EPA United States Environmental Protection Agency

Chesapeake Bay Program
40 years of science, restoration and partnership

Key Airshed Model Scenarios for Phase 7

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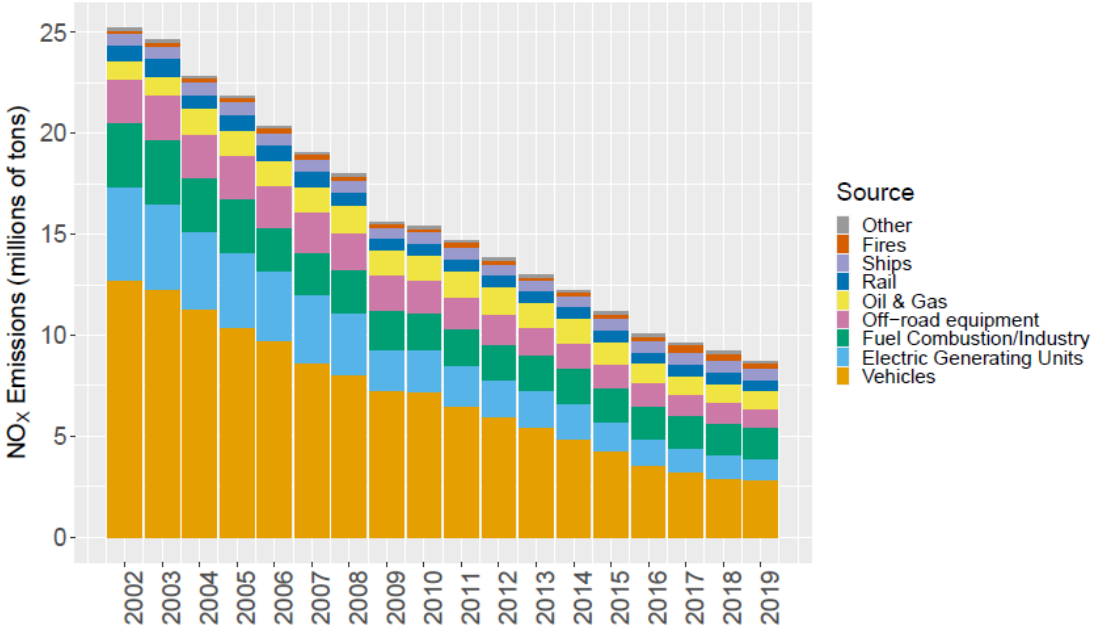
Disclaimer: The views expressed in this presentation are those of the authors and do not necessarily reflect the views or policies of the U.S. EPA.

Model Simulations

- 2002 – 2019 Retrospective CMAQ simulations
  - EPA'S Air QUAlity TimE Series (EQUATES) project
  - CMAQ v5.3.2 simulation for 108 km northern hemisphere and 12 km Conterminous U.S. simulations
  - Emissions based on 2017 NEI methodology
- 2016, 2035, and 2050
  - CMAQ v5.4 with integrated source apportionment
  - Base 2016 emissions scaled to Global Change Analysis Model (GCAM) for future energy scenarios using CMAQ's Detailed Emissions Scaling, Isolation, and Diagnostics (DESID) module

