ALASKA DEPARTMENT OF ENVIRONMENTAL CONSERVATION

Amendments to:

State Air Quality Control Plan

Vol. II: III.D.7.8

Modeling

Adopted

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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

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

modeling. An analysis of the organic chemical 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

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

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 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.

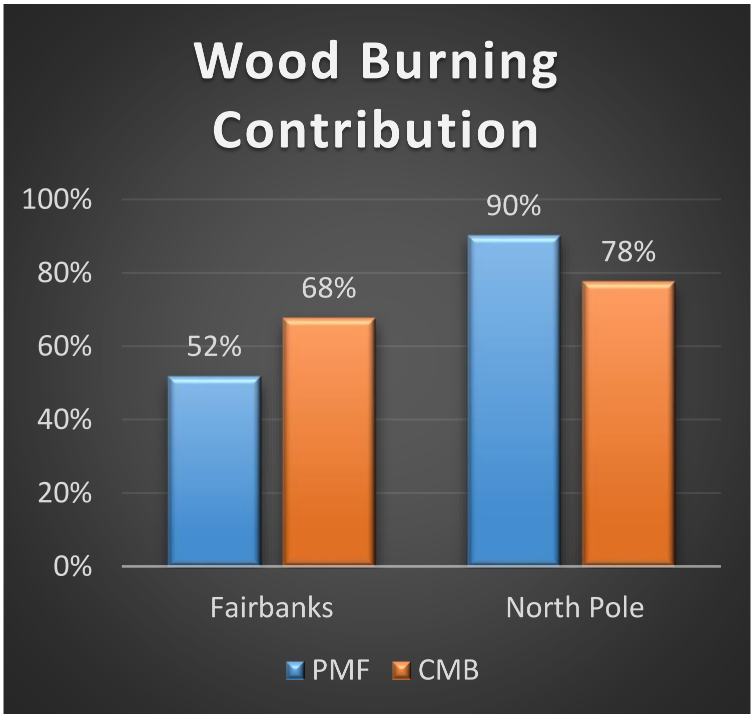

Figure 7.8-1. Fairbanks and North Pole wood burning contribution findings summary from filter based monitoring speciation results from 2011 to 2015.

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[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

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.

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

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[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

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 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.

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[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/

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 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:

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[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.

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 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.

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[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.

[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

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
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

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[22] Appendix III.D.5.8 – EPA RARE project

***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.

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

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[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

[25] Ibid.

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"
Mechanism	*cb05cl_ae5_aq*	"CB05 gas-phase mechanism, fifth-generation CMAQ aerosol mechanism with sea salt, aqueous/cloud chemistry, and active chlorine"

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[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*

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
Eielson AFB	1.63	1.28	1.18	0.69

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[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
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.

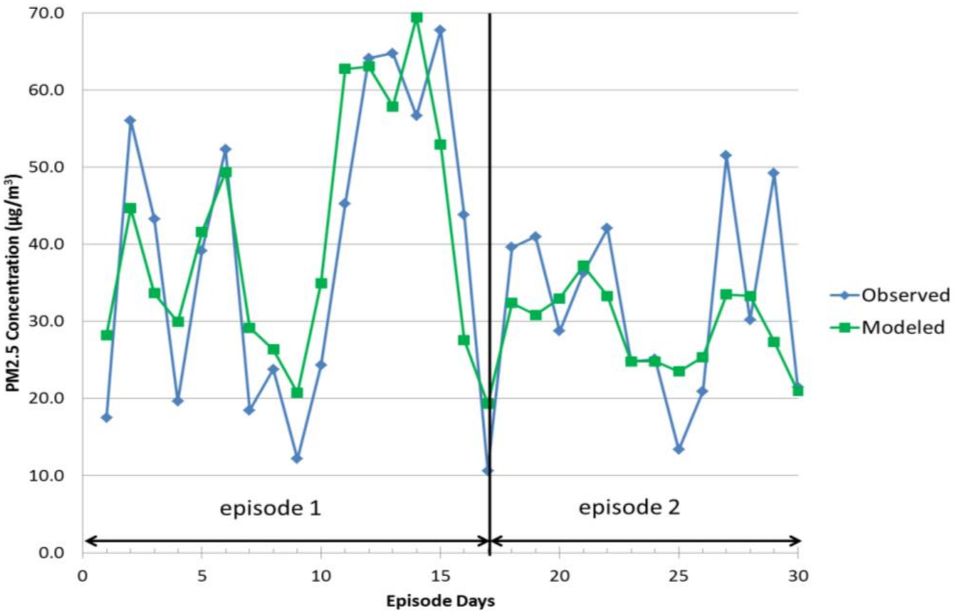

Figure 7.8-2. Modeled and Observed 24-hour Averaged $PM_{2.5}$ at the State Office Building Monitor for Both Winter Episodes

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 $PM_{2.5}$.

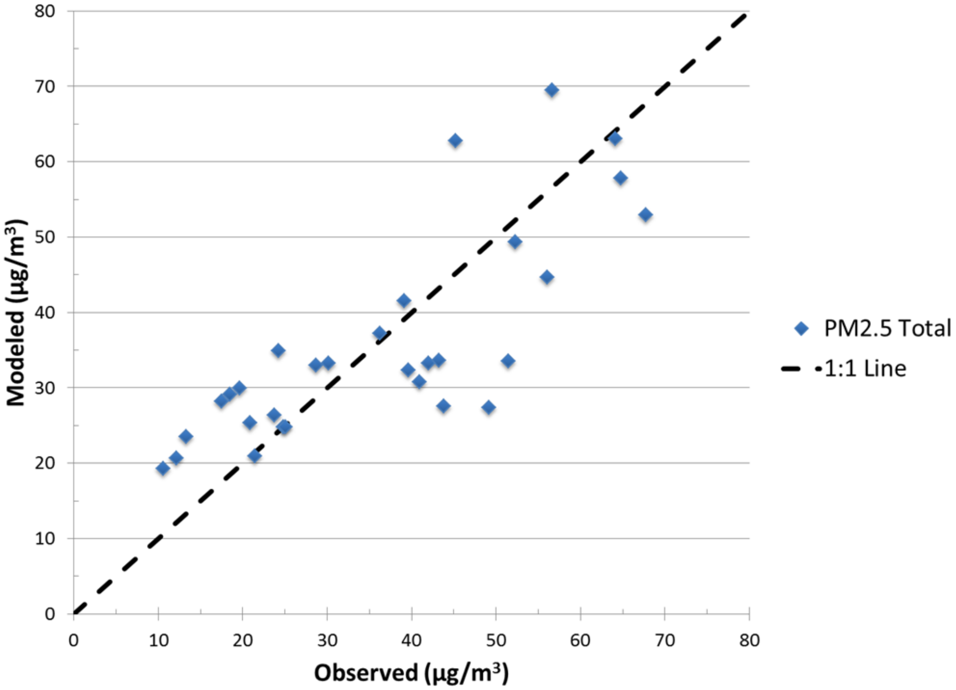

Figure 7.8-3. Scatter Plot of Observed and Modeled State Office Building Daily Episodic 24-hr $PM_{2.5}$ Concentrations

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.

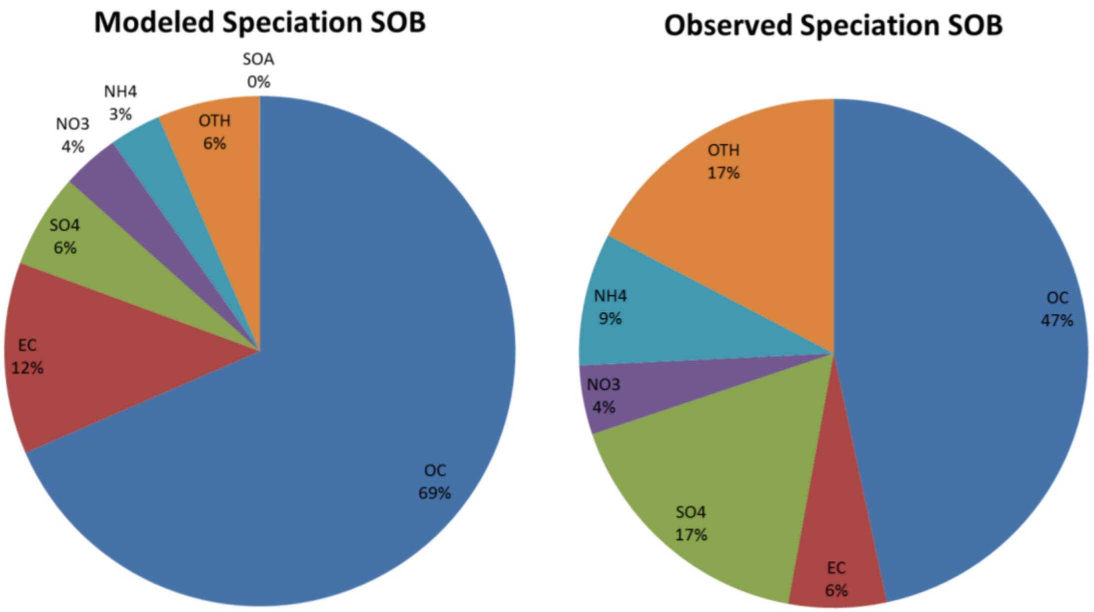

Figure 7.8-4. Baseline 24-hour Averaged Modeled and Observed $PM_{2.5}$ Speciation Over all Episode FRM Days

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 µg/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 (µg/m^3)	Modeled (µg/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

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

DEC needs 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 [$SO_{4\mathit{STN}}$];
- Adjusted nitrate [$NO_{3\mathit{FRM}}$] (retained on the FRM filter);
- Adjusted ammonium [$NH_{4\mathit{FRM}}$] (retained on the FRM filter);
- Measured elemental carbon [EC_{STN}] (corrected IMPROVE to NIOSH analysis);

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[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.

