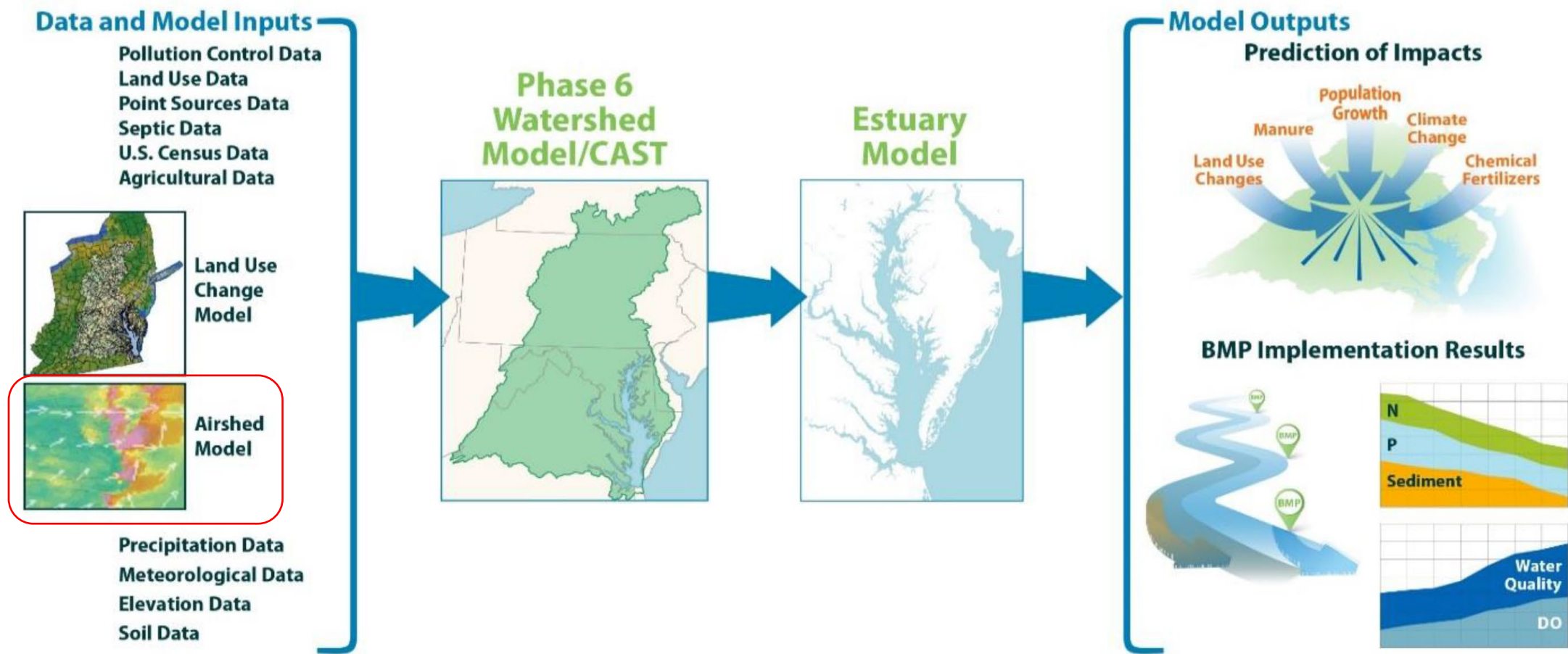


Atmospheric Deposition and Emission Contributions using EPA's Community Multiscale Air Quality (CMAQ) Model

Jesse Bash¹, Sarah Benish¹, Tesh Rao², Gary Shenk³,
Lewis Linker⁴, Kristen Foley¹, Sergey Napelenok¹,
James Kelly², Yijia Dietrich¹, Ian Rumsey¹

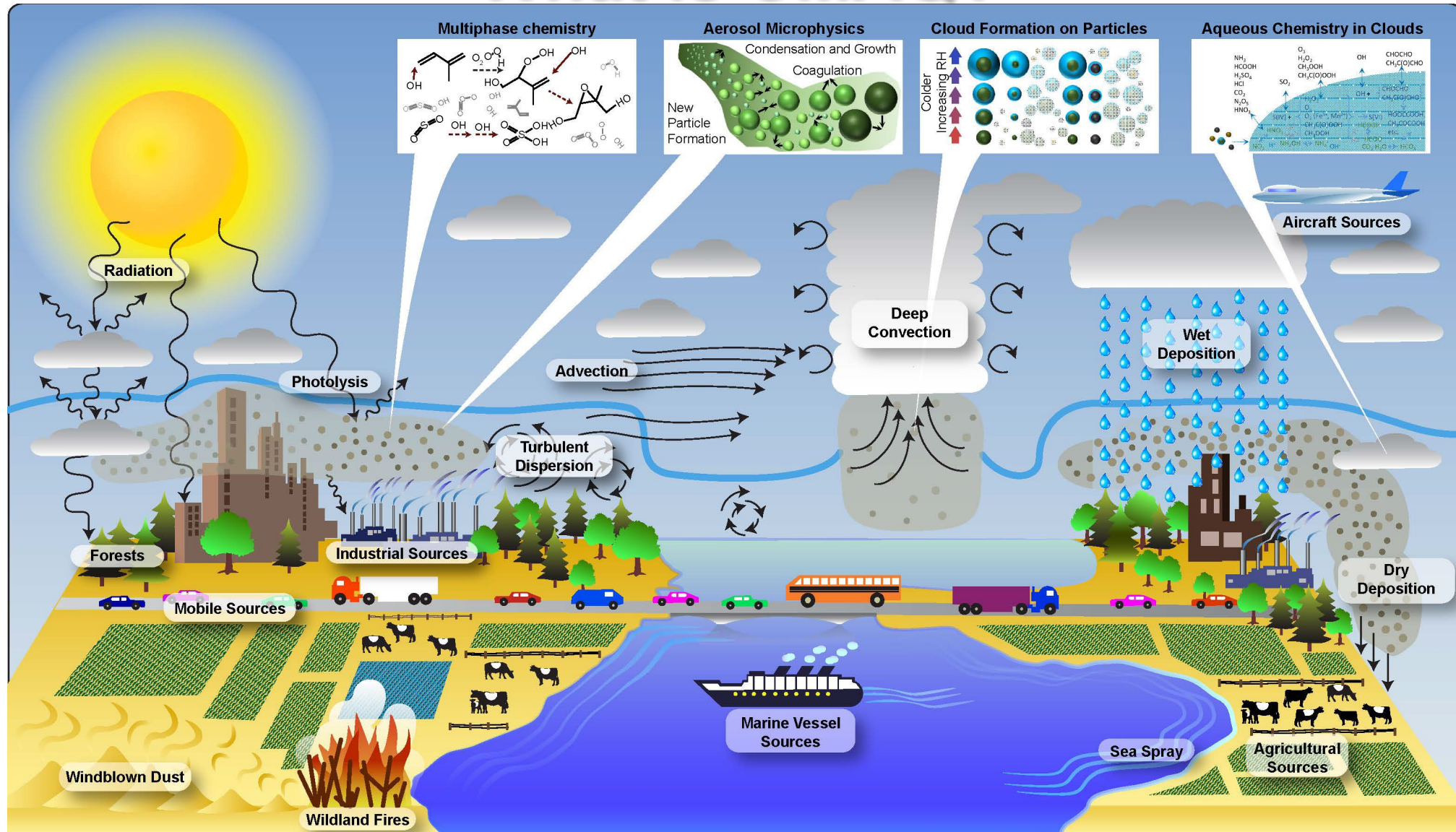
1. EPA Office of Research and Development
2. EPA Office of Air Quality Planning and Standards
3. EPA Chesapeake Bay Program Office
4. U.S. Geological Survey

