Projected 2050 Model Simulations for the Chesapeake Bay Program

Climate and the Bay

"Changes in climate systems are expected to alter key variables and processes within the Watershed and should be examined in concurrence with land use changes that will interact with and potentially exacerbate climate impacts"

- Scientific and Technical Advisory Committee (STAC)
- ORD is well poised to assess the impact that changes in climate, land use and emission may have on atmospheric nutrient loading
  - Recognized by the Chesapeake Bay Program and resulted in a request for assistance
  - Key scientific question: How do changes in climate, land use, and emissions impact regional meteorological drivers and nutrient deposition loading important to the Chesapeake Bay's water quality and ecosystem health?

Overview

- Background
  - 2017 Midpoint Assessment
- Chesapeake Bay Modeling
  - Background and needs
- Project Timeline and Deliverables
  - Chesapeake Bay Program
  - Publications, presentations and ACE product
- Coordination with program offices
  - Updates on emissions

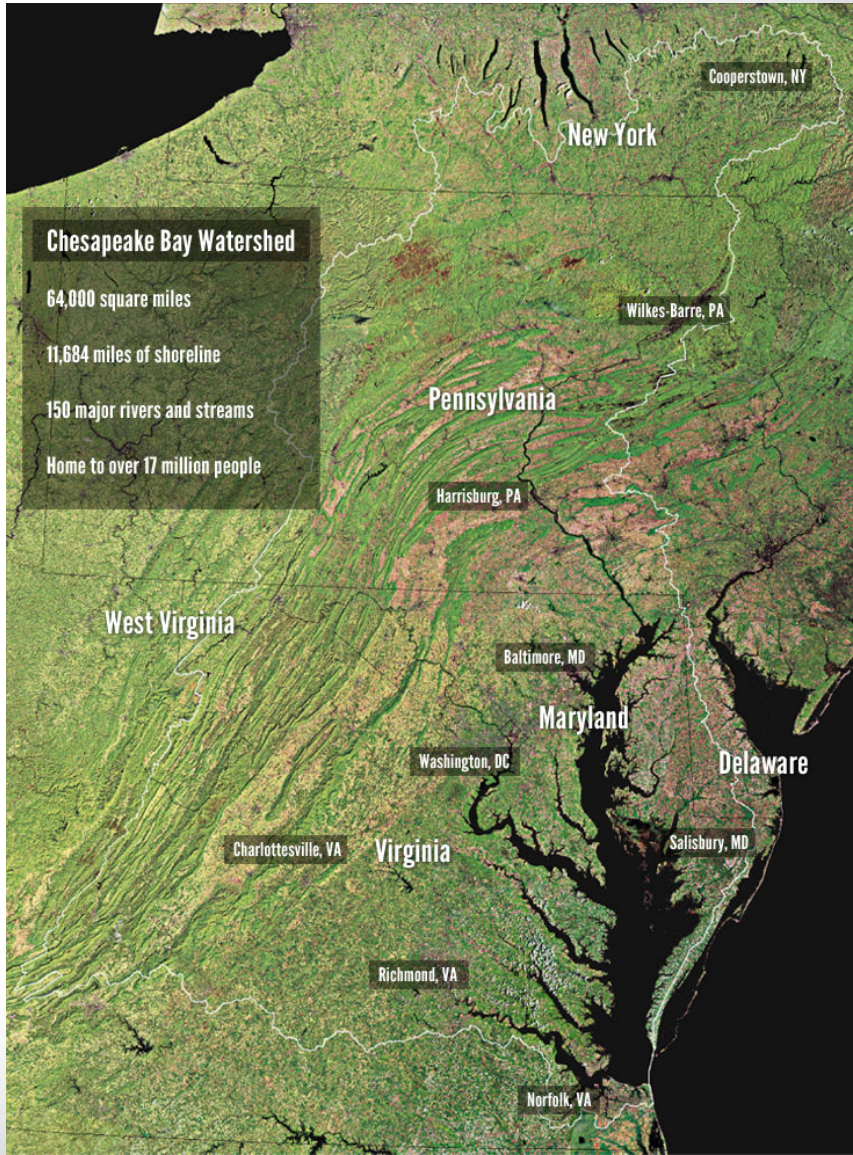
Old bridge through marsh, Tangier Island courtesy Chesapeake Bay Program

