ALASKA DEPARTMENT OF ENVIRONMENTAL CONSERVATION

Amendments to:
State Air Quality Control Plan

Vol. II: III.D.7.8

Modeling

Public Review Draft

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Note: This document consists of the Fairbanks North Star Borough $PM_{2.5}$ Serious SIP (189(b)), the 2020 Amendments (189(d)), and the new 2024 Revised/Amendments. The new 2024 Amendments are proposed for inclusion in this section of the State Air Quality Control Plan to address the disapproval of the Serious SIP and the 2020 Amendments. The new language/revisions, which are in bold and underlined format and start from Section III.D.7.8-15 on page 83, are the only parts that are open for public review and comment. The Serious SIP requirements from Sections III.D.7.8.1 through III.D.7.8.13.1 and 2020 Amendments requirements from Sections III.D.7.8.14 through III.D.7.8.14.4 from page 1 to 82 are included to provide historical background on the approved NOx and VOC precursor demonstration.

7.8 Modeling

7.8.1 Overview

A variety of modeling studies using different analytical techniques have been performed to provide alternate insights into emission source significance and assess chemical mechanisms influencing particle formation in the atmosphere under conditions associated with exceedances of the 24-hour ambient $PM_{2.5}$ standard. The insight gained from these studies focused attention on the sources that needed to be characterized in the emissions inventory and the chemical mechanisms that needed to be considered in the modeling used to assess the impact on $PM_{2.5}$ concentrations in future years due to control strategies and emission inventory changes over time.

Since the Moderate Area SIP, data has been collected at three additional monitoring sites for which a 5 year design value can be calculated (see Section III.D.7.4 Ambient Monitoring and Trends) for the modeling years 2011 to 2015. In addition, the Hurst Road monitor is now the violating monitor for the area. The Serious SIP analyzes these additional data, new speciation data for $PM_{2.5}$, new insights into the North Pole model performance, and sensitivity testing in this modeling chapter.

This section provides a summary of initial modeling studies used to characterize source apportionment that were performed as part of the Moderate Area SIP[1], including (1) a statistical evaluation (using positive matrix factorization or PMF) of the variance in speciated measurements of $PM_{2.5}$ collected on filters at the Federal Reference Monitor (FRM) located at the State Office Building in downtown Fairbanks, to attribute source significance; (2) another statistical evaluation using Chemical Mass Balance (CMB) modeling to compare the mix of chemical compounds collected at multiple Fairbanks monitoring sites to the mix of chemical compounds emitted from each emission source, to prioritize source significance; (3) Carbon-14 (^{14}C) assessment of the age distribution of carbon molecules found at each site, to provide insight into the distribution of emissions from wood burning versus fossil fuels; and (4) analysis of an organic chemical compound known as levoglucosan, which is a unique byproduct of wood burning, to assess its significance. In addition to the statistical analyses, a dispersion modeling study using CALPUFF was used to assess the impact of pollutants emitted from the six power plants located in the nonattainment area. That study provided insight into how pollutants emitted above the mixed (i.e. inversion) layer were dispersed during the 2008 Jan/Feb modeling episode.

In addition to studying carbon, sulfate is the second largest component of $PM_{2.5}$ in the Fairbanks North Star Borough nonattainment area. Recognizing that sulfate particles collected on the monitoring filters are a mix of primary (i.e. directly emitted) and secondary particles formed from gases emitted into the atmosphere, an analysis of the chemical mechanisms governing sulfate formation was conducted. The results were used to assess how well secondary particulate formation could be simulated in photochemical modeling. An analysis of the organic chemical

[1] https://dec.alaska.gov/air/anpms/communities/fbks-pm2-5-moderate-sip

composition of $PM_{2.5}$ from Fairbanks was also prepared to identify and quantify the chemical species emitted from fossil fuel combustion.

As discussed earlier, emission inventory estimates were prepared for 2013, the base year and 2019, the attainment year. Control measures were then applied to these inventories to quantify their effect on emissions in these years. The inventory estimates—baseline and with controls (discussed in Section III.D.7.7)—were combined with meteorological inputs developed for the selected episodes (discussed in Section 7.3) and available chemistry mechanisms in the Community Multiscale Air Quality (CMAQ) Modeling System to assess the ability of Fairbanks to demonstrate attainment with the controls added for 2019 and assess the potential for attainment in 2024. A detailed summary of the CMAQ modeling results are presented in this section.

7.8.2. Sources of $PM_{2.5}$ Emissions In and Around Fairbanks:

Winters in Fairbanks, Alaska present unique meteorological conditions; cold air is trapped close to the ground, causing minimal vertical mixing within the stable boundary layer; a lack of weather systems at this latitude limits the amount of horizontal mixing. These conditions lead to elevated concentrations of air pollutants from local emissions of $PM_{2.5}$ and its precursors, especially sulfur dioxide (SO_2). To further understand these elevated concentrations, Sierra Research conducted an initial source contribution analysis based on monitoring data from a site in downtown Fairbanks. This analysis was performed on filter based data from 2005 to 2008 and the results were in the Moderate Area SIP (Section III.D.5.8). The study found that, in winter months, secondary aerosols—such as sulfate and nitrate—make up about 40 to 55 percent of the monthly average mass concentrations of $PM_{2.5}$. The concentrations are highest in January, the coldest month.

The results of this preliminary study led to a number of questions regarding the sources of the $PM_{2.5}$ in Fairbanks. To address these questions, further studies such as chemical mass balance (CMB) modeling were conducted to estimate future $PM_{2.5}$ concentrations, carbon studies and an updated 2016 PMF study of wood smoke in Fairbanks by EPA. All of these studies are summarized below.

7.8.3. Fairbanks $PM_{2.5}$ Source Apportionment Estimates Study

To understand the sources of $PM_{2.5}$ in the Fairbanks airshed, the University of Montana, Center for Environmental Health Sciences, conducted a source apportionment study based on monitoring data collected during the winters of 2005 to 2013. This information was critical to identify which sources need to be controlled in order to reduce wintertime $PM_{2.5}$ concentrations in Fairbanks. The CMB modeling[2] found that wood smoke was the major source of $PM_{2.5}$ throughout the three winter months study in Fairbanks and North Pole, contributing between 60% and nearly 80% of the measured $PM_{2.5}$ at the four sites across the nonattainment area.

The Carbon isotope ^{14}C and levoglucosan results, analyzed from a subset of filters collected from each of the four monitoring sites, also showed that approximately 50% to 80% of the measured

[2] Friedlander, S.K., 1973. Chemical element balances and identification of air pollution sources. *Environ. Sci. Technol.*, 7, 235-240.

ambient $PM_{2.5}$ came from a new-carbon source (i.e., a wood smoke source). The CMB modeling coupled with the ^{14}C and Levoglucosan results support that wood smoke is the largest contributor to the ambient $PM_{2.5}$ in the Fairbanks air shed during the winter months.

After the initial PMF studies performed in the Moderate Area SIP, a source apportionment of $PM_{2.5}$ study was conducted by Robert Kotchenruther of EPA Region 10 in 2016 using the Fairbanks speciation data from 2011-2015[3]. The results agreed with CMB from 2010 to 2015 and found wood burning dominated the $PM_{2.5}$ in the Fairbanks and North Pole areas. Figure 7.8-1 shows the summary of wood burning contribution from all of the winter filters from 2010 to 2015 using PMF and CMB.

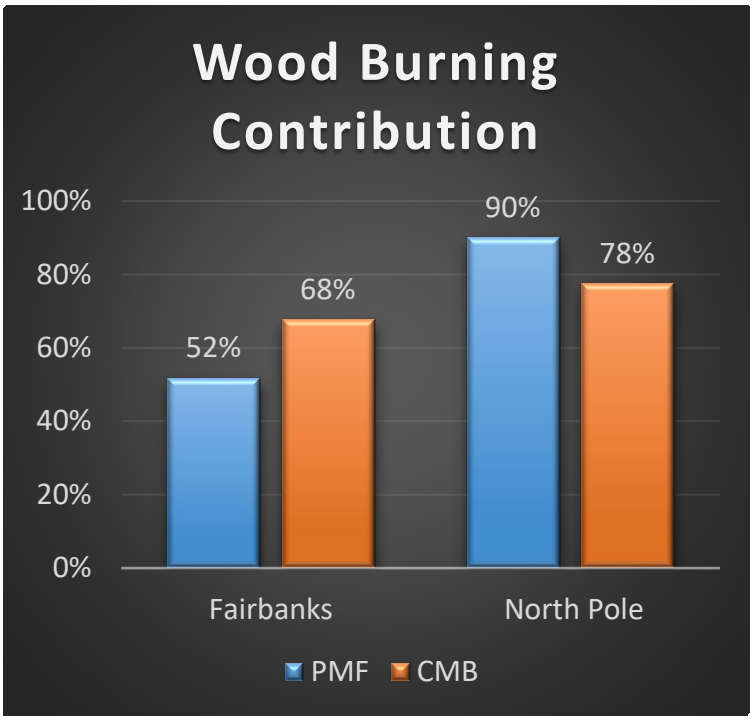


Figure 7.8-1. Fairbanks and North Pole wood burning contribution findings summary from filter based monitoring speciation results from 2011 to 2015.

7.8.4 Using the CALPUFF Dispersion Model to Characterize the Fairbanks Power Plant Plumes

EPA Region 10 suggested running a dispersion model to assess the plumes from the point sources located at the nonattainment area. DEC and EPA agreed that CALPUFF would be an appropriate model to run to characterize the plumes from the power plants located within the vicinity of the nonattainment area.

[3] Source apportionment of $PM_{2.5}$ at multiple Northwest U.S. sites: Assessing regional winter wood smoke impacts from residential wood combustion, Robert A. Kotchenruther, 2016

CALPUFF is a non-steady-state meteorological and air quality modeling system used by the EPA for studies that include long-range transport of pollutants. The model was configured with WRF inputs using Mesoscale Model Interface (MMIF) program and was modified to handle 38 vertical layers representing Fairbanks, with the lowest layer being 4 meters above ground level on a 1.33 x 1.33 km grid cell. The results of the CALPUFF concluded that 10% of direct $PM_{2.5}$ is from all of the point sources combined at the State Office Building monitor[4].

7.8.5 Sulfur Formation in Fairbanks

According to observations for the highest concentration winter days between 2006 and 2010, the second largest component of $PM_{2.5}$ is sulfur-containing particles amounting to 18% of the $PM_{2.5}$ composition for the Moderate Area SIP. For the Serious Area SIP modeling years from 2011 to 2015, the sulfur content in the Fairbanks area at 16% is similar to the earlier period. In addition the newer speciation data in North Pole shows a sulfur content of 8% with the difference being attributed to the fraction of organic carbon. Sulfur is emitted to the atmosphere through biogenic or anthropogenic sources; anthropogenic sources are quite extensive, resulting from the combustion of petro-fuel such as heating oil, diesel, and coal.

Due to the significance and complexity of sulfate formation, Dr. Richard Peltier drafted a comprehensive review of the heterogeneous and homogenous reactions that control the conversion of SO_2 to sulfate for the Moderate Area SIP.[5] In Fairbanks, the specific sources of sulfur are thought to be from coal-fired power plants, on-road diesel fuel, and home heating oil; however, the mechanisms of formation of sulfate are not fully understood. SO_2 gas phase reactions from point sources are not likely a major source of sulfate. According to several studies, heterogeneous process is most likely the mechanism involved in formation of sulfur bound particles; the mediating factors needed for the formation are oxidants such as metal catalysis, hydroxyl radical, ozone, organic peroxides, etc.

The aerosol acidity profiles of the $PM_{2.5}$ data collected by FNSB differed for winter and non-winter months. There was an excess of positively charged ammonium ions during the winter season, which suggests that sulfur conversion reactions were not highly favored; however, sulfur compounds are the second highest contributor of $PM_{2.5}$ in Fairbanks. Measurements of elemental sulfur and particulate sulfate examined in Fairbanks show significant wintertime spikes in sulfate. The understanding of aerosol chemistry related to sulfur is quite poor in Fairbanks. Additional studies pertaining to the formation of ice fog, air quality model calibration, and source apportionment are needed to better understand the elevated $PM_{2.5}$ levels and develop strategies to reach attainment.

Since the Moderate Area SIP, several research studies have been developed and planning to be implemented to help answer the sulfur formation questions in Fairbanks. The ALPACA study is a measurement campaign organized by scientists from all over the world. Fairbanks, Alaska will be the wintertime study base in the January/February 2021 time frame for an intensive measurements, modeling and assessment campaign. DEC has sent a letter of support for this study and has been involved in reviewing the white paper. This study should be an invaluable

[4] https://dec.alaska.gov/air/anpms/communities/fbks-pm2-5-moderate-sip
[5] Peltier, R.E. (2011): Aerosol Chemistry in Fairbanks: A Summary of Prevailing Conditions, May 27, 2011

resource for DEC and for further SIP work for $PM_{2.5}$, but the results will not be available on the timeline of the Serious SIP.[6]

Source contributions and possible chemical mechanisms have not been fully resolved in the case of particulate sulfate in Fairbanks. These analyses provide context to understanding the model performance for secondary sulfate as a component of $PM_{2.5}$. An SO_2 analysis has to be evaluated for the Serious SIP and that information is summarized in the SO_2 assessment section of this modeling chapter.

7.8.6. Organics Analysis for Residential Oil Burner Emissions

Several studies conducted for possible sources of $PM_{2.5}$ in Fairbanks Alaska determined that residential heating, transportation, and coal combustion are a few of the major sources contributing to the elevated concentrations of particulate matter. DEC contracted with the University of Montana for the Moderate Area SIP to characterize the organic chemical composition of $PM_{2.5}$ from Fairbanks with the goal of identifying and quantifying chemical species that can be used to indicate and monitor $PM_{2.5}$ emissions from fossil fuel combustion.[7]

Selected samples representing typical or high $PM_{2.5}$ days from the winter of 2009-2010 in Fairbanks were analyzed for organic compounds: Hopanes, steranes, and polynuclear aromatic hydrocarbons (PAHs). Emphasis was placed on sulfur-containing compounds such as dibenzothiophene with known emission of diesel fuels and residential oil burners. The PAH picene was also looked at in determining the emissions from coal combustion.

The study found high concentrations of hopanes, steranes, picene and thiophenes in the air and $PM_{2.5}$ composition, indicating that coal combustion may account for a significant level of the sulfur/sulfate fraction of $PM_{2.5}$. Overall, the results indicated that fossil fuel and coal combustion significantly add to the $PM_{2.5}$ problem seen in Fairbanks.

These sources potentially contribute to the total sulfur and carbon measured in particles in Fairbanks. This study provides some insight into the importance of oil burning and coal burning sources that can be useful comparison points for air quality modeling outputs.

7.8.7. Rationale for Model Selections

Air quality attainment modeling is divided into three different modeling tasks:
(1) meteorological modeling/processing, (2) emissions modeling/processing, and
(3) photochemical transport modeling. There are a number of available computer models for each of these tasks. The models chosen for the meteorological and photochemical transport tasks are explained below.

7.8.7.1. Meteorology Model

The Weather Research Forecasting Model (WRF) Advanced Research WRF (WRF-ARW) model was chosen as the meteorological model. Typically either the Mesoscale Meteorological

[6] ALPACA: Alaskan Layered Pollution And Chemical Analysis (ALPACA) White Paper, Fairbanks, Alaska. [online] Available from: https://alpaca.community.uaf.edu/files/2018/11/ALPACA-whitepaper-30Nov2018.pdf, 2018. https://alpaca.community.uaf.edu/

[7] https://dec.alaska.gov/air/anpms/communities/fbks-pm2-5-science/

Model Version 5 (MM5) or the WRF model are considered for generating gridded, regional meteorological data as inputs for a photochemical transport model. For Fairbanks, the meteorological model must be able to accurately represent a subarctic environment with extreme atmospheric inversions, cold ambient temperatures, and low wind speeds over long periods.

Based on past research at the University of Alaska Fairbanks (UAF)[8] and Penn State University,[9] the WRF model was ultimately selected as the meteorological model for this SIP. Researchers at UAF have had success adapting WRF to the unique winter surface conditions of the subarctic region around Fairbanks. As part of an EPA-funded Regional Applied Research Effort (RARE), project researchers at Penn State tested WRF model sensitivity when optimized to represent a low wind speed under extreme cold conditions.[10]

7.8.7.2. CMAQ Model

The Community Multiscale Air Quality (CMAQ) Modeling System was chosen as the model for the $PM_{2.5}$ attainment test in Fairbanks for the SIP. Generally, EPA defines an air quality attainment model as one that accurately represents the observed ambient particulate matter concentrations across a geographic region. Model considerations include the following:

1. Are the model's functions and their implementation well documented and tested?
2. Does the model support the relevant atmospheric physical and chemical functions?
3. Are experienced personnel available to deploy the model?
4. Would implementation of the model produce a prohibitive cost in time or effort?
5. Is use of the model consistent with the efforts in neighboring regions (U.S. EPA 2007)?[11]

The CMAQ model has a long track record of use in the study of regional air quality and $PM_{2.5}$ attainment modeling.[12] The model is well documented,[13] peer reviewed,[14,15] and supported

[8] Mölders, N. and G. Kramm, 2010: A case study on wintertime inversions in interior Alaska with WRF. Atmos. Res., 95, 314-332

[9] Gaudet, B., D. Stauffer, N. Seaman, A. Deng, K. Schere, R. Gilliam, J. Pleim, and R. Elleman, 2009: Modeling extremely cold stable boundary layers over interior Alaska using a WRF FDDA system. 13th Conference on Mesoscale Processes, 17-20 Aug, Salt Lake City, UT, American Meteorological Society.

[10] Gaudet, B.J., and D.R. Stauffer, 2010: Stable boundary layer representation in meteorological models in extremely cold wintertime conditions. Final Report, Purchase Order EP08D000663, Environmental Protection Agency.

[11] U.S. EPA, 2007, Guidance on the Use of Models and Other Analyses for Demonstrating Attainment of Air Quality Goals for Ozone, PM2.5, and Regional Haze, EPA-454/B07-002.

[12] San Joaquin Valley 2008 and 2012 SIPs http://www.arb.ca.gov/planning/sip/sjvpm25/24hrsjvpm25.htm

[13] Community Modeling & Analysis System provides a detailed user's guide and technical documentation https://www.cmascenter.org/cmaq/documentation/5.0.2/users_guide.cfm

[14] Aiyyer, A., Cohan, D., Russell, A., Stockwell, W., Tanrikulu, S., Vizuete, W., and Wilczak, J., 2007, Final Report: Third Peer Review of the CMAQ Model, submitted to the Community Modeling and Analysis System Center, University of North Carolina, Chapel Hill

[15] Byun, D., Schere, K.L., (2006), Review of the governing equations, computational algorithms, and other components of the models-3 Community Multiscale Air Quality (CMAQ) modeling system. Applied Mechanics Reviews 59, 51-77.

actively by EPA and a broader academic community.[16,17,18] The CMAQ model is a 3-D Eulerian photochemical transport model that can simulate atmospheric aerosols, gaseous compounds, acidity and visibility. A combination of contractors with photochemical modeling experience and DEC modelers were used by DEC for the modeling for the Serious Area SIP.

At the time of the Moderate Area SIP development CMAQv4.7.1[19] (Foley et al., 2010) was the most current version of the model and used throughout the modeling process. CMAQ versions 5.0[20] (September 2011) and 5.0.1[21] (July 2012) were released during the SIP development process and then most recently version 5.3, but these versions were not used due to the effort already invested in adapting version 4.7.1 for Fairbanks.

Even though the version CMAQ 4.7.1 is outdated, it was used for the Serious Area SIP, see Section 7.8.8.1 for more detail. Further modeling work after the Serious Area SIP will use this version of the modeling platform until it can be updated with new design values, speciation data for North Pole, and new WRF meteorology.

7.8.8 Model Setup

Several computer models are used in the process of attainment modeling. The configuration of the meteorological, emissions, and photochemical-transport models is described below.

7.8.8.1 WRF Setup

WRF model version 3.1 using data assimilation was used to complete the meteorological modeling for both episodes. For the Moderate and Serious Area SIP modeling, WRF version 3.1 was used with CMAQ because Penn State conducted the meteorology study under the EPA RARE project. Newer available versions of WRF were not used due to the considerable resources invested in adapting WRF to Fairbanks.[22] The model configurations are shown in Tables 7.8-1 through Table 7.8-3. A nested gridding configuration was used to simulate three grids: Grid 1 a 401x301 cell area with 12km horizontal resolution, Grid 2 a 202x202 cell area with 4km horizontal resolution, and Grid 3 a 202x202 cell area with 1.33km horizontal resolution. The nesting configuration is shown in Table 7.8-2. Vertical gridding was held constant between the cells at 39 layers with heights described in Table 7.8-1.

Table 7.8-1. Grid-Independent Features of WRF Simulations

WRF Feature	Value
nesting procedure	one-way concurrent

[16] Chemel, C., et al. "Application of chemical transport model CMAQ to policy decisions regarding PM2. 5 in the UK." Atmospheric Environment 82 (2014): 410-417.
[17] Shimadera, Hikari, et al. "Sensitivity analyses of factors influencing CMAQ performance for fine particulate nitrate." Journal of the Air & Waste Management Association 64.4 (2014): 374-387
[18] Zhang, Y., Liu, P., Liu, X., Pun, B., Seigneur, C., Jacobson, M.Z., and Wang, W., 2010, Fine scale modeling of wintertime aerosol mass, number, and size distributions in Central California, Journal of Geophysical Research, 115, D15207, doi:10.1029/2009JD012950..
[19] http://www.epa.gov/AMD/Research/CMAQ/release4_7_1.html
[20] http://www.airqualitymodeling.org/cmaqwiki/index.php?title=CMAQ_version_5.0_ %28February_2012_ release%29_Technical_Documentation
[21] http://www.airqualitymodeling.org/cmaqwiki/index.php?title=CMAQ_version_5.0.1_ %28July_2012_ release%29_Technical_Documentation
[22] Appendix III.D.5.8 – EPA RARE project

model top (hPa)	50
Number of vertical layers	39
eta value of full levels	1.0, 0.9995, 0.999, 0.9984, 0.99705, 0.99415, 0.99155, 0.986, 0.78, 0.966, 0.95, 0.034, 0.918, 0.902, 0.886, 0.866, 0.842, 0.814, 0.78, 0.74, 0.694, 0.648, 0.602, 0.556, 0.51, 0.464, 0.418, 0.372, 0.326, 0.282, 0.24, 0.2, 0.163, 0.128, 0.096, 0.066, 0.04, 0.018, 0
Approximate height above ground level of half levels (m)	2.0, 6.0, 10.5, 18.4, 35.5, 57.8, 90.9, 146.2, 228.3, 344.5, 478.7, 614.8, 752.7, 892.5, 1052.3, 1251.1, 1491.2, 1785.4, 2148.4, 2587.7, 3079.8, 3598.2, 4146.0, 4727.3, 5346.7, 6010.4, 6725.8, 7502.6, 8333.4, 9208.6, 10135.5, 11190.6, 12139.8, 13234.2, 14408.4, 15652.1, 16921.7, 18193.7
Exclude nudging from the boundary layer	No
***G* for analysis nudging, when used (s^{-1})**	0.0003
***G* for obs nudging, when used (s^{-1})**	0.0004
obs nudging half-time window (hr)	2
Specified, relaxed zone width	1, 9

Table 7.8-2. Grid-Dependent Features of Baseline WRF-Model Configuration

	Grid 1	Grid 2	Grid 3
Horizontal extent	401 x 301	202 x 202	202 x 202
Horizontal Δx (km)	12	4	1.33
i parent start	-	156	103
j parent start	-	106	106
Time step (s)	24	8	4
Sound step ratio	8	8	4
Dampcoef	0.0	0.0	0.0
Analysis nudging	yes	no	no
obs nudging	yes	yes	yes
Surface obs nudging xy radius (km)	100	100	75
Topographic dataset	USGS 10 m	USGS 2 m	USGS 30 s

Table 7.8-3. Grid-Independent WRF Preprocessor System (WPS) Features

Feature	Value
Projection	Lambert conformal
Reference latitude, longitude	64.8, -148.0
True latitudes	50.0, 70.0
Standard longitude	-148.0
Initial conditions	0.5 degree GFS analyses
Analysis interval (hr)	6

The high-resolution Grid 3 outputs were used in the processing of the emissions and air quality modeling. All grids used a Lambert conformal projection with reference latitude and longitude of 64.8, -148.0. Meteorology fields were processed through the Meteorology-Chemistry Input Processor (MCIP) version 3.6. Minor changes were made to MCIP due to bugs during the execution of the air quality model.[23] Emissions processing using SMOKE and MOVES emission inventories are prepared for the air quality model using the Sparse Matrix Operator Kernal Emissions (SMOKE) model. SMOKE will convert inventories to the needed spatial, temporal, and speciation formats for the air quality model. Inventories for the SMOKE model cover the following source categories: Home heating, industrial point sources, onroad mobile, nonroad, air travel, and area sources (excluding home heating). Raw inventory summaries are provided in the emissions inventory overview section (Section III.D.7.6). SMOKE version 2.7.5b was used to create 3-D photochemical transport model ready inputs for CMAQ. Modifications to SMOKE were made to allow for importing of hourly home heating gridded area source inventories. Modifications that were made to the model have been outlined model in the areas of the inventory importing (SMKINVEN), gridding (GRDMAT), temporal (TEMPORAL) and merging (SMKMRG) processes of the source code and were part of the Moderate Area SIP[24].

MOVES version 2010a was used to generate mobile source emission rates lookup tables by hour using modeled temperature data generated by WRF and processed through MCIP.

7.8.8.2 Air Quality Model Setup

Computer simulations of the two model episodes were performed with the Community Multiscale Air Quality (CMAQ) model version 4.7.1. CMAQ was compiled on a Linux custom-built computer (Intel i7 950 4 core/8 thread, 8 GB system memory, 1 TB hard disk drive) running Ubuntu 10.04 OS using the Portland Group Fortran compiler version 11.4 for the contractor simulations and then more recently CMAQ was compiled on a Linux computer (Dual Intel Xeon E5630 4 core/8 thread, 24 GB system memory, 2 TB hard disk drive) running Red Hat Enterprise 6 OS using the Portland Group Fortran at DEC in Anchorage and accessed using putty software from DEC in Juneau, Alaska.

[23] "Fairbanks North Star Borough $PM_{2.5}$ Non-Attainment Area CMAQ Modeling: Final Report Phase I," Project: 398831 CMAQ-DEC, Mölders, N., Leelasakultum, K. University of Alaska Fairbanks, Geophysical Institute, College of Natural Science and Mathematics, Department of Atmospheric Sciences, December 1, 2011

[24] https://dec.alaska.gov/air/anpms/communities/fbks-pm2-5-moderate-sip

The CMAQ model was configured with the modules shown in Table 7.8-4. The module selection followed the default options for CMAQ-4.7.1 with the exceptions of vertical diffusivity and photolysis modules. These modules were chosen based on a review of the CMAQ-model conducted by Mölders and Leelasakultum at UAF.[25]

The model was compiled with version 11.4 of the PGI Fortran compiler with the Message Passing Interface Library (MPICH 2 version 1.3.2). The CMAQ source code was modified to incorporate changes from a UAF study of the CMAQ-model usage in the Fairbanks North Star Borough $PM_{2.5}$ nonattainment area.[26]

Table 7.8-4. CMAQ Model Module Configuration Options

CMAQ Module	Selected Option[27]	Description[28]
Horizontal Advection	*hyamo*	"Global mass-conserving scheme"
Vertical Advection	*vyamo*	"Global mass-conserving scheme"
Horizontal Diffusivity	*multiscale*	"Use diffusion coefficient based on local wind deformation"
Vertical Diffusivity	*eddy*	"eddy diffusivity theory"
Photolysis	*photo_inline*	inline photolysis rate calculations
Gas-phase Chemistry Solver	*ebi_cb05cl_ae5*	"Euler Backward Iterative solver optimized for Carbon Bond-05 mechanism with chlorine and extended aerosols"
Aerosol	*aero5*	"fifth-generation model CMAQ aerosol model with extensions for sea salt emissions and thermodynamics and anew formulation for secondary organic aerosol"
Deposition	*aero_depv2*	"second-generation CMAQ aerosol deposition velocity routine"
Cloud Chemistry	*cloud_acm_ae5*	"ACM cloud processor that uses the ACM"

[25] Ibid.

[26] "Fairbanks North Star Borough $PM_{2.5}$ Non-Attainment Area CMAQ Modeling: Final Report Phase I," Project: 398831 CMAQ-DEC, Mölders, N., Leelasakultum, K. University of Alaska Fairbanks, Geophysical Institute, College of Natural Science and Mathematics, Department of Atmospheric Sciences, December 1, 2011 *http://dec.alaska.gov/air/anpms/comm/docs/fbxSIPpm2-5/CMAQ_final_report_December_1_2011_Molders_Leelasakultum.pdf*

[27] Ibid.

[28] Descriptions are reproduced from Operational Guidance for the "Community Multiscale Air Quality (CMAQ) Modeling System Version 4.7.1 (June 2010)" accessed from *https://www.cmascenter.org/cmaq/documentation/4.7.1/Operational_Guidance_ Document.pdf*

CMAQ Module	Selected Option[27]	Description[28]
Mechanism	*cb05cl_ae5_aq*	"CB05 gas-phase mechanism, fifth-generation CMAQ aerosol mechanism with sea salt, aqueous/cloud chemistry, and active chlorine"

7.8.9 Model Performance

A model performance evaluation is generally performed in support of a SIP to determine how well meteorological model outputs and air quality model predicted concentrations match measured values within those grid cells for which measurements are available (both meteorological measurements and ambient pollutant concentration measurements). A number of statistical techniques are employed to ensure that the models are behaving within acceptable ranges based on guidance established by EPA. Model performance for a photochemical air quality model is not just evaluated based on its prediction of total ambient concentrations, $PM_{2.5}$ in Fairbanks case, but also contributions from secondary particulate species.

Under the Moderate Area SIP (Section III.D.5.8.9), a robust model performance evaluation was performed for both the meteorological and photochemical air quality models. The performance of both models against measured data from the 2008 episodes was found to generally be within EPA-established ranges for good model performance. However, the extent of the evaluation was largely limited to the Fairbanks portion of the nonattainment area since Federal Reference Method regulatory monitoring in the North Pole area did not begin until 2010.

For this Serious Area SIP, the modeling platform and historical episodes were not updated from those used under the Moderate Area SIP due to a combination of factors that included relocation of regulatory monitors in North Pole, limited availability of speciated monitoring data during this North Pole monitor re-siting, and schedule/data availability constraints associated with revising both the meteorological and photochemical model platforms.

As a result, a true model performance evaluation that extended to North Pole could not be conducted for the Serious Area SIP. Instead, comparisons of regulatory monitoring data collected in Fairbanks and North Pole (specifically including the Hurst Road monitor which came on line in 2012) for the same years were used to support a qualitative assessment of photochemical modeling performance for North Pole relative to that established for Fairbanks based on the 2008 modeling episodes.

Monitored $PM_{2.5}$ concentrations in both Fairbanks and North Pole starting in calendar year 2012 were evaluated. As detailed in Section III.D.7.4, the 98th percentile values in each calendar year were found to be significantly higher in North Pole than in Fairbanks. CMAQ model outputs were examined to determine if the predicted $PM_{2.5}$ concentrations in North Pole were higher than predicted in Fairbanks and were consistent with the ratio of higher measured concentrations in North Pole vs. Fairbanks found from 2012 and later monitoring data for the same calendar year. Modeled concentrations in North Pole did not show two to four-fold higher levels than Fairbanks as seen from the measured regulatory monitoring data.

Since these comparisons were performed with outputs based on an initial 2013 baseline nonattainment area emissions inventory and the earlier 2008 modeling episodes, there was insufficient information to rigorously assess model performance that included North Pole since modeling episodes and meteorological outputs for periods in 2012 and later years for which Hurst Road monitoring data exist were not available. It is unknown whether the fact that modeled $PM_{2.5}$ concentrations in North Pole vs. Fairbanks do not match ambient measurements was due to spatial bias/inaccuracy in either the modeled meteorology, the emissions inventory or a combination of both.

Since it was not possible to evaluate bias/inaccuracy in the modeled meteorology (in the absence of updated meteorological modeling/episodes for 2012 or later years for which Hurst Road monitoring data exist), the findings of this qualitative model performance assessment triggered a re-evaluation of the data sources and uncertainties in the emissions inventory.

This inventory re-evaluation led to a series of adjustments to the Space Heating sector of the emissions inventory (the largest contributing sector). The adjustments are described in detail in Section III.D.7.6 and included:

1. More spatially-resolved home heating survey data;
2. Use of a database of known outdoor hydronic heater locations compiled by the Fairbanks Borough; and
3. Integration of commercial solid fuel heating device usage based on a survey conducted by DEC.

The space heating inventory adjustments generally resulted in increases in $PM_{2.5}$, SO_2 and NOx emissions in the North Pole portion of the nonattainment area relative to the initial 2013 inventory as summarized below in Table 7.8-5. As shown, the combined effects of these adjustments were more heavily focused in North Pole, resulting in an average increase in episodic $PM_{2.5}$ emissions of 24% (with lesser increases for SO_2 and NOx precursor emissions). Over the entire nonattainment area, the $PM_{2.5}$ space heating emissions increased 8% due to these adjustments.

Table 7.8-5. Adjustments in 2013 Baseline Space Heating Emissions by Area

	Change in Emissions (%)		
Spatial Area	$PM_{2.5}$	SO_2	NOx
North Pole Area	+24%	+17%	+3%
Fairbanks Area	+0%	-2%	+5%
Entire Nonattainment Area	+8%	+2%	+4%

As explained in greater detail in Section III.D.7.6, the magnitude of these adjustments within each area also varied significantly, with greater upward adjustments within the vicinity of the Hurst Road monitor as well as several known hotspots in the Fairbanks portion of the nonattainment area. Also as noted in Section III.D.7.6, these inventory adjustments were evaluated and applied in an objective manner where supported by more refined data, not simply in response to the model performance assessment.

Beyond this qualitative assessment that triggered inventory adjustments, there are several other ways that the monitored and modeled data were evaluated for North Pole through sensitivity analyses in the sections below. Since there is no 2008 monitoring data for North Pole for model performance, the model and episodes were not updated for the Serious Area SIP, there is no 2008 monitored data in North Pole for model performance. As stated previously, the modeling platform will remain the same for future modeling efforts until it can be updated.

7.8.9.1 Weather Research and Forecasting Model (WRF)

Observed meteorology data from METAR stations are compared against the final configuration of the WRF model (dubbed TWIND2X30 in Appendix III.D.7.8). The meteorology statistics presented here are comparable to the meteorology statistics suggested in EPA $PM_{2.5}$ modeling guidance.[29] The statistics presented are for root-mean-square error (RMSE), mean absolute error (MAE), and bias. A comparison of the observed meteorology statistics between the final WRF model outputs of the Nov 2008 and Jan-Feb 2008 episodes (Table 7.8-6) shows that the modeled version of the Jan-Feb 2008 episode arguably has better statistics than the Nov 2008 episode, despite the more extreme cold present in the former. However, the more negative temperature bias in the Nov 2008 versus the Jan-Feb 2008 episode is consistent with the relative absence of extreme cold periods in Nov 2008 and the configurations general tendency to have a negative temperature bias in milder winter conditions for the Fairbanks region. While the model tends to be too warm during the periods of the coldest temperatures, the coldest temperature periods also tend to be of short duration.

Table 7.8-6. Comparison of Statistics for Nov 2008 and Jan-Feb 2008 Episodes for the WRF Model Outputs

	Nov 2008 RMSE (MAE for wind direction)	Nov 2008 Bias	Jan-Feb 2008 RMSE (MAE for wind direction)	Jan-Feb 2008 Bias
Temperature (°C)				
Fairbanks	2.75	-1.16	2.22	-0.12
Eielson AFB	2.03	-0.47	2.05	-0.23
Ft. Wainwright	2.38	-0.97	1.83	0.51
Three Stations	2.43	-0.86	2.07	0.00
Relative Humidity (%)				
Fairbanks	5.43	0.71	8.15	2.55
Eielson AFB	5.93	3.35	12.45	-2.49
Ft. Wainwright	12.48	-10.39	17.09	-13.67
Three Stations	7.14	0.05	12.44	-3.32
Wind Speed (m s-1)				
Fairbanks	1.27	0.91	1.51	0.86

[29] Tesche, T.W.and D.E.McNally, and C.Tremback, (2002), "Operational evaluation of the MM5 meteorological model over the continental United States: Protocol for annual and episodic evaluation."

	Nov 2008 RMSE (MAE for wind direction)	Nov 2008 Bias	Jan-Feb 2008 RMSE (MAE for wind direction)	Jan-Feb 2008 Bias
Eielson AFB	1.63	1.28	1.18	0.69
Ft. Wainwright	0.95	0.45	1.21	0.25
Three Stations	1.41	1.00	1.34	0.68
Wind Direction (degrees)				
Fairbanks	32.8	6.1	21.6	-5.6
Eielson AFB	38.6	18.2	26.0	-10.3
Ft. Wainwright	50.8	17.9	40.3	3.4
Three Stations	41.3	13.6	29.2	-3.6

7.8.9.2 Photochemical Transport Modeling

Baseline air quality model performance was evaluated for daily 24-hour average $PM_{2.5}$ over both 2008 episodes. Modeled results were compared at the State Office Building grid cell in the model using speciated $PM_{2.5}$ FRM measurement data and BAM corrected total $PM_{2.5}$ concentrations at the State Office Building monitor. Figure 7.8-2 shows the trends over the modeling episode days for observed concentrations at the State Office Building (blue line) and the modeled concentrations (green line). The modeled and observed days for episode 1 show good agreement on both high and low concentration days. In episode 2 the model does not reproduce the maximum and minimums as accurately as in episode 1, but the periods of the high and low concentrations do generally match.

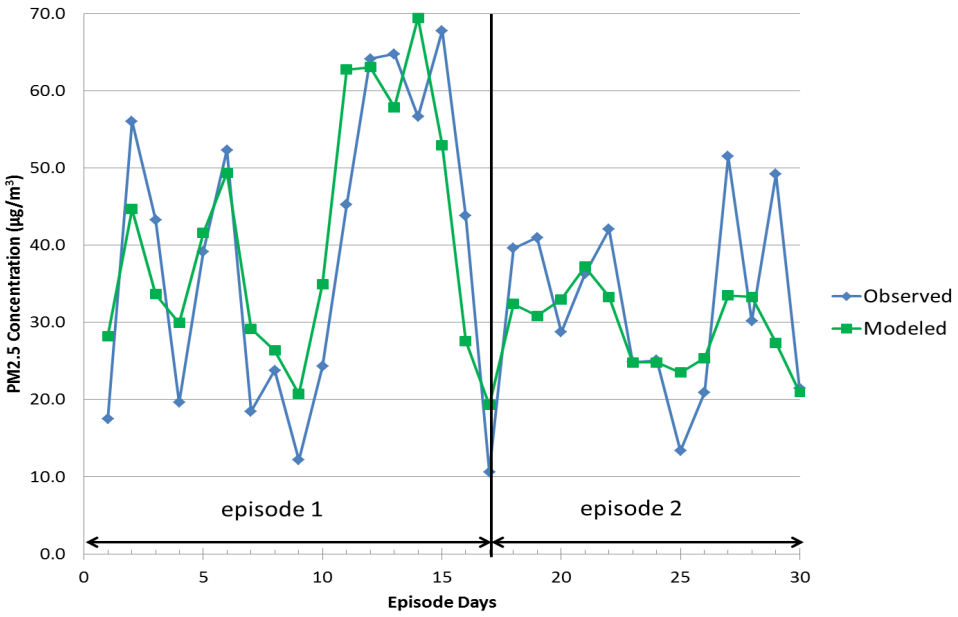


Figure 7.8-2. Modeled and Observed 24-hour Averaged $PM_{2.5}$ at the State Office Building Monitor for Both Winter Episodes

On a day-to-day basis the observed and modeled concentrations during the episodes generally track a 1:1 line seen in the scatter plot below (Figure 7.8-3.). For episode days with observations

on the low end of the range of measured $PM_{2.5}$ concentrations, the model tends to overestimate the $PM_{2.5}$ concentrations. Days with higher observed concentrations tend to show the model under-predicts total $PM_{2.5}$.

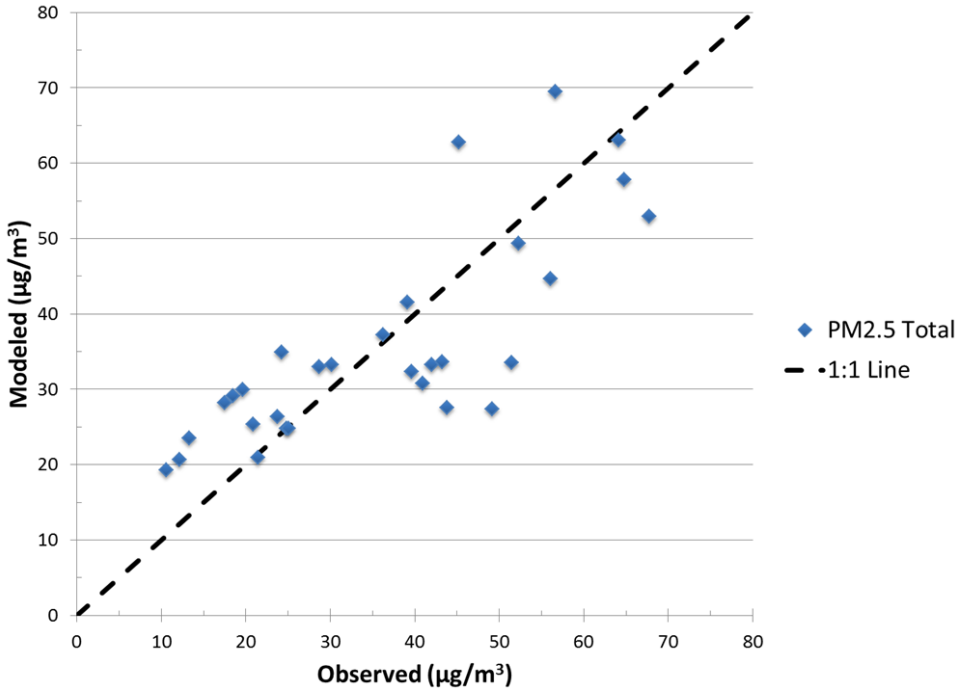


Figure 7.8-3. Scatter Plot of Observed and Modeled State Office Building Daily Episodic 24-hr $PM_{2.5}$ Concentrations

The breakdown of total particulate concentrations during the modeling episodes by percent contribution for each species is given in Figure 7.8-4. For the modeled and observed $PM_{2.5}$ at the State Office Building monitor. Observations show the $PM_{2.5}$ during the two modeling episodes is largely composed of the following in order of their contribution: organic carbon (OC), sulfate (SO_4), other primary particulates (OTH), ammonium (NH_4), elemental carbon (EC), and nitrate (NO_3). The modeled concentrations similarly reflect OC as the primary contributing species to total $PM_{2.5}$; however, the model tends to over-predict the contribution of OC and EC while under predicting the contributions of SO_4, OTH, and NH_4. The CMAQ model's low estimates of sulfate and ammonium are likely due to underperforming chemistry limiting the production of sulfate from SO_x precursor gases. This under-prediction of sulfate and ammonium increases the apparent share of OC and EC in the modeled $PM_{2.5}$. The under-prediction of $PM_{2.5}$ OTH is most likely caused at the level of the emissions inventory, as OTH is not formed in the atmosphere but contributed solely by direct emissions.

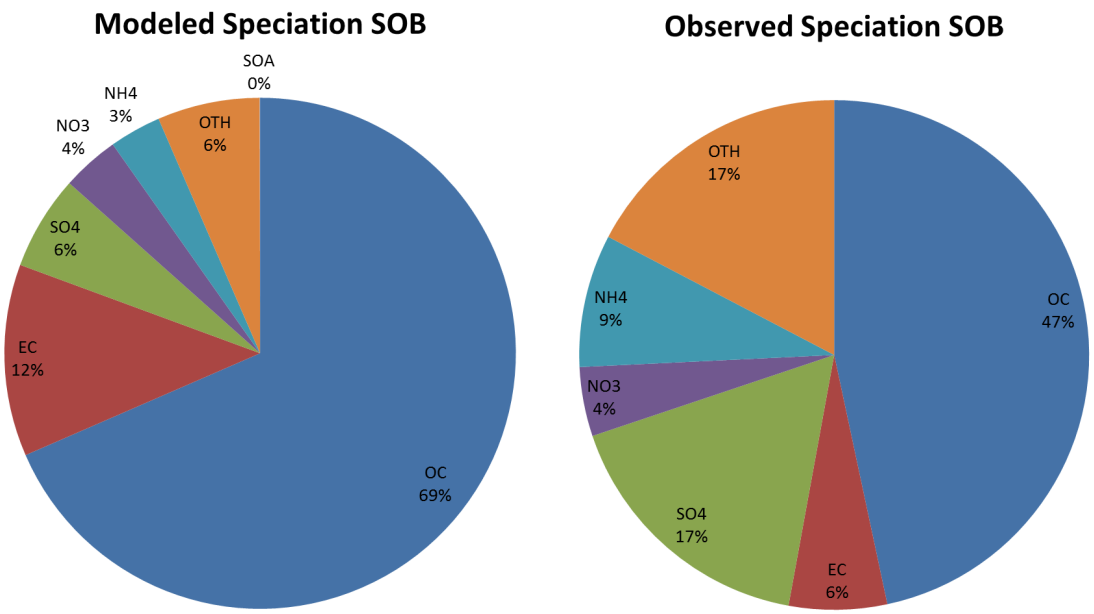


Figure 7.8-4. Baseline 24-hour Averaged Modeled and Observed $PM_{2.5}$ Speciation Over all Episode FRM Days

Speciation profiles of the $PM_{2.5}$ emissions used in the model may be the cause considering that the direct emitted OC and EC are over-predicted.

Table 7.8-7 shows the average modeled and observed concentrations in micrograms per cubic meter for the winter episodes. The total $PM_{2.5}$ for the modeled and observed match to within 0.4 $\mu g/m^3$; however, the species show the over-prediction of carbon-containing compounds (OC and EC) and under-prediction of SO_4, NH_4, and OTH.

Table 7.8-7. Comparison of Modeled and Observed Particulate Matter Components

Species	Observed ($\mu g/m^3$)	Modeled ($\mu g/m^3$)
$PM_{2.5}$	36.1	35.7
OC	17.0	24.5
EC	2.3	4.3
SO_4	6.2	2.1
NO_3	1.6	1.3
NH_4	3.1	1.2
OTH	6.3	2.3
SOA	N/A	0.01

The model performance evaluation in Table 7.8-7 was performed during the Moderate Area SIP.[30] No new model performance was conducted for the Serious Area SIP, for this DEC needs

[30] https://dec.alaska.gov/air/anpms/communities/fbks-pm2-5-moderate-sip

to update the WRF meteorology, emission inventory, and all new modeling episodes to reflect a time when North Pole speciation data is available.

The updates performed for the Serious SIP modeling include updated SMAT (Speciated Modeled Attainment Test) calculations, an updated required 5 year modeling design value for the years 2011 to 2015, a new base modeling year of 2013 and updated speciation for four monitor sites: State Office Building, NCORE, Hurst Road, and the North Pole Elementary Monitors. These Serious SIP modeling updates are in the next few sections of this chapter.

Overall, the model performance shows that the model does provide confidence in the prediction of total $PM_{2.5}$ at the State Office Building monitor site. As the control scenarios are evaluated, some components will receive extra scrutiny due to their performance such as sulfate, ammonium, and other primary particulates.

7.8.9.2 Modeling Ambient Air Quality Data using Sandwich and SMAT Methods

40 C.F.R. part 58 requires States to monitor $PM_{2.5}$ mass concentrations using Federal Reference Method (FRM) devices to determine compliance with the NAAQS. Following 2007 EPA Modeling Guidance and Attachment B (Fox, 2011), DEC produced the Speciated Modeled Attainment Test (SMAT) for the 24-hour $PM_{2.5}$ NAAQS. The method uses winter quarterly (Q1 and Q4) average FRM-derived species concentrations from the STN (speciation trend network) monitor.

The FRM monitor uses a gravimetric weight-based analysis compared to the nylon filter and denuder set up on the STN monitor. The methodology for the recommended treatment of the species data references the EPA (2007) guidance incorporating the Frank (2006) paper and several others.[31] The SMAT technique uses the design value site at the Fairbanks Alaska State Office Building (SOB), NCORE, Hurst Road (NPFS) and North Pole Elementary (NPE) to calculate the quarterly average species mass fractions. Collocated at this site are the FRM monitor used in designation of Fairbanks as a nonattainment area and an STN monitor. The data used in the quarterly calculations for the years 2011-2015 are for the following seven major components of $PM_{2.5}$ as recommended (USEPA, 2007):

- Measured sulfate [SO_{4STN}];
- Adjusted nitrate [NO_{3FRM}] (retained on the FRM filter);
- Adjusted ammonium [NH_{4FRM}] (retained on the FRM filter);
- Measured elemental carbon [EC_{STN}] (corrected IMPROVE to NIOSH analysis);
- Organic carbonaceous mass estimated from a mass balance [OCMmb];
- Estimated particle bound water [PBW]; and
- Estimated other primary $PM_{2.5}$ components [OPP].

[31] Frank, N. (2006): Retained nitrate, hydrated sulfates, and carbonaceous mass in Federal Reference Method fine particulate matter for six Eastern U.S. cities. J.Air and Waste Manage.Assoc. 56:500-511.
U.S. EPA, 2007, Guidance on the Use of Models and Other Analyses for Demonstrating Attainment of Air Quality Goals for Ozone, PM2.5, and Regional Haze, EPA-454/B07-002.

Details on how each of the major components were calculated are provided in Appendix III.D.7.8.

The Fairbanks $PM_{2.5}$ Serious area SIP will require new analysis beyond the work that was completed for the Moderate area SIP. Broadly speaking, the attainment test is being updated to reflect new base year conditions centered on 2013; assumptions informing projections through 2019 will be revised, and the Speciated Modeled Attainment Test (SMAT) will include additional monitors at NCore, NPE, and Hurst Road. Additionally, the monitoring data used in SMAT will be revised to use data gathered between 2011 and 2015. The design values are presented in Table 7.8-8 as rounded to the nearest 1 $\mu g/m^3$ in accordance with 40 C.F.R. part 50 Appendix N.

The speciated $PM_{2.5}$ analysis was revised for the Serious Area SIP to reflect data acquired between 2011 and 2015 at both the downtown Fairbanks monitor (i.e., the SOB and NCore) and the North Pole monitors (NPFS and NPE). The SANDWICH processed data for the four monitors is presented in Table 7.8-9. $PM_{2.5}$ is dominated by organic carbon (OC) at all monitors, a clear indication of the dominance of wood burning influencing concentrations throughout the nonattainment area. The concentration share of OC in the North Pole sites is drastically higher than those in Fairbanks suggesting that wood burning may be a stronger influence in North Pole area. Sulfate (SO_4) represents the second highest contributor at the Fairbanks monitor sites and third highest at the North Pole monitors. SO_4 concentrations are the result of distillate oil and coal combustion, and while SO_4 concentrations are much lower than OC, it is still a significant contributor to the $PM_{2.5}$ totals. Elemental carbon (EC) is the third highest component of $PM_{2.5}$.

