Regional Trends and Sources of Nitrogen Deposition in the United States from 2002-2017

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[1]Oak Ridge Institute for Science and Education (ORISE), US Environmental Protection Agency, Research Triangle Park, NC, USA
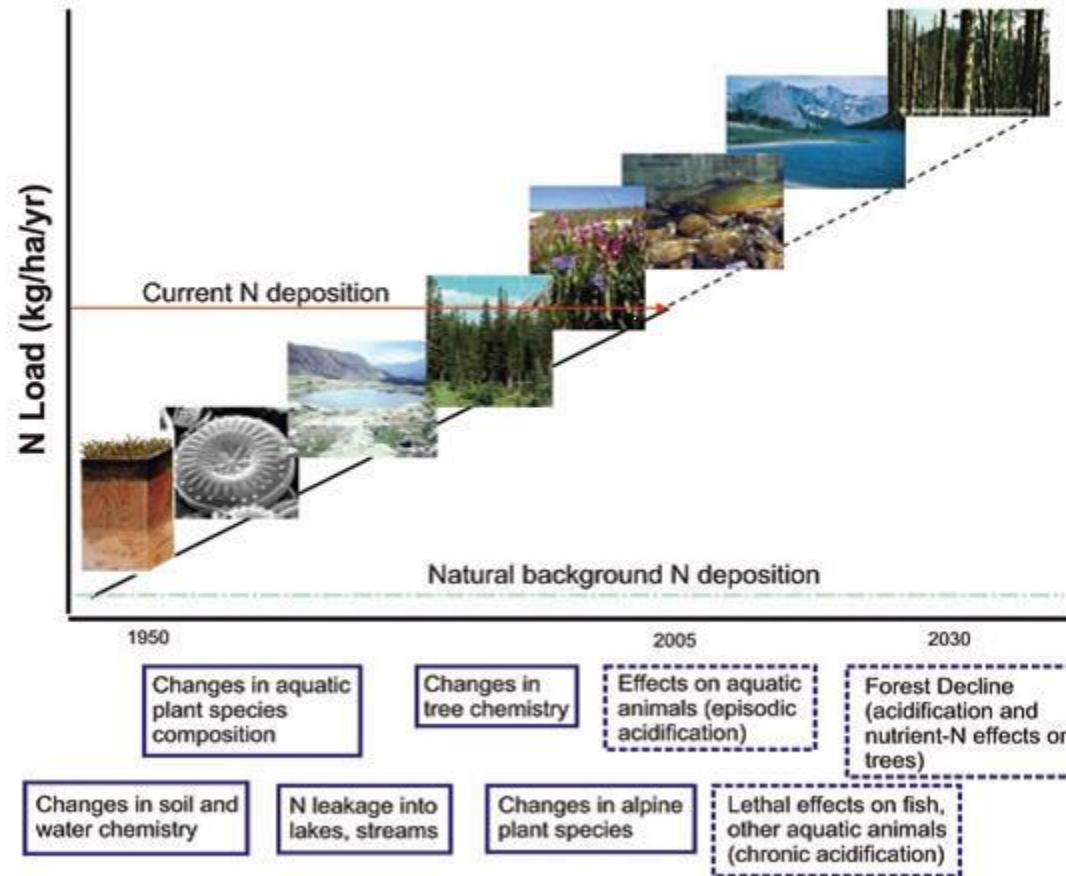[2]US Environmental Protection Agency, Research Triangle Park, NC, USA
[3]US Environmental Protection Agency, Annapolis, MD, USA

Disclaimer: The views expressed in this presentation are those of the authors and do not necessarily represent the views or policies of the U.S. Environmental Protection Agency.
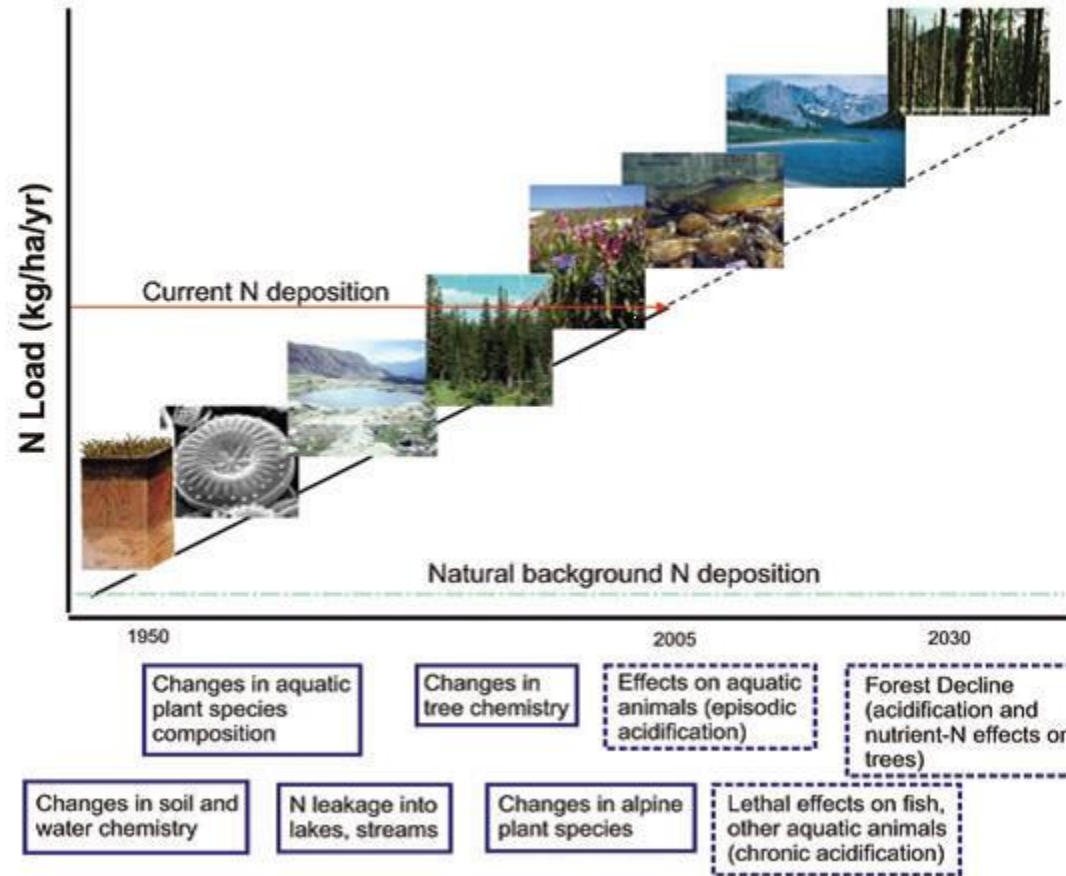
Office of Research and Development
Center of Environmental Measurement and Modeling

American Geophysical Union
December 16, 2021

Why care about atmospheric N deposition?

Rocky Mountain National Park, Colorado

Why care about atmospheric N deposition?

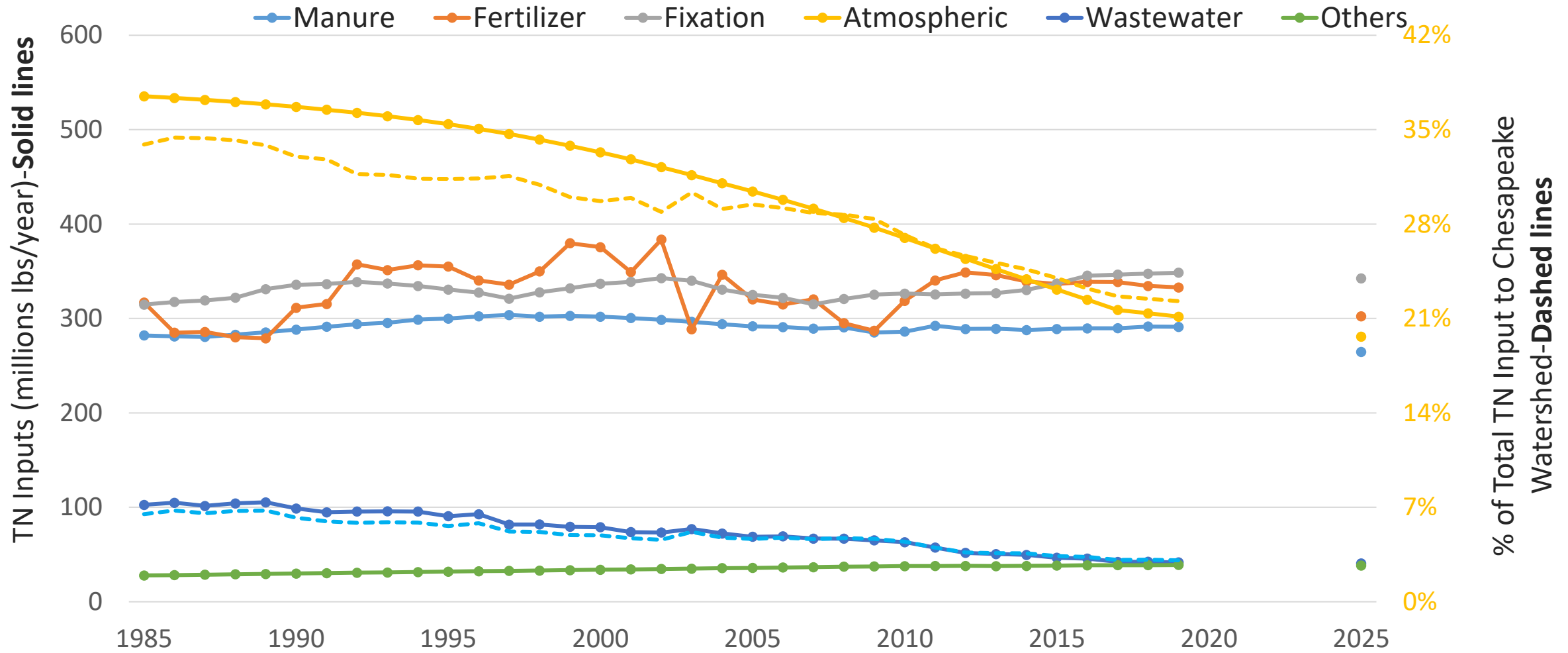Rocky Mountain National Park, Colorado

Within the Chesapeake Bay Watershed:

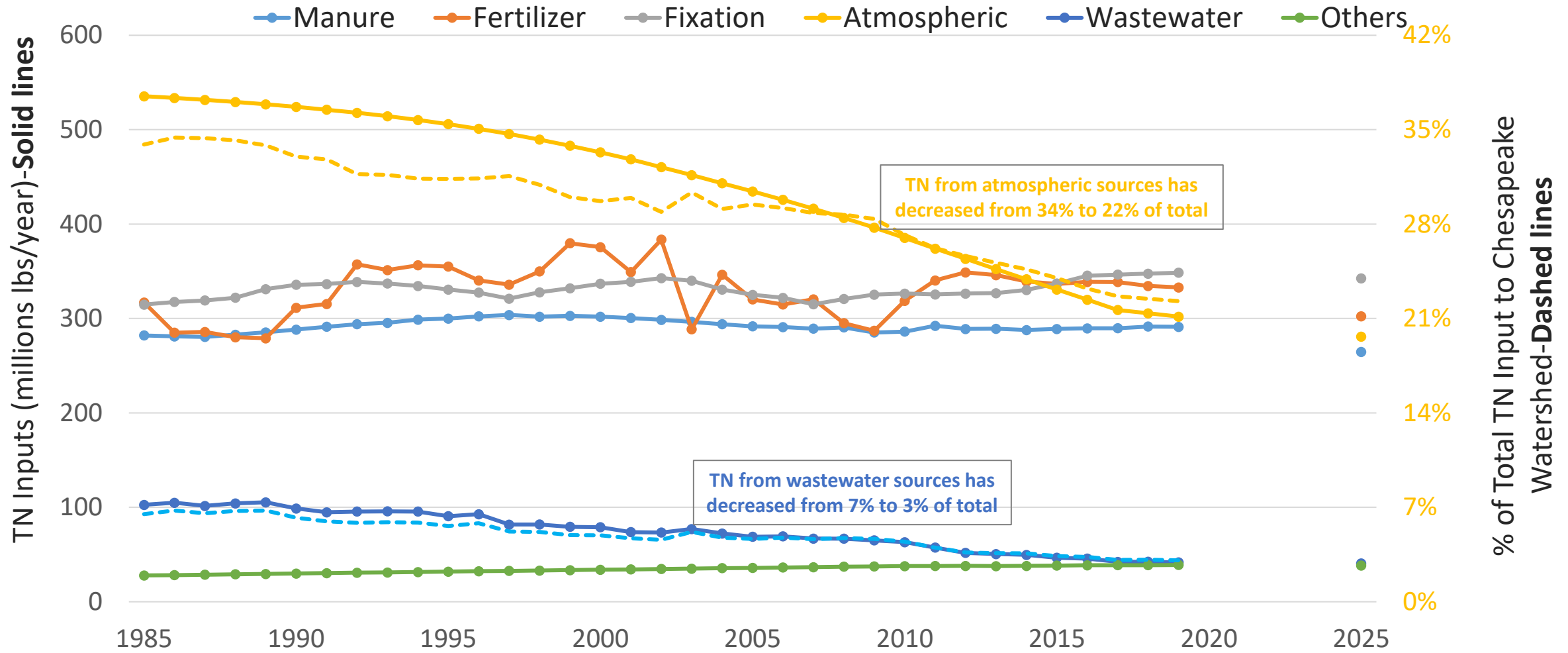Declines in fish populations, including blue crab

Costly drinking water treatment exceeding $100 million annually

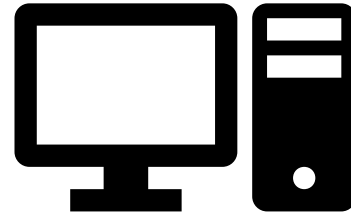# How have Total Nitrogen Inputs Changed over the Chesapeake Bay Watershed?

