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2020 ATTAINMENT DEMONSTRATION MODELING FOR THE DENVER METRO/NORTH FRONT RANGE SERIOUS OZONE STATE IMPLEMENTATION PLAN

RAMBOLL

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1. INTRODUCTION

This document describes the 2020 ozone attainment demonstration modeling for the Denver Metropolitan/North Front Range (DM/NFR) ozone Nonattainment Area (NAA). The 2020 DM/NFR NAA attainment demonstration modeling used a 2016 photochemical grid model (PGM) modeling platform and was conducted as part of the DM/NFR Serious ozone NAA State Implementation Plan (SIP) under the 2008 ozone National Ambient Air Quality Standard (NAAQS).

Currently there are two ozone NAAQS that the DM/NFR NAA is required to address:

1. The 70 parts per billion (ppb) ozone NAAQS promulgated in 2015 (i.e. the "2015 ozone NAAQS"); and

2. The 75 ppb ozone NAAQS promulgated in 2008 (i.e. the "2008 ozone NAAQS").

Both standards are based on maximum daily average 8-hour (MDA8) ozone concentrations with a Design Value (DV) expressed as the three-year average of the fourth highest MDA8 ozone concentration. The 2008 ozone NAAQS cannot exceed 75 ppb and the 2015 ozone NAAQS cannot exceed 70 ppb. The convention is to truncate an ozone DV to a nearest ppb for comparison to the NAAQS, thus 76.0 and 71.0 are the lowest level of ozone DVs that violate the 2008 and 2015 ozone NAAQS, respectively.

DM/NFR ozone NAA SIP development is underway for both ozone NAAQS, with the current report addressing 2020 attainment of the 2008 ozone NAAQS as a Serious NAA. Future analysis will address 2023 attainment of the 2015 ozone NAAQS as a Moderate NAA. Although the DM/NFR NAA is currently designated as a Marginal NAA under the 2015 ozone NAAQS, it is expected to be re-designated as a Moderate ozone NAA in the future.

The Denver Regional Air Quality Council (RAQC) is the lead agency in charge of developing the DM/NFR NAA ozone attainment plan with assistance from and consultation with the Colorado Department of Health and Environment (CDPHE), Denver Regional Council of Governments (DRCOG), North Front Range Metropolitan Planning Organization (NFRMPO), Colorado Department of Transportation (CDOT), and other local agencies. Region 8 of the U.S. Environmental Protection Agency (EPA) will have approval authority over the DM/NFR ozone NAA Serious SIP and is consulted frequently in the SIP development process. The team of Ramboll and Alpine Geophysics is under contract to RAQC to develop a 2016 PGM modeling platform and conduct the 2020 ozone attainment demonstration modeling.

1.1 Organization of the Report

The procedures used to develop the 2016 PGM modeling platform and conduct the 2020 attainment demonstration modeling were outlined in a formal Modeling Protocol dated April 2019 (Ramboll, 2019a). An overview of those procedures is provided in the remainder of this chapter. Details on the development of the 2016 PGM modeling platform and model performance evaluation are contained in a report dated August 2020 (Ramboll, 2020a). This report contains the following information:

- Chapter 2 presents the development of the 2020 and 2023 emissions and a comparison with the 2016 emissions.
- The 2020 base case modeling, ozone design value projections and 2020 modeled ozone attainment demonstration are discussed in Chapter 3.
- The weight of evidence (WOE) containing supplemental information supporting the 2020 attainment demonstration is given in Chapter 4.
- Summary and conclusions are discussed in Chapter 5.
- References are provided in Chapter 6.

1.2 Overview of the DM/NFR NAA 2016 Modeling Approach

The 2020 ozone attainment demonstration modeling for the DM/NFR NAA using the 2016 PGM platform includes emissions, meteorological and ozone model simulations using a nested 36/12/4-km grid with the 4-km grid domain focused on the state of Colorado. The development of the DM/NFR NAA 2016 36/12/4-km PGM modeling platform leveraged data from the EPA 2016 36/12-km PGM modeling platforms. The EPA 2016 36/12-km PGM platforms are described next, followed by an overview of the development of the DM/NFR NAA 2016 36/12/4-km PGM modeling platform used for the 2020 attainment demonstration modeling.

1.2.1 EPA 2016 36/12-km PGM Modeling Platforms

The EPA and Multi-Jurisdictional Organizations (MJOs) conducted a 2016 inventory collaborative study[1] to develop 2016 emissions inventory of comparable quality to the National Emissions Inventory (NEI[2]). EPA developed a 2016 PGM modeling platform that used the same 12-km grid resolution continental U.S. domain (12US2) used in previous EPA PGM platforms (i.e., 2011 and 2014), but added an expanded 36-km grid resolution 36US3 domain as shown in Figure 1-1. EPA has released several versions of their 2016 36/12-km PGM modeling platform as follows:

- 2016v7.1 Alpha[3] PGM platform was available in June 2019 and was based mainly on 2014 NEIv7.1 emissions (2016fd emissions).
- The 2016v7.2 Beta (2016ff) PGM platform used 2016 emissions from the joint EPA/MJO emissions collaborative study. The original 2016v7.2 Beta PGM platform was released in March 2019 through the Intermountain West Data Warehouse (IWDW[4]).
- EPA made some updates to the 2016v7.2 PGM platform and used the new 2016v7.2 "Beta Prime" (2016fg) modeling platform for their preliminary 2028 regional haze modeling (EPA, 2019b). Details on EPA's 2016v7.2 modeling platform are contained in a Technical Support Document (TSD[5]).

[1] http://views.cira.colostate.edu/wiki/wiki/10197
[2] EPA develops an NEI inventory every 3-years, including 2011 and 2014. The 2017 NEI is in development.
[3] https://www.epa.gov/air-emissions-modeling/2016-alpha-platform
[4] http://views.cira.colostate.edu/iwdw/
[5] https://www.epa.gov/sites/production/files/2019-09/documents/2016v7.2_regionalhaze_emismod_tsd_508.pdf

- The final EPA 2016v1[6] (2016fh) PGM modeling platform was released in November 2019, with updates to Commercial Marine Vessels occurring in February 2020, which is also available on the IWDW. The 2016v1 inventory included emission projections for 2023 and 2028.

The DM/NFR NAA 2016 36/12/4-km PGM modeling platform is using the same 36US3 and 12US2 PGM modeling domains as used in the EPA 2016 modeling platform so it can use the same 2016v1 36/12-km emissions for the 2016 PGM base case and future year modeling.

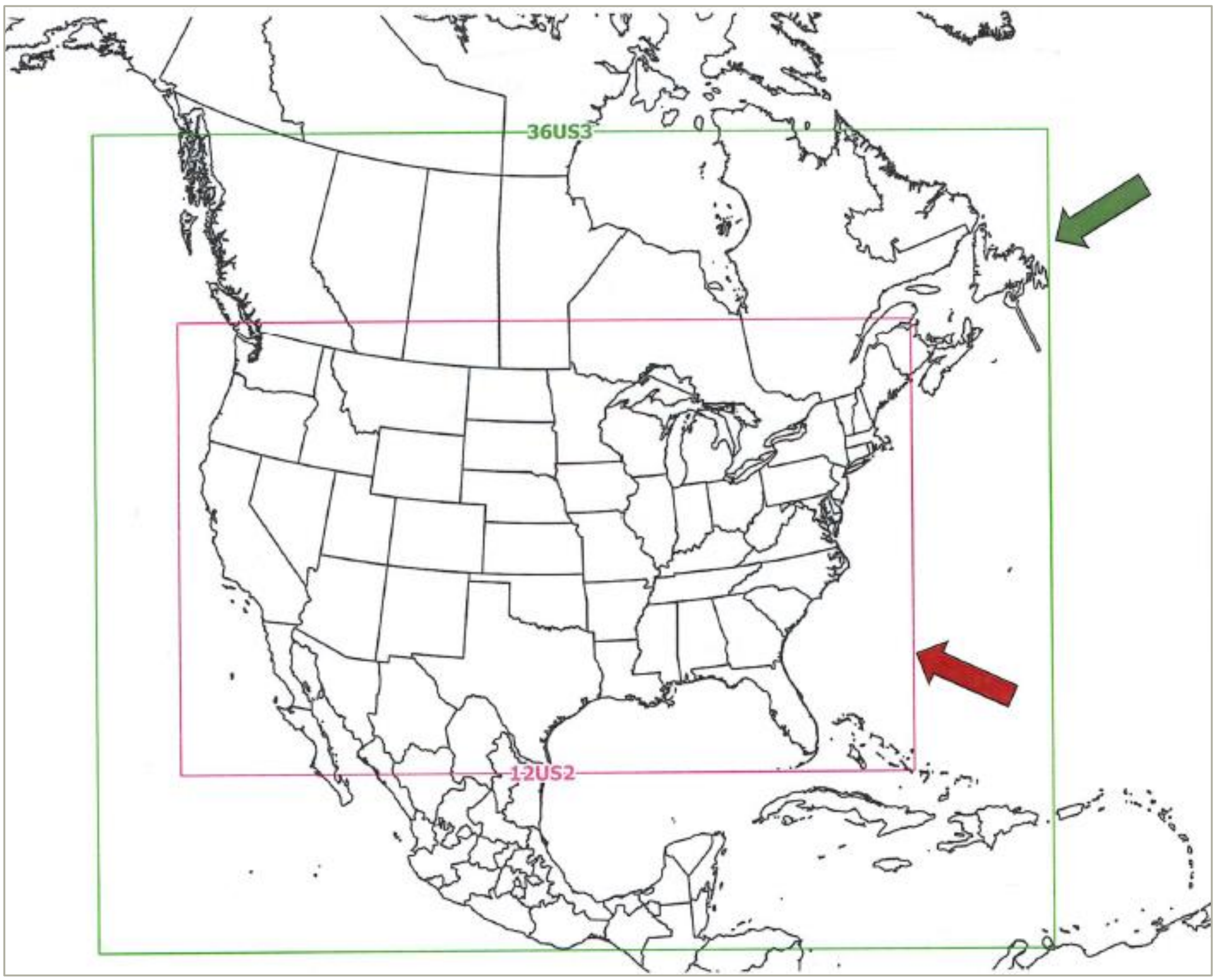

Figure 1-1. 36-km grid resolution 36US3 domain (green) and 12-km grid resolution 12US2 domain (red) used in EPA's 2016 modeling platforms.

[6] https://www.epa.gov/air-emissions-modeling/2016v1-platform

1.2.2 Episode Selection

Episode selection is an important component of an 8-hour ozone attainment demonstration. EPA guidance recommends that 10-days be used to project 8-hour ozone Design Values at each critical monitor (EPA, 2018d). The RAQC and CDPHE/APCD specified that the baseline modeling period should be either the summer of 2016 or 2017. The summer of 2016 episode was selected for the 2020 attainment demonstration modeling for the following reasons (see Chapter 3 of the Modeling Protocol for details, Ramboll, 2019a):

- 2016 has higher ozone concentrations than 2017 and the annual 4^{th} high MDA8 ozone for key monitors in 2016 are generally closer to the 2014-2016, 2015-2017 and 2016-2018 ozone DVs than 4^{th} highest MDA8 ozone concentration that occurred in 2017;
- 2016 is not an unusually low ozone year;
- Ozone concentrations in 2016 are less influenced by emissions from wildfires than in 2017;
- 2016 emissions were developed by a joint EPA/MJO study and EPA is developed a 2016 36/12-km PGM modeling platform that can be leveraged to reduce the amount of resources and time needed to develop a completely new modeling platform, as would be needed for 2017.
- Emissions from the 2017 NEI were not available at the time the study was initiated.

The DM/NFR NAA PGM modeling was conducted for May through August 2016. However, since the first ozone exceedance days was in mid-June, May 2016 was used as an initialization period using just the 36-km modeling domain for computational efficiency, with the full 36/12/4-km domain configuration started on June 1^{st}.

1.2.3 Model Selection

Details on the rationale for model selection are provided in Chapter 2 of the Modeling Protocol (Ramboll, 2019a). The Weather Research Forecast (WRF) prognostic meteorological model was selected using a 36/12/4-km resolution grid, with the 4-km grid covering Colorado. Emissions modeling was conducted the Sparse Matrix Operator Kernel Emissions (SMOKE) model for most source categories. The Model of Emissions of Gases and Aerosols from Nature (MEGAN v3.1) was used for biogenic emissions. There are CAMx emission pre-processors that were used for windblown dust (WBD), lightning NOx (LNOx), sea salt (NaCl) and Dimethyl Sulfide (DMS) emissions. The 2014 version of the MOtor Vehicle Emissions Simulator (MOVES2014b) on-road mobile source emissions model was used with SMOKE-MOVES and 2016 WRF meteorological data to generate on-road mobile source emissions. The use of link-based vehicle activity data within the DM/NFR NAA was evaluated and ultimately used at the county-level to be consistent with the conformity calculations. The Comprehensive Air-quality Model (CAMx) PGM was used to simulate ozone and other concentrations across the 36/12/4-km modeling domains.

The modeling protocol (Ramboll, 2019a) also recommended carrying the Community Multiscale Air Quality (CMAQ[7]) PGM as a supporting model in the weight of evidence (WOE) portion of the 2020 attainment demonstration. However, EPA did not have a corresponding CMAQ 2016v1 modeling platform to use as input for the 36/12-km domains as they do for CAMx. Furthermore, EPA updated the CMAQ model (CMAQ v5.3) during the middle of the 2016 platform development that required changes to the inputs (MCIP). Ultimately it was determined to be more important to carry a second meteorological input configuration for CAMx as part of the WOE than use an alternative photochemical model (i.e., CMAQ).

1.2.4 Domain Selection

The DM/NFR NAA 2016 PGM modeling platform used the same 36-km 36US3 and 12-km 12US2 domains as used in the EPA 2016 modeling platform (see Figure 1-1). A 4-km Colorado domain was added to the 36/12-km domain structure using the same 4-km Colorado domain as used in the previous DM/NFR NAA 2017 ozone SIP. Figure 1-2 displays the CAMx 36/12/4-km domain structure with Figure 1-3 displaying the 4-km Colorado domain with locations of ozone monitoring sites. The domains use a Lambert Conformal Conic (LCC) projection defined using the parameters in Table 1-1 with the extent of the 36/12/4-km grid domains given in Table 1-2. New WRF 2016 36/12/4-km meteorological modeling was conducted to generate finer scale 4-km meteorological conditions for the Colorado domain and consistent meteorology among the 36/12/4-km domains. CAMx was run using the 36/12/4-km domain structure shown in Figure 1-2 using two-way interactive grid nesting.