The design values of the base year used in the attainment test were established based on data from 2011 through 2015 for all monitors as part of the Serious Area SIP. The calculation of the design values is based on guidance from EPA suggesting that these values be based on a five-year weighted average (2011–2015) centered on a base year (2013) for each compliance monitor in the nonattainment area: NCore, SOB, Hurst, and NPE. Due to the limited lifespan of the North Pole monitors, it is not possible to calculate a weighted, five-year average for those sites. Instead, an average from 2011-2013 is used for NPE and a weighted four-year average is used for Hurst (2012–2015).

Table 7.8-8. Five Year Design Values ($\mu g/m^3$) for 2011-2015 and the 3-Year Design Values Used to Calculate the Rolling 5-Year Averages

	3-yr DV						Modeled DV (5-yr except Hurst)
Site	2013	2014	2015	2016	2017	2018	2011-2015 rolling average
SOB	41	40	35	37	38	37	38.9
NCORE	40	39	35	34	35	32	38.0
Hurst Road	N/A	139	124	106	85	66	131.6
NPE	45	N/A	N/A	N/A	N/A	N/A	45.3

An independent analysis of this data has been presented by Dr. Bill Simpson and K.C. Nattinger at the University of Alaska at Fairbanks (UAF), and is summarized in Table 7.8-10. These data have not yet been fully processed through the SANDWICH method used in SMAT and do not include data through the end of 2015, because that is all that was available at the time of the data completed for the thesis in August of 2015. The observed species generally agree with the findings of the SANDWICH processed speciation data though comparisons of potassium (K), OPP, and PBW cannot be made. Both data sets show some differences between the Fairbanks and North Pole portions of the nonattainment area with respect to the magnitude of the OC and SO_4 shares of the $PM_{2.5}$ total. An additional point is that in the past five years the speciation at the downtown monitoring site has transitioned from the State Office Building site to the NCore location, but the two sites generally show good agreement.

Table 7.8-9
Speciation at Fairbanks Nonattainment Area Monitors
2011-2015

SITE	OC	EC	SO_4	NO_3	NH_4	OPP	PBW
SOB	54%	11%	17%	5%	7%	1%	5%
NCORE	56%	10%	17%	5%	7%	1%	5%
Hurst Road	80%	9%	6%	1%	2%	0%	2%
NPE	77%	8%	8%	2%	3%	0%	2%

Table 7.8-10
Speciation at SOB and Hurst
Includes Data through 11/2014

(February 2015 Correlation)		
PM Species	**SOB**	**Hurst Road**
OM (OC*1.4)	61.6%	82.9%
EC	7.7%	8.7%
SO_4	18.1%	6.6%
NO_3	4.5%	1.3%
NH_4	8.6%	2.5%
K	0.51%	0.93%
Total[a]	101%	103%

Notes:

[a] The totals sum to over 100% due to the methodology employed to calculate the species contributions and then recalculate the total PM. From the presentation "Reconciling various particulate matter carbon (OC and EC) methods and samplers," B. Simpson, K.C. Nattinger, UAF, August 8th 2015.

7.8.9.4 SMAT Methods

The method used for establishing the design value follows the first three steps of the SMAT process as performed in the Moderate Area SIP. The most important difference for the Serious Area SIP is that the process will be applied to four sites: SOB, NCore, NPE, and Hurst Road.

- Step 1: Establish the high concentration days and 98th percentile day for each year (2011-2015).

- Step 2: Develop representative chemical speciation profile of $PM_{2.5}$ for the 25% highest concentration days using SANDWICH as represented by Table 7.8-9. For the case of the NPE and Hurst Road monitors, DEC used all days over 35 $\mu g/m^3$ instead of the top 25% highest concentration days due to the higher number of exceedances.

- Step 3: Use the speciation profile to calculate speciation of the highest days

- Step 4: Calculate Relative Response Factors (RRFs) for each component of $PM_{2.5}$ at both monitors. RRFs are calculated as the future modeled concentrations divided by the baseline concentrations. The RRF values represent the fractional change in concentrations due to changes in population, activity, and control measures that occur between the base year and the attainment year.

- Step 5-6: Apply RRFs to quarterly observations (only Q1 and Q4 are relevant for Fairbanks and North Pole monitors).

- Step 7: Sum the RRF-adjusted species to obtain total daily $PM_{2.5}$.

- Step 8: Determine the RRF-adjusted 98th percentile concentrations for each monitor.
- Step 9: Calculate the future projected 5-year weighted 24-hr design value for project base year and control model runs.

The speciated PM that is calculated through SANDWICH as a component of SMAT differs from the speciated values measured off of filters. The speciated design value is represented in the tables below for SOB, NCore, Hurst Road, and NPE monitors. A five-year modeling design

value was calculated for the SOB and NCore sites. Since the Hurst monitor was not in operation in 2011 a four-year design value from 2012-2015 was calculated. The North Pole Elementary (NPE) site was discontinued in 2013, and as a result, a three-year design value for the NPE site was calculated from 2011-2013 data. The tables and figures below present the average speciated values developed in Step 2. Details on steps 3-9 are in the 2019 Scenario section below.

Table 7.8-11 SMAT Speciation for State Office Building Monitor 2011-2015

SOB (Highest 25% Speciation 2011-2015)									
$PM_{2.5}$ Species	Total	OC	EC	SO_4	NO_3	NH_4	OPP	Blank	PBW
Percentage	100.0	53.0	11.1	16.3	4.7	7.0	1.3	1.6	5.2
SMAT	32.0	16.9	3.5	5.2	1.5	2.2	0.4	0.5	1.7
5-yr DV	38.9	20.7	4.3	6.4	1.8	2.7	0.5	0.5	2.0

Table 7.8-12 SMAT Speciation for NCore Monitor 2011-2015

NCORE (Highest 25% Speciation 2011-2015)									
$PM_{2.5}$ species	Total	OC	EC	SO_4	NO_3	NH_4	OPP	Blank	PBW
Percentage	100.0	55.0	10.0	16.3	4.5	6.6	1.0	1.5	5.0
SMAT	32.9	18.1	3.3	5.4	1.5	2.2	0.3	0.5	1.6
5-yr DV	38.0	20.9	3.8	6.2	1.7	2.5	0.4	0.5	1.9

Table 7.8.-13 SMAT Speciation for Hurst Monitor 2012-2015

Hurst Road (>35 $\mu g/m^3$ Speciation 2012-2015)									
$PM_{2.5}$ species	Total	OC	EC	SO_4	NO_3	NH_4	OPP	Blank	PBW
Percentage	100.0	79.1	8.9	5.9	1.2	2.2	0.3	0.6	1.9
SMAT	83.6	66.1	7.5	4.9	1.0	1.8	0.2	0.5	1.6
4-yr DV	131.6	104.3	11.8	7.7	1.6	2.9	0.4	0.5	2.5

Table 7.8-14 SMAT Speciation for NPE Monitor 2011-2013

NPE (>35 $\mu g/m^3$ Speciation 2011-2013)									
$PM_{2.5}$ species	Total	OC	EC	SO_4	NO_3	NH_4	OPP	Blank	PBW
Percentage	100.0	75.8	8.0	7.9	1.7	2.9	0.4	1.0	2.4
SMAT	50.1	38.0	4.0	4.0	0.9	1.4	0.2	0.5	1.2
3-yr DV	45.3	34.3	3.6	3.6	0.8	1.3	0.2	0.5	1.1

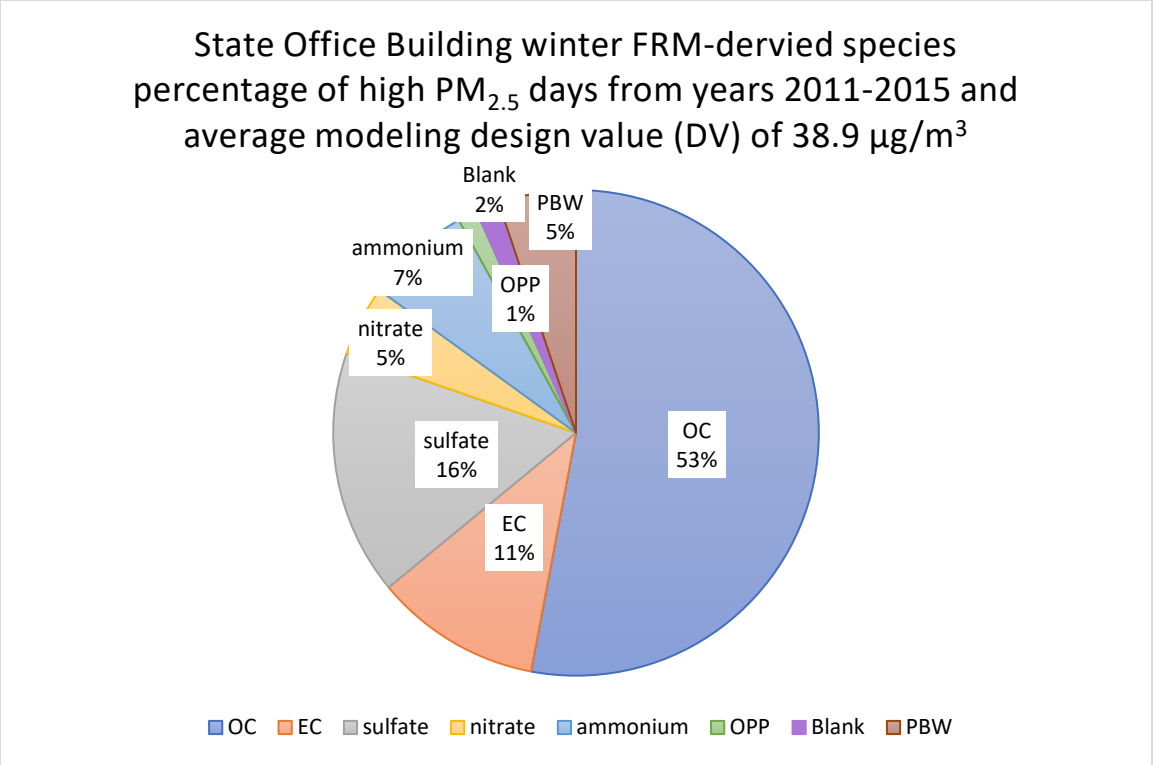


Figure 7.8-5: 24-hr average FRM-derived PM $_{2.5}$ speciation concentrations based on the design value (DV) of 38.9 µg/m^3 for the high $PM_{2.5}$ winter days at the State Office Building monitor.

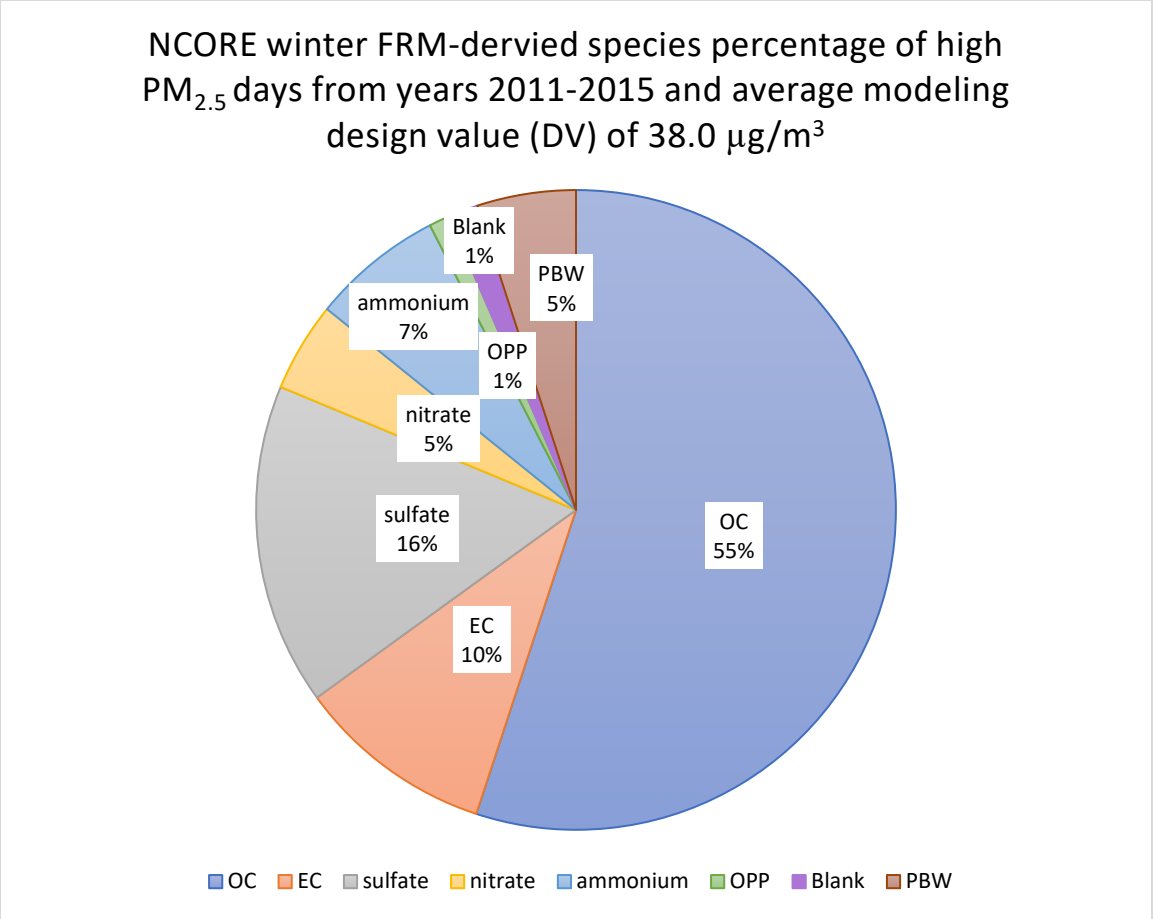


Figure 7.8-6: 24-hr average FRM-derived $PM_{2.5}$ speciation concentrations based on the design value (D7) of 38.0 µg/m^3 for Fairbanks NCORE Monitor

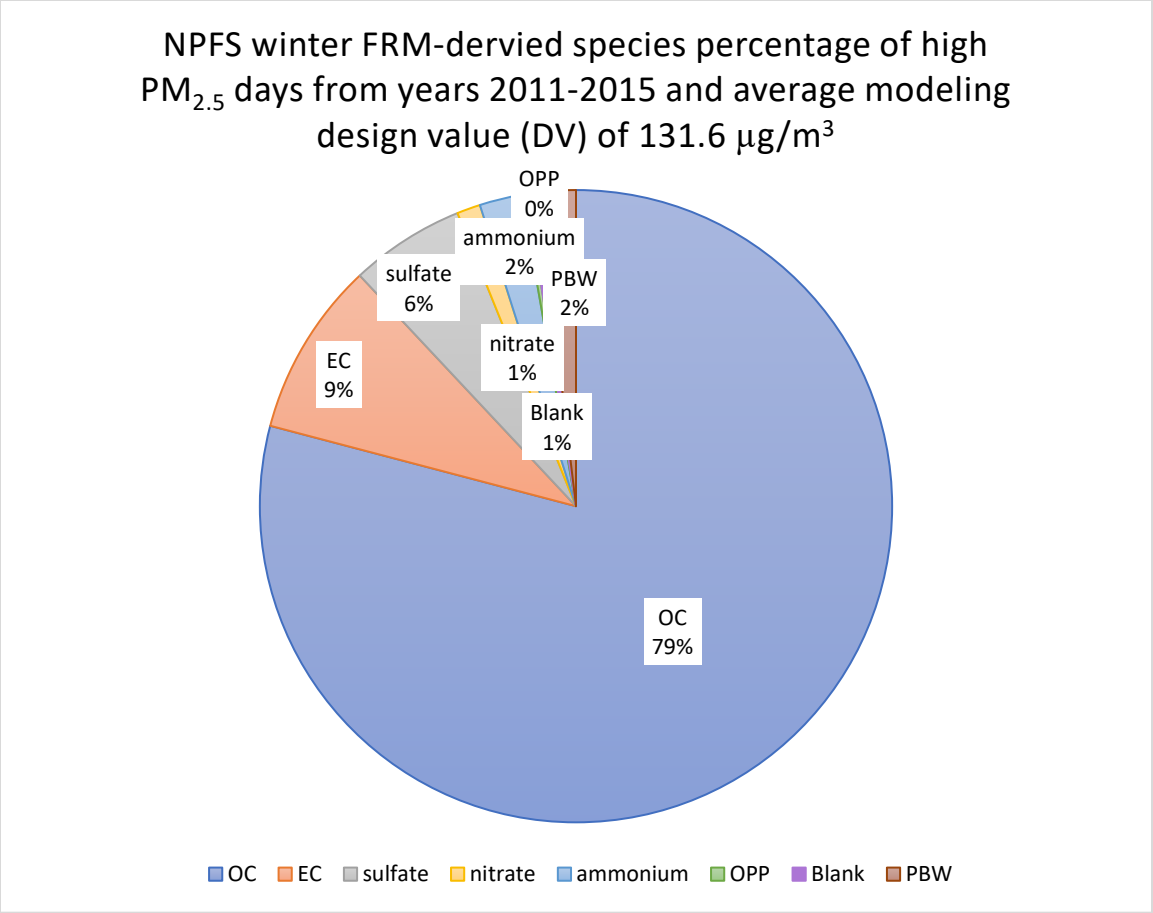


Figure 7.8-7. 24-hr average FRM-derived $PM_{2.5}$ speciation concentrations based on the design value (DV) of 131.6 µg/m^3 for the high $PM_{2.5}$ winter days at Hurst Road

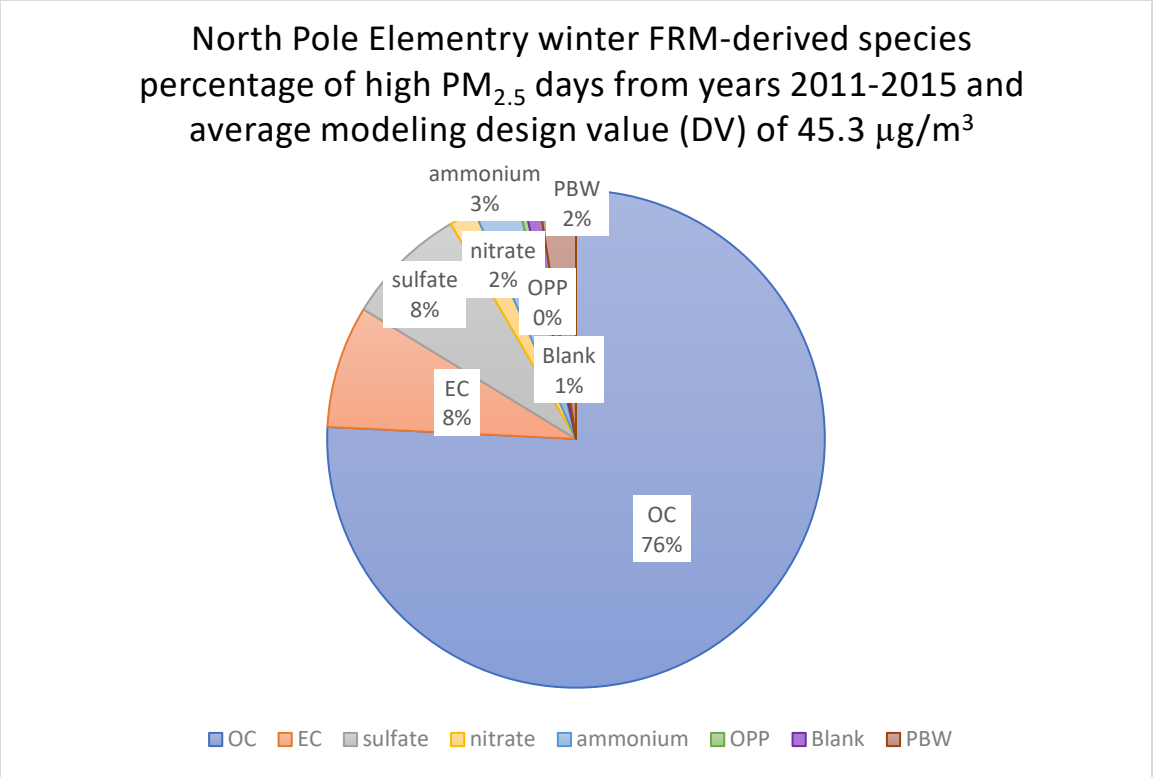


Figure 7.8-8. 24-hr average FRM-derived PM $_{2.5}$ speciation concentrations based on the design value (DV) of 45.3 µg/m^3 for North Pole Elementary School Monitor.

Sulfates are a major component of the $PM_{2.5}$ mass; estimates show that sulfates comprise approximately 6-16% of the total mass of Fairbanks $PM_{2.5}$ (Figures 7.8-5-7.8-8). Direct emissions and atmospheric formation of particulate sulfate contribute to measured sulfate concentrations. The speciation profiles used for the different emission categories show that primary sulfate is emitted by point, area (home heating), and mobile sources. Direct emissions of sulfate are not enough to account for the amount of sulfate observed in Fairbanks and North Pole. The CMAQ inventory for point and area sources reveal that point sources are responsible for a majority of the primary sulfate emissions emitted into the airshed but do not contribute to the same level to the concentrations at the monitors. Sulfate contribution at the monitors is 6-16% (Figures 7.8-5-7.8-8) and that equates to 4.9-5.4 µg/m^3.

Speciation data shows that 3-8 % of total $PM_{2.5}$ mass on violation days is ammonium. Based on the emissions inventory used in the CMAQ modeling the leading sources of ammonia are automobiles and industrial sources.

Speciation of the Fairbanks winter $PM_{2.5}$ components (Figure 7.8-5 – 7.8-8) are derived from the high $PM_{2.5}$ days from the years 2011-2015. The speciation concentrations that represent the breakdown of the components of $PM_{2.5}$ in the Fairbanks area are measured from the SASS (Speciation Air Sampling System) speciation instrument. The speciation SASS monitor is different from the Federal Reference Monitor (FRM) that measures total $PM_{2.5}$. The components of $PM_{2.5}$ measured by the SASS instrument are compared to the FRM measurements that measure total $PM_{2.5}$ for regulatory purposes; but these technologies have different measurement

artifacts. The goal is to derive concentrations of chemical components as they would be found on the official FRM monitor filter, not as they are found through the SASS instrument. To convert the concentrations of each chemical species from the measurement by the SASS to what would have been found on the FRM filter, we use the SANDWICH method. A detailed account of the adjustments made to compare speciation measurements to FRM total $PM_{2.5}$ measurements as well as the conversion of precursor gases and chemistry are found in Appendix III.D.5.8 of the Moderate Area SIP.

The largest component of $PM_{2.5}$ in the Fairbanks area is organic carbon. Organic carbon is primarily due to direct emission with very little resulting from secondary formation. The direct $PM_{2.5}$ reductions will be addressed as part of BACM, which is evaluating controls for all source sectors for $PM_{2.5}$ and precursor gases except point sources which are evaluated through BACT.

7.8.9.5 Sensitivity Modeling Analysis – Speciation Profile Changes

Currently, the modeling platform uses speciation profiles from an outdated modeling platform. Updating the entire speciate database is not compatible with the old version of SMOKE 2.7 and CMAQ 4.7. Instead, we selectively updated the speciation profiles based on the largest contributors to the emission inventory for Fairbanks, Alaska.

The speciation profile ID changes and the source sector are listed in Table 7.8-15a, and Table 7.8-15b provides percentage differences and sectors for the EPA updated speciation profiles. The Source Classification Code (SCC) is the type of sector source, for example the point source SCC code description is for distillate oil burning and a separate point source description is listed for coal. The SCC relates to a specific profile with the different percentage of $PM_{2.5}$ components for each and the change in those components is listed for POC (organic carbon), PEC (elemental carbon), PSO_4 (sulfate), PNO_3 (nitrate) and PMOTHER for other elemental particles (Silica, aluminum etc.). The 5 speciation profiles that were updated had the highest emission inventory percentage. The 5 speciation changes were made in the GC SPEC files in CMAQ that contain the emission profiles and the modeling design values were recalculated before and after speciation changes for 2013 to understand the difference in the profiles and the changes in the mode. Table 7.8-16 has the DV change for all four monitoring sites for the year 2013 before and after the speciation change.

For further information on how the species changes effect the emissions inventory, please see the emissions inventory chapter (Section III.D.7.6). The following tables describe the modeling effects of the updated speciation for the year 2013. The updated speciation was then used for projected baseline and control run modeling. Table 7.8-16 shows the difference in the modeling design value from the change in the speciation profiles.

Table 7.8-15a Updated PM Speciation Profiles for the Five Highest Emitting Categories

Source Sector	SCC Code	Source Description	Profile IDs	
			Old	New

Point	20100109	Internal Combustion Engines / Electric Generation / Distillate Oil (Diesel) / Turbine: Exhaust	92035	91115
Point	10200229	External Combustion Boilers / Industrial / Subbituminous Coal / Cogeneration	92084	91110
Point	10100224	External Combustion Boilers / Electric Generation / Subbituminous Coal / Boiler, Spreader Stoker	92084	91110
Mobile-Nonroad	2260001020	Mobile Sources / Off-highway Vehicle Gasoline, 2-Stroke / Recreational Equipment / Snowmobiles	92049	91113
Area-Other	2311020000	Industrial Processes / Construction: SIC 15 - 17 / Industrial/Commercial/Institutional / Total	92020	91107

Table 7.8-15b Comparison of PM Speciation Profile Changes by SCC Code

SCC Code(s)	Profile Status	Profile ID	PM Speciation Fractions				
			POC	PEC	PSO4	PNO3	PMOTH
20100109	Old	92035	0.1756	0.7713	0.0029	0.0011	0.0491
	New	91115	0.2433	0.0973	0.1849	0.0000	0.4744
	Relative Change (%):		+39%	-87%	+6276%	-100%	+866%
10200229 & 10100224	Old	92084	0.0316	0.0428	0.1017	0.0006	0.8233
	New	91110	0.0263	0.0188	0.1267	0.0016	0.8266
	Relative Change (%):		-17%	-56%	+25%	+180%	+0%
2260001020	Old	92049	0.4752	0.1218	0.0005	0.0007	0.4018
	New	91113	0.6940	0.1001	0.0025	0.0035	0.1999
	Relative Change (%):		+46%	-18%	+400%	+400%	-50%
2311020000	Old	92020	0.0462	0.0000	0.0105	0.0004	0.9429
	New	91107	0.0462	0.0000	0.0011	0.0004	0.9523
	Relative Change (%):		+0%	+0%	-90%	+10%	+1%

The 91115 profile is from SPECIATE 4.3 for distillate oil combustion with Low NOx burners, but no PM controls. The speciation profiles for 91106 and 92035 are for HDDV exhaust, and both are based on 3914 which was testing of HDDV's in 1997, though not given, the sulfur level in diesel fuel in 1997 was about 0.04% (400 ppm). The new profile (91115) is for distillate oil combustion, with a likely fuel content of 0.24-0.30% by weight (2400-3000 ppm Sulfur). The distillate fuel emissions are from HAGO (Heavy Atmospheric Gas Oil) and the sulfur content is 7600 ppm. The new profile 91115 is the best fit to represent HAGO fuel emissions.

Table 7.8-16 Updated 2013 Speciation modeling design values in µg/m^3 of $PM_{2.5}$ after the speciation update for all four monitors location grid cells.

Monitor	Old Speciation DV	New Speciation DV
Year	2013	2013
SOB	38.83	38.93
NCORE	37.64	37.96
NPE	45.3	45.3
Hurst Road	131.63	131.74

The updated speciation modeling design values for 2013 have a 0.1 to 0.3 $\mu g/m^3$ change in the overall 2013 design value (DV). The 2013 base year modeling and analysis was completed with updated speciation reflected in this section as well as all further modeling for the Serious SIP.

7.8.10 2013 Base Year Modeling

The CMAQ and SMOKE modeling estimates that the wood burning share of the inventory is on the higher end of the winter averages established by CMB, C-14 and PMF analyses, but the results are not outside of their range of estimates. Each of these techniques can provide some insight into the local sources that contribute to higher concentrations, but they are not perfect estimates and show disagreements as to the importance of secondary pollutants. If the modeled contributions from home heating are overestimated, the control impacts may also be overestimated; the five-year design value (FDV) would thus be higher than the value provided.

The following modeled concentrations show total $PM_{2.5}$ and the individual components: OC, EC, SO_4 and NH_4 in a gridded output of the nonattainment area for 2013. The following are direct outputs from the CMAQ model. These outputs are then used for the SMAT calculations that anchor the outputs in the monitored 5-year design values discussed above. The 2013 base year concentrations are the starting point for the Serious SIP modeling process. The darker red the grid cell color, the higher the concentrations of $PM_{2.5}$. These grid cells inform the control strategy process to understand the higher concentration grid cells. Estimates can be made for the reduction and then apply those reduction in pollutants to future modeling years. Note in the Figures for the 2013 gridded outputs below, the scale is not the same across species and the units are $\mu g/m^3$ for concentrations as labeled and ppm (parts per million) for the SO_2 plots (Figures 7.8-9-16).

The 2013 base year modeling is the first step and no RRF (relative response factor) is calculated and the values are 1 for $PM_{2.5}$ and all components. The relative response factor change in $PM_{2.5}$ and its components is referenced to the base year and is calculated for 2019 baseline and all future model runs. The RRFs represent the relative response of each component of $PM_{2.5}$ (OC, EC, NH_3, SO_4, and NO_3) from 2013 to 2019. An RRF below the ratio of 1 (2019 RRF/2013 RRF) shows that 2019 had a decrease in that component from either an emission decrease, change in the chemistry or from a control. An RRF above 1 is from an increase in emissions, a change in the chemistry or results from a decrease in another component or species of $PM_{2.5}$. The 2019 modeling results are in the next section.

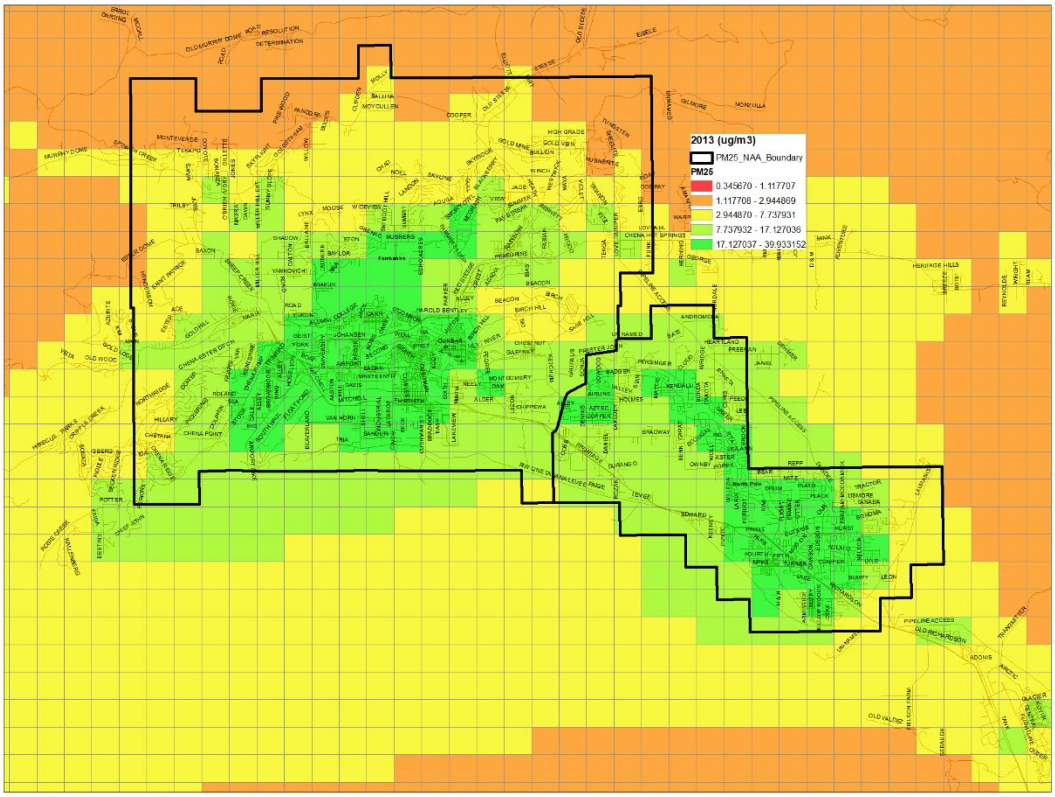


Figure 7.8-9. 2013 Base year 24-hour Averaged Model Total $PM_{2.5}$ Concentrations for the Nonattainment Area over All Episode Days (January 23 to February 10 and November 2 to 17, 2008)

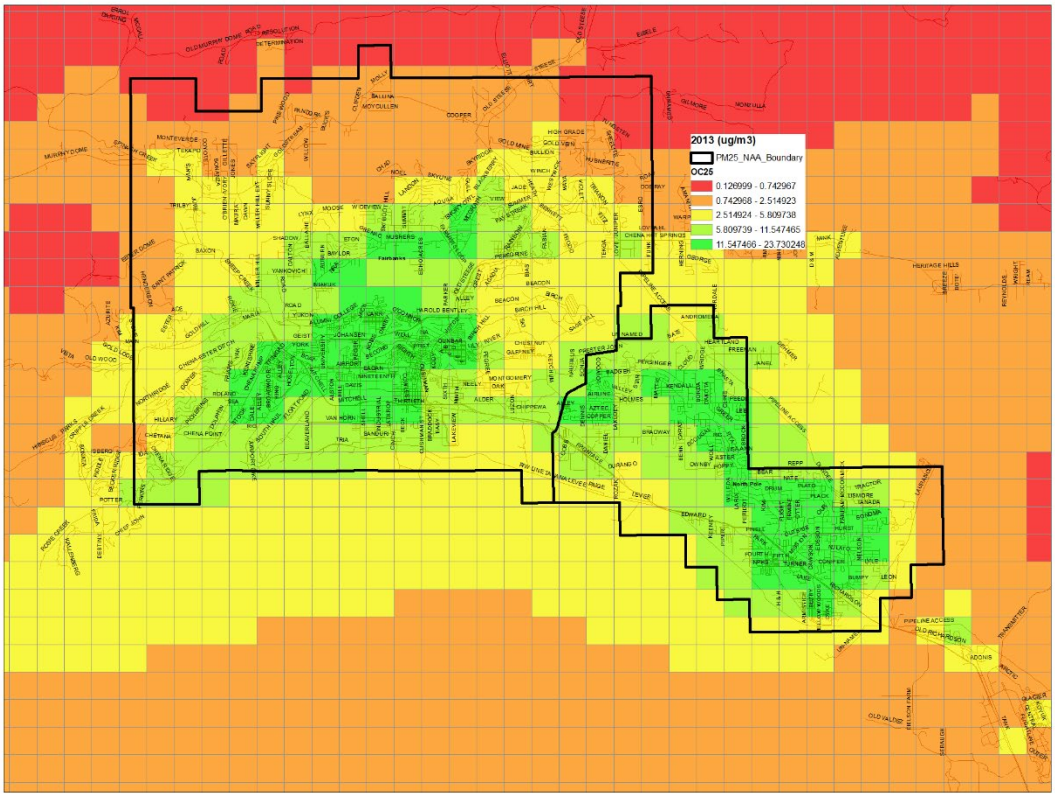


Figure 7.8-10. 24-hour Averaged Model OC $PM_{2.5}$ Concentrations for the Nonattainment Area over All Episode Days (January 23 to February 10 and November 2 to 17, 2008)

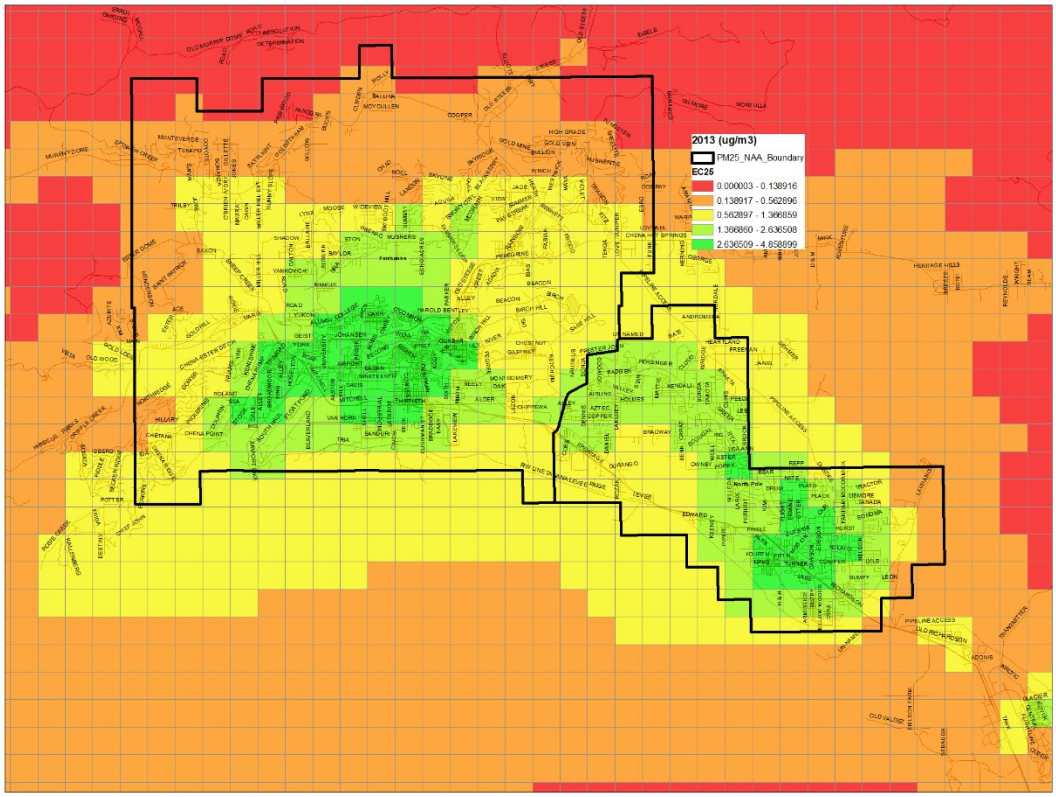


Figure 7.8-11. 2013 Base year 24-hour Averaged Model EC $PM_{2.5}$ Concentrations for the Nonattainment Area over All Episode Days (January 23rd to February 10 and November 2 to 17, 2008)

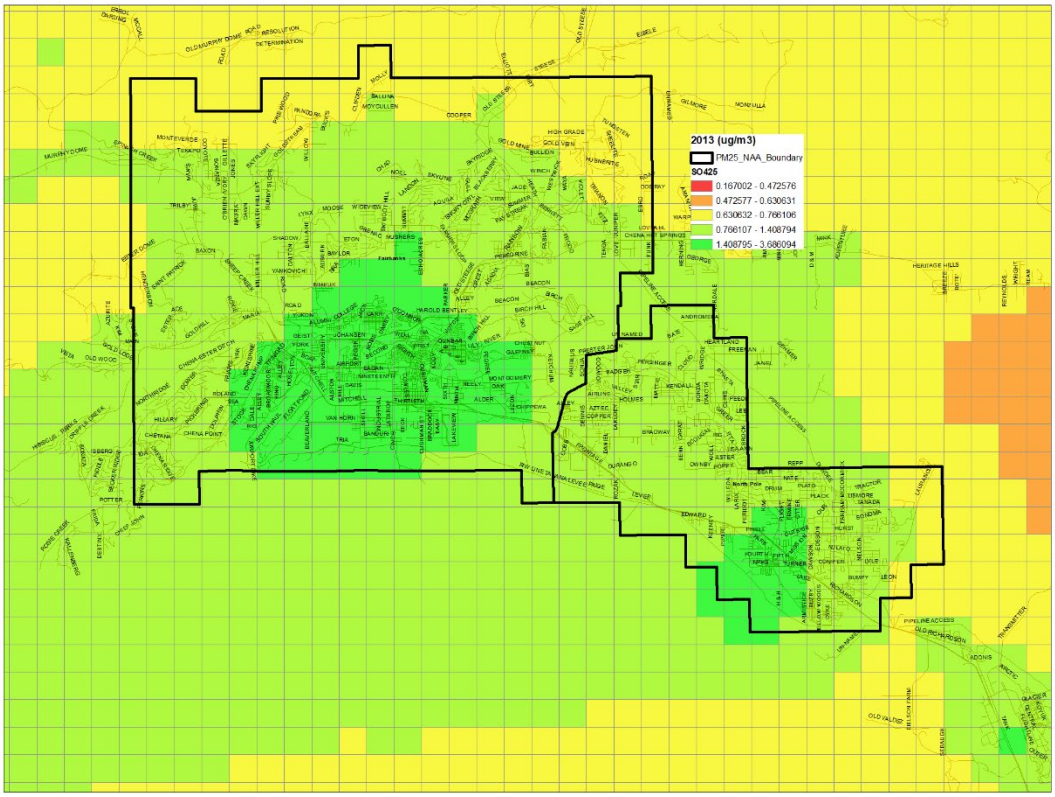


Figure 7.8-12. 2013 Base year 24-hour Averaged Model SO_4 $PM_{2.5}$ Concentrations for the Nonattainment Area over All Episode Days (January 23 to February 10 and November 2 to 17, 2008)

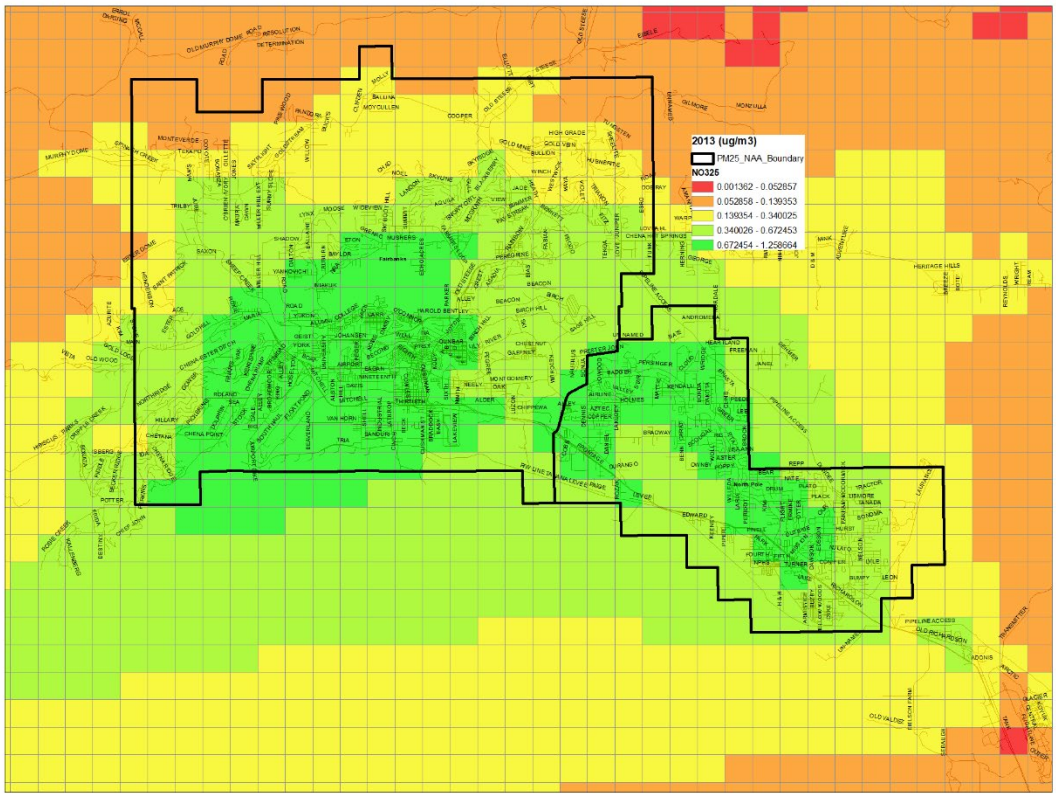


Figure 7.8-13. 2013 Base year 24-hour Averaged Model NO_3 $PM_{2.5}$ Concentrations for the Nonattainment Area over All Episode Days (January 23 to February 10 and November 2 to 17, 2008)

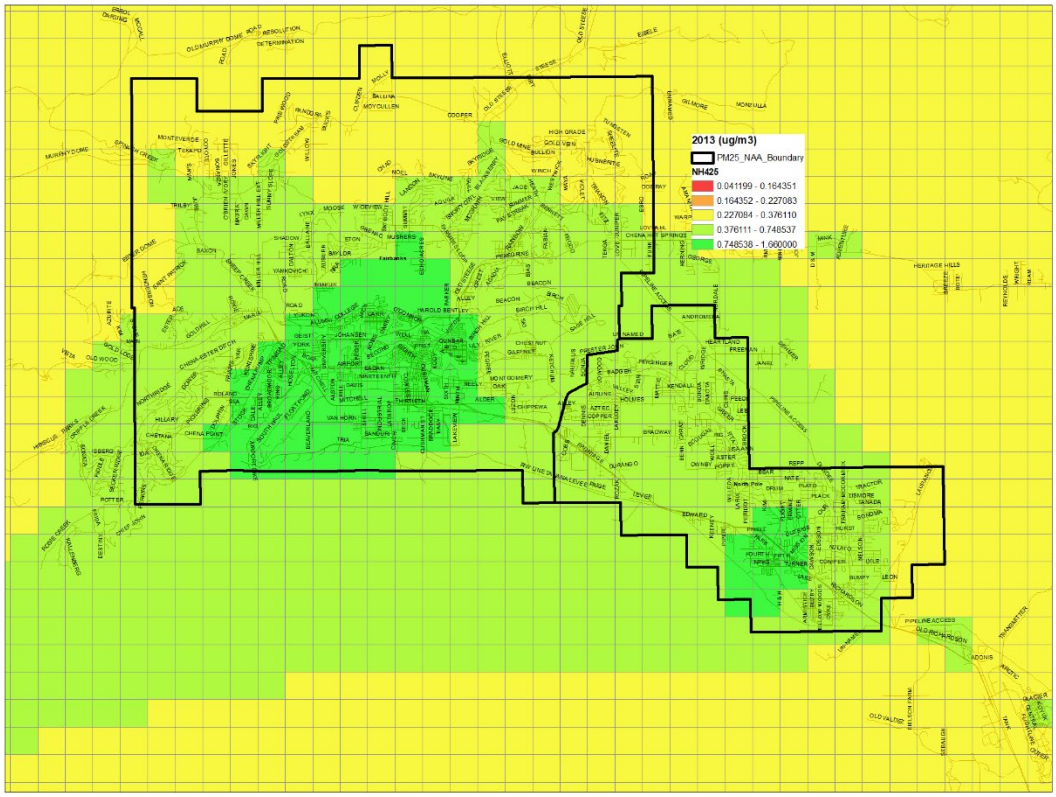


Figure 7.8-14. 2013 Base year 24-hour Averaged Model NH_4 $PM_{2.5}$ Concentrations for the Nonattainment Area over All Episode Days (January 23 to February 10 and November 2 to 17, 2008)

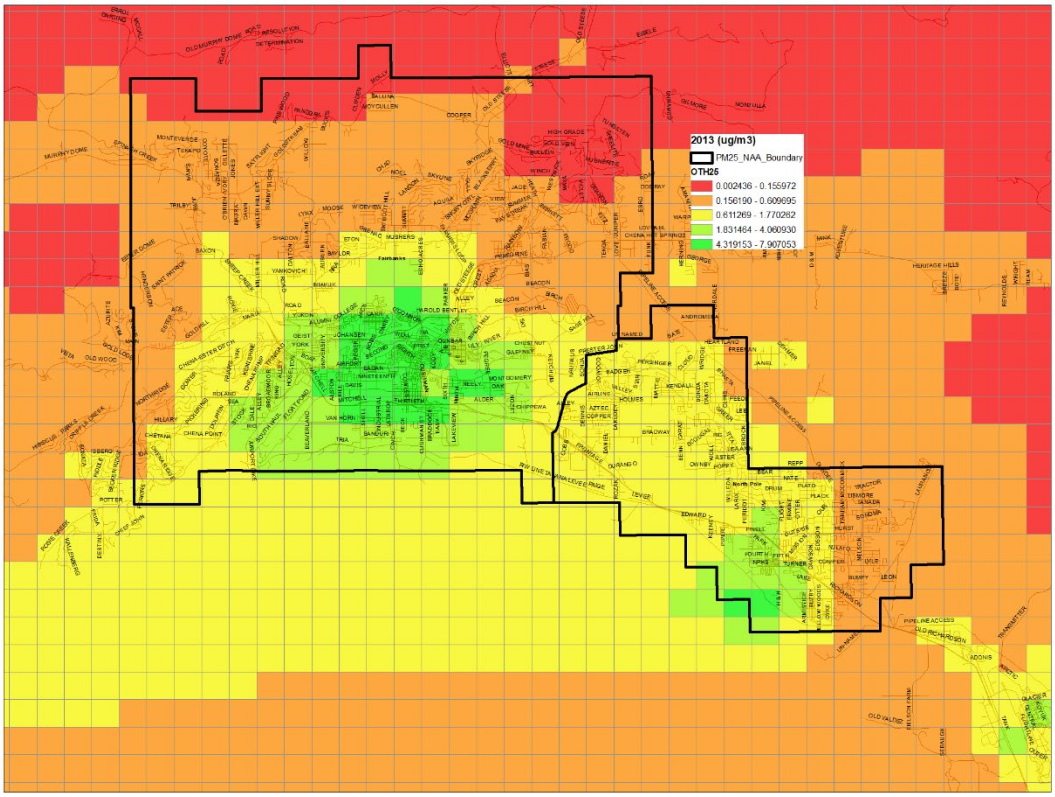


Figure 7.8-15. 2013 Base year 24-hour Averaged Model Other $PM_{2.5}$ Concentrations for the Nonattainment Area over All Episode Days (January 23 to February 10 and November 2 to 17, 2008)

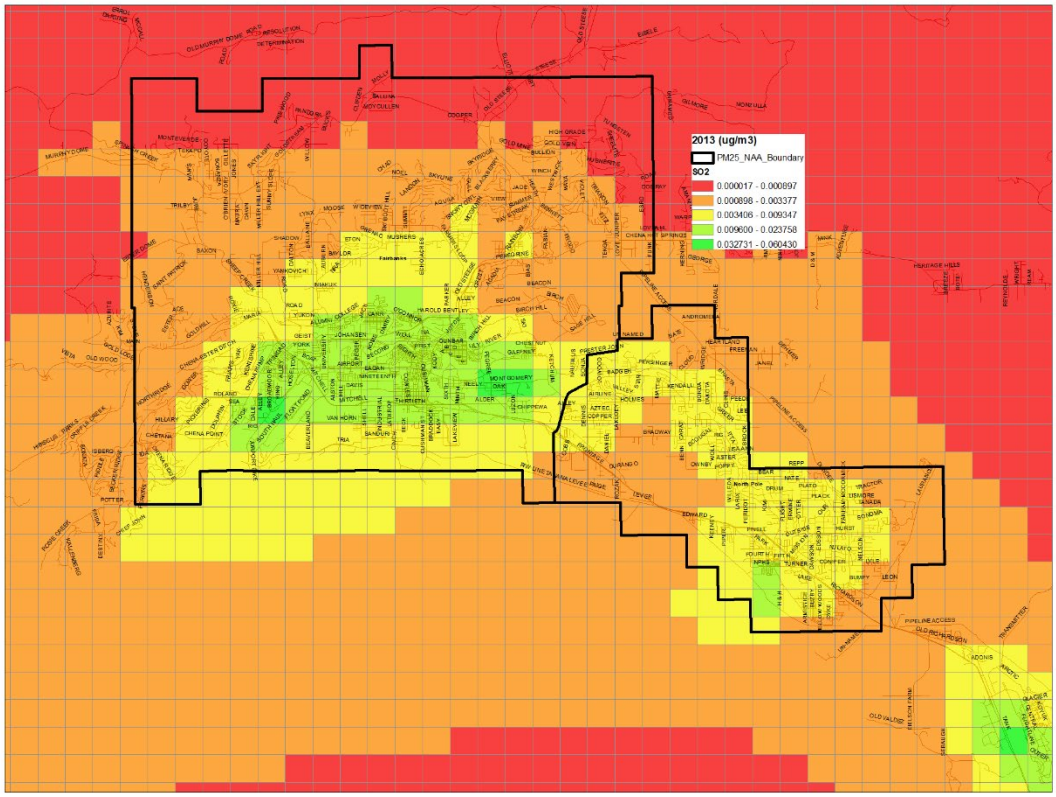


Figure 7.8-16. 2013 Base year 24-hour Averaged Model Gaseous SO_2 Concentrations for the Nonattainment Area over All Episode Days (January 23 to February 10 and November 2 to 17, 2008)

7.8.11 2019 Control Run Modeling

The modeled FDV at the Hurst Road for 2019 is above the attainment level of 35 µg/m^3 (Table 7.8-29), and the monitor has already monitored nonattainment for 2019 for the last 3-year DV without finishing the calendar year of monitoring at Hurst Road. The projected baseline in 2019 is the next step in the modeling before running a control run, the emissions are updated for 2019 and then the 2019 controls are evaluated. The projected baseline is needed to show the changes in the emissions inventory from the base year and the resulting modeling design value for the 2019 projected baseline. The changes to the inventory are discussed in detail in the emissions inventory (Section III.D.7.6). The next step is the 2019 control run, where the controls in place from December 31, 2018, are included in the emission inventory. The following plots show the difference in concentration from 2013 to the 2019 control run for all of the grid cells in the nonattainment area. The need to show attainment in other grid cells is eliminated due to the monitored nonattainment in 2019. However, the unmonitored area analysis (UMAA) will be performed for future modeling that is required after the Serious SIP.

