



The Design and Application of a Chesapeake Bay Environmental Observatory

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<http://cbeo.communitymodeling.org/>

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About CBEO

The mission of the CBEO project is to develop a Chesapeake Bay Environmental Observatory as a prototype of cyberinfrastructure (CI) for environmental observatory networks (EONs) -- demonstrating the transformative power of CI. The project is organized around four concurrent and interacting activities:

- **CBEO:S** provides science, engineering and management research context by defining and tackling major science and management questions.
- **CBEO:E** is the education and outreach element, aimed to translate science for the public.
- **CBEO:T** constructs a new locally accessible CBEO test-bed prototype from existing but heretofore separately maintained data sources, including model input and output as data.
- **CBEO:N** incorporates testbed CI into national EONs and links the CBEO to EON resources.

CBEO Data

Long-term station-based water quality

Data Set (source)	Description	Years
CIMS water quality data (Chesapeake Bay Program -- CBP)	Physical and water quality observations from 100s of sample locations in the bay and tributaries	1984-2006
Historic water quality data (Chesapeake Bay Institute, EPA, MDDNR, CBP)		1937-1982
CIMS light attenuation (CBP)	Photosynthetic active radiation	1985-2006
River Input Monitoring Program (USGS)	10 fall-line river monitoring stations: nutrient, sediment, and flow	1975-2007



CBP monitoring stations (source: CBP)

Model output

Data Set	Description (source)	Years
Model output: 4,000 cells	Water quality and hydrodynamic model output for 3 versions of the CBP/Army Corps of Engineers Bay models (C. Cerco and M. Noel)	1984-1985
Model output: 12,920 cells		1985-1994
Model output: 56,920 cells		1991-2000
HSPF watershed model output	Modeled watershed loads of nutrients, sediment, etc. from nonpoint, point, and atmospheric sources. (Gary Shenk, CBP)	1985-2005



13k model grid (source: M. Noel, ACoE)

Individual investigator data

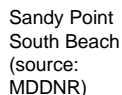
Data Set (source)	Description	Years
Multicultural Students at Sea Together (B. Cuker, Hampton U)	DO, temp, salinity, chl measured each June at 20 stations (see CBEO:E for example data)	2001-2008
Overflight data (L. Harding, UMCES)	Surface temperature, chlorophyll observations from aircraft, interpolated	1998-2000
Ches. Bay Flux Synthesis Database (E. Bailey, W. Boynton, UMCES)	Sediment-water flux measurements and bottom water concentrations of nutrients, DO	1978-2006



MAST cruise (source: B. Cuker)

Continuous monitoring

Data Set (source)	Description	Years
Eyes on the Bay (MDNR)	Water quality at up to 57 stations	2000-2006
Ches. Bay Observing System (CBOS)	Physical (5 stations); meteorology (7 stations); water quality (1 station)	1996-2005



Sandy Point South Beach (source: MDDNR)



Benthic

Data Set: Chesapeake Bay Long-Term Benthic Monitoring Program data (1971-present). Includes species identification and abundance from sampling throughout the Bay. (Sources: Versar, MDDNR) (Source: www.marinespecies.org)

CBEO:S (Science)

The CBEO:S team worked with the network, education, and test bed teams to provide scientific context and direction for the environmental observatory. Focus is on using the test bed and CI to tackle a major unresolved scientific issue.

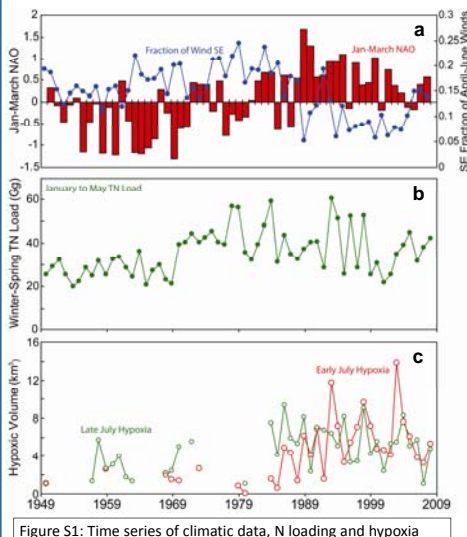


Figure S1: Time series of climatic data, N loading and hypoxia

- CBEO:S has used novel interpolation tools and targeted data analysis to investigate the cause of an unexpected doubling of the volume of mean July hypoxia per unit TN load since 1985 relative to the previous 35 years (Hagy et al. 2004)
- Recent findings indicate two contrasting trends in July hypoxia; early July hypoxia has increased ~3-fold since 1985, late July hypoxia has stabilized or slightly declined over the past 2 decades (Fig. 1c)
- The early July increase may be due to a shift to less southerly winds and more westerly winds in the last 25 years (Fig. 1a), which may relate to a shift in the winter North Atlantic Oscillation index from negative to positive (Fig. 1a) – the late July hypoxia appears to be more correlated to TN loading (Fig. 1b)

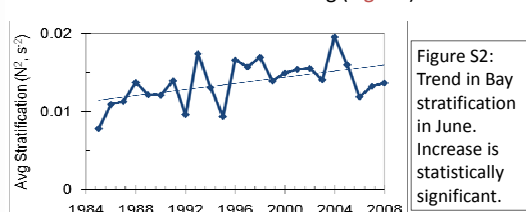


Figure S2: Trend in Bay stratification in June. Increase is statistically significant.

