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Modeling Atmospheric Nitrogen Deposition: The Current State of the Science and Future Directions

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Chesapeake Bay Program Modeling in 2025 and Beyond, National Conservation Training Center, Shepherdstown WV
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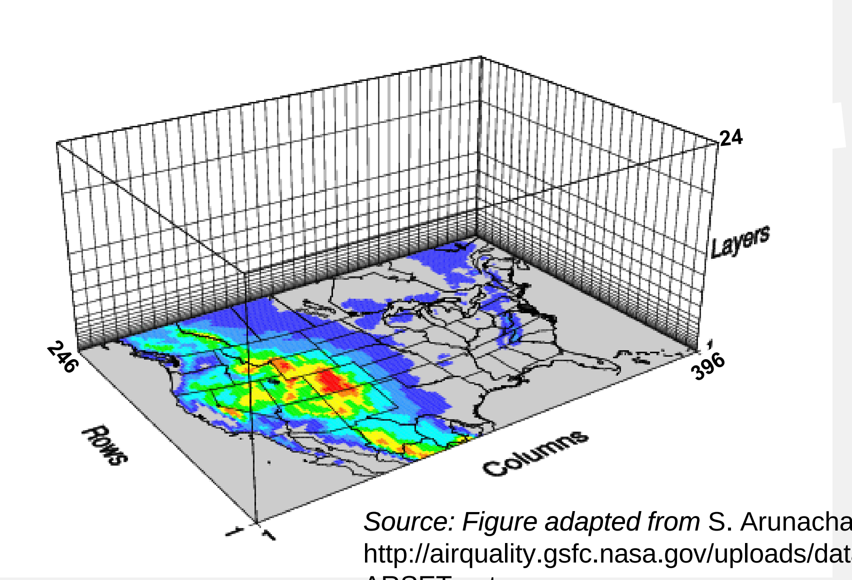
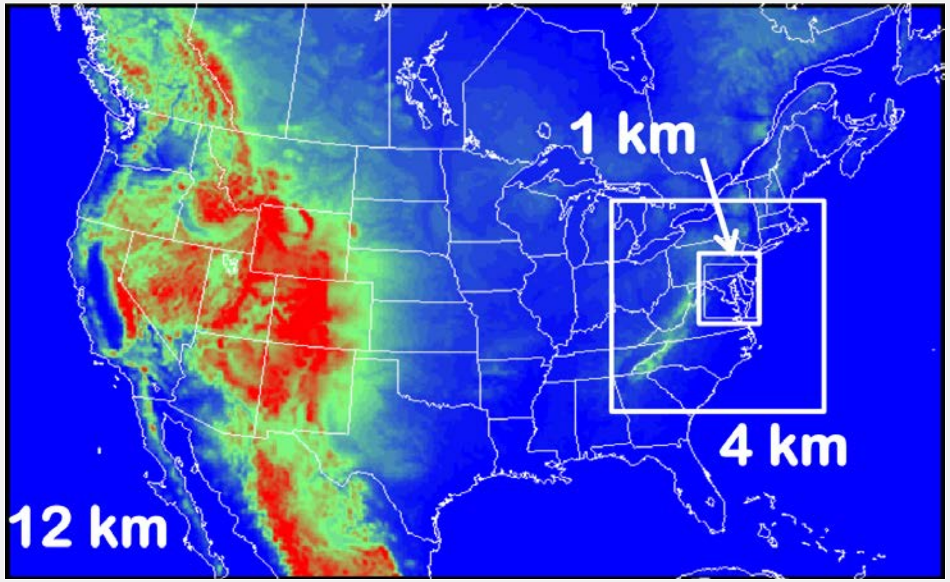
Comprehensive Air Quality Models

- Simulate ozone, particulate matter (ultrafine to coarse), toxics, acid deposition, visibility, etc. on 3-D fixed grid
- Require inputs for emissions, meteorology, and initial & boundary conditions
- Generally open-source and are widely developed and used by government, academia, and the private sector



