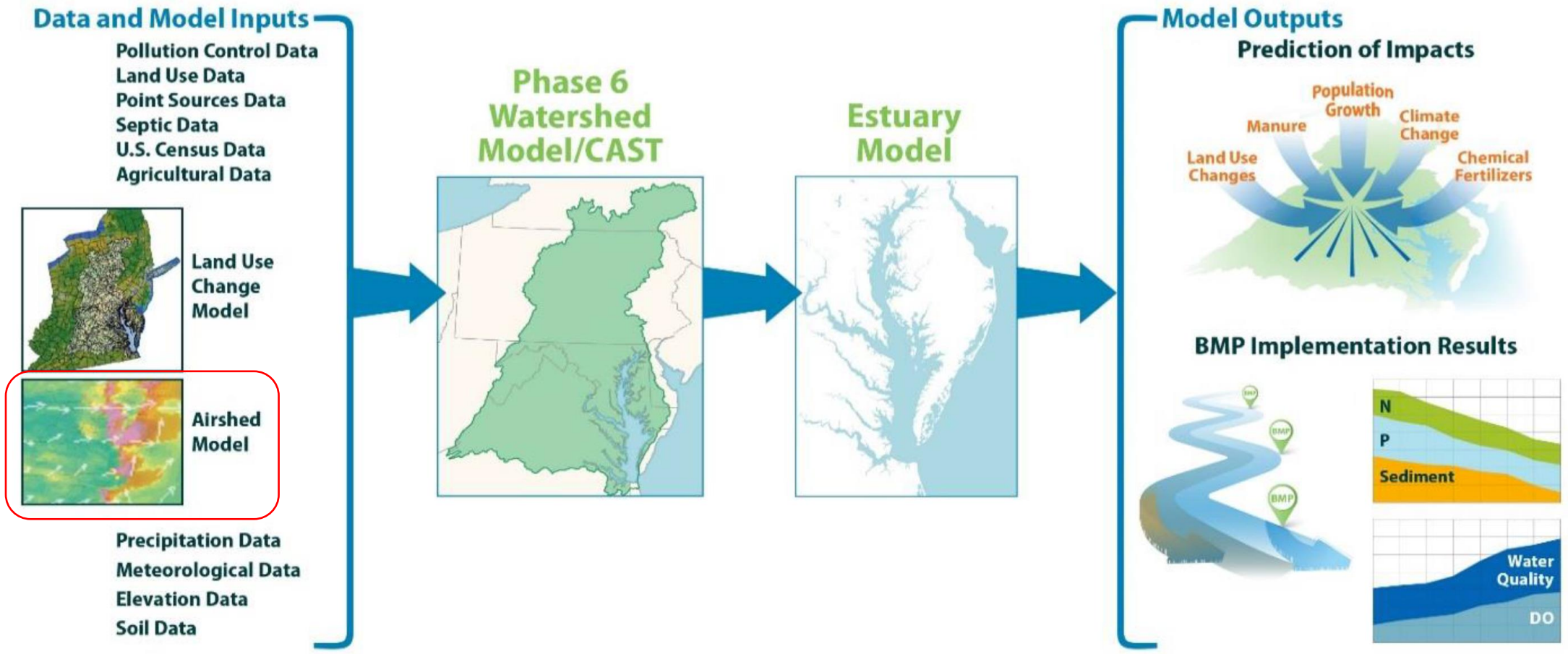
Atmospheric Nitrogen Deposition Contributions to the Chesapeake Bay Watershed: Maryland Animal NH_3 Emissions Sensitivity

Jesse Bash[1], Sarah Benish[1], Tesh Rao[2], Gary Shenk[3], Lewis Linker[4], Kristen Foley[1], Sergey Napelenok[1], James Kelly[2], Yijia Dietrich[1], Ian Rumsey[1]

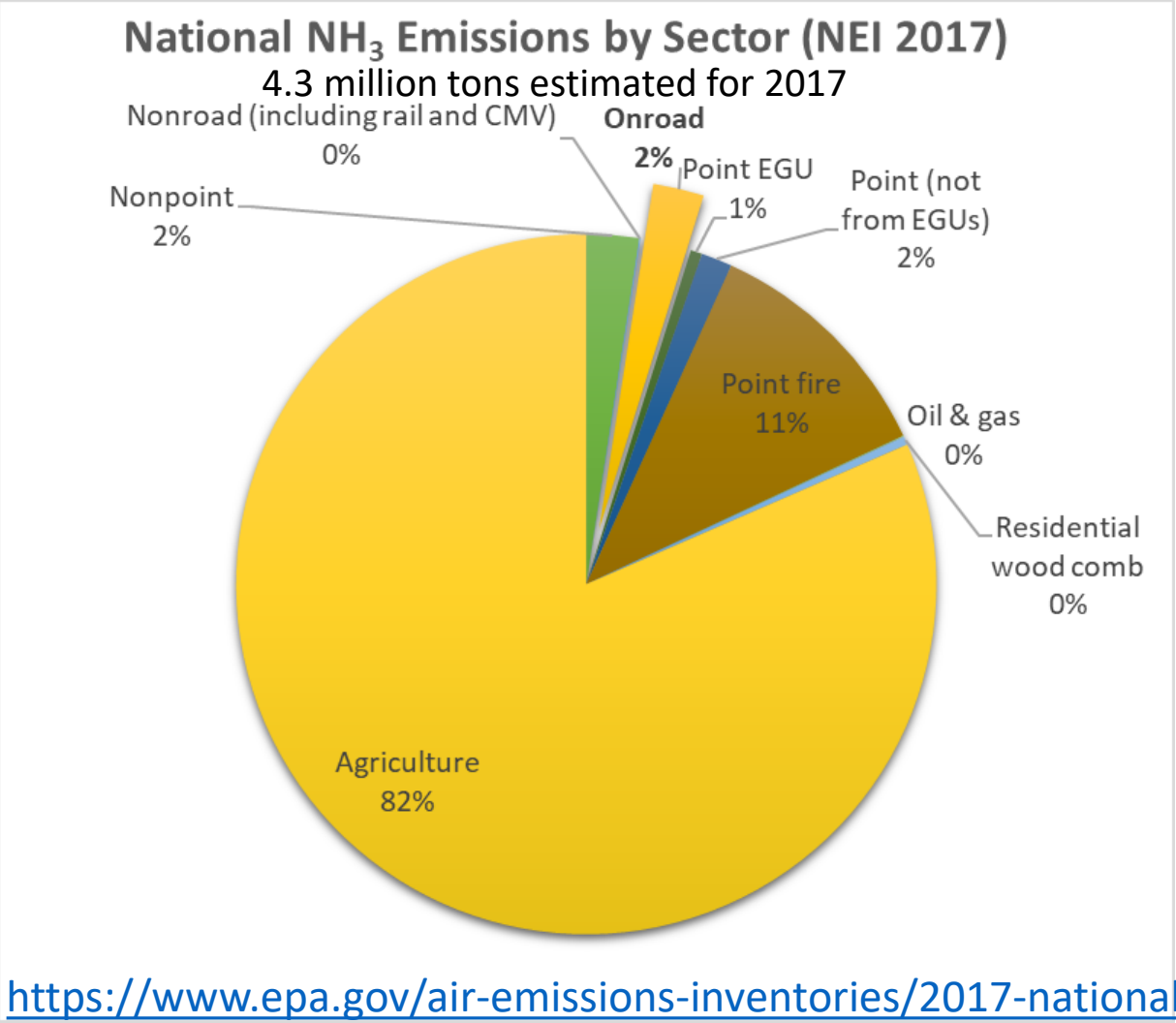
1. EPA Office of Research and Development
2. EPA Office of Air Quality Planning and Standards
3. EPA Chesapeake Bay Program Office
4. U.S. Geological Survey