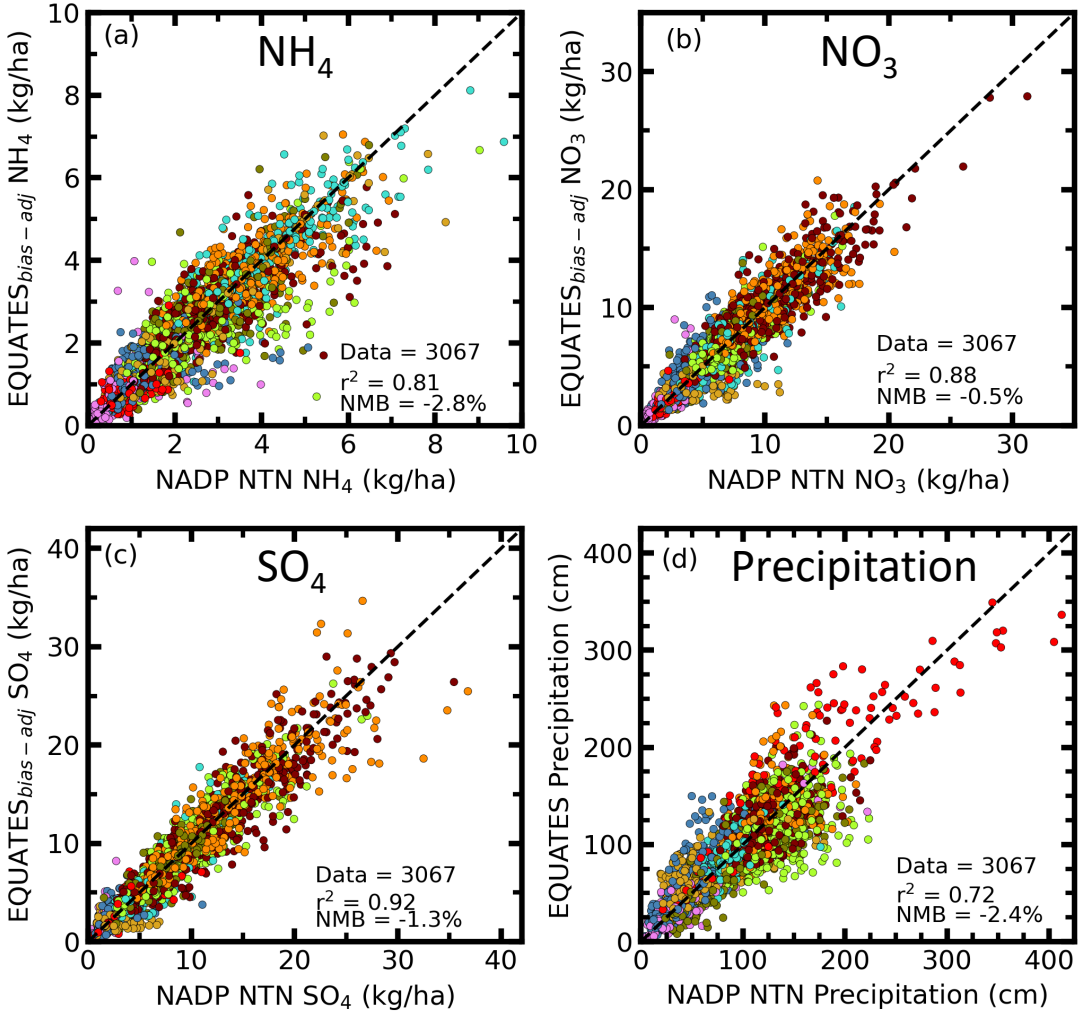
2002 -2019 CMAQ Simulations

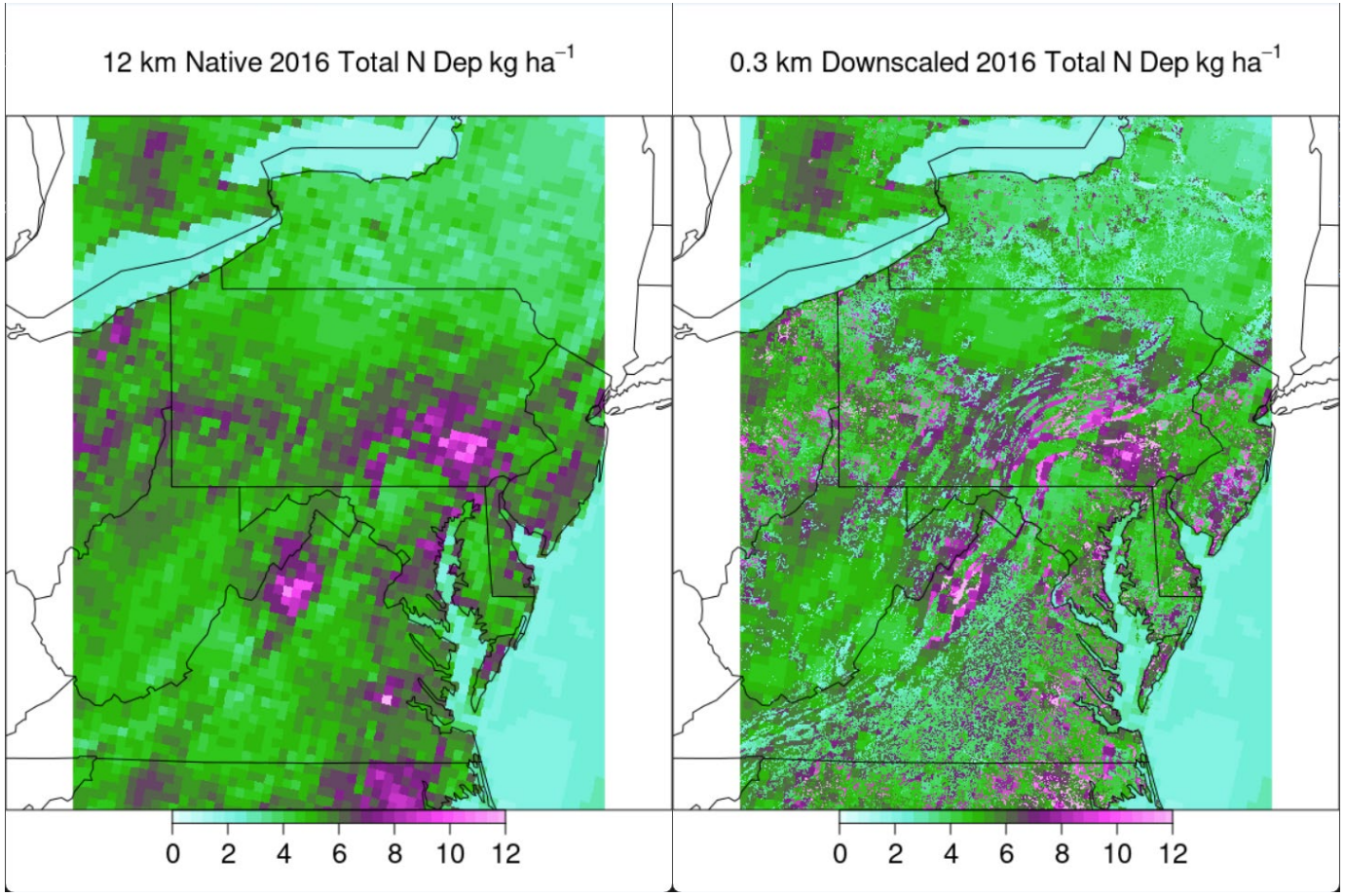
- Changes from Phase 6
  - Developed new methodology for emission estimates
    - Foley et al., 2023 https://doi.org/10.1016/j.dib.2023.109022
  - Consistent CMAQ model version for all simulations
    - Benish et al., 2022 https://doi.org/10.5194/acp-22-12749-2022
  - Source apportionment data is available for 2005, 2011, 2016, and 2018
    - de la Paz et al., 2014 https://doi.org/10.5194/acp-24-4949-2024
  - Available land use/high-resolution deposition
    - Hogrefe et al., 2023 https://doi.org/10.5194/acp-23-8119-2023