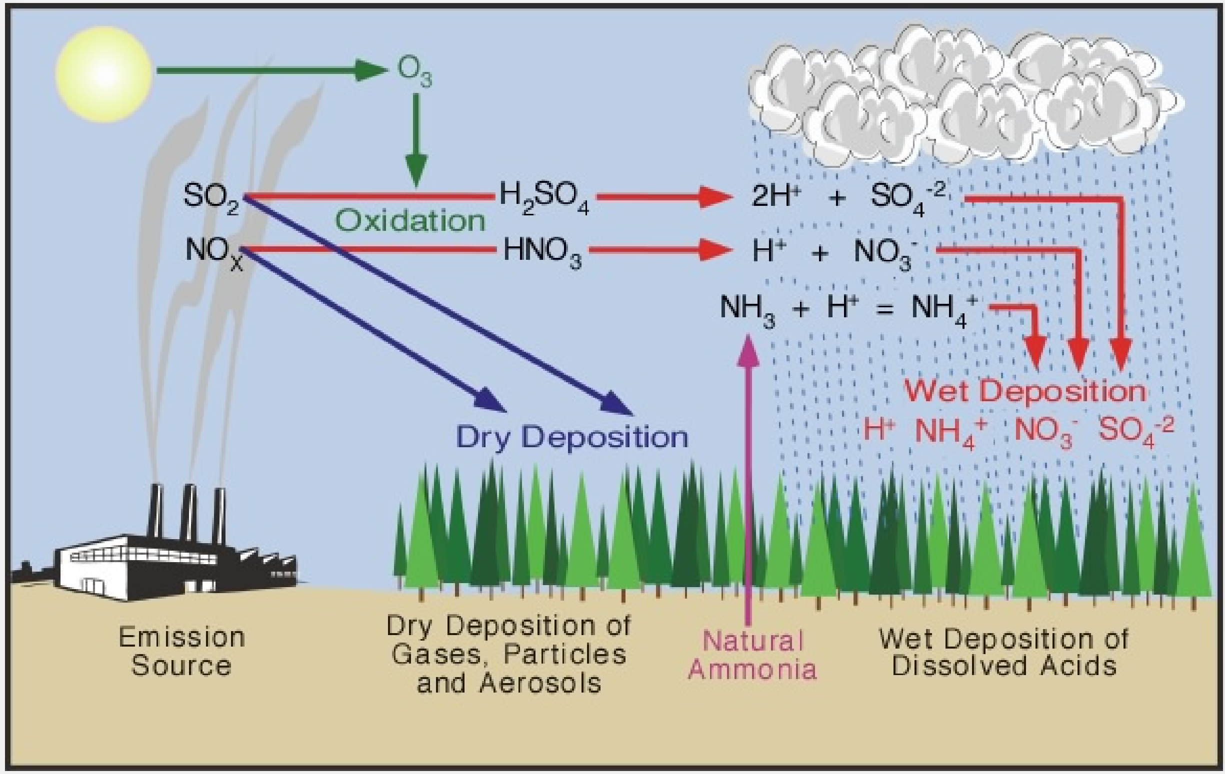
Source: Figure adapted from S. Arunachalam, http://airquality.gsfc.nasa.gov/uploads/data/CMAQ-Introduction-for-ARSET.ppt



Gilliam et al. 2013
http://www2.mmm.ucar.edu/wrf/users/workshops/WS2013

Community Multiscale Air Quality (CMAQ) Model

- EPA's state-of-the-science comprehensive air quality model
  - Available at https://github.com/USEPA/CMAQ
- "One atmosphere model"
  - Simulates transport, chemistry and deposition (gaseous and precipitation scrubbing) for ozone, particulate matter ($PM_{2.5}$), toxics, acids, trace gasses, etc. simultaneously
- Moving towards a "One biosphere model"
  - Integrating terrestrial and aquatic biogeochemistry
  - Better parameterization of the nitrogen cascade and trade offs between air and water quality
- Largely based on first principles
  - Not tuned to specific applications
- Continuously evaluated against network, satellite and field campaign atmospheric chemistry and air-quality observations