- Organic carbonaceous mass estimated from a mass balance [OCMmb];
- Estimated particle bound water [PBW]; and
- Estimated other primary $PM_{2.5}$ components [OPP].

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 (µg/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 µg/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 µg/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

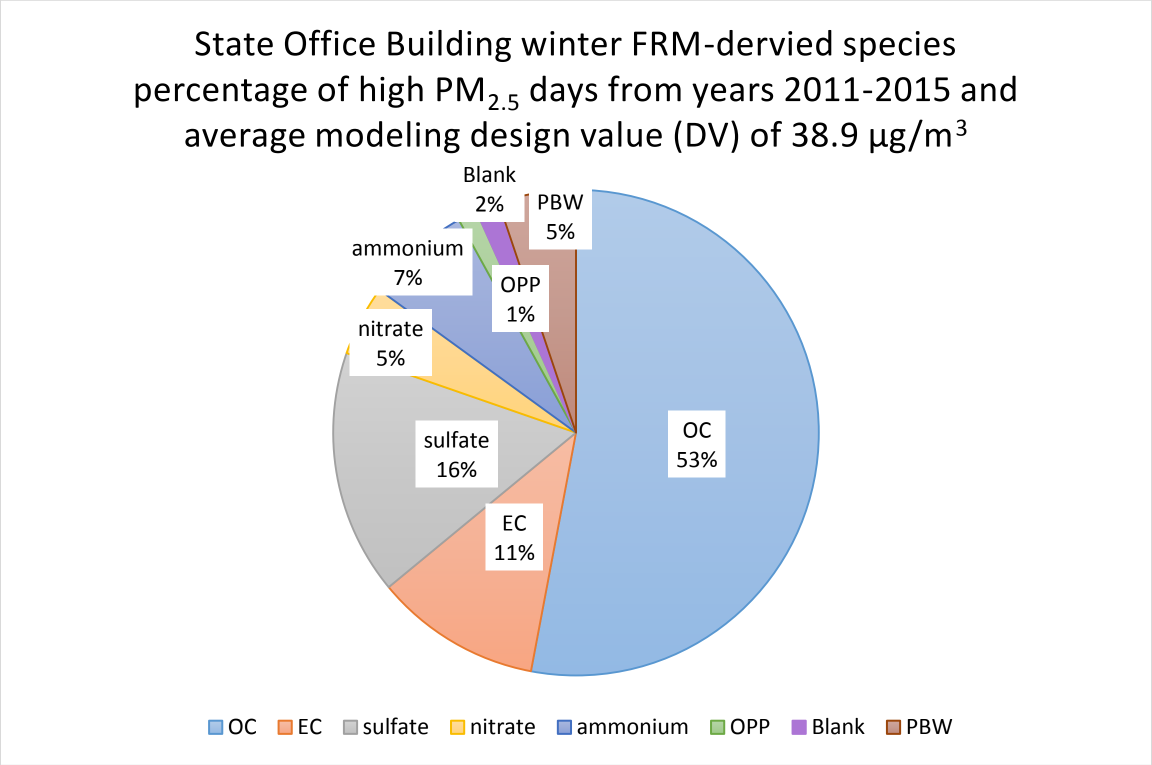

Figure 7.8-5: 24-hr average FRM-derived PM $_{2.5}$ speciation concentrations based on the design value (DV) of 38.9 µg/m^3 for the high $PM_{2.5}$ winter days at the State Office Building monitor.

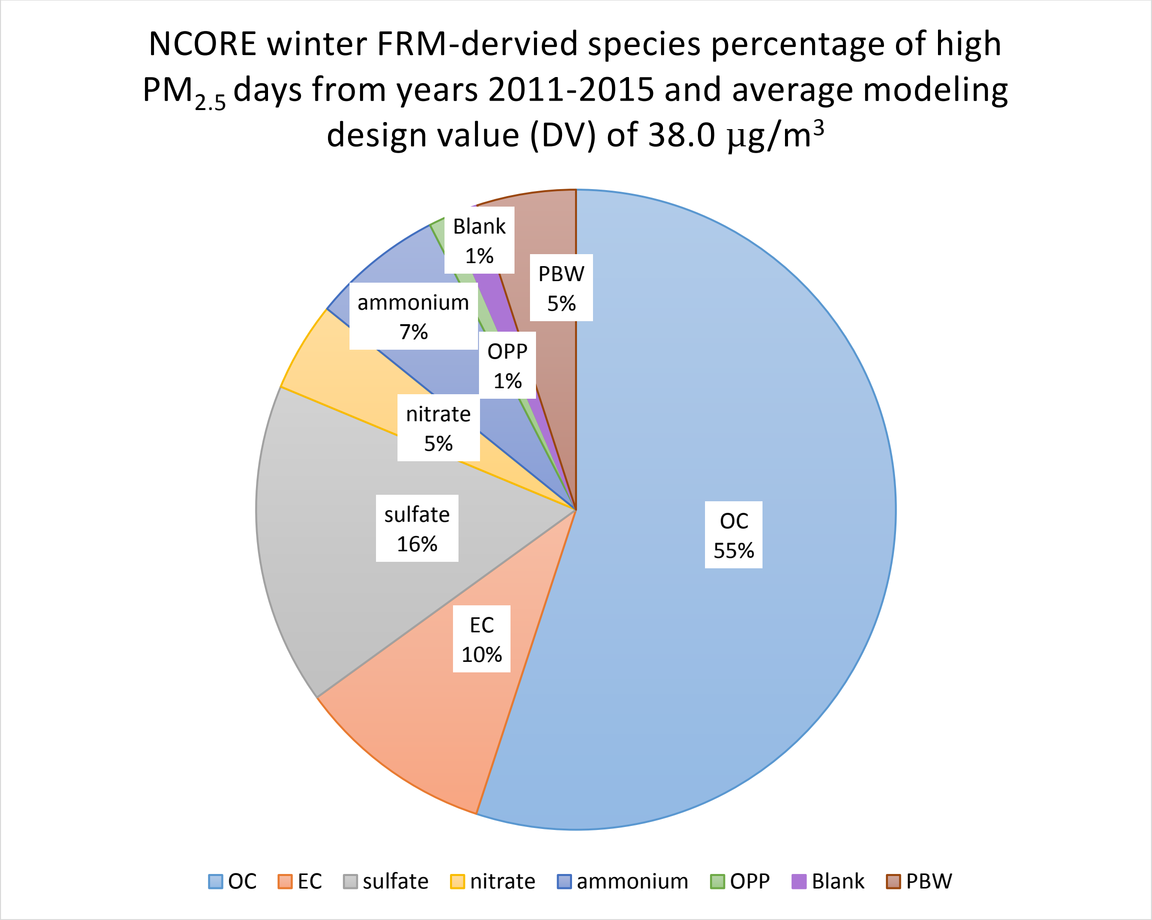

Figure 7.8-6: 24-hr average FRM-derived PM $_{2.5}$ speciation concentrations based on the design value (D7) of 38.0 µg/m^3 for Fairbanks NCORE Monitor