Chesapeake Bay Program Modeling System



Hood et al. 2021 https://doi.org/10.1016/j.ecolmodel.2021.109635

NH_3 Emissions Sources

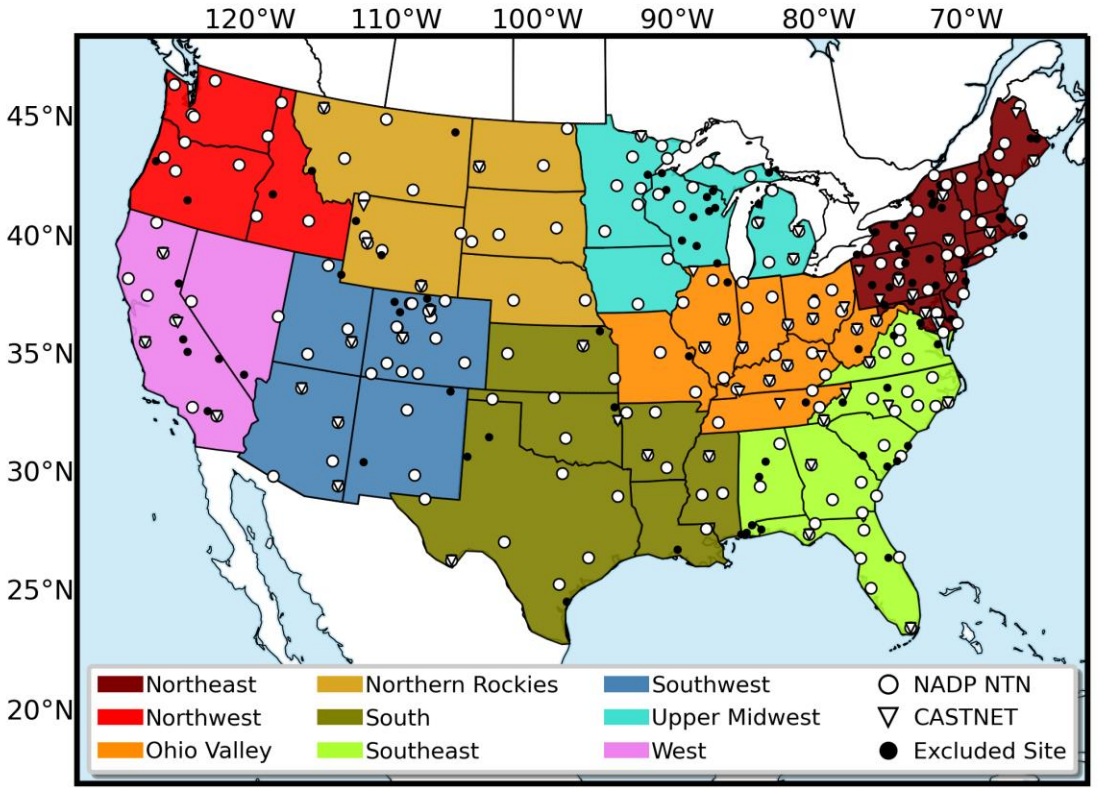


- Process-based estimates for all emission sectors
- Agriculture is the largest source of atmospheric NH_3 emissions
- NH_3 from animal housing and manure and the process of manure application are the largest source of agriculture emissions
  - 64% from animal sectors
  - 36% from fertilizer and manure once applied

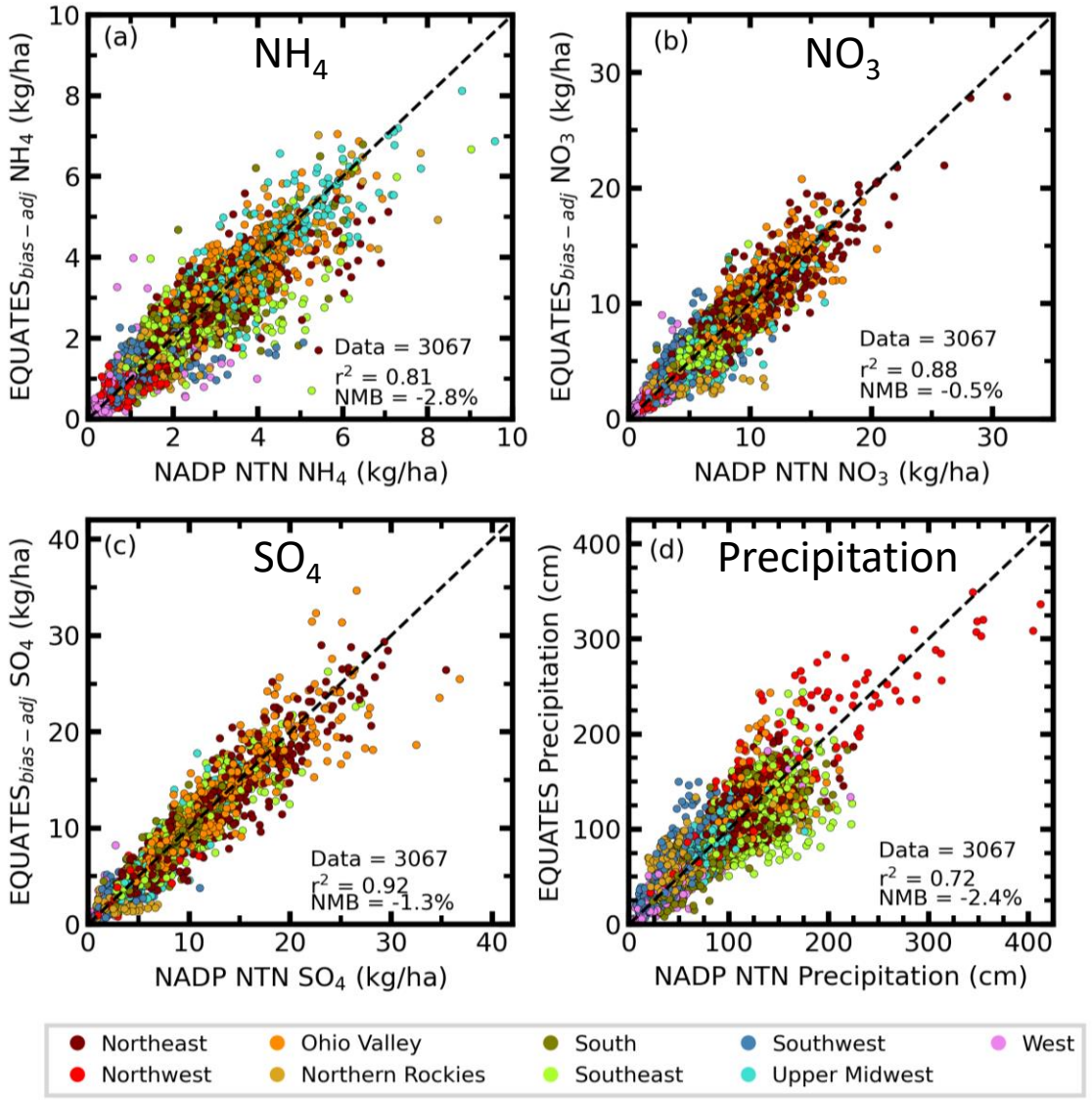
https://www.epa.gov/air-emissions-inventories/2017-national-emissions-inventory-nei-data