Source: Bhatt, Linker, and Shenk 2020, Chesapeake Bay Program Modeling Quarterly, September 2020

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How have Total Nitrogen Inputs Changed over the Chesapeake Bay Watershed?

Legend: Manure — Fertilizer — Fixation — Atmospheric — Wastewater — Others

TN from atmospheric sources has decreased from 34% to 22% of total

TN from wastewater sources has decreased from 7% to 3% of total

Y-axis (left): TN Inputs (millions lbs/year)-**Solid lines**

Y-axis (right): % of Total TN Input to Chesapeake Watershed-**Dashed lines**

Research Questions

How do new estimates of deposition compare to observations?	Where and why does deposition change throughout the United States between 2002 and 2017?	Which emission sources are contributing to the Bay's high nutrient loading?

EQUATES: **E**PA's Air **QUA**lity **T**im**E S**eries Project

- Temporal coverage: 2002-2017

- Spatial domains: Northern Hemisphere and contiguous US

- Meteorology inputs: New meteorological modeling for both domains using state-of-the-science retrospective simulations

- Emissions inputs: New inventories were developed using EPA's 2017 NEI as the base year with consistent methods used for each sector to avoid artificial step changes

- CMAQ version 5.3.2 (publicly released in October 2020)

  EQUATES will supersede previous CMAQ time series and provide a unified set of modeling data across applications

108km resolution N Hemi Domain

Boundary Conditions

12km resolution CONUS Domain

For more information and data access, please visit: https://www.epa.gov/cmaq/equates
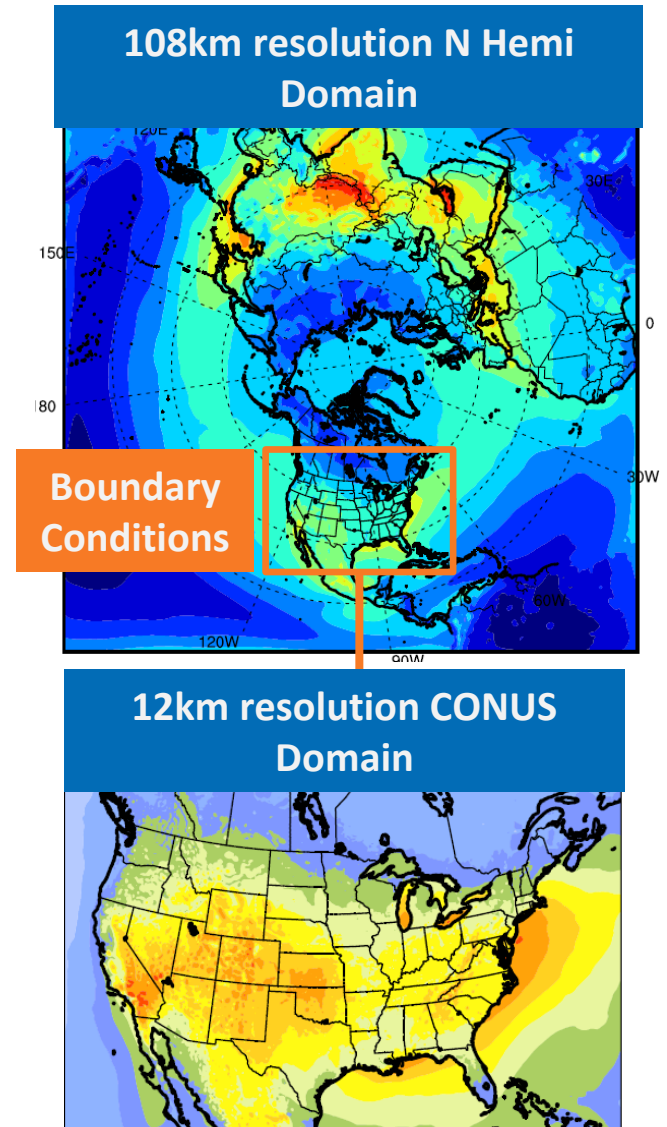
How well does the model compare with observed concentrations?
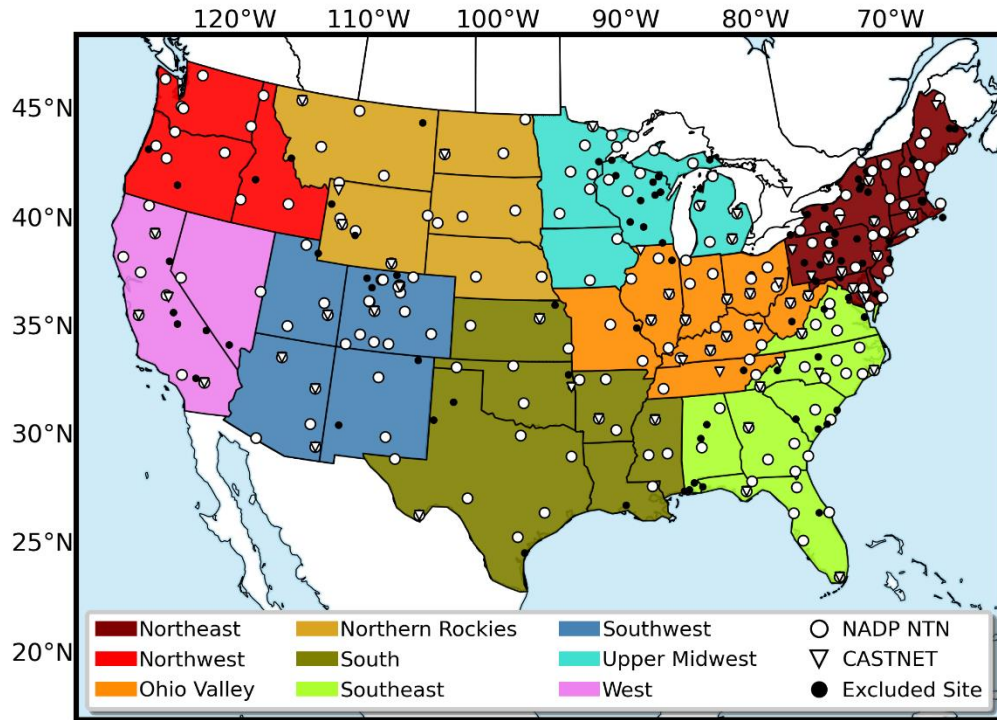
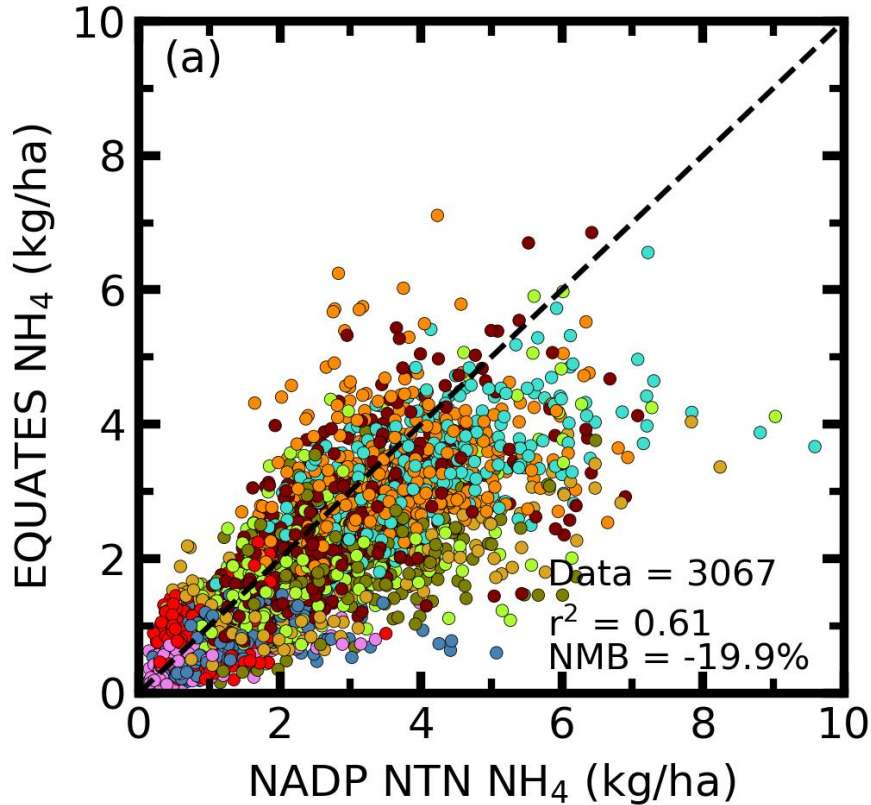Annual Average CASTNET Concentrations
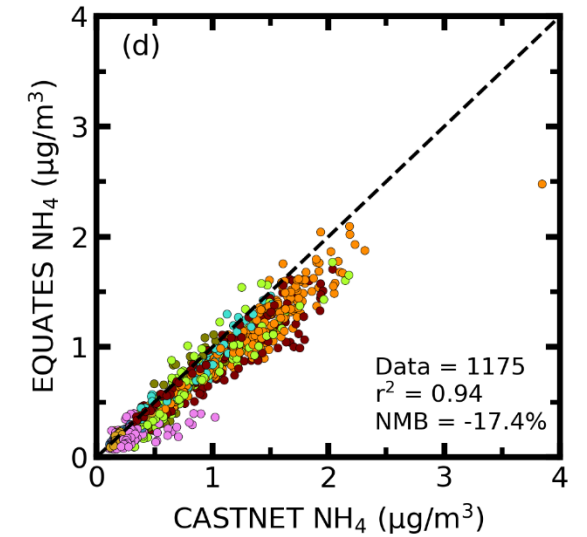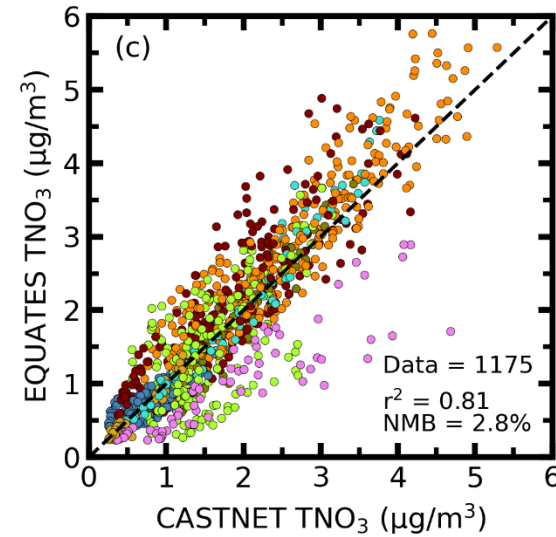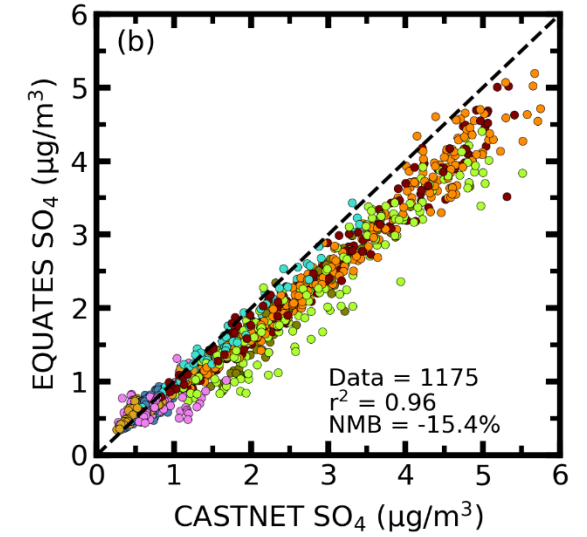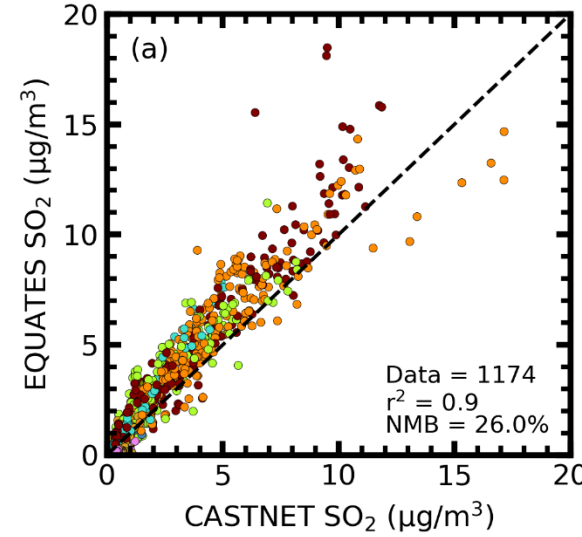
How does wet deposition compare?