Chesapeake Bay

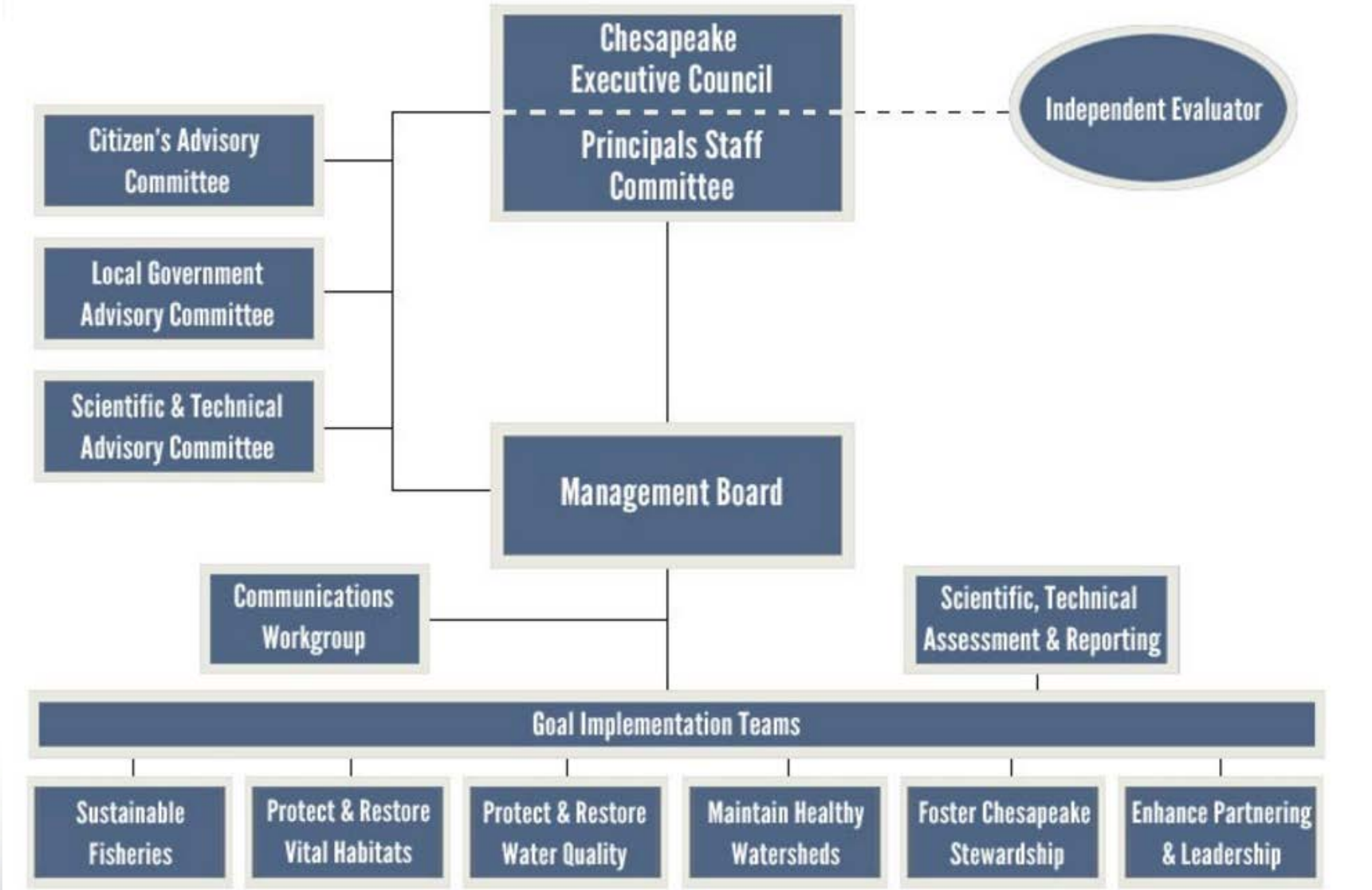
- Recreation and fisheries are important to the economy in the Chesapeake Bay
  - Clean water and healthy habitats are necessary to support these activities
- Chesapeake Bay Program established in 1983 as a federal, state and local regional partnership
- EPA ORD has been providing atmospheric nitrogen loading estimates for more than two decades
- Chesapeake Bay restoration efforts are improving water quality, habitat and fisheries according the 2016 State of the Bay assessment
  - There are sill areas in need of further improvement
    - Particularly nutrient loading and oyster and shad fisheries

