United States Environmental Protection Agency

Introducing and Evaluating SABAQS, a New Reduced Form Air Quality Model

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Background

- Reduced form modeling tools are quicker and easier to implement than photochemical air quality models and are being increasingly applied in the literature to analyze $PM_{2.5}$ impacts from policy scenarios.
- We introduce a new reduced form modeling tool, the Source Apportionment-Based Air Quality Surfaces (SABAQS) method which is one of the first reduced form models in the literature to include ozone in addition to $PM_{2.5}$ impacts (Simon et al., 2023; https://doi.org/10.1039/d3ea00092c).
- We compare SABAQS results against full-form CAMx modeling.

SABAQS methodology

Input Data

- Enhanced Voronoi Neighbor Averaging (eVNA) fused surfaces for ozone and $PM_{2.5}$ component species
- CAMx source apportionment gridded contribution files
  - Anthropogenic Precursor Culpability Assessment (APCA): Apr-Sep average of 8-hr daily maximum (MDA8) ozone
  - Particle source apportionment technology (PSAT): Annual Average speciated $PM_{2.5}$
  - Emissions tagged by location (state) and sector (Electric Generation Units [EGUs] or Oil & Gas)
- Emissions of VOC, NO_X, SO_2, and/or primary $PM_{2.5}$ associated with each tag in the source apportionment modeling
- Emissions of VOC, NO_X, SO_2, and/or primary $PM_{2.5}$ associated with each tag for the emissions scenario being analyzed

Methodology Steps

The SABAQS method starts with the eVNA fused surface for ozone or $PM_{2.5}$ component species. SABAQS then linearly scales ozone and $PM_{2.5}$ component species based on emissions levels. The source apportionment contributions for each tag are applied to adjust the eVNA fused surface based on emissions changes associated with each tag.

$$C_{g,i} = \mathrm{eVNA}_g \times \left(\sum_{t=1}^{T} \frac{C_{g,t}\, S_{t,i}}{C_{g.\mathrm{Tot}}} + \right)$$

- $C_{g,i}$ is the estimated concentration in grid-cell, "g", for emissions scenario, "i" for summer season ozone and/or annual average PM species concentrations;
- $eVNA_g$ is the eVNA concentration in grid-cell "g" for summer season ozone and/or annual average PM species concentrations;
- $C_{g,Tot}$ is the total modeled concentration in grid-cell "g" from all sources in the source apportionment modeling;
- $C_{g,t}$ is the modeled source apportionment contribution in grid-cell, "g", from source apportionment tag, "t";
- $S_{t,i}$ is the scaling factor for emissions tag, "t" and scenario "i". For each pollutant, $S_{t,i}$ is calculated as the ratio of emissions associated with the tag, "t", in emissions scenario, "i", to emissions associated with tag, "t", in the modeled source apportionment case

Emissions species used to calculate scaling factors for ozone and $PM_{2.5}$ component species

Pollutant	Emissions used to calculate $S_{t,i}$
Ozone formed under NO_X-limited conditions (O3N)	Ozone season (May-Sep) NO_x
Ozone formed under VOC-limited conditions (O3V)	Ozone season (May-Sep) VOC
Ammonium sulfate	Annual SO_2
Ammonium nitrate	Annual NO_x
Primary OC, EC, and crustal PM	Annual primary $PM_{2.5}$

Scenarios for Comparing SABAQS to CAMx

- Five emissions sensitivities are used to evaluate SABAQS against CAMx
  - For each emissions sensitivity, ozone and speciated $PM_{2.5}$ surfaces are created for a basecase scenario and for an emissions sensitivity scenario
  - The emissions sensitivity impact is calculated as the difference between the basecase and emissions sensitivity surfaces

