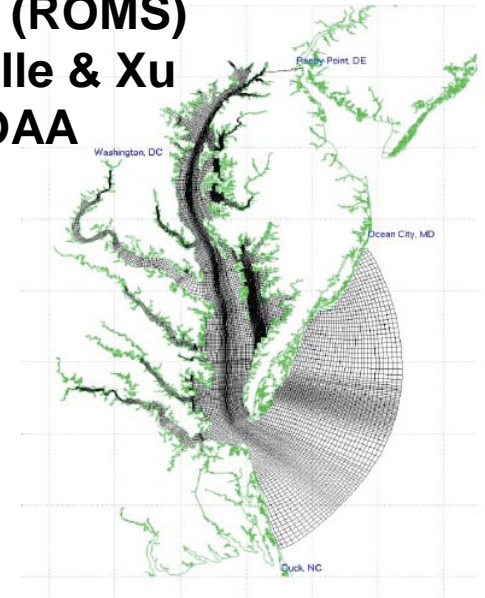
UMCES-ROMS
Li & Li
UMCES



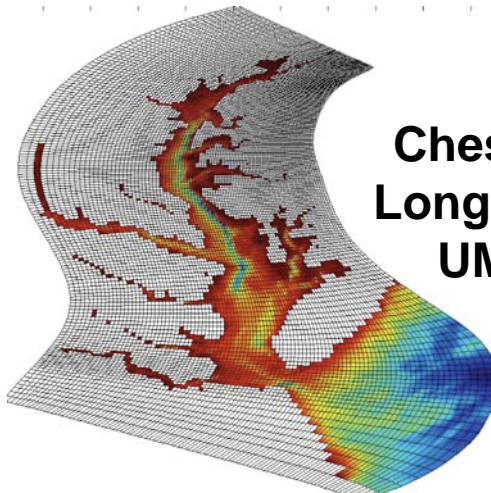
EFDC
Shen
VIMS



CBOFS (ROMS)
Lanerolle & Xu
NOAA

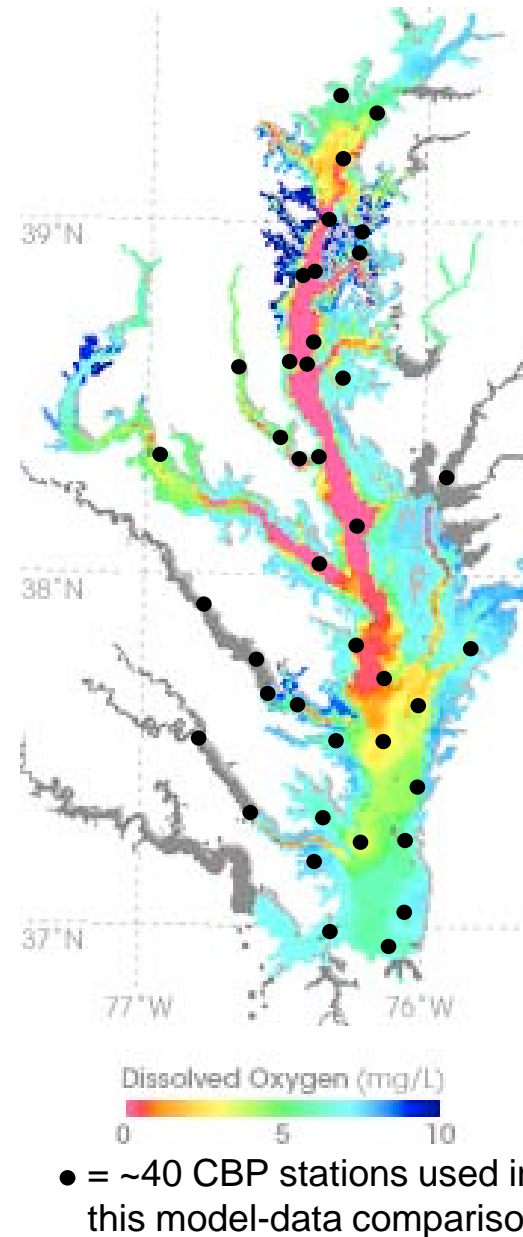


ChesROMS
Long & Hood
UMCES



Hydrodynamic Model Skill

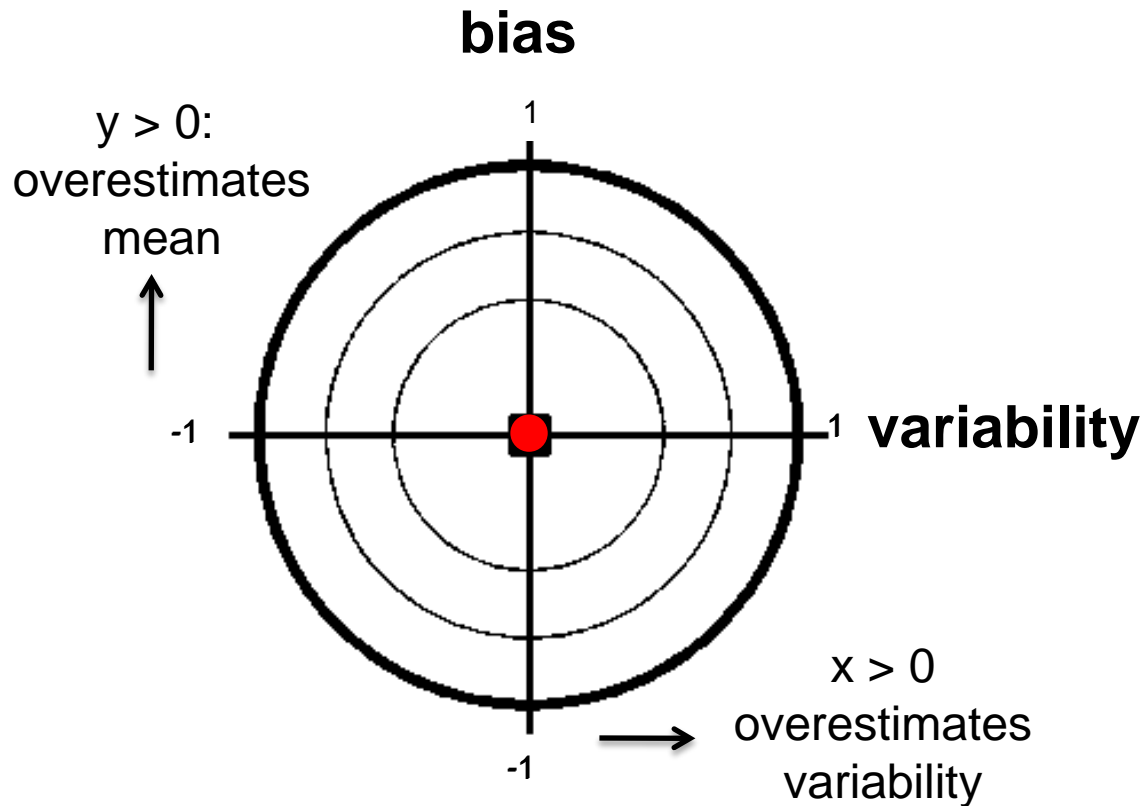
How well do the models represent the mean and variability of **stratification** and **dissolved oxygen** at ~40 CBP stations in 2004 and 2005?