Chesapeake Bay Program Modeling System



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

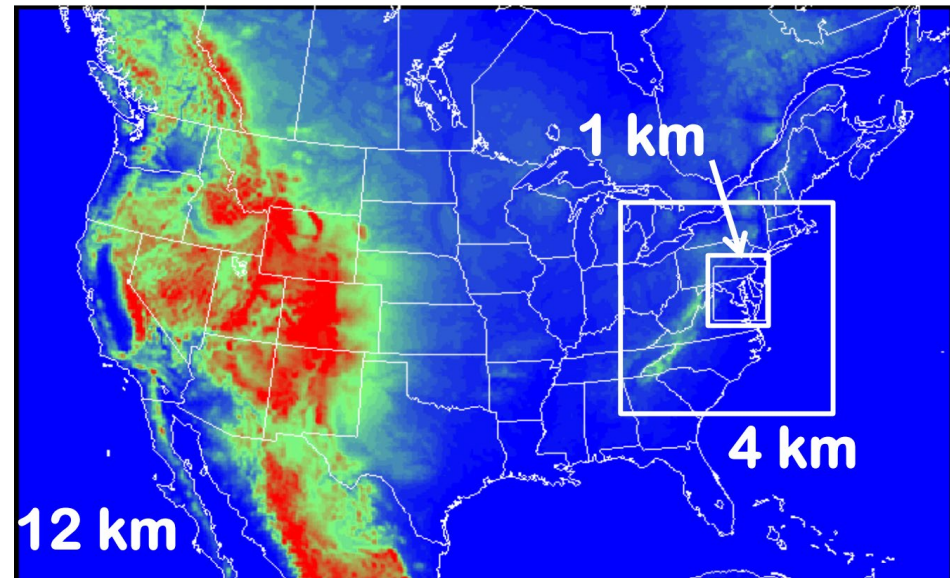
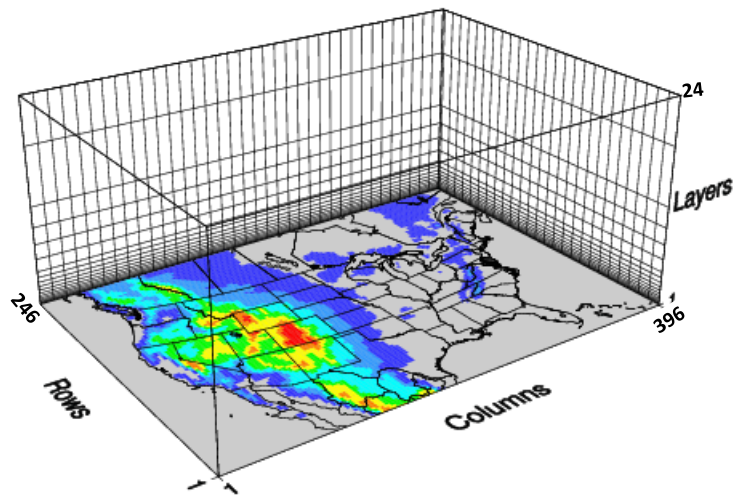
What is CMAQ?



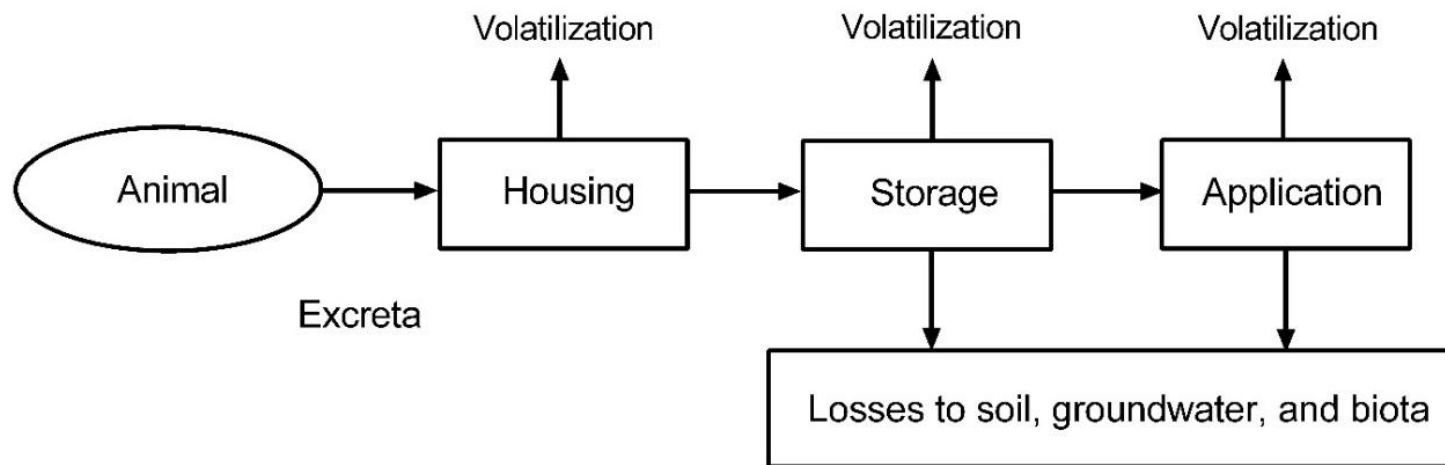
<https://www.epa.gov/cmaq/overview-science-processes-cmaq>