https://www.epa.gov/cmaq/equates

2002 -2019 CMAQ Simulations





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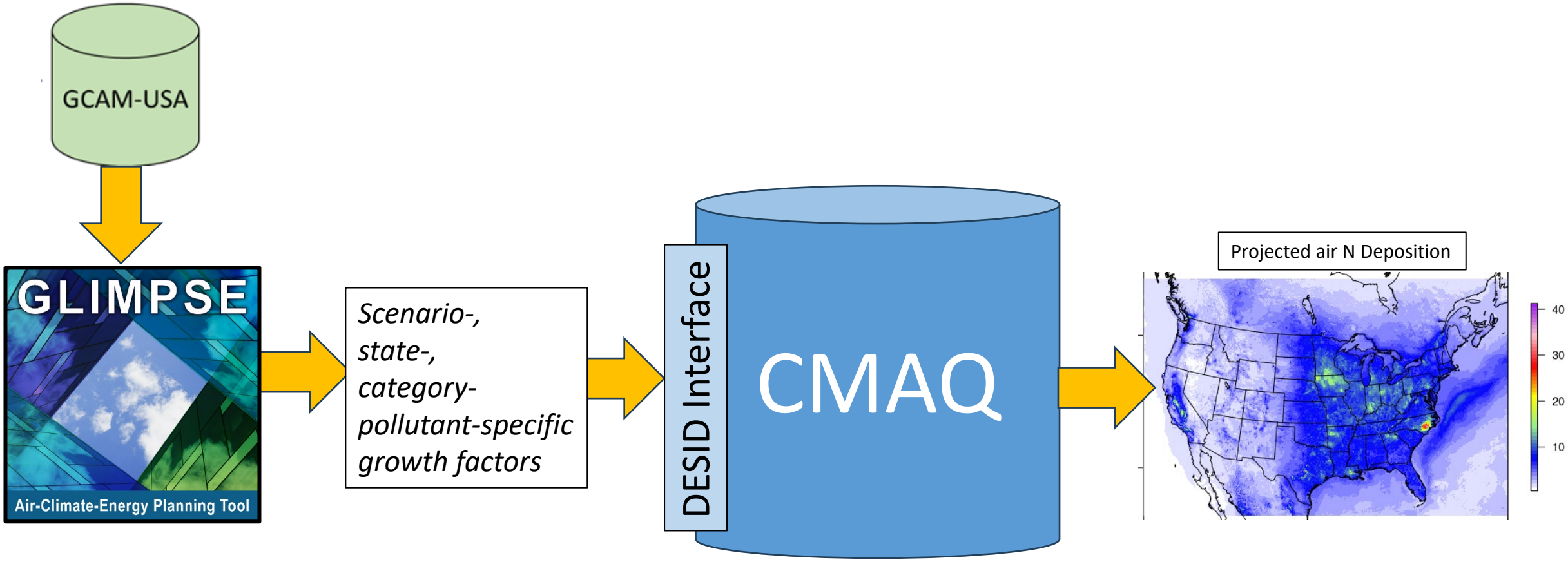
Modeling Framework