[7] https://www.epa.gov/cmaq/cmaq-models-0

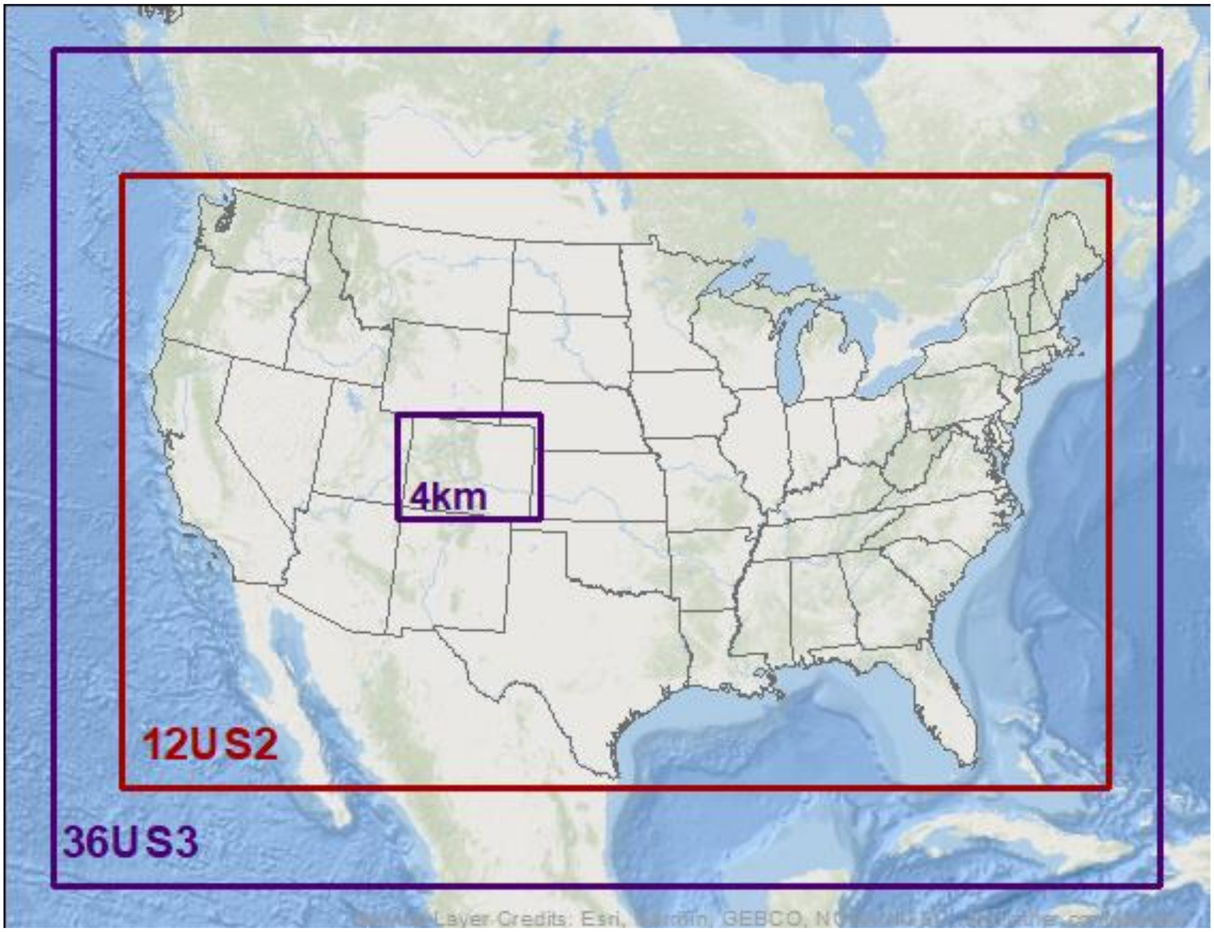

Figure 1-2. DM/NFR NAA 2016 36/12/4-km CAMx and emissions modeling domains.

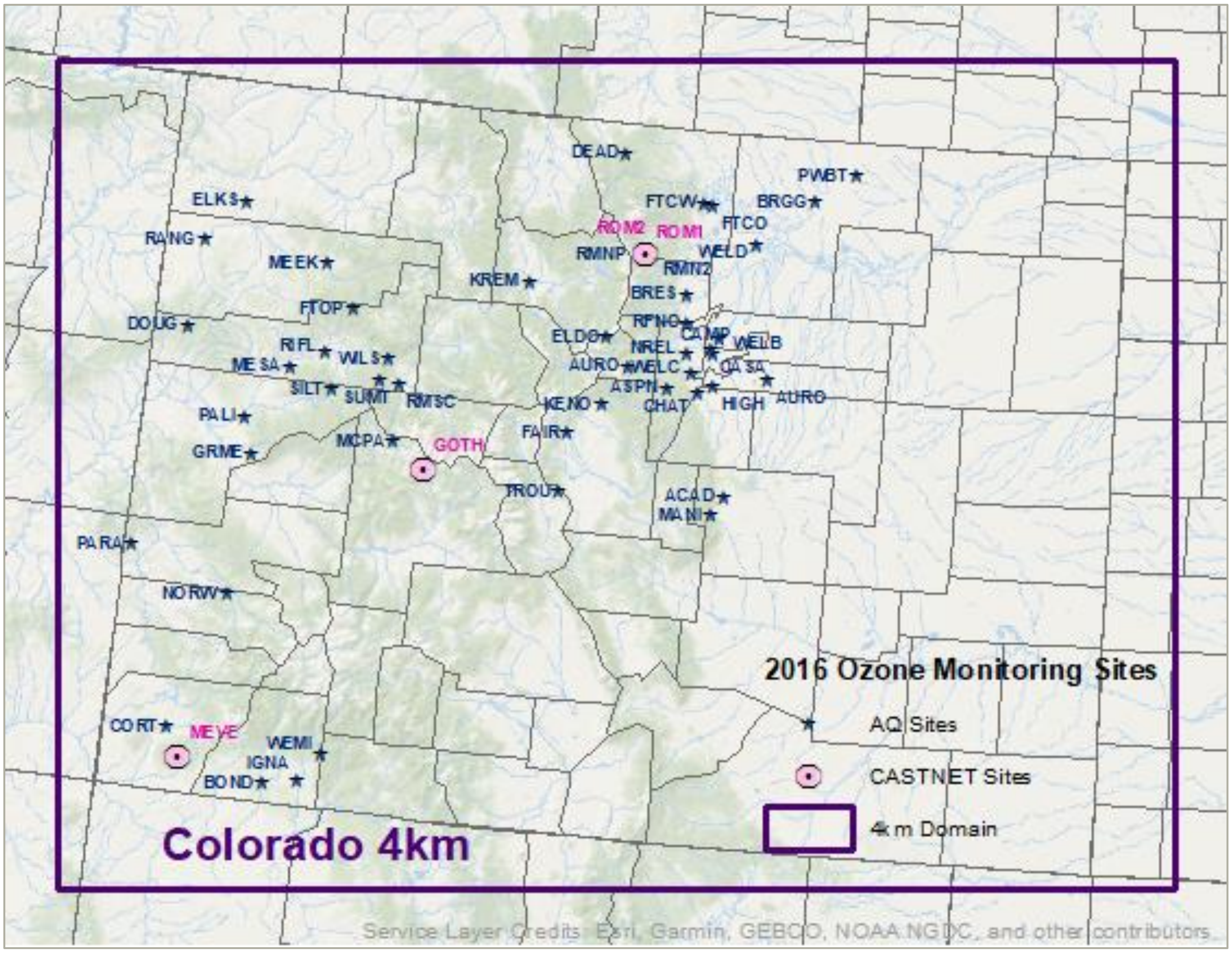

Figure 1-3. DM/NFR NAA 4-km Colorado domain for CAMx and emissions modeling, with locations of ozone monitors that were operating during some portion of 2016.

Table 1-1. Lambert Conformal Conic projection parameters for the DM/NFR NAA 36/12/4-km modeling domains.

Parameter	Value
Projection	Lambert-Conformal
1st True Latitude	33 degrees N
2nd True Latitude	45 degrees N
Central Longitude	-97 degrees W
Central Latitude	40 degrees N

Table 1-2. Grid definitions for CAMx DM/NFR NAA 2016 36/12/4-km modeling domains.

Grid	Origin (SW) (km)	Extent (NE) (km)	NX	NY
36 km	(-2952, -2772)	(3240, 2556)	172	148
12 km*	(-2424, -1632)	(2352, 1344)	398	248
4 km*	(-1084, -328)	(-392, 184)	173	128

1.2.5 Base and Future Year Emissions Data

The 2016 base year emissions data for the 36/12-km domains were initially based on the EPA/MJO 2016 Beta emissions (2016ff) and then updated to the 2016v1 emission estimates (2016fh). For the 4-km Colorado domain, the EPA 2016fh emissions with CDPHE updates for Colorado oil and gas and on-road mobile sources were used. New emissions were generated for natural emission sources, including biogenic and lightning NOx (LNOx) for all three domains. The EPA 2016 platform does not include LNOx emissions and used the BEIS biogenic emission model whose emissions were replaced by MEGAN biogenic emissions in all three domains. 2020 future year emissions were based on an interpolation between EPA's 2023 and 2016 emissions with some updates to Colorado provided by the CDPHE. Chapter 2 of this report compares the 2016, 2020 and 2023 emissions within the DM/NFR NAA.

1.2.6 Meteorology Input Preparation and QA/QC

The CAMx 2016 36/12/4-km meteorological inputs were based on output from 2016 WRF meteorological model simulation for the 36/12/4-km domains conducted by the Ramboll/Alpine team for the DM/NFR NAA 2020 attainment demonstration study. The 2016 36/12/4-km WRF output was processed by WRFCAMx processor to generate meteorological inputs for CAMx. Chapter 2 of the 2016 base case report (Ramboll, 2020a) describes the DM/NFR NAA 2016 36/12/4-km WRF modeling with more details provided in a separate WRF 2016 application/evaluation report (Ramboll, 2019b).

CAMx was also run using EPA's 2016 36/12-km meteorological inputs that were based on EPA's 2016 36-km and 12-km domain WRF modeling (EPA, 2019a). Because EPA's 2016 database did not use a 4-km modeling domain, the meteorological inputs for the 4-km Colorado domain were based on interpolation of the 12-km domain meteorological inputs using the CAMx flexi-nest feature, although high-resolution 4-km emissions were used.

1.2.7 Initial and Boundary Conditions Development

Boundary Conditions (BCs) for the 36-km 36US3 domain were based on a 2016 simulation of the GEOS-Chem global chemistry model. The GC2CAMx processor was used to generate day-specific diurnally varying BCs extracted from the global chemistry model to define the lateral boundaries around the 36-km 36US3 modeling domain (i.e., GCBC). Given uncertainties in global emission inventories, the 2016 BCs were held constant for the 2020 modeling. As noted previously, the entire month of May was used to initialize the model and wash out any influence of initial concentrations.

1.2.8 Diagnostic Sensitivity Analyses

Starting with EPA's 2016 36/12-km Beta CAMx modeling platform, a series of diagnostic sensitivity tests were conducted arriving at the final CAMx 2016 36/12/4-km base case model configuration that used EPA 2016v1 emissions for the 36/12-km domains. The results of these diagnostic sensitivity tests are given in Chapter 5 of the 2016 base case modeling report (Ramboll, 2020a) and included investigations into the following:

- Boundary Conditions (BCs) using output from a 2016 GEOS-Chem versus 2016 Hemispheric CMAQ global chemistry model simulations.
- Biogenic emissions using BEIS versus MEGAN biogenic emissions models.
- Meteorology using CAMx meteorological inputs based on processing of the DM/NFR NAA 36/12/4-km WRF versus EPA's 2016 36/12-km WRF simulations.
- Use of 4-km Colorado domain emissions and meteorological inputs.
- Treatment of on-road mobile source emissions in the DM/NFR NAA.

1.2.9 Final 2020 Base Case Modeling and Model Performance Evaluation

Two final CAMx 2016 36/12/4-km base case simulations were performed that are referred to as "S9" and "S10":

- S9 CAMx 36/12/4-km base case simulation used meteorological inputs based on the 2016 36/12/4-km WRF simulation (Ramboll, 2019b) conducted for the DM/NFR NAA 2020 attainment demonstration modeling study.
- S10 CAMx 36/12/4-km base case simulation used meteorological inputs based on EPA's 2016 36/12-km WRF simulation (EPA, 2019a) with the 4-km Colorado domain meteorology interpolated from the 12-km resolution data using the CAMx flexi-nest feature.

The Model Performance Evaluation (MPE) followed EPA's recommendations in their ozone modeling guidance (EPA, 2007; 2014d; 2018a) and other sources (e.g., Simon, Baker and Phillips, 2012; Emery et al., 2016). The focus of the MPE was on MDA8 ozone performance at sites within the DM/NFR NAA, especially for the four highest ozone sites and for days used to project future year 2020 ozone design values for the attainment demonstration. The CAMx 2016 36/12/4-km base case MPE for the two WRF meteorological input datasets were presented in Chapter 7 of the 2016 base case modeling report (Ramboll, 2020a).

1.2.10 2020 Attainment Demonstration Modeling

EPA's Software for the Modeled Attainment Test (SMAT-CE[8]) version 1.6 was used to make 2020 ozone design value projections using the CAMx 2016 and 2020 modeling results for both the S9 and S10 configurations. 2020 ozone projections were made several different ways as described in Chapters 3 and 4 of this document.

[8] https://www.epa.gov/scram/photochemical-modeling-tools

1.2.11 Weight of Evidence

A weight of evidence (WOE) supplemental analysis was performed that looks at the various modeled 2020 ozone projections, ambient air quality data including ozone trends and other analysis to support that by 2020 the 4th highest MDA8 ozone concentrations in the DM/NFR NAA will likely be below the 75 ppb 2008 ozone NAAQS under typical meteorological and emission conditions. Chapter 3 provides the 2020 attainment demonstration with Chapter 4 proving the WOE supplemental analysis.

