Update on retrospective and future CMAQ Atmospheric Deposition Scenarios

Overview

- 2011 Base year
  - Emission and observations
  - Discover AQ special observations
- 2002-2012 model evaluation
- Updates on 2017, 2025 and 2030 simulations
  - Updates on emissions
- Updates on 2050 future climate and land use simulations
  - First simulation estimate (March 2017)
  - Refinements (Dec 2017)

2011 Base Year

- 2017, 2025 and 2030 emissions are built on the 2011 National Emissions Inventory and meteorological simulations
- Why 2011?
- Represents our latest evaluated model platform
- Base year for most OAQPS applications
- 2011 DISCOVER AQ measurement platform
    - Multi agency measurement campaign
    - Provides a unique data set to evaluate CMAQ simulations
    - Currently developing CMAQ modeling manuscript

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Overview and evaluation of the Community Multiscale Air Quality (CMAQ) model version 5.1

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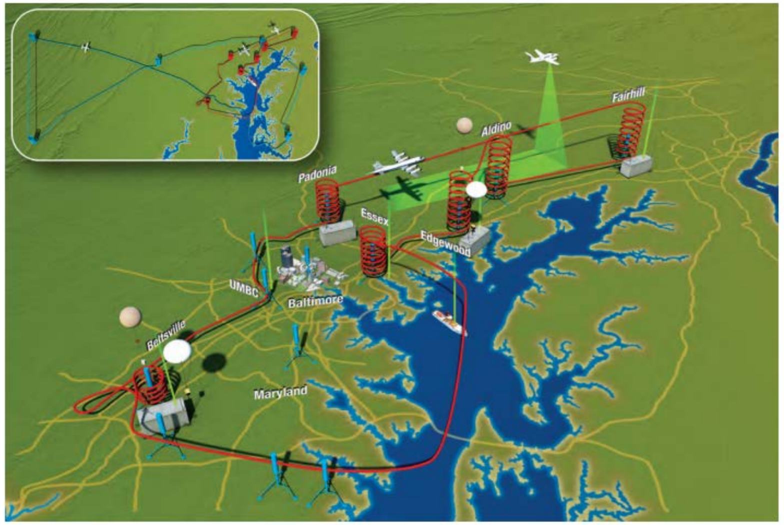
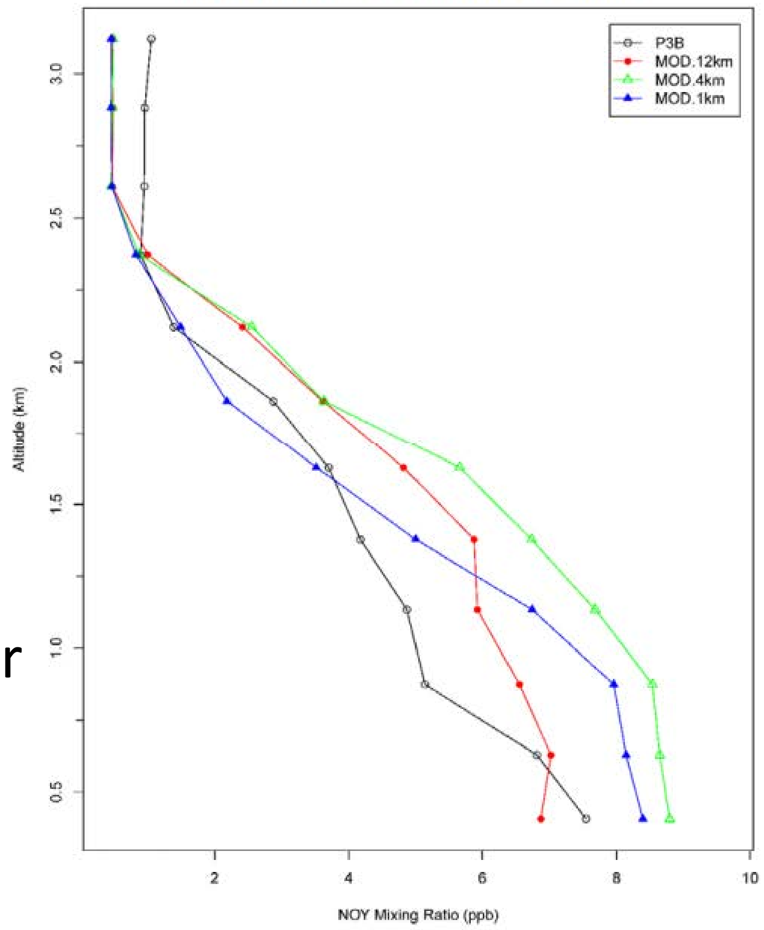


Figure 1. DISCOVER-AQ observing strategy employed during the Baltimore–Washington study.