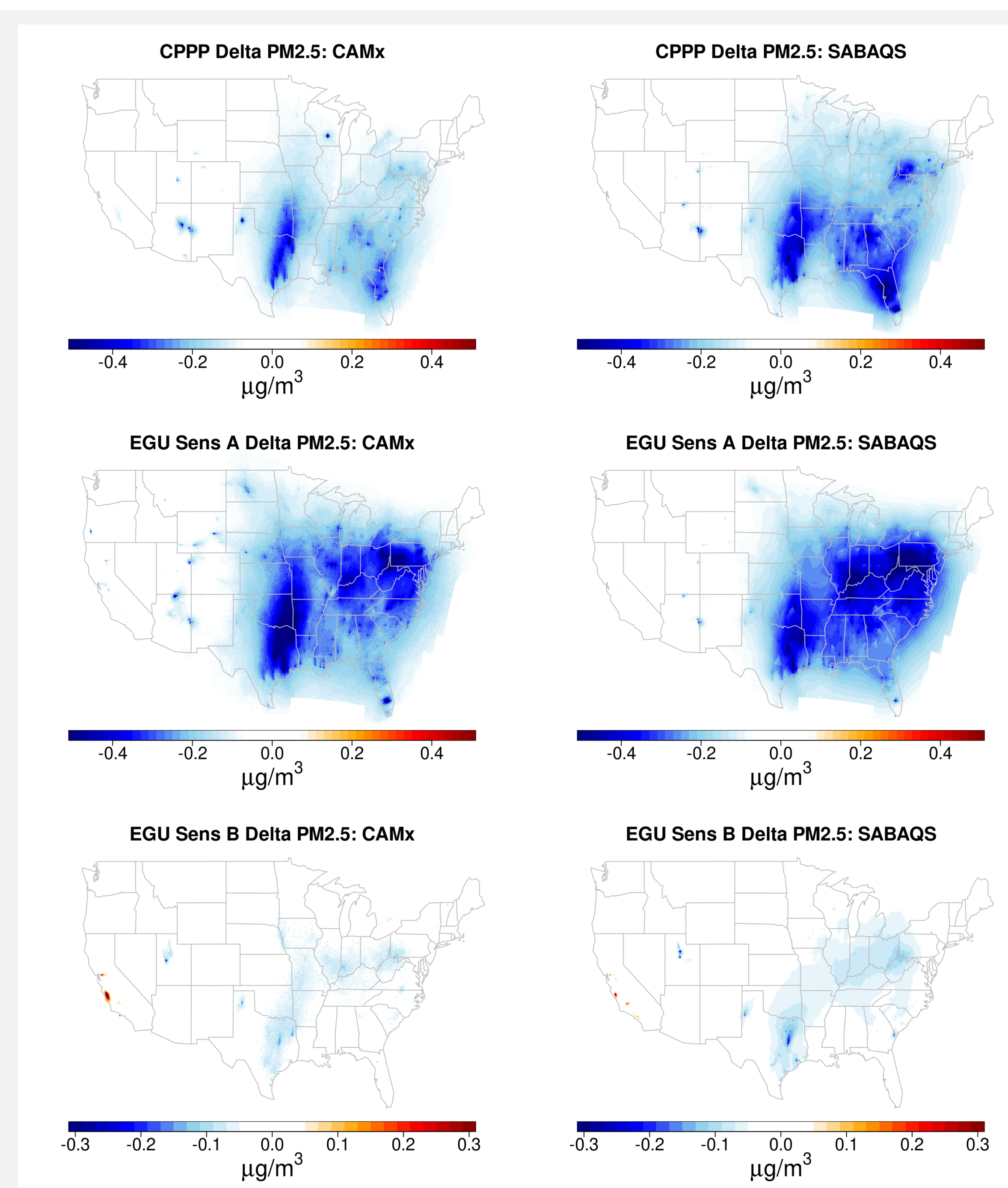
Emissions sensitivity scenarios used to compare SABAQS predictions to CAMx results