CMAQ Evaluation Against Network Wet Deposition

National Atmospheric Deposition Program wet deposition (from precipitation) observation sites

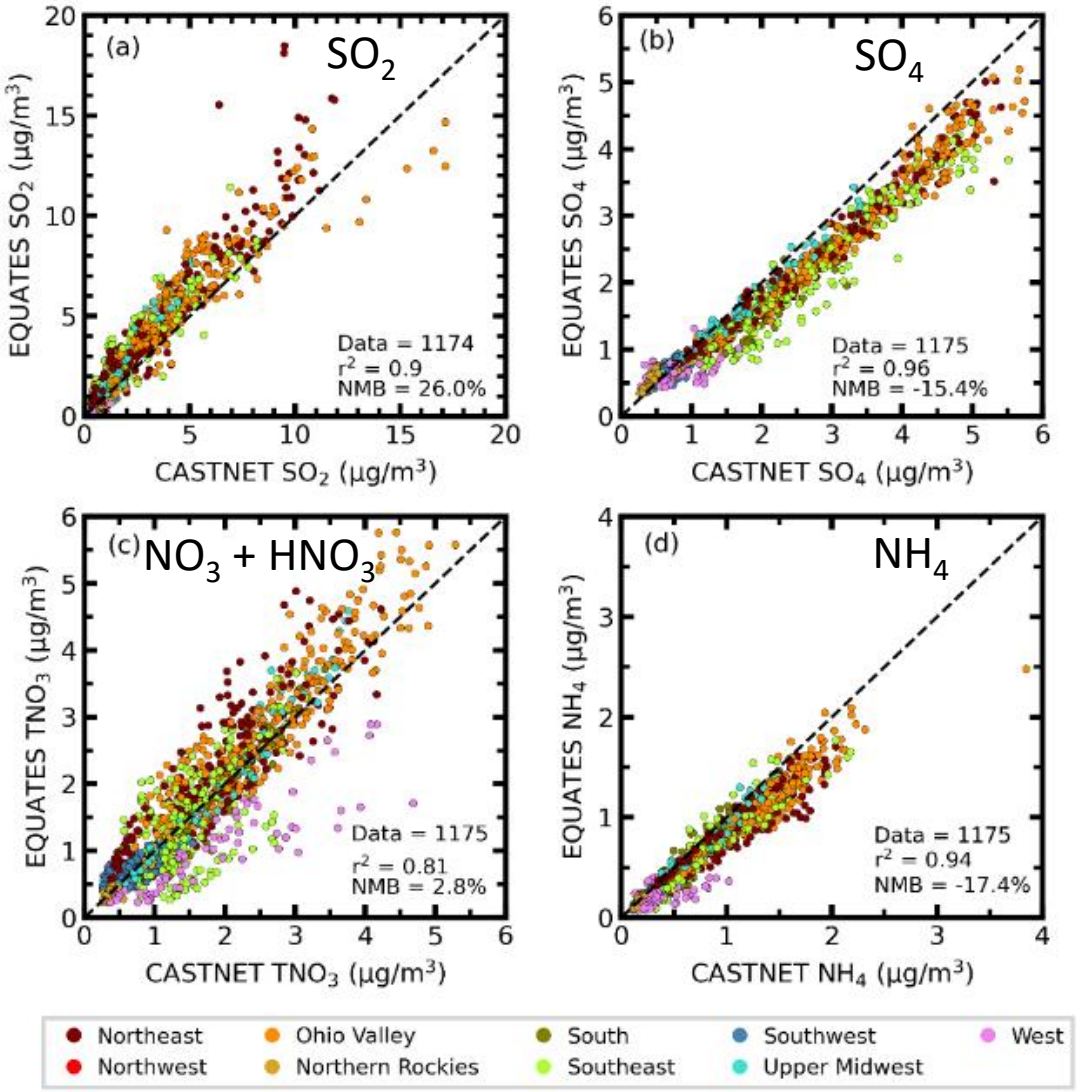


Benish et al. 2022



CMAQ Evaluation Against Network Ambient Concentrations

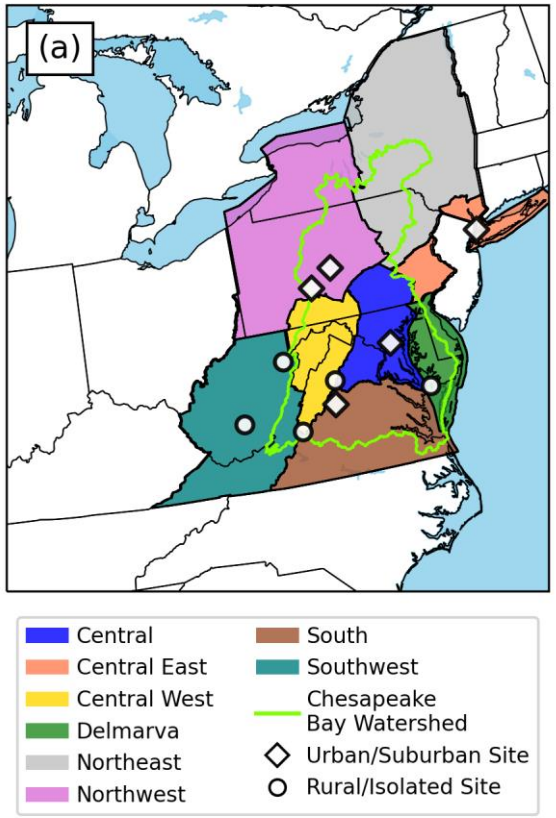
- Measurement networks do not exist for dry deposition observations
  - Measurements are difficult and costly
- Evaluation against concentrations provides some constraints on dry deposition
  - Atmospheric concentrations are proportional to dry deposition
- Ammonia concentration measurements are sparse



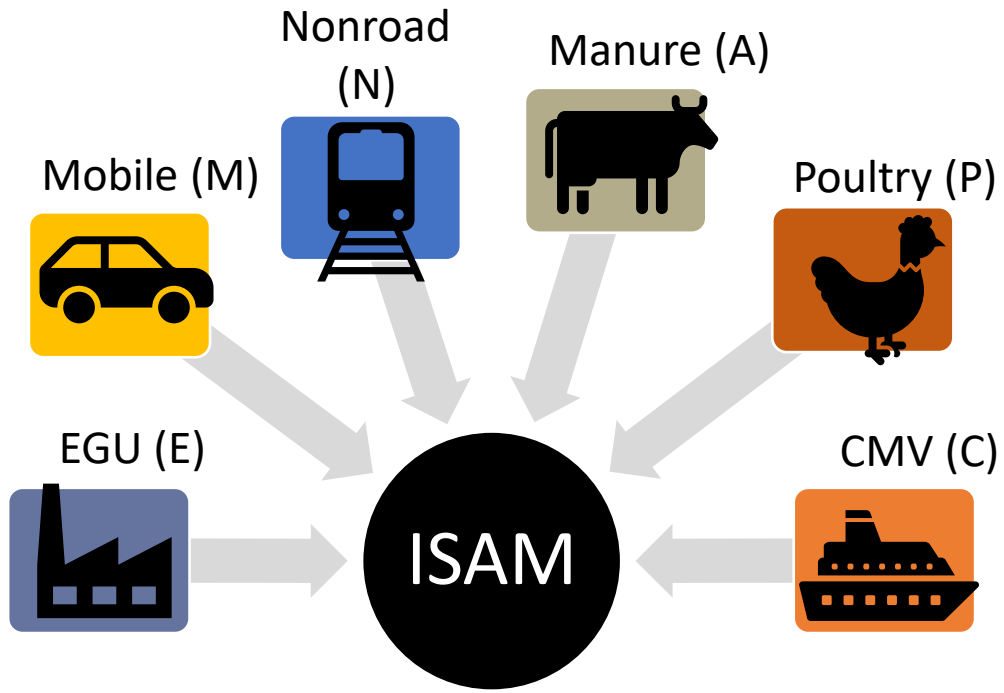
Benish et al. 2022

CMAQ Integrated Source Apportionment Method (ISAM)