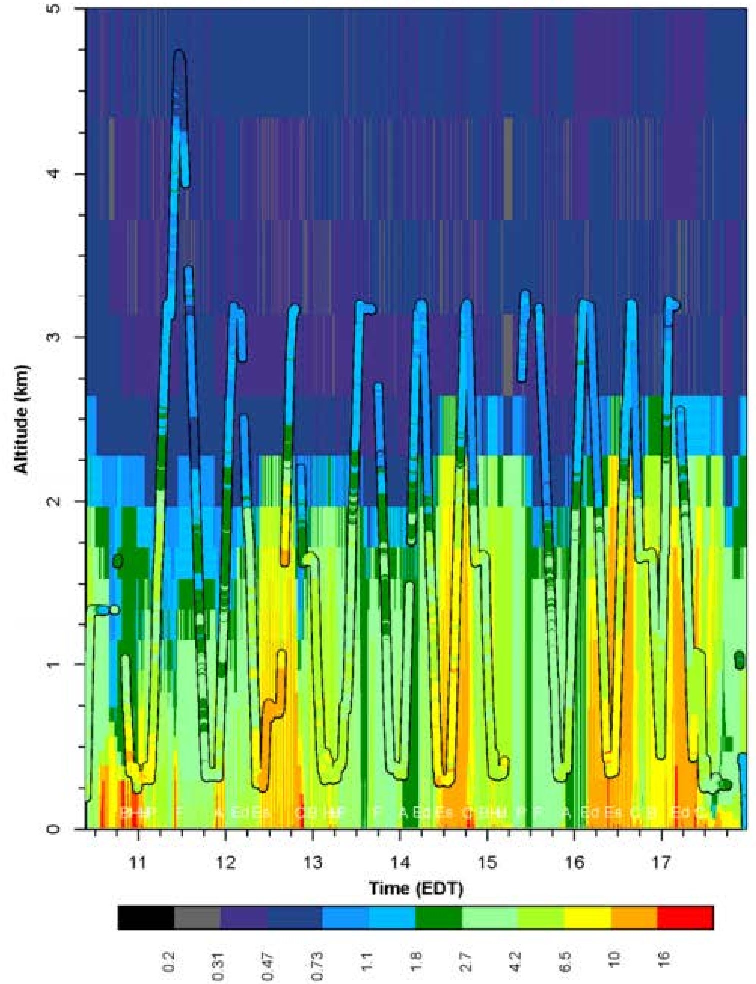
2011 Discover AQ

- Special surface, satellite and aircraft observations
  - Allows the evaluation of model species and processes not typically examined
- NO_y contains most of the oxidized N species that are deposited
- Ambient concentrations of oxidized species are generally over estimated
- Evaluation of model grid resolution on results

Edgewood P3B NO_Y Spiral – July 2nd



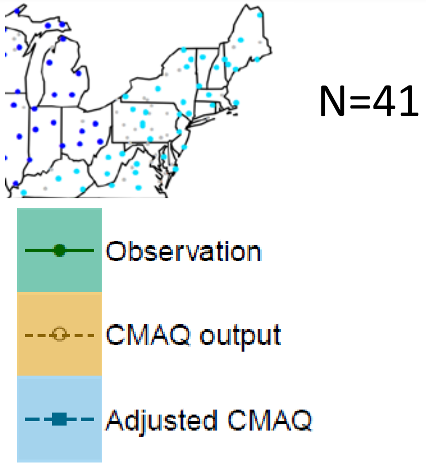
P3B NO_Y Transect – July 2nd

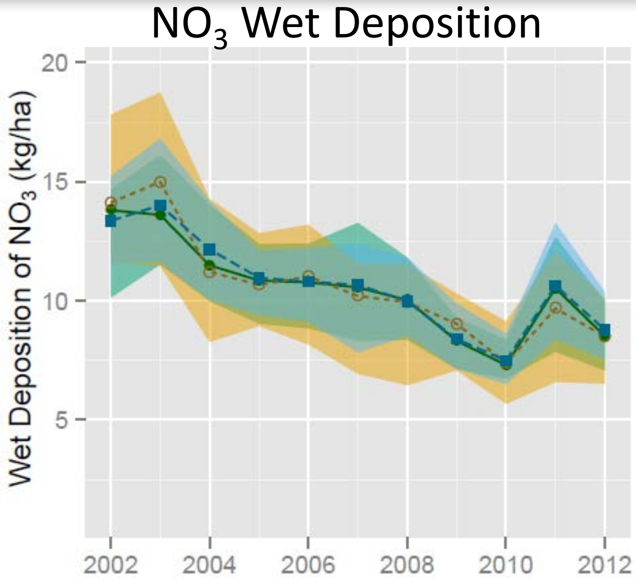


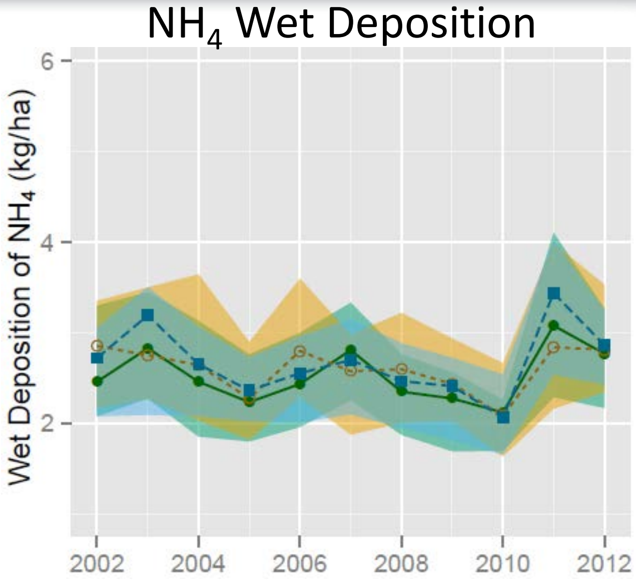
2002 – 2012 Model evaluation

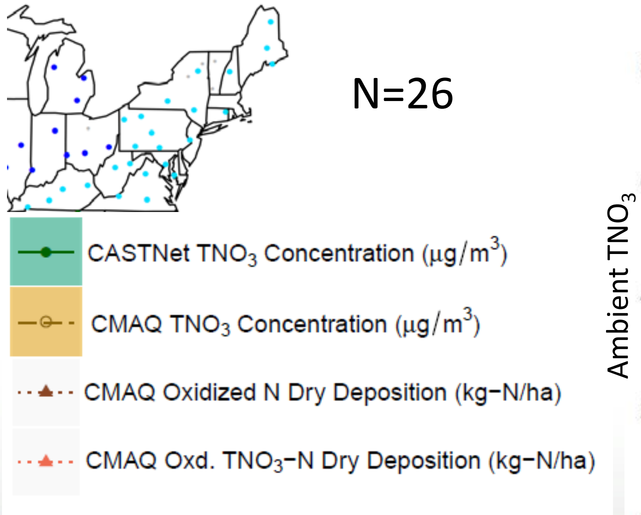
- Evaluation of ambient concentrations
  - Confidence in dry deposition estimates
  - These species comprise the bulk of the dry deposition to the watershed
- Evaluation of trends in deposition and concentrations
  - How well are we capturing the response to emission changes
    - Critical to provide confidence in future emission projections