For the 2019 modeling for $PM_{2.5}$, all other species and future years the RRF is calculated as the ratio of the 2013 episode 24-hour averaged concentration of a species by the 2019 episode 24-hour averaged concentration:

$$RRF_i = \frac{[i_{2019}]}{[i_{2013}]}$$

Where *RRF* is the relative response factor of species *i* and [*i*] is the concentration of *i* for 24-hours averaged over all episode days in 2013 and 2019.

There are several key differences worth noting in the speciation plots in Figures 7.8-17-7.8-24 for $PM_{2.5}$, SO_2 and all the components in the 2019 difference plots below. The 2019 difference plots were created by subtracting species specific differences from 2013 in the plots, Figure 7.8-9-7.8-16 above.

The RRF tables are explained in detail in the 2019 control run section, Table 7.8-28a-d. In general, the 2019 RRFs for sulfate reflect reductions from 2013 contributions in the 5% to 30% range across the nonattainment area. The red (highest reduction) area locations are consistent with removal of very high-sulfur HAGO fuel from GVEA Zehnder (downtown) and GVEA North Pole (HAGO was 7,600 ppm S, lighter distillates are now being burned in the ~3,100 ppm S range).

The 2019 RRFs for elemental carbon (EC) for the nonattainment area exhibit reductions of 10-50% consistent with point source and space heating EC reductions between 2013 and 2019.

For the 2019 control model run SO_2 concentrations (ppm) averaged over modeling episode days, the locations of almost no change (0.02 ppm) generally correspond to the three airports in/near the nonattainment area: Fairbanks International to the west, Fort Wainwright (just east of downtown Fairbanks) and Eielson AFB southeast of the nonattainment area.

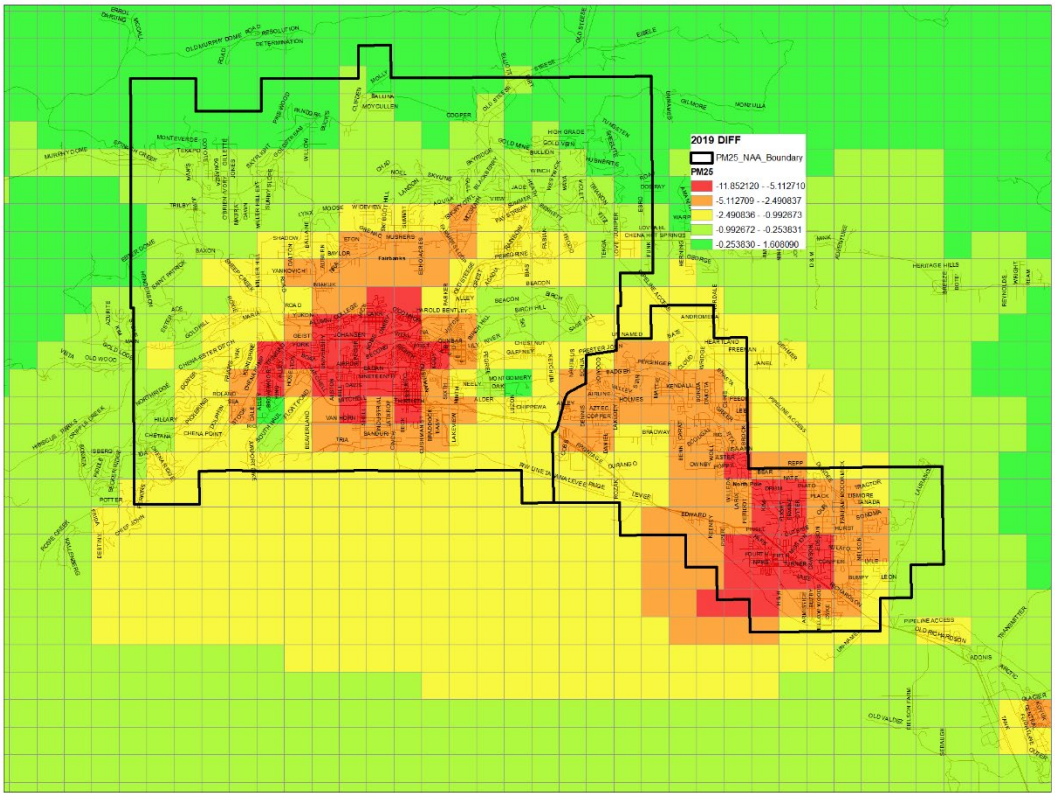


Figure 7.8-17. 2019 difference (2019-2013) of 24-hour averaged modeled $PM_{2.5}$ Concentrations for the Nonattainment Area over All Episode Days (January 23 to February 10 and November 2 to 17, 2008)

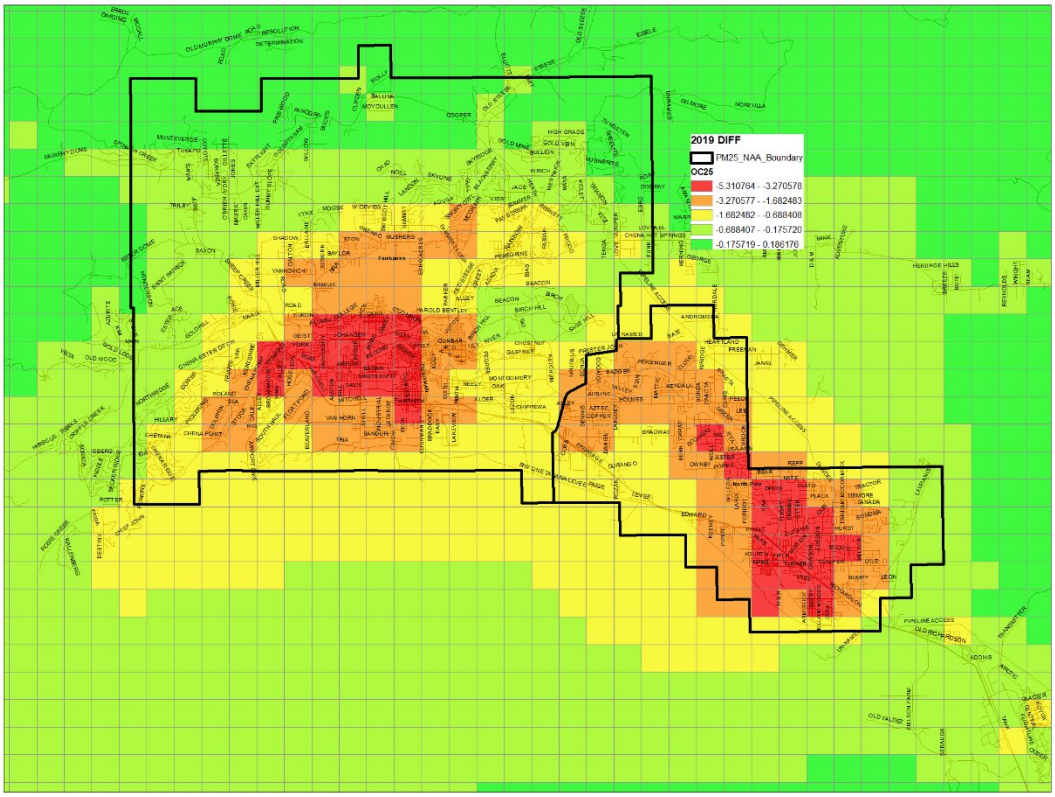


Figure 7.8-18. 2019 difference (2019-2013) of 24-hour averaged modeled OC (organic carbon) concentrations for the Nonattainment Area over All Episode Days (January 23 to February 10 and November 2 to 17, 2008)

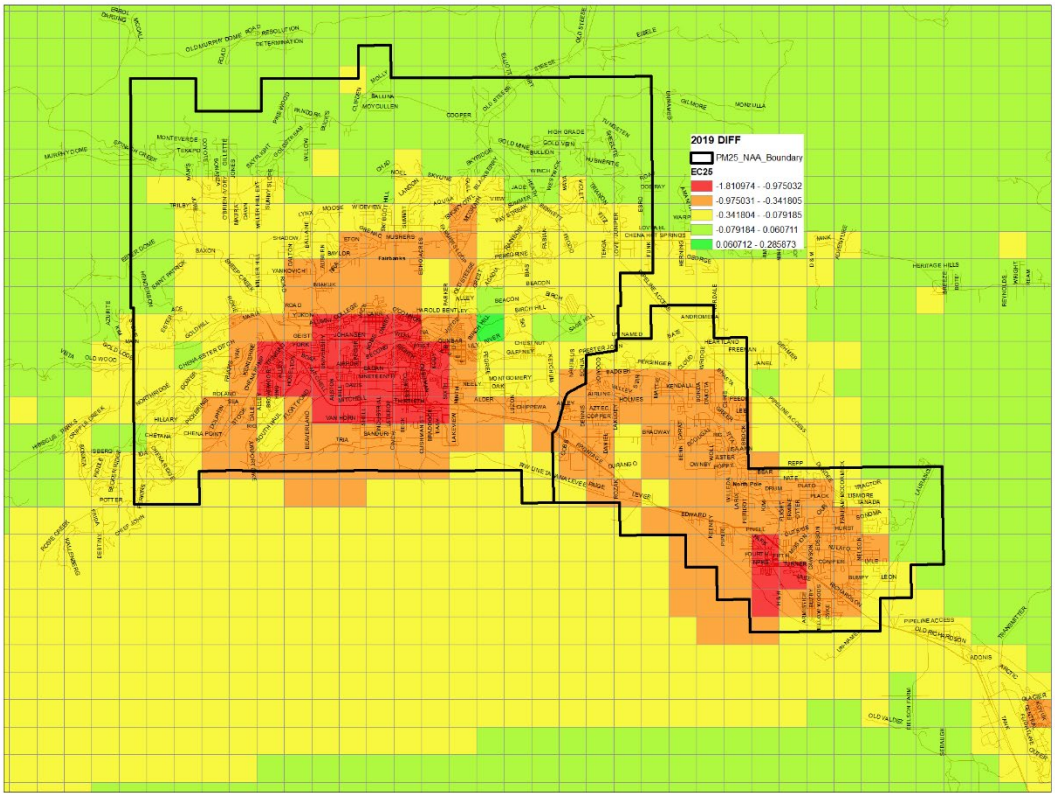


Figure 7.8-19. 2019 difference (2019-2013) of 24-hour averaged modeled EC (elemental carbon) concentrations for the Nonattainment Area over All Episode Days (January 23 to February 10 and November 2 to 17, 2008)

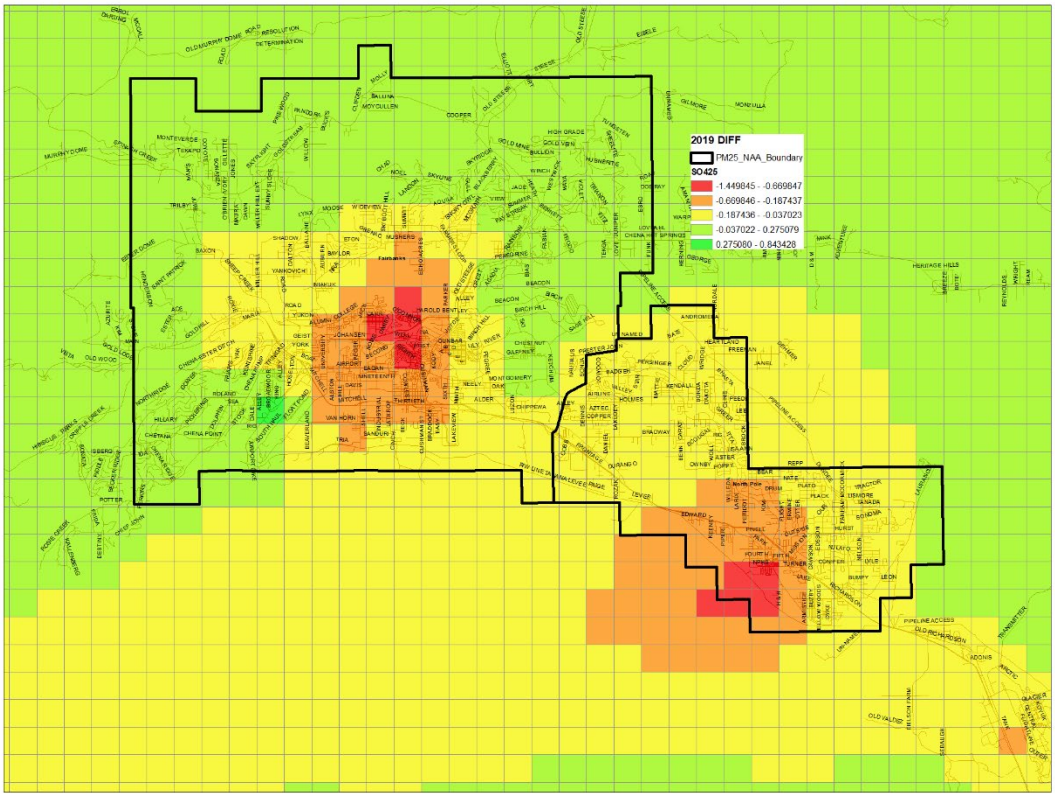


Figure 7.8-20. 2019 difference (2019-2013) of 24-hour averaged modeled SO_4 (sulfate) concentrations for the Nonattainment Area over All Episode Days (January 23 to February 10 and November 2 to 17, 2008)

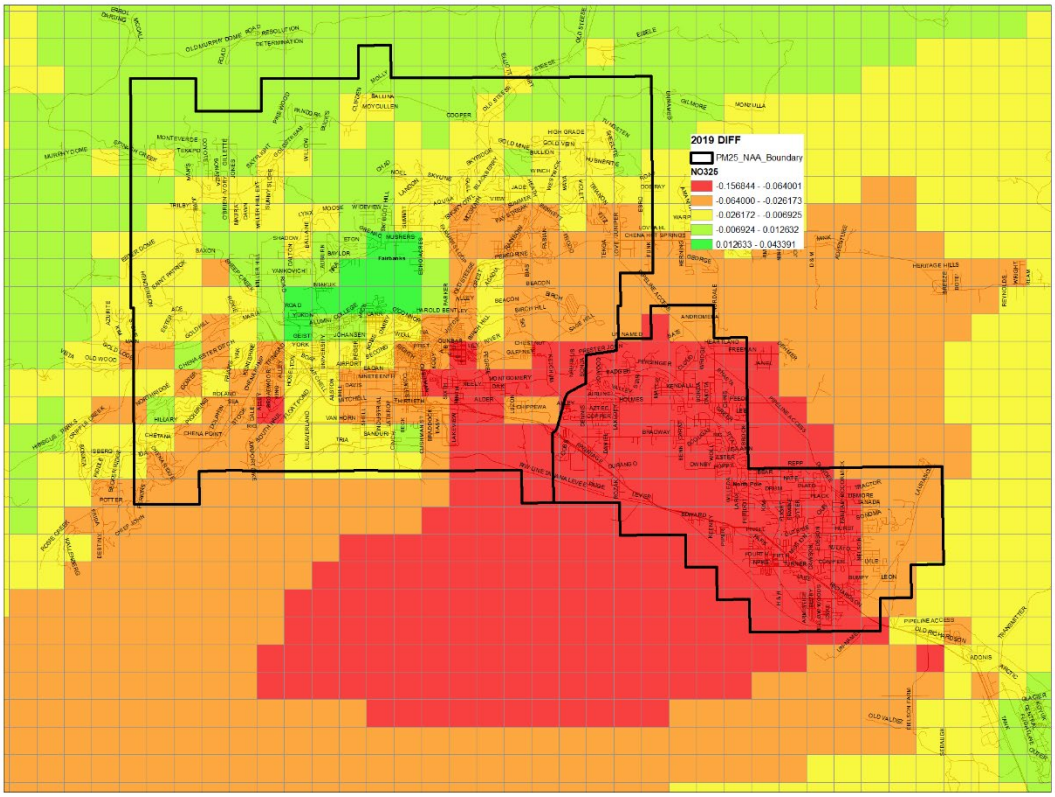


Figure 7.8-21. 2019 difference (2019-2013) of 24-hour averaged modeled NO_3 (nitrate) concentrations for the Nonattainment Area over All Episode Days (January 23 to February 10 and November 2 to 17, 2008)

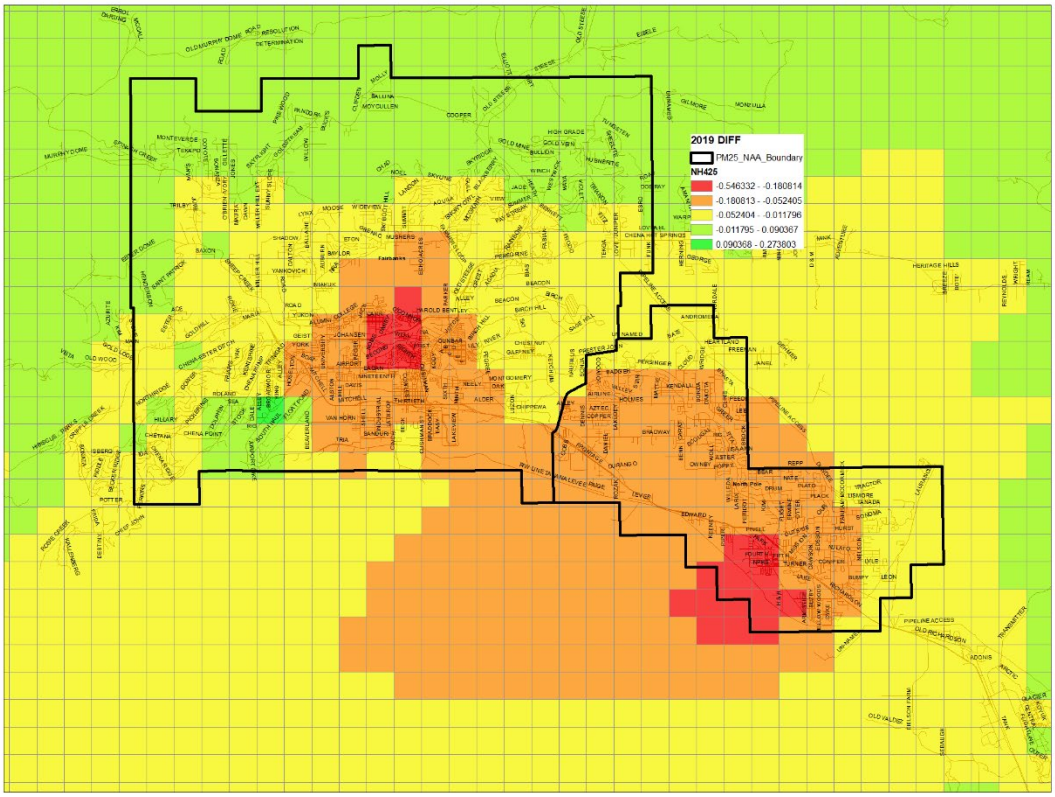


Figure 7.8-22. 2019 difference (2019-2013) of 24-hour averaged modeled NH_4 (ammonium) concentrations for the Nonattainment Area over All Episode Days (January 23 to February 10 and November 2 to 17, 2008)

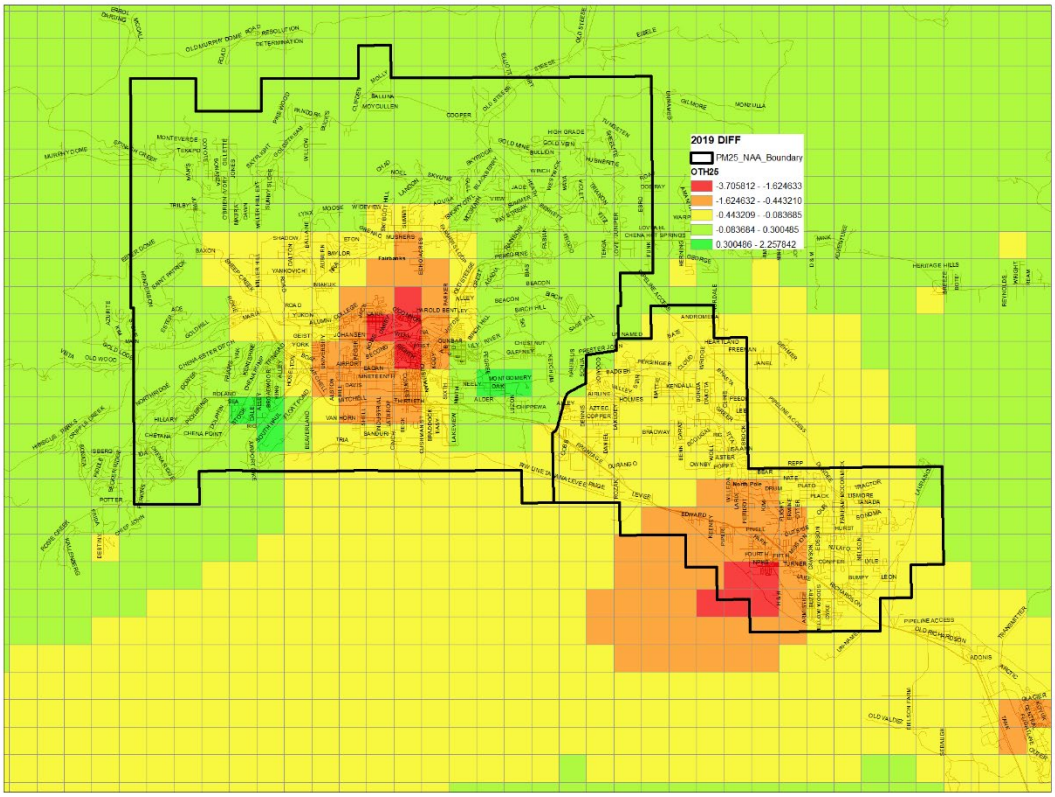


Figure 7.8-23. 2019 difference (2019-2013) of 24-hour averaged modeled OTH (other) concentrations for the Nonattainment Area over All Episode Days (January 23 to February 10 and November 2 to 17, 2008)

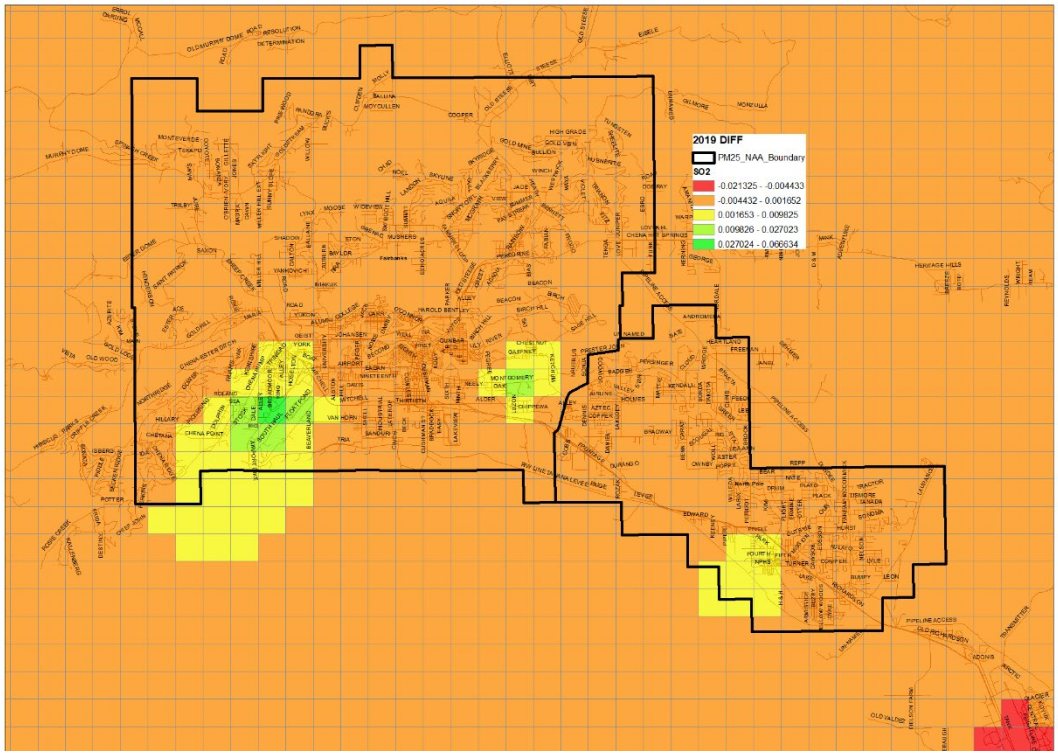


Figure 7.8-24. 2019 difference (2019-2013) of 24-hour averaged modeled gaseous (SO_2) concentrations (ppm) for the Nonattainment Area over All Episode Days (January 23 to February 10 and November 2 to 17, 2008)

7.8.12 Precursor Demonstration for 2013 and 2019

This section serves as an optional precursor demonstration for the $PM_{2.5}$ Serious SIP. Precursor gases include (sulfur dioxide, nitrogen oxides, ammonia, and volatile organic compounds) and contribute to the formation of $PM_{2.5}$ in the Fairbanks North Star Borough Nonattainment Area (NAA). The goal of the precursor demonstration is to determine whether controls are not needed on any of the four precursors in order to attain the standard. EPA has provided guidance to produce a precursor demonstration.[32] The analysis has been completed using the USEPA recommended threshold of 1.5 µg/m^3 in assessing the need for controls of a precursor. This is the value suggested by the EPA guidance.

As part of the Serious SIP development the Clean Air Act (Subpart 4 of Part D of Title I, id. 7513-7513b (Subpart 4)) calls upon states to develop an analysis called BACM (Best Available Control Measures) for all source sectors that emit $PM_{2.5}$ and the four major precursor gases. The BACM process treats area and mobile sources differently from major stationary sources. A Best Available Control Technology (BACT) analysis is conducted specifically for the major stationary sources as a part of the BACM process. BACM and BACT are required to be evaluated regardless of the level of contribution by the source to the problem or its impact on the areas ability to attain. If the state seeks an extension of the attainment date for the area further

[32] https://www.epa.gov/pm-pollution/pm25-precursor-demonstration-guidance

control measures must also be evaluated. These measures are called Most Stringent Measures (MSM). The $PM_{2.5}$ NAAQS Final SIP Requirements Rule states if the state determines through a precursor demonstration that controls for a precursor gas are not needed for attaining the standard, then the controls identified as BACT/BACM and MSM for the precursor gas are not required to be implemented[3].

EPA's *Draft $PM_{2.5}$ Precursor Demonstration Guidance* recommends five analyses that can be performed to demonstrate that a precursor gas is not significant in contributing to concentrations of $PM_{2.5}$. There are two main steps in the precursor demonstration process first a concentration-based analysis is conducted and failing that a sensitivity based analysis can be conducted. These analyses can be performed in a comprehensive manner meaning that it considers precursor emissions from all sources or they can be performed specifically for major stationary sources.

The concentration based analysis is initially conducted using ambient data collected at monitors within the nonattainment area where the precursor gas contributions are measured and assessed against the threshold of 1.5 $\mu g/m^3$ for 24-hour $PM_{2.5}$. Air quality modeling can also be used to perform the concentration based analysis by zeroing out the emissions of a precursor and running a photochemical grid model (PGM) to estimate the impact on $PM_{2.5}$. Should the concentration based analysis show impacts above the threshold, a sensitivity based analysis can be performed with an air quality model. There are three recommended tiers in the sensitivity based analysis: 70% reduction of emissions, 50%, and 30%. For each tier, the PGM is configured to reduce a precursor's emissions by a large percentage, and the impacts on $PM_{2.5}$ concentration are modeled. These impacts are compared to the same threshold as the concentration based analysis. Supplemental analysis may also be included to further support the findings of the precursor demonstration.

The following is a brief summary of the $PM_{2.5}$ precursor gases that are evaluated in the precursor demonstration:

SO_2: Direct emissions and atmospheric formation of particulate sulfate contribute to measured sulfate concentrations. Most of the sulfate is in the form of ammonium sulfate; in absolute terms sulfate contributes 5.4 $\mu g/m^3$ in Fairbanks and 4.9 $\mu g/m^3$ in North Pole on the average of high concentration days. These values are above the 1.5 $\mu g/m^3$ and SO_2 does not pass a contribution-based threshold analysis. Given the magnitude of these exceedances above the threshold no sensitivity-based precursor demonstration was pursued. As a result, SO_2 precursor emissions are considered significant, and any controls deemed feasible for the Fairbanks North Star Borough Nonattainment area would need to be implemented.

NO_x: Ammonium nitrate is the main particulate compound formed from NO_x emissions. The underlying chemistry and sensitivity are explained in the following sections. Concentrations of ammonium nitrate were calculated as 2.4 $\mu g/m^3$ in Fairbanks, 2.0 $\mu g/m^3$ at Hurst Road, and 1.0 $\mu g/m^3$ at the North Pole Elementary site. The Fairbanks and Hurst Road sites do not pass a comprehensive contribution-based analysis. DEC has decided to perform an optional modeling precursor demonstration for NOx from all sources (comprehensive) and from major stationary sources. For the comprehensive demonstration, NOx passes a 75% sensitivity-based analysis. A

separate major stationary source analysis shows that NOx passes a zero-out sensitivity-based analysis. Both of these demonstrations and supplemental analysis are provided in this section.

NH_3: Emitted ammonia is a precursor to the formation of particulate ammonium nitrate and ammonium sulfate. The major contributors to $PM_{2.5}$ from ammonia (biomass burning, mobile, home heating) in wintertime Fairbanks are drastically different from those commonly found in the contiguous US, where ammonia from agricultural activities typically dominate smaller contributions from vehicles, and other industrial activities. In the Fairbanks North Star Borough Nonattainment area, ammonium nitrate is a minor contributor to the total $PM_{2.5}$ while ammonium sulfate does contribute significantly to ambient concentrations of $PM_{2.5}$. Contributions of emitted ammonia to $PM_{2.5}$ were calculated as 4.6 $\mu g/m^3$ and 4.2 $\mu g/m^3$ at the Fairbanks monitors and 4.4 $\mu g/m^3$ and 2.1 $\mu g/m^3$ at the North Pole monitors. These values do not pass the contribution-based analysis. No sensitivity tests were performed for ammonia.

VOCs: Emissions of VOCs contribute to $PM_{2.5}$ by condensing after exiting a high temperature stack and then undergoing further chemical processing in the atmosphere to form secondary organic aerosols (SOA). Given the atmospheric and meteorological conditions in wintertime Fairbanks, VOCs are not expected to be major contributors to $PM_{2.5}$ in the nonattainment area. A contribution-based analysis of ambient data for VOC was not performed. A contribution-based zero-out air quality modeling demonstration shows VOC's contributing well below the threshold of 1.5 $\mu g/m^3$ at all monitors. For this reason we believe the contribution from VOCs to $PM_{2.5}$ are insignificant and do not plan to implement the BACT/BACM controls for VOCs.

7.8.12.1 Fairbanks Ambient Air Quality Overview for Precursor Demonstration

Addressing the precursor gases and how they are related to $PM_{2.5}$ requires understanding of the Fairbanks and North Pole wintertime characteristics that lead to the formation of $PM_{2.5}$ from both direct and secondary formations. Precursor gases form secondary $PM_{2.5}$ and this component of $PM_{2.5}$ is addressed through reviewing current knowledge of the chemistry involved in the secondary formation in the Fairbanks and North Pole NAA.

Particulate Matter ($PM_{2.5}$) is directly emitted into the atmosphere or formed by secondary chemical reactions from precursor gases. The major components of atmospheric aerosols formed by secondary chemistry are nitrate (NO_3^-), sulfate (SO_4^{-2}) and ammonium (NH_4^+). These species are formed primarily from chemical reactions in the atmosphere involving the gas-phase precursors, nitrogen oxides (NO_x), sulfur dioxide (SO_2) and ammonia (NH_3). The major component of Fairbanks $PM_{2.5}$ is organic carbon and is directly emitted as particles, condenses to existing particles, or contributes to the formation of new particles from gaseous molecules. The major components of $PM_{2.5}$ in the Fairbanks area are determined from filter based speciation data. There are four monitors that have speciation measurements during the modeling design value years of 2011 to 2015. In order to represent the monitored speciation values and compare to modeling outputs a process called SANDWICH is used and detailed in Section 7.8.9.3 of this chapter.

A precursor demonstration has been conducted for NOx and VOC. Table 7.8-17 summarizes the precursor demonstration tests that were passed at all monitor sites. VOCs were shown to be insignificant using a comprehensive air quality modeling zero-out analysis. NOx was demonstrated to be insignificant from a 75% sensitivity based analysis. A second NOx

demonstration was performed for major stationary sources with a zero-out air quality modeling analysis. This major stationary source demonstration was conducted in the event that EPA does not approve the comprehensive sensitivity based analysis.

Table 7.8-17: NOx and VOC Precursor Demonstrations

Precursor	Source(s)	Test Details	Pass
NOx	Comprehensive	Sensitivity Based Analysis 75%	Y
NOx	Major Stationary Source	Concentration Based Analysis - Air Quality Modeling zero-out	Y
VOC	Comprehensive	Concentration Based Analysis - Air Quality Modeling zero-out	Y

7.8.12.2 Precursor Gas Chemistry Overview

7.8.12.2.1 Nitrogen oxide precursors and nitrates

Nitrogen oxides are referred to as the chemical family NO_x (NO_2+NO), NO, and NO_2 with primary emissions coming from combustion processes, home heating, vehicles and industry. Typically, during the day, NO_x is oxidized by reacting with ozone and OH radical chemistry and forms nitric acid (HNO_3), and during the night NO_x is oxidized to form $N_2O_{5\ (g)}$, which reacts on aerosol surfaces to form $HNO_{3(aq)}$ and deposition to snowpack. Particles containing nitrate are neutralized via reaction with ammonia gas (NH_3) to form ammonium nitrate.

Due to the low to no sunlight and cold conditions during the winter, the photochemical production of nitric acid from the daytime processes of OH and NO_2 is limited in the Fairbanks and North Pole areas. In addition, at night, NO titrates the ozone removing the main oxidant to form nitrate.[33] Joyce showed that ammonium nitrate is formed downwind of downtown, adding to the probability that aerosol nitrate from nitric acid is not being formed in downtown Fairbanks. Heterogeneous nighttime chemistry involving N_2O_5 is thought to be responsible for 80% of the nitric acid formation at high latitudes[5], but in polluted areas nitric acid formation is hindered at night because of the fast reaction of excess NO with the nitrate radical. As nitric acid is further oxidized to form particle nitrate, it is important to understand the production of nitric acid and ammonium nitrate.

Aerosol processes play a dominant role in the formation of nitrate. Most nitrate is formed in the atmosphere from NO_x emissions that transform into ammonium nitrate from secondary processes. The monitored observations show that ammonium nitrate accounts for between 1% and 5% and of the total $PM_{2.5}$. As mentioned in the Moderate Area Plan, ammonium nitrate production is limited by the dark and cold conditions and by NO emissions hindering the nitrate production. The formation of ammonium nitrate is controlled by day time processes of OH and NO_2, and at night, NO titrates the ozone removing the main oxidant to form nitrate. During the day the photochemistry is limited by low sunlight and under low wind conditions when $PM_{2.5}$ is high, the NO emissions hinder further formation of nitrate. There are no OH measurements to compare to the model in the Fairbanks area, but there are no high ozone days which would form

[33] https://www.atmos-chem-phys.net/14/7601/2014/

from reactions with VOCs and sunlight (details on ozone and NOx measurements during the episodes can be found in the III.D.7.8 Modeling Appendix under the nitrate chemistry section).

The modeling precursor demonstration to estimate the potential for NO_x to create ammonium nitrate should be representative of the ammonium nitrate measured on the filters, in that only a few percent of $PM_{2.5}$ even on the highest days is ammonium nitrate. The modeling outputs were examined for NO, O_3, and NO_2. Please see the modeling appendix for a detailed discussion on the ozone and figures showing titrated ozone, background ozone conditions, and low wind found during the 2008 meteorological episodes. When the ozone is not titrated out and NO is low, the presence of wind and/or snow have reduced the $PM_{2.5}$. The background level ozone present under clean air quality conditions (approximately 40 ppb) on 1/23/2008 until 1/24/2008, is when there is a light wind of 5-10 mph. During these conditions $PM_{2.5}$ is reduced by the wind. Under the conditions when we have high $PM_{2.5}$: low wind, strong inversion in place, a buildup of excess NO and low ozone, further oxidation of NO_x and reactions with ammonia that produce particle nitrate are hindered (R2).

$$NO+O_3 \rightarrow NO_2 + O_2 \ (R1)$$
$$NO_2 + O_3 \rightarrow NO_3 + O_2 \ (R2)$$

At night when there is no excess NO and temperature is cold, the following is the dominant pathway to form nitric acid.

$$NO_2+NO_3 \leftrightarrow N_2O_5 \ (R3)$$

N_2O_5 further reacts on a surface to form nitric acid. Once nitric acid is formed, the remaining reactions depend on the availability of ammonia, temperature and the pH of the aerosol to form ammonium nitrate. Joyce et al found in a modeling study that secondary formation of particulate nitrate in downtown Fairbanks does not contribute significantly to the $PM_{2.5}$ concentration, but there is a potential to react with ammonia downwind of the Fairbanks area.

At night, when there is no photolysis controlling the oxidation of NOx, the reaction of NO and NO_3 is very fast and if there was enough ozone to produce NO_3, it would quickly be removed by fresh NO emissions (5 seconds) in an urban polluted environment.

$$NO+NO_3 \rightarrow 2\ NO_2 \ (R4)$$

The CMAQ model version 4.7.1 was applied in the precursor demonstrations to estimate $PM_{2.5}$ concentrations. The model has full representations of gas and aerosol phase chemistry. Nitrate formation involves chemical reactions in both gas and aerosol phases.

Two major pathways of nitrate formation are parameterized in CMAQ 4.7.1:

1. Heterogeneous reaction of N_2O_5; and
2. Thermodynamic equilibrium reactions among HNO_3, NH_3 and aerosols.

N_2O_5 is considered the reservoir for NO_x and it is thermally unstable. Its reaction with water on aerosol surface was found to be a significant source for aerosol nitrate[11]. Parameterization of

heterogeneous reactions of N_2O_5 in CMAQ 4.7.1 is based on the method developed by Davis et al. (2008)[34], which calculates the N_2O_5 hydrolysis probability as a function of temperature, relative humidity (RH), inorganic aerosol composition, and phase state. The N_2O_5 photolysis probability is defined as the fraction of collisions between N_2O_5 molecules and particle surfaces that lead to the production of HNO_3. The photolysis probability is higher at lower temperature and higher RH, so nitrate formation through this pathway is more active at nighttime when N_2O_5 is accumulated and the temperature is low and RH is high. The N_2O_5 hydrolysis can be simply represented by the reaction below. More detailed reactions can be found in Reactions R1 – R3 of Davis et al. (2008).

$$N_2O_5 + H_2O \rightarrow_{\text{aerosol}} 2HNO_3 \qquad \text{(R5)}$$

Nitrate formation through the second pathway occurs when gas phase HNO_3, NH_3, and aerosols try to reach a thermodynamic equilibrium. The major reactions represented in the model are listed below:

$$NO2 + OH \rightarrow HNO3 \qquad \text{(R6)}$$

$$HNO3 + NH3 \leftrightarrow NH4NO3 \qquad \text{(R7)}$$

$$HNO3\ (g) \leftrightarrow H^+ + NO_3^- \qquad \text{(R8)}$$

$$NH4NO3\ (s) \leftrightarrow NH_4^+ + NO_3^- \qquad \text{(R9)}$$

Reaction R6 produces gas phase HNO_3 during daytime. Gas phase HNO_3 and NH_3 react to form NH_4NO_3 particles. Both gas phase HNO_3 and NH_4NO_3 particles hold thermodynamic equilibrium with aerosols, as shown in reactions R8 and R9. The thermodynamic equilibrium is simulated by a thermodynamic model implemented in CMAQ.

7.8.12.2.2 Sulfur dioxide precursor gas and sulfate

It is very likely that SO_2 is converted into sulfate in the atmosphere after being emitted and thus accounts for the remainder of the observed sulfate. As control strategies are adopted for BACT and BACM, for example, switching from fuel oil which has higher SO_2 and primary sulfate emissions to ULSD will reduce the SO_2 and sulfate. Due to the complex nature of the sulfate chemistry a white paper on sulfur chemistry was included in the Moderate Area SIP, the white paper concludes that the lack of oxidants available in the dark and cold conditions would impede production of sulfate by the most common photochemical pathways.

The photochemical grid model does not perform well for sulfate and does not convert much of the SO_2 to sulfate. It is possible to estimate the amount of SO_2 that converts to sulfate and the contribution to sulfate from point sources. That estimate relies on the assumption that all of the SO_2 from all sources is equally likely to convert to sulfate. If that assumption holds true the ratio

[34] Davis, J. M., Bhave, P. V., and Foley, K. M.: Parameterization of N_2O_5 reaction probabilities on the surface of particles containing ammonium, sulfate, and nitrate, Atmos. Chem. Phys., 8, 5295-5311, https://doi.org/10.5194/acp-8-5295-2008, 2008.

of point source SO_2 to total SO_2 can be used to estimate the contribution of point source SO_2 to sulfate. DEC conducted an analysis using the non-conservative approach to estimate the secondary sulfate from point sources for 2019 as an SO_2 analysis in Section 7.8.13 and allowed for public review and comment. However, this approach is not an EPA-approved scientific method. In the context of a major stationary source precursor demonstration the most conservative and defensible approach is to apportion all of the secondary sulfate to the point sources.

Without a defensible means to apportion sulfate between secondary and primary sources, it is not possible to demonstrate conclusively that the major stationary source contribution is below the 1.5 $\mu g/m^3$ threshold. The conservative approach would associate all of the measured sulfate 4.9 to 6.2 $\mu g/m^3$ with major stationary sources, far above the threshold of 1.5 $\mu g/m^3$. There are additional considerations with a precursor demonstration such as the inclusion of ammonium and particle bound water, however, the current result is already above the threshold. As a result DEC has not included an optional precursor demonstration for SO_2. DEC may pursue a precursor determination for SO_2 in a future SIP update, if the modeling platform is updated, and if the results are feasible, below the threshold and defensible.

7.8.12.2.3 Ammonia precursor gas and ammonium

Ammonia gas (NH_3) reacts with acid aerosols containing nitrate (NO_3^-) and sulfate (SO_4^{2-}) to from ammonium nitrate (NH_4NO_3) and ammonium sulfate ($(NH_4)_2SO_4$). Nitrate is assumed to be all ammonium nitrate. Sulfates are partially neutralized to form ammonium sulfate and are associated with a degree of neutralization. As discussed in the Moderate Area SIP, if sulfate is reduced in Fairbanks, $PM_{2.5}$ is reduced by the weight of the sulfate reduced and also by the weight of the ammonium.

7.8.12.2.4 Volatile organic compounds

The emissions of volatile organic compounds (VOCs) are precursor gas emissions that contribute to the secondary formation of $PM_{2.5}$ by forming particulate organic carbon through condensing in the cold air after emission and through photochemistry to form secondary organic aerosols (SOA). The VOC emissions for home heating are 15.9 TPD. The condensable fraction of PM from point sources, gases that are emitted and form particles right out of the high temperature stack could be significant from the condensation due to low temperature.

7.8.12.3 2013 Precursor Demonstration

We applied a tiered approach to the precursor demonstration for both NO_x and VOCs in the Fairbanks North Star Borough 24-hour $PM_{2.5}$ Nonattainment Area. This process is in keeping with EPA's *Draft $PM_{2.5}$ Precursor Demonstration Guidance*[35] and 2016 $PM_{2.5}$ Implementation rule.[36] The tiered analysis can be broken down into five stages each with a decreasing level of confidence in the demonstration. The various precursor demonstration available are the following:

[35] https://www.epa.gov/pm-pollution/pm25-precursor-demonstration-guidance
[36] https://www.epa.gov/pm-pollution/implementation-national-ambient-air-quality-standards-naaqs-fine-particulate-matter

- Concentration Based Analysis
  - Ambient data
  - Air Quality Modeling (zero-out)

- Sensitivity Based Analysis
  - 70% Reduction
  - 50% Reduction
  - 30% Reduction

These analyses are broken down further in the sections below. EPA recommends a threshold of 1.5 µg/m^3 as a starting point for the precursor demonstration for 24-hour $PM_{2.5}$[17]. This analysis has chosen the recommended threshold. A precursor can be identified as not significant when it does not exceed the threshold. Except for the ambient data analysis, the precursor demonstration can be conducted in either a comprehensive manner, meaning that it applies to all sources or specifically for major stationary sources. The ambient data analysis test can only be conducted on a comprehensive basis. The threshold for significance is the same in both the comprehensive or major stationary source tests.

7.8.12.3.1 Concentration-based ambient data analysis

First the concentration-based analysis is performed using ambient data. For this step, we assessed the concentration of different precursor contributions for all four monitor sites between 2011 and 2015 on the highest concentration days. The high concentration days are described in the Speciated Modeled Attainment Test (SMAT) section above. In short, the top 25% days were analyzed for the NCORE, SOB, and NPE monitors and all days over 35 µg/m^3 were used for the Hurst Road monitor. The speciated $PM_{2.5}$ data was analyzed using the results of the SANDWICH data processing technique. The ambient dataset is the same that is used in the attainment plan portion of the Serious Area Plan.

Contributions from SO_2, NO_x, and NH_4 could be determined from the data available, but the data was not analyzed in such a way that VOC contributions could be determined. Section 3.1.5 of EPA's *Draft $PM_{2.5}$ Precursor Demonstration Guidance* summarizes the means by which each precursor gas is assigned to a $PM_{2.5}$ species in the ambient $PM_{2.5}$ measurements. These assignments are summarized for SO_2, NO_x, and NH_3 below. Contributions for SO_2 were assessed using the mass of sulfate measured on the filters on the highest concentration days at each monitor site. Contributions for NOx were assessed as the concentration of nitrate and the portion of the ammonium associated with nitrate. This is calculated as the sum of the nitrate concentration with the molar ratio equivalent amount of ammonium. If the ammonium is assumed to perfectly balance the nitrate then we determine the concentration of ammonium associated with nitrate in µg/m^3 as 18/62 multiplied by the nitrate concentration in µg/m^3. NH_3 contributions were calculated from the ambient data as the sum total of all ammonium and all nitrate. Any precursor demonstrations using ambient data would be considered comprehensive, meaning that controls for that precursor would not be required on any source.

7.8.12.3.2 Concentration-based air quality modeling analysis

An air quality modeling analysis of precursor impacts on $PM_{2.5}$ utilizes a photochemical grid model (PGM) that can account for the non-linear secondary effects of precursor gases. PGMs account for the atmospheric chemistry, transport, and deposition of pollutants using local

emissions and meteorological data. This demonstration used the Community Multiscale Air Quality (CMAQ) model version 4.7.1 as configured for the Moderate and Serious $PM_{2.5}$ SIPs for Fairbanks. Precursor significance for Fairbanks was determined using the zero-out approach. The zero-out approach compares a baseline model run with a model run where a precursor's emissions are set to zero in order to determine the influence of that precursor on $PM_{2.5}$ formation. The emissions base year was updated to 2013 for this analysis. The CMAQ model was run with the 2013 baseline inventory first without any alterations to generate baseline modeled concentrations for the nonattainment area. Separate runs were performed for VOC and NOx where each precursor's emissions were set to zero for all sources, while all other emissions were left at baseline 2013 levels. Another separate model run was conducted where NOx emissions from major stationary sources were set to zero. In the Tables 7.8-18-20, the green indicates a level that is below the guidance threshold of 1.5 $\mu g/m^3$ and red indicates that it is above the threshold. All monitored cells for the NOx comprehensive 75% knock run are green and below the threshold of significance (Table 7.8-18), NOx 100% knock out for point sources (Table 7.8-20) and VOC comprehensive (Table 7.8-19).

Table 7.8-18 2013 NOx Comprehensive and Major Stationary Precursor Demonstrations

NOx Episode Average Contributions (SMAT $\mu g/m^3$)						
Test	**SOB**	**NCORE**	**NCORE BAM**	**Hurst Road**	**NPE**	**Max Cell**
Comprehensive Ambient	2.4	2.4	2.4	2.0	1.0	N/A
CMAQ 100% reduction	1.5	1.4	1.5	1.3	0.5	1.6
CMAQ 75% reduction	0.7	0.7	0.7	0.8	0.3	0.8
Major Stationary Zero-out	0.3	0.3	0.3	0.4	0.1	0.3

Table 7.8-19 2013 VOC Comprehensive Precursor Demonstrations

VOC Episode Average Contributions (SMAT $\mu g/m^3$)						
Test	**SOB**	**NCORE**	**NCORE BAM**	**Hurst Road**	**NPE**	**Max Cell**
Comprehensive Ambient						N/A

Modeled Zero-out (100% reduction)	0.1	0.1	0.1	0.1	0.0	0.1

Table 7.8-20. 2013 NOx Comprehensive and Major Stationary Precursor Demonstrations Maximum Daily Impacts

NOx Highest Daily Contributions (SMAT µg/m^3)						
Test	**SOB**	**NCORE**	**NCORE BAM**	**Hurst Road**	**NPE**	**Max Cell**
Modeled Zero-out	1.81	1.69	1.84	1.33	0.62	1.85
Modeled 75% Reduction Sensitivity	0.81	0.76	0.83	0.72	0.35	0.89
Major Stationary Sources Zero-out (100% reduction)	0.38	0.38	0.36	0.39	0.74	0.29

The following figures (7.8-25 and 26) are the histograms of the daily $PM_{2.5}$ differences at the grid cells where the monitors are located. The differences were calculated based on the raw CMAQ output by subtracting the control case results (i.e., PT0NOX and NOX75OFF) from the baseline for each day of the total 35 episode days.