CMAQ Emissions

- Hourly emissions processed from NEI
- Using the Sparse Matrix Operator Kernel Emissions (SMOKE) model
- Year specific meteorology and Continuous Emissions Monitoring (CEM) observations
- Emission sectors are modeled separately
- Meteorology and land use dependent emissions modeled within CMAQ
  - NH_3 from fertilizer, Dust, Soil NO, Sea Salt Aerosols, Biogenic Volatile Organic Carbon

www.gsb.stanford.edu

www.nysenate.gov

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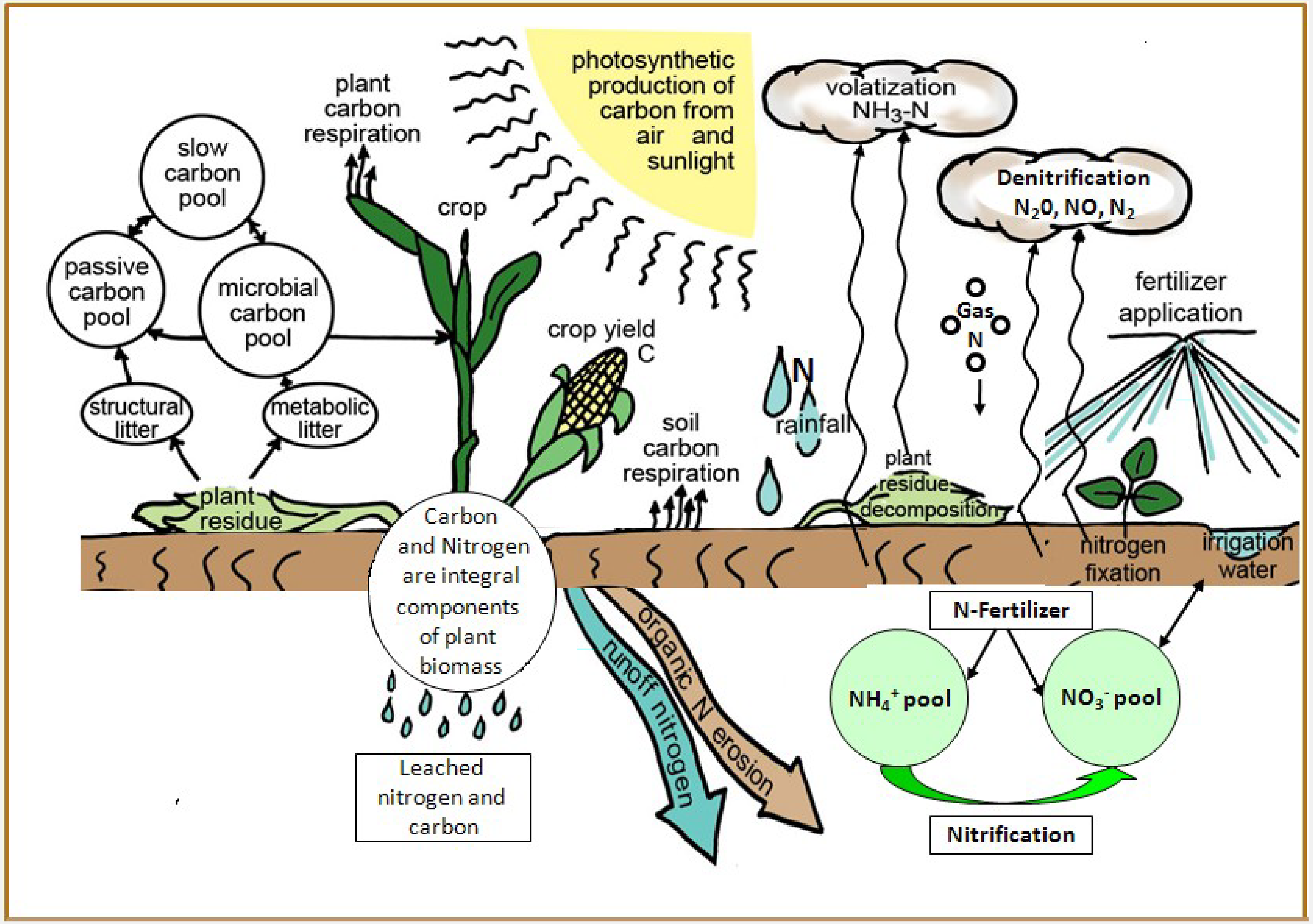
Nitrogen Cycling in CMAQ