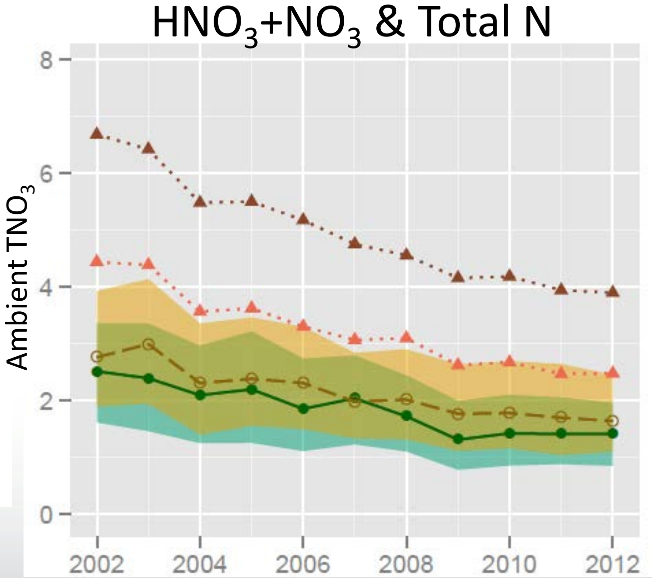
Model Evaluation







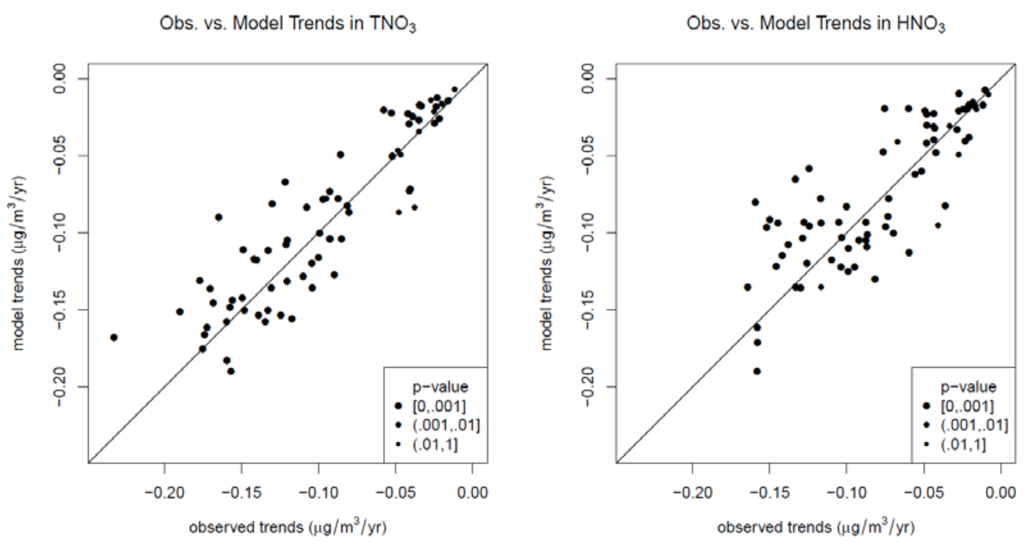


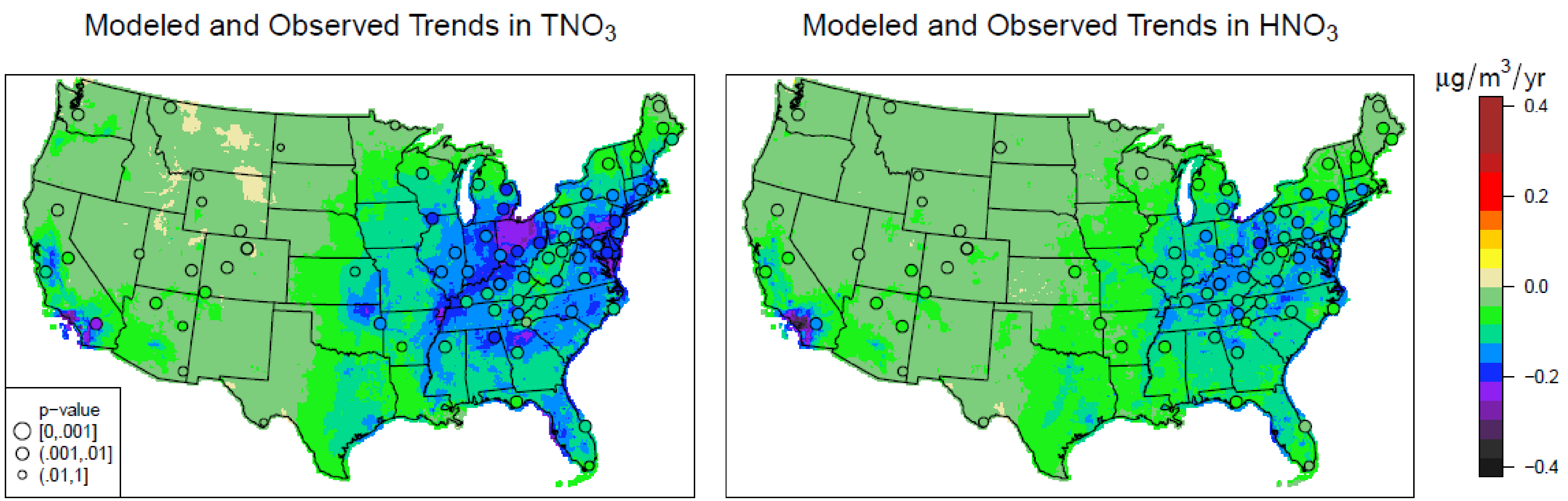


Captures the trends and magnitude in deposition and ambient concentrations well - (approximately 14% and 17% error for NO_3 and NH_4 respectively)

