EPA United States Environmental Protection Agency

CRC Chesapeake Research Consortium

Evaluating the impacts of decarbonization scenarios on nitrogen deposition

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Modeling Framework

Scenario assumptions

GCAM-USA

GLIMPSE

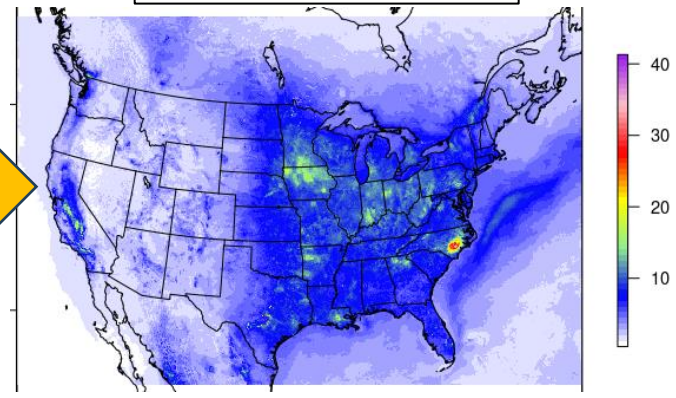
Air-Climate-Energy Planning Tool

Scenario-, state-, category-pollutant-specific growth factors

DESID Interface

CMAQ

Projected air N Deposition



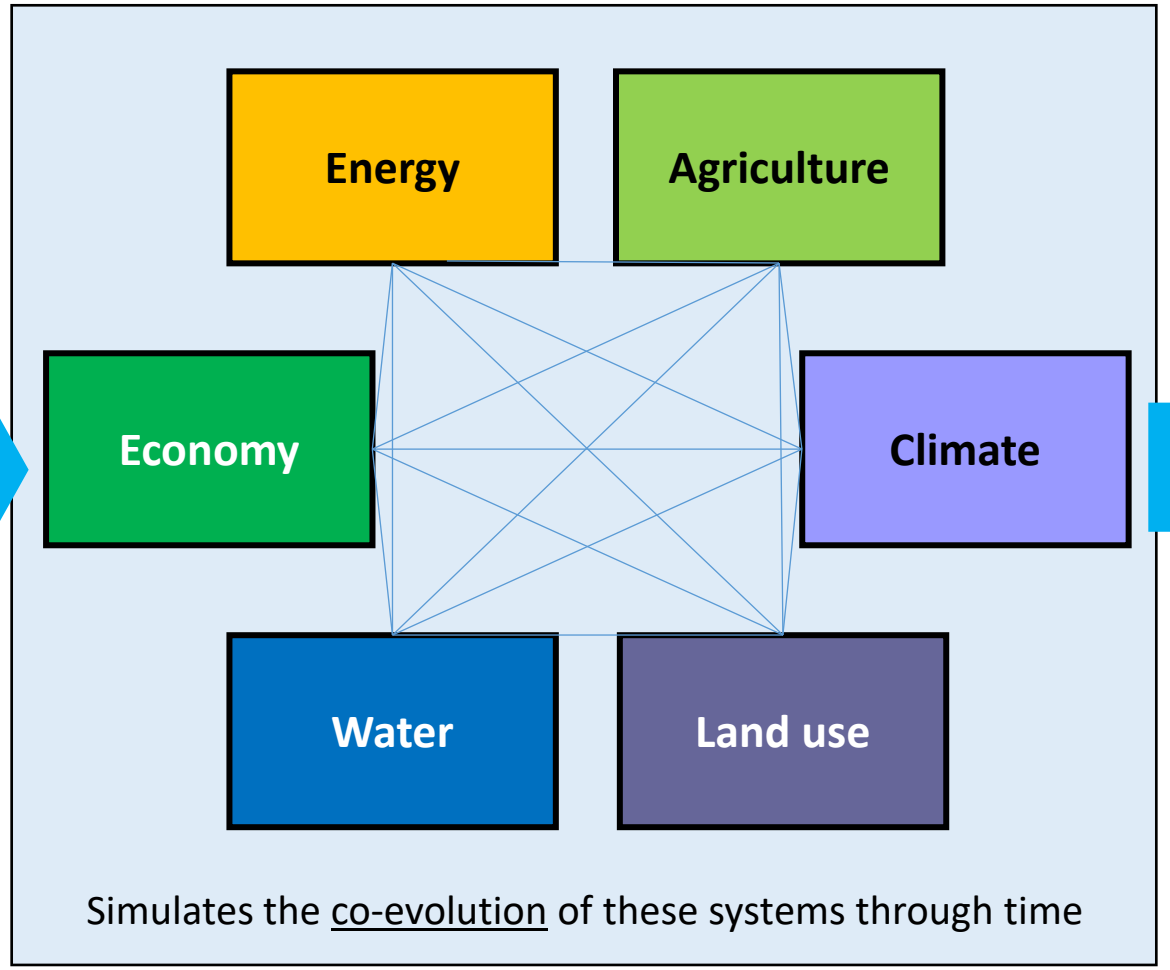
DESID: Detailed Emission Scaling, Isolation, and Diagnostics module