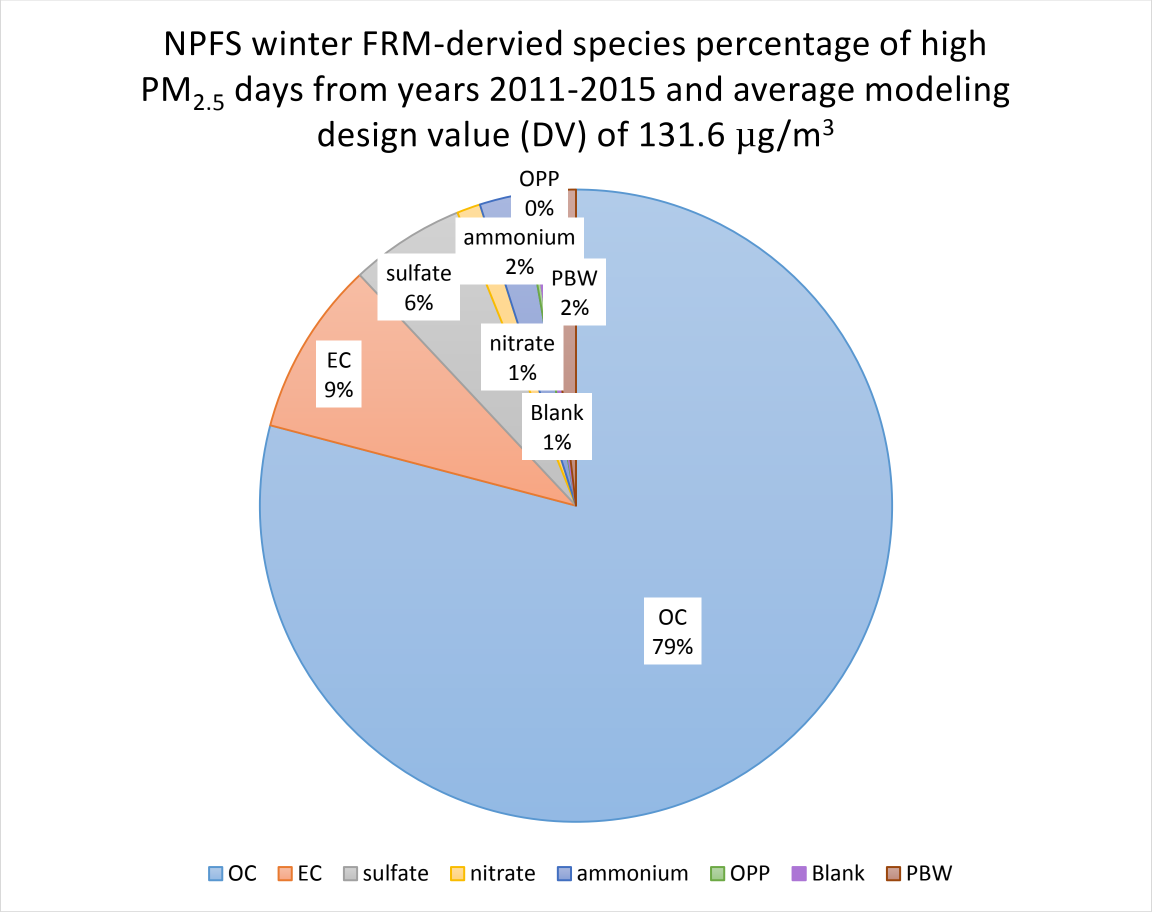

Figure 7.8-7. 24-hr average FRM-derived PM $_{2.5}$ speciation concentrations based on the design value (DV) of 131.6 µg/m^3 for the high $PM_{2.5}$ winter days at Hurst Road

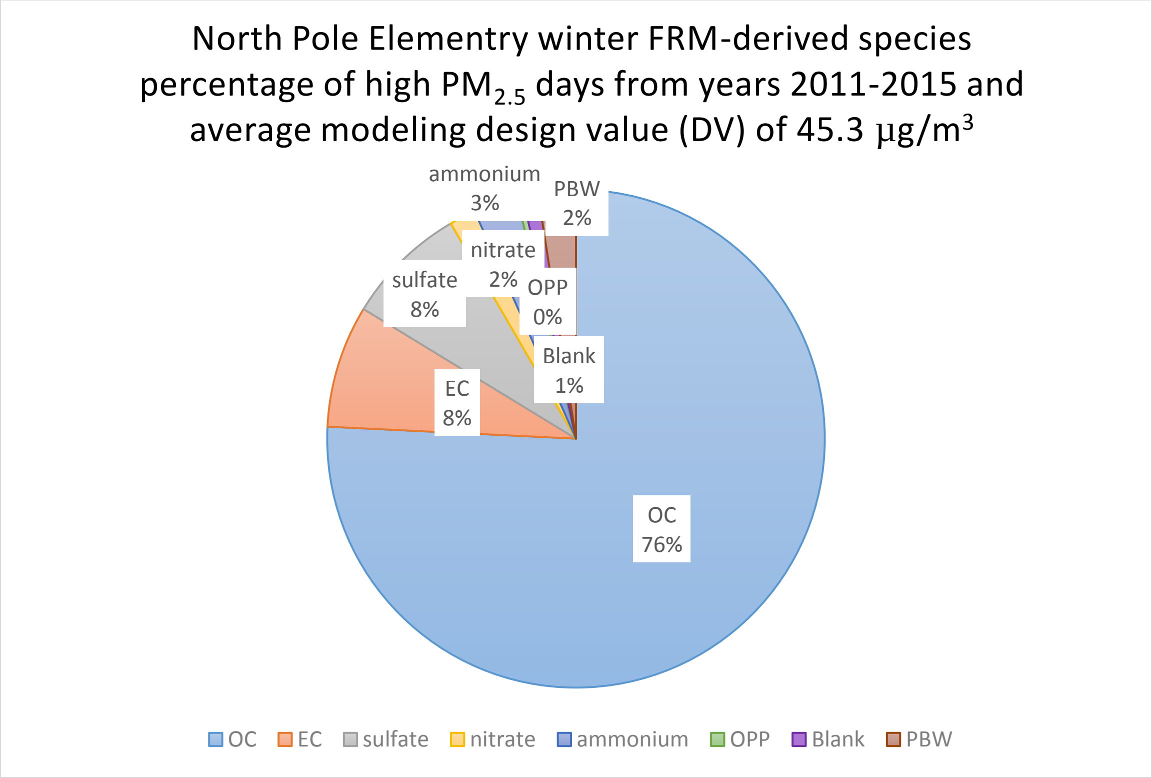

Figure 7.8-8. 24-hr average FRM-derived PM $_{2.5}$ speciation concentrations based on the design value (DV) of 45.3 µg/m^3 for North Pole Elementary School Monitor.

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 µg/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 µg/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.

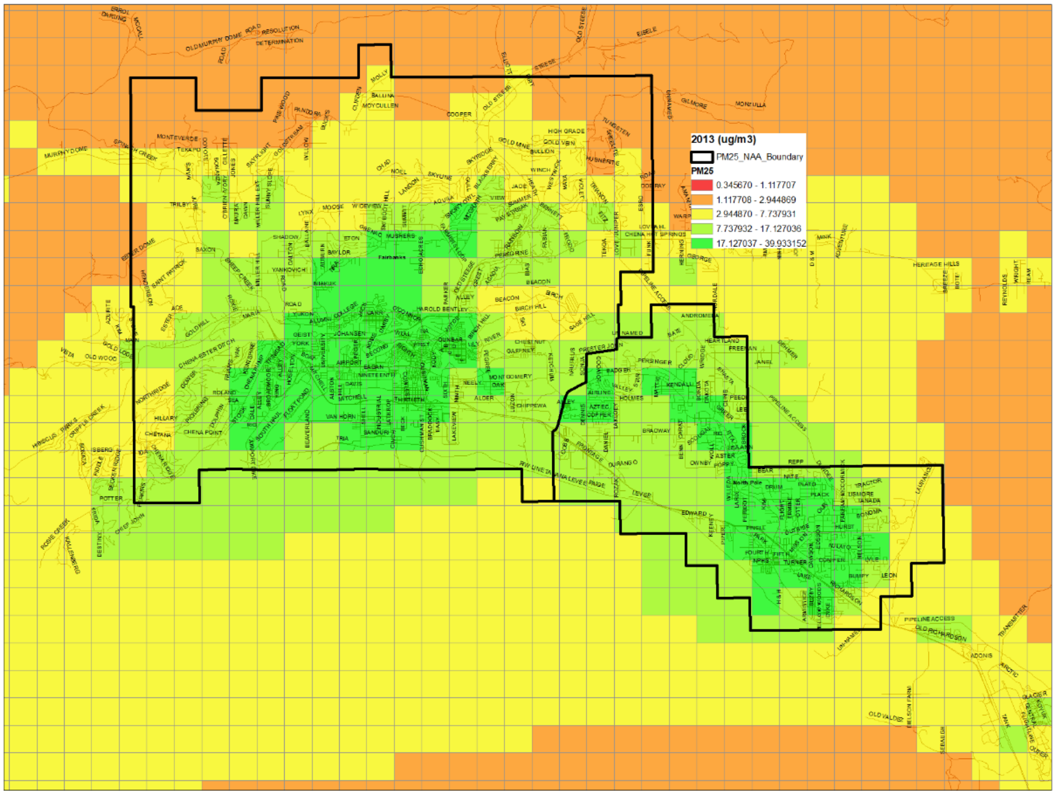

Figure 7.8-9. 2013 Base year 24-hour Averaged Model Total $PM_{2.5}$ Concentrations for the Nonattainment Area over All Episode Days (January 23 to February 10 and November 2 to 17, 2008)

