Appendix E-2d

Regional Haze Modeling for Southeastern VISTAS II Regional Haze Analysis Project 2028 CAMx Version 6.32 and 6.40 Comparison Report

Benchmark Run #4

August 17, 2020

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Regional Haze Modeling for Southeastern VISTAS II Regional Haze Analysis Project 2028 CAMx Version 6.32 and 6.40 Comparison Report

Task 6 Benchmark Report #4
Covering Benchmark Run #4

Prepared for:

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Under Contract No. V-2018-03-01

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Abbreviations/Acronym List

Alpine	Alpine Geophysics, LLC
CAMx	Comprehensive Air Quality Model with Extensions
dv	Deciview
DV	Design Value
EGU	Electric Generating Unit
EPA	Environmental Protection Agency
ERG	Eastern Research Group, Inc.
ERTAC	Eastern Regional Technical Advisory Committee
FLM	Federal Land Manager
FR	Federal Register
IPM	Integrated Planning Model
km	kilometer
$\mu g/m^3$	microgram per cubic meter
NAAQS	National Ambient Air Quality Standard
NO_x	Oxides of nitrogen
OAQPS	Office of Air Quality Planning and Standards
O_3	Ozone
OC	Organic carbon
OSAT	Ozone Source Apportionment Technology
PEC	Primary elemental carbon
PM	Particulate matter
$PM_{2.5}$	Fine particle; primary particulate matter less than or equal to 2.5 microns in aerodynamic diameter
PNH4	Particulate ammonium
PNO3	Particulate nitrate
POA	Primary Organic Aerosol
PSAT	Particulate Source Apportionment Technology
PSO4	Particulate sulfate
R^2	Pearson correlation coefficient squared
RADM-AQ	Regional Acid Deposition Model – aqueous chemistry
RHR	Regional Haze Rule
SESARM	Southeastern States Air Resource Managers, Inc.
SIP	State Implementation Plan
SMAT-CE	Software for Model Attainment Test – Community Edition
SMOKE	Sparse Matrix Operator Kernel Emissions
SO_2	Sulfur dioxide
SOA	Secondary organic aerosol
SOAP	Secondary organic aerosol partitioning
tpy	Tons per year
U.S.	United States
VISTAS	Visibility Improvement – State and Tribal Association of the Southeast
VOC	Volatile organic compounds

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1.0 INTRODUCTION

1.1 Overview

Southeastern States Air Resource Managers, Inc. (SESARM) has been designated by the United States (U.S.) Environmental Protection Agency (EPA) as the entity responsible for coordinating regional haze evaluations for the ten Southeastern states of Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee, Virginia, and West Virginia. The Eastern Band of Cherokee Indians and the Knox County, Tennessee local air pollution control agency are also participating agencies. These parties are collaborating through the Regional Planning Organization known as Visibility Improvement - State and Tribal Association of the Southeast (VISTAS) in the technical analyses and planning activities associated with visibility and related regional air quality issues. VISTAS analyses will support the VISTAS states in their responsibility to develop, adopt, and implement their State Implementation Plans (SIPs) for regional haze.

The state and local air pollution control agencies in the Southeast are mandated to protect human health and the environment from the impacts of air pollutants. They are responsible for air quality planning and management efforts including the evaluation, development, adoption, and implementation of strategies controlling and managing all criteria air pollutants including fine particles and ozone (O_3) as well as regional haze. This project will focus on regional haze and regional haze precursor emissions. Control of regional haze precursor emissions will have the additional benefit of reducing criteria pollutants as well.

The 1999 Regional Haze Rule (RHR) identified 18 Class I Federal areas (national parks greater than 6,000 acres and wilderness areas greater than 5,000 acres) in the VISTAS region. The 1999 RHR required states to define long-term strategies to improve visibility in Federal Class I national parks and wilderness areas. States were required to establish baseline visibility conditions for the period 2000-2004, natural visibility conditions in the absence of anthropogenic influences, and an expected rate of progress to reduce emissions and incrementally improve visibility to natural conditions by 2064. The original RHR required states to improve visibility on the 20% most impaired days and protect visibility on the 20% least impaired days.[1] The RHR

[1] RHR summary data is available at: http://vista.cira.colostate.edu/Improve/rhr-summary-data/

requires states to evaluate progress toward visibility improvement goals every five years and submit revised SIPs every ten years.

EPA finalized revisions to various requirements of the RHR in January 2017 (82 FR 3078) that were designed to strengthen, streamline, and clarify certain aspects of the agency's regional haze program including:

A. Strengthening the Federal Land Manager (FLM) consultation requirements to ensure that issues and concerns are brought forward early in the planning process.

B. Updating the SIP submittal deadlines for the second planning period from July 31, 2018 to July 31, 2021 to ensure that they align where applicable with other state obligations under the Clean Air Act. The end date for the second planning period remains 2028; that is, the focus of state planning will be to establish reasonable progress goals for each Class I area against which progress will be measured during the second planning period. This extension will allow states to incorporate planning for other Federal programs while conducting their regional haze planning. These other programs include: the Mercury and Air Toxics Standards, the 2010 1-hour sulfur dioxide (SO_2) National Ambient Air Quality Standards (NAAQS); the 2012 annual fine particle ($PM_{2.5}$) NAAQS; and the 2008 and 2015 ozone NAAQS.

C. Adjusting interim progress report submission deadlines so that second and subsequent progress reports will be due by: January 31, 2025; July 31, 2033; and every ten years thereafter. This means that one progress report will be required midway through each planning period.

D. Removing the requirement for progress reports to take the form of SIP revisions. States will be required to consult with FLMs and obtain public comment on their progress reports before submission to the EPA. EPA will be reviewing but not formally approving or disapproving these progress reports.

The RHR defines "clearest days" as the 20% of monitored days in a calendar year with the lowest deciview (dv) index values. "Most impaired days" are defined as the 20% of monitored days in a calendar year with the highest amounts of anthropogenic visibility impairment. The long-term strategy and the reasonable progress goals must provide for an improvement in visibility for the most impaired days since the baseline period and ensure no degradation in visibility for the clearest days since the baseline period.

1.2 2028 CAMx 6.32 and CAMx 6.40 Comparison

Recent EPA 2011el and 2028el platform simulations were performed with the Comprehensive Air Quality Model with Extensions (CAMx) version 6.32. Since that time the CAMx model has been updated to include better physical treatment, and to correct any model flaws that were discovered after the release of 6.32.

Under subcontract to Eastern Research Group, Inc, (ERG), Alpine Geophysics, LLC (Alpine) has executed two air quality simulations for the 2028el projection year modeling platform; one run with CAMx 6.32 and one with CAMx 6.40. We note that CAMx 6.50 has now been released, however that model release was too late to be included with sufficient certainty in the VISTAS II project schedule.

This comparison is to document the differences in model estimates between 2028el simulated with CAMx 6.32 and 2028elv3 CAMx 6.40 as is discussed in the VISTAS II Modeling Protocol[2] in Section 6.5.2 model comparison number 4.

2.0 DIFFERENCES BETWEEN CAMX 6.32 AND 6.40 SIMULATIONS

Differences in modeled output concentrations between the 2028el CAMx 6.32 and 2028elv3 6.40 simulations were as a result both of changes to the CAMx model code, changes to the model configuration and changes to the emissions inventory.

2.1 Model Code Differences

Many updates to the CAMx model were implemented between the 6.32 and 6.40 release. According to the CAMx 6.40 release notes, the significant changes included:

[2] "Regional Haze Modeling for Southeastern VISTAS II Region Haze Analysis Project, Final Modeling Protocol." Prepared for SESARM under Contract No. V-2018-03-01. Prepared by Alpine Geophysics, LLC and Eastern Research Group, Inc. June 27, 2018.

1. Updates to the chemistry to include a condensed halogen mechanism for ocean-borne inorganic reactive iodine, hydrolysis of isoprene-derived organic nitrate and SO_2 oxidation on primary crustal fine particulate matter (PM). This update includes the changes to the Ozone and Particulate Source Apportionment Technology (OSAT/PSAT) algorithms;

2. Inclusion of in-line inorganic iodine emissions to support halogen chemical mechanisms;

3. A major revision to the secondary organic aerosol partitioning (SOAP) secondary algorithm;

4. Updates to the Regional Acid Deposition Model – aqueous chemistry (RADM-AQ) algorithm; and

5. A major revision to the wet deposition algorithm to identify assumptions or processes that were unintentionally or otherwise unreasonably limiting gas and PM update into precipitation. The wet deposition algorithm was simplified and improved in several ways, resulting in the increased scavenging of gases and PM.

2.2 Configurations Difference

In addition to the model version, the CAMx 6.32 and 6.40 simulations contained differences in the EPA modeling platform that had been made subsequent to the 2011el/2028el model release. In the most current 2023en simulation, EPA developed new photolysis rates and ozone column data. These updates were included in the updated modeling platform and resulting CAMx 6.40 simulation and were consistent with those used in the VISTAS II 2011el simulations.

Another configuration difference is how the boundary conditions were mapped for speciation in the two versions of the model. EPA and the VISTAS CAMx 6.32 and 6.40 simulations all used the same boundary condition files. However, when CAMx was updated from 6.32 to 6.40 the species in the secondary organic aerosol (SOA) scheme changed. The SOA5, SOA6, and SOA7 were removed and SOA3 and SOA4 were redefined. Neither EPA nor this study remapped the boundary conditions to account for this change. EPA examined the regional haze summary data for all Class I areas and found the total organic carbon (OC) species (not just SOA) accounted for 1-5% of the boundary condition impairment at the Southeastern Class I areas.[3] This is a small impact on regional haze and the impact of SOA on regional haze is even smaller.

2.3 Emissions Differences

Finally, there are notable emissions inventory differences used in the modeling by SESARM compared to EPA's 2028el modeling platform. SESARM updated the 2028 emissions inventory used in this analysis (2028elv2) with changes to both electric generating unit (EGU) and non-EGU point source emissions. A summary of the emission differences are presented in the Task 2 emissions inventory report[4] for this study and summarized in Section 4.1.

3.0 CONFIRMATION METHODOLOGY

The presented comparison of model simulations are based on annual and 24-hour $PM_{2.5}$ design values as generated from the output of the two 12US2-based simulations; CAMx 6.32 with 2028el and CAMx 6.40 with 2028elv2 emissions. This report does not compare hourly concentrations for each PM species as the model version, platform configuration and processing methods, and the underlying projection year emissions inventories differ significantly between the two model runs making it difficult, if not impossible, to determine the cause of any differences seen in concentrations. We also provide a comparison of gridded 12-kilometer (km) annual elevated and low level emissions for the domain. The metric for comparison of the design values are the absolute difference (Equation 1) and percent difference (Equation 2) defined as:

(Equation 1) $$(C_{6.40} - C_{6.32})$$

(Equation 2) $$\frac{(C_{6.40} - C_{6.32})}{(C_{6.32})}$$

Where $C_{6.40}$ is the design value at each receptor for the CAMx 6.40 simulation and $C_{6.32}$ is the design value at each receptor for the CAMx 6.32 simulation. The order of the comparison

3 Brian Timin, EPA Office of Air Quality Planning and Standards (OAQPS) personal communication October 11, 2018.
4 Southeastern States Air Resource Managers, Inc. "Southeastern VISTAS II Regional Haze Analysis Project - Task 2 Emission Inventory Report." Prepared by Eastern Research Group, Inc. under Contract V-2018-03-01. Revised Final. August 28, 2018.

variables differs from earlier benchmark reports as the intention of this report is to confirm appropriate use of the CAMx 6.40 configuration as compared to the CAMx 6.32 configuration and therefore by using the switched order, we give more weight to the CAMx 6.40 run. For the emission comparison plots, only Equation 1 results were calculated for each grid cell and plotted for review.

The results are presented for each receptor in the VISTAS states within the larger 12US2 domain for each of the two design values. Spatial maps are presented for the domain as a whole. On each spatial emissions difference plot presented, the maximum positive and negative values, along with the grid cell in which these occur, are presented at the top of the graphic. The coordinates refer to the row and columns of the cell referenced to the cell coordinates on the bottom (column) and left (row) of the graphic.

Scatterplots of the daily average concentrations of ozone and the various calculated PM species in local standard time at the Interagency Monitoring for Protected Visual Environment (IMPROVE) monitors across all modeled days are also presented with the CAMx 6.40 results plotted on the x-axis and the CAMx 6.32 results plotted on the y-axis.

3.1 CAMx Species Mapping

Updates to the CAMx model between version 6.32 and 6.40 necessitated making changes to how the individual CAMx species were aggregated to the presented species. The CAMx species mapping between the two compared versions are presented in Table 3-1.

Table 3-1. Species Mapping from CAMx into Aggregated Species

Aggregated Species	CAMx 6.32 Species	CAMx 6.40 Species
Ozone	O3	O3
$PM_{2.5}$	PSO4+PNO3+PNH4+SOA1+SOA2+SOA3+SOA4+SOA5+SOA6+SOA7+SOPA+SOPB+POA+PEC+FPRM+FCRS+NA+PCL	PSO4+PNO3+PNH4+SOA1+SOA2+SOA3+SOA4+SOPA+SOPB+POA+PEC+FPRM+FCRS+NA+PCL
Sulfate	PSO4	PSO4
Nitrate	PNO3	PNO3
Organic Matter (OM)	SOA1+SOA2+SOA3+SOA4+SOA5+SOA6+SOA7+SOPA+SOPB+POA[1]	SOA1+SOA2+SOA3+SOA4+SOPA+SOPB+POA

[1] SOAH was not included in the 6.32 comparison since it was not included as an output species in the EPA simulation.

4.0 CAMX 6.32 2028EL AND CAMX 6.40 2028ELV3 COMPARISON

This section presents comparisons of the simulations using CAMx 6.32 2028el and CAMx 6.40 2028elv3 performed on the Alpine computer system. Emissions presented are the post-processed results of the Sparse Matrix Operator Kernel Emissions (SMOKE) emissions tool, including oxides of nitrogen (NO_X), volatile organic compounds (VOC), and speciated $PM_{2.5}$ components (e.g., particulate nitrate (PNO3), particulate sulfate (PSO4), etc.) for elevated and low level sources. Annual and 24-Hour $PM_{2.5}$ design values are the result of running each of the model platforms through the Software for the Modeled Attainment Test - Community Edition (SMAT-CE) tool to generate receptor-level values.

4.1 Emissions

Annual emission summaries have been prepared from the model-ready input files for both elevated and low level sources. Elevated sources include all CEM-based emissions in the modeling platform, non-EGU point sources with explicit latitude and longitude release coordinates and calculated plume rise greater than or equal to twenty (20) meters, emissions from wildfires, and international commercial marine emissions not otherwise associated with specific U.S. states. Low-level sources are comprised of all other anthropogenic source types including non-EGU point sources with a calculated plume rise of less than twenty (20) meters, agricultural and prescribed fires, biogenic and other natural source emissions, and commercial marine emissions associated with sources assigned to specific U.S. states. Results presented include maps of the 12US2 domain with annual emissions (tons per year) and emission differences by grid cell and pollutant. Table 4-1 presents summary results by pollutant over the entire 12US2 domain for elevated and low level comparisons. Figures 4-1 through 4-7 present the annual emissions and emission differences for elevated sources by pollutant in the 12US2 modeling domain. Figures 4-8 through 4-15 present annual emissions and emission differences for low level sources, by pollutant, in the 12US2 modeling domain.

As expected with the changes in emission inventories between the EPA 2028el and SESARM 2028elv2 platforms, we see the largest changes in elevated (point source) emissions largely concentrated in the southeastern sector of the modeling domain with scattered differences in other regions. These changes are related to the replacement of 2028 Integrated Planning Model (IPM) EGU emissions with 2028 Eastern Regional Technical Advisory Committee

(ERTAC) EGU emissions in the 2028elv2 emissions platform. These differences are consistent with the emission inventory changes documented[4] for this project. Low-level emission changes are also seen predominantly in the VISTAS states for areas where emission inventory modifications were applied for this analysis with scattered changes elsewhere due to the replacement of IPM with ERTAC as noted above. Note that as a result of reprocessing the 2028elv2 elevated emissions to correct an earlier omission, results are reported in this document 2028elv3 where appropriate.

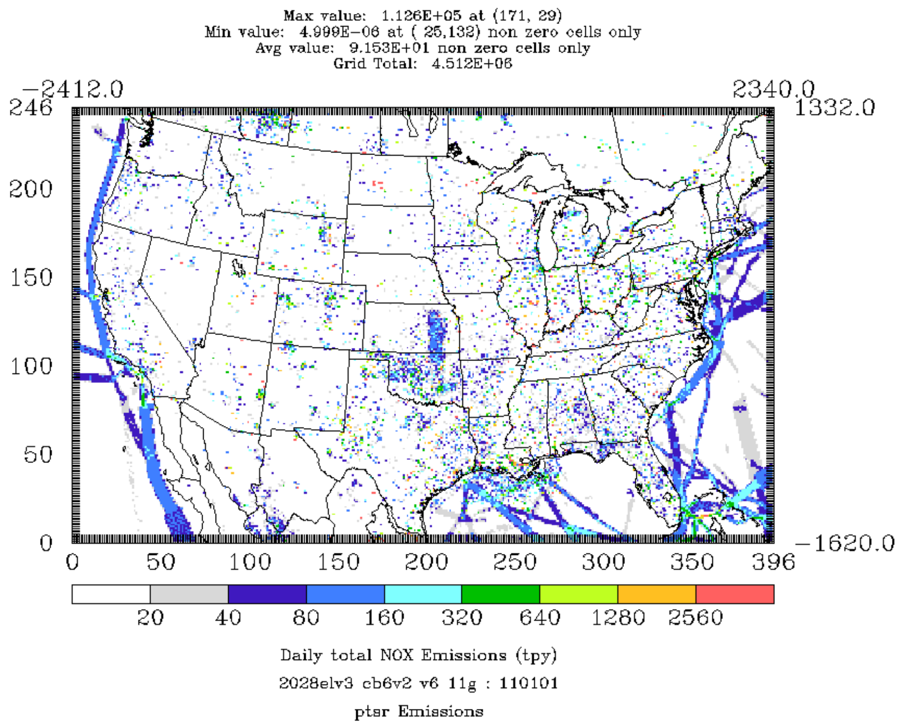
Table 4-1. Comparison of 2028el CAMx 6.32 and 2028elv2/v3 CAMx 6.40 Annual Emissions

		2028 Annual Emissions				
		CAMx 6.40	6.40 - 6.32	Domain Wide	Individual Grid Cell	
Source Type	Pollutant	Total Tons	Total Change	% Change	Max Increase	Max Decrease
Elevated	NO_X	4,512,000	489,300	10.84%	25,810	-25,250
Elevated	VOC[a]	4,707,000	-8,096	-0.17%	2,046	-2,615
Elevated	SO_2	3,977,000	795,000	19.99%	54,910	-38,780
Elevated	PEC	261,300	16,620	6.36%	358	-126
Elevated	PNH4[b]	14,690	3.47E+01	0.24%	32	-15
Elevated	PNO3	15,460	8.64E+02	5.59%	20	-25
Elevated	POA	1,734,000	12,240	0.71%	323	-1,269
Elevated	PSO4	83,570	1,814	2.17%	388	-298
Low Level	NO_X	7,302,000	5,788	0.08%	632	-1,695
Low Level	VOC	60,670,000	45,170	0.07%	2,615	-861
Low Level	SO_2	321,500	2,623	0.82%	1,487	-501
Low Level	PEC	151,900	324	0.21%	77	-9
Low Level	PNH4[b]	6,696	13	0.20%	6	-3
Low Level	PNO3	4,671	44	0.95%	12	-5
Low Level	POA	909,600	-2,630	-0.29%	54	-87
Low Level	PSO4	198,300	1,223	0.62%	82	-19

[a] VOC emissions are approximate since calculated from CB6 speciated emissions.
[b] PNH4 = Particulate ammonium

Annual NO_X Emissions – Elevated Sources

2028elv3



Difference (2028elv3 - 2028el)