The CMAQ Model

- Simulate atmospheric pollutants
- Require inputs for emissions, meteorology, and initial & boundary conditions
- Open-source and is widely developed and used by government, academia, and the private sector



Animal NH₃ Emissions

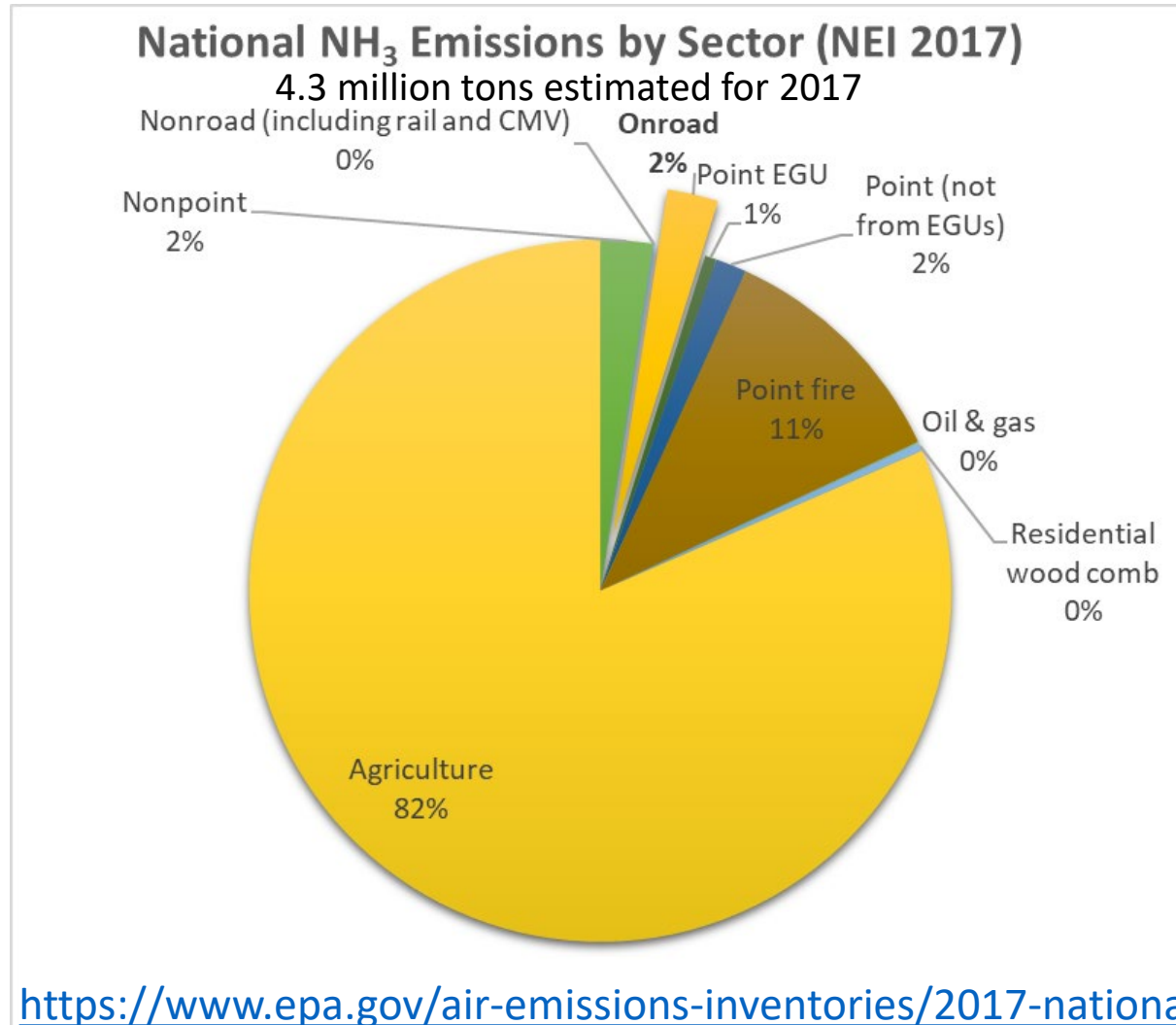


- USDA National Agricultural Statistics Service (NASS) and state submitted data are used as inputs
- In the 2017 NEI and Phase 7 inputs, emission from animal husbandry are estimated using a semi-empirical process farm emissions model
- Nitrogen losses are modeled for each process using measurement to calibrate emission factors
- Volatilization estimates are used in CMAQ
- Emissions are estimated for specific animal and housing type

McQuilling and Adams 2015 <http://dx.doi.org/10.1016/j.atmosenv.2015.08.084>

<https://www.epa.gov/air-emissions-inventories/2017-national-emissions-inventory-nei-technical-support-document-td>