- Nitrogen is transported across multiple media
- CMAQ can be coupled to an agro-ecosystem model
  - USDA's Environmental Policy Integrated Climate (EPIC) model
- Considers multimedia gradients and biogeochemical processes to model fluxes



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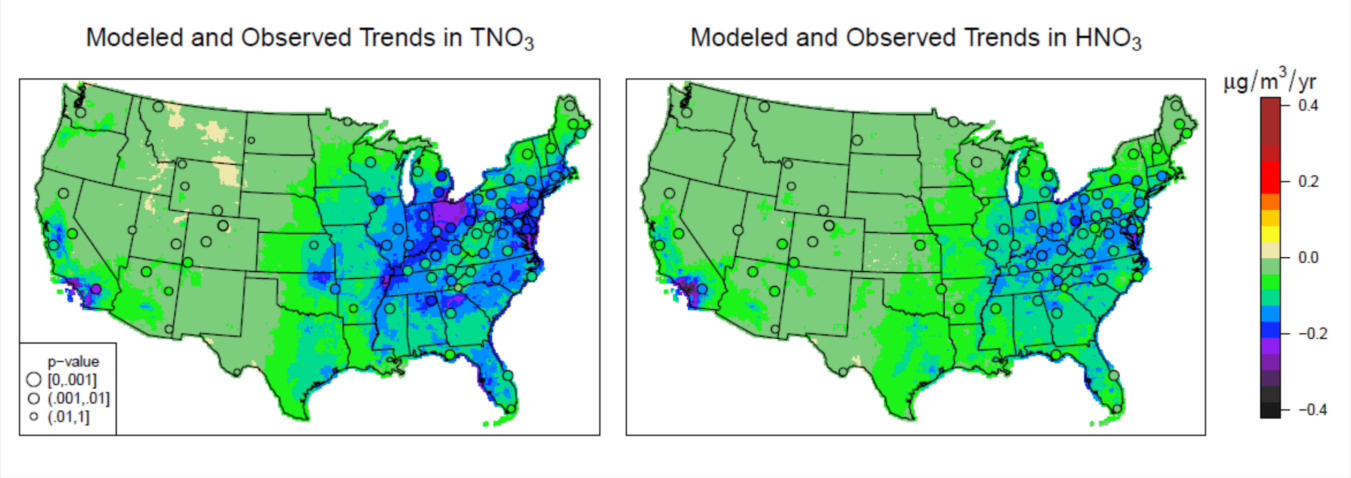
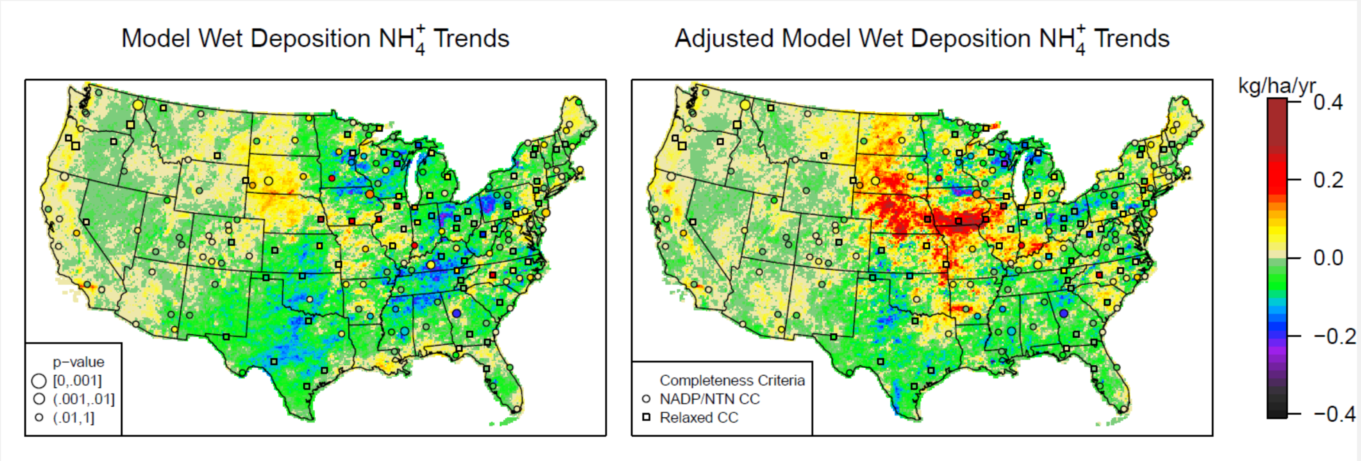
Nitrogen Concentration Trends