Relative model skill: Target diagrams

Model skill = Distance from Origin

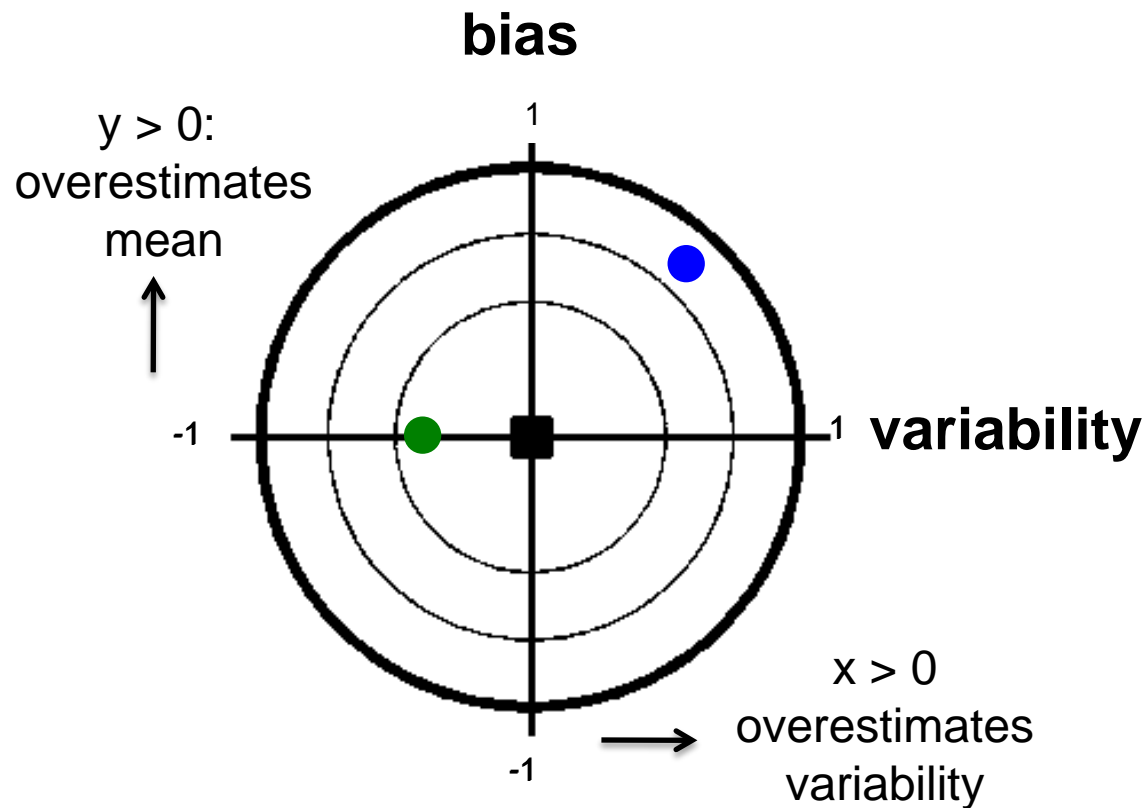
symbol at origin \rightarrow model fits observations perfectly



