# Chesapeake Bay Hydrodynamic Modeling: A Proactive STAC Workshop

**Workshop Steering Committee:**

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

**Time**: 9-10 June 2011

**Location**: Smithsonian Environmental Research Center
Edgewater, Maryland

# Justification

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

**Now is ideal time for a community-wide discussion as to what a *"Next Generation Bay Model"* should entail**

# 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?**

# Workshop Specifics

Roughly 40 participants from:

- Chesapeake Bay Program
- Chesapeake Community Modeling Program
- U.S. IOOS Modeling Testbed Project
- Other universities from across U.S.

# Workshop Agenda

***DAY 1***

| Time | Title | Presenter |
|---|---|---|
| *8:30* | Introduction | Raleigh Hood, UMCES |
| *9:00* | CBP Model Needs | Lewis Linker, CBPO |
| *9:15* | US IOOS Modeling Testbed Comparisons: Hydrodynamics and Hypoxia | Marjy Friedrichs, VIMS |
| *10:00* | Delaware River and Bay Model Evaluation Experiment | Rich Patchen, NOAA |
| *10:30* | Break | |
| *10:45* | CH3D | Carl Cerco, USACE |
| *11:30* | FVCOM | Robert Beardsley, WHOI |
| *12:15* | Lunch | |
| *1:00* | EFDC | Jian Shen, VIMS |
| *1:45* | sECOM | Nickitas Georgas, SIT |
| *2:30* | ADH | Gaurav Savant, USACE |
| *3:15* | Break | |
| *3:30* | ROMS | Hernan Arango, Rutgers |
| *4:15* | Discussion | |
| *5:00* | Reception/Posters | |

# Workshop Agenda

***DAY 2***

| Time | Title | Presenter |
|---|---|---|
| *8:30* | Coastal Shelf Influences on Chesapeake Bay, from a Modeling Perspective | Wen Long, UMCES |
| *9:15* | Modular Modeling Approaches | Scott Peckham, CSDMS |
| *10:00* | Break | |
| *10:15* | Estuarine Turbulence Modeling | Malcolm Scully, ODU |
| *11:00* | Panel Discussion | Dom Di Toro, U Del. & Carl Friedrichs, VIMS |
| *12:30* | Lunch | |
| *13:30* | Panel Discussion (cont.) | |
| *14:30* | Wrap-up | Raleigh Hood, UMCES |
| *15:00* | Adjourn | |

# Six Distinct 3-D Estuarine Hydrodynamic Models

**Configured for Chesapeake Bay:**

- CH3D
- ROMS (three separate configurations)
- EFDC

**Not yet configured for Chesapeake Bay:**

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

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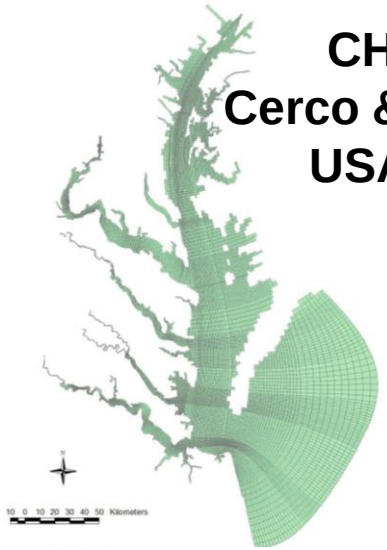
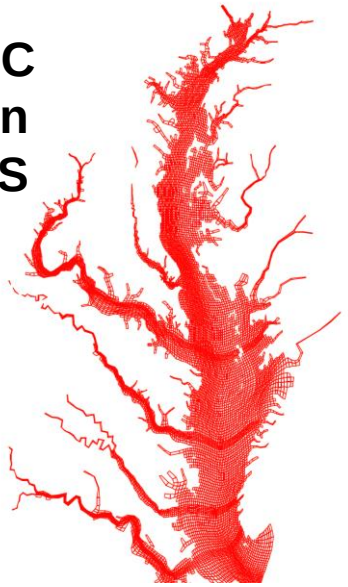
# Five Hydrodynamic Models Configured for the Bay