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

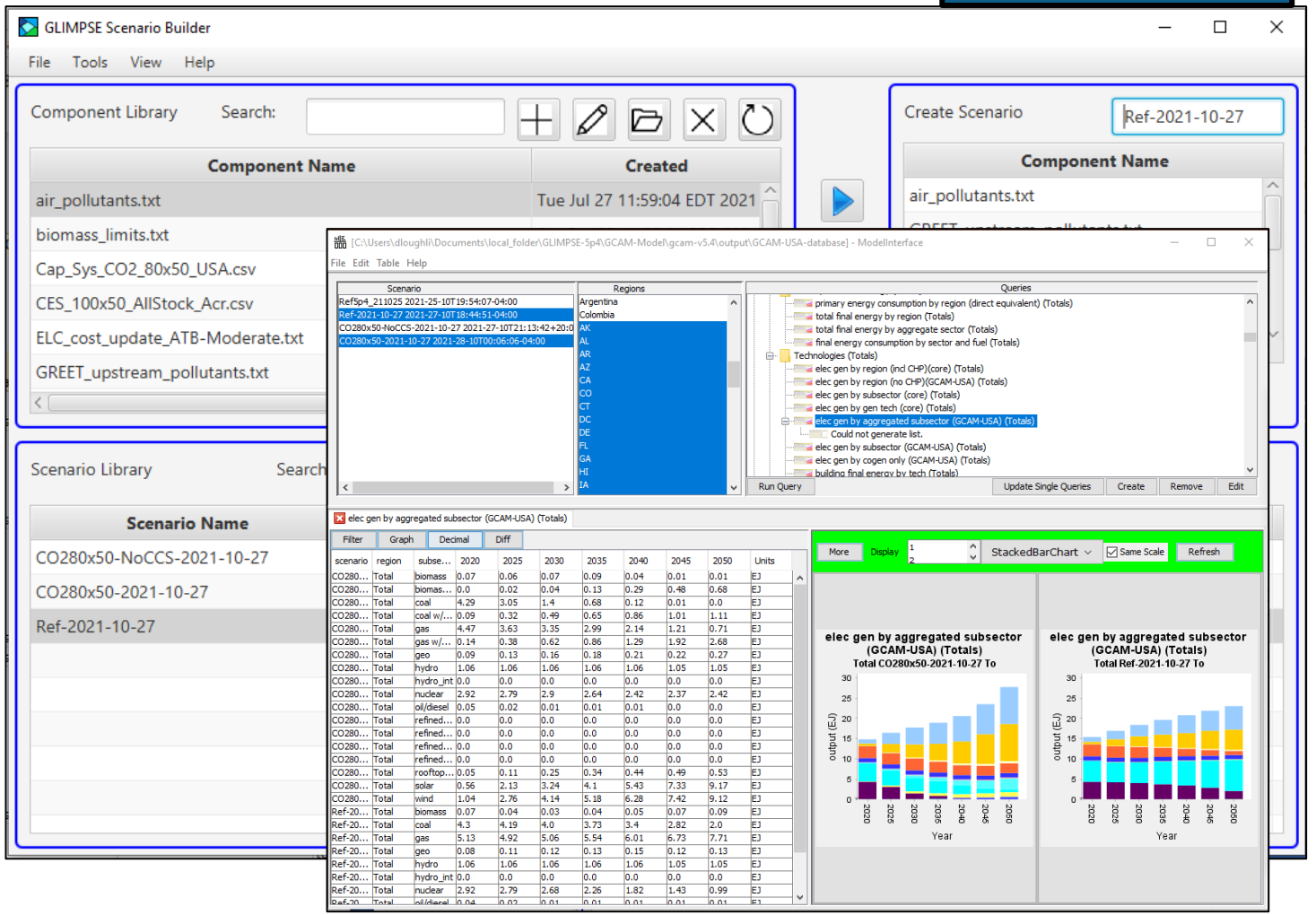
GCAM documentation: http://jgcri.github.io/gcam-doc/

EPA GLIMPSE Project

GLIMPSE: GCAM Long-term Interactive Multi-Pollutant Scenario Evaluator

Decision support system

- GLIMPSE graphical user interface for GCAM
- Supports exploratory analyses
  - Constructing scenarios
  - Managing GCAM execution
  - Visualizing results
- Facilitates policy evaluation
  - Technology market share targets
  - Technology and fuel subsidies or taxes
  - Pollutant taxes and caps
  - Technology availability
- Operational modes
  - Test specific policy or scenario
  - Outline goals; GCAM identifies strategy



https://www.epa.gov/glimpse

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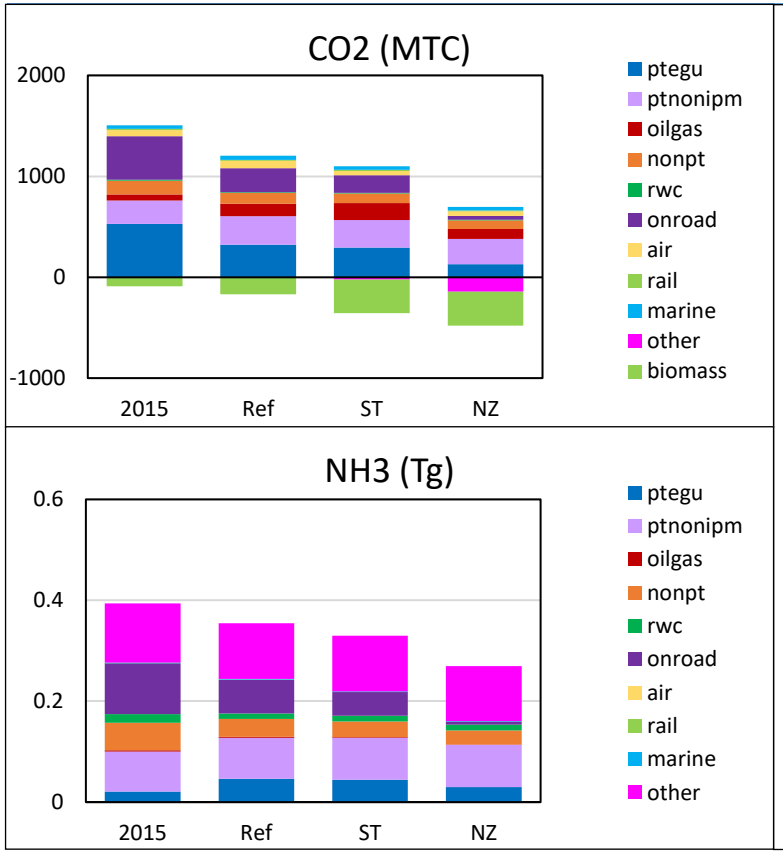
Application