Chesapeake Bay TMDL

- Largest estuary in the United States
- Encompasses parts of six states
- Home to more than 18 million people
- Land-to-water ratio of 14:1
  - The largest of any coastal water body in the world
  - Sensitive to atmospheric inputs
- Total Maximum Daily Load (TMDL) established in Dec 2010
  - Sets limits to nitrogen and phosphorus loading for Bay restoration by 2025



Chesapeake Bay Program Organization



Chesapeake Bay Program Partners

Principal Partners

- Chesapeake Bay Commission
- Commonwealth of Pennsylvania
- Commonwealth of Virginia
- District of Columbia
- State of Delaware
- State of Maryland
- State of New York
- State of West Virginia
- U.S. Environmental Protection Agency

Federal Agency Partners

- Cooperative State Research Education and Extension Service
- Farm Service Agency (FSA)
- National Arboretum
- National Ocean Service
- National Oceanic and Atmospheric Administration (NOAA)
- National Park Service (NPS)
- National Weather Service
- U.S. Army Corps of Engineers (USACE)
- U.S. Coast Guard (USCG)
- U.S. Department of Agriculture (USDA)
- U.S. Department of Defense (DOD)
- U.S. Department of Education
- U.S. Department of Homeland Security (DHS)
- U.S. Department of the Interior
- U.S. Federal Highway Administration (FHA)
- U.S. Fish and Wildlife Service (USFWS)
- U.S. Forest Service (USFS)
- U.S. Geological Survey (USGS)
- USDA Natural Resources Conservation Service (NRCS)
- USGS Chesapeake Bay

Academic Partners

- Academy of Natural Sciences
- Chesapeake Research Consortium
- College of William and Mary
- Cornell Cooperative Extension (New York)
- Cornell University
- Delaware Sea Grant
- Dickinson College
- Hood College
- John Hopkins University
- Maryland Sea Grant
- Old Dominion University (ODU)
- Pennsylvania Sea Grant
- Pennsylvania State University (Penn State)
- Smithsonian Environmental Research Center (SERC)
- Smithsonian Institution
- UMCES Chesapeake Biological Laboratory (CBL)
- UMCES Horn Point Laboratory
- University of Delaware
- University of Maryland
- University of Maryland Center for Environmental Science (UMCES)
- University of Pennsylvania
- University of Virginia
- Virginia Cooperative Extension Office
- Virginia Institute of Marine Science (VIMS)
- Virginia Polytechnic Institute and State University (Va Tech)
- Virginia SeaGrant Program
- West Virginia University