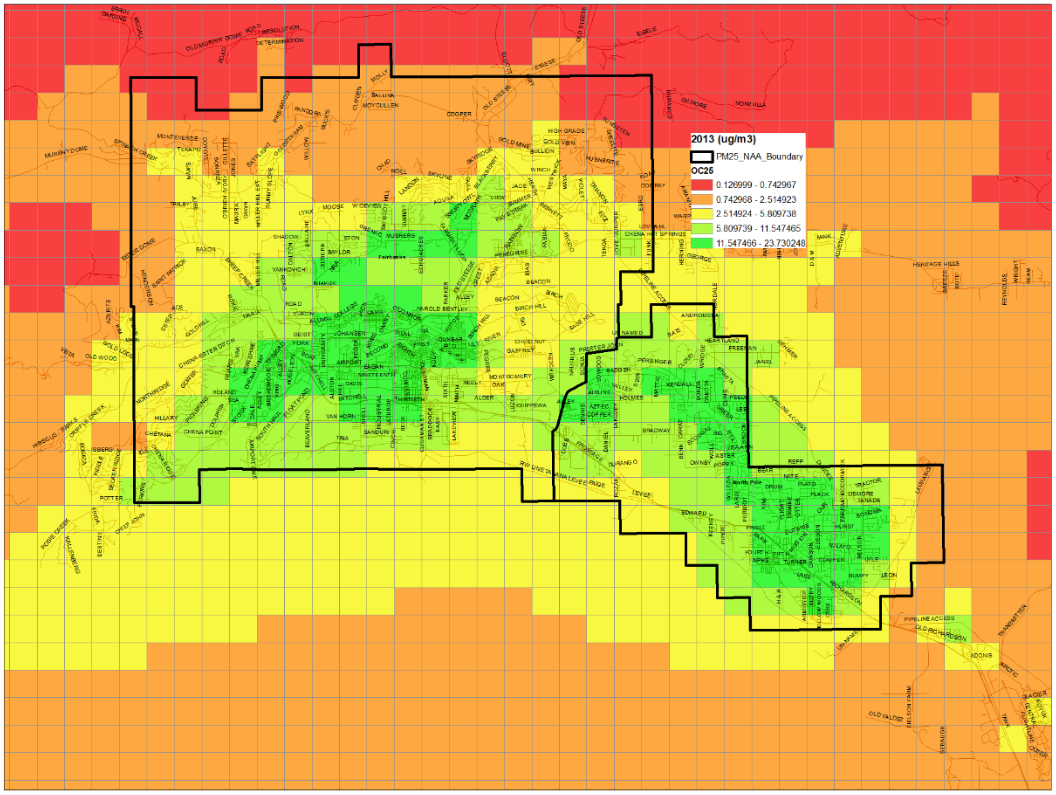

Figure 7.8-10. 24-hour Averaged Model OC $PM_{2.5}$ Concentrations for the Nonattainment Area over All Episode Days (January 23 to February 10 and November 2 to 17, 2008)

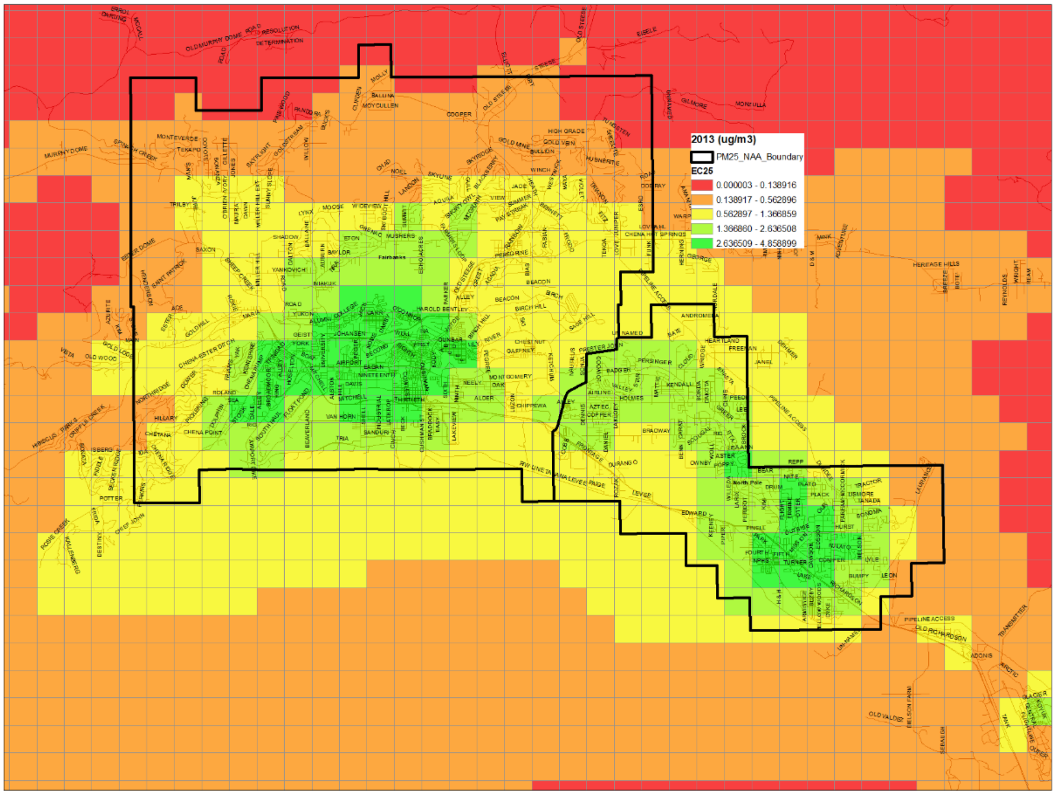

Figure 7.8-11. 2013 Base year 24-hour Averaged Model EC $PM_{2.5}$ Concentrations for the Nonattainment Area over All Episode Days (January 23rd to February 10 and November 2 to 17, 2008)

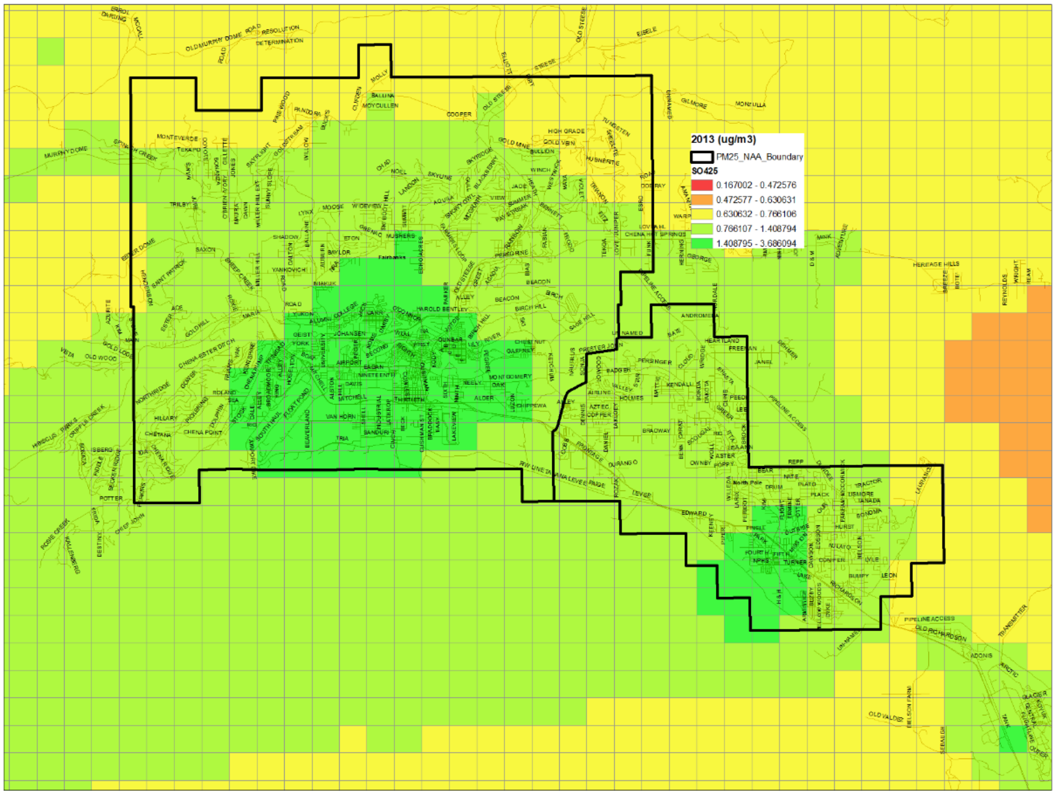

Figure 7.8-12. 2013 Base year 24-hour Averaged Model SO_4 $PM_{2.5}$ Concentrations for the Nonattainment Area over All Episode Days (January 23 to February 10 and November 2 to 17, 2008)

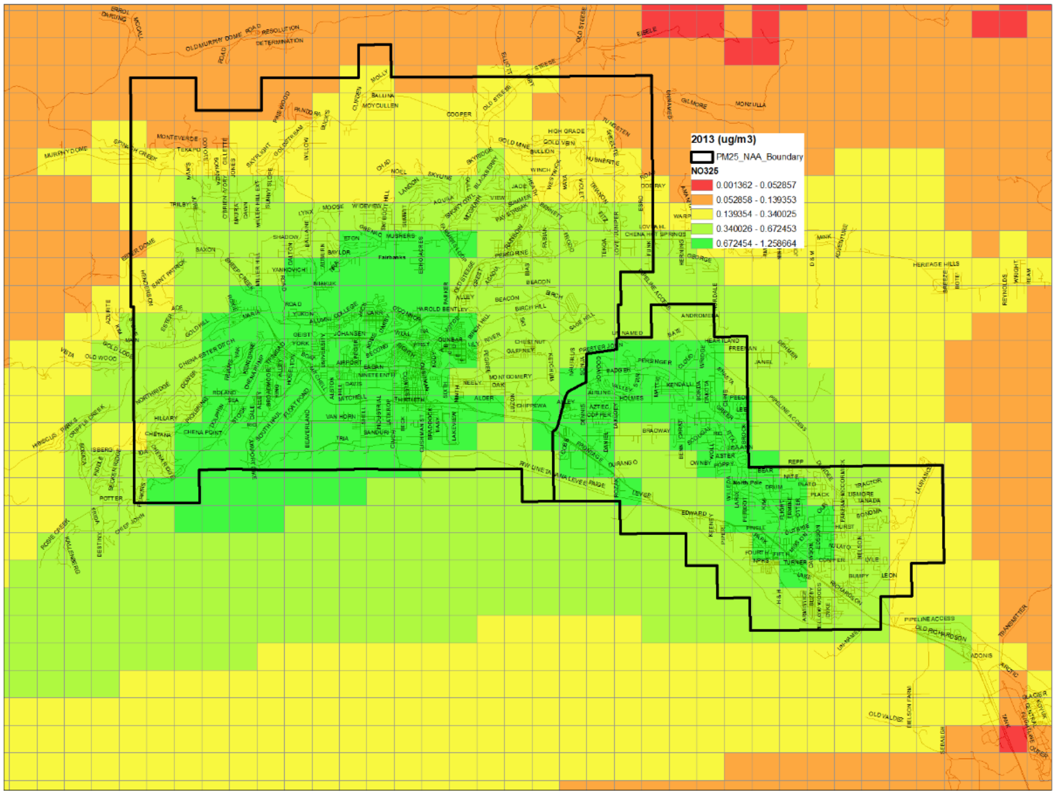

Figure 7.8-13. 2013 Base year 24-hour Averaged Model NO_3 $PM_{2.5}$ Concentrations for the Nonattainment Area over All Episode Days (January 23 to February 10 and November 2 to 17, 2008)