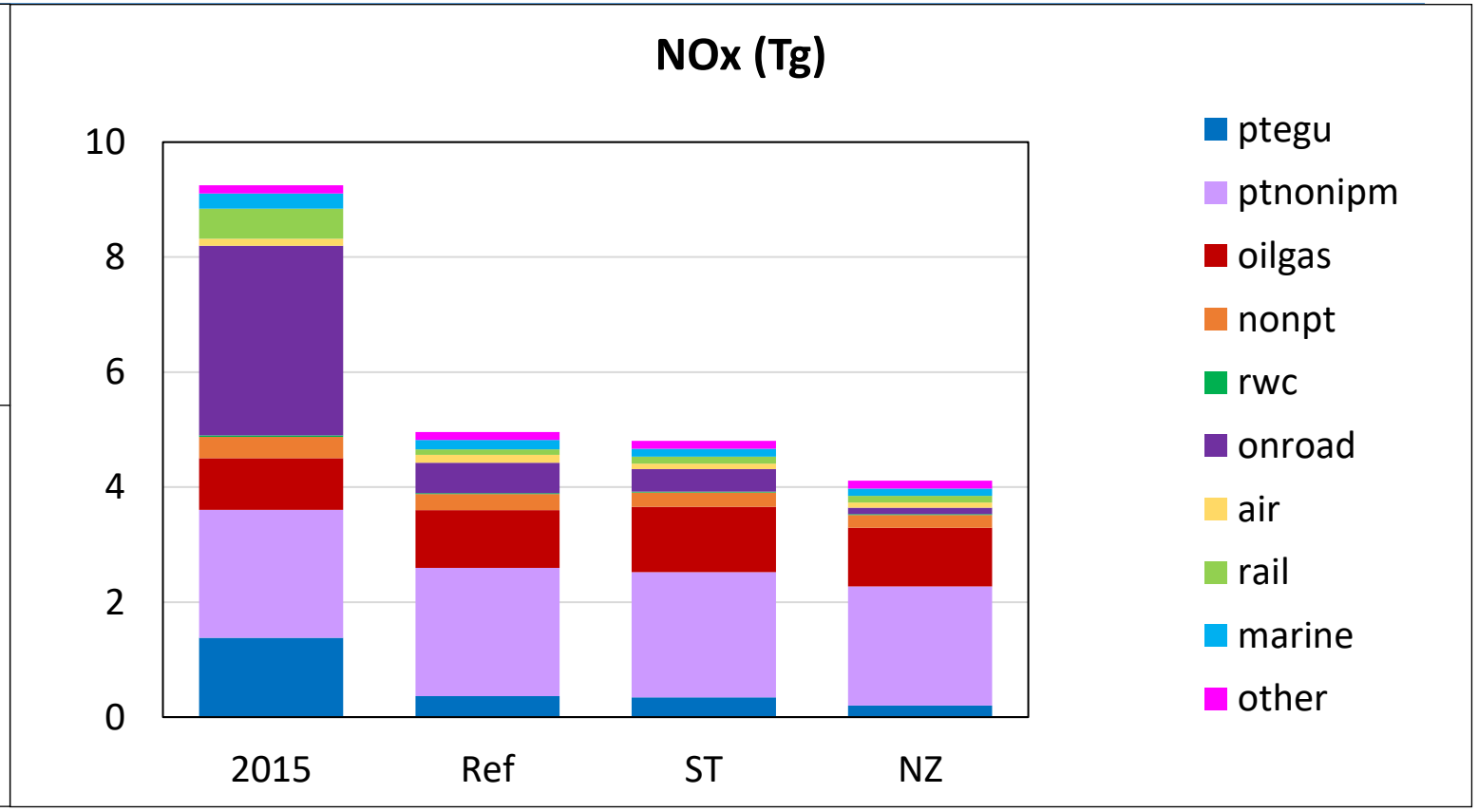
Air pollutant emission co-benefits of deep decarbonization pathways

Scenario Design

- *Reference*: A baseline scenario that includes:
  - limited GHG mitigation and no additional air pollutant control requirements and Inflation Reduction Act
- *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%

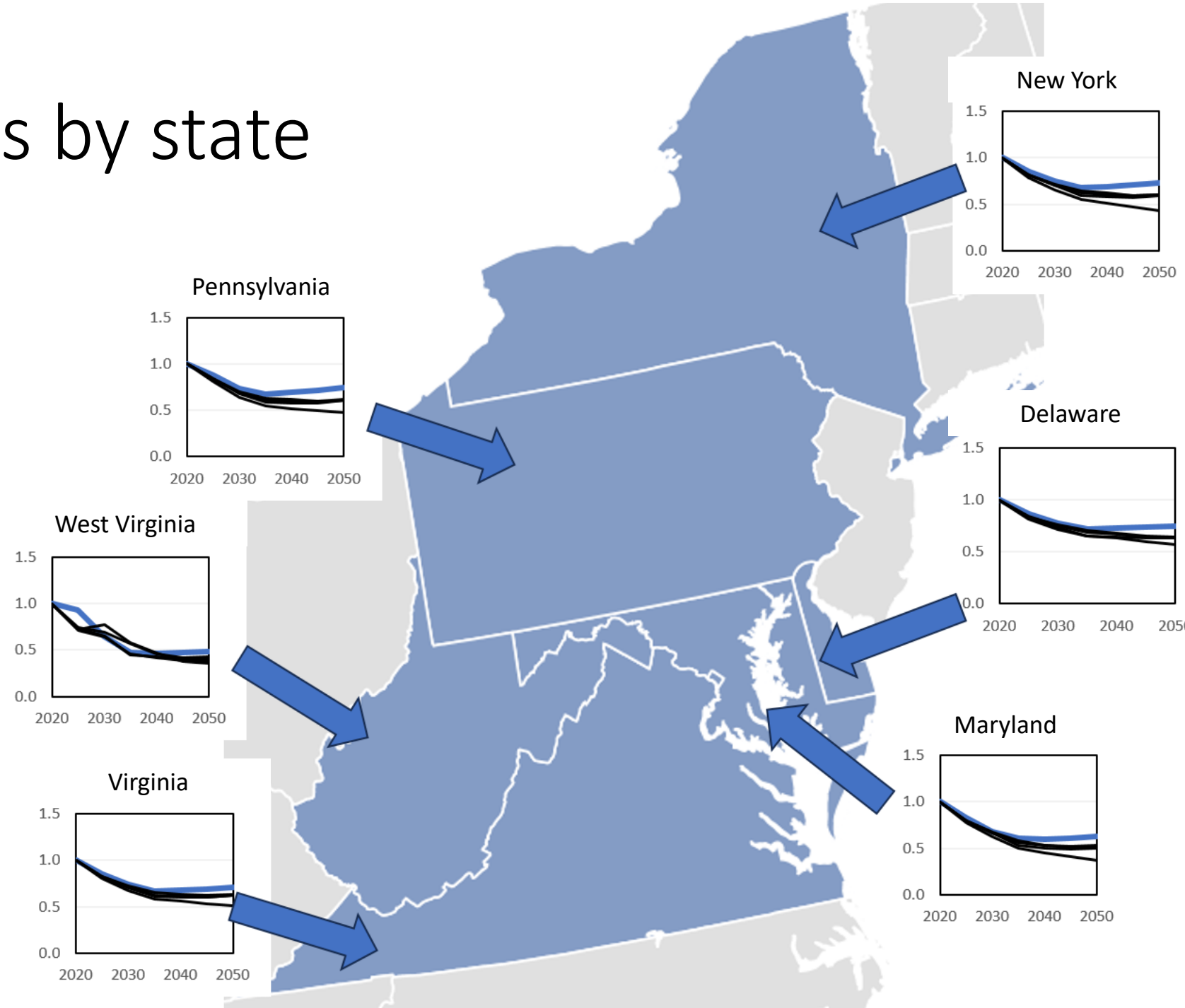
	2023	2026	2028	2032	2050
StateTargets	-1.2%	-2.0%	-1.8%	-2.2%	-7.0%
NetZeroZEV	-0.9%	-2.7%	-5.3%	-10%	-21%