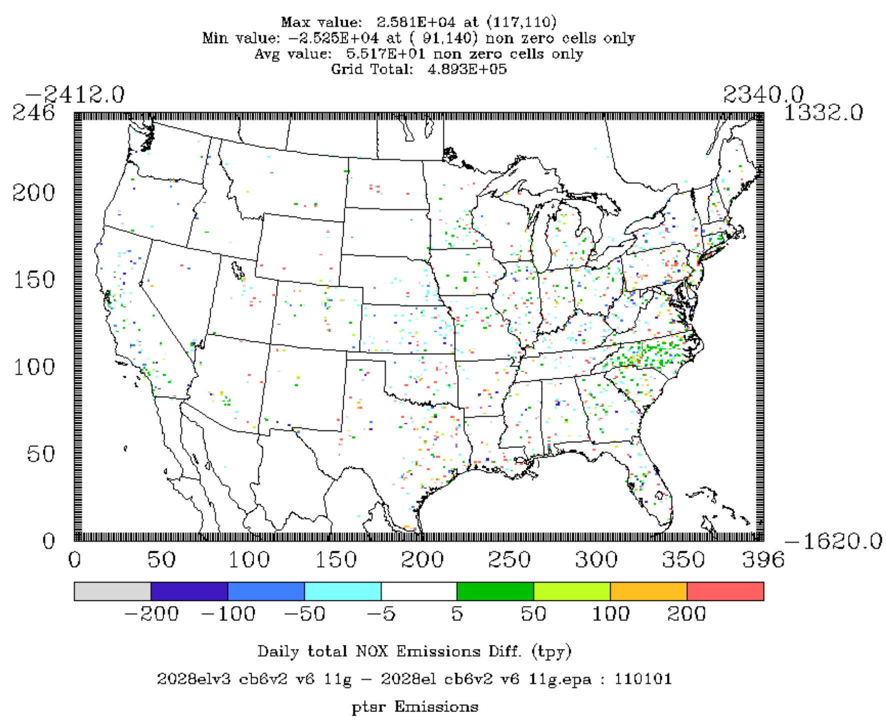
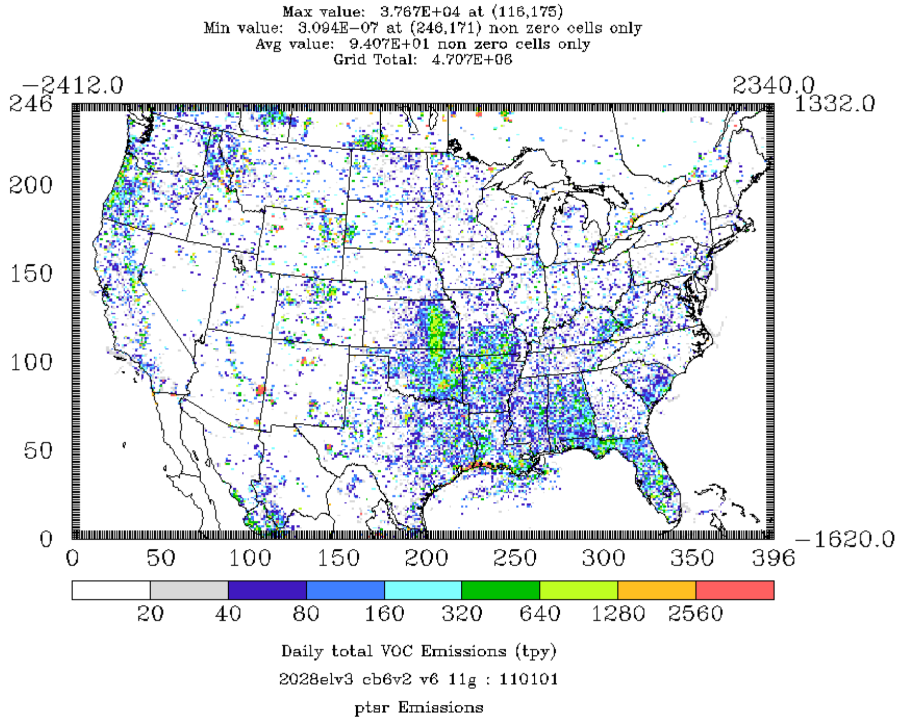


Figure 4-1. Comparison of Elevated NO_X Emissions (tpy) for CAMx 6.40 2028elv3 and CAMx 6.32 2028el Simulations

Annual VOC Emissions – Elevated Sources

2028elv3



Difference (2028elv3 - 2028el)

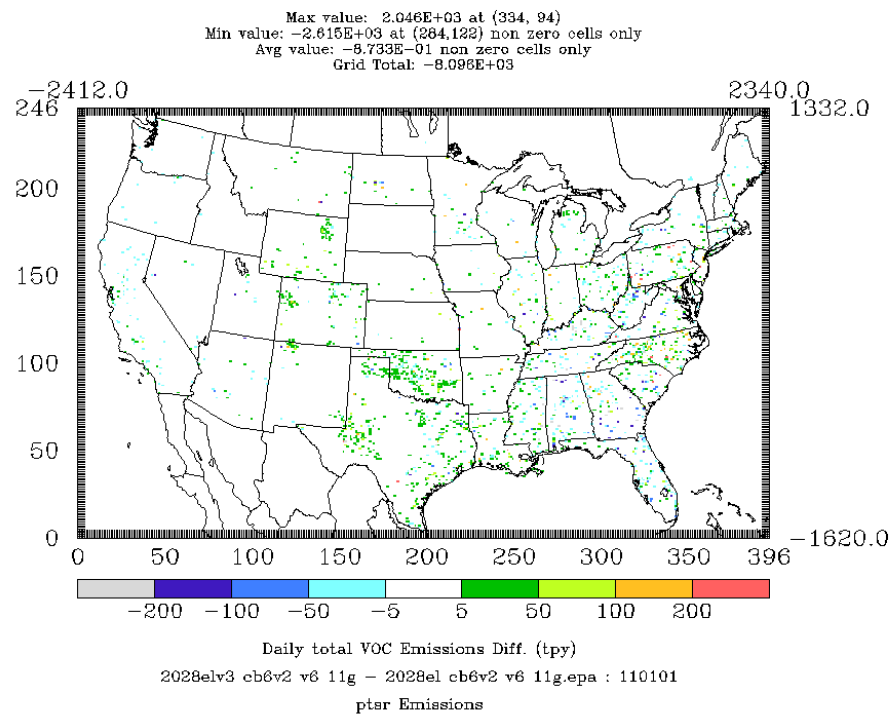


Figure 4-2. Comparison of Elevated VOC Emissions (tpy) for CAMx 6.40 2028elv3 and CAMx 6.32 2028el Simulations

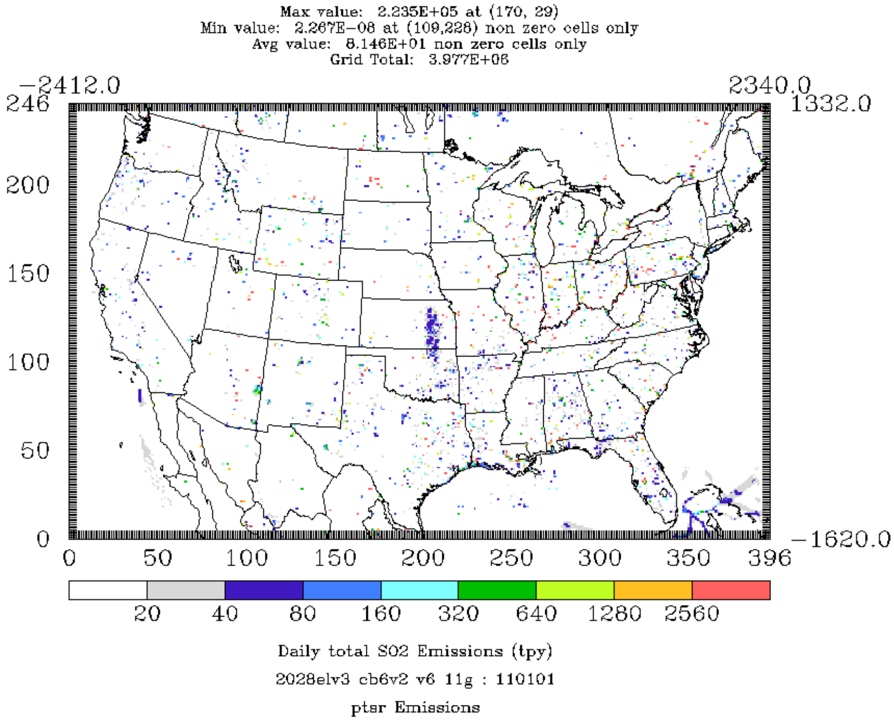
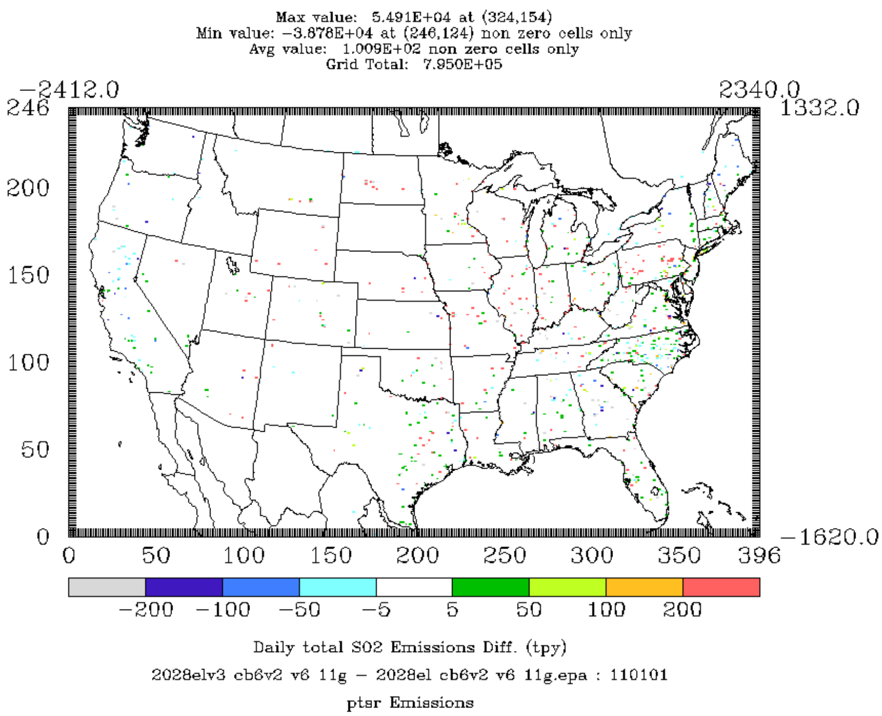
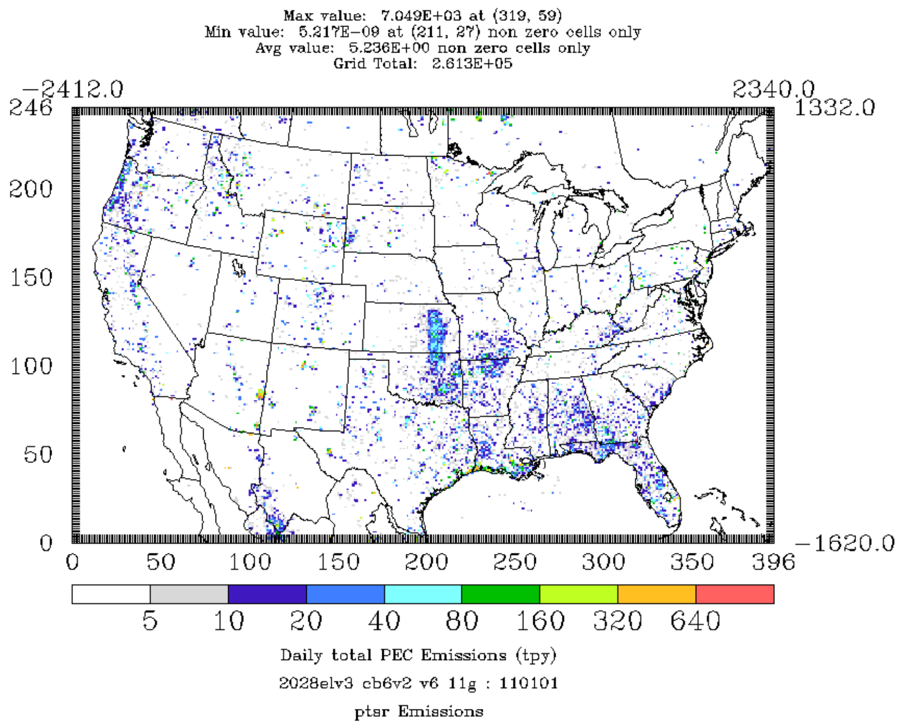
Annual SO_2 Emissions – Elevated Sources
2028elv3

Difference (2028elv3 - 2028el)


Figure 4-3. Comparison of Elevated SO_2 Emissions (tpy) for CAMx 6.40 2028elv3 and CAMx 6.32 2028el Simulations

Annual PEC Emissions – Elevated Sources

2028elv3



Difference (2028elv3 - 2028el)

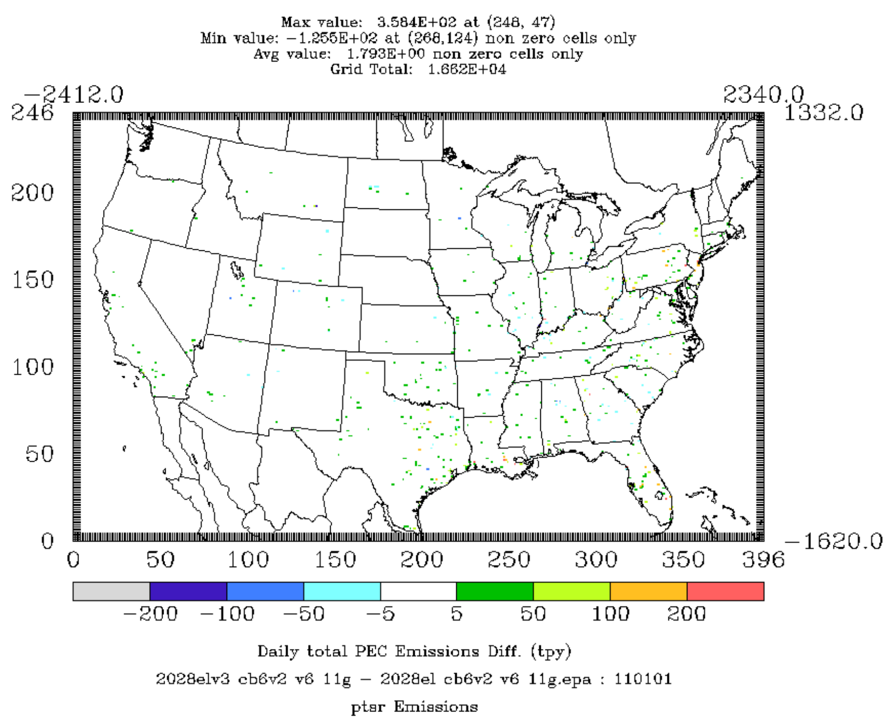
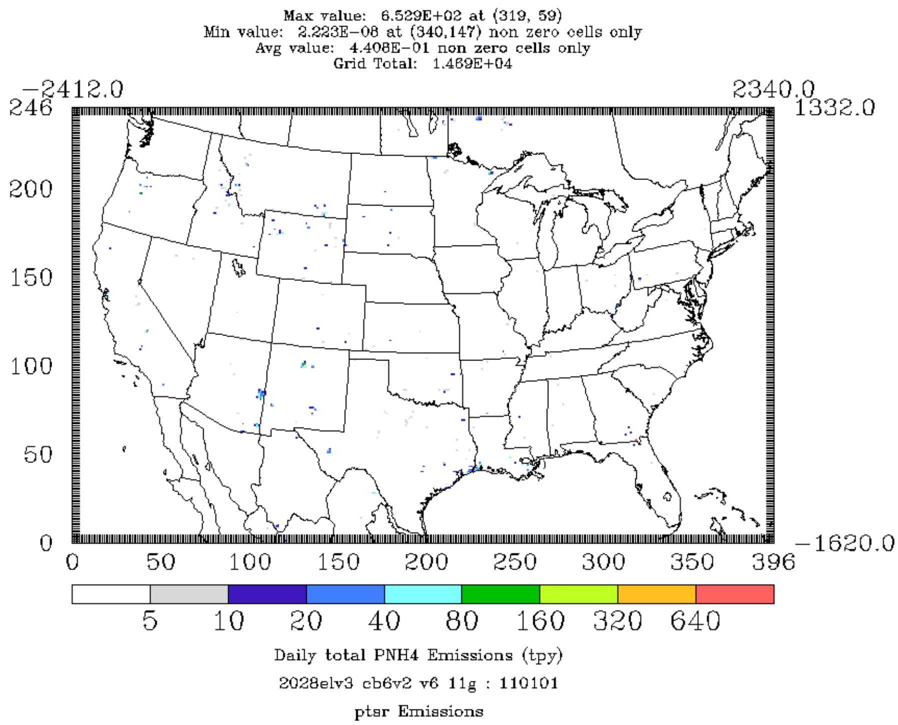


Figure 4-3. Comparison of Elevated PEC Emissions (tpy) for CAMx 6.40 2028elv3 and CAMx 6.32 2028el Simulations

Annual PNH4 Emissions – Elevated Sources
2028elv3



Difference (2028elv3 - 2028el)

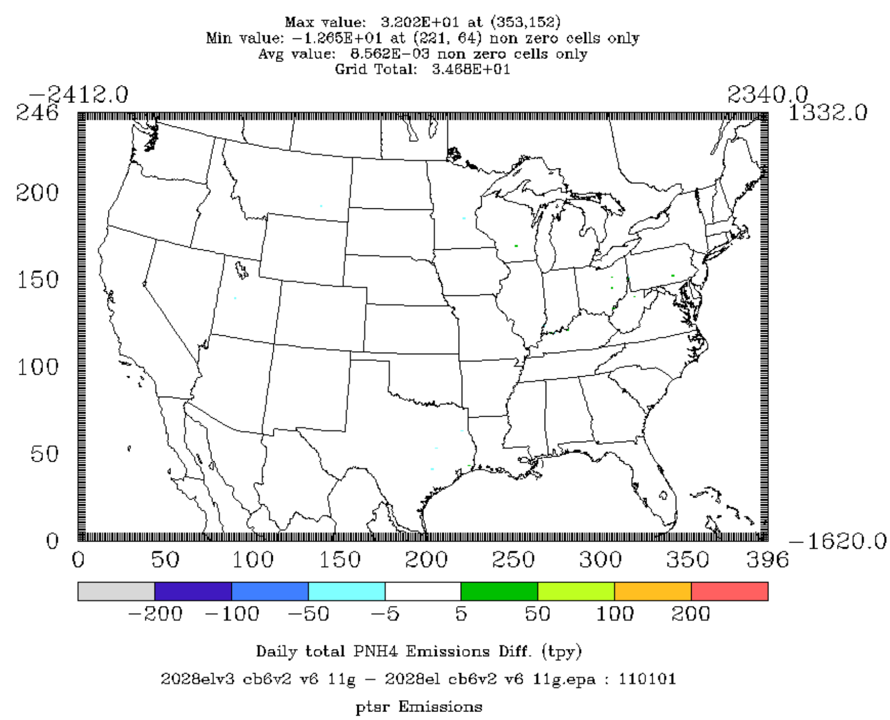
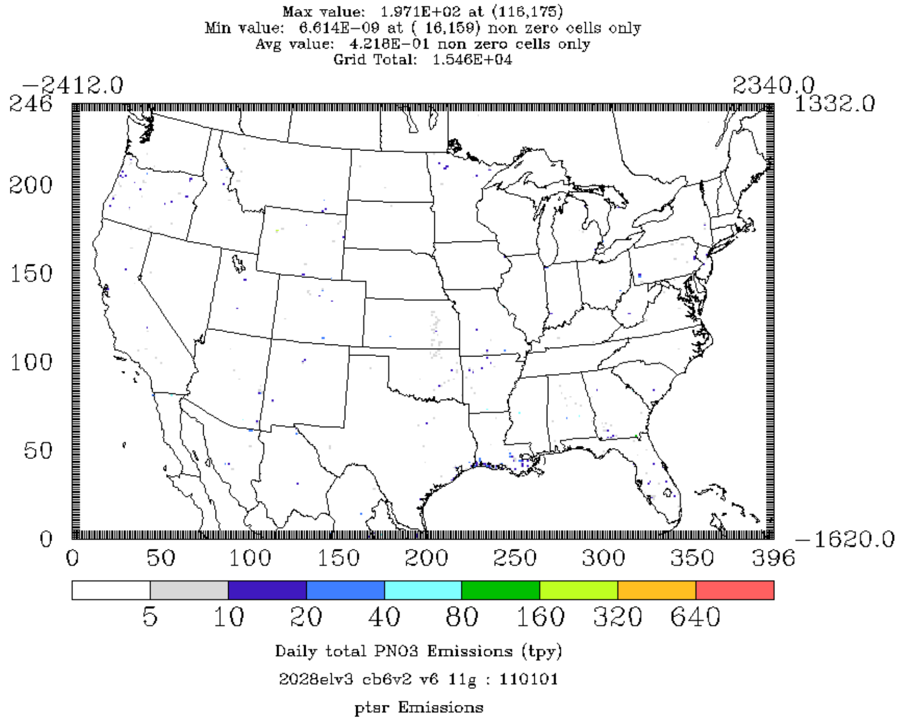


Figure 4-4. Comparison of Elevated PNH4 Emissions (tpy) for CAMx 6.40 2028elv3 and CAMx 6.32 2028el Simulations

Annual PNO3 Emissions – Elevated Sources

2028elv3



Difference (2028elv3 - 2028el)