Scenario assumptions



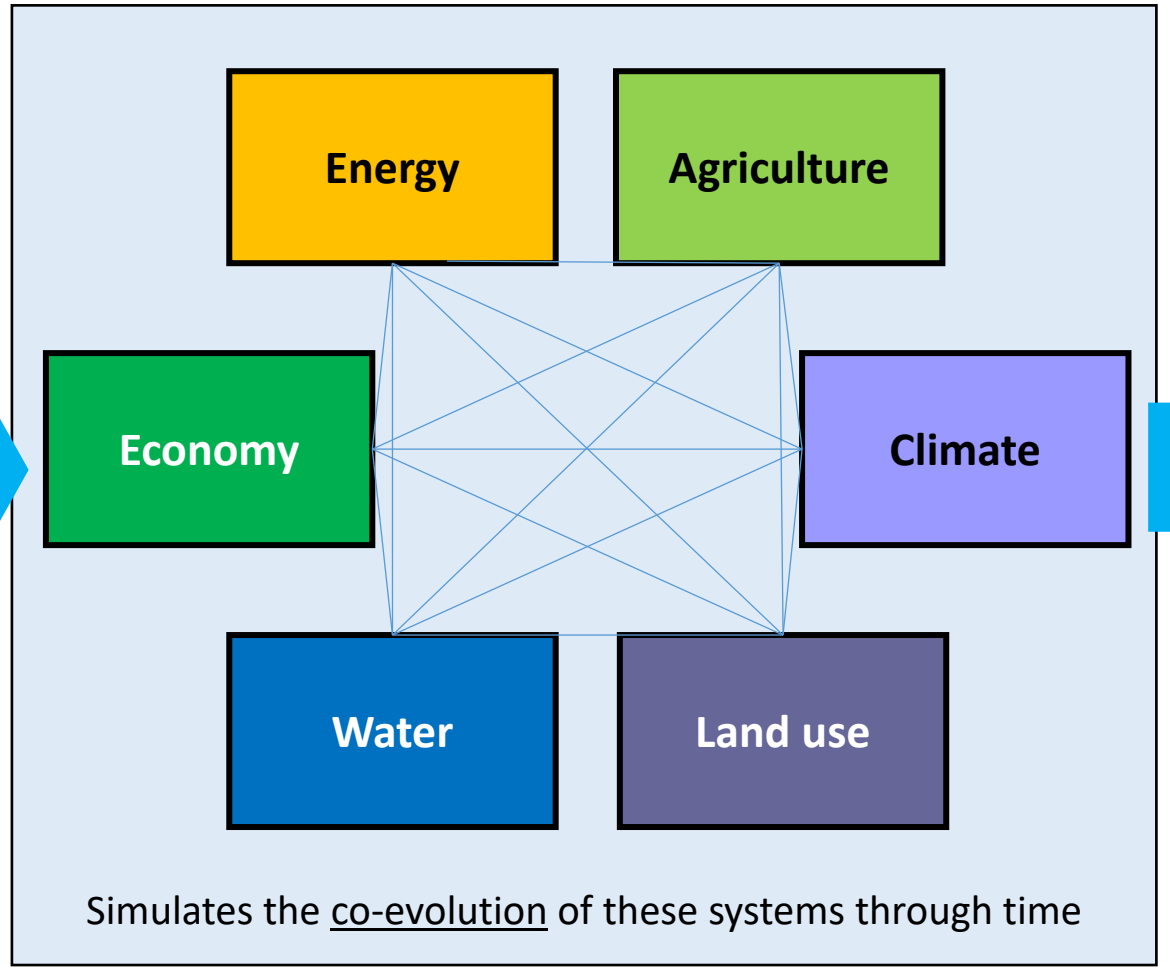
GCAM: Global Change Analysis Model
GLIMPSE: GCAM Long-term Interactive Multi-Pollutant Scenario Evaluator
DESID: Detailed Emission Scaling, Isolation, and Diagnostics module

Global Change Analysis Model

Scenario assumptions

- Population growth
- Economic growth
- Resource availability
- Climate change
- Technology development
- Behavior and preferences
- Policies

GCAM



End points

Energy
- Technology penetrations
- Fuel use and prices

Economic
- Policy cost
- Cost of energy services
- Land and food prices

Climate
- GHG emissions
- Global mean temperature

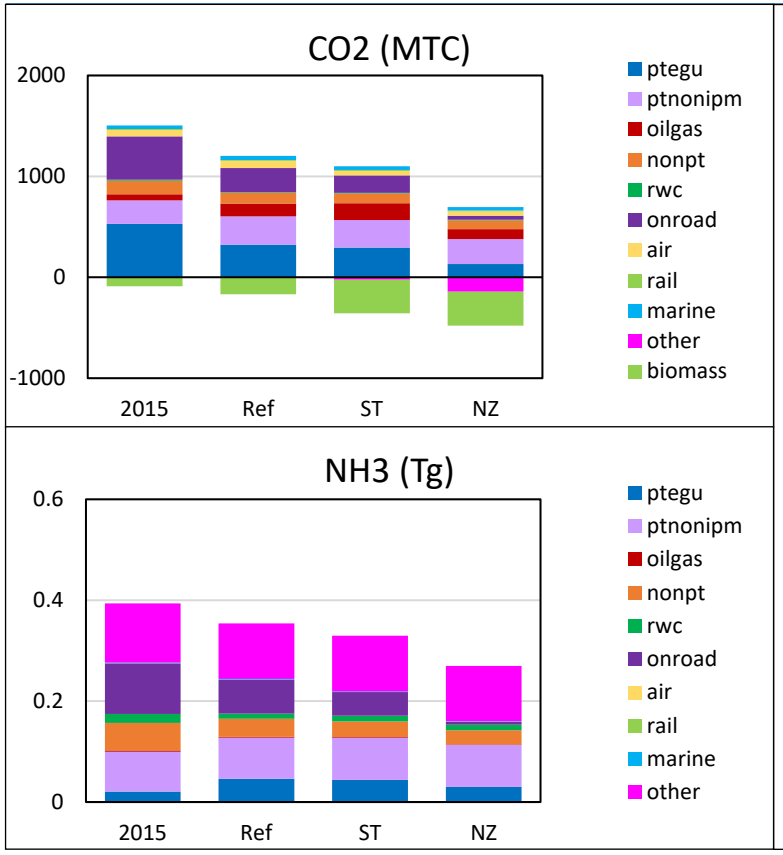
Environmental
- Air pollutant emissions
- Water use
- Health impacts