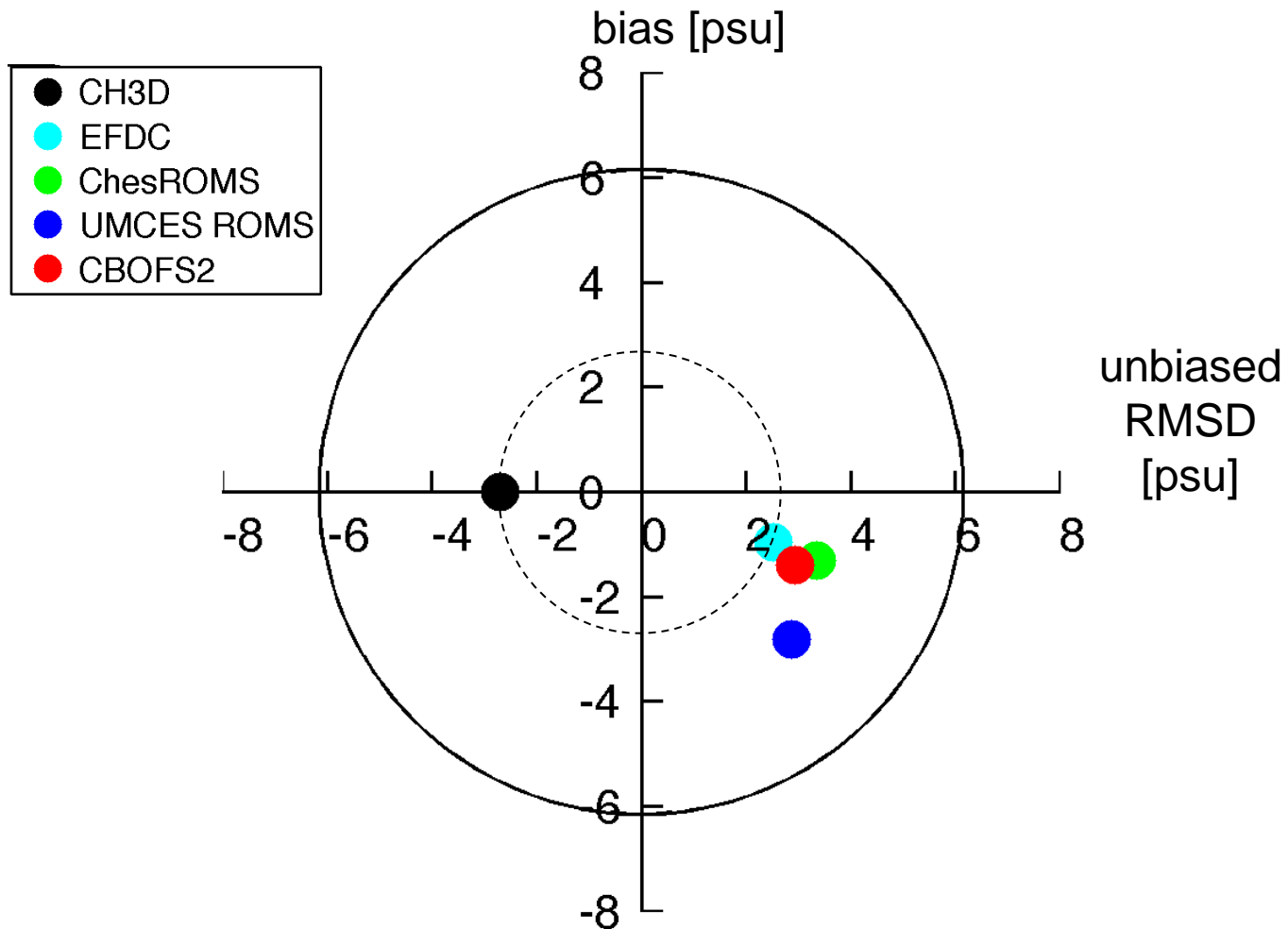
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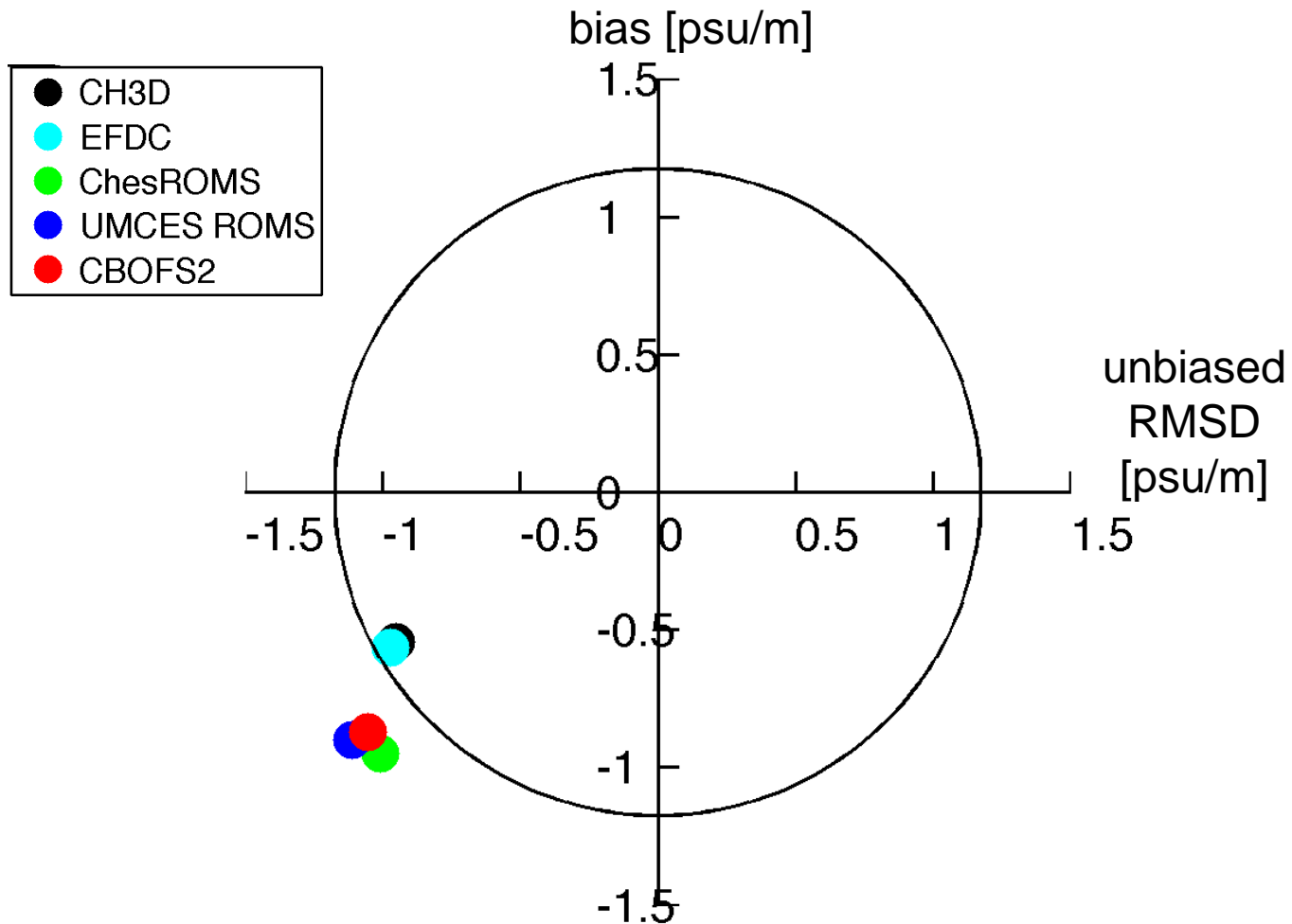