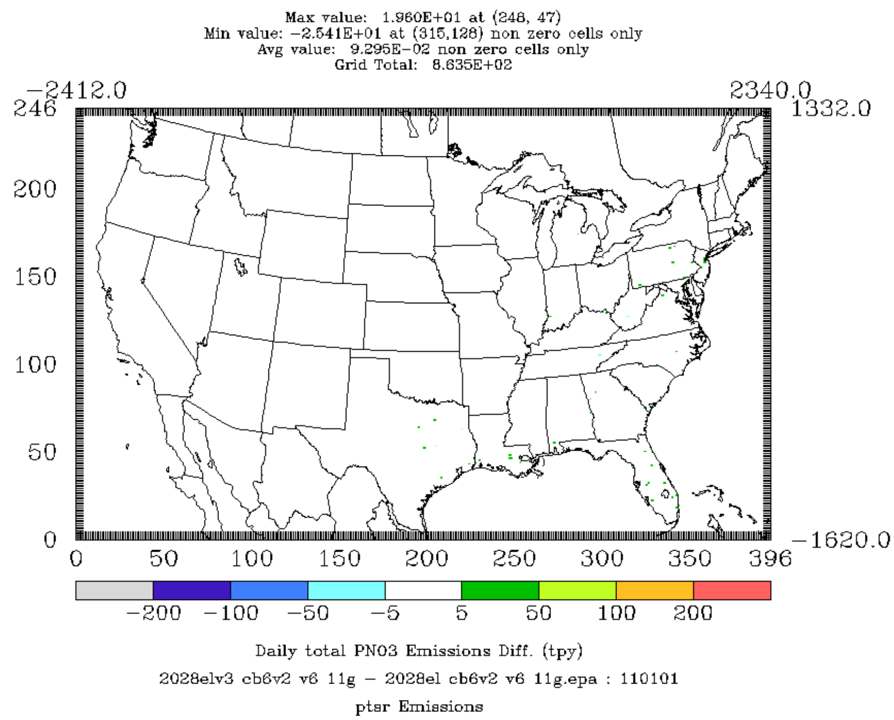
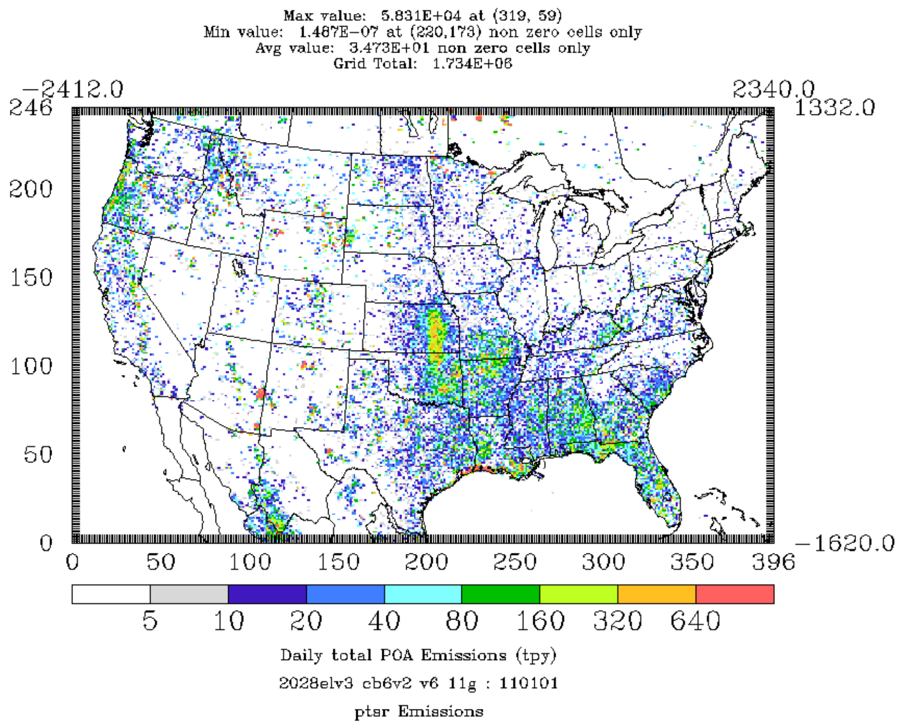


Figure 4-5. Comparison of Elevated PNO3 Emissions (tpy) for CAMx 6.40 2028elv3 and CAMx 6.32 2028el Simulations

Annual POA Emissions – Elevated Sources
2028elv3



Difference (2028elv3 - 2028el)

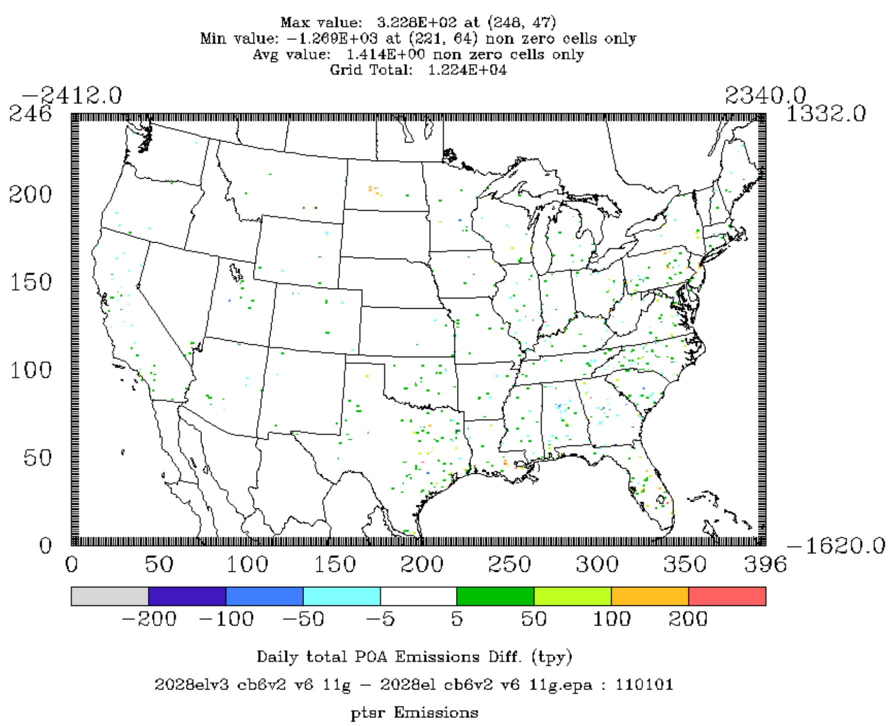
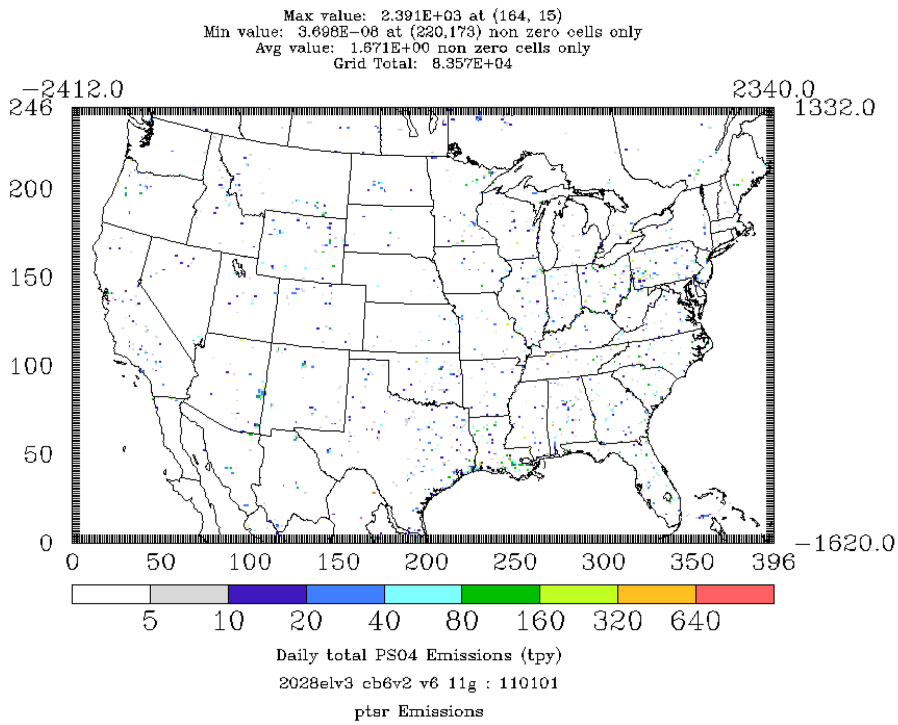


Figure 4-6. Comparison of Elevated POA Emissions (tpy) for CAMx 6.40 2028elv3 and CAMx 6.32 2028el Simulations

Annual PSO4 Emissions – Elevated Sources

2028elv3



Difference (2028elv3 - 2028el)

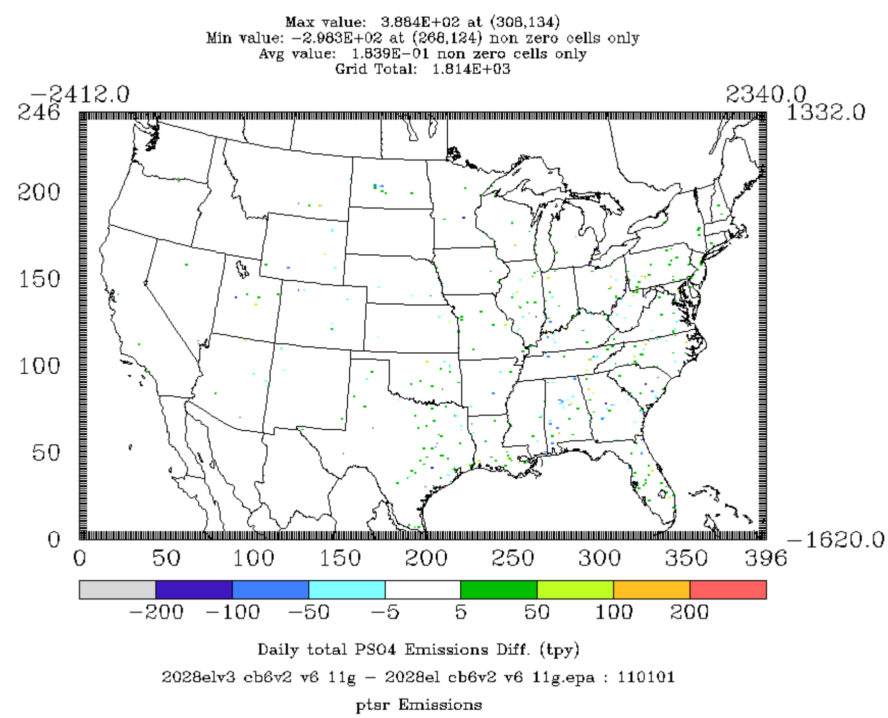
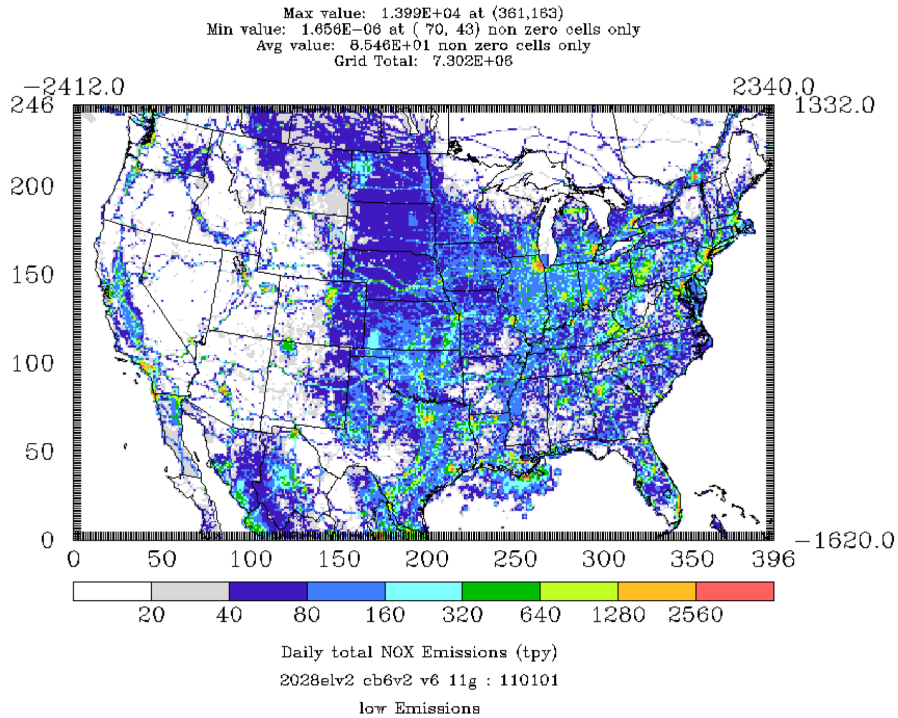


Figure 4-7. Comparison of Elevated PSO4 Emissions (tpy) for CAMx 6.40 2028elv3 and CAMx 6.32 2028el Simulations

Annual NO_X Emissions – Low Level Sources

2028elv2



Difference (2028elv2 - 2028el)

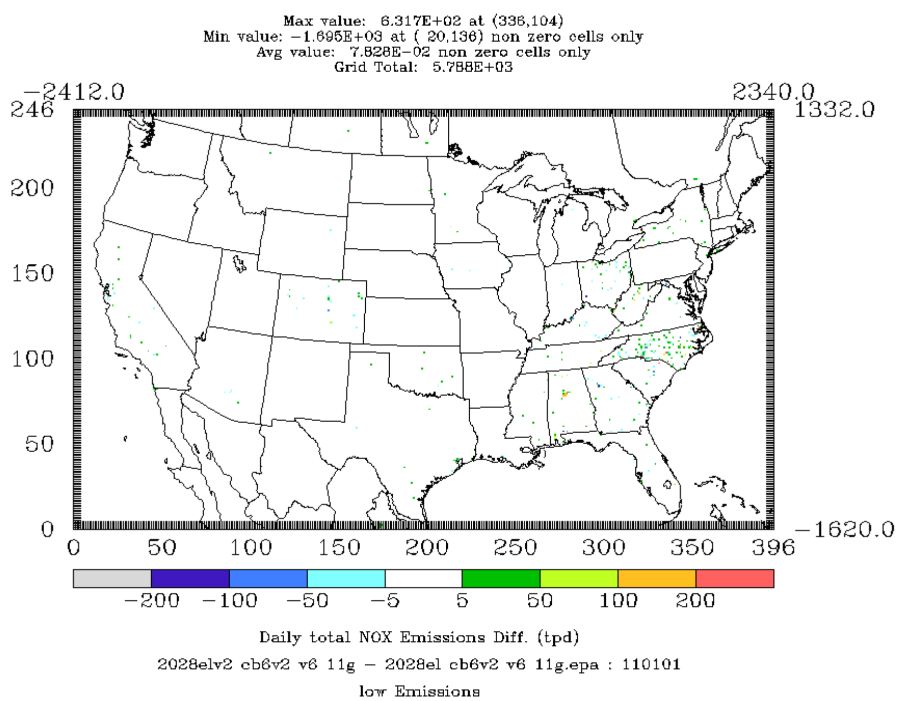
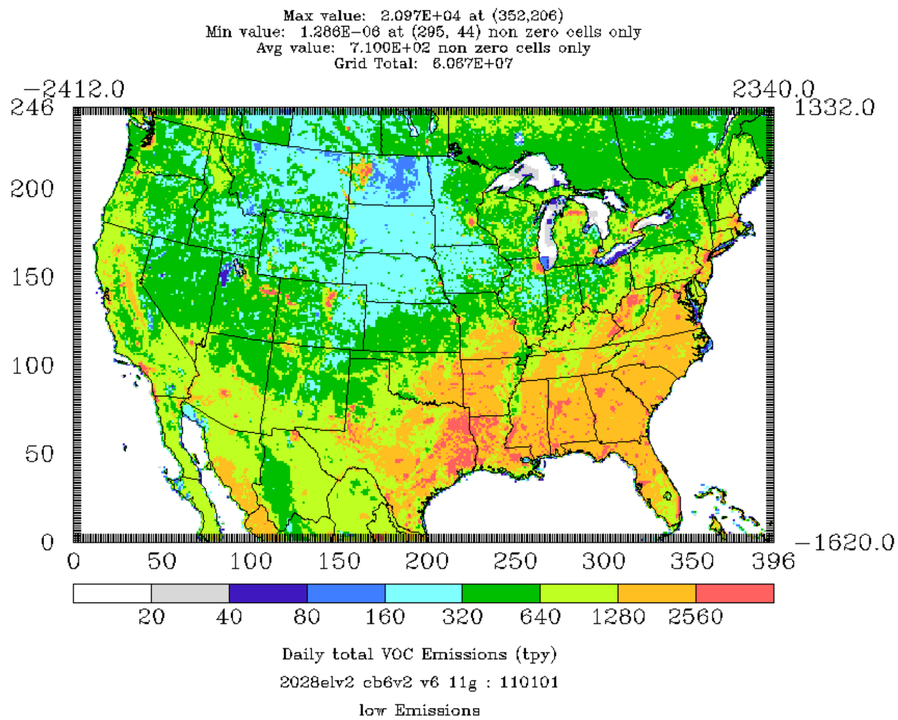


Figure 4-8. Comparison of Low Level NO_X Emissions (tpy) for CAMx 6.40 2028elv2 and CAMx 6.32 2028el Simulations

Annual VOC Emissions – Low Level Sources

2028elv2



Difference (2028elv2 - 2028el)

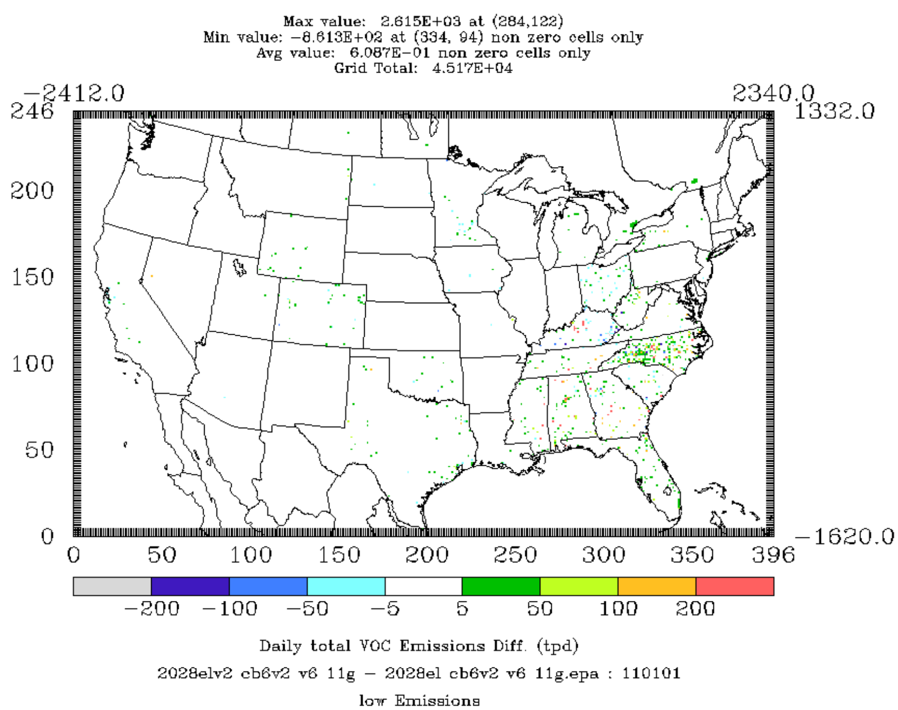
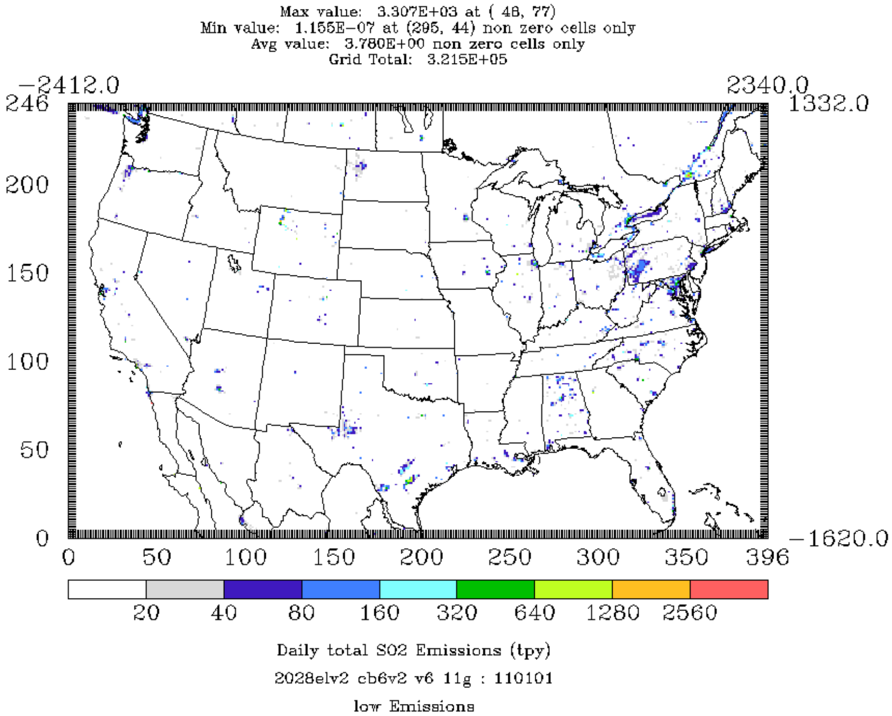