Non-Governmental Organizations

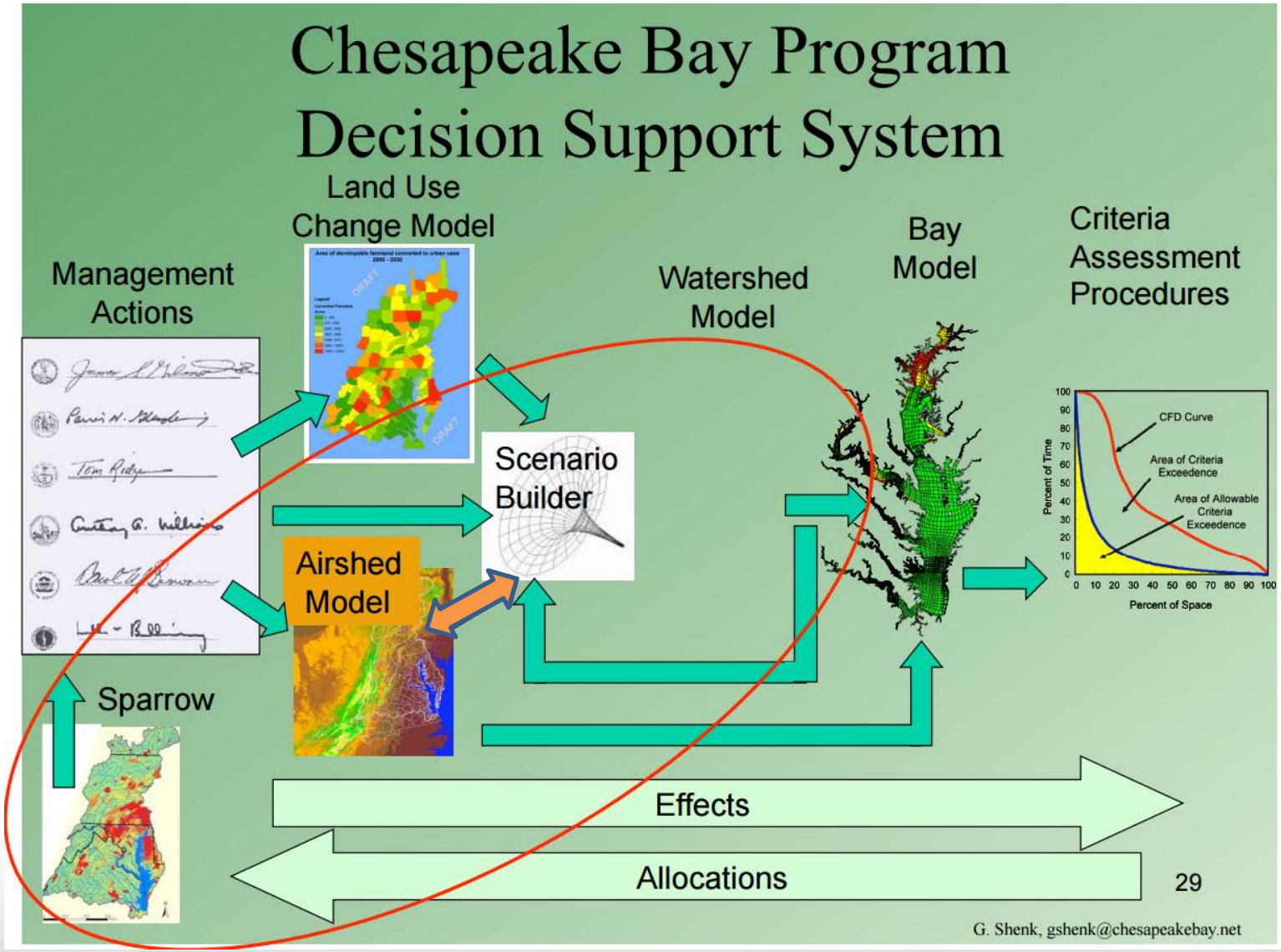
- Alice Ferguson Foundation
- Alliance for the Chesapeake Bay
- American Forests
- Anacostia Unplugged
- Anacostia Watershed Society
- Arlington Echo Outdoor Education Center
- Biohabitats
- Cacapon Institute
- Center for Chesapeake Communities (CCC)
- Center for Watershed Protection
- Chesapeake Bay Foundation
- Chesapeake Bay Trust
- Chesapeake Conservancy
- DC Environmental Education Consortium
- Ducks Unlimited
- Earth Conservation Corps
- Groundwork Anacostia River DC
- Interfaith Partners for the Chesapeake
- International City/County Management Association
- Interstate Commission on the Potomac River Basin (ICPRB)
- Maryland Association for Environmental and Outdoor Education
- Maryland League of Conservation Voters
- Metropolitan Washington Council of Governments
- National Fish and Wildlife Foundation
- National Geographic Society
- National Wildlife Federation
- NatureServe
- Parks & People Foundation
- Patterson Park Audubon Center
- Pennsylvania Institute for Conservation Education
- Potomac Conservancy
- Rivanna River Basin Commission
- Student Conservation Association
- Upper Susquehanna Coalition
- Watershed Stewardship Inc.

Other Partners

- Anne Arundel County Department of Public Works
- Hampton Roads Sanitation District
- Northern Virginia Regional Commission
- Pennsylvania Bureau of State Parks
- Tetra Tech
- Versar