2004 Bottom Salinity



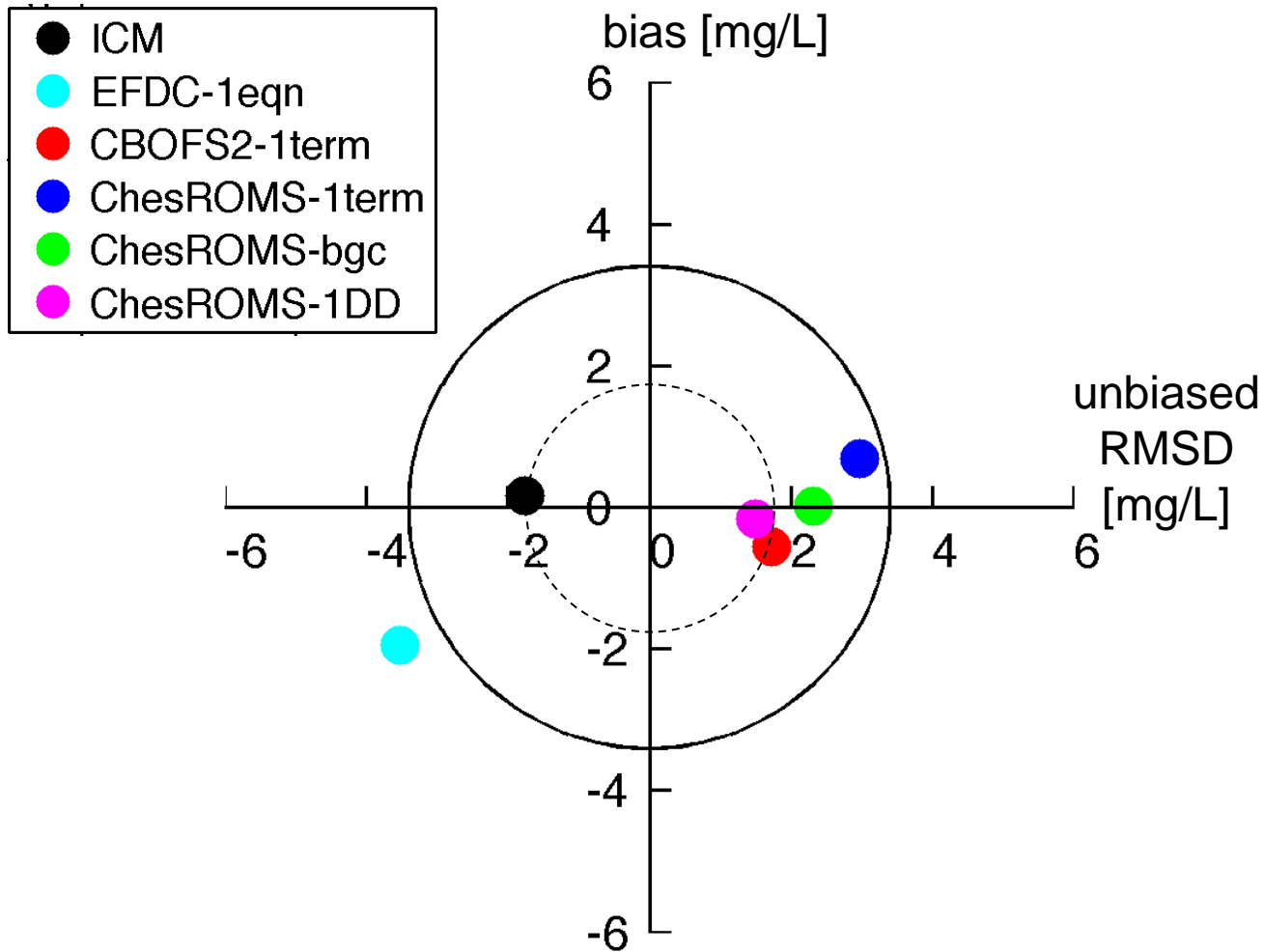
CH3D, EFDC reproduce bottom salinity best

2004 Stratification



CH3D, EFDC underestimate stratification less than the ROMS models

2004 Hypoxic Volume



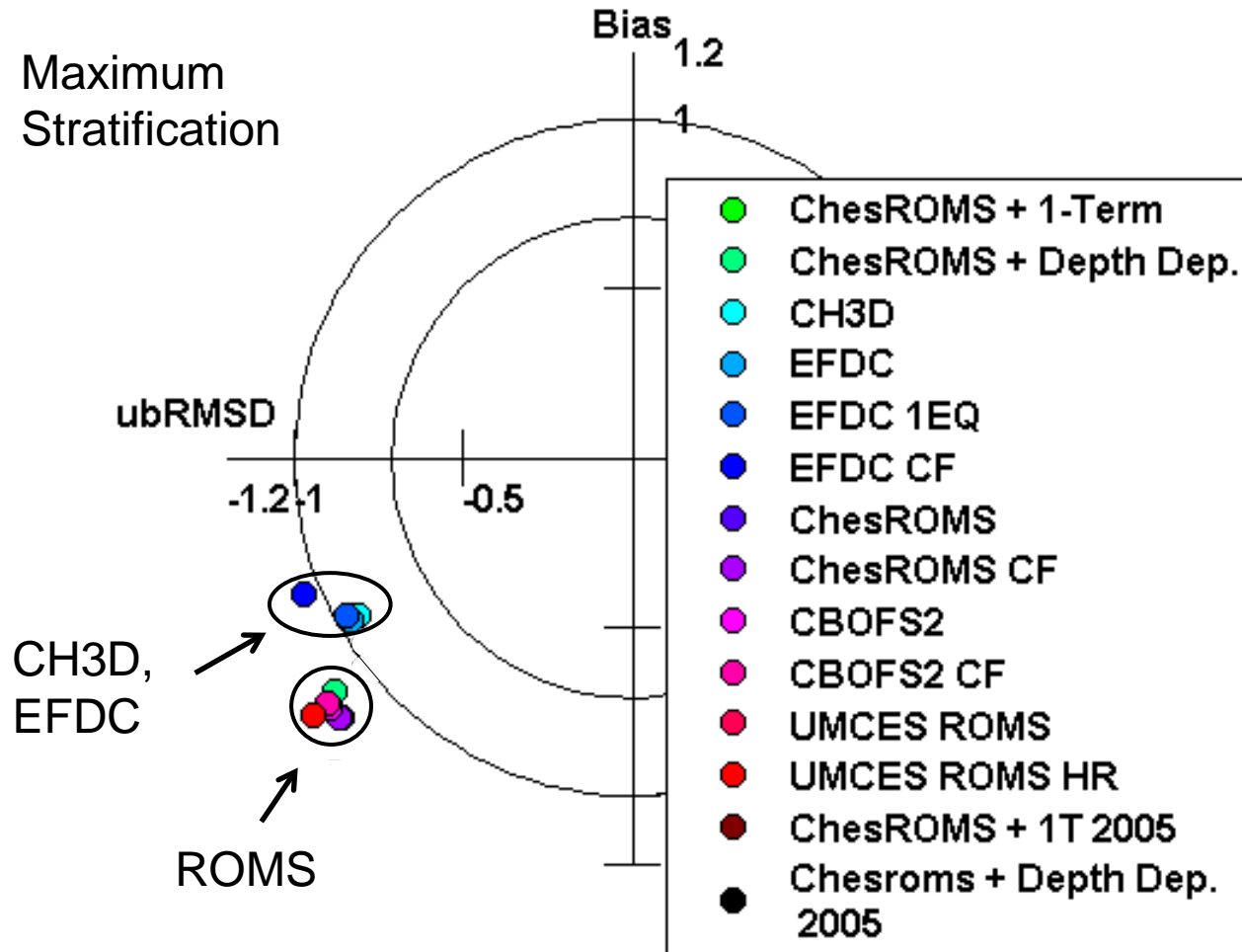
CBP model does well, but other models do equally well