Figure 4-9. Comparison of Low Level VOC Emissions (tpy) for CAMx 6.40 2028elv2 and CAMx 6.32 2028el Simulations

Annual SO_2 Emissions – Low Level Sources

2028elv2



Difference (2028elv2 - 2028el)

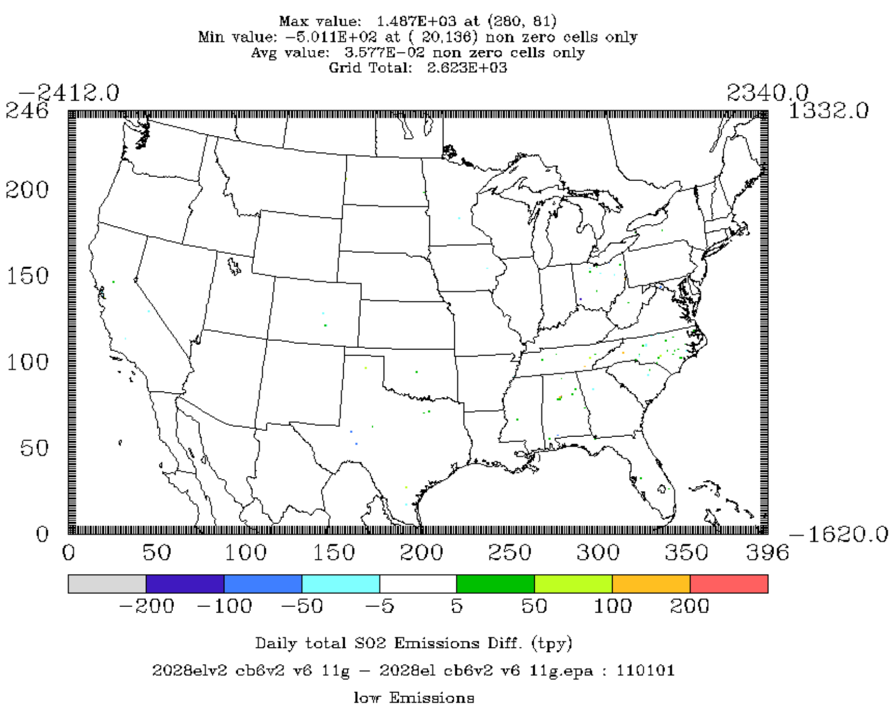
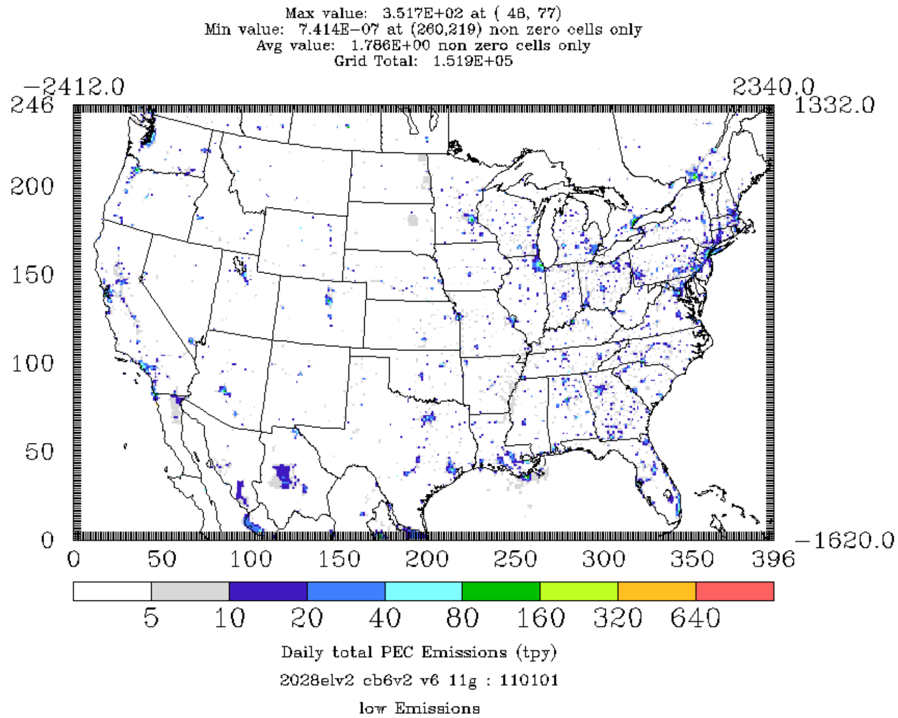


Figure 4-10. Comparison of Low Level SO_2 Emissions (tpy) for CAMx 6.40 2028elv2 and CAMx 6.32 2028el Simulations

Annual PEC Emissions – Low Level Sources

2028elv2



Difference (2028elv2 - 2028el)

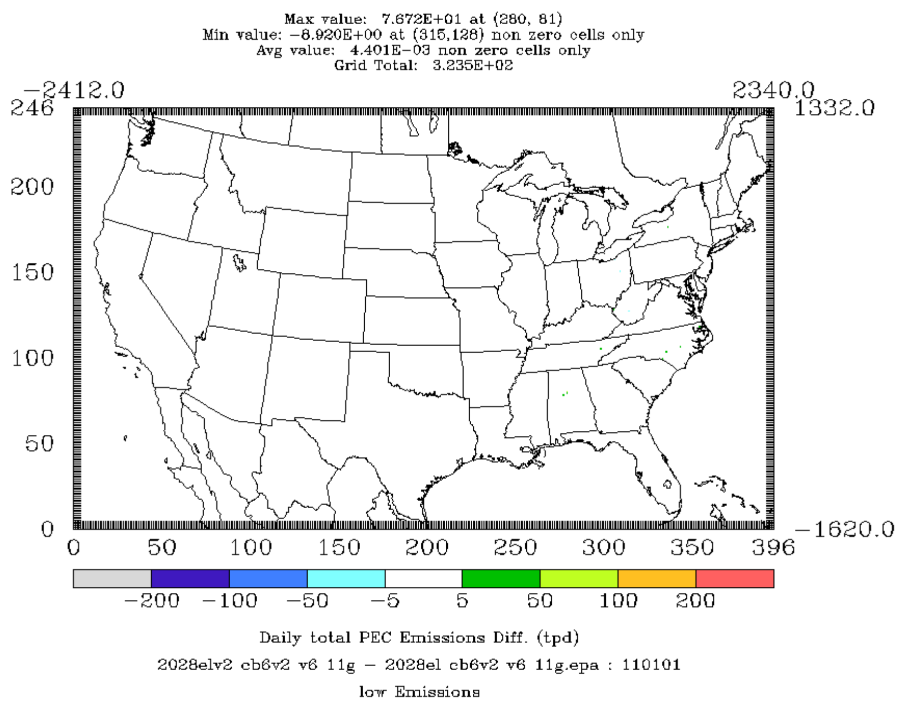
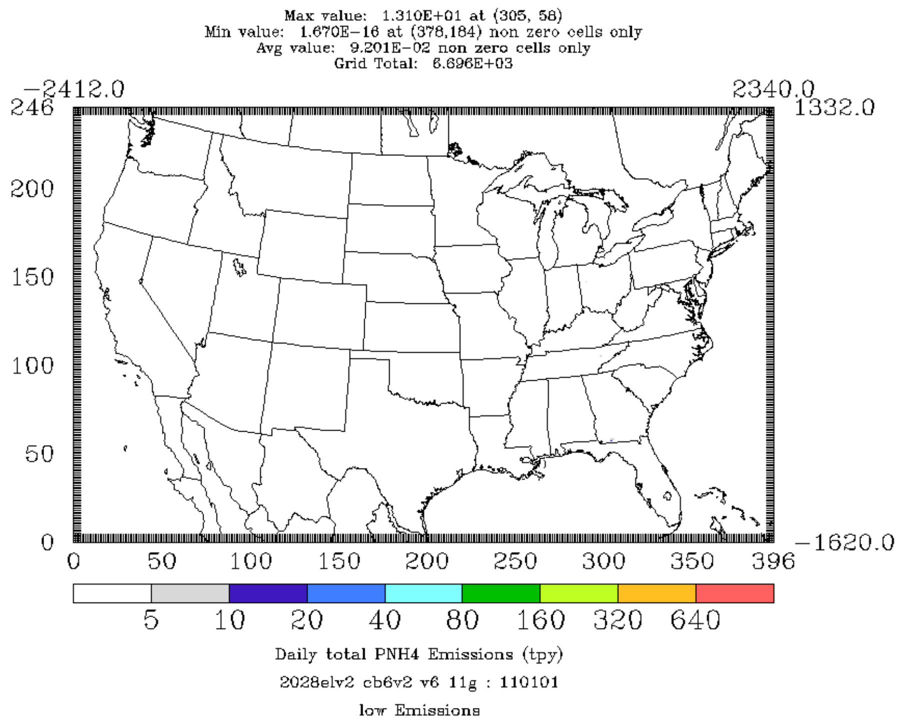


Figure 4-11. Comparison of Low Level PEC Emissions (tpy) for CAMx 6.40 2028elv2 and CAMx 6.32 2028el Simulations

Annual PNH4 Emissions – Low Level Sources
2028elv2



Difference (2028elv2 - 2028el)

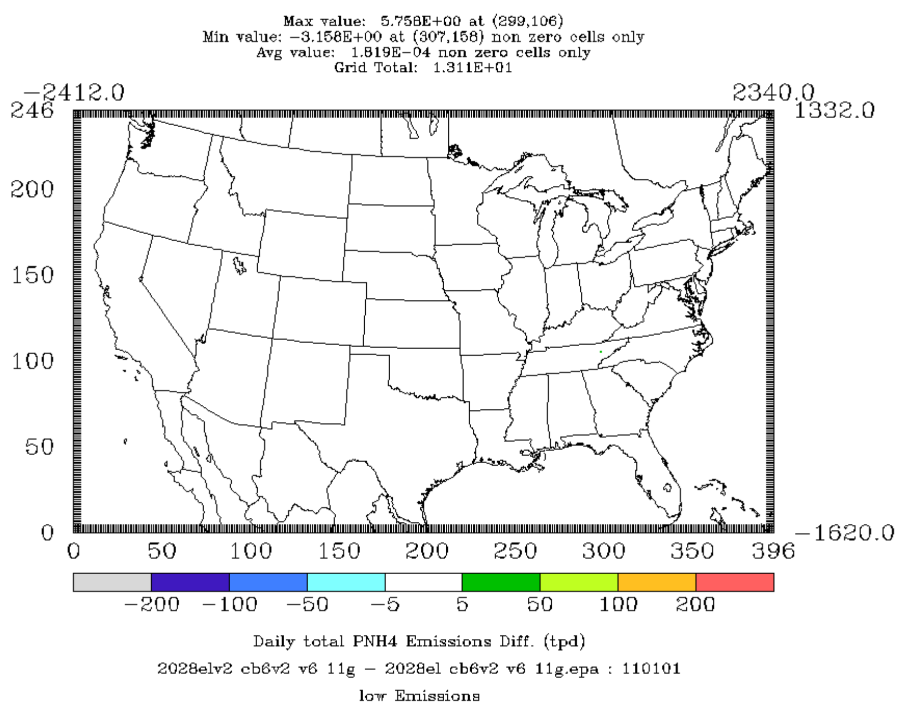
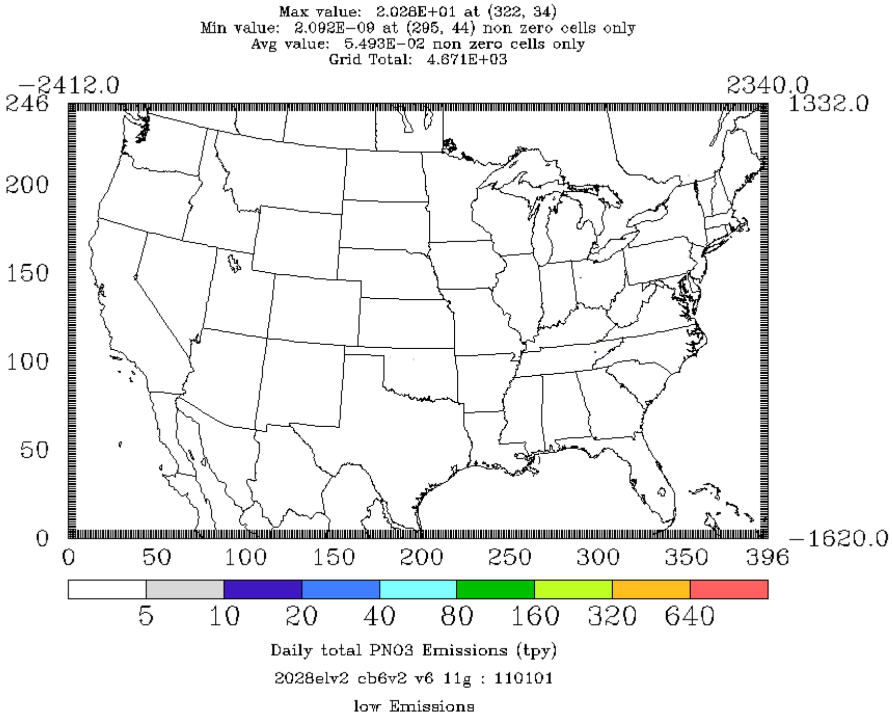


Figure 4-12. Comparison of Low Level PNH4 Emissions (tpy) for CAMx 6.40 2028elv2 and CAMx 6.32 2028el Simulations

Annual PNO3 Emissions – Low Level Sources

2028elv2



Difference (2028elv2 - 2028el)

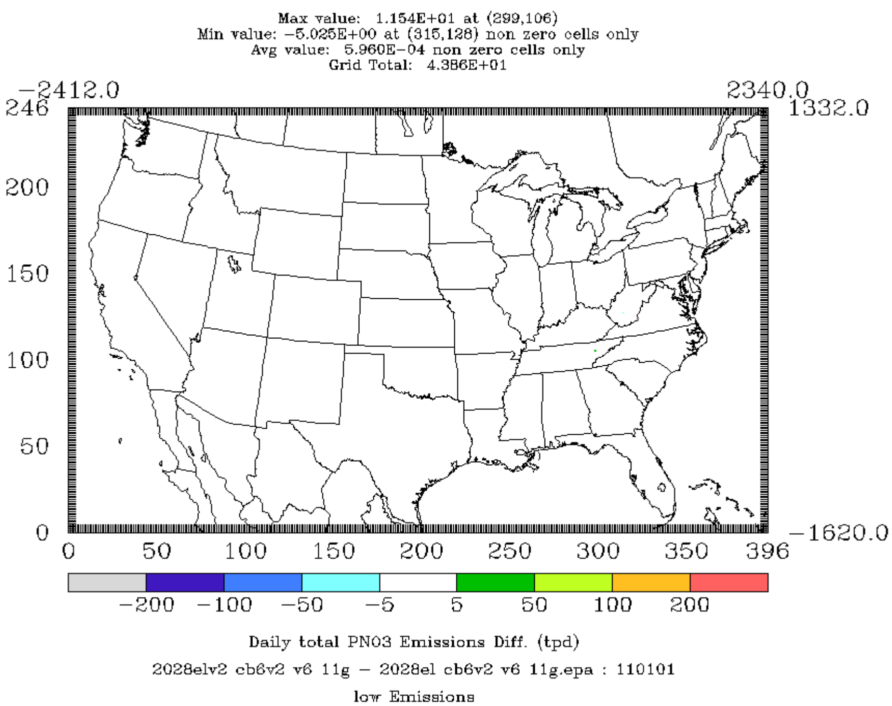
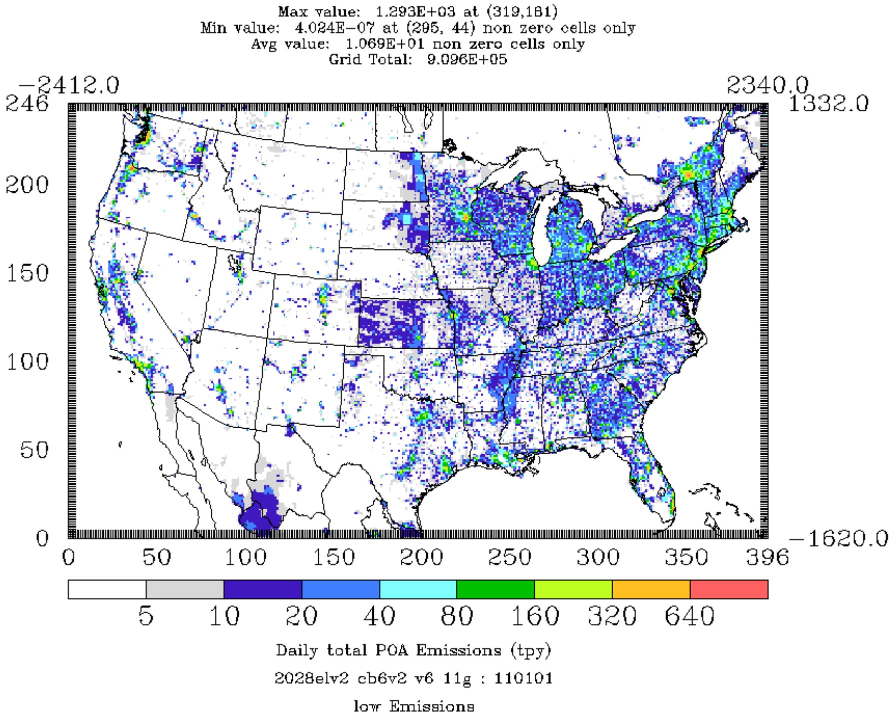


Figure 4-13. Comparison of Low Level PNO3 Emissions (tpy) for CAMx 6.40 2028elv2 and CAMx 6.32 2028el Simulations

Annual POA Emissions – Low Level Sources
2028elv2



Difference (2028elv2 - 2028el)

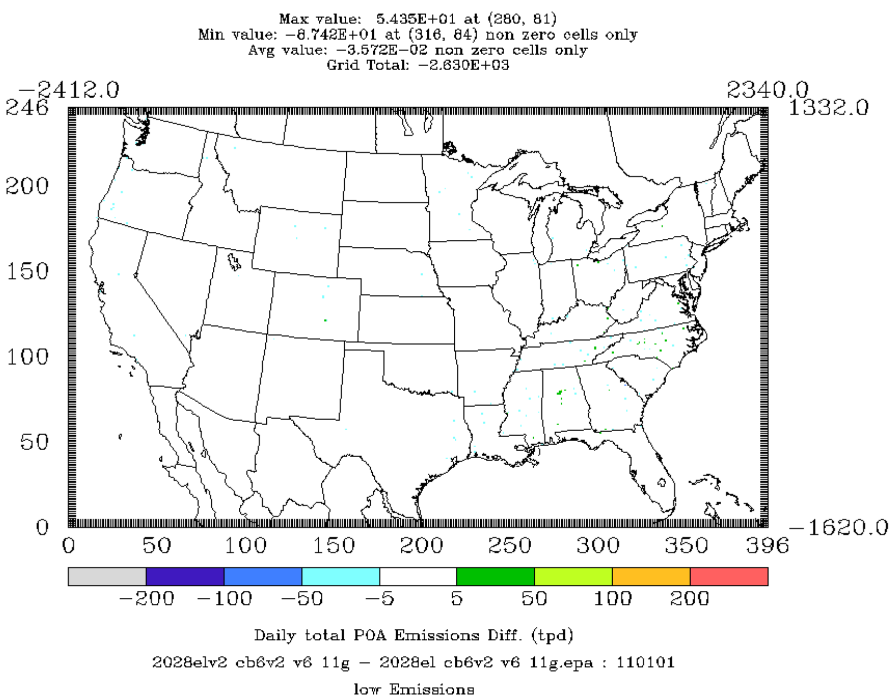
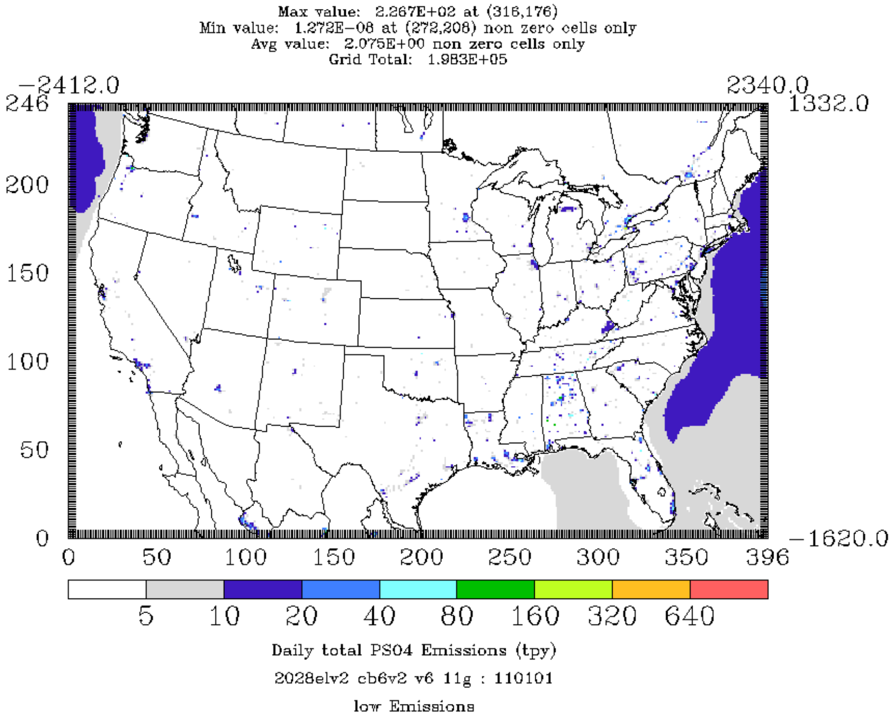