2. SUMMARY OF 2016, 2020 AND 2023 EMISSIONS

This Chapter provides an overview on the development of the 2016, 2020 and 2023 36/12/4-km domain emission inputs for CAMx modeling and a summary of the 2016, 2020 and 2023 NO_X and VOC emissions within the DM/NFR NAA. Details on the 2016 emissions modeling procedures are provided in Chapter 4 of the 2016 base case modeling report (Ramboll, 2020a).

2.1 Overview of 2016, 2020 and 2023 Emissions Development

The EPA/MJO 2016v1 modeling platform 2016fh and 2023fh emissions were the primary source of the CAMx 36/12/4-km 2016, 2020 and 2023 emission inputs.

2.1.1 2016 Base Case Emissions

The 2016 base case emissions were based on the EPA 2016v1 emission inventories version 2016fh with some updates for Colorado. The EPA 2016v1 modeling platform 36/12-km anthropogenic emissions were provided in CMAQ model format so were converted to CAMx format using the CMAQ2CAMx converter.[9] The EPA 2016v1 BEIS biogenic emissions were replaced by MEGAN biogenic emissions and processors were run to generate lightning NOx (LNOx), sea salt and dimethyl sulfide (DMS) emissions.

For the 4-km Colorado domain, on-road mobile source emission inputs for the 2016 base case were developed using the SMOKE-MOVES processor with: (1) EPA's 2016 MOVES emissions factor (EF) look-up table; (2) county-level vehicle activity data based on DRCOG and NFRMPO link-based activity data from their travel demand model (TDM) modeling for counties in the DM/NFR NAA or using EPA's default county-level activity data outside of the DM/NFR NAA; and (3) 4-km gridded hourly WRF meteorological data. 2016 oil and gas emissions developed by WRAP were processed for the 2016 base case. For other anthropogenic emission source categories, the SMOKE emissions processor was used to process the 2016fh emissions for the 4-km Colorado domain. 2016fh point source electric generating units (EGUs) emissions include hourly 2016 Continuous Emissions Monitoring System (CEMS) values for NO_X and SO_2.

2.1.2 2023 Future Case Emissions

The procedures used to develop the CAMx 2023 36/12/4-km emission inputs were similar those for the 2016 base case. The CAMx 2023 36/12-km domain anthropogenic emissions were based on EPA's CMAQ-ready 2023fh emissions converted to CAMx using the CMAQ2CAMx processor. Natural emissions and fires were held constant at 2016 levels.

For the 4-km Colorado domain, 2023 on-road mobile source emission inputs were generated by running SMOKE-MOVES using EPA's 2023 MOVES EF look-up table, county-level activity data based on DRCOG/NFRMPO TDM model output for the DM/NFR NAA counties and EPA defaults elsewhere and the 2016 WRF gridded hourly meteorology. The CDPHE provided 2023 emissions for the Denver International Airport (DIA) that were processed by SMOKE. The WRAP 2023 O&G emissions were used. For

[9] http://www.camx.com/download/support-software.aspx

all other anthropogenic emission source categories, EPA's 2023fh emissions were processed by SMOKE to generate 2023 hourly gridded speciated emission inputs for the 4-km Colorado domain.

2.1.3 2020 Future Case Emissions

EPA did not develop model-ready 36/12-km emission inputs for the 2020 emissions year. EPA did develop a 2020 MOVES EF look-up table and 2020 emissions for non-road mobile sources. Table 2-1 shows the source of the 2020 anthropogenic emissions for the CO 4-km and 36/12-km domains.

The 2020 36/12-km emission inputs were calculated by interpolating EPA's model-ready 2016 and 2023 emissions for low-level gridded anthropogenic emission source categories. 2020 36/12-km domain elevated point source emissions were generated by interpolating the 2016 and 2023 point source emission rates and then processing them by SMOKE.

For the 4-km modeling domain, 2020 on-road mobile source emission inputs were obtained using SMOKE-MOVES the same way that they were obtained for the 2016 and 2023 model inputs. The CDPHE provided 2020 DIA emissions that were processed by SMOKE. For other anthropogenic emission source categories, the 2016fh and 2023fh emissions were interpolated to 2020 and processed by SMOKE to generate 2020 emission inputs for the 4-km Colorado domain.

Table 2-1. Source of the 2020 anthropogenic emissions for the Colorado 4-km and 36/12-km modeling domains.

Source Category	Colorado Domain* (4-km Domain)	12US2 Continental U.S. (12-km Domain)	36US3 Continental U.S. (36-km Domain)
Area: *ag, rwc, afdust, nonpt*	Interpolate 2016fh and 2023fh emissions - **apply Reg. No. 21 reductions**	Interpolate model-ready files for 2016fh and 2023fh	Interpolate model-ready files for 2016fh and 2023fh
Oil & Gas: *np_oilgas, pt_oilgas*	**APCD O&G emissions for 2020 – add tribal emissions**	Interpolate model-ready files for 2016fh and 2023fh	Interpolate model-ready files for 2016fh and 2023fh
Onroad Mobile: *onroad*	EPA 2016v1 platform: 2020fh MOVES emissions table – SMOKE-MOVES processing	EPA 2016v1 platform: 2020fh MOVES emissions table – SMOKE-MOVES processing	EPA 2016v1 platform: 2020fh MOVES emissions table – SMOKE-MOVES processing
Nonroad: *Nonroad*	EPA 2016v1 platform: 2020fh emissions	EPA 2016v1 platform: 2020fh emissions	EPA 2016v1 platform: 2020fh emissions
Airports: *airports*	Interpolate 2016fh and 2023fh emissions - **update DIA emissions**	Interpolate model-ready files for 2016fh and 2023fh	Interpolate model-ready files for 2016fh and 2023fh
CMV: *cmv_c1c2, cmv_c3*	N/A	Interpolate model-ready files for 2016fh and 2023fh	Interpolate model-ready files for 2016fh and 2023fh
Locomotives: *rail*	Interpolate 2016fh and 2023fh emissions	Interpolate model-ready files for 2016fh and 2023fh	Interpolate model-ready files for 2016fh and 2023fh
EGU Point: *ptegu*	**APCD EGU emissions** (use 2016 CEM for temporal)	Interpolate model-ready files for 2016fh and 2023fh	Interpolate model-ready files for 2016fh and 2023fh
Point: *ptnonipm*	Interpolate 2016fh and 2023fh emissions	Interpolate model-ready files for 2016fh and 2023fh	Interpolate model-ready files for 2016fh and 2023fh
Non-US: *Canada/Mexico/Offshore*	N/A	Interpolate model-ready files for 2016fh and 2023fh	Interpolate model-ready files for 2016fh and 2023fh
Fires	EPA 2016fh FIRES	EPA 2016fh FIRES	EPA 2016fh FIRES

Source Category	Colorado Domain* (4-km Domain)	12US2 Continental U.S. (12-km Domain)	36US3 Continental U.S. (36-km Domain)
Biogenics	2016 MEGAN	2016 MEGAN	2016 MEGAN

Acronyms

- ag = agriculture
- rwc = residential wood combustion
- afdust = dust
- nonpt = non-point
- np_oilgas = non-point oil and gas
- pt_oilgas = point oil and gas
- CMV = Commercial Marine Vessels
- EGU = Electrical Generating Units
- ptnonipm = non-EGU point sources

2.2 Summary of Emission Results for the DM/NFR NAA

Table 2-2 summarizes the NO_X and VOC emissions for the whole 9-county[10] DM/NFR NAA by major source category. The on-road mobile, biogenic and LNOx emissions are episode average (i.e., May-August 2016), the non-road source categories in the NONROAD model are typical July weekday, the remaining source categories are typical day emissions (i.e., annual average divided by 365).

2.2.1 2016 Base Case Emissions

The percent contribution of major source categories to total anthropogenic NO_X and VOC emissions in the DM/NFR NAA for the three emission modeling years are shown in, respectively, Figures 2-1 and 2-2. The largest contributor to total NO_X in the 2016 Base Case is on-road mobile (31%) followed by biogenic (20%), area oil and gas (O&G) (12%), non-EGU Point (8%) and EGU Point (7%). The high contributions of biogenic NO_X emissions is surprising and discussed in more detail later in this Chapter. Note that O&G emissions are split into three source categories (Point, Storage Tanks[11] and Area) and the total O&G NO_X contribution in 2016 is 18%. The Non-Road emissions entry in Table 2-2 includes traditional non-road equipment in the NONROAD model as well as locomotives and pleasure craft, but not airports.

For 2016 VOC emissions, as expected biogenic emissions is the largest contributor (33%), followed by O&G Storage Tanks (28%) and Non-Point (area sources) at 12%. Total O&G VOC contribution is 37% in 2016.

[10] The DM/NFR ozone NAA does not include the northern portions of Weld and Larimar County (roughly at the city of Wellington northward), but emissions are processed by county, so the full 9-county emissions are included in the summary tables.

[11] In previous DM/NFR ozone SIPs, we have used the term O&G Condensate to refer to O&G Storage Tank emissions because most of the O&G Storage Tank VOC Emissions in the DM/NFR NAA is high API gravity oil that condenses into liquid after being freed from high pressure underground wells.

Table 2-2. Summary of total NO_X and VOC emissions (tons per day, tpd) within the 9-county DM/NFR NAA.

	NOx (tpd)			VOC (tpd)		
Source Sector	**2016**	**2020**	**2023**	**2016**	**2020**	**2023**
EGU Point[1]	17.70	3.90	3.90	0.40	0.03	0.03
Non-EGU Point	20.90	21.20	21.50	26.40	26.30	26.30
O&G Point	12.72	13.80	13.80	14.14	15.70	15.70
O&G Storage Tanks	3.20	1.00	0.40	151.80	70.60	31.00
O&G Area	32.10	37.00	40.00	38.29	58.09	71.00
Non-Point	13.30	13.12	12.87	64.73	53.43	57.01
Non-Road	14.54	12.06	10.92	22.35	20.85	20.92
On-Road	80.14	48.80	37.64	45.50	33.23	28.44
Airports	11.59	7.69	8.34	4.38	2.30	2.47
Biogenic	50.89	50.89	50.89	178.68	178.68	178.68
LNOx	0.10	0.10	0.10	0.00	0.00	0.00
Total	257.18	209.56	200.36	546.68	459.22	431.55

1 excludes Rawhide Energy Station

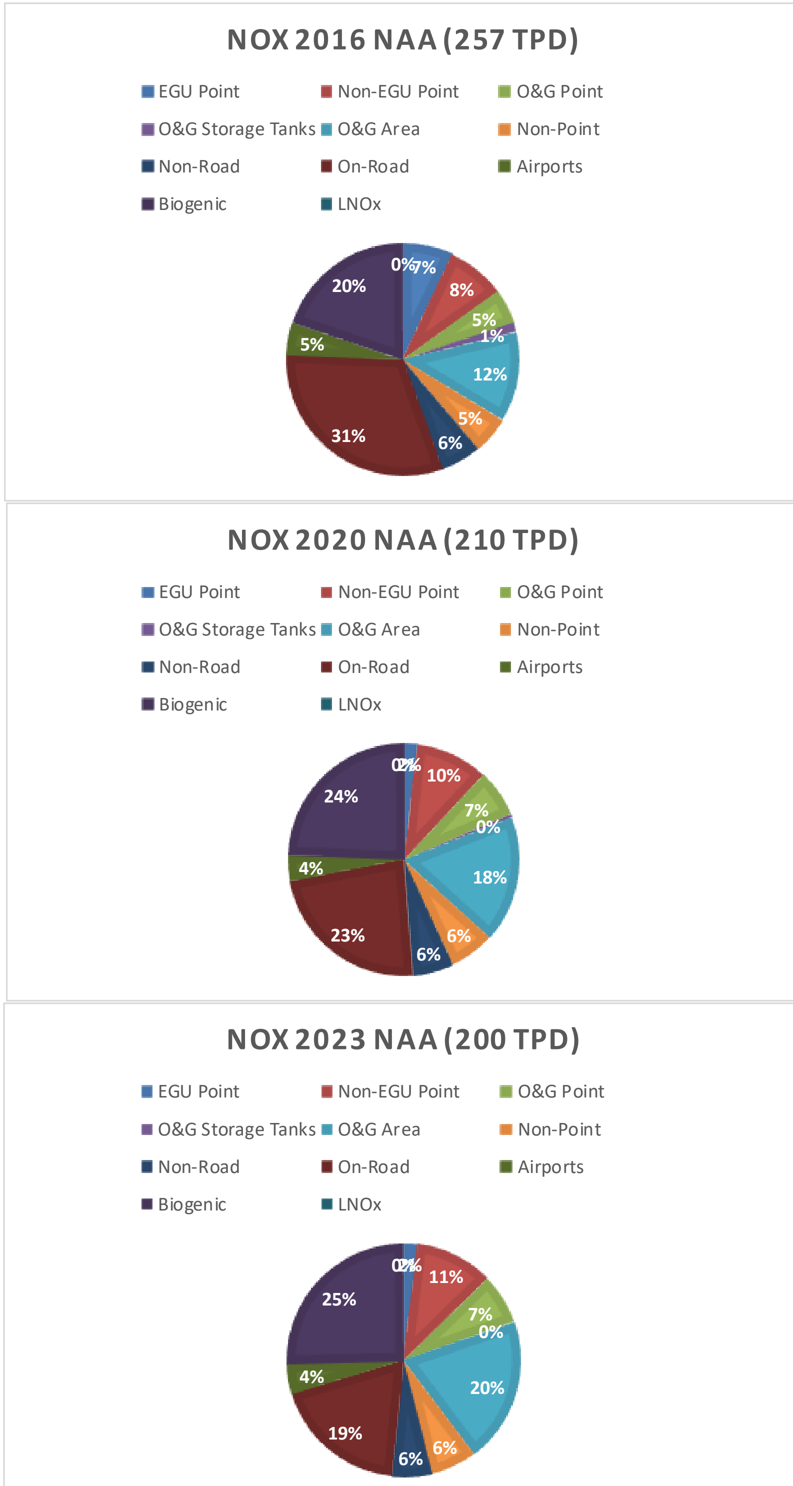

Figure 2-1. Percent contribution of major source categories to total NO_x emissions in the DM/NFR NAA for 2016 (top), 2020 (middle) and 2023 (bottom) base case emission scenarios.