2002 – 2012 Model evaluation

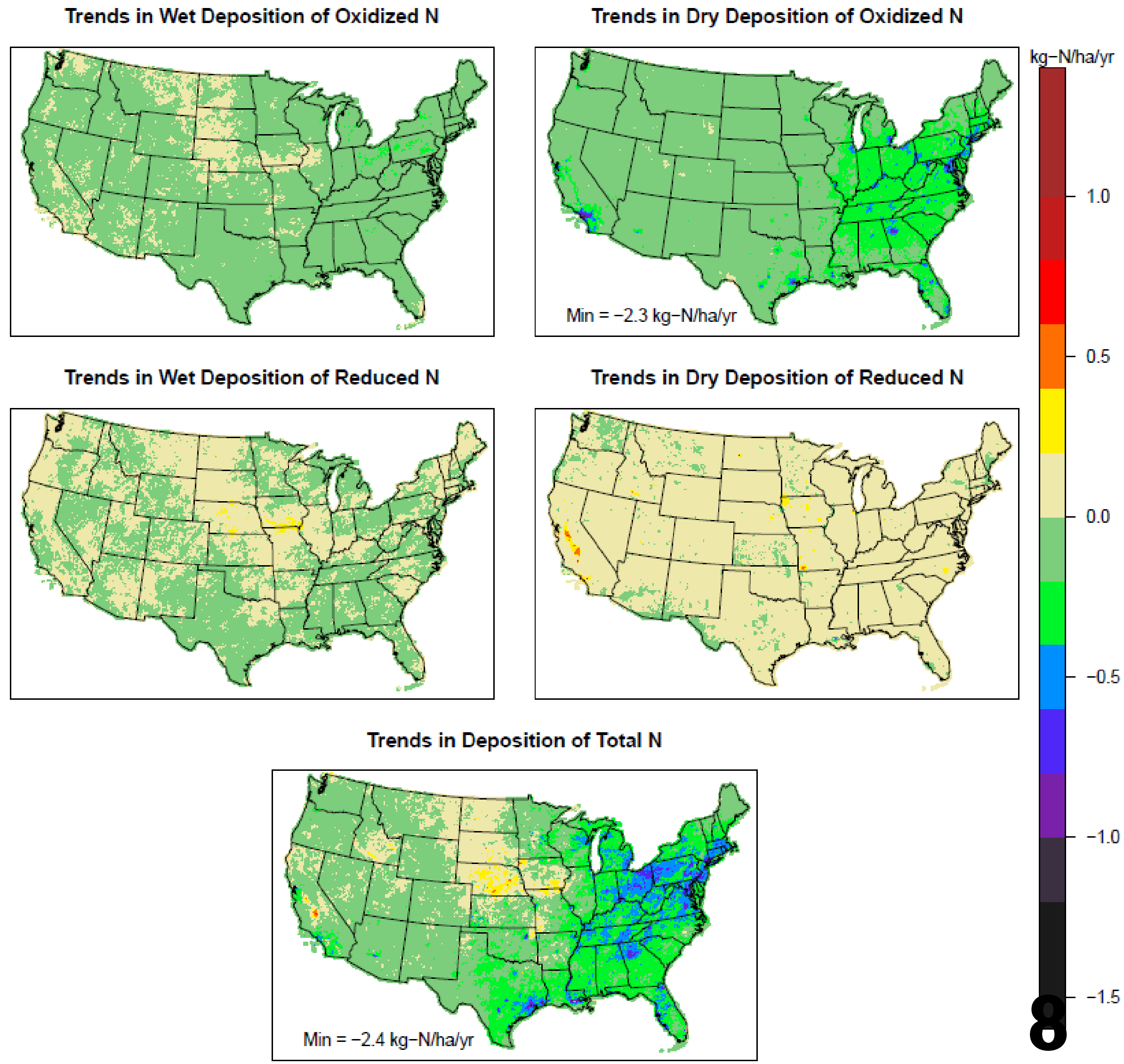
- Theil-Sen trends (i.e. slopes) for the 2002-2012
- Trends in observed ambient concentrations are captured well
- TNO3 accounts for approximately half the N deposition to the Chesapeake Bay Watershed