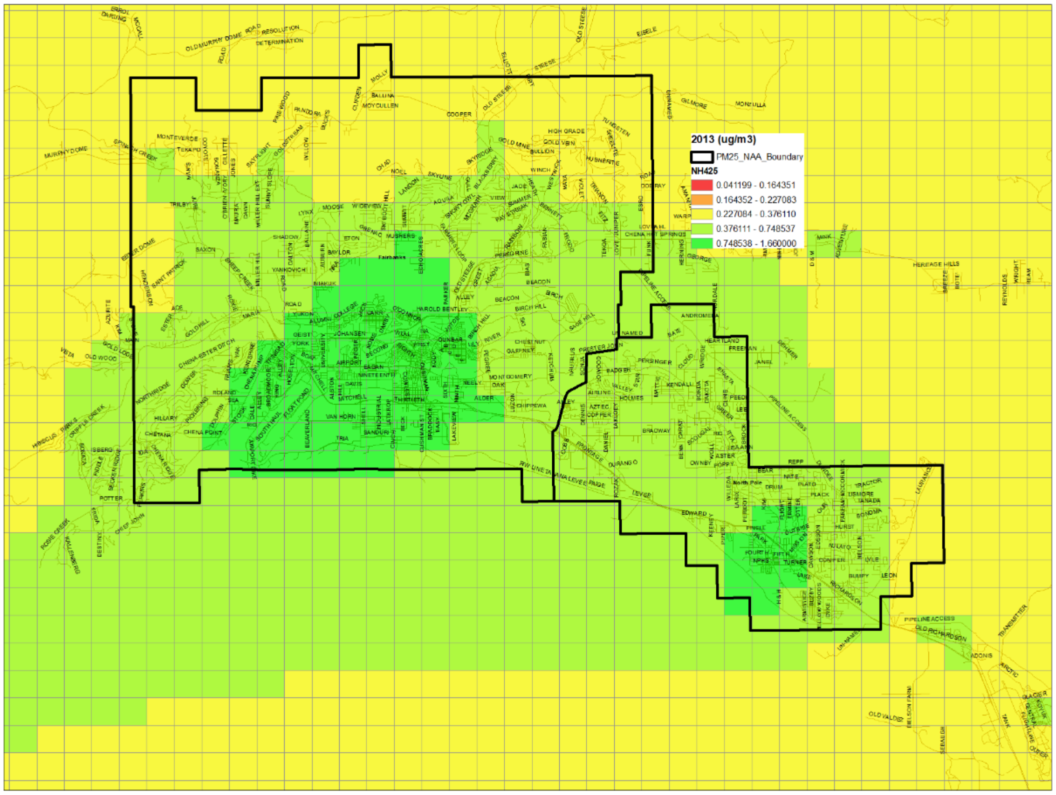

Figure 7.8-14. 2013 Base year 24-hour Averaged Model NH_4 $PM_{2.5}$ Concentrations for the Nonattainment Area over All Episode Days (January 23 to February 10 and November 2 to 17, 2008)

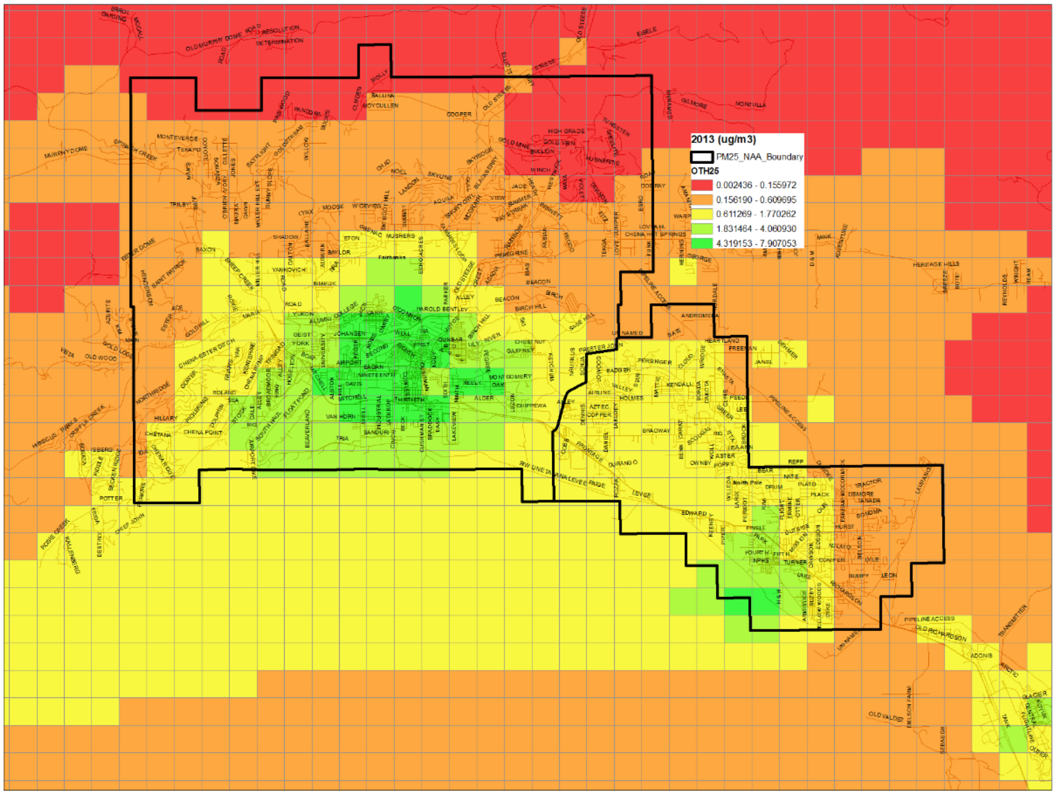

Figure 7.8-15. 2013 Base year 24-hour Averaged Model Other $PM_{2.5}$ Concentrations for the Nonattainment Area over All Episode Days (January 23 to February 10 and November 2 to 17, 2008)

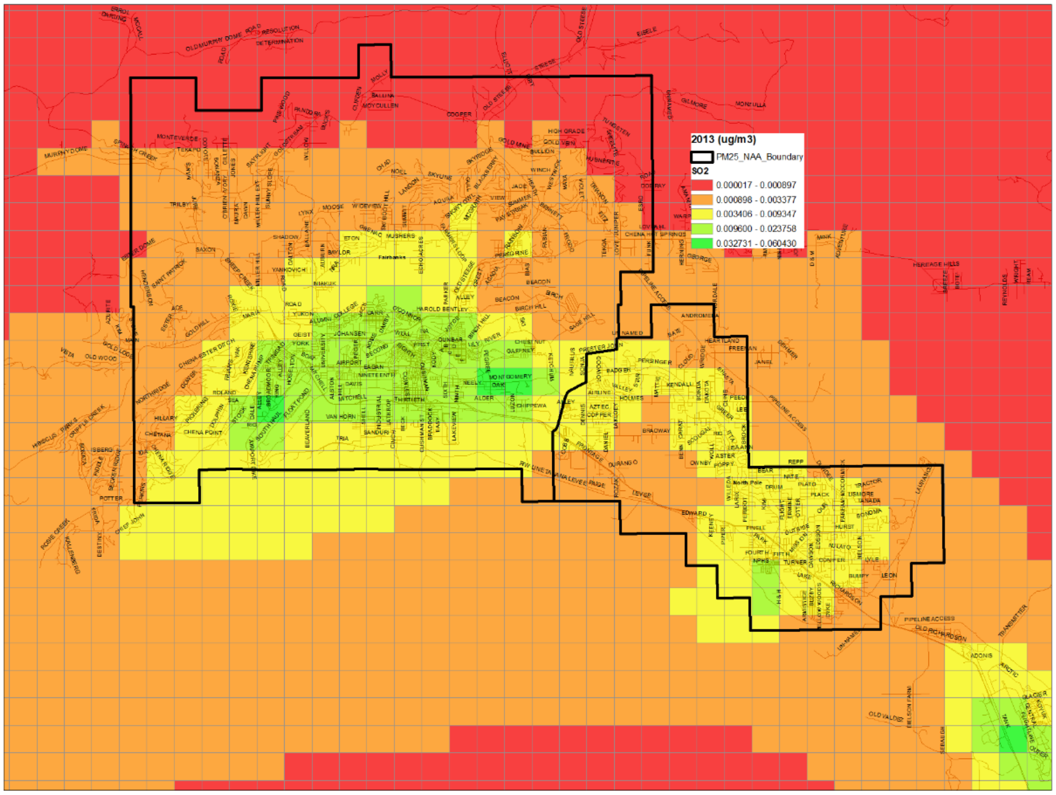

Figure 7.8-16. 2013 Base year 24-hour Averaged Model Gaseous SO_2 Concentrations for the Nonattainment Area over All Episode Days (January 23 to February 10 and November 2 to 17, 2008)

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.