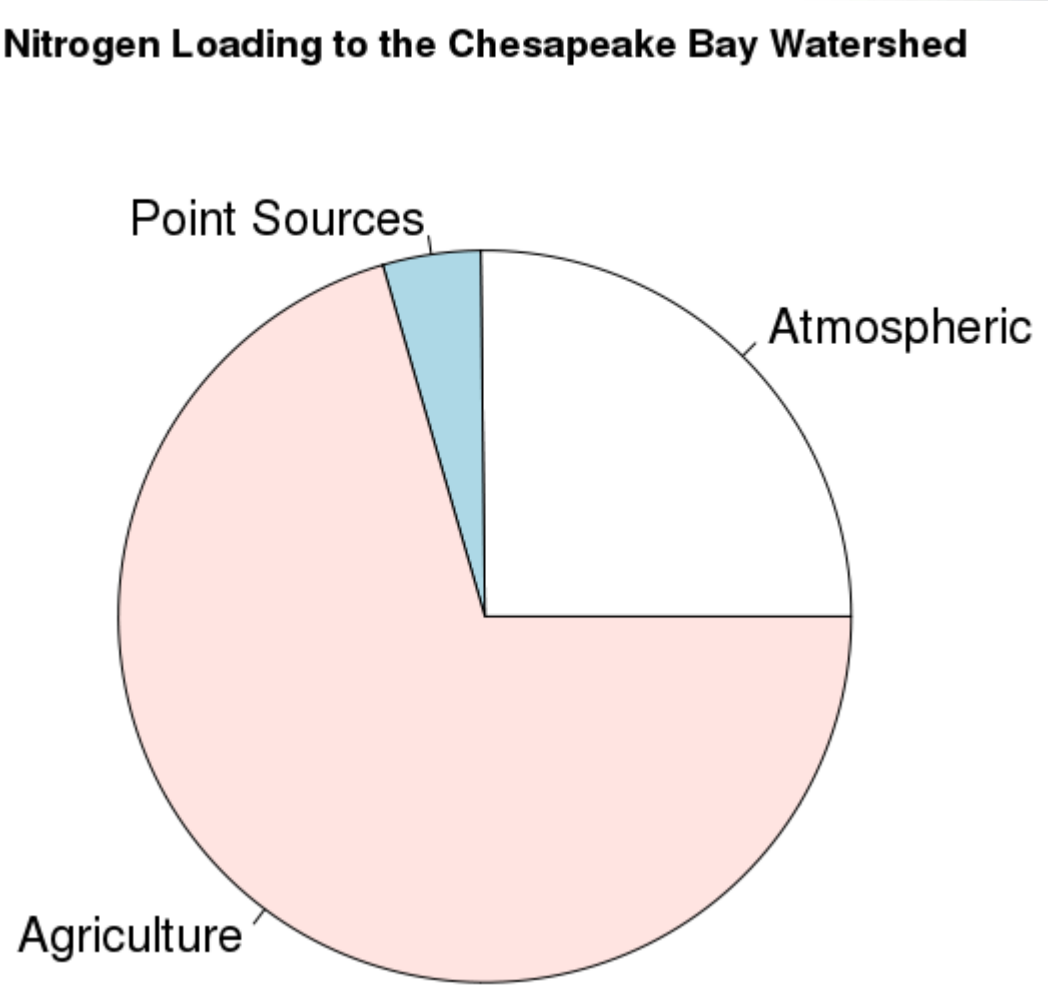
Linked Ecosystem Modeling System

- The Chesapeake Bay modeling system connects land use, management decisions, air quality, water quality and ecosystem services/health
- NERL's Community Multiscale Air Quality (CMAQ) model is an integral part of this system
- This linked modeling system is used to assess the water quality and ecosystem health of the Chesapeake Bay



Nitrogen Loading

- Atmospheric nitrogen loading is the second largest source of nitrogen in the watershed
  - Point and Agriculture loading presented here are direct loading to the watershed
- Modeling results indicate that a 23% reduction in atmospheric nitrogen loading has been achieved through air quality regulations from 2002 to 2012
- The composition of atmospheric reactive nitrogen deposition is shifting from oxidized (fossil fuel combustion) to reduced (largely agricultural) over the past decade
  - Controls of emissions differ
    - Fossil fuel combustion emissions regulated under Clean Air Act
    - Agricultural best management practices are largely voluntary
  - Ecosystem impacts differ