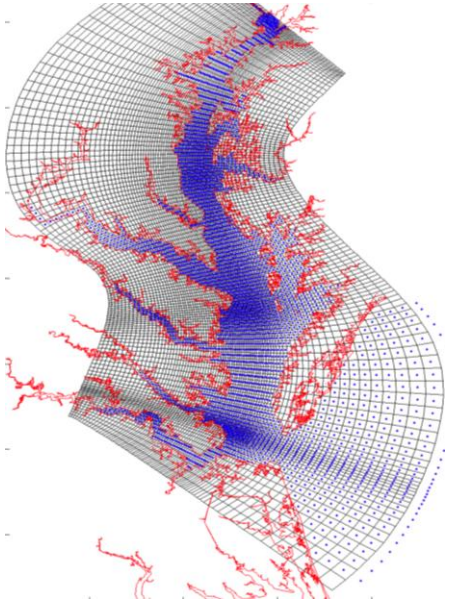
**CH3D**
**Cerco & Wang**
**USACE**



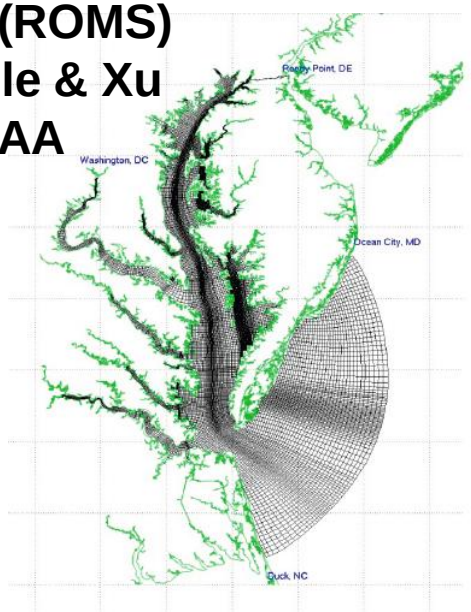
**EFDC**
**Shen**
**VIMS**

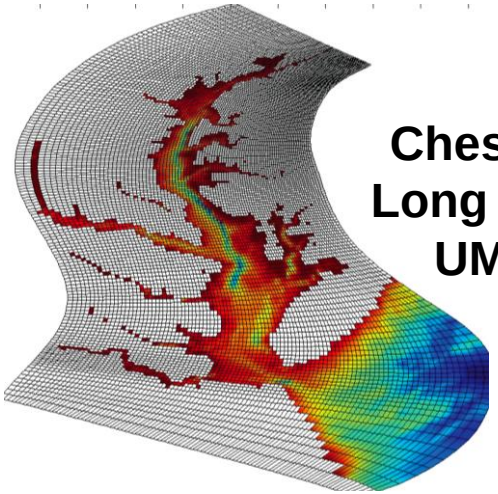


**UMCES-ROMS**
**Li & Li**
**UMCES**



**CBOFS (ROMS)**
**Lanerolle & Xu**
**NOAA**

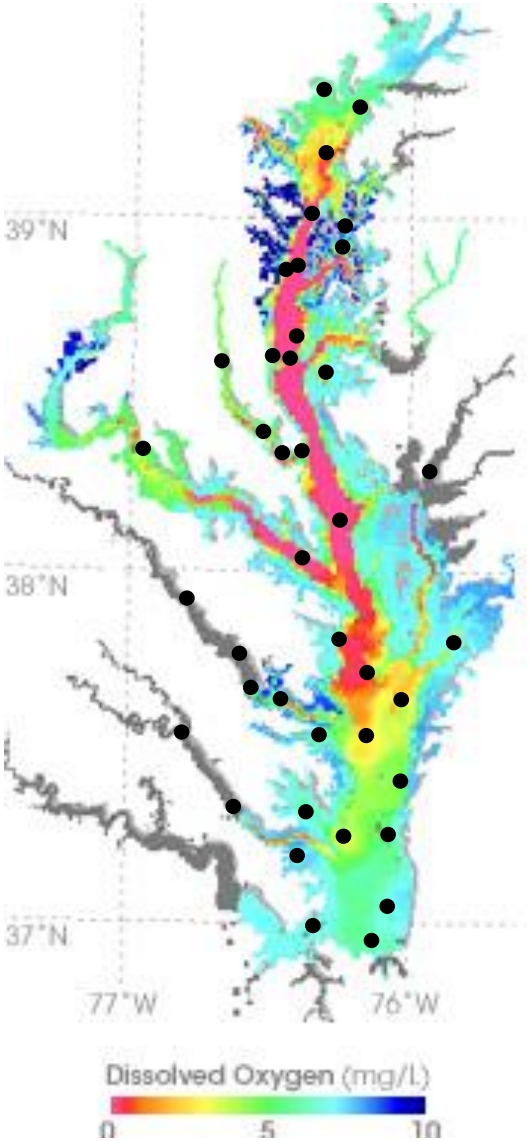