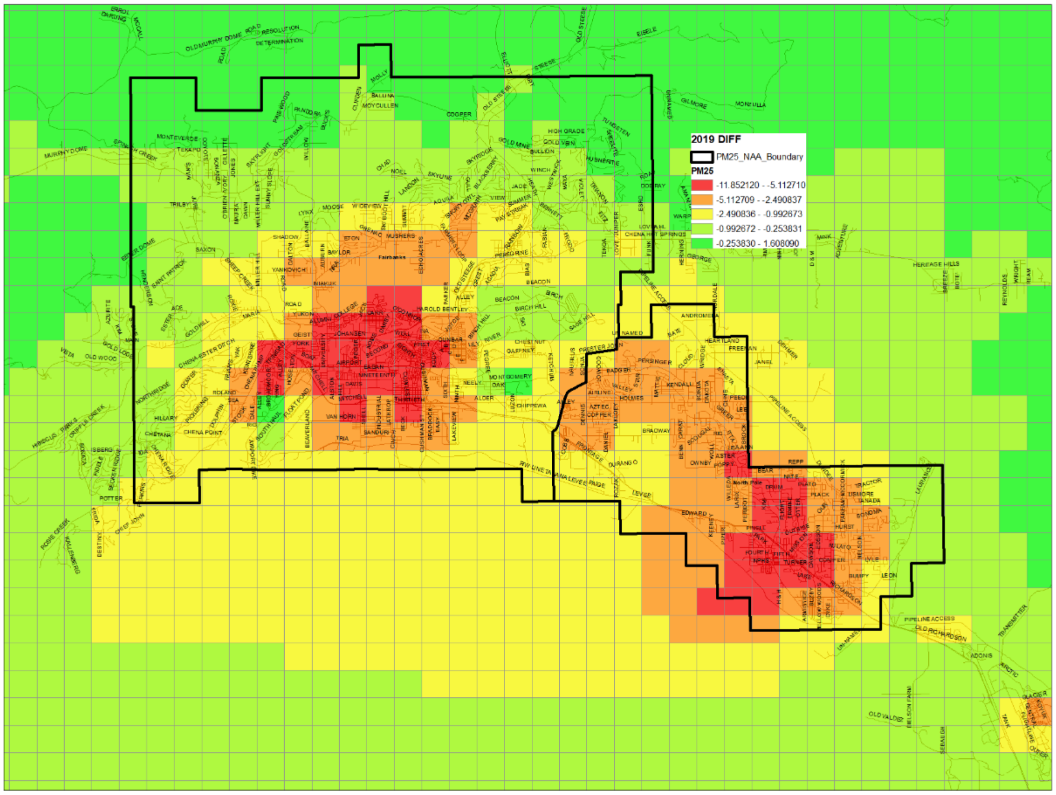

Figure 7.8-17. 2019 difference (2019-2013) of 24-hour averaged modeled PM2.5 Concentrations for the Nonattainment Area over All Episode Days (January 23 to February 10 and November 2 to 17, 2008)

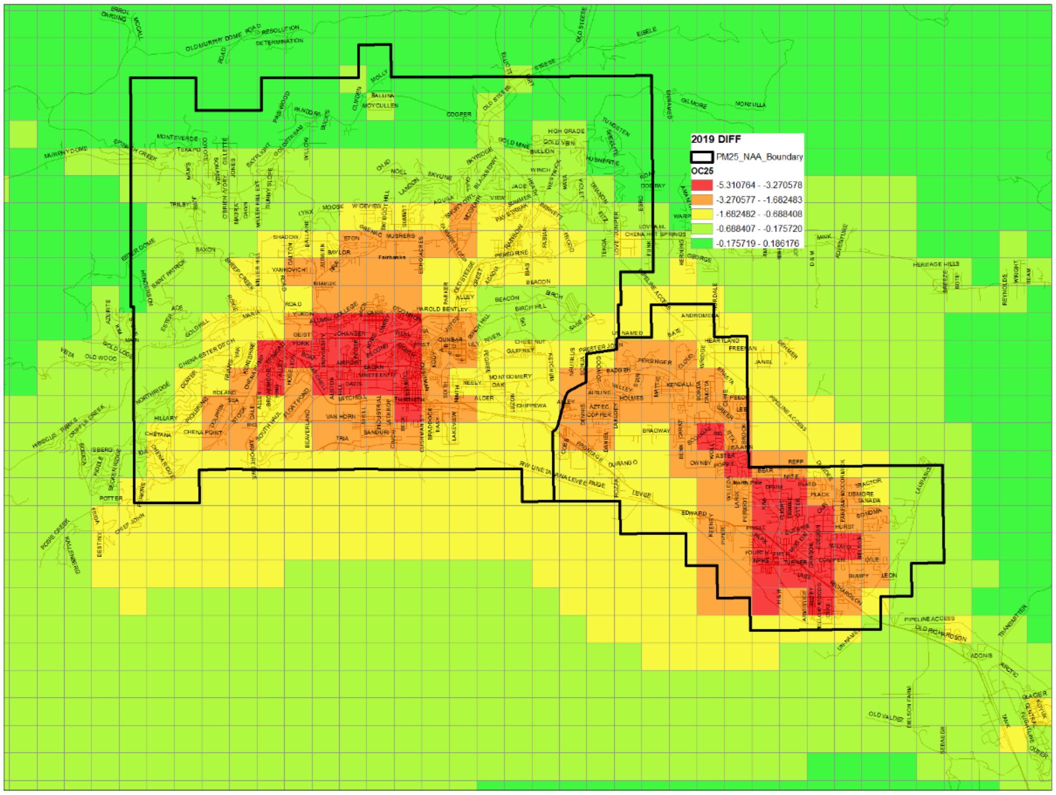

Figure 7.8-18. 2019 difference (2019-2013) of 24-hour averaged modeled OC (organic carbon) concentrations for the Nonattainment Area over All Episode Days (January 23 to February 10 and November 2 to 17, 2008)

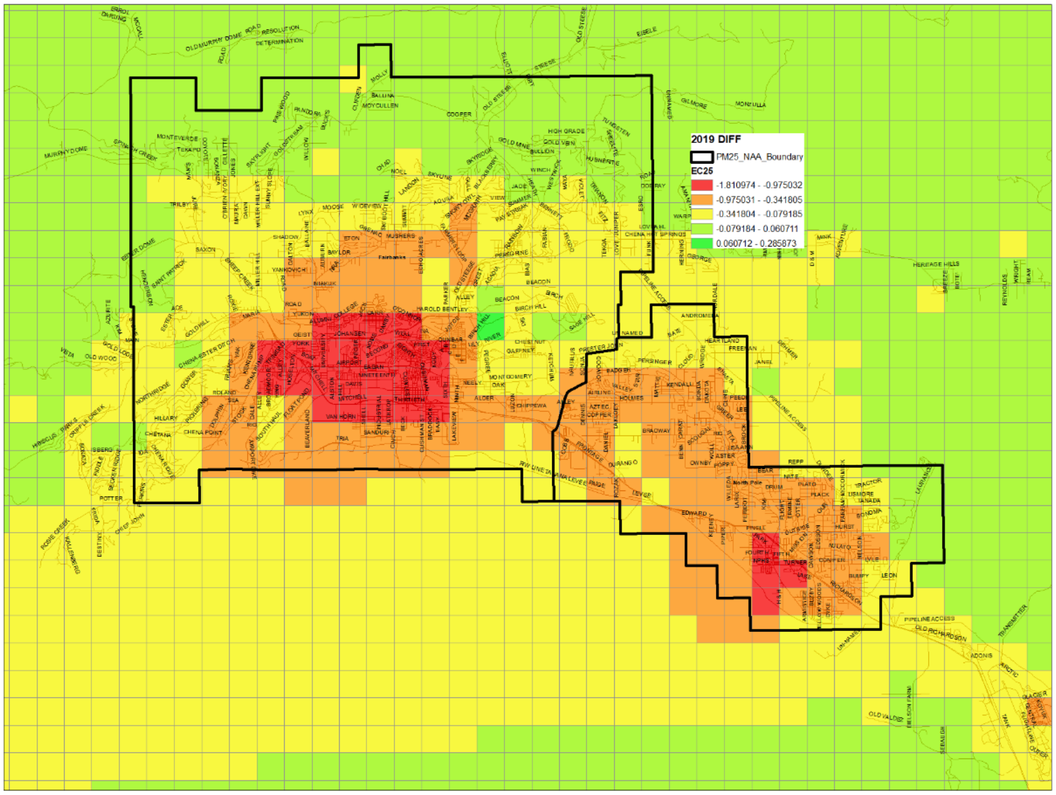

Figure 7.8-19. 2019 difference (2019-2013) of 24-hour averaged modeled EC (elemental carbon) concentrations for the Nonattainment Area over All Episode Days (January 23 to February 10 and November 2 to 17, 2008)

