9-13-2011

Chesapeake Bay Hydrodynamic Modeling Workshop Report Summary

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STAC Workshop Steering Committee

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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?
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

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

### DAY 2

<table>
<thead>
<tr>
<th>Time</th>
<th>Title</th>
<th>Presenter</th>
</tr>
</thead>
<tbody>
<tr>
<td>8:30</td>
<td>Coastal Shelf Influences on Chesapeake Bay, from a Modeling Perspective</td>
<td>Wen Long, UMCES</td>
</tr>
<tr>
<td>9:15</td>
<td>Modular Modeling Approaches</td>
<td>Scott Peckham, CSDMS</td>
</tr>
<tr>
<td>10:00</td>
<td>Break</td>
<td></td>
</tr>
<tr>
<td>10:15</td>
<td>Estuarine Turbulence Modeling</td>
<td>Malcolm Scully, ODU</td>
</tr>
<tr>
<td>11:00</td>
<td>Panel Discussion</td>
<td>Dom Di Toro, U Del. &amp; Carl Friedrichs, VIMS</td>
</tr>
<tr>
<td>12:30</td>
<td>Lunch</td>
<td></td>
</tr>
<tr>
<td>13:30</td>
<td>Panel Discussion (cont.)</td>
<td></td>
</tr>
<tr>
<td>14:30</td>
<td>Wrap-up</td>
<td>Raleigh Hood, UMCES</td>
</tr>
<tr>
<td>15:00</td>
<td>Adjourn</td>
<td></td>
</tr>
</tbody>
</table>
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)
Six Distinct 3-D Estuarine Hydrodynamic Models

Configured for Chesapeake Bay:
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Five Hydrodynamic Models Configured for the Bay

CH3D
Cerco & Wang
USACE

UMCES-ROMS
Li & Li
UMCES

ChesROMS
Long & Hood
UMCES

EFDC
Shen
VIMS

CBOFS (ROMS)
Lanerolle & Xu
NOAA
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$^2 = \text{Bias}^2 + \text{unbiased RMSD}^2$

- **Distance from origin**
- **Mean**
- **Variability**

$y > 0$: overestimates mean
$x > 0$: overestimates variability

Jolliff et al., 2009
Relative model skill: Target diagrams

Total $\text{RMSD}^2 = \text{Bias}^2 + \text{unbiased RMSD}^2$

distance from origin

$y > 0$: overestimates mean

model does worse than mean of the data

$x > 0$: overestimates variability

outer circle: model-data misfit = variability in data

Jolliff et al., 2009
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
Stratification is insensitive to: vertical grid resolution, vertical advection scheme and freshwater river input
Stratification is insensitive to horizontal grid resolution and changes in atmospheric forcing.
Sensitivity Experiments

Models do better in 2005 than 2004!
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