**ChesROMS**
**Long & Hood**
**UMCES**

# Hydrodynamic Model Skill

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

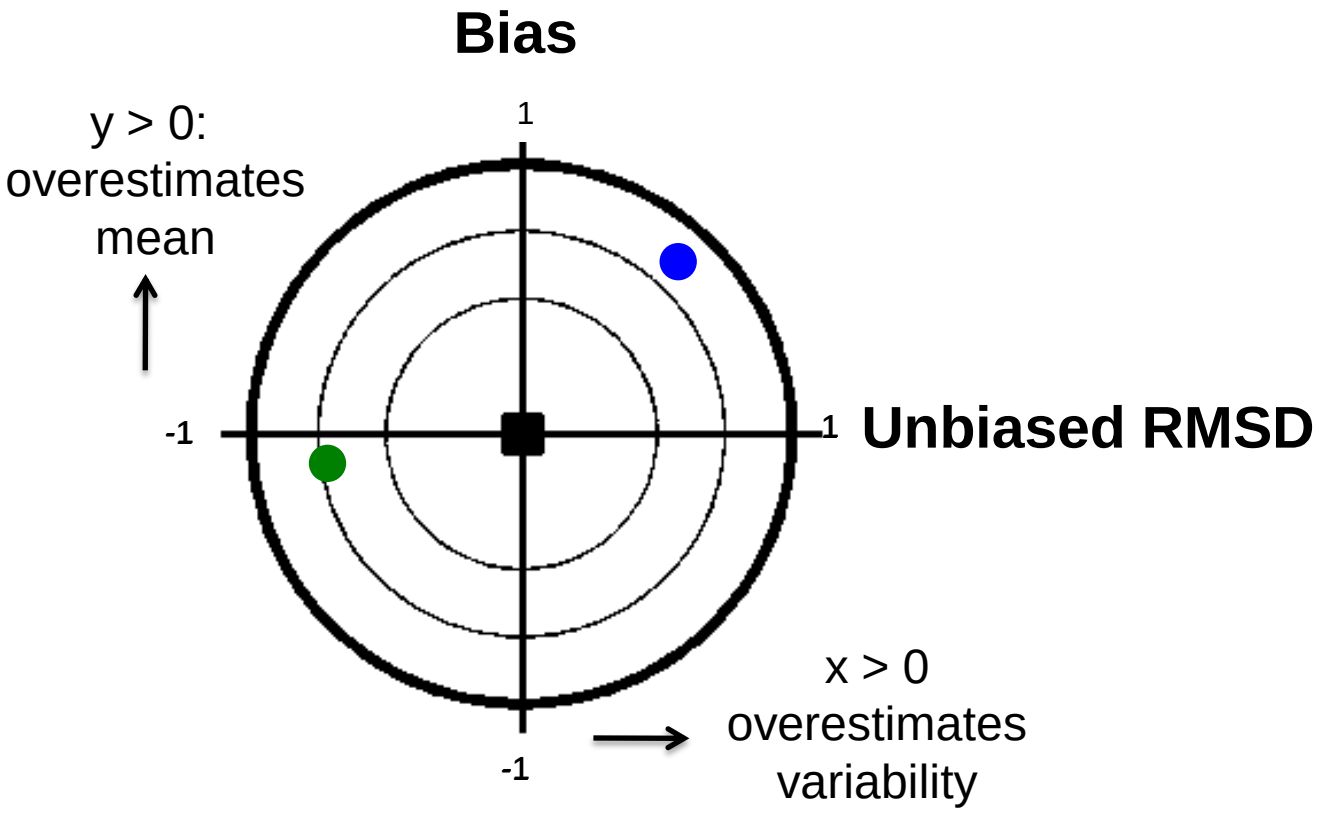



● = ~40 CBP stations used in this model-data comparison

# Relative model skill: Target diagrams

**Total $RMSD^2$ = $Bias^2$ + unbiased $RMSD^2$**

**distance from origin** | mean | variability




Jolliff et al., 2009

# Relative model skill: Target diagrams

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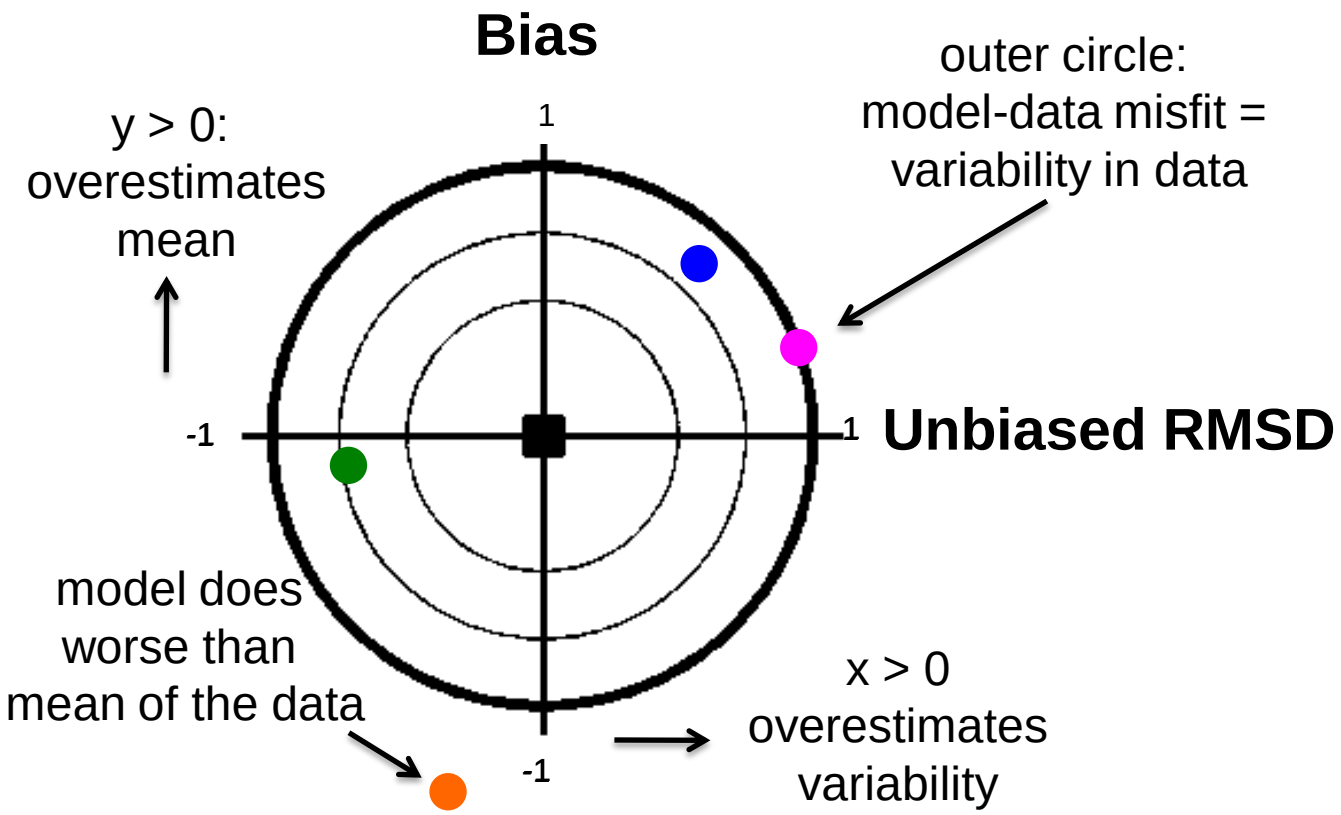
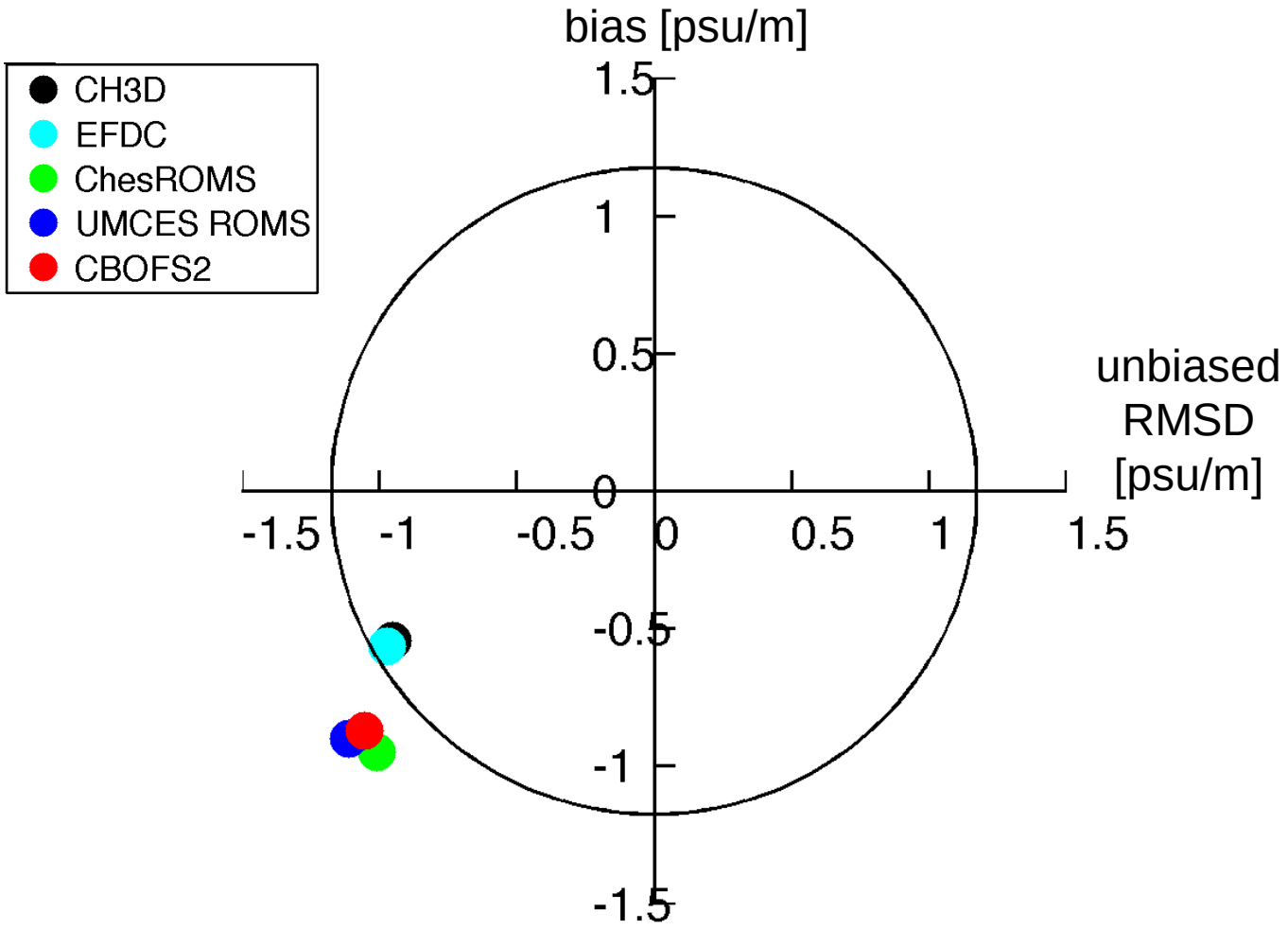
**distance from origin** — mean — variability