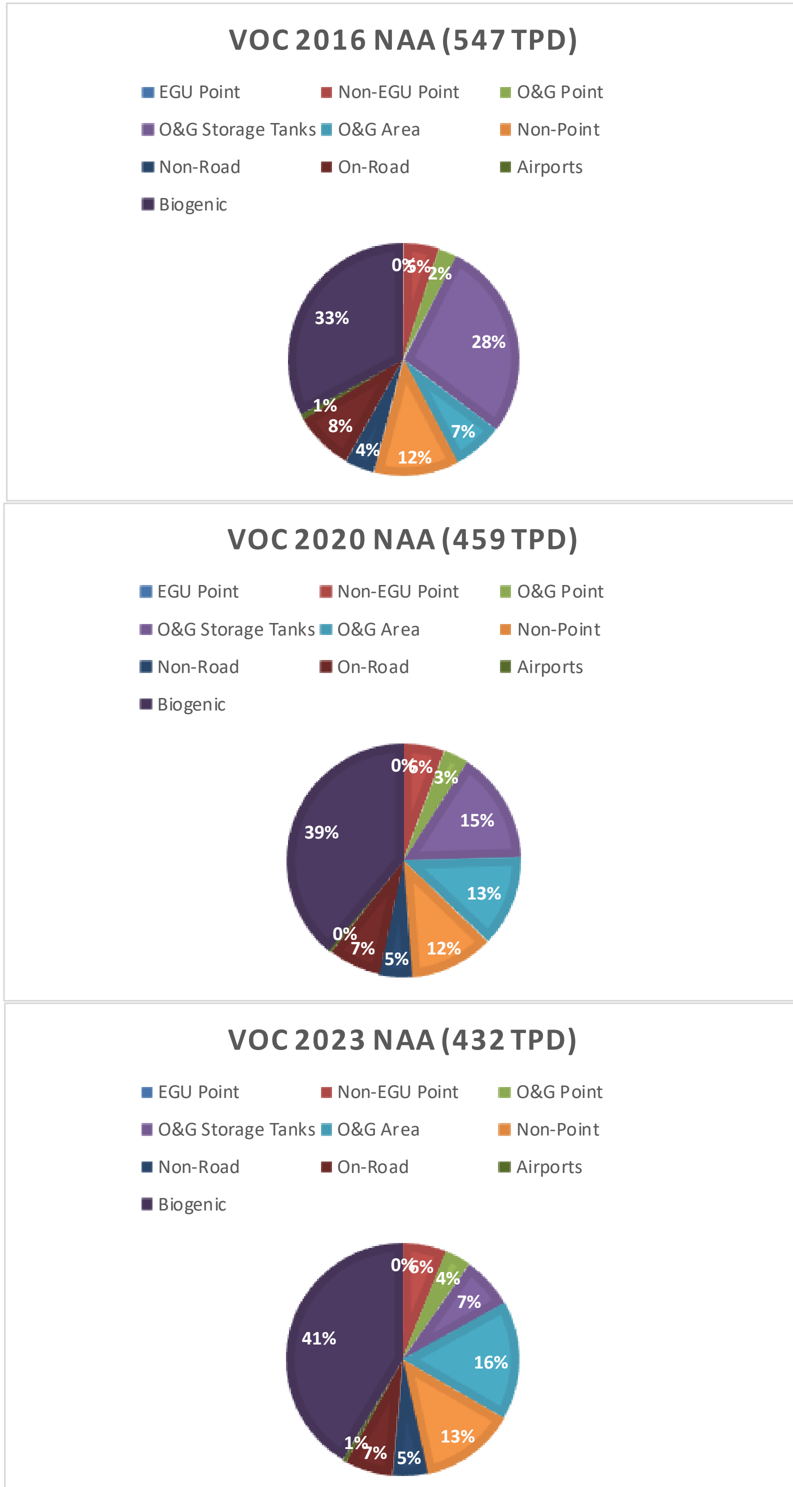

Figure 2-2. Percent contribution of major source categories to total VOC emissions in the DM/NFR NAA for 2016 (top), 2020 (middle) and 2023 (bottom) base case emission scenarios.

2.2.2 2020 and 2023 Future Year Emissions

In the 2020 and 2023 future years, on-road mobile emissions becomes a smaller fraction (23% and 19%) of the total DM/NFR NAA NO_X emissions, while biogenic NO_X becomes a relatively larger fraction (24% and 25%) although the magnitude of biogenic emissions remains unchanged from 2016 base case levels. Future year total O&G NO_X emissions also increased their fractional contribution from 2016 levels (25% and 27% for 2020 and 2023), however it is not that O&G NO_X emissions are increasing that much in the three years (48, 52, and 54 tpd), just that the total NO_X emissions are being reduced.

Since biogenic VOC remains unchanged from 2016 levels it becomes a relatively larger contributor in 2020 and 2023 (39% and 41%) than in 2016 (33%). The largest anthropogenic VOC contributor by far is O&G with an approximately 30% contribution for the three years.

Table 2-3 and 2-4 shows the NO_X and VOC emission reductions across the DM/NFR NAA from the 2016 base year levels for the two future year emission scenarios. There is a total of 48 and 57 tpd (19% and 22%) reduction in 2020 and 2023 NO_X emissions across the NAA from 2016 levels of which most (31 and 43 tpd) comes from on-road mobile sources. There is also significant (78%) reduction in EGU NO_X emissions (14 tpd) in the DM/NFR NAA.

Total VOC emissions in 2020 and 2023 are reduced 88 and 115 tpd from 2016 levels with O&G Storage Tanks sources (reductions of 81 and 121 tpd) accounting for by far the largest VOC reduction. However, O&G Area VOC is increasing, which offsets some of the O&G Storage Tanks VOC reductions.

Table 2-3. 2020 and 2023 reductions in NO_X and VOC emissions (tpd) in the DM/NFR NAA from 2016 base case levels.

	NOx Reduction (tpd)		VOC Reduction (tpd)	
Source Sector	**2020**	**2023**	**2020**	**2023**
EGU	-13.8	-13.8	-0.4	-0.4
Non-EGU Point	0.3	0.6	-0.1	-0.1
Oil & Gas Point	1.1	1.1	1.6	1.6
Oil & Gas Storage Tanks	-2.2	-2.8	-81.2	-120.8
Oil & Gas Area	4.9	7.9	19.8	32.7
Area Sources	-0.2	-0.4	-11.3	-7.7
Non-Road Mobile	-2.5	-3.6	-1.5	-1.4
On-Road Mobile	-31.3	-42.5	-12.3	-17.1
Airports	-3.9	-3.3	-2.1	-1.9
Total	-47.6	-56.8	-87.5	-115.1

Table 2-4. 2020 and 2023 reductions in NO_X and VOC emissions (percent) in the DM/NFR NAA from 2016 base case levels.

	NOx Reduction (%)		VOC Reduction (%)	
Source Sector	**2020**	**2023**	**2020**	**2023**
EGU Point	-78%	-78%	-92%	-92%
Non-EGU Point	1%	3%	0%	0%
Oil & Gas Point	8%	8%	11%	11%
Oil & Gas Storage Tanks	-69%	-88%	-53%	-80%
Oil & Gas Area	15%	25%	52%	85%
Area Sources	-1%	-3%	-17%	-12%
Non-Road Mobile	-17%	-25%	-7%	-6%
On-Road Mobile	-39%	-53%	-27%	-38%
Airports	-34%	-28%	-48%	-44%
Total	-19%	-22%	-16%	-21%

2.2.3 Biogenic NO_X emissions

It is surprising that biogenic NO_X emissions in the DM/NFR NAA is the second largest source sector in the 2016 base case (behind on-road mobile) and the largest contributing source sector in the 2020 and 2023 emission scenarios. Biogenic NO_X emissions are not all natural in origin. Soil NO_X emissions occur when microbial action processes nitrogen in soil and releases it to the atmosphere as reactive oxidized nitrogen (NO). The source of the nitrogen in the soil can be natural (e.g., wildfires and LNOx) and anthropogenic in origin, including fertilizer application and nitrogen deposition of anthropogenic NO_X emissions.

The contribution of biogenic NO_X emissions within the DM/NFR NAA in the current 2016 base year modeling is much higher than in previous DM/NFR NAA ozone SIPs. In the DM/NFR Moderate NAA ozone SIP, which used a 2011 modeling platform, the biogenic VOC and NO_X emissions in the DM/NFR NAA were 170 and 6 tpd that compares to 179 and 51 tpd in the currently modeling. That is, in the current 2016 base case modeling the biogenic VOC emissions in the DM/NFR NAA are comparable (within 5%) to the previous SIP, but the biogenic NO_X emissions are almost an order magnitude higher (8.5x) than they were in the previous SIP. The reasons for this are recent updates to version 3.1 (v3.1) of the MEGAN biogenic emissions model used in the current study.

MEGAN v3.1 updated the biogenic NO_X emissions methodology using an improved approach for estimating soil NO emissions based on Hudman et al. (2012) and Rasool et al. (2016). Key improvements in the MEGAN v3.1 soil NO_X emissions include: (1) relating emissions to soil moisture, rather than precipitation; (2) decoupling water availability and temperature dependence and modifying the time scale; (3) improving gridded inventories for chemical fertilizers and manure; (4) using MODIS-based growing season start and end dates for fertilizer application; (5) including wet and dry nitrogen deposition; and (6) incorporating a representation of available nitrogen pool that includes natural, fertilizer and deposition sources. The resulting procedures were integrated into the GEOS-Chem model and evaluated using satellite observations to show that the approach better reproduced the observed interannual variability (Hudman et al. 2012).

Addition studies and verification of the new MEGAN v3.1 soil NO_X emissions are needed, but beyond the current scope of the DM/NFR NAA ozone SIP modeling. The sensitivity of the future attainment demonstration modeling should also be examined. If biogenic NO_X emissions are overstated that would provide a conservative estimate of future year attainment (i.e., overstating future year ozone design values) as biogenic NO_X remains unchanged between the base and future years. Note that some biogenic soil NO_X emissions is anthropogenic in origin, which brings up the concept of control measures to reduce soil NO_X emissions (e.g., better fertilizer application management practice).

3. 2020 OZONE ATTAINMENT DEMONSTRATION

EPA's latest ozone State Implementation Plan (SIP) modeling guidance (EPA, 2018d) contains detailed procedures for how to use base and future year photochemical grid model (PGM) modeling results to make future year ozone design value (DVf) projections. The EPA-recommended ozone attainment demonstration includes procedures for projecting observed base year ozone design values (DVb) to the future year (DVf) to conduct a modeled attainment test and suggests procedures for a weight of evidence (WOE) supplemental analysis that is used to confirm and corroborate the modeled attainment demonstration test. EPA has developed the Software for the Modeled Attainment Test (SMAT-CE[12]) tool that codifies the EPA-recommended procedures (EPA, 2018d) for projecting future year ozone DVfs.

3.1 EPA Recommended Future Year Ozone Design Value Projection Procedures

The procedures for making future year ozone DV projections are outlined in Chapter 4 of EPA's latest ozone modeling guidance (EPA, 2018d, pp. 99-110). EPA recommends using the PGM modeling results in a relative fashion to scale the observed base year ozone design value (DVb) to estimate the future year ozone design value (DVf). The model derived scaling factors are called Relative Response Factors (RRF) and are the ratio of future to base year ozone modeling results averaged over the 10 highest base year base case modeled Maximum Daily 8-hour Average (MDA8) ozone concentrations near the monitor:

$$RRF = \sum Model_{2020} / \sum Model_{2016}$$

$$DVf = DVb \times RRF$$

3.1.1 Base Year Ozone Design Value (DVb)

EPA guidance recommends that the DVb is calculated as the average of three-years of ozone design values centered on the base modeling year. As an ozone design value is defined as the three-year average of the 4th highest MDA8 ozone concentrations at a monitor, the DVb is based on 5 years of 4th highest MDA8 ozone concentrations centered on the base year so the highest weight (3x) is on the 4th highest MDA8 ozone for the base year with less weights in the 2 years before and after the base year (i.e., weighting factors of 1, 2, 3, 2, 1).

For the DM/NFR NAA 2020 attainment demonstration modeling, the base year is 2016 so that the DVb at each site will be defined from three years of ozone design values (DV) as follows:

$$DVb_{2016} = (DV_{2014\text{-}2016} + DV_{2015\text{-}2017} + DV_{2016\text{-}2018}) / 3$$

[12] https://www.epa.gov/scram/photochemical-modeling-tools

3.1.2 Calculation of Relative Response Factors (RRFs)

As discussed above, the RRF is defined as the ratio of the average of the PGM future year (FY) to base year (BY) MDA8 ozone concentrations for the 10 days with the highest base year modeled MDA8 ozone concentrations near the monitor.

3.1.2.1 Near the Monitor

By near the monitor, EPA guidance recommends that the highest modeled base year MDA8 ozone is selected within a 3x3 array of grid cells centered on the monitor. For the future year, the future year MDA8 ozone is selected from the same grid cell in the 3x3 array centered on the monitor as used in the base year.

Previous EPA modeling guidance used an array of cells around the monitor that was grid cell size dependent such that a 3x3 array was used for a 12-km grid resolution and a 7x7 array was used for a 4-km grid resolution. Thus, previous DM/NFR NAA ozone SIPs using a 4-km grid resolution have used a 7x7 array around the monitor to define near the monitor. In our 2020 attainment demonstration WOE supplemental analysis in Chapter 4, we also examine the 7x7 array ozone projection approach in additional to the EPA-recommended 3x3 array, as well as a 1x1 array (i.e., at the monitoring site) to define near the monitor.

3.1.2.2 10 Highest Base Year MDA8 Ozone Days

EPA recommends that the RRF be based on the 10 days with the highest base year modeled MDA8 ozone concentrations near the monitor, provided the base year MDA8 ozone is greater or equal to 60 ppb. If there are less than 10 days with base year MDA8 ≥ 60 ppb, just the days ≥ 60 ppb are used provided there are at least 5 days. If there are less than 5 days with base year MDA8 ozone ≥ 60 ppb EPA recommends that RRFs not be calculated for that site.