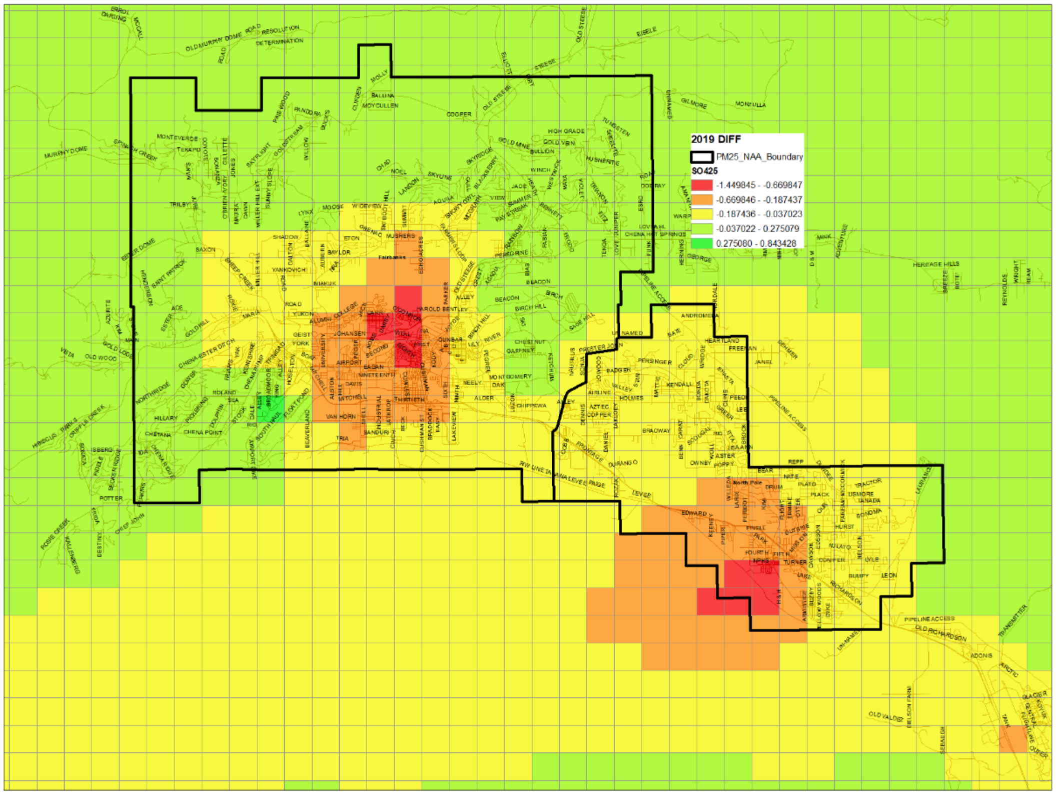

Figure 7.8-20. 2019 difference (2019-2013) of 24-hour averaged modeled SO$_4$ (sulfate) concentrations for the Nonattainment Area over All Episode Days (January 23 to February 10 and November 2 to 17, 2008)

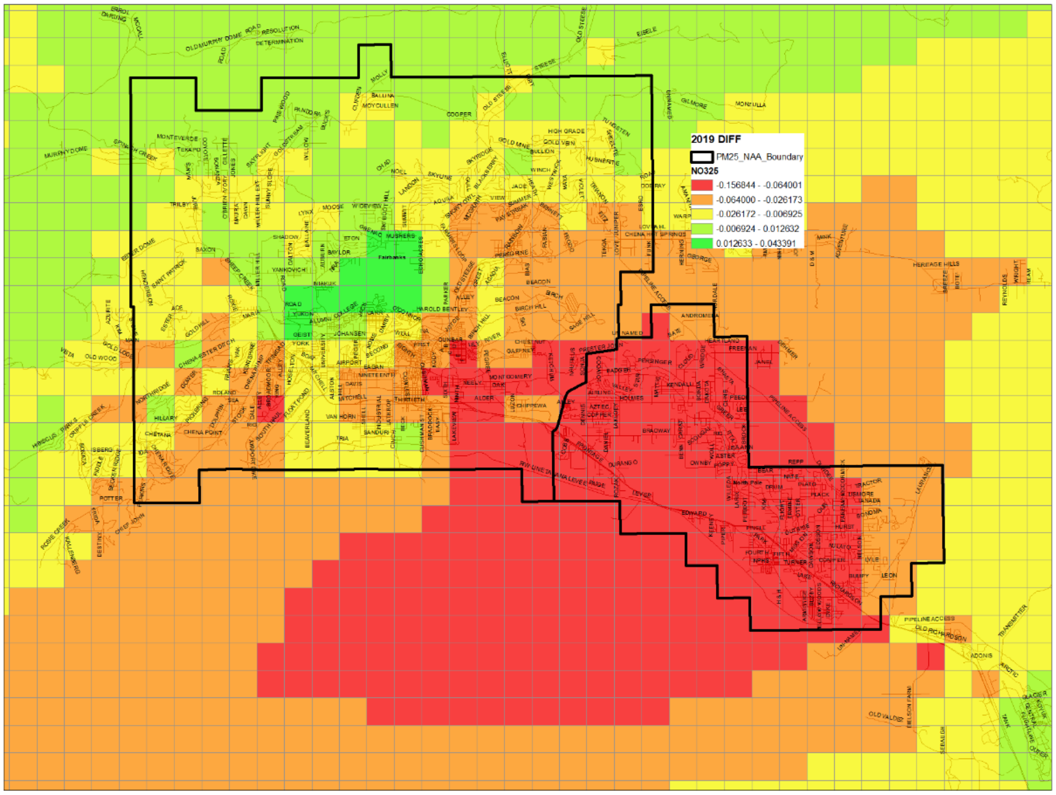

Figure 7.8-21. 2019 difference (2019-2013) of 24-hour averaged modeled NO$_3$ (nitrate) concentrations for the Nonattainment Area over All Episode Days (January 23 to February 10 and November 2 to 17, 2008)

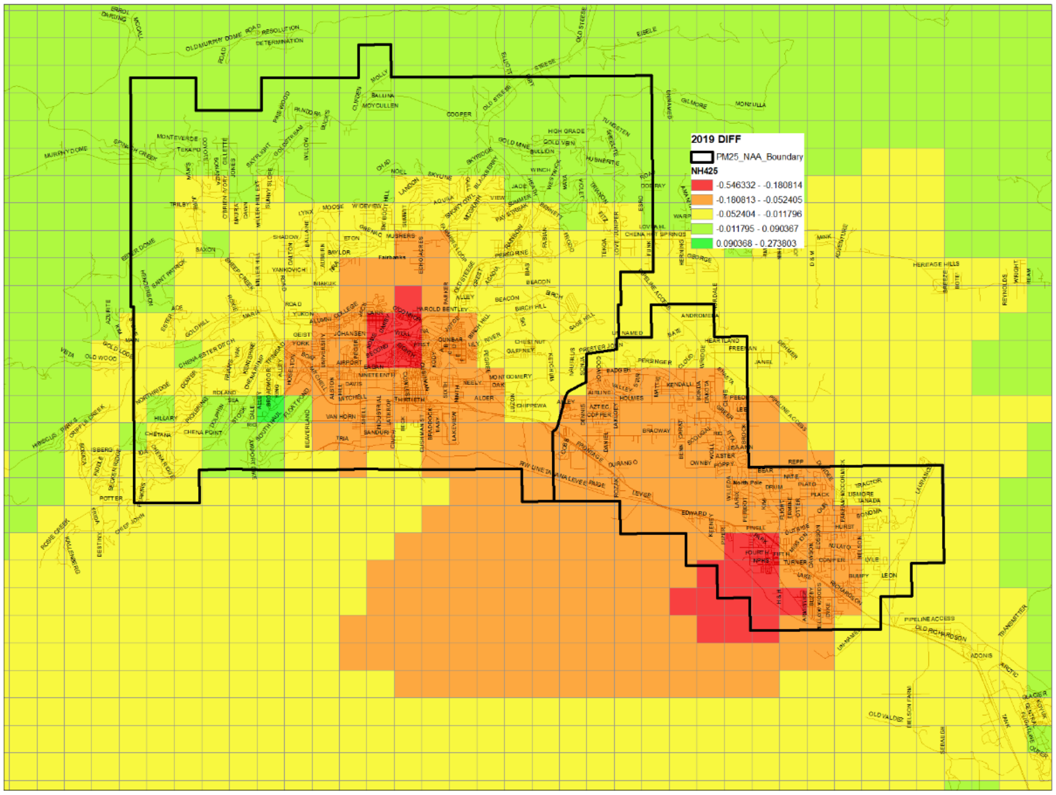

Figure 7.8-22. 2019 difference (2019-2013) of 24-hour averaged modeled NH_4 (ammonium) concentrations for the Nonattainment Area over All Episode Days (January 23 to February 10 and November 2 to 17, 2008)