Figure 4-14. Comparison of Low Level POA Emissions (tpy) for CAMx 6.40 2028elv2 and CAMx 6.32 2028el Simulations

Annual PSO4 Emissions – Low Level Sources

2028elv2



Difference (2028elv2 - 2028el)

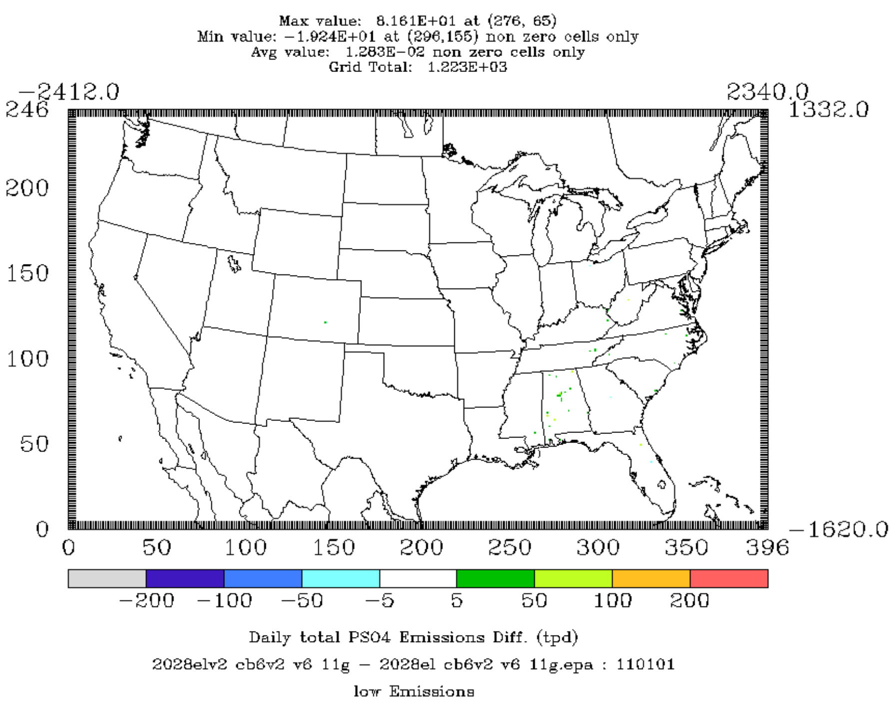


Figure 4-15. Comparison of Low Level PSO4 Emissions (tpy) for CAMx 6.40 2028elv2 and CAMx 6.32 2028el Simulations

4.2 Annual $PM_{2.5}$ Design Value

Annual $PM_{2.5}$ design values were generated using the results of each individual CAMx simulation (version 6.32 with EPA's 2028el platform and version 6.40 with SESARM's 2028elv3 emissions platform) and the SMAT-CE tool. Results for each individual receptor in the VISTAS states are presented in tabular format in Table 4-2 along with the absolute difference and percent difference in design value.

The maximum calculated increase is 0.51 μg/m^3 at monitor 510590030 in Fairfax, Virginia (7% increase between 6.32 and 6.40) and maximum decrease is 0.43 μg/m^3 at monitor 210290006 in Bullitt County, Kentucky (4% decrease going from 6.32 to 6.40). The average change in annual design value for all monitors in the VISTAS states is an increase of 0.20 μg/m^3, with an average annual percent increase of 3% at these same locations.

Geographic distribution of the 6.40 annual $PM_{2.5}$ design values and differences in design values compared to the 6.32 simulation is presented in Figure 4-16. In the VISTAS state region, the largest annual $PM_{2.5}$ design value fractional change is seen along the Atlantic coast and through much of North Carolina. The smallest fractional changes seen inside the heart of the SESARM state domain consistent with significant emission reductions modeled from updated EGU inventories within these states.

A scatterplot of the annual $PM_{2.5}$ design values for all FRM monitors in the 12US2 domain is presented in Figure 4-17. The CAMx 6.40 results are plotted on the x-axis and the CAMx 6.32 results are plotted on the y-axis. The data has a high degree of correlation with a line of best fit with a slope of 0.9875, an intercept of -0.1058 μg/m^{3}and an R^2 of 0.9825. The agreement between the models is higher at lower concentrations. CAMx 6.40 concentrations appear to be marginally higher compared to CAMx 6.32 at low and medium concentration ranges and slightly lower than the CAMx 6.32 results in high concentration ranges.

Table 4-2. Comparison of 2028el CAMx 6.32 and 2028elv3 CAMx 6.40 Predicted Annual $PM_{2.5}$ Design Values ($\mu g/m^3$) for FRM Monitors in VISTAS States

Monitor	State	County	2028 Annual $PM_{2.5}$ Design Value ($\mu g/m^3$)			
			6.32 2028el	6.40 2028elv3	Difference	Percent Difference
010030010	Alabama	Baldwin	7.98	8.06	0.08	1%
010270001	Alabama	Clay	7.78	7.92	0.14	2%
010331002	Alabama	Colbert	8.21	8.37	0.16	2%
010491003	Alabama	DeKalb	8.33	8.52	0.19	2%
010550010	Alabama	Etowah	8.66	8.84	0.18	2%
010690003	Alabama	Houston	8.12	8.25	0.13	2%
010730023	Alabama	Jefferson	10.92	11.17	0.25	2%
010731005	Alabama	Jefferson	9.25	9.33	0.08	1%
010731009	Alabama	Jefferson	8.16	8.24	0.08	1%
010731010	Alabama	Jefferson	9.44	9.56	0.12	1%
010732003	Alabama	Jefferson	10.14	10.31	0.17	2%
010732006	Alabama	Jefferson	9.42	9.50	0.08	1%
010735002	Alabama	Jefferson	8.74	8.97	0.23	3%
010735003	Alabama	Jefferson	8.55	8.68	0.13	2%
010890014	Alabama	Madison	8.94	9.15	0.21	2%
010970003	Alabama	Mobile	8.02	8.16	0.14	2%
010972005	Alabama	Mobile	7.74	7.83	0.09	1%
011011002	Alabama	Montgomery	9.33	9.58	0.25	3%
011030011	Alabama	Morgan	8.53	8.73	0.20	2%
011130001	Alabama	Russell	9.98	10.17	0.19	2%
011170006	Alabama	Shelby	8.11	8.18	0.07	1%
011210002	Alabama	Talladega	9.02	9.14	0.12	1%
011250004	Alabama	Tuscaloosa	8.60	8.74	0.14	2%
011270002	Alabama	Walker	9.00	9.12	0.12	1%
120990008	Florida	Palm Beach	6.84	6.94	0.10	1%
120990009	Florida	Palm Beach	5.70	5.85	0.15	3%
130210007	Georgia	Bibb	10.70	10.60	-0.10	-1%
130210012	Georgia	Bibb	8.08	7.95	-0.13	-2%

Table 4-2. Comparison of 2028el CAMx 6.32 and 2028elv3 CAMx 6.40 Predicted Annual $PM_{2.5}$ Design Values ($\mu g/m^3$) for FRM Monitors in VISTAS States

Monitor	State	County	2028 Annual $PM_{2.5}$ Design Value ($\mu g/m^3$)			
			6.32 2028el	6.40 2028elv3	Difference	Percent Difference
130510091	Georgia	Chatham	8.57	8.54	-0.03	0%
130590002	Georgia	Clarke	8.01	8.13	0.12	1%
130630091	Georgia	Clayton	9.30	9.43	0.13	1%
130670004	Georgia	Cobb	8.48	8.73	0.25	3%
130890002	Georgia	DeKalb	8.60	8.76	0.16	2%
130950007	Georgia	Dougherty	10.33	10.41	0.08	1%
131150003	Georgia	Floyd	9.31	9.48	0.17	2%
131210039	Georgia	Fulton	10.18	10.36	0.18	2%
131390003	Georgia	Hall	7.94	8.07	0.13	2%
131530001	Georgia	Houston	8.60	8.55	-0.05	-1%
132150001	Georgia	Muscogee	10.59	10.78	0.19	2%
132450005	Georgia	Richmond	9.53	9.27	-0.26	-3%
132450091	Georgia	Richmond	9.87	9.54	-0.33	-3%
132950002	Georgia	Walker	7.90	8.02	0.12	2%
133190001	Georgia	Wilkinson	10.26	9.97	-0.29	-3%
210130002	Kentucky	Bell	8.68	8.80	0.12	1%
210190017	Kentucky	Boyd	8.00	8.31	0.31	4%
210290006	Kentucky	Bullitt	9.75	9.32	-0.43	-4%
210373002	Kentucky	Campbell	7.36	7.61	0.25	3%
210430500	Kentucky	Carter	6.57	6.80	0.23	4%
210470006	Kentucky	Christian	8.28	8.39	0.11	1%
210590005	Kentucky	Daviess	9.11	9.25	0.14	2%
210670012	Kentucky	Fayette	7.76	7.97	0.21	3%
210930006	Kentucky	Hardin	8.30	8.40	0.10	1%
211010014	Kentucky	Henderson	8.68	8.96	0.28	3%
211110067	Kentucky	Jefferson	9.53	9.44	-0.09	-1%
211451004	Kentucky	McCracken	8.57	8.84	0.27	3%
211510003	Kentucky	Madison	6.77	6.97	0.20	3%

Table 4-2. Comparison of 2028el CAMx 6.32 and 2028elv3 CAMx 6.40 Predicted Annual $PM_{2.5}$ Design Values ($\mu g/m^3$) for FRM Monitors in VISTAS States

Monitor	State	County	2028 Annual $PM_{2.5}$ Design Value ($\mu g/m^3$)			
			6.32 2028el	6.40 2028elv3	Difference	Percent Difference
211950002	Kentucky	Pike	7.71	8.03	0.32	4%
212270008	Kentucky	Warren	8.72	8.83	0.11	1%
280330002	Mississippi	DeSoto	8.15	8.36	0.21	3%
280350004	Mississippi	Forrest	9.81	9.92	0.11	1%
280430001	Mississippi	Grenada	7.81	8.00	0.19	2%
280450003	Mississippi	Hancock	8.31	8.23	-0.08	-1%
280470008	Mississippi	Harrison	7.99	7.99	0.00	0%
280490010	Mississippi	Hinds	9.45	9.58	0.13	1%
280590006	Mississippi	Jackson	7.91	7.90	-0.01	0%
280670002	Mississippi	Jones	10.01	10.10	0.09	1%
280750003	Mississippi	Lauderdale	9.13	9.20	0.07	1%
280810005	Mississippi	Lee	9.21	9.36	0.15	2%
370010002	North Carolina	Alamance	7.01	7.36	0.35	5%
370210034	North Carolina	Buncombe	6.77	6.97	0.20	3%
370330001	North Carolina	Caswell	6.22	6.57	0.35	6%
370350004	North Carolina	Catawba	7.71	7.98	0.27	4%
370370004	North Carolina	Chatham	5.73	6.07	0.34	6%
370510009	North Carolina	Cumberland	7.38	7.65	0.27	4%
370570002	North Carolina	Davidson	8.14	8.54	0.40	5%
370610002	North Carolina	Duplin	6.36	6.48	0.12	2%
370630015	North Carolina	Durham	6.69	7.00	0.31	5%
370650004	North Carolina	Edgecombe	6.35	6.66	0.31	5%
370670022	North Carolina	Forsyth	6.91	7.33	0.42	6%
370670030	North Carolina	Forsyth	6.91	7.34	0.43	6%
370710016	North Carolina	Gaston	7.52	7.77	0.25	3%
370810013	North Carolina	Guilford	6.59	6.97	0.38	6%
370810014	North Carolina	Guilford	6.72	7.13	0.41	6%
370870012	North Carolina	Haywood	7.84	7.86	0.02	0%

Table 4-2. Comparison of 2028el CAMx 6.32 and 2028elv3 CAMx 6.40 Predicted Annual $PM_{2.5}$ Design Values (µg/m³) for FRM Monitors in VISTAS States

Monitor	State	County	2028 Annual $PM_{2.5}$ Design Value (µg/m³)			
			6.32 2028el	6.40 2028elv3	Difference	Percent Difference
370990006	North Carolina	Jackson	7.06	7.15	0.09	1%
371010002	North Carolina	Johnston	6.38	6.70	0.32	5%
371070004	North Carolina	Lenoir	6.59	6.85	0.26	4%
371110004	North Carolina	McDowell	7.37	7.60	0.23	3%
371170001	North Carolina	Martin	6.01	6.38	0.37	6%
371190041	North Carolina	Mecklenburg	7.86	8.11	0.25	3%
371190042	North Carolina	Mecklenburg	8.21	8.45	0.24	3%
371190043	North Carolina	Mecklenburg	7.37	7.64	0.27	4%
371210001	North Carolina	Mitchell	7.04	7.19	0.15	2%
371230001	North Carolina	Montgomery	6.62	6.95	0.33	5%
371290002	North Carolina	New Hanover	5.39	5.61	0.22	4%
371470006	North Carolina	Pitt	5.98	6.29	0.31	5%
371550005	North Carolina	Robeson	7.29	7.51	0.22	3%
371590021	North Carolina	Rowan	7.54	7.84	0.30	4%
371730002	North Carolina	Swain	7.40	7.50	0.10	1%
371830014	North Carolina	Wake	7.58	7.89	0.31	4%
371830020	North Carolina	Wake	6.78	7.09	0.31	5%
371890003	North Carolina	Watauga	6.07	6.28	0.21	3%
371910005	North Carolina	Wayne	7.14	7.40	0.26	4%
450190048	South Carolina	Charleston	6.91	7.11	0.20	3%
450190049	South Carolina	Charleston	6.66	6.88	0.22	3%
450250001	South Carolina	Chesterfield	7.46	7.69	0.23	3%
450370001	South Carolina	Edgefield	8.01	8.03	0.02	0%
450410003	South Carolina	Florence	8.45	8.65	0.20	2%
450450009	South Carolina	Greenville	8.41	8.65	0.24	3%
450450015	South Carolina	Greenville	8.68	8.92	0.24	3%
450630008	South Carolina	Lexington	8.57	8.64	0.07	1%
450830011	South Carolina	Spartanburg	8.26	8.47	0.21	3%

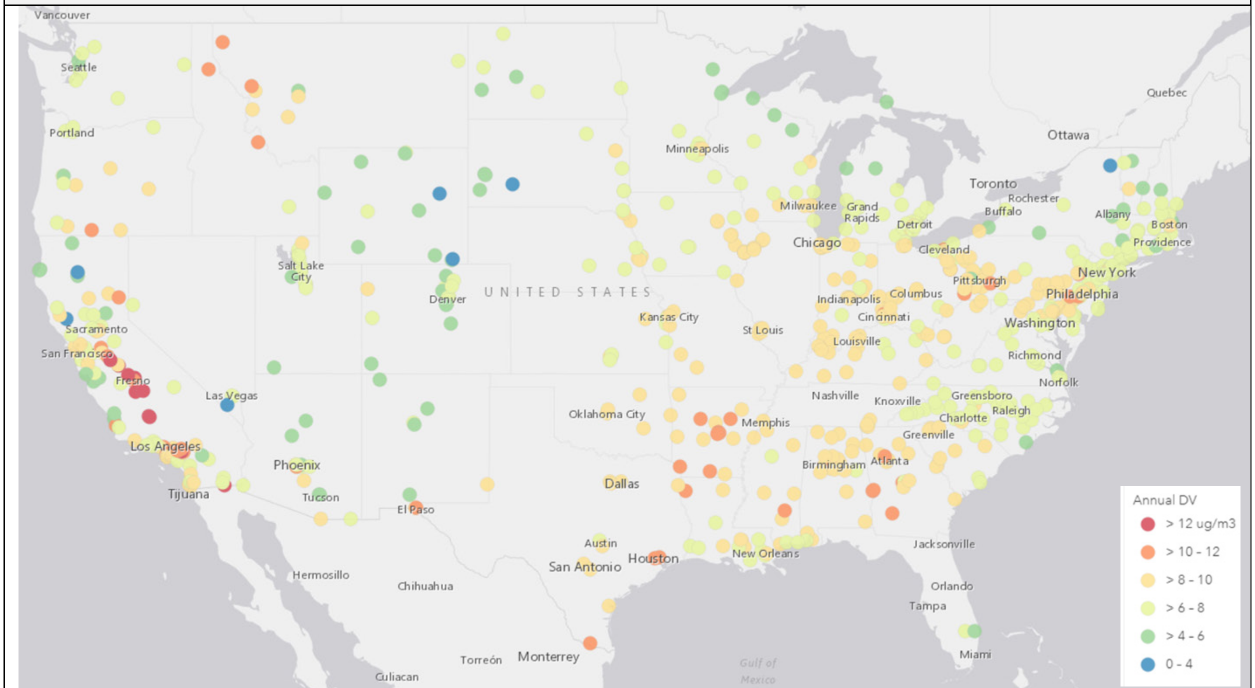
Table 4-2. Comparison of 2028el CAMx 6.32 and 2028elv3 CAMx 6.40 Predicted Annual $PM_{2.5}$ Design Values (µg/m^3) for FRM Monitors in VISTAS States

Monitor	State	County	2028 Annual $PM_{2.5}$ Design Value (µg/m^3)			
			6.32 2028el	6.40 2028elv3	Difference	Percent Difference
470650031	Tennessee	Hamilton	8.43	8.55	0.12	1%
470651011	Tennessee	Hamilton	8.32	8.45	0.13	2%
470654002	Tennessee	Hamilton	8.16	8.30	0.14	2%
510030001	Virginia	Albemarle	6.32	6.67	0.35	6%
510360002	Virginia	Charles	6.23	6.57	0.34	5%
510410003	Virginia	Chesterfield	7.06	7.44	0.38	5%
510590030	Virginia	Fairfax	6.87	7.38	0.51	7%
510690010	Virginia	Frederick	7.70	8.19	0.49	6%
510870014	Virginia	Henrico	6.81	7.17	0.36	5%
510870015	Virginia	Henrico	6.38	6.76	0.38	6%
511071005	Virginia	Loudoun	7.08	7.57	0.49	7%
511390004	Virginia	Page	6.77	7.13	0.36	5%
511650003	Virginia	Rockingham	7.56	7.89	0.33	4%
515200006	Virginia	Bristol City	7.53	7.73	0.20	3%
516500008	Virginia	Hampton City	5.65	5.93	0.28	5%
516800015	Virginia	Lynchburg City	6.24	6.52	0.28	4%
517100024	Virginia	Norfolk City	6.77	7.04	0.27	4%
517700015	Virginia	Roanoke City	7.47	7.73	0.26	3%
517750011	Virginia	Salem City	7.24	7.50	0.26	4%
518100008	Virginia	Virginia Beach City	6.71	6.98	0.27	4%
540030003	West Virginia	Berkeley	8.90	9.38	0.48	5%
540090005	West Virginia	Brooke	9.10	9.59	0.49	5%
540110006	West Virginia	Cabell	8.81	9.09	0.28	3%
540291004	West Virginia	Hancock	8.27	8.73	0.46	6%
540390010	West Virginia	Kanawha	7.84	8.14	0.30	4%
540391005	West Virginia	Kanawha	8.97	9.27	0.30	3%
540490006	West Virginia	Marion	8.75	9.21	0.46	5%
540511002	West Virginia	Marshall	9.85	10.03	0.18	2%

Table 4-2. Comparison of 2028el CAMx 6.32 and 2028elv3 CAMx 6.40 Predicted Annual $PM_{2.5}$ Design Values (µg/m^3) for FRM Monitors in VISTAS States