3.1.3 Alternative Future Year Ozone Design Value Projection Procedures

EPA’s modeling guidance includes flexibility to modify the recommended ozone DVf projection procedure discussed above. Depending on the application, there may be a reason that grid cells in the 3x3 array centered on the monitor are not representative of conditions at the monitor. For example, if the monitor is a coastal site and the 3x3 array of grid cells includes cells dominated by water that have different mixing characteristics than the overland monitoring site, it may be appropriate to exclude the over water grid cells in the 3x3 array.

There may be reasons that one or more of the highest 10 base year MDA8 ozone days are not appropriate to be used in the RRF. For example, if the modeled base year MDA8 ozone is highly influenced by emissions from wildfires it could be excluded and the next highest modeled MDA8 ozone included in the RRF so that 10 modeled days are still used.

Past DM/NFR NAA ozone SIPs have made future year ozone DV projections with slight deviations from the current EPA recommended test as follows:

- Defining near the monitor by using a 7x7 and 1x1 array of 4-km grid cells centered on the monitor in addition to a 3x3 array in EPA's guidance.
- Elimination of observed MDA8 ozone concentrations in the calculation of the ozone DVb for those days flagged as having been influenced by emissions from wildfires or contributions from stratospheric ozone.
- Invoke a model performance evaluation (MPE) criteria that requires the modeled and observed MDA8 ozone match each other within sufficient accuracy to be included in the 10 highest modeled MDA8 ozone days used to develop RRFs and make future year ozone DVf projections.

In the DM/NFR NAA 2020 attainment demonstration modeling WOE supplemental analysis discussed in the next Chapter, we are making alternative ozone projections using an MPE requirement that the modeled MDA8 ozone at the monitor for the top 10 modeled MDA8 ozone days used in the RRF match the observed MDA8 ozone within 10% and 15%.

3.2 2020 Modeled Attainment Demonstration Test

In this section we demonstrate that 2020 ozone air quality within the DM/NFR NAA is estimated to be below the 75 ppb 2008 ozone NAAQS under more typical meteorological conditions (e.g., 2016). As the convention is to truncate the ozone to the nearest ppb, ozone is attaining the NAAQS when it is 75.9 ppb or lower and is above the NAAQS when it is 76.0 ppb or higher.

3.2.1 Primary Model Configuration

Two CAMx 2016 36/12/4-km base case configurations were examined in this analysis:

- S9 that used meteorological inputs based on a 2016 36/12/4-km WRF/GFS simulations conducted as part of the DM/NFR NAA 2020 modeling study (Ramboll, 2019b); and
- S10 that used EPA's 2016v2 meteorological inputs based on a 2016 36/12-km WRF/NAM simulation conducted by EPA (EPA, 2019a).

The CAMx S9 ozone model performance produced large ozone overestimation on some days leading to an ozone overestimation bias that sometimes failed to achieve ozone Performance Goals. The CAMx S10 base case produced lower ozone bias and error that more frequently achieved ozone Performance Goals. Given the better ozone performance of the CAMx S10 base case (Ramboll, 2020a), it was selected as the primary 2020 ozone attainment demonstration configuration with 2020 ozone projections using the CAMx S9 configuration presented as part of the WOE supplemental analysis in Chapter 4.

3.2.2 2020 Ozone Attainment Demonstration

Table 3-1 displays the base year (2014-2018) ozone DVb and projected 2020 ozone DVf at all the monitoring sites in Colorado using the CAMx S10 2016 base case and 2020 future year 4-km modeling results and the EPA's default ozone projection approach (EPA, 2018d). The ozone design values that exceed the 75 ppb 2008 ozone

NAAQS are shaded red. Also shown in Table 3-1 are the RRFs used to scale the ozone DVb to obtain the 2020 ozone DVf.

There are three monitoring sites that have current base year (2014-2018) ozone DVb that exceed the 2008 ozone NAAQS: 79.3 ppb at the National Renewable Energy Laboratory (NREL) and 77.3 ppb at both the Chatfield (CHAT) and Rocky Flats North (RFNO) monitoring sites. The Fort Collins West (FTCW) monitoring site has also exceeded the 2008 ozone NAAQS in the past, but its 5-year 2014-2018 DVb is 75.7 ppb so is below the 2008 ozone NAAQS, but is above the 70 pb 2015 ozone NAAQS. The Highland (HIGH) and Welch (WELC) monitoring sites also have 2014-2018 DVb (73.0 ppb) above the 2015 ozone NAAQS.

Using the EPA-recommended default projection approach, the projected 2020 ozone DVf at all of monitoring sites in the DM/NFR NAA are below the 75 ppb 2008 ozone NAAQS thereby demonstrating attainment. Since the monitored 2020 ozone DV will be based on the average of the 4th highest MDA8 ozone from three years (2018, 2019 and 2020) and 2018 was a high ozone year, some of the observed 2020 ozone DVs will likely be above the 2008 NAAQS. But the 2020 future modeling suggests that the 2020 4th highest MDA8 ozone will be below the 2008 ozone NAAQS under typical meteorological conditions.

The highest projected 2020 ozone DVf is 75.9 ppb at the NREL monitoring site that is only 0.1 ppb below the NAAQS exceedance level (76.0 ppb). The projected 2020 ozone DVf at CHAT, RFNO and FTCW are, respectively, 74.4, 72.7 and 72.0 ppb that, along with NREL, are above the 70 ppb 2015 ozone NAAQS. The projected 2020 ozone DVf at all other sites in the DM/NFR NAA are below the 2015 ozone NAAQS.

Also shown in Table 3-1 are the ozone DVb and DVf for sites within the Colorado 4-km domain but outside of the DM/NFR NAA. All of these sites in the ozone attainment portions of Colorado have current DVb and future DVf values below both of the ozone NAAQS. The highest ozone DVb (~68 ppb) and DVf (~66 ppb) at these Colorado attainment area sites are in La Plata County (e.g., Durango).

Table 3-1. Base year (2014-2018) ozone design value (DVb) and projected 2020 future year ozone design value (DVf) using EPA default SMAT projection procedures and the CAMx S10 4-km 2016 and 2020 modeling results.

AIRS ID			DVb	RRF	DVf
DM/NFR NAA	**Site**	**County**	**(ppb)**	**3x3**	**(ppb)**
80350004	CHAT	Douglas	77.3	0.9630	74.4
80590006	RFNO	Jefferson	77.3	0.9413	72.7
80590011	NREL	Jefferson	79.3	0.9577	75.9
80690011	FTCW	Larimer	75.7	0.9523	72.0
80310002	CAMP	Denver	67.7	0.9749	66.0
80310026	CASA	Denver	68.7	0.9679	66.4
80013001	WELB	Adams	67.0	0.9616	64.4
80050002	HIGH	Arapahoe	73.0	0.9681	70.6
80050006	AURE	Arapahoe	67.7	0.9650	65.3
80590005	WELC	Jefferson	73.0	0.9551	69.7
80590013	ASNP	Jefferson	70.0	0.9481	66.3
80690007	RMNP	Larimer	69.0	0.9531	65.7
80691004	FTCO	Larimer	69.0	0.9528	65.7
81230009	WELD	Weld	70.0	0.9577	67.0
Attainment Area	**Site**	**County**	**DVb**	**RRF**	**DVf**
80410013	ACAD	El Paso	68.0	0.9677	65.8
80410016	MANI	El Paso	66.7	0.9531	63.5
80450012	RIFL	Garfield	62.0	0.9825	60.9
80519991	GOTH	Gunnison	64.7	0.9838	63.6
80671004	WEMI	La Plata	67.0	0.9767	65.4
80677001	DNGO	La Plata	68.7	0.9664	66.3
80677003	ANRV	La Plata	68.3	0.9736	66.4
80770020	PALI	Mesa	64.0	0.9785	62.6
80830006	CORT	Montezuma	61.5	0.9719	59.7
80830101	MEVE	Montezuma	66.3	0.9681	64.1
81030005	MEEK	Rio Blanco	60.3	0.9854	59.4

4. 2020 WEIGHT OF EVIDENCE ATTAINMENT DEMONSTRATION

In this section we provide support for the Chapter 3 modeled 2020 ozone attainment demonstration using the CAMx S10 model configuration through a weight of evidence (WOE) supplemental analysis.

4.1 EPA Recommendations of Supplemental Analysis to Support a Modeled Attainment Demonstration

As noted in EPA's latest ozone SIP modeling guidance (EPA, 2018d): "By definition, models are simplistic approximations of complex phenomena." There are numerous uncertainties in the modeling used to conduct the 2020 modeled attainment demonstration presented in Chapter 3 that used the CAMx S10 configuration (emissions, meteorology, level and role of transport, science formulations in the model, numerical solution techniques, etc.). EPA believes that the modeled attainment demonstration can be strengthened through supplemental analysis, as discussed in Chapter 6 of their latest ozone SIP modeling guidance (EPA, 2018d). EPA identifies three basic types of supplemental analysis:

1. Additional modeling analysis.
2. Analyses of trends in ambient air quality and emissions.
3. Additional emission controls/reductions.

4.1.1 EPA-Recommended Additional Modeling Analysis

EPA's ozone SIP modeling lists several additional modeling analysis activities that can be performed to supplement a modeled attainment demonstration. Below we list each of EPA's supplemental modeling analysis (EPA, 2018d, pp. 171-172) and our response on how they are addressed in this Chapter.

- Available regional or national scale modeling applications that are suitable for the local area, for example, modeling in support of EPA rulemakings or regional, multi-jurisdictional organization modeling that may be available for the appropriate future year of interest. Modeling analyses may be available that used different models and/or inputs.
    - <u>Response</u>: A recent regional or national scale simulation for 2020 was not available for a direct application. However, the CAMx S10 configuration used in the modeled attainment demonstration is very similar to and an enhancement to EPA's latest 2016v1 modeling platform.
- Use of other appropriate local modeling that includes the nonattainment area of interest. This may include applications using alternative models and/or inputs or research-oriented analyses.

  - Response: Additional 2020 ozone projections were made using the CAMx S9 configuration that uses alternative meteorological inputs (WRF/GFS).

- Use of photochemical source apportionment, DDM, and/or process analysis modeling tools to help explain why attainment is (or is not) demonstrated.

  - Response: Ozone source apportionment is planned in late summer 2020 using the 2023 future year emissions.

- Use of multiple air quality models / model input data sets (e.g., multiple meteorological data sets, alternative chemical mechanisms or emissions inventories, etc.). Multiple model configurations can be used to estimate sensitivity and uncertainty of future year design value predictions. For results to be most relevant to the way we recommend models be applied in attainment demonstrations, it is preferable that such procedures focus on the sensitivity of estimated RRFs and resulting projected design values to the variations in inputs and/or model formulations.

  - Response: As noted above, additional 2020 ozone DVf projections are made using the CAMx S9 configuration with completely different meteorological inputs than S10.

- Application of the attainment test with alternative procedures compared to the default recommendations in EPA's guidance. Any alternate approaches should be accompanied with a technical justification to explain why the approach is appropriate for the area in question and should be discussed with the appropriate EPA Regional office.

  - Response: As discussed in Chapter 3 and presented below, alternative future year ozone DVf projections are made using: (1) different definitions of "near the monitor"; (2) eliminating days that have been flagged as influenced by smoke or stratospheric ozone in the base year ozone DVb; and (3) invoking a model performance evaluation criteria when selecting days for use in the RRFs.

- Use of dispersion models to address primary $PM_{2.5}$ contributions to $PM_{2.5}$ concentrations.

  - Response: As this is an ozone attainment demonstration, this type of analysis is not relevant.

- The EPA has determined that the best approach to using models to demonstrate attainment of the NAAQS is to use a model in a relative mode. However, some types of "absolute" model results may be used to assess general progress towards attainment from the baseline inventory to the projected future inventory. Example metrics include:

- Percent change in total amount of ozone or $PM_{2.5}$ ≥ NAAQS within the nonattainment area
- Percent change in number of grid cells ≥ NAAQS within the nonattainment area
- Percent change in grid cell-hours (days) ≥ NAAQS within the nonattainment area
- Percent change in maximum modeled 8-hour ozone within the nonattainment area
  - Response: The changes in absolute ozone concentrations within the DM/NFR NAA for the S10 2016 base case and 2020 future year emissions scenarios are reported below.

4.1.2 Analysis of Observed Ozone Trends

Weather corrected ozone trends were updated to the most current year of available observations using the same technique as used in previous DM/NFR ozone SIPs (e.g., CDPHE and RAQC, 2016c). For the DM/NFR NAA 2020 ozone attainment demonstration SIP, a separate report (Ramboll, 2020b) was prepared on the meteorological adjusted ozone trends whose highlights are discussed in Section 4.3.

4.1.3 Additional Emission Controls/Reductions

As part of the supplemental WOE analysis, EPA recommends documenting any additional emission reductions that may be occurring that may not be included in the future year emission estimates. Such additional controls can include:

- Measures that are difficult to quantify or may not be enforceable in the SIP.
- Voluntary measures.
- Regional/super-regional and/or national programs that may not have been accounted for in the attainment demonstration.

Additional emission controls/reductions are discussed later in this Section 4.4.

4.2 Weight of Evidence Supplemental Analysis

Each of the components of EPA recommended supplemental analysis is discussed below as part of our WOE analysis that supports the Chapter 3 modeled attainment demonstration.

4.2.1 Additional Modeling WOE Analysis

We conducted the following additional modeling analysis as part of the WOE attainment demonstration.

- Examination of the sensitivity of the CAMx S10 configuration (i.e., EPA 2016 36/12-km WRF/NAM meteorological inputs) projected 2020 ozone DVf to:
    - Definition of "near the monitor" using a 7x7 and 1x1 array of cells around the monitor to define the RRFs in addition to the 3x3 array of cells recommended in EPA's guidance (EPA, 2018d).
    - Use of current year 2014-2018 ozone DVb eliminating observed ozone concentrations that have been flagged as being influenced by influenced by smoke or stratospheric ozone. Note that ozone observations that have been official approved by EPA as being influenced by smoke or stratospheric ozone have already been eliminated from the ozone DVb, such as September 2 and 4, 2017 (CDPHE, 2018).
    - Using alternative RRFs that use the days with the 10 highest modeled MDA8 ozone concentrations days in which the predicted and observed MDA8 ozone concentrations meet a model performance evaluation (MPE) criteria of being with 10% and 15% of each other.
- Making 2020 ozone DVf projections using the alternative CAMx S9 configuration (i.e., DM/NFR NAA study 2016 36/12/4-km WRF/GFS meteorological inputs):
    - Following EPA recommended ozone DVf procedures (EPA, 2018d).
    - Alternative definitions of near the monitor (i.e., 7x7 and 1x1).
    - Using ozone DVb without observations flagged as being influenced by influenced by smoke or stratospheric ozone.
    - Invoking the 10% and 15% MPE criteria.
- EPA suggested absolute ozone metrics showing level of ozone reductions between 2016 and 2020.