Data from: Linker et al. 2013

2017 Midpoint Assessment

- The Chesapeake Bay Program (CBP) partnership is undergoing a midpoint assessment of progress to ensure that the seven Chesapeake Bay watershed jurisdictions are on track to meet the 2025 Chesapeake Bay Total Maximum Daily Load (TMDL) goal.
  - The six governors of the Chesapeake Bay watershed states and the EPA Executive Council to decide how climate change will be addressed
- The Scientific and Technical Advisory Committee recommendations
  - Consensus that all aspects of climate change should be addressed in the 2017 Midpoint Assessment
  - Changes in climate systems are expected to alter key variables and processes within the Watershed and should also be examined in concurrence with land use changes
  - Assess all of these changes on key living resources
- These model results will be used to inform the assessment on potential climate implications on the TMDL

ORD Research Support

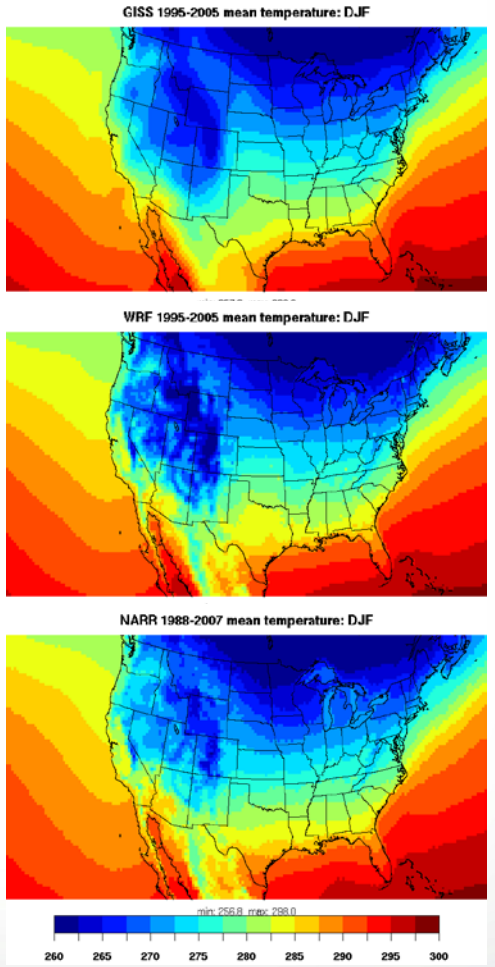
- March 2017 deadline
  - Update the CMAQ and Weather Research and Forecast (WRF) modeling system to be more consistent with the air-biosphere exchange physics (Completed)
  - Evaluate the updated modeling system (Underway)
  - Dynamically downscaled simulations historical and future Representative Concentration Pathway (RCP) 4.5 scenarios (February 2017)
    - Three years each with high, low and average precipitation
  - Dynamically downscaled WRF and CMAQ 2050 and historical nitrogen deposition and weather data to be delivered

Mean Temperature: Winter

Global Model (ModelE2)