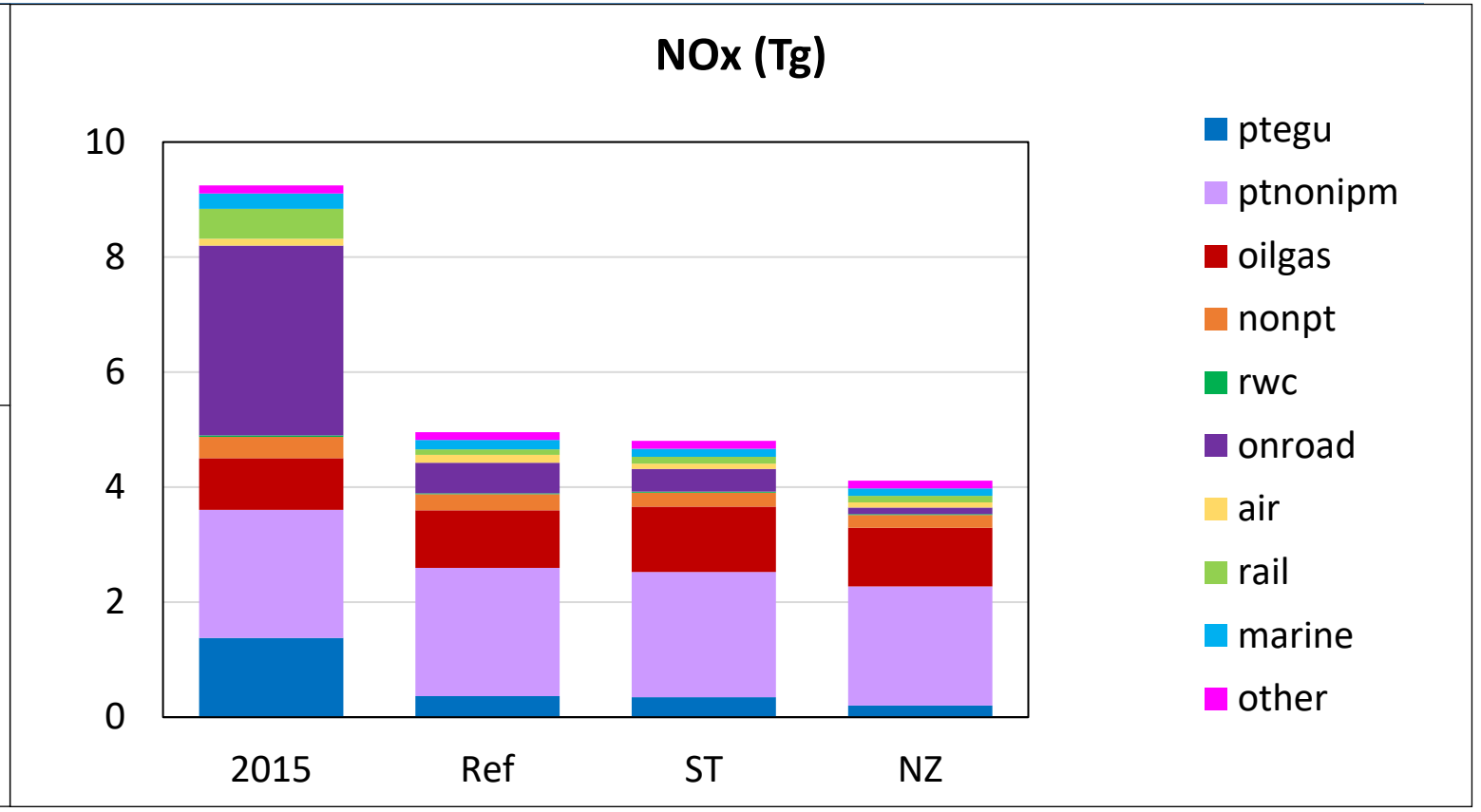
GCAM documentation: http://jgcri.github.io/gcam-doc/