Monitor	State	County	2028 Annual $PM_{2.5}$ Design Value (µg/m^3)			
			6.32 2028el	6.40 2028elv3	Difference	Percent Difference
540610003	West Virginia	Monongalia	7.57	8.07	0.50	7%
540690010	West Virginia	Ohio	8.37	8.72	0.35	4%
540810002	West Virginia	Raleigh	6.68	6.99	0.31	5%
541071002	West Virginia	Wood	8.91	9.12	0.21	2%

Annual $PM_{2.5}$ Design Value – 12US2 Domain
CAMx 6.40



Percent Difference (CAMx 6.40 - CAMx 6.32) / CAMx 6.32

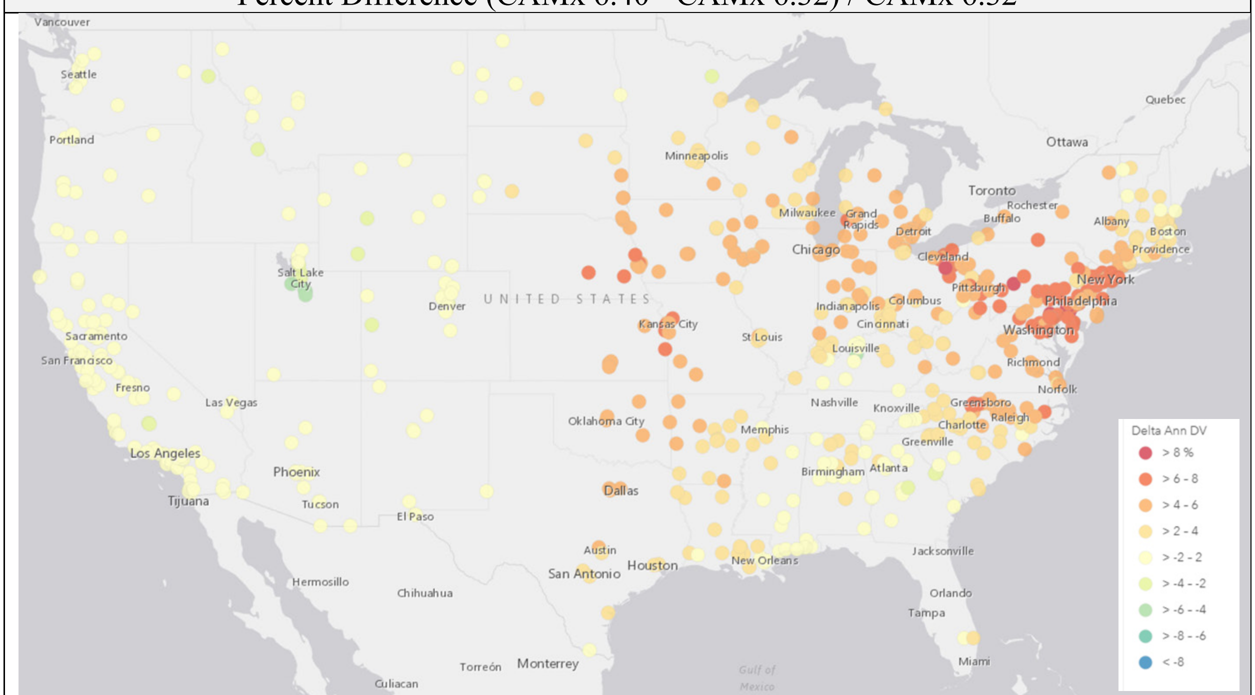


Figure 4-16. Comparison of Annual $PM_{2.5}$ Design Values ($\mu g/m^3$) for CAMx 6.32 2028el and CAMx 6.40 2028elv3 Simulations

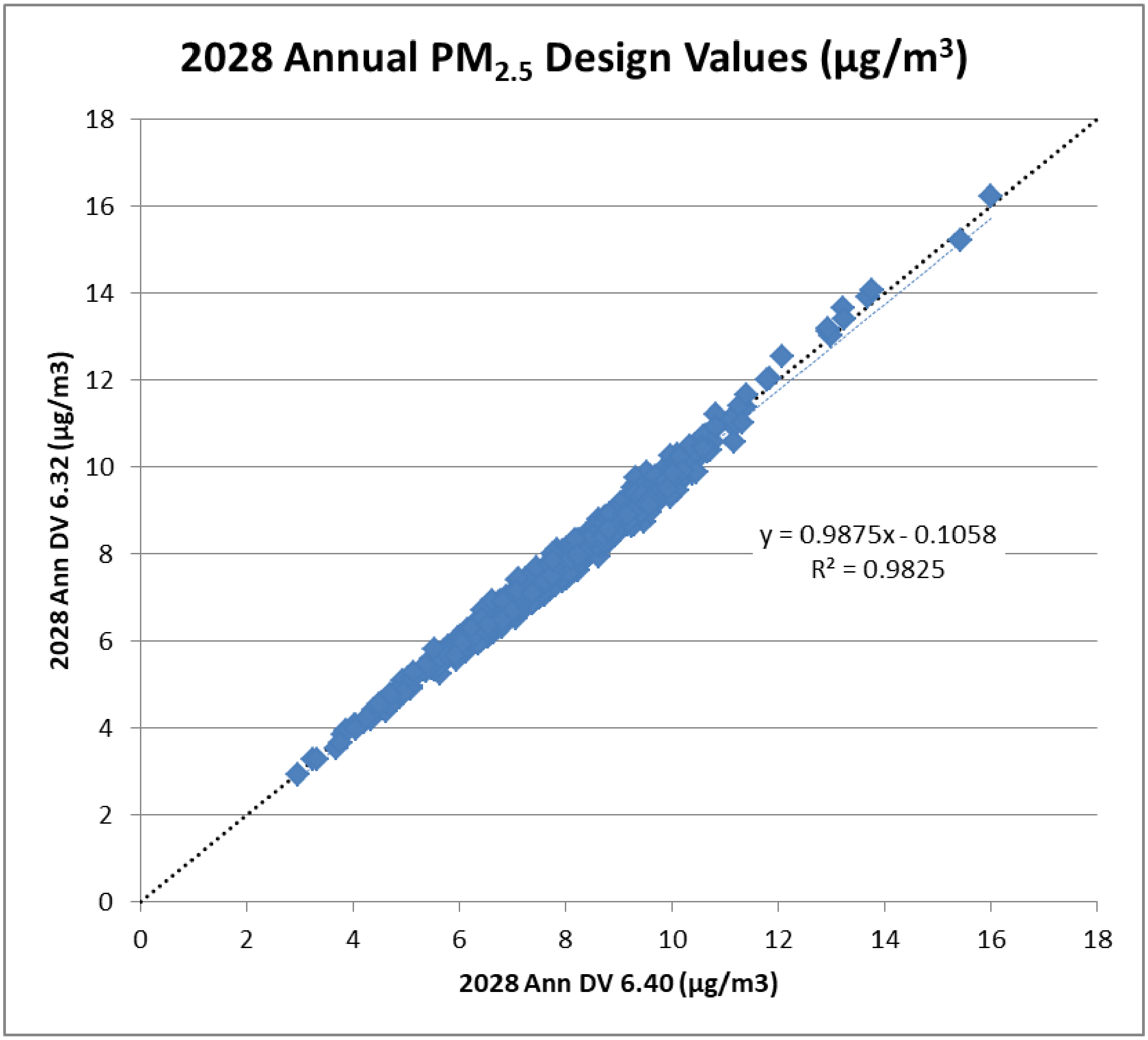


Figure 4-17. Scatterplot Comparing Annual Average Predicted $PM_{2.5}$ Design Values ($\mu g/m^3$) at all Monitor Locations for CAMx 6.32 2028el and CAMx 6.40 2028elv3 Simulations Performed by VISTAS (Alpine)

4.3 24-Hour (Daily) $PM_{2.5}$ Design Value

Daily $PM_{2.5}$ design values were generated using the results of each individual CAMx simulation (version 6.32 with EPA's 2028el platform and version 6.40 with SESARM's 2028elv3 platform) and the SMAT-CE tool. Results for each individual receptor in the VISTAS states are presented in tabular format in Table 4-3 along with the absolute difference and percent difference in design value.

The maximum calculated increase is 1.1 $\mu g/m^3$ at monitor 510030001 in Albemarle, Virginia (9% increase going from CAMx 6.32 to 6.40) and maximum calculated decrease is 0.7 $\mu g/m^3$ at monitor 130210007 in Bibb, Georgia (3% decrease going from CAMx 6.32 to 6.40). The average change in daily design value for all monitors in the VISTAS states is 0.20 $\mu g/m^3$, with an average daily percent difference of 2% at these same locations.

Geographic distribution of the 6.40 daily $PM_{2.5}$ design values and differences in design values compared to the 6.32 simulation is presented in Figure 4-18. As similarly seen in the annual $PM_{2.5}$ design values, daily $PM_{2.5}$ design values have the smallest fractional change within the middle of the VISTAS state domain and the largest daily design value fractional changes are seen across much of the central states region, running north to south along the western border of the VISTAS domain and along the northeastern boundary of the VISTAS domain, adjacent to MARAMA state boundaries.

A scatterplot of the daily $PM_{2.5}$ design values for all FRM monitors in the 12US2 domain is presented in Figure 4-19. The CAMx 6.40 results are plotted on the x-axis and the CAMx 6.32 results are plotted on the y-axis. The data has a high degree of correlation with a line of best fit with a slope of 1.0395, an intercept of -1.1381 $\mu g/m^3$ and an R^2 of 0.9895. CAMx 6.40 concentrations appear to be marginally higher compared to CAMx 6.32 at low concentration ranges and slightly lower than the CAMx 6.32 results in medium to high concentration ranges.

Table 4-3. Comparison of CAMx 6.40 2028elv3 and CAMx 6.32 2028el Simulation of Daily (24-Hour) $PM_{2.5}$ Design Values (µg/m³)

Monitor	State	County	2028 Daily (24-Hr) $PM_{2.5}$ Design Value (µg/m³)			
			6.32 2028el	6.40 2028elv3	Difference	Percent Difference
010030010	Alabama	Baldwin	15.8	15.9	0.1	1%
010270001	Alabama	Clay	17.1	17.2	0.1	1%
010331002	Alabama	Colbert	16.4	16.2	-0.2	-1%
010491003	Alabama	DeKalb	16.9	17.1	0.2	1%
010550010	Alabama	Etowah	17.8	17.7	-0.1	-1%
010690003	Alabama	Houston	17.0	17.0	0.0	0%
010730023	Alabama	Jefferson	22.8	22.9	0.1	0%
010731005	Alabama	Jefferson	18.0	17.8	-0.2	-1%
010731009	Alabama	Jefferson	17.8	17.8	0.0	0%
010731010	Alabama	Jefferson	18.2	18.3	0.1	1%
010732003	Alabama	Jefferson	20.9	21.2	0.3	1%
010732006	Alabama	Jefferson	18.6	18.6	0.0	0%
010735002	Alabama	Jefferson	17.6	17.4	-0.2	-1%
010735003	Alabama	Jefferson	17.8	17.7	-0.1	-1%
010890014	Alabama	Madison	18.5	18.6	0.1	1%
010970003	Alabama	Mobile	16.0	16.1	0.1	1%
010972005	Alabama	Mobile	16.6	16.7	0.1	1%
011011002	Alabama	Montgomery	19.9	19.9	0.0	0%
011030011	Alabama	Morgan	16.5	16.5	0.0	0%
011130001	Alabama	Russell	23.3	23.4	0.1	0%
011170006	Alabama	Shelby	15.8	15.8	0.0	0%
011210002	Alabama	Talladega	18.5	18.5	0.0	0%
011250004	Alabama	Tuscaloosa	18.9	19.0	0.1	1%
011270002	Alabama	Walker	17.8	17.8	0.0	0%
120990008	Florida	Palm Beach	15.6	15.7	0.1	1%
120990009	Florida	Palm Beach	13.5	13.6	0.1	1%
130210007	Georgia	Bibb	22.8	22.1	-0.7	-3%
130210012	Georgia	Bibb	18.3	17.9	-0.4	-2%

Table 4-3. Comparison of CAMx 6.40 2028elv3 and CAMx 6.32 2028el Simulation of Daily (24-Hour) $PM_{2.5}$ Design Values ($\mu g/m^3$)

Monitor	State	County	2028 Daily (24-Hr) $PM_{2.5}$ Design Value ($\mu g/m^3$)			
			6.32 2028el	6.40 2028elv3	Difference	Percent Difference
130510017	Georgia	Chatham	24.7	24.3	-0.4	-2%
130510091	Georgia	Chatham	24.3	24.4	0.1	0%
130590002	Georgia	Clarke	17.4	17.6	0.2	1%
130670004	Georgia	Cobb	16.9	17.1	0.2	1%
130890002	Georgia	DeKalb	17.1	17.2	0.1	1%
130950007	Georgia	Dougherty	24.4	24.3	-0.1	0%
131390003	Georgia	Hall	16.3	16.5	0.2	1%
131530001	Georgia	Houston	19.7	19.5	-0.2	-1%
132950002	Georgia	Walker	17.5	17.2	-0.3	-2%
133190001	Georgia	Wilkinson	20.5	20.2	-0.3	-1%
280330002	Mississippi	DeSoto	15.6	15.9	0.3	2%
280350004	Mississippi	Forrest	19.5	19.5	0.0	0%
280430001	Mississippi	Grenada	15.5	15.8	0.3	2%
280450003	Mississippi	Hancock	18.4	18.3	-0.1	-1%
280470008	Mississippi	Harrison	15.3	15.1	-0.2	-1%
280490010	Mississippi	Hinds	18.1	18.5	0.4	2%
280590006	Mississippi	Jackson	17.7	17.6	-0.1	-1%
280670002	Mississippi	Jones	20.1	20.3	0.2	1%
280750003	Mississippi	Lauderdale	18.5	18.6	0.1	1%
280810005	Mississippi	Lee	17.0	17.4	0.4	2%
370010002	North Carolina	Alamance	14.7	15.2	0.5	3%
370210034	North Carolina	Buncombe	13.0	13.5	0.5	4%
370330001	North Carolina	Caswell	12.7	12.8	0.1	1%
370350004	North Carolina	Catawba	16.3	16.4	0.1	1%
370370004	North Carolina	Chatham	12.6	13.0	0.4	3%
370510009	North Carolina	Cumberland	16.6	17.0	0.4	2%
370570002	North Carolina	Davidson	15.4	15.9	0.5	3%
370610002	North Carolina	Duplin	14.2	14.4	0.2	1%

Table 4-3. Comparison of CAMx 6.40 2028elv3 and CAMx 6.32 2028el Simulation of Daily (24-Hour) $PM_{2.5}$ Design Values (µg/m^3)

Monitor	State	County	2028 Daily (24-Hr) $PM_{2.5}$ Design Value (µg/m^3)			
			6.32 2028el	6.40 2028elv3	Difference	Percent Difference
370630015	North Carolina	Durham	13.6	13.9	0.3	2%
370650004	North Carolina	Edgecombe	14.3	14.7	0.4	3%
370670022	North Carolina	Forsyth	14.9	15.3	0.4	3%
370670030	North Carolina	Forsyth	14.4	14.8	0.4	3%
370710016	North Carolina	Gaston	16.2	16.4	0.2	1%
370810013	North Carolina	Guilford	15.5	16.1	0.6	4%
370810014	North Carolina	Guilford	13.5	14.4	0.9	7%
370870012	North Carolina	Haywood	18.7	18.8	0.1	1%
370990006	North Carolina	Jackson	13.9	13.8	-0.1	-1%
371010002	North Carolina	Johnston	13.8	14.1	0.3	2%
371070004	North Carolina	Lenoir	15.3	15.8	0.5	3%
371110004	North Carolina	McDowell	15.1	15.4	0.3	2%
371170001	North Carolina	Martin	16.5	17.3	0.8	5%
371190041	North Carolina	Mecklenburg	17.2	17.5	0.3	2%
371190042	North Carolina	Mecklenburg	17.7	17.9	0.2	1%
371190043	North Carolina	Mecklenburg	15.0	15.2	0.2	1%
371210001	North Carolina	Mitchell	13.8	13.8	0.0	0%
371230001	North Carolina	Montgomery	14.5	14.9	0.4	3%
371290002	North Carolina	New Hanover	15.6	15.9	0.3	2%
371470006	North Carolina	Pitt	14.8	15.4	0.6	4%
371550005	North Carolina	Robeson	16.3	16.9	0.6	4%
371590021	North Carolina	Rowan	14.9	15.3	0.4	3%
371730002	North Carolina	Swain	15.5	15.6	0.1	1%
371830014	North Carolina	Wake	16.9	17.4	0.5	3%
371830020	North Carolina	Wake	14.1	14.4	0.3	2%
371890003	North Carolina	Watauga	12.6	13.0	0.4	3%
371910005	North Carolina	Wayne	15.3	15.8	0.5	3%
450190048	South Carolina	Charleston	16.2	16.3	0.1	1%

Table 4-3. Comparison of CAMx 6.40 2028elv3 and CAMx 6.32 2028el Simulation of Daily (24-Hour) $PM_{2.5}$ Design Values (µg/m³)

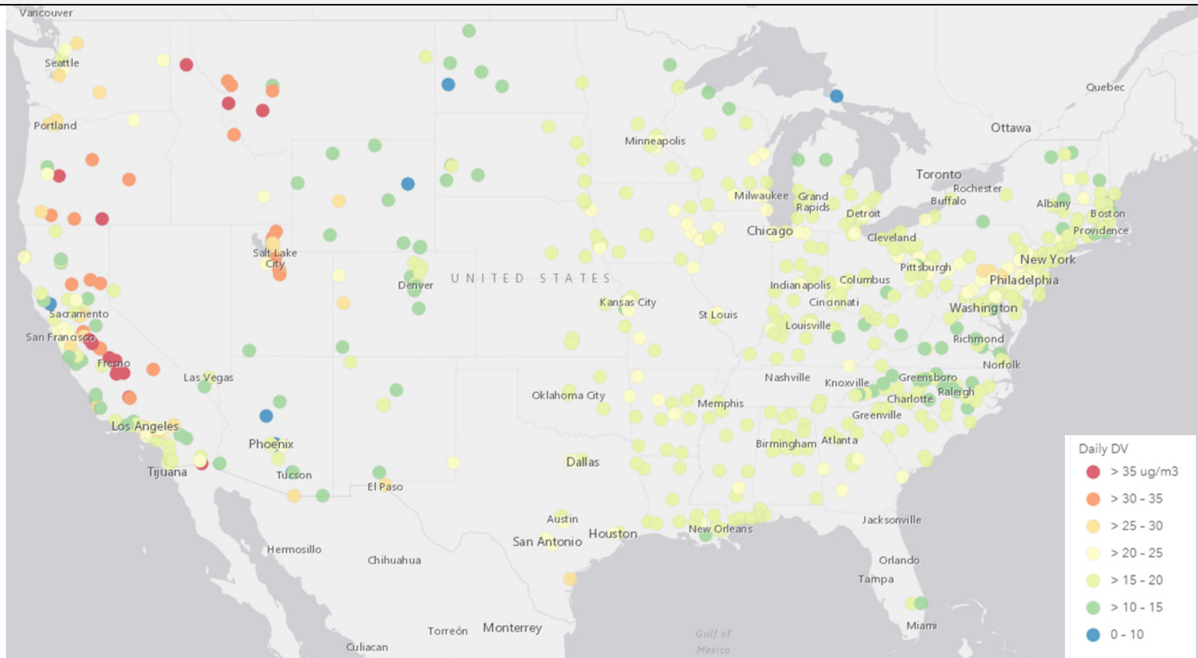
Monitor	State	County	2028 Daily (24-Hr) $PM_{2.5}$ Design Value (µg/m³)			
			6.32 2028el	6.40 2028elv3	Difference	Percent Difference
450190049	South Carolina	Charleston	15.6	15.9	0.3	2%
450250001	South Carolina	Chesterfield	15.5	15.5	0.0	0%
450370001	South Carolina	Edgefield	17.0	16.9	-0.1	-1%
450410003	South Carolina	Florence	18.2	18.4	0.2	1%
450450009	South Carolina	Greenville	17.9	18.1	0.2	1%
450450015	South Carolina	Greenville	19.2	19.3	0.1	1%
450630008	South Carolina	Lexington	18.9	19.0	0.1	1%
450790019	South Carolina	Richland	19.5	19.4	-0.1	-1%
450830011	South Carolina	Spartanburg	17.2	17.4	0.2	1%
470650031	Tennessee	Hamilton	18.6	18.6	0.0	0%
470651011	Tennessee	Hamilton	17.3	17.0	-0.3	-2%
470654002	Tennessee	Hamilton	17.0	16.7	-0.3	-2%
510030001	Virginia	Albemarle	12.7	13.8	1.1	9%
510360002	Virginia	Charles	13.2	13.9	0.7	5%
510410003	Virginia	Chesterfield	14.7	15.5	0.8	5%
510590030	Virginia	Fairfax	17.3	18.0	0.7	4%
510690010	Virginia	Frederick	18.1	18.6	0.5	3%
510870014	Virginia	Henrico	15.4	16.1	0.7	5%
510870015	Virginia	Henrico	13.1	14.1	1.0	8%
511071005	Virginia	Loudoun	16.1	16.5	0.4	2%
511390004	Virginia	Page	15.2	16.1	0.9	6%
511650003	Virginia	Rockingham	17.1	17.7	0.6	4%
515200006	Virginia	Bristol City	15.7	16.2	0.5	3%
516500008	Virginia	Hampton City	14.1	14.9	0.8	6%
516800015	Virginia	Lynchburg City	13.4	13.9	0.5	4%
517100024	Virginia	Norfolk City	15.0	15.7	0.7	5%
517700015	Virginia	Roanoke City	16.4	16.9	0.5	3%
517750011	Virginia	Salem City	14.6	15.0	0.4	3%