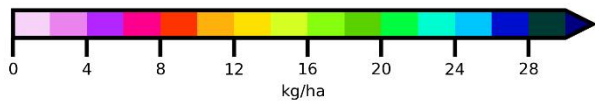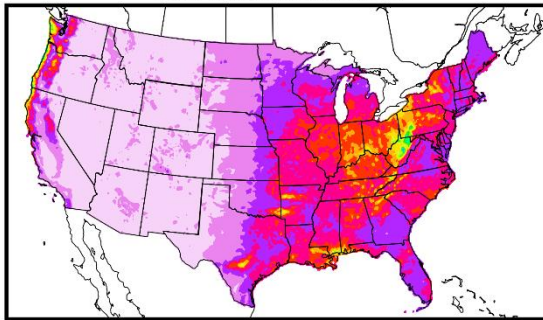## Annual accumulated NADP wet deposition
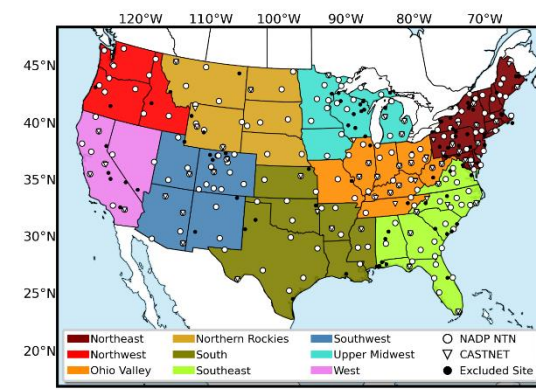
Improving Wet Deposition Estimates
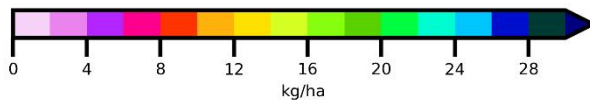
- Annual sums of wet deposition from CMAQv5.3.2

EQUATES

2010 SO$_4$ Wet Deposition

kg/ha
0   4   8   12   16   20   24   28
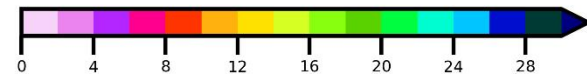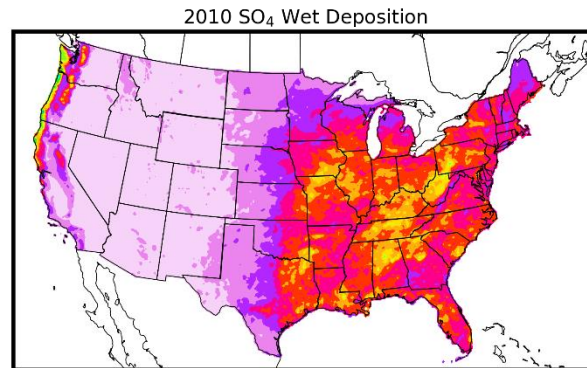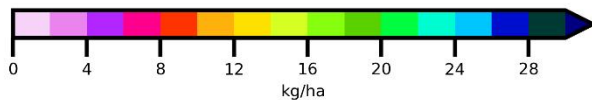
Improving Wet Deposition Estimates

- Annual sums of wet deposition from CMAQv5.3.2
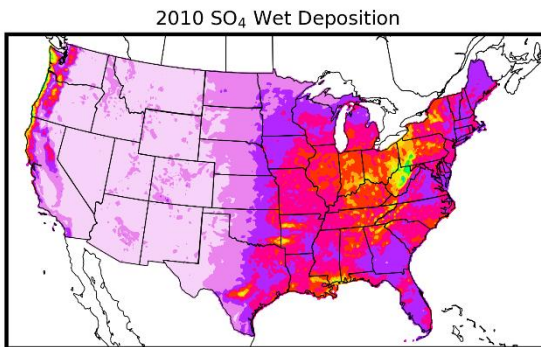
EQUATES

EQUATES$_{precip-adj}$

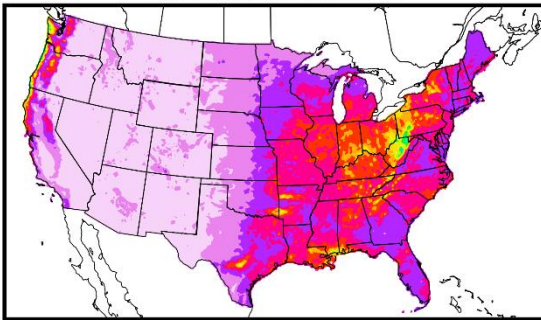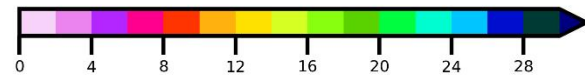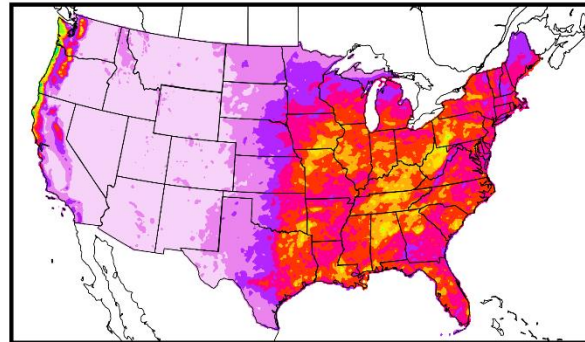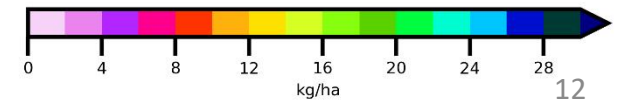- Adjustment factor using 12 km regridded PRISM and WRF precipitation

2010 SO$_4$ Wet Deposition

2010 SO$_4$ Wet Deposition

kg/ha

Improving Wet Deposition Estimates

- Annual sums of wet deposition from CMAQv5.3.2

EQUATES

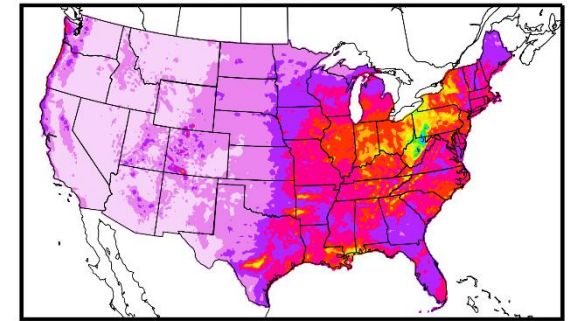- Adjustment factor using 12 km regridded PRISM and WRF precipitation
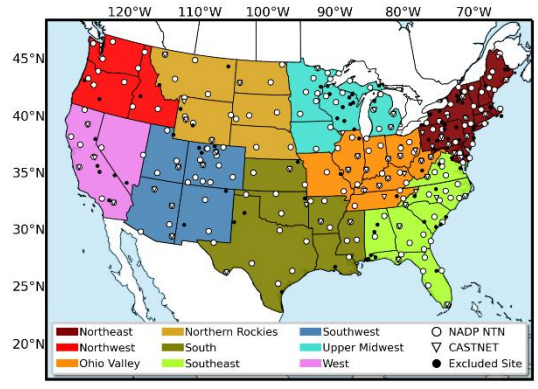
EQUATES$_{precip-adj}$

- Universal kriging with linear trend and exponential covariance applied to median ratios

