Description of model output

Aaron J. Bever

aaron@deltamodeling.com

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These directories contain the model output that was used in the manuscript submitted to the Journal of Geophysical Research, Oceans, for inclusion in the SURA special volume. The manuscript citation is:

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**Overview:**

We have included model results from two years (2004 and 2005) and from 4 different model implementations. Most of the results within these directories are either zipped netcdf files or zipped tar files. The CBOFS output is all contained within one directory, while the other model implementations have different directories for the 2004 and the 2005 model output.

The CH3D output is made up of numerous text files for station information and the full 3D model output. When these tar files are expanded the station files will be named with the Chesapeake Bay program station name and the variable (i.e. DO is dissolved oxygen). There are also files for the model grid, both originally supplied text files and post processed .mat Matlab files for easier use. There are also matlab scripts for the creation of stations files from the 3D output and for the reading of the original text grid files and manipulation into a more usable format. However, these scripts are only provided as a guide to whoever may want to use the CH3D+ICM output, and are in no way considered finished scripts. There also may be functions imbedded in the scripts that are not provided and may cause the scripts to not work directly as supplied.

The ROMS models are all older implementations of the ROMS code, so care must be taken when calculating the vertical locations of the model grid layers that the correct equations are being used. The dissolved oxygen variable in the ROMS output is the dye\_01 variable, and needs multiplied by 0.032 to convert into mg/L.

**Model Details:**

Two 3D hydrodynamic numerical models are used in this study: (1) The Chesapeake Bay Program’s Curvilinear Hydrodynamics in 3 Dimensions (CH3D) model, and (2) the Regional Ocean Modeling System (ROMS).

**Hydrodynamic Models.**

The CH3D model used a curvilinear boundary-fitted horizontal grid with 11,064 horizontal cells and a five-foot (1.52 m) Cartesian vertical grid with a maximum of 19 vertical layers [[*Cerco et al.*, 2010](#_ENREF_7); [*Johnson et al.*, 1991](#_ENREF_20); [*Wang and Johnson*, 2000](#_ENREF_48)]. Turbulence was modeled using the k-ε turbulence closure scheme. The open boundary with the Atlantic Ocean was set at the mouth of the Chesapeake Bay, with open boundary conditions based on CBP monitoring observations at three stations spanning the Bay mouth (Fig. 1) (Ping Wang, Pers. Comm. 2013). Freshwater flow from above the fall line was from the U.S. Geological Survey, and freshwater input below the fall line was from the CBP watershed model [[*Donigian et al.*, 1994](#_ENREF_12); [*Linker et al.*, 2000](#_ENREF_25)]. Wind velocity was taken from the Thomas Point Light, Patuxent Naval Station, Richmond International Airport, Norfolk International Airport, and DC National Airport, then scaled to represent the magnitude over water and interpolated to the model grid [[*Cerco et al.*, 2010](#_ENREF_7)].

The ROMS model used a curvilinear horizontal grid and a stretched terrain-following vertical grid with twenty vertical layers [[*Haidvogel et al.*, 2008](#_ENREF_16); [*Shchepetkin and McWilliams*, 2005](#_ENREF_43)]. ROMS results were based on both the Chesapeake Bay ROMS Community model (ChesROMS) [[*Xu et al.*, 2012](#_ENREF_50)] and the Chesapeake Bay Operational Forecast System (CBOFS2) [[*Lanerolle et al.*, 2009](#_ENREF_22); [*Lanerolle et al.*, 2011](#_ENREF_23)] implementations. Both versions of ROMS used the k-ω turbulence closure, and temperature and salinity open boundary conditions were based on the World Ocean Atlas 2001. Tidal forcing was based on ADCIRC, with non-tidal water levels accounted for using observations along the Atlantic Ocean coastline near the Bay mouth. Rivers were included using U.S. Geological Survey data. Meteorology, wind and heat fluxes were a combination of model results and observations. A major difference between ChesROMS and CBOFS2 was the horizontal grid resolution; ChesROMS was 100x150 cells with about 1 to 7 km resolution; CBOFS2 was 332x291 cells with about 0.03 to 4 km resolution. In ChesROMS and CBOFS2 about 68% and 80% of the cells were on land, respectively, and were not include in the dynamic calculations.

**DO Model Implementations.**

Four DO model implementations were used in this analysis and are described below: (1) CH3D with the ecological Integrated Compartment Model (ICM), (2) CBOFS2 with a constant respiration rate DO formulation [[*Scully*, Accepted](#_ENREF_41)], (3) ChesROMS with the same constant respiration rate as in (2), and (4) ChesROMS with a depth-dependent respiration rate DO formulation.

(1) CH3D + ICM: The ICM is a complex multi-component ecological model that was forced offline with output from CH3D, and has been extensively calibrated to the Chesapeake Bay [[*Cerco*, 2000](#_ENREF_3); [*Cerco and Noel*, 2004](#_ENREF_5); [*Cerco et al.*, 2010](#_ENREF_7); [*Linker et al.*, 2000](#_ENREF_25)]. Simulations analyzed here (provided to us by the CBP) used 24 state variables in the water column (including: physical variables, multiple algal and zooplankton groups, nitrogen, phosphorous, and silica) and a full sediment diagenesis component. The model computed algal biomass, nutrient cycling, and DO, as well as numerous additional constituents and processes (Ping Wang Pers. Comm., 2013). For this study we were provided output from the CBP Modeling Team run number 379, which used the 11064 horizontal grid cell version of ICM.

(2) CBOFS2 + 1-Term and (4) ChesROMS + 1-Term: These two implementations used the ROMS hydrodynamic model and a simplified single-term DO formulation that specified a constant rate of oxygen drawdown due to respiration [[*Scully*, 2010](#_ENREF_39)]. As such, these implementations did not explicitly model nutrients, primary production, etc. Oxygen was added to the water at the surface assuming a constant piston velocity of 3 cm h-1.

(3) ChesROMS + DD: This implementation used the ChesROMS hydrodynamic model and a depth-dependent respiration rate. It was nearly identical to the constant respiration rate implementations, except the respiration rate increased with water depth such that the respiration rate was zero at the surface and increased linearly to 1.25 gO2/m3/day at 30 m water depth and the surface oxygen concentration was set to saturation.

Modeled DO results were provided by the original modelers in different output time-steps. The full 3D modeled DO fields were supplied as daily averaged output for the ICM model and daily instantaneous snapshots for the ROMS implementations. Time series at each of the Chesapeake Bay Program station locations were also provided, and are hourly for the ROMS implementations and daily averaged for the ICM model.

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