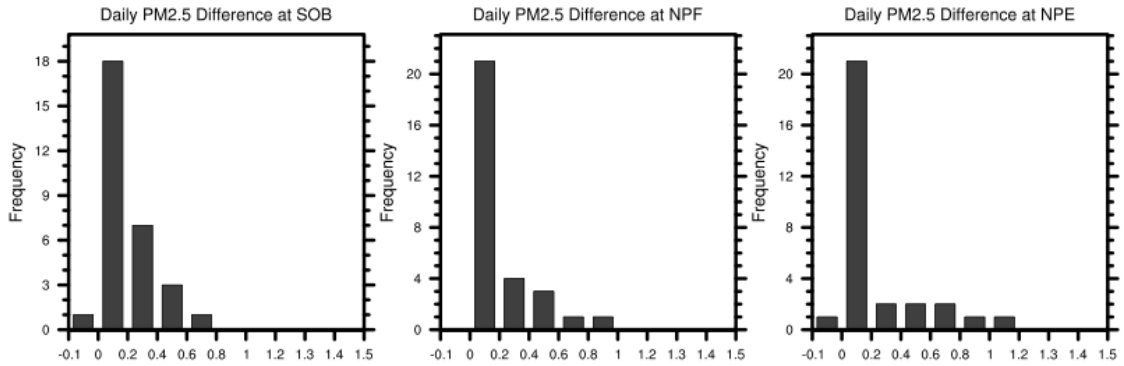


Figure 7.8-25. Histograms of the daily $PM_{2.5}$ differences at monitor grid cells for the point source NOx knock out run (PT0NOx).

For the stationary source NO_x zero out case, the reductions in daily $PM_{2.5}$ at the three grid cells containing monitored locations are mostly (~20 days) less than 0.2 µg/m^3. None of the daily differences exceed the 1.5 µg/m^3 threshold. There is one day at the SOB grid cell monitor and another day at the NPE grid cell monitor with a slight increase (less than 0.1 µg/m^3) in daily $PM_{2.5}$ when point source NOx emissions were removed. The nitrate concentration was decreased

for both days, but the other $PM_{2.5}$ species were slightly increased due to the removal of point source NOx emissions. Both days have a relatively low nitrate concentrations, and it could be that the interaction of various $PM_{2.5}$ species on those days is very sensitive to the changes in NOx emissions.

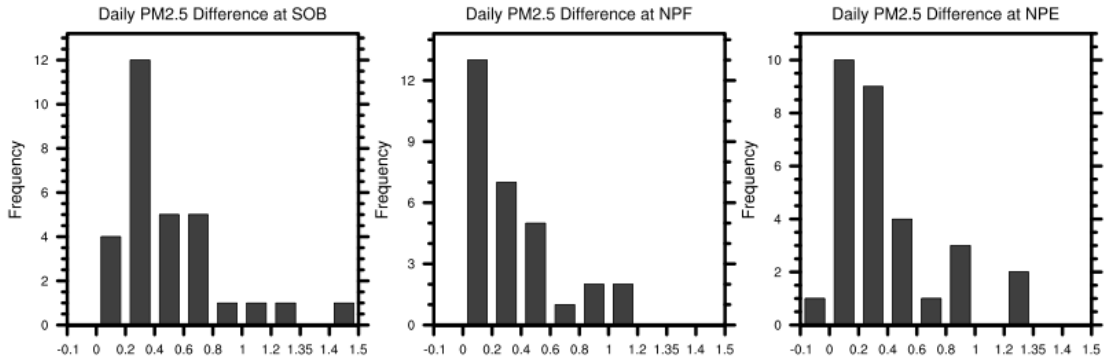


Figure 7.8-26. Histograms of the daily $PM_{2.5}$ differences at monitor grid cells for the comprehensive NOx 75% off sensitivity run (NOX75OFF).

For the comprehensive NOx 75% off case, most of the days have a reduction of $PM_{2.5}$ less than 0.6 µg/m^3. There is one day at SOB with a reduction slightly larger than 1.3 µg/m^3. There are two days at NPE that have a reduction above 1.3 µg/m^3, but below 1.35 µg/m^3. When rounded to the nearest tenth of a µg/m^3, these days fall below the threshold value 1.5 µg/m^3.

7.8.12.4 Precursor Demonstration updates for 2019 for NOx and VOCs

Updated additional optional 2019 precursor analysis were performed for 2019 to make sure there were no major changes since the preliminary Serious Area SIP precursor demonstration was released. The 2019 updated results show a slight increase in NOx but not above the threshold at 75% knock out for comprehensive NOx in Table 7.8-24a. The point source 100% knock out run difference from 2013 to 2019 had minimal increases to the design value and the differences are listed in Table 7.8-24c, but these changes are still far below the threshold of 1.5 µg/m^3. The largest difference of 0.4 µg/m^3 for total design value of 0.8 was in North Pole at the Hurst Road monitor. The design value uses the SMAT data that reflects the 5-year modeling design value and not the absolute or raw model outputs. This is the same procedure used for all modeling design value calculations and the 2013 precursor runs, for detailed description of modeling ambient air quality data using SANDWICH and SMAT methods (refer to section 7.8.9.3 above). The 2019 precursor results are summarized in the tables below. The 2019 precursor runs use a max daily, not a max cell episode average which is why the concentrations are higher. The max daily is a monitor grid cell daily value. All monitored cells are green for the 75% NOx Comprehensive, 100% NOx point source, and the 100% VOC model runs, which indicate that the concentrations are below the threshold of significance. The monitored grid cells that are red are optional max daily concentrations to show the highest impact site, but they are not episode average concentrations as required for the precursor demonstration.

Table 7.8-24a and 24b. NOx and VOC Comprehensive and NOx Major Stationary Precursor Demonstrations for 2019.

		Episode average µg/m³				Max Daily µg/m³			
		SOB	NCORE	Hurst Road	NPE	SOB	NCORE	Hurst Road	NPE
CMAQ Precursor Sensitivity									
100%	**NOx**	1.1	1.1	0.3	0.6	4.4	4.4	1.9	2.0
	VOC	0.1	0.1	0.0	0.1	0.3	0.3	0.1	0.2
100%	Design Value **NOx**	1.5	1.4	0.4	0.5				
	VOC	0.2	0.2	0.1	0.1				
75%	Absolute **NOx**	0.5	0.5	0.3	0.3	2.4	2.4	1.3	1.2
75%	Design Value **NOx**	0.8	0.7	0.4	0.3				

Major Stationary Source Analysis

	Episode Average				Max Daily Value			
CMAQ Sensitivity 100%	**SOB**	**NCORE**	**Hurst Road**	**NPE**	**SOB**	**NCORE**	**Hurst Road**	**NPE**
NOx absolute	0.3	0.3	0.2	0.2	1.2	1.2	1.0	1.2
NOx Design Value	0.4	0.4	0.4	0.2				

Table 7.8-24c. 2019-2013 Difference in NOx precursor comprehensive and point sources at all four monitors in episode average design value concentrations in µg/m^3

CMAQ Sensitivity	SOB	NCORE	HURST Road	NPE
75% NOx Comprehensive	0.1	0.0	0.4	0.1
100% VOC Comprehensive	0.1	0.1	0.0	0.1
100% NOx Point Source	0.1	0.1	0.2	0.3

7.8.12.5 SO_2 Analysis

The SO_2 analysis was completed using the 2019 projected baseline inventory and run through the CMAQ model. All of the SO_2 emissions were removed from the point source sector, this is also referred to as a 100% knock out model run. All other source sectors were left the same. The WRF model meteorology was from 2008, which is consistent for all of the model runs. Table 7.8-25 represents the difference in SO_2 contribution from 2013 to 2019 at the monitored grid cells. The SO_2 decreases by 20-45% at the monitors. The SO_2 from major stationary sources was found to contribute significantly to PM2.5 at the SOB and NCORE monitors at 1.79 and 1.70 µg/m^3 respectively (Table 7.8-26).

Table 7.8-25 SO_2 Analysis of point source contribution of PM 2.5 at the monitored grid cells

Point Contribution	
SITES	SO_2
SOB/NCORE	-39%
Hurst Road	-20%
NPE	-45%

Table 7.8-26 Design value contribution from major stationary source SO_2

Point Source SO_2 Design Value Contribution (µg/m^3)			
SOB	NCORE NB	Hurst Road	NPE
1.79	1.70	0.04	0.10

In the base case model performance runs for 2008 it was estimated that the model under predicted secondary sulfate (details are in the Moderate SIP Modeling Chapter). To address the underperformance of the model another approach was employed to estimate major stationary source SO_2 contributions to $PM_{2.5}$. The model performance analysis estimated that 61% of the sulfate was due to secondary sulfate in 2008 and the remaining 39% was contributed from direct $PM_{2.5}$ sulfate emissions. The CMAQ knockout runs of point source SO_2 allow for the apportioning of SO_2 that reaches the monitor grid cell to point sources (see Table 7.8-27). In the case of the SOB/NCORE site 39% of the SO_2 was contributed from point sources. Using the

secondary sulfate percentage and the SO_2 contribution percentage we find that removing SO_2 from point sources should impact the RRF for SO_4 (see Table 7.8-27). Using SOB/NCORE as an example: RRF = 1 – 0.39 * 0.61 = 0.76. When this is processed through SMAT the FDV reduction from removing SO_2 from point sources is found to be significant at all sites.

Table 7.8-27 Alternative approach to estimate design value contribution from major stationary source SO_2

Point Source SO_2 Influence on Concentrations		
Monitor Sites	SO_4 RRF	FDV Contribution ($\mu g/m^3$)
SOB	0.76	2.66
NCORE	0.76	2.53
Hurst Road	0.88	1.55
NPE	0.72	1.35

Both the primary approach and alternative approach show contributions to $PM_{2.5}$ at multiple monitor sites above the 1.5 $\mu g/m^3$ (Tables 7.8-26 and 7.8-27). DEC does not believe these results are strong enough to pursue a precursor determination for sulfate for point sources. The uncertainty in the sulfate model performance and the contribution above the threshold is not strong enough to negate evaluating BACT for the point source for sulfate.

7.8.13 2019 Control Run

The modeling of attainment requires the calculation of future design values using the Species Modeled Attainment Test (SMAT) method discussed below (SMAT details to establish a base year RRF and Future Design Value (FDV) are in Section 7.8.8). Modeling must be completed for the year 2019 with projected growth and control scenarios in place prior to December 31, 2018. If the projected control scenario shows attainment at the monitoring cites, then an unmonitored area analysis (UMAA) must be performed to demonstrate attainment in other grid cells.[37]

Details for how these adjustments are calculated can be found in Appendix III.D.7.8. For the 2019 baseline modeling for $PM_{2.5}$, all other species and future years the RRF is calculated as the ratio of the 2013 episode 24-hour averaged concentration of a species by the 2019 episode 24-hour averaged concentration:

$$RRF_i = \frac{[i_{2019}]}{[i_{2013}]}$$

[37] Guidance on the Use of Models and Other Analyses for Demonstrating Attainment of Air Quality Goals for Ozone, PM2.5 , and Regional Haze U.S. Environmental Protection Agency Office of Air Quality Planning and Standards Air Quality Analysis Division Air Quality Modeling Group Research Triangle Park, North Carolina - EPA -454/B-07-002 April 2007

Where *RRF* is the relative response factor of species *i* and [*i*] is the concentration of *i* for 24-hours averaged over all episode days in 2013 and 2019.

Table 7.8-28a-d. RRF Values for 2019 Control Scenario against a 2013 Base Year

Scenario Name- NCORE	Organic Carbon (OC)	Elemental Carbon (EC)	SO_4	NO_3	Other Primary Particulate (OTH)
2013 Base Year	1.00	1.00	1.00	1.00	1.00
2019 Control Package	0.75	0.62	0.78	0.96	0.75

Scenario Name- SOB	Organic Carbon (OC)	Elemental Carbon (EC)	SO_4	NO_3	Other Primary Particulate (OTH)
2013 Base Year	1.00	1.00	1.00	1.00	1.00
2019 Control Package	0.75	0.62	0.78	0.96	0.75

Scenario Name-Hurst Road	Organic Carbon (OC)	Elemental Carbon (EC)	SO_4	NO_3	Other Primary Particulate (OTH)
2013 Base Year	1.00	1.00	1.00	1.00	1.00
2019 Control Package	0.78	0.74	0.89	0.87	0.56

Scenario Name-NPE	Organic Carbon (OC)	Elemental Carbon (EC)	SO_4	NO_3	Other Primary Particulate (OTH)
2013 Base Year	1.00	1.00	1.00	1.00	1.00
2019 Control Package	0.77	0.71	0.75	0.87	0.59

For Fairbanks and the North Pole Monitors, the RRF of OC has the most impact on the total $PM_{2.5}$ FDV concentration, which is also reflected by OC making up the largest share of the total aerosol mass. The OTH or other component of PM has the weakest impact on the FDV. The FDV calculated from the RRF values are shown in Table 7.8-28.

Table 7.8-29. 2019 FDV for the Control Scenario Calculated against a 2013 Base year

Scenario	Hurst Road	NPE	NCORE	SOB

	Future Design Value ($\mu g/m^3$)	Future Design Value ($\mu g/m^3$)	Future Design Value ($\mu g/m^3$)	Future Design Value ($\mu g/m^3$)
2013 Base Year	131.63	45.3	37.96	38.93
2019 Control	104.16	36.42	28.87	29.57

The 2019 control package with actual point source levels reaches an FDV of 104.16 $\mu g/m^3$ at the Hurst Road monitor, the official violating monitor for Fairbanks nonattainment area. This value is still well above the 24-hour $PM_{2.5}$ NAAQS of 35 $\mu g/m^3$.

Discussion of the curtailment, wood stove change out (WSCO), vehicles and all other sector benefits are in the emissions inventory chapter in Section III.D.7.6. Emission Inventory and calculations are provided in Appendix III.D.7.6.

7.8.13.1 2019 Control Run Modeling

The future modeling required after the Serious Area SIP will include a new updated design value, new calculation for SMAT (Speciated Modeled Attainment Test) that allows the model to represent actual monitored data and updated CMAQ model, new source apportionment tools and new WRF data set will be completed.

The following modeling results are included to show the effectiveness of control programs when projected to 2019. Based on projections for the current control programs for 2019 along with the addition of new control programs, a FDV was calculated for a 2019 control package. For details on the control package, see Section III.D.7.6 Emission Inventory. The RRFs by species are shown in Table 7.8-28 for all four monitored sites.

Using the RRFs presented in Table 7.8-28, the FDV for the 2019 control package reduces concentrations to 104.16 $\mu g/m^3$ at the North Pole Monitoring site (Table 7.8-29 above). The projected control scenario does not reduce concentrations to below the 35 $\mu g/m^3$ 24-hour average $PM_{2.5}$ NAAQS.

Due to the timing of the Serious Area SIP, it is not possible to demonstrate attainment through the monitoring data and the 3 year average design value, even if zero was entered for the rest of 2019 the design value is still be above 35 $\mu g/m^3$. Due to this monitored data, no further analysis was completed on the 2019 control modeling run.

The attainment demonstration modeling for 2024 and 2029 is in the Attainment Demonstration Chapter, Section III.D.7.9.

ALASKA DEPARTMENT OF ENVIRONMENTAL CONSERVATION

Amendments to:

State Air Quality Control Plan

Vol. II: III.D.7.8

Modeling

Draft

Date

Michael J. Dunleavy, Governor

Jason W. Brune, Commissioner

Note: DEC proposes to repeal and replace this State Air Quality Control Plan section to address the disapproval of the Fairbanks North Star Borough $PM_{2.5}$ Serious SIP. To aid in the public comment process, the currently adopted section of the air quality plan can be found and referenced at the following internet site: https://dec.alaska.gov/air/anpms/sip/fbks-pm2-5-regs-amends-2020/

7.8.14 Overview Modeling 2020 Amendment SIP

Since the development of the Serious Area SIP, DEC has collected monitoring data at an additional monitoring site in the Fairbanks area: A Street in the Hamilton Acres Subdivision. This monitoring site was established as the maximum impact site for the Fairbanks portion of the nonattainment area. The monitoring chapter has additional information on the A street site. The 2020 amendment includes new design values for all four monitoring sites, SOB, NCORE, Hurst Road and A street and a new 4 year modeling design value has been calculated (see Section III.D.7.4 Ambient Monitoring and Trends) for the modeling years 2016 to 2019 (Table 7.8.14-1.). The PM 2.5 modeling guidance suggests using one of the three years of nonattainment that include the base year. Maximizing the latest emissions inventory and controls, DEC selected the most current base year possible: 2019. That 2019 base year is then included in the modeling design value and the 3,4- or 5-year design value is calculated to reflect current conditions. The North Pole area monitor has been consistently in the 60-70 $\mu g/m^3$ range for PM2.5 and therefore DEC, in consultation with EPA, chose 2016-2019 for the 4-year design value to be representative of Hurst Rd concentrations. Prior to 2016, the PM 2.5 concentration was significantly higher. These additional data add new insights into the future design values. DEC has a separate and ongoing effort to collect new speciation data for PM2.5 and perform a modeling system update. The modeling system update is a long-term process that is detailed in a Technical Analysis Protocol in Appendix III.D.7.8 and will be used for future Fairbanks Area modeling efforts along with updated speciation data.

The updated design value for the 2020 amendment results from the need to update the modeling analyses to a base year of 2019. The base year is typically one of the years used to calculate the modeling design value. In the Serious Area SIP, 2019 was the most recent year with a complete year of data, which is why DEC selected it for use as the base year inventory for the 2020 amendment. Since completing the Serious Area SIP, the emission inventory for the 2019 base year was updated to reflect actual emissions that occurred during the year 2019 for all source sectors. The design value update is presented below in Table 7.8.14-1 and shows a new violating monitor DV at the Hurst Road site of 64.7 $\mu g/m^3$ of PM2.5. All future year modeling in the 2020 amendment will be measured against this design value for the Hurst Road monitor. The details of the updates to the emissions inventory are provided in the emission inventory section (III.D.7.7).

Table 7.8.14-1. PM2.5 Design Value updated table for Fairbanks and North Pole monitors in µg/m^3

	PM2.5 yearly 98%- tile				PM2.5 Design Values (3 year DV unless noted)					
Site	2016	2017	2018	2019	2016	2017	2018	2019	Serious SIP Modeling Design Value rolling average 2011-2015 (5 year)	2020 Amendment Modeling Design Value 2016-2019 (4 year)
SOB	39.7	38.0	27	27.7	37	38	35	31	38.9	32.9
NCORE	30.3	34.4	25.3	27.7	33	34	30	29	38.0	29.6
Hurst Road	66.8	75.5	52.8	65	106	85	65	64	131.6	64.7
A St				34.1				N/A		

Note: SOB shut down in June of 2019

7.8.14.1 2019 Base Year Modeling

As described previously, the base year for the 2020 amendment modeling is 2019 and modifications to the 2019 emission inventory since the Serious Area SIP include updates to reflect actual 2019-point source and mobile source emission data as well as updated aircraft emissions. The details of the emissions inventory are presented in Section III.D.7.7. The plots below for total PM2.5 from the Serious SIP 2019 modeling year and the 2020 amendment 2019 base year show very little change. The emissions difference for each category is used in the precursor demonstration update for 2019 and can be found below in the precursor section 7.8.14.3. The base year concentration 64.7 µg/m3 at the Hurst Road monitor and all emission inventory changes are from this base year and starting the relative response factors for all species are 1 and decrease or increase depending on the controls applied.

7.8.14.2 2024 Modeling

For the 2020 amendment, the 2024 model year was rerun with the new design values provided in Table 7.8.14-1. The 2024 future design values for each species were added together to determine the total PM2.5. The modeling used relative response factors (RRFs) for each species to determine if each species increased or decreased in every grid cell in the NAA. The final concentration is subtracted from the base year, which in this case is 2019. The difference plots show the difference in PM2.5 from 2019 to 2024. The analysis starts with the 2019 base year and the design values in Table 7.8.14-1 and then the effects of emissions from future controls change the RRF from a starting value of 1.0.

The details of the RRF calculations are found in the Serious SIP Modeling section, III.D.7.8.11, *2019 Control Run Modeling*.

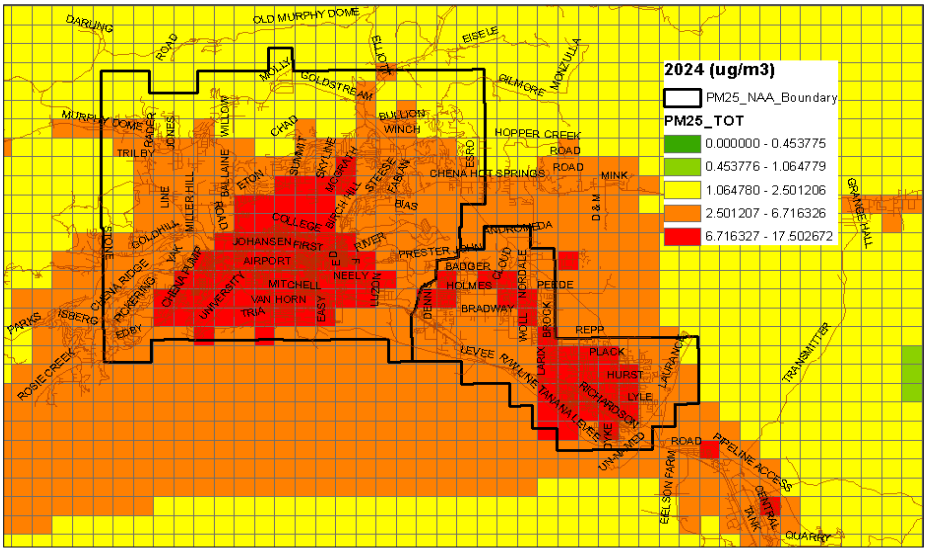


Figure 7.8.14.2-1 Non-attainment area grid cell plot for the modeling year 2024 24-hr average PM 2.5 (µg/m^3) for all episode days

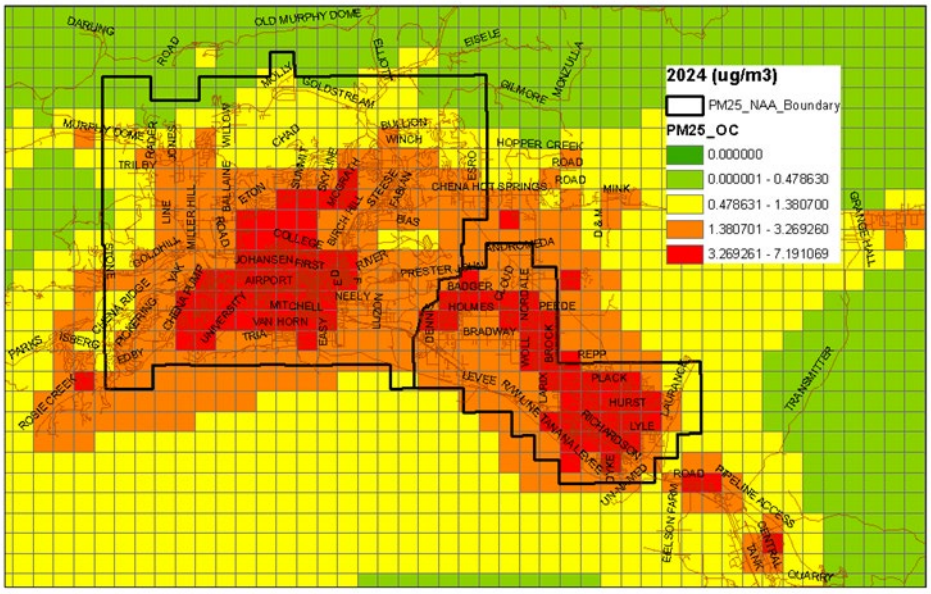


Figure 7.8.14.2-2 Non-attainment area grid cell plot for the modeling year 2024 24-hr average Organic Carbon (µg/m^3) for all episode days

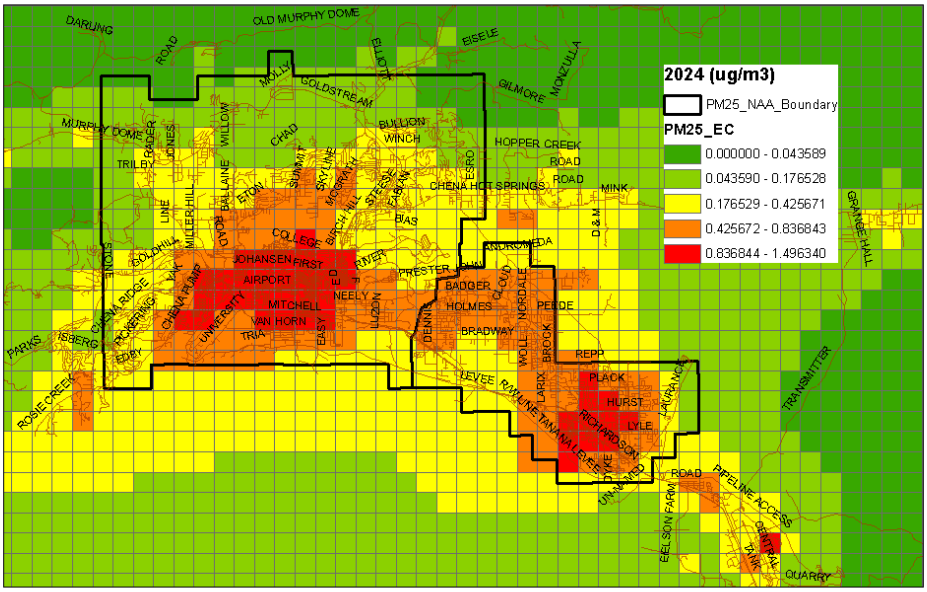


Figure 7.8.14.2-3 Non-attainment area grid cell plot for the modeling year 2024 24-hr average Elemental Carbon (µg/m^3) for all episode days

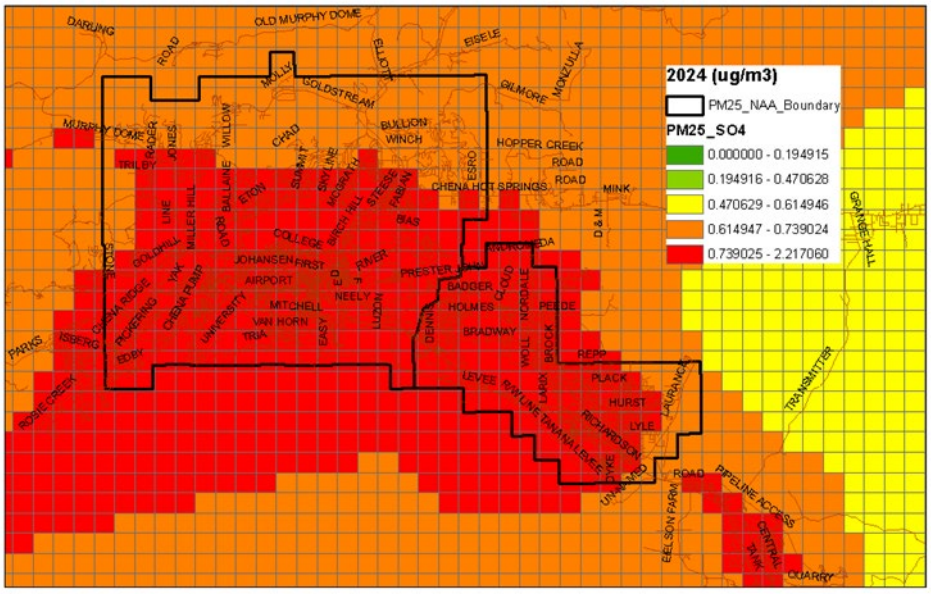


Figure 7.8.14.2-4 Non-attainment area grid cell plot for the modeling year 2024 24-hr average sulfate (µg/m^3) for all episode days

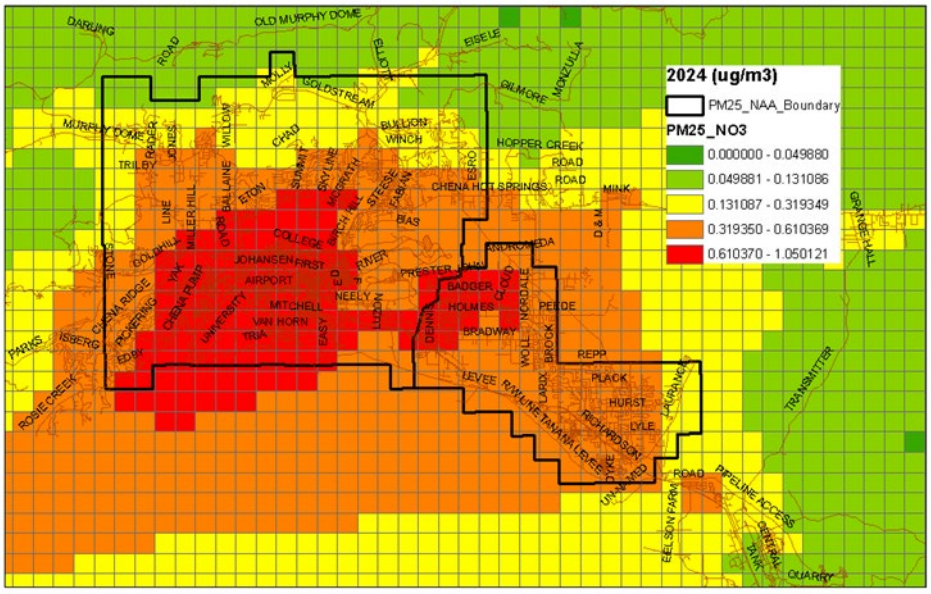


Figure 7.8.14.2-5 Non-attainment area grid cell plot for the modeling year 2024 24-hr average nitrate (µg/m^3) for all episode days

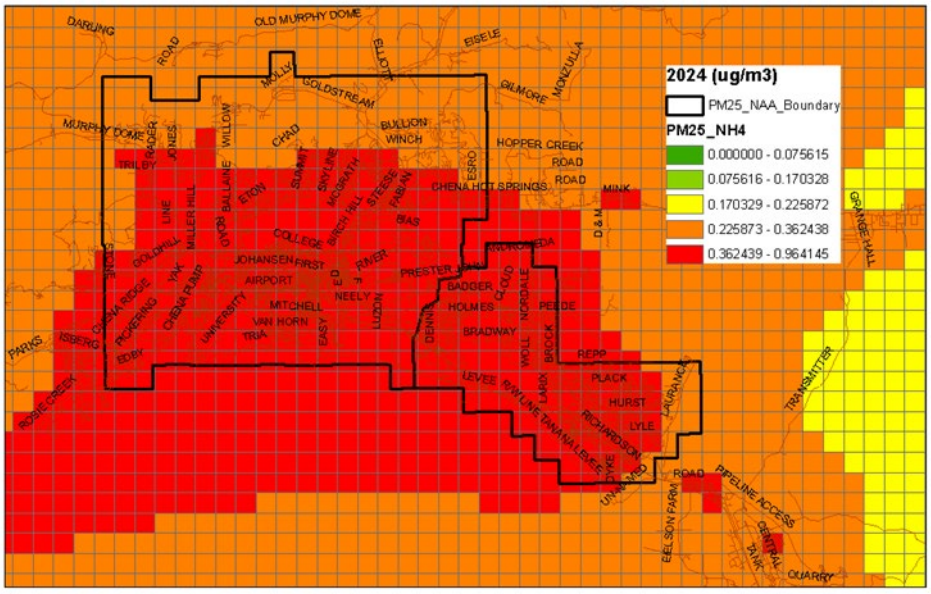


Figure 7.8.14.2-6 Non-attainment area grid cell plot for the modeling year 2024 24-hr average ammonium (µg/m^3) for all episode days

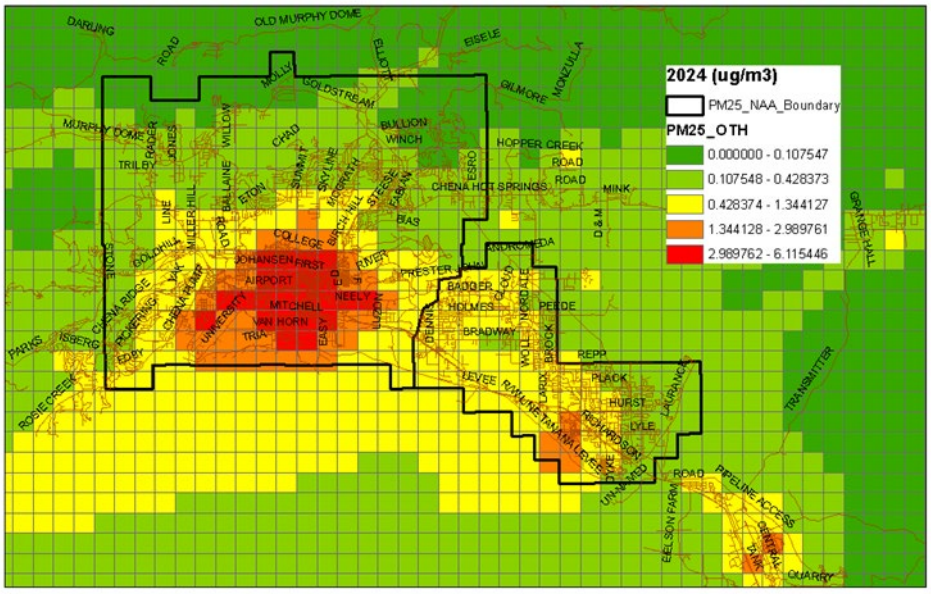


Figure 7.8.14.2-7 Non-attainment area grid cell plot for the modeling year 2024 24-hr average other (µg/m^3) for all episode days

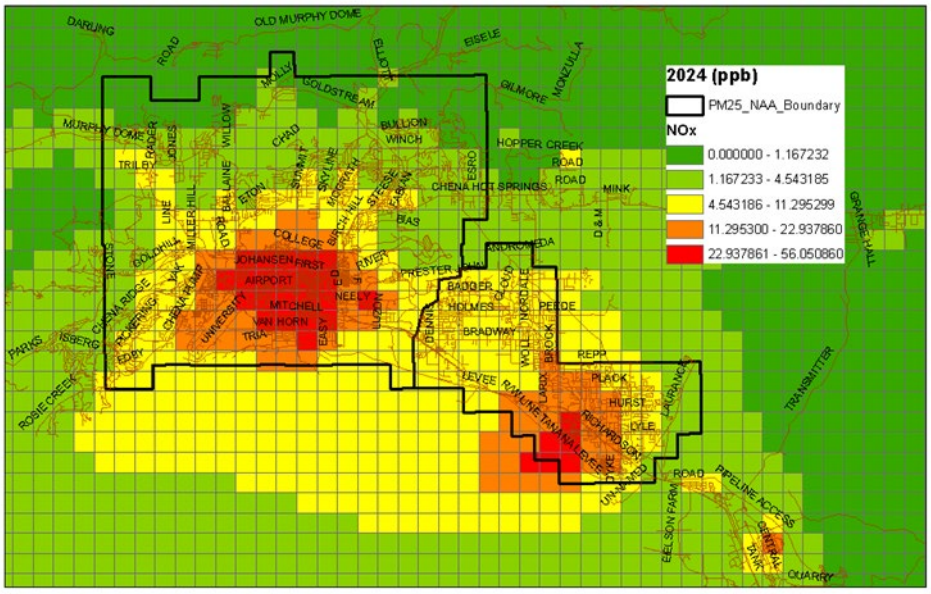


Figure 7.8.14.2-8 Non-attainment area grid cell plot for the modeling year 2024 24-hr average NOx (µg/m3) for all episode days

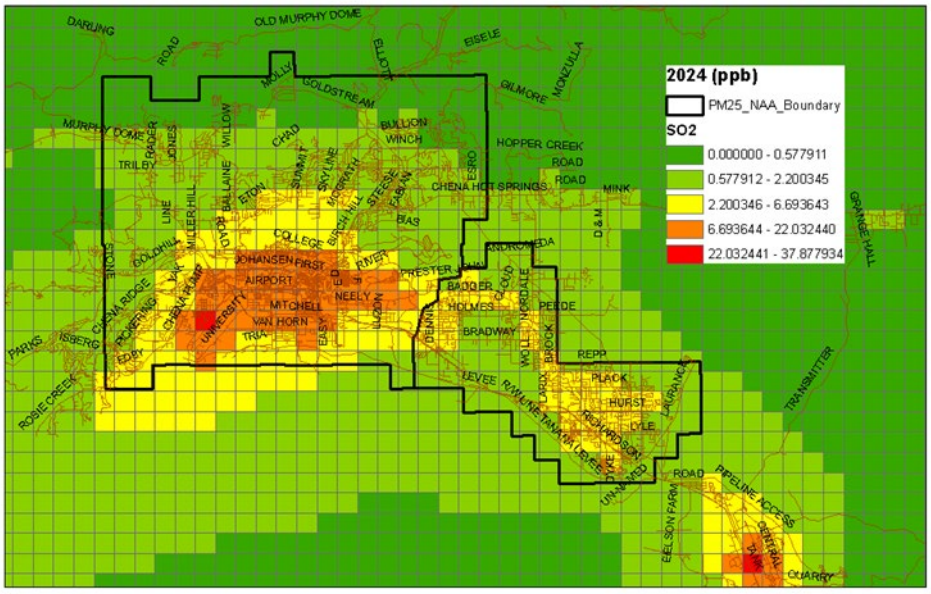


Figure 7.8.14.2-9 Non-attainment area grid cell plot for the modeling year 2024 24-hr average SO2 (µg/m^3) for all episode days

The 2024 species plots are consistent with what is expected in the non-attainment area. For the SO2, the two highest grid cells are the Fairbanks and Eielson airport. The organic carbon is the largest species concentration compared to the total PM 2.5. The sulfate is higher in Fairbanks where there is more fuel oil burned compared to North Pole. The total PM 2.5 is highest where expected, but absolute concentrations are low. These are raw model outputs and have not gone through SMAT. The SMAT concentrations used to calculate a Future Design Value are in section 7.8.14.5.

7.8.14.3 Precursor Demonstration Update – 2020 Amendment SIP

This updated precursor demonstration is based on the 2019 emissions inventory developed for the Serious Area SIP and builds upon the precursor analysis conducted under that plan to meet the requirements under 40 CFR 51.1006. Please see the 2019 Precursor demonstration in the Serious SIP chapter 7.8.12.4 Precursor Demonstration updates for 2019 for NOx and VOCs. The following precursor demonstration update is for the NOx comprehensive 50% off model run and the 2019 final emissions inventory changes. The additional information added to that emissions inventory since the Serious Area SIP is the actual 2019-point source emissions, aircraft and updates to motor vehicle emissions. These updates resulted in a small change in the inventory and less overall PM2.5, from 3.67 tons per day in the Serious Area SIP to 3.17 tons per day in the 2020 amendment. Since the result is a small decrease, the 100% and 75% off precursor runs from the Serious Area SIP were not updated. In the clarifying document associated with the

Serious Area SIP, a 50% knock-out quantitative analysis was completed for NO_x emissions from anthropogenic sources to demonstrate that NO_x emissions were insignificant in the nonattainment area. For the 2020 amendment, an actual precursor model run was performed for this NOx comprehensive precursor demonstration, to further support the weight of evidence presented in the Serious Area SIP.

Table 7.8.14.3-1 Episodic emissions for all precursors and PM 2.5 in tons per day for the year 2019 for the Serious SIP

	Modeling Domain Episodic Emissions (tons/day)				
Source Sector	PM2.5	NOx	SO2	VOC	NH3
Point	0.59	10.36	5.87	0.03	0.073
Area, Space Heat, All	2.21	2.61	4.16	9.55	0.145
Area, Space Heat, Wood	2.05	0.45	0.17	9.31	0.096
Area, Space Heat, Oil	0.07	1.94	3.87	0.11	0.004
Area, Space Heat, Coal	0.08	0.06	0.10	0.12	0.016
Area, Space Heat, Other	0.01	0.17	0.02	0.01	0.029
Area, Other	0.24	0.38	0.03	2.25	0.050
On-Road Mobile	0.27	2.30	0.01	4.90	0.055
Non-Road Mobile	0.36	1.75	7.78	5.26	0.003
TOTALS	3.67	17.40	17.85	22.00	0.325

Table 7.8.14.3-2 Episodic emissions for the Fairbanks non-attainment area for the year 2019 for precursors and PM 2.5 for the 2020 amendment

	NA Area Episodic Emissions (tons/day)				
Source Sector	PM2.5	NOx	SO2	VOC	NH3
Point	0.57	10.31	5.68	0.03	0.073
Area, Space Heat, All	1.91	2.43	3.88	8.60	0.132
Area, Space Heat, Wood	1.77	0.39	0.16	8.38	0.086
Area, Space Heat, Oil	0.06	1.82	3.62	0.10	0.004
Area, Space Heat, Coal	0.07	0.05	0.09	0.11	0.014
Area, Space Heat, Other	0.01	0.17	0.02	0.01	0.029
Area, Other	0.22	0.36	0.03	2.10	0.046
On-Road Mobile	0.22	1.70	0.01	3.83	0.040
Non-Road Mobile	0.26	0.94	5.41	4.16	0.002
TOTALS	3.17	15.73	15.01	18.72	0.293

The results of the 50% off NO_x precursor modeling run are plotted in Figure 7.8.14.3-1 through 3.

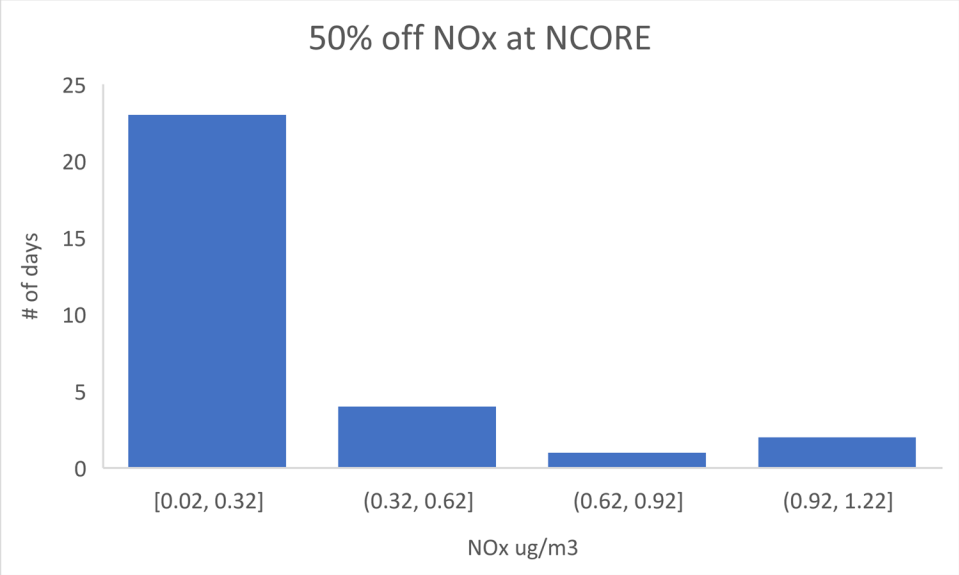


Figure 7.8.14.3-1 Precursor 50% off model run results for 2019 all days at NCORE and SOB monitor grid cell for NOx comprehensive

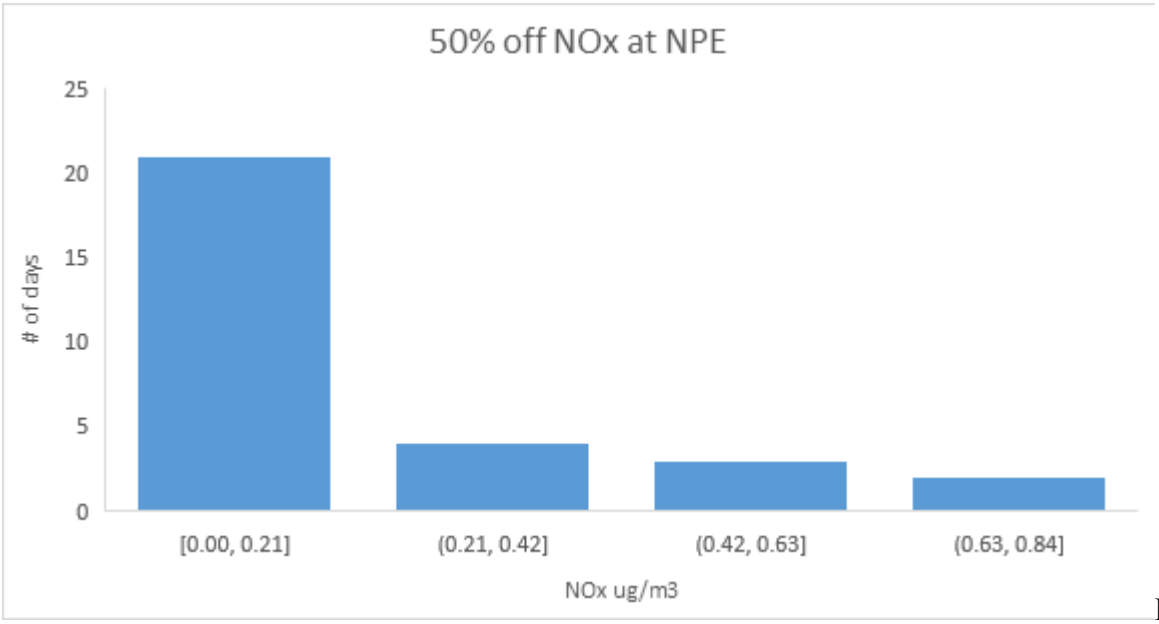


Figure 7.8.14.3-2 Precursor 50% off model run results for 2019 all days at the NPE monitor grid cell for NOx comprehensive

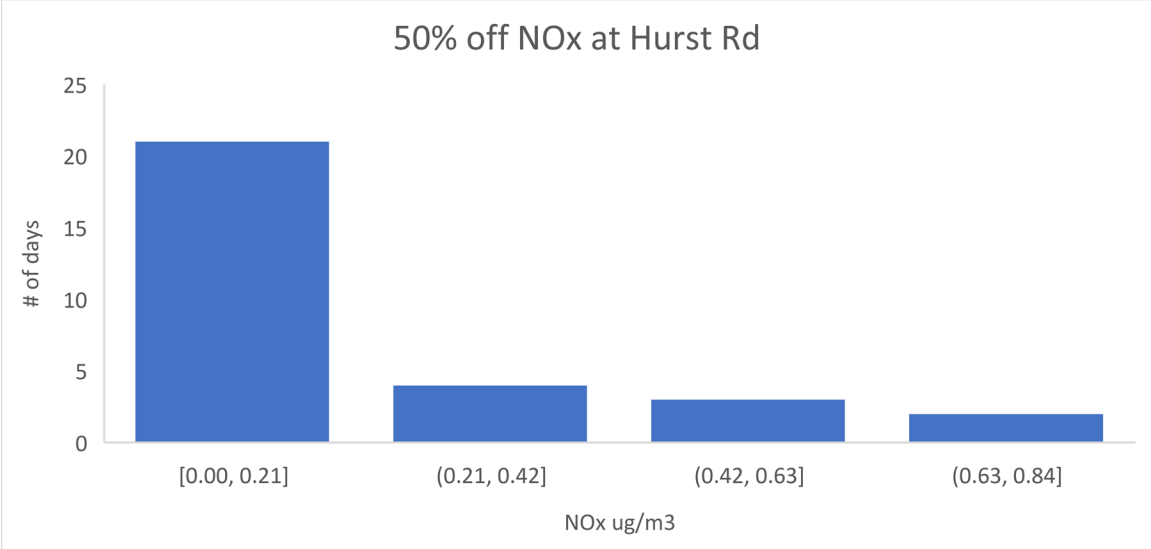


Figure 7.8.14.3-3 Precursor 50% off model run results for 2019 all days at the Hurst monitor grid cell for NOx comprehensive

The plots represent the difference in the 2019 base year to the 50% off emissions inventory precursor model run. All days at all monitors and all anthropogenic sources (NOx comprehensive) are below the threshold of 1.5 $\mu g/m^3$ for NOx comprehensive at 50%. The closest day or largest difference is 1.2 $\mu g/m^3$ at the NCORE monitor on November 8, 2008 model run day for the meteorology. The NCORE and SOB monitors are in the same grid cell, and these are raw model output results. Since SOB and NCORE have the same grid cell value, only NCORE is shown.

7.8.14.4 Modeling Future Design Value

The modeling future design values as stated above are calculated by multiplying the relative response factors (RRFs) by the concentration in the monitored grid cell in a process called SMAT (speciated modeled attainment test). The SMAT process uses the design values in Table 7.8.14-1 and the SMAT calculations that can be found in the Serious SIP modeling section III.D.7.8.9.4 *SMAT Methods*. The species concentration percentage of the PM2.5 used in the calculations are below for each monitor grid cell. Note that new speciation data was not available for the 2020 amendment, and the 5 years of speciation data used in the SMAT calculations are 2011 to 2015. The NCORE speciation data was analyzed for 2016 to 2018 and the difference between the new data and the 2011-2015 data was minimal (Figure 7.8.13.3-3). NCORE is the only monitor that had speciation data collected during the updated design value years of 2016 to 2019 with enough data to perform SMAT, Hurst Rd speciation began in the fall of 2019. For consistency, all SMAT calculations were completed using 2011 to 2015 speciation data, but the analyzation of 2016-2018 is included. The 2016 to 2018 data is similar to 2011 to 2015, there was identified issue with using 2011 to 2015 for all monitors. Note for the updated design value of 2016 to 2019 the NPE monitor is no longer included, because it has not operated since 2009. The A street monitor will be added to future modeling analyses once there is sufficient speciation data collected and analyzed from the site.

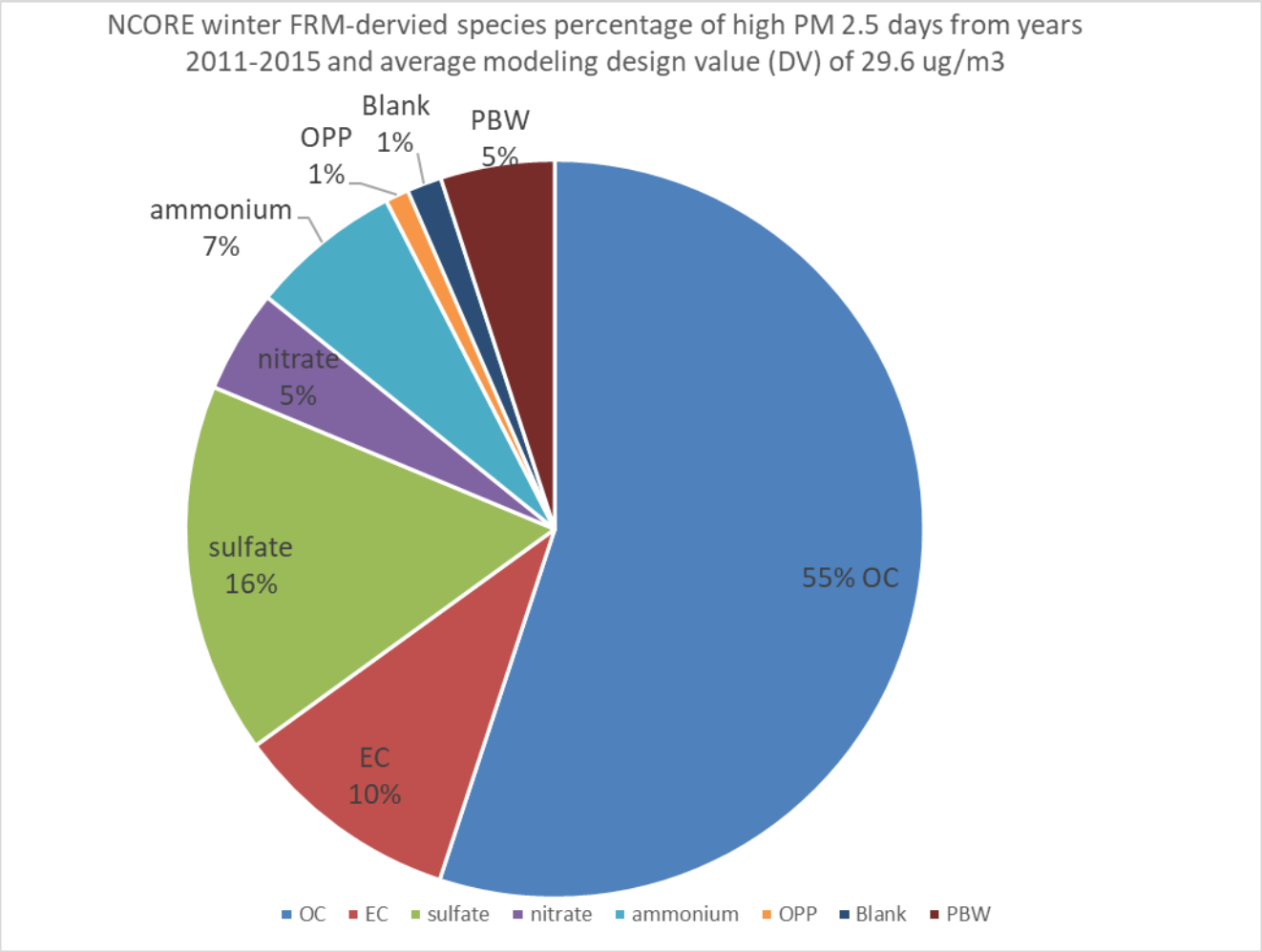


Figure 7.8.14.4-1 NCORE winter FRM – derived species percentage of high PM2.5 days from years 2011 to 2015 and average modeling design value (DV) of 29.6 µg/m^3.