EQUATES$_{bias-adj}$

2010 SO$_4$ Wet Deposition

2010 SO$_4$ Wet Deposition

2010 SO$_4$ Wet Deposition

kg/ha

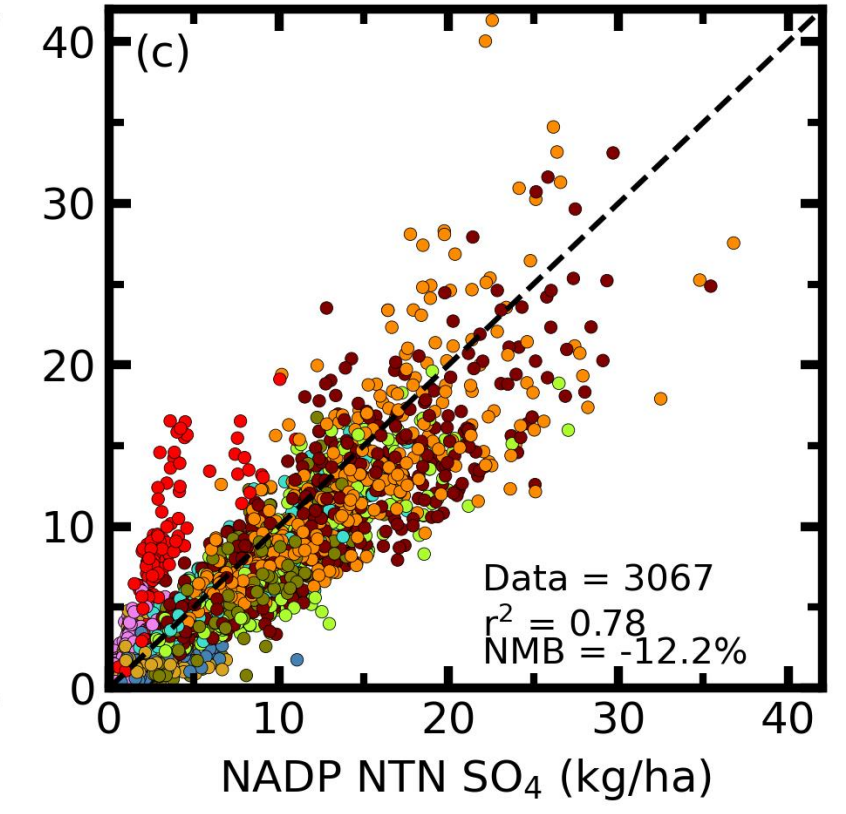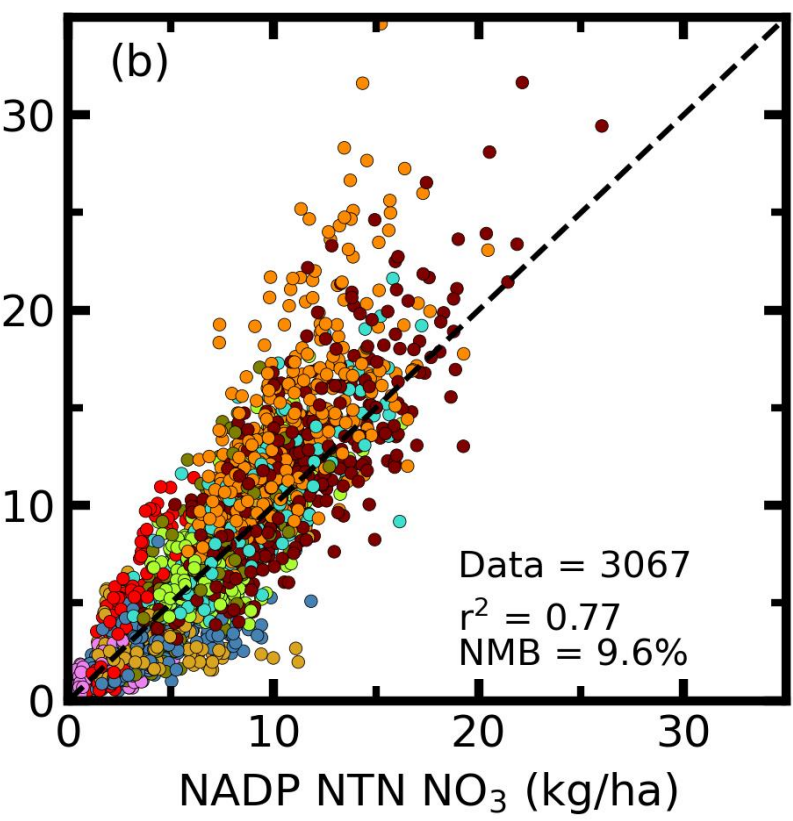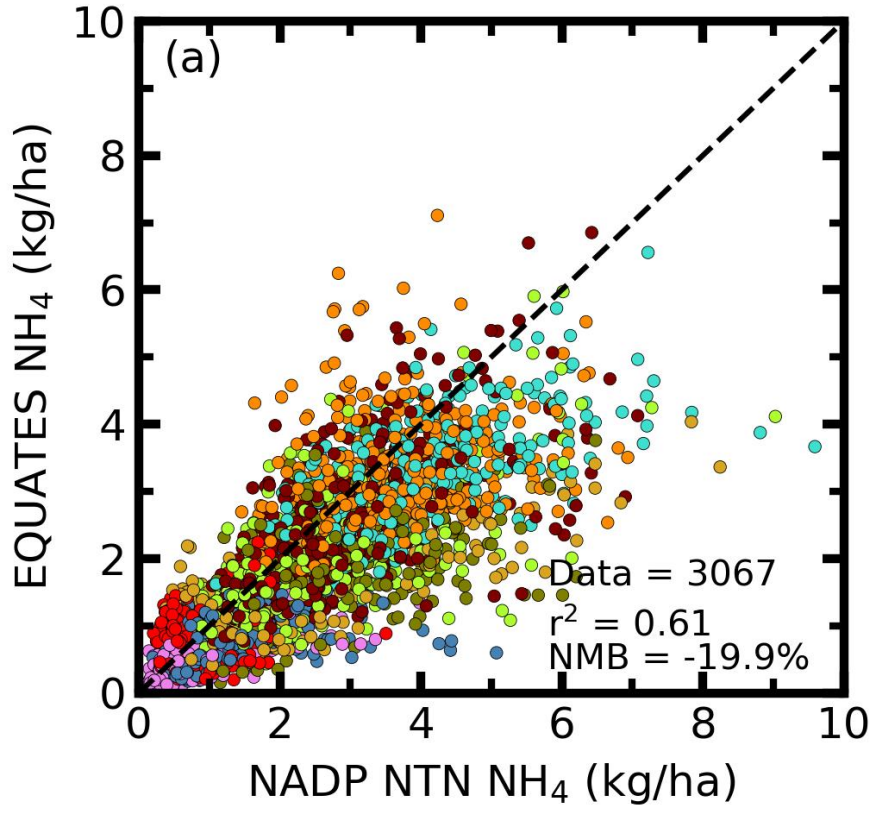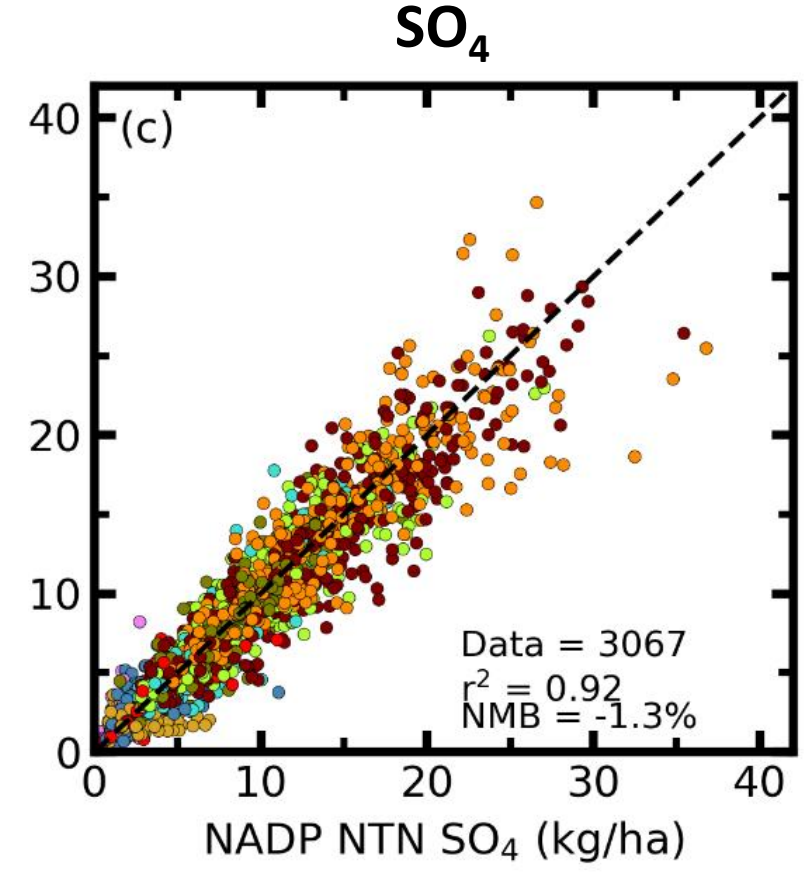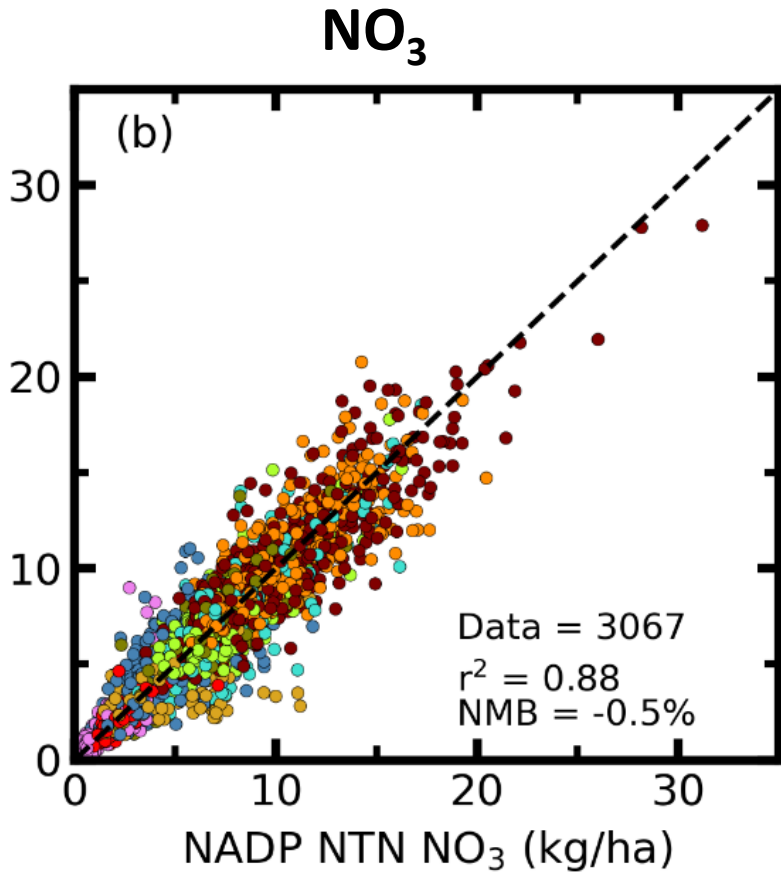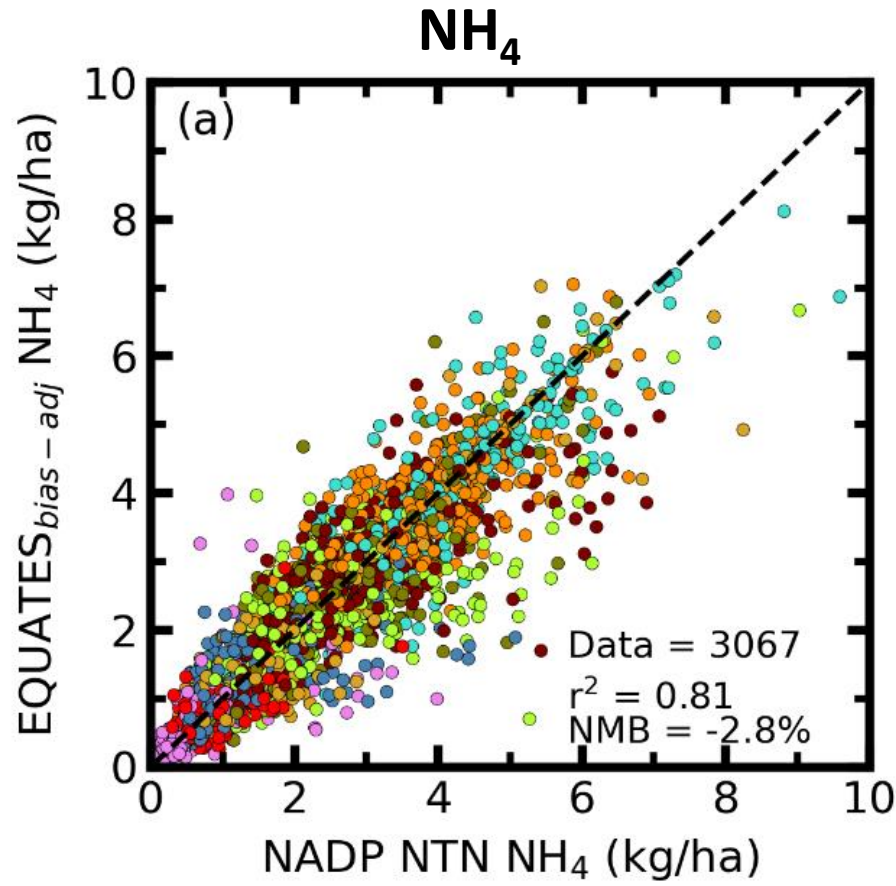*For more details on the measurement model fusion technique, please see: Zhang et al. (2019) https://doi.org/10.1029/2018jd029051*