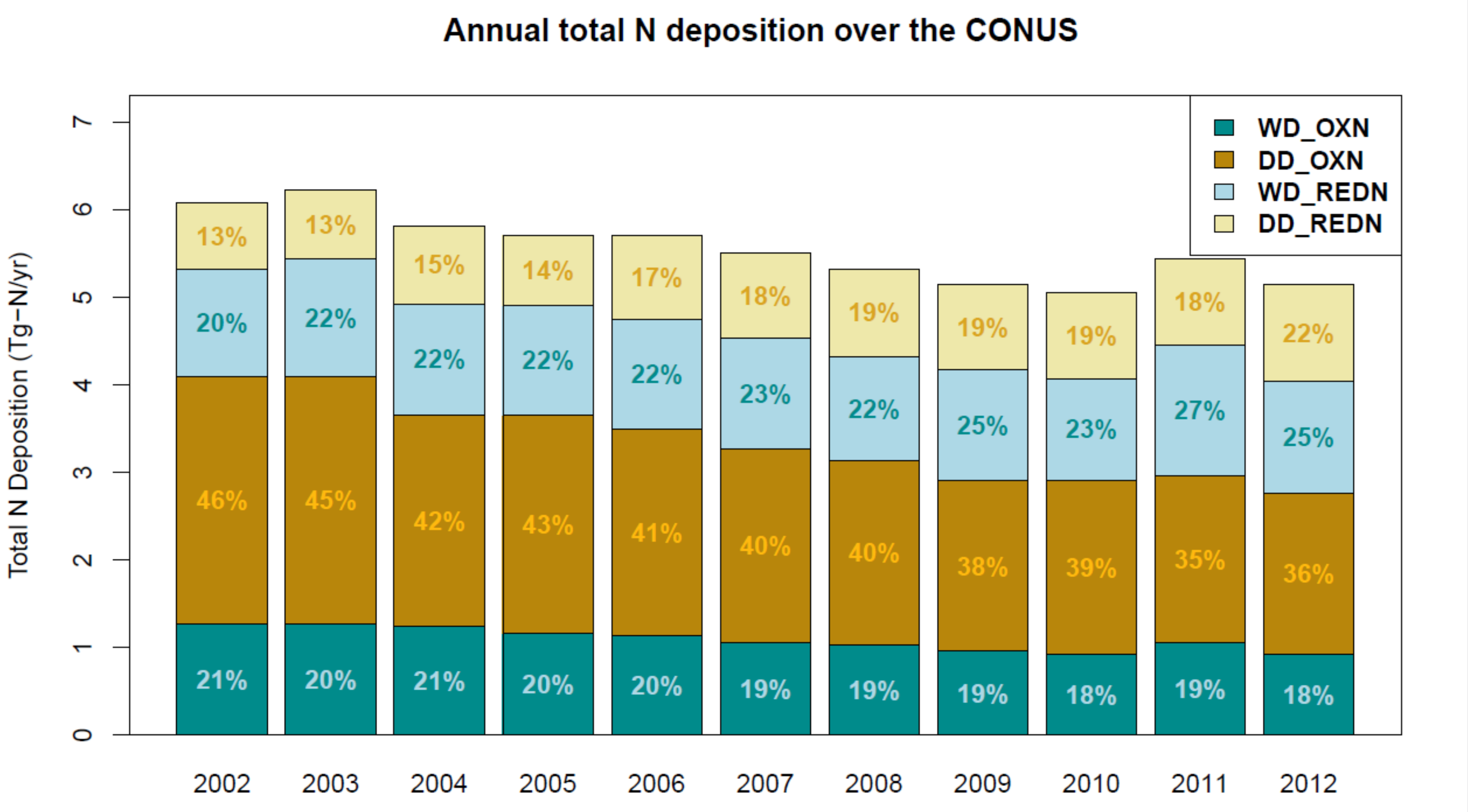
2002-2012 Trends

- Trends in dry deposition are larger than in wet deposition
  - Driving trends in total deposition
- Decreasing trend in dry and wet oxidized N deposition
- Increasing trend in reduced N dry deposition
- Trend in oxidized N deposition is driving the overall deposition trends



Composition of Total N deposition

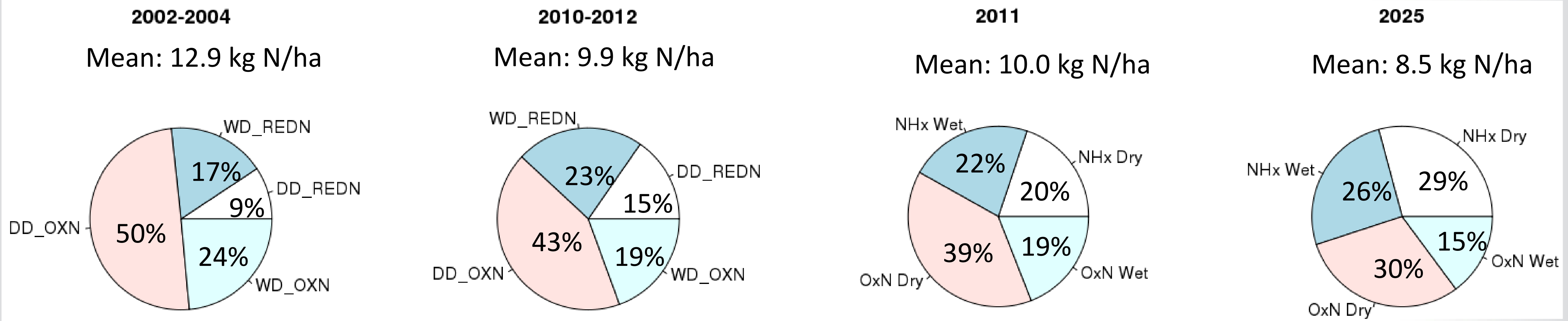
- Total N deposition is decreasing
- Reductions in oxidized N deposition dominates the increases in reduced N deposition
- Total N deposition is increasingly shifting to reduced N species (ammonia and ammonium)



2017, 2025 and 2030 Simulations

- 2011 base year from meteorology and emissions based on a CONUS 12 km grid spacing
- Includes current emission reductions on the books, e.g. TIER 3 mobile, CSAPR updates, CAFÉ standards, etc.
- Includes bidirectional NH_3 and lightning generated NO_x
- 2011, 2017, 2025 and 2030 will all be simulated using the latest update to the 2011 NEI
  - Should be completed in late February, 2017
- An earlier 2025 simulation using an older version of the 2011 NEI should provide a good first cut at the deposition to the Chesapeake Bay Watershed