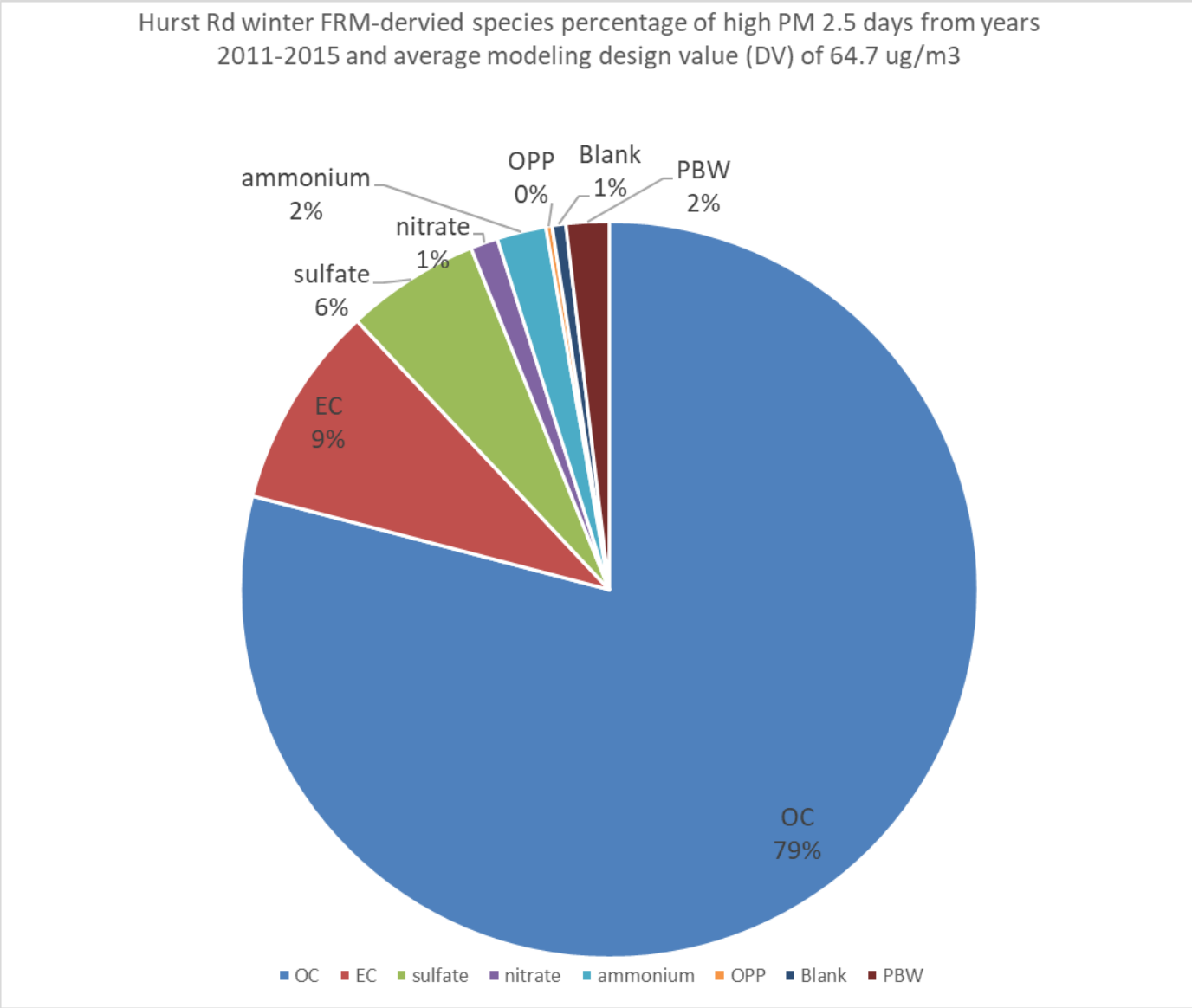


Figure 7.8.14.4-2 Hurst Rd. winter FRM – derived species percentage of high PM2.5 days from years 2011 to 2015 and average modeling design value (DV) of 64.7 µg/m^3.

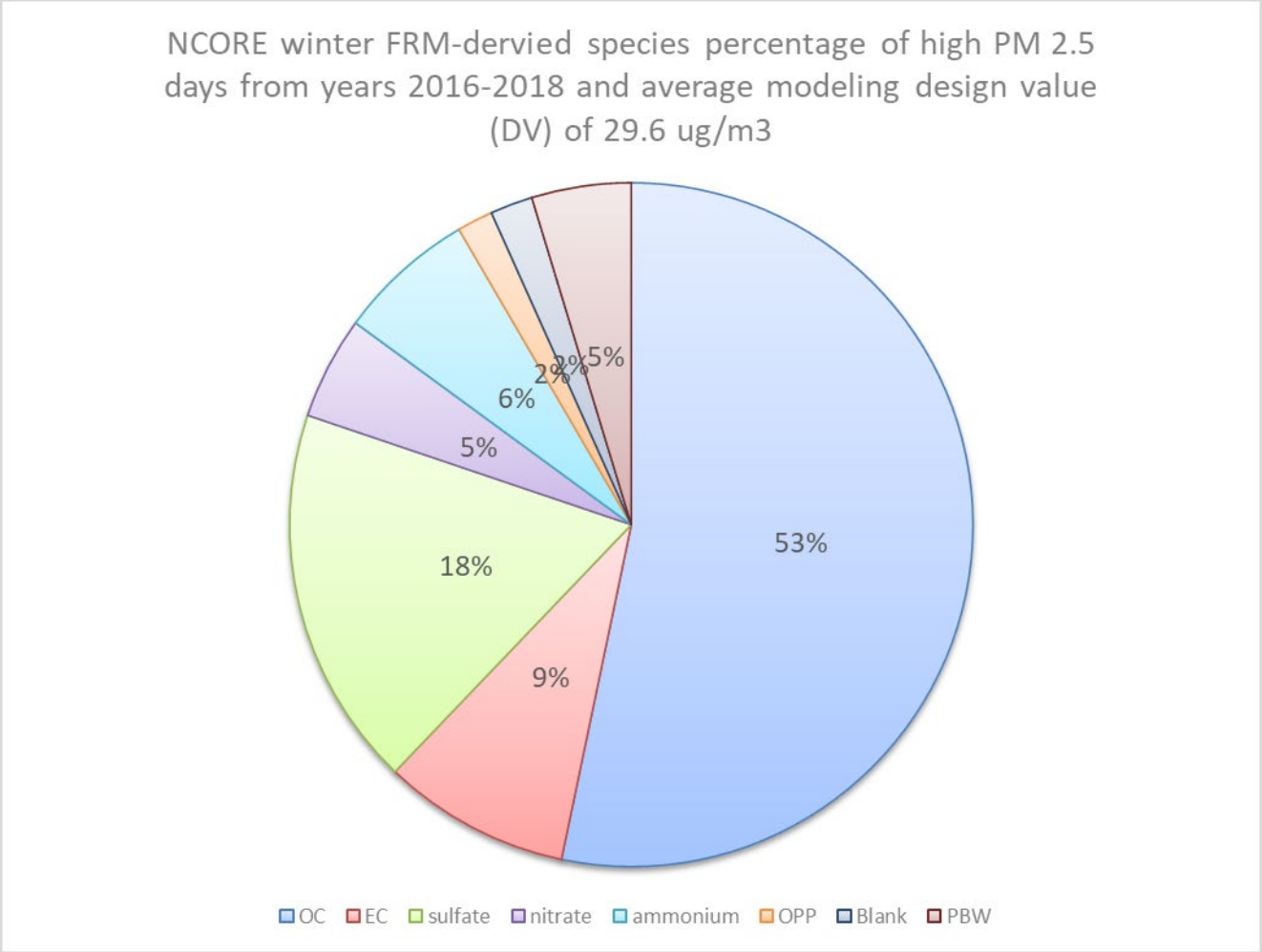


Figure 7.8.14.4-3 NCORE winter FRM – derived species percentage of high PM2.5 days from years 2016 to 2018 and average modeling design value (DV) of 29.6 µg/m^3.

Table 7.8.14.4-1 Summary of Future Design Values (FDV) and species RRF at the Hurst Rd. monitor for base year modeling 2019, attainment year 2024, and sensitivity analysis for future and prior year 2026 and 2023

	OC	EC	SO4	NO3	NH4	OTH	FDV
2019	1.00	1.00	1.00	1.00	1.00	1.00	64.7
2023	0.52	0.67	0.82	0.93	0.86	0.97	37.0
2024	0.42	0.46	0.81	0.88	0.83	0.96	30.9
2026	0.34	0.37	0.81	0.90	0.84	0.98	26.7

Note: 2026 was completed with a preliminary emissions inventory

Table 7.8.14.4-2 Summary of the Future Design Values (FDV) and species RRF at the NCORE monitor for base year modeling 2019, attainment year 2024 and sensitivity analysis for future and prior years 2026 and 2023.

NCORE							
	OC	EC	SO4	NO3	NH4	OTH	FDV
2019	1.00	1.00	1.00	1.00	1.00	1.00	29.60
2023	0.61	0.91	1.00	0.96	0.92	1.13	23.2
2024	0.52	0.59	0.92	0.94	0.92	1.15	21.0
2026	0.42	0.51	0.88	0.92	0.89	1.15	19.3

Note: 2026 was completed with a preliminary emission inventory

The current modeling FDV shows attainment at the Hurst Road monitor in 2024. The largest reductions in species is the Organic Carbon (OC) at 0.45 RRF compared to 1. Initially DEC conducted a model run for the future year 2026 and attainment was shown so far below the 35 µg/m3 threshold, that a 2024 emissions inventory was completed for another updated modeling run to determine the modeled attainment year. The detailed discussion on the modeled attainment of the monitor Hurst Road grid cell and its meaning on the attainment of the Fairbanks and North Pole nonattainment area are discussed in the attainment section III.D.7.9. The model run for future year 2023 was included as a sensitivity run to show that the expeditious attainment year is 2024. The modeling run for 2023 clearly shows the area would not reach attainment at 37.0 µg/m3 . Additional analysis on the changes in the emission inventory were calculated to estimate the most expeditious year for attainment possible.

Table 7.8.14.4-3 Summary of Hurst Rd 2023 FDV estimated by emission reductions to all sources and home heating sector only.

Inventory-Interpolated Estimation of 2023 DV at Hurst Road Monitor				
	CMAQ-Based DVs		% Red'n (2019-2024)	
	2019	2024	No Bkgnd	With Bkgd
Hurst Road DV (µg/m^3):	64.7	30.9	52.2%	49.6%
% of DV from Bkgnd & Outside NA Area:	5%			
	NA Area Emissions (tpd)			2023 % of

	2019	2023	2024	2024 Redn
Direct PM Emissions (all sources):	3.370	2.147	1.993	
PM Emission Reductions (relative to 2019):	n/a	36.3%	40.8%	88.8%
Direct PM Emissions (space heating):	2.106	1.086	0.740	
PM Emission Reductions (relative to 2019):	n/a	48.4%	64.9%	74.7%
	No Bkgnd	With Bkgd		
Linearly-Interpolated 2023 DV (µg/m3):	37.7	39.0		
EI-Interpolated 2023 DV (µg/m3), All Sources:	34.7	36.2		
EI-Interpolated 2023 DV (µg/m^3), Space Heating Sources:	39.5	40.7		

The additional analysis of the estimated FDV based on emission inventory and an assumed background is at 36.2 µg/m3 to 40.7 µg/m3 depending on the interpolation (Table 7.14.4.-3). The 39.5 µg/m3 concentration is only the heating source category changed and the 40.7 µg/m^3 is the 5% background added in that contains what other sources are estimated to affect that grid cell. The 40.7 µg/m3 is a variable number that changes with the assumed background percentage in Table 7.8.14.4-8. The attainment demonstration in section 7.9 has more details on this table the emission inventory changes.

The 2023 model run most closely represents a linear change in the emission inventory for all sources and including a background estimate of 5%. This is logical since most of the changes in the emissions inventory are for organic carbon and primarily emitted. The attainment demonstration section 7.9 has the details of 2024 being the most expeditious year for attainment. Future modeling efforts will include the A street monitor design value as a max impact site. The modeling will be completed with an updated modeling platform (meteorology, emissions and CMAQ version) and details can be found in the modeling protocol the modeling appendix.

ALASKA DEPARTMENT OF ENVIRONMENTAL CONSERVATION

Amendments to:

State Air Quality Control Plan

Vol. II: III.D.7.8

Modeling

Public Notice Draft

August 19, 2024

Michael J. Dunleavy, Governor

Emma Pokon, Commissioner

Note: This document provides the 2024 Revised/Amended language proposed for inclusion in this section of the State Air Quality Control Plan to address the disapproval of the Serious SIP and the 2020 Amendments. The 2024 Amendment language is in bold and underlined format and starts from Section III.D.7.8.15 from page 83. The Serious SIP requirements from Sections III.D.7.8.1 through III.D.7.8.13.1 and 2020 Amendments requirements from Sections III.D.7.8.14 through III.D.7.8.14.4 from page 1 to 82 are included in the 2024 Amendments to provide historical background on the approved NOx and VOC precursor demonstration.

7.8.15 Modeling

7.8.15.1 Overview

The current modeling platform that the Alaska Department of Environmental Conservation (ADEC) submitted on December 13, 2019, for the Serious Area State Implementation Plan (SIP) and 2020 Amendment is outdated. First, the Community Multiscale Air Quality model (CMAQ) used an older version of the model. Second, all the preprocessing models (WRF, SMOKE and MCIP – described below) that are required to format the emissions and meteorology that are used to drive the model are also older versions. The December 13, 2019, submissions were based on 2008 winter conditions and may no longer be representative of Fairbanks winter conditions. Third, the highest violating monitor for the Fairbanks nonattainment area is at Hurst Road in North Pole. There was no speciation monitoring data available for the North Pole and there was no model performance analysis performed. The North Pole area remains the focus for control analysis, model attainment, and poor sulfate model performance. The past controls have centered on woodstoves and mainly organic carbon reduction. The United States Environmental Protection Agency (EPA) has outlined these technical deficiencies in its July 19, 2019, and October 29th, 2020, and January 2023 Federal Register Notice comments on the Fairbanks $PM_{2.5}$ State Implementation Plan (SIP). The deficiencies included that the CMAQ model does not represent secondary sulfate, and no model performance evaluation was submitted for the SO_2 analysis.

Since 2019, over the last few years, a technical report was written addressing phase 1 and 2 of the modeling platform upgrade. The bullets points listed below are for the work completed in the technical modeling report up to 2/10/23.[38] The online technical report summarizes those deficiencies, outlines the major components of a future SIP amendment (now in the Modeling Chapter below), and the weight of evidence work, current at the time, by the ALPACA (Alaska Layered Pollution and Chemical Analysis) campaign supporting wintertime sulfate chemistry at high latitudes and sulfate model performance.

The technical modeling report contains (phase 1 and 2):

- **New versions available at the time for the meteorological model (WRF), the air quality model (CMAQ) and the pre-processor models (SMOKE, MOVES, MCIP)**
- **New model results for the final configuration selected for CMAQ**
- **New speciation data in North Pole for year 2019-2021**
- **New Model Performance Evaluation**
- **New 5-year design value and Speciated Model Attainment Test (SMAT) calculations needed for a future complete SIP amendment and precursor analysis.**
- **Updated Weight of Evidence addressing secondary sulfate chemistry in the model and local studies addressing wintertime pollution in the Fairbanks area**

[38] https://dec.alaska.gov/air/anpms/communities/fbks-pm2-5-sip-development/

The technical modeling report focused on the modeling platform upgrade of moving from CMAQ 4.7.1 to CMAQ 5.3.2, the modeling chapter below focuses on the regulatory modeling. Included in the regulatory modeling is new meteorology, new emissions, CMAQ version 5.33 configured in collaboration with EPA-Office of Research and Development (ORD) as part of ALPACA RARE (Regional Applied Research Effort) project and updated base year and attainment year modeling. The regulatory modeling was outlined in the technical modeling report as phase 3, it is completed below and is the focus of this Modeling Chapter.

The Modeling Chapter below contains (phase 3):

- **CMAQ version 5.3.3 with heterogenous chemistry update (CMAQv533hetchem), rationale for model selection and set up.[39,40]**
- **Updated Initial and Boundary conditions from EQUATES[41] model data.**
- **Final WRF (Weather Research and Forecast) meteorological version and MCIP5 (pre-processor model for CMAQ meteorology) for wintertime 2019-2020 episode.**
- **Final Mode Performance Evaluation using the base year 2020 emissions and the meteorological 2019-2020 episode.**
- **Base year 2020 gridded emissions spatial plots and the updated emissions processing system SMOKE 4.81 (Sparse Matrix Operator Kernel Emissions) configuration (detailed emissions write ups are in the Emission Inventory Chapter (Section III.D.7.6).**
- **Attainment year modeling for the year 2027 showing the Hurst Road grid cell is at 31.9 µg/m3 , below the 24 hr- $PM_{2.5}$ standard of 35 µg/m^3.**
    - **Gridded spatial plots for $PM_{2.5}$, sulfate (SO4), nitrate (NO3),organic carbon (OC), elemental carbon (EC), ammonium (NH4), PM other (Silica, Calcium, Iron and Titanium).**
- **Expeditious Attainment modeling results showing 38.1 µg/m^3 at Hurst Road, showing attainment in 2026 is not possible.**
- **SO_2 major stationary source precursor demonstration at 100% zero-out run showing a contribution of 0.21 µg/m^3 to the $PM_{2.5}$ design value and additional max cell max day at the monitors and the entire nonattainment area, as well as zero-out sensitivity runs for space heating that show a majority of the sulfate (5 µg/m^3) is from space heating.**
- **Reference to existing NO_X and VOC comprehensive precursor demonstrations that were already approved using the 2013 and 2019 emissions in the Emission Inventory Chapter (Section III.7.6) and CMAQ version 4.7.1 with Alaskan code changes for photolysis.**
- **Final post SMAT 5-year $PM_{2.5}$ design value concentrations for years 2017-2021, showing attainment at Hurst Road in 2027 and all grid cells in the nonattainment area.**

[39] https://cfpub.epa.gov/si/si_public_record_report.cfm?Lab=CEMM&dirEntryId=359147&submit=Search
[40] Fahey, K.M., Gilliam, R.C., Pouliot, G., Huff, D., Murphy, B.N., Holder, A., Martin, J., Farrell, S., Pye, H.O.T., Sarwar, G., Briggs, N. Predicting PM2.5 in and around Fairbanks with the Community Multiscale Air Quality modeling system during the ALPACA winter air quality study. In preparation, 2024.
[41] https://www.epa.gov/cmaq/equates

- **Weight of Evidence containing the list of Alaska Layered Pollution and Chemical Analysis campaign in Fairbanks, Alaska in winter of 2022 (ALPACA) published papers on wintertime chemistry.**

7.8.15.2 Rationale for Model Selections

The current model selection is the CMAQ version 5.3.3 Alaska submitted code that EPA ORD has completed for the ALPACA RARE project.[42] The model used according to the $PM_{2.5}$ guidance and Section 3.2.2 states that no photochemical grid model is preferred for $PM_{2.5}$, the best model fit for the application is allowed. DEC is following the $PM_{2.5}$ guidance[43] with our selections. The final configuration name for the model is CMAQv533hetchem.

The CMAQ model version 4.7.1 – adapted for Fairbanks has been used since the Moderate Area SIP with a meteorological episode spanning two-week episodes. The CMAQ model was configured with the default modules. The module selection followed the default options for CMAQ-4.7.1 with the exceptions of vertical diffusivity and photolysis modules. This model version was approved for the NOx and VOC precursor analysis. These modules were chosen based on a review of the CMAQ-model conducted by Mölders and Leelasakultum[44] at UAF. The model performance was only completed for the Fairbanks State Office Building (SOB) monitor. This model selection was the most up to date for the 2009 nonattainment area[45], but not when North Pole was selected with higher concentrations as the violating monitor for $PM_{2.5}$.

There are five factors identified in the 2018 $PM_{2.5}$ guidance (mirrors Appendix W) to determine whether another model will qualify for a specific application, including:[46]

1. **Documentation and past track record of candidate models in similar applications.**
2. **Advanced science and technical features (e.g., probing tools) available in the model and/or modeling system.**
3. **Experience of staff and available contractors.**
4. **Required time and resources versus available time and resources; and**
5. **In the case of regional applications, consistency with regional models applied in adjacent regions.**

The five factors were addressed in the Moderate Area SIP and state that the CMAQ is well documented, and peer reviewed. The current amendment is using the default CMAQ model version 5.3.3, with the exception to the default code in the ALPACA RARE grant version with added sulfate heterogenous chemistry. The addition multiphase sulfate chemistry code was provided to ADEC by the EPA Office of Research and Development

[42] https://cfpub.epa.gov/si/si_public_record_report.cfm?Lab=CEMM&dirEntryId=359147&submit=Search
[43] https://www.epa.gov/sites/default/files/2020-10/documents/final-03-pm-rh-guidance.pdf
[44] https://dec.alaska.gov/air/anpms/communities/fbks-pm2-5-science/
[45] https://dec.alaska.gov/air/anpms/communities/fbks-pm2-5-moderate-sip/
[46] https://www.epa.gov/sites/default/files/2018-04/documents/sils_guidance_2018.pdf

(ORD), and the manuscript in is in the process of being submitted[47]. The final steps in study are to incorporate the new multiphase sulfur chemistry into a future CMAQ release[48].

The details of the transition from CMAQ 4.7.1 to CMAQv533hetchem are detailed in the technical modeling report that is on the ADEC website[49] and has been reviewed by the EPA Region 10. In summary, the old emissions inventory and meteorology from 2008 were first run through standard version CMAQ version 5.3.2 to see if there was any improvement from CMAQ version 4.7.1. The model performance improved for organic carbon. The next steps were making sure the two different Linux machines were compiled the same with no difference to have models running at the same time in ADEC and at the consultants. Other sensitivity tests were run using wood smoke dominated areas profiles that resulted in only a small change. Then the ALPACA version with sulfate chemistry code was started and initial results were compared. The sulfate performance was improved, and all the future modeling used the CMAQ version 5.3.3 with updated sulfate chemistry. The details of these model runs are contained in this chapter.

The regulatory version of the modeling phase 3 in the technical modeling report [50] for the base year and the future years are contained in the Modeling Chapter below.

7.8.15.3 CMAQ and WRF Model Setup

7.8.15.3.1 WRF Setup

The final WRF set up included a new winter episode (Figure 7.8.15-1) that was 74 days long and satisfied all the EPA $PM_{2.5}$ guidance in EPA's 2018 Memorandum titled Modeling Guidance for Demonstrating Air Quality Goals for Ozone, $PM_{2.5}$ and Regional Haze, which is summarized in the listed bullets 1 to 4. [51]

1. **Days with 24-hour concentrations near the 2019-2021 current design value (i.e., 67 µg/m^3 at Hurst Rd).**
2. **Sufficient days with total $PM_{2.5}$ and $PM_{2.5}$ speciation measurements at regulatory monitors to facilitate model performance evaluation.**
3. **Meteorological conditions representative of inversion conditions typically associated with high pollution episodes.**
4. **Time periods of elevated concentrations and sufficient days before and after these time periods to show the transitions from low --> high --> low pollutant concentrations**.

[47] Fahey, K.M., Gilliam, R.C., Pouliot, G., Huff, D., Murphy, B.N., Holder, A., Martin, J., Farrell, S., Pye, H.O.T., Sarwar, G., Briggs, N. Predicting PM2.5 in and around Fairbanks with the Community Multiscale Air Quality modeling system during the ALPACA winter air quality study. In preparation, 2024.
[48] https://cfpub.epa.gov/si/si_public_record_report.cfm?Lab=CEMM&dirEntryId=359147&submit=Search
[49] https://dec.alaska.gov/air/anpms/communities/fbks-pm2-5-sip-development/
[50] https://dec.alaska.gov/air/anpms/communities/fbks-pm2-5-sip-development/

[51] https://www.epa.gov/sites/default/files/2018-04/documents/sils_guidance_2018.pdf

Past meteorological studies on long term weather patterns in the Crawford (2019) study show severe inversion conditions in recent years have included temperatures decreasing to approximately -25 to -35 degrees C. Using the median temperatures (-8 to -12 degrees C) presented in the Crawford (2019) study as pollution episode guides for temperatures during non-severe pollution episodes was also suggested as a relevant criterion for the Fairbanks wintertime episode.

The episode selection is from 12/1/2019 to 2/12/2020 (Figure 7.8.15-1). There are 10 days greater than 50 µg/m^3 (all the highest $PM_{2.5}$ days at Hurst Road) and this satisfies the criteria of having design value episode days at 67 µg/m^3. The wintertime episode includes all days at 40 below for the winter 2019/2020 and strong inversions. There are a few missing FRM days at 40 below, but the one long episode will ensure that there are plenty of FRM days for model performance. The quantity and quality of the sonic anemometer data at Hurst Road during this time is being evaluated by ADEC. There are missing data, but with a long episode ADEC will capture enough additional met data. The NCore sonic anemometer is available at 10 and 3 meters for the Fairbanks area to help with the model performance. The Hurst Road sonic anemometers are at 3, 10 and 23 meters. The sonic anemometers track wind speed, and wind direction. There are separate temperatures probes at 3, 10, and 23 meters.

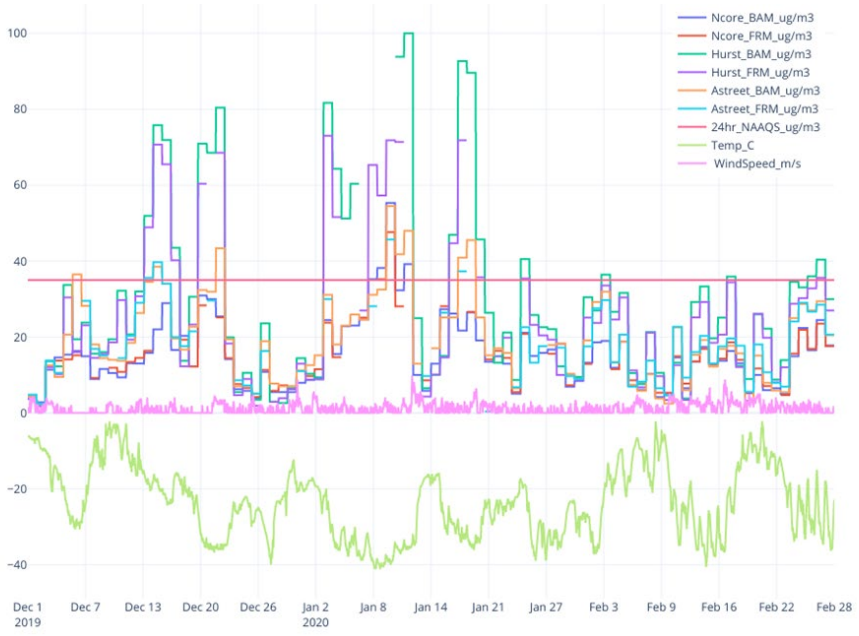


Figure 7.8.15-1 WRF Episode for Fairbanks Winter 2019-2020, 74 days from December 1st to 2019, to February 12th, 2020

The ALPACA study for new meteorology for the 2022 field campaign led to many sensitivity tests completed by PA-ORD using WRF version 4.3. The updates are detailed

below and the final configuration for 2022 ALPACA meteorology was employed for the ADEC winter met episode and run through the latest current version of MCIP 5 (pre-processor for meteorology for CMAQ) for the use of the regulatory modeling in this chapter for all model runs, the base year, attainment year (2027), expeditious attainment (2026), SO_2 point source precursor demonstration run, and sensitivity runs for space heating contribution to sulfate.

Table 7.8.15-1 WRF 4.3 Final Configuration for the Meteorological Episode December 5th, 2019, to February 12th, 2020

Input/Scheme	Final WRF 4.3
BC and Data Assimilation	NCEP GFS boundaries GFS FDDA (4 km) Obs nudging (1.33km) (METAR, Mesonet and RAOB-PAFA)
Physics	RUC LSM MYNN TKE PBL Morrison Mp RRTMG SW/LW No subgrid Cp scheme
Levels	39 (concentrated at lower levels 2,5,9,17,32,52,82,132,207,311,433,555 meters)

Source[52]

The final configuration in Table 7.8.15-1 was used to run the ADEC winter episode and compare to the latest version and EPA final is in Figure 7.8.15-2. The red line, the EPA final in the bottom, outperformed the current WRF and moving forward, the US EPA final configuration was used in the detailed write up in the Modeling Chapter Appendix. (Rob Gilliam, Notes_20192020_ADEC_SIP_modeling.docx, December 2022)

[52] https://cfpub.epa.gov/si/si_public_record_report.cfm?dirEntryId=358955&Lab=CEMM

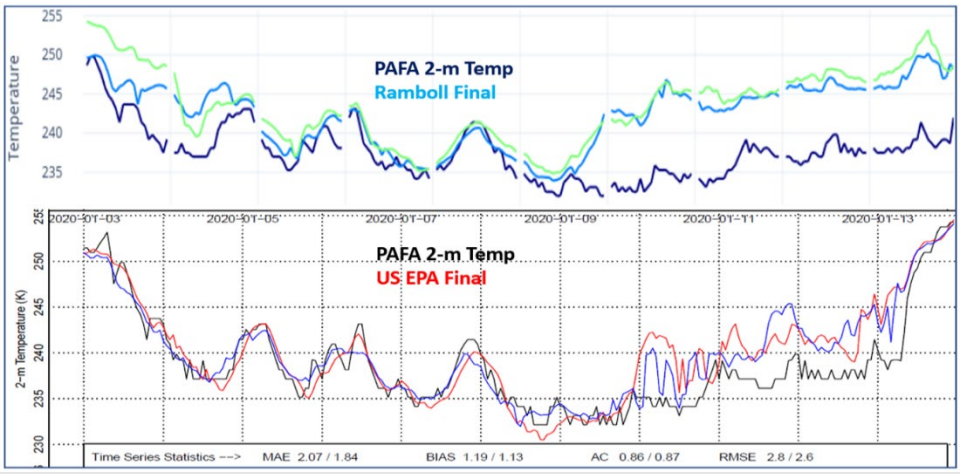


Figure 7.8.15-2. ADEC Winter Episode Latest Version Compared with the EPA Final Version

7.8.15.3.2 CMAQ Set Up

CMAQ version 5.3.3 (CMAQv533hetchem) was run in the default configuration with the runtime option for sulfur tracking method (STM) for additional tracking of sulfur species with the addition of heterogenous chemistry for sulfate. Each tracked species is treated as other modeled species, undergoing transport (advection, diffusion, cloud-mixing) and removal by deposition (both wet and dry). The grid cells resolution are 1.33km and 199x 199 km as the domain boundary, the same domain as all previous CMAQ SIP submissions in the Moderate[53] and Serious Area SIPs.[54] The chemical mechanism module is now the Aero 7, the standard chemistry model for CMAQ version 5.33, Carbon Bond 6 version r3 with aero7 treatment of the secondary organic aerosol (SOA) set up for standard cloud chemistry. The initial and background conditions were time and date shifted to December – February 2019 to 2020 from the EQUATES hemispheric model from 2016. The EQUATES hemispheric model provides seasonal monthly background conditions and daily initial conditions for the model. The daily average IC/BC conditions for sulfate are 0.4 ug/m^3, the concentrations were tagged using STM. The daily values for the 74-day episode for the IC/BC concentrations are in the appendix spreadsheet – Primary/Secondary SO_4. The summary of the final model configuration is in the last column of Table 7.8.15-2.

Table 7.8.15-2 All CMAQ Versions from the First Configuration in the Moderate and Serious Area SIP to the Final Configuration for the Updated CMAQ model

1 CMAQ 4.71 (Serious Area SIP)[a]	2 CMAQ 5.32	3 CMAQ 5.33 + "science" Base case	4 CMAQver533 hetchem

[53] https://dec.alaska.gov/air/anpms/communities/fbks-pm2-5-moderate-sip/
[54] https://dec.alaska.gov/air/anpms/communities/fbks-pm2-5-serious-sip/

			(current best configuration)[b.c.d]
1.33 km resolution, 199x199 cells, 38 vertical layers	1.33 km resolution, 199x199 cells, 38 vertical layers	1.33 km resolution, 199x199 cells, 38 vertical layers	1.33 km resolution, 199x199 cells, 38 vertical layers
monthlyaveraged Denali and Poker flat monitored data	Initial Boundary conditions are 2016 hemispheric seasonal averages	Initial Boundary conditions are 2016 hemispheric seasonal averages	Initial Boundary conditions are 2016 hemispheric seasonal averages
Aero 5	Aero 7	Aero 7, STM, ALPACA code sensitivity run all heterogenous chemistry Fe/Mn Solubility change	Aero 7, STM, ALPACA AK-submitted code all heterogenous chemistry Fe/Mn Solubility change
MCIP 3 processed from WRF 3.1	MCIP 5 processed from WRF 3.1 (grid modification and Biogenic option)	MCIP5 processed from WRF 4.2 Ramboll	MCIP5 processed from WRF 4.2 EPAORD
SMOKE 2.7	SMOKE 4.7	SMOKE 4.7	SMOKE 4.81
MPE Fairbanks	MPE Fairbanks and North Pole and A Street	MPE Fairbanks, North Pole and A Street	MPE Fairbanks, North Pole and A Street
2008 WRF 3.1 22 days Base year 2013 Modeling DV 2011-2015	2019/2020 WRF 4.1 74 days Base year 2020 Modeling DV of 2017-2021	2019/2020 WRF 74 days Base year 2020 Modeling DV of 2017-2021	2019/2020 WRF 74 days Base year 2020 Modeling DV of 2017-2021

•a Alaska Adaptad CMAQ Model[55]
•b Current DRAFT best model performance for RARE grant modeling effort for ALPACA, in process are reviewing and documenting, completion end of 2023
•c grid modification due to rounding error in MCIP not being able to handle the full grid sig figures, EPA and ADEC are now using same grid
•d Biogenic change in the emission control file suggested by Havala Pye[56] for use in woodsmoke areas, changes to partitioning approximately 1 µg/m^3

[55] https://dec.alaska.gov/air/anpms/communities/fbks-pm2-5-science/

[56] https://acp.copernicus.org/articles/16/4081/2016/acp-16-4081-2016.pdf

In Table 7.8.15-2 above, model versions 1-3 are discussed in detail in the Technical Model Report in the modeling appendix. The final configuration in column number 4 or v533hetchem is the model version used for all the regulatory modeling. There are 39 layers set by the WRF configuration in Table 7.8.15-2, a 1.33 km grid cell, and the domain are 199x199 km. The emissions used for the model performance are the final version of the base year 2020 emissions and the spatially gridded plots are in the next section.

The CMAQ version 5.33 has an emissions control file that is used to easily change the Primary Organic Aerosols (POA) partitioning factors and run sensitivity runs on certain pollutants without re-running SMOKE. ADEC utilized this feature of changing the emissions control file to run precursor model runs and sector sensitivity runs details below for sulfate are in the SO2 precursor section (7.8.15-9) and a biomass burning profile, in the final configuration. The biomass burning profile resulted in a slight increase in organic carbon mass, less than 1 µg/m^3. The final emissions control file (ECF) provided by EPA-ORD and updated with local pathways to the emissions with the heterogenous chemistry updated and the biomass profile. The emission control file changed the semi volatile organic carbon fractions to represent a biomass dominated emissions, such as Fairbanks and wood stove emissions.[57] The details of the difference with and without using biomass profile are detailed in the technical modeling report phase 2 and the ECF for each run is in the Modeling Chapter Appendix.

The original Moderate Area SIP CMAQ modeling platform with 2008 meteorology and emissions sulfate performance has been notably low with over 89% of the sulfate found on the filters missing from the model. The collaboration with EPA-ORD on the final model configuration produced has led to vastly improved model performance, updated version of CMAQ to version 5.3.3 and updated pre-processor model versions. The Model Performance Evaluation utilized filter-based concentrations for NCore, Hurst Road and A Street, unlike the previous MPE using only the SOB monitor. All these improvements have led to a model configuration that is acceptable for $PM_{2.5}$ and all its species for wintertime pollution events. The configuration allows for sensitivity runs with control measures, a reasonable attainment year and precursor demonstrations. ADEC has collaborated with EPA Region 10 on the best final configuration to move forward with regulatory modeling in this updated Modeling Chapter as amendment to the current SIP.

7.8.15.4 Gridded Emissions Spatial Plots for Base Year 2020

The meteorology and final configuration for the CMAQ model are complete and then the SMOKE version 4.81 is run to process emission files for each emission sectors. The CMAQ model-ready emissions were then summarized for each emission sectors as well as total emissions for grid cells in the nonattainment area.

[57] https://acp.copernicus.org/articles/16/4081/2016/acp-16-4081-2016-supplement.pdf

The SMOKE version 4.81 (released in January 2020) was used to generate CMAQ-ready emissions. Most ancillaries used in SMOKE are based on EPA 2016v1 (2016fh_16j) modeling platform except for temporal profiles and spatial surrogates, which are provided ADEC consultants. Speciation profiles for all sectors are based on EPA 2016v1 defaults, except for space heating, for which OMNI profiles were used for local fuel and wood stove emissions. These OMNI profiles were compiled at OMNI labs for the Moderate Area SIP. Details for the OMNI lab report can be found in the Emission Inventory Chapter of the Moderate Area SIP[58]. Emission processed through SMOKE along with the spatial gridded emissions plots as post-SMOKE processing are generated for the following sectors (additional information provided in parentheses):

- **Aircraft (3D 4-layers emissions were vertically allocated with SCC-specific temporal profiles*)**
- **Area (SCC-specific temporal profiles*)**
- **Nonroad (SCC-specific temporal profiles*)**
- **Point (hour- and day-specific inventories using CMAQ's in-line processing)**
- **On-road (SMOKE-MOVES processing with on-road specific sub-processes including RPD, RPH, RPHO, RPP, RPSand RPV)**
- **Space Heat (hour and day-specific inventories; emissions were 3D 4-layers vertically allocated)**

**Ancillary files provide in the emissions chapter*

Hourly CMAQ files were produced for each day for the entire episode (12/2019 – 2/2020) and for all sectors.

Emission QAs were performed through SMOKE reports and summaries of model-ready emissions files.

Figure 7.8.15-9 display the combined total $PM_{2.5}$, SO_2, NOx and VOCs emissions from all sectors vertically in 38 layers in the model foreach grid cell. In addition to the combined emissions, Figures 7.8.15-2-8 display sector-specific emissions for the $PM_{2.5}$, SO_2, NOx and VOCs. For the space heating sector in Figure 7.8.15-7, the maximum $PM_{2.5}$ max emissions occur in the grid cell near Badger Road in North Pole, known to have high quantity of wood stoves in the vicinity. The highest $PM_{2.5}$ emissions grid cell for all sectors is east of the NCore monitor in the Ft Wainwright area in Figure 7.8.15-8, this does not coincide with the highest surfaced based concentration. Similarly, each sector was examined for locations of the actual emissions sources to ensure the accuracy of the emissions processing. The SO_2 sector plots, show the aircraft as the primary emissions sources, clustered around the grid cells where the airport runways of Fairbanks International Airport, FT Wainwright and Eielson air force base are located. Further the details of the vertical allocations of aircraft emissions in the upper layers can be found in chapter 7.6, the emissions inventory. The NOx sector spatial plot shows that the emissions occur along the road systems in the Fairbank areas. .

[58] https://dec.alaska.gov/air/anpms/communities/fbks-pm2-5-moderate-sip/

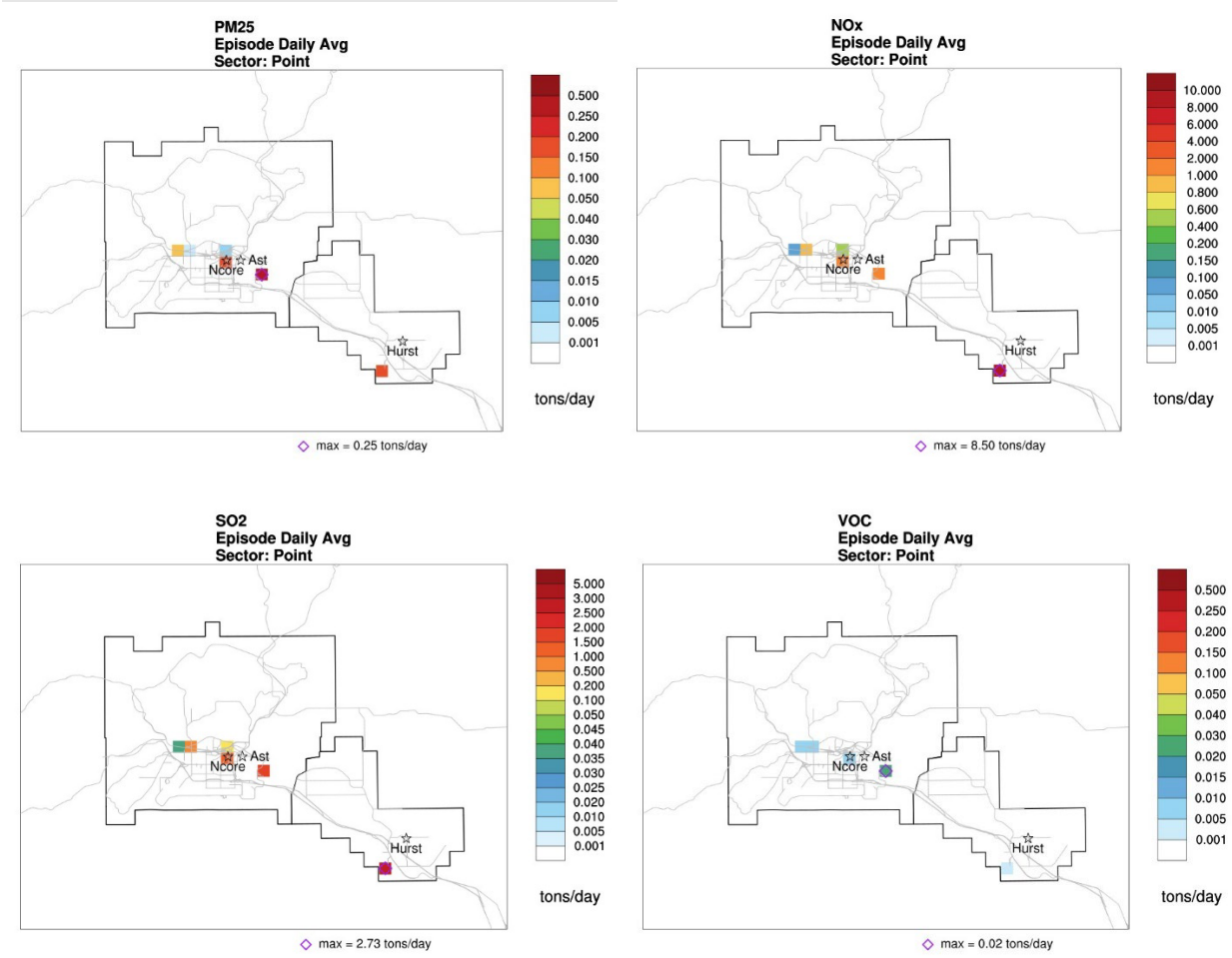
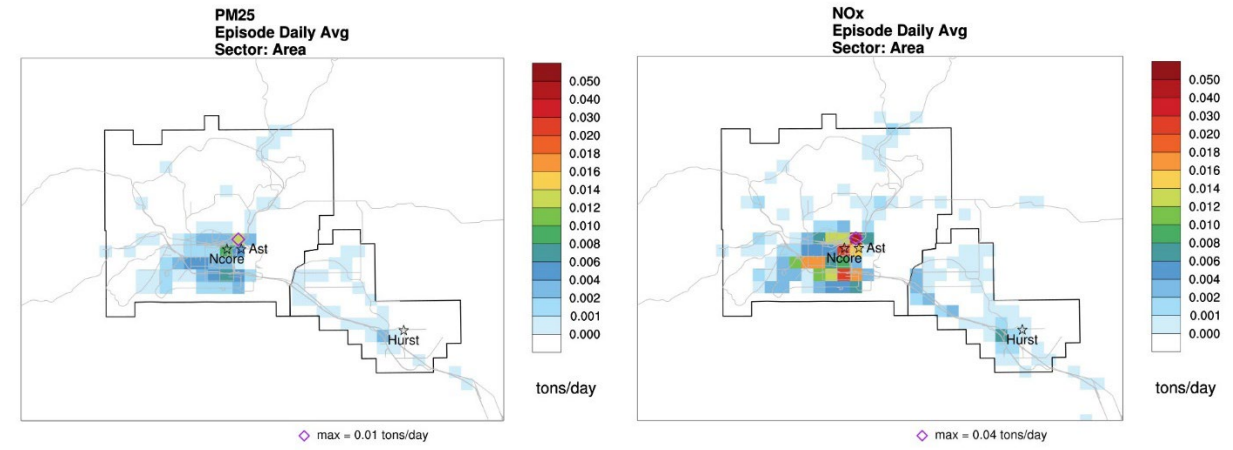


Figure 7.8.15-3 Point Source Base Year 2020 Gridded Emissions Spatial Plots for $PM_{2.5}$ (Upper Left), NOx (Upper Right), SO_2 (Lower Left), and VOC (Lower Right)



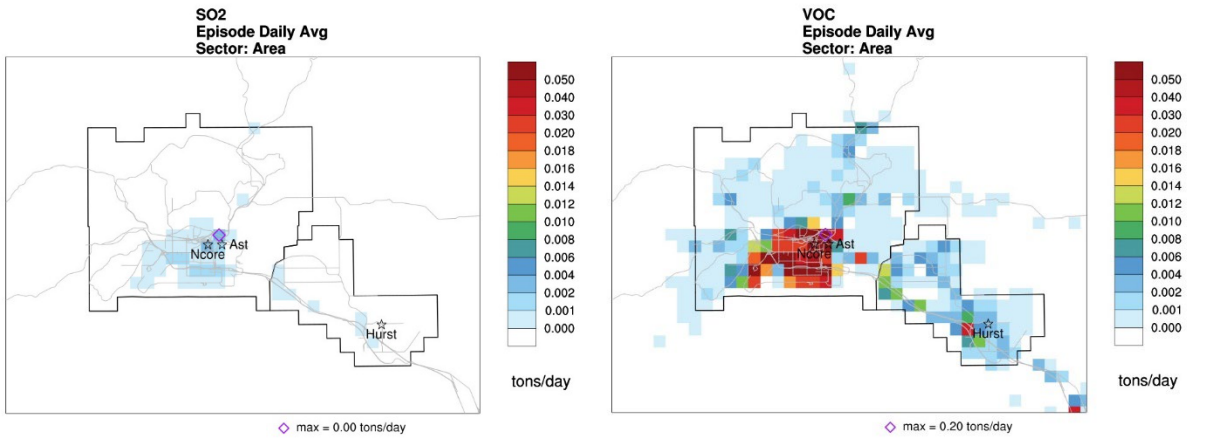


Figure 7.8.15-4 Area Source Base Year 2020 Gridded Emissions Spatial Plots for $PM_{2.5}$ (Upper Left), NOx (Upper Right), SO_2 (Lower Left), and VOC (Lower Right)

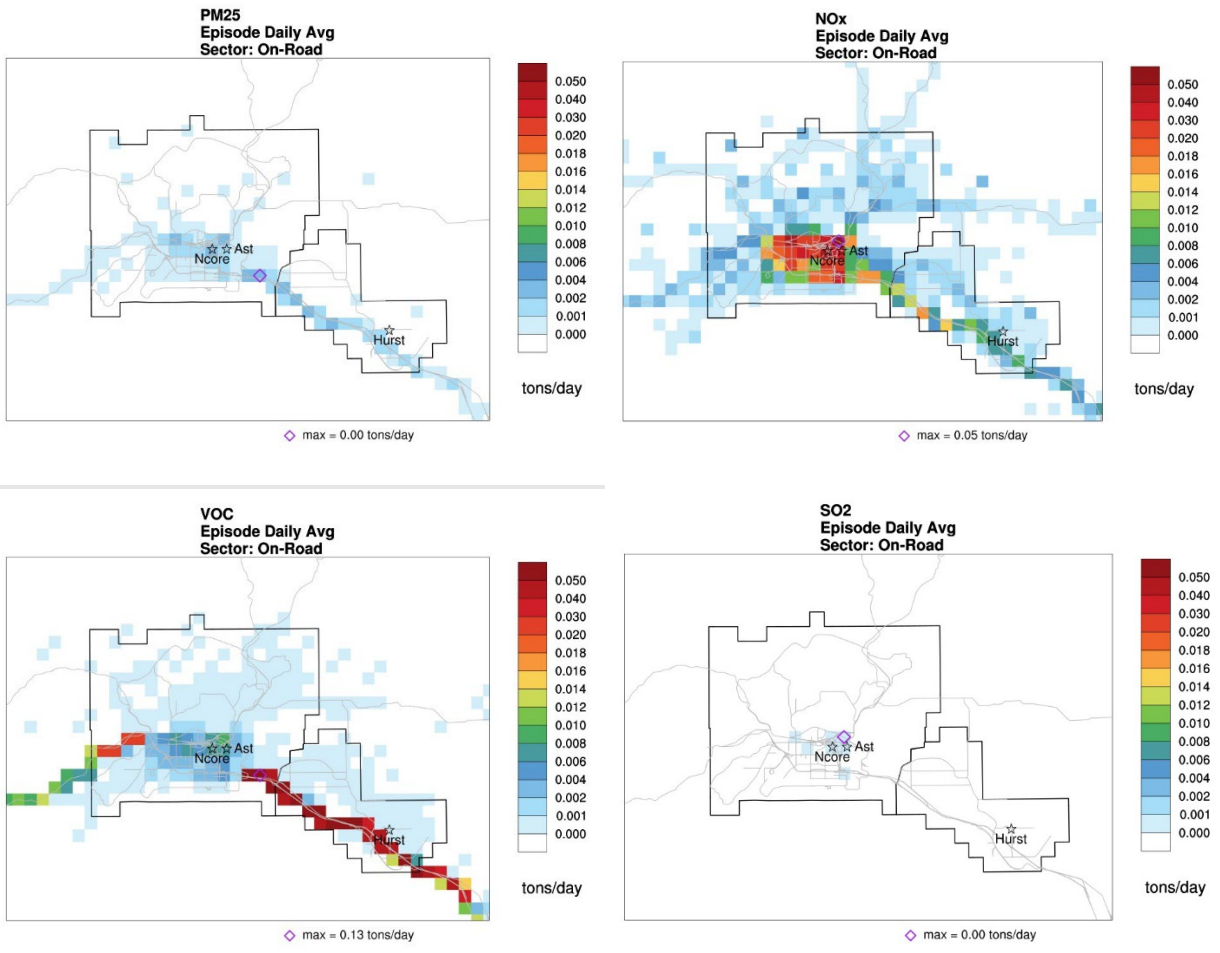


Figure 7.8.15-5 On-road Base Year 2020 Gridded Emissions Spatial Plots for $PM_{2.5}$ (Upper Left), NOx (Upper Right), SO_2 (Lower Left), and VOC (Lower Right)