Also, in this section we present the Unmonitored Area Analysis (UAA).

4.2.1.1 Alternative 2020 Ozone Projection Procedures using CAMx S10 Configuration

Table 4-1 displays the base year (DVb) and projected 2020 future year (DVf) ozone design values at sites within the Colorado 4-km domain using the CAMx S10 2016 and 2020 4-km modeling results that examine the sensitivity of the ozone DVF to using observed ozone data that have been flagged as influenced by smoke or stratospheric ozone and alternative definitions to near the monitor. Ozone design values that are above the 2008 ozone NAAQS (i.e., ≥76.0 ppb) are colored red, values above the 2015 ozone NAAQS but below the 2008 NAAQS (i.e., 71.0 ppb ≤ ozone DV < 76.0 ppb) are colored yellow and values below the 2015 ozone NAAQS are not colored.

As noted in Chapter 3, using the standard DVb and EPA default 3x3 definition of near the monitor, all monitoring sites are projected to have 2020 ozone DVf that are below the 2008 ozone NAAQS, with the highest value of 75.9 ppb at NREL. Using the 1x1 definition of near the monitor and standard DVb, the NREL ozone DVf is above the 2008 ozone NAAQS (76.8 ppb), but 2020 ozone DVf at all other sites are below the 2008 ozone NAAQS. When the 7x7 definition of near the monitor is used, the NREL 2020 DVf (75.2 ppb), along with all other sites, are below the 2008 ozone NAAQS.

The use of the 2014-2018 base year ozone DVb in which the observed ozone on days flagged as influenced by smoke or stratospheric ozone are excluded in calculating the ozone DVb results in a reduction in the ozone DVf at the four key monitoring sites in the DM/NFR NAA (CHAT, RFNO, NREL and FTCW) so that they are all below the 2008 ozone NAAQS. For example, at NREL the 3x3 2020 ozone DVf using standard DVb is 75.9 ppb and is reduced to 74.7 ppb when the flagged data are removed from the DVb. Removal of the flagged data for the 1x1 grid cell case drops the ozone DVF (75.6 ppb) to below the 2008 ozone standard at NREL.

Table 4-1. 2014-2018 base year ozone design value (DVb) and CAMx S10 projected future-year 2020 ozone design values (DVf) examining sensitivity of ozone DVf projections to use of data flagged as influenced by smoke or stratospheric ozone and definition of near the monitor.

		2014-18 DVb	DVf (3x3)	DVf (1x1)	DVf (7x7)
AIRS ID	Station	(ppb)	(ppb)	(ppb)	(ppb)
DM/NFR NAA					
80350004	CHAT	77.3	74.4	74.5	73.7
	CHAT Flagged	76.7	73.9	73.9	73.2
80590006	RFNO	77.3	72.7	72.8	72.9
	RFNO Flagged	76.7	72.2	72.2	72.4
80590011	NREL	79.3	75.9	76.8	75.2
	NREL Flagged	78.0	74.7	75.6	74.0
80690011	FTCW	75.7	72.0	72.0	71.6
	FTCW Flagged	73.7	70.2	70.2	69.8
80310002	CAMP	67.7	66.0	66.1	65.5
80310026	CASA	68.7	66.4	67.3	66.4
80013001	WELB	67.0	64.4	64.4	65.4
80050002	HIGH	73.0	70.6	71.0	70.2
80050006	AURE	67.7	65.3	65.4	65.0
80590005	WELC	73.0	69.7	70.1	69.6
80590013	ASNP	70.0	66.3	66.5	66.7
80690007	RMNP	69.0	65.7	66.3	65.2
80691004	FTCO	69.0	65.7	66.3	65.1
81230009	WELD	70.0	67.0	67.5	65.7
Attainment Area					
80410013	ACAD	68.0	65.8	66.6	65.0
80410016	MANI	66.7	63.5	64.4	63.0
80450012	RIFL	62.0	60.9	60.9	60.9
80519991	GOTH	64.7	63.6	63.6	63.7
80671004	WEMI	67.0	65.4	65.6	65.4
80677001	DNGO	68.7	66.3	66.4	66.6
80677003	ANRV	68.3	66.4	66.5	65.6
80770020	PALI	64.0	62.6	62.5	62.7
80830006	CORT	61.5	59.7	60.1	59.6
80830101	MEVE	66.3	64.1	64.3	63.7
81030005	MEEK	60.3	59.4	59.5	59.4

Table 4-2 displays the sensitivity of the CAMx S10 projected 2020 ozone DVf to imposing that the days used in the RRFs achieve a MPE criteria that the observed and predicted 2016 MDA8 ozone concentrations be within 10% and 15% of each other. Using the 10% MPE all sites are below the 2008 ozone NAAQS with the NREL projected DVf being the same as when no MPE criteria is required (i.e., 75.9 ppb). Using the 15% MPE criteria increases the projected 2020 ozone DVf at NREL by 0.1 ppb to 76.0 ppb so that it no longer is below the 2008 ozone NAAQS.

Table 4-2. 2014-2018 base year ozone design value (DVb) and CAMx S10 projected future-year 2020 ozone design values (DVf) examining sensitivity of ozone DVf projections to use of data flagged as influenced by smoke or stratospheric ozone in the DVb and using the 10% and 15% MPE criteria (using 3x3 near the monitor).

AIRS ID	Station	2014-18 DVb (ppb)	DVf 10% MPE (ppb)	DVf 15% MPE (ppb)
80350004	CHAT	77.3	74.5	74.4
	CHAT Flagged	76.7	73.9	73.9
80590006	RFNO	77.3	73.2	73.2
	RFNO Flagged	76.7	72.7	72.7
80590011	NREL	79.3	75.9	76.0
	NREL Flagged	78.0	74.7	74.8
80690011	FTCW	75.7	72.1	72.1
	FTCW Flagged	73.7	70.3	70.2

4.2.1.2 Unmonitored Area Analysis

The SMAT ozone projection tool includes an unmonitored area analysis (UAA) that spatially interpolates the base year ozone DVb to each grid cell in the modeling domain and then projects it to the future year using a similar procedure as used for the projection at a monitoring site, only the RRFs are based on the modeled base and future year concentrations in the grid cell (i.e., a 1x1 array of grid cells). The spatial interpolation procedure used in the SMAT UAA allows, as an option, the use of modeled base year concentration gradients. Note that because the interpolation of the observed ozone DVb across the modeling domain introduces additional uncertainties, the UAA is not considered as reliable as the monitor based attainment test so is typically not used as a primary source in the modeled attainment test. However, it may identify ozone hot spots that warrant additional investigations. For example, it was in a DM/NFR NAA ozone SIP over a decade ago that identified higher ozone concentrations west of the Fort Collins monitoring site that led to the placement of a new Fort Collins West monitoring site that became one of the four key monitoring sites in the DM/NFR NAA.

Figure 4-1 displays the spatial distribution of the projected 2020 ozone DVf across the 4-km Colorado monitoring domain using the CAMx S10 2016 and 2020 modeling results with (right) and without (left) using the modeled concentration gradients in the ozone DVb interpolation procedure. 2020 projected ozone DVf in excess of 80 ppb are estimated in the furthest western portion of the Colorado 4-km modeling domain that are due to high ozone DVb in the Unita Basin in Utah. These high ozone DVb are winter high ozone concentrations that are due to cold pooling and not related to elevated ozone concentrations within the DM/NFR NAA. The highest ozone DVf within the DM/NFR NAA in the UAA is 75.5 and 75.1 with and without using the modeled concentration gradients in the ozone DVb interpolation procedure, respectively. Thus, the UAA analysis using the CAMx S10 modeling results estimate that 2020 ozone DVf will be below the 2008 ozone NAAQS throughout the DM/NFR NAA.

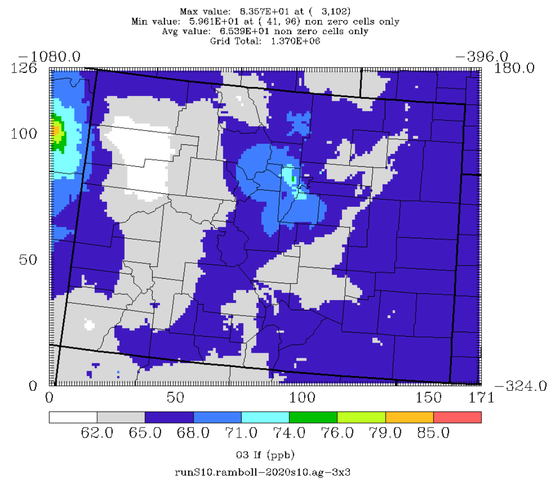

Figure 4-1. Unmonitored Area Analysis (UAA) using the CAMx S10 2016 and 2020 modeling results with (right) and without (left) using the concentration gradients in the interpolation of the ozone DVb to the grid cells in the Colorado 4-km modeling domain.

4.2.1.3 Alternative 2020 Visibility Projection Procedures using the Alternative S9 Configuration

The same suite of 2020 ozone DVf projections as used for the CAMx S10 configuration discussed above were made using CAMx 2016 and 2020 4-km modeling results with the S9 configuration (i.e., meteorological inputs based on the DM/NFR WRF/GFS 2016 36/12/4-km simulation). As shown in Table 4-3, the CAMx S9 configuration ozone estimates are less responsive to changes in emissions between 2016 and 2020 than the CAMx S10 configuration so estimate higher projected 2020 ozone DVf. Using the EPA-recommended default 3x3 projection approach, all monitoring sites have 2020 ozone DVf below the 2008 ozone NAAQS except NREL that has an ozone DVf of 76.8 ppb. The CAMx S9 projected 2020 ozone DVf at NREL is estimated to be above the 2008 NAAQS no matter which near the monitor definition is used or whether the 10% or 15% MPE criteria is used, while the projected 2020 ozone DVf at all other monitoring sites remain below the 2008 ozone NAAQS using all the alternative projection procedures. However, when accounting for potential contributions by smoke or stratospheric ozone by removing the flagged observations from the base year ozone DVb, the CAMx S9 projected 2020 ozone DVf at NREL (75.6 ppb), as well as all other monitoring sites, is below the 2008 ozone NAAQS using EPA recommended 3x3 near the monitor definition.

Table 4-3. 2014-2018 base year ozone design value (DVb) and CAMx S9 configuration projected future-year 2020 ozone design values (DVf) examining sensitivity of ozone DVf projections to use of data flagged as influenced by smoke or stratospheric ozone, definition of near the monitor and using the 10% and 15% MPE criteria (using 3x3 near the monitor).

	2014-2018	DVf	DVf	DVf	DVf	DVf
	DVb	3x3	1x1	7x7	10% MPE	10% MPE
Station	(ppb)	(ppb)	(ppb)	(ppb)	(ppb)	(ppb)
CHAT	77.3	74.8	74.6	74.8	74.8	74.8
CHAT Flagged	76.7	74.2	74.0	74.3	74.3	74.3
RFNO	77.3	73.1	73.9	73.5	74.1	73.5
RFNO Flagged	76.7	72.5	73.4	72.9	73.6	73.0
NREL	79.3	76.8	76.8	76.0	77.5	76.6
NREL Flagged	78.0	75.6	75.6	74.8	76.3	75.4
FTCW	75.7	71.6	72.0	71.5	71.6	71.9
FTCW Flagged	73.7	69.8	70.1	69.6	69.8	70.1

4.2.2 Additional Modeled Ozone Metrics

Section 4.1.1 discusses several absolute modeling ozone metrics that EPA's guidance (EPA, 2018d) suggests should be examined for the base and future to demonstrate that ozone concentrations above the NAAQS are being reduced in the NAA. Table 4-4 displays these ozone metrics for the CAMx S10 2016 and 2020 simulation. The metrics were calculated across the 9-county area that covers the DM/NFR NAA (including northern portions of Larimer and Weld Counties) using a 76 ppb ozone threshold. The change in ozone metrics between the 2016 base and 2020 future year are remarkably consistent showing large reductions (71% to 77%) in ozone concentrations and days above the 2008 ozone NAAQS. The absolute peak modeled MDA8 ozone concentration in the DM/NFR NAA is reduced by almost 5 ppb between the base and future year.

Table 4-4. EPA recommended absolute model ozone metrics showing reduction in ozone concentrations greater than or equal to 76 ppb across the DM/NFR NAA using the CAMx S10 2016 base case and 2020 future year modeling results.

CAMx S10 2016 4-km Modeling Results	76 ppb Threshold		
Ozone Metric	2016	2020	Reduction
Episode integrated ozone >= threshold (ppb)	19,327	4,416	-77%
Number of cells >= threshold in episode	221	57	-74%
Number of Grid cell days >= threshold	246	57	-77%
Maximum MDA8 ozone in episode (ppb)	84.2	79.5	-4.66
Number of days ≥ threshold	7	2	-71%

4.3 Observed Ozone Trends

Ozone trends were calculated with and without accounting for year-to-year variations in meteorology and with and without using observed ozone data that have been flagged as influenced by influenced by smoke or stratospheric ozone using the same procedures as used in previous DM/NFR NAA ozone SIPs (e.g., CDPHE and RAQC, 2016c), only using observed ozone data updated through 2019. The uncorrected ozone and meteorologically-adjusted ozone trends were made for the 4^{th} highest MDA8 ozone concentrations at the four key monitoring sites in the DM/NFR NAA. Regression equations were fitted to the observed 4^{th} high MDA8 ozone data from 2006-2019 and extrapolated out to 2023. This includes values for 2020 that can be compared against the projected 2020 ozone DVf from Chapter 3 and the WOE supplemental analysis discussed above. Below we summarize the results of the ozone trends analysis with more details provided in a companion ozone trends report (Ramboll, 2020b).