Table 4-3. Comparison of CAMx 6.40 2028elv3 and CAMx 6.32 2028el Simulation of Daily (24-Hour) $PM_{2.5}$ Design Values (µg/m^3)

Monitor	State	County	2028 Daily (24-Hr) $PM_{2.5}$ Design Value (µg/m^3)			
			6.32 2028el	6.40 2028elv3	Difference	Percent Difference
518100008	Virginia	Virginia Beach City	16.4	16.8	0.4	2%
540030003	West Virginia	Berkeley	22.8	23.5	0.7	3%
540090005	West Virginia	Brooke	18.9	19.2	0.3	2%
540110006	West Virginia	Cabell	17.9	18.8	0.9	5%
540291004	West Virginia	Hancock	19.6	20.5	0.9	5%
540390010	West Virginia	Kanawha	16.1	17.0	0.9	6%
540391005	West Virginia	Kanawha	18.2	18.6	0.4	2%
540490006	West Virginia	Marion	19.1	19.3	0.2	1%
540511002	West Virginia	Marshall	23.1	23.3	0.2	1%
540610003	West Virginia	Monongalia	16.2	17.1	0.9	6%
540690010	West Virginia	Ohio	17.7	17.9	0.2	1%
540810002	West Virginia	Raleigh	13.9	14.3	0.4	3%
541071002	West Virginia	Wood	18.6	18.6	0.0	0%

Daily $PM_{2.5}$ Design Value – 12US2 Domain

CAMx 6.40



Percent Difference (CAMx 6.40 – CAMx 6.32) / CAMx 6.32

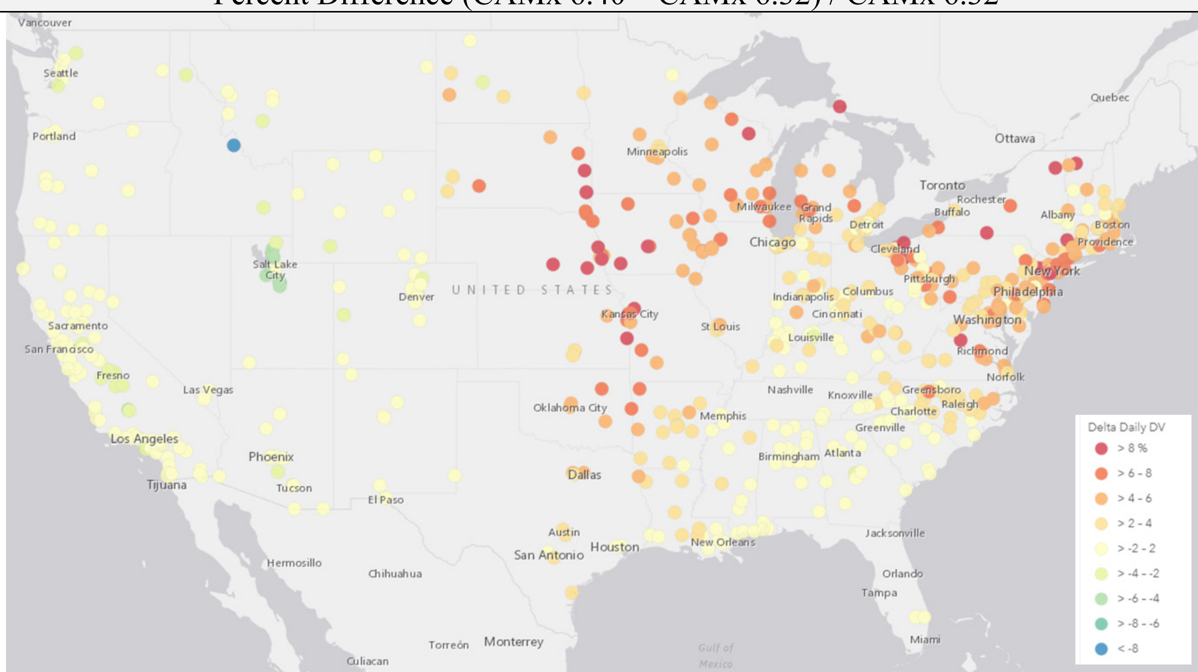


Figure 4-18. Comparison of Daily $PM_{2.5}$ Design Values ($\mu g/m^3$) for CAMx 6.32 2028el and CAMx 6.40 2028elv3 Simulations

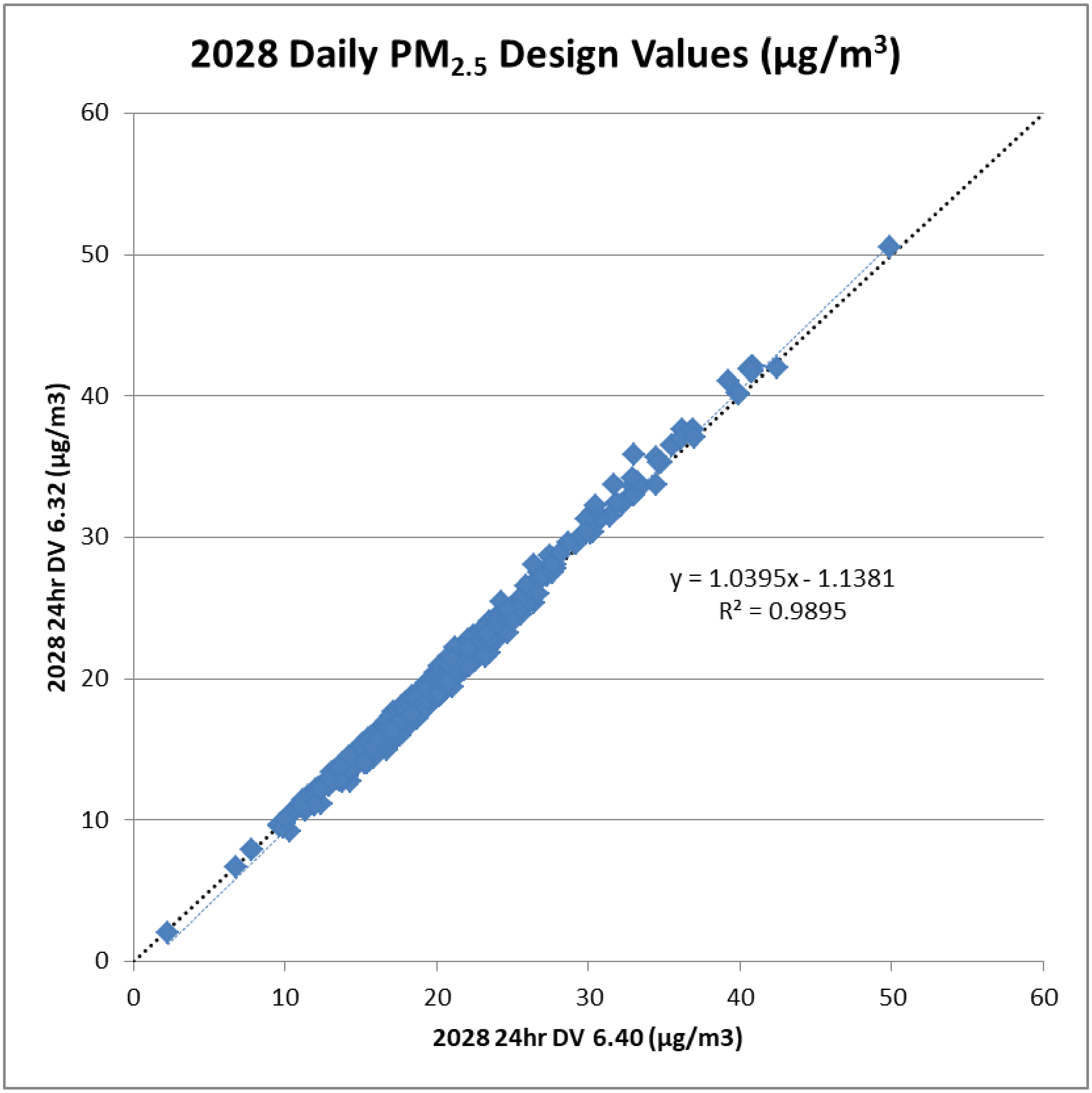


Figure 4-19. Comparison of Daily $PM_{2.5}$ Design Values (µg/m^3) for CAMx 6.32 2028el and CAMx 6.40 2028elv3 Simulations

4.4 Scatterplots of Ozone and PM Species Concentrations

Scatterplots of the daily average concentrations of ozone and the various calculated PM species in local standard time at the Interagency Monitoring for Protected Visual Environment (IMPROVE) monitors across all modeled days are presented in Figures 4-20 through 4-26. The CAMx 6.40 results are plotted on the x-axis and the CAMx 6.32 results are plotted on the y-axis.

Figure 4-20 exhibits concentrations for ozone have a high degree of correlation with a line of best fit with a slope of 0.9754, an intercept of 0.5203 ppb and an R^2 of 0.9974. Results are scattered both above and below the 1:1 line, with marginally higher concentrations estimated by CAMx 6.40 across the concentration range.

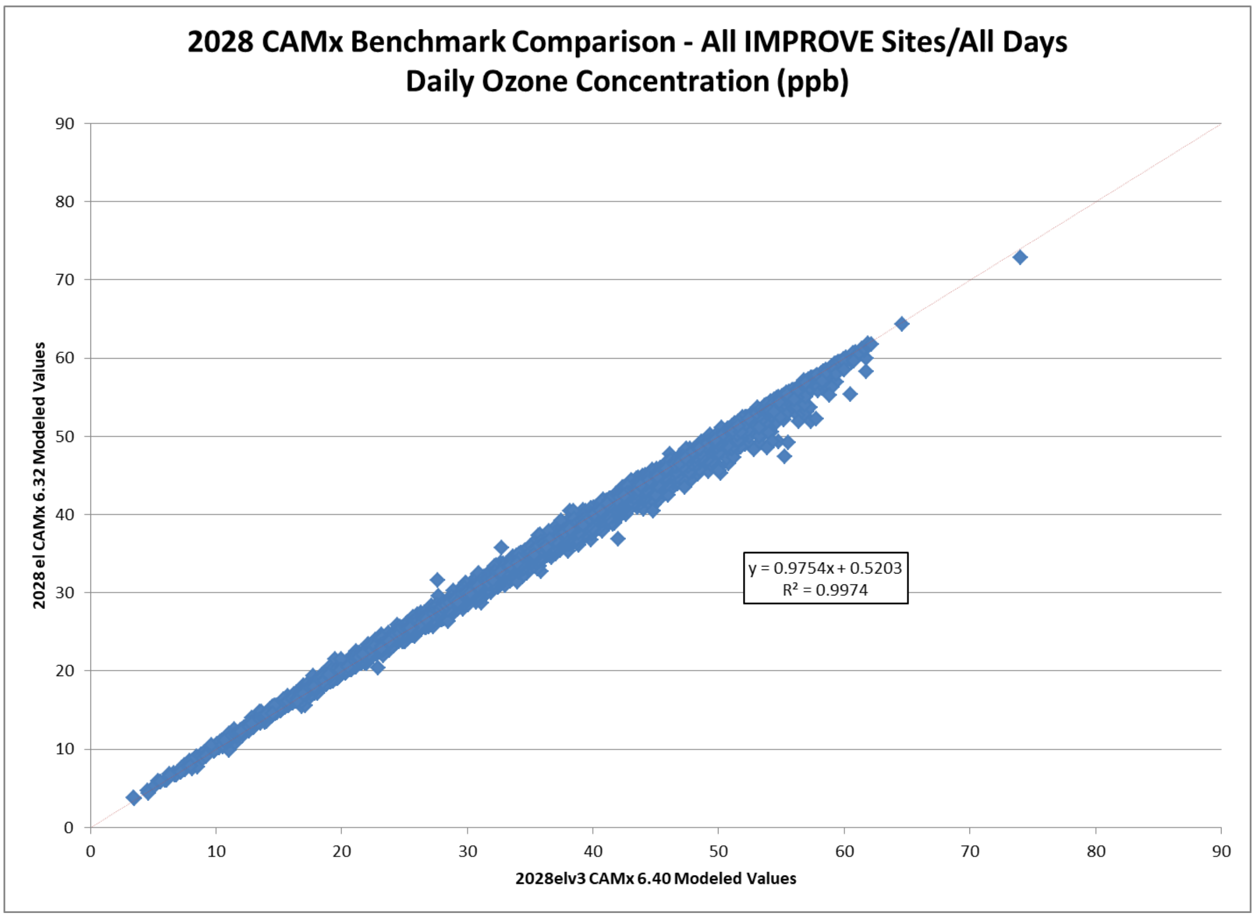


Figure 4-20. Scatterplot Comparing 24-hour Average Predicted Ozone Concentrations (ppb) for All Days at all IMPROVE Monitor Locations for CAMx 6.32 and CAMx 6.40 2028 Simulations Performed by VISTAS (Alpine)

Scatterplots of the daily average $PM_{2.5}$ concentrations in local standard time at the IMPROVE monitors are presented in Figures 4-21 and 4-22 with different axis scaling to facilitate analysis over the full range of concentrations. The CAMx 6.40 results are plotted on the x-axis and the CAMx 6.32 results are plotted on the y-axis. The data has a high degree of correlation with a line of best fit with a slope of 0.9973, an intercept of 0.3731 μg/m^{3}and an R^2 of 0.9845. The agreement between the models is higher at higher concentrations. At lower concentrations the CAMx 6.32 results are slightly higher than the CAMx 6.40 results.

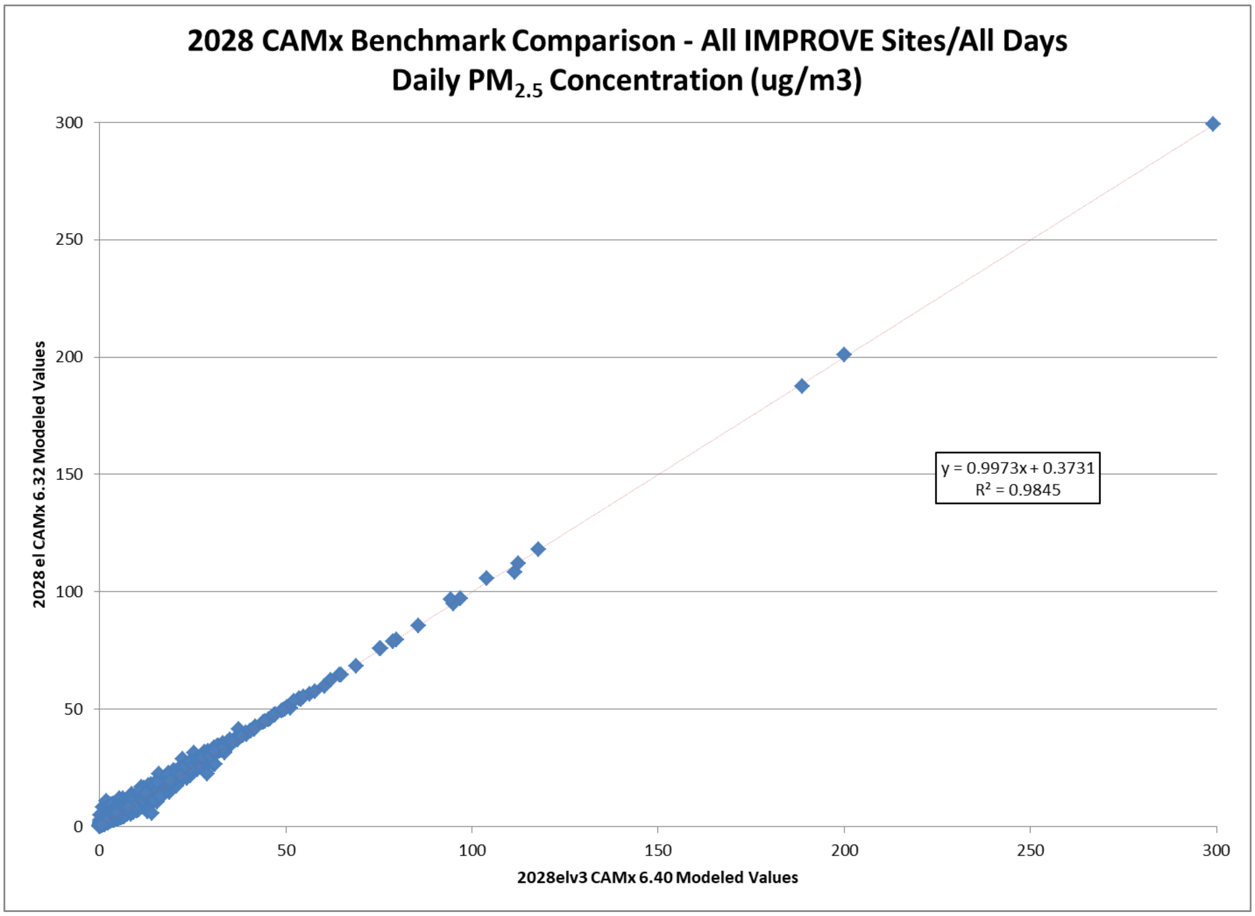


Figure 4-21. Scatterplot Comparing 24-hour Average Predicted $PM_{2.5}$ Concentrations (μg/m^3) for All Days at all IMPROVE Monitor Locations for CAMx 6.32 and CAMx 6.40 2028 Simulations Performed by VISTAS (Alpine)

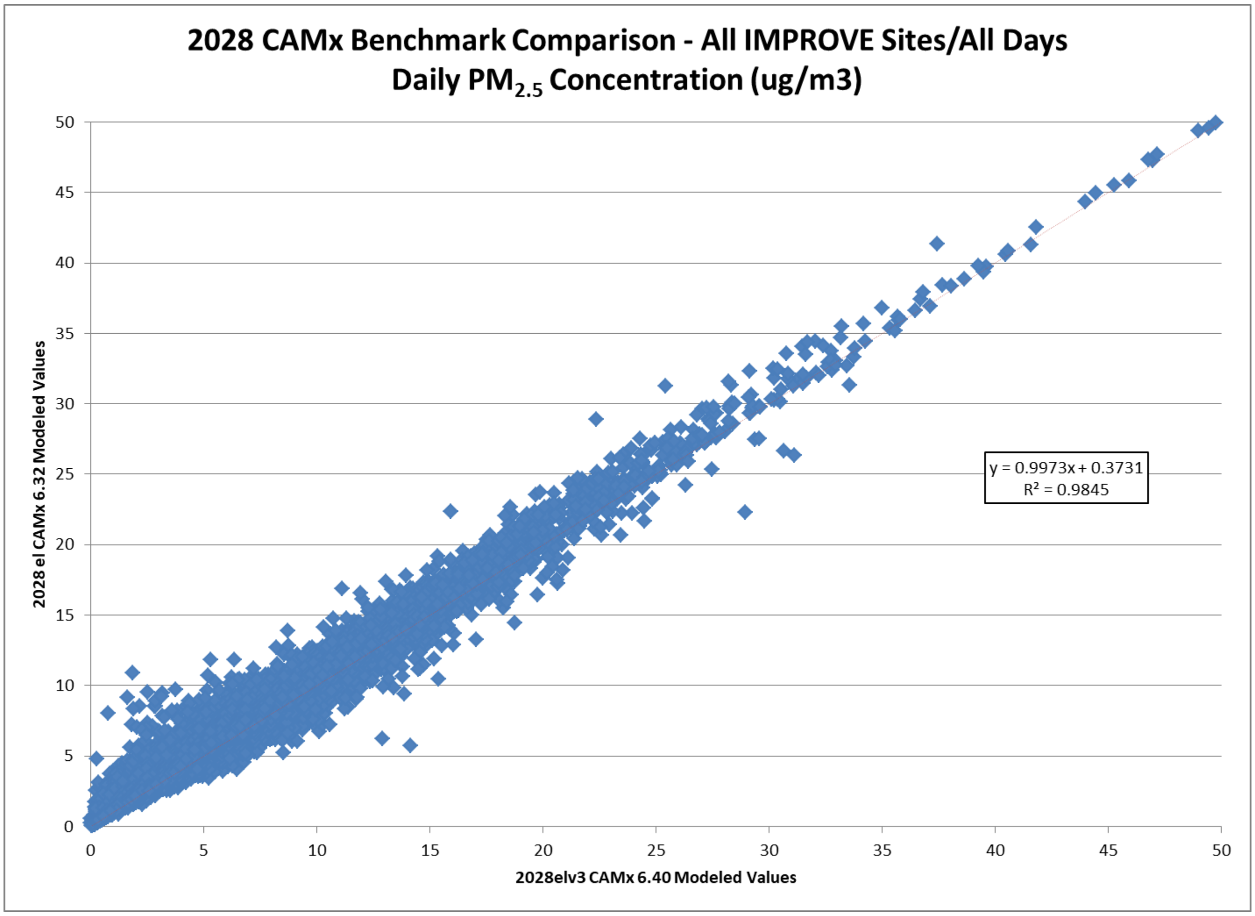


Figure 4-22. Scatterplot Comparing 24-hour Average Predicted $PM_{2.5}$ Concentrations ($\mu g/m^3$) for All Days at all IMPROVE Monitor Locations for CAMx 6.32 and CAMx 6.40 2028 Simulations Performed by VISTAS (Alpine); Modified Scale

Scatterplots of the daily average sulfate concentrations in local standard time at the IMPROVE monitors are presented in Figure 4-23. The CAMx 6.40 results are plotted on the x-axis and the CAMx 6.32 results are plotted on the y-axis. The data has considerably more scatter than the ozone or $PM_{2.5}$ results with a line of best fit with a slope of 0.9057, an intercept of 0.0.092 $\mu g/m^3$ and an R^2 of 0.8566. The vast majority of the points at low concentrations are above the 1:1 line, meaning that the CAMx 6.32 modeled values are higher than the CAMx 6.40 results. The reverse is true at medium and high concentrations where CAMx 6.40 tends to estimate higher concentrations than CAMx 6.32. These are likely a result of the changes in the wet deposition algorithms and the oxidation of SO_2 on primary crustal particles and updates to the RADM aqueous chemistry algorithm in addition to the changes in the elevated SO_2 emissions.