Sensitivity Experiments

Use ROMS and EFDC to test sensitivity of hydrodynamic skill to:

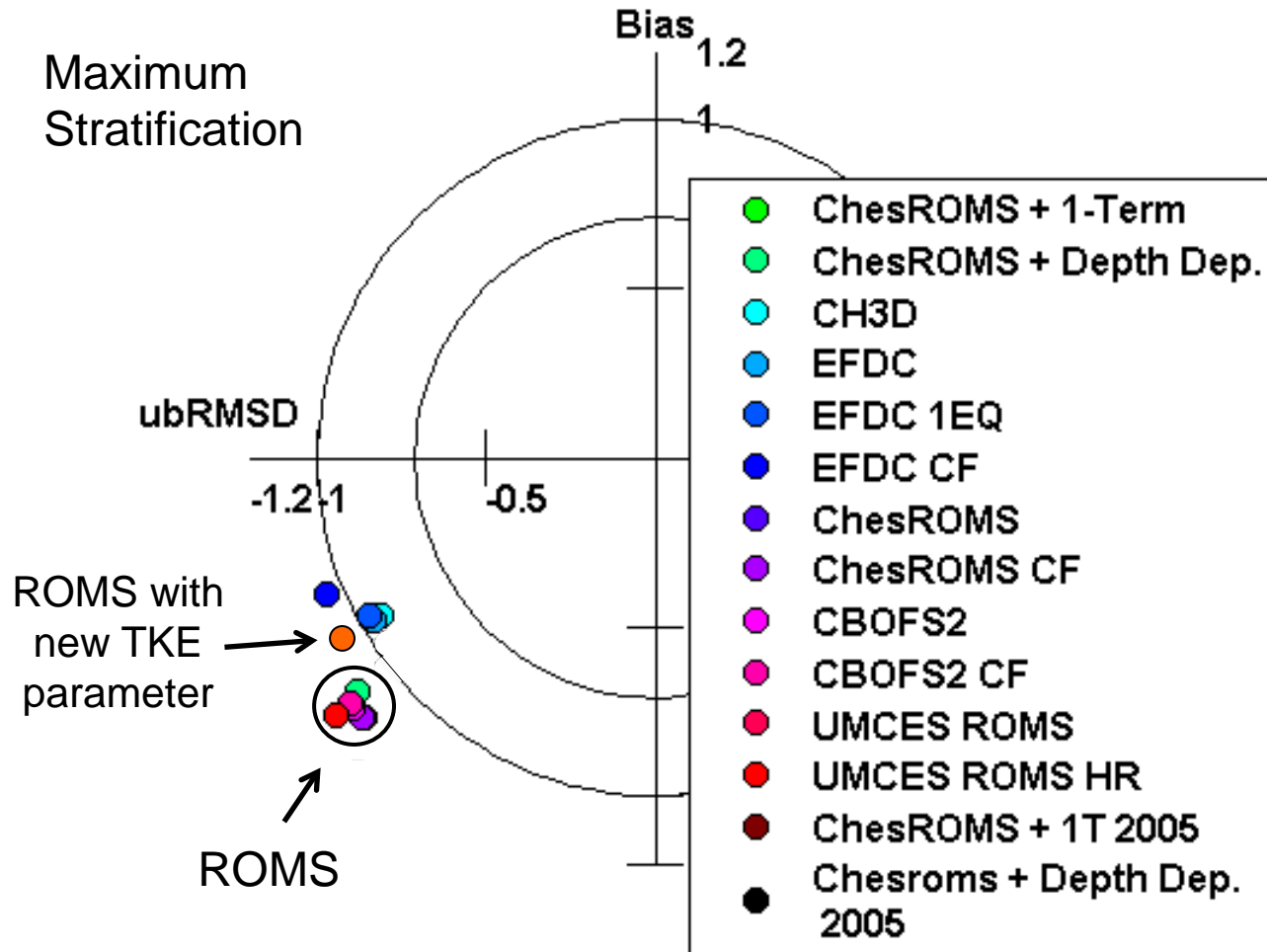
- Vertical grid resolution
- Horizontal grid resolution
- Vertical advection scheme
- Atmospheric forcing – winds
- Freshwater inflow
- Coastal boundary condition
- Mixing/turbulence closure

Sensitivity Experiments



Stratification is insensitive to horizontal/vertical grid resolution, freshwater inflow, coastal boundary, atmospheric forcing

Sensitivity Experiments



Stratification is insensitive to horizontal/vertical grid resolution, freshwater inflow, coastal boundary, atmospheric forcing

What have we learned from the IOOS testbed CB model comparison project?

Modeled stratification **is not highly sensitive** to:

- choice of wind forcing
- choice of river flow
- grid resolution
- coastal boundary condition

Modeled stratification **is most sensitive** to:

- turbulence closure parameterizations
- advection scheme

Critical importance of:

- quantitatively assessing model skill
- multiple open source, community models
- large group of people from multiple institutions,
all collaborating on CB modeling issues

- What have we learned from the IOOS testbed CB model comparison project?
- How/why was STAC asked to sponsor this workshop to frame a shallow water multiple model pilot project?



Chesapeake Bay Hydrodynamic Modeling: A Proactive STAC/CCMP Workshop

Workshop Steering Committee:

Carl Cerco
Carl Friedrichs
Marjy Friedrichs
Raleigh Hood
David Jasinski
Wen Long
Kevin Sellner

Time: 9-10 June 2011

Location: Smithsonian Environmental Research Center
Edgewater, Maryland



June 2011 Workshop Justification

- CBPO initiated discussions of a *“Next Generation Chesapeake Bay Model”*
- CBPO were planning for a fully calibrated and operational new model by 2015
- USACE had suggested that the CBP transition to using the USACE Adaptive Hydraulics Model (ADH; currently two-dimensional)

An ideal time for a community-wide discussion as to what a *“Next Generation Bay Model”* should entail

Workshop Objectives

- Review existing state-of-the-art estuarine hydrodynamic models
- Compare relative skill of various CB models
- Compare strengths/weaknesses of various models
- Assess how model differences affect water quality simulations

What should a “*Next Generation Bay Model*” entail?