4.3.1 Fort Collins West

In the trend analysis plots discussed here, the straight red line is the linear regression line with curved confidence limits and the blue-green line is a locally estimated scatterplot smoothing (LOESS) curve (with a smoothing factor of 0.30). Figure 4-2 displays the uncorrected ozone trends that included the flagged observed ozone concentrations, the meteorologically adjusted ozone trends with the flagged data and the meteorologically adjusted ozone trends excluding the flagged data. The regression lines for all three ozone trend approaches indicate that the 4^{th} highest MDA8 ozone at the FTCW monitor will be below the 2008 ozone NAAQS in 2020 with projected ozone values of 73.7, 72.4 and 70.1 ppb for the three approaches.

4.3.2 Rocky Flats North

The three approaches for doing ozone trends at the RFNO monitoring site are shown in Figure 4-3. The trends regression equations for all three approaches indicate the 4^{th} high MDA8 ozone at RFNO will be below the 2008 ozone NAAQS by 2020. The regression equation using the straight ozone trends using flagged data estimates a 2020 value of 74.1 ppb that is reduced to 72.2 ppb when meteorology is accounted for. The regression equation for the meteorological-adjusted ozone trend without flagged data estimates a 72.0 ppb 4^{th} highest MDA8 ozone at RFNO in 2020.

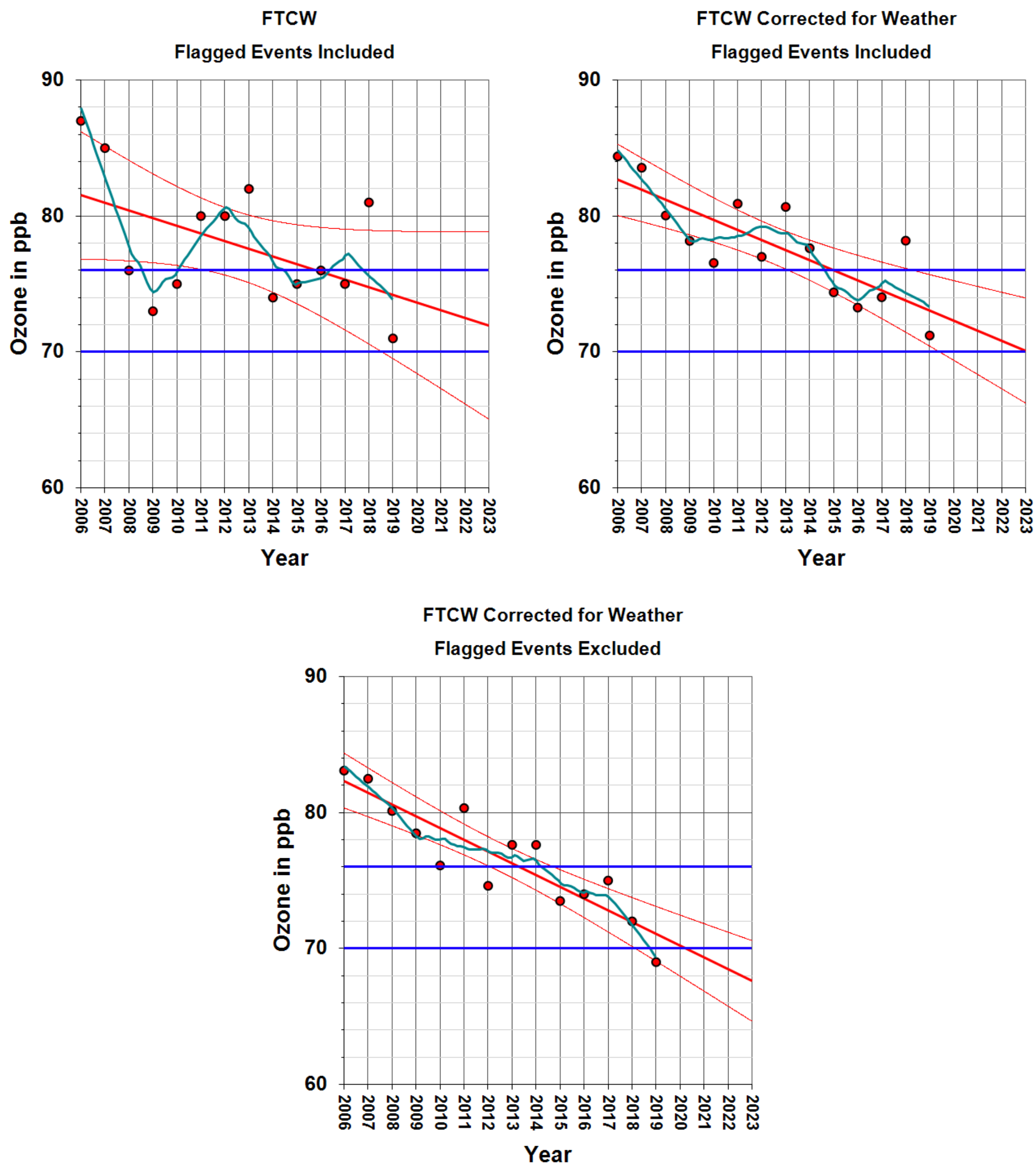

Figure 4-2. Ozone trends at the Fort Collins West (FTCW) monitoring site using flagged data (top left), using flagged data and adjusting for meteorology (top right) and excluding flagged data and adjusting for meteorology (bottom).

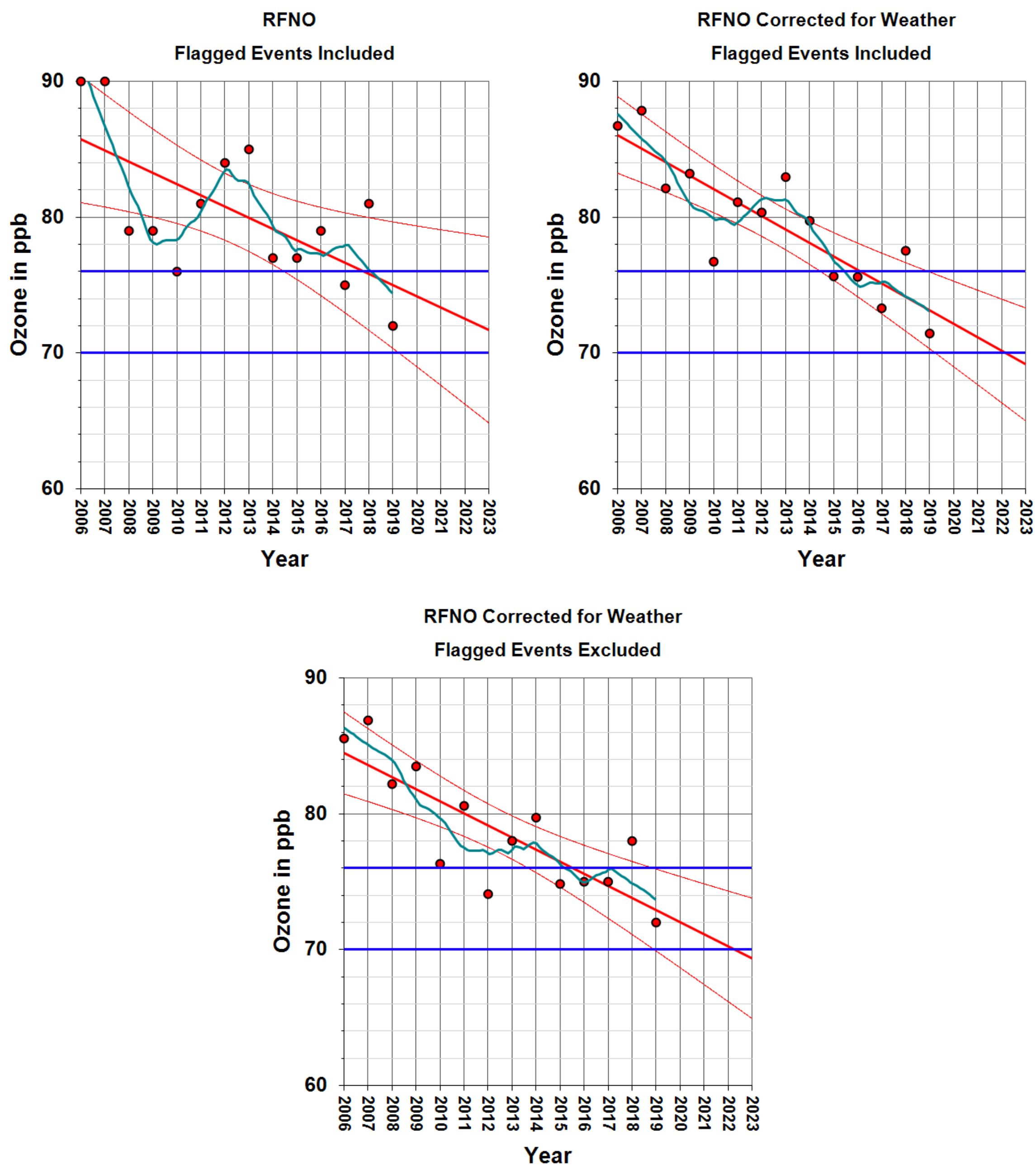

Figure 4-3. Ozone trends at the Rocky Flats North (RFNO) monitoring site using flagged data (top left), using flagged data and adjusting for meteorology (top right) and excluding flagged data and adjusting for meteorology (bottom).

4.3.3 Chatfield

In more recent years, there is a flat to increasing trend in the 4th high MDA8 ozone at the CHAT monitoring site when examining ozone trends with flagged data and not adjusting for meteorological conditions (Figure 4-4, top left). Using flagged data and not accounting for meteorology, the regression equation estimates a 2020 4th highest MDA8 ozone value of 78.0 ppb that is above the 2008 ozone NAAQS. This is due in part to the meteorological conditions in 2018 being very conducive to ozone formation resulting in high observed ozone at CHAT. When looking at ozone trends with flagged data but accounting for meteorology, the regression equation estimates a 2020 4th high ozone value of 75.8 ppb at CHAT, which is below the 2008 ozone NAAQS (Figure 4-4, top right). When excluding flagged data and adjusting for weather the ozone trend regression estimates a 2020 4th high MDA8 ozone at Chat of 74.1 ppb that is below the 2008 ozone NAAQS.

4.3.4 National Renewable Energy Laboratory

The ozone trend results for the NREL monitoring site are shown in Figure 4-5, which also includes a fourth ozone trend that excludes flagged data and accounts for meteorology but only considers years from 2010 on after the 2009 recession. When using flagged data, the ozone trend regression equation estimates the 4th high MDA8 ozone at NREL will be above the 2008 ozone NAAQS whether adjusting for meteorology (76.1 ppb) or not (78.4 ppb). However, when excluding flagged data and adjusting for weather, the trend regression equation estimates a 2020 4th high ozone value at NREL (74.0 ppb) that is below the 2008 ozone NAAQS. And just looking at trends from 2010 on without flagged data and adjusting for meteorology results in an even lower 4th high ozone value at NREL.

4.3.5 Ozone Trends Discussion

The ozone trend analysis is very sensitive to the inclusion or exclusion of flagged data and corrections for meteorology in the ozone trend analysis. Thus, the occurrence of wildfires whose emissions contribute to elevated ozone concentrations in the DM/NFR NAA (e.g., the September 2 and 4 exceptional event days in 2017, CDPHE, 2018) or meteorological conditions that are conducive to ozone formation (e.g., 2018) can greatly influence ozone in the DM/NFR NAA. The year-to-year changes in wildfire contributions and meteorologically conducive ozone formation conditions can overwhelm the effects of typical year-to-year reductions in anthropogenic emissions on ozone concentrations in the DM/NFR NAA. However, as the NREL trends analyses in Figure 4-5 suggest, there can be much lower ozone concentrations across the DM/NFR NAA when there are larger reductions in emissions combined with meteorological conditions not as conducive to ozone formation and limited wildfire contributions, as in 2009.

The above analysis demonstrates how important meteorology is to ozone formation in the DM/NFR NAA. The analysis suggests that if average meteorological conditions occur and in the absence of smoke and stratospheric ozone, the 4th highest MDA8 ozone will likely be below the 2008 ozone NAAQS in 2020.

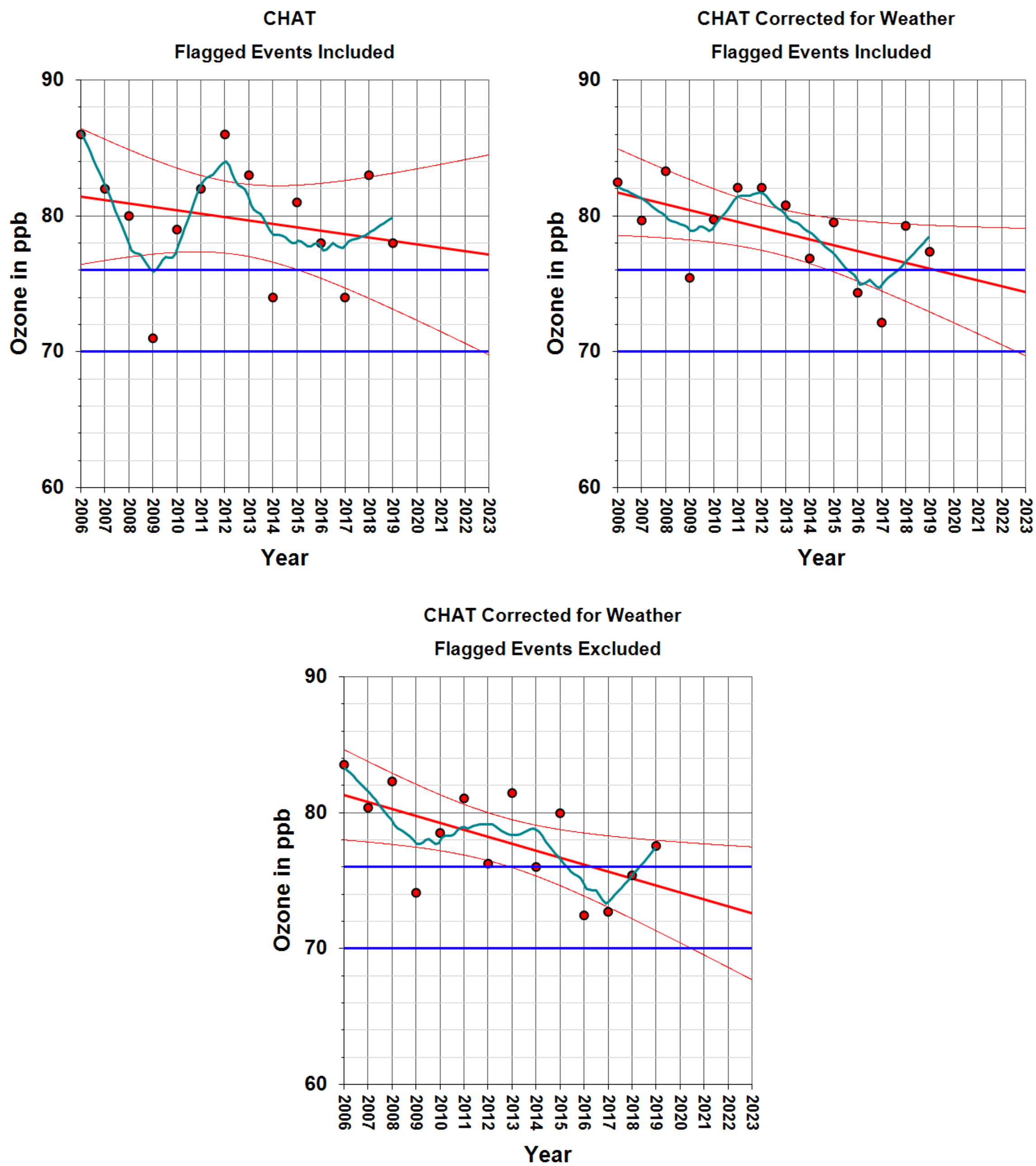

Figure 4-4. Ozone trends at the Chatfield (CHAT) monitoring site using flagged data (top left), using flagged data and adjusting for meteorology (top right) and excluding flagged data and adjusting for meteorology (bottom).