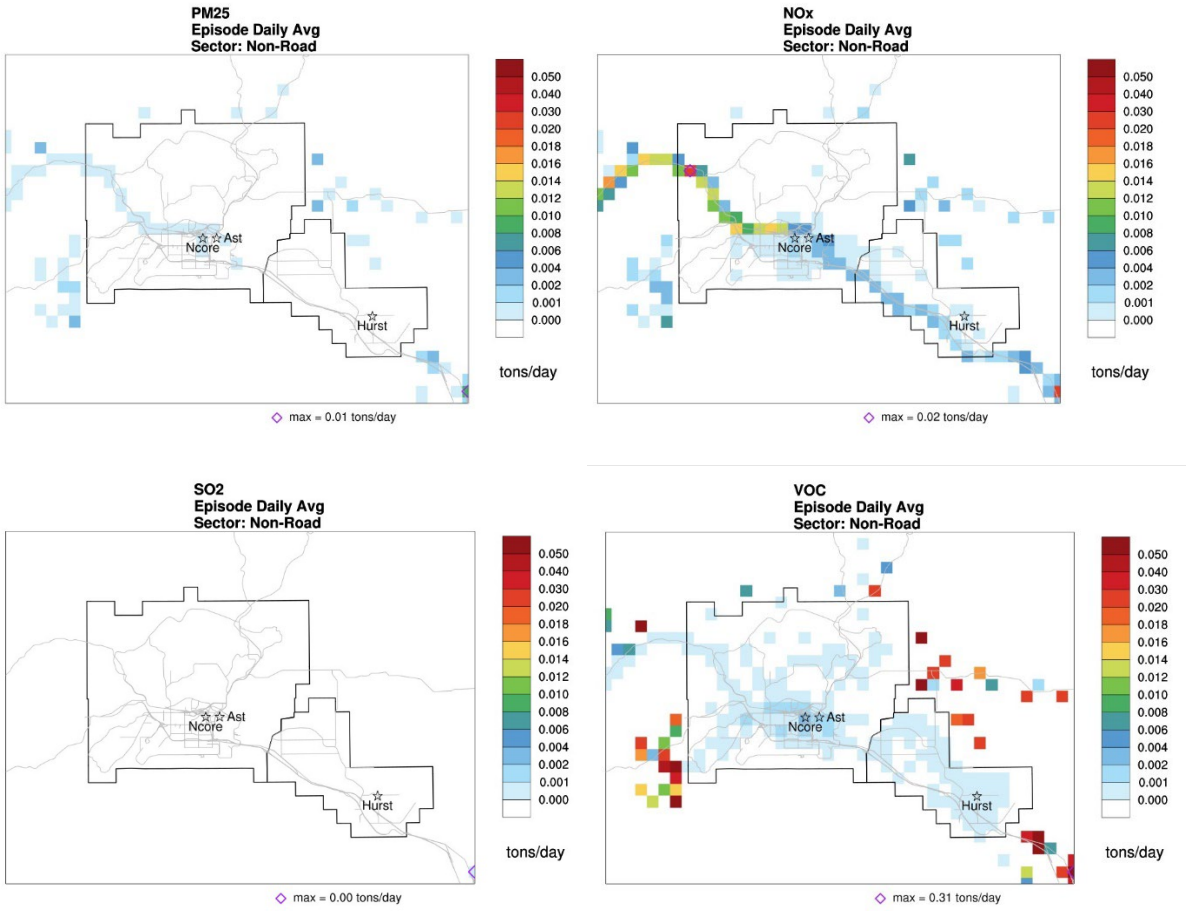


Figure 7.8.15-6 Non-road Base Year 2020 Gridded Emissions Spatial Plots for $PM_{2.5}$ (Upper Left), NOx (Upper Right), SO_2 (Lower Left), and VOC (Lower Right)

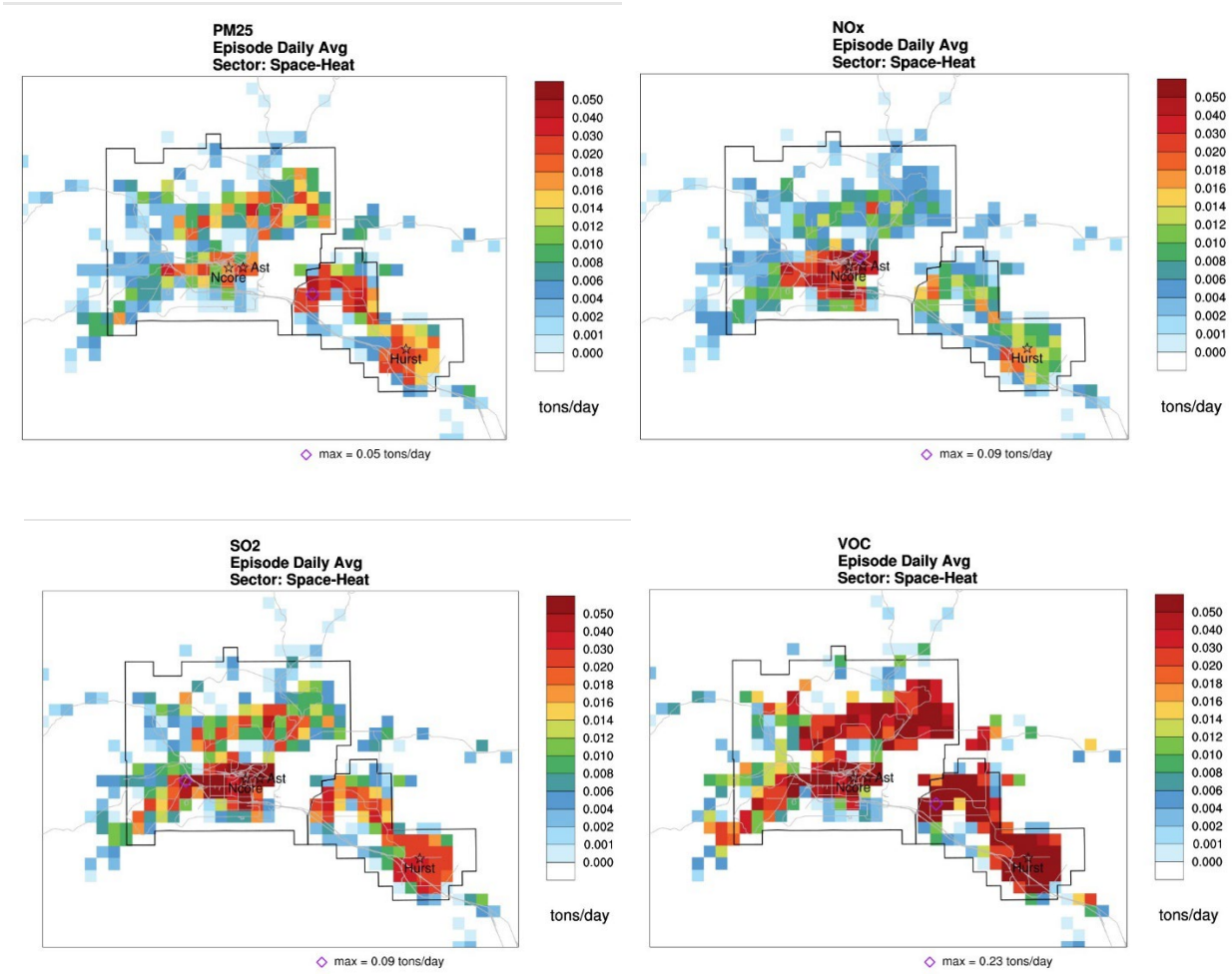


Figure 7.8.15-7 Space-heat Base Year 2020 Gridded Emissions Spatial Plots for $PM_{2.5}$ (Upper Left), NOx (Upper Right), SO_2 (Lower Left), and VOC (Lower Right)

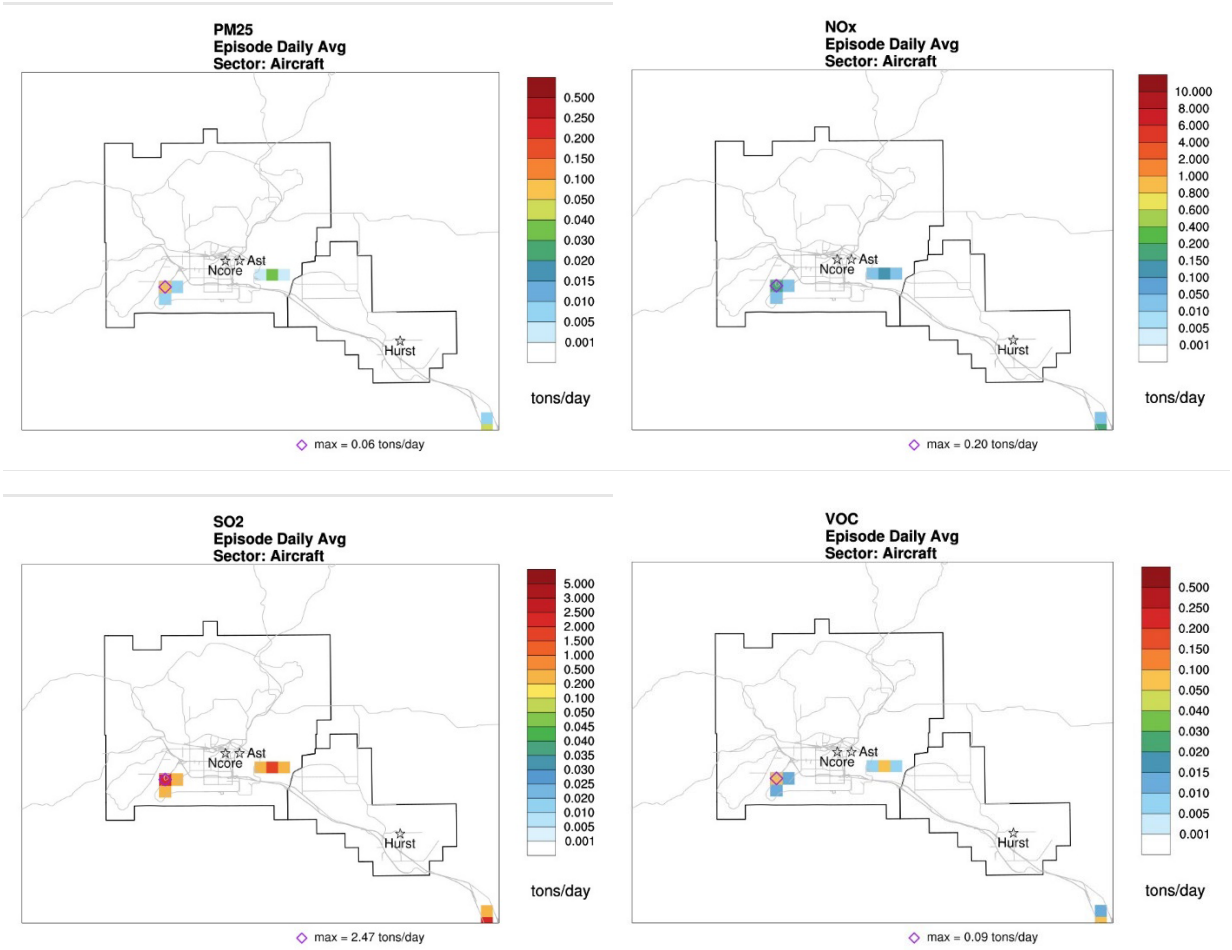


Figure 7.8.15-8 Aircraft Base Year 2020 Gridded Emissions Spatial Plots for $PM_{2.5}$ (Upper Left), NOx (Upper Right), SO_2 (Lower Left), and VOC (Lower Right)

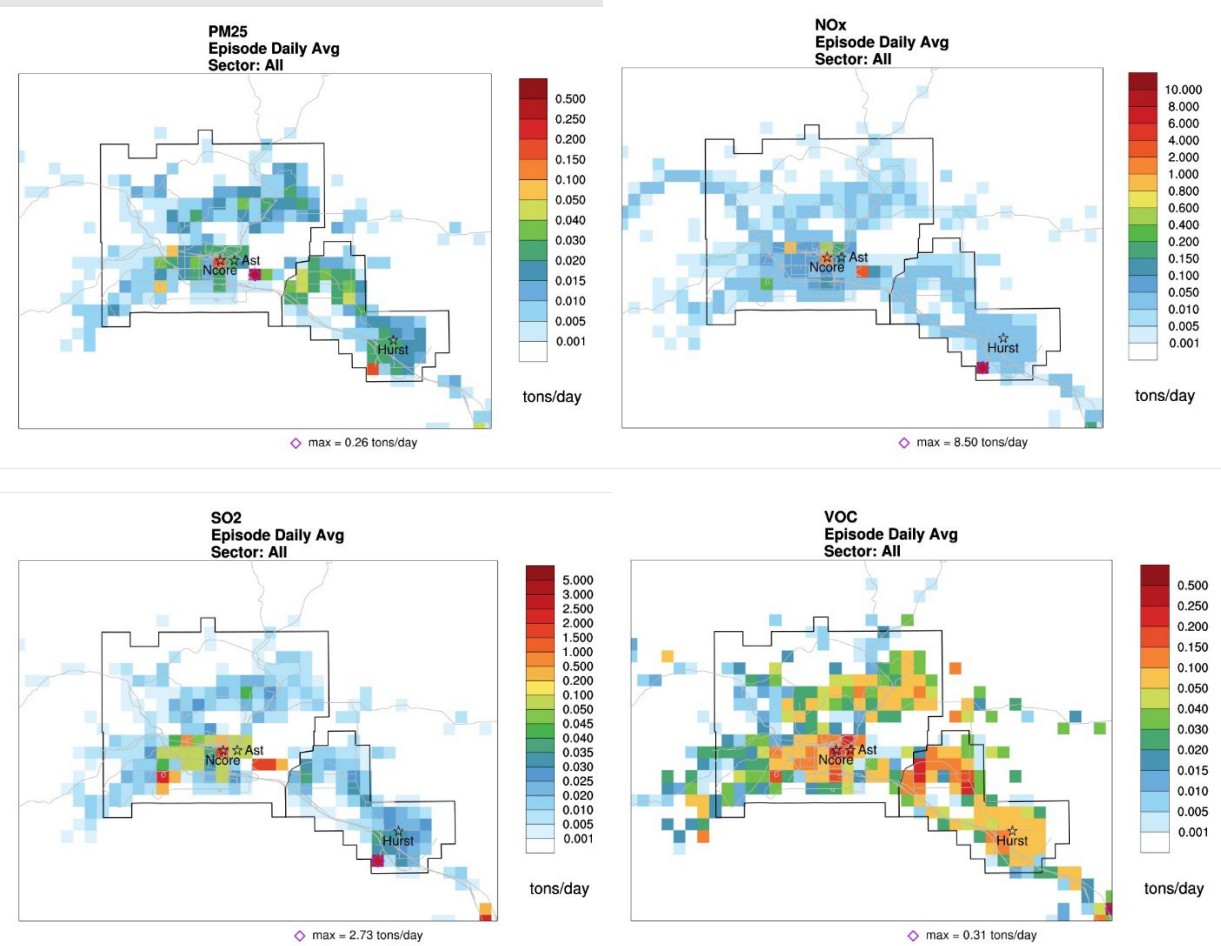


Figure 7.8.15-9 All Sectors Base Year 2020 Gridded Emissions Spatial Plots for $PM_{2.5}$ (Upper Left), NOx (Upper Right), SO_2 (Lower Left), and VOC (Lower Right)

Table 7.8.15-4 CMAQ-Ready Emissions (post-SMOKE) in tons/day

Source Sector	$PM_{2.5}$	NOx	SO_2	VOC	NH_3
Point	0.66	13.6	6.59	0.04	0.09
Space heat	2.14	2.33	3.96	6.38	0.12
Area	0.12	0.39	0.03	2.05	0.05
Onroad, merged	0.13	1.60	0.005	3.02	0.05
Nonroad, All	0.29	1.44	8.46	2.55	0.002
nonroad	0.09	0.77	0.002	2.25	0.002

airports/aircrafts	0.20	0.67	8.46	0.30	0.00
TOTALS	3.34	19.36	19.05	14.04	0.31

Note: 1. On-Road Mobile is based on Ramboll's SMOKE-MOVES results
2. Non-Road mobile include both non-road and airports/aircrafts

7.8.15.4 Model Performance Evaluation

The new model performance evaluation (MPE) is on the base year 2020 emissions, updated meteorology for 2019-2020 and uses new speciation data for the Hurst Road monitor in North Pole and NCore for the concurrent days the filters are available during the 74-day modeling episode. The total $PM_{2.5}$ is evaluated at NCore in Fairbanks, Hurst Road monitor in North Pole, and A Street monitor in Fairbanks. The species sulfate, nitrate, organic carbon, elemental carbon, PMother and ammonium are used for MPE. The same metrics identified in Table 7.8.15-1 in the Moderate Area SIP for the approved NOx and VOC precursors were used for the new MPE for the CMAQv533hetchem final configuration. The EPA's Atmospheric Model Evaluation tool (AMET, https://www.epa.gov/cmaq/atmospheric-model-evaluation-tool) is used to conduct the MPE analysis and to generate various plots.

The summary of the CMAQ model MPE from the Moderate Area SIP is below in Table 7.8.15-3 and the detailed write-up can be found in the Moderate Area SIP. The largest missing component in the old model performance was the sulfate at – 89%. The second issue was the model performance was only complete at the SOB monitor, there was no monitoring in North Pole at the time. The new model performance has corrected both deficiencies.

Table 7.8.15- 5 Moderate Area SIP Mean Factional Error and Mean Fractional Bias Using 2008 Meteorology and Emissions, the State Office Building Monitor and CMAQ4 .7.1

Species	MFE (%)	MFB (%)
$PM_{2.5}$	30.2%	8.0%
OC	37.3%	34.2%
EC	52.8%	52.8%
SO_4	88.5%	-88.5%
NO_3	57.9%	-35.2%
NH_4	79.9%	-79.9%
OTH	87.3%	-87.3%

Table 7.8.15-6 Model Performance Metrics from EPA PM-2.5 Guidance

Statistical Measure	Mathematical Expression	Performance Goals	Performance Criteria
Normalized Mean Bias (%), NMB	$\frac{\sum_{i=1}^{N}(P_i - O_i)}{\sum_{i=1}^{N} O_i}$	MDA8 O_3 <±5% $PM_{2.5}$, SO_4,NH_4 <±10% NO_3 <±15% OC <±15% EC <±20%	MDA8 O_3 <±15% $PM_{2.5}$, SO_4,NH_4 <±30% NO_3 <±65% OC <±50% EC <±40%
Normalized Mean Error (%), NME	$\frac{\sum_{i=1}^{N}\lvert P_i - O_i\rvert}{\sum_{i=1}^{N} O_i}$	MDA8 O_3 <15% $PM_{2.5}$, SO_4,NH_4 <35% NO_3 <65% OC <45% EC <50%	MDA8 O_3 <25% $PM_{2.5}$, SO_4,NH_4 <50% NO_3 <115% OC <65% EC <75%
Fractionalized Bias (%), FB	$\frac{2}{N}\sum_{i=1}^{N}\left(\frac{P_i - O_i}{P_i + O_i}\right)$	24-hr total and speciated $PM_{2.5}$ <±30%	24-hr total and speciated $PM_{2.5}$ <±60%
Fractional Error (%), FE	$\frac{2}{N}\sum_{i=1}^{N}\left\lvert\frac{P_i - O_i}{P_i + O_i}\right\rvert$	24-hr total and speciated $PM_{2.5}$ <50%	24-hr total and speciated $PM_{2.5}$ <75%

Performance Goals and criteria Values Source[59]

The MPE was completed using the base year 2020 modeling results (Section 7.8.15.2) and concurrent 2020 meteorology (Section 7.8.15.3), run with the latest CMAQ configuration (v533het) from Section 7.8.15.3. For all of the MPE plots, NCore is site 34, Hurst Road is site 35 and A Street is site 40.

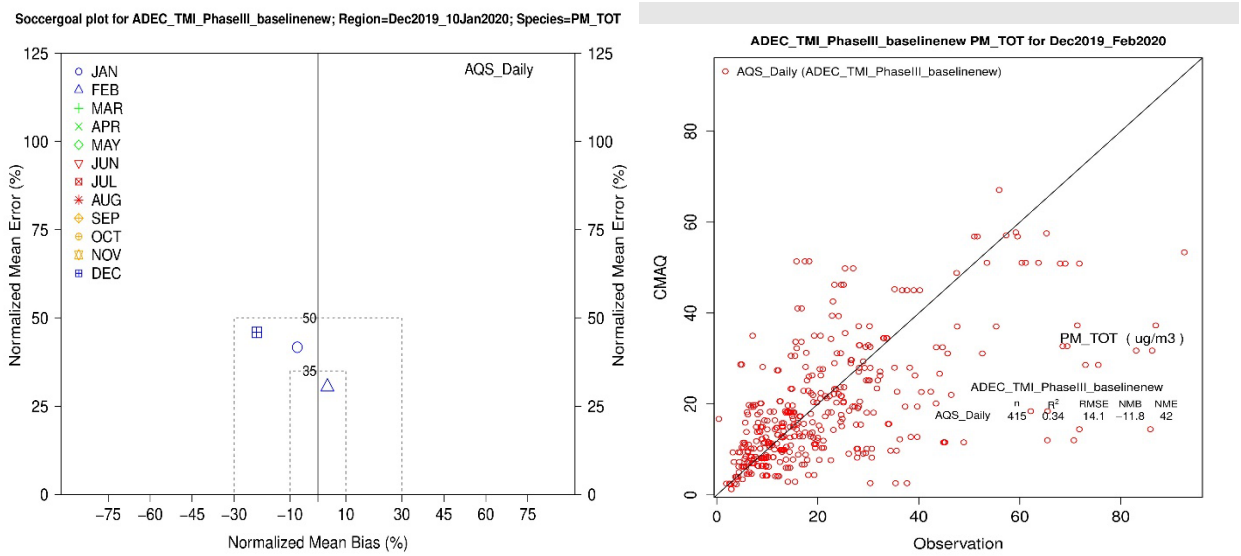


Figure 7.8.15-10 Domain wide Soccer Plot (Left) and Scatter Plot (Right) for Total $PM_{2.5}$ (PM_TOT) Using the Baseline 2020 Modeling Run and the Latest CMAQ Configuration (v533hetcehm) 2020 Emissions and Meteorology

[59] Christopher Emery, Zhen Liu, Armistead G. Russell, M. Talat Odman, Greg Yarwood & Naresh Kumar (2017) Recommendations on statistics and benchmarks to assess photochemical model performance, Journal of the Air & Waste Management Association, 67:5, 582-598, DOI: 10.1080/10962247.2016.1265027

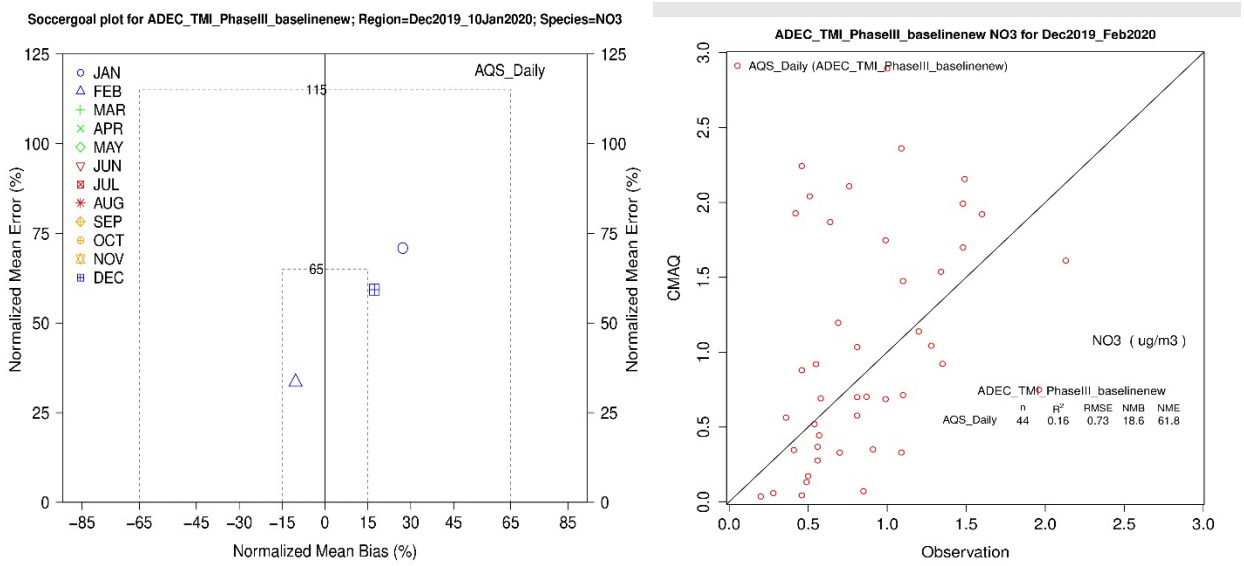


Figure 7.8.15-11 Domain wide Soccer Plot (Left) and Scatter Plot (Right) for NO_3 Using the Baseline 2020 Modeling Run and the Latest CMAQ Configuration (v533hetchem) 2020 Emissions and Meteorology

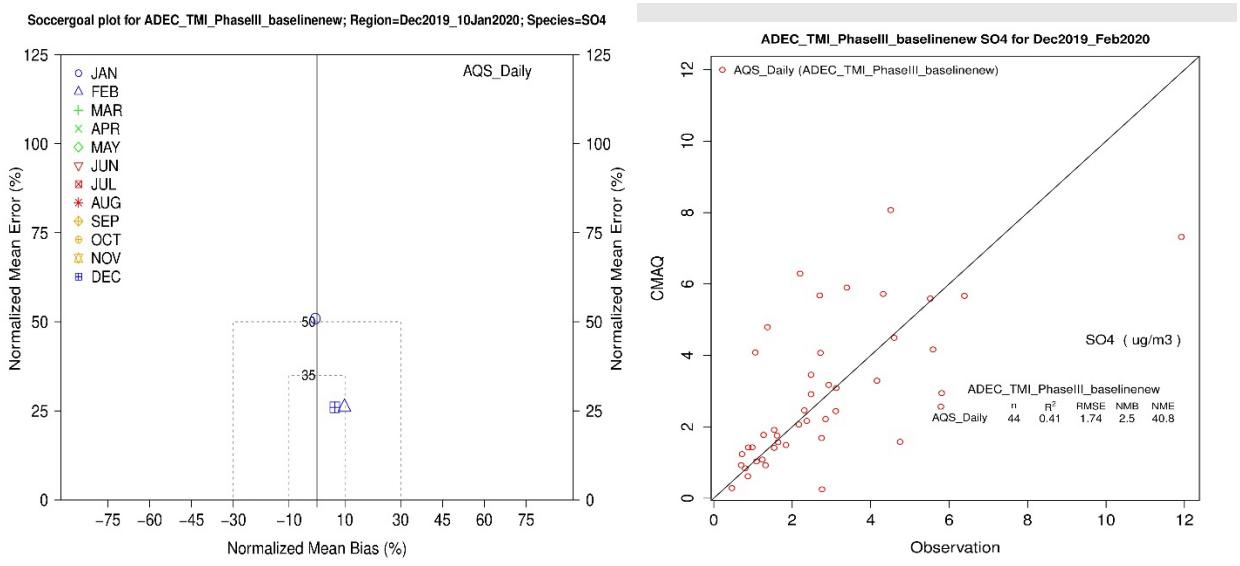


Figure 7.8.15-12 Domain wide Soccer Plot (Left) and Scatter Plot (Right) for SO_4 Using the Baseline 2020 Modeling Run and the Latest CMAQ Configuration (v533hetchem) 2020 Emissions and Meteorology

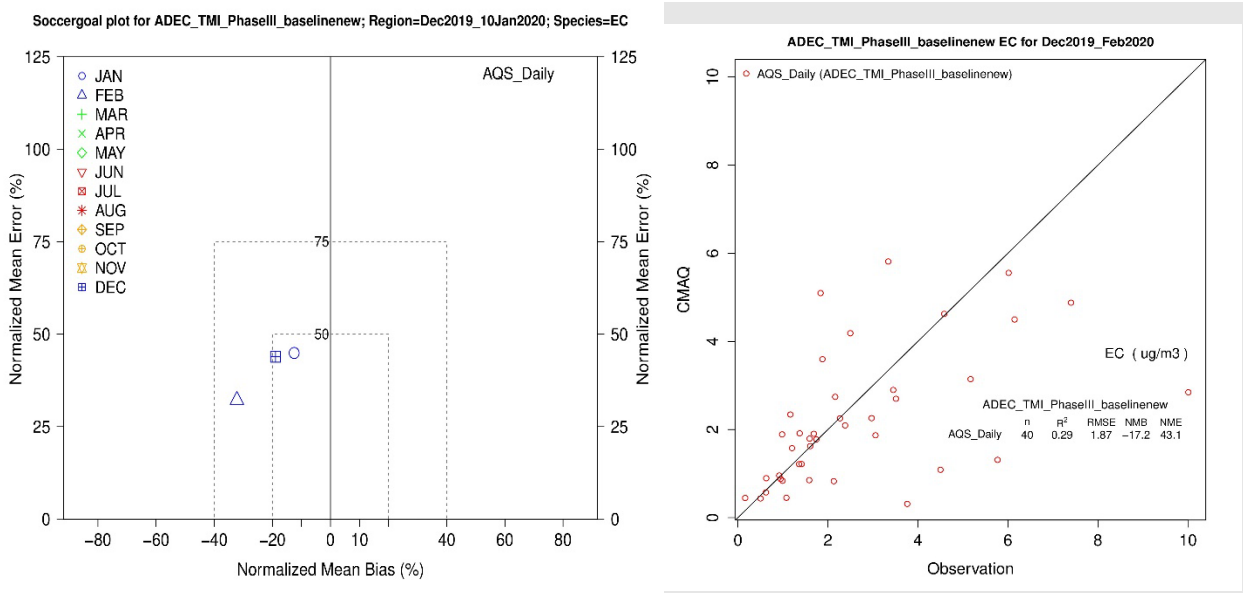


Figure 7.8.15-13 Domain wide Soccer Plot (Left) and Scatter Plot (Right) for EC Using the Baseline 2020 Modeling Run and the Latest CMAQ Configuration (v533hetchem) 2020 Emissions and Meteorology

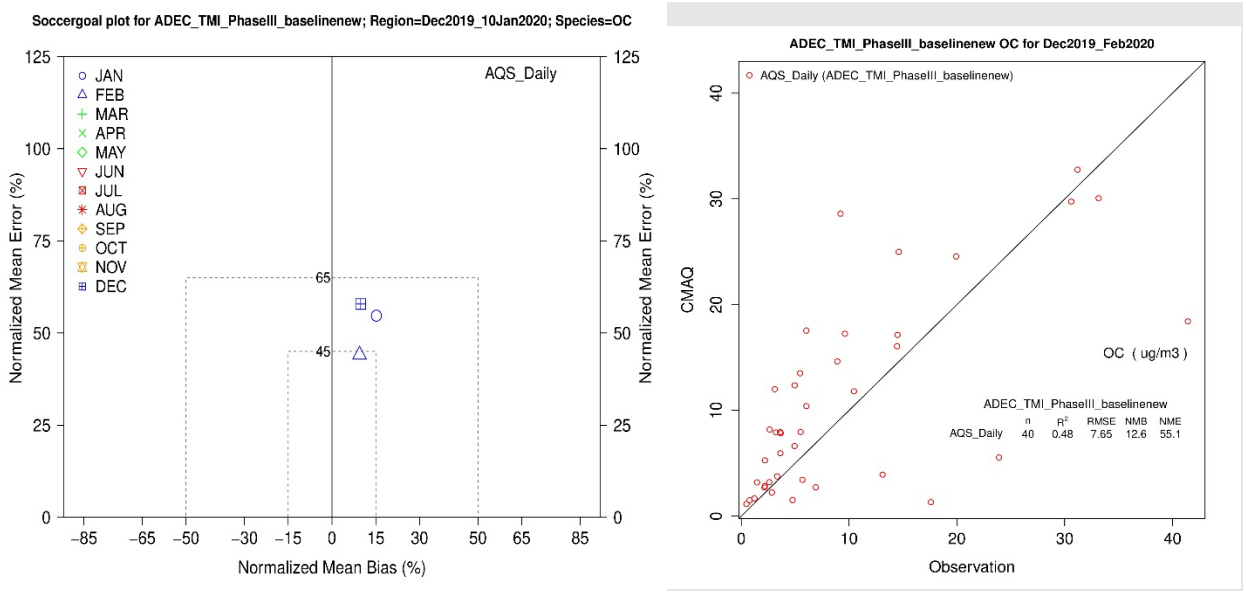


Figure 7.8.15-14 Domain wide Soccer Plot (Left) and Scatter Plot (Right) for OC Using the Baseline 2020 Modeling Run and the Latest CMAQ Configuration (v533hetchem) 2020 Emissions and Meteorology

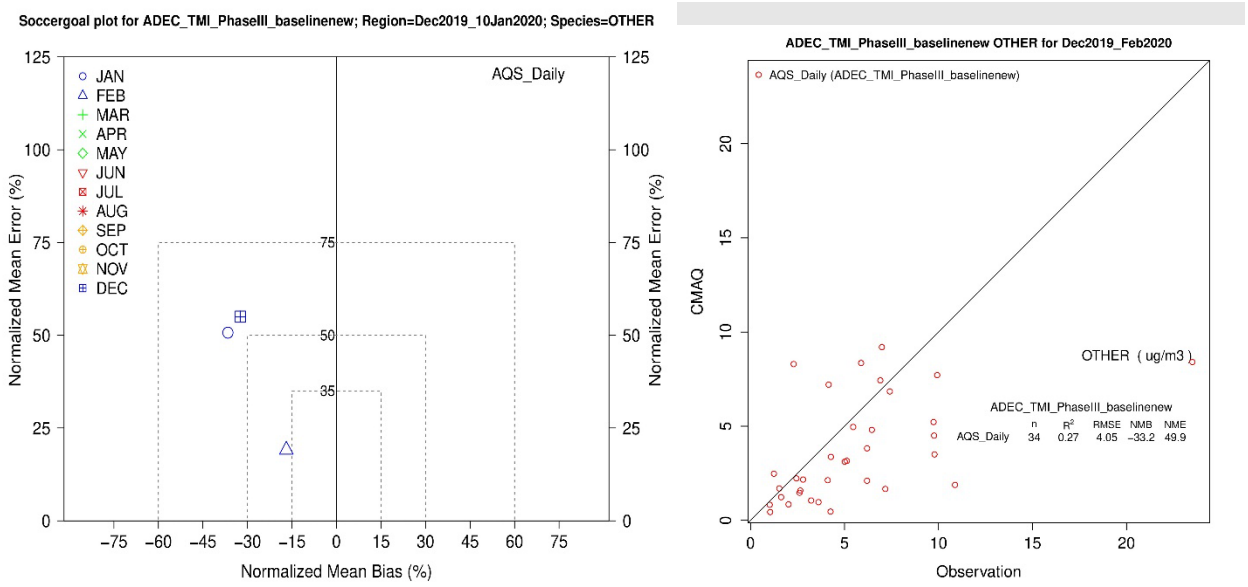


Figure 7.8.15-15 Domain wide Soccer Plot (Left) and Scatter Plot (Right) for OTHR Using the Baseline 2020 Modeling Run and the Latest CMAQ Configuration (v533hetchem) 2020 Emissions and Meteorology

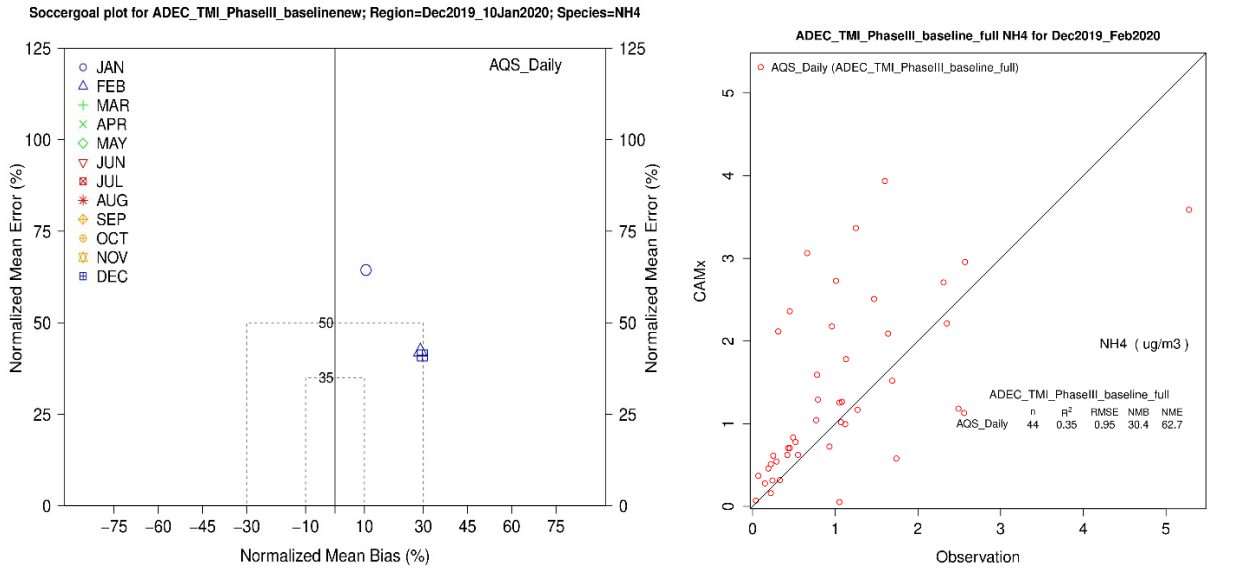


Figure 7.8.15-16 Domain wide Soccer Plot (Left) and Scatter Plot (Right) for NH_4 Using the Baseline 2020 Modeling Run and the Latest CMAQ Configuration (v533hetchem) 2020 Emissions and Meteorology

The soccer plots Figures 7.8.15-10-16 are inside of the "goal" set by the metrics used for $PM_{2.5}$ and all of the species for all three months of the episode December, January and

February, except for one month for ammonium. The soccer plots and statistics are domain wide stats and include both Hurst and NCore for the species and A Street, Hurst and NCore for the total $PM_{2.5}$. The scatter plots show good agreement with lower organic carbon concentrations and an overall R2 value of 0.48.

The normalized mean bias (NMB) and normalized mean error (NME) columns are within the statistical metrics set in Table 7.8.15-6 above for all species and total $PM_{2.5}$. In addition to the domain wide model performance, the individual monitor site at Hurst Road and NCore statistics are provided in Tables 7.8.15-6 and 7.8.15-7. The A Street monitor does not have a speciation monitor and is only included in the total $PM_{2.5}$ domain wide statistics. At Hurst Road, the violating monitor, all of the NMB and NME statistics are in the recommended model performance metrics. At NCore there is an over prediction of organic carbon from the new survey results added to the emissions inventory in the final baseline (details in the Emissions Inventory Chapter (Section III.D.7.6).

The time series have three lines for the updated standard model CMAQ version 5.3.3, the updated emissions for the new meteorological episode for December 2019-2020 (ADEC_all_emiss) green line, the same emissions using the biogenic wood stove specific profile in the emissions control file (allemis_gridmod_biogenic) and a grid modification that moved the grid 50 meters based on a rounding affect from MCIP (details are in the technical modeling report in the modeling appendix), the final (the red line labeled as ADEC_TMI_PHASEIII_baselinenew) configuration using CMAQ version 5.33 hetchem, and the filter-based measurements for comparison. The largest improvement with the final model configuration is in Figure 7.18.15-22 for sulfate below.

The statistics for the soccer plots, scatter plots, times series and bias and errors in Tables 7.8.15-5 to 7.8.15-7 were discussed with EPA Region 10 and together with ADEC believe that the model behaved appropriately for developing this SIP.

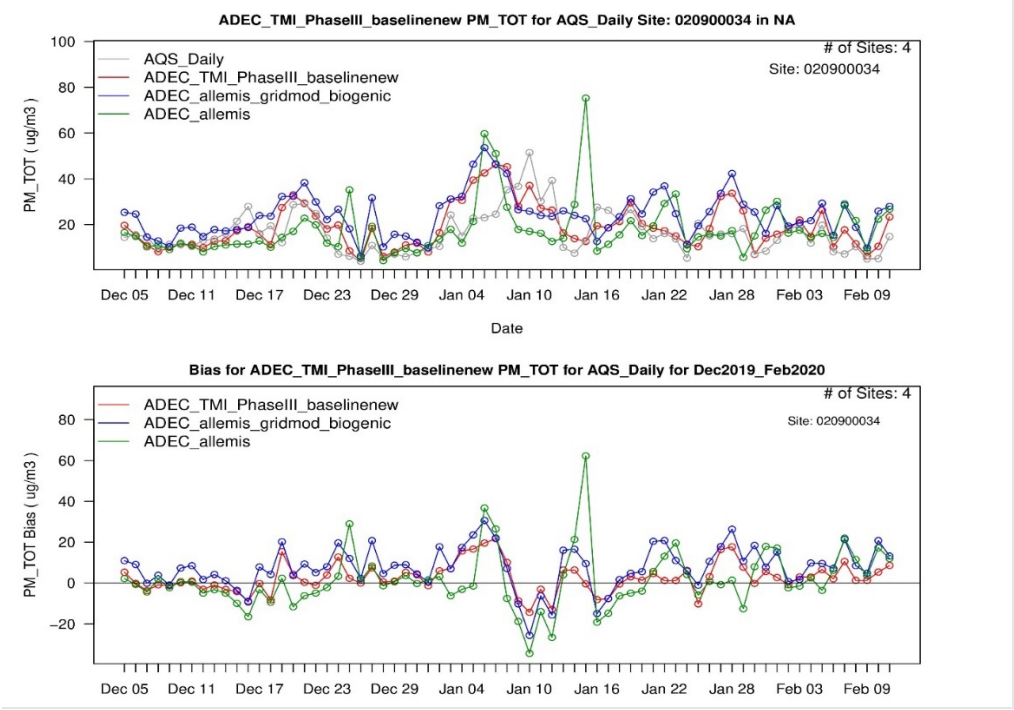


Figure 7.8.15-17 Timeseries Plot for NCore Total $PM_{2.5}$ (PM_TOT) Using the Baseline 2020 Modeling Run and the Latest CMAQ Configuration (v533het) 2020 Emissions and Meteorology

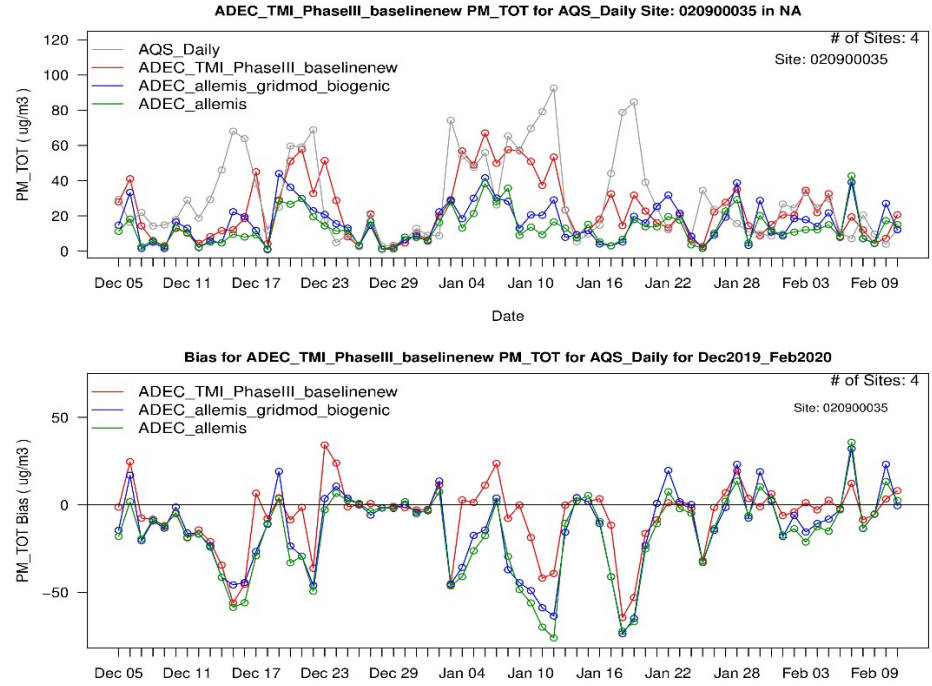


Figure 7.8.15-18 Timeseries Plot for Hurst Road Total $PM_{2.5}$ (PM_TOT) Using the Baseline 2020 Modeling Run and the Latest CMAQ Configuration (v533hetchem) 2020 Emissions and Meteorology

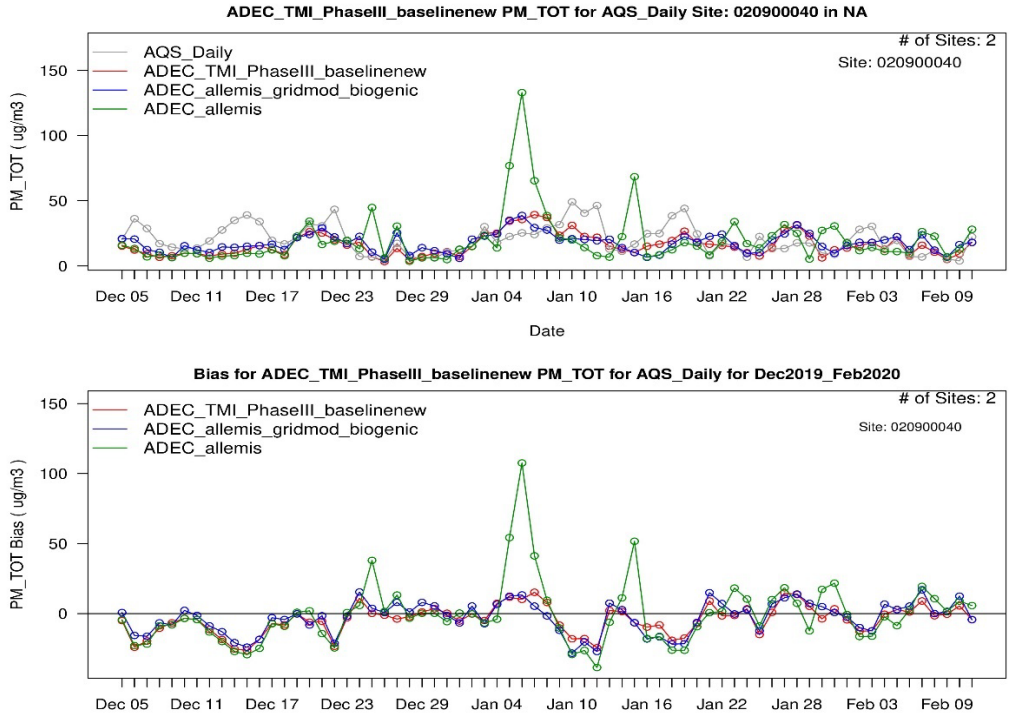


Figure 7.8.15-19 Timeseries Plot for A-Street Total $PM_{2.5}$ (PM_TOT) Using the Baseline 2020 Modeling Run and the Latest CMAQ Configuration (v533hetchem) 2020 Emissions and Meteorology

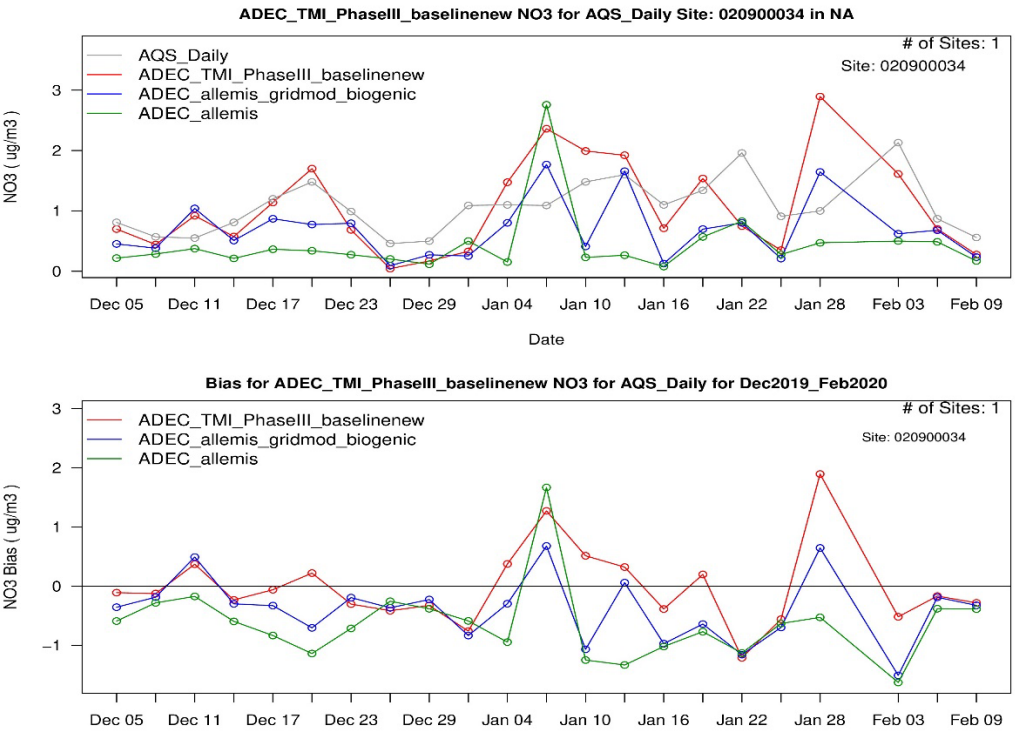


Figure 7.8.15-20 Timeseries Plot for NCore NO_3 Using the Baseline 2020 Modeling Run and the Latest CMAQ Configuration (v533hetchem) 2020 Emissions and Meteorology