EQUATES Wet Deposition

EQUATES$_{bias-adj}$ Wet Deposition
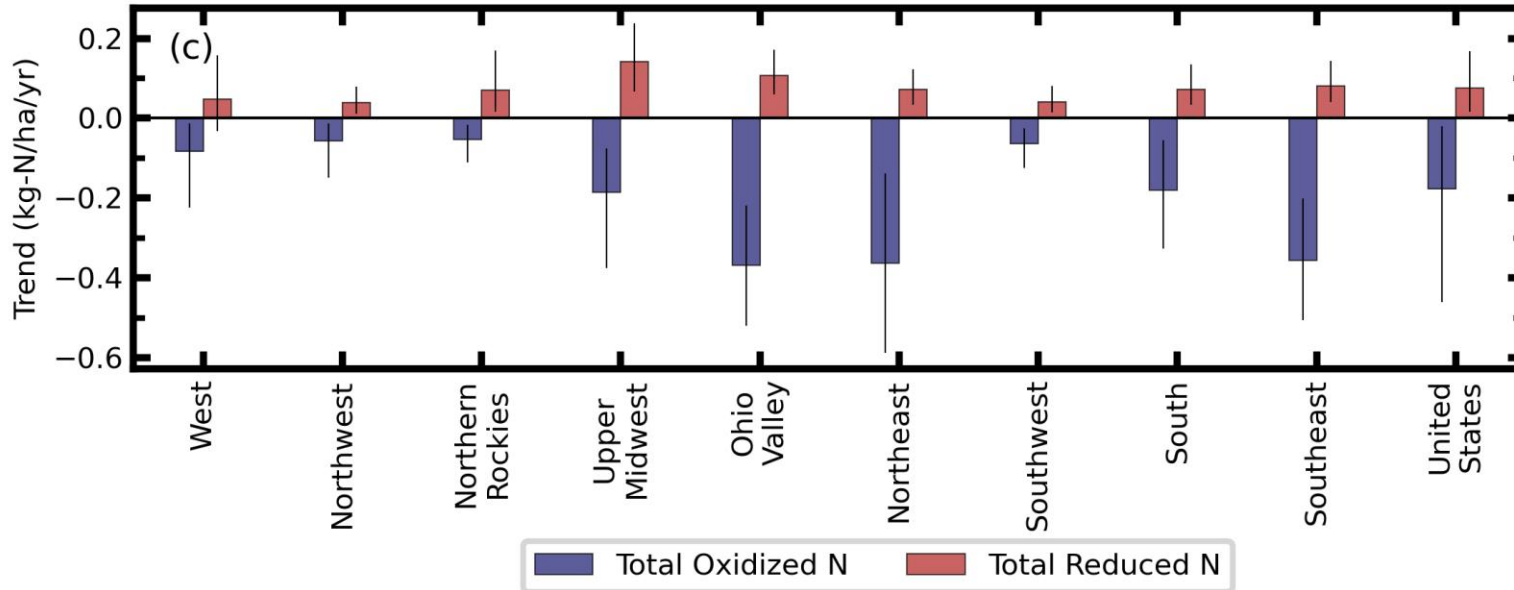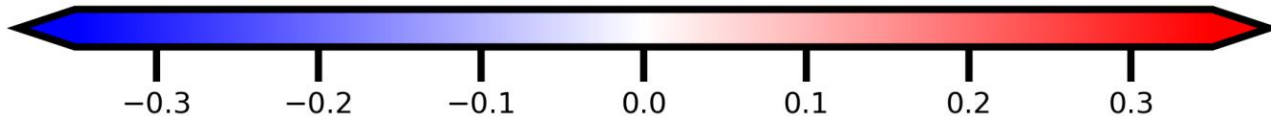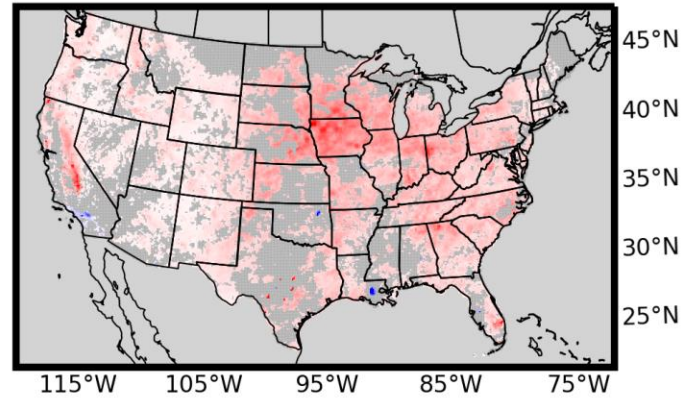

NH$_4$ **NO$_3$** **SO$_4$**

How has N deposition changed from 2002-2017?
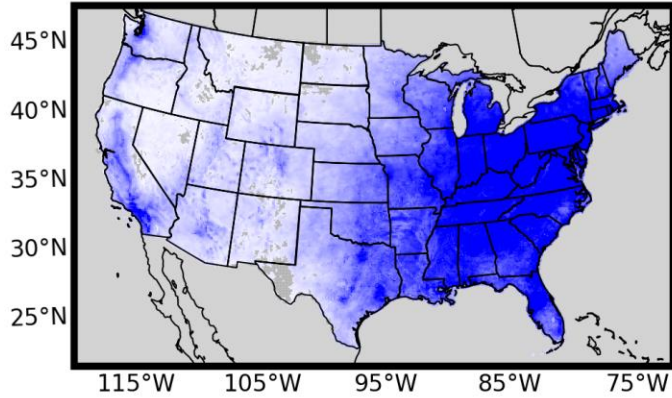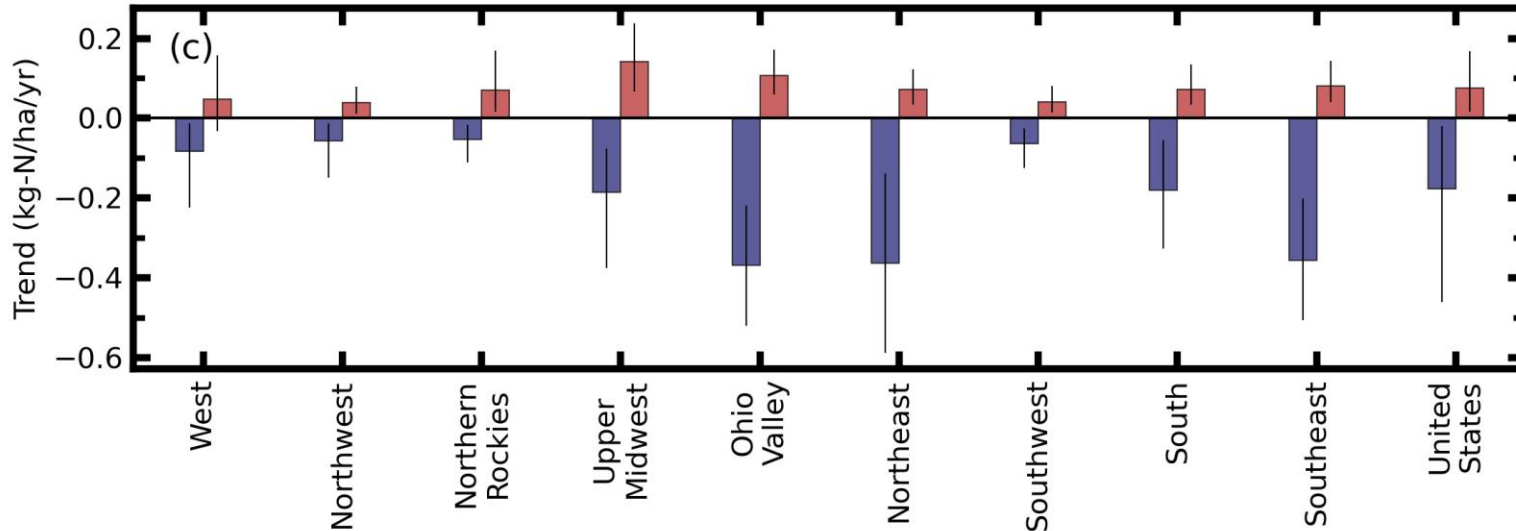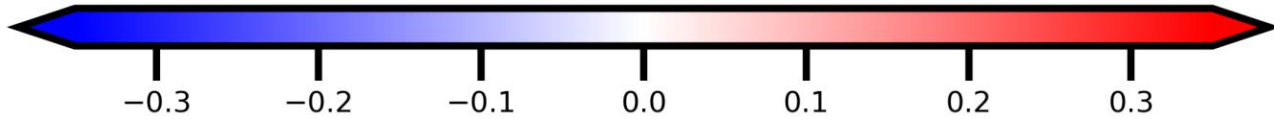

(a) Total Oxidized N Trend (kg-N/ha/yr)

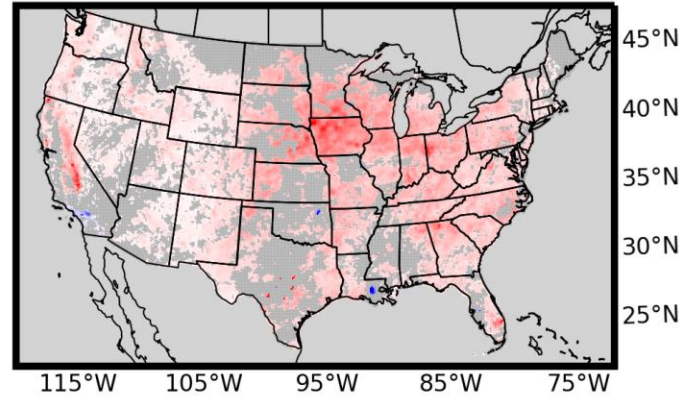(b) Total Reduced N Trend (kg-N/ha/yr)

(c)
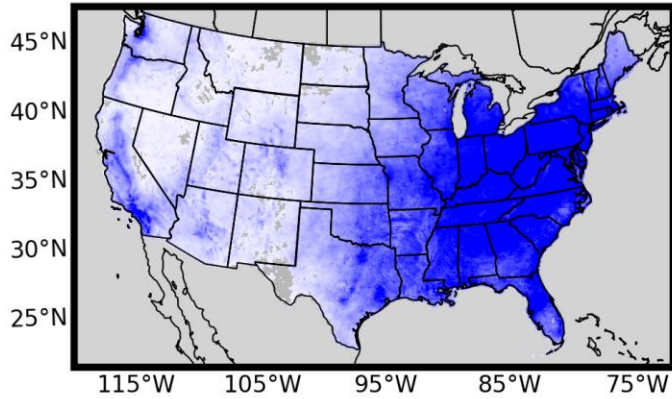
How has N deposition changed from 2002-2017?

(a) Total Oxidized N Trend (kg-N/ha/yr)

(b) Total Reduced N Trend (kg-N/ha/yr)

Comparison to Observations:

(c)

West, Northwest, Northern Rockies, Upper Midwest, Ohio Valley, Northeast, Southwest, South, Southeast, United States

Total Oxidized N   Total Reduced N

NO_3

NH_4

Why has N deposition changed?