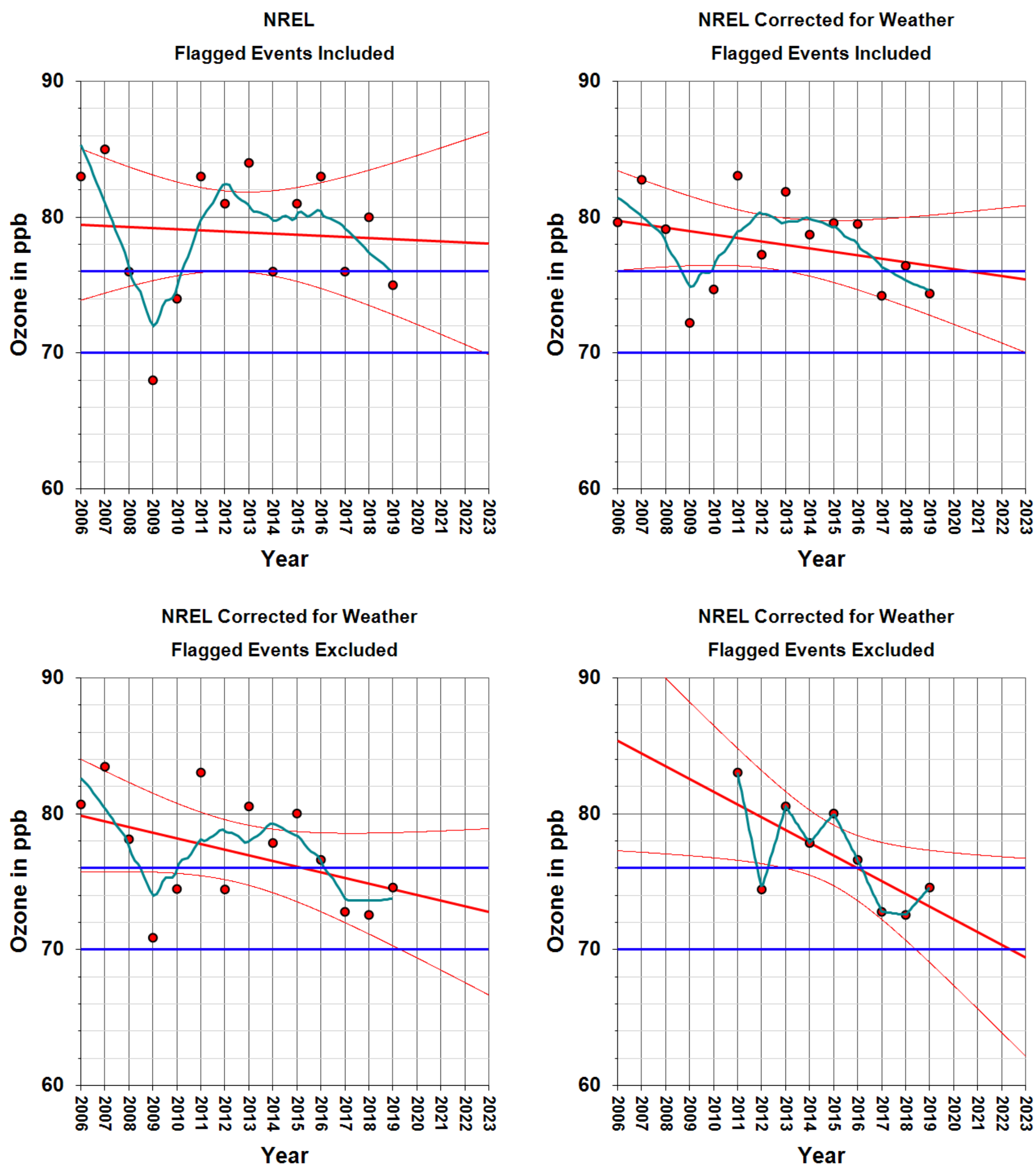

Figure 4-5. Ozone trends at the NREL monitoring site using flagged data (top left), using flagged data and adjusting for meteorology (top right), excluding flagged data and adjusting for meteorology (bottom left) and excluding flagged data, adjusting for meteorology and only considering years after the 2009 recession (bottom right).

4.4 Additional Emission Controls/Reductions

Chapter 7 of the Serious area ozone SIP lists the reasonably available control measures (RACM) adopted in the SIP and other potential control measures. These include a discussion of voluntary emission reduction control measures that are being implemented in the region but are not included as enforceable measures, so the emissions reductions are not reflected in the 2020 emissions inventory. However, such voluntary reduction in ozone precursors in the DM/NFR NAA would result in reductions in ozone concentrations so are part of the WOE supporting the 2020 attainment demonstration.

Table 4-5 lists the voluntary emissions reductions control measures that lead to real-world emissions reductions but are not federally enforceable so are not included as part of the 2020 emissions reductions in the attainment demonstration modeling. Details on these voluntary control measures are given in Section 7.4 of the SIP.

Table 4-5. Voluntary emission reduction measures that are not federally enforceable so are not accounted for in the emission reductions used in the 2020 attainment demonstration modeling.

Stationary Sources
Energy Efficiency and Renewable Energy Policies and Programs
State–Only Oil and Gas Controls – AQCC Regulation No. 7
Small Business Assistance Program
Mobile Sources
Diesel Retrofits and Fleet Fuel Use Reduction (Clean Air Fleets)
Charge Ahead Colorado Electric Vehicle Program
Expand Use of Alternative Fuels in Government and Private Fleets (ALT Fuels Colorado)
Electric Vehicle Group Purchase Programs
Innovative Motor Vehicle and Alternative Fuel Vehicle Tax Credits
Diesel Inspection and Maintenance Programs – AQCC Regulation No. 12
High Altitude Emissions Laboratory
Colorado Low Emission Automobile Regulation – AQCC Regulation No. 20
Electric Car Shares, Electric Scooter, and Electric Bike Infrastructure
Lawn and Garden
Mow Down Pollution Lawn Mower Exchange
Commercial Lawn and Garden Program
Zero Emission Lawn and Garden Equipment – Commercial Sector
Education and Outreach
Ozone Education and Outreach Program
Ozone Forecast Advisory – Voluntary Emission Reduction Action Days
Transportation Systems
Transit and Transportation Network
Transportation Demand Management Programs
Bicycle and Pedestrian Facilities
Land Use Planning and Development
CAA 108(f) Transportation Measures

5. SUMMARY AND CONCLUSIONS

This report presents a 2020 ozone attainment demonstration for the DM/NFR ozone nonattainment area (NAA) to address attainment of the 2008 ozone National Ambient Air Quality Standard (NAAQS) as a Serious ozone NAA.

5.1 2020 Ozone Attainment Demonstration

Two CAMx 2016 36/12/4-km base case and 2020 future year simulations were conducted that differed in the meteorological inputs used. The CAMx S9 configuration used meteorological inputs based on the DM/NFR WRF/GFS 36/12/4-km meteorological model simulation and the CAMx S10 configuration used meteorological inputs based on the EPA WRF/NAM 36/12-km meteorological model simulation. Because the CAMx 2016 36/12/4-km base case using the S10 configuration produced better ozone model performance than S9, the CAMx 2020 future year design value (DVf) projections using the CAMx S10 configuration was used for the 2020 attainment demonstration modeling, which is presented in Chapter 3. The CAMx 2020 projected 2020 DVf at all monitoring sites using the S10 configuration and the EPA default projection approach achieved the 2008 ozone NAAQS thereby demonstrating attainment. The highest CAMx S10 projected 2020 ozone DVf was 75.9 ppb at the NREL monitoring site that is truncated to 75 ppb so attains the 2008 ozone NAAQS.

5.2 Weight of Evidence Supplemental Analysis

A weight of evidence (WOE) supplemental analysis was conducted that examined alternative 2020 DVF projection approaches, alternative CAMx configuration (i.e., S9) for making DVf projections, changes in absolute modeled ozone metrics between 2016 and 2020 years and trends in observed ozone concentration that is presented in Chapter 4 and summarized below.

- Alternative 2020 DVf projection procedures from the EPA guidance default approach were used with the CAMx S10 configuration.
    - Two different alternative definitions of "near the monitor" were used to project 2020 DVf using the CAMx S10 configuration. One alternative near the monitor approach increased the NREL projected 2020 ozone DVf to above the 2008 ozone NAAQS, whereas the other further lowered the projected 2020 ozone DVf at NREL so that it was even further below the ozone NAAQS than estimated using the EPA default projection approach. The projected 2020 DVf at all other monitoring continued to be below the 2008 NAAQS using the alternative near the monitor definitions.
    - The removal of observed ozone data that have been flagged as being influenced by smoke or stratospheric ozone from the observed base year (i.e., 2014-2018) design value (DVb) reduced the projected 2020 ozone DVf at the four key monitoring sites so that they were all below the 2008 ozone NAAQS using all three definitions of near the monitor.

  - The use of the within 10% model performance evaluation (MPE) criteria that requires CAMx 2016 base case Maximum Daily Average 8-hour (MDA8) ozone estimates used in the projections to be within 10% of the observed MDA8 ozone concentration still resulted in projected 2020 DVf at all sites to be below the 2008 ozone NAAQS. For example, at NREL use of the 10% MPE criteria resulted in the same 75.9 ppb projected 2020 DVF as when no 10% MPE criteria was used. However, using the 15% MPE criteria increased the projected 2020 DVF at NREL by 0.1 ppb to 76.0 ppb.

- An Unmonitored Area Analysis (UAA) was conducted that interpolated the 2014-2018 base year DVb to each 4-km grid cell in the 4-km grid resolution Colorado domain and then make 2020 ozone DVf projections in each 4-km grid cell using the CAMx S10 2016 and 2020 modeling results. The UAA projected 2020 DVf in each grid cell of the DM/NFR NAA were below the 2008 ozone NAAQS.

- 2020 DVf projections were made with the alternative CAMx S9 2016 36/12/4-km model configuration that used different meteorological inputs than S10. Projected 2020 DVf were made using CAMx S9 modeling results using the EPA default and alternative projection procedures discussed above. The CAMx S9 configuration ozone projections were less responsive to the changes in emissions than S10 so that the projected 2020 DVFs at NREL were above the 2008 ozone NAAQS using all projection techniques when flagged data were included in the DVb; the CAMx S10 projected 2020 DVf at all other monitoring sites were below the 2008 ozone NAAQS. However, when data flagged as influenced by smoke or stratospheric ozone were removed from the DVb, the projected 2020 DVf at NREL were below the 2008 ozone NAAQS in 4 of the 5 alternative projection techniques analyzed.

- As recommended in EPA's ozone SIP modeling guidance, several absolute CAMx modeling metrics were used to examine the changes in CAMx modeled absolute ozone between the 2016 and 2020 years for ozone concentrations above the 2008 ozone NAAQS. Large (70-80 percent) reductions were found in the integrated ozone, number of grid cells, number of grid cells-days and number of days that the CAMx absolute ozone was reduced to below 76.0 ppb across the DM/NFR NAA.

- Observed ozone trends were examined from 2006 to 2019 at the four key monitoring sites in the DM/NFR NAA. The trends were calculated with and without accounting for meteorological adjustments and with and without including observed ozone data that were flagged as being influenced by influenced by smoke or stratospheric ozone. Regression equations were fitted to the observed ozone trends that indicated that when adjusting for meteorology and excluding flagged data the 4^{th} high MDA8 ozone is expected to be below the 2008 ozone NAAQS in 2020.

- There are numerous additional voluntary emission control measures being implemented in the DM/NFR NAA that were not included in the 2020 emissions because they are not federally enforceable. However, these voluntary measures will result in additional emission reductions that would lower 2020 ozone concentrations than those calculated in the 2020 attainment demonstration modeling.

5.3 Conclusions

Ozone precursor emissions have been steadily reduced in the DM/NFR NAA and surrounding areas over the last two decades. Ozone concentrations in the DM/NFR NAA have a lot of year-to-year variability due to variations in meteorology, intensity and frequency of occurrence of wildfires and stratospheric ozone intrusions and other phenomena that affect ozone transport and ozone formation within the DM/NFR NAA. Thus, projecting the 2020 ozone levels in the DM/NFR NAA has a lot of uncertainties as the occurrence of meteorological conditions that are highly conducive or suppress ozone formation will affect the actual 2020 ambient ozone levels. The 2020 attainment demonstration modeling indicates that if 2020 meteorological conditions and other phenomena (e.g., wildfires) are similar to 2016, the 2020 4th high MDA8 should be below the 2008 ozone NAAQS.

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