



Session 5 Overview: Linking Air Quality and Ecosystem Health

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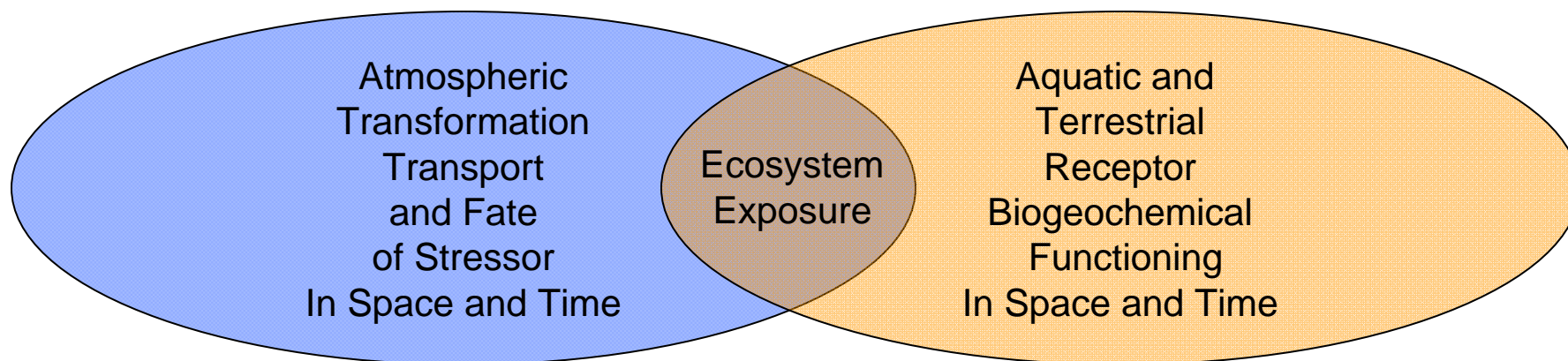


Environmental Issue

- Degradation of the nation's ecological resources due to excess nutrient loading and acidification
- Focus: Degradation of the aquatic resources of coastal estuaries and surface waters due to excess nitrogen
 - Atmospheric deposition contributes 15-40% of the annual nitrogen nutrient load to coastal estuaries
 - Nitrogen is the cause of impairment in about 1/3rd of surface waters
- Acidification from S and N deposition being addressed in the meantime by Title IV controls in the 1990 Clean Air Act Amendments
 - until recent assessments began showing otherwise

The Focus of AMAD Research

- Developing and applying/demonstrating regional atmospheric modeling tools to link atmospheric models with ecosystem models through air-surface exchange to address the contribution of atmospheric stressors to the exposure of ecosystem receptors, affecting ecosystem health





Strategic Context

- Clean Water Act (1972, as amended in 1977 and **1987**)
 - National Estuary Program (NEP) established by Congress in 1987
 - Total Maximum Daily Load limits (TMDL's) required for impaired waters
 - Started addressing non-point sources in 1987 (includes air deposition in concept)
 - Last decade focused on a more holistic watershed approach to TMDL's
- Chesapeake Bay targeted for restoration by Congress in early 1980's
 - First location atmospheric deposition suggested to be important in early 1990's
- Clean Air Act (1990): NO_x & SO_x reductions to meet NAAQS standards and Title IV acid rain controls
- Ecological Research Program MultiYearPlan (emphasis on aquatic resources)
 - Long Term Goal 1: ecological condition - status and trends
 - Long Term Goal 3: develop and apply predictive tools and strengthen the scientific basis for assessments



Research Challenges

- Integrating air and water science (bringing atmospheric deposition into a water-centric analysis)
 - Crossing paradigms (deterministic/first principles vs. calibrated)
 - Temporal disparities
- Identification of key atmospheric deposition uncertainties for a calibrated model world
 - Wet deposition/precipitation errors
 - Dry deposition uncertainty (also, subgrid) and parameterization uncertainty
- Evaluating, identifying, and addressing key uncertainties and missing pathways relevant to deposition
- Assessing the characteristics of atmospheric deposition relevant to the support of management decisions (e.g. source attribution)



General Approach

Conduct Research as Three Interrelated Themes:

- Multimedia applications (guide understanding and define research needs)
 - Thrust: Use the model as a laboratory in real world applications to develop an understanding of deposition characteristics that relate to management needs (connect problem-driven research with core research)
- Air-water linkage investigations
 - Thrust: Reconcile space-time mismatches and data accuracy requirements for effective model-to-model communication to provide atmospheric stressors to ecosystem models for management support
- CMAQ model development
 - Thrust: Improve deposition process descriptions and/or include missing pathways to reduce uncertainty in deposition calculations