Emissions Sensitivity	Description	Emissions Species Involved	Modeled Year	Source Apportionment Input Dataset
CPPP	Proposed option 1S of the Clean Power Plan Rule	VOC, NO_x, SO_2, $PM_{2.5}$, and NH_3*	2025	APCA and PSAT state-level EGU sector tagging
EGU Sensitivity A	Emissions differences from older (2023en) vs newer (2023fj) EPA EGU projections	VOC, NO_x, SO_2, $PM_{2.5}$, and NH_3*	2023	APCA and PSAT state-level EGU sector tagging
EGU Sensitivity B	Projected EGU sector emissions changes to occur between 2023 and 2026 based on EPA 2016v2 emissions platform	VOC, NO_x, SO_2, $PM_{2.5}$, and NH_3*	2023	APCA and PSAT state-level EGU sector tagging
O&G Sensitivity A	35% cut of oil & gas sector VOC emissions	VOC	2026	APCA state-level oil & gas sector tagging**
O&G Sensitivity B	Projected oil & gas sector emissions changes to occur between 2023 and 2026 based on EPA 2016v2 emissions platform	VOC, NO_x	2026	APCA state-level oil & gas sector tagging**

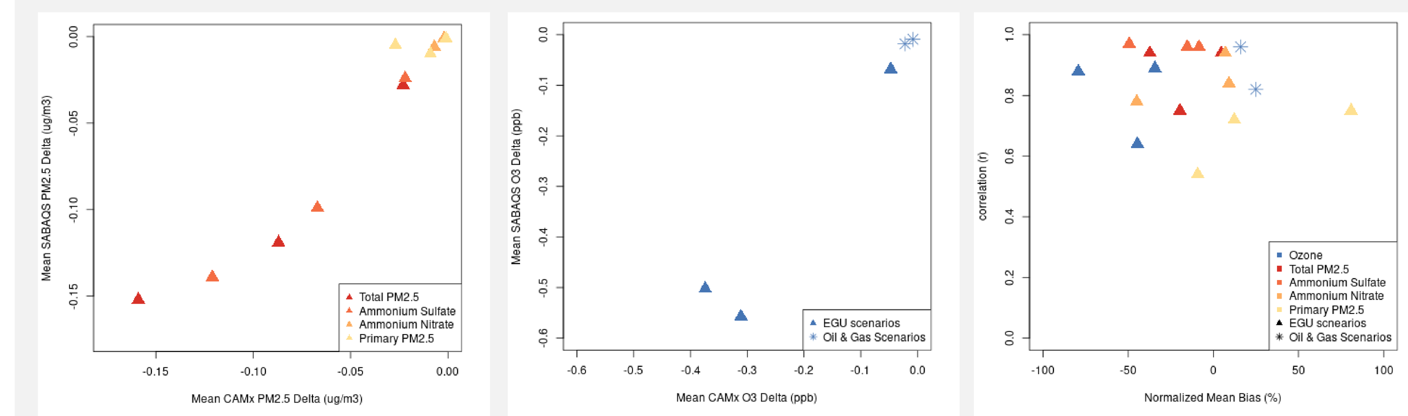
*NH_3 emissions only impact CAMx results and are not accounted for in SABAQS

**Only the subset of oil and gas SCCs impacted by EPA's "Proposed Standards of Performance for New, Reconstructed, and Modified Sources and Emissions Guidelines for Existing Sources: Oil and Natural Gas Sector Climate Review" are tracked in the source apportionment tags. This led to mismatches in available VOC emissions to reduce in ND for O&G sensitivity A and available NOx emissions to reduce in CA for O&G sensitivity B.

Comparison of CAMx & SABAQS $PM_{2.5}$ Impacts



CAMx vs SABAQS Overall Performance Stats



Comparison of impacts predicted by CAMx vs SABAQS for each scenario for: national mean $PM_{2.5}$ impacts (left) and national mean O_3 impacts (center). CAMx vs SABAQS correlation and NMB for each scenario for $PM_{2.5}$ and O_3. Negative NMB values indicate SABAQS has larger magnitude reductions than CAMx. (right)

Comparison of CAMx & SABAQS O_3 Impacts