- This shift to more westerly winds may be a cause for increased early summer stratification in the Chesapeake Bay (Fig. 2) which in turn may drive increased hypoxic volume (Fig. 1c)

CBEO:E (Education)

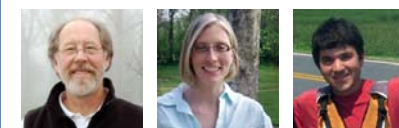
COSEE Partnership

In an effort to expand the information gained through this project beyond the scientific community, CBEO has partnered with Centers for Ocean Science Education Excellence (COSEE)-Coastal Trends to form a Scientist-Educator team. The team worked together for a summer on the CBEO research project and created an education module on hypoxia, or the "Dead Zone."



The "Dead Zone" Education Module

- Features CBEO research
- Offers content and activities and to help students understand hypoxia
- Disseminates CBEO research to a broad audience
- Teacher reviewed and scientifically vetted
- Housed on the COSEE Coastal Trends website: www.coseecoastaltrends.net



The team: CBEO scientist, W. Michael Kemp; CBEO graduate students, Jeremy Testa and Jennifer Bosch

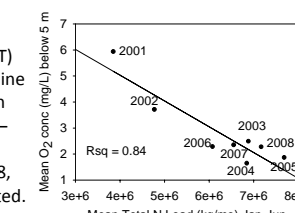


High school science teacher, William Gray; Hampton University undergraduate, Chris Burrell



MAST Program (B. Cuker, Hampton Univ.)

Oxygen Conc in the Chesapeake Bay vs Spring TN Load from the Susquehanna 2001-2008 (<5m)



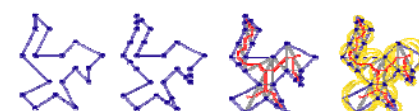
Multicultural students **At Sea Together (MAST)** collected & analyzed nine years of data on oxygen distribution in the Bay – see Figure to right. Between 2000 and 2008, 108 students participated.

CBEO:T (Testbed)

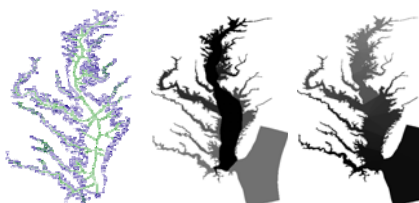
The CBEO Testbed has provided an environment for writing new types of queries to compare, correlate, and reference heterogeneous datasets.

Integration of high-resolution water-quality observations and hydrodynamic model outputs into the database allows these data to be used in non-traditional ways. One example is using the model data to improve the quality of geostatistical kriging.

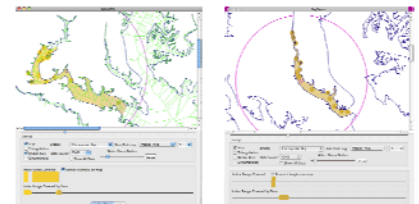
We have also used the testbed as a platform to develop new spatial indexing and data organization techniques that will improve the efficiency of queries across multiple data sets. We use techniques from computational geometry to characterize and partition the space. Additionally, we can use these structures to provide efficient support for non-Euclidian distance queries such as "water-distance" (shortest distance w/o crossing land).



Using computation geometry to partition and characterize a sample shape.



The skeletonization of the Chesapeake Bay and two spatial indexing orders.



Examples of queries using water distance in lieu of straight line or absolute distance.

CBEO:N (Network)

The CBEO:N team has been integrating the CBEO as a node into the CUAHSI HIS network by installing and populating the CBEO HIS server with data products. One very important product of this type is the Rainfall Data which have been harvested from two nationwide derived NEXRAD based products: Hydro NEXRAD from the U of Iowa (hourly and 1" * 1" grid) and Multi Process Estimator (MPE, daily and HRAP grid) from the NWS. 3.7 billion RF data points have been stored on the server.

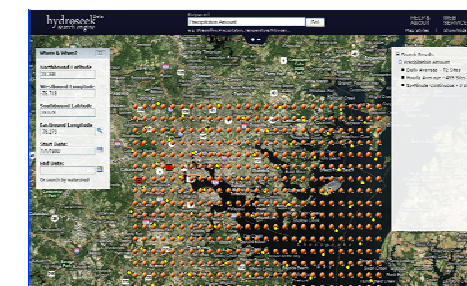


Figure N1: Rainfall Stations (MPE yellow, Hydro-NEXRAD orange, Local Rain Gauge Network red), in Baltimore area



Figure N2: Average Dissolved Phosphorus for June across the 10 years of Chesapeake Bay 13K WQM run

The CBEO:N team at SDSC develops tools for managing and publishing Chesapeake Bay observations and model-generated data of different types and size. Above is a snapshot of an application for rapid extraction, summarization, mapping and animation of Water Quality Model output, represented as an OLAP data cube. This and other applications implementing CBEO research workflows are found on the CBEO portal (<http://geon16.sdsc.edu:8080/gridsphere>)