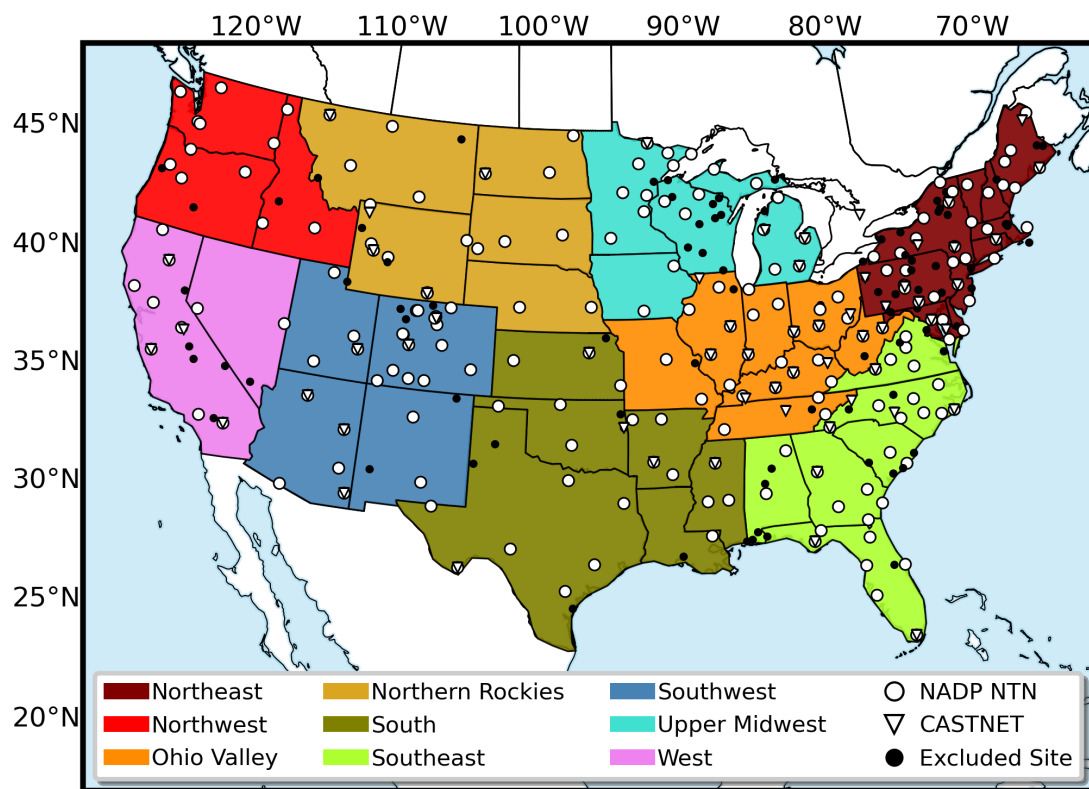
NH₃ Emissions From Other Sources



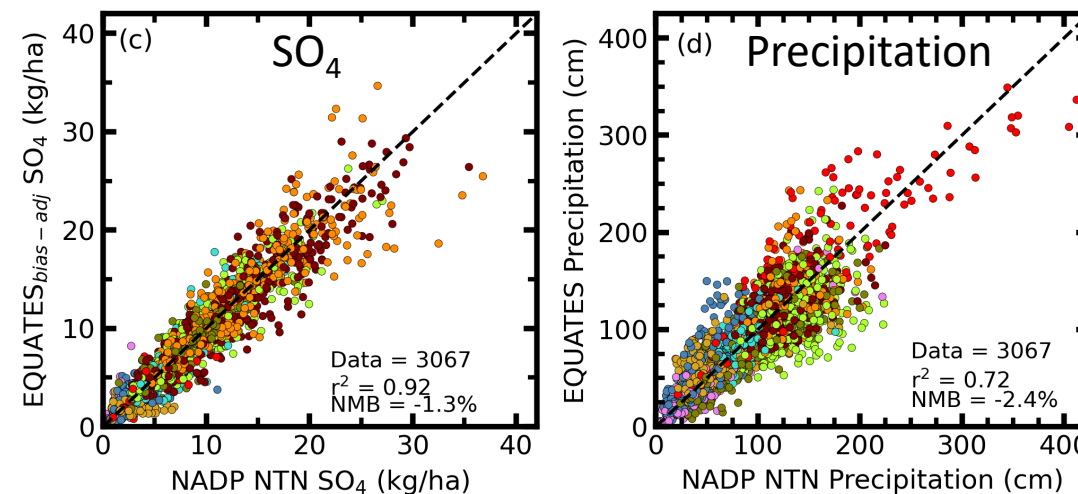
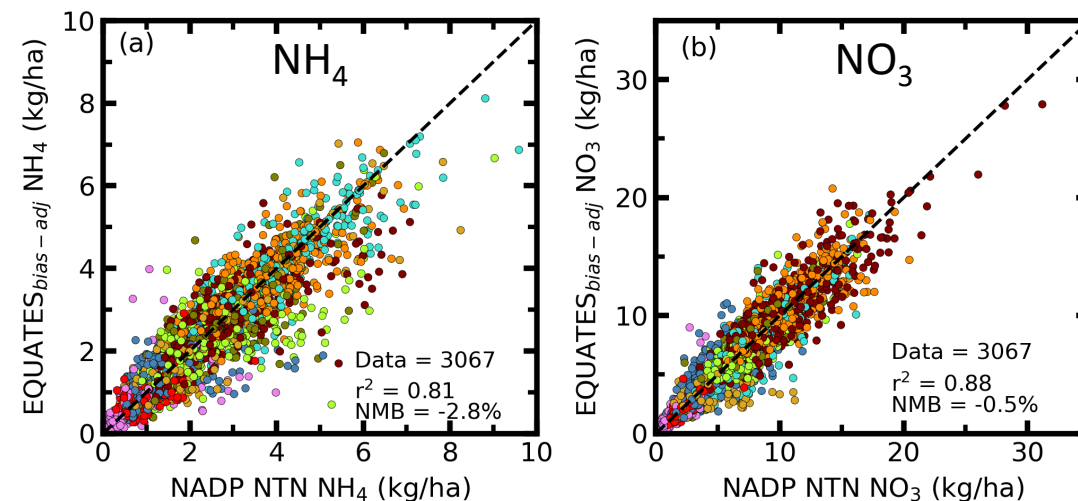
- Process-based estimates for all emission sectors
- Agriculture is the largest source of atmospheric NH₃ emissions
- NH₃ from animal housing and manure and the process of manure application are the largest source of agriculture emissions
 - 64% from animal sectors
 - 36% from fertilizer and manure once applied