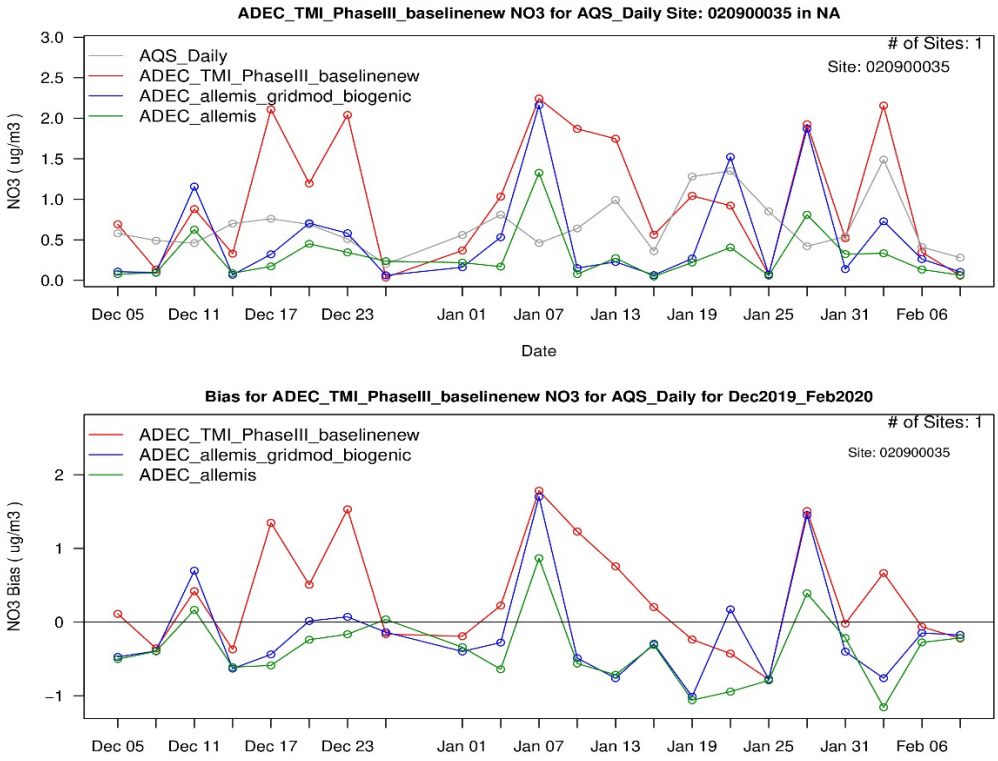


Figure 7.8.15-21 Timeseries Plot for Hurst Road NO_3 Using the Baseline 2020 Modeling Run and the Latest CMAQ Configuration (v533het) 2020 Emissions and Meteorology

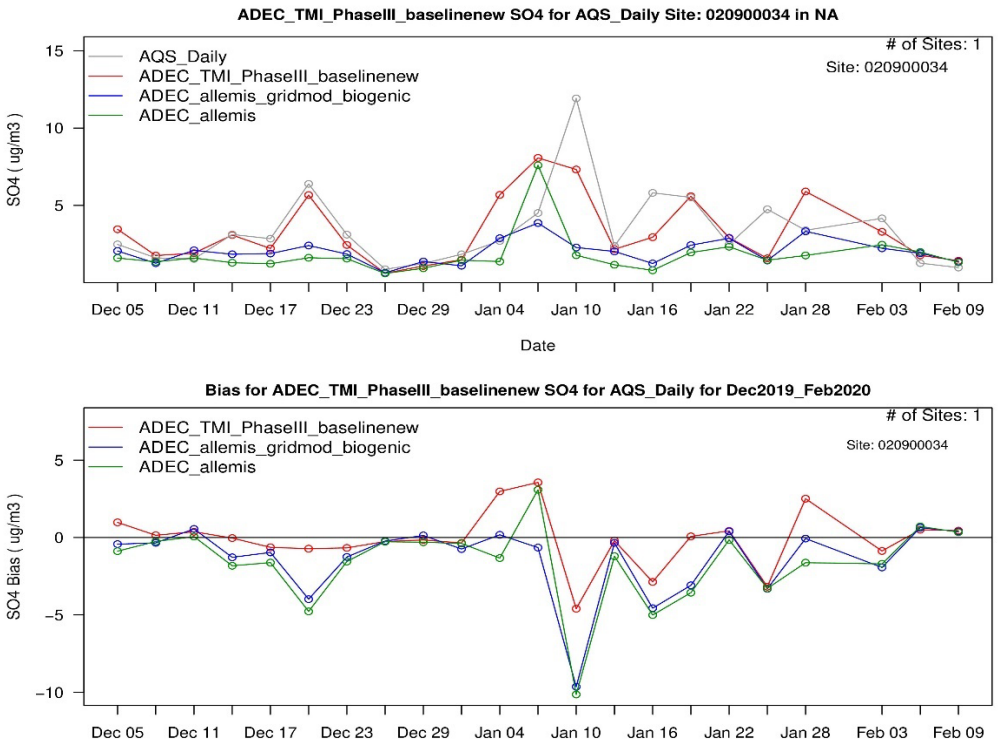


Figure 7.8.15-22 Timeseries Plot for NCore SO_4 for Using the Baseline 2020 Modeling Run and the Latest CMAQ Configuration (v533hetchem) 2020 Emissions and Meteorology

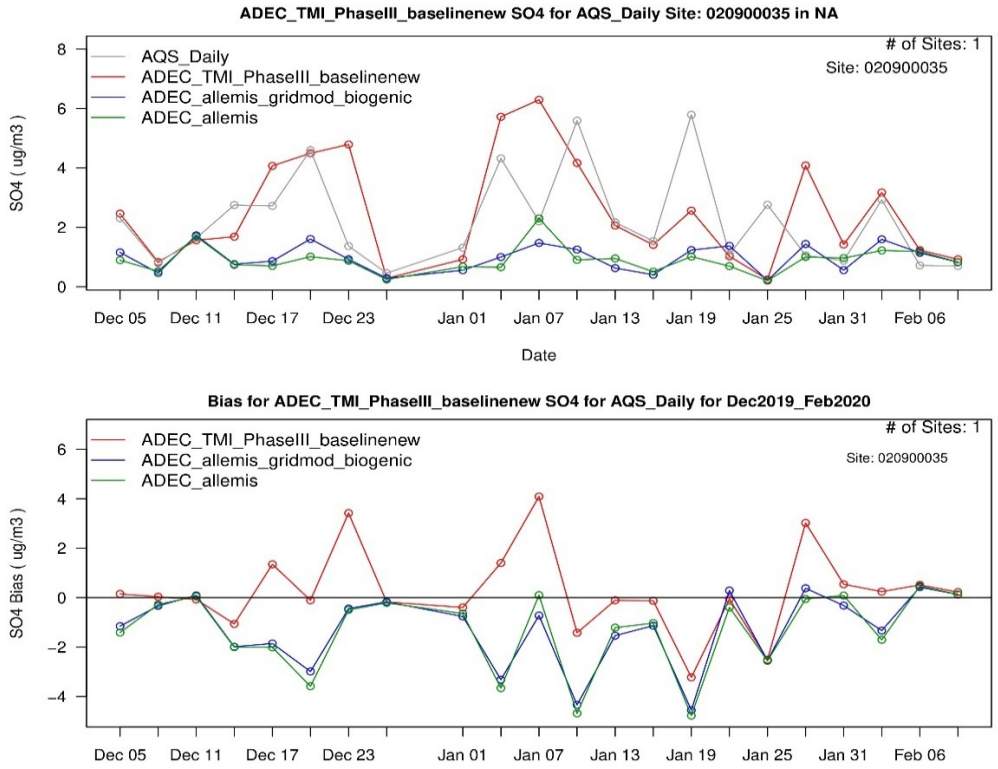


Figure 7.8.15-23 Timeseries Plot for Hurst Road SO_4 Using the Baseline 2020 Modeling Run and the Latest CMAQ Configuration (v533hetchem) 2020 Emissions and Meteorology

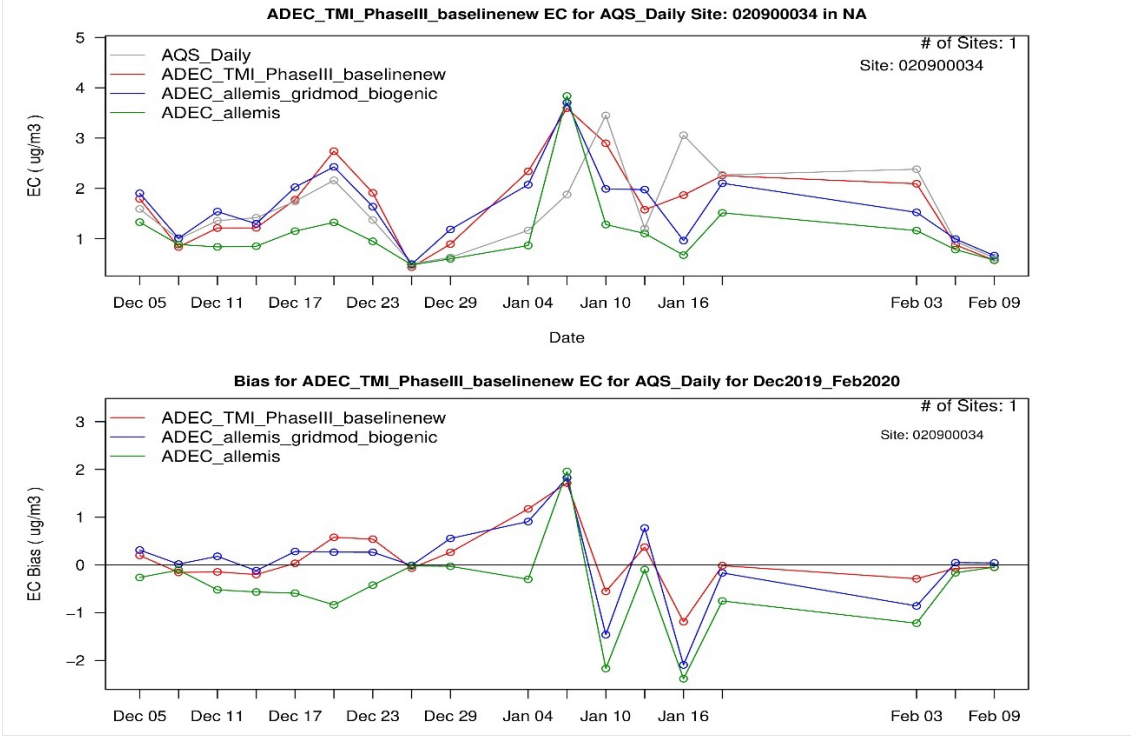


Figure 7.8.15-24 Timeseries Plot for NCore EC Using the Baseline 2020 Modeling Run and the Latest CMAQ Configuration (v533hetchem) 2020 Emissions and Meteorology

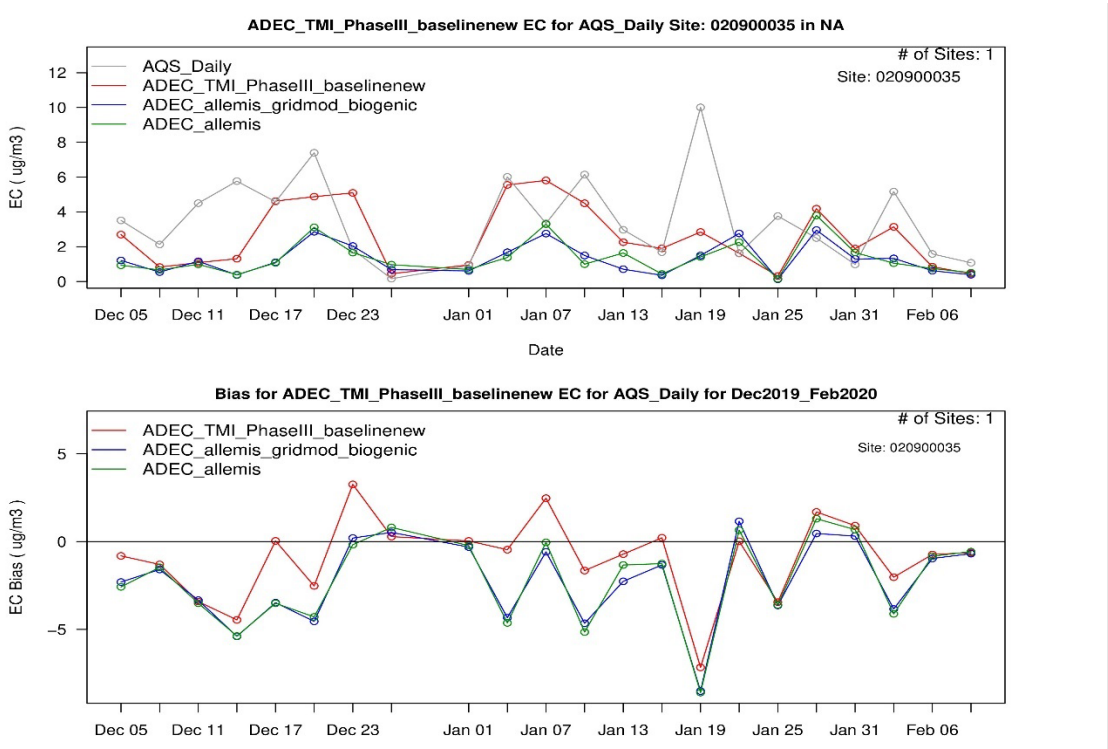


Figure 7.8.15-25 Timeseries Plot for Hurst Road EC Using the Baseline 2020 Modeling Run and the Latest CMAQ Configuration (v533hetchem) 2020 Emissions and Meteorology

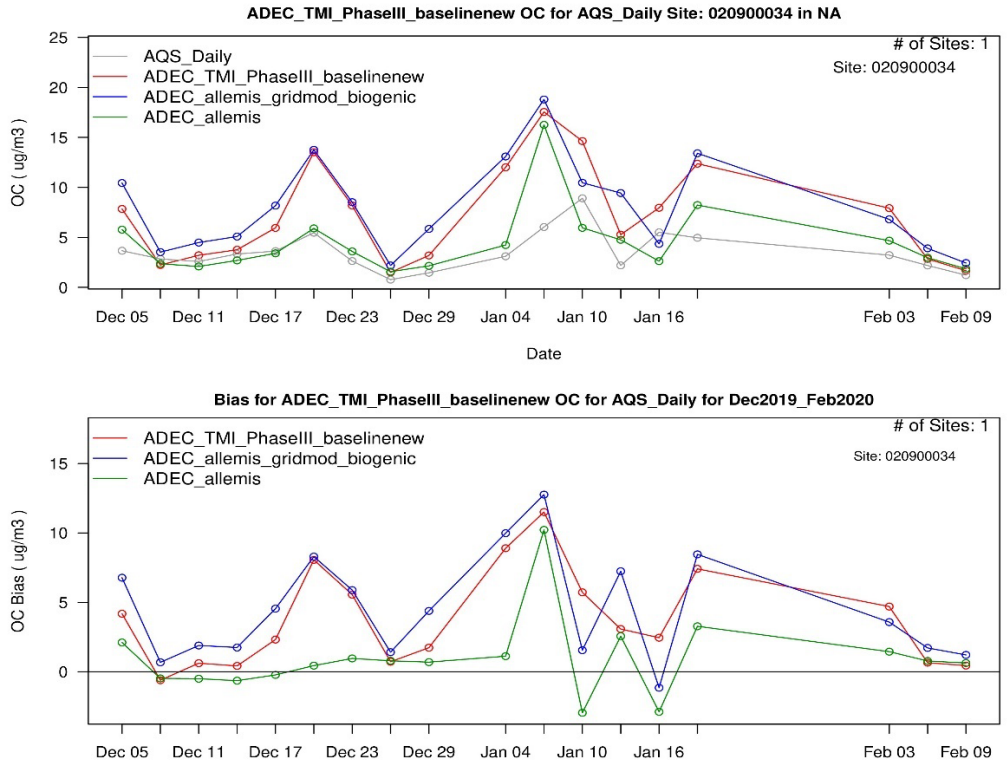


Figure 7.8.15-26 Timeseries Plot for NCore OC Using the Baseline 2020 Modeling Run and the Latest CMAQ Configuration (v533hetchem) 2020 Emissions and Meteorology

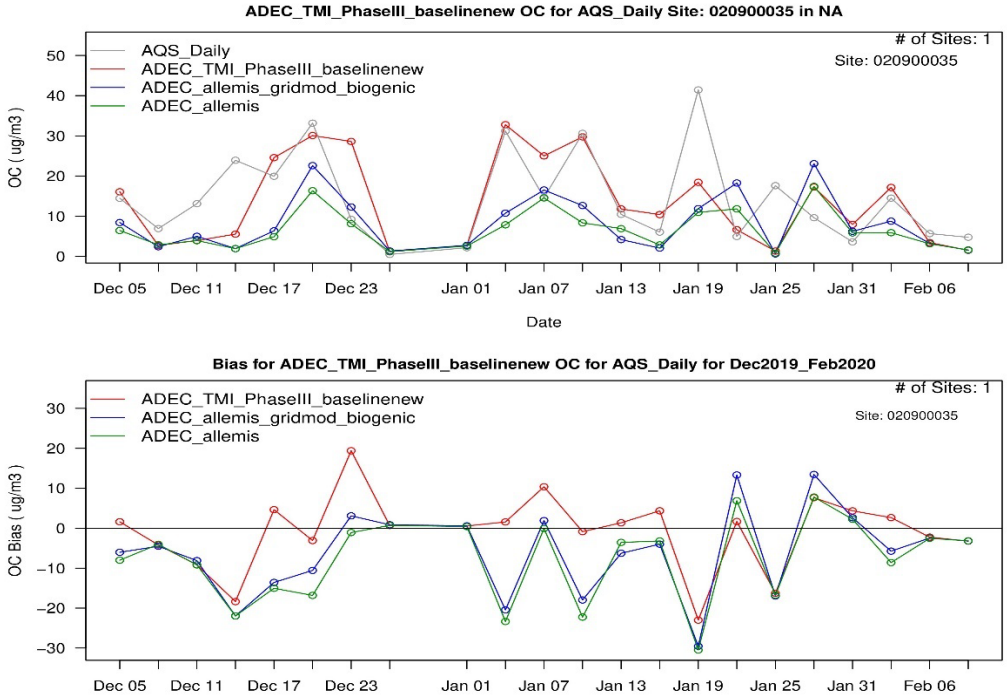


Figure 7.8.15-27 Timeseries Plot for Hurst Road OC Using the Baseline 2020 Modeling Run and the Latest CMAQ Configuration (v533hetchem) 2020 Emissions and Meteorology

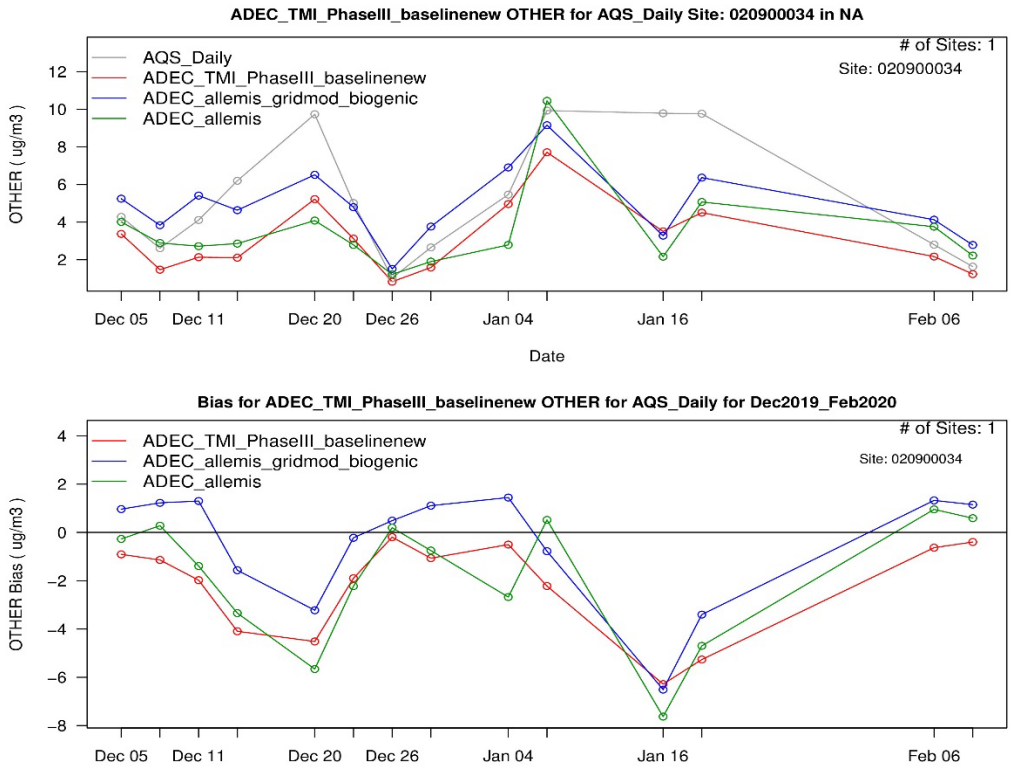


Figure 7.8.15-28 Timeseries Plot for NCore OTHER Using the Baseline 2020 Modeling Run and the Latest CMAQ Configuration (v533hetchem) 2020 Emissions and Meteorology

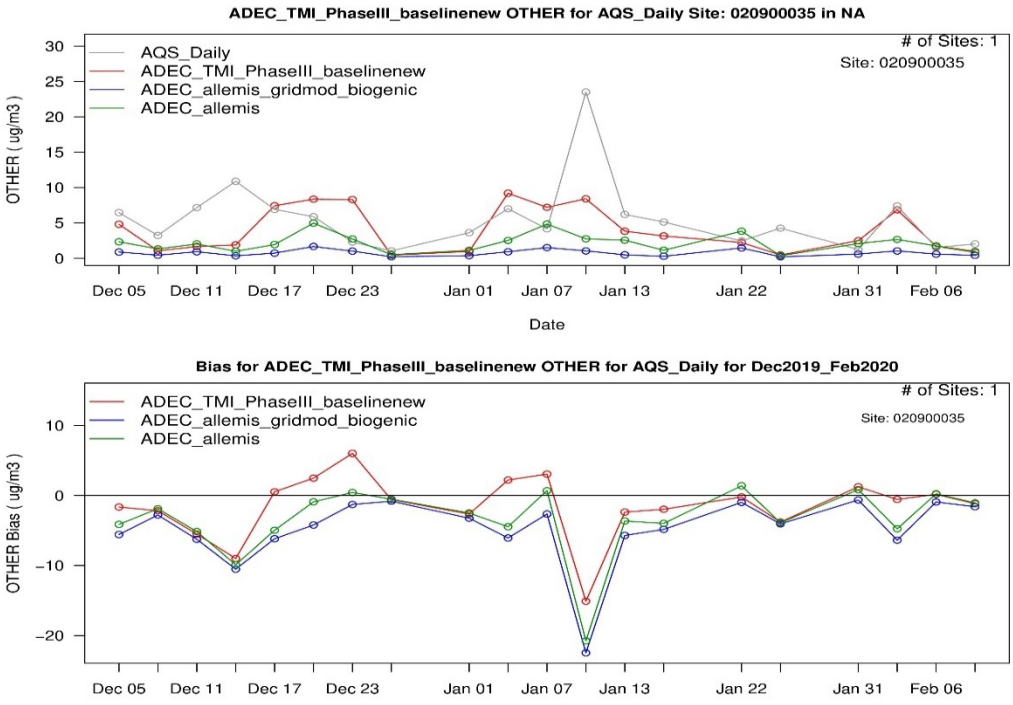


Figure 7.8.15-29 Timeseries Plot for Hurst Road OTHER Using the Baseline 2020 Modeling Run and the Latest CMAQ Configuration (v533hetchem) 2020 Emissions and Meteorology

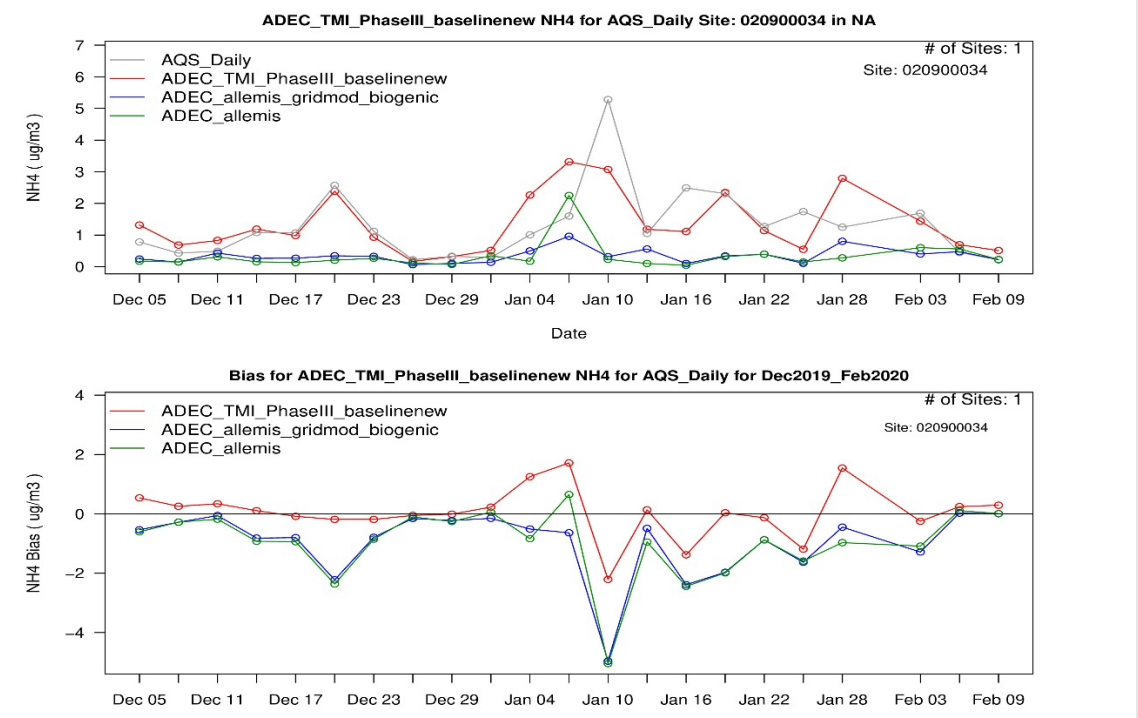


Figure 7.8.15-30 Timeseries Plot for NCore NH_4 Using the Baseline 2020 Modeling Run and the Latest CMAQ Configuration (v533het) 2020 Emissions and Meteorology

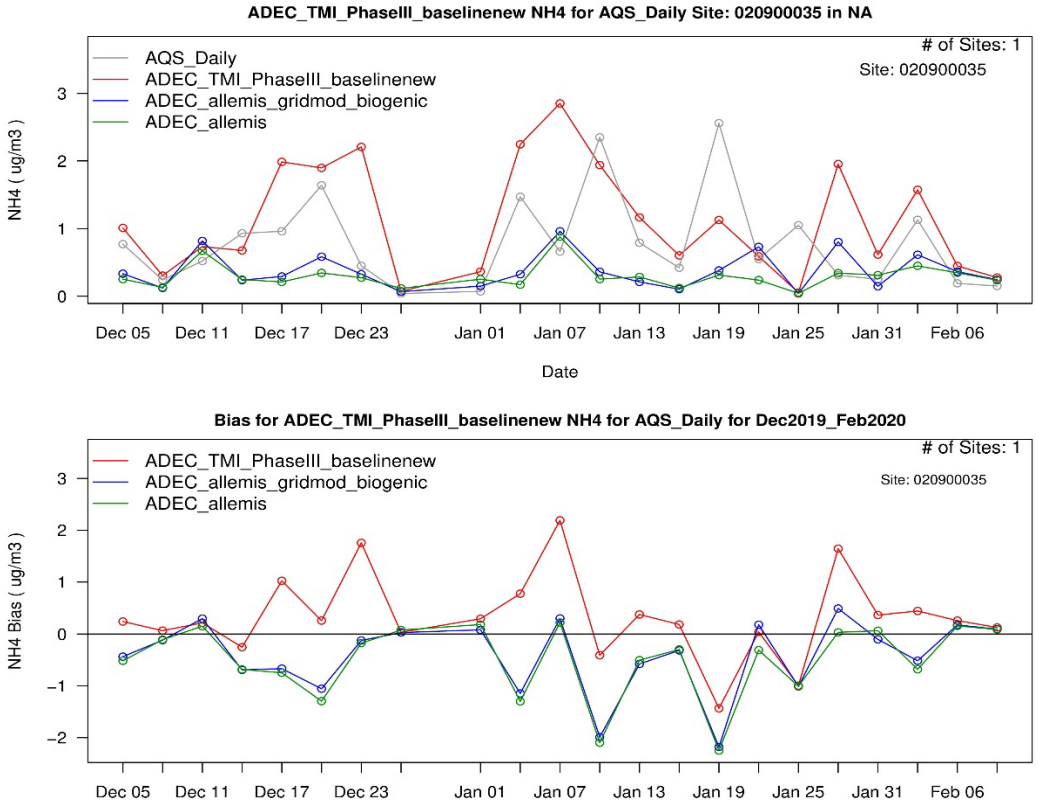


Figure 7.8.15-31 Timeseries Plot for Hurst Road NH_4 Using the Baseline 2020 Modeling Run and the Latest CMAQ Configuration (v533hetchem) 2020 Emissions and Meteorology

Table 7.8.15-5 Domain Wide Statistics

Species	NUM OBS	Mean Obs	Mean Model	Mean Bias	Mean Error	NMB	NME	FB	FE	RMSE	Correlation
NO_3	44	0.87341	1.0356	0.162	0.54	18.6	61.8	-8.57	62.7	0.726	0.4
SO_4	44	2.8325	2.9046	0.0721	1.15	2.55	40.8	1.43	38.2	1.74	0.64
NH_4	44	1.0509	1.2368	0.186	0.585	17.7	55.7	24.6	53.4	0.857	0.58
EC	40	2.6602	2.2028	-0.457	1.15	-17.2	43.1	-11.5	43.3	1.87	0.54
OC	40	9.5506	10.757	1.21	5.26	12.6	55.1	21.8	59.7	7.65	0.69
NaCl	39	0.11387	0.089251	-0.0246	0.0769	-21.6	67.5	8.51	74.1	0.105	0.15
PM_TOT	415	21.481	18.942	-2.54	9.02	-11.8	42	-7.51	43.4	14.1	0.58
TC	40	12.211	12.96	0.749	6.08	6.14	49.8	14.1	52.7	9.28	0.67

Table 7.8.15-6 Hurst Road Statistics

Species	NUM OBS	Mean Obs	Mean Model	ME	MB	NMB	NME	FB	FE	RMSE	Correlation
NO3	22	0.67	1.01	0.60	0.34	50.2	88.5	5.5	73.3	0.79	0.33
SO4	22	2.26	2.52	1.10	0.26	11.5	48.8	4.9	44.0	1.68	0.50
NH4	22	0.80	1.12	0.61	0.33	41.1	76.5	37.9	66.0	0.86	0.43
EC	22	3.53	2.60	1.74	-0.93	-26.3	49.3	-25.9	59.8	2.45	0.45
OC	22	14.47	13.58	6.42	-0.89	-6.2	44.4	-8.9	57.8	9.24	0.64
NaCl	18	0.10	0.08	0.07	-0.02	-19.0	67.7	8.3	77.6	0.09	0.12
PM_TOT	21	25.08	24.96	11.06	-0.12	-0.5	44.1	-9.3	50.1	16.11	0.61
TC	22	18.00	16.18	7.79	-1.82	-10.1	43.3	-12.0	56.2	11.51	0.61

Table 7.8.15-7 NCore Statistics

Species	NUM OBS	Mean Obs	Mean Model	ME	MB	NMB	NME	FB	FE	RMSE	Correlation
NO3	22	1.07	1.06	0.48	-0.01	-1.3	45.0	-22.6	52.2	0.65	0.51
SO4	22	3.41	3.29	1.21	-0.12	-3.4	35.4	-2.1	32.3	1.80	0.69
NH4	22	1.31	1.35	0.56	0.05	3.4	43.0	11.2	40.8	0.85	0.66
EC	18	1.60	1.72	0.42	0.12	7.5	26.5	6.0	23.1	0.63	0.71
OC	18	3.54	7.31	3.84	3.77	106.6	108.5	59.3	61.9	5.06	0.82
NaCl	21	0.13	0.10	0.08	-0.03	-23.4	67.4	8.7	71.0	0.12	0.13
PM_TOT	18	15.31	18.16	5.68	2.85	18.6	37.1	9.7	27.8	8.52	0.72
TC	18	5.14	9.03	3.98	3.89	75.8	77.4	46.0	48.5	5.44	0.80

Tables 7.8.15-5-7 contain the induvial site statistics. The number of observations available during the 74-day modeling episode are available along with bias, error, root mean square error (RMSE) and the correlation compared to the site-specific filter measurements. There is an overprediction of Organic Carbon at the NCore site and an underprediction at Hurst Road.

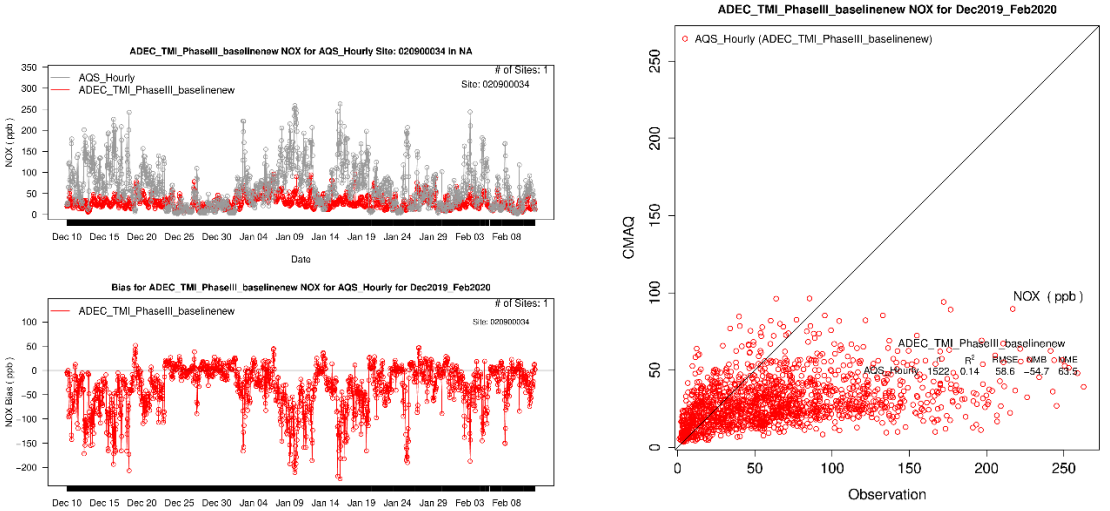


Figure 7.8.15-32 Modeled NOx vs Observed NOy Hourly from the NCore Analyzer in Time Series and Scatter Plots

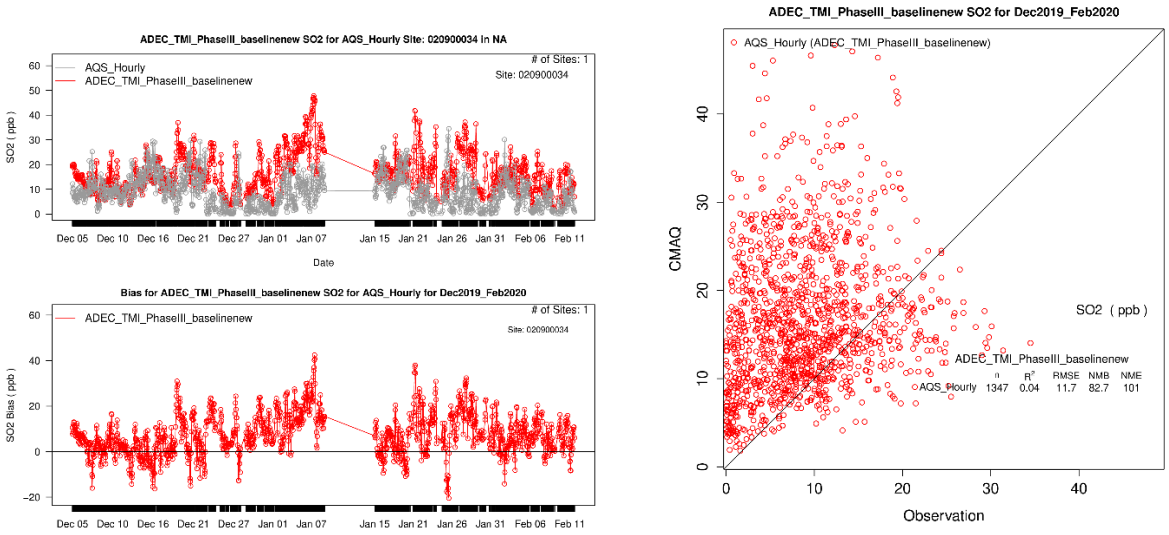


Figure 7.8.15-33 Modeled vs observed SO_2 Hourly from NCore in Times Series and Scatter Plots

Figures 7.8.15 -32 and 33 Hourly precursor model performance is available for NCore compared to the NOy analyzer at NCore and the SO_2. The model is overpredicting for SO_2 and underpredicting for NOx.

7.8.15.5 SMAT Methods

The method used for establishing the design value follows the first three steps of the SMAT process as performed in the Serious Area SIP. The most important difference for the 2024 Revised/Amended Serious SIP is that the process will be applied to three sites: A Street, NCore, and Hurst Road monitors.

- **Step 1: Establish the high concentration days and 98th percentile day for each year (2017-2021).**
- **Step 2: Develop representative chemical speciation profile of $PM_{2.5}$ for the 10% highest concentration days using SANDWICH as represented by Table 7.8.15-8. For the case of the Hurst Road monitor, ADEC used the top 15% highest concentration days due to the higher number of exceedances.**
- **Step 3: Use the speciation profile to calculate speciation of the highest days.**
- **Step 4: Calculate Relative Response Factors (RRFs) for each component of $PM_{2.5}$ at both monitors. RRFs are calculated as the future modeled concentrations divided by the baseline concentrations. The RRF values represent the fractional change in concentrations due to changes in population, activity, and control measures that occur between the base year and the attainment year.**
- **Step 5-6: Apply RRFs to quarterly observations (only Q1 and Q4 are relevant for Fairbanks and North Pole monitors).**
- **Step 7: Sum the RRF-adjusted species to obtain total daily $PM_{2.5}$.**
- **Step 8: Determine the RRF-adjusted 98th percentile concentrations for each monitor.**
- **Step 9: Calculate the future projected 5-year weighted 24-hr design value for project base year and control model runs.**

The summary of the result of using the SMAT process to establish the percent of each species at each monitor is in Table 7.8.15-8. The design values allow the model to be anchored in filter-based measurements before attempting control model runs. The process is outlined in the EPA $PM_{2.5}$ guidance and a compete spreadsheet with of the calculations is found in the Modeling Appendix. The 5-year DV for Hurst is 64.9, NCore is 27.7 and A street is 34.9 in $\mu g/m^3$ for $PM_{2.5}$. Using modeling as a tool, the modeling runs then used emissions with controls updated based on the table in the Emission Inventory Chapter

(Section III.D.7.6). The modeling runs are anchored by the base year 2020 and the relative response factors (RRFs) are all 1. They are 1 as a starting point or base year and then additional control strategies are applied. The RRFs are reflective of the changes to each species as noted above until the final attainment year is reached when every grid cell in the nonattainment area is below 34.5 µg/m^3 for $PM_{2.5}$. The pie charts in Figures 7.8.15-32 to 7.8.15-34 show that organic carbon is between 47-71% (depending on the monitor location) are attributed to home heating with wood stoves is the highest species and the second is sulfate at 9-21%,

	Table 7.8.15-8 Speciation at Fairbanks Nonattainment Area Monitors 2017-2021						
SITE	OC	EC	SO_4	NO_3	NH_4	OPP	PBW
A Street	48.9%	10.0%	21.1%	4.5%	7.5%	1.2%	6.8%
NCore	48.2%	10.0%	21.5%	4.6%	7.6%	1.2%	6.8%
Hurst	71.3%	12.3%	9.2%	1.7%	2.4%	0.5%	2.6%

Table 7.8.15-9 SMAT Speciation Data for NCore Monitor 2017-2021

	NCore Top 10% Speciation Data: NCore 2017-2021								
$PM_{2.5}$ Species	Total	OC	EC	SO_4	NO_3	NH_4	OPP	Blank	PBW
% (includes blank)	100%	47%	10%	21%	5%	8%	1%	2%	7%
SMAT (µg/m^3)	32.19	15.29	3.16	6.83	1.47	2.42	0.40	0.50	2.14
5-yr DV*	27.7	13.11	2.71	5.85	1.26	2.07	0.34	0.50	1.84

Table 7.8.15-10 SMAT Speciation Data for Hurst Monitor 2018-2021

	Hurst Top 15% Speciation Data: Hurst 2018-2021								
$PM_{2.5}$ Species	Total	OC	EC	SO_4	NO_3	NH_4	OPP	Blank	PBW
% (includes blank)	100%	71%	12%	9%	2%	2%	0%	1%	3%
SMAT (µg/m^3)	49.26	34.79	6.02	4.46	0.81	1.16	0.24	0.50	1.29
5-yr DV*	64.9	45.97	7.95	5.90	1.06	1.53	0.31	0.50	1.70

Table 7.8.15-11 SMAT Speciation Data for A Street Monitor 2017-2021

	A Street Top 10% Speciation Data: A Street 2017-2021) (Speciation data is from NCore)								
$PM_{2.5}$ Species	Total	OC	EC	SO_4	NO_3	NH_4	OPPa	Blank	PBW
% (includes blank)	100%	48%	10%	21%	4%	7%	1%	2%	7%
SMAT (µg/m^3)	32.98	15.87	3.24	6.86	1.45	2.44	0.40	0.50	2.21
5-yr DV*	34.8	16.75	3.42	7.24	1.53	2.57	0.42	0.50	2.33

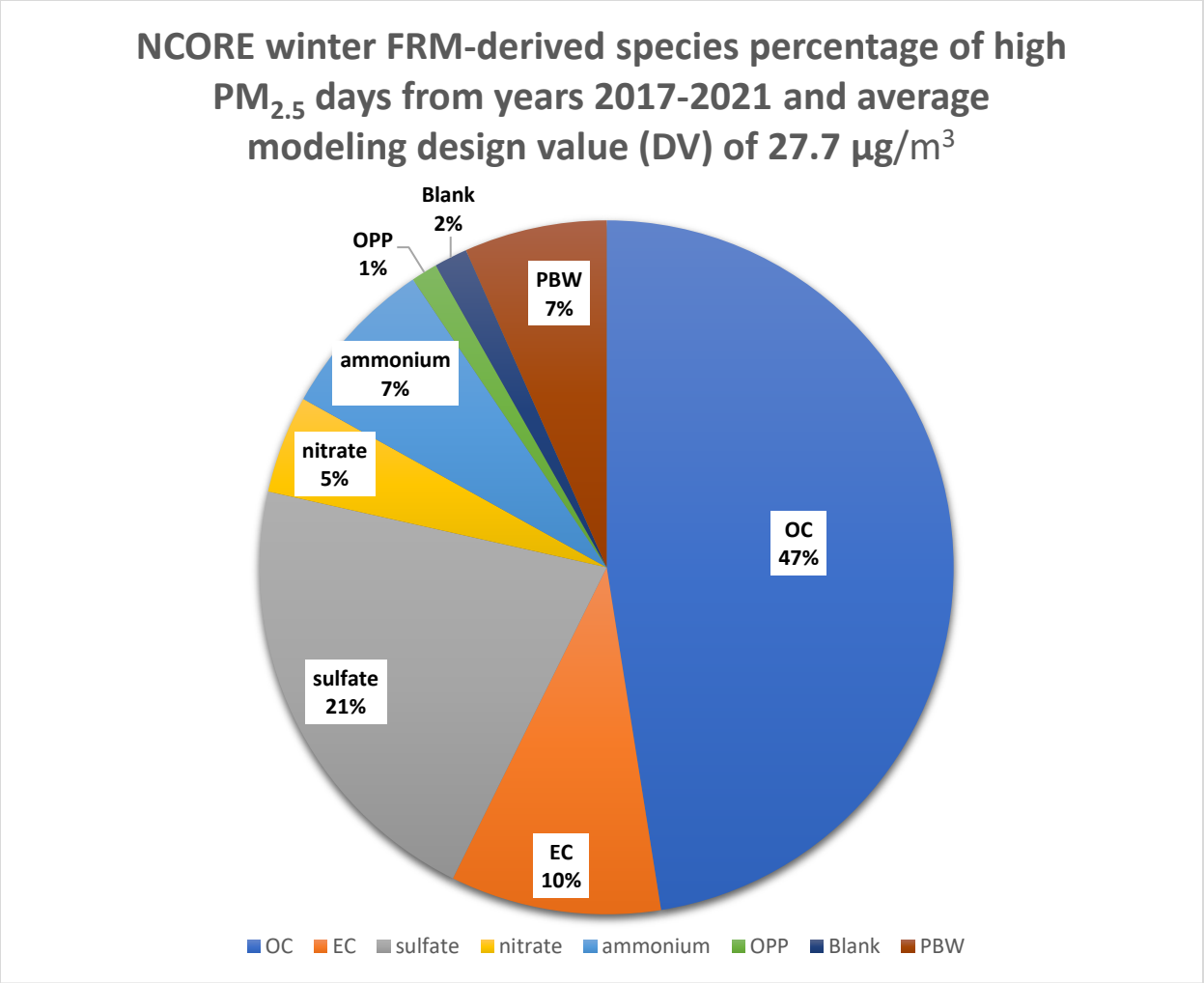


Figure 7.8.15-34 24-hr Average FRM-derived $PM_{2.5}$ Speciation Concentrations Based on the Design Value (DV) of 27 µg/m³ for Fairbanks NCore Monitor

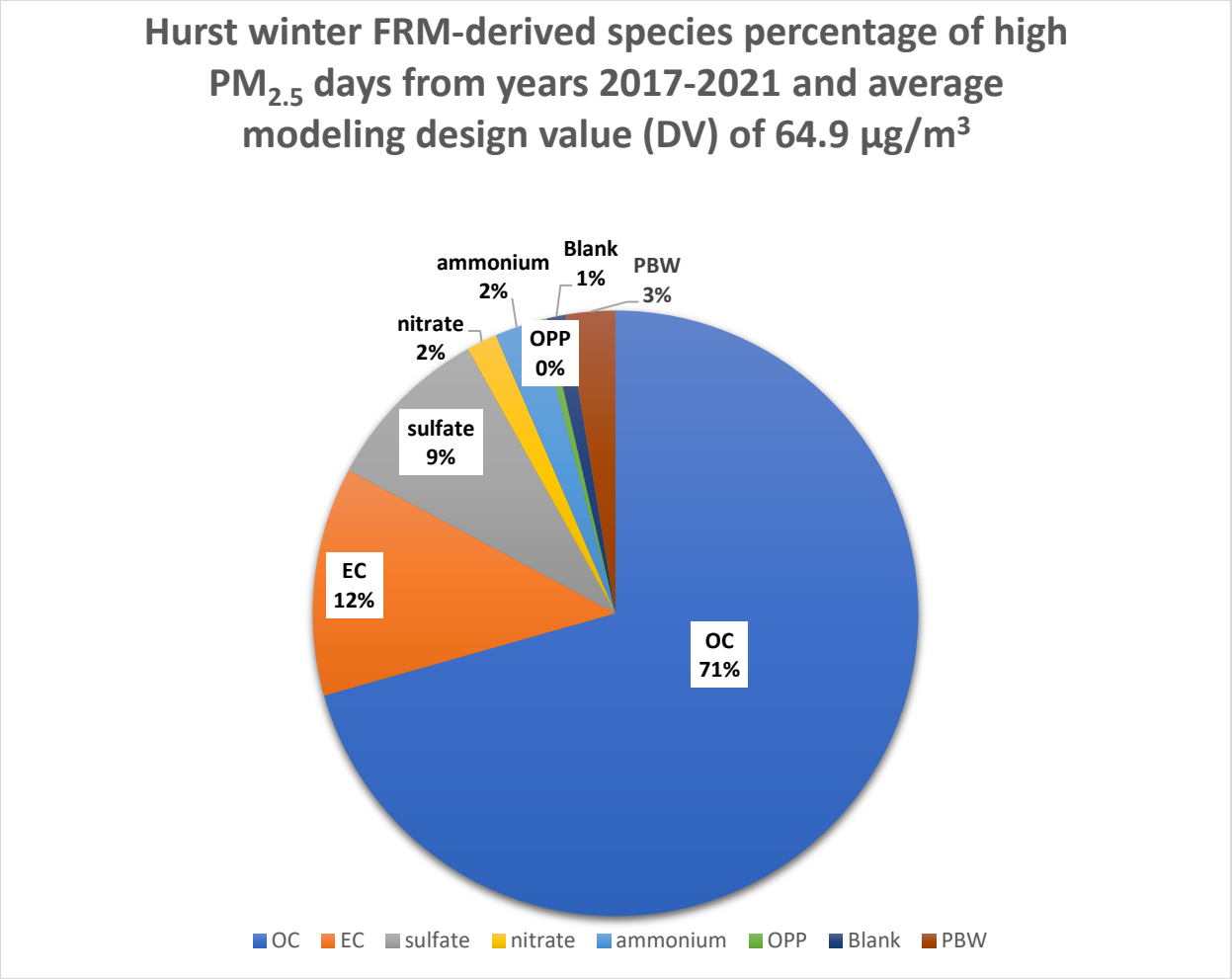


Figure 7.8.15-35 24-hr Average FRM-Derived $PM_{2.5}$ Speciation Concentrations Based on the Design Value (DV) of 64.9 µg/m^3 for the High $PM_{2.5}$ Winter Days at Hurst Road

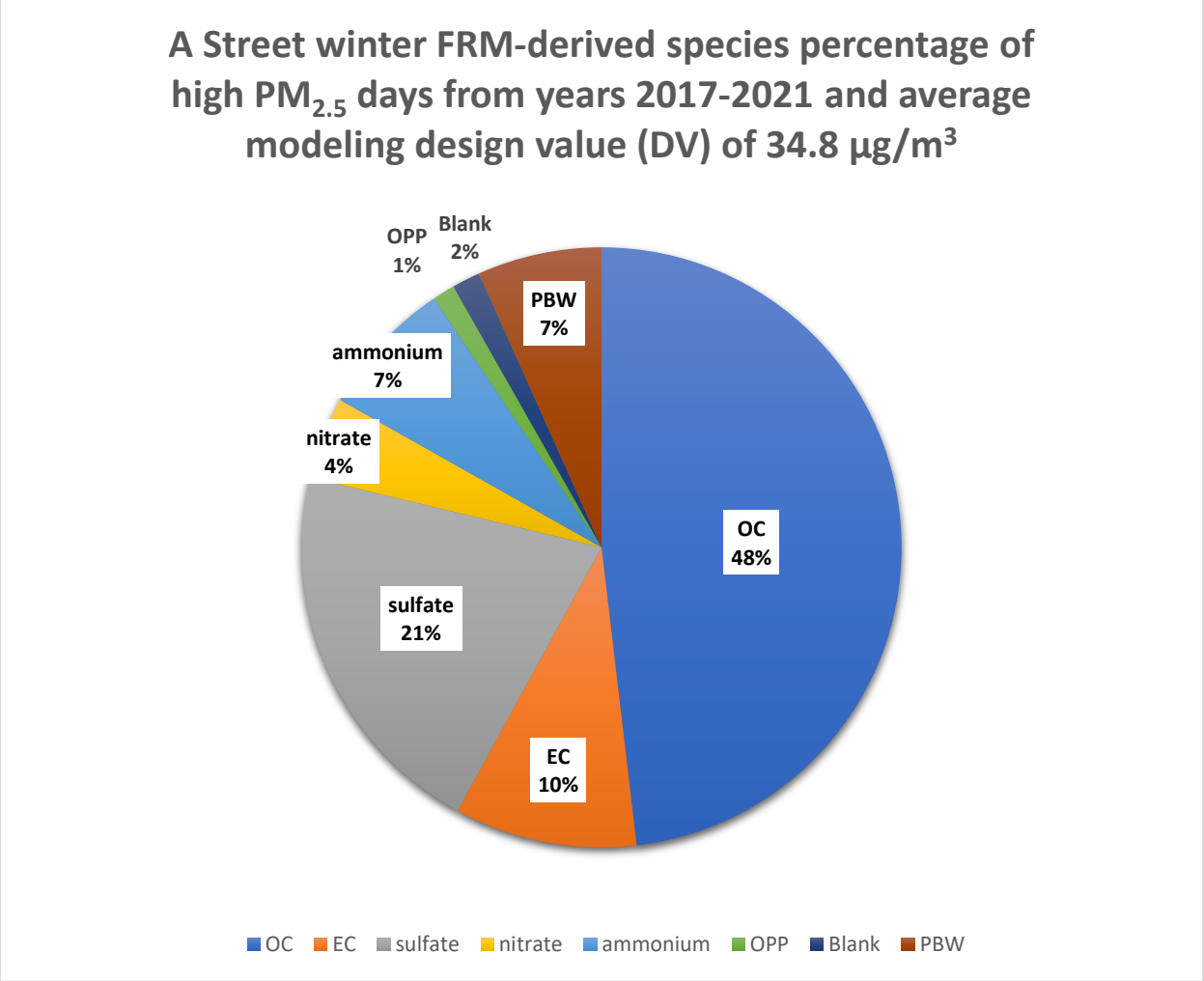


Figure 7.8.15-36 24-hr Average FRM-Derived $PM_{2.5}$ Speciation Concentrations Based on the Design Value (DV) of 34.8 µg/m³ for A Street Monitor

7.8.16 2020 Base Year and 2027 Attainment Demonstration

The base year 2020 spatially gridded plots are below. The plots are the raw model outputs, before the SMAT process and reflect the high and low episode average concentrations throughout the nonattainment area. The end result is the attainment model run showing concentrations below 34.5µg/m^3 of total $PM_{2.5}$, note the concentrations maybe higher then the gridded plots below (Figure 7.8.16-1 through 10) after the SMAT process. The spatial plots are used to make sure the high concentration areas make sense and in line with filter-based measurements of the area. The attainment year is 2027 and is the second plot, the model run has all the controls that plan to be in place in 2027 and that is why it is called a control run. After the SMAT process the result of the 2027 control run is that the monitored grid cells are in attainment at Hurst Road, NCore and A street. The 2027 control run is the attainment year. Then the third plot is the difference of the two showing the areas where the control strategies have the largest effect. The plots are for total $PM_{2.5}$ and species: sulfate, nitrate, ammonium, organic and elemental carbon, and PM other.