- Trends (2002-2012) in ambient oxidized nitrogen concentrations are captured well
  - Gives confidence that dry deposition is captured well
- Underestimating the reduced N wet deposition trends in the Midwest
  - Ambient NH_3 measurements do not cover a sufficient amount of time for trends
  - Mid Atlantic trends captured well





Zhang et al. in Prep

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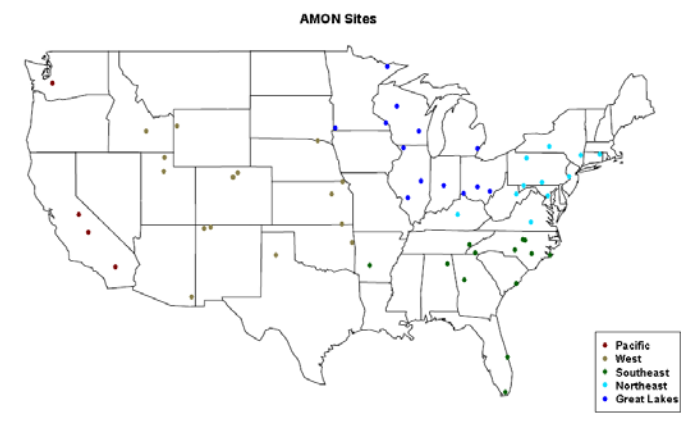
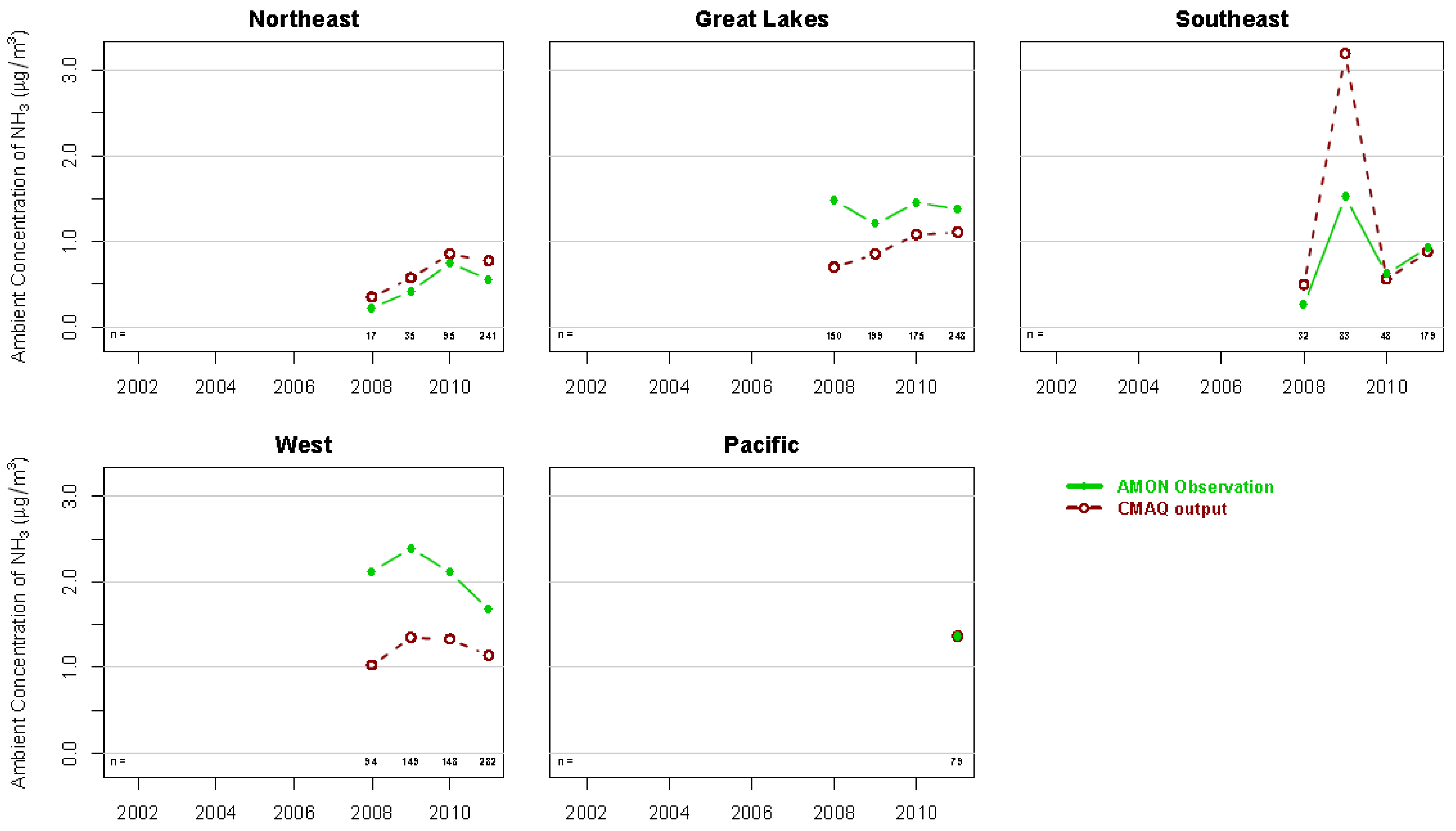
CMAQ NH_3 Evaluation



Regional Averages of Annual Ambient NH_3 (ug/m^3)