Annual NO$_x$ Emissions
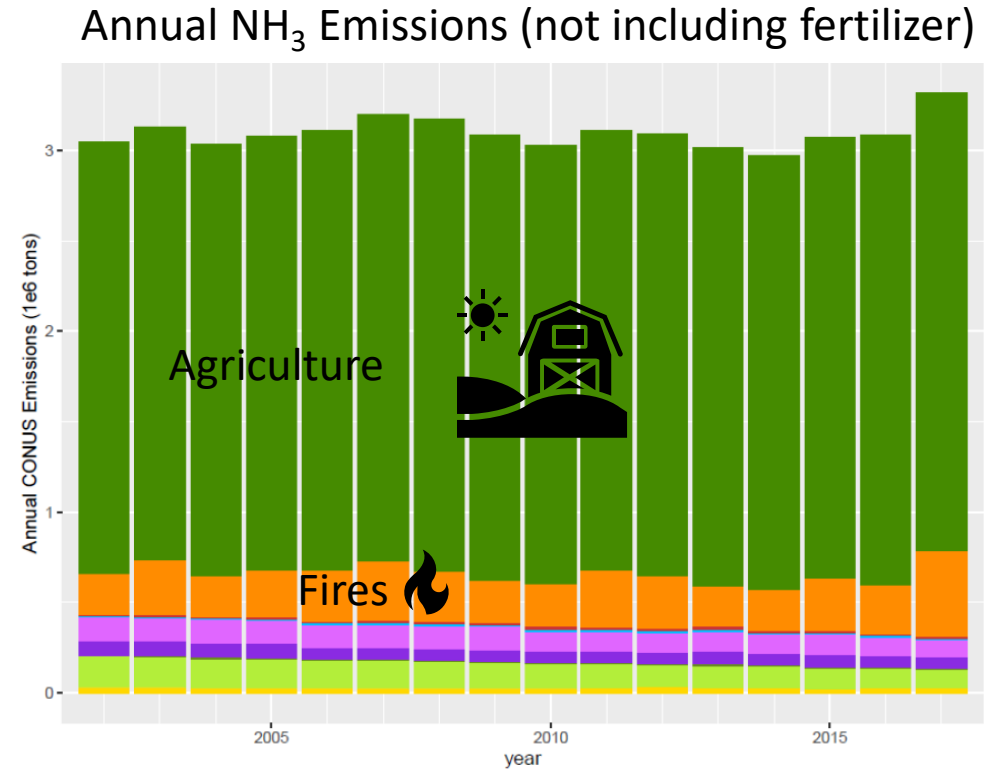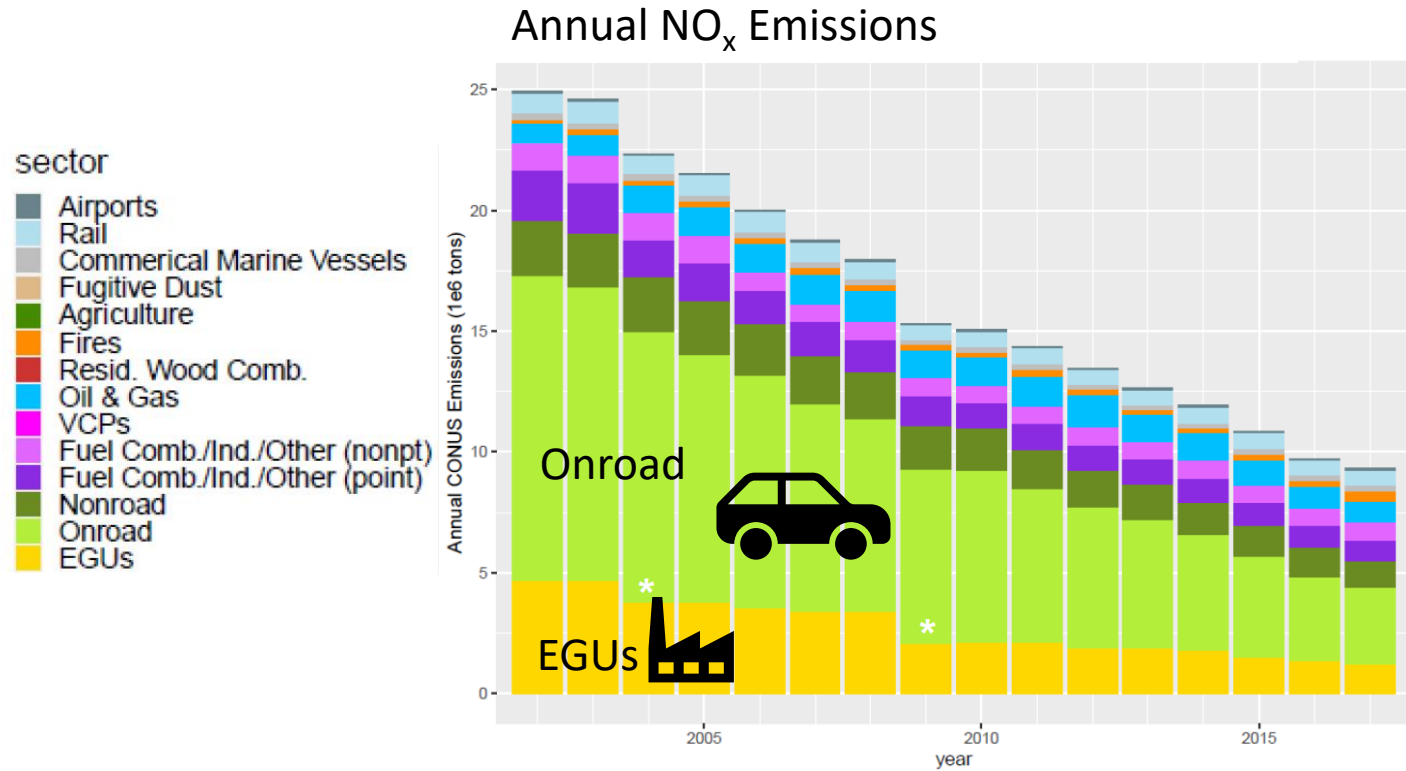
Annual NH$_3$ Emissions (not including fertilizer)

sector
- Airports
- Rail
- Commerical Marine Vessels
- Fugitive Dust
- Agriculture
- Fires
- Resid. Wood Comb.
- Oil & Gas
- VCPs
- Fuel Comb./Ind./Other (nonpt)
- Fuel Comb./Ind./Other (point)
- Nonroad
- Onroad
- EGUs

Why has N deposition changed?

Annual NOₓ Emissions — Annual NH₃ Emissions (not including fertilizer)
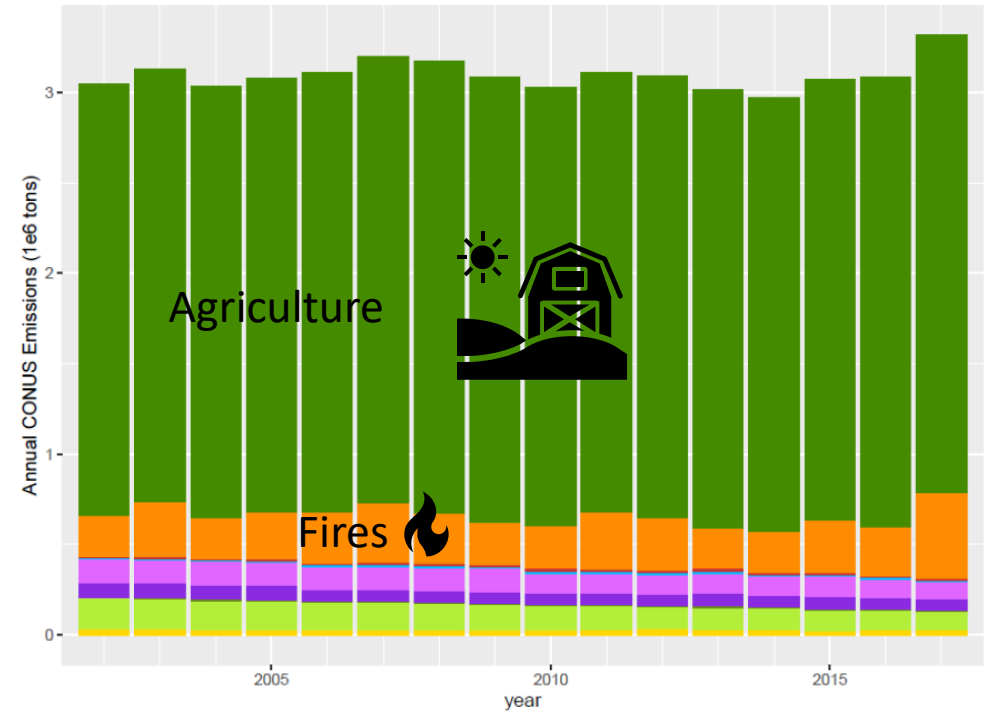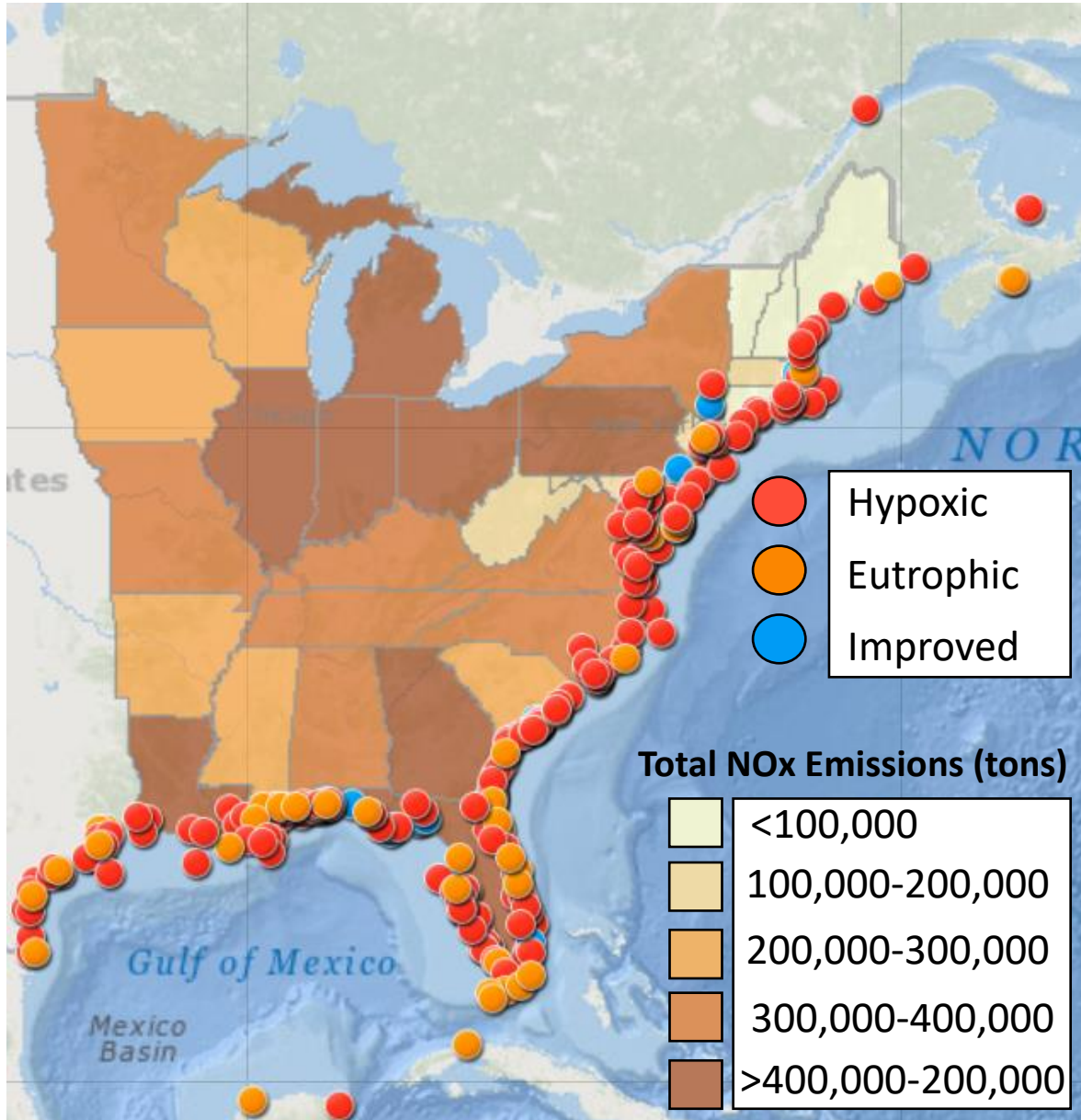
sector legend: Airports, Rail, Commerical Marine Vessels, Fugitive Dust, Agriculture, Fires, Resid. Wood Comb., Oil & Gas, VCPs, Fuel Comb./Ind./Other (nonpt), Fuel Comb./Ind./Other (point), Nonroad, EGUs