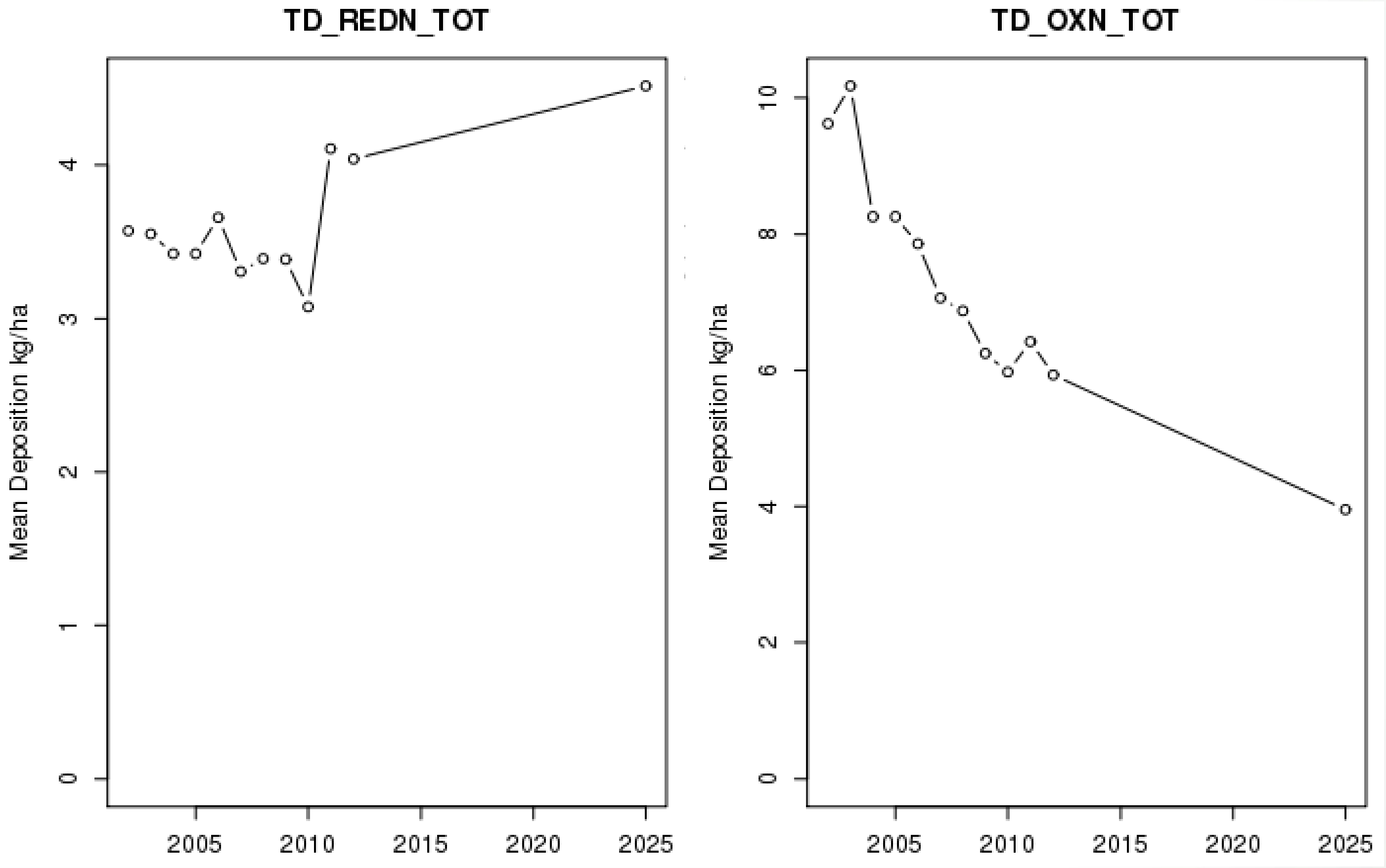
Preliminary 2025 results



- Emission reductions on the books for 2025 lower estimated total N deposition by approximately 14%
- Total N deposition to the Chesapeake Bay dominated by reduced N species