Six Distinct 3-D Estuarine Hydrodynamic Models

Configured for Chesapeake Bay:

- CH3D (the CBP model)
- ROMS (three separate configurations)
- EFDC

Not yet configured for Chesapeake Bay:

- sECOM
- FVCOM
- ADH (only 2-D in Bay so far)

Workshop Agenda

DAY 1

Workshop Agenda

-up

Recommendations for how CBP should proceed with future modeling efforts

- 1) Assess model skill
- 2) Use multiple models
- 3) Use open source community models
- 4) Form a Chesapeake Modeling Laboratory to enable the above, as suggested in the NRC report; extension of CCMP

Establish a Modeling Advisory Committee to advise CBP on future modeling efforts

STAC Discussions on CBP Modeling

1. National Academy of Sciences Report
2. STAC LimnoTech Review
3. CB Hydrodyn. Modeling Workshop Report



→ **Future of Modeling Letter
from STAC to the MB (Oct. 2011)**

STAC Future of Modeling Letter: Recommendations

1. STAC strongly recommends that any future hydrodynamic/water quality model shall be selected through **quantitative skill assessment and an independent peer review process**
2. STAC strongly encourages the EPA to direct a portion of its modeling funds each year to the modeling community **to develop and run multiple hydrodynamic/water quality models.** The output from these multiple models shall then be routinely compared to the EPA regulatory model output to build scientist, management, and other stakeholder confidence in the model, which is critical for generating support for the appropriate use of public funds in meeting TMDLs across the region.



Recommendations for inclusion of multiple models

1. National Academy of Sciences Report
2. STAC LimnoTech Review
3. CB Hydrodyn. Modeling Workshop Report
4. Future of CBP Modeling Letter from STAC



→ **STAC Management Board presentation (Jan. 2012)**

Vision for Using Multiple Models in the CBP Modeling Suite

- **CBP model continue to be used as the sole regulatory model for WQ management decisions**
- **Several other community models, partially supported by CBP, to be used for comparison and R&D. This would:**
 - Demonstrate that the CBP model is equally as skillful as a range of models routinely used in modeling the system
 - Bolster community-wide (management and academic) support for the TMDL Modeling

Framework

Next steps...

- **At the Nov. 2011 Modeling Workgroup meeting, a USACE demonstration project for Gunston Cove was proposed for transitioning the 2-D ADH model into a 3-D configuration for improving hydro+WQ simulations in < 3m waters**
- **At its Dec. 2011 meeting, STAC felt that this would be an ideal opportunity for the CBP to implement a prototype multiple modeling strategy as has been suggested in multiple recent CBP reports and reviews**

Next steps...

- **We surveyed the U.S. estuarine modeling community and found 4 or 5 modeling groups that would jump at an opportunity to participate in a Gunston Cove model intercomparison experiment, even if only limited funding were available**
- **Are we sure that ADH is the hydrodynamic model that is best suited for these < 3m waters? What about these other 4-5 community models?**

→ Forthcoming Letter from STAC (~Jan. 2012)

STAC Letter: Shallow-water multiple model pilot project

- STAC recommends that the MB consider directing the CBP to **implement a prototype multiple modeling strategy** involving both skill assessment and peer review for the identification of models that best match observations **in this shallow border** of the tidal Chesapeake Bay and its tributaries.
- **STAC volunteers to assist the effort** through the identification of a group of experts to meet with the CBP and identify (1) technical requirements for these models, (2) potential model candidates, and (3) the model inter-comparison requirements that would be needed to ensure adequate skill assessment and peer review.

MB Response: Shallow-water multiple model pilot project

- A demonstration project in a well monitored system... would serve as a prototype for the application and assessment of multiple models.
- **The EPA is now examining the potential to fund a few prototype shallow water models this year**
- To move this forward, ...**[the MB] would welcome STAC's assistance in implementing a prototype multiple modeling strategy** involving both skill assessment and peer review for the identification of models that best match observations in the shallow water systems of Chesapeake Bay.

MB Response: Shallow-water multiple model pilot project

The MB would welcome a STAC workshop that would:

- identify technical requirements for these models
- identify/assess/rank potential model candidates
- develop the model inter-comparison requirements

that are needed to ensure adequate skill assessment and peer review in a test-case shallow water system

Further STAC/MB conversations

(Feb-Mar 2012)

Two goals for Multiple Management Models (M3) workshop:

- (1) Define elements that should be included in such a pilot project
- (2) Discuss benefits and challenges of using multiple models in a regulatory framework

STAC decided two separate workshops would be necessary:

M3.1: this workshop to address (1)

M3.2: a larger open workshop to concentrate on (2)

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**Using Multiple Management Models in the Chesapeake Bay:
A Shallow Water Pilot Project**

Classroom A/B, Waterman's Hall
Virginia Institute of Marine Science
1375 Greate Rd, Gloucester Point, VA

Workshop goal: The Chesapeake Bay Program (CBP) currently intends to find funds in next year's federal budget to fund multiple modeling teams to develop, run and compare the output of multiple coupled shallow water hydrodynamic+water quality/sediment models within a data-rich, shallow water area of the estuary. STAC has specifically been asked to conduct a workshop to help the CBP:

- (1) Define elements that should be included in such a pilot project, and
- (2) Begin a discussion of the benefits and challenges of using multiple models in a regulatory environment.