Scenario Design

- *Reference*: A baseline scenario that includes:
  - **limited GHG mitigation, Inflation Reduction Act**, and no additional air pollutant control requirements
- *StateTargets:* A mitigation scenario that includes:
  - State GHG reduction goals, implemented as regional CO_2 targets
  - New CA light-duty electrification targets adopted by Section 177 states
  - Medium- and Heavy-Duty Electrification MOU adopted by signatory states
- *NetZeroZEV*: A mitigation scenario that includes:
  - A national, economy-wide declining CO_2 cap reaches Net-Zero by 2050
  - Transportation electrification targets in *StateTargets* adopted nationally

National CO2 and NOx projections from GCAM





	2023	2026	2028	2032	2050
StateTargets	-1.2%	-2.9%	-4.5%	-8.4%	-28%
NetZeroZEV	-1.9%	-5.6%	-11%	-22%	-79%

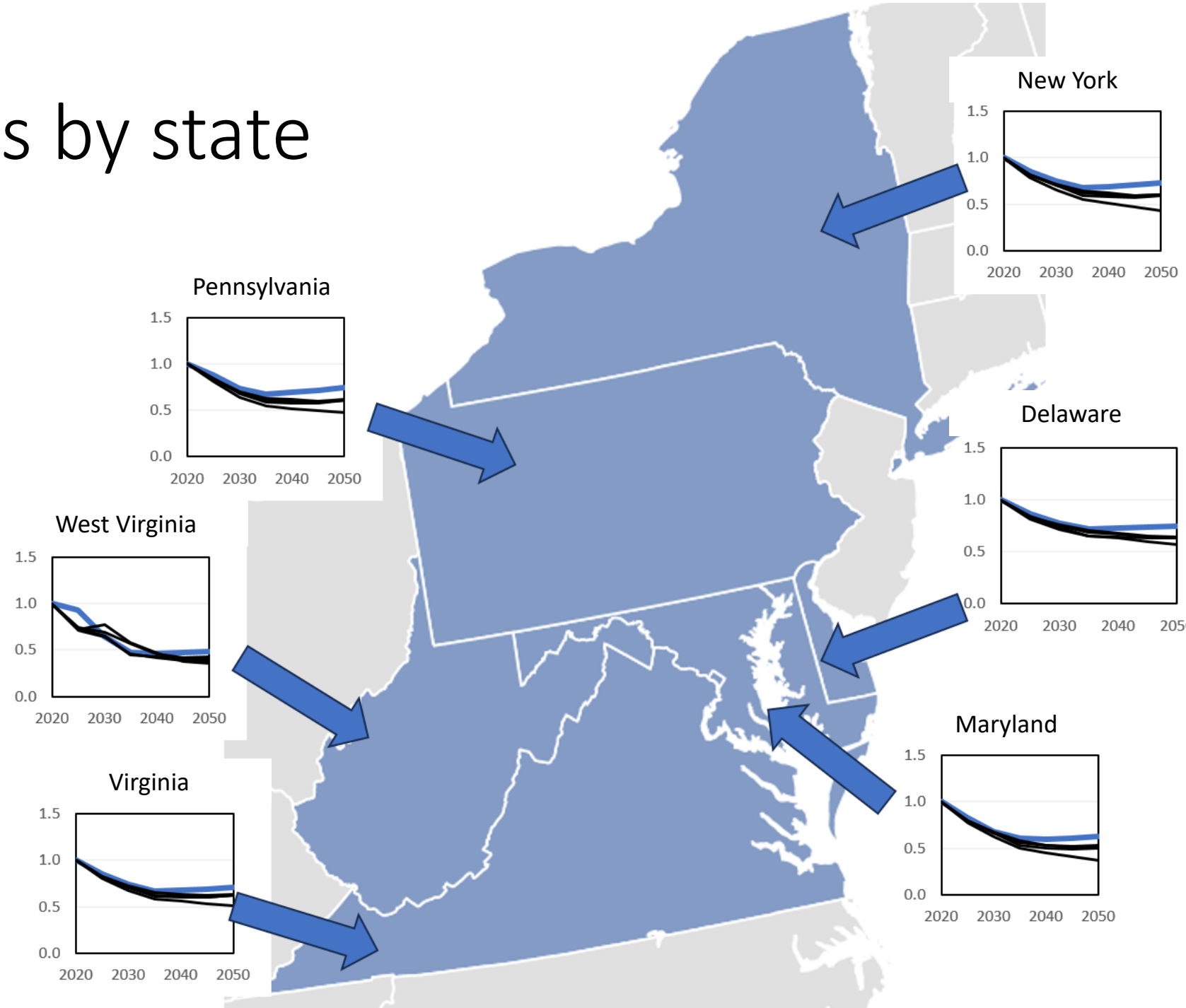
	2023	2026	2028	2032	2050
StateTargets	-1.2%	-2.0%	-1.8%	-2.2%	-7.0%
NetZeroZEV	-0.9%	-2.7%	-5.3%	-10%	-21%