Geographic emission source regions



Emission source categories



Maryland Animal Emissions Simulations

EQUATES – Simulation

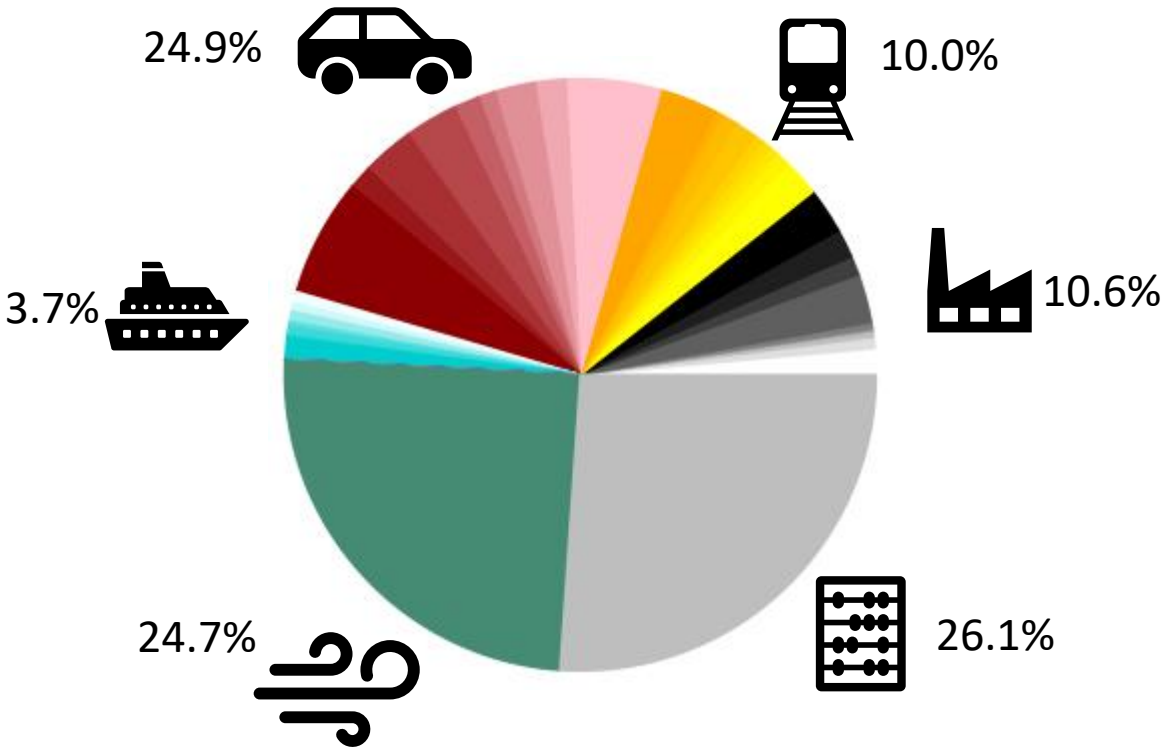
- Annual 2016 CMAQ v5.3.3
- 2017 NEI methodology for all sectors
- Maryland Animal NH_3 Emissions were provided by the state
  - Approximately two orders of magnitude smaller than previous NEI estimates
  - Poultry only included layers and broilers
  - Animal emissions included turkeys, ducks, etc. and other animals

Emissions Update – simulation

- Annual 2016 CMAQ v5.3.3
- 2017 methodology for all sectors except Maryland animal NH_3 emissions
- EPA provided animal NH_3 emissions
  - Similar magnitude as previous NEI estimates
  - Poultry sector included all birds
  - Animal emissions did not include birds

CMAQ Integrated Source Apportionment Method

Total Oxidized N
69,633 metric tons N

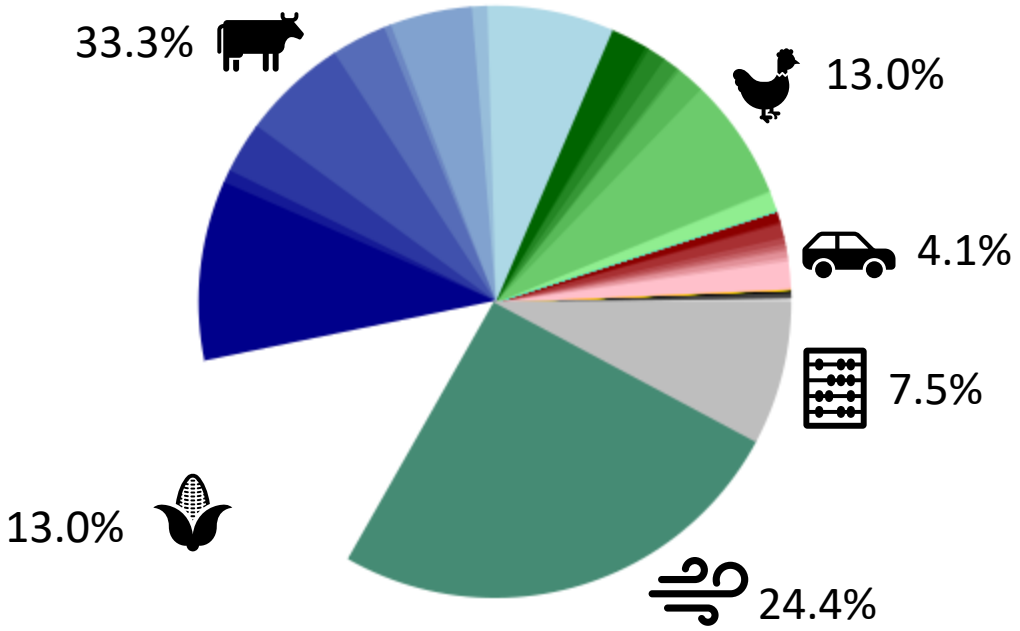


- Oxidized N deposition is largely unchanged
- Mobile on-road is the dominant deposition source of the tracked emissions
- The existing airshed appears to still capture the emission region for 75% of the deposition for oxidized N