NOx emissions by state

Observations:

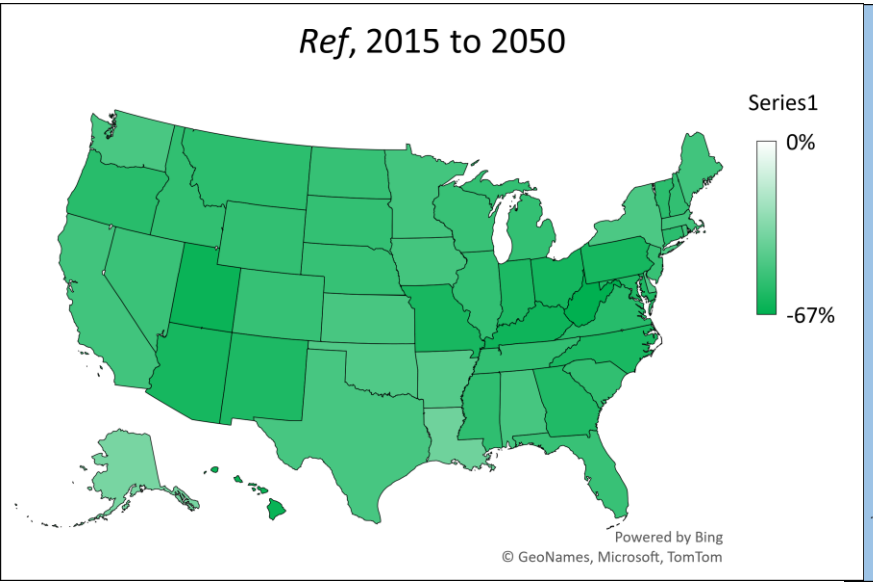
- NOx emissions tend to decrease for every state and across all scenarios
- Emission vary across NetZero scenarios, but tend to be less than in the IRA scenario