NOx emissions by state

Observations:

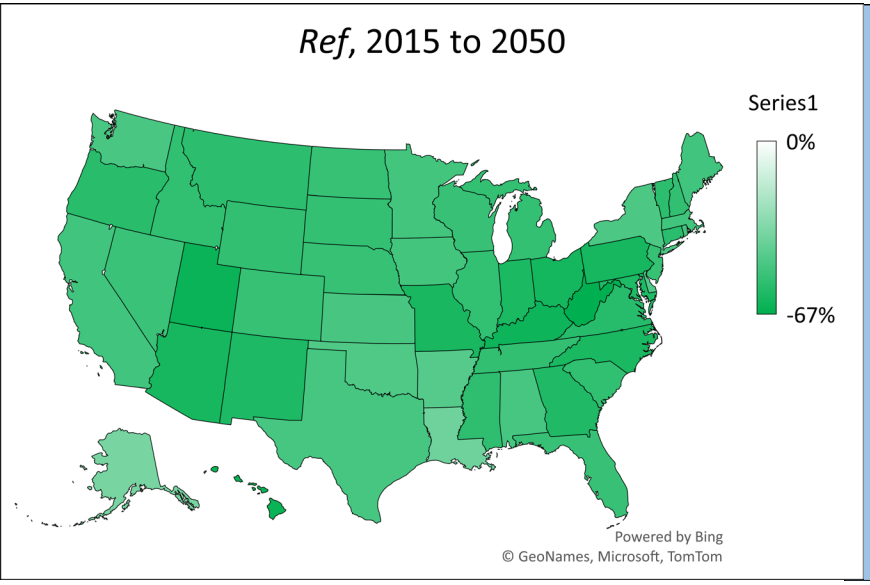
- NOx emissions tend to decrease for every state and across all scenarios
- Emission vary across NetZero scenarios, but tend to be less than in the IRA scenario