Reduced N Deposition to the Chesapeake Bay Watershed

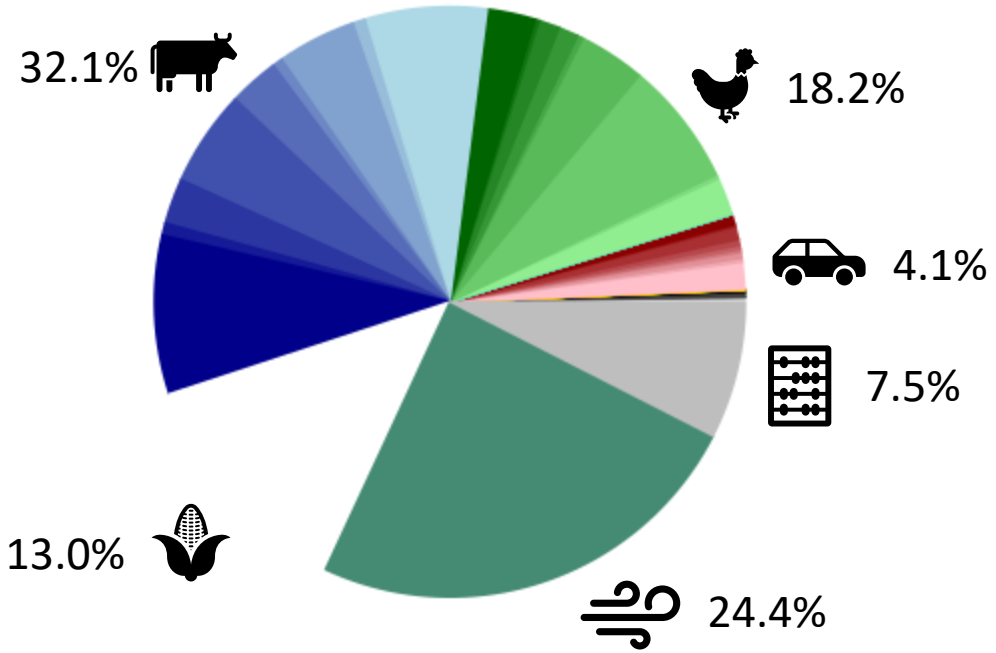
EQUATES

55,394 metric tons N



Emissions Update

57,688 metric tons N



Long Range Transport

Mineral Fertilizers

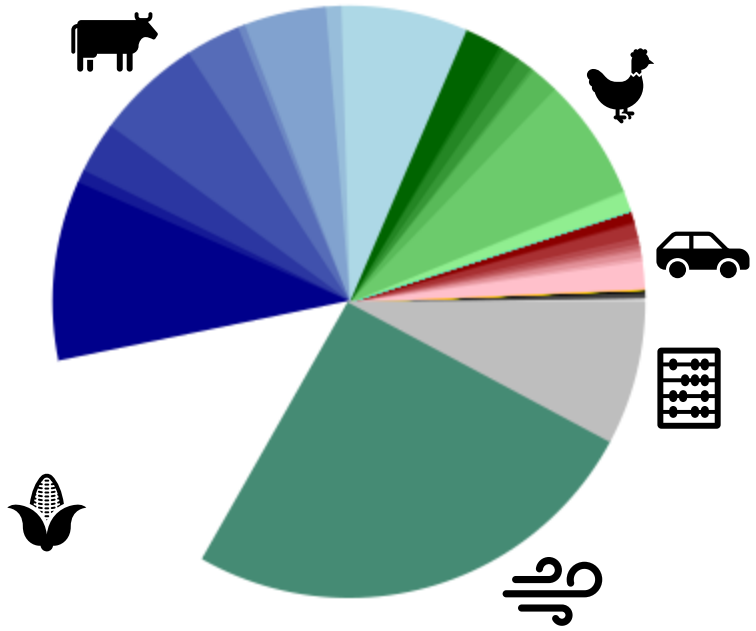
Other/ Untracked

* Note that the poultry and animal sectors were redefined in the new emissions

Reduced N Deposition to the Chesapeake Bay Watershed

EQUATES

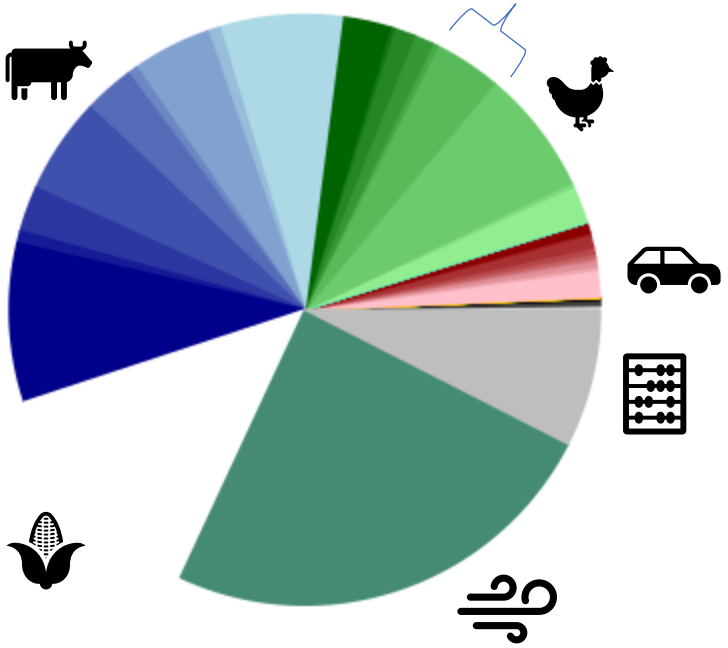
55,394 metric tons N



Emissions Update

57,688 metric tons N