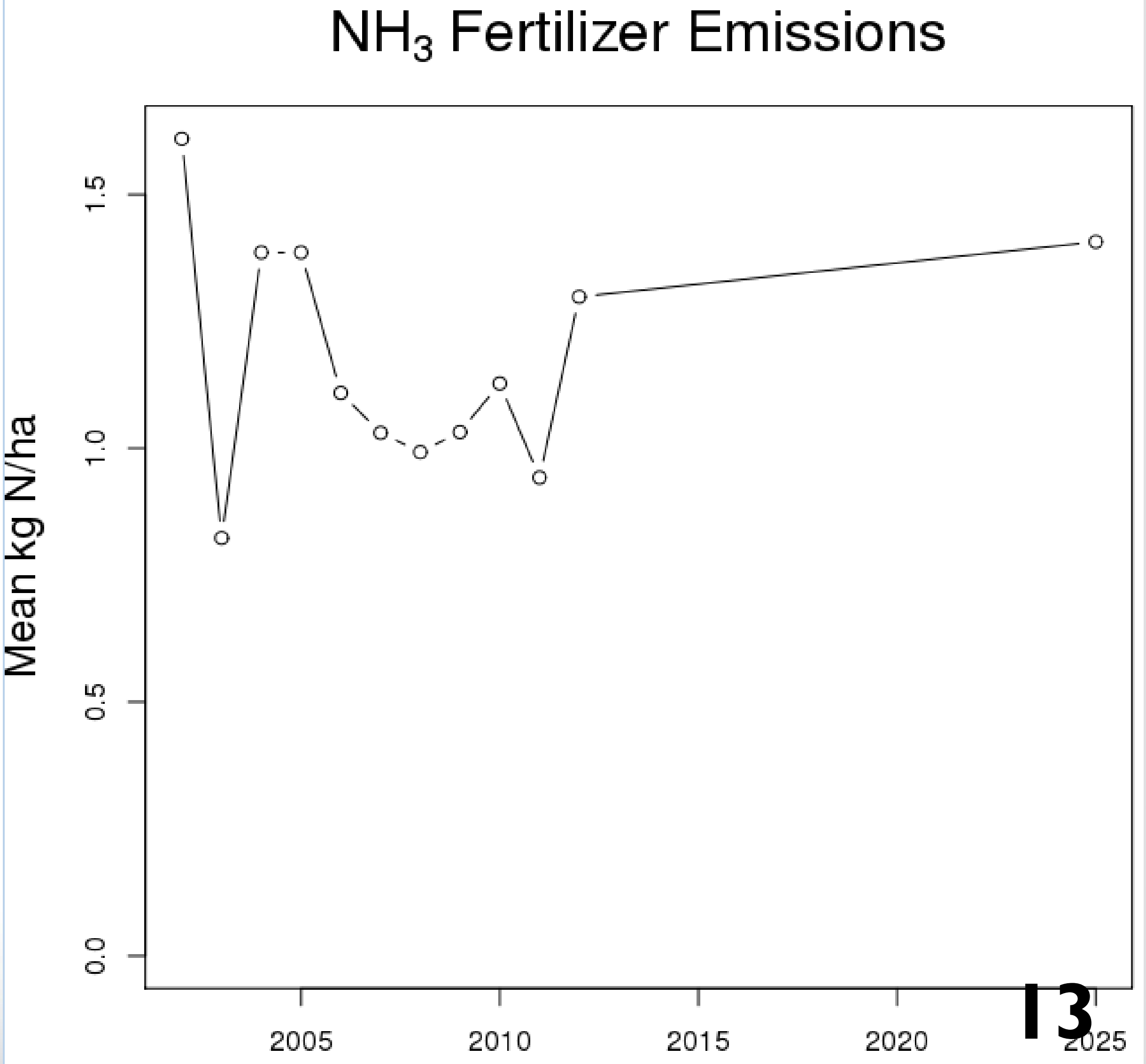
Total N and Reduced N Dry Deposition

- Trend in reduced N deposition is driven by increases in NH_3 dry deposition
- Oxidized N deposition is projected to be half of the 2002 estimates



Total N and Reduced N Dry Deposition

- Total N deposition decreases due to projected NOx reductions
- Reduced N deposition increases due to atmospheric chemistry and NOx reductions
  - Lower NO_x and SO_x concentrations reduced aerosol NH_4
  - Results in higher NH_3 concentrations
  - NH_3 dry deposited faster than NH_4
- Emissions have remained largely constent



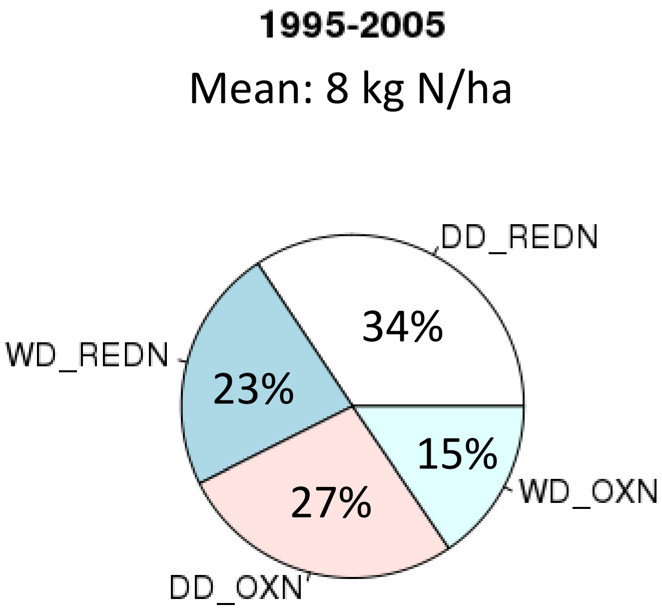
Climate scenario simulations

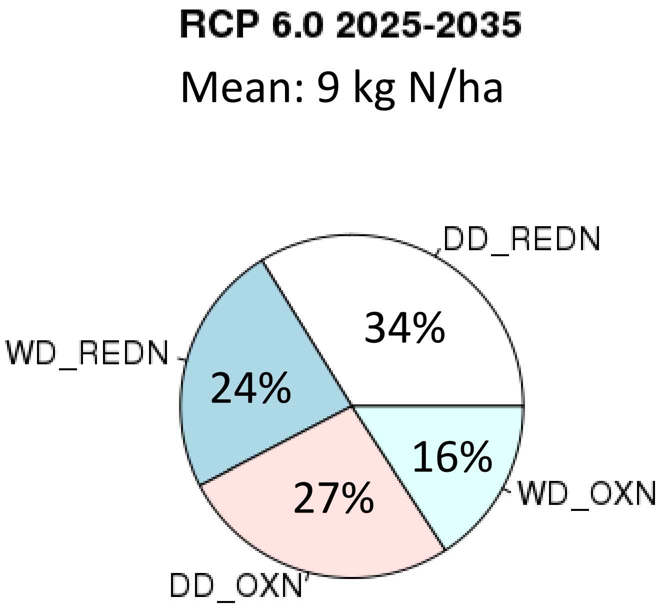
- Based on Community Earth System Model v1.0 (CESM) GCM simulations
- Dynamically downscaled using Weather Research and Forecasting (WRF) v3.8.1 model using spectral nudging
  - Preserves large scale atmospheric motions from CESM and allows WRF to provide the more detailed regional scale dynamics
- 2050 land use change data to be used for meteorology and air quality simulations
- Modifications to WRF to work more consistently with CMAQ
- EPIC agricultural simulations based on downscaled CESM data
- 36 km grid spacing output by end of March 2017
- Refined emissions with growth to energy sector and mobile emissions by end of 2017