Next?????
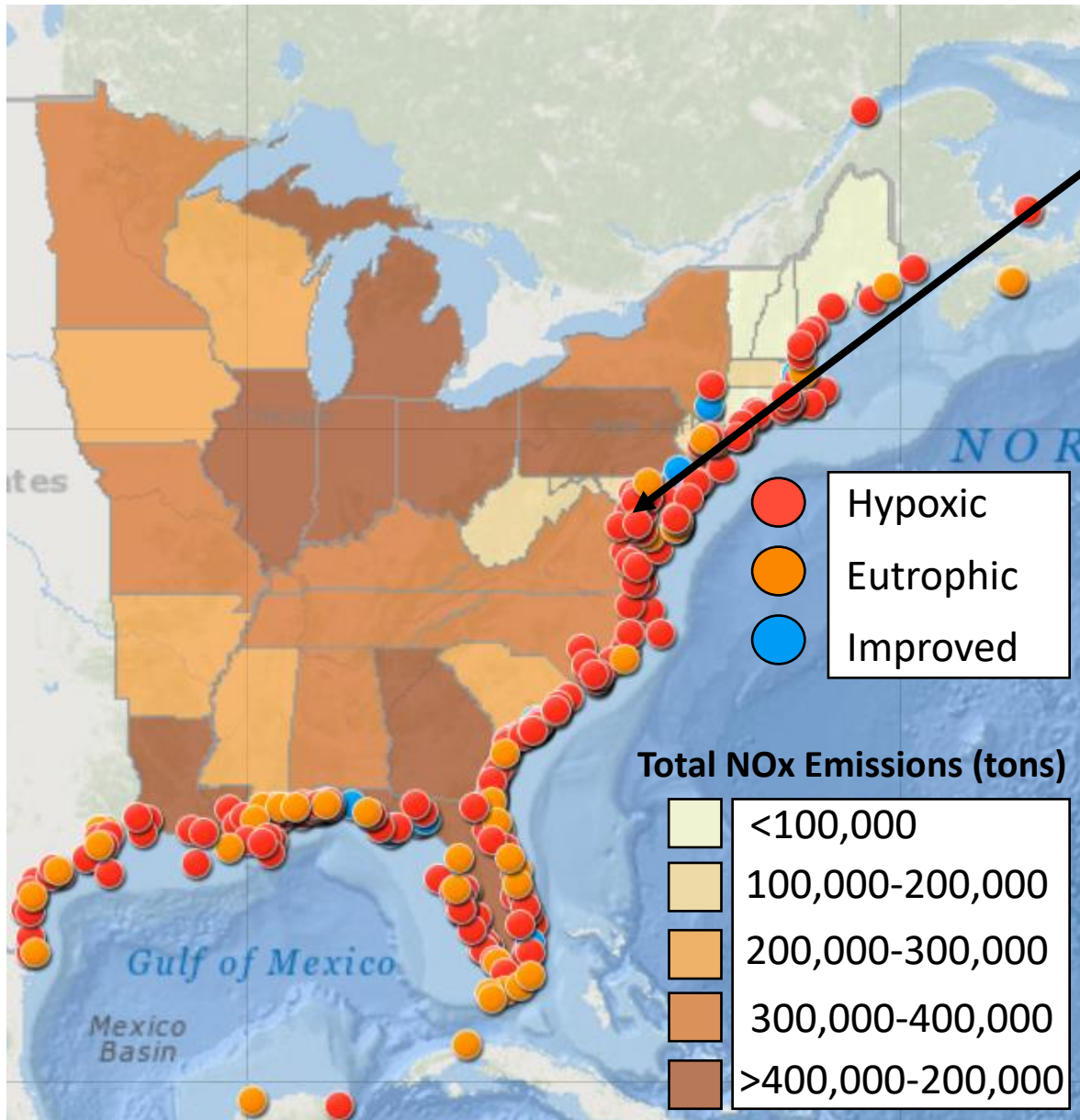
Figures courtesy of Kristen Foley

Total NOx Emissions (tons)

	<100,000
	100,000-200,000
	200,000-300,000
	300,000-400,000
	>400,000-200,000

Legend:
- 🔴 Hypoxic
- 🟠 Eutrophic
- 🔵 Improved

Adapted from: http://gis.chesapeakebay.net/air/
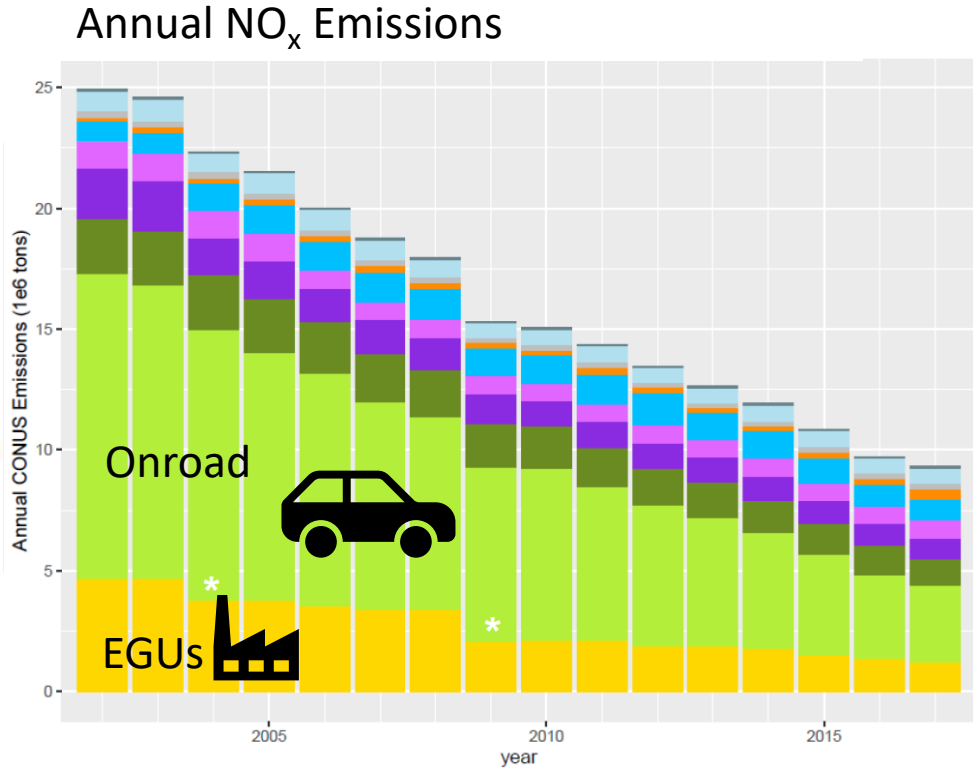
Annual Nox Emissions (tons) by Tier 1 Sector
Washington, D.C.

Legend (pie chart):
- Highway Vehicles — 4739
- Off Highway — 2588
- Fuel Comb. Electric Utility — 245
- Fuel Comb. Industrial — 213
- Fuel Comb. Other — 1612

Map legend:
- 🔴 Hypoxic
- 🟠 Eutrophic
- 🔵 Improved

Total NOx Emissions (tons)
- <100,000
- 100,000-200,000
- 200,000-300,000
- 300,000-400,000
- >400,000-200,000

Adapted from: http://gis.chesapeakebay.net/air/

20
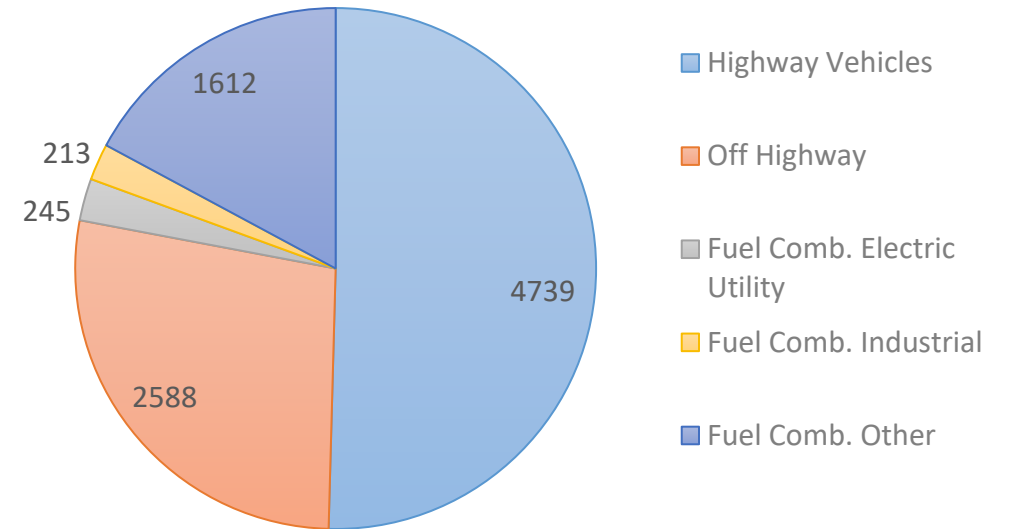
What sources are contributing to the high N loading to the Chesapeake Bay Watershed?

Model Set Up

Model
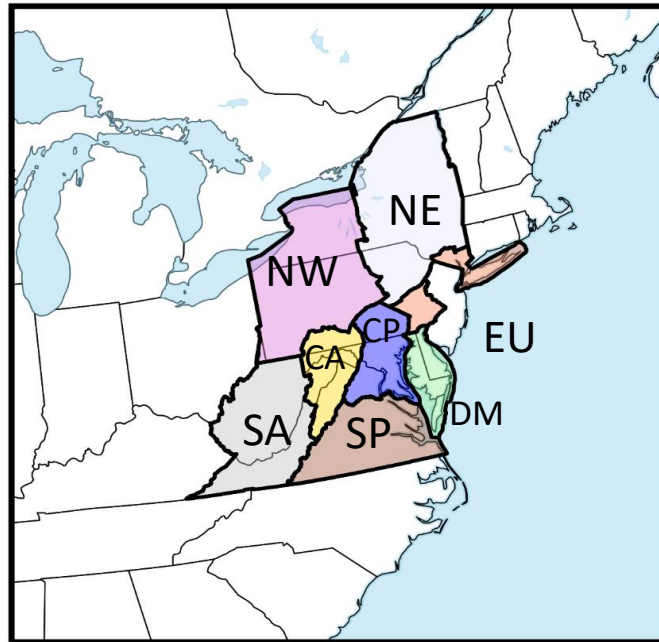- CMAQv5.3.2 with Integrated Source Apportionment Method (ISAM)
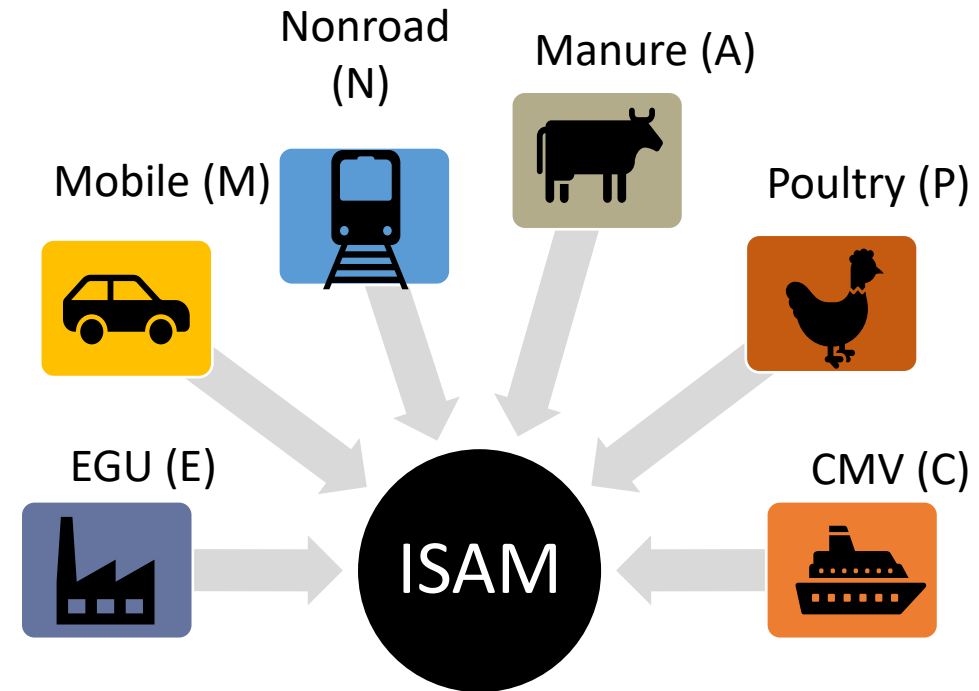
Time
- January-December 2016
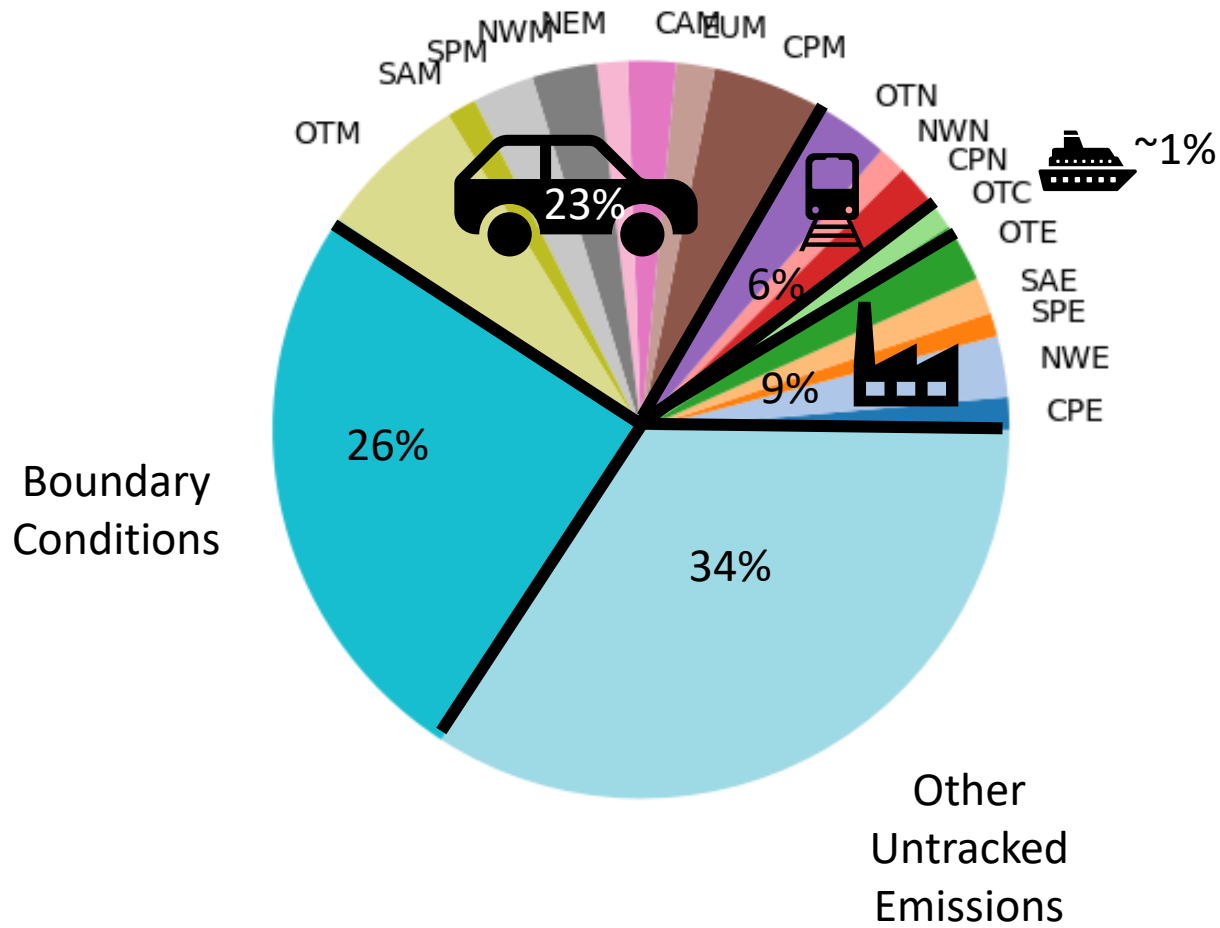
Grid
- 12 km windowed domain