CMAQ Evaluation Against Network Wet Deposition

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



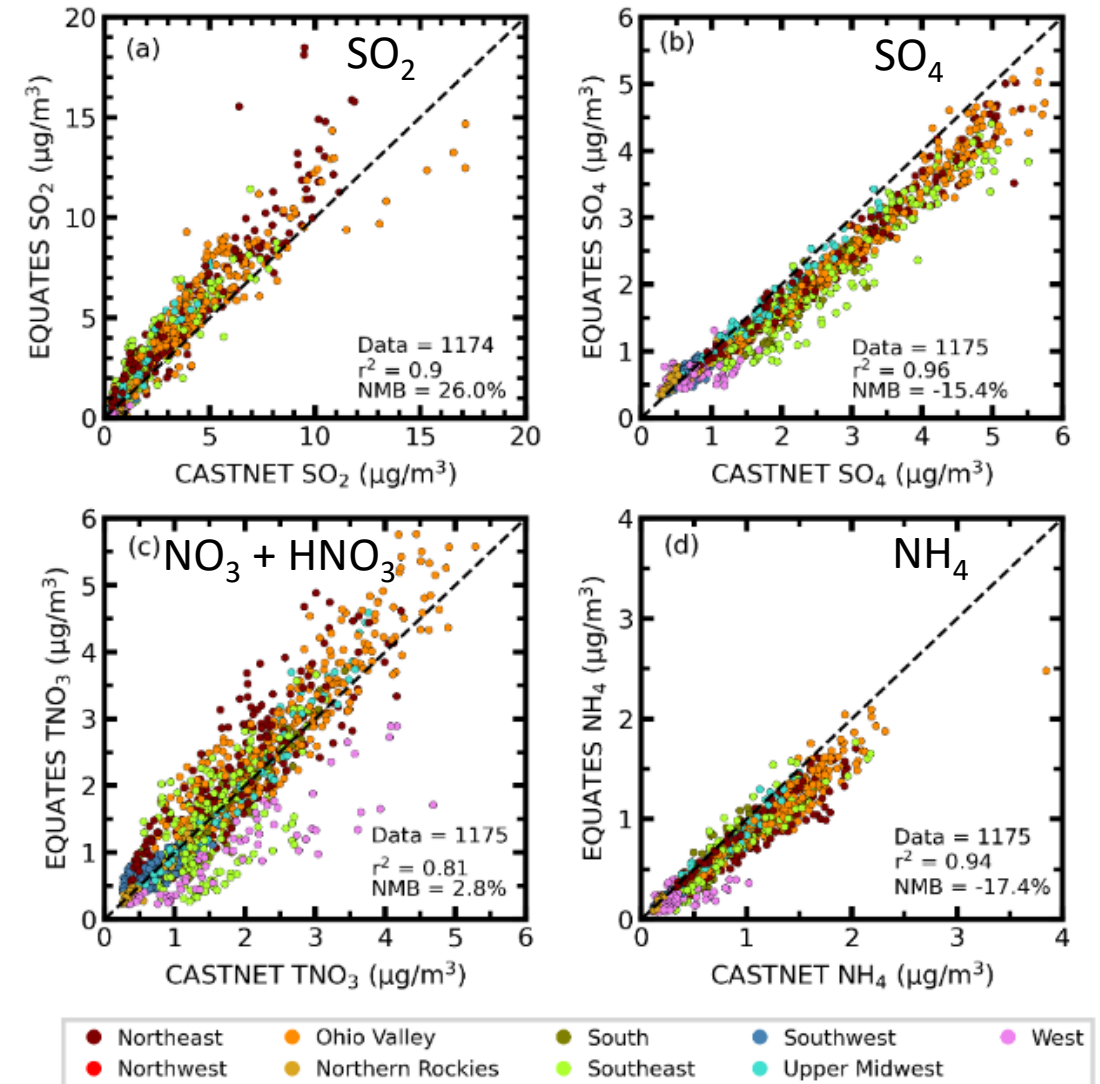
Benish et al. 2022



CMAQ Evaluation Against Network Ambient Concentrations

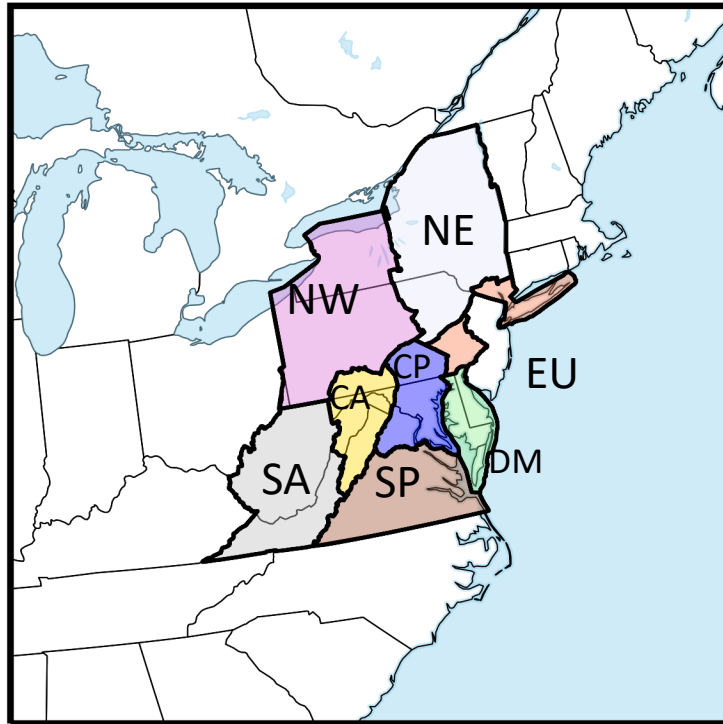
- Measurement networks do not exist for dry deposition observations
 - Measurements are difficult and costly
- Atmospheric concentrations are proportional to dry deposition
 - Evaluation against concentrations provides some constraints on dry deposition
- Ammonia concentration measurements are sparse