Jolliff et al., 2009

# Stratification




Stratification is a challenge; CH3D, EFDC reproduce seasonal/spatial variability best; Why??

# Sensitivity Experiments

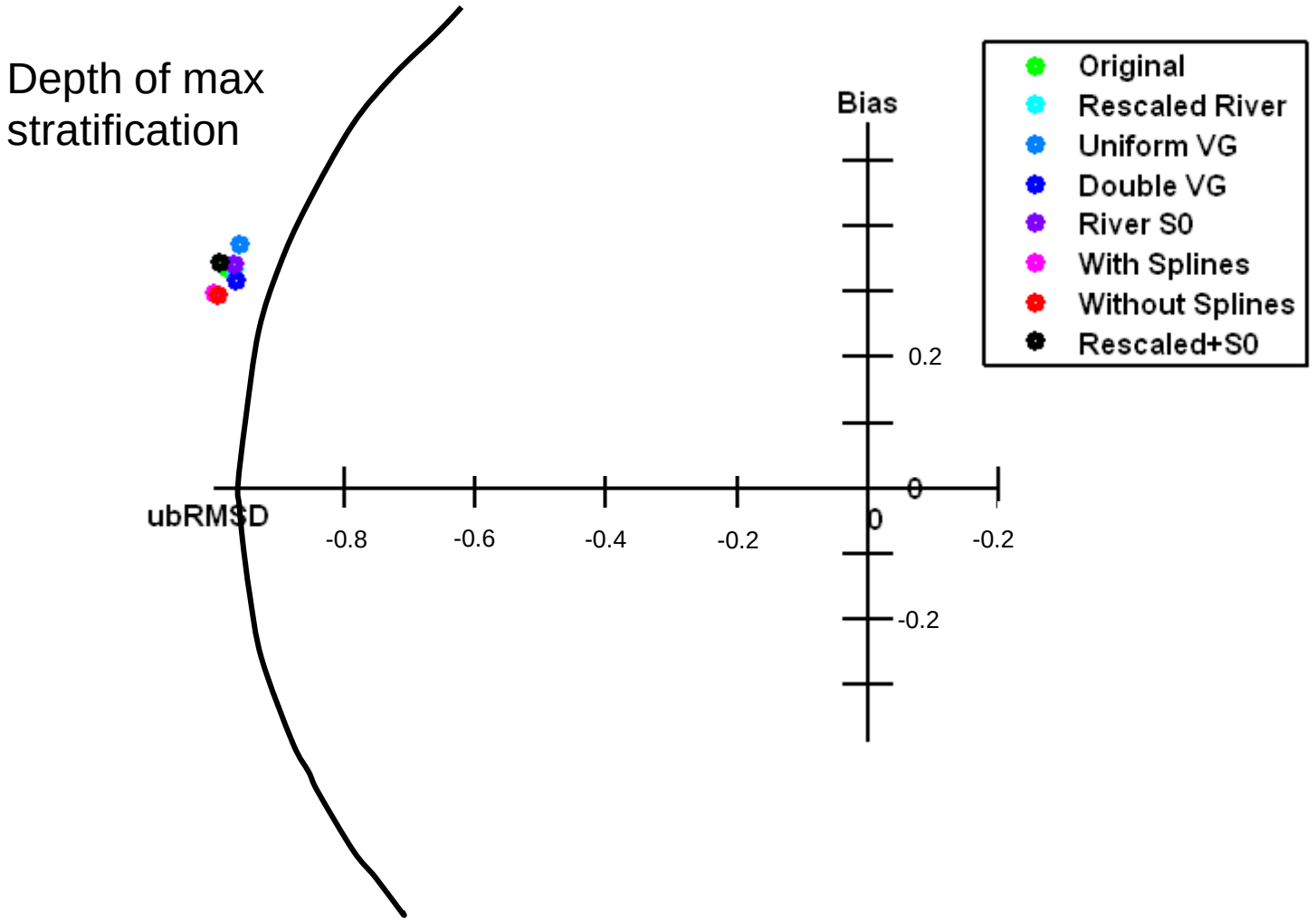
**Use ROMS and EFDC to test sensitivity of hydrodynamic skill to:**