249% increase in Delmarva contribution



Long Range Transport

Mineral Fertilizers

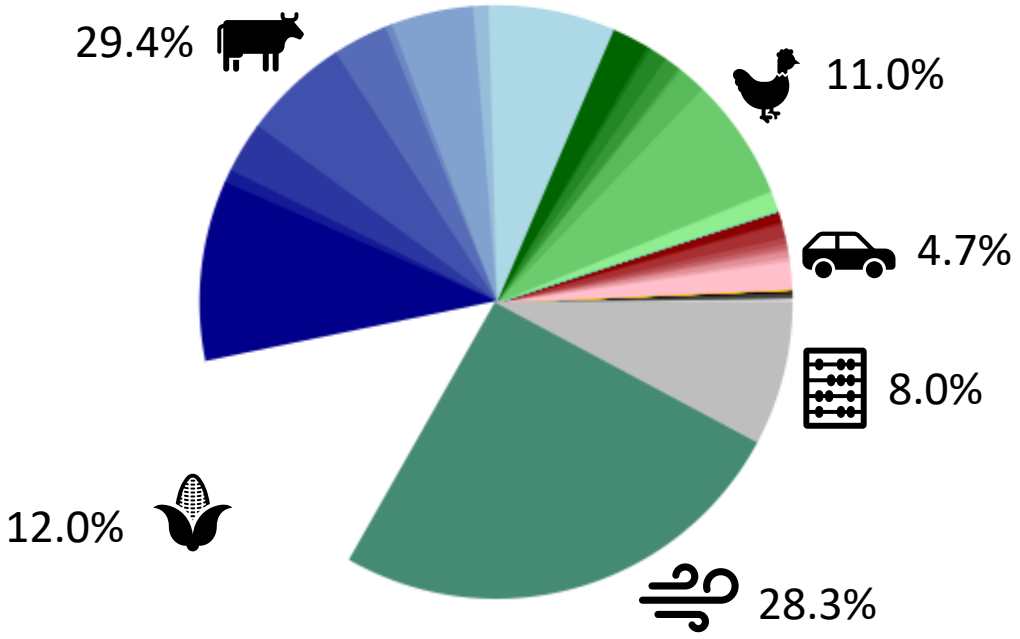
Other/ Untracked

MD Animal NH_3 Emissions contributed to 4.1% of the reduced N deposition

Reduced N Deposition to the Chesapeake Bay Tidal Waters

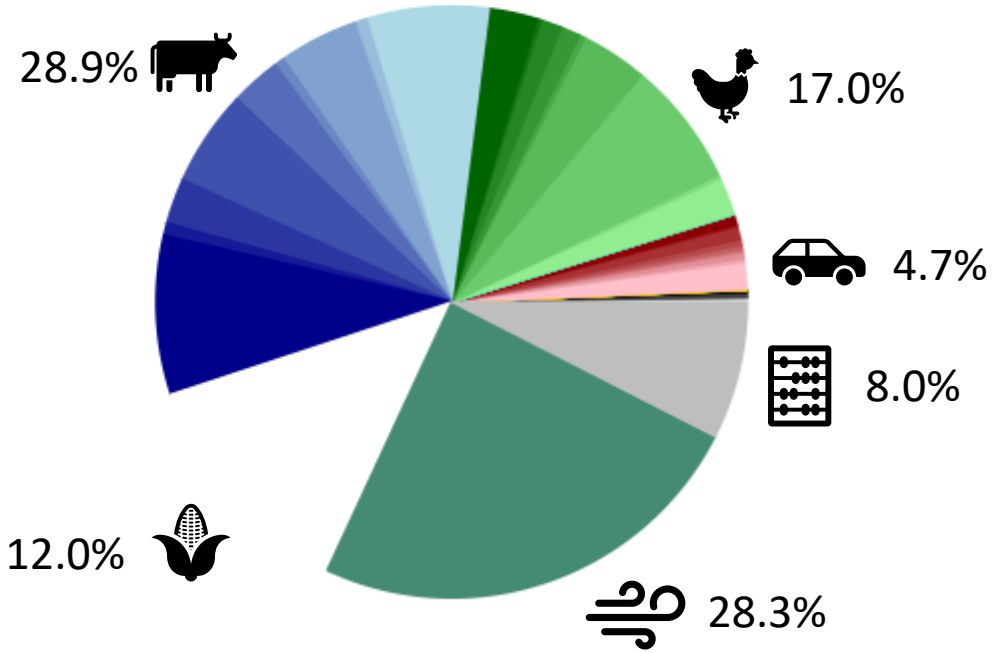
EQUATES

2,777 metric tons N



Emissions Update

2,941 metric tons N



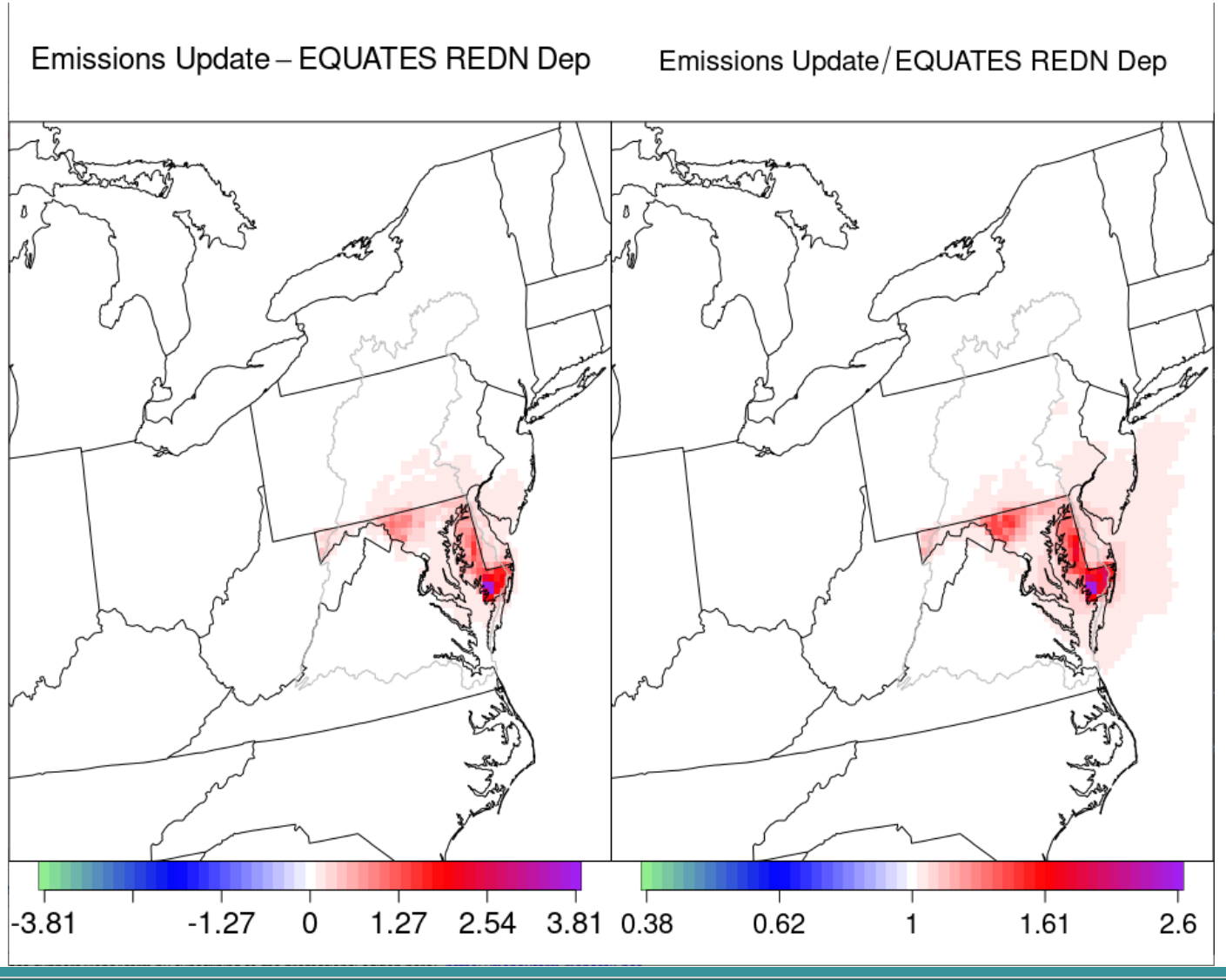
Long Range Transport

Mineral Fertilizers

Other/ Untracked

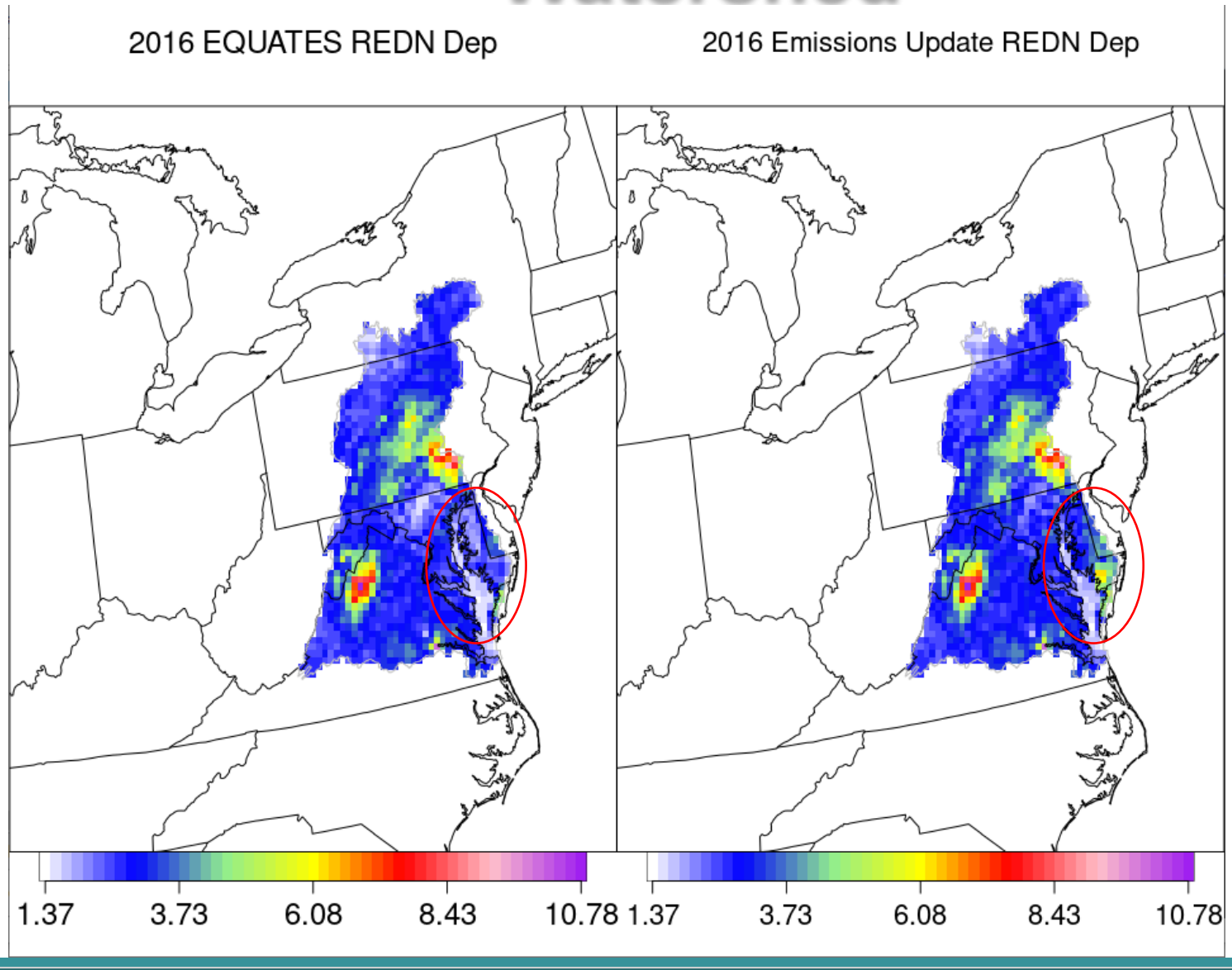