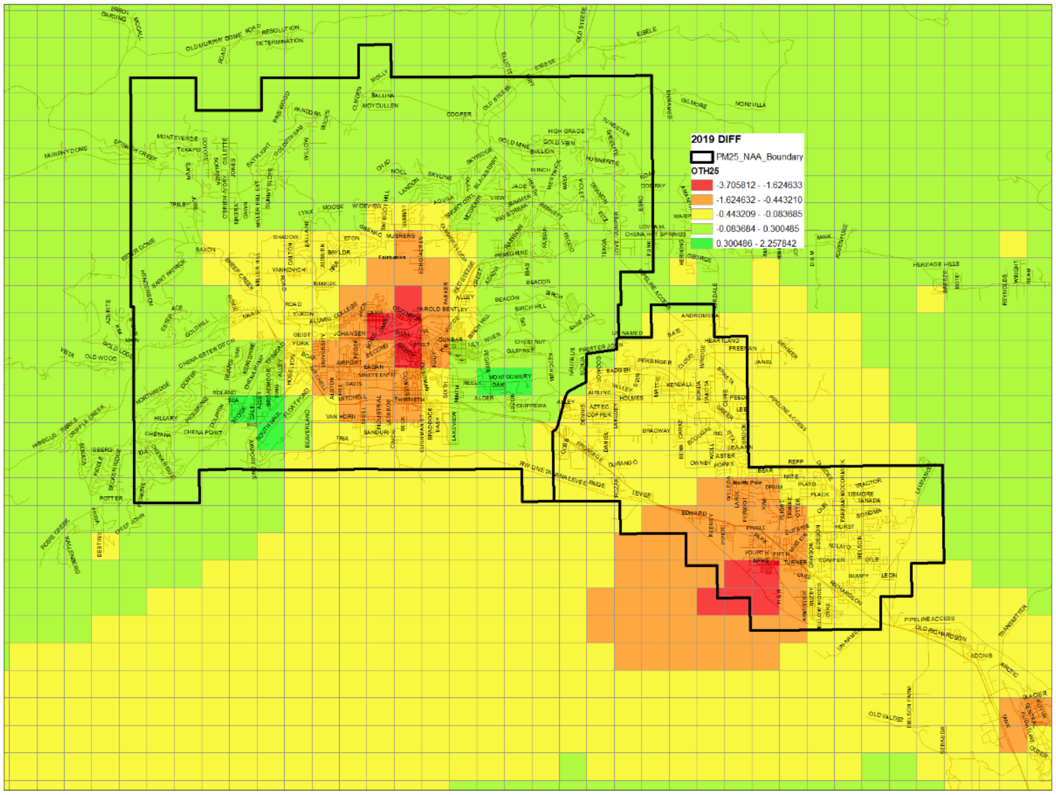

Figure 7.8-23. 2019 difference (2019-2013) of 24-hour averaged modeled OTH (other) concentrations for the Nonattainment Area over All Episode Days (January 23 to February 10 and November 2 to 17, 2008)

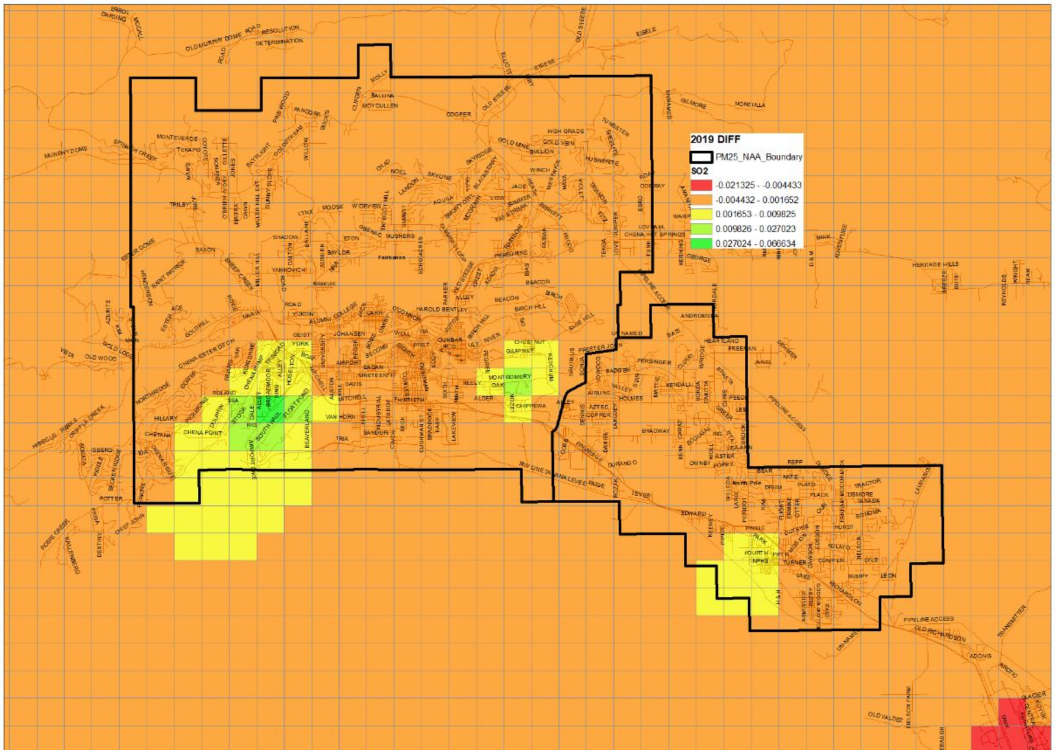

Figure 7.8-24. 2019 difference (2019-2013) of 24-hour averaged modeled gaseous (SO_2) concentrations (ppm) for the Nonattainment Area over All Episode Days (January 23 to February 10 and November 2 to 17, 2008)

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

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

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 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.

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

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 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).

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

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:

$$NO2 + OH \rightarrow HNO3 \qquad (R6)$$

$$HNO3 + NH3 \leftrightarrow NH4NO3 \qquad (R7)$$

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

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

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.

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[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.

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 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:

- 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.

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[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

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 $\mu g/m^3$ as 18/62 multiplied by the nitrate concentration in $\mu g/m^3$. 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 $\mu g/m^3$)						
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.

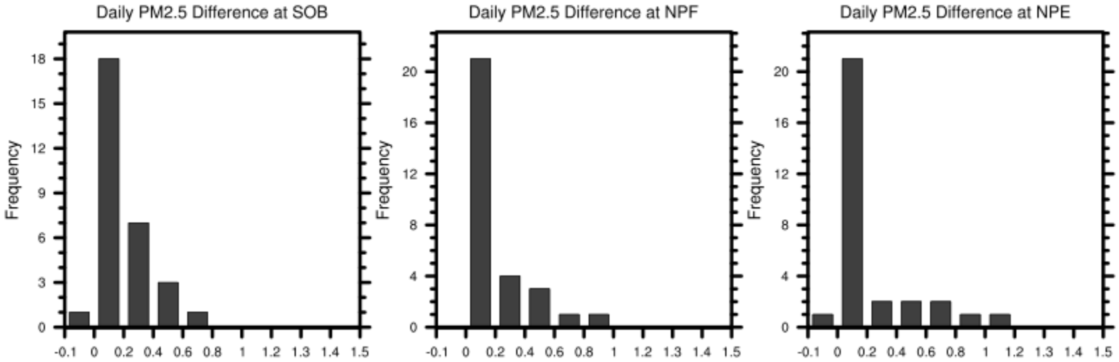
Daily PM2.5 Difference at SOB
Daily PM2.5 Difference at NPF
Daily PM2.5 Difference at NPE

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.

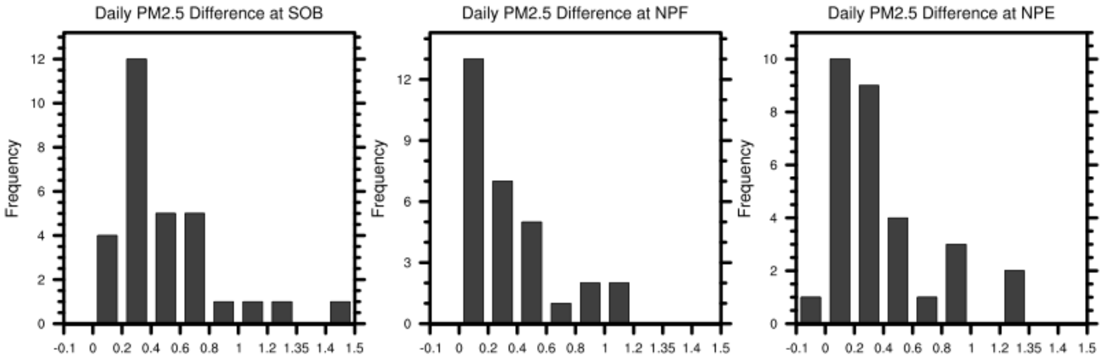
Daily PM2.5 Difference at SOB
Daily PM2.5 Difference at NPF
Daily PM2.5 Difference at NPE

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 $\mu g/m^3$				**Max Daily $\mu g/m^3$**			
		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 (µg/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 µg/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:

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[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

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

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.

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 Future Design Value ($\mu g/m^3$)	NPE Future Design Value ($\mu g/m^3$)	NCORE Future Design Value ($\mu g/m^3$)	SOB 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.