NH_3 evaluates well in the Eastern US

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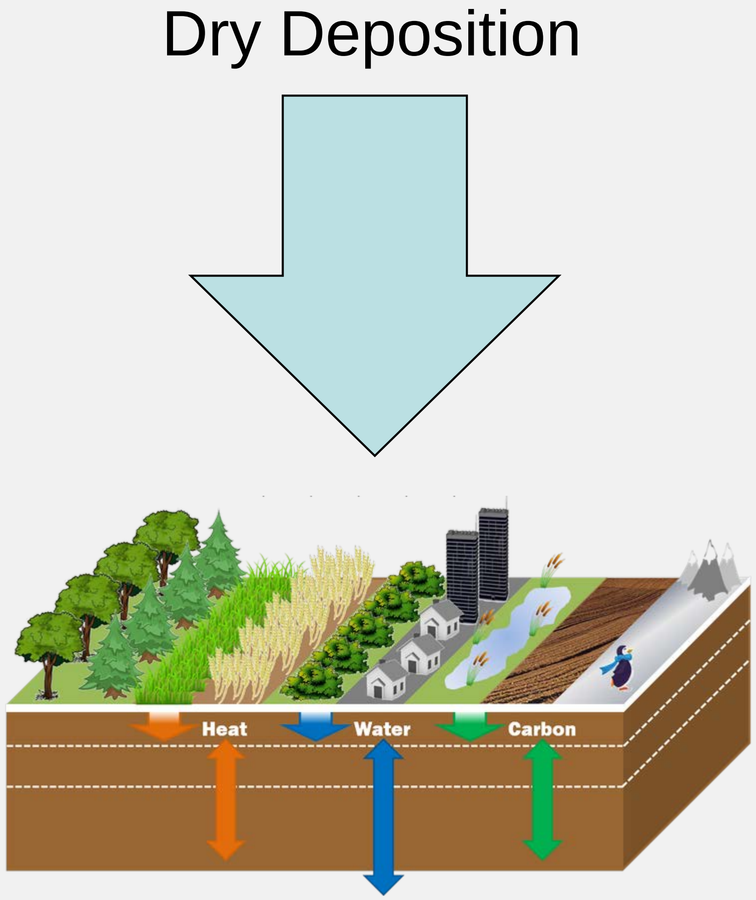
Atmospheric Deposition Developments

Planned short term

- Expanded organic N deposition
- Better quantification of oxidized nitrogen concentration biases
- Land use specific deposition estimates
  - –More evaluation against field campaigns
- Higher resolution simulations
  - –Retrospective and future simulations at 4km
- Additional deposition options in CMAQ
  - –Better quantification of parameterization uncertainty