MD Animal NH_3 Emissions contributed to 5.9% of the reduced N deposition

Reduced N Deposition to the Chesapeake Bay Watershed



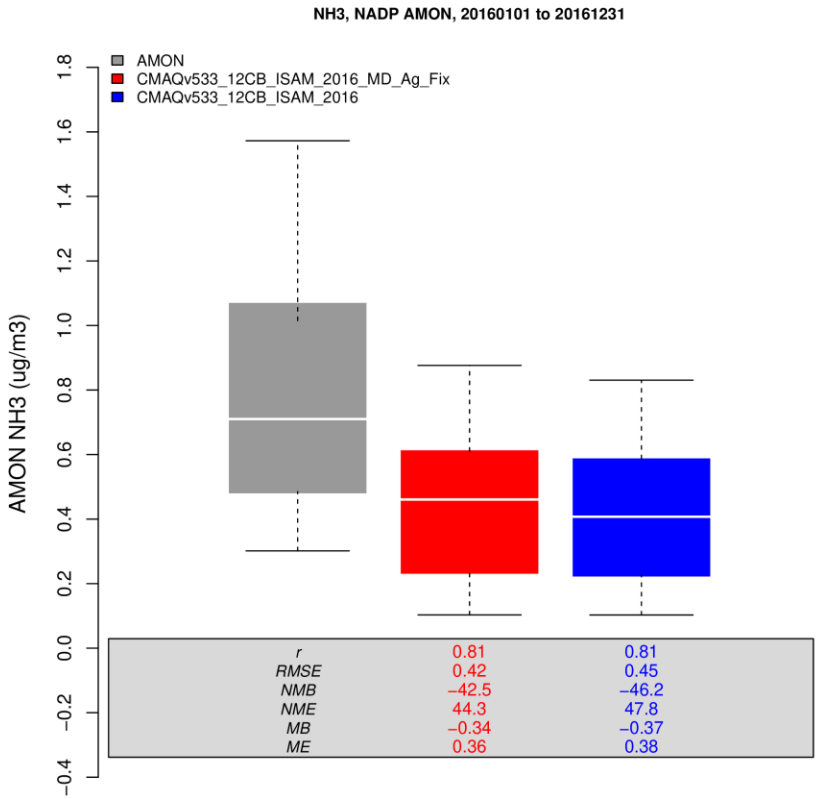
- The change in reduced nitrogen deposition primarily co-located with the changes in NH_3 emissions.

Reduced N Deposition to the Chesapeake Bay Watershed



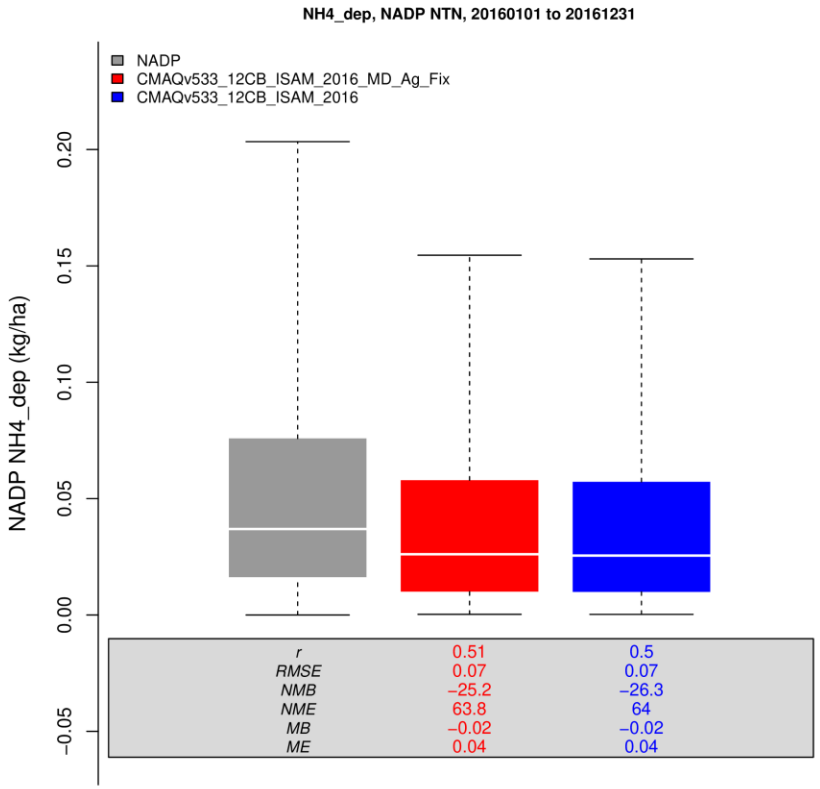
- Reduced N deposition is locally important in the emission regions
- Annual deposition increased by nearly 4 kg ha^{-1} $year^{-1}$ in some areas