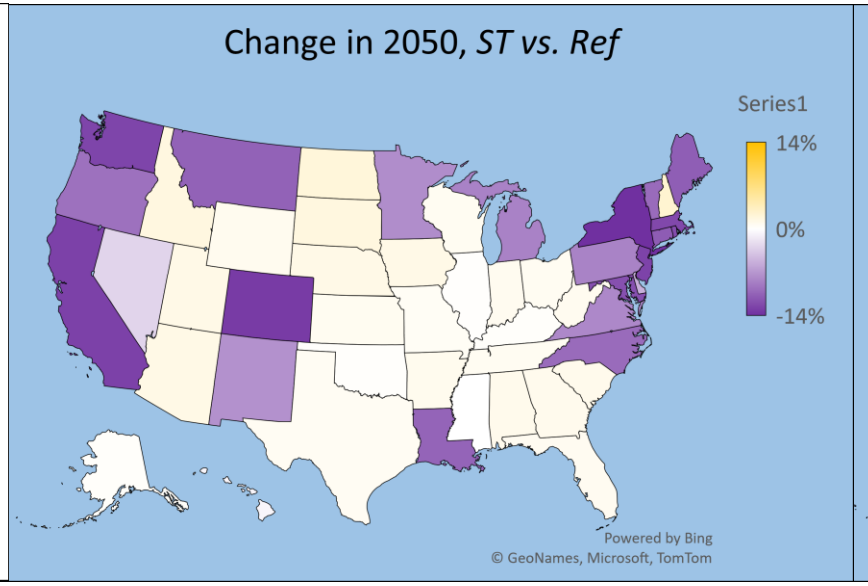
Blue – Reference
Black – NetZero

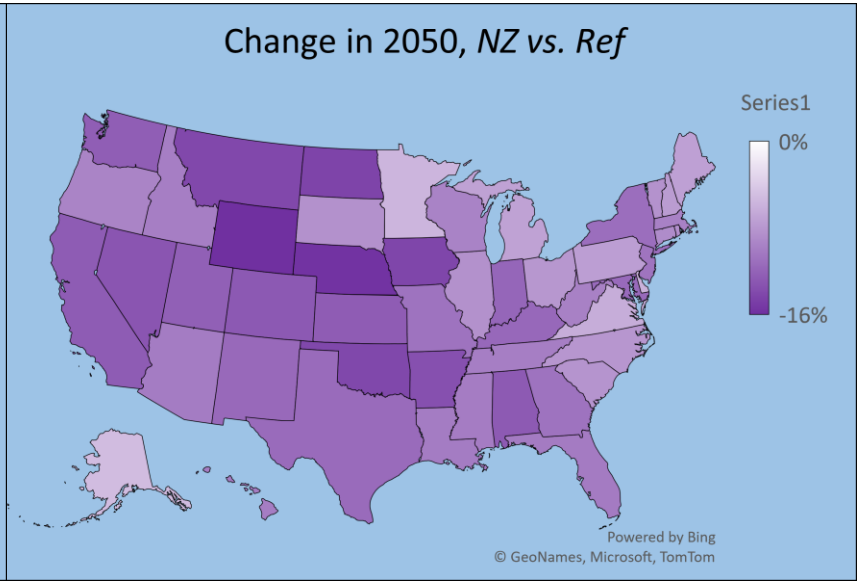


Linking GCAM to CMAQ

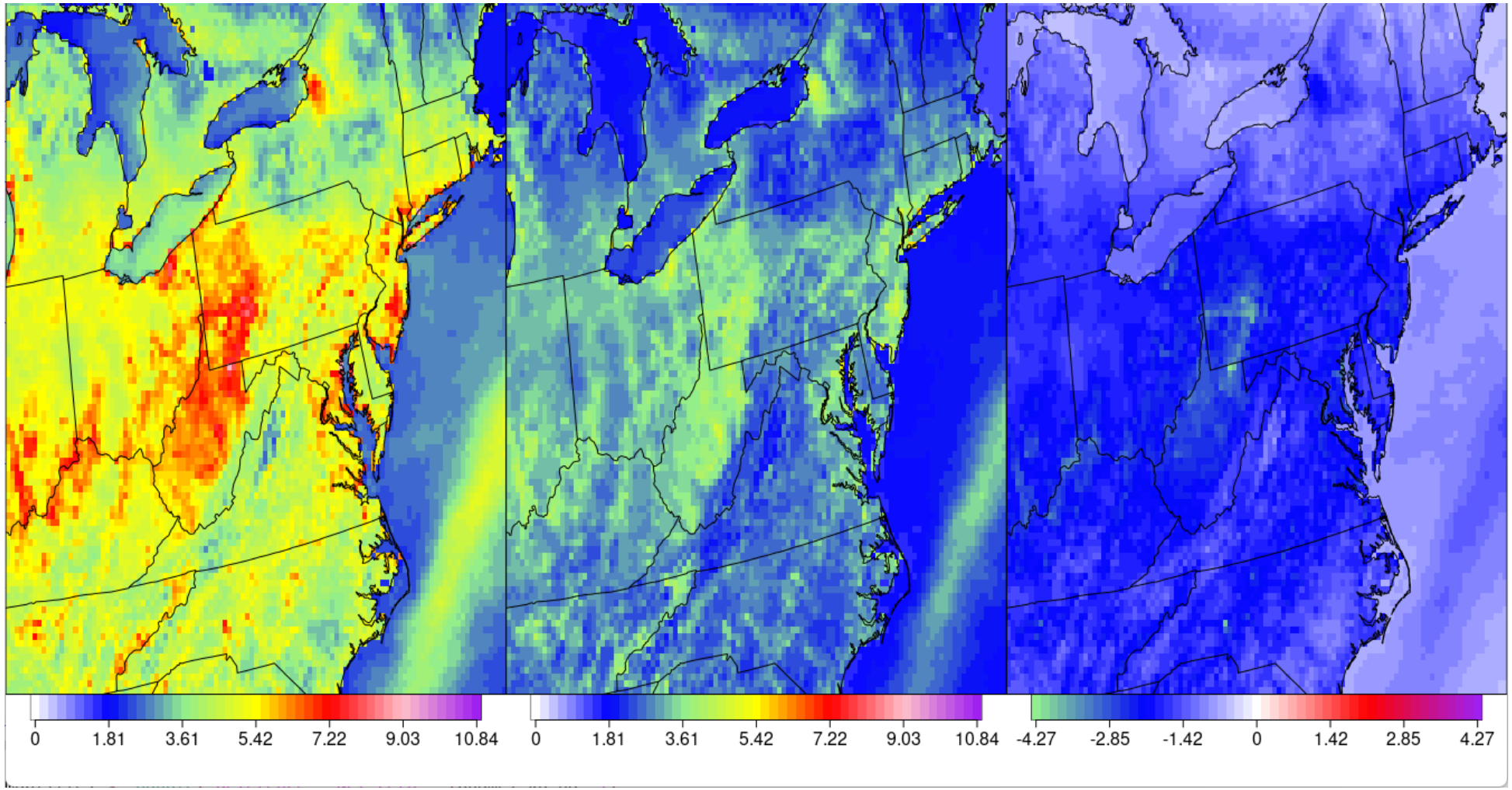
- Use CMAQ's Detailed Emissions Scaling, Isolation, and Diagnostics (DESID) module (Murphy et al., Geosci Model Dev 2021)
- Apply regional (state level) and sectoral scaling factors for NOx, SO2, primary PM25, VOCs, and NH3
  - applied to sources modeled by GCAM, i.e., those related to energy system.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