Climate Air Quality Modeling

- Meteorological models must be run differently for future applications
  - Retrospective studies are heavily reliant on observational assimilation
  - Meteorological models must use more comprehensive physics packages
  - Represents a departure from traditional CMAQ applications
  - Updates required to accommodate land use change in the modeling system
- We have made modifications to the WRF meteorological model to better support CMAQ applications
  - Currently being evaluated
- 2011 base year will be rerun with modified WRF to establish model performance and provide a basis for relative changes in deposition
- Typical climate simulations have been conducted on coarser grid resolution
  - Fine resolution (12km and 4km) simulations will be explored

N Deposition Budget





- Climate downscaling in WRF requires different configuration of CMAQ
  - Likely overestimates NH_3 dry deposition
- All Representative Concentration Pathways (RPC) scenarios result in increased N deposition

Scenario	Precipitation Change (%)	N Deposition Change (%)
RCP 4.5	+3.9%	+2.2%
RCP 6.0	+8.9%	+2.9%
RCP 8.5	+1.0%	+3.3%

2050 Greenhouse Gas Phase 2 Final Rule

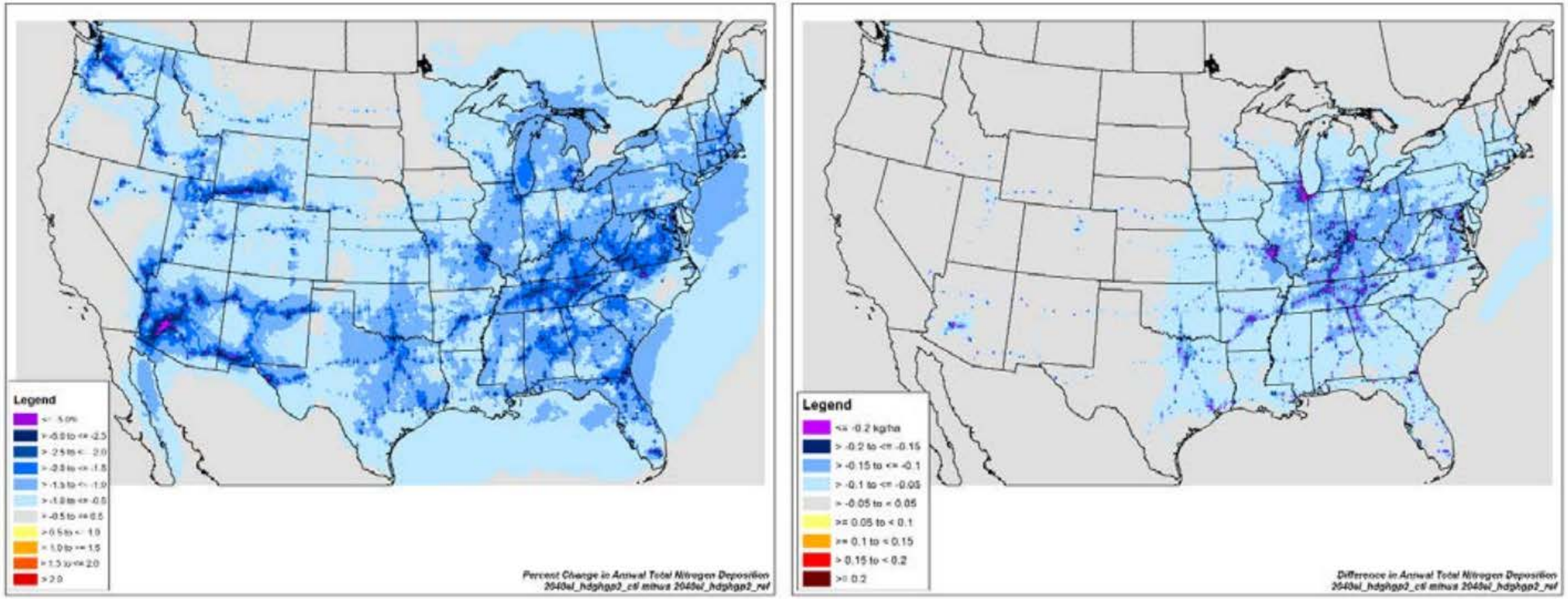


Figure III-23. Changes in Nitrogen Deposition between the Reference Case and the Control Case in 2040 using Air Quality Modeling Inventories: Percent Changes (left) and Absolute Changes in kg/ha (right)

- Approximately 2% (0.15 kg/ha) reduction in total N atmospheric deposition to Chesapeake Bay Watershed
- These emission are being processed for 2050 weather
- Can reallocate emissions due to land use change

Review

- 2002-2012 model simulations capture ambient $THNO_3$ and NH_3concentrations well
  - Confidence in dry deposition estimates
  - These species comprise the bulk of the dry deposition to the watershed
- 2011 base year has advantages due to the measurements in the area and developments by the OAQPS emissions team
- Progress is being made on the 2017, 2025 and 2030 simulations
- Meteorological and air quality updates for the 2050 simulations are being evaluated
  - Working on 2050 emissions

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Pat Dolwick – 2050 emissions

Barron Henderson – 2050 emission projections

Tanya Spero – 2050 Climate downscaling

Chris Nolte – 2050 CMAQ modeling scenarios