Multimedia (Air-Water) Applications

Chesapeake Bay, Tampa Bay and General Studies

- Elucidated the range of transport of nitrogen species, defined airsheds and developing guidance on the range of influence of ammonia that counters conventional wisdom in the ecological community
 - Showed atmospheric deposition is a regional, not a local management issue
- Established CMAQ dry deposition estimates as a valuable contribution to NEP and TMDL assessments
- Reduced temporal and spatial scale mismatches
- Evolved source attribution approaches to use DDM-3D capabilities of CMAQ to replace brute force calculations
- Showed that CAA regulations should reduce future nitrogen deposition



Air-Water Linkage Studies

Chesapeake Bay, Cape Fear River Basin (NC) and General Studies

- Demonstrated need for dry deposition estimates from a model for more accurate deposition budget estimates and identified need for land-use specific dry deposition
- Developed Watershed Deposition Tool (WDT) to map gridded CMAQ output to watershed polygons (HUC's)
- Identifying key uncertainties in wet and dry deposition
- Studying the impact of precipitation error when using CMAQ precipitation and wet deposition fields with ecosystem models
- Providing targeted support of ammonia and mercury bi-directional model development efforts (surface model development)



CMAQ Model Development

- Incorporated sea salt into a science version of CMAQ, CMAQ-UCD through collaboration with University of California-Davis
 - Collaborated in design of Bay Regional Air Chemistry Experiment (BRACE) in Tampa to test the model
- Incorporated sea salt dynamics into the standard version of CMAQ
- Developed a bi-directional flux formulation for ammonia for CMAQ
 - Collaborated with NRMRL, NC State and NOAA in design and conduct of NH₃ flux field study data collection to meet needs of bi-directional flux parameterization
 - Collaborated with Center for Ecology and Hydrology (Edinburgh, UK) on measurements and model parameterizations
- Improved Hg deposition algorithms and developed a consistent bi-directional flux formulation for Hg for CMAQ



Impacts

- CMAQ deposition results now a vital part of the Chesapeake Bay restoration strategy
- CMAQ-UCD results being used for the Tampa Bay TMDL assessment
- The Watershed Deposition Tool opened the door for water quality researchers within and outside EPA to include air deposition in TMDL and other assessments
- CMAQ deposition outputs being used by OAQPS in the NAAQS review of NO_x and SO_x secondary standards
- CMAQ being used to provide deposition estimates for multi-agency critical loads analyses and exploration of potential deposition-based management directions at EPA for protecting ecosystems
- CMAQ, and its deposition and air concentrations fields, being incorporated into the EPA Ecosystem Services Research Program assessment process



New Drivers of Future Research

- Change of Focus: Ecosystem Research Program converted to Ecosystem Services Research Program (ESRP)
 - New ecological research Multi-Year Plan in 2008
 - New ESRP Long Term Goals, restructured with emphasis on ecosystem services
- New emphasis in the air office (OAR) on NO_x and SO_x secondary welfare standards to protect ecosystems (response to NRC 2004 recommendations)
- Climate change as a potential priority area

Development directions fit well: Continue development research directions and attention on nitrogen; linkage research targeted to ESRP and related multidisciplinary work and a natural extension to consider climate change



Future Research

- Multimedia/Multidisciplinary Applications/Studies
 - ESRP Program Studies
 - Biofuels, Nitrogen, Land-use Change, & Climate Change
 - NO_x-SO_x secondary standards and tipping point levels of deposition
- Linkage to Climate Change
 - Precipitation/temperature improvement for current and future condition assessments (e.g., climate change); deposition improvements
 - Connect to hydrologic modeling
- CMAQ Development
 - Land use update (NLCD); land use change capability
 - NH₃ and Hg bi-directional flux formulation completion
 - Lightning NO_x inclusion (collaboration with development/evaluation teams)
 - Extension of Hg soil and vegetation model to nitrogen species (e.g., N₂O)



Posters

- 5.1. Improving Atmospheric Deposition Processes in CMAQ for Ecosystem Applications
 - **Jesse Bash** and Prakash Bhave
- 5.2. Linking CMAQ to Watershed/Estuarine Models
 - **Donna Schwede** and Ellen Cooter
- 5.3. Providing Guidance and Advice to Ecosystem Management Community Using CMAQ as a Laboratory
 - **Robin Dennis**
- 5.4. Using CMAQ in Managing Mercury Deposition to Sensitive Ecosystems
 - **Russell Bullock** and Jesse Bash