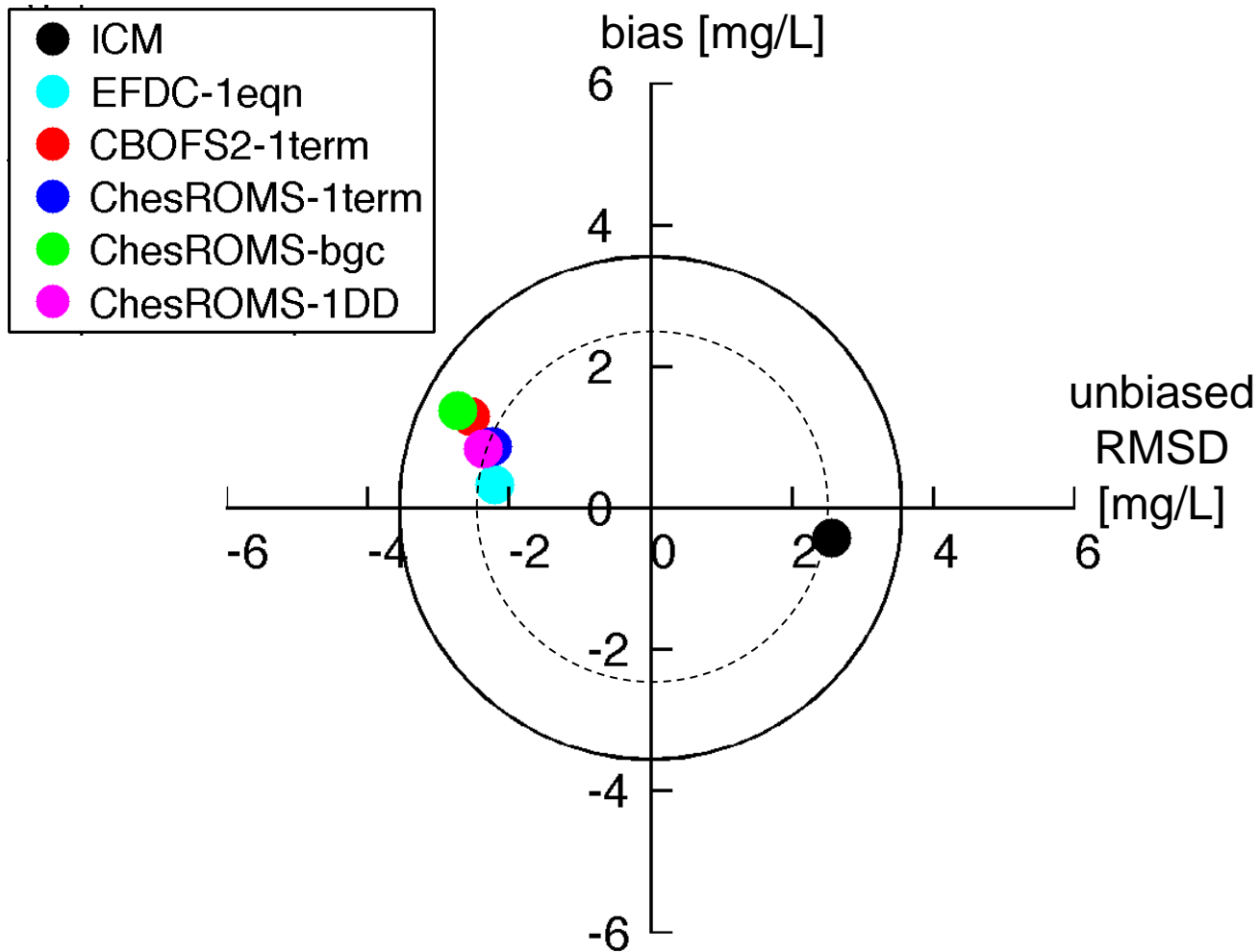
Thursday, 26 April 2012

- 8:15 am** **Continental Breakfast at VIMS**
- 8:45 am** **Introduction** – Marjy Friedrichs, VIMS
How did we get here?
Lessons learned from the IOOS testbed
Steering Committee charge and workshop goals
- 9:30 am** **Overview of the Chesapeake Bay Program modeling capacity and future needs** – Lewis Linker, EPA-CBPO
What are the short term (by 2015) and longer term (by 2025) management goals for the shallow waters of the CB?
What is the vision for the refinements that will need to be made to the existing CBP estuarine modeling suite in order to successfully address these goals?
What are the specific challenges in modeling shallow waters of the CB?
How could this M3 pilot project help address these challenges?
- 10:00 am** **Challenges for CH3D in the shallow waters of the Bay** – Carl Cerco, US ACE
What are the specific challenges in modeling shallow waters of the CB?
How can the current hydrodynamic simulation for the shallow waters of the Bay be improved?
How will these hydrodynamic improvements affect the water quality/sediment model results in these waters?
- 10:30 am** **Morning Break**
- 10:45 am** **Chesapeake Bay data availability** – Mark Trice, MD DNR, Ken Moore, VIMS and Chris Jones, GMU (5 min slides, 5 min Q/A for each)
What types of data are available in the shallow waters (<2m)?
What is the temporal frequency/extent of these data?
What is the spatial resolution of these data?
- 11:15 am** **Review of workshop goals and afternoon discussion topics**
- 12:15 pm** **Catered Lunch at VIMS**