- Vertical grid resolution
- Horizontal grid resolution
- Vertical advection scheme
- Atmospheric forcing – winds
- 2004 vs. 2005
- Freshwater inflow
- Coastal boundary condition
- Mixing/turbulence closure

Sensitivities not tested:

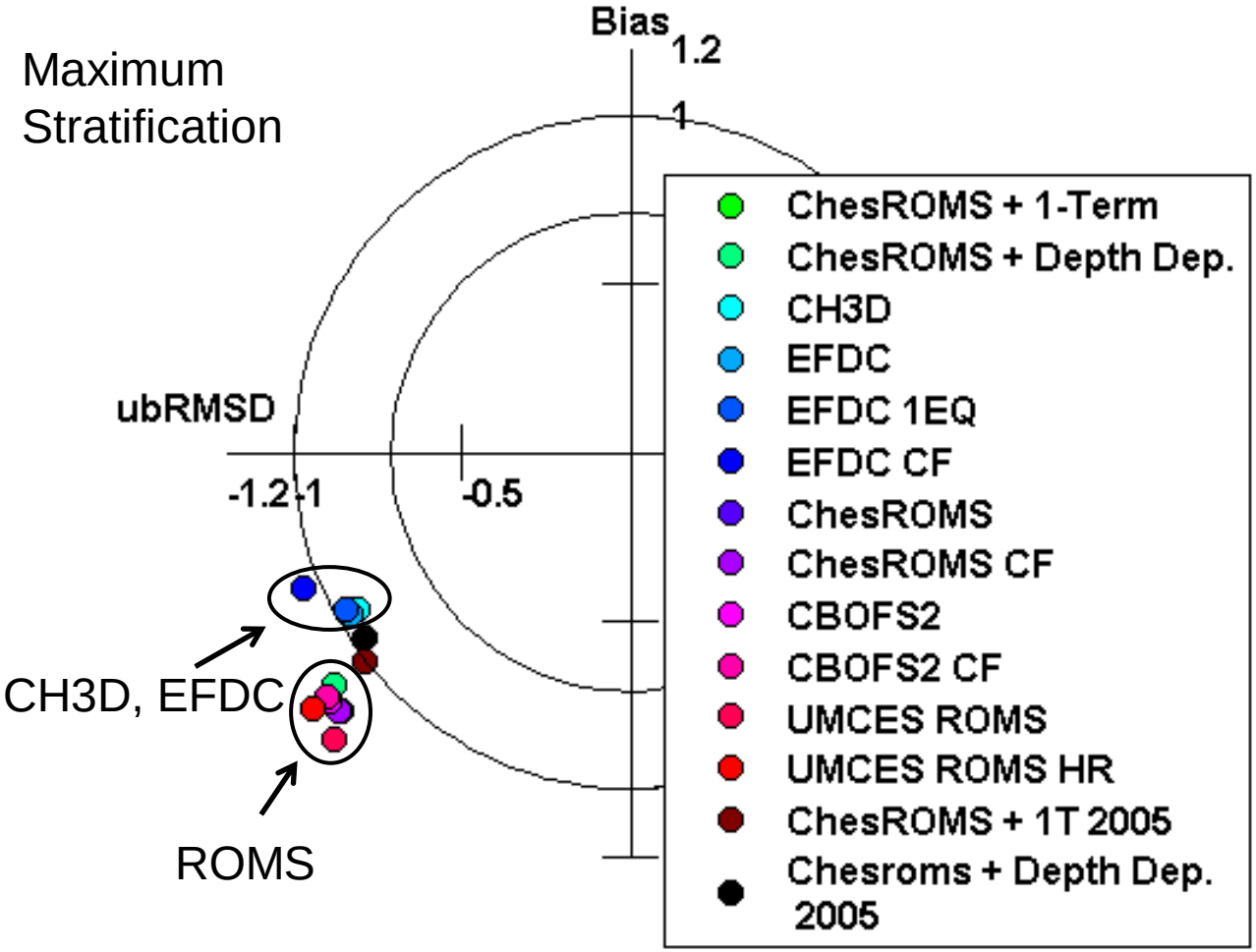
bathymetry
sigma vs. z-grid

# Sensitivity Experiments



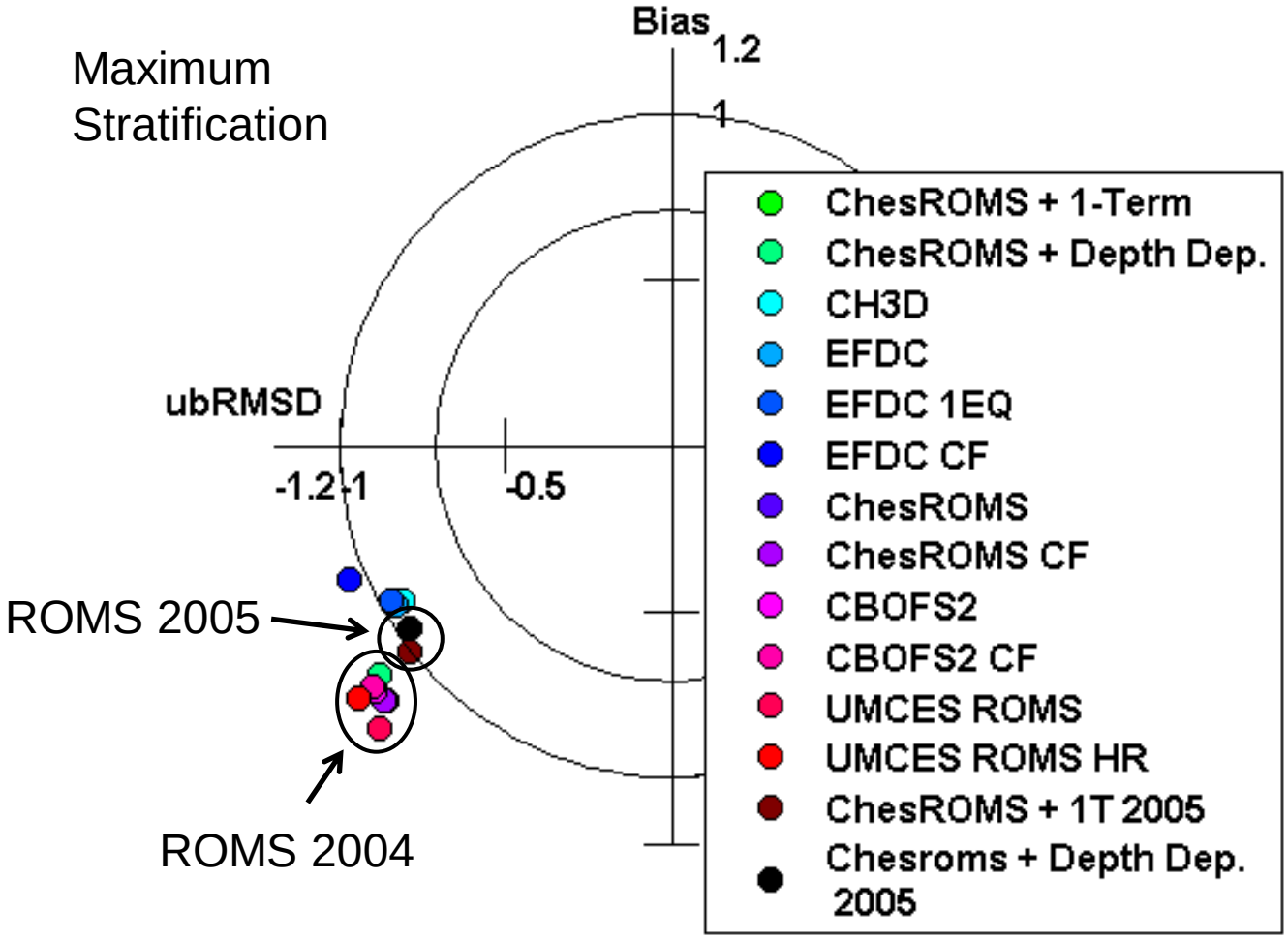

Stratification is insensitive to: vertical grid resolution, vertical advection scheme and freshwater river input