The final result of the modeling spatial plots is to take the monitored grid cells and go through the SMAT process and have design value for $PM_{2.5}$ that is below 34.5 µg/m^3 and therefore in attainment. Once the attainment year is established, an additional emissions inventory is produced (details in the Emission Inventory Chapter (Section III.D.7.6) for the year 2026 to make sure a more expeditious attainment is not possible. The results of the attainment year and 2026 are in Table 7.8.16-1. The Hurst Road monitor is estimated to be 31.9 in the year 2027 and in attainment and the prior year 2026, is 38.1. The discussion of controls that led to the attainment year is in the Attainment Demonstration Chapter (Section III.D.7.9).

Table 7.8.16-1 The Results for Attainment Year and 2026 at Hurst Road, NCore, and A Street

Fairbanks Nonattainment Area Monitor	Base year 2020 5-year modeling design value for $PM_{2.5}$ (µg/m)	Expeditious Attainment not possible 2026 $PM_{2.5}$ (µg/m^3)	Attainment Future 3 -year modeling DV 2027 $PM_{2.5}$ (µg/m^3)
Hurst Road	64.9	38.1	31.9
NCore	27.7	19.8	18.4
A Street	34.8	24.5	22.7

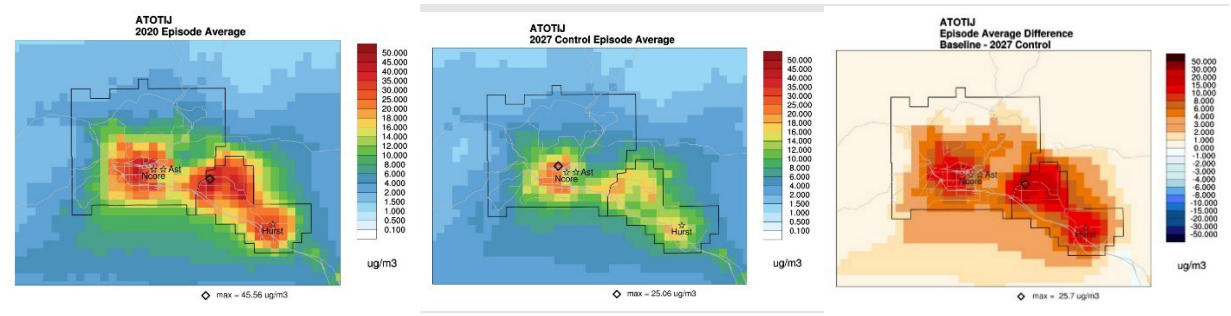


Figure 7.8.16-1 Base Year 2020, 2027 (Control Run), Difference PM Total Plots

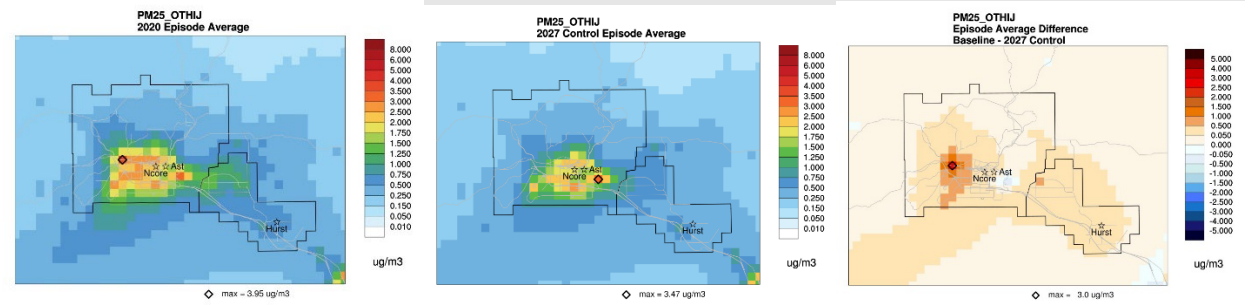


Figure 7.8.16-2 Base Year 2020, 2027 (Control Run), Difference PM Other Plots

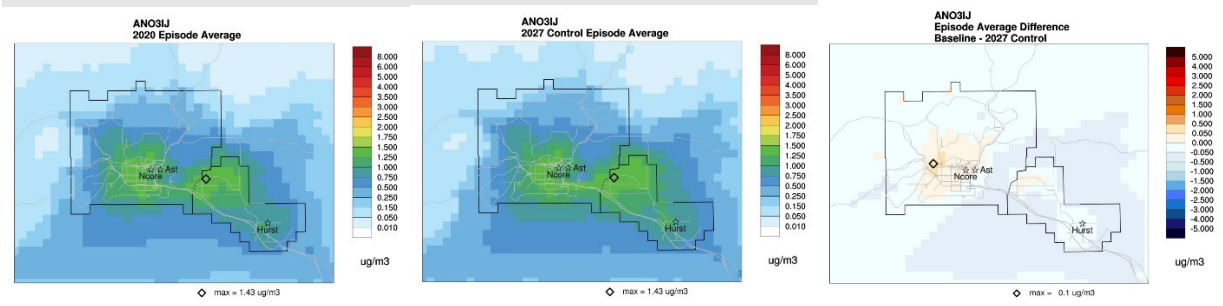


Figure 7.8.16-3 Base Year 2020, 2027 (Control Run), Difference NO_3 Plots

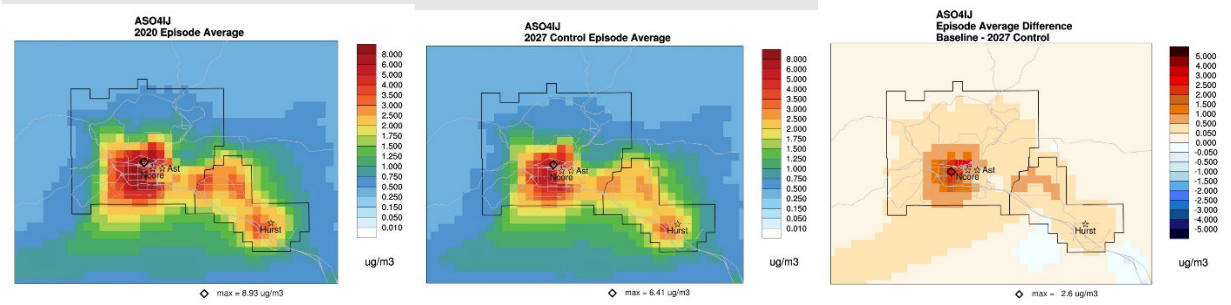


Figure 7.8.16-4 Base Year 2020, 2027 (Control Run), Difference SO_4 Plots (Fuel Oil Switch from 2020 to 2027)

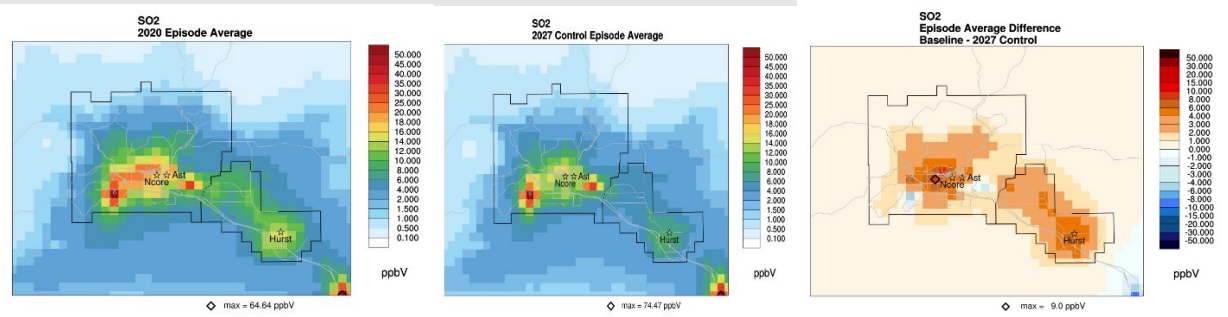


Figure 7.8.16-5 Base Year 2020, 2027 (Control Run), Difference SO_2 Plots

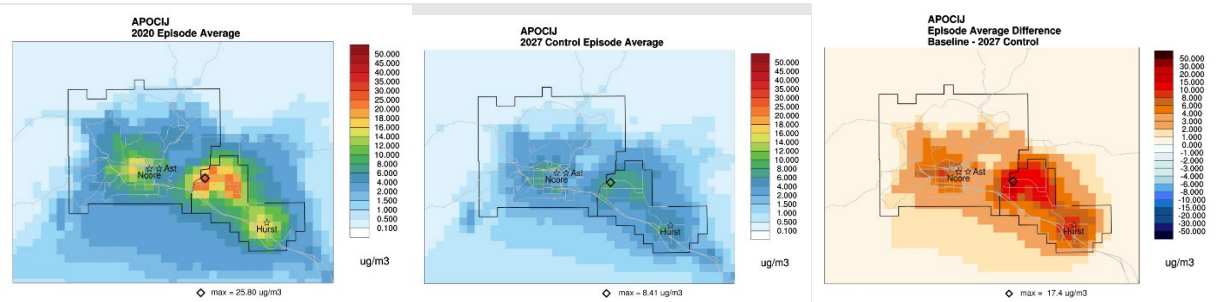


Figure 7.8.16-6 Base Year 2020, 2027 (Control Run), Difference OC Plots

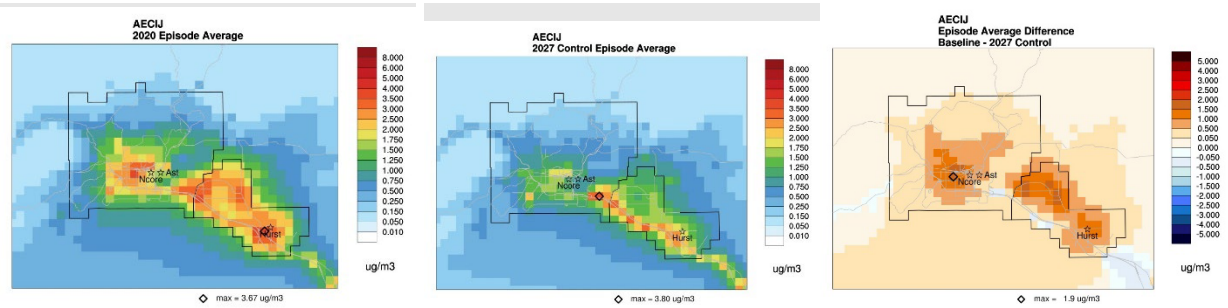


Figure 7.8.16-7 Base Year 2020, 2027 (Control Run), Difference EC Plots

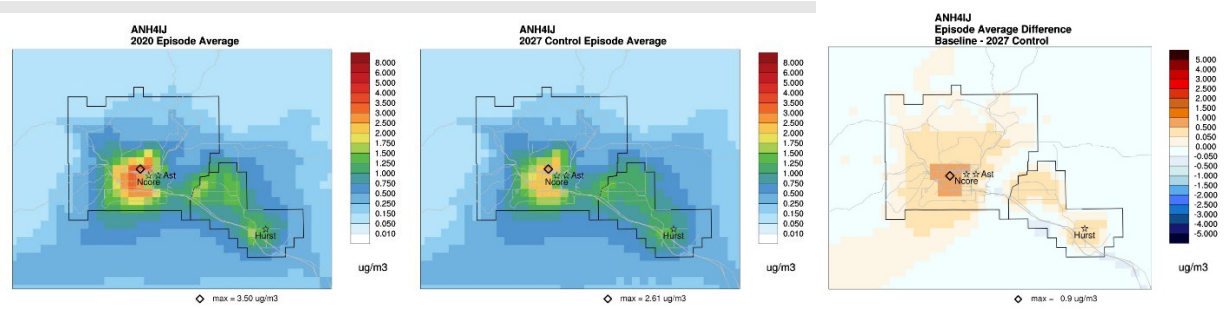


Figure 7.8.16-8 Base Year 2020, 2027 (Control Run), Difference NH_4 Plots

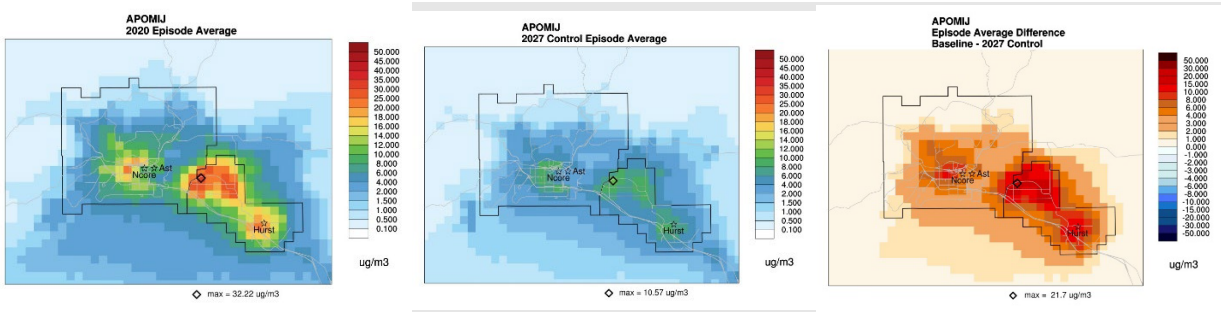


Figure 7.8.16-9 Base Year 2020, 2027 (Control Run), Difference POM Plots

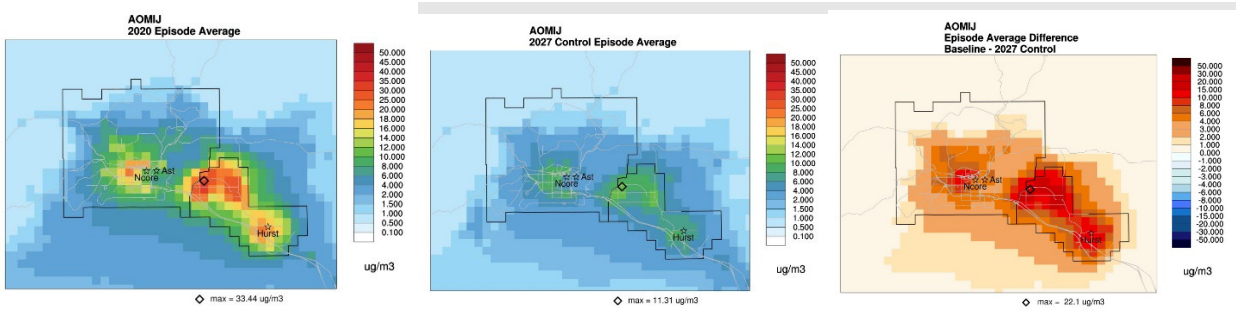


Figure 7.8.16-10 Base Year 2020, 2027 (Control Run), Difference OM Plots

7.8.18 SO_2 Precursor Demonstration

Summary:

In accordance with 40 CFR 51.1006(a)(2), the SO_2 precursor demonstration below shows that SO_2 emissions from all existing major stationary sources located in the Fairbanks PM 2.5 Nonattainment Area do not contribute significantly to $PM_{2.5}$ levels that exceed the 24-hr standard in that area. ADEC performed a concentration-based contribution analysis using air quality modeling with "zero-out" model runs. EPA guidance establishes an threshold of 1.5 µg/m^3 below which precursor impacts are insignificant, and ADEC's analysis shows that major stationary sources contribute 0.21 µg/m^3, meaning they do not contribute significantly to $PM_{2.5}$ levels that exceed the 24-hr standard.

Regulatory Framework and EPA Guidance:

The SO_2 precursor demonstration is an optional demonstration showing the insignificance of a precursor gas on the concentration of the 24-hour $PM_{2.5}$ design value in a nonattainment area.[60] Under federal regulation, "[a] major stationary source precursor demonstration must show that emissions of a particular precursor from all existing major stationary sources located in the nonattainment area do not contribute significantly to $PM_{2.5}$ levels that exceed the standard in the area."[61] The state *must* conduct a concentration-based analysis, and *may* conduct a sensitivity-based analysis.[62] If the precursor contribution to area $PM_{2.5}$ levels or the estimated air quality changes in the sensitivity analysis are "not significant, based on the facts and circumstances of the area," then EPA may approve the demonstration.[63]

EPA has published guidance for $PM_{2.5}$ precursor demonstrations.[64] The guidance identifies 1.5 µg/m^3 as the threshold below which precursor impacts are "insignificant," and thus do not "contribute" to $PM_{2.5}$ concentrations that exceed the 24-hr $PM_{2.5}$ standard.[65] A precursor demonstration is generally adequate to support exempting sources of a precursor from control requirements if the analysis shows that the air quality impact at all relevant locations does not exceed the recommended contribution threshold, (i.e. 1.5 µg/m^3 for the 24-hour $PM_{2.5}$ standard).[66]

SO_2 Precursor Demonstration for the Fairbanks North Star Borough 24-hour $PM_{2.5}$ Nonattainment Area:

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[60] 42 U.S.C. § 7513a(e); *see also NRDC v. EPA*, 706 F.3d 428, at 437 n.10 (2013) (applying this statutory provision to the regulation of sources of PM 2.5 precursors).
[61] 40 C.F.R. § 51.1006(a)(2).
[62] *Id.*
[63] 40 C.F.R. § 51.1006(a)(2)(i)–(ii).
[64] EPA, Fine Particulate Matter ($PM_{2.5}$) Precursor Demonstration Guidance, EPA-454/R-19-004 (May 30, 2019), transmittal_memo_and_pm25_precursor_demo_guidance_5_30_19.pdf (epa.gov).
[65] *Id.* at 17.
[66] *Id.* at 18.

The major stationary source SO_2 precursor demonstration below shows the air quality change of 0.21 µg/m^3 from the major stationary source sector in relevant locations does not "contribute significantly" to the $PM_{2.5}$ standard.

The precursor gases that can convert into $PM_{2.5}$ through secondary chemistry processes are VOCs, NOx, SO_2 and NH_3. The NOx precursor gas forms ammonium nitrate, VOCs condense to form SOA and SO_2 precursor gases form ammonium sulfate and all these components are part of $PM_{2.5}$.

ADEC is applying the same tiered approach to this SO_2 precursor demonstration as for both NOx and VOCs in the Fairbanks North Star Borough 24-hour $PM_{2.5}$ Nonattainment Area in the Serious Area SIP.[67] The NOx and VOC precursor was approved, and it is left as is in this chapter section 7.8.12 and 17, along with the SMAT calculations for the design value used for the precursor demonstration (2011-2015) for NOx and VOC in section7.8.9.4 . It was completed with the speciation, design values, and emissions for the base year 2013 and one later run with the emissions for 2019.

The following approach is for SO_2 precursor gas for the major stationary source sector. The major stationary source sector is defined in the Control Strategies Chapter (Section III.D.7.7). The precursor demonstration uses the base year 2020 and was run with the final updated modeling platform configuration described in Section 7.8.15.2 above, CMAQv533hetchem.

The tiered analysis can be broken down into five stages, each with a decreasing level of confidence in the demonstration. The various precursor demonstrations available are the following:

- **Concentration Based Analysis**
  - **Ambient data**
  - **Air Quality Modeling (zero-out emissions from a precursor gas for NO_X, VOC, and SO_2)**

- **Sensitivity Based Analysis (only if needed- not used for SO_2)**
  - **70% Reduction**
  - **50% Reduction**
  - **30% Reduction**

In other words, ADEC performed the required concentration-based contribution analysis using air quality modeling through "zero-out" model runs.[68] An air quality modeling

[67] ADEC, Amendments to: State Air Quality Control Plan, Vol. II: III.D.7.8, Modeling (Nov. 19, 2019) at III.D.7.8-47, https://dec.alaska.gov/air/anpms/communities/fbks-pm2-5-serious-sip/.

[68] EPA, Fine Particulate Matter ($PM_{2.5}$) Precursor Demonstration Guidance, EPA-454/R-19-004 (May 30, 2019), at 26, transmittal_memo_and_pm25_precursor_demo_guidance_5_30_19.pdf (epa.gov) ("Zero-out" model runs involve at least two model runs: one "baseline" run with all emissions, and one with anthropogenic emissions of the precursor of interest removed from the nonattainment area in the original baseline simulation. The difference between these simulations provides an estimate of the air quality change due to the precursor emissions).

analysis of precursor impacts on $PM_{2.5}$ utilizes a photochemical grid model (PGM) that can account for the non-linear secondary effects of precursor gases. PGMs account for the atmospheric chemistry, transport, and deposition of pollutants using local emissions and meteorological data. The zero-out approach compares a baseline model run with a model run where a precursor's emissions are set to zero to determine the influence of that precursor on $PM_{2.5}$ formation.

The concentration-based analysis was completed as required in the guidance using the tiered approach and the first check is the monitored filter sulfate and the concentrations from the 5-yr DV in Section 7.8.15 above show total sulfate from ALL sectors is 5.9 µg/m^3 or 21% of the $PM_{2.5}$ at NCore and 5.9 µg/m^3 or 9% of the $PM_{2.5}$ at Hurst Road. The total sulfate for all sectors is above 1.5 µg/m^3, as expected since primary sulfate and SO_2 are also emitted from fuel oil in home heating. This SO_2 precursor demonstration is for the major stationary source sector contribution for sulfate.

The major stationary source sector SO_2 precursor model run used the emissions for the base year 2020 and a zero out SO_2 emissions model run. Here, this means 100% of the SO_2 was removed from the point source sector and then the difference in resulting sulfate from the base year to precursor has to be below the limit of 1.5 µg/m^3 in the final design value (DV). The concentration-based modeling demonstrated the insignificance of SO_2 when compared with the 1.5 µg/m^3 threshold in EPA guidance, and so under 40 CFR 51.1006(a)(2)(ii) a sensitivity-based contribution analysis was unnecessary.

The SO_2 precursor demonstration of the Design Value concentration of 0.21 µg/m^3 of sulfate contribution to $PM_{2.5}$ at Hurst Road monitor is for the episode average concentration.

In table 7.8.18-1 is a summary of the concentrations at the monitors from the base year 2020 SO_2 zero out major stationary source model run. This includes the max cell, max day in the absolute concentration, and the max day in the design value concentration at the monitors NCore, Hurst and A Street and all of the concentrations are below 1.5µg/m^3, the recommended 24-hour NAAQS threshold for $PM_{2.5}$ precursor demonstrations. The largest daily value is at Hurst Road, which is – 0.6 µg/m^3. The value is negative because it is the daily average SO2 precursor. So, that decrease in sulfate as a result of the SO_2 removed from the point source sector. Another way to think about this is when the SO_2 is present from all the point sources, the max daily contribution of sulfate is 0.6 µg/m^3 to $PM_{2.5}$. This is the most conservative assessment of the contribution to the monitored grid cells. The spreadsheet with the detailed calculations for Table 7.8.17-1 is in the modeling chapter appendix.

Table 7.8.18-1 SO_2 Precursor Summary

New!		Episode Average			Max Daily Value		
CMAQ Sensitivity 100%		A Street	NCore	Hurst	A Street	NCore	Hurst
CMAQ - Absolute							
	SOx	-0.08703	-0.14015	-0.06109	-0.23067	-0.37986	-0.60623
CMAQ - Design Value							
	SOx	-0.21665	-0.14372	-0.21052			

Additional weight of evidence analyses were performed after the episode average and maximum daily monitored concentrations to find the max concentration during the 74-day meteorological episode at any single grid cell in the entire non-attainment area on any day. A script was used to look at all grid cells in the nonattainment area and the highest concentration was 1.5 µg/m^3. The resulting spatial plots in Figure ~~7.8.~~ 18-2 shows that the day is January 28th when the FRM monitors were at 29 at NCore, 21 at Astreet and Hurst at 34 µg/m^3 of $PM_{2.5}$, the contribution was 1.5µg/m^3 at one cell in North Pole. The Figures 7.8.17-1 and 7.8.17-2 show the gridded spatial results of removing the SO_2 and the resulting missing sulfate so that it is assured there are no cells above the limit.

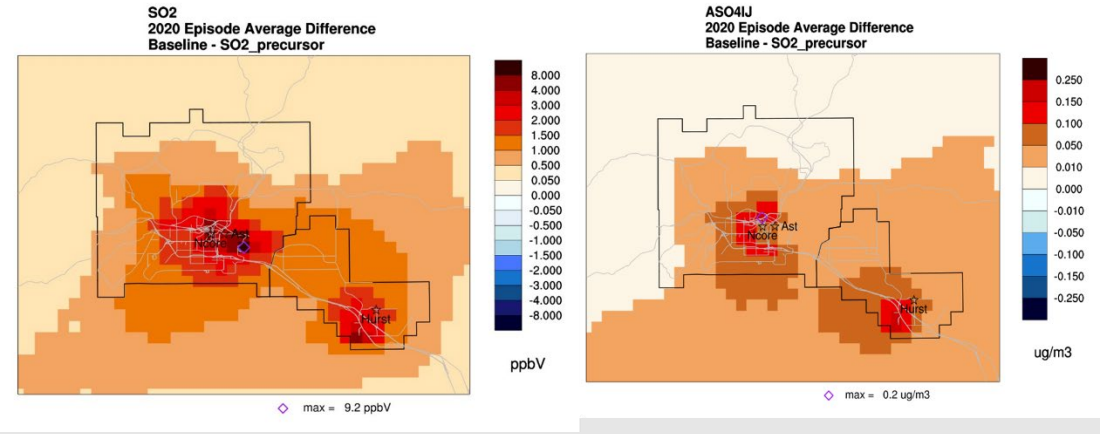


Figure 7.8.17-1 Zero Out SO_2 for the Point Source Sector Model Run

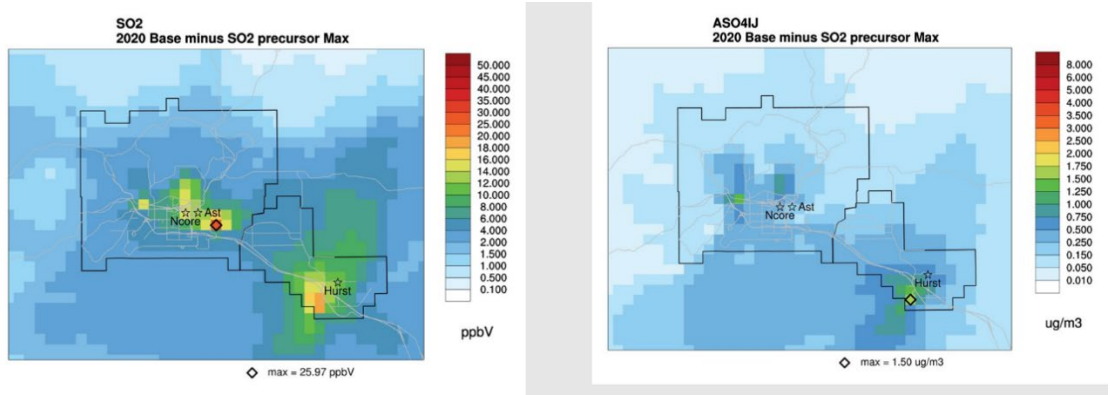


Figure 7.8.18-2 Showing the Max Cell and Max Day in the Entire Nonattainment Area, Grid 91,114 for the SO_2, and Grid 84,121 for the Sulfate on Jan 28th, 2020

Beyond the required modeling for the precursor demonstration, zero out runs for space heating for $PM_{2.5}$ and zero out runs for all pollutants from the point source sector were completed. Removing $PM_{2.5}$ looks at both the primary and secondary contribution of sulfate to $PM_{2.5}$. The summary of these runs is in Table 7.8.18-2. There are caveats to removing all the pollutants in a category and non-linearities may be present, as well as to comparing an episode average to a 5-year Design Value. The concentrations are considered sensitivity runs and not complete mass balance of $PM_{2.5}$. In Table 7.8.18-2, the space heating is the majority of the sulfate at 5.3 µg/m^3 of approximately 5.9 in the 5-year Design Value. The other sector contributions of 0.45 µg/m^3 are mostly from the IC/BC concentrations, as noted above in the CMAQ Set Up (Section 7.8.15.3.), and the 74-day average background concentrations are 0.4 µg/m^3.

Table 7.8.18-2 SO_2 Precursor Additional Sensitivity Model Runs looking at the Contribution from Space Heating

Model run results from zero out point source and space heating (all pollutants) *	**NCore (µg/m^3)**	**Hurst (µg/m^3)**
Space heating sulfate (all sulfate primary and secondary)	**4.6**	**5.3**
Point source sulfate (all sulfate pri and sec* Ccgrid file from base year 2020 12/31/23 and removing all pollutants (not just SO_2)	**0.6**	**0.46**
SUM of Space Heat and Point source sulfate	**5.2**	**5.76**
5-year DV sulfate (monitored data)	**5.85**	**5.9**
other sectors contribution	**0.45**	**0.14**
***non-linear processes may be affecting these numbers**		

The point source sector contribution from the SO_2 precursor gas of less than 1.5 µg/m^3 to $PM_{2.5}$ is an insignificant contribution.

For major stationary sources, the cumulative impact[69] of the modeled SO_2 precursor combined with the prior approved NO_x and VOC precursors is also below the recommended value of 1.5 µg/m^3. The major stationary source contribution to $PM_{2.5}$ from SO_2 is 0.21 µg/m^3, and the contributions from the prior approved demonstrations are 0.4 µg/m^3 from NOx at Hurst Road and equal to or less than 0.1 µg/m^3 from VOC[70] at Hurst Road. From major stationary sources, the total cumulative impact of these three precursors is 0.71 µg/m^3, which is less than the recommended contribution threshold of 1.5 µg/m^3.

Additionally, the combined total precursor contribution from major stationary sources would not meet expeditious attainment. ADEC's updated attainment demonstration in this SIP revision models 38 µg/m^3 in 2026 (i.e. that expeditious attainment of the 35 µg/m^3 standard in that year is not possible), and 31.9 µg/m^3 attainment in 2027. Subtracting 0.71 µg/m^3 (the combined major stationary source precursor contributions) from 38 µg/m^3

[69] *See* EPA, Fine Particulate Matter ($PM_{2.5}$) Precursor Demonstration Guidance, EPA-454/R-19-004 (May 30, 2019), at 18 n.21, transmittal_memo_and_pm25_precursor_demo_guidance_5_30_19.pdf (epa.gov) ("…the individual impact and the cumulative impact of all modeled precursors should be calculated and documented.").

[70] A separate major stationary source precursor demonstration was not completed for VOC, so 0.1 µg/m^3 represents the comprehensive demonstration for that precursor. The major stationary source contribution is equal to or less than that total comprehensive contribution. This analysis adds the full 0.1 µg/m^3 to be conservative. *See* ADEC, Amendments to: State Air Quality Control Plan, Vol. II: III.D.7.8, Modeling (Nov. 19, 2019) at III.D.7.8-56, https://dec.alaska.gov/air/anpms/communities/fbks-pm2-5-serious-sip/.

would not get to attainment. More on the attainment demonstration is found in the Attainment Demonstration Chapter (Section III.D.7.9) of this SIP revision.

7.8.18.1 Additional Sulfate analyses

The final configuration of CMAQver5.33hetchem with updated heterogenous chemistry for sulfate had led to large improvement in the model performance for sulfate. The old model performance was missing 89% of the sulfate at the only site, the Fairbanks monitor. The current sulfate for domain wide (Hurst and NCore) is 2.5% NMB and +/- 40% NME. The tool for sulfur tracking is called sulfur tracking method (STM) in the model, and allows tracking of primary and secondary species. Included in Figures 7.8.17-3-5 is the amount of sulfate produced from secondary chemistry from each monitor site in green, and the primary sulfate in red. The model shows on average 60% of the sulfate is primary, and 40% is secondary. The modeled primary and secondary fractions of sulfate are corroborated by the Moon et al. 2023 paper from the ALPACA field campaign(see weight of Evidence section 7.8.18), showing 62% of the ambient measured sulfate particles are primary and 38% are secondary.[71] The secondary sulfate production is variable due to the different chemical processes that control sulfate by transition metals and HMS being the dominant pathways. The contributions overall are as follows:

S(IV)+HCHO → HMS in aerosol water
S(IV)+NO2→ sulfate in aerosol and cloud/fog water
S(IV)+O2 catalyzed by TMI→ sulfate in cloud/fog water

The dominate contribution pathways are different for different locations in the non-attainment area and change under different meteorological conditions.
These contributions added to the model resulted in improved model performance due to the ALPACA and RARE project CMAQ work.[72]

[71] Moon et al., *Primary Sulfate Is the Dominant Source of Particulate Sulfate during Winter in Fairbanks, Alaska*, ACS EST Air 2024, 1, 3, 139–149 (November 29, 2023), https://pubs.acs.org/doi/10.1021/acsestair.3c00023.
[72] https://cfpub.epa.gov/si/si_public_record_Report.cfm?Lab=CEMM&dirEntryId=358029

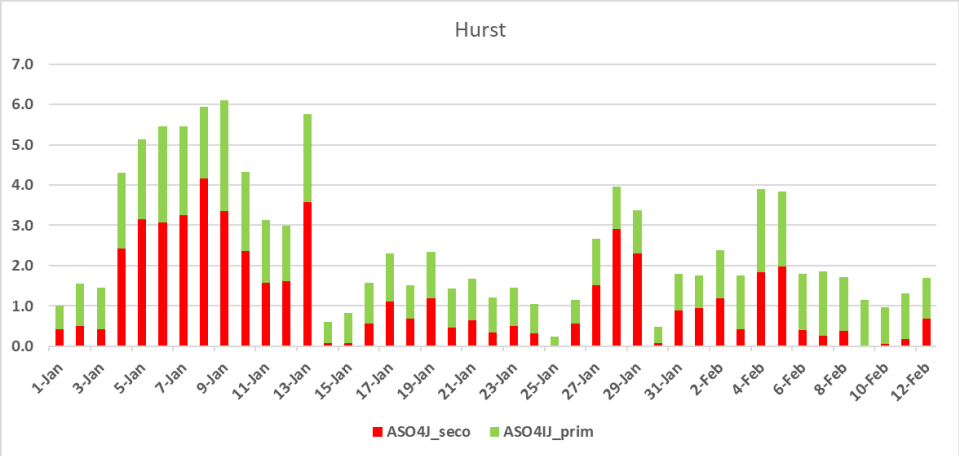
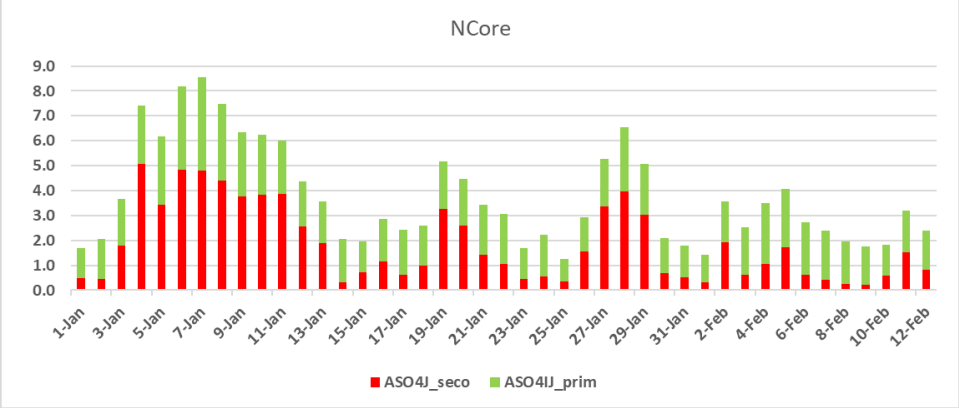


Figure 7.8.18-3 Amount of Sulfate Produced from Secondary Chemistry in green (ASO4IJ) at Hurst Road



[73]

Figure 7.8.18-4 Amount of Sulfate Produced from Secondary Chemistry in green (ASO4IJ) at NCore

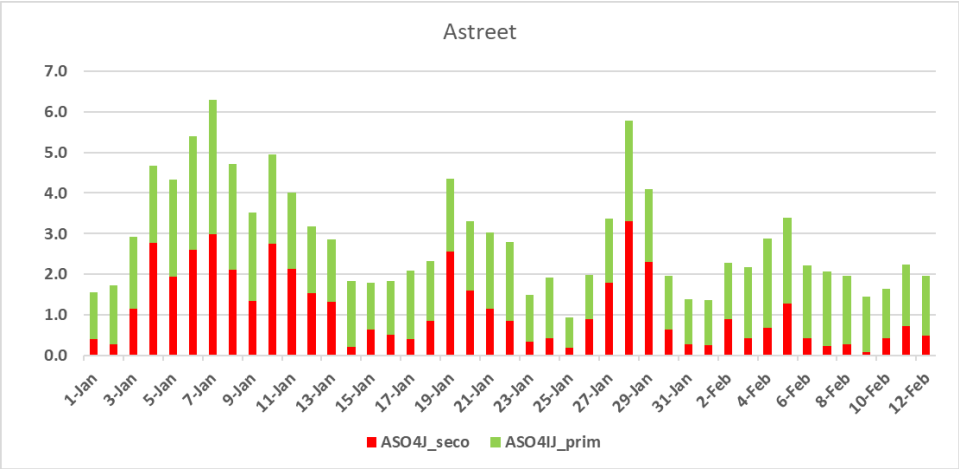


Figure 7.8.18-5 Amount of Sulfate Produced from Secondary Chemistry at A Street

[73] https://acsopenscience.org/researchers/open-access/

The EPA-ORD recently found a bug (a misplaced parenthesis) in the ionic strength factor for the SO_2 Henry's law coefficient in the version used for regulatory analysis. The figure 7.8.18-6 shows the generally decreased modeled SO_4 as the red line (bug fix) vs orange (old) during the ALPACA 2022 field study. DEC is not updating the code because the amount of sulfate is conservative, slightly higher for regulatory modeling, and the % decrease in sulfate for MPE is still within the goals at 42% +/-27. The updated bug fix code was sent to DEC and the model run showed the same decrease in sulfate for site 34 and 35 (NCore and Hurst) in Figure 7.8.18-7 and 8 . for sulfate. The change did not affect the other species, but the resulting time series for the updated bug fix are in the modeling appendix.

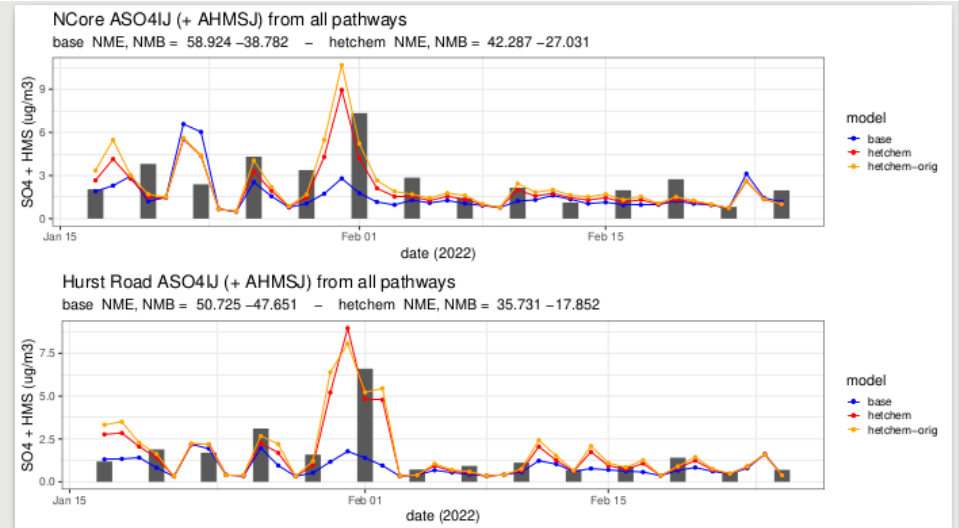


Figure 7.8.17-6 Comparing the original CMAQ code to the updated code with the bug fix from EPA-ORD and the 2022 ALPACA field study.

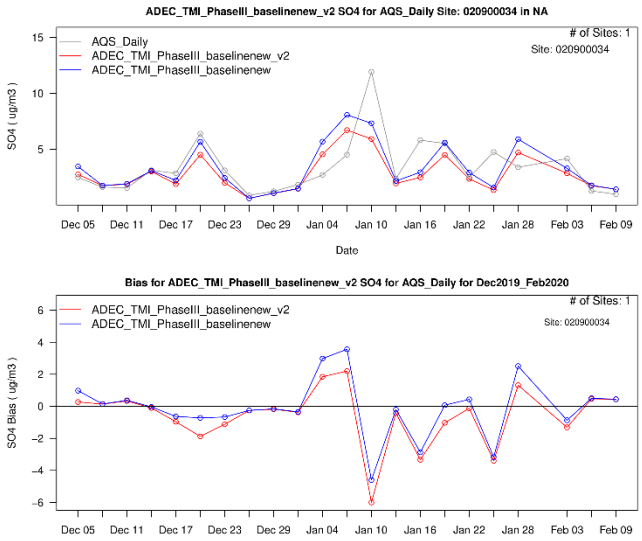


Figure 7.8.18-7 comparing the current final CMAQ code CMAQv533hetchem to the bug fix code labeled ADEC_TMI_PhaseIII_baselinenew_v2 for site 34, NCore

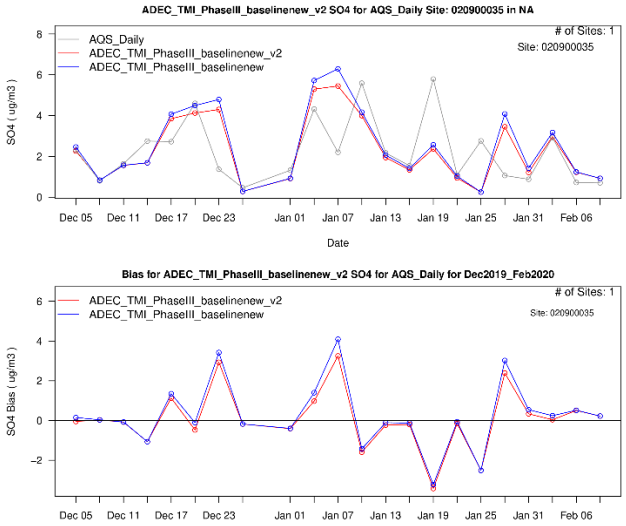


Figure 7.8.18-8 comparing the current final CMAQ code CMAQv533hetchem to the bug fix code labeled ADEC_TMI_PhaseIII_baselinenew_v2 for site 35, Hurst

7.8.19 Weight of Evidence

The Fairbanks Alaskan Layered Pollution and Chemical Analysis (ALPACA) winter air quality study in 2022 brought 50 scientists from all over the world to study air pollution in

Fairbanks. The study was designed to better understand what processes, sources and chemistry lead to high PM concentrations in an extremely cold and dark environment. There was an extensive suite of meteorological and chemical measurements collected in and around Fairbanks in combination with modeling during and after the field experiments were completed.

The current version of the CMAQ version 5.33 was improved as part of ALPACA through an EPA RARE project and working with EPA-ORD. The final code is in the draft phase and in process for publication. The main changes, as mentioned above, are CMAQ updated with heterogeneous sulfur chemistry in aerosol water, including the production and loss of HMS, which may sometimes be misidentified as sulfate during routine PM composition analysis.[74]

The ALPACA group of scientists is still actively publishing papers, and they are involved in local air quality stakeholder meetings as well as publishing articles in local newspapers and journals.[75]

The paper by Moon et al. is directly related to the proportion of primary and secondary sulfate found in the modeling, corroborating the model is appropriate for the SIP analysis with the same findings that primary sulfate is dominate in the Fairbanks area.

Table 7.8.19-1 Weight of Evidence – ALPACA papers and status as of 3/14/2024

Working title	Lead Author	Present to team	Unavailable dates	Intended Journal	Status	
The Alaskan Layered Pollution and Chemical Analysis (ALPACA) field experiment	Bill Simpson	June	6 June -- PACES mtg.		Published ASAP 21 Feb 2024	https://doi.org/10.1021/acsestair.3c00076
Shallow boundary layer heights controlled by the surface-based temperature inversion strength are responsible for trapping home-heating emissions near the ground level in Fairbanks, Alaska.	Meeta Cesler-Maloney	June	06/27 to 07/01	ACP	pre-print online (ACPD) 3 Jan 2024	https://egusphere.copernicus.org/preprints/2024/egusphere-2023-3082/

[74] https://cfpub.epa.gov/si/si_public_record_report.cfm?Lab=CEMM&dirEntryId=359147&submit=Search
[75] https://www.newsminer.com/news/local_news/updated-air-quality-report-highlights-sulfur-decrease/article_c15cab74-79b7-11ee-804b-13f6af1b735f.html

Primary sulfate is the dominant source of particulate sulfate during winter in Fairbanks, Alaska	Allison Moon	June	PACES meeting	ES&T Air	Accepted! Published ASAP	https://pubs.acs.org/doi/10.1021/acsestair.3c00023
Reactive Oxygen Species and Oxidative Potential of Particulate Matter in Wintertime Fairbanks during ALPACA 2022 campaign	Sukriti Kapur	June	7th June	ACS Earth & Space Chemistry	Draft circulating	
Hydroxymethanesulfonate and Sulfur (IV) in Fairbanks Winter During the ALPACA Study	Kayane Dingilian	June	6/17-6/21 (tent.) Brother's graduation	ES&T Air	Submitted	
Enhanced aqueous formation and neutralization of fine atmospheric particles driven by extreme cold	James Campbell	June		PNAS	Submitted	
Assessing the Oxidative Potential of $PM_{2.5}$ in Wintertime Fairbanks, Alaska	Yuhan Yang	June		ES&T Air	Published	
Investigating processes affecting wintertime air pollution variability in the Arctic boundary layer during ALPACA-2022	Natalie Brett	June		ACP	Drafting	
Estimating power plant contributions relative to the surface in the stable Arctic boundary layer	Natalie Brett	June (1 paper divided into two)		ES&T Air	Drafting	
Residential Wood Burning and Vehicle Emissions as Major Sources of Environmentally	Kasey Edwards	June		EST	Submitted	

Persistent Free Radicals in Fairbanks, AK						
Manuscripts discussed in September 2023	**Lead Author**	**Present to team (Sept.)**	**Unavailable dates**	**Intended Journal**	**Status**	
Source apportionment of organic aerosol in Fairbanks, Alaska, during wintertime with insights from molecular characterization with the CHARON PTR ToF MS	Amna Ijaz	Sept.		ACP (journal tentative)	Drafting	
Unexpected Photochemistry in Subarctic Particles During Winter: Evidence from Photooxidants	Laura Heinlein	Sept.		ACP	Writing	
Hydrogen peroxide photoformation and its contribution to sulfate formation in winter particles from Fairbanks, Alaska	Michael Sunday	Sept.		ACP	Writing	
Real-time chemical composition and size of cooking-generated aerosols indoors	Logan Forshee	Sept.		ES&T Air	Manuscript in prep	
Microspectroscopic Observations of Primary and Secondary Sulfur within Individual Atmospheric Particles in Wintertime Fairbanks, Alaska	Emily Costa	Sept.		ES&T Air	Manuscript in prep	
Identification and Quantification of Sulfur-containing Species	Andrew Holen, Judy Wu	Sept.		ES&T Air	Manuscript in prep	

Indoor - Outdoor Oxidative Potential of $PM_{2.5}$ in Wintertime Fairbanks, Alaska: Impact of Air Infiltration and Indoor Activities	Yuhan Yang	Sept.		ES&T Air	Published	
Multi-year, high-time resolution aerosol chemical composition and mass measurements from Fairbanks, Alaska	Ellis Robinson	Sept.		ES: Atmospheres	Submitted 15 Jan 2024	
Snow chemical composition during ALPACA and contribution from atmospheric dry depositions	Federico Scoto	All-Hands Mtg. 2023-10-05				
Indoor and Outdoor Source Apportionment and Phase Partitioning of Atmospheric Semi-Volatile Organic Compounds during the Alaskan Wintertime	Karolina Cysneiros de Carvalho	All-Hands Mtg. 2023-10-19				
Vertical dispersion of air pollution in Fairbanks	Roman Pohorsky	All-Hands Mtg. 2023-11-02				
Indoor particulate matter mass and composition in a residential home in Fairbanks, Alaska	Ellis Robinson	No				
Size-dependent removal of aerosol components in a residential home in Fairbanks, Alaska	Ellis Robinson	No				
Exploring the Sources of NOx emissions in a	Sarah Albertin	CATCH		JGR	Draft	

Polar Urban Atmosphere using NO_2 Nitrogen Isotopes		seminar 30 Nov 2023				
Oxygen Isotope Dynamics of NO_2 in a Polar Urban Atmosphere and Implications for Tracing Formation Processes of Atmospheric Nitrate	Sarah Albertin	CATCH seminar 30 Nov 2023		JGR	Draft	
The abundance and sources of ice nucleating particles (INPs) within Alaskan ice fog	Emily Lill				Draft	
Fugitive Emissions of Trace Gases and Particulate Matter from a “Leaky” Pellet Stove Insert	Damien Ketcherside	All-Hands Mtg. 2024-03-21		ES&T	Draft	
Diverse Sources of Ice Fog Nuclei in Wintertime Fairbanks, Alaska	Emily Costa			GRL (tentative)	Drafting	