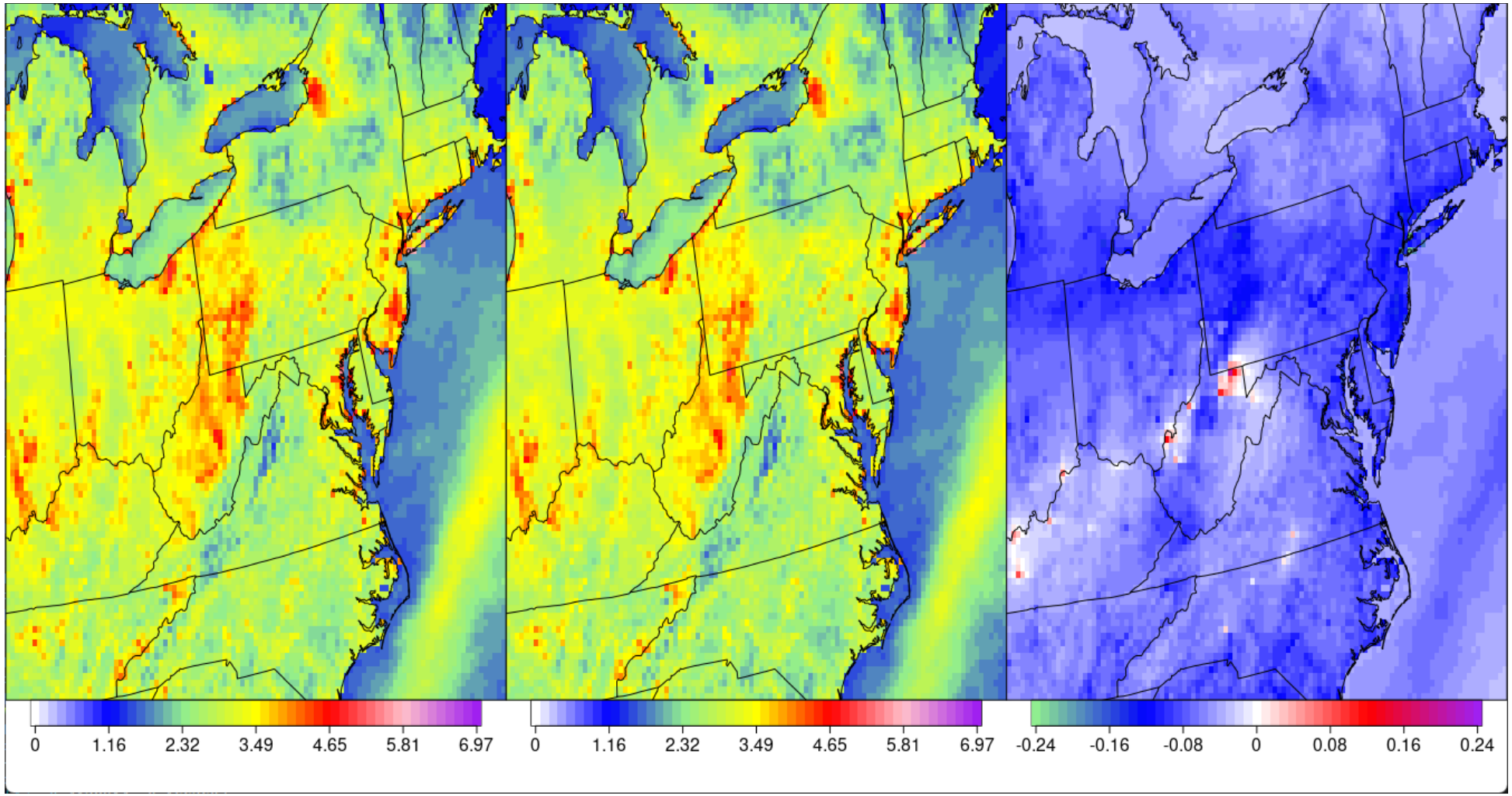


Initial Results: Oxidized N deposition



kg N ha^{-1}

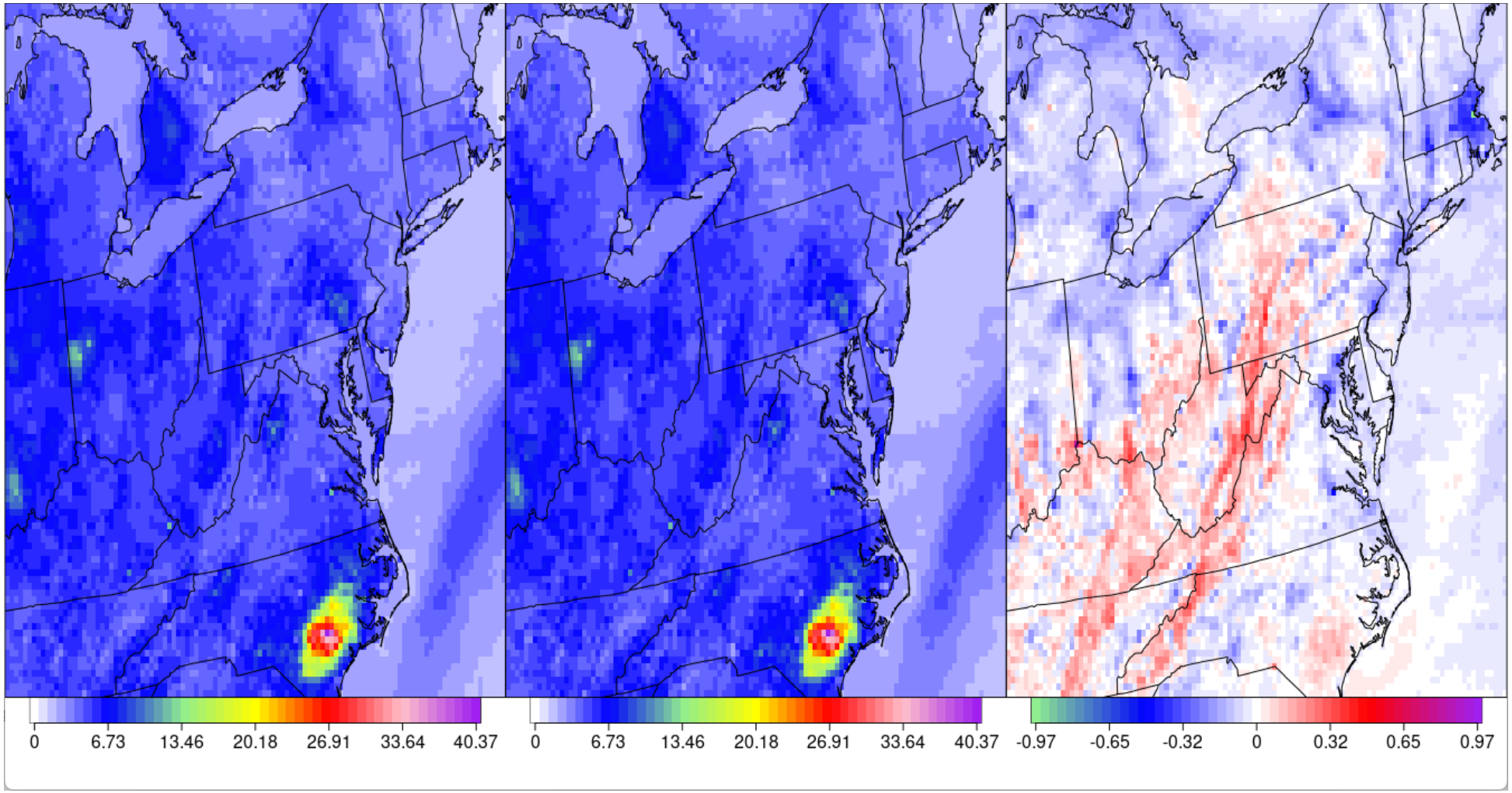
Initial Results: Oxidized N deposition (2035)