Benish et al. 2022

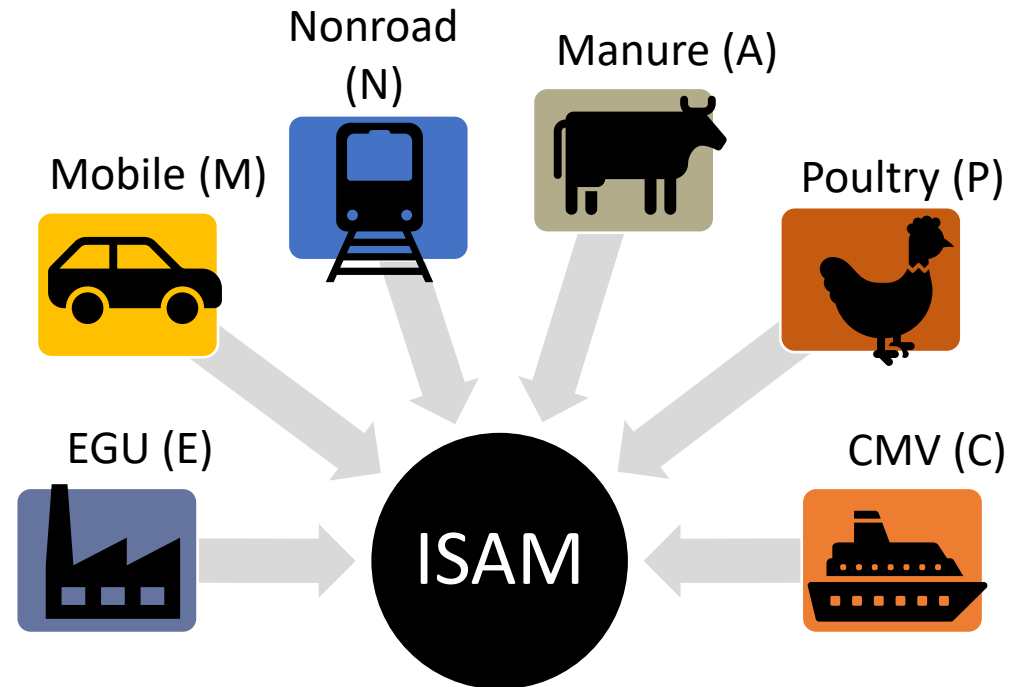


CMAQ Integrated Source Apportionment Method (ISAM)