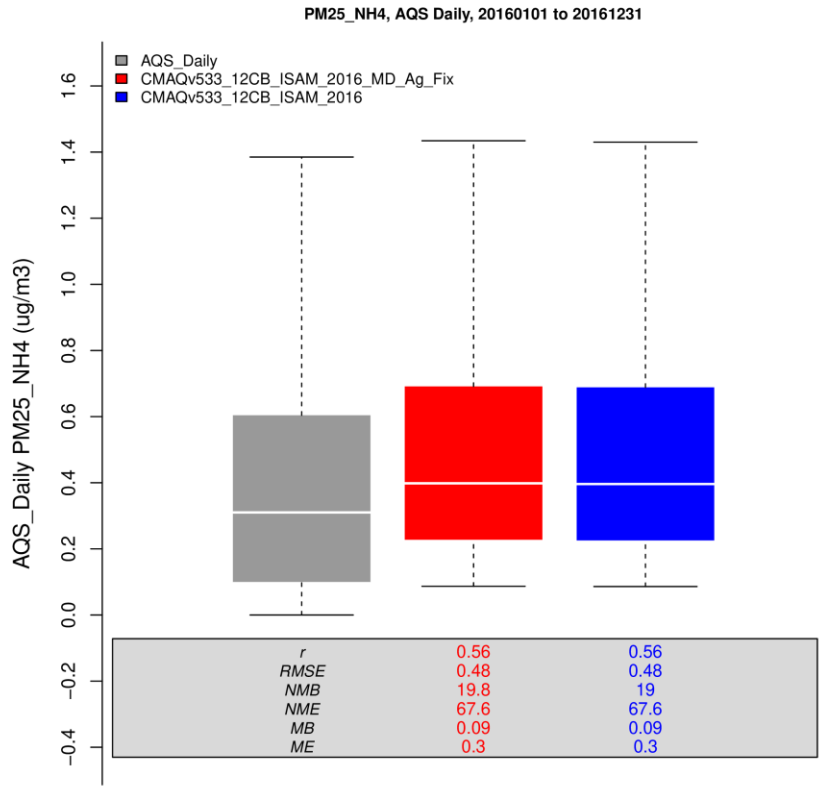
Evaluation Against Network Observations



- The omission of NH_3 emissions from Maryland animal sources had little noticeable impact on the valuation against AMoN observations in the impacted states (MD, DE, PA, NJ).
- Indicates that current monitor site locations are not representative of animal emissions in this area

Evaluation Against Network Observations

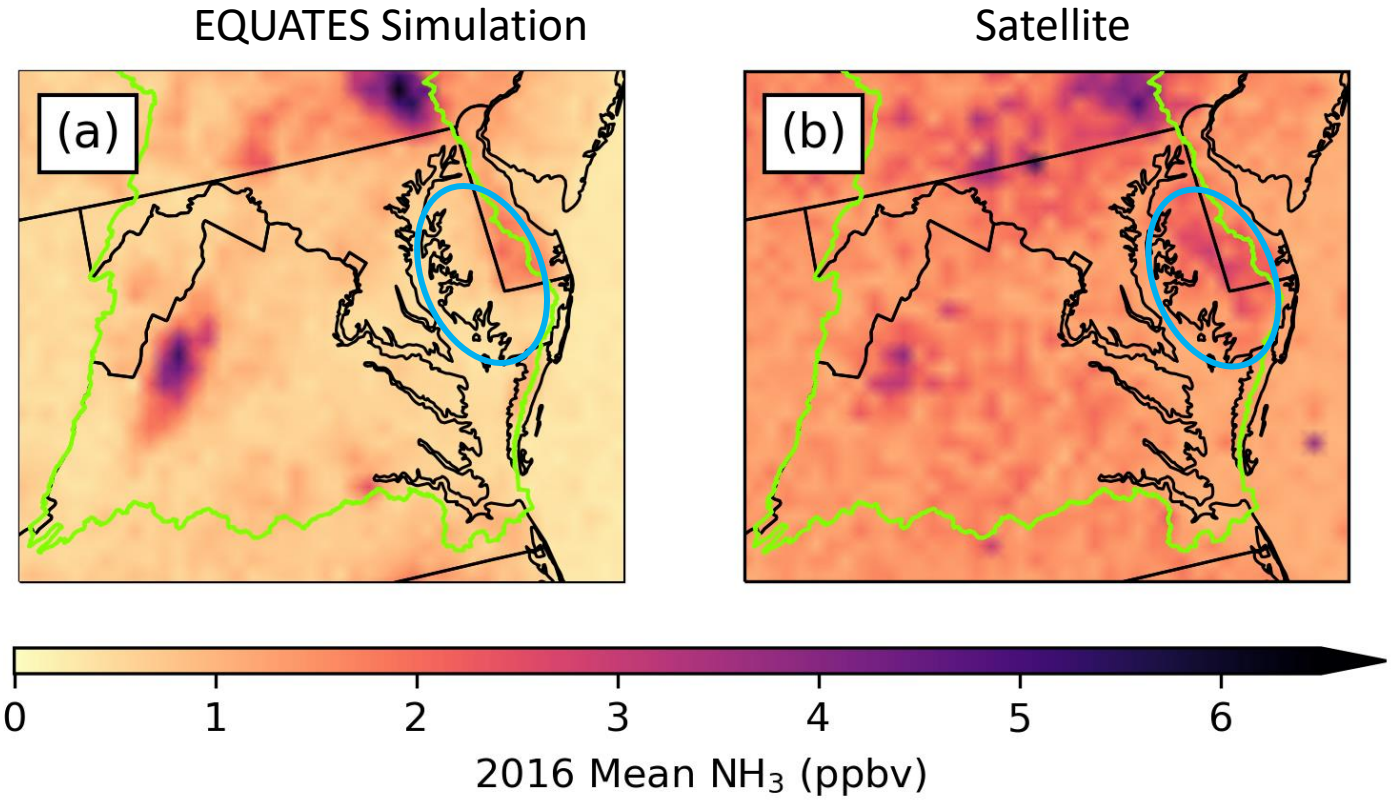




NADP and AQS observation sites do not show a substantial impact of MD animal NH_3 emissions

Satellite NH_3 Observations for Emissions Evaluation

- Network observations do not capture the omission of NH_3 animal emission form Maryland in the EQUATWS simulations
- CrIS satellite observations indicate that there is a low NH_3 bias in the original EQUATES simulations where emissions were omitted



Summary and Data Needs

Summary

- CMAQ evaluates well against existing observations
- Provides atmospheric nitrogen deposition to the Chesapeake Bay modeling system
- We have developed methods to estimate emission source contributions to deposition
- This sensitivity demonstrates that the impact of modeled NH3 emissions have a local deposition impact
  - In agreement with deposition observations taken downwind from a NC poultry facility (Walker et al. 2014) and Australian feed lot (Shen et al. 2016).

Data Needs

- Emission activity data, e.g. best management practices, source measurements for livestock waste operations, etc.
  - Needed for emissions modeling
- Atmospheric concentration observations
  - Simulations evaluated with large changes in the NH_3 emissions inventory evaluate similarly against current network observations
  - Satellite observations appear to capture the missing emissions

Shen et al. 2016 https://doi.org/10.1038/srep32793; Walker et al. 2014 https://doi.org/10.1016/j.agee.2013.10.029

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.