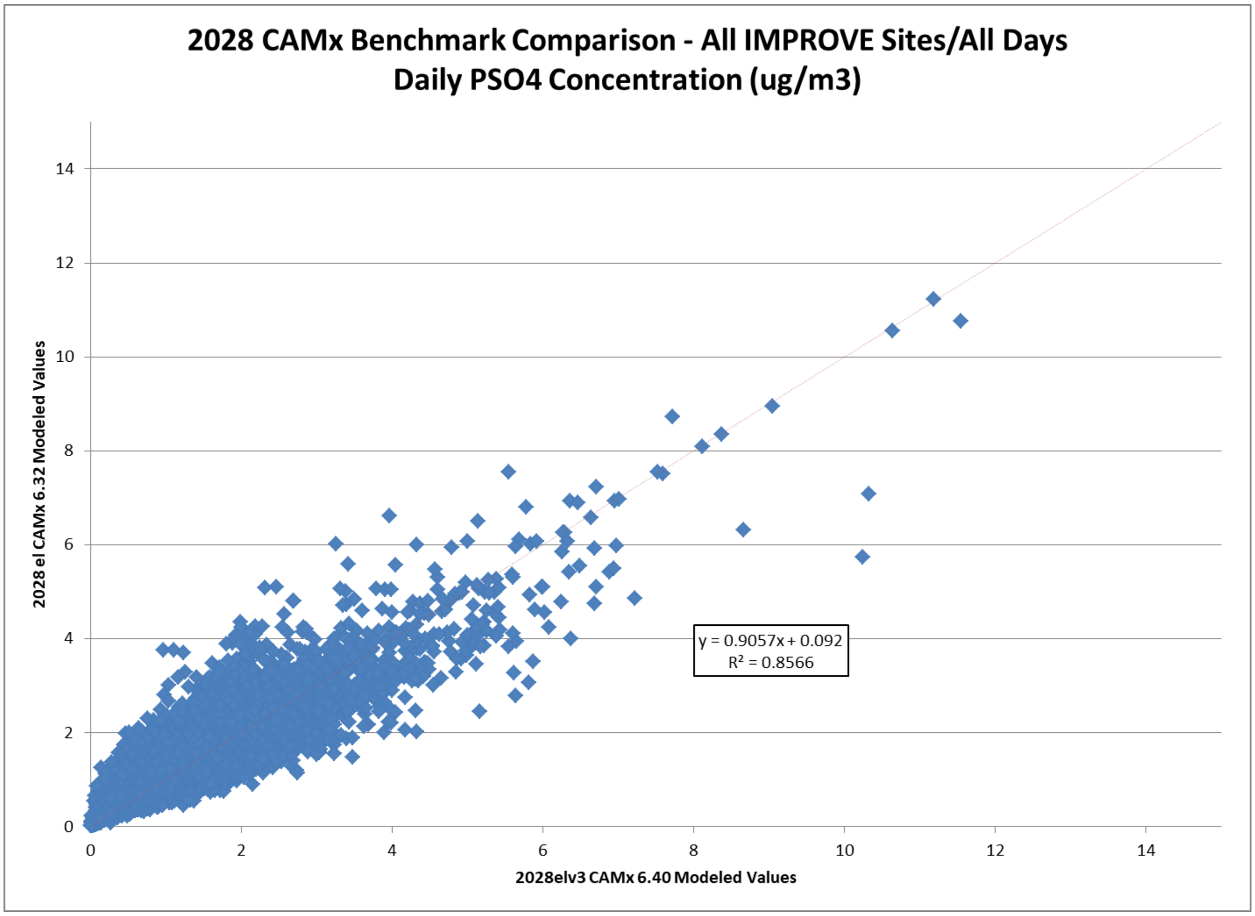


Figure 4-23. Scatterplot Comparing 24-hour Average Predicted Sulfate Concentrations (µg/m^3) for All Days at all IMPROVE Monitor Locations for CAMx 6.32 and CAMx 6.40 2028 Simulations Performed by VISTAS (Alpine)

Scatterplots of the daily average nitrate concentrations in local standard time at the IMPROVE monitors are presented in Figure 4-24. The CAMx 6.40 results are plotted on the x-axis and the CAMx 6.32 results are plotted on the y-axis. The data has slightly more scatter than the ozone or $PM_{2.5}$ results with a line of best fit with a slope of 0.9266, an intercept of 0.0009 µg/m^3 and an R^2 of 0.9743. Unlike the sulfate results which showed more uniform scatter around the 1:1 line, the CAMx 6.40 nitrate results are marginally higher than CAMx 6.32 except at low concentrations.

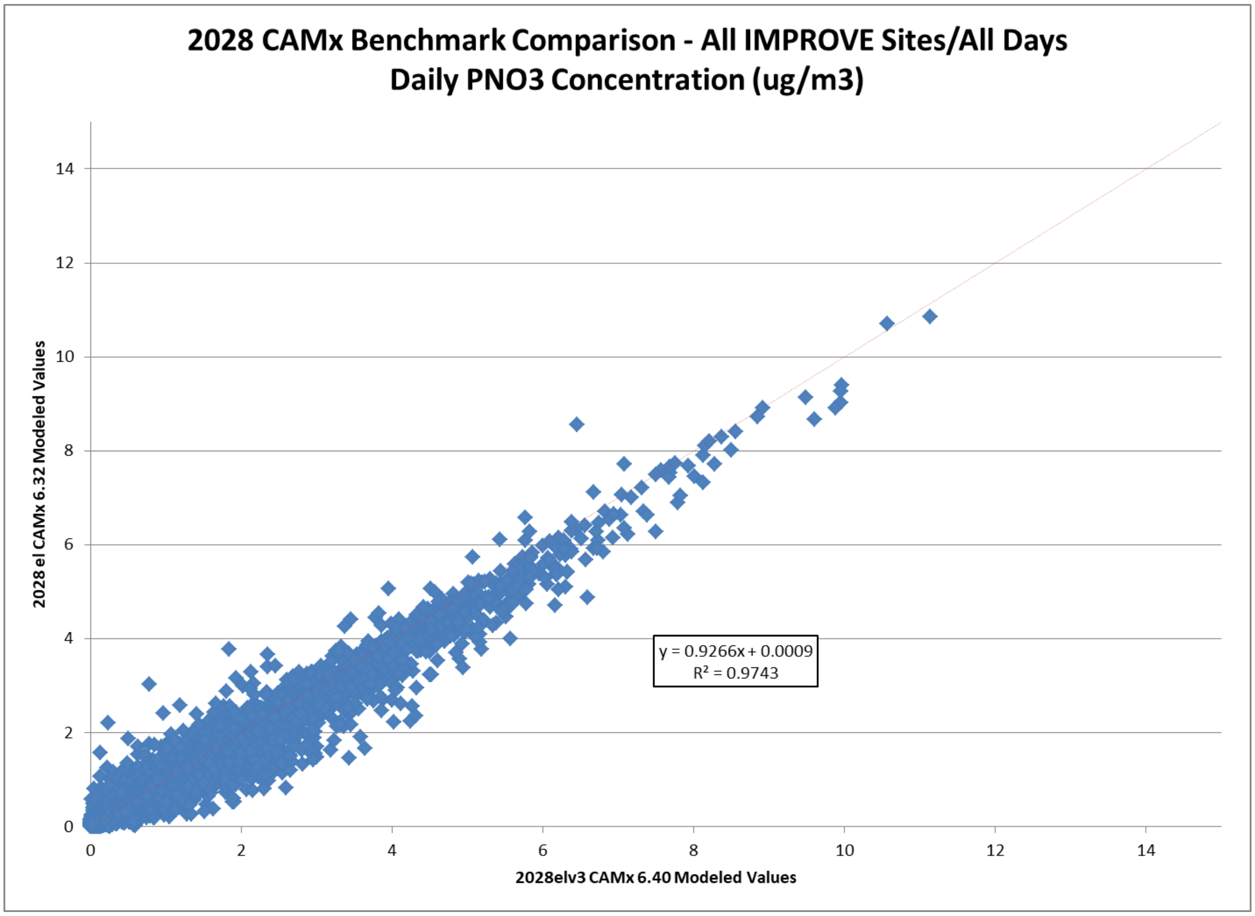


Figure 4-24. Scatterplot Comparing 24-hour Average Predicted Nitrate Concentrations (µg/m^3) for All Days at all IMPROVE Monitor Locations for CAMx 6.32 and CAMx 6.40 2028 Simulations Performed by VISTAS (Alpine)

Scatterplots of the daily average organic carbon concentrations in local standard time at the IMPROVE monitors are presented in Figures 4-24 and 4-25 with different axis scaling to facilitate analysis over the full range of concentrations. The CAMx 6.40 results are plotted on the x-axis and the CAMx 6.32 results are plotted on the y-axis. The data has a high degree of correlation with a line of best fit with a slope of 1.0146, an intercept of 0.3025 ppb and an R^2 of 0.9837. The CAMx 6.40 results are slightly lower than CAMx 6.32 across the concentration range.

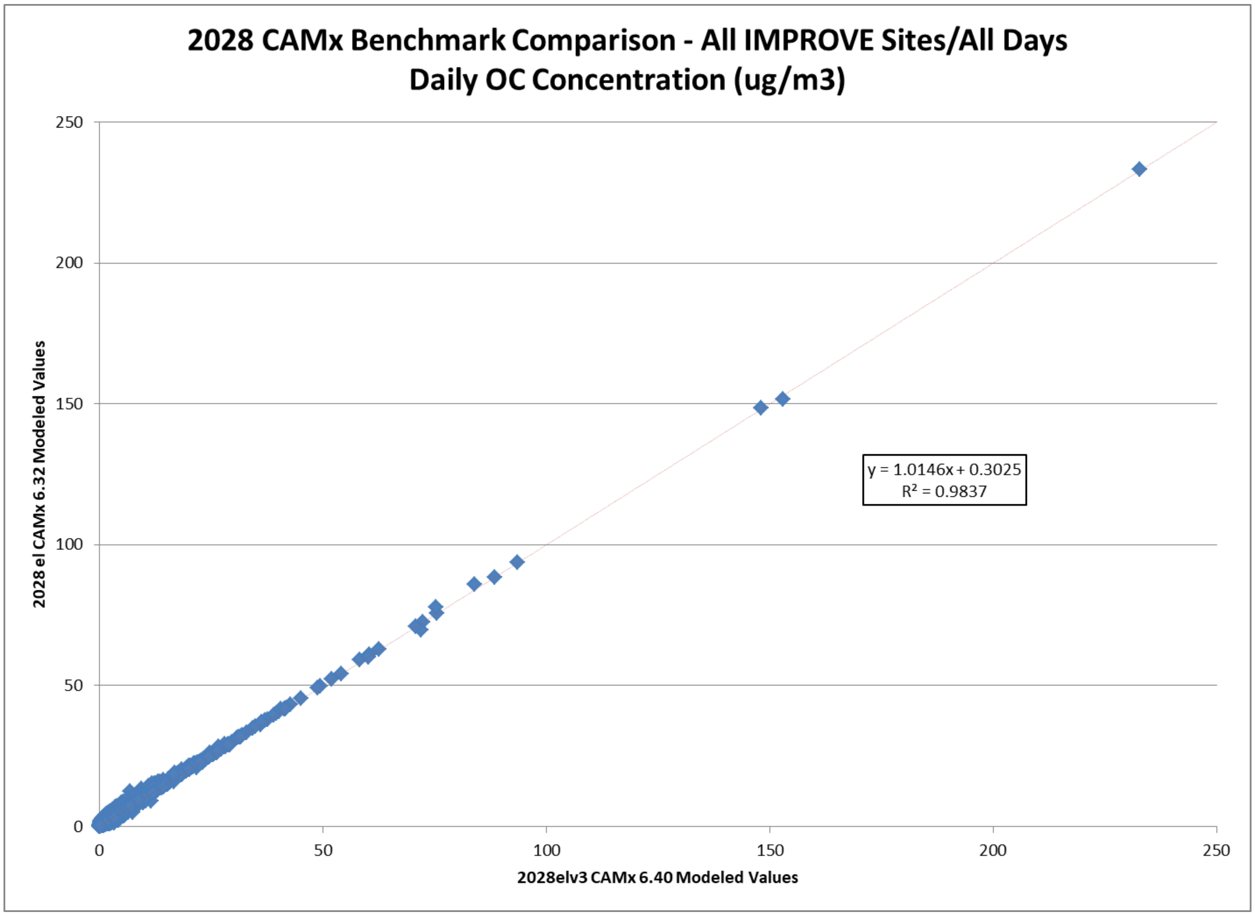


Figure 4-25. Scatterplot Comparing 24-hour Average Predicted Organic Carbon Concentrations (µg/m^3) for All Days at all IMPROVE Monitor Locations for CAMx 6.32 and CAMx 6.40 2028 Simulations Performed by VISTAS (Alpine)

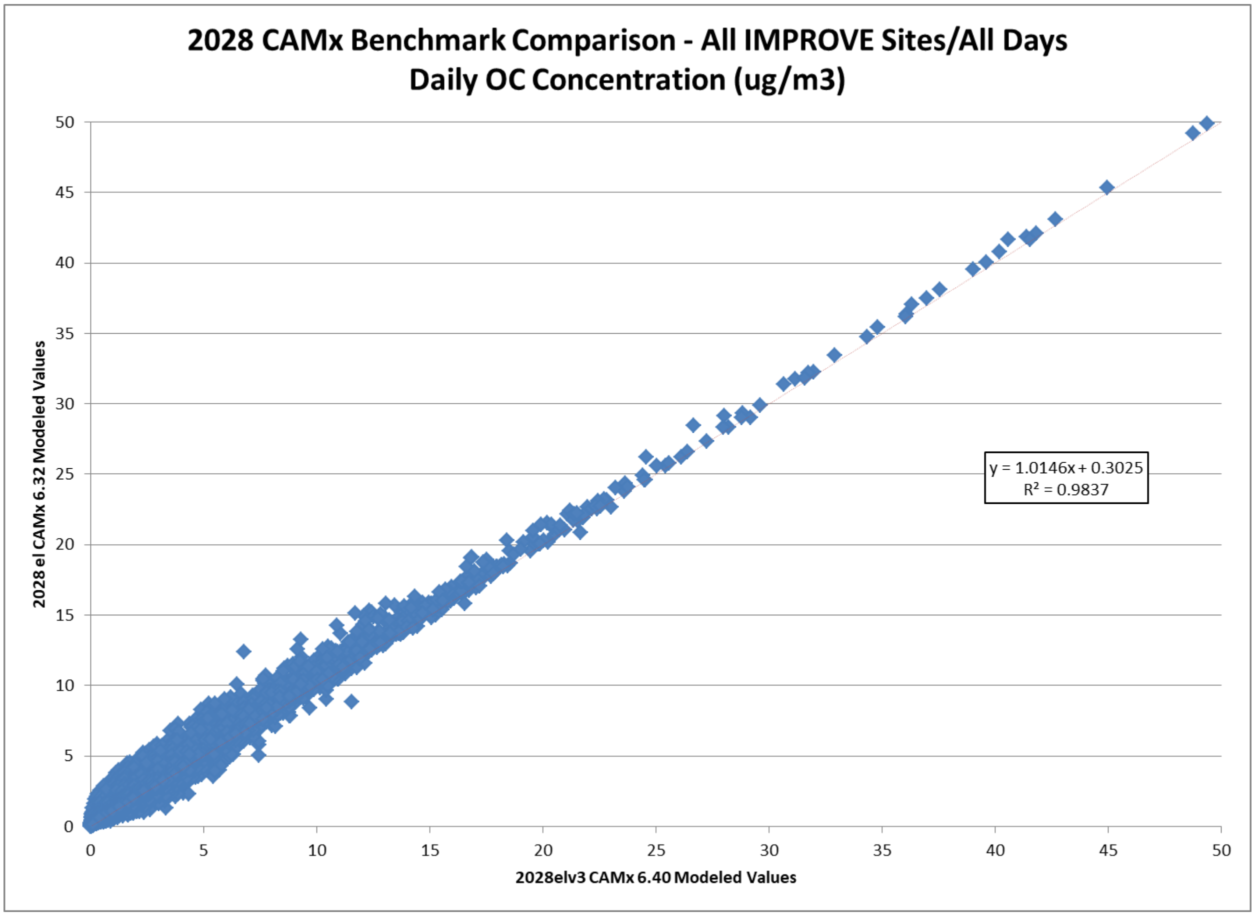


Figure 4-26. Scatterplot Comparing 24-hour Average Predicted Organic Carbon Concentrations (µg/m^3) for All Days at all IMPROVE Monitor Locations for CAMx 6.32 and CAMx 6.40 2028 Simulations Performed by VISTAS (Alpine); Modified Scale

5.0 CONCLUSIONS

A comparison has been made between CAMx 6.32 and CAMx 6.40 simulations using EPA's 2028el and SESARM's 2028elv3 modeling platform as performed on the Alpine Geophysics computer system. The comparison was conducted for $PM_{2.5}$ and included an examination both of annual emissions for elevated and low level sources and annual and daily future year design values at monitors in the modeling domain.

The annual emissions comparisons showed areas of differences across the domain that are consistent with documented changes in the 2028 emissions inventories used by SESARM for this analysis. A comparison of the annual and daily $PM_{2.5}$ design values at the monitors in the 12US2 modeling domain showed a systematic increase for the majority of FRM monitors for both values between the CAMx 6.32 and CAMx 6.40 platform. The greatest change in design values are seen in and around boundaries of VISTAS states and other outside regions (e.g., OTC and CENRAP) with smallest change noted centrally within the VISTAS state domain itself.

A comparison of the daily average concentrations at the IMPROVE monitors showed fairly small differences for ozone between the two simulations with CAMx 6.40 estimating slightly larger values in the high concentration range. Organic Carbon was estimated as slightly lower across all concentration ranges using CAMx 6.40 compared to CAMx 6.32. For sulfate, the CAMx 6.40 results were generally higher than CAMx 6.32, especially across the medium and high concentration ranges. This is likely a result of the changes in the wet deposition algorithms, the oxidation of SO_2 on primary crustal particles, and updates to the RADM aqueous chemistry algorithm and changes in SO_2 emissions. For nitrate, the CAMx 6.40 results were consistently higher across all ranges compared to CAMx 6.32 except at very low concentrations. The $PM_{2.5}$ results generally showed lower CAMx 6.40 concentrations compared to CAMx 6.32 at low concentration levels.

The comparison of CAMx 6.32 and 6.40 showed differences in both annual and daily $PM_{2.5}$ design values as well as in daily concentrations of various $PM_{2.5}$ species. This is to be expected given the changes to the model from the inclusion of new science into CAMx 6.40 over that which was included in CAMx 6.32 and the changes made in the 2028 projection emission inventory across the modeling domain. Alpine Geophysics does not see any features in the modeling that would preclude the use of the better science and updated emission inventories in CAMx 6.40 for use in the VISTAS air quality planning.