Extra Slides



2004 Bottom DO



CBP model does well, but other models do equally well

TMDL Modeling Framework

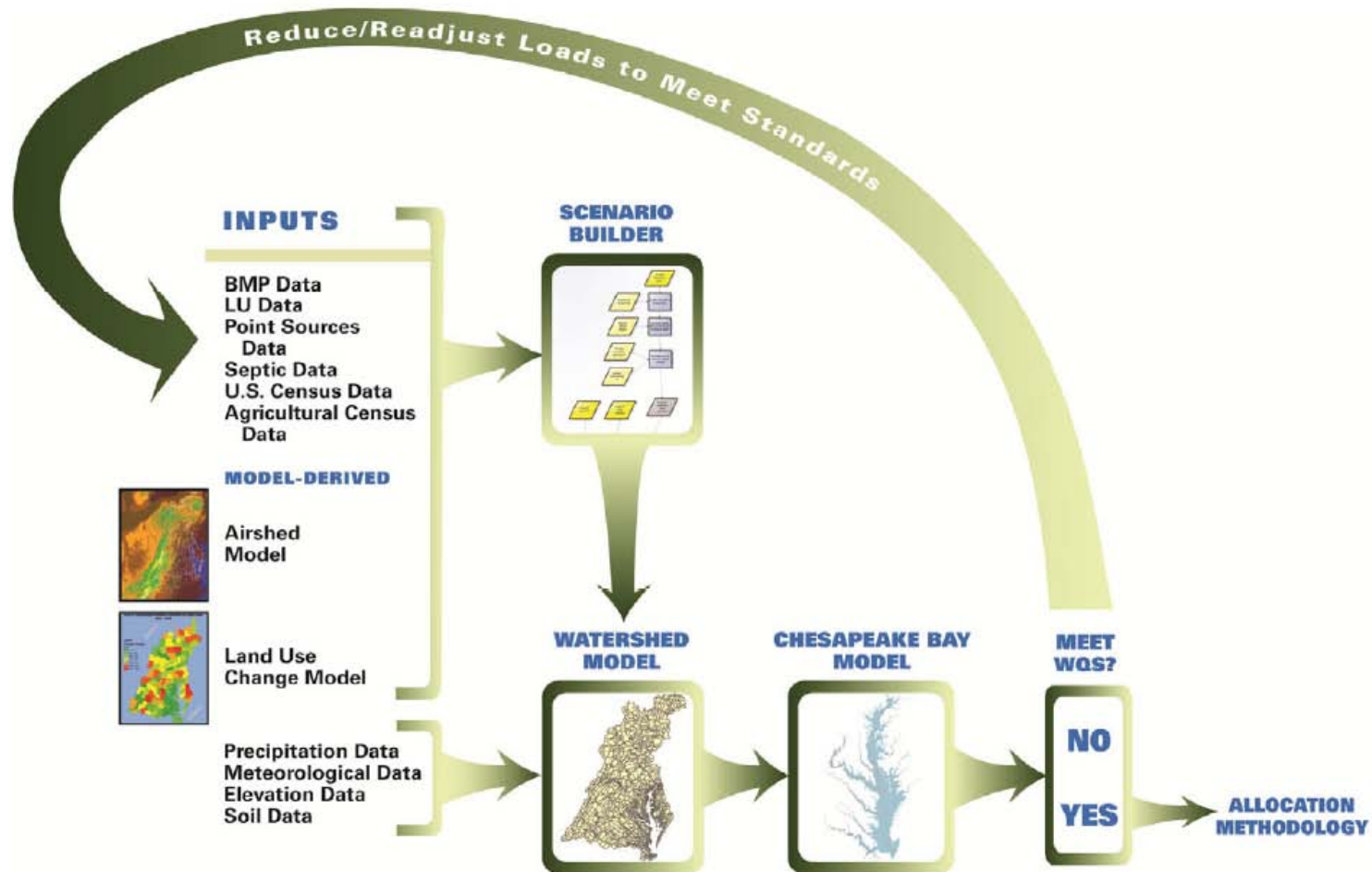


Figure 5-8. Chesapeake Bay TMDL modeling framework.

TMDL Modeling Framework

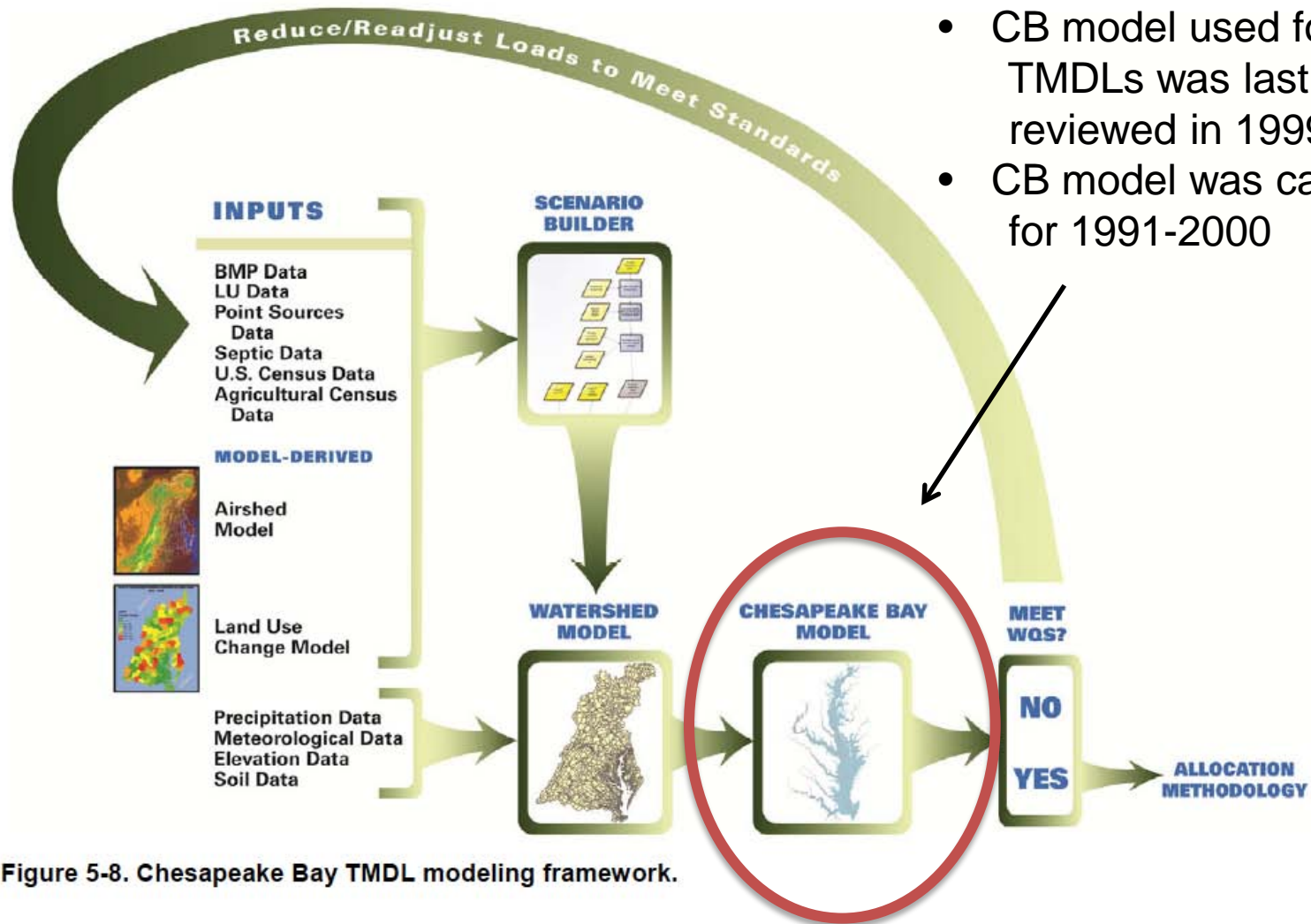


Figure 5-8. Chesapeake Bay TMDL modeling framework.

Time Line

2006: workshop report?

2010: IOOS testbed project begins

May 2011: NRC report released?

June 2011: CB hydrodynamic modeling workshop

July 2011: Formal letter to MB

Sept 2011: Limnotech report

Oct 2011: Workshop report with second letter

Nov 2011: moving forward with ADH

Early Jan 2012: Presentation to MB

Late Jan 2012: Third letter to MB specifically asking for response to pilot project idea