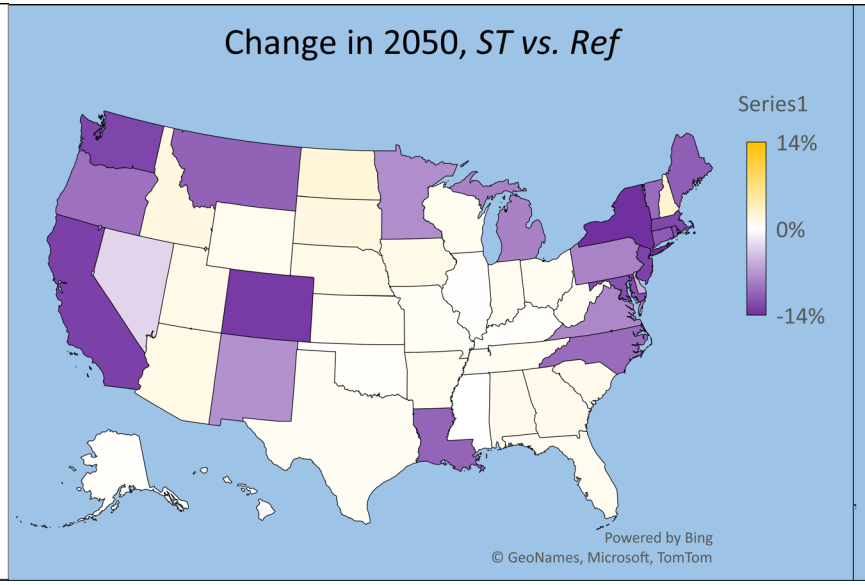
Blue – Reference
Black – NetZero

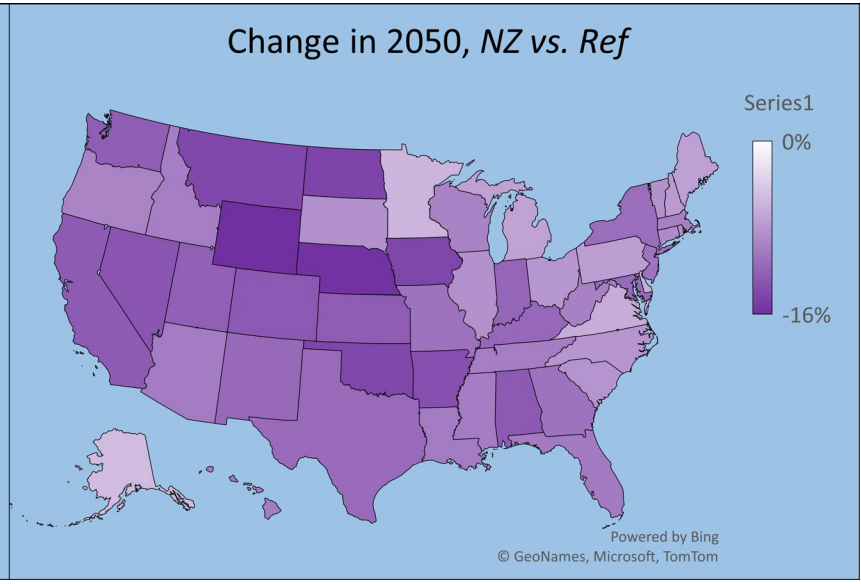


Linking GCAM to CMAQ

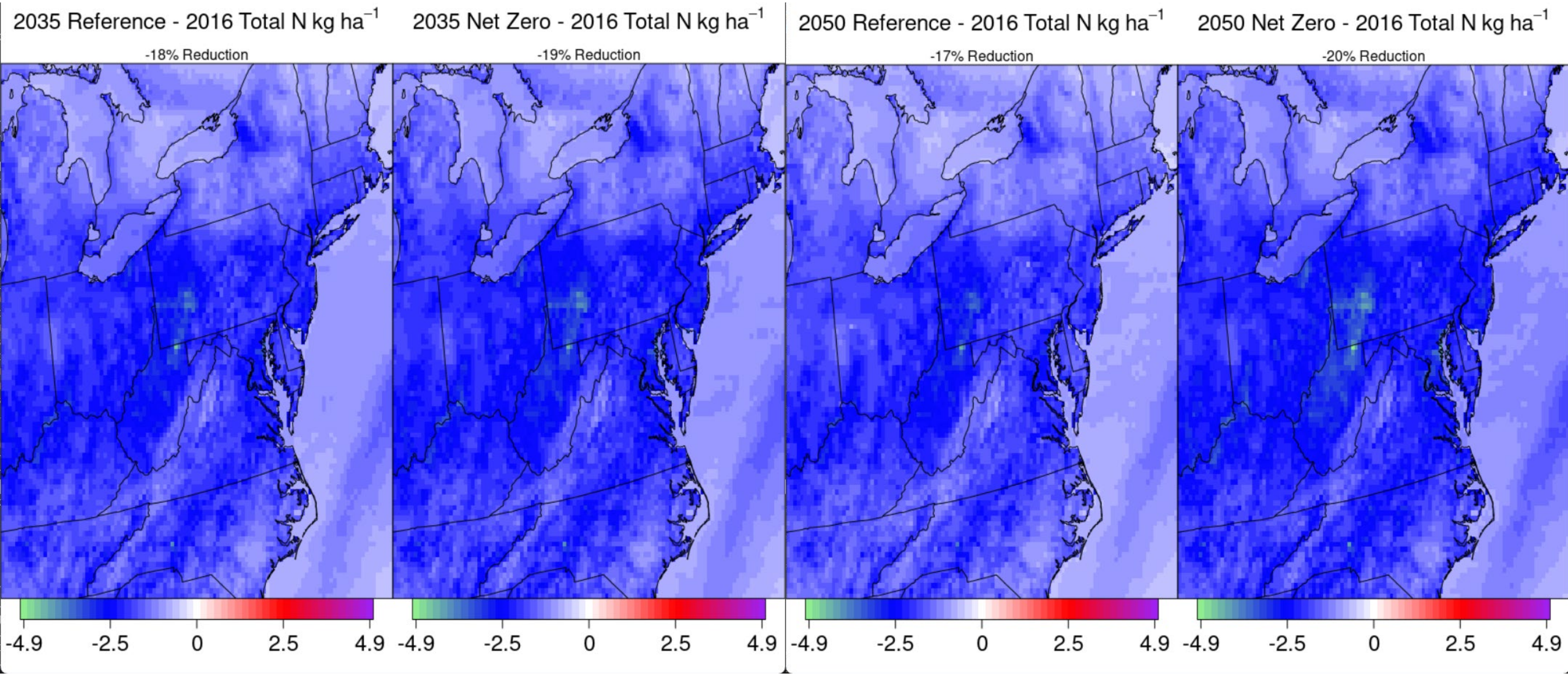
- Use CMAQ's Detailed Emissions Scaling, Isolation, and Diagnostics (DESID) module (Murphy et al., Geosci Model Dev 2021)
- Apply regional (state level) and sectoral scaling factors for NOx, SO2, primary PM25, VOCs, and NH3
  - applied to sources modeled by GCAM, i.e., those related to energy system. While GCAM has an ag sector, we are not linking changes in cropland simulated by GCAM to changes in fertilizer application







Initial Results: Total N deposition



Preliminary Results

- 2002 to 2019 retrospective CMAQ simulations completed using revised methodology and evaluate well against measurements
- GCAM simulations are complete for 2035 and 2050 scenarios are complete
- CMAQ simulations for 2016 and with projected 2035 emissions for reference and NetZero cases are complete
- 2035 Reference case resulted in substantial reductions in total N deposition
  - 18% reduction for the domain
- The NetZero case reduced total N deposition by up to 5%
  - Average reduction 1% for the modeling domain
  - The bulk of the reductions are in the oxidized N deposition
  - Small regional increases in oxidized N deposition seen in power production areas due to increased electrical demand in NetZero case
  - Regional increased in reduced N deposition are due to non-linear atmospheric impacts