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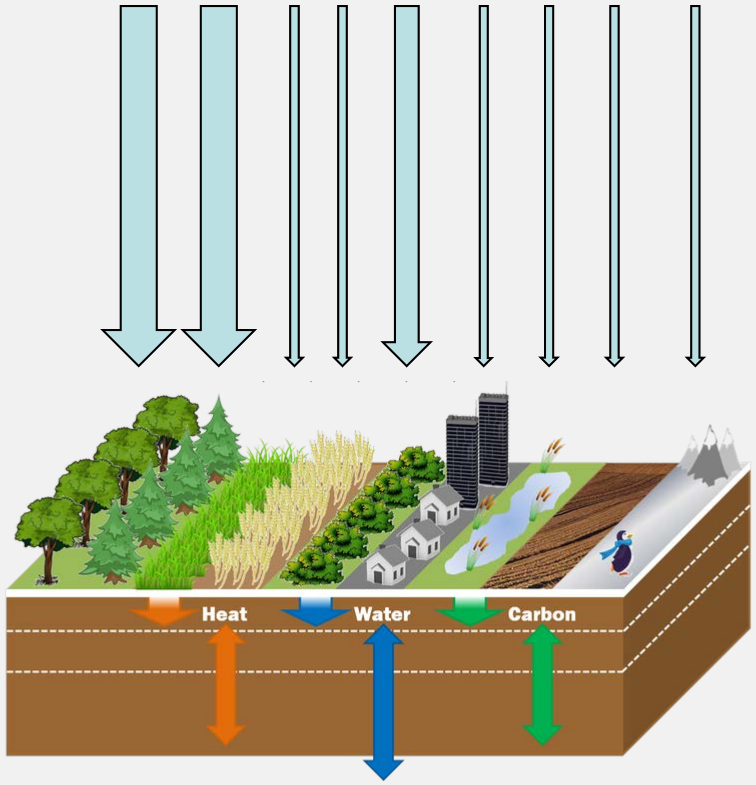
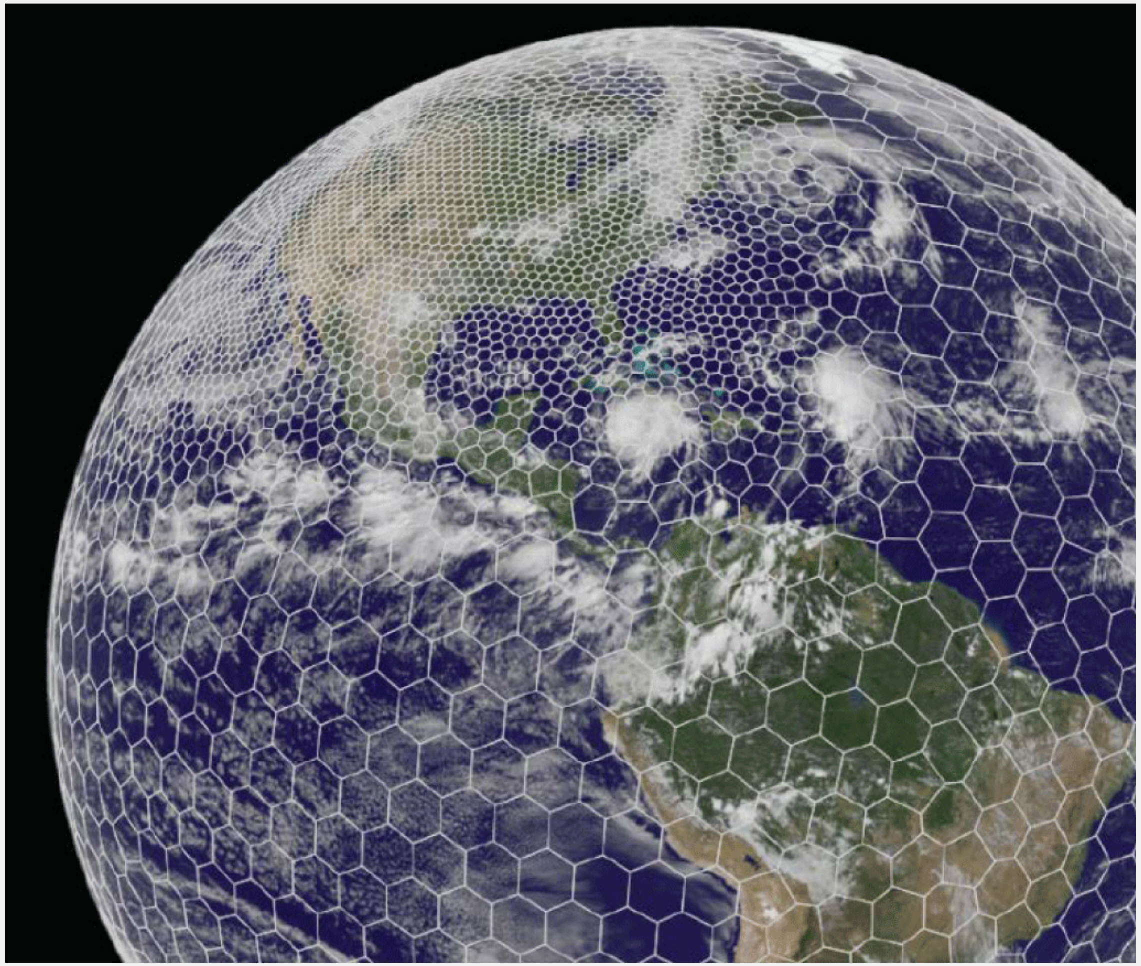
Dry Deposition



Atmospheric Deposition Developments

<u>Planned long term</u>

- Non uniform model grid
  - Higher resolution where it is needed
- Direct connection to hydrology and ecosystem models
  - Capture environmental feedbacks
- Local, regional and global scale simulations with consistent model parameterizations
  - Better quantification of long range transport



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