# Sensitivity Experiments



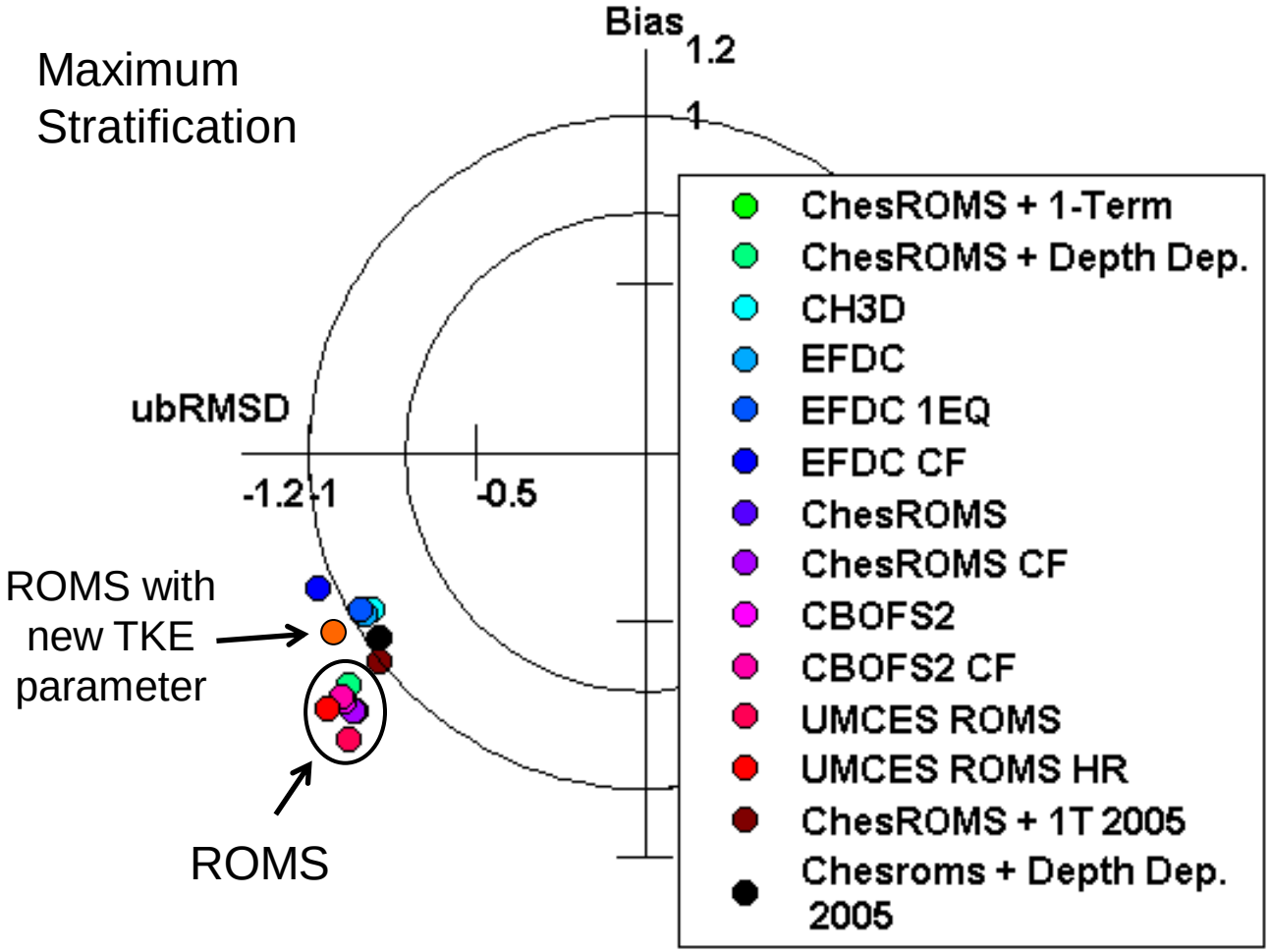

Stratification is insensitive to horizontal grid resolution and changes in atmospheric forcing

# Sensitivity Experiments




Models do better in 2005 than 2004!

# Sensitivity Experiments




Stratification is sensitive to minimum TKE parameter used in turbulence closure scheme

# Sensitivity Experiments

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

- wind
- river flow
- grid resolution
- coastal boundary condition

Modeled stratification **is most sensitive** to:

- turbulence closure parameters

Only possible because:

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

# Five Recommendations for how CBP should proceed with future modeling efforts

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

**Establish an ad-hoc modeling advisory committee to advise CBP on future modeling efforts**

# Chesapeake Bay Hydrodynamic Modeling Workshop

## Recommendation for STAC:

Majority of the Workshop Steering Committee believes:

(1) It is critical for the CBP to issue an RFP for the purpose of identifying and implementing a new hydrodynamic model(s) for the Bay through peer-review

(2) This recommendation should come directly from STAC