Geographic emission source regions

NE
NW
CP
CA
EU
SA
SP
DM

Emission source categories

Mobile (M)
Nonroad (N)
Manure (A)
Poultry (P)
EGU (E)
CMV (C)

ISAM

Total Oxidized N

Total Reduced N

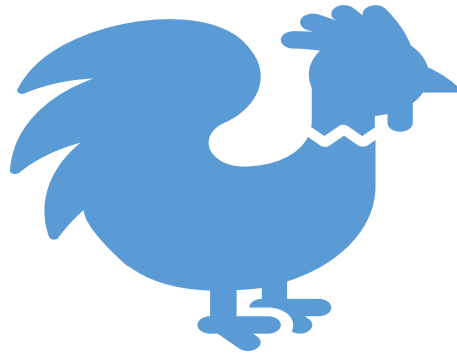3-letter tag name=2-letter region ID+1 letter emission sector ID
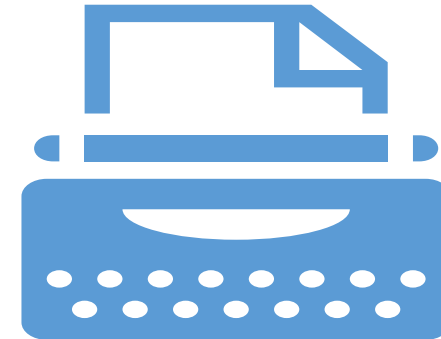
22
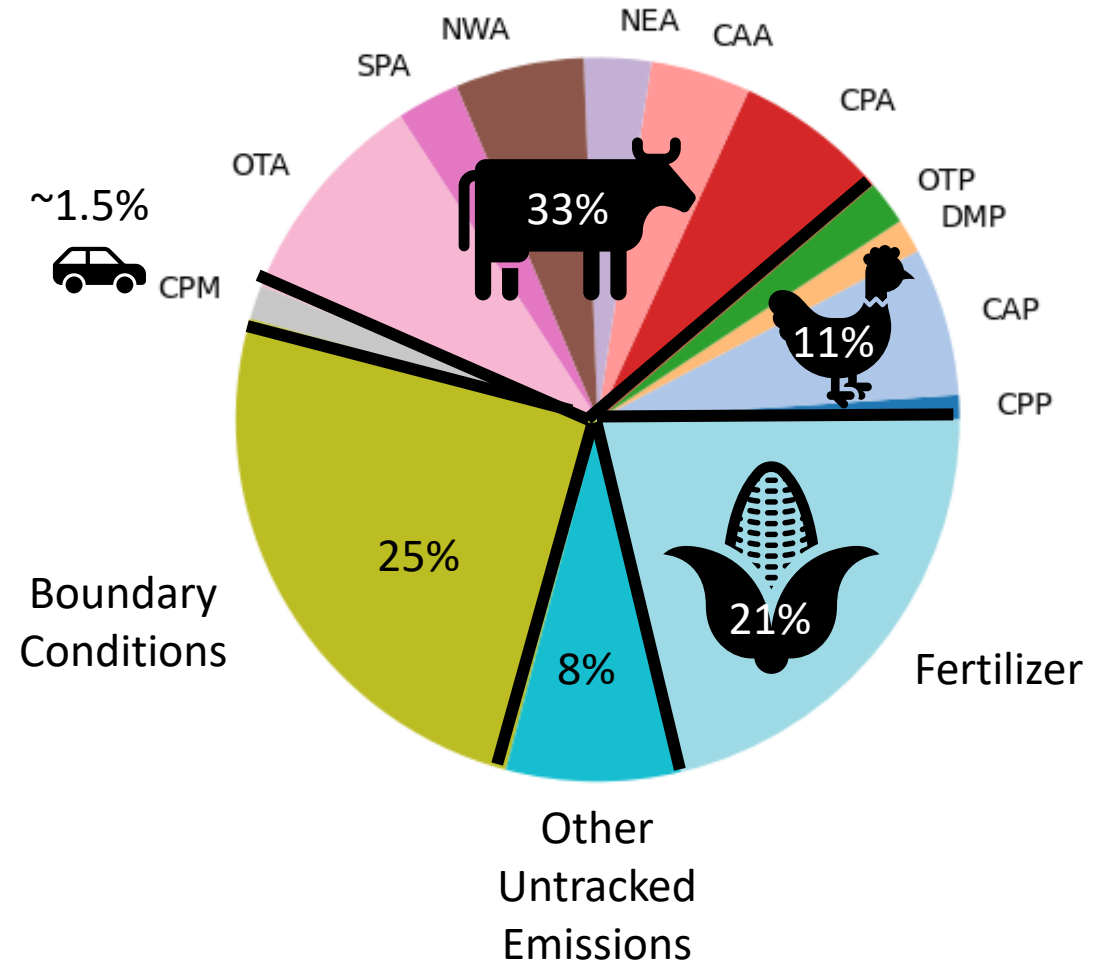
Next Steps

Submit EQUATES trends manuscript

Continue coefficient calculations

Evaluate poultry emissions

Prepare ISAM Manuscript

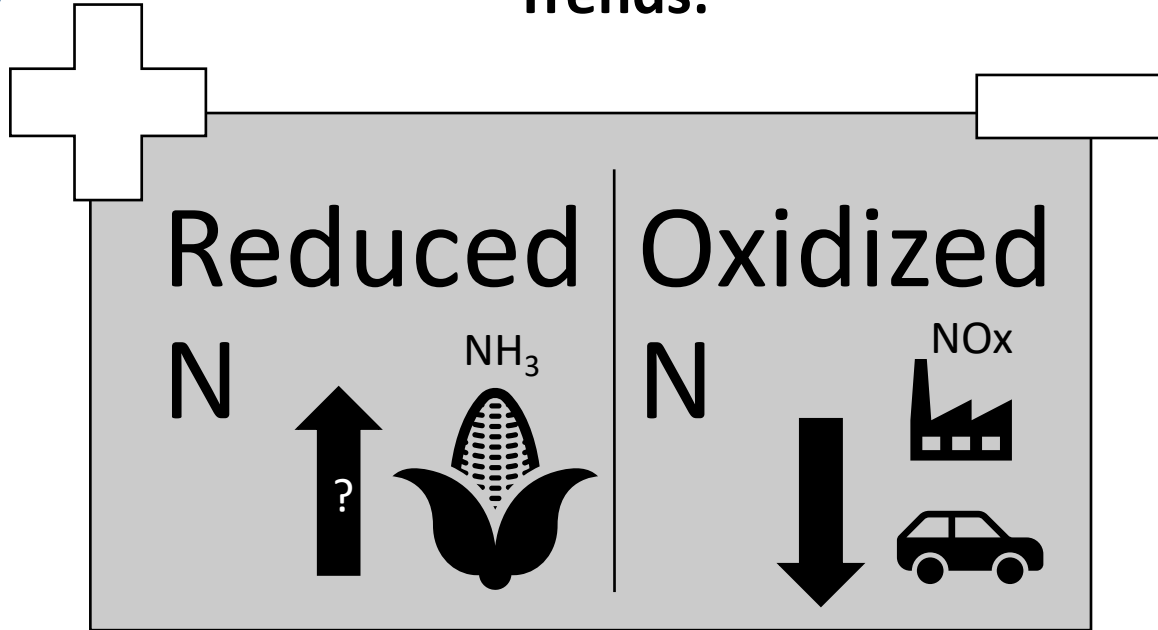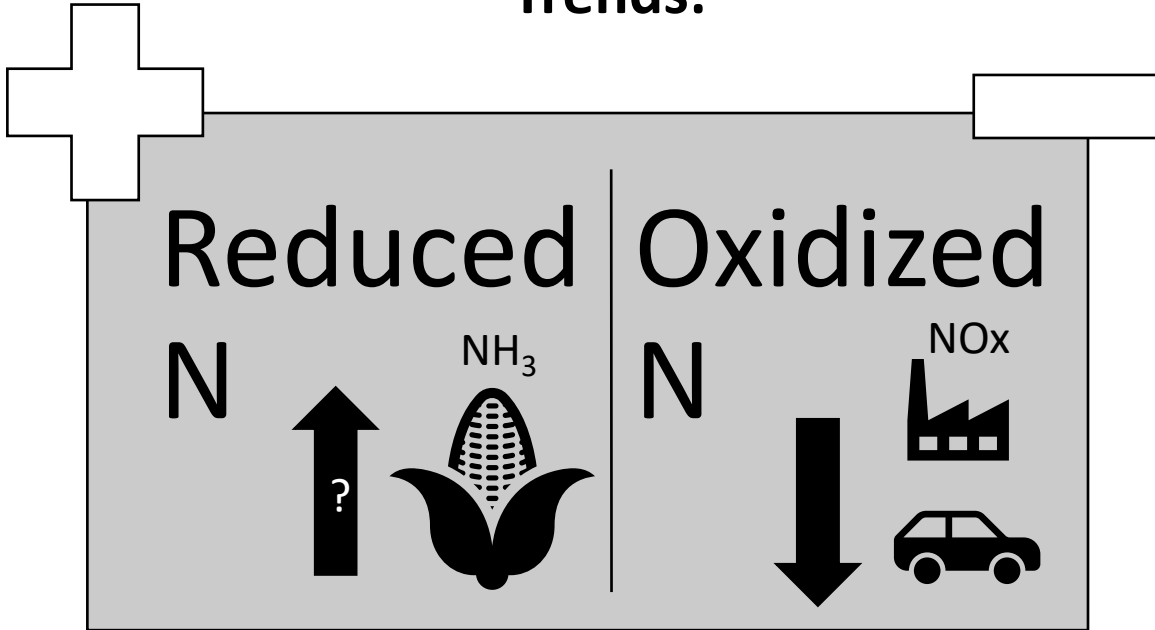# Summary of N Deposition Evolution in the US: Trends & Sources

Trends:

Reduced N | Oxidized N

NH₃

NOx

Summary of N Deposition Evolution in the US: Trends & Sources