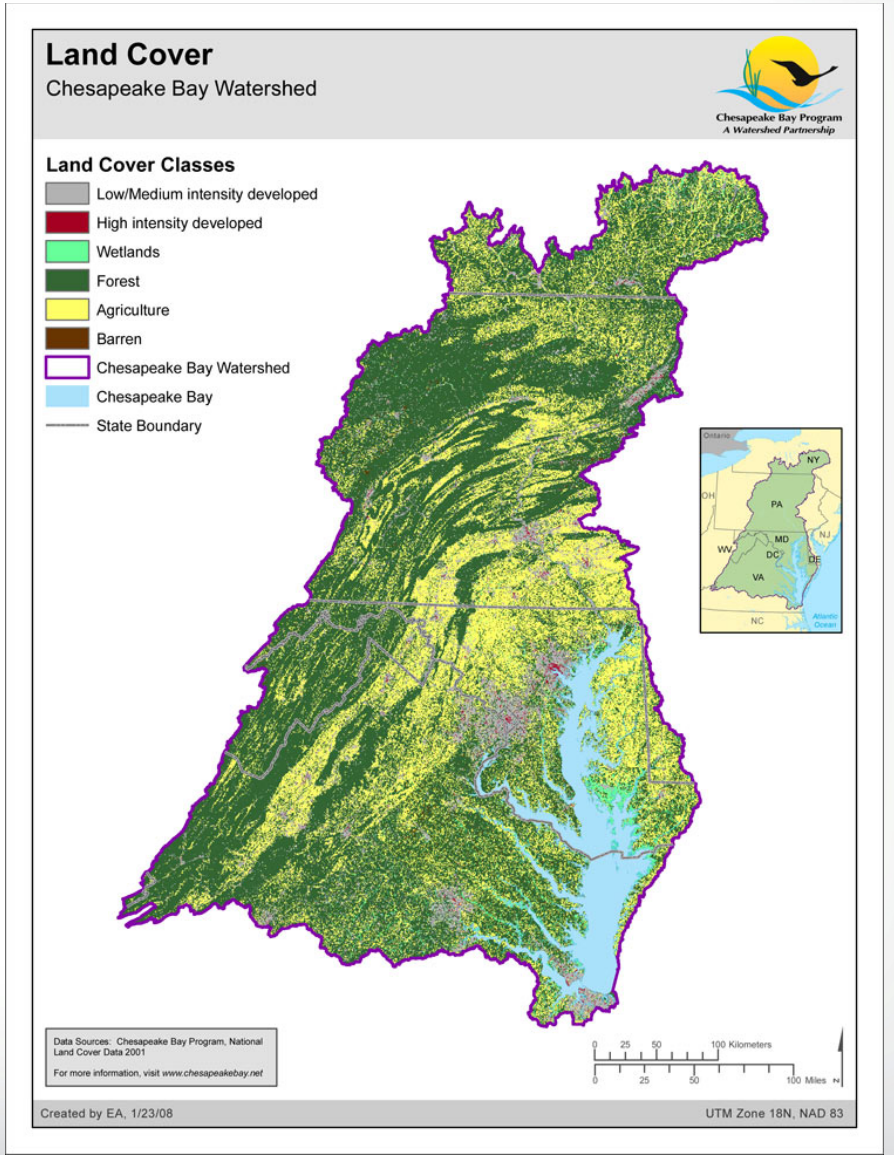
Regional Model (WRF)

Obs



ORD Research Support

- December 2017 updates
  - Incorporate USGS projected land use change into simulations
    - Includes Chesapeake Bay specific best management practices, population and economic growth in accordance with RCP 4.5
  - Refine 2050 emission estimates with OAR and NRMRL
    - Mobile emission factors and fleet
    - Growth in the energy sector and potential point source siting
    - Development in area source emissions, e.g. agricultural, home heating, etc.
      - Connected to land use updates
  - Explore higher spatial resolution or more years of simulations



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ORD Scientific Communication

- May – Division seminar presenting the findings from the initial simulations to EPA ORD and program office
- June – WRF Users' workshop
  - Feedback on meteorological modifications and determine pathway to incorporate them into the WRF model
- November – Coastal & Estuarine Research Federation (CERF) 2017 conference
  - Coordinated with Chesapeake Bay Program
- Early 2018 – Submission of the analysis of meteorological and nitrogen loading results to *Estuaries and Coasts*
  - Review and documentation of the model simulations
- September 2018 – Deliver ACE AIMS 2.2 Chesapeake Bay atmospheric nutrient loading product
  - Delivery and summary of model output

Project Time Line

January 2017	• Update modeling system
February 2017	• Evaluation of updated modeling system
March 2017	• Deliver 2050 and historical simulations
May 2017	• Division Seminar
June 2017	• WRF Users' Workshop
November 2017	• CERF Presentation
April-December 2017	• Provide model result updates
December 2017	• Finalize 2050 and historical model simulations
January 2018	• Submit manuscript to special issue of *Estuaries and Coasts*
September 2018	• Deliver ACE AIMS 2.2 Chesapeake Bay Nutrient loading product

Contributions to Other ORD Research

- Simulations will cover the continental United States and be available to the research community
  - Interest has already been expressed by regional offices through the reactive nitrogen and co-pollutants cross cutting group
- Modifications to the modeling system are coordinated with ORD climate and Green Infrastructure research groups
- Connections made to develop emission scenarios will benefit work being developed by other climate, land use, and green infrastructure research groups
- Stronger ORD ties with regional, state and local air and water quality managers and researchers

Thank you

Questions?

courtesy Chesapeake Bay Program

Acknowledgments

Lewis Linker	– Chesapeake Bay Program modeling coordinator
Patrick Campbell	– WRF and CMAQ modifications
Pat Dolwick and Barron Henderson	– 2050 emissions projections
Tanya Spero	– 2050 Climate downscaling
Chris Nolte	– 2050 CMAQ modeling scenarios