Geographic emission source regions

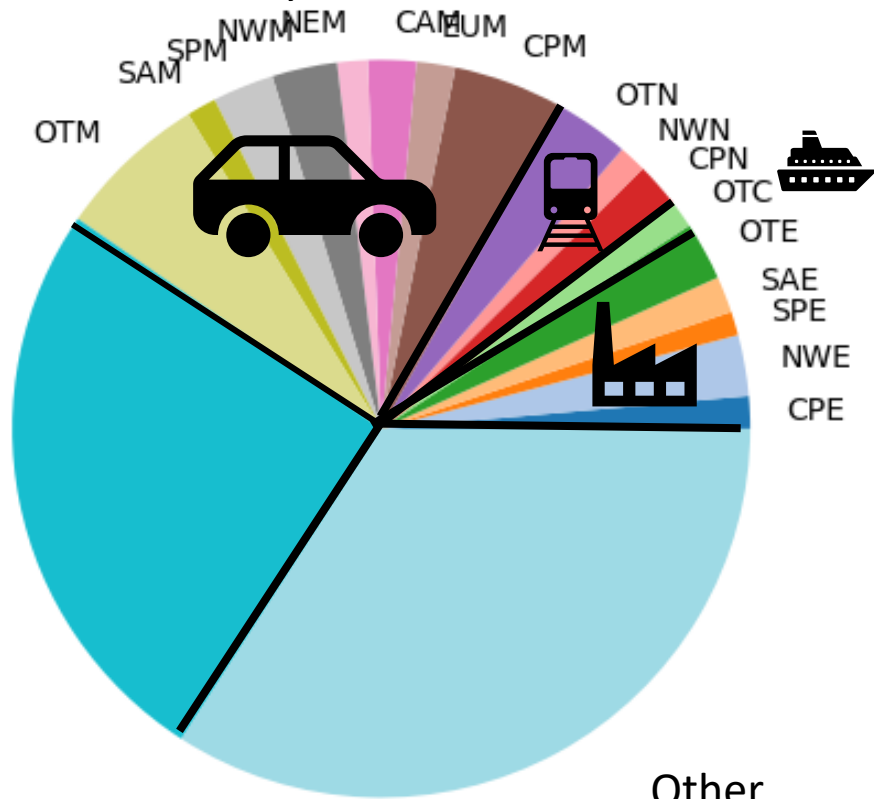


Emission source categories



CMAQ Integrated Source Apportionment Method

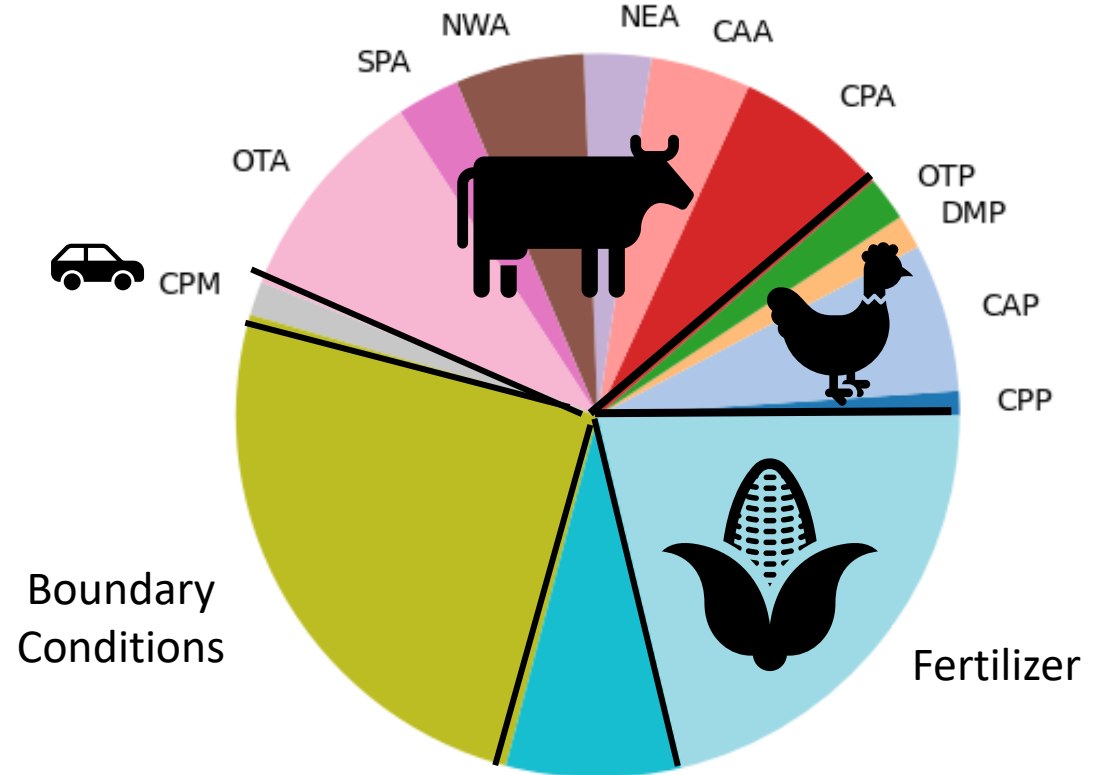
Total Oxidized N
147,854 tons N



Boundary Conditions

Other Untracked Emissions

Total Reduced N
123,611 tons N



Boundary Conditions

Other Untracked Emissions

Fertilizer

Source Apportionment to Chesapeake Bay Watershed

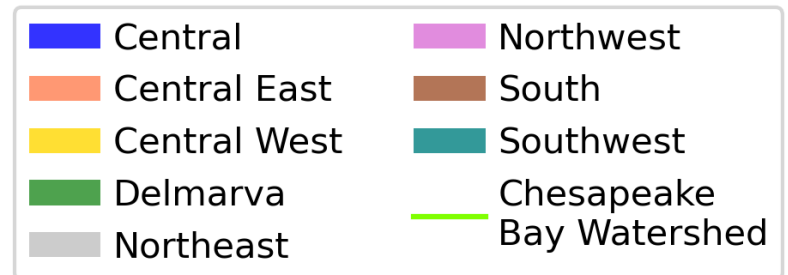
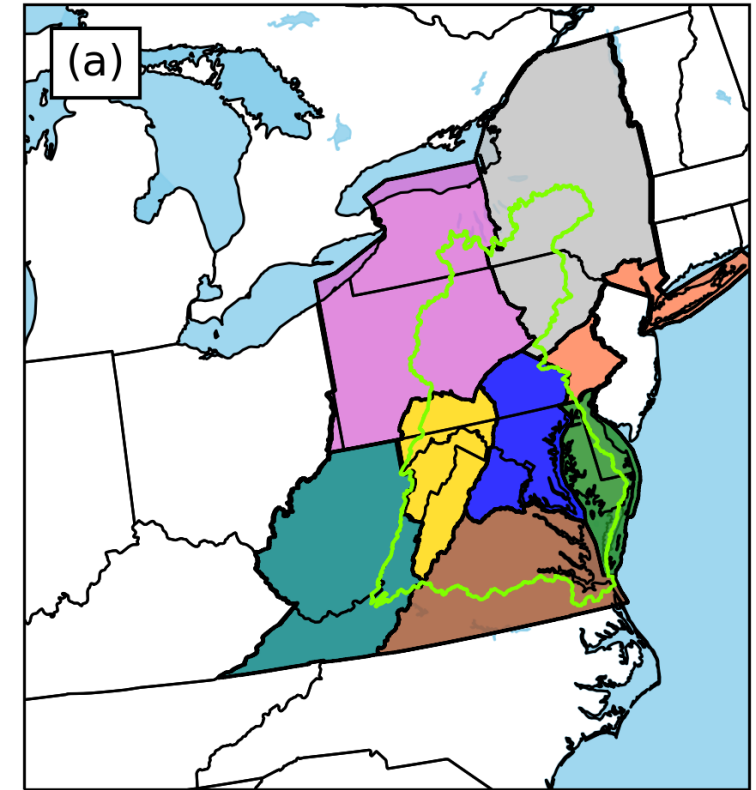
Total Reduced N Deposition

Source Regions	Animal	CMV	EGU	Mobile	Nonroad	Poultry	Total
Central	35%	0%	1%	4%	0%	14%	10%
Central East	7%	0%	0%	2%	0%	1%	1%
Central West	1%	0%	0%	0%	0%	0%	11%
Delmarva	4%	0%	0%	0%	0%	7%	2%
Northeast	0%	0%	0%	0%	0%	2%	3%
Northwest	3%	0%	0%	0%	0%	0%	7%
Other	6%	0%	0%	0%	0%	1%	13%
South	10%	0%	0%	1%	0%	2%	5%
Southwest	3%	0%	0%	1%	0%	1%	1%
Southwest	1%	0%	0%	0%	0%	0%	1%