kg N ha^{-1}

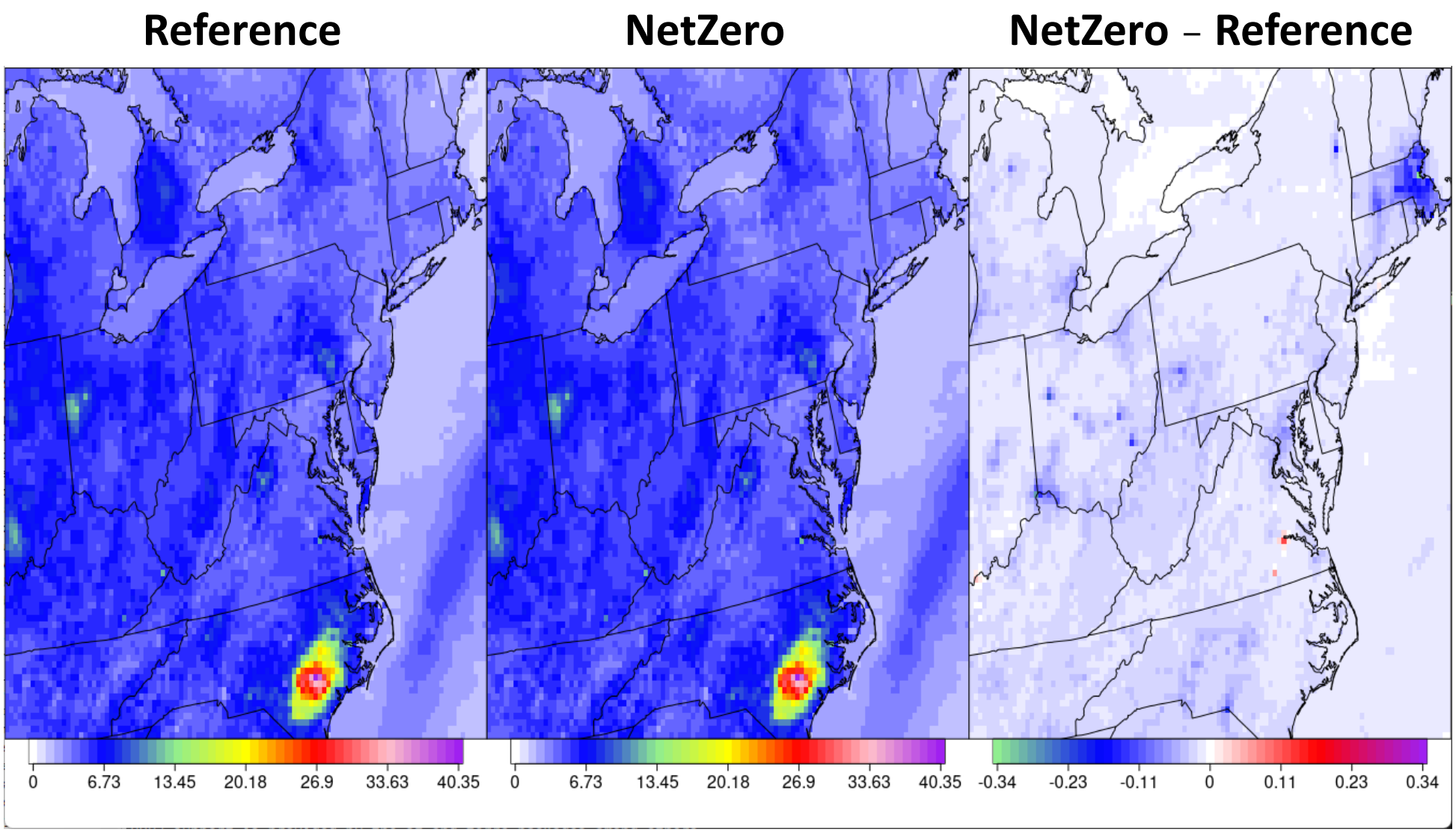
Initial Results: Reduced N deposition

2016 Reference | 2035 Reference | 2035-2016



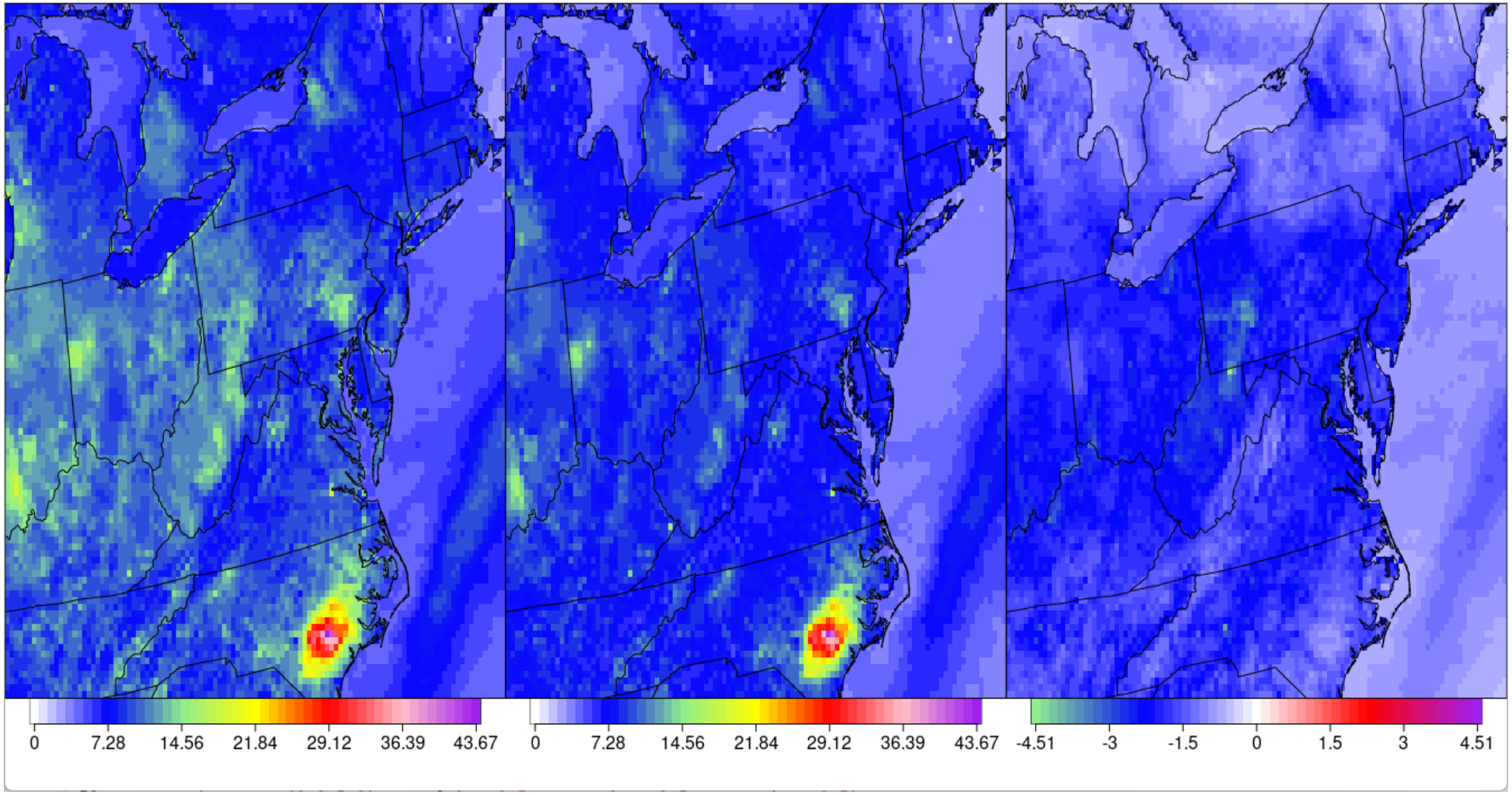
kg N ha^{-1}

Initial Results: Reduced N deposition (2035)



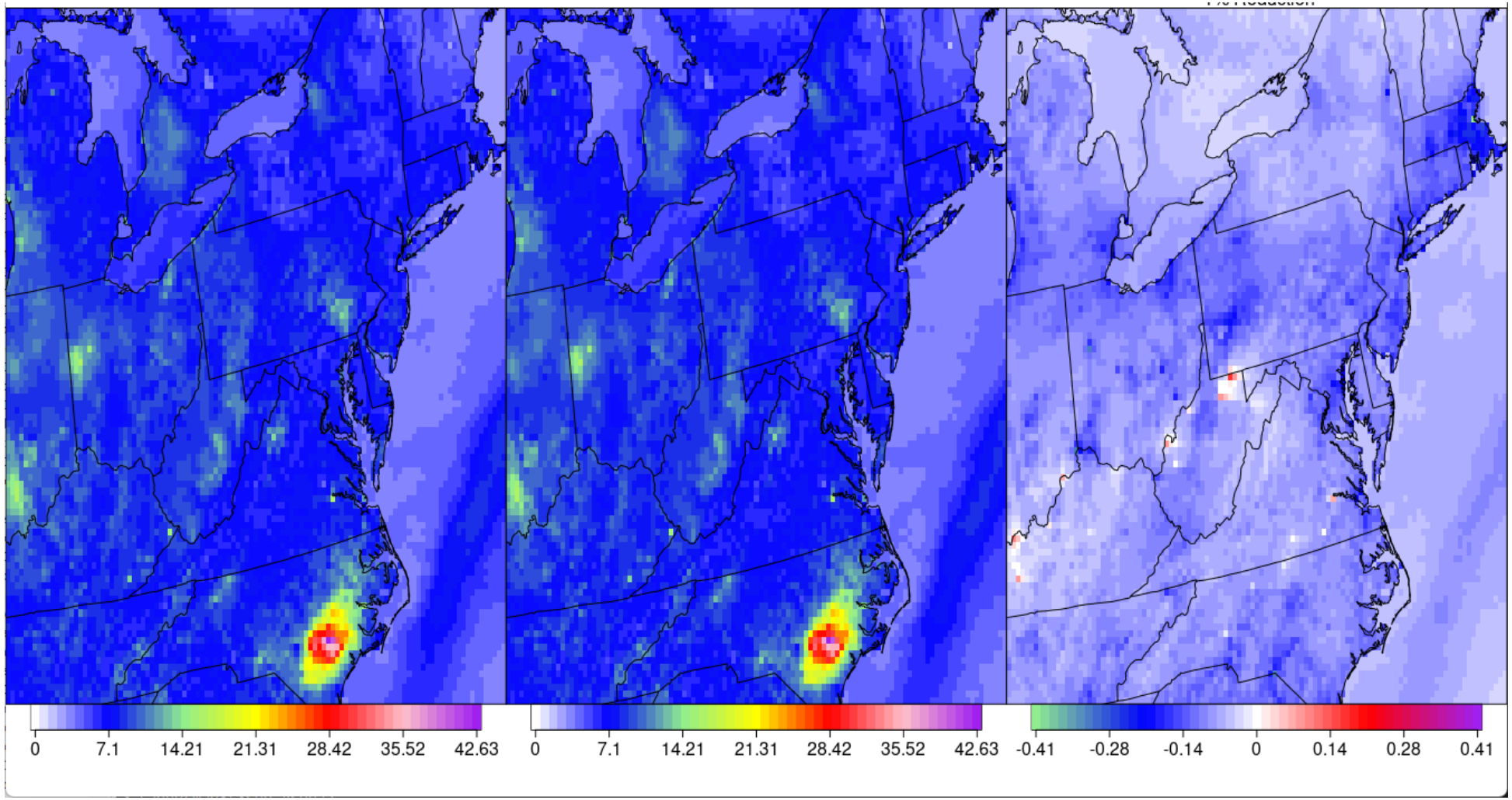
kg N ha^{-1}

Initial Results: Total N deposition



kg N ha^{-1}

Initial Results: Total N deposition (2035)



kg N ha^{-1}

Preliminary Results

- 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

Ongoing Work

- Completion of the 2035 State Targets simulations and 2050 simulations are ongoing
  - To be completed this summer
- Evaluation and post processing
  - Integrated Source Apportionment simulations
- Explore the interactions between NO_x reductions and NH_3 deposition
  - Previous simulations indicate the NO_x and SO_x reductions lead to increased NH_3 deposition near agricultural sources (Pan et al. 2024)
  - Deposition of NH_3 is reduced in this simulation possibly due to addition aerosol formation from aerosol SO_4^{2-} increases