 Long Range Transport
25%

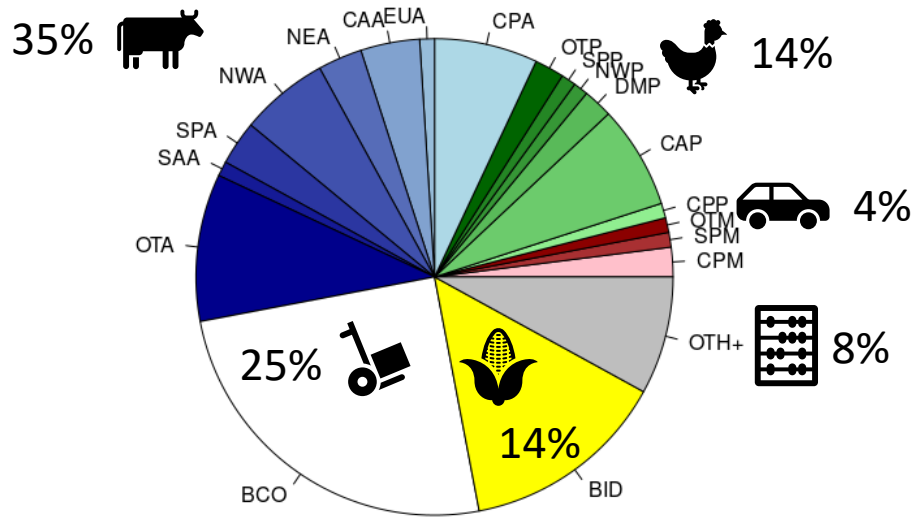
 Mineral Fertilizers
14%

 Other/Untracked
8%

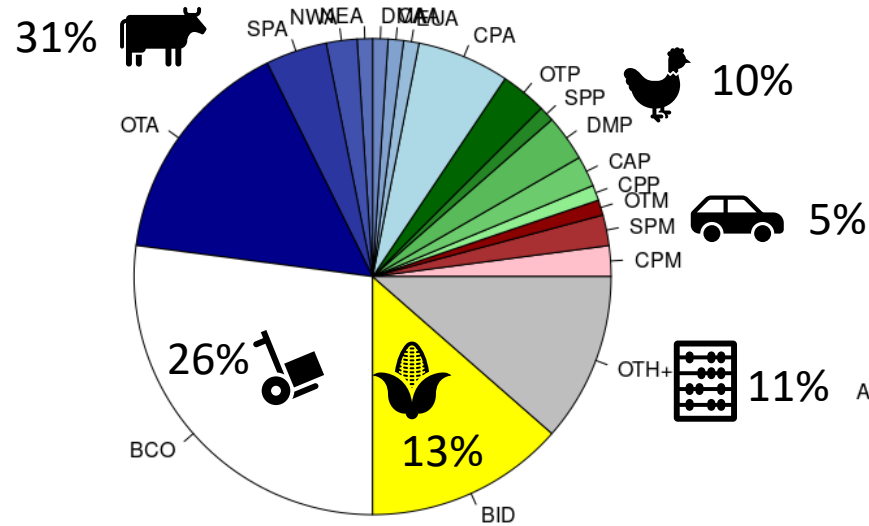


Reduced N Deposition and Emissions

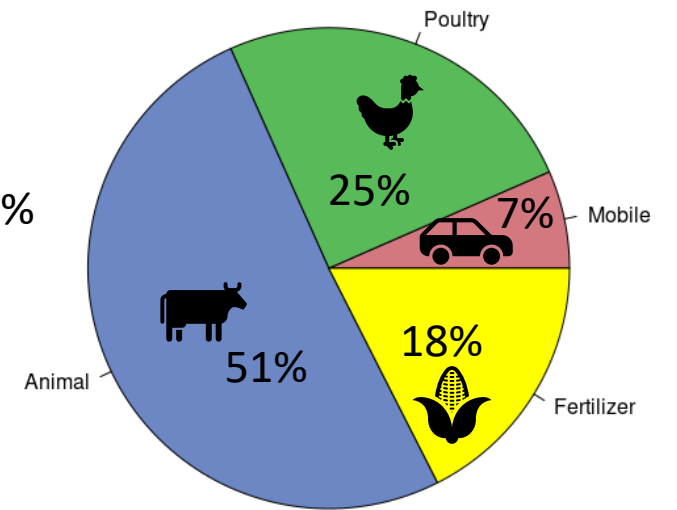
Reduced N Watershed
123,611 tons N



Reduced N Tidal Waters
10,949 tons N

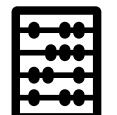


2016 Total Chesapeake Bay Watershed NH3 Emissions
160,073 tons N*



 Long Range Transport

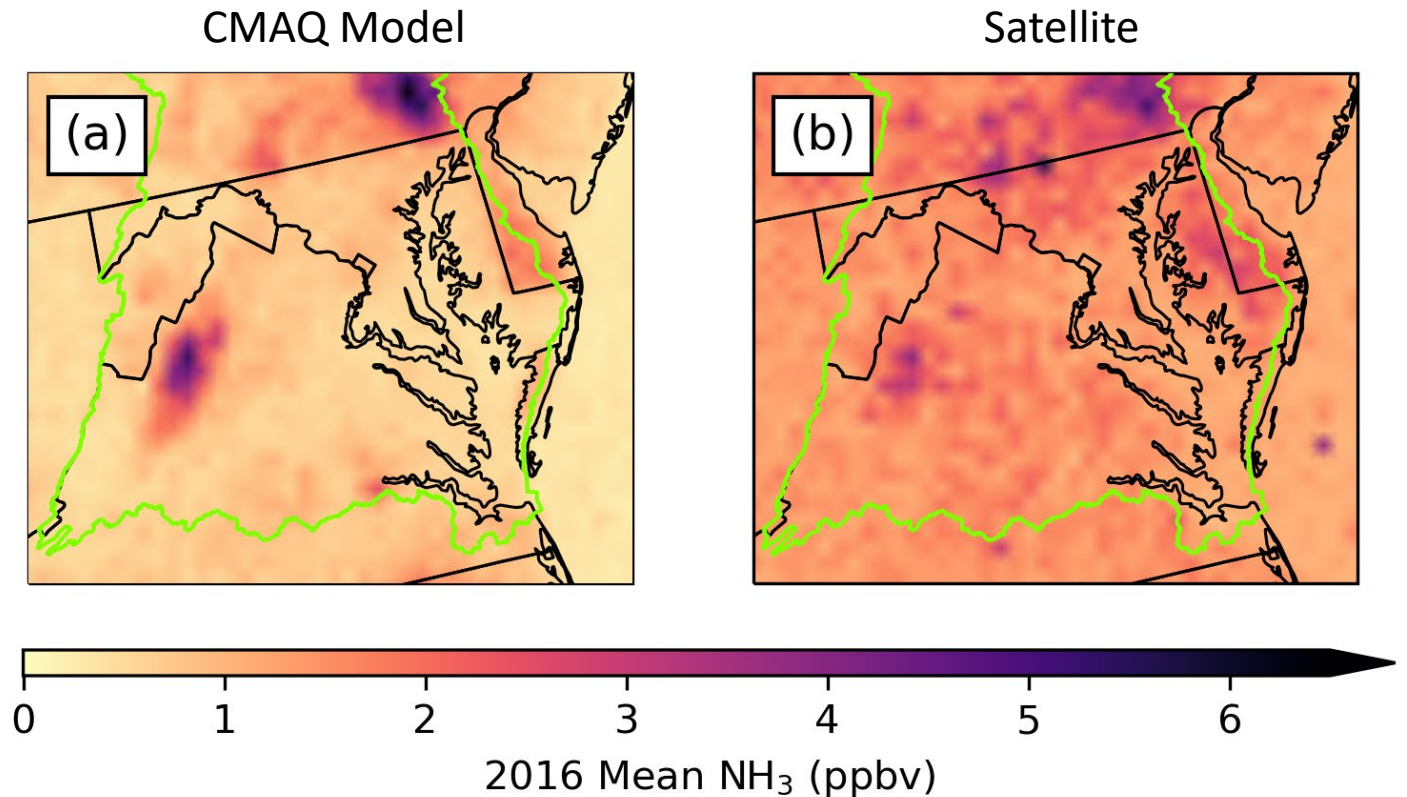
 Mineral Fertilizers

 Other/Untracked

*Does not include other emission categories (wildland fires, other point sources, etc.)

Closing Thoughts

- Source apportionment modeling within CMAQ is a critical tool for decisionmakers
 - Relies on accurate spatial and temporal emissions
- Satellites may be an additional tool to help constrain emissions in critical areas
 - Higher resolution data is being developed
 - Likely to improve spatial surrogates in emissions



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

Data Needs

- Emission activity data, e.g. best management practices, source measurements for livestock waste operations, etc.
 - Needed for emissions modeling
- Atmospheric concentration observations
- Better understanding of producer needs from the CMAQ/